IBIC 2025

PROGRAMME

THE FOURTEENTH

INTERNATIONAL BEAM INSTRUMENTATION CONFERENCE

Liverpool, UK

7 – 11 September 2025

As of 1 August 2025

Contents

Contents

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	Dimtel	Booth 6
	Hamamatsu	Booth 17
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	Royal Holloway	Booth 10
	Safran	Booth 12
	Sensic	Booth 9
	Teledyne SP Devices	Booth 1
	UHV Design	Booth 20
	University of Liverpool	Booth 11
	XRnanotech AG	Booth 16

MOA: Welcome Talks

09:00 Welcome & Opening Remarks

C P Welsch (University of Liverpool)

09:10 Keynote talk: UK Accelerators and Beam Instrumentation

MOAKN01

J Wolfenden (Cockcroft Institute)

The UK accelerator community has established itself as an international leader in beam instrumentation R&D, contributing cutting-edge technologies and methodologies to accelerator science across the world. An overview of UK achievements in beam instrumentation will be presented, spanning developments in non-invasive diagnostics, advanced sensor technologies, and innovative data science, while highlighting the collaborations across national laboratories, universities, and international research infrastructures which have shaped this success. Looking ahead, this talk will explore emerging diagnostic challenges and opportunities, particularly in high-brightness beamlines, novel accelerators, and AI-integrated instrumentation and control. It will also examine the growing importance of translating instrumentation R&D into tangible societal and economic benefit: through stronger industry partnerships, support for spin-outs, and alignment with UK and EU knowledge valorisation strategies. These efforts aim to drive innovation, skills development, and cross-sector impact, and in doing so, demonstrate how beam instrumentation can deliver both scientific excellence and real-world benefit.

09:30 Vice-Chancellor's Welcome Address – University of Liverpool

T Jones (University of Liverpool)

09:40 Experience with proton beam instrumentation during commissioning of the ESS superconducting linac

MOAI01

T Shea (European Spallation Source)

In March 2025, the beam commissioning of the entire ESS linac commenced, supported by a diverse suite of instrumentation systems. This campaign followed the 2023 commissioning of the normal-conducting linac, which accelerated protons to 70 MeV. During the intervening period, the entire superconducting linac and the transport line to the tuning dump were installed. Several instrumentation systems underwent expansion, including the deployment of new position and phase measurement devices, current monitors, and beam loss detectors. In addition, various types of instruments saw beam for the first time, such as ionization profile monitors, fast wire scanners,

beam stops, imaging systems, and an aperture monitor. The commissioning campaign culminated in the acceleration of first protons through the final drift tube linac tank (to 90 MeV), the superconducting spoke structures (to 216 MeV), and the medium-beta and high-beta elliptical structures (to >800 MeV). In this paper, we present the initial beam measurements, as well as verification of the protection functions and lessons learned from the experience.

MOB: Oral Presentations

10:50 Transverse Momentum Measuring Systems: The Cryogenic Momentatron and the TESS

MOBI01 **L Jones (STFC)**, *et al.*

Photocathode performance optimization is crucial to the operation of X-ray Free Electron Laser (FEL) facilities such as LCLS-II and the future UK XFEL as the initial photoelectron phase-space distribution directly impacts x-ray generation efficiency in the undulator. Key photocathode parameters such as transverse emittance and quantum efficiency are routinely measured to monitor and improve performance; metrics that are influenced by the photocathode material, operating temperature, vacuum and RF environmental conditions, and the characteristics of laser illumination (e.g., wavelength, and pulse energy, duration, and repetition rate). To better understand these factors, SLAC has developed a laboratory-based cryogenic Momentatron system to measure the emission properties of photocathodes from 30 K to 300 K using 200-800 nm wavelength-tunable light. The system's design and initial commissioning performance have been validated through simulations and error analysis, confirming its reliability for photocathode characterization. We present measurements taken at SLAC, along with complementary data for Cs-Te obtained using the TESS system at Daresbury Laboratory - a similar photocathode characterization tool. These results provide valuable insights into photoemission physics that may be leveraged to optimize photocathode performance and thus that of X-ray FELs.

11:20 Measurement of nA Beam Intensities at FAIR

MOBC01 **T Sieber (GSI Helmholtz Centre for Heavy Ion Research)**

Like standard beam transformers the cryogenic current comparator (CCC) measures the intensity of particle beams via the azimuthal magnetic field. The superior performance of the CCC derives from a superconducting magnetometer (SQUID - Superconducting Quantum Interference Device), which detects fields in the fT range. This enables for current resolution in the nA range but in return needs extremely careful protection from external influences like stray fields and mechanical vibrations. The CCC therefore requires an elaborated superconducting magnetic shielding and is housed in a specially developed, vibration damped He bath cryostat. We have recently achieved half a year of non-stop operation in stand-alone (closed Helium circuit) mode. The nA resolution has been demonstrated earlier during several beamtimes, in CRYRING as well as with slow extracted beams from SIS18. Among the CCC types, which have been investigated, the 'Dual Core' (DCCC) version showed

the best performance with respect to bandwith and current resolution. The DCCC and its cryostat therefore mark a provisional closure of CCC development for FAIR. In this contribution we present the latest results and system status.

11:40 **Performance study of Fast Beam Current Transformer calibration in the LHC**

MOBC02 **J M Gaspar (European Organization for Nuclear Research)**, *et al.*

Fast Beam Current Transformers (FBCTs) are essential devices for measuring bunched beam intensities in the Large Hadron Collider (LHC). A cross-calibration of these devices against DC Beam Current Transformers (DC-BCTs) is used in the LHC ring, but this method relies on assumptions that introduce inaccuracies. FBCTs are also used in the LHC transfer lines, where DC-BCTs are unavailable, making absolute calibration crucial for transmission studies. To allow absolute calibration, the FBCTs are equipped with a pulsed current source to perform a calibration before each fill. However, a systematic underestimation in the calculated scaling factors has been observed when comparing them to the cross-calibration with the DC-BCTs. This work characterizes the calibrator performance, evaluates different algorithms for calculating the scaling factors and reports
on issues found linked to processing chain modeling inaccuracies, ghost/satellite bunches, and the FPGA-based digital integration. A revised model of the processing chain improved calibration accuracy by 0.4%, while an initial test of a batch-by-batch baseline in the digital integration seems to explain the remaining 3% underestimation.

MOC: Oral Presentations

13:00 Commissioning and First Operation of SLS 2.0, the Upgrade of the Swiss Light Source

MOCI01 B Keil (Paul Scherrer Institute)

After more than 20 years of successful operation, the storage ring of the Swiss Light Source (SLS) has recently been replaced with a new diffraction-limited storage ring (DLSR) called SLS 2.0. After a dark time of 15 months from October 2023 until December 2024, SLS 2.0 now provides more than 40 times higher brilliance for hard X-ray users, thanks to an innovative compact 7-bend achromat magnet lattice with reverse bending magnets that fits into the old SLS 1.0 tunnel. In this contribution, we give an overview of the commissioning of the new storage ring and first user operation experience, highlighting key differences between SLS 1.0 and 2.0, as well as the role and usage of different beam instrumentation systems during the commissioning process from the operations perspective. Moreover, we present the status of beam based feedbacks systems, and the resulting beam stability and performance that has been achieve so far during first user operation. This includes an orbit stability analysis using frequency-resolved principal component analysis (FPCA), comparing beam measurements with pre-beam vibration measurements and stability simulations.

13:30 Beam Diagnostics in the J-PARC Linac and Its Current Activities

MOCC01 K Moriya (Japan Proton Accelerator Research Complex)

J-PARC Linac accelerates the high-intensity beam of 50 mA using an RF system of 324 MHz and 972 MHz. In order to accelerate and transport the high-intensity beam to facilities stably, the current value, centroid, and distribution of the beam must be measured to realize optimum operating conditions. This paper reports on the transformations and improvements of the linac beam diagnostics since 2015. As an example, carbon nanotubes (CNTs) were employed in the WSM at the upstream of the linac. There has never been an unintentional WSM failure after the CNT replacement. Other reports on the status of BSM operations will also be presented. The diagnosis of beam anomalies experienced during beam tuning will also be reported.

13:50 Beam diagnostics for IFMIF-DONES: Addressing the challenges of high-power irradiation facilities

MOCC02 **A Ortega Moral (Universidad de Granada)**

The IFMIF-DONES facility, currently under construction in Granada (Spain), is dedicated to testing materials under neutron irradiation, as part of advanced materials research for next-generation fusion reactors. The superconducting linear accelerator of the facility is intended to deliver a continuous-wave deuteron beam with an energy of 40 MeV and an unprecedented current of 125 mA. The production of neutrons is then achieved by driving the 5 MW beam into a liquid lithium target. Beam diagnostics play a critical role in the IFMIF-DONES accelerator due to several unique challenges. These include the extremely high beam power, the harsh environment due to neutron and gamma radiation and the required operational availability of the accelerator. Moreover, the accelerator may operate in pulsed and continuous wave for commissioning and standard operation, respectively. This work presents an overview of the main beam diagnostics techniques and strategies needed to address these challenges, as well as the construction plan and the prototyping works. ACKNOWLEDGEMENT This work has been carried out within the framework of the EUROfusion Consortium.

MOD: Oral Presentations

14:50 The Role of Beam Diagnostics during APS-U Commissioning

MODI01 **W Cheng (Argonne National Laboratory)**

The Advanced Photon Source Upgrade (APS-U) represents the latest advancement in ultra-low emittance storage ring light sources. Since its commissioning and the commencement of user operations in 2024, APS-U has successfully reached its design beam current of 200 mA and operates reliably for user experiments. The diagnostic systems have been integral to the successful commissioning and operation of the machine. This paper presents the beam commissioning results of various diagnostic systems in the APS-U storage ring, with a focus on beam position monitors. Additionally, we will discuss various beam measurements, including beam current and lifetime, tune, beam stability, and swap-out injection bunch motion.

15:20 The BI system design and preliminary tests for HIAF

MODC01 **H Ming (Institute of Modern Physics, Chinese Academy of Sciences)**

High Intensity heavy ion Accelerator Facility (HIAF) is now under equipment tests and about to deliver multiple beam species from Proton (9.3 GeV, 6E12 ppp) to Uranium (835 MeV, 2E11 ppp) into various experimental terminals. Undoubtedly, it demands a lot of functions and challenges for BI system both in instruments and electronics. This BI system totally possesses more than 650 number and 20 types of monitors, including nearly 300 scintillators for the fast loss determination of primary beams and field emitted X-ray by cavities, and more than 2000 units and 20 kinds of fully self-developed electronics for data acquisitions as well. The system design and deployment details, problems encountered like EMI during preliminary tests, and progress of beam commissioning at MEBT now are all about to be described. As for the monitors, we have mainly designed cold buttons, capacitive and linear-cut BPMs for beam position and phase, various CTs and faraday cup for beam current, IPM and wire scanner for transverse profiles, WCM and fast faraday cup for the bunch length, collimator and halo ring for beam scraping, and many pickups for extraction, Schottky, tune and feedback applications as well.

15:40 Performance Analysis of the LHC BSRL and Possible Improvements

MODC02 **A Jury (University of Liverpool)**, *et al.*

The Beam Synchrotron Radiation Longitudinal density monitor (BSRL) at the LHC leverages time-correlated single-photon counting to provide high-dynamic-range measurements of the relative charges in each RF bucket with a time resolution of 50 ps. These measurements are needed for the operation of the LHC as well as for the luminosity calibration required by the LHC Experiments. In this work we identify sources of error for each the BSRL components. These components are the optics (mirrors, filters and optical fibres), the detector (a hybrid photomultiplier - HPM), the electronics (a Time to Digital Converter - TDC) and some data analysis used for the final results. Knowledge of the errors of the BSRL is crucially important as any errors are passed directly into the luminosity calibration of the LHC experiments. We quantify the errors introduced by each of these parts and for external systems, like the LHC timing. For the largest contributors to the overall error, we propose mitigation strategies that can be deployed in the short term.

MOPCO: Poster Presentations

MOPCO01 End to end simulations of a novel optical fibre monitoring system for energy recovery LINACs

A Jones (Cockcroft Institute), J Wolfenden, C Welsch (University of Liverpool; Cockcroft Institute); S Boogert (Cockcroft Institute; University of Manchester)

Energy recovery LINACs (ERLs) are a type of novel accelerator, which recycle energy from old beams to new beams to increase machine energy efficiency. However, this can heighten beam instabilities, which limits the maximum beam current and increases beam losses. An optical fibre beam loss monitor (OBLM) can provide rapid and reliable beam loss monitoring, which is important for mitigating these instabilities. It obtains the beam loss location via time-of-flight analysis of Cherenkov radiation (CR) produced in optical fibres by relativistic particle showers from beam loss events. Operational demonstration of the OBLM system has previously been shown at several non-ERL facilities, but the multi-energy, fast-repeating beams of ERLs present a unique challenge. Successful interpretation of ERL beam loss signals involves distinguishing losses from beams of different energies, which can be investigated through end-to-end Monte Carlo simulations of the radiation environment and its interaction with the OBLM system. This contribution presents Geant4 simulations of the OBLM response to sample sources of beam loss for beam energies of 7-500 MeV and bunch populations of 1-10M electrons.

MOPCO02 Data-Driven Prediction of Infrared Free-Electron Laser Performance Using BPM Measurements and Machine Learning

C Liu (University of Science and Technology of China), Y Leng, Z Fang, X Yang, Y Deng (University of Science and Technology of China)

This study proposes a machine learning approach to analyze the correlation between beam position monitor (BPM) measurements and output laser power in the Hefei Infrared Free-Electron Laser (FEL) facility. Using bunch-by-bunch data of transverse position, charge, and longitudinal phase collected from upstream undulator BPM probes, we develop a predictive model to evaluate whether BPM measurements can effectively forecast the infrared FEL's laser power output. If the model demonstrates significant predictive capability, we will decompose the network to identify the most influential bunches or parameters, providing targeted optimization strategies for beam tuning experiments. This data-driven approach reduces reliance on empirical tuning methods and improves accelerator operational stability.

MOPCO03 Beam Diagnostics of the NEWGAIN Project

C Jamet (Grand Accélérateur Nat. d'Ions Lourds), C Maazouzi, P Graehling, T Adam (Institut Pluridisciplinaire Hubert Curien); C Potier de Courcy, C Hocini, E Dessay, G Ledu, J Foy, P Salou, S Leloir, S Rueff, T Andre, g monier (GANIL)

The aim of the NEWGAIN Project (NEW Ganil INjector), is to build a second injector on the SPIRAL2 accelerator to produce and accelerate heavier beams with A/q up to 7. The NEWGAIN injector is based on 2 ECR ion sources, two LEBT, one RFQ and a MEBT lines to send new ion beams in the linac and the S3 experimental room. Diagnostic monitors are planned to measure and control beam intensities, profiles, phases, energies and emittances. A presentation of beam characteristics and a description of the diagnostic monitors are done. Modifications of the beam duty cycle system and the machine protection system are also detailed.

MOPCO04 Modelling, anomaly detection and classification of slow losses using machine learning for Diamond-II Beam Loss Monitors

C Lehmann (John Adams Institute for Accelerator Science), L Bobb (Diamond Light Source); P Burrows (John Adams Institute for Accelerator Science; University of Oxford)

The slow losses measured by Beam Loss Monitors (BLMs) at synchrotron light source facilities offer useful but indirect insight into the state of the beam. Patterns arise across the set of BLMs depending on the movement of insertion devices, beam current, temperature, humidity, and other contributors. A variety of neural network models were designed and evaluated to model this behaviour under user beam operation to enable anomaly detection and aid fault investigations.

MOPCO05 LHC BLM System Automations for Fault Prognosis, Detection and Issue Tracking

D Tzamarias (European Organization for Nuclear Research), B Salvachua, C Zamantzas (European Organization for Nuclear Research)

One of the principal roles of CERN's Beam Loss Monitoring (BLM) system pertains to the protection of LHC's superconducting magnets against quench-inducing beam losses. Thus, the continuous surveillance of the BLM system's performance is essential for the high reliability and availability of the LHC. This paper focuses on the architecture of a novel data pipeline with implementations on monitoring the communication status between the 864 acquisition tunnel modules that digitize the analog loss measurements, and the 432 processing surface modules

that determine and act upon the criticality of the beam losses. The discussed pipeline replaces an older batch Extraction-Transformation-Loading (ETL) process, which published daily BLM status reports, in favor of a streaming ETL process. The new pipeline expands beyond the daily publication of static status reports by exploiting real-time data analysis and processing enabling the live assessment of the system's status via online fault detection and web-based dashboards. Future development on the implemented pipeline envisions online machine learning and automated Jira issue generation features permitting fault prognosis and issue tracking.

MOPCO06 High-resolution diagnostics of the TOP-IMPLART 71 MeV proton beam using photoluminescent color centers in LiF crystals

E Nichelatti (ENEA Casaccia), M Piccinini, A Ampollini, M Denise Astorino, G Bazzano, A Doria, F Fortini, P Nenzi, E Pavoni, G Picardi, V Surrenti, E Trinca, M Vincenti, C Ronsivalle (Ente per le Nuove Tecnologie, l'Energie e l'Ambiente)

Optically active point defects, known as color centers (CCs), are created in the crystal lattice of lithium fluoride (LiF) by irradiation with various types of ionizing radiation. Some of these CCs emit light in the red and green regions of the visible spectrum when optically excited with blue light. When a proton beam irradiates a LiF crystal, a volume distribution of CCs is formed, with defect concentration point-by-point proportional to the absorbed dose for values up to approximately 10^5 Gy. By illuminating the irradiated crystal with blue light in a fluorescence microscope, a luminescent image produced by the CCs can be observed and recorded. A high-resolution diagnostics both for spot imaging and energy in a proton accelerator has been developed based on this technique. Regarding energy, a luminescent replica of the Bragg curve in LiF is extracted and analyzed using a theoretical model of Bragg curve applied to dose deposition, taking into account the crystal dimensions. We report an application of this method to the 71 MeV TOP-IMPLART linac at ENEA Frascati, where it was used to evaluate the beam energy spectrum at both the crystal position and the accelerator exit.

MOPCO07 The SPS SPS Beam Loss Monitoring System renovation plan

E Calvo Giraldo (European Organization for Nuclear Research), B Salvachua, C Zamantzas, E Effinger, M Saccani, W Vigano' (European Organization for Nuclear Research)

The Super Proton Synchrotron (SPS) beam loss monitoring (BLM) system at CERN, operational for several decades, currently comprises 286 Ionisation Chambers (ICs) around

the SPS ring and approximately 144 additional detectors along various extraction lines (TT20, TT40, TT60, etc.). A complete renovation of the system is planned during Long Shutdown 3 (LS3), encompassing detectors, cabling, and acquisition electronics. The upgraded architecture will adopt a design similar to the current LHC BLM system—featuring front-end and back-end electronics housed in separate crates and connected via optical links—ensuring compatibility with the LHC upgrade scheduled around LS4. This paper presents an overview of the proposed architecture for the SPS ring and transfer lines, detailing the key components and expected improvements in performance, modularity and reliability.

MOPCO08 A 3GHz Wall Current Transformer for Very High Bandwidth Beam Current Measurements

F Stulle (Bergoz Instrumentation, P Korysko (University of Oxford); H Bayle, L Dupuy (Bergoz Instrumentation (France); R Corsini, W Farabolini (European Organization for Nuclear Research)

Non-destructive beam current measurements are a crucial aspect of beam instrumentation in any particle accelerator. Often, these measurements must be capable of distinguishing individual beam pulses. In an increasing number of accelerators, pulse repetition rates reach the GHz range. Consequently, beam current measurement bandwidth must exceed a few GHz. To meet this requirement, a wall current transformer was developed with a bandwidth exceeding 3 GHz. It was tested using a vector network analyzer and with an electron beam at CERN's CLEAR facility. Both measurements showed excellent agreement. We introduce the wall current transformer principle and discuss the measurement results. Additionally, we highlight some challenges that must be addressed when measuring high-frequency signals.

MOPCO09 EPAC Beamline Prototype: Development and Optimization of a High-Repetition-Rate LWFA System

K Fedorov (Central Laser Facility), A Bennett, O Finlay (Central Laser Facility)

The Extreme Photonics Applications Centre (EPAC) is a next-generation high-power laser facility designed to deliver stable, high-repetition-rate (10 Hz) LWFA electron beamline with high quality parameters (~1 nC, ~1 GeV, <5% energy spread). As a crucial preparatory step, one of the 10 TW laser system (Gemini) at the Central Laser Facility is being repurposed as a prototype beamline to de-risk EPAC commissioning and to develop critical subsystems. We report on a progress in three core areas: 1. Targetry Development: We designed and implemented gas-cell

targets featuring enhanced durability, leveraging replaceable CVD diamond apertures and modular components to support 5 Hz operation. 2. Beam Optimization: Using Bayesian optimization, we explore tuning of key LWFA outputs-electron charge, energy, divergence, and X-ray flux and energy-achieving improved performance across shots. 3. Integrated Simulation Framework: To support beamline design, we are developing a modular toolkit that couples fluid dynamics (OpenFOAM), particle-in-cell (FBPIC), and Monte Carlo (Geant4) simulations.

MOPCO10 Considering the Suitability of X-Ray Detectors for Medical Imaging and Accelerator Applications

L Eley (Cockcroft Institute), A Hill, C Welsch, D Aflyatunova (University of Liverpool; Cockcroft Institute); A Mavalankar, S Wells (Adaptix (United Kingdom)

Digital tomosynthesis (DT) is an x-ray scanning modality that creates 3D images similarly to Computed Tomography, but over a lower angular range. Recent innovation by company Adaptix have revised this technology to allow for the development of portable DT devices that retain the low dose benefit of this technique. The detector is a key component of this device. For medical imaging, detectors require a fast read-out time to optimise patient comfort with sufficient pixel resolution to see details of interest, such as tumours. This compares to detectors used in synchrotrons, for example, which similarly must have a suitably fast read-out time for the pulse spacing with resolution adequate for a range of objects of interest. Therefore, this work aims to focus on the role of detectors as a key hardware component in both accelerator and medical imaging research. Two detectors with distinct parameters each, the DRTech1624 and DRTech3643, will be compared to inform discussion as to their usefulness for DT imaging as well as relating how applicable these findings might be in other modern x-ray contexts, such as within XFEL technology.

MOPCO11 Optical beam loss monitor installed at the SPS slow extraction region

M King (European Organization for Nuclear Research), B Salvachua, E Effinger, J Michel Meyer, J Kearney, J Esteban, S Benitez Berrocal (European Organization for Nuclear Research); C Welsch, J Wolfenden (University of Liverpool; Cockcroft Institute)

An optical beam loss monitor (oBLM) has recently been installed at the slow extraction region of the Super Proton Synchrotron (SPS) at CERN. The oBLM offers a new method for detecting beam losses at the SPS by utilizing the Cherenkov radiation emitted during beam loss interactions with an optical fibre. This setup should allow to measure

losses continuously over a large section of the accelerator, thus minimising the non-linearities caused by the finite coverage of the currently installed ionisation chambers. Due to the high radiation levels and low expected signals at this location, special care was taken during the procurement process to maximise the signal levels while at the same time extending the lifetime of the system as much as possible. The rationale behind the choice of specific components is discussed, highlighting their advantages compared to other options. Furthermore, initial measurements of beam loss during extraction are presented, and the system's ability to provide real-time diagnostics for beam protection and machine optimization investigated.

MOPCO12 First Beam Commissioning Experience With RF System On Chip Based Bunch By Bunch Signal Processing Systems at SLS 2.0

P Baeta Neves Diniz Santos (Paul Scherrer Institute), *et al.*

After a dark time of 15 months, the new diffraction limited storage ring SLS 2.0 had first beam in January 2025. In April 2025, the nominal beam current of 400 mA was reached. In this contribution, we present the status and first beam commissioning experience with the RF System-on-Chip (RFSoC) based signal processing systems of the new SLS 2.0 ring. RFSoCs integrate several fast multi-GSample/s ADCs and DACs, FPGA (programmable logic) fabric and multi-core CPUs all on the same chip. During SLS 2.0 commissioning, the integrated EPICS IOC of the RFSoCs provided bunch-by-bunch diagnostics of dedicated BPM position and charge readings. Integrated DACs are driving newly developed transverse and longitudinal kicker magnets, enabling bunch-by-bunch excitation and damping. Bidirectional multi-Gigabit fiber optic links connect the RFSoC to the event system master, thus enabling both synchronisation of the RFSoC to the event system, as well as real-time control of the event system master by the RFSoCs, e.g. for control of beam injection timing and filling pattern.

MOPCO13 Simulation and feasibility analysis of a Non-Invasive Cavity Beam Current Monitor for Low-Energy Antiproton beams

S Chandran (University of Liverpool), N Kumar (Cockcroft Institute); B Rienäcker (The University of Liverpool); B Rawat, C Welsch (University of Liverpool)

For high-precision experiments involving low-energy antiprotons, non-invasive beam charge measurements with high accuracy are crucial. This paper presents a simulation study investigating the feasibility of a cavity-based beam current monitor (BCM) for low-energy antiprotons.

Conventional invasive methods, such as Faraday Cups and MCPs, suffer from charge loss, limiting measurement accuracy. This issue is particularly challenging for low energy charged antimatter, where accounting for charge loss is complex due to uncertainties in their interactions with matter. Existing techniques are reviewed and compared, and efforts to improve measurement accuracy within a tighter error margin than current methods are discussed. This study is motivated by challenges faced by antimatter experiments such as AEgIS at CERN, which aim to probe antimatter behavior under gravity. The preliminary results of the simulation and feasibility analysis of the BCM will be discussed.

MOPCO14 Commissioning of the CLARA Facility: Status Update and Diagnostics Performance

T Pacey (STFC), *et al.*

The Compact Linear Accelerator for Research and Applications (CLARA) is STFC Daresbury Laboratory's flagship accelerator facility. In this talk we present the latest data from the commissioning of the CLARA facility at Daresbury Laboratory. This will include initial beam measurements and diagnostic performance for the 250 MeV high brightness, highly compressed electron bunches. Once commissioned, CLARA will transition to provide beam for user led experiments; covering areas such as R&D into electron radiotherapy and laser-plasma accelerators. An overview of the diagnostic requirements and anticipated challenges for these high impact user experiments will be provided. Finally, the future direction of diagnostics at CLARA will be discussed, including: potential system upgrades, plans for virtual diagnostics, and opportunities for collaboration.

MOPCO15 Physics-Guided ML Driven Data Expansion for Photocathodes using TESS Measurements

S Malhotra (University of Liverpool), L Jones (ASTeC, STFC Daresbury Laboratory; Cockcroft Institute); C Welsch, N Kumar (University of Liverpool; Cockcroft Institute)

Photocathodes are critical components in advanced electron sources, and accurate characterization of their performance is essential. Direct measurements of mean transverse energy (MTE) using the Transverse Energy Spread Spectrometer (TESS) at Daresbury Laboratory often yield modest datasets. Physics-informed machine learning, particularly generative models like GANs and diffusion models, offers a way to expand these into larger sets of physically consistent synthetic images. Preliminary results show structural similarity indices (SSIM) >0.95 and predictive accuracies with $R^2 \sim 0.98$. A predictive model for estimating MTE at a given wavelength is also introduced. This enables rapid optimization of materials and

parameters, cutting experimental overhead. These data-driven methods improve electron beam diagnostics, aid photocathode development, and may enhance accelerator performance. The approach also shows promise for optimizing free-electron laser (FEL) systems, advancing ML in accelerator science.

MOPCO16 Development of Monitoring and Analysis System for Beam Operation in RAON

E Im (Institute for Basic Science), J Kwon, M Park, S Lee, Y Ahn, e kwon (Institute for Basic Science)

The Rare-isotope Accelerator complex for ON-line experiment (RAON) is a heavy ion accelerator with maximum beam power of 400 kW. To facilitate efficient information sharing among multiple users, we have developed an integrated system to monitor and analyze beam operations at the RAON accelerator. This system enables real-time tracking of beam transmission paths by analyzing the status of beam dump and bending magnets. Beam delivery times are calculated for each section based on the defined transmission paths, and the data are recorded by date and experiment to support beam usage analysis. In addition to beam tracking, the system monitors and records changes in key parameters such as vacuum conditions, LLRF settings and beam properties including width and frequency. The records are utilized not only used for monitoring but also serve as data for post-experiment analysis, troubleshooting, and optimization of beam operations, thereby ensuring tracking of facility status and supporting efficient management.

MOPCO17 Design Status of the Electron-Ion Collider Beam Instrumentation

D Gassner (Brookhaven National Laboratory), A Pramberger, A Blednykh, B Bacha, C Hetzel, C Liu, E Skordis, F Micolon, G Bassi, I Pinayev, J Pomaro, J Bellon, K Matsushima, L Flader, M Wendt, M Esposito, M Paniccia, M Sangroula, R Hulsart, R Michnoff (Brookhaven National Laboratory)

The Electron Ion Collider (EIC) is being built at Brookhaven National Laboratory (BNL). The early preliminary design phase efforts are underway. In addition to upgrading the existing RHIC instrumentation for the EIC hadron storage ring, new electron accelerator subsystems will include a 750 MeV Linac, accumulator ring, rapid-cycling synchrotron, electron storage ring, and a hadron cooling facility. The scope of the instrumentation includes devices to measure beam position, loss, current, charge, tune, transverse and longitudinal profiles, emittance, and crabbing angles. A description of the planned instruments and the present design status will be presented.

MOPCO18 Software Upgrade of Beam Diagnostics Readout System Based on PXIe Hardware

W Huang (Institute of High Energy Physics), B Zhang, F Li, L Zeng, M Abdul Rehman, R Yang, R Qiu, W Chen (Institute of High Energy Physics); C Chen (China Spallation Neutron Source)

In the beam diagnostics system of the CSNS accelerator, multiple National Instruments (NI) PXIe multifunction DAQ modules were utilized for readout system development. The original software architecture, implemented with LabVIEW+DSC modules on Windows system, introduced substantial challenges in EPICS integration. This paper details a software upgrade methodology that preserves the existing NI PXIe hardware infrastructure. The upgraded system implements standard EPICS Input/ Output Controllers (IOCs) developed in C language under Linux system, integrating signal acquisition and front-end electronics control functionalities within EPICS IOCs. This re-engineering approach enhances the readout system stability while improving the reliability and flexibility of EPICS data interaction. The successful migration demonstrates an effective hardware-preserving software optimization strategy for accelerator instrumentation systems.

MOPCO19 Large Dynamic Range Beam Intensity Measurement of Both H0 and Proton Beams in Injection Upgrade of CSNS-II

W Huang (Institute of High Energy Physics), R Qiu, X Nie, F Li, L Zeng, R Yang, Z Xu (Institute of High Energy Physics)

China Spallation Neutron Source (CSNS) upgrade project (CSNS-II) started in 2024. As the first important task, the injection section will be redesigned and a lot of beam instruments will be installed along the injection to I-Dump beam line. The H0 beam intensity at the downstream of the stripping foil is several microampere during the normal operation, while the proton beam intensity at the I-dump may be over 80mA during the commissioning of linac and RCS. A corresponding design of the ACCT sensor and electronics is introduced in this paper. There are two nanocrystalline cores in H0CT, providing two different turns ratio for the large dynamic range beam intensity measurement. The gain of the electronics is switchable in two ranges. The INDCT is equipped with only one core and the electronics design is aiming to a high SNR for the injected proton beam power evaluation. Tests in the lab showed a good linearity of the H0CT and INDCT sensors with the electronics. Beam commissioning of the injection section is planned in October of 2025.

MOPCO20 CSNS-II superconducting Section Beam Loss Measurement Electronic Design

W Huang (Institute of High Energy Physics), F Li, M Abdul Rehman, R Yang, R Qiu, Z Xu (Institute of High Energy Physics)

The CSNS-II linear accelerator upgrade will adopt superconducting accelerator structures, with the beamline enclosed in low-temperature modules. Detection of beam loss can only be done on the outer surface of the low-temperature modules. The CSNS-II accelerator plans to use a parallel plate multi-electrode ionization chamber as the beam loss monitor (BLM) probe for the superconducting section. The electronic system of the beam loss measurement (BLM) is primarily used for signal conditioning, digitization (ADC), transmission storage as EPICS PV quantities, and providing interlock signals for machine protection based on the output signals from the BLM probes. The main tasks of the development of the beam loss measurement (BLM) electronic system include: signal conditioning of weak current output from the BLM probes in the analog circuit section; and analog-to-digital conversion, digital signal processing, storage, PV quantity publication in the digital circuit section for the front-end analog output signals.

MOPCO21 Investigation and improvement of slow extraction quality at HIRFL-CSRm

T Liu (Institute of Modern Physics, Chinese Academy of Sciences), G Zhu, K Gu, X Qiu, H Ming Xie, L Li, Z Li, Y Wei, Y Zhang, J Wu (Institute of Modern Physics)

The slow extraction experimental users are urgent and imperative for the quasi-consecutive and uniform beam during the spill, generally several seconds. The online monitoring of the beam spot and intensity are also demanded. Recently, a set of slow extraction instruments were upgraded at the HIRFL-CSRm not only for the online monitoring, but also the improvement of the spill quality and the investigation of the micro structure. A new RF knockout (RF-KO) with the equivalent power up to 9 kW was equipped at the CSRm for the third-integer resonance. An online ionization chamber was fixed at the CSR External-target Experiment (CEE) monitoring the pre-target beam spot and intensity. A feedback loop comprises the RF-KO, IC and the home-made electronics, was adopted and demonstrated a significant improvement on the spill quality. A pilot experiment with a SiPM based plastic scintillator at the CEE revealed the sub-ns micro structures. The data acquisition system features 1 Gsps sampling rate and 5s storage, covering the whole spill. The measurement in recent campaigns is presented and the further improvement of the feedback system, the detector design, the electronics parameters is given.

MOPCO22 Signal reconstruction method applied in HEPS beam charge measurement

Y Zhao (Institute of High Energy Physics), *et al.*

The technology of signal reconstruction, baseline correction and adaptive integration method has been applied to the High Energy Photon Source (HEPS) charge measurement for high accuracy measurement. In this paper, simulation of signal reconstruction, algorithm of baseline correction and integration are present, the . At last, the results of the application on beam charge measurement are also discussed.

MOPCO23 Commissioning of the 71 MeV beam delivery line of the TOP-IMPLART accelerator

P Nenzi (Ente per le Nuove Tecnologie, l'Energie e l'Ambiente), A Ampollini, M Denise Astorino, G Bazzano, A Doria, F Fortini, E Nichelatti, E Pavoni, G Picardi, M Piccinini, C Ronsivalle, V Surrenti (National Agency for New Technologies, Energy and Sustainable Economic Development); E Trinca (National Agency for New Technologies Energy and Sustainable Economic Development)

TOP-IMPLART is a pulsed RF proton linear accelerator in operation at the ENEA Frascati Research Center originally built as a technological demonstrator for a full-linear solution to protontherapy, it is currently evolving towards a facility available for research and industrial users in different fields, ranging from biomedical to aerospace applications. It consists of a commercial AccSys PL7 model 425 MHz injector followed by eight SCDTL accelerating modules operating at 3 GHz. Proton beams in the range 1-6 MeV are available from a vertical delivery line placed at the exit of the injector, and at 63 MeV or 71 MeV (intermediate and lower energies are achieved by degraders) from a horizontal delivery line at the exit of the accelerator, where a pulse current variable up to 20 μA is provided in pulses 2.5 μs long at a typical repetition rate of 25 Hz. Our contribution presents the first experimental results from the commissioning of the high-energy line. It is a multi-purpose in-house designed line featuring a magnetic scanning system and a set of instrumentation, diagnostics, and target positioning frames placed on motorized platforms allowing for customizable irradiation setups.

MOPCO24 Advancements in Cherenkov fiber-based machine protection system at TRIUMF's e-Linac

R Hermann (TRIUMF), F Ames, H Wen Koay, M Alcorta Moreno (TRIUMF)

A Cherenkov fiber-based shut-off system is being developed for TRIUMF's ARIEL e-Linac to provide a scalable, cost-

effective solution for monitoring beam losses in high-radiation environments. The system uses a single 100m long thin silica fiber with photomultiplier tubes at both ends, allowing sensitive electronics to be located outside the radiation area. This design is favorable over bulky ionization chambers and more expensive scintillation-based detectors, as it improves and simplifies deployment in complex environments, particularly the ARIEL beamline tunnel. The prototype demonstrates sub-10 µs response times and position-sensitive detection via the time delay between upstream and downstream signals. Ongoing work focuses on the achievable spatial resolution, the integration into ARIEL's operations control environment and the systematic evaluation of reliability and sensitivity.

MOPCO25 Design and development of turn-by-turn and bunch-by-bunch high-speed 128-channel data acquisition electronics applied to the HIAF facility

Z Li (Institute of Modern Physics, Chinese Academy of Sciences), J Wu, K Gu, S LU, X Qiu (Institute of Modern Physics, Chinese Academy of Sciences)

Real-time precision monitoring of beam profiles and emittance parameters in the High-Intensity Heavy-Ion Accelerator Facility (HIAF) presents critical challenges for analyzing collective beam effects and optimizing operations. During acceleration phases requiring sub-microsecond temporal resolution (0.1-2.048 MHz cyclotron frequency), we developed a heterogeneous computing-based diagnostic system achieving 15 MS/s 128-channel synchronous sampling.The hardware integrates ZYNQ-UltraScale+ MPSoC with eight Kintex-7 FPGAs through a custom nanosecond-synchronized backplane, delivering 26.88 GS/s parallel throughput. A phase-locked adaptive algorithm using multi-channel SUM values enables dynamic frequency matching and real-time turn-by-turn processing. Coupled with multi-wire detectors and residual gas probes (IPM), the system resolves transverse beam profiles (≤500 ns/turn) and longitudinal charge dynamics simultaneously, enabling full 4D phase-space reconstruction for unprecedented accelerator control.

MOPCO26 Compact NMR Magnet Design for In-Vivo Measurement Applications

D Aflyatunova (University of Liverpool), C Welsch (University of Liverpool; Cockcroft Institute); G Gao, G Travish (ViBo Health)

This paper presents the design and simulation of miniaturized permanent magnet configurations for Nuclear Magnetic Resonance (NMR) applications capable of in-vivo measurements. Traditional NMR systems require

large, expensive equipment with high field uniformity, making portable applications challenging. We compare various compact magnet geometries, including H-type and Halbach arrays, evaluating their field strength, homogeneity, and suitability for finger-scanning applications. Our work demonstrates that carefully designed permanent magnet arrays can achieve sufficient field uniformity for localized metabolite detection in a compact form factor. Through computational modelling, we establish a framework for quantifying and optimizing magnetic field homogeneity critical for accurate NMR measurements in portable diagnostic devices.

MOPCO27 Web Streaming Integration for the TLS Beam Size Monitoring Broadcast System

L Hsu (National Synchrotron Radiation Research Center), C Liao, C Wu (National Synchrotron Radiation Research Center)

The beam size monitor broadcast system at the Taiwan Light Source (TLS) has traditionally used analog coaxial cables and modulators to transmit measurement images and data to control rooms and beamline stations via televisions and tuners. While simple and network-independent, this setup suffers from low resolution, frequent interference, and aging hardware with no ongoing maintenance. This paper presents a lightweight, non-intrusive upgrade that replaces the legacy system with a web-based real-time streaming solution. By capturing the existing output from the measurement system and streaming it using standard web technologies, users can access beam size visuals on any browser-enabled device, gaining better image quality and improved stability while eliminating traditional broadcast maintenance. As TLS is scheduled to be decommissioned in 2027, this solution offers a fast, low-risk, and cost-effective modernization path without altering existing instruments or computing environments. The system is currently under testing, and this paper describes its architecture, implementation, and preliminary results.

MOPCO28 Web Streaming Integration for the TLS Beam Size Monitoring Broadcast System

L Hsu (National Synchrotron Radiation Research Center), C Liao, C Wu, J Liao, Z Wu (National Synchrotron Radiation Research Center)

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MOPCO29 Exploring beam diagnostic performances of cSTART using the KARA booster synchrotron

D El Khechen (Karlsruhe Institute of Technology), M Fuchs, R Ruprecht, A Mueller, J Steinmann, E Blomley, K Kaljic, M Schuh, E Huttel, A Mochihashi, P Schreiber (Karlsruhe Institute of Technology)

cSTART is a future storage ring currently under development at KIT with the purpose to investigate various non-equilibrium beam conditions and the injection and storage of LPA (Laser Plasma Accelerator) like beams. To understand and control the non-equilibrium beam dynamics at cSTART, various beam diagnostics with demanding specifications are required. The KARA booster has been used as an important tool to explore diagnostics for cSTART due to similarities in parameters, in particular the low electron beam energy (50 MeV) and the relatively high revolution frequency. Several beam diagnostics installed in the booster will be also installed in cSTART, i.e. the BPM readout electronics, the Bunch-by-Bunch (BBB) feedback system, the beam loss detection system, etc. In this context, dedicated beam time was used to test the performances of the different beam diagnostics systems, and to prepare for work around solutions in case of limitations if any. In this paper, we will describe the different experiments, emphasizing the procedures and highlighting the applied analysis. Moreover, we will discuss the obtained results and elaborate on their indications for the cSTART performance.

MOPCO30 Monitoring modulated slow extraction spills with capacitive pick-ups

R Singh (GSI Helmholtz Centre for Heavy Ion Research), T Reichert (GSI Helmholtz Centre for Heavy Ion Research)

Non-invasive monitoring of nA-level currents in slowly extracted hadron beams is a challenging diagnostic task. Invasive instruments such as ionization chambers and secondary emission monitors (SEMs) are commonly employed for monitoring of such intensities. For low-intensity beam monitoring in storage rings like CRYRING

and ELENA, capacitive pick-ups equipped with charge amplifiers have proven effective. In rings, beam power is concentrated at the revolution and betatron frequencies, which enables filtering techniques for both intensity and position measurements. For slowly extracted beams, we propose introducing a controlled modulation to the spill in order to concentrate the signal power at a specific frequency. This modulated signal can then be demodulated at the same frequency to extract intensity or position information. First proof of concept measurements of such a technique is presented in this contribution.

MOPCO31 Development of BPM electronics for PIP-II at Fermilab

S Liu (Fermi National Accelerator Laboratory), N Eddy (Fermi National Accelerator Laboratory)

PIP-II (Proton Improvement Plan-II) is a critical upgrade to the Fermilab accelerator complex. The 800 MeV superconducting linear accelerator will utilize 126 beam position monitors (BPMs) across the Warm Front End (WFE), superconducting linac (SC LINAC), and Beam Transfer Line (BTL). These BPMs provide beam position, phase, timing, and intensity data, meeting stringent physics requirements: 10 μm position resolution, 0.1 mm position accuracy, 1% intensity resolution, 0.3° phase resolution, and 1° phase stability. This paper presents the uTCA4.0-based BPM electronics system. Each AMC with an RTM processes eight signals from two BPMs, with a 12-slot uTCA chassis supporting up to 24 BPMs. The system features 8-channel 250 MSPS ADCs and a Xilinx UltraScale+ SoC FPGA running Linux, facilitating high-speed data transfer via 10 Gigabit Ethernet. Key design aspects include analog signal conditioning, JESD204B routing, clock distribution, and thermal management. FPGA handles BPM signal processing, time tag, digital down-conversion, and phase drift compensation. Performance benchmarks, including position, phase resolution and temperature stability, are validated through dedicated testing.

MOPCO32 Development of a fast extraction method for short high intensity pulses at ELSA

M Switka (University of Bonn), D Proft, K Desch (University of Bonn)

Studies concerning the FLASH effect for radiation therapy are currently performed at ELSA. The booster synchrotron is used in a preliminary mode of operation to deliver electron beam pulses of 1.2 GeV energy with fixed length of 250 ns to irradiate cell samples. To enable different spill durations ranging from ns up to several ms in an energy range of 0.8 to 3.2 GeV a fast extraction from the stretcher ring is developed. Therefore a repurposing of the existing injection kickers for extraction is under study to achieve

single turn extraction, up to extraction within a few turns. For longer spill durations, reaching up to ms, the feasibility of multiple concepts for a quicker resonant extraction at ELSA is investigated. These include a fast tune shift via air quadrupoles dedicated for extraction, a frequency detune of the acceleration RF and a driven increase of the particle amplitude with a bunch by bunch feedback system. While the effect on the beam dynamics is observed with a streak camera, the measurement of the extracted beam is performed via current and chromox monitors.

MOPCO33 Optimization of Electron Transfer from a Source of Polarized Electrons with Improved Visual Laser and Electron Beam Diagnostics

M Switka (University of Bonn), K Desch (University of Bonn)

The ELSA facility at the University of Bonn uses a storage ring to accelerate polarized electrons up to 3.2 GeV. The photoinjector source is driven by a Ti:Sa laser beam to obtain a high polarization degree (~80%) from a strained-layer GaAsP superlattice crystal photocathode. To improve beam transfer efficiency following a prolonged shutdown of the source, the in-house developed diagnostic software Fgrabbit has been employed for the analysis of laser and electron beam camera images. This provides increased precision in the optimization process and, in particular, enables spatially resolved quantum efficiency mapping of the photocathode surface.

MOPCO34 Development of 4GSR BPM Electronics for the Korean 4th Generation Storage Ring

S Jang (Pohang Accelerator Laboratory), D Shin (Pohang Accelerator Laboratory)

New BPM electronics have been developed for installation in the storage ring of the 4th Generation Synchrotron Radiation Facility in Ochang, South Korea. Based on the first prototype, two different platforms were utilized for the development of the second prototype. The first version employs an RFSoC-based design, which acquires broadband signals up to 2 GHz using a high-performance 2.5 GS/s ADC, enabling real-time turn-by-turn data measurement. The second version is implemented using a commercial uTCA board along with a newly developed RTM card designed specifically for BPM electronics. This uTCA-based system utilizes a 500 MHz center frequency with a ±10 MHz narrowband AFE RTM card and a 250 MS/s ADC to perform turn-by-turn data acquisition. This paper presents detailed hardware specifications and configurations and provides an in-depth analysis of beam test results conducted at PLS-II.

MOPCO35 An overview of the beam instrumentations for the CSNS upgrade

R Yang (Institute of High Energy Physics)

The China Spallation Neutron Source (CSNS) is a major facility for neutron science in China, and is currently operating at an averaged beam power of 170 kW with a beam energy of 1.6 GeV and repetation rate of 25 Hz. In 2024, the CSNS Upgrade project (CSNS-II) was launched with a goal beam power of 500 kW. We will present an overview of the new diagnostics and the corresponding challenges. We will also review the recent R&D activities on the laser-wire monitor system, ionization profile monitor, bunch shape monitors, beam position monitor and the development of the new material such as carbon-nano tube (CNT) wire, florescence wire and low-resistance MCP.

MOPCO36 Application of Convolutional Neural Networks for Pile up correction in single particle counting

T Habermann (Fulda University of Applied Sciences),
M Kumm (Fulda University of Applied Sciences);
P Boutachkov, R Singh (GSI Helmholtz Centre for Heavy Ion Research)

An exploration into the application of machine learning (ML) approaches to identify pile-ups and correct them in single particle counters at the GSI Helmholtz Centre for Heavy Ion Research in presented. About 100000 particle pulse data from various spills were manually labelled and a convolutional neural network (CNN) was developed to accurately count the number of particles without domain-specific knowledge. This contribution represents proof-of-work for a fast error free automated particle counting system. The identified algorithm was developed with a perspective of implementation into an FPGA.

MOPCO37 A Proposed CEBAF Diagnostics Upgrade

N Rider (Thomas Jefferson National Accelerator Facility),

The Continuous Electron Beam Facility (CEBAF) has been in operation since 1994. The accelerator has seen several upgrades to RF and cryogenic systems and capabilities. However, the diagnostics used for beam delivery have remained largely unchanged. With several challenging experiments on the way and obsolescence issues with existing hardware, the time has come to explore a significant upgrade to CEBAF's diagnostic capabilities. The primary focus for the upgrade will be the development of a next generation beam position monitoring system along with a new accelerator timing and synchronization system. Research and development efforts are underway with prototypes for both systems in testing. Updates, plans, challenges and potential solutions will be presented.

MOPCO39 Design and Implementation of Embedded System in HIAF Beam Diagnostics System

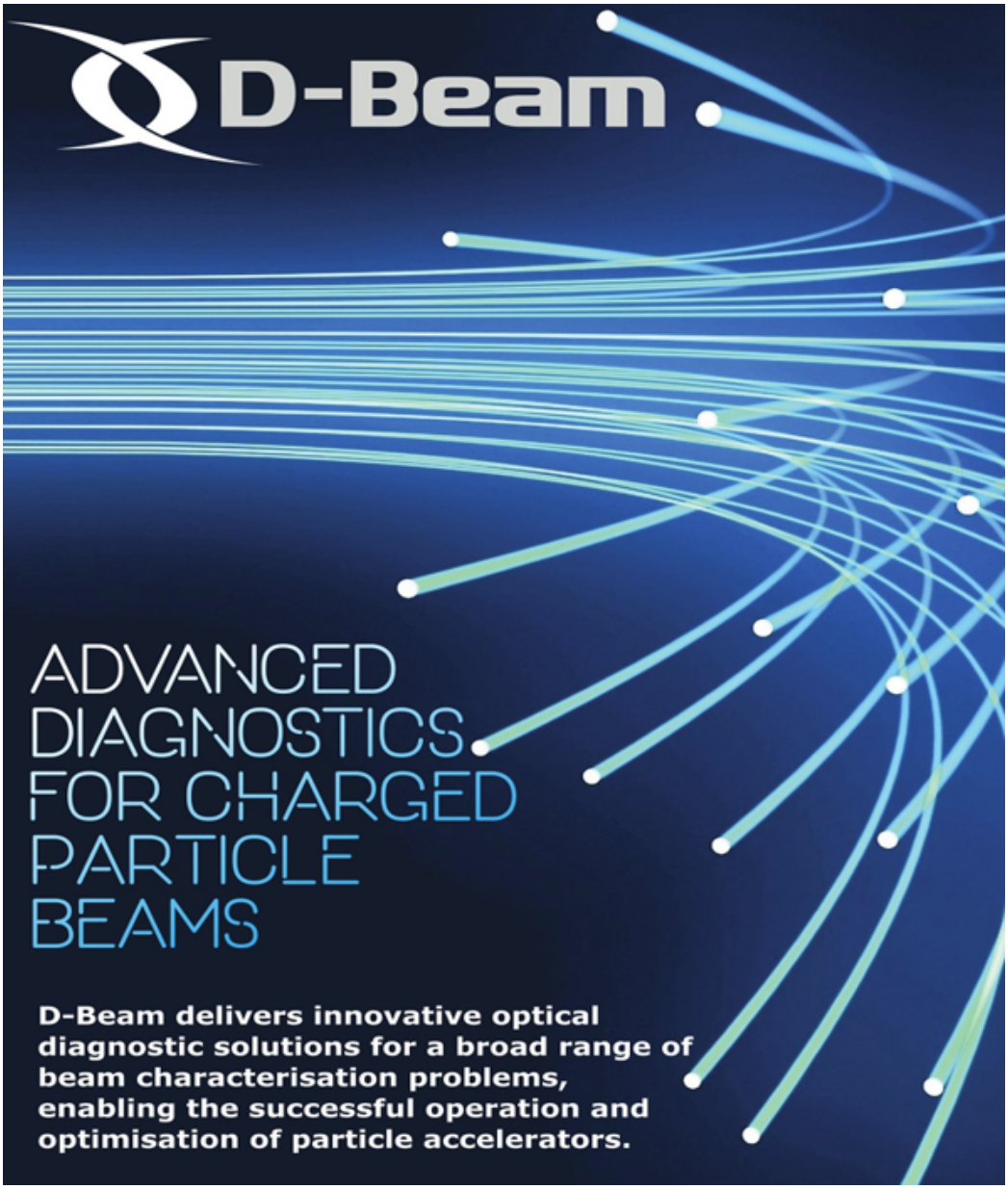
R Tian (Institute of Modern Physics, Chinese Academy of Sciences), G Zhu, H Ming Xie, J Wu, K Gu, Y Zhang, Y Wei, Z Li (Institute of Modern Physics)

The beam diagnostic system of HIAF includes many subsystems, and the self-developed and researched electronic hardware adopts a highly integrated software and hardware architecture.To meet the requirements of beam debugging and measurement as well as user testing and experiments, the author of this paper developed a beam diagnostic embedded system based on EPICS and LACCS.This system fully utilizes whole resources to achieve real-time parameter setting, dynamic monitoring of status quantities, real-time transmission and monitoring of beam waveform data, and processing and storage of beam big data.The system have been online and operate for nearly a thousand sets, and run stably for a long time. The long-term stable operation of the laboratory and the temperature drift is respectively <3 μm/°C and 0.02°/°C which meet the beam debugging and operation requirements of the HIAF and other accelerator beam diagnosis systems like SSC-Linac, LEAF, CAFe and PREF.

MOPCO40 Design of High Speed Digital Acquisition for Beam Current Monitor

R Turner (Fermi National Accelerator Laboratory), J Berlioz (Fermi National Accelerator Laboratory)

As a part of the Proton Improvement Plan – II (PIP-II) at Fermilab, instrumentation systems are being modernized to take advantage of the higher speeds and ease of use offered by standardized embedded systems like MicroTCA. A rear-transition module (RTM) is being designed to interface with said embedded systems. In each of the four identical channels on the RTM, the differential signal from an alternating-current current transformer transimpedance amplifier will again be amplified by a differential operation-amplifier then filtered by a low-pass topology. The conditioned signal is then digitized at a maximum of 10 MS/s by an analog to digital converter (ADC) integrated circuit. After digitization, the ADC passes the data to an off the shelf AdvancedMC (AMC) Xilinx FPGA module using low voltage differential signals. Once in the AMC, the FPGA filters, decimates, and packages the data before transferring it via the AXI bus to the SoC CPU, which then uploads it to a server. The processed data is subsequently used to calculate secondary measurements such as intensity and current, which are presented alongside waveform data in Fermilab's ACNET as Process Variables (PVs) to users.



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MOPMO: Poster Presentations

MOPMO01 Bunch-by-bunch beam current and lifetime measurement with interleaved sampling at Hefei Light Source

A Wang (National Synchrotron Radiation Laboratory), Y Leng (National Synchrotron Radiation Laboratory)

To achieve high-precision bunch-by-bunch current and lifetime measurements at the Hefei Light Source (HLS), we developed a beam diagnostics system based on interleaved sampling technology, achieving an equivalent sampling rate of 6.5 GHz. In single-bunch mode, amplitude extraction via cross-correlation with a single response function achieves a turn-by-turn current relative resolution of 0.12%. By averaging over 200 turns, the resolution is improved to 0.04% with a 23 kHz data refresh rate, enabling fast and accurate lifetime calculations. However, in multi-bunch high-current mode, large longitudinal oscillations degrade the accuracy of amplitude extraction when using a fixed-response function. We propose a data-processing algorithm to jointly extract bunch length, phase, and current, thereby mitigating the impact of longitudinal oscillations on amplitude extraction. The method and experimental results provide a practical solution for machines exhibiting large longitudinal oscillations, such as HLS.

MOPMO02 DESIGN STUDIES OF A RETARDING POTENTIAL ENERGY ANALYSER (RPEA) FOR LOW-ENERGY ANTIMATTER EXPERIMENTS

B Rawat (University of Liverpool), N Kumar, B Rienäcker, S Chandran, C Welsch (University of Liverpool)

Retarding Potential Energy Analysers (RPEAs) are widely used diagnostic instruments for measuring energy distribution of charged particle beams. In this work we will discuss the conceptual design studies of a novel RPEA for low-energy antimatter beams (antiprotons/positrons). Simulation tools such as CST studio and G4Beamline were used for studying the prototype RPEA and to optimize its geometry for considering different parameters such as, beam characteristics, collector geometry, the losses occurring due to secondary electrons and annihilation, grid design etc. The proposed diagnostic can offer the potential for measuring the energy and current of low-energy (1–10 keV) antiproton/positron bunches in experiments such as AEgIS, with promising energy resolution. However, further detailed studies are required to assess its viability for implementation in a practical detector system.

MOPMO03 Development of a novel DC Current Monitor device, based on Tunnelling MagnetoResistive sensors, for ion beam current measurement

C Manna (Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Sud)

In this work, the development of a non-invasive DC Current Monitor device (DCCM), based on Tunnelling MagnetoResistive (TMR) sensors, is presented. The device is primarily intended for measuring the current intensity of an ion beam without the need of intercepting it (therefore not altering its characteristics), making it suitable for online current monitoring. Details are given about the design of the device and its performance assessment, namely the linearity of its static response and its frequency-domain behavior.

MOPMO04 Diagnostic Contributions to the Commissioning of SLS 2.0

C Ozkan (Paul Scherrer Institute), A Fazan, A Foskolos, F Armborst, J Kallestrup, M Paula Rey Barrera, M Aiba, R Ischebeck (Paul Scherrer Institute)

In January 2025, beam was first stored in the SLS 2.0, and by April 2025, the milestone of a 400 mA beam was reached. A variety of diagnostics were utilized to reach these milestones; for example, charge, current and loss monitors for minimizing losses and optimizing transmission and injection efficiency, polarized visible light for vertical beam size measurement, and more. This paper will highlight the contributions of the various diagnostics to the machine commissioning process.

MOPMO05 Wide dynamic range and high-precision ammeter for beamline instrumentation at SIRIUS

P Nallin (Brazilian Synchrotron Light Laboratory), F Cardoso (Brazilian Synchrotron Light Laboratory)

Sirius beamlines require specialized electronic devices to monitor key parameters of the photon beam, such as position and flux, through the detection of extremely low-level electrical currents. Furthermore, experiments conducted in fly-scan mode usually demand fast, high-precision low-level current measurements. To address these requirements, the development of a wide dynamic range ammeter (from 1 pA to 10 mA) has been addressed, based on a logarithmic transimpedance amplifier, eliminating the need for scale switching and featuring high precision and fast response. The proposed device converts the input current into a logarithmic output voltage and offers two operation modes: the logarithmic ammeter and the logarithmic ratiometer, both of which are particularly useful in X-ray spectroscopy experiments. This paper considers an overview of the device as well as its preliminary characterization and results, including logarithmic conformity, bandwidth, and noise.

MOPMO06 Challenges with the beam destinations for the ESS linac

E Donegani (European Spallation Source), A Olsson, A Gevorgyan, L Page (European Spallation Source ERIC); I Bustinduy (ESS Bilbao); J Herranz (European Organization for Nuclear Research); M Ruelas (RadiaBeam Technologies (United States); P Brooker (The Welding Institute); V Bertrand (Pantechnik)

For the ESS linac commissioning, twelve extremely compact beam destinations were designed in place of bulky and expensive beam dumps, in order to dump [0.075, 250] MeV protons. The beam destinations were either Faraday Cups (FC) for the NCL commissioning or Insertable Beam Stops (IBS) for the SCL commissioning. Both FC and IBS are beam-intercepting devices, operated under vacuum, water cooled and movable by means of a pneumatic actuator. The manufacturing of FC and IBS relied on high-precision machining. The limited installation space and vacuum requirements required strict tolerances, complex welding of small components and vacuum brazing of compact cooling pipes. The installation of the devices themselves, their radiation shielding and portable cleanrooms were particularly challenging due to the limited space not only outside but also inside the beamline. The main challenge during the operation was posed by the beam power density. Radiation transport calculations allowed to minimize residual dose rates. Thermo-mechanical simulations allowed to define the operational limits thus avoiding damage to the beam destinations themselves and linac components nearby.

MOPMO07 First Attila4MC simulations for the high-power proton accelerator of the European Spallation Source

E Donegani (European Spallation Source)

Radiation transport simulations allow the design and operation of entire facilities such as the European Spallation Source (ESS) in Lund, Sweden. This paper summarizes three of the first applications of Attila4MC simulations to the high-power proton accelerator of ESS and its beam instrumentation. Entire linac sections and beam-interceptive instrumentation were modelled by implementing existing CAD models, relying on unstructured tetrahedral meshes and zeroing out the time spent in manually crafting MCNP6 models. As a result, it was possible to accurately quantify the beam power density within beam-interceptive devices and in turn their operational limits. Activation and 3D dose maps were computed and swiftly visualized in 3D, on top of the actual linac model. This work paves the way for e.g. advanced instrumentation design, linac operation, safe maintenance, categorization of radiation waste and future dismantling.

MOPMO08 Development and Characterisation of a Radiation-Tolerant Power Supply for Beam Instrumentation

E Effinger (European Organization for Nuclear Research), C Zamantzas, J Michel Meyer, S Michelis (European Organization for Nuclear Research)

CERN's Beam Instrumentation Group is developing a mini-crate to host the future BLM and BPM systems acquisition electronics at HL-LHC and SPS accelerators. For this purpose, a new power supply has been designed to meet the low noise requirements, high reliability, and availability standards for these harsh radioactive environments. The design makes use of CERN-developed ASICs and radiation-tolerant qualified COTS, and follows a modular architecture for quick interventions and safe handling. The paper presents the design, prototype characterisation results, identified issues, and mitigation methods to achieve the required radiation tolerance.

MOPMO09 Robotic Solution for BLM Detector Maintenance in High Radiation Areas

E Effinger (European Organization for Nuclear Research), C Zamantzas, F Sanda, M Di Castro, M Sta, S Di Giovannantonio (European Organization for Nuclear Research); J Piehl (Karlsruhe Institute of Technology)

CERN's beam-loss system is essential for the protection of machine elements against energy deposition due to beam losses. The protection function is based on Ionization Chambers Detectors installed along all of CERN's accelerators, totalling about 4000 detectors. Some of the areas where the detectors are installed have a high background dose (above 2mS per hour), so installation and maintenance times must be very short for the safety of the operators. For this reason, a new solution was designed that allows the manipulation of detectors and detector holders by robotic action. Every detail of this solution has been designed to reduce intervention time thanks to a rapid locking mechanism and the possibility of transporting the material by robot. The paper presents the design, prototype characterisation results, identified issues, and mitigation methods to achieve the automatised manipulation of the detectors.

MOPMO10 Performance of the Cryogenic Beam Loss Monitors Developed at the LHC

E Effinger (European Organization for Nuclear Research), C Zamantzas, S Morales Vigo (European Organization for Nuclear Research); E Griesmayer (TU Wien)

Several systems protect the superconducting magnets of the Large Hadron Collider (LHC), which operate at -271.3C. The Beam Loss Monitoring (BLM) system is critical for detecting lost particles around the machine and reacting on their quantity and associated energy. It protects the machine from quenching and irreversible damage. To measure these losses, various detectors are used, primarily ionisation chambers (IC), but also other types of monitors depending on loss intensity. In injection and extraction areas, additional fast polycrystalline Chemical Vapor Deposition (pCVD) diamond detectors measure time structured losses. To increase sensitivity, a new detector, the cryogenic Beam Loss Monitor (CryoBLM), based on pCVD, was developed. It is mounted inside the cryostat between two superconducting magnets in the vicinity of the beam pipes and operates at cryogenic temperatures. Two CryoBLM locations in the LHC target different loss scenarios: betatron halo cleaning and luminosity losses from the CMS physics debris. This contribution presents the CryoBLM performance and comparisons with other detectors.

MOPMO11 Machine vision cameras for beam spot analysis

M Bree (Canadian Light Source, J Vogt, T Batten, W Javed (Canadian Light Source)

The Canadian Light Source is a third generation synchrotron which supports 22 operational beamlines. A project to replace all beam diagnostic analog cameras with CCD cameras was initiated in 2020. Over time this project has been expanded to include beam analysis capabilities. We present an EPICS-based imaging system that uses inexpensive CCD cameras. The system computes beam parameters including strength, centroid, ellipticity, eccentricity, and angle. Analysis is performed in real time, and images can also be saved for post processing. Features, implementation details, obstacles and long term plans will be discussed.

MOPMO12 Optimization of beam intensity measurement system of HIPA at PSI

P Huber (Paul Scherrer Institute), P Duperrex (Paul Scherrer Institute); W Koprek (Paul Scherrer Institut)

Beam intensity measurement of high intensity proton accelerator at PSI mainly consists of several passive cavity type monitors and corresponding electronics. New VME based electronics are running in parallel for final online

testing with the old CAMAC ones, which will be replaced soon. The new pre-amplifier of the VME system is suffering significant temperature-dependent drift, leading to an inaccurate measurement. Further, wrong transmission rate may lead to unexpected interlock and beam losses during operation. To address this issue many temperature compensation schemes were considered, numerous lab tests were conducted, eventually reach a temperature stabilization solution. Experimental validation demonstrates a factor of 6 reduction in temperature-induced measurement variance compared to previous implementation, achieving a temperature coefficient better than 100 ppm/degree for RF test signal. Furthermore, the new electronics incorporate a phase measurement of the 50.6 MHz proton bunches for beam energy monitoring. Beam tests show energy measurement consistency within ±0.15%. This implementation greatly facilitates the commissioning and status monitoring of the accelerator.

MOPMO13 A Large Language Model to Assist Users of Beam Instrumentation in HIPA

R Ischebeck (Paul Scherrer Institute), M Sapinski, Q Dai (Paul Scherrer Institute)

The High Intensity Proton Accelerator HIPA at PSI has been in operation since 1974. A large trove of documentation for its beam instrumentation exists, in the form of publications, internal notes, spreadsheets and e-mails. We have built a retrieval-augmented generation (RAG) system, based on a large language model (LLM) that assists scientists and operators with the maintenance and use of the instrumentation.

MOPMO14 Development of a Faraday Cup for the FETS-FFA

S Sapkota (University of Portsmouth), D Posthuma de Boer, E Yamakawa (Science and Technology Facilities Council)

The proposed FETS-FFA would exhibit high-intensity operation of a Fixed-Field Alternating Gradient (FFA) accelerator, as a demonstrator for a spallation neutron source driver. Faraday cups are planned to be installed in the injection straight to investigate injection efficiency and infer beam-position during early commissioning stages; and in the extraction line to inspect extraction efficiency. The chosen Faraday cup design must be suitable for the 3-12 MeV proton energy range, the average beam power of the FETS Linac and the FETS-FFA's extracted beam. Thermal aspects of this design will be introduced, including cooling water flow-rate calculations and an approximate method of simulating this flow with equivalent convective cooling. The 3D tracking for a secondary electron suppressor will also be presented, as well as calculations to estimate the required suppression voltage.

MOPMO15 Beam Instrumentation for the new linear accelerator at the CLS

T Batten (Canadian Light Source), *et al.*

The Canadian Light Source (CLS) linear accelerator (linac) serves as the injector for the 2.9 GeV synchrotron. The original linac, which was installed in the 1960's, was replaced in 2024. The new 3000.24 MHz linac was designed and built by RI Research Instruments GmbH. The linac makes use of a 90kV-thermionic-ion-source, three 5m long accelerating S-band structures and a SLED pulse compressor system to accelerate electrons to 250 MeV. The initial beam instrumentation included a faraday cup, yag screens, beam position monitors and fast current transformers. During the course of commissioning directional couplers and microphones were added to provide insight into the location of RF breakdowns. This paper will provide an overview of the new linear accelerator and our experience commissioning the new equipment.

MOPMO16 Joint Analysis of Beam Loss and Beam Position During the Injection Process at Hefei Light Source

Y Xiao (University of Science and Technology of China), Y Liu, Y Leng (University of Science and Technology of China)

The Hefei Light Source is a synchrotron radiation facility operating in the vacuum ultraviolet and soft X-ray regions. If the evolution of beam parameters and beam loss during the injection transient process can be observed synchronously, analyzing their correlation can provide more quantitative guidance for further optimizing the injection process. To achieve this goal, a monitoring system capable of synchronously capturing the 3D position of each bunch and rapid beam loss has been established at the Hefei Light Source. Experiments investigated both TOP-UP injection and empty-ring injection processes. Thanks to the unique multi-parameter synchronous diagnosis capability of this system, some previously unnoticed special phenomena have been captured, and a deeper analysis of the correlation between bunch parameters can be conducted. TOP-UP mode exhibited maximum beam loss in the injected bunch, with secondary losses at the 14th subsequent bunch. Peak beam loss occurred immediately after injection in both modes, followed by rapid attenuation within several turns. Loss resurgence appeared after ~85 turns (TOP-UP) or 320 turns (empty ring), followed by oscillatory decay.

MOPMO17 Development of an Integrated Control and Monitoring System for Centralized Beam Operation at RAON

J Kwon (Institute for Basic Science), E Lim, M Park (Institute for Basic Science)

RAON is a heavy-ion accelerator supporting a wide range of beam energies and charge states. An integrated operational environment has been developed to enable centralized control and monitoring of accelerator systems. Machine states are defined through a structured framework combining source, machine, and beam modes, providing clear visibility of system readiness via an EPICS-based architecture. The beam permit system monitors the real-time status of cryogenics, vacuum, RF, and beam diagnostics, and inhibits beam extraction under unsafe conditions. Interlock logic is supported by a Readiness Manager and IOC monitor, while a post-mortem system captures PV data at the time of beam failure for root-cause analysis. A user interface built on the Phoebus platform offers integrated access to operation logs, alarm handling, and save-and-restore functionality. Additionally, operation time tracking and event-based logging support systematic record-keeping. This framework enhances operational efficiency and lays a foundation for future automation of beam delivery and diagnostics at RAON.

MOPMO18 X-RAY CHARACTERIZATION OF A HIGH-ENERGY Gd2O2S FLAT PANEL FOR ELSA FACILITY

R Rosch (Commissariat à l'Énergie Atomique et aux Énergies Alternatives), A Pires, A Ebran, A CHAUCHAT, B Laurent, C Grit, D Denis-Petit, E Poirier, J Dumazert, J Houzet, M Collet, N Dufour, S Vayre, V Jacob, V Le Flanchec (Commissariat à l'Énergie Atomique et aux Énergies Alternatives)

The ELSA facility located at CEA DAM DIF consists of a 30 MeV, 15 ps rms, 1 nC compact linac. X-rays are produced either in the MeV energy range through interaction between the electron beam and a solid Ta conversion target (Bremsstrahlung radiation) or in the 10-80 keV energy domain through interactions between electrons with a Nd:YAG laser (inverse Compton Scattering radiation). ELSA is dedicated to X-ray test of detectors and thus requires a good knowledge of the X-ray beam. We present here a spatial ans spectral characterization of a new high energy flat panel detector devoted to the X-ray beam parameter measurements. This characterization was achieved with X-ray portable generators and radioactive sources. A methodology for using this flat panel in dosimetry measurements is also proposed and scheduled for experimental validation on ELSA in 2025.

MOPMO19 The new SLS 2.0 Booster-to-Ring Transfer Line - Design Criteria, Diagnostics Layout and First Beam Results

V Schlott (Paul Scherrer Institute), B Keil, C Ozkan Loch, F Armborst, J Kallestrup (Paul Scherrer Institute)

Due to the limited transverse acceptance of 4th generation light sources, the characterization and control of the incoming beam from the booster to the storage ring is an important asset to achieve highly efficient and reproducible injection. For the upgraded SLS 2.0 storage ring, a new booster-to-ring transfer line (BRTL) has been designed, which includes a non-dispersive section for beam parameter measurements and a double-BPM-corrector configuration for position and angle feedback of the injected beam. Based on the BRTL design criteria, first beam results during SLS 2.0 commissioning are presented, including experience with quadrupole scans to document emittance exchange at the end of the booster ramp and steering-stabilization of the beam at the injection point, resulting in a step-wise optimization of transmission into the storage ring.

MOPMO20 Beam loss monitoring system at SOLARIS

K Dudek (SOLARIS National Synchrotron Radiation Centre), A Wawrzyniak, P Andryszczak, R Panas (SOLARIS National Synchrotron Radiation Centre)

SOLARIS storage ring has been equipped with a set of twelve Beam Loss Detectors, controlled by Libera Beam Loss Monitors. This system enhances the ability to monitor and analyze beam losses and operational efficiency. Detectors were strategically placed around storage ring and transfer line, providing ability to optimize injection losses and enable precise localization of beam loss events. Real-time monitoring enables faster identification and mitigation of abnormal loss patterns, improving machine protection, stability and reliability. Data collected by the system will support beam lifetime studies and provide valuable insights for future performance.

MOPMO21 Development of Beam Signal Processors for SHINE

L Lai (Shanghai Advanced Research Institute), Y Zhou (Shanghai Advanced Research Institute)

Shanghai High Repetition Rate X-ray FEL and Extreme Light Facility (SHINE) is currently under construction. There are hundreds of beam signal processors of different types along the accelerator, including processors for stripline beam position measurement (BPM), cavity BPM, cold button BPM, beam arrival time measurement (BAM), bunch length measurement (BLM), bunch charge interlock, and transverse feedback system. The processors are developed

on a common FPGA platform. The processors were installed and running on the SHINE injector section. The paper will present processor optimization and the development of various specialized processors, including the beam scanning measurement processor for a dump, the beam loss interlock processor, and the fast transverse orbit feedback processor.

MOPMO22 Upgrade of the BPM Processor for SXFEL

L Lai (Shanghai Advanced Research Institute), Y Zhou (Shanghai Advanced Research Institute); Q Yan (Nanchang University)

An upgrade of the Shanghai Free Electron Laser (SXFEL) BPM signal processor is under preparation to implement the high-speed intelligent commissioning and bunch-by-bunch feedback control of the SXFEL beam. The function of synchronizing the acquisition of all BPM data from the SXFEL will be implemented. A new digital carrier board has been developed, using a Zynq UltraScale+ MPSoC FPGA as the core, an FMC slot for White Rabbit timing module to accept bunch ID and trigger, and 10Gb SFP ports for high-speed data transmission between the processors. The design of the hardware, firmware and software of the upgraded BPM signal processor will be introduced in this paper.

MOPMO23 Current Development Status of Beam Diagnostics Electronics at SSRF

L Lai (Shanghai Advanced Research Institute), *et al.*

Shanghai Synchrotron Radiation Facility (SSRF) and Shanghai Soft X-ray FEL(SXFEL) are open to user, and the Shanghai High Repetition Rate X-ray FEL and Extreme Light Facility (SHINE) is under construction. These accelerator facilities require diverse beam diagnostics electronics to ensure their high-performance and stable operation. After more than a decade of development, the SSRF has developed beam diagnostic electronics that meet various application requirements. This poster will introduce the current progress and application status of the electronics developed at SSRF.

MOPMO24 Overview of Diagnostics and Instrumentation for Siam Photon Source-II

P Sudmuang (Synchrotron Light Research Institute), S Jummunt, T Phimsen, T Pulampong, W Promdee (Synchrotron Light Research Institute)

Siam Photon Source II (SPS-II) is a 4th-generation synchrotron light source to be constructed in Thailand, envisioned as a major synchrotron facility for Southeast Asia. It is designed with a 3 GeV low-emittance electron storage ring based on a Double Triple Bend Achromat (DTBA) lattice, with a circumference of 327.6 meters

and a natural emittance of 0.97 nm·rad. The design and machine parameters have recently been carefully revised to enhance beam stability and operational reliability. In parallel, key prototypes are being developed to support smooth construction and ensure long-term performance. This paper presents the detailed specifications and a comprehensive overview of the planned beam diagnostics and instrumentation systems, along with initial results from their ongoing R&D and testing.

MOPMO25 Operational experience with Machine Protection System for high current, high brightness accelerator

S Seletskiy (Brookhaven National Laboratory), A Fedotov, D Gassner, D Kayran, J Kewisch, K Mernick, L Smart, M Paniccia, P Inacker, P Oddo, R Hulsart, R Michnoff, W Pekrul (Brookhaven National Laboratory)

The Low Energy RHIC Electron Cooler (LEReC), the world's first electron cooler utilizing an RF electron accelerator, was designed to operate with 1.6-2.6 MeV electron beams of up to 140 kW beam power. The LEReC successfully worked through RHIC Runs 2019-2021, substantially increasing RHIC luminosity, and has been routinely used for various studies since then. A dedicated, highly configurable Machine Protection System (MPS) is a critical part of the LEReC. This paper summarizes our experience with operating the LEReC MPS.

MOPMO26 Perfomance evaluation of tailored shielding for energy-selective neutron detection in reactor environments

A Jones (University of Liverpool), *et al.*

With nuclear reactor technology rapidly advancing and the plan to raise the nuclear energy production by a factor of 4, the need for advanced detectors, geometries and shields has become apparent. The precise and reliable measurement of the neutron flux is not only relevant for the safe operation of nuclear reactors, but also for future reactor experiments essential for progressing the technology. In the presented work, simulations were performed using MCNP-6.3 to investigate the effects of various common reactor materials in different shield geometries on the performance of benchmark detectors. This was performed using a validated simulation of a 1 Ci Am/Be neutron source located at the University of Liverpool for a detailed experiment to simulation evaluation. The use of a conical shield/reflector material around the detector showed lower efficiency for the detection of thermal neutrons, and higher efficiency for the detection of fast neutrons when compared to the results for no additional material. The tailored measurement of neutrons of specific energies is highly relevant for reactor experiments on innovative technologies.

MOPMO27 The Beam Test Facility of the National Laboratories of Frascati

E Diociaiuti (Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati), B Buonomo, C Taruggi, C Di Giulio, D Di Giovenale, F Cardelli (Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati)

The Beam Test Facility (BTF) at the National Laboratories of Frascati provides highly configurable positron/electron beams for different type of experiments. Extracted from the DAΦNE LINAC, the beam delivers up to 49 bunches/s, with 1 to 10^{10} particles/bunch. Secondary beams span 25-780 MeV (electrons) and up to 550 MeV (positrons). BTF includes two experimental halls: BTFEH1, suited for high-intensity and long-term experiments, and BTFEH2, optimized for lower intensities (up to 10^6 particles/s). Both halls feature remote-controlled movable tables, beam diagnostics, and essential services like laser alignment, networking, high-voltage support, and gas pipelines, ensuring comprehensive experimental capabilities and 24/7 user support. A notable strength of BTF lies in the user-friendly approach: beam is easily manipulated to meet users' specific needs, even during ongoing data collection. In this talk the upgrades concerning the development of a new control system based on Epik8s (EPICS on Kubernates) will be reported as well as the new improvement in beam dimension and energy loss concerning the substitution of the 500 μm BeO exit window with 120 μm Anticorodal one.

MOPMO28 Study of UV-VIS Emissions from Heavy Ions Interacting with Matter at SIS Extraction Energies

R Ghagi (University of Liverpool), R Singh, B Walasek-Hoehne (GSI Helmholtz Centre for Heavy Ion Research); H Zhang, C Welsch (Cockcroft Institute; University of Liverpool)

This paper reviews the cross sections of various processes contributing to UV-Vis emissions from highly charged heavy ions interacting with matter at SIS extraction energies (300 to 1500 MeV/u). The interaction of these ions with matter generates detectable radiation, with mechanisms influenced by both material properties and beam characteristics. By analyzing theoretical models and experimental results from the literature, we elucidate the dynamics governing these interactions, particularly with gaseous targets and thin foils. Furthermore, we extend this understanding to applications in particle detection and counting, presenting selected novel results obtained with various detector prototypes.

MOPMO29 Next-Gen Middleware for Fermilab Beam Instrumentation DAQ Systems

D Steinkamp (Fermi National Accelerator Laboratory), Shreya Joshi (Fermi National Accelerator Laboratory)

Fermilab Accelerator Division, Instrumentation Department is always adopting modern and current software methodologies for complex DAQ architectures. This paper presents the Redis Adapter (RA), a high-performance, modular interface bridging digitizers and distributed control systems like ACNET and EPICS. Using Redis and containerization, RA streamlines communication by linking Redis-based data streams to ACNET front ends, IOCs, and EPICS frameworks. Previously, data passed through a UDP-based Distributed Data Communication Protocol (DDCP). In the updated architecture, DDCP remains as the ingestion layer, while RA decouples and reformats timestamped data for downstream use. The proposed architecture replaces legacy VME digitizers with new SOM-based ones that interface with Redis via the RA. RA acts as both a performance-critical bridge and a protocol-agnostic adapter, ensuring compatibility with legacy control frameworks while enabling future scalability and modularity. It simplifies the data flow, lowers latency, and supports high throughput. We will demonstrate RA's role in core products GRAFE and GREFE, showcasing its dual support for legacy systems and evolving architectures.

MOPMO30 Diagnostics Layout for the PERLE Injector

A Fomin (Université Paris-Saclay, CNRS/IN2P3, IJCLab), C Monaghan (University of Liverpool; Cockcroft Institute; Laboratoire de Physique des 2 Infinis Irène Joliot-Curie)

The PERLE (Powerful Energy Recovery Linac for Experiments) project is a high current and high charge testbed for the technologies required to realise future ERLs. A 20 mA electron beam with a bunch charge of 500 pC will be accelerated to 7 MeV by the booster and injected into the ERL. To deliver the beam to the ERL loop, a three-dipole merger with variable momentum compaction has been selected. At this energy, emittance growth is dominated by space charge effects, imposing strict constraints on the beam transport and diagnostic design. This study presents the design and optimisation of the diagnostic layout within the merger, taking into account instrumentation requirements, spatial constraints, and beam dynamics considerations. Beam tracking is used to evaluate these factors and determine optimal diagnostic positioning based on measurable beam parameters. These findings support the commissioning strategy and tuning procedures of the PERLE injector.

MOPMO31 Quantum efficiency measurements and beam diagnostics test stand design for a dual-mode electron gun at ELSA

S Kronenberg (University of Bonn), B Simon Gatzsche, D Proft, K Desch, M Switka, Y Schober (University of Bonn)

To support both routine operation and accelerator research at ELSA, a dual-mode dispenser-cathode based electron gun capable of thermionic emission and thermally assisted photoemission (TAPE) is being developed. A dedicated gun test stand is being designed to measure beam properties and quality, as well as quantum efficiency in the TAPE mode under operational conditions. Instrumentation will include a pepper pot emittance stage, quadrupole scan capabilities, profile measurements using screens and wire-scans or SEM grids, and bunch charge and energy spread determination. In a basic test environment, experiments were carried out at low accelerating voltages using a setup consisting of the dispenser cathode, a pickup anode, and a simple laser system with an optical shutter. The shutter enables alternating measurements of photocurrent and dark current at the anode, allowing first estimations of quantum efficiency. The influence of different cathode heating cycles on both the absolute quantum efficiency and its temporal stability was investigated with this setup. Quantum efficiency measurements under different conditions and simulations of the test beamline are presented.

MOPMO32 Characterization of the radiation environment in the FCC-ee tunnel

A Frasca (European Organization for Nuclear Research), A Ciarma, M Boscolo (Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati); A Lechner, G Lerner (European Organization for Nuclear Research); C Welsch, N Kumar (University of Liverpool)

The Future Circular electron-positron Collider (FCC-ee) at CERN will provide collisions at four interaction points along a 91 km ring, with beam energies ranging from 45.6 GeV (Z pole) to 182.5 GeV (ttbar threshold). The radiation environment along the accelerator varies significantly, with different dominant sources depending on location and operational mode. Accurate characterization of this environment is essential for the design and placement of machine equipment, particularly electronic systems and beam instrumentation. In this study, the Monte Carlo code FLUKA is used to characterize tunnel radiation levels from the main sources, including radiative Bhabha scattering, synchrotron radiation, beam-gas interactions, and the beamstrahlung dump. The results at the Z pole and ttbar threshold for both the interaction regions and arcs are presented to guide early-stage design considerations and to quantify exposure risks for electronics at potential installation locations.

MOPMO33 Early Prediction of System Failures at Los Alamos Nuclear Science Center (LANSCE)

N Yampolsky (Los Alamos National Laboratory),
A Scheinker, E Huang, J Quemuel (Los Alamos National Laboratory)

Accelerators are complex systems composed of tens of thousands of individual components requiring continuous maintenance. Aging facilities such as LANSCE face an increased rate of equipment failures, resulting in costly unscheduled shutdowns for maintenance. Early identification and localization of problems along the accelerator can mitigate future failures during scheduled maintenance periods rather than emergency shutdowns. This approach will significantly enhance the facility's reliability and increase beam availability for users. We have developed a mathematical formalism to analyze all available data for a LANSCE subsystem and generate signals indicating abnormal operation. The system accounts for hidden internal correlations between various parameters, which the existing warning system does not. We report progress on developing an anomaly detection system for LANSCE by expanding predictions to all subsystems, increase LANSCE's data archiving capability by an order of magnitude, and developing algorithms to provide operators with signals indicating developing abnormalities and pinpointing problematic beamline elements.

MOPMO34 Performance Validation of High-Gradient X-Band Structures at the University of Melbourne's X-LAB

M Volpi (The University of Melbourne), *et al.*

The X-band Laboratory for Accelerators and Beams (X-LAB) at the University of Melbourne enables high-power testing of X-band accelerator technologies, including components for CERN's Compact Linear Collider (CLIC). At its core is Mel-BOX, a high-gradient test stand rebuilt from CERN's XBOX3. Two TD24 structures, previously conditioned at CERN, have been successfully re-tested, along with RF windows, SLED-I pulse compressors, and 3D-printed loads. Beam instrumentation at X-LAB includes Faraday cups with high-resolution digitizers to measure dark current and breakdown emissions. Fast time-domain measurements along the waveguide using GHz-bandwidth oscilloscopes allow localization of breakdown events. Optical fibers detect Cherenkov light near the structures, providing complementary pulse-resolved signals. These are cross-referenced with Faraday cup data to study early-stage field emission. X-LAB integrates RF testing and diagnostics to support the development of compact, high-gradient accelerator systems.

MOPMO35 Measurements of Dark Current and Breakdown Processes using Faraday Cups and Fast Digitisers at the XBand Laboratory for Accelerators and Beams (XLAB)

M Volpi (The University of Melbourne), P Pushkarna, P Giansiracusa, R Rassool (The University of Melbourne)

Two CLIC TD24 accelerating structures, manufactured by CERN, are undergoing high-power testing on the 12 GHz RF test stand, MelBOX, at the x-Band Laboratory for Accelerators and Beams (XLAB). Installed in late 2024, these are the first devices tested at the facility. The goal is to condition the structures for stable operation at gradients of 100 MV/m. The maximum gradient is limited by electrical breakdown-vacuum arc formation under high electric fields-which interrupts RF transmission and can damage the structure. To study breakdown dynamics and validate models of their initiation, detailed, time-resolved charge measurements are needed. Faraday cups upstream and downstream, combined with high-performance 5 GS/s, 12-bit, 3 GHz FEB digitisers, enable precise characterisation of both dark and breakdown current emissions. Fast digitiser readout allows continuous acquisition at the 400 Hz repetition rate, capturing breakdown events and several hundred preceding pulses. This dataset supports in-depth analysis of precursors. We present initial results from structure conditioning, including breakdown statistics, dark current trends, and preliminary analysis of breakdown behaviour.

MOPMO36 Realisation of a Faraday Cup for the Gun of PERLE Accelerator

S Mohammed (Université Paris-Saclay, CNRS/IN2P3, IJCLab), R Roux, d reynet (Laboratoire de Physique des 2 Infinis Irène Joliot-Curie)

Faraday Cups have been used as diagnostic tools to measure the charged particle beam current directly. Up to now, different designs have been introduced for this purpose. In this work, a new design of Faraday Cup has been performed for the gun of PERLE, a Powerful Energy Recovery Linac to be installed at IJClab Orsay. FC's dimensions and desirable material have been considered based on PERLE Gun beam characteristics (maximum energy of 350 KeV and maximum current of 20mA). Appropriate specifications were written for this FC. In addition, the heat power generated by electron collision with FC material has been calculated and the required cooling system has been specified. The Faraday Cup is under fabrication and tests should be run early next year to measure the electron beam current out of PERLE Gun

MOPMO37 Development of CMOS beam loss monitor for Korea-4GSR

B Shin (Pohang Accelerator Laboratory), C Kim, D Tae Kim, D Shin, D Song, G Hahn, G Kim, S Jang (Pohang Accelerator Laboratory)

The beam loss monitor (BLM) is a diagnostic system designed to protect accelerator components from unexpected high-energy radiation. We have developed a cost-effective BLM system for the next-generation synchrotron light source, Korea-4GSR. The system uses plastic scintillators, optical fibers, and a CMOS camera to localize beam losses with 10 ms time resolution. Scintillators placed along the beam-line emit blue light proportional to the ionization energy deposited by beam losses. The light is transmitted through optical fibers, bundled into a 2D array, and imaged by a CMOS sensor at 100 Hz. The BLM's sensitivity and calibration were verified using a 2 MBq Co-60 gamma-ray source. The preliminary result shows ~45 counts/GeV. Energy deposition was estimated using Geant4 simulations, and photon-to-count conversion was characterized with a calibrated LED source. The DAQ includes a built-in LED pulser for in-situ calibration of the CMOS detector and cable integrity check. This presentation outlines the system design, calibration methods, and performance results.

MOPMO38 Development of Current Monitor for Stacking Beam in FETS-FFA Test Ring

E Yamakawa (Science and Technology Facilities Council), J FitzGibbon (Science and Technology Facilities Council); Y Iwashita (Kyoto University)

Design studies of the FETS-FFA demonstration ring have been conducted as part of the ISIS-II proposal for a new high-power spallation neutron source. Beam stacking has been proposed to overcome space-charge limits in an FFA, and the feasibility of this will be evaluated in the FETS-FFA test ring by stacking up to four pulses at 50 Hz. To monitor the long-pulsed current of the coasting stacked beams over around 80 ms, the demonstration monitor of large-aperture Current Transformer (CT) with a Negative Impedance Converter (NIC) amplifier is being developed. NIC amplifier compensates the decay constant of the CT signal by cancelling the resistance of the wound coil. In addition to measuring long-pulsed coasting beam currents, the feedforward system is also added in NIC amplifier to boost the frequency band up to a few MHz to enable to measure accelerating bunch currents. In this paper, the design study of CT monitor with NIC amplifier as well as feasibility tests of demonstration monitor will be presented by detecting a long-pulsed signal (1s) and a short-pulsed signal (a few hundreds of ns).

MOPMO39 Development of Wall Current Monitor on FETS-FFA Test Ring

E Yamakawa (Science and Technology Facilities Council), I Gardner, K Fazlee (Science and Technology Facilities Council)

The conceptual design studies of FETS-FFA demonstration ring has been actively performed to confirm the reliability of Fixed Field Alternating gradient (FFA) accelerator for future high-power spallation neutron source, called ISIS-II. Wall Current Monitor (WCM) is a choice of non-destructive intensity monitor to evaluate circulating proton beams from 3 MeV (about 1 MHz in revolution frequency) to 12 MeV (about 2 MHz in revolution frequency) in the FETS-FFA test ring. As the beam orbit shifts radially with beam energies in FFAs, the aperture of FETS-FFA WCM will be about 700 mm in horizontal. The maximum mean beam current is ~100 mA and tomographic and Schottky measurements require a bandwidth of 370 MHz (100 harmonics) with an intensity resolution of 1%. This is a challenge for such a large monitor. The half-width of demonstration WCM (demo-WCM) was designed and manufactured to benchmark numerical simulations and to understand monitor responses. Whilst measured frequency band was shorter than expected, 1% intensity resolution was achieved in demo-WCM. In this paper, the detail design study as well as the signal response of demo-WCM will be presented.

MOPMO40 Development of an Imaging Protocol for Laser Driven X-ray Sources

E Kiely (University of Warwick), A Bennett (University of Nottingham; Central Laser Facility); J Giles-Friend (Swansea University; Central Laser Facility); K Fedorov, O Finlay, A Bhardwaj, C Armstrong, D Symes (Central Laser Facility); M Williams, J Warnett (University of Warwick)

The Extreme Photonics Applications Centre (EPAC) being built at the Central Laser Facility in the UK will utilise a 10Hz Laser Wakefield Accelerator (LWFA) to produce a tuneable x-ray source, with energies ranging from 3keV up to 10's of MeV while maintaining a micron-scale source size and ultra-short pulse duration. Combination of such characteristics opens an opportunity for cutting-edge high-resolution industrial imaging of dense materials: battery packs, historical artifacts and dynamic processes: crack propagation, motor engines running. The primary challenge in imaging with LWFA X-ray sources stems from shot-to-shot instabilities of flux, energies and pointing. We will present an imaging protocol developed using a combination of particle-in-cell, ray tracing and Monte Carlo simulations to simulate instabilities of EPAC and correct for them in x-ray radiographic and tomographic imaging.

MOPMO41 The CEPC beam instrumentation design and R&D status

Y Sui (Institute of High Energy Physics)

The Circular Electron Positron Collider (CEPC) is a 100-kilometer-circumference accelerator complex that includes a linear accelerator, transfer lines, a booster, and a storage ring. Given its massive scale, the CEPC requires a substantial number of beam diagnostic devices to ensure precise and reliable operation. These devices are tasked with measuring critical parameters such as beam current, beam position, beam profile, bunch length, tune, and bunch current, as well as implementing bunch-by-bunch feedback systems. Beyond the use of traditional beam measurement equipment, the CEPC beam diagnostics system also encounters significant challenges.

MOPMO42 Measuring the effects of fast beam loss on the APS-U storage-ring collimators

J Dooling (Argonne National Laboratory), A Dick, G Navrotski, M Borland, R Lindberg (Advanced Photon Source); D Lee, S Riedel (University of California, Santa Cruz); N Cook (RadiaSoft) (United States)

The Advanced Photon Source Upgrade (APS-U) storage-ring (SR) is equipped with five horizontal collimators used to intercept 6-GeV electrons during fast whole-beam aborts and protect the rest of the SR. The collimators are located in sectors 37, 38, 39, 40, and 1. A fan-out kicker (FOK) system has been installed to reduce damage to the

collimators during whole-beam loss events. Since APS-U began commissioning in April 2024, dozen of these events have taken place; in most, but not all cases, the FOK system has worked properly. Turn-by-turn beam position monitors provide beam centroid dynamics data during the loss events; however, limited diagnostics prevent in situ evaluation of the collimator beam-facing jaw surfaces. During maintenance periods in August 2024 as well as January and May 2025, some of the collimators were extracted from the vacuum chamber and examined. Faint beam strike damage was observed on the S01 collimator jaw, but more significant effects were seen on the S38 jaw. Measurements of beam motion during fast aborts is presented as well as microscopy images of the S38 damage. Coupled simulations results are compared with observations.

MOPMO43 Beam Loss Measurements during Injection into the Advanced Photon Source Upgrade Storage Ring

W Cheng (Argonne National Laboratory), A Brill (Advanced Photon Source); J Calvey, J Dooling (Argonne National Laboratory)

A fiber-optic (FO) beam loss montior (BLM) system, installed along the booster to storage ring (BTS) trasnport line has been useful in identifying loss locations employing time-of-flight (TOF) analysis. The BTS BLM TOF system is comprised of a pair of rad-hard, fused-silica FO cables running along either side of the BTS line at beam elevation. In the initial configuration, we measured losses at both the upstream (US) and downstream (DS) ends of the FO cable pair. However, losses further DS along the septum and injection kicker set are also of interest. We therefore added a 20-m-length, multi-strand fused-silica FO cable bundle, replacing the DS outer FO radiator input. Thus, three of the detectors are configured at the US end of their respective FO radiators. The US detector location provides lower signal but improved spatial resolution over the DS. Loss location identification has been accomplished by inserting YAG screen flags at different positions along the BTS. We present results from studies and operations.

MOPMO44 Non-linear optimization of Iranian Light Source Facility storage ring using MOGA

K Noori (Iran University of Science and Technology)

Nonlinearities pose several challenges for accelerator physicists. In order to optimize nonlinearities in the lattice and improve the dynamic aperture (DA) and lifetime of the lattice, the designer utilized a variety of algorithms and trial and error methods. The Multi-Objective Genetic Algorithm

(MOGA) is a commonly used method for optimizing lattice nonlinearities. This technique involves tracking particles to select the working tuning points and the multipole strength, thereby improving DA and Momentum Acceptance (MA). This paper provides a summary of the preliminary optimization study on nonlinearities using MOGA in the ELEGANT accelerator simulation code. We used the Turin System at the Iranian Light Source Facility (ILSF). Our primary objective was to determine the optimal strength for three families of employed octupoles in the ILSF lattice. The last DA and lifetime of the beam is studied, and the RDTs are estimated.

MOPMO45 PIP II machine protection system ADC data noise elimination and de-ripple algorithm

J Wu (Fermi National Accelerator Laboratory), A Warner (Fermi National Accelerator Laboratory)

In Fermilab's PIP-II machine protection system, beam loss signals from various detectors are digitized at 125 MS/s. Noise from both high-frequency sources and low-frequency 60 Hz AC power equipment can contaminate the data. To suppress noise across these ranges—especially 60 Hz and its harmonics, which overlap with beam loss signal frequencies - advanced digital processing beyond standard filtering is required. Several real-time functional blocks were simulated and tested on an FPGA: (1) a dual time-constant discharging integrator filter, (2) a de-ripple baseline extraction and storage block, and (3) a fast-recovery discharging integrator. The nonlinear IIR integrator filter removes high-frequency noise and feeds into the baseline extractor. Upon detecting abrupt beam loss, it switches to a longer time constant to prevent baseline distortion. The de-ripple block calculates a valid baseline by averaging over multiple 60 Hz periods, storing results in a 4096-word FPGA RAM. This baseline is subtracted from raw data before integration by the fast-recovery block, which resets quickly after use. All blocks achieved expected performance and were successfully implemented on a low-cost FPGA.

Special Issue

Selected Papers from the 14th International Beam Instrumentation Conference (IBIC2025)

Message from the Guest Editors

The 14th International Beam Instrumentation Conference (IBIC 2025) will be held in England in the beautiful city of Liverpool between 7th–11th September 2025. The conference will be jointly hosted by STFC, the Cockcroft Institute and the John Adams Institute. IBIC is dedicated to exploring the physics and engineering challenges of beam diagnostic and measurement techniques for particle accelerators worldwide. It brings together the international community of experts in instrumentation for particle accelerators. The conference programme includes tutorials on selected topics, invited and selected talks, as well as poster sessions. The scientific programme is complemented by an industry exhibition featuring product manufacturers and service providers as well as social events to encourage informal knowledge exchange. We are delighted to announce that this Special Issue of *Instruments* will allow conference delegates to publish an expanded version of their conference proceedings in a peer-reviewed journal with global reach and impact.

Guest Editors

Prof. Dr. Carsten P. Welsch

Mrs. Tonia Batten

Prof. Dr. Alessandro Cianchi

Dr. Thibaut Lefevre

Dr. Junxia Wu

Deadline for manuscript submissions

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TUA: Oral Presentations

09:00 High-Throughput DPDK-Based Framework for Real-Time Applications in Elettra 2.0

TUAI01 G Gaio (Elettra-Sincrotrone Trieste S.C.p.A.)

The Data Plane Development Kit (DPDK) is a framework that enhances real-time communications by providing direct, high-speed access to network interfaces. This architecture centralizes acquisition and control in an HPC cluster, ensuring ultra-fast in-memory updates of all critical data, making it a viable choice for real-time feedback and machine control in particle accelerators. This approach was chosen for Elettra 2.0 to enable pre-mortem beam dump mitigation, more detailed post-mortem inspection, advanced correlation analysis and the implementation of complex control schemes. Time-sensitive applications implemented in C code interact with Beam Position Monitors (BPM), Low-Level RF (LLRF), Beam Loss Monitors (BLM) and Magnetic Power Converters through simple memory read and write operations at megahertz rates, making the system competitive with high-level processing applications based on FPGA architectures. This paper presents the system under test at Elettra, highlighting its architecture, performance, and integration, while demonstrating the successful implementation of Fast Orbit Feedback in parallel with turn-by-turn (TbT) data acquisition from twelve BPMs and an LLRF system.

09:30 Towards to continual machine learning for your ever changing accelerator (K. Rajput, JLAB)

TUAI02 K Rajput (Thomas Jefferson National Accelerator Facility)

This talk covers our work on errant beam prognostics at the Spallation Neutron Source (SNS), focusing on the end-to-end process from data collection to the development and deployment of predictive models in specific. A short overview of AIML work done for accelerators and current trends will be presented. We will walk through key steps involved in creating robust Machine Learning (ML) models, including model training, validation, and deployment in an operational setting. In addition to presenting our technical approach, we will share valuable lessons learned, emphasizing the importance of infrastructure to support the continuous adaptation of models to evolving data and system behaviors. This talk will provide insights into the challenges and solutions involved in applying ML to real-world operational environments, with a particular focus on managing data drift and changes in accelerator setup while ensuring model resilience over time.

10:00 Control-Agnostic Beam Instrumentation with Redis at the Core

TUAC01 **D Steinkamp (Fermi National Accelerator Laboratory)**

Redis isn't a database — it's our protocol. Fermilab's RedisAdapter provides a high-performance, control-system-agnostic bridge between digitized beam data and downstream consumers such as ACNET and EPICS. It forms the foundation of three new software components deployed across MicroTCA-based digitizers: GMMDM, a runtime for memory-mapped data movement from Zynq-based platforms; GRAFE, a front end for Redis-to-ACNET presentation; and GREFE, an EPICS IOC front end. Together, these tools enable modular, standardized instrumentation pipelines. Precision timing is handled via White Rabbit PPS distribution, allowing nanosecond-scale synchronization across crates. This architecture, originally prototyped in Booster BPM systems, is now deployed on modern hardware and designed to meet the performance, modularity, and scalability requirements of the PIP-II era.

TUB: Oral Presentations

10:50 Experimental investigation of beam instabilities in BEPCII

TUBI01 Y Liu (Insititute of High Energy Physics)

With the high current physical operations of the upgraded Beijing Electron–Positron Collider (BEPCII), thresholds on collision luminosity and beam current have been presented due to various factors such as collision background, noise, equipment stability under high power operation, and so on. One of the most serious influences on beam dynamics was beam instability which has been clearly exhibited. The comprehensive experimental investigation of beam instabilities in BEPCII is an indispensable part of beam physics research and can provide references for the upgrade project of BEPCII. Over the past two years, the experimental investigation of beam instabilities in BEPCII has been carried on with the single and multiple bunch filling in the storage ring. With the optimization of the bunch-bunch feedback system, the designed collision luminosity , $1.0x10^{33}cm^{-2}s^{-1}$ was achieved during the physical operation and the primary process on configuration of Feedback system will be introduced. For comprehensive understanding the feedback system, a physical model is developed and analysis is conducted to demonstrate the relationship between feedback capability and various parameters. This comprehensive physical model and analysis of the practical feedback system may provide valuable insights into the optimization of the feedback system.

11:20 Isolating the light of a single bunch: determining the viability of operating vertical-plane ‘Pulse Picking by Resonant Excitation’ at Diamond-II to serve timing mode users

TUBC01 S Wilkes (University of Oxford)

“Pulse Picking by Resonant Excitation” (PPRE), first developed by Holldack et al.* at BESSY in 2014, is a beam operation method that simultaneously serves standard synchrotron users and ‘timing mode’ users who require precise X-ray pulse timing from single bunches. PPRE selectively enlarges one electron bunch’s (horizontal) emittance through resonant excitation, creating an enlarged X-ray beam. A beamline can isolate this X-ray beam with their optical apertures whilst blocking the light from regular bunches. We investigate implementing PPRE in the vertical plane – an approach never before demonstrated but potentially advantageous for timing users – using Diamond’s existing multi-bunch feedback (MBF) system to assess potential capability for Diamond-II, a 4th

generation light source. This paper reports on the efficacy of providing vertical PPRE using an MBF by demonstrating live measurements from the I19 beamline, and then by contextualising the results with simulations as part of preparations for Diamond-II.

11:40 **Beam diagnostics, data acquisition system, and applications of machine learning at the KEK e+/e- Linac**

TUBC02 **F Miyahara (High Energy Accelerator Research Organization)**

The KEK e^+/e^- Linac supplies electron beams to SuperKEKB HER, PF, and PF-AR, and positron beams to SuperKEKB LER. We utilize machine learning for both online beam tuning and offline data analysis. Machine learning based on Bayesian optimization has been employed to improve and maintain beam quality, contributing to the enhancement and stabilization of beam injection efficiency into SuperKEKB HER and LER. In this report, we present monitors and beam tuning methods that incorporate machine learning. Identifying parameters that affect beam quality and stability is important, but finding them among the vast number of parameters is not easy. In machine learning-based beam tuning, selecting the appropriate parameters for tuning is crucial, and another important issue is identifying factors that lead to beam instability. To address this, we have applied explainable AI techniques to analyze archived data and attempted to extract parameters that have a significant impact on the beam. This report also covers our data archiving system and analysis efforts using explainable AI.

TUC: Oral Presentations

13:00 Breaking Boundaries: Innovation and Inclusion in Instrumentation Science

TUCPD01 **J Bell-Burnell (University of Oxford)**

This contribution will reflect on Professor Bell-Burnell's career, spanning decades of groundbreaking work in astrophysics, from the discovery of pulsars to leadership in the global scientific community. Along the way, she has received numerous prestigious awards, including the Special Breakthrough Prize in Fundamental Physics, the Royal Astronomical Society Gold Medal, and the President's Medal of the Institute of Physics, recognizing her outstanding contributions to science and beyond. Professor Bell-Burnell has worked as an observer in gamma ray, X-ray, IR and millimetre and radio astronomy and will describe each phase briefly. Beyond the science, Professor Dame Bell-Burnell will explore the importance of promoting equality, diversity, and inclusion (EDI) in STEM, drawing on her experiences to highlight how fostering an inclusive environment strengthens innovation and career development.

14:00 Novel method for real-time temperature monitoring of isotope production targets

TUCC01 **A Laxdal (TRIUMF)**

The extraction of radioactive ion beams (RIB) from proton bombardment on Isotope Separation On-Line (ISOL) production targets depends on the optimization of multiple parameters. Proton beam intensity, the position and shape of the proton beam onto the target are important factors. Crucial for the efficient release of radioactive isotopes from a target are peak temperatures up to 2300 C and temperature gradients within. Since ISOL targets operate in a hard radiation environment conventional temperature diagnostics are not feasible. We have developed an optical system for remote temperature measurements in ISOL targets. It detects the emitted light of the hot target from a distance and correlates near infrared emissions (NIR) to temperature. The device includes a set of optics that transports the light to a NIR spectrometer, and the calculated target temperature is integrated into EPICS and MIDAS frameworks. The strength of the method is that no prior knowledge of the emissivity is required. The diagnostic guides on-line RIB delivery and supports R&D activities to optimize RIB production. Details of the device and measurements will be reported.

TUD: Oral Presentations

14:50 A Review of Space Charge Compensation Diagnostics

TUDI01 **E Flannigan (Science and Technology Facilities Council)**

The space charge of high-intensity ion beams makes it challenging to transport the beam through the LEBT and inject it into the subsequent accelerator. Space charge compensation (SCC) is a process that lowers the space charge of an ion beam by trapping either positive ions or electrons, created by interaction of the beam with residual gas. The compensating secondary particles reduce the beam potential and the space charge-induced divergence of the beam. Significant beam losses during SCC build-up necessitate minimising the SCC time of pulsed high-current ion beams. To address this, diagnostics techniques are used to study the SCC process and measure its degree or time. These techniques include emittance meters, beam profile monitors, wire scanners, retarding field analysers, and optical sensors. Such diagnostics are applicable to positive and negative ion beams, with unique challenges based on the specific ion beam and residual gas used. In this paper we review common SCC diagnostic techniques, discuss the differences in SCC diagnostics for continuous and pulsed beams as well as positive and negative beams, and highlight the importance of supporting particle-in-cell simulations.

15:20 Study of super-resolution reconstruction in transverse phase space measured via slit-scanning method

TUDC01 **H Hu (Huazhong University of Science and Technology)**, *et al.*

Electron beam injectors, critical to advanced light sources and ultrafast diffraction systems, require precise transverse phase space diagnostics to optimize beam quality. Conventional slit-scanning combined with computed tomography (CT) enables non-presumptive phase space reconstruction but faces resolution limitations under sparse sampling. This study introduces a deep learning framework to achieve super-resolution reconstruction from minimal scan data. By integrating beam transport physics with neural networks, the method overcomes resolution degradation in low-data regimes. Numerical validations on a low-energy injector test platform demonstrate significant resolution improvements over algebraic techniques. The proposed algorithm, coupled with beam dynamics simulations, forms a systematic engineering solution for high-fidelity diagnostics. This approach enhances phase space characterization efficiency, supporting accelerator commissioning with reduced experimental overhead.

15:40 **Beam profile measurement with pinhole camera and Kirkpatrick-Baez mirror at HEPS**

TUDC02 **D Zhu (Institute of High Energy Physics)**, *et al.*

The High Energy Photon Source (HEPS) is a 6 GeV electron storage ring light source currently under beam commissioning. We have designed a beam diagnostics beamline that integrates both pinhole imaging and KB mirror imaging systems, enabling the measurement of beam profiles and the calculation of beam sizes and emittance. Both systems are designed to measure the same source point, with the capability to switch between them for beam imaging. Currently, the measured emittance values are 91.8 pm in the horizontal and 4.9 pm in the vertical. This paper provides a detailed account of the measurement results from both imaging systems. In the pinhole imaging system, we conducted a pinhole size calibration experiment by inserting aluminum attenuators of varying thicknesses and comparing the observed size changes with theoretical point spread function variations to determine the pinhole aperture. For the KB imaging system, detailed commissioning data will be presented.

TUPCO: Poster Presentations

TUPCO01 Design and Prototyping for Diamond-II Stripline Kickers

A Morgan (Diamond Light Source), *et al.*

Diamond-II will require two types of stripline kickers during normal operation: the kicker actuators for the transverse multibunch feedback system; and the injection stripline kickers which enable transparent injection. Both are very similar in design as they need to kick individual bunches without disturbing the following bunches. The main difference is the voltage requirements. The feedback kicker is expected to be driven with a maximum peak voltage of ~1.4 kV using a broadband power amplifier, whereas the injection stripline kicker is driven with a trapezoid voltage signal with a maximum peak voltage of 20 kV using a dedicated power supply. This paper will describe the design and prototyping for both stripline kickers along with discussion of the required steps to get to final designs for each type.

TUPCO02 Commissioning of a laser wire profile monitor prototype at CSNS

B Zhang (Institute of High Energy Physics), *et al.*

China Spallation Neutron Source (CSNS) accelerator complex will employ a new superconducting accelerating section to achieve high beam power. To protect the superconducting cavity from contamination, the second phase of the CSNS superconducting linac section will adopt laser stripping technology for transverse distribution measurements of the negative hydrogen beam at nine stations. In 2024, a laser wire(LW) prototype was installed to measure the profile of the 80MeV H- beam. This paper describes the commissioning results of this LW prototype, including the optimization before scanning, and data analysis.

TUPCO03 Status of the Synchrotron Radiation Telescope at the Large Hadron Collider

D Butti (European Organization for Nuclear Research), E Bravin, S Burger, F Roncarolo, G Trad (European Organization for Nuclear Research)

Accurate and continuous measurement of the transverse beam profile is essential for optimizing the performance of particle accelerators. At the Large Hadron Collider (LHC), this task is performed non-invasively by the Synchrotron Radiation Telescope (BSRT). Operational since Run 2, the BSRT has undergone upgrades enhancing its reliability and

performance. It operates under conditions that pose specific challenges not commonly encountered in synchrotron radiation diagnostics at electron facilities. These include the complexity of the radiation source, consisting of multiple magnetic elements evolving during the machine cycle, operation near the diffraction limit in the shortwave ultraviolet, and the requirement for full remote control, as the setup is inaccessible during regular machine operation. This contribution presents the current status of the BSRT system, reviewing its key capabilities, operational limitations, and role in both routine machine operations and dedicated beam physics studies. Finally, an outlook is provided on future upgrades under study, aimed at extending the instrument's performance and ensuring readiness for the upcoming High-Luminosity LHC era.

TUPCO04 Performance of the Beam Gas Curtain as emittance monitor at the Large Hadron Collider

D Butti (European Organization for Nuclear Research), H Zhang, O Stringer, O Sedlacek, C Welsch (Cockcroft Institute); C Pasquino, G Schneider, R Veness, S Mazzoni, T Lefevre (European Organization for Nuclear Research); P Forck, S Udrea (GSI Helmholtz Centre for Heavy Ion Research)

The Beam Gas Curtain (BGC) is an instrument for transverse diagnostics in operation at the Large Hadron Collider (LHC). The transverse beam profile is obtained by imaging the fluorescence light resulting from the interaction between the beam and a thin supersonic neon gas jet. This technique can provide minimally invasive and absolute measurements of both proton and ion beams, throughout the full machine cycle. It is therefore a potential candidate to complement the limitations of existing LHC transverse diagnostic systems. This contribution highlights the results obtained during the ongoing LHC Run 3. The instrument configuration has been optimized for best performance by combining observations in two spectral ranges of the fluorescence signal: a yellow range, originating from the fluorescence of neutral neon atoms, and a UV range, emitted by ionic neon species. The measurements are consistent with those from other profile monitors within operational requirements and allow real-time tracking of the average beam emittance. Finally, an overview of planned upgrades is presented, aimed at further improving system performance and progressing towards a fully operational instrument.

TUPCO05 Research and development of a radiation hard beam profile monitor for use in the CERN North Area secondary beamlines

I Ortega (European Organization for Nuclear Research), *et al.*

The CERN Beam Instrumentation group is currently investigating a radiation-hard beam profile monitor for the CERN North Area. Our main efforts are now focused on straw tubes, a type of wire chamber detector that offers the advantage of being vacuum-compatible and easily equipped with in/out motorisation. We have launched an extensive testing campaign across several CERN accelerators to demonstrate that straw detectors can cover the same dynamic range as traditional wire chambers, from individual particles up to intensities of around 10^{11} particles per second, and to prove that they can perform reliably with beams of both protons and heavy ions.

TUPCO06 Study of pulsed jet operation for beam gas curtain monitors

H Zhang (University of Liverpool; Cockcroft Institute), S Sethi, C Welsch (University of Liverpool; Cockcroft Institute)

A beam gas curtain (BGC) monitor was installed in the LHC for continuous transverse beam profile and emittance measurement. A molecular gas curtain was injected into the LHC continuously. In this work, a pulsed gas jet operation was proposed to minimize the introduction of gas molecules to the beam line and optimize the background pressure. The study was conducted on a gas curtain beam profile monitoring system using nitrogen gas. In this case, the pulse gas jet mechanism enables controlled gas injection into the multiple skimmer chamber to generate a supersonic pulse gas curtain. To achieve maximum current intensity and minimum chamber pressure, key parameters were optimized such as pulse duration or duty cycle, nozzle-skimmer distance, and inlet gas pressure. The results demonstrate a well-tuned pulse jet system can significantly reduce background and enhance the signal-to-noise ratio to monitor a pulse beam. The proposed study exhibits potential applications for beam diagnosis, especially for medical accelerators and laser based linear accelerators.

TUPCO07 Reconstruct phase space of high intensity beams using machine learning

H Zhang (Cockcroft Institute), C Welsch, Q Xu (University of Liverpool)

Space charge effect was considered a driving force for emittance growth in high-intensity beams. To understand it, the emittance needs to be measured. In the past, the quadruple scan was one of the simple and efficient methods

to measure beam emittance, but it is difficult to apply to high-intensity beams where the space charge plays a dominant role due to the deviation from the quadratic fitting. The tomography method was used before for this case to reconstruct phase space and then obtain the emittance, but the scan was time-consuming, and the post-analysis is very complex. One of the solutions is to use the genetic algorithm and treat this as an optimisation problem where the emittance needs to be optimised for the beam to match the quadruple scans. This method also involves heavy post-analysis, which limits its online application. In this contribution, machhine learning methods will be used to reconstruct the phase space based on PIC simulations of space charge-dominated beams. of effectiveness of the machine learning method against the space charge level will be studied.

TUPCO08 Status of longitudinal instability suppression at NanoTerasu

K Ueshima (National Institutes for Quantum Science and Technology), A Agui, C Saji, K Moriya, K Inaba, K Kan, N Nishimori, R Yoshioka, R Saida, S Obara, S Takahashi, T Asaka, T Tsuchiyama, Y Hosaka (National Institutes for Quantum Science and Technology)

NanoTerasu is a 3 GeV light source newly constructed in Sendai, Japan. The circumference is 349 m and the natural emittance is 1.1 nm rad, which is realized by a double-double-bend achromat lattice. The commissioning of the storage ring started in June 2023. The longitudinal instability was observed when the stored beam current reached 150 mA in August 2023. The temperature of RF cavity was adjusted to suppress the instability. The user operation was started on schedule in April 2024 with a stored beam current of 160 mA. The stored beam current was reached 200 mA without the beam instability in July 2024. The stored beam current at user operation period was limited to 200 mA by the longitudinal instability. We try to suppress the longitudinal beam instability using several methods. We developed the pillbox type RF kicker cavity to suppress the instability. In addition, we tried to suppress the longitudinal instability using the transverse feedback kicker. I will report the status of longitudinal instability suppression at NanoTerasu.

TUPCO09 Side effects of bunch-by-bunch feedback system on SuperKEKB collider

M Tobiyama (High Energy Accelerator Research Organization)

The bunch-by-bunch feedback system is now an key function in high-current, multi-bunch storage rings to suppress coupled-bunch instability and/or to reduce the effects of injection vibration. In high-luminosity e+e- colliders such as SuperKEKB, strong beam-beam interactions

occur due to collisions, which usually introduce very wide frequency response on the transverse bunch motion far out of the betatron tune. In vertical plane it may cause increase of the beam size which has a large impact on the luminosity. In this presentation, we will present the principle and configuration of our bunch feedback system, the cause of the side effects of the bunch feedback system, and several trials to overcome them.

TUPCO10 Overview of the Pinhole Camera Design for the Diamond-II Upgrade

N Vitoratou (Diamond Light Source), L Bobb (Diamond Light Source)

Pinhole cameras serve as the primary diagnostic for emittance and energy spread measurements in the storage ring of Diamond Light Source. Similar pinhole cameras will be employed for the Diamond-II upgrade, to enable direct imaging of the stored beam while also allowing for the monitoring of skew, profile, position, and instabilities. The emittance and coupling are calculated from the acquired beam size measurement, combined with the lattice parameters. In this paper, an overview of the new system for Diamond-II is presented. The changes and upgrades made to the existing setup, the challenges and the choice of the different components are described. Additionally, future work that could improve the performance of the system is explored.

TUPCO11 Developing radiation-tolerant transverse beam imaging using machine learning

Q Xu (Cockcroft Institute), A Hill, C Welsch, H Zhang (University of Liverpool; Cockcroft Institute); D Metin, F Roncarolo, G Trad, S Burger (European Organization for Nuclear Research)

Transverse beam-profile monitoring is crucial for the safe and efficient operation of particle accelerators. In high-radiation zones near fixed targets and beam dumps, imaging sensors - especially cameras used for beam-profile measurements - degrade rapidly, compromising beam diagnostics. In this study, we propose using a single multimode fiber (MMF) to relay optical signals from an interceptive screen located in a high-radiation area to a low-radiation area, combined with a machine learning model to reconstruct the transmitted signals. To overcome the lack of sufficient and balanced real data for training, we developed an unnormalized Gaussian Mixture Model to generate synthetic data. The machine learning model trained exclusively on this synthetic dataset reconstructs beam profiles from speckle patterns transmitted through the MMF. Experimental validation was conducted in the laboratory using a laser-illuminated Digital Micromirror Device (DMD) and real transverse beam samples from the CLEAR facility.

The results demonstrate the potential of this approach for radiation-resistant transverse beam imaging.

TUPCO12 Measurement of transverse profile in electron linacs: recent advances in SwissFEL

R Ischebeck (Paul Scherrer Institute), E Prat, F Addesa, G Luca Orlandi, P Juranić, P Dijkstal, S Reiche, T Schietinger, V Guzenko (Paul Scherrer Institute); G Erin Tekin, J Schlör (ETH Zurich)

The measurement of transverse profiles of the electron beam is key to measuring and optimizing the emittance of a linear accelerator. Also, transverse profile monitors are used in conjunction with an RF deflecting structure to measure bunch length and slice emittance. An RF deflector and a profile monitor behind the undulator can furthermore be used to reconstruct the FEL pulse profile. I will give an overview on recent advances in beam profile measurements at SwissFEL, including scintillating screens as well as wire scanners. The goal of these advances is the improvement of the resolution in both screens and wire scanners, both by improving the optics, and by improved data processing. Furthermore, we are exploring the possibility to do non-invasive wire scans with micrometer-size wires.

TUPCO13 Development of a Cherenkov Radiation–Based Beam Profile Monitor for a Muon Linear Accelerator

R Nakagawa (The Graduate University for Advanced Studies, SOKENDAI), F Miyahara, M Otani, T Mitsuhashi, Y Hashimoto (High Energy Accelerator Research Organization)

In order to test the Standard Model through a precision measurement of the muon anomalous magnetic moment, a 212 MeV muon accelerator is being developed and constructed for the J-PARC muon g-2/EDM experiment. During the early stage of commissioning, the number of muons per pulse could be fewer than 100, necessitating a highly sensitive monitor. In addition, muon identification must be performed in the presence of dark current from the accelerating structure. In this study, we are developing a beam position monitor that utilizes Cherenkov radiation to select the muon beam and measure its profile. To focus only the Cherenkov light originating from muons onto the light detection system, we have designed a beam profile monitor based on an Offner relay optical system, consisting of a convex and a concave mirror. This monitor enables the detection of ultra-low-charge muon bunches, which are extremely difficult to observe with conventional beam position or profile monitors. We report on the detailed design of a monitor optimized for kinetic energy of 40 MeV, along with the fabrication and testing of a prototype.

TUPCO14 Status of oscillating arm wire monitor development

R Dölling (Paul Scherrer Institute), A Sandström, D Befus, M Schneider, M Sapinski, M Mähr, M Rohrer, R Baldinger, R Nicolini, S Jaroslawzewa, S Warren, X Wang (Paul Scherrer Institute)

Oscillating arm wire monitors are in use at PSIs HIPA facility since the 1970s. Molybdenum wires or foils, carbon fibres, or tungsten blades are passed through the proton beam in the 0.87 MeV, 72 MeV and 590 MeV beam lines to measure secondary electron emission current. We are developing an improved monitor to serve in the new proton beam lines of the IMPACT project, as spares, and later as replacement. The new monitor retains the basic mechanical concept, but at increased wire speeds. This will allow to measure at full beam current even at low beam energy. Further it will reduce the beam losses during the wire passing as well as the resulting need to temporarily increase the interlock levels of the beam loss monitors at higher energies. A prototype is under construction, which allows to test a low inertia setup with stepper and DC motors and eventually gears using optimized speed trajectories and to compare it with simulations. The performance of the light-weight arm, the bellow and other mechanics, potentiometer, resolver, and end switches will be studied. We discuss the mechanical setup, the manufacturing of the arm, simulations, the test setup, and first measurement results.

TUPCO15 Fast Corrector Vessel Selection for High Bandwidth Fast Orbit Feedback

S Banerjee (Diamond Light Source), L Bobb (Diamond Light Source)

The Diamond-II upgrade will enhance the performance of the Diamond Light Source synchrotron, including improved beam stability by the Fast Orbit Feedback system. Achieving the targeted closed-loop bandwidth of 1 kHz necessitates an open-loop actuator bandwidth of approximately 10 kHz, which presents significant design challenges for the corrector magnet vacuum vessel. Additionally, subsystems such as the corrector magnet power supplies and Beam Position Monitors, must comply with a stringent closed-loop latency of less than 100 microseconds. Initially, a 1 millimetre stainless steel vessel was deemed viable; however, experimental findings indicated that the combination of stainless steel and neighbouring copper vessels resulted in a decrease in both integrated magnetic field strength and system bandwidth. This prompted a reassessment of the material selection for the fast corrector vessels to optimise orbit feedback performance. This paper investigates these challenges, analyses experimental data, and explores solutions to achieve the necessary bandwidth for the Diamond-II upgrade.

TUPCO16 Irradiation Tests of a Digital Radiation-Tolerant Camera for CERN's Particle Accelerator Instrumentation

S Burger (European Organization for Nuclear Research), E Bravin, F Roncarolo (European Organization for Nuclear Research)

Beam imaging systems are integral parts of beam instrumentation at CERN, measuring the shape, size, and position of particle beams in accelerators. Following the worldwide phasing out of analog cameras and vidicon tubes (which the system was initially based on and still partially uses), part of the ongoing consolidation program involves developing a new camera system based on digital technology for use in CERN's medium radiation environments up to few 100 Gy total dose. For this purpose, the CERN Beam Instrumentation group initiated the development of a digital camera system in col- laboration with MCSE*, a Swiss company specializing in space instrumentation. The new camera's performance un- der radiation was evaluated at CERN's CHARM test facility, with promising results in terms of radiation immunity while maintaining sufficient sensitivity and resolution—which will be the focus of this contribution. Following this prototyping phase, an industrial version is now in development and is expected to undergo testing in 2025.

TUPCO17 Upgrade and Evolution of the Ad Target Beam Imaging System at CERN: A Two-Year Performance Analysis

S Burger (European Organization for Nuclear Research), F Roncarolo, J Martínez Samblas, M Gonzalez-Berges (European Organization for Nuclear Research)

During CERN's Long Shutdown 2 (LS2) in 2022, the Anti-Proton Decelerator (AD) target area underwent major renovations, including a significant upgrade to its beam imaging system. The previous tube-based camera, used in a high-radiation environment, had limitations in sensitivity and resolution for continuous measurements. The upgraded design uses an innovative in-air light-emitting screen mechanically coupled to the AD target, monitored by a digital camera through a 20-meter optical line from a radiation-safe zone. This setup improves accessibility during beam operation and enhances measurement capabilities. Over two years of operation, several crucial modifications were made. A key change was transitioning from a scintillation material screen to an Optical Transition Radiation (OTR) screen, though this created new challenges with background interference. To address temperature-dependent calibration variations, an automated calibration mechanism was developed, utilizing advanced image analysis algorithms for real-time adjustments. This paper discusses these developments, challenges, solutions, and future optimization opportunities for the AD facility's evolving experimental needs.

TUPCO18 Experimental Investigation Into Supersonic Gas Jet Induced Beam Perturbation

W Butcher (Cockcroft Institute), N Kumar, M Patel, O Stringer, F Thesni Mada Parambil, B Rawat, H Zhang, C Welsch (Cockcroft Institute; University of Liverpool)

In radiotherapy, treatment beams warrant fine margins due to the goal of sparing the patient's healthy tissue. Studies have found that to counteract Bragg peak range deviations, safety margins of approximately less than 5% around the target volume are normally used in clinical settings. Hence, diagnostics would be improved if they cause as close to zero beam perturbation as possible. A minimally-invasive gas jet beam profile monitor for medical treatment facilities is being developed at the Cockcroft Institute (UK) to provide online monitoring. The monitor operates a thin, low-density, gas jet curtain, transecting with the beam. A proof-of-concept experimental study was carried out to quantify the degree of perturbation the gas jet has on a beam, using a 10 keV electron gun. Any changes in beam profile and current were measured via a scintillator screen and Faraday cup respectively in path of the beam. In the future, a simulation study will be carried out using BDSIM, a Beam Delivery Simulation program built on GEANT4, with the experimental beam parameters. This contribution examines experimental study into the perturbation experienced by a particle beam from a gas jet monitor.

TUPCO19 4D transverse beam characterization with a virtual pepper pot

C Richard (Deutsches Elektronen-Synchrotron DESY), A Hoffmann, B Li, D Dmytriiev , D Xu, F Stephan, G Vashchenko, J Good, M Gross, M Krasilnikov, N Aftab, S Zeeshan, X Li (Deutsches Elektronen-Synchrotron DESY)

Characterization and optimization of the transverse phase space is crucial for the performance of photoinjectors. To this end, many measurements of the transverse phase spaces are taken. Often, the x and y 2D phase spaces are measured separately because they are assumed to be primarily uncoupled. However, there will be some 4D coupling due to solenoid fields, asymmetries in the beamline, or higher multipole moments in the focusing elements. To measure this coupling, a Virtual Pepper Pot (VPP) method was previously developed at the Photo-Injector Test facility at DESY Zeuthen (PITZ) that combines measurements taken with a slit-screen emittance scanner of the x and y 2D phase spaces to reconstruct the full 4D phase space distribution. Presented here are measurements from PITZ using the VPP method to characterize a new photo-gun installed at the end of 2024 including a newly designed symmetric RF coupler with a focus on quantifying and mitigating the x-y coupling.

TUPCO20 Design and implementation of Allison scanner at the KOMAC LEBT

S Ho Moon (Korea Multi-purpose Accelerator Complex), D Kim, S Lee, S Yun, H Kim, H Kwon (Korea Atomic Energy Research Institute); S Cho (Korea Multi-purpose Accelerator Complex)

This study presents the design, specifications, and experimental validation of the Allison scanner installed at the injector of the 100 MeV proton accelerator operated by the Korea Multi-purpose Accelerator Complex (KOMAC). The Allison scanner was developed to enable precise characterization of the proton beam's phase space at the injector stage. Detailed design parameters and operational principles of the system are described. Experimental measurements were conducted under various operating conditions to assess the performance and reliability of the scanner. Furthermore, the daily measurement data collected by the Allison scanner were analyzed to evaluate the long-term stability of the ion source.

TUPCO21 Low energy experimental bench (LEEx-B) and emittance-meter developments at IPHC

E Traykov (Institut Pluridisciplinaire Hubert Curien), C Maazouzi, E Traykov, P Graehling, T Adam (Institut Pluridisciplinaire Hubert Curien)

A low energy experimental bench called LEEx-B is being developed at IPHC-CNRS of Strasbourg, France. The bench is composed of a CS+ ion gun mounted on a HV platform and beams up to 25 keV are provided. The main objective of this bench is to support the advancement of beam diagnostics, including the ongoing development of the Allison-type emittance-meter. This paper presents the progress of the construction of the LEEx-B and of the beam diagnostics.

TUPCO22 Cherekov radiation spectral and resolution properties studies at SINBAD ARES

G Kube (Deutsches Elektronen-Synchrotron DESY), M Joseph Kellermeier, T Vinatier, W Kuropka (Deutsches Elektronen-Synchrotron DESY); A Potylitsyn (Institute of Applied Problems of Physics of the National Academy of Sciences of the Republic of Armenia IAPP NAS RA)

Optical Cherenkov Radiation (ChR) is a well-known type of radiation, which is utilized in different fields of physics such as charged particle detection or generation of intense THz radiation. It is also widely used in beam diagnostics, for instance, in beam loss monitors or for bunch length measurements. In addition, it is of potential interest for transverse beam profile diagnostics as an alternative for

standard techniques as scintillating screens and optical transition radiation. In this work, spectral and resolution properties of optical ChR were studied at the SINBAD ARES accelerator with an electron beam energy of 150 MeV. Several fused silica crystals of different thicknesses were used as radiators. They could be rotated relative to the beam, which allowed to investigate the angular dependency of the ChR spectrum which is quasi-monochromatic. The monochromatization effect arises from the frequency-dependent nature of the fused silica permittivity. In addition, the beam size dependency on the target angle was investigated in view of differences for various crystal thicknesses.

TUPCO23 High-Precision Profile Measurement with COTR Interference Resistance

L Hua (Shanghai Advanced Research Institute), R Yuan, J Chen, J Dong (Shanghai Advanced Research Institute, Chinese Academy of Sciences)

Transverse beam profile diagnostics constitute a critical component in free-electron laser (FEL) operation and optimization. As a standard diagnostic tool, optical transition radiation (OTR) has been widely adopted in FEL facilities. However, as the bunch longitudinal length below 500 fs, the OTR method becomes significantly affected by coherent effects. This paper presents a systematic approach employing fluorescent screens combined with spatial separation measurement methodology to effectively circumvent coherent optical transition radiation (COTR) interference while achieving high-precision measurements. Experimental results obtained at the SXFFL demonstrate the system's capability to resolve beam spikes smaller than 20 μm, with agreement observed in comparison with wire scanner measurements.

TUPCO24 Design and Programming of a Multifunctional Device for Accelerator Beam Profile Measurement and Beam Stop

M Abdul Rehman (Institute of High Energy Physics), L Zeng, R Qiu, Z Xu, W Huang, Y Lv, R Yang (Institute of High Energy Physics)

During the pre-research phase of China Spallation Neutron Source (CSNS) upgrade project (CSNS-II), in order to conduct beam commissioning of the Radio Frequency Quadrupole (RFQ) under high-intensity beam conditions, The structure of the last-stage wire scanner of the Medium Energy Beam Transport (MEBT) was innovatively modified. This modification not only added a Beam Stop but also significantly enhanced the efficiency of wire scanner. This paper presents the architecture and operational programming of a novel multifunctional device designed for

accelerator beam diagnostics and beam termination: beam profile measurement via advanced sensing mechanisms and Beam Stop using a braided carbon fiber plate as the primary beam stop.

TUPCO25 Direct X-Ray imaging for the new pinhole diagnostics at BESSY II

M Marongiu (Helmholtz-Zentrum Berlin für Materialien und Energie), A Schälicke, C Kalus, G Rehm, M Ries, V Dürr (HZB für Materialien und Energie)

In order to improve our transverse diagnostic tools, two new pinhole beamlines will be designed. The pinhole arrays will be in air for easier maintenance: this will result in a significant loss of X-Ray photons when passing through the vacuum window. To overcome this issue, the option to directly illuminate a CCD/CMOS camera with X-Ray radiation without prior conversion into visible light is under study. Tests in the existing beamline both with a conventional CMOS camera and with a dedicated X-Ray camera are foreseen. This report describes our findings regarding the current status regarding the use of X-Ray cameras as a “high flux” diagnostic tool, as well as our preliminary experimental results.

TUPCO26 Requirements for equipment in Cooling Section of EIC Low Energy Cooler

S Seletskiy (Brookhaven National Laboratory), A Fedotov , D Kayran (Brookhaven National Laboratory)

The Electron Ion Collider (EIC) requires an electron cooler operating at the EIC injection energy to obtain the design proton beam emittances. A non-magnetized RF-based electron cooler, the EIC Low Energy Cooler (LEC), is currently under design. It will be operating at γ-factor 25 and will be delivering 70 mA electron current to a 170 m long cooling section (CS). To obtain required cooling an input from electron-proton relative trajectory misalignment into an overall angles in the cooling section must be kept below 15 urad. In this paper we give comprehensive consideration of the factors affecting the trajectory angles and set the resulting requirements to various CS subsystems.

TUPCO27 Feedbacks at Low Energy RHIC Electron Cooler

S Seletskiy (Brookhaven National Laboratory), K Mernick, L Nguyen, P Inacker, R Hulsart (Brookhaven National Laboratory)

The Low Energy RHIC Electron Cooler (LEReC), the world’s first RF-based non-magnetized electron cooler successfully provided cooling of gold ions at γ-factors 4.1 and 4.9 during RHIC Runs 2019-2021, substantially increasing RHIC luminosity. Since then, LEReC has been routinely used for numerous cooling studies. Development of trajectory and

energy feedbacks for electron beam was an important step in achieving the optimized cooling in LEReC. This paper summarizes our experience with design, commissioning and operation of the LEReC feedback systems.

TUPCO28 Implementation and Initial Operation of the Bunch-by-Bunch Feedback System at SOLARIS

M Szczepaniak (SOLARIS National Synchrotron Radiation Centre), A Wawrzyniak, R Panas (SOLARIS National Synchrotron Radiation Centre)

The SOLARIS synchrotron light source has commissioned a transverse bunch-by-bunch feedback system designed to suppress coupled-bunch instabilities and serve as a diagnostic tool for accelerator studies. The system was successfully installed and integrated with the existing infrastructure, including timing and control systems. After a series of commissioning steps, it was brought into operation and tested under standard user conditions. Although routine instability suppression is not currently needed during regular operation, the system has been effectively used in dedicated machine studies. It enabled detailed observation of transverse bunch motion, instability spectra, and individual bunch tune measurements. The system also played a crucial role in advanced measurements such as LOCO experiments with selectively emptied buckets and tune shift studies under varying machine conditions. The bunch-by-bunch feedback system significantly enhances the diagnostic and research capabilities at SOLARIS and provides a solid foundation for potential future applications in active beam stabilization.

TUPCO29 Real-time embedded feedforward correction for SIRIUS undulators

P Nallin (Brazilian Synchrotron Light Laboratory), D Tavares, G Rodrigues de Lima, J Pedro Burle Ishida (Brazilian Synchrotron Light Laboratory)

SIRIUS, the Brazilian 4th generation synchrotron light source, has been in operation since 2020. Over time, insertion devices (IDs) are expected to populate its straight sections. To supress edge effects from undulators and support overall beam stability, a feedforward correction system is currently available through EPICS layer for the first installed ID. However, performance could be improved by adopting a lower-level solution with higher actuation rates and reduced jitter. To address this, a new approach has been developed using hardware technology already available: control system nodes based on BeagleBone Black platform, which integrates both embedded linux and dedicated real-time processors within the same SoC. This setup enables current setpoints updates at rates up to 1 kHz and aiming to be scalable. This paper presents an overview of the system's architecture and objectives, first results with IVU and VPU undulators and future developments and improvements.

TUPCO30 Dependence of tune-sweep waveforms in Diamond on mode number

D Rabusov (Diamond Light Source), A Morgan (Diamond Light Source); I Martin (Diamond Light Source; John Adams Institute for Accelerator Science)

At Diamond, it was previously observed that the response of the beam changes with mode number when excited by the transverse multi-bunch feedback (TMBF). This study presents the results of various experimental campaigns carried out to investigate the behaviour of tune-sweep waveforms for a variety of stored beam conditions and TMBF settings. We demonstrate that it is unlikely that wakefields cause the mode dependence in the output TMBF waveforms. Investigations to explain what is causing the mode-dependent behaviour are ongoing.

TUPCO31 R&D of an Ultrafast X-ray Beam Size Monitor for SuperKEKB

R Nomaru (The University of Tokyo), G Mitsuka (High Energy Accelerator Research Organization); K Yoshihara, M Andrew (University of Hawai'i at Mānoa); L Ruckman (SLAC National Accelerator Laboratory)

SuperKEKB is a high luminosity electron-positron collider that aims to achieve an instantaneous luminosity ten times higher than the present world luminosity record by SuperKEKB itself. However, stable operation is hampered by a phenomenon known as Sudden Beam Loss (SBL), where beam instability occurs within tens of microseconds, resulting in significant beam loss and triggering a beam abort. It has been suggested that a fast increase in beam size may accompany SBL events. To study this rapidly evolving beam size instability and to gain deeper insights into SBL, we are developing a new bunch-by-bunch X-ray beam size monitor. It uses a silicon strip sensor to read the synchrotron radiation from the bending magnet and can record the transverse size of all bunches arriving at least 4 ns intervals. This presentation will detail the development of the X-ray beam size monitor and report on preliminary performance tests using laser light as a proxy for synchrotron radiation.

TUPCO32 Turnkey scintillating beam profiler for high-resolution and high-rate beam diagnostics

B Truc (Swiss Center for Electronics and Microtechnology, V Leccese (École Polytechnique Fédérale de Lausanne; Swiss Center for Electronics and Microtechnology (Switzerland); M Caldara, F Carbone (École Polytechnique Fédérale de Lausanne)

Organic scintillators offer high sensitivity and fast response but face challenges in achieving both high spatial resolution and rapid acquisition, and are prone to radiation damage. We present a novel beam profiler based on silicon microchannels filled with scintillating resin, each individually read out by a photodiode array connected to custom microcontroller-based electronics. The 60x60 mm^2 sensitive area is modular and easily replaceable, addressing radiation-induced degradation over time. Designed as a plug-and-play solution for high-energy beamlines in particle therapy center, the compact detector achieves ~100 µm spatial resolution and is designed to reach profiling rates up to 4 kHz, although such rates are yet to be experimentally validated. Integration times are configurable between 20 µs and 1.4 s. Testing at CNAO with 70–230 MeV proton beams showed good agreement with reference detectors at low energies (<100 MeV), with a broadening effect observed at higher energies. This detector offers precise, high-rate beam characterization and is well-suited for commissioning and routine operation in a wide range of accelerator facilities.

TUPCO33 Development and experimental validation of a PI control system for synchrotron X-Ray beam stabilization

N La Rosa (University of Catania; STLab srl), G Trovato (University of Catania; Institute for Microelectronics and Microsystems; Istituto Nazionale di Fisica Nucleare, Sezione di Catania; STLab srl); S Moscato (University of Catania; STLab srl); M Bucolo (University of Catania); M Camarda (Institute for Microelectronics and Microsystems; STLab srl; SenSiC GmbH); M Birri (Paul Scherrer Institute); J Rueff, J Ablett (Synchrotron soleil)

This work presents the development and experimental validation of a control system for synchrotron X-ray beam stabilization. A laboratory-scale replica of a beamline was constructed using an analog oscilloscope to emulate beam dynamics. Electrical actuation was implemented via deflection plates, while disturbances were introduced using an electromagnet. Beam position monitoring was performed through a 2x2 photodiode matrix, replicating the functionality of X-ray Beam Position Monitors (XBPMs). System identification through steady-state and transient analysis resulted in a first-order linear dynamic model relating input voltages to beam position. A PI controller was designed based on this model, and experimental validation demonstrated the controller's effectiveness in maintaining beam stability under position drift conditions - typical disturbances during X-ray Absorption Spectroscopy (XAS) experiments - achieving a control frequency of 1 kHz, limiting the steady-state error to below 0.2% of the total drift. The proposed approach provides a foundation for the development of high-performance control systems for synchrotron beamlines, with potential application to operational facilities.

TUPCO34 FOC Algorithm Based on ML for the HEPS

Y Zhao (Institute of High Energy Physics), J He, Y Li, H Zhang (Institute of High Energy Physics)

The High Energy Photon Source (HEPS) is the fourth-generation synchrotron light source with a beam energy of 6 GeV, developed by the Institute of High Energy Physics. As a essential partment of the HEPS, The Fast Orbit Feedback (FOFB) systemhas been developed to maintain the beam orbit stability. In this work, a neural network-based algrithm has been designed and developed to replace the tradional PID control algrithm of FOFB. In this papaer, we have introduced the design and developmenyt of the MLP neural network, which has been trained using operational data from HEPS, and hyperparameter optimization was conducted to improve performance. The trained model was then quantized to support deployment on FPGA hardware. A laboratory test environment was set up, where BPM data was fed into the neural network, and the corrected values for the corrector magnets were output after computation. Experimental results show that the neural network maintained a control error of approximately 1 mA. These results demonstrate the feasibility of using neural networks as an effective alternative to PID control in FOFB systems.

TUPCO35 Design and Testing of a Universal Embedded Feedback Controller for RF Cavities

A Sharma (Indian Institute of Technology Delhi), B Kumar Sahu, P Singh, S Venkataramanan, V Satyanarayana, Y Mathur, Y Dabas (Inter-University Accelerator Centre); S Kar (Indian Institute of Technology Delhi)

The design of low-level feedback (LLRF) controllers used to stabilize amplitude and phase of the field inside the RF cavities are customized in nature depending upon the frequency and mode of operation. IUAC, India, operates accelerators with RF structures in the range from 12.125-97 MHz in normal and superconducting mode. Currently, all the LLRF controllers operational for many years, are structure specific and designed in analog domain. Component ageing, obsolescence and limited availability has made it difficult to maintain them amid frequent failures. To overcome this a universal digital controller has been developed whose design is based on using the same hardware for all the RF structures at IUAC. It is a compact, reconfigurable and standalone device with a microcontroller programmed Phase Locked Loop multiplier, a wideband analog front end and a System-on-Chip-FPGA based digital board with fast ADCs and DACs controlled using EPICS IOC. The controller is designed as a Sawtooth Waveform Generator for the Multi-Harmonic Buncher, and Generator Driven and Self-Excited Loop based LLRF for various RF cavities at IUAC. Design details and test results will be discussed in this paper.

TUPCO36 Fast orbit feedback system upgrade plan for TPS

C Wu (National Synchrotron Radiation Research Center), P Chiu (National Synchrotron Radiation Research Center)

Orbit feedback system of the Taiwan Photon Source (TPS) had been deployed one decade ago and upgraded from 10 kHz to 30 kHz in 2020. To further improve orbit feedback performance, the FOFB system is proposed to upgraded to 48 kHz. The integration of BPM, power supply control and fast orbit feedback will be summarized in this report.

TUPCO37 Design of a laser-based emittance meter for the H- beam based upon LGAD sensor

C Chen (Dongguan Neutron Science Center)

After the success of 80 MeV negative hydrogen beam profile measurement based on laser wire monitor, in order to further realize the beam emissivity measurement, an emissivity measurement system combining the laser wire monitor and LGAD (low-Gain Avalanche Diode) sensor has been designed. The idea is to use the LGAD sensor to detect and reconstruct the H0 distribution, combined with the laser-beam interaction position information, to realize the online emittancemeter. In this paper, we will show the design of the H0 distribution measurement system based on the LGAD sensor. It mainly includes the characterization of the LGAD sensor by the emissivity source; the evaluation of H0 particle energy deposition; the design of the ceramic PCB board of the LGAD sensor and the response test of the local signal.

TUPCO38 Laser transport and stabilization for the CSNS laser wire profile monitor prototype

B Zhang (Institute of High Energy Physics), *et al.*

A laser wire monitor has bean developed at the China Spallation Neutron Source (CSNS).The monitor utilizes a 1064 nm laser source to measure the horizontal and vertical profiles of a negative hydrogen ion (H-) beam with an energy of 80 MeV in the injection zone. This paper describes the design of the laser optical path layout and the characterization of the transport performance. The experiment focuses on the laser system's quality factor M2 of the laser after more than 60 meters of transmission as well as the beam pointing stability. In this experiment, the laser quality factor M2 after transmission is better than 4, and the beam pointing stability after focusing is less than ± 2.5 um, which is able to satisfy the required specifications for the first laser wire monitor of the CSNS.

TUPCO39 Development of Wire Scanner Profile Monitor in FETS-FFA Test Ring

E Yamakawa (Science and Technology Facilities Council), A Chamberlain (Science and Technology Facilities Council)

Wire Scanner profile Monitor (WSM) has been developed for the demonstration ring of Fixed Field Alternating gradient (FFA) accelerator, called FETS-FFA. From previous studies, Carbon Nano Tube (CNT) wire is selected for the FETS-FFA WSM, durable for the heat damage of low energy proton beams on FETS-FFA test ring (3-12 MeV). The bias voltages are required to prevent secondary electrons returning to the wire due to stray magnetic fields of FFA main magnets. The endurance tests of bias voltages on different size of CNTs were performed prior to the beam tests on the the Front-End Test-Stand (FETS) beam line. The beam tests with bias voltages and numerical simulations revealed secondary electrons from adjacent wires degraded the reading sensitivity hence profile accuracy, explaining the peak of beam profile was not proportional to the wire size in previous studies. This paper will focus on the endurance test of bias voltages on CNTs as well as beam profile measurements with bias voltages on FETS beam line. The mechanical design of automation zig to install a thin CNT wire (diameter of 10 um) on the frame head of FETS-FFA WSM will be also presented.

TUPMO: Poster Presentations

TUPMO01 Development of a High-Gain Residual Gas Ionization Profile Monitor (HGRGIPM) for the slow extraction proton beamline at the J-PARC Hadron Experimental Facility

A Toyoda (High Energy Accelerator Research Organization), K Agari, H Akiyama, K Aoki, E Hirose, M Ieiri, T Itaba, R Kurasaki, M Minakawa, Y Morino, F Muto, Y Sato, S Sawada, Y Shirakabe, H Takahashi, T Takahashi, K Tanaka, H Watanabe, T Yamaga, Y Yamanoi (High Energy Accelerator Research Organization)

We have developed a highly sensitive beam profile monitor, the High-Gain Residual Gas Ionization Profile Monitor (HGRGIPM). The HGRGIPM detects electrons ionized by the proton beam in residual gas, which are guided by electric fields to a phosphor screen. The fluorescence is collected by an optical system. RGIPMs have proven to be powerful diagnostic tools for high-intensity beams because they have non-destructive nature. They have been used as the main profile monitors in the primary beamline, A-line (30 GeV, 83 kW, vacuum ~0.3 Pa). However, the newly constructed B-line (11 W) presents a significant challenge, as its beam intensity is four orders lower than that of the A-line. To overcome this issue, several improvements were made in the design of the HGRGIPM. These include the use of a thin phosphor screen to enhance the signal-to-noise ratio, optimizing electrode geometry for higher acceleration voltages and improved sensitivity, and incorporating a high-efficiency optical system. These innovations allow profile monitoring even in the low-intensity B line. In this presentation, we report on the HGRGIPM's design and performance, beam response measurements, and future prospects.

TUPMO02 Novel gas jet-based measurement method for beam profile and emittance analysis on the HUN-REN EK-CER microwave proton ion source

A Zsákai (HUN-REN Centre for Energy Research), G Pokol (Budapest University of Technology and Economics; HUN-REN Centre for Energy Research); G Anda (HUN-REN Centre for Energy Research)

An ECR microwave H^+ source has been built at the HUN-REN EK-CER that targets medium current (20 mA) and 35 keV beam energy in continuous or pulsed mode (0.1-10ms @ 0.01-25 Hz) and low normalized beam emittance (< 1 π mm·mrad). A new gas jet-based diagnostic system installed on the proton source provides non-invasive beam profile measurement, and allows a novel way for emittance

evaluation with an additional mesh to create beamlets. The diagnostic uses a nozzle and skimmers to form a thin (~2 mm) and dense (10^{17} $1/m^3$) gas curtain of an interaction cross section of ~10x10 mm^2 inclined at 45° to the beam axis. A CMOS camera is installed to record the yielded photons (~s exposure time) from the interaction of the proton beam and gas curtain. It is crucial to use a gas that has a high collisional cross section (e.g. Ar, N or Ne), and is easy to distinguish from the residual gas (N) excitation to ensure effective detection. This study describes the optimization of the gas jet-based beam diagnostic including gas selection, jet formation (nozzle and skimmer design, curtain thickness and density) and vacuum system configuration. Finally, measurement results are compared with simulations.

TUPMO03 Performance of Titanium, Tungsten, and Carbon as Beam Profile Monitor Materials

D Metin (European Organization for Nuclear Research), A Goldblatt, C Vuitton, F Roncarolo, M Duraffourg, M Hamani (European Organization for Nuclear Research)

This paper investigates the signal characteristics of Titanium, Tungsten, and Carbon materials used in a secondary electron emission grid setup at CERN's North Area. Periodic scans were conducted to reconstruct beam profiles and assess the performance of these materials, configured as wires and bands, under slow-extracted 400 GeV protons. The study aims to inform the design and optimization of new secondary electron emission monitor systems for the NA consolidation project and future installations.

TUPMO04 Study of Optical Synchrotron Radiation as a Non-Invasive Tool for emittance diagnostics

D Ghosal (University of Liverpool), J Wolfenden, C Welsch (University of Liverpool; Cockcroft Institute)

We present a robust simulation framework for using Optical Synchrotron Radiation (OSR) as a non-invasive tool to extract the transverse emittance of relativistic electron beams in advanced accelerator facilities. As next-generation accelerators target higher brightness and lower emittance, conventional diagnostics may fall short. OSR, coupled with an optimized optical transport system, offers a scalable, high-resolution alternative. Using the Synchrotron Radiation Workshop (SRW) code, we model OSR emission and propagation through realistic optics, incorporating detector and transport effects. Feasibility of this emittance measurement study was assessed using a microlens array (MLA) system to capture angular beam distributions from OSR. To validate the imaging performance, we integrate SRW with optical ray-tracing simulations in Zemax. Successful reconstruction of the emittance and Twiss parameters from the simulated results in the end validate the framework's accuracy in optimizing beam diagnostics. The method is benchmarked using beam conditions from

the CLEAR facility at CERN, while also providing a blueprint for extending OSR-based emittance diagnostics to other facilities.

TUPMO05 Gas-Jet based Ionization Profile Monitor for Proton FLASH Therapy

F Thesni MP (University of Liverpool), N Kumar, M Patel, B Rawat, W Butcher, C Welsch (University of Liverpool; Cockcroft Institute)

In proton FLASH therapy the beam monitoring is crucial to ensure the conformal dose deposition to the tumour and effective Organ at Risk (OAR) sparing. A non- invasive real time beam monitoring improves the efficacy as the dose is delivered in shorter time scales. To achieve this, gas-jet based Ionization Profile Monitor (IPM) is developed with potential capability towards real time beam monitoring. It detects ions produced by the interaction of primary beam with a thin (<1 mm) gas-curtain without perturbing the beam. This work presents the simulation of IPM to study the ion extraction under different configuration for accurate reconstruction of the beam shape. The role of electric field in the IPM on the trajectory of the ions and the inhomogeneity in their energy distribution affecting the beam profile are studied. The study also investigates the effect of beam misalignment, relative contribution of individual ion states generated due to interaction, and the gas-curtain density distribution. Future work will address configuration required to accommodate broader range of beam relevant to clinical application.

TUPMO06 Designing a next generation beam wire scanner for the Large Hadron Collider

H Sullivan (European Organization for Nuclear Research), C Pasquino, F Roncarolo, H Bursali, J Emery, L Hanson, M Faure, M Hamani, N El-Kassem, R Veness, W Andreazza (European Organization for Nuclear Research); M Teresa Ramos Garcia (Universitat Politècnica de Catalunya)

Linear wire scanners are an essential instrument for beam profile measurements in the CERN accelerator complex. However, in the Large Hadron Collider, an aging design has led to performance issues in recent years. This study presents a next-generation wire scanner design that enhances reliability and measurement accuracy through advancements in motion technology. A key innovation is replacing vacuum bellows with a planar magnetically coupled linear drive system, paired with a ceramic linear guide inside the vacuum chamber capable of operating at high velocities. A test rig has been created to validate this novel motion design, which has demonstrated the effectiveness and long-term durability of the system. The next phase of the project will see a prototype instrument

installed in the LHC for impedance verification. The new technology developed in this study holds potential for a broad range of motion applications in ultra-high vacuum environments.

TUPMO07 Beam size measurement at SBL in SuperKEKB

H Ikeda (High Energy Accelerator Research Organization), G Mitsuka, H Fukuma, M Tobiyama, T Mitsuhashi (High Energy Accelerator Research Organization)

Sudden beam loss (SBL) is one of the obstacles to improving the luminosity of SuperKEKB. SBL cause damage to collimators and other accelerator components, QCS quench, and large background to the Belle II detector. It also causes beam abort and prevents the accumulation of high currents. Therefore, it is an important issue to investigate and resolve the causes of SBL events. In order to investigate the causes of SBL events, we measured the beam profile at the moment abort due to SBL using three different cameras and found that the beam size was larger than at the moment of abort due to other causes. This paper summarizes the results of the beam size measurements made as part of the investigation into the cause of the SBL.

TUPMO08 Progress on Gas-Sheet Beam Profile Monitor

I Yamada (Japan Atomic Energy Agency)

A non-invasive photon-detection beam profile monitor using a gas sheet, named the gas sheet monitor, has been developed. Our gas sheet is formed based on rarefied gas dynamics. To obtain a beam profile quantitatively, we have also devised a beam reconstruction method with a response function measurement method. These methods gave a 2-D beam profile of a high-intensity 3 MeV beam at the J-PARC RFQ test stand, which well agreed with a simulated 2-D profile by a particle-in-cell code and 1-D profiles measured by a wire-scanner monitor. As the next step, measurement of a 400 MeV hydrogen negative ion beam at the end section of the J-PARC Linac was challenged. Since a high-energy beam rarely interacts with a gas due to the small cross-section and induces an intense radiation noise, the captured image had a very low signal-to-noise ratio though the beam-induced signal was detected. Through some measurements, it was found that the primary noise was a radiation directly acting on a built-in multi-channel plate of an image intensifier. We will reports the details of these recent efforts on the gas sheet monitor.

TUPMO09 Exploiting Non Redundant Aperture Interferometry as a Diagnostics Tool for Synchrotron Light Characterization

L Torino (ALBA Synchrotron, B Nikolic (University of Cambridge); C Carilli (National Radio Astronomy Observatory); N Thyagarajan (Commonwealth Scientific and Industrial Research Organisation); U Iriso (ALBA Synchrotron (Spain)

We recently introduced a novel interferometric method inspired by radio astronomy, utilizing a Non-Redundant Aperture (NRA) mask with self-calibration to fully characterize the two dimensional transverse shape of electron beams from a single-shot interferogram. This paper reports the latest advancements in this technique, including a new data analysis approach based on closure amplitudes, which removes the need for self-calibration. We also demonstrate the method's applicability to wavefront sensing, and we explore its potential for resolving beam halos superimposed on well-defined Gaussian beam core.

TUPMO10 Passive Transverse Beam Profiler for Real-Time Monitoring for FLASH radiotherapy

M Patel (University of Liverpool), N Kumar, C Welsch (University of Liverpool; Cockcroft Institute)

Real-time beam monitoring is essential for enhancing the efficacy and reliability of radiotherapy. FLASH radiotherapy has shown a strong potential in improving treatment effectiveness by delivering doses at ultrahigh dose rates (>40 Gy/s). Beam monitoring at FLASH is challenging, as existing devices like Ionization chambers face saturation. We are developing an all-optical monitor for real-time transverse beam profile measurements in the treatment beam delivery zone. As the therapeutic beam must inherently traverse the ambient air path from the nozzle to the patient, the monitor passively captures beam-induced fluorescence along its trajectory without affecting the beam. This contribution present proof-of-concept measurements with 10.8–28 MeV protons at MC40 Cyclotron at University of Birmingham for 1 to 25 nA beam current, achieving a temporal resolution of up to 10 ms, and compared with beam size measurements with RCF. The fluorescence intensity exhibits a linear response to beam current, suggesting its potential for dose prediction after calibration. This work also discusses the challenges and potential for improvement for FLASH radiotherapy systems.

TUPMO11 Conceptual design of collision feedback system for the Super Tau-Charm Facility

Q Chen (University of Science and Technology of China), Q Luo (University of Science and Technology of China)

The Super Tau-Charm Facility (STCF) is a next-generation electron-positron collider designed to explore tau-charm physics within a center-of-mass energy range of 1 to 3.5

GeV. To achieve a peak luminosity exceeding 5 x 10^{34} $cm^{-2}s^{-1}$, STCF adopts advanced beam dynamics techniques, including large Piwinski angle collisions to mitigate the hourglass effect* and crab waist correction to suppress coupling resonances*. The beam size at the interaction point (IP) is compressed to sub-micron levels, making it highly sensitive to beam orbit deviations caused by ground motion and mechanical noise, which can significantly reduce luminosity*. To address this challenge, we analyze the primary sources of orbit perturbations and their impact on collision performance. A high-speed beam position monitoring and real-time correction feedback system is proposed. Simulation and experimental results demonstrate the system's feasibility and effectiveness. This study provides essential references for the design of precise beam stabilization systems at STCF and contributes to the development of IP orbit feedback technologies for future high-luminosity colliders.

TUPMO12 Transverse emittance measurements of electron beams from the superconducting RF gun at Helmholtz-Zentrum Dresden-Rossendorf for high-current operation

R Niemczyk (Helmholtz-Zentrum Dresden-Rossendorf), A Arnold, A Ryzhov, J Teichert, R Xiang (Helmholtz-Zentrum Dresden-Rossendorf)

High-brightness, megahertz-rate electron sources are a curial component of future light sources, including the Linac Coherent Light Source II High Energy project, the continuous wave (cw) operation mode of the European X-ray Free-Electron Laser, or the superconducting rf (SRF) photoinjector at SEALAB at Helmholtz-Zentrum Berlin. The Helmholtz-Zentrum Dresden-Rossendorf has employed an SRF gun as one of its cw electron sources for user operation at ELBE since 2010. The SRF gun is used to drive the superradiant THz source TELBE, typically at repetition rates of 50 kHz and bunch charges of 200 pC. To determine the operating envelope of the SRF gun injector, a slit-scan setup was installed in the diagnostics beamline after the SRF gun, enabling characterization of the vertical phase space. In this proceeding, we describe the slit-scan setup at the diagnostics beamline of the SRF gun. Measurements of the vertical emittance at bunch charges between 50 pC and 250 pC at beam energies of 3.5 MeV will be presented.

TUPMO13 Development of low density materials for beam intercepting instruments

R Veness (European Organization for Nuclear Research)

Materials with a minimal interaction with particle beams are widely used in accelerators in interceptive instruments

such as screens, secondary emission grids and wire scanners. Material damage limits are already exceeded in energy frontier and high brightness machines. A new generation of 'low density' materials with nano-structures are becoming available at scales of interest for use in beam instrumentation. Specifications are increasingly of use but still with fundamental issues that limit their application. This paper will demonstrate the potential for this class of materials for beam intercepting materials. It will outline the current limitations and ongoing research to overcome them both in the short and long-term.

TUPMO14 Novel hollow core optical fibre-based radiation sensing technique for medical applications and extreme environments.

R Larsen (European Organization for Nuclear Research), A Gerbershagen (University Medical Center Groningen); I Davidson (University of Southampton); I Ortega (European Organization for Nuclear Research)

As part of our search for radiation-hard techniques for beam profile monitoring, we have conducted a novel experiment using microstructured optical fibres, which are known for their extremely high radiation tolerance, filled with scintillation gases, which are also inherently radiation hard. We tested this new technique at the CLEAR accelerator at CERN, demonstrating its potential for beam diagnostics. It shows particular promise for FLASH therapy, where it could offer significant improvements in reliability and functionality compared to current instrumentation.

TUPMO15 Gas Sheet Beam Profile Monitor Test Performance at Crocker Nuclear Lab. Cyclotron

S Szustkowski (Los Alamos National Laboratory), D Hersey (Los Alamos National Laboratory); D Crawford, J Santucci (Fermi National Accelerator Laboratory); E Prebys, M Novotny, M Backfish (UC Davis)

A Gas Sheet Beam Profile Monitor (GSBPM) was designed and developed for the Integrable Optics Test Accelerator (IOTA) at Fermilab. IOTA will receive 2.5 MeV protons, with an average beam current of 8 mA. Before implementation at IOTA, the GSBPM performance was tested at the Crocker Nuclear Laboratory cyclotron at UC Davis, CA. The cyclotron proton energy produces at the range from 60-5.45 MeV at 0.1 uA. Measurements of the cyclotron transverse beam profile with a gas sheet were performed and analysed. The transverse beam profile is compared to the beam profile at the entrance of the GSBPM with radiochromic film.

TUPMO16 Upgraded beam profile monitoring using Chromox and fiber optic imaging for high-radiation environments

A Gottstein (University of Bern), E Kasanda, I Mateu, S Braccini (University of Bern)

We present an upgraded beam monitoring system designed for use in high-radiation environments where conventional imaging solutions rapidly degrade. In the presented device the radiation-sensitive P47 phosphor screen of the previous system* is replaced with a radiation-hard Chromox ceramic scintillator and relocates the CMOS camera outside the irradiation zone by transmitting the optical signal through a 20-meter radiation-tolerant fiber optic bundle. To enhance operational flexibility, a pneumatic actuator enables remote insertion and retraction of the scintillating screen into the beam path. The radiation hardness of the Chromox ceramic and the fiber bundle was evaluated, and the optical system's resolution and fidelity were characterized. The new setup demonstrated stable imaging performance under irradiation, addressing the frequent maintenance issues of the previous system. These improvements offer a robust and low-maintenance solution for beam profile monitoring in demanding accelerator environments.

TUPMO17 Phase contrast issues operating pinhole cameras with low-emittance beams

N Hubert (Synchrotron soleil), M Labat (Synchrotron soleil)

In the framework of SOLEIL-II, the project of SOLEIL's storage ring upgrade towards lower emittances, preliminary studies were performed to pinpoint the resolution limits of the exisiting pinhole cameras. However, while reducing the vertical emittance from the SOLEIL's nominal 50 pm.rad value to 8 pm.rad, unexpected filaments were observed in the image plane of the pinhole cameras, severely spoiling the reliability of the emittance measurement. Investigations, on the existing pinhole cameras as well as on the Metrology beamline of SOLEIL, revealed that those filaments correspond to a phase contrast imaging of the UHV Aluminium window, located before the pinhole. In this work, we first report on experimental measurements performed to identify the origin of this issue and on our attempts of mitigation using a phase blurrer. We then report on SRW simulations targetting the reproduction of these experimental results and further oriented to predict the impact of this effect on SOLEIL-II pinhole cameras configurations.

TUPMO18 Using Machine Learning to accurately predict the transverse beam profile at CLARA's Interaction Point

V Malconi (Science and Technology Facilities Council), A Pollard, J Jones, S Mathisen, T Overton (Science and Technology Facilities Council; Cockcroft Institute); R Ward (Lancaster University)

Non-destructive methods for measuring beam qualities like transverse beam profile are at times preferable for a range of reasons, including less down time and more reliability. These methods are, however, not always viable, for example for lack of space at the interaction point, where users typically place instrumentation needed for their experiment. In this paper we present a Machine Learning model to infer the electron beam transverse profile at the interaction point without the need for dedicated diagnostics. For this, we have generated large sets of training data and images using Elegant simulations and plan to test and extend the model using real beam images on CLARA. While focused on the transverse beam profile for now, a longer-term aim is to generalise the Machine Learning algorithm for other beam characteristics.

TUPMO19 Current status of developing pepper-pot emittance monitor for high-intensity ion beam

Y Kotaka (The University of Tokyo), H Matsuzaki, K Kamakura, Y Sakemi (The University of Tokyo); J Ohnishi (RIKEN Nishina Center)

At the Center for Nuclear Study, The University of Tokyo, the experiments to measure the Electric Dipole Moment (EDM) of Francium is in progress. Francium is produced via a nuclear fusion reaction by bombarding a gold target with an oxygen-18 ion beam, requiring a beam intensity of 18 eμA or higher. However, the current beamline's transport efficiency decreases to approximately 66 % when the beam intensity exceeds 10 eμA. To address this issue, we have developed a pepper-pot emittance monitor (PEM) optimized for high-intensity beams. The improvements include positioning the camera farther from the beamline to minimize radiation damage, achieving a distance of 4.1 m – double the previous setup – while maintaining an image position accuracy of 0.15 mm. Additionally, we conducted beam tests using two types of PEMs at the Micro Analysis Laboratory, Tandem Accelerator, University of Tokyo, and confirmed that the results from both devices were consistent with the estimated measurement accuracy. Furthermore, to prevent overheating of the PEM, a beam shutter system was implemented, enabling a measurement time of just 0.27 s.

TUPMO20 Evaluation of accuracy and resolution of the electron beam profile scanner at the Fermilab Main Injector

M Mwaniki (Illinois Institute of Technology), P Snopok (Illinois Institute of Technology); R Thurman-Keup, R Ainsworth (Fermi National Accelerator Laboratory)

The objective of this work is to assess the accuracy of measurements made by the Electron Beam Profile Scanner (EBPS), which captures the trajectory of an electron beam

with and without a proton beam present. The proton beam induces deflection in the electron beam, which is influenced by proton charges. For high-resolution images, the probe beam needs to be of high intensity, small diameter, and small divergence, evaluated using a YAG screen and an optical transition radiation (OTR) screen. Additionally, the point spread function (PSF) will be calculated to characterize the optical system's properties using ZEMAX software. The capabilities of the Hamamatsu Charge-Injection Device (CID) camera and Kimball Physics electron gun (e-gun) will be considered for accuracy.

TUPMO21 Pre-commissioning of the wide-dynamic range Halo Monitor to be installed in the Fermilab MI-8 Line

B Babacan (Fermi National Accelerator Laboratory), A Schreckenberger, R Ainsworth (Fermi National Accelerator Laboratory); C Ohmori, M Tejima, Y Sato (Japan Proton Accelerator Research Complex); M Uota, T Toyama, T Sasaki, T Mitsuhashi, Y Hashimoto (High Energy Accelerator Research Organization); P Snopok (Illinois Institute of Technology)

The beam halo can contribute to beam losses in accelerators and is very difficult to measure. With an increase in beam intensity following the PIP-II upgrade at Fermilab, the beam losses are expected to be higher with some coming from beam halo. Therefore, it is important to measure the sources of beam halo to minimize the beam losses. A modified Halo Monitor developed by J-PARC will be installed in Fermilab MI-8 transfer line to measure the beam halo. In this paper, an update on the beam profile monitor fabrication is covered. The updates include the location selection for the Halo Monitor in the MI-8 transfer line, shielding options for instrumentation, initial testing of equipment, and ray tracing simulations for the Offner optics and the targets used in the monitor.

TUPMO22 Low-Density Wires for Beam Halo Monitoring

G Aliana Cervera (European Organization for Nuclear Research), C Pasquino, R Veness (European Organization for Nuclear Research); A Lunt, D Mattia (University of Bath)

Beam Halo Monitoring (BHM) is essential for high-intensity accelerators like the HL-LHC. Carbon Nanotube (CNT) wires offer a promising alternative to traditional carbon fibre scanners due to their lower density, improved thermal properties, and reduced beam interaction. This work evaluates the performance of CNT wires in beam halo diagnostics, focusing on their energy and intensity range, durability, and operational feasibility. Preliminary results show that CNT wires provide better contrast and lower beam perturbation, with enhanced thermal stability under HL-LHC conditions. However, sudden temperature increases lead to significant shape deformation due to catalytic particles

sublimating. We discuss challenges in manufacturing, post-processing, and limitations related to wire diameter and density. While CNT wires show strong potential for next-generation scanners, further studies are needed to optimise long-term performance.

TUPMO23 IPM design and new ideas for HIAF

H Ming Xie (Institute of Modern Physics, Chinese Academy of Sciences),

As one of the most valuable noninvasive profile monitors in proton and heavy ion facilities, 6 Ionization Profile Monitors (IPM) have been installed in two synchrotrons of High Intensity heavy ion Accelerator Facility (HIAF). Among them, 5 IPMs are equipped with the Micro Channel Plates (MCPs), Phosphor screen (P46) and camera acquisition. The goal is to obtain the large envelop with good spatial resolution less than 0.1 mm, and also 1 IPM is designed with an anode and electronics acquisition for fast turn-by-turn profile measurements. We also have come up some new ideas for IPMs during HIAF IPM design, like using an optical IPM with a slit to successfully measure the emittance. And also, a compact structure of one IPM can measure both horizontal and vertical profiles have been verified practical by beam experiments. Besides, the bunch length measurement based on electrons from residual gas ionization is also promising, with a tapered high bandwidth MCP working as the current detector. In the end, a novel idea and structure seems possible that using static electric field scanning for 2D profile measurements, and also the RF deflector scanning for fast bunch length determination.

TUPMO24 PEPITES: an ultra-thin beam profiler with wide dynamic range for charged particle beams

M Verderi (Laboratoire Leprince-Ringuet), A FLACCO (Laboratoire d'Optique Appliquée); A Mereghetti, C Viviani, M Donetti, M Pullia (National Center for Oncological Hadrontherapy); A Esper, A Mahjoub, C Thiebaux, C Larran, F Gastaldi, L Bernardi, R Duhamel, R Guillaumat (Laboratoire Leprince-Ringuet); C Koumeir (Laboratoire de Physique Subatomique et des Technologies Associées); F Gebreyohannes, O Gevin (CEA Paris-Saclay)

PEPITES is an ultra-thin and wide dynamic range charged particle beam profiler. Its signal uses secondary electron emission, effective with only O(10 nm) of matter and highly linear with beam intensity. Thin film techniques are used for the sensitive area, enabling multiple monitor variants. Typical electrodes are membranes with 50 nm thick gold strips or fully metallized. Several systems will be presented. A first PEPITES profiler was installed at ARRONAX in May 2022 and is used routinely. It features a 10 µm Water Equivalent Thickness (WET) and two 32-strip 7x7 cm^2 planes to sample the beam along X and Y, each facing a

positively biased plain electrode to collect the electrons. A second monitor is under development with CNAO for therapeutic beams. Its lower, 5 µm WET, is motivated by the long 6.5 m patient-monitor distance and is obtained by replacing the anode plans by off-axis metallic bars. First results show that the resulting non-parallel collection field has minimal impact on profiles. Portable devices for profile or intensity measurement withstanding flash beams and viability of PEPITES for O(10 fs) laser-plasma beams, like at LOA, will also be discussed.

TUPMO25 Initial implementation of a new orbit feedback system using MicroTCA.4 for the PF user operations

R Takai (High Energy Accelerator Research Organization), H Sagehashi, M Shiozawa, M Tadano, T Obina (High Energy Accelerator Research Organization)

A new orbit feedback system has been introduced to the PF-ring, a synchrotron radiation source at KEK, starting from the third operation period of FY2024. The new system is built with state-of-the-art digital signal processing circuits based on the MicroTCA.4 standard. The stored beam's closed orbit distortion (COD) is measured at a 10 kHz rate using the circuits matched to the number of BPMs, and corrected to a designated reference orbit by feeding back the results of matrix calculations using the inverse response matrix to the currents of fast steering magnets. The transition from the legacy VME-based system, which had been in service for nearly 30 years, was carried out carefully and stepwise during the startup phase of the third operation period. The reference orbit was successfully transferred to the new system, and even in-vacuum undulators with a minimum gap of 4 mm were operated without requiring additional orbit corrections. In this presentation, we will describe the setup of the newly implemented system, the transition process from the old system, and plans for future improvements.

TUPMO26 Beam Energy Measurement with X-ray Scintillator Imaging in the 6-MeV Linac at SLRI

T Chanwattana (Synchrotron Light Research Institute), S Chunjarean, J Nadeedanklang, K Manasatitpong, N Yachum, S Kokkrathoke (Synchrotron Light Research Institute)

The Synchrotron Light Research Institute (SLRI) in Thailand aims to operate a 6-MeV electron linear accelerator for irradiation, supporting various agricultural and industrial applications. This study presents a method for measuring electron beam energy using the existing dipole magnet in the beamline, originally designed for scanning X-rays on samples through a scan horn. An aluminum sheet coated with terbium-doped gadolinium oxysulfide (Gd_2O_2S) was used as a scintillation screen for X-ray illumination and

placed downstream of the scan horn. X-ray scintillator images were captured with a CCD camera. By analyzing shifts in the X-ray image centroid as the dipole magnet current varied, we were able to determine the electron beam energy. The experimental setup, simulations, and measurement results are presented and discussed.

TUPMO27 Model-based Optimal Control Design for Slow Orbit Feedback at the Siam Photon Source

T Chanwattana (Synchrotron Light Research Institute), N Yachum, N Suradet, S Chunjarean, S Kokkrathoke, T Pulampong (Synchrotron Light Research Institute)

A model-based optimal control approach has been developed for the slow orbit feedback (SOFB) system to enhance orbit stability in the Siam Photon Source (SPS) storage ring. The control strategy utilizes a linear quadratic regulator (LQR) based on a multi-input, multi-output (MIMO) state-space model of the linear SPS storage ring, derived through system identification using MATLAB and SIMULINK. The necessary and sufficient conditions for controllability and boundedness of the dynamic system are established. Experimental simulations were conducted to assess the performance of the LQR controller in a practical SPS storage ring. The results demonstrate that the proposed control method effectively minimizes the quadratic cost function and error signals between setpoints and process variables for both horizontal and vertical orbit positions while ensuring system stability and robustness. The study also outlines the fundamental principles of optimal control theory, system identification, and future development directions.

TUPMO28 Overview of Beam Instrumentation at SPS-I Linac Injector

T Chanwattana (Synchrotron Light Research Institute), T S Chunjarean, C Dhammatong, N Juntong, T Pulampong, S Klinkhieo (Synchrotron Light Research Institute)

The Synchrotron Light Research Institute (SLRI) operates the SPS-I facility located in Nakhon Ratchasima, Thailand, which provides synchrotron light for various scientific and industrial applications. The linac injector, serving as the primary injector, is responsible for electron beam bunching and acceleration to 40 MeV, after which the beam is transported to the booster ring via the Low-Energy Beam Transport line (LBT). To ensure optimal beam quality and efficient transport, various beam instrumentation devices are installed along the linac injector and LBT for diagnostics and monitoring. This contribution presents an overview of the beam instrumentation used to measure beam current,

transverse profiles, and energy profiles, serving as a fundamental reference for future beam optimization and performance improvements of the SPS-I linac injector system.

TUPMO29 Upgrade of Screen Monitor System for SPS-I Linac Injector

T Chanwattana (Synchrotron Light Research Institute), P Boonpornprasert, N Juntong, S Bootiew, C Dhammatong, T Pulampong, S Klinkhieo (Synchrotron Light Research Institute)

Siam Photon Source I (SPS-I) is a 1.2-GeV synchrotron facility in Thailand, operated by the Synchrotron Light Research Institute (SLRI), providing synchrotron radiation for various applications to the user community. The SPS-I linac injector generates 40-MeV electron bunches, which are then transported to the booster synchrotron via the Low-Energy Beam Transport line (LBT). To ensure effective beam monitoring along the linac injector and LBT, key beam diagnostics - including beam current, transverse profile, and energy profile monitoring - have been installed in the linac injector. In order to maintain full diagnostic performance, the screen monitor system is planned to be upgraded to enhance transverse beam profile monitoring, improve radiation resistance, and support linac injector optimization for higher machine performance. This paper presents the current status of the screen monitor system for the SPS-I linac injector and discusses the design and implementation plan for its upgrade.

TUPMO30 A Closed-Loop Photon Beam Control Approach for the Siam Photon Source

T Chanwattana (Synchrotron Light Research Institute), N Suradet, S Chunjarean, T Pulampong (Synchrotron Light Research Institute)

This paper presents the enhancement of photon beam position stability at the Siam Photon Source (SPS) synchrotron through a real-time feedback control system incorporating a fault-tolerant control (FTC) algorithm. The system utilizes Photon Beam Position Monitor (pBPM) measurements within a global orbit feedback loop to minimize beam position fluctuations. The FTC algorithm plays a critical role in ensuring system reliability by detecting and compensating for disturbances, sensor errors, and actuator faults, maintaining stable beam conditions under varying operational scenarios. Experimental results demonstrate that the FTC-based feedback system significantly reduces photon orbit deviations, improving synchrotron radiation quality. By enhancing robustness and adaptability, the control system ensures precise beam positioning, making the SPS more reliable for scientific and industrial applications requiring high beam stability.

TUPMO31 Design of a Non-Invasive Laser-based Beam Profile Monitor System for the New Fermilab PIP-II Superconducting H- Linac

R Thurman-Keup (Fermi National Accelerator Laboratory), J Ruan, D Krokosz, J Thangaraj, T Price, T Johnson, A Saewert (Fermi National Accelerator Laboratory); P Landon (Boston University)

As part of the new Proton Improvement Plan (PIP-II), Fermilab is undertaking the development of a new 800 MeV, 2 mA H- superconducting RF linac to replace its present normal conducting 400 MeV linac. The PIP-II linac consists of a series of superconducting RF cryomodules from 2.1 MeV to 800 MeV. To limit the potential damage to the superconducting RF cavities, PIP-II will utilize non-invasive laser-based monitors (laserwires) to obtain beam profiles via photoionization. This paper will present the design of this PIP-II laserwire system including the picosecond pulsed laser, optical transport line, 13 individual laserwire stations, laser feedback and timing controls. The paper also describes the signal detection system and operation of the profile measurements.

TUPMO32 Wide range low cost digital RF phase shifter

K Zenker (Helmholtz-Zentrum Dresden-Rossendorf), A Ernesto Rivera Osorio (TU Dresden); M Kuntzsch, R Steinbrück, U Lehnert (Helmholtz-Zentrum Dresden-Rossendorf)

Shifting RF phases is a common task in particular at particle accelerators. Which RF frequencies need to be shifted is highly facility dependent, which demands a wide range phase shifter. The phase shifter presented in this contribution consists of a custom board, that includes a high-performance quadrature modulator, voltage regulators and an 16-bit digital-to-analogue converter that offers an I2C interface. The quadrature modulator is specified to work in the frequency range between 50 MHz and a 6 GHz. The board is combined with commercial off-the-shelf products to provide a software interface and a RF tight compact housing. We present amplitude and phase noise measurements and amplitude stability measurements. At the ELBE Center for High-Power Radiation Sources we use the phase shifter to shift the phase of the superconducting RF gun laser with respect to the accelerator cavity RF field. This allows to implement a feedback loop that stabilizes the THz output power of the THz undulator source at ELBE. In order to achieve this, the beam position is monitored in an energy dispersive beam line section and the gun laser phase is used to keep it constant.

TUPMO33 Beam Stability with Ground Vibration Measurements at the Korea-4GSR

H Jin (Korea Basic Science Institute), G Hong, G Jang, J Kim, J Lee (Pohang Accelerator Laboratory); S Shin, Y Kim, Y Sohn (Korea Basic Science Institute)

The Korea-4GSR (4th Generation Synchrotron Radiation Source) is under construction since 2021 to be a state-of-the-art research facility requiring exceptional stability for its electron beam to ensure high-quality experimental data. Ground vibrations originating from both natural and artificial sources can significantly impact the stability of critical components, particularly the accelerator and beamline elements. To assess the potential influence of these vibrations, we conducted comprehensive ground vibration measurements at the Korea-4GSR construction site. This study was performed with the sensitive accelerometer at various locations across the construction site to characterize the amplitude and frequency content of the ambient vibrations. The collected data were analyzed to evaluate the potential impact on the beam stability, considering the vibration tolerance levels of key accelerator components. This paper presents the preliminary findings of our ground vibration measurements, discussing the observed vibration characteristics and their implications for maintaining the high level of beam stability required for the successful operation of the Korea-4GSR.

TUPMO34 Development of White Beam Profile Monitor for Korea-4GSR

W Song (Pohang University of Science and Technology), G Hahn, H Hyun, S Kim, S Lee, S Hwang, Y PARK (Pohang Accelerator Laboratory); M Chung (Pohang University of Science and Technology)

Accurate measurement of photon beam position and profile is crucial for beamline users to achieve precise alignment and efficient utilization of the desired photon beam. In low-emittance storage rings, however, the power density of the photon beam has increased, making it challenging for conventional profile monitors such as wire scanners and scintillating screens to withstand the high power without damage. Here, we present the development of an Ionization Profile Monitor (IPM) capable of robustly measuring the photon beam position and enabling non-destructive beam profile measurement. A noble gas environment was designed to ensure sufficient ionization signal strength, and a defocusing electrode structure was introduced to fully utilize the relatively large active area of the readout system. Since the magnification induced by the defocusing field depends on the vertical position, we proposed a calibration method to correct for the resulting non-linearity. Finally, we present the results from prototype testing, including the measured position accuracy and the point spread function analysis.

TUPMO35 Evaluation of a 4D phase-space mapping using two orthogonal slits

B Zhang (Institute of High Energy Physics), *et al.*

To enhance the performance of next-generation X-ray Free Electron Lasers (XFELs), it is crucial to produce high-quality electron beams with low emittance, particularly for attaining emittances below 0.2 mm.mrad for 100 pC bunch charges. This study introduces an emittance measurement method using an orthogonal dual-slit technique, aimed at enhancing measurement efficiency and achieving the necessary measurement accuracy for such small emittances. An emittance meter based on this method has been designed for a C-band photocathode RF gun at the CSNS campus. Finally, we present numerical simulations to optimize the primary parameters of the emittance meter, focusing on beam drift distance, combined with the motion accuracy of the stepper motor and the expected resolution of the optical observation system to ensure the accuracy of the emittance measurement.

TUPMO36 Design considerations of the bunch-by-bunch transverse feedback system for the CSNS RCS

B Zhang (Institute of High Energy Physics), *et al.*

The CSNS RCS (Rapid Cycling Synchrotron) is a proton accelerator designed to achieve a target beam energy of 1.6 GeV, with a typical operating intensity of 140 kW, which is expected to increase to 500 kW after the CSNS II upgrade. However, a significant current instability has been observed during the 100 kW beam operation. To mitigate this instability, techniques such as operational tuning and chrominance modulation were previously used to make the 100 kW beam operate stably. In order to face the subsequent stronger instability, a bunch-by-bunch transverse feedback system is required to mitigate the coherent lateral oscillations caused by instability and injection errors. In this paper, the preliminary design of the feedback system will be presented.

TUPMO37 Development of an optical simulation toolkit for transverse beam profile characterization

Y Leng (University of Science and Technology of China), *et al.*

The increasing demands for high-resolution beam diagnostics necessitate advanced simulation tools capable of modeling complex wave-optics phenomena. We present an optical simulation toolkit based on the angular spectrum propagation method, validated through comparisons with SRW. For synchrotron radiation interferometer simulations, the toolkit demonstrates excellent agreement with SRW results, showing 97.3% similarity in fringe patterns based

on perceptual hashing analysis. The toolkit's unique capabilities are further demonstrated through three key applications: modeling complex mask instead of double-slit interferometers, simulating X-ray pinhole camera with more precise pinhole structure, and analyzing the impact of thermal-induced wavefront distortions on beam profile characterization. HALF's X-ray pinhole camera and interferometry-based dimension measurement subsystem require this toolkit for optimized design. Through its physics-based modeling and wave-optics simulation capabilities, the simulation toolkit provides support for both optimized hardware design and methodology research to enhance the accuracy of beam profile characterization.

TUPMO38 Model Enhanced IPM Based Emittance Measurements at the BNL Alternating Gradient Synchrotron

C Hall (RadiaSoft), G Hoffstaetter (Cornell University); J Edelen (RadiaSoft) (United States); K Brown, V Schoefer (Brookhaven National Laboratory)

The Alternating Gradient Synchrotron (AGS) at Brookhaven National Lab is equipped with two types of Ionization Profile Monitors (IPMs): ion-collecting and electron-collecting. Ion-collecting IPMs are susceptible to significant distortions in the measured beam size due to the space charge of the passing beam. Conversely, electron-collecting IPMs are much less affected but can only be operated periodically to preserve sensor lifespan. In this work, WarpX simulations of IPM operation are used to characterize the measured beam size as a function of circulating beam parameters and IPM operating conditions. We then study the efficacy of integrating machine learning models into the beam size prediction algorithm to generate a better emittance measurement. We consider both supervised and unsupervised approaches. The former utilizes simulations to back out the contribution of space-charge when the ions drift from their point of origin to the collection rods. The latter case uses machine learning for noise reduction to get a better fit of the beam size data.

TUPMO39 Nanostructured targets for advanced beam diagnostics

M Siano (Università degli Studi di Milano), A Nosych, E Solano, L Torino, U Iriso (ALBA Synchrotron (Spain); B Paroli, C Piazzoni, M Potenza (University of Milan); D Butti, F Roncarolo, G Trad, S Mazzoni, T Lefevre (European Organization for Nuclear Research)

Transverse beam diagnostics with standard imaging techniques represent a challenge for next-generation accelerators and colliders due to the extremely small beam sizes, and X-ray interferometry offers an interesting

method to overcome this challenge. In this regard, the X-ray Heterodyne Near Field Speckles (X-HNFS) technique has successfully been used to resolve few-micrometer beam sizes and at the same time attain a full 2D beam reconstruction. The method relies on diffracting the emitted X-ray radiation off a water suspension of spherical nanoparticles, which however pose several limitations for the full exploitation of the technique during normal operations. In this contribution we report on recent advances in the development of solid targets based on nanostructured materials with characteristics compatible with accelerator requirements. We present preliminary numerical and experimental results on the target design, prototyping and testing. Emphasis is given to the application as a transverse beam size monitor in the framework of the Feasibility Study of the Future Circular Collider (FCC) at CERN.

TUPMO40 OTR beam profile monitor for online measurements

C Sun (Lawrence Berkeley National Laboratory), *et al.*

Optical Transition Radiation (OTR) is a widely used diagnostic technique in accelerator particle beam applications, providing high-resolution beam profile measurements. This work focuses on the development and implementation of OTR-based beam profile monitors for the transfer lines at the Advanced Light Source (ALS) and its upgrade (ALS-U), with the goal of enabling real-time, online beam characterization. We present key design considerations for the OTR screens, including material selection, optical properties, and mechanical integration. Furthermore, we discuss experimental results from OTR monitor tests conducted at ALS, evaluating their performance in terms of spatial resolution, signal-to-noise ratio, and capability for online measurements. These advancements are expected to enhance beam diagnostics and facilitate improved beam quality control at ALS/ALS-U.

TUPMO41 Preminary data analysis of the CSNS RCS IPM prototype

R Yang (Institute of High Energy Physics), M Abdul Rehman (Institute of High Energy Physics)

In the China Spallation Neutron Source (CSNS), an Ion Profile Monitor (IPM) was installed in the Rapid Cycling Synchrotron (RCS) to address challenges in measuring strong-current beam profiles and enable real-time monitoring. This study focuses on the preliminary analysis of IPM data signals, aiming to accurately extract critical beam information from the signals. Residual gas components in the vacuum chamber were identified through peak spacing calculations. Real-time beam profiles (0–20 ms, low power) were obtained, revealing the beam center and temporal evolution of rms beam size. Fast Fourier Transform (FFT) of

signal peaks uncovered dynamic changes in the synchrotron tune. Single- and multi-Gaussian fitting methods were used to analyze MCP-collected charge over time and determine MCP saturation time point. The results demonstrate that IPM data analysis effectively extracts beam information, supporting real-time monitoring and optimization of CSNS RCS beam stability and quality.

TUPMO42 Results from the new titanium wired harp at the Spallation Neutron Source*

W Blokland (Oak Ridge National Laboratory), A Aleksandro, W Willis (Oak Ridge National Laboratory)

A new harp has been installed in the Ring To Target Beam line (RTBT) section of Spallation Neutron Source. The Harp is made of two planes with 30 titanium 50 micron wide wires each plane. The narrow, low-Z wires versus the 100 micron tungsten wires of the original harp, are to minimize the beam scattering. This harp will be both a backup and a complement to the existing harp further downstream. The newly created data-acquisition system is also suitable to replace the existing's harp data-acquisition system, now over 20 years old. We show the use a of cRIO platform as a cost-effective way to process many channels and sample the beam profile at the full 60 Hz beam repetition rate. We also describe the performance of the titanium wires. A passive analog board is used to lengthen the signals to allow sampling at <= 10 kS/s/ch. The data is acquired by the FPGA, passed on to the real-time OS, LabVIEW RT, and through the SNS EPICS Channel Access server presented to the control room.

TUPMO43 Time-resolved measurements of transverse beam excitation in an electron storage ring

M Noll (Karlsruhe Institute of Technology), E Huttel, E Bründermann, J Steinmann, M Caselle (Karlsruhe Institute of Technology)

In the Karlsruhe Research Accelerator (KARA), electron beams of up to 200 mA are stored with an energy of 2.5 GeV, while injection is performed at 500 MeV. At the injection energy, the beam life time and the injection efficiency depend largely on Touschek scattering. As a counter-measure, the beam size can be enlarged transversally by an excitiing modulation, e.g. applied via a strip-line. Here, we examine different excitation strategies and their effects on beam size and the beam orbit. The ultra-fast line camera KALYPSO is used to measure the transverse beam profile via the emitted synchrotron radiation on a turn-by-turn basis.

WEA: Tutorial and Oral Presentation

09:00 **Stable Orbits, Brighter Beams: Understanding and Controlling Orbit Stability in 4th Generation Synchrotron Light Sources**

WEAT01

S Hussain Mirza (Deutsches Elektronen-Synchrotron DESY)

The advent of 4th generation synchrotron light sources has placed unprecedented demands on beam stability, requiring sub-micron orbit control to fully exploit their ultra-low emittance and high-brightness capabilities. This tutorial explores orbit stability, covering sources of perturbations like magnet misalignments, ground vibrations, and power supply fluctuations, as well as correction algorithms used to mitigate their effects. One focus of the tutorial will be on advances in simulations, which have played a crucial role in optimizing the design and performance of subsystems as well global mode space analysis. Various correction techniques, including slow and fast orbit feedback systems, beam-based girder alignment, and the integration of XBPMs into the electron beam control system, will also be discussed to improve long-term beam stability and performance. Real-world examples from leading 4th-generation facilities will highlight how advanced orbit control strategies and cutting-edge hardware have enabled the achievement of remarkable orbit correction bandwidths, significantly enhancing electron beam stability

10:00 **Analysis of a phase modulated interferometric Electro-Optic BPM at the CERN SPS**

WEAC01

M Bosman (Royal Holloway University of London)

The Electro-Optic Beam Position Monitor (EO-BPM) is a new diagnostic tool being developed to enhance the intra-bunch transverse beam position monitoring in the High Luminosity LHC at CERN. This EO-BPM has been installed in the Super Proton Synchrotron (SPS) since 2024. The Pockels effect in lithium niobate crystals is exploited to detect the propagating electric field from passing proton bunches, enabling measurement of beam position and intra-bunch instabilities. Light is conveyed from a remote laser via optical fibres to a Mach-Zehnder interferometer formed between two waveguide pick-ups. The rapid response of the EO-BPM enables intra-bunch turn-by-turn measurements. Data recorded over a range of beam conditions have been studied to characterise its performance, stability, and sensitivity. This paper presents the latest data collected from the SPS and discusses the analysis and future development of the EO-BPM.

WEB: Oral Presentation

10:50 Simultaneous measurements with fast beam size and position monitors disentangle the sudden beam loss evolution mechanism

WEBI01 G Mitsuka (High Energy Accelerator Research Organization)

At the SuperKEKB electron-positron collider, which aims to achieve the world's highest luminosity, "Sudden Beam Loss events (SBL)" have prevented its stable operation, in which several tens of percent of the beam current is lost and aborted within several turns (20-50 μs). Elucidating SBLs, which can cause extensive damage to accelerator components and the Belle II experiment detectors, is a pressing issue for SuperKEKB. To measure the beam size and position variation, key information for disentangling SBLs, over dozens of turns just before the SBL-induced beam aborts, we have developed new turn-by-turn beam size monitors in two different wavelength regions, X-ray and visible light, and bunch-by-bunch beam position monitors where one has utilized a novel architecture AMD/Xilinx RFSoC. Simultaneous measurements of turn-by-turn beam size and bunch-by-bunch beam position enable elucidation of the cause and time evolution mechanism of the SBL events. In this presentation, we will first introduce recently developed fast beam size and beam position monitors, then show their simultaneous measurements of SBL events. Finally, we will discuss the possible causes and time evolution mechanisms of the SBL events.

11:20 BLM signal thresholds for ion operation during the LHC Run 3

WEBC01 S Morales Vigo (European Organization for Nuclear Research)

In 2024, the Large Hadron Collider (LHC) delivered Pb-Pb ion collisions at a beam energy of 6.8 Z TeV with a stored beam energy of more than 20 MJ. In order to clean beam halo particles and avoid quenching the LHC superconducting magnets, the novel crystal collimation method employing 4 mm-long crystals was introduced for ion operation in the LHC Run 3. The LHC Beam Loss Monitoring (BLM) system triggers the beam dump in case the measured losses are above certain predetermined thresholds. Important adjustments were needed in order to optimize these thresholds in accordance with the peculiar loss pattern produced by crystal collimation. This contribution explains the newly observed beam loss patterns during Pb ion operation with crystal collimation in place, as well as the study that was carried out to update the BLM thresholds for Pb ion operation in the LHC Run 3.

11:40 **Lessons learned in commissioning the new beam-loss monitors for the superconducting upgrade to LCLS**

WEBC02 **A Fisher (SLAC National Accelerator Laboratory)**

The superconducting upgrade to the LCLS x-ray free-electron laser at SLAC is now in commissioning, as we gradually raise the repetition rate of the 4-GeV beam toward 1 MHz and the beam power toward 120 kW. A further upgrade next year will double the energy and power. Machine protection at this extremely high power required a novel system of fast beam-loss monitors (BLMs). Points of concern, such as collimators or kickers, are covered by diamond detectors (PBLMs). Long optical fibres (LBLMs) of up to 200 m span the entire 4-km facility, generating and capturing Cherenkov emission from beam-loss showers. Previous papers have reported on the design and early commissioning of this safety system, and on plans to use the loss signals for wire scanners and loss localisation. Subsequent experience in commissioning and operating the full system has demonstrated that the concept is sound and sensitive, but several aspects of the implementation have proven troublesome. Extensive testing and debugging uncovered issues with both hardware and firmware. We will detail these problems, their remedies, and the improvements in performance.

WEC: Oral Presentation

13:00 Machine Learning-based beam sculpting and measurement using a multileaf collimator and emittance exchange

WECI01 N Majernik (SLAC National Accelerator Laboratory)

This paper presents a novel, rapidly reconfigurable multileaf collimator (MLC) for high-fidelity beam shaping. The MLC, compatible with ultra-high vacuum, features independently actuated leaves to tailor mask profiles. Coupled with an emittance-exchange (EEX) beamline at the Argonne Wakefield Accelerator, transverse profiles are transformed into custom longitudinal distributions, including ramped beams. We demonstrate various measurements of tailored beam profiles, both transverse and longitudinal. A new, rotor-based design increases flexibility, and a feed-forward control algorithm enables on-demand shaping. Machine learning optimizes MLC degrees of freedom for applications like FEL gain or wakefield accelerator performance, and adapts beam parameters in real-time to changing accelerator conditions. This versatile beam sculpting instrument has broad relevance for next-generation accelerators across FEL, AAC, and hadron-beam communities.

13:30 Experimental demonstration of a single-shot, nondestructive electron beam diagnostic based on the ionization of a low-density pulsed gas jet

WECI02 P Denham (Particle Beam Physics Lab)

7 MeV electron bunches from a radiofrequency photoinjector, carrying up to 100 pC of charge, traversed a localized distribution of nitrogen gas (N2). The interaction of the electron bunches with the N2 gas generated a correlated signature in the ionized particle distribution, which was spatially magnified using a series of electrostatic lenses and recorded with a microchannel-plate detector. Various modalities, including point-to-point imaging and velocity mapping, are investigated. A temporal trace of the detector current enabled the identification of single- and double-ionization events. The characteristics of the ionization distribution, dependence on gas density, total bunch charge, and other parameters, are described. Approaches to scaling to higher electron bunch density and energy are suggested. Additionally, the instrument proves useful for comprehensive studies of the ionization process itself.

14:00 Minimally Invasive Nano-Fabricated Wire Scanner for FEL Operations

WECC01 **F Addesa (Paul Scherrer Institute)**

At the Paul Scherrer Institute (PSI), a minimally invasive wire scanner with sub-micrometer spatial resolution has been developed with a twofold objective: enabling real-time monitoring of the SwissFEL (Free Electron Laser) electron beam transverse size during lasing operation while also paving the way for a new generation of customizable wire scanners. These scanners are designed to be suitable for low and ultra-low emittance beams highly demanded by FEL developments and advanced acceleration concepts. Building on previous experience, nanotechnology has been further explored, utilizing photolithography to fabricate low-stress silicon nitride (Si_3N_4) wires suspended on a C-shaped silicon fork. Each fork hosts two perpendicular wires, allowing for the reconstruction of the beam profile in both the x and y directions. The wires are 2,4 and 6 µm wide and only 200 nm thick, and their length is tailored to match the SwissFEL beam clearance. Several prototypes have been successfully produced and installed at SwissFEL. This work presents the wire scanner's design and fabrication process, along with initial beam measurements at SwissFEL under lasing operations at 10 pC.

WED: Oral Presentation

14:50 Summary of the workshop on BPMs buttons for synchrotron light sources

WEDI01 **L Torino (ALBA-CELLS Synchrotron)**

In the context of building the next generation of synchrotron light sources, significant effort has been directed towards developing BPM buttons. The design of these components needs to consider several factors related to the miniaturization of the beam pipe and the broadening of the beam spectrum, while still guaranteeing high resolution for commissioning and feedback purposes. A workshop was held in December 2024 at ALBA light source organized in collaboration with DESY, aiming to bring together experts from various light sources to share their experiences on the different stages of the deployment process, from simulation to manufacturing and characterization. This presentation reviews the key topics presented at the workshop.

15:20 Design, characterization, and validation of a pulsed RF burst source for In-situ beam position monitor calibration

WEDC01 **M McCallum (RHUL)**, *et al.*

Beam Position Monitors are the essential diagnostics tools in any accelerator facility. They enable precise beam orbit measurements with nanometer-level resolution which are crucial for the operation of modern linac-based Free Electron Lasers and future linear colliders. In this work we present the development and implementation of a pulsed RF burst source synchronized with accelerator timing for BPM calibration. This source was installed and characterized at the ATF2 facility in KEK, Japan. The system injects tailored RF pulses into the BPM cavity via one of the two output ports present for each axis. With the capability to adjust frequency and pulse width, to emulate beam pulses, the system demonstrated nearly complete cancellation of beam-generated signals when the injected RF pulse overlapped with the beam pulse. This source has the potential for in-situ BPM calibration without relying on motion systems or “dog-leg” orbit bumps. Beyond calibration, it provides a method to mitigate static signal contributions caused by cavity misalignments and shows potential for compensating wakefield effects, offering a versatile tool for improving beam diagnostics and accelerator performance.

15:40

Sub-2 µm Silicon Carbide Membranes for In-Line X-ray Beam Monitoring Across Soft to Hard Energy Ranges

WEDC02

G Trovato (University of Catania), *et al.*

Conventional X-ray beam monitors, such as gold meshes and conductive diamond films, often suffer from significant drawbacks, as diffraction effects, non-uniform transparency, low signal levels, and poor spatial resolution, particularly when applied to soft and tender X-ray beams. To address these limitations, we explore the use of ultra-thin (<2 µm) free-standing Silicon Carbide (SiC), developed by SenSiC GmbH, membranes as in-line, minimally invasive beam position monitors. These devices offer high lateral resolution and minimal beam perturbation, making them particularly suitable for synchrotron radiation applications. Preliminary beam tests were conducted at the NanoMAX beamline (MAX IV) using highly focused (<1 µm FWHM) soft X-ray beams. SiC devices with 4-quadrant layouts demonstrated clear beam detection capability, though limitations emerged at the quadrant interfaces due to charge collection losses and charge multiplication under high electric fields. These effects were further investigated using Sentaurus TCAD simulations, which highlighted the potential for optimized sensor geometries to mitigate such issues. Results from a related SiC membrane intensity monitor, tested at the PTB four-crystal monochromator beamline at BESSY II demonstrated compatibility with tender and hard X-rays. This device features a 3 mm diameter membrane consisting of a 0.3 µm p^+ layer, 1.5 µm n^- active region, and a 370 µm n^+ substrate, with Al contacts. Transmission tests in the 1.75 - 10 keV range confirmed excellent transparency (up to 97.55%) and uniform photocurrent response under 8 keV raster scans. The measured photocurrent at zero bias was 0.586 nA with 86% charge collection efficiency. Together, these results highlight the promising role of sub-2 µm SiC membranes for high-precision, in-line monitoring of X-ray beams across a wide spectral range, with ongoing developments targeting even thinner devices for optimized performance in soft X-ray applications.

WEPCO: Poster Presentations

WEPCO01 Single-shot electron bunch profile monitor based on coherent transition radiation imaging

A Maria Guisao Betancur (University of Liverpool), J Wolfenden, C Welsch (University of Liverpool); E Mansten, S Thorin, J Lundquist, O Grimm (MAX IV Laboratory)

The development of longitudinal diagnostics for short-pulse electron accelerators is challenging but necessary to provide high-brightness electron bunches. This is equally true for novel plasma accelerators as for free electron lasers. The gold standard for such measurements is a transverse deflecting cavity (TDC), but these are typically invasive, are costly to produce and operate, and have resolution limited to around 10 fs. To this end, a THz-based reflective imaging system has been designed and installed at the MAX IV Short Pulse Facility (SPF) for imaging Coherent Transition Radiation (CTR). This contribution presents the initial results of applying transfer learning to deep learning models, such as convolutional neural networks, for evaluating the reconstruction of bunch profiles from experimentally acquired CTR images, building on previous successes in profile prediction using simulated data. The reconstruction of the longitudinal profile can be achieved using single CTR images and benchmarked against a TDC. Practical resolution limits and the next steps in the development of this monitor are also discussed.

WEPCO02 Study of XBPM Diagnostic Parameters in the TPS Frontend

C Cheng (National Synchrotron Radiation Research Center), B Chen, C Chan, C Shueh, Y Yang, Y Tsun Cheng, Y Hsiao (National Synchrotron Radiation Research Center)

The XBPM installed in the TPS frontend determines the center position of the photon beam using four CVD diamond blades. The combination of XBPM and upstream/downstream EBPM readings of the insertion device enables verification of the photon beam's alignment along the correct trajectory. Significant changes in the beam position or profile, as well as prolonged periods without recalibration, may cause the XBPM measurement data to lose its reliability. Therefore, evaluating the reliability of the XBPM measurement data is of critical importance. By analyzing the deviation between the theoretical and measured blade intensities and calculating the standard deviation of the similarity percentage among the four blades, a reliability indicator is established. The variation of this indicator is analyzed under different conditions and compared with the corresponding Q values.

WEPCO03 Results of HESR BPM Testing

C Boehme (Forschungszentrum Jülich), V Kamerdzhiev, A Halama, G Koch (GSI Helmholtz Centre for Heavy Ion Research)

For the HESR diagonally cut BPMs were designed, with 64 manufactured and tested with a purpose-built BPM test-stand. This test-stand had to host BPMs of various lengths, the overall length of the complete vacuum system varies from 450 mm to 1585 mm. For all BPMs several properties, e.g. the geometric factors or the electrical center in relation to the geometric center, were measured utilizing the test stand. The results of these measurements will be presented together with the challenges resulting from the design choices made for the layout of the test stand.

WEPCO04 Bunch Shape Measurements at the Los Alamos Neutron Science Center

M Kay (Los Alamos National Laboratory), C Taylor (Los Alamos National Laboratory)

A Feshenko-style Bunch Shape Monitor (BSM) is used to measure longitudinal profiles of the H+ and H- beams at the Los Alamos Neutron Science Center. We present the results of a study done to characterize how the longitudinal profile of each species if affected by different parameters of the RF bunchers and linac modules upstream of the BSM. Features of the longitudinal profiles are elucidated using the High-Performance Simulator (HPSim) code.

WEPCO05 Design of spectrometer energy measurement setups for the future EuPRAXIA@SPARC_LAB and SSRIP linacs

D Quartullo (Istituto Nazionale di Fisica Nucleare), A Cianchi, A Vannozzi, A Ghigo, A Stella, A Giribono, C Vaccarezza, D Alesini, F Demurtas, G Franzini, L Faillace, R Pompili (Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati)

EuPRAXIA@SPARC_LAB is a FEL user-facility currently under construction at INFN-LNF in the framework of the EuPRAXIA collaboration. The electron beam will be accelerated to 1 GeV by an X-band linac followed by a plasma wakefield acceleration stage. This high-brightness linac requires diagnostic devices able to measure the beam parameters with high accuracy and resolution. To monitor the beam energy and its spread, magnetic dipoles and quadrupoles will be installed along the linac, in combination with scintillating screens and CCD cameras. Macroparticle beam dynamics simulations have been performed to determine the energy measurement setup which provides the best compromise in terms of accuracy and resolution. Similar diagnostics evaluations were carried

out for the spectrometer installed at the 100 MeV RF linac of the radioactive beam facility SSRIP, located at IFIN-HH (Romania) and whose commissioning phase is foreseen for 2026. Optics measurements have been performed to characterize the resolution and field of view of the optics system foreseen to be used for beam energy monitoring at EuPRAXIA@SPARC_LAB and SSRIP.

WEPCO06 Performance Analysis of the RF Analog Frontend for Diamond–II Electron Beam Position Monitors

H Malik (Diamond Light Source), L Bobb (Diamond Light Source)

Diamond-II is a major upgrade to the current synchrotron facility, Diamond Light Source. The low emittance electron beam requires more stable, low drift beam position monitor electronics which are also essential for the Fast Orbit Feedback system. This paper presents measured and simulated results of the analog frontend for the electron beam position monitors. This work aims to deliver an analog frontend with stable gain and high linearity that meets the dynamic range and noise figure requirements effectively to capture beam positions for single and multi-bunch operation. Performance evaluations have been conducted using the SystemVue simulation suite alongside experimental measurements.

WEPCO07 Fast beam-based alignment of BPMs and quadrupole magnets for SPring-8-II

H Maesaka (RIKEN SPring-8 Center), H Dewa, M Masaki, S Takano (Japan Synchrotron Radiation Research Institute)

In modern low-emittance electron storage rings, precise beam orbit control is crucial to ensure the beam passes through the magnetic center of each high-gradient multipole magnet, with an accuracy of 10 μm or even better. Accurate alignment of a BPM with the center of the neighboring magnet is imperative, a critical requirement for SPring-8-II. With a total of 340 BPMs, efficient beam commissioning of SPring-8-II necessitates a fast beam-based alignment (BBA) method. To assess the feasibility of this method, we conducted a fast BBA experiment at the current SPring-8 storage ring utilizing new BPM readout electronics based on MicroTCA.4, enabling a data acquisition rate at 10 kHz. We varied the strength of a quadrupole magnet adjacent to a BPM head connected to the new fast readout. We scanned the electron beam across the quadrupole center by adjusting a steering dipole magnet. The BPM offset from the quadrupole center was then determined by analyzing data from all BPMs connected to the fast readout. This contribution will detail the proposed fast BBA procedure for SPring-8-II and present the results obtained from the feasibility test at the existing SPring-8 storage ring.

WEPCO08 ChDR bunch length monitor improvements at CERN

J McGunigal (University of Manchester), C Davut, G Xia (University of Manchester; Cockcroft Institute); P Karataev (Royal Holloway University of London; John Adams Institute for Accelerator Science); S Mazzoni, T Lefevre (European Organization for Nuclear Research)

The goal of the Advanced Wakefield Experiment (AWAKE) is to accelerate externally injected electrons using a plasma wakefield driven by a 400 GeV proton bunch. To achieve this, the electron bunches must have a short bunch length of 200 fs, making the implementation of a real-time, non-invasive bunch length monitor essential. This monitor uses alumina dielectric prisms inserted into the vacuum chamber to generate Cherenkov Diffraction Radiation (ChDR) as the beam passes nearby. The ChDR is detected using Schottky diodes sensitive to frequencies in the coherent regime. In this paper, we will present theoretical bunch length calculations based on the polarization current approach (PCA) to determine the appropriate frequency ranges for the Schottky diodes, along with CST simulation studies of the monitor's design in preparation for upcoming experiments.

WEPCO09 Bunch by bunch measurement by oscilloscope

J He (Institute of High Energy Physics), Y Sui (Institute of High Energy Physics)

By directly sampling the BPM signals with a high sampling rate oscilloscope, the bunch-by-bunch position and phase were calculated. With the help of injection trigger signal, oscilloscope was utilized to capture the injection process. The energy mismatch of the injection transient process and the residual oscillation of the injection bunch were studied. The longitudinal tune and oscillation amplitudes can be inferred. The bunch-by-bunch transverse position and longitudinal phase were analyzed by principal component analysis (PCA). The method also can be used to study the instability of the coupled bunches.

WEPCO10 Button BPM Development and Prototyping for ALBA II

L Torino (ALBA Synchrotron, O Traver Ramos, U Iriso (ALBA Synchrotron (Spain)

As part of the ongoing ALBA II upgrade, which aims to significantly enhance the performance of the ALBA Synchrotron Light Source, a new design for button Beam Position Monitors (BPMs) is under investigation. In this contribution, we present the results of a characterization study conducted on button prototypes supplied by two different manufacturers. Furthermore, we introduce the preliminary design of an alternative button BPM intended for direct welding to the copper vacuum chamber of the upgraded machine.

WEPCO11 Beam Diagnostic for the DALI accelerator

M Kuntzsch (Helmholtz-Zentrum Dresden-Rossendorf), A Penirschke, B Scheible, R Yadav (Technische Hochschule Mittelhessen); K Zenker, U Lehnert (Helmholtz-Zentrum Dresden-Rossendorf)

DALI is an envisioned suite of advanced accelerator-based THz sources that are continuously tunable over the frequency range from 0.1 THz to 30 THz. The THz sources will provide radiation with high pulse energy (up to 100 µJ – 1 mJ) at a high but flexible repetition rate up to 1 MHz. An MeV ultra-fast electron diffraction (UED) source will complement this facility. The contribution will illustrate the machine design as well as discuss the foreseen diagnostic systems used for every machine part. Bunch position, arrival time and bunch compression state are crucial properties of the generated beams. Especially the low-charge operation (< 1 pC) of the UED beamline is a challenge for every non-invasive diagnostic systems.

WEPCO12 Development of a Rectangular Diagonal Cut-Plane BPM for the CSNS-II Injection Upgrade

M Abdul (Institute of High Energy Physics), R Yang (China Spallation Neutron Source; Institute of High Energy Physics); x Nie, Z Xu (Institute of High Energy Physics; China Spallation Neutron Source)

As part of the CSNS-II upgrade, an improved injection scheme will be implemented to mitigate the space charge effect. To precisely measure the transverse beam position during injection, painting, and storage in the Rapid Cycling Synchrotron (RCS), a large-aperture (260 mm x 180 mm) Beam Position Monitor (BPM) is essential. The rectangular cut-plane BPM was selected for its excellent linearity over a large area and high signal-to-noise ratio (SNR). Due to limited space in the injection section, the BPMs must be integrated into the AC steering magnet. To prevent thermal heating from eddy current flow, a rib structure has been incorporated into the BPM's outer body. The BPM was designed using numerical simulation codes and subsequently manufactured. This paper details the simulation, design, and calibration results of the diagonal cut-plane BPM.

WEPCO13 Investigation of Diagonal Cut-Plane BPM Performance in the CSNS RCS

M Abdul (Institute of High Energy Physics), R Yang, R Qiu, Z Xu (Institute of High Energy Physics; China Spallation Neutron Source)

Diagonal-cut plane Beam Position Monitors (BPMs) are utilized to measure the transverse position of the proton beam at the Rapid Cycling Synchrotron (RCS) of the CSNS. Custom developed electronics are employed to process

signals from the BPMs. Significant transverse beam position offsets were observed at several locations along the RCS. These offsets were attributed to abrupt changes in the cross-section of the upstream vacuum duct and BPM, calibration constants determined at a single frequency on the test bench, and limitations in the position calculation algorithm. Analytical estimates and numerical simulations were conducted to assess the impact of the sudden change in the beam duct aperture. Additionally, BPMs were recalibrated at the test bench to evaluate the influence of different frequencies on the observed offsets.

WEPCO14 Spiral Beam Position Monitor for Heavy Ion Beams

T Adachi (RIKEN Nishina Center), T Nishi, T Watanabe, O Kamigaito (RIKEN Nishina Center)

Our heavy ion beams are slow, short, and thick. For such beams, spiral beam position monitors(BPMs) are expected to provide good linearity and multiple information readouts despite their small size. At the RIKEN Nishina Center, various ion beams are accelerated using linacs and cyclotrons. However, the beams handled are slow enough compared to relativistic speeds, the bunch length is only about the same as the electrode size, and the beam diameter may be close to the electrode spacing. Conventional “diagonal cut” or “cosine two-theta cut” (for quadratic moments) BPMs produce deviations in wave height*. To solve this problem, it is expected that the wave height deviation can be eliminated by cutting the electrode in a spiral shape. Furthermore, by cutting in a spiral shape, multiple cuts can be placed in one BPM, and it is expected that beam intensity, horizontal position, vertical position, and second moment can be read out at a single location. The performance shown by simulations of the spiral BPM and the development of a prototype will be presented.

WEPCO15 Influence Analysis of Dipole Magnet Design and Beam Collimation in the High-Precision Energy Spectrometry System

Y Zeng (Huazhong University of Science and Technology), D Xiao, Y Wang, H Hu, K Liu, T Hu (Huazhong University of Science and Technology); W Han (Institute of High Energy Physics)

The high-precision energy spectrometer, as a key electron beam diagnostic device, is capable of accurately measuring the energy distribution of electron beams, thereby providing essential data for optimizing electron beam injector performance. Simultaneously, the upstream beam collimation also influences the measurement accuracy of the spectrometer. In this context, electron beam injectors operating in the MeV range were examined, and an energy

spectrometry system based on the magnetic deflection method—valued for its straightforward operational principle and ease of implementation—was constructed. An energy measurement model for MeV-scale electron beam injectors was developed, focusing on the impact of the dipole magnet—a key component—and the upstream beam collimation on both the beam deflection trajectory and energy resolution. The results indicate that the optimized dipole magnet design and the refined analysis of beam collimation substantially enhance the measurement precision of the energy spectrometry system, providing robust technical support for the high-precision energy diagnosis of electron beams with energies of several MeV.

WEPCO16 The FERMI FEL2 Electro Optical Sampling Design and Operational Experience

M Veronese (Elettra-Sincrotrone Trieste S.C.p.A.), A Demidovich, C Spezzani , E Allaria, G Gaio, G Penco, M Tudor, M Bossi, M Trovo, M Danailov, P Cinquegrana, P Sigalotti, S Grulja (Elettra-Sincrotrone Trieste S.C.p.A.)

This paper reports on the design and operational experience of an electro optical sampling (EOS) diagnostics based on the same femtosecond laser used for the seeding process of the FERMI FEL2. This design allows operating in parallel with the FEL2, minimizing time jitter with respect to the seed laser which is the main time marker of the FEL process by removing the time jitter contributions related to the use of an external laser. In our setup a fraction of the energy from the seed laser amplifier is extracted and delivered via a dedicated low vacuum transport system to the EOS setup in the tunnel with beam pointing stabilization actively obtained by piezo actuators. The laser beam size, pulse compression management, polarization cleaning and selection are performed in the tunnel prior to injecting the laser beam in the vacuum chamber. The spatial encoding scheme is employed, with a 100-micron thick GaP crystal and a detection performed in cross polarizers setup using a CMOS camera. The EOS has been characterized in terms of temporal resolution, jitter and drift. Finally, its capability to operate as longitudinal feedback system is also reported.

WEPCO17 Innovative resistive X-ray beam position monitors based on Silicon Carbide free-standing membrane

G Trovato (University of Catania), F La Via, S De Luca (Institute for Microelectronics and Microsystems); F Romano, G Milluzzo (Istituto Nazionale di Fisica Nucleare, Sezione di Catania); L Lanzanò, N La Rosa (University of Catania); M De Napoli (University of Catania; Istituto Nazionale di Fisica Nucleare, Sezione di Catania); M Camarda (Institute for Microelectronics and Microsystems; SenSiC GmbH; STLab srl); S Moscato (University of Catania; STLab srl)

Solid State X-ray beam position monitors (XBPMs) are an established reality for in-line, real-time monitoring for X-ray beams. Commercial products are available in different materials, such as diamond (CIVIDEC, DECTRIS) and Silicon Carbide (SenSiC GmbH)*. One issue related to this class of devices is the presence of a separation cross in the center of the device, used to obtain four independent diodes to reconstruct the position of the beam. When dealing with monochromatic highly focused beams, diffraction effects could occur. To overcome this issue, a device inspired by Position Sensitive Diodes (PSD) is currently under study by SenSiC. This device, named “resistive-XBPM”, consists of a thin (1 um – 10 um), 5mm wide, 4H-SiC single-crystal free standing membrane. An additional thin resistive layer allows, for the four metallic contacts on the edges of the device, to collect charge which is proportional to the position of the beam onto the surface of the device. A dedicated electronic system has been optimized to have the simultaneous reading of the four channels, thus achieving real-time reconstruction of the beam position without the limits of the “standard” XBPM-type sensors.

WEPCO18 Theoretical and experimental Investigation, and resolution optimization, of Semiconductor-Based Sensors for Non-Fully Intercepting Whitebeam Monitoring of Synchrotron Beams

G Trovato (University of Catania), Massimo Camarda, B Wang, Y Liu (High Energy Photon Source (HEPS); M Birri (Paul Scherrer Institute); N La Rosa, S Moscato (University of Catania; STLab srl)

In this study we present an extensive theoretical investigation, and lateral resolution optimization, into the use of semiconductor-based sensors (semicon-sensors) for real-time monitoring of high-intensity synchrotron whitebeams. Leveraging internal photoemission, these sensors can give critical advantages over conventional metal-based blade monitors that rely on surface photoemission. Notably: (i) semicon-sensors generate signals up to three orders of magnitude higher, unaffected by surface contamination; (ii) they can intrinsically suppress low-energy background from bending magnet radiation, greatly improving signal fidelity; (iii) through a novel optimization strategy termed harmonic-tuning - which uses spectral filters to selectively enhance detection of specific harmonics from insertion devices-semicon-sensors can achieve up to 10x superior spatial resolution. These capabilities enable precise, stable beam diagnostics upstream of monochromators in modern 4th-generation synchrotron facilities. At the conference, we will present comparative modelling results across multiple beamlines, facilities and gap/K-values, demonstrating/establishing

performances gains. Furthermore we will present first experimental results of these sensors tested at the Swiss Light Source (SLS) in Switzerland and at IHEP synchrotron in China

WEPCO19 Functionalization of SiC diodes for soft X-ray optics

G Trovato (University of Catania; Institute for Microelectronics and Microsystems; Istituto Nazionale di Fisica Nucleare, Sezione di Catania; STLab srl), Massimo Camarda, S Finizio, J Reuteler, J Raabe (Paul Scherrer Institute); N La Rosa, S Moscato (University of Catania; STLab srl)

In scanning transmission X-ray microscopy (STXM) beamlines, precise control of X-ray beam position and intensity (I_0) is crucial to minimize imaging artefacts and improve spectral quality. However, limited working distances in STXM setups restrict the integration of conventional diagnostics. To address this, we have developed a center-stop-based Silicon Carbide (SiC) device that integrates beam position sensitivity directly into the optical path, by functionalizing the order sorting aperture (OSA). The device was fabricated from a 20 µm thick single-crystalline SiC membrane using plasma focused ion beam (PFIB) lithography, enabling accurate microstructuring while preserving front-side electrode integrity. Live recording of beam position and I_0 during measurements is enabled through the 4-sector diode geometry patterned around the center stop. Validation experiments at the PolLux beamline (Swiss Light Source) demonstrate the device's suitability for real-time correction of beam-induced artefacts in next-generation STXM. Additional fabrication details and characterization will be presented at the conference

WEPCO20 Development of Novel, Radiation-Hard, Ultra-Compact Active Beamstops with Integrated X-ray Sensors for Scattering Experiments on High-Brilliance Undulator Beamlines

G Trovato (University of Catania), Massimo Camarda, K Nygard (MAX IV Laboratory); M Camarda (Institute for Microelectronics and Microsystems; STLab srl; SenSiC GmbH); D Sanchez, M Birri, N La Rosa, O Bunk (Paul Scherrer Institute); S Moscato (University of Catania; STLab srl)

SenSiC GmbH, a spin-off from the Swiss Light Source (SLS), has developed a new class of beamstopper sensors, termed Beamstopper Integrated Sensors (BIS), based on Silicon Carbide (SiC) semiconductor technology. Using custom processing and assembly methods, BIS devices achieve ultra-compact footprints below 1 mm and are designed for both real-time intensity monitoring and four-

quadrant beam position sensing. The choice of SiC enables extreme radiation hardness and intrinsic insensitivity to visible light, enhancing sensitivity and signal fidelity by suppressing stray light contributions. BIS sensors have been successfully validated in operational environments: intensity-monitoring devices were tested at the SLS, while position-sensitive variants were deployed at MaxIV. These results demonstrate the robustness and precision of the BIS technology, offering a compact, radiation-resistant solution for integrated beam diagnostics in high-brilliance synchrotron beamlines.

WEPCO21 Experiments on a BSM test bench for CSNS-II linac upgrade

X Yang (Institute of High Energy Physics), W Huang, L Zeng, Q Liu, X Liu, X Nie, X sun, B Tan, J liang, J Wei, F Li, Z Xu, R Qiu, M Abdul Rehman, R Yang, Y Sui (Institute of High Energy Physics)

A test bench for commissioning the 324 MHz RF deflectors used in BSMs has been in use for the upgrade project CSNS-II linac. The pulsed 10keV electron beam produced by a Kimball focusable electron gun has been captured by a YAG:Ce screen and imaged by an industrial camera installed vertically right above the view port of the screen after passing through the body of the RF deflector undertest. This paper introduces the verificating experiments of static electric lens, RF deflections and bending magnet, also with the postprocessing of the beam spot images. Results of theoretical analysis and the tests were compared and agreed very well. The experiments verified the feasibility of the BSM test bench, playing a critical role in shortening the future commissioning time of BSM equipment in the tunnel.

WEPCO22 High-resolution longitudinal beam diagnostics with a Fast Faraday Cup at the UNILAC accelerator

N Schmidt (GSI Helmholtz Centre for Heavy Ion Research), M Miski-Oglu, P Forck, R Singh (GSI Helmholtz Centre for Heavy Ion Research); S Klaproth (Technische Hochschule Mittelhessen; GSI Helmholtz Centre for Heavy Ion Research; Technical University of Darmstadt); W Barth (GSI Helmholtz Centre for Heavy Ion Research; Johannes Gutenberg University Mainz; Helmholtz Institute Mainz)

At the heavy ion accelerator UNILAC at GSI Helmholtz Center for Heavy Ion Research in Darmstadt, measurements were carried out with a Fast Faraday Cup (FFC) in order to precisely measure the time structure of the particle beam. The FFC offers a highly accurate time-resolved recording of the charge distribution along the longitudinal beam profile. The data obtained in combination with a dipole magnet is used to determine the longitudinal phase space and

emittance of the beam. After analyzing the measurement results, the method is integrated into the regular beam diagnostics to ensure continuous monitoring and control of the particle beam during operation. Measurement procedure and results are presented.

WEPCO23 Recent upgrades on longitudinal diagnostics at FLASH

B Steffen (Deutsches Elektronen-Synchrotron DESY), J Kral, B Lautenschlager, D Rothe, J Roever, J Georg, J Kral, M Buechler (Deutsches Elektronen-Synchrotron DESY)

In the framework of the recent FLASH2020+ upgrade program, the longitudinal electron beam diagnostics of the FLASH accelerator had been modernized and extended by additional devices, including an electro-optical bunch length detector (EOD), as well as an additional bunch compression monitor (BCM) and a bunch arrival-time monitor (BAM) in the new direct seeding beamline FLASH1. Also, the THz intensity spectrometer (CRISP) received a modernized control interface that will allow non-experts to perform bunch profile measurements. The paper presents an overview on the current status of the longitudinal electron beam diagnostics at FLASH and the ongoing (re-) commissioning. Compact single-shot electro-optic detection system for THz pulses with femtosecond time resolution at MHz repetition rates, B. Steffen et al., RSI, 91, 391 (2020)

WEPCO24 Compact electro-optical bunch length detector: from an expert device to an operator tool

B Steffen (Deutsches Elektronen-Synchrotron DESY), D Rothe, M Kristin Czwalinna, T Kozak (Deutsches Elektronen-Synchrotron DESY)

Laser-based electro-optic detection (EOD) has been a valuable tool to measure the longitudinal electron bunch shape with sub-ps resolution for almost a decade, but it has always been a tool for expert use. Recently, the server and the user interface has been updated allow automated laser locking, time calibration and measurements to prepare for general operator use at the EuXFEL. It is currently prepared for EO Spectral Decoding measurements, but the implementation of advanced reconstruction algorithms (Diversity Enhanced EO Spectral Decoding, DEOS[*]) is ongoing. The paper presents details of the setup and the user interface as well as recent measurements.

WEPCO25 SOLEIL II BPMs development progress

M El Ajjouri (Synchrotron soleil), A Gamelin, F Alves, N Hubert, Z FAN (Synchrotron soleil)

SOLEIL II is the low emittance upgrade project for Synchrotron SOLEIL, targeting an emittance of ~80 pm.rad. The new lattice includes 196 Beam Position Monitors (BPM) distributed in 3 different types depending on the vacuum chamber diameter. To ensure consistent signal levels across varying pipe diameters, two button sizes were selected: 6 mm diameter for 16 mm beam pipes, and 7 mm diameter for the 20 mm and 24 mm sections. To optimize the BPM impedance, button shape is conical. Electromagnetic and thermal simulations have been conducted to validate the proposed designs. In parallel, prototypes have been installed and tested on the existing machine to confirm the simulation results and validate the design. This paper summarizes the simulation outcomes, and the test results obtained on the current machine.

WEPCO26 First measurements of a prototype Stripline BPM for PETRA IV: geometry effects and comparison with simulation

G Kube (Deutsches Elektronen-Synchrotron DESY), D Lipka, M Lantschner (Deutsches Elektronen-Synchrotron DESY)

We present voltage and thermal measurements from the first prototype of a stripline BPM intended for the PETRA IV synchrotron ring. The monitor was installed at the PETRA III testbed for evaluation and compared with CST Microwave Studio simulation results. Initial measurements revealed unexpected voltage oscillations and significant heating (~135°C) which were not reproduced in idealized models. For a smooth beam pipe, the expected highest power loss based on the wake-loss factor would only be 1.8 W. Including mechanical details such as flanges and gaskets in the simulation revealed cavity-induced resonances that increased the power loss to 96 W. The updated model showed good agreement with the measured voltages in both time and frequency domains as well as with thermal data. Replacing the gasket with a smaller inner diameter reduced the power loss to 27 W and lowered the measured temperature to ~92°C. This study highlights that multiple mechanical and electromagnetic factors must be understood and included in simulations to accurately predict beam-induced effects in high-frequency diagnostics.

WEPCO27 Measurement of Crabbing Angle With Phase Information From BPM

I Pinayev (Brookhaven National Laboratory)

The Electron-Ion Collider is being constructed at the Brookhaven National Laboratory. The crab cavities will be utilized for the increase of the luminosity. While the initial set-up of crab cavities can be based on the orbit measurements during dedicated development time, we need to utilize a less invasive approach for monitoring the longitudinal beam tilt during operations. We propose to measure a phase shift between two beam position monitor channels for this purpose. The signal can be easily incorporated into the RF system feedback to suppress noise in the system. Theoretical considerations as well as tests with the electron beams are presented.

WEPCO28 Measurement of Two Beams Positions With Button BPM

I Pinayev (Brookhaven National Laboratory)

Modern BPM processors utilize digital processing of the beam induced signals. The information on the signal amplitudes is used for the delta over sum calculation of the beam position, while the readily available phase information is usually discarded. We have experimentally tested measurement of the individual positions of two beams propagating in the common beampipe utilizing both phase and amplitude data. The proposed method can be used for the energy recovery linacs and colliders.

WEPCO29 Development of Analog Front-End Module for the BPM Signal Processor at SSRF

L Lai (Shanghai Advanced Research Institute), Q Yan (Nanchang University); S Wang (Shanghai Advanced Research Institute; Nanchang University)

A new BPM processor is being developed to address the ageing of BPM signal processors and the new demand for synchronised data acquisition at the storage ring of Shanghai Synchrotron Radiation Facility (SSRF). The BPM processor consists primarily of a digital carrier board and an analog front-end (AFE) module. The AFE is responsible for the conditioning of the BPM output RF signal and for the compensation of long-term drift. This paper presents the design of the AFE module and gives an evaluation of its performance. The experimental results show that the AFE module under development fully satisfies the high resolution and high stability requirements of the upgraded SSRF BPM processor.

WEPCO30 Development of a Bunch-by-Bunch BPM Processor at SSRF Based on Direct RF Sampling

L Lai (Shanghai Advanced Research Institute), Y Zhou, Y Yan (Shanghai Advanced Research Institute)

The current bunch-by-bunch beam position measurement system at electron storage ring mainly based on high-sampling-rate oscilloscopes and transverse feedback electronics. The oscilloscope cannot achieve real-time bunch-by-bunch beam position measurement or large-scale online applications. The TFB electronics can only perform simple relative position measurements of single bunch at a time. The turn-by-turn BPM processor has matured over 20 years. With the advancement of high sampling rate direct RF sampling ADCs and related electronics technologies, now is the time to initiate the development of a bunch-by-bunch BPM processor. A bunch-by-bunch BPM electronics using direct RF sampling technology has been developed at SSRF. The processor performs 2 GSPS direct sampling and real-time processing of four-channel BPM signals, enabling real-time measurement of all bunch-by-bunch positions and providing BPM data from turn-by-turn rate to closed orbit. This bunch-by-bunch processor eliminates the need for complex delay adjustments RF front-end for peak sampling, providing a solid foundation for future large-scale online engineering applications.

WEPCO31 Development and evaluation of an RFSoC based stripline BPM readout hardware prototype

B Urbschat (Nagoya University), G Mitsuka (High Energy Accelerator Research Organization); L Ruckman (SLAC National Accelerator Laboratory)

We have developed a Stripline BPM readout device based on an AMD/Xilinx RFSoC chip which integrates multiple ADCs, DACs, a large scale FPGA, and an ARM processor in a single package. The developed device is intended for use at the beam transfer line connecting the KEK injector Linac to the SuperKEKB collider rings. SuperKEKB will operate at unprecedented luminosities requiring very high beam currents. To reach and maintain such currents, high injection efficiency is essential which in turn requires precise tuning of the injection process. The RFSoC based BPM will provide a highly flexible platform for beam orbit measurements near the injection point required for the tuning. One objective is to enable the separate resolution of the orbit of both bunches in the two-bunch injection mode, where two bunches are accelerated and injected with 96 ns spacing. Additionally, we plan to utilize resulting measurements as inputs for real-time automated injection tuning and feedback to the upstream steering in the beam transport line. Here, we present the status of the development including results from prototype tests conducted at the KEK injector Linac.

WEPCO32 Upgrade of Beam Position Diagnostics System at FELiChEM

Y Leng (University of Science and Technology of China), Y Leng, X Yang, D Wang (University of Science and Technology of China)

The FELiChEM is a user facility dedicated for energy chemistry research, developed at University of Science and Technology of China in Hefei. The beam position diagnostics system at FELiChEM are upgraded recently. The facility operates with a special mode: macropulses at 1 Hz repetition rate with microsecond duration, each containing micropluses at 59.5 MHz repetition rate. The key advancement of beam position monitor (BPM) system lies in the upgraded which now achieves micropluse-level resolution. This enhancement enables real-time measurement of transverse position deviations for individual micropluses, providing essential diagnostics for investigating intra-macropulse instabilities. Post-upgrade characterization demonstrates a transverse position resolution better than 20 μm, satisfying design specifications. The upgraded BPM system has been successfully integrated into routine beam tuning operations.

WEPCO33 Electro-optic sampling based measurement of near field of RF-compressed relativistic electron beams

M Lenz (Particle Beam Physics Lab, B Schaap, P Musumeci (University of California, Los Angeles); M Ota (National Institute for Fusion Science)

We present an improved electro-optic sampling technique that extends the sensitivity and temporal resolution of beam diagnostics beyond conventional limits. Through precise calibration of the detection system, we reconstruct the spatio-temporal profile of the near-field generated by a relativistic electron beam in a ZnTe crystal. This allows for accurate retrieval of the beam's peak current with temporal resolution exceeding the nominal THz bandwidth of the electro-optic response. The method is validated at the UCLA Pegasus Laboratory, enabling single-shot detection of electron beams with charges below 100 fC.

WEPCO34 Ultrashort Relativistic Electron Bunch Characterization via High-Gradient THz Streaking

M Lenz (Particle Beam Physics Lab, P Musumeci (University of California, Los Angeles)

We report progress on a THz streaking experiment at the UCLA Pegasus Laboratory enabling femtosecond-resolution electron bunch length measurements. Single-cycle, 50 μJ THz pulses centered at 0.6 THz are coupled into a metallic

horn structure, enhancing field strengths to several hundred MV/m while simultaneously establishing boundary conditions for a strong streaking gradient. A multi-frequency RF photoinjector system produces ultralow-emittance, high-brightness electron beams, which are compressed to sub-femtosecond durations at MeV energies. This setup enables demonstration of THz streaking-based longitudinal point-spread function measurements with femtosecond resolution.

WEPCO35 Accurate offline calibration and simulation analysis of various types of BPM position sensitivity

P He (Institute of Modern Physics, Chinese Academy of Sciences), J Wu, H Ming Xie, L Li, J Yin, Z Du, Z Li, R Tian, J Yang, J Xia (Institute of Modern Physics)

Beam Position Monitors (BPMs) are the most commonly used non-destructive diagnostics for almost all linear accelerators, cyclotrons, and synchrotrons. It is very important for BPM to provide accurate beam position for closed-orbit correction, and etc. Meanwhile, it is necessary to accurately offline calibrate the BPM position sensitivity and evaluate whether the result is correct or not. In this paper, a method based on the principle of microwave multi-port network in the field of electromagnetic field is proposed to efficiently simulate the BPM position sensitivity; a large number of various BPMs (capacitive , linear-cut and stripline type) for HIAF and PREF projects were calibrated; comparing the calibration and simulated position coefficients, combined with the three-dimensional field distribution analysis, an in-depth and systematic study was carried out on various types of BPM calibration, during which some key points that determine whether the calibration results were accurate after the BPM was launched were found.

WEPCO36 Bead Test Result of Cavity Beam Position Monitor for PAL-XFEL

C Kim (Pohang Accelerator Laboratory)

A bead test was conducted to measure the shunt impedance (R/Q) of the cavity beam position monitor (BPM) for PAL-XFEL. R/Q is an important parameter of a cavity BPM because it relates to the signal strength, which determines the resolution of the beam position measurement. In the bead test, a dielectric and metal bead were used to assess the frequency change at various bead positions. The measurement results of the two beads from the monopole cavity were similar, but the results from the dipole cavity differed significantly. This discrepancy can be explained by considering the distribution of the electric and magnetic fields in the cavity structure and the materials of the two beads.

WEPCO37 Beam position monitors design for PERLE project

S Mohammed Ben Abdillah (Université Paris-Saclay, CNRS/IN2P3, IJCLab)

PERLE is an Energy-Recovery Linac (ERL) to be constructed at IJCLab in Orsay. It will be the First multi-turn ERL with superconducting RF (SRF) with the ambition to reach 10MW beam operation (20mA beam current and 500MeV beam energy) Diagnostics are a key element for PERLE operation and among diagnostics, the salient feature for Beam position monitors (BPMs) is the presence of multiple beams which need to be individually diagnosed and controlled. This document describes the design and the operation of PERLE BPMs with particular attention given to how these BPMs will handle multiple beams during commissioning and under normal operation of PERLE

WEPCO38 Current profile and longitudinal phase space measurement using a corrugated structure

C Sung (Pohang Accelerator Laboratory), C Hyun Shim, H Yang, K Moon, M Cho, S Kim (Pohang Accelerator Laboratory)

We present preliminary experimental results on the measurement of the current profile and longitudinal phase space (LPS) of an ultrarelativistic electron beam using a corrugated structure at the Pohang Accelerator Laboratory X-ray Free-Electron Laser (PAL-XFEL). The electron bunch is streaked by the transverse wakefield induced by the corrugated plates, resulting in a correlation between the transverse and longitudinal beam distributions. By analyzing the transverse distribution of the streaked beam, we reconstructed the current profile and the LPS. Tracking simulations were performed to validate the reconstruction method, showing good agreement between the reconstructed and actual beam profiles. Based on these simulations, we applied the method to experimental data and characterized the longitudinal beam properties at PAL-XFEL. This paper presents our preliminary results on current profile reconstruction and LPS characterization with the high temporal resolution.

WEPCO39 Development of Bunch Selector Modules for Double Bunch Operation in PAL-XFEL BPM Systems

D Shin (Pohang Accelerator Laboratory), G Kim, C Kim, H Yang, S Jang, H Heo (Pohang Accelerator Laboratory)

PAL-XFEL is preparing for double bunch operation scheduled for 2027 by upgrading various systems, including the BPM (Beam Position Monitor) infrastructure. However, the existing BPM electronics are optimized for single bunch

signals, and when double bunches are injected, signal overlap occurs, making accurate position measurements difficult. To address this issue without significantly modifying the existing electronics, an RF switch module was externally added to suppress one of the two bunches. This approach was adopted based on the beam physics group's assessment that accurate monitoring of a single bunch allows for reliable estimation of the second bunch's position. To implement this approach, a bunch selector module was developed and applied to the system, and this paper presents the prototype development process and its application results in BPM systems.

WEPCO40 Electro-optical spectral interferometry longitudinal profile monitor design updates and performance on CLARA

D Walsh (Science and Technology Facilities Council), E Snedden, T Pacey (Daresbury Laboratory; Cockcroft Institute)

Electro-optic (EO) diagnostics offer non-destructive methods to resolve the longitudinal charge profile of highly relativistic bunches without the need for complex calibrations or ambiguous phase recovery techniques. The most commonly used technique, EO spectral decoding, is favoured for its simplicity, reliability, and straightforward output interpretation. However, its resolution is constrained by the geometric mean of the transform-limited and stretched probe laser durations. At the CLARA accelerator at Daresbury Laboratory, we have demonstrated an EO system utilizing common-path spectral interferometry (EOSI), which overcomes this limitation, by adding a single optical element to an EO spectral decoding system. This system successfully measured 35 MeV/c bunches with charges ranging from 150 pC to 2 pC and compressions from several picoseconds to approximately 300 fs RMS. Here, we discuss the technique with a focus on its current limitations and proposed improvements for an implementation on the upgraded 250 MeV CLARA beam.

WEPMO: Poster Presentations

WEPMO01 Versatile Bunch Length Measurement Setup for Low Bunch Charges at the S-DALINAC

A Brauch (Technical University of Darmstadt), D Schneider, F Schliessmann, J Enders, L Jürgensen, M Dutine, M Arnold, N Pietralla, R Grewe (Technical University of Darmstadt)

Energy-recovery linacs provide high beam currents with low externally provided RF power compared to conventional linacs while maintaining high beam quality. The S-DALINAC is a multiple recirculating accelerator operating with a frequency of 3 GHz. It can be operated as a multi-turn superconducting energy-recovery linac. The bunch length is suspected to limit the efficiency of this operation mode. In the past, the bunch length was determined at the S-DALINAC using the RF zero-crossing method. A new setup, enabling bunch length measurements with low bunch charges at various locations of the S-DALINAC, has been developed and commissioned. Light pulses of optical transition radiation are produced by the electron bunches passing an aluminium-coated Kapton screen. Their lengths are measured with a streak camera. An imaging system consisting of multiple mirrors is used to maintain a high temporal resolution for the measurement and to support in protecting the streak camera from damaging radiation. The design and measurement results of the setup will be presented.

WEPMO02 Preparing the next phase of the steady-state microbunching proof-of-principle experiment at the Metrology Light Source

A Kruschinski (Helmholtz-Zentrum Berlin für Materialien und Energie), X Deng, X Liu, X Lu, C Tang, L Yan, Z Yang, a chao (Tsinghua University); A Hoehl, R Klein (Physikalisch-Technische Bundesanstalt); C Mai, M Marongiu, M Ries (Helmholtz-Zentrum Berlin für Materialien und Energie)

Steady-state microbunching (SSMB) is a proposed scheme to generate coherent radiation at short wavelengths from a microbunched electron beam in a storage ring. The feasibility of the idea is investigated in an ongoing proof-of-principle (PoP) experiment conducted at the Metrology Light Source (MLS). Phase I of the SSMB PoP experiment has been using an experimental setup employing a single-shot modulation laser to show the general viability of the idea, and has explored the underlying complex storage ring dynamics. The next step in the SSMB PoP campaign is to progress from the single-shot setup of phase I towards quasi-steady state. To this end, a new laser system is installed at the MLS that can provide turn-by-turn modulation

of the electron beam for 1000 revolutions. The main goal of this phase II of the SSMB PoP experiment will be to show bound motion of electrons within individual laser-induced microbunches. In this paper, we show the progress of preparation for PoP phase II, with emphasis on the setup and integration of the new laser system and diagnostics challenges.

WEPMO03 Smith-Purcell and transition radiation based charged particle beam diagnostics for the femtosecond-range

B Stacey (Deutsches Elektronen-Synchrotron DESY), W Hillert, W Kuropka, T Vinatier (Deutsches Elektronen-Synchrotron DESY)

We will give an overview of the Smith-Purcell and transition radiation based longitudinal diagnostic methods employed at the ARES (Accelerator Research Experiment at SINBAD) linear accelerator to characterize femto-second long electron bunches. The Smith-Purcell radiation mechanism has been studied for the case of metallic gratings, but not much experimental data has been published yet with respect to dielectric gratings as charged particle beam diagnostic devices. We expect a number of advantages in the detection of the radiation at the substrate side and the spectral properties of the radiation tailored by the geometric shape of the grating structures. Due to the advances in lithographic techniques dielectric gratings can be produced with optical wavelength periodicities and the shapes can be controlled with nano-meter precision. For femto-second bunch lengths the coherence of transition radiation starts to reach the near-infrared to optical regime. This opens up the possibility of characterizing the spectrum with readily available high sensitivity semi-conductor based detectors to draw conclusions on the form factor and measure bunch lengths.

WEPMO04 Diamond dosimeter for the measurement of the proton beam impact position on a neutron spallation target

J Melbinger (TU Wien; CIVIDEC Instrumentation, E Griesmayer (TU Wien; CIVIDEC Instrumentation (Austria); E Jericha, M Bacak (TU Wien); H Frais-Kölbl (Fachhochschule Wiener Neustadt); K Kaperoni, M Diakaki, M Kokkoris (National Technical University of Athens)

In close proximity to the spallation neutron source of the neutron time-of-flight facility n_TOF at CERN, diamond detectors are installed to measure the fast neutron beam. The detectors are located 2.3 m from the center of the spallation target at 100° with respect to the impinging proton beam. The 20 GeV/c proton beam from CERNs Proton Synchrotron (PS) hits the Pb-spallation target with a nominal

intensity of 8.5e12 protons/bunch, a proton bunch length of 16 ns FWHM and a maximum repetition rate of 0.8 Hz. The proton beam intensity is monitored with a beam current transformer (BCT) installed in the PS extraction line to n_TOF. The proton beam position is measured using a SEM grid 2 m before the spallation target. A linear correlation between the horizontal proton beam impact position on the Pb-target and the measured dose of the secondary radiation at the measurement station for each pulse is observed. While the proton beam impact position varies by 12 mm, the normalised dose varies by 20%. The achievable precision of the proton beam position measurement using the diamond dosimeter and the linearity of the dose measurement for individual bunches is studied and will be presented.

WEPMO05 Testing of SiC Blade X-ray Beam Position Monitors for Synchrotron Front Ends

C Houghton (Diamond Light Source), L Bobb (Diamond Light Source)

X-ray beam position monitors (XBPMs) play a crucial role in accurately measuring the position of the white beam in synchrotron front ends. Traditional XBPM designs typically feature four tungsten blades arranged at the full width at half maximum (FWHM) of the white beam. However, the high absorption and lower thermal resistance of tungsten limit the proximity of the blades to the X-ray source, which may negatively impact measurement precision. This study investigates the performance of an innovative XBPM design that utilises silicon carbide (SiC) blades, which provide enhanced thermal conductivity and reduced absorption. This advancement may allow for closer placement of the blades to the beam, potentially improving measurement accuracy. This experimental setup aims to assess the impact of SiC blades on measurement accuracy, signal-to-noise ratio, and linearity compared to conventional tungsten XBPMs. The results will offer valuable insights into the benefits and limitations of SiC-based XBPMs compared to their tungsten counterparts.

WEPMO06 Studies of an optimal geometry for arc beam position monitors of the FCC-ee

E Howling (John Adams Institute), M Gasior, S Mazzoni, T Lefevre (European Organization for Nuclear Research); P Burrows (John Adams Institute for Accelerator Science; University of Oxford)

The electron-positron Future Circular Collider (FCC-ee) has challenging requirements for beam instrumentation, including the need for thousands of high-resolution beam position monitors (BPMs) presenting low impedance to the circulating beam. This paper details the requirements for the FCC-ee arc BPMs and presents the simulation results of BPM button pickups with various geometries modelled

with FCC-ee beam parameters. These simulation results are used to estimate BPM parameters, including impedance and heating. Applying results from bench-marking tests of other BPMs, a suggested geometry and expected performance are presented.

WEPMO07 Gain calibration for X-Y coupling correction of X-ray beam position monitors at SPring-8 photon beamlines

H Aoyagi (Japan Synchrotron Radiation Research Institute

At the insertion device beamline in SPring-8, a photoelectron emission X-ray beam position monitor that utilizes four tungsten-blade detectors is currently in operation. The horizontal and vertical position sensitivity coefficients (gains) are determined by analyzing the output signals of the four detectors as the monitor body is translated horizontally or vertically, respectively, from the reference position. In general, these responses exhibit a slight coupling between the horizontal and vertical directions, attributable to radiation from the leaky magnetic field at the edge of the bending magnet. This coupling becomes more pronounced as the distance between detector elements increases. Therefore, we propose a simple gain calibration method that decouples the X and Y responses. Specifically, we devised a 2x2 matrix formulation that achieves accurate mapping in practical applications by measuring only four points (top, bottom, left, and right). In this report, we introduce the transformation matrix formula and present an actual application example of gain calibration with decoupled X-Y couplings.

WEPMO08 Development of BPM electronics for TRIUMF's BL4N

H Jones (TRIUMF)

The BL4N beamline at TRIUMF, currently under development, will transport proton beam from the 500 MeV cyclotron to an ISOL target station. The peak beam current will be varied from 1 to 100 microamps, and the beam position must be measured over a 10mm range. The beam position is measured using inductive pick-ups and a new narrowband frontend. The electronics consist of a crossbar-switched front-end, FPGA-based down-conversion and position calculation, and an SoC module for nonlinear corrections and device readout. This report presents the design and testing of the BPM electronics, including benchtop validation and beam test results. Measurements of position sensitivity, beam current dependence, and non-linearity are included.

WEPMO09 Online position conversion factor calibration study for BPM system

J Chen (Shanghai Synchrotron Radiation Facility), L Lai (Shanghai Advanced Research Institute); R Yuan (Shanghai Advanced Research Institute, Chinese Academy of Sciences); Y Leng (University of Science and Technology of China)

Transverse beam position is one of the most critical parameters in accelerator commission and operation. As non-invasive diagnostic devices, beam position monitors (BPMs) are the main “workhorse” in accelerators, providing beam center of mass position information. The position conversion factor (K-factor) of BPM systems constitutes a fundamental determinate of measurement accuracy. While precision calibration traditionally relies on moveable calibrate platforms, the prohibitive cost of equipping each BPM with a dedicated two-dimensional calibration platform remains a widespread practical constraint. In this paper, an innovative online calibration method that synergizes machine learning with beam response matrix analysis to achieve per-BPM K-factor determination is introduced. The preliminary beam experiments have been carried out at Shanghai Soft X-ray Free-Electron Laser (SXFEL) facility. The proposed method offers a robust and resource-efficient calibration solution, particularly advantageous for cavity BPM systems where conventional approaches such as theoretical calculation and offline wire scanning, fail to provide reliable results.

WEPMO10 Performance evaluation of front-end attenuators and integrated gain calibration system for new BPM DAQ system at J-PARC MR

K Satou (High Energy Accelerator Research Organization), T Toyama, S Yamada, A Kobayashi, M Okada (High Energy Accelerator Research Organization)

The J-PARC MR achieved its initial target of 750 kW operation and is currently upgrading its equipment to reach the next target of 1.3 MW. The Beam Position Monitor (BPM) must enhance position accuracy to less than one-third of that of the current system to mitigate beam losses caused by accelerating the high-intensity proton beam of 3.3E14ppp. To address this, a new Data Acquisition System (DAQ), comprising Front-end Attenuator Boards (ATT), ADC Boards, Network Interface Controllers, and a Data Storage System, is under development. Improving position accuracy relies on improving reflection at the ATT’s input terminal and adjusting the gain balance for each signal channel. A self-contained gain tuning system using a self-generating test pulse and an input impedance tuning circuit has been adopted to mitigate the reflection at the ATT and enhance the gain balance across all components, including sensors, signal transmission cables (100–300m), and the DAQ. The

installation of the DAQ system is for this winter and the ATT calibration and performance testing are currently underway. This report presents the calibration results and their impact on beam position accuracy.

WEPMO11 Design and Expected Performance of the new BPM systems for AWAKE Run 2C

L Stant (European Organization for Nuclear Research), A Jevtic, A Boccardi, C Pakuza, I Degl'Innocenti, M Krupa, S Mazzoni, T Bogey (European Organization for Nuclear Research)

The AWAKE facility at CERN uses novel proton beam-driven plasma wakefields to accelerate electron bunches over a 10 m plasma source. The facility will soon be rebuilt to study methods to improve the quality of the accelerated electron beam, requiring better resolution from the proton BPMs. In addition, it is desirable to replace the existing bespoke electron BPMs with an in-house solution. Both upgrades will reuse the existing BPM pickups (electrostatic buttons and striplines, respectively) but replace the electronic front-ends and control system interfaces. An RFSoC-based BPM front-end is concurrently being developed for the HL-LHC upgrade, which, if appropriate for AWAKE, would reduce production and maintenance efforts. For the proton BPMs, distributed along an 800 m transfer line, time-multiplexing of both pickups per plane has been chosen both to reduce cabling and channel count and improve systematic errors in the measurements. We present the expected performance of both the AWAKE proton and electron BPMs using the prototype HL-LHC BPM front-end, based on measurements from the existing facility.

WEPMO12 Digital signal processing improvements of the SPIRAL2 Beam Position Monitors at low intensity

P Salou (GANIL), C Jamet, C Potier de Courcy, C Tréangle, C Houarner, O Delahaye (GANIL)

The SPIRAL2 accelerator, designed for high intensity beams (up to 5 mA), needs to evolve for low intensities in order to reach the requirements of the S3 experimental room. This means increasing the operating range of diagnostic monitors including the Beam Position Monitors (BPM). Twenty BPM are installed in the warm sections of the linac to measure positions, ellipticities and phases. The digital processing of the BPM acquisition has been modified to operate at low intensity. This was done by improving the signal-to-noise ratio with an increase of the averaging resolution, an improvement of the channel equalisation system and with a deduction of parasitic signals induced by the surrounding equipment. The process was also modified to operate with chopper frequencies between 1 Hz and

1 kHz. A new BPM interface, with tables and graphical displays in order to control beam phases and energies in the linac, is now available. These new developments and measurement results in laboratory and with SPIRAL2 beams are presented, which show good results with a low intensity down to 1 µA.

WEPMO13 Single-shot detection of short electron bunch shapes at MHz repetition rates using diversity electro-optic scheme with advanced reconstruction algorithms at EuXFEL and FLASH.

Q Demazeux (Université de Lille), C Szwaj, E Roussel, S Bielawski (Laboratoire de Physique des Lasers, Atomes et Molécules; Université de Lille); M Kristin Czwalinna, B Steffen (Deutsches Elektronen-Synchrotron DESY)

To surpass limitations in sub-picosecond electro-optic electron bunch length diagnostics[1], we present an innovative detection method utilizing diversity schemes[2]. This approach employs simultaneous multi-output measurements of the chirped optical probe modulated by the electron bunch's field. We introduce a novel inversion algorithm that automatically recognizes and compensates for imperfections in the probe laser spectrum and chirp, enabling high-fidelity retrieval of bunch shapes, particularly for broadband THz radiation over a long temporal window. Numerical simulations and initial experimental results demonstrate the system's potential for advanced, real-time bunch shape monitors at FLASH and EuXFEL, and can be extended to THz CTR or FEL based THz sources. [1] F. Sun, Z. Jiang, and X.-C. Zhang, Appl. Phys. Lett. 3, 2233 (1998) [2] E. Roussel et al., Light: Science & Applications 11, 14 (2022)

WEPMO14 Development of Pyroelectric Detectors for THz Diagnostics on CLARA

S Mathisen (Science and Technology Facilities Council), C Moffat, D Walsh, E Shackleton, J Gawthorpe, V Malconi (Science and Technology Facilities Council); E McCormack (Rutherford Appleton Laboratory); K Fedorov, P Bradford (Central Laser Facility)

CLARA is a high-brightness 250 MeV electron test facility, which aims to deliver high quality beams to a flexible user area called FEBE, supporting experiments in areas such as novel acceleration. The requirements of these experiments impose stringent diagnostic requirements. This paper will describe progress on the pyroelectric detectors intended for use with a multi-channel THz spectrometer, including their design and offline tests with a THz source, as well as future plans for integrating them with the spectrometer design.

WEPMO15 CLS Timing System

T Batten (Canadian Light Source, J Vogt (Canadian Light Source (Canada)

The Canadian Light Source (CLS) is a third generation 2.9 GeV synchrotron comprised of a 250 MeV LINAC, a full energy booster, and a storage ring with 13 insertion devices and 22 operational beamlines ranging from infrared light to hard X-rays. The Timing System supplies the triggers required to synchronize operation of all components responsible for injecting current into the storage ring. Signals from the Timing System can also be used to synchronize data acquisition on beamlines. The Trigger Generator Unit (TGU), which was designed by the CLS, is the centerpiece of the timing electronics. The TGU is driven by the 500 MHz master oscillator and is controlled using digital I/O. The trigger signals are distributed via a fiber optic system, which was also designed in house. The Timing System has been in operation since 2001 and has proven itself to be stable and robust. This paper provides a detailed overview of the system and its history and operational performance.

WEPMO16 A compact device for measuring and monitoring the energy of accelerated particle beams

Z Kormány (HUN-REN Institute for Nuclear Research)

A Beam Energy Monitor (BEM) was developed for the cyclotron of the HUN-REN ATOMKI, using TOF measurements on a short flight path. The sensor unit uses two capacitive probes at a distance of 20 cm, the entire geometry is about 40 cm long. The compact size allowed the unit to be installed in the main beamline, making it possible to measure and monitor the beam energy independently of the beamline actually used. The probe signals are acquired by a digital oscilloscope and the time difference between the pulses generated by a beam bunch on the probes is determined by digital signal processing algorithms. The unique design of the sensor unit and the signal processing hardware and software combine to provide accurate beam energy measurement despite the short flight path. Accuracy in practical operation was investigated by neutron threshold reactons. They showed that the measurement accuracy is at least one order of magnitude better than the accuracy of the energy value calculated from the cyclotron settings. The accuracy of the signal processing shows that the beam energy can be scaled up to several hundred MeV while maintaining the measurement accuracy at the tenth of a percent level.

WEPMO17 New Photon BPM setup using SiC devices in photoconductive mode

M Colja (Elettra-Sincrotrone Trieste S.C.p.A.), D Giuressi, G Brajnik, G Cautero (Elettra-Sincrotrone Trieste S.C.p.A.)

Photon Beam Position Monitors (pBPM) detect photon beam intensity and position in synchrotron light sources and are capable to operate in real time during experiments, without altering beam properties and ideally discriminating between insertion device (ID) and bending magnet (BM) radiation. Early approaches used metallic blades based on photoemission from beam tails, but failed with micrometric beams or too high energy photons. They were also unable to distinguish between BM and ID radiation. Newer techniques based on CVD diamond detectors, using charge collection in four quadrants, work well at high energies but absorb too much at soft X-rays or lower energies. Thinning sensors down to the nanometer scale is technically challenging and does not solve the problem of light source discrimination. We propose an innovative method using intrinsic silicon carbide (SiC) sensors, not as a replacement for blades, but as a matrix of photoconductive elements, positioned directly after the synchrotron source, each capable of separately detecting BM and ID radiation. Initial tests show sub-micron sensitivity and clear separation of beam contributions, offering a new way forward.

WEPMO18 Beam Measurements during Swap-out Injection of the APS-U Storage Ring

W Cheng (Argonne National Laboratory), A Brill, R Hong, S Grass Wang (Argonne National Laboratory)

The Advanced Photon Source Upgrade (APS-U) implements a novel swap-out injection scheme. To comprehensively characterize the beam dynamics during swap-out injections, approximately 20 Beam Position Monitors (BPMs) in the initial sections of the storage ring have been equipped with high-precision single-bunch electronics. These systems are capable of measuring the turn-by-turn positions of the injecting bunch. Using similar techniques, the longitudinal phase and energy of the injecting bunch can be accurately assessed. Additionally, bunch-by-bunch feedback systems have been used to measure transient beam motions, extending their primary functionality of suppressing coupled bunch instabilities. This paper presents the results of beam measurements during swap-out injections utilizing these advanced systems.

WEPMO19 Longitudinal Profile Measurements of Particle Beams with Deconvolution in the APS-U Storage-ring

W Cheng (Argonne National Laboratory), A Brill (Argonne National Laboratory)

Accurate measurement of the longitudinal profile, or bunch length, of particle beams is essential for evaluating and optimizing beam quality in the Advanced Photon Source Upgrade (APS-U) Storage Ring. While Beam Position Monitor (BPM) signals are typically used for precise position measurements, they also contain information about the longitudinal bunch distribution, convolved with the BPM system's transfer function. To extract the true bunch profile, CST Studio is used to simulate the BPM response to a short Gaussian pulse—approximating a Dirac delta function—thereby providing the BPM's transfer function. The transfer functions of signal cables and attenuators are also measured and combined with the simulated BPM response to construct a complete system transfer function. This composite response serves as the deconvolution kernel for reconstructing the original time-domain bunch profile from the measured BPM signals. BPM signals from the APS-U's tuned Bunch Lengthening System (BLS) are analyzed in both time and frequency domains. Deconvolution with the simulated transfer function yields accurate longitudinal profiles and enables precise extraction of bunch lengths.

WEPMO20 Study of a novel eight electrodes RF pickup

A Ortega Moral (Universidad de Granada), I Podadera, J Francisco Valenzuela Valdés (Universidad de Granada)

The IFMIF-DONES facility located at Escúzar in Spain will consist of an accelerator delivering 125 mA of 40 MeV deuterons onto a Lithium target. At the last part of the accelerator, when the beam footprint is almost shaped, different beam diagnostics are considered. In order to protect the machine against changes of the beam and give a safe interlock, a novel RF pickup made of eight electrodes is designed. This RF pickup is designed with the objective to sense displacements of the beam centroid as changes of the beam profile. In this paper a preliminary study is presented based on an analytical and CST simulation approach.
Both approaches, considering pencil and real beams from TraceWin simulations, are compared. Next, a sensitivity study of how different parameters affect the response is performed in CST simulations. This work has been carried out within the framework of the EUROfusion Consortium.

WEPMO21 Progress of the EIC HSR cold BPM mechanical design and integration

D Gassner (Brookhaven National Laboratory),
K Matsushima, M Wendt (Brookhaven National Laboratory)

The Electron Ion Collider (EIC) Hadron Storage Ring (HSR) aims to leverage the hardware from the RHIC storage ring as much as possible. However, the RHIC stripline beam position monitors (BPM) used in the superconducting magnet cryostat will not be compatible with the planned EIC hadron beam parameters that include shorter bunches, higher beam current and operation of the beam with a radial offset in the vacuum chamber. A new cryogenic BPM design using button pick-ups integrated in a new interconnect bellow assembly will be installed adjacent to the decommissioned RHIC stripline BPMs. This paper will review some of the design considerations of the BPM system ahead of their procurement.

WEPMO22 Button-Type Beam Position Monitors for Elettra 2.0: from design to real measurements.

G Brajnik (Elettra-Sincrotrone Trieste S.C.p.A.), *et al.*

This paper describes the main stages of the journey from preliminary ideas on button shapes to actual measurements on prototypes of Beam Position Monitor (BPM) devices for Elettra 2.0. In the first stage, the electromagnetic phenomena involved in BPM sensors were studied taking into account different pick-up geometries, dielectric and conductive materials, and bunch lengths. Critical aspects such as beam coupling impedance, transfer impedance, impedance matching, trapped/propagating mode effects and heating were evaluated through numerical simulations. In the second stage, three families of vacuum-tight pick-up samples were fabricated in-house, and their actual performance was evaluated both on a microwave test bench and in real operating conditions on the Elettra storage ring. To carry out future measurements on alternative BPM designs, the third family was specifically conceived and built to allow quick and easy pick-up replacement using ultra-high vacuum shape memory alloy sealing technology. The third stage focused on comparing the signals produced by the Elettra BPMs with those foreseen for Elettra 2.0, and also allowed validation of the in-house developed BPM electronics.

WEPMO23 Performance results of the novel photoemission mask type X-ray Beam Position Monitor (PheM XBPM) for the 'white' undulator radiation.

P Ilinski (MAX IV Laboratory)

A novel photo-emission type of X-ray Beam Position Monitor (PheM XBPM) for the 'white' undulator radiation was proposed [1]. After that a prototype was designed and manufactured at the MAX IV. Two PheM XBPMs were installed at the SoftiMAX and CoSAXS frontends of the MAX IV R3 storage ring. Performance results of the PheM XBPM prototype will be presented.
[1] https://accelconf.web.cern. ch/ibic2022/papers/mop44.pdf

WEPMO24 Design strategy of the Frontend Blade X-ray Beam Position Monitors (FEXBPM) based on the MAX IV experience.

P Ilinski (MAX IV Laboratory)

An overview of performance and operation of Blade FEXBPMs installed at the MAX IV R3 storage ring frontends will be presented. FEXBPM design, position calibration techniques, normalization to the storage ring current, resolution and some deficiencies of the operation will be discussed. Suggestions for design strategy of the Blade FEXBPMs and overall improvements of the FEXBPM based on extensive Blade FEXBPM signal modeling will be presented.

WEPMO25 Suitability of GHz frequency beam position monitors for electron bunch position discrimination in the AWAKE facility

B Spear (John Adams Institute), P Burrows (University of Oxford); C Pakuza, T Lefevre, S Mazzoni, M Krupa, M Wendt (European Organization for Nuclear Research); S Liu (TRIUMF)

The AWAKE facility at CERN utilises proton beam-driven plasma wakefields to accelerate electron bunches in a 10-meter long rubidium plasma cell. Precise monitoring of the electron bunches in the presence of the more intense proton bunches, which have distinct temporal and spatial characteristics, requires a beam position monitor (BPM) operating in the tens of GHz frequency range, assuming Gaussian longitudinal particle distributions. Two types of BPMs, one based on Cherenkov diffraction radiation (ChDR), and the other utilising high frequency (HF) conical shaped pickups, have been explored as a method to distinguish the electromagnetic signals of the shorter electron bunches (a few ps) from those of the longer proton bunches (a couple of hundred ps) co-propagating in the AWAKE beamline. Recent tests of both BPMs in the AWAKE common beamline have been conducted across frequencies

in the range 20 – 110 GHz. The sensitivity of the HF and ChDR BPMs to the electron beam position was determined under various beam conditions, with and without proton bunches present. The read-out, utilising a RF front-end developed by TRIUMF, is additionally discussed.

WEPMO26 Investigation of readout methods for electro-optical beam position monitor pickups

D Harryman (John Adams Institute), A Schloegelhofer, T Lefevre, T Levens (European Organization for Nuclear Research); M Bosman, S Gibson (Royal Holloway University of London)

Electro-optical pickups are being explored at CERN for the development of a high-bandwidth beam position monitor capable of measuring intrabunch beam position. To support this effort, a prototype electro-optical beam position monitor has been installed in the SPS. The installation utilises a fibre-coupled laser directed into lithium niobate crystals. As the beam passes a crystal, its electromagnetic field induces a proportional phase shift in the laser light by altering the crystal's refractive index. Signal readout is typically performed using a Mach-Zehnder interferometric setup, with crystals placed on either side of the beam. This configuration currently faces challenges including imperfect pickup matching, baseline instability, and limited dynamic range. This paper examines and evaluates various methods and techniques for reading out the beam position from the phase-shifted laser to mitigate these limitations.

WEPMO27 Transverse and Longitudinal Beam Diagnostics and Characterizations at IUAC-High Current Injector

R Hariwal (Inter-University Accelerator Centre), C Safvan, G Rodrigues, R Mehta, S Kumar, T Varughese, P Lakshmi, K Mal (Inter-University Accelerator Centre)

The High Current Injector features normal-conducting RF Linac structures intended to accelerate various ion species with a mass-to-charge ratio of up to 6, achieving a maximum output energy of 1.8 MeV/u. It can deliver an intense analyzed beam up to 100pnA at the target. To preserve the beam quality at the target and to improve the performance of RF cavities and beam transmission, both destructive and non-destructive, fast and precise transverse and longitudinal beam diagnostics (including FFCs and CPOs for phase space and ToF measurements) are deployed in LEBT, MEBT and HEBT section of HCI. The beam energy was validated through the existing Surface Barrier Detector measurement setup. Recently, during $^{20}Ne^{9+}$ beam test, we observed a notable energy spread of approximately 1%, which led to pronounced debunching and a complete loss of the necessary signal component in the downstream BPMs. To

mitigate the energy spread, slits have been installed at the image plane of the fourth achromatic bending magnets, and it was observed that optimally adjusting the slits can reduce the spread by over fifty percent. This paper will present the latest measurements, challenges and future plans.

WEPMO28 Synchronisation performance of a fibre-based two-colour balanced optical cross-correlator

J Christie (University of Liverpool), E Snedden (Science and Technology Facilities Council); L Corner (University of Liverpool; Cockcroft Institute)

As part of the ongoing Full-Energy Beam Exploitation (FEBE) upgrade to the CLARA accelerator at Daresbury, few-fs optical synchronisation between the new Ti:Sapphire terawatt FEBE laser and the Er:Yb optical master oscillator (OMO) is required for user experiments. To achieve this, a fibre-based two-colour balanced optical cross-correlator (BOXC) using waveguided periodically-poled lithium niobate (PPLN) crystals is being developed at Daresbury. A fibre-based BOXC could allow for greater sensitivity to timing jitter between two lasers than traditional free-space devices. In this manuscript, the design of the fibre-based two-colour BOXC is presented. By using the BOXC to lock a Ti:Sapphire laser system to the OMO, measurements of the integrated timing jitter performance of the BOXC have been obtained. These results will be discussed along with plans for integrating the fibre-based BOXC into the optical synchronisation network at Daresbury.

WEPMO29 Application of Phase Detectors at the Taiwan Photon Source

C Huang (National Synchrotron Radiation Research Center), C Wu, K Hwa Hu, K Hsu, P Chiu, S Lee (National Synchrotron Radiation Research Center)

A phase detection system has been implemented at the Taiwan Photon Source, employing beam position monitor (BPM) electronics integrated with a digital inphase/quadrature (I/Q) demodulation scheme. This system enables high-resolution analysis of beam phase stability, RF cavity field phase, and synchronization integrity of the RF clock distribution. It also facilitates the investigation of beam phase variations under dynamic operational conditions, including changes in insertion device gaps and booster ramping cycles. This paper presents the operational principles, implementation architecture, and representative experimental results of the developed detector system.

WEPMO30 Design Study of the Beam Position Monitor for the Hadron Center at Kutaisi International University

R Shanidze (Kutaisi International University)

Cyclotron-based proton beams are widely used in research and medical applications due to their capability to deliver bunched beams across a broad range of bunch charges. One of the most critical components in beam diagnostics is the beam position monitor (BPM), which must accurately measure the beam's position while minimizing disturbance to the beam. At Kutaisi International University (KIU), a superconducting synchro-cyclotron (S2C2) provided by Ion Beam Applications (IBA) will be dedicated exclusively to research, supporting diverse experiments that benefit from proton bunched beams of different intensities. To accommodate these experiments, construction of compact beamline is planned. In this work, we present the electromagnetic design study of an electrostatic BPM that can operate effectively address to the physical and operational constraints of the new beamline.

WEPMO31 Noninterceptive beam energy measurement of high-frequency free electron lasers

A Wang (National Synchrotron Radiation Laboratory), Y Leng, Y Deng (University of Science and Technology of China); A Wang (National Synchrotron Radiation Laboratory)

Free electron lasers (FEL), which can generate ultra-high brightness rediation are working horses for radiation science research over the world. For FEL, the higher the repetition frequency of the beam in the device, the higher the user's experimental efficiency, and more experimental stations can conduct experiments simultaneously. Therefore, there is a trend to increase the repetition frequency in its development process. Therefore, it is necessary to develop relevant technologies for high repetition frequency FEL. Beam energy is one of the most fundamental and critical parameters in FEL. This paper developed a fusion algorithm based on beam position monitor (BPM) in the dispersion structure of a FEL, which extracts the transverse position of the beam using both the arrival time and amplitude information of the beam, to achieve high-precision and noninterceptive measurement of beam energy. Provide powerful diagnostic, operational, and maintenance tools for high-frequency free electron laser devices.

WEPMO32 Transverse Beam Position Monitoring and Polarimetry with a Compton Backscattering Polarimeter

M Switka (University of Bonn), D Proft, K Desch (University of Bonn)

The ELSA facility at the University of Bonn uses a storage ring to accelerate polarized electrons up to 3.2 GeV. To monitor the polarization degree of the stored beam a Compton polarimeter is used to analyze the profile of the back-scattered beam of gamma rays. In addition to a silicon microstrip detector with vertical resolution, state-of-the-art pixel detectors are tested for both, polarimetry and monitoring of the electron beam's long-term position and angular stability. The current status of the polarimeter performance is presented.

WEPMO33 Studies of longitudinal phase space tomography using booster cavity and dipole spectrometer

G Kim (Pohang University of Science and Technology), M Chung (Pohang University of Science and Technology)

Information on the longitudinal phase space (LPS) is essential for tuning injectors that deliver a few-femtosecond electron bunches to beam–plasma interaction experiments and ultrafast diffraction facilities. Direct time–energy characterization, however, is challenging due to the limited resolution of conventional diagnostics. To address this, we apply a tomographic algorithm that uses a booster cavity and a downstream dipole spectrometer to indirectly reconstruct the LPS. A phase scan of the booster cavity adjusts the longitudinal chirp, while the dipole converts the correlated energy spread into a transverse distribution on a screen. An iterative algorithm then retrieves the time–energy distribution. Particle tracking simulations confirm that the method successfully reconstructs the LPS structure. Our next step is to verify the technique on the actual beamline, compare the LPS measured using an RF deflecting cavity with the reconstructed distribution, and use the results to guide injector tuning. We also discuss the potential application of the LPS tomography algorithm developed in this study to non-relativistic ion beams, using a re-bunching cavity and a bunch shape monitor.

WEPMO34 Longitudinal bunch profile reconstruction via Cherenkov radiation in optical fibers

M Volpi (The University of Melbourne), P Bennetto, R Dowd (Australian Nuclear Science and Technology Organisation; Australian Synchrotron); P Giansiracusa, R Rassool (The University of Melbourne; Australian Synchrotron); S Sheehy (The University of Melbourne; Australian Nuclear Science and Technology Organisation); Y Tan (Australian Synchrotron; Australian Nuclear Science and Technology Organisation)

Optical beam diagnostics, such as OTR screens and streak cameras, can overcome bandwidth limitations of electronic diagnostics. However, efficient light collection and transport is challenging. At the PEER (Pulsed Energetic Electrons for Research) facility at the Australian Synchrotron (AS), we use Cherenkov radiation (CR) generated in optical fibers to reconstruct longitudinal bunch profiles at ps timescales, using a streak camera. This is enabled by proportionality of emitted CR intensity to incident charge, when electrons directly impact the fiber. Streak cameras have been used to image CR, but generating and transporting CR in the same fiber is novel, simplifying detector design and light transport. We present bunch profile measurements using this technique and assess its feasibility. We quantify distortion of CR due to modal and chromatic dispersion in the fiber, survey methods to reduce distortion, and improve signal-to-noise ratio. Bunch profile measurements at ps resolution may enable bunch purity optimisation and detection of microbunching, previously not possible at PEER. This will greatly benefit PEER users, as well as beam quality in the AS booster and storage rings.

WEPMO35 Novel high-current multichannel ammeter for X-ray Beam Position Monitoring (XBPM) applications

N La Rosa (University of Catania; STLab srl), G Trovato (Institute for Microelectronics and Microsystems; University of Catania; Istituto Nazionale di Fisica Nucleare, Sezione di Catania; STLab srl); M Bucolo, A Amato (University of Catania); S Moscato (University of Catania; STLab srl); M Birri (Paul Scherrer Institute); M Camarda (Institute for Microelectronics and Microsystems; STLab srl; SenSiC GmbH)

This work presents the development and characterization of PCR4, a novel pico-to-milli ammeter jointly developed by STLab srl and SenSiC GmbH, specifically designed for applications requiring high-current readout, allowing for monochromatic and polychromatic beams measurement. PCR4 features four independent channels, each with 24-bit resolution, a 10 kHz sampling rate, and an ultra-wide dynamic range spanning 9 decades - from 1 pA to 50 mA. The system is optimized for non-destructive white-beam X-ray detection and incorporates an integrated bipolar voltage bias source (-20 V to +20V), facilitating the commissioning of Silicon Carbide (SiC) sensors and allowing pre-installation dark current measurements. A detailed metrological characterization will be presented, including spectral noise density, linearity, dynamic range, signal-to-noise ratio (SNR), and long-term stability across varying input capacitances. Additionally, the integration of feedback control loops into the system and strategies for further bandwidth extension will be discussed, with the aim

of supporting low-latency orbit feedback systems operating at 10 kHz.

WEPMO36 Concepts for beam diagnostics based on planar pickups on a printed circuit board

B Scheible (Technische Hochschule Mittelhessen), A Penirschke (T echnische Hochschule Mittelhessen); H De Gersem, W Ackermann (Technical University of Darmstadt); H Schlarb, M Kristin Czwalinna (Deutsches Elektronen-Synchrotron DESY); M Kuntzsch (Helmholtz-Zentrum Dresden-Rossendorf)

For the upgrade of the electro-optical bunch arrival-time monitors (EO-BAMs) employed at several X-ray free-electron laser (XFEL) facilities, a novel pickup structure has been proposed, and its feasibility was successfully tested at the ELBE accelerator. The design, comprising planar pickups on a printed circuit board (PCB) with an integrated combination network, delivers a significantly stronger signal compared to established pickups. Applying the upgrade to existing machines enables two key capabilities: Reliable operation at 1 pC charge levels for XFELs and ultrafast electron diffraction facilities, and enhanced arrival-time resolution for standard operational modes. Furthermore, the PCB implementation enables unprecedented flexibility in planar pickup design, facilitating multi-functional diagnostic capabilities. This work presents a compact implementation strategy for integrating high- and low-resolution channels for EO-BAMs on a single substrate through an optimized dual-functionality layout, and conceptual advancements in beam diagnostics using an PCB architecture for measuring other beam properties.

WEPMO37 Development of Ultra-broadband Direct THz Detectors based on Schottky diodes and AlGaAs/GaAs FETs for Longitudinal Beam Diagnostics

R Yadav (Technical University of Darmstadt), Bernhard Scheible, M Salman, B Scheible, A Penirschke (Technische Hochschule Mittelhessen); F Bek, F Rushd Faridi, S Preu (Technical University of Darmstadt); M Kuntzsch, J Michael Klopf (Helmholtz-Zentrum Dresden-Rossendorf)

Many currently operating and future FELs can generate broadband radiation at MHz repetition rate, requiring a fast diagnostic tool(response time at least on a single-digit ns scale),ultra-broadband, & robustness. We develop ultrafast-operating THz detectors based on Schottky-diodes*,** and field-effect transistors (FET)***operating at room temperature. We present four critical features of our newly developed detectors:(1) frequency coverage: ultra-broadband single-pixel THz detectors (based on both technologies) covering 0.05 to 54.8 THz, which essentially

covers full operational spectral range of the ELBE facility in Dresden-Rossendorf, Germany,(2) ultra-wide band IF bandwidth up to ~50 GHz: this enables single shot detection of ps-scale THz pulses with response time in ps range (overcome the pile up issue faced by its counterparts),(3) bunch compression monitoring capability from single-digit pC to ~220 pC: this is essential for precise machine settings for desired beam parameter output, and(4) Radiation hardness examination of the developed detectors for their smooth operation at accelerator facilities. These detectors can be implemented at other accelerators and FEL facilities.

WEPMO38 High-Frequency Beam Position Monitoring: A 500 MHz BPM System by Safran

J Fernández (Safran Electronics & Defense Spain S.L.), J Benavides, P Gil (Safran Electronics & Defense Spain S.L.); J Gabriel Ramírez Escalona (Safran (France)

Beam Position Monitors (BPMs) are essential diagnostic tools in any particle accelerator, as they provide accurate measurements of the beam's position, phase, and intensity along the accelerator line. Safran Electronics & Defense, Spain is responsible for the complete design, implementation, production, and validation of a BPM electronic system tailored to project-specific requirements. Operating at a frequency of 500 MHz, the system has undergone initial testing at Safran's facilities, yielding promising preliminary results. This paper presents the overall system architecture, the design and development process, and an overview of the system's performance. It also highlights the advantages of the chosen architecture and summarizes the results obtained under various testing scenarios.

WEPMO39 Machine learning based image processing technology for longitudinal phase space analysis in a compact THz-FEL

A Lei (Huazhong University of Science and Technology), Q Chen, R Luo (Huazhong University of Science and Technology)

The longitudinal phase space characterization of electron bunches plays a crucial role in operational optimization of accelerator facilities. Currently, the terahertz free-electron laser (THz-FEL) facility at Huazhong University of Science and Technology (HUST) uses a combined deflecting cavity and dipole magnet system for longitudinal phase space measurements of bunches. In order to achieve non-intercepting measurements and also for automated parameter optimization, we developed an image-based virtual diagnostic system utilizing convolutional neural networks trained on simulated bunch data. Our preliminary

results demonstrate successful longitudinal phase space reconstruction of the injector output bunch with prediction accuracy exceeding 85%.

WEPMO40 Optimization and Upgrade of the BPM Electronics System for CSNS-II RCS

R Qiu (Institute of High Energy Physics), F Li, L Zeng, M Abdul Rehman, R Yang, W Huang, W Chen, Z Xu (Institute of High Energy Physics)

As the China Spallation Neutron Source (CSNS) Phase II project increases the Rapid Cycling Synchrotron (RCS) power to 500 kW, the signal intensity of Beam Position Monitors (BPMs) is expected to rise tenfold, necessitating a comprehensive upgrade of the electronics system to meet high-power operational requirements. Drawing on the experience of the J-PARC Main Ring (MR) 1.3 MW power upgrade, CSNS optimized the analog front-end using a MicroTCA-based RTM board. The initial four-stage passive resistive divider was upgraded to a switchable attenuator combined with proportional voltage division, alongside impedance matching techniques, ensuring stable signal attenuation under high input voltages, minimal reflections, and compatibility with the Analog-to-Digital Converter (ADC) dynamic range. The digital processing is implemented on a self-developed MicroTCA.4-based AMC board, utilizing the Xilinx Zynq-7045 SoC with 8 channels of 16-bit ADC (125 MSPS). The system has successfully transplanted algorithms, supports real-time beam position calculations, and publishes position signals via EPICS. Tests demonstrate low noise, high linearity, and performance.

Special Issue

Selected Papers from the 14th International Beam Instrumentation Conference (IBIC2025)

Message from the Guest Editors

The 14th International Beam Instrumentation Conference (IBIC 2025) will be held in England in the beautiful city of Liverpool between 7th–11th September 2025. The conference will be jointly hosted by STFC, the Cockcroft Institute and the John Adams Institute. IBIC is dedicated to exploring the physics and engineering challenges of beam diagnostic and measurement techniques for particle accelerators worldwide. It brings together the international community of experts in instrumentation for particle accelerators. The conference programme includes tutorials on selected topics, invited and selected talks, as well as poster sessions. The scientific programme is complemented by an industry exhibition featuring product manufacturers and service providers as well as social events to encourage informal knowledge exchange. We are delighted to announce that this Special Issue of *Instruments* will allow conference delegates to publish an expanded version of their conference proceedings in a peer-reviewed journal with global reach and impact.

Guest Editors

Prof. Dr. Carsten P. Welsch

Mrs. Tonia Batten

Prof. Dr. Alessandro Cianchi

Dr. Thibaut Lefevre

Dr. Junxia Wu

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THA: Oral Presentations

09:00 Experimental Investigation of Selective Photo-Detachment for Longitudinal Scraping in H^- Linacs

THAI01 **P Landon (Boston University)**

Longitudinal emittance growth is a critical challenge in RF linacs. We propose a novel solution to mitigate this issue: employing temporally spaced laser pulses to selectively photo-detach electrons from the longitudinal head and tail regions of H- ion bunches. This removal is theorized to reduce particle distributions in the extreme orbits, thereby improving beam uniformity and minimizing emittance growth. Our experimental investigation used the LaserNotcher system at the front end of Fermilab's linac. The laser delivers peak powers of 1.6 MW with sub-nanosecond temporal precision. Using this system, we successfully neutralized the first and last half-nanosecond of several H- bunches, which were subsequently propagated through the linac and injected into the booster. Data on pulse width, average height, and temporal spacing over several booster cycles were measured for both the scraped and unscraped bunches. Statistical analysis was done to evaluate the significance of these results. This study aims to assess the feasibility of laser-based scraping systems in future linac designs and their potential to enable higher beam energies with improved emittance control.

09:30 Multi-Facility Virtual Diagnostic for Longitudinal Phase Space Imaging

THAI02 **J Lundquist (MAX IV Laboratory),** E Mansten, S Werin (MAX IV Laboratory); F Curbis (Lund University); G Penco (Elettra-Sincrotrone Trieste S.C.p.A.); P Dijkstal (Paul Scherrer Institut)

A thorough understanding of the Longitudinal Phase Space (LPS) of the electron beam is of great advantage to any modern linear accelerator, and of critical importance for operating a Free Electron Laser (FEL). A diagnostic system equipped with a Transverse Deflecting Structure (TDS) allows full imaging of a beam's LPS. However, measurements with a TDS are not always easily accessible and are often destructive. In this talk, we present an application of machine learning in the form of a virtual diagnostic which allows for online extraction of the beam's LPS based on non-destructive measurements. We present how such virtual diagnostics have been developed and tested for three different accelerators: the MAX IV linac and the FELs at FERMI and SwissFEL. We show how a single, general network architecture and training set up can be used to reach reliable predictions of the LPS for all three facilities.

For future work, we show how virtual diagnostics could be further developed to suit the specific needs of operations at each facility.

10:00 **Characterization of sub-femto-second pulse duration of low-charge electron bunches using a Bunch-Compressor-Monitor at SwissFEL**

THAC01

G Luca Orlandi (Paul Scherrer Institute), E Prat, F Addesa, P Dijkstal, R Ischebeck, S Meaney, S Reiche, T Schietinger (Paul Scherrer Institute)

The absolute characterization of the electron pulse duration- bunch length - in the ultra-short and low- charge (3-10 pC) operation mode of SwissFEL is relevant to a deeper understanding of the spectral structure and broad-band distribution of the resultant Free-Electron-Laser (FEL) pulse. Under this operation mode of SwissFEL, the output signals of the Bunch-Compressor-Monitor (BCM) in operation after the final magnetic chicane (ECOL) of the hard x-ray undulator line of SwissFEL (Aramis) can be suitably processed to obtain an absolute characterization of the electron bunch-length. This is possible in the ECOL-BCM thanks to the simultaneous detection of the Edge-Synchrotron radiation pulse in two different and partially overlapping spectral bands by means of a pyro-detector and an optical fiber spectrometer. Experimental results on the absolute characterization of the electron bunch-length at the ultra-short and low-charge operation mode of SwissFEL will be presented together with details on the formal method applied for processing the two output signals of the ECOL-BCM.

THB: Oral Presentations

10:50 High-performance bunch arrival time monitors with fs precision at DESY

THBC01 **J Kral (Deutsches Elektronen-Synchrotron DESY),** J Georg, M Büchler, J Roever, M Kristin Czwalinna (Deutsches Elektronen-Synchrotron DESY)

Pump-probe experiments at Free-Electron Laser facilities depend heavily on the relative timing precision of the pump and the probe, which determines the resolution of the observed ultrafast phenomena. The DESY's Bunch Arrival Time Monitors (BAM) are state-of-the-art sensors based on an electro-optical detection principle, that delivers information on the bunch timing with unprecedented femtosecond-level precision. Timing synchronization at machine level is achieved through a complex system of arrival time sensors, stabilized optical distribution, and feedback controls. Major advances in the performance, construction, and operation of the BAMs are discussed in detail. Integration of the sensor into the synchronization system, and important global optimization and interplay are mentioned as well. These improvements enabled a synchronization of the electron beam with a world-leading precision of less than 3 fs at European XFEL.

11:10 Positronium Laser Cooling: A Science Highlight and Instrumentation Challenges

THBI01 **B Rienäcker (University of Liverpool)**

The successful laser cooling of positronium (Ps) via the 1^3S – 2^3P transition using broadband laser pulses, recognized as a Physics World Top 10 breakthrough in 2024, marked a milestone in antimatter research. Ps, a bound state of a positron and electron, posed significant challenges due to its 142 ns lifetime and broad Doppler profile. Achieved by the AEgIS collaboration at CERN, this breakthrough relied on precise positron beam control from a Surko-style buffer gas trap, nano-engineered positron-to-positronium converters, and advanced detection systems. This contribution highlights the instrumentation challenges underlying this success, including stabilizing and fine-tuning the positron beam with advanced magnetic and electrostatic confinement, nanosecond-level synchronization of laser pulses, and high-resolution, low-noise detection systems. These developments enabled positronium cooling and laid the groundwork for precision antimatter studies, underscoring the critical role of beam stability, timing, and diagnostics in fundamental physics.

11:40 IBIC 2026

11:50 Closing Remarks