Diagnostics Upgrade at FLASH

Upgrade and Status of Standard Diagnostics-Systems at FLASH and FLASHForward

Nicoleta Baboi, DESY, Hamburg
IBIC 2018, Shanghai, 10 Sep. 2018

DESY.
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

Contents

FLASH
Free-electron laser FLASH

http://flash.desy.de/

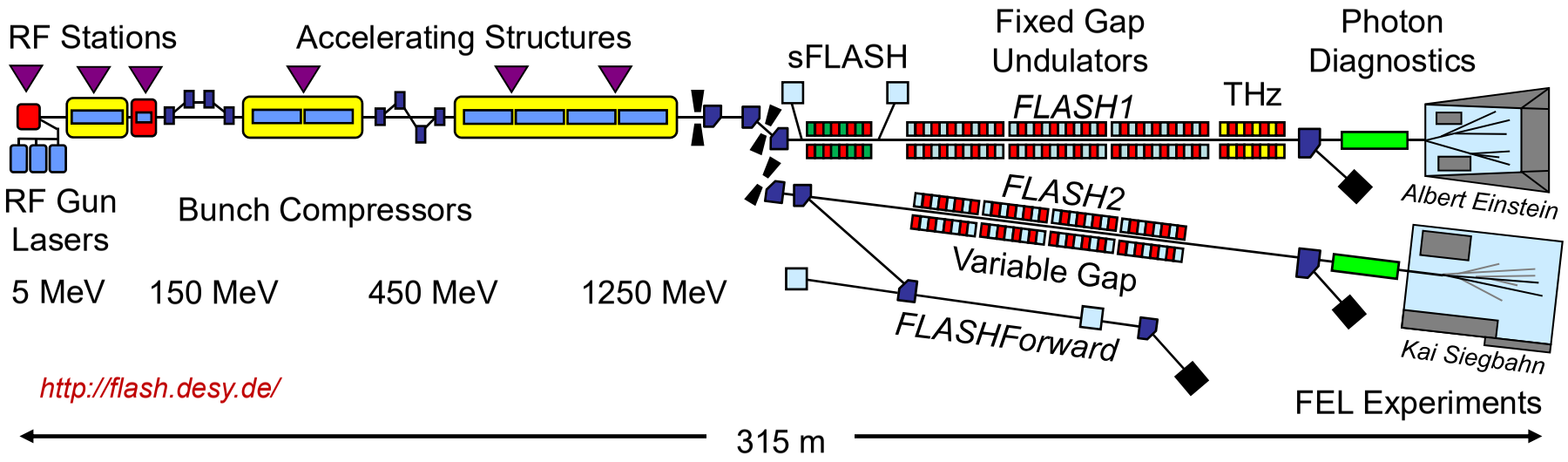
1. Introduction

FLASH

FLASH
Free-electron laser FLASH

- Superconducting FEL user facility
- 3 beamlines:
  2 user undulator beamlines
  and 1 plasma experiment
  (FLASHForward)
- 3 injector lasers

Some linac parameters		
Train repetition freq.	10	Hz
Intra-train bunch freq.	≤ 1	MHz
Typical train duration	400-600	μs
Typical bunch charge	0.1-1	nC
Electron beam energy	0.35-1.25	GeV

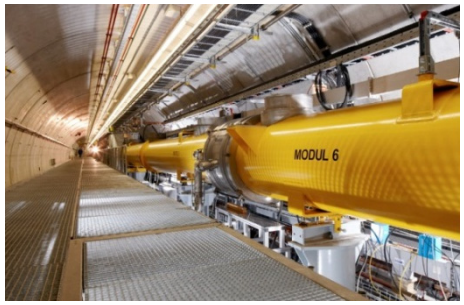


1. Introduction

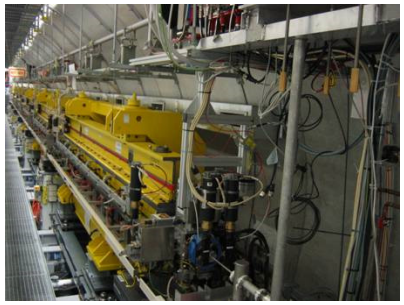
FLASH (2)

FLASH
Free-electron laser FLASH

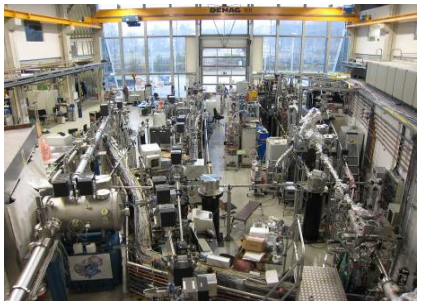
> Normal conducting RF gun
> Ce_2Te cathode
> Three photocathode lasers



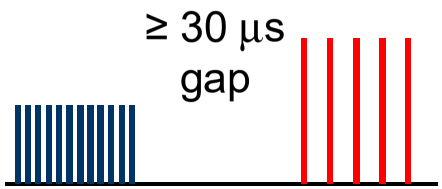
> TESLA type superconducting accelerating modules 1.3 GHz



> FLASH1 fixed gap undulators



> FLASH1 Experimental Hall



> Extraction to FLASH2

> FLASH2 variable gap undulators

> FLASH2 Experimental Hall

Courtesy: DESY

1. Introduction

Standard Diagnostics at FLASH

System	Electronics Type	#
Charge monitors	E-XFEL	19
Button BPMs	FLASH	39
Stripline BPMs	FLASH	34
Magnetic BPMs	FLASH	2
Cold Cavity BPMs	TTF2	6
Cavity BPMs	E-XFEL	21
Screen Stations	E-XFEL & TTF2	32
Wire Scanners	TTF2	7
BLMs	E-XFEL	162
Beam Halo Monitors	E-XFEL	2
& others		

- Many systems developed for the European XFEL and FLASH2
  - Replaced VME-based systems
  - Mostly bunch-by-bunch systems
- MTCA-based
  - Also used by other systems
  - Resources sharing: Crate, CPU, power supply etc.
  - Easier maintenance
  - Synergies in hard- and firmware development
- Some TTF2-type systems remain
  - Vacuum work needed for their upgrade

*D. Nölle et al., **TUOA01**, IBIC 2018 (E-XFEL)*
N. Baboi et al., THIXB1, IBIC 2014 (FLASH2)

2. Upgraded Diagnostic Systems

FLASH
Free-electron laser FLASH

Overview

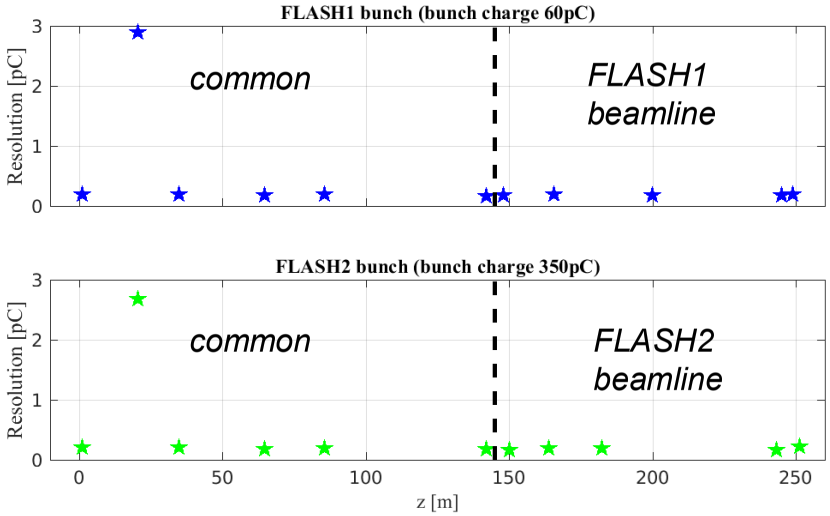
- Upgrade and further improvement of systems designed for the European XFEL and FLASH2
- Installation of fully new systems in FLASHForward
- Partial replacement of old, VME-based systems in the old part of the linac (common part and FLASH1 beamline) with the new, improved systems
  - Toroid
  - BPM
  - BLM

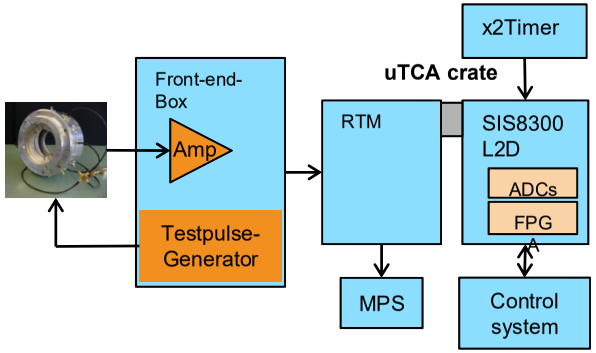
  } same vacuum parts remain
- Minor work on other systems
  - ADC upgrade from VME to MTCA-type

2. Upgraded Diagnostic Systems

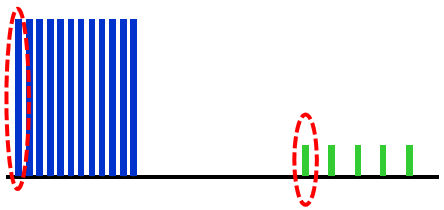
Charge Monitor (Toroid)

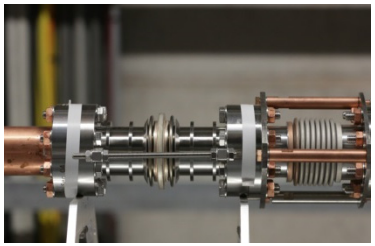
- MTCA-based electronics developed for the E-XFEL
  - Replaced TTF2 electronics and temporary solution
  - No automatic re-adjustment of trigger → detect changes in laser timing
- Transmission interlock
  - Single, slice and integration alarm

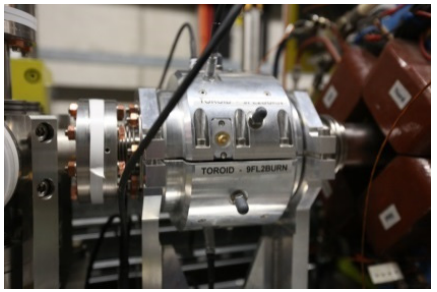




Single bunch resolution: 0.2 pC rms





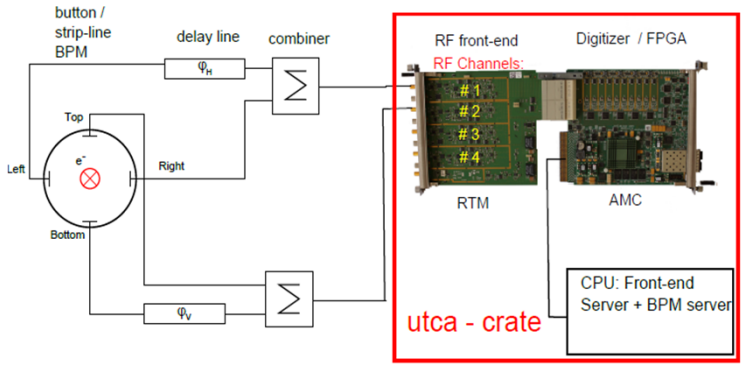


see also M. Werner, WEPF02, IBIC 2014

2. Upgraded Diagnostic Systems

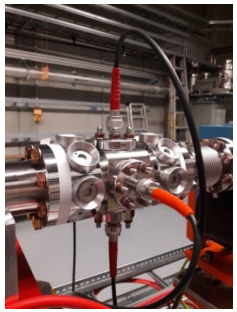
Stripline and Button BPM

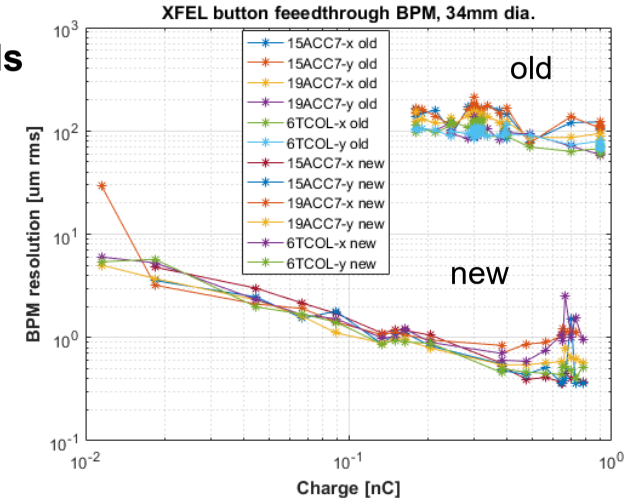
- MTCA-based electronics initially developed for FLASH2; upgraded version:
  - Two BPMs (4 channels) connected one RTM;
  - Automatic firmware adjustment to the signal peak;
  - Addition of on-board test circuit, improved sensitivity, signal integrity and channel separation, etc.



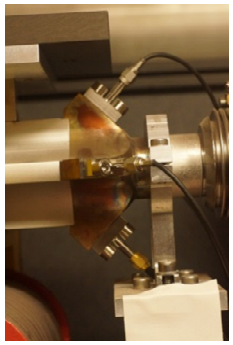
Single bunch resolution: ≤1 μm /100pC

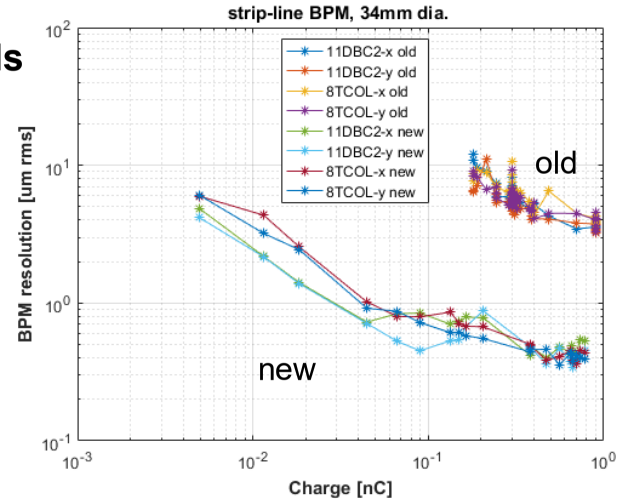
Button BPMs





Stripline BPMs





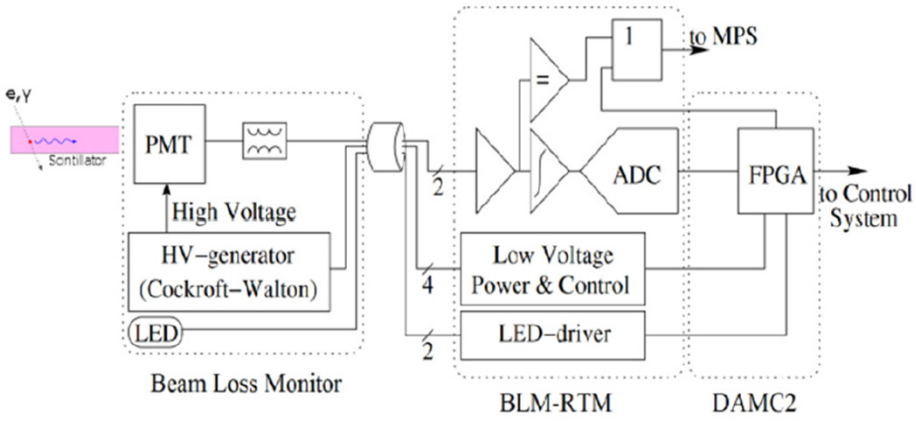
B. Lorbeer et al., IBIC2015, TUPB014; B. Lorbeer et al., IPAC2018, WEPAF048

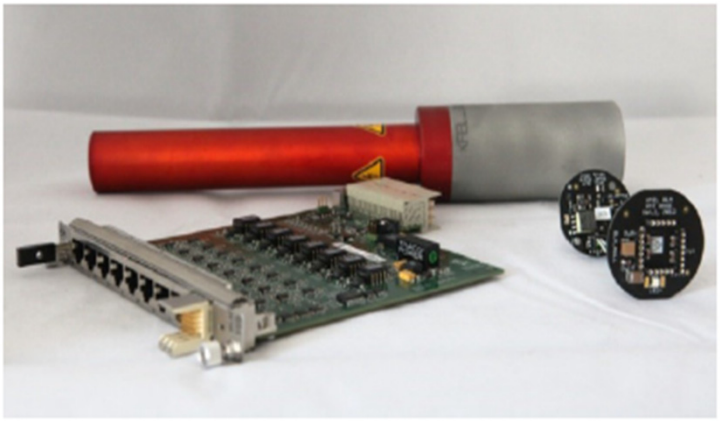
2. Upgraded Diagnostic Systems

BLM

- MTCA-based electronics developed for the E-XFEL
- Alarms are send to MPS: single bunch, multi-bunch and integration alarms
- Masking of special bunches

*T. Wamsat, **WEOB03**, IBIC2018*





- Beam Halo Monitors (BHM):
  - diamond and sapphire sensors
  - use the same electronics, except for a specially designed box for HV generation and signal matching

A. Ignatenko, IPAC 2012, p. 816

2. Upgraded Diagnostic Systems

FLASH
Free-electron laser FLASH

Other Monitors

- ADC upgrade: VME-type replaced with MTCA-type (SIS8300)

- Cold Cavity BPMs
  - In 6 accelerating modules; 1.5 GHz; I/Q electronics

R. Lorenz et al., PAC97, p. 2137

- Faraday Cups:
  - One fixed and two movable monitors
- Ionization chambers
  - Air filled Heliax cables; along last 2m of beamline, before dump vacuum window

N. Baboi et al., BIW10, p. 420

- Dark Current Monitor (DCM, aka DaMon)
  - Non-destructive monitoring

D. Lipka et al., BIW10, p. 572

- HOM-based beam diagnostics (next) in accelerating cavities
  - Based on same principle as cavity BPMs

S. Molloy et al., Measur.Sci.Tech. 18 (2007) 2314-2319
*J. Wei, **TUPB07**, IBIC2018*

3. Status of Other Monitors

FLASH
Free-electron laser FLASH

- Screen stations
  - E-XFEL type: LYSO:Ce screens ⊥ to the beam axis; Camera under 45deg → suppress potential COTR radiation.

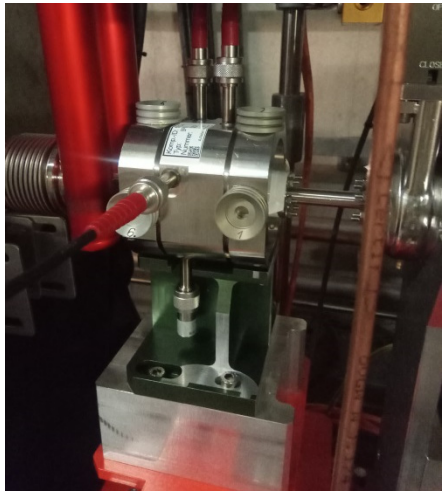
    C. Wiebers et al., IBIC2013, p. 807
  - TTF2-type: 45deg OTR screens

    K. Honkavaara et al., Conf.Proc. C030512 (2003) 2476
- Wire scanners
  - Only stations in undulator maintained → match beam into this section

    D. Nölle, EPAC 2002, p. 242
- Cherenkov fibres (loss monitors)
  - Installed in both main undulators

    W. Goettmann et al., DIPAC 2007, p. 123
- Cavity BPMs
  - Developed for the E-XFEL
  - 3.3 GHz
  - 2 types: 10 and 40.5mm beam-pipe
  - Single bunch resolution < 2 μm rms

D. Lipka et al., IBIC2014, p. 315



10mm cavity BPM

4. Summary and Outlook

FLASH
Free-electron laser FLASH

- MTCA-based diagnostics has been developed for the E-XFEL and FLASH
- Further upgrades and improvements have been made recently
- New systems installed in FLASH2 and FLASHForward, partial replacement in old part of facility
  - Major changes for toroid, button and stripline BPMs, BLMs
  - ADC replaced for several systems: cold cavity BPMs, ionization chambers, DCM etc.
- Status or further monitor presented: screen stations, wire scanners, cavity BPMs etc.
- Outlook:
  - Replacement of button type BPMs with cavity BPMs between undulators
  - Replacement of TTF2 screen stations and wire scanners with new type, possibly new development.
  - 2 accelerating modules will lead to the replacement of 2 cold cavity BPMs with E-XFEL cold button BPMs.

- **Thanks to the many people who directly or indirectly contributed to the work presented here!**

Thank you!

Contact

DESY. Deutsches
Elektronen-Synchrotron

www.desy.de

Nicoleta Baboi
MDI
E-mail: nicoleta.baboi@desy.de
Phone: +49 40 8998 3052