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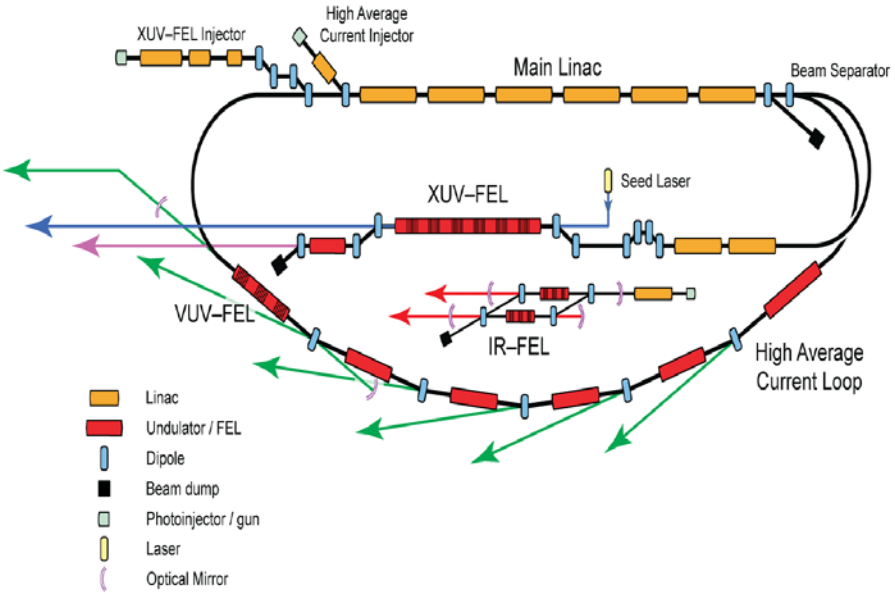
ALICE Beam Loss Monitoring System

Susan Smith for Steve Buckley

Motivation in ALICE = ERLP

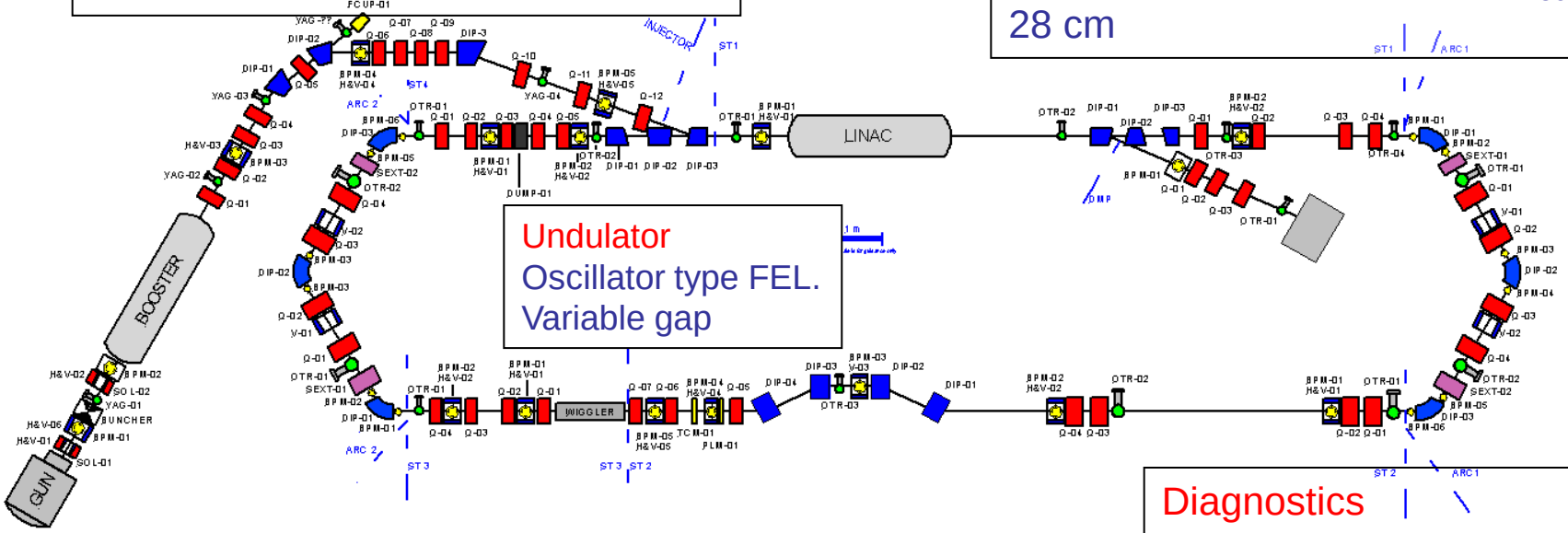


100 mA @ 600 MeV
60MW

ALICE Machine Description

RF System
Superconducting booster + linac
9-cell cavities. 1.3 GHz, ~10 MV/m.
Pulsed up to 10 Hz, 100 μS bunch trains

Beam transport system.
Triple bend achromatic arcs.
First arc isochronous
Bunch compression chicane R_{56} = 28 cm



Undulator
Oscillator type FEL.
Variable gap

DC Gun + Photo Injector Laser
230 kV
GaAs cathode
Up to 100 pC bunch charge
Up to 81.25 MHz rep rate

TW laser
For Compton Backscattering and EO
~70 fs duration, 10 Hz
Ti Sapphire

Diagnostics
YAG/OTR screens + stripline BPMs
Electro-optic bunch profile monitor

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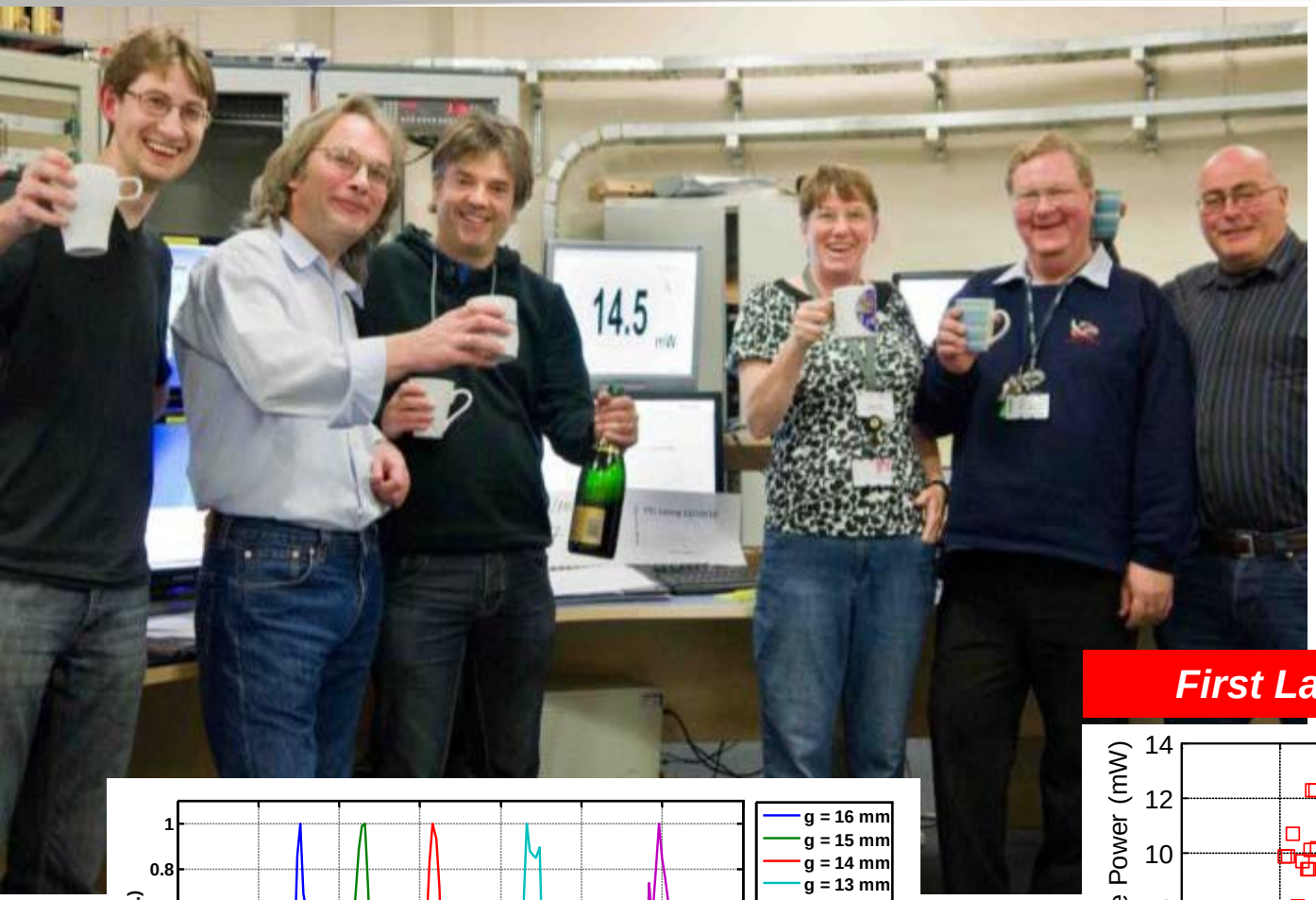
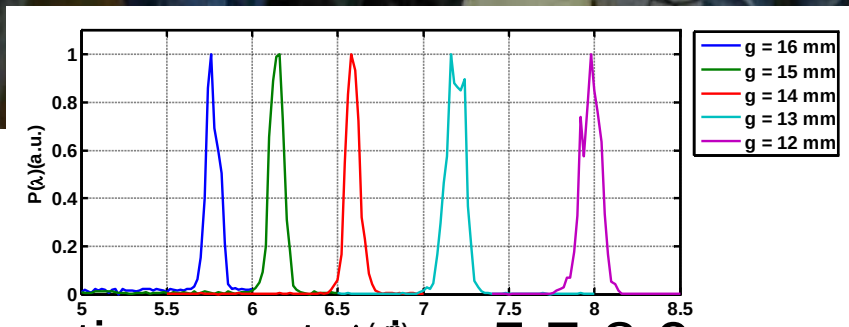
23rd October 2010: ALICE FEL First Lasing



Lasing
100-40 pC @
16.25 MHz

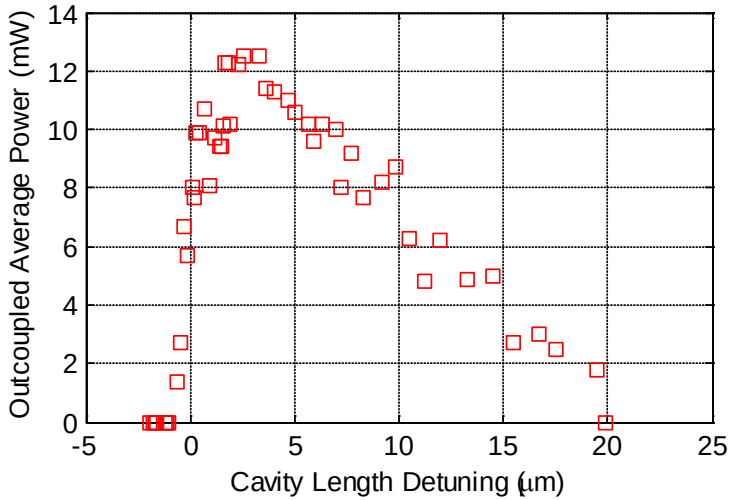
The peak power ~3 MW

Single pass gain ~20 %



Continuous tuning 5.7-8.0 μm, varying undulator gap.

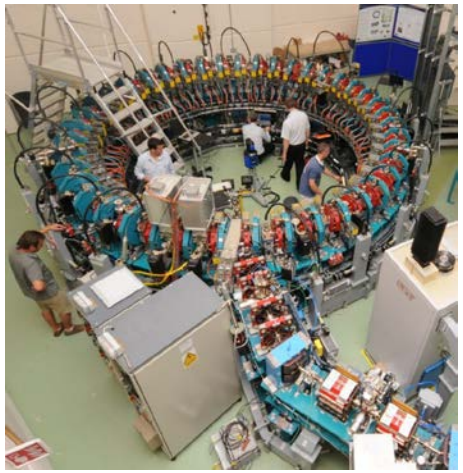
First Lasing Data: 23/10/10

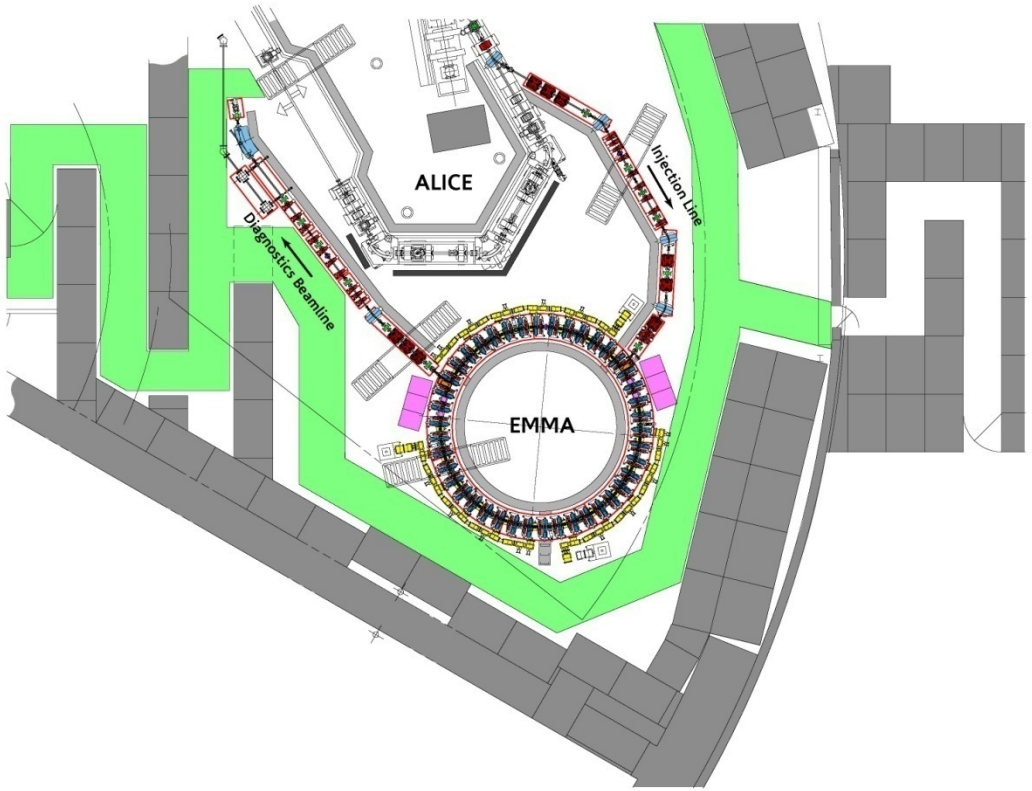


2011: EMMA

- First extraction of beam from the ring (March)
- First acceleration in EMMA (March)
- Acceleration by EMMA : 12 → 21MeV (April)
- Proof-of-principle demonstrated
- Paper to Nature Physics submitted (and accepted ?)
- ... to be continued

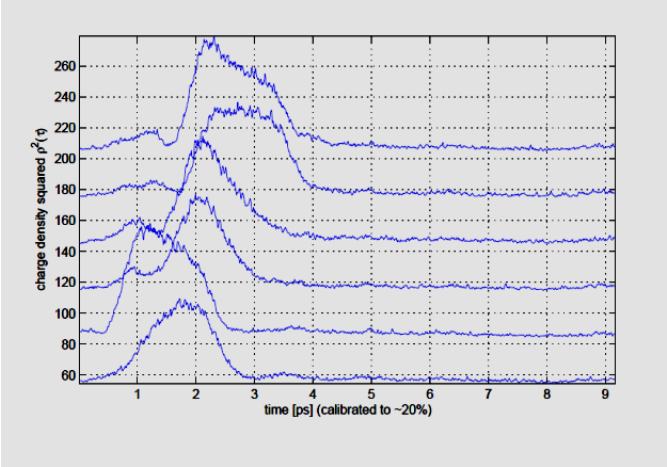
First NS FFAG “EMMA”: Successful International Collaboration

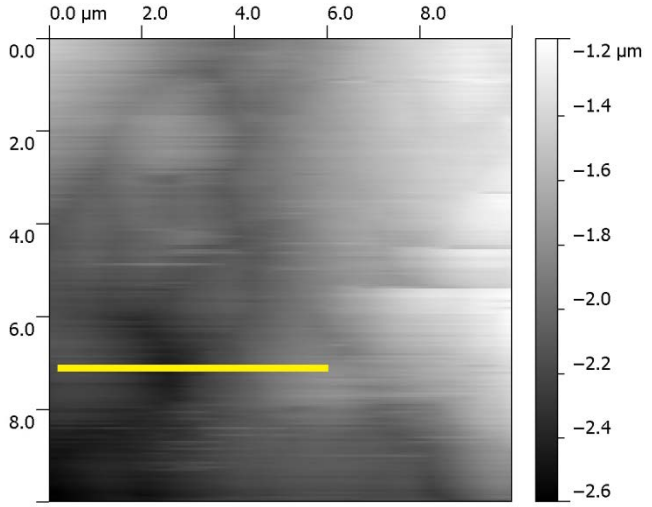




2011: FEL and FELIS

- FEL beam transported to the Diagnostic room (March)
- Scanning Near-field Optical Microscope (SNOM) installed
  received from Vanderbuilt Uni.
- Free Electron Laser integration with
  Scanning Near-field Optical Microscope →FELIS
- First SNOM image (September)
- Short e-bunch characterisation with EO diagnostic





Electro-optic bunch profile measurement (ZnTe crystal probed by Ti Sapphire laser)

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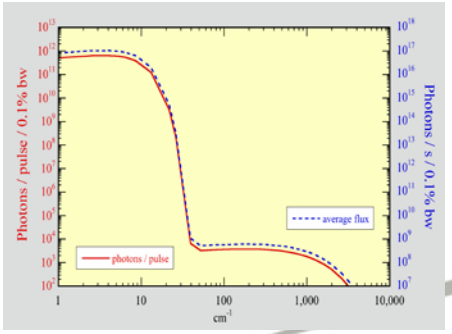
2011: THz for biology

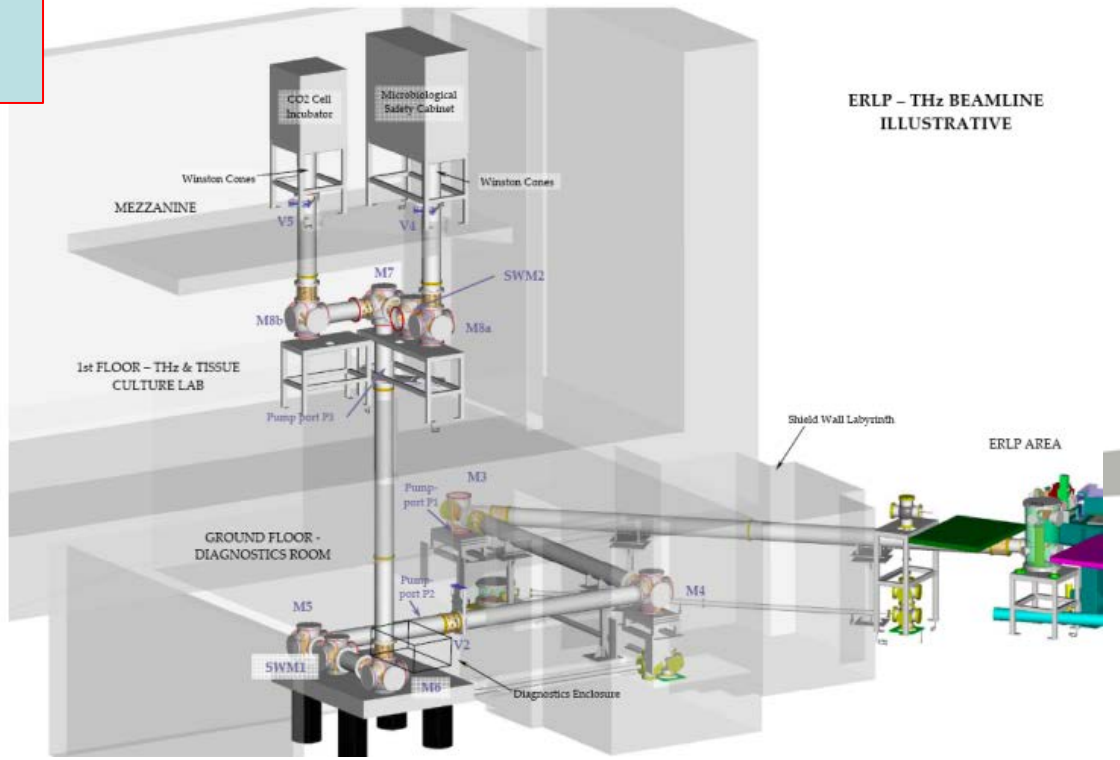
ALICE : a source of high power broadband coherently enhanced THz radiation

- THz beam transported to the TCL (Tissue Culture Lab) that's ~ 30m away from chicane
- Biological experiments in TCL started (June)

Estimate > 10 KW in single THz pulse with ~ 20% transport efficiency to TCL

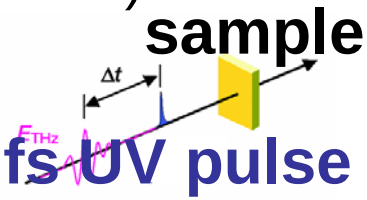
Research program to determine safe limits of exposure of human cells to THz and effect of THz on differentiation of stem cells





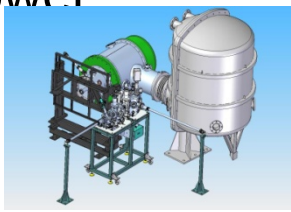
2011: Other developments

- Quantum dots studies for novel solar cells (with Manchester Uni.)
  - employs high power THz from ALICE

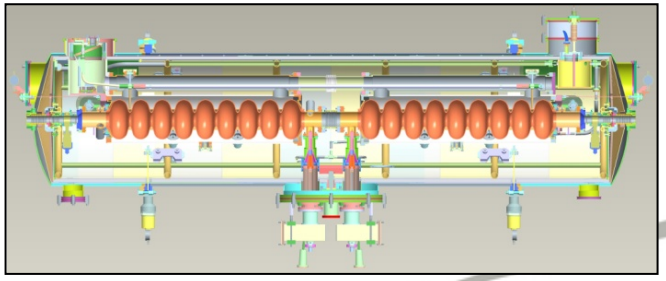


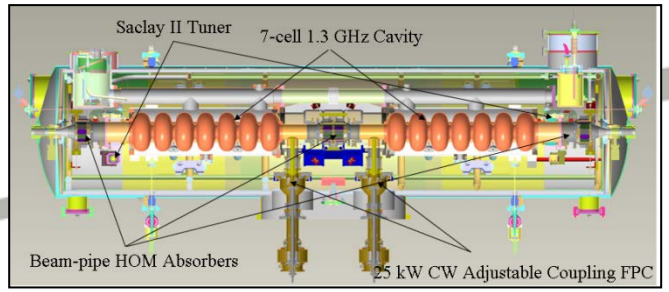
- Timing and synchronisation experiments
  - fibre-ring-laser-based system;
  - aims for sub-10fs timing distribution for future light sources

- Digital LLRF development
- Experiments on interaction of short electron bunches with high power electromagnetic radiation
- Photocathode research



- DICC: International collaboration on SC cryomodule development





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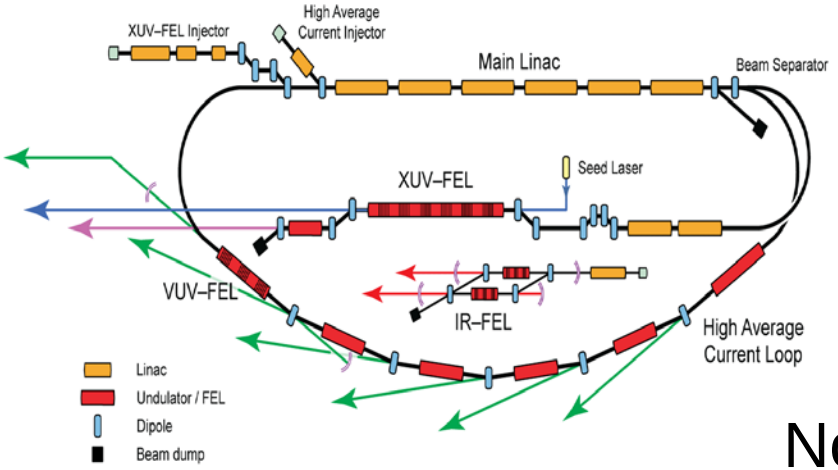
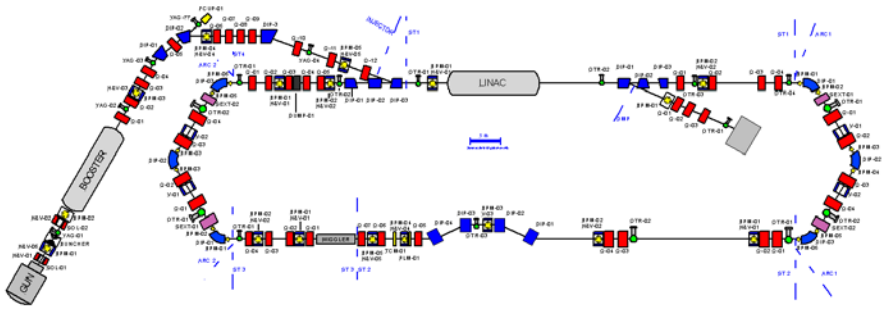
4GLS



ALICE



	Nominal (“routine maximum”)
Bunch Charge 77pC	77 (60)pC
Rep Rate 1.3 GHz	81.25 (40.6)MHz
Duty factor CW	100 us train with 20(10)Hz Rep rate
Current 100 mA	12.5 (2.4)uA
Energy 600 MeV	35 (27) MeV
Beam Power 60 MW	438 (68)W

Objectives

- Protect equipment
  - Disable drive laser if losses exceed preset threshold
- Optimise machine set-up
  - Monitor losses to optimise beam steering

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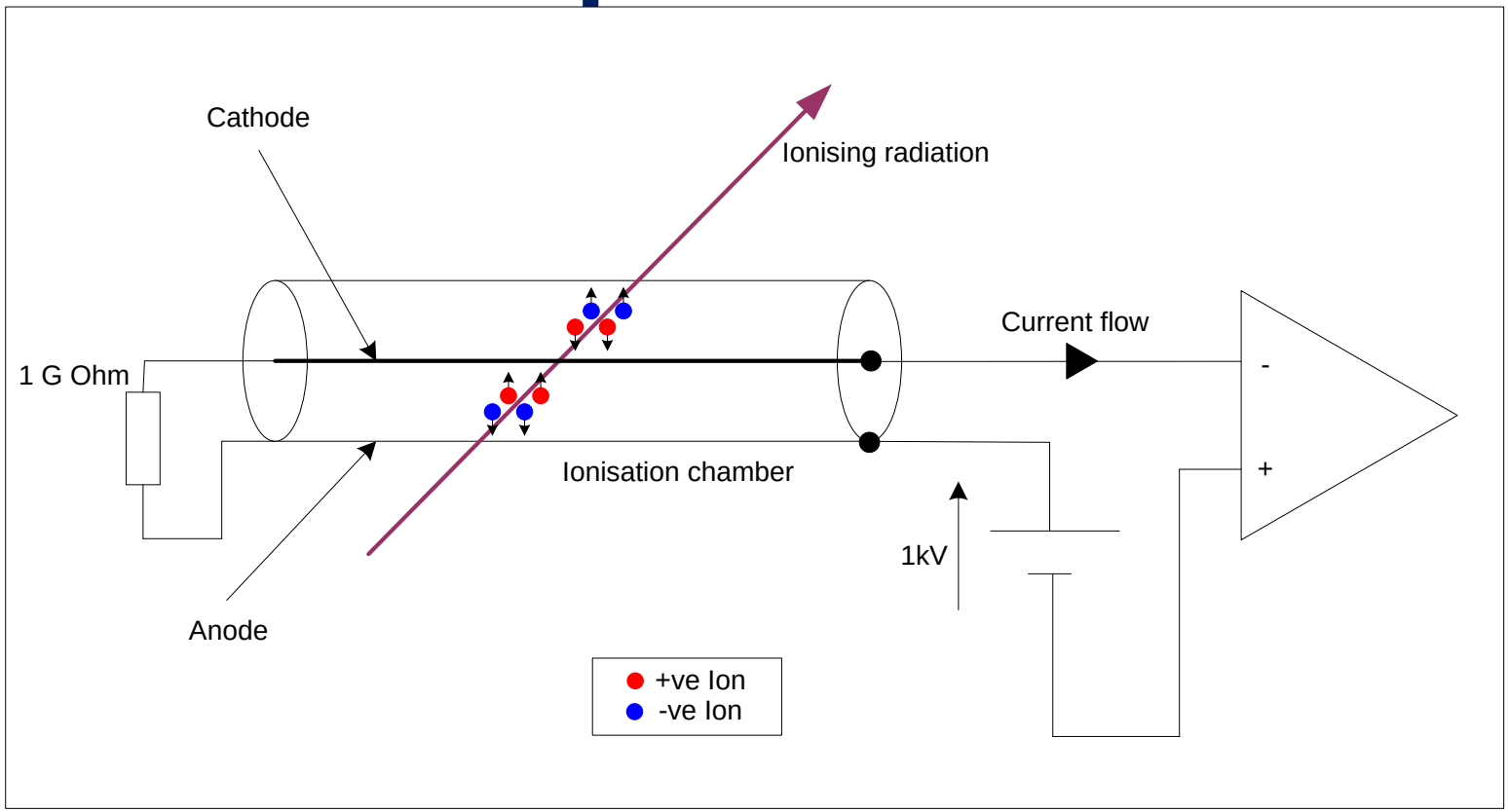
Beam Loss Monitoring System Hardware

- Long Ionisation Chambers (LIC)
  - Andrew HJ4-50 coaxial cable
- Current Difference Monitor (CDM)
  - Uses beam position monitor sum signal and compares upstream with downstream.

Belts & Braces (Suspenders)

Long Ionisation Chambers Operation



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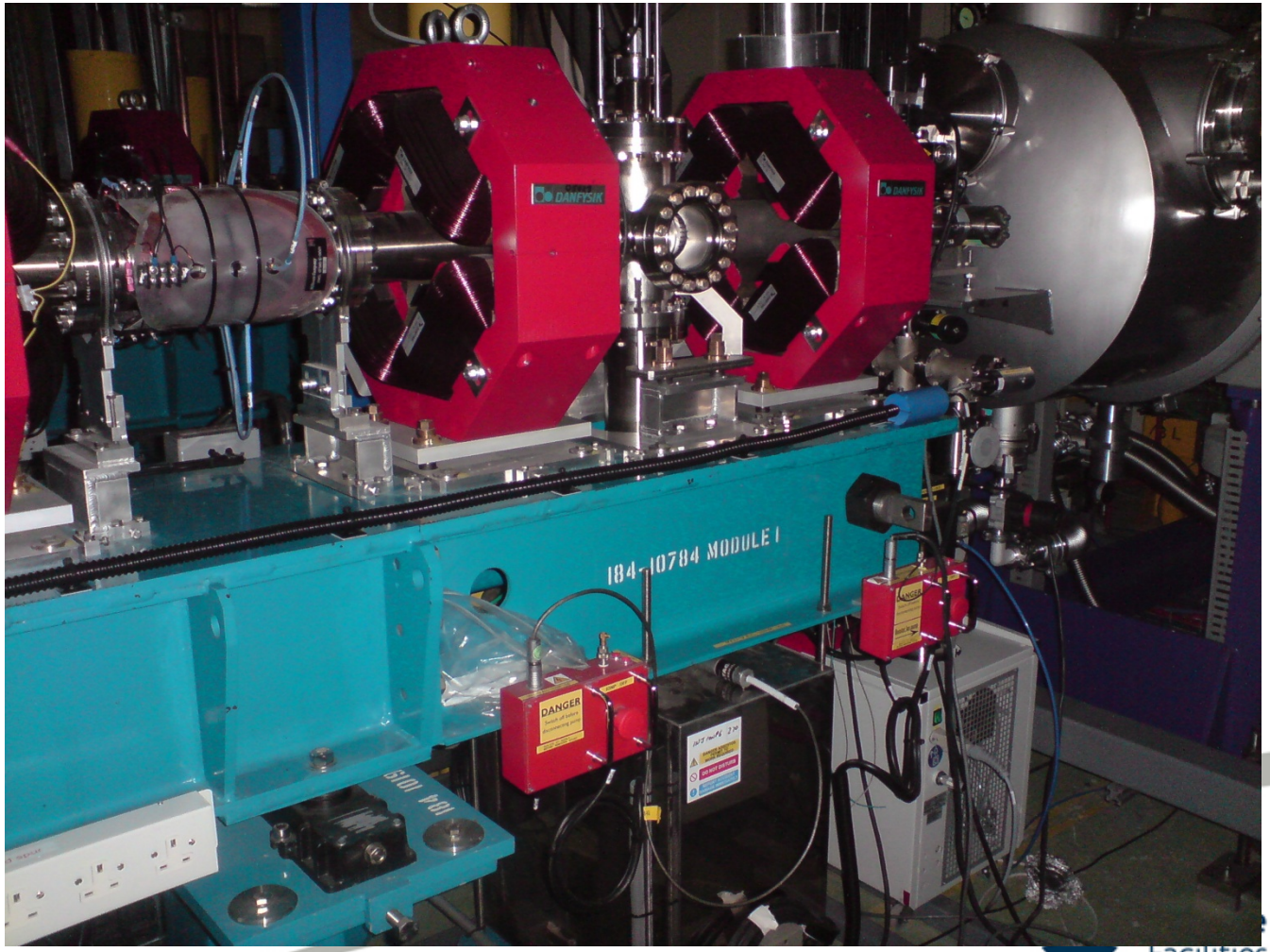
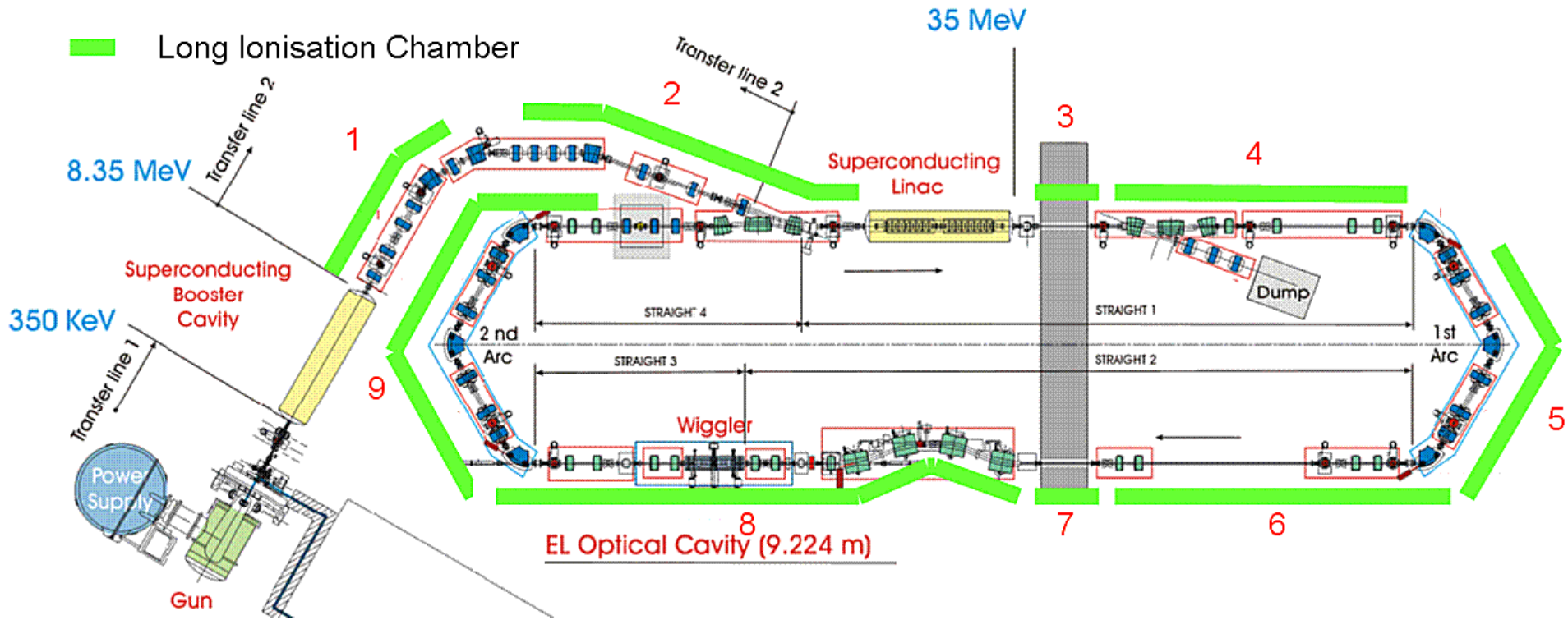
Long Ionisation Chambers Installation



Long Ionisation Chambers Layout



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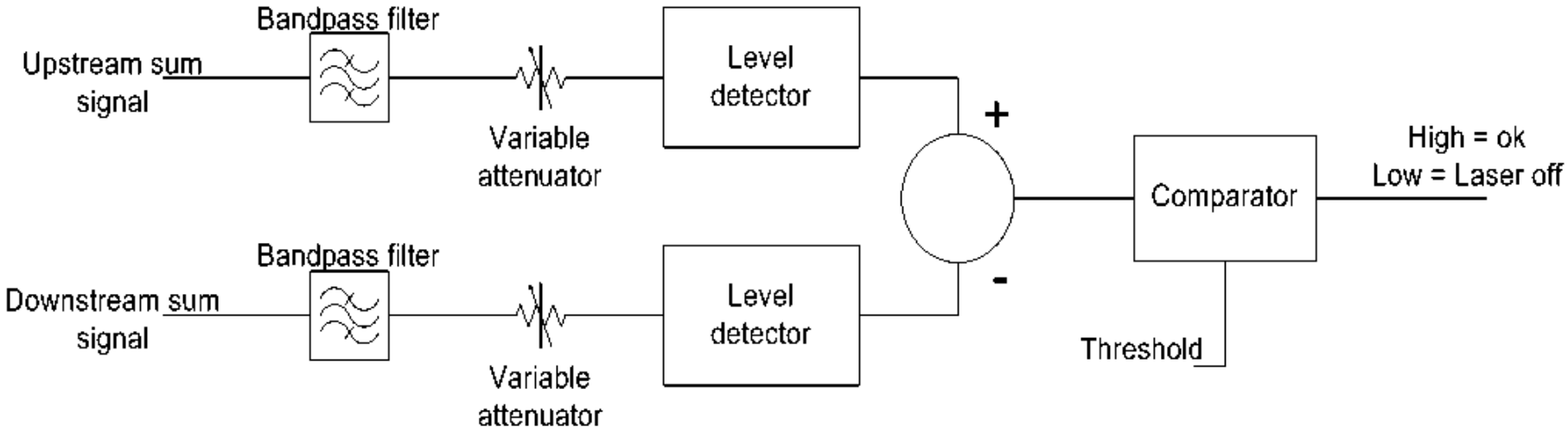
Current Different Monitor Operation



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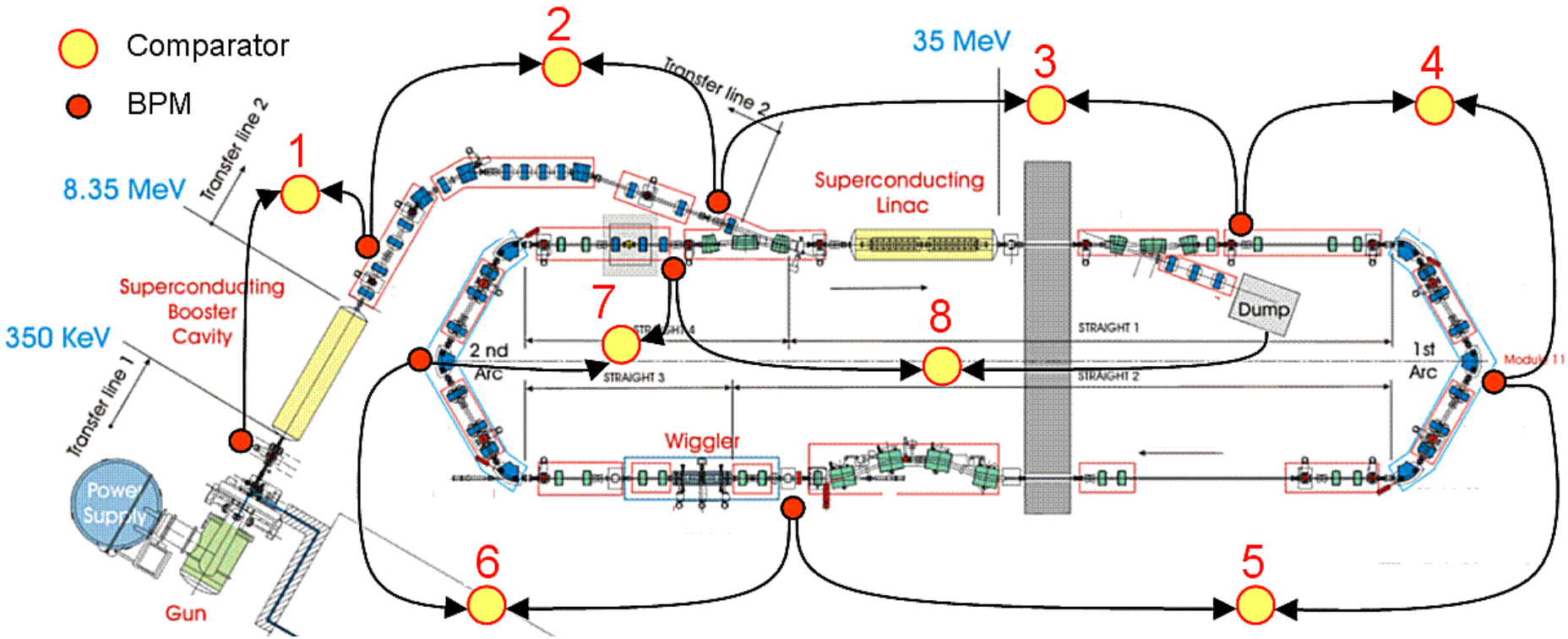
Current Different Monitor Layout



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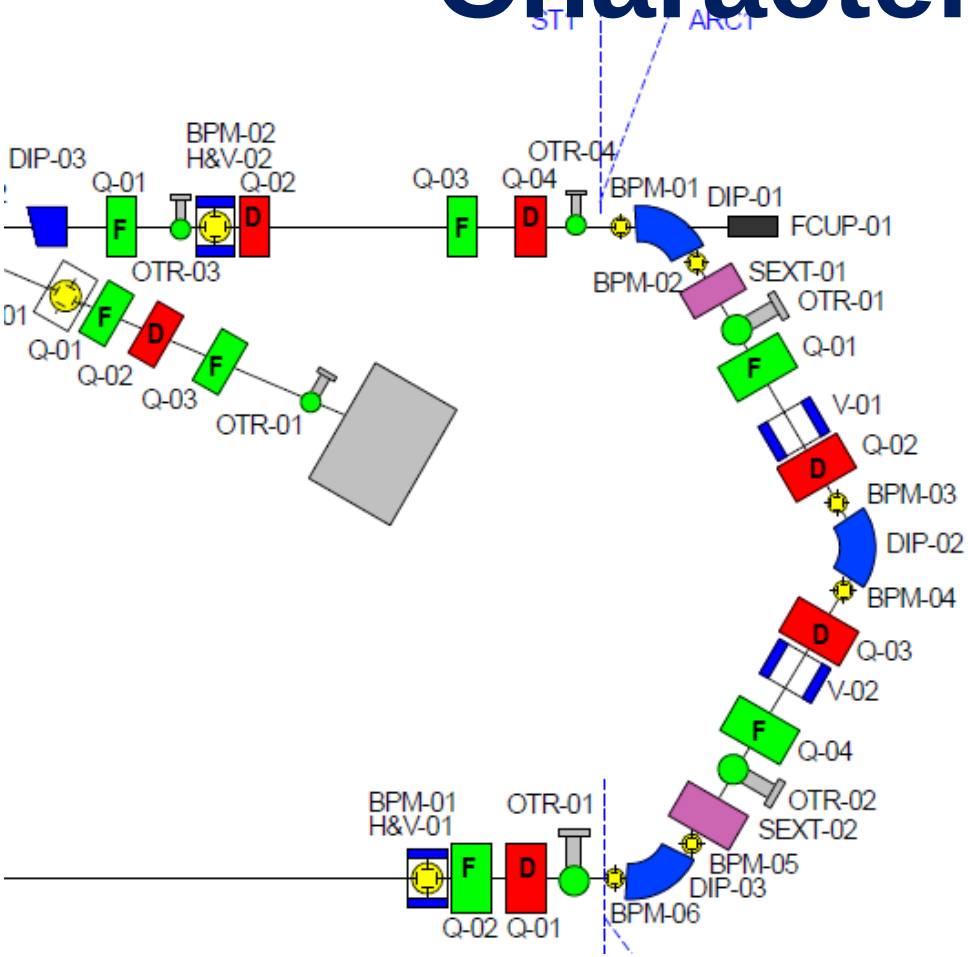
Long Ionisation Chamber Characterisation



- Used LIC 4 (ST1),LIC 5 (ARC1) & LIC 6 (ST2)
- Varied currents in:
  - ST1-DIP03
  - ARC1-DIP01
  - ARC1-DIP02
  - ARC1-DIP03
- Analysed detector output signal

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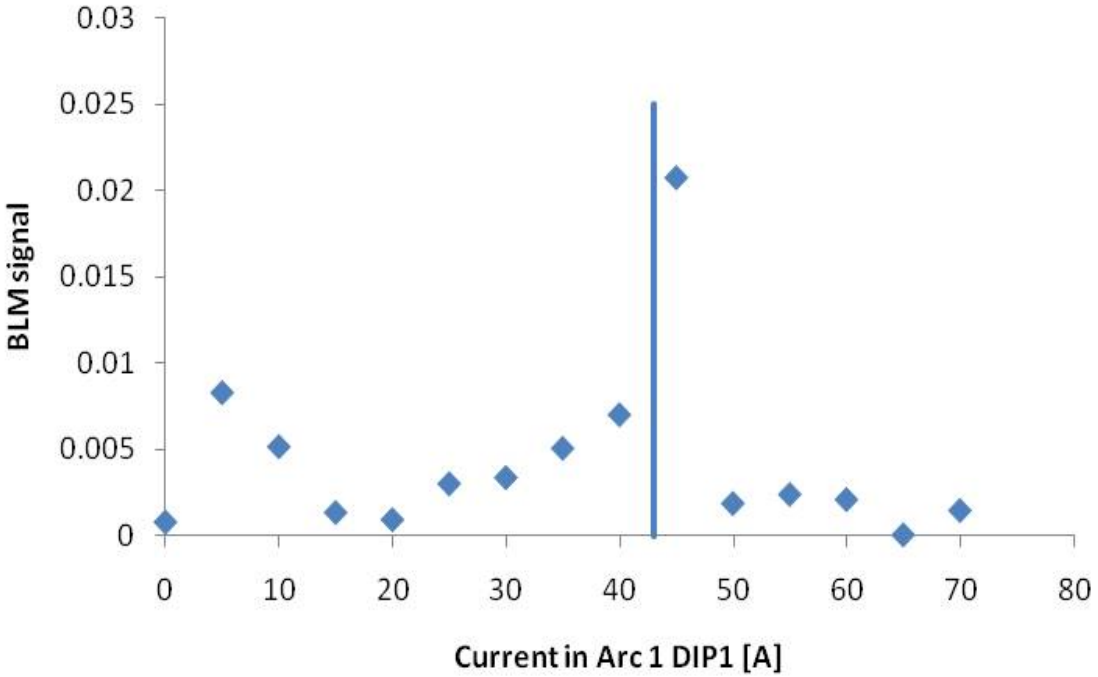
Characterisation results of LIC5

- Current varied in ARC1-DIP01
- High signal detected when current is close to nominal due to large radiation shower
- Signal decreases as the loss point changes



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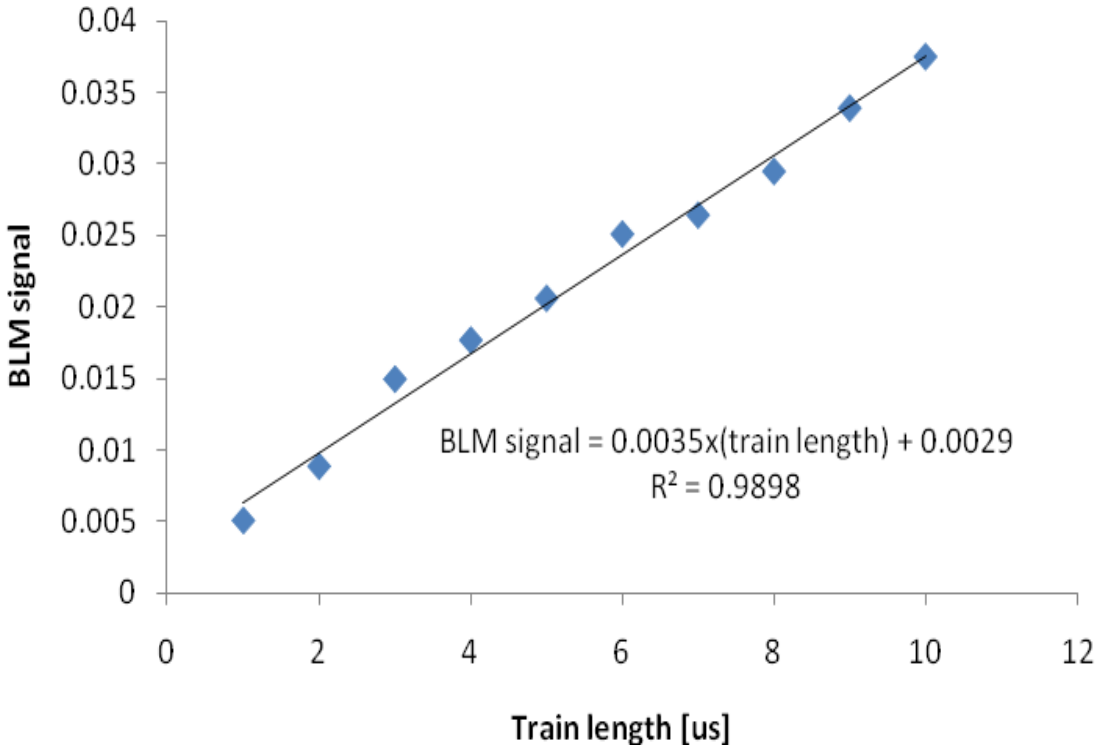
Linearity check of LIC4

- ST1 DIP03 current maintained at 20 A
- Train length incremented from 1 μs to 10 μs
- LIC output signal shows good linearity with linear beam loss



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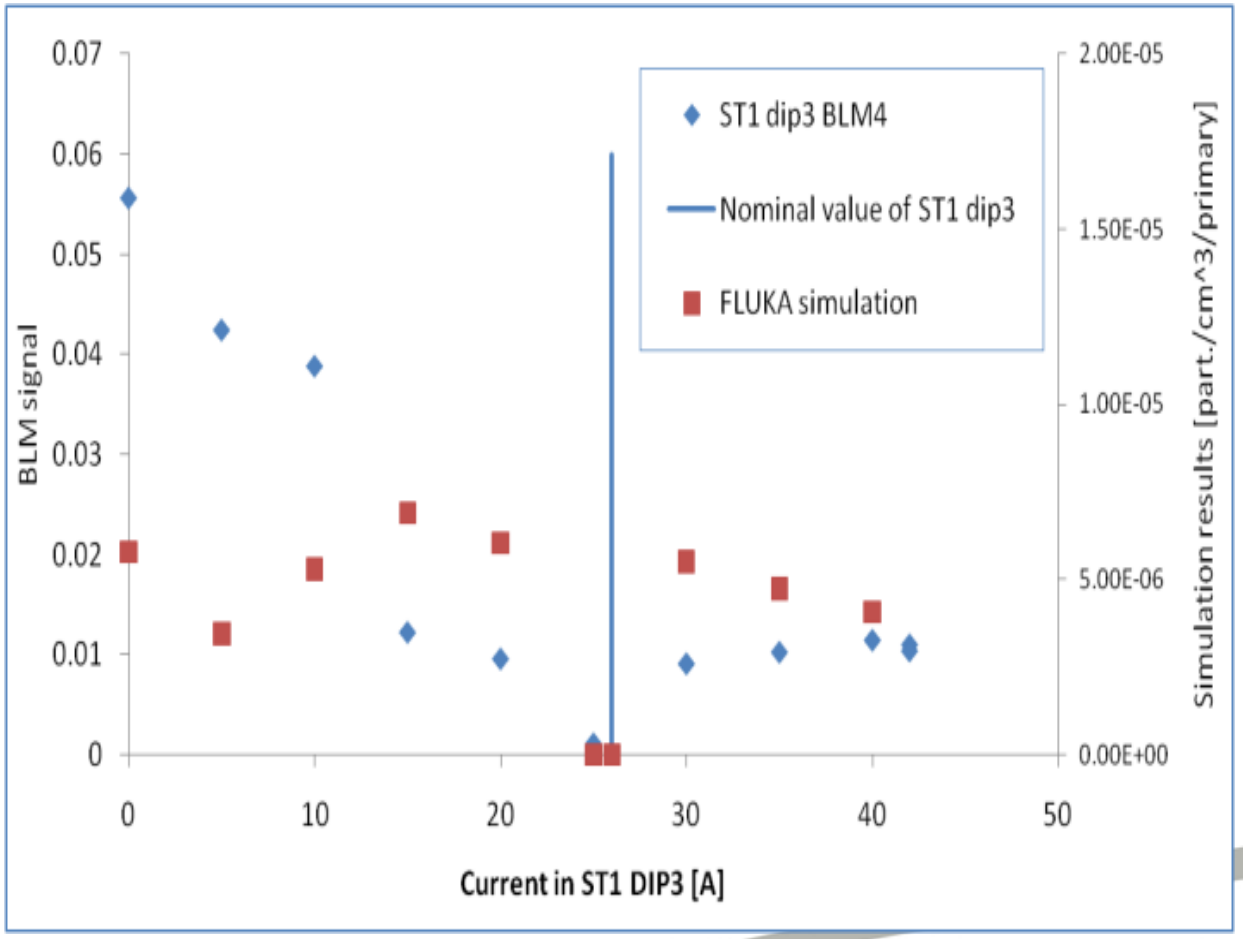
FLUKA Simulation of Loss



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Conclusion

- Long ionisation chambers are a reliable tool for detection of ionising radiation
- It is impossible, however, to correlate beam loss quantity to LIC signal output; as it is dependant on where the loss is and what machine components are struck by the beam
- LIC's will be a very useful diagnostic tool showing beam loss during machine set-up
- Additional chambers would give more information and allow implementation of effective machine protection system integration

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