

Latest irradiation test results for diamond & silicon loss detectors

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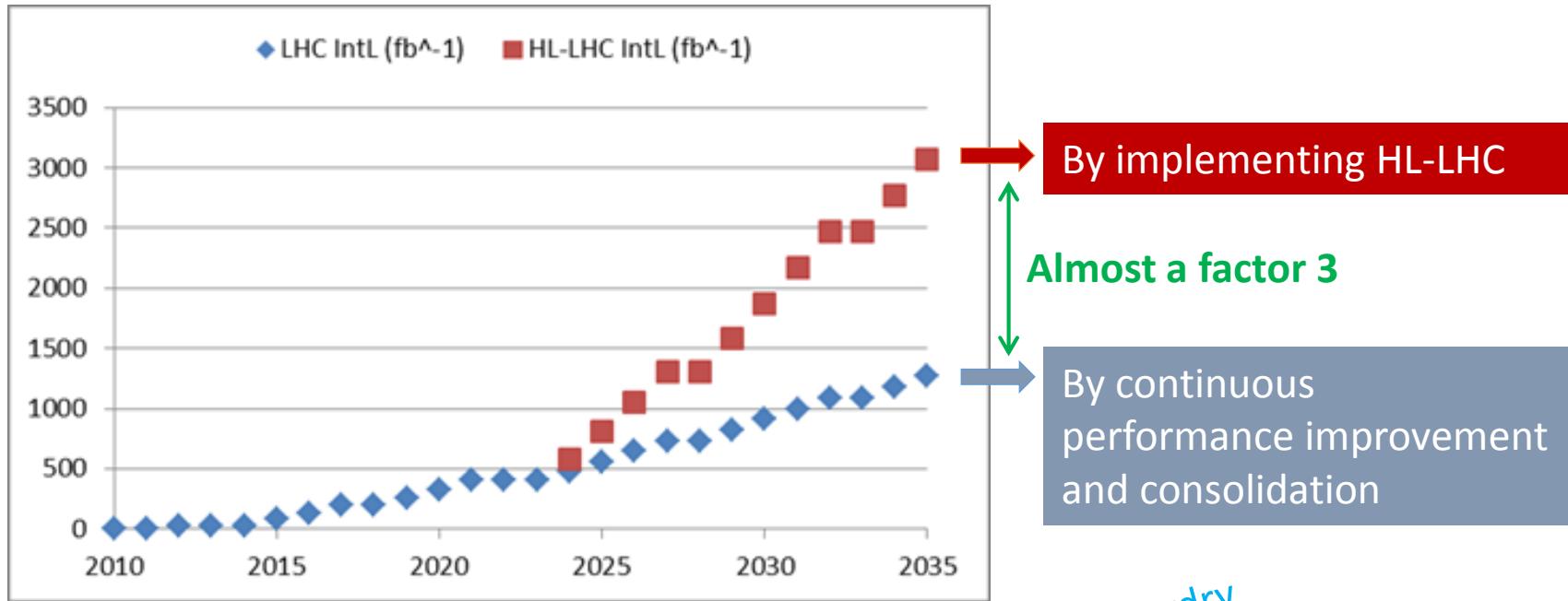


Plan

1. Motivation
2. Cryogenic irradiations
3. Outlook

Motivation

Cryogenic BLMs for HL-LHC



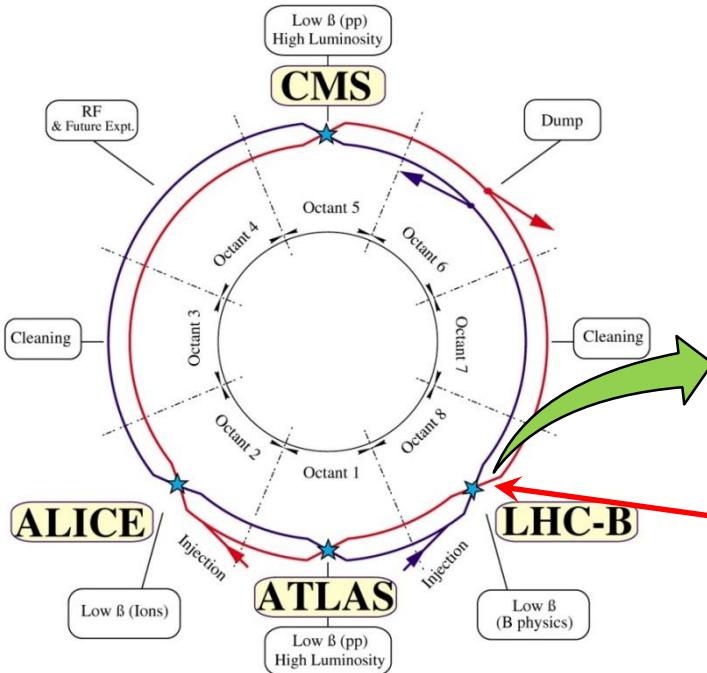
Goal of the HL-LHC project:

- 250 – 300 fb^{-1} integrated luminosity per year
- 3000 fb^{-1} integrated luminosity in about 10 years

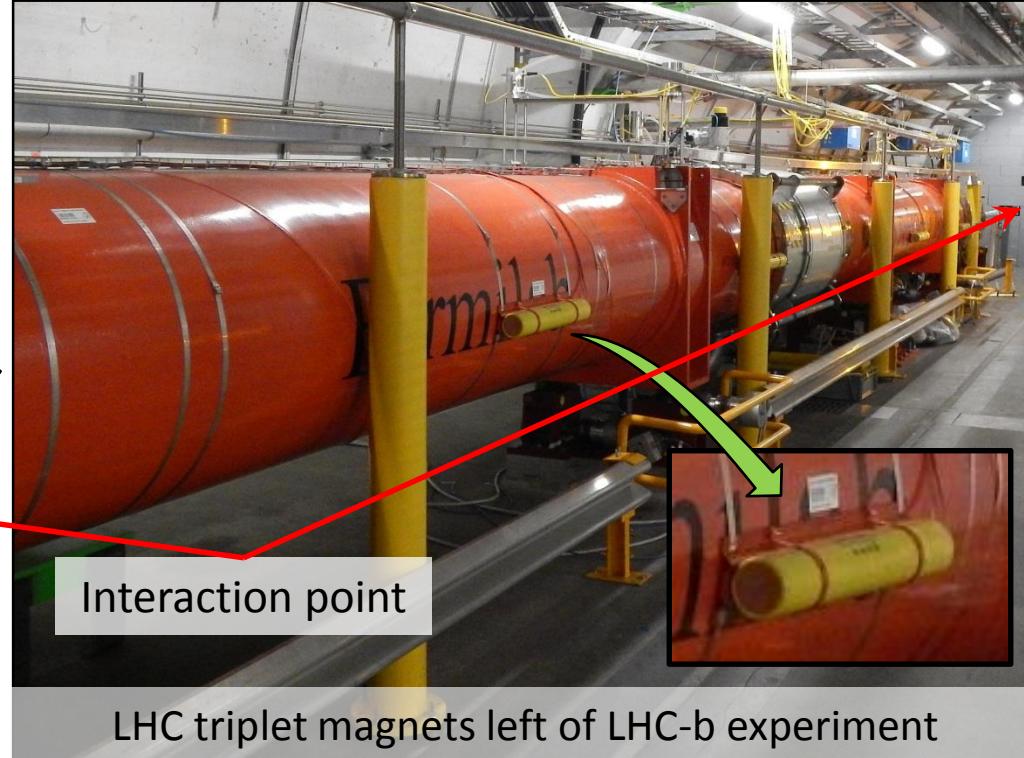
Courtesy of F. Bordry



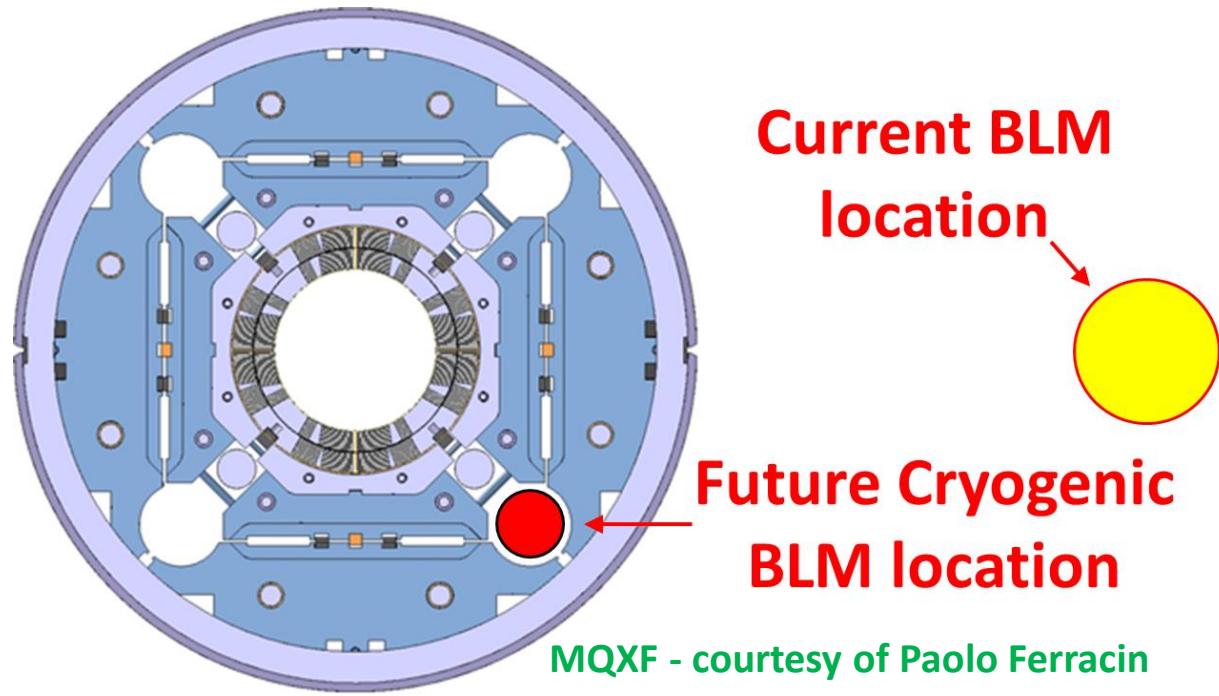
Cryogenic BLMs for HL-LHC



Overview of LHC ring with four main experiments



Requirements of Cryogenic BLMs



Mechanical requirements:

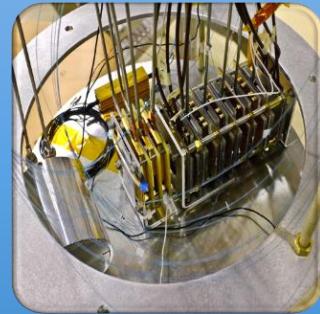
- total radiation dose of 2MGy,
- low temperature of 1.9K,
- 20 years, maintenance free operation,
- resistance to magnetic field of 2T,
- resistance to a pressure of 1.1 bar, and capability of withstanding a fast pressure rise up to 20bar in case of a magnet quench.

Electronic requirements:

- direct current readout,
- response linear between 0.1 and 10 mGy/s, and
- response time faster than 1 ms.

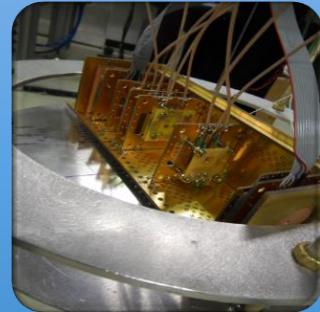
Cryogenic irradiations

Cryogenic irradiations



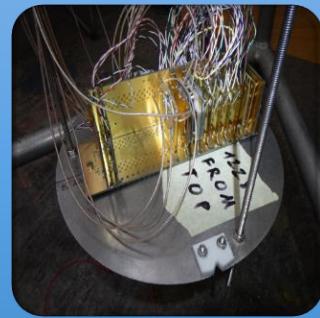
December 2012

- $6 \times p^+ \text{-} n \text{-} n^+$ silicon detectors, different intrinsic resistivity, $300\mu\text{m}$ thick, aluminium metallized.
- $2 \times \text{scCVD}$ diamond detectors, $500\mu\text{m}$ thick, titanium and gold metallized.



November 2014

- $2 \times p^+ \text{-} n \text{-} n^+$ silicon detectors, same intrinsic resistivity of $10k\Omega\text{cm}$, $300\mu\text{m}$ and $100\mu\text{m}$ thick.
- $2 \times \text{3D}$ detectors (silicon and scCVD diamond).



October 2015

- $18 \times$ different $p^+ \text{-} n \text{-} n^+$ silicon detectors, aluminium metallized.
- $2 \times \text{scCVD}$ diamond detectors $300\mu\text{m}$ and $500\mu\text{m}$ thick, chromium and gold metallized.

Cryogenic Irradiation - December 2012

- $6 \times p^+ \text{-} n \text{-} n^+$ silicon detectors, intrinsic resistivity: $10\Omega\text{cm}$, $500\Omega\text{cm}$ and $4.5\Omega\text{cm}$, $300\mu\text{m}$ thick, aluminium metalized.
- $2 \times \text{scCVD}$ diamond detectors, $500\mu\text{m}$ thick, titanium and gold metalized.
- Superfluid helium environment of **1.9K**.
- DC readout (Keithley 2410, Keithley 6517B).
- Total integrated fluence of **$1.225(85) \cdot 10^{16}$ protons/cm²**,
 - Total dose of **$3.26(23)$ MGy** for silicon and **$3.42(24)$ MGy** for diamond,
 - Up to $1.3 \cdot 10^{11}$ protons/cm² per spill,
 - 24 GeV/c particle momentum.

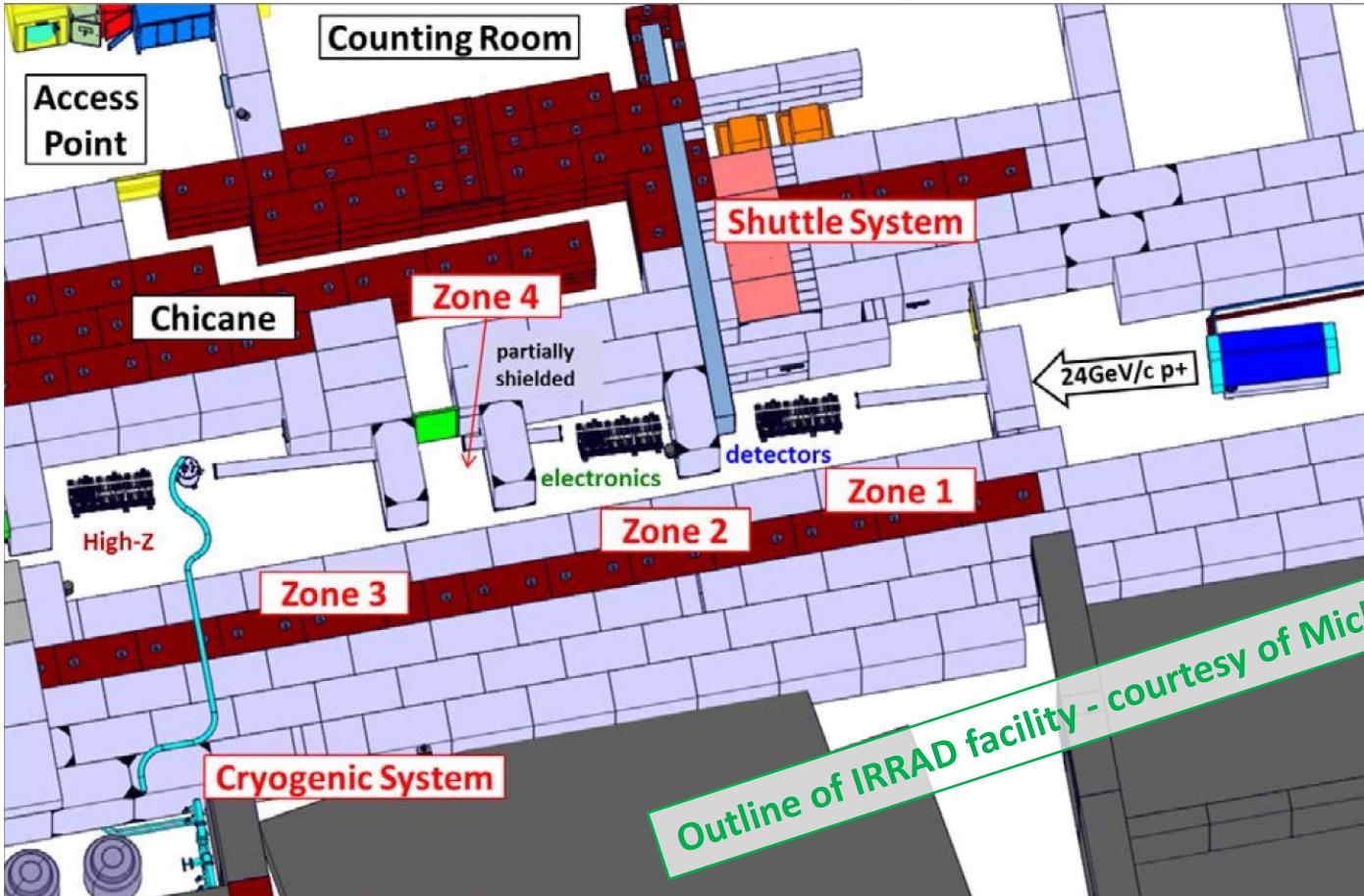
Cryogenic Irradiation - December 2012

- 6 × p⁺-n-n⁺ silicon detectors, intrinsic resistivity: 10kΩcm, 500Ωcm and 4.5Ωcm, 300μm thick, aluminium metalized.
- 2 × scCVD diamond detectors, 500μm thick, titanium and gold metalized.
- Superfluid helium environment
- DC readout (Keithley 2410 multimeter).
- Total integrated fluence of $(1.3 \cdot 10^{11} \text{ to } 1.3 \cdot 10^{12}) \cdot 10^{16} \text{ protons/cm}^2$,
 - Total dose of 3.2(6) MGy for silicon and 3.42(24) MGy for diamond,
 - Up to 1.3 · 10¹¹ protons/cm² per spill,
 - 24 GeV/c particle momentum.

We have learned that...

More in "C. Kurfürst, et al., In situ radiation test of silicon and diamond detectors operating in superfluid helium and developed for beam loss monitoring".

Cryogenic Irradiation - 2013



Cryogenic Irradiation - November 2014

- 2 × p⁺-n-n⁺ silicon detectors, 10kΩcm intrinsic resistivity, 300μm and 100μm thick.
- 2 × 3D detectors (silicon and scCVD diamond).
- DC readout with use of BLEDP [1].
- Liquid helium environment of **4.2K**.
- Total integrated fluence of **2.83(24) · 10¹⁵ protons/cm²**,
 - Total dose of **0.756(75) MGy** for silicon and **0.793(78) MGy** for diamond,
 - Up to $2.6 \cdot 10^{11}$ protons/cm² per spill,
 - 24 GeV/c particle momentum.

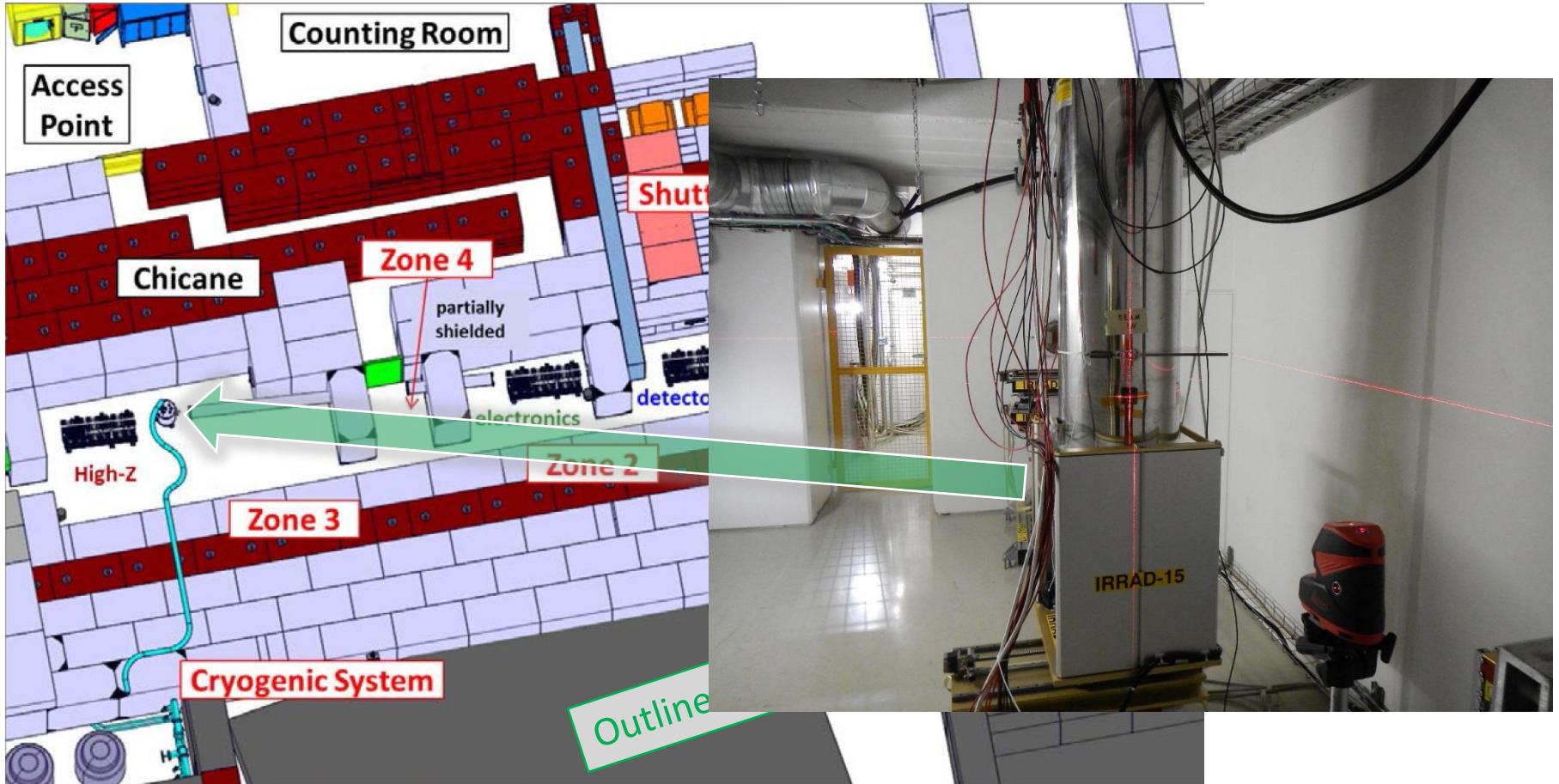
[1] Ch. Zamantzas et al, System Architecture for measuring and monitoring Beam Losses in the Injector Complex at CERN, CERN-ACC-2013-0252, CERN, Geneve, 2012

Cryogenic Irradiation - November 2014

- 2 × p⁺-n-n⁺ silicon detectors, 10kΩcm intrinsic resistivity, 300μm and 100μm thick.
- 2 × 3D detectors (silicon and scCVD diamond).
- DC readout with use of BLEDP [1].
- Liquid helium environment
- Total integrated fluence **We have learned that...**
 - Total dose of $0.756(75)$ MGy
 - Up to $2.6 \cdot 10^{11}$ protons/cm² per spill,
 - 24 GeV/c particle momentum.

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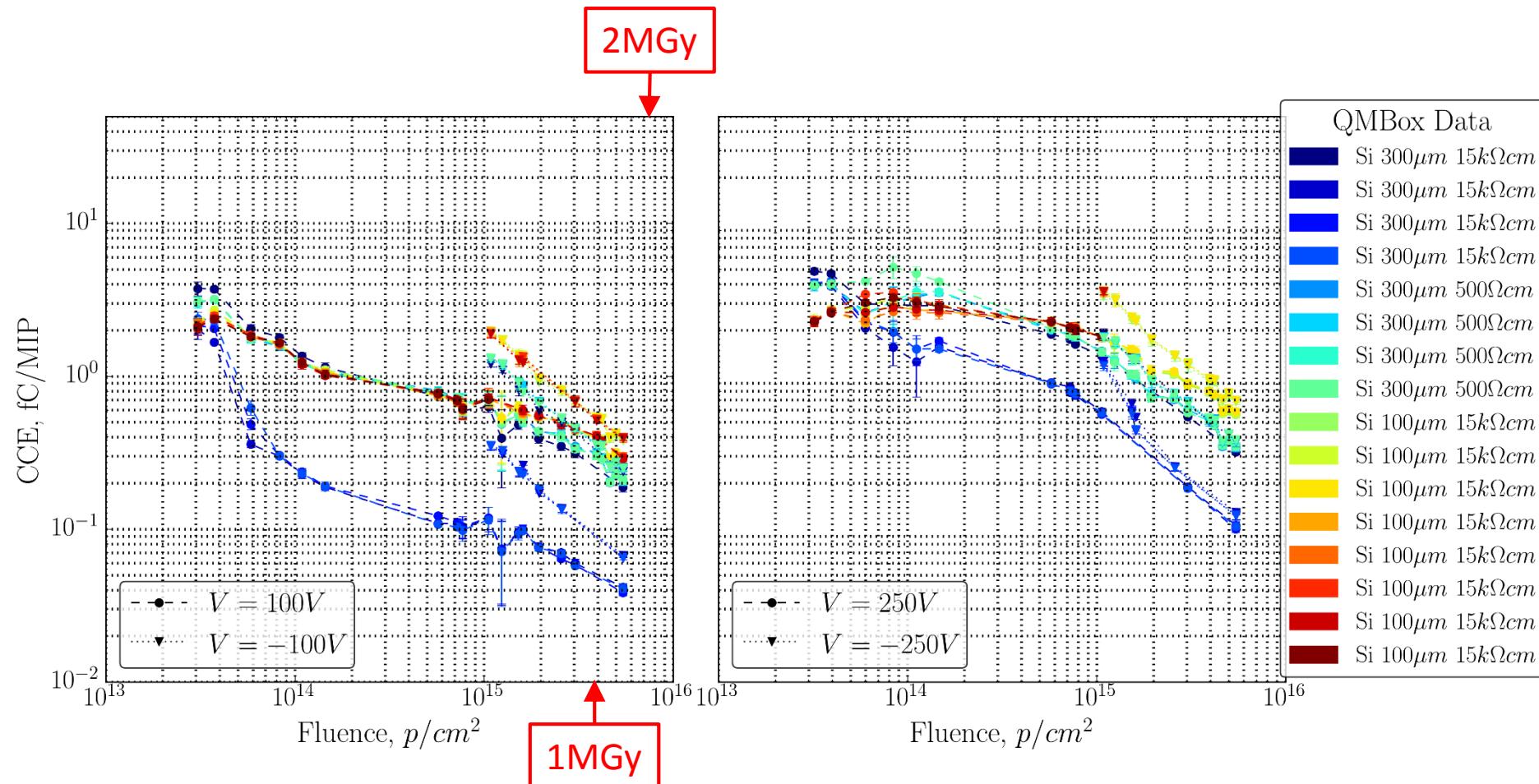
Cryogenic Irradiation – 2015



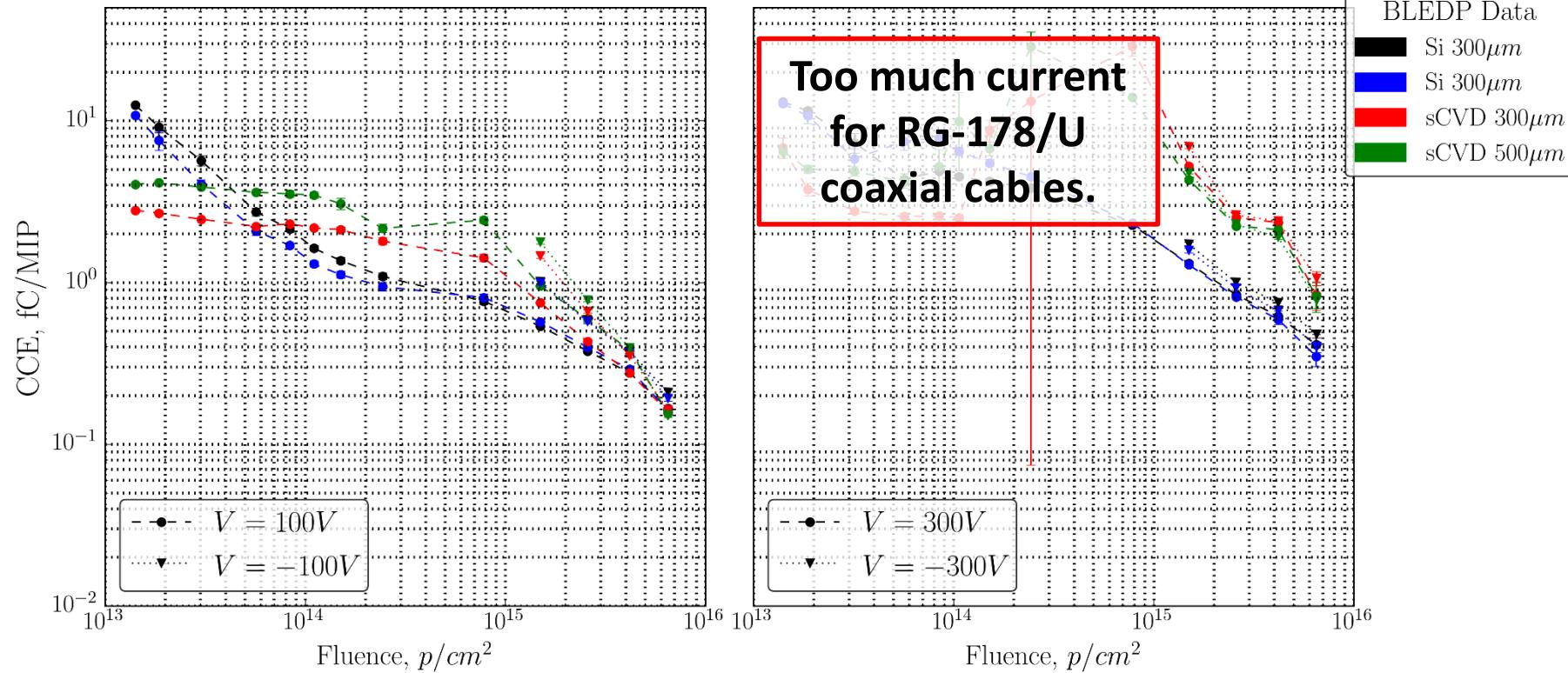
Cryogenic Irradiation – October 2015

- 18 × different p⁺-n-n⁺ silicon detectors, aluminium metallized.
- 2 × scCVD diamond detectors 300μm and 500μm thick, chromium and gold metallized.
- DC readout (BLEDP and QMBox).
- Liquid helium environment of **4.2K**.
- Total integrated fluence of **6.84(48) · 10¹⁵ protons/cm²**,
 - Total dose of **1.82(13) MGy** for silicon and **1.91(13) MGy** for diamond,
 - Up to $1.1 \cdot 10^{11}$ protons/cm² per spill,
 - 24 GeV/c particle momentum.

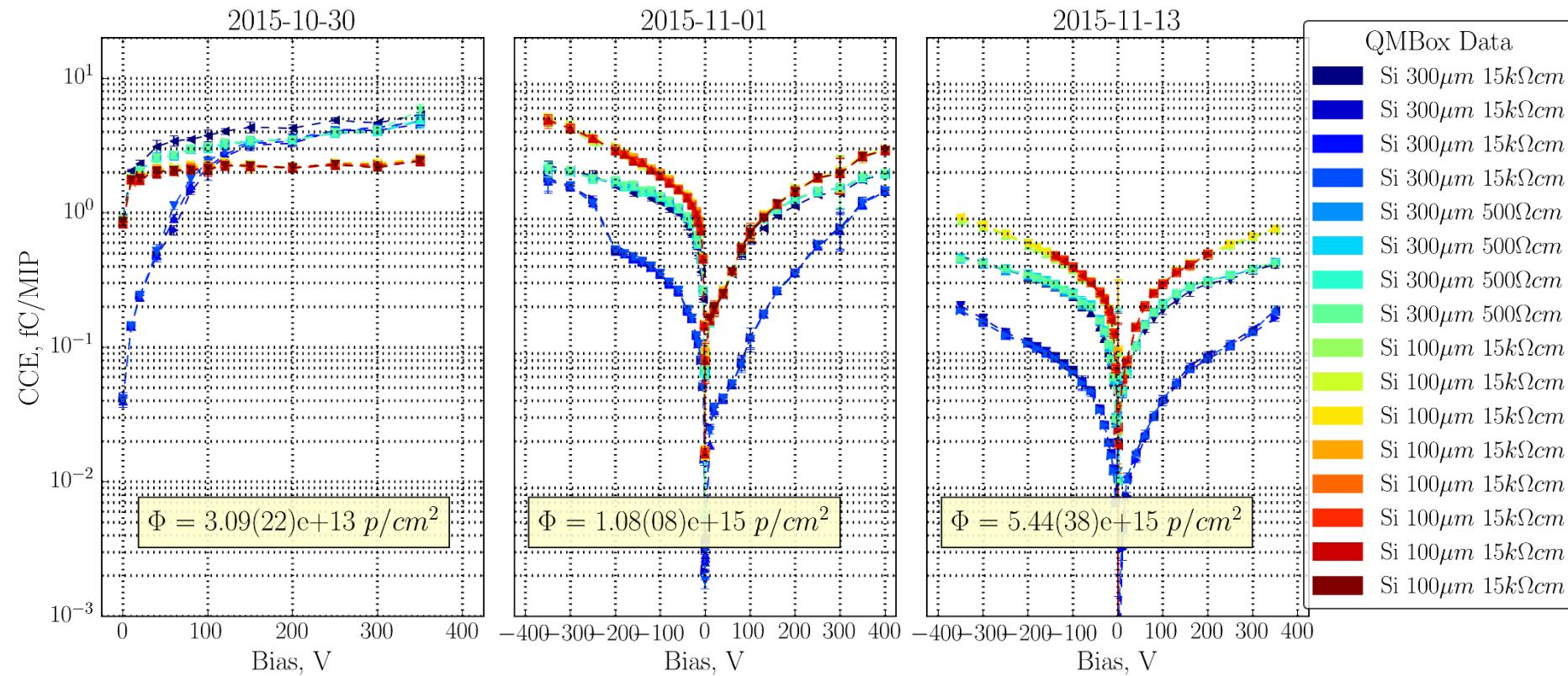
Cryogenic Irradiation – October 2015



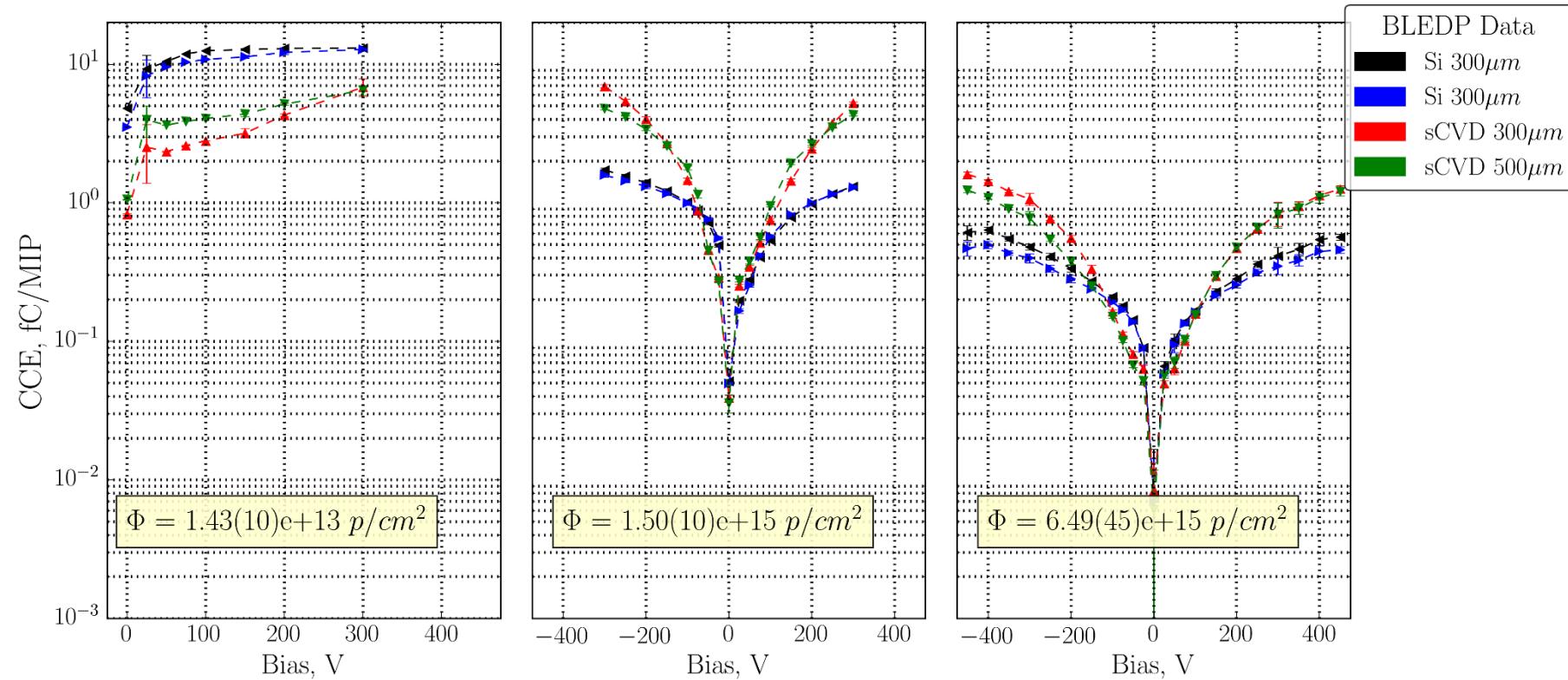
Cryogenic Irradiation – October 2015



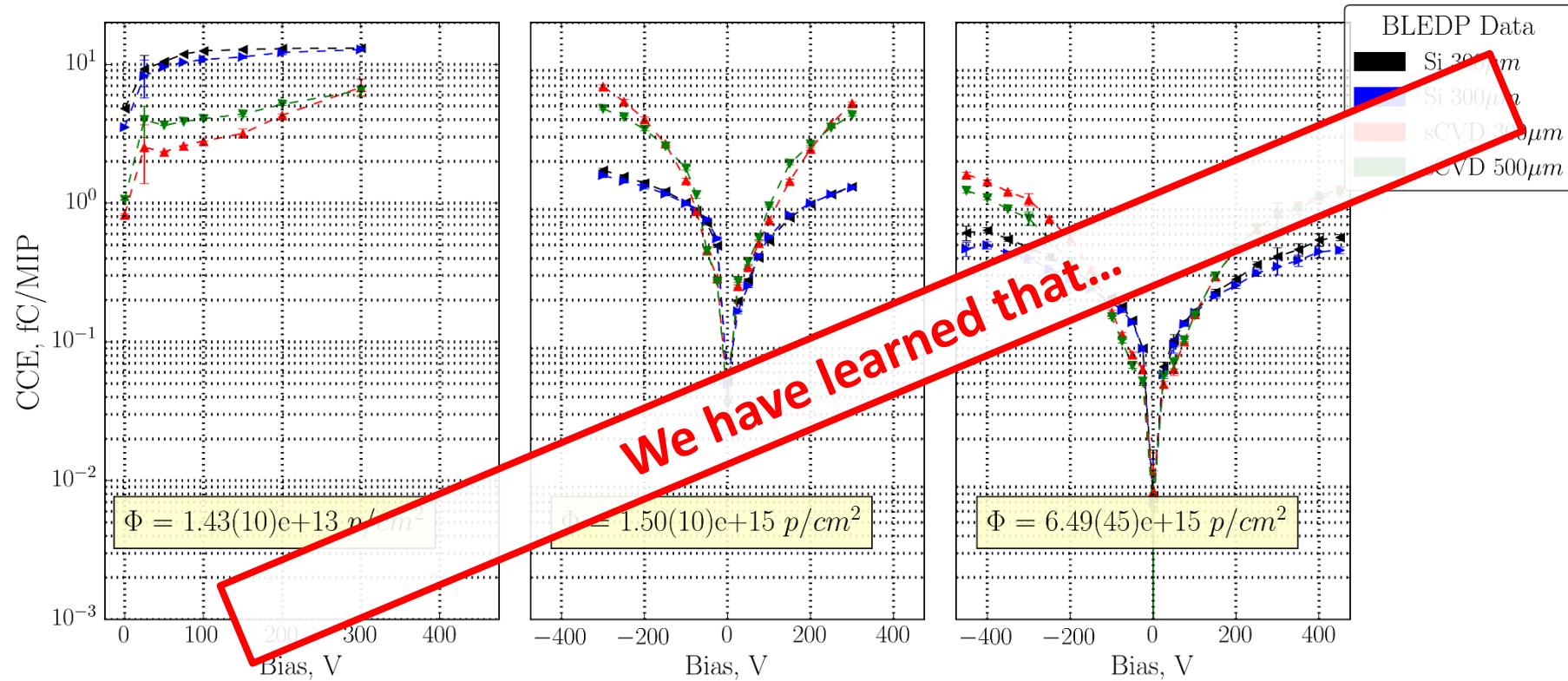
Cryogenic Irradiation – October 2015



Cryogenic Irradiation – October 2015

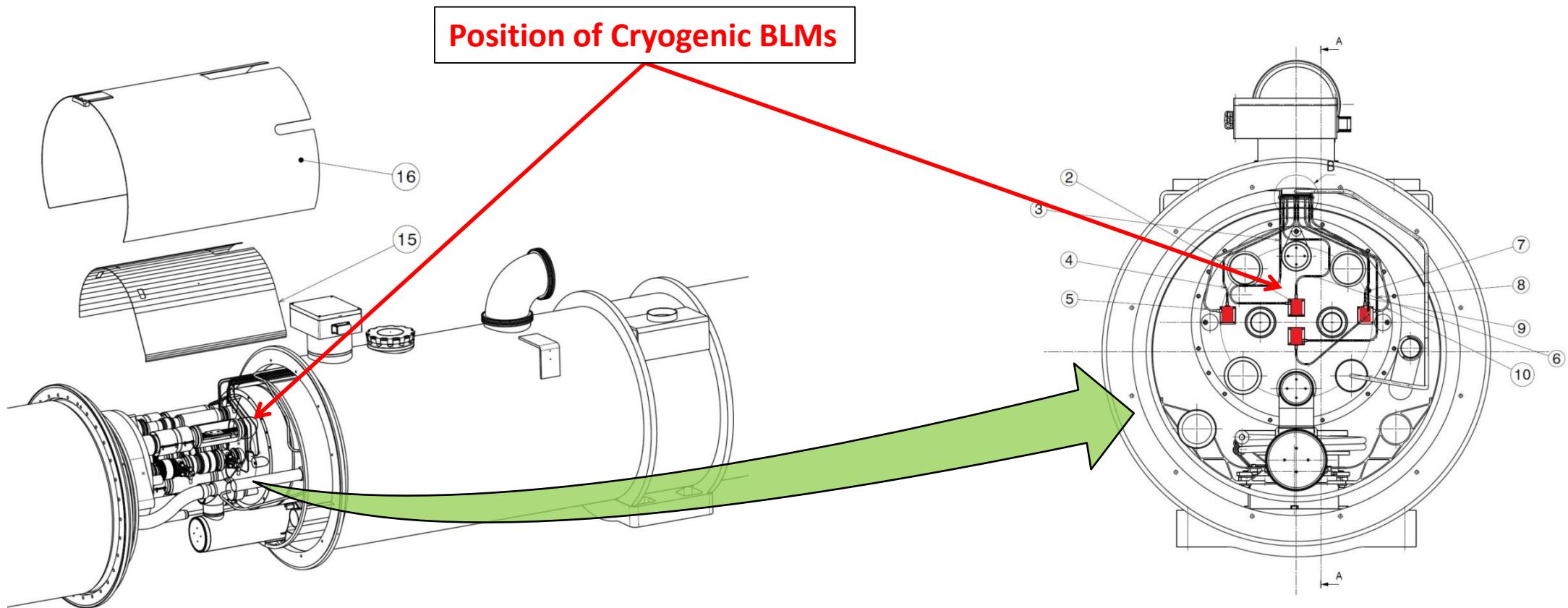


Cryogenic Irradiation – October 2015



Outlook

Cryogenic BLMs in LHC ring



Long term correlation between Ionization Chamber BLM and Cryogenic BLM to be done in 9R7 and 9L5

Thank you!