Research towards diamond based cryogenic beam loss monitors for LHC magnets

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Plan

- 1. Motivation
- 2. Radiation hardness test of detectors in cryogenic temperatures
- 3. Tests of detectors in magnetic field

Motivation

Cryogenic BLMs for HL-LHC



- 250 300 fb⁻¹ integrated luminosity per year
- 3000 fb⁻¹ integrated luminosity in about 10 years



Cryogenic BLMs for HL-LHC



Requirements of Cryogenic BLMs



Inner Triplet Quadruples (MQXF) for HL-LHC (MQXFS1 Quadrupole design report) 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 100 μ s.

Radiation hardness test of detectors in cryogenic temperatures



December 2012 (Superfluid helium environment of **1.9K)**

- 6 \times p⁺-n-n⁺ silicon detectors, different intrinsic resistivity, 300µm thick, aluminium metalized.
- 2 × scCVD diamond detectors, 500μm thick, titanium and gold metalized.
- Integrated fluence of 1.225(85) · 10¹⁶ protons/cm²



November 2014 (Liquid helium environment of 4.2K)

- 2 \times p⁺-n-n⁺ silicon detectors, same intrinsic resistivity of 10k Ω cm, 300 μ m and 100 μ m thick.
- $2 \times 3D$ detectors (silicon and scCVD diamond).
- Integrated fluence of 2.83(24) · 10¹⁵ protons/cm²



October 2015 (Liquid helium environment of 4.2K)

18 × different p⁺-n-n⁺ silicon detectors, aluminium metallized.
2 × scCVD diamond detectors 300μm and 500μm thick, chromium and gold metalized.
Integrated fluence of 6.84(48) · 10¹⁵ protons/cm²

Cryogenic Irradiation - setup





- 2 × scCVD diamond detectors from Element Six (UK) Ltd. (300µm and 500µm thick), chromium and gold metalized at GSI by Robert Visinka under supervision of dr. Mladen Kiš.
- 18 × different p⁺-n-n⁺ silicon detectors, aluminium metallized.
- DC readout.
- 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.







Tests of detectors in magnetic field

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.

MQXF - courtesy of Paolo Ferracin

Diamonds in magnetic field

Transit time of electrons in RT (90deg inclination between electric and magnetic field)



Diamonds in magnetic field

Transit time of holes in RT (90deg and 60deg inclination between electric and magnetic field)



Thank you!