Overview of the CMS beam loss monitoring system (BCML) and the performance of the system in 2017

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on behalf of the CMS collaboration
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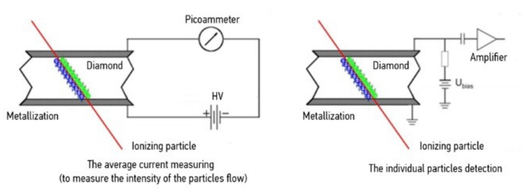
Introduction

In CMS a beam loss monitoring system (BCML) is in place to protect the CMS Tracker from potentially damaging, high intensity beam loss events. Above a pre-defined detector current the LHC beams are automatically dumped. Detectors for this system require high radiation tolerance for stability over time, sufficient signal over noise at a given particle rate and a linear response up to the abort threshold. Poly-crystalline (pCVD) diamond sensors are used as detectors. Additionally sapphire based and diamond-on-iridium prototype sensors were installed during 2017 to investigate more radiation tolerant detectors. This report discusses - the BCML system, as well as promising ways of solving problems with adhesion to the detector's plates by using the diamond surface modification by using doped diamond sublayers.

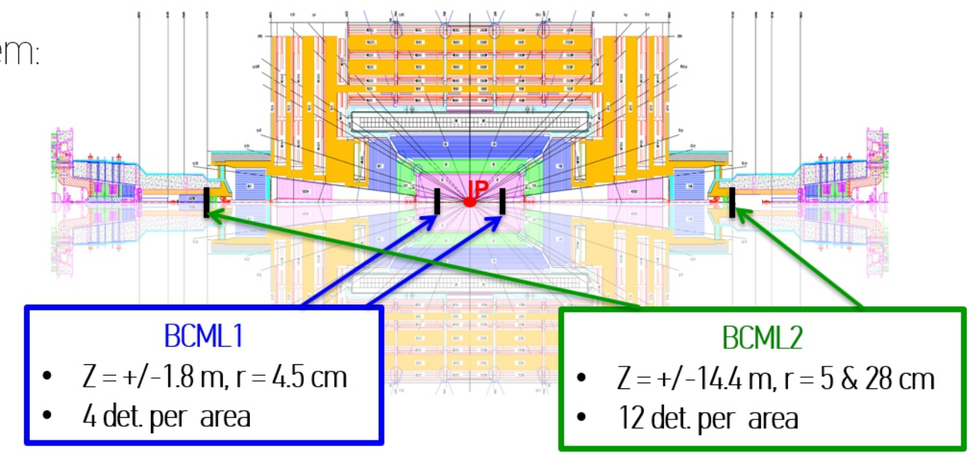
BCML (Beam Condition Monitor Leakage)

The BCML detectors measure the current created by ionization in sensors. This signal current is proportional to the ionizing particle flux through the active detector material thus providing a relevant measurement for the radiation load in detectors at that location. It consists of *16-pCVD detectors* in abort system and *6-sapphire, 2-diamond on iridium (DOI), one-3D diamond detectors* in prototype system



BCML system:

Beam Condition Monitor Leakage



Read out and calculation principle

Electrical read out - Hardware:

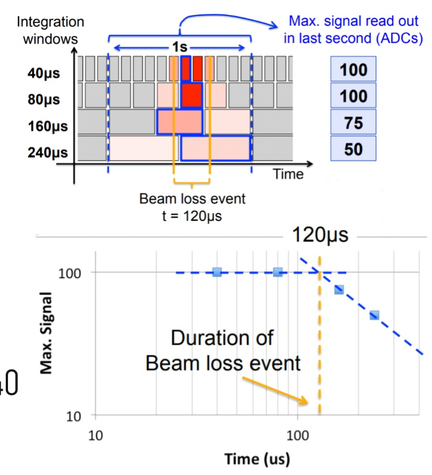
- Identical to the BLM system of LHC.
- Abort functionality is 'hard coded' into system, no software used in process of sending the beam abort signal.

Electrical read out - Measurement:

- In total 12 integration windows = called 'Running Sums (RS)'
- RS1 (40 μs) till RS12 (83 s)
- Read out frequency is 1 Hz

Abort threshold are defined for RS1 and for RS12

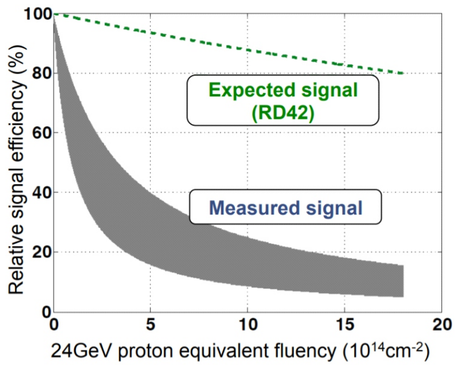
- RS1: Protection against very short beam loss events (≤ 40 μs)
- RS12: Protection against a long term increase in beam background (> 60 s)



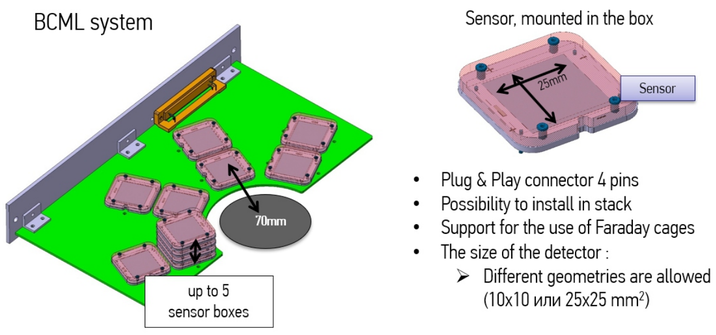
Degradation of detectors over time

Decrease of detector efficiency was higher than expected in comparison to lab measurements (RD42 collaboration CERN)

The main goal is to understand the cause of the degradation of diamond detectors and find ways of reducing this effect or predicting such behavior.



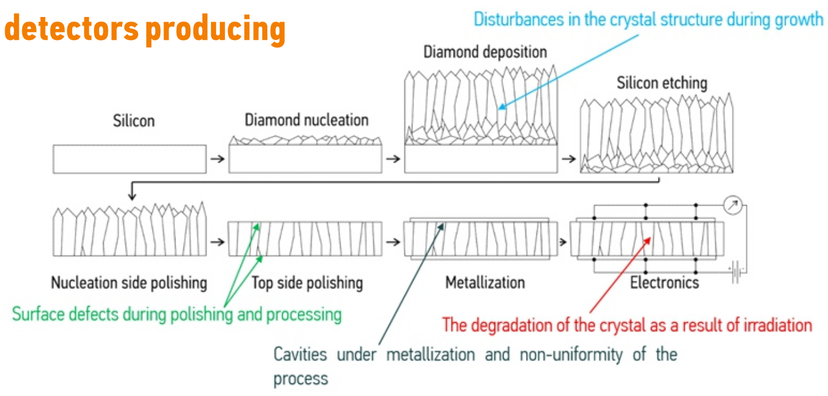
Mounting system

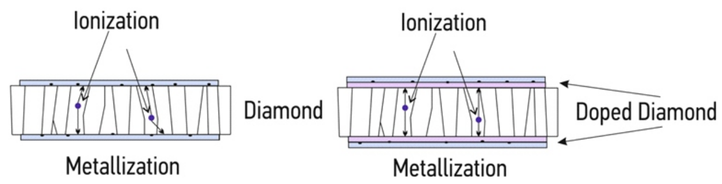


- Plug & Play connector 4 pins
- Possibility to install in stack
- Support for the use of Faraday cages
- The size of the detector :
  - Different geometries are allowed (10x10 или 25x25 mm^2)

Main problems during pCVD detectors producing

There are many problems that may occur during the production of sensors. Like *surface defects and cavities* and some inner deformation, stress and impurities

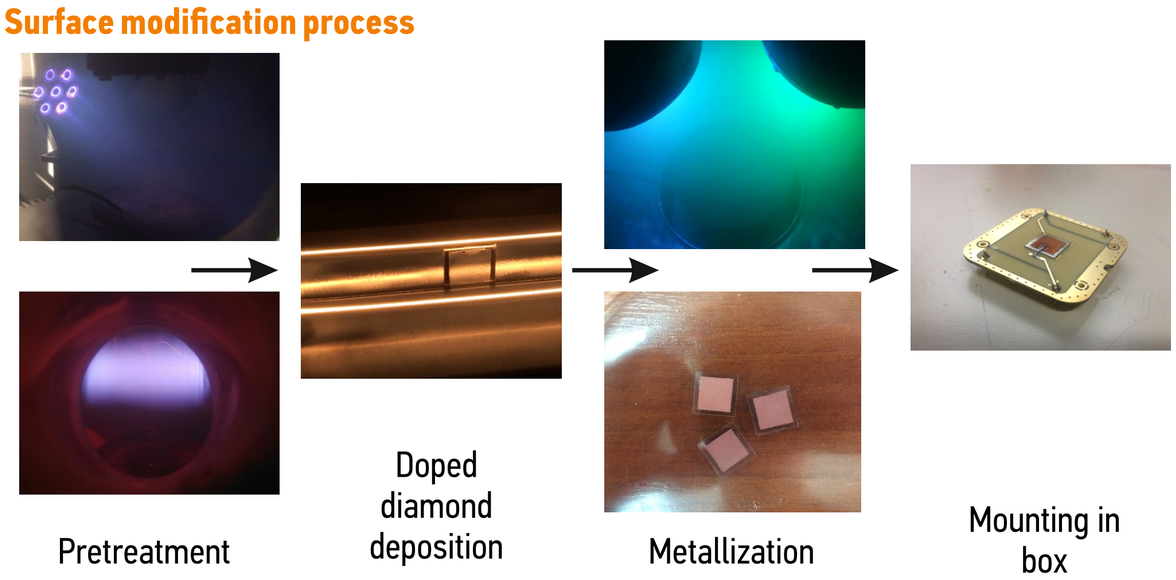




Detection of individual particles

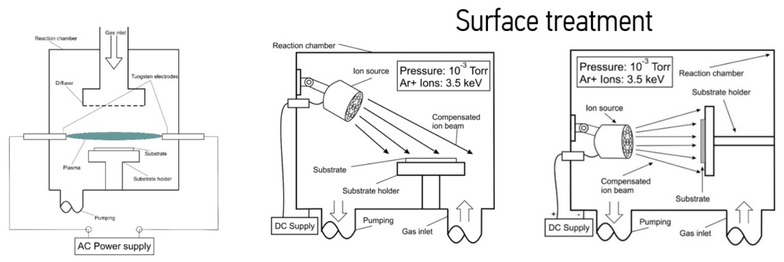
One of the potential way to improve the *pCVD* diamond sensors radiation resistivity is to remove the cavities between the diamond detectors surface and metallization.

Surface modification process



The full process contains *more than 20 steps* of cleaning/pretreatment/modification/deposition processes where we attempt to reduce the effect of defects on the final detector

Surface treatment

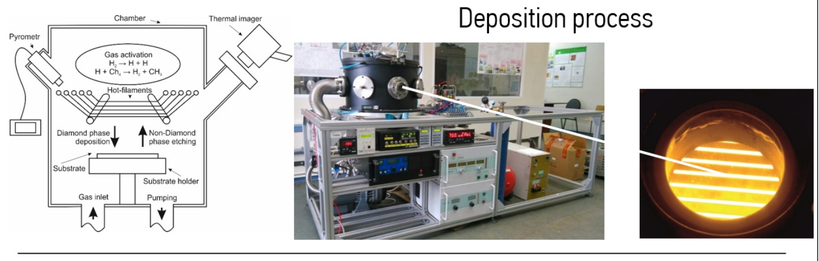


Technology	Pressure, (Torr)	Gas	Power, (W)	Substrate temperature (° C)
Reactive ion etching	10^{-3}	Ar	300	25-50
Etching in a glow discharge plasma	40	H_2	5500	800±25

Surface treatment is a very important step to prepare the diamond for future deposition. In this process we carry out final cleaning to reduce the defects on the surface and to increase the adhesion to next layers.

Right after the etching process we provide a ***boron doped pCVD*** deposition process for applying an interlayer between diamond detector body and metallization plates.

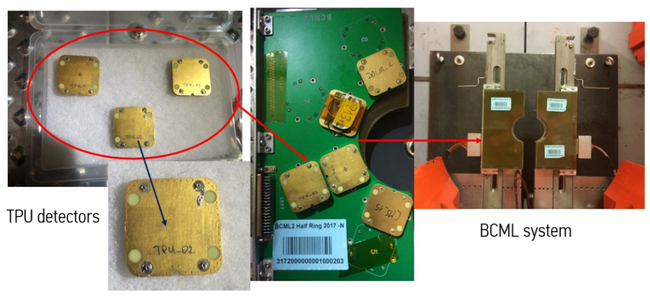
Deposition process



Filaments temperature	Plate temperature	Operating pressure	Deposition rate	Distance to plate
2000±50°C	800±25°C	20±1 Torr	0.5 -3 μm/h	10 mm

Conclusion

- The BCML system works fine, no major problems, no LHC downtime due to system failure.
- The first prototype detectors are ready to be installed and tested



References

- Topical Workshop on Beam Loss Monitors – Barcelona, Florian Kassel, 2016
- The CMS Beam Condition Monitoring Leakage system at the LHC -Florian Kassel, 2016
- The Rate Dependent Radiation Induced Signal Degradation of Diamond Detectors / ph.D thesis Florian Robert Kassel

Acknowledgements

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