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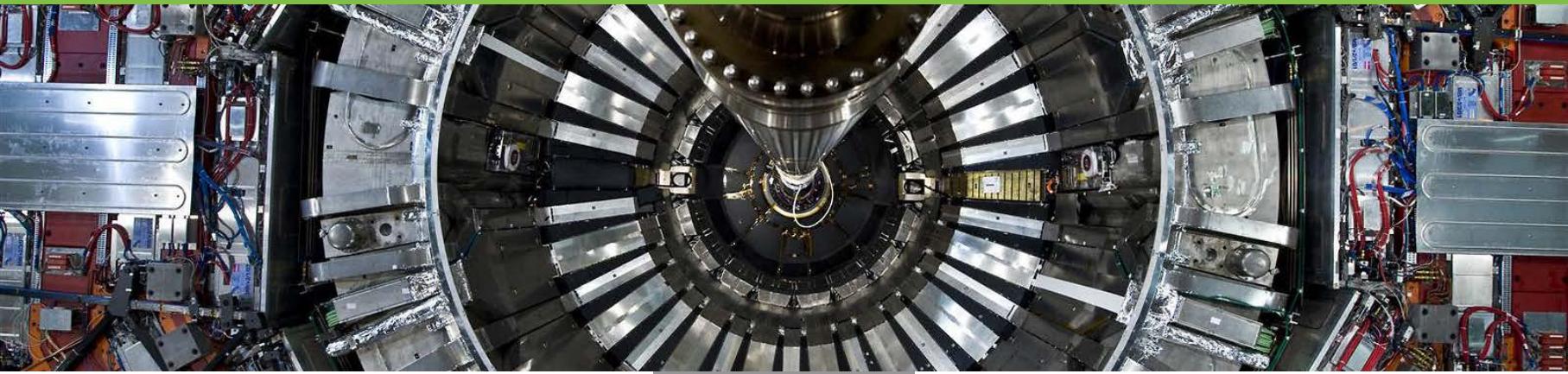
CERN CMS BRIL

Overview of the CMS BCML beam loss monitoring system and the pCVD diamond modification technology



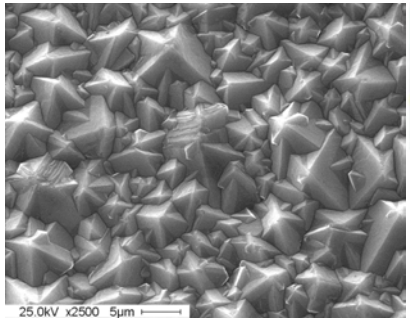
20th annual RDMS CMS Collaboration Conference

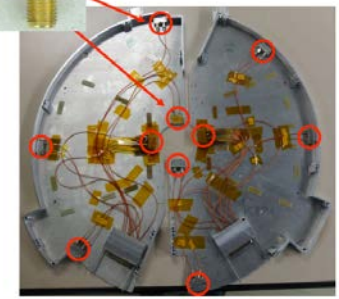
September 13 2018

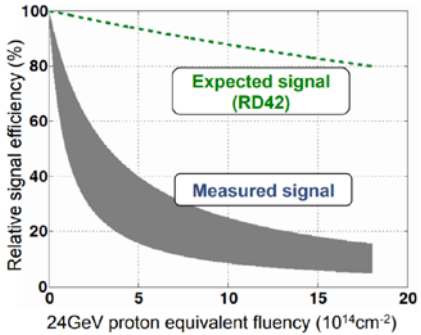
Vitalii Okhotnikov

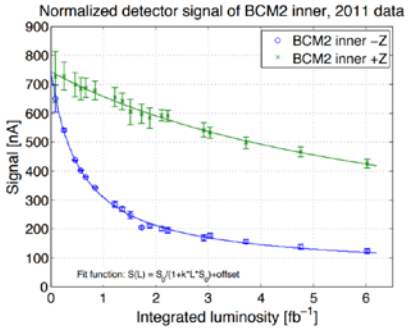
Outline

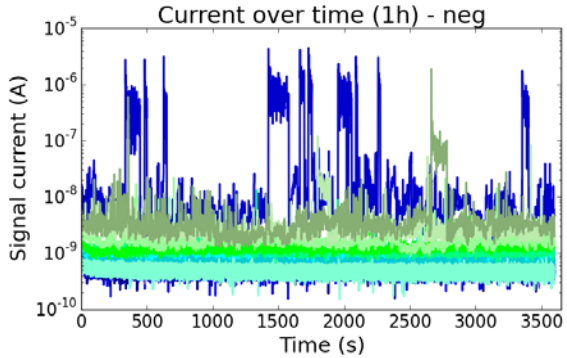
- The CMS BCML system
- Radiation induced detector degradation
- Diamond detectors damage understanding
- Degradation calculation



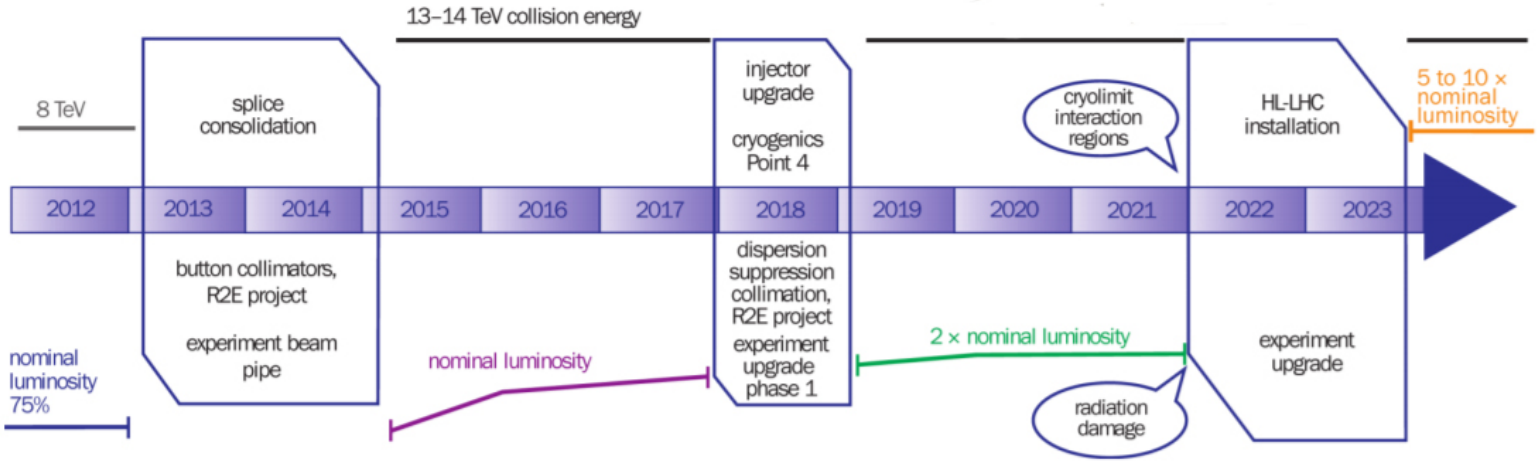




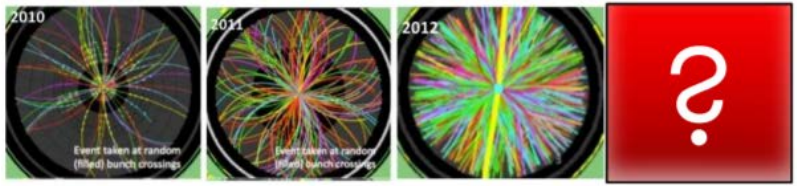




The CMS Beam Condition Monitoring Leakage system at the LHC -Florian Kassel, CMS, M.Guthoff, "Radiation damage to the diamond based Beam Condition Monitor of the CMS Detector at the LHC ", Ph.D. thesis, 2014, CMS, BRIL

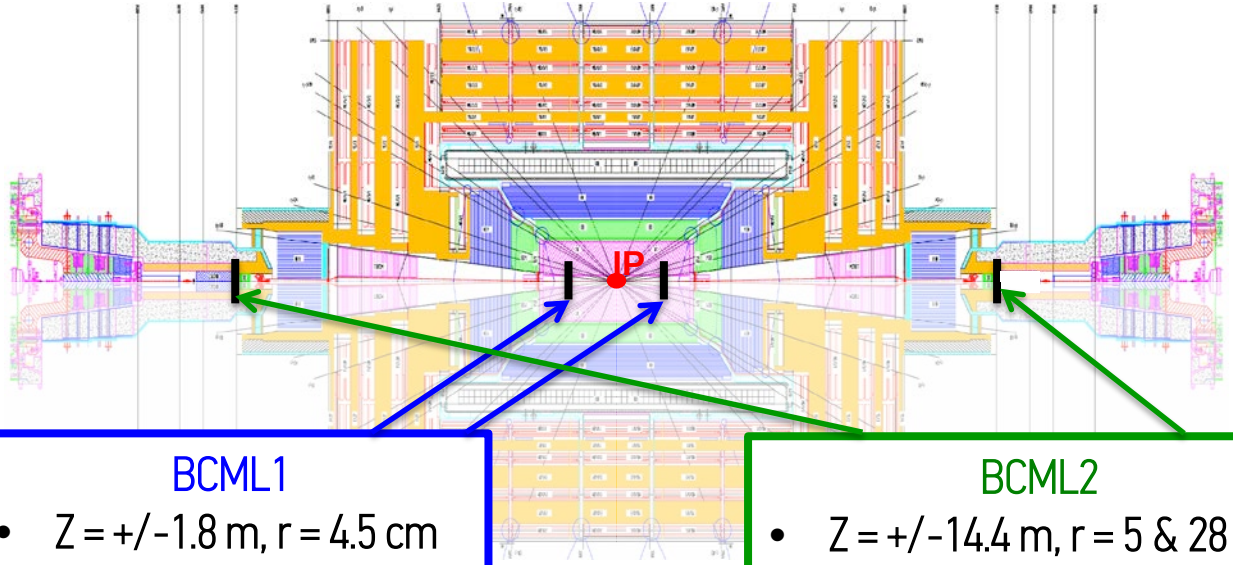


- Luminosity ~ Radiation damage.
- Need new technologies in the innermost layers to survive the radiation levels.



BCML system:

Beam Condition Monitor Leakage



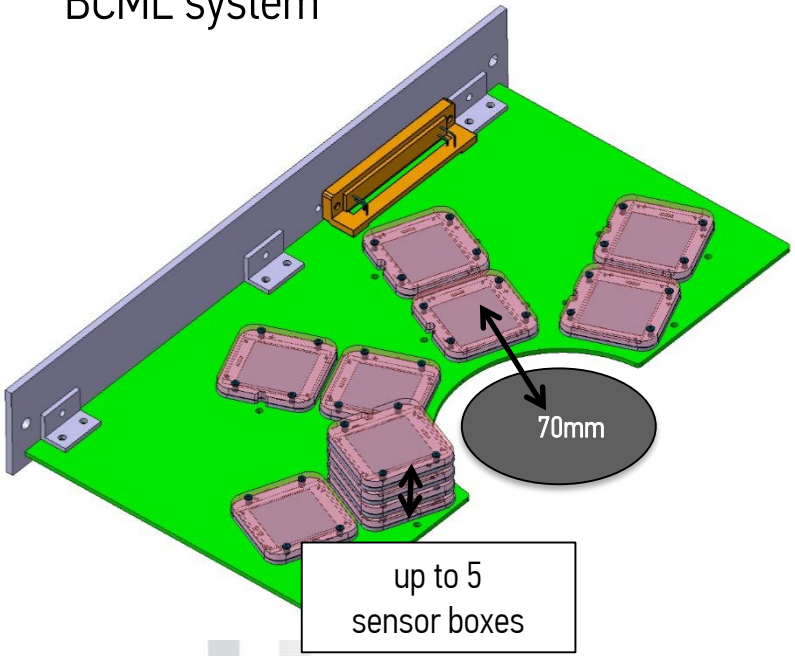
BCML1

- Z = +/-1.8 m, r = 4.5 cm
- 4 det. per area

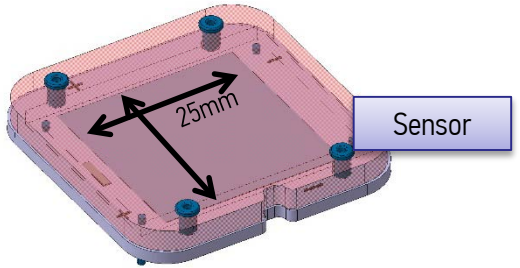
BCML2

- Z = +/-14.4 m, r = 5 & 28 cm
- 16 det. per area

BCML system

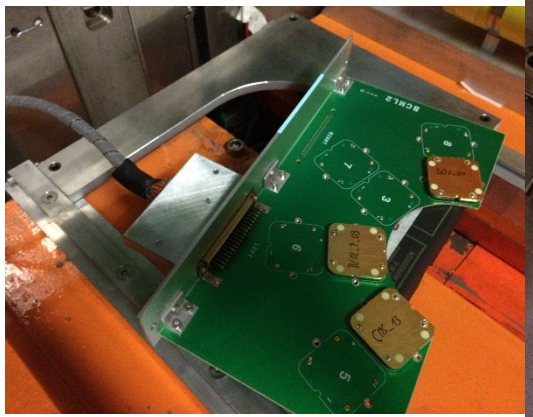


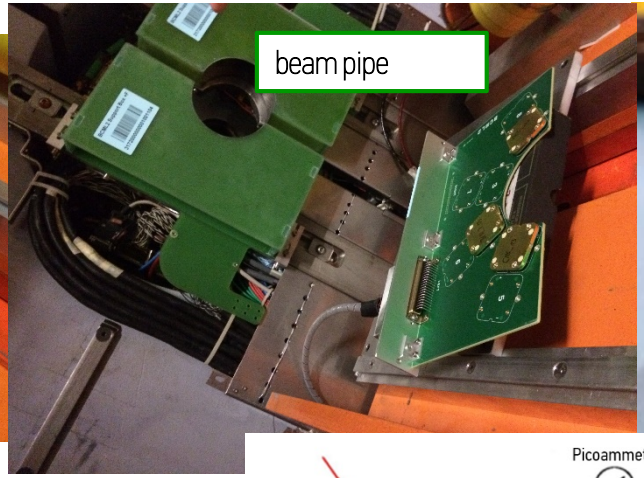
Sensor, mounted in the box

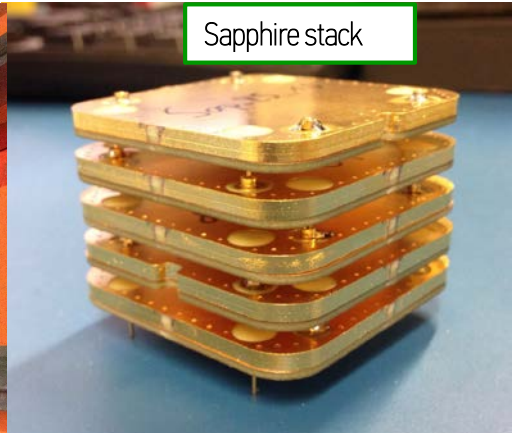


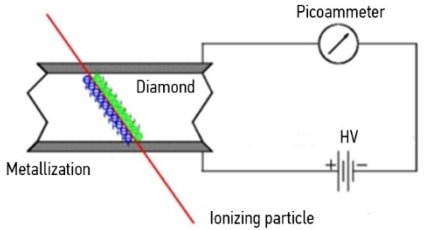
- Plug & Play connector 4 pins
- Possibility to install in stack
- Support for the use of Faraday cages
- The size of the detector :
  - ➢ Different geometries are allowed (10x10 или 25x25 mm^2)

BCML2 system mounting

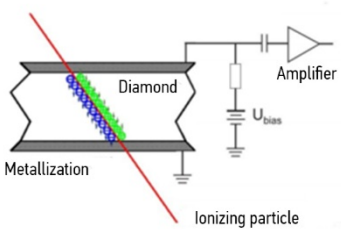








The average current measuring
(to measure the intensity of the particles flow)



The individual particles detection

BCML: Electrical read out - Properties

Electrical read out - Hardware:

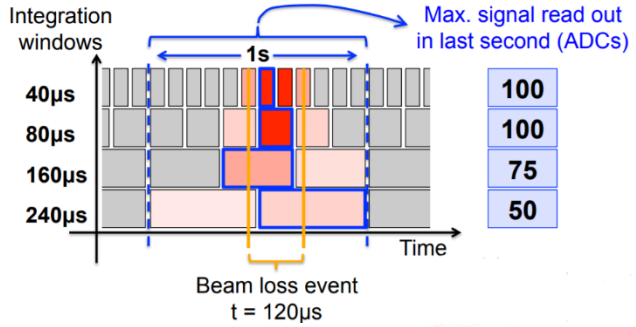
- Identical to the BLM system of LHC.
- Abort functionality is 'hard coded' into system, no software used in process of sending the beam abort signal.

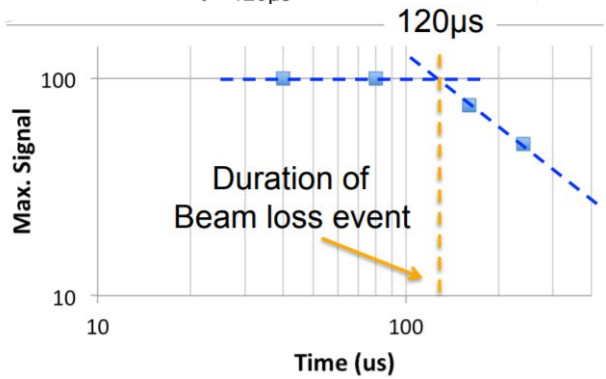
Electrical read out - Measurement:

- In total 12 integration windows = called 'Running Sums (RS)'
- RS1 (40 µs) till RS12 (83 s)
- Read out frequency is 1 Hz
- 5 TB of binary data per year
- Every 40ns 48Ch/12RS

Abort threshold are defined for RS1 and for RS12

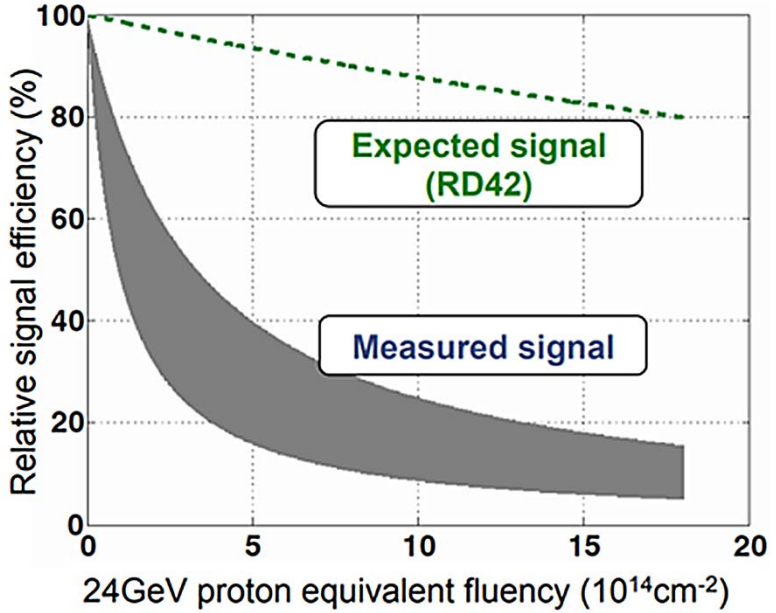
- RS1: Protection against very short beam loss events (≤ 40 µs)
- RS12: Protection against a long term increase in beam background (> 60 s)





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

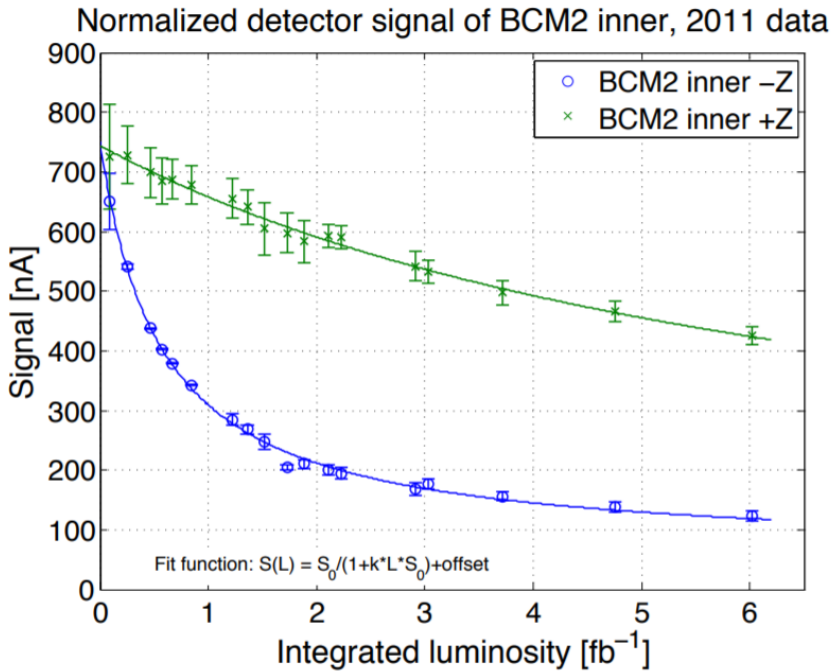
Decrease of detector efficiency was higher than expected in comparison to lab measurements (RD42 collaboration CERN)



Source of graph: M.Guthoff, "Radiation damage to the diamond based Beam Condition Monitor of the CMS Detector at the LHC ", Ph.D. thesis, 2014

- A reduced detector efficiency requires a reduced abort threshold in order to keep the same safety margin.
- Detector efficiencies are continuously calculated by comparing current detector signal with the expected signal for an undamaged sensor for nominal luminosity.

- Detector degradation depends strongly from detector location.
- BCML2 detector on the –Z side was located close to the CASTOR detector, a source for a high neutron flux

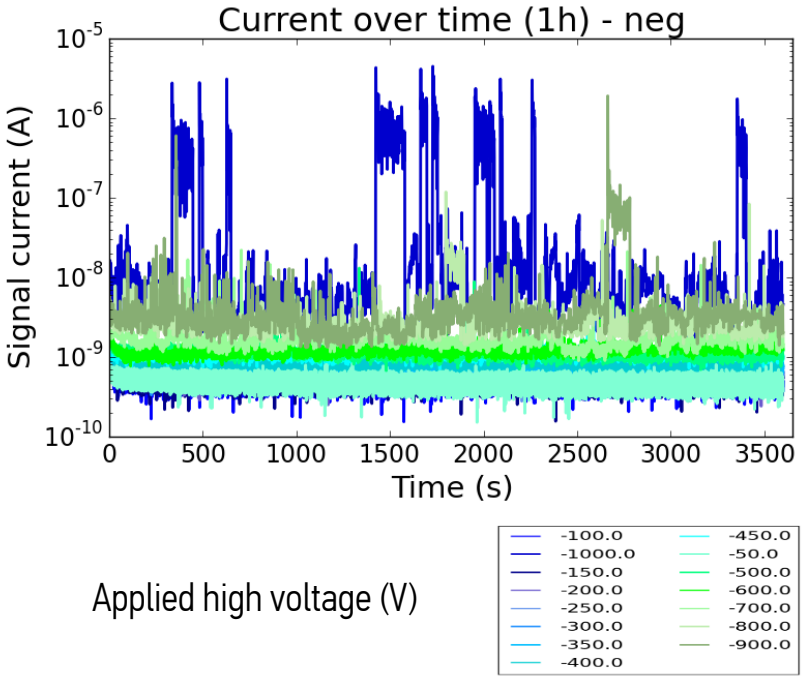


Source of graph: M.Guthoff, "Radiation damage to the diamond based Beam Condition Monitor of the CMS Detector at the LHC ", Ph.D. thesis, 2014

High electrical fields

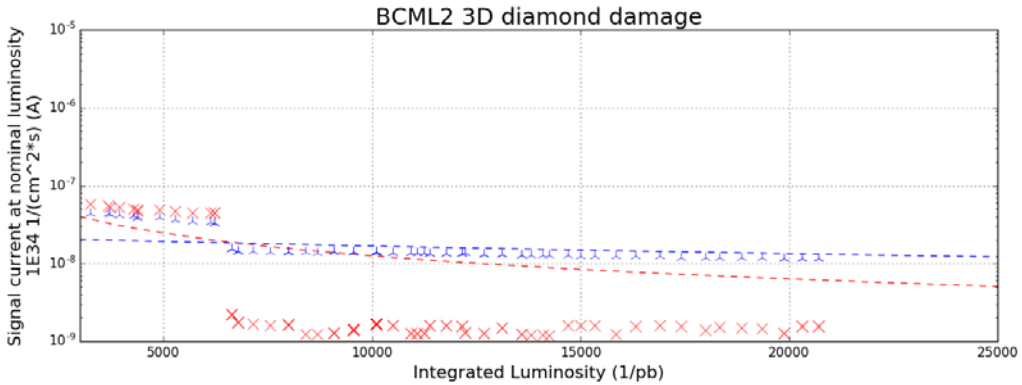
Unstable behavior during the high voltage applying

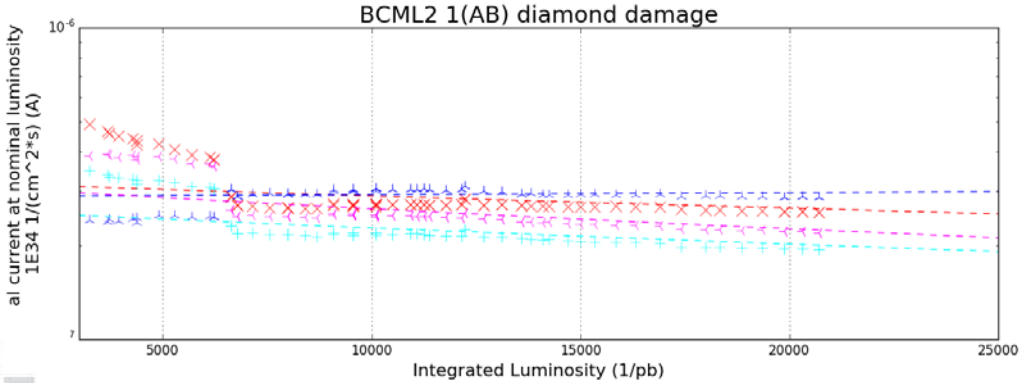
- pCVD (and sCVD) become unstable at high electric fields
- 'Erratic signal bursts'
- Diamond quality related!



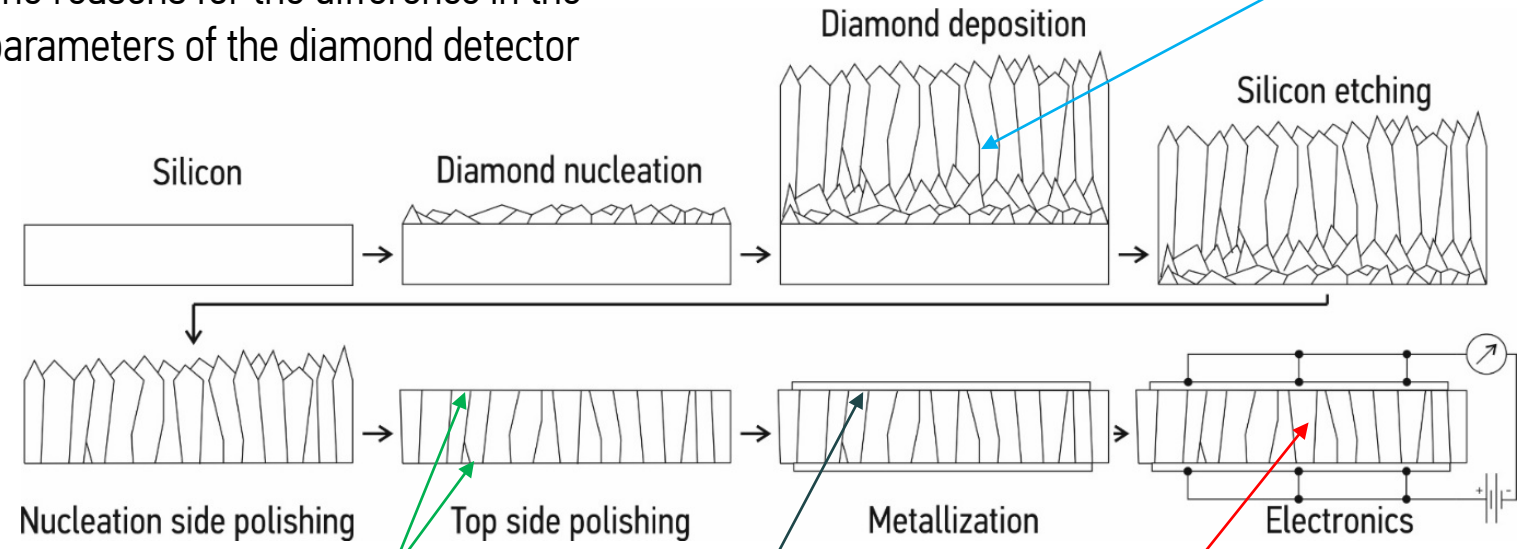
Degradation of signal efficiency during irradiation

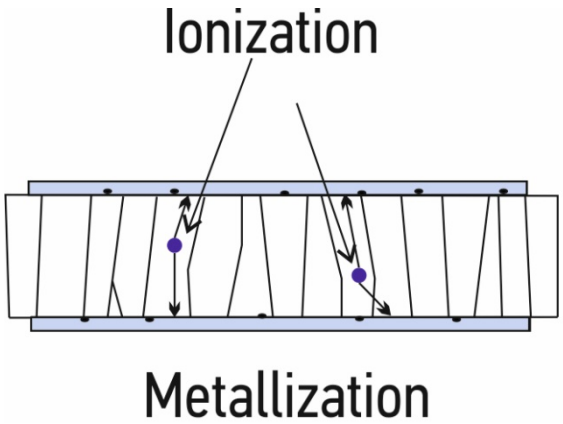
- K - parameter displays the degradation rate of the detector
- Changing in voltage – change the behavior



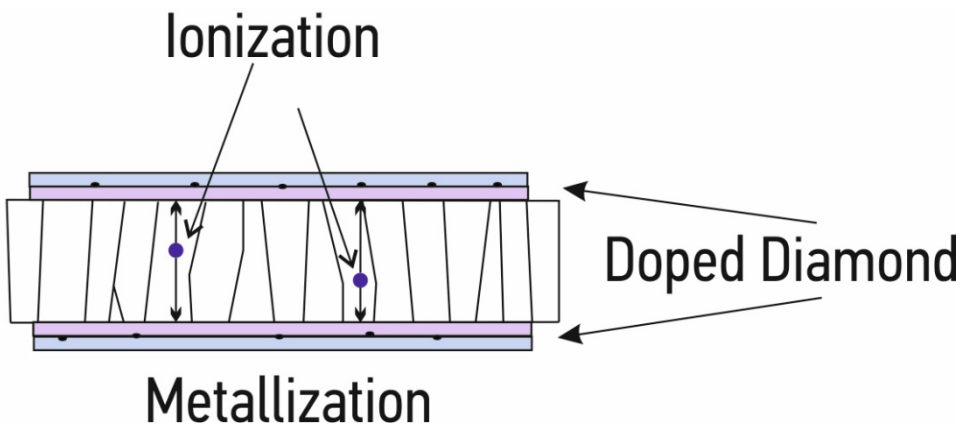


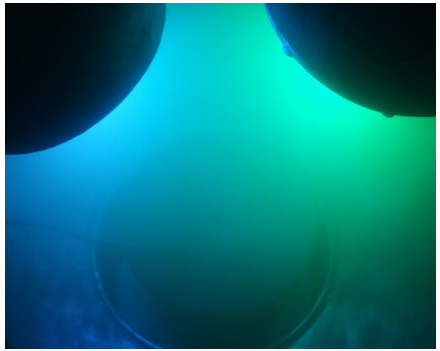
The reasons for the difference in the parameters of the diamond detector

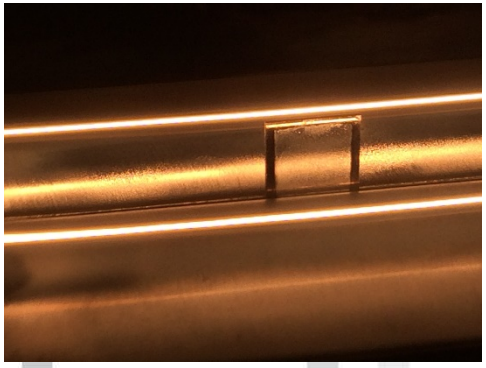



Ionization
Metallization

Diamond

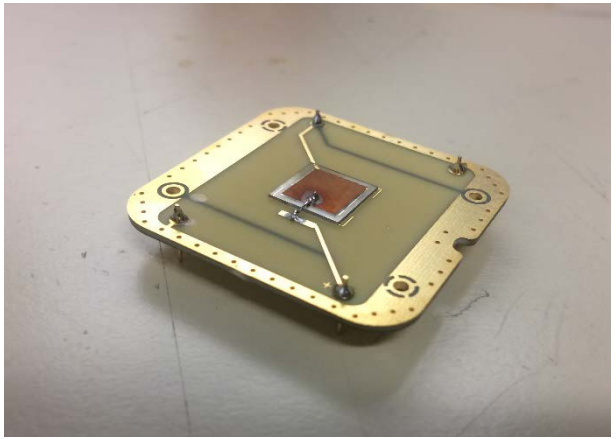

Ionization
Doped Diamond
Metallization

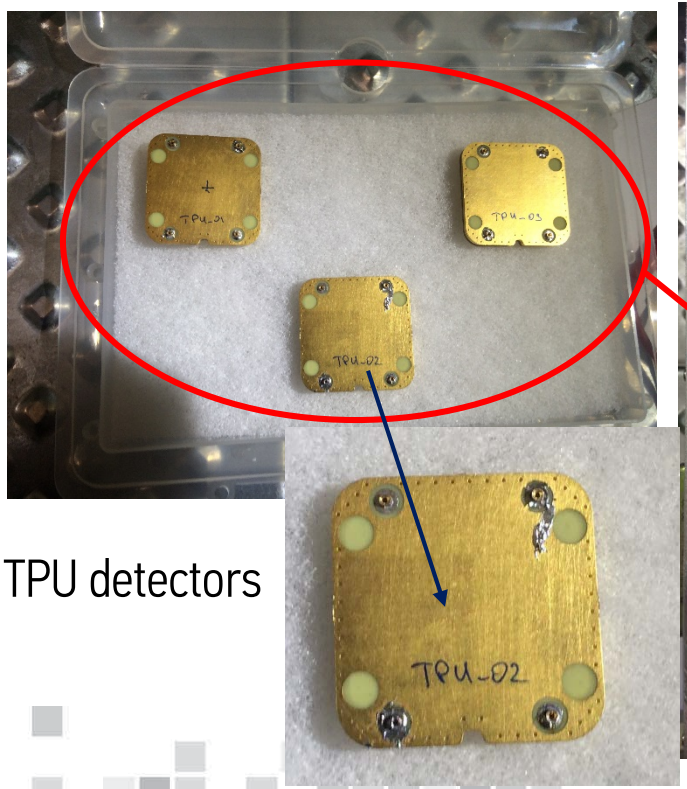




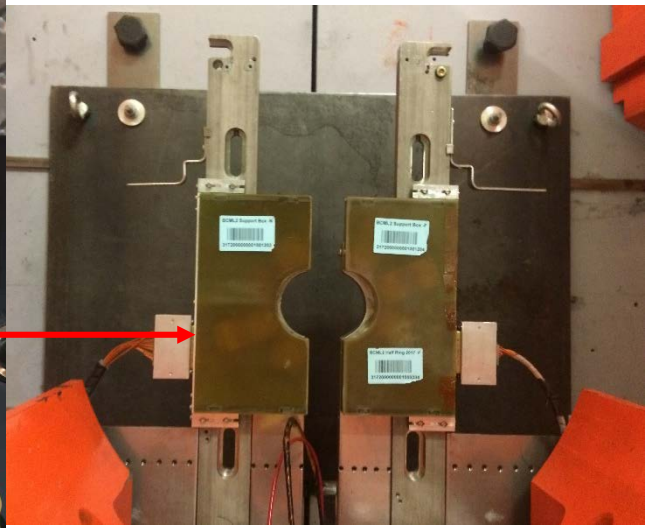
Pretreatment and metallization deposition

Soldering and installation



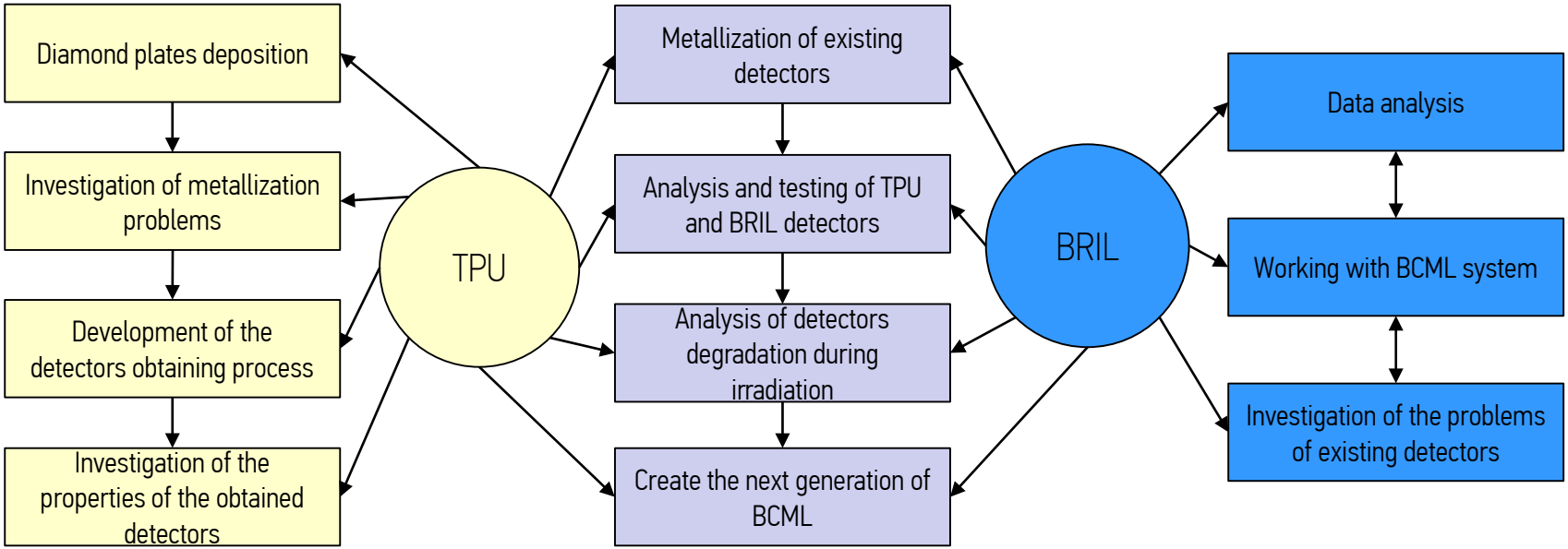


TPU detectors



BCML system

General BCML detectors work plan



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THANK YOU
FOR YOUR ATTENTION!