Silicon PhotoMultiplier (SiPM) characterization for LHCb RICH Upgrade II

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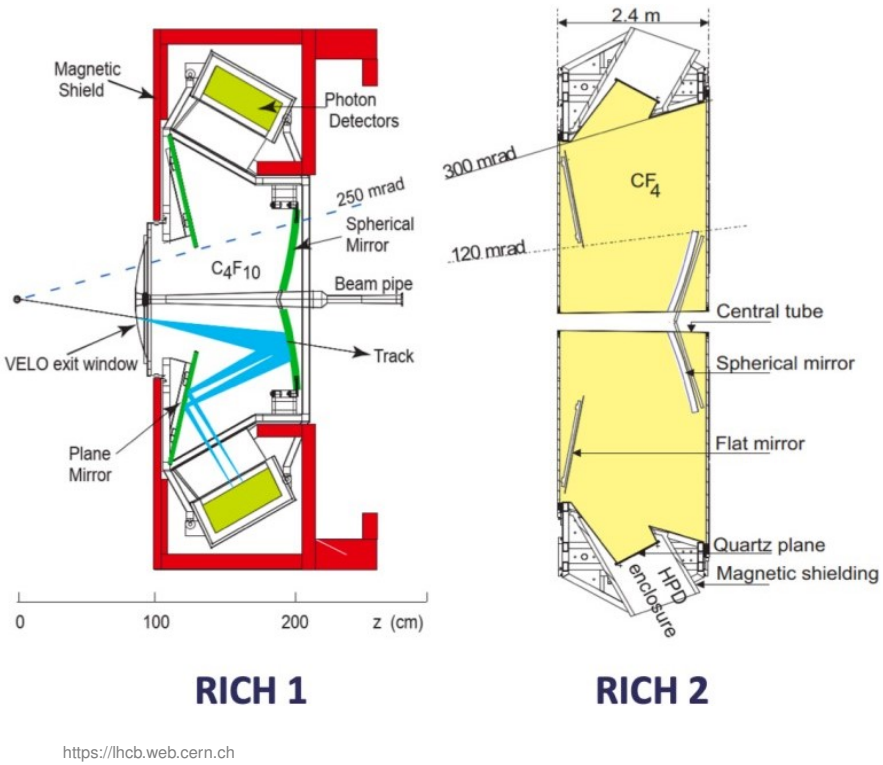
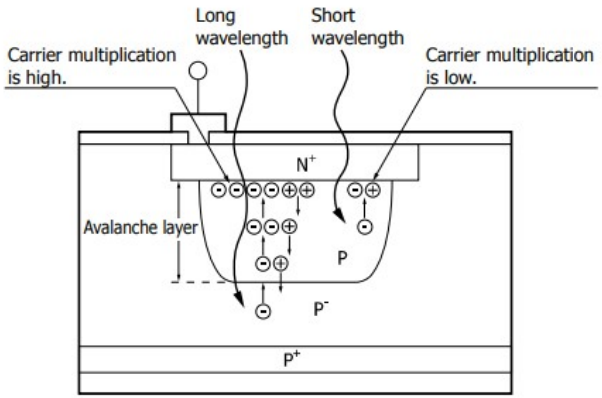
LHCb RICH detectors and Upgrade II



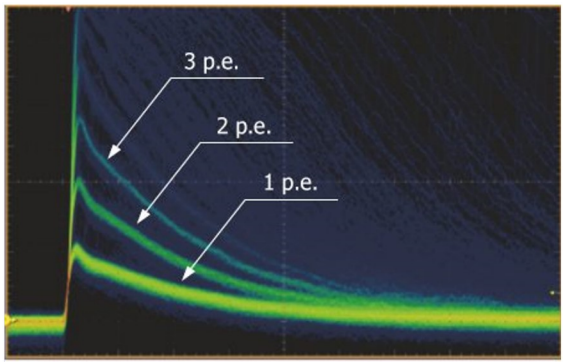
https://lhcb.web.cern.ch

- Single photon angular resolution of less than 0.5 mrad
- Maintain the occupancy below 30%
- Increase spatial granularity with 1 - 3 mm^2 pixel size
- Introduce timing information with < 100 ps resolution per channel
- Replace MaPMTs; SiPMs are considered as an option

Silicon PhotoMultiplier



https://www.hamamatsu.com



https://www.hamamatsu.com

Solid-state single photon sensors.

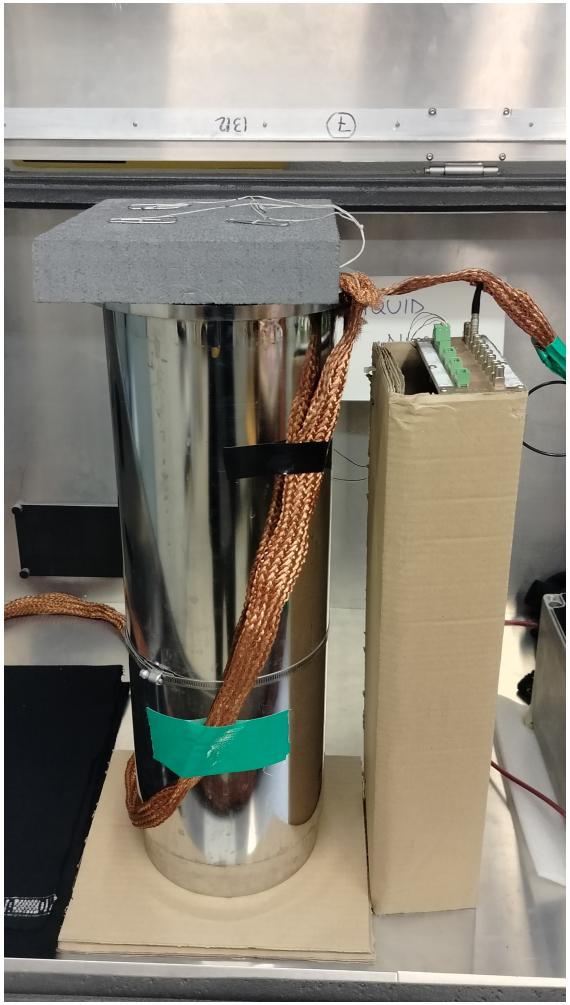
Formed by a grid of many Single Photon Avalance Diode (SPAD) $\rightarrow$ proportional behaviour.

High photon detection efficiency (PDE), high gain, insensitivity to magnetic fields, low bias voltage, and good timing resolution.

High dark count rate (DCR) at room temperature, which increases significantly with irradiation.

Mitigation by operating SiPMs at sufficiently low temperatures, radiation shielding, and annealing during detector maintenance periods.

SiPM characterization in lab

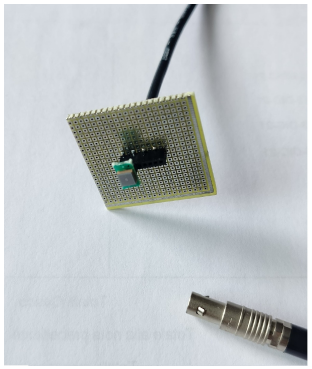


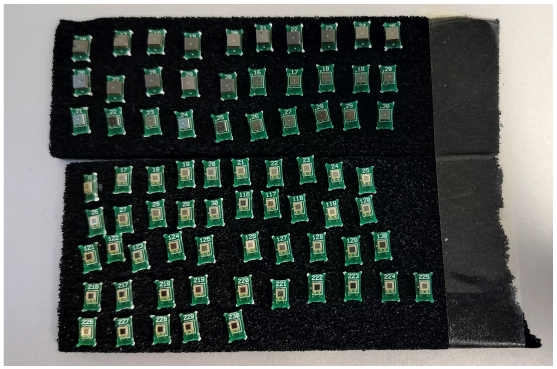
Joint effort of all LHCb/RICH INFN institutes (MiB, FE, PG, PD).

Preliminary measurements to validate the methodology.

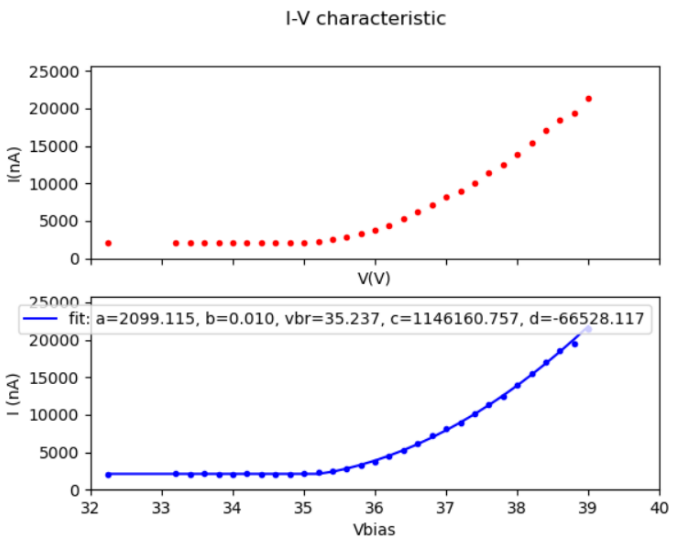
Full characterization before and after irradiation (and annealing), starting with measurements of V_{br} and DCR, using a cryostat with liquid nitrogen (from +25 ℃ to $\sim$ -190 ℃).

Characterization of 75 SiPMs of 5 different models.

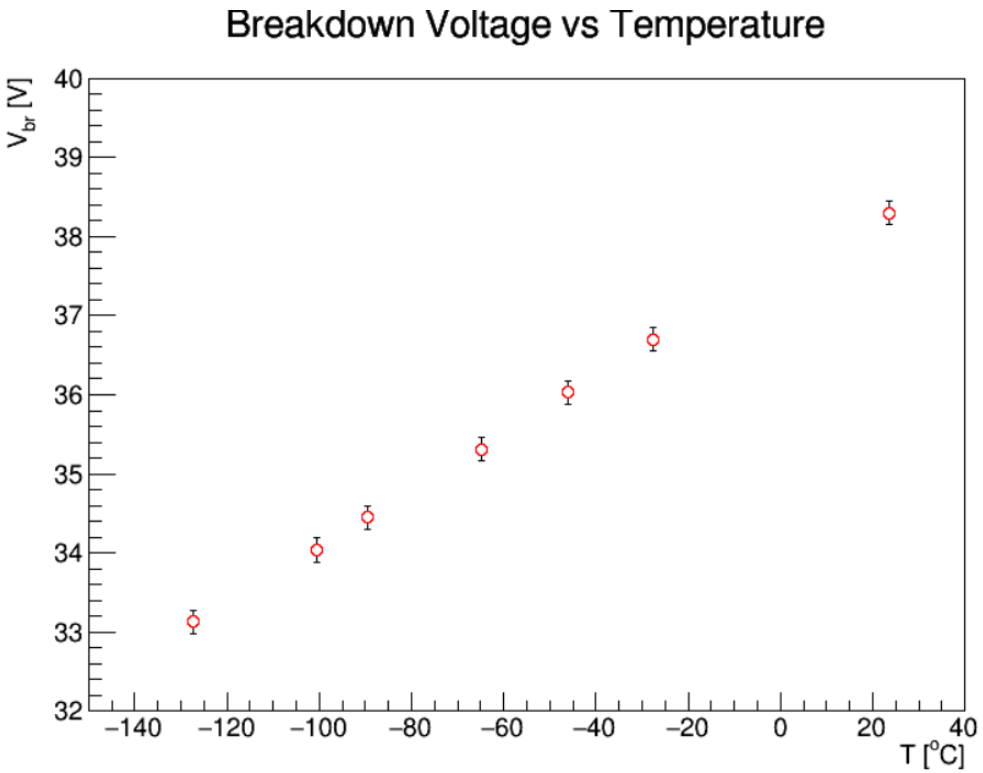




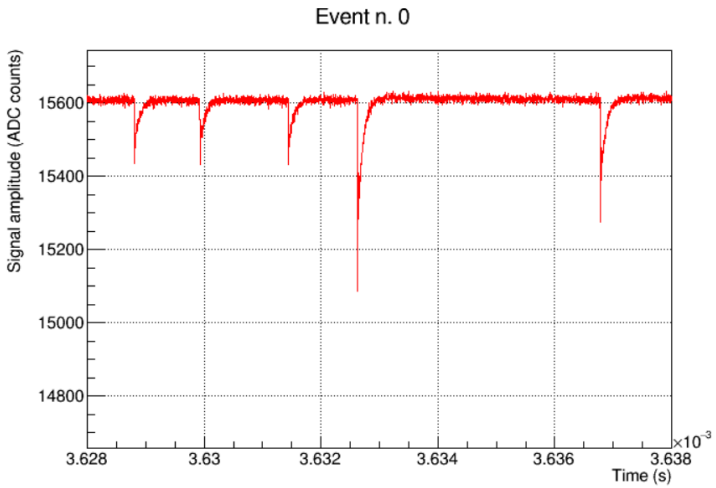
Preliminary results - V_{br}



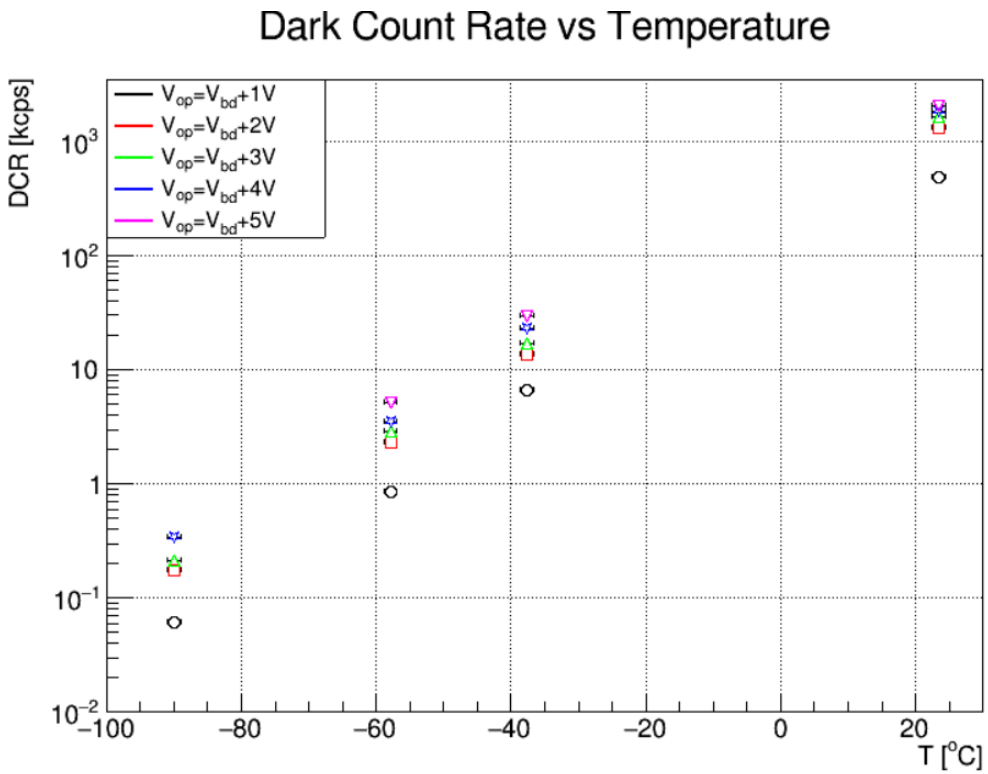
The temperature dependence of V_{br} is linear.



Preliminary results - DCR



The temperature dependence of DCR is exponential-like.



Conclusion and Future Outlooks

- Preliminary evaluation of the temperature dependencies of V_{br} and DCR is consistent with expectations.
- Perform other measurements:
  - Gain
  - Photon Detection Efficiency (PDE)
  - Time resolution

  To do this, integrate a laser into the setup.
- Plan to use the amplifier designed by MiB (see D. Trotta talk) to characterize all the 75 SiPMs.
- Use a bigger LN2 cryostat to have access to a finer gradient in temperature.
- Perform characterization after irradiation and annealing.

THANK YOU FOR

YOUR ATTENTION