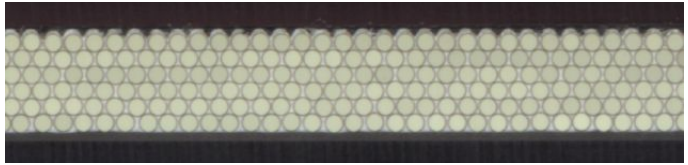
SiPMs aging and upgrade studies for the LHCb SciFi tracker

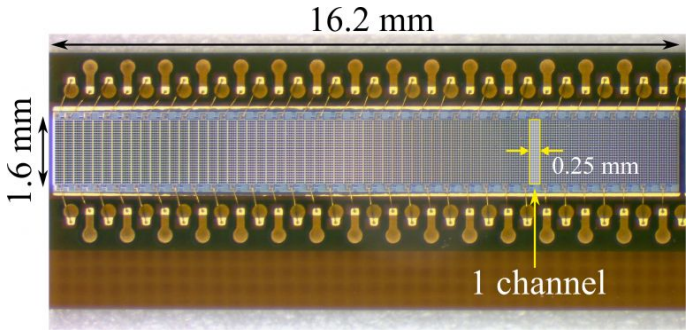
Monitoring of the radiation damage induced aging of the LHCb SciFi tracker SiPMs during the first 9 months of Run 3 and development of new SiPMs for the SciFi upgrade.

Federico Ronchetti

École Polytechnique Fédérale de Lausanne (EPFL)
Laboratoire de Physique des Hautes Énergies (LPHE)

The SciFi tracker of LHCb

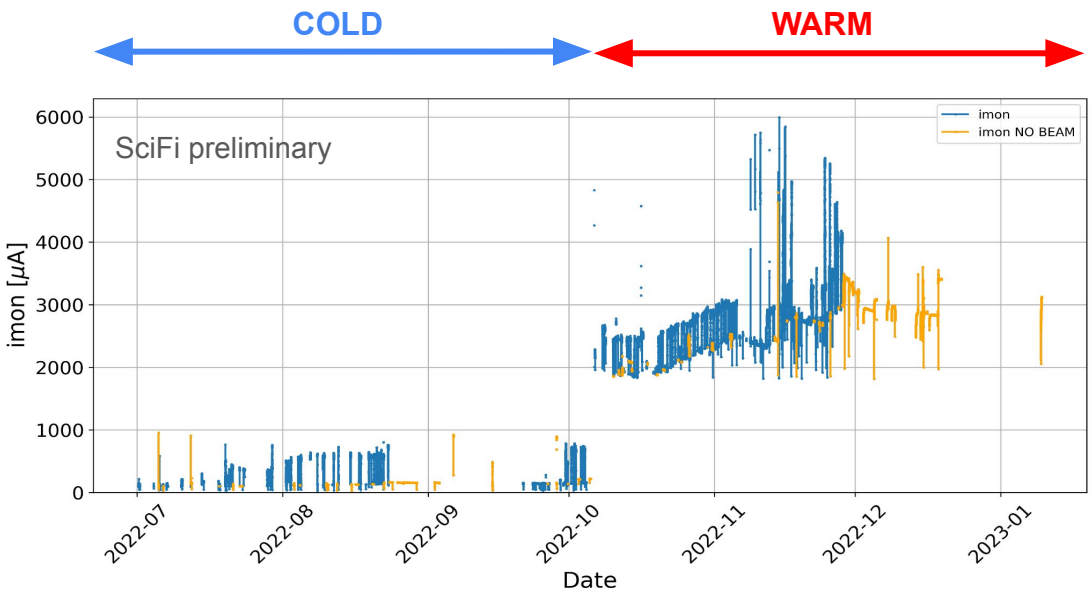


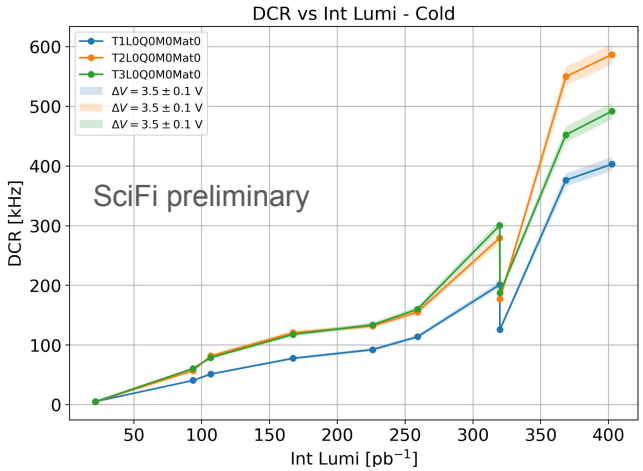


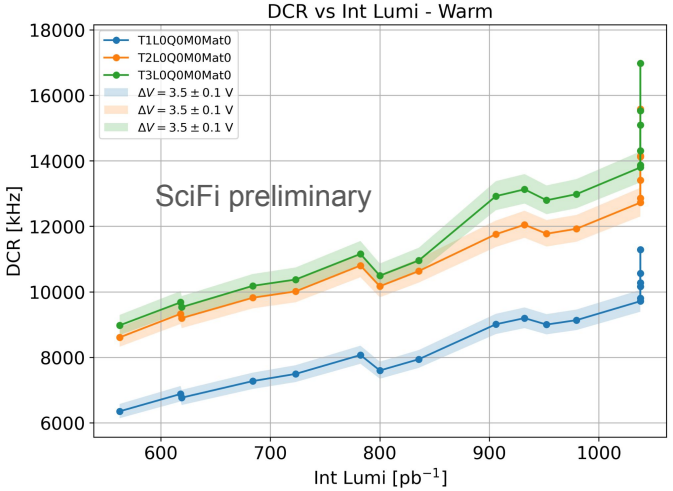
- 250 µm ⌀ Scintillating Fibers mats readout by multichannel SiPMs arrays
- 12 layers → 6 x 5 m^2 each and a total of 340 m^2
- All cooling and readout electronics located outside the acceptance
- SiPMs cooled @-40°C

SiPM aging: monitoring currents

- DCR increases with radiation damage
- DCR is T dependant
- At room temperature we operated the detector as at the end of life

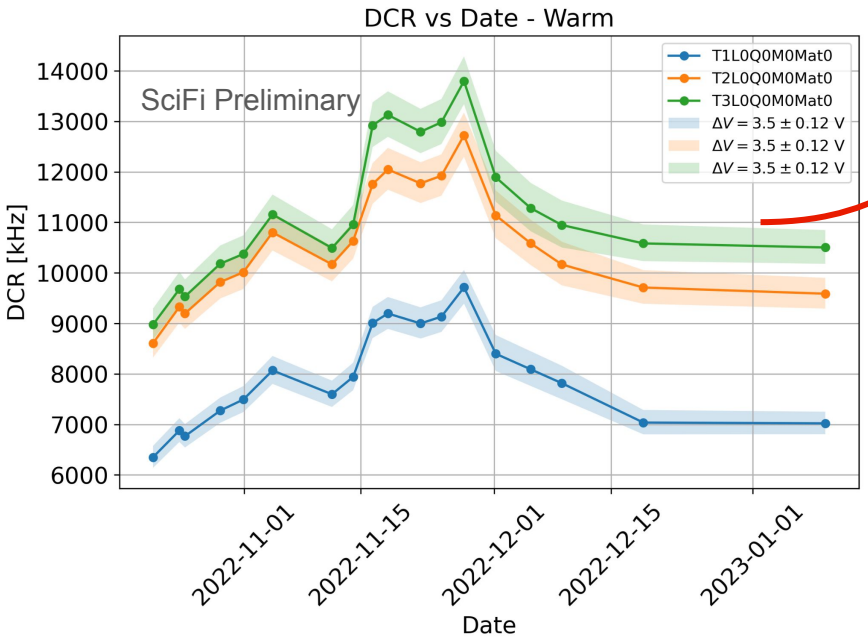


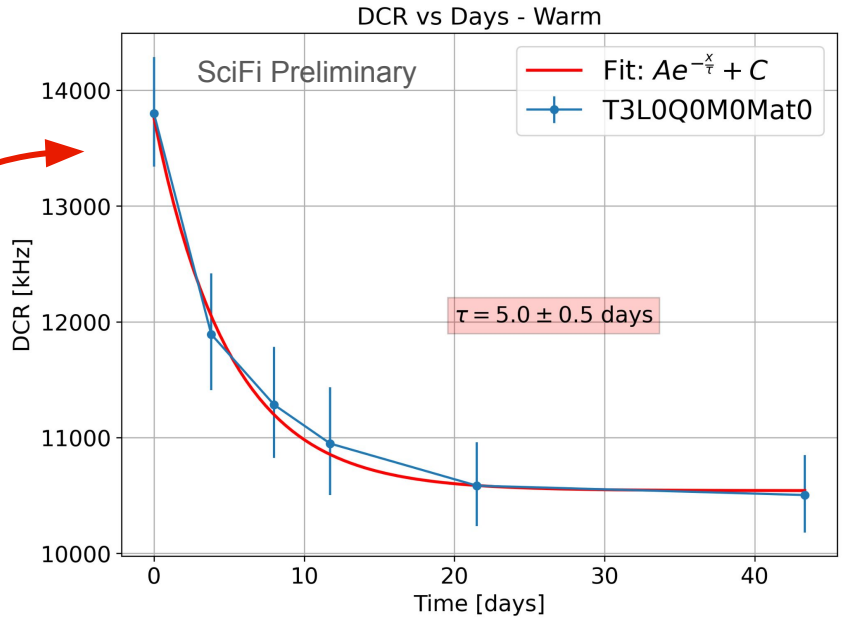




Annealing at room temperature

- Heating up the detector to ~30°C
- Can be performed during LHC shutdown periods

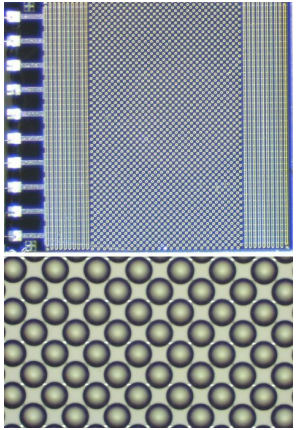


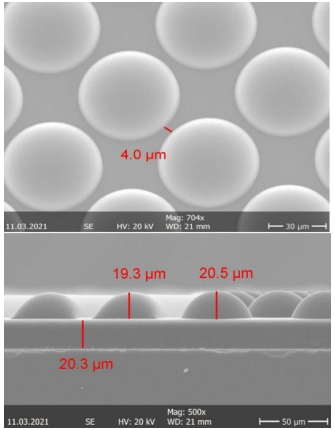


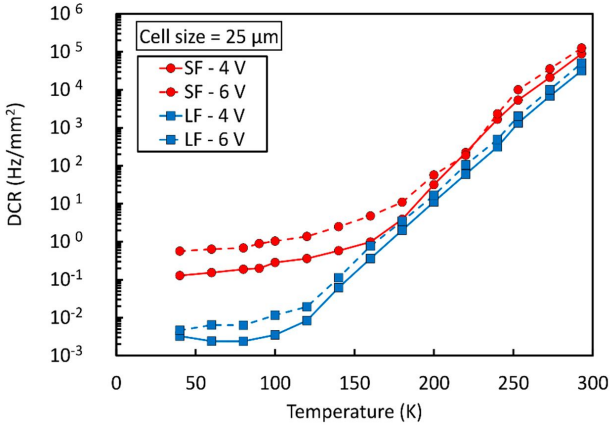
SciFi upgrade II (2034)

How to mitigate radiation damage?

- Improve SiPM characteristics
  - reduce pixel size→lower gain and therefore x-talk, faster recovery time and lower after-pulse
  - introducing micro-lenses to recover light from the dead regions→ expect +20% light yield
- Reduce number of fibre layers per detection plane
  - smaller clusters → less channel occupancy
  - lower material budget
- Reduce SiPM DCR with cryogenic cooling to LN2 temperature (–196ºC), expected 100x less noise with 10x more radiation compared to current detector







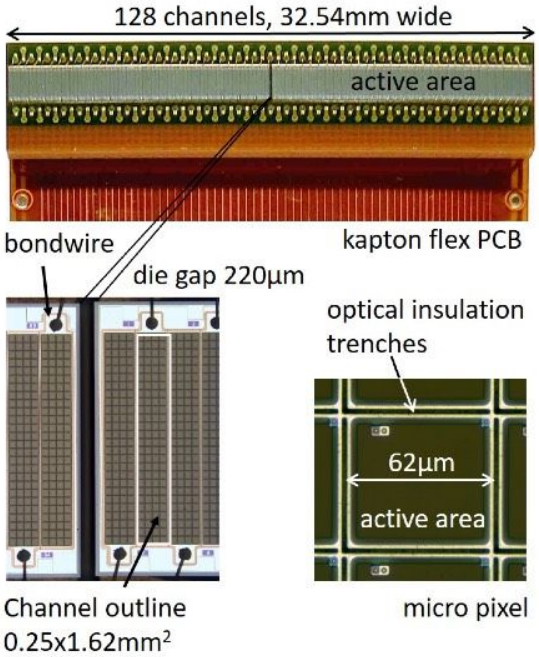
Thanks for the attention

Backup slides

SiPM characteristics

Hamamatsu, custom made SiPMs arrays

- 4096 arrays × 128 channels → 524k readout channels
- 250 µm channel pitch
- 62.5 x 57.5 µm^2 pixel size - 104 pixels per channel
- Kapton flex PCB for readout and bias
- Pt1000 temperature sensor soldered backside



Irradiation environment

With the assumption of a proton-proton cross-section of 84 mb, an integrated luminosity of 50 fb−1 and 14 TeV center-of-mass energy collision, the maximum neutron fluence expected is $8.1 \cdot 10^{11}$ neq/cm2 for T1 and $14 \cdot 10^{11}$ neq/cm2 for T3.

The shield reduces the neutron flux by more than a factor two for T1 and more than a factor three for T3. The neutron fluence is then reduced to $3.5 \cdot 10^{11}$ neq /cm2 and $4.7 \cdot 10^{11}$ neq/cm2