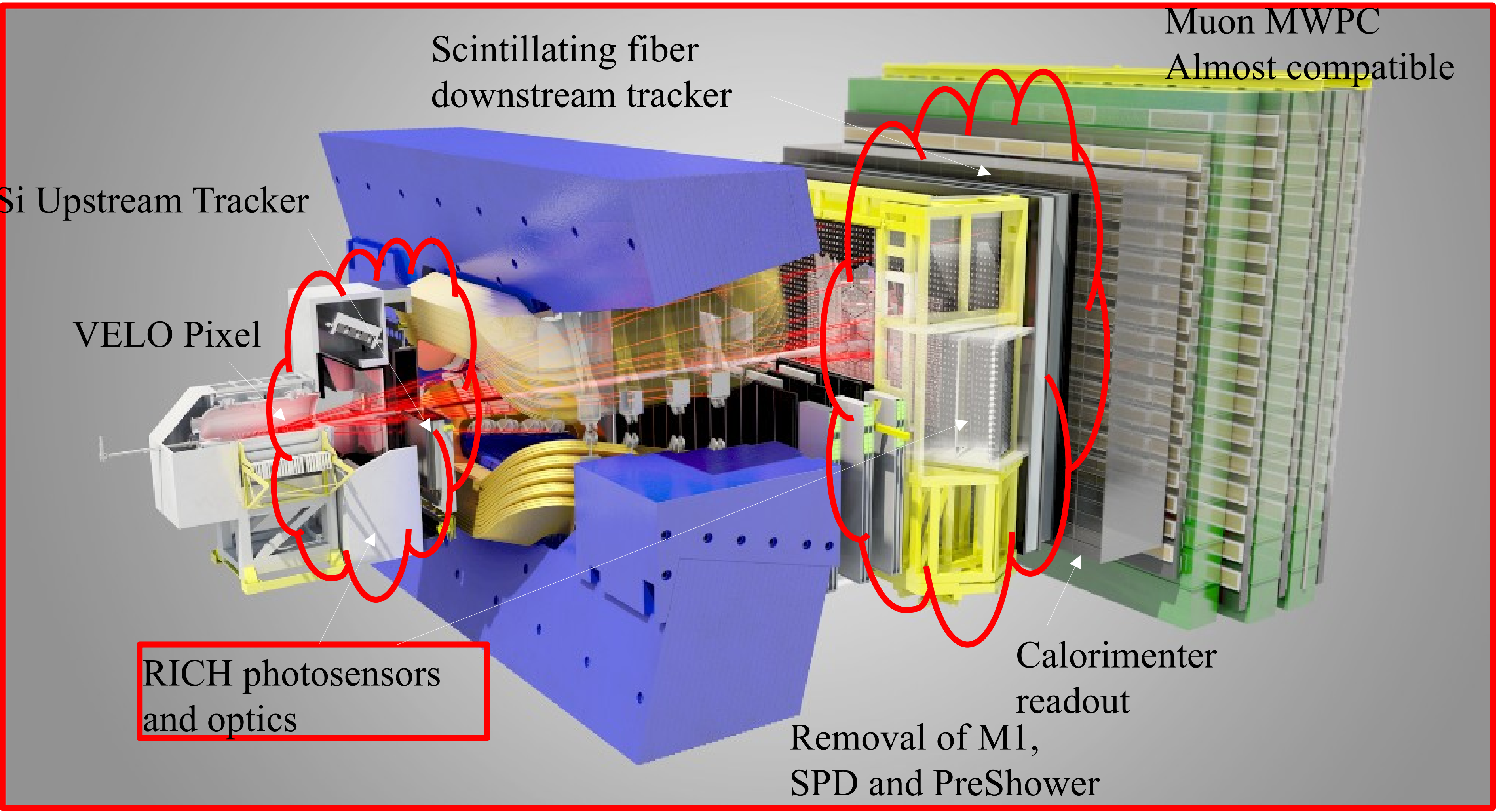
LHCb Upgrade of the Tracking and RICH detector

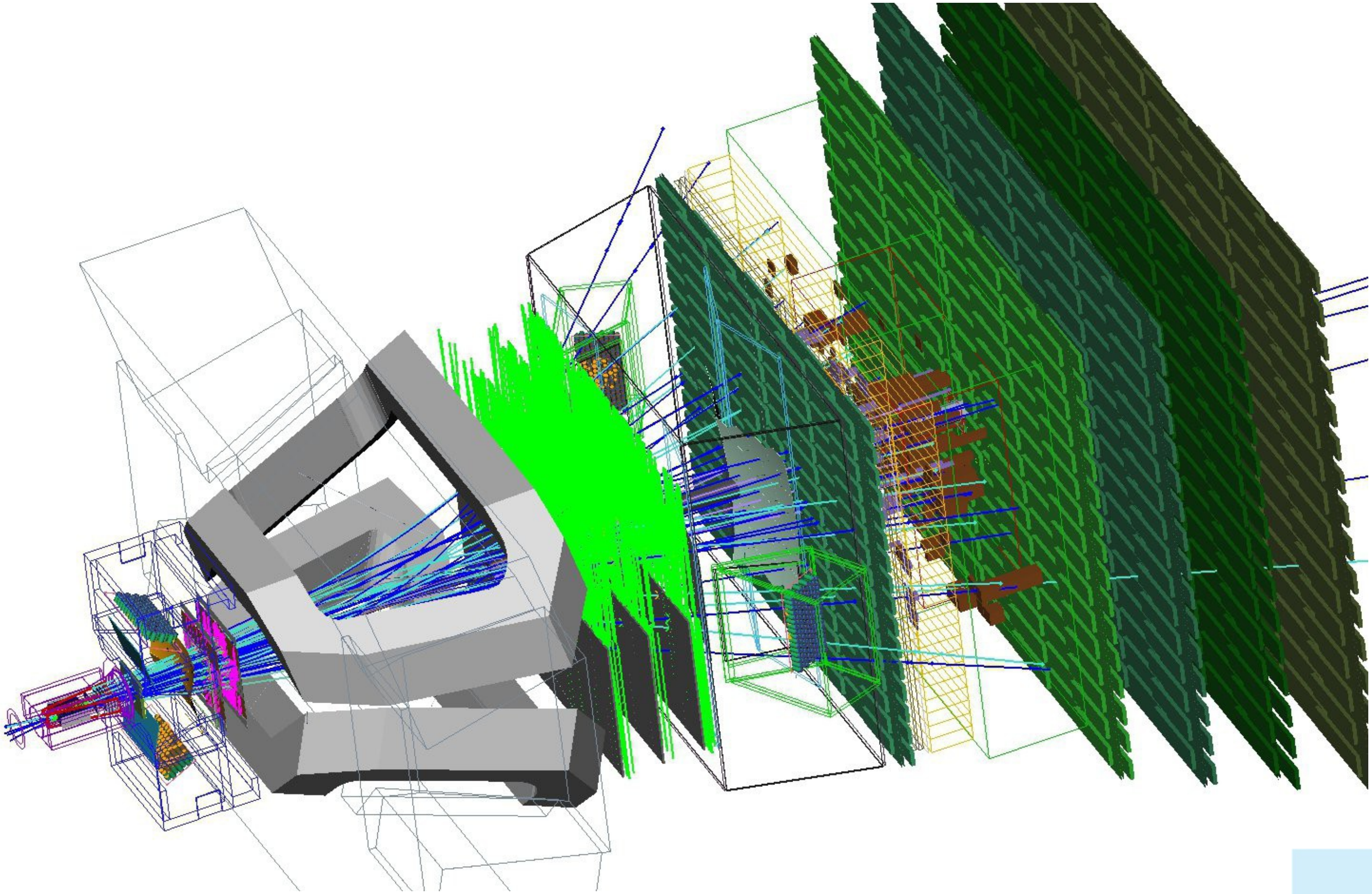
Speaker: Gabriele Simi

Group: LHCb

LHCb Upgrade I

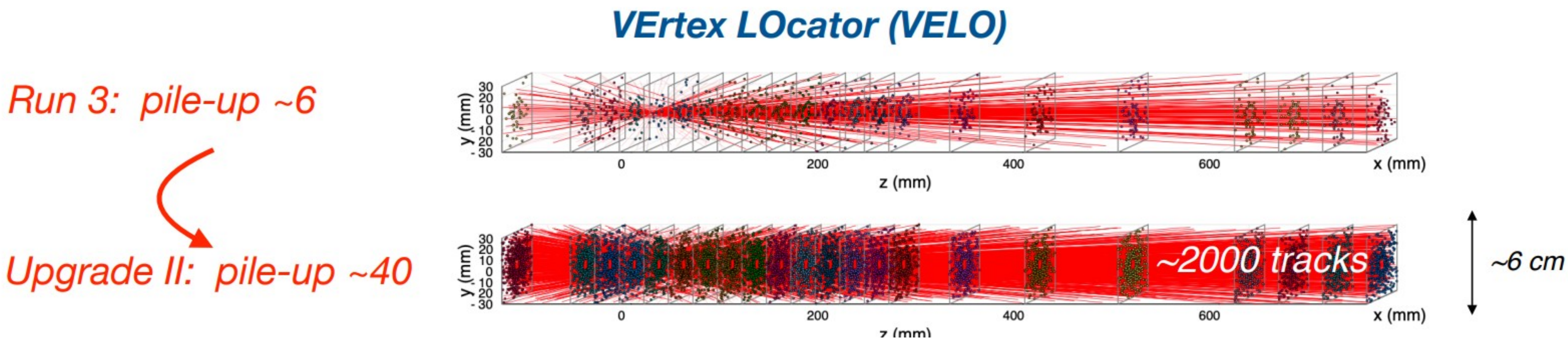


The detector challenge high luminosity running of LHC



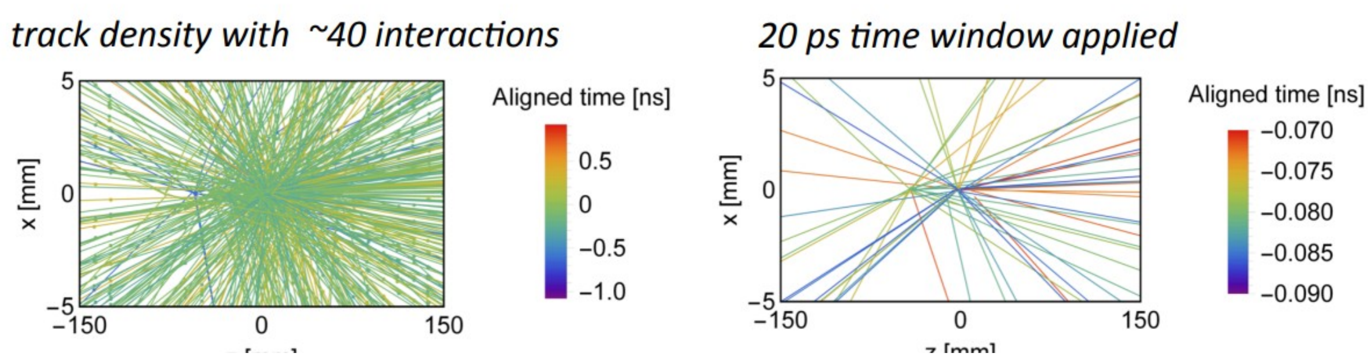
The detector challenge for upgrade II

Targeting same performance as in Run 3, but with pile-up ~40!



Pile-up suppression

Each hit in VELO time-stamped with 50 ps resolution → 20 ps per track

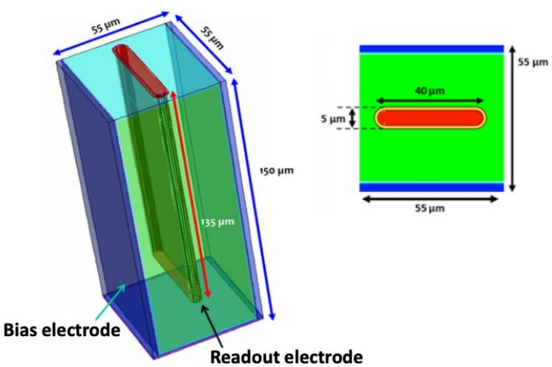


TimeSPOT → IGNITE

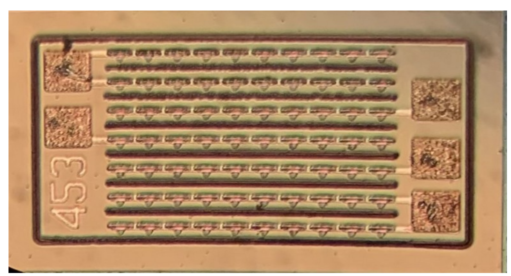
INFN Ground-up iNITiative for µElectronics developments

Italian lead project to develop of a **complete tracking demonstrator** capable of copying with extremely **high instantaneous luminosities** foreseen at HL-LHC (High Luminosity LHC)

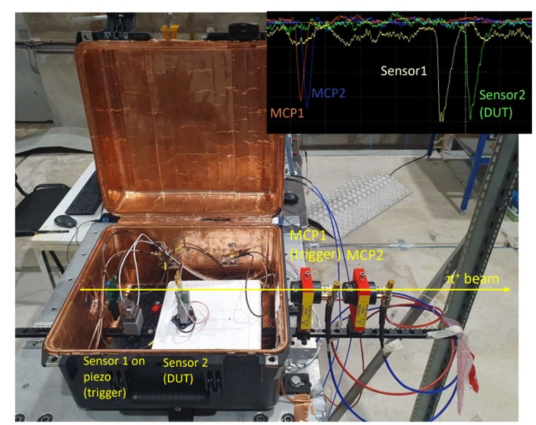
Pixel Sensor



Pixel Array



TimeSPOT sensors:
3D Silicon sensors with **high space resolution, wolrd's best time resolution**, and **great radiation hardness**



Possible activities in Padova:
Test of complete tracking demonstrator of an array of planes of pixels with particle beam at CERN

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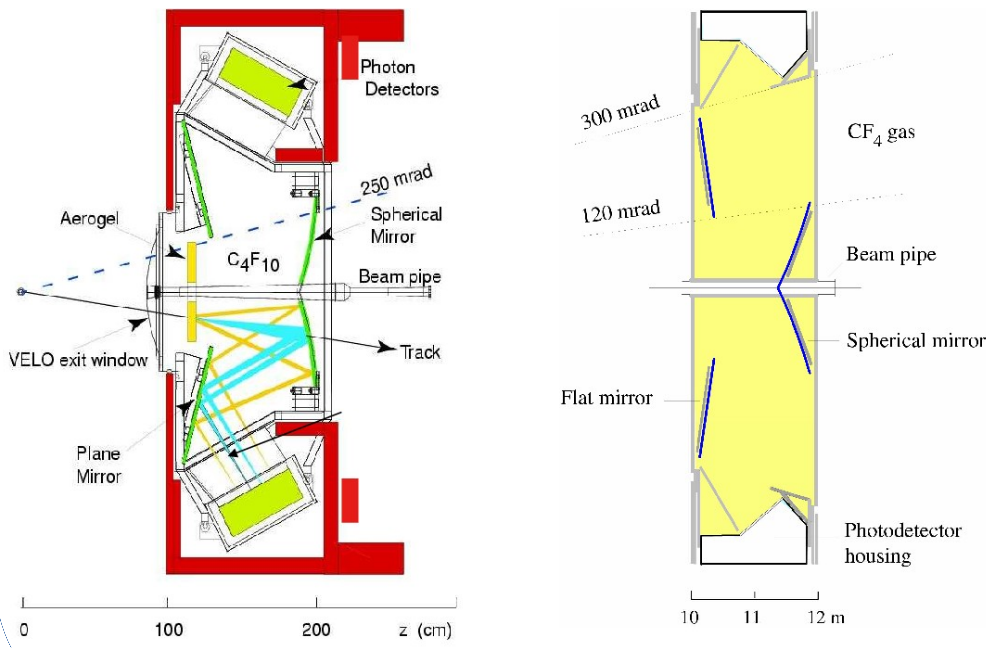
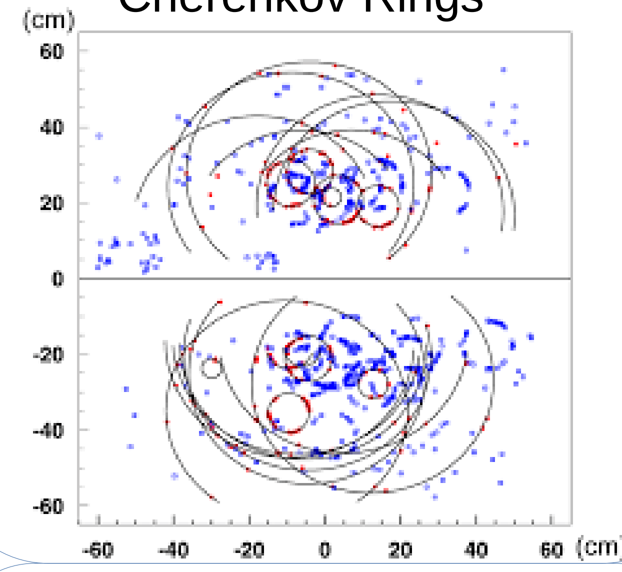
LHCb Particle Identification: RICH

RICH 1 and RICH 2 detectors

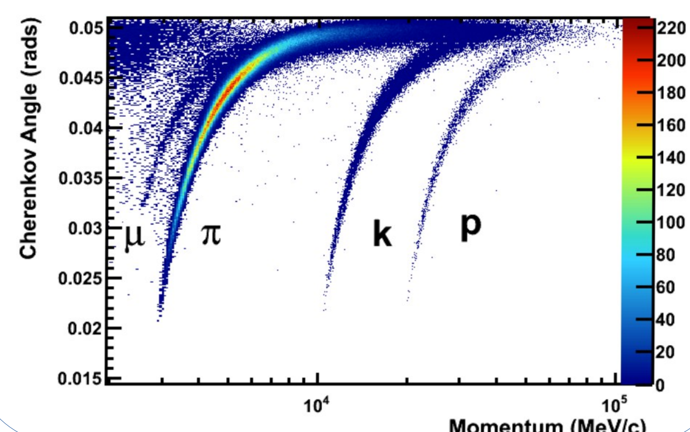


(a) (b)

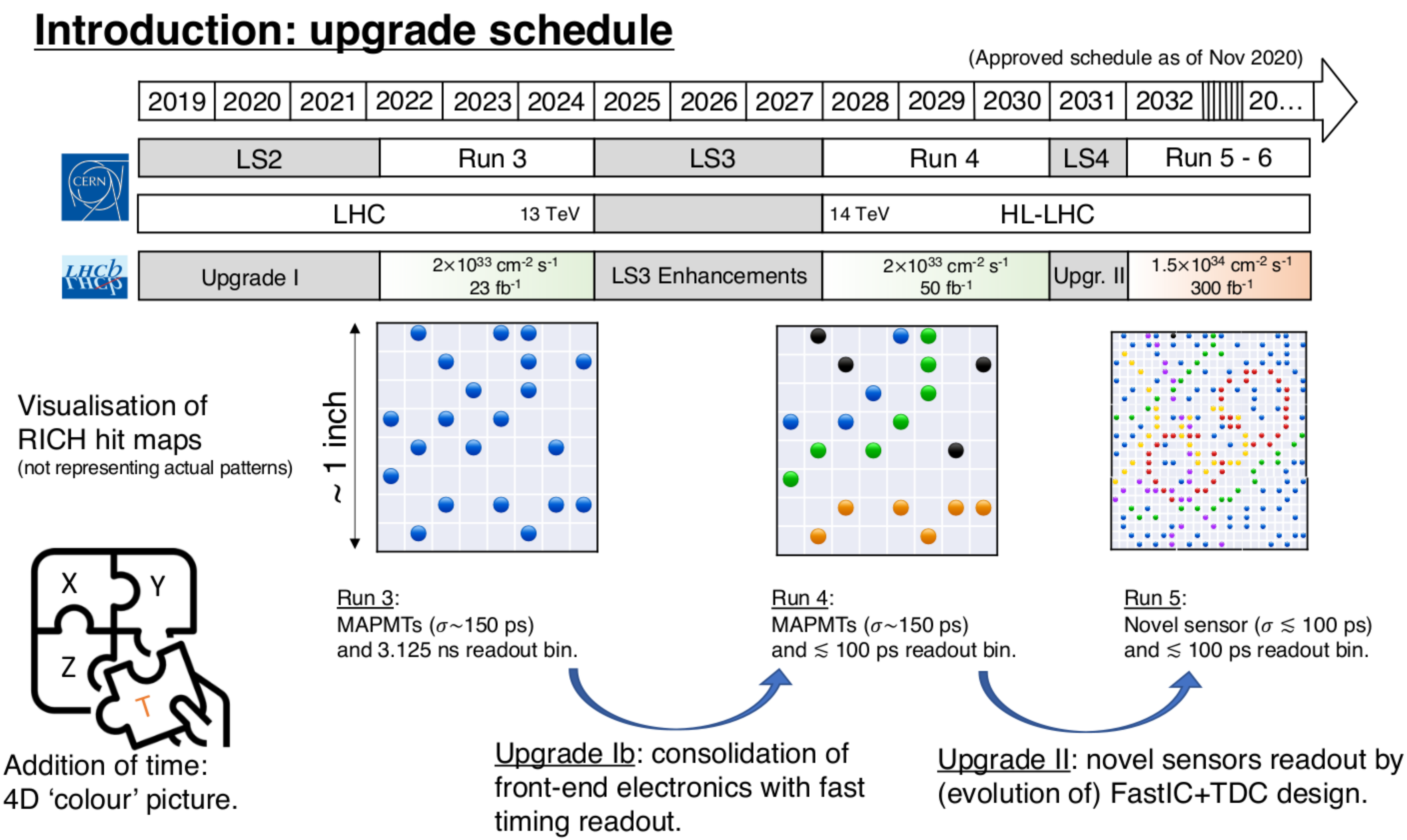
Cherenkov Rings



Cherenkv angle vs momentum

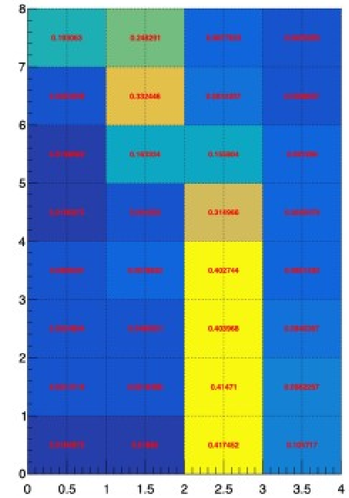


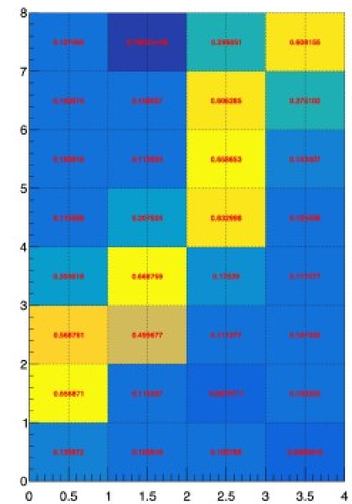
LHCb Upgrade II - PID

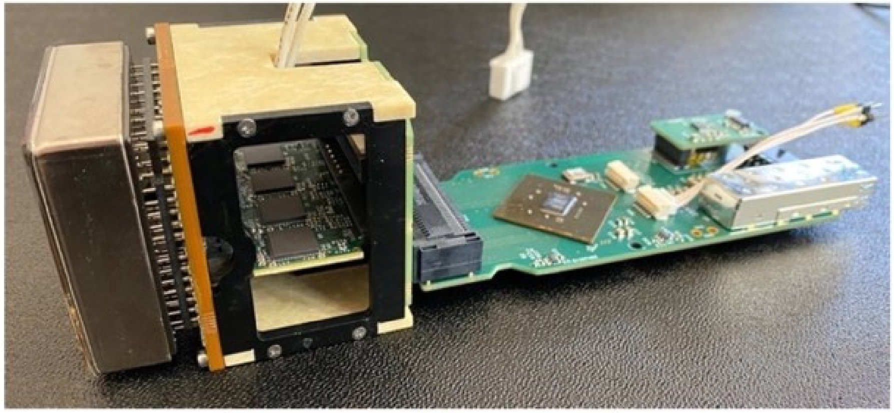


RICH Upgrade: LS3 enhancements

- During the next shutdown the detector will be equipped with new electronics capable of measuring the time of arrival of photons with 100 ps accuracy
- The Padova group is involved in the characterization of the prototypes of electronics + detectors with a beam of protons at CERN







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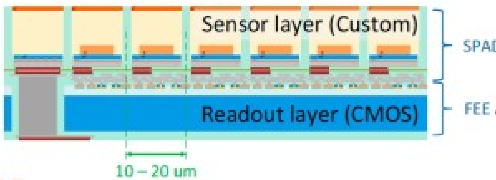
LHCb Upgrade II - PID

2.5D and 3D Integration
Next-generation development: Backside Illuminated SiPMs

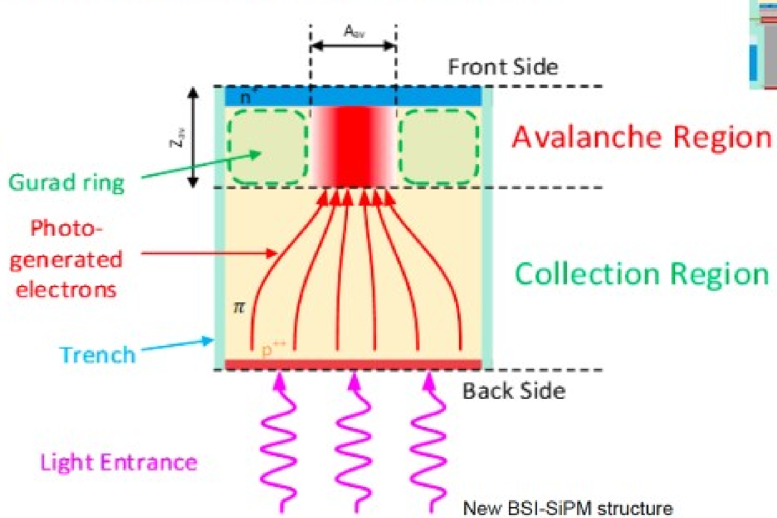
The next-generation of developments, currently being investigated at FBK, is building a *backside-illuminated, NUV-sensitive SiPM*. Several technological challenges should be overcome.

Clear *separation between charge collection and multiplication regions*.



Potential Advantages:

- Up to 100% FF even with small cell pitch
- Ultimate Interconnection density: < 15 um
- High speed and dynamic range
- Low gain and external crosstalk
- (Uniform) entrance window on the backside, ideal for enhanced optical stack (VUV sensitivity, nanophotonics)
- Local electronics: ultra fast and possibly low-power.



New BSI-SiPM structure

Development Risks:

- Charge collection time jitter
- Low Gain → SPTR?
- Effectiveness of the new entrance window

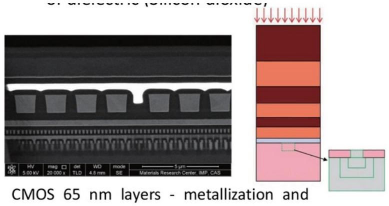
Radiation hardness:

- The SiPM area sensitive to radiation damage, is much smaller than the light sensitive area
- **Assumption**: the main source of DCR is field-enhanced generation (or tunneling).

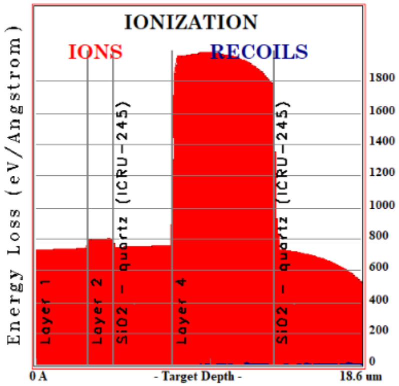
- **Prof. G. Simi, Dott. F. Borgato, Rich. A. Lupato**

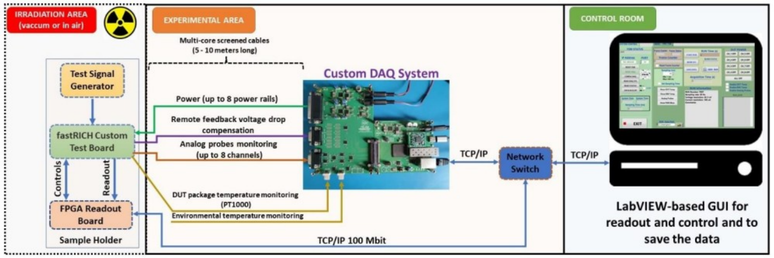
Radiation hardness of the new electronics

- The readout electronics will be subject to radiation damage from neutrons and ionizing particles.
- Radiation resistance will be tested with neutrons sources from a reactor and with protons
- Possible activities:
  - Simulation of radiation damage
  - Development of readout and control board



CMOS 65 nm layers - metallization and passivation layers are on top of Poly-Si gates and critic Silicon dioxide layers (taken from Chin. Phys. B Vol. 26, No. 8 (2017) 088501) , modeled with staked layers.





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