

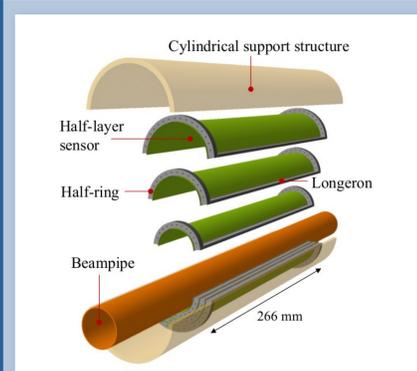


ALICE

BabyMOSS stitched sensors: results of characterisation tests for ALICE ITS3 upgrade

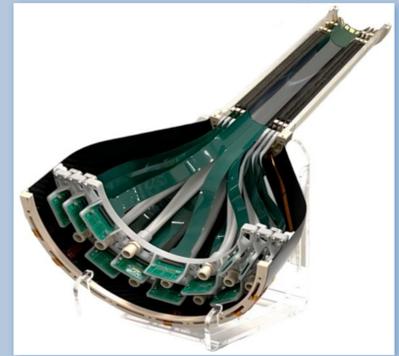
Alessandro Sturniolo (University of Messina, MIFT Department and INFN Sezione di Catania), on behalf of ALICE Collaboration

26th International Workshop on Radiation Imaging Detectors (Bratislava, 6-10 July 2025)



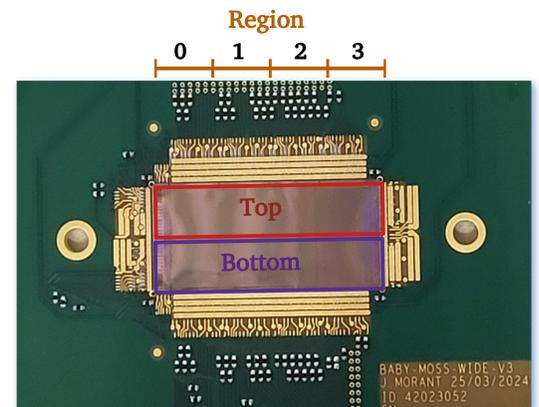
ALICE ITS3 upgrade project:

- Inner Barrel (IB), i.e. 3 innermost layers, replaced with 6 bent, wafer-scale, stitched CMOS MAPS 65 nm sensors
- 27 cm long sensitive area, radius: 19 mm (L0), 25.2 mm (L1), 31.5 mm (L2)
- Pseudo-rapidity $|\eta| \leq 2.5$ (L0), 2.3 (L1), 2.0 (L2)
- $20.8 \mu\text{m} \times 22.8 \mu\text{m}$ pixel size, $50 \mu\text{m}$ sensor thickness (average material budget = 0.09% X_0 /layer)
- Improved impact parameter resolution at low p_T compared to current ITS2 (lower by a factor of 2 at $p_T < 1 \text{ GeV}/c$)
- Radiation load: $4 \cdot 10^{12} \text{ 1 MeV } n_{\text{eq}} \text{ cm}^{-2} \text{ NIEL} + 4 \text{ kGy TID}$



ITS3 sensor R&D: what is the current state?

- Engineering Run 1 (ER1) submission: wafer-scale devices like 26 cm long Monolithic Stitched Sensors (MOSS) and 3 cm long babyMOSS
- MOSS: made of 10 Repeated Sensor Units (RSU), digital readout, 2 rows (top and bottom) of 4 pixel matrices (regions)
- babyMOSS: ER1 devices ($\sim 14 \times 30 \text{ mm}^2$), structured like a single MOSS RSU + Left End-Cap (LEC)
 - Top regions: 256×256 pixels, $22.5 \mu\text{m}$ pitch, varying transistor geometries
 - Bottom regions: 320×320 pixels, $18 \mu\text{m}$ pitch
- MOSS and babyMOSS studied in several test beams since August 2023, to evaluate performances under varying radiation scenarios (NIEL and TID)

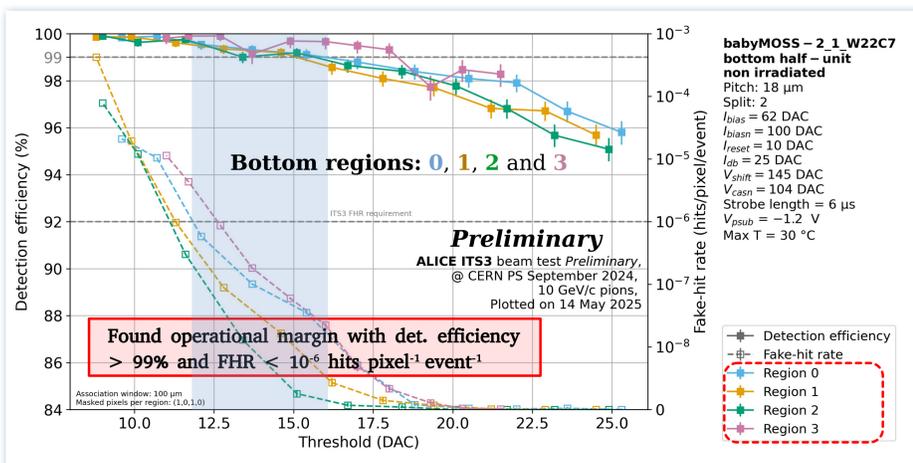


September 2024 babyMOSS test beam: setup and goals

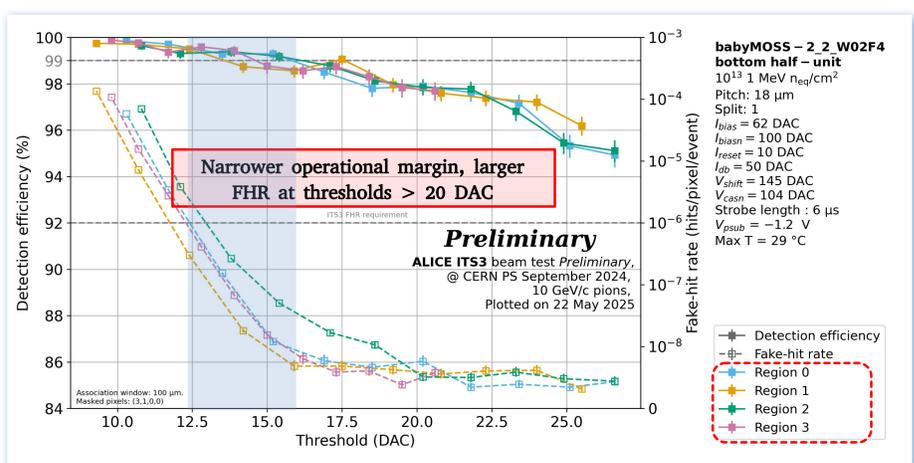
- 7 and 10 GeV/c π^\pm @CERN Proton Synchrotron
- 3 babyMOSS chips tested: 2 irradiated, 1 non-irradiated
- 6 babyMOSS tracking planes, 1 babyMOSS DUT, 2 scintillators for trigger

- Can we find an operational margin with high detection efficiency and low FHR?
- How does irradiation affect chip performance?

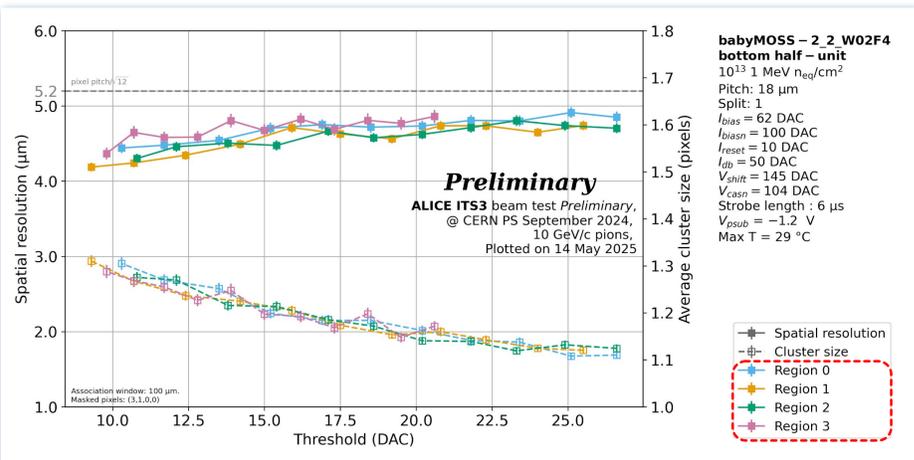
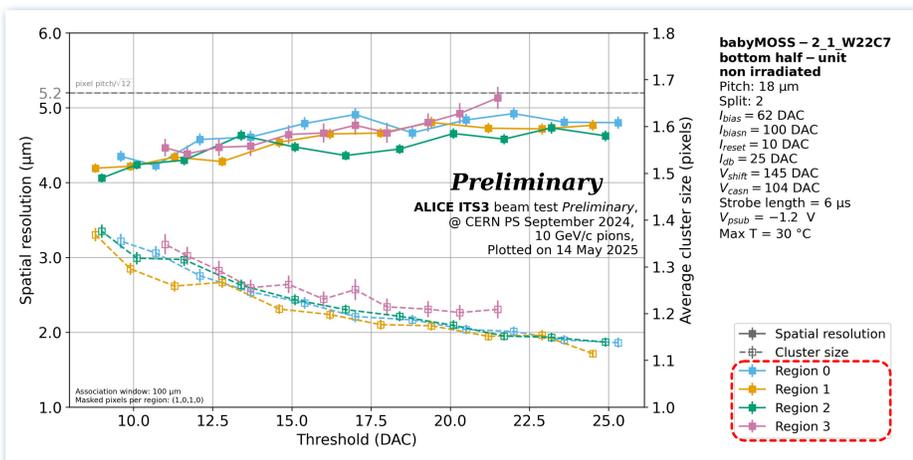
Non-irradiated babyMOSS



Irradiated babyMOSS ($10^{13} \text{ 1 MeV } n_{\text{eq}} \text{ cm}^{-2} \text{ NIEL}$)



Spatial resolution < 6.5 μm for top regions, < 5.2 μm for bottom: comparable between non-irradiated and NIEL-irradiated



Conclusions

- Test beams with (baby)MOSS have contributed to studies on detection efficiency, spatial resolution, FHR, average cluster size of stitched devices in several NIEL and TID radiation scenarios
- Found operational margin with detection efficiency > 99% and FHR < 10^{-6} hits pixel⁻¹event⁻¹, narrower margin with increasing NIEL
- Spatial resolution < 6.5 μm for top regions, < 5.2 μm for bottom, no significant effects from irradiation
- Irradiation effects: FHR increase at high thresholds (> 20 DAC), little effect on average cluster size
- Tested babyMOSS have shown excellent performance!