Beam test results for the new prototype ITS3 sensor design

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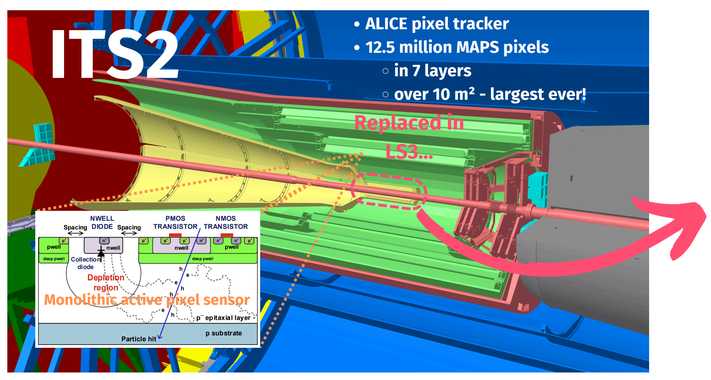
The Inner Tracking System (ITS2)



ITS3: a precision tracker for the high-luminosity era

The ITS will replace its inner three layers in LS3, improving along *three axes* [1]:

Pixel

- **Denser circuitry**: 180 → 65 nm process
- Full **depletion** and gapped **low-dose *n*-type implant**: enhanced, homogenized charge collection

Sensor

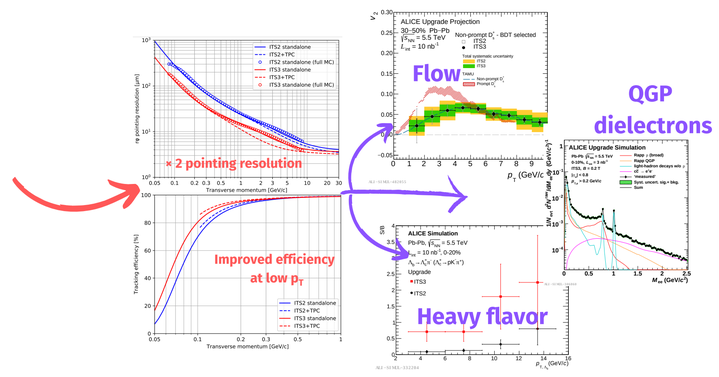
- 260 mm-long **wafer-scale** sensors
- **Stitched** continuous silicon: no need for FPC or supports

Structure

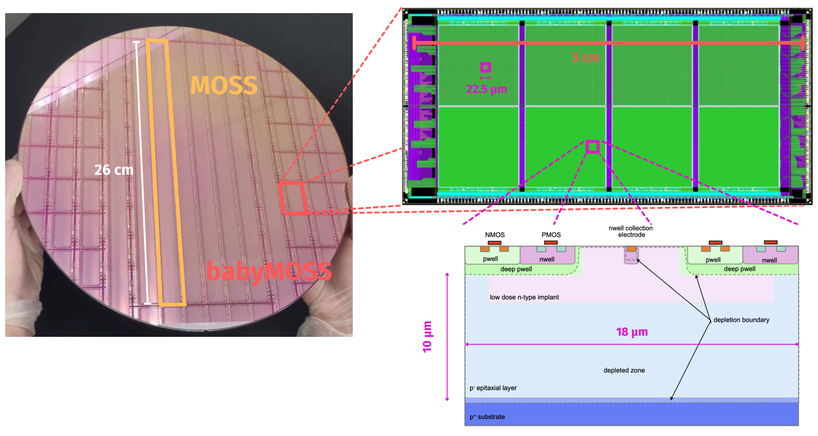
- Water → **air cooling**: reduced services
- Narrower beampipe: IO at 23 → 19 mm **closer** to beam
- Truly **cylindrical**: bent, self-supporting silicon at 0.36% → 0.07% X/X_0 per layer

****See talk by Bong-Hwi Lim (Wed 3:55 PM, parallel 24) on ITS3 design and performance!****

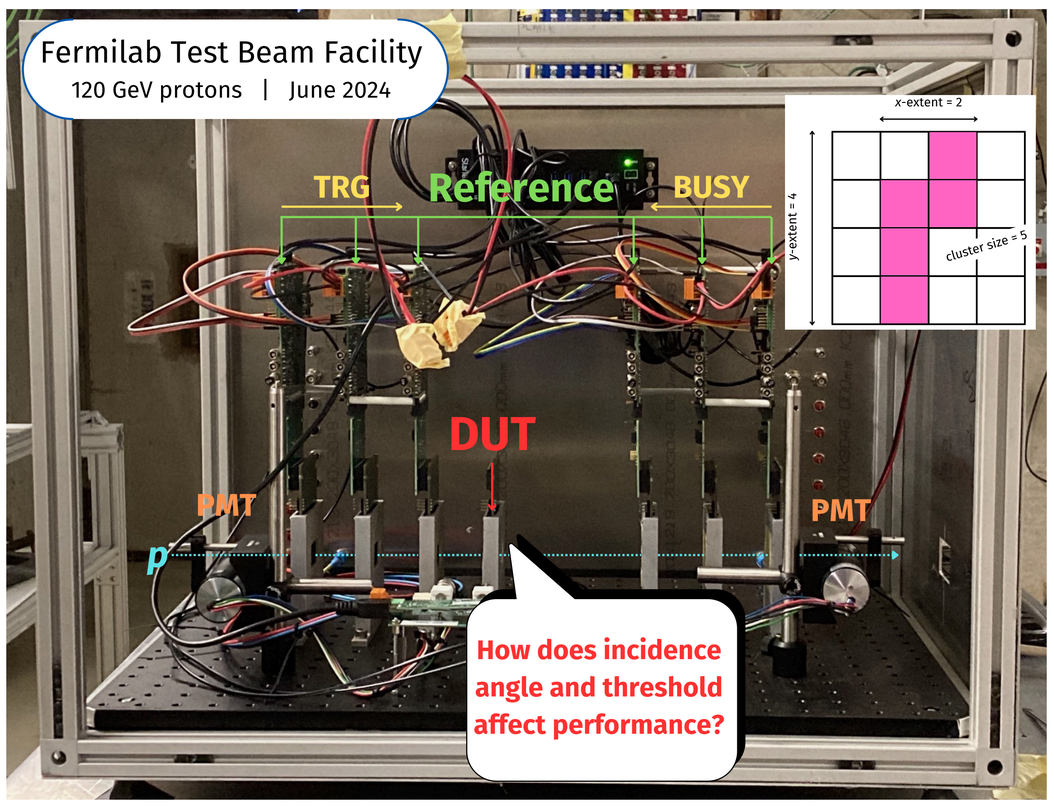
Physics performance



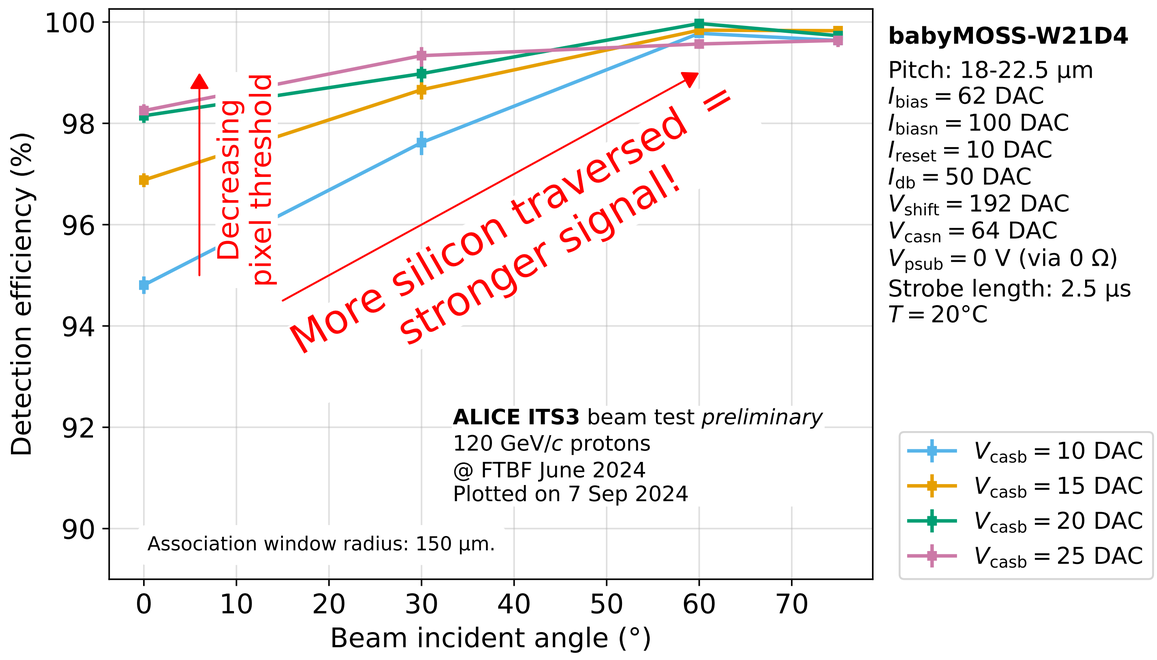
(baby)MOSS: a MOnolithic Stitched Sensor

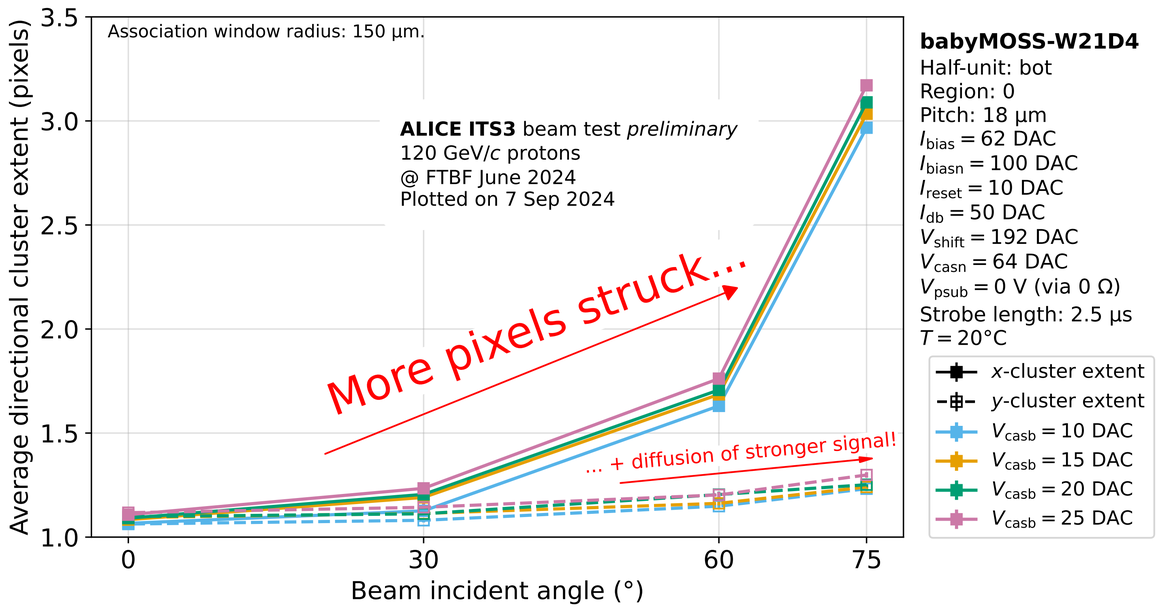


The telescope



Sensor performance

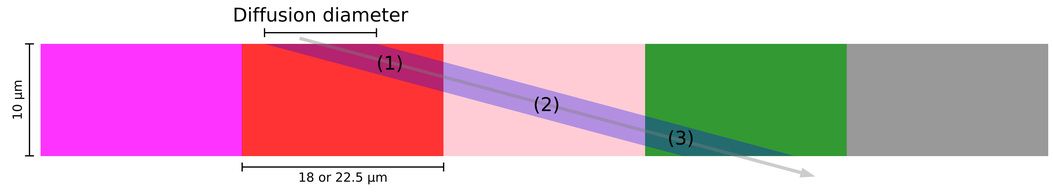


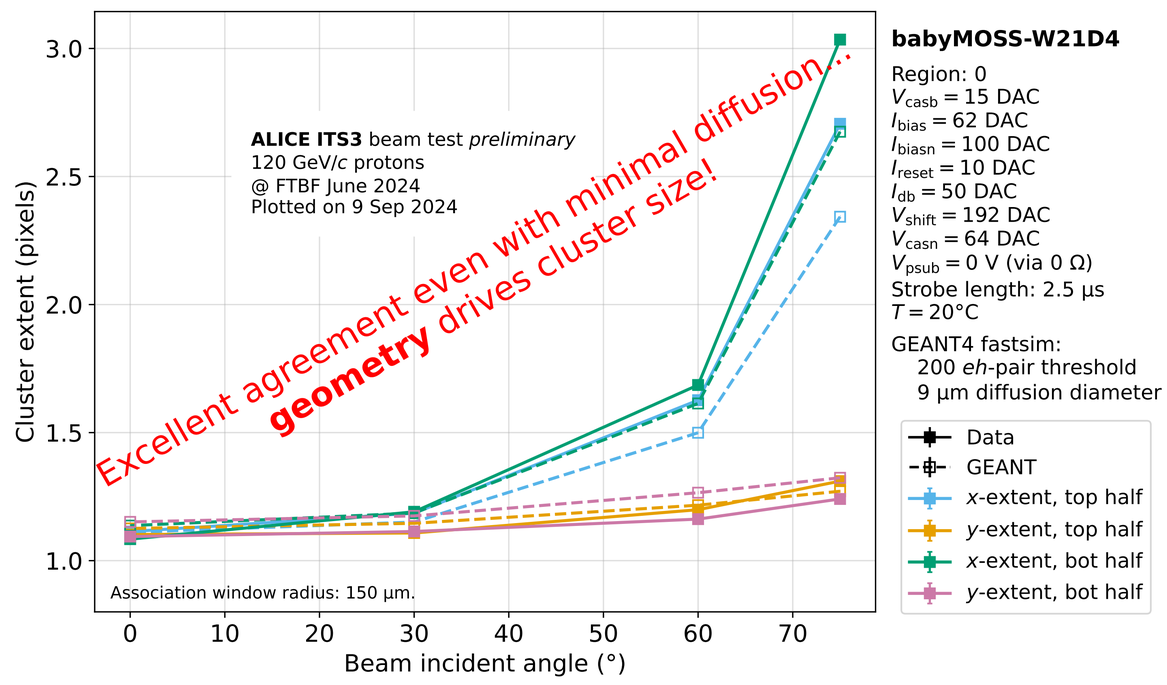


Geometry vs. diffusion: modeling cluster size

Does *track geometry* or *charge diffusion* drive cluster size at high incidence?

1. Randomly select particle path at fixed angle, and determine pixels intersected
2. Determine length of silicon to traverse at fixed angle
3. Determine energy deposition from GEANT4 [2]
4. Convert to number of electron-hole pairs at 3.6 eV/pair
5. Divide among hit pixels in proportion to "area"
6. Impose *eh*-pair threshold and determine cluster extent





Conclusions

- Increase in efficiency from **longer path-length in silicon**
- **Strong cluster extent dependence** on inclination angle
- **Track geometry, *not charge diffusion*, determines cluster size**, confirmed by fast simulation

Acknowledgements

We thank Danush Shekar, Grigory Nigmatkulov, and Abhishek Hingrajiya from the University of Illinois, Chicago for their contributions to the beam telescope assembly, data taking and analyses. We also thank the Fermilab accelerator and FTBF personnel for the excellent performance of the accelerator and support of the test beam facility, in particular M. Kiburg, E. Niner, J. Pastika, E. Schmidt and T. Nebel.

References

[1] The ALICE Collaboration, *Technical Design Report for the ALICE Inner Tracking System 3 - ITS3; A bent wafer-scale monolithic pixel detector*, tech. rep. (CERN, Geneva, 2024).

[2] S. Agostinelli et al., "Geant4—a simulation toolkit", Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment **506**, 250–303 (2003).

[3] *Fermilab Test Beam Facility*, (2024) `www.ftbf.fnal.gov`.

[4] The ALICE Collaboration, "Upgrade of the ALICE Inner Tracking System during LS3: study of physics performance", (2023).