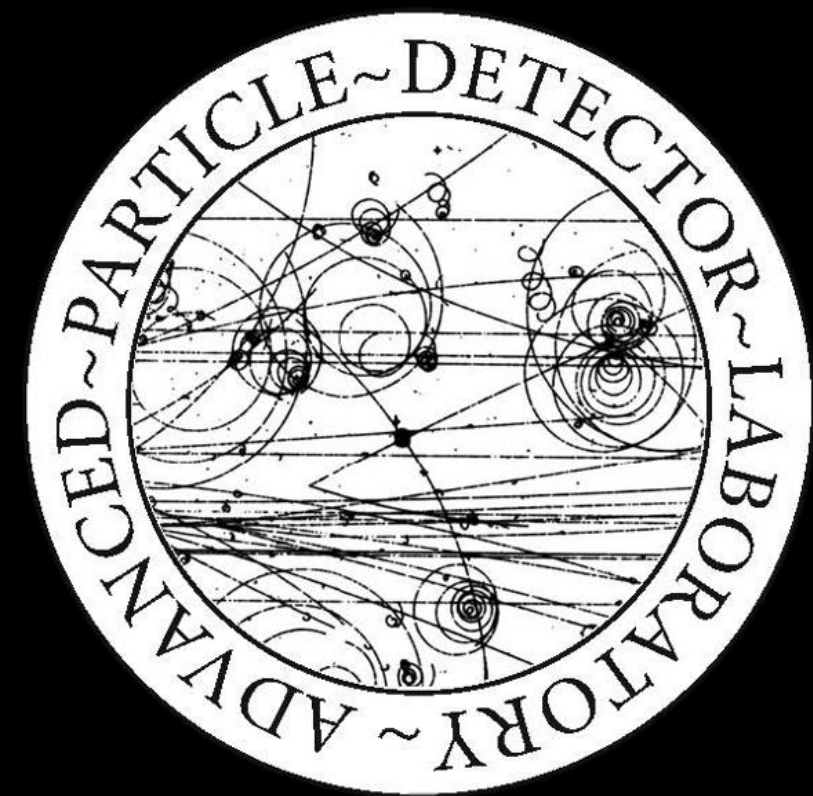




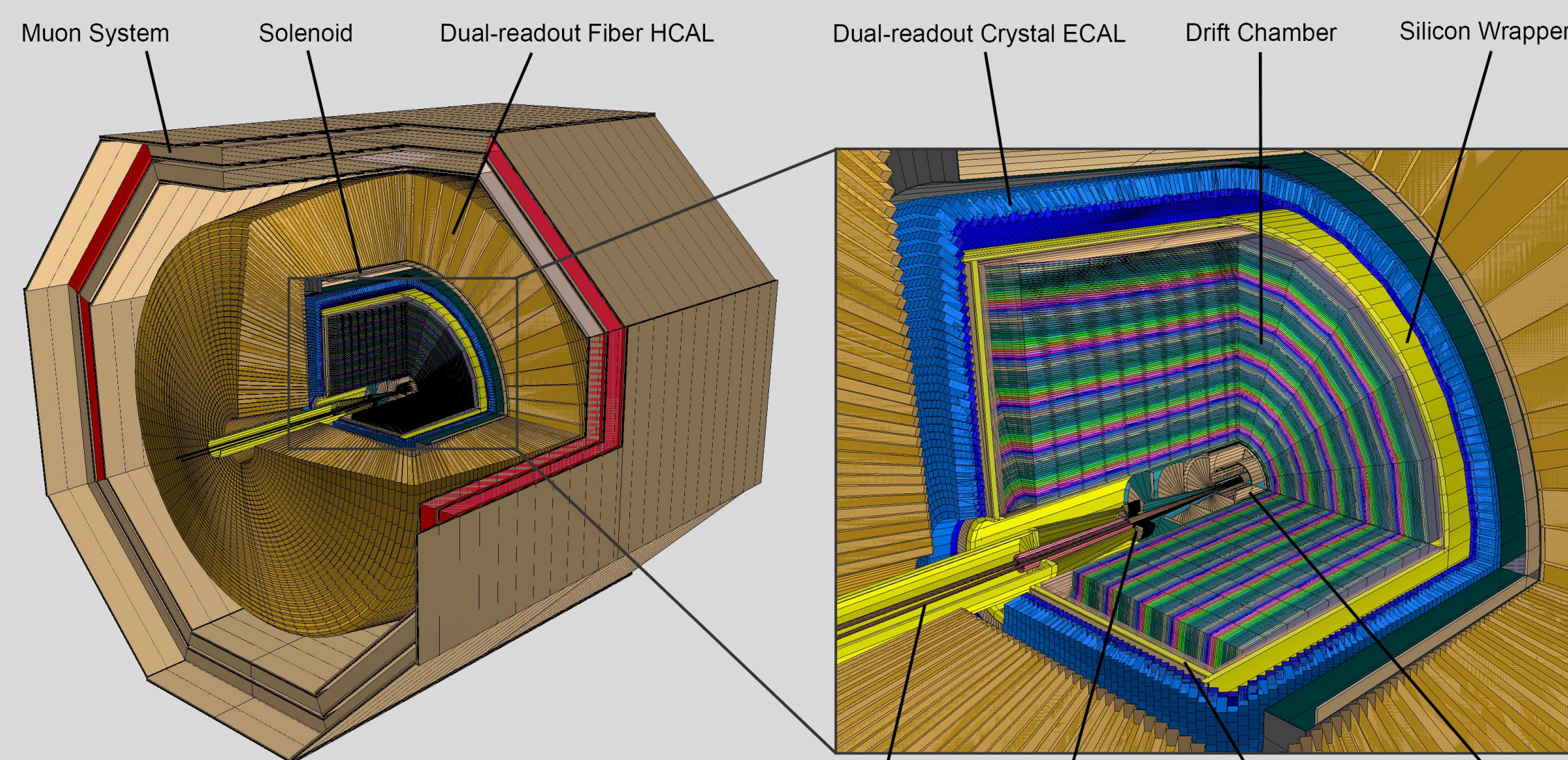
Construction and Characterization of a Scintillating Fiber Hodoscope Tracker

Texas Tech University | Department of Physics and Astronomy | Advanced Particle Detector Laboratory



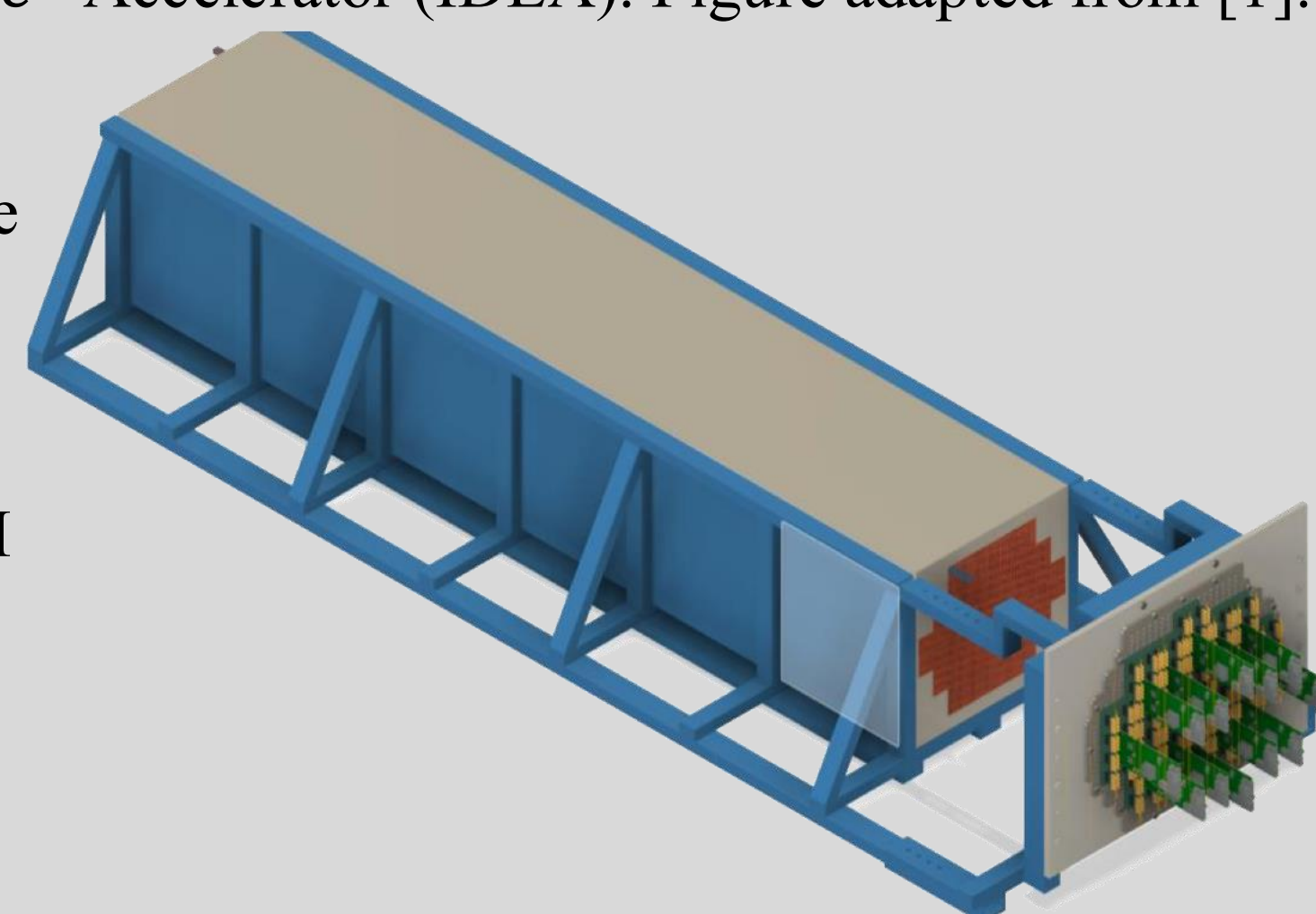
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Motivation



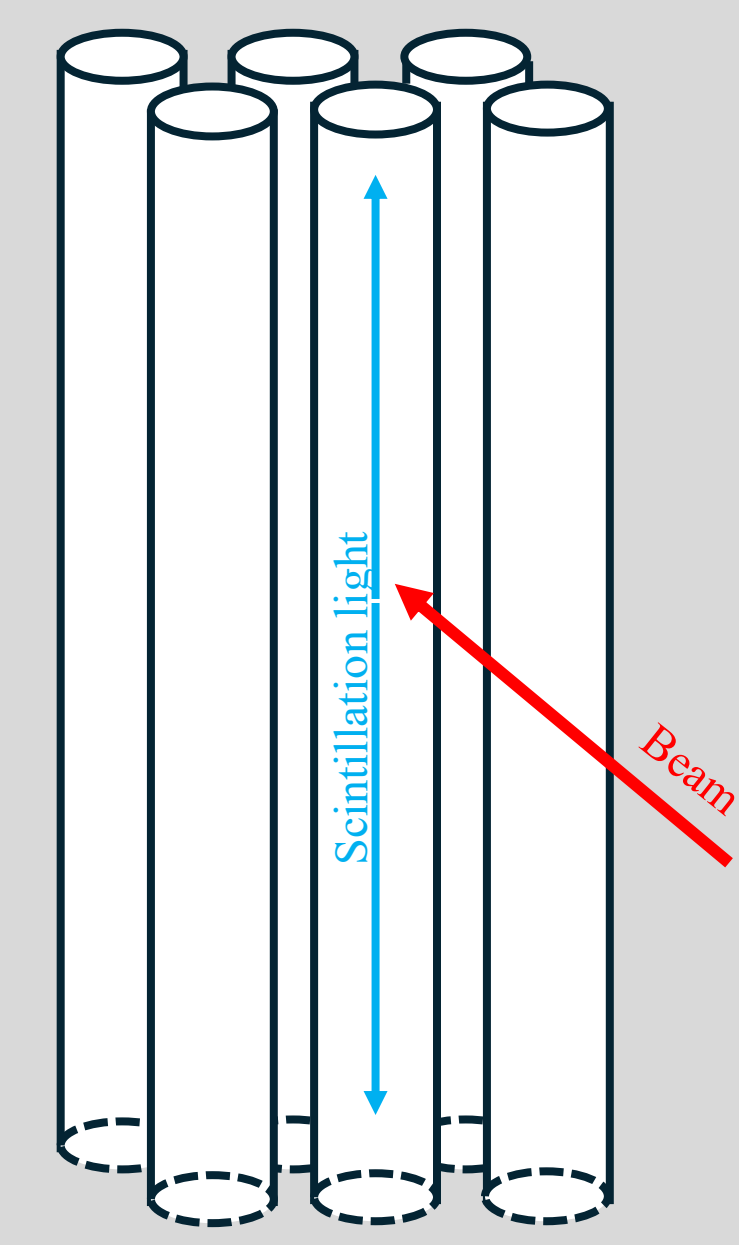
The Innovative Detector for the e^+e^- Accelerator (IDEA). Figure adapted from [1].

- In the post HL-LHC era, the Future Circular Collider (FCC) represents the next era of high-energy physics, utilizing the IDEA detector concept [1].
- Texas Tech University's HG-DREAM is a prototype of IDEA's DR fiber calorimeter.
- To characterize HG-DREAM's response, a scintillating fiber hodoscope was built to precisely track incident particle positions at the calorimeter face.



The High Granularity Dual Readout Calorimeter (HG-DREAM) utilizes Dual Readout (DR) to improve the hadronic energy resolution.

Design

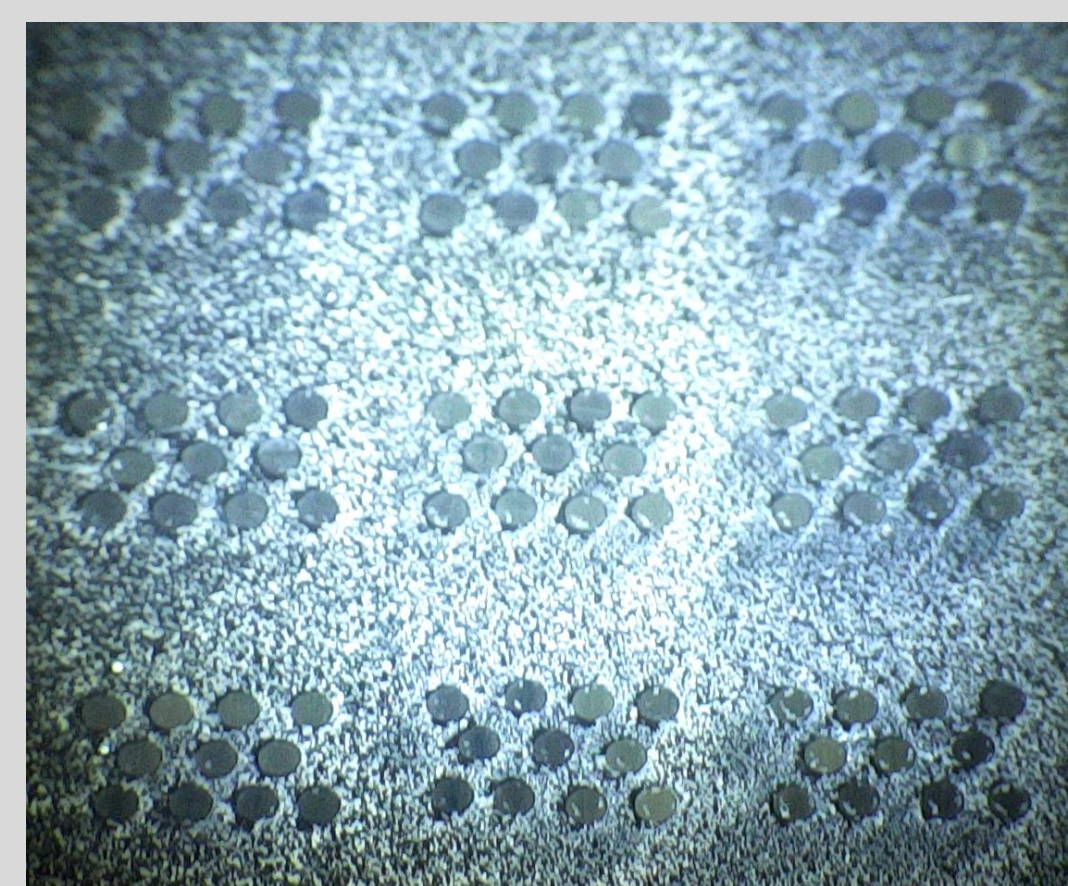


Silicon Photomultipliers (SiPM)

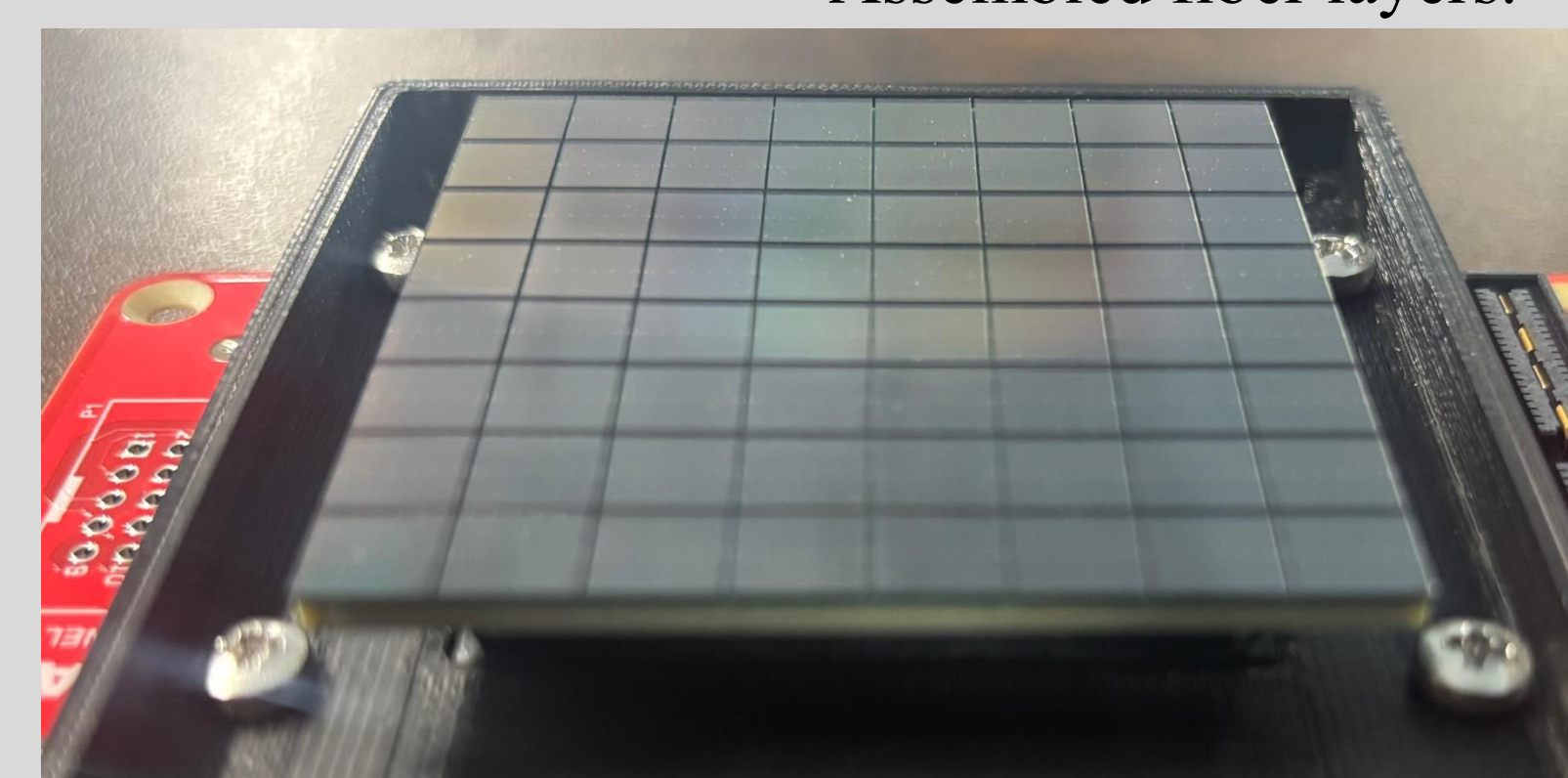
- Particles traverse the fibers producing scintillation light collected by SiPMs at the fiber ends. X and Y arrays provide 2D position reconstruction.
- 704 scintillating fibers, 0.8 mm diameter, 0.6 mm fiber pitch
- Two orthogonal X/Y arrays, 4 cm $\times$ 4 cm active area
- Readout:
 - 2×64 -channel Onsemi SiPM arrays
 - CAEN A5202 FERS boards
- Theoretical resolution: 173 μ m



Assembled fiber layers.

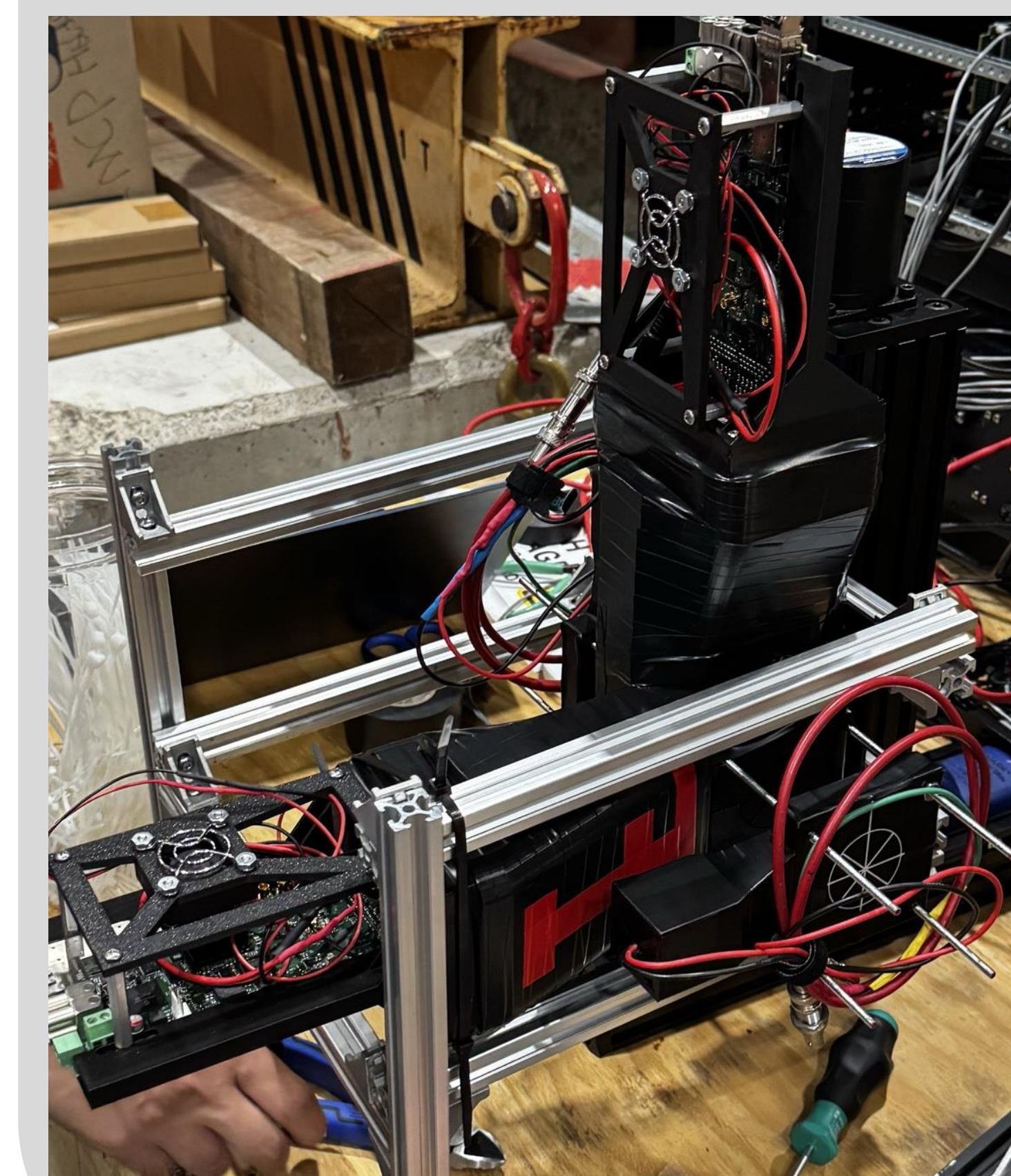
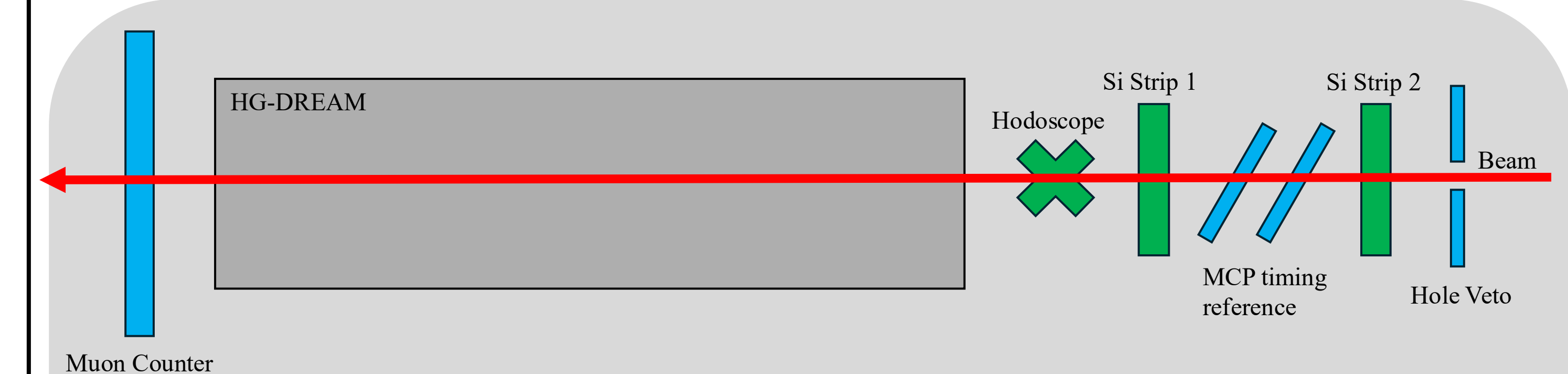


Fiber ends at the SiPM face.



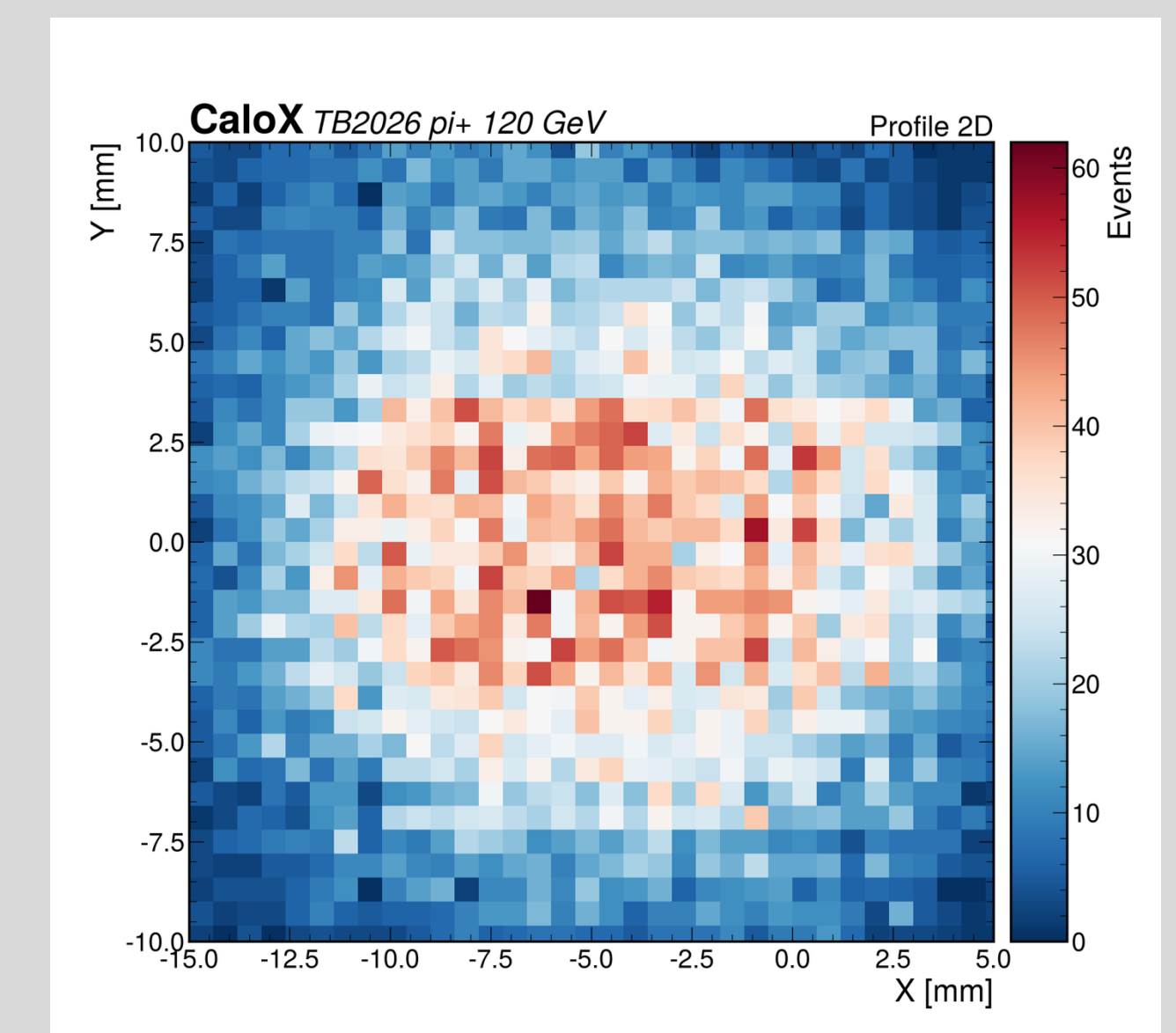
8x8 SiPM Array

Test Beam Setup



Fully Constructed Hodoscope

The HG-DREAM group collected data at the CERN H8 beamline (SPS North Area) during the 2025-26 test beam campaign.

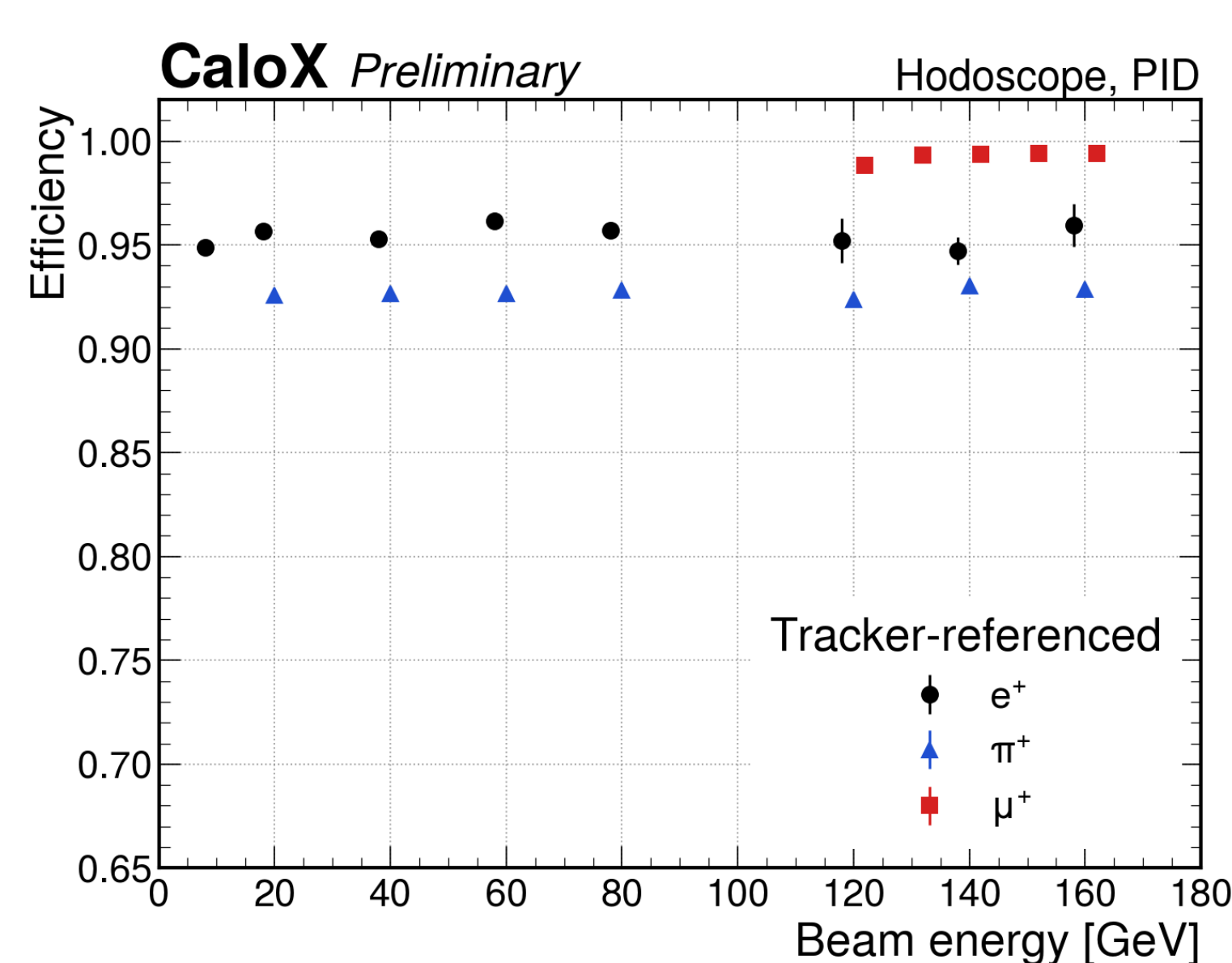


2D beam profile at the hodoscope face. Gaussian spot confirms beam centering within the 4 cm $\times$ 4 cm active area.

Characterization and Results

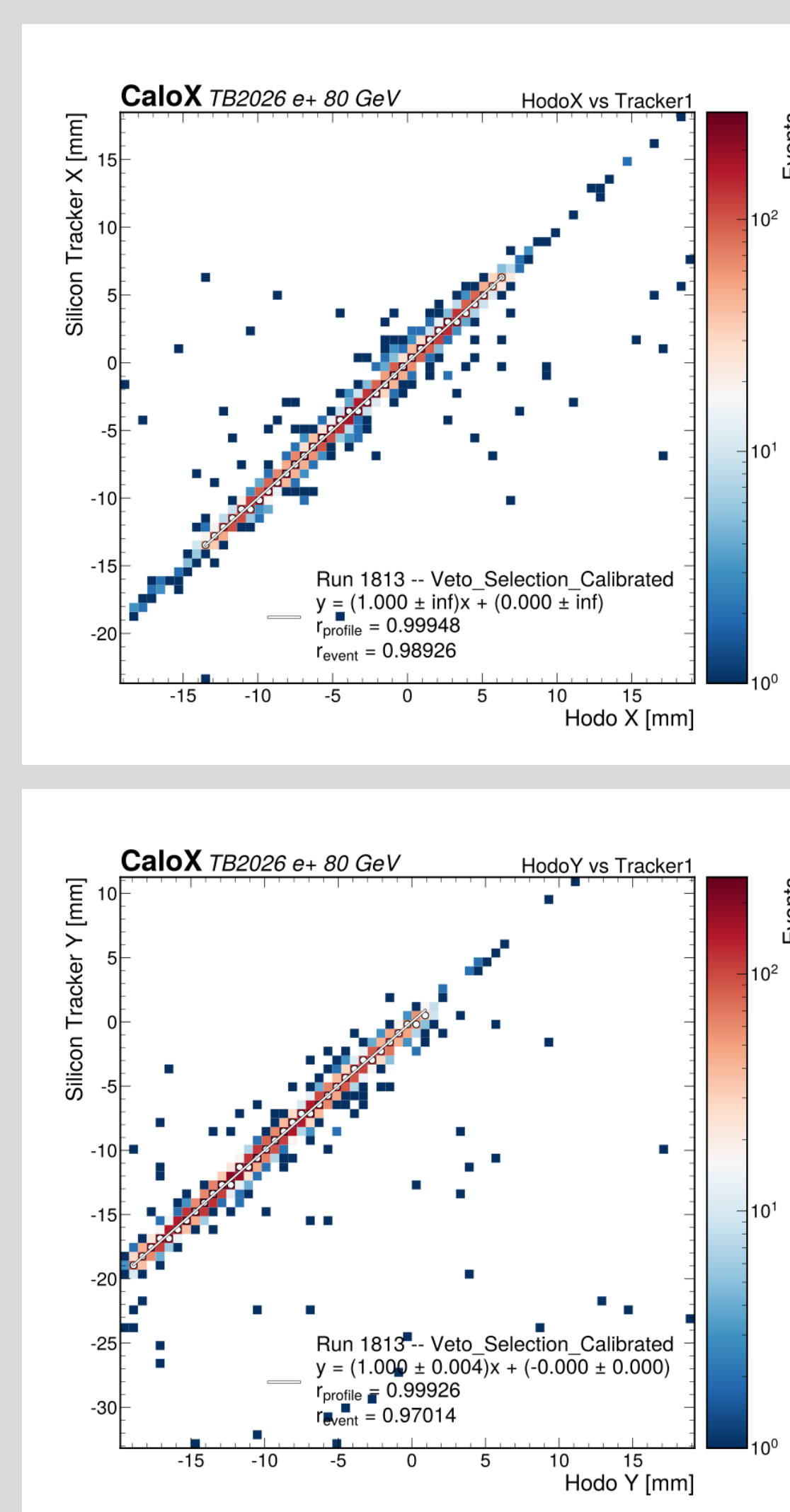
Efficiency

- Detector efficiency is the fraction of beam particles which the hodoscope records a reconstructed hit.
- Tracker reference eliminates events with 2+ recorded particles



Beam	Hodoscope Efficiency
e^+	95.5%
π^+	92.7%
μ^+	99.2%

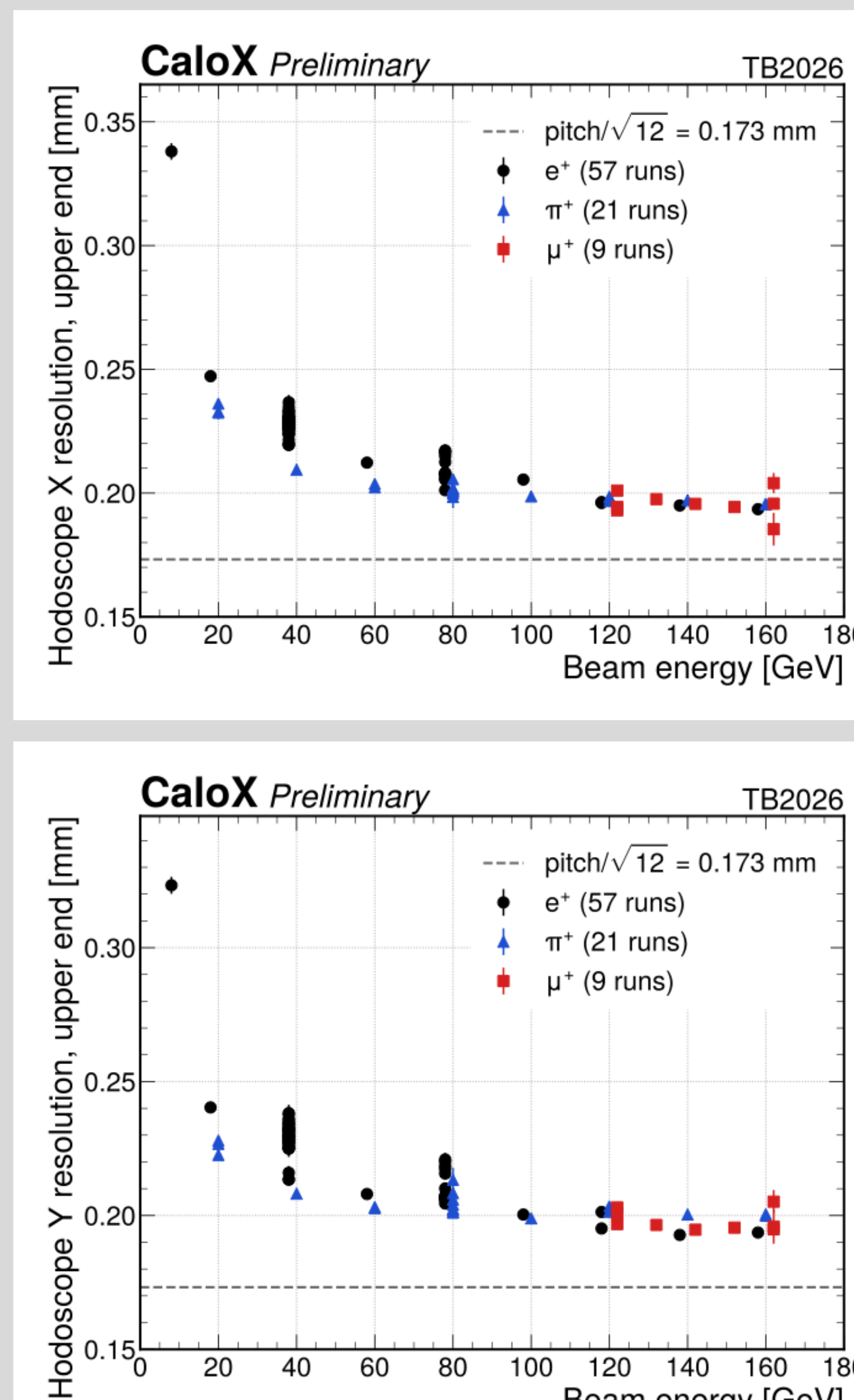
Correlation



Hodoscope X and Y positions compared to silicon tracker. Confirms positional accuracy.

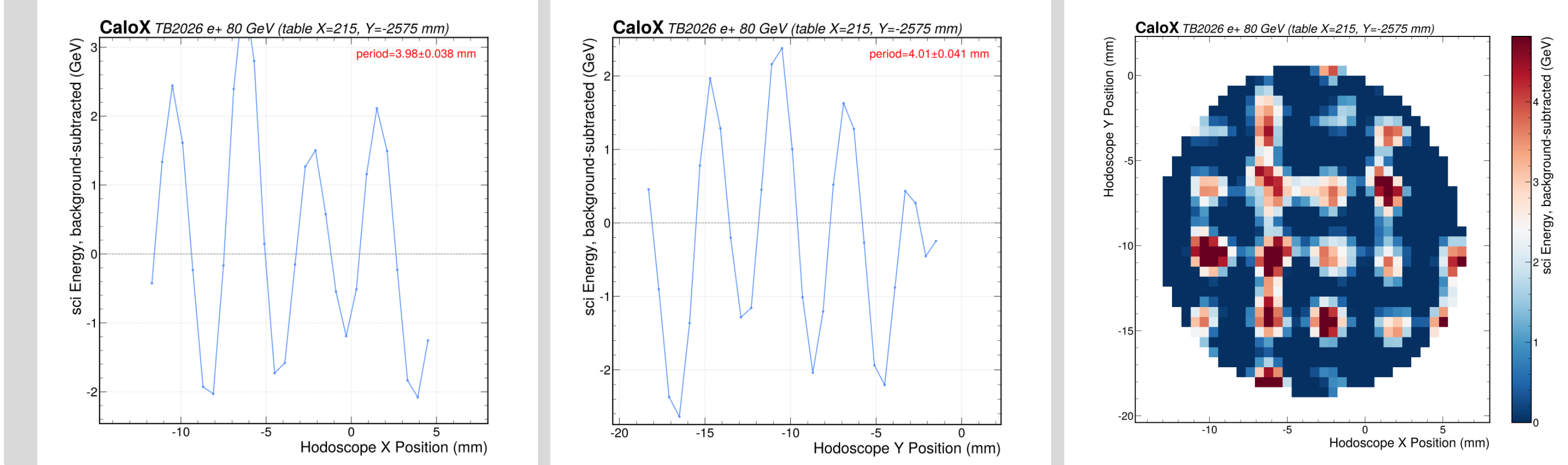
Resolution

Spatial resolution measured across beam energies for X and Y planes. Dashed line: theoretical resolution $\text{pitch}/\sqrt{12} = 173 \mu\text{m}$. Median: 216 μm .



Applications & Conclusions

Fiber Reconstruction



- Hodoscope position plus deposited energy resolves the fiber periodicity inside HG-DREAM, enabling fiber-level reconstruction. Fibers have 4 mm spacing.

Shape reconstruction

- Beam data maps the geometry of the hole veto's aperture: the efficiency map is well described by a circle.
- Hole veto efficiency vs. reconstructed beam position (left). A circular fit gives an aperture radius of $R = 9.87 \pm 0.01 \text{ mm}$ with an edge smearing of $\sigma = 0.20 \text{ mm}$.

Conclusion

- We successfully built and operated a scintillating fiber hodoscope at the CERN H8 test beam.
- Positions correlate with the silicon tracker at $r > 0.99$.
- Measured resolution of 216 μm , approaching the $\text{pitch}/\sqrt{12} = 173 \mu\text{m}$ limit at high beam energy.
- Efficiency is ~ 92 – 95% for π^+ and μ^+

References & Acknowledgements

[1] M. Abbrescia et al., The Idea Detector Concept for FCC-ee, arXiv:2502.21223 (2025)

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