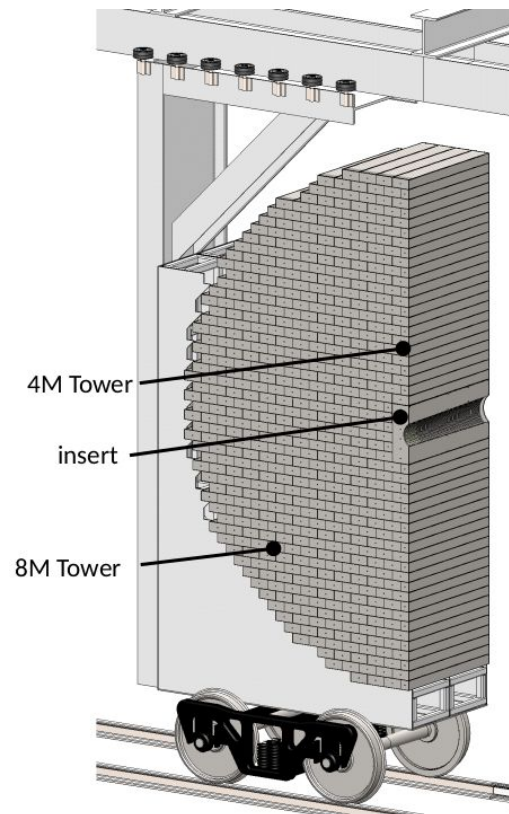
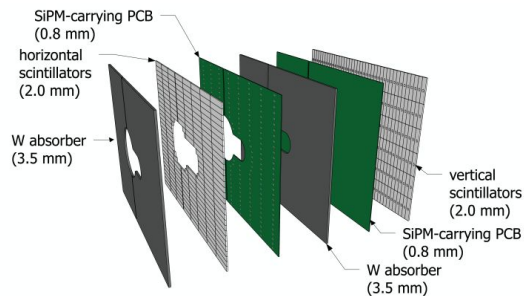
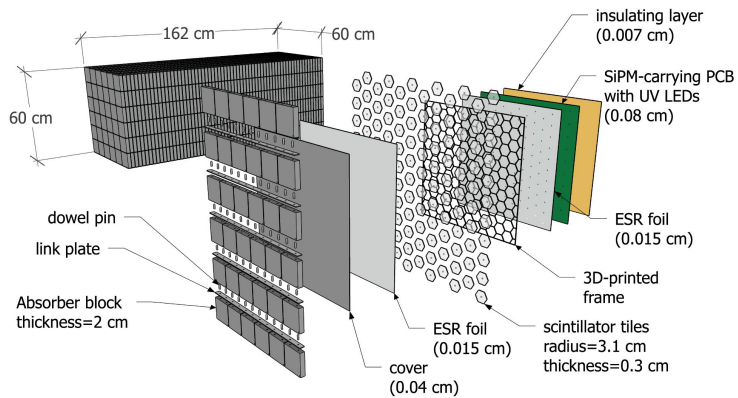
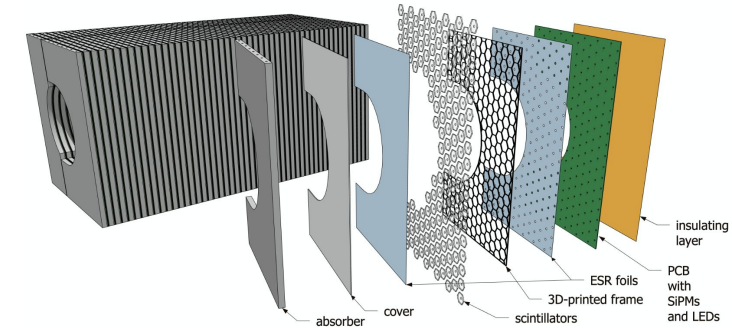


SiPM-on-tile Calorimetry @EIC

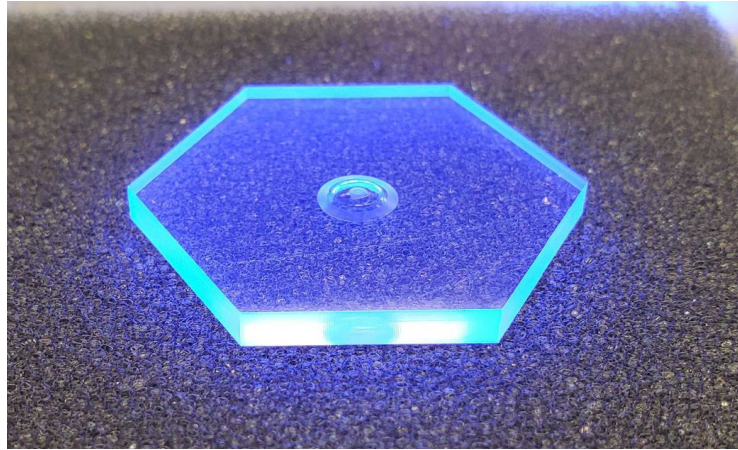
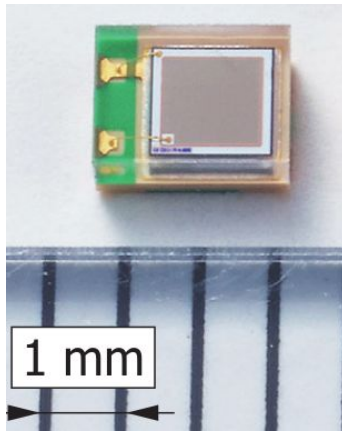
Miguel Arratia



CPAD 2023 @ SLAC

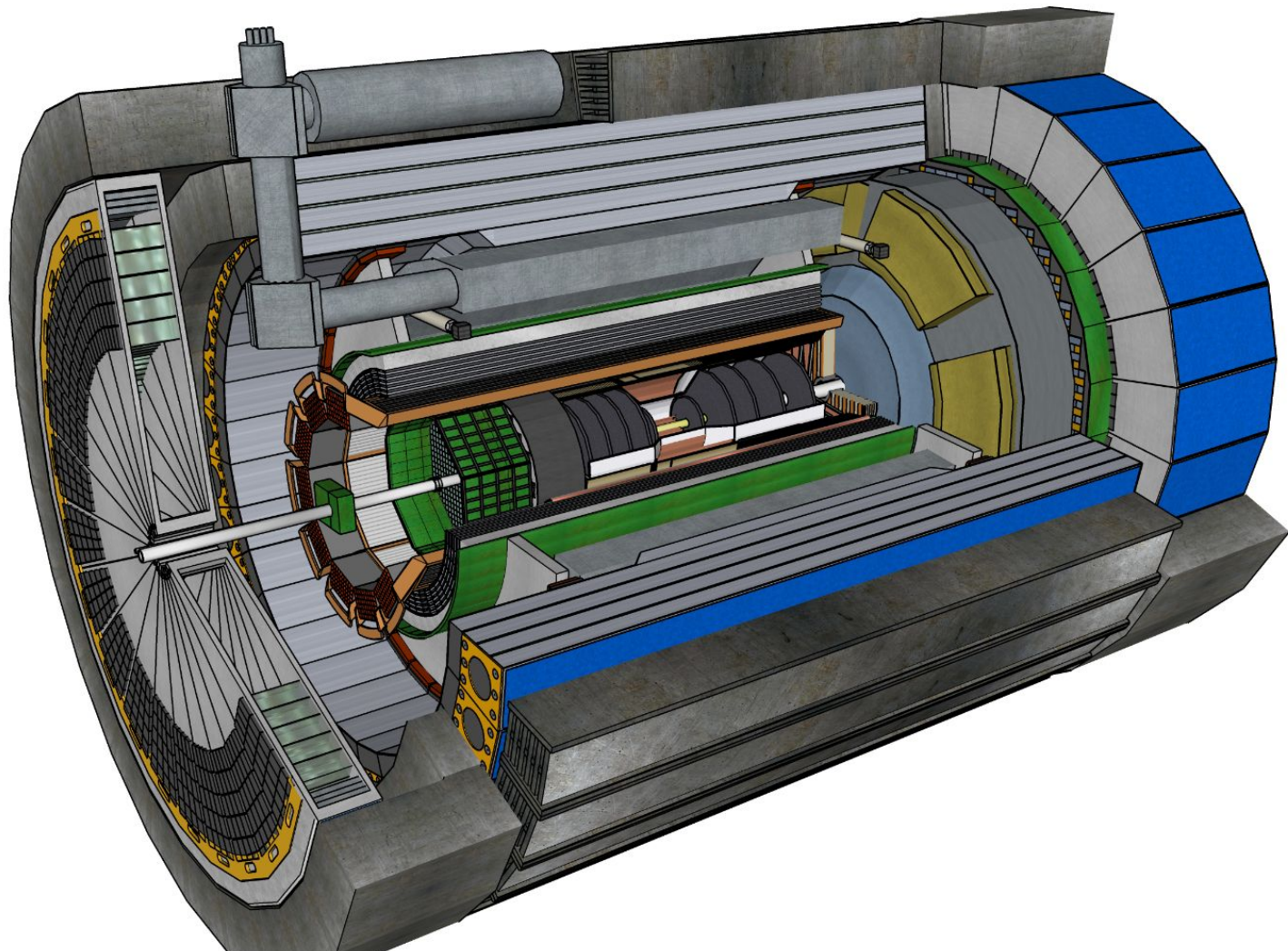


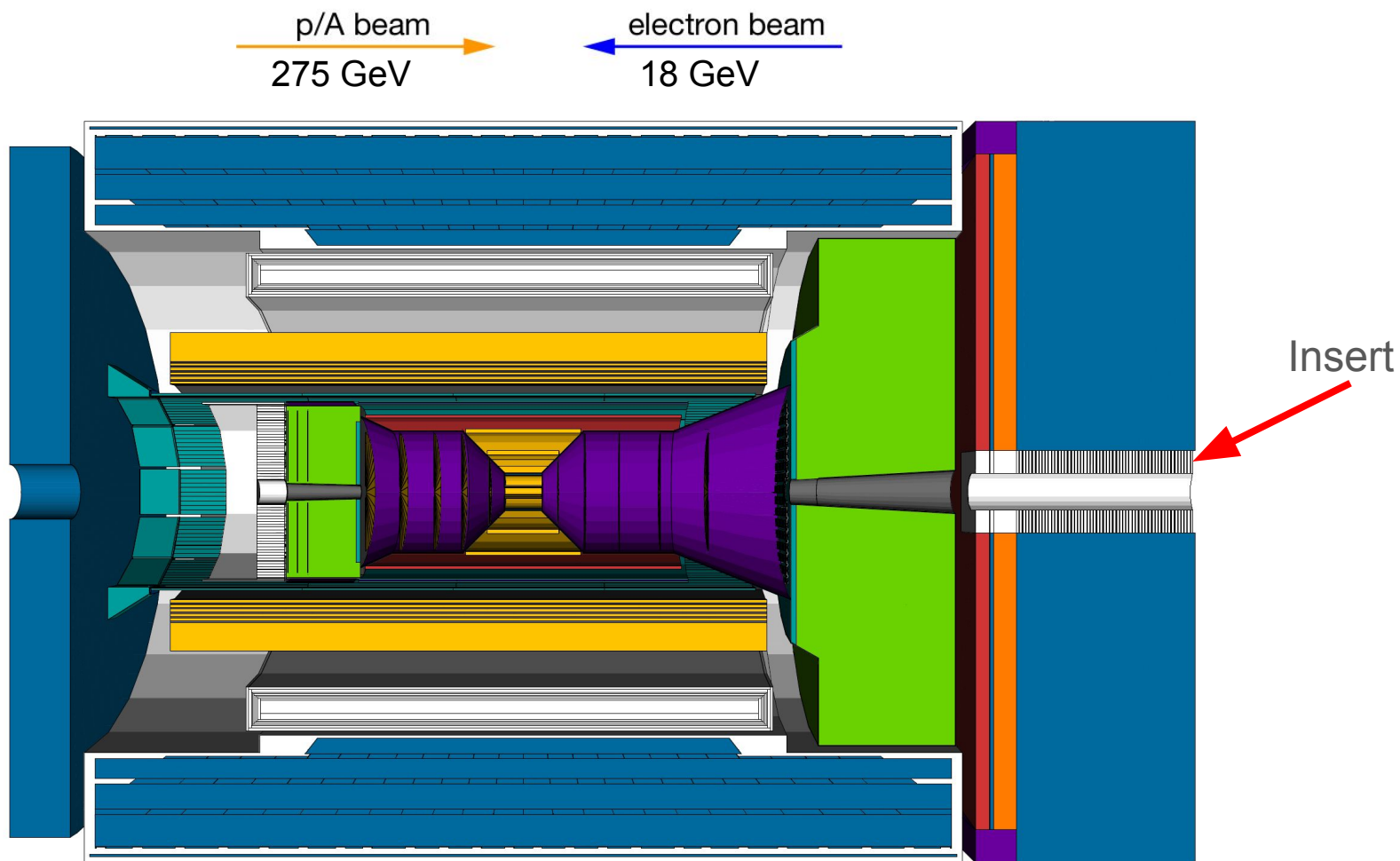
“SiPM-on-Tile” technology



Developed as unit cell for highly granular calorimeter by CALICE for e^+e^- colliders. Now being deployed at scale at the LHC and EIC

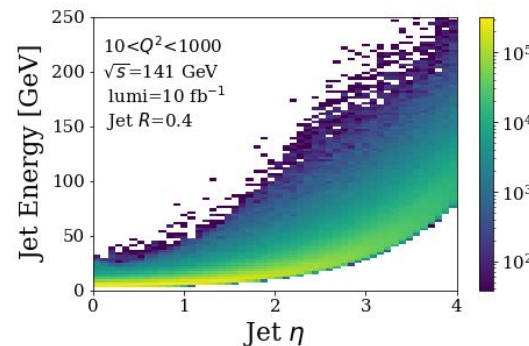
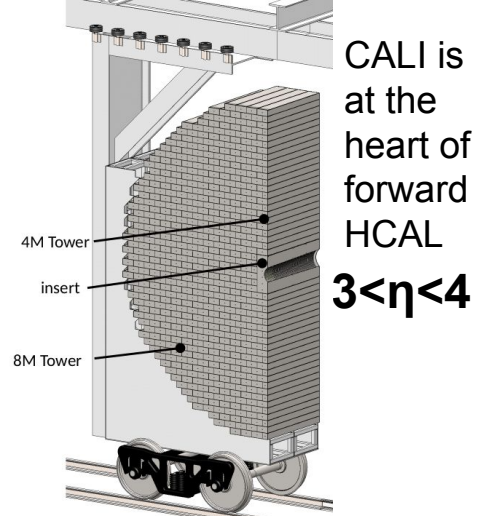
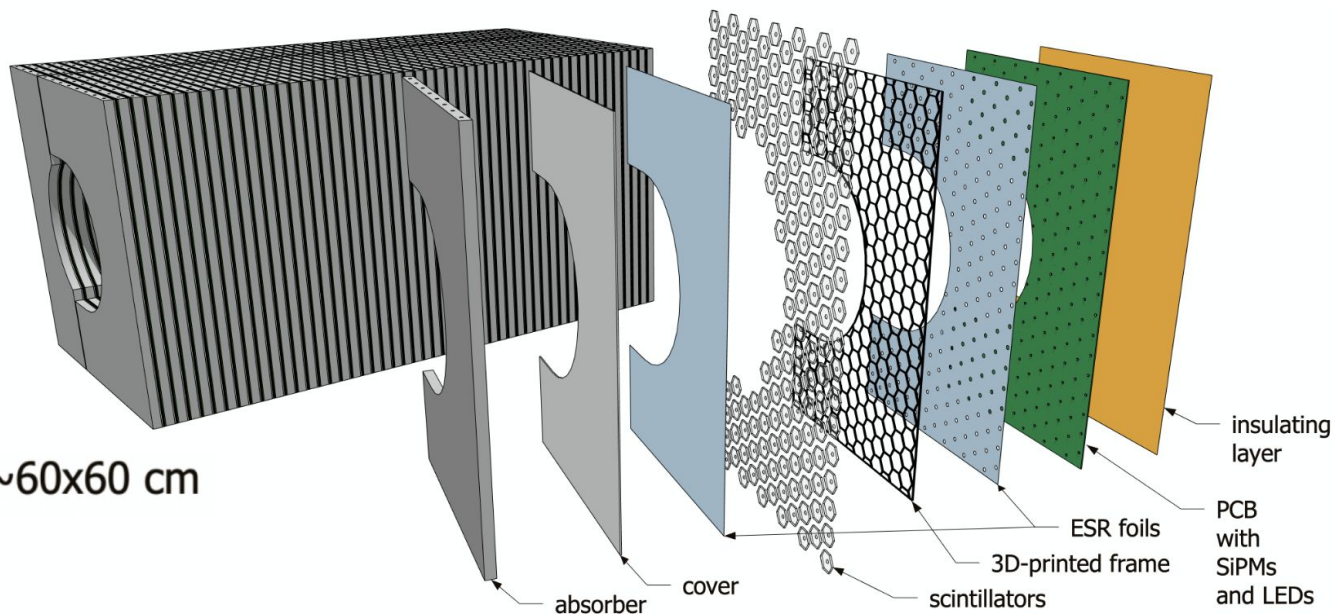
**“ePIC”
detector
for EIC**





The Calorimeter Insert (CALI)

To cover near beam pipe in forward direction to measure energetic jets

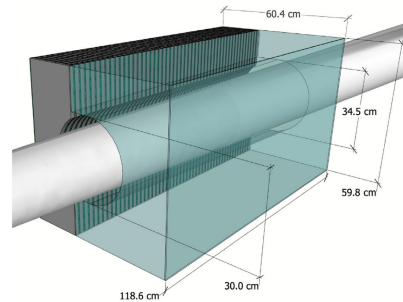
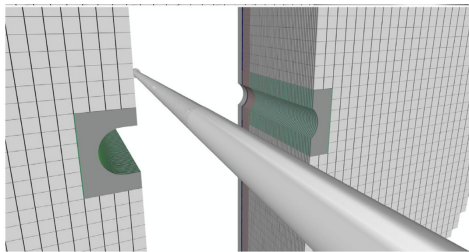
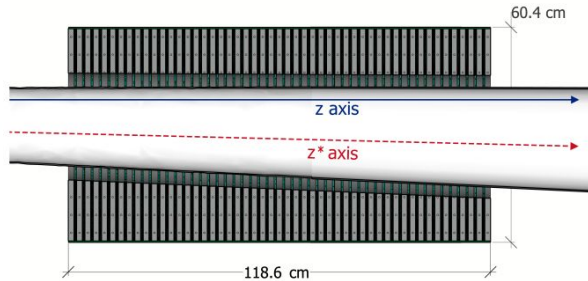
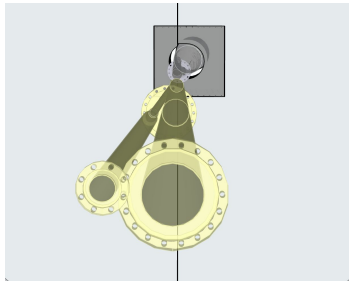


CALI was first EIC detector design using SiPM-on-tile technology.

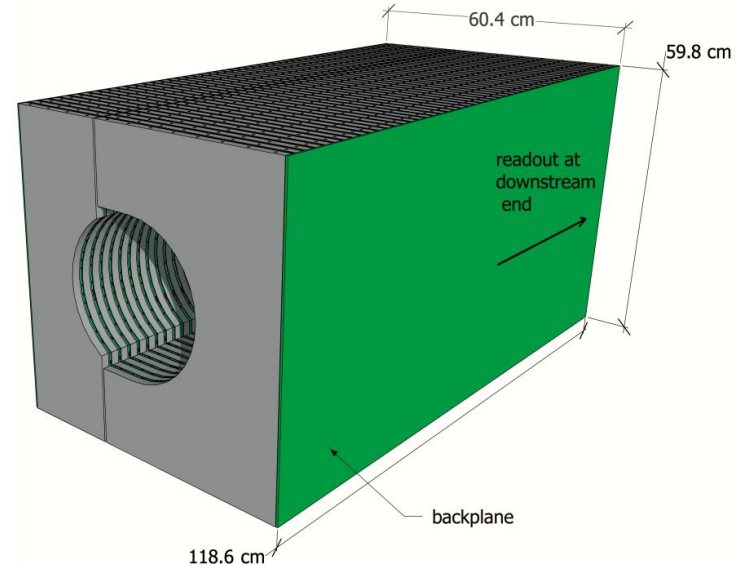
[M. Arratia et al. NIMA 1047 \(2023\) 167866](#)

Geometry and Readout

Complex Shape to accommodate the EIC crossing angle

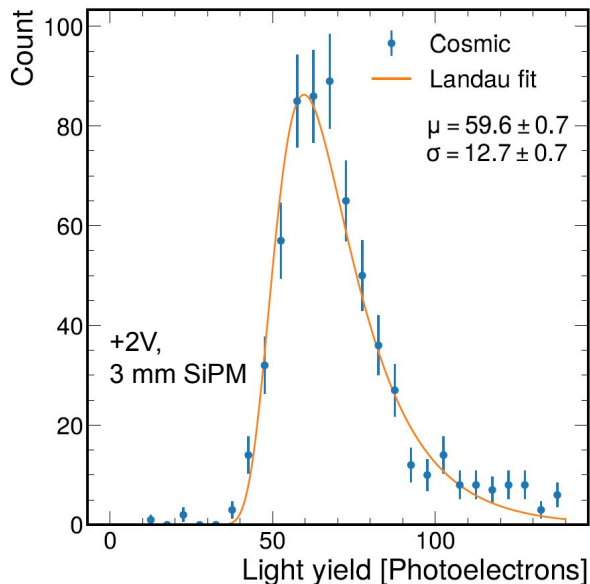


Novel readout approach to save longitudinal space and avoid cooling: ASIC away from SiPM with analog signal transport to back of detector

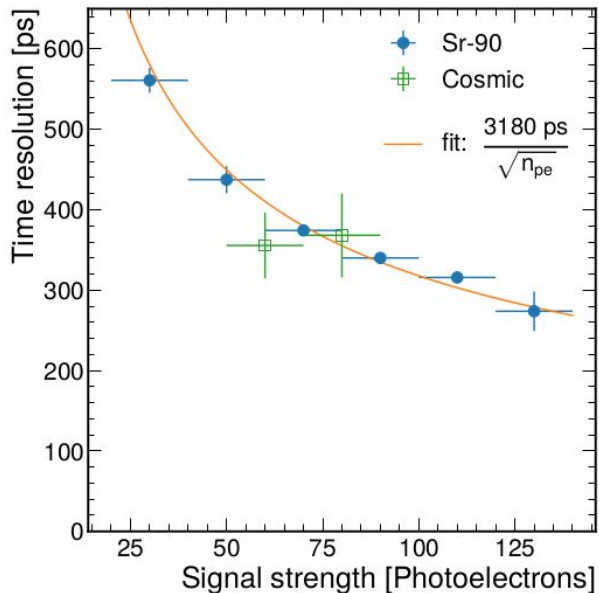


Light Yield & Time Resolution

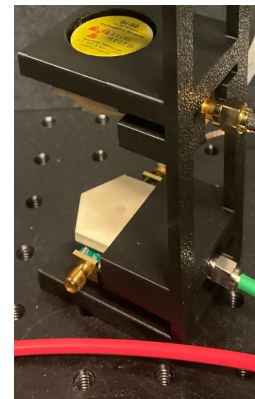
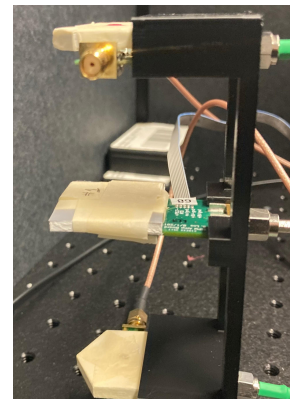
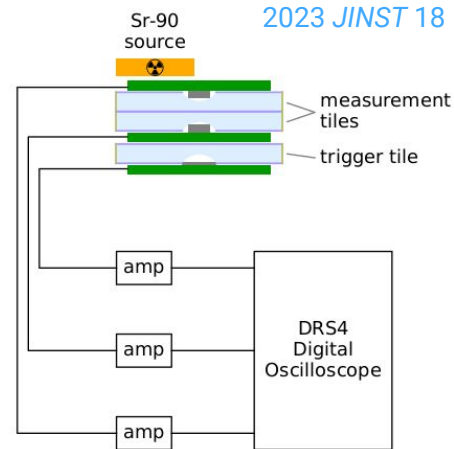
Miguel Arratia et al
2023 JINST 18 P05045



High light yield at low operating voltage to buffer rad damage

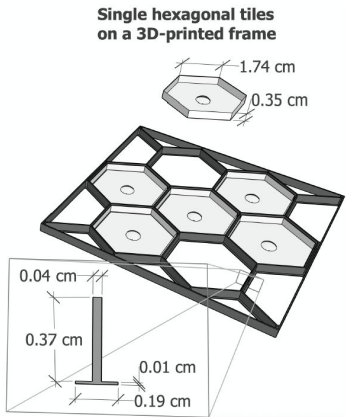
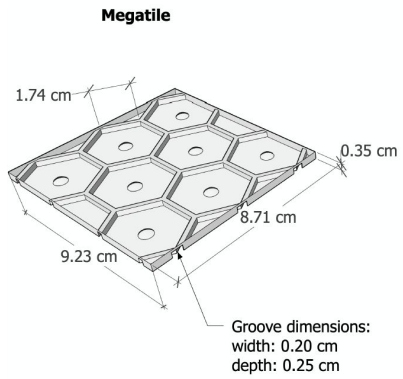


First (published) measurement of intrinsic time resolution of SiPM-on-tile

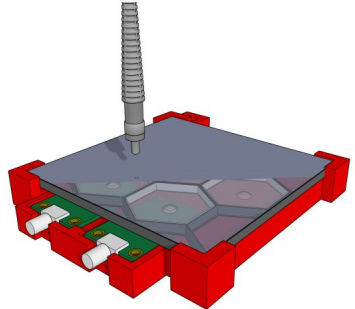
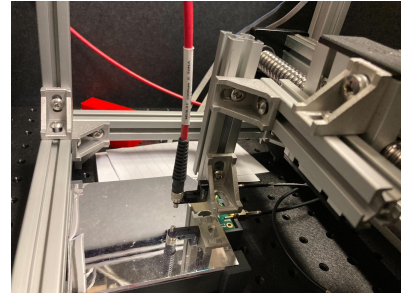
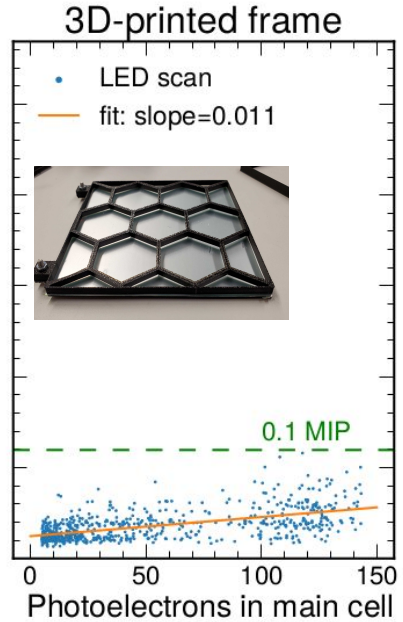
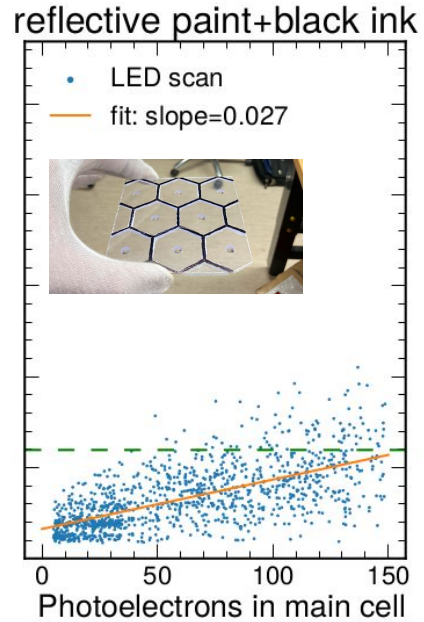
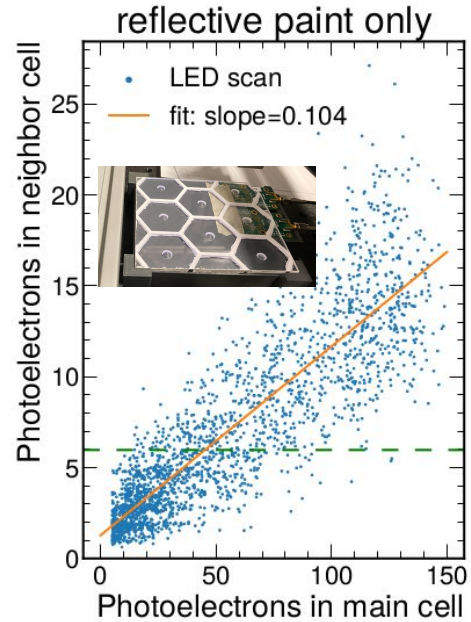


Optical Crosstalk

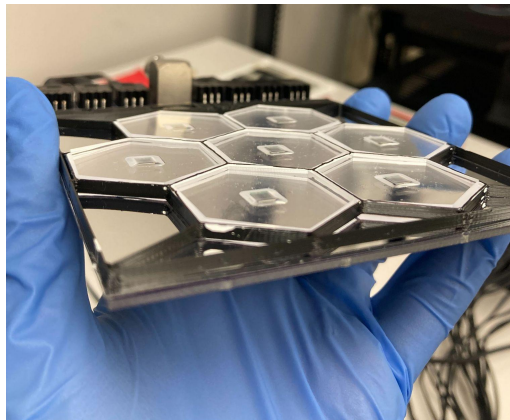
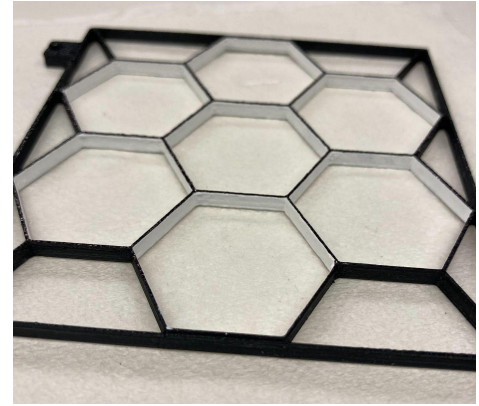
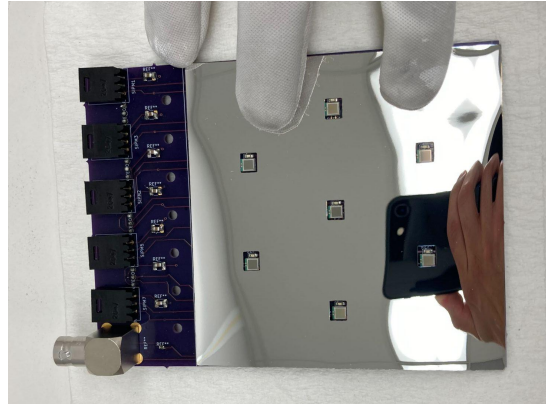
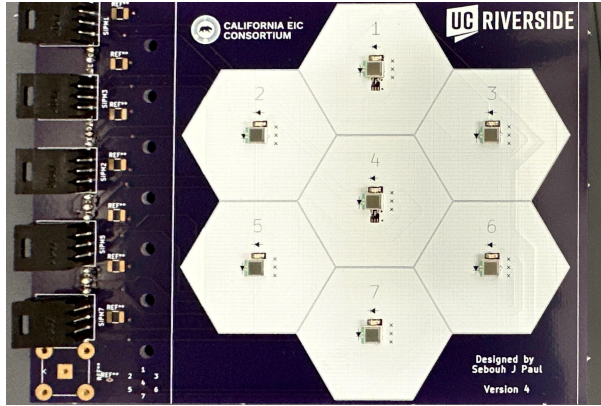
Miguel Arratia et al
2023 JINST 18 P05045



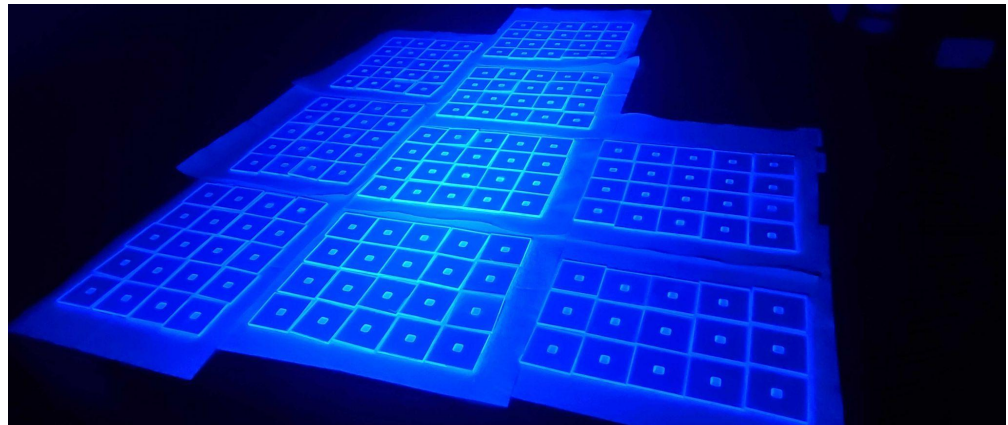
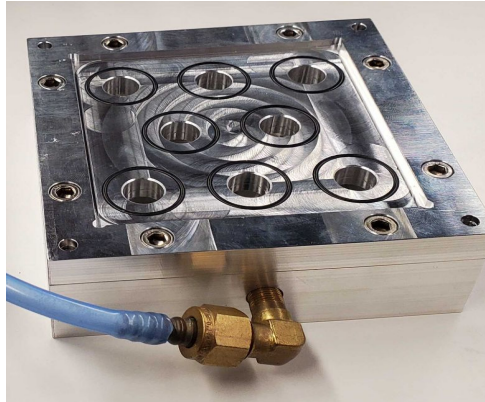
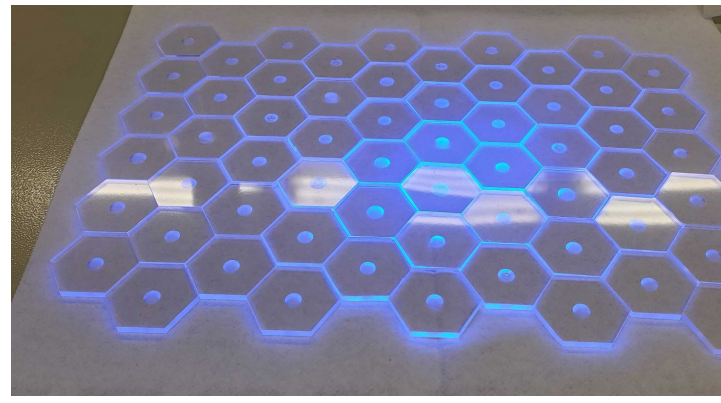
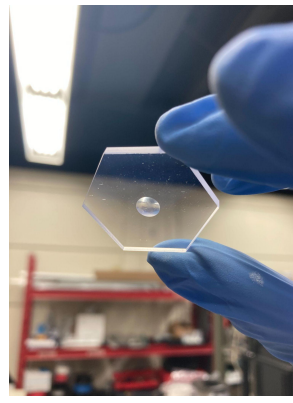
← Novel approach



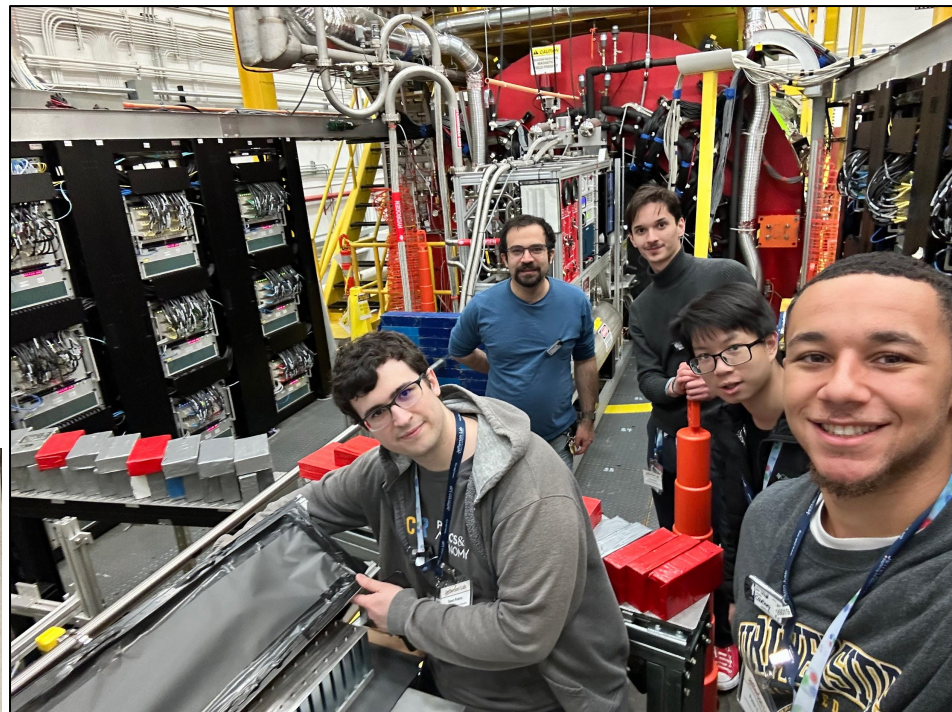
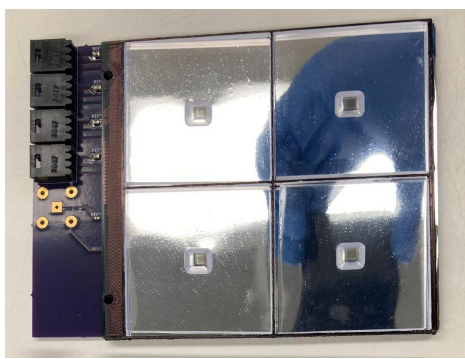
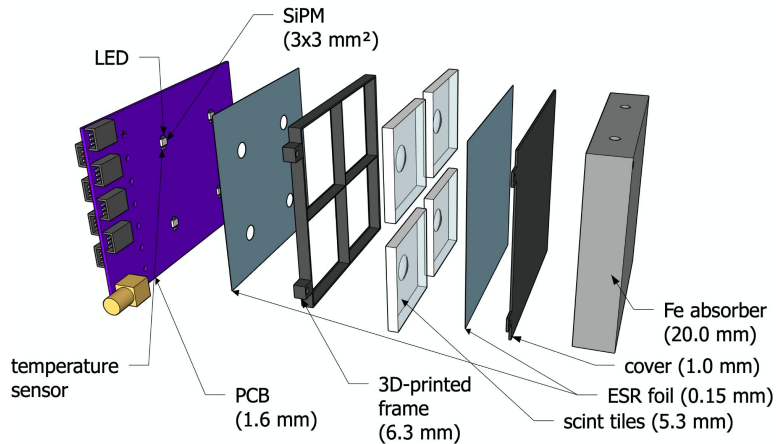
The making of prototype layers



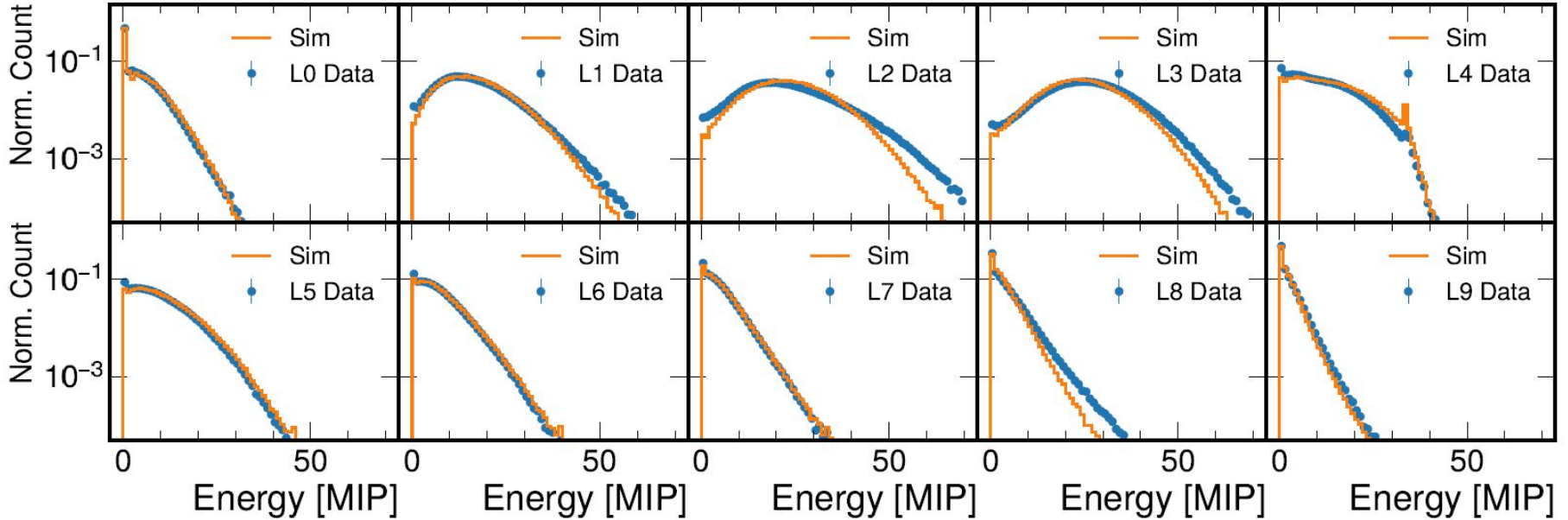
Machining Scintillator tiles @ UCR



First beam test with positrons (@JLab, Jan 2023)



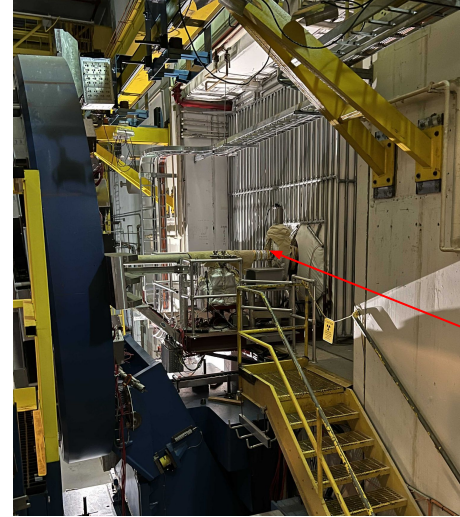
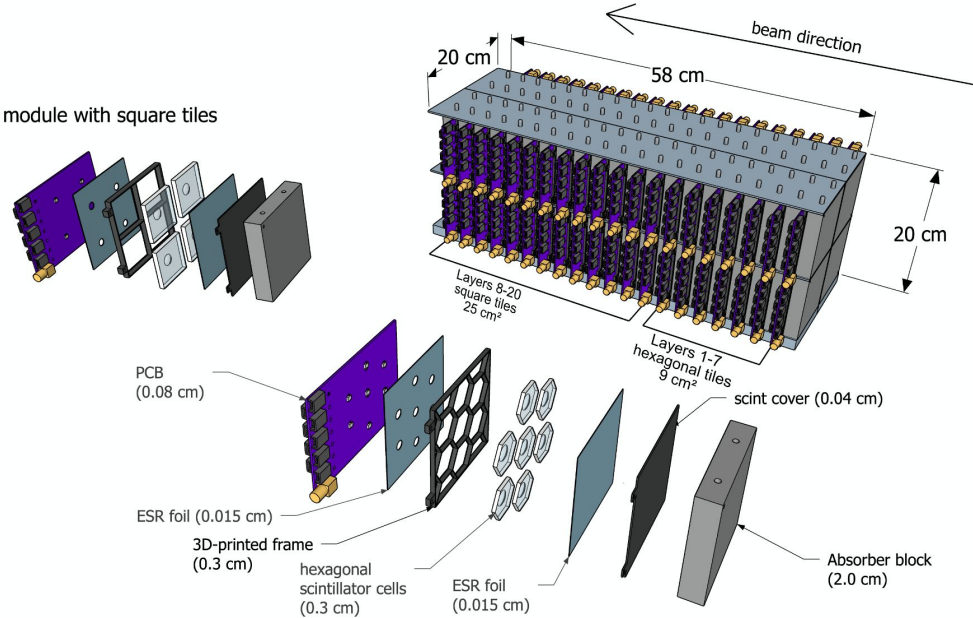
Energy spectra per layer (~4 GeV positron)



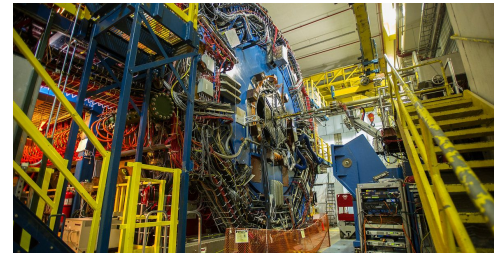
“Beam Test of the First Prototype of SiPM-on-Tile Calorimeter Insert for the EIC Using 4 GeV Positrons at JLab”
M. Arratia et al. (arXiv:2309.00818)

Gen-II Calorimeter Insert prototype being built, to be tested at RHIC

(~400 channels. ~5% of full size)



We plan to test our prototype parasitically here during the 2024 RHIC run 200 GeV pp collisions

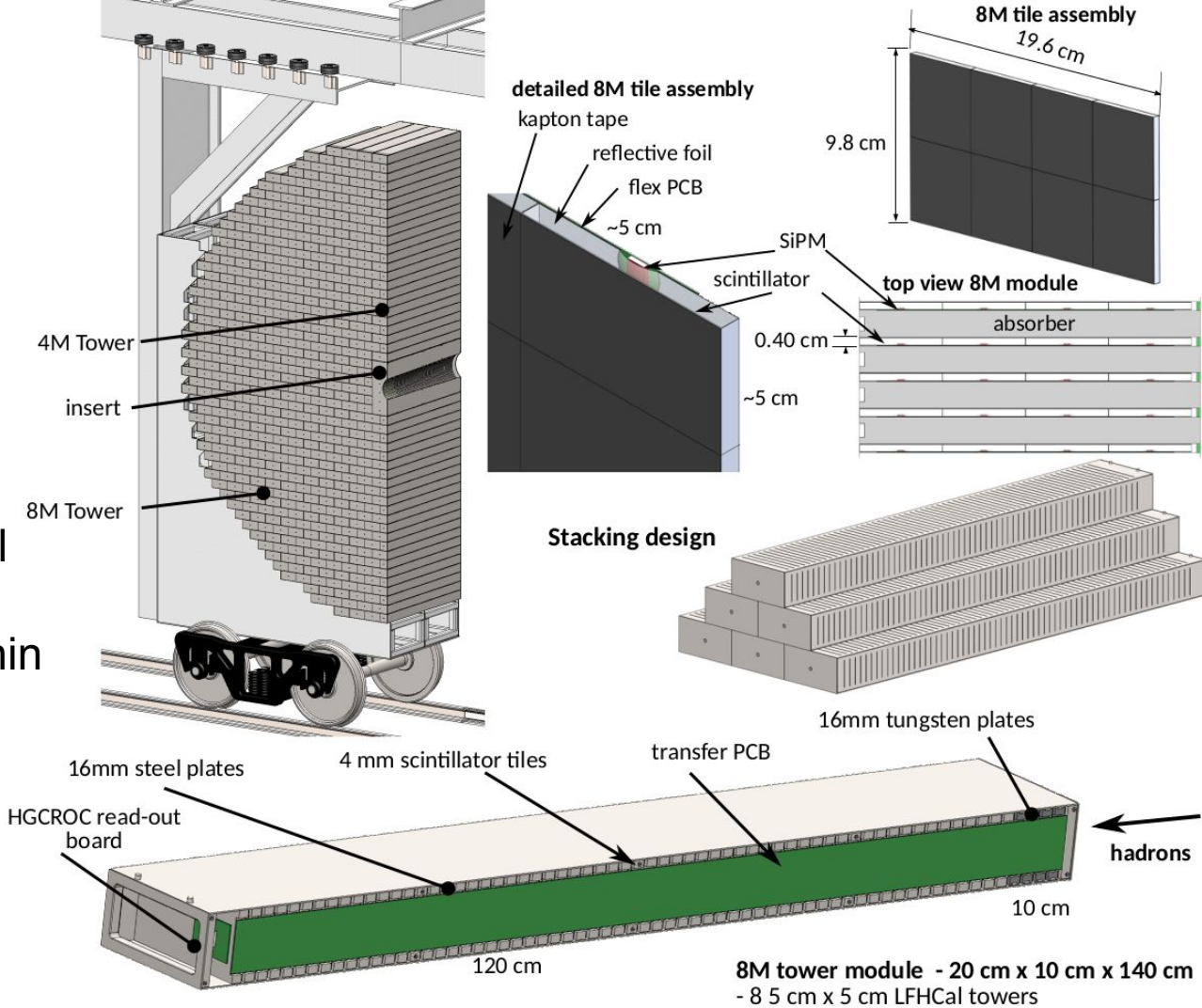


Forward HCAL at EIC
will use SiPM-on-tile

~600k SiPMs (record?)

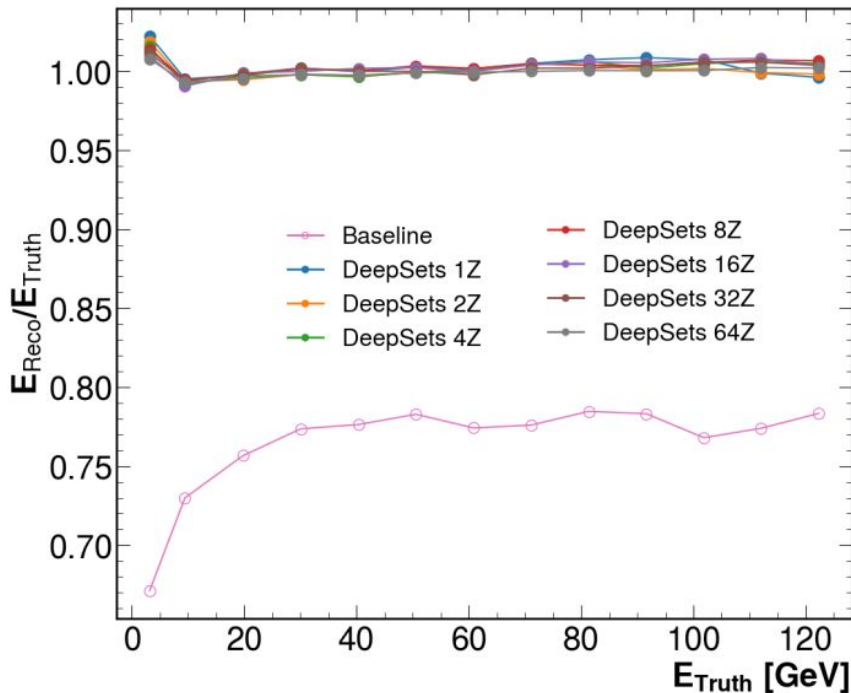
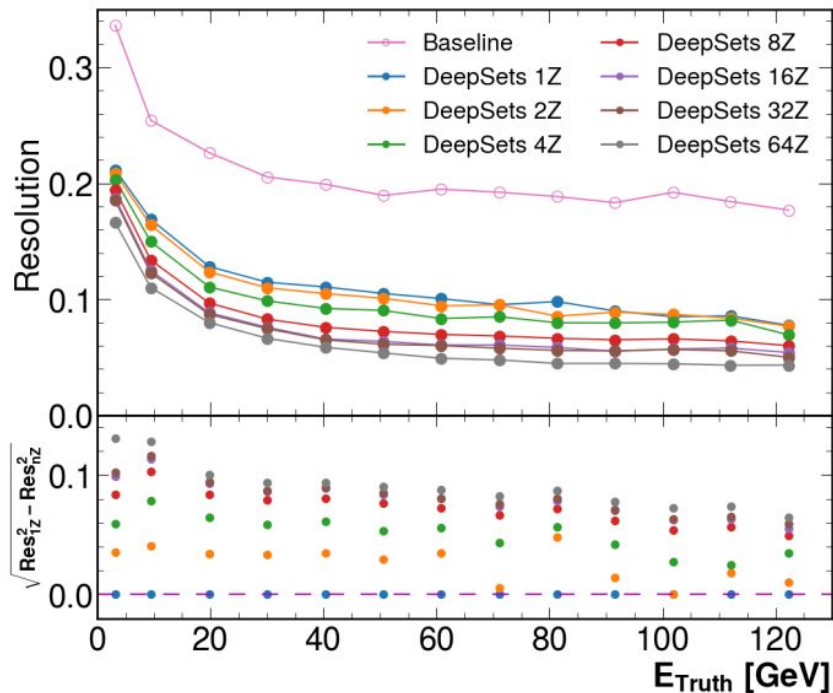
Passed final mechanical
design review recently,
to start construction within
months!

[See Oskar
Hartbrich's slides](#)



AI/ML providing optimal reconstruction from the get go!

Informs ongoing layout optimization, e.g. quantifies cost-benefit analysis of HCAL longitudinal granularity



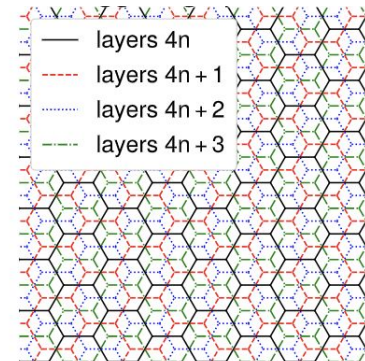
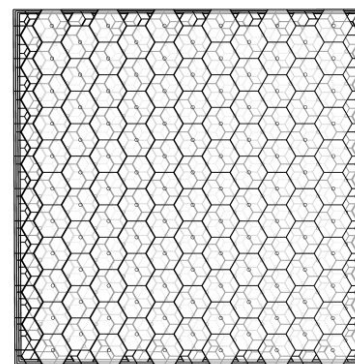
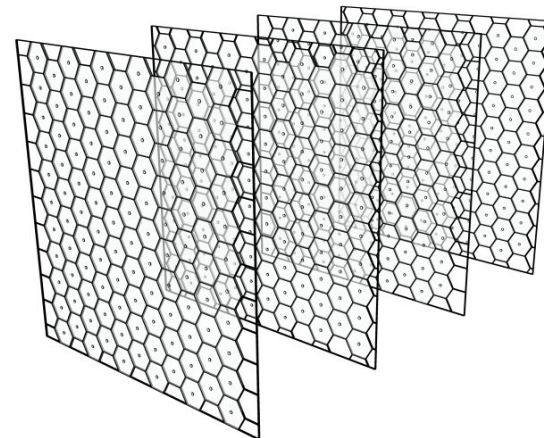
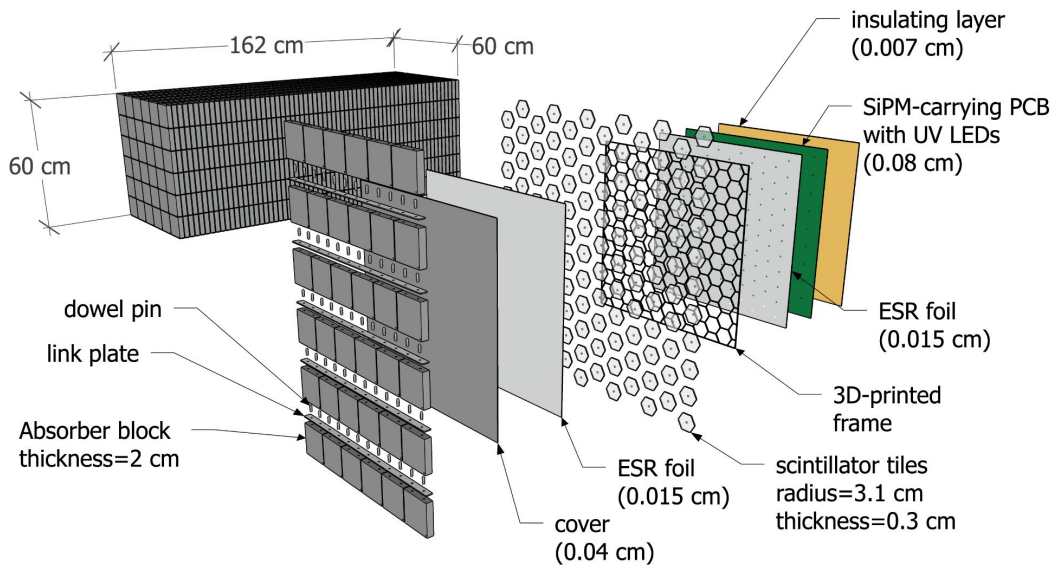
Deepset/Graph-neural network approach corrects for non-compensation of calorimeter

[See Ryan Milton's slides](#)

Zero Degree Calorimeter (ZDC)

Goal: to measure angle and energy of neutrons at small angles, $\eta > 6$

Novel “staggered design”



The HEXPLIT algorithm

Exploits subcells defined by overlap in staggered design

[arXiv:2308.06939](https://arxiv.org/abs/2308.06939)

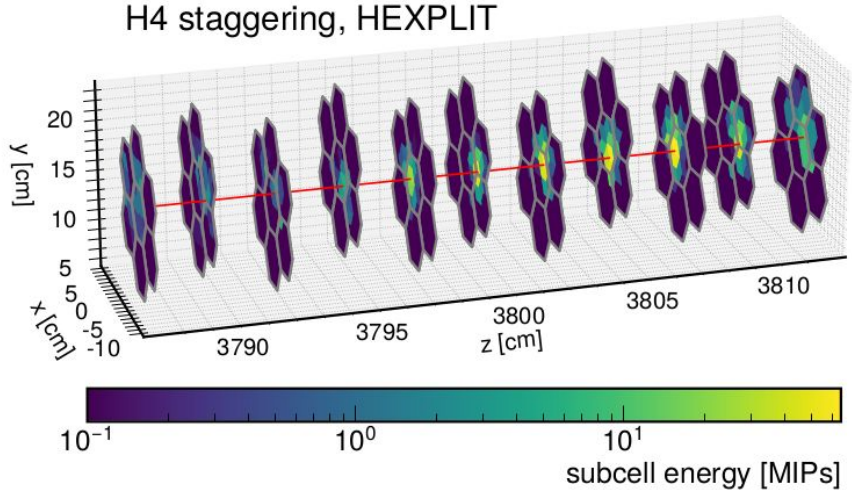
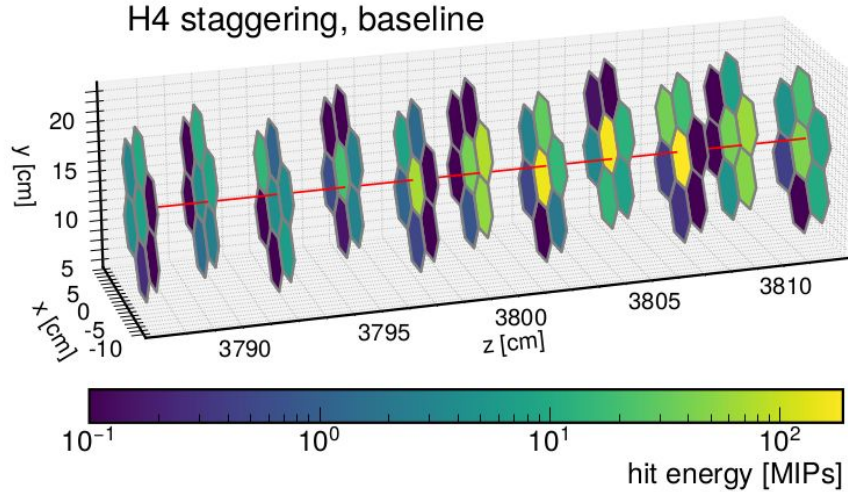
Define subcells with overlap and assign weights:

$$W_i = \prod_{j=1}^{N-1} \max(E_j, \delta),$$

Product over overlapping cells, j , in neighboring layers

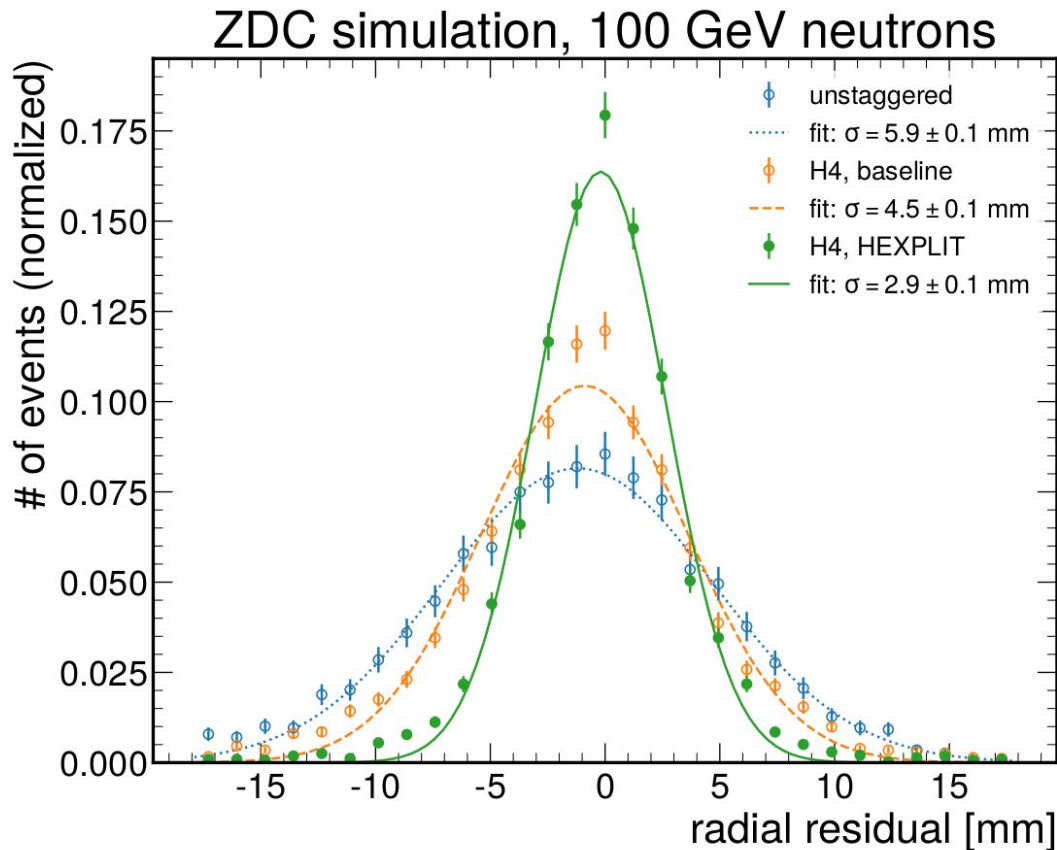
$$E_i = E_{\text{tile}} W_i / \sum_j W_j.$$

Energy in a given subcell, i



Same event before and after HEXPLIT

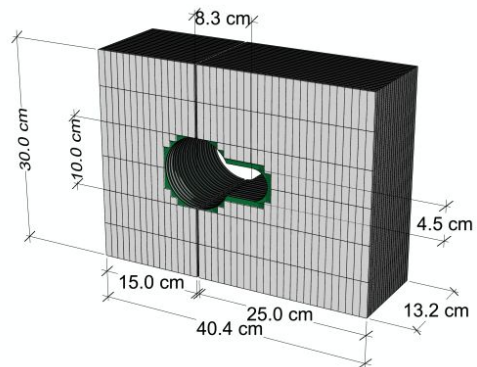
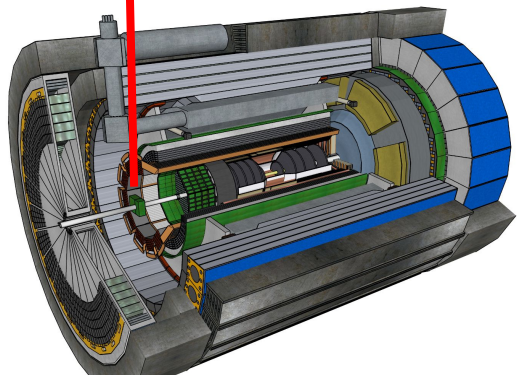
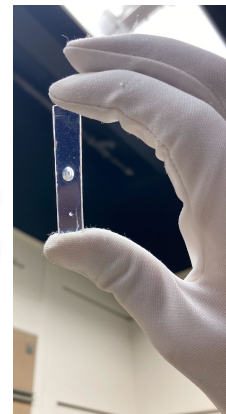
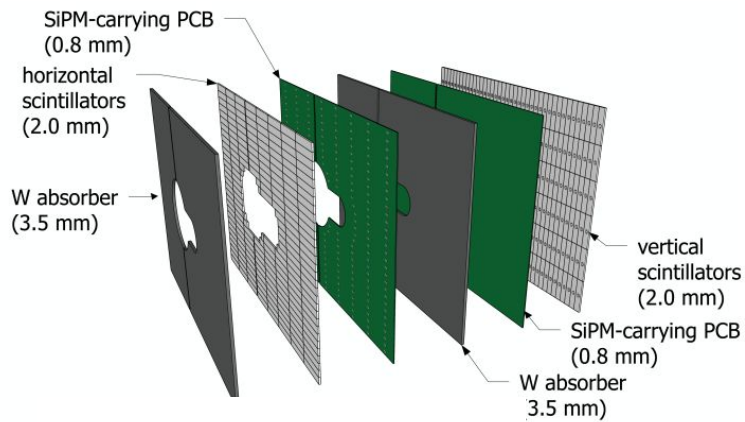
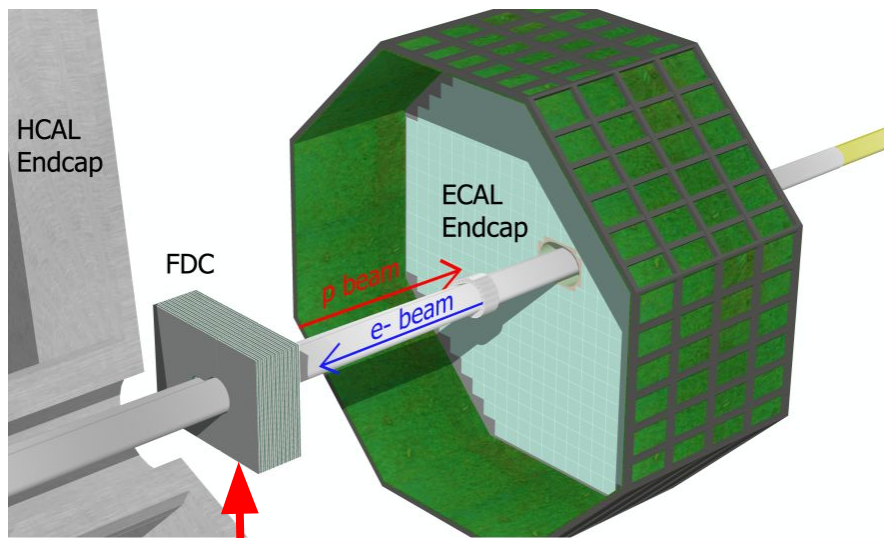
Staggering + HEXPLIT algorithm lead to a factor of 2 improvement in position resolution



Similar improvement over range 10-300 GeV

[Sean Prein's talk](#)

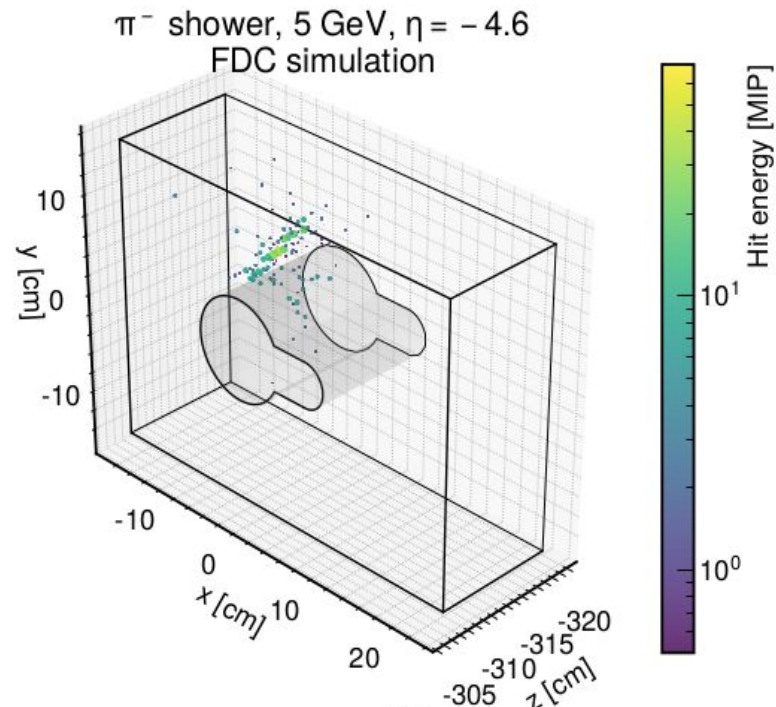
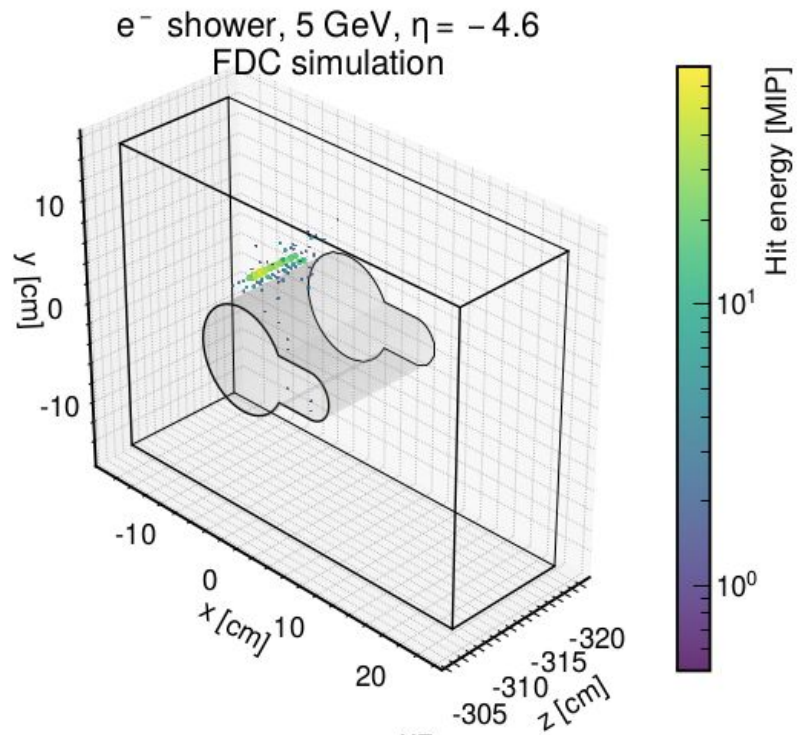
Few Degree Calorimeter (FDC) $-4.6 < \eta < -3.6$



M. Arratia et al. arXiv:2307.12531

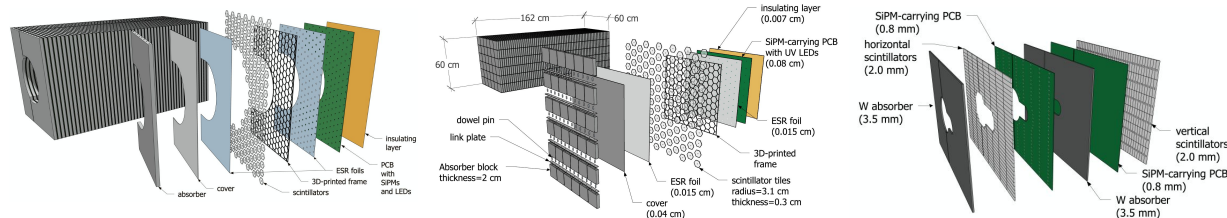
Highly granular 5D shower shapes can yield the standalone electron tagging we need.

R&D on “timing layers” ongoing for $O(10)$ ps shower timing

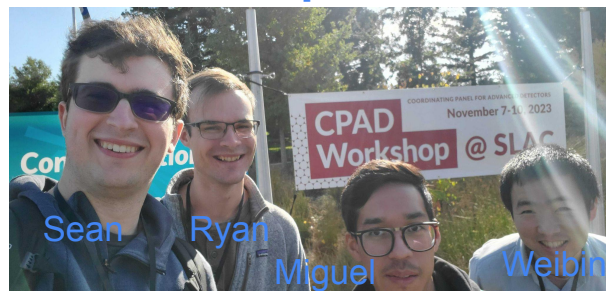


Summary

- SiPM-on-tile technology is an enabling technology for highly granular calorimeters.
- EIC detector moved from 0 SiPM-on-tile subsystems to ~5 since last CPAD!
- Construction phase of ~600k SiPM HCAL set to start next year.
- We are exploiting this technology's flexibility, and developing new approaches for hardware design and algorithms.



UCR speakers



You can see more details on our work on in:

- [NIMA 1047 \(2023\) 167866](#)
- [JINST 18 \(2023\) 05, P05045](#)
- [arXiv:2310.04442](#)
- [arXiv:2309.00818](#)
- [arXiv:2308.06939](#)
- [arXiv:2307.12531](#)
- [arXiv:2307.04780](#)

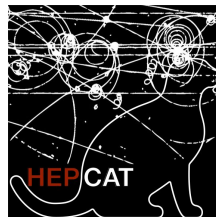
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ENERGY

Office of
Science

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