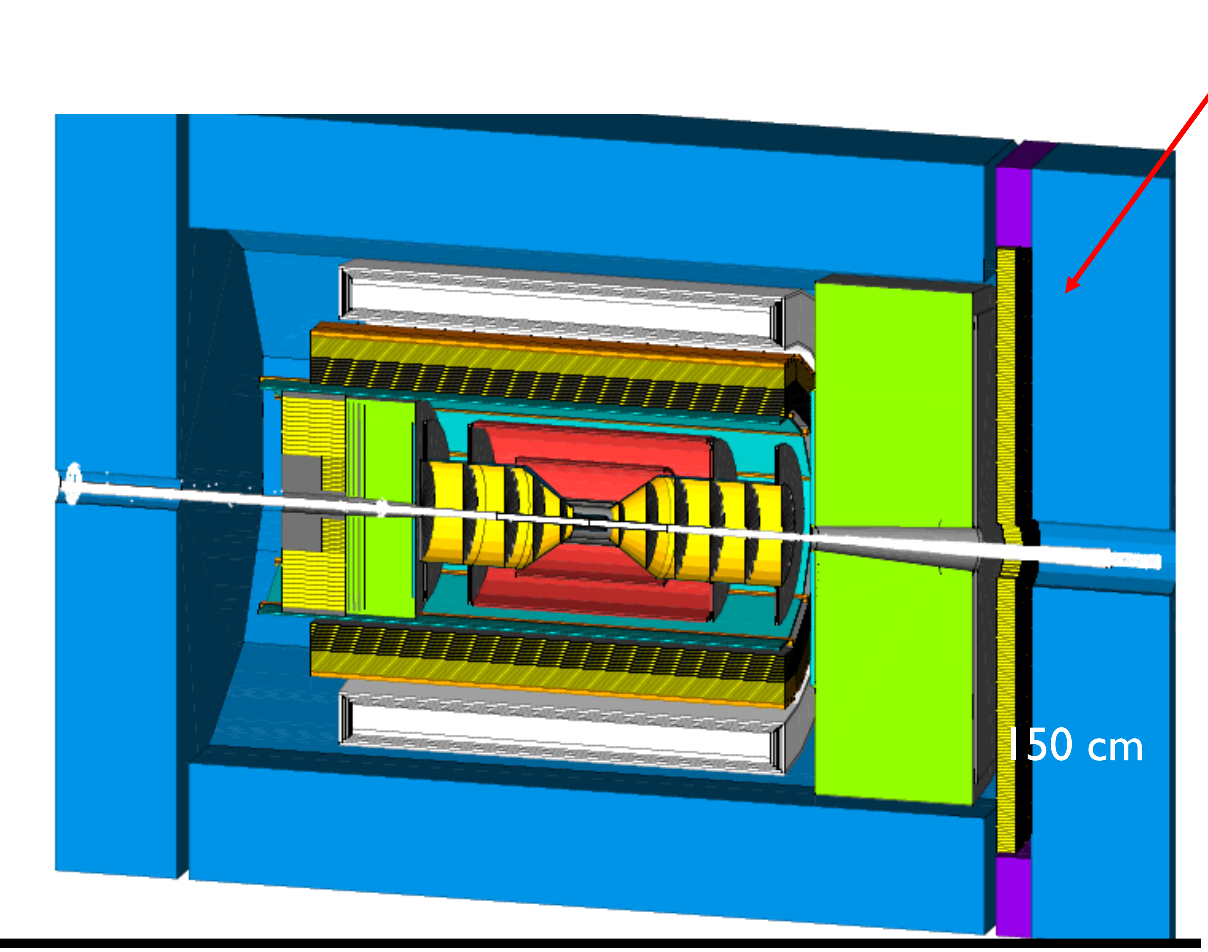
# pECal in ATHENA. Details

O.Tsai (UCLA) ACU, BNL, IUCF, Rutgers, UCLA, UCR, Valpo eRD107 (HCal)




ATHENA Integrations:
IP shifted by 50 cm (Accelerator-Detector)
pRICH requires more space (Detector sybsustems)

Integration Envelope:
Length along Z – 120 cm, R out -275 cm

Integration envelope sub-division:
- Fe/Sc – 112 cm (~ 7 int. length with Ecal)
- Readout (FEE+LED+Cooling) – 8 cm

Nomenclature:
- Tower ~ 10 x 10 $cm^2$
- 2 WLS plates per tower / 4 longitudinal segments
- Installation/assembly – layer-by-layer

Photosensors:
6 HPK S14160-3015PS* per WLS Plate

Number of towers – 2660
Number of readout channels – 5320

SiPM pixels size changes with eta.

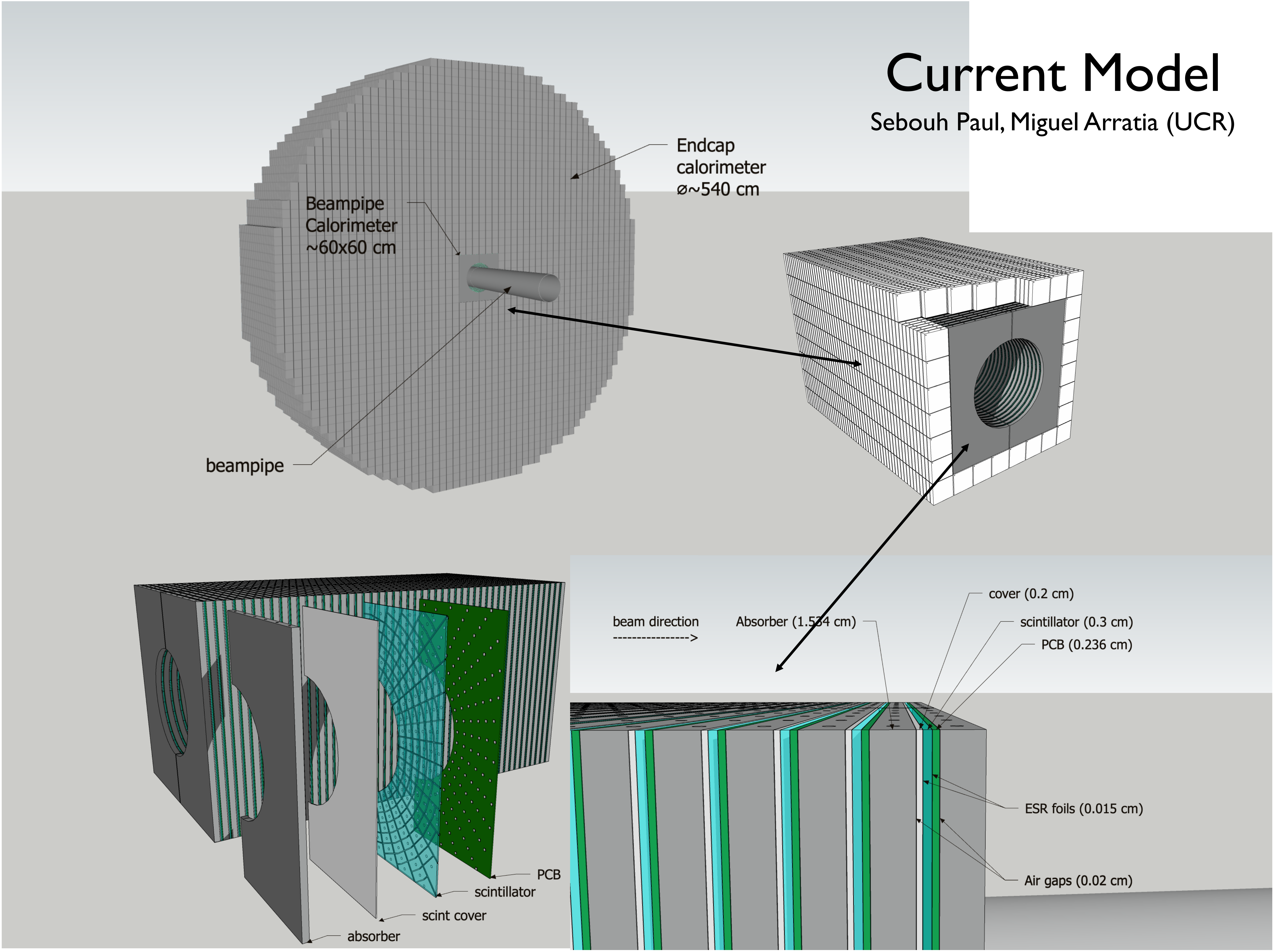
## Cost drivers (ATHENA dimensions)

- Scintillating plates – \$2.4M (Quoted, EJ)
- Absorber Plates - \$2.8M (Quoted, Chapman Lakes)
- WLS Plates - \$1.4M (Quoted, EJ)
- Electronics - \$0.9M (Direct scaling from STAR FCS)
- Labor - \$2.3 M (Direct scaling from STAR FCS)

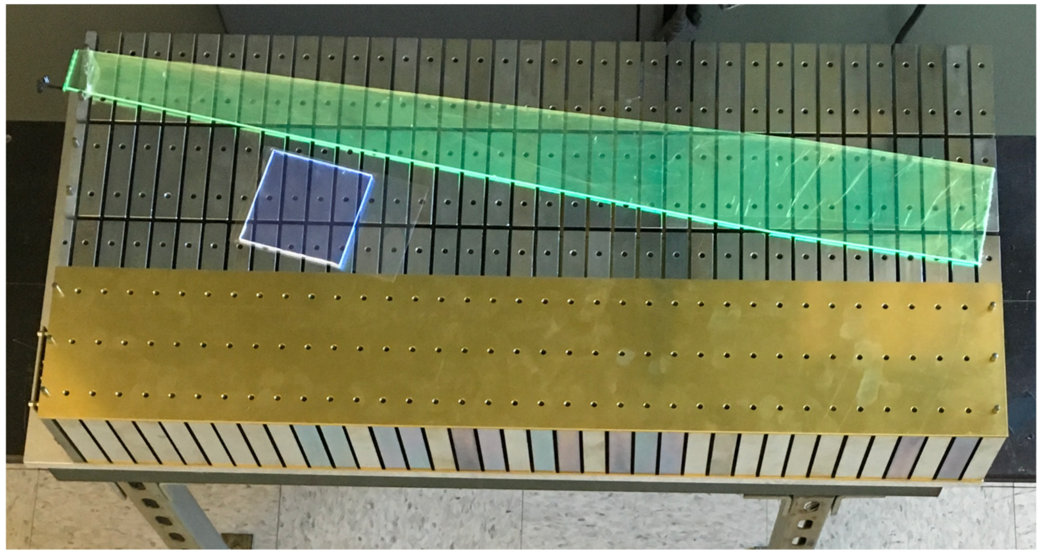
Total: ~\$11M (using project templates)

# Current Model

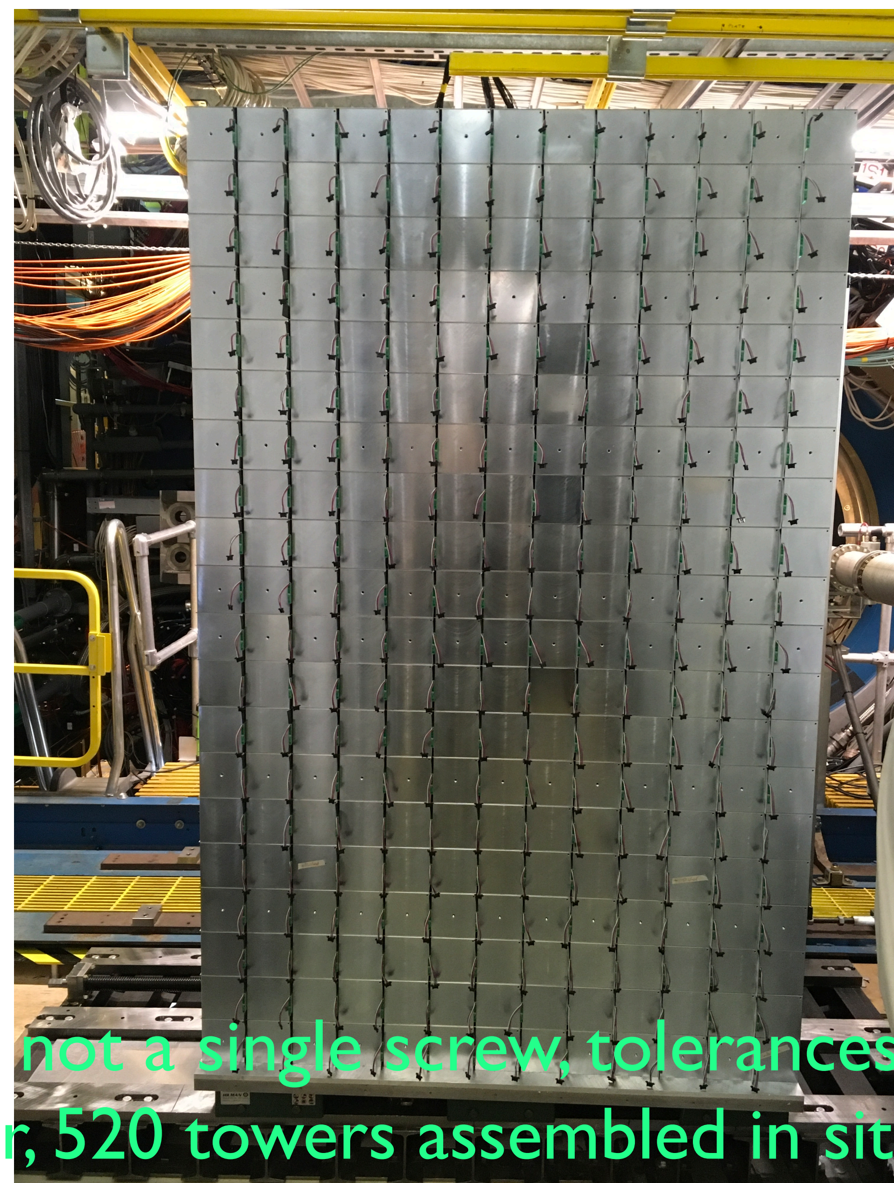
Sebouh Paul, Miguel Arratia (UCR)



# LEGO construction technique.



- Very simple design (6 parts)
- Standard industrial production
- Assembly and installation is a single step
- Simple 'logistics'
- Good for universities (workforce, infrastructure)


2 Stacks, each 2m x 1.3 m not a single screw, tolerances better than 100 mkm

30 tons detector, 520 towers assembled in situ in 20 days

STAR FCS type  design and technology key points:

- Very efficient construction technique allows:
- Tight tolerances assembly -> high effective density (total 20 mm air gap for 51 layers)
- ‘Solid’ mechanical structure, links in X ,Y ,Z across entire detector
- Minimized dead areas
- Very simple mechanical integration/installation with Ecal
- Simple Logistics (calorimeter on demand ☺)

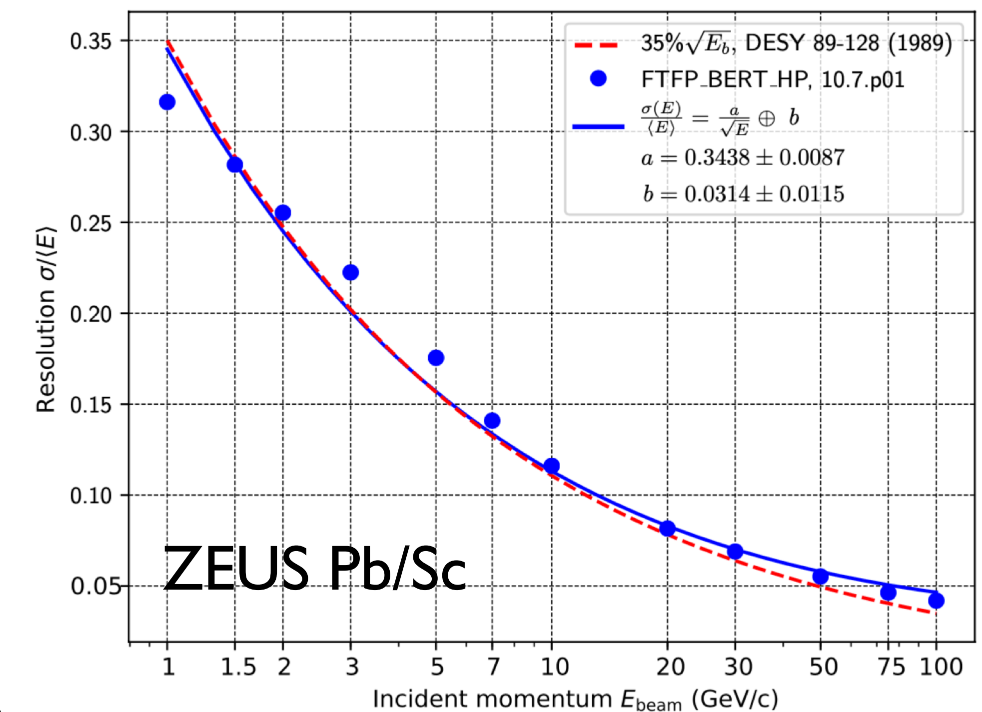
- Performance, cost and risk are well understood, R&D and STAR FCS construction
- Perfect for universities (workforce and infrastructure)  STAR FCS construction team build from 11 institutions  (ACU, BNL, UCLA, UCR, IUCF, UKY, OSU, Rutgers, Temple, TAMU, Valpo)

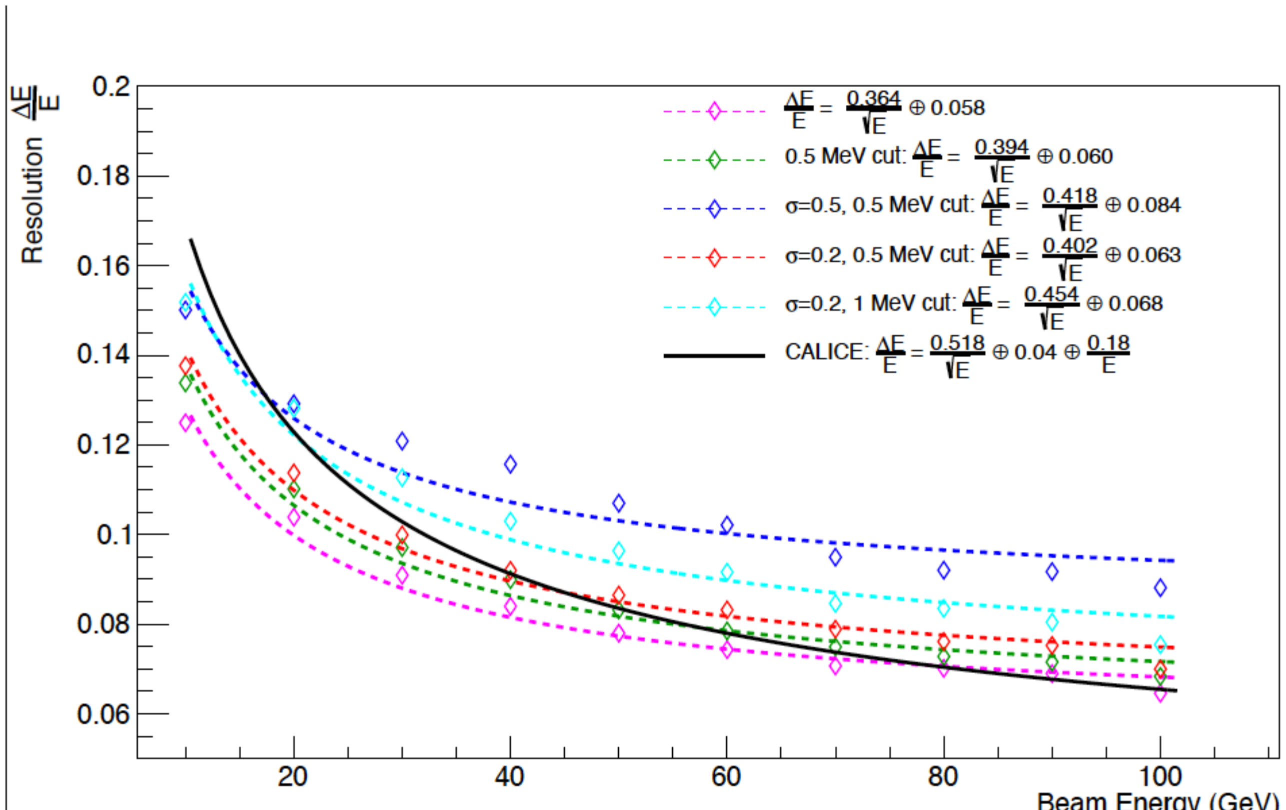
- Cost effective readout for longitudinal segmentation with fast/slow scintillator.

- R&D plan was submitted (pended now) eRD107 to address segmentation, light collection efficiency and with eRD106 to answer the question what energy resolution is achievable?

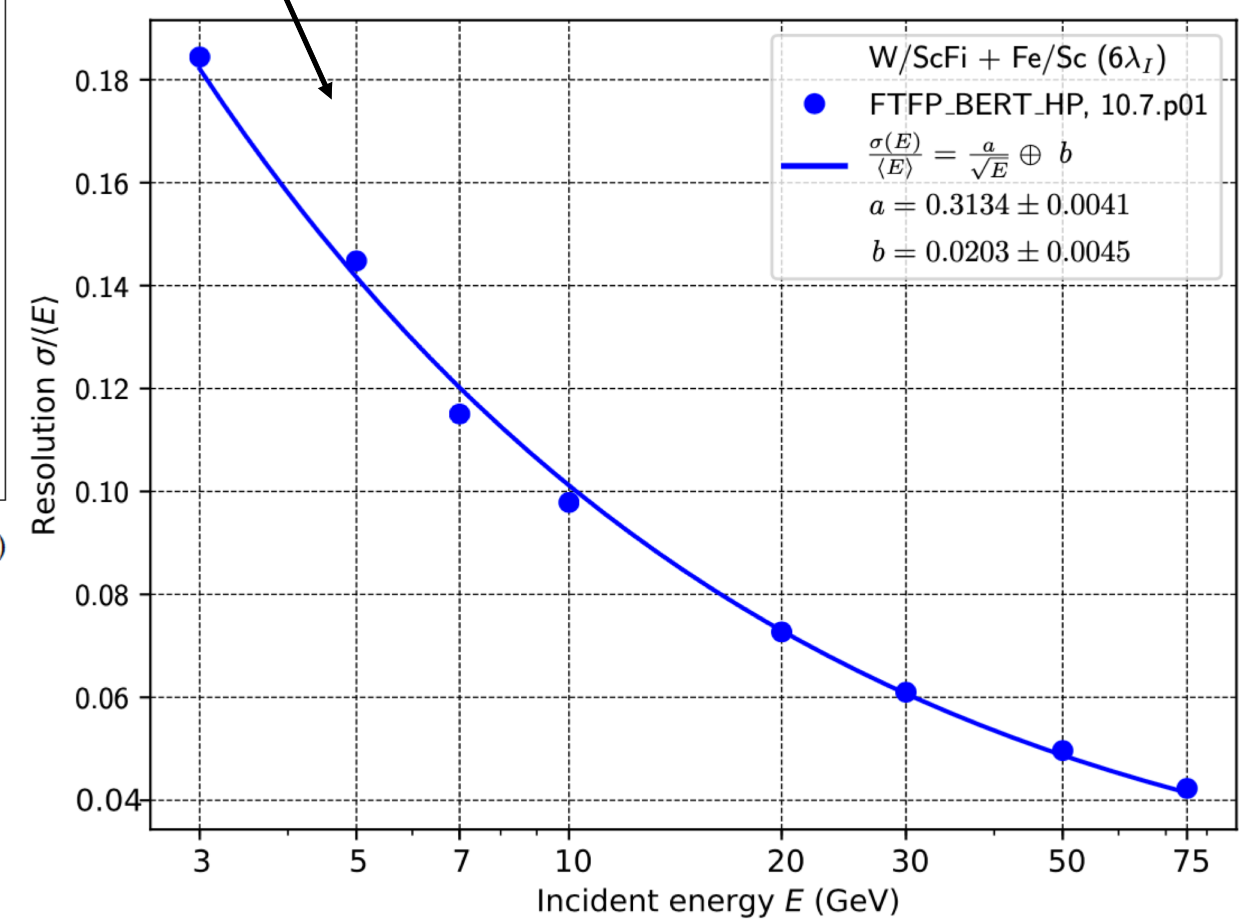
# MC results should be taken with a grain of salt…

- Validation for high Z absorbers looks fine
- (J.Adam, A. Jentsch (BNL), earlier studies with Pb/Sc hcal eRD1/STAR)
- Work in progress to tune MC for Fe absorber.
- For more details e/h, f_em, segmentation etc. see my talk here https://indico.bnl.gov/event/15493/




Fe/Sc, CALICE Model R.Milton (UCLA)



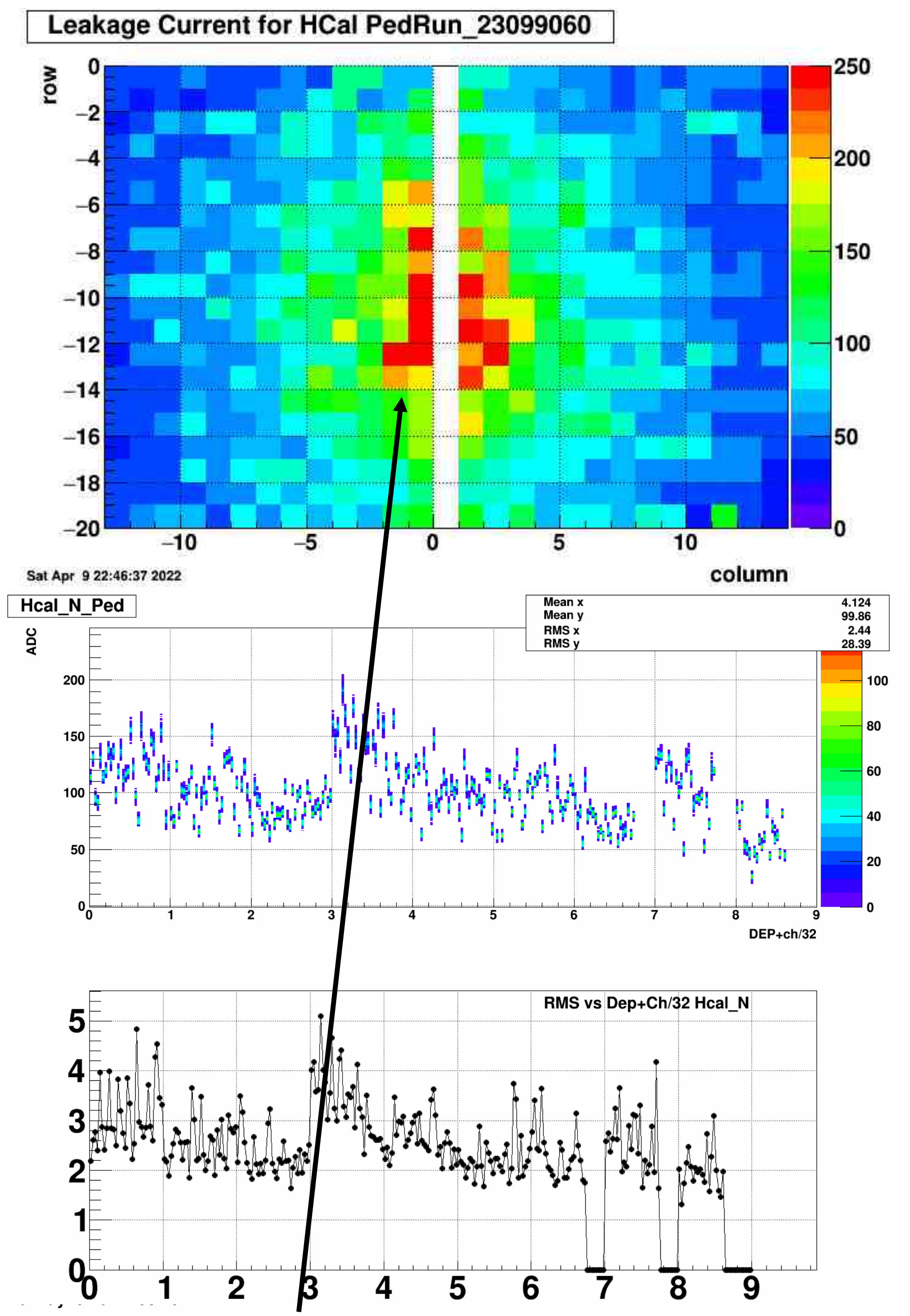

J.Adam (BNL)

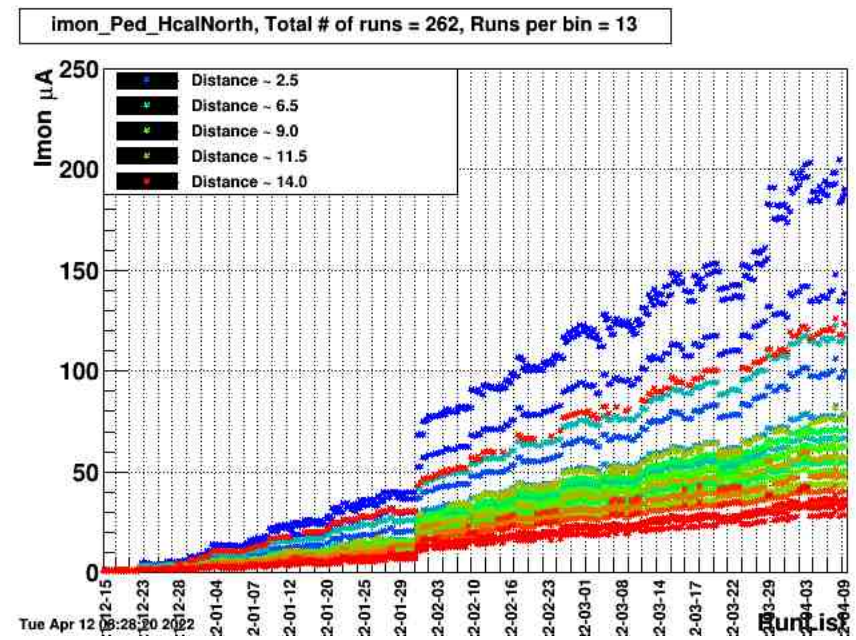
- Very productive 'CALICE validation' meeting between ORNL and UC EIC team, ~ two weeks ago.
- Presentations from Oskar Hartbrich (ORNL) and Ryan Milton (UCLA)
- Timing cut and 'first hard interaction' cut were missing in UCLA simulations, will be implemented.

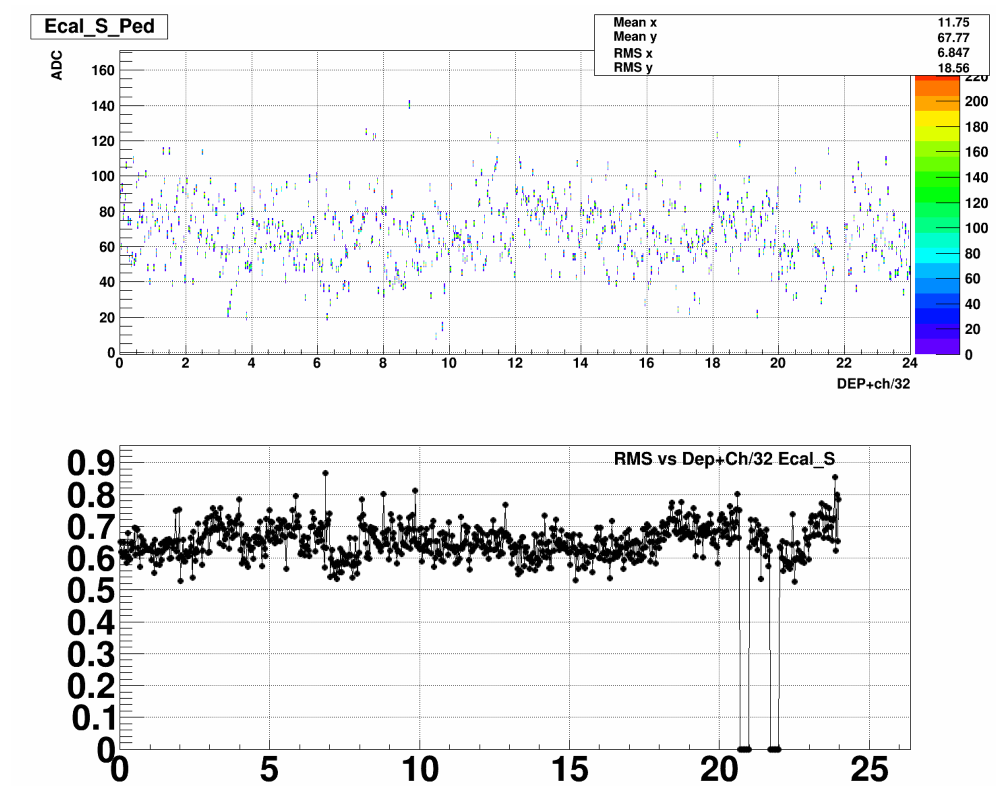
Details. Importance of LY.

Successful 2022 pp 510 GeV run. First data taking run with FCS.

As expected SiPMs get noisy.



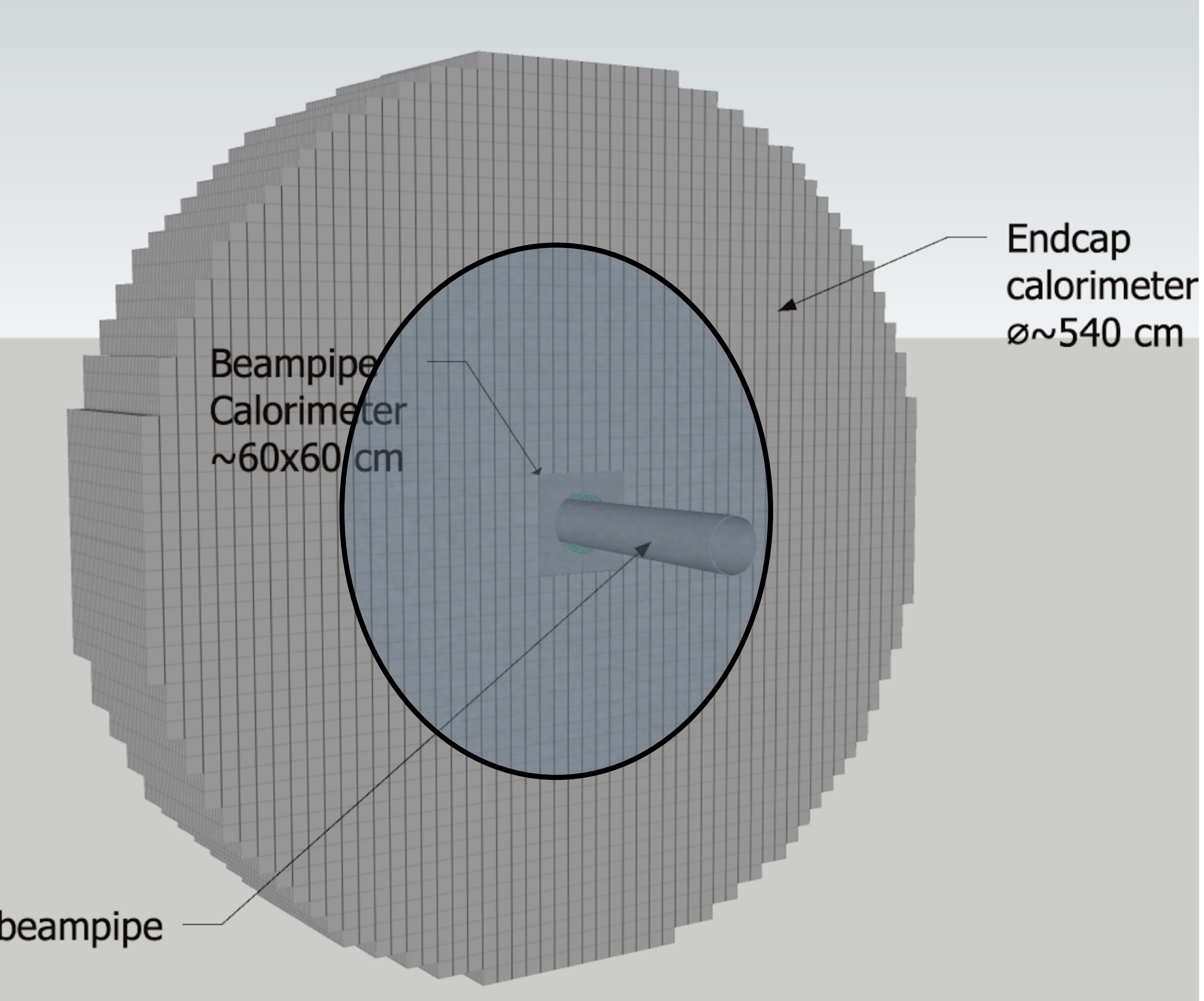




HCal noise ~ 25 MeV

ECal noise ~ 3 MeV

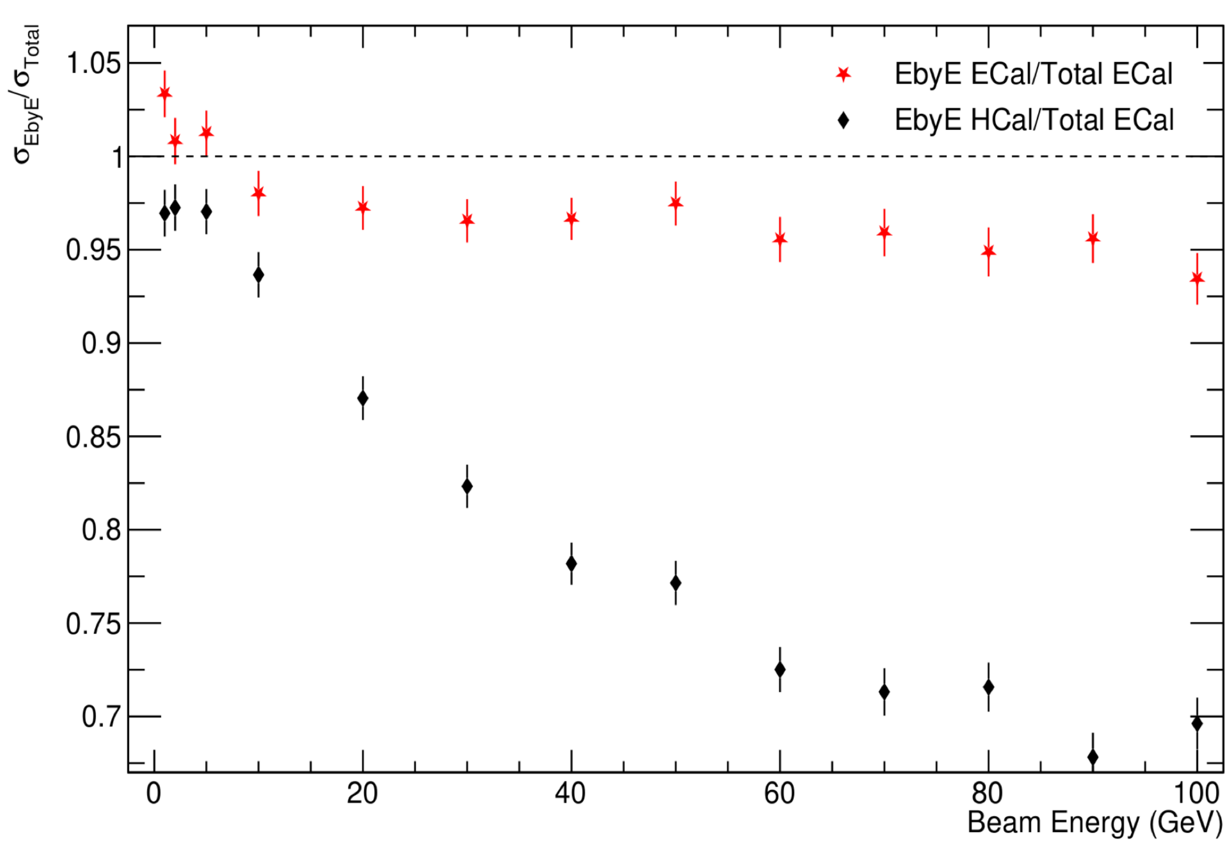
- Direct consequence of LY (HCal LY < 190 pixels/GeV, ECal < 1500 pixels/GeV)
- For EIC we would like to improve LY in HCal

Post proposal 'optimizations' and discussions for pHCal




Longitudinal segmentation for HCal – define crisply the purpose and area where it is important.

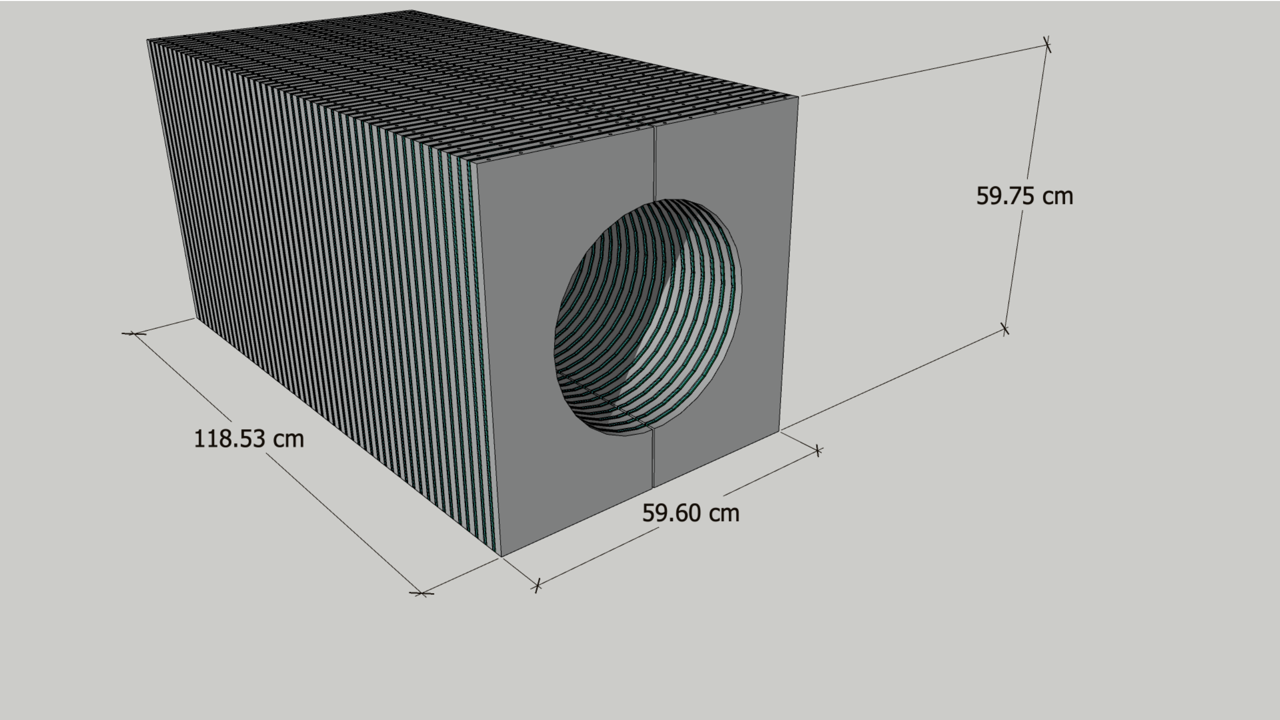
For example:
'Software compensation' in outer area most likely will not work (low energy hadrons).

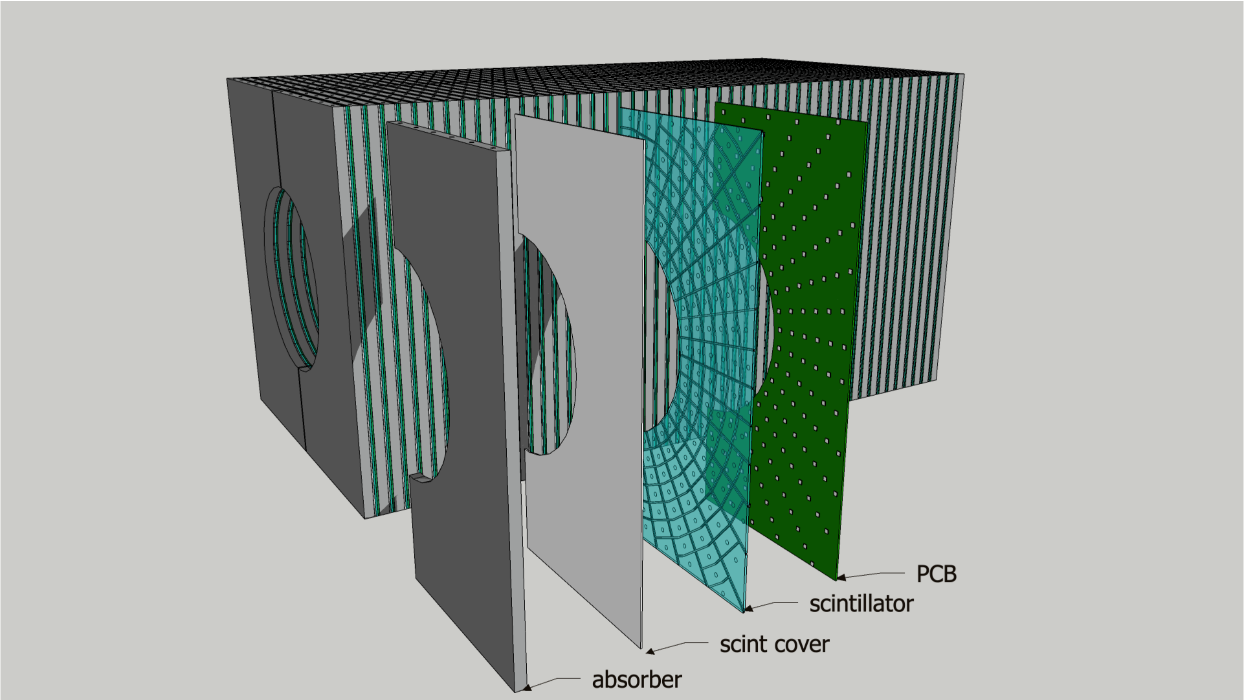


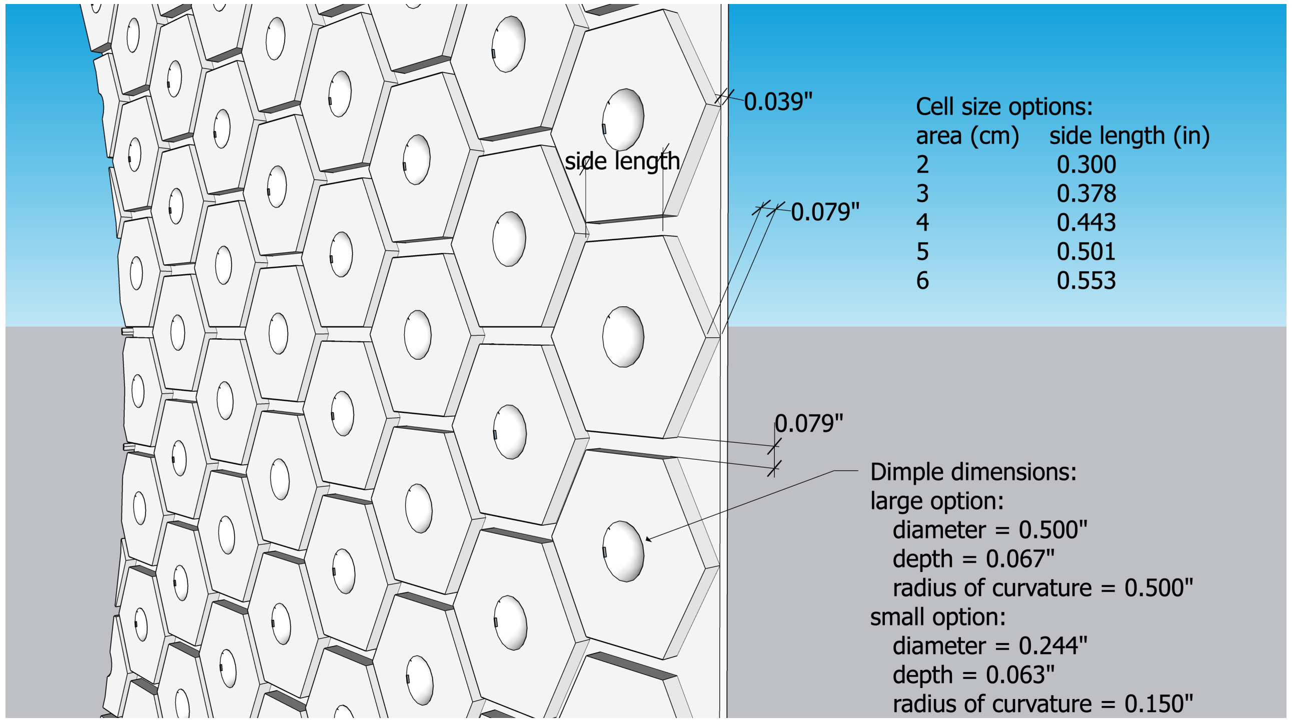

If one believes MC, calorimetry only methods outperform tracker at eta? Even without software compensation (longitudinal segmentation).

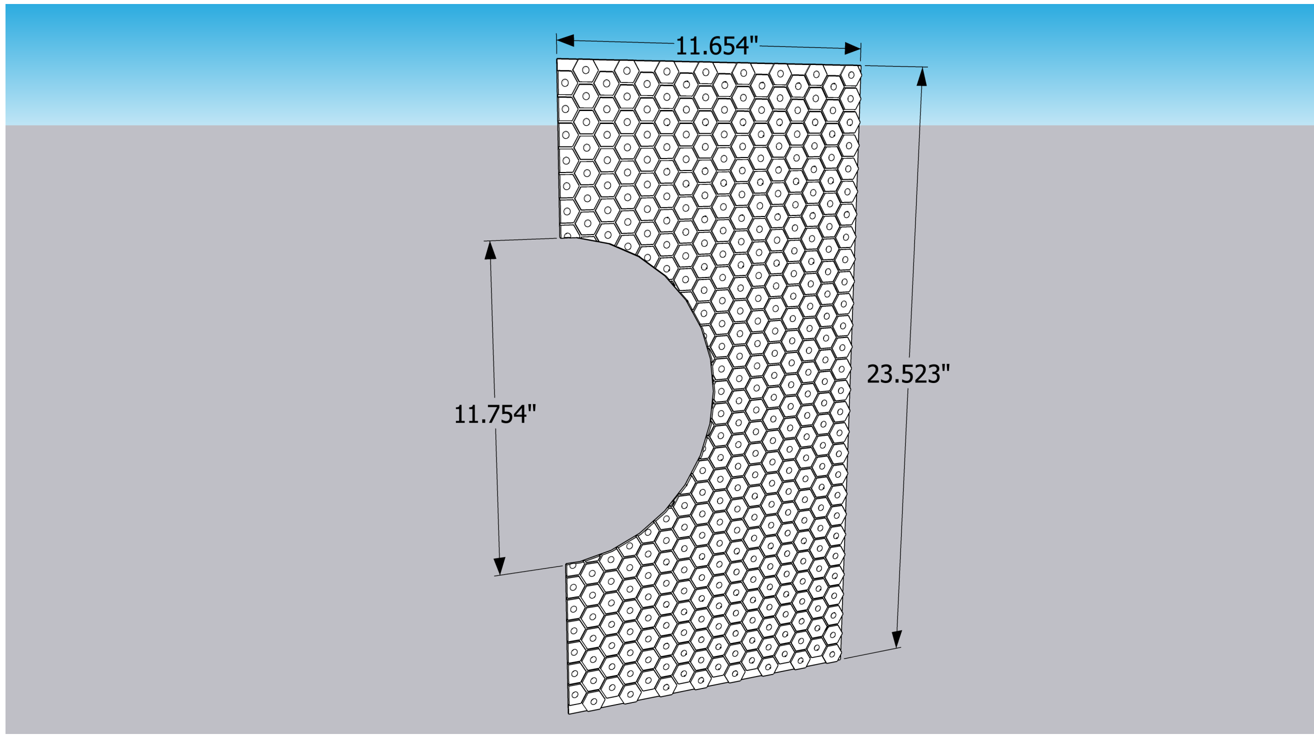
Optimizations require validated MC and comprehensive model of the whole detector (magnet, tracker, pid, ecal) this is not a two months task.

# Post proposal ‘optimizations’ and discussions for pHCal




Very active discussion for insert. Goal is to define configuration technology wise possible, include it in DD4HEP run MC. One of the question how well AI/ML can help with extension of acceptance (mitigation of leakages into opening).

# Summary:

- We have good foundation to develop pHCal for detector-1
- Range of discussions is very wide from super detailed to conceptual, which we consider as very positive process. New ideas being incorporated.
- For bulk of the detector cost, and risks are well understood. Performance based on MC is questionable.
- It is also understood that optimizations will take significant time as it is part of global detector optimization (requires not just detailed model but validations and algorithms, which may not even exists yet).
- Very important! Since proposal time a team of active developers been growing significantly. Thanks to UC EIC consortia funding for next three years.

# Backup Slides

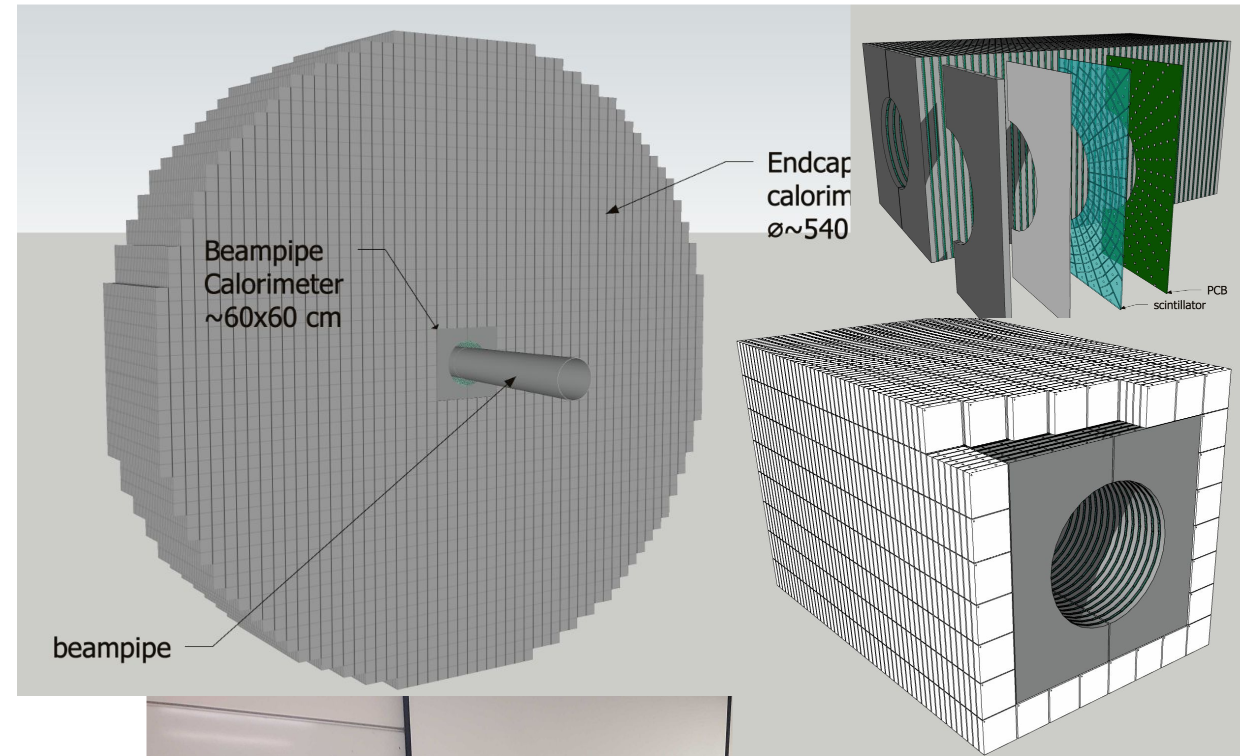
# CALIFORNIA EIC CONSORTIUM

Formed in 2019, now includes [4 UC campuses and 3 labs].
Institutions most active in calorimetry are

UCLA UC RIVERSIDE

Currently funded by the UC Office of the President (~1.8 M grant for 21-24).
In addition, calorimetry optimization efforts are funded by DOE NP AI grant (~1 M for 21-22), with LLNL and LBNL

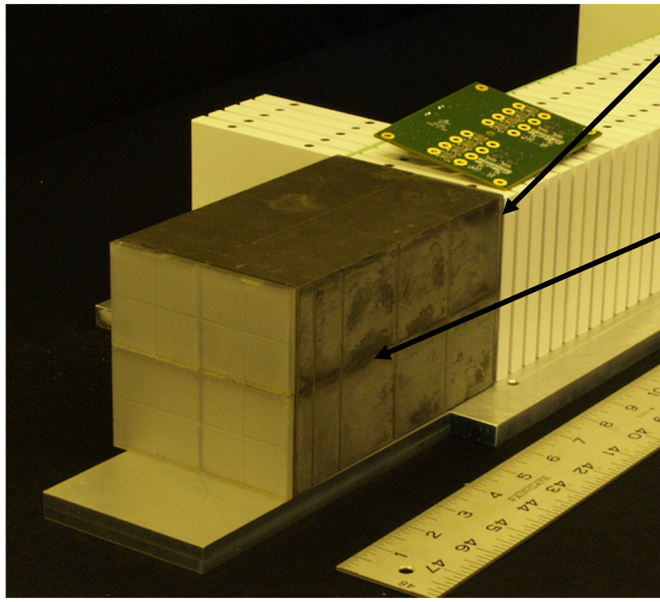
Our team at UCR, UCLA, LLNL and LBNL include **6 postdocs and 3 grad students at 0.5 FTE** working on forward calorimeter design & optimization.
We look forward to contribute to Detector-1 in this critical period

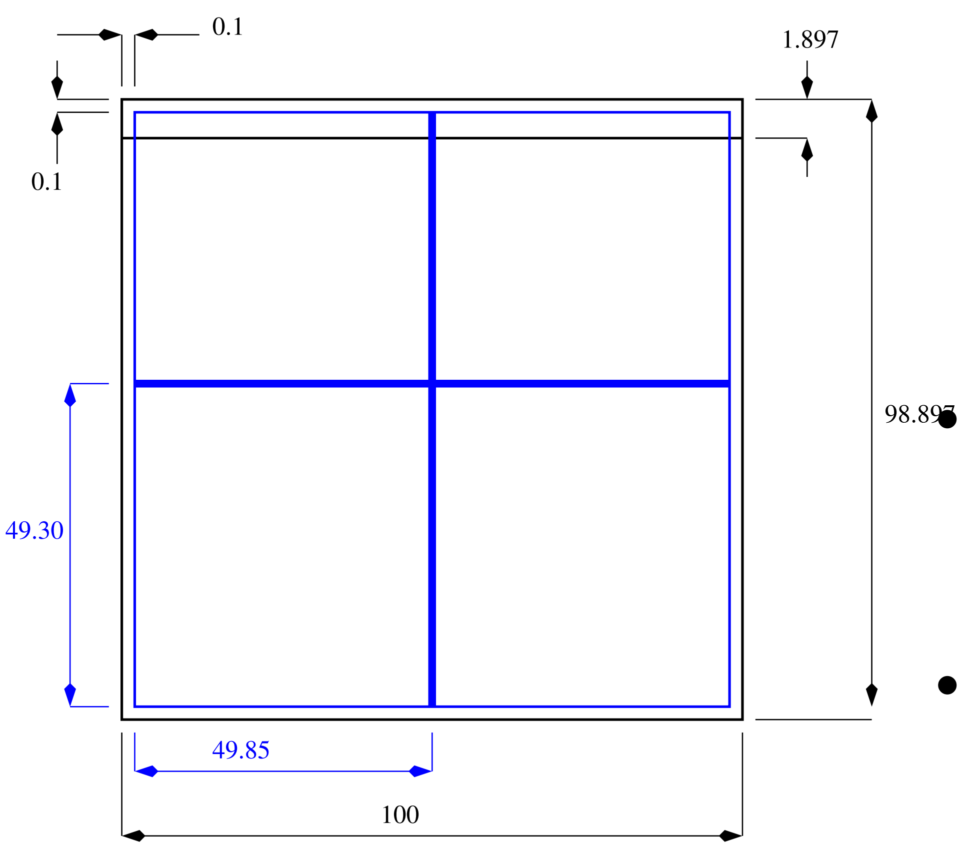




Some members of our team (not all!) in one of our regular in-person workshops in SoCal

## Integration with ECal






Glue Joint between EMcal blocks is 0.1 mm thick

EMcal block external dimensions are 49.85 x 49.30
HCal tower external dimensions are 100 x 98.897
Clearance gap between edges of EMcal and Hcal towers is 0.1mm

- First absorber plate of Hcal is a ‘strong back’ for ECal
- Installation block glued to that plate prior assembly of Hcal.
- Installation of ECal goes along with assembly of Hcal, i.e. layer by layer as it was done for STAR FCS. First absorber blocks of Hcal bolted to each other.
- Installation gaps 0.2 mm seemingly easy to achieve (production tolerances of ECal and tolerances for Hcal assembly, which were verified with STAR FCS ( 2m high, 30 t, better than 0.1 mm tolerances achieved)
- ECal is self supporting, in current version there is no pressure from one ecal installation block to another.
- Mechanical properties of compound is close to construction steel.

N.B. Gaps, Dead areas in modular calorimeters and resolution.