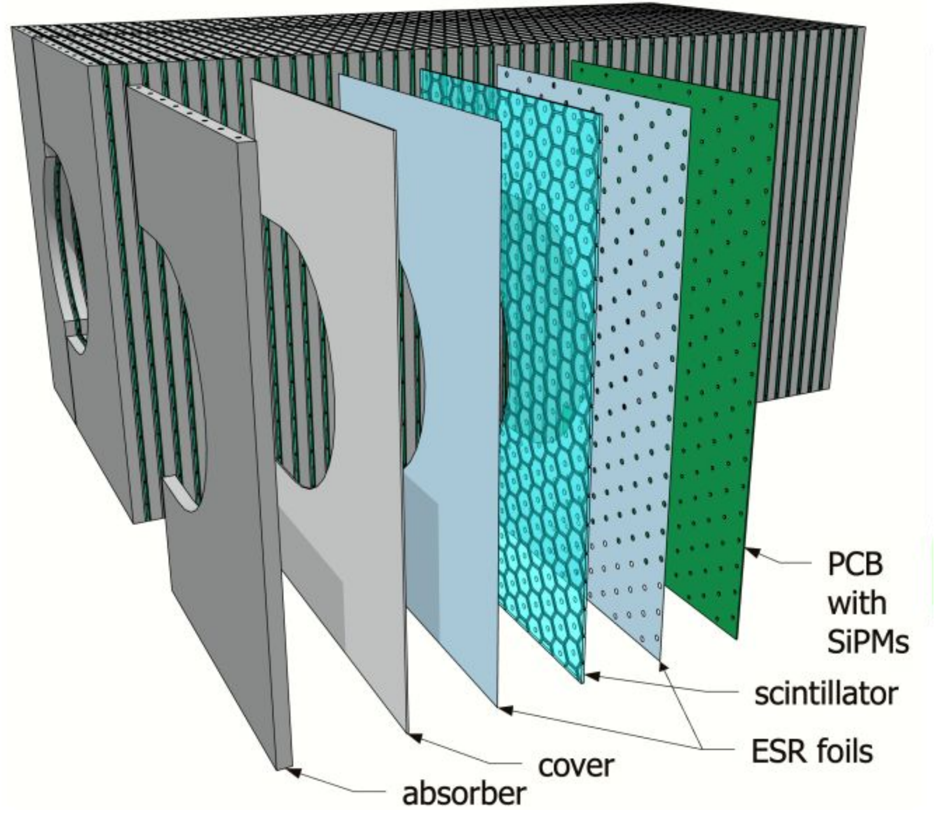
Calorimeter Insert for ePIC

Miguel Arratia,
on behalf of the insert team



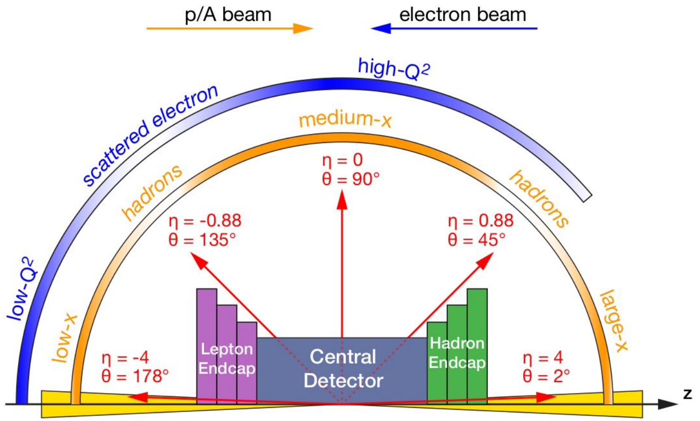
January 10th 2023, EPIC collaboration meeting

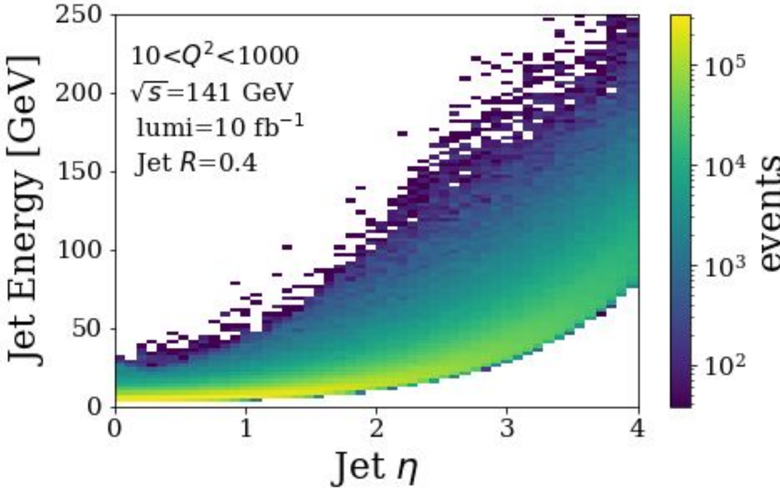
Motivation

EIC detectors should have **"as large coverage as technically possible"**, up to η=4.0

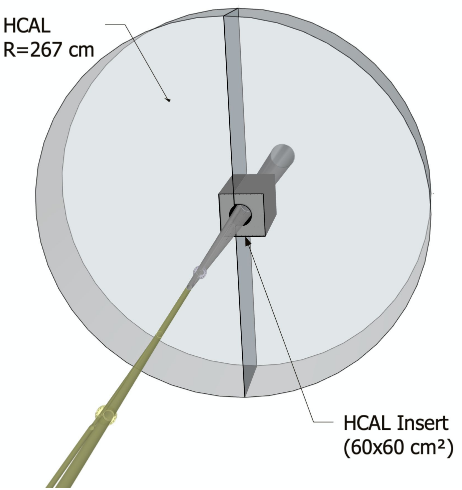
Tracking degrades rapidly at forward rapidity, so calorimeters at 3<η<4 crucial to:

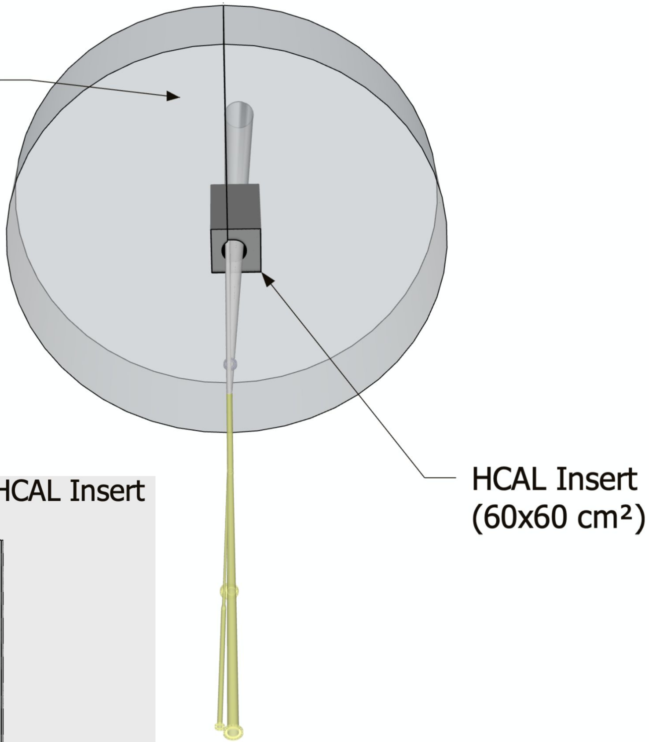
- Highest-energy jets
  (sensitive to both high-x and low-x)
- Hadronic-final-state transverse momentum to reconstruct low-y NC DIS and CC DIS

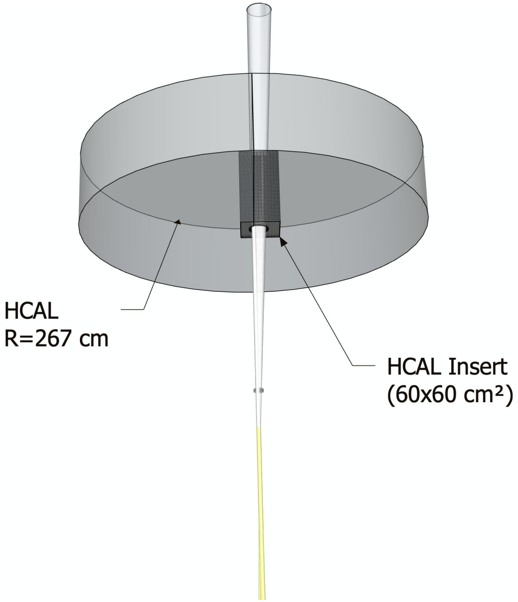


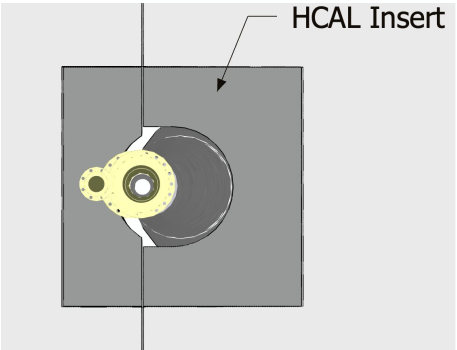


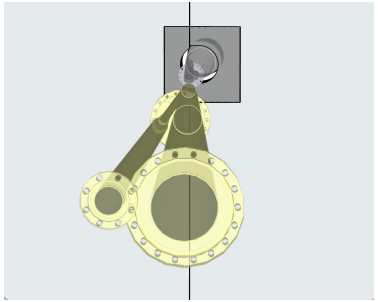
Challenge: crossing-angle complicates geometry near beampipe



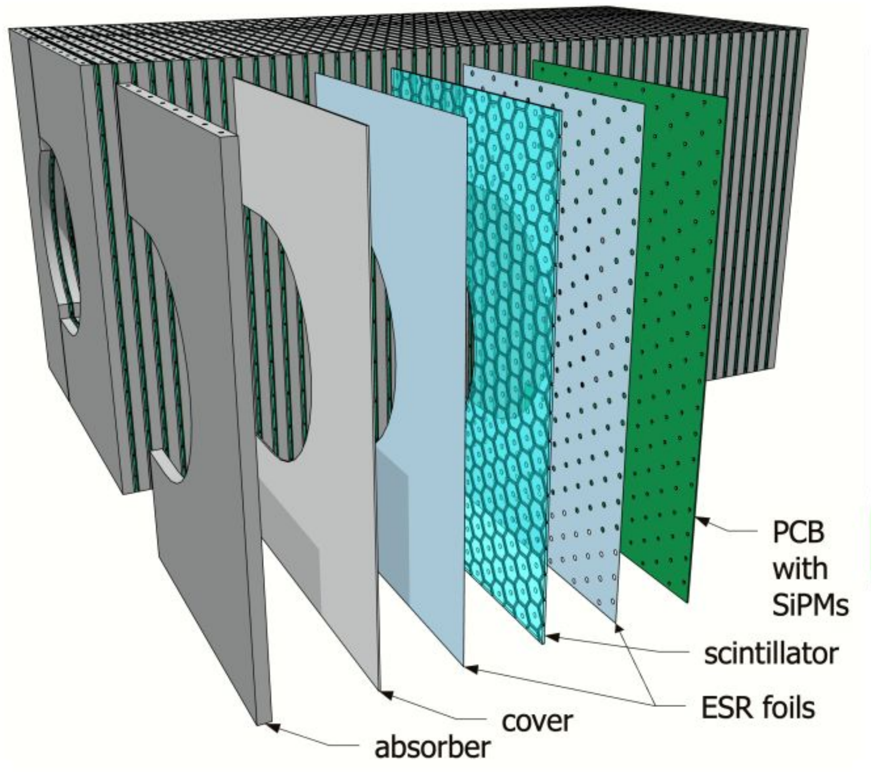








The HCAL insert



What is it?

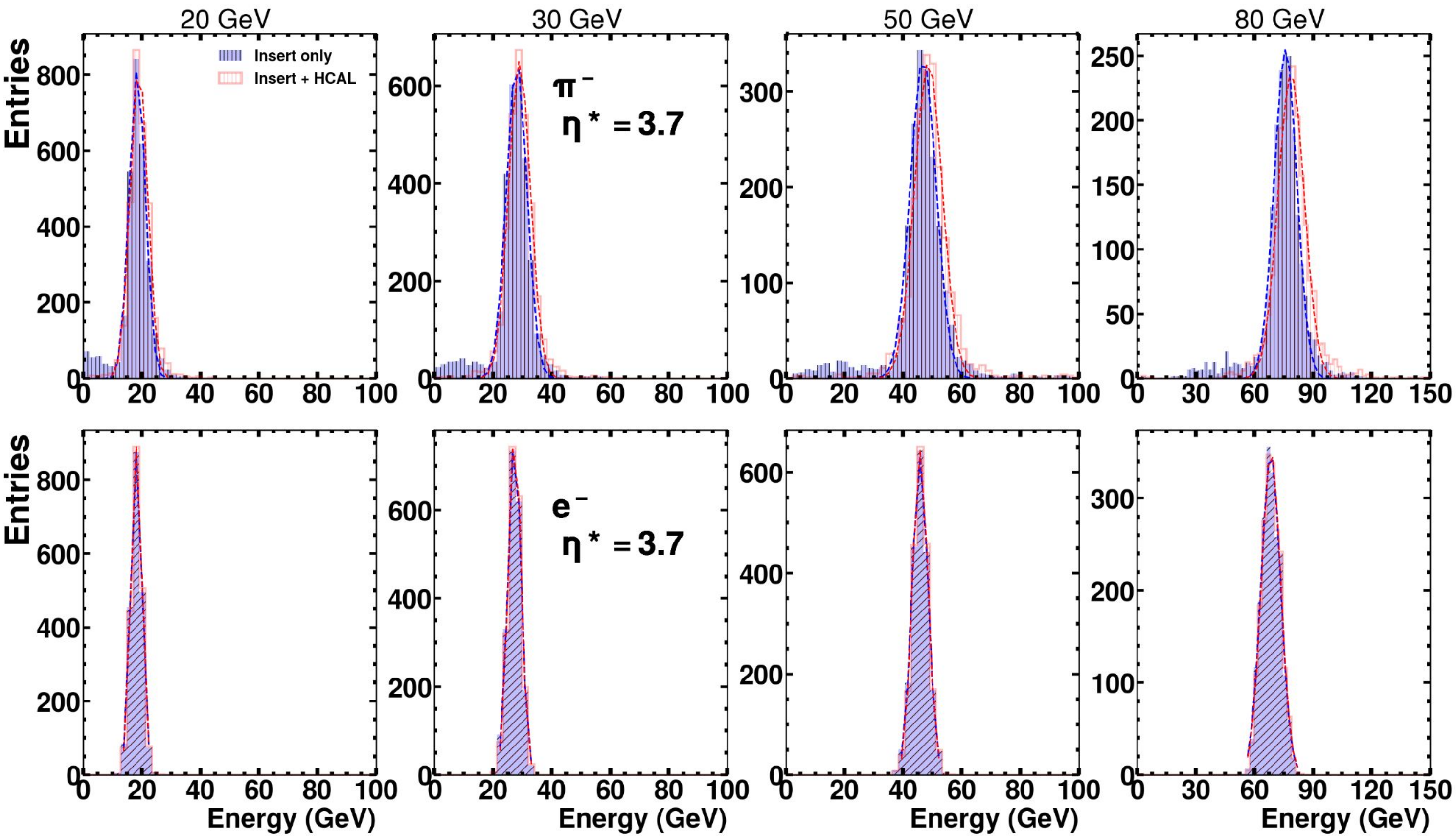
Scintillator / Fe+W sampling calorimeter.
High-granularity with “SiPM-on-tile” tech (CALICE, CMS)

What does it do?

Maximizes acceptance, while fitting rest of end cap thus solving mechanical constraints on tough geometry.

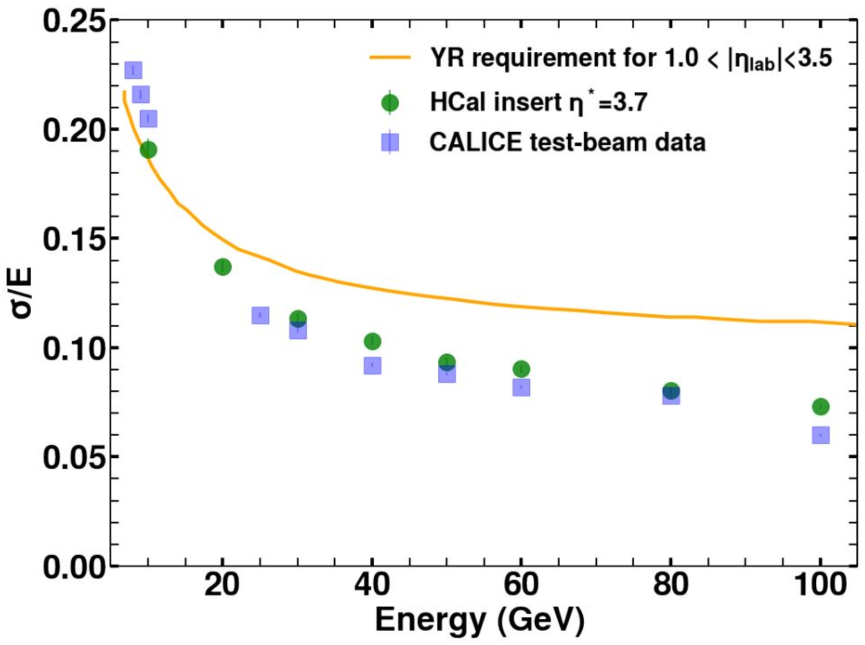
Yields 5D shower info for sophisticated reconstruction algorithms (AI)

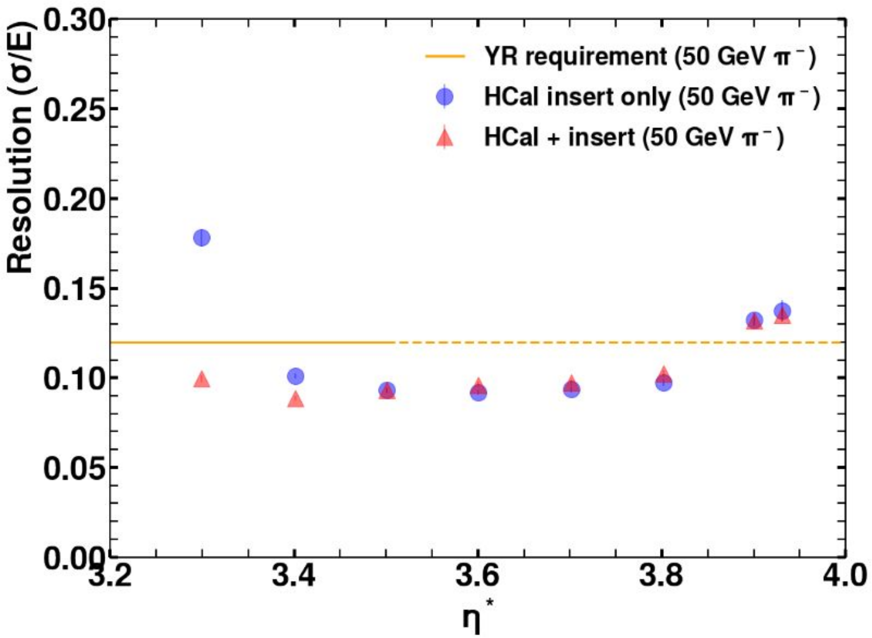
Linear, compensated response (e/h~1)



Energy resolution (with basic reconstruction algorithm)

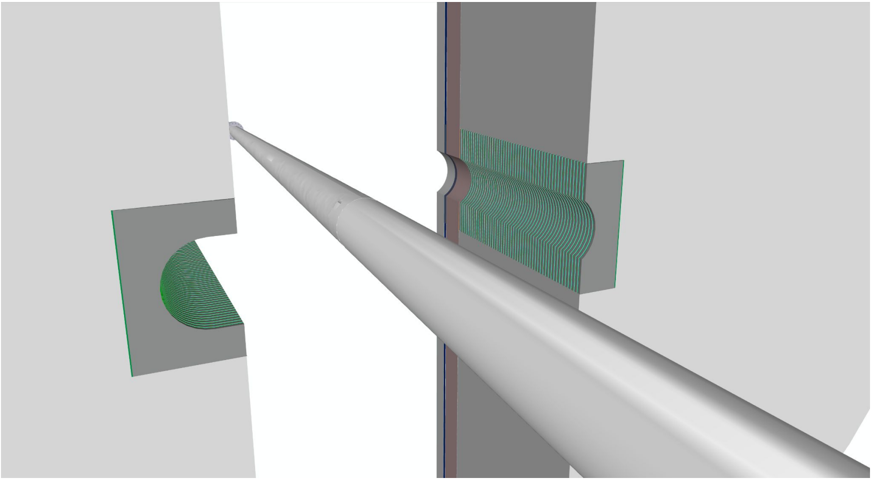
(assuming 25 W layers, 30 Fe layers)





- Performance meets YR requirements. Extends acceptance to true limit
- Projections validated against CALICE data.

Design will gives us easy access to active layers



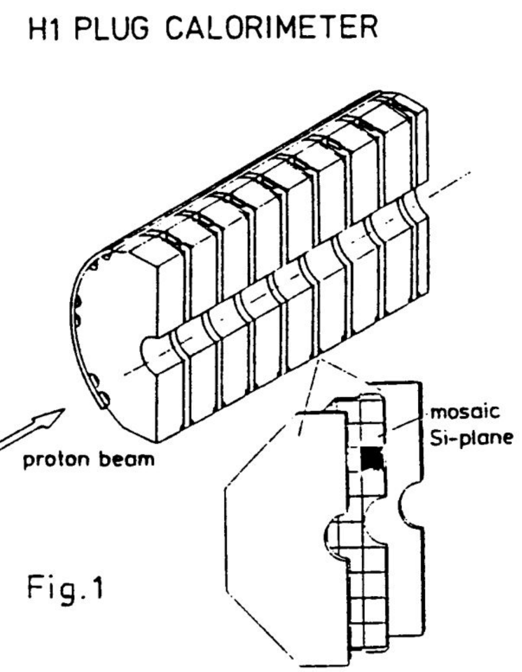
- Can remove active layers and do **annealing** every shutdown to **mitigate radiation damage** and extend lifetime of SiPMs

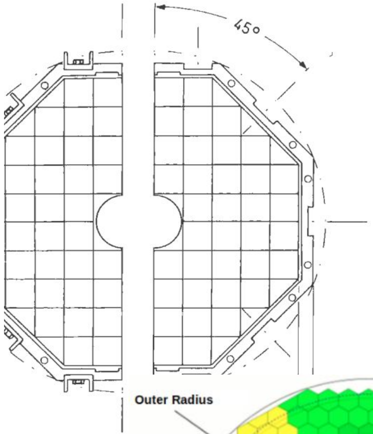
- Straightforward access to active elements maximizes potential for **upgrades**
  e.g. with glass (see Tanja's recently funded R&D and CEPC glass R&D) or timing layer, or dual tile readout, or whatever future holds.

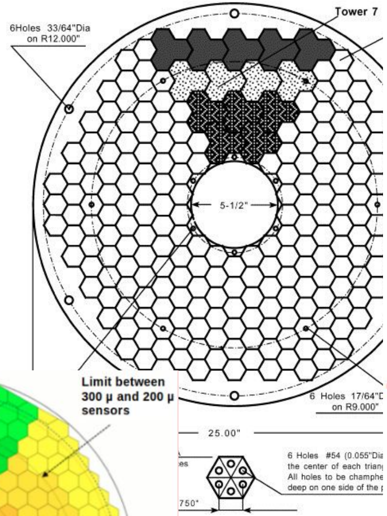
Calorimeter Inserts were deployed @HERA, Tevatron, LHC, and are planned for LHeC, ILC, CLIC, etc.

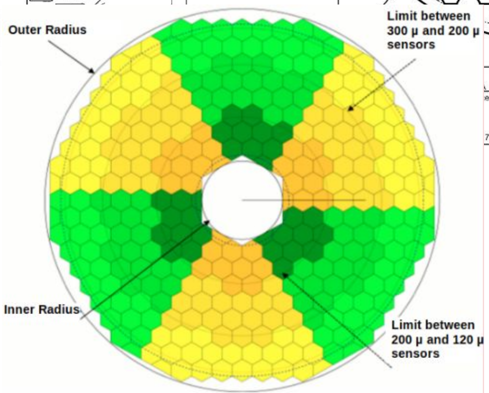
In most cases using different technology, with more granular readout.

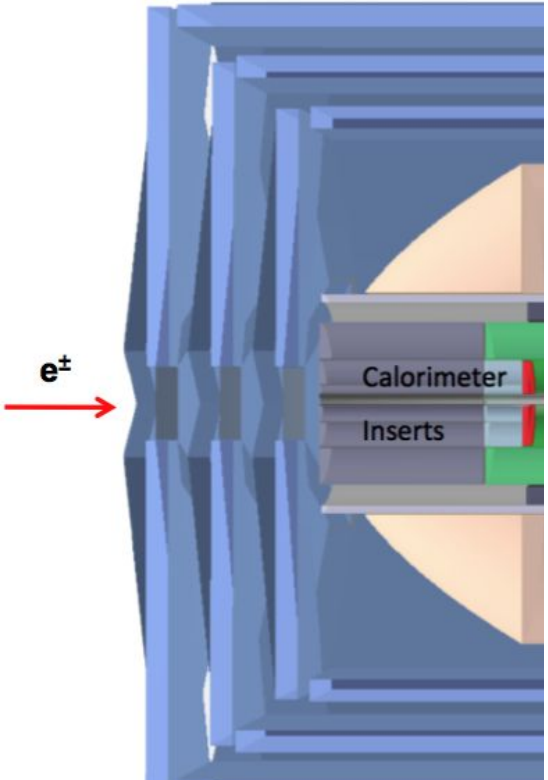
In our case, SiPM-on-tile is an ideal candidate











Cost estimates

Hardware (~50% W, 50% Fe)	k$USD
Absorber plate (W)	325
Absorber plate (Fe)	20
Scintillator plates (EJ-212)	50
SiPMs (14160-3015PS)	35
LED monitoring system	10
Supplies	10
Electronics (4k channels)	
Digitizers (HGROC)	50
Patch panels/LV	160
Total hardware + electronics:	**660**

*All info either from direct quote, or from info from ATHENA proposal
** Adapted digitizers based on most-recent estimate for HGROC

Quotation

Quote To: Miguel Arratia
University of California, Riverside
Riverside, CA 92521
United States

Quote Number:	22048			**Contact:**	
Quote Date:	10/25/2022	**Expires:**	11/24/2022	**Inquiry:**	
Customer:	UCR			**Terms:**	25% due at order placement
Salesman:	In House Sales			**Phone:**	310-825-3124
Ship Via:	United Parcel Service			**FAX:**	

Estimated lead time for all 100: 16 weeks

Quote is for Manufacturing only. Freight charges to be invoiced to customer at time of shipment.

Pricing is subject to change based on timing of order and price of raw material at time of order.

Item	Part Number / Description	Revision	Quantity	Price
1	UCR PRELIM PLATE Plate, A36 Steel, .625 x 23.523 x 11.811, holes on two ends, semi-circle cutout		100	$415.000 /EA
			Total:	***$41,500.00***

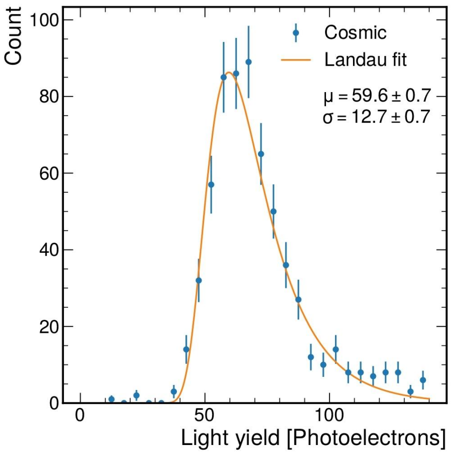
Notes & Instructions

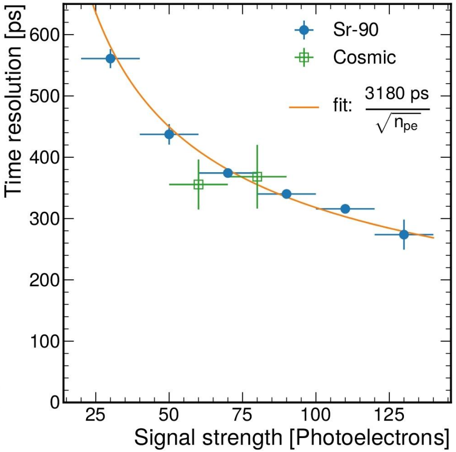
TUNGSTEN HEAVY ALLOY - ASTM B777 CLASS 1 - ET90
0.602" X 11.65" X 23.52" - CUT TO SHAPE WITH MACHINED HOLES PER SKETCH.
NO DRAWING NUMBER OR TITLE ON SKETCH
****
BUDGETARY QUOTE

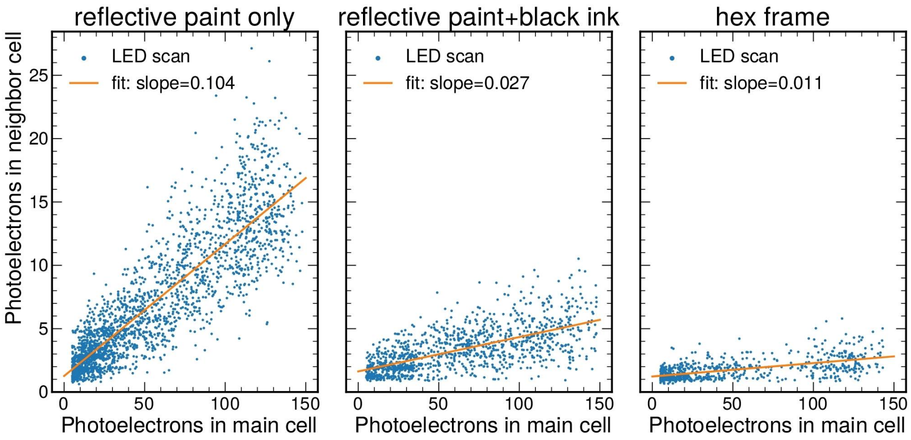
Line	Qty	UM	Elmet Part#	Description	Price
001	100.0000	EA	ETOFAB-1	FPWHA-0.602" PER SKETCH	$7,500.0000
				Total for Quote	

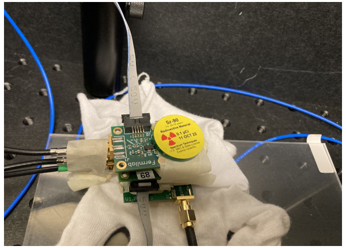
Light yield, time resolution, optical cross-talk

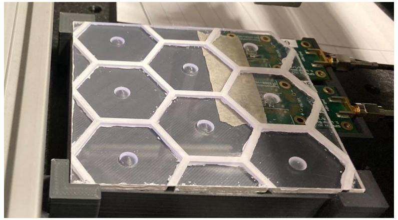
measured with cosmics & Sr-90, and LED

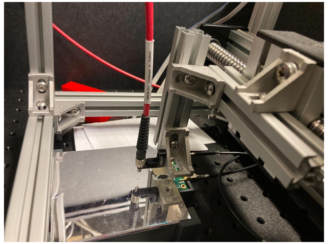




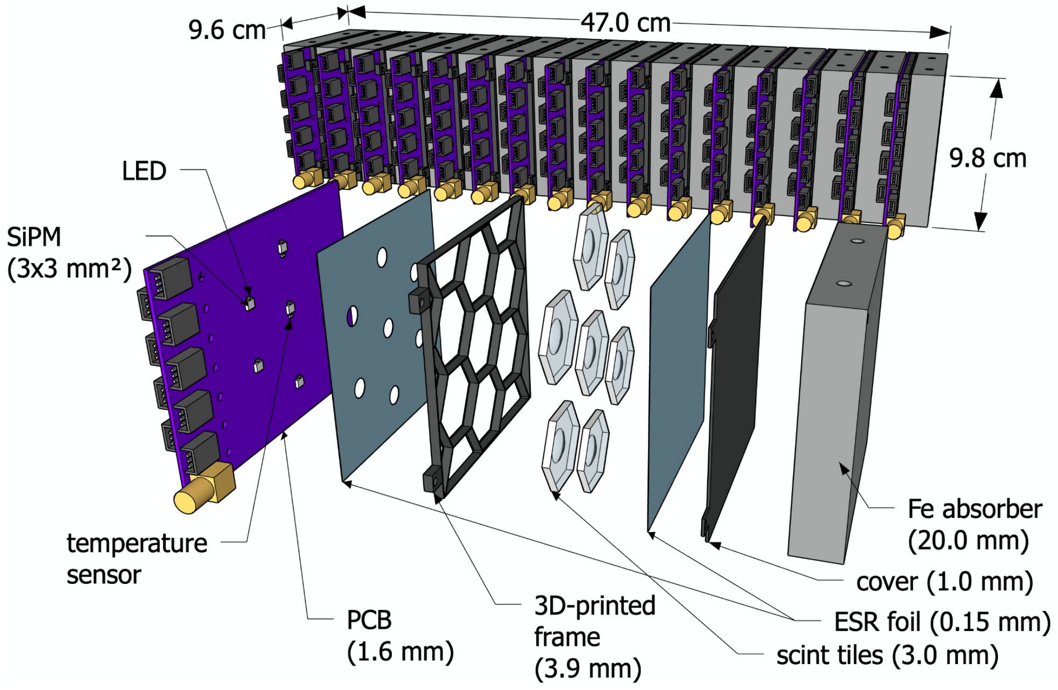






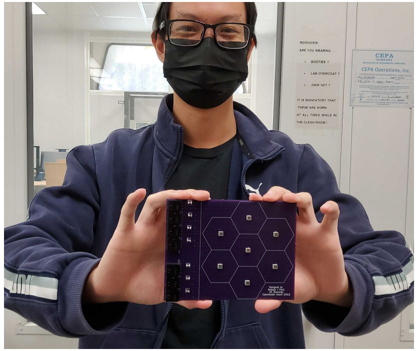


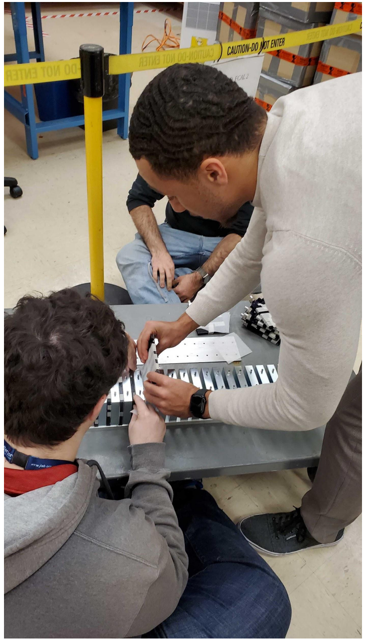
We are starting with a“ECAL-size” prototype



- ~10x10 cm2, 18 X0 depth and 128 channels.
- Have all the materials at hand, including SiPMs, bias & readout, EJ-212, etc.
- Plan to test at JLab, FNAL & RHIC
- Also plan radiation test at Berkeley


CALIFORNIA EIC
CONSORTIUM

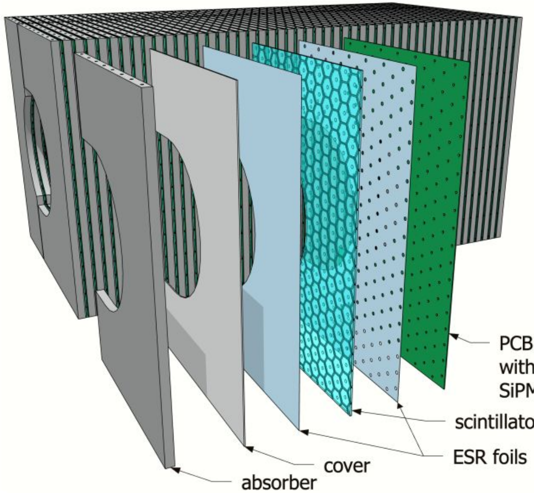



CAUTION-DO NOT ENTER


Quick Installation Guide
CALIFORNIA EIC
CONSORTIUM

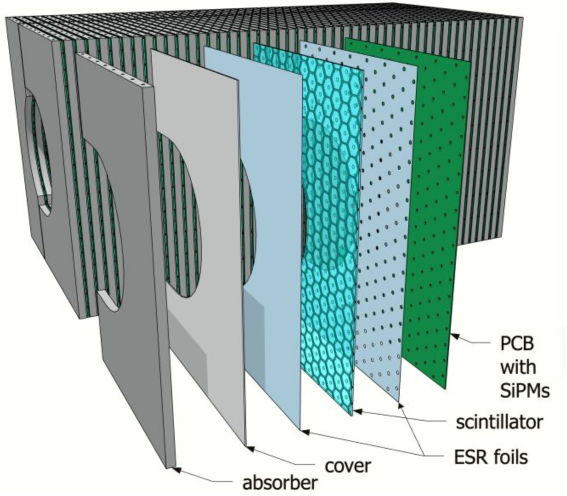
Take home messages

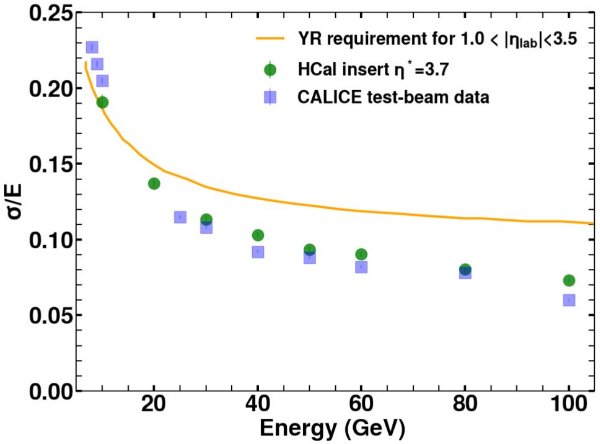
- SiPM-on-tile technology is ideally suited for insert at EIC
  20+ years of R&D, now deploying @ LHC
  → **low risk.**
  Straightforward to build & low-cost raw materials
  → **no significant added cost**
- **Optimal acceptance** pushed to the real limit.
  Crossing-angle issue solved with instrumented support
- Particle-flow calorimeter, with **5D hits (energy, time, 3D)** capabilities ideal for AI.
  Meets YR requirements and more even with rudimentary (non-AI) algorithms.
- **Future-proof design** enables easy maintenance and upgrades, (e.g. with glass tiles)
- **Large team** dedicated to its success.



We have proposed a ***"contribution that impacts the capabilities and success of the experiment in a significant way"***, using a ***"new experimental concept and technology that improves physics capabilities without introducing inappropriate risks"***.

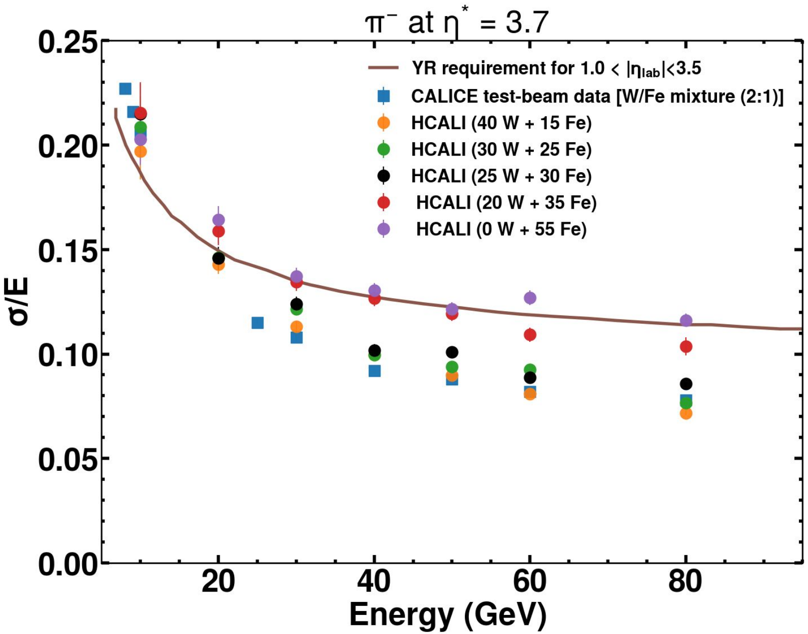
We would like to suggest the collaboration to incorporate the Calorimeter Insert into the baseline design as soon as possible and request the needed engineering studies to go to the next level

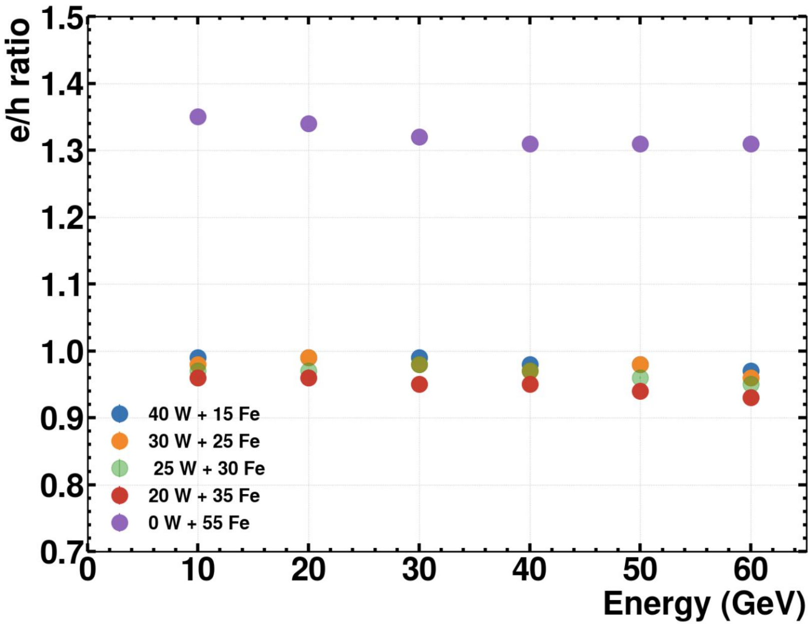




Backup

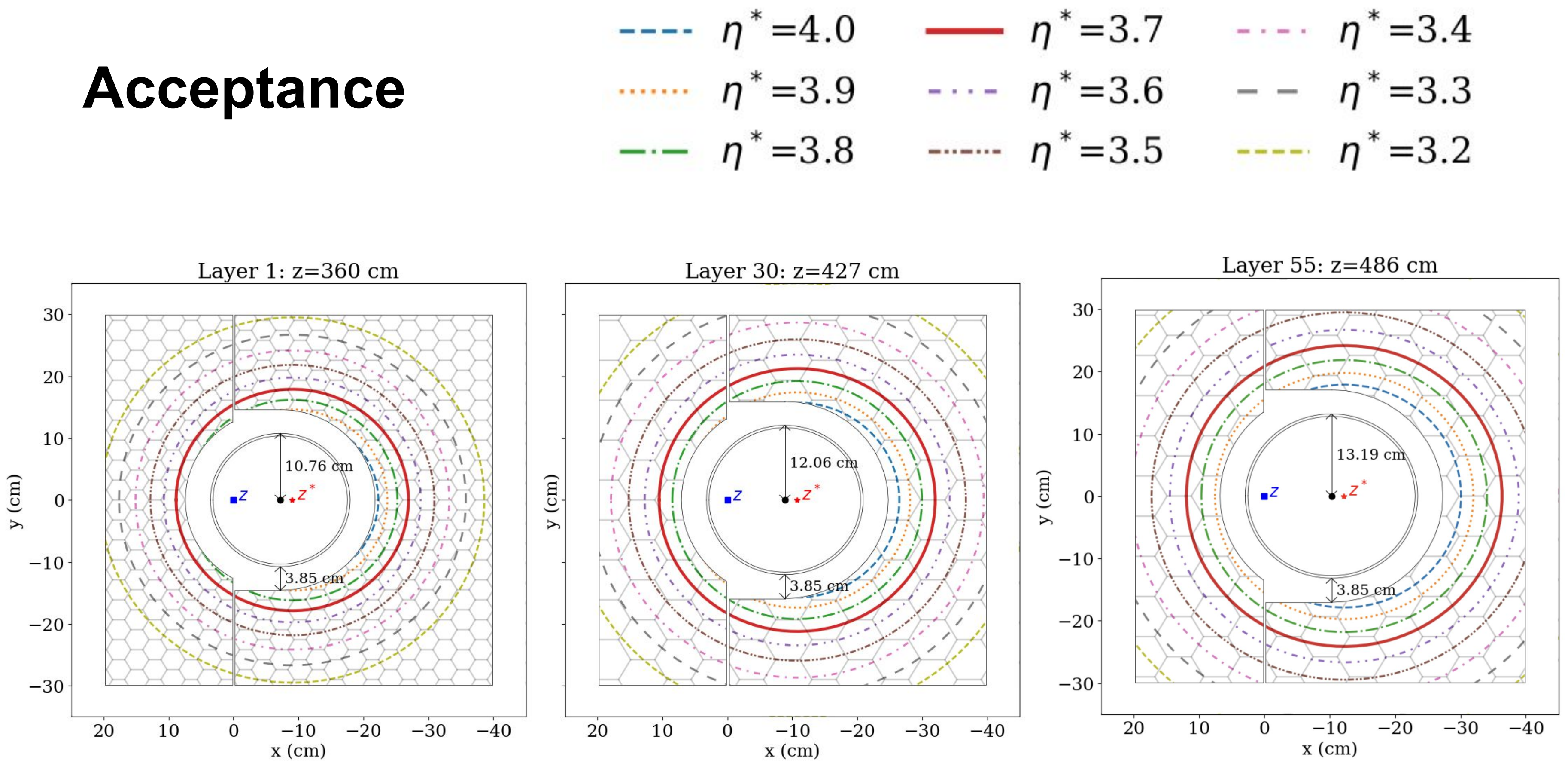
Performance with varying tungsten layers





- Tungsten helps maximize acceptance (reduced leakage of EM-like core of hadronic showers), and yields compensated response
- But if needed, calorimeter insert could work OK even with 0% tungsten

Acceptance



η* =4.0
η* =3.7
η* =3.4
η* =3.9
η* =3.6
η* =3.3
η* =3.8
η* =3.5
η* =3.2
Layer 1: z=360 cm
Layer 30: z=427 cm
Layer 55: z=486 cm
10.76 cm
12.06 cm
13.19 cm
3.85 cm
z
z*
y (cm)
x (cm)
30
20
10
0
−10
−20
−30
−40