Part 1. Progress Report
EIC Sampling Calorimeter Developments

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BeAST detector layout

-3.5<η<3.5: Tracking & e/m Calorimetry (hermetic coverage)

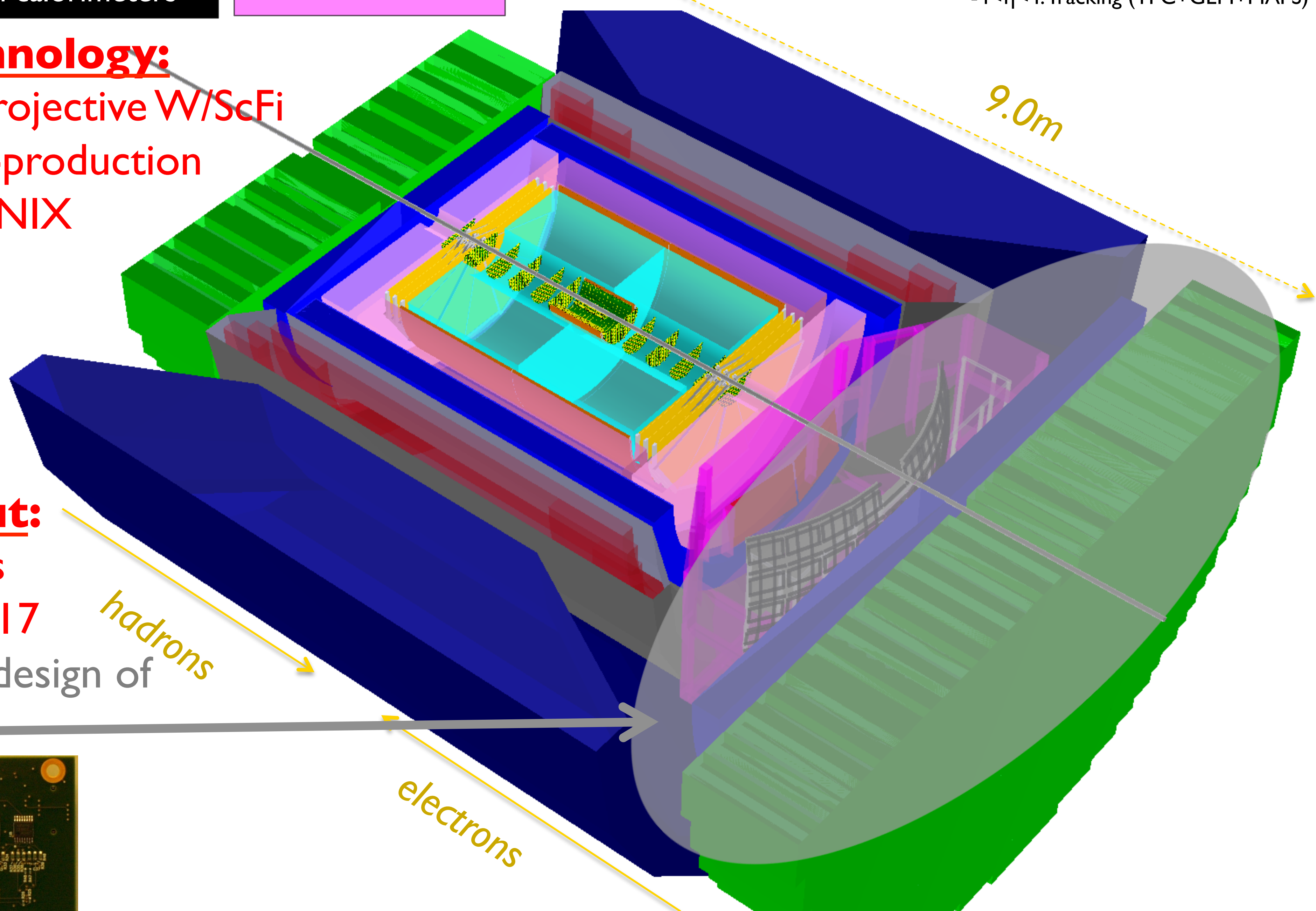
Hadron PID:
- -1<η<1: proximity focusing RICH + TPC: dE/dx
- 1<η<3: Dual-radiator RICH
- -1<η<-3: Aerogel RICH

Lepton -ID
- -3 <η< 3: e/p
- 1<|η|<3: in addition HCal response & γ suppression via tracking
- |η|>3: ECal+Hcal response & γ suppression via tracking

-4<η<4: Tracking (TPC+GEM+MAPS)

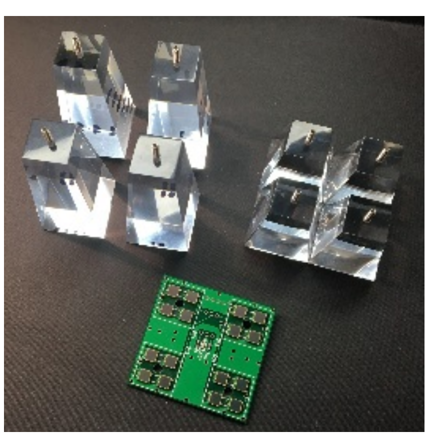
hadronic calorimeters | e/m calorimeters | RICH detectors

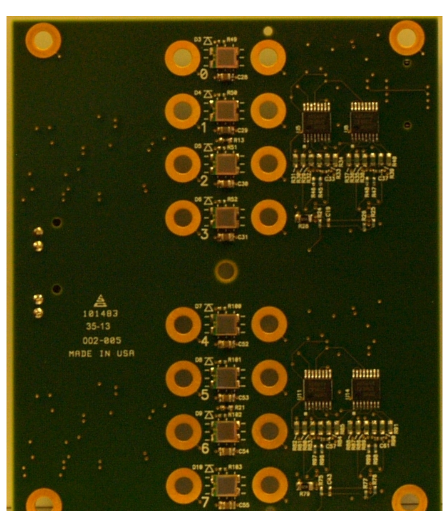
Technology:
2D Projective W/ScFi
Mass-production
sPHENIX



silicon trackers | TPC | GEM trackers | 3T solenoid coils

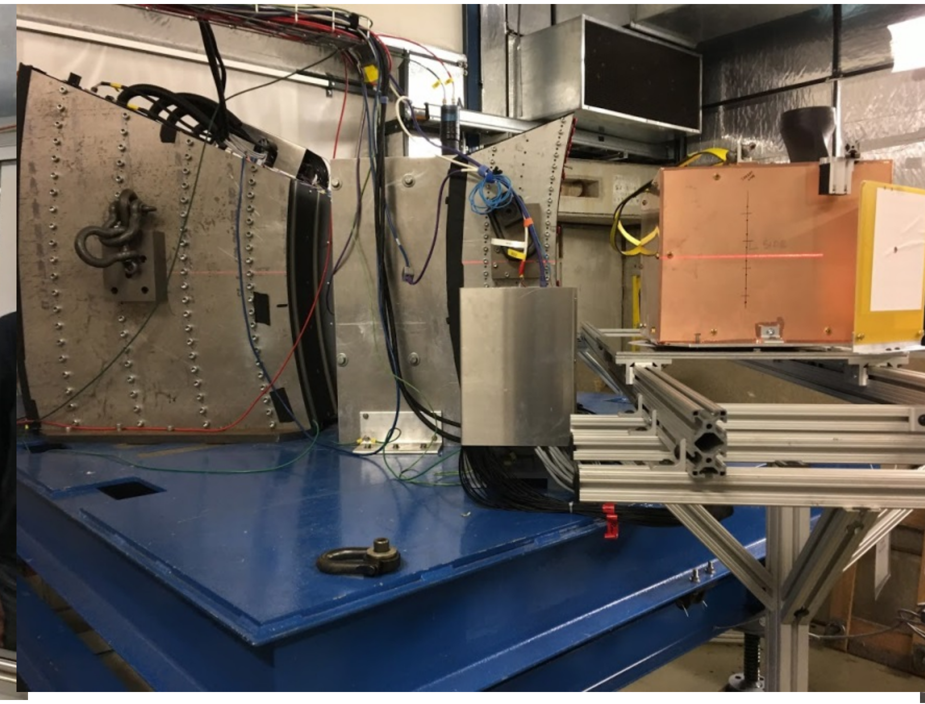
Optimization of Readout:
- Light Collection Schemes
- Radiation Damages, Run 17
- May need to reconsider design of FEMC. Run 17

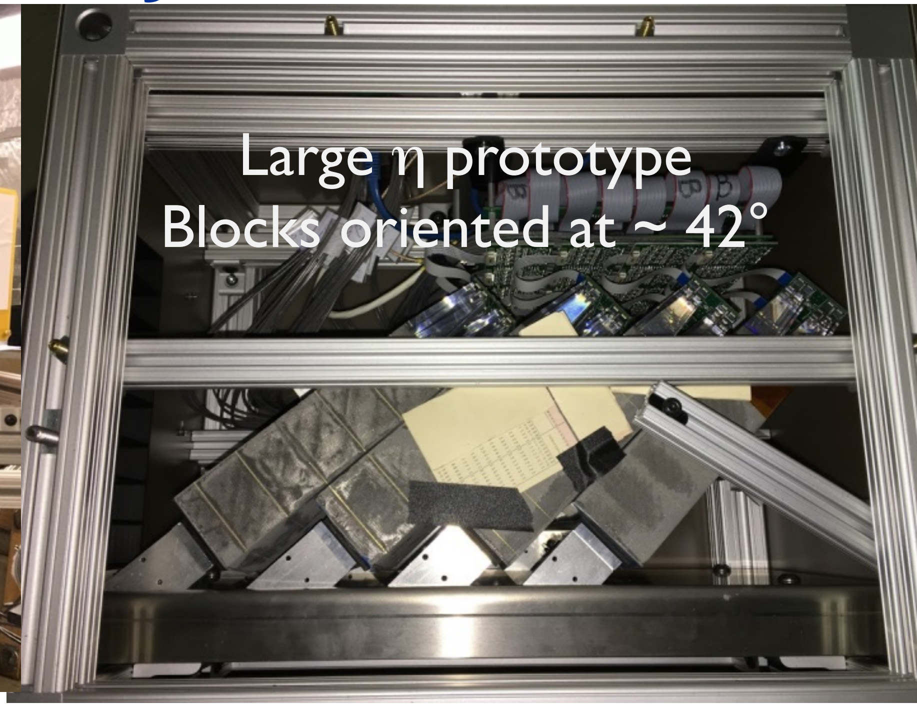


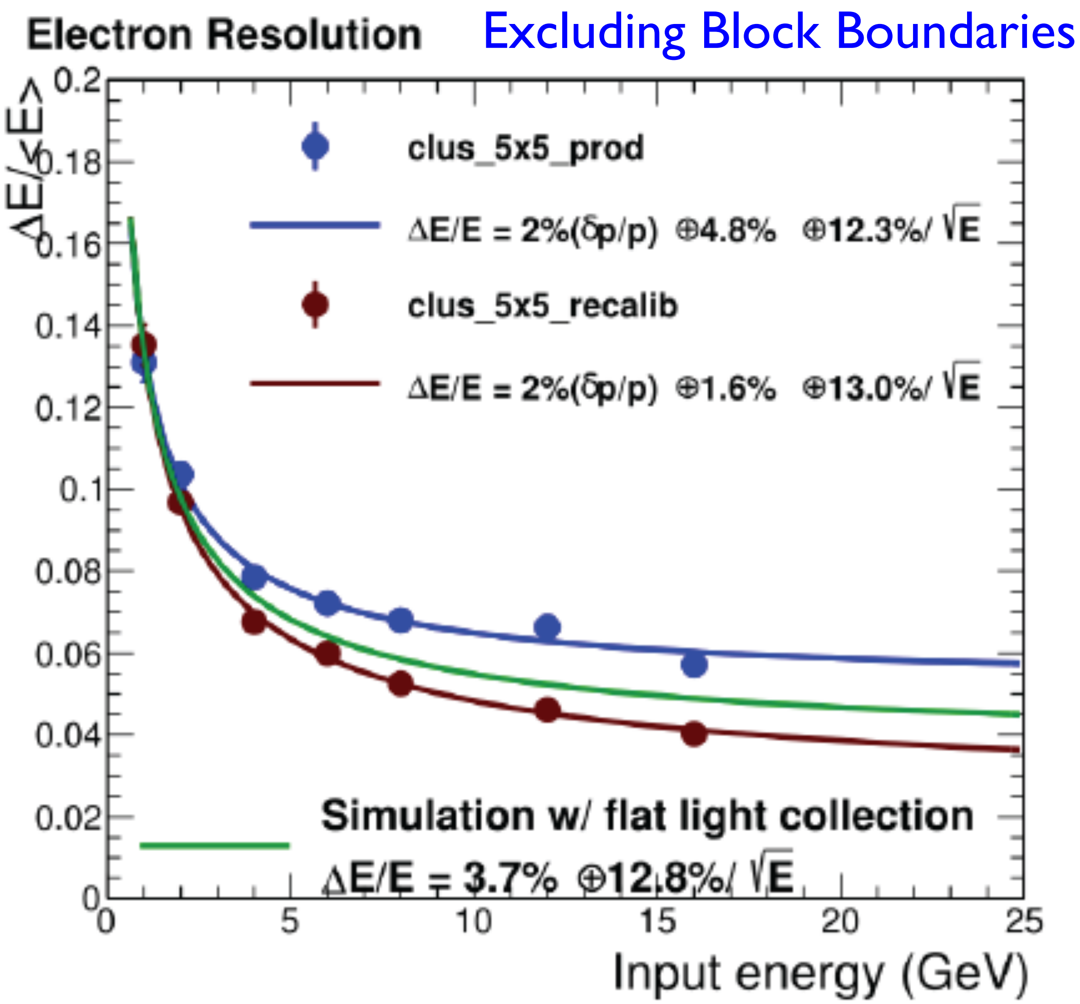


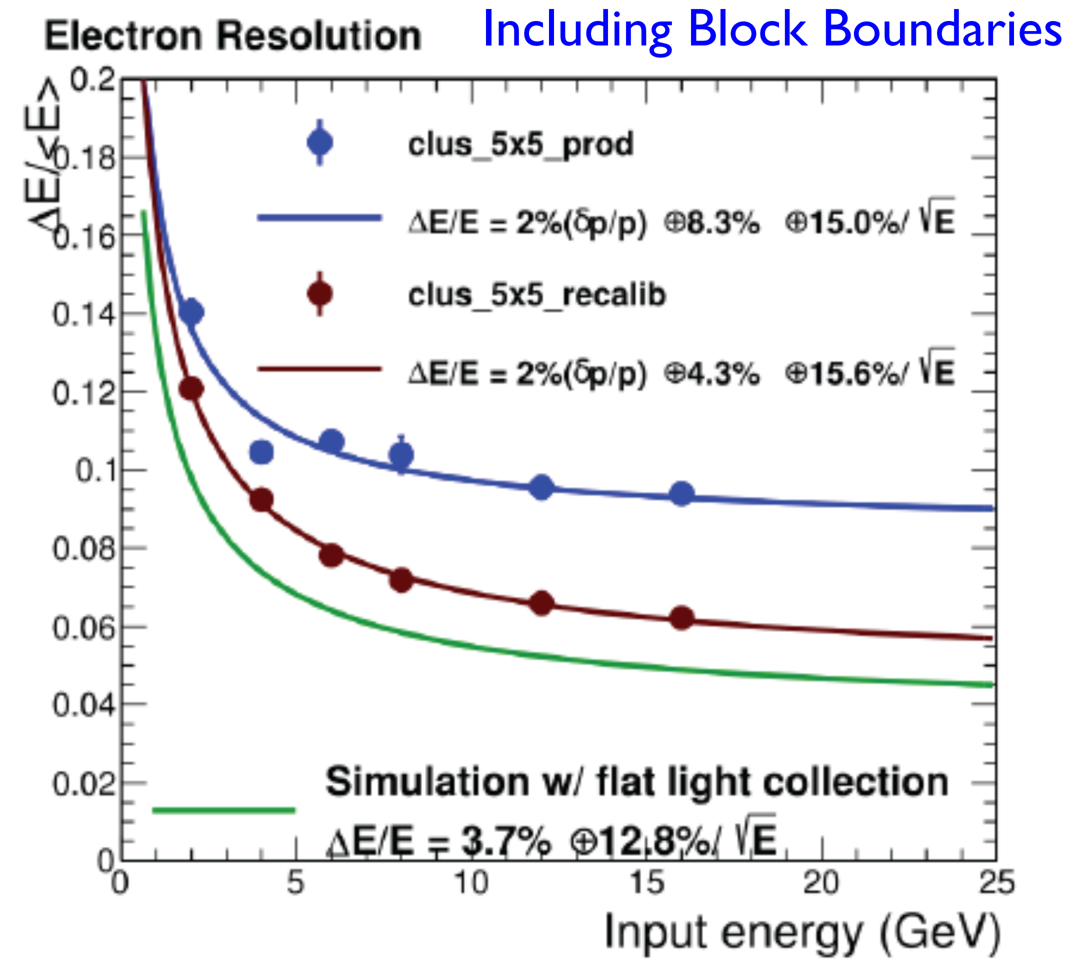
E.C. Aschenauer

sPHENIX Fermilab Test Beam Jan-Feb 2017





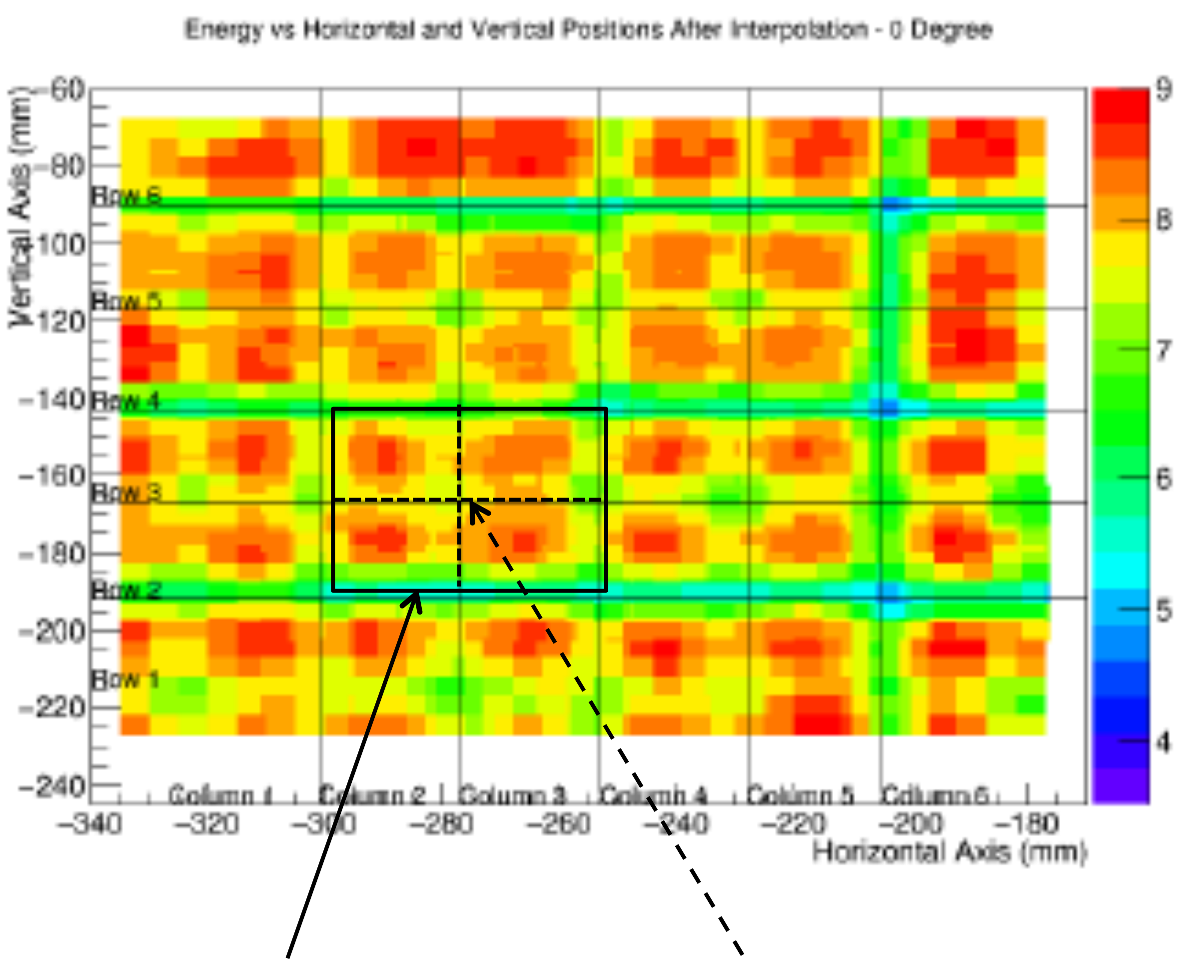




Position Dependence of Energy Response

8 GeV Electrons

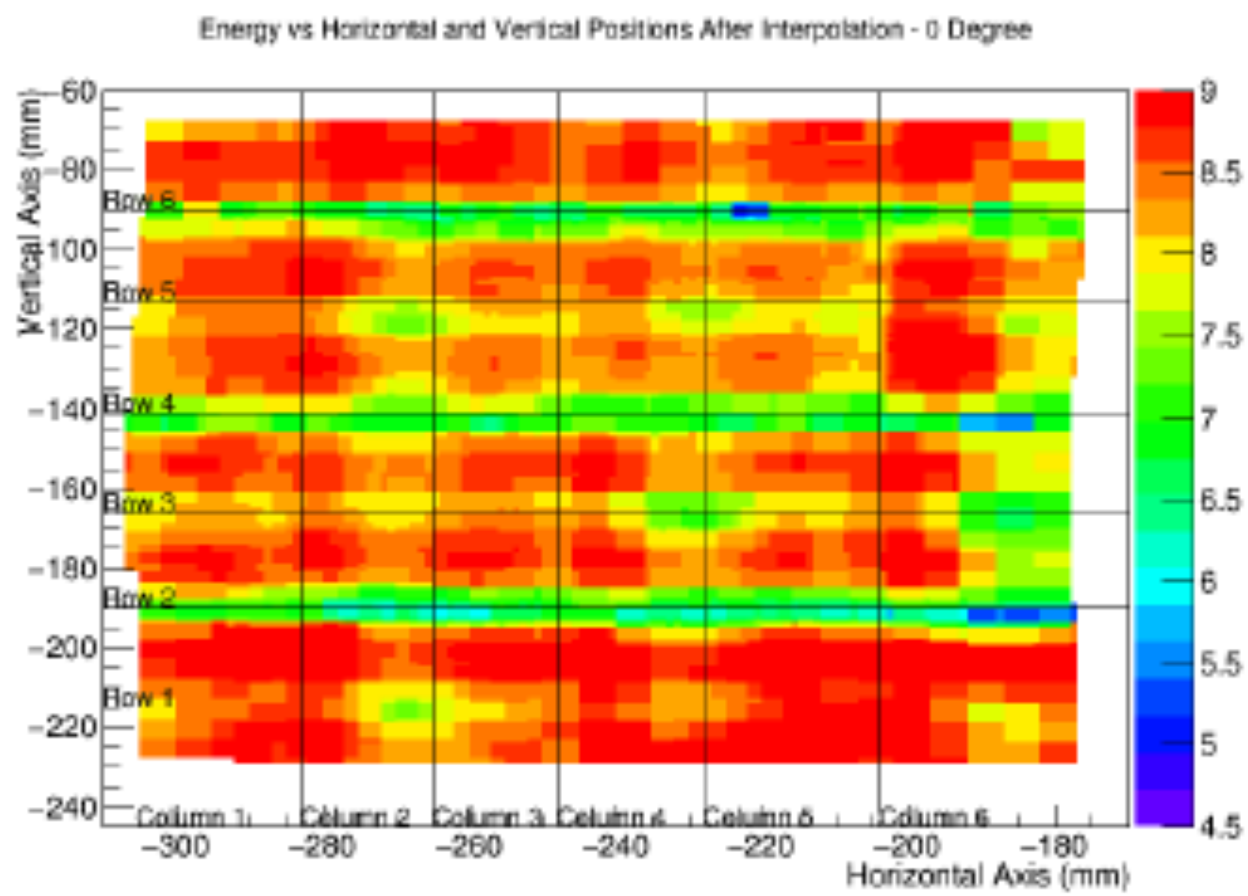
0° Incidence



Block boundary

Light guide boundaries

10° Incidence (horizontal)

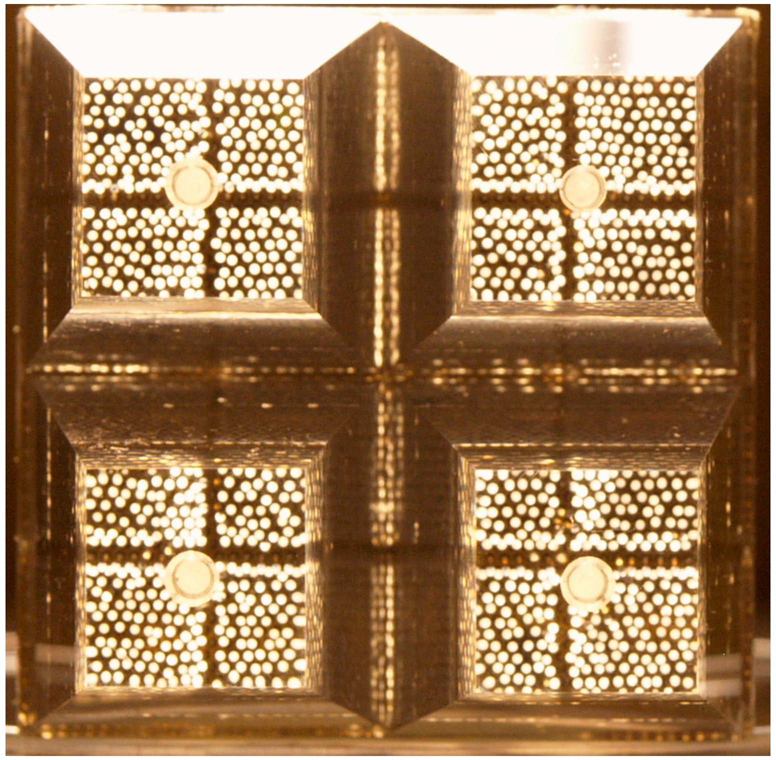


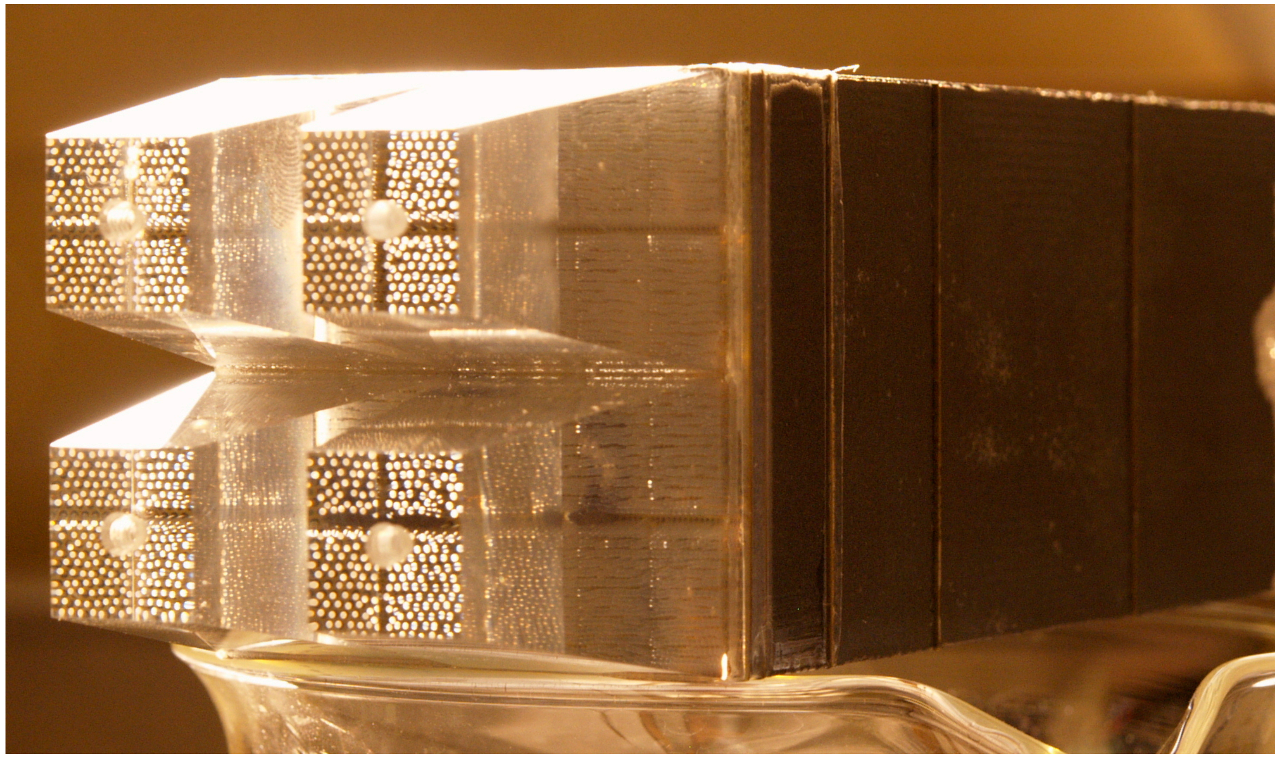
Z.Shi (MIT)

- Reduce imperfections as much as possible.
- Make the blocks slightly non-projective by tilting

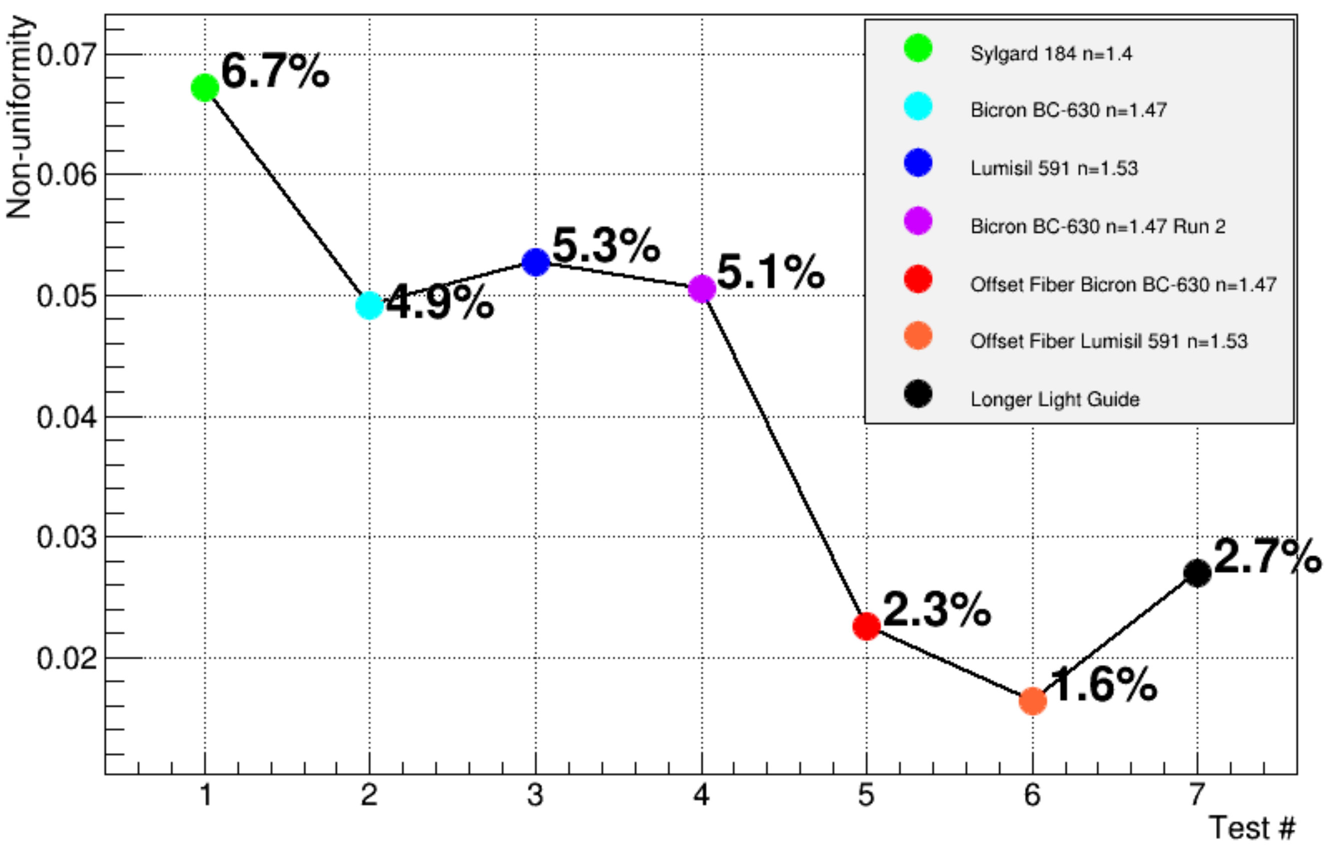
Optimization (geometry, coupling, length of light guides) of light collection:

Compact scheme with 4 SiPMs, which only partially covering output area and **partially mixed light** due to short light guide especially prone to be non-uniform.

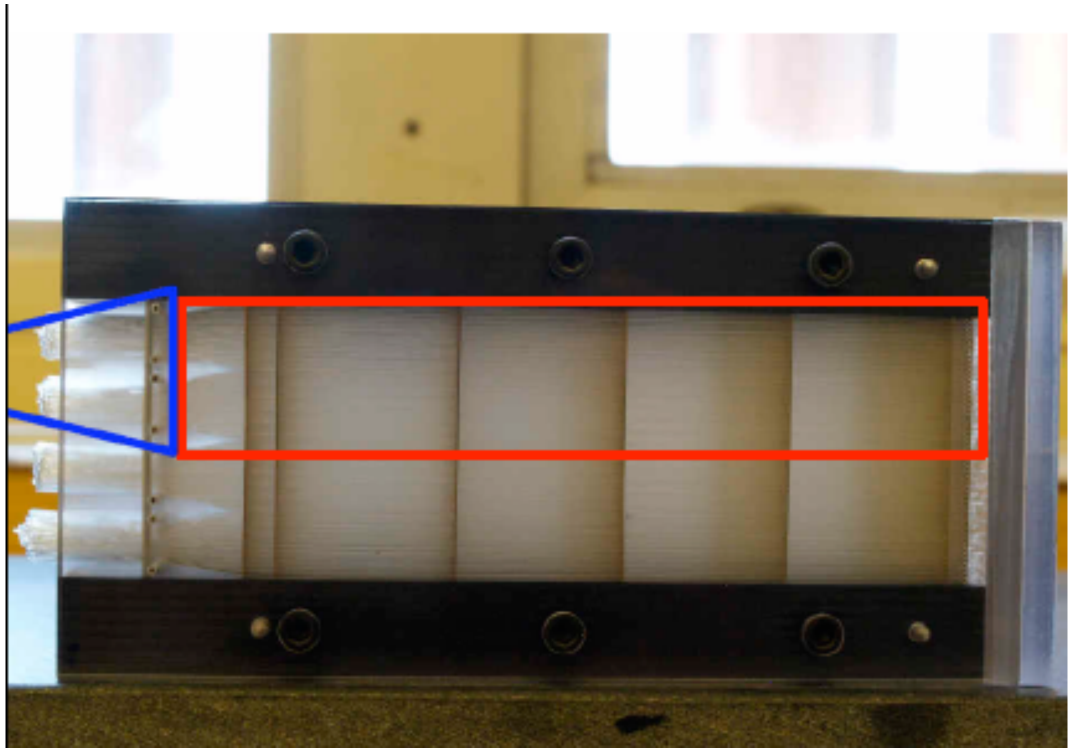




- UV LED Mapping. Uniformity of Light Collection

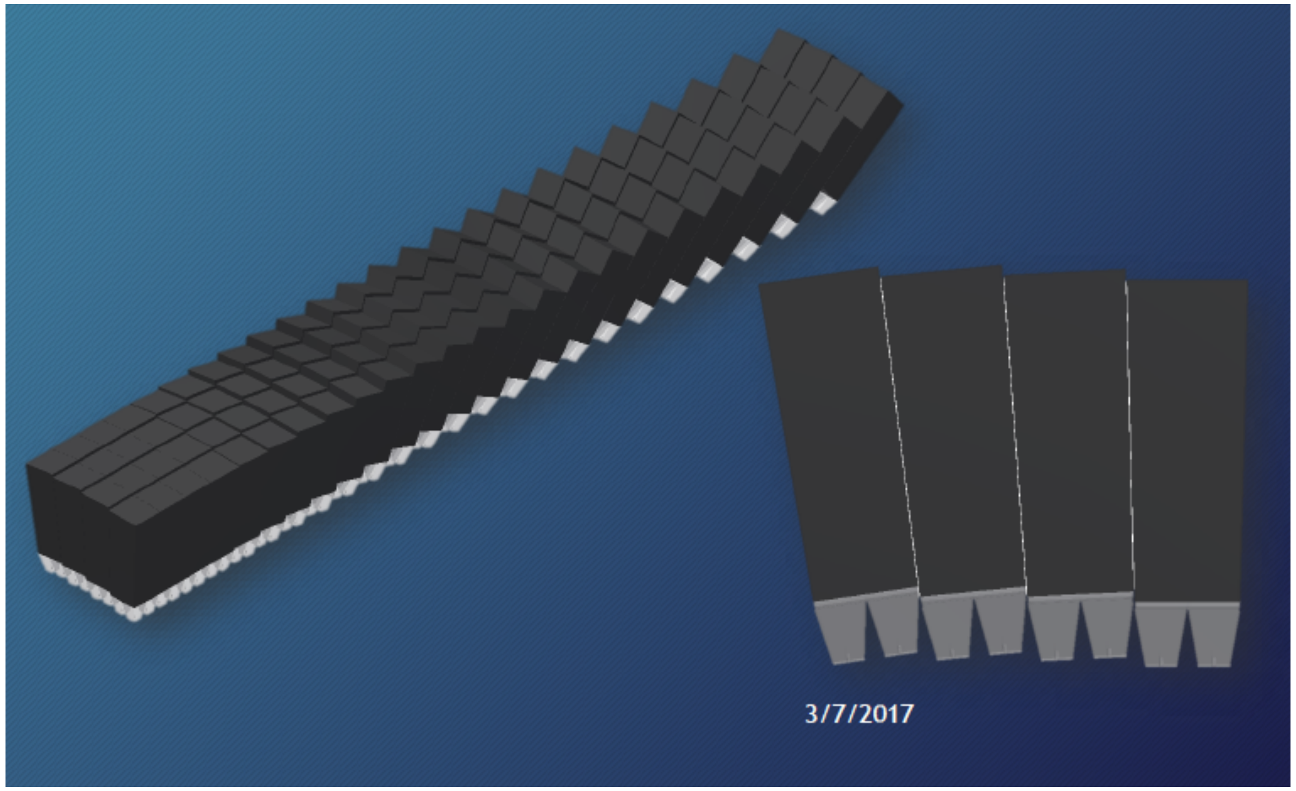


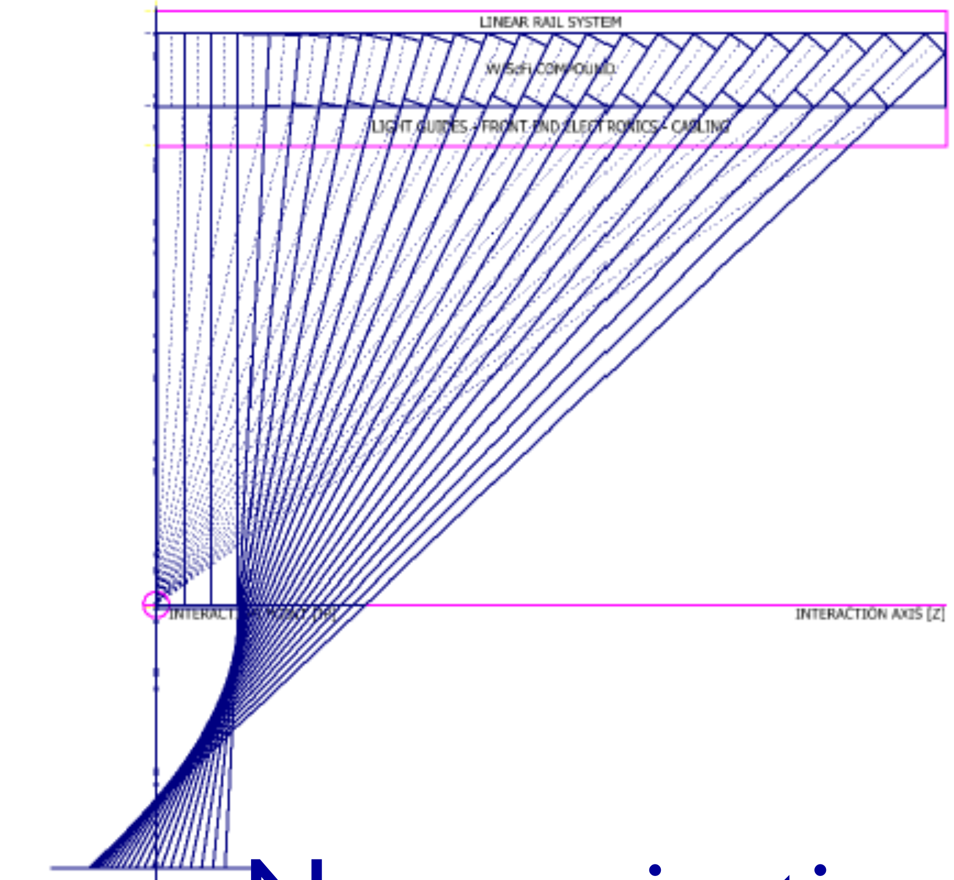
- Fibers bent away from the light guide edges to minimize losses at edges.
- Fibers bent away in the center of the tower to equalize with corners.

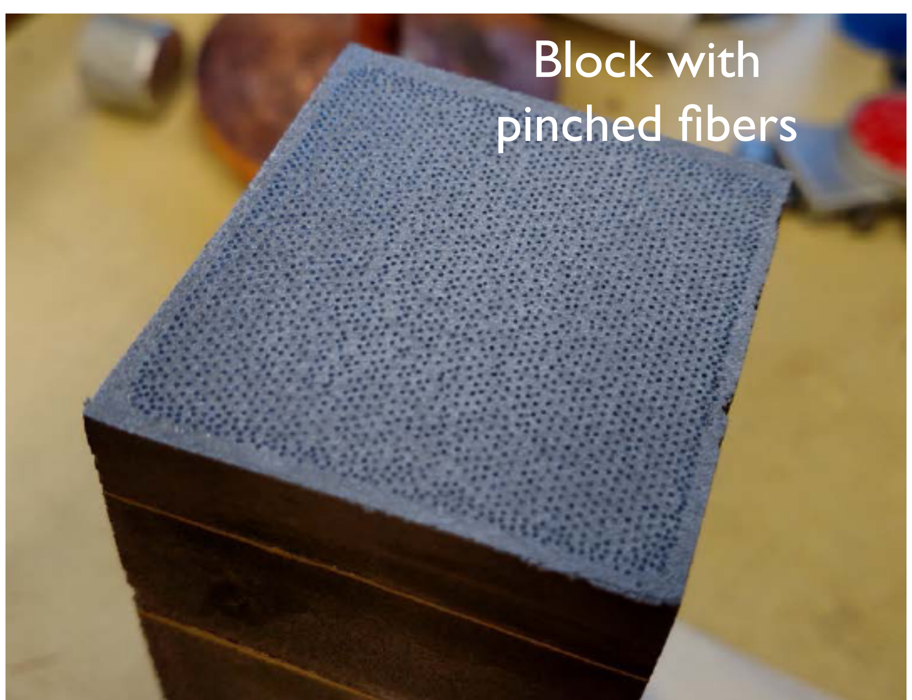


sPHENIX Tilted Sector Design

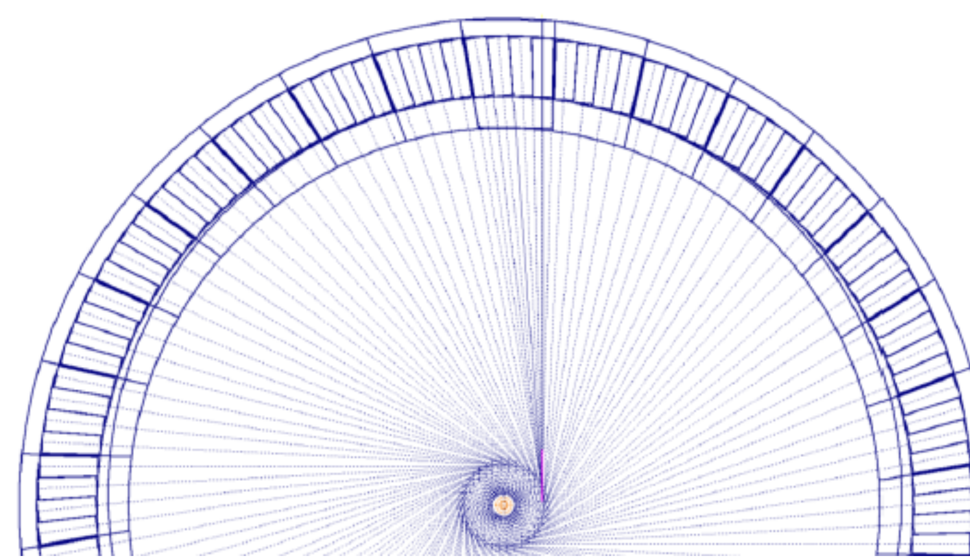
Improved uniformity of light collection, reduced effects of block boundaries.







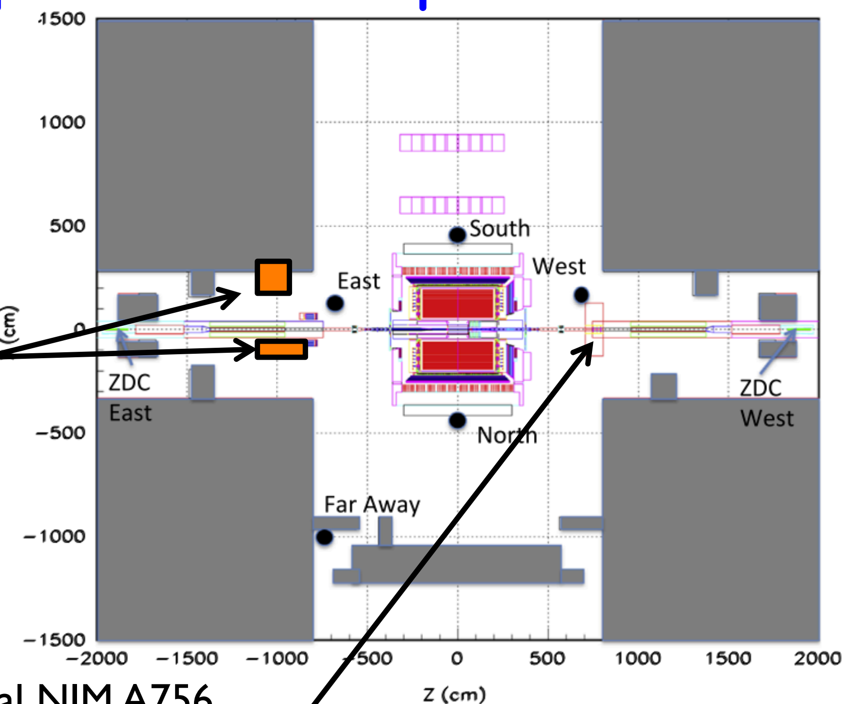
Non-projective in both η and ϕ



SiPMs and APDs in 'realistic' conditions:
Large sample of SiPM exposed in Run17.

- STAR IP ideal test place for EIC.
- Conditions for FEMC in BeAST very close to one we have in STAR now.

EIC R&D 2017

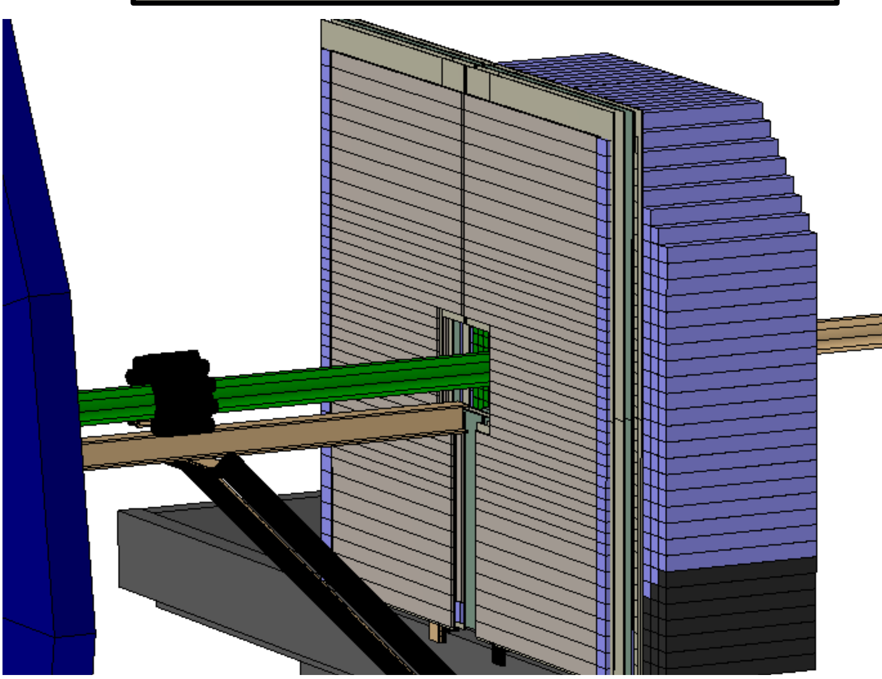


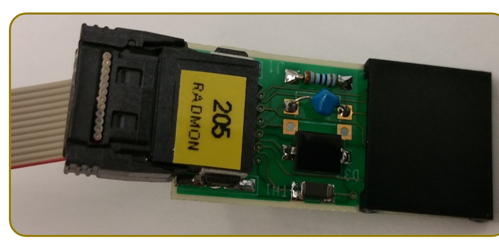
Y.Fisyak, et.al NIM A756

EIC, Run 17 STAR IP:

- 152 SiPM at ~135 cm (since Feb.)
- 26 SiPMs at ~45 cm (since April)
- APDs at ~45 cm, (since April)

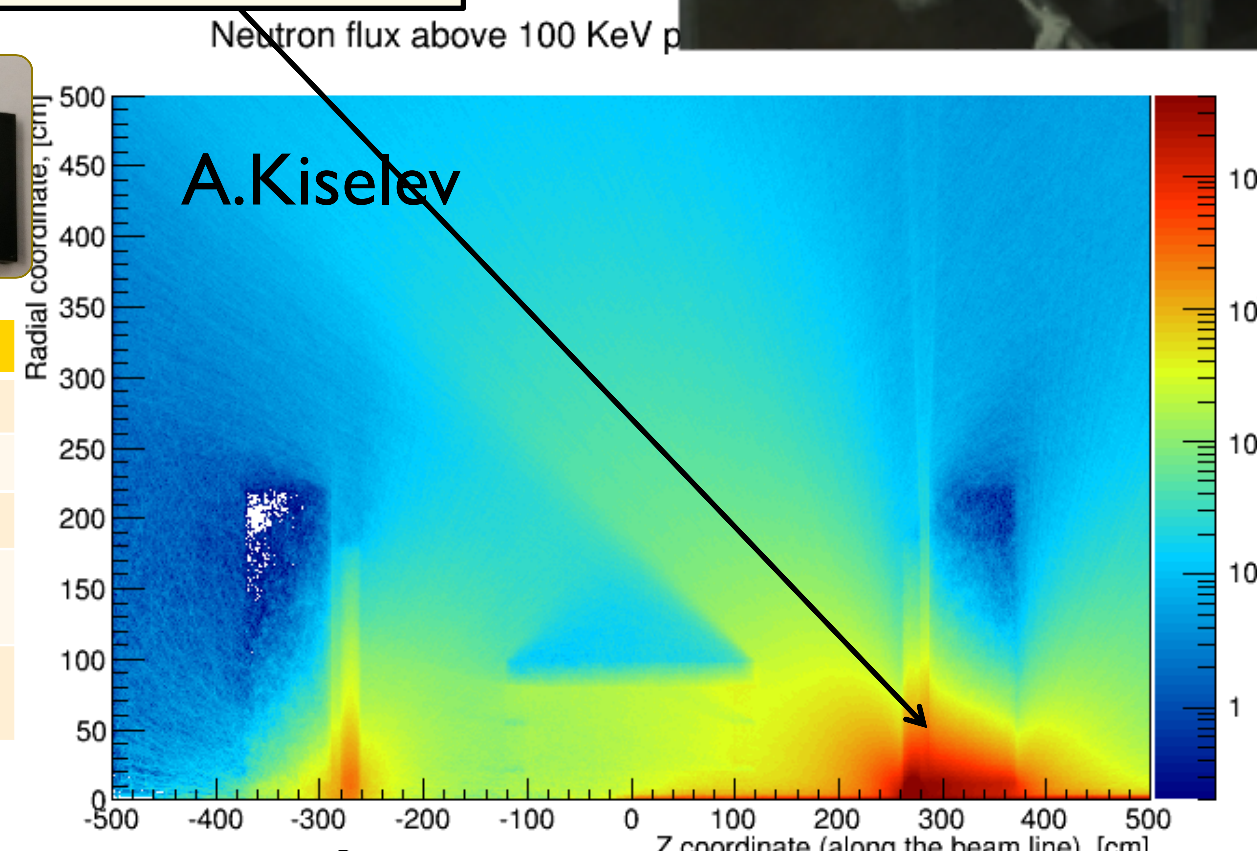
Forward Preshower (FPS)
Forward PostShower (FPOST)





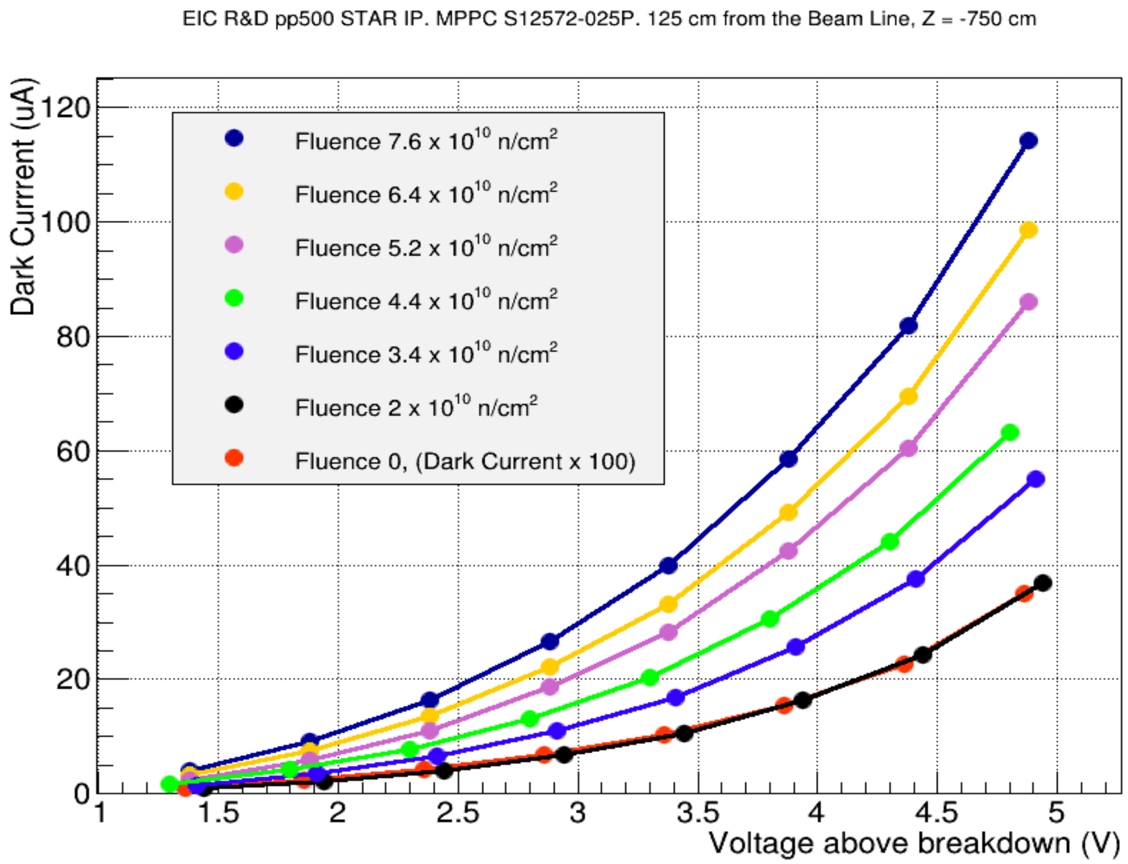
No	Board	Location
1	205	near beam
2	206	FPS layer 2
3	207	FPS layer 3
4	208	FPOST layer 2/3
5	209	FPOST layer 4

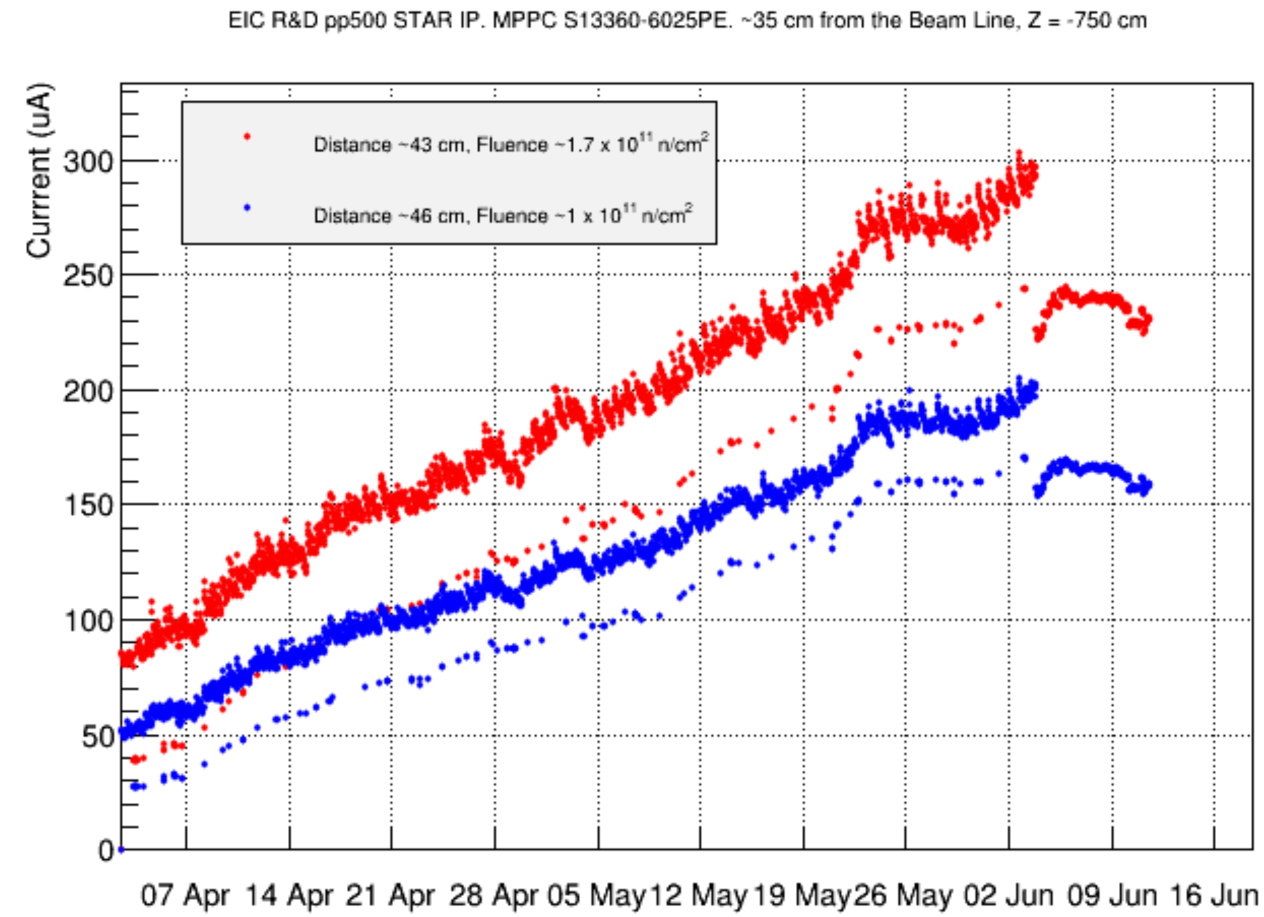
FEMC Run16, Run17

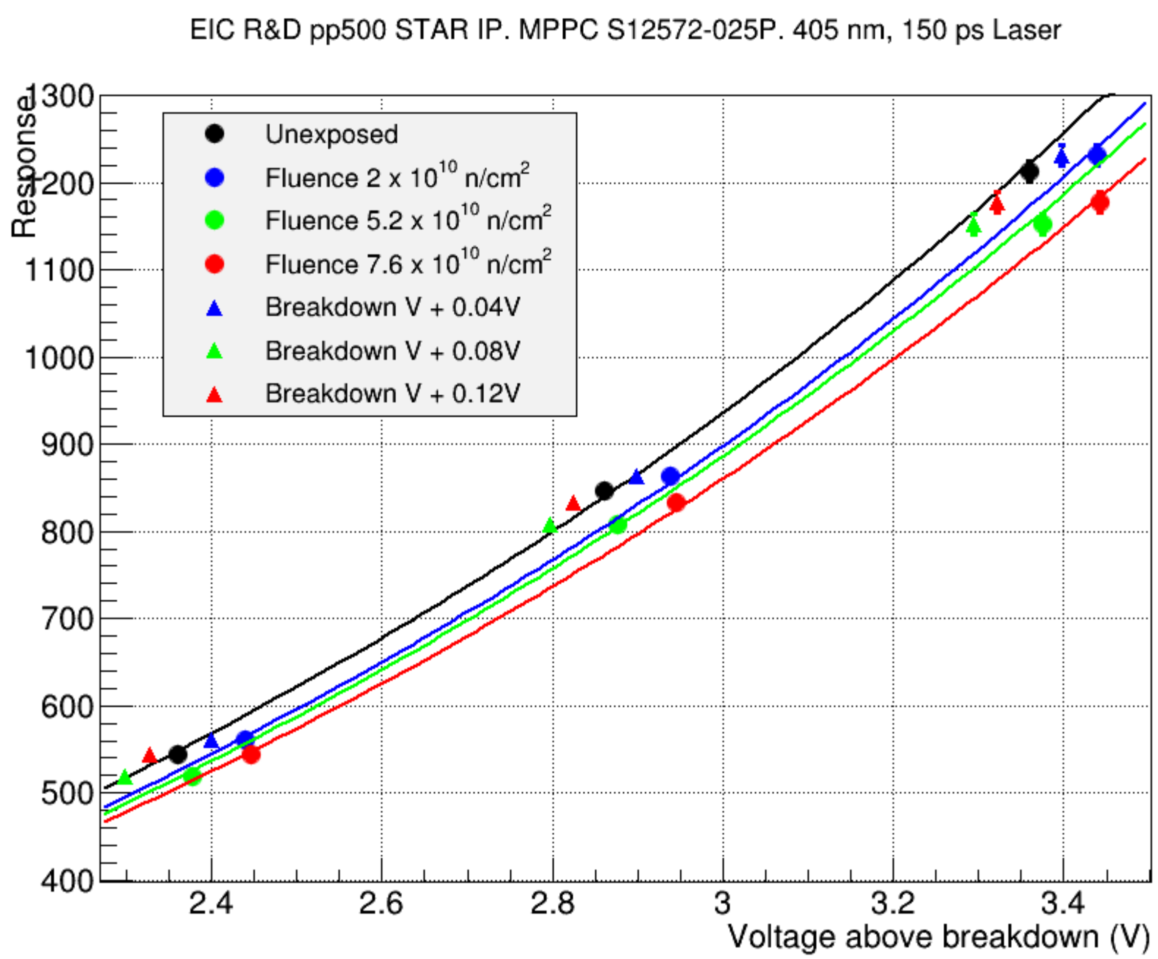


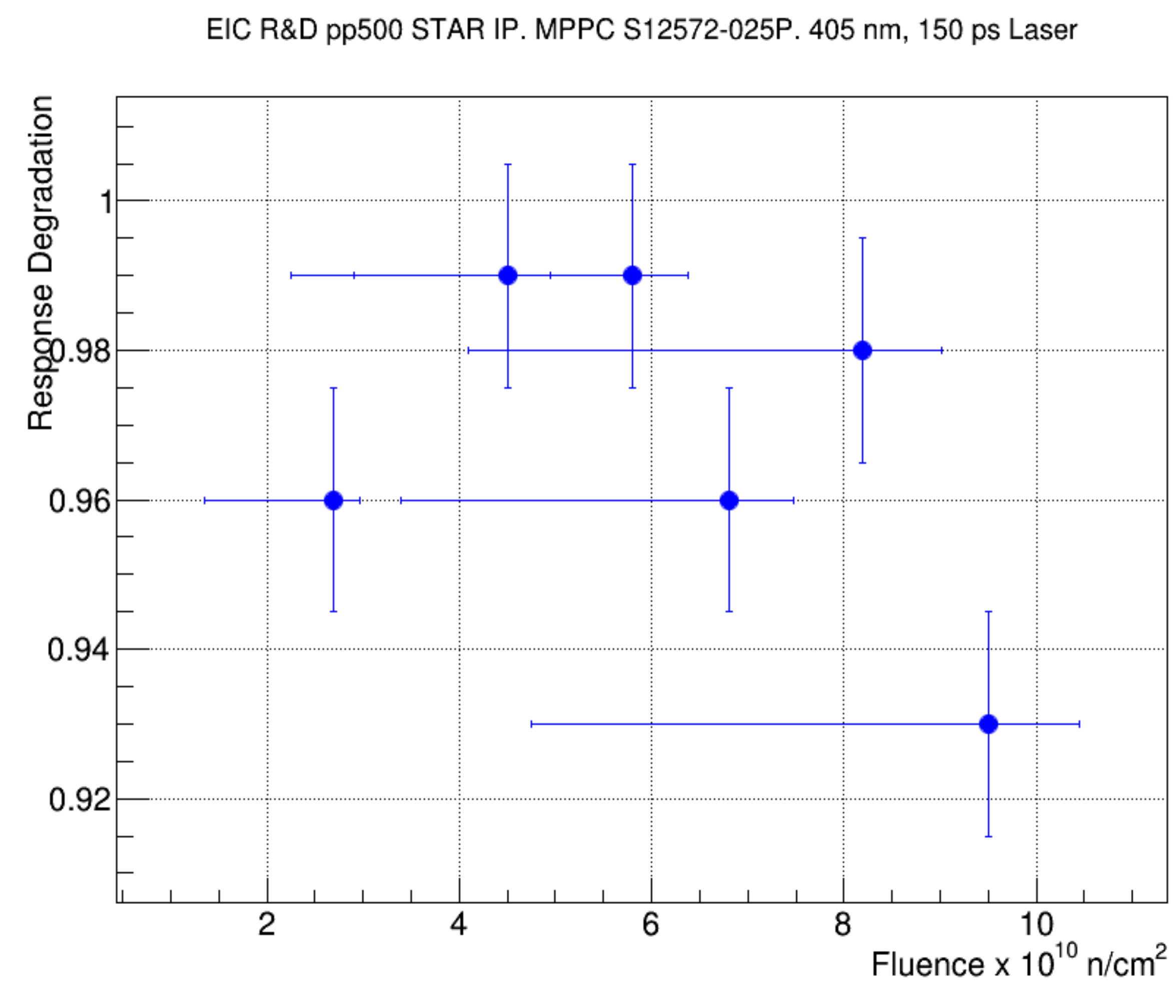
Neutron fluxes at BeAST, ep 20 x 250 GeV

Run 17 data. At a glance, preliminary…







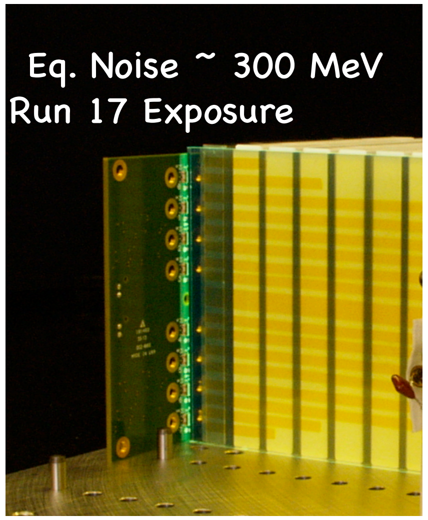


SiPMs , Neutrons, Light Collection Schemes…

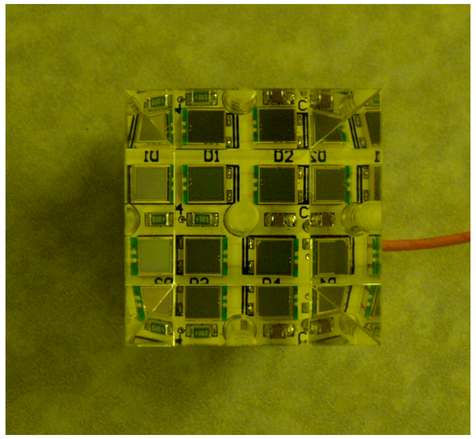
Sensor:
- Small Active Area
- Limited # pixels

Requires:
Multiple Sensors per tower

Calorimeter
- Light Collection Scheme
- Dynamic Range



Neutrons in IP
Degradation of Response
Is It Differential ?



Light perfectly Mixed
- Energy Resolution, term (1/E)
- Loss of Calibration Signals

Light partially Mixed
- Energy Resolution, term (1/E)
- Energy Resolution, constant term ?

- Increase LY
- Focus and Mix Light
- Minimize # sensors

Need to be done for HCAL next. (Work in progress)

- Consider alternative technologies for high n flax areas.
- Consider non Si based sensors for high resolution calorimetry.

Next Steps :

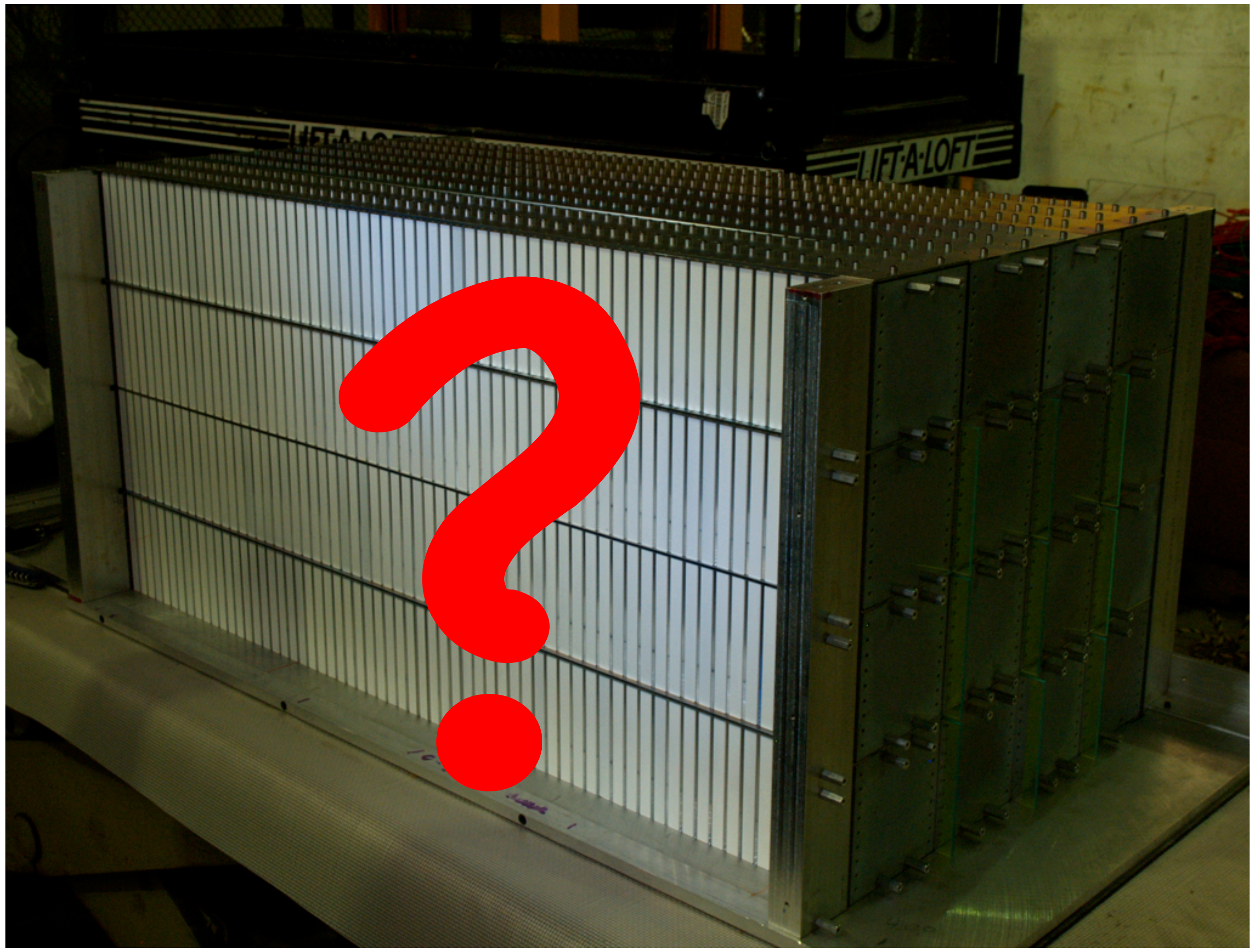
- Is degradation of response is the same for sensors located at the same positions?
- Do we see change in Vb and is it the same for different sensors?
- Is degradation of response depends on the shape of the light pulse?
- Noise as a function of ΔV and gate width, optimal bias V?
- Effect of increased after pulses, trap lifetime and high hit rate case.
- Excess noise factor, by direct comparison of response of HCAL and EMcal to cosmic muons (exposed/unexposed sensors, both SiPMs and APDs).
- T dependence.

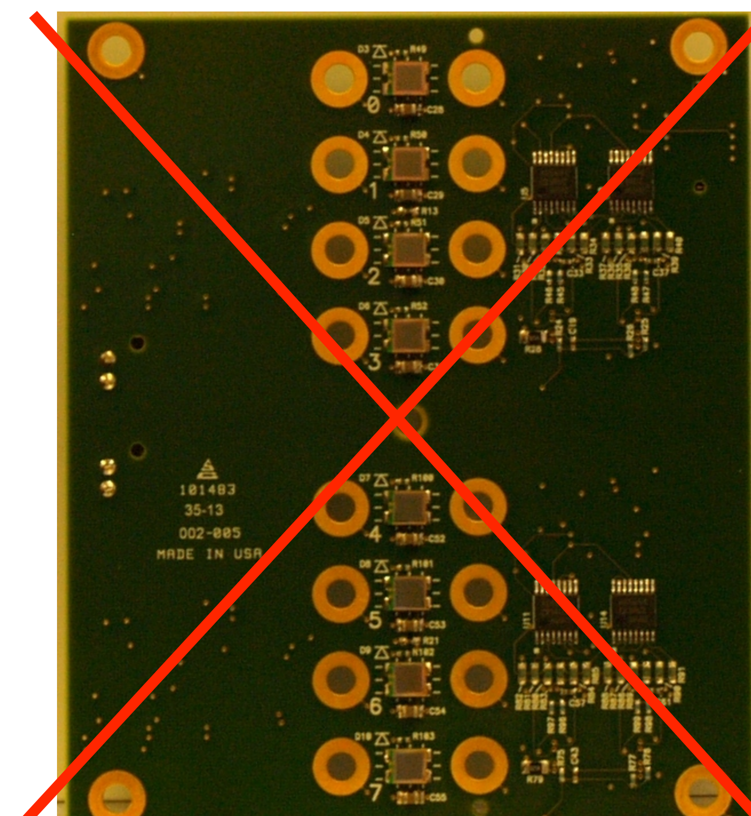
- Prepare two HCAL towers with optimized light collection scheme with dual readout for Run 18.
- Expose new HPK SiPMs during Run 18.

- sPHENIX, Tilted Sector FNAL Test Run.

- MC HCal optimization.
- MC Neutrons.
- MC Machine background.
- IP design, subsystem integration envelopes.

Consequences ?





- Preliminary results from Run17 at STAR IP, we see about 10^{11} n/cm^2 (eta ~3.75) with small prototypes.
- With 2014 readout -> MIP is lost (calibration, primary tool to track stability). Trivial readout will not work.
- Switching from Pb to Fe (reduce neutron flux), relaxing energy resolution for HCAL.
- Switching from SiPMs to APDs (doubling # readout ch.)

Budget scenario	100%	20% cut	40% cut
Hamamatsu Sensors	$15k	$7k	$0
UCLA Electronics Shop (26% overhead included)	$6.3k	$4.64k	$1.69k
UCLA support for students (26% overhead included)	$15.12k	$15.12k	$15.12k
Travel (26% overhead included)	$12.6k	$12.6k	$12.6k
Total Direct	$42.0k	$30.95k	$21.76
Total	$49.02	$39.36k	$29.41k

Backup Slides.