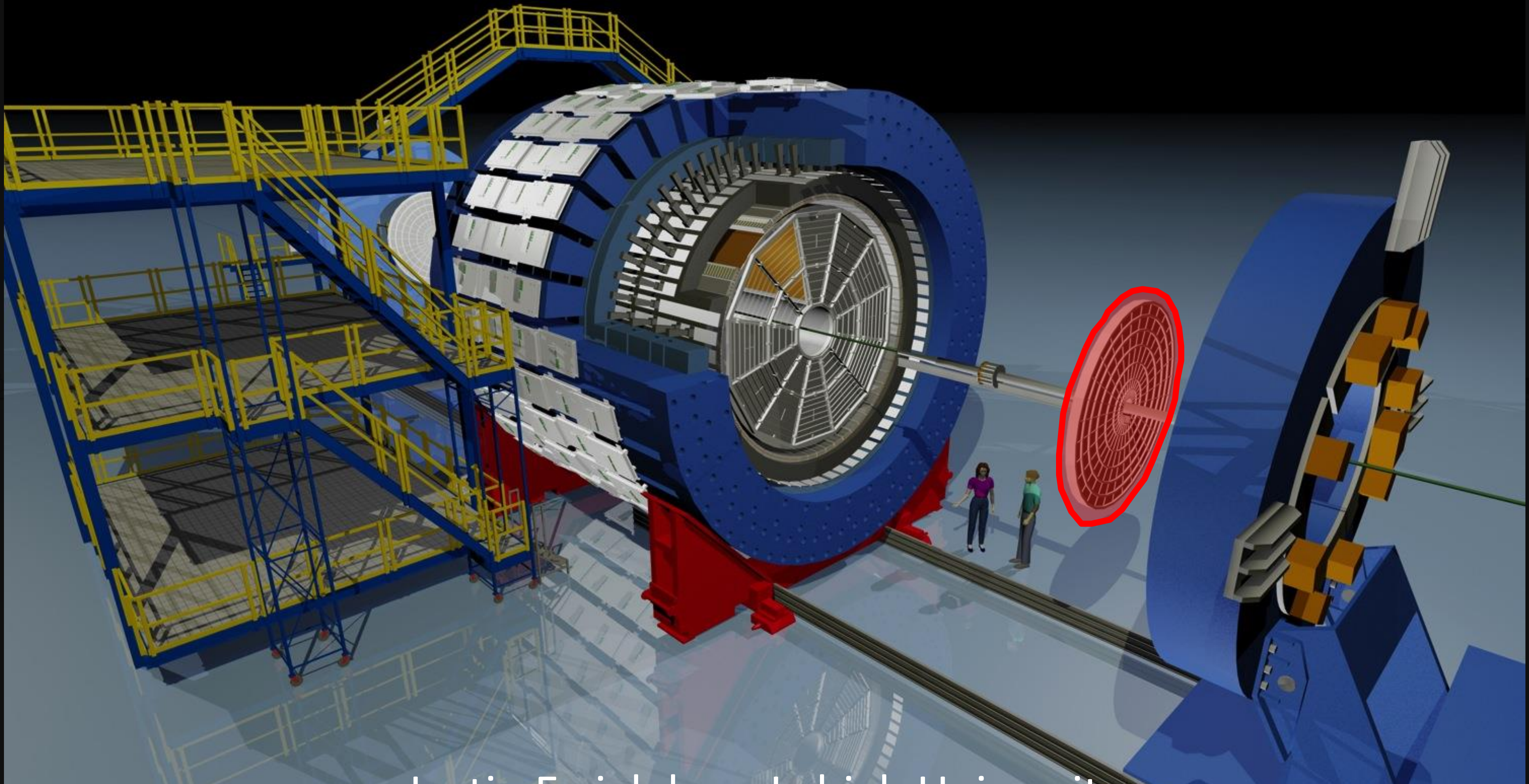
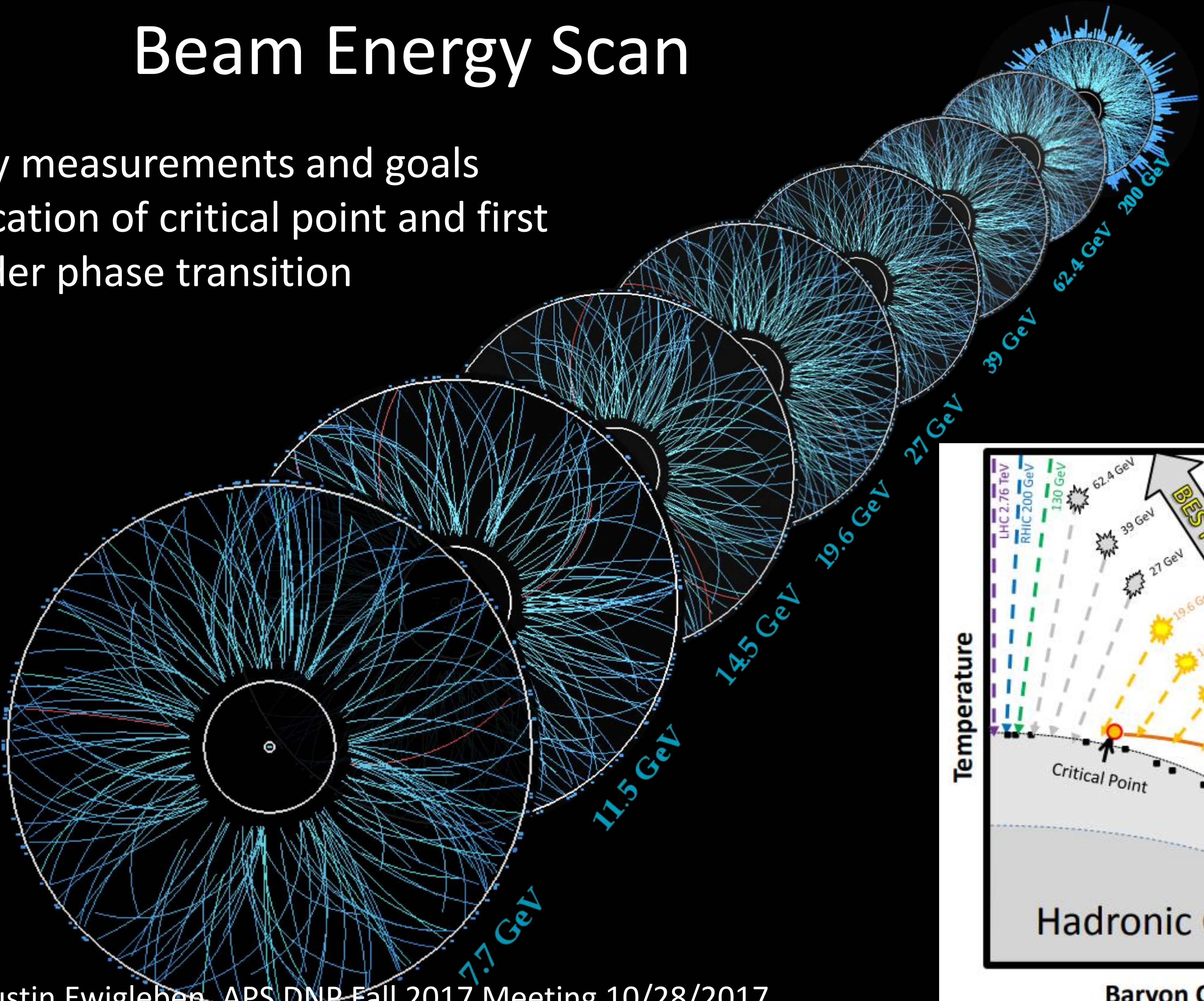
Performance of the STAR Event Plane Detector



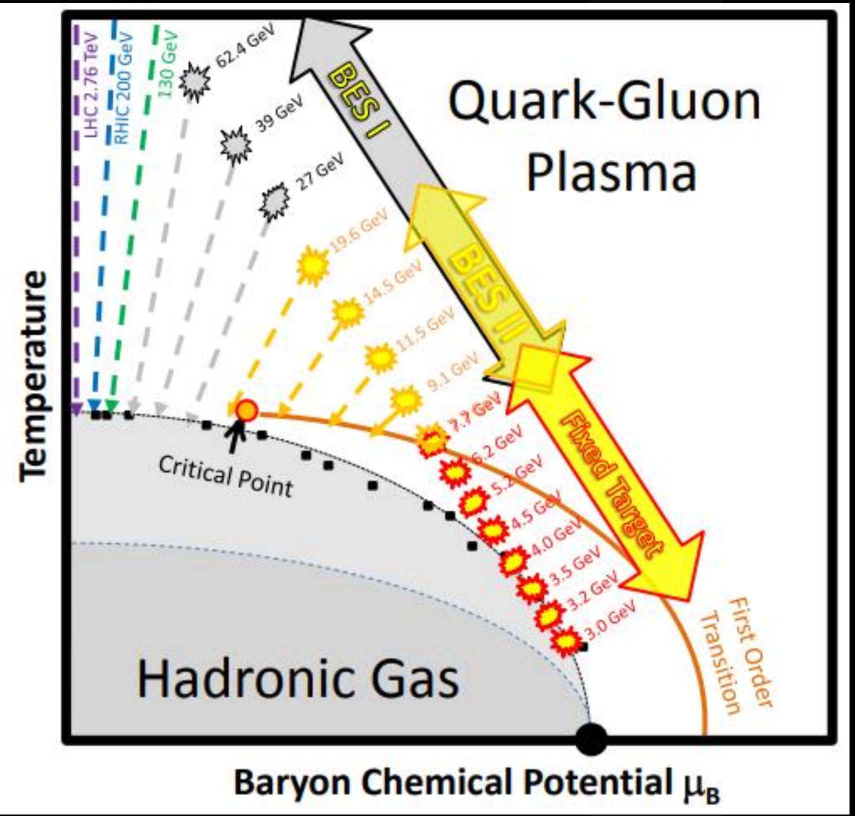
Justin Ewigleben, Lehigh University
For the STAR Collaboration

Beam Energy Scan

Key measurements and goals
Location of critical point and first order phase transition



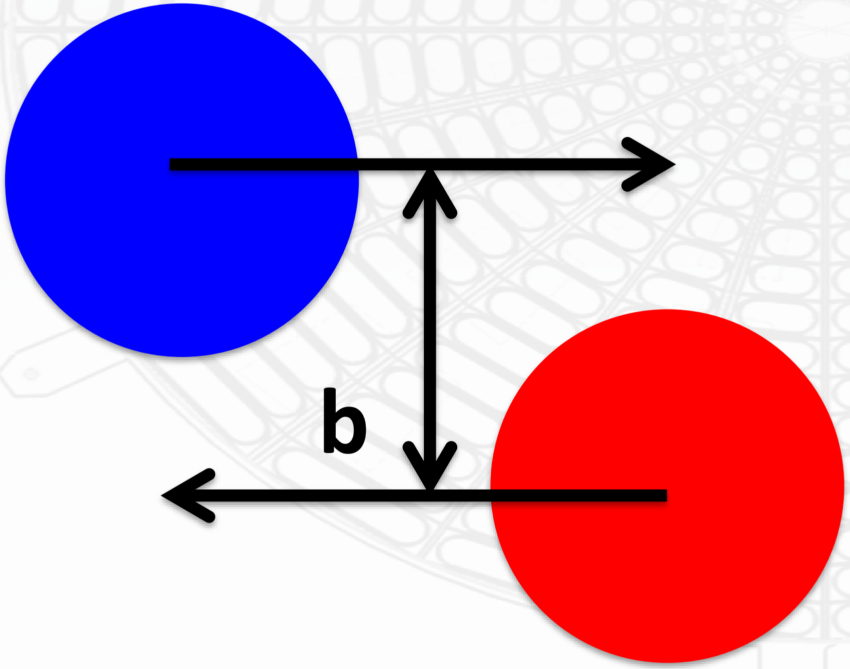
Centrality, Event Plane and Triggering



Centrality and Heavy-Ion Collisions

Collision centrality defined by **impact parameter** between colliding nuclei

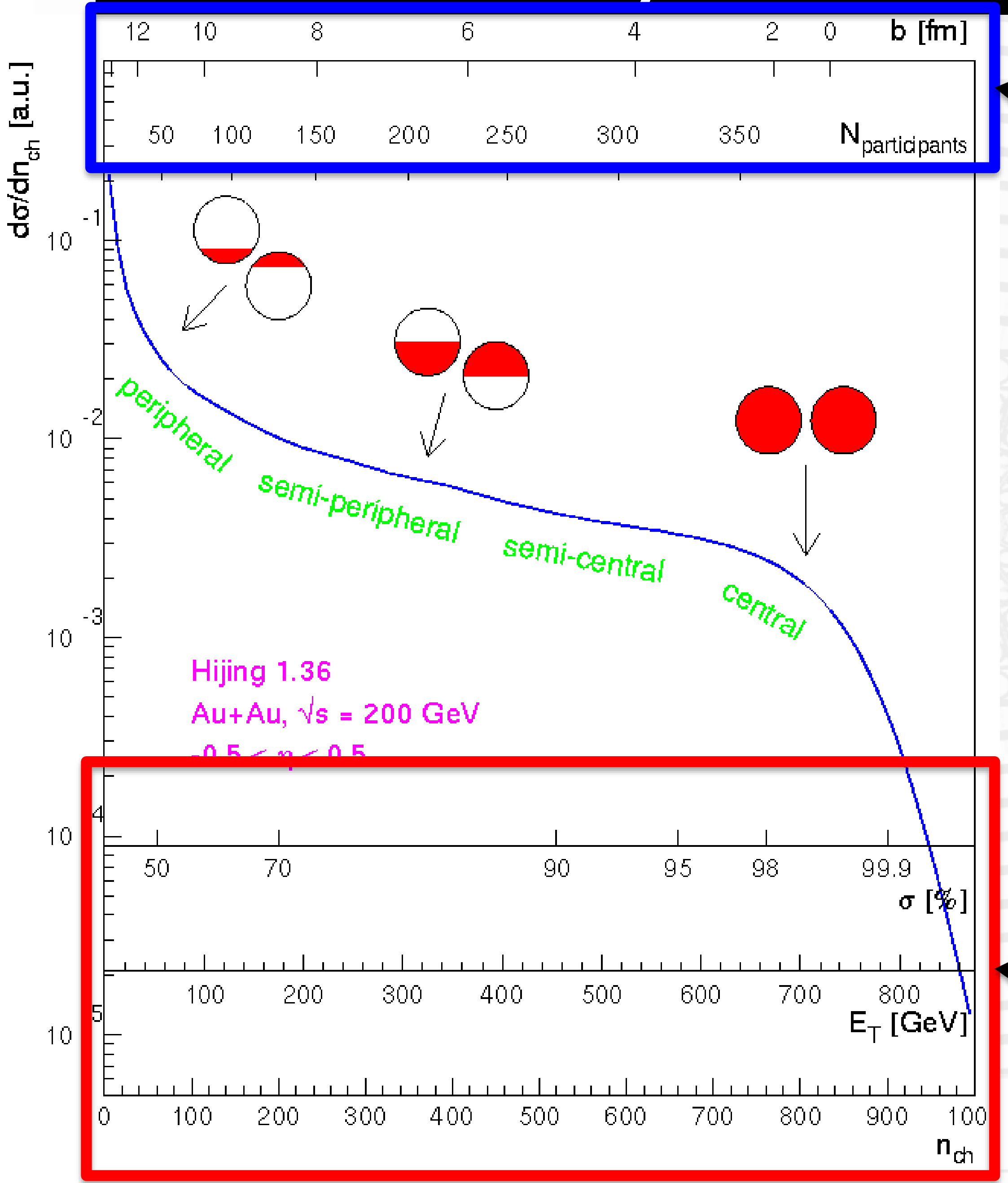
b = impact parameter



Central collisions should see the **strongest effects** due to the Quark Gluon Plasma

But → **We can't measure b (and thus centrality) directly!**

Centrality in Heavy-ion Collisions

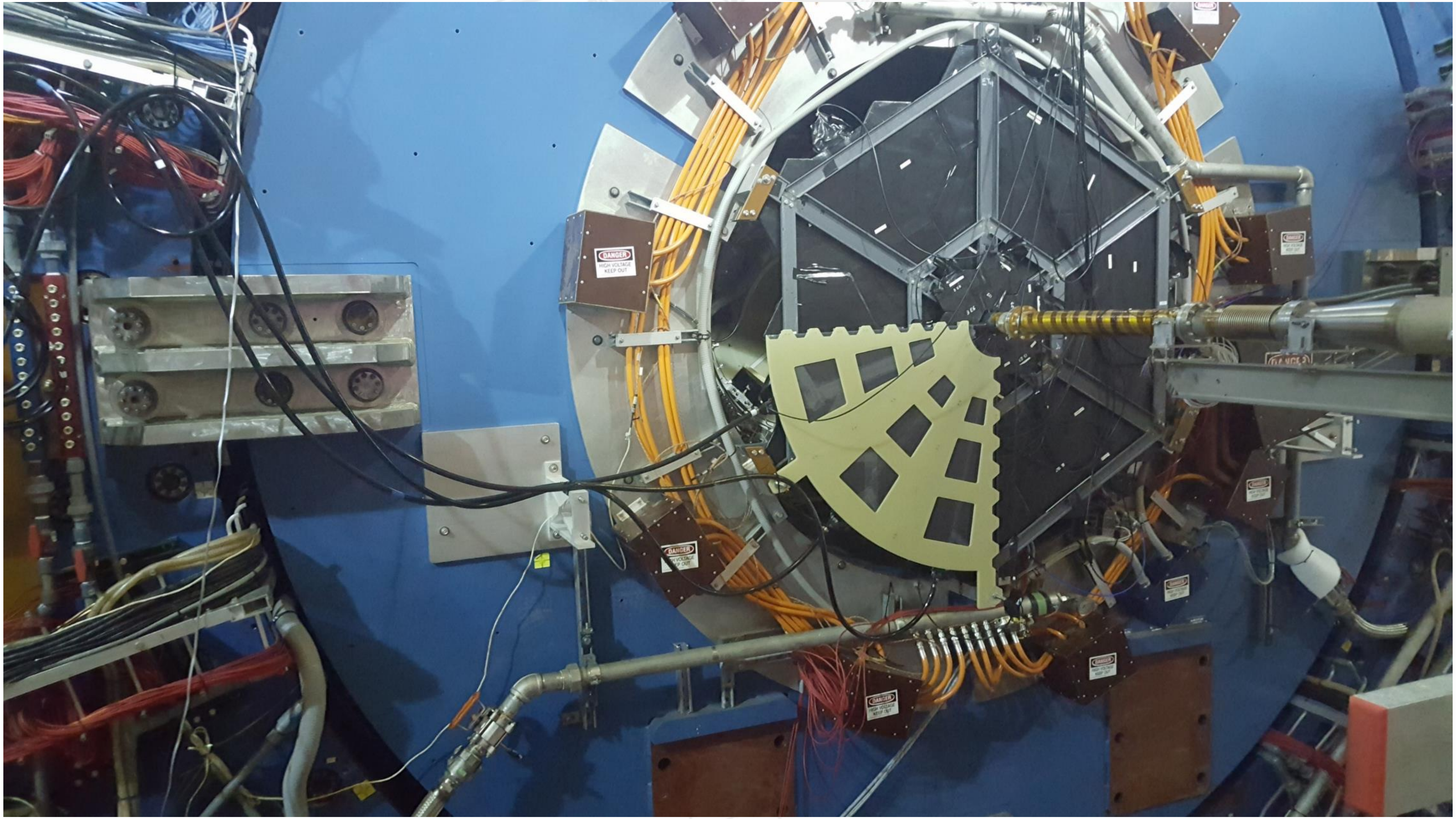


Calculated

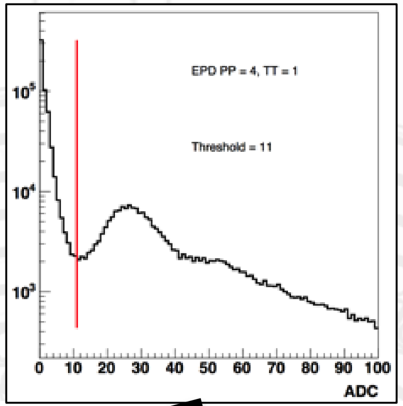
Measured

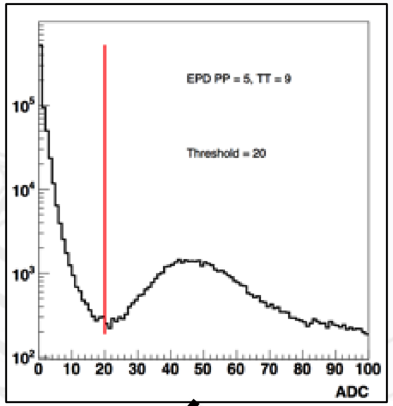
We measure the number of particles in a heavy-ion collision and then calculate the impact parameter

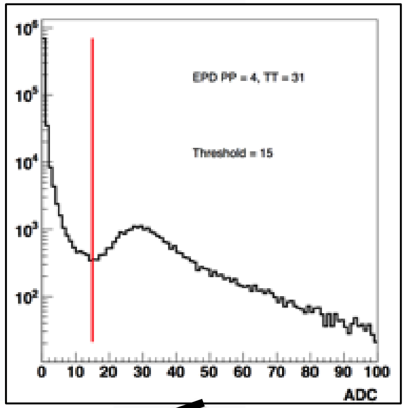
Quarter Wheel in place at STAR, 2017

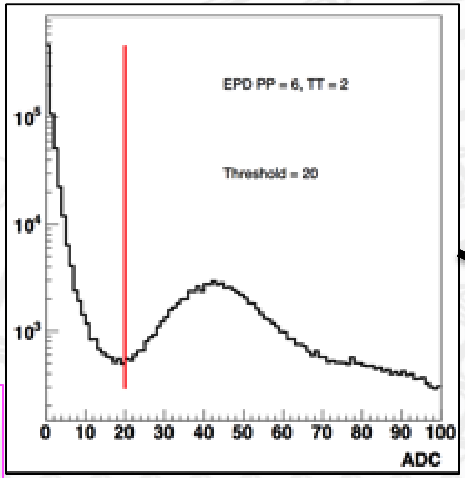


Hit/No-hit

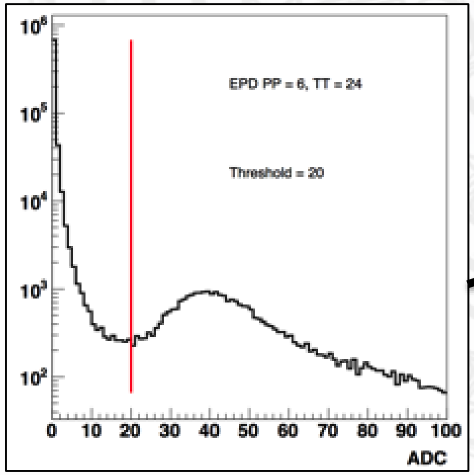


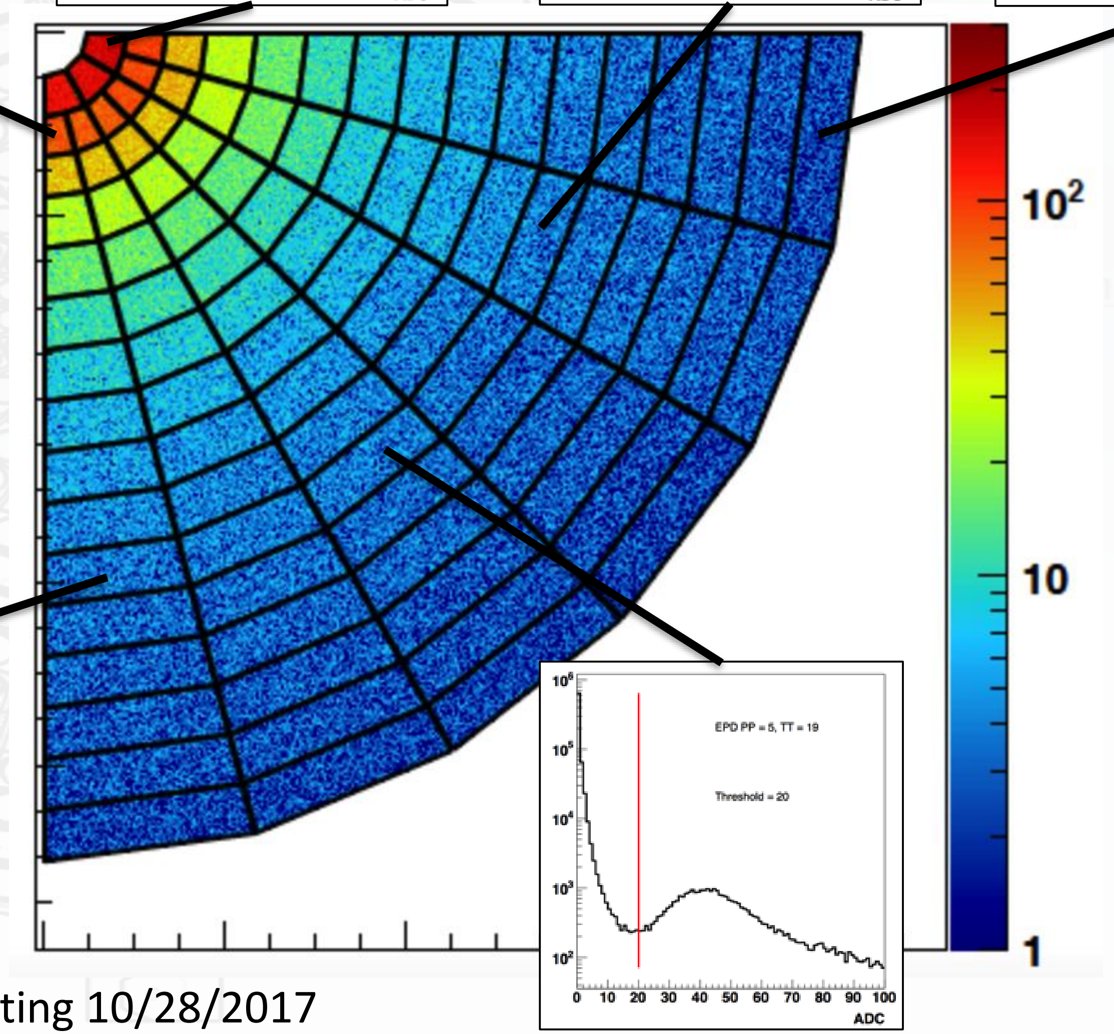




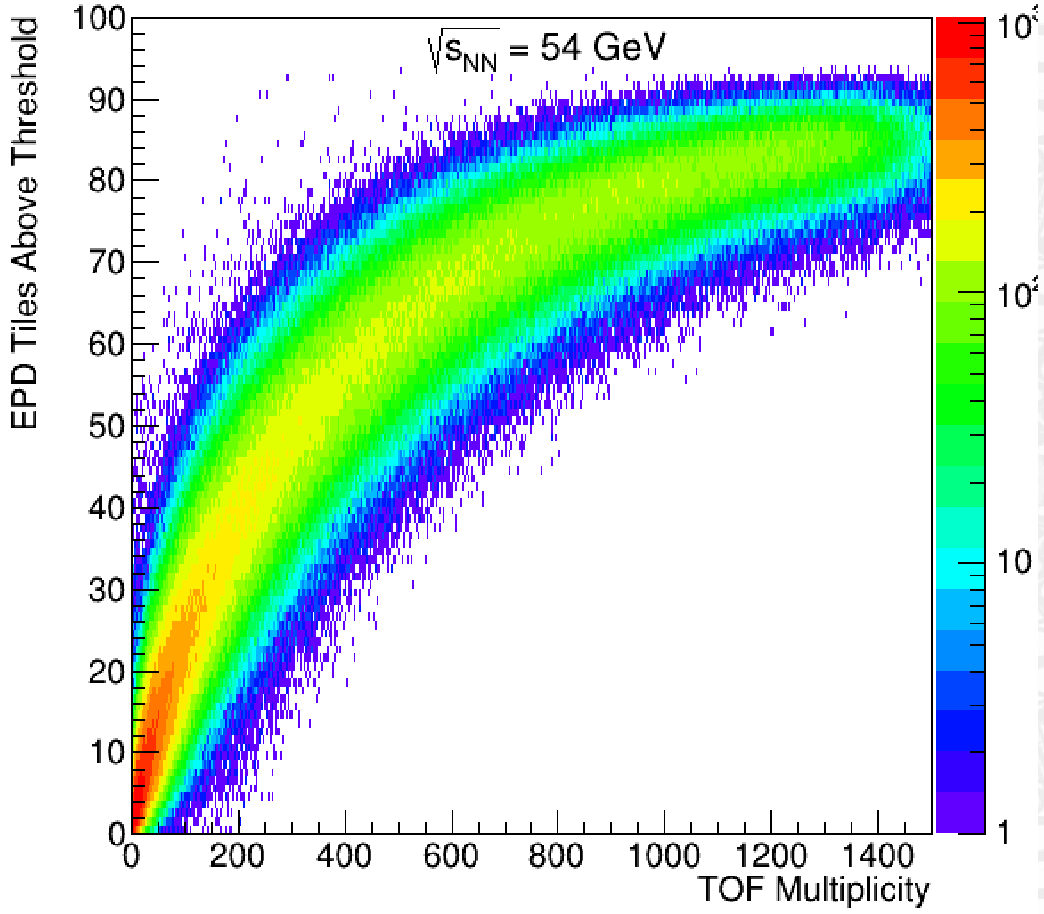


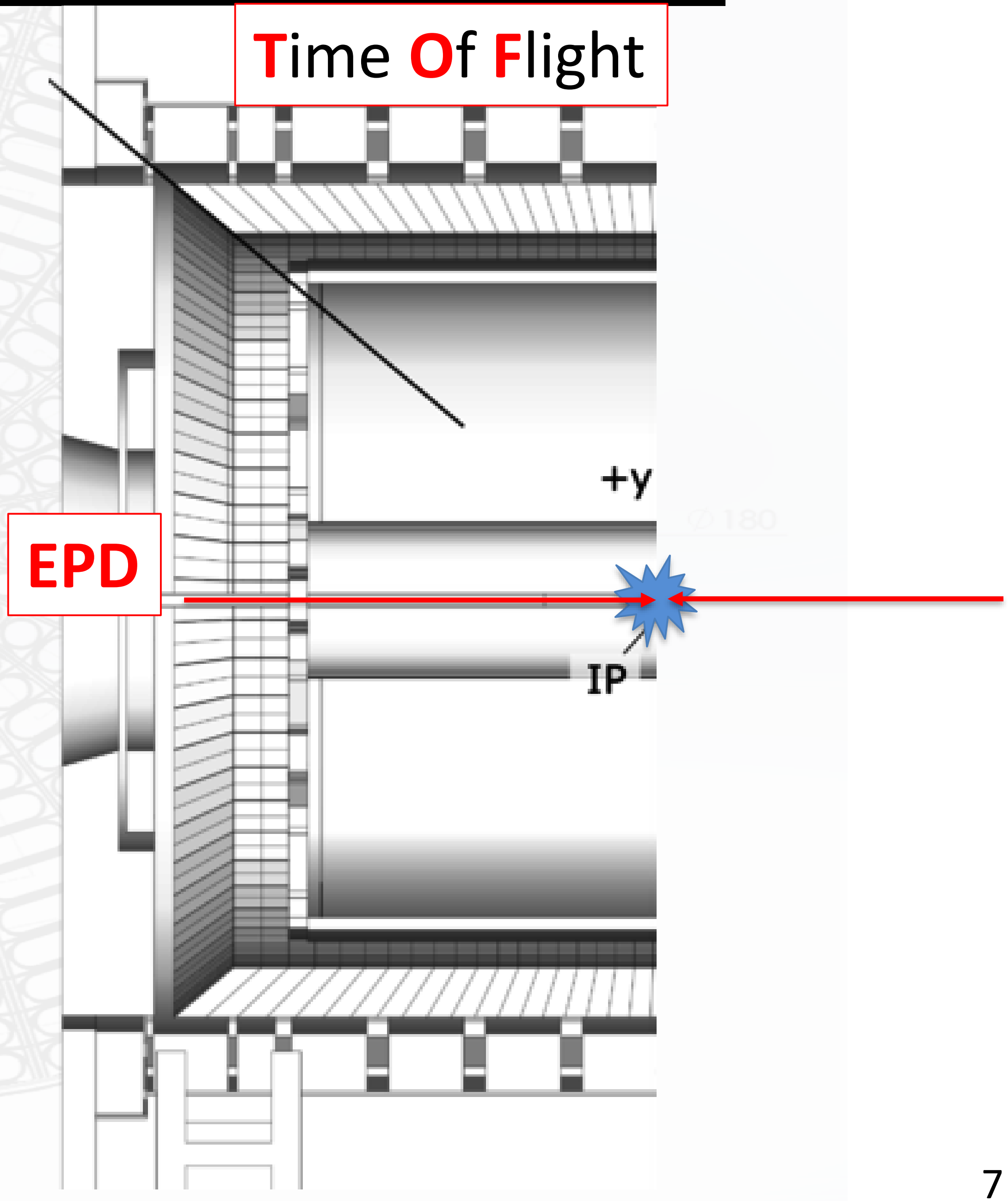
All 93 channels show good signals ✓





Centrality Determination





Nice correlation between EPD centrality at forward rapidity and TOF centrality at center rapidity!

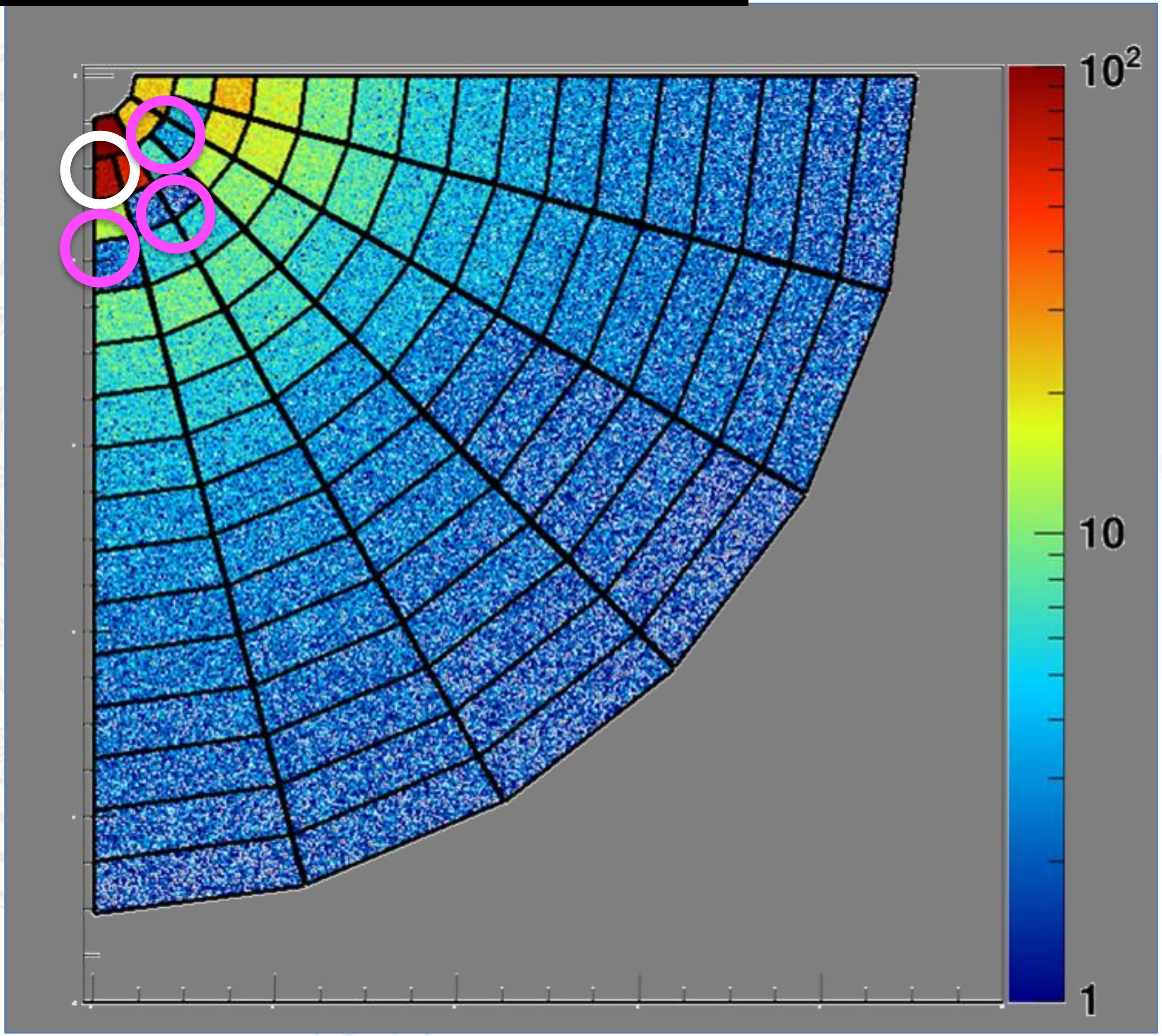
EPD-BBC correlation

require BBC hit

require no BBC hit

Specific tiles registering hits are correlated ✓

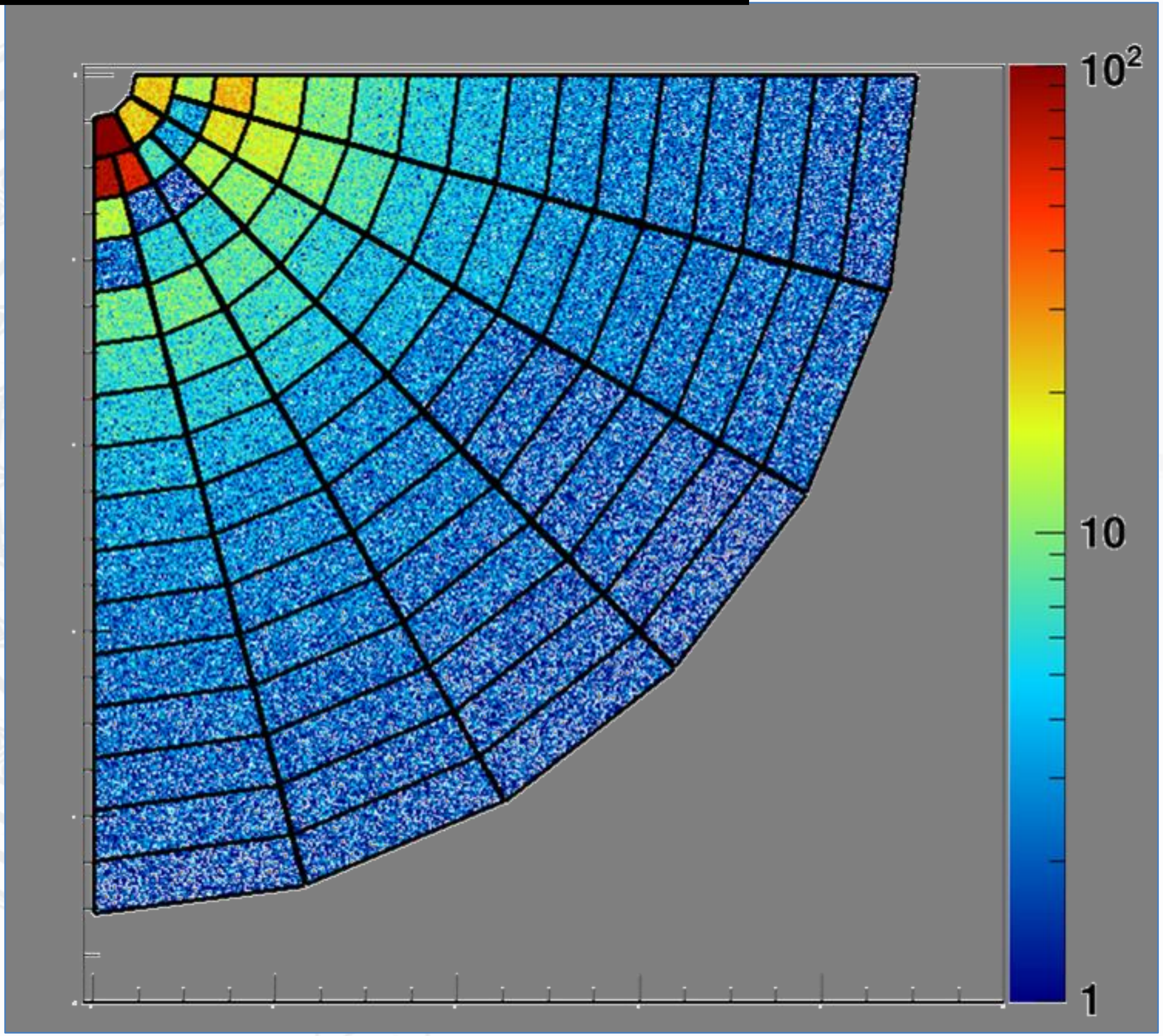
BBC tiles indicated at *approximately* correct *position*



EPD-BBC correlation

require BBC hit

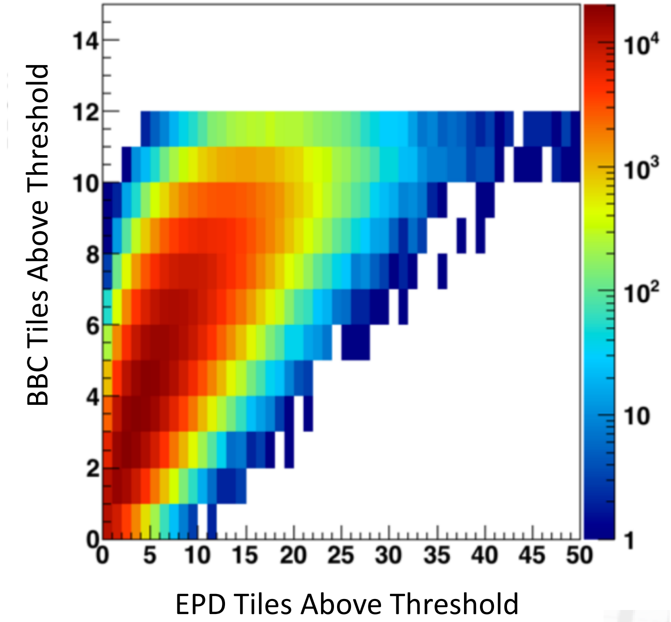
require no BBC hit



Specific tiles registering hits are correlated ✓

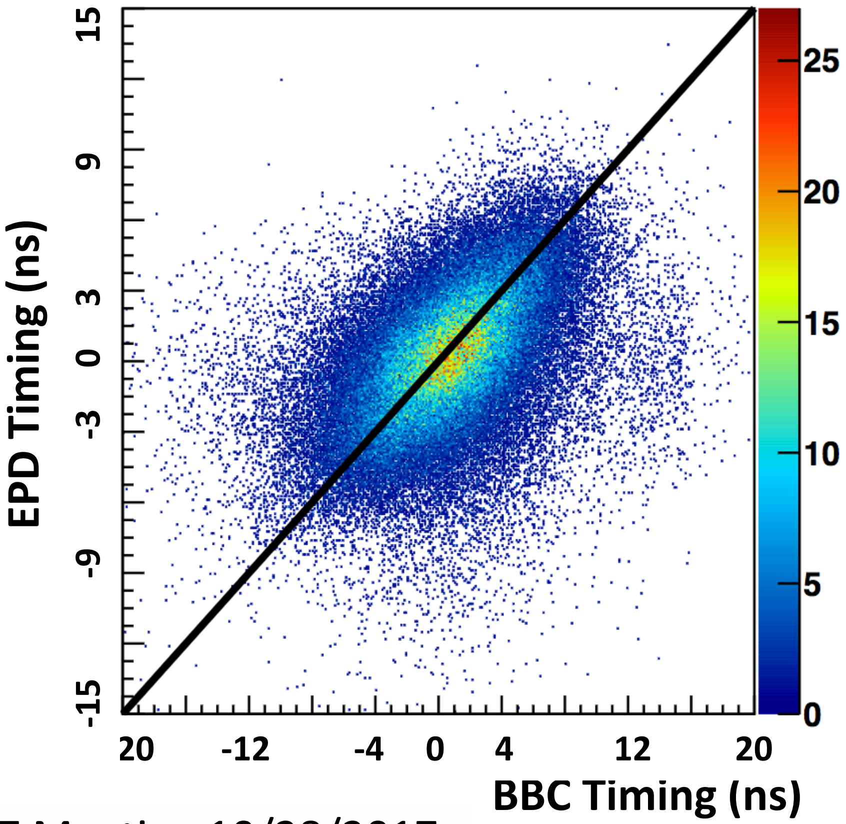
BBC tiles indicated at *approximately* correct *position*

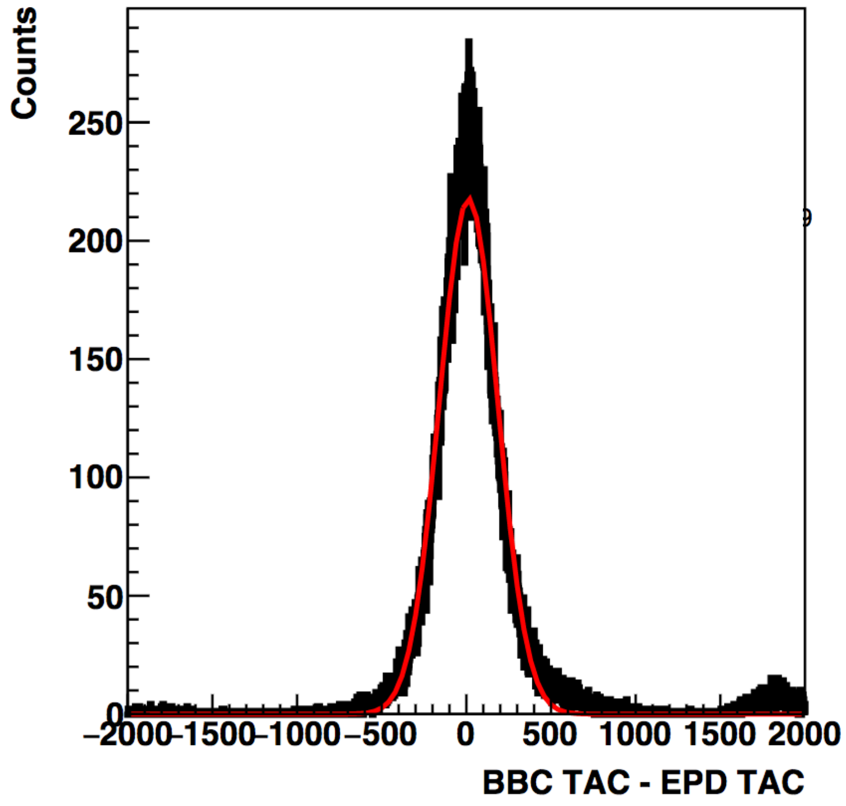
EPD-BBC correlation



- EPD vs. BBC timing shows good agreement, difference is sharply peaked ✓

- EPD correlated with BBC tiles overlapping with it ✓

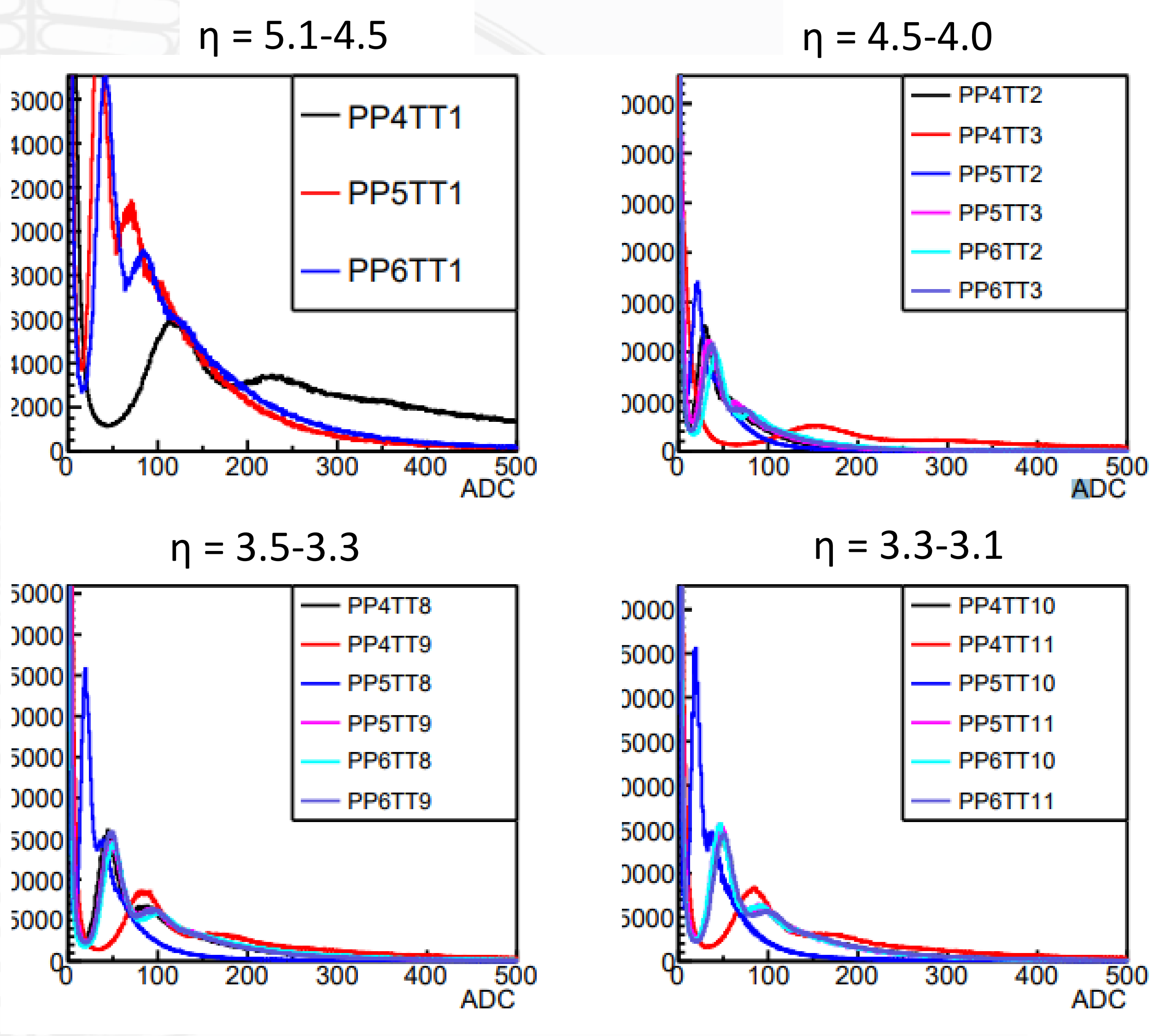




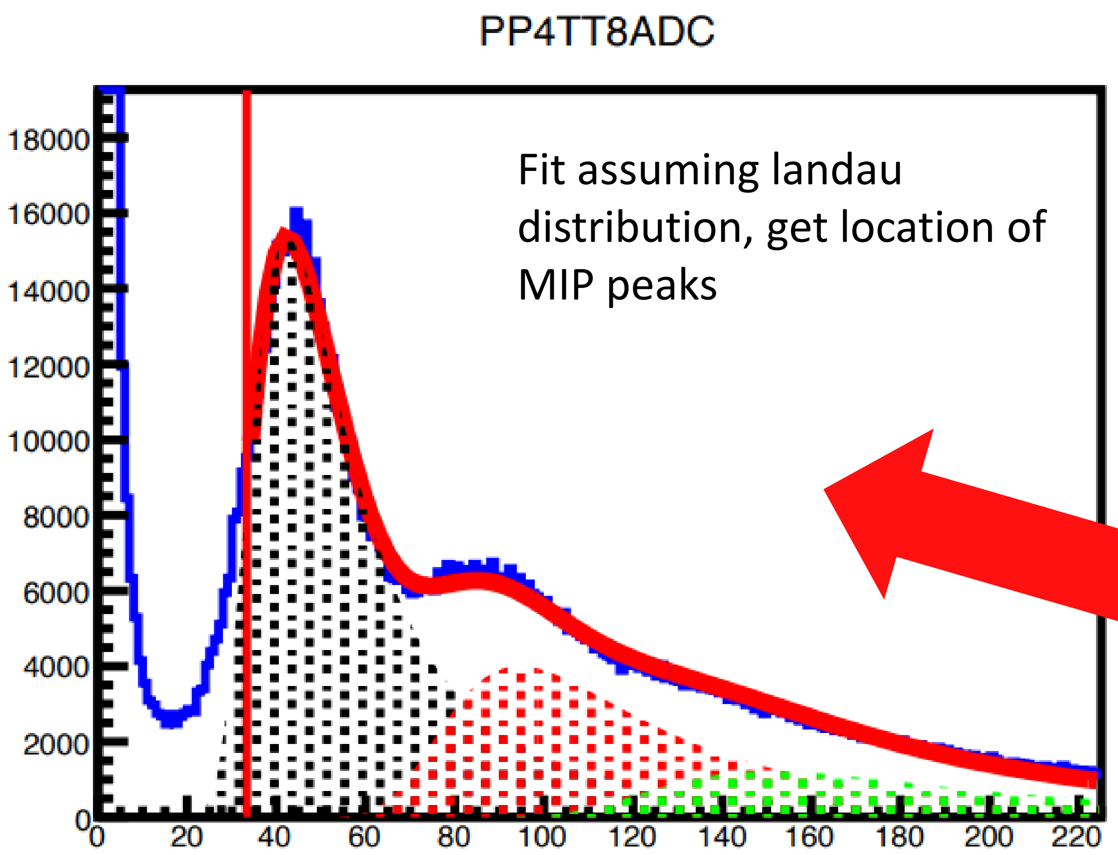
From ADC -> nMIPs

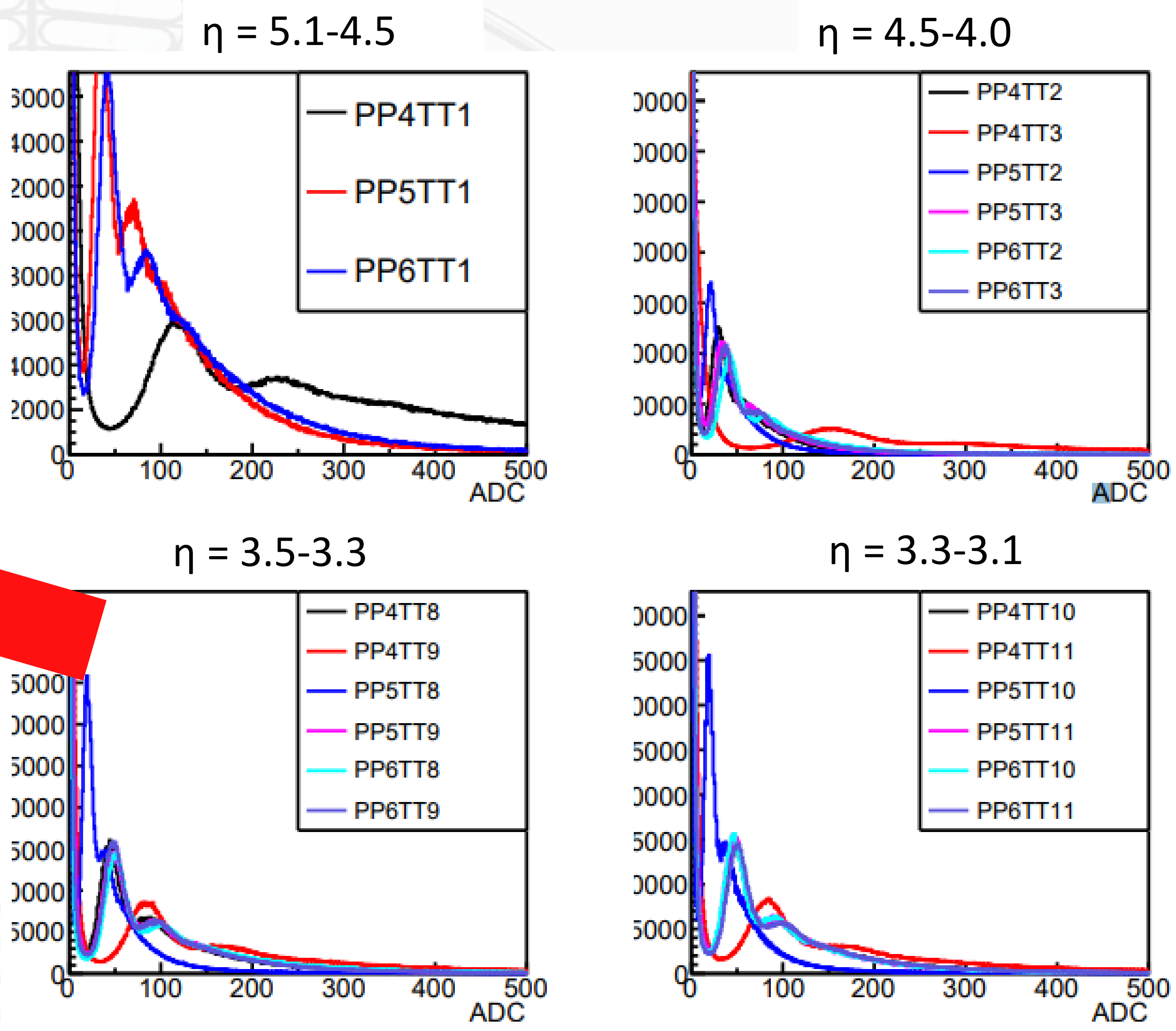
- Sample of ADC plots from 2017

- Data shown just from 4 η-rings, the rest are consistent. Different colors indicate different tiles in a ring



From ADC -> nMIPs



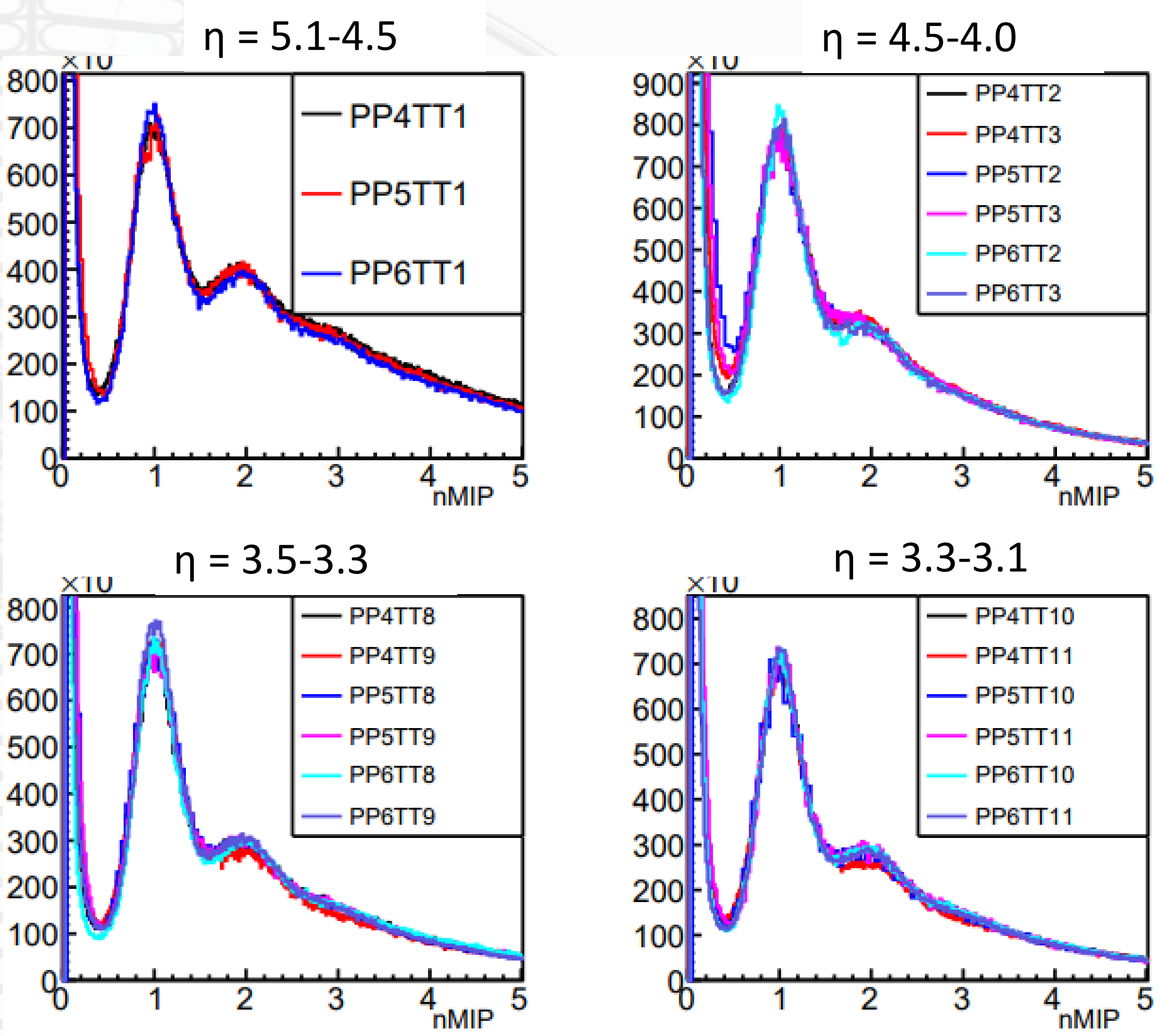


From ADC -> nMIPs

- Sample of nMIP plots from 2017
- Only position of 1 MIP peak is fixed, height of peak and position of 2+ MIP peaks are all real (i.e. no "vertical" normalization), only the equation below for nMIP was used
- Data shown just from 4 η-rings, the rest are consistent. Different colors indicate different tiles in a ring

nMIP = (ADC)/MIP

MIP is actually the MPV for the 1-MIP Landau distribution

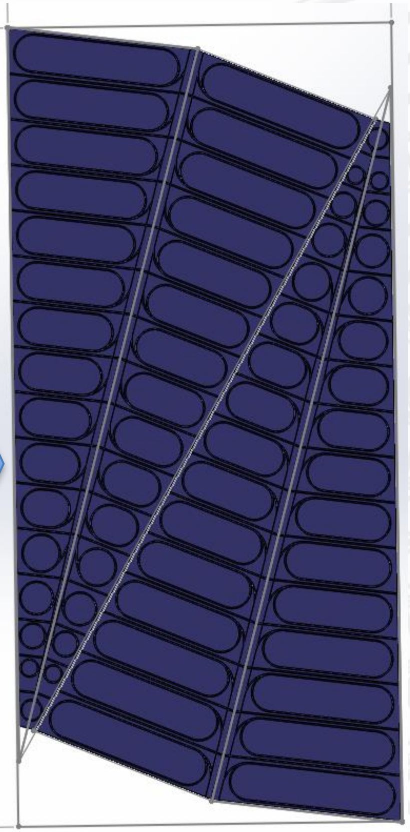


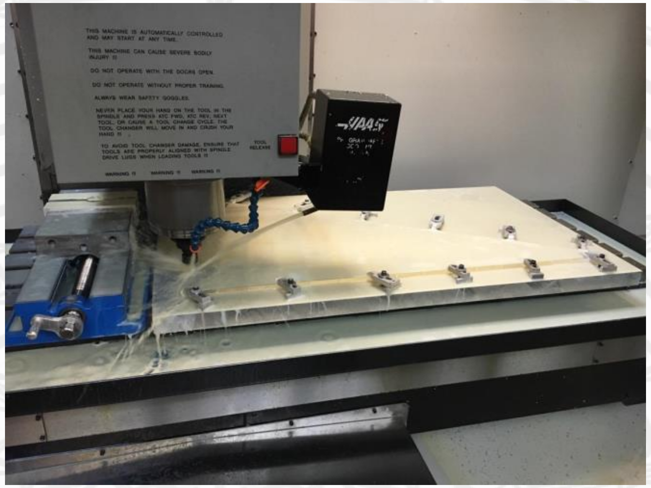
Wrapping Up (the End is in Sight!)

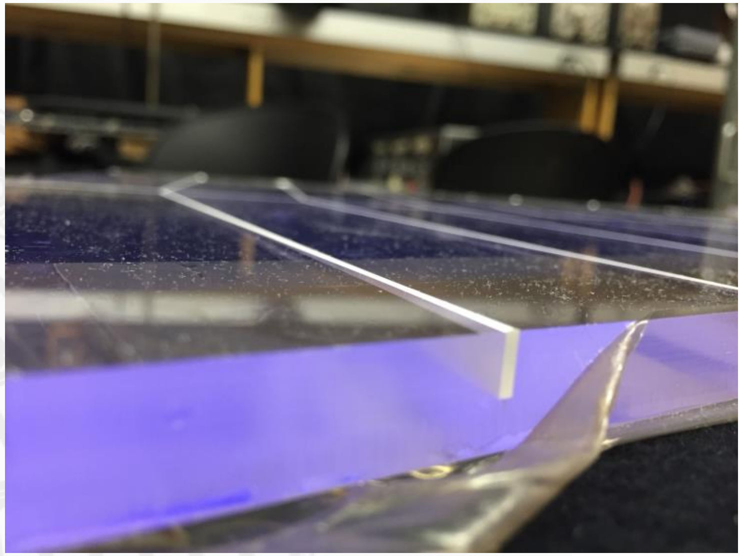
- Will provide independent measurement of centrality and EP
- Performance results from 2017 are all well understood and outperforming all expectations (really outperforming!)
- **Supersector Construction and testing is completed!**
- Clear Fiber Bundle construction ongoing at Lehigh
- **Installation at the end of January**
- Run 18 scheduled start is early MARCH 2018
  - BBC will be run in parallel in 2018 to validate performance
  - $\sqrt{S_{NN}}$ = 27 GeV → summer 2018

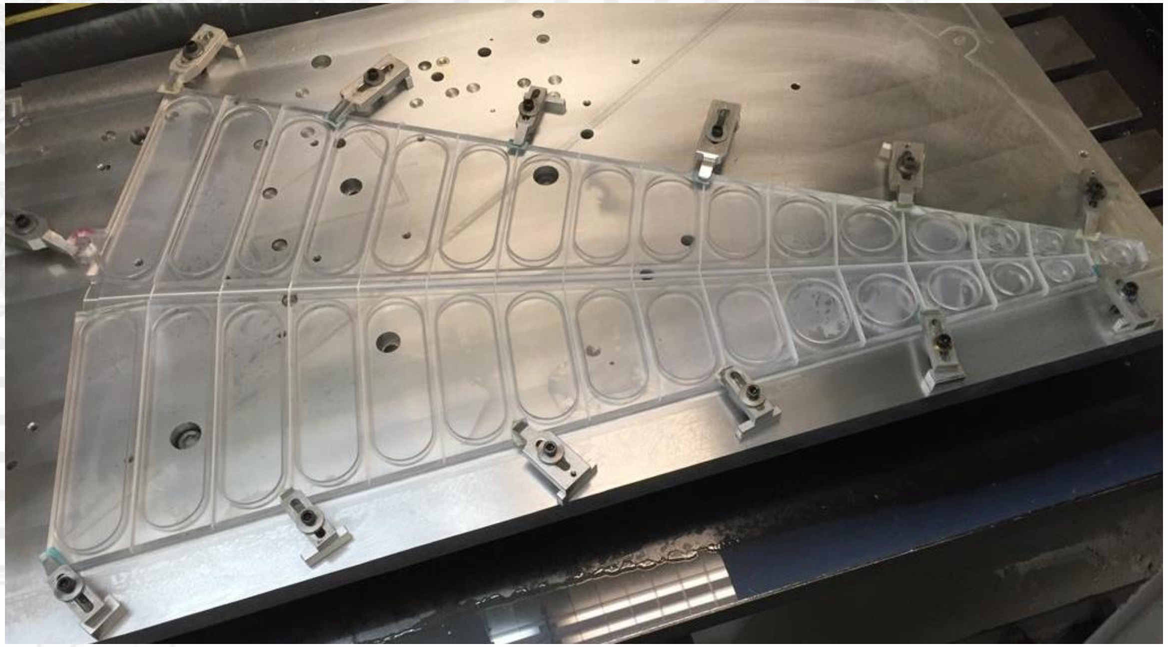
Questions?

Machining and Optical Isolation







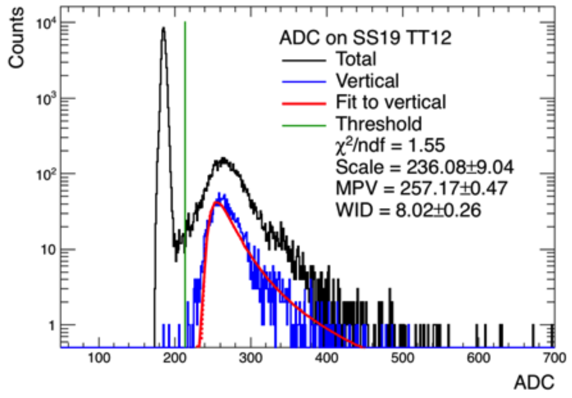


CNC milling

- high volume water/oil for cooling, debris

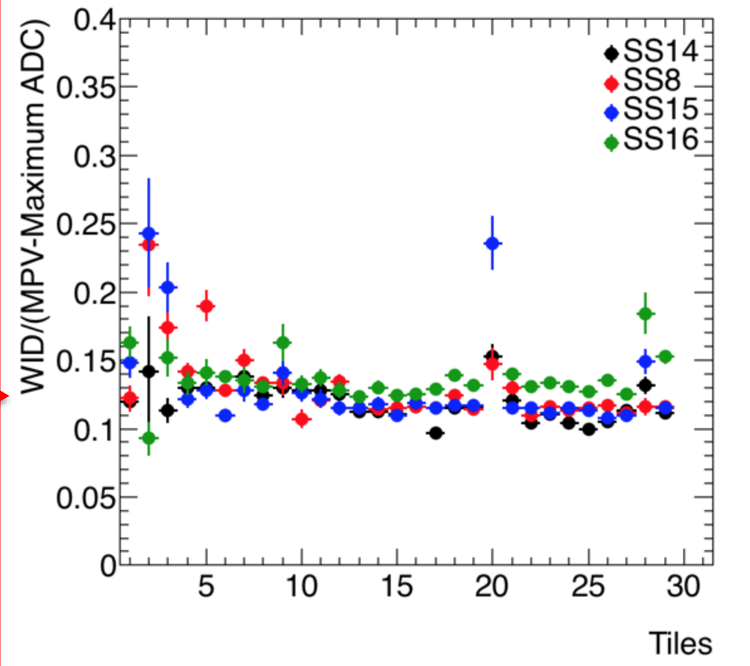
Testing the new EPD

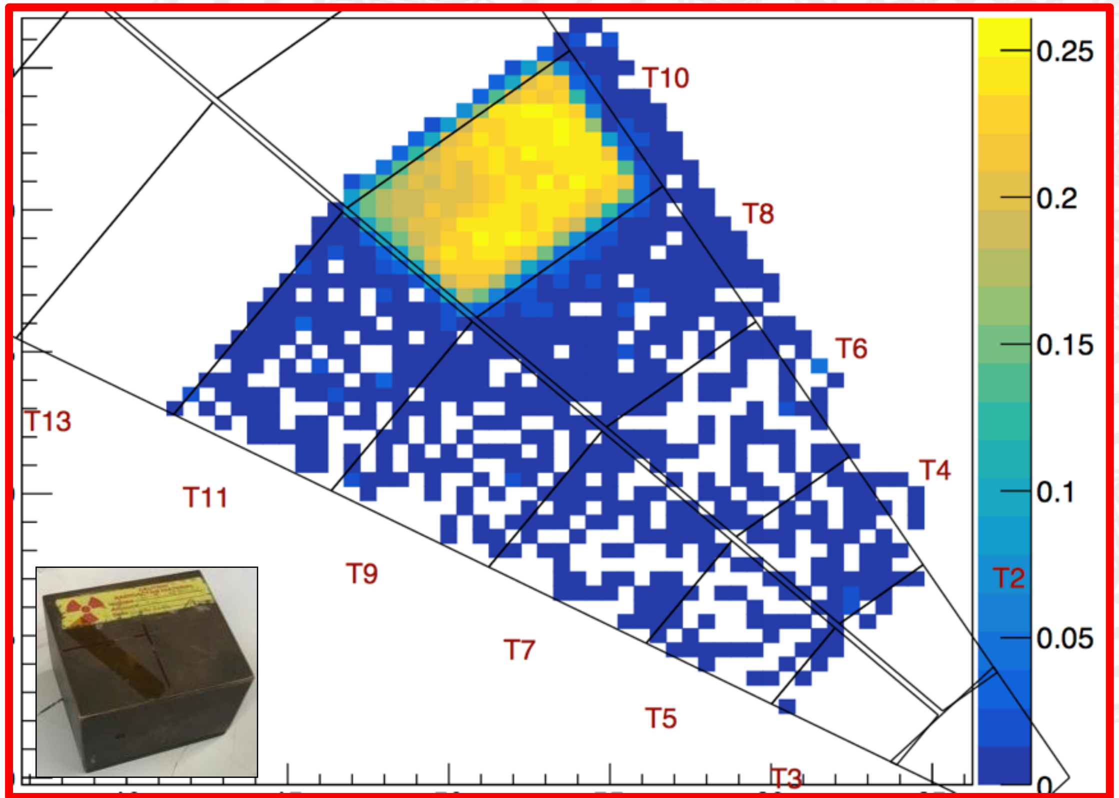
Cosmic ray



Landau fits to the data show a nice uniform response

- **99.5% good tiles!**



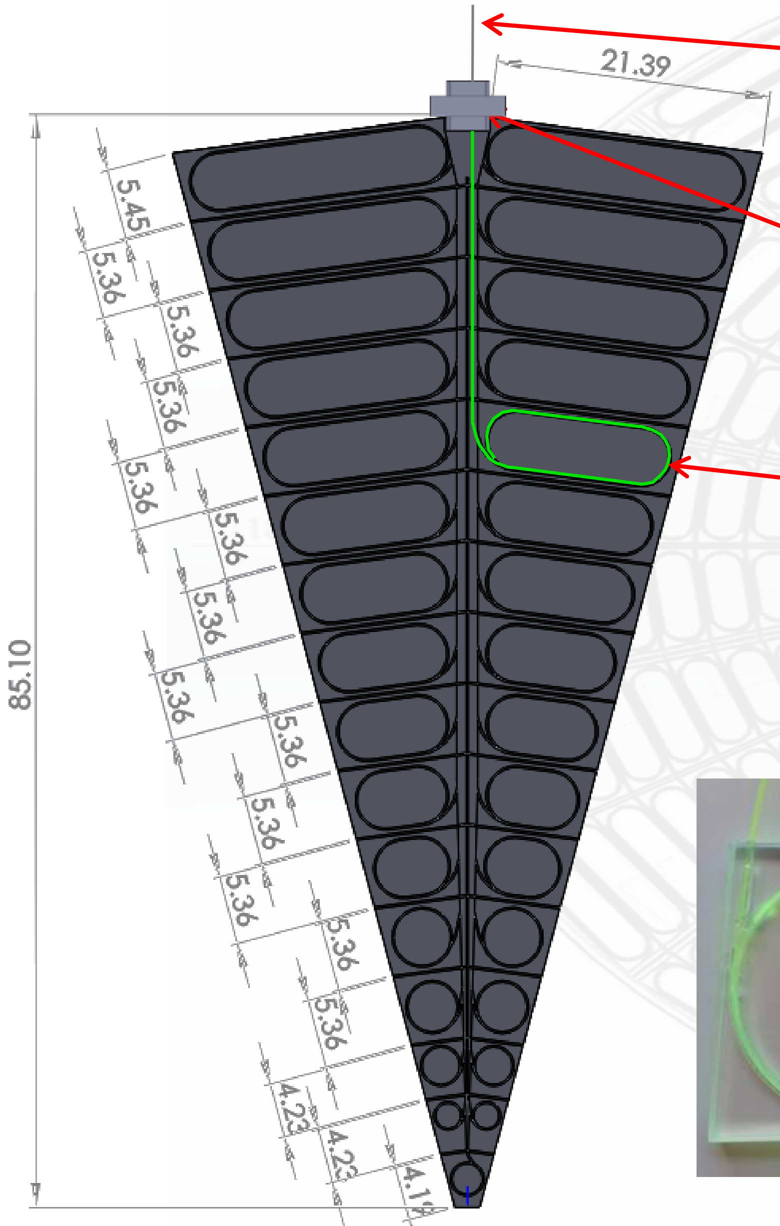


$^{90}Sr \rightarrow {}^{90}Y + e \rightarrow {}^{90}Zr + e$

Measure current in SiPM due to Strontium source

- Test within tile uniformity (**within 20%!**)
- Test cross-talk (**less than 1%!**)

Super Sector Construction

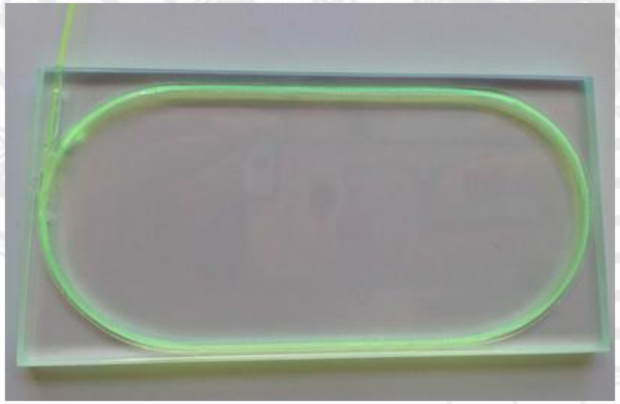


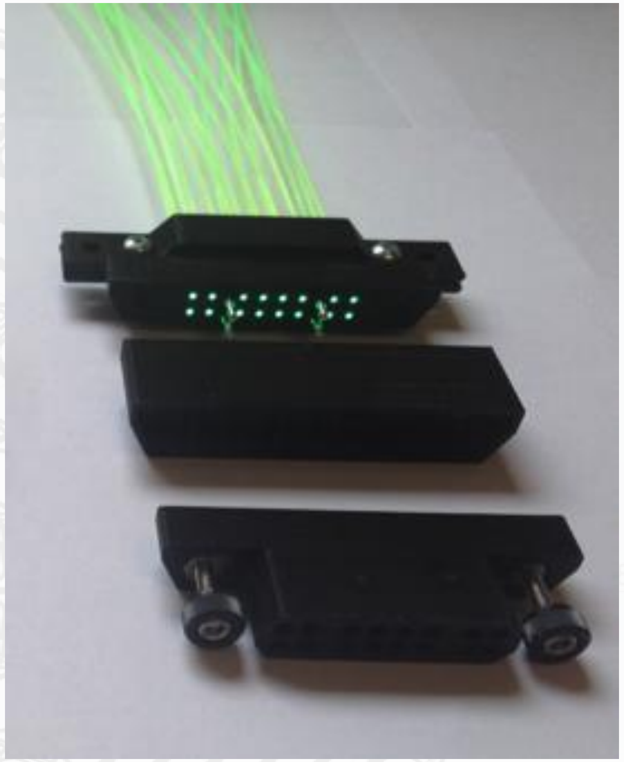
Clear fibers

Embedded 32-channel fiber-to-fiber connector

Embedded WLS fibers

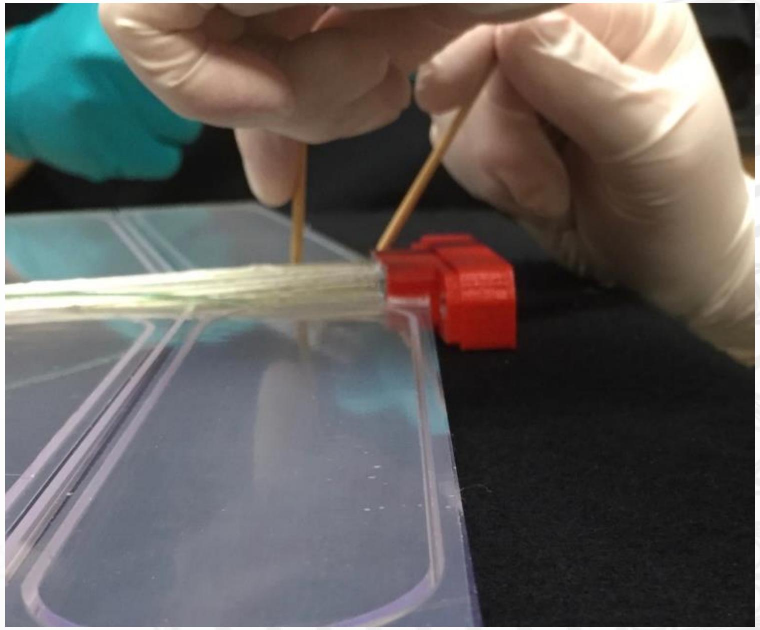
A test tile

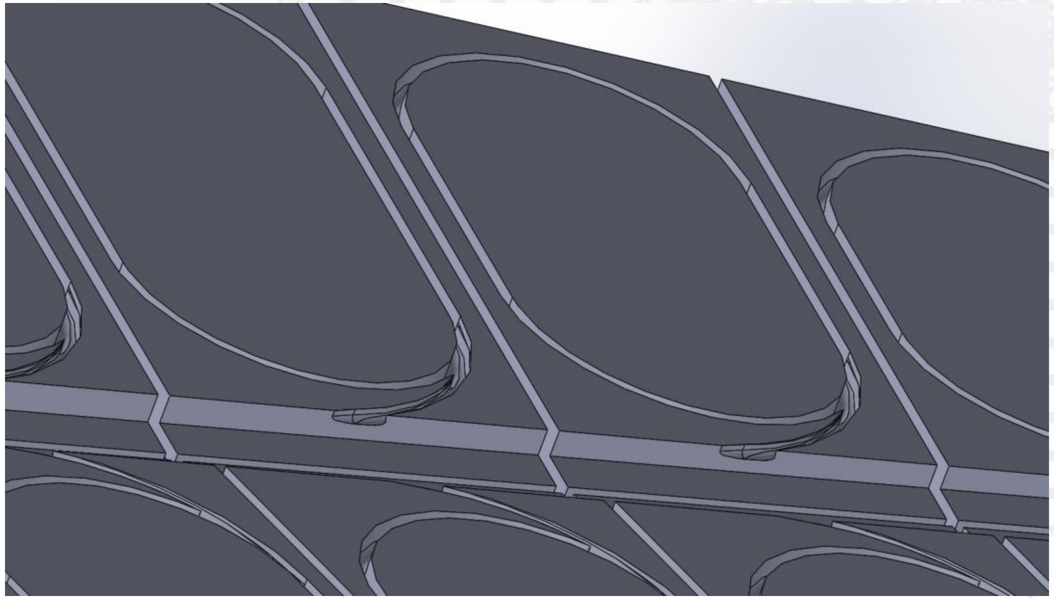


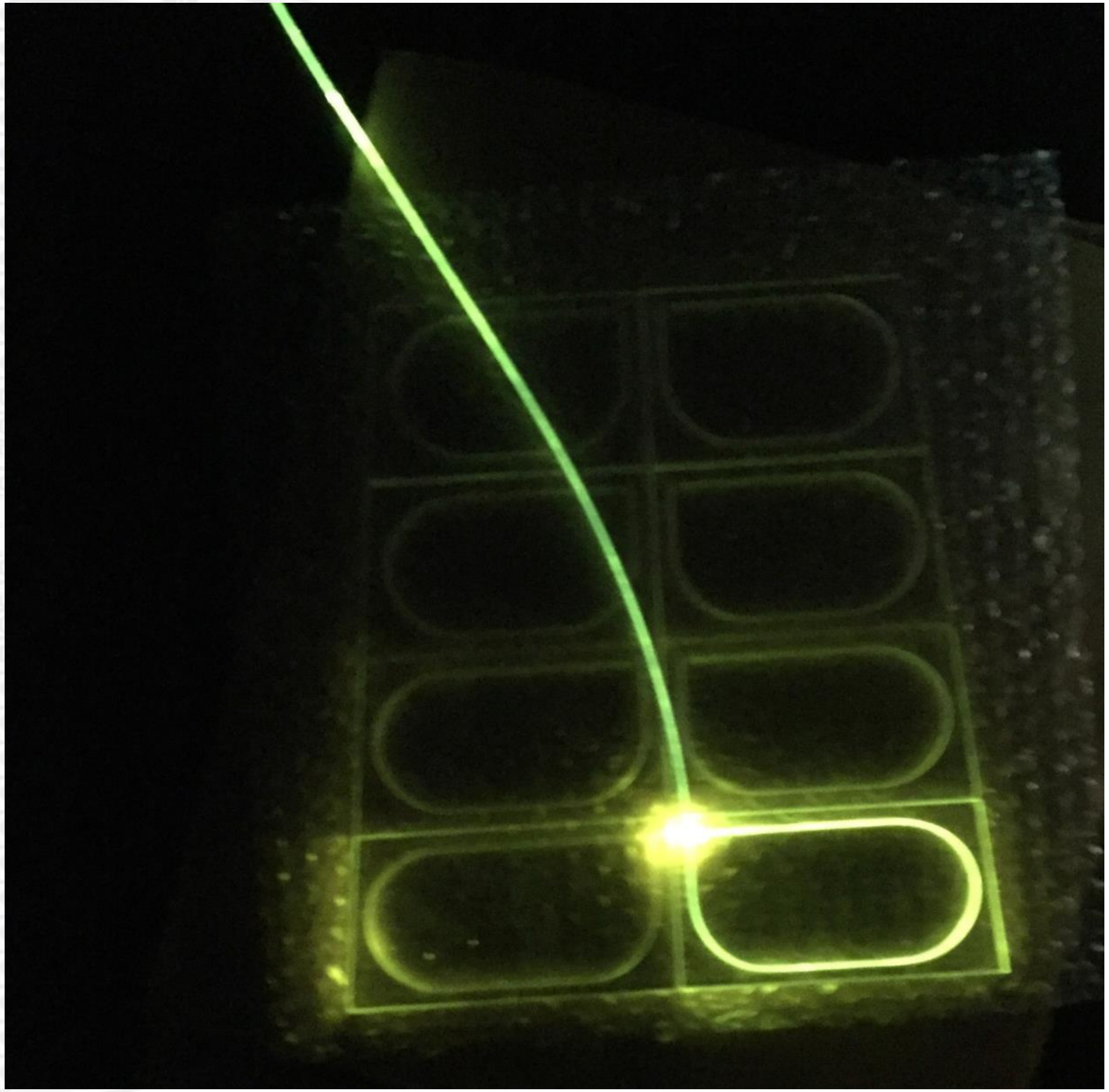


- Connected to 5 meters of clear fiber with 3D-printed custom connectors
- Super Sector will be wrapped in Tyvek and 2 layers of black paper (light tight)

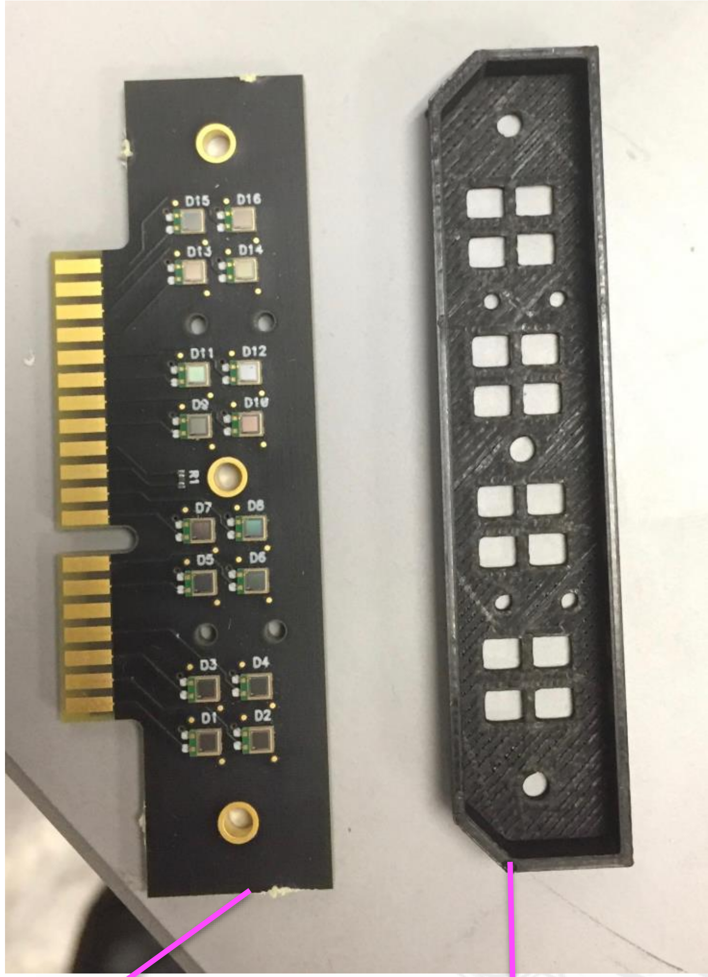
Front WLS grooves

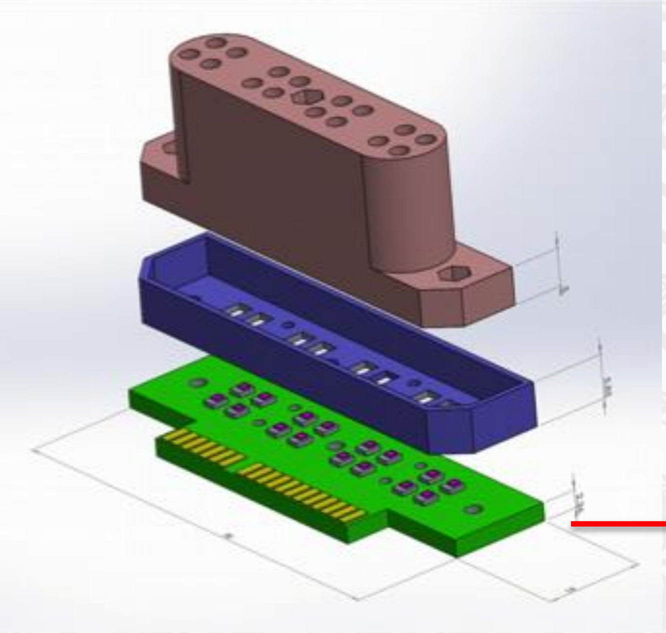


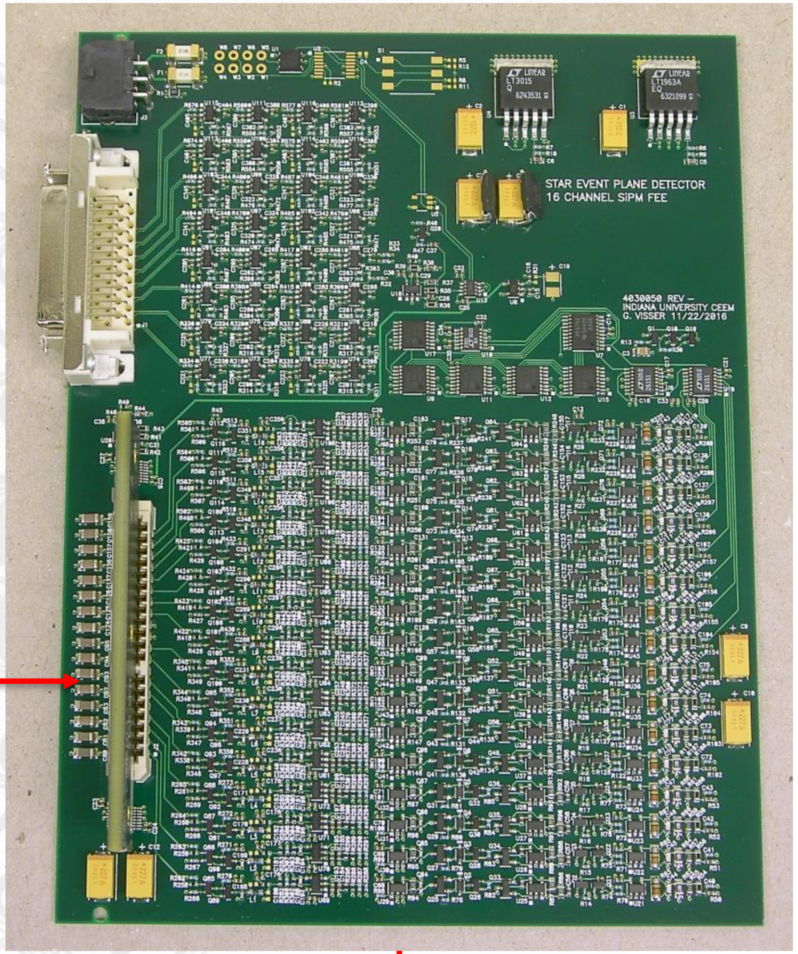




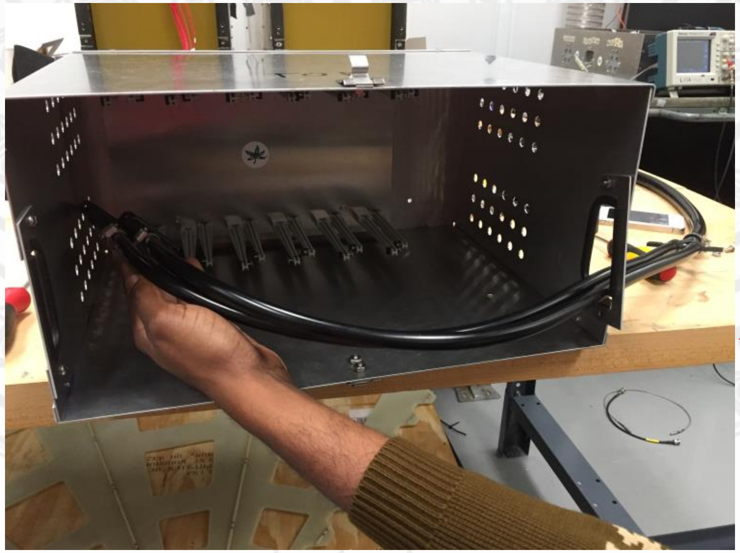
Clear fiber bundle meets readout electronics







FEE Card

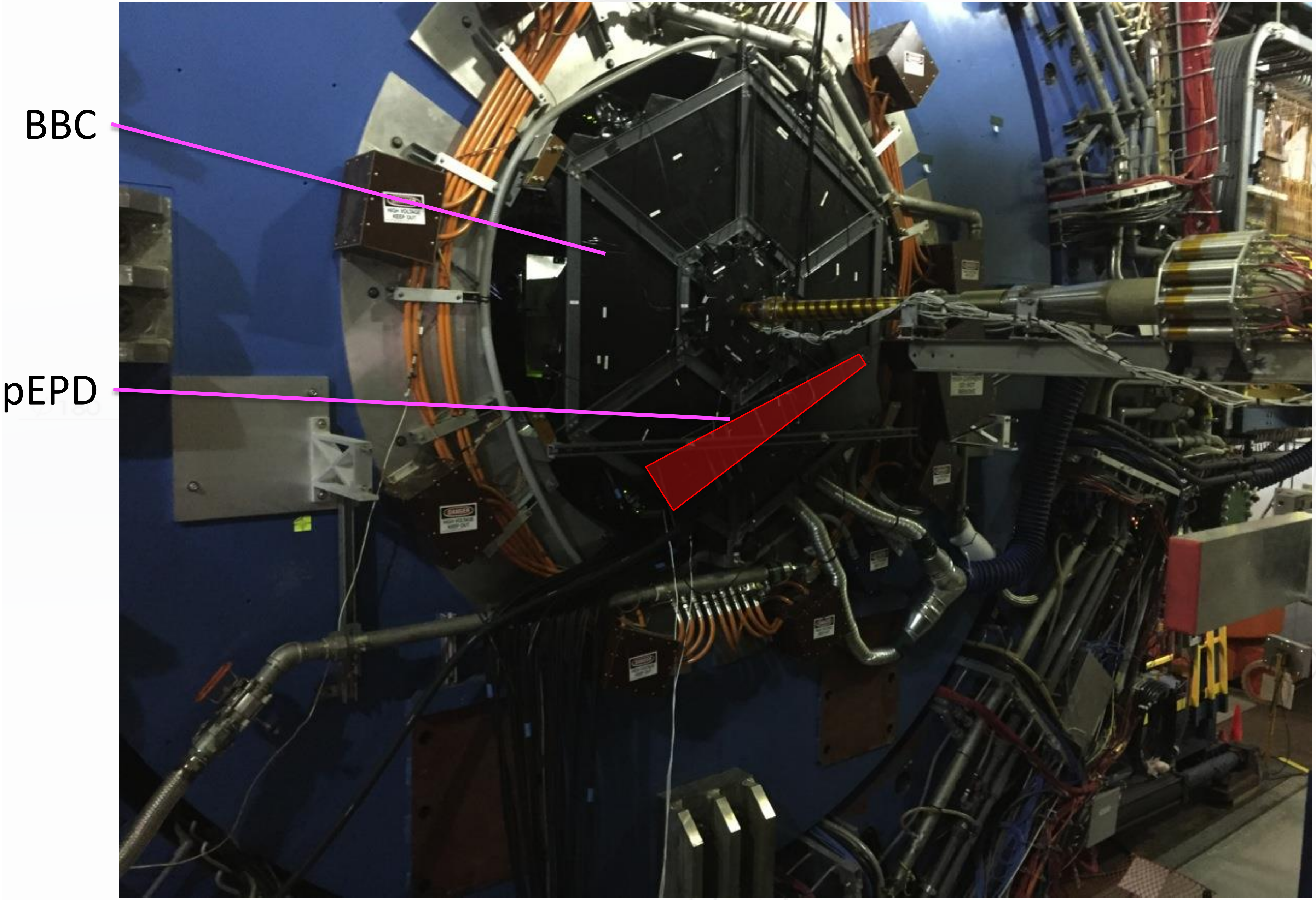


EPD FSC spacer block

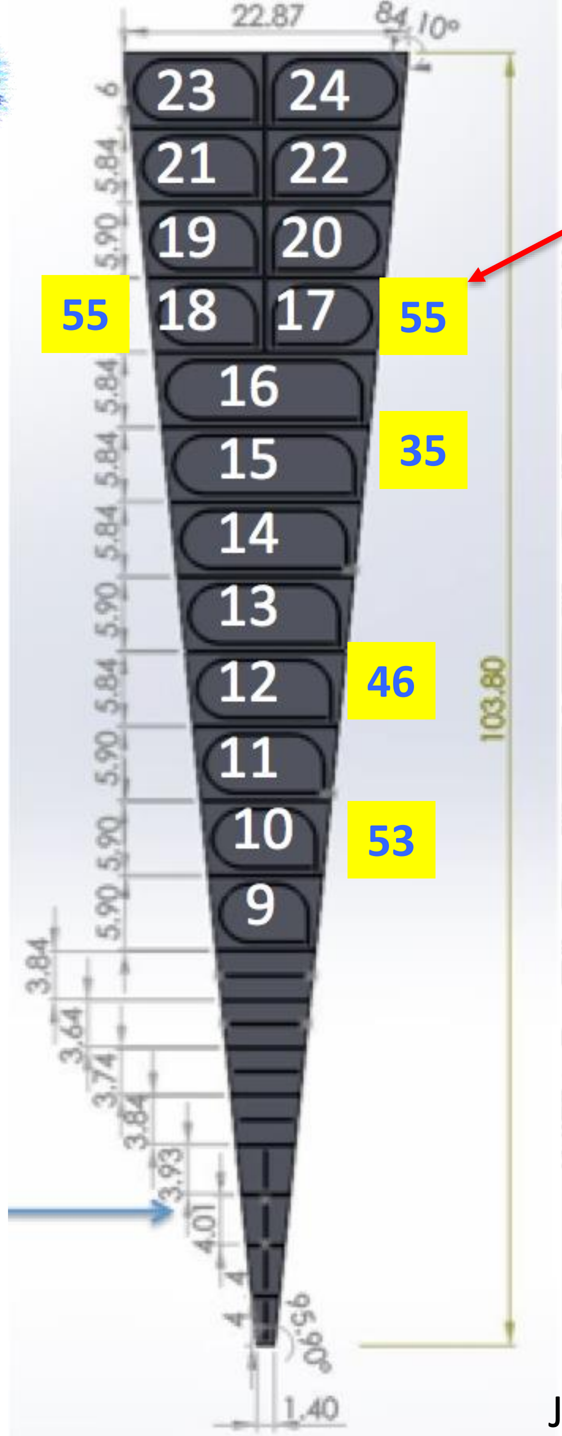
EPD SiPM card: 16, 25-µm SiPMs

FEE Box

Prototype run 2016



Prototype Results



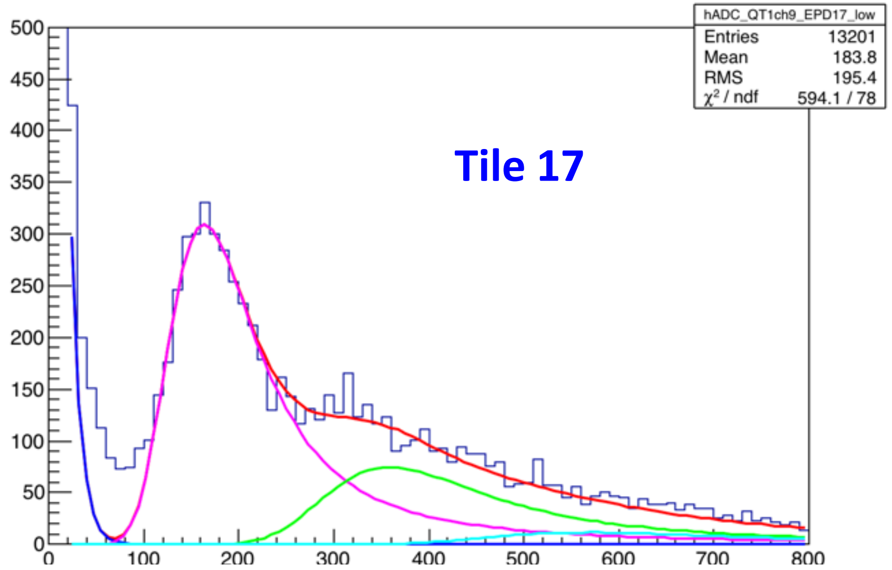
Avg. photons per MIP

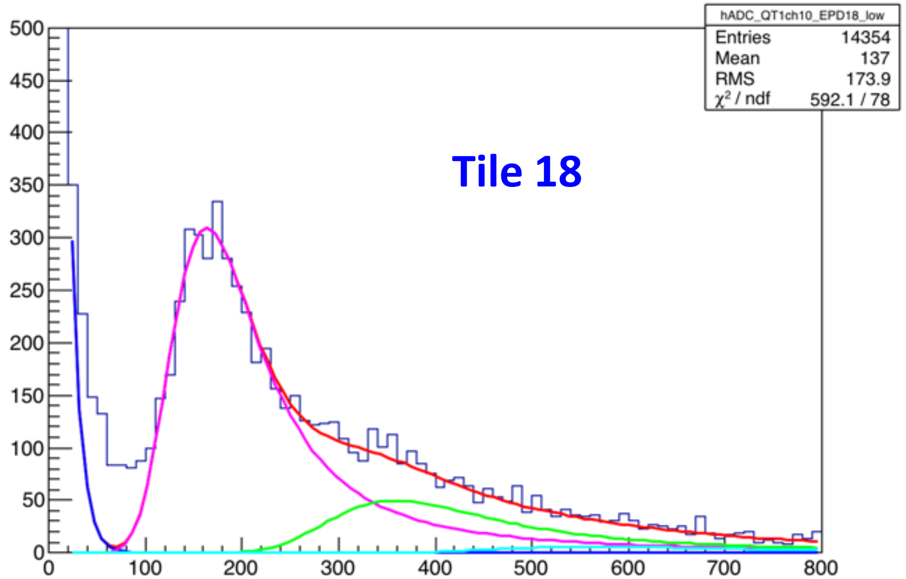
Systematics as expected

larger tiles → fewer photons

"Twin tiles" display identical Minimum Ionizing Particle (MIP) response

The only difference is higher multi-hit probability in tile 17, which was closer to the beam

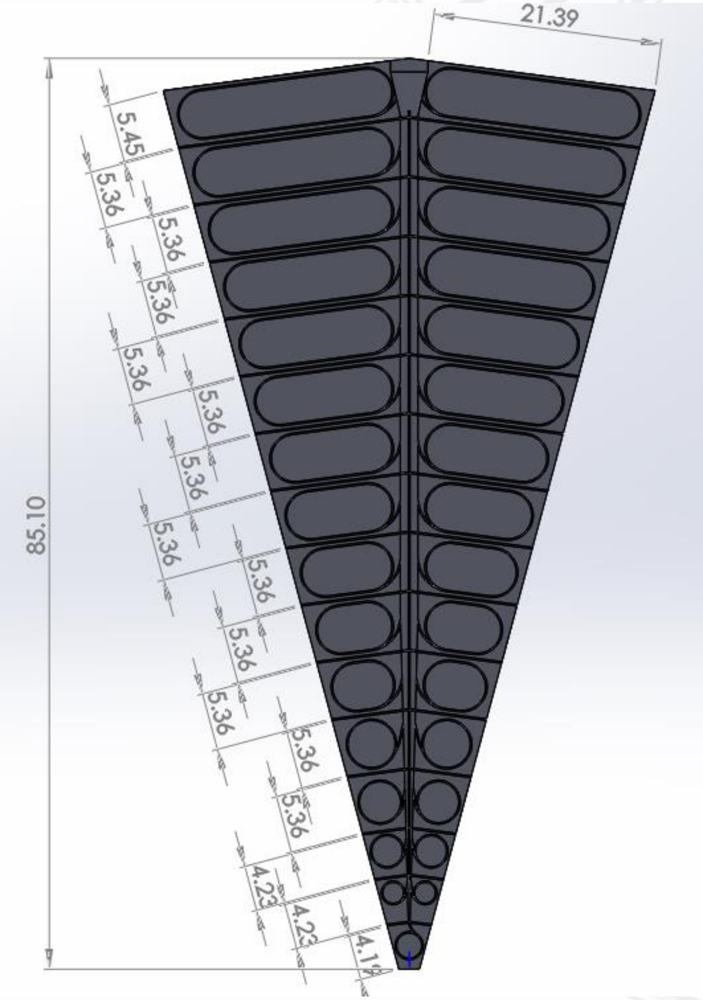




Supersector production

1. mill isolation grooves (1.65 mm wide) on back ½-way (6 mm deep)
2. TiO_2 + epoxy mixture for isolation grooves, mill the front
    - remaining isolation grooves
    - WLS fiber grooves (3.5mm), with ramps
3. epoxy FFC with WLS fibers
4. optical glue WLS in sigma grooves and central channel
5. TiO_2 + epoxy mixture for front isolation grooves
6. polish edges, touch-up
7. wrap
8. bench tests

Design



2 Wheels, each composed of 12 supersectors

Each supersector: 31 optically-isolated tiles
- 1.2-cm-thick scintillator (Eljen EJ-200)
- 3 turns of WLS fiber (Kuraray Y-11, 1 mmD)
  - (3 turns ~doubles light output rel. 1 turn)
- R_{in}=4.5 cm, R_{out}=90 cm, z_{mount}=375 cm

Each of 12x31x2=744 channels
- optical signal transported 5.5 m on clear fiber (Kuraray 1.15 mmD BJ round)
- coupled to SiPM (Hamamatsu S13360-1325PE)
  - 25-µm pixels → 1600+ illuminated pixels
- read out by STAR FEEs/QTs, similar FPS

Custom-built connector components
- 3D-printed