An Improved Event Plane Detector for the STAR Experiment

Justin Ewigleben, Lehigh University
For the STAR Collaboration

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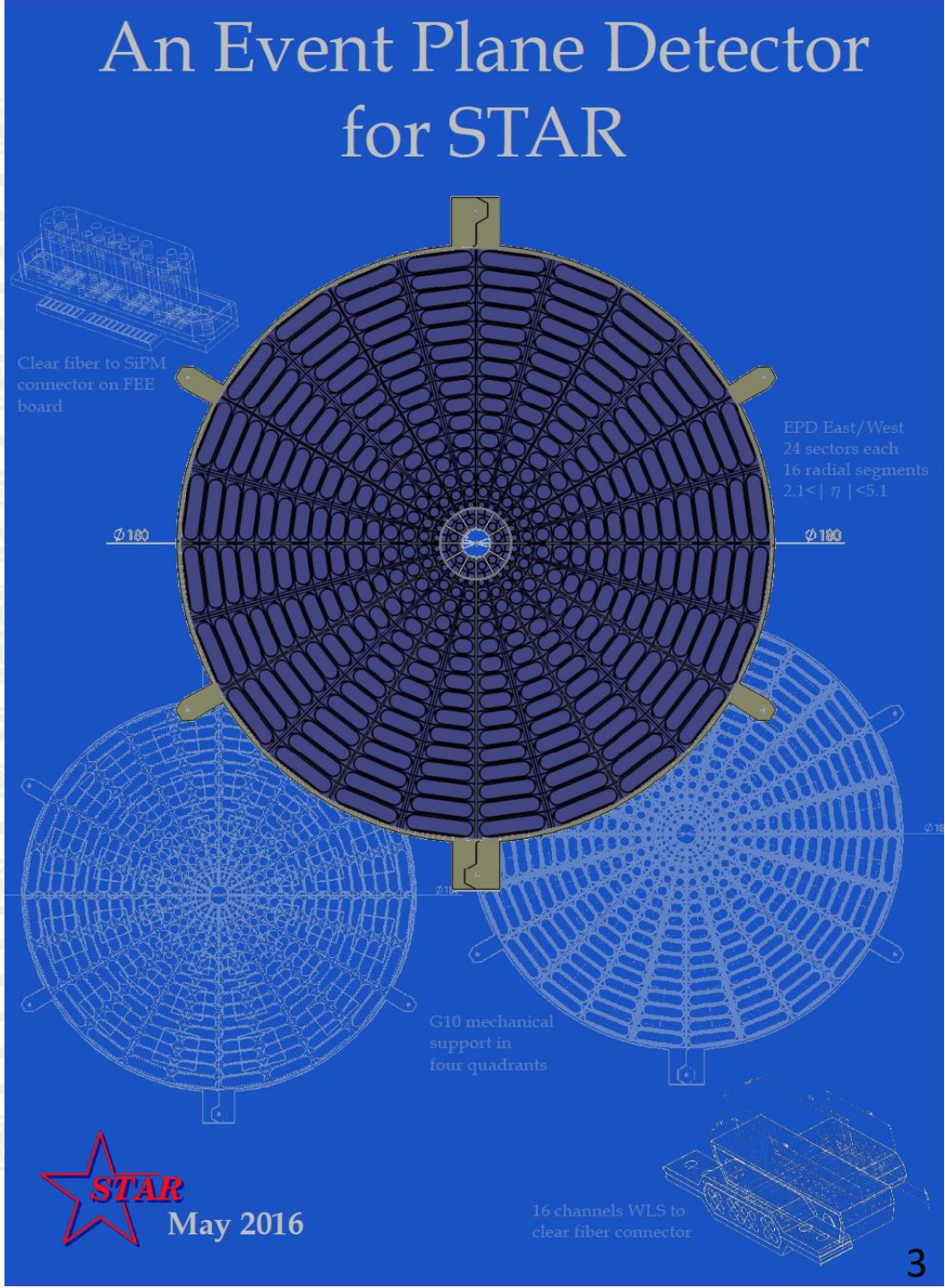
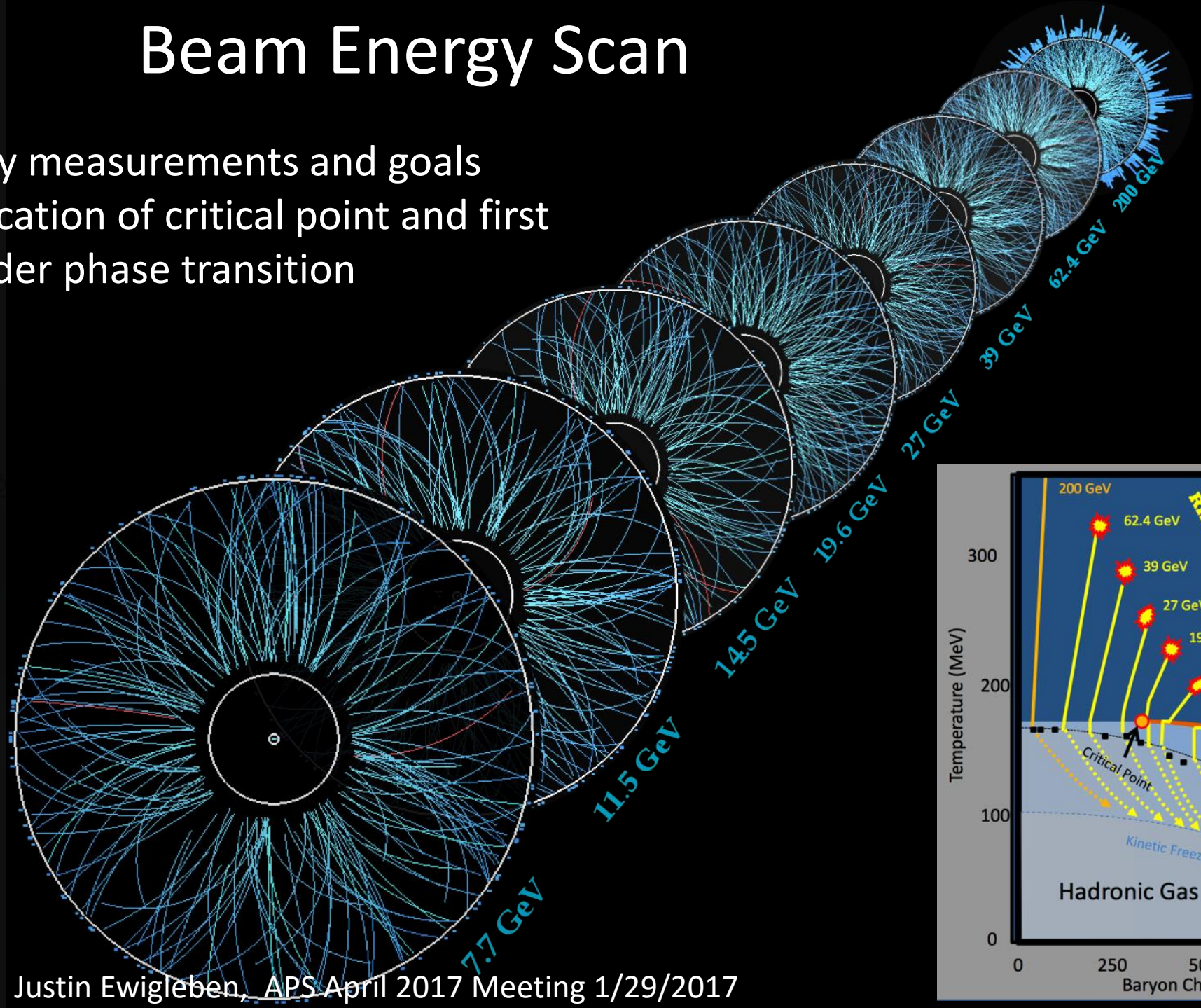
Outline

- Motivation
- Design/Construction
- Timeline
- Summary

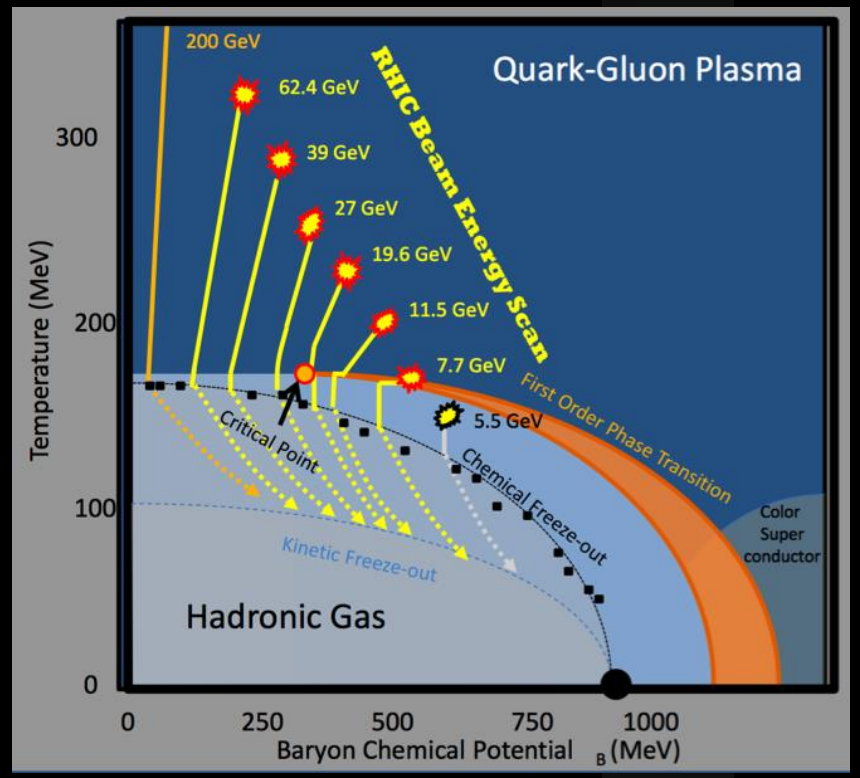


Beam Energy Scan

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

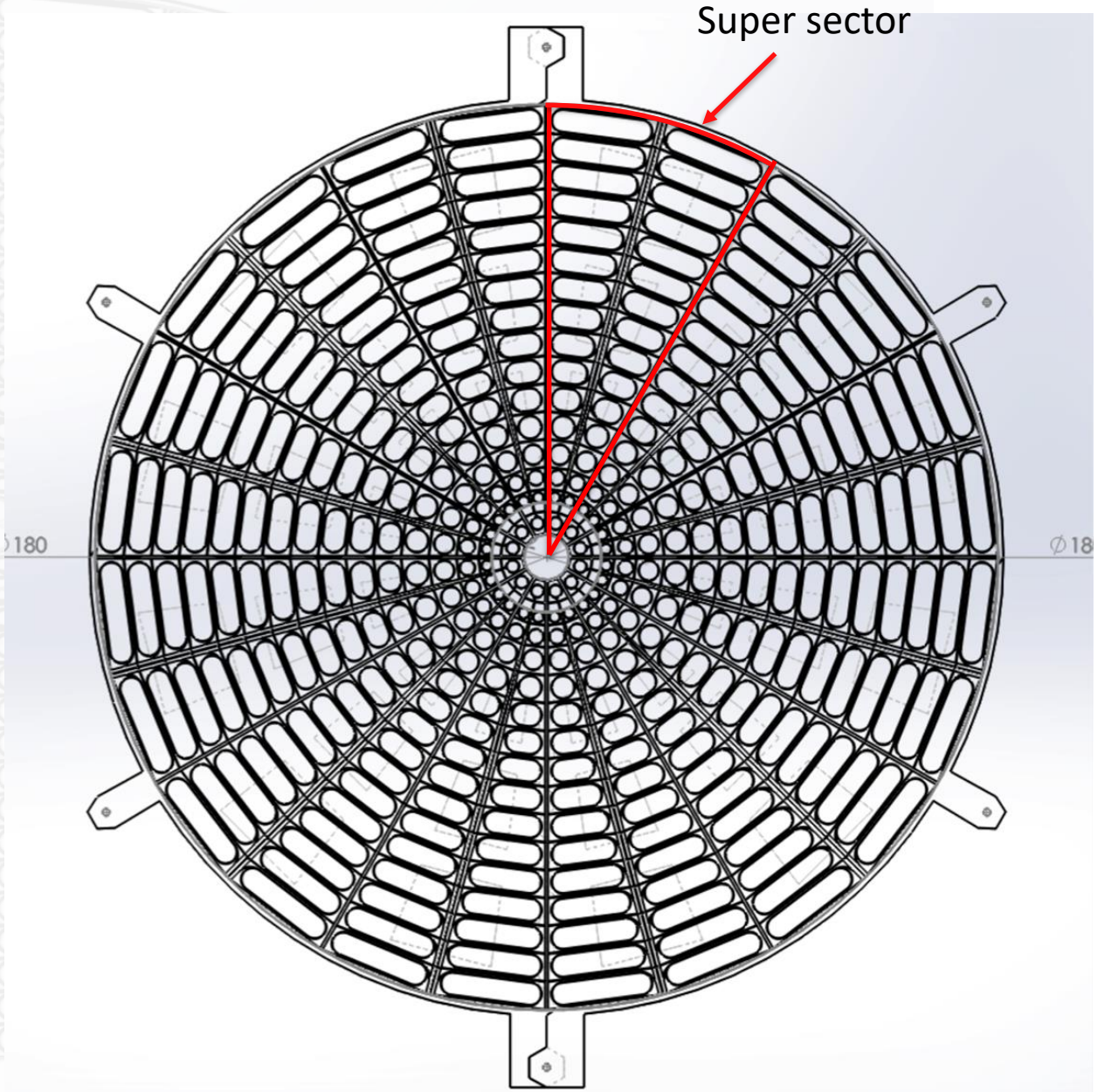


Centrality, Event Plane and Triggering

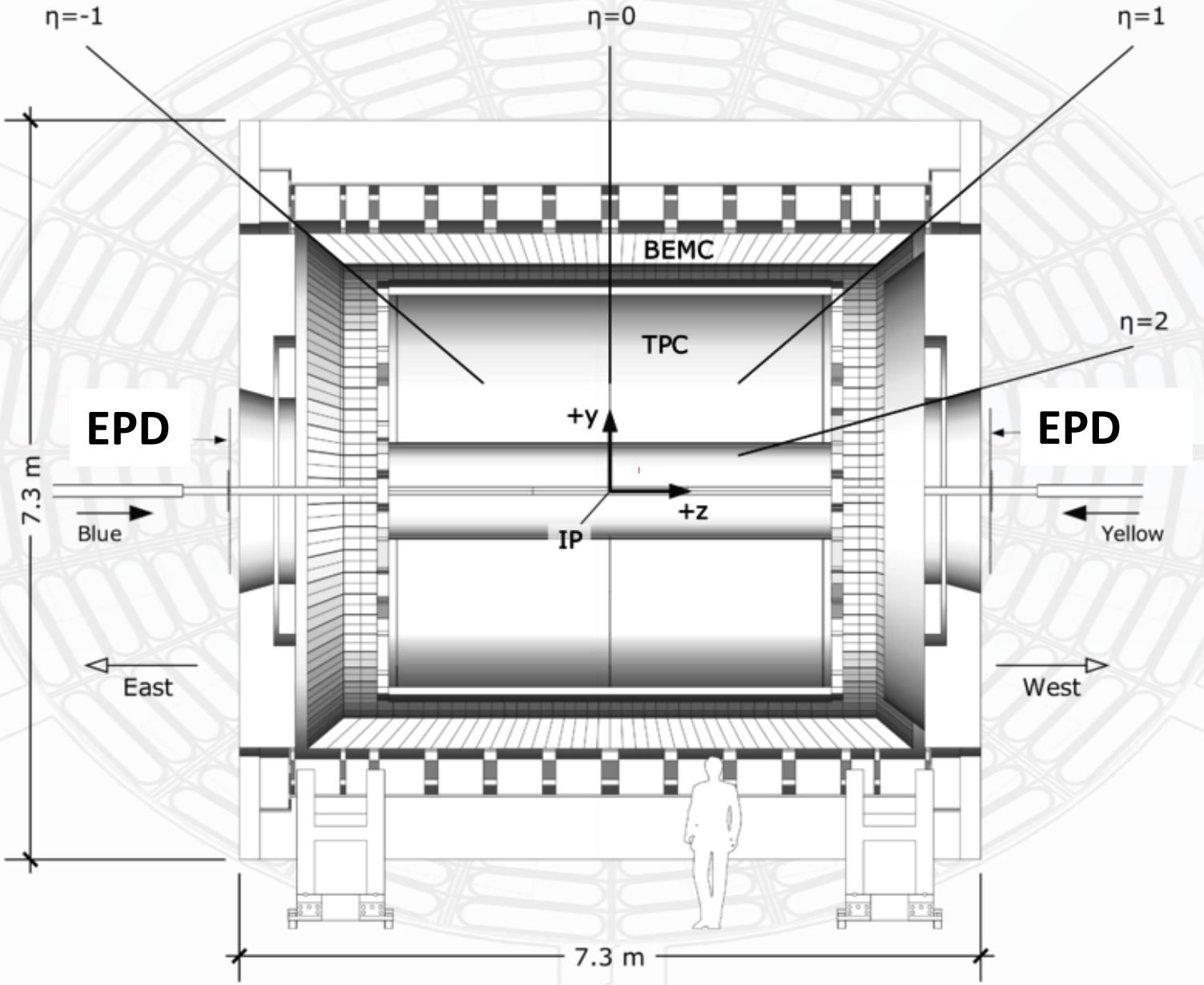


Overview

- Replacement for Beam-Beam Counter (BBC)
- Made of scintillator plastic
- Two, 1.8m diameter wheels of 12 super sectors each
- Each super sector contains 31 optically isolated channels (744 total)
- Optical fiber coupled to Silicon Photomultipliers (SiPMs)
- Read out by STAR electronics

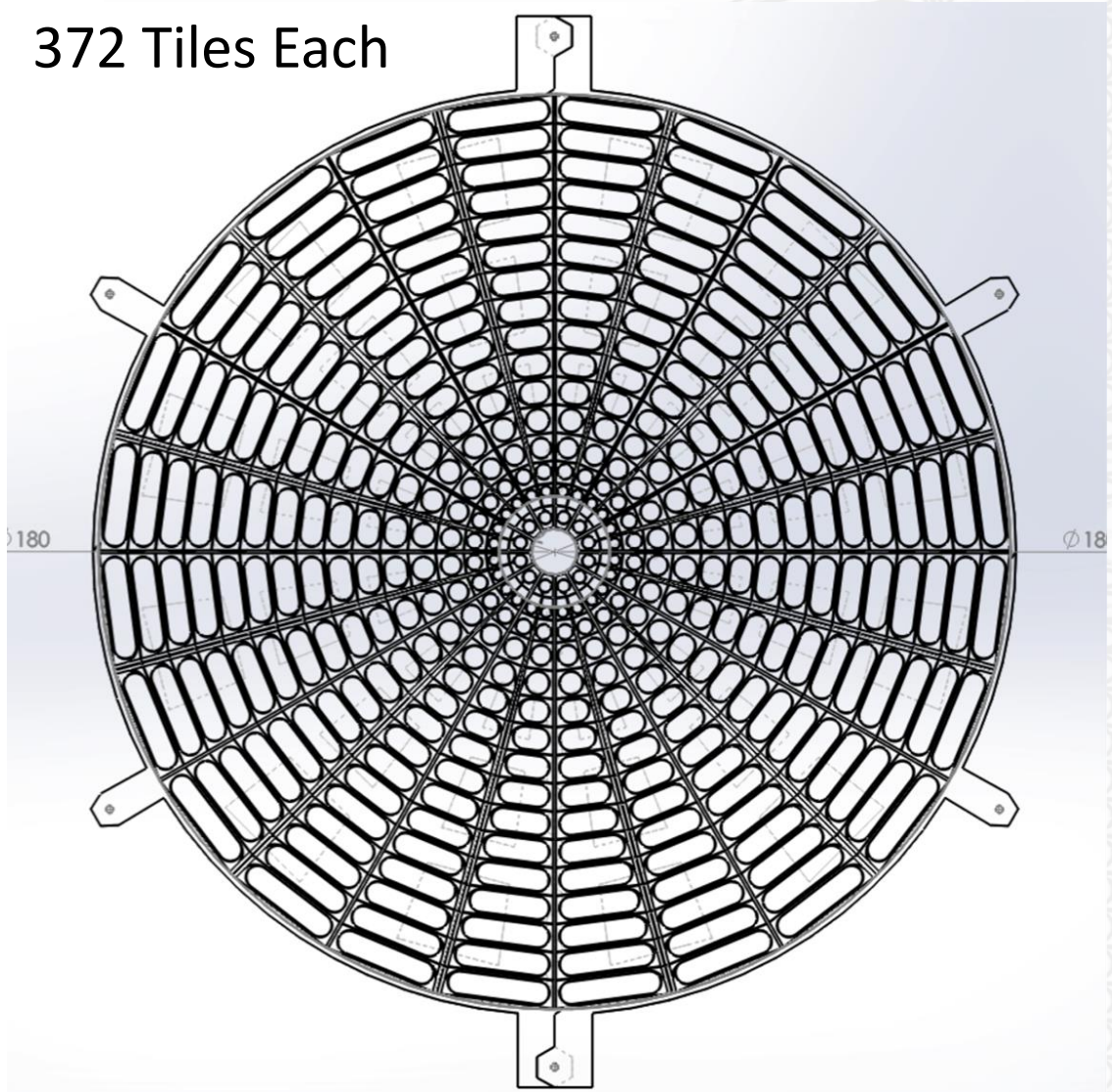


STAR TPC and EPD

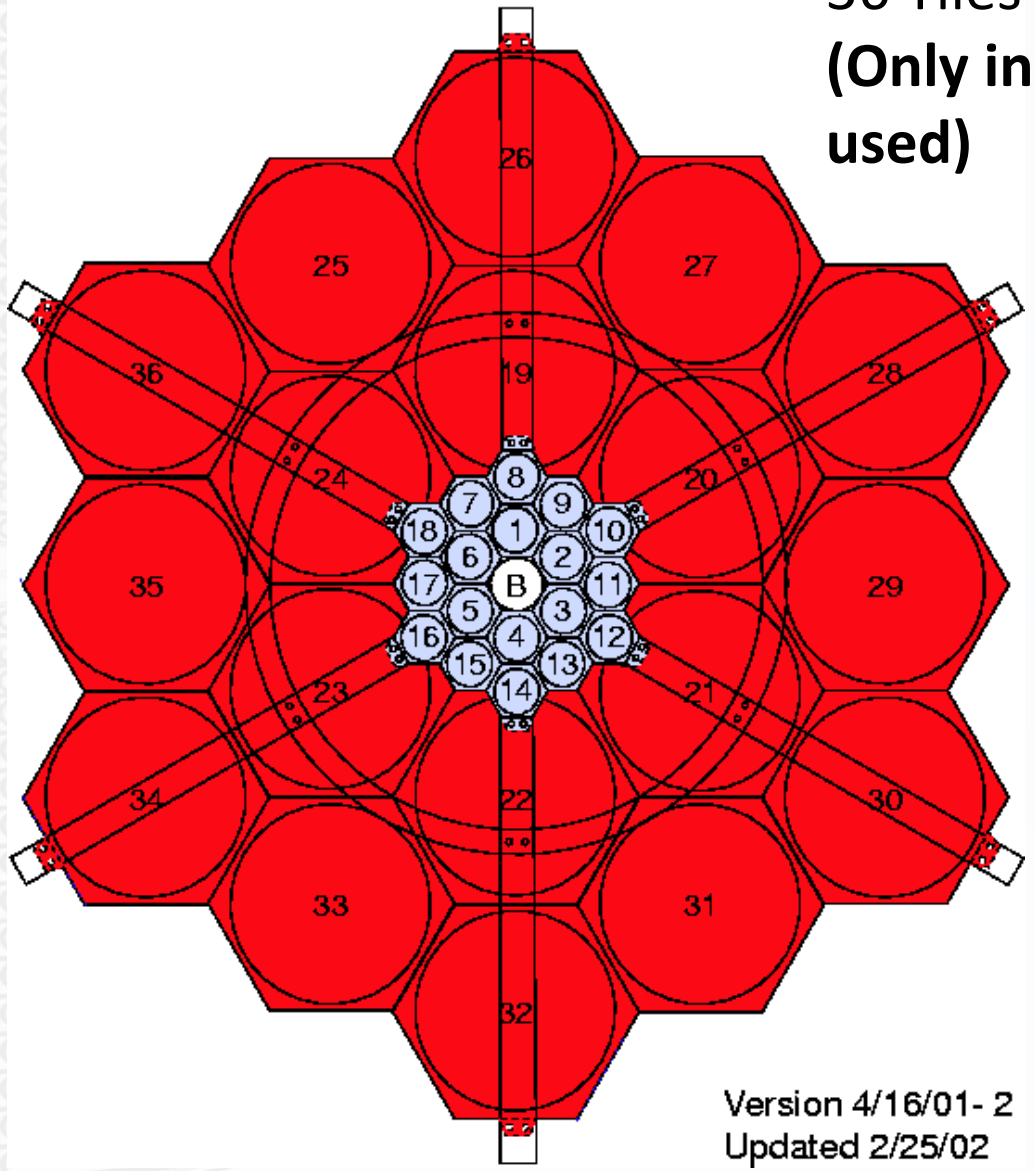


EPD vs BBC

372 Tiles Each

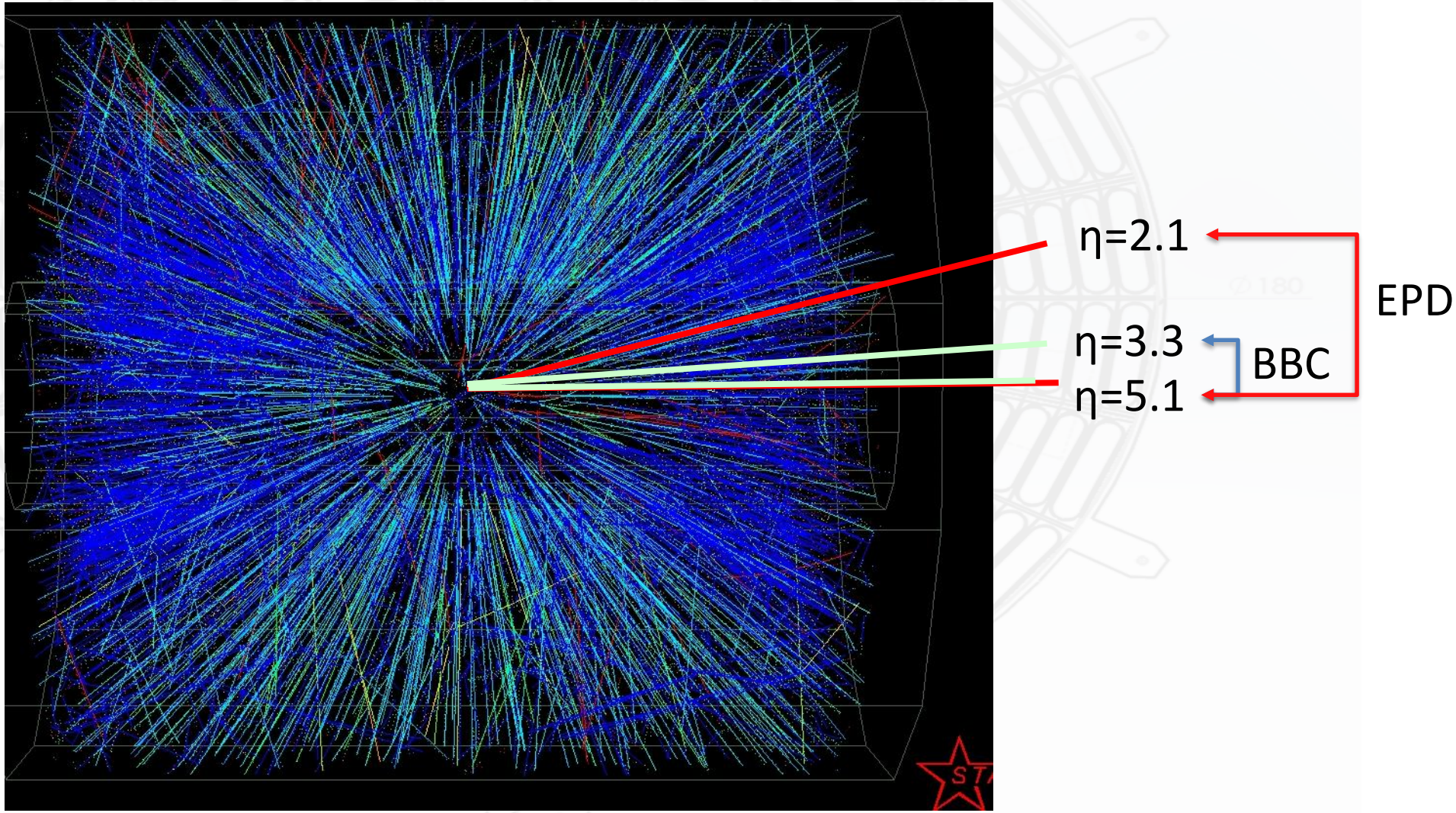


36 Tiles Each
(Only inner 18 used)

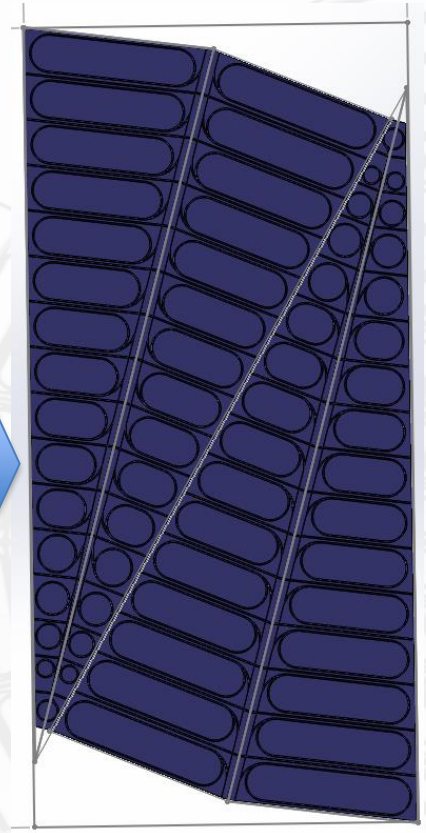


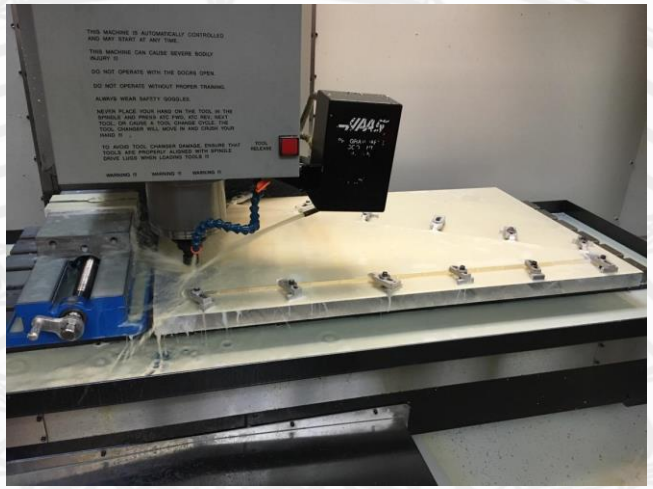
EPD, BBC coverage

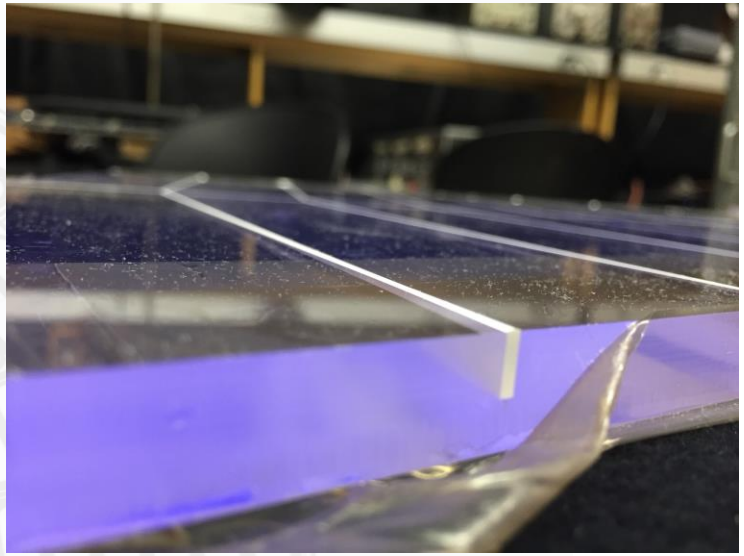
BBC: |η|=3.3-5 → θ=0.8°-4.2°
EPD: |η|=2.1-5.1 → θ=0.7°-14°

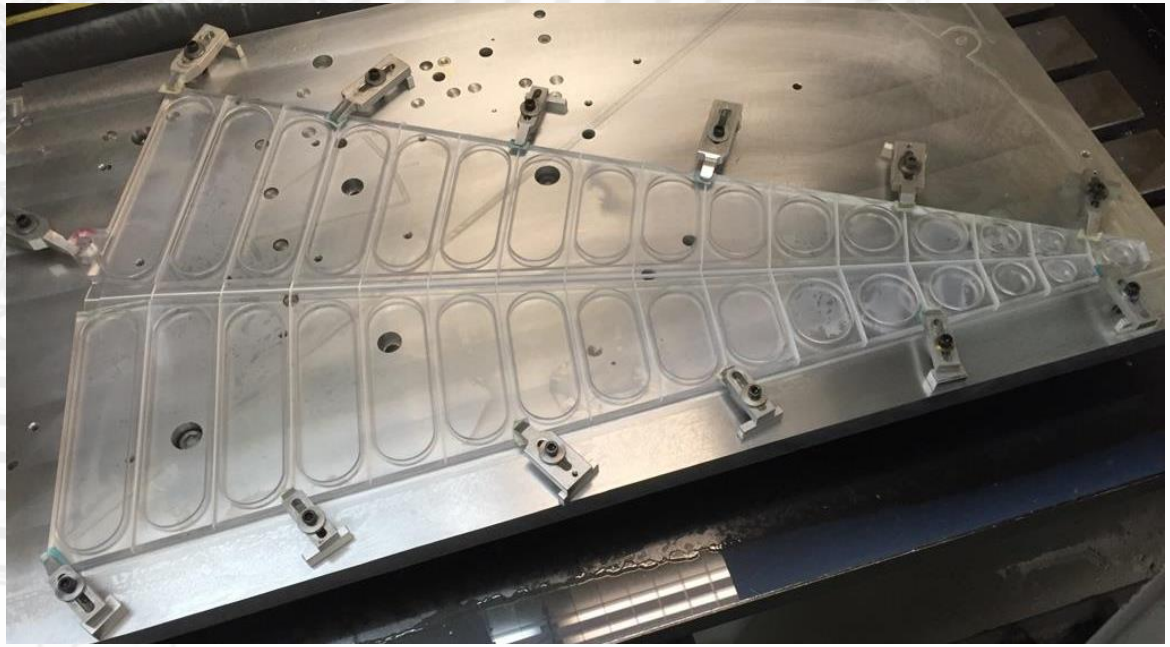


Machining and Optical Isolation





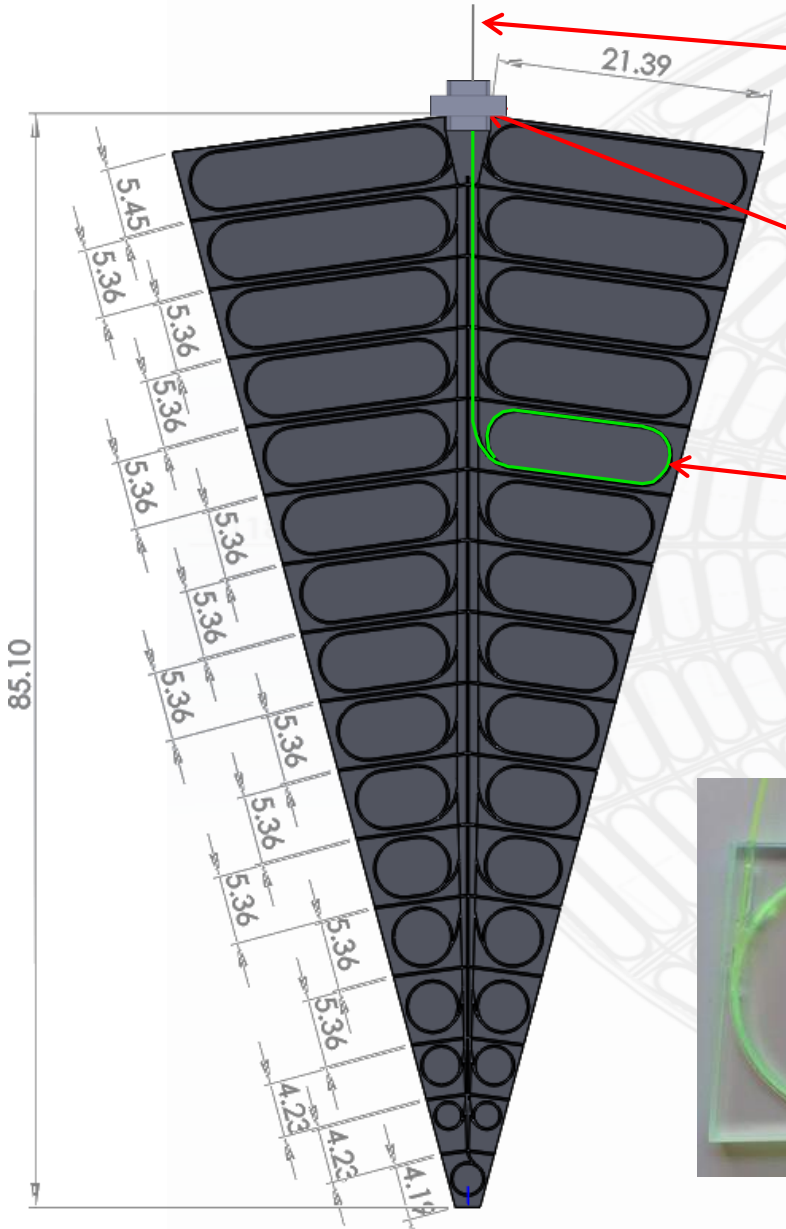




CNC milling

- high volume water/oil for cooling, debris

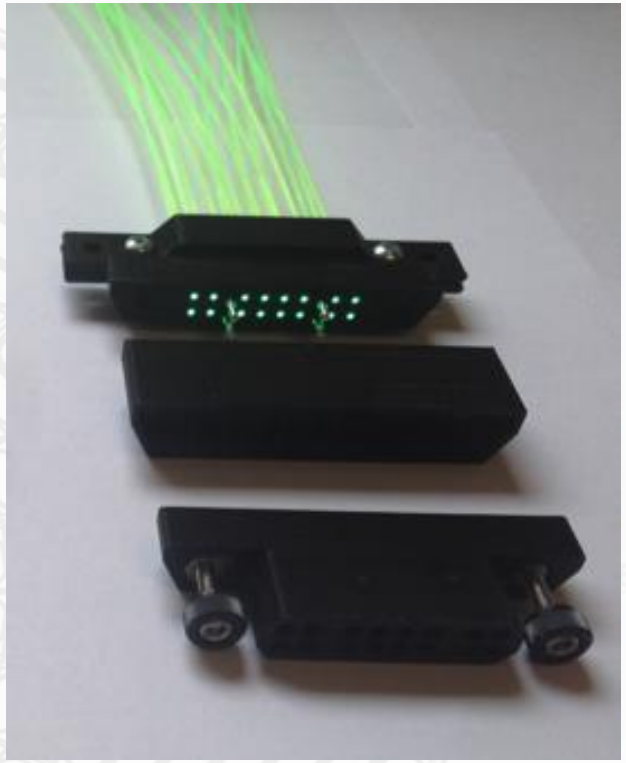
Super Sector Construction



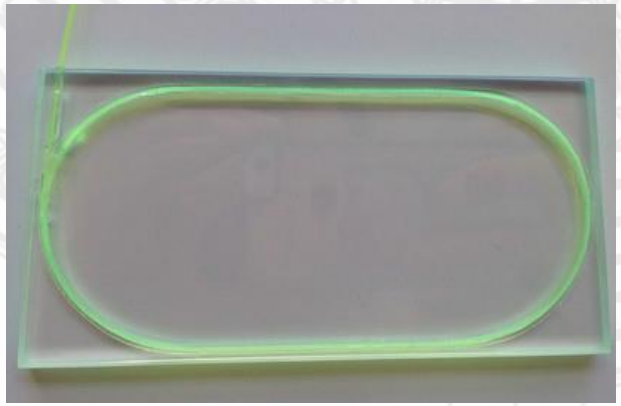
Clear fibers

Embedded 32-channel fiber-to-fiber connector

Embedded WLS fibers

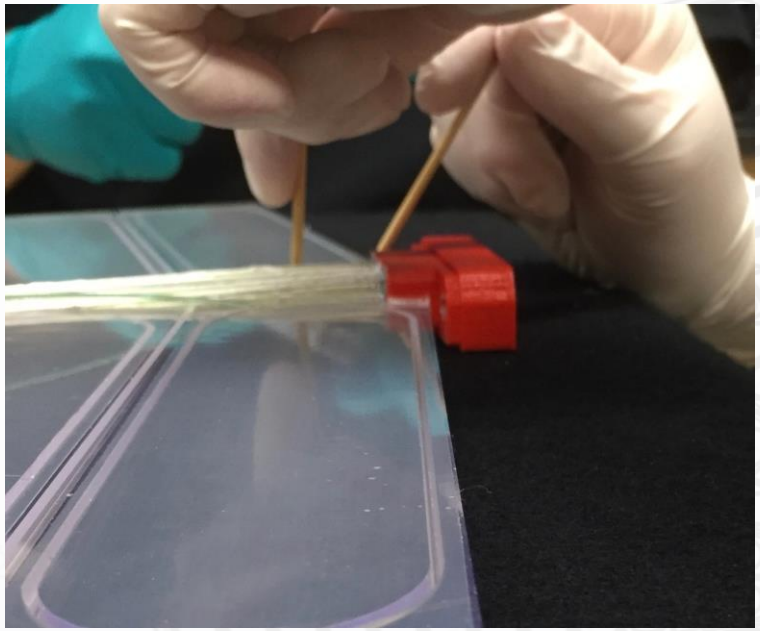


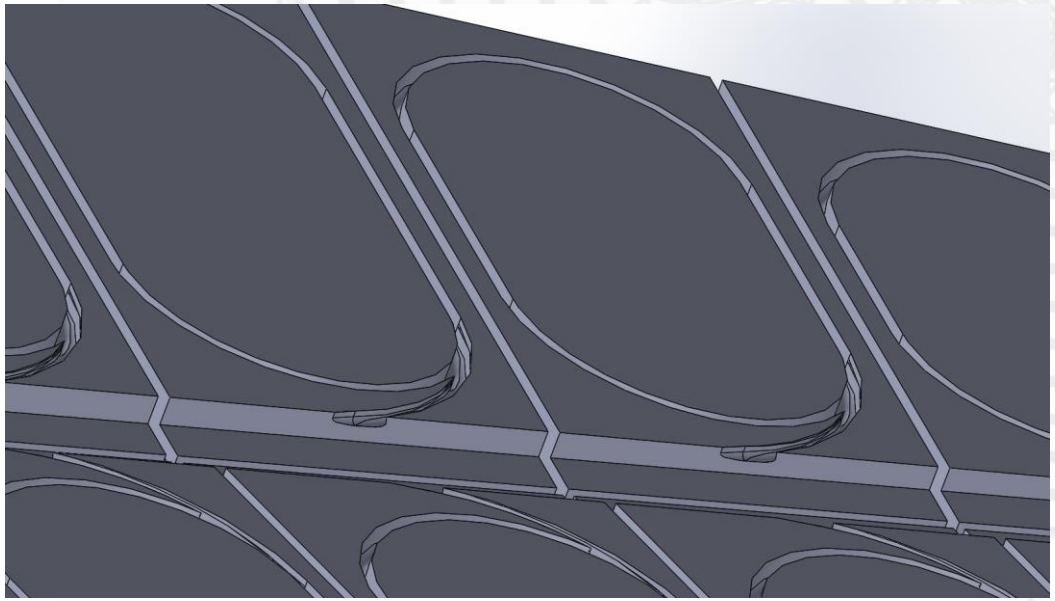
A test tile

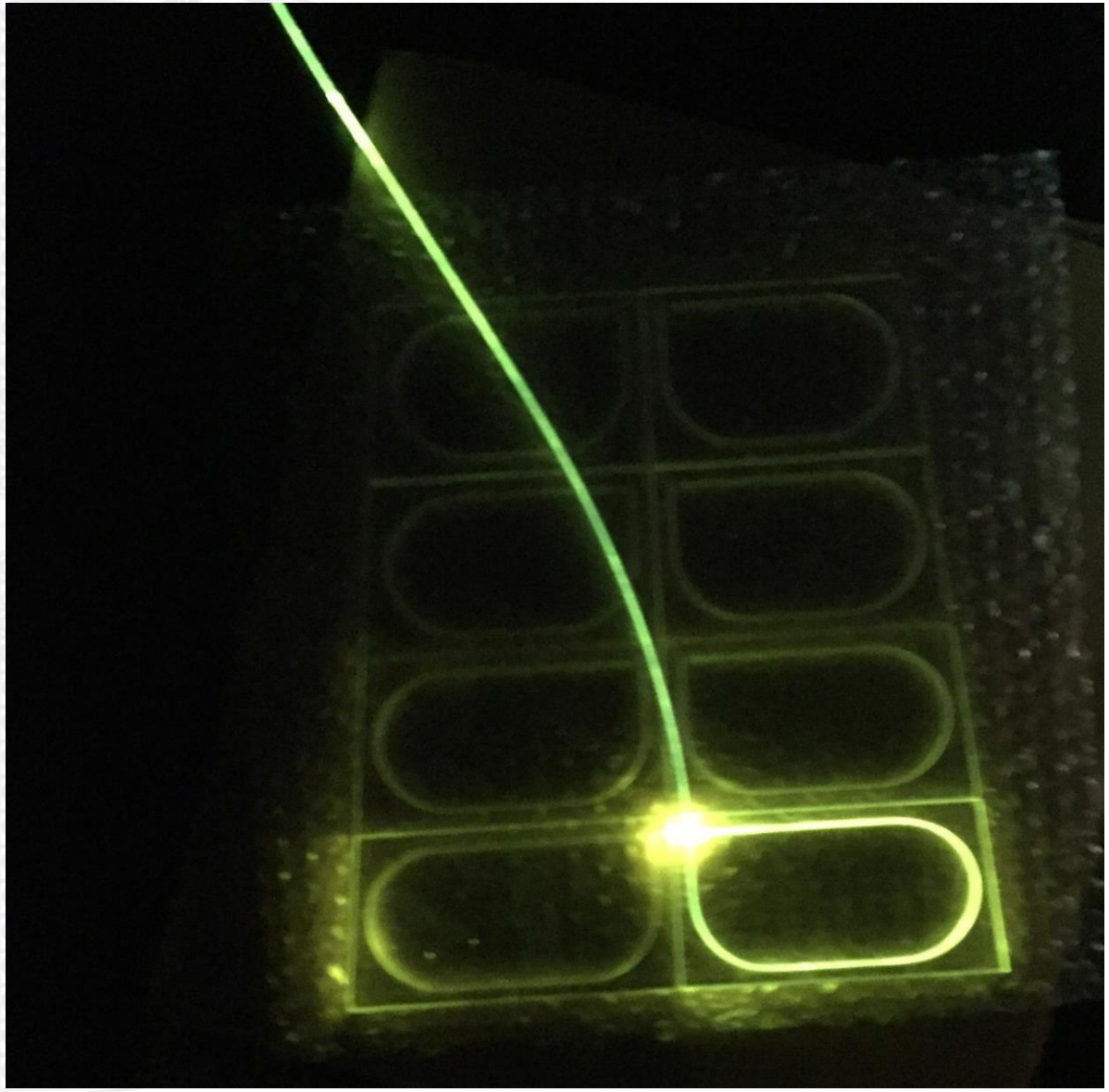


- Connected to 5 meters of clear fiber with 3D-printed custom connectors
- Super Sector will be wrapped in Tyvek and 2 layers of black paper (light tight)

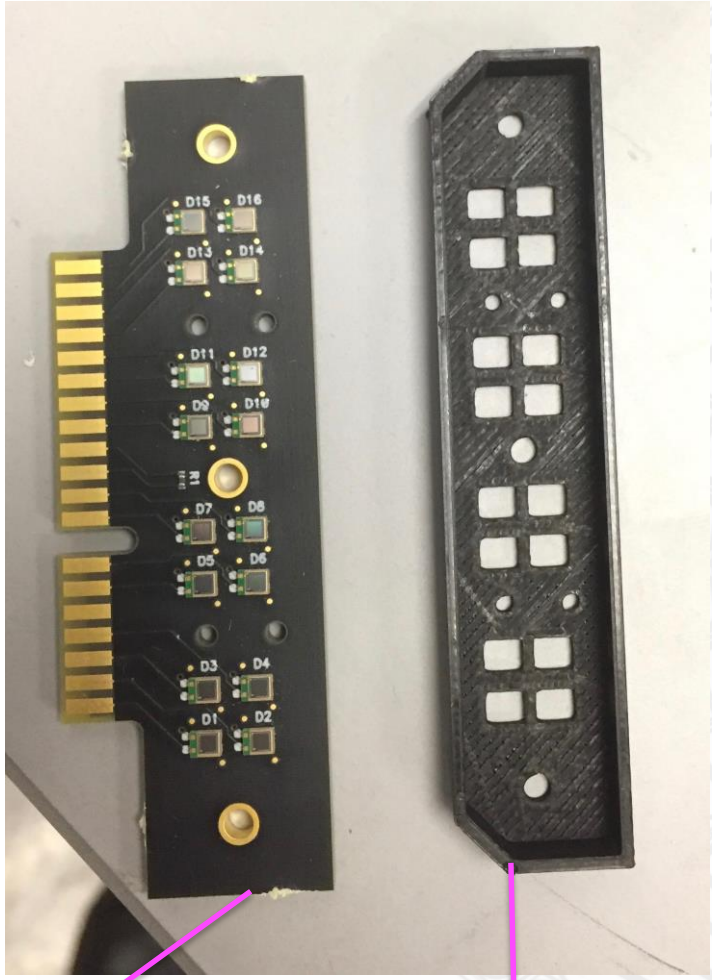
Front WLS grooves





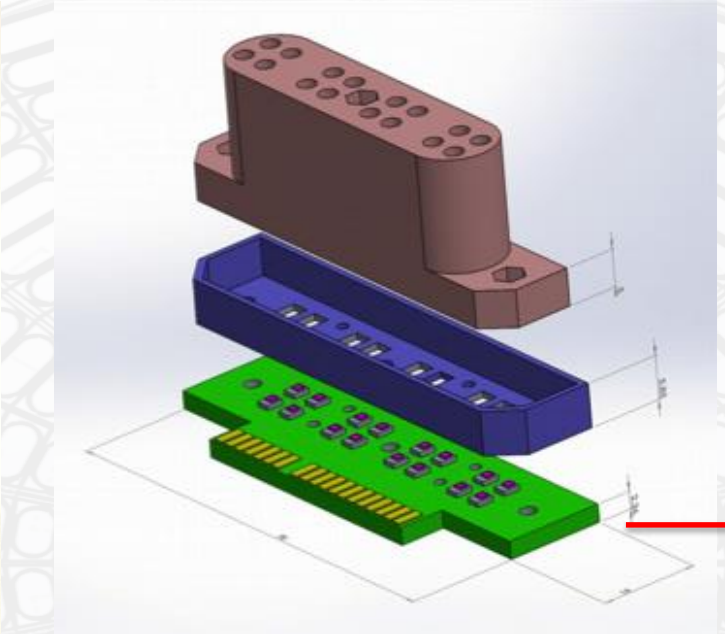


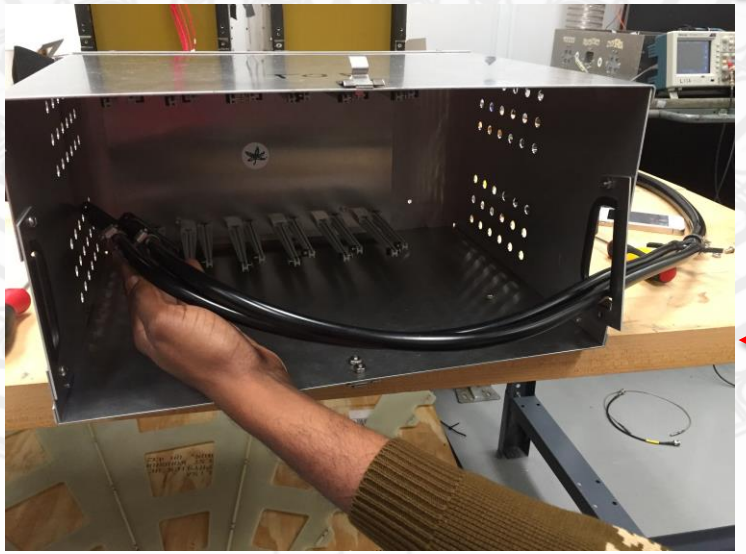
Clear fiber bundle meets readout electronics



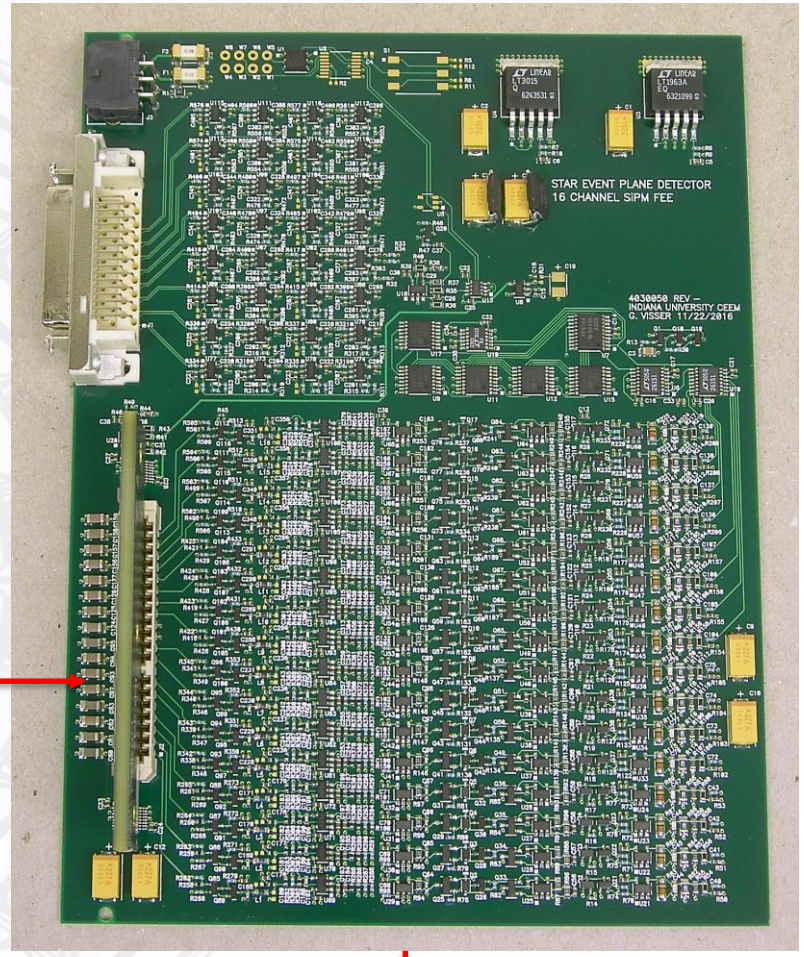
EPD FSC spacer block

EPD SiPM card: 16, 25-µm SiPMs



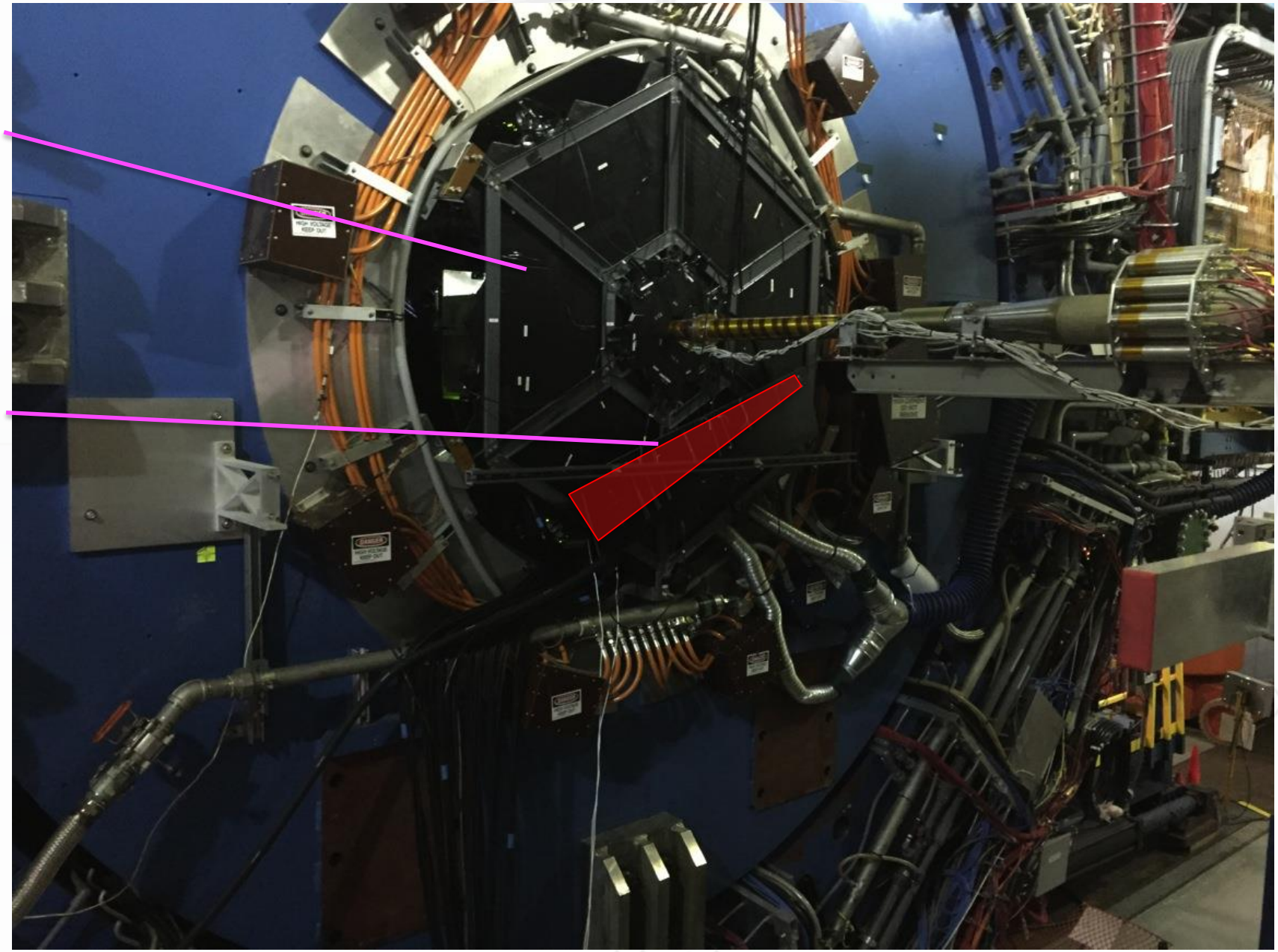


FEE Box

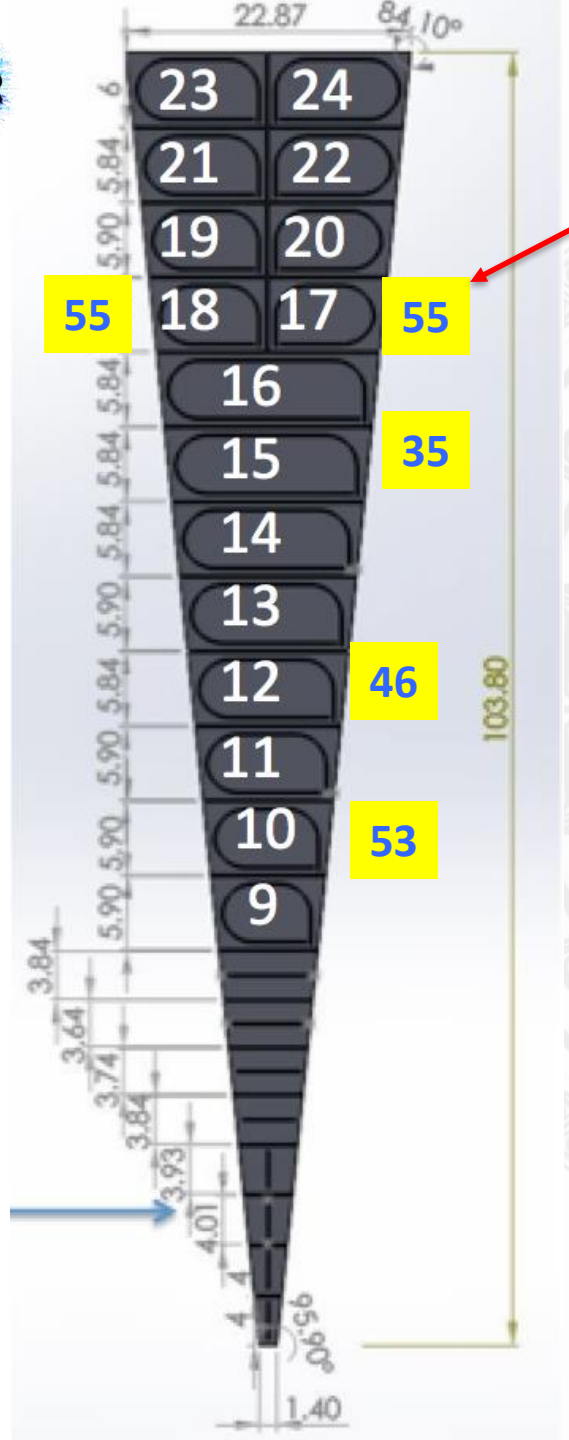


FEE Card

Prototype run 2016



Prototype Results



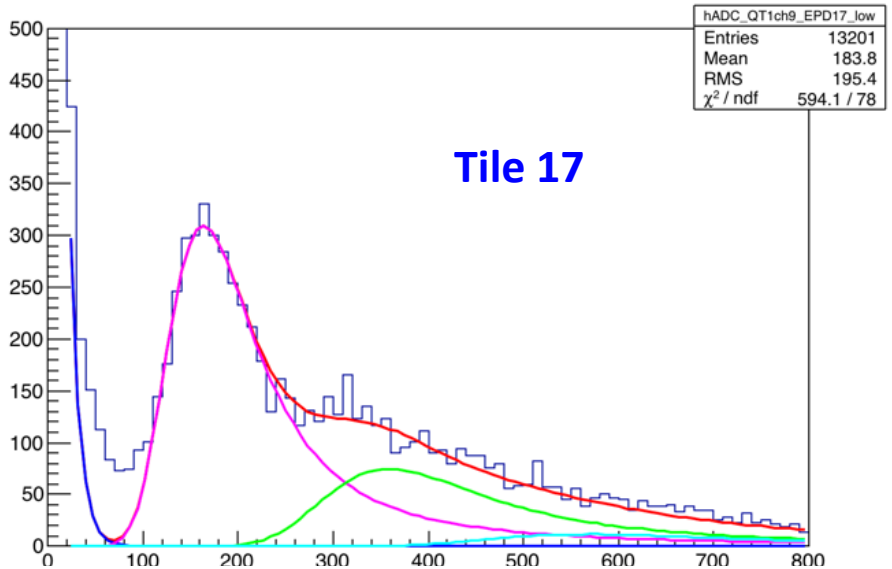
Avg. photons per MIP

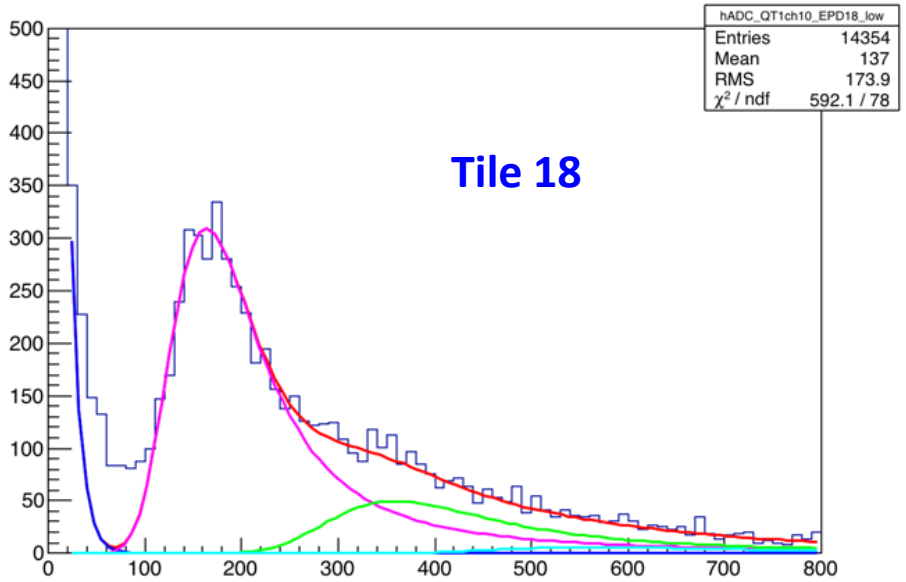
Systematics as expected

larger tiles → fewer photons

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

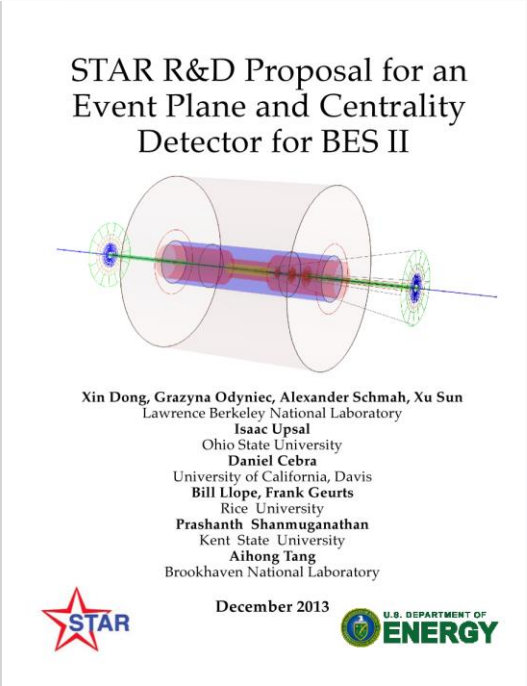
The only difference is higher multi-hit probability in tile 17, which was closer to the beam

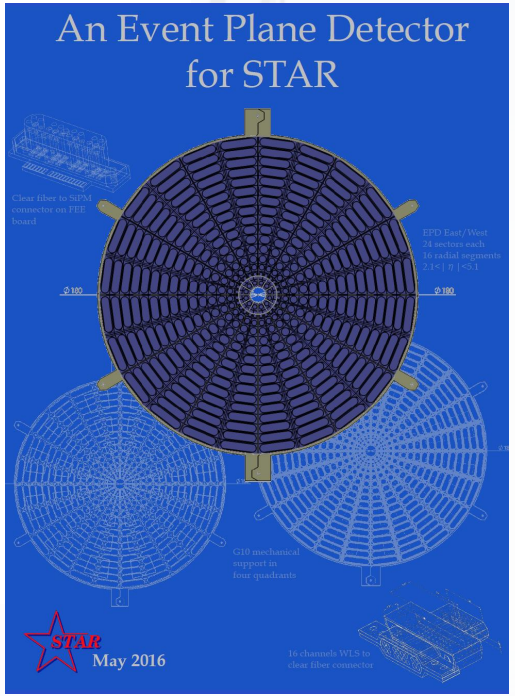




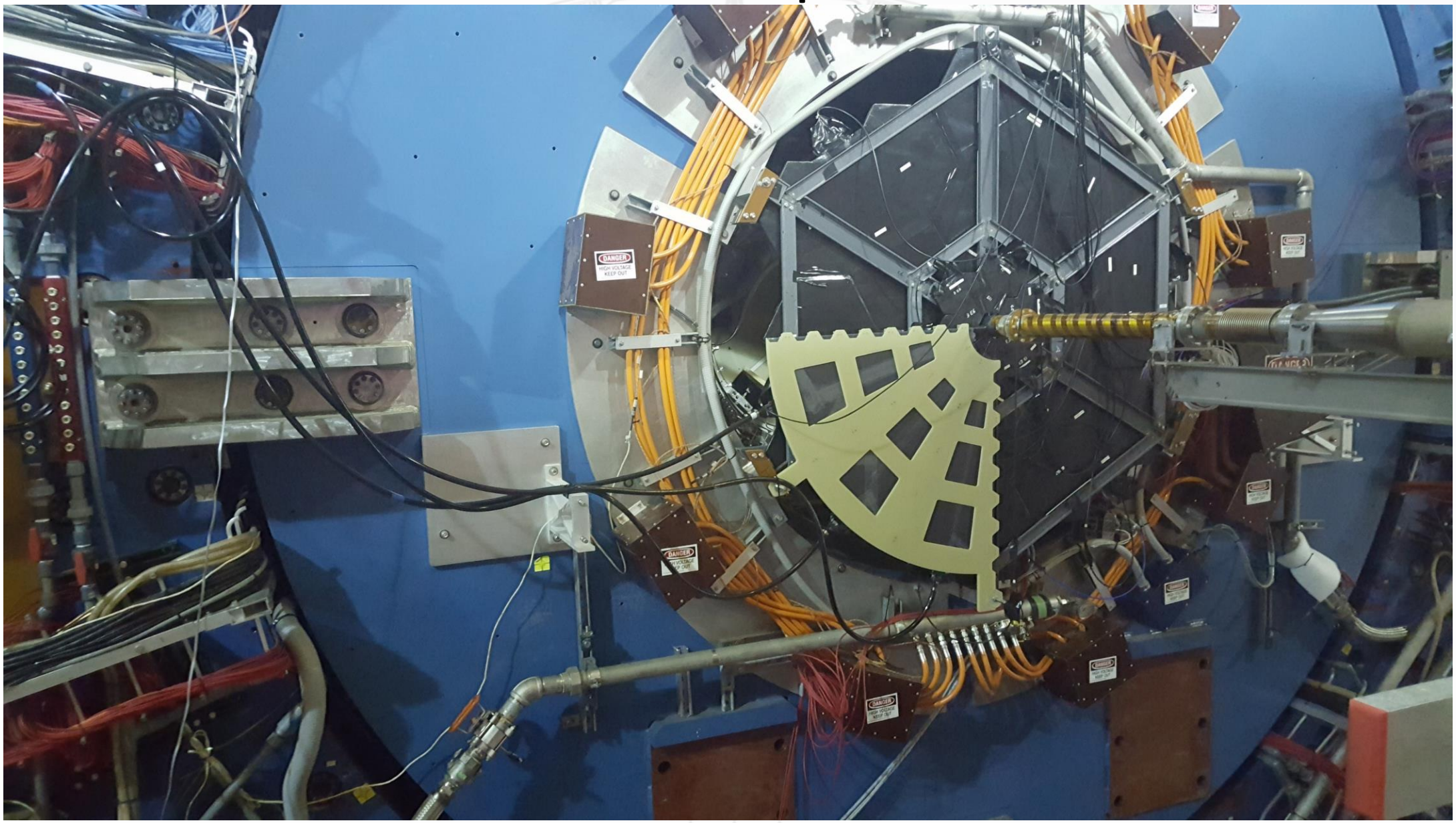
Timeline

- 2015
  - Pre-prototype **run in STAR**
  - Prototype construction
- 2016
  - Prototype **run in STAR** (behind BBC)
  - Analysis of 2016 data
  - Install 1/8 EPD in STAR behind BBC
- 2017
  - Commissioning **run in STAR** of 1/8 EPD behind BBC
  - completion of EPD (24 supersectors) & installation at STAR
- 2018 and beyond – EPD as trigger and physics detector





Quarter Wheel in place at STAR



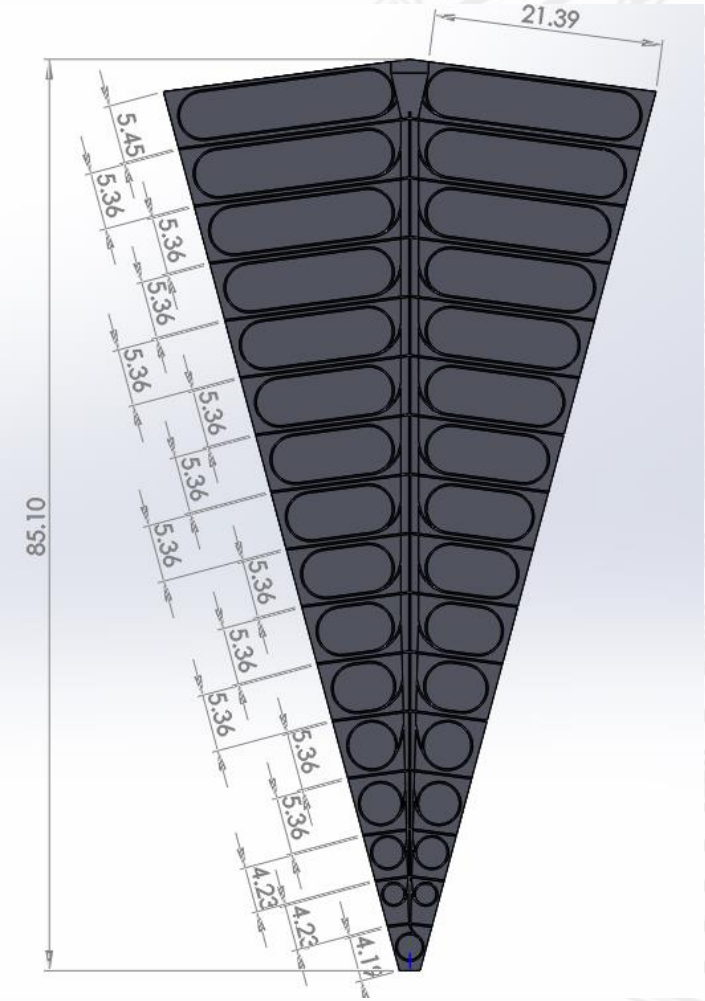
Summary

- EPD is an important upgrade for many measurements, including those for BES-II
- Increased spatial and timing resolution over BBC, as well as pseudorapidity coverage
- Will allow centrality determination without use of TPC to reduce auto-correlation effects
- Design is finalized, first quarter wheel in place for 2017
- Data coming soon!
- Final 7/8 to be completed over 2017 to be installed by end of year, with an extra 4 super sectors to be constructed as a failsafe

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