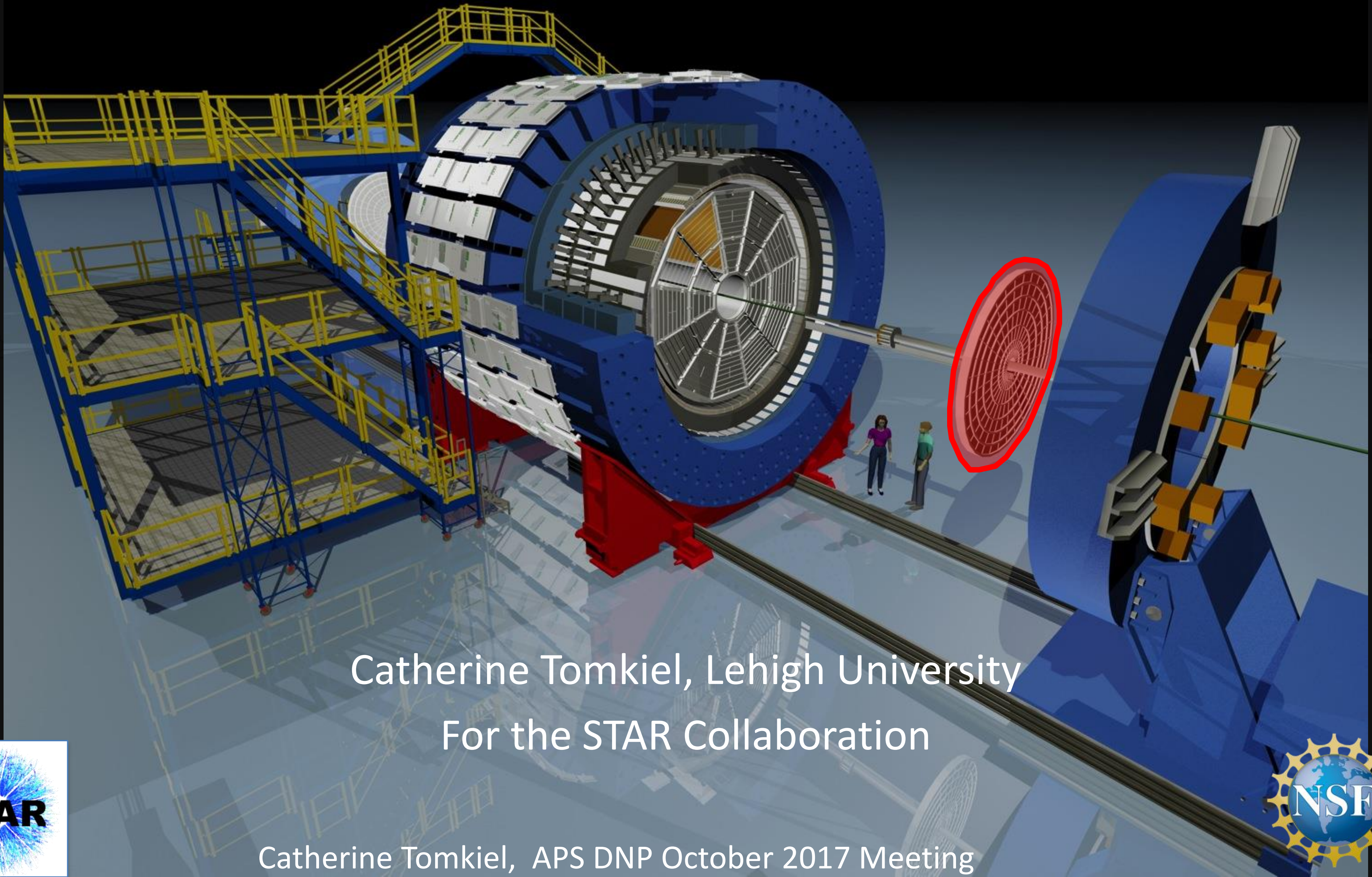
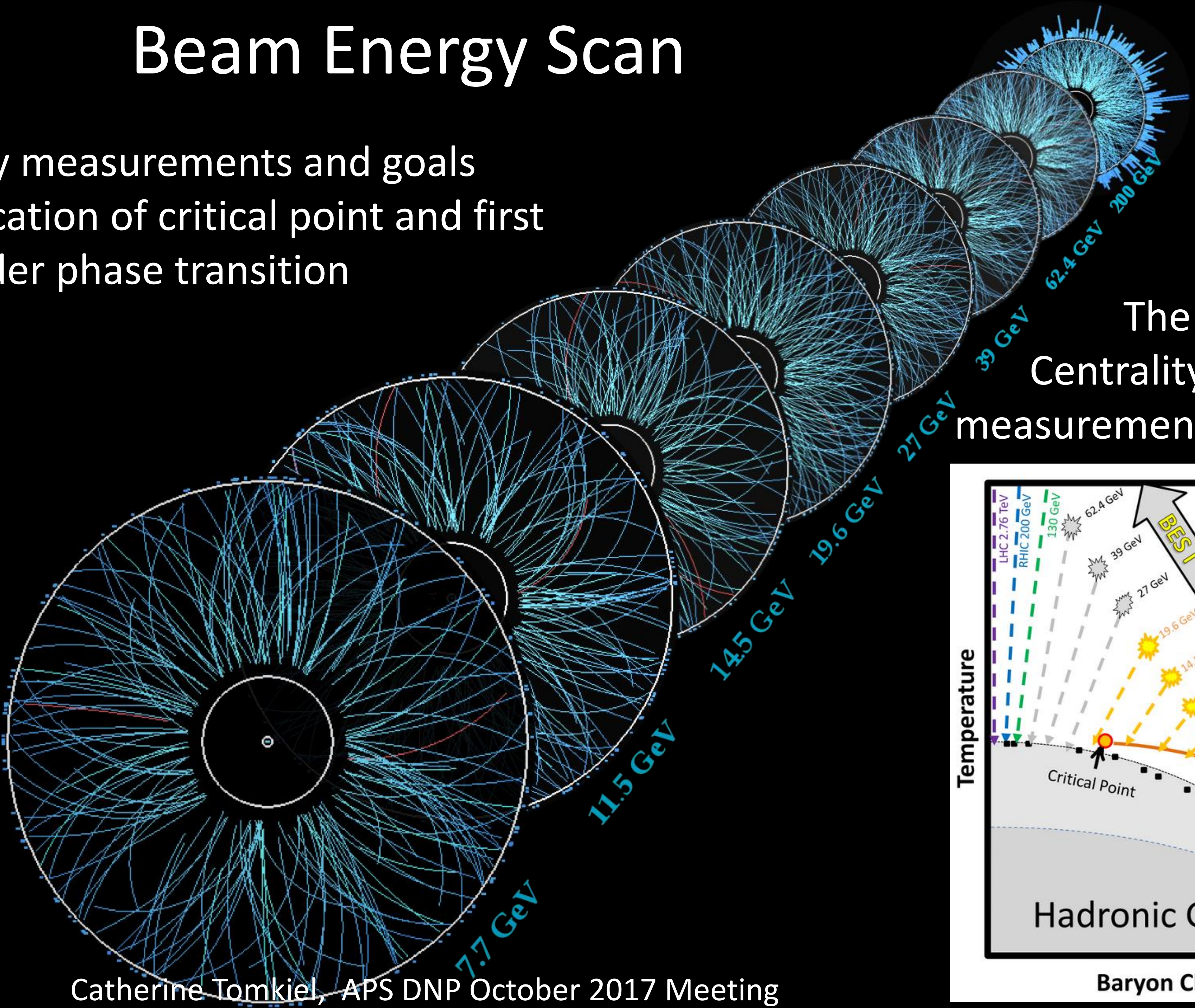
Optical Fibers and Electronics for the STAR Event Plane Detector



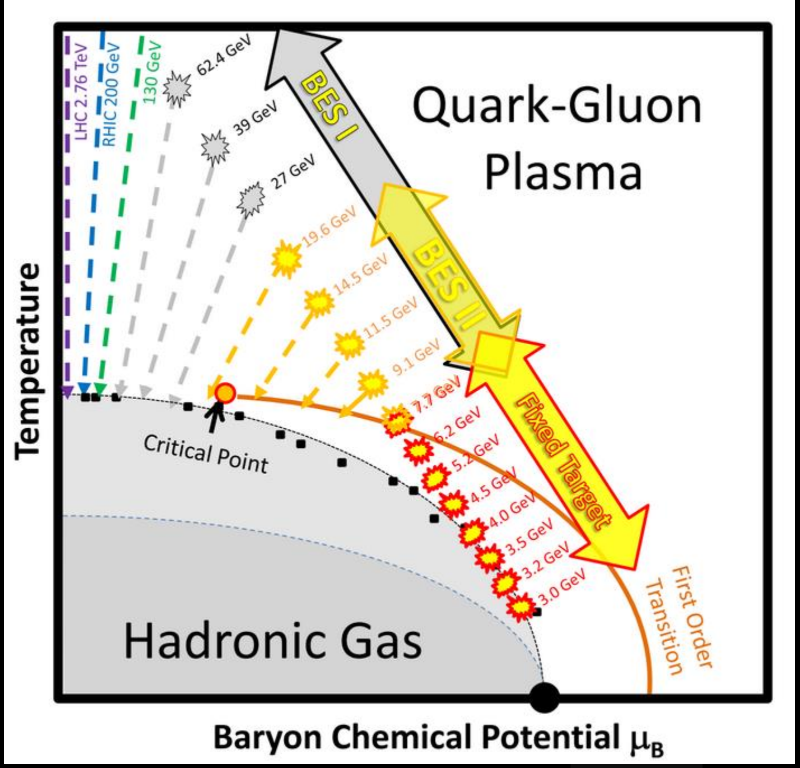
Catherine Tomkiel, Lehigh University
For the STAR Collaboration

Beam Energy Scan

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

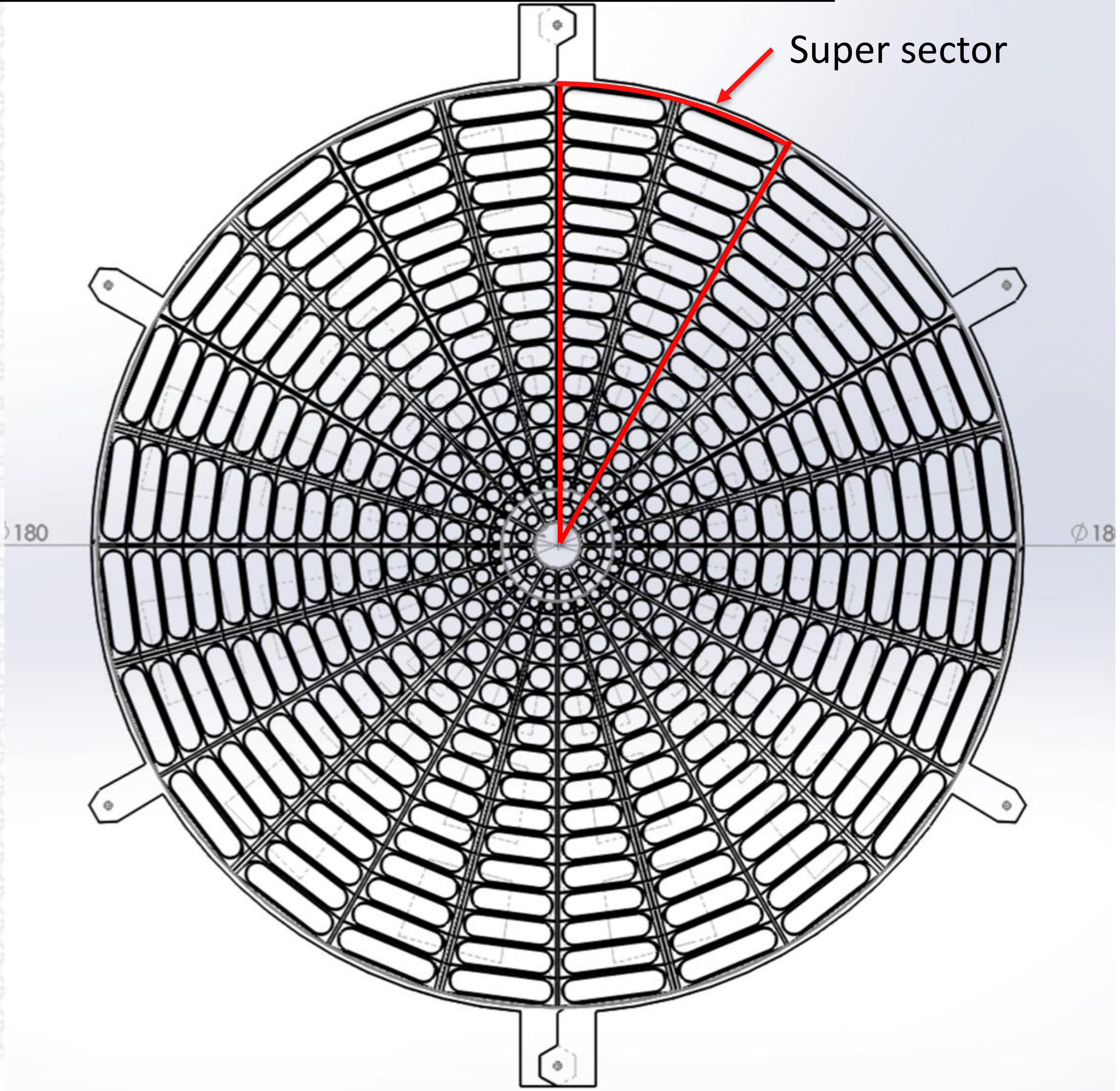


The EPD will improve Centrality and Event Plane measurements, and Triggering

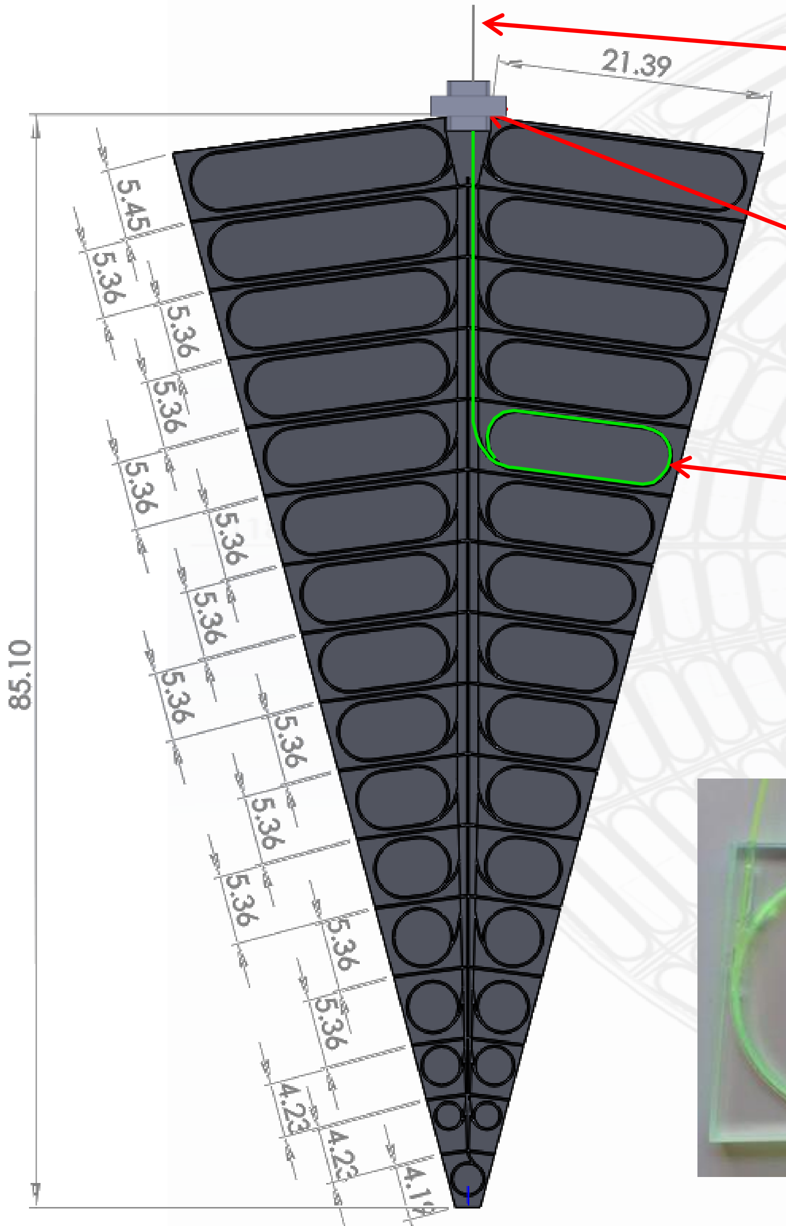


Overview

- Replacement for Beam-Beam Counter (BBC)
- Made of plastic scintillator
- 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



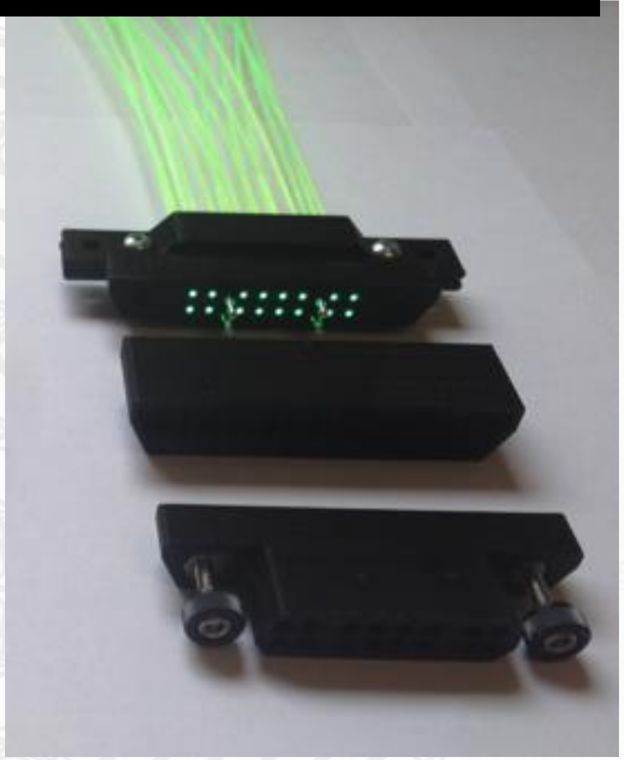
Super Sector Construction



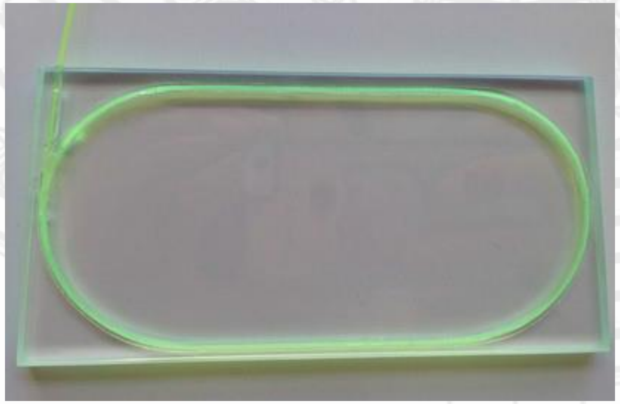
Clear fibers

Embedded 32-channel fiber-to-fiber connector

Embedded Wavelength Shifting (WLS) fibers

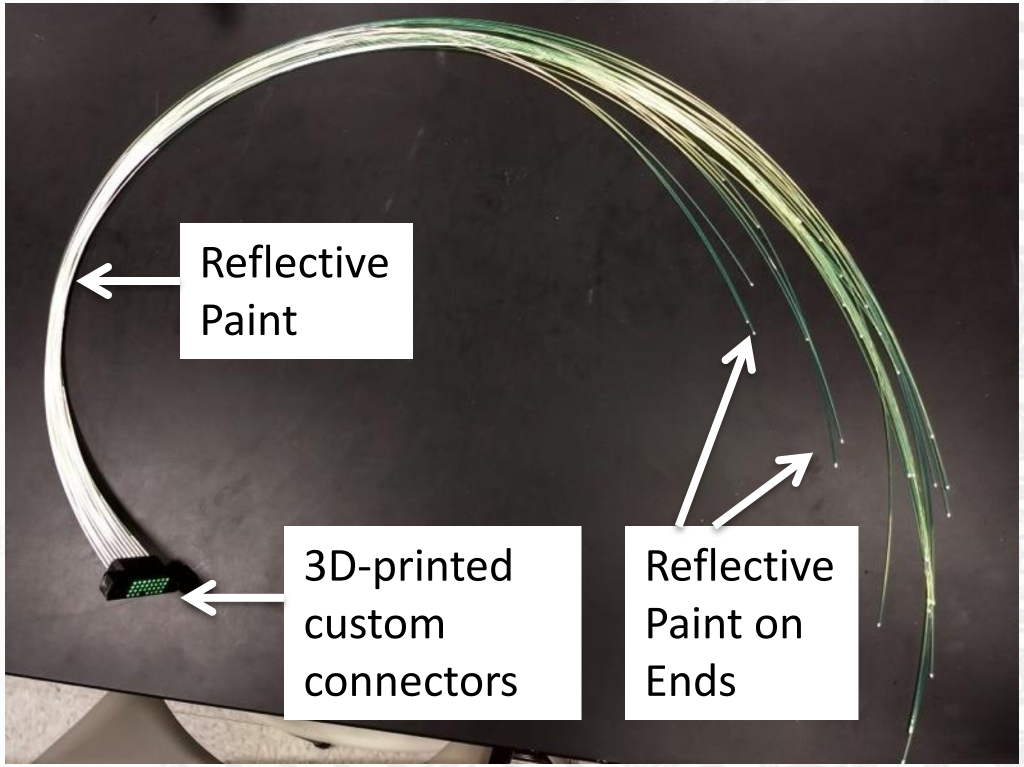


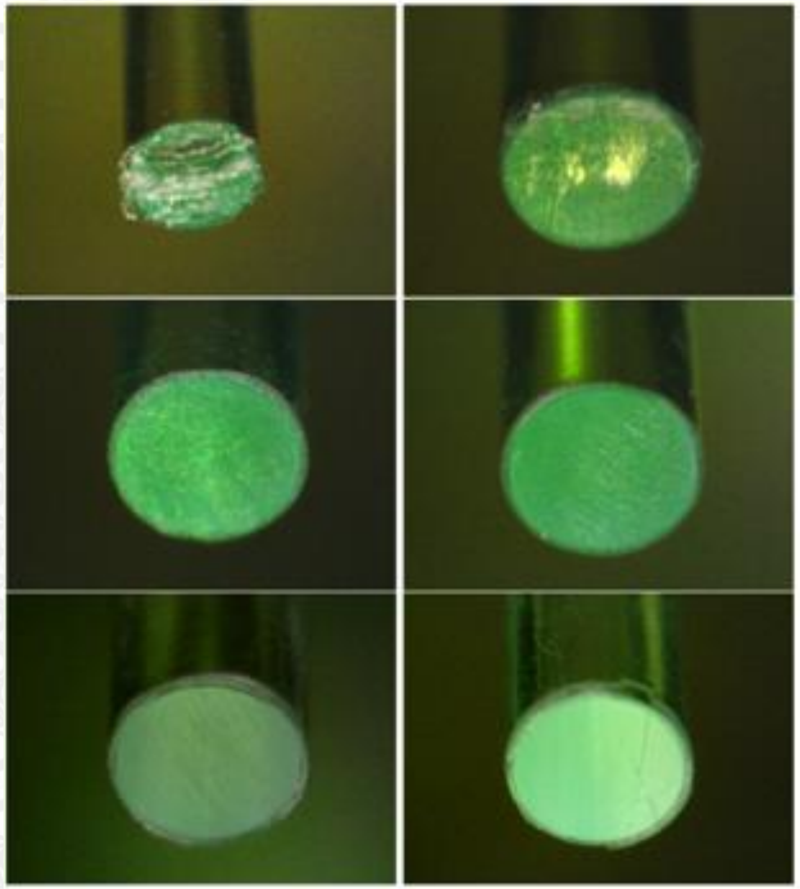
A test tile



- Connected to 5.5 meters of clear fiber with 3D-printed custom connectors
- Super Sector wrapped in Tyvek and 2 layers of black paper (light tight)

Wave Length Shifting Fiber Preparation





WLS→ reflective paint for "Central Channel"

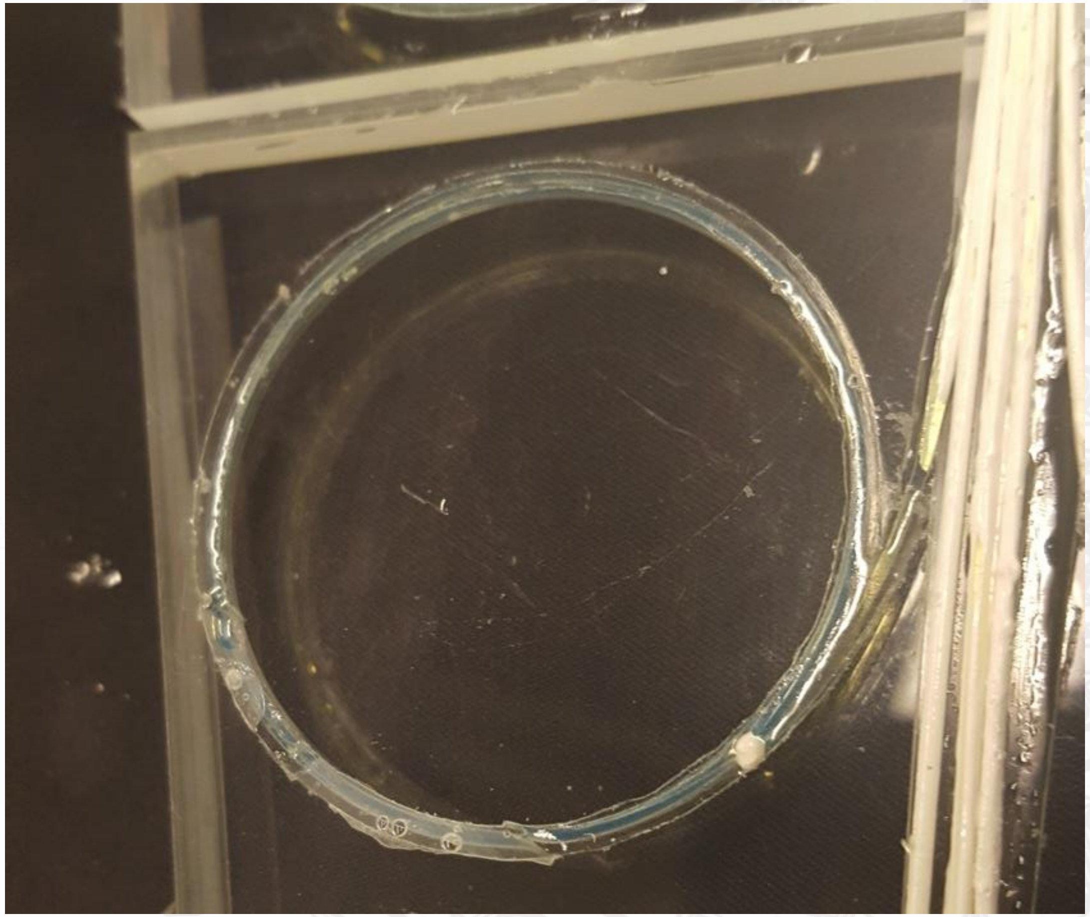
- **Decreases cross-talk**

WLS Fiber ends painted

- Increases light yield by ~30-50%

Fibers must be polished for optimal coupling

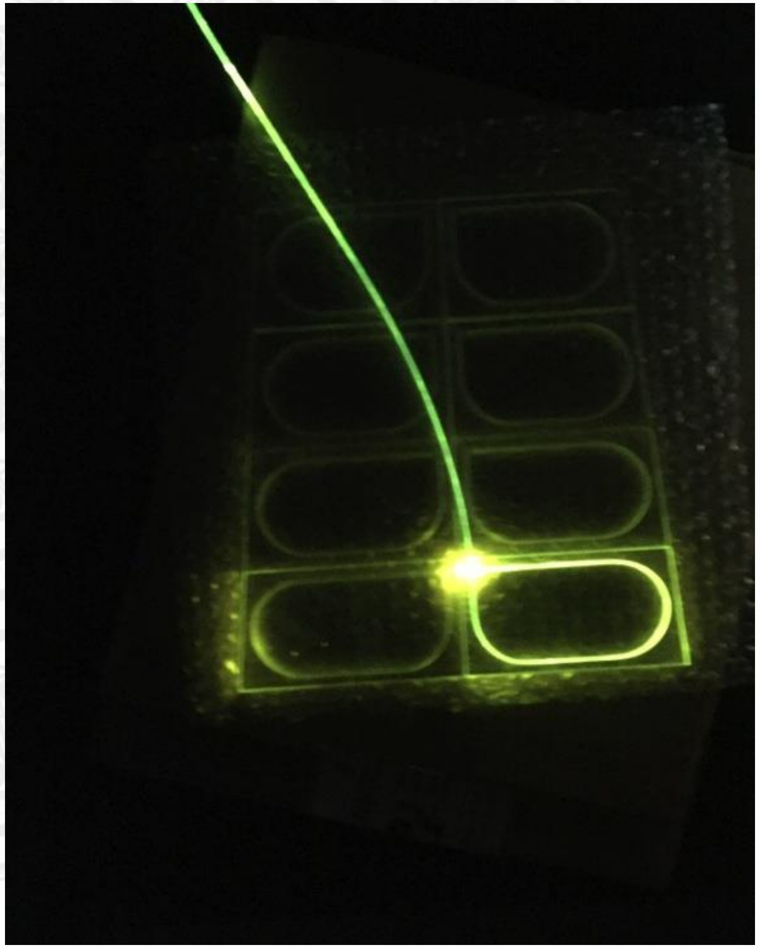
Front WLS grooves



Central channel and front grooves filled with reflective epoxy

3 Loops of WLS per tile

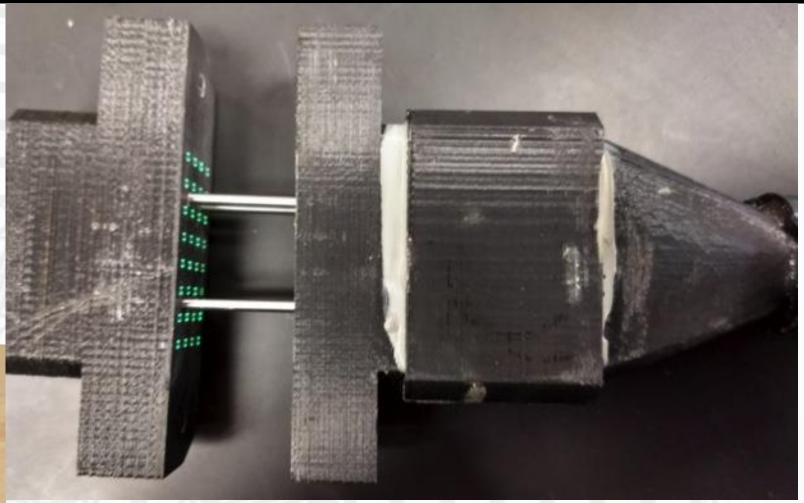
- **Increases yield by ~2x compared to 1 loop**

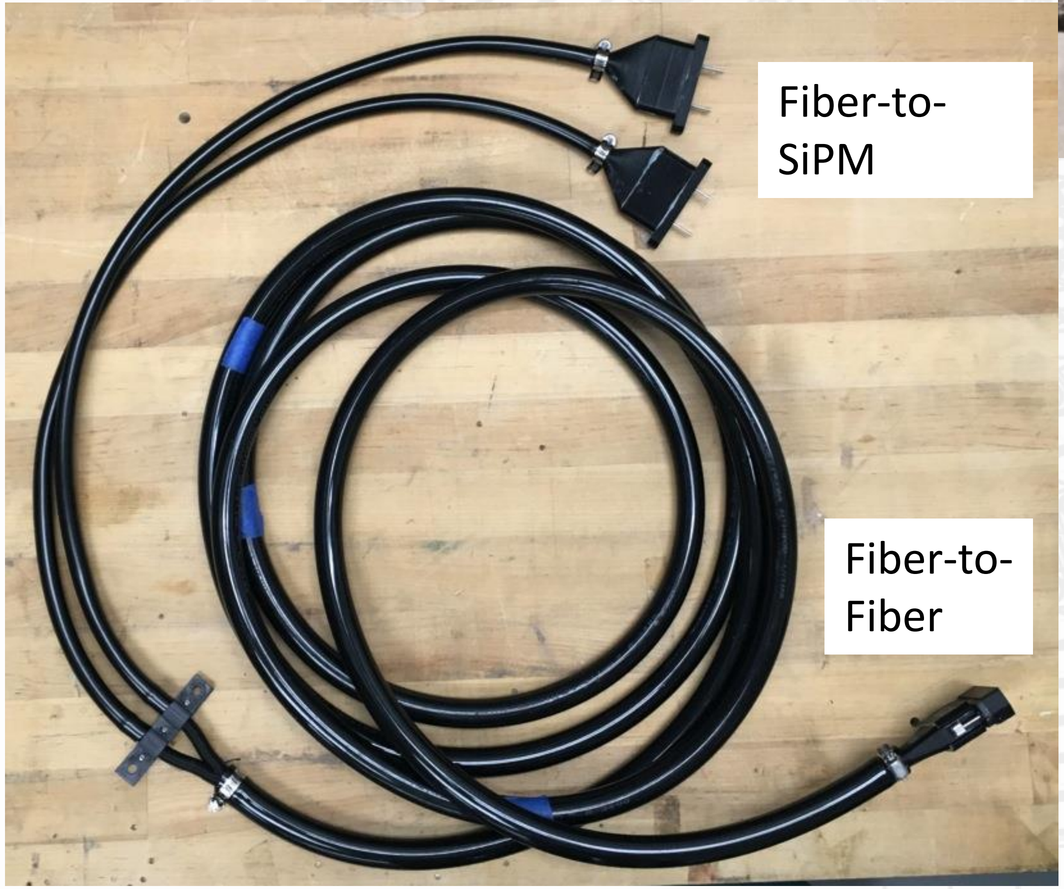


5.5-m-long Clear Fiber Bundles

Connected to 5.5 meters of clear fiber

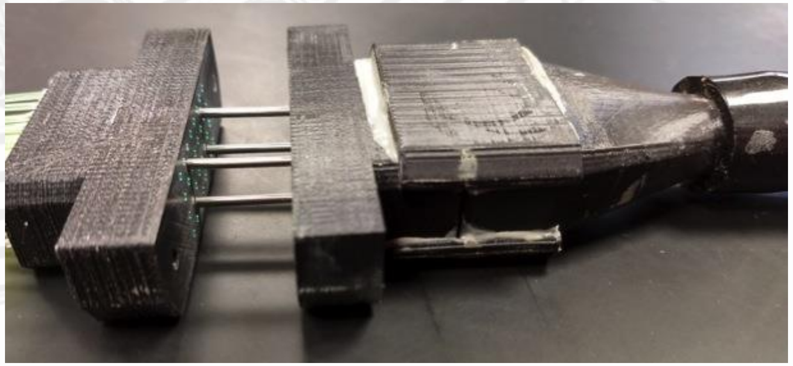
- CF attenuation length: >10 m
- WLS attenuation length: >3.5m



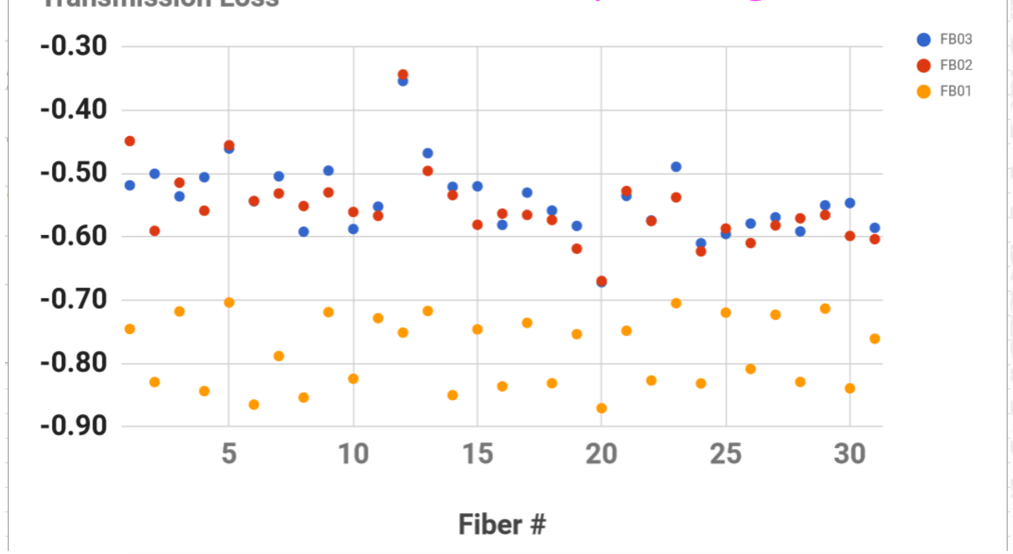


CF Connector epoxied together for mechanical stability and light-tightness

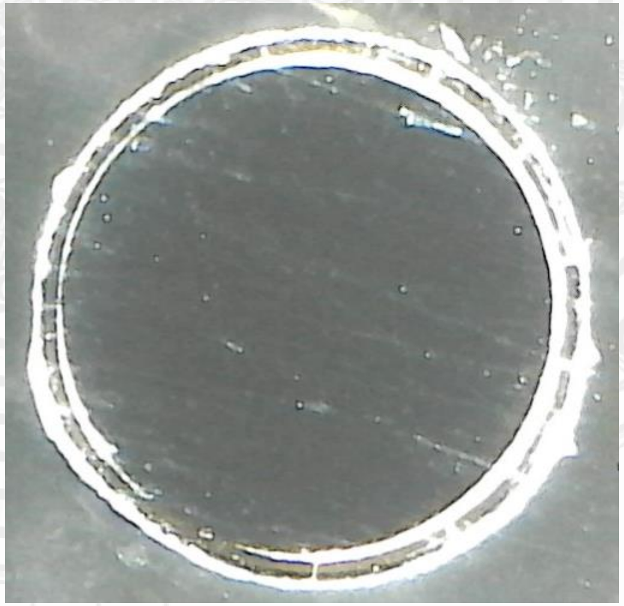
- Alignment pins

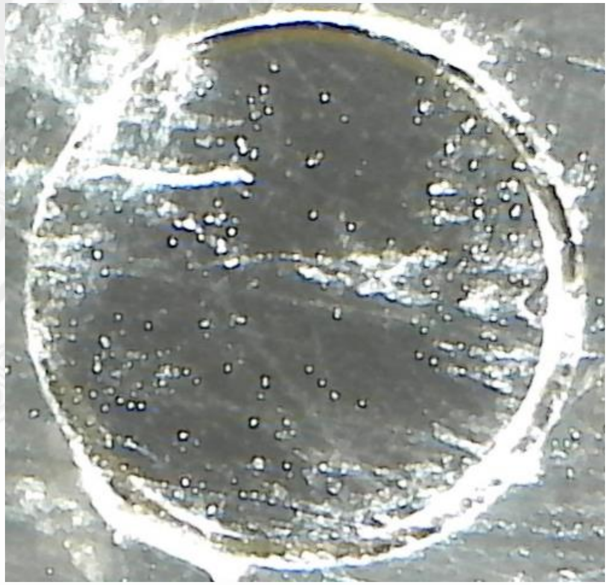


Effect of Polishing on Transmission

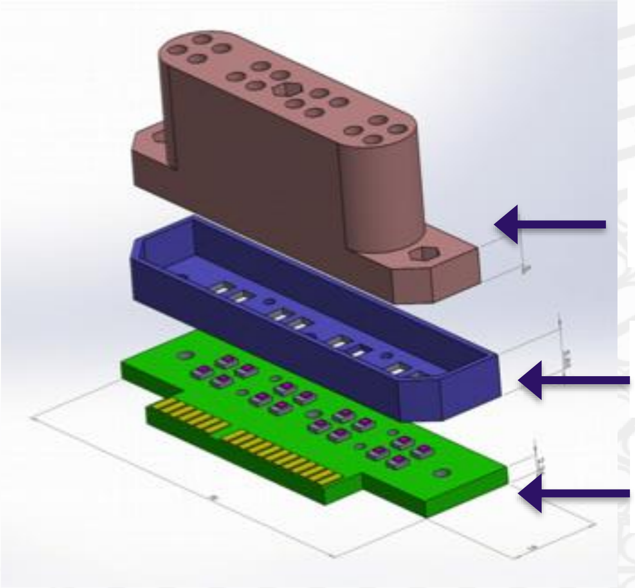


- Better polish improves transmission
- Correlation between visual inspection and transmission test





Clear fiber bundle meets readout electronics

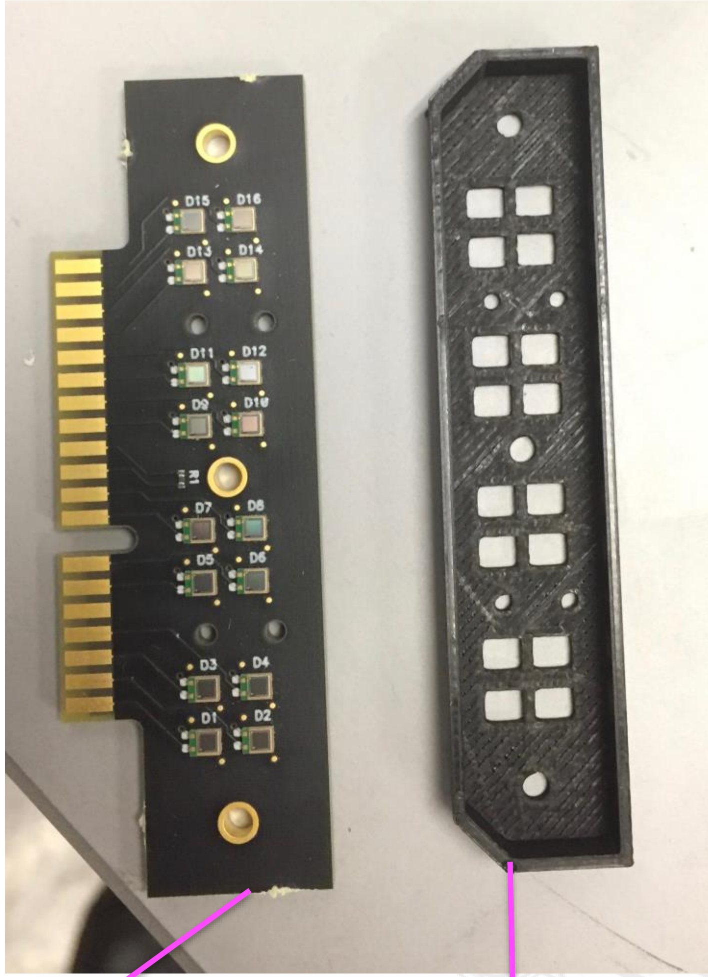


Fiber-to-Silicon Photomultiplier connector (FSC)

CF Connector epoxied together for mechanical stability and light-tightness

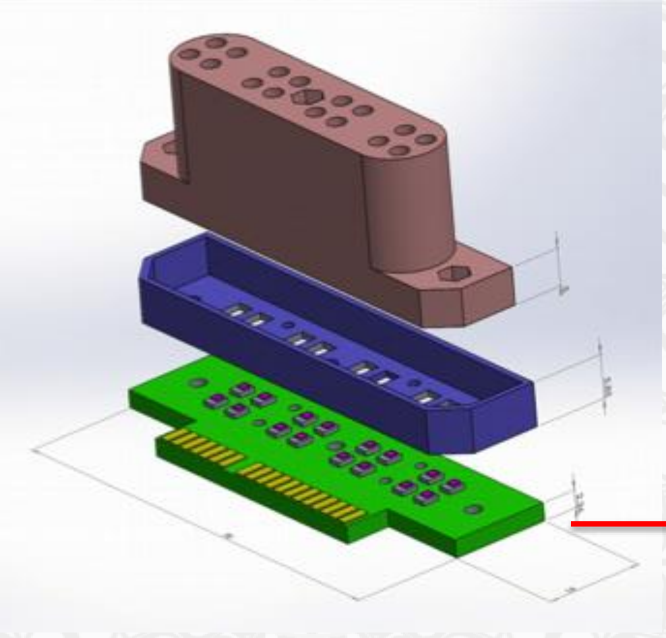
- Alignment pins

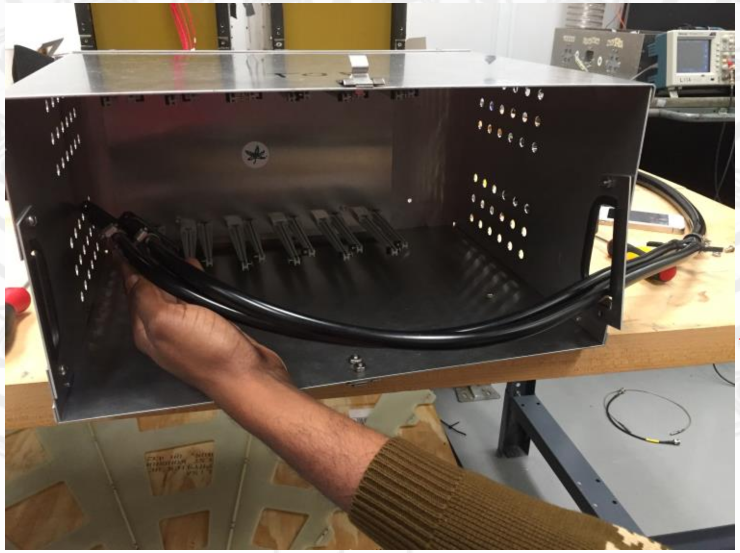
Clear fiber bundle meets readout electronics



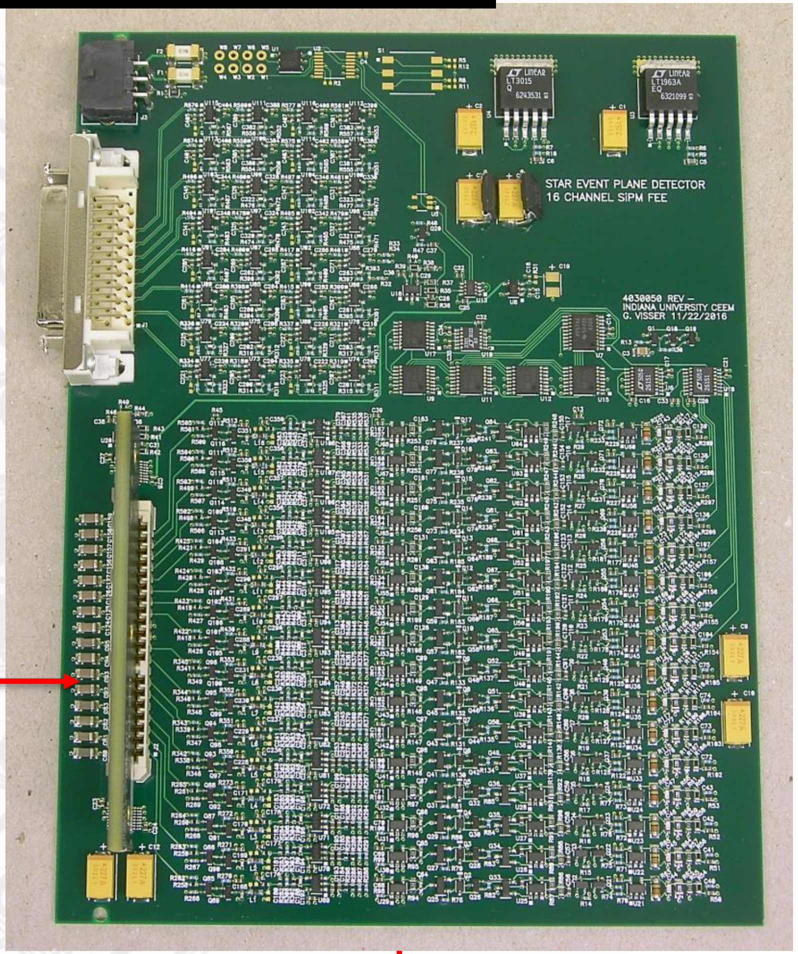
EPD FSC spacer block

EPD SiPM card: 16, 25-µm SiPMs



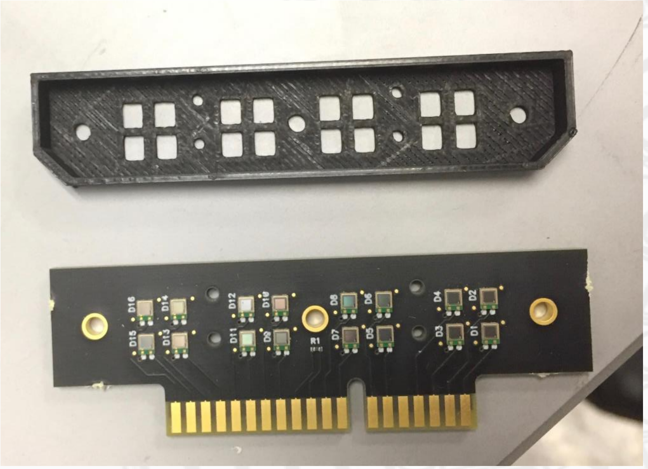


FEE Box



Custom Designed
Front End
Electronics Card

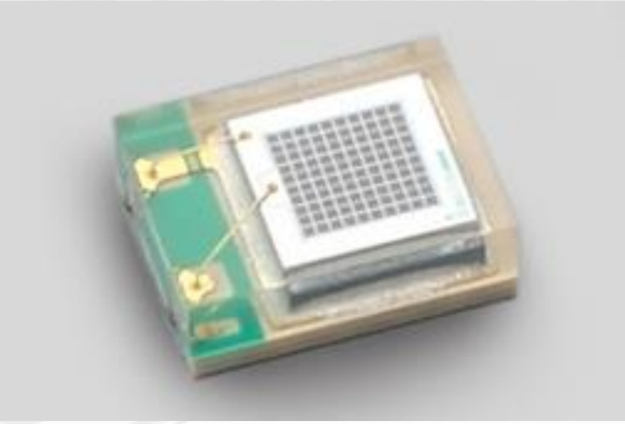
Read-Out
Silicon Photomultipliers – (SiPM)



- Clear fiber leads into photosensitive area of SiPM, which digitizes the signal
- New technology for hadron colliders
  – Used in medical technology

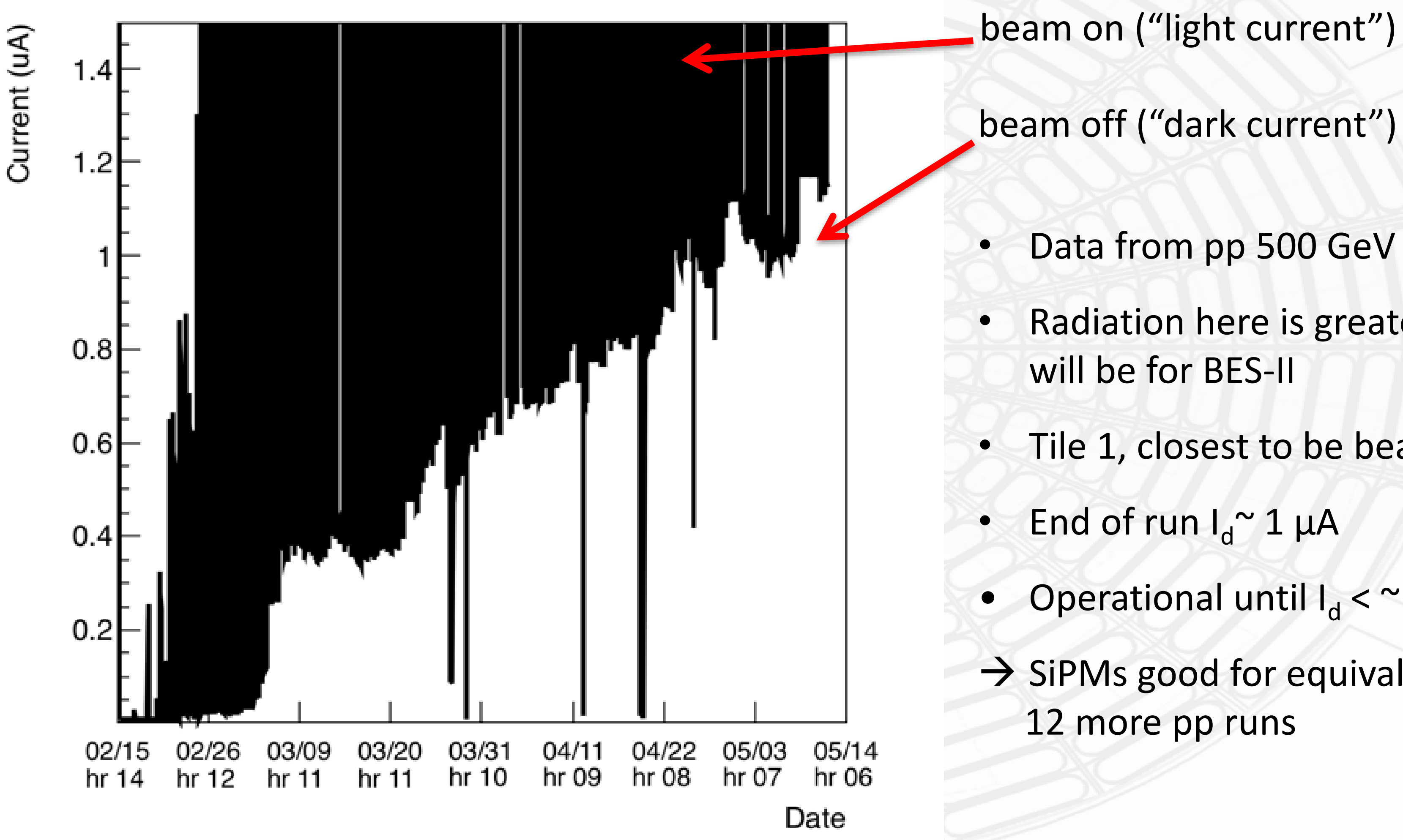
Advantages:
– No sensitivity to magnetic fields
– very compact

Disadvantages:
– Neutron radiation sensitive
→ Placement is important!



Hamamatsu SiPM:S13360-1325PE
25x25 micron pixels

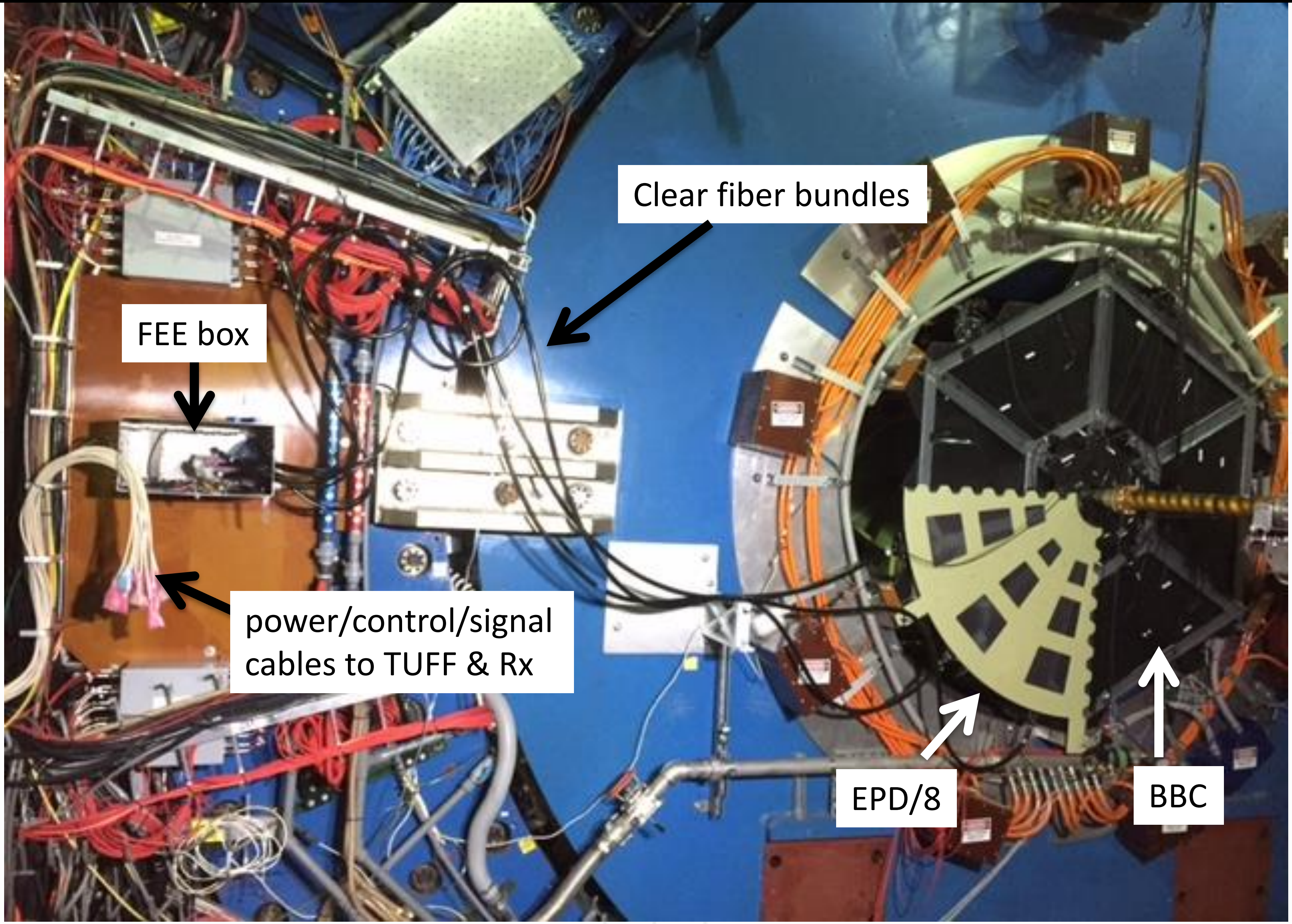
Dark Current
Silicon Photomultipliers – (SiPM)



- Data from pp 500 GeV run
- Radiation here is greater than it will be for BES-II
- Tile 1, closest to be beampipe
- End of run I_d~ 1 μA
- Operational until I_d < ~15 μA

→ SiPMs good for equivalent of 12 more pp runs

2017 – Quarter Wheel in place at STAR



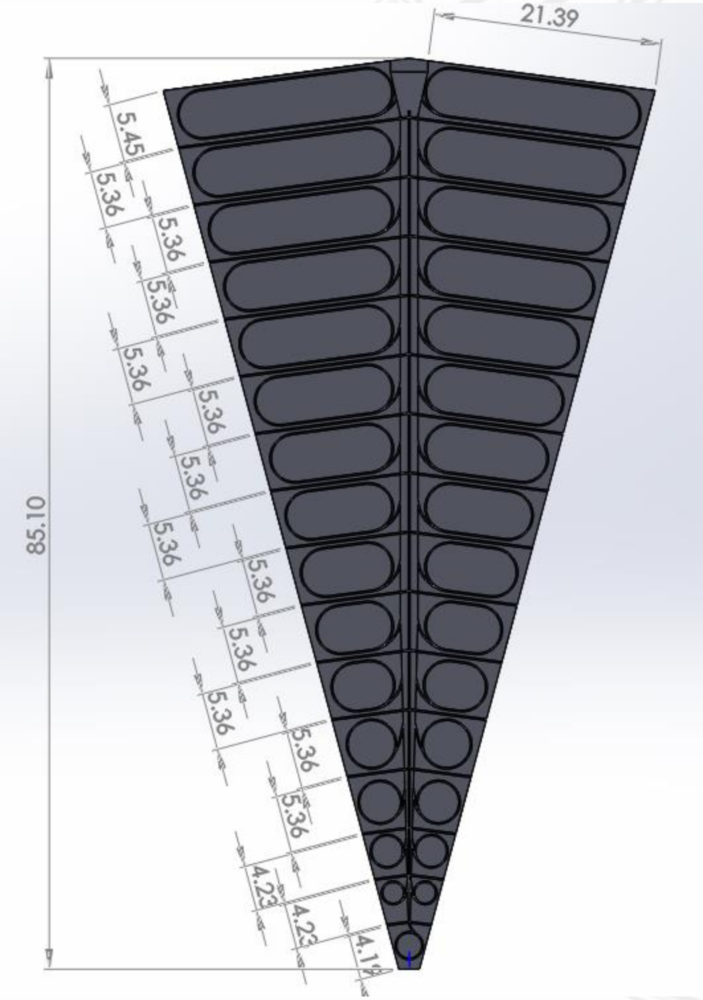
Summary

- Updated electronics and increased number of channels is an important upgrade for many measurements, including those for BES-II
- Data from Run 17 will be discussed by Justin Ewigleben
- All super sectors have been constructed: 24 SS plus extra 6 as spares. They are to be installed before Run 18.

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

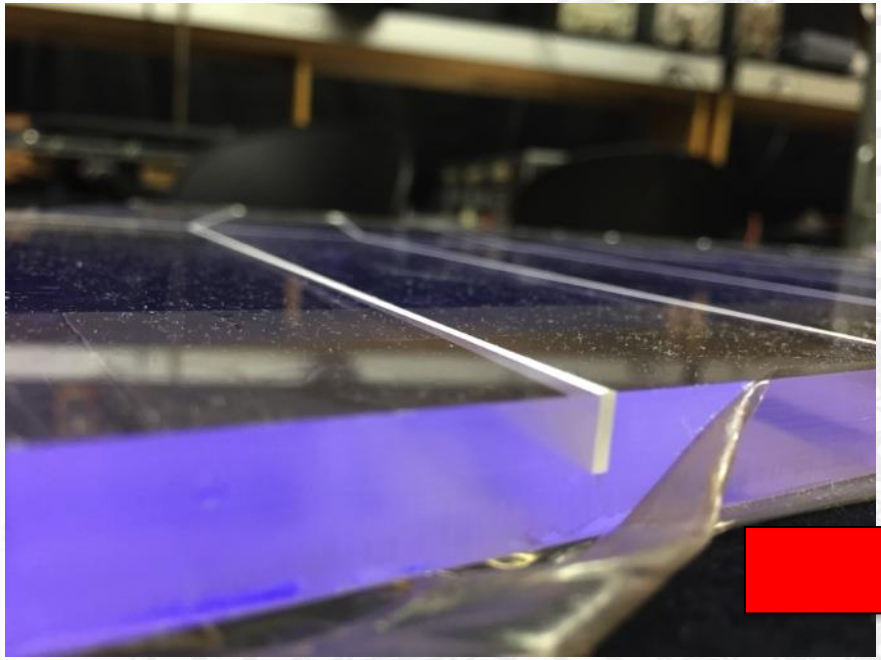
Each of 12x31x2=744 channels

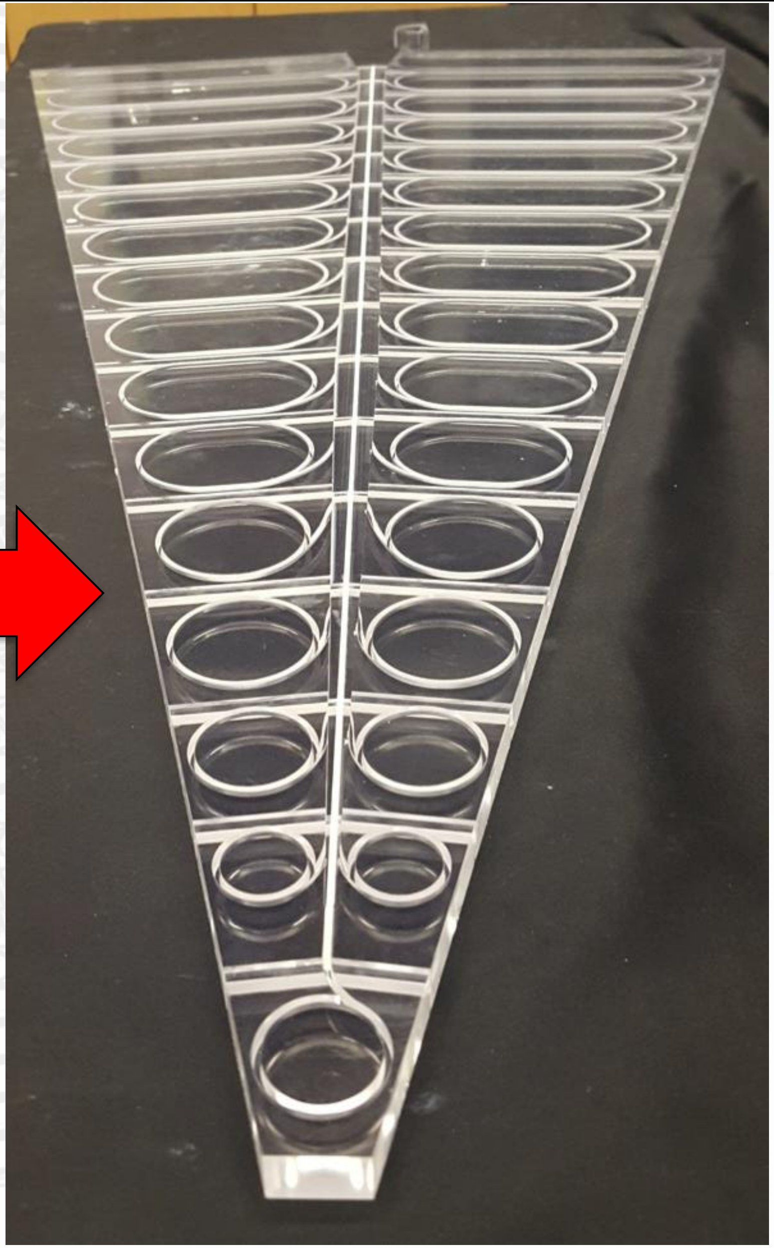
- optical signal transported 5.5 m on clear fiber (Kuraray 1.15 mmD BJ round)
- coupled to SiPM (Hamamatsu S13360-1325PE)
  - 25-µm pixels → 1600+ illuminated pixels
- read out by STAR FEEs/QTs, similar FPS

Custom-built connector components

- 3D-printed

Front isolation grooves





Mill “half-way” and fill groves with TiO_2 + epoxy mixture (reflective epoxy)

- **Optical isolation!**

Flip over and finish milling the groves + Fiber channels

Fiber bundle construction at Lehigh

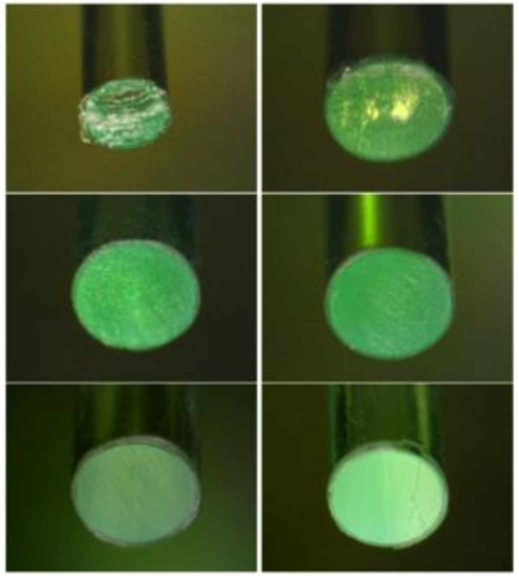
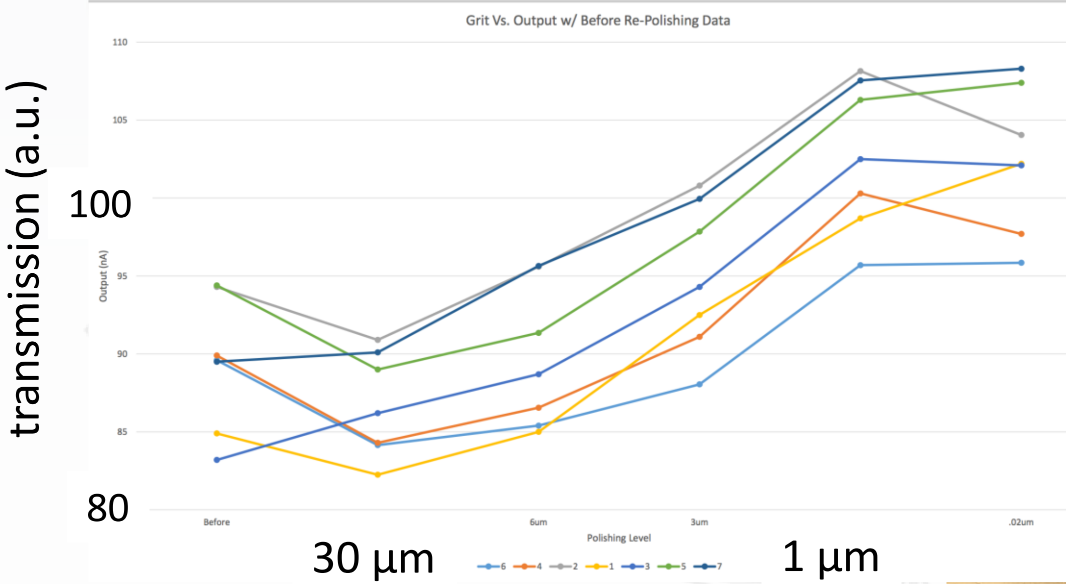
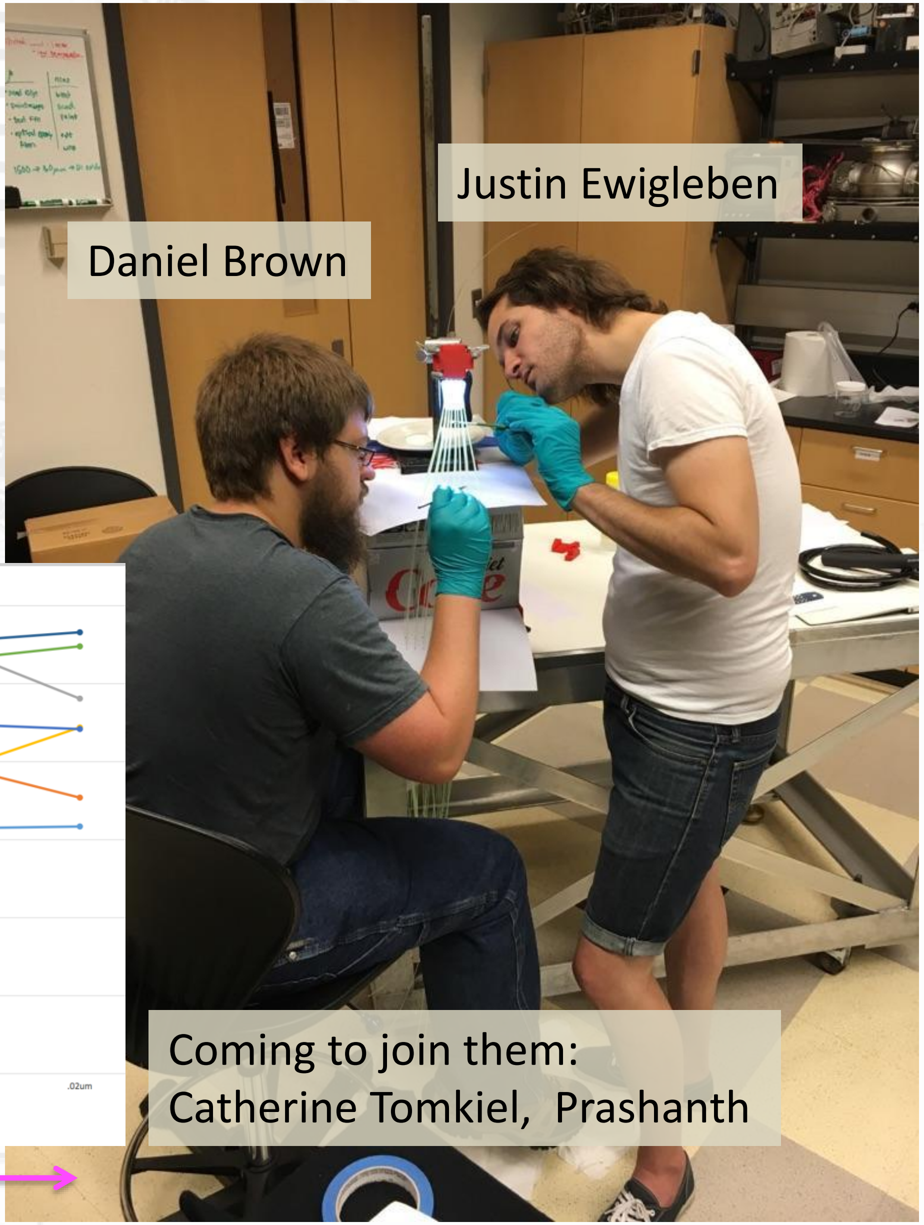


Figure 33: Kuraray Y-11(200) wavelength shifting fibers after different steps of cutting and polishing (see text for details).





fineness of polishing cloth