Construction of the sPHENIX Event Plane Detector

Valerie Wolfe, Lehigh University *for the sPHENIX Collaboration*

Abstract

Constructed at Lehigh University between 2021 and 2023, the sPHENIX Event Plane Detector (sEPD) will measure charged particle multiplicity at forward rapidity from the collision of hadrons. This detector consists of 24 triangular sectors, 12 in each disk. The sectors are divided into 31 optically isolated tiles of plastic scintillating material, such that light can be collected from a discrete area of the detector then converted later to an electronic signal. A wavelength shifting fiber is glued into each tile using an optical epoxy with an index of refraction matching that of the scintillator. The tiles cover 16 segments in eta and 24 in phi. The sectors were installed into two disks covering a pseudorapidity of $2.1 < |\eta| < 4.9$. To build the detector, scintillating plastic was milled into a triangular shape to create 24 sectors. Grooves for the optical fibers were then machined into the sectors, in addition to channels to divide each sector into 31 tiles. Optical fibers were glued into the grooves, and the channels were filled with a reflective epoxy to achieve optical isolation between tiles. An overview of this construction process will be given in detail, including the machining of the sectors, the installation of the fibers in the tiles, and the creation of two types of bundles of fiber optic assemblies.

Purpose

The sPHENIX Event Plane Detector (sEPD) was designed to measure the event plane with the best possible resolution. The event plane is used to experimentally determine collision geometry (Fig. 1), which is needed to study many of the physics channels core to the sPHENIX physics mission.
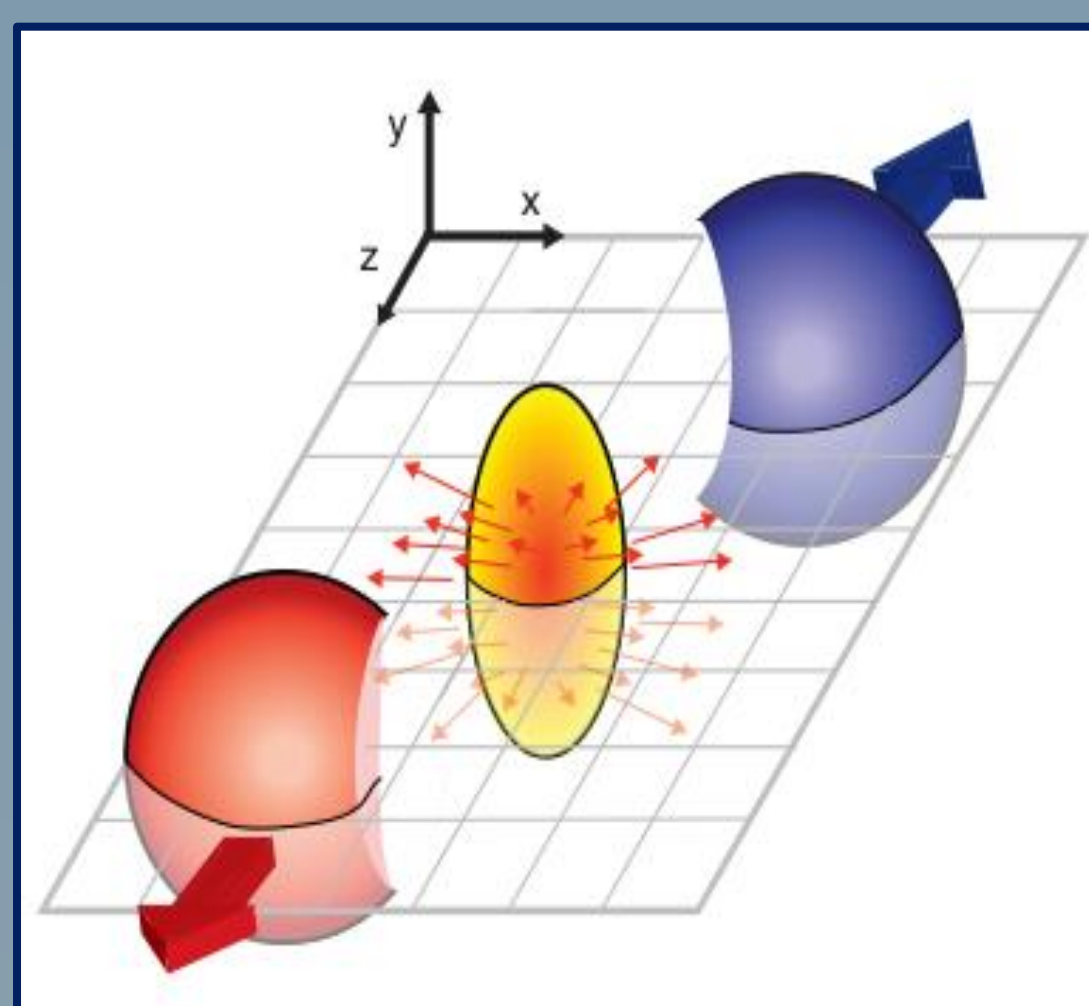

Figure 1. The geometry of the collision within the beamline. The two partial spheres represent the heavy ions colliding with one another. The yellow oval between them represents the QGP. (Left)
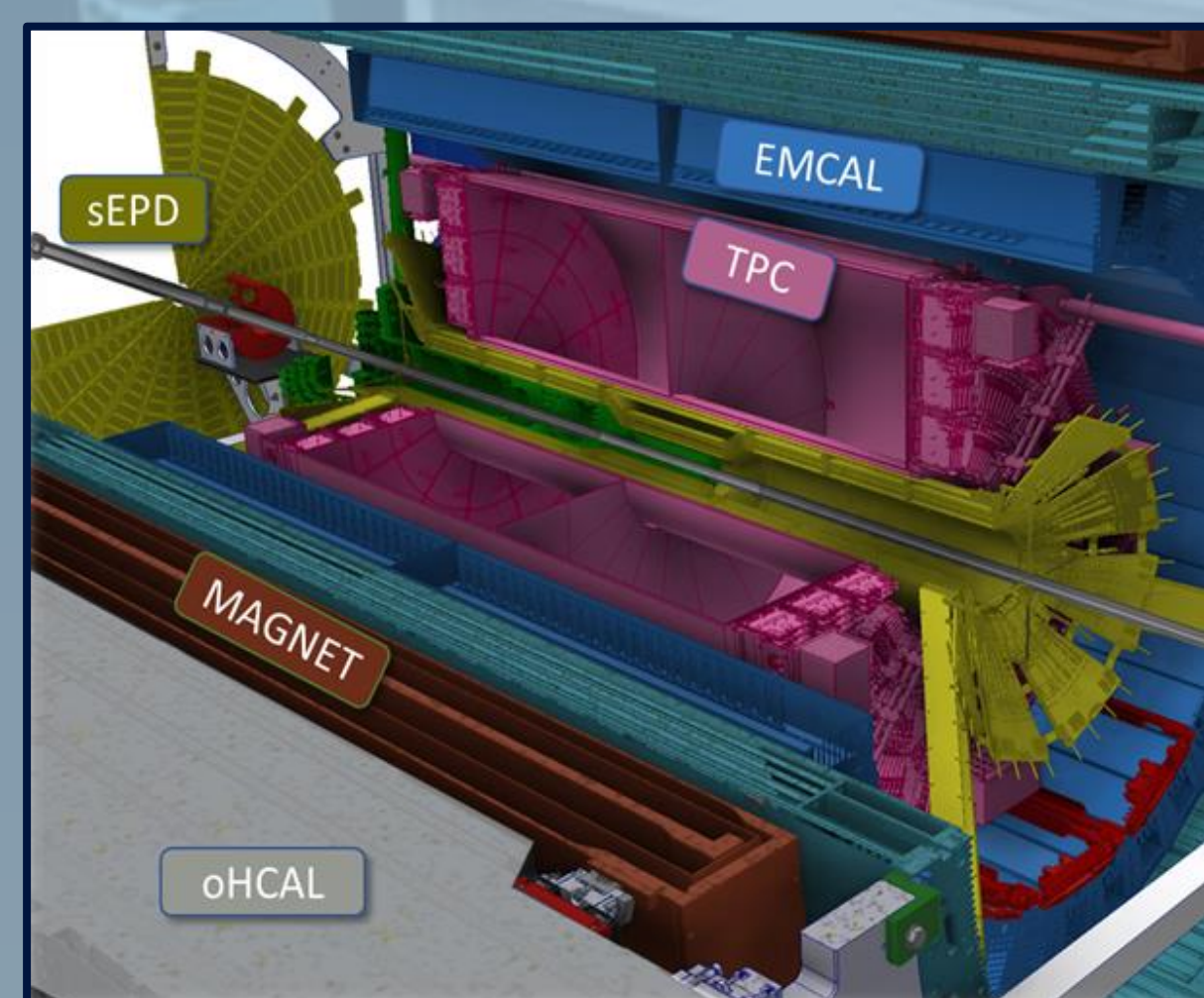*Figure 2.* A schematic of the sPHENIX detector, including the sEPD. (Middle)
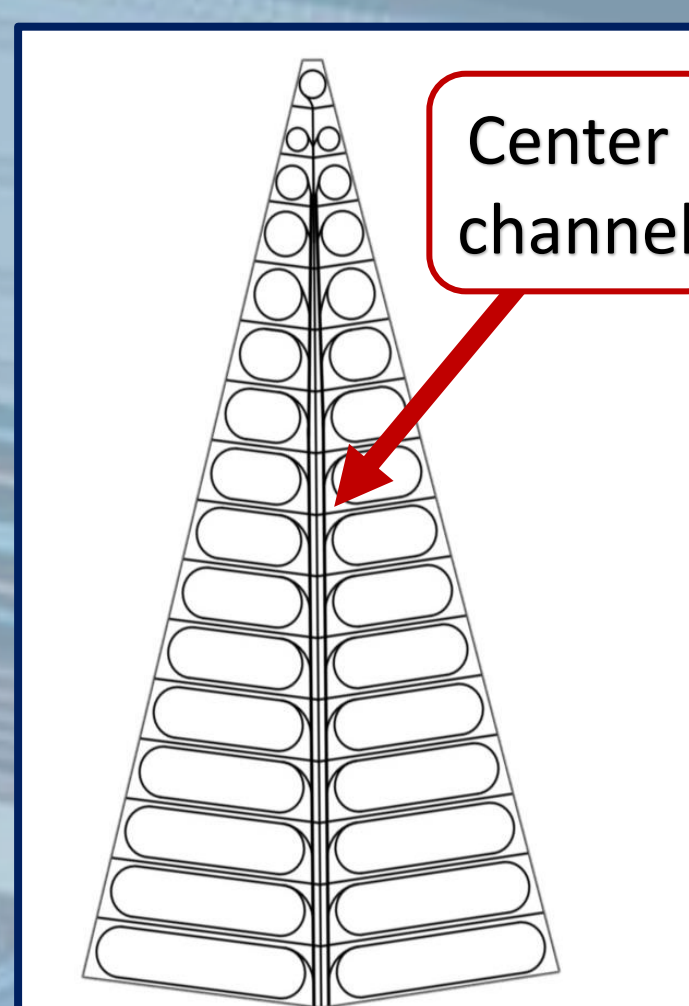*Figure 3.* A schematic of an sEPD sector. (Right)

Design of the sEPD

- 24 triangular sectors made of 31 tiles of scintillating material are installed into two disks, 12 sectors in each (Fig. 2 and 3)
- Charged particles outgoing from collisions pass through the sEPD, depositing energy into the scintillator, producing photons
- The light is collected by wavelength shifting (WS) fibers that are embedded into the sector tiles by being wound into a groove three times and glued in place with an optical epoxy
- The light is transported via clear fiber bundles into Silicon Photomultipliers (SiPMs)

Sector Machining

- Scintillating material was cut into triangular shapes, then grooves were machined into the back face and filled with a reflective epoxy (Fig. 4) made at Lehigh using the technique described by [1]
- Isolation grooves, center channel, and fiber grooves were machined on front side
- This process allows for isolation between the tiles of the sectors, decreasing cross-talk
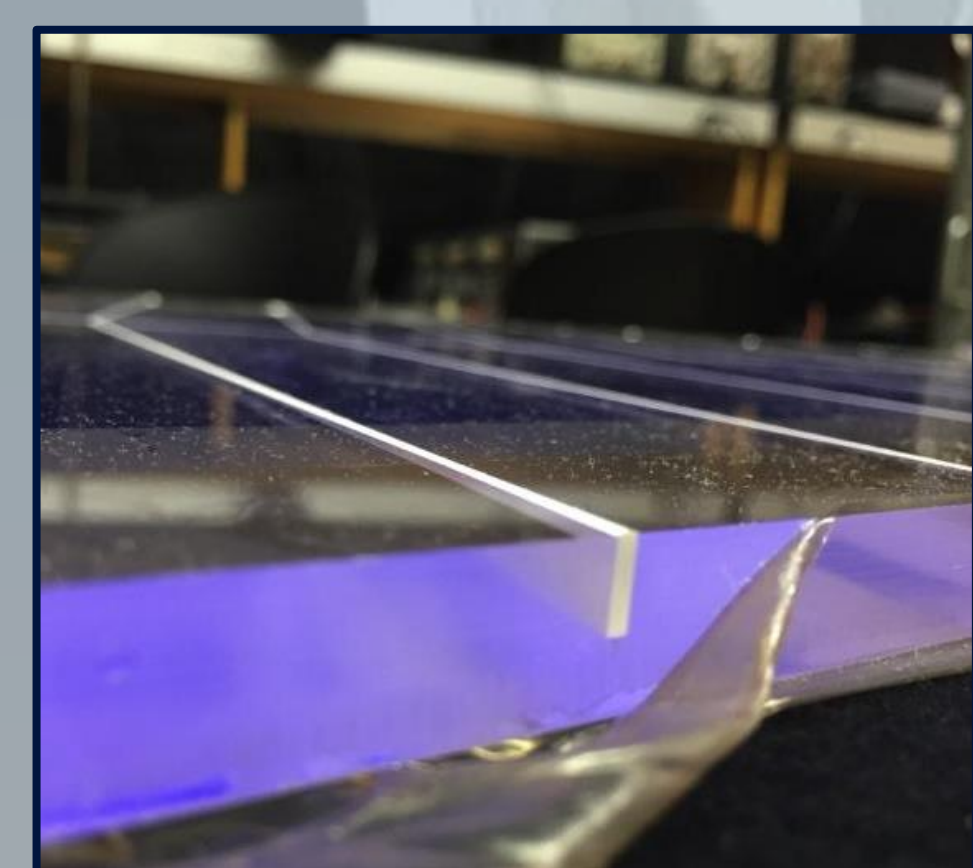

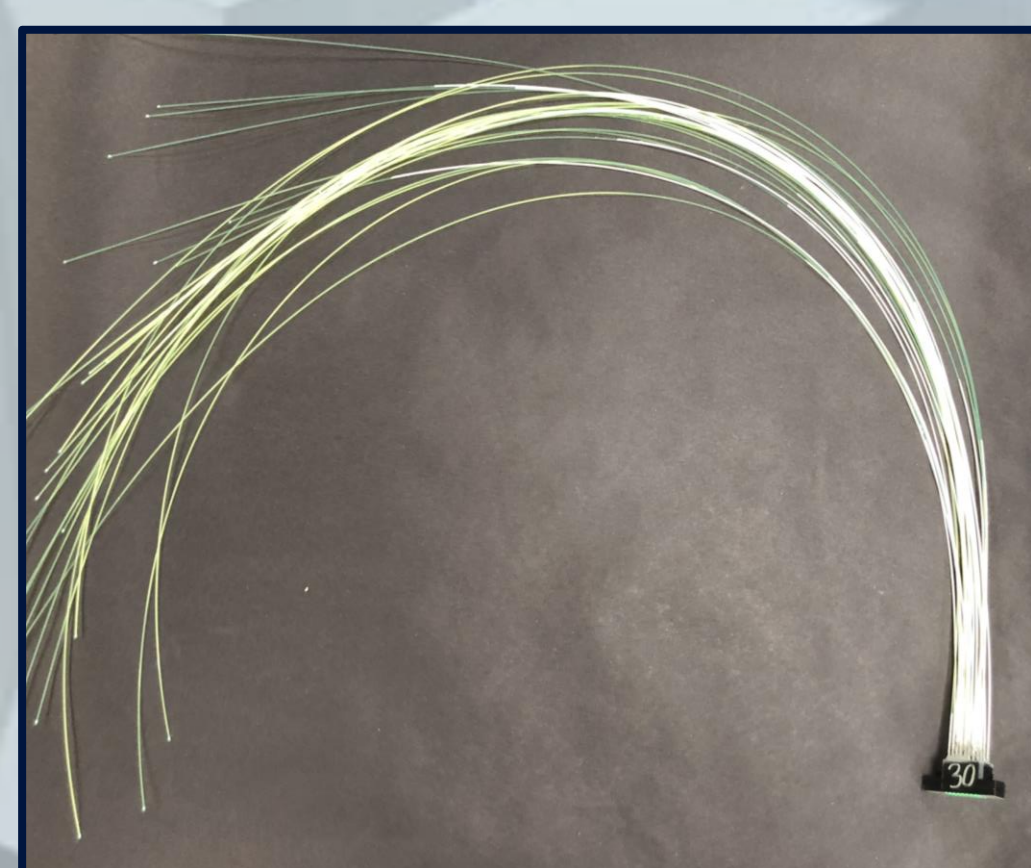*Figure 4.* A partially machined sector. (Left)
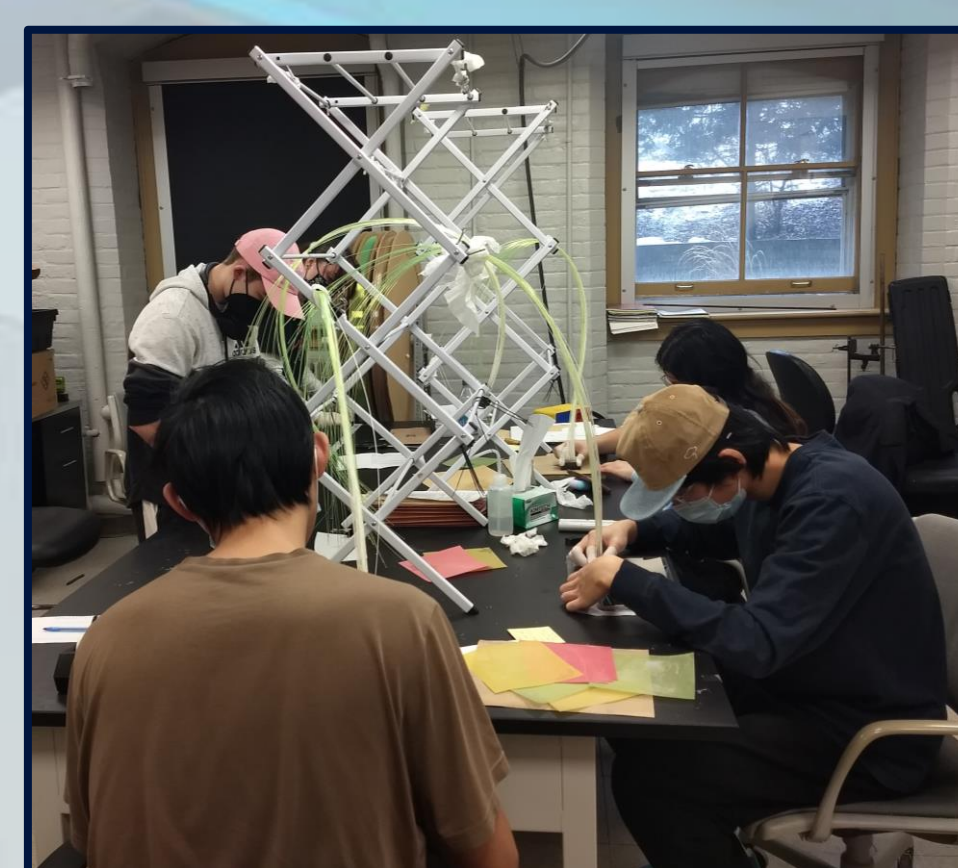*Figure 5.* A completed fiber bundle.(middle)
Figure 6. Students constructing and polishing fiber bundles. (Right)

Wavelength-shifting Fiber Bundles

- Fibers were cut to precise lengths according to their placement in the sector
- The portion of the fibers that lay in the central channel was painted with reflective paint to decrease cross-talk (Fig. 5)
- Fibers were glued into 3-D printed connectors, then the connector faces were polished (Fig. 6)
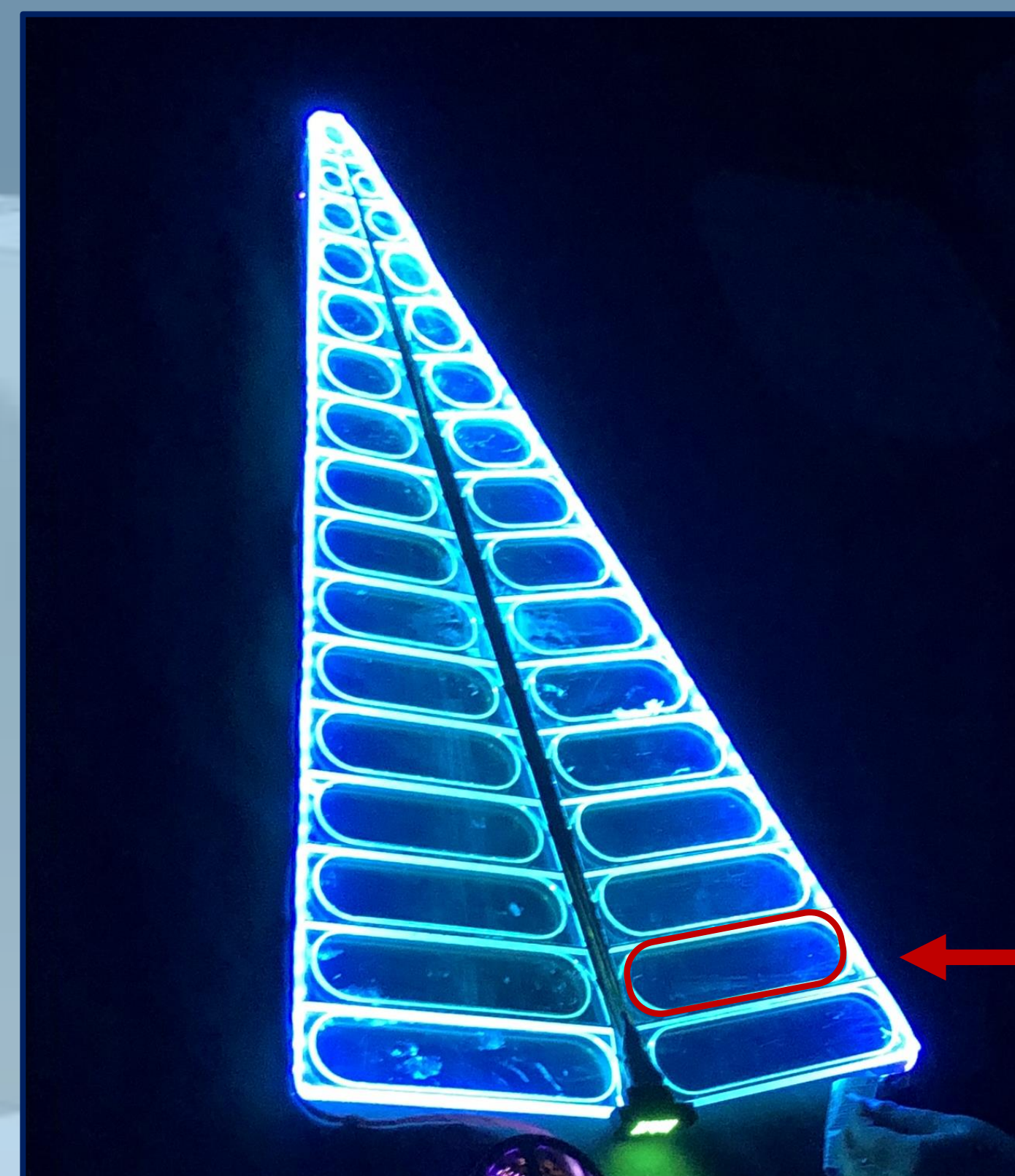- The ends of the fibers were polished and painted with reflective paint

Figure 7. An image of a completed sector being illuminated by LED lights. (Above)

Sector Assembly

- Top of sectors were covered in Teflon tape to protect the scintillator
- The connector of a WS fiber bundle was glued into the base of each sector
- The fibers were glued into the tiles (Fig. 7 and 8) using an optical epoxy which matches the index of refraction of the scintillator
- The tiles were optically separated from one another by filling isolation grooves and center channel with reflective epoxy
- The tape was removed, then the sides of the sectors were polished with 12k grit sandpaper
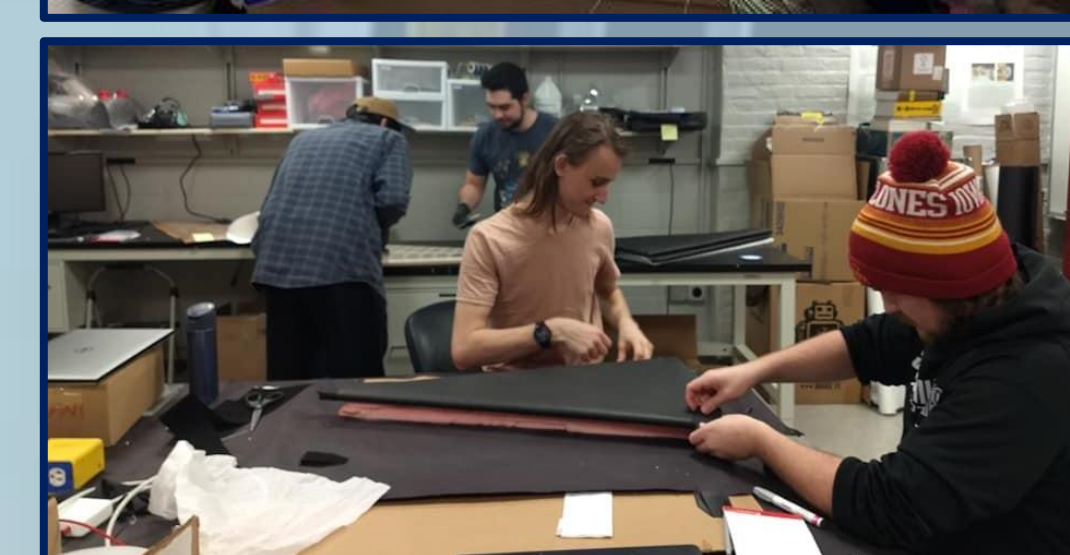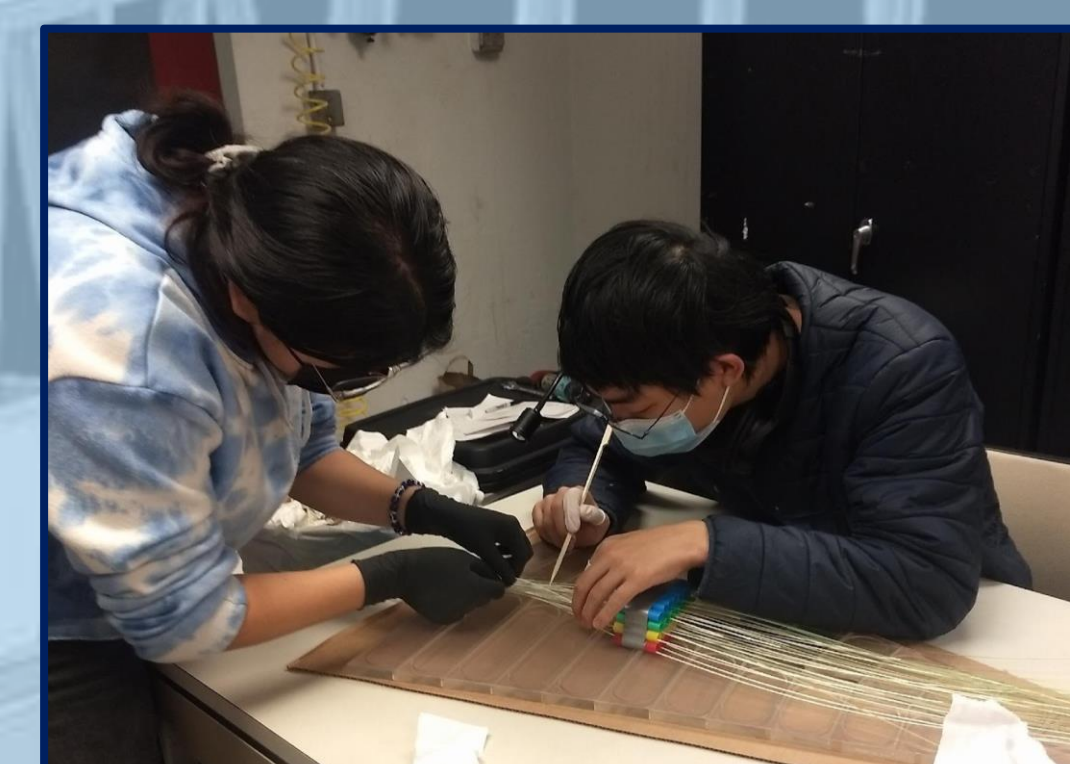
Clear Fiber Bundles

- Clear fibers were cut to a length of 6.8 meters
  - 1 meter longer than the STAR EPD [2]
- The fibers were put into thick tubing measuring 4.4 meters,
- The fibers at one end were glued into a connector, then the connector was polished
- The fibers at the other end were split into two sections and put into smaller tubing
  - The electronics accept inputs of 16 sources
- Two more connectors were glued to the ends of the fibers, then polished

Installation

- Each sector was wrapped in a layer of Tyvek and blackout paper to block out ambient light
- At BNL, the sectors were mounted in groups of two onto a strongback for stability, creating supersectors
- The north side disk was installed June 21st, 2023, and the south side was installed July 5th (Fig. 9)

Figure 8. Three images showcasing students and Lehigh faculty assembling sectors.

Figure 9. Three pictures showing the installation of the north side disk.

Performance Data

- Please see Poster 504, presented by Jaebeom Park

Acknowledgements

References

[1] M. Olsson, P. de Barbaro, A. Bodek, H. S. Budd, P. Koehn, M. Pillai, W. Sakumoto, R. C. Walker, B. Winer, Techniques for optical isolation and construction of multitile assemblies in scintillator tile - fiber calorimeters using white epoxy (1995).
[2] Joseph Adams et al. The STAR Event Plane Detector. Vol. 968. 2020, p. 163970. doi: 10.1016/j.nima.2020.163970.