SPHENIX

Construction and Installation of the sPHENIX Event Plane Detector at RHIC

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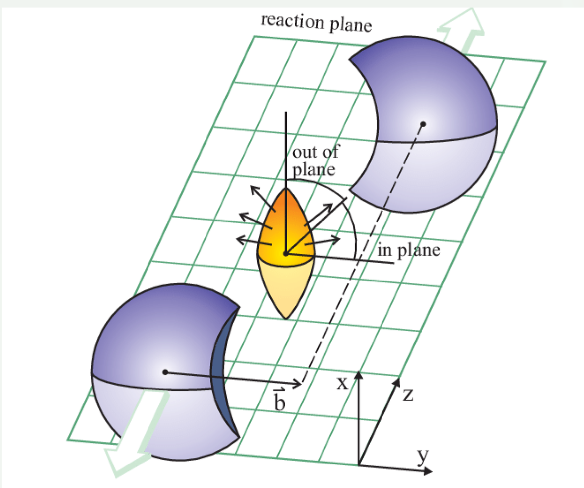
Abstract

Developed at Lehigh University between 2021 and 2023, the sPHENIX Event Plane Detector (sEPD) was designed to measure the charged particle multiplicity resulting from hadron collisions at forward rapidity. The detector is composed of 24 triangular sectors, each subdivided into 31 optically isolated tiles made of Eljen EJ-200 plastic scintillator. This arrangement allows for the collection of light from discrete regions within the detector, which is then converted into electronic signals. To ensure efficient light collection, a wavelength-shifting fiber is affixed to each tile using an optical epoxy with a matching refractive index to that of the scintillator material. The layout covers a region comprised of 16 segments in eta and 24 in phi and is installed into two disks encompassing a pseudorapidity range of $2.1 < |\eta| < 4.9$. The construction process involved milling the scintillating plastic into triangular shapes, followed by machining grooves for the optical fibers and channels to partition each sector into 31 tiles. Subsequently, the optical fibers were securely attached to the grooves, and the channels were filled with a reflective epoxy to ensure optical isolation between the tiles. We provide a comprehensive account of the detector's construction, including details on the sector machining, fiber installation in the tiles, and the creation of two distinct bundles of fiber optic assemblies. Additionally, a visualization of the sEPD's initial performance during the current sPHENIX run is presented. Overall, the sEPD represents a valuable tool for investigating charged particle multiplicity in hadron collision experiments, offering insights into the underlying physics processes. This material is based upon work supported by the National Science Foundation under Grant No. 2117773.

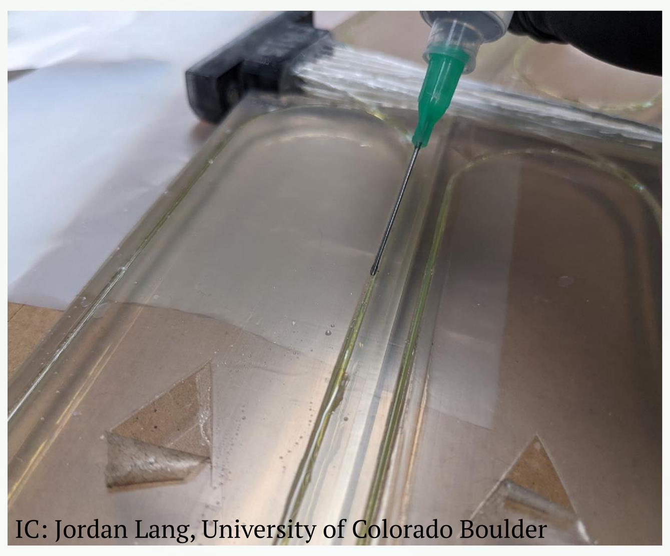
Concept



- Goal of the sPHENIX Event Plane Detector (sEPD) is to measure the event plane of a particle collision, an approximation of the reaction plane created by the impact parameter and beam axis (left figure)
- Made of 2 disks of 12 sectors with each sector subdivided into 31 optically isolated channels
- Covers pseudo rapidity range of $2.1 < |\eta| < 4.9$.
- Each sector machined from EJ-200 scintillating plastic material (milling table in right figure)
- Each sector is also connected to an optical fiber bundle which carry the signal to silicon photomultipliers and amplifiers, before the signal is finally sent to DAQ,.

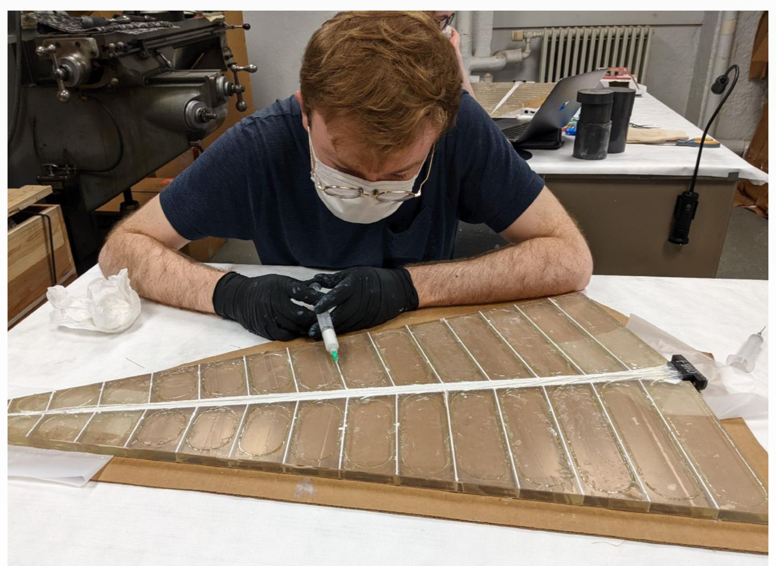
Sector Construction

IC: Jordan Lang, University of Colorado Boulder



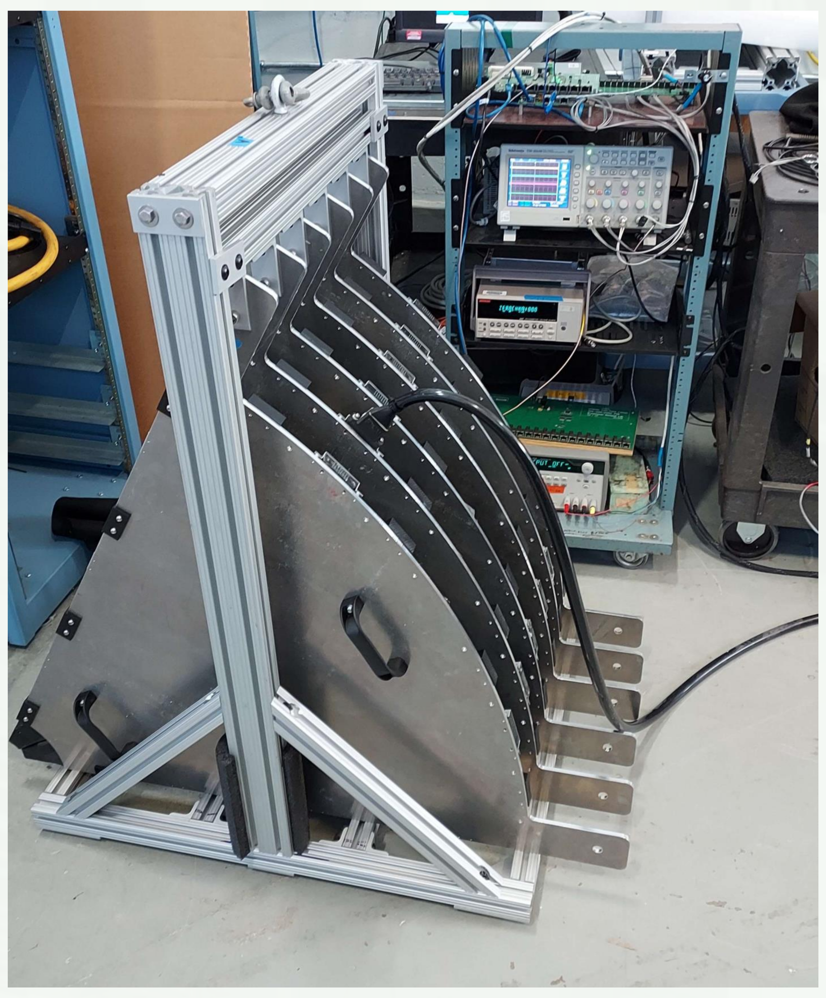
IC: Jordan Lang, University of Colorado Boulder

- 30 Sectors milled from EJ-200 scintillating plastic off-site
- Backside of scintillator milled and filled with reflective epoxy that was manufactured at Lehigh Then frontside of scintillator milled to ensure optical isolation of channels
- Sectors then shipped to Lehigh and covered in Teflon tape
- 30 wavelength-shifting (WLS) fiber bundles created by cutting 31 WLS fibers to specified lengths
- WLS fiber connector polished to maximize transmission of optical signals to optical fiber bundles (Top Left)
- WLS fibers wound around each channel groove 3 times and glued in with an optical epoxy matching the index of refraction of the scintillator (Top Right)
- Isolation grooves between each channel and central channel filled with reflective epoxy (Bottom Left)
- Teflon tape removed, and each side of the sector was polished (completed sector in Bottom Right)
- Also constructed were 26 clear optical fiber bundles, one end near the sector, the other split into 2 tubes to connect to SiPMs



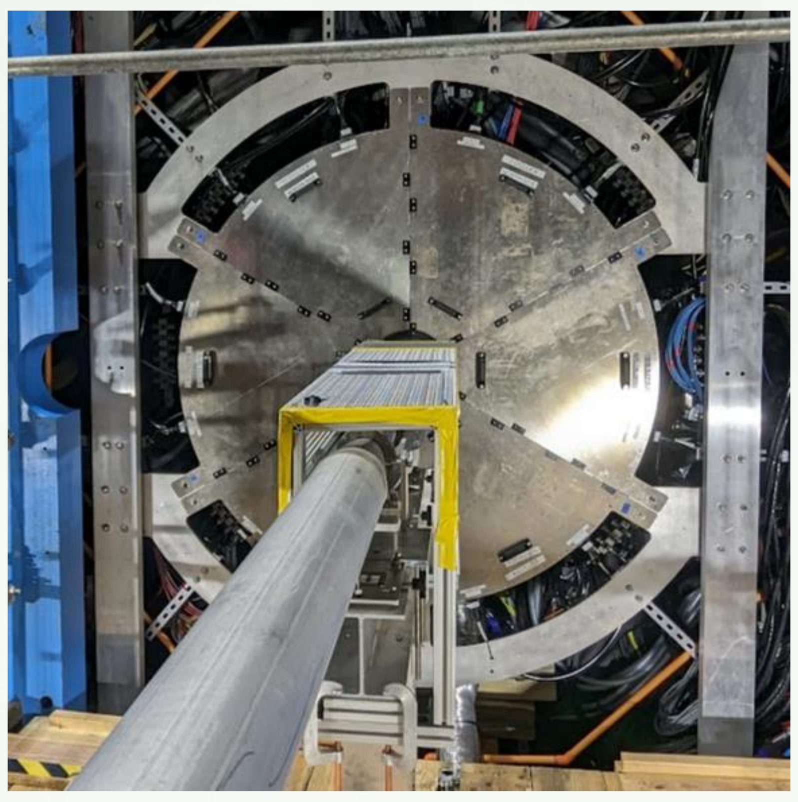
Pictured: Ryan Hamilton of University of Colorado Boulder
IC: Jordan Lang, University of Colorado Boulder

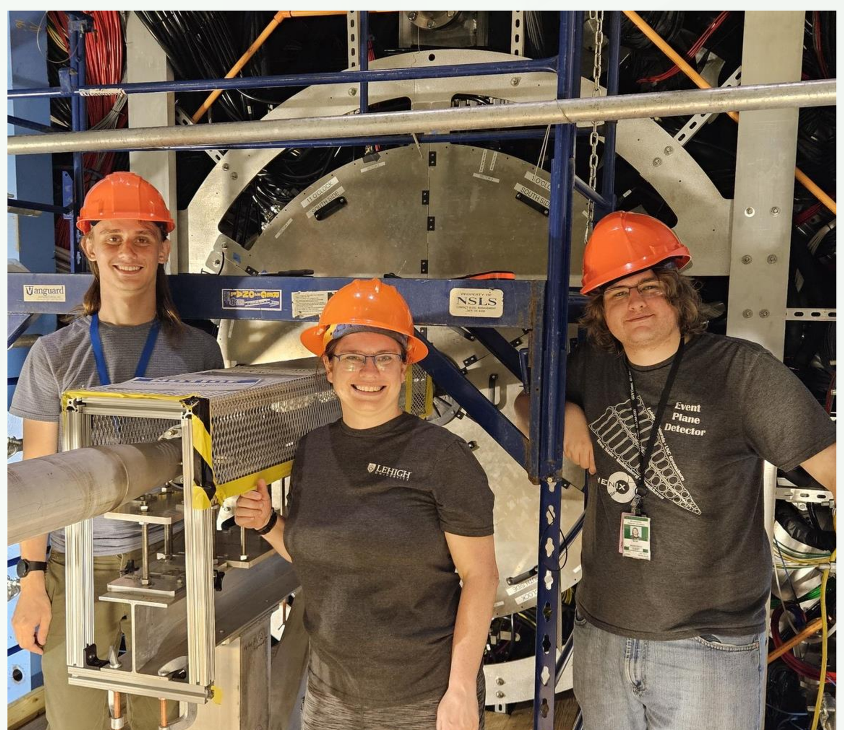
Testing and Strongback Assembly



- Wrapped sectors (top figure) shipped to either University of Colorado Boulder or BNL for cosmic testing
- Test sector and control sector placed between two external scintillator "trigger" paddles
- When cosmic rays passed through both the external paddles, data would be taken
- Data acquired to see how well one could distinguish a peak of minimally ionizing particles (MIPs) for each channel
- Independent tests for both the odd-numbered and even numbered channels
- 24 sectors with channels with the most distinguishable MIP peaks fastened onto aluminum strongbacks
- Before strongbacks installed, each sector light-tighted
- Clear optical fiber bundle attached to each sector
- Signal visualized on an oscilloscope
- Light shown on each sector to see if signal changed
- Light leaks covered in blackout tape until the leak was no longer present.
- Light-tight testing setup shown in bottom figure

Installation





Pictured (L to R): Tristan Protzman, Rosi Reed, and Micah Meskowitz of Lehigh University

- Prior to installation each strongback was placed on a "bike-rack" to safely store the sectors
- North side disk of the sEPD (left figure) was installed on June 21st, 2023
- South side disk of the sEPD (right figure) was installed on July 5th, 2023
- Test electronics for reading out the signal for 2 sectors on the North side installed on July 19th, 2023

Initial Performance

Plot of MIP Distributions still being approved

- Plot of MIP distributions for 3 channels of the sEPD using the test electronics with beam running
- All channels are from north sector 5
- Data from runs 22102 and 22108
- Run 22102 has 150,000 events and was taken with LL1, MBD and ZDC, with ZDC triggering
- Run 22108 ended at 350,000 events and included the MDB, HCAL, ZDC and INTT
- sEPD bias voltage set to 60V for these tests

Acknowledgements

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