An Improved Event Plane Detector for the STAR Experiment

Justin Ewigleben, Lehigh University
For the STAR Collaboration

Justin Ewigleben, APS April 2017 Meeting 1/29/2017
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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
• 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
EPD vs BBC

372 Tiles Each

36 Tiles Each
(Only inner 18 used)

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EPD, BBC coverage

BBC: $|\eta| = 3.3 - 5 \Rightarrow \theta = 0.8^\circ - 4.2^\circ$

EPD: $|\eta| = 2.1 - 5.1 \Rightarrow \theta = 0.7^\circ - 14^\circ$
Machining and Optical Isolation

CNC milling
- high volume water/oil for cooling, debris
Super Sector Construction

- 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)

Embedded 32-channel fiber-to-fiber connector

Embedded WLS fibers

Clear fibers

A test tile
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 $\rightarrow$ 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

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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 $12 \times 31 \times 2 = 744$ 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 $\rightarrow$ 1600+ illuminated pixels
  - read out by STAR FEEs/QTs, similar FPS

Custom-built connector components
  - 3D-printed