Performance of the STAR Event Plane Detector

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For the STAR Collaboration
Beam Energy Scan

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

Centrality, Event Plane and Triggering
Collision centrality defined by impact parameter between colliding nuclei

$b = \text{impact parameter}$

Central collisions should see the strongest effects due to the Quark Gluon Plasma

But $\rightarrow$ We can’t measure $b$ (and thus centrality) directly!
We measure the number of particles in a heavy-ion collision and then calculate the impact parameter.
Hit/No-hit

All 93 channels show good signals ✓
Nice correlation between EPD centrality at forward rapidity and TOF centrality at center rapidity!

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require BBC hit
require no BBC hit

Specific tiles registering hits are correlated ✓

BBC tiles indicated at approximately correct position
Specific tiles registering hits are correlated ✓

BBC tiles indicated at approximately correct position
• EPD correlated with BBC tiles overlapping with it √

• EPD vs. BBC timing shows good agreement, difference is sharply peaked √
From ADC -> nMIPs

- Sample of ADC plots from 2017

- Data shown just from 4 \( \eta \)-rings, the rest are consistent. Different colors indicate different tiles in a ring.

\( \eta = 5.1-4.5 \)

\( \eta = 4.5-4.0 \)

\( \eta = 3.5-3.3 \)

\( \eta = 3.3-3.1 \)
Fit assuming landau distribution, get location of MIP peaks

- $\eta = 5.1-4.5$
- $\eta = 4.5-4.0$
- $\eta = 3.5-3.3$
- $\eta = 3.3-3.1$
From ADC -> nMIPs

• Sample of nMIP plots from 2017
• Only position of 1 MIP peak is fixed, height of peak and position of 2+ MIP peaks are all real (i.e. no “vertical” normalization), only the equation below for nMIP was used
• Data shown just from 4 η-rings, the rest are consistent. Different colors indicate different tiles in a ring

\[ \text{nMIP} = \frac{\text{ADC}}{\text{MIP}} \]

MIP is actually the MPV for the 1-MIP Landau distribution
Wrapping Up (the End is in Sight!)

- Will provide independent measurement of centrality and EP
- Performance results from 2017 are all well understood and outperforming all expectations (really outperforming!)
- **Supersector Construction and testing is completed!**
- Clear Fiber Bundle construction ongoing at Lehigh
- **Installation at the end of January**
- Run 18 scheduled start is early MARCH 2018
  - BBC will be run in parallel in 2018 to validate performance
  - $\sqrt{s_{NN}} = 27$ GeV $\rightarrow$ summer 2018
Questions?
CNC milling
- high volume water/oil for cooling, debris
Testing the new EPD

Landau fits to the data show a nice uniform response
• 99.5% good tiles!

Cosmic ray

$^{90}\text{Sr} \rightarrow ^{90}\text{Y} + e \rightarrow ^{90}\text{Zr} + e$

Measure current in SiPM due to Strontium source
• Test within tile uniformity (within 20%!)
• Test cross-talk (less than 1%)
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)
Front WLS grooves
Clear fiber bundle meets readout electronics

EPD FSC spacer block

EPD SiPM card: 16, 25-μm SiPMs

FEE Card

FEE Box
Prototype run 2016

BBC

pEPD
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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Supersector production

1. mill isolation grooves (1.65 mm wide) on back ½-way (6 mm deep)
2. TiO₂ + 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. TiO₂ + 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)
- $R_{in}=4.5 \text{ cm}$, $R_{out}=90 \text{ cm}$, $z_{mount}=375 \text{ cm}$

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 $\rightarrow$ 1600+ illuminated pixels
- read out by STAR FEEs/QTs, similar FPS

Custom-built connector components

- 3D-printed