Physics goals of the Event Plane Detector (EPD)

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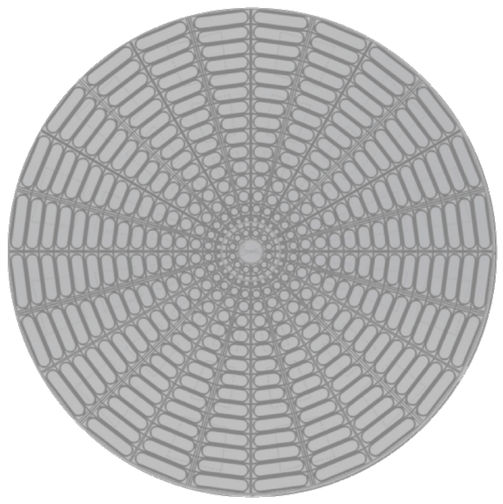
Abstract

The Event Plane Detector (EPD) is an upgrade to the STAR experiment that will significantly improve event plane resolution and provide a measure of collision centrality at forward rapidity ($2.1<|\eta|<5.1$). The complete detector, composed of two scintillator wheels, will be operational in the 2018 run, but in 2017, a quarter of one wheel was operated. Results from this run including the partial EPD from Au+Au collisions at $\sqrt{s_{NN}}$ = 54 GeV will be presented. The track densities at this energy are considerably higher than those expected for RHIC Beam Energy Scan energies ($\sqrt{s_{NN}} \leq 20$ GeV) for which the detector was originally designed. Nevertheless, the detector performed very well in this higher density environment. Preliminary pseudorapidity distributions and anisotropic flow (v_1 and v_2) results is presented for forward rapidities measured by the EPD during the 2017 run.

Why build an EPD?

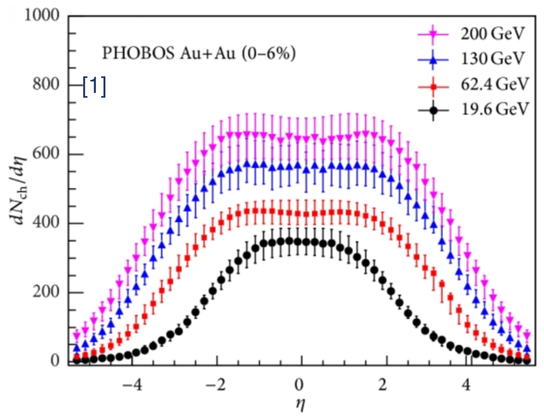
The EPD was designed for the following tasks in BES-II:

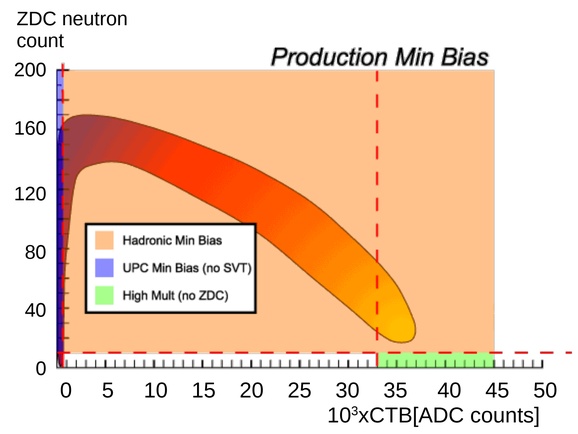
- Triggering (Justin Ewigleben's poster #14)
- Forward event plane determination (2x resolution improvement = 4x increase statistics)
  - First-order flow
  - Global polarization
  - Azimuthal HBT (twist)
  - Mid-rapidity flow analysis (cross-check)
  - Chiral measurements (cross-check)
- General purpose, high-η hit detector
  - Flow as a function of η (decorrelation)
  - Δη-Δφ correlations
  - dN/dη (charged particle)
- Forward centrality determination
  - Cross-check, especially for fluctuation based analyses



*Also see Joseph Adams' poster (#20) for details on the EPD construction

Challenges of forward centrality





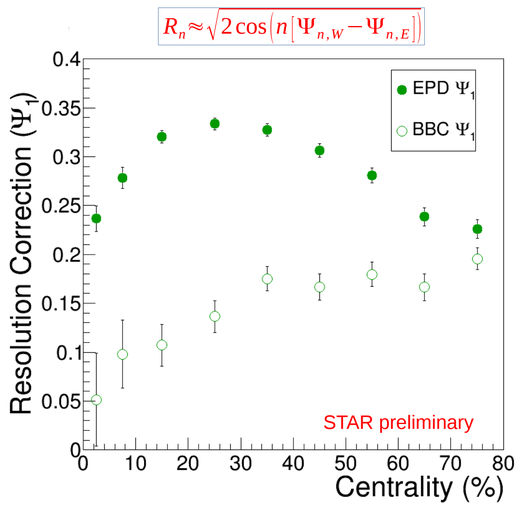
- At very high collision energy EPD detects produced particles (positive correlation of EPD multiplicity with TPC)
- At very low collision energy EPD detects spectators (negative correlation of EPD multiplicity with TPC)
- In BES-II the reality is somewhere in between. A mix of positive and negative correlations is a *significant* complication

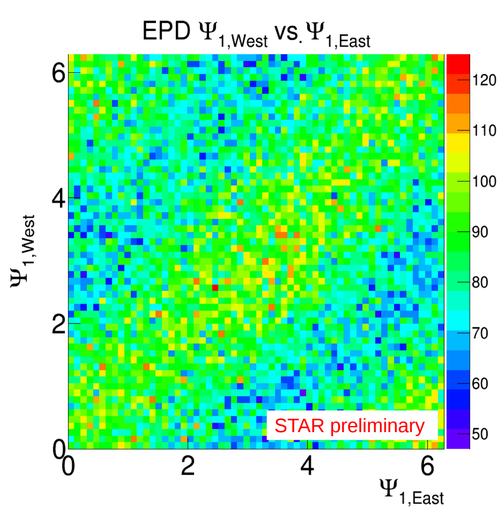
Forward event plane determination

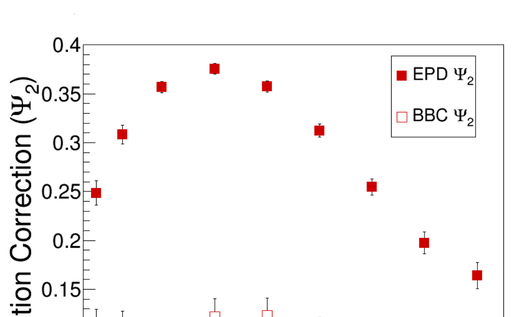
West: η > 0
East: η < 0

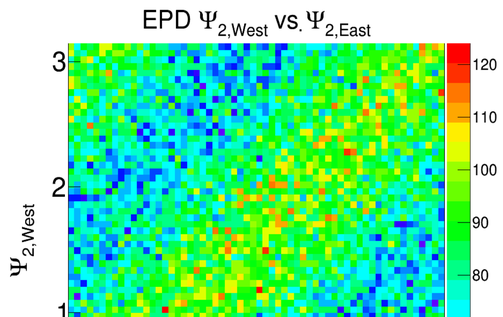
- First dataset with fully installed EPD: 2018 isobar run (200 GeV RuRu + ZrZr)
- We can compare EPD event plane with BBC event plane
- Centrality is loosely based on not fully calibrated TPC multiplicity percentages
- Quoted resolution is the resolution of the full, combined EP
- First order event plane found by the East EPD is rotated by π

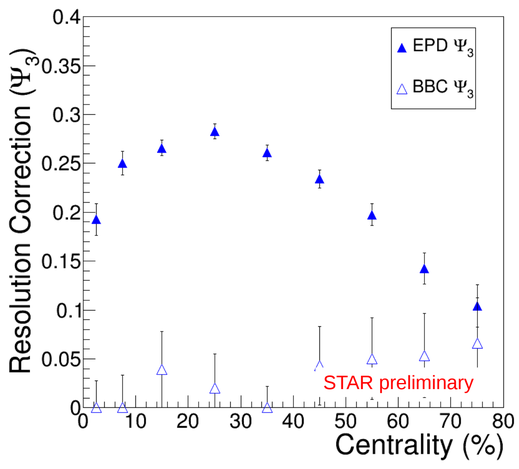
$$R_n \approx \sqrt{2\cos\left(n\left[\Psi_{n,W}-\Psi_{n,E}\right]\right)}$$

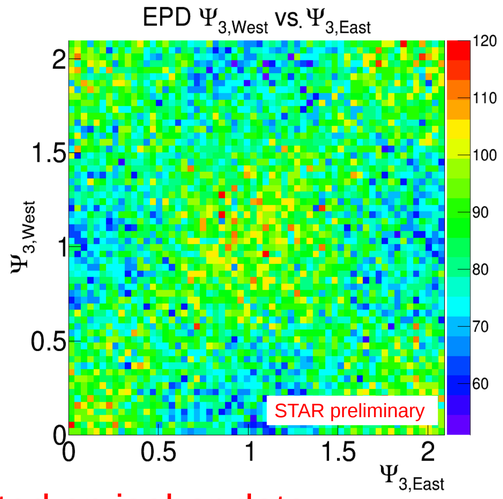








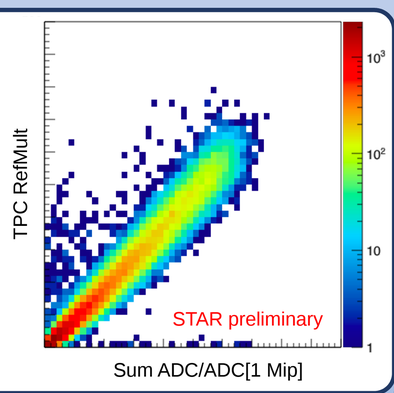




- Basic analysis methods tested on isobar data
- The EPD is a *significant* improvement on the BBC

High energy multiplicity correlation

- Strong correlation seen in 200 GeV RuRu+ZrZr
- RuRu + ZrZr datasets are combined
- TPC data is not fully calibrated



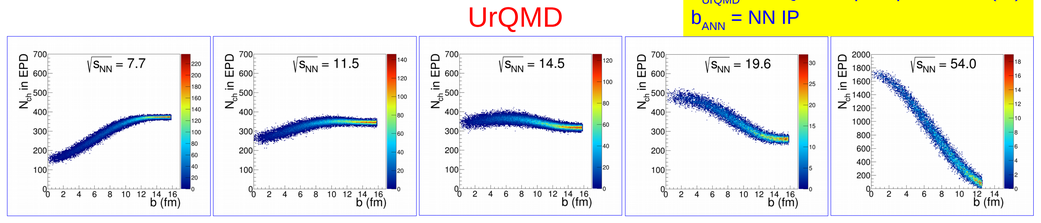
Centrality at mid-to-low collision energy: ring weighting

- Though the spectators and produced particles have opposite correlations, they have characteristically different rapidity ranges
- By weighting the multiplicity of the 16 rings of EPD tiles differently (including negative weights) we can take care of this mix
- No models describe forward rapidity well, instead use neural network (NN)
  - Train NN to best correlate hits in the EPD coverage to mid-rapidity multiplicity
  - Forward particle yield is compared to mid-rapidity particle yield in UrQMD data both before and after NN-based ring weighting below
    - Proof of concept, BES-II weights should be taken from data
  - Calculation also performed for for 54 GeV data taken by STAR in 2017
    - This only uses 1/8th installation of the EPD ($\eta>0$, $3\pi/2 < \varphi < 2\pi$)

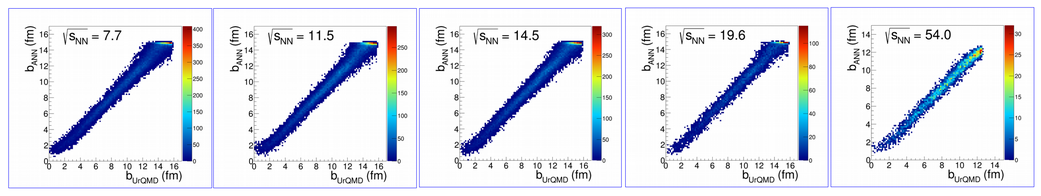
b_{UrQMD} = UrQMD impact parameter (IP)
b_{ANN} = NN IP

UrQMD

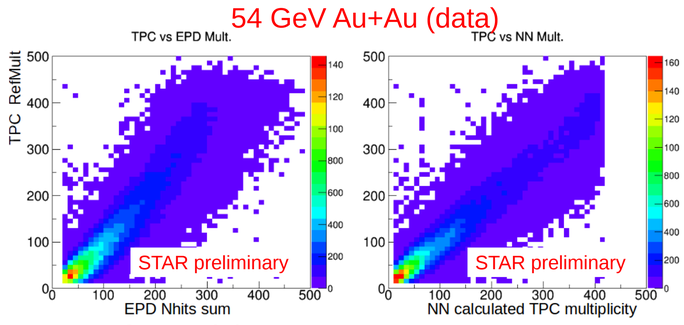
Before training



After training



54 GeV Au+Au (data)



Before training

After training

- The improvement in the BES-II simulations is obvious
- The improvement in the data will have to be done on an energy-by-energy basis

References

[1] B. B. Back *et al.* [PHOBOS Collaboration], *Phys. Rev. C* **74**, 021901 (2006)

[2] Sahoo, Raghunath & Mishra, A & K. Behera, Nirbhay & K. Nandi, Basanta, *Advances in High Energy Physics* (2015) 10.1155/2015/612390.