

# Event-shape engineering of charged hadron spectra in heavy-ion collisions at $\sqrt{s_{NN}} = 200$ GeV at STAR



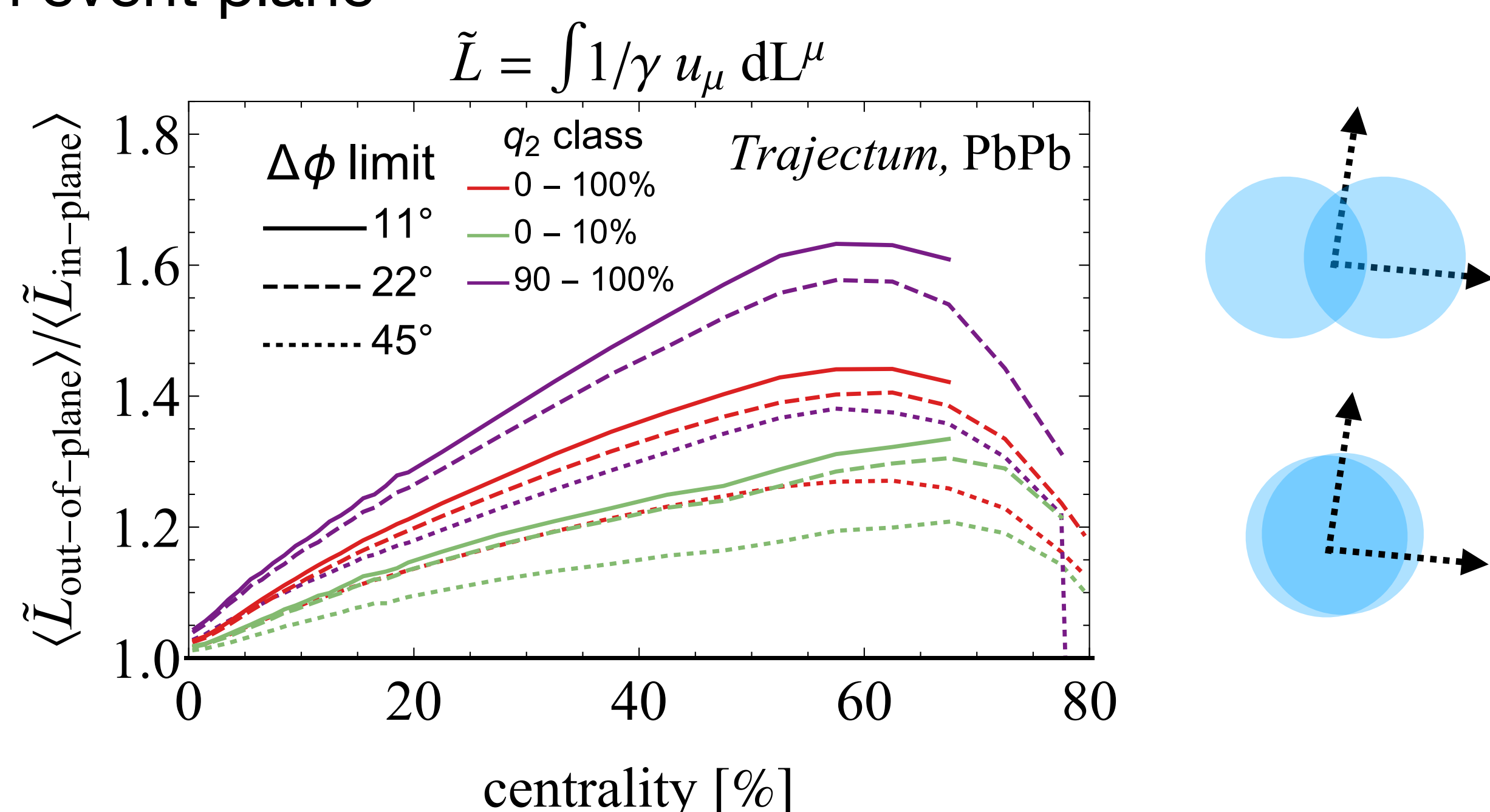
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## Abstract

Partonic scatterings with high momentum transfer occur before the formation of the quark-gluon plasma (QGP) in heavy-ion collisions and result in collimated collections of hadrons, called jets. The modification of the high-virtuality parton shower in the QGP compared to that in proton-proton collisions offers insight into the nature of the medium's interactions with colored probes. To study the path-length dependence of hard partons traveling through the QGP, we apply a technique known as event-shape engineering to data from heavy-ion collisions at  $\sqrt{s_{NN}} = 200$  GeV at STAR. Within a given eccentricity and centrality class, charged-hadron spectra are compared. By fixing the centrality, we can control for the energy density. Work is ongoing to then compare charged-hadrons traveling in the event plane direction (having shorter path length) to those traveling perpendicular to it (having longer path length) in different eccentricity classes to access the dependence of energy loss on the path length.

## Motivation

Jet-medium interaction influenced by **path length**.  
Control with system **geometry** → fix energy density (~centrality), vary geometry with “event shape engineering”<sup>1</sup>  
Possible by relation between final state flow ( $q_2$ , 2nd order reduced flow vector) and initial state eccentricity ( $\epsilon$ )  
**Access path length dependence:** comparing yields along/away from event plane<sup>2,3</sup>



## The STAR Experiment

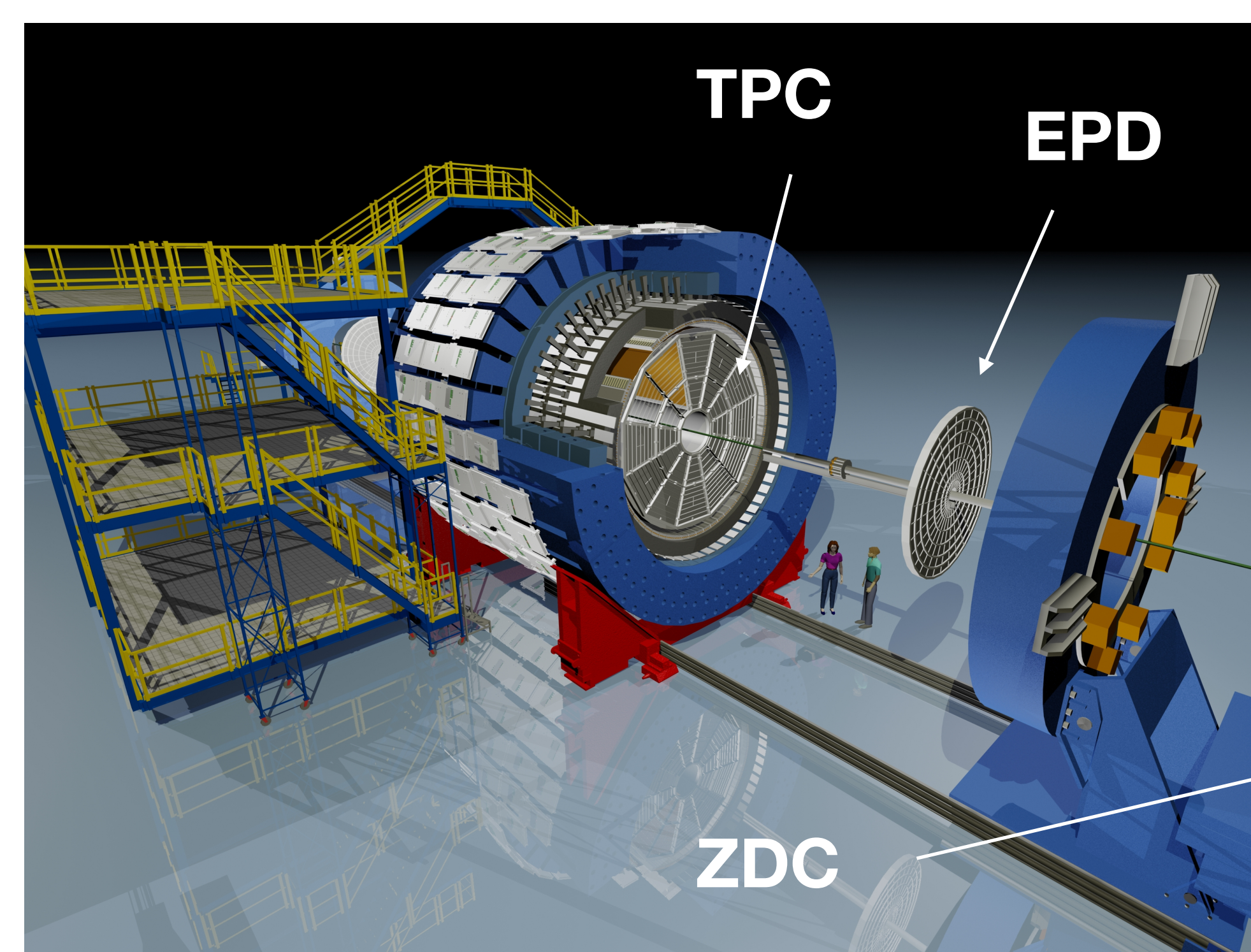
**Time Projection Chamber (TPC):**

Charged track reconstruction + momentum determination

**Zero Degree Calorimeter (ZDC):** Triggering

**Event Plane Detector (EPD):**

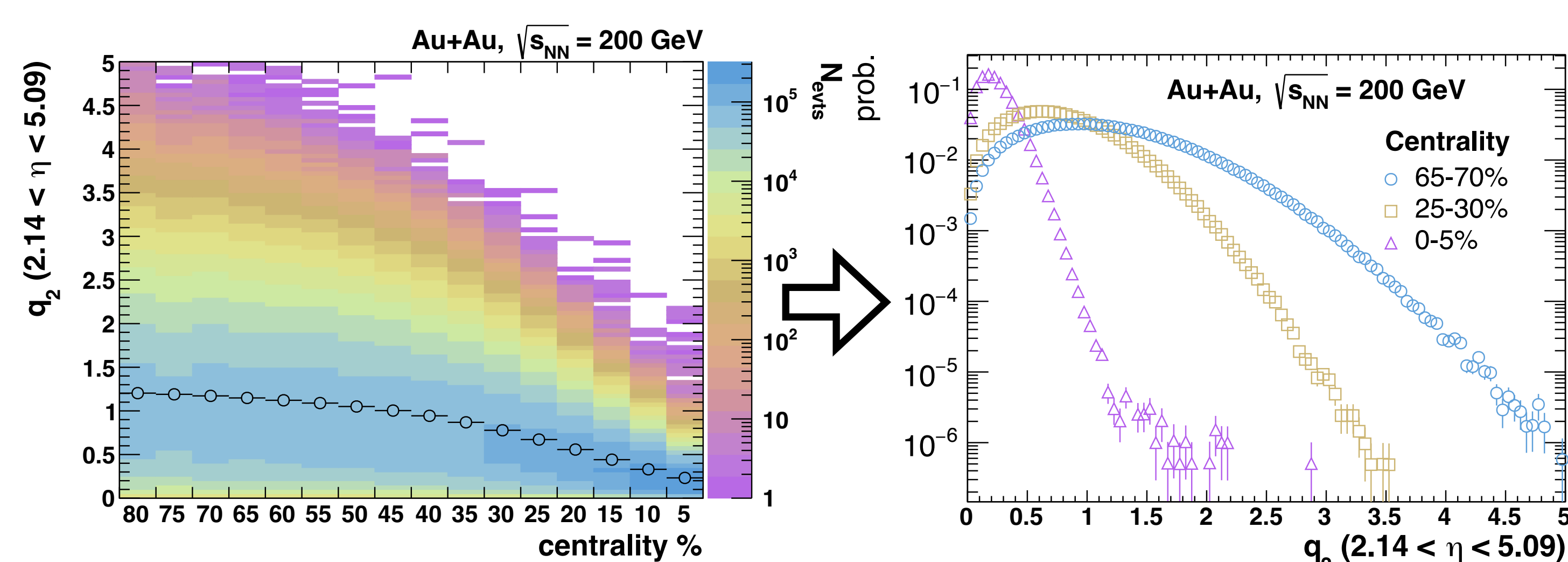
West: flow ( $q_2$ ) determination East: event plane angle ( $\Psi_2$ ) (future)



## Event characterization

$$Q_2 = \left( \sum_{i=1}^M w_i \cos(2\phi_i), \sum_{i=1}^M w_i \sin(2\phi_i) \right), \quad q_2 = |Q_2| / \sqrt{M},$$

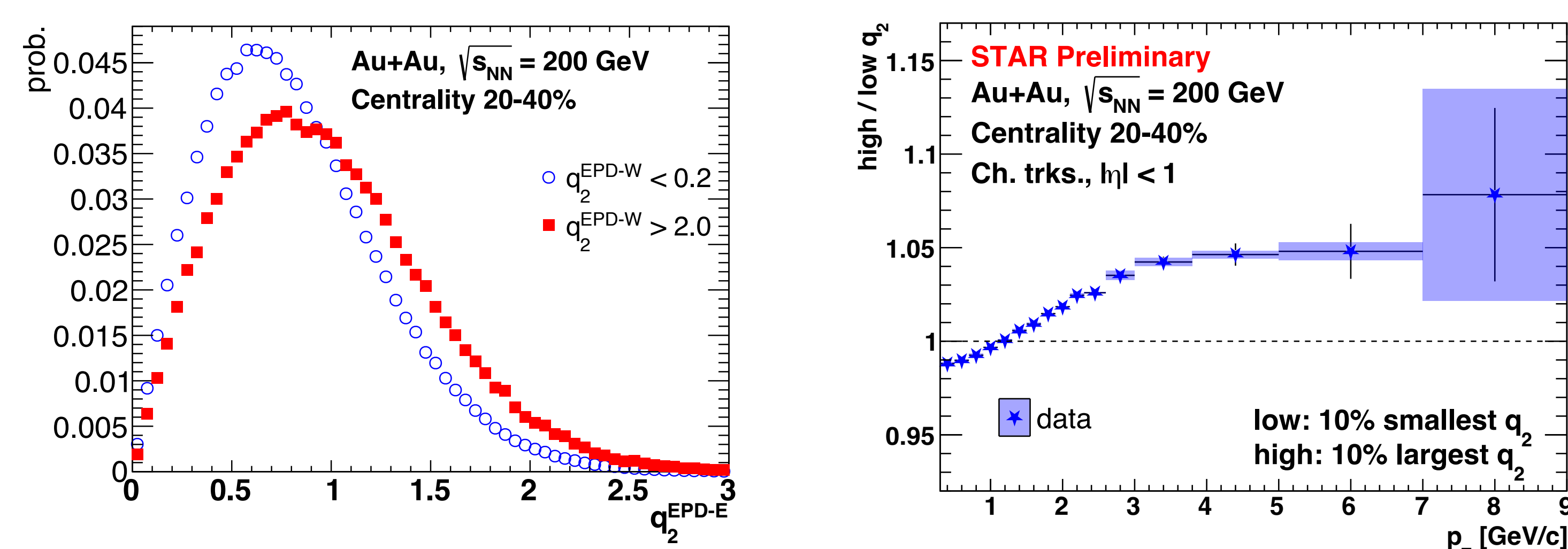
$w_i$ : nMIP weight,  $M$ : multiplicity



- Centrality and  $q_2$  are correlated. We select on each. For given centrality, large variation in event shapes.
- Avoid autocorrelation: EPD-W ( $q_2$ ), TPC (spectra), future: EPD-E ( $\Psi_2$ )

## Charged-hadron spectra comparisons

- Select on 10% highest/lowest eccentricity ( $q_2$ ) events, and compare charged-hadron spectra
- Systematic uncertainty on spectrum ratio (compare East, West; weak correlation — left fig.)



- Right fig.: Interplay between elliptic and radial flow → hardening of spectra at mid- $p_T$ . Ratio flattens at high- $p_T$
- $q_2$  sensitive to azimuthal anisotropy  $v_2 = \langle \cos(2(\phi - \Psi_2)) \rangle$

- Results: hardening of spectra in high- $q_2$  events; flatten at high- $p_T$  where quenching expected to be minimal by average path length argument. Consistent with ALICE 2.76 TeV<sup>4</sup>.
- Work ongoing to select on the event plane angle to allow for comparison between longer and shorter path length

<sup>1</sup>Schukraft, Timmins, Voloshin, *Phys.Lett.B* 719 (2013), 394-398 <sup>2</sup>Beattie, Nijs, Sas, van der Schee, *Phys.Lett.B* 836 (2023), 137596 <sup>3</sup>ALICE, 2307.14097 <sup>4</sup>ALICE, *Phys.Rev.C* 93 (2016) 3, 034916

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The STAR Collaboration  
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