Studying path-length dependent energy loss using jet v_1 and event shape engineered high momentum probes in heavy-ion collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV by STAR

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Motivation

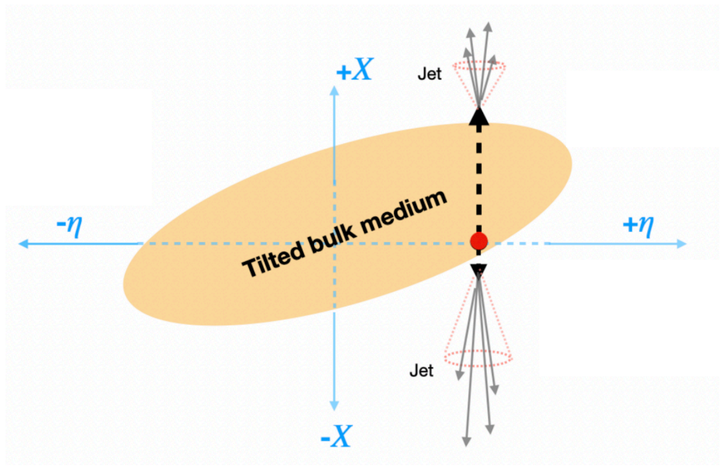
Jet-medium interaction influenced by **path length**, L

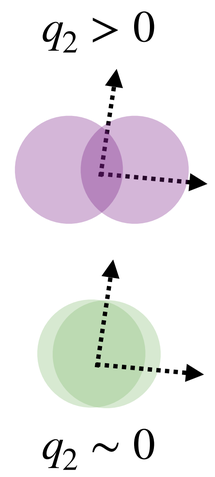
Goal: Control system **geometry** at fixed energy density.

→ fix centrality, vary path length, by taking advantage of

1) bulk medium asymmetry in x-direction at finite rapidity[1,2]
2) relation between final-state flow (q_2, 2nd-order reduced flow vector) and initial-state eccentricity (ε)[3,4,5]

→ hard-probe yields with respect to event plane





The STAR Experiment

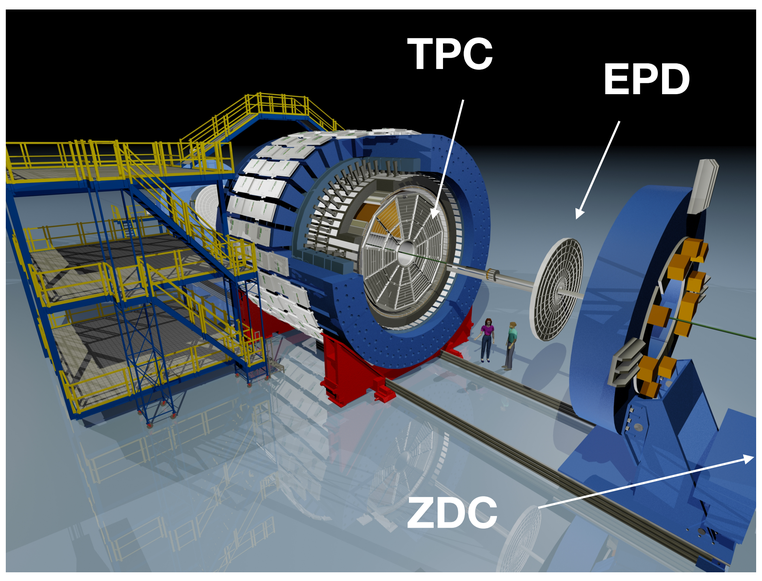
Time Projection Chamber (**(i)TPC**) ($|\eta| < 1$ (1.5)):

Charged-track reconstruction + momentum determination

Zero Degree Calorimeter (**ZDC**) (18 m): Triggering, EP angle (Ψ_1)

Event Plane Detector (**EPD**):

West ($2.15 < \eta < 5.09$): q_2 determination *East*: EP angle (Ψ_2)



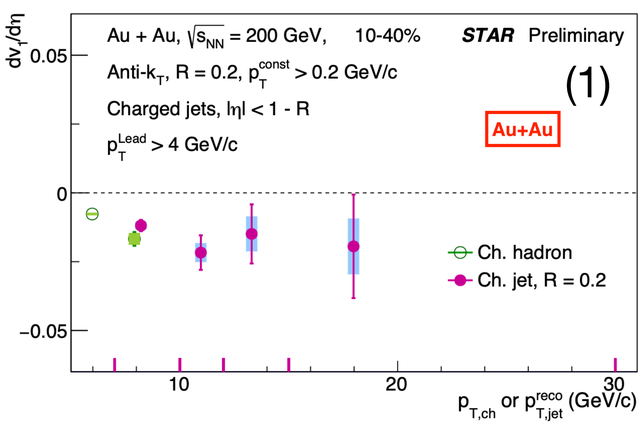
Methodology of jet v_1

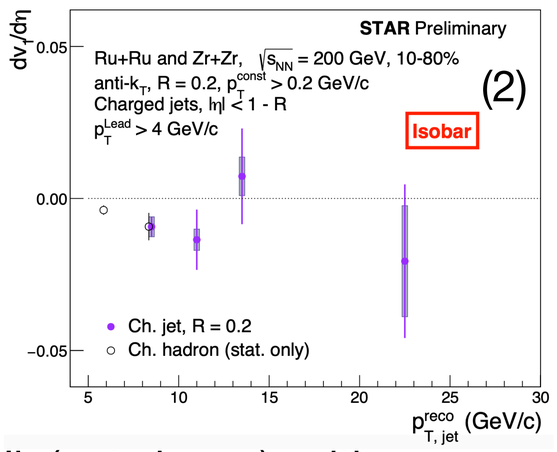
- **Reconstruct jets:** Charged-particle jets with leading hadron $p_{\mathrm{T}} > 4$ GeV/c, clustered with anti-k_{T}, radius $R = 0.2, 0.3$
- **Subtract uncorrelated background:** $p_{\mathrm{T,jet}}^{\mathrm{reco}} = p_{\mathrm{T,jet}}^{\mathrm{raw}} - \rho A$, with ρ from k_{T} algorithm
- **Determine Ψ_1 from ZDC and v_1 of jets as function of** p_T, R

Methodology of event-shape engineering

- **Determine Ψ_2 from EPD**
- **Select events** with 10% highest/lowest q_2 (eccentricity), and compare charged-hadron spectra in-plane vs. out-of-plane

Results: jet v_1

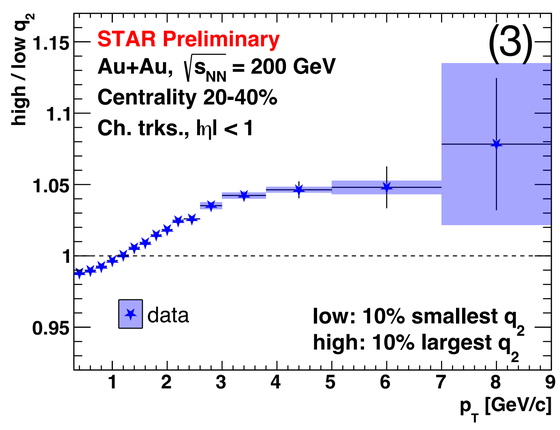


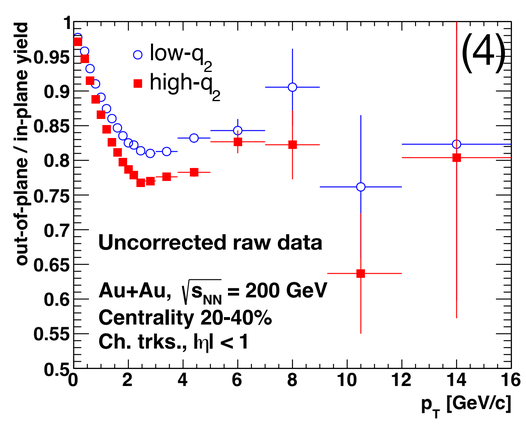


- Larger v_1 of jets compared to bulk (not shown), with non-zero slope as a function of rapidity
- Hint of jet p_{T} dependence, minimal R dep. (not shown)
- Au+Au (Fig. 1) and isobar (Fig. 2) results consistent, as expected from similar initial asymmetry in AMPT
- Charged jet and hadron show similar trends in overlap region
- Extract $\langle p_x \rangle = 0.232 \pm 0.068$ (stat) ± 0.03 (sys) GeV/c for $R = 0.2$ and $10 < p_{\mathrm{T,jet}}^{\mathrm{reco}} < 12$ GeV/c in $10 - 40\,\%$ Au+Au

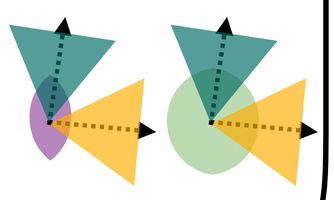
Event-shape engineering

- *Fig. 3*: Interplay between elliptic and radial flow[6] → hardening of spectra at mid-p_{T}. Ratio flattens at high-p_{T}





- Analysis steps to access L dependence:
  - Flatten EP distribution, divide spectra: $\Psi_2 \pm \pi/6$ ('in'), $(\Psi_2 + \pi/2) \pm \pi/6$ ('out')
  - Fig. 4: out/in raw ratio for mid-central low- vs. high-q_2 events
  - Corrected ratio diff. would indicate L-dep. E_{loss}



Summary

- Results: **first measurement of non-zero jet v_1 in heavy-ion collisions**
  Outlook: extract path length dependence; enhance signal with event-shape engineering of multiplicity fluctuations
- Results: **hardening of spectra in high-q_2 events**; work ongoing to correct data for event-shape engineering analysis
  Outlook: Apply resolution correction; determine full set of systematics (3-sub-event[7], etc.)

[1]S. Chatterjee, P. Bozek, PRL 120, 192301 (2018); A. Adil, M. Gyulassy PRC 72, 034907 (2005) [2]STAR Collaboration, PRL 123, 162301 (2019)
[3]Schukraft, Timmins, Voloshin, PLB 719 (2013), 394-398 [4]Beattie, Nijs, Sas, van der Schee, PLB 836 (2023), 137596 [5]ALICE, PLB 851 (2024), 138584 [6]ALICE, PRC 93 (2016) 3, 034916 [7]Festanti, PhD thesis

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The STAR Collaboration: