Radial Flow Fluctuations of Identified Hadrons in Heavy-Ion Collisions at RHIC-STAR

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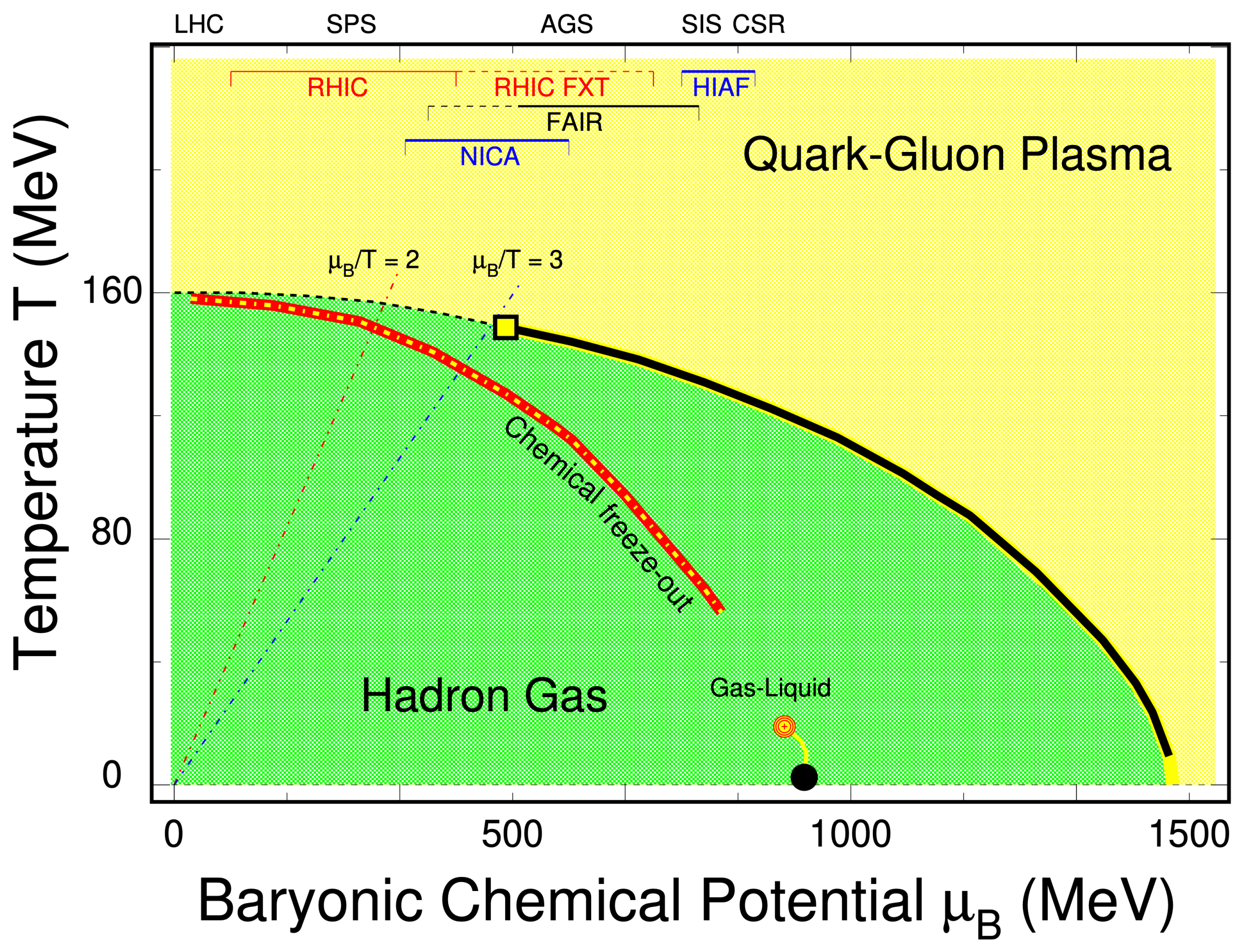
Outline

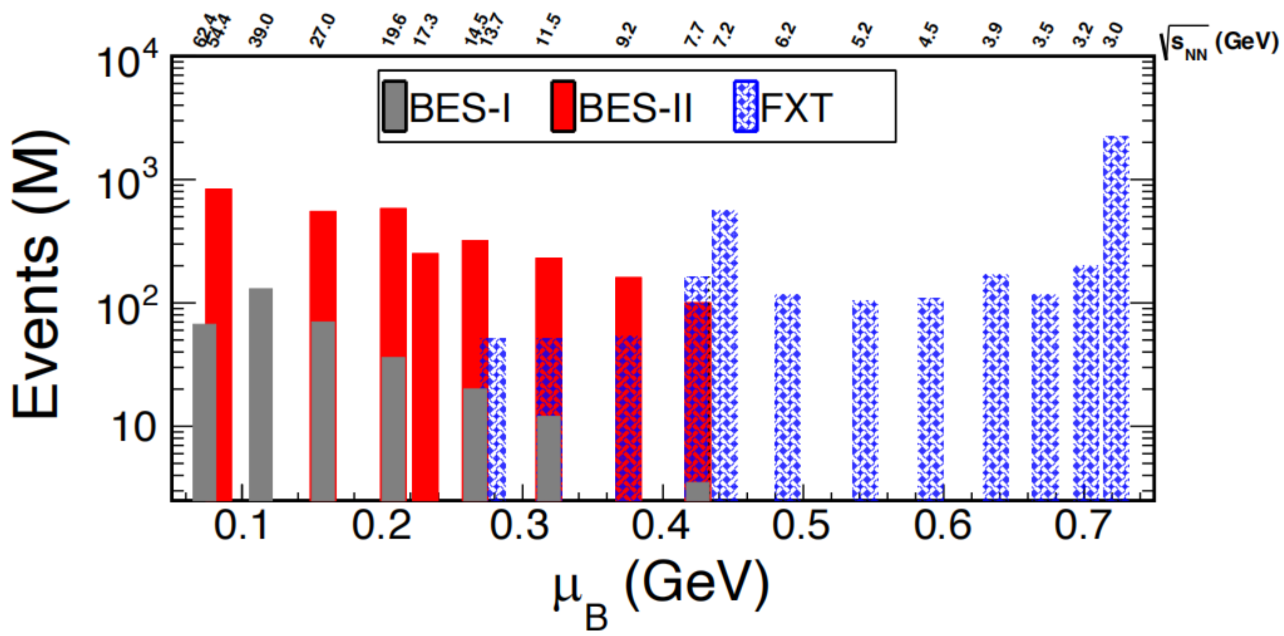
- Introduction & Motivation
- STAR detector
- Results and discussion
- Summary

Introduction



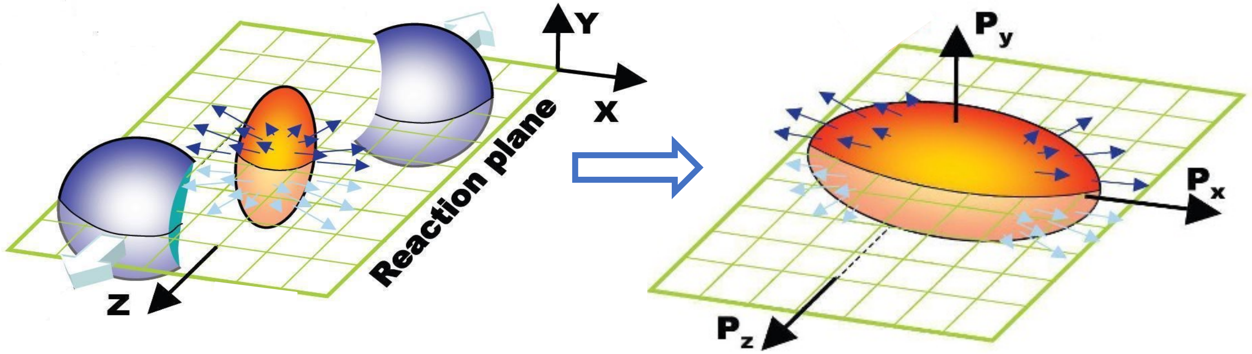
Beam Energy Scan (BES) program at RHIC:

- Search for the QCD critical point
- Explore the first-order phase boundary



X. Luo, S. Shi, Nu Xu et al. Particle 3, 278 (2020)

Motivation

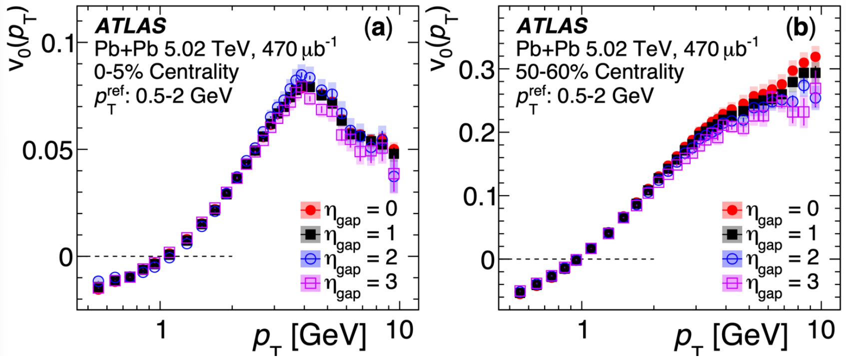


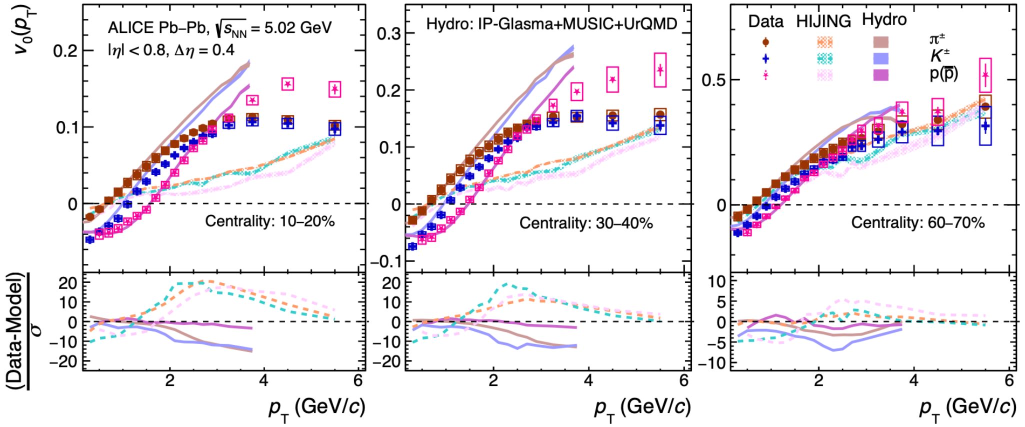
$$\frac{d^2N}{d\phi dp_T} = N(p_T)\{1 + 2\sum_{n\geq 1} v_n \cos[n(\phi - \Psi_n)]\}$$

Shaped by radial flow

Anisotropic flow v_n

- ➢ Sensitive to the initial state
- ➢ Sensitive to the bulk viscosities
- ➢ Sensitive to the equation of state





STAR provides:

- ✓ Different collision system
- ✓ More particle species
- ✓ Energy dependence

Phys. Rev. C 58, 1671(1998)
Phys. Rev. Lett. 136, 032301 (2026)
Phys. Rev. Lett. 136, 032302 (2026)

Definition

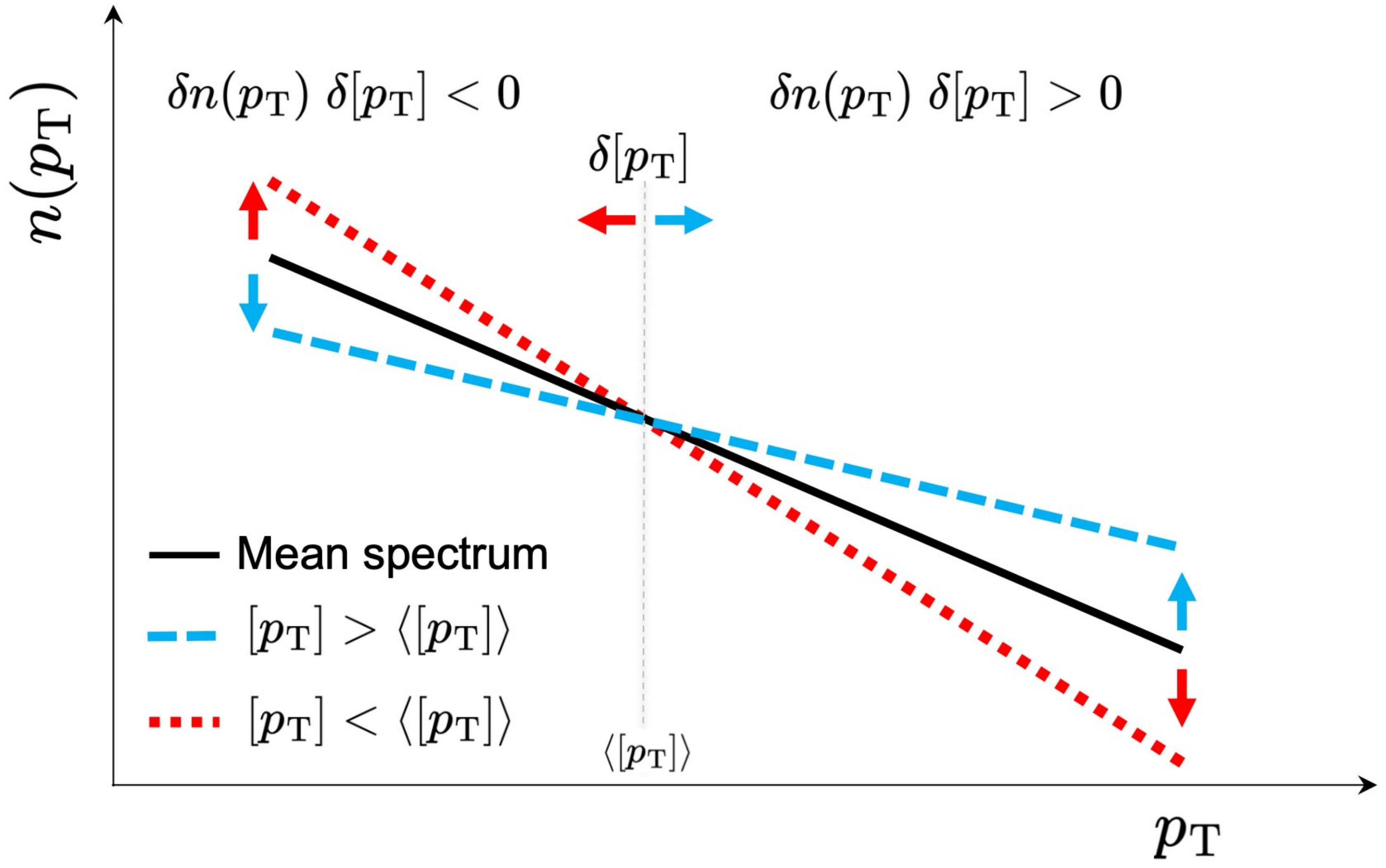
Correlations between the EbE local yield $n(p_T)$ and the EbE global mean p_T

$$v_0(p_T) \equiv \frac{\langle \delta n(p_T)\delta[p_T]\rangle}{\langle n(p_T)\rangle \sigma_{p_T}} \longrightarrow \delta x = x - \langle x\rangle$$

$$n(p_T) = \frac{N(p_T)}{\int N(p_T)dp_T}$$

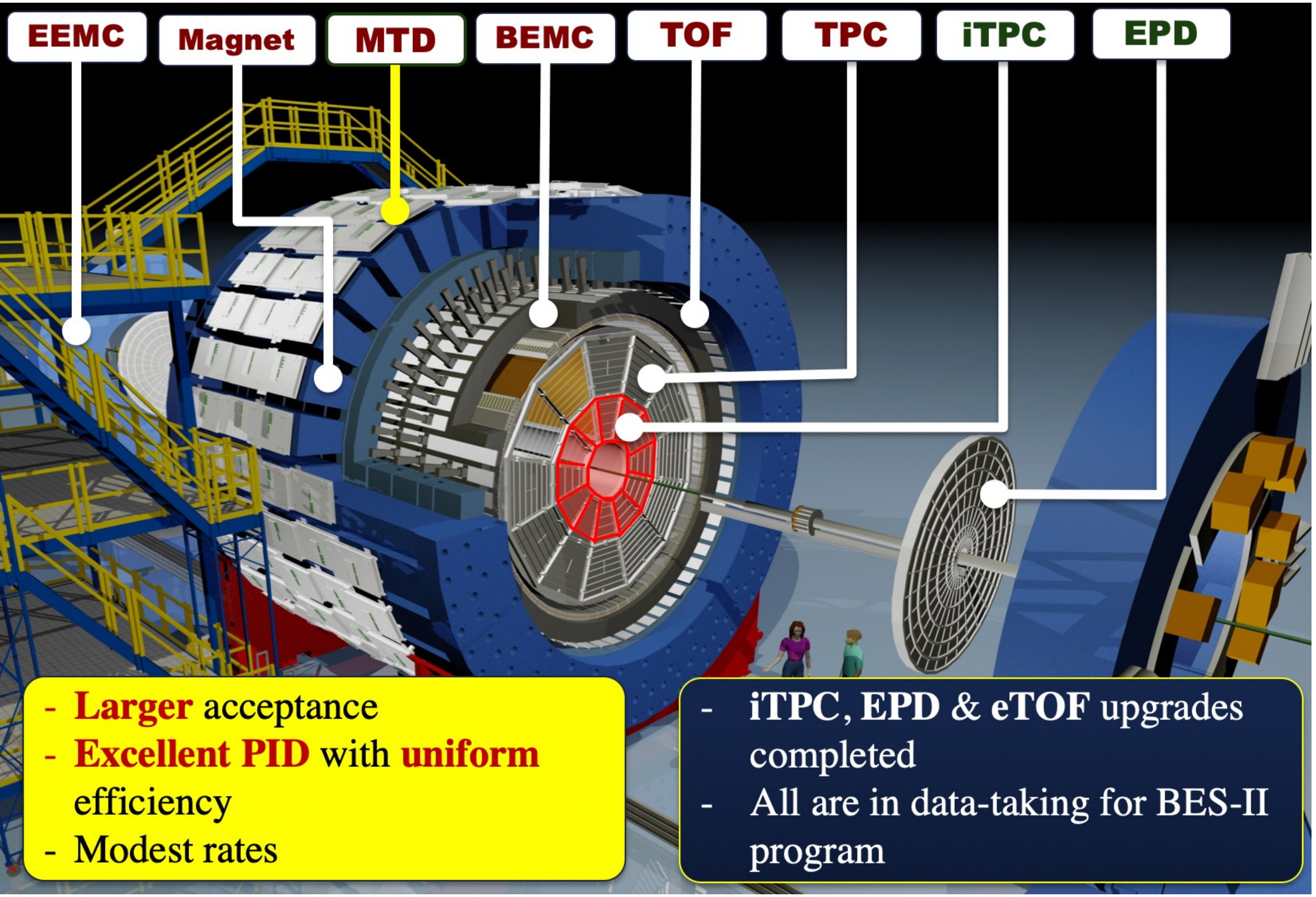
$$\sigma_{p_T}^2 \equiv \langle(\delta[p_T])^2\rangle$$

The brackets ⟨..⟩ indicate event averages.



Phys. Rev. Lett. 136 (2026) 032301
Phys. Rev. C 102 (2020), 034905
Phys. Lett. B 857 (2024), 138985

STAR experiment

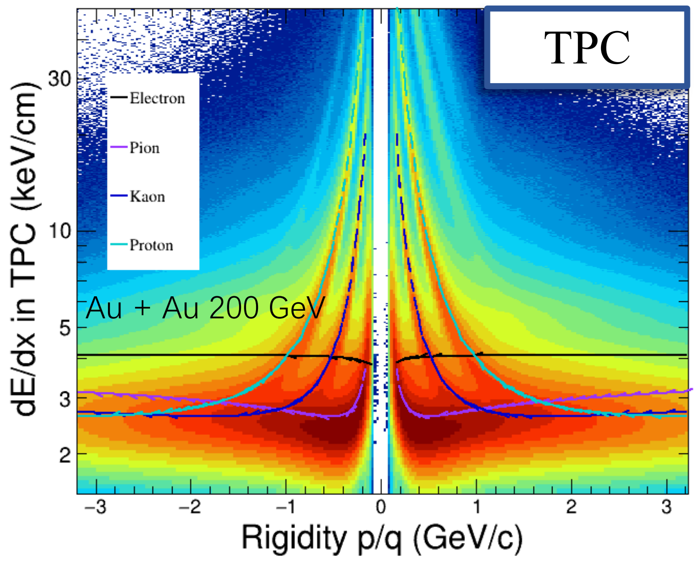


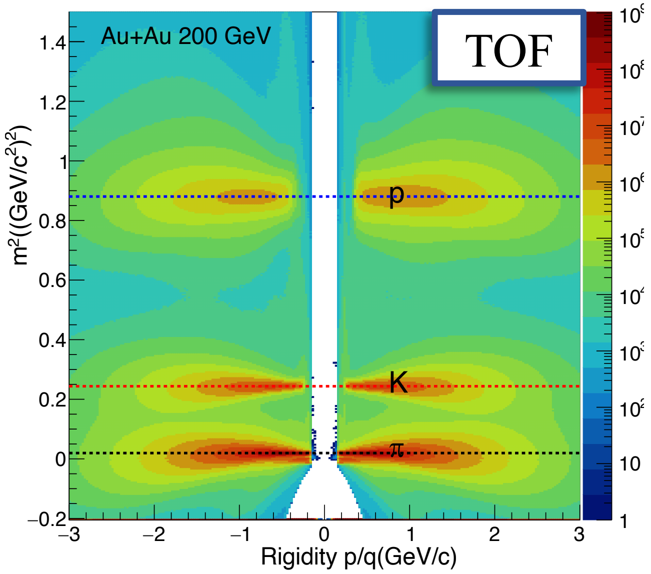
Time Projection Chamber (TPC):
- Particles identification with dE/dx
- Momenta measurement $p \in (0.1, 30)$ GeV/c

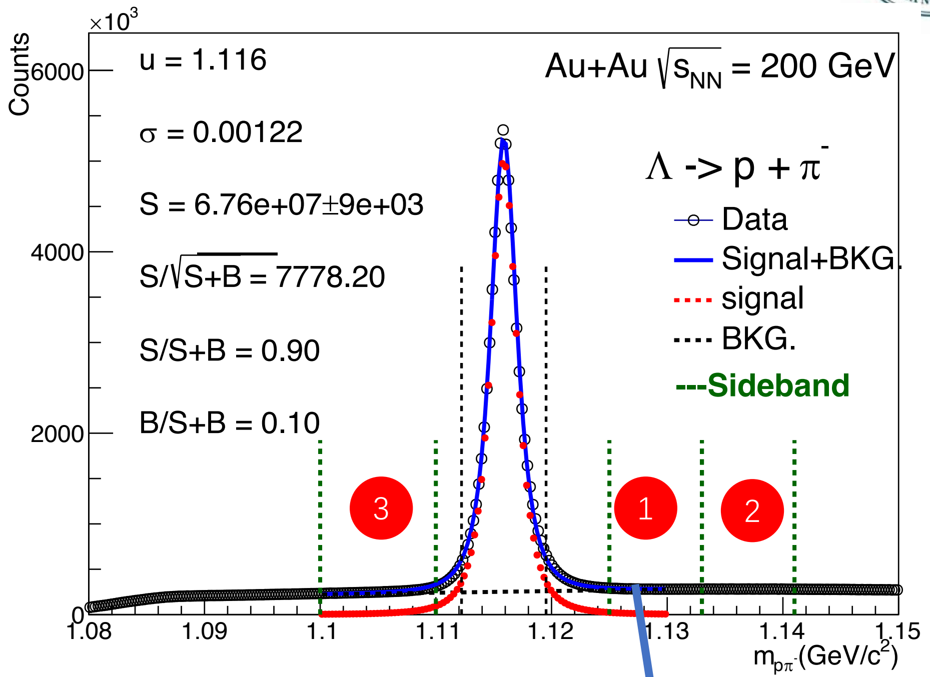
inner TPC upgrade:
- Improves dE/dx
- Extends $|\eta|$ coverage from 1.0 to 1.5

Time of Flight (TOF):
- Particles identification

Particle identification and reconstruction







Side-band used to estimate the BG v_0

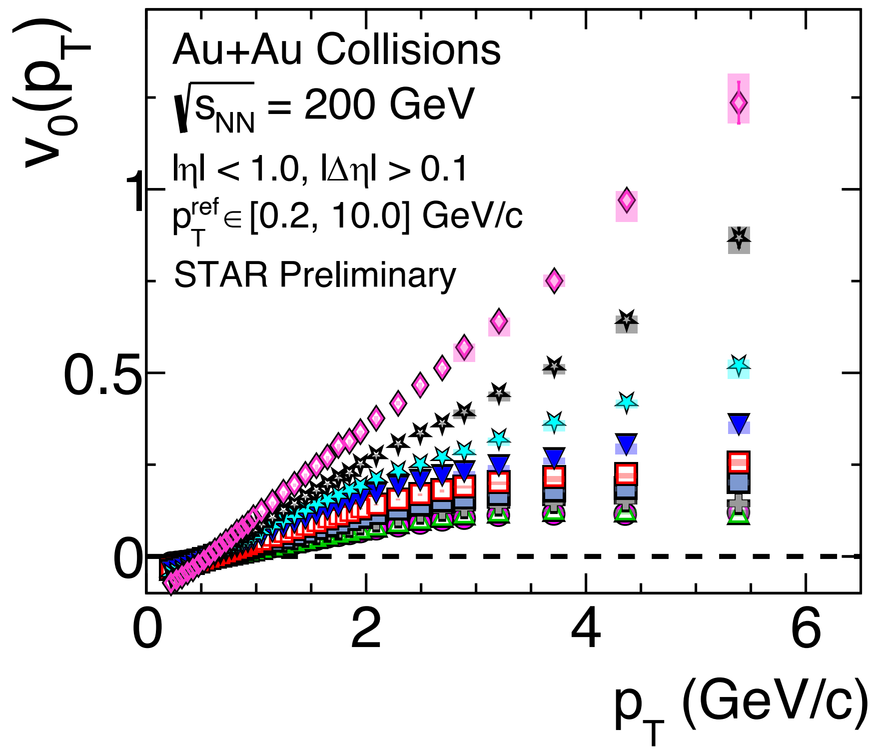
- Good capability of particle identification (PID)
  - ✓ based on TPC and TOF
- Decayed particles are reconstructed
  - ✓ by KF(Kalman Filter) particle package

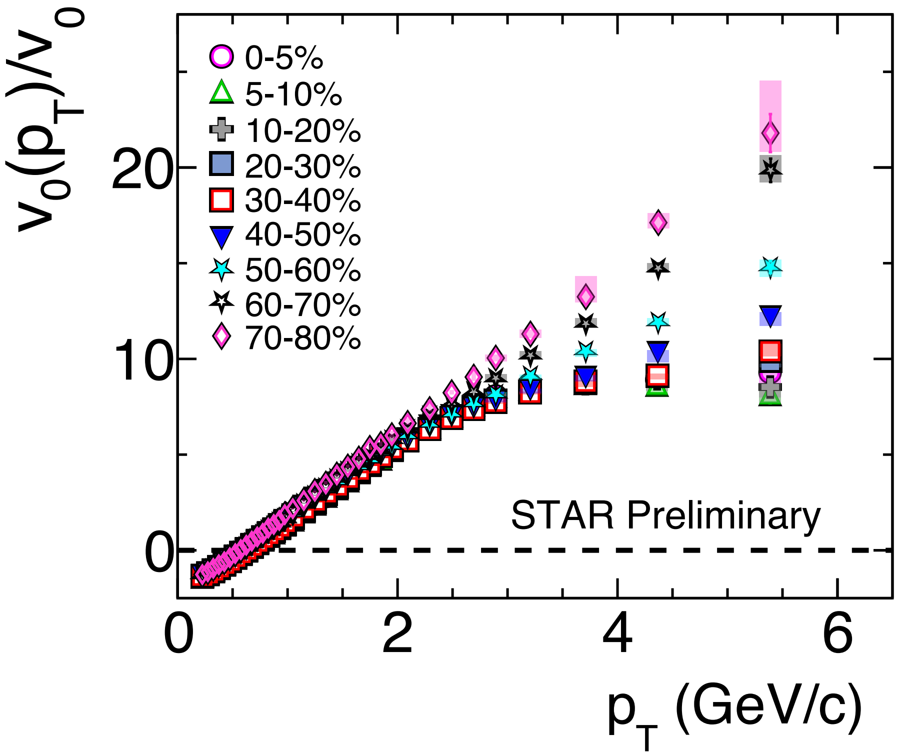
- Estimate of background contribution on v_0:
  - ✓ side-band used to estimate the BG contribution on the signal peak range.

$v_0(p_T)$ & $v_0(p_T)/v_0$

κ_0 is hydrodynamic response coefficient

$\frac{\delta X}{\langle X \rangle}$ is initial-state fluctuation





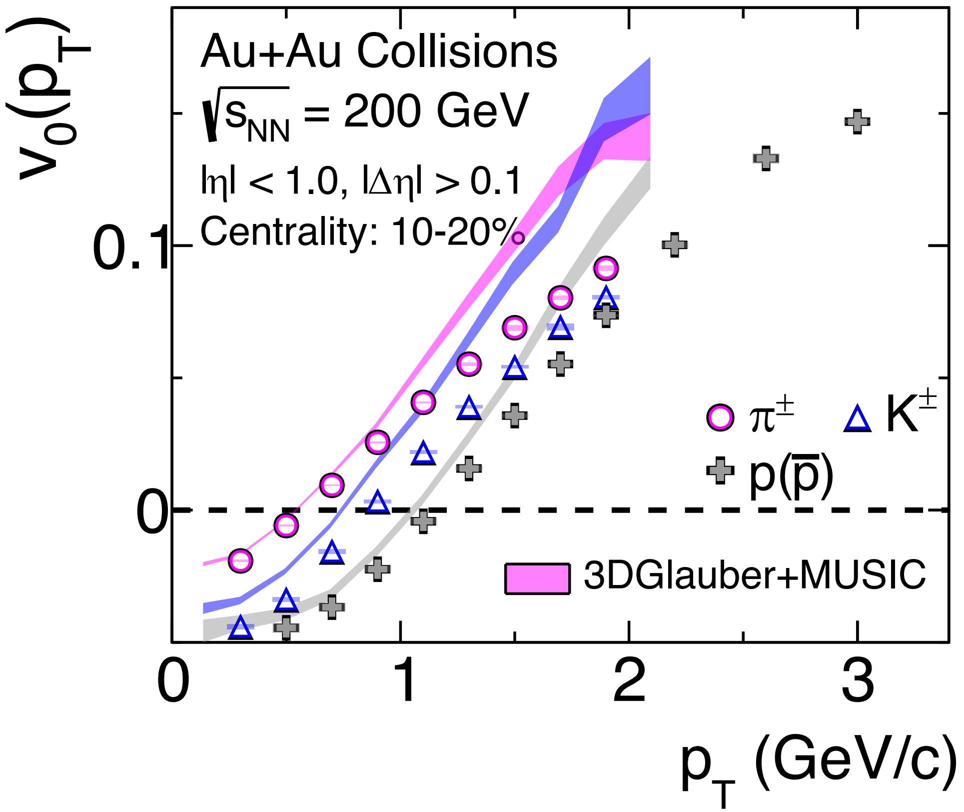
$$v_0(p_T) = \kappa_0(p_T)\frac{\delta X}{\langle X \rangle}$$

$$v_0 = \kappa_0 \frac{\delta X}{\langle X \rangle}$$

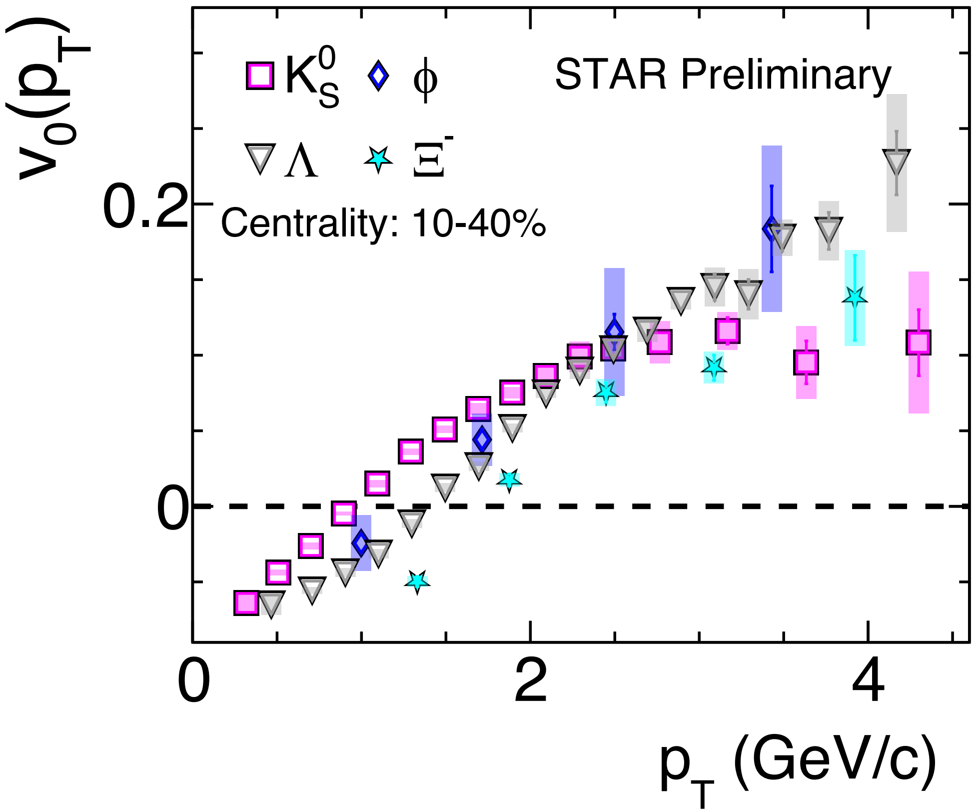
$$\frac{v_0(p_T)}{v_0} = \frac{\kappa_0(p_T)}{\kappa_0}$$

- Strong centrality dependence of $v_0(p_T)$: radial flow fluctuation depends on initial size
- No centrality dependence of $v_0(p_T)$ normalized by integrated v_0 at low p_T (< 3 GeV/c)

Mass ordering

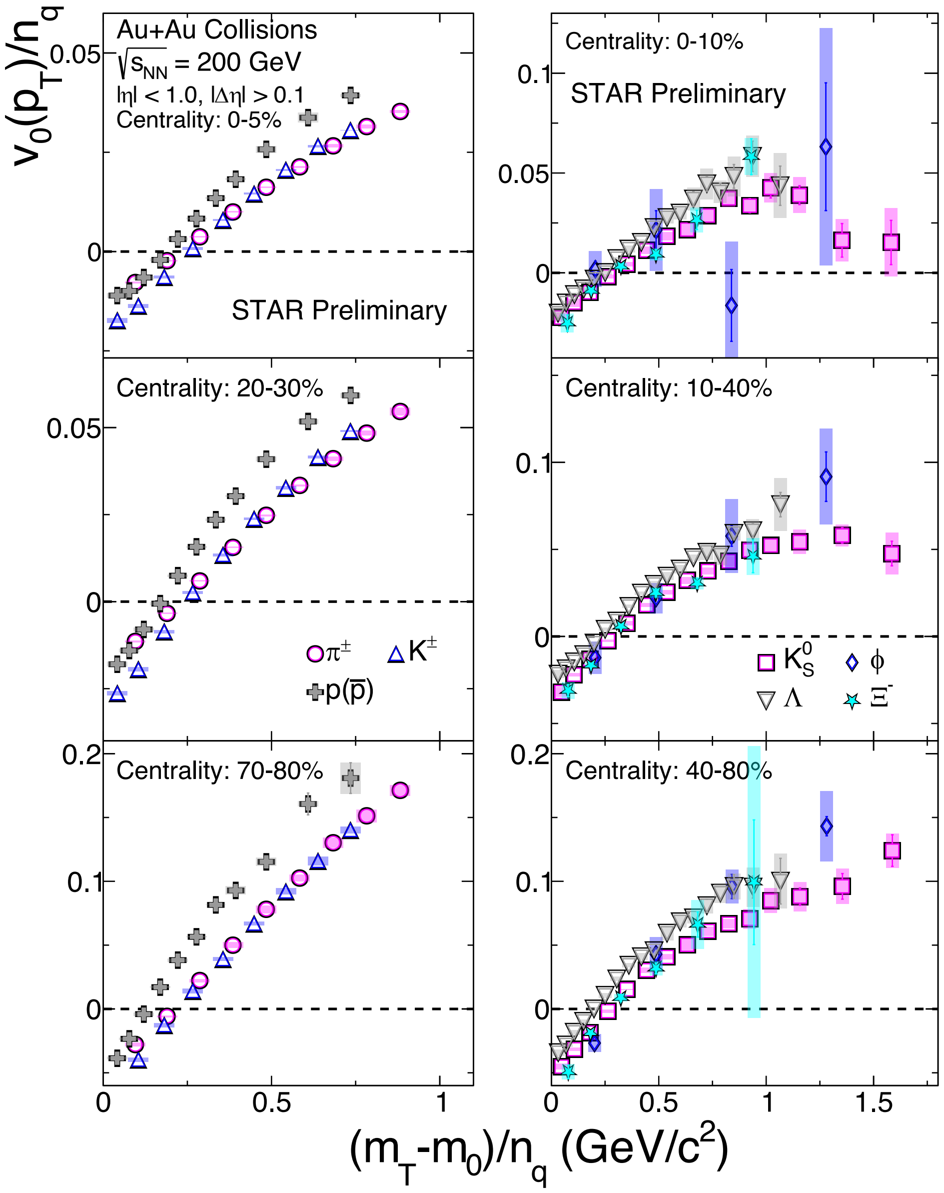


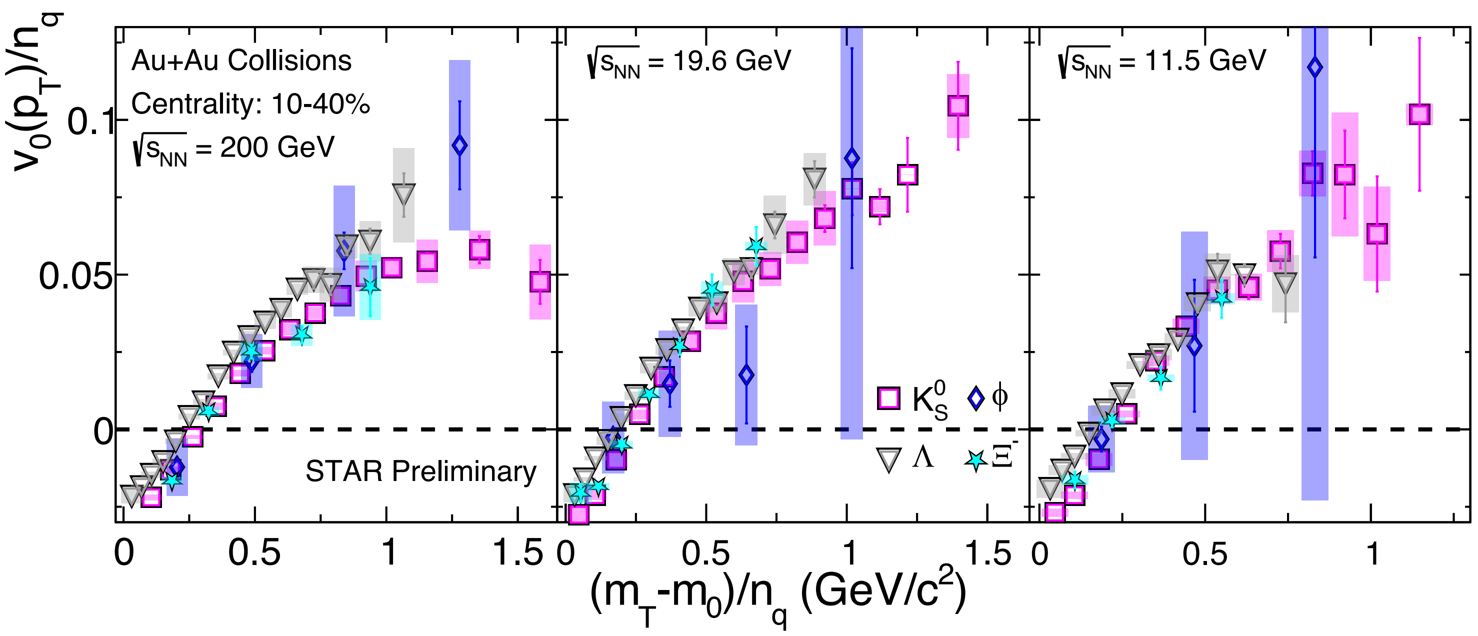
Phys. Rev. C 113 (2026) 024919



- ➢ Mass ordering observed at low p_T: a mass-dependent zero-crossing point.
- ➢ Hydrodynamic model calculations reproduces the mass ordering

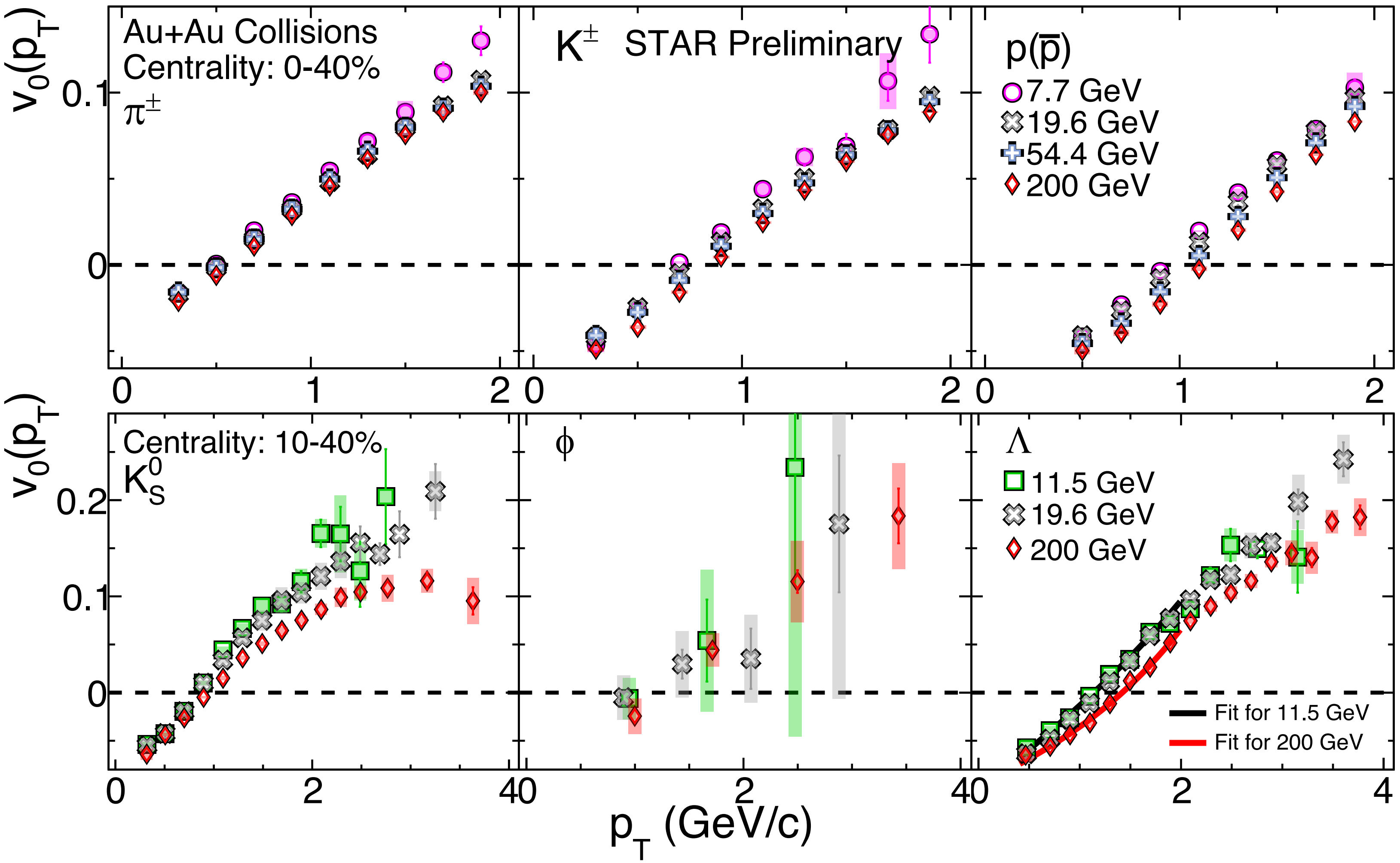
NCQ scaling





- NCQ scaling: holds better in more central collisions

Energy dependence



➢ The energy dependence of zero-cross point: larger radial flow at higher energy

Summary

The measurement of p_T-differential radial flow fluctuation $v_0(p_T)$

- Low p_T mass ordering
- Better NCQ scaling in central collisions
- Energy dependence of $v_0(p_T)$

Outlook

- Scanning the energy of BES II
- Studying more collision systems

Thank you for your attention!

BACKUP