STAR

RHIC & AGS
Annual Users' Meeting
From Protons to Heavy Ions, and Back Again
Hosted By Brookhaven National Laboratory

Beam-Energy and Centrality Dependence of Directed Flow of Identified Particles

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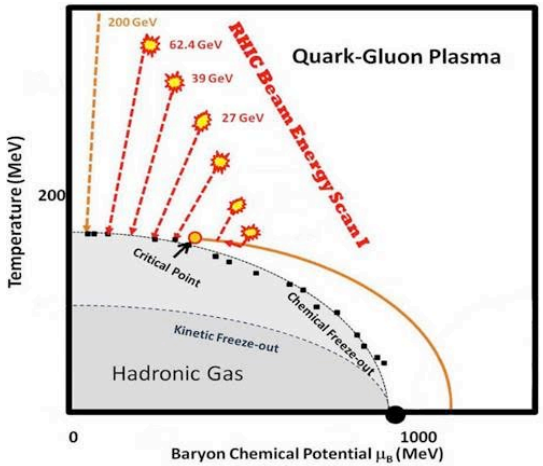
BES Program at STAR and Directed Flow

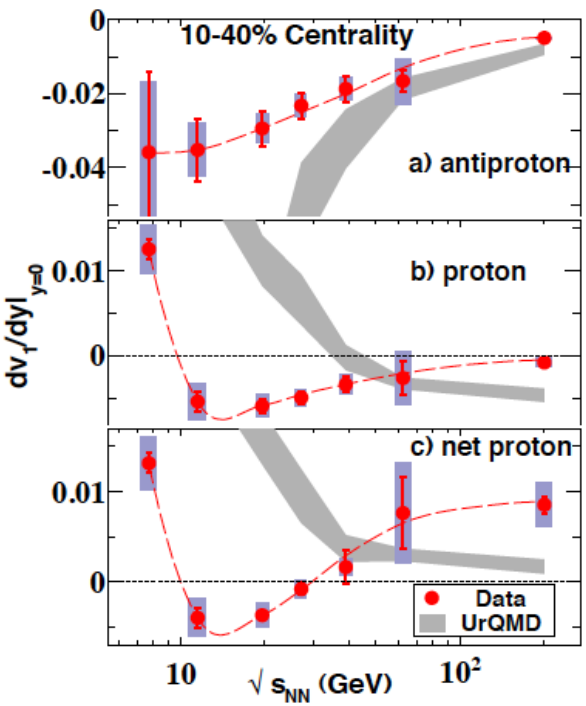


Goals of BES : Explore QCD phase diagram

- Map turn-off of QGP signatures
- Search for a Critical Point
- Search for a First-Order Phase Transition

Data: Au+Au collisions

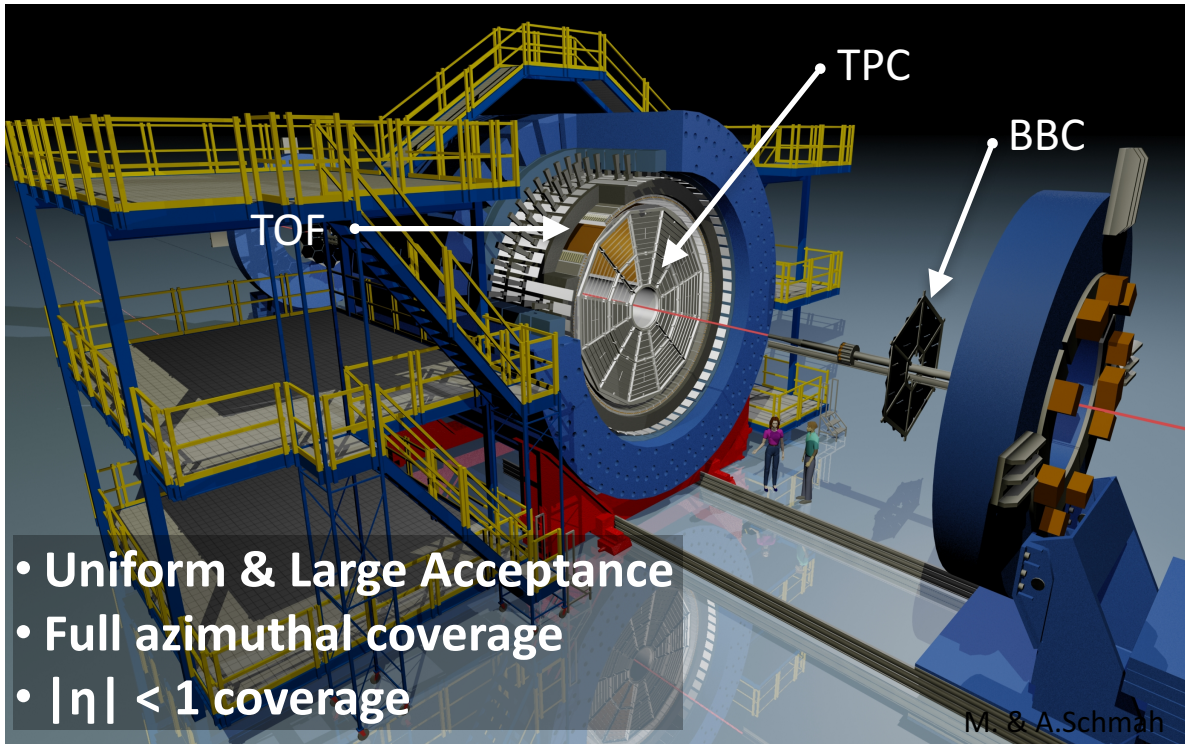
$\sqrt{s_{NN}}$(GeV)	7.7	11.5	14.5	19.6	27	39
Events (10^6) Minimum-bias	4	12	20	36	70	130



PRL **112**, 162301 (2014)

- Hydro with the 1st-order phase transition shows dip in directed flow vs. beam energy due to sudden softening of EOS
- Proton v_1 probes interplay of baryon transport and hydro behavior
- Proton dv1/dy vs. beam energy changes sign, with a minimum.
- EOS softening?
- New Λ data offer more insight into transport of baryons

STAR & Particle Identification

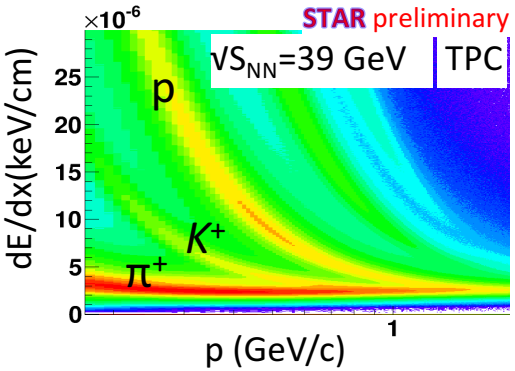


Long-lived: *p, K, π*

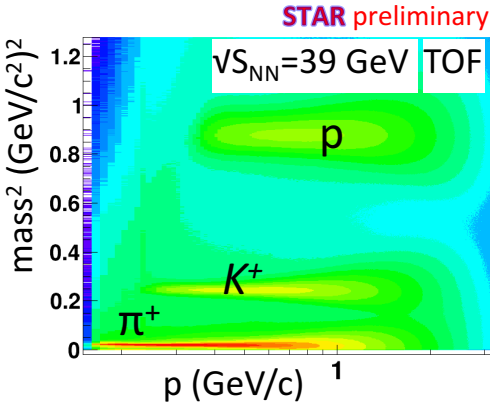
- Requires TPC & TOF hits
- *dE/dx* cut of nσ ≤ 2
- *p* : $0.4 < p_T < 2.0$ GeV/c
- $K^{\pm}$ & $\pi^{\pm}$: $p_T > 0.2$ GeV/c
- $p < 1.6$ GeV/c

Short-lived : Λ & K^0_S

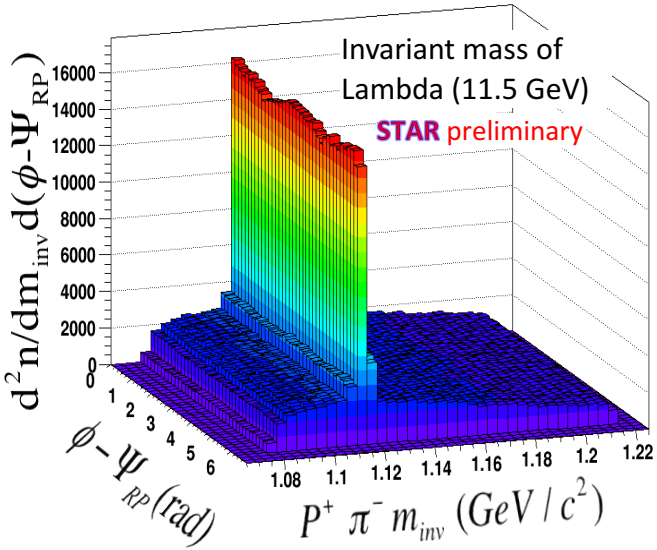
- Invariant mass technique
- Mixed-event background
- V0 topological cuts
- TPC and/or ToF hits for daughters
- $0.2 < p_T < 5.0$ GeV/c



- PID using energy loss in TPC d*E*/d*x*



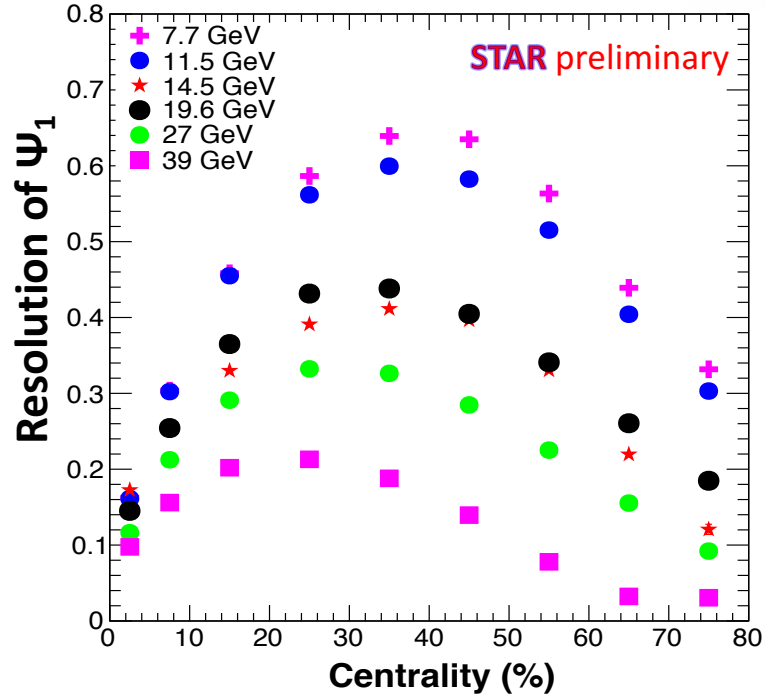
- PID using time of flight and momentum from TPC

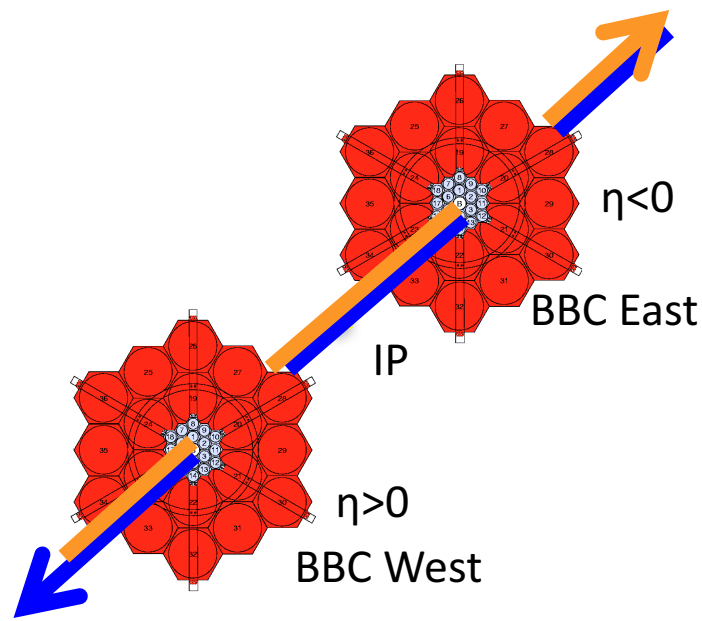


Event Plane Estimation

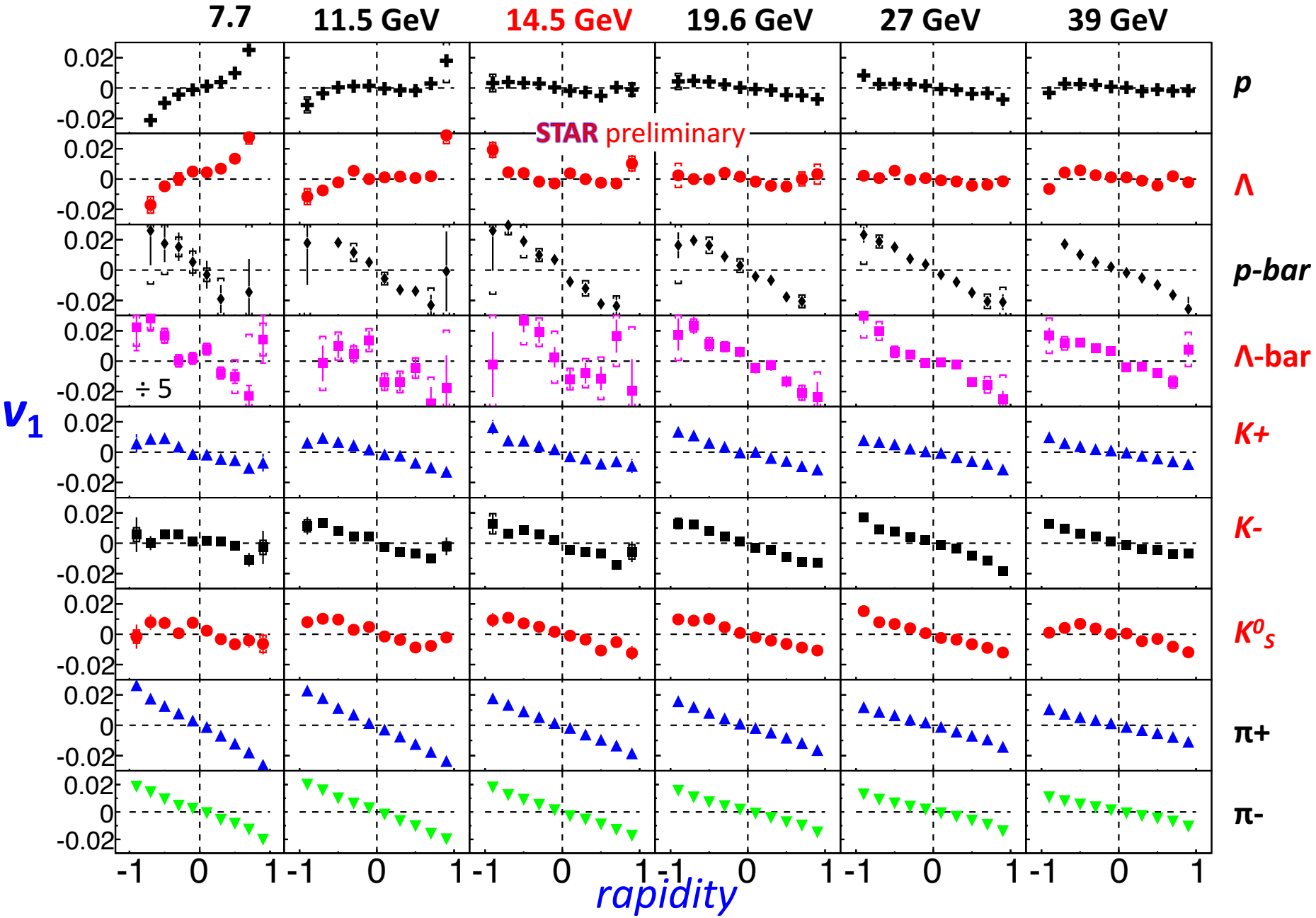
- 1st-order reaction plane estimated using East & West BBC detectors
  - Coverage: $3.3 < |\eta| < 5.0$
  - η gap between TPC and BBC reduces non-flow
- BBC event plane resolution improves at lower energies due to strong v_1 signal near beam rapidities aligning with BBC acceptance
- Non-flat BBC Ψ_1 distribution corrected by shifting method

(Voloshin, Poskanzer, Snellings, arXiv:0809.2949)

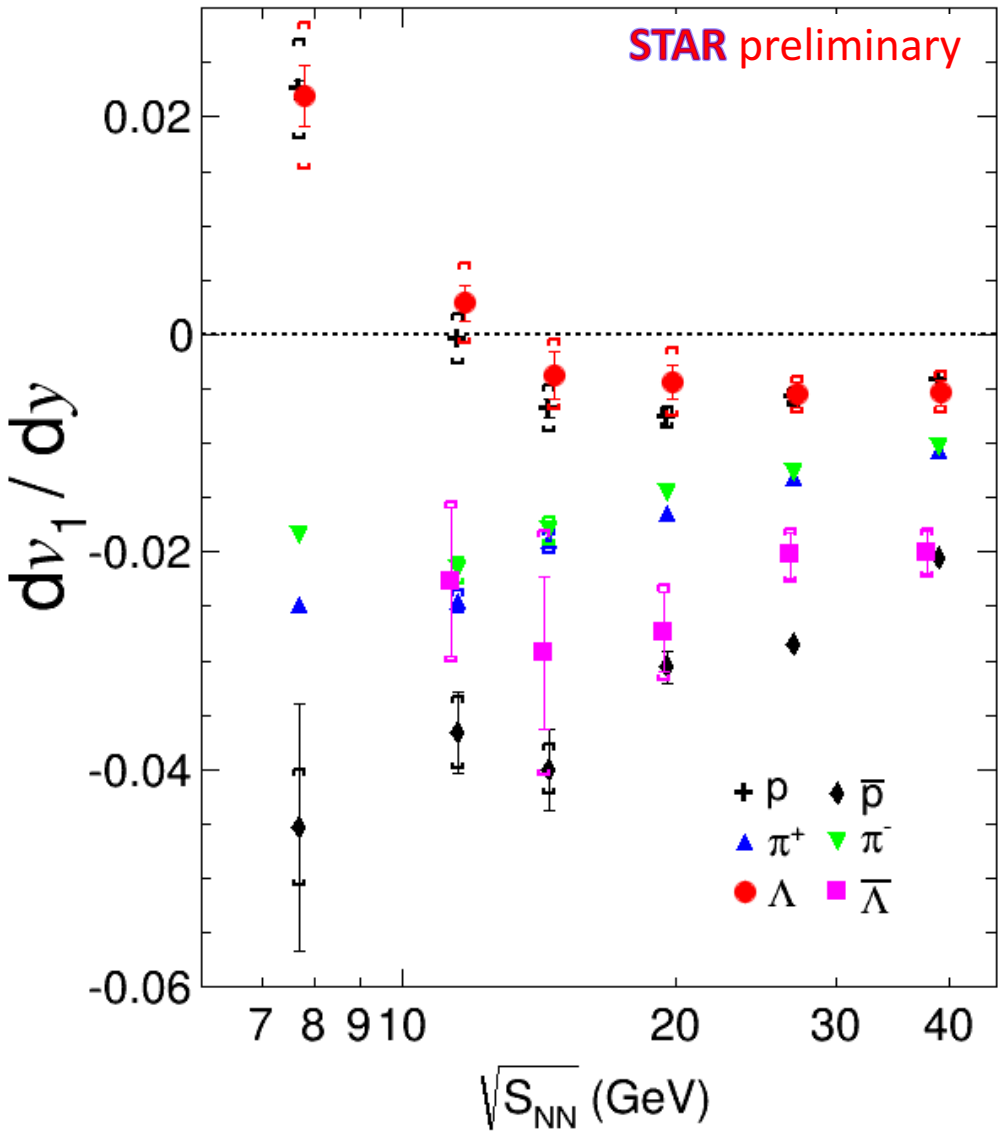




v_1 vs. rapidity for 10-40% centrality

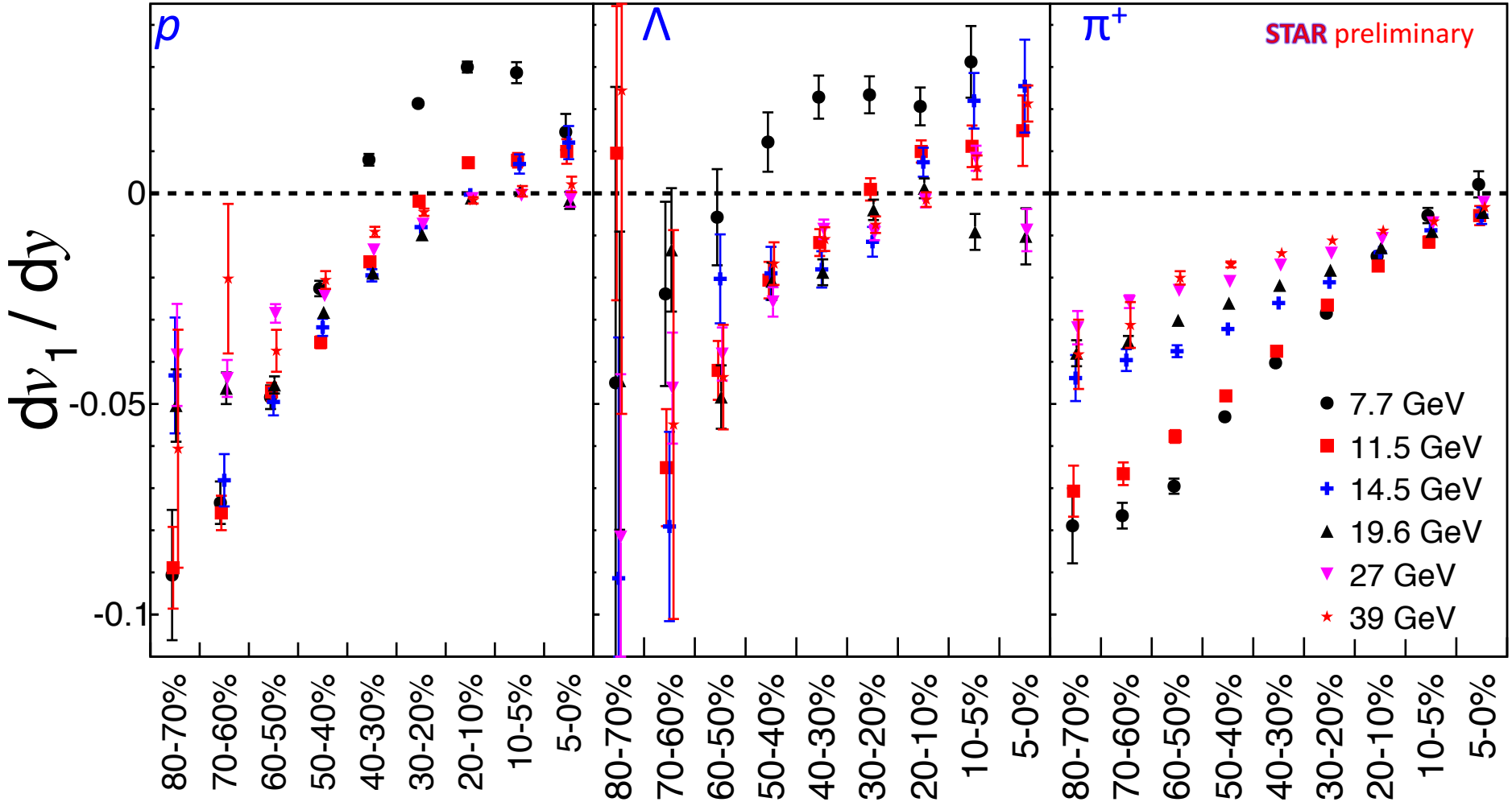


dv_1/dy vs. Beam Energy for 10-40% centrality



- A linear fit over $|y| \leq 0.8$ used to find dv_1/dy for all species & energies
- Λ follows *p* within errors
- Anti-p and anti-Λ have negative slope for all BES energies
- Charged pions have negative slope for all BES energies

dv_1/dy vs. centrality for $\pi^{\pm}$, p, Λ



Summary

- We present $v_1(y)$ and midrapidity dv_1/dy at 7.7, 11.5, 14.5, 19.6, 27 and 39 GeV in Au+Au collisions for *p,* anti-*p,* Λ, anti-Λ, $K^{\pm}$, K^0, $\pi^{\pm}$, at 9 centralities

- $dv_1/dy|_{y=0}$ for both *p*, Λ shows sign change and strongly depends on beam energy and collision centrality

- There are distinct qualitative features in 10-40% centrality dv1/dy for baryons (sign change & minimum), antibaryons (always negative), mesons (negative & smaller magnitude)

- Models with and without phase transitions don't reproduce notable qualitative features of data (especially *p*, Λ)