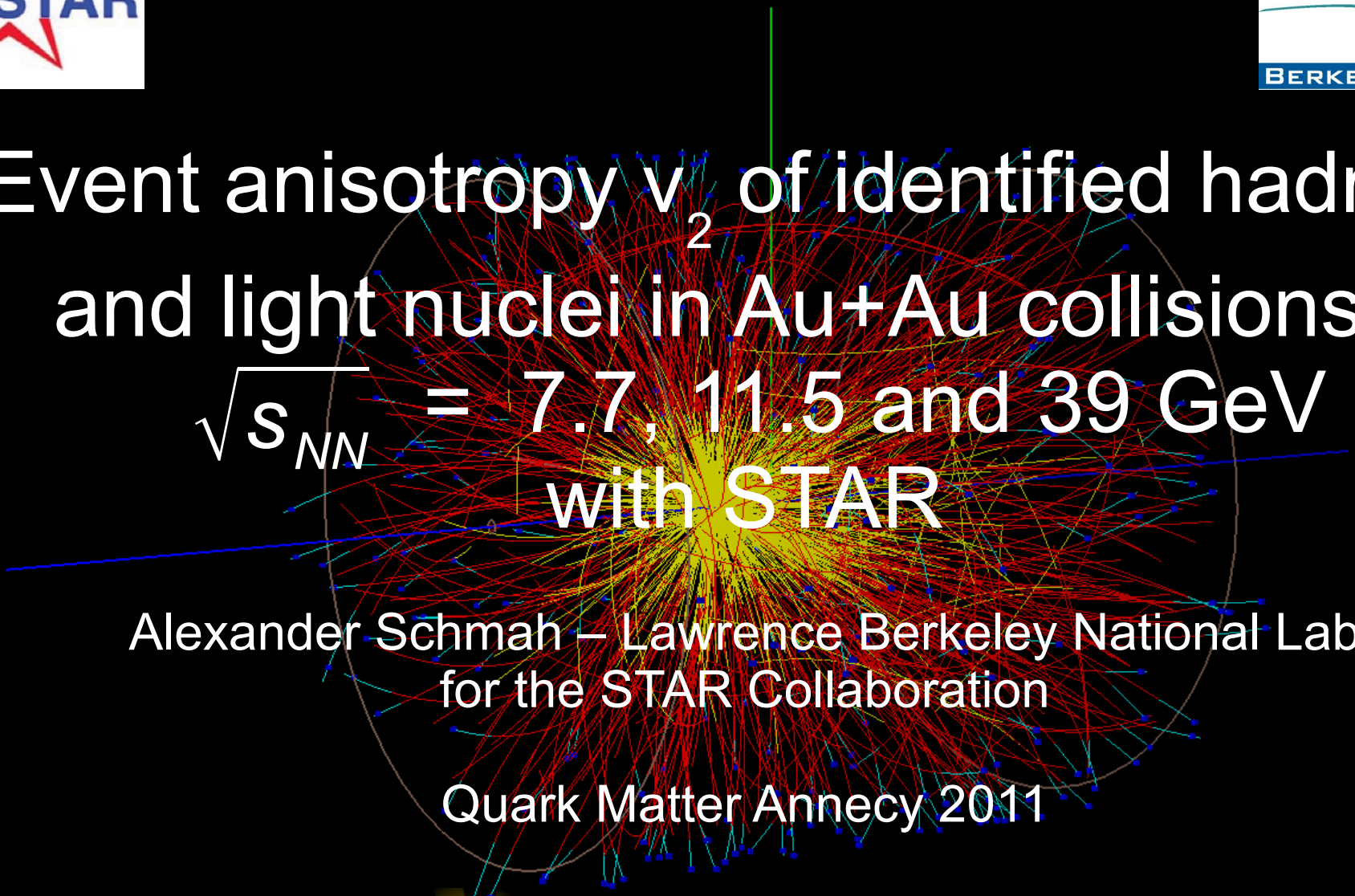


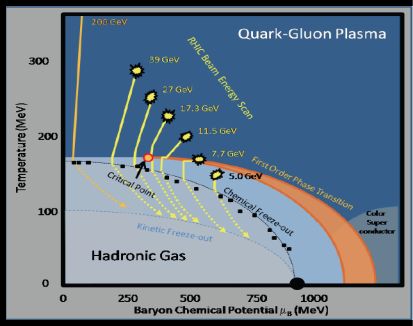
Event anisotropy v_2 of identified hadrons and light nuclei in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 11.5 and 39 GeV with STAR

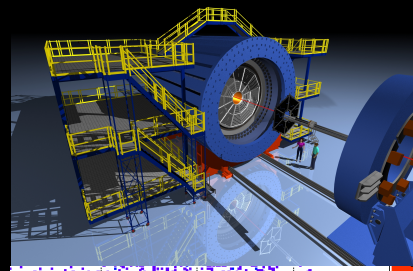
Alexander Schmah – Lawrence Berkeley National Lab
for the STAR Collaboration

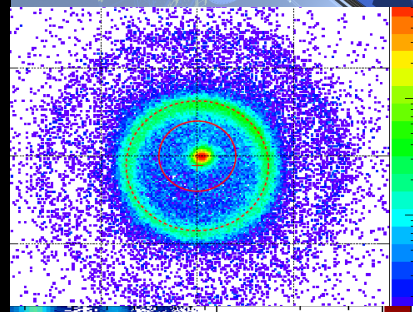
Quark Matter Annecy 2011

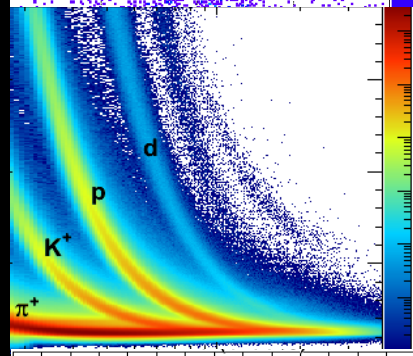
Outline:

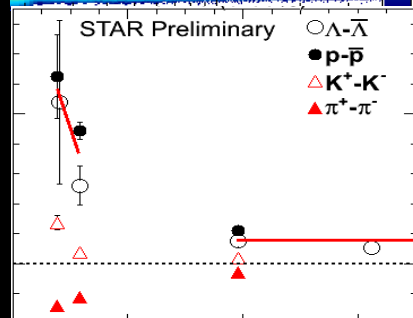
- Introduction and Motivation
- The Beam Energy Scan and the STAR experiment at RHIC
- Particle Identification
- v_2 results @ 7.7, 11.5 and 39GeV
- Summary and Outlook









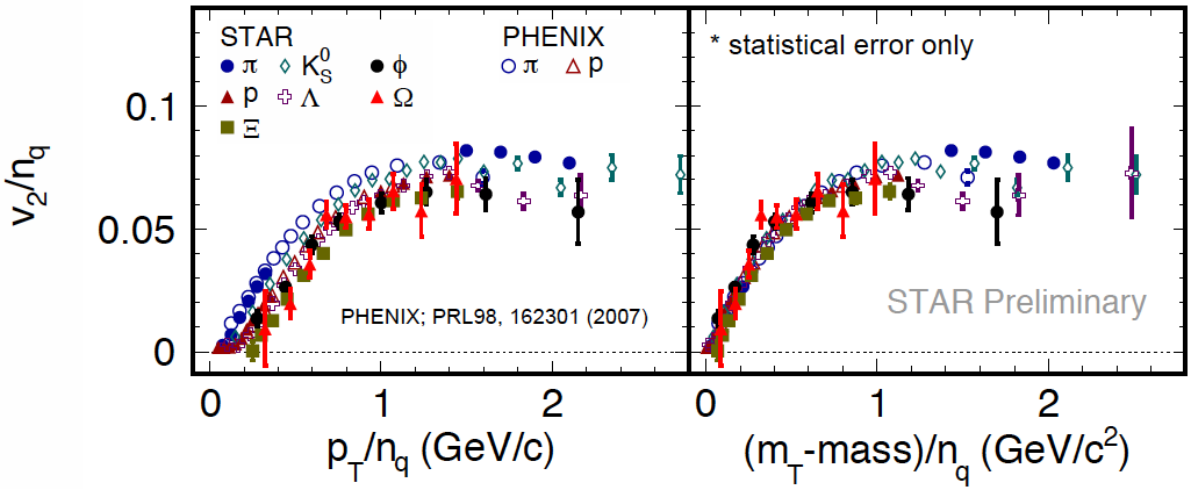


Introduction and Motivation

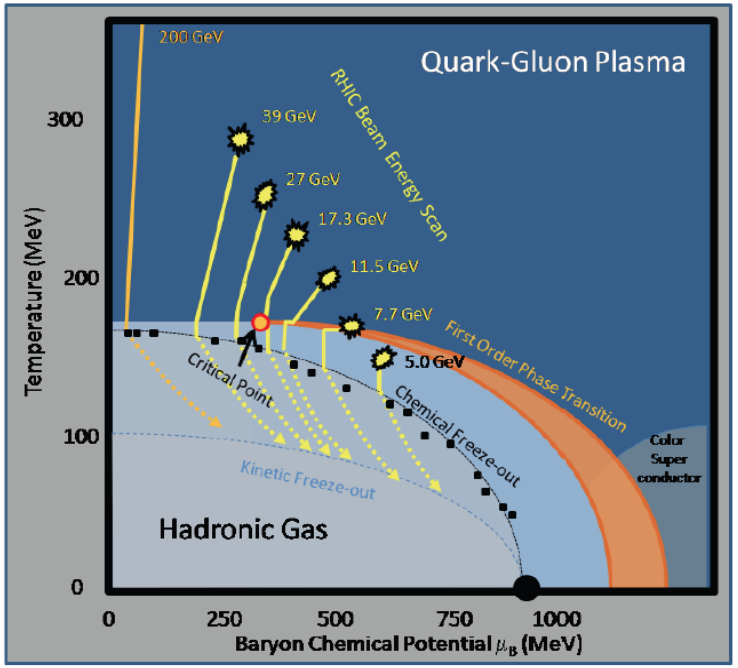
Goal:
- Signatures for a QCD phase transition
  → difference between the partonic and the hadronic degrees of freedom

How To?
- Onset of Quark-Gluon Plasma
  → e.g. Number of Constituent Quark (NCQ) scaling of v_2

Minimum bias, Au + Au at $\sqrt{s_{NN}}$ = 200 GeV



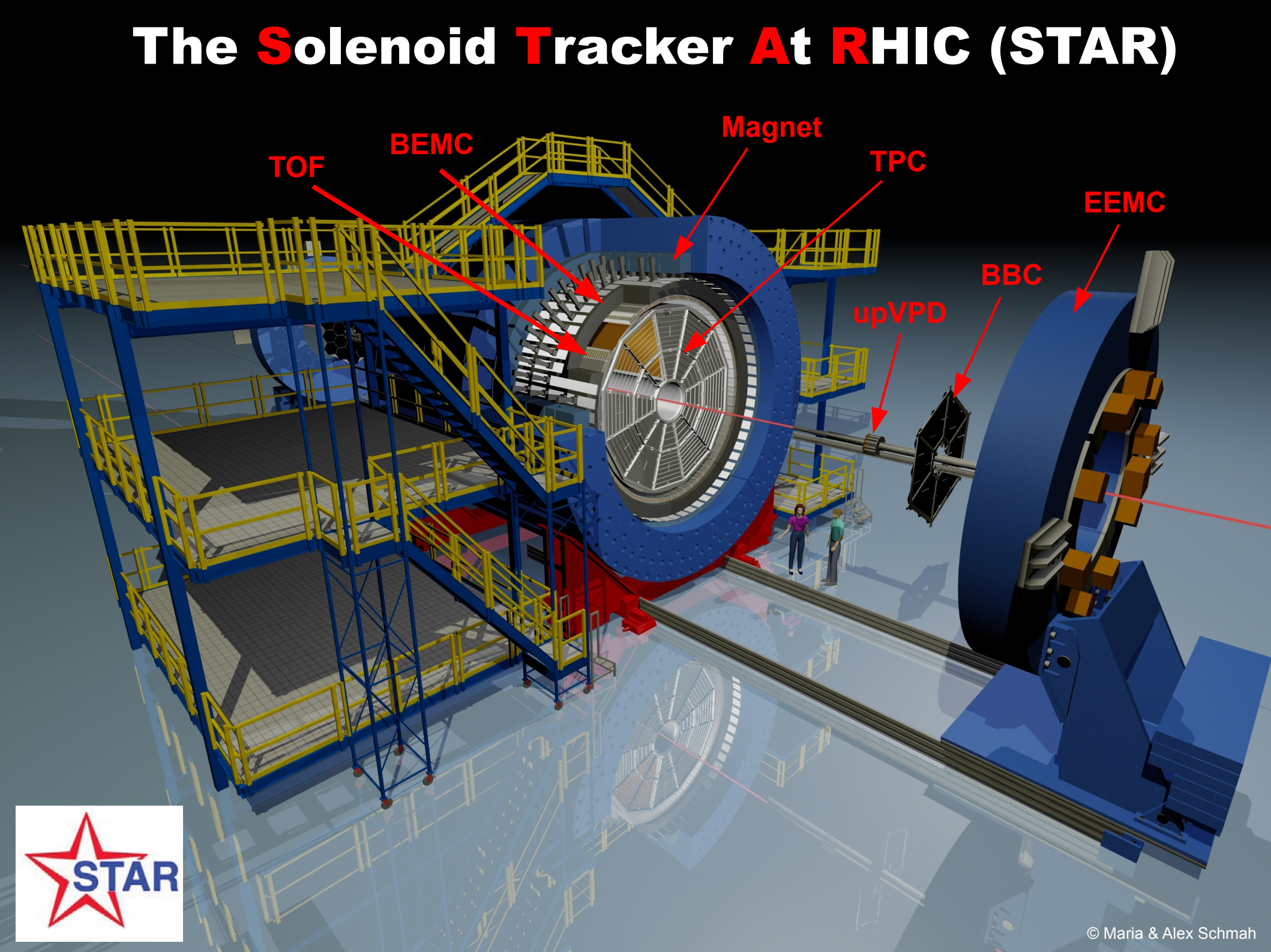
The RHIC Beam Energy Scan (BES)



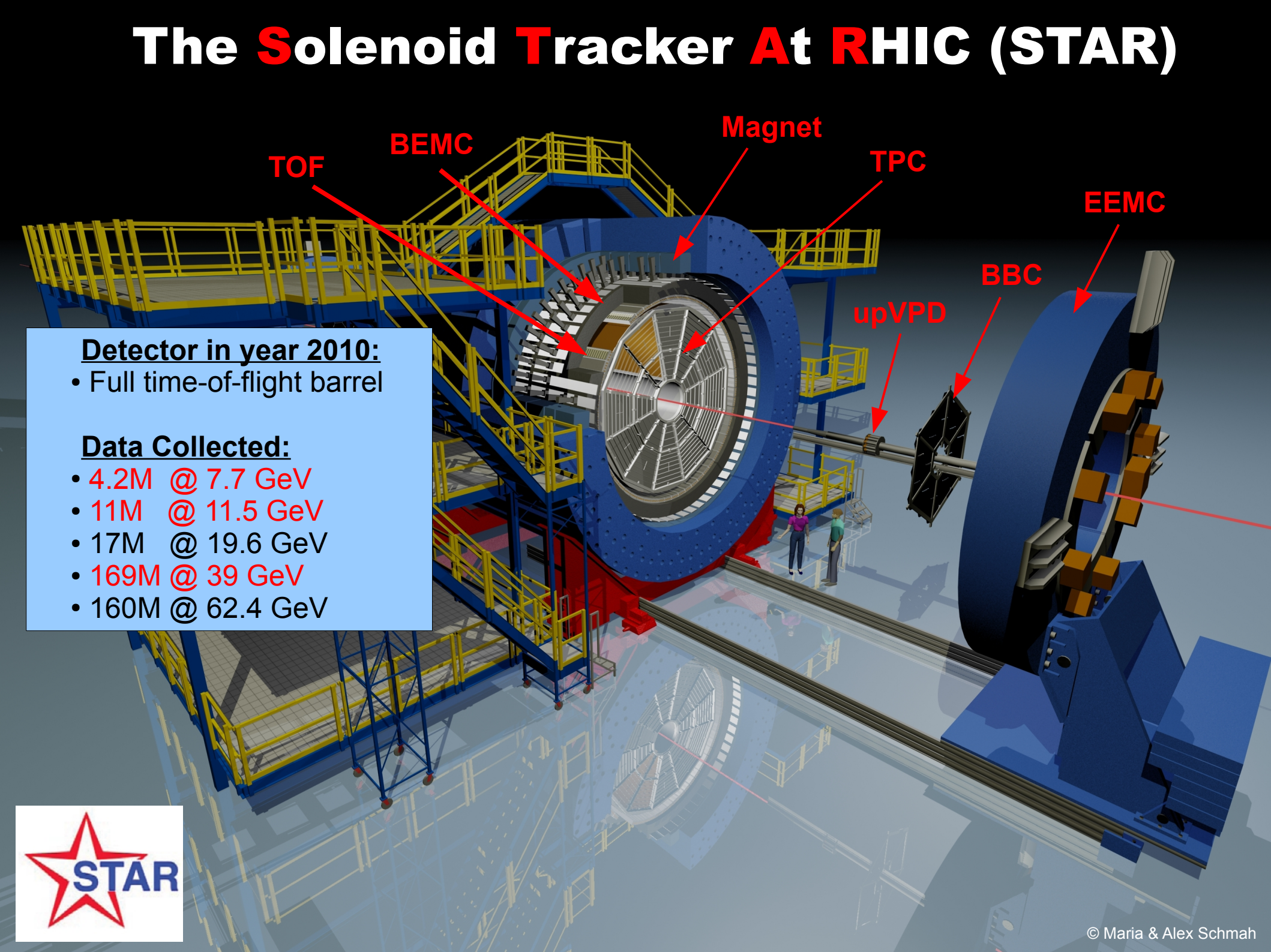
→ B. Mohanty: "***STAR: results from the beam energy scan program***" (Thursday 8:55)

NCQ scaling @ STAR:
Phys.Rev.Lett. 92 (2004) 052302
Phys.Rev.Lett. 99 (2007) 112301

The Solenoid Tracker At RHIC (STAR)



The Solenoid Tracker At RHIC (STAR)



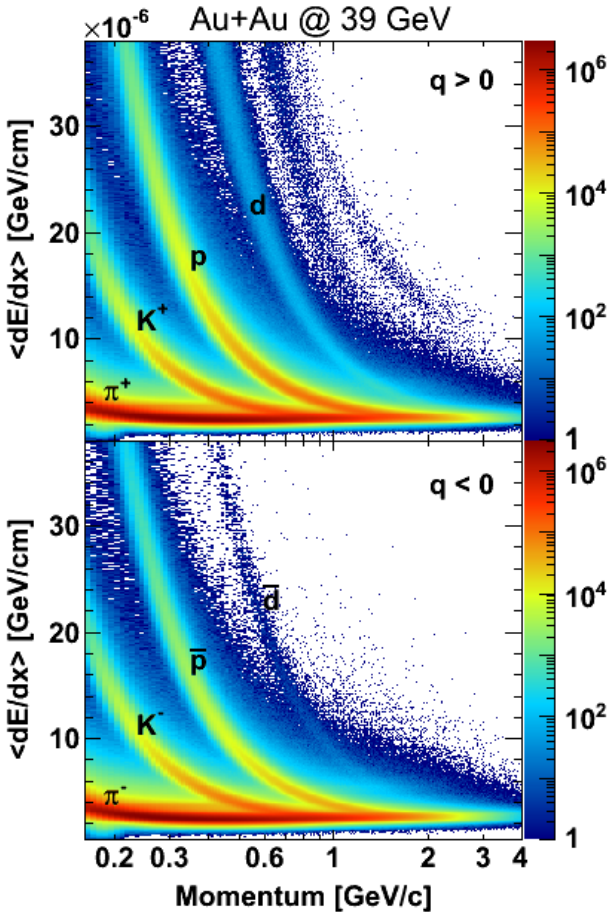
Detector in year 2010:

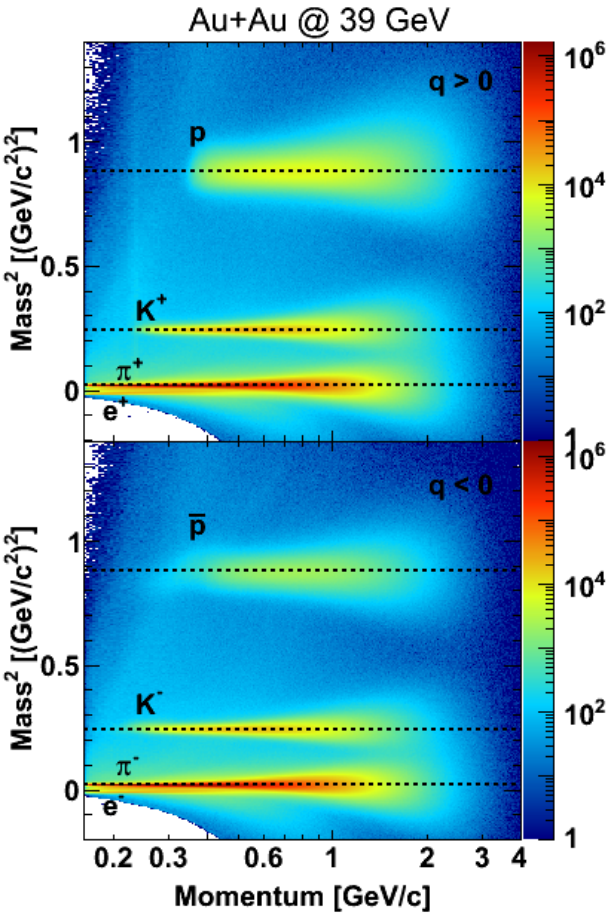
- Full time-of-flight barrel

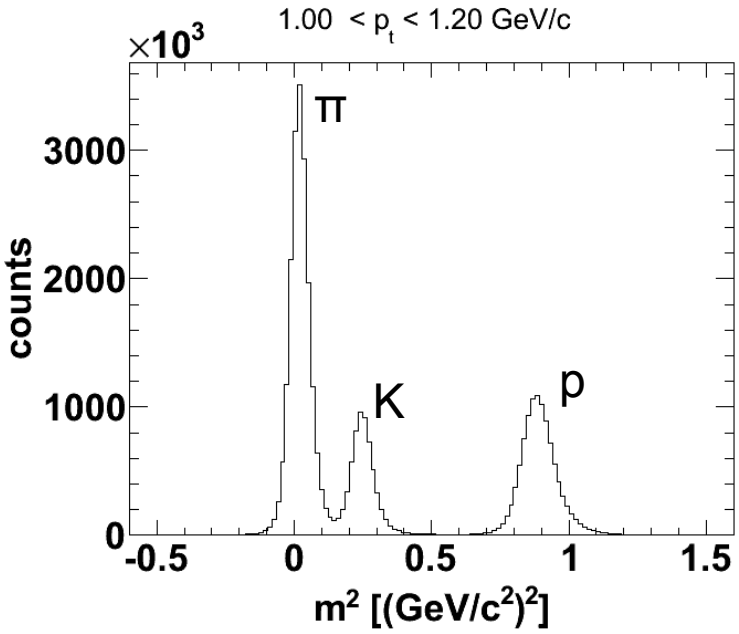
Data Collected:

- 4.2M @ 7.7 GeV
- 11M @ 11.5 GeV
- 17M @ 19.6 GeV
- 169M @ 39 GeV
- 160M @ 62.4 GeV

Particle Identification via TPC and TOF

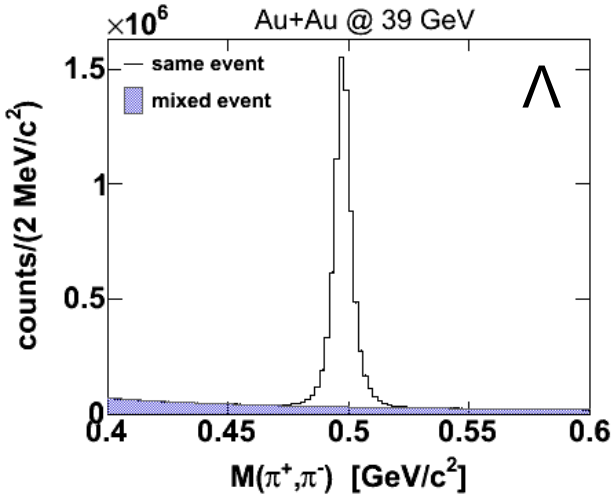


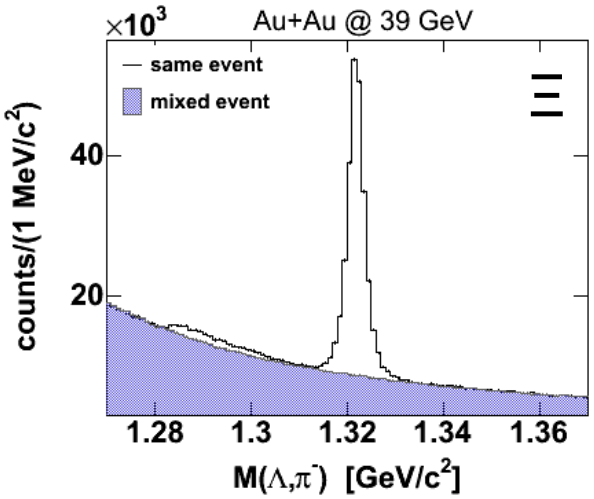


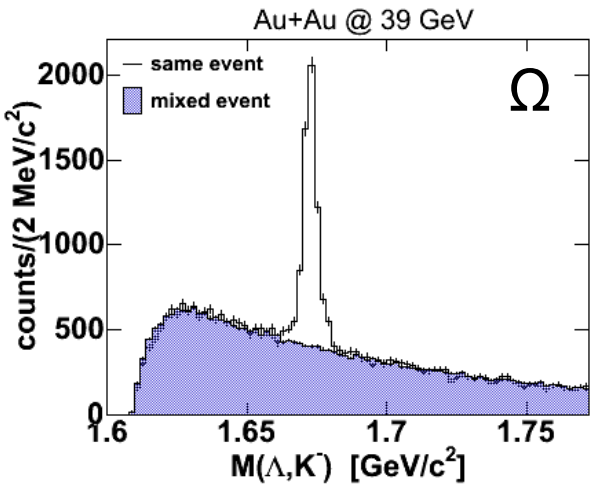


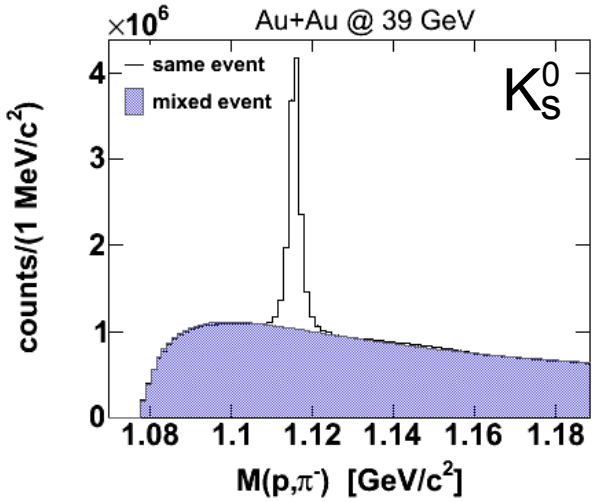
- dE/dx can separate the particles up to ~1 GeV/c
- First beam time period with full TOF system
  → Clean separation of K,π up to 1.6 GeV/c

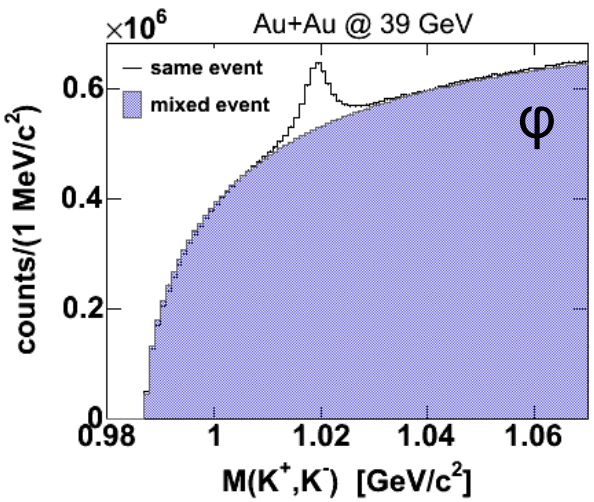
Reconstructed Particles

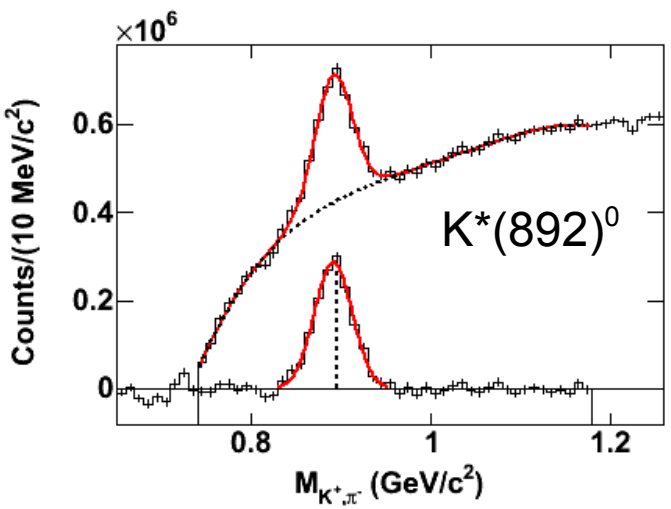






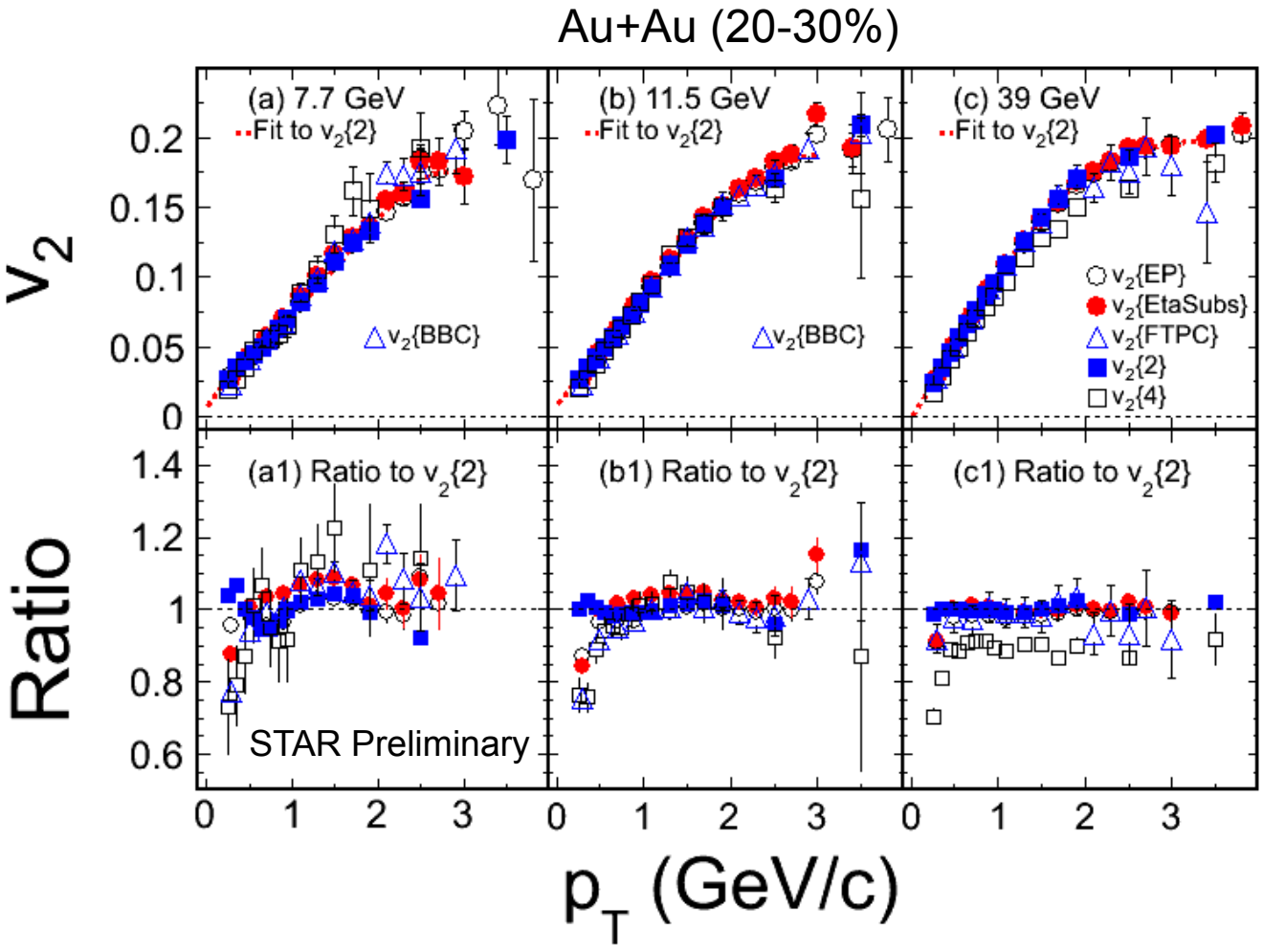






- Improved S/B ratio compared to previous results due to additional time-of-flight PID

Inclusive Hadron v_2 @ 7.7, 11.5 and 39 GeV

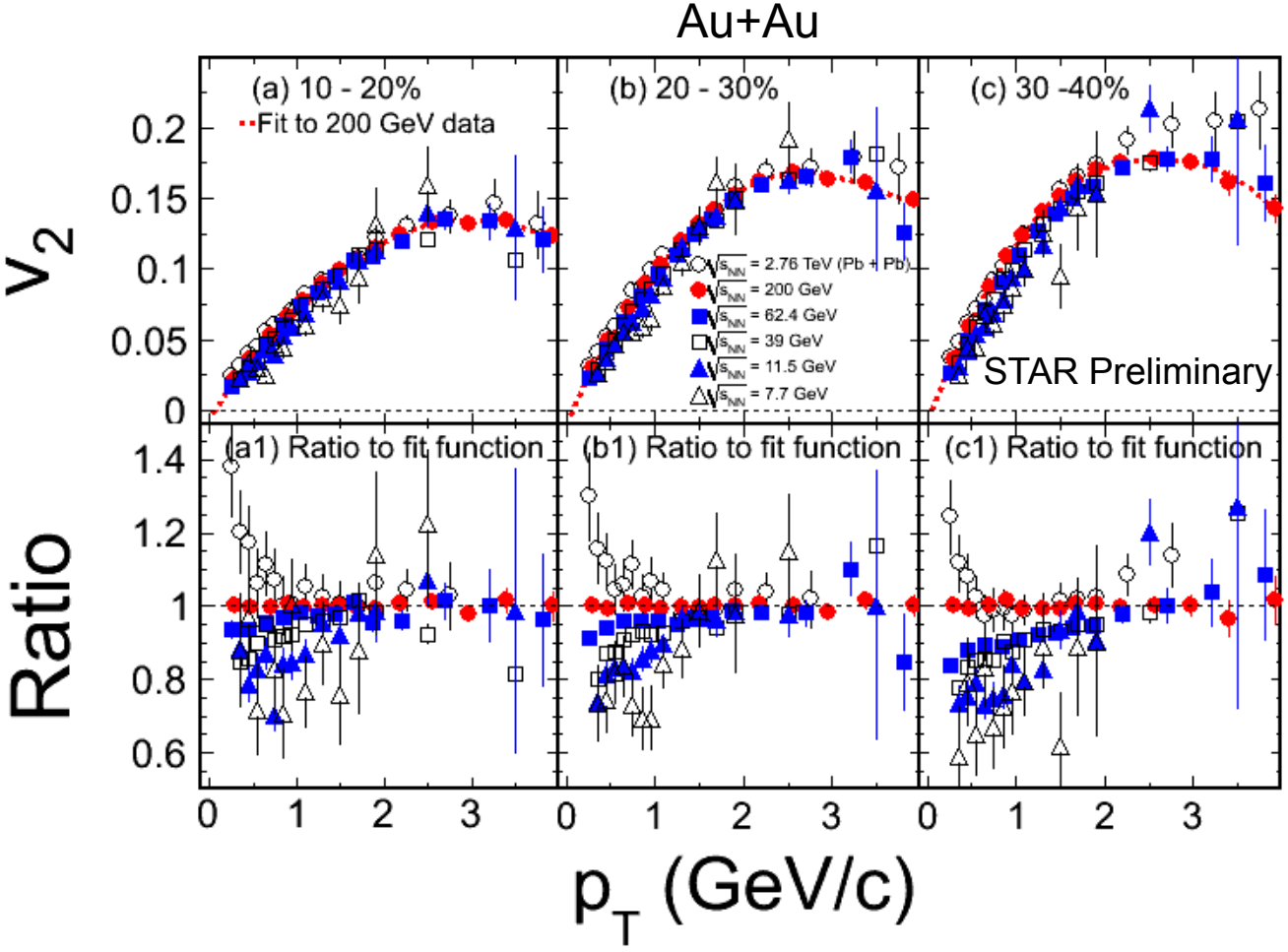


- Systematic study of inclusive charged hadron v_2
- Various methods are used to extract v_2
- Overall a good agreement between the different methods
- 7.7, 11.5 GeV: less difference between $v_2\{2\}$ and $v_2\{4\}$

  → non-flow, fluctuations

→ M. Mitrovski: "***Elliptic Flow of charged particles in Au+Au collisions***" (Poster session: ID 291, Board #19)

Inclusive Hadron v_2 @ 7.7 GeV – 2.76 TeV

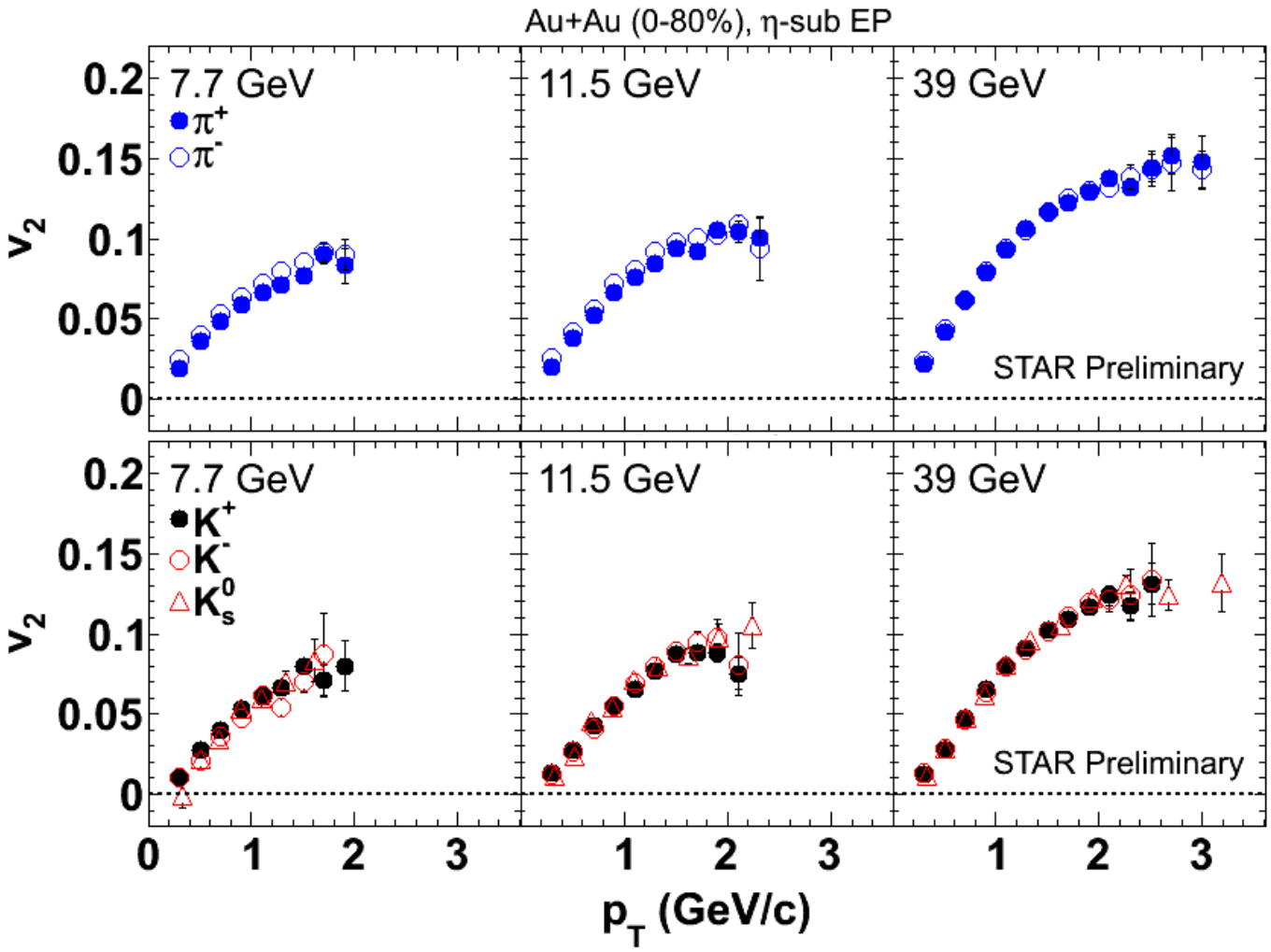


ALICE data: Phys. Rev. Lett. 105, 252302 (2010)

- Comparison of $v_2(p_T)$ over several orders of magnitude in energy
- Overall $v_2(p_T)$ shape looks very similar
- Deviations of +/- 30% relative to 200 GeV at low p_T

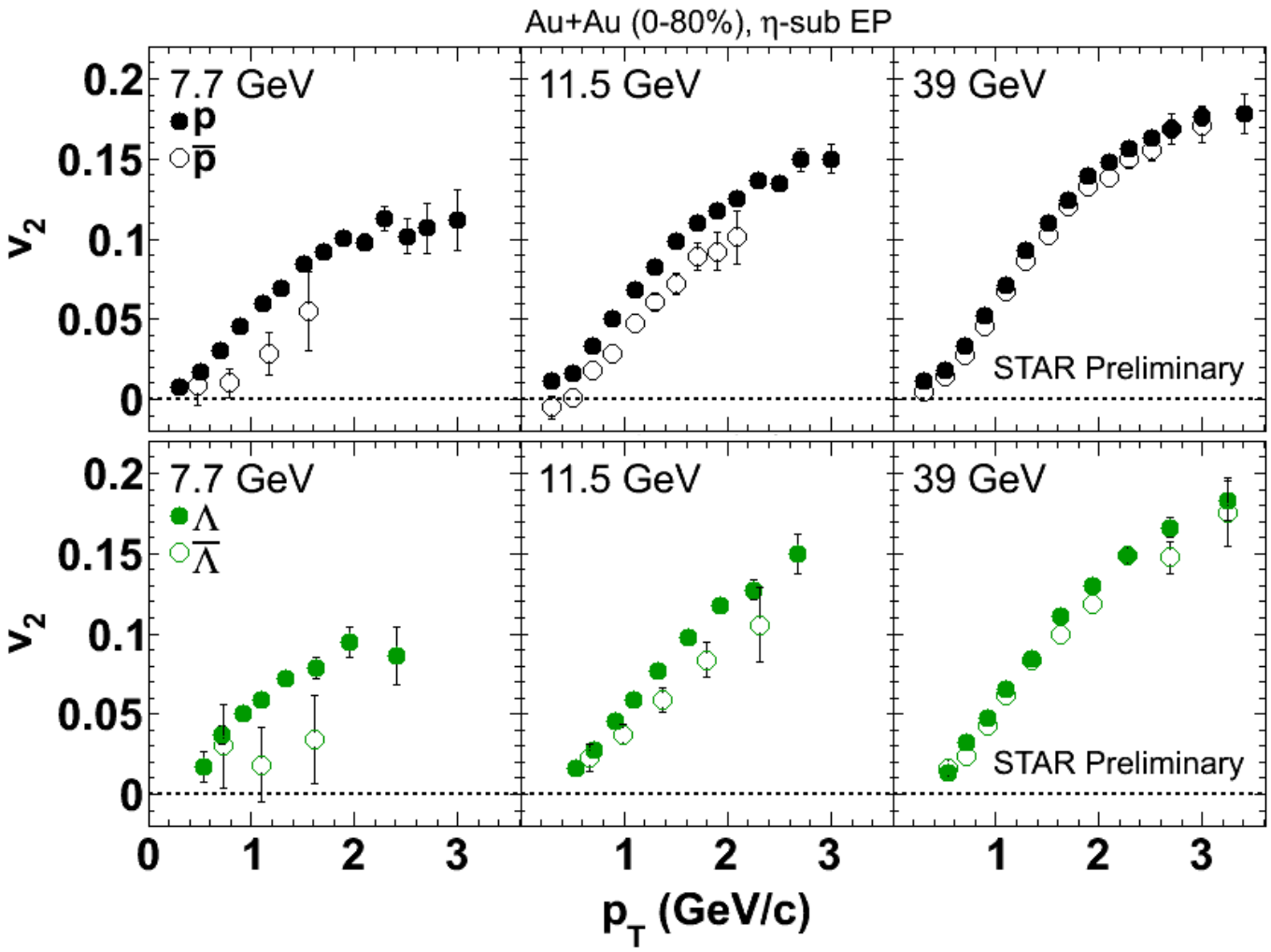
→ S. Shi: "***Inclusive charged hadron elliptic flow in Au+Au collisions***" (Poster session: ID 281, Board #16)

Pion and Kaon v_2 @ 7.7, 11.5 and 39 GeV



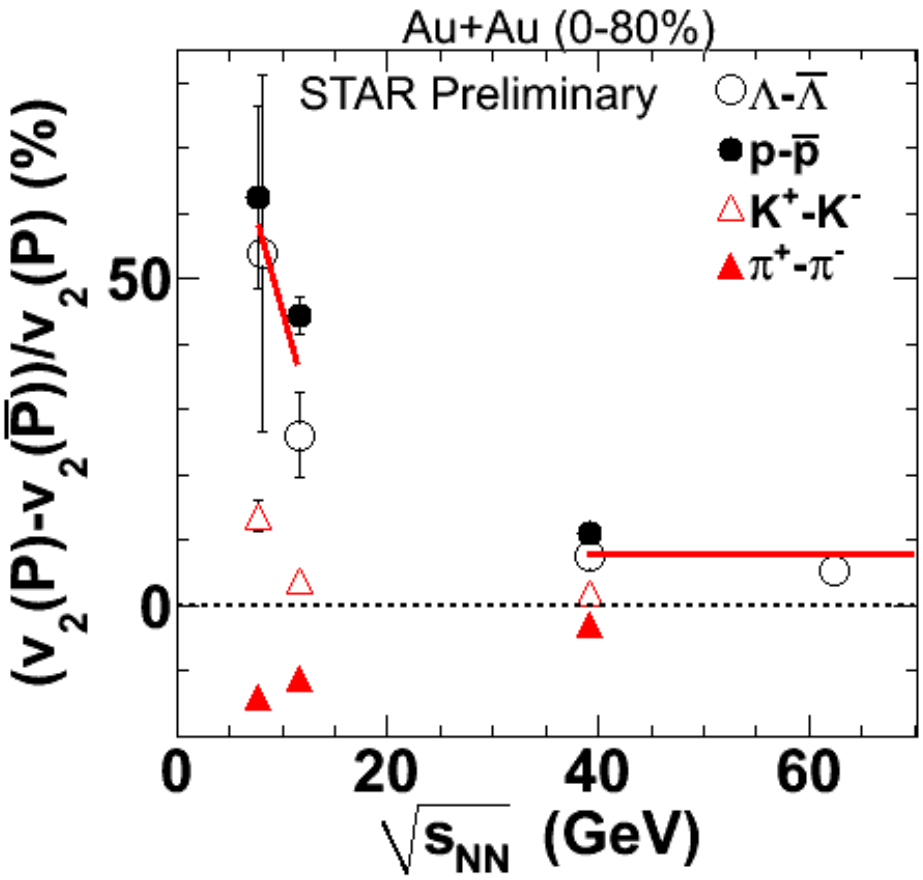
- All kaon species show similar $v_2(p_T)$ at 11.5 and 39 GeV
- $v_2(K^+) > v_2(K^-)$ @ 7.7 GeV
- $v_2(\pi^-) > v_2(\pi^+)$ at 11.5 and 7.7 GeV, identical at 39 GeV

Proton and Λ v_2 @ 7.7, 11.5 and 39 GeV



- $v_2(p) > v_2(\bar{p})$ at all energies, increasing difference with decreasing energy, or larger μ_B
- Same behavior for Λ and $\bar{\Lambda}$

Particle-anti-Particle Difference in v_2

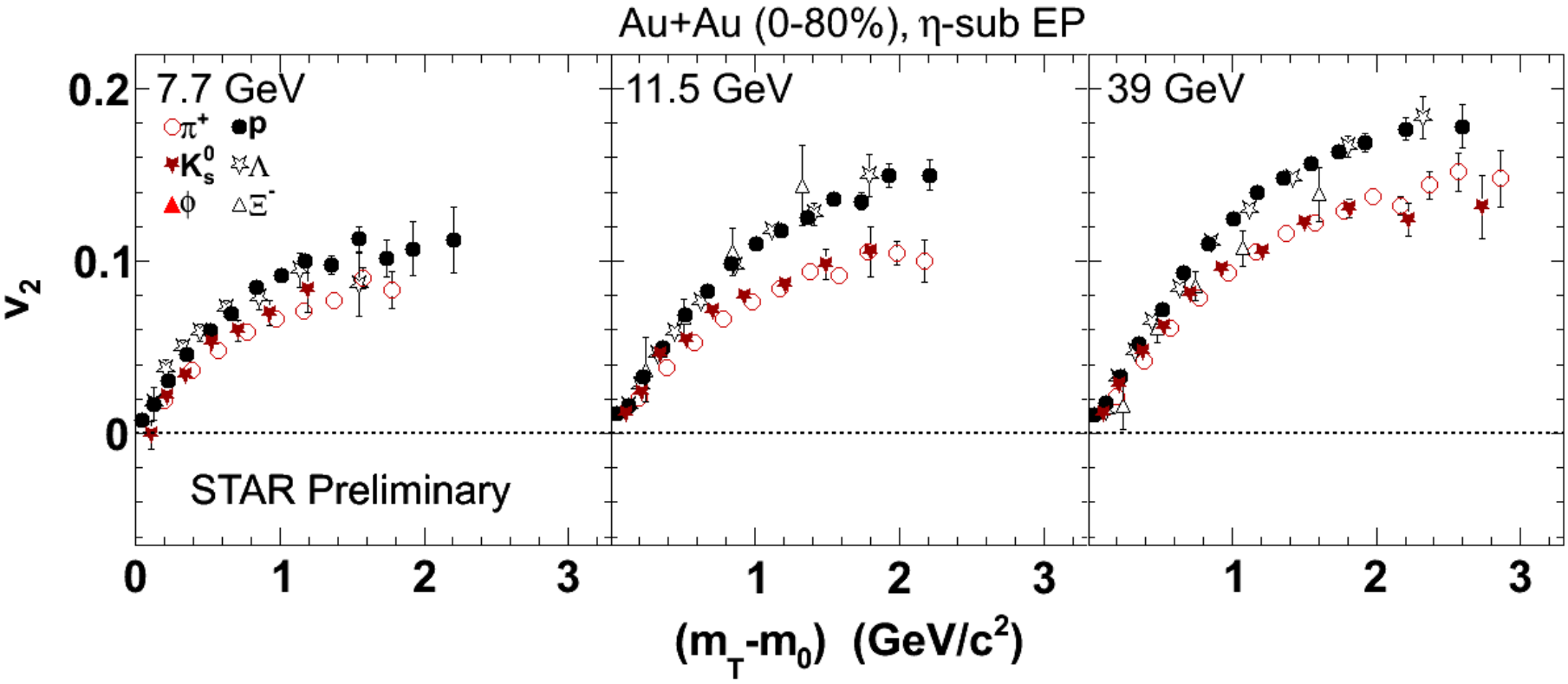


- Baryon-anti-baryons show at higher energies a constant difference of ~10%
- Difference for meson v_2 is ~0 at higher energies
- Huge increase of baryon-anti-baryon difference at 11.5 and 7.7 GeV
  → Baryon transport to mid-rapidity?
  → Absorption in hadronic environment?
- Significant difference between K^+ and K^- at 7.7 GeV
- Opposite trend for π^+ and π^-

STAR (62.4 GeV): Phys.Rev.C75, 054906 (2007)

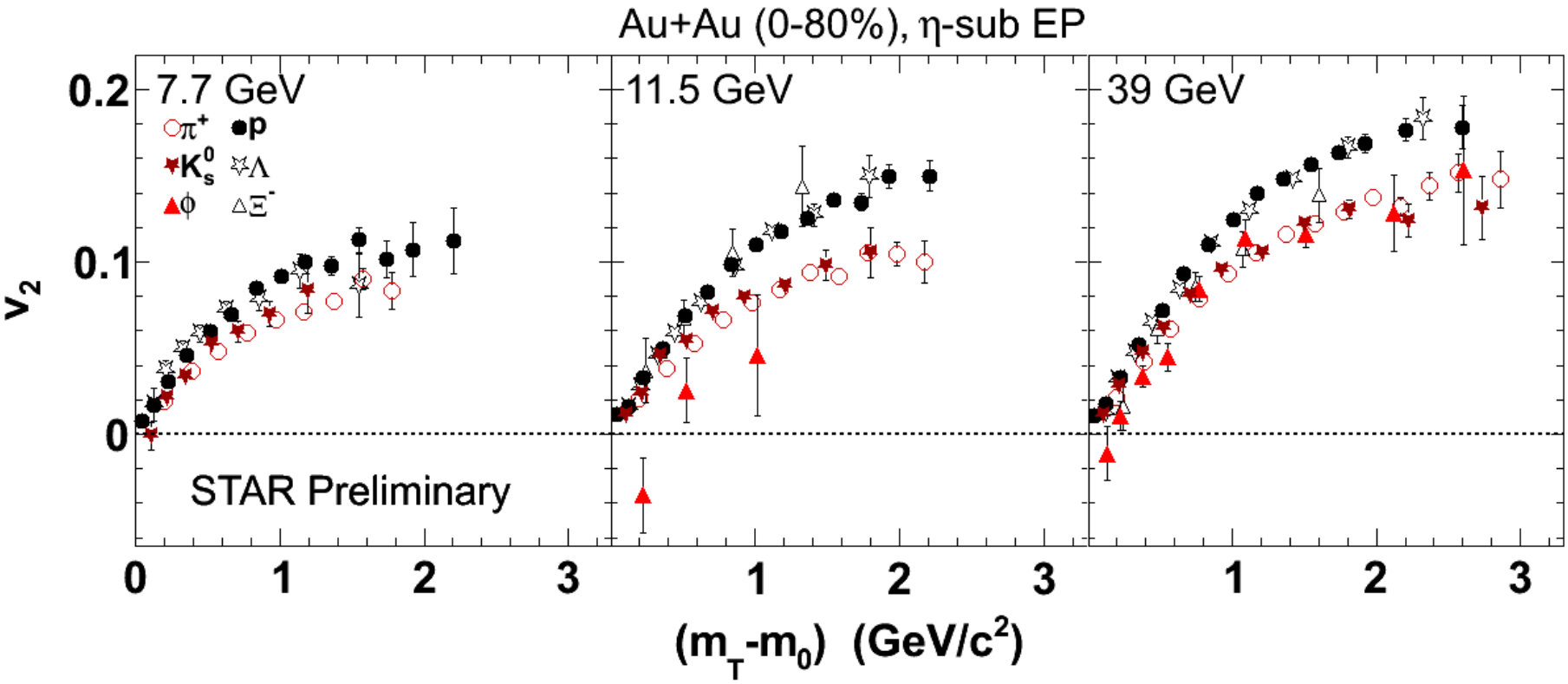
→ NCQ-scaling between particles and anti-particles is broken @ 11.5 and 7.7 GeV

v_2 vs. (m_T-m_0) of Particles



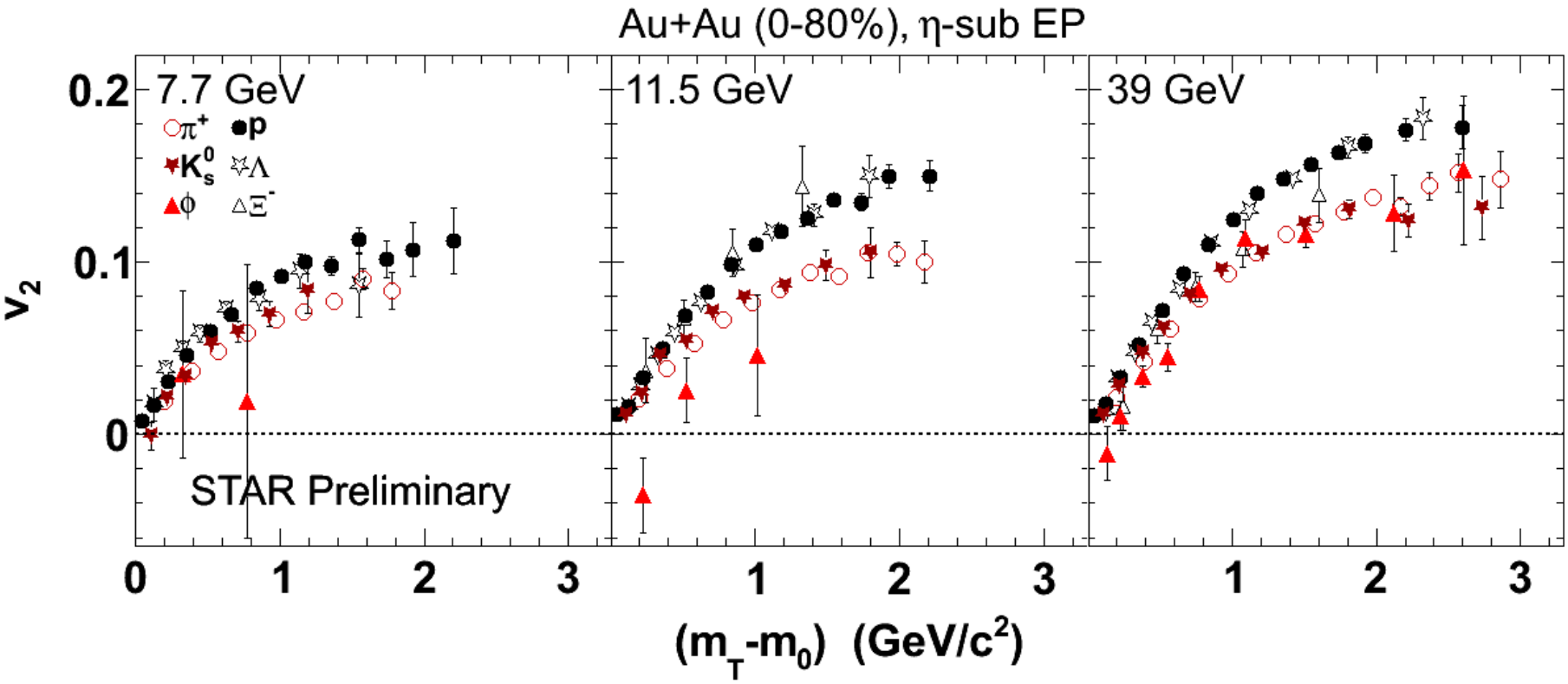
- Meson ↔ Baryon splitting for particles @ 11.5 and 39 GeV
- Splitting is smaller @ 7.7 GeV

v_2 vs. (m_T-m_0) of Particles



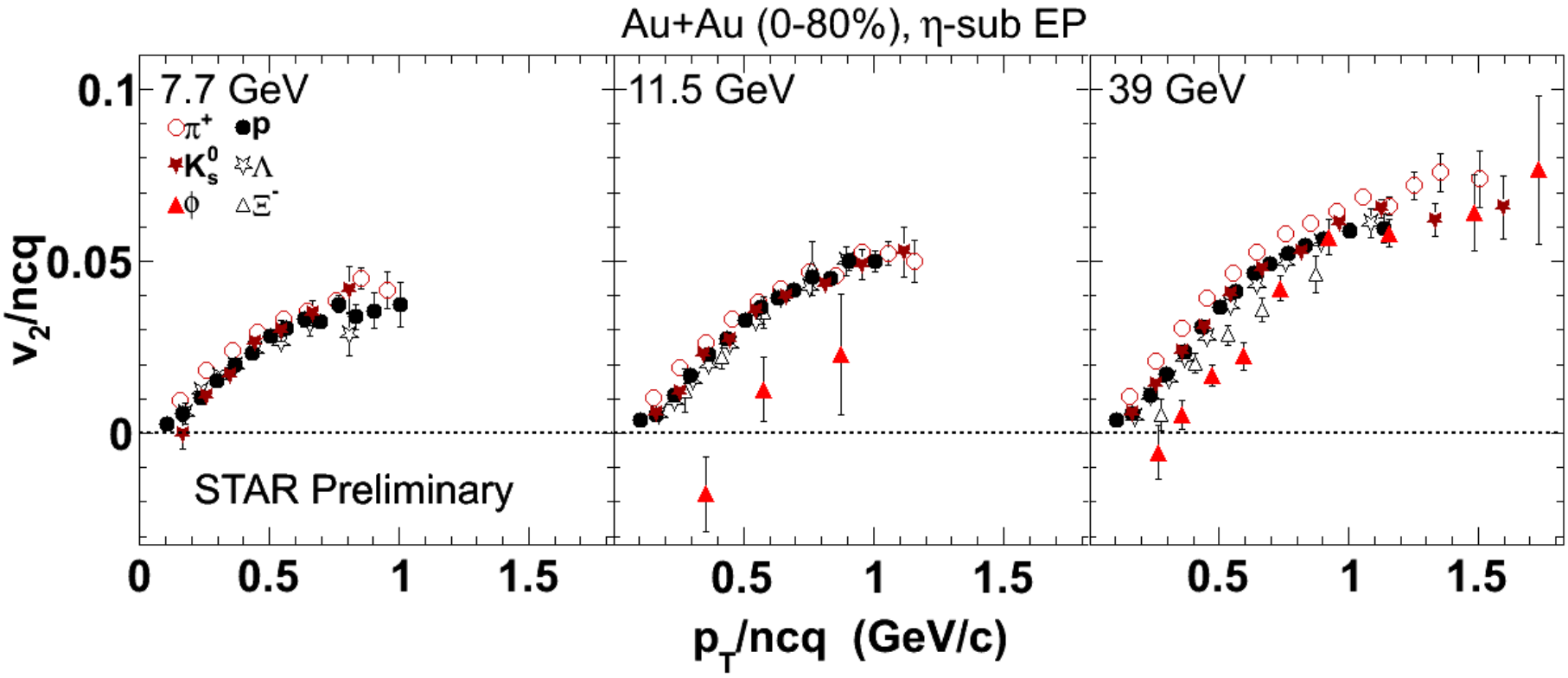
- Meson ↔ Baryon splitting for particles @ 11.5 and 39 GeV
- Splitting is smaller @ 7.7 GeV
- Φ-mesons @ 11.5 GeV show a different trend

v_2 vs. (m_T-m_0) of Particles



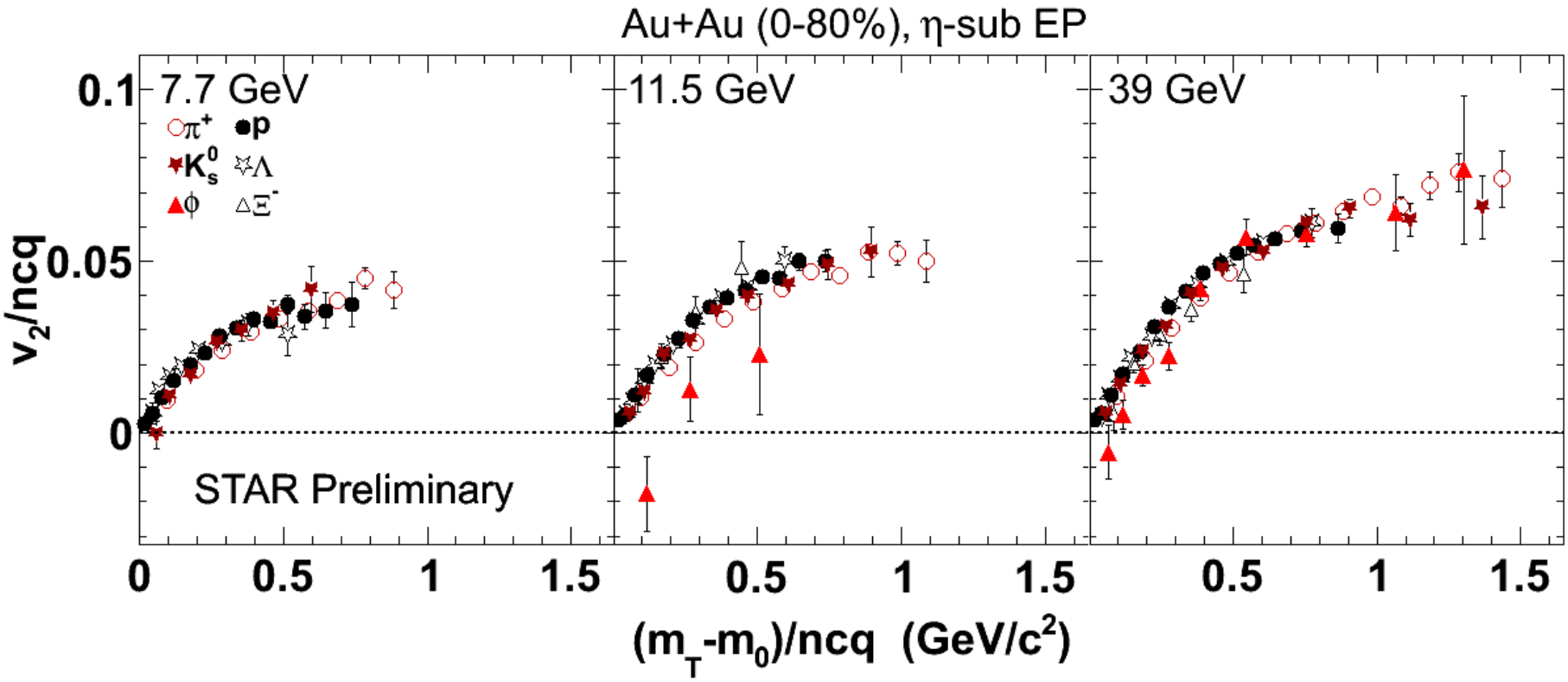
- Meson ↔ Baryon splitting for particles @ 11.5 and 39 GeV
- Splitting is smaller @ 7.7 GeV
- Φ-mesons @ 11.5 GeV show a different trend
- Φ-mesons @ 7.7 GeV would need ~ a factor 5 more statistics to have a reasonable small error bar

Test of NCQ-Scaling for Particles: v_2 vs. p_T



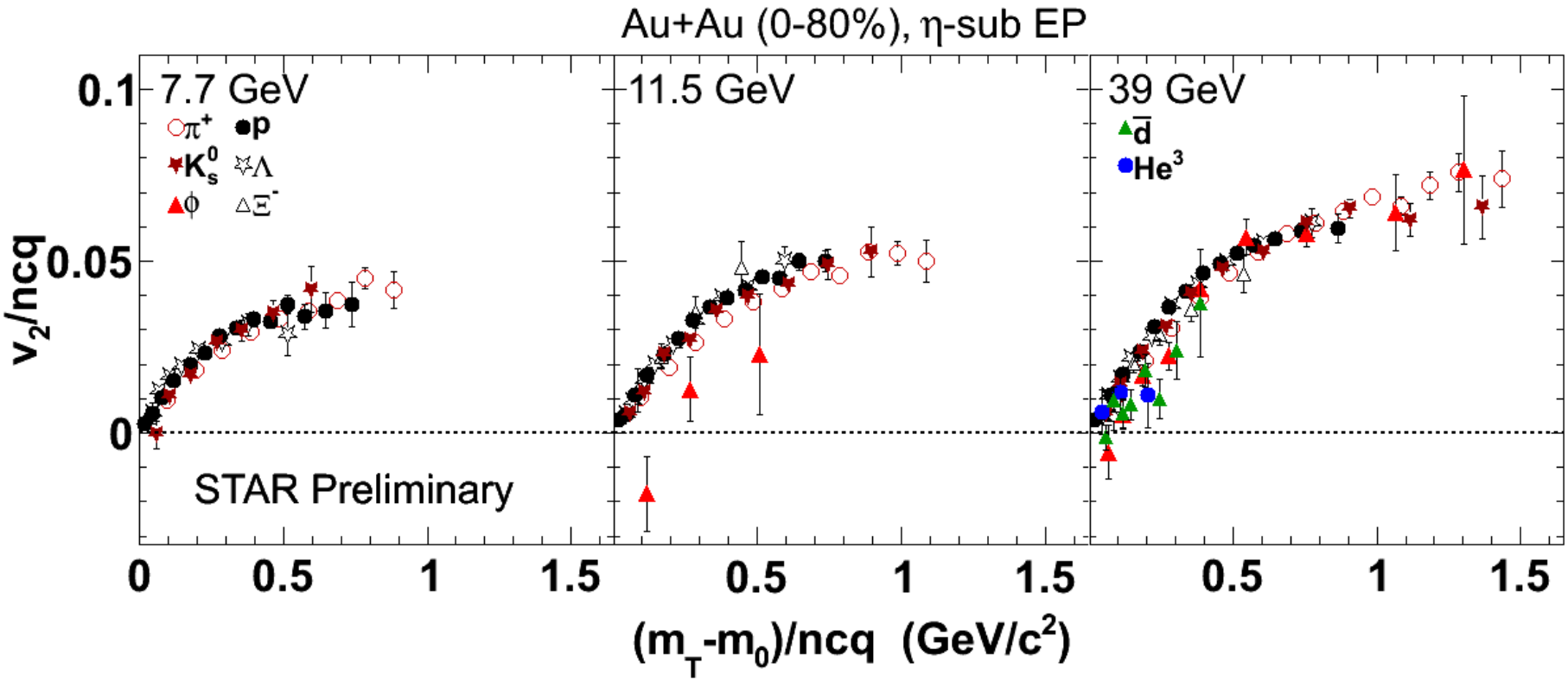
- 39 GeV NCQ-scaling at intermediate p_T looks similar to 200 GeV
- Φ-mesons @ 11.5 GeV do not follow the trend of other hadrons!
- Rest of the particles follow NCQ-scaling, separated from anti-particles

Test of NCQ-Scaling for Particles: v_2 vs. (m_T-m_0)



- Most of the particles follow one common v_2 distribution
- Φ-mesons @ 11.5 GeV do not follow the trend of other hadrons: Mean deviation from pion distribution: 0.02±0.008 (→ 2.6 σ)
- Rest of the particles follow NCQ-scaling, separated from anti-particles

Test of NCQ-Scaling for Particles: v_2 vs. (m_T-m_0)



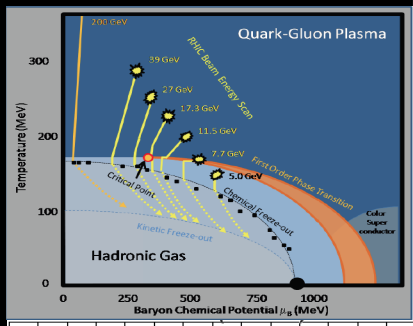
- Most of the particles follow one common v_2 distribution
- Φ-mesons @ 11.5 GeV do not follow the trend of other hadrons: Mean deviation from pion distribution: 0.02±0.008 (→ 2.6 σ)
- Rest of the particles follow NCQ-scaling, separated from anti-particles
- Light nuclei can be used to study nucleon ↔ quark coalescence

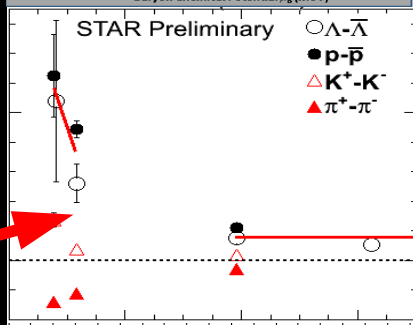
Summary

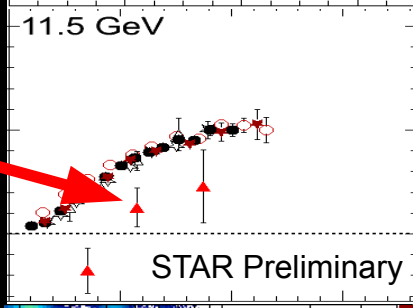
- At 39 GeV the NCQ scaling looks similar to the results obtained at 200 GeV

- NCQ-scaling between particles and anti-particles is broken @ 11.5 and 7.7 GeV

- φ-meson v_2 does not follow the trend of other particles at 11.5 GeV

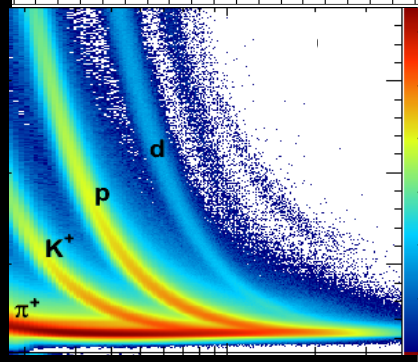


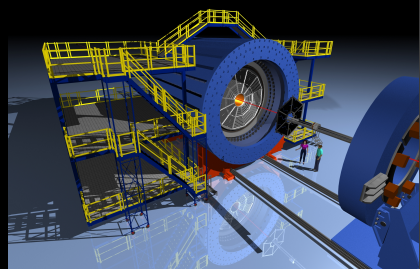




Outlook

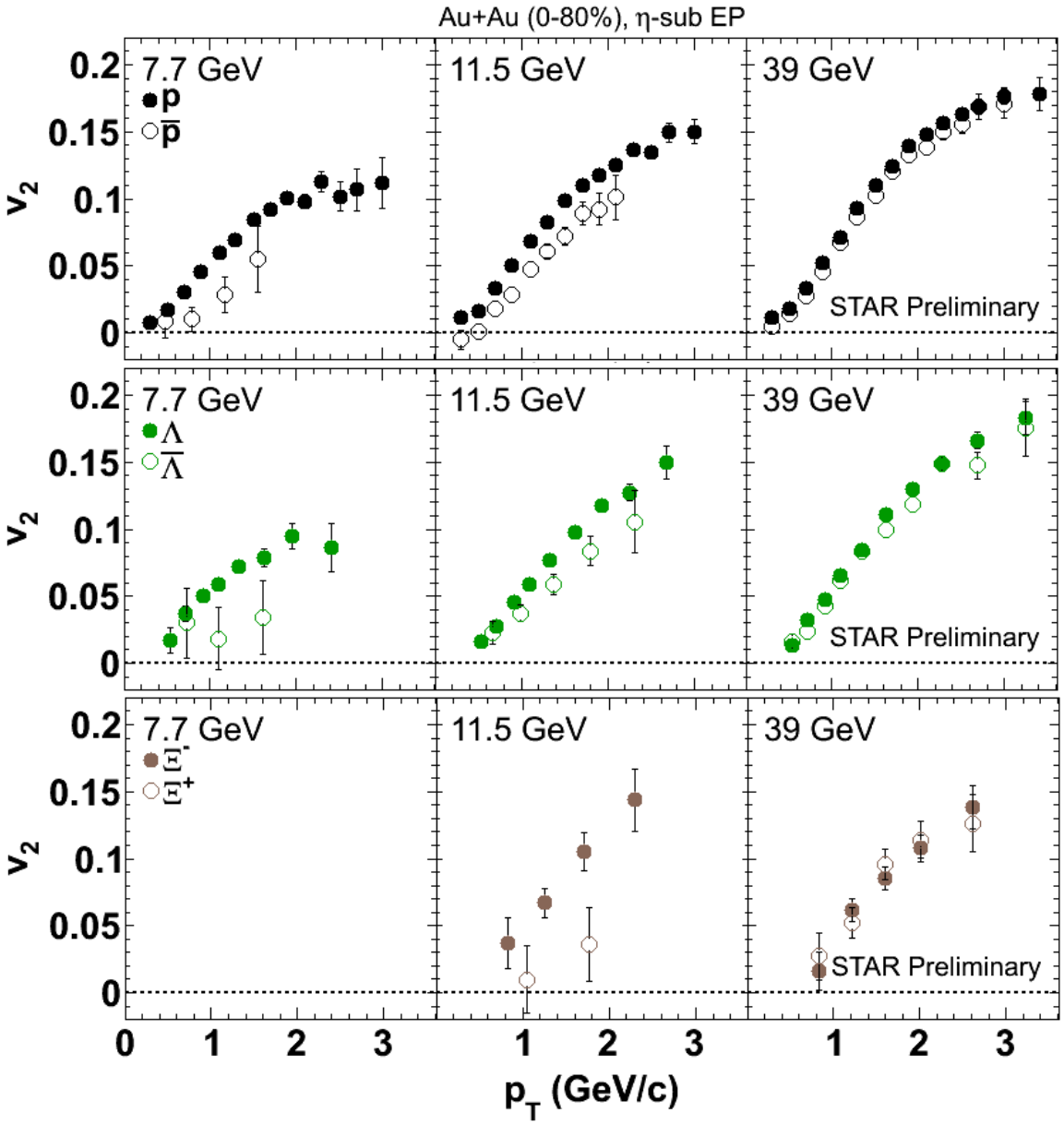
- Au+Au @ 19.6 and 62.4 GeV are ready, Au+Au @ 27 GeV is requested for 2012
  → 19.6 and 27 GeV important to scan in detail the region of interest!





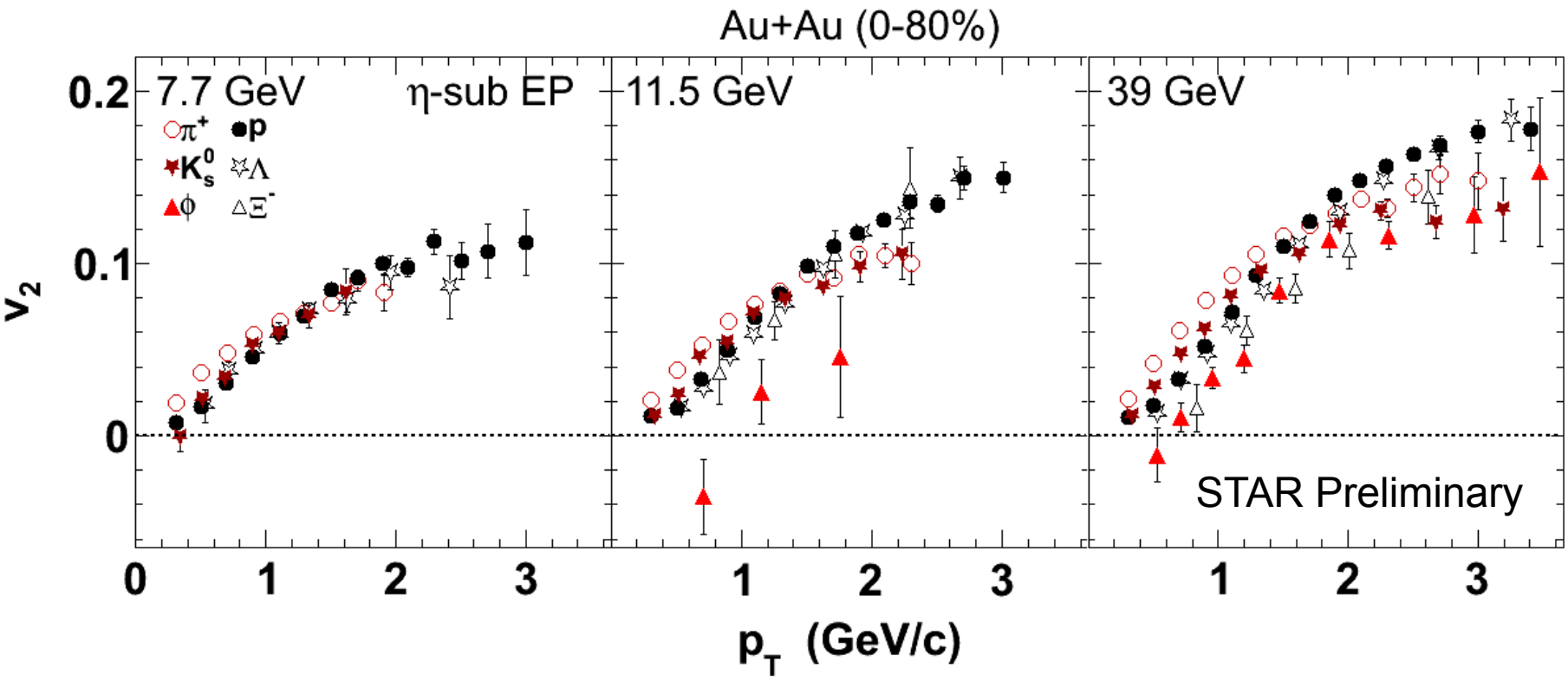
BACKUP

Baryon v_2 @ 7.7, 11.5 and 39 GeV



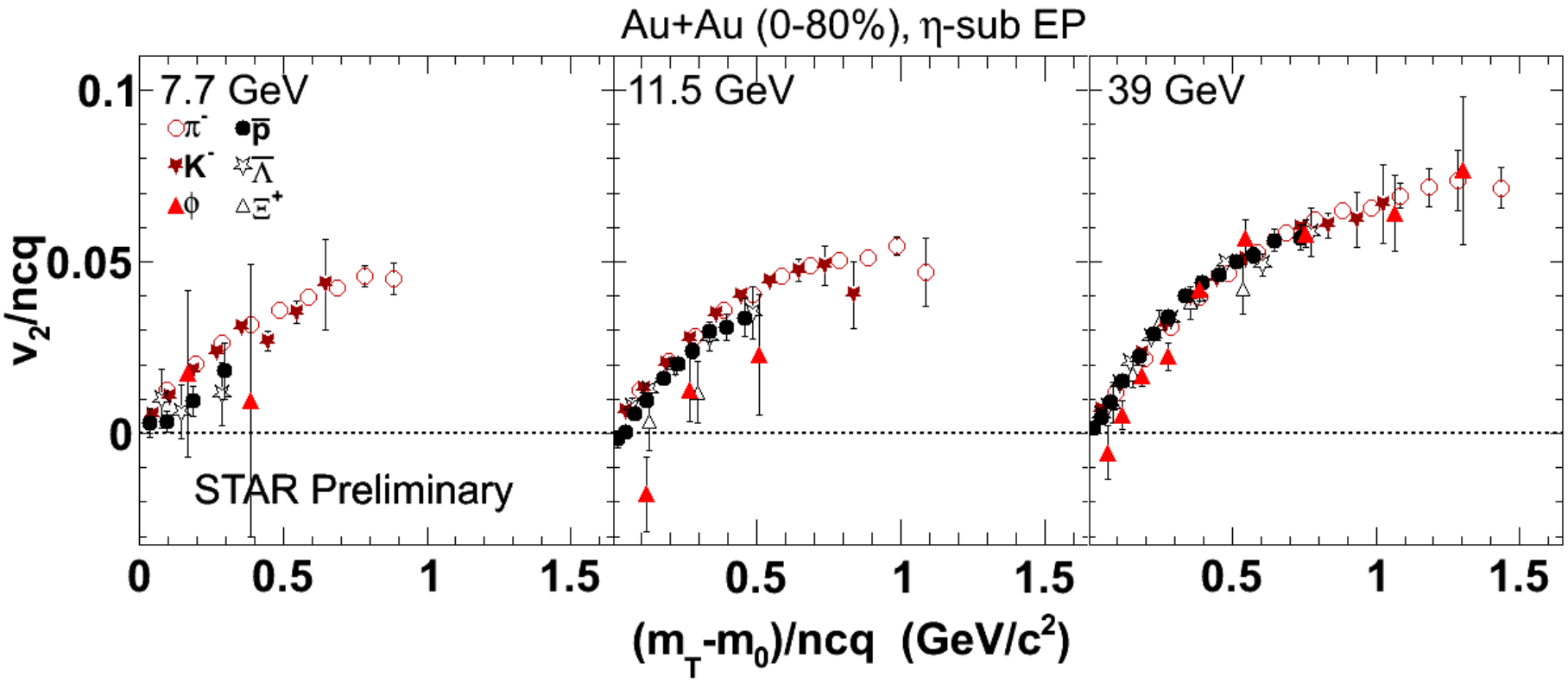
- $v_2(p) > v_2(\bar{p})$ at all energies, increasing difference with decreasing energy, or larger μ_B
- Same behavior for Λ and $\bar{\Lambda}$

v_2 vs. p_T

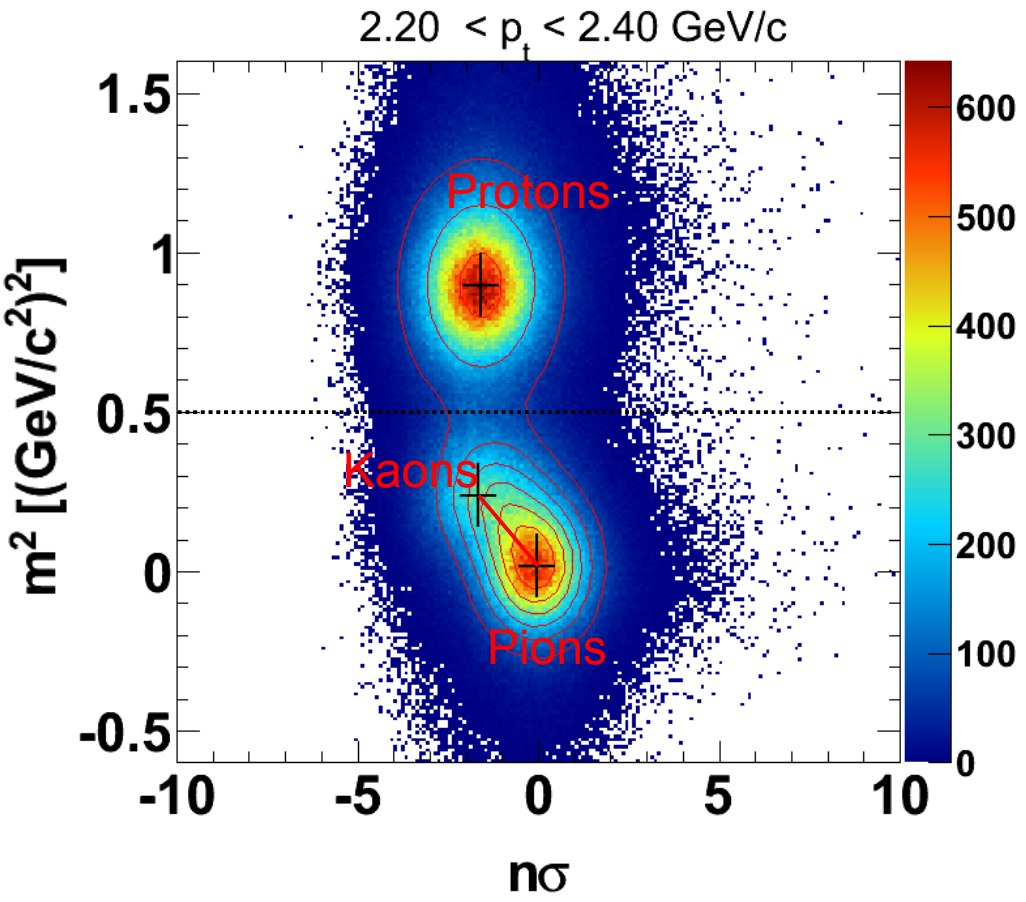


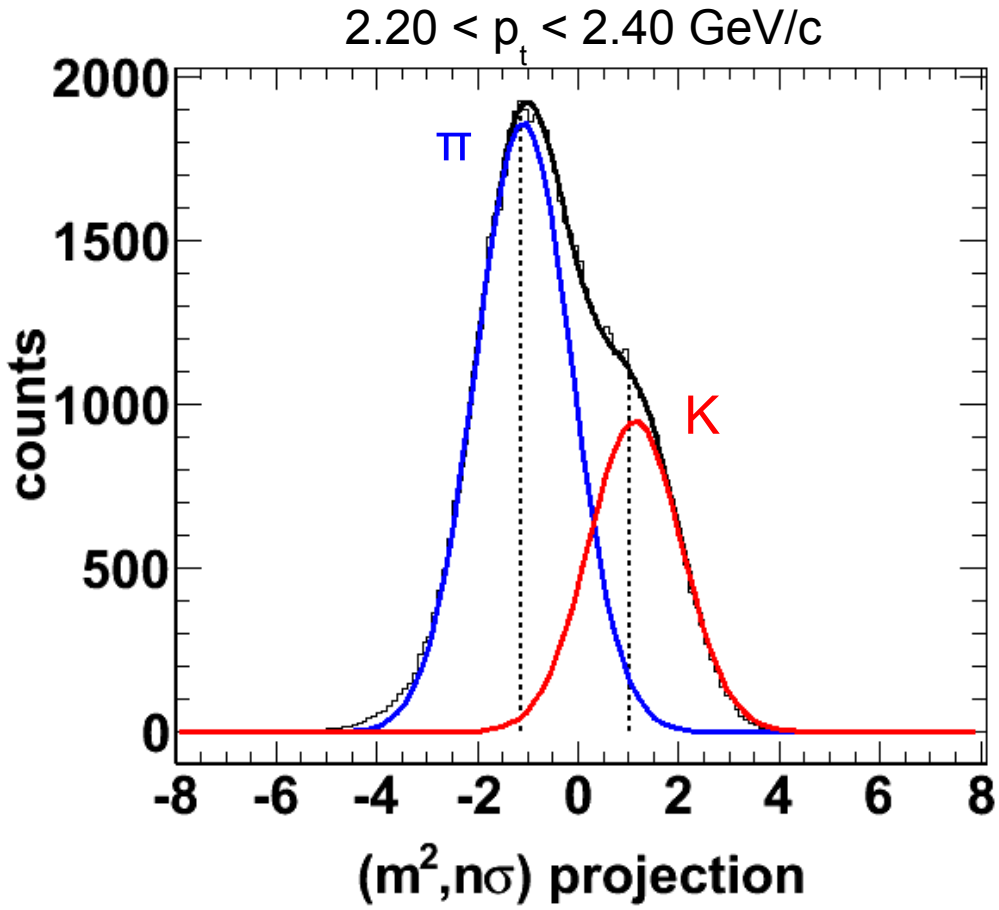
- Φ-meson $v_2(p_T)$ << $v_2(p_T)$ of other particles @ 11.5 GeV
- Mass scaling of v_2 at low p_T, except for Φ-mesons

Anti-Particles: v_2 vs. m_T



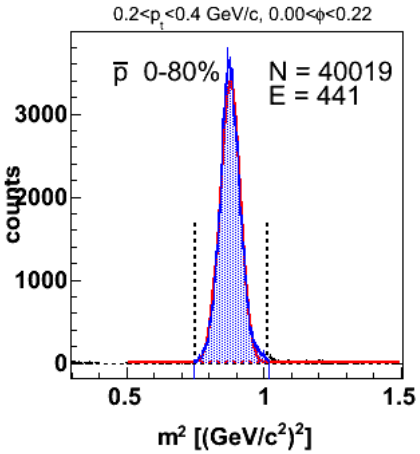
Combined TPC and TOF PID

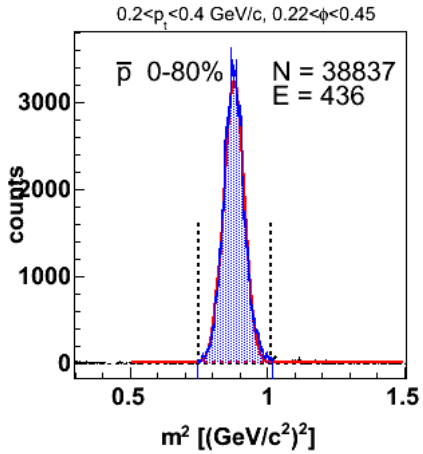


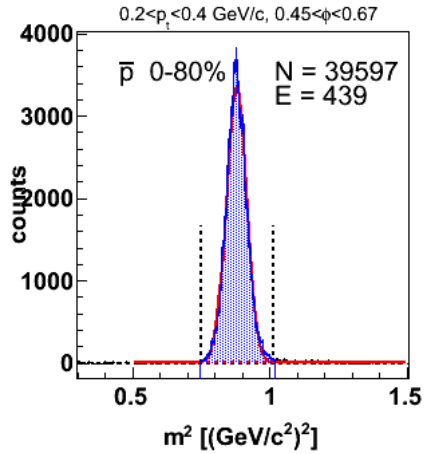


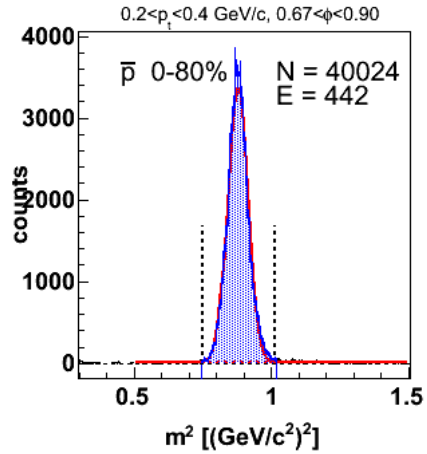
- Combined TPC and TOF PID at high momenta
- Best separation of Kaons and Pions for the shown projection axis
  → Particle identification at high p_t

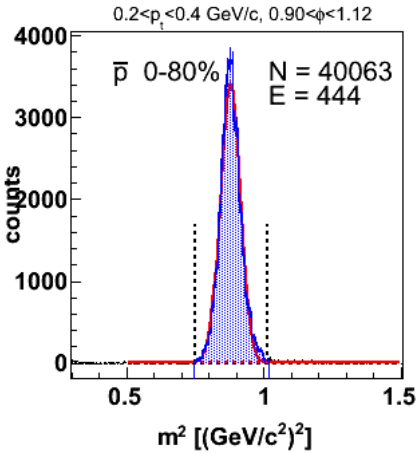
Anti-Proton PID @ 7.7 GeV

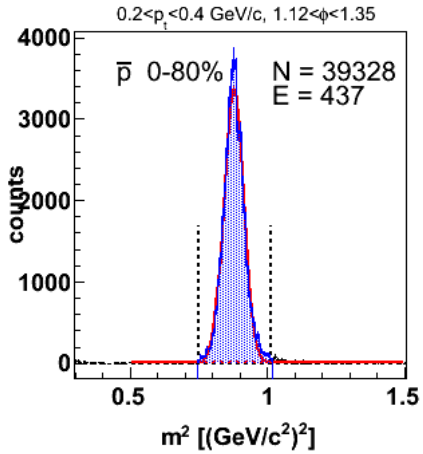


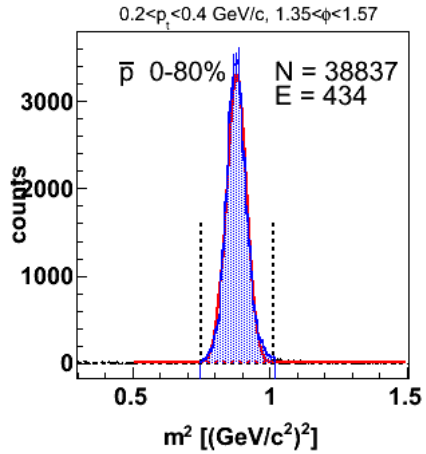












Phi-mesons @ 11.5 GeV, Systematics