The Elliptic Flow in Au+Au Collisions at $\sqrt{s_{NN}}$ = 7.7, 11.5 and 39 GeV at STAR

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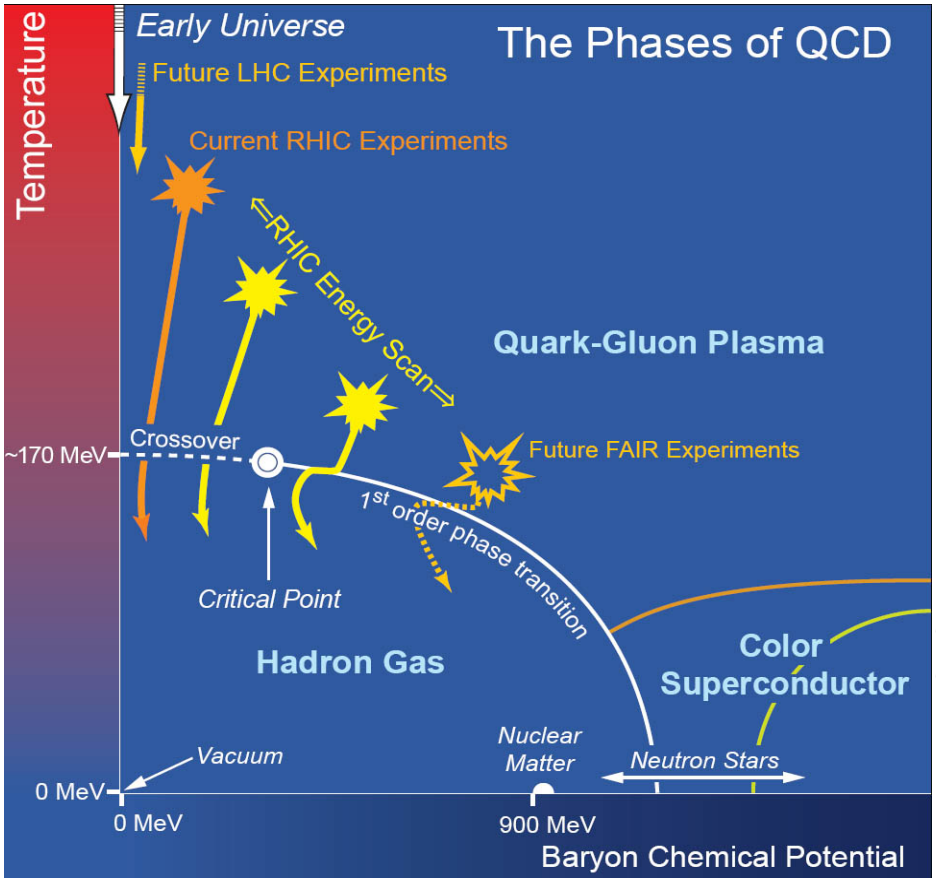
Outline

- **Introduction**
- **STAR detector and Data analysis**
- **Results and Discussions**
  - v_2 method comparison
  - Energy dependence
  - v_2 of particles and anti-particles
  - NCQ scaling test
- **Summary**

Introduction

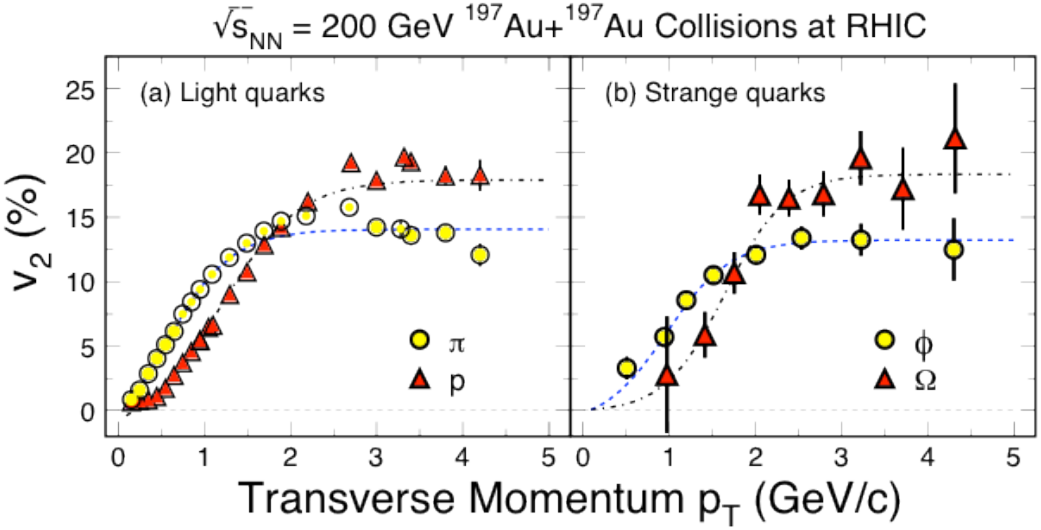
The RHIC Beam Energy Scan (BES)



- **BES Motivations**
  - **Search for critical point**
  - **Search for phase boundary**

  Number of Constituent Quark scaling on v_2

  partonic vs. hadronic degree of freedom



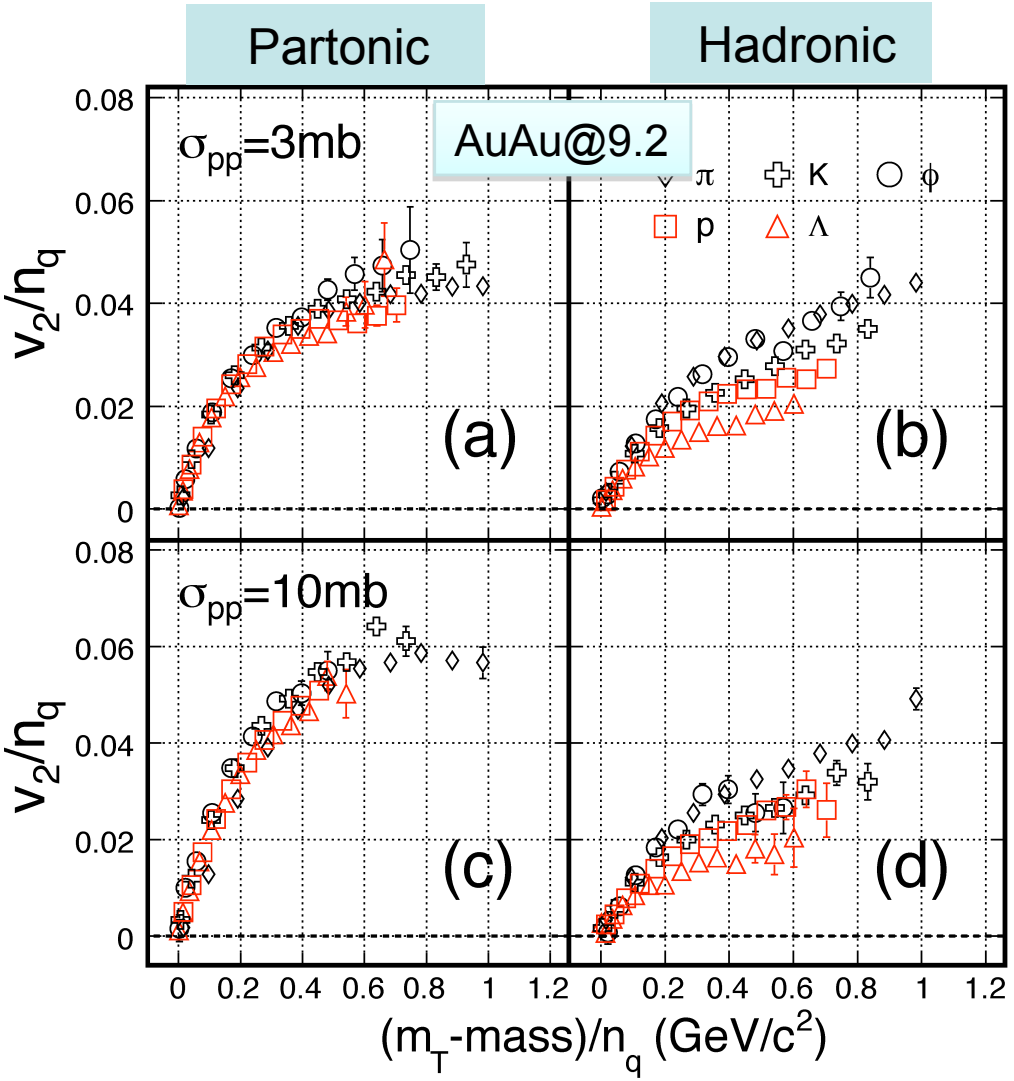
Data Collected in 2010:

- 4.2M @ 7.7 GeV
- 11M @ 11.5 GeV
- 169M @ 39 GeV

STAR: PRL99, 112301 (2007)
NPA830:187c-190c(2009)
PHENIX: PRL98, 162301 (2007)

Energy Dependence of NCQ Scaling

F. Liu, K.J. Wu, and N. Xu: J. Phys. G 37 094029(2010)



AMPT model results:

➢Scaling in v_2: partonic dof dominant;

No scaling in v_2 : hadronic dof dominant

=>

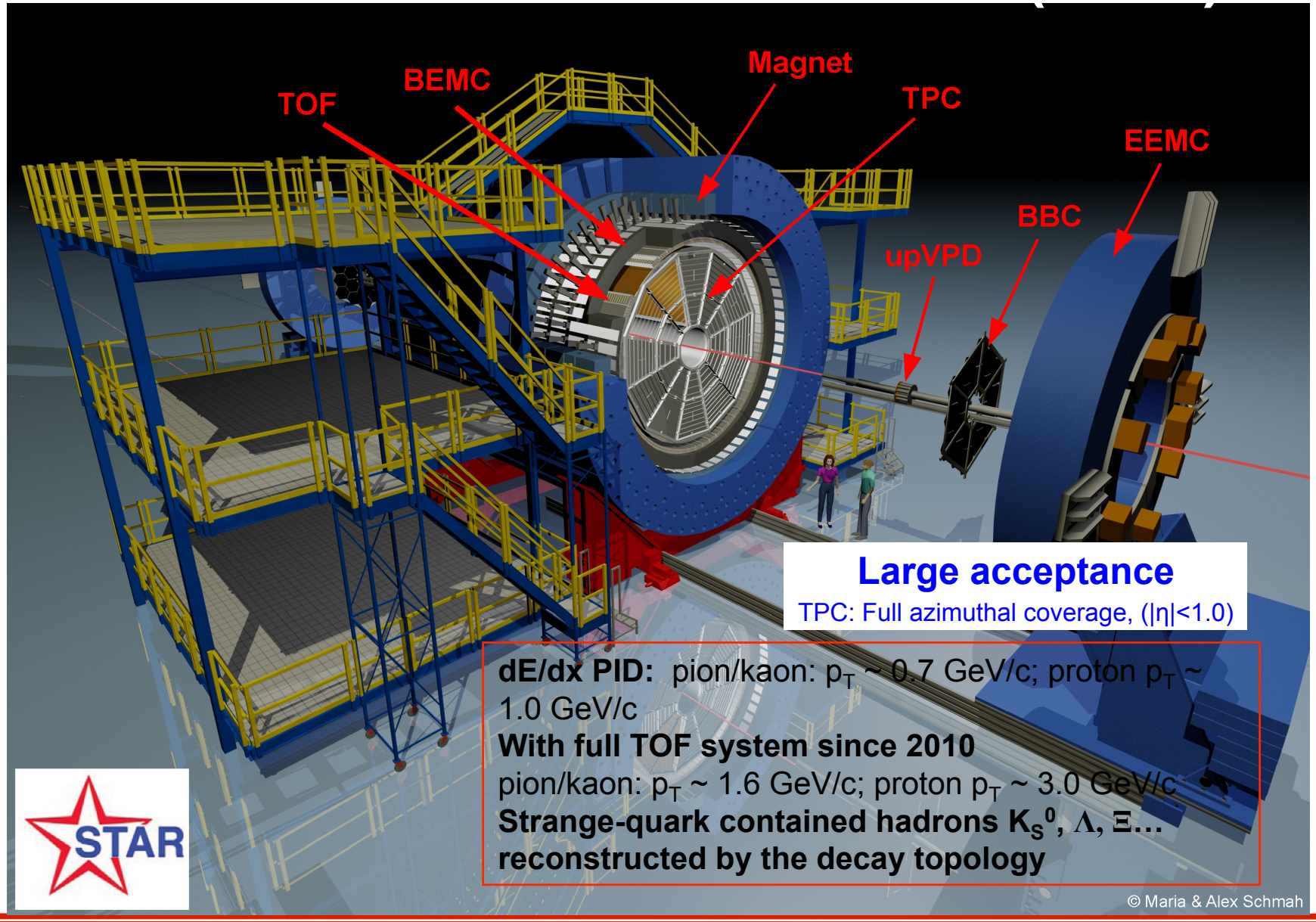
A tool to search for the possible phase boundary!

➢The beam energy dependence of the partonic cross sections will not affect the v_2 scaling argument.

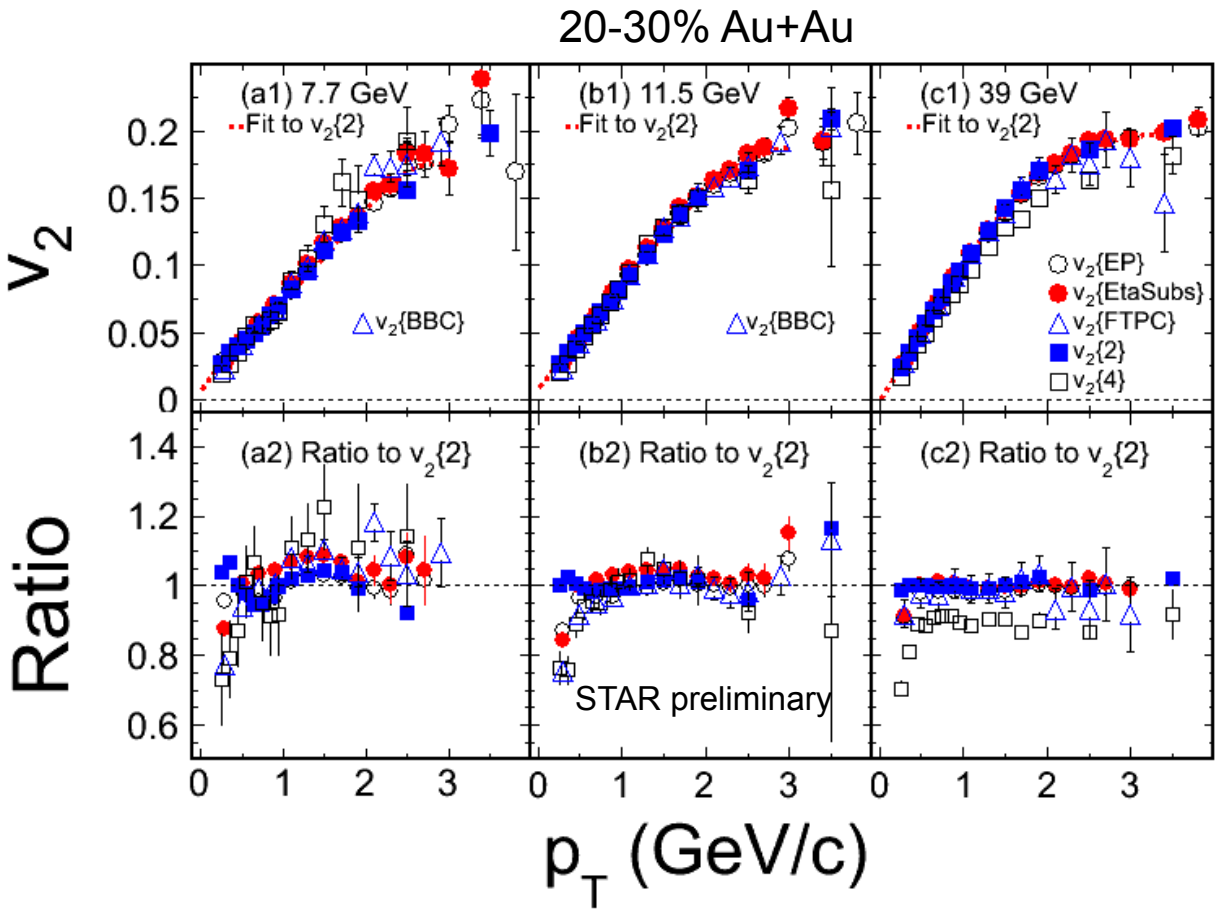
=>

Important for Beam Energy Scan program.

STAR Detectors

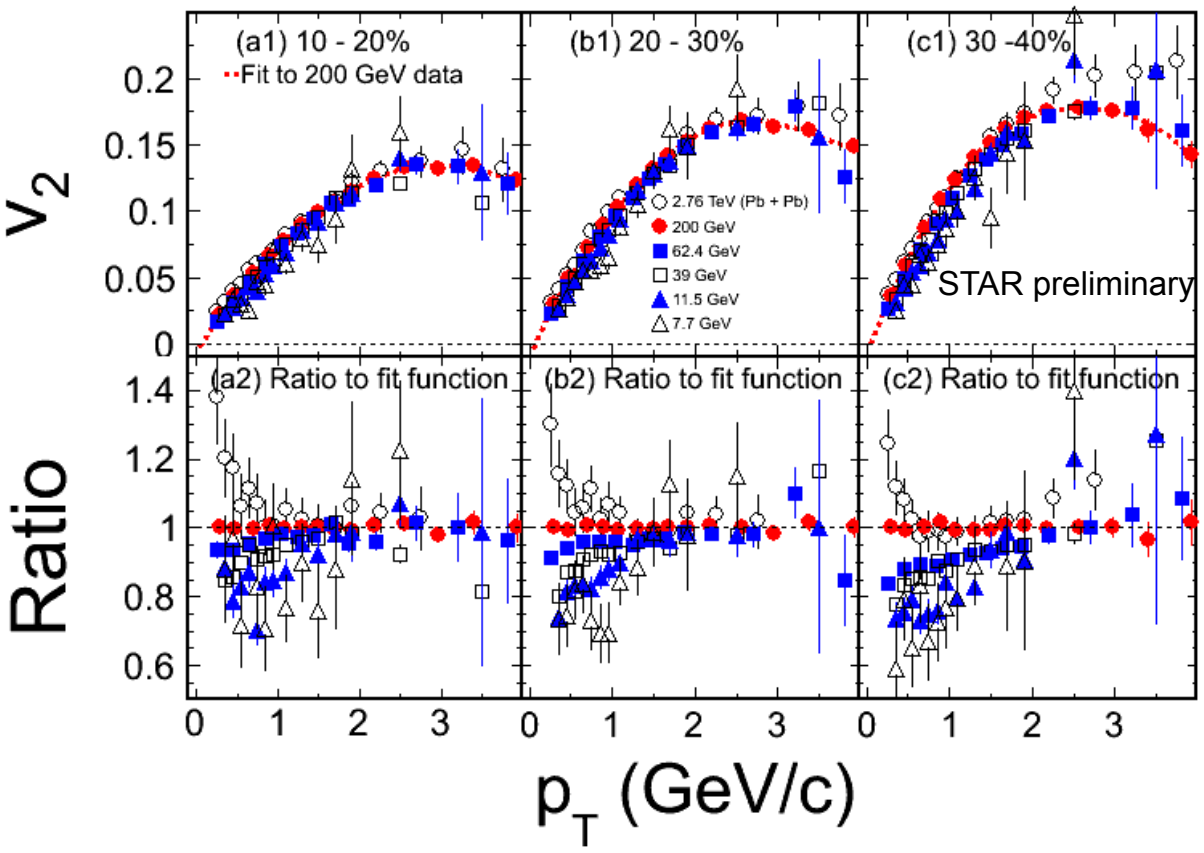


Method Comparison



- **v_2 method**
  - Event Plane method
    TPC EP (|η|<1.0)
    FTPC EP (2.5<|η|<4.0)
    BBC EP (3.8<|η|<5.2)
  - Cumulant method
    v_2{2}, v_2{4}
  - Different methods show different sensitivity to non-flow and fluctuations
- **The difference between v_2{2} and v_2{4} decreases with decrease in beam energy**
  - non-flow and fluctuations
- **The systematic error is ~10%**

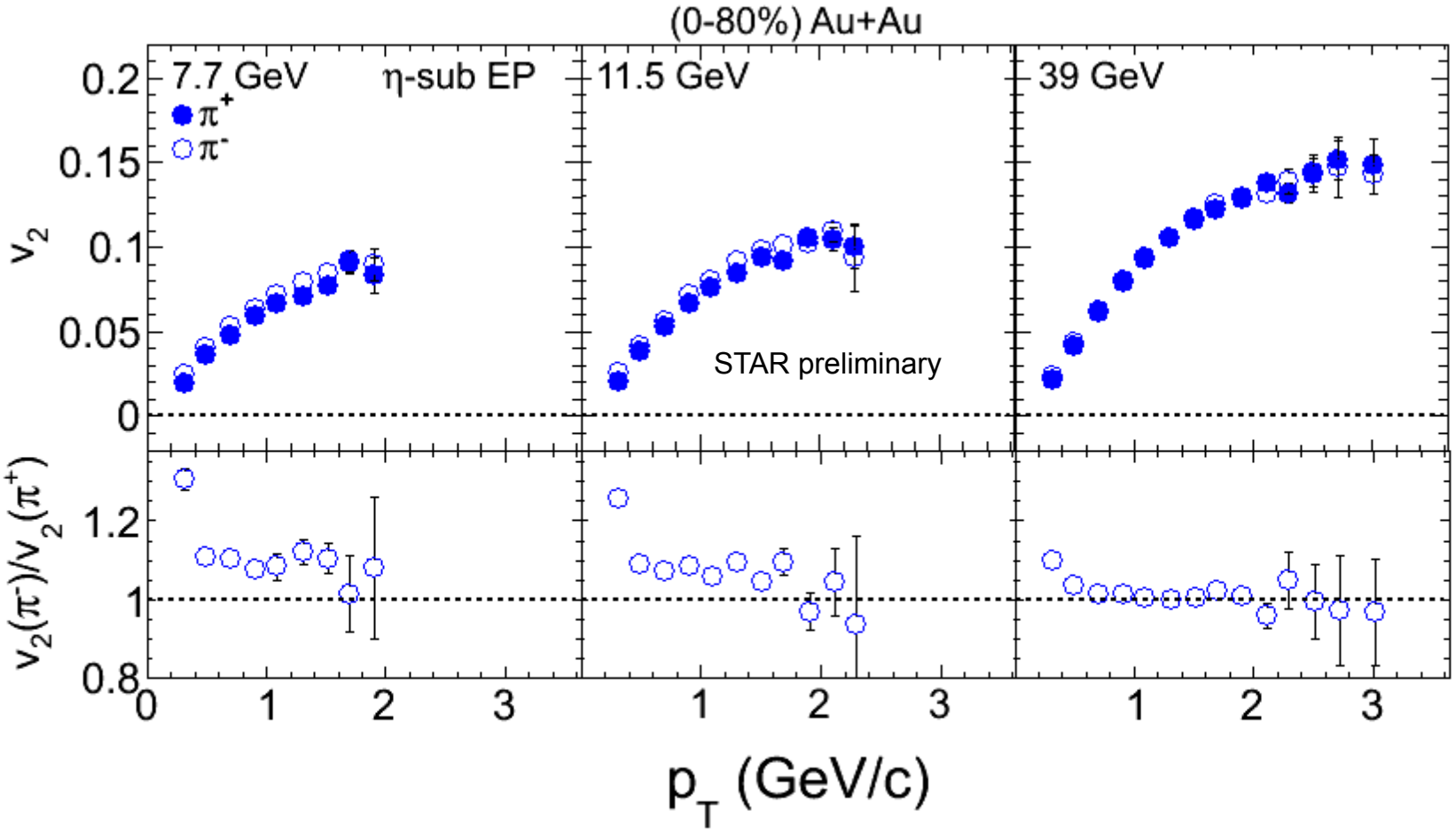
Energy Dependence



- **v_2{4} results**
- Three centrality bins
- **The shape of $v_2(p_T)$ looks similar in all beam energies**
- **p_T< 2GeV/*c***
- The v_2 values increase with increase in beam energy

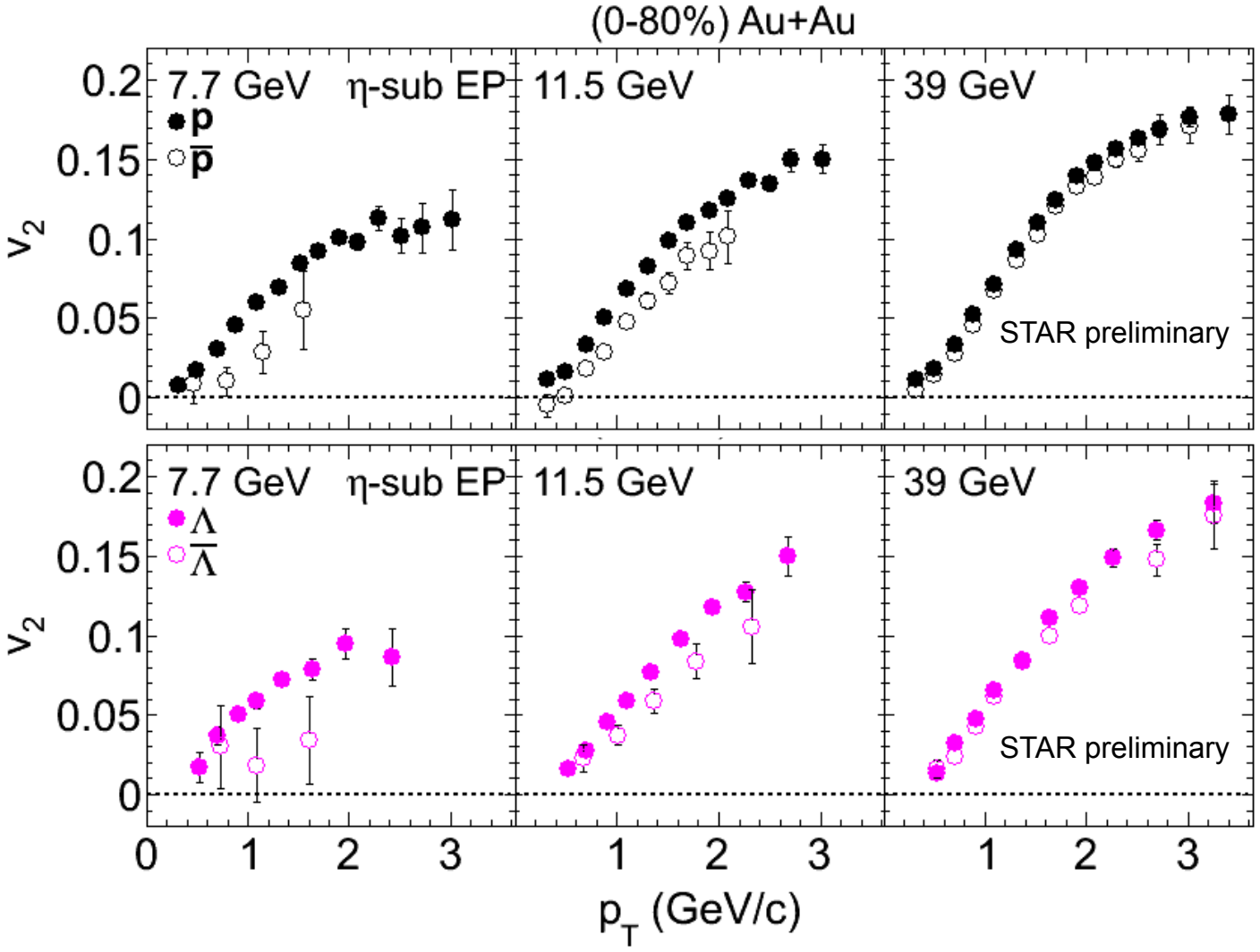
ALICE data: Phys. Rev. Lett. 105, 252302 (2010)

π^+ vs. π^-



- $v_2(\pi^-) > v_2(\pi^+)$ in Au + Au collisions at 11.5 and 7.7 GeV
- Same magnitude of v_2 at 39 GeV

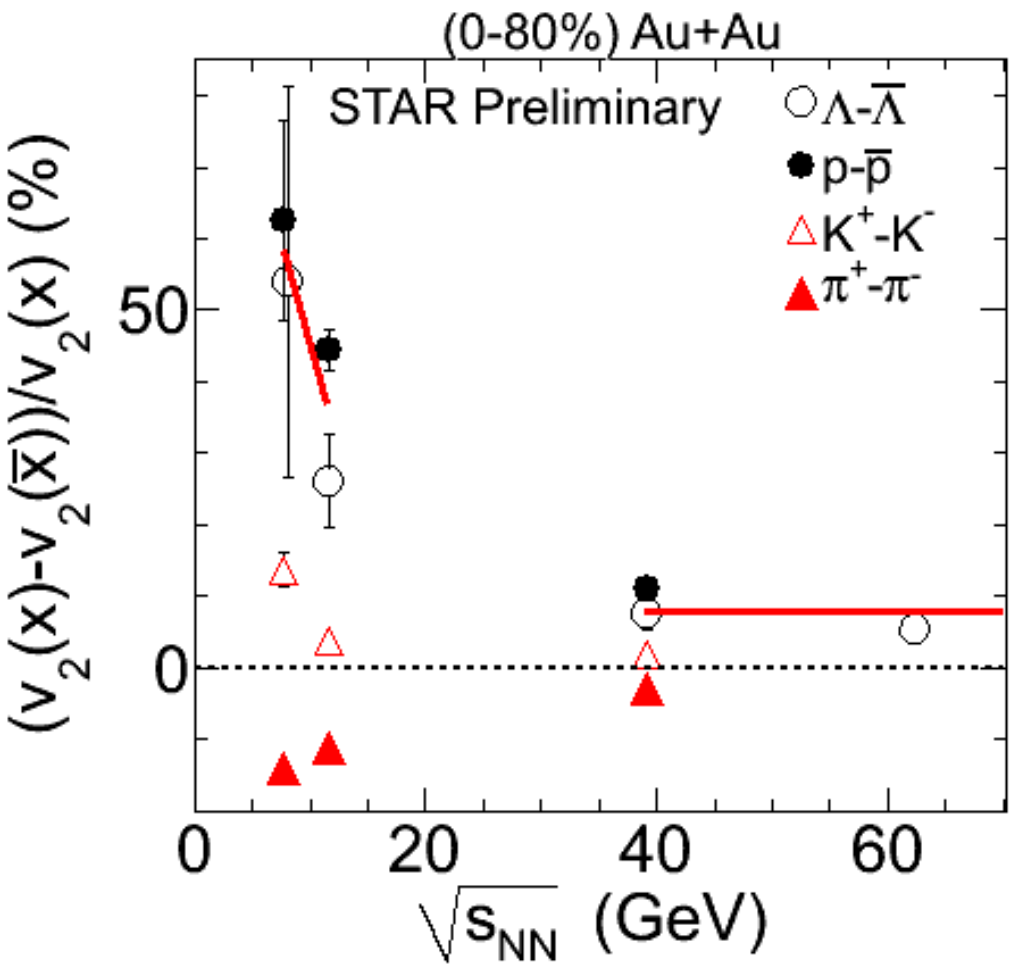
p (Λ) vs. Anti-p (Λ)



- v_2(p) > v_2(anti-p) at all energies, The difference is increasing as beam energy decreasing
- Similar trend observed for Λ and anti- Λ

Particles vs. Anti-particles

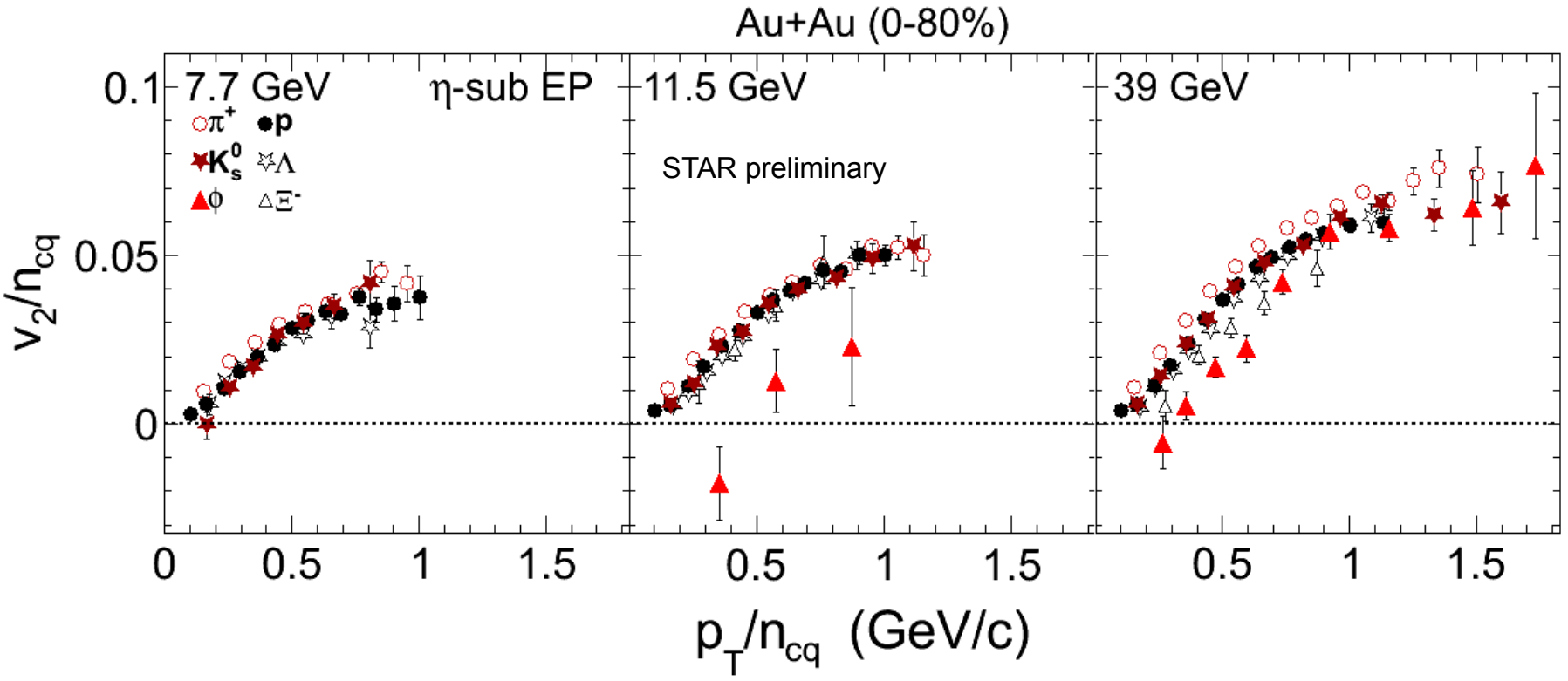
STAR AuAu@62.4: Phys.Rev.C75, 054906 (2007)



- **Beam energy >= 39 GeV**
- Baryon and anti-baryon v_2 consistent within 10%
- Almost no difference for meson v_2
- **Beam energy = 7.7, 11.5 GeV**
- Significant difference of baryon and anti-baryon v_2
  → *Increasing with decrease of beam energy*
- $v_2(K^+)>v_2(K^-)$ at 7.7 GeV
- $v_2(\pi^-) >v_2(\pi^+)$ at 7.7, 11.5 GeV
- **Possible explanation**
- Baryon transport to mid-rapidity?
- Absorption in hadronic environment?

The difference between particles and anti-particles is observed

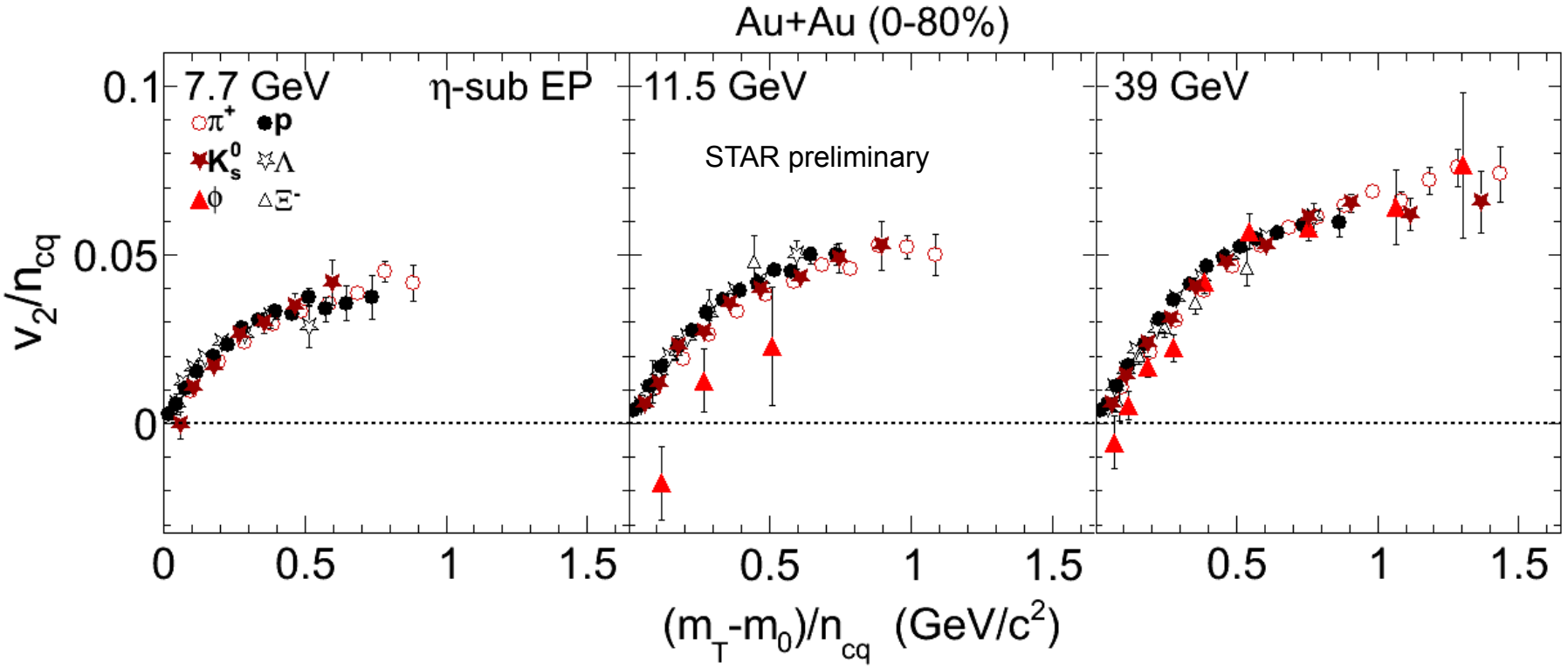
NCQ Scaling Test: p_T



- NCQ scaling at Intermediate p_T for Au+Au@39 GeV is similar to 200 GeV.
- ϕ meson v_2 significantly falls off the trend of other particles in Au+Au@11.5 GeV

More details on ϕ meson v_2: ***Md. Nasim*** *"Energy Dependence of Elliptic Flow of the ϕ Meson"* ***Sep. 20, 17:10***
Xiaoping Zhang *"Probe the QCD phase diagram with phi meson production in relativistic nuclear collisions"* ***Sep. 23, 17:50***

NCQ Scaling Test: m_T - m



- Universal trend for most of particles
- ϕ meson v_2 deviates from other particles in Au+Au@11.5 GeV:
  Mean deviation from pion distribution: 0.02±0.008 (→ 2.6 σ)

Small or zero v_2 for ϕ meson -> without formation of partonic matter

Ref: B. Mohanty and N. Xu: J. Phys. G 36, 064022(2009)

Summary

- Reported the v_2 results on Au+Au at 7.7, 11.5 and 39 GeV
- The difference between particles and anti-particles is observed
- φ meson deviates the trend of other particles at 11.5 GeV: Mean deviation from pion distribution: 2.6 σ

  Au+Au collisions between 11.5 and 39 GeV are needed

Outlook

- Au+Au at 19.6 and 27 GeV data has been taken in 2011