APRIL MEETING 2021

Identified particle v_1 and v_2 in 3 GeV Au+Au collisions at STAR

Sooraj Radhakrishnan
(for the STAR Collaboration)
Kent State University/Lawrence Berkeley National Laboratory

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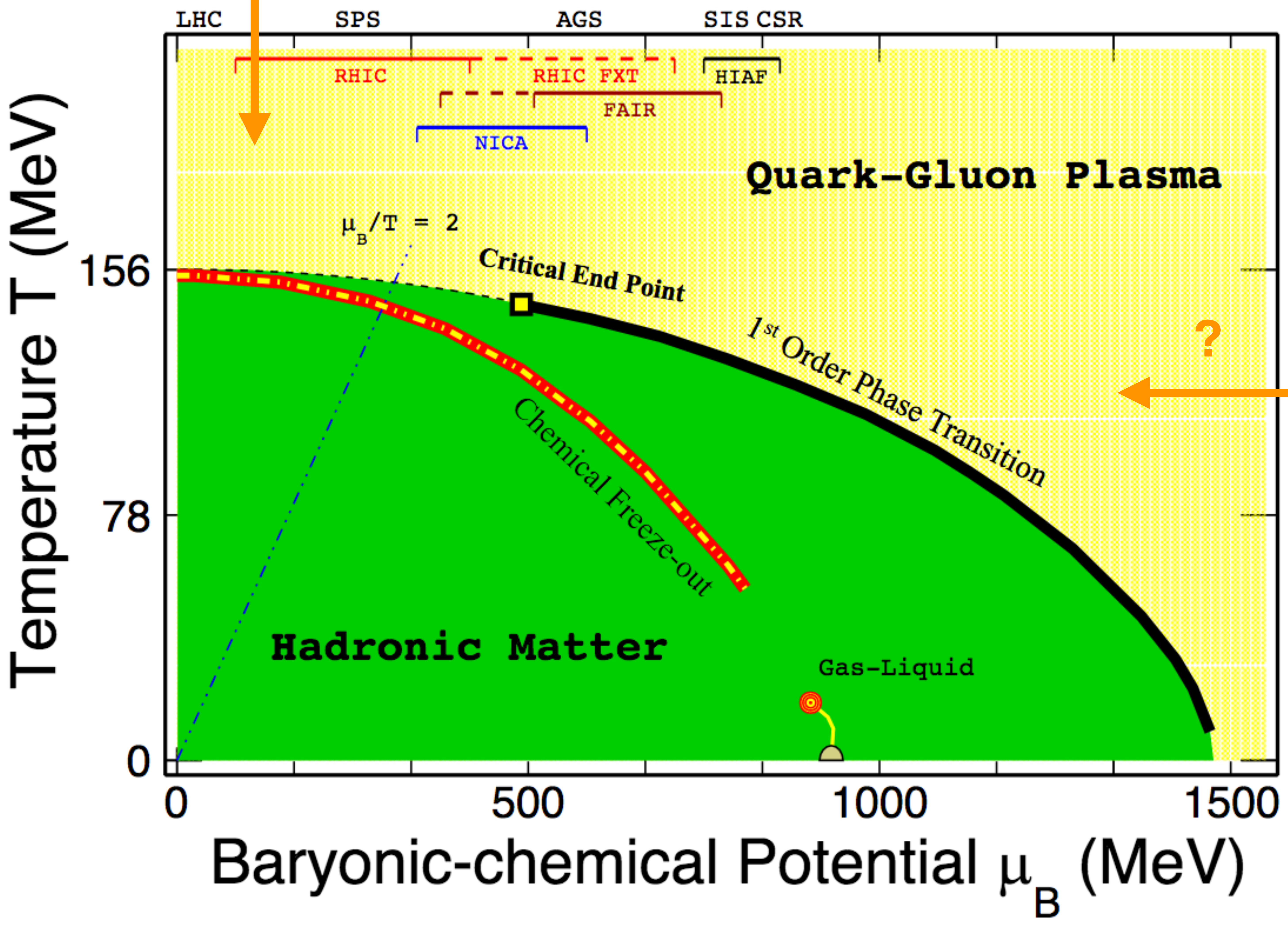
Exploring QCD matter

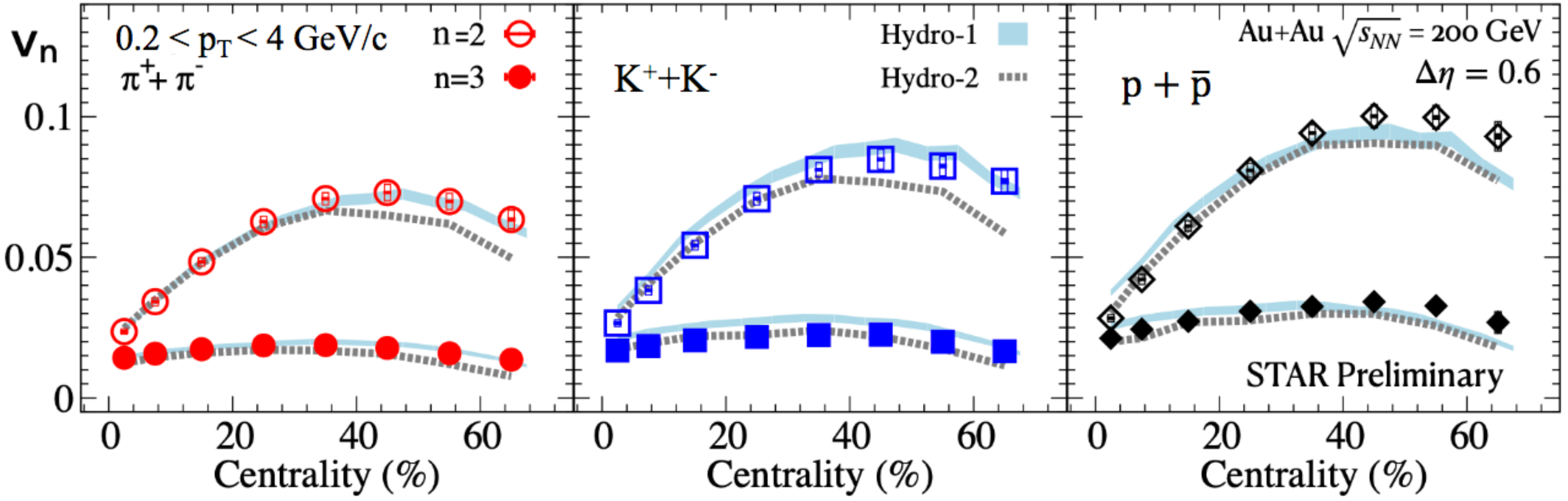


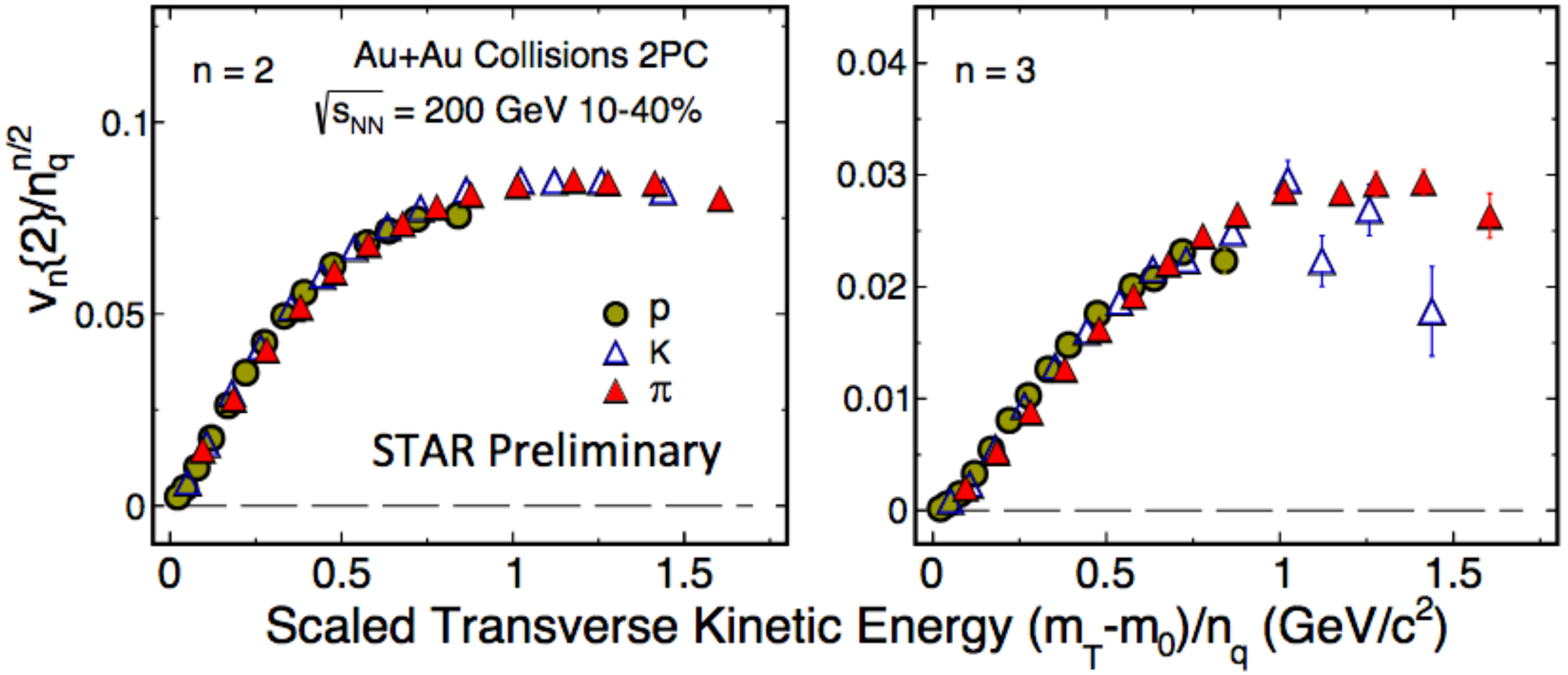
Conjectured QCD Phase diagram

- Quark Gluon Plasma
  - Partonic degrees of freedom
- Where are we in low energy collisions?
  - Hadronic matter?
  - What is the EoS of nuclear matter?
- 'Collective flow' ideal tool to study nature and properties of the medium produced

Collective flow in heavy-ion collisions

- High energies:
  - v_n from hydrodynamic response to initial geometry
  - Well described by hydro calculations





$$\frac{dN}{d\phi} \sim 1 + \sum_{n=1}^{\infty} 2v_n \cos(n(\phi - \Psi))$$

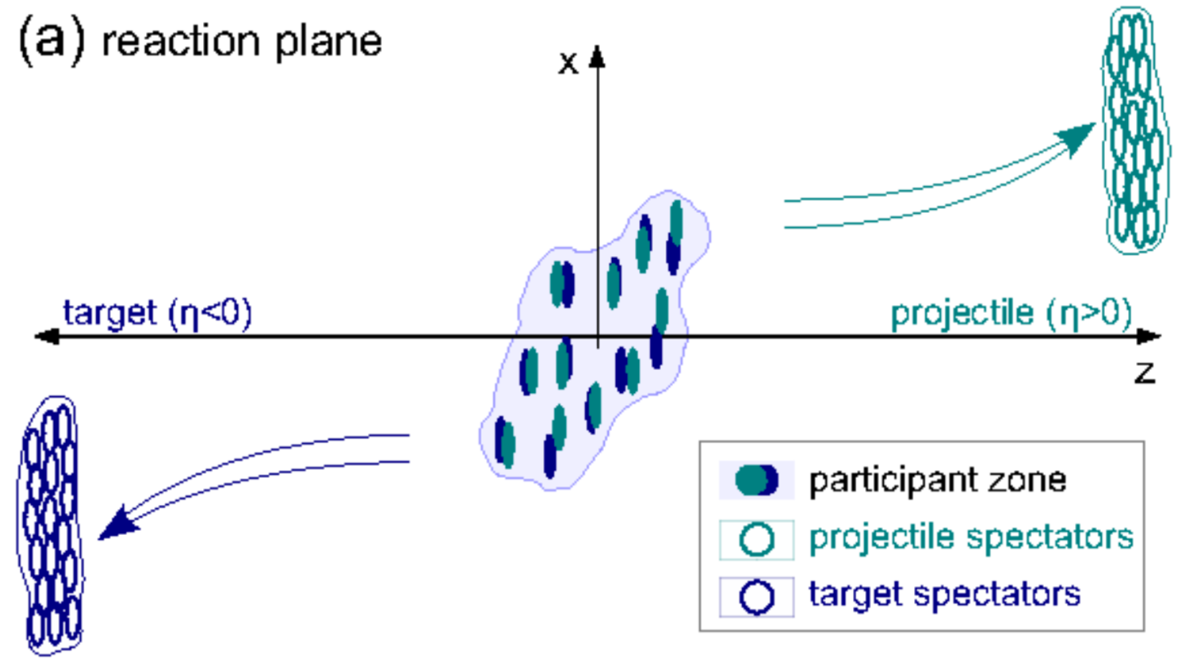
←

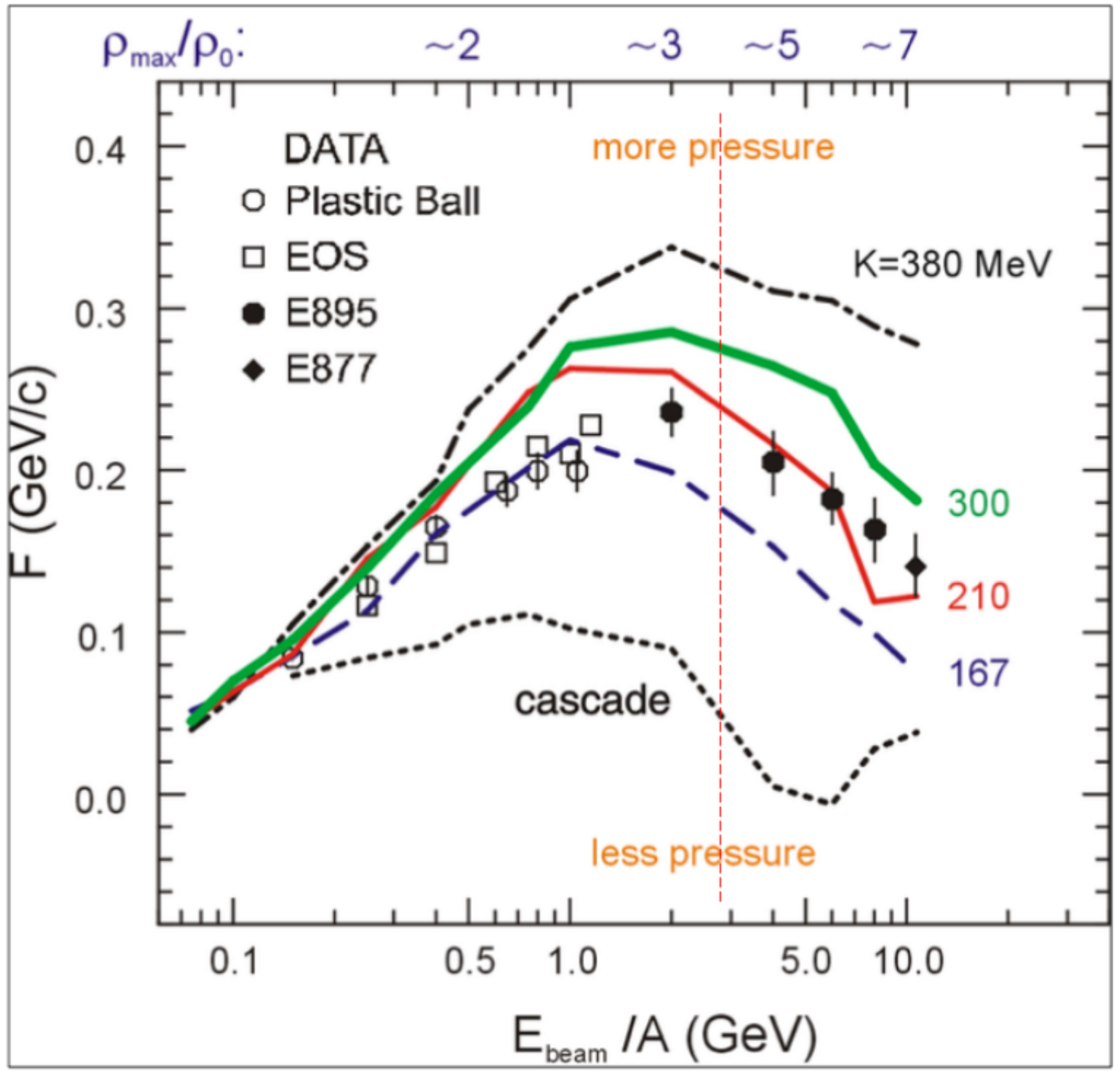
- Follows number of quark scaling
  - Partonic degrees of freedom

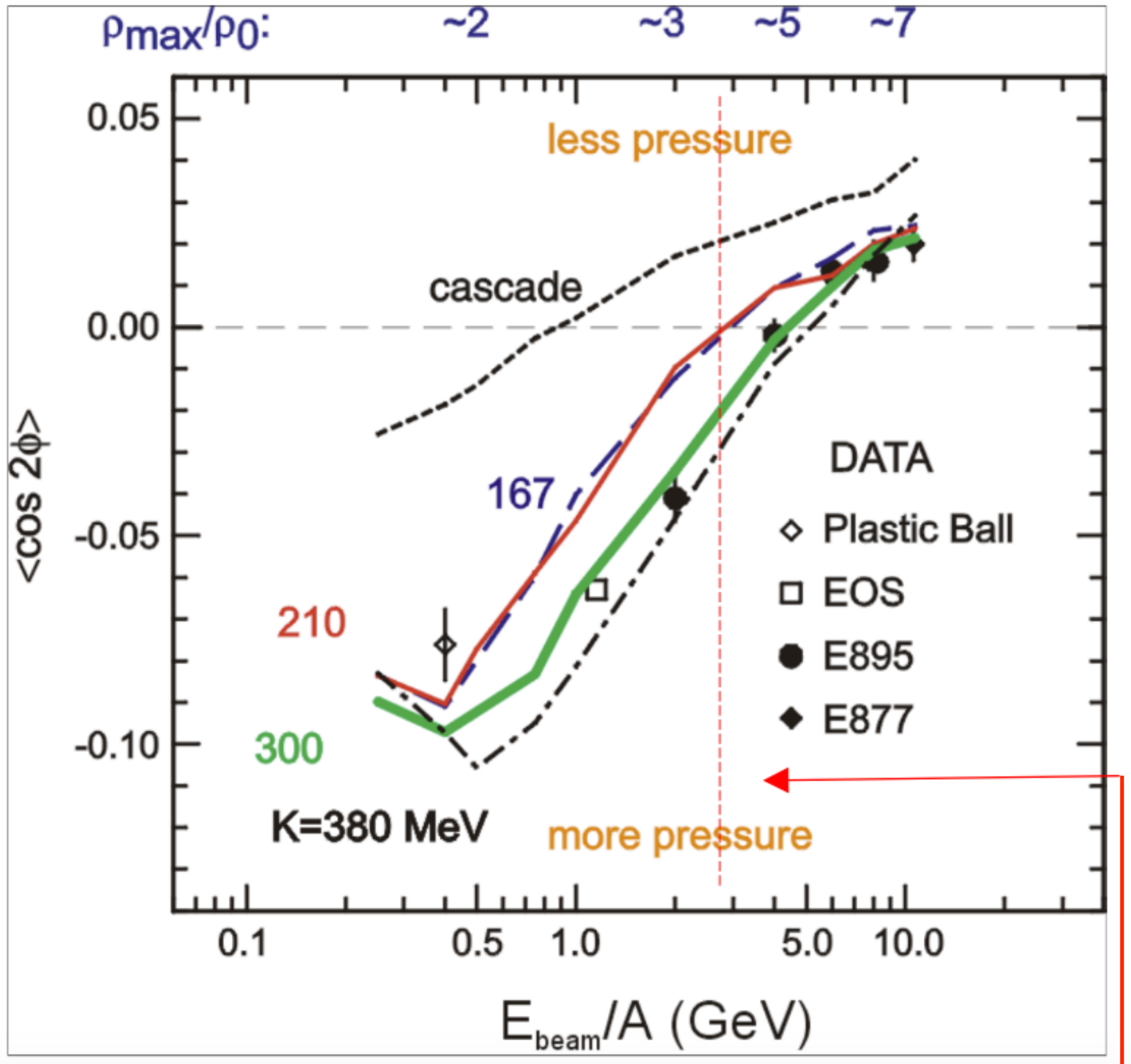
Hydro Models: 1) Phys. Rev. C 98 034909,
2) Phys. Rev. C 99 044908

Collective flow in heavy-ion collisions

- Low energies:
  - Contribution from spectator shadowing
  - Out of plane v_2 from squeeze out







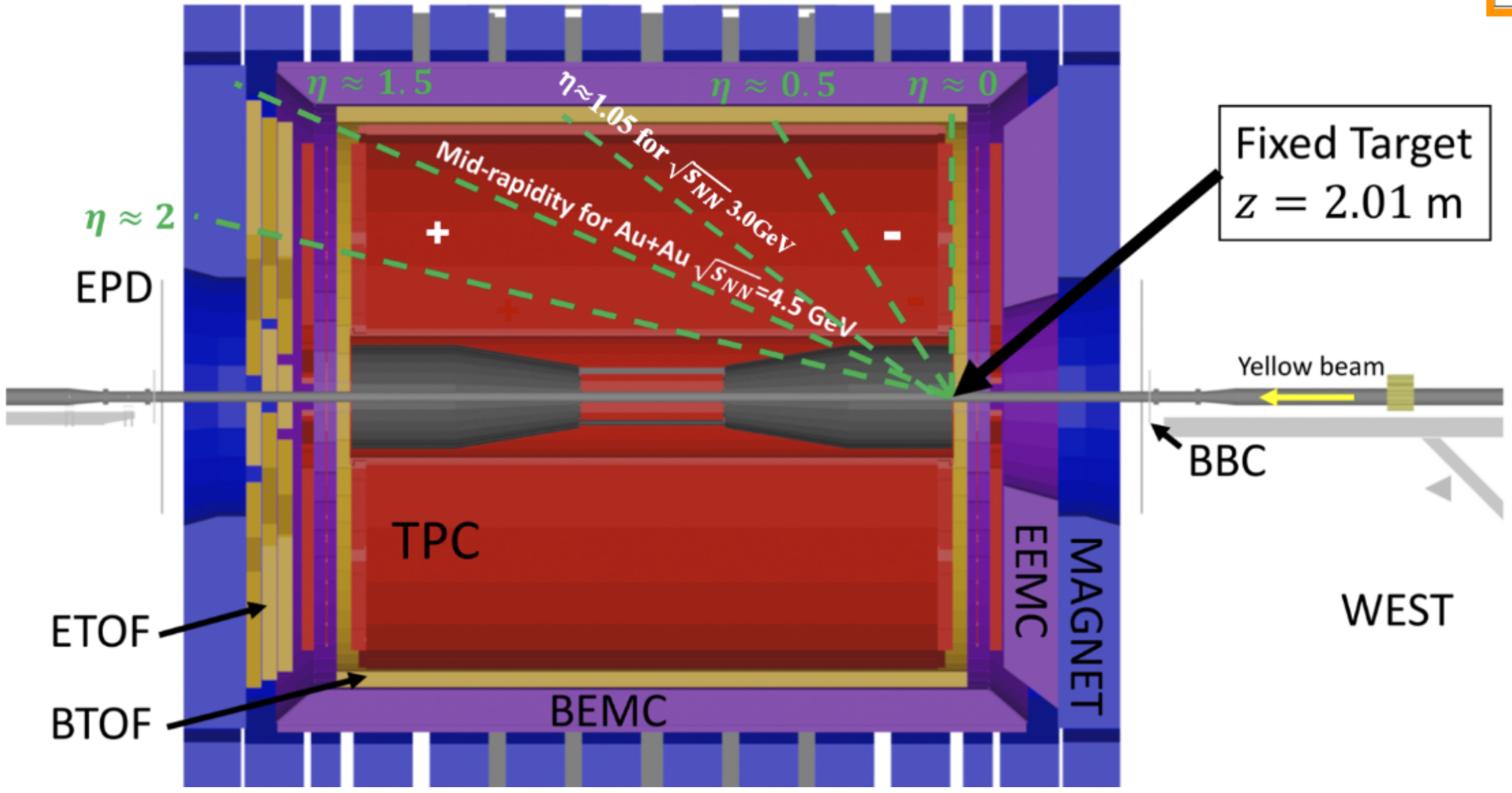
Science 298, 1592-1596

- Baryonic mean-field potentials also important in generating v_1, v_2
- Information on EoS, incompressibility (K) of nuclear matter

FXT Collisions at 3 GeV at STAR

- FXT program extends the STAR Beam Energy Scan-II to lower collision energies (7.7 — 3 GeV) and higher μ_B (420 — 720 MeV) regions

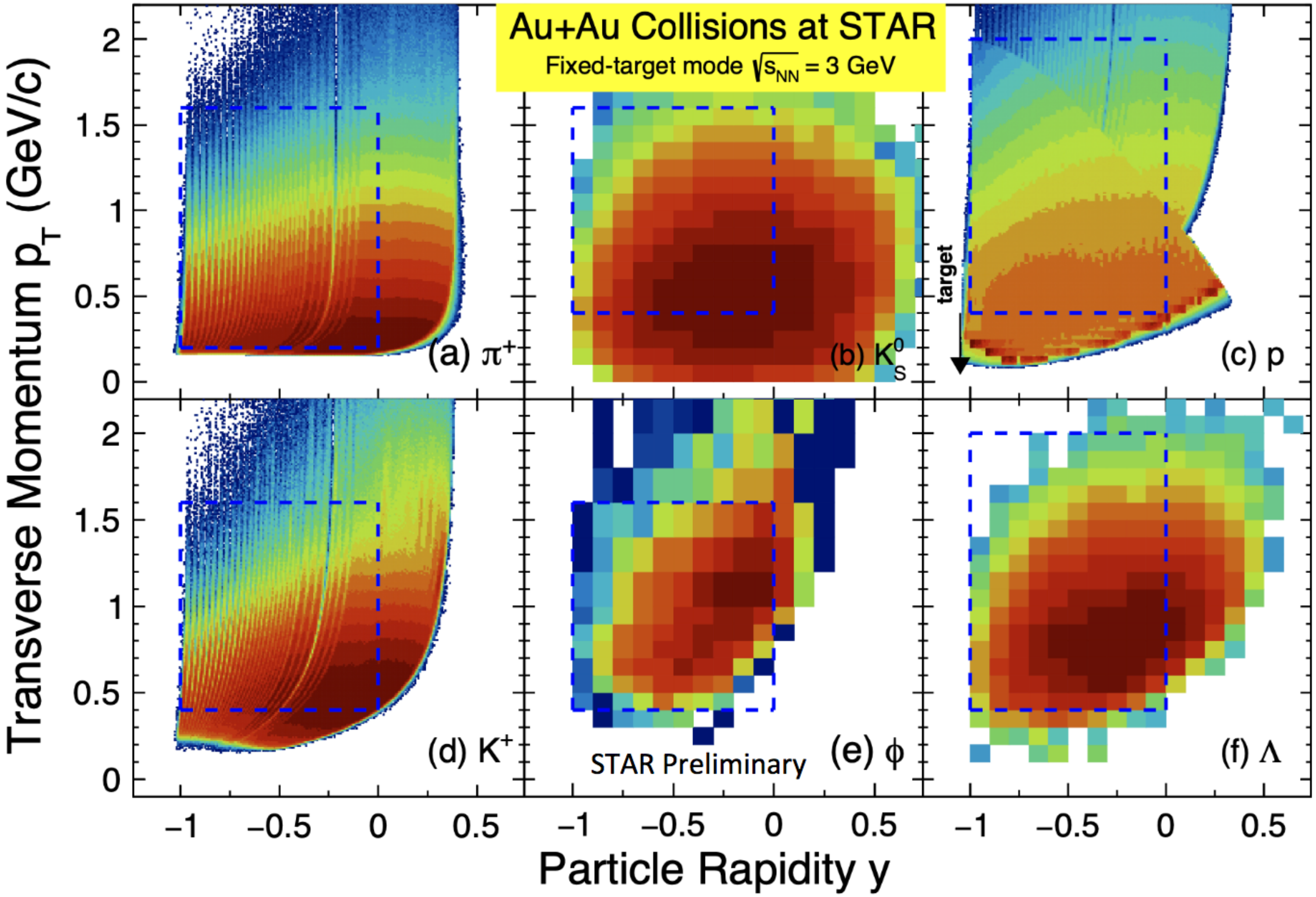
Beam Energy (GeV/nucleon)	$\sqrt{s_{NN}}$ (GeV)	μ_B (MeV)	Run Time	Number Events Requested (Recorded)	Date Collected
31.2	7.7 (FXT)	420	0.5+1.1 days	100 M (50 M+112 M)	Run-19+20
19.5	6.2 (FXT)	487	1.4 days	100 M (118 M)	Run-20
13.5	5.2 (FXT)	541	1.0 day	100 M (103 M)	Run-20
9.8	4.5 (FXT)	589	0.9 days	100 M (108 M)	Run-20
7.3	3.9 (FXT)	633	1.1 days	100 M (117 M)	Run-20
5.75	3.5 (FXT)	666	0.9 days	100 M (116 M)	Run-20
4.59	3.2 (FXT)	699	2.0 days	100 M (200 M)	Run-19
3.85	3.0 (FXT)	721	4.6 days	100 M (259 M)	Run-18



STAR in FXT mode

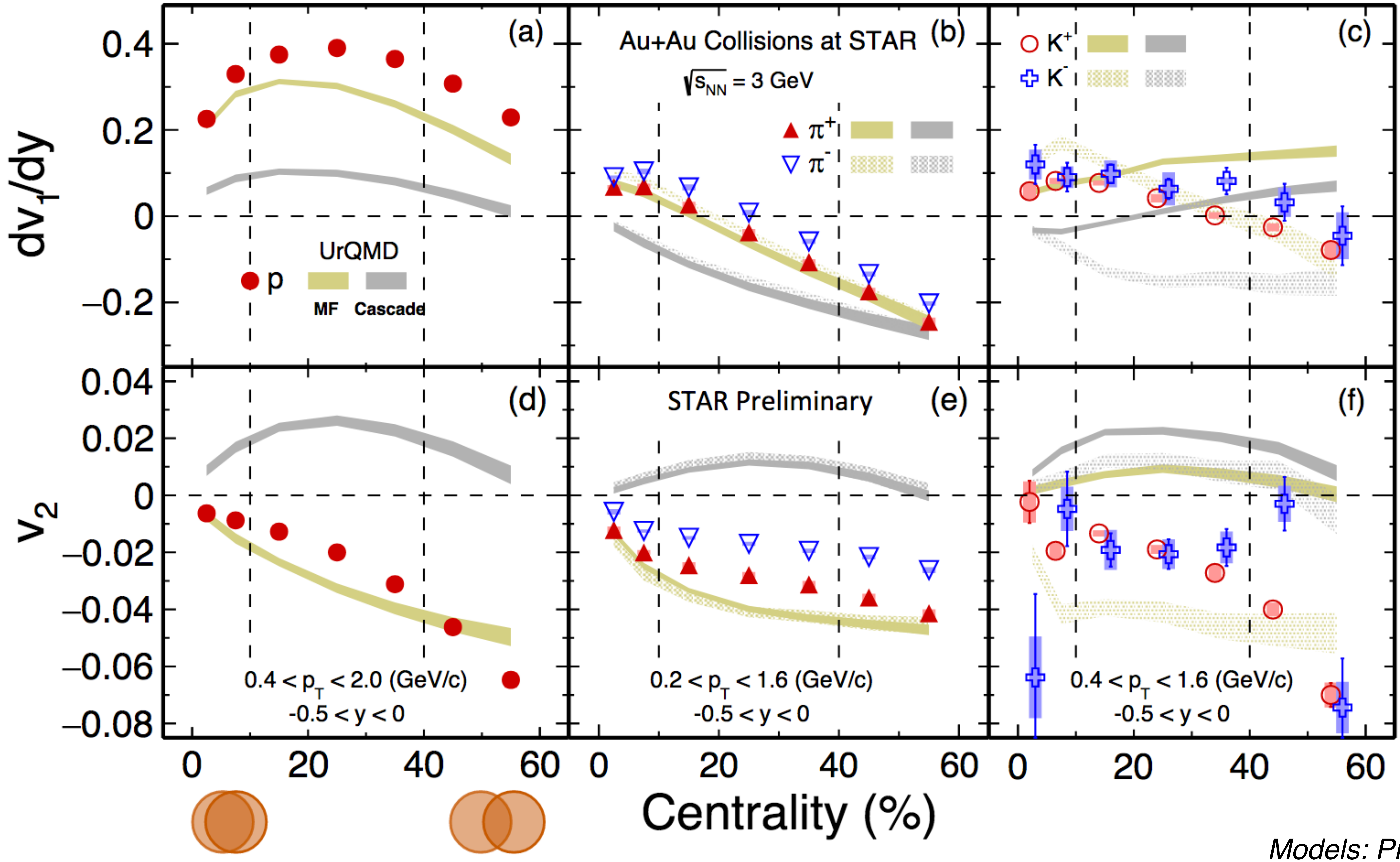
- STAR FXT Au+Au run at 3 GeV in 2018
- High statistics (~250 million events), mid-rapidity acceptance
- Enables differential study of identified hadron v_1, v_2

Particle acceptance



- Efficiency uncorrected transverse momentum (p_T) and rapidity coverage for different particles
- Acceptance extending from mid-rapidity to target rapidity for all particles studied (π, K, K_S, p, Λ)

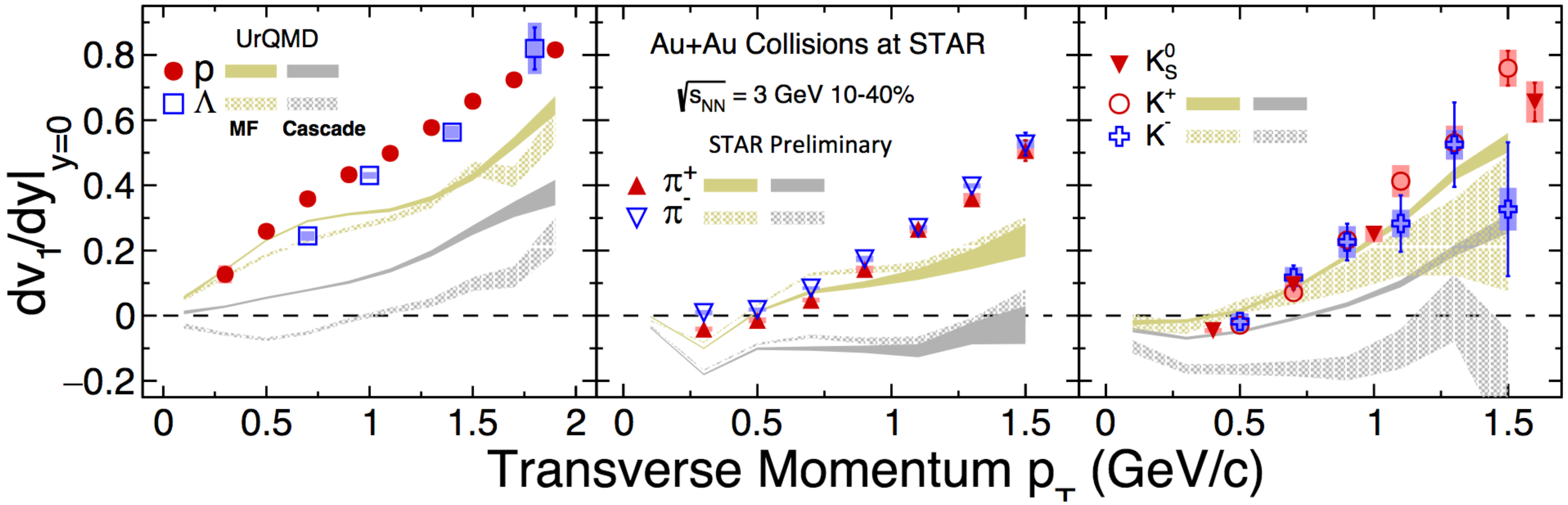
Identified hadron v_1 and v_2 at FXT 3 GeV



- Positive v_1 slope and negative v_2 for all particles in central collisions
- UrQMD cascade mode cannot describe data
- Need baryonic mean field interactions to generate trends seen in data

Models: Prog. Part. Nucl. Phys. 41, 225-370
J. Phys. G: Nucl. Part. Phys. 25, 1859-1896
Eur. Phys. J. A1 15, 1-16

Identified hadron v_1 vs p_T



Models: *Prog. Part. Nucl. Phys. 41, 225-370*
J. Phys. G: Nucl. Part. Phys. 25, 1859-1896
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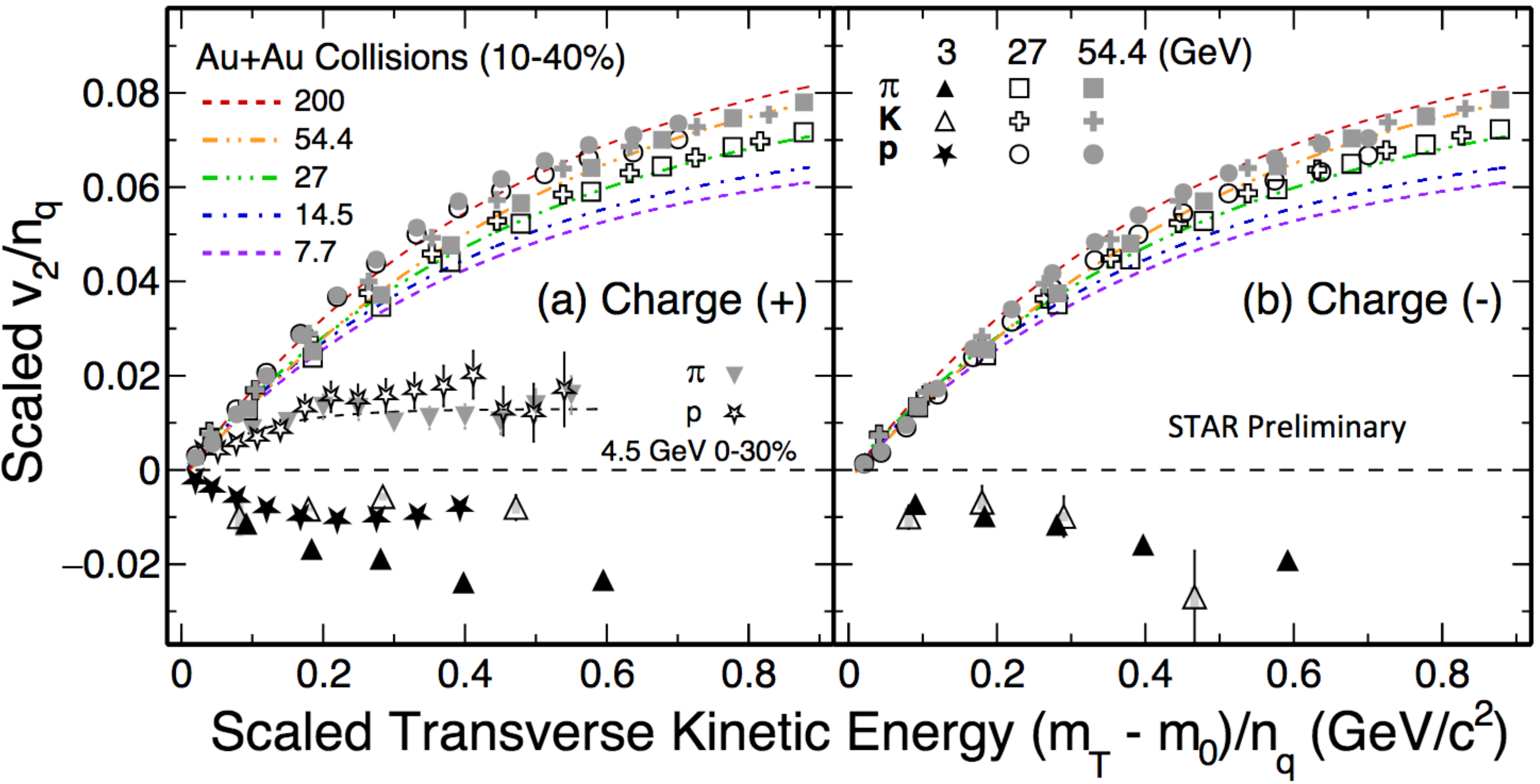
- dv_1/dy increases with p_T for all particles
- UrQMD cascade mode cannot describe data
- Need baryonic mean field interactions to generate trends seen in data

Identified hadron v_2 vs p_T: Disappearance of quark number scaling

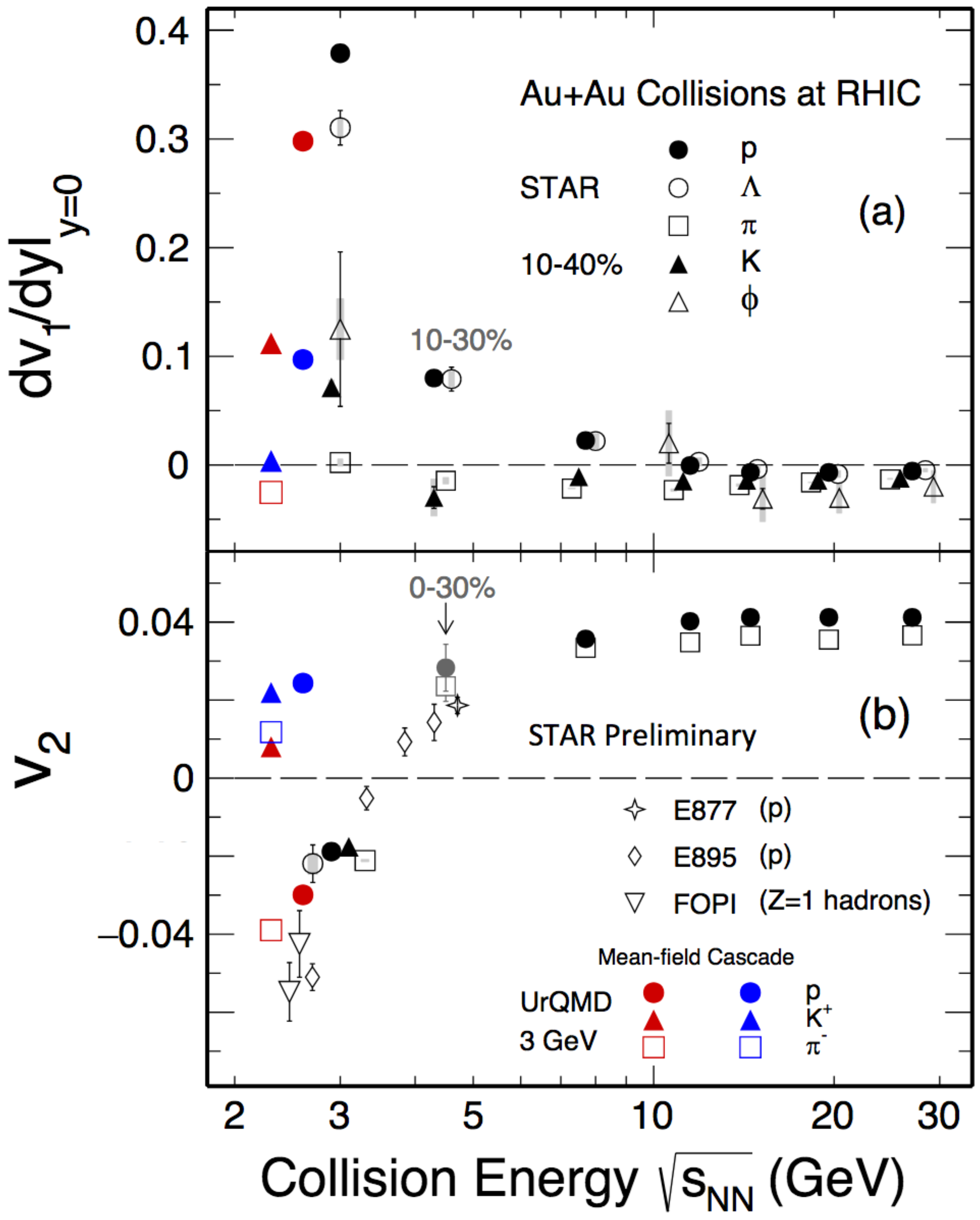


- NCQ scaling holds for energies from 200 down to 4.5 GeV collisions
  - — Partonic collectivity
- v_2 values are negative and NCQ scaling breaks down at 3 GeV
  - — indicative of medium without partonic degrees of freedom

Measurements from new data at 27 and 54.4 GeV

STAR: Phys. Rev. C88149020
STAR: Phys. Rev. C.103, 034908
X. Dong et al. Phys. Lett. B 597 328-332

Energy dependence of v_1 and v_2



- Negative v_1 slope and large positive v_2 at high energy collisions
- Positive v_1 slope and negative v_2 for all measured particles in 3 GeV collisions
- Positive v_1 slope observed for kaons and phi mesons for the first time
- Results from UrQMD with baryonic mean-field interactions qualitatively describe the data
- EoS dominated by baryonic interactions at 3 GeV

Models: Prog. Part. Nucl. Phys. 41, 225-370
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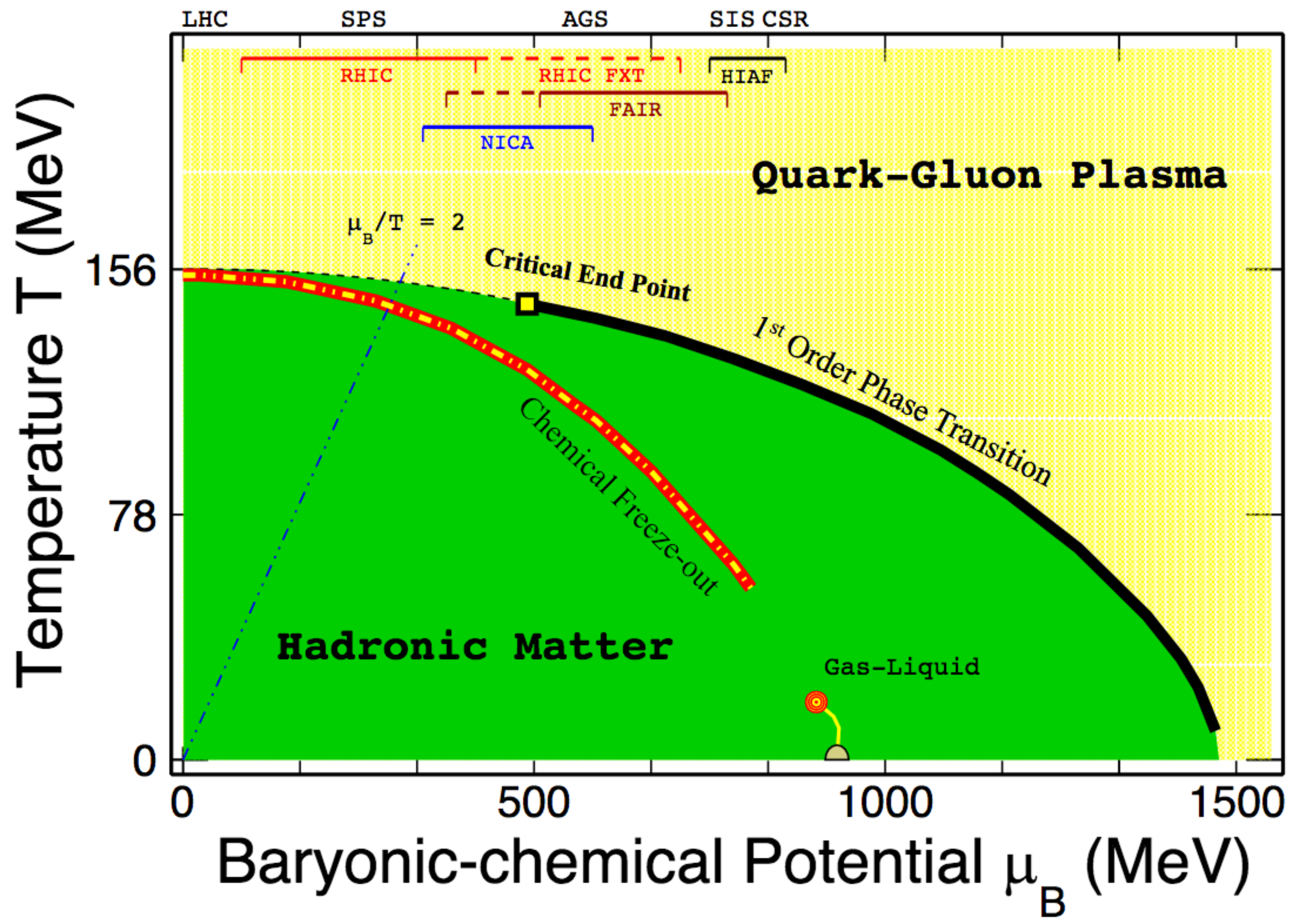
Summary

- Flow measurements at high energies:
  - Positive v_2 values, quark number scaling
  - Partonic collectivity

- Flow measurements at 3 GeV:
  - Positive dv_1/dy and negative v_2
  - Break down of quark number scaling
  - Need baryonic mean-field potential to reproduce trends seen in data

- **Different medium properties and EoS dominated by baryonic mean-field interactions for matter created in 3 GeV collisions**



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Identified hadron v_1 and v_2 at FXT 3 GeV: Rapidity dependence