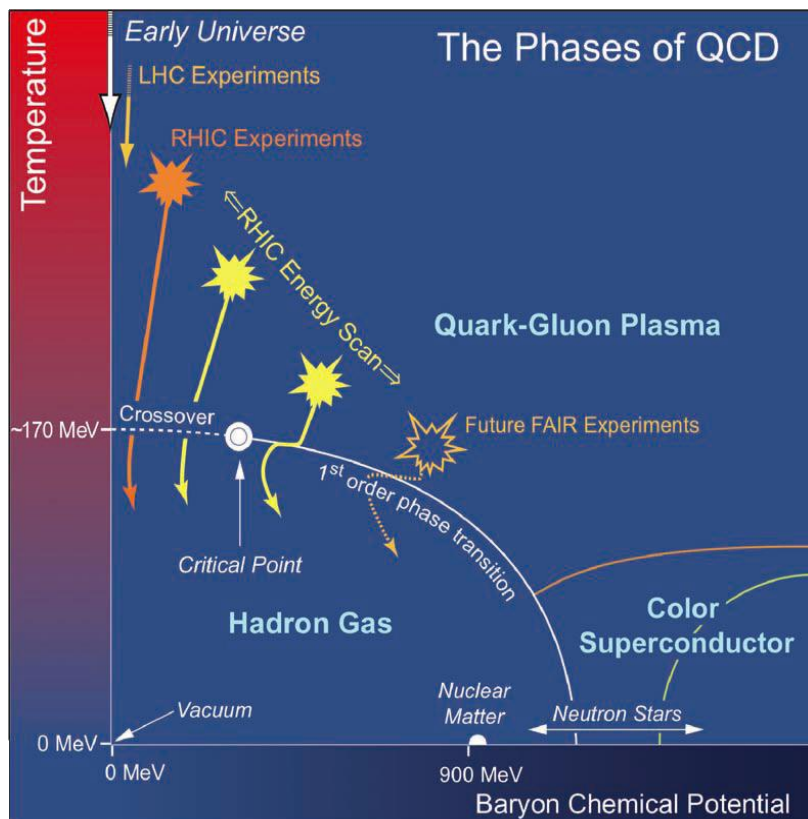




Highlights from STAR



Xin Dong (for the STAR Collaboration)
Lawrence Berkeley National Laboratory

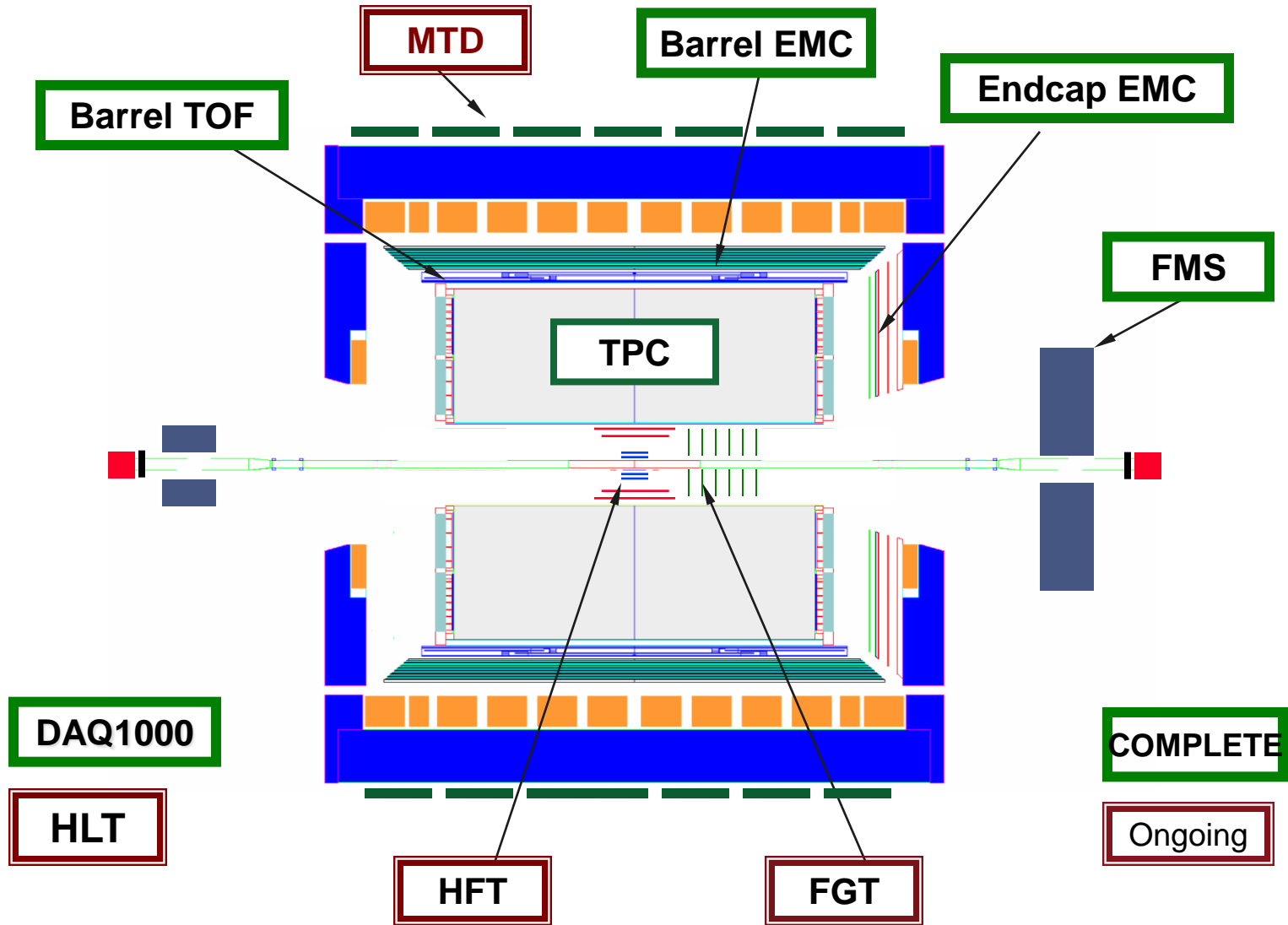


STAR Heavy Ion Program

- 1) QCD in cold nuclear matter
 - 2) QCD in hot nuclear matter
- sQGP properties
 - QCD phase structure



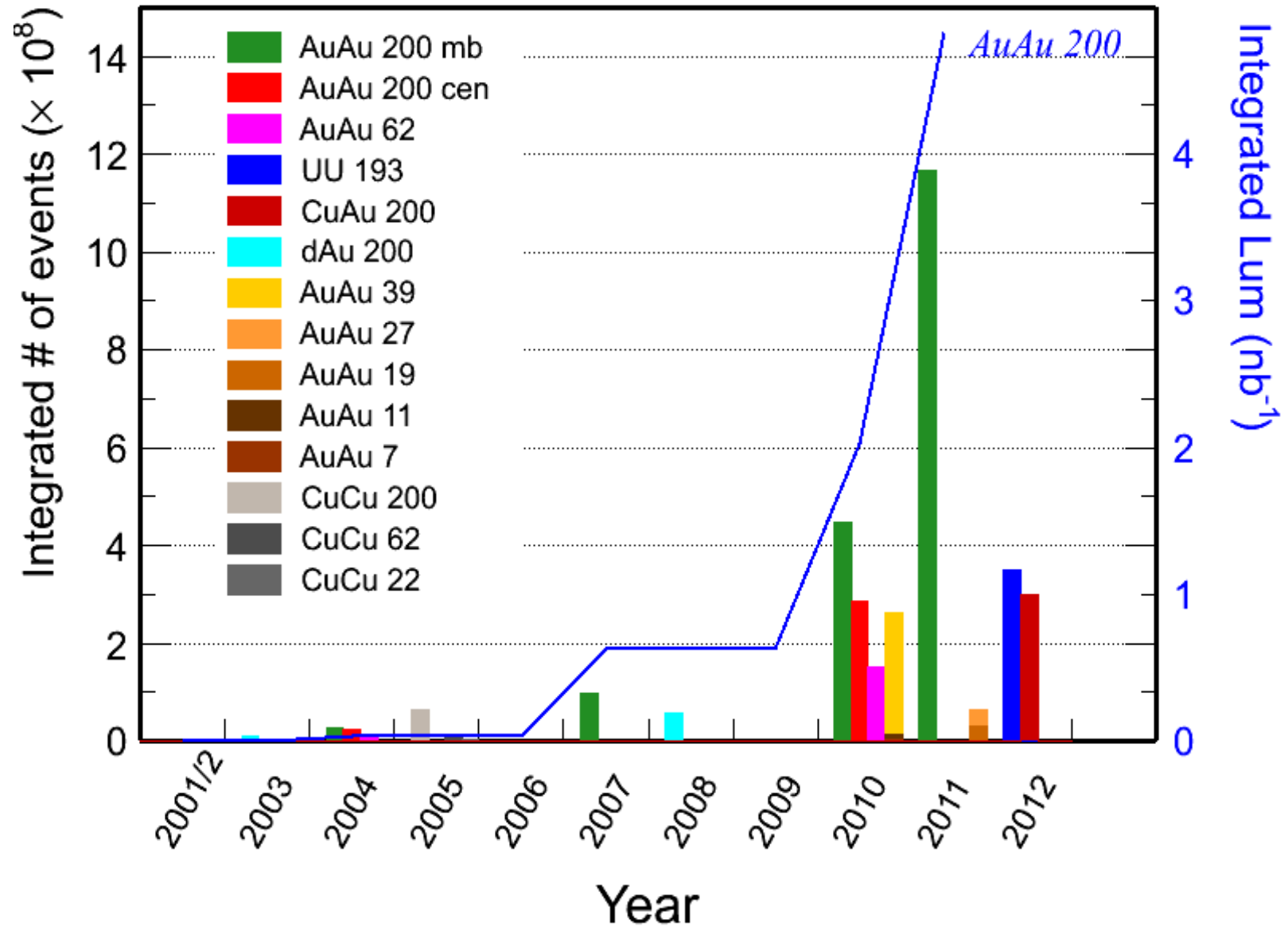
STAR Detector



Large & uniform acceptance at mid-rapidity
Excellent particle identification
Fast data acquisition



Recorded Datasets



STAR Presentations at this QM

1) Initial Condition – Search for CGC

- Forward triggered correlations
- Vector meson photoproduction in Ultra-peripheral collisions

2) sQGP Properties

- Anisotropic flow: identified particle v_2 , v_n ; nonflow/flow fluctuation
- CME observables: A_{\pm} dependency of π^{\pm} v_2 , charge separation signal in U+U
- Dielectrons: differential studies, energy dependence
- Jet v_2 : jet azimuthal corr. w.r.t. the reaction plane
- Triggered and untriggered particle correlations
- Heavy Flavor: improved precision on R_{AA} of D^0 , NPE, J/ψ , Upsilon
- Exotic particles: hypertriton
- Identified particle HBT

3) Beam Energy Scan

- Freeze-out parameters
- Turn-off of sQGP signatures: NCQ-scaling, R_{cp} , charge separation signal
- Search for 1st order phase transition: v_1 , asHBT
- Search for critical point: higher moments, particle ratio fluctuations

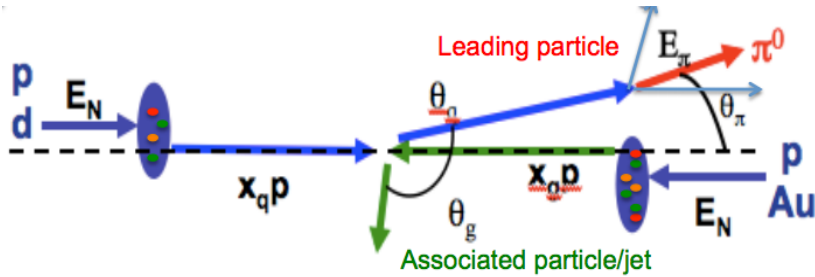


this presentation

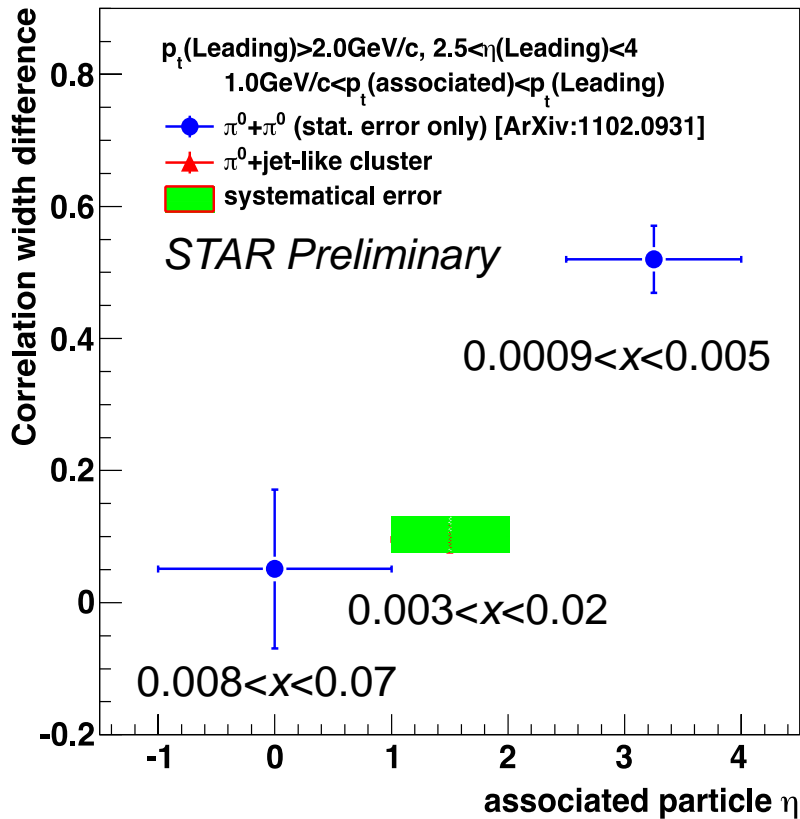
Initial Condition



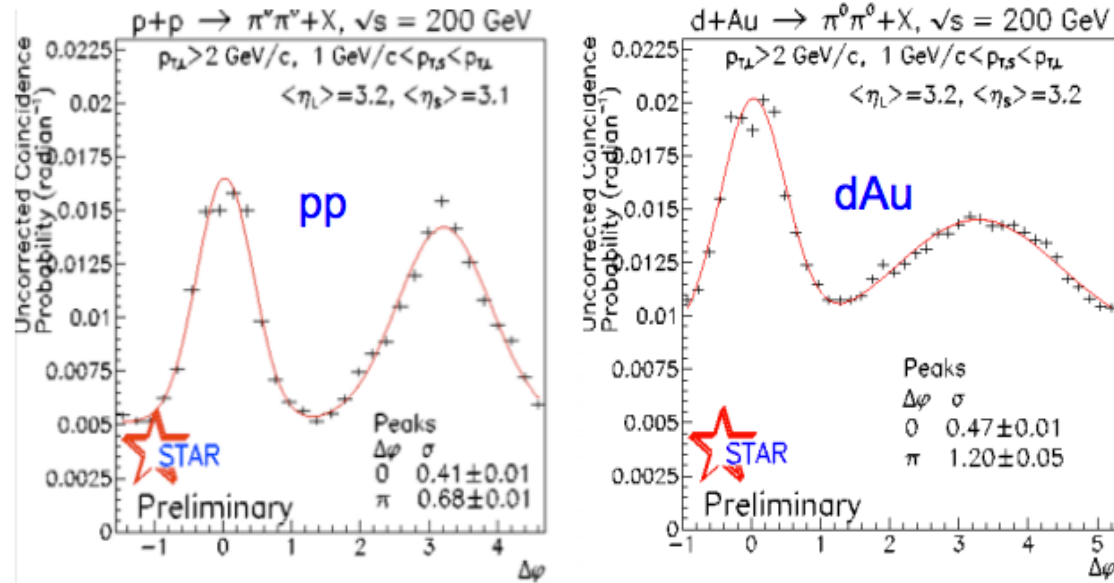
Forward Triggered Correlations



Correlation width difference VS associated particle η



Pion(FMS) – Pion(FMS) correlation



- Away side width broadening consistent with CGC expectations.
- Evolution of width vs. rapidity (x_g): *the smaller x_g , the larger broadening* consistent with a smooth transition from dilute parton system to CGC.

BEMC EEMC FMS

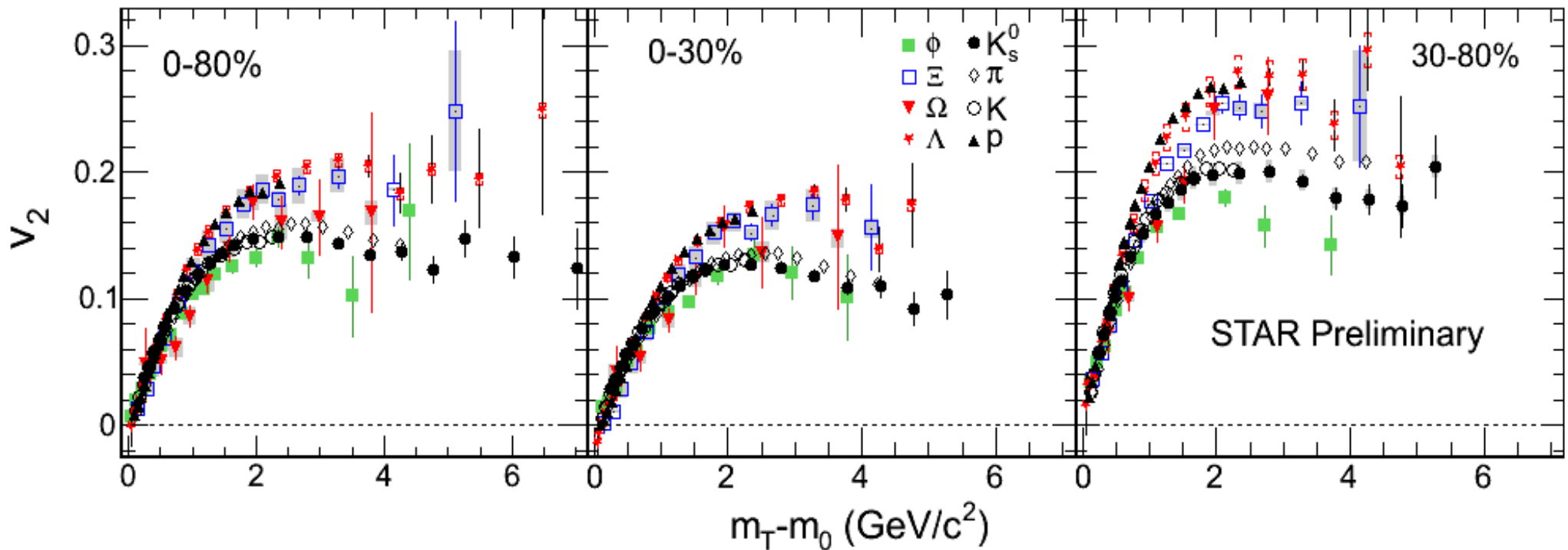
Li, 4D, Wed.



sQGP Properties



Identified Particle Elliptic Flow @ 200 GeV



Precision measurements on identified particle v_2 from high statistics Au+Au 200 GeV.

0-30%: baryon-meson grouping / NCQ scaling holds.

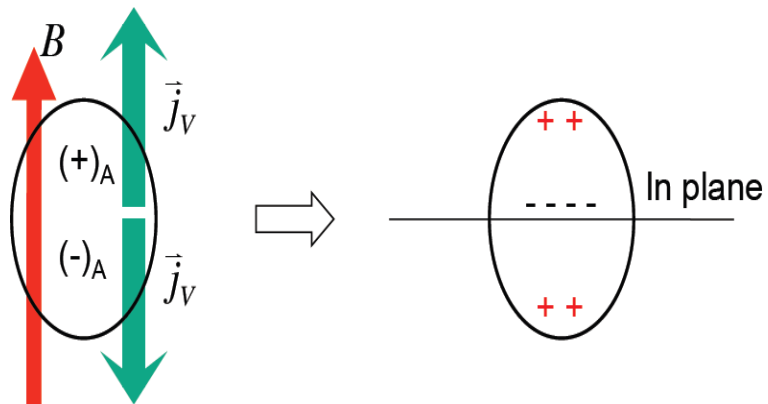
30-80%: Multi-strange hadron v_2 deviate from NCQ scaling at $m_T - m_0 > 1 \text{ GeV}/c^2$.

Precision identified particle v_2 data provide constraints to study the sQGP properties.



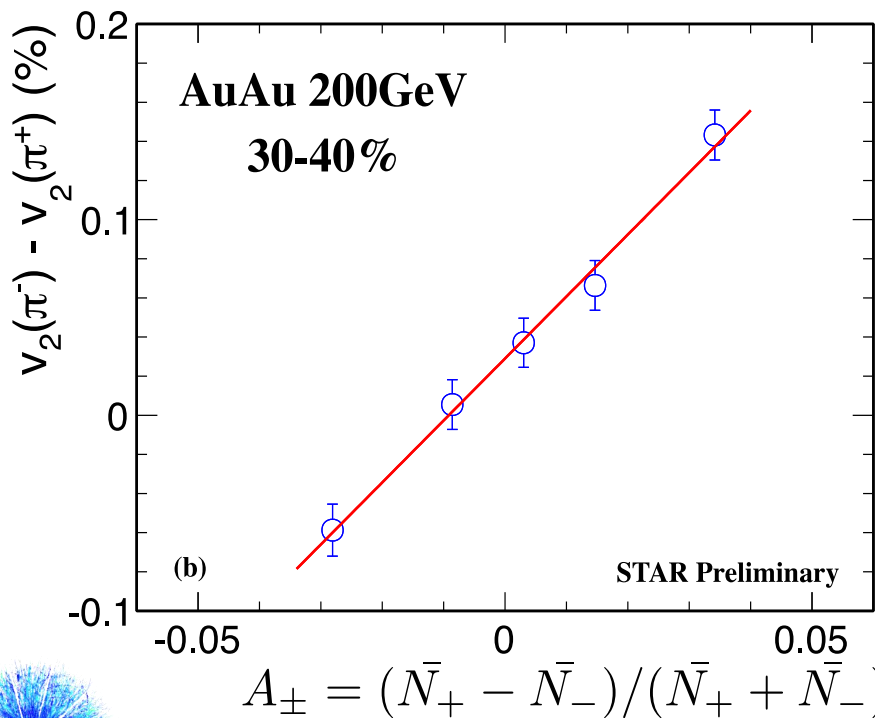
Cebra, IC, Mon.; Nasim, 3A, Wed; Masui, poster #145

Charge Asymmetry Dependence of $\pi^{+/-} v_2$

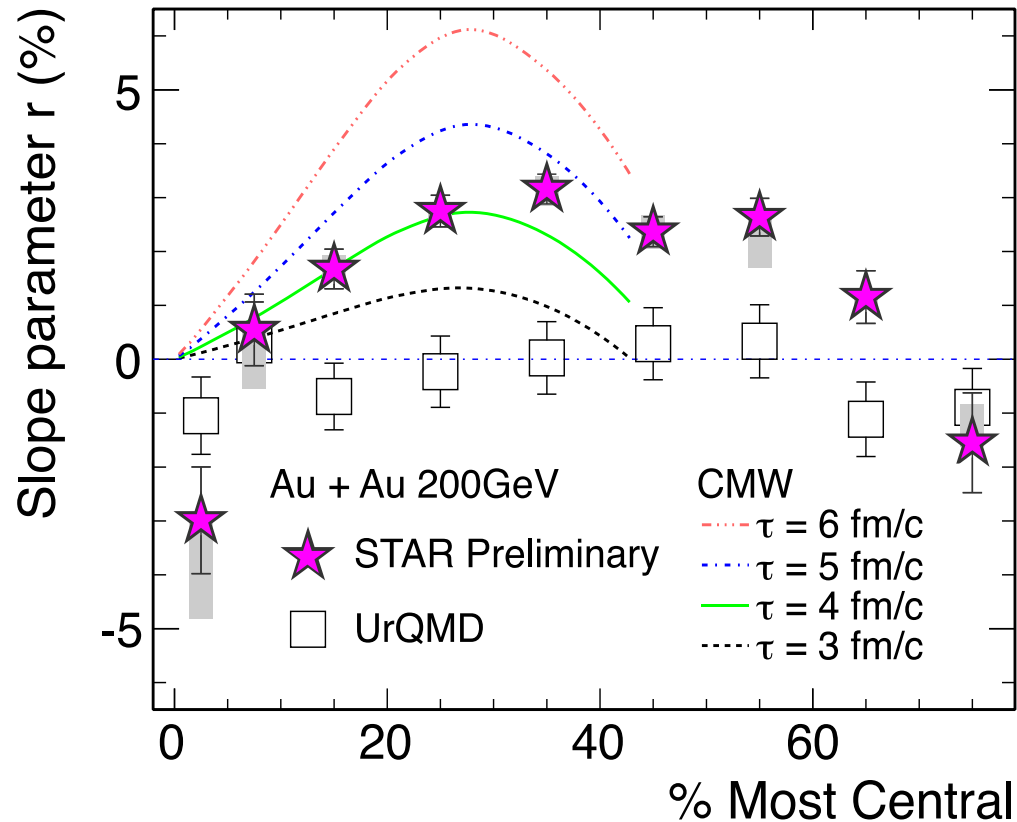


Chiral Magnetic Effect + Chiral Separation Effect
 → Chiral Magnetic Wave → electrical quadrupole

$$v_2^- - v_2^+ = C + 2\left(\frac{q_e}{\bar{\rho}_e}\right)A_{\pm}$$



CMW: Burnier et al. PRL 107 (2011) 052303, priv. comm.

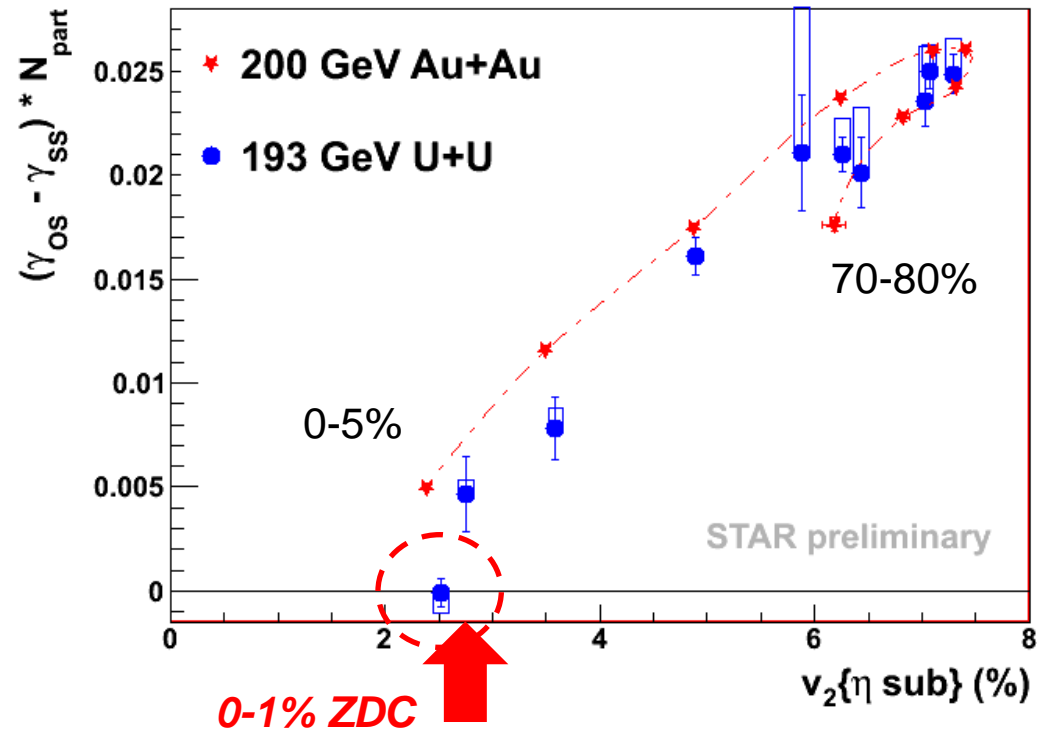
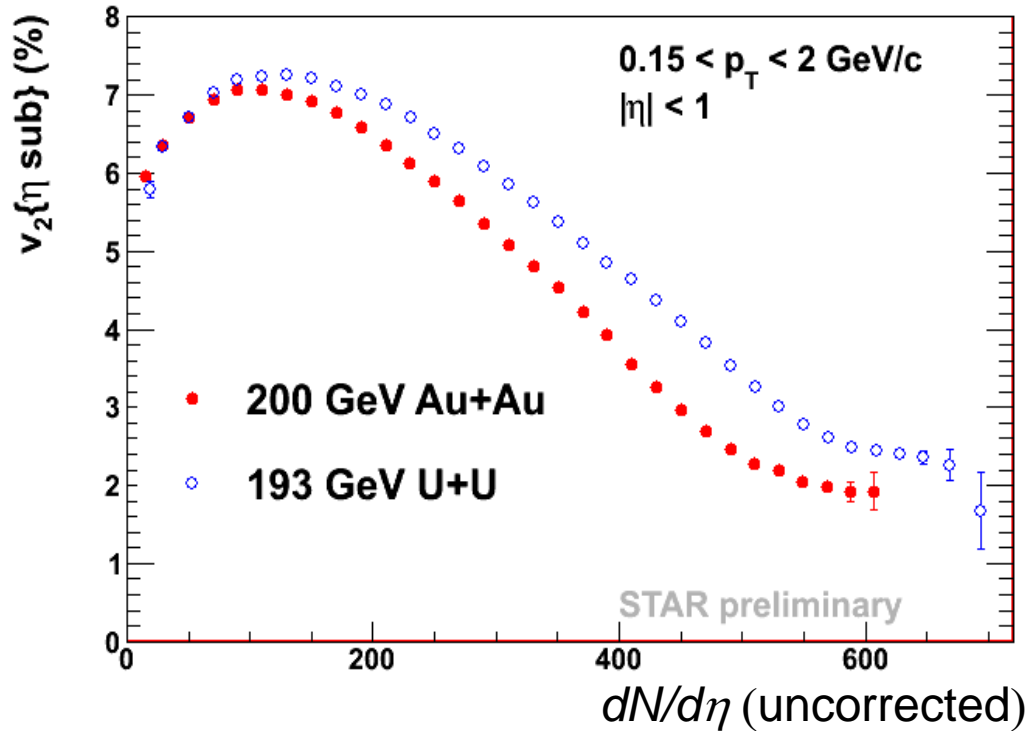


**Theoretical calculations
 consistent with data.**

Wang, IVB, Thu.; Ke, poster #387



Charge Separation w.r.t. EP in U+U

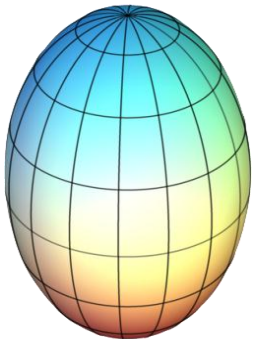


Wang, IVB, Thu.

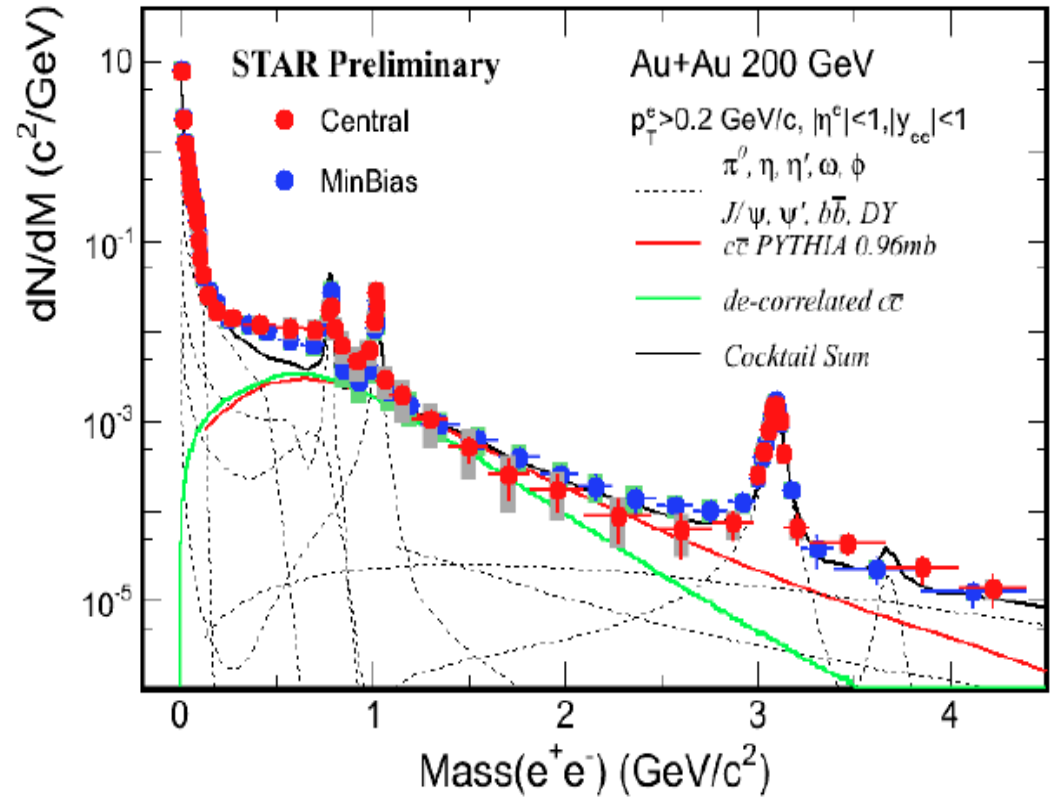
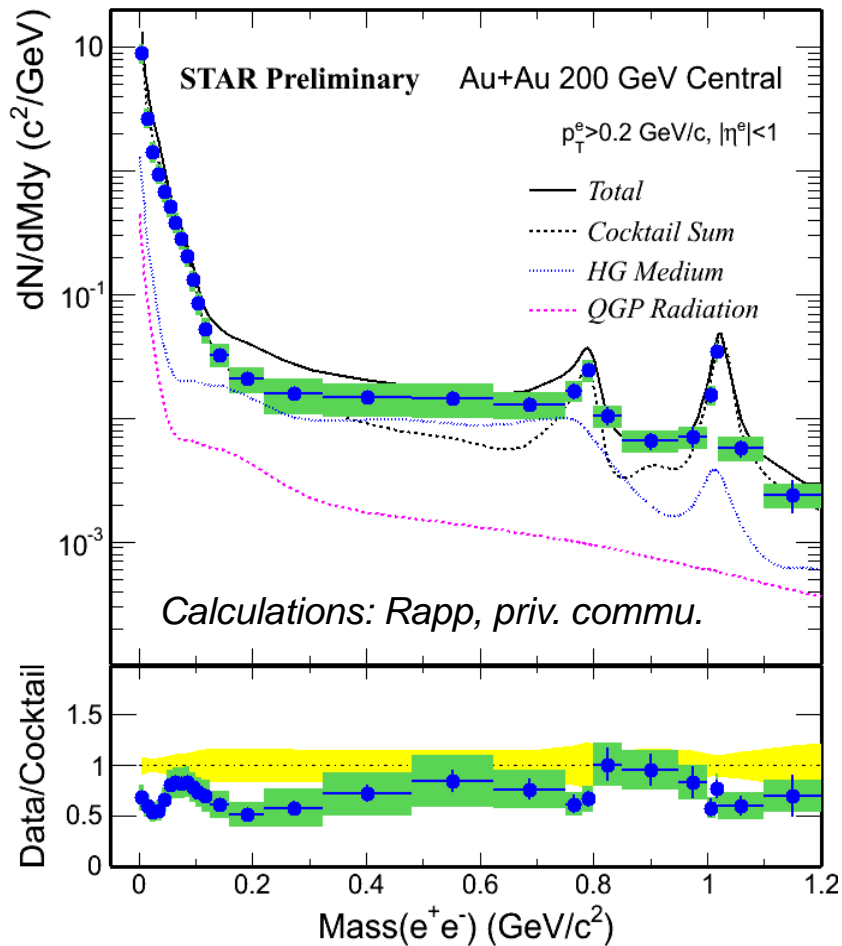
$$\gamma = \langle \cos(\phi_\alpha + \phi_\beta - 2\Psi_r) \rangle$$

- Charge separation – motivated by search for LPV + CME.
 - Other interpretations involving v_2 background.
- v_2 in U+U is higher than that in Au+Au at the same uncorr. $dN/d\eta$.
- In 0-1% central collisions, with the magnetic field “turned off”, the charge separation signal $(\gamma_{OS} - \gamma_{SS})$ disappears while v_2 is still $\sim 2.5\%$.
 - **consistent with no signal in the LPV + CME expectation.**

Uranium



Dielectrons at Au+Au 200 GeV



Geurts, IV, Thu.; Huang, 3C, Wed.

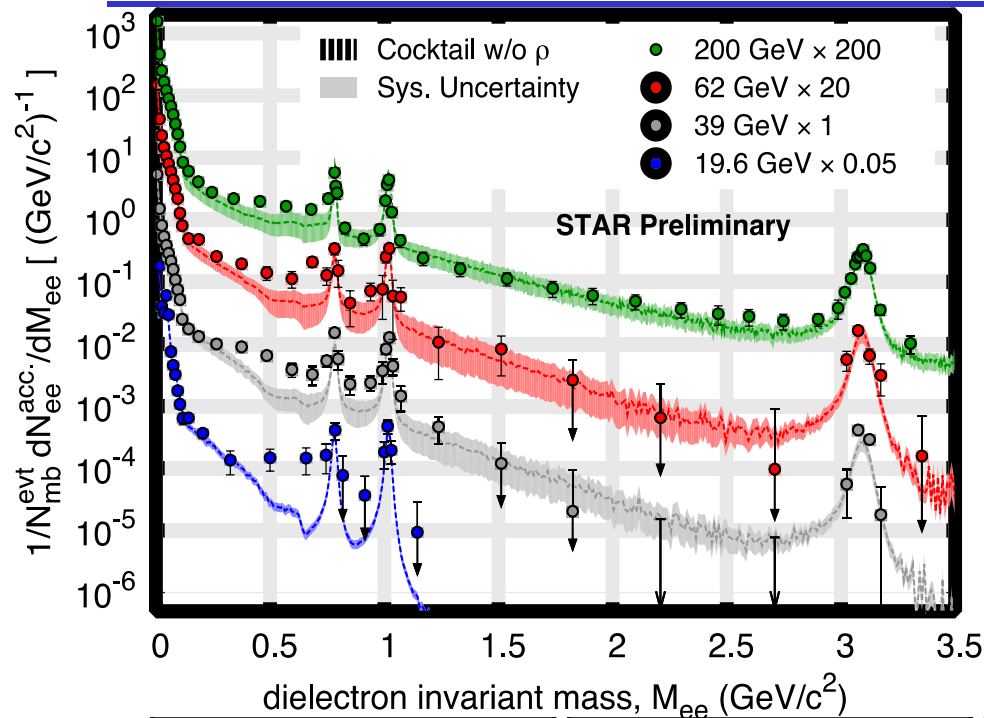
- Low mass enhancement in Au+Au 200 GeV is accounted for by theoretical calculations of in-medium ρ broadening.
- Data in central/minbias show hints of charm modifications/other sources in IMR.
- Systematic studies on dielectron production:
 - p_T and centrality dependence at 200 GeV
 - elliptic flow measurements

Zhao, poster #153

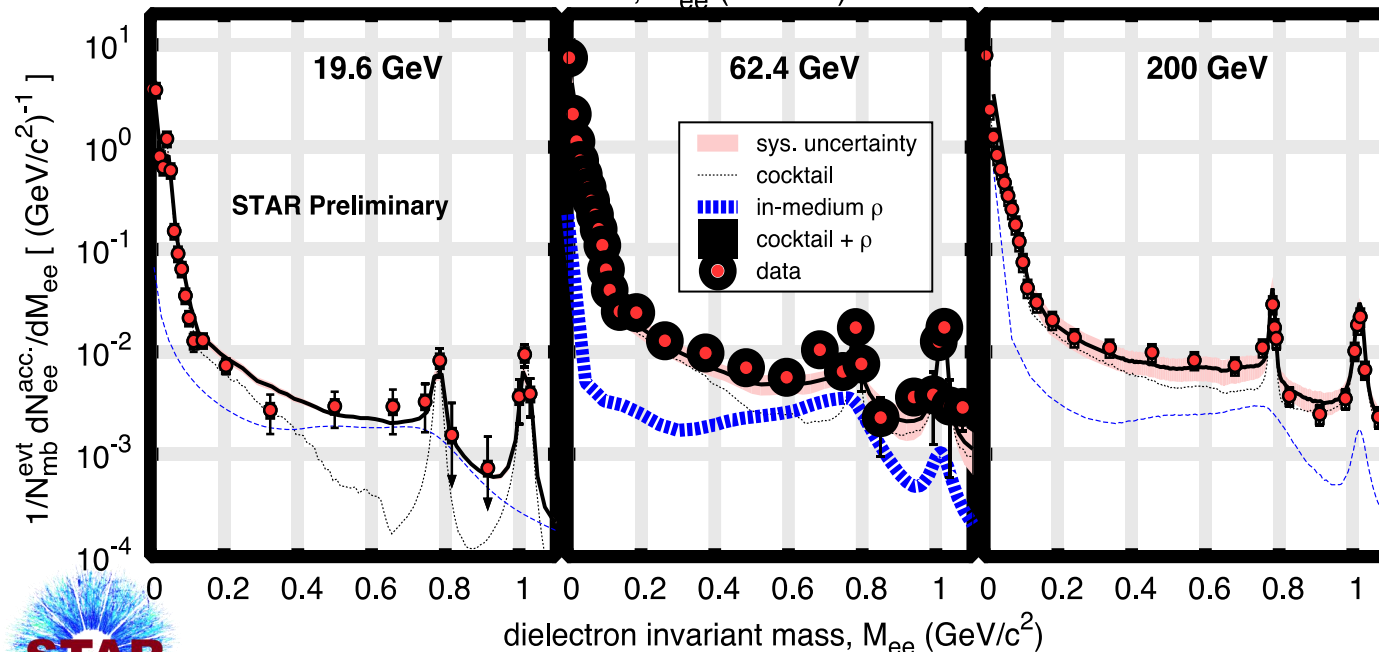
Cui, poster #322



Energy Dependent Dielectron Production



- Systematic measurements of dielectron mass spectra over a broad energy range.
- LMR enhancement persists down to 19.6 GeV.
- Theoretical calculations of in-medium ρ broadening with similar baryon densities from 19.6 - 200 GeV reproduce LMR excesses well.



In-medium ρ broadening
R. Rapp: private communications

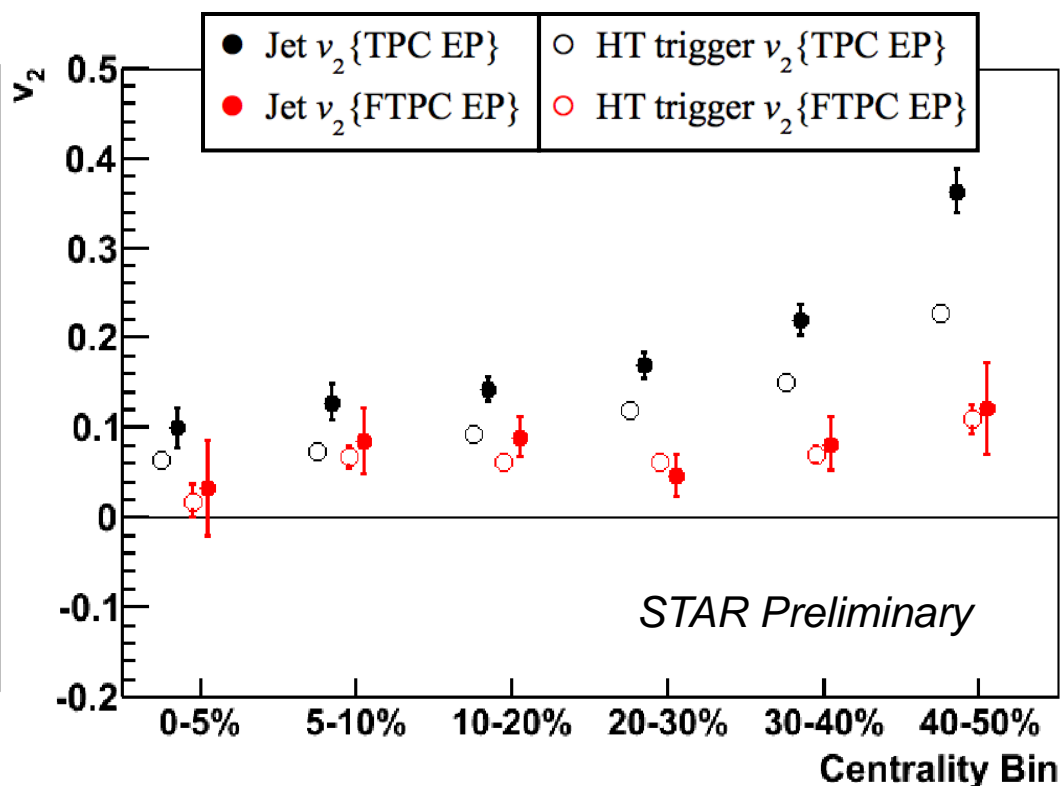
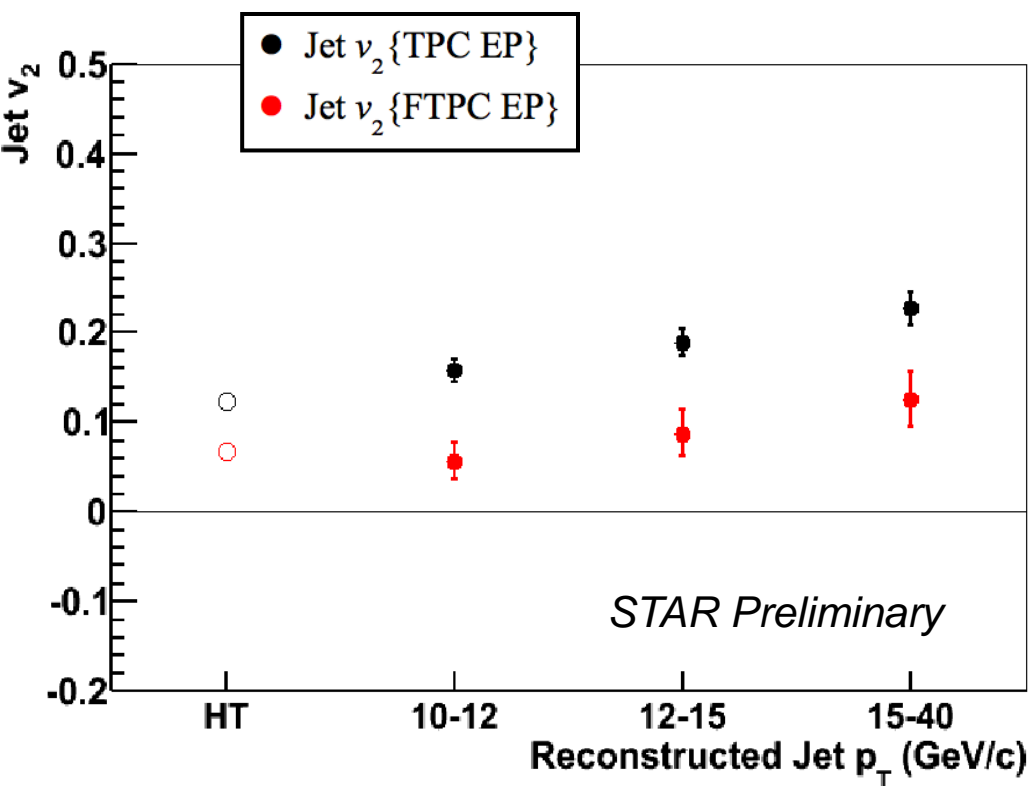
Geurts, IV, Thu.
Huang, 3C, Wed.

Huck, Huang,
poster #113, 269



Reconstructed Jet v_2

Jet v_2 = correlation between recon. jets and the event plane. \neq Jet flow
 - to probe path-length dependence of the jet quenching.



$$|\eta_{jet}| < 0.6$$

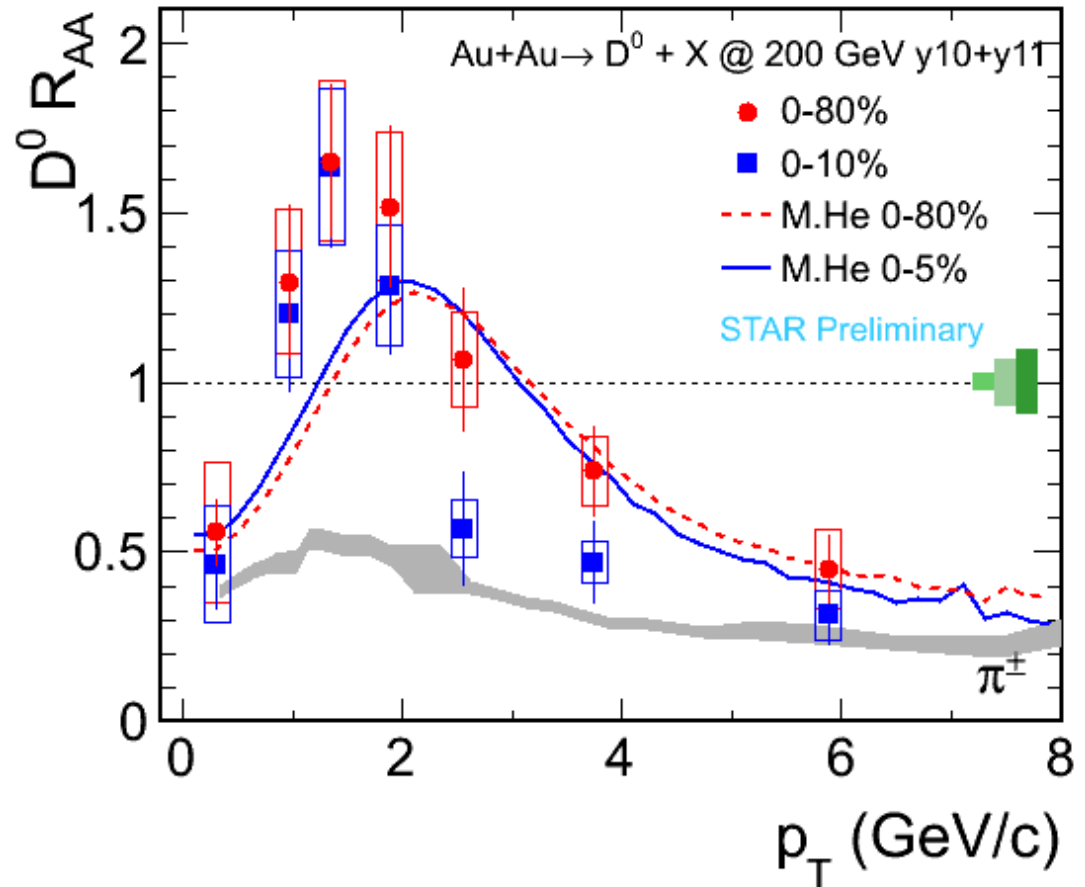
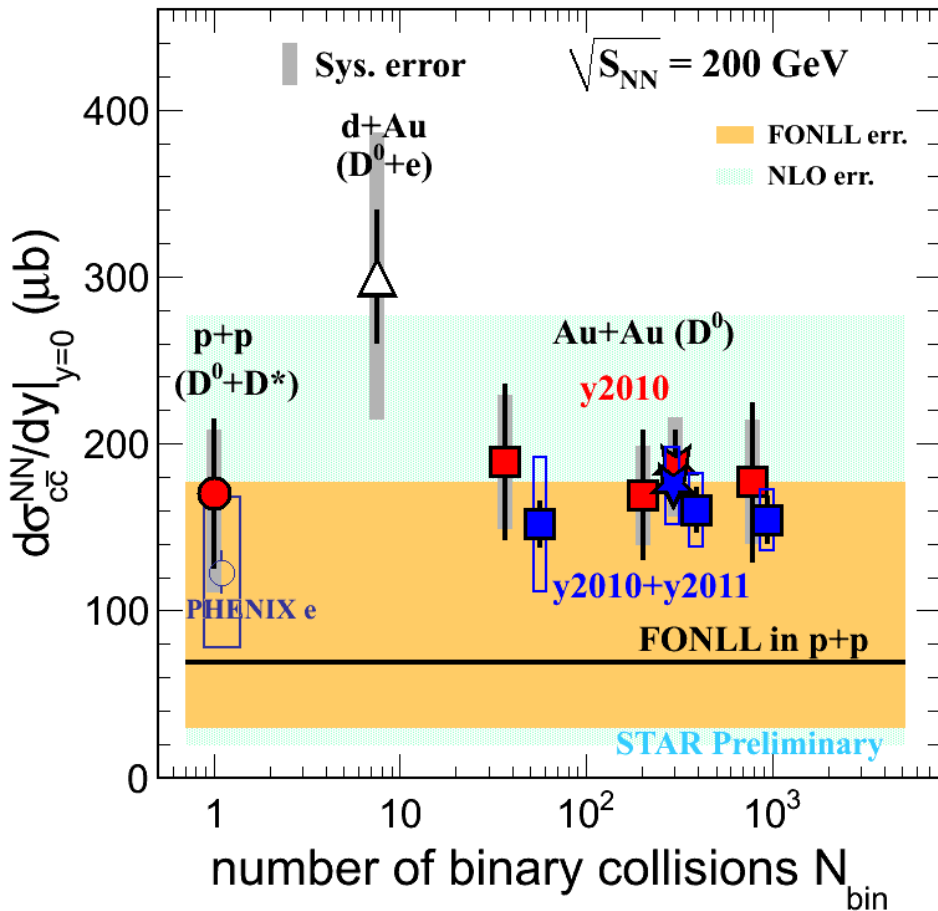
$$FTPC: \quad 2.8 < |\eta| < 3.7$$

• Non-zero jet v_2 {FTPC} in mid-central collisions.
pathlength dependent parton energy loss.

Ohlson, 4B, Wed.



Open Charm Hadrons



Model curves: M. He, et al. arXiv: 1204.4442,
 private communications

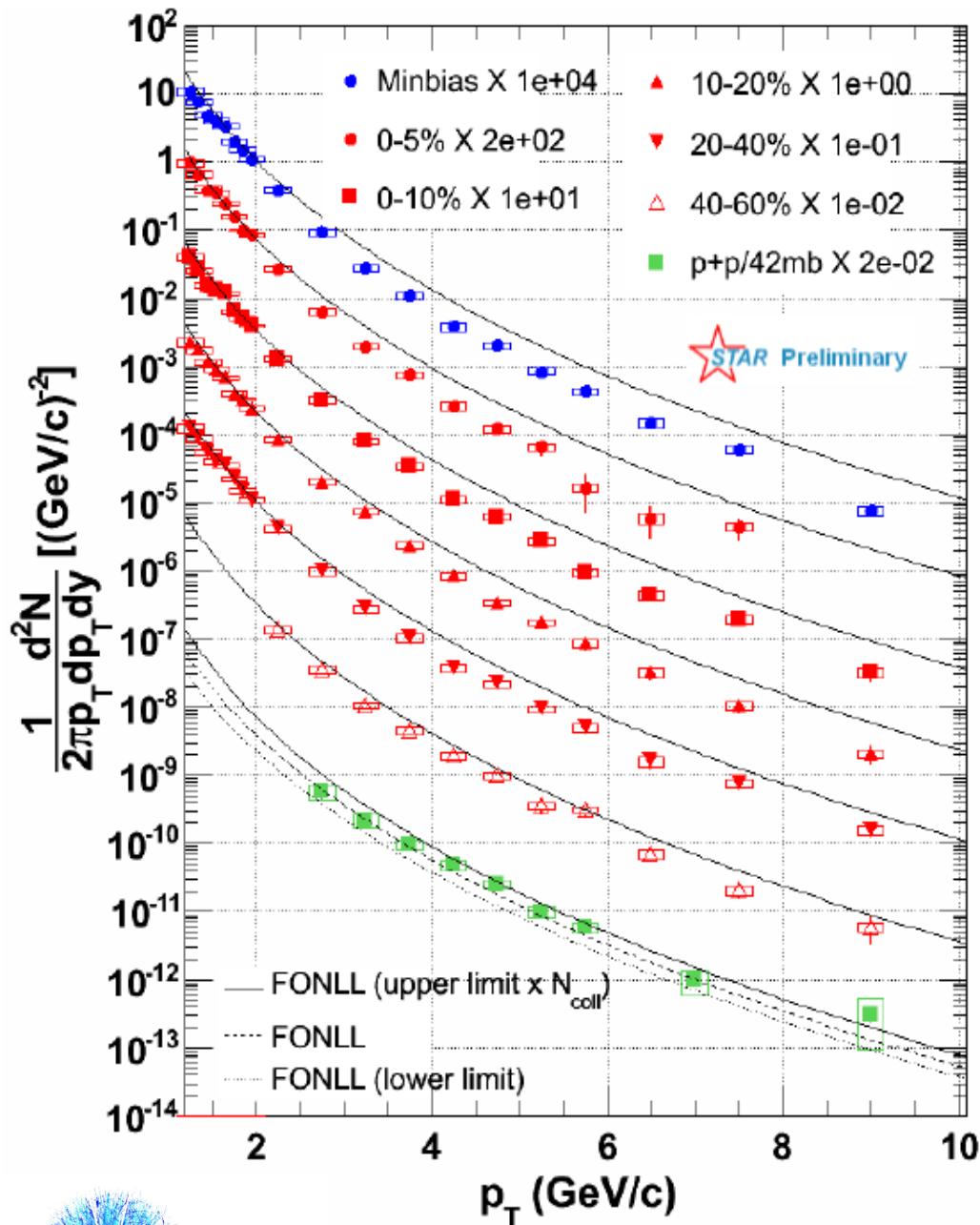
Xie, IIB, Tue.; Tlusty, 6A, Fri.

Combined year 2010 and 2011 statistics.

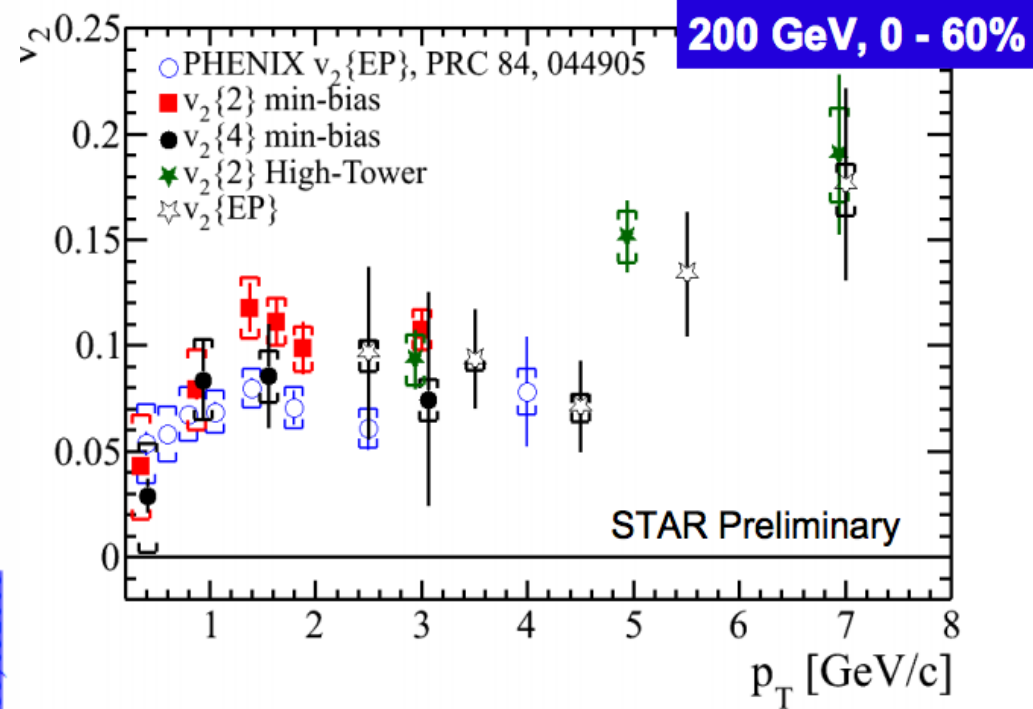
- Charm production cross section follows N_{bin} scaling \rightarrow improved precision.
- Small hump structure in $D^0 R_{AA}$ in low p_T – similar in theoretical calculation.
- R_{AA} in Au+Au collisions suppressed at $p_T > 3 \text{ GeV/c}$.



Non-photonic electrons



p+p NPE STAR Phys. Rev. D. 83 (2011) 052006



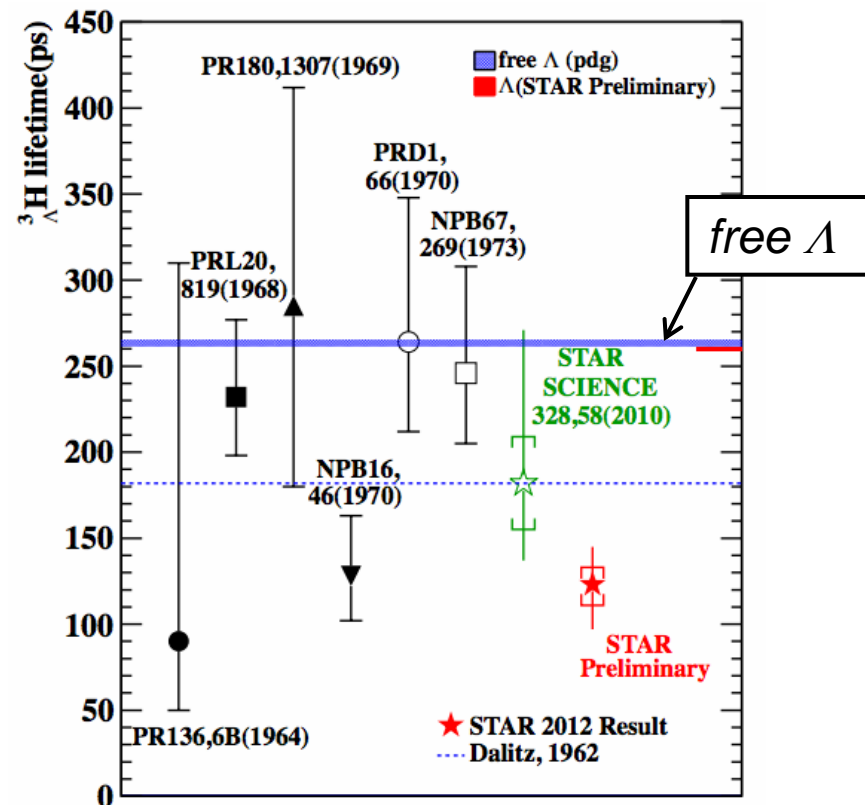
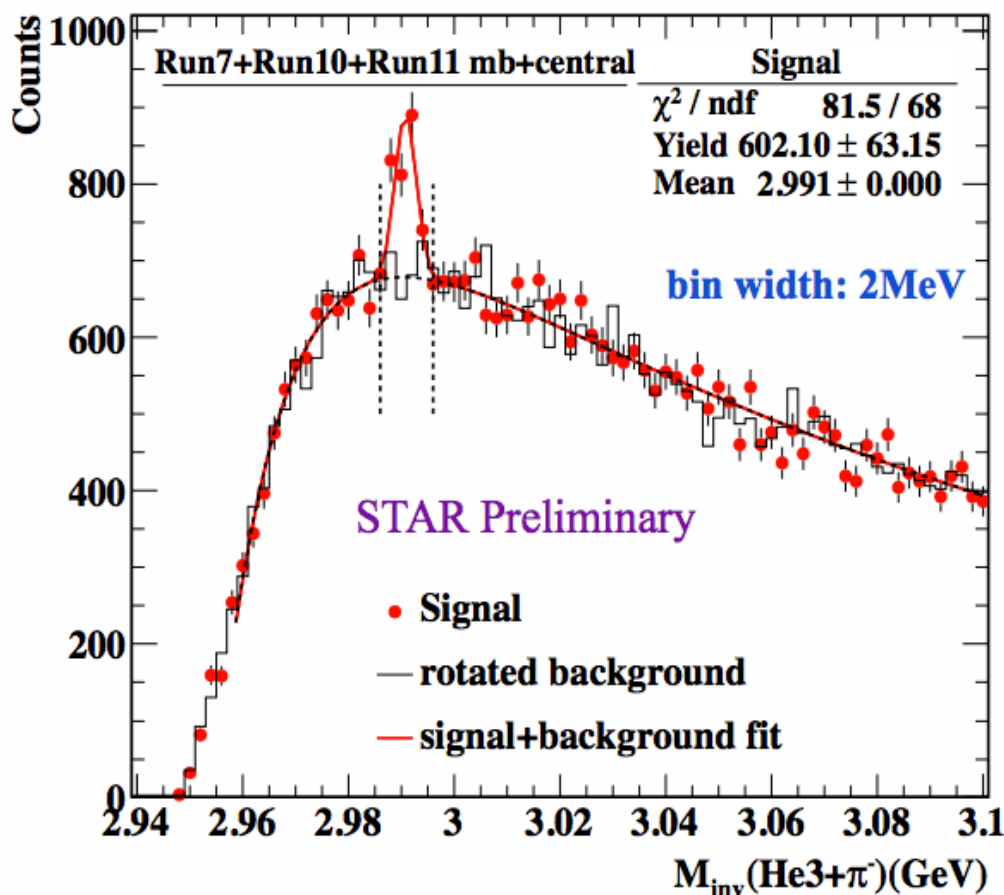
High statistics data @ 200, 62.4, 39 GeV

- Significant suppression in 200 GeV central collisions.
- Finite NPE v_2 at 200 GeV.

Mustafa, 7A, Fri.; Kikola, poster #459



Exotics: Hypertriton Production



$^3\Lambda\text{H} + ^3\bar{\Lambda}\bar{\text{H}}$ produced: 602 ± 63 significance: 9.6σ

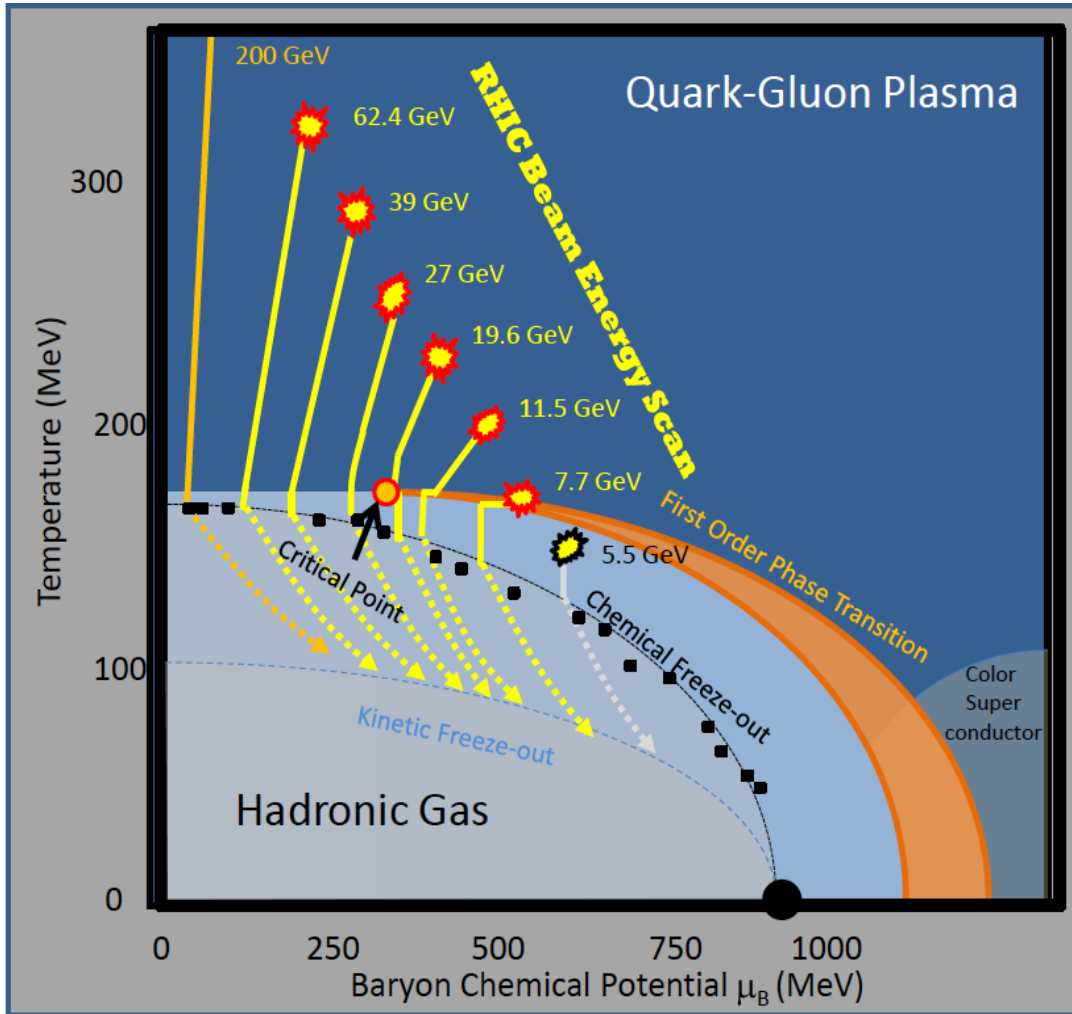
Zhu, 5A, Thu.

- Combined various datasets: x 3 more statistics compared to the Science publication.

Lifetime significantly lower than that of free Λ .



Beam Energy Scan



Kumar, VA, Fri.

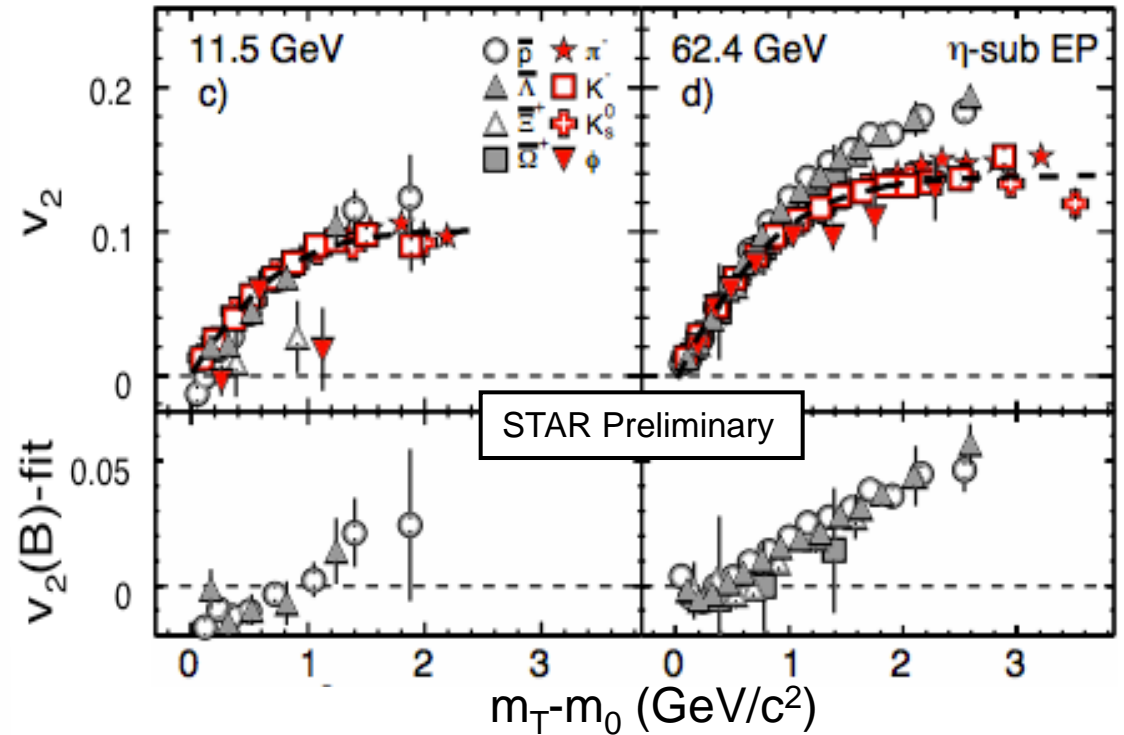
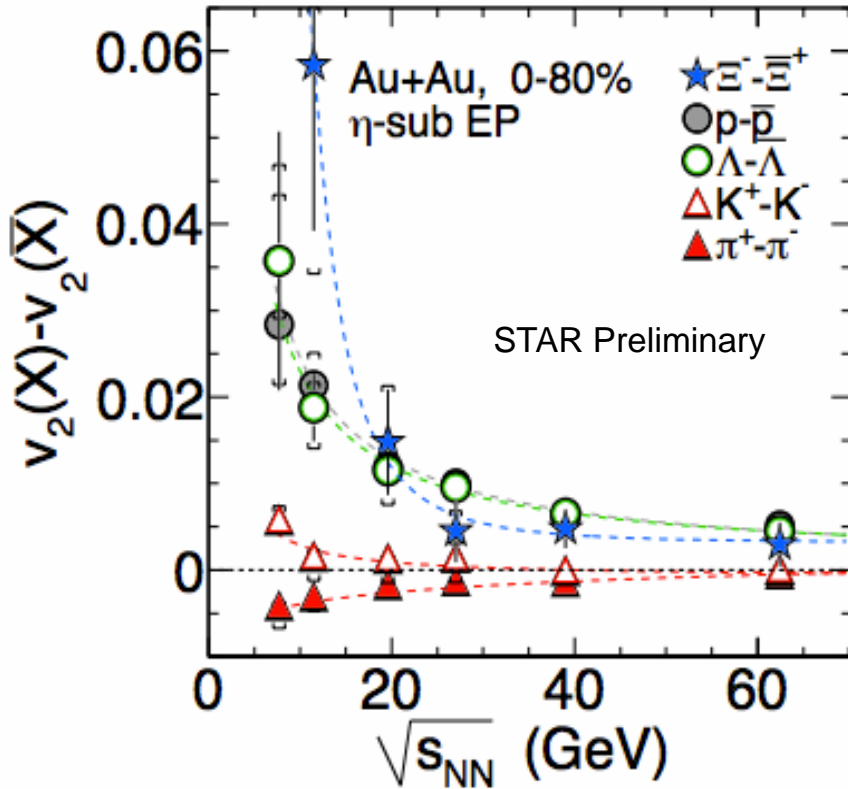
- 0) Turn-off of sQGP signatures
- 1) Search for the signals of phase boundary
- 2) Search for the QCD critical point

BES Phase-I

Year	$\sqrt{s_{NN}}$ (GeV)	Events (10^6)
2010	39	130
2011	27	70
2011	19.6	36
2010	11.5	12
2010	7.7	5



Breakdown of NCQ-scaling



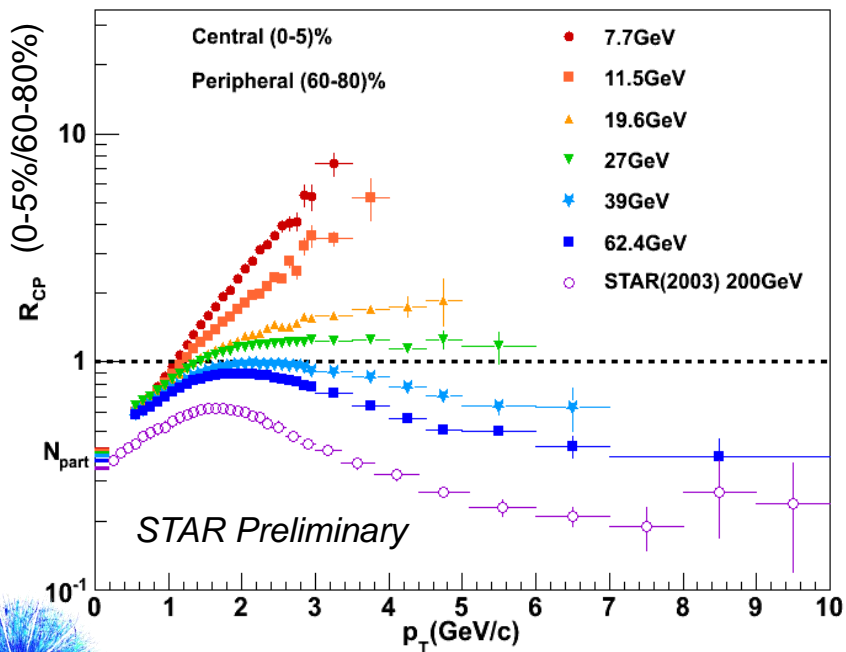
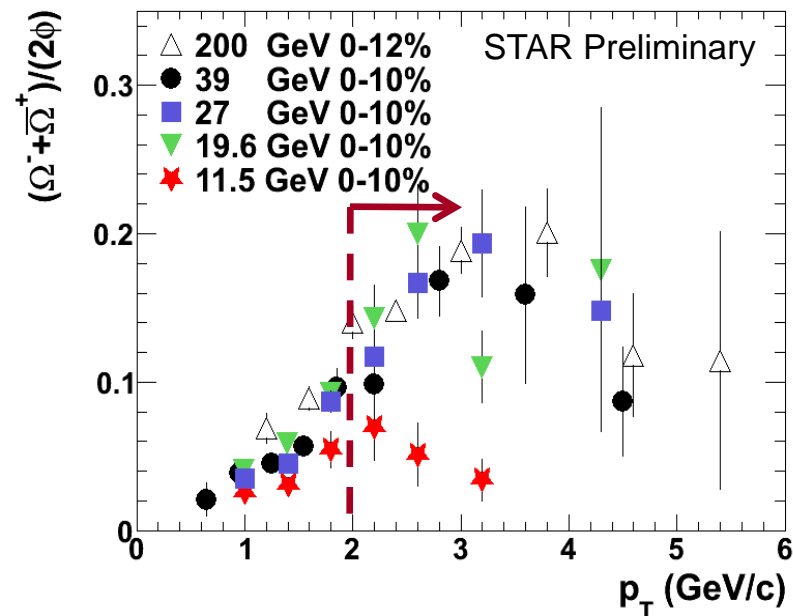
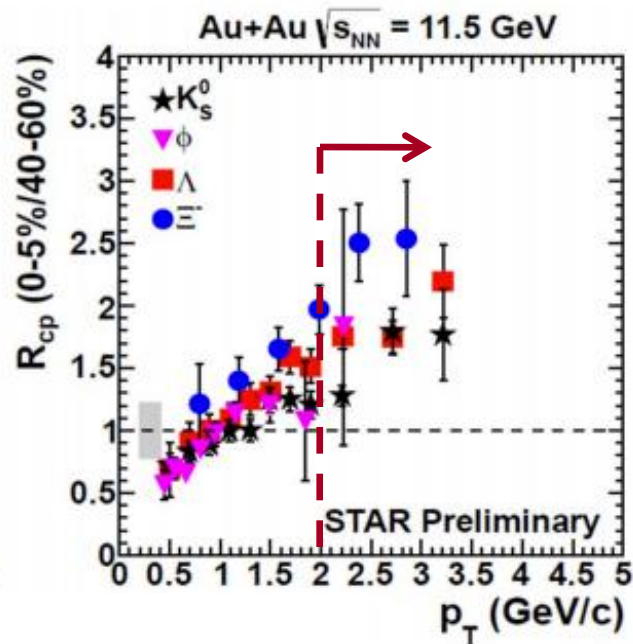
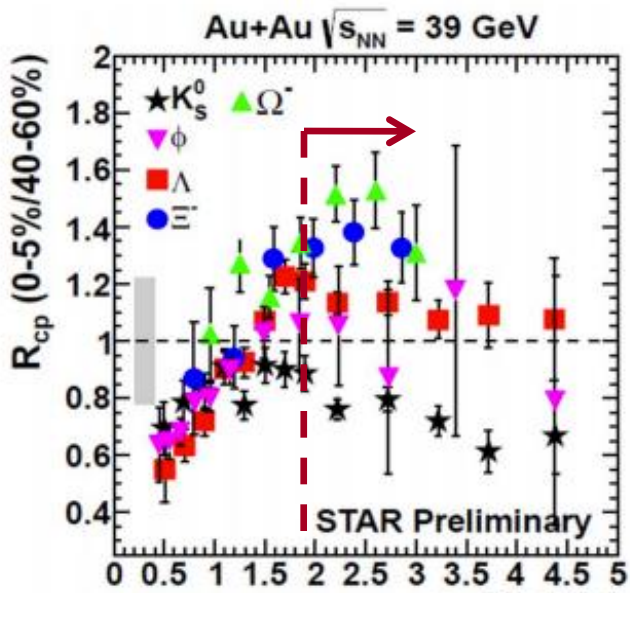
- Significant difference between baryon-antibaryon v_2 at lower energies.
- No clear baryon/meson grouping for anti-particles at ≤ 11.5 GeV.

NCQ scaling is broken!

Shi, 6B, Fri; Schmah, poster #141



Disappearance of R_{cp} Suppression



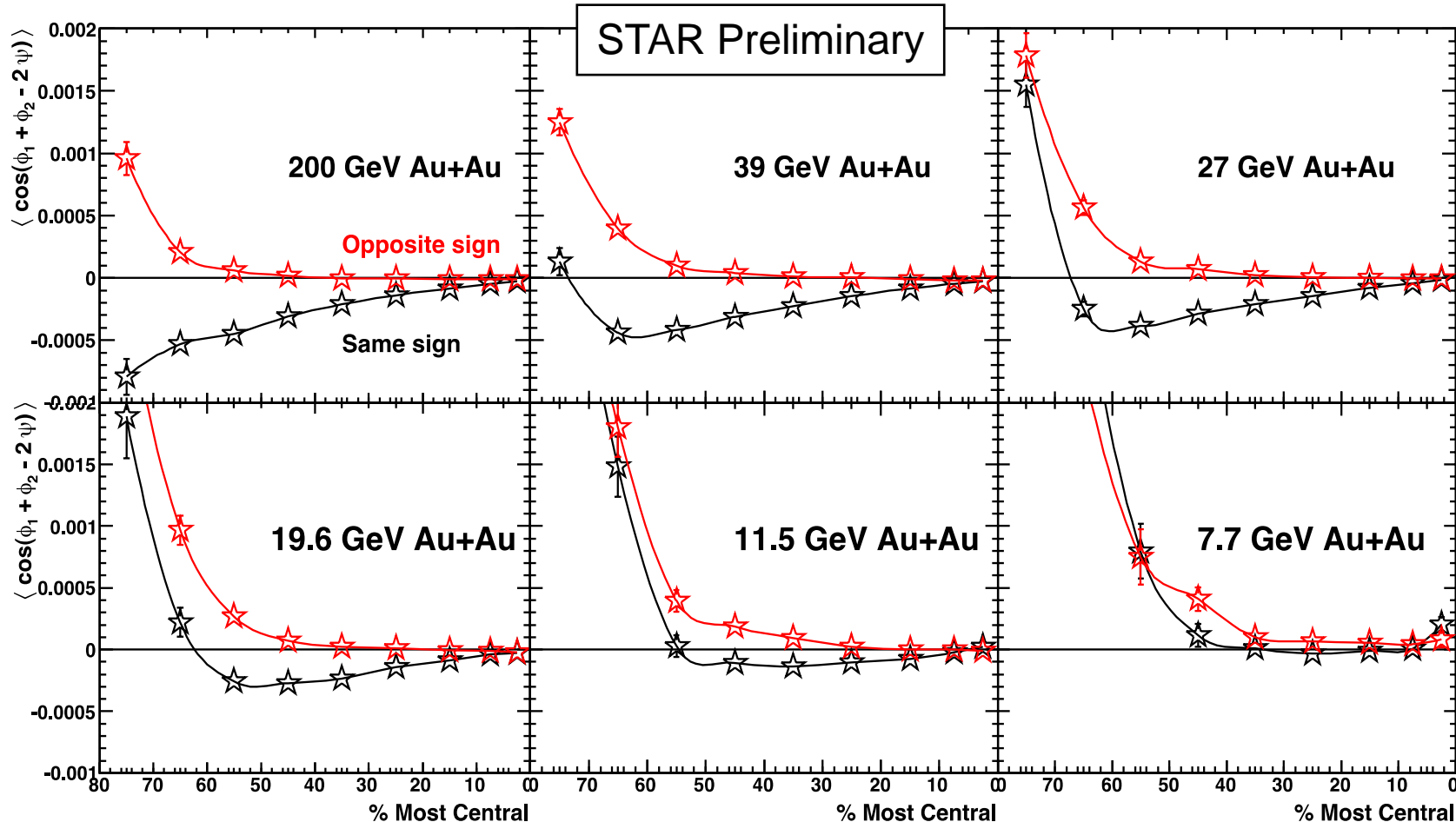
- Baryon-meson splitting reduces and disappears with decreasing energy.
- Ω/ϕ ratio falls off at 11.5 GeV.
- $R_{cp} > \sim 1$ at 11.5, 7.7 GeV. - Cronin effect?

R_{cp} suppression NOT seen at lower energies!

Zhang, 5A, Thu. Sangaline, 5C, Thu.
Horvat, poster #94



Disappearance of Charge Separation w.r.t. EP



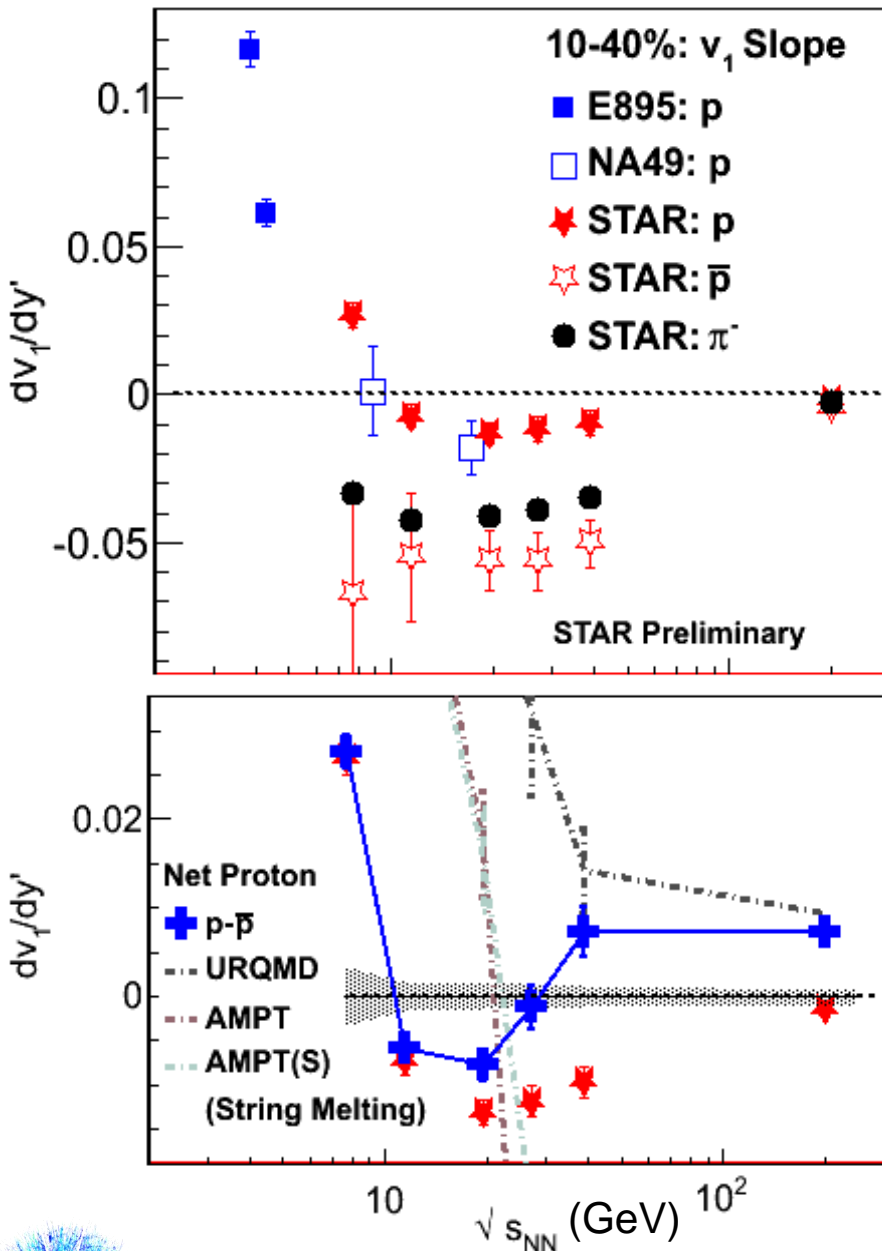
Wang, IVB, Thu.

- Motivated by search for local parity violation. Require sQGP formation.
- The splitting between OS and LS correlations (charge separation) seen in top RHIC energy Au+Au collisions.

This charge separation signal disappears at lower energies (≤ 11.5 GeV)!



Directed Flow of Protons

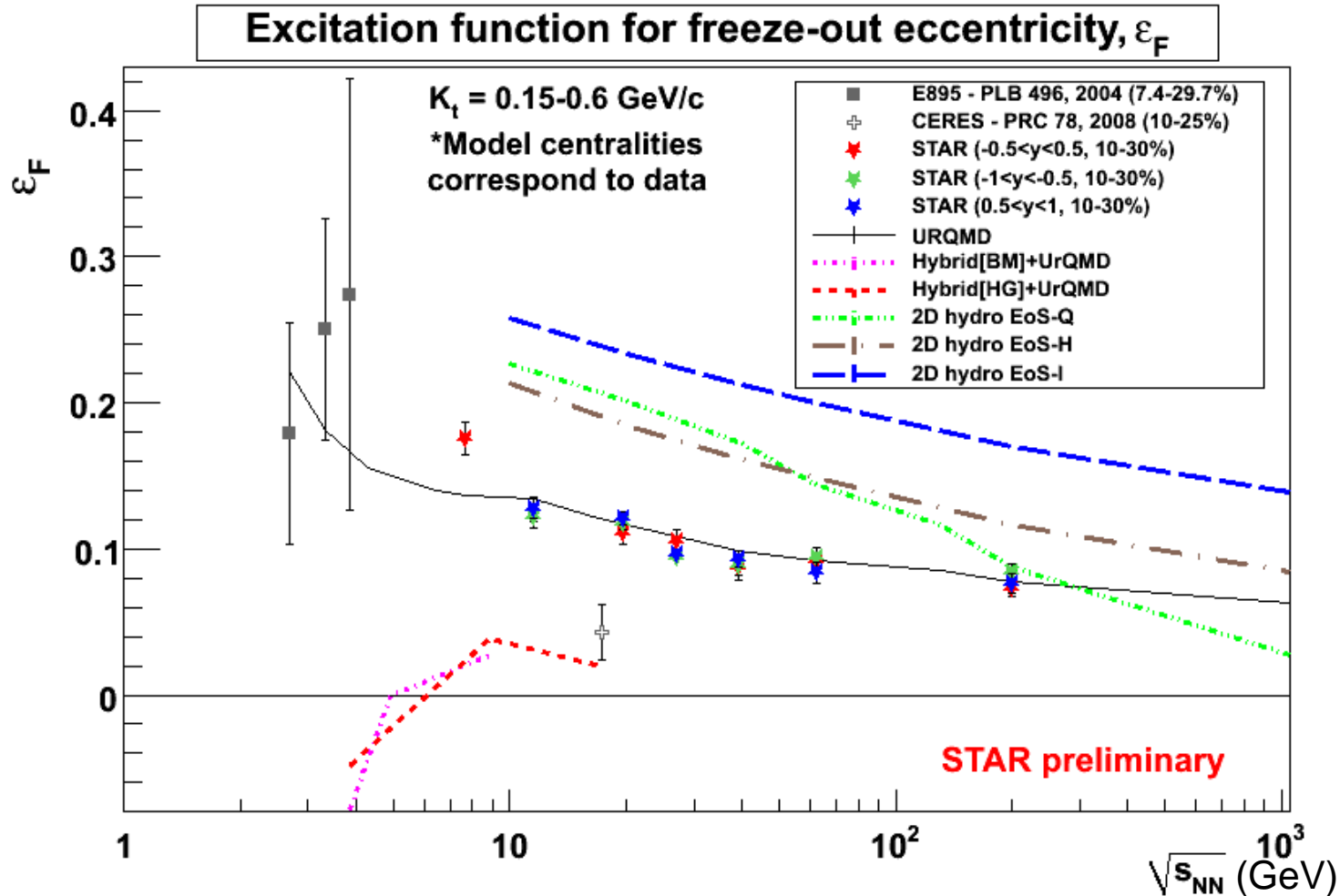


- Directed flow (v_1) slope: sensitive to 1st order phase transition.
- Proton v_1 slope changes sign from + to – between 7.7 and 11.5 GeV and remains small but negative up to 200 GeV.
- v_1 slopes for other particles are all negative.
- “net-proton” v_1 slope shows a minimum around 11.5-19.6 GeV.
- AMPT/UrQMD models cannot explain data.

Pandit, 1A, Tue.



Azimuthal HBT for Freeze-out Eccentricity

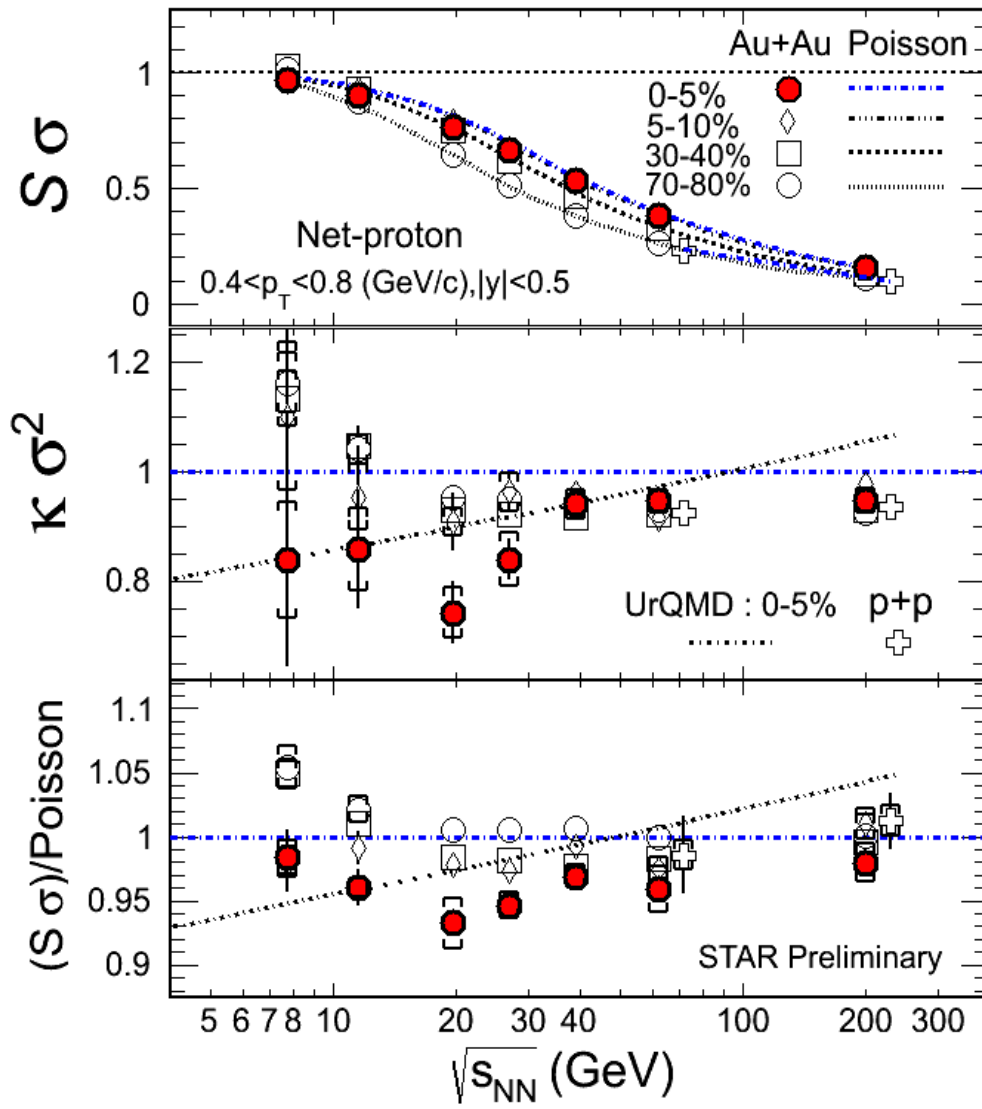


Shah, 1C, Tue.

- Evolution of the initial shape depends on the pressure anisotropy.
 - Freeze-out eccentricity sensitive to the 1st order phase transition.
- **Measured freeze-out eccentricity parameters show a smooth decrease from low to high energies.**



Higher Moments of Net-protons



$$\sigma^2 = \langle (N - \langle N \rangle)^2 \rangle$$

$$S = \langle (N - \langle N \rangle)^3 \rangle / \sigma^3$$

$$\kappa = \langle (N - \langle N \rangle)^4 \rangle / \sigma^4 - 3$$

- Higher moments - more sensitive to Critical Point induced fluctuations.
- Deviation from Poisson baseline in 0-5% collisions at >7.7 GeV.
- Above Poisson baseline in peripheral collisions below 19.6 GeV.
- UrQMD shows monotonic behavior.
- Need precision measurements at low energies.

Net-proton/Net-charge/Net-kaon

Luo, 7B, Fri.; McDonald, 7B, Fri.

Li/Sahoo/Sarkar, poster #215/557/394



Summary of BES Phase-I at RHIC

1) Several key sQGP signatures NOT seen at low energies.

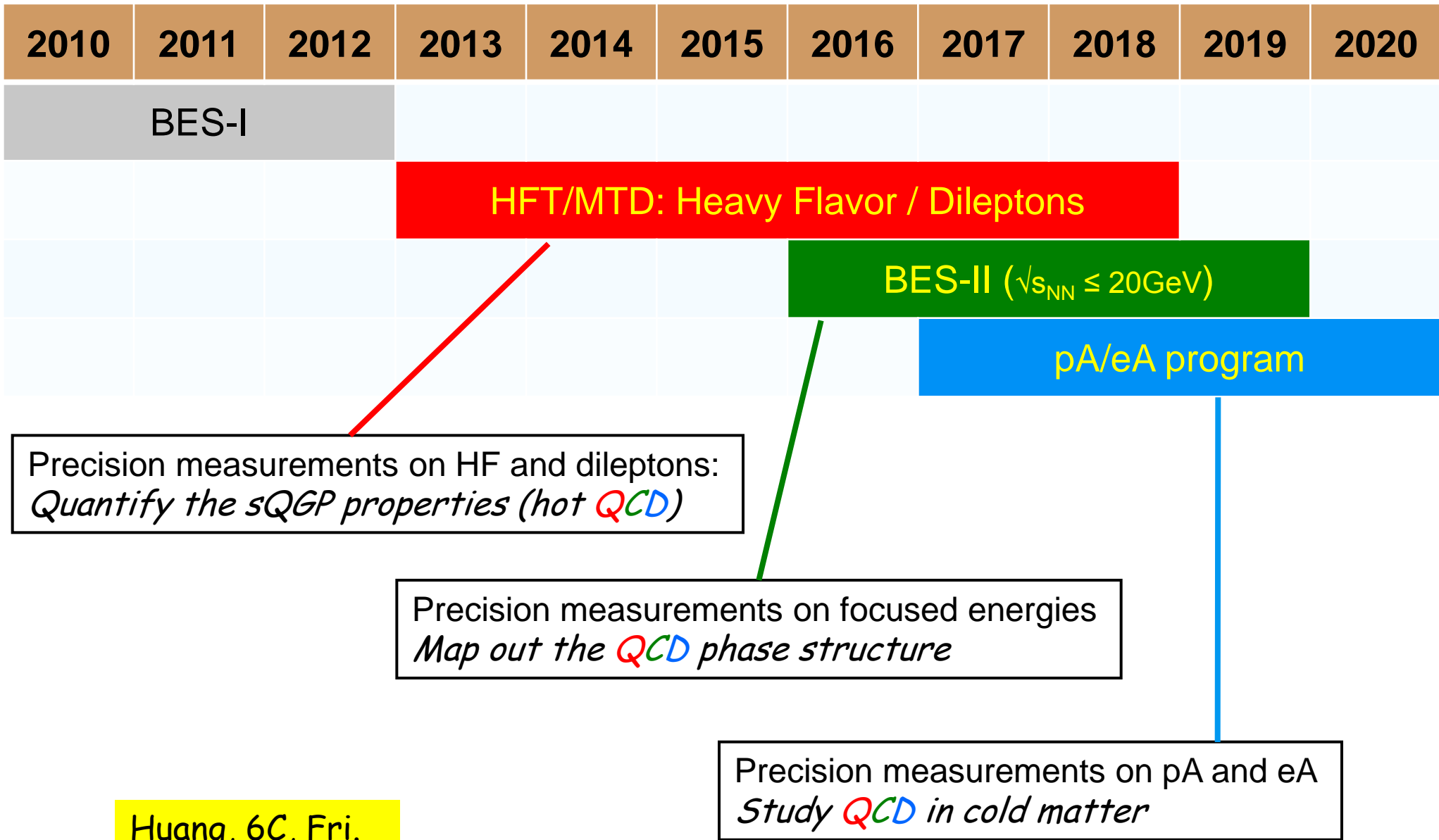
Hadronic interactions become more important in the system created at low collision energies.

2) Deviations from the Poisson baseline in net-proton higher moment analysis.

BES-II with significantly improved statistics focusing on beam energies ≤ 20 GeV.



Outlook



Huang, 6C, Fri.



Full List of Oral Presentations

Plenary Presentations:

Azimuthal Anisotropy Results from STAR	Daniel Cebra	IC, Mon 15:55
Heavy Flavor Results from STAR	Wei Xie	IIB, Tue 11:15
Di-lepton Physics Program at STAR	Frank Guerts	IVA, Thu 8:30
Search for Chiral Magnetic Effect in High Energy Nucleus Collisions	Gang Wang	IVB, Thu 12:20
STAR Results from RHIC Beam Energy Scan	Lokesh Kumar	VA, Fri 8:30

Parallel Presentations:

1) Forward azimuthal correlations in p+p and d+Au collisions at $\sqrt{s} = 200\text{GeV}$ at STAR

Xuan Li, 4D, Wed 12:20

Initial cond.

2) Systematic Investigation on Partonic Collectivity through Centrality Dependence of Elliptic Flow for Multi-strange Hadrons in STAR at RHIC

Md. Nasim, 3A, Wed 10:10

Bulk probes

3) Two- and Multi-particle cumulant measurements of v_n and isolation of flow and nonflow in 200 GeV Au+Au collisions by STAR

Li Yi, 3A, Wed 9:30

4) Di-electron differential cross section in Au+Au collisions at different beam energies at STAR

Bingchu Huang, 3C, Wed 9:10

5) Measurements of Non-photonic Electrons Production and Elliptic Flow in $\sqrt{s_{NN}} = 39, 62.4$ and 200 GeV Au+Au Collisions from STAR at RHIC

Mustafa Mustafa, 7A, Fri 16:50

Hard probes

6) Open charm hadron production in p+p and Au+Au collisions at STAR

David Tlusty, 6A, Fri 14:20

7) Quarkonia production in the STAR experiment

Barbara Trzeciak, 1D, Tue 15:35

8) Measurements of the Correlation between Jets and the Reaction Plane in STAR at RHIC

Alice Ohlson, 4B, Wed 11:40



Full List of Oral Presentations

BES

- 9) Centrality dependence of freeze-out parameters from the Beam Energy Scan at STAR
Sabita Das, 6B, Fri 15:00
- 10) R_{CP} and R_{AA} Measurements of Identified and Unidentified Charged Particles at High p_T in Au+Au Collisions at $\sqrt{s_{NN}}=7.7, 11.5, 19.6, 27, 39,$ and 62.4 GeV in STAR
Evan Sangaline, 5C, Thu 15:00
- 11) Beam Energy Dependence of Strange Hadron Production from STAR at RHIC
Xiaoping Zhang, 5A, Thu 15:00
- 12) Event anisotropy v_2 in Au+Au collisions at $\sqrt{s_{NN}}=7.7 - 62.4$ GeV with STAR
Shusu Shi, 6B, Fri 15:20
- 13) Beam Energy Dependence of First and Higher-Order Flow Harmonics from the STAR Experiment at RHIC
Yadav Pandit, 1A, Tue, 14:55
- 14) Femtoscopy of identified particles at STAR
Neha Shah, 1C, Tue 14:35
- 15) Beam Energy Dependence of Hypertriton Production and Lifetime Measurement at STAR
Yuhui Zhu, 5A, Thu 15:40
- 16) Search for QCD Phase Transitions and the Critical Point Utilizing Particle Ratio Fluctuations and Transverse Momentum Correlations from the STAR Experiment
Prithwish Tribedy, 2C, Tue 16:45
- 17) Search for the QCD Critical Point by Higher Moments of Net-proton Multiplicity Distributions at STAR
Xiaofeng Luo, 7B, Fri 17:30
- 18) Beam energy and centrality dependence of the statistical moments of the net-charge multiplicity distributions in Au+Au collisions at STAR
Daniel McDonald, 7B, Fri 16:50
- 19) Study of the Sixth Order Cumulant of Net-proton Distributions Measured in STAR at RHIC
Lizhu Chen, 2C, Tue 17:25

20) STAR Upgrade Plan for the Coming Decade

Huang Z. Huang, 6C, Fri 14:00

Upgrade

