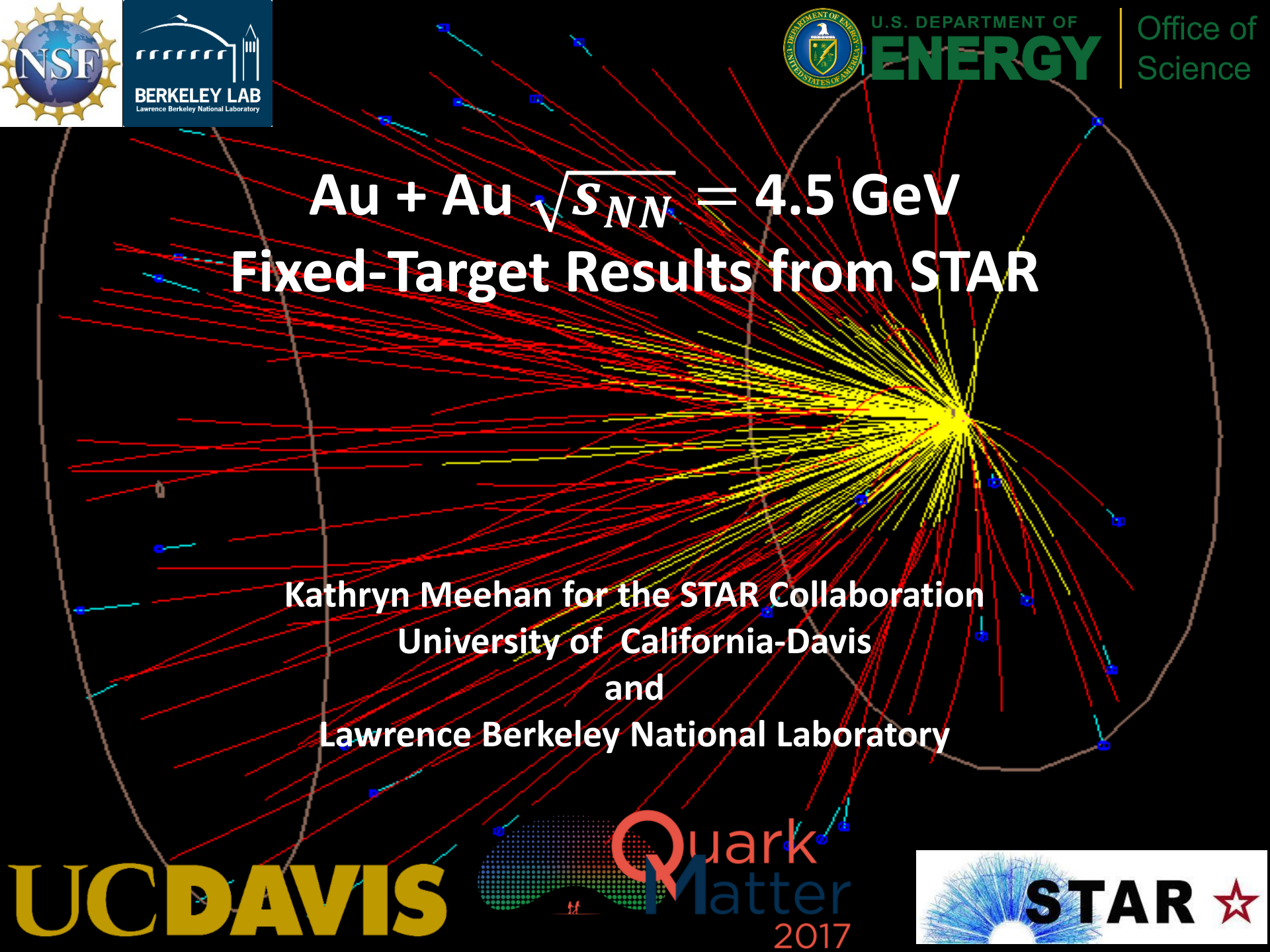


Au + Au $\sqrt{s_{NN}} = 4.5$ GeV Fixed-Target Results from STAR

Kathryn Meehan for the STAR Collaboration

University of California-Davis

and

Lawrence Berkeley National Laboratory

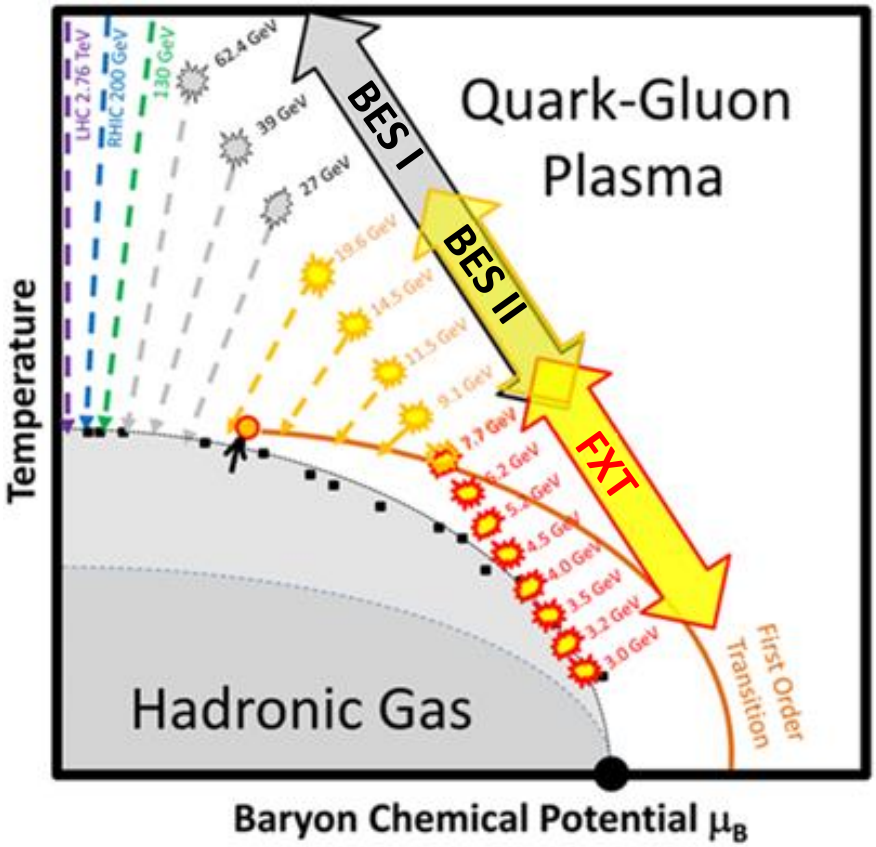
Quark Matter 2017

Outline

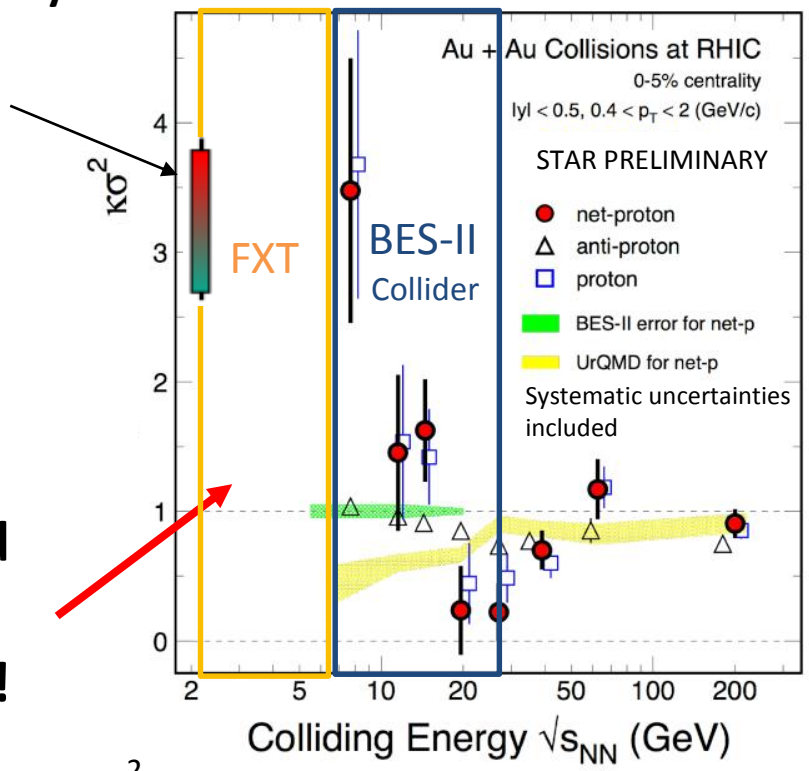
1. Introduction to STAR Fixed-Target (FXT)
2. Results
   - Hadron spectra and yields
   - Directed flow of hadrons
   - Elliptic flow
   - HBT
   - Fluctuations
3. Future work
4. Conclusions

"Buddy Guy"
Famous Chicago Blues Musician

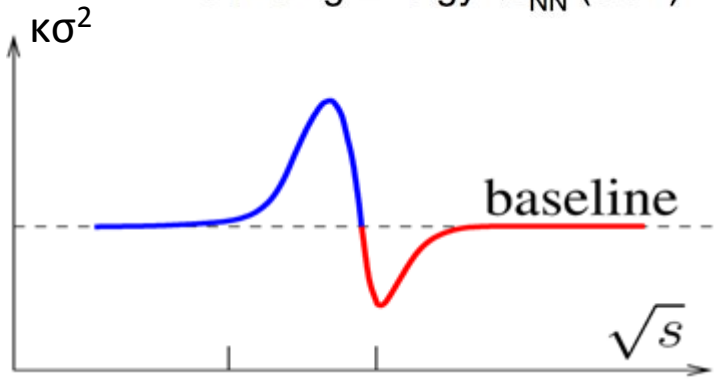
Why a Fixed-Target Program?



Preliminary HADES result
0-10%
(QM 2017)



Need data here!



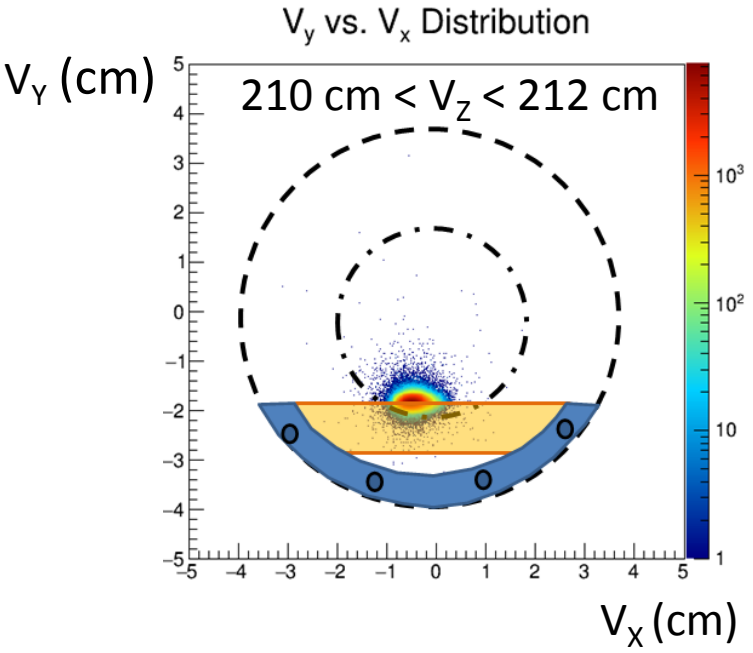
M. Stephanov. J. Physics G.: Nucl. Part. Phys. ***38*** (2011) 124147

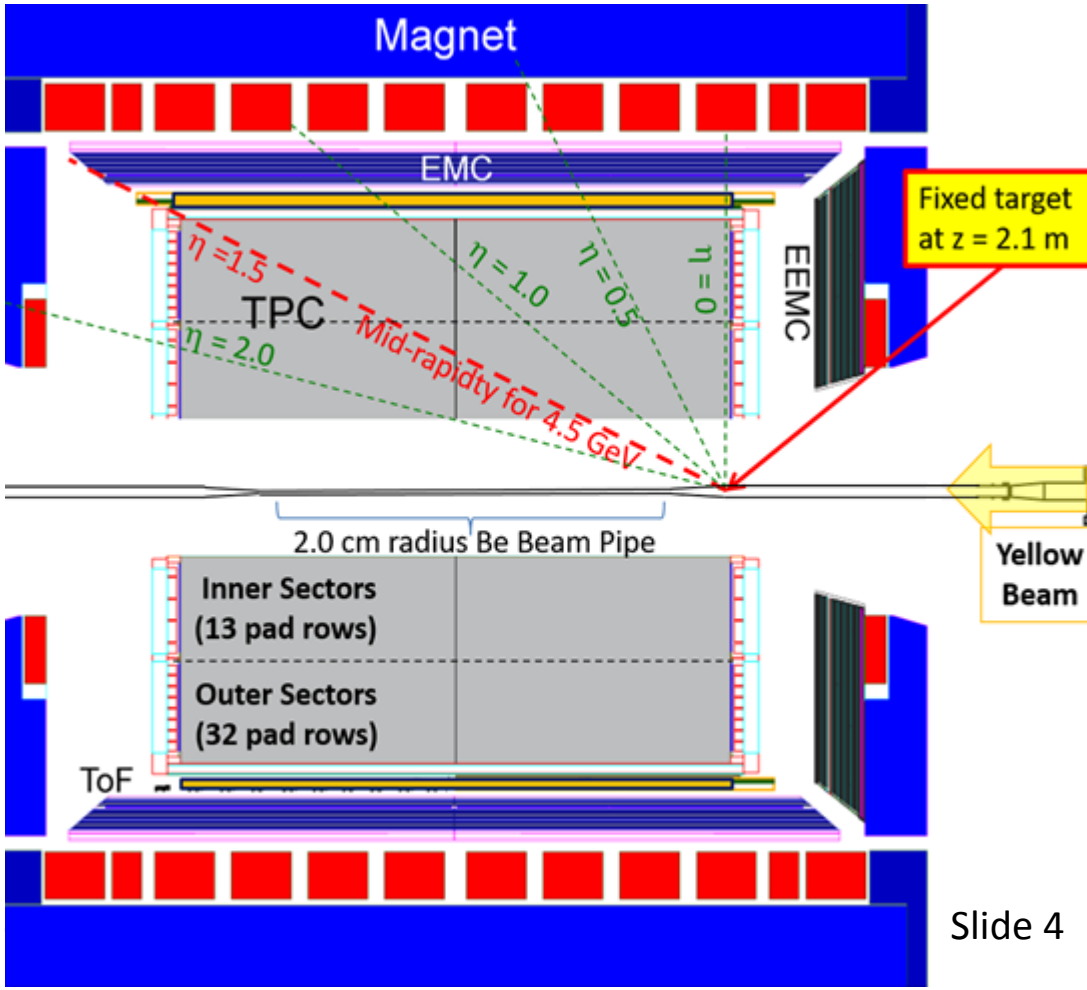
- FXT could provide control measurements for searches for critical point and onset of deconfinement
- Kurtosis measurement is one of the future program goals and not in this talk.
- Test run focused on demonstrating STAR FXT capabilities

First Dedicated Au + Au FXT Test Run In 2015

$$\sqrt{s_{NN}} = 4.5\ \text{GeV}$$

- 1.3 million events, top 30% central trigger
- Filled trigger bandwidth ➔ DAQ limited
- 1 mm thick (4% interaction probability) gold foil target

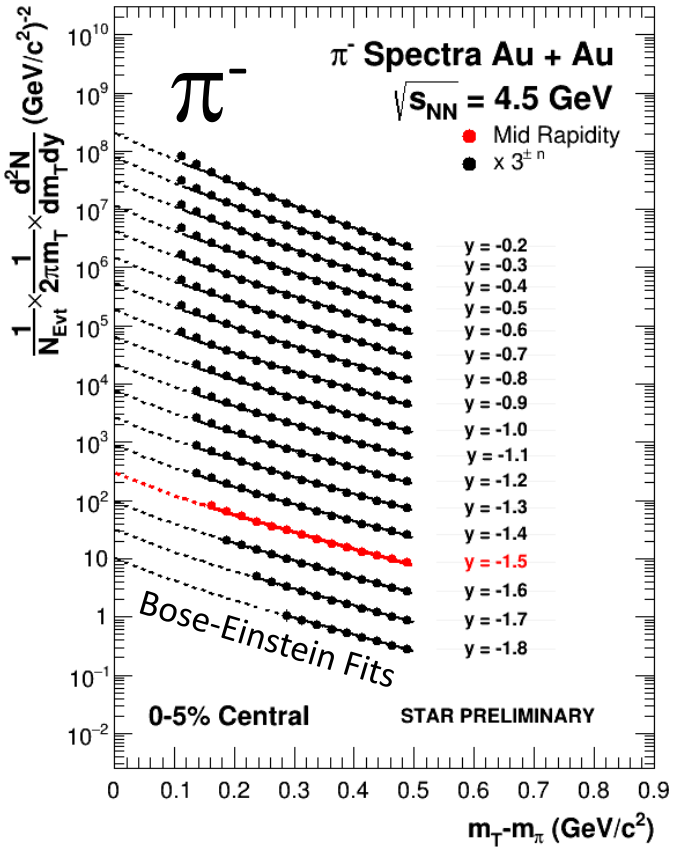


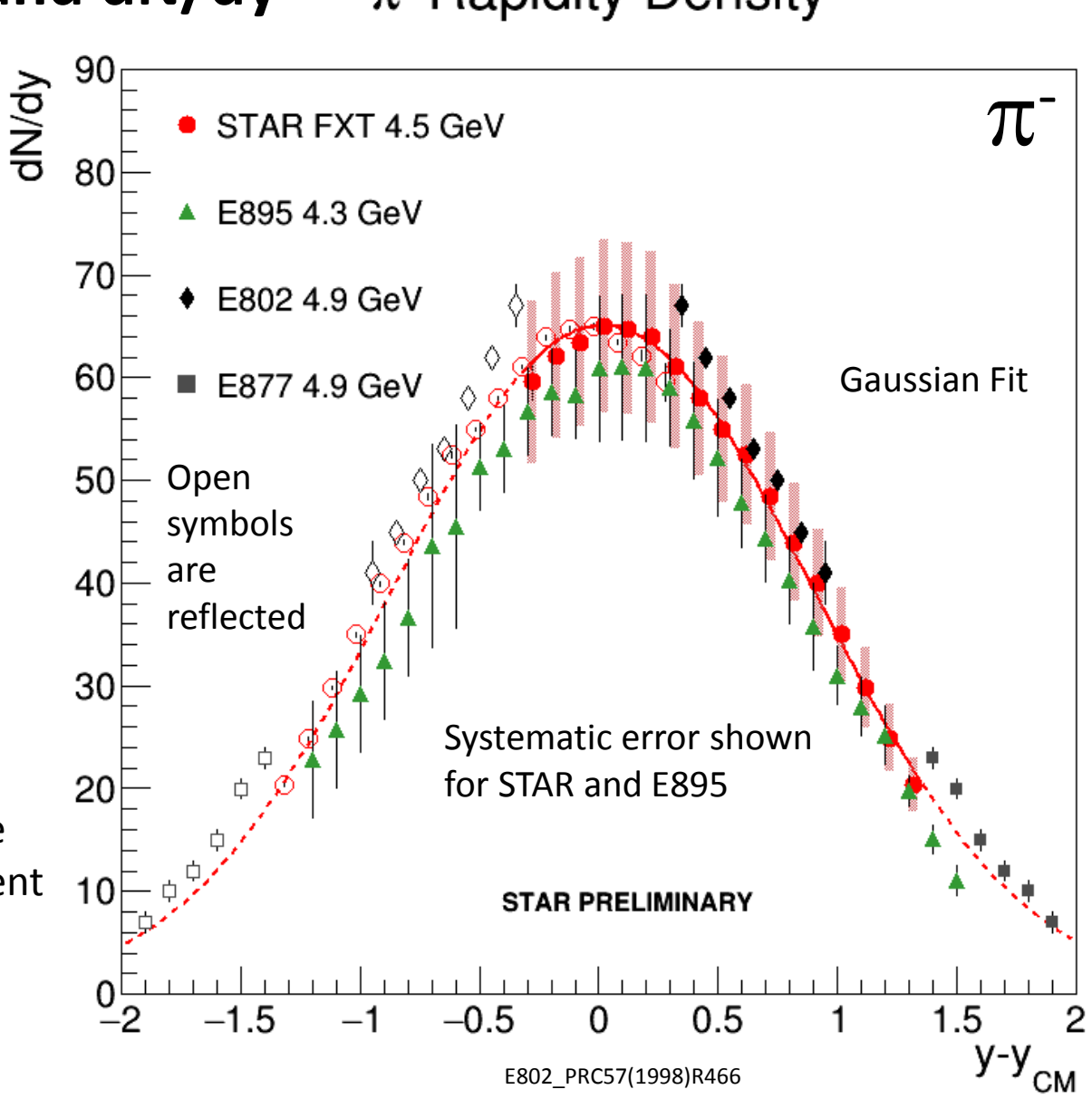


Physics Results

Au + Au $\sqrt{s_{NN}} = 4.5$ GeV

TPC Pion Spectra and dN/dy

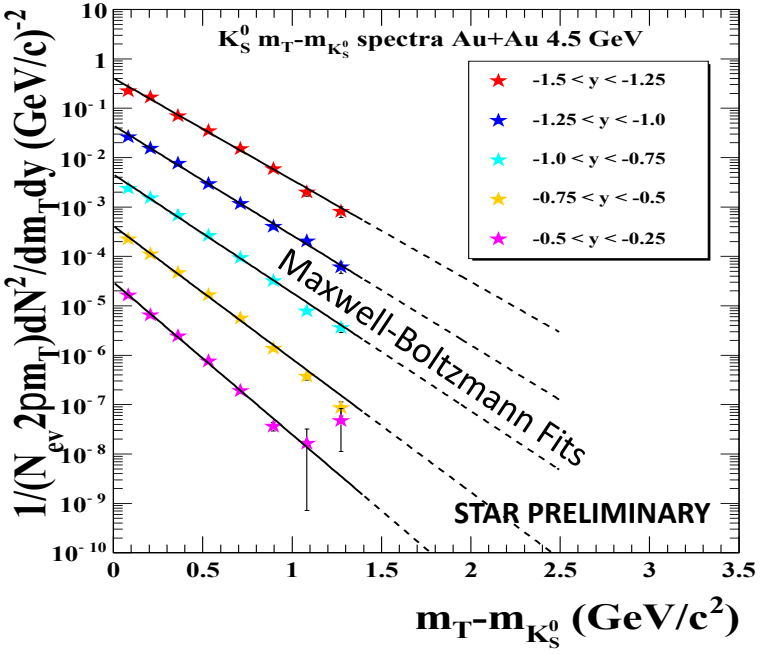


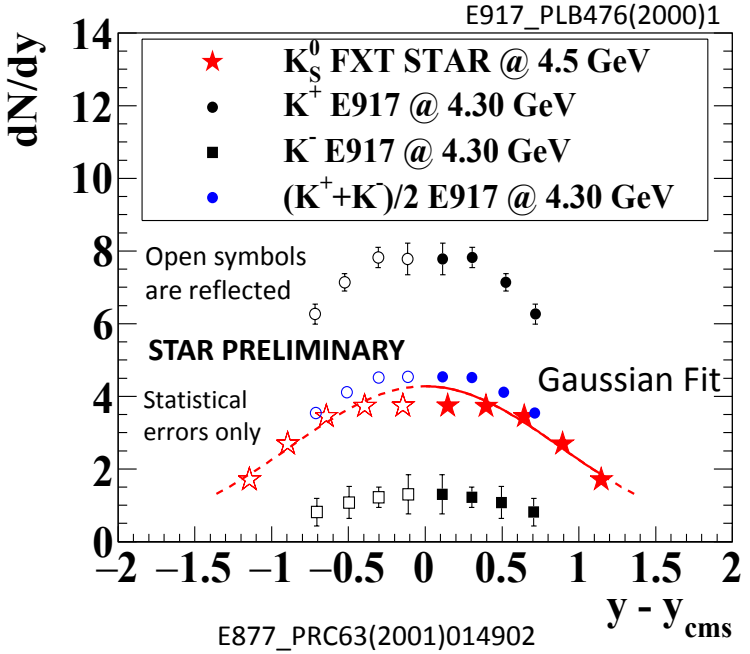


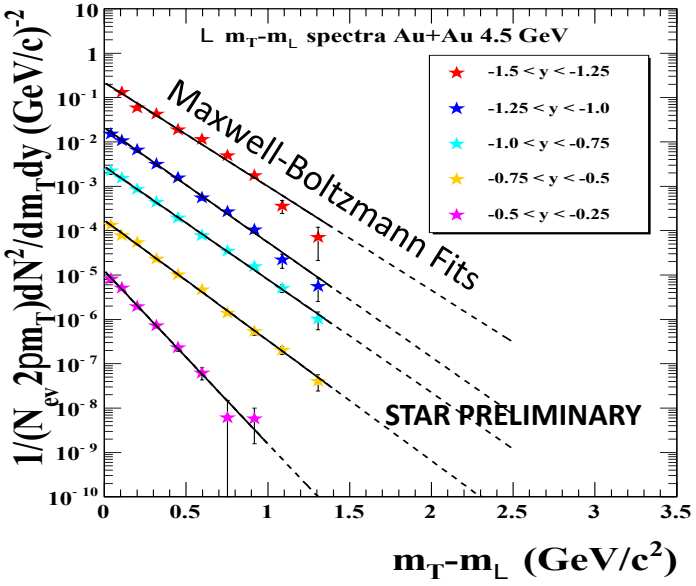
- Amplitudes and widths of the rapidity densities are consistent with AGS
- $m_T - m_0$ and y range will be extended with time-of-flight detector

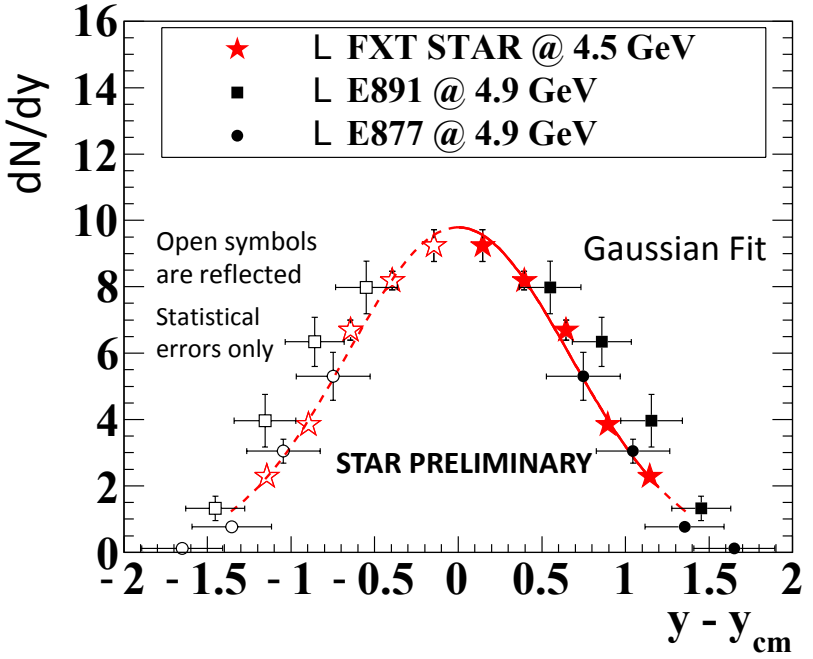
E802_PRC57(1998)R466
E877_PRC62(2000)024901
E895_PRC68(2003)054905

Kaon and Lambda Spectra and dN/dy



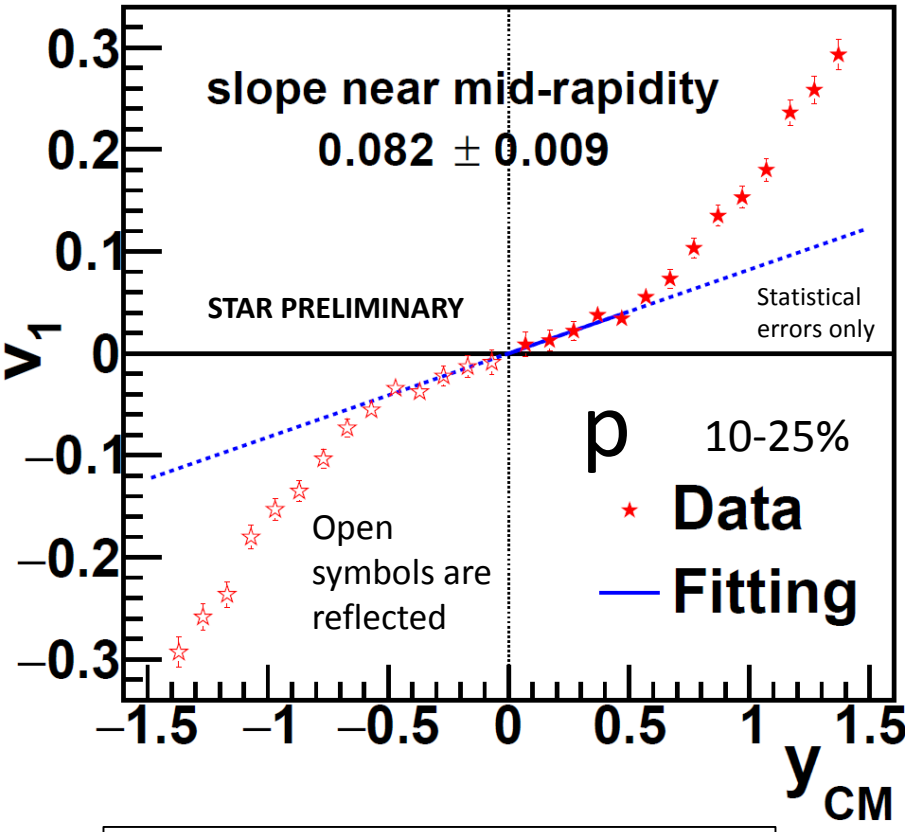


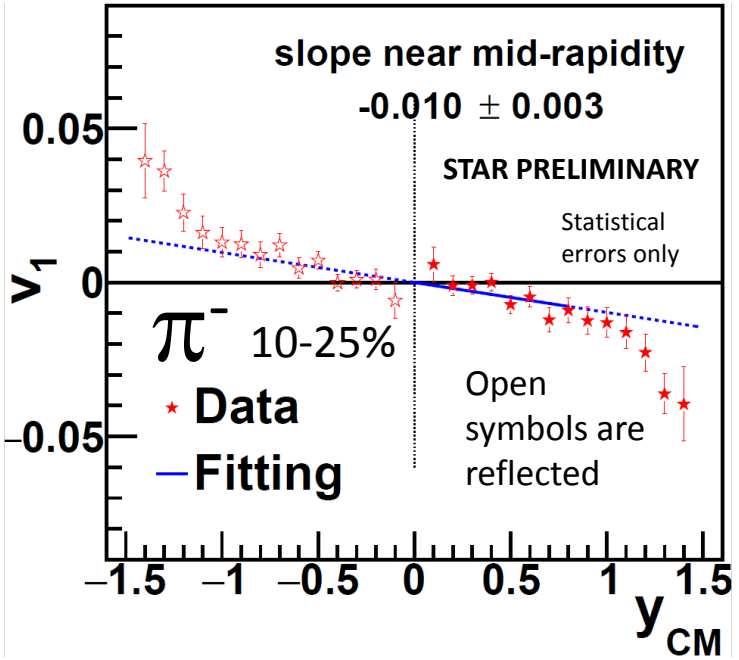


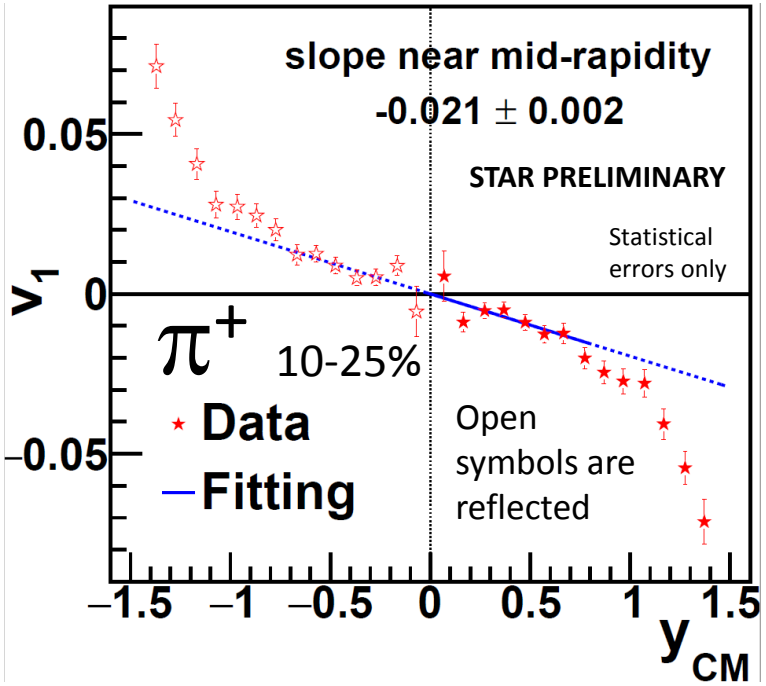


Amplitudes and widths comparable with AGS

Directed flow of protons and pions at $\sqrt{s_{NN}}$ = 4.5 GeV

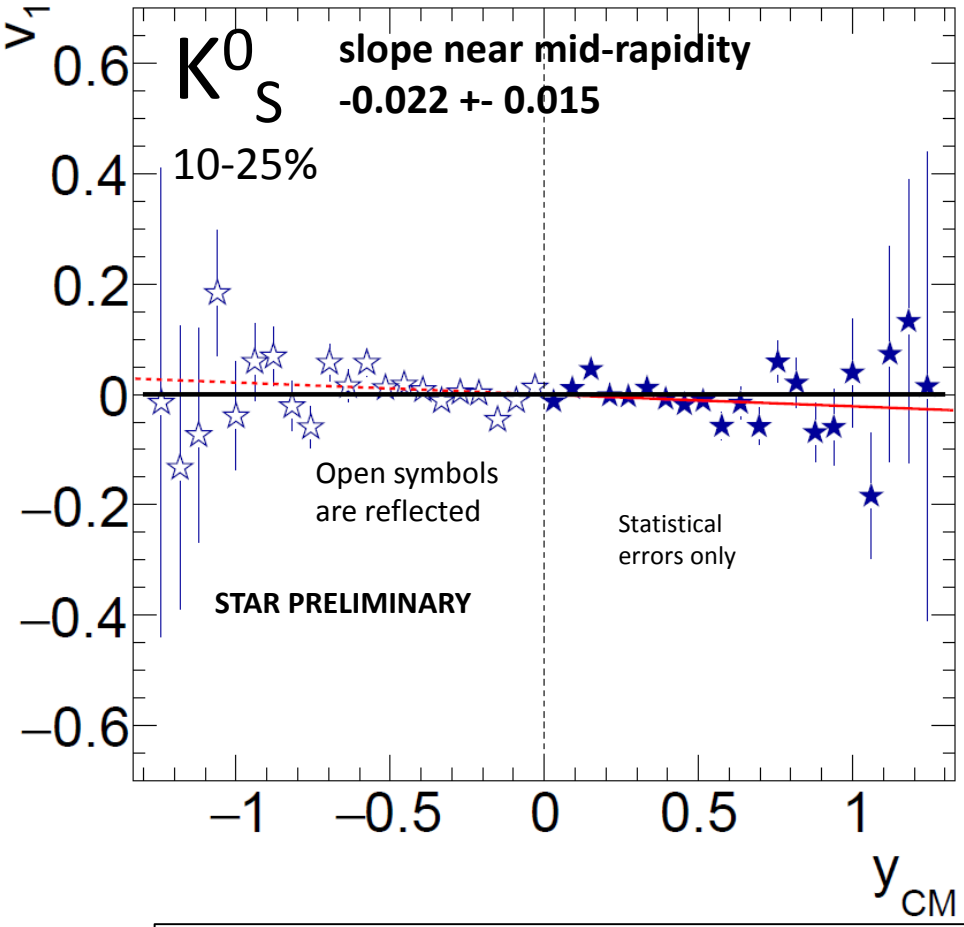


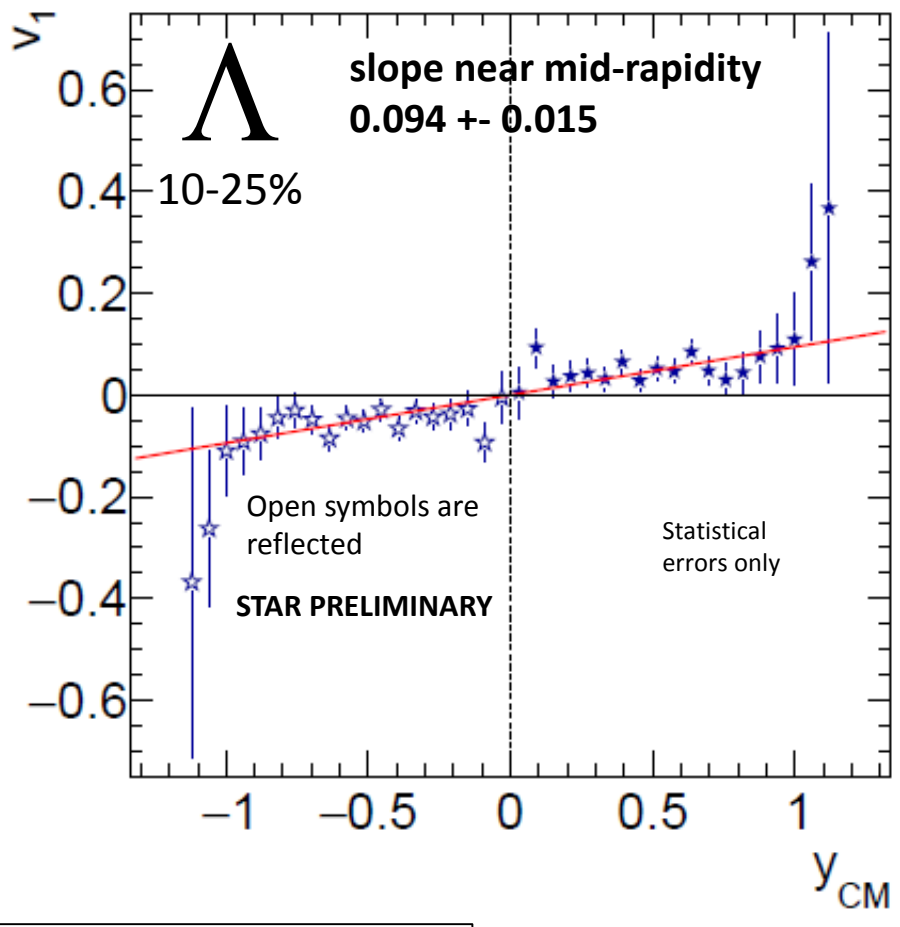




- Proton flow is "positive"
- Pion flow is "negative"
- π^+ flow twice that of π^-

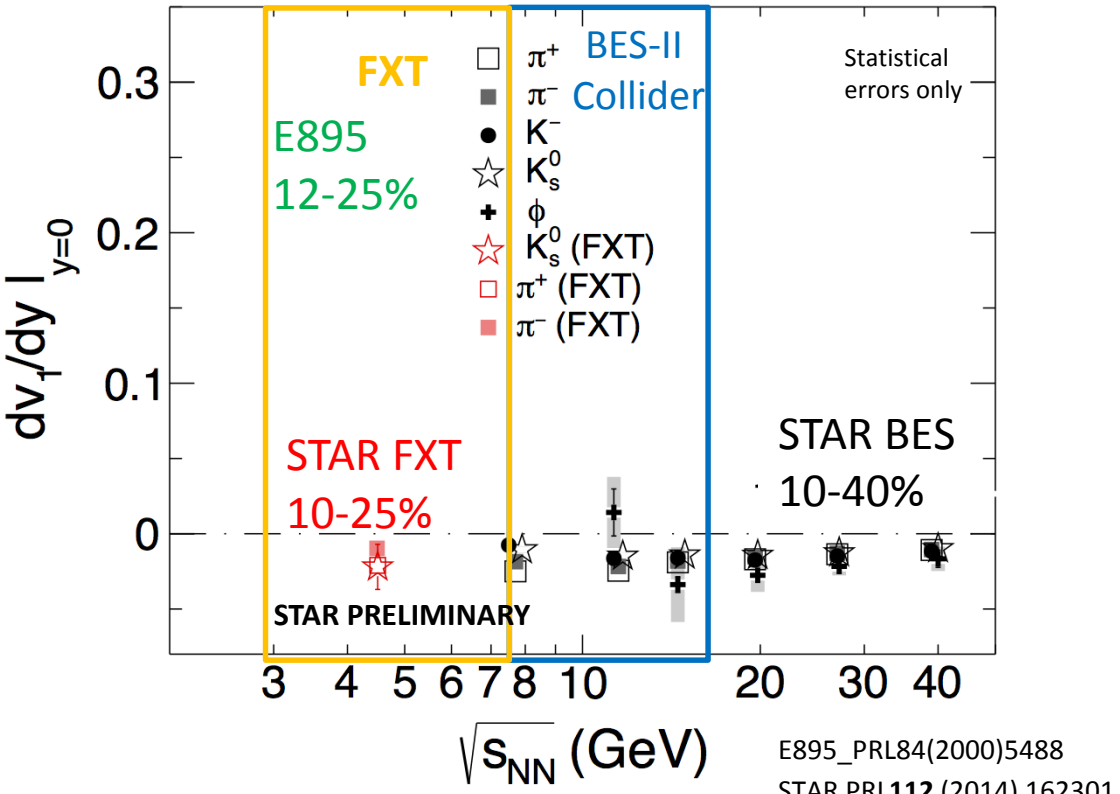
Directed flow of kaons and lambdas at $\sqrt{s_{NN}}$ = 4.5 GeV





- Flow of kaons (mesons) is negative.
- Flow of lambdas (baryons) is positive.
- See D. Tlusty's poster on directed flow in STAR fixed-target

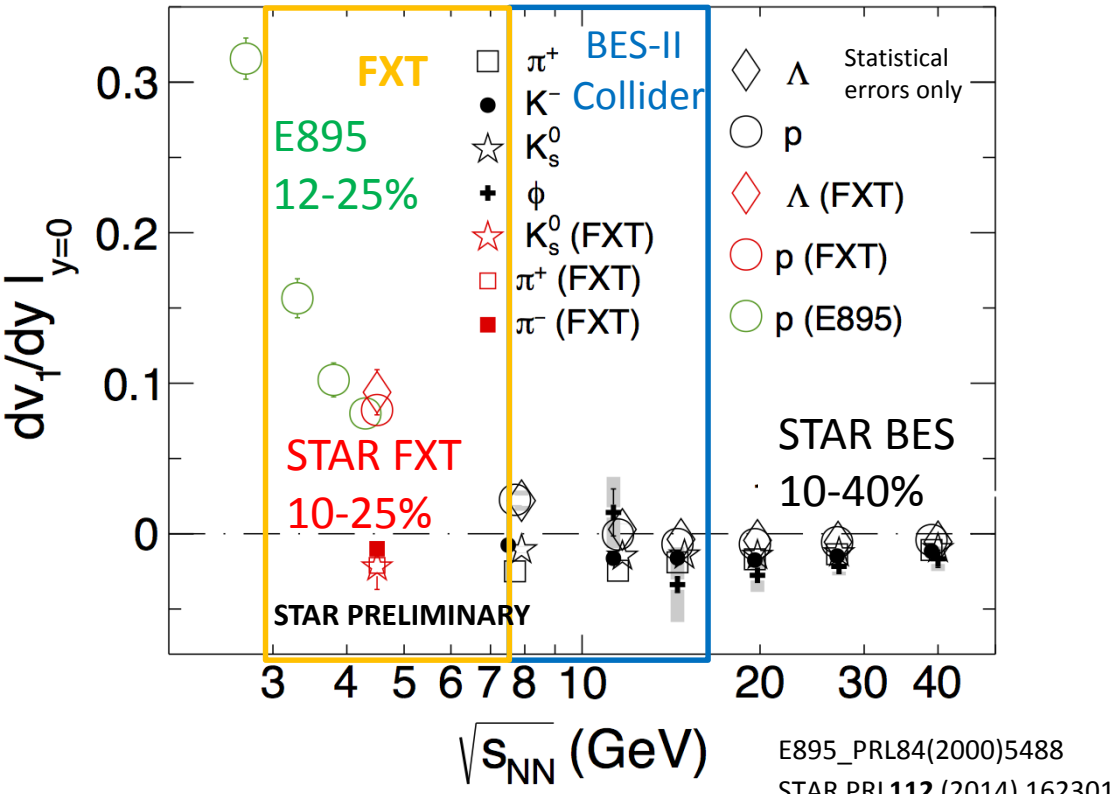
Directed Flow Comparison Across Experiments and Energies



E895_PRL84(2000)5488
STAR PRL**112** (2014) 162301

- First π results shown for this energy range.
- The mesons continue the trend of negative flow seen at higher energies.
- Protons and lambdas are consistent with positive flow indicative of compression.

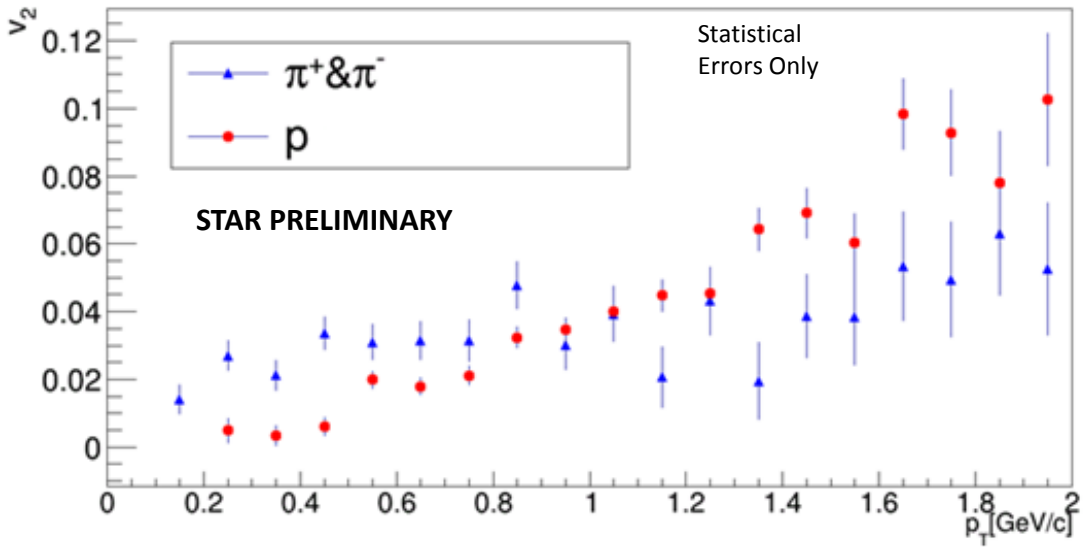
Directed Flow Comparison Across Experiments and Energies



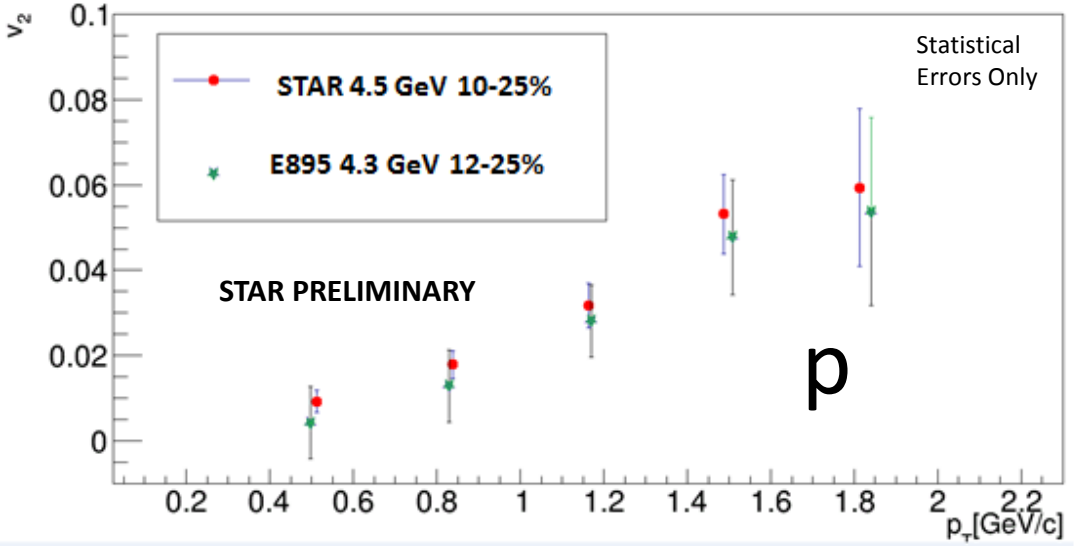
E895_PRL84(2000)5488
STAR PRL**112** (2014) 162301

- First π results shown for this energy range.
- The mesons continue the trend of negative flow seen at higher energies.
- Protons and lambdas are consistent with positive flow indicative of compression.

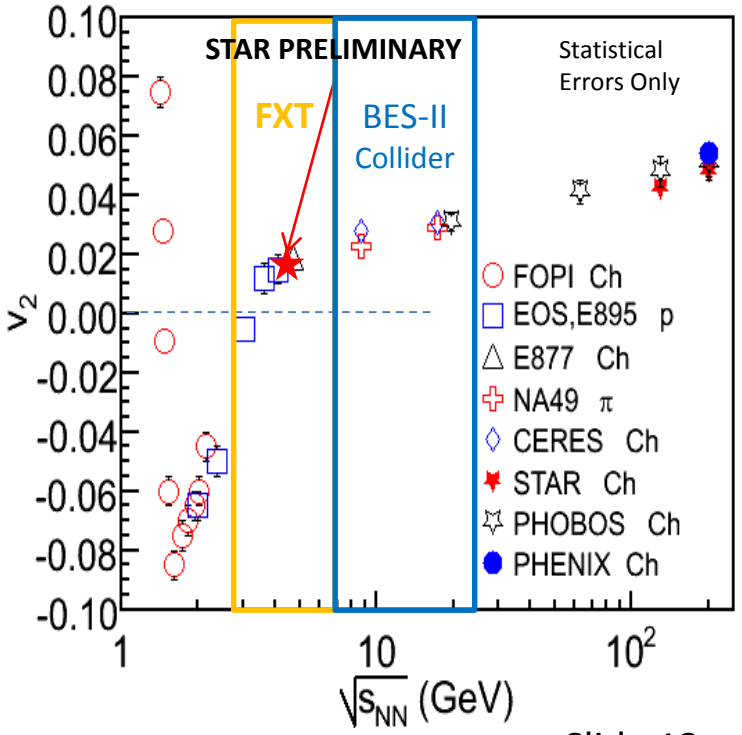
Elliptic Flow of Pions and Protons



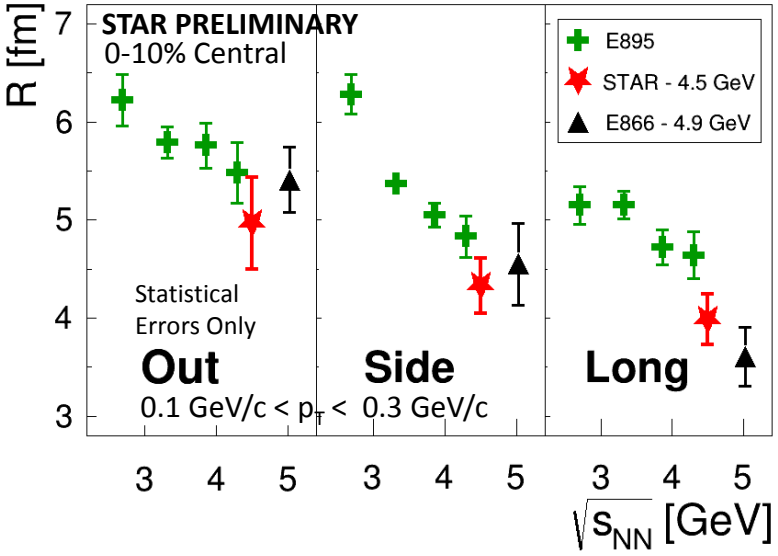
E895_PRL83(1999)1295

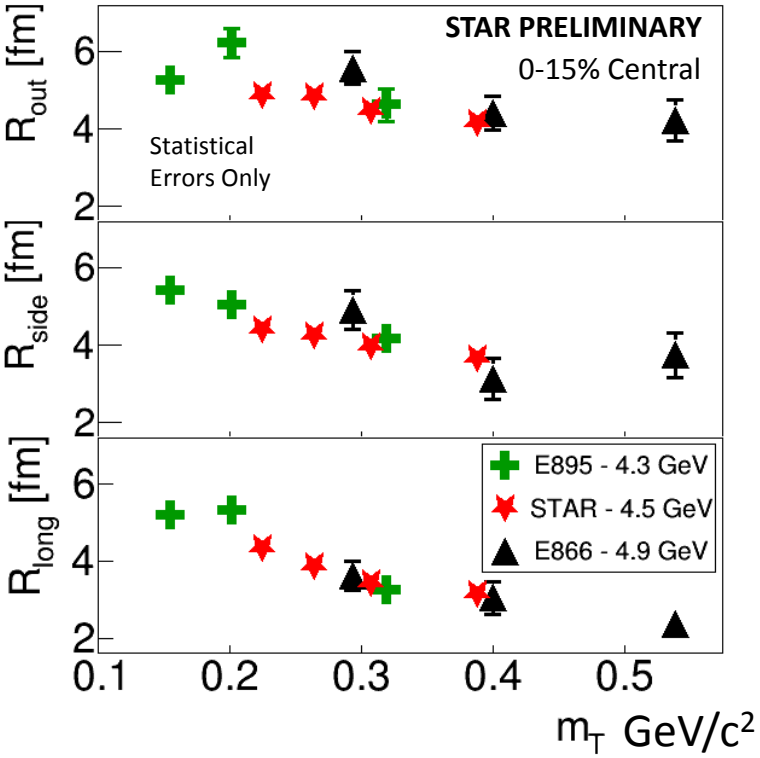


- Mass ordering between pions and protons continues to be observed at this energy
- Good agreement with E895 supports the known change in behavior between FXT and BES collider regimes



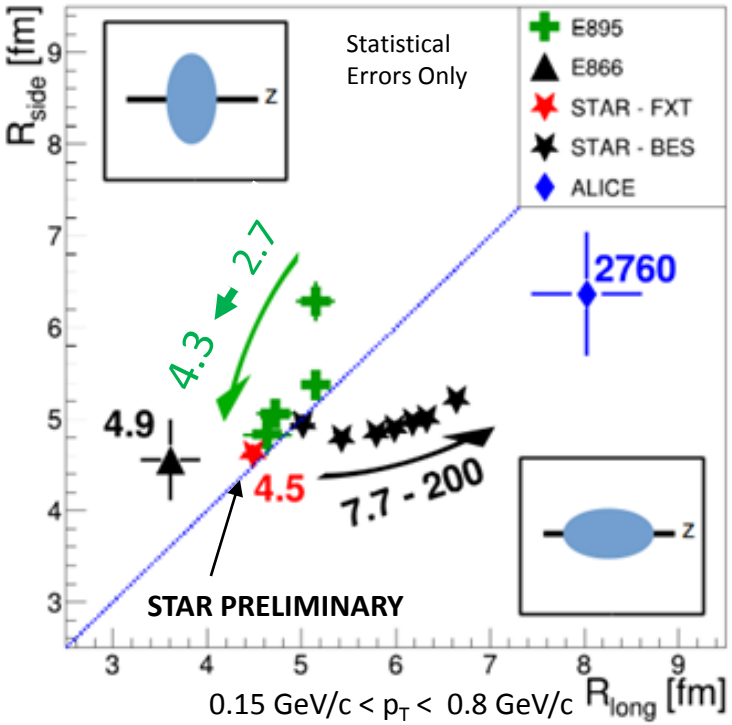
Pion HBT Results



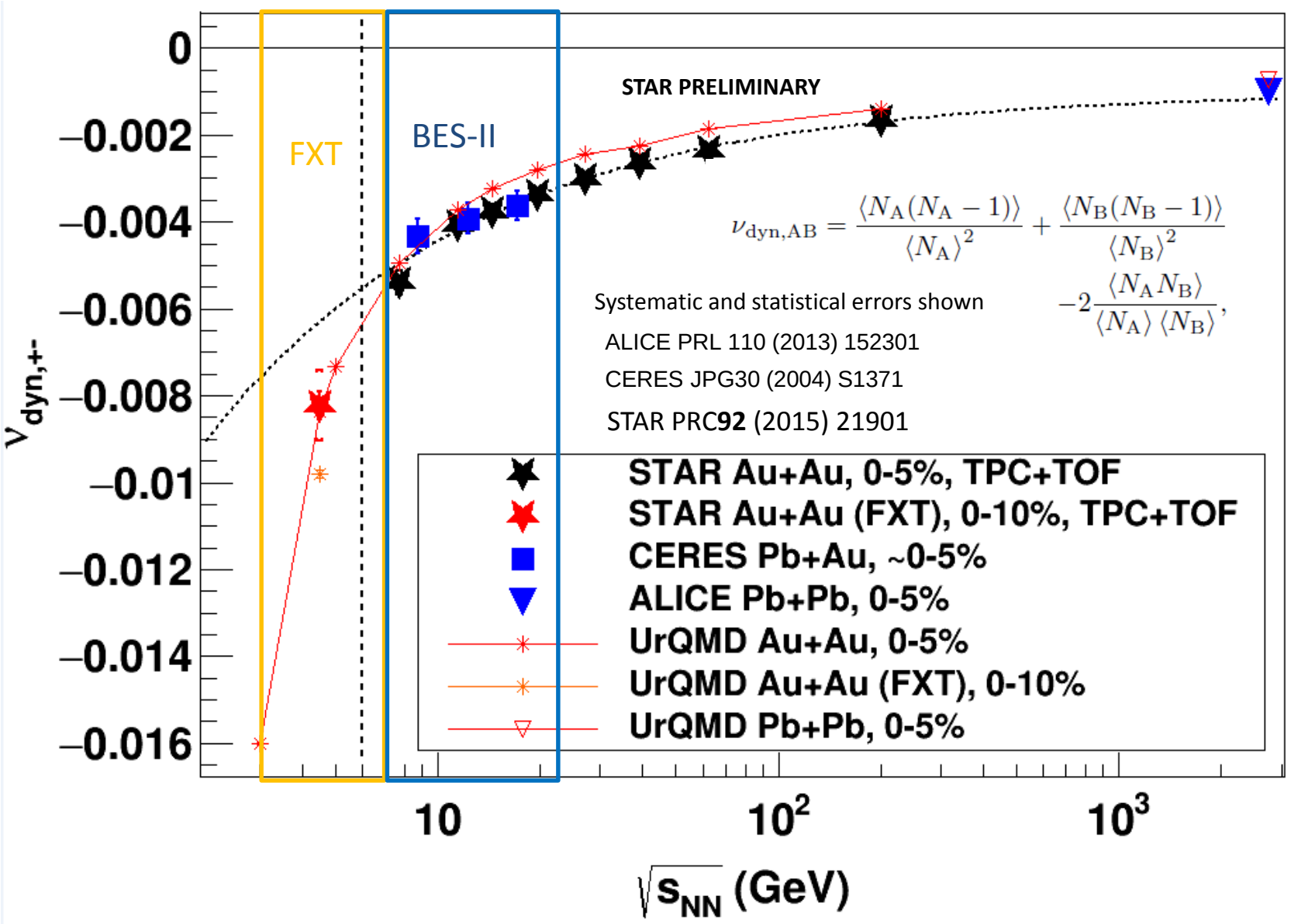


- Consistency with AGS results
- As the collision energy rises in the FXT regime, compression reduces the source size and increases the baryon density, whereas the BES collider regime shows increased longitudinal expansion

E866 PRC66 (2002) 054096
E895 PRL84 (2000) 2798
ALICE PLB 696 (2011) 328
STAR BES PRC**92** (2015) 14904



Dynamical Relative Charge Number Fluctuations



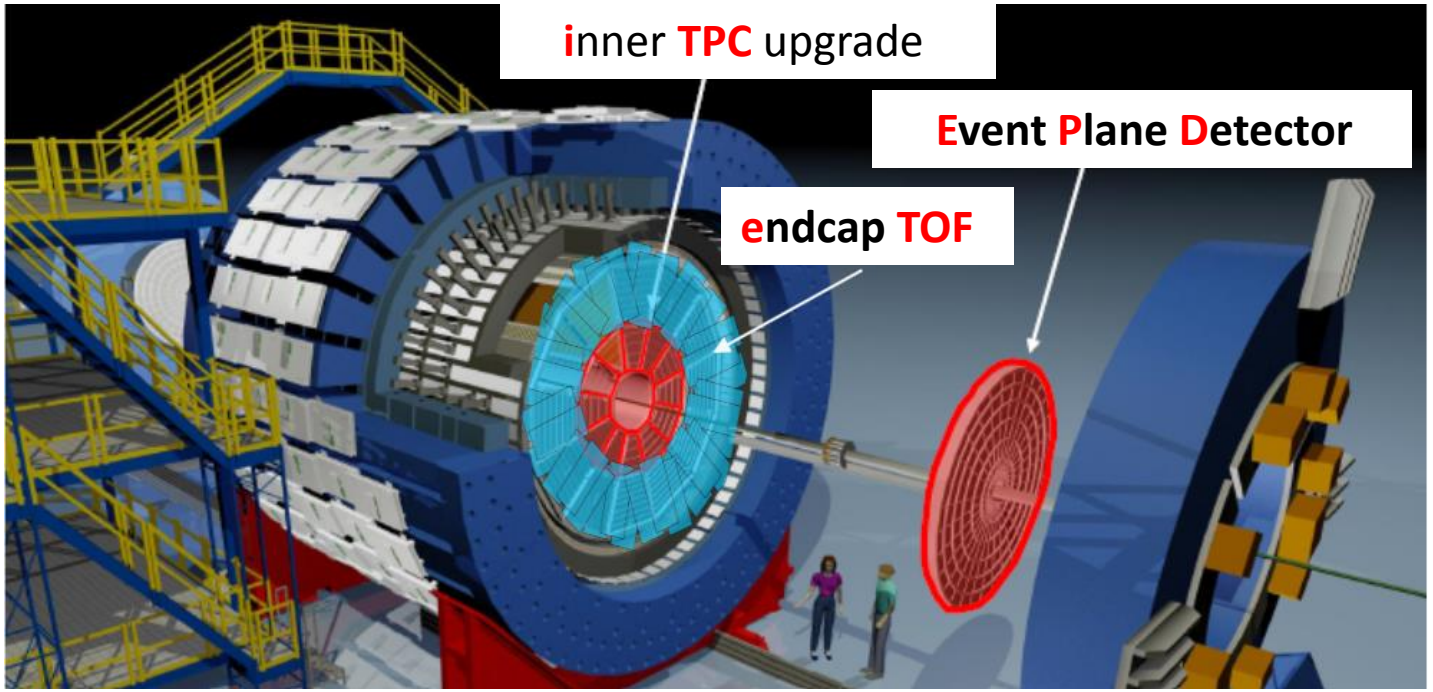
Fluctuation measurement shows significant changes between the collider and fixed-target energy regimes.

Plans for the Future
2018-2020

The STAR Upgrades and the FXT program

J. Ewigleben's poster on EPD

F. Geurts' poster on eTOF



iTPC Upgrade:
- Improves dE/dx
- Extends η coverage from 1.5 to 2.2 (mid-rapidity for FXT)
- Lowers p_T cut-in
- Ready in 2019

Star Note 0644 : Technical Design Report for the iTPC Upgrade

See Chi Yang's BES-II Upgrades talk Parallel Session 4.1

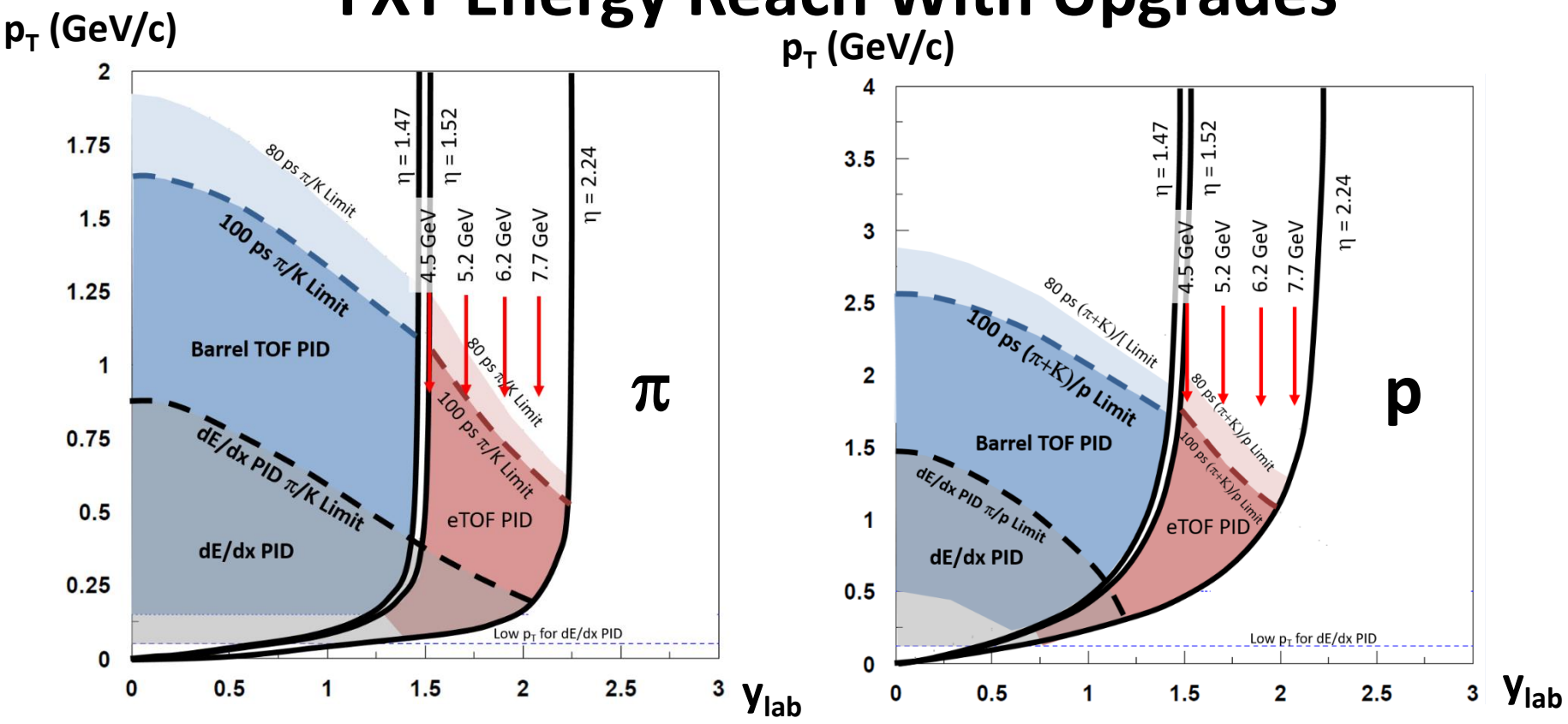
EndCap TOF Upgrade:
- Mid-rapidity coverage is critical
- Needed for PID at mid-rapidity
- Allows higher energy range of FXT program
- Ready 2019

https://arxiv.org/pdf/1609.05102.pdf

EPD Upgrade:
- Independent trigger
- Reduces background
- Allows a better and independent reaction plane measurement critical to FXT physics
- Ready 2018

Star Note 0666 : An Event Plane Detector for STAR

FXT Energy Reach With Upgrades



- Would need 100 Million Events at each energy to make the sensitivity of BES-II, 2 days per energy
- Data rate is DAQ limited
- Detector upgrades required to extend STAR FXT up to 7.7 GeV, an overlap energy with the collider

Conclusions

• We've demonstrated STAR operates successfully in FXT mode, despite being optimized as a collider experiment.

• Spectra and yields are comparable to results from the AGS.

• Directed flow of pions has not previously been published for this energy range, and continues the trend of negative flow for mesons.

• First pion elliptic flow measurements have been made for this energy which show mass ordering.

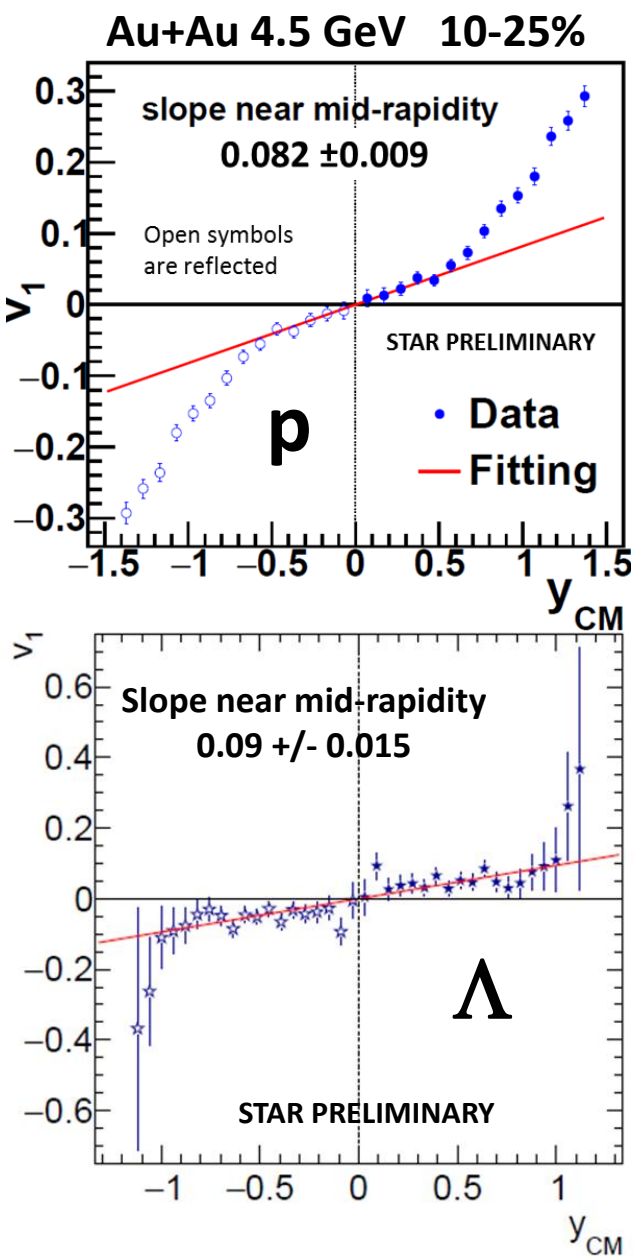
• HBT radii measurements are consistent with results from AGS.

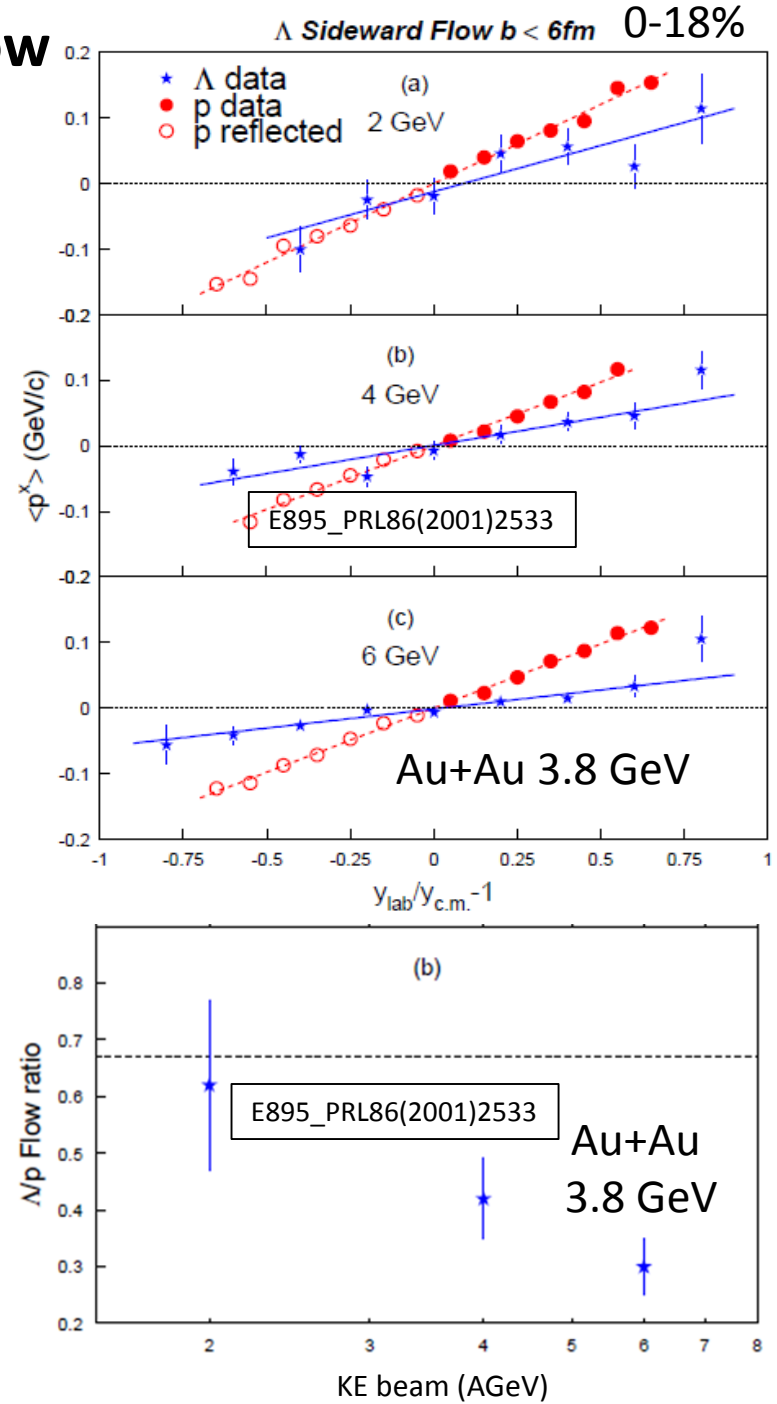
• First dynamical fluctuation measurements (ν_{dyn}) taken for this energy range.

• A FXT energy scan is proposed to extend the reach of the BES-II program down to 3.0 GeV ($\mu_B \approx 720$ MeV) to include the high baryon density regime.

Backup Slides

Comparison to E895 Λ Flow





Differences:

E895 -- $\langle p^x \rangle$

STAR-FXT – v_1

E895 – 0-18%

STAR-FXT 10-25%

E895 *trend*:

Λ/p flow ratio at 4.5 GeV ➔ 0.2

STAR FXT:

Λ/p flow ratio at 4.5 GeV ➔ 1.1