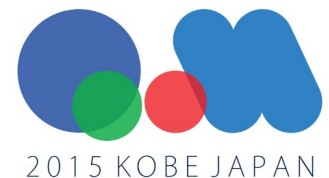


The Rapidity Density Distributions and Longitudinal Expansion Dynamics of Identified Pions from the STAR Beam Energy Scan

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For the STAR Collaboration

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Outline



Motivation

Beam Energy Scan Program
Rapidity Density Distributions and
Longitudinal Dynamics

STAR - Particle Identification

Identified Pion Spectra

Rapidity Density Distributions

Identified π^+/π^- and NA49 Comparison

Full Phase Space Yields

Longitudinal Expansion

"Dale" Observable

Summary



The Beam Energy Scan Program at RHIC

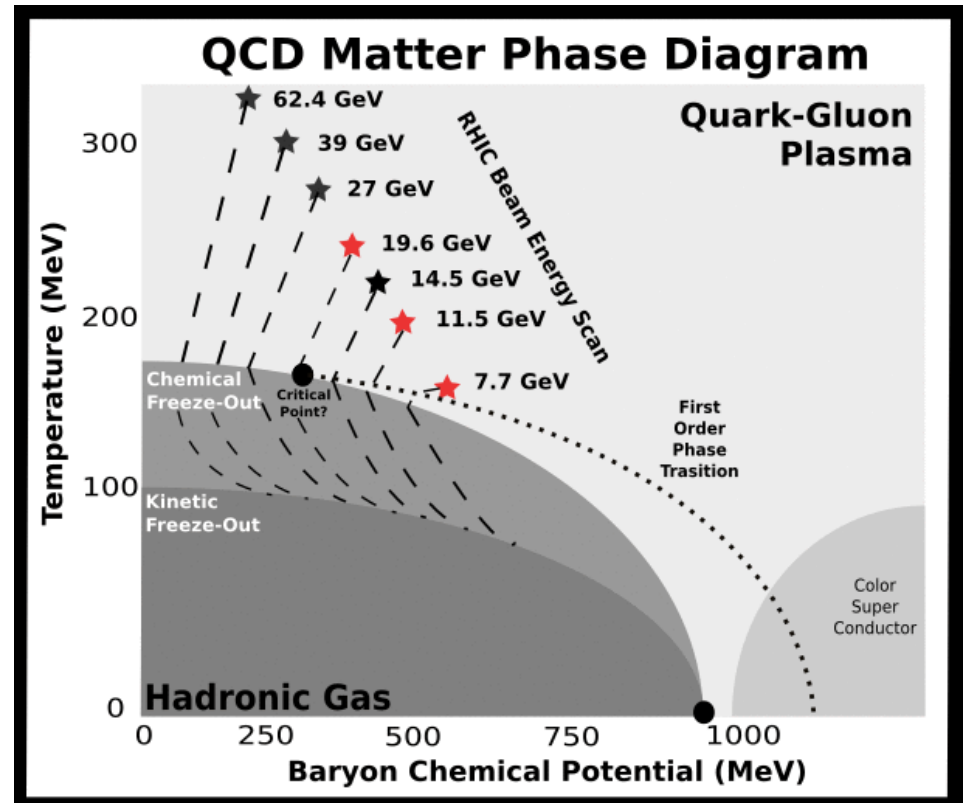


Study of the QCD Phase Diagram

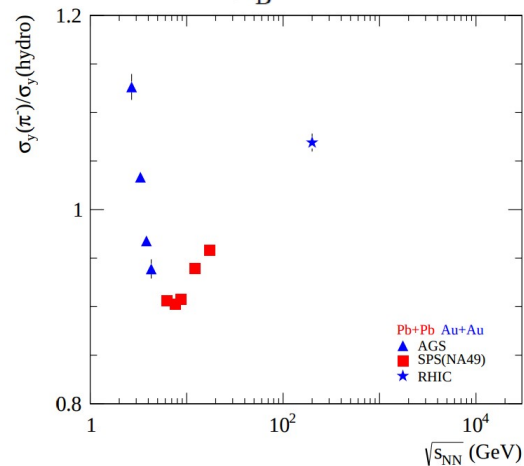
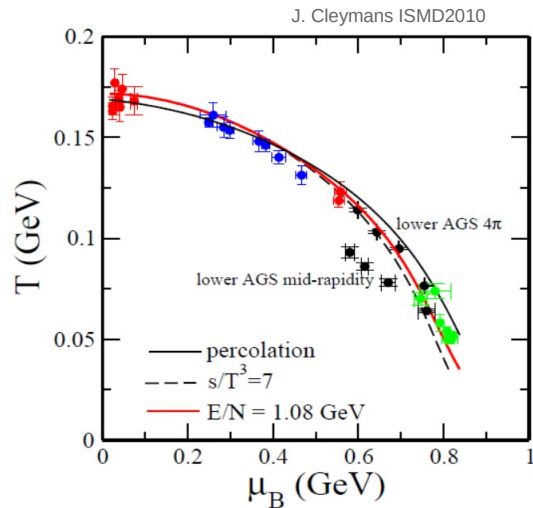
- Search for Critical Point
- Search for Phase Transition
- Phenomena - softening of EOS

In this Talk

- Top 10% Central Au+Au :
 $\sqrt{s_{NN}} = 7.7, 11.5, \text{ and } 19.6 \text{ GeV}$
- Rapidity dependence of pions
- Longitudinal expansion dynamics



Rapidity Density Distributions and Longitudinal Expansion



M. Bleicher hep-ph/0509314, H. Petersen nucl-th/0611001, A. Rustamov arXiv:1201.4520

Rapidity Density distributions allow:

More complete characterization of the whole system chemistry

Full Phase Space Yields

Studies of the system's longitudinal expansion dynamics \rightarrow dN/dy width

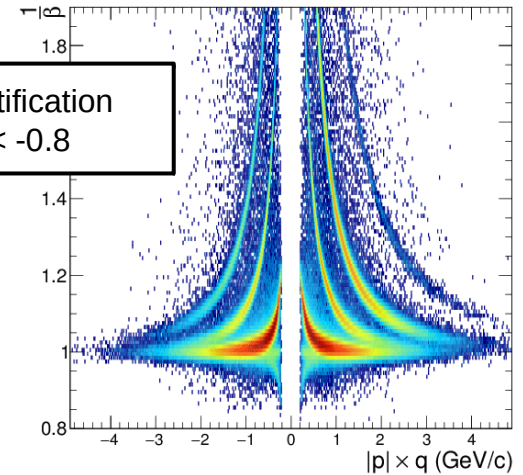
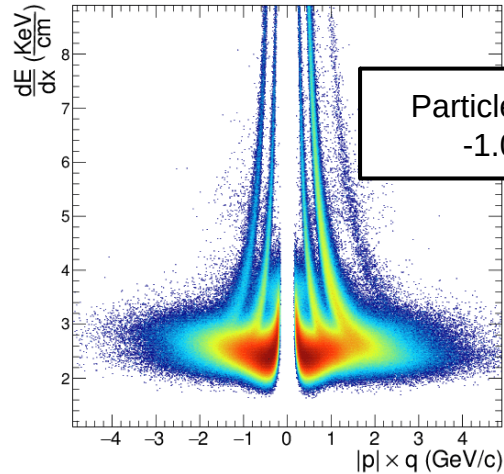
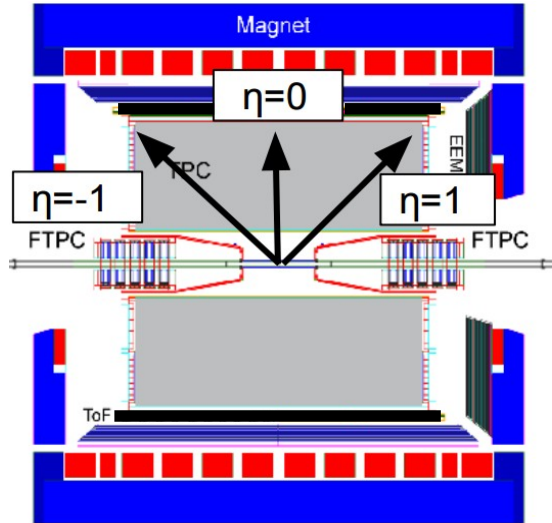
Results from AGS and SPS show minimum at $\sim \sqrt{s_{NN}} = 7$ GeV

Interpreted as a minimum in speed of sound

Would be a consequence of a softening of the EOS

Used as evidence of the onset of deconfinement

The STAR Detector



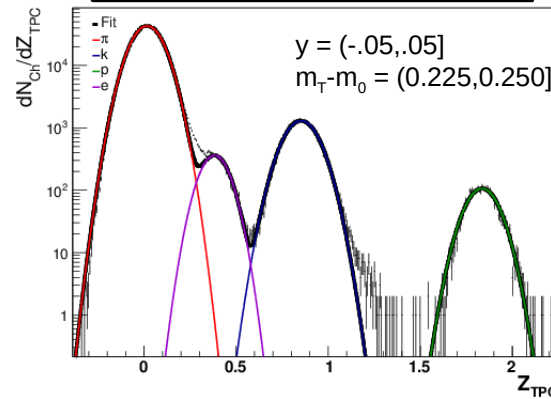
Event Selection:

- ▮ Top 10% Central
- ▮ $|Vz| < 30$ cm

Particle Identification:

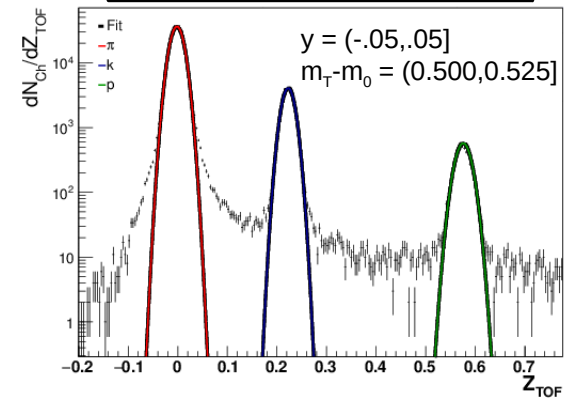
- ▮ Energy Loss in TPC
- ▮ Time of Flight in TOF
- ▮ Excellent PID throughout full rapidity range

Yield Extraction from TPC



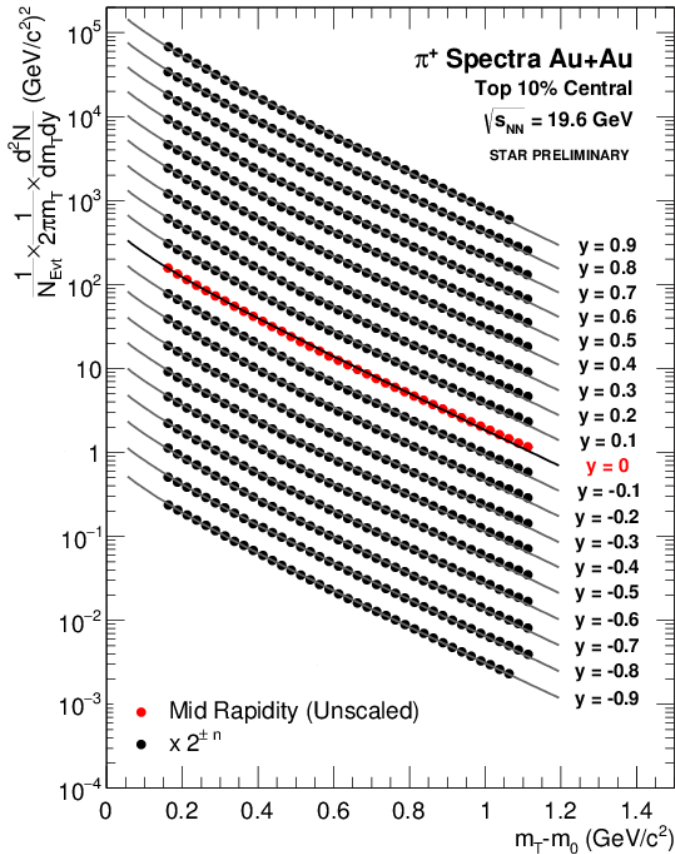
$$Z_{TPC} = \ln\left(\frac{dE/dx_{Measured}}{dE/dx_{Expected, \pi}}\right)$$

Yield Extraction from TOF



$$Z_{TOF} = \ln\left(\frac{1/\beta_{Measured}}{1/\beta_{Expected, \pi}}\right)$$

Identified Pion Spectra at 19.6 GeV



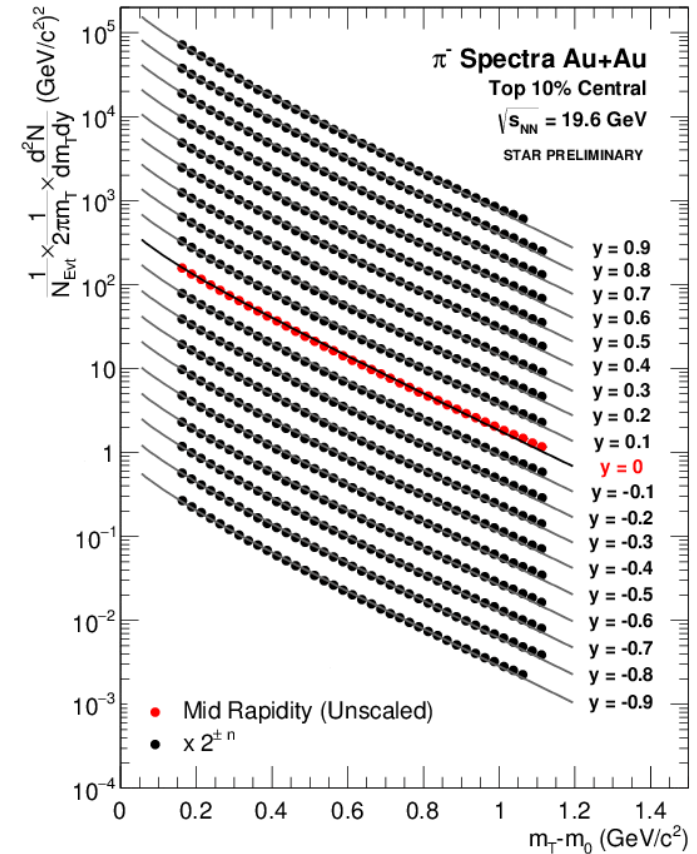
Spectra corrected for detector efficiency and acceptance in each rapidity bin

Spectra Fit with two parameter Bose-Einstein

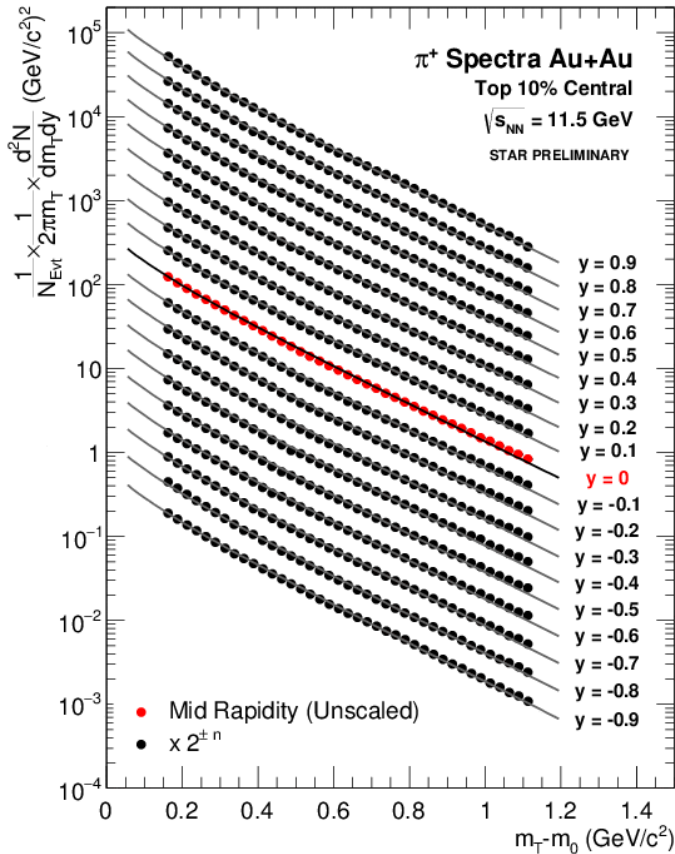
Fit is extrapolated into unmeasured region and integrated to obtain dN/dy

Points with $m_T - m_0 < .5$ (GeV/c²) are obtained from TPC (dE/dx)

Points with $m_T - m_0 \geq .5$ (GeV/c²) are obtained from TOF (1/β)



Identified Pion Spectra at 11.5 GeV



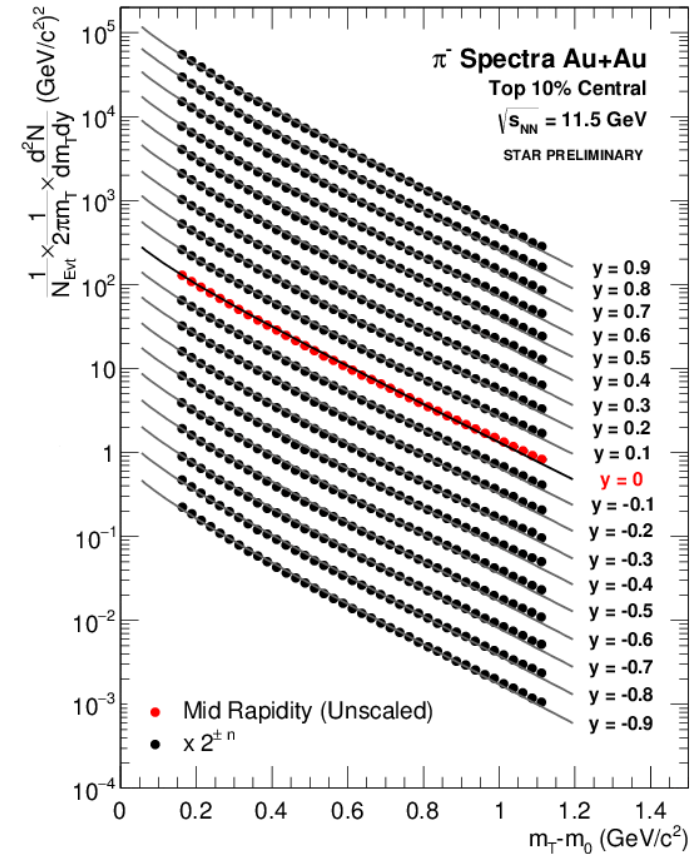
Spectra corrected for detector efficiency and acceptance in each rapidity bin

Spectra Fit with two parameter Bose-Einstein

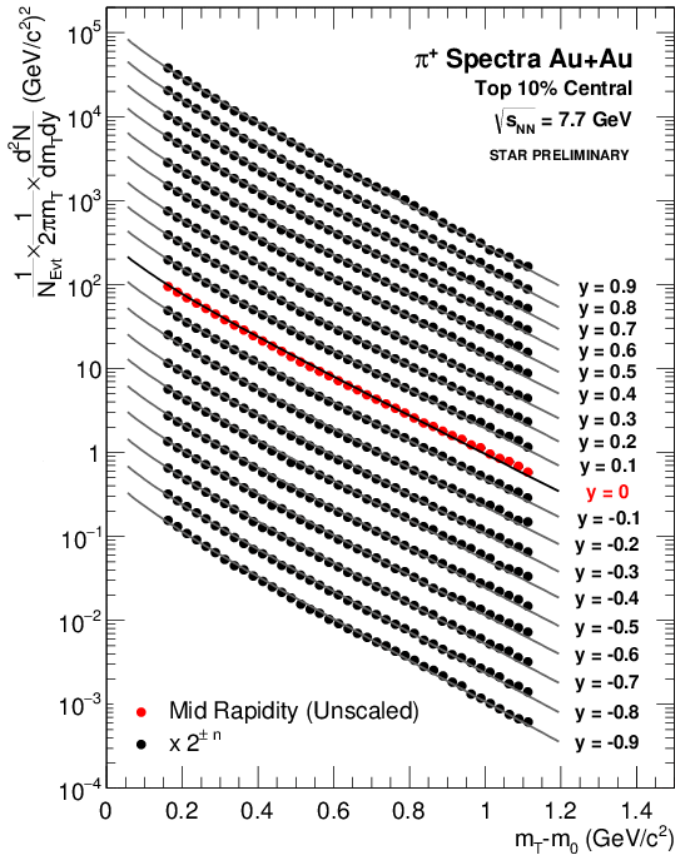
Fit is extrapolated into unmeasured region and integrated to obtain dN/dy

Points with $m_T - m_0 < .5$ (GeV/c²) are obtained from TPC (dE/dx)

Points with $m_T - m_0 \geq .5$ (GeV/c²) are obtained from TOF ($1/\beta$)



Identified Pion Spectra at 7.7 GeV



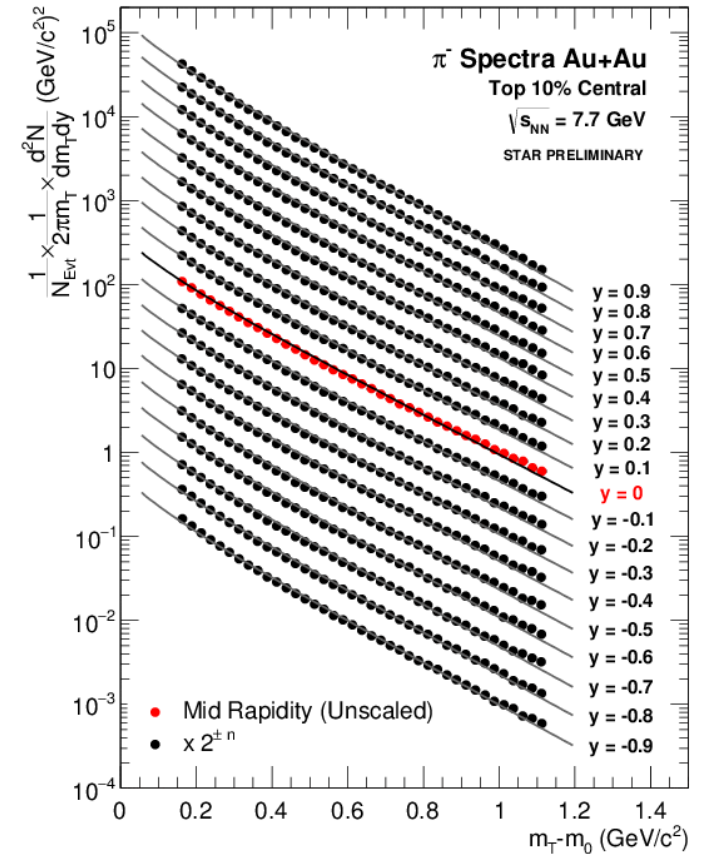
Spectra corrected for detector efficiency and acceptance in each rapidity bin

Spectra Fit with two parameter Bose-Einstein

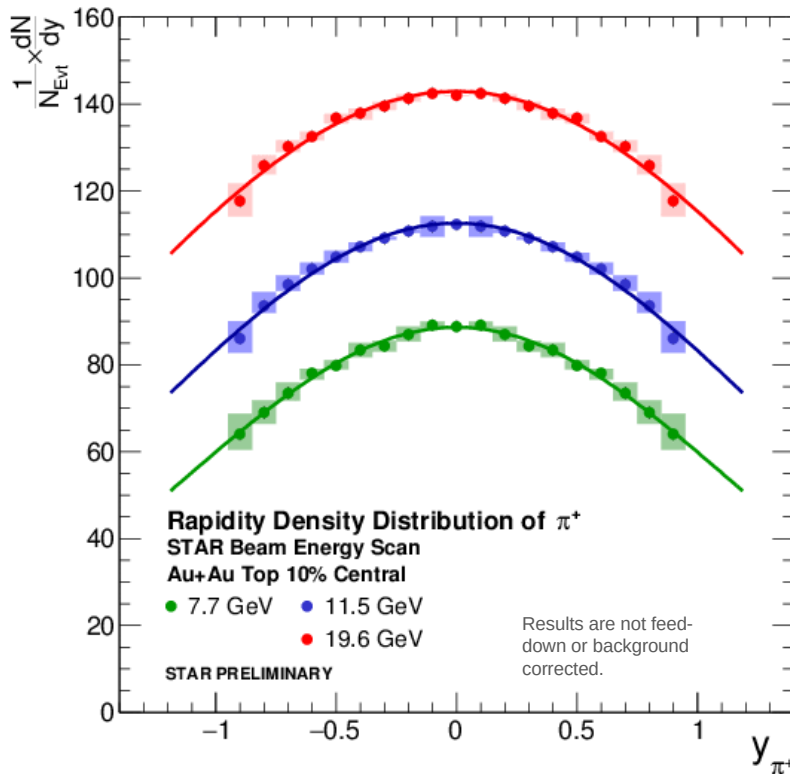
Fit is extrapolated into unmeasured region and integrated to obtain dN/dy

Points with $m_T - m_0 < .5$ (GeV/c²) are obtained from TPC (dE/dx)

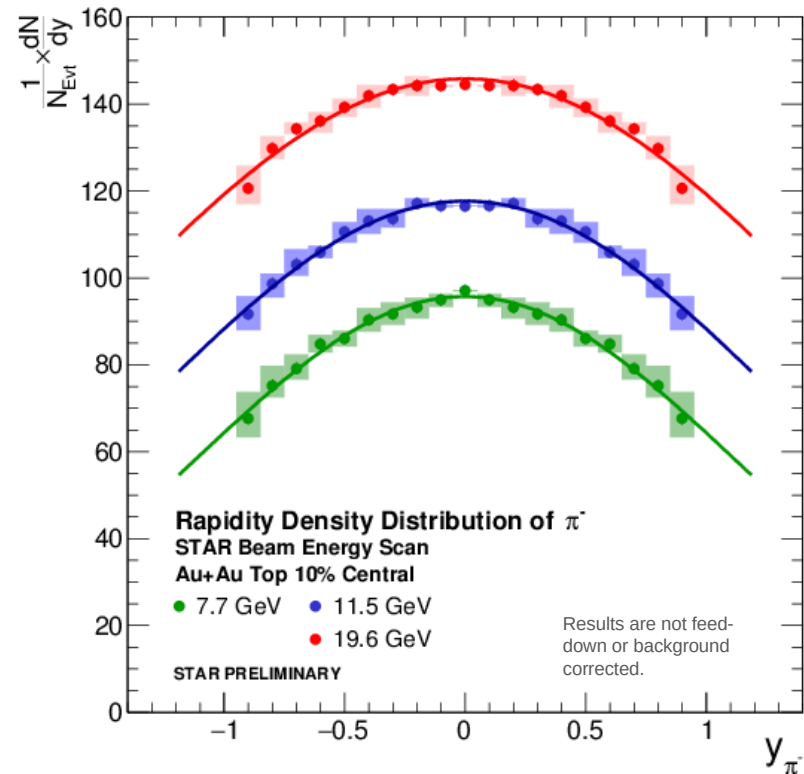
Points with $m_T - m_0 \geq .5$ (GeV/c²) are obtained from TOF ($1/\beta$)



Rapidity Density Distributions of π

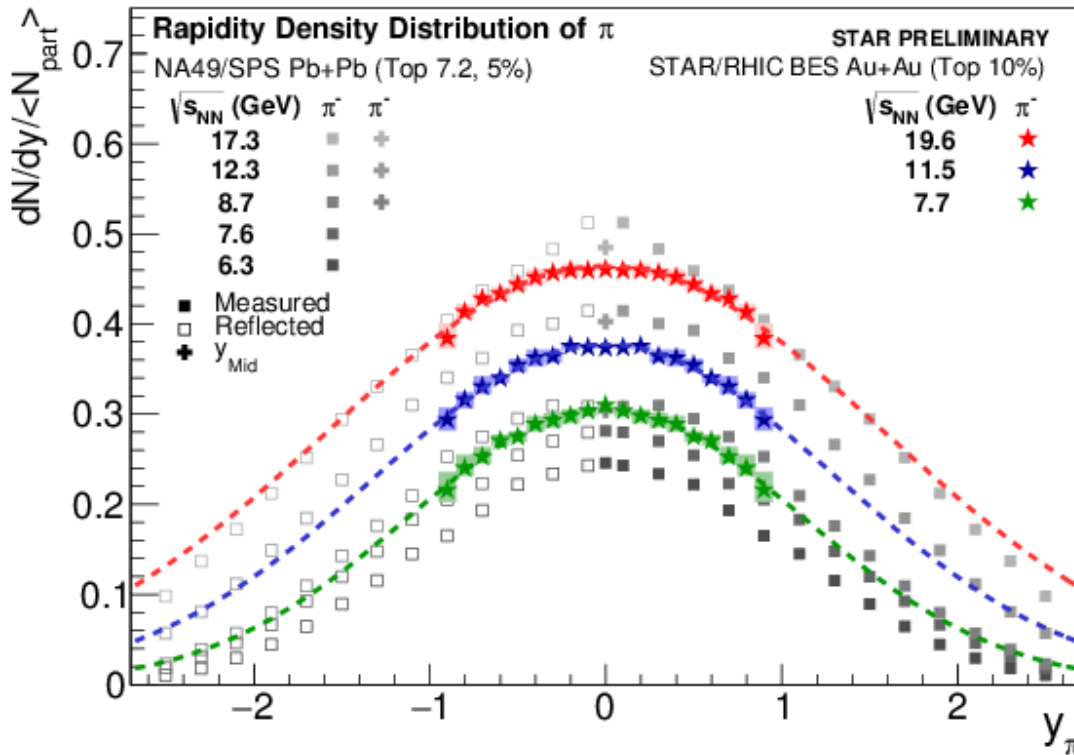


Forward/Backward asymmetries remaining after efficiency and acceptance corrections are included as systematic errors.



Distributions are fit with Gaussian functions with means fixed to $y = 0$.

Comparison with NA49



NA49: S. V. Afanasiev et al. PRC 66, 054902 (2002)

System size dependence
is removed by $\langle N_{Part} \rangle$
scaling

STAR's acceptance
permits measurements
forward and backward of
mid-rapidity

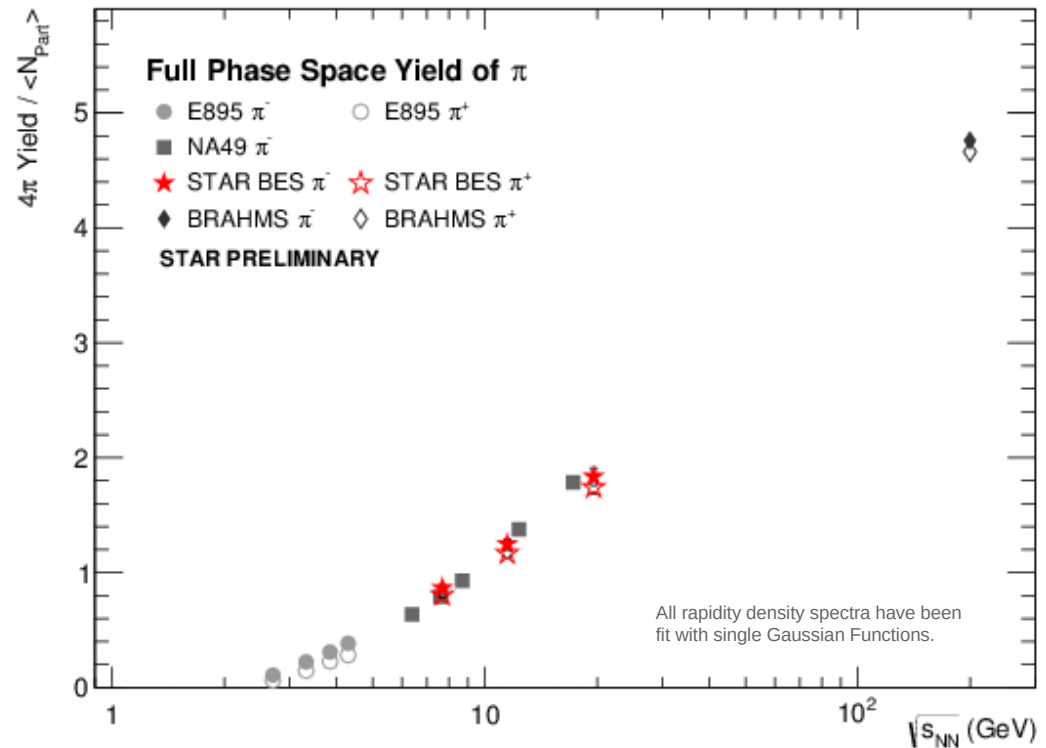
Full Phase Space Yields



STAR results continue the trend of full phase space yields

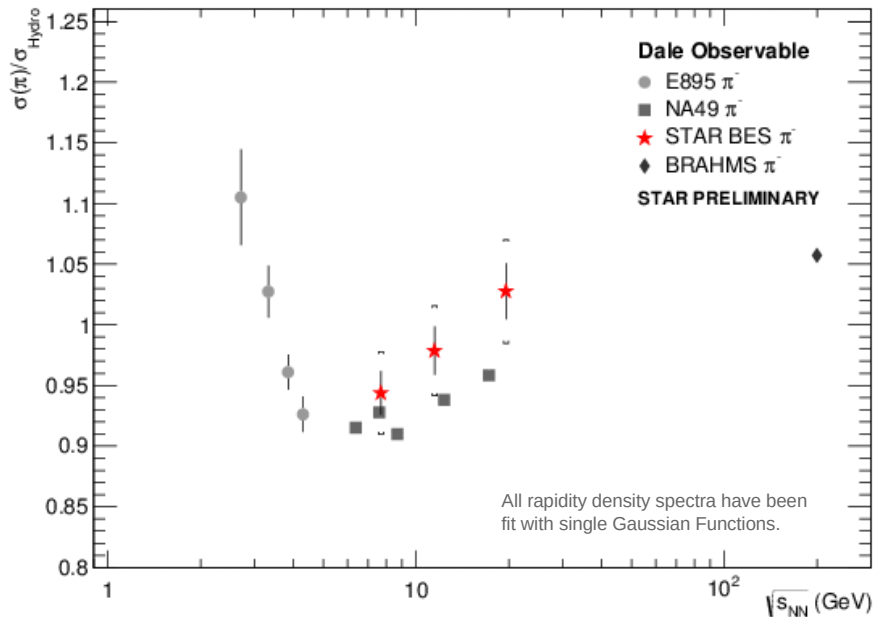
STAR results include both π^+ and π^- (only π^- in this energy range previously)

STAR data points include both statistical and systematic errors



E895: J. L. Klay et al, PRC 68, 05495 (2003)
NA49: S. V. Afanasiev et al. PRC 66, 054902 (2002)
BRAHMS: I.G. Bearden et al., PRL 94, 162301

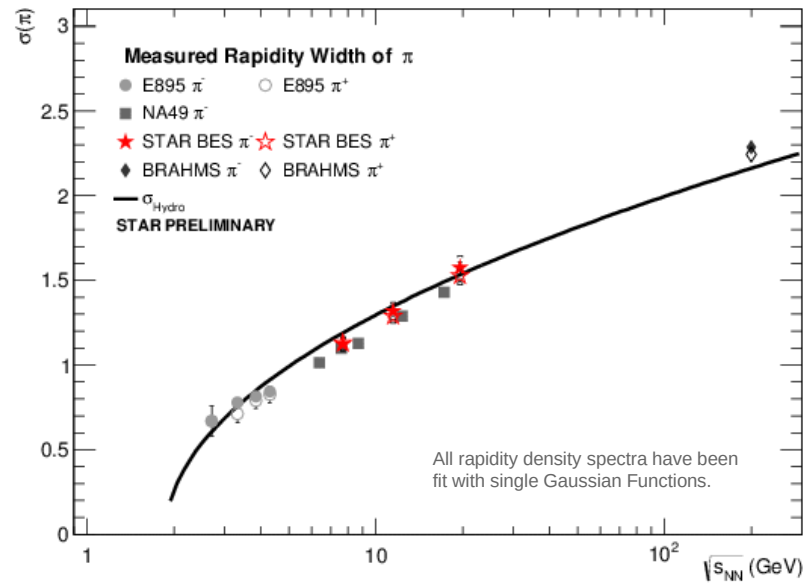
Dale Observable



E895: J. L. Klay et al, PRC 68, 05495 (2003)
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 BRAHMS: I.G. Bearden et al., PRL 94, 162301

STAR Data points include both statistical and systematic errors.

STAR sees an increase in the ratio of the measured pion width to the predicted hydro width confirming trend of previous NA49 measurements.



$\sigma_y(\text{hydro})$: P. Carruthers and M. Duong-van, Phys.Lett. B41, 597 (1972)

Summary



STAR has measured the transverse mass spectra of identified pions over a broad rapidity range for the first time from the lower energies of the beam energy scan.

The Spectra have been used to:

Obtain the rapidity density distributions

Shown Comparison with NA49's Results

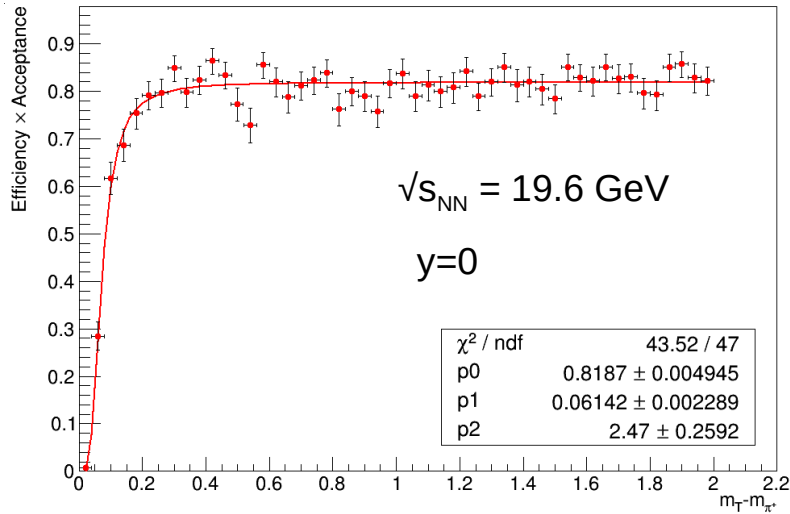
Extract full phase space yields

STAR contributes **both** π^+ and π^-

Study the expansion dynamics

STAR observes increase in $\sigma(\pi)/\sigma(\text{hydro})$ as a function of $\sqrt{s_{NN}}$ in measured range

Back-Up: Efficiency and Acceptance



Efficiency X Acceptance obtained for each energy and rapidity bin via embedding Monte-Carlo Tracks into real data.

