Strange Baryon Production and AntiBaryon to Baryon Ratios in RHIC Beam Energy Scan Program

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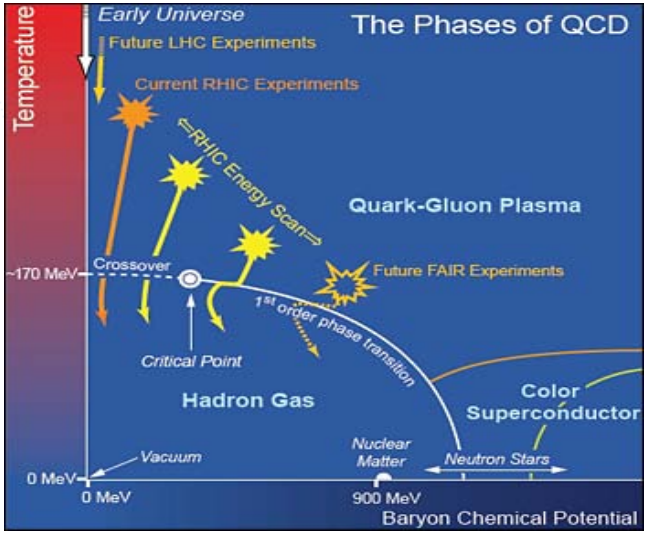
For the STAR Collaboration

Outline

- Physics Motivation
- STAR Detector
- Data Set and Signal Reconstruction
- Analysis Result
- Summary

Physics Motivation



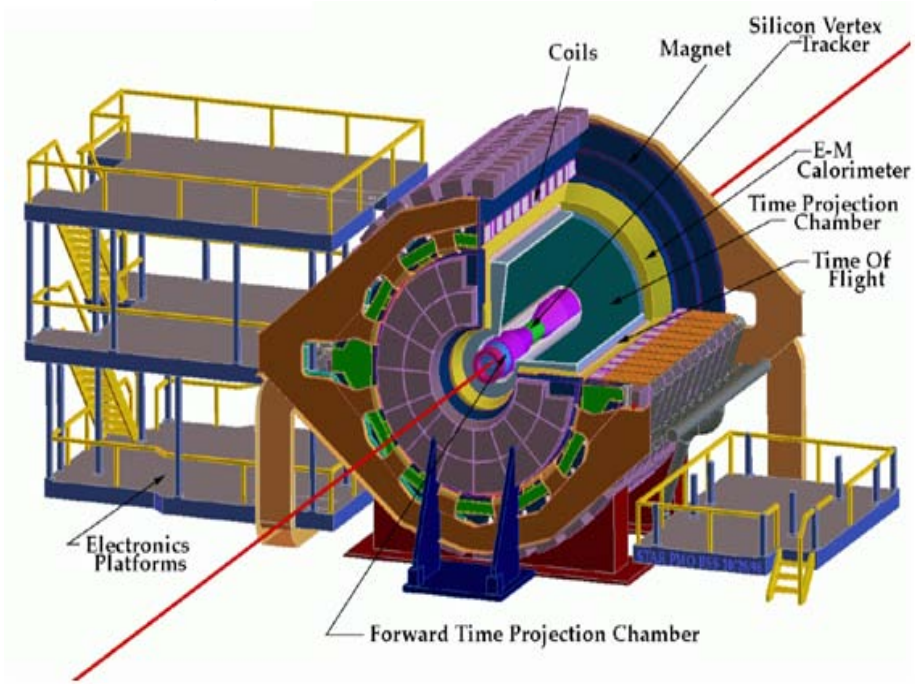
- BES Program:

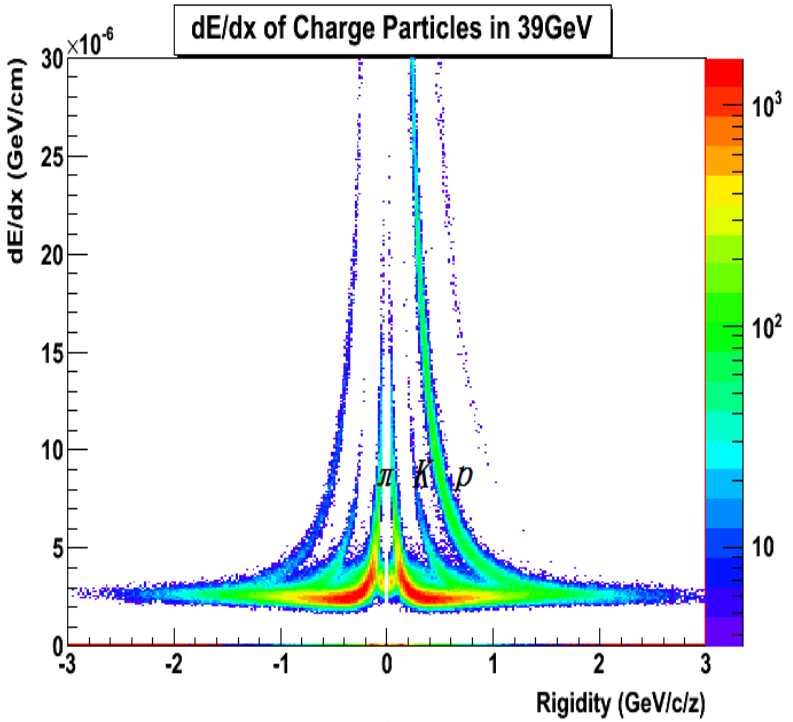
1) Study the phase boundary;
2) Search for the possible QCD critical point

http://drupal.star.bnl.gov/STAR/starnotes/public/sn0493 arXiv: 1007.2613

- Strangeness is sensitive to the dynamics of deconfined quark-gluon matter created in heavy ion collisions.
- Strange baryon production and anti-baryon to baryon ratios can be used to test the statistical thermal model, in particular the strange equilibration of the collision system.

STAR Detector





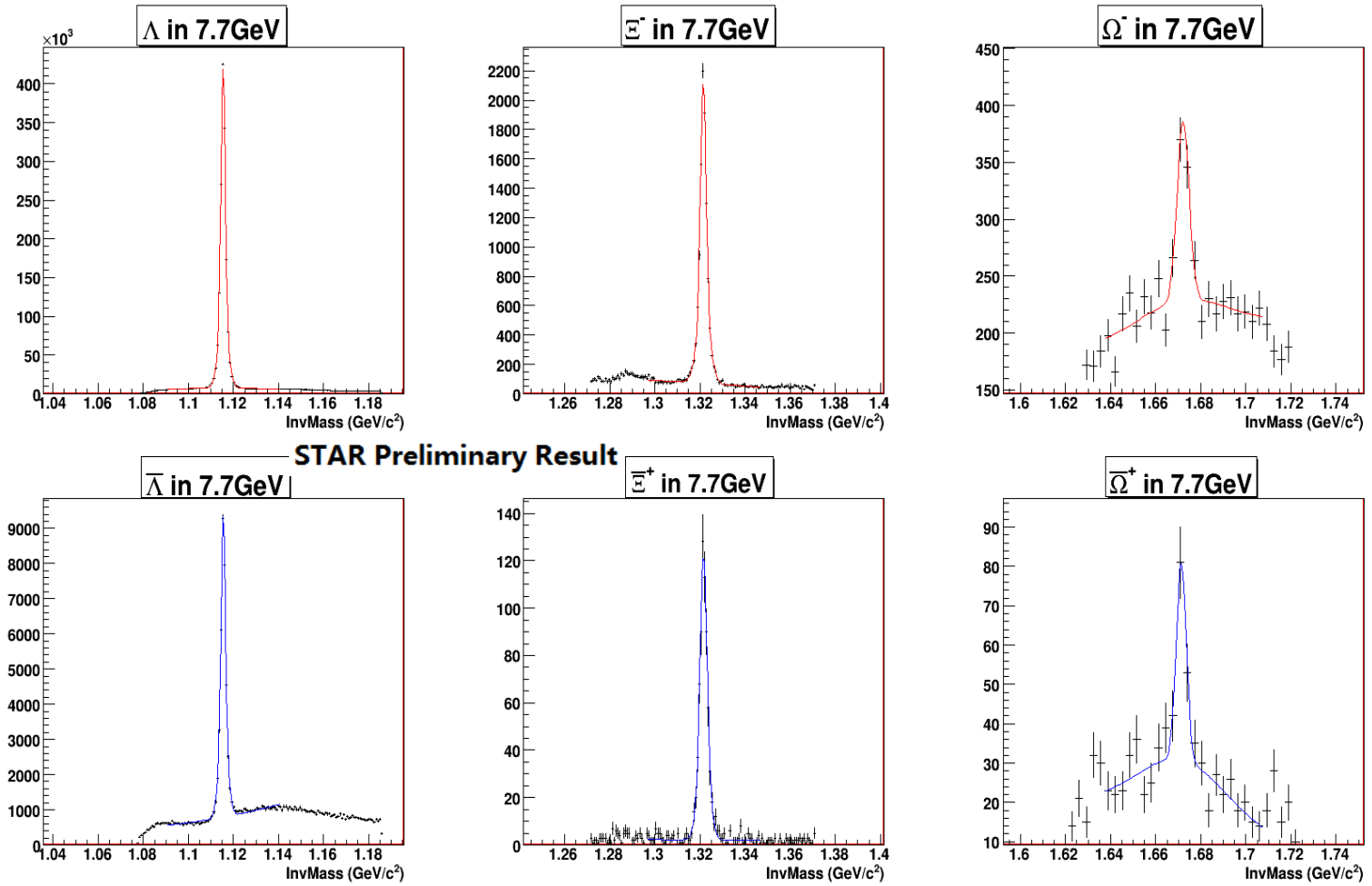
- Time Projection Chamber is used for particle identification.

Data Set

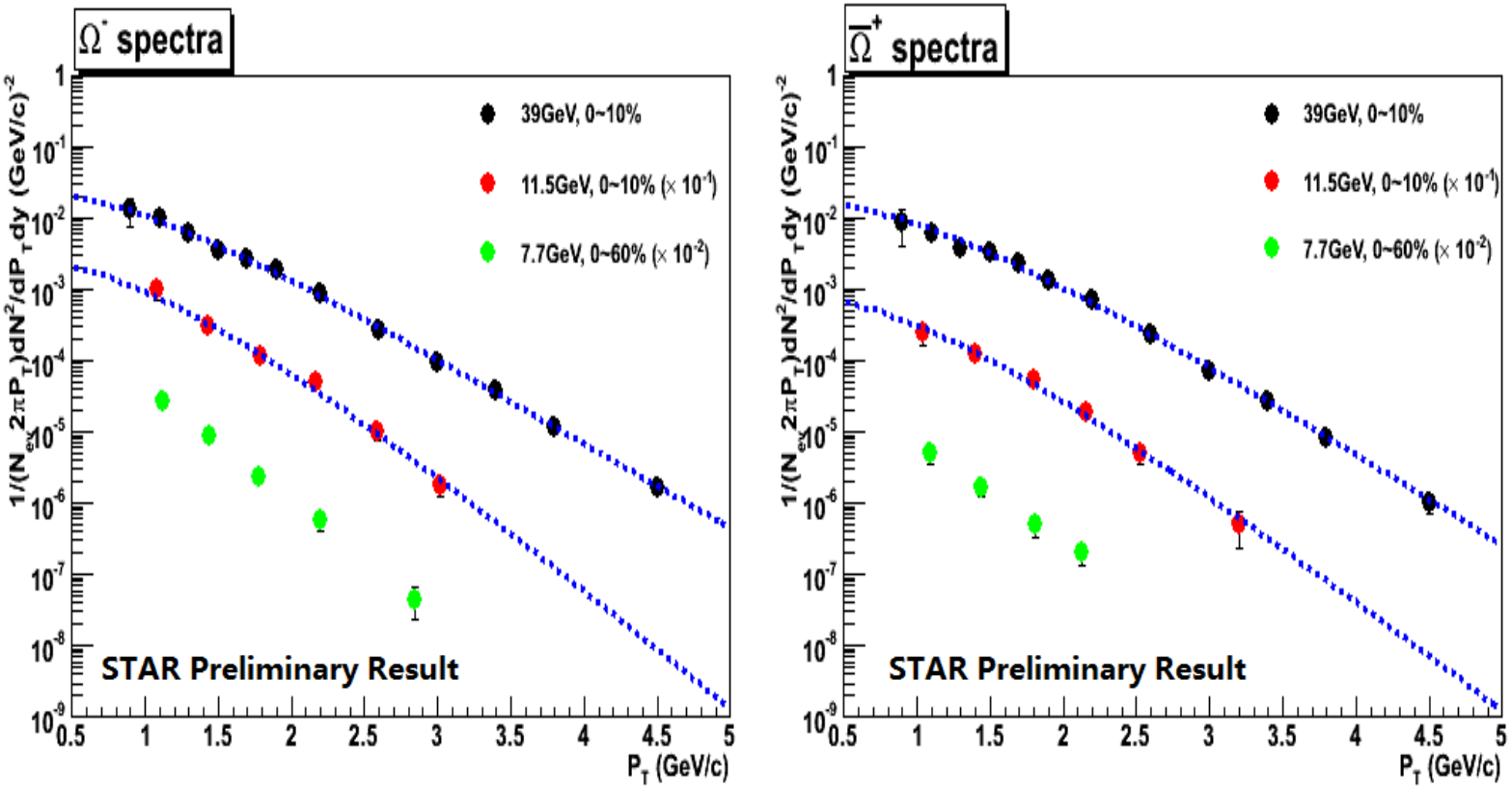
Center Mass Energy	Number of Events
7.7 GeV	5 million
11.5 GeV	16.5 million
39 GeV	136 million

Decay Channel	Branching Ratio
$\Lambda \rightarrow p + \pi$	63.9%
$\Xi \rightarrow \Lambda + \pi$	99.887%
$\Omega \rightarrow \Lambda + K$	67.8%

Signal Reconstruction

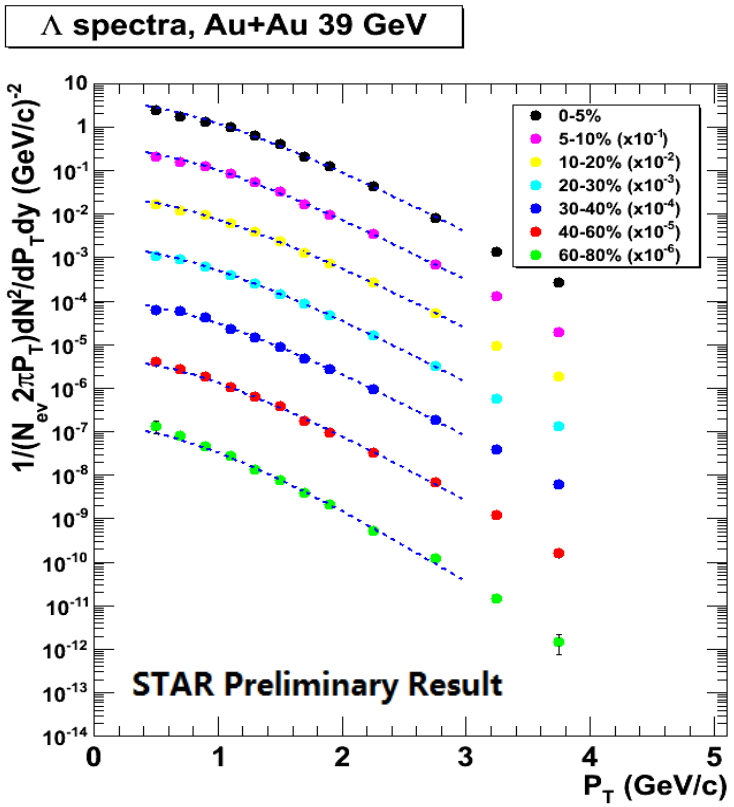


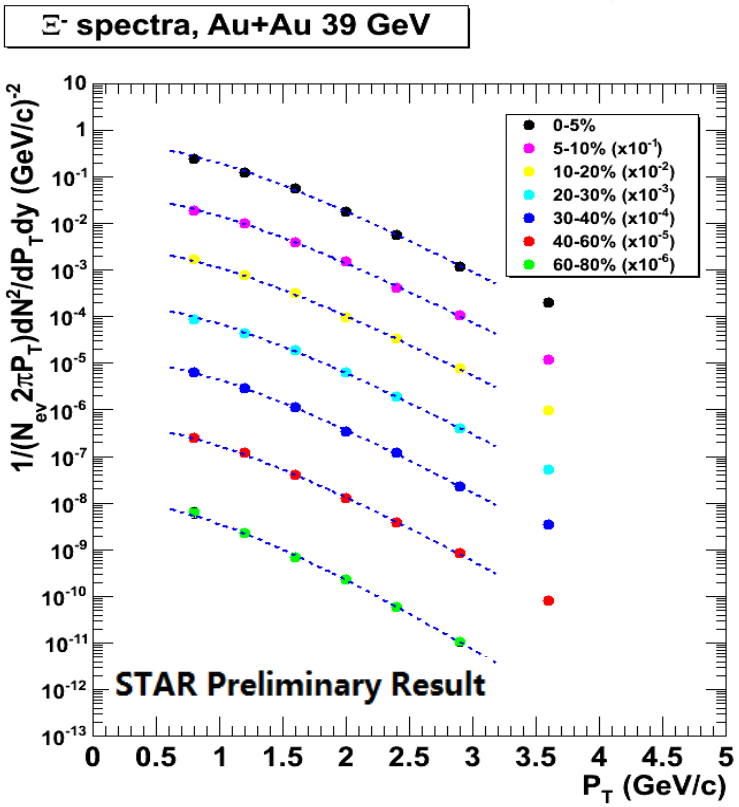
Transverse Momentum Spectra



- Yields of measured pT range are used in the following analysis.
- Statistical error only.

Transverse Momentum Spectra





- Yields of measured pT range are used in the following analysis.
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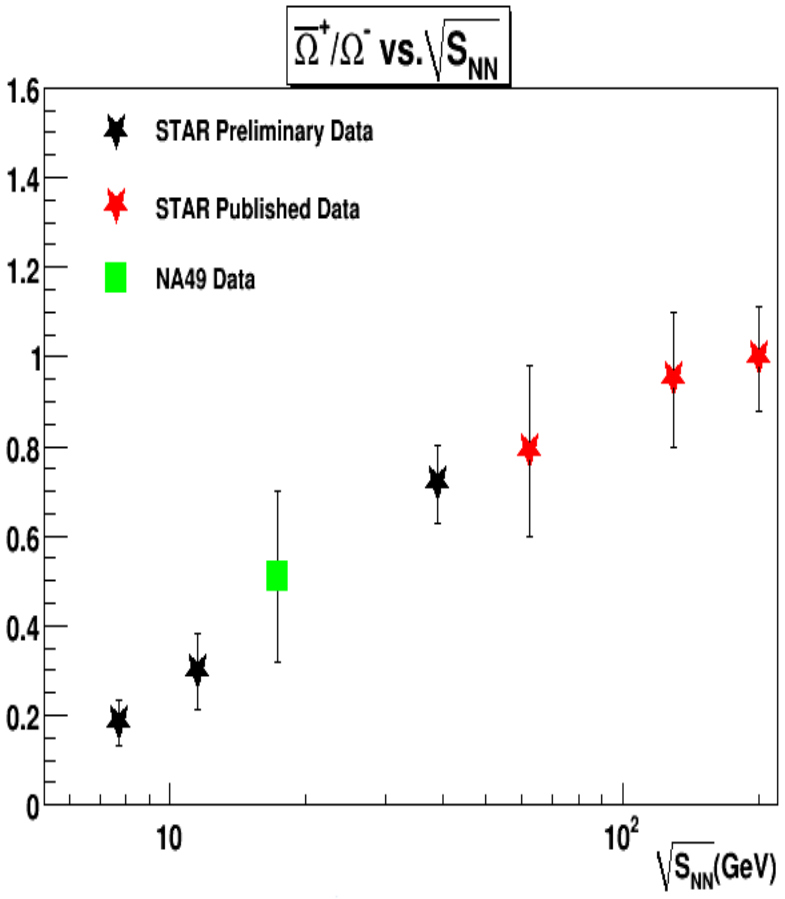
Anti-Omega to Omega Ratio



- Statistical error only.

References:

NA49:
PhysRevLett.94.192301

STAR:
PhysRevC.83.024901(2011)
Phys.Lett.B567:167-174,2003
Nucl.Phys.A 715(2003)470-4735

Energy (GeV)	Rapidity |y|	Centrality
7.7	<0.5	0~60%
11.5	<0.5	0~10%
39	<0.5	0~10%
62	<1.0	0~20%
130	<1.0	0~11%
200	<0.75	0~10%
158A	<0.5	0~23.5%

Statistical Thermal Model

$$\frac{\bar{\Lambda}}{\Lambda} = \exp(-\frac{2\mu_B}{T} + \frac{2\mu_S}{T}) \qquad \ln(\frac{\bar{\Lambda}}{\Lambda}) = -\frac{2\mu_B}{T} + \frac{2\mu_S}{T}$$

$$\frac{\bar{\Xi}^+}{\Xi^-} = \exp(-\frac{2\mu_B}{T} + \frac{4\mu_S}{T}) \Rightarrow \ln(\frac{\bar{\Xi}^+}{\Xi^-}) = -\frac{2\mu_B}{T} + \frac{4\mu_S}{T}$$

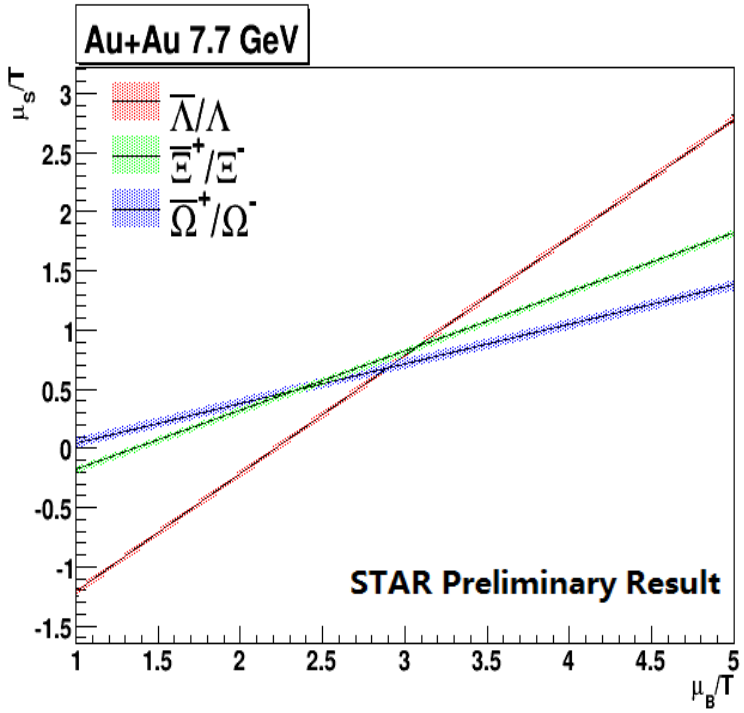
$$\frac{\bar{\Omega}^+}{\Omega^-} = \exp(-\frac{2\mu_B}{T} + \frac{6\mu_S}{T}) \qquad \ln(\frac{\bar{\Omega}^+}{\Omega^-}) = -\frac{2\mu_B}{T} + \frac{6\mu_S}{T}$$

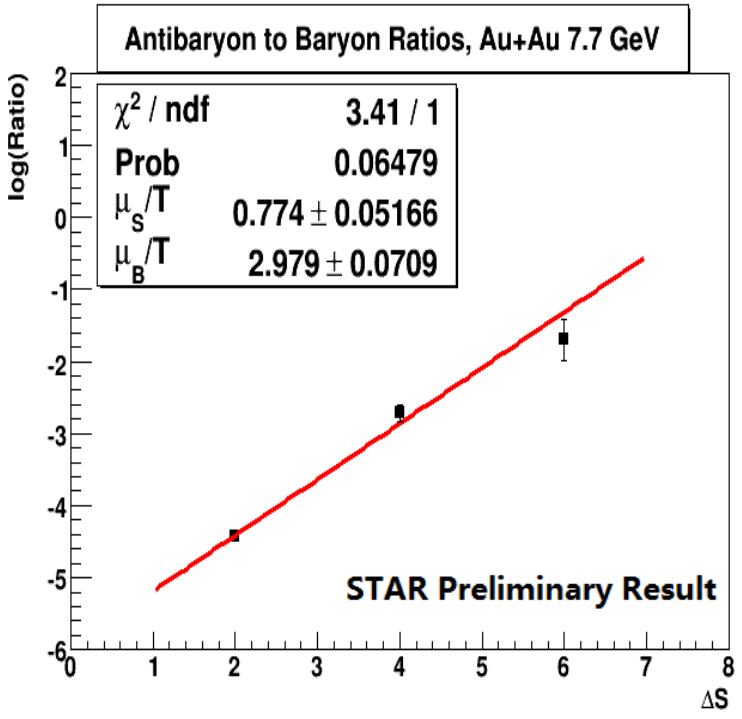
- T is the temperature.
- μ_B is the baryon chemical potential.
- μ_S is the strangeness chemical potential.

(arXiv:nucl-th/9704046v1 by J.Cleymans)

7.7 GeV

$$\ln(Ratio) = -\frac{2\mu_B}{T} + \frac{\mu_S}{T} \times \Delta S$$

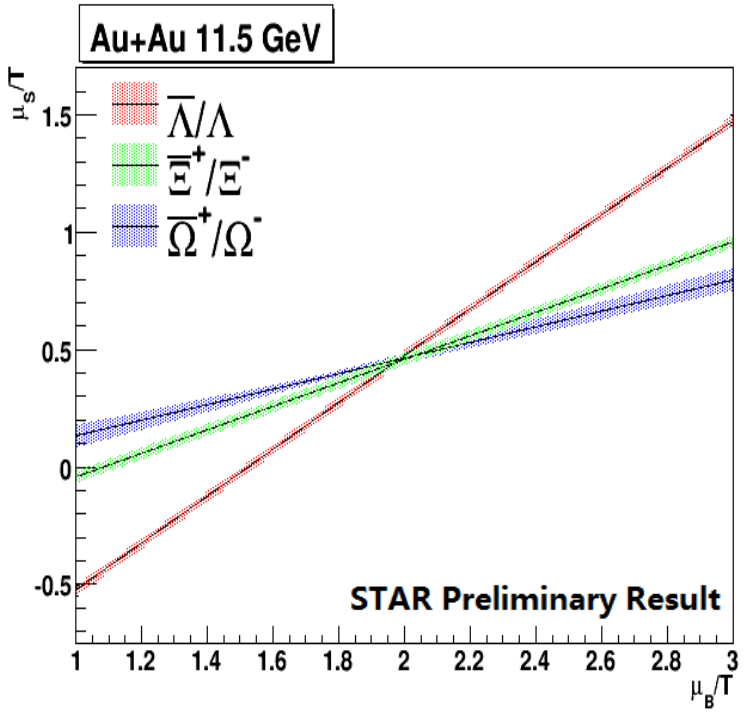


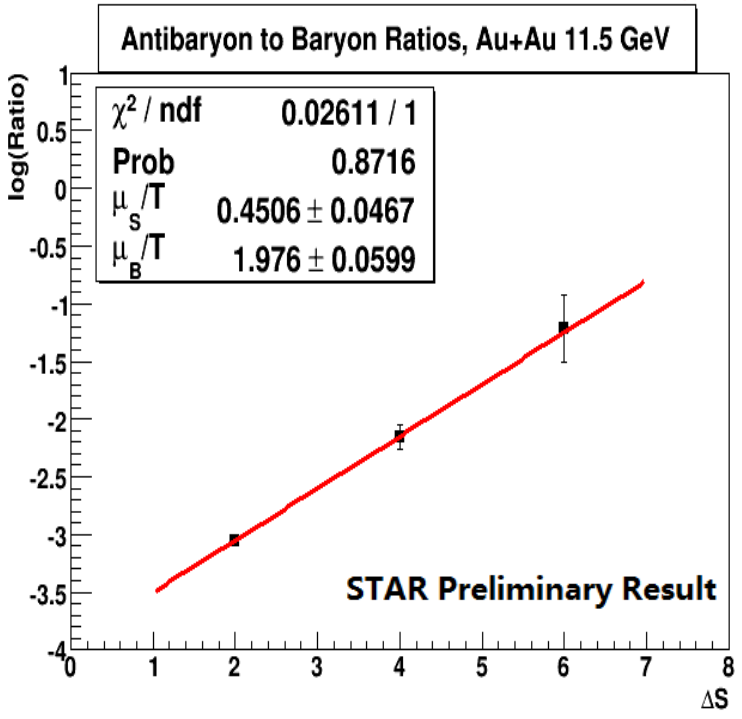


- Statistical error only.

11.5 GeV

$$\ln(Ratio) = -\frac{2\mu_B}{T} + \frac{\mu_S}{T} \times \Delta S$$

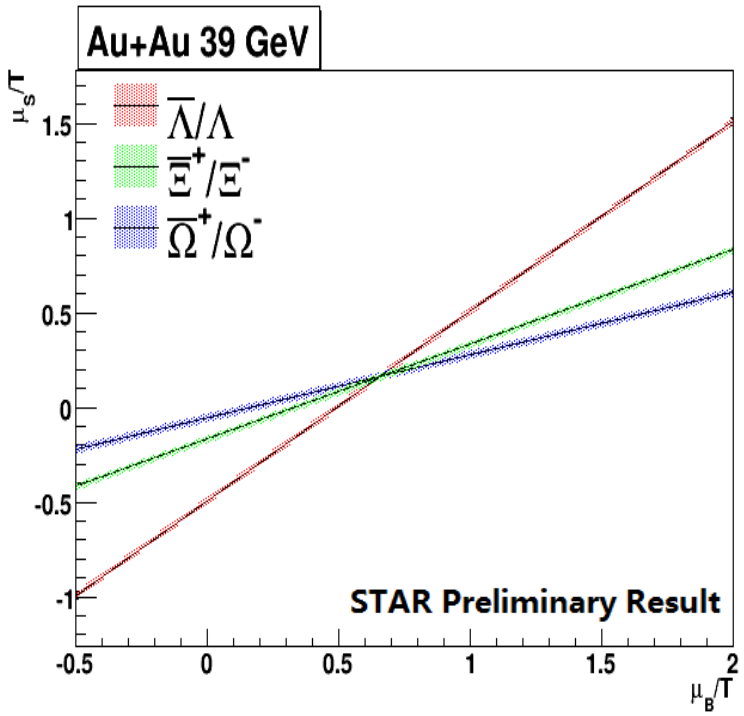


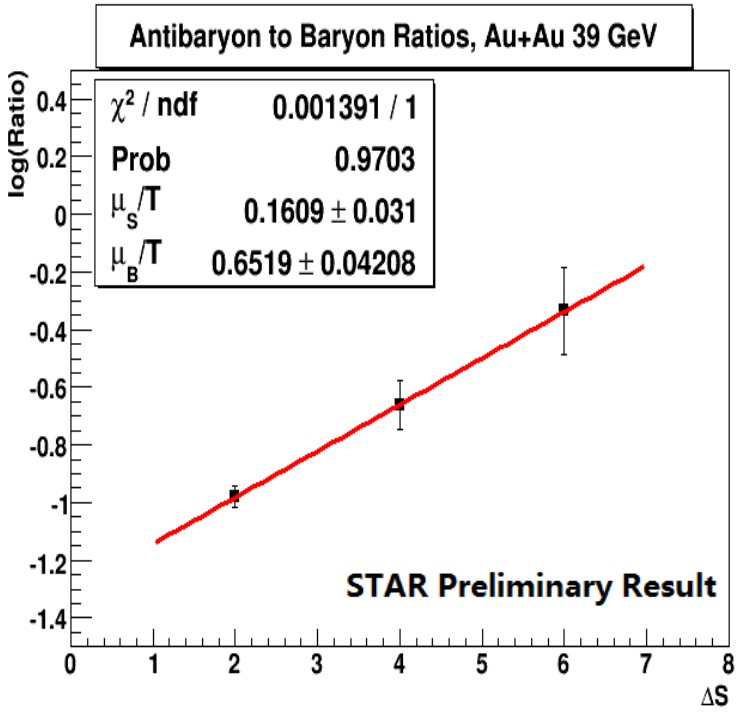


- Statistical error only.

39 GeV

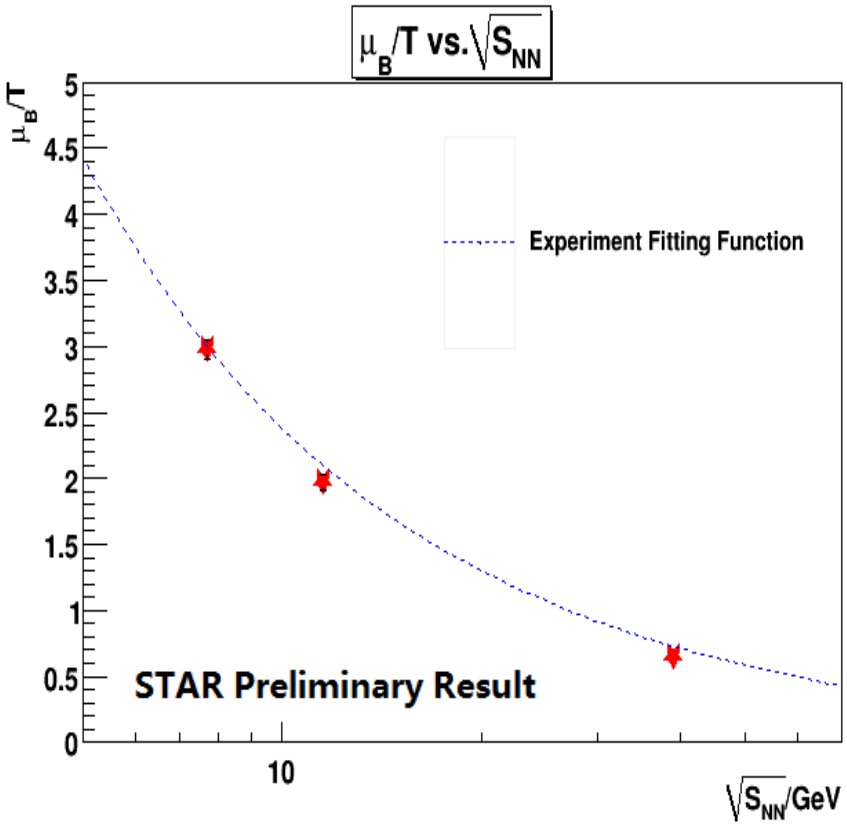
$$\ln(Ratio) = -\frac{2\mu_B}{T} + \frac{\mu_S}{T} \times \Delta S$$





- Statistical error only.

Test Thermal Model



$$T \approx T_0 - b\mu_B^2$$

$$\mu_B = \alpha \frac{\log \sqrt{S_{NN}}}{(\sqrt{S_{NN}})^{\beta}}$$

$Where:$

$T_0 = 167.5 MeV$

$b = 0.1583 GeV^{-2}$

$\alpha = 2.06$

$\beta = 1.13$

Parameters are from the fitting of published data of AGS, SPS and RHIC 130 GeV data.

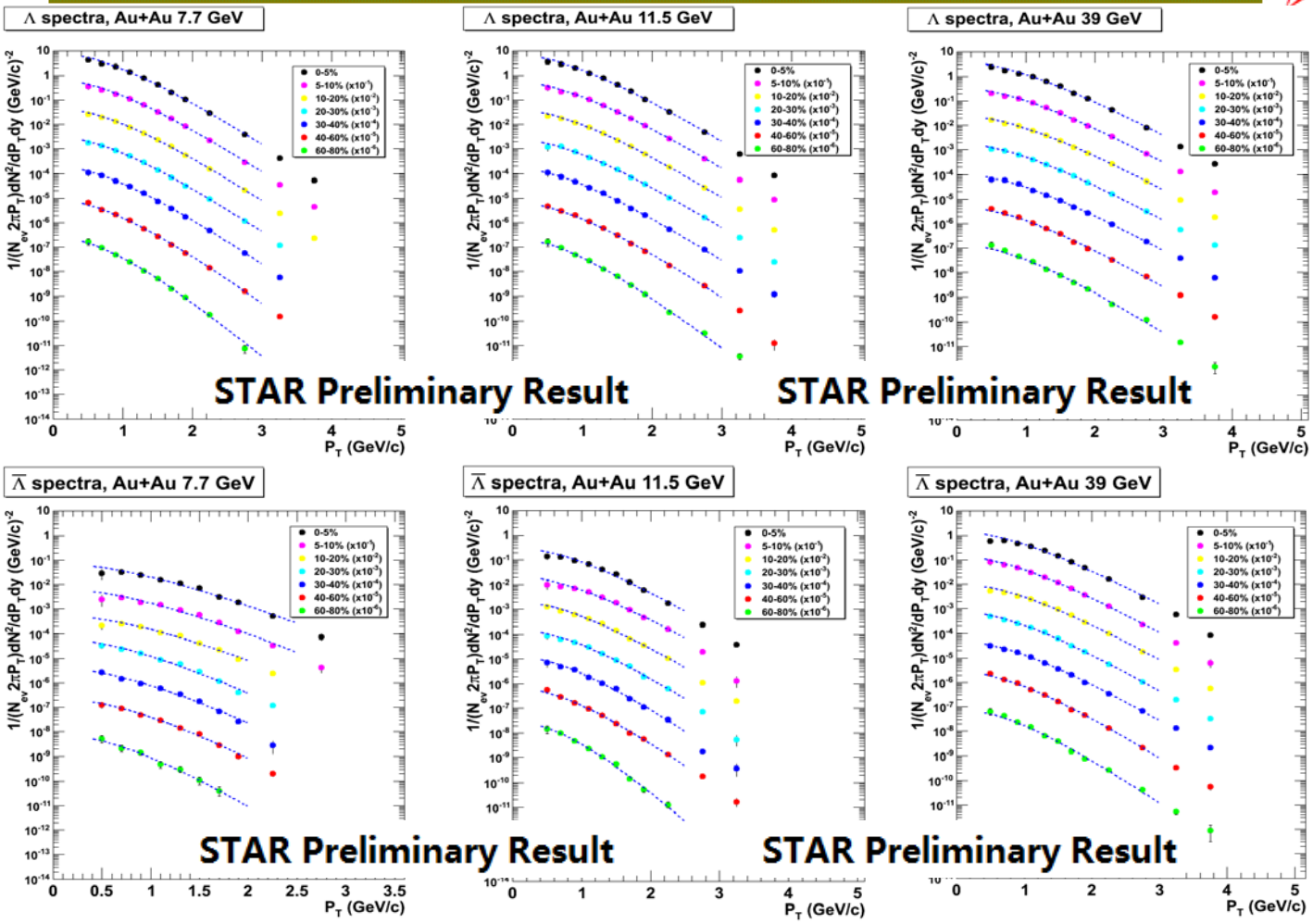
- Reference: F.Becattini et al. PhysRevC 73, 044905 (2006)
- Statistical error only.

Summary

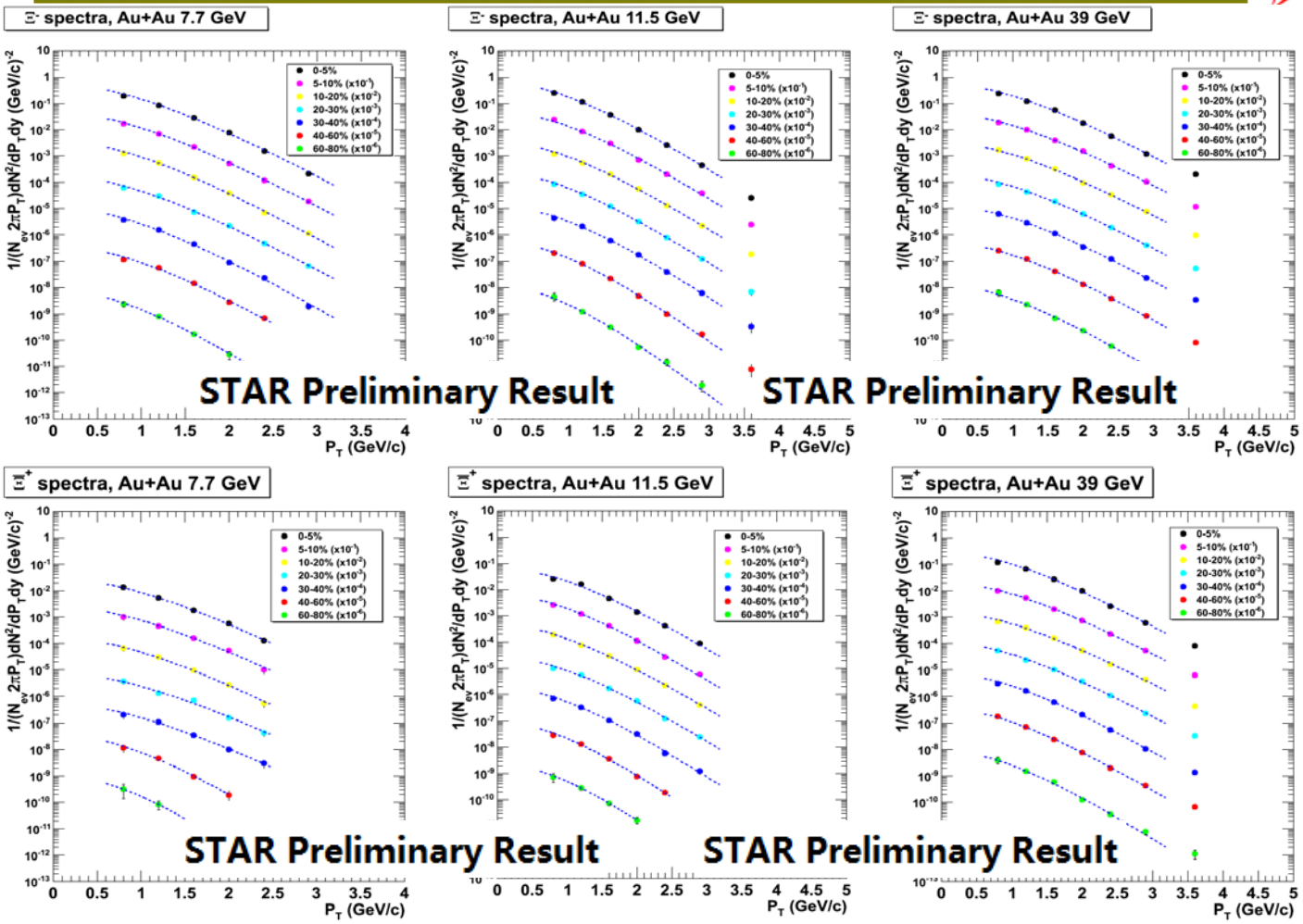
- We have reported the STAR measurement of strange baryon production in central collisions of RHIC beam energy scan program.
- We have compared the strange anti-baryon to baryon ratios with statistical thermal model, to test the validity of equilibrium thermal statistical model calculations.
- We investigated the energy dependence of the baryon and strangeness chemical potentials.

Back Up

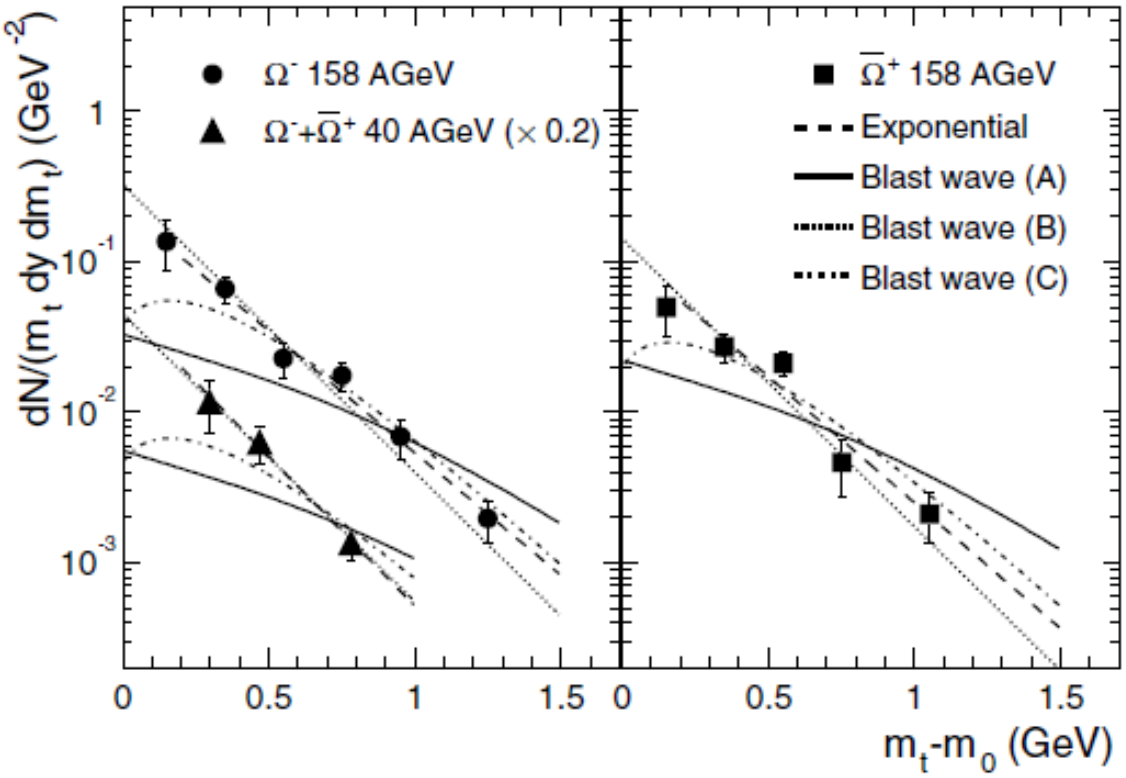
Lambda Spectra



Xi Spectra

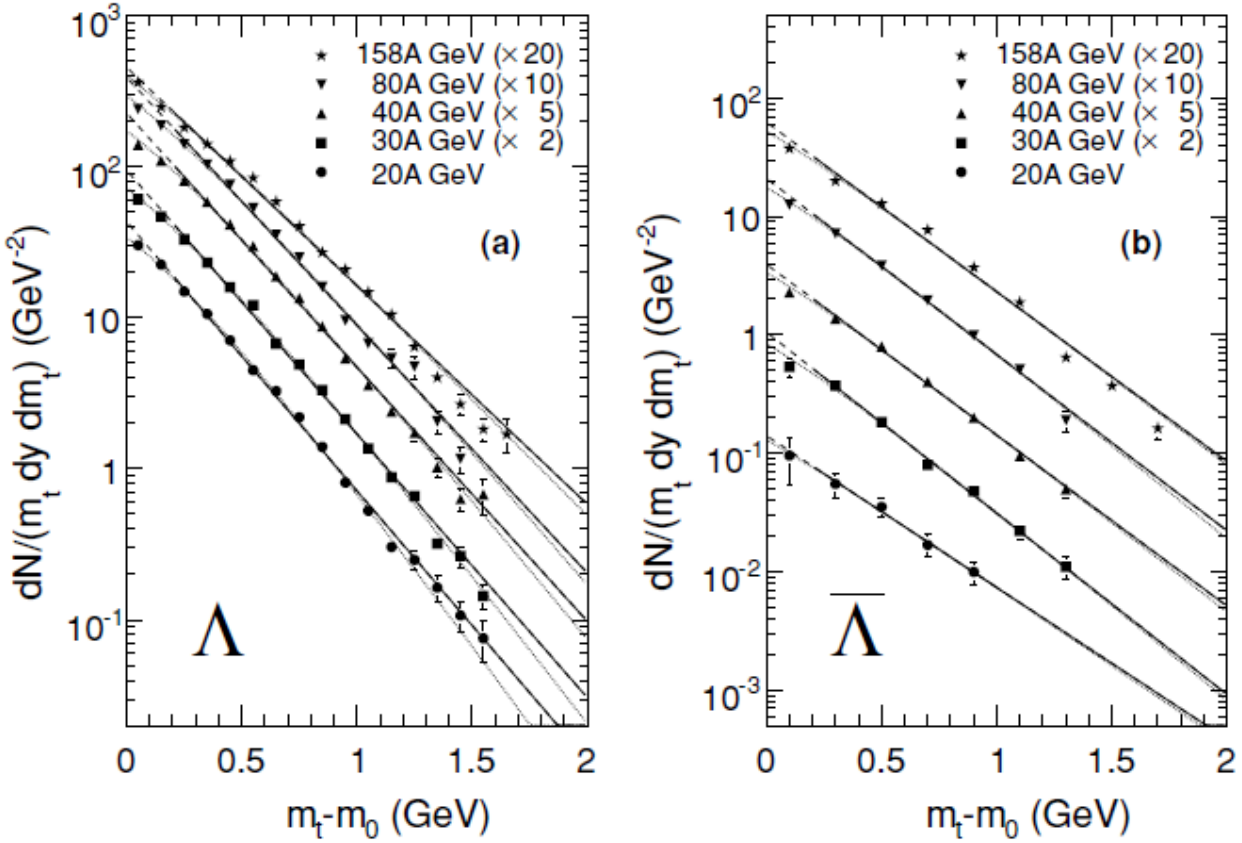

Ξ⁻ spectra, Au+Au 7.7 GeV
Ξ⁻ spectra, Au+Au 11.5 GeV
Ξ⁻ spectra, Au+Au 39 GeV
$\bar{\Xi}^+$ spectra, Au+Au 7.7 GeV
$\bar{\Xi}^+$ spectra, Au+Au 11.5 GeV
$\bar{\Xi}^+$ spectra, Au+Au 39 GeV
0-5%
5-10% (x10⁻¹)
10-20% (x10⁻²)
20-30% (x10⁻³)
30-40% (x10⁻⁴)
40-60% (x10⁻⁵)
60-80% (x10⁻⁶)
$1/(N_{ev} 2\pi P_T) dN^2/dP_T dy$ (GeV/c)$^{-2}$
P_T (GeV/c)
STAR Preliminary Result
STAR Preliminary Result
STAR Preliminary Result
STAR Preliminary Result

NA49 Results



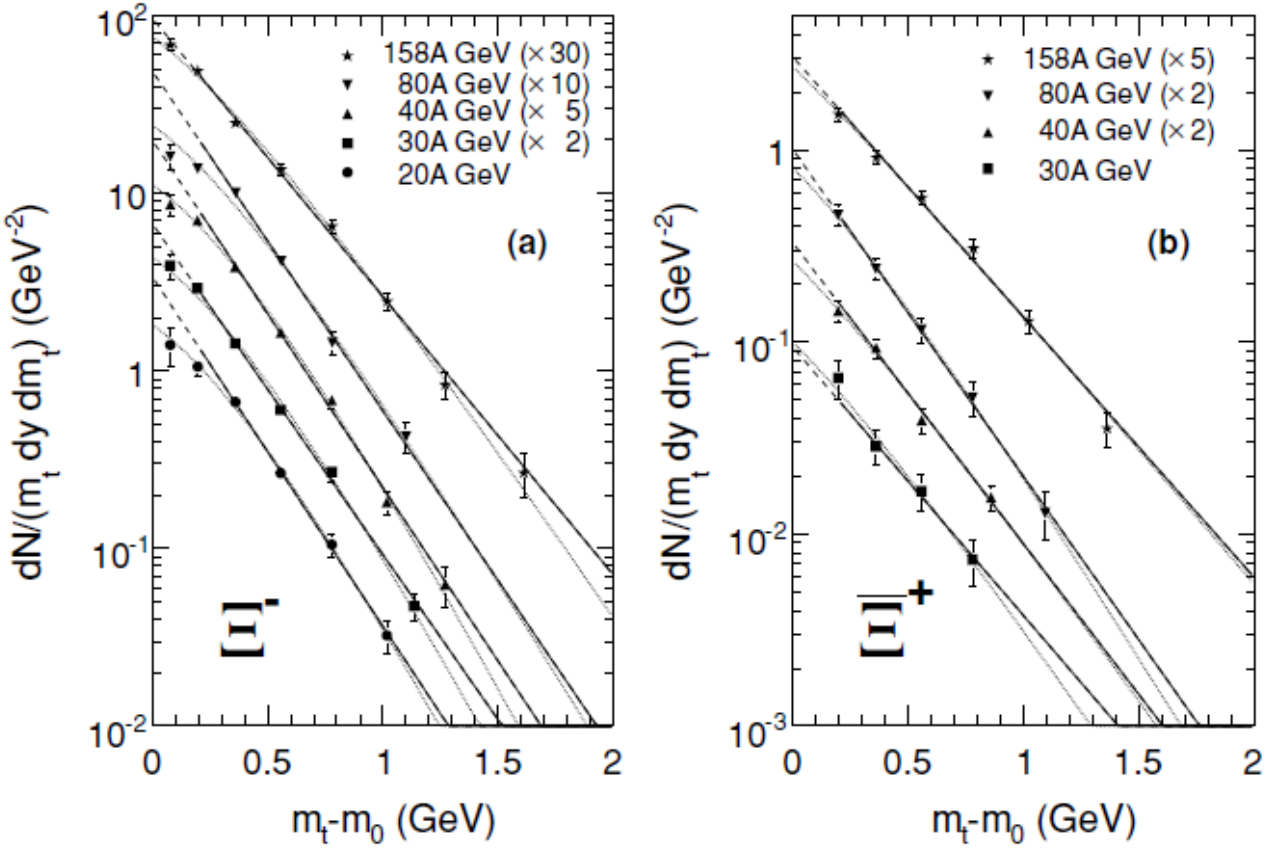
- PhysRevLett.94.192301

NA49 Results



- PhysRevC.78.034918

NA49 Results



- PhysRevC.78.034918