

A Statistical Analysis of Excitation Functions

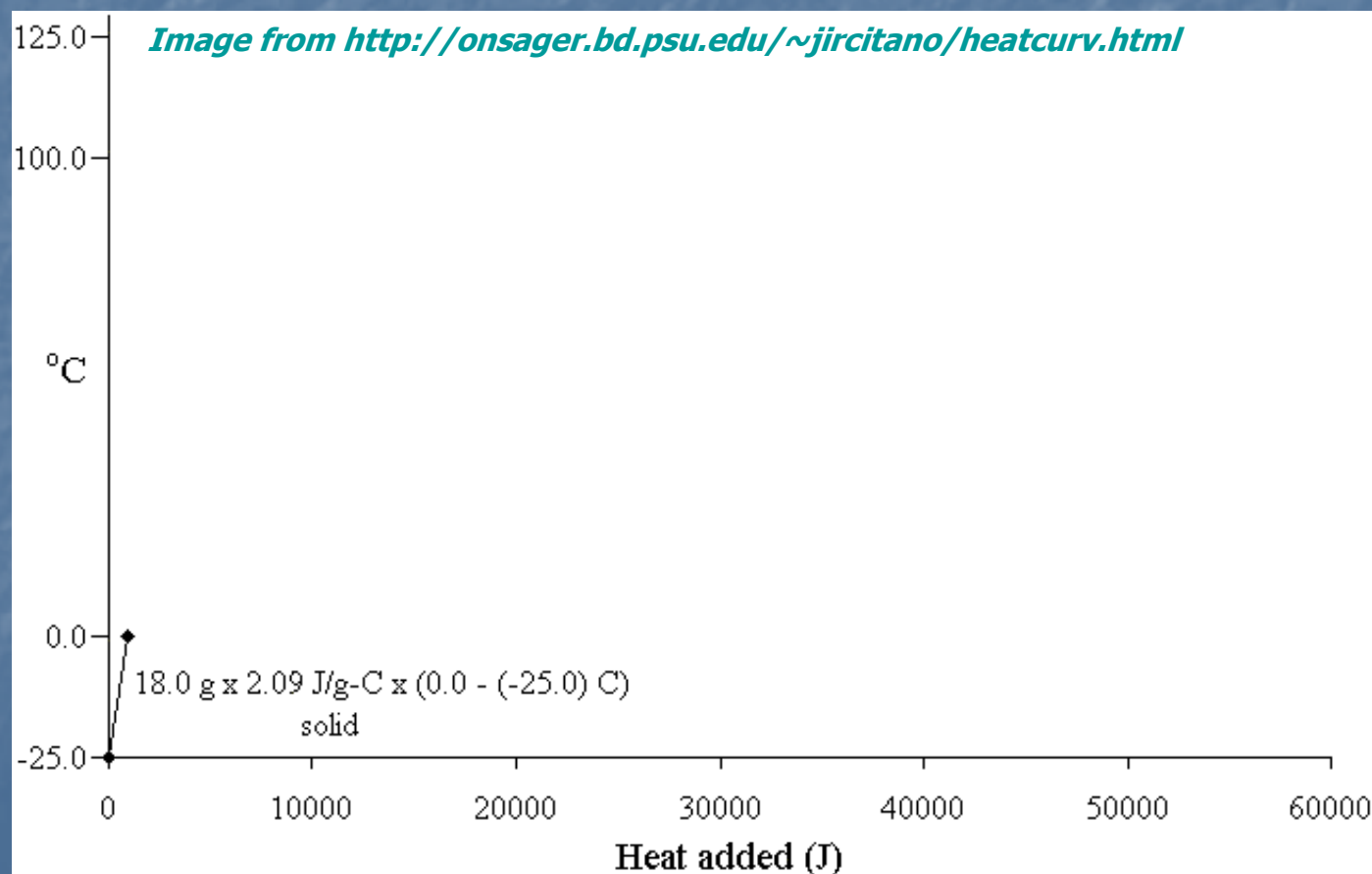
PHENIX-BNL Group Meeting – 11/4/04
Jeffery T. Mitchell
(Brookhaven National Laboratory)

Outline:

- **Motivation**
- **Rules and Procedures**
- **Survey and Analysis of Excitation Functions**
- **Summaries**
- **Conclusions**

Motivation I

- Is there any sign of critical behavior due to a phase transition to the Quark-Gluon Plasma in the available world dataset?

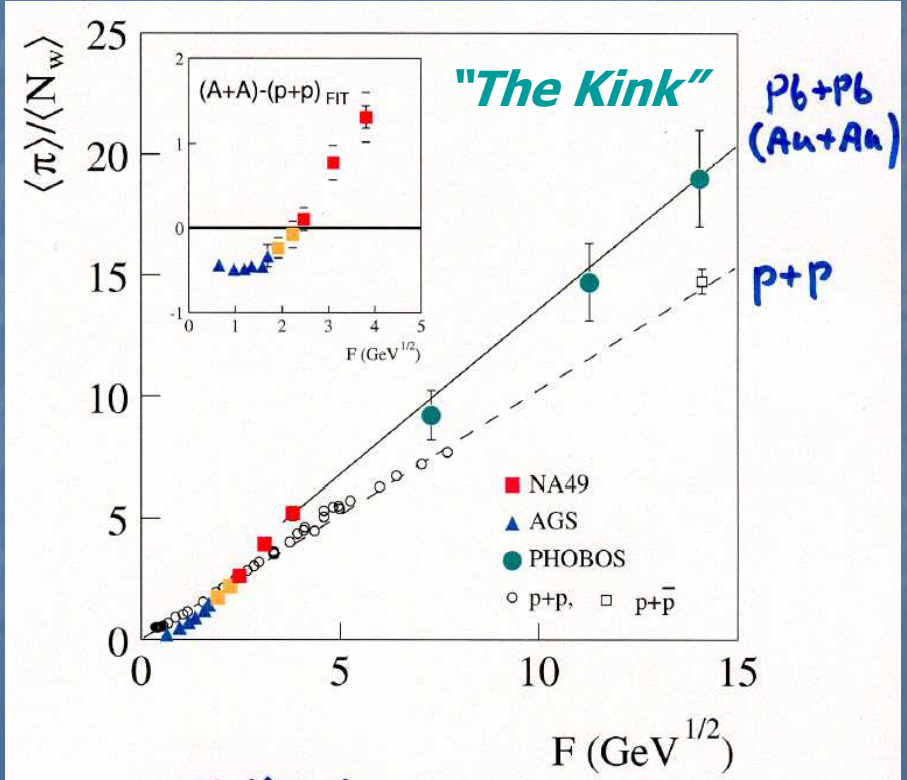
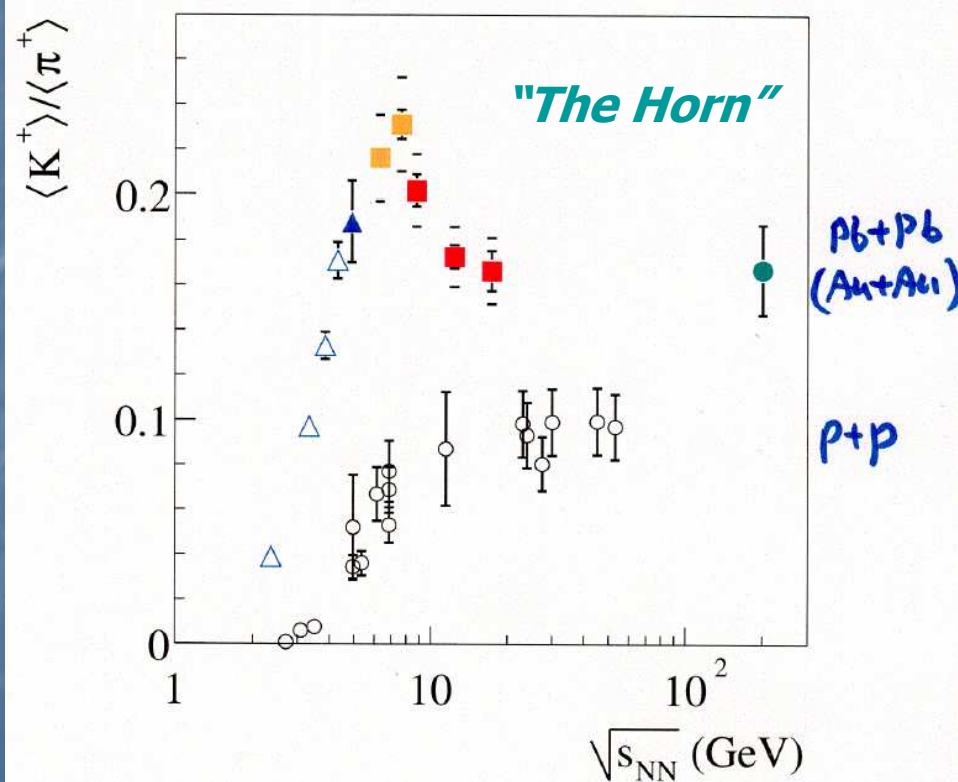


**Example: The
Heating Curve
for Water**

Motivation II

- A scan by eye of excitation functions of relativistic heavy ion observables suggests that there is "something going on" at $\sqrt{s_{NN}} \sim 5-10$ GeV.
- Is this a statistically significant statement?

From M. Gazdzicki for the NA49 Collaboration at QM2004

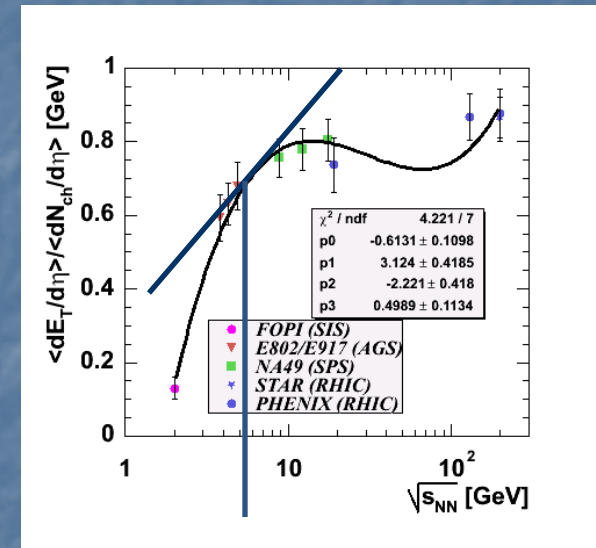


Rules of the Game I

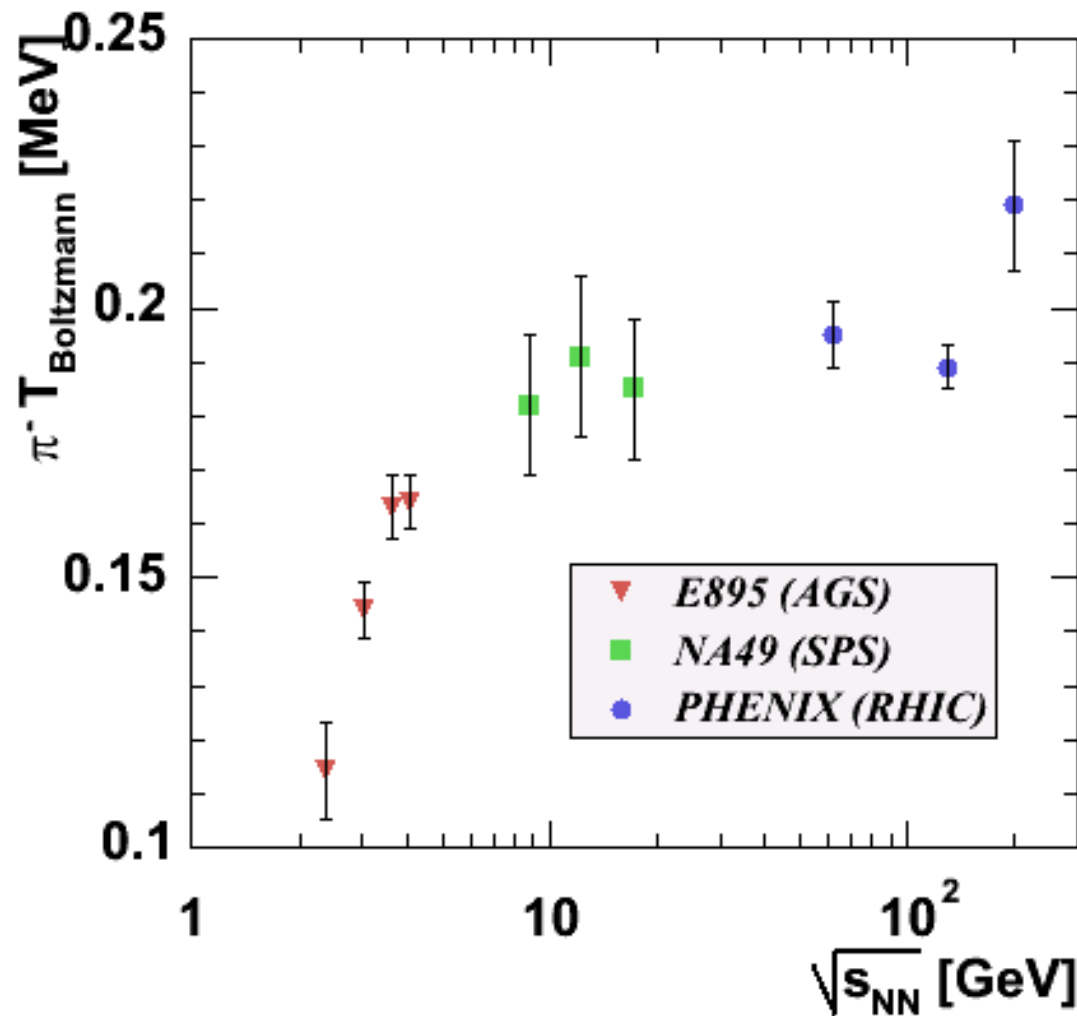
- This is a statistical analysis of 32 excitation functions of various relativistic heavy ion observables.
- Each observable will be plotted as a function of the energy available for particle production cast as $\sqrt{s_{NN}}$ on a log scale.
- Each observable will be fit up to 150 GeV with the following functional forms (meant to be phenomenological forms only):
 - Linear
 - Linear + Linear, continuous curve constraint
 - Linear + 2nd-order polynomial, continuous curve constraint
 - 3rd-order polynomial
- NOTE: The observable will be plotted in the appropriate linear or log scale. The fit will be done to be linear in that scale, so log-log plots are fitted exponentially on the x- and y-axes.
- NOTE: Each point from all experiments is counted, weighted only by the error bars. The error bars include statistical and systematic errors, when available.

Rules of the Game II

- The line, line+line, and line+polynomial fits will be tested for compatibility with the dataset by applying a chi-square goodness-of-fit test down to a 1% Confidence Level (C.L). The result of the test will be stated as follows:
 - C.L. of test passed at the chi-square minimum.
 - Range of a PASS result above the 5% C.L.
 - $\sqrt{s_{NN}}$ of the chi-square minimum
- Most of the excitation functions exhibit a flattening at or above CERN energies, therefore, the turn-over point of a fit to a 3rd-order polynomial will also be stated. This point will be universally defined as the point at which the scaled first derivative of the curve crosses the 45 degree inclination on the plot (see figure).
- At the end, the mean and standard deviation of the points of minimum chi-square and the mean of the 3rd-order polynomial turn-over points will be calculated.



Pion Temperature



Linear Fit:

FAIL. $\chi^2 = 34.7/8$

Line+Line Fit:

C.L.=50%. [4.0,10.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=50%. [4.0,9.0+]

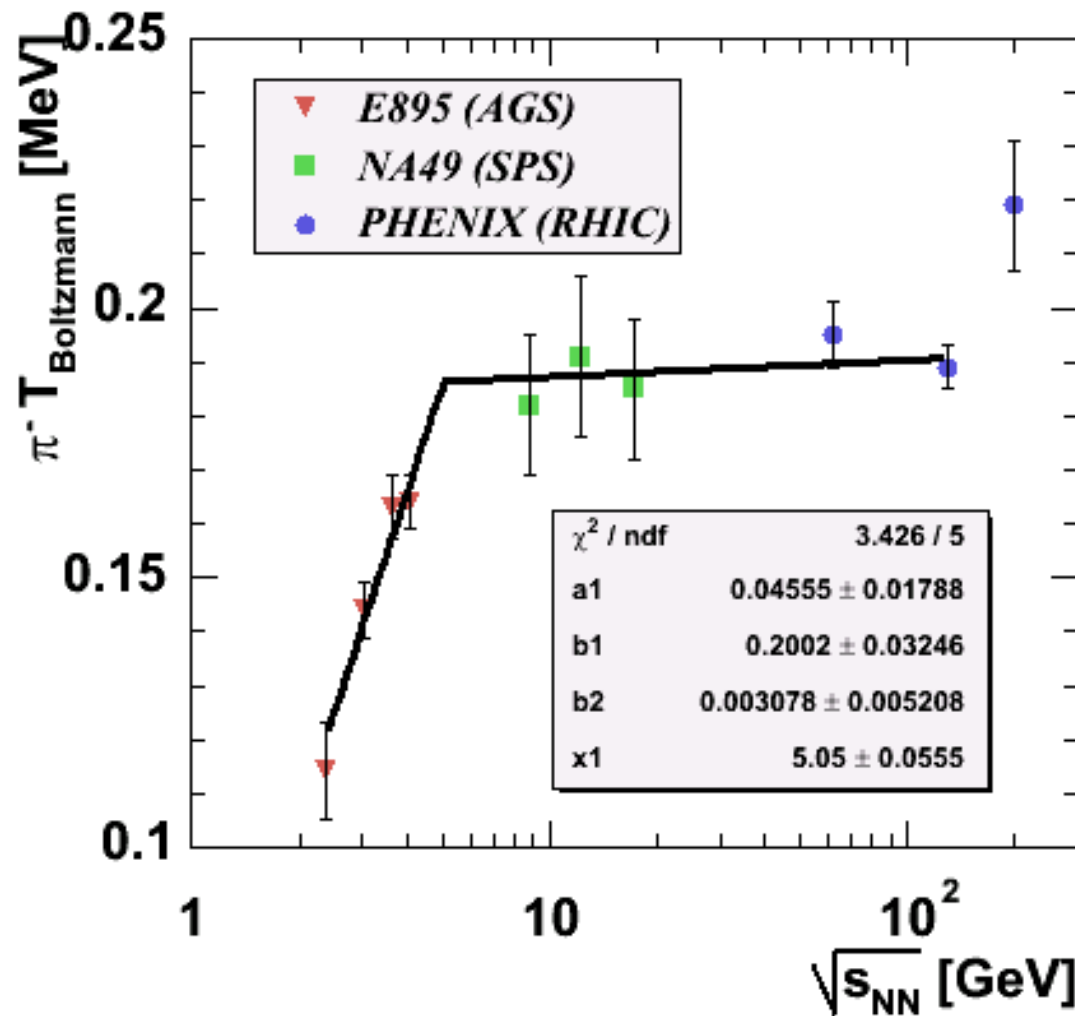
Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

Pass w/ C.L.=25%.

Turn-over=7.3

Pion Temperature



Linear Fit:

FAIL. $\chi^2 = 34.7/8$

Line+Line Fit:

C.L.=50%. [4.0,10.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=50%. [4.0,9.0+]

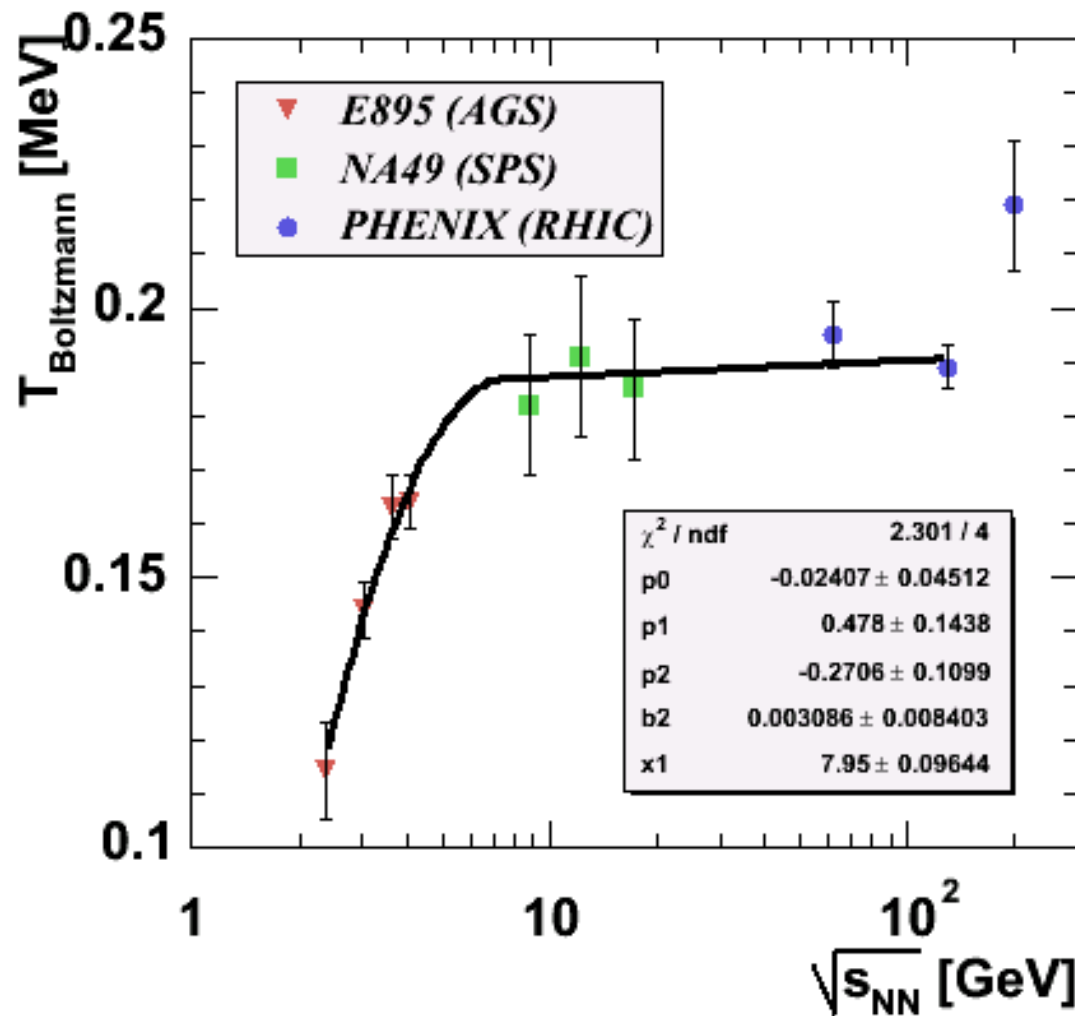
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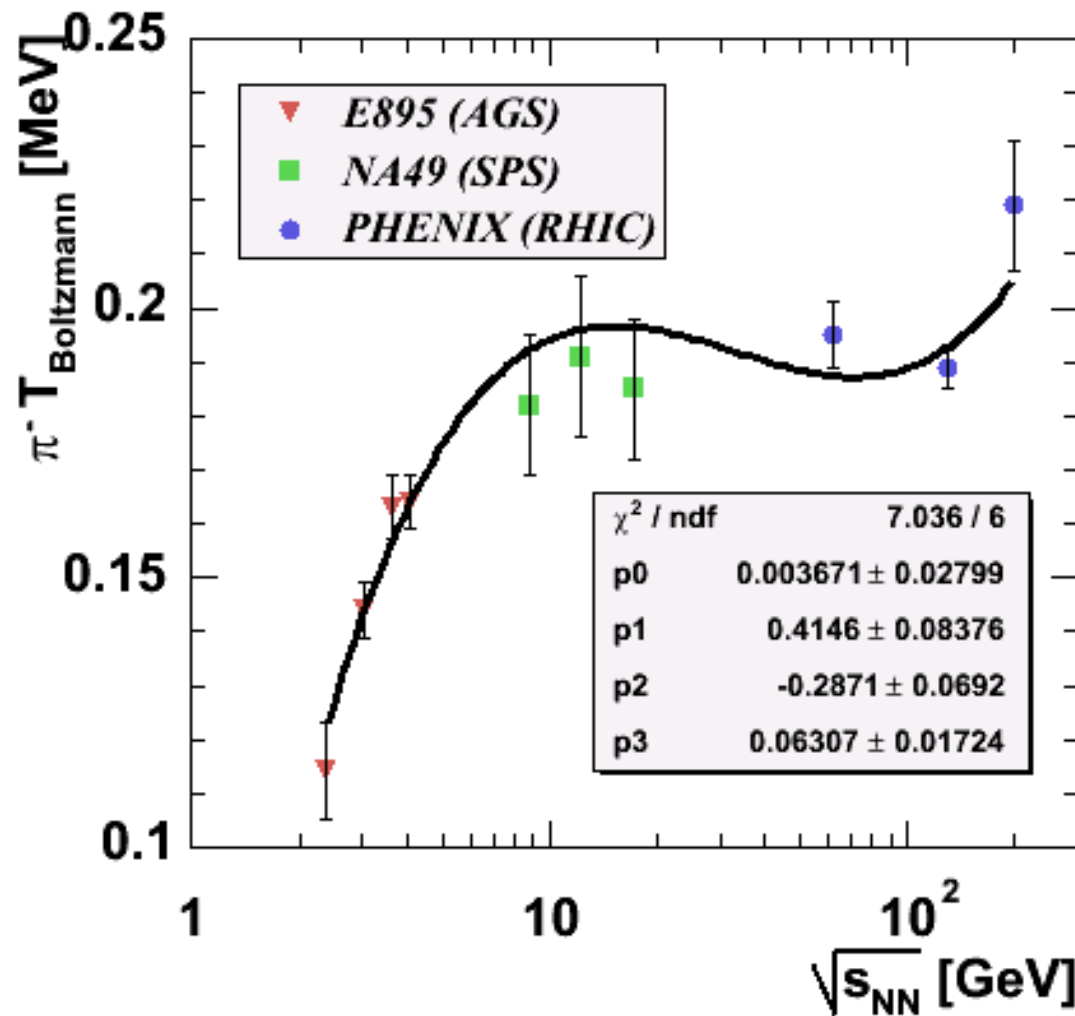
Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

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Turn-over=7.3

Pion Temperature



Linear Fit:

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Line+Line Fit:

C.L.=50%. [4.0,10.0]

Minimum at $s^{1/2}=5.0$

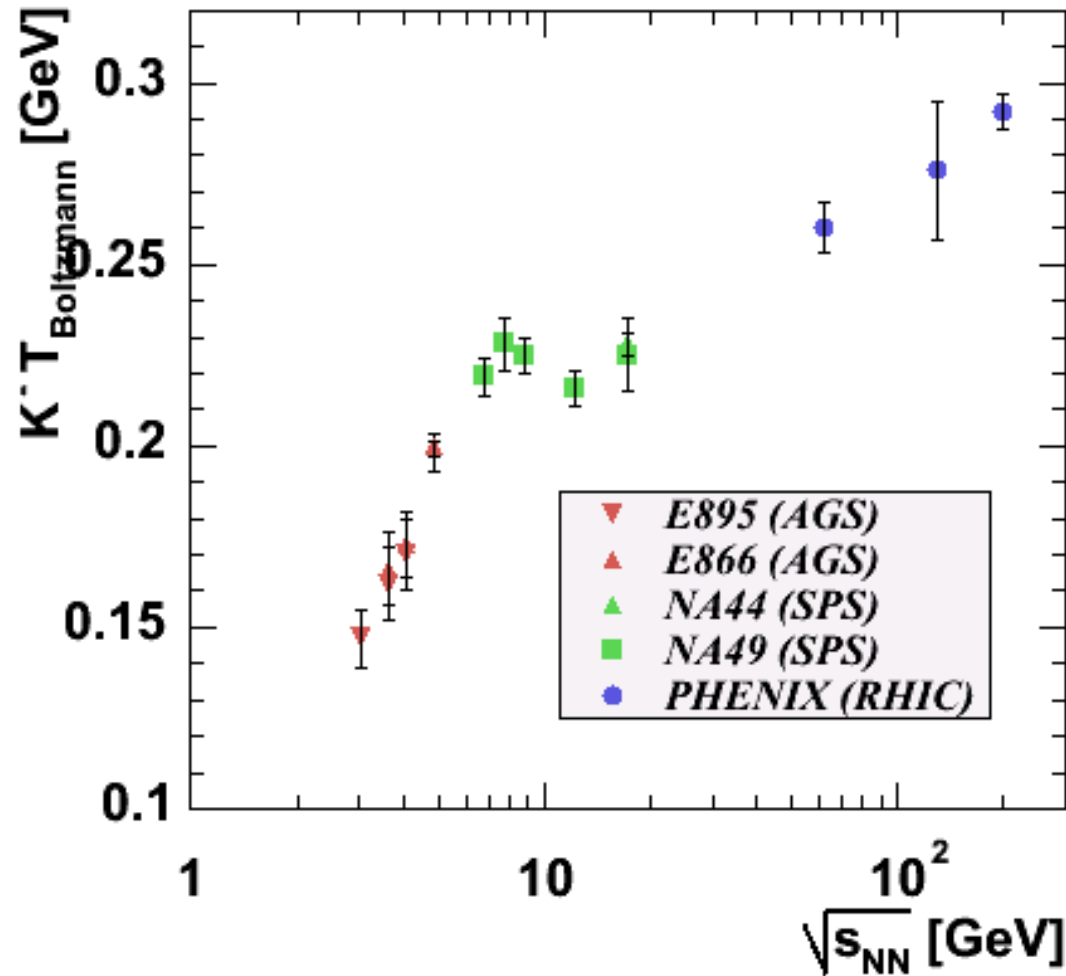
Poly+Line Fit:

C.L.=50%. [4.0,9.0+]

Minimum at $s^{1/2}=8.0$

**3rd-order polynomial:
Pass w/ C.L.=25%.
Turn-over=7.3**

Negative Kaon Temperature



Linear Fit:

FAIL. $\chi^2 = 57.3/11$

Line+Line Fit:

C.L.=25%. [5.0,6.0]

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

C.L.=10%. [5.0,31.0]

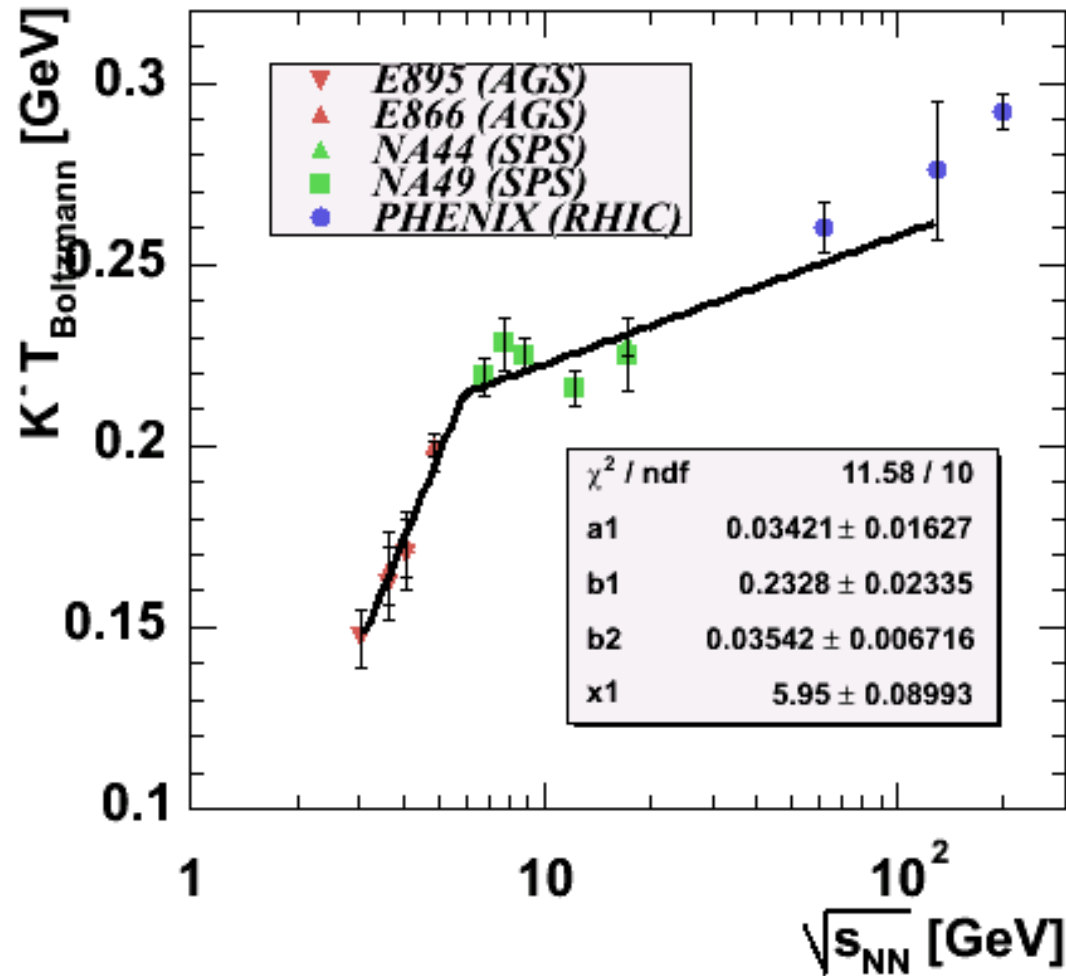
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=7.5

Negative Kaon Temperature



Linear Fit:

FAIL. $\chi^2 = 57.3/11$

Line+Line Fit:

C.L.=25%. [5.0,6.0]

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

C.L.=10%. [5.0,31.0]

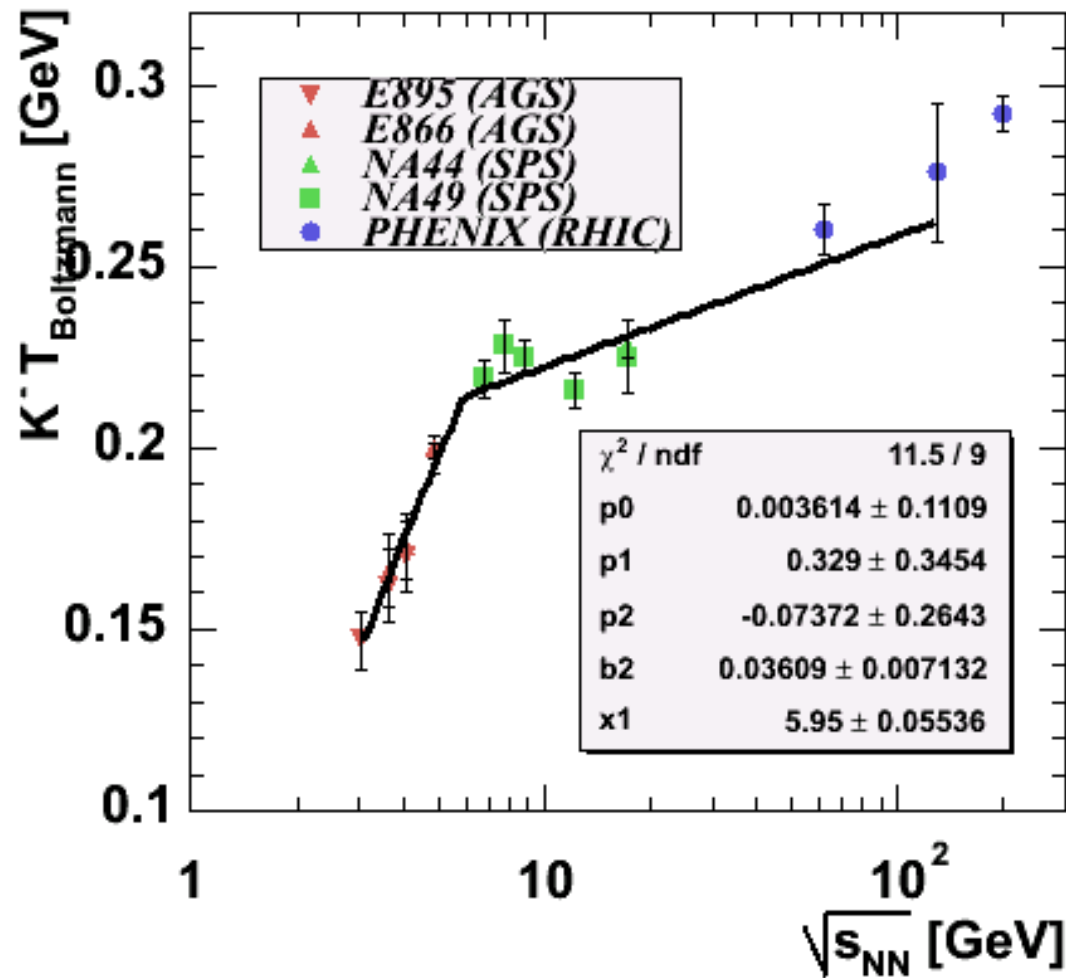
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=7.5

Negative Kaon Temperature



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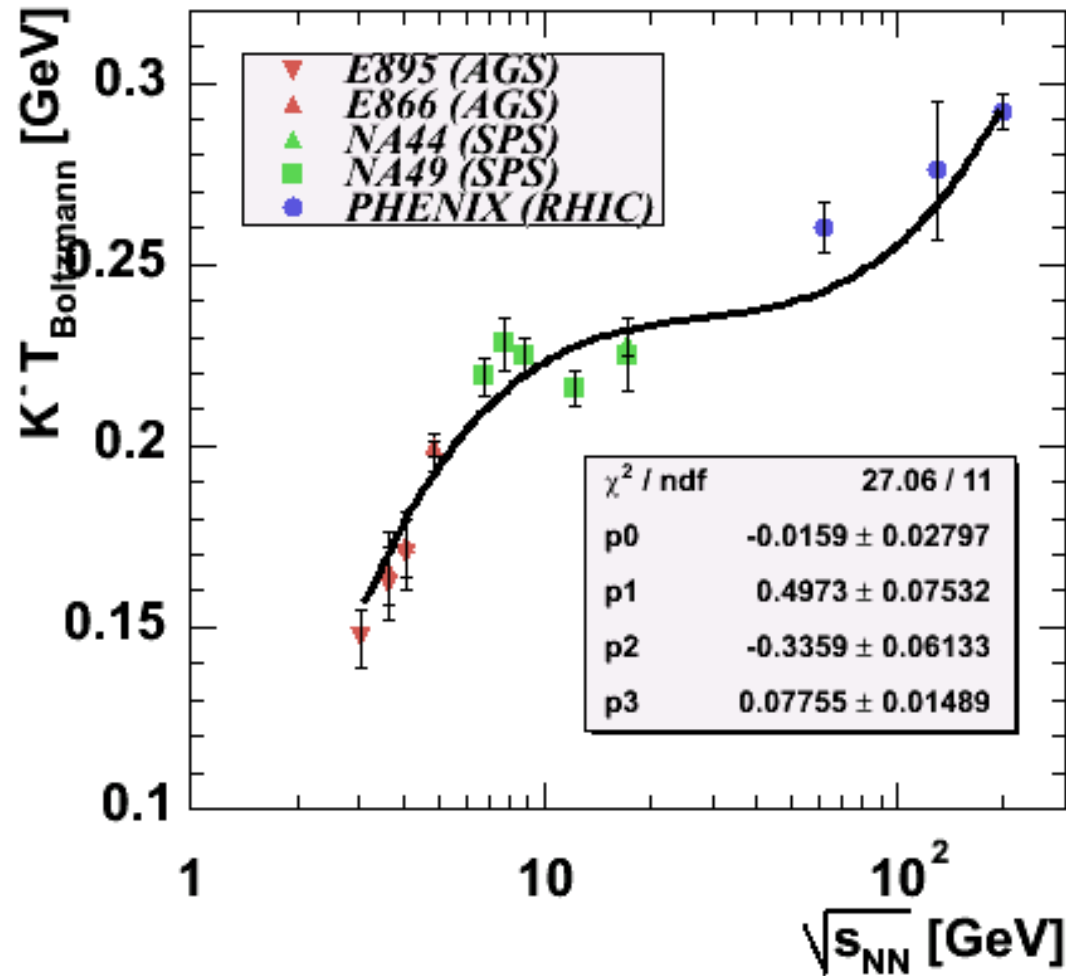
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=7.5

Negative Kaon Temperature



Linear Fit:

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C.L.=10%. [5.0,31.0]

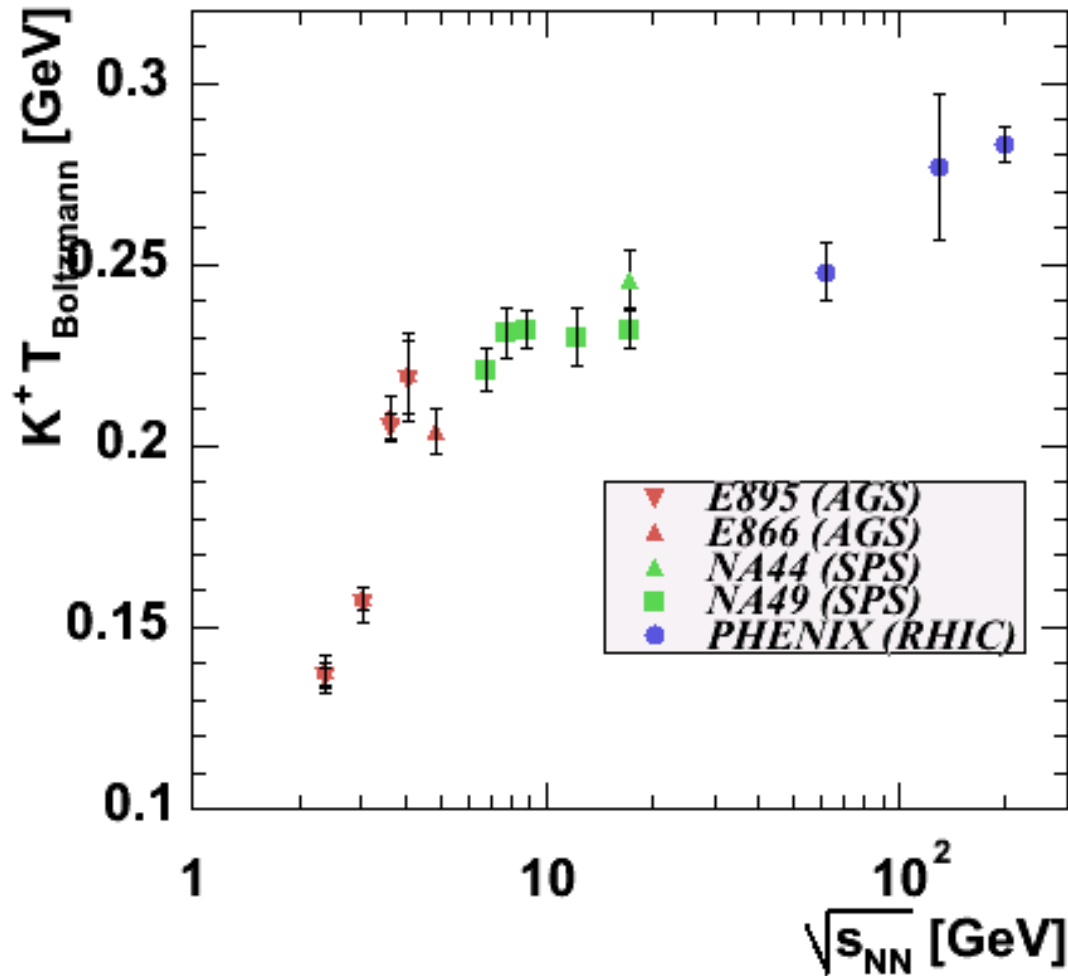
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=7.5

Positive Kaon Temperature



Linear Fit:

FAIL. $\chi^2 = 348.3/15$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

C.L.=1%.

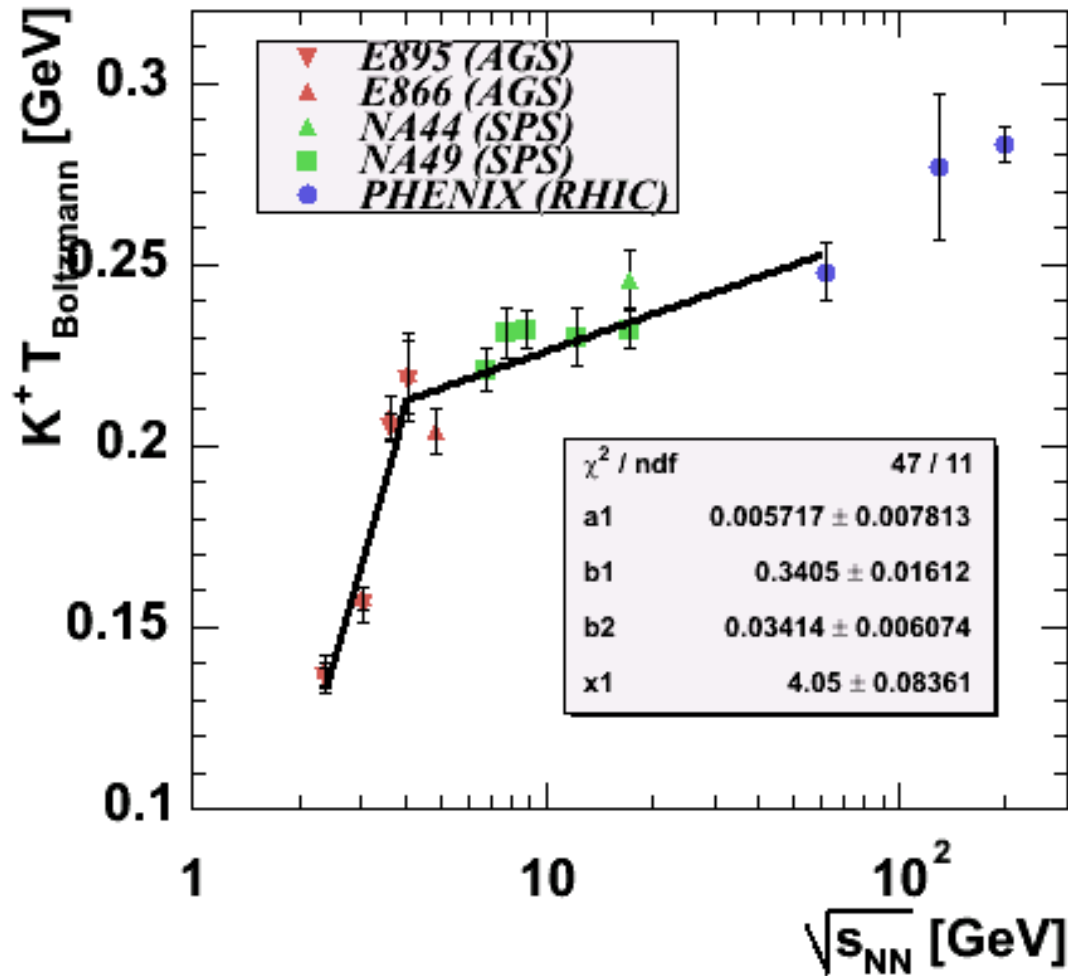
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

FAIL.

Turn-over=6.9

Positive Kaon Temperature



Linear Fit:

FAIL. $\chi^2 = 348.3/15$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

C.L.=1%.

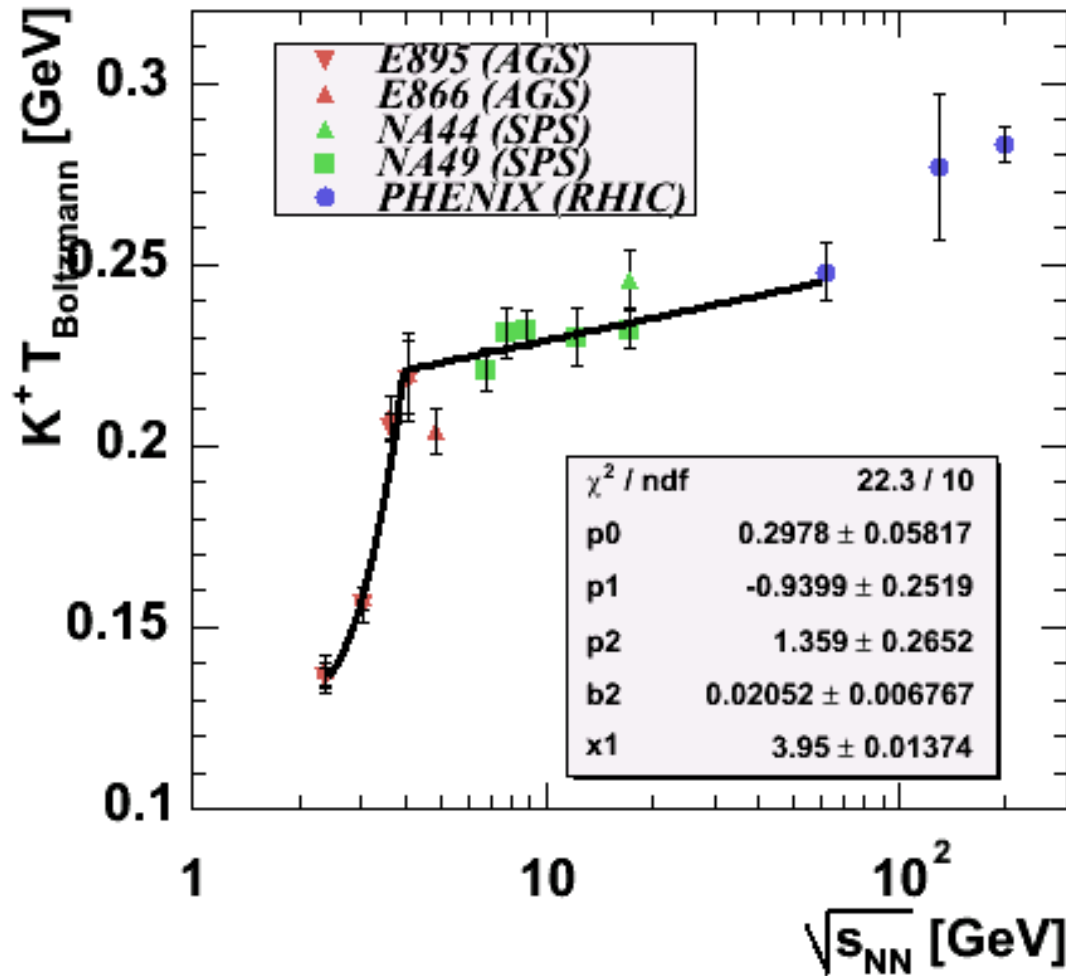
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

FAIL.

Turn-over=6.9

Positive Kaon Temperature



Linear Fit:

FAIL. $\chi^2 = 348.3/15$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

C.L.=1%.

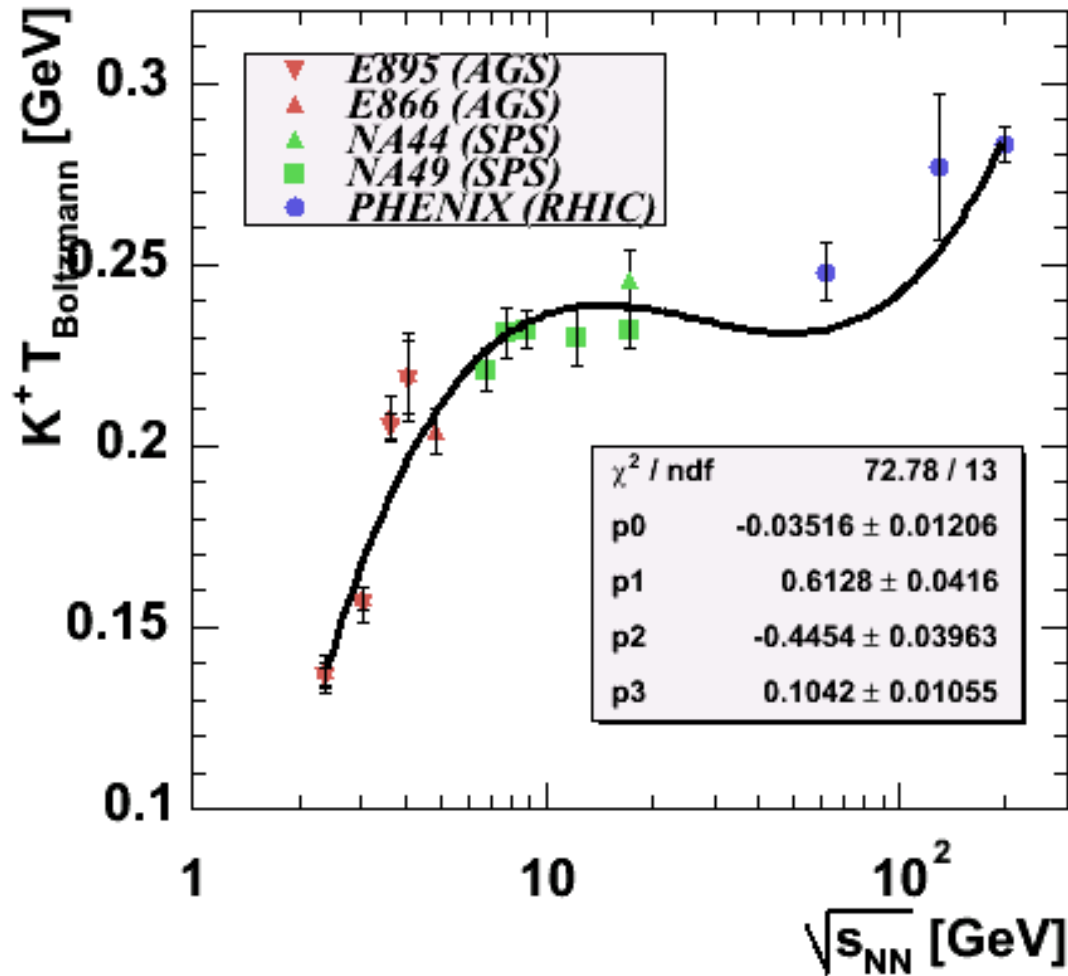
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

FAIL.

Turn-over=6.9

Positive Kaon Temperature



Linear Fit:

FAIL. $\chi^2 = 348.3/15$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

C.L.=1%.

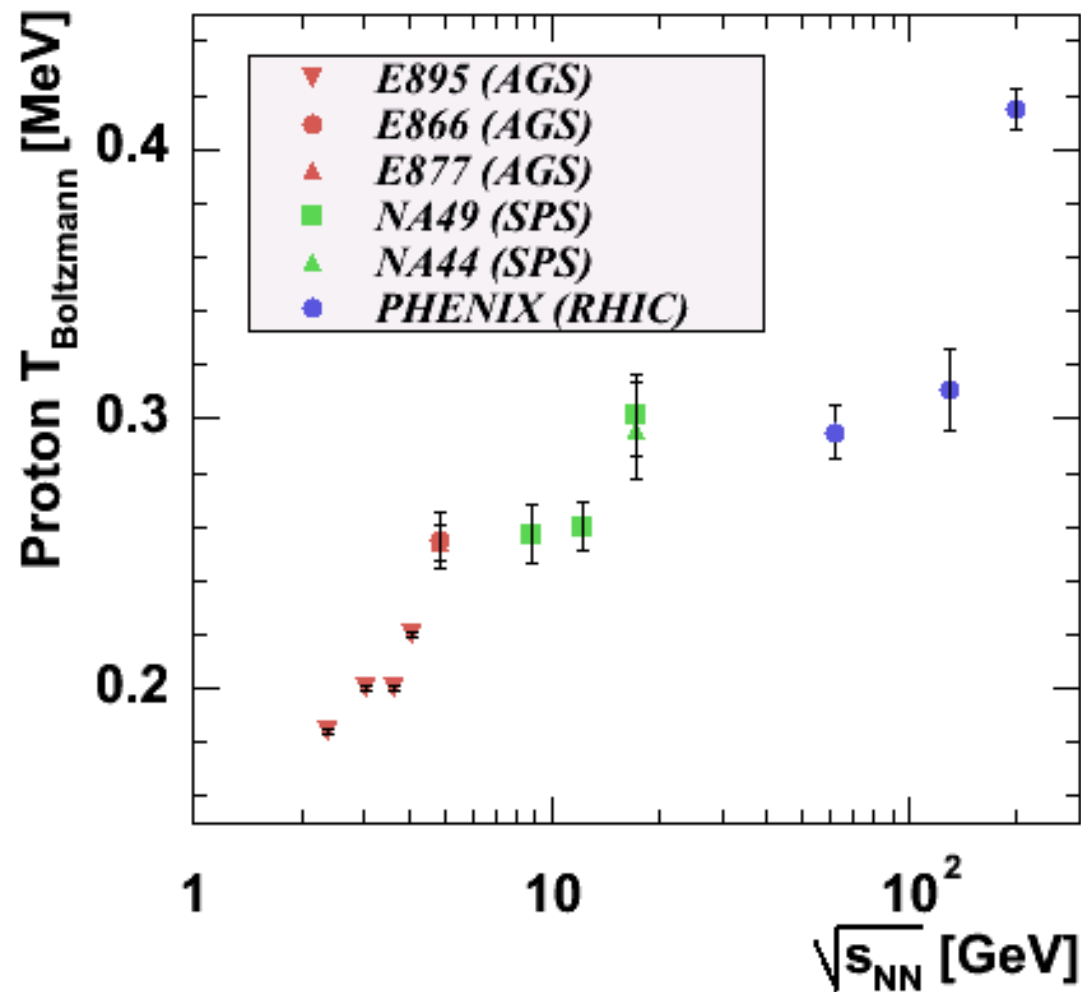
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

FAIL.

Turn-over=6.9

Proton Temperature



Linear Fit:

FAIL. $\chi^2 = 157.3/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=10.0$

Poly+Line Fit:

FAIL.

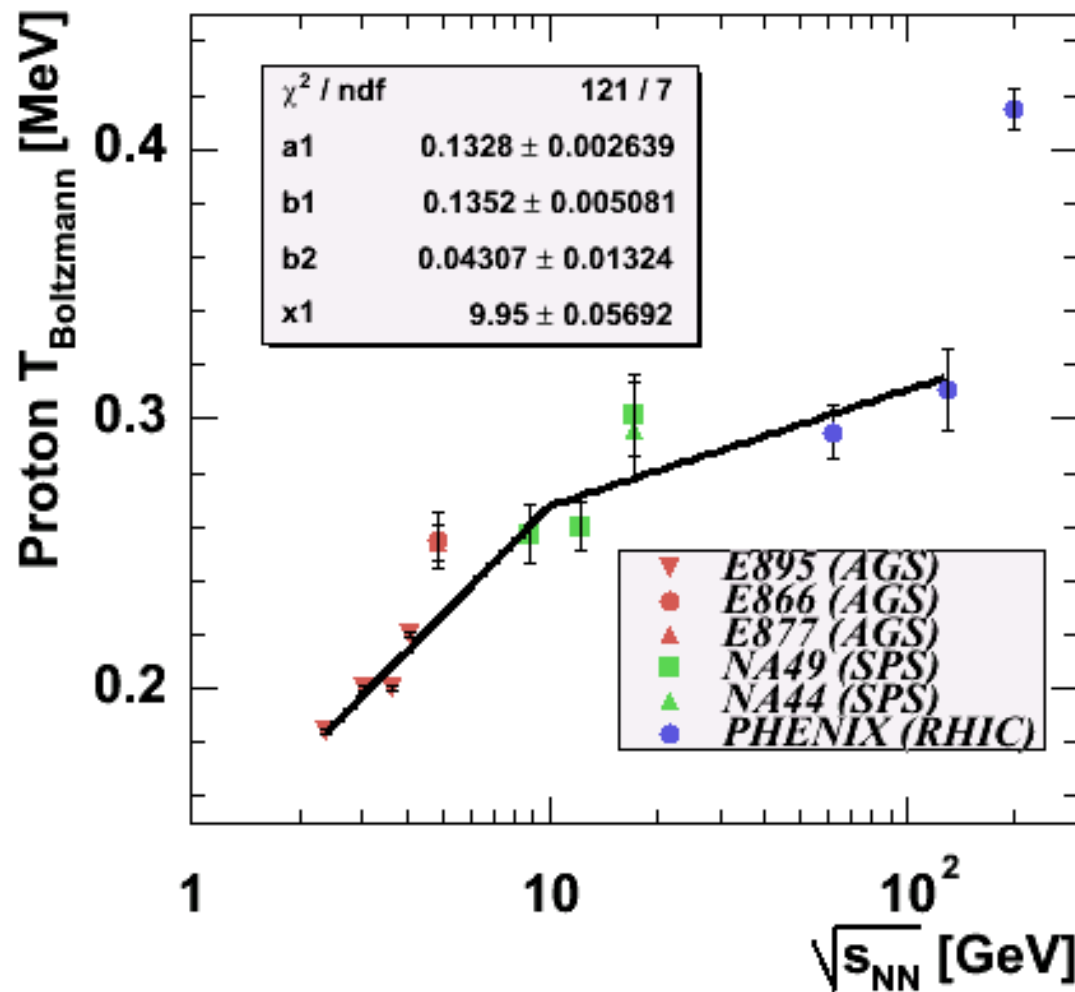
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

FAIL.

Turn-over=5.1

Proton Temperature



Linear Fit:

FAIL. $\chi^2 = 157.3/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=10.0$

Poly+Line Fit:

FAIL.

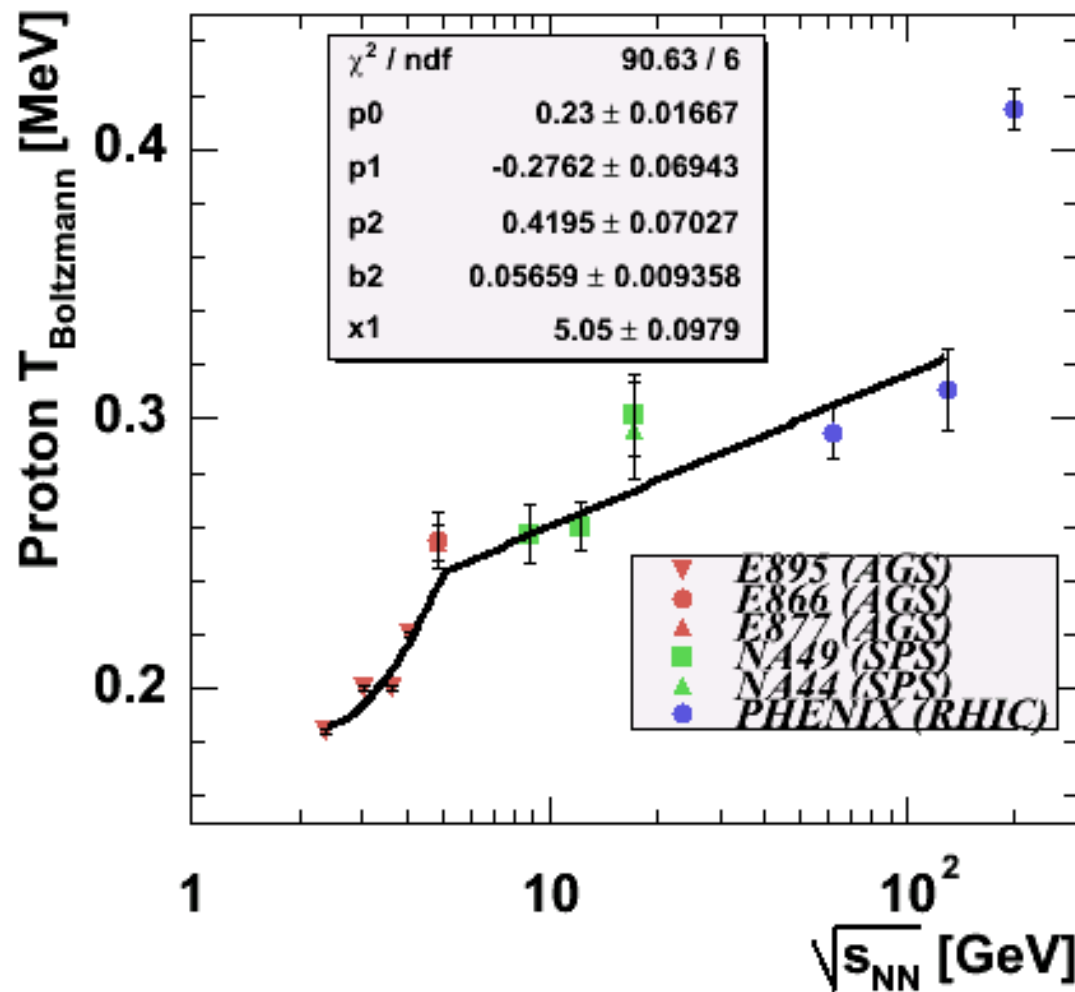
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

FAIL.

Turn-over=5.1

Proton Temperature



Linear Fit:

FAIL. $\chi^2 = 157.3/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=10.0$

Poly+Line Fit:

FAIL.

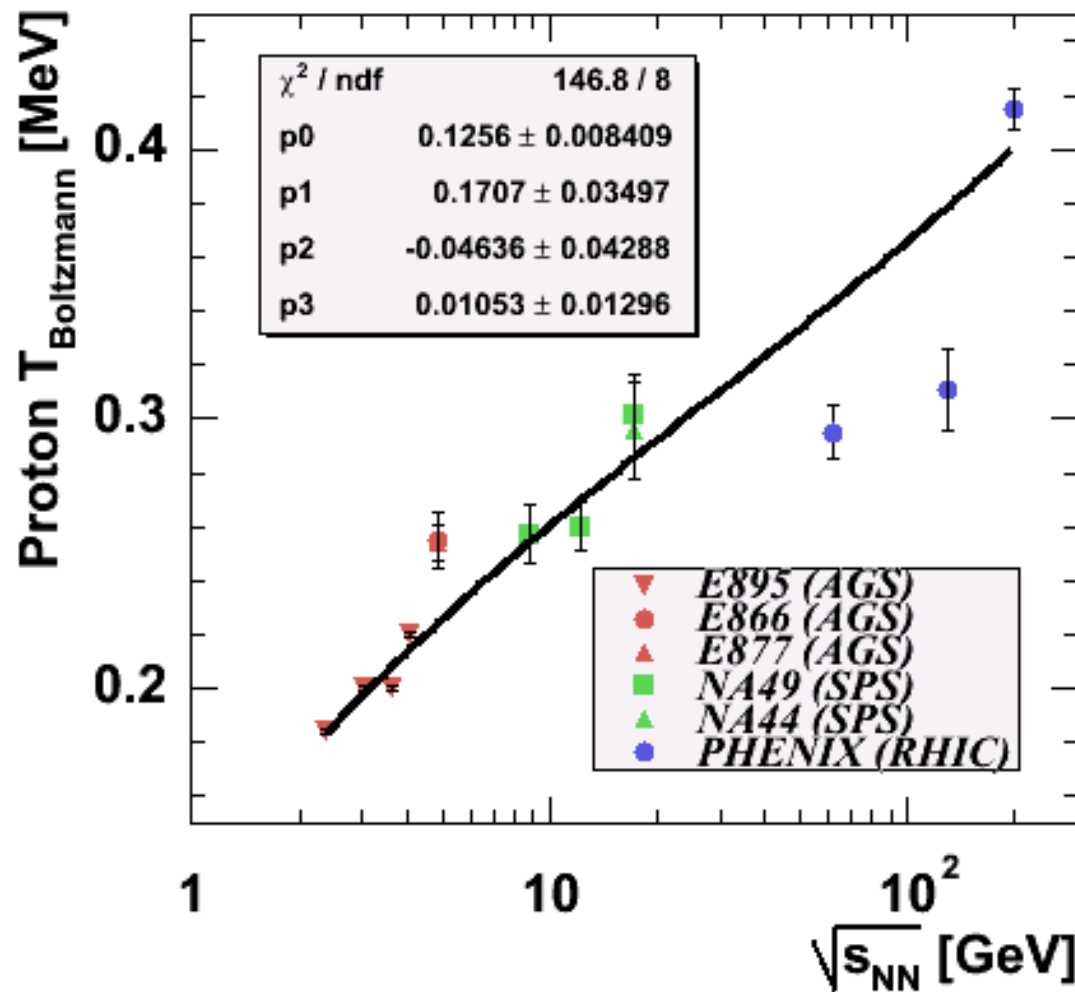
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

FAIL.

Turn-over=5.1

Proton Temperature



Linear Fit:

FAIL. $\chi^2 = 157.3/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=10.0$

Poly+Line Fit:

FAIL.

Minimum at $s^{1/2}=5.0$

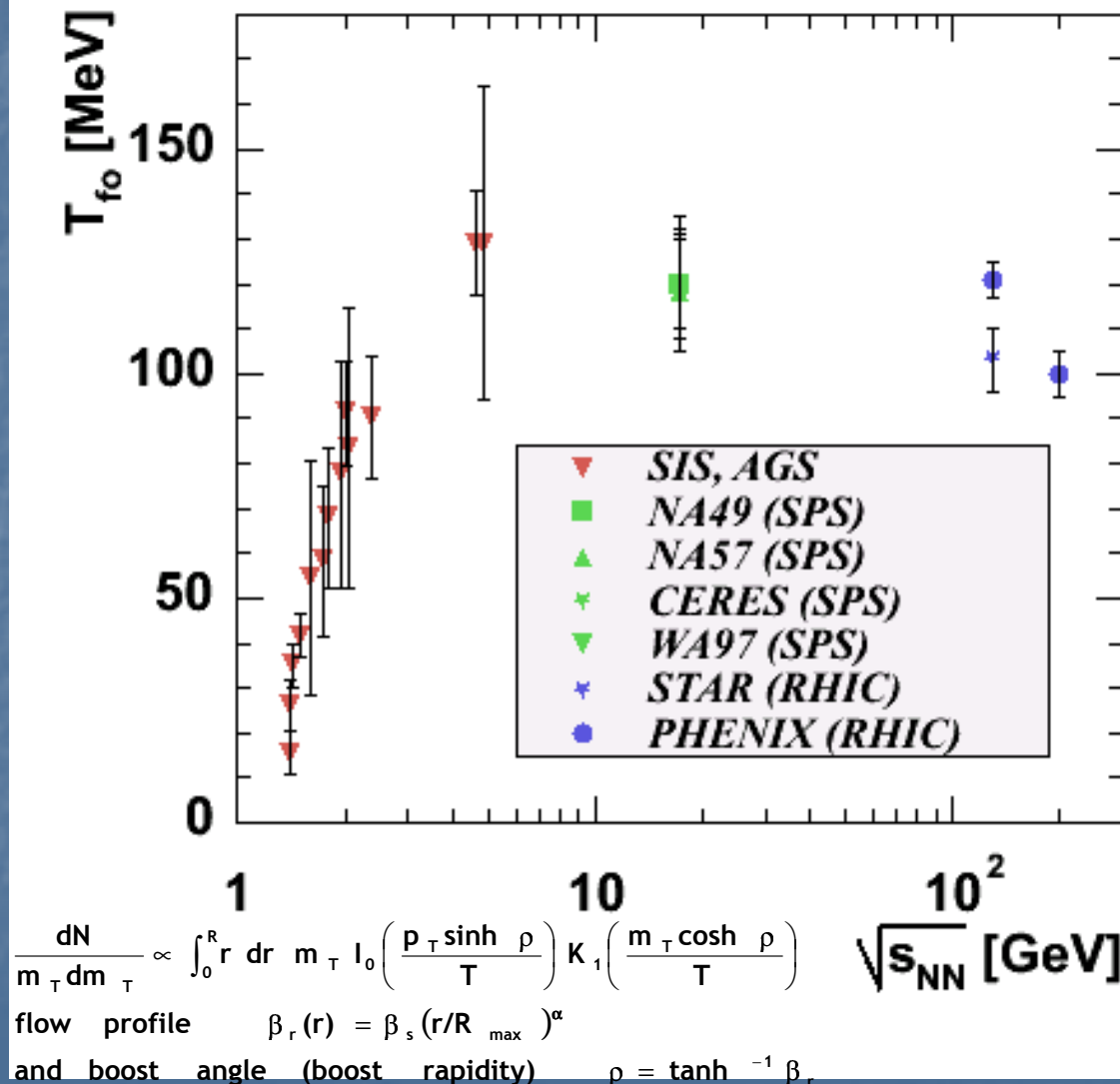
3rd-order polynomial:

FAIL.

Turn-over=5.1

"Freeze-out" Temperature

Blast wave



Linear Fit:

FAIL. $\chi^2 = 165.5/18$

Line+Line Fit:

C.L.=25%. [2.0,4.0]

Minimum at $s^{1/2}=3.0$

Poly+Line Fit:

C.L.=50%. [2.0,4.0]

Minimum at $s^{1/2}=4.0$

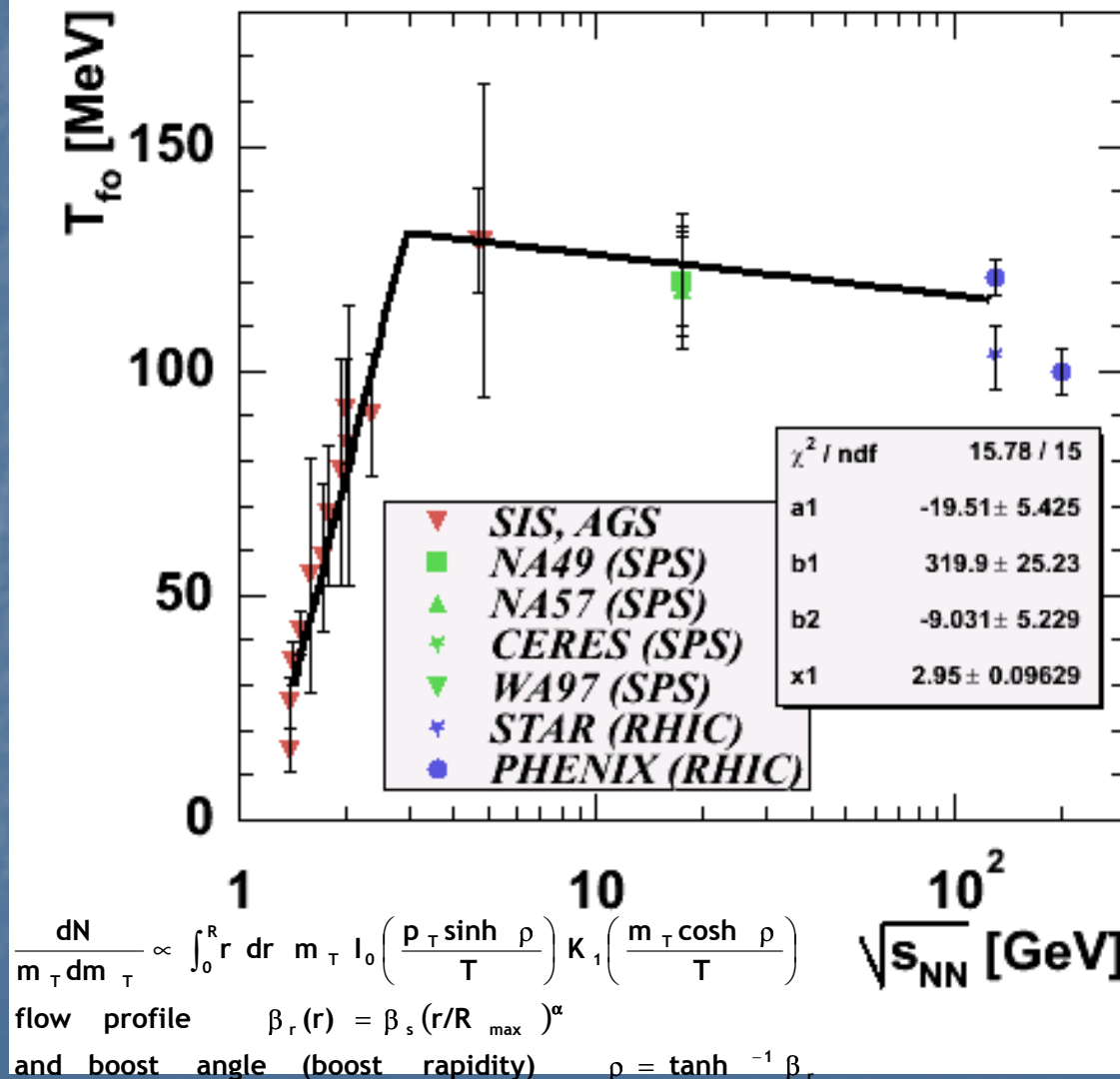
3rd-order polynomial:

FAIL.

Turn-over=5.5

"Freeze-out" Temperature

Blast wave



Linear Fit:

FAIL. $\chi^2 = 165.5/18$

Line+Line Fit:

C.L.=25%. [2.0,4.0]

Minimum at $s^{1/2}=3.0$

Poly+Line Fit:

C.L.=50%. [2.0,4.0]

Minimum at $s^{1/2}=4.0$

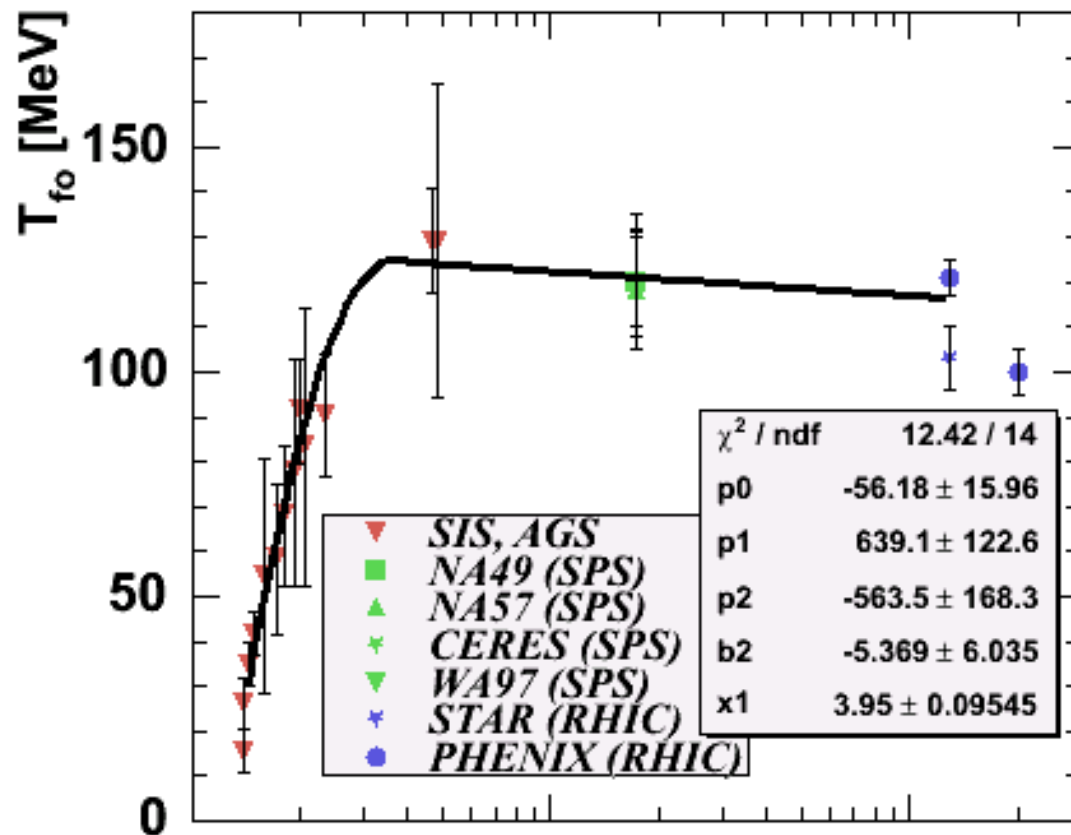
3rd-order polynomial:

FAIL.

Turn-over=5.5

"Freeze-out" Temperature

Blast wave



$$\frac{dN}{m_T dm_T} \propto \int_0^R r dr m_T I_0\left(\frac{p_T \sinh \rho}{T}\right) K_1\left(\frac{m_T \cosh \rho}{T}\right)$$

flow profile $\beta_r(r) = \beta_s(r/R_{\text{max}})^\alpha$
 and boost angle (boost rapidity) $\rho = \tanh^{-1} \beta_r$

Linear Fit:

FAIL. $\chi^2 = 165.5/18$

Line+Line Fit:

C.L.=25%. [2.0,4.0]

Minimum at $s^{1/2}=3.0$

Poly+Line Fit:

C.L.=50%. [2.0,4.0]

Minimum at $s^{1/2}=4.0$

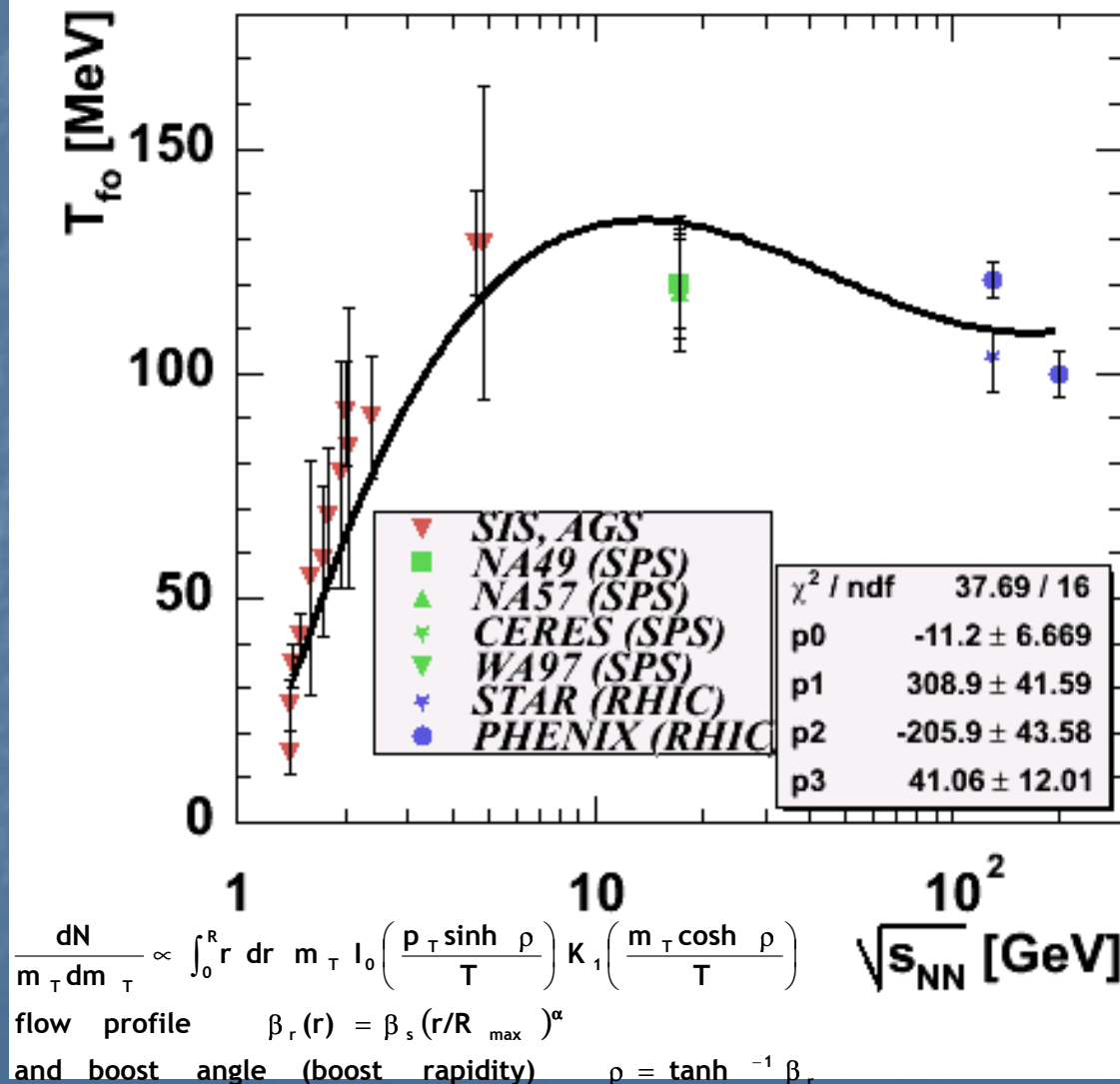
3rd-order polynomial:

FAIL.

Turn-over=5.5

"Freeze-out" Temperature

Blast wave



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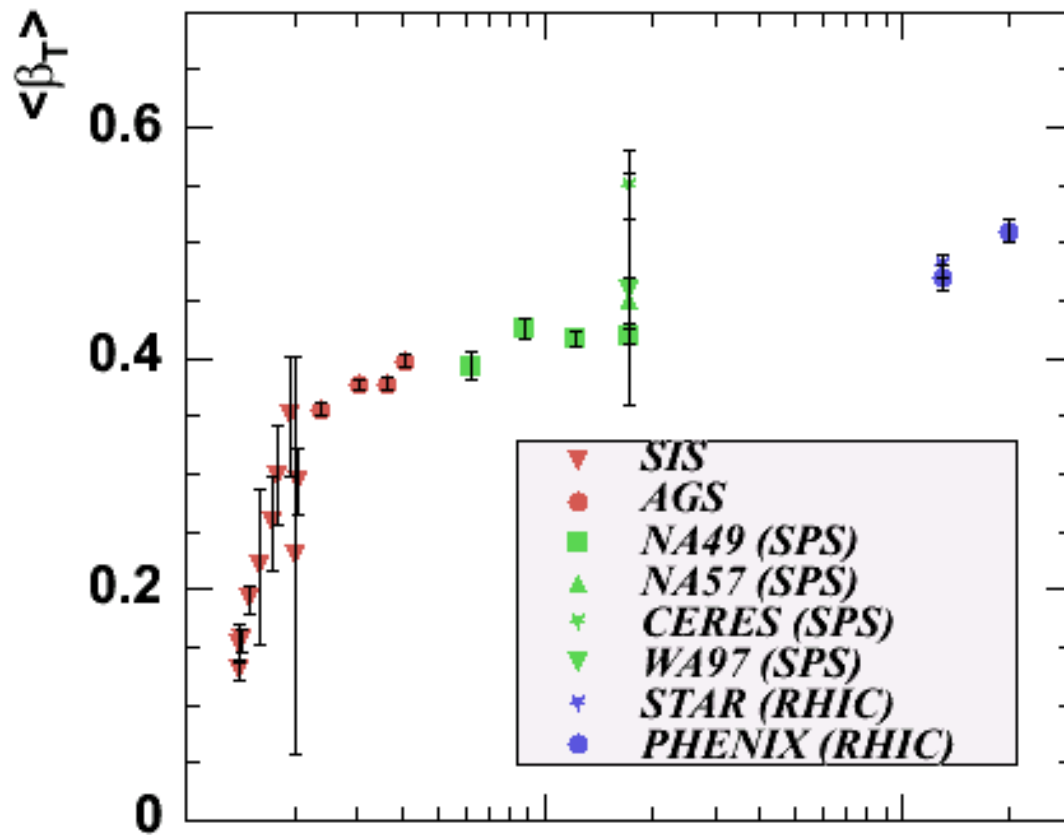
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

FAIL.

Turn-over=5.5

Transverse Velocity



$$\frac{dN}{m_T dm_T} \propto \int_0^R r dr m_T I_0\left(\frac{p_T \sinh \rho}{T}\right) K_1\left(\frac{m_T \cosh \rho}{T}\right)$$

flow profile $\beta_r(r) = \beta_s (r/R_{max})^\alpha$
 and boost angle (boost rapidity) $\rho = \tanh^{-1} \beta_r$

Linear Fit:

FAIL. $\chi^2 = 1053/21$

Line+Line Fit:

C.L.=10%. [2.4,2.6]

Minimum at $s^{1/2}=2.5$

Poly+Line Fit:

C.L.=25%. [2.4,3.7]

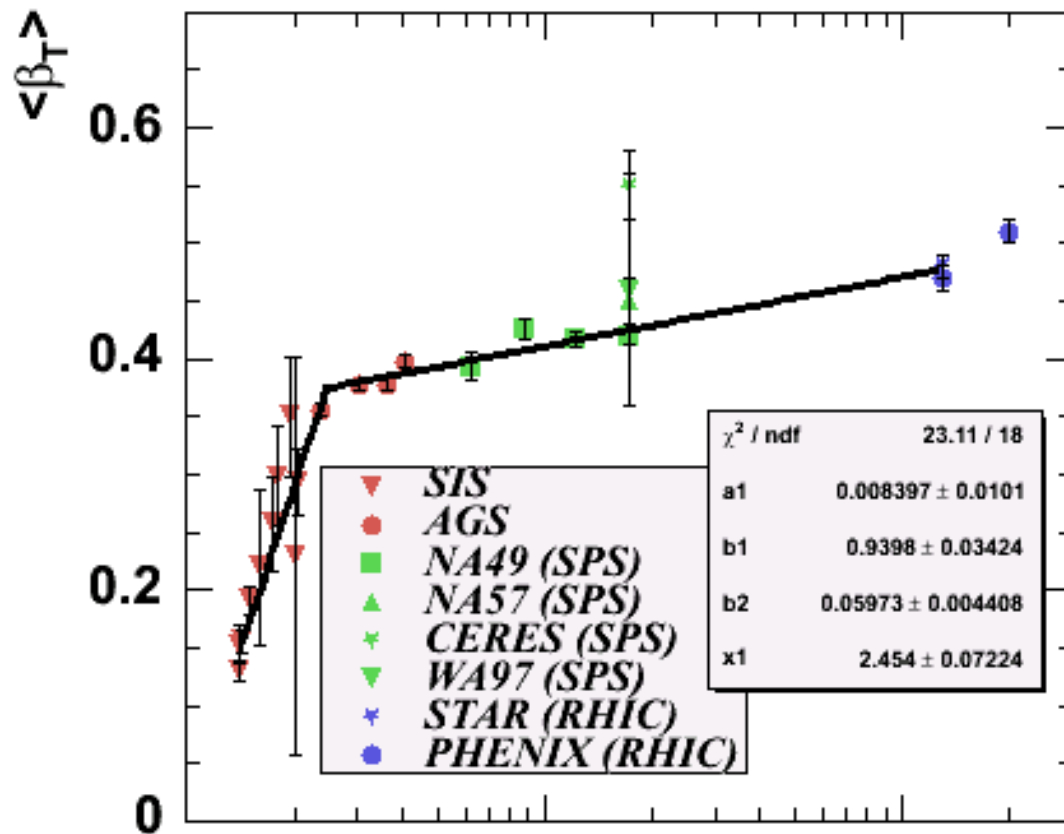
Minimum at $s^{1/2}=2.9$

3rd-order polynomial:

FAIL.

Turn-over=3.9

Transverse Velocity



Linear Fit:

FAIL. $\chi^2 = 1053/21$

Line+Line Fit:

C.L.=10%. [2.4,2.6]

Minimum at $s^{1/2}=2.5$

Poly+Line Fit:

C.L.=25%. [2.4,3.7]

Minimum at $s^{1/2}=2.9$

3rd-order polynomial:

FAIL.

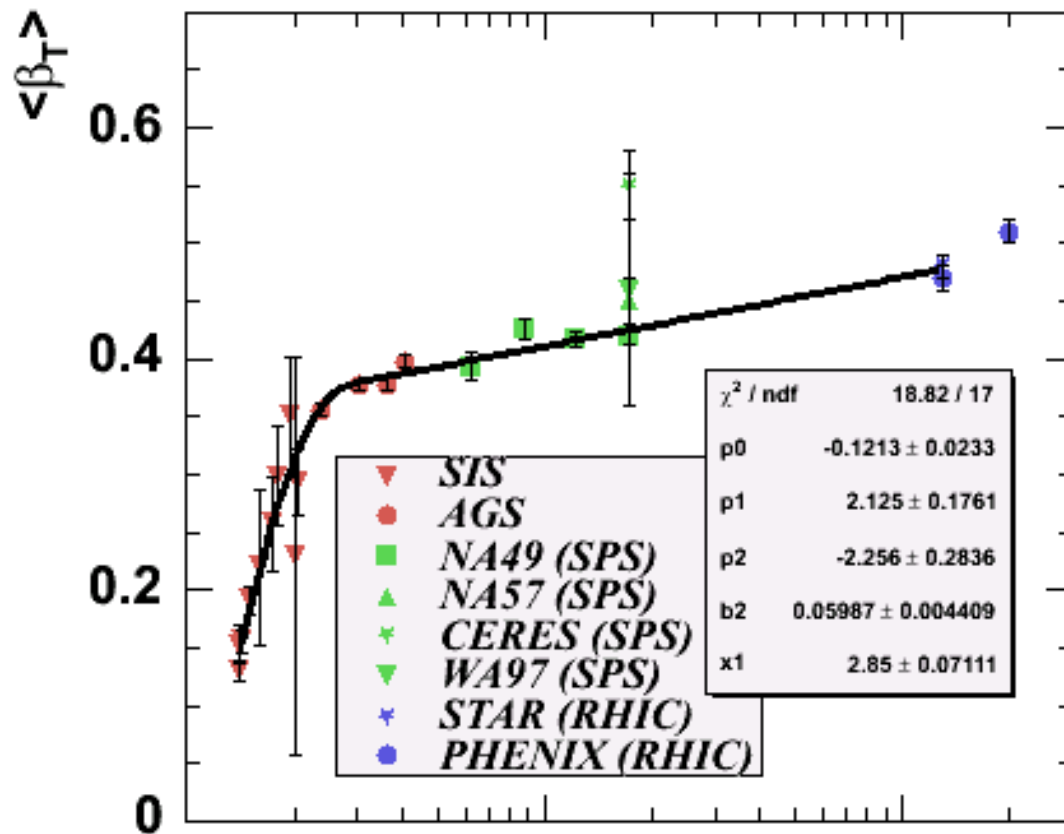
Turn-over=3.9

$$\frac{dN}{m_T dm_T} \propto \int_0^R r dr m_T I_0\left(\frac{p_T \sinh \rho}{T}\right) K_1\left(\frac{m_T \cosh \rho}{T}\right)$$

flow profile $\beta_r(r) = \beta_s (r/R_{\max})^\alpha$

and boost angle (boost rapidity) $\rho = \tanh^{-1} \beta_r$

Transverse Velocity



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C.L.=25%. [2.4,3.7]

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$$\frac{dN}{m_T dm_T} \propto \int_0^R r dr m_T I_0\left(\frac{p_T \sinh \rho}{T}\right) K_1\left(\frac{m_T \cosh \rho}{T}\right)$$

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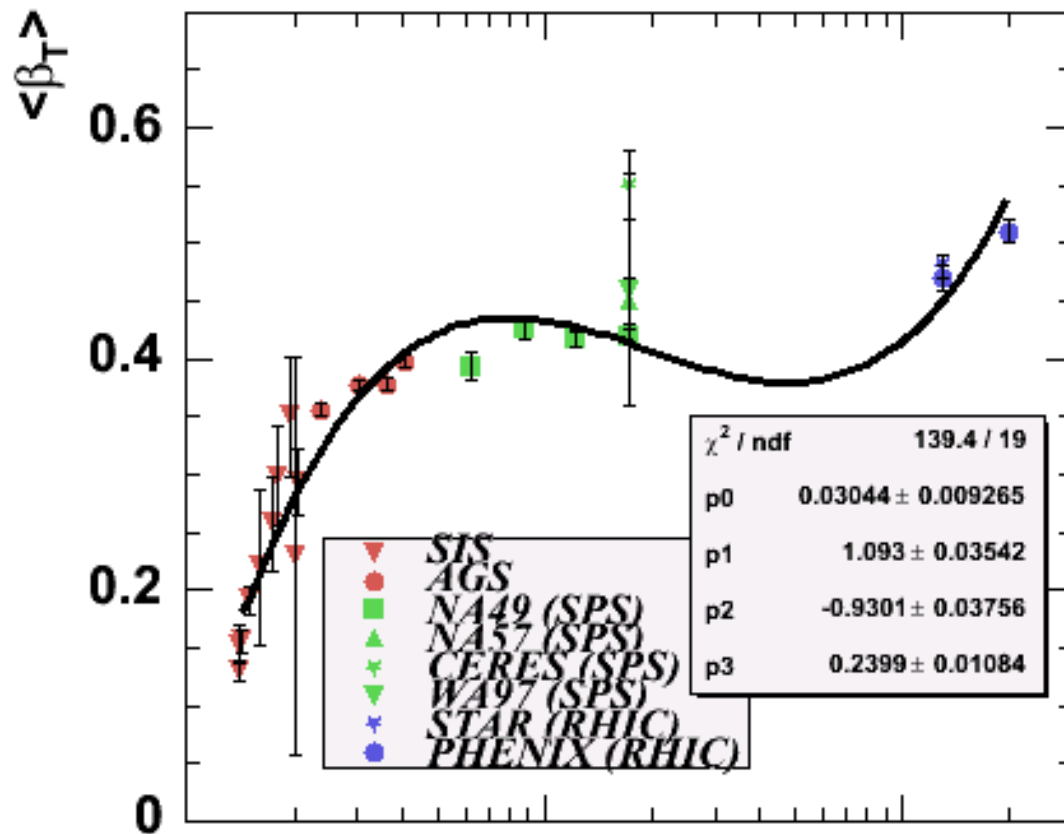
and boost angle (boost rapidity) $\rho = \tanh^{-1} \beta_r$

3rd-order polynomial:

FAIL.

Turn-over=3.9

Transverse Velocity



Linear Fit:

FAIL. $\chi^2 = 1053/21$

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3rd-order polynomial:

FAIL.

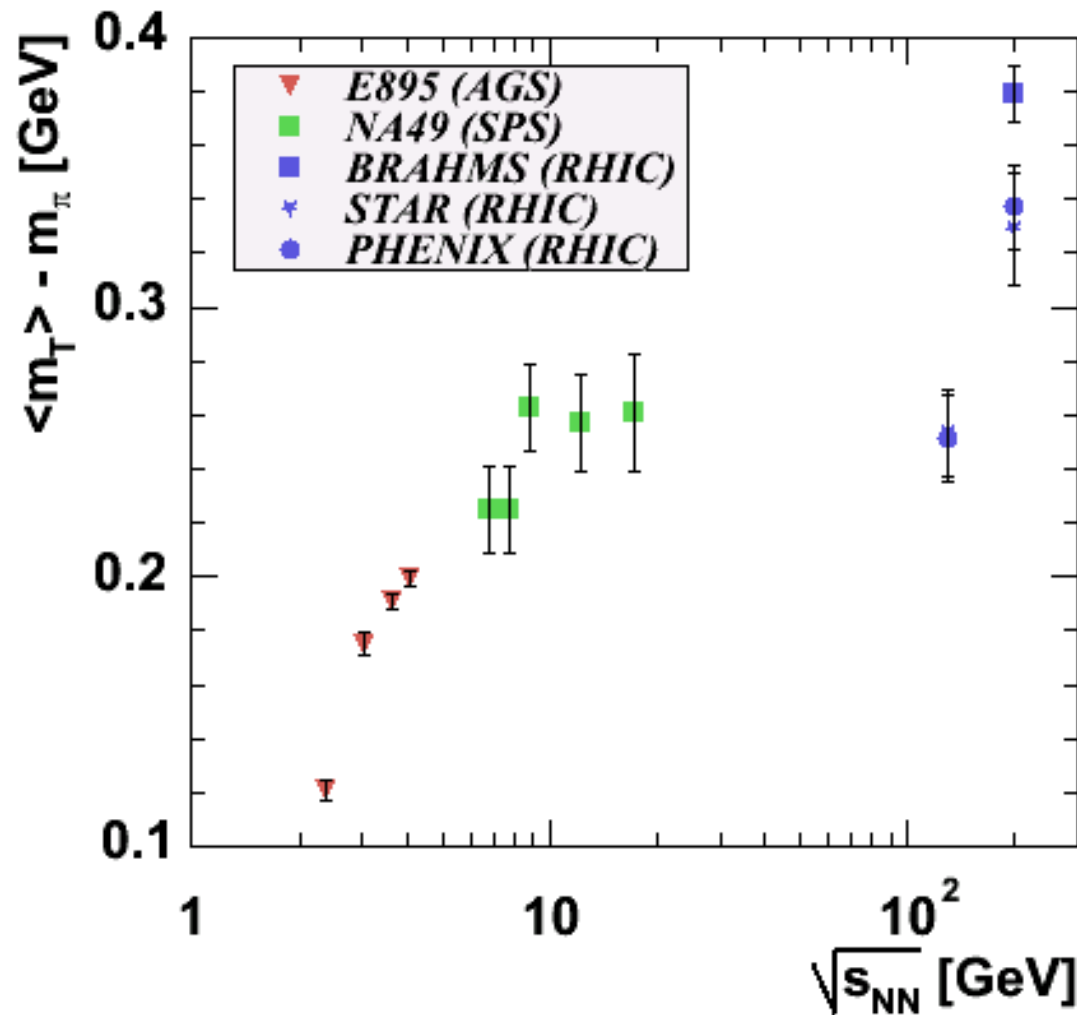
Turn-over=3.9

$$\frac{dN}{m_T dm_T} \propto \int_0^R r dr m_T I_0\left(\frac{p_T \sinh \rho}{T}\right) K_1\left(\frac{m_T \cosh \rho}{T}\right)$$

flow profile $\beta_r(r) = \beta_s (r/R_{\max})^\alpha$

and boost angle (boost rapidity) $\rho = \tanh^{-1} \beta_r$

Pion $\langle m_T \rangle - m_0$



Linear Fit:

FAIL. $\chi^2 = 209.2/11$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=5%. [8.0,10.0]

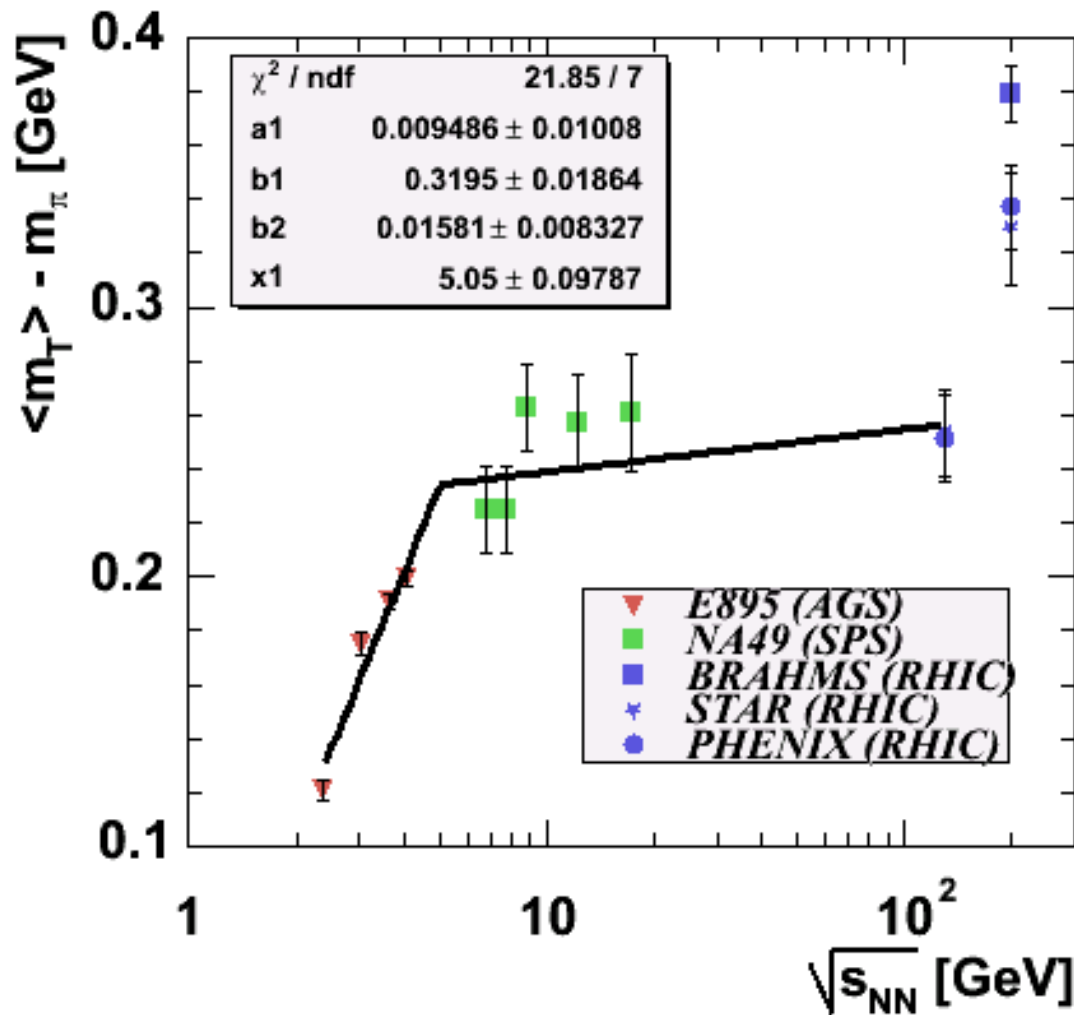
Minimum at $s^{1/2}=9.0$

3rd-order polynomial:

FAIL.

Turn-over=5.5

Pion $\langle m_T \rangle - m_0$



Linear Fit:

FAIL. $\chi^2 = 209.2/11$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=5%. [8.0,10.0]

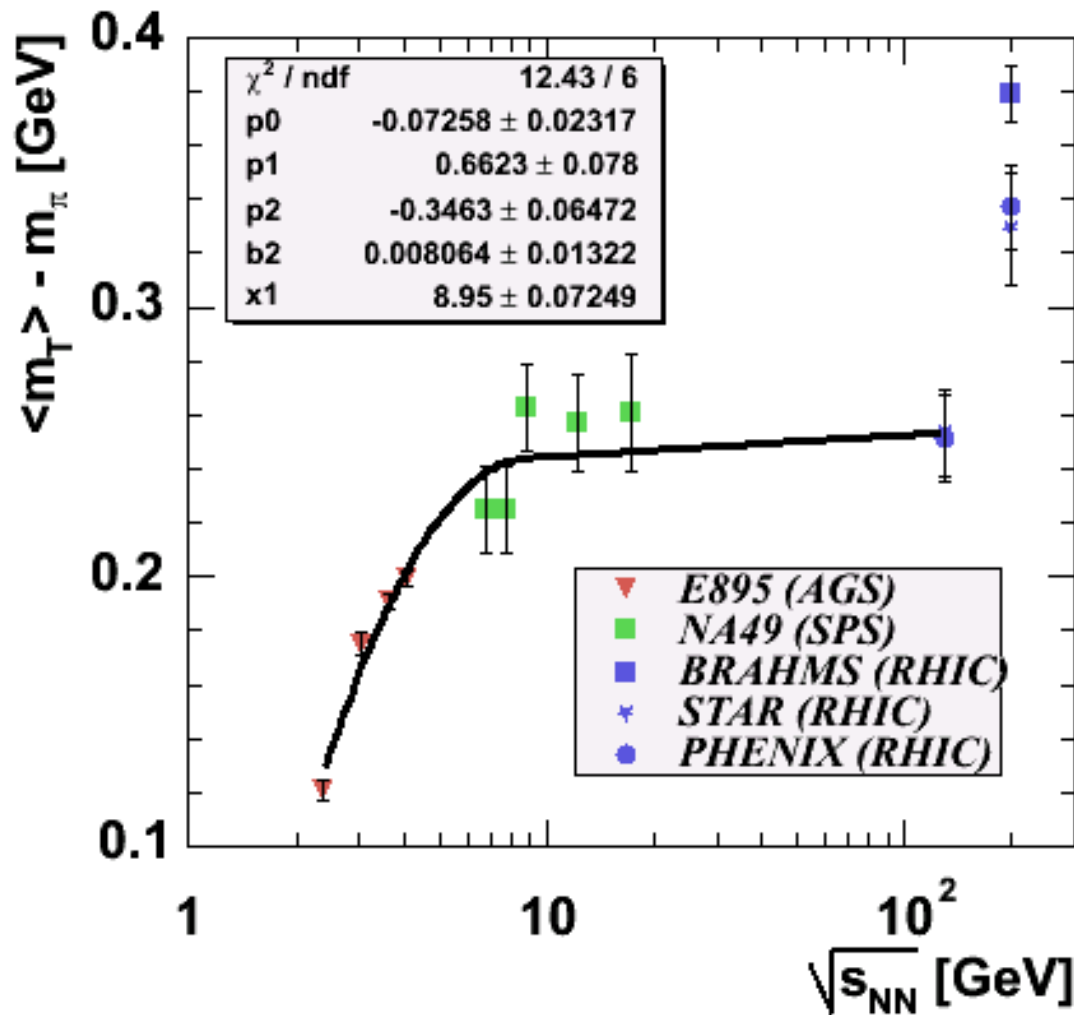
Minimum at $s^{1/2}=9.0$

3rd-order polynomial:

FAIL.

Turn-over=5.5

Pion $\langle m_T \rangle - m_0$



Linear Fit:

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FAIL.

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Poly+Line Fit:

C.L.=5%. [8.0,10.0]

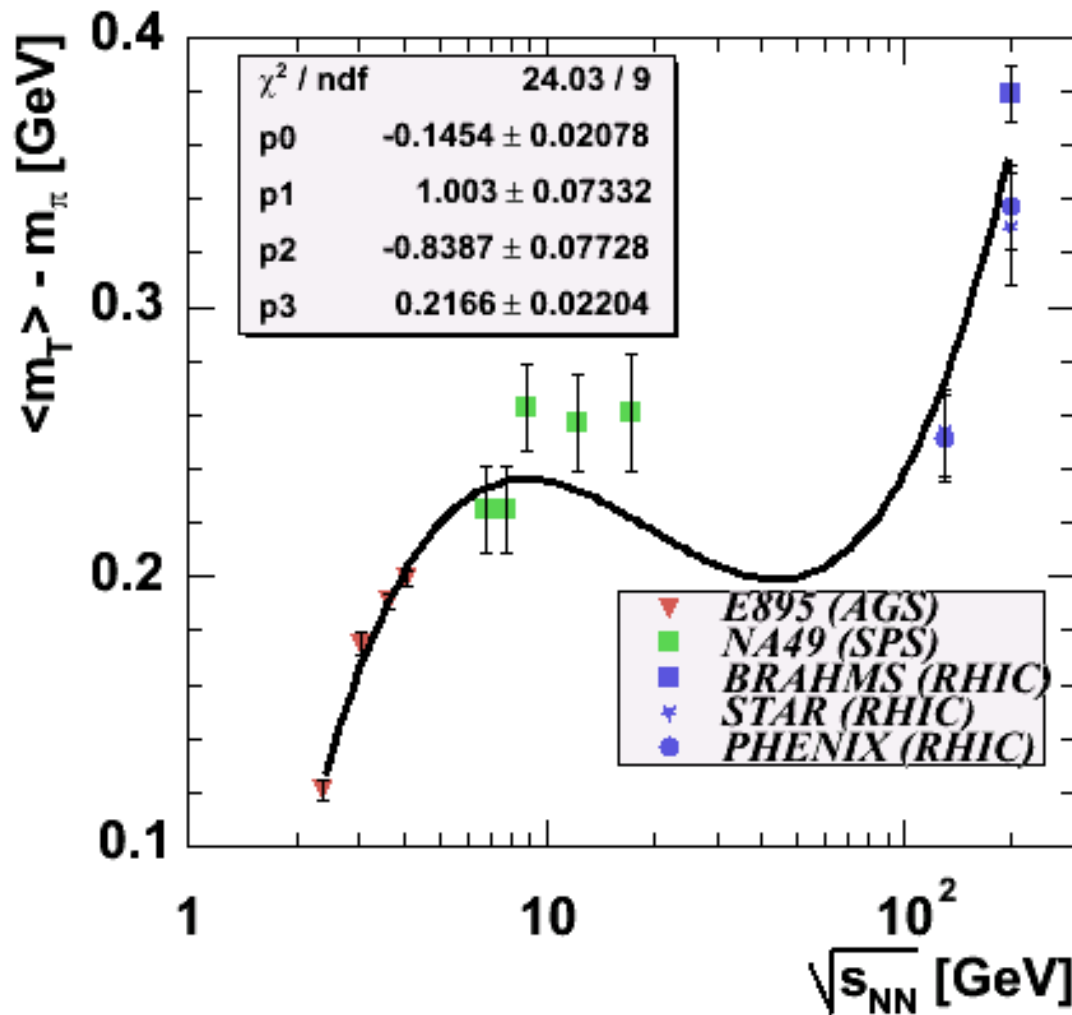
Minimum at $s^{1/2}=9.0$

3rd-order polynomial:

FAIL.

Turn-over=5.5

Pion $\langle m_T \rangle - m_0$



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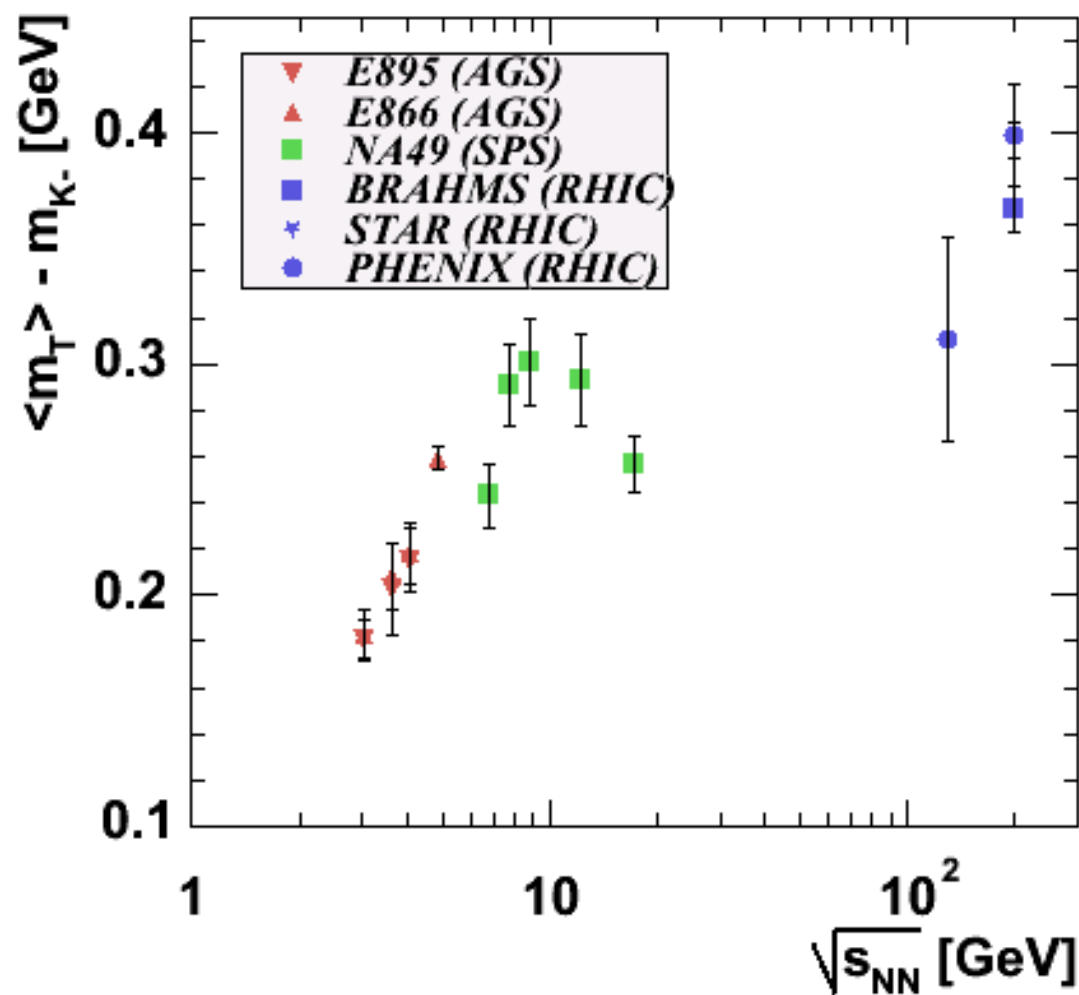
Minimum at $s^{1/2}=9.0$

3rd-order polynomial:

FAIL.

Turn-over=5.5

Negative Kaon $\langle m_T \rangle - m_0$



Linear Fit:

FAIL. $\chi^2 = 78.37/14$

Line+Line Fit:

C.L.=10%. [5.0,6.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=10%. [5.0,6.0]

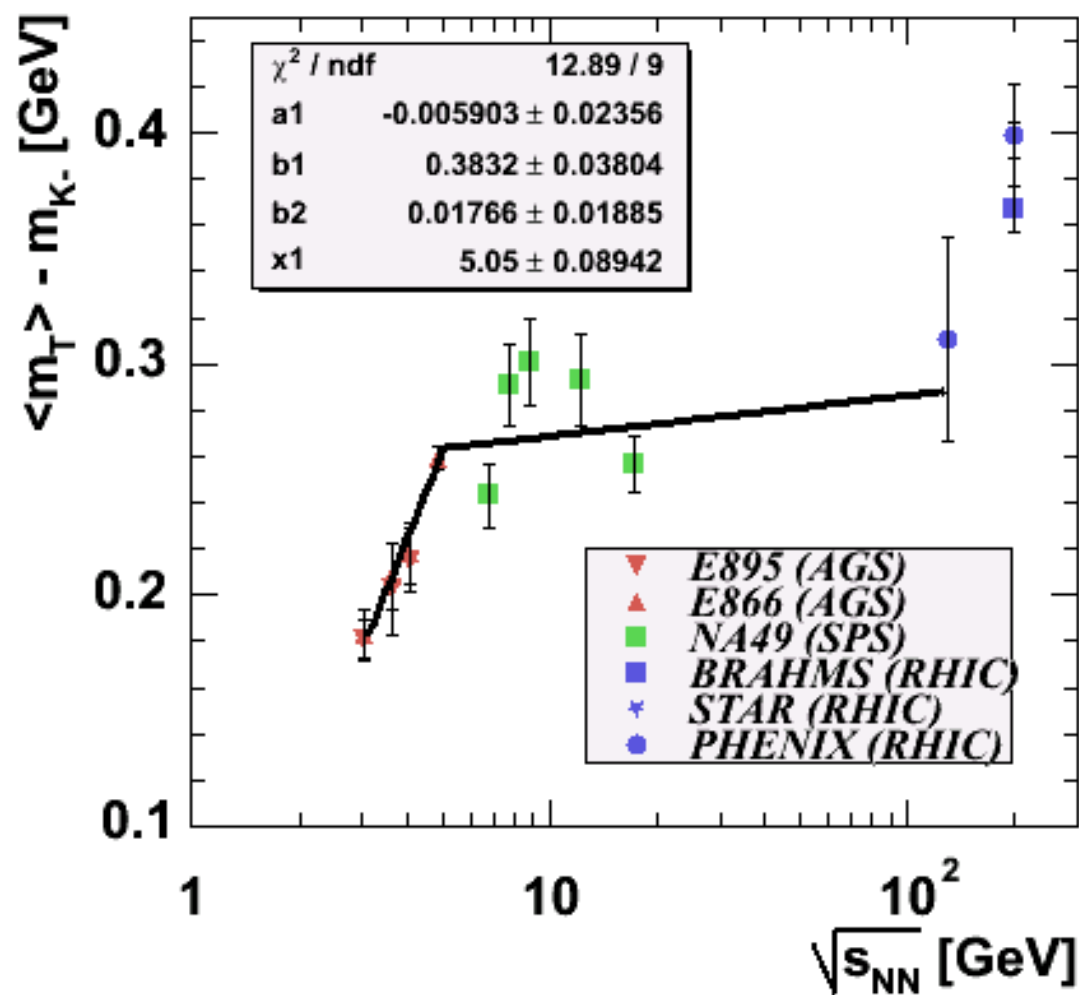
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

Pass w/ C.L.=5%.

Turn-over=6.1

Negative Kaon $\langle m_T \rangle - m_0$



Linear Fit:

FAIL. $\chi^2 = 78.37/14$

Line+Line Fit:

C.L.=10%. [5.0,6.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=10%. [5.0,6.0]

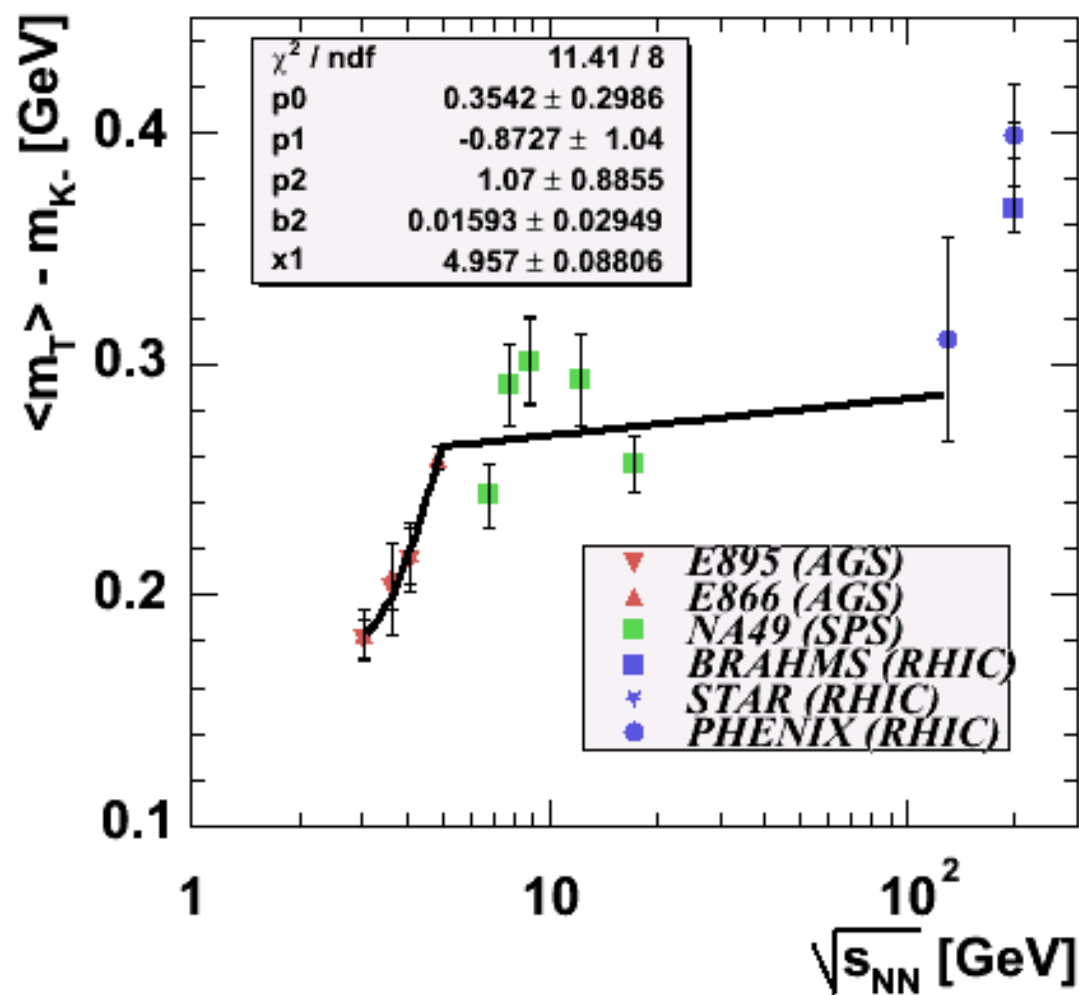
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

Pass w/ C.L.=5%.

Turn-over=6.1

Negative Kaon $\langle m_T \rangle - m_0$



Linear Fit:

FAIL. $\chi^2 = 78.37/14$

Line+Line Fit:

C.L.=10%. [5.0,6.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=10%. [5.0,6.0]

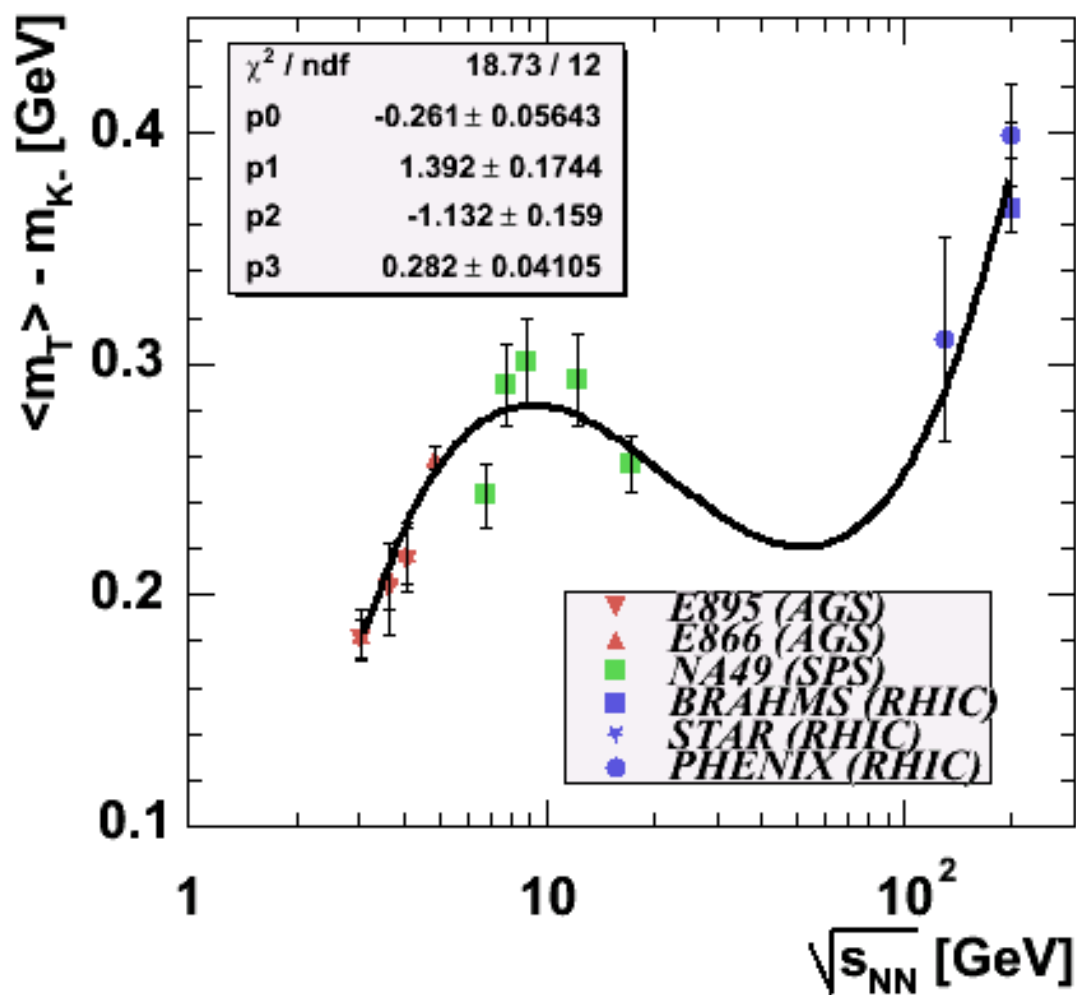
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

Pass w/ C.L.=5%.

Turn-over=6.1

Negative Kaon $\langle m_T \rangle - m_0$



Linear Fit:

FAIL. $\chi^2 = 78.37/14$

Line+Line Fit:

C.L.=10%. [5.0,6.0]

Minimum at $s^{1/2}=5.0$

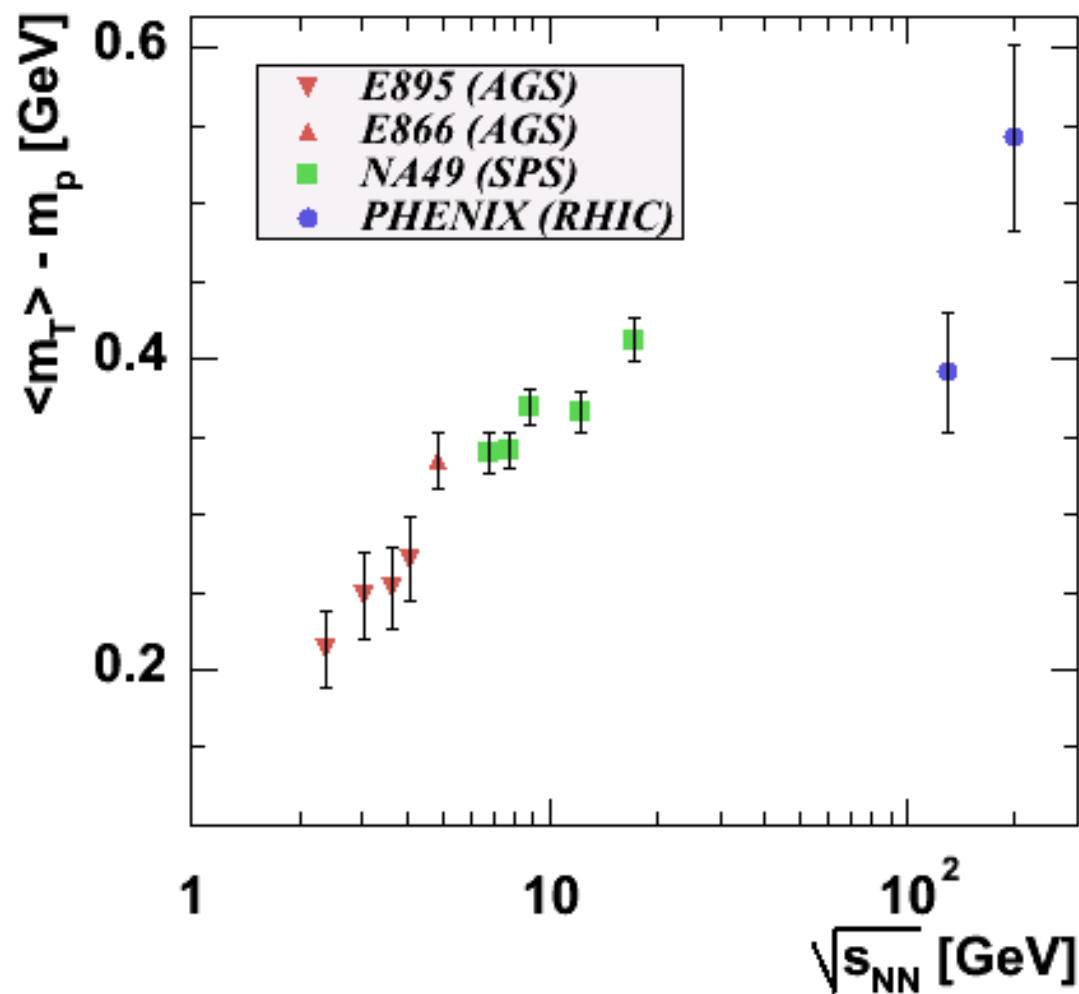
Poly+Line Fit:

C.L.=10%. [5.0,6.0]

Minimum at $s^{1/2}=5.0$

**3rd-order polynomial:
Pass w/ C.L.=5%.
Turn-over=6.1**

Proton $\langle m_T \rangle - m_0$



Linear Fit:

FAIL. $\chi^2 = 28.0/10$

Line+Line Fit:

C.L.=5%. [5.0,+]

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

C.L.=10%. [5.0,+]

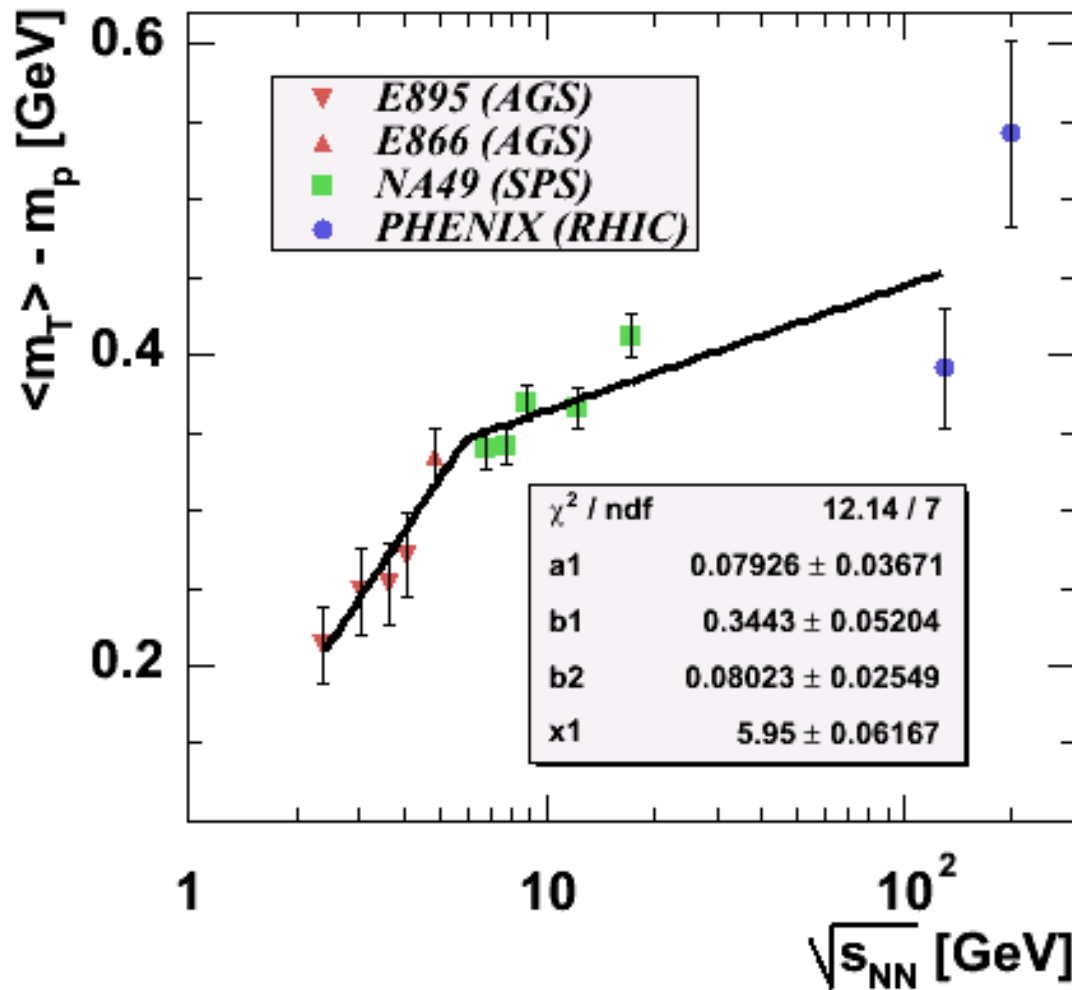
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

PASS w/ C.L.=25%.

Turn-over=6.2

Proton $\langle m_T \rangle - m_0$



Linear Fit:

FAIL. $\chi^2 = 28.0/10$

Line+Line Fit:

C.L.=5%. [5.0,+]

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

C.L.=10%. [5.0,+]

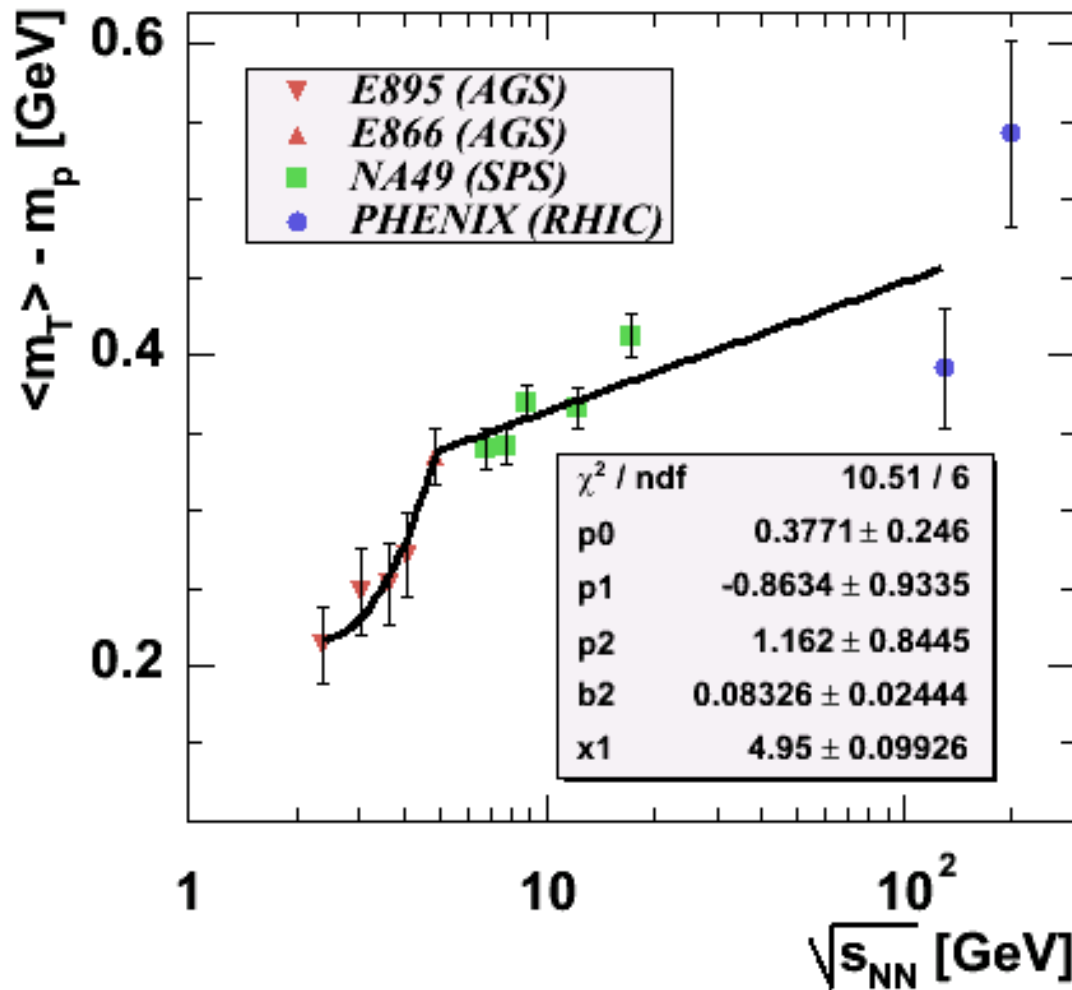
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

PASS w/ C.L.=25%.

Turn-over=6.2

Proton $\langle m_T \rangle - m_0$



Linear Fit:

FAIL. $\chi^2 = 28.0/10$

Line+Line Fit:

C.L.=5%. [5.0,+]

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

C.L.=10%. [5.0,+]

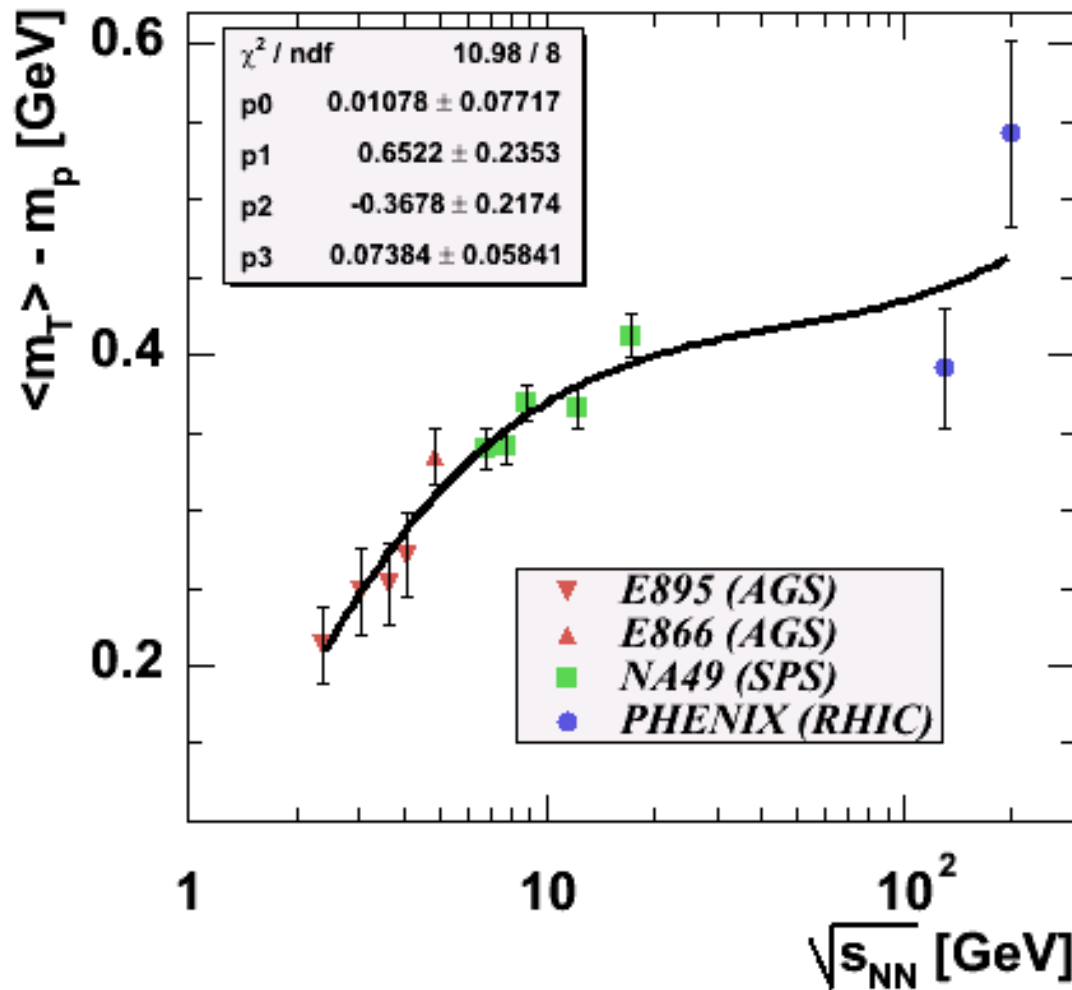
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

PASS w/ C.L.=25%.

Turn-over=6.2

Proton $\langle m_T \rangle - m_0$



Linear Fit:

FAIL. $\chi^2 = 28.0/10$

Line+Line Fit:

C.L.=5%. [5.0,+]

Minimum at $s^{1/2}=6.0$

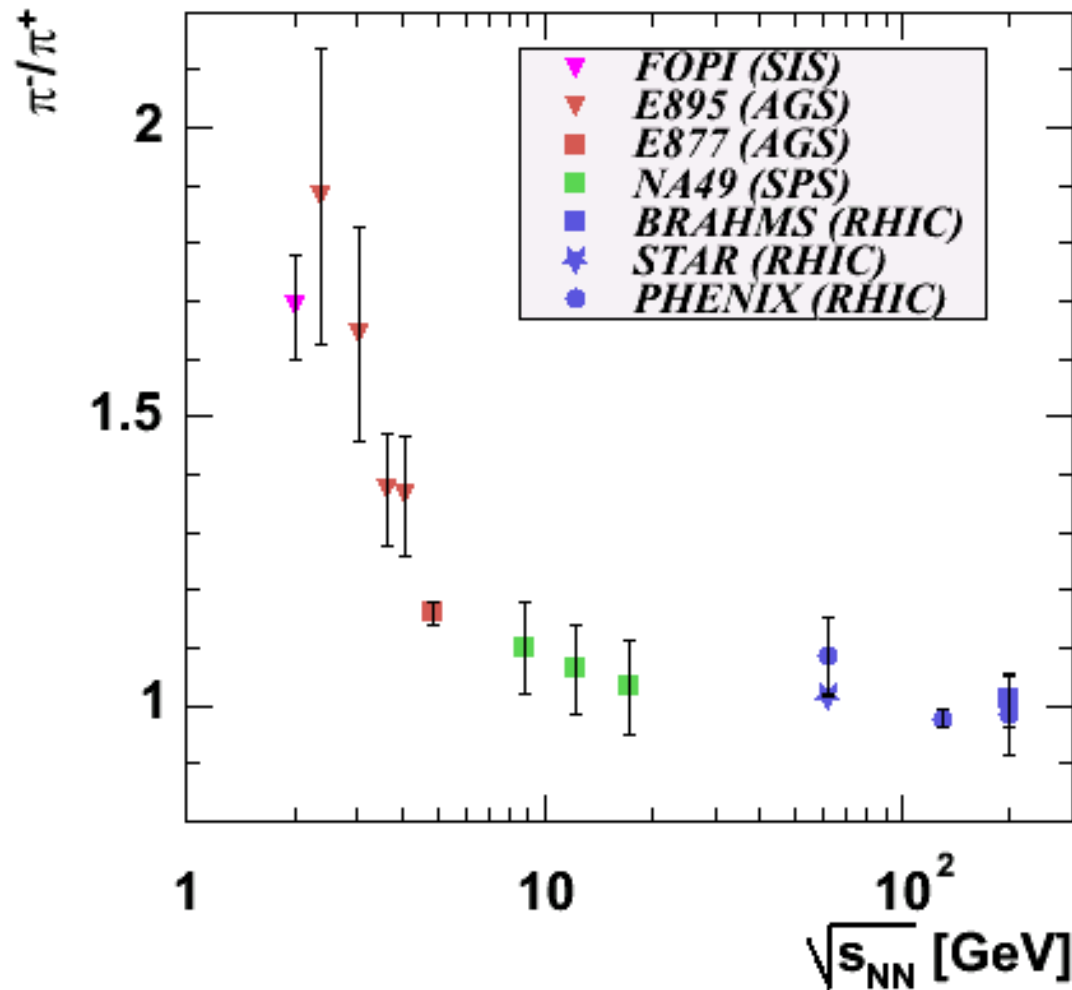
Poly+Line Fit:

C.L.=10%. [5.0,+]

Minimum at $s^{1/2}=5.0$

**3rd-order polynomial:
PASS w/ C.L.=25%.
Turn-over=6.2**

π^-/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 49.0/12$

Line+Line Fit:

C.L.=90%. [4.0,7.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=90%. [4.0,8.0]

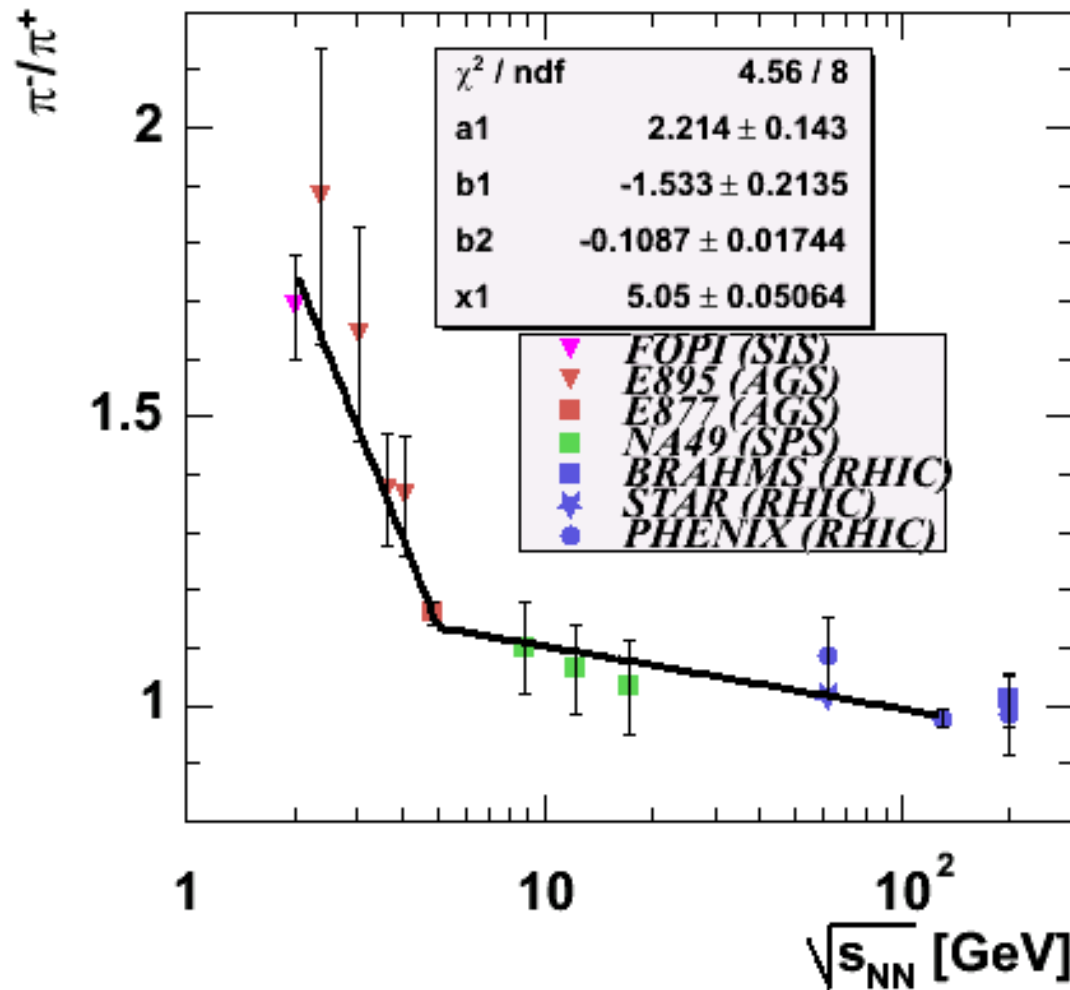
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

PASS w/ C.L.=25%.

Turn-over=6.6

π^-/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 49.0/12$

Line+Line Fit:

C.L.=90%. [4.0,7.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=90%. [4.0,8.0]

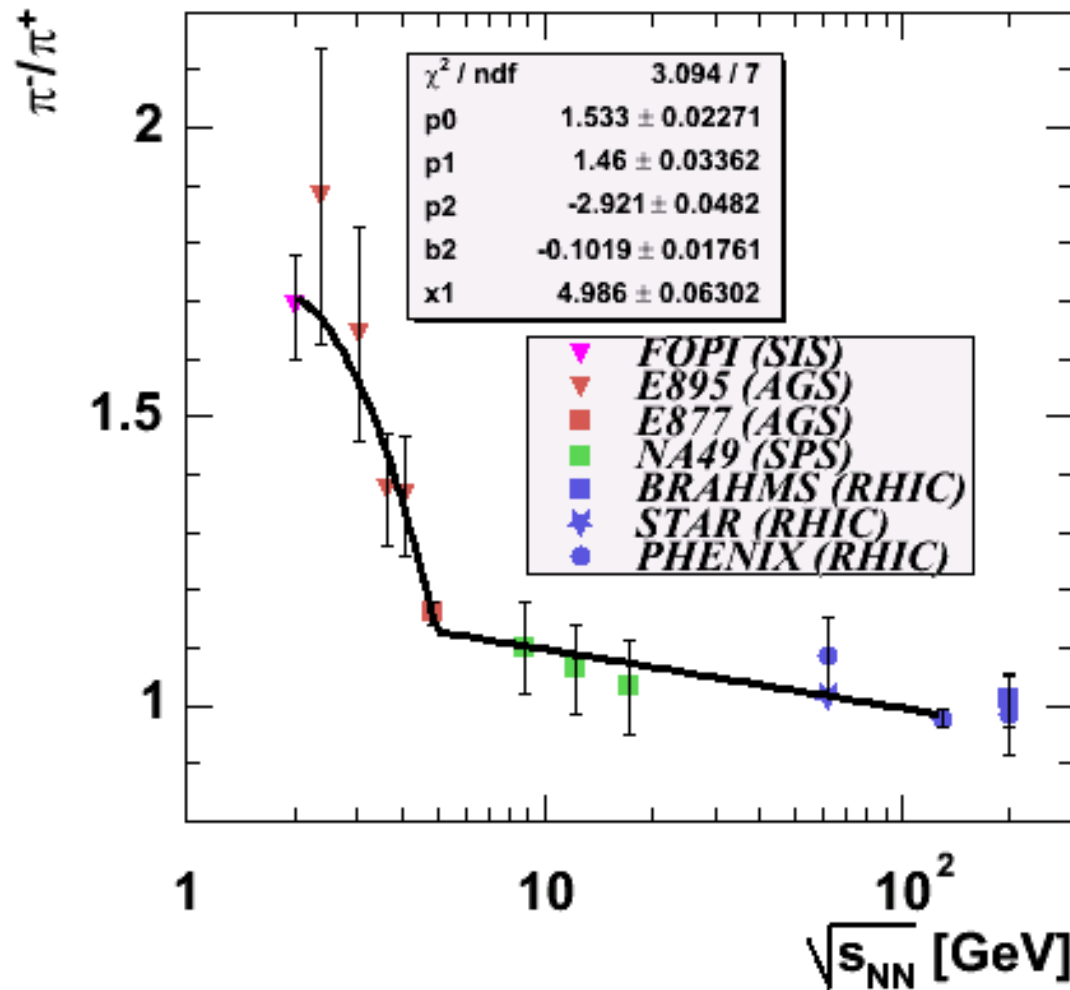
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

PASS w/ C.L.=25%.

Turn-over=6.6

π^-/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 49.0/12$

Line+Line Fit:

C.L.=90%. [4.0,7.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=90%. [4.0,8.0]

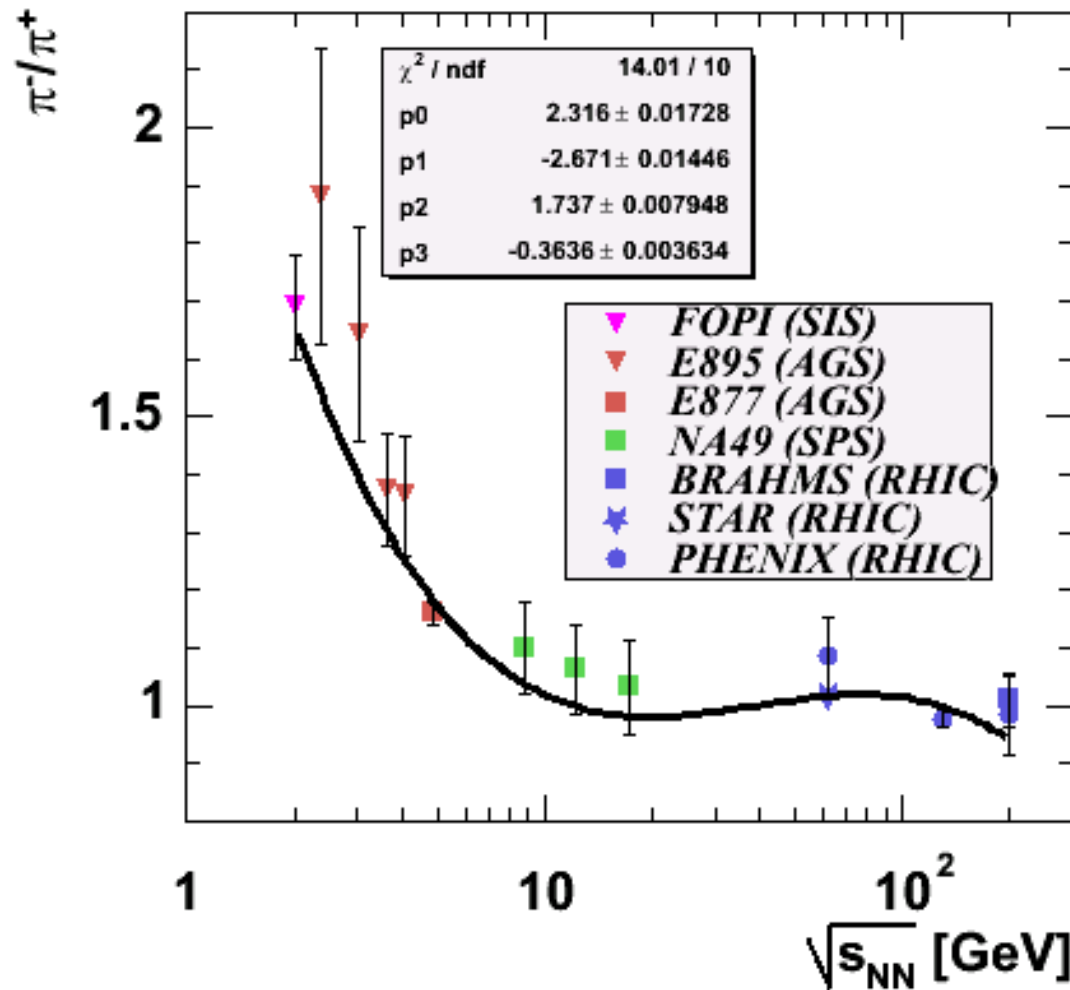
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

PASS w/ C.L.=25%.

Turn-over=6.6

π^-/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 49.0/12$

Line+Line Fit:

C.L.=90%. [4.0,7.0]

Minimum at $s^{1/2}=5.0$

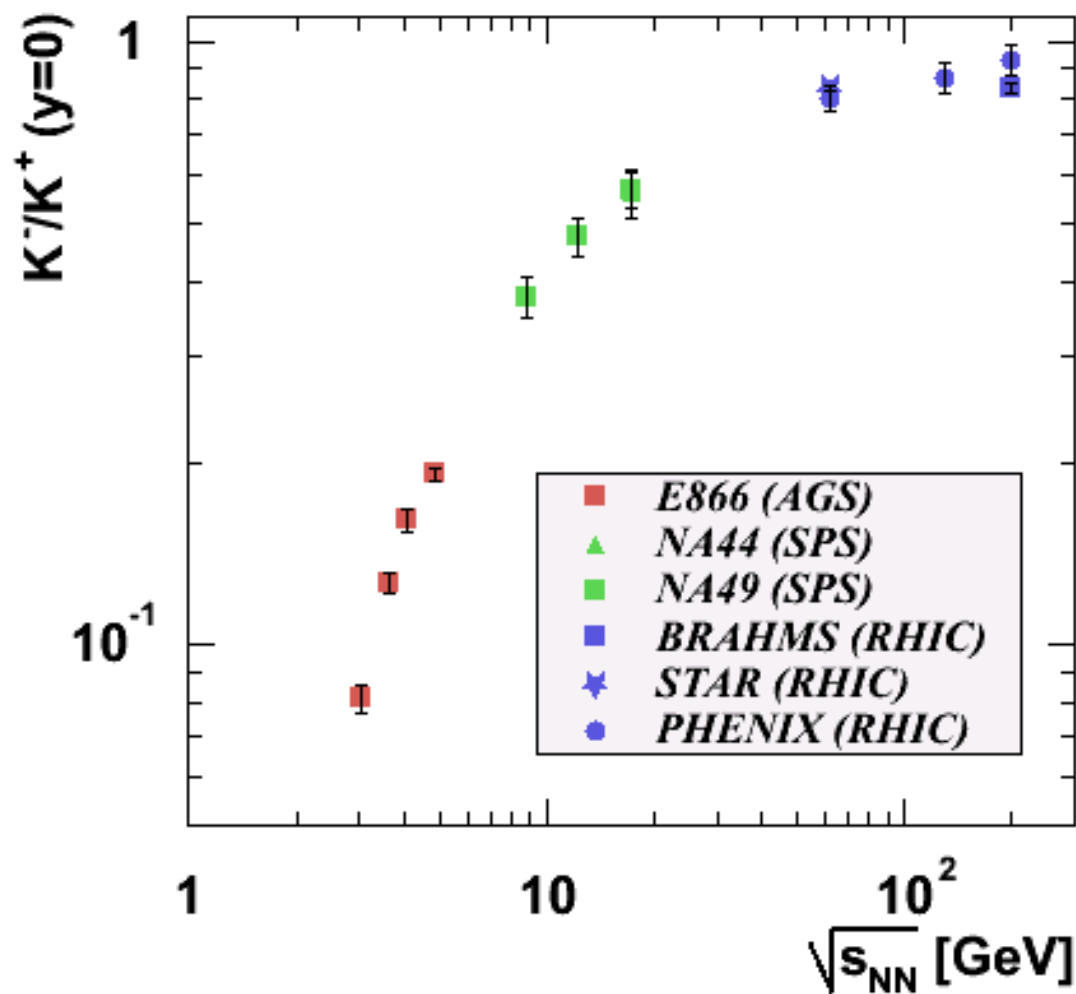
Poly+Line Fit:

C.L.=90%. [4.0,8.0]

Minimum at $s^{1/2}=5.0$

**3rd-order polynomial:
PASS w/ C.L.=25%.
Turn-over=6.6**

K⁻/K⁺ Ratio



Linear Fit:

FAIL. $\chi^2 = 1255/11$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=7.0$

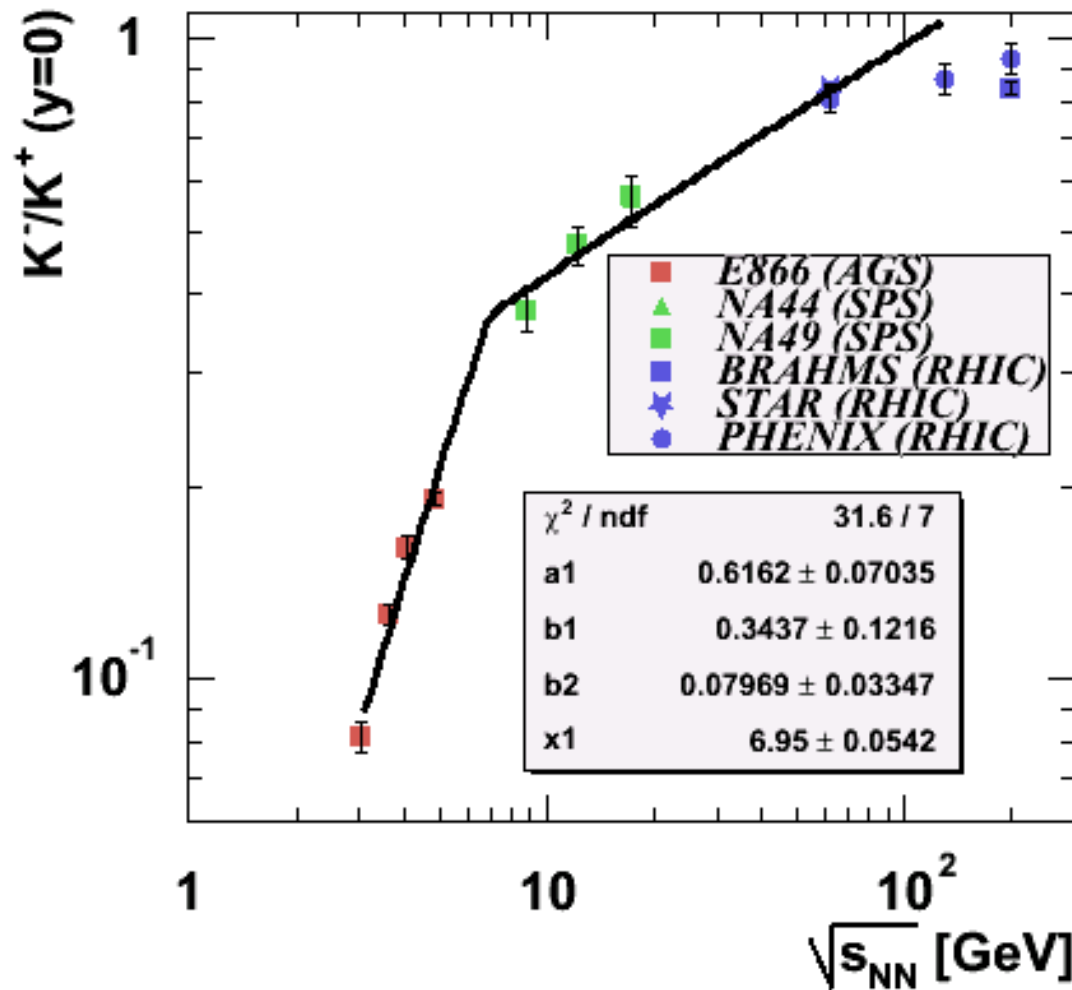
Poly+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

3rd-order polynomial:
PASS w/ C.L.=50%.
Turn-over=27.5

K⁻/K⁺ Ratio



Linear Fit:

FAIL. $\chi^2 = 1255/11$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=7.0$

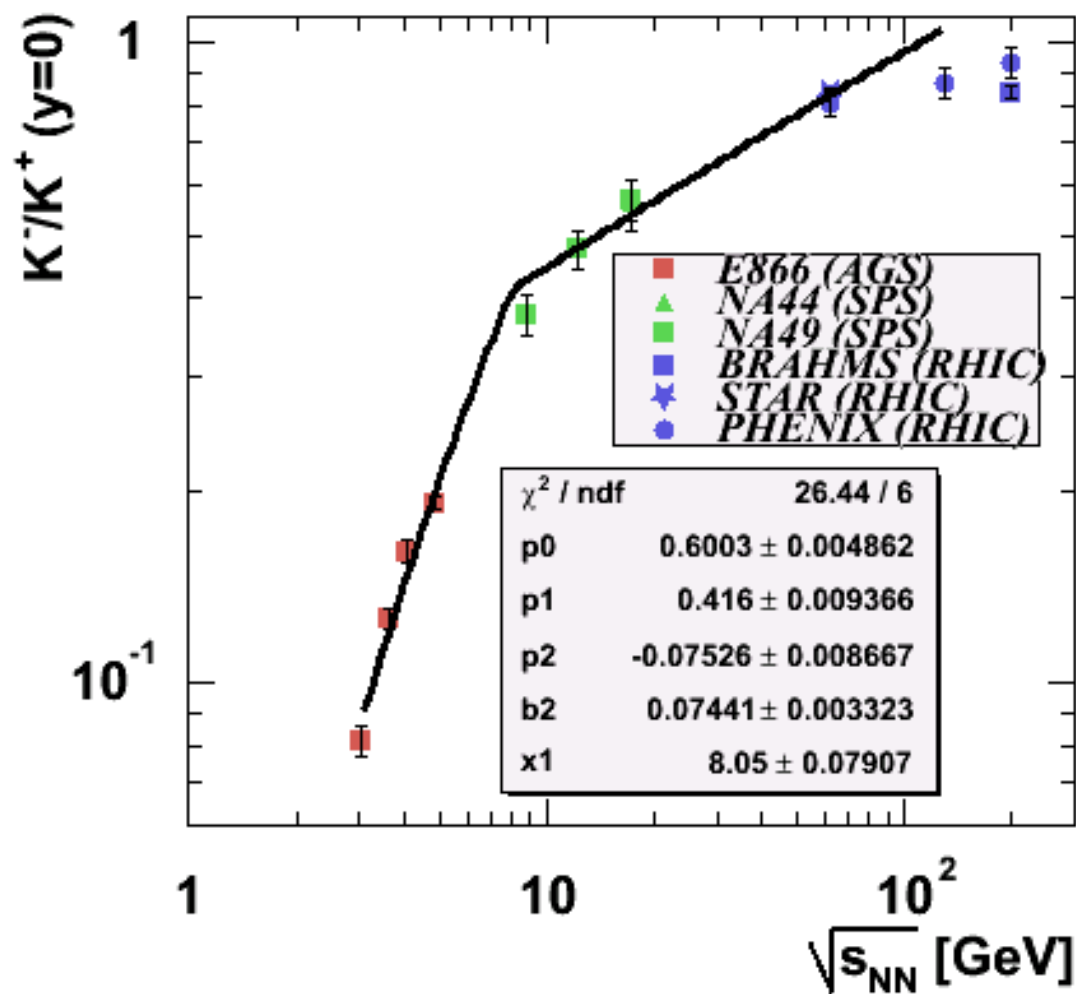
Poly+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

3rd-order polynomial:
PASS w/ C.L.=50%.
Turn-over=27.5

K⁻/K⁺ Ratio



Linear Fit:

FAIL. $\chi^2 = 1255/11$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=7.0$

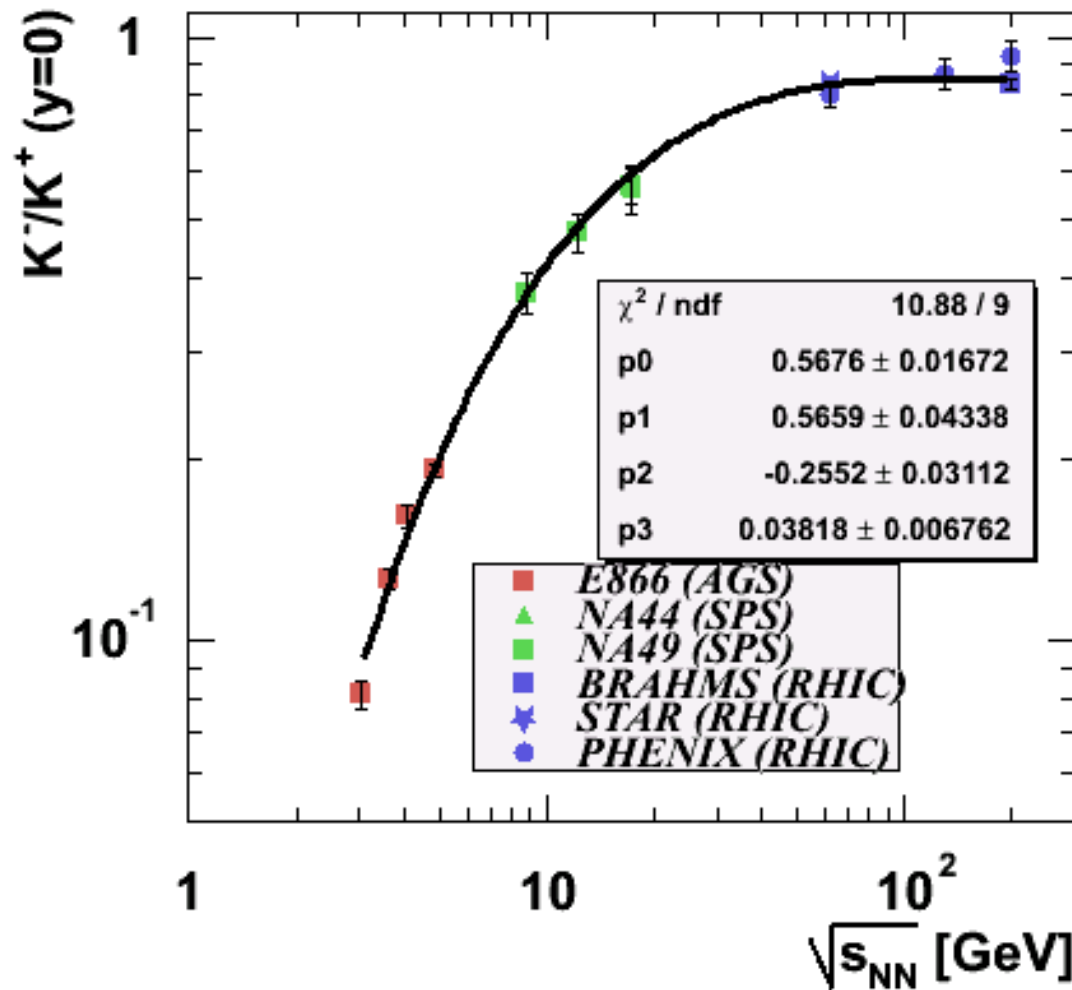
Poly+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

3rd-order polynomial:
PASS w/ C.L.=50%.
Turn-over=27.5

K⁻/K⁺ Ratio



Linear Fit:

FAIL. $\chi^2 = 1255/11$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=7.0$

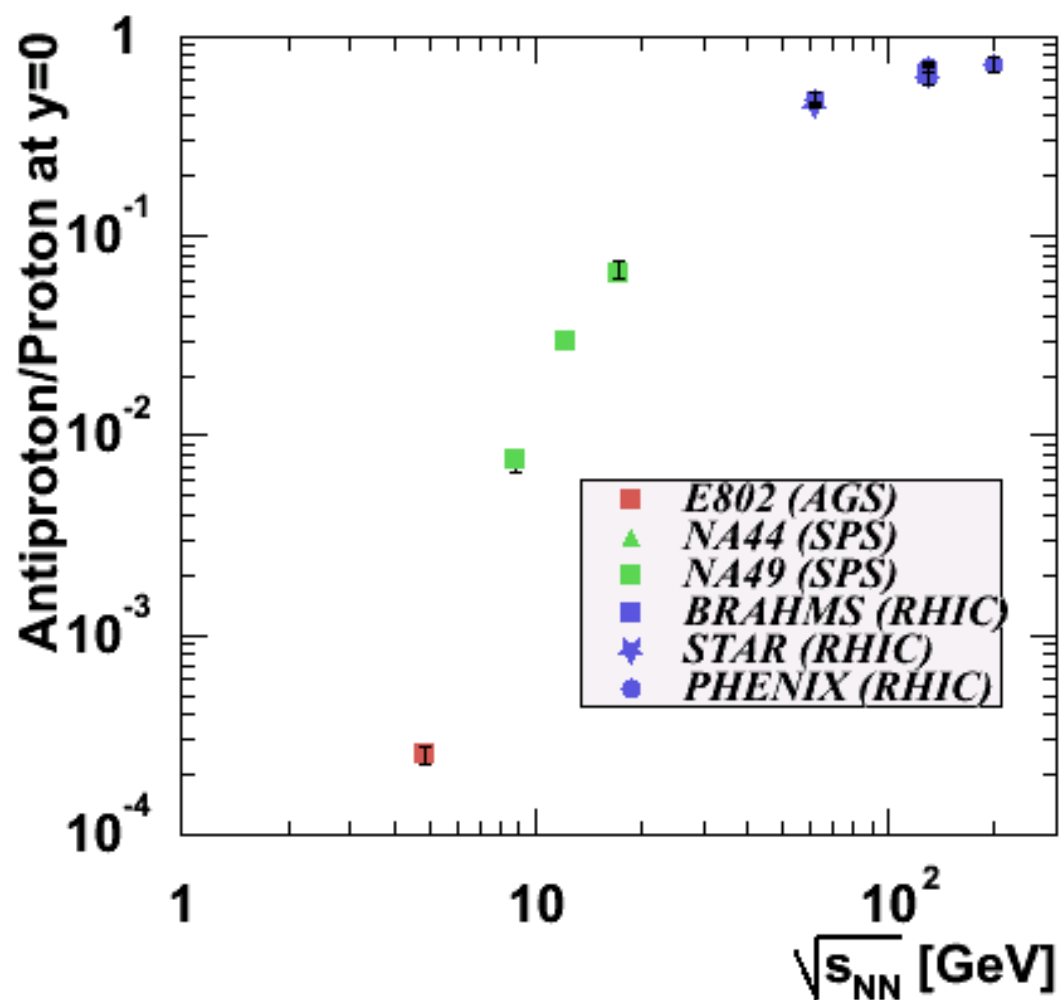
Poly+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

3rd-order polynomial:
PASS w/ C.L.=50%.
Turn-over=27.5

Antiproton/Proton Ratio



Linear Fit:

FAIL. $\chi^2 = 1886/9$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

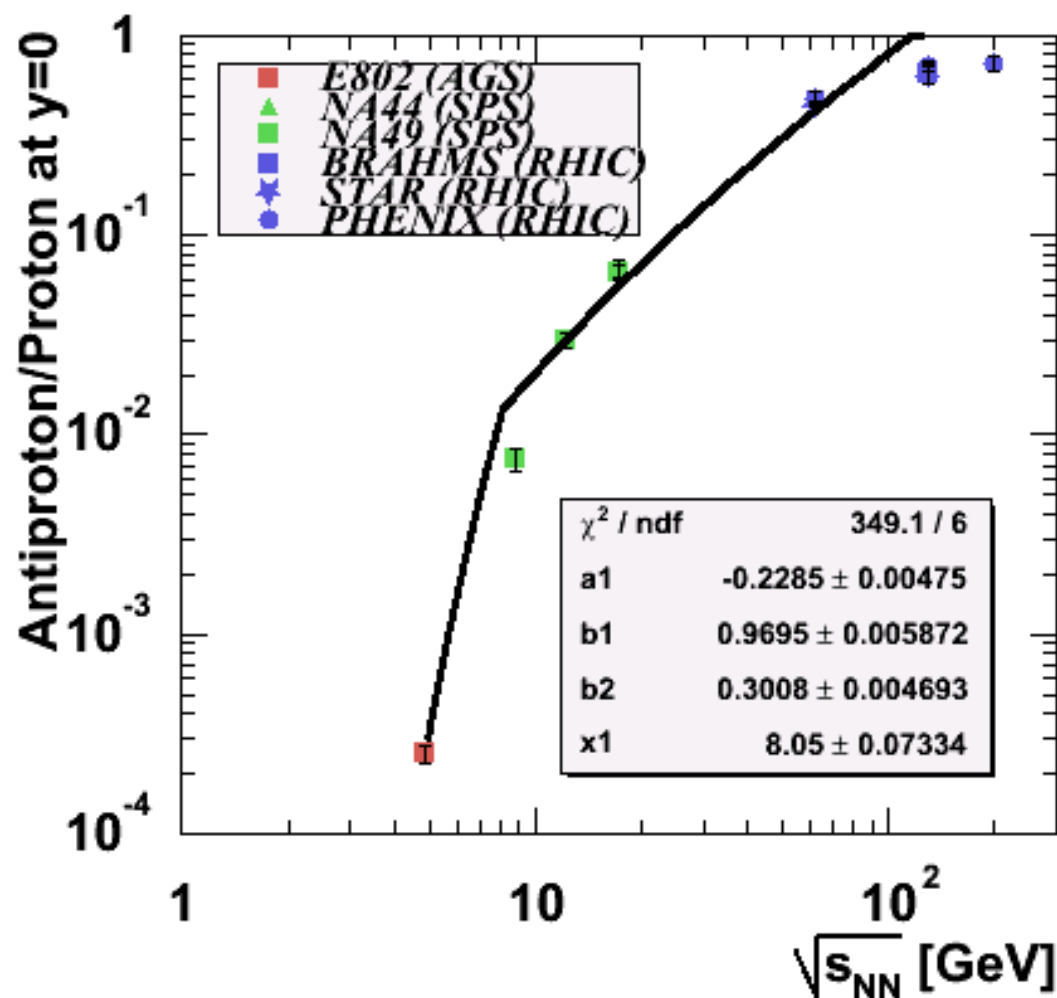
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=27.0

Antiproton/Proton Ratio



Linear Fit:

FAIL. $\chi^2 = 1886/9$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

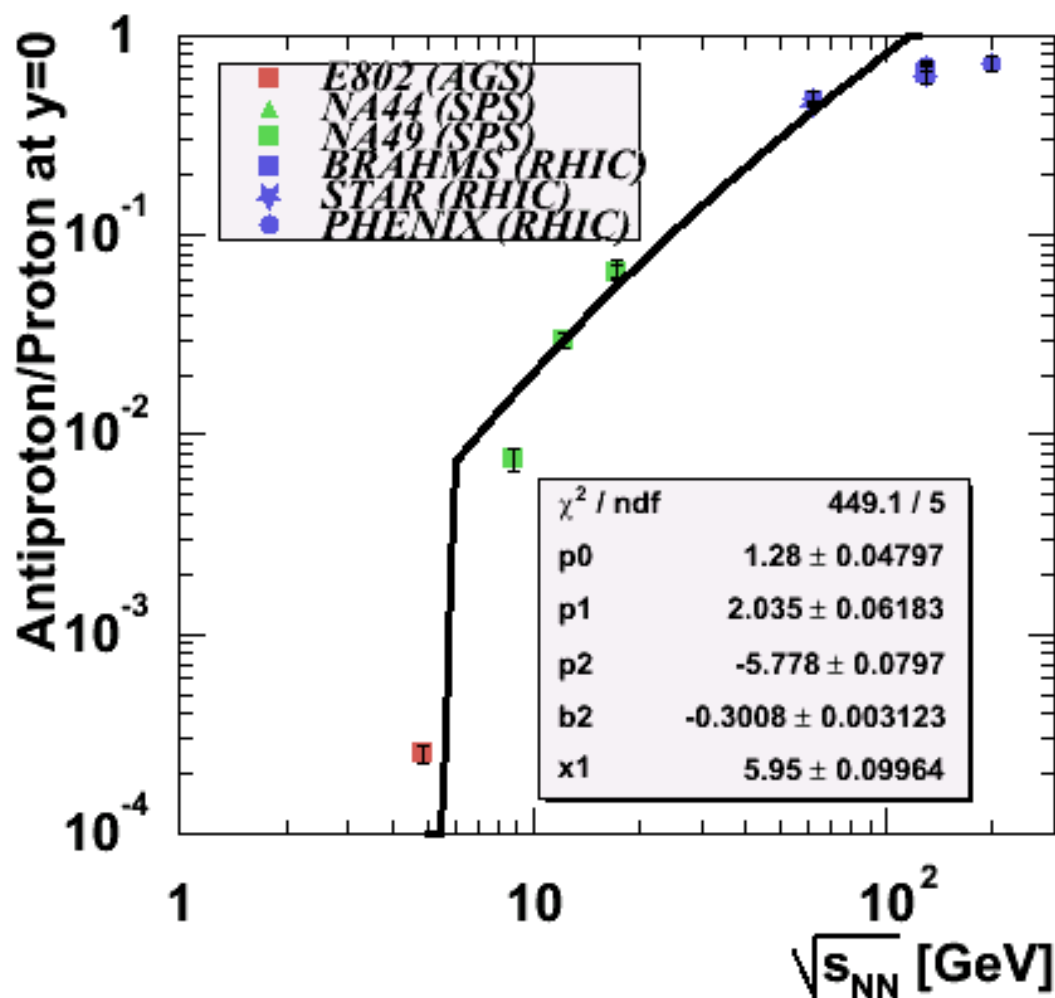
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=27.0

Antiproton/Proton Ratio



Linear Fit:

FAIL. $\chi^2 = 1886/9$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

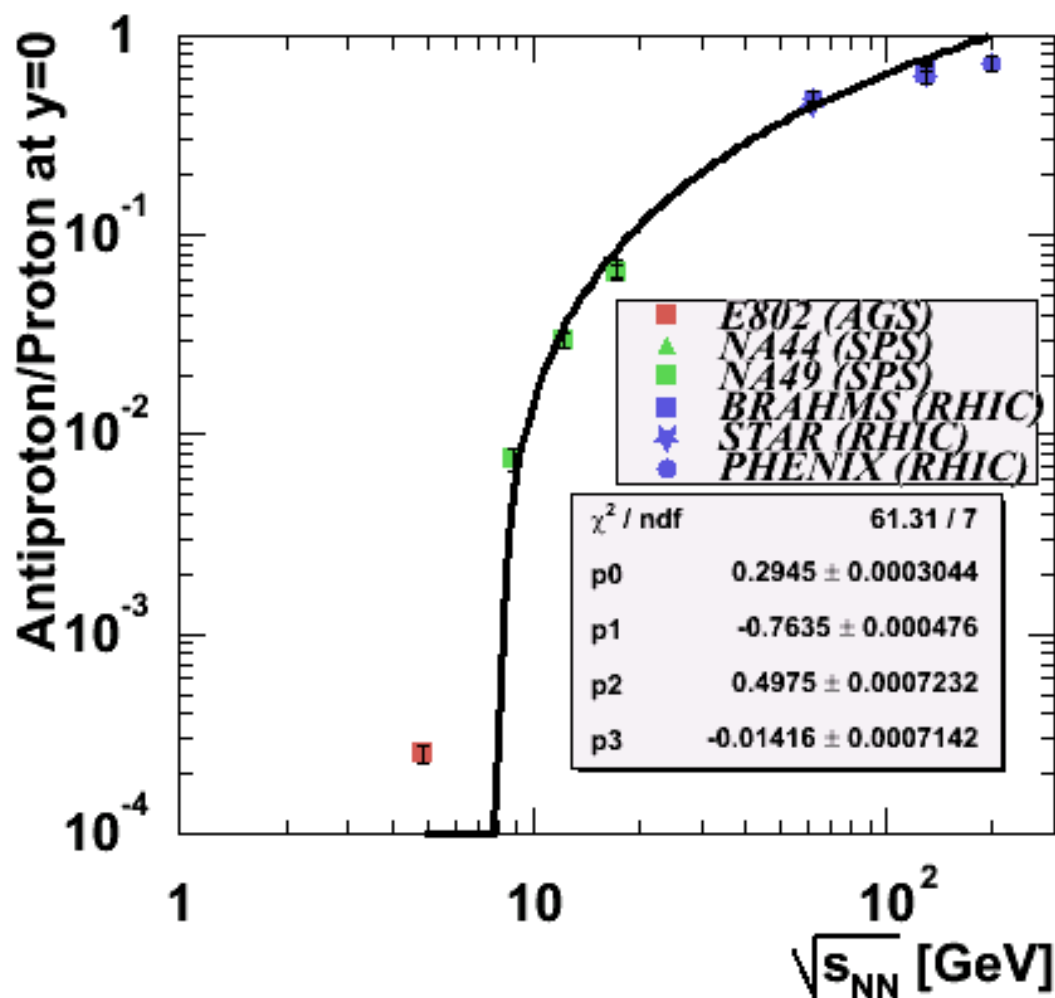
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=27.0

Antiproton/Proton Ratio



Linear Fit:

FAIL. $\chi^2 = 1886/9$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

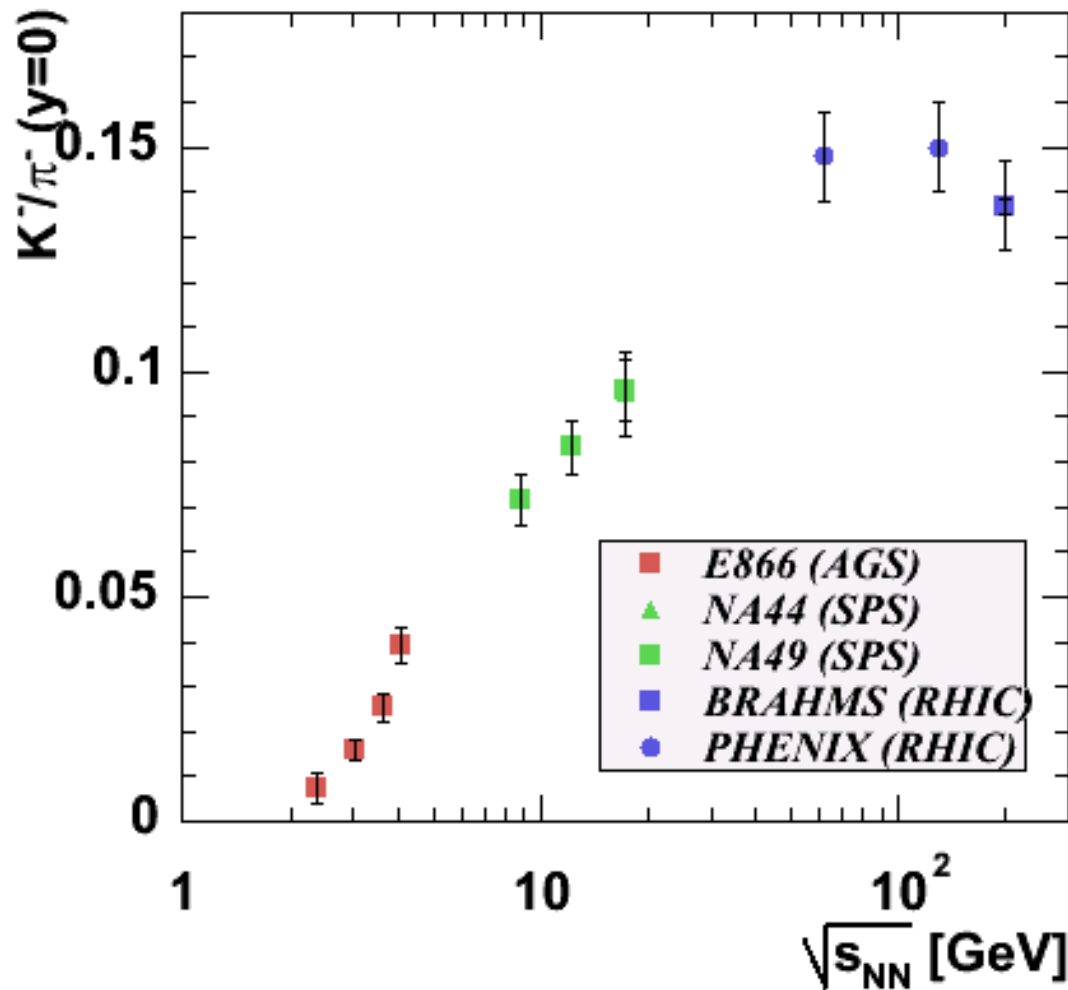
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=27.0

K^-/π^- Ratio



Linear Fit:

FAIL. $\chi^2 = 89.2/10$

Line+Line Fit:

C.L.=50%. [4.0,+]

Minimum at $s^{1/2}=10.0$

Poly+Line Fit:

C.L.=75%. [4.0,+]

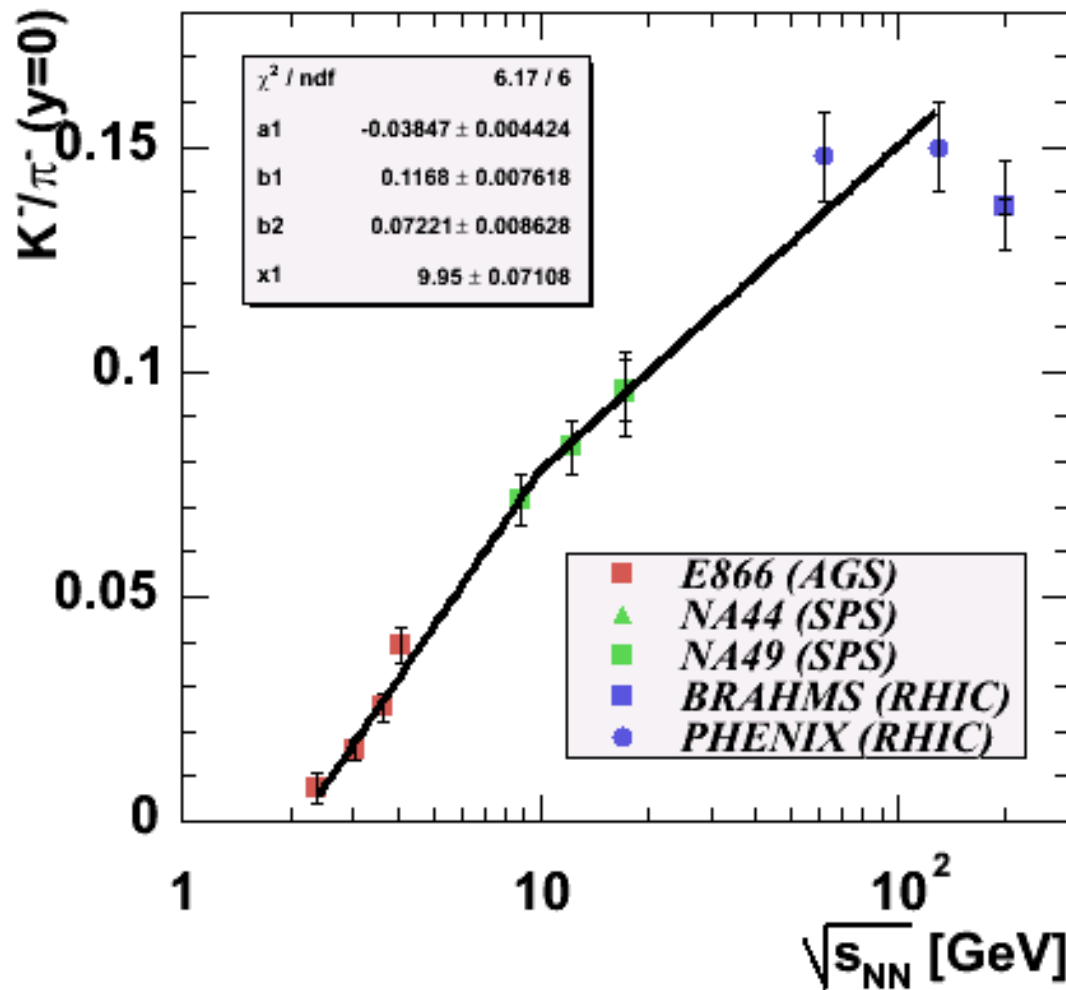
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

PASS w/ C.L.=75%.

Turn-over=34.2

K^-/π^- Ratio



Linear Fit:

FAIL. $\chi^2 = 89.2/10$

Line+Line Fit:

C.L.=50%. [4.0,+]

Minimum at $s^{1/2}=10.0$

Poly+Line Fit:

C.L.=75%. [4.0,+]

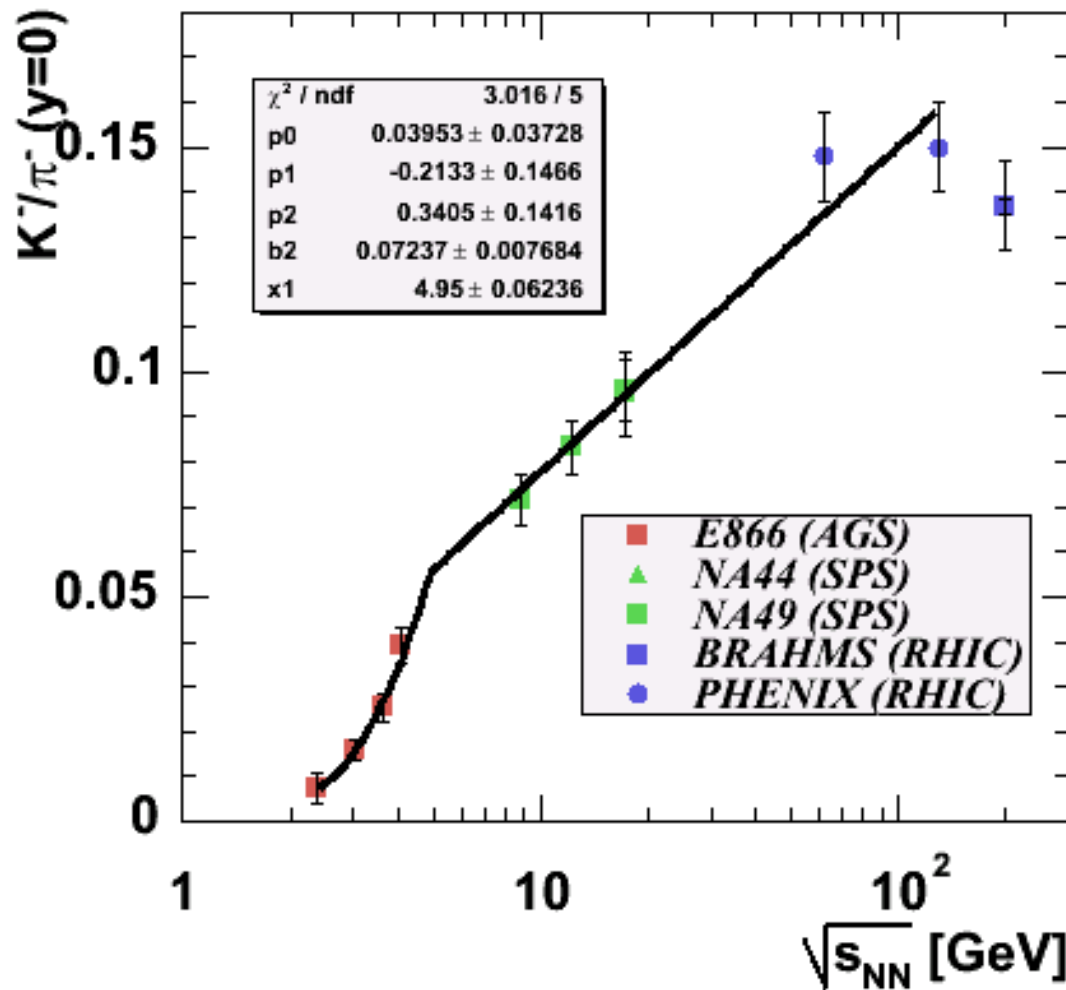
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

PASS w/ C.L.=75%.

Turn-over=34.2

K^-/π^- Ratio



Linear Fit:

FAIL. $\chi^2 = 89.2/10$

Line+Line Fit:

C.L.=50%. [4.0,+]

Minimum at $s^{1/2}=10.0$

Poly+Line Fit:

C.L.=75%. [4.0,+]

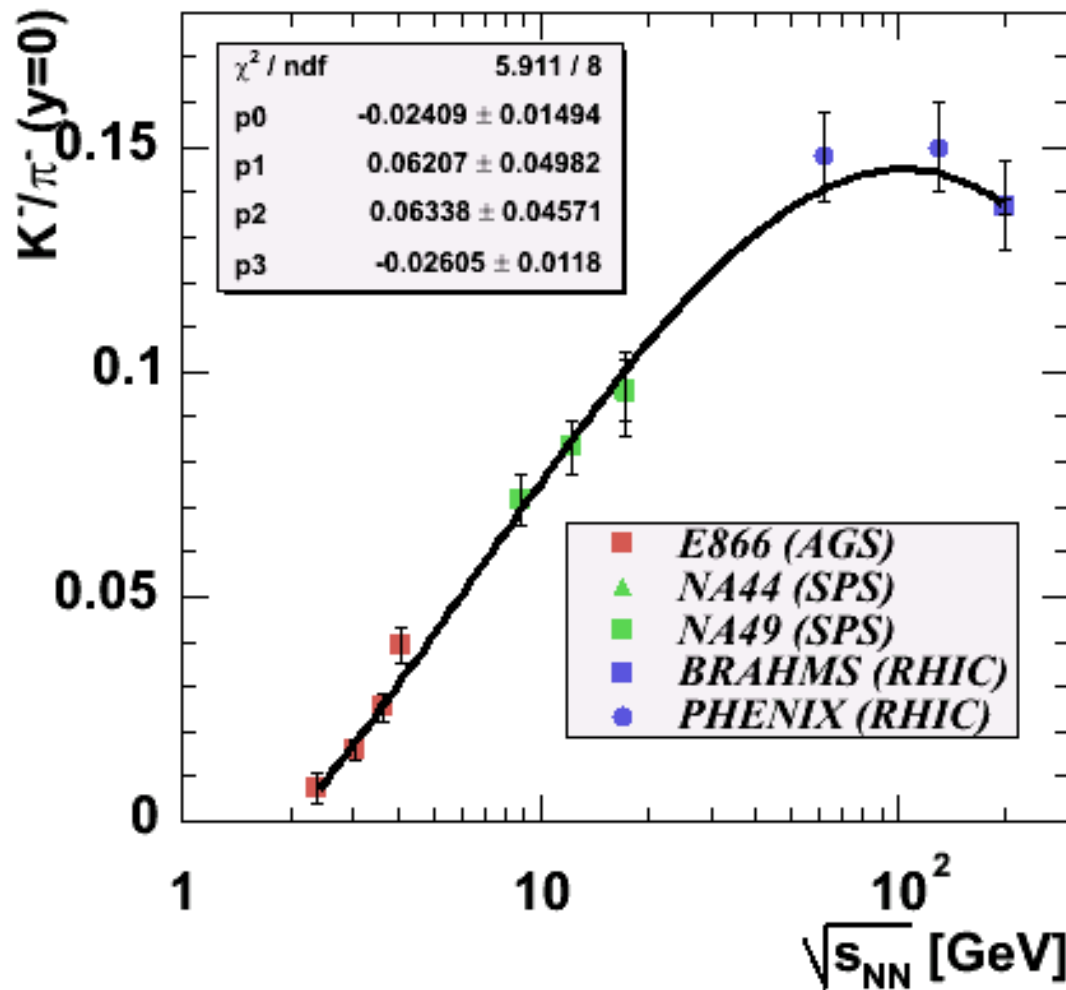
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

PASS w/ C.L.=75%.

Turn-over=34.2

K^-/π^- Ratio



Linear Fit:

FAIL. $\chi^2 = 89.2/10$

Line+Line Fit:

C.L.=50%. [4.0,+]

Minimum at $s^{1/2}=10.0$

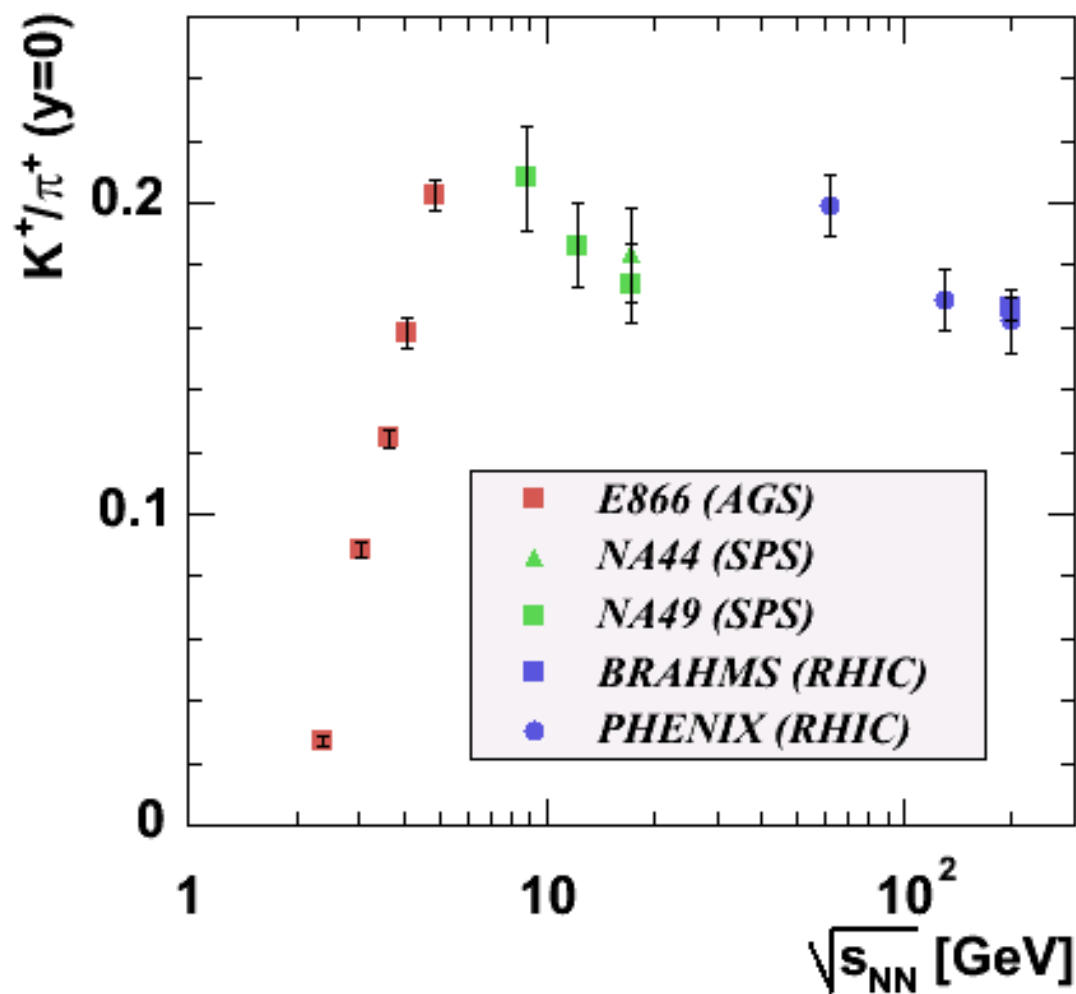
Poly+Line Fit:

C.L.=75%. [4.0,+]

Minimum at $s^{1/2}=5.0$

**3rd-order polynomial:
PASS w/ C.L.=75%.
Turn-over=34.2**

K^+/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 1990/11$

Line+Line Fit:

C.L.=25%. [5.0,5.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=25%. [5.0,5.0]

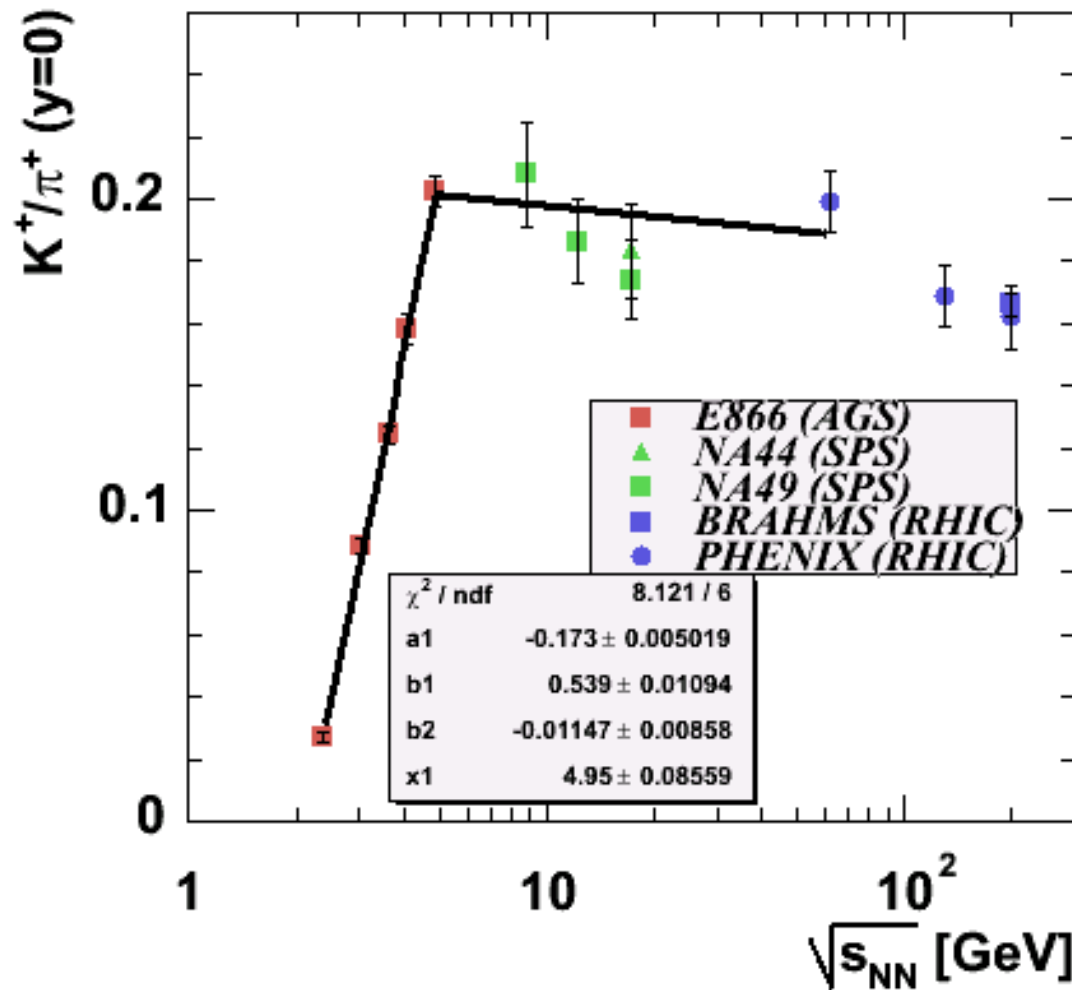
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

FAIL.

Turn-over=**17.8 (10.6)**

K^+/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 1990/11$

Line+Line Fit:

C.L.=25%. [5.0,5.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=25%. [5.0,5.0]

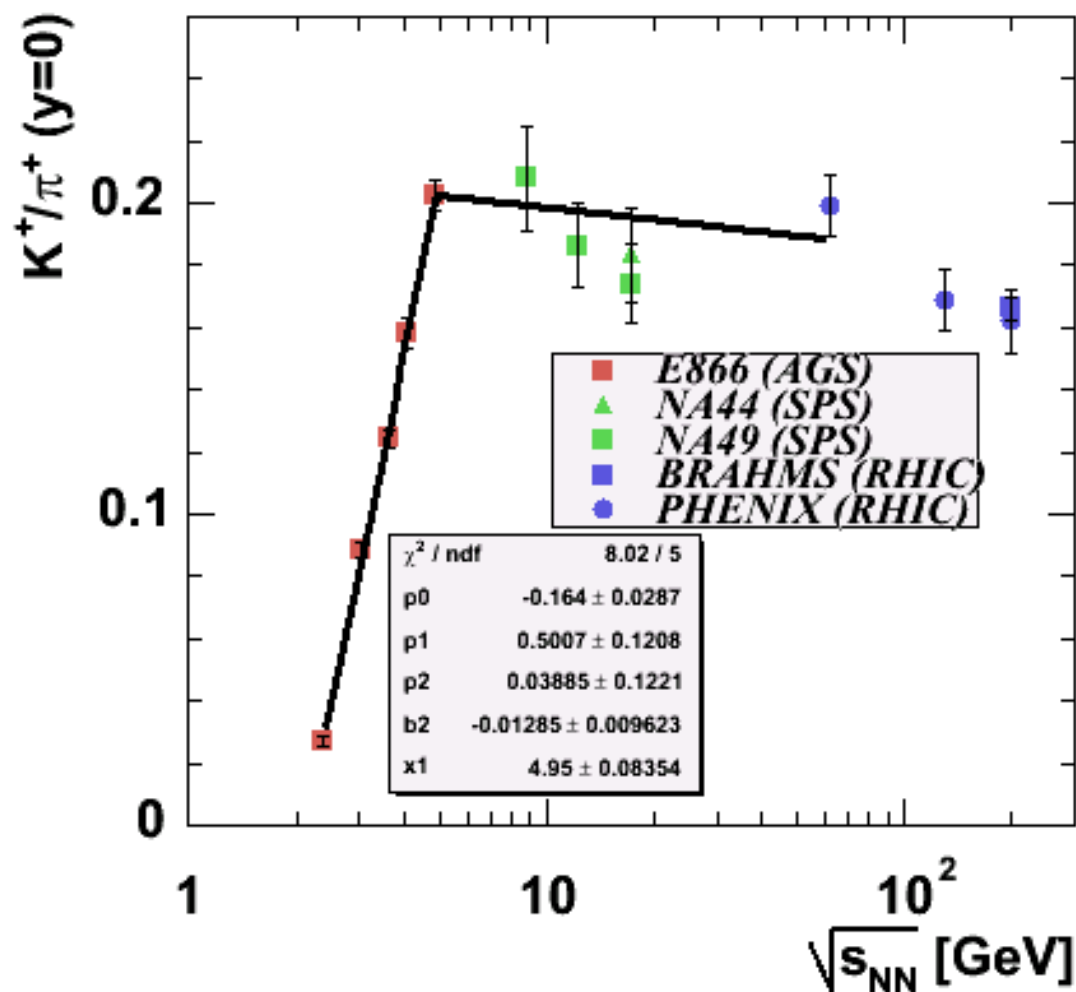
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

FAIL.

Turn-over=17.8 (10.6)

K^+/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 1990/11$

Line+Line Fit:

C.L.=25%. [5.0,5.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=25%. [5.0,5.0]

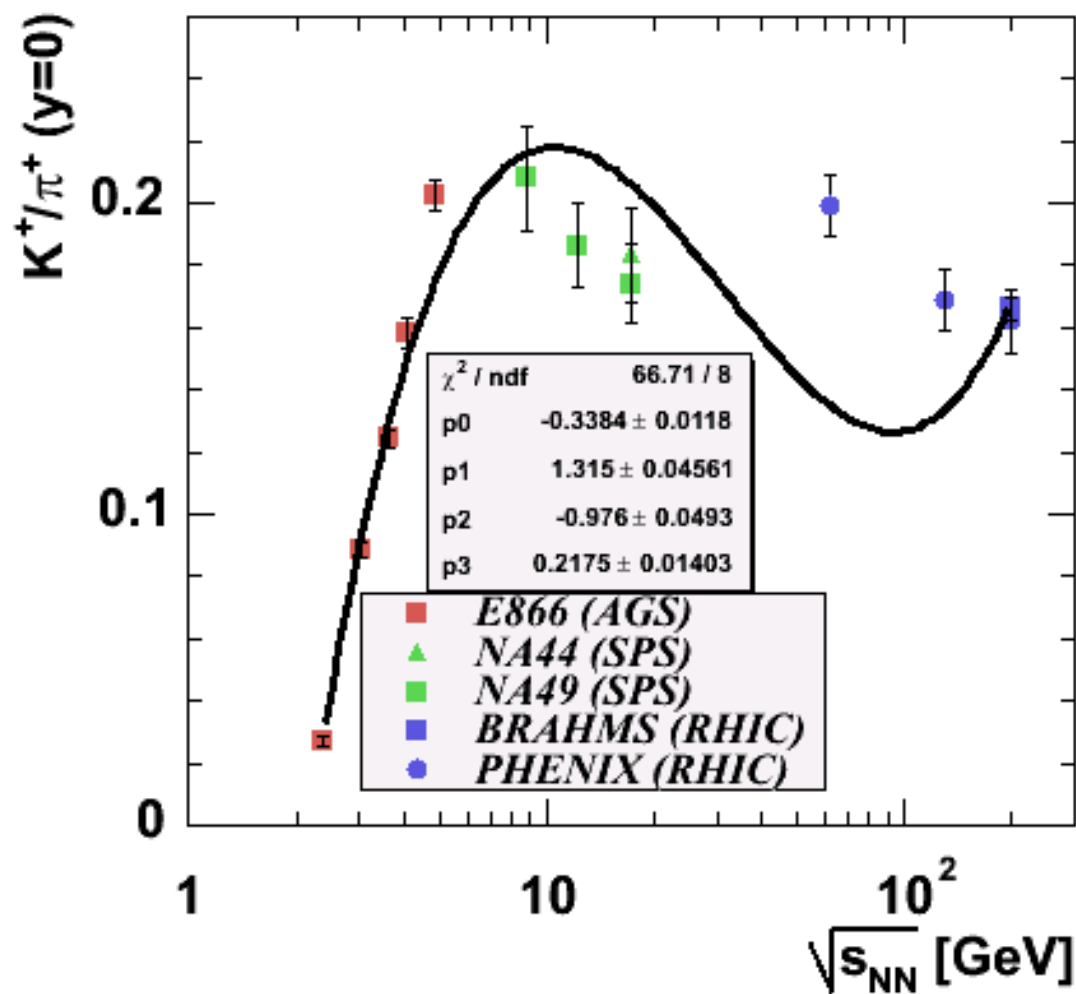
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

FAIL.

Turn-over=**17.8 (10.6)**

K^+/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 1990/11$

Line+Line Fit:

C.L.=25%. [5.0,5.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=25%. [5.0,5.0]

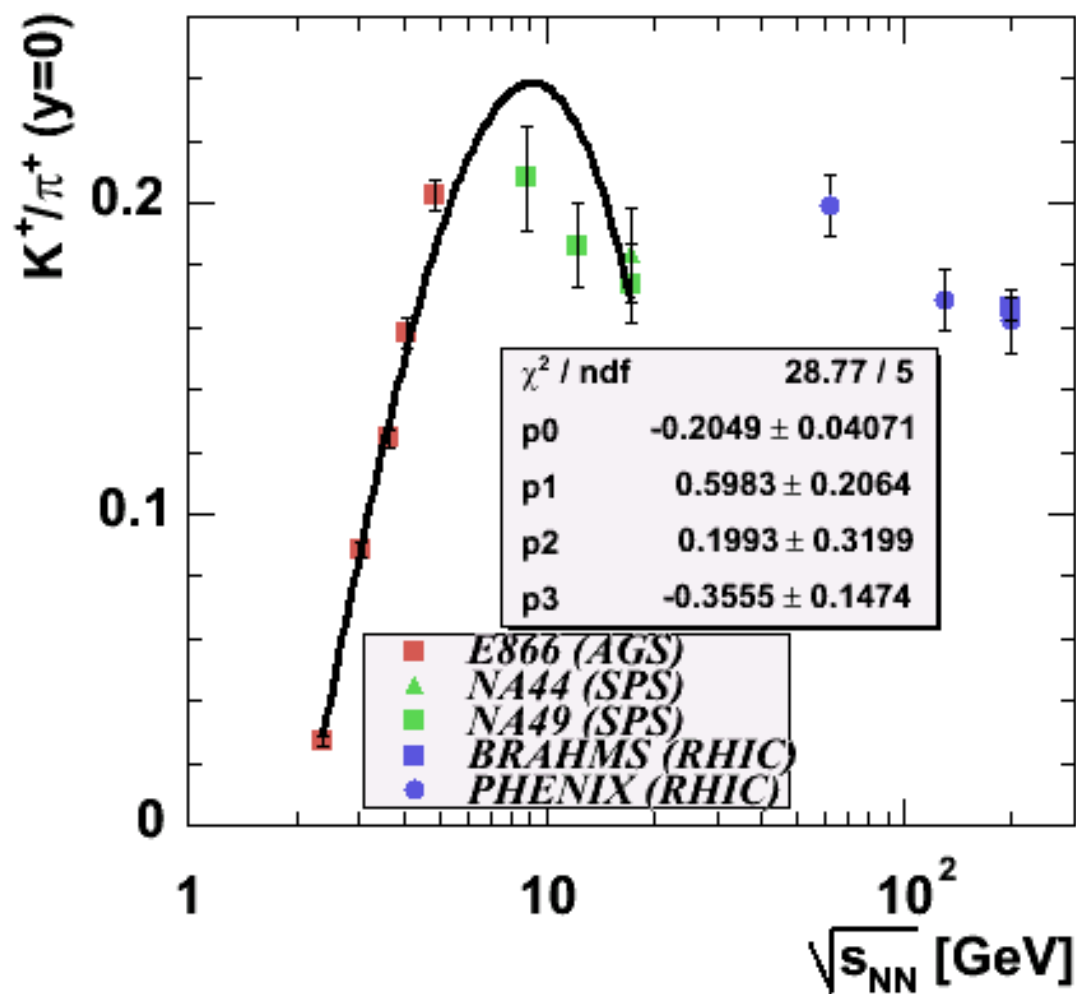
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

FAIL.

Turn-over=17.8 (10.6)

K^+/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 1990/11$

Line+Line Fit:

C.L.=25%. [5.0,5.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=25%. [5.0,5.0]

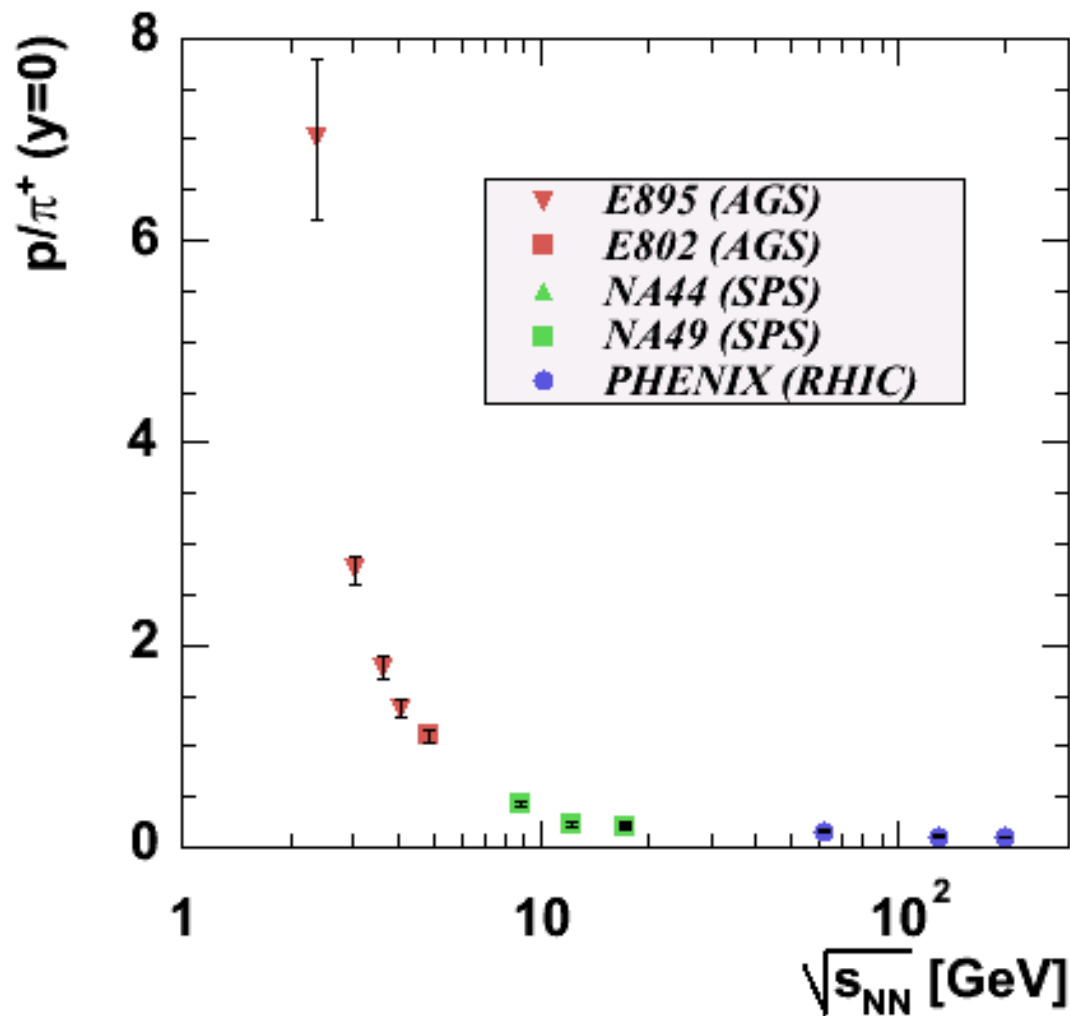
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

FAIL.

Turn-over=17.8 (10.6)

p/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 85.8/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

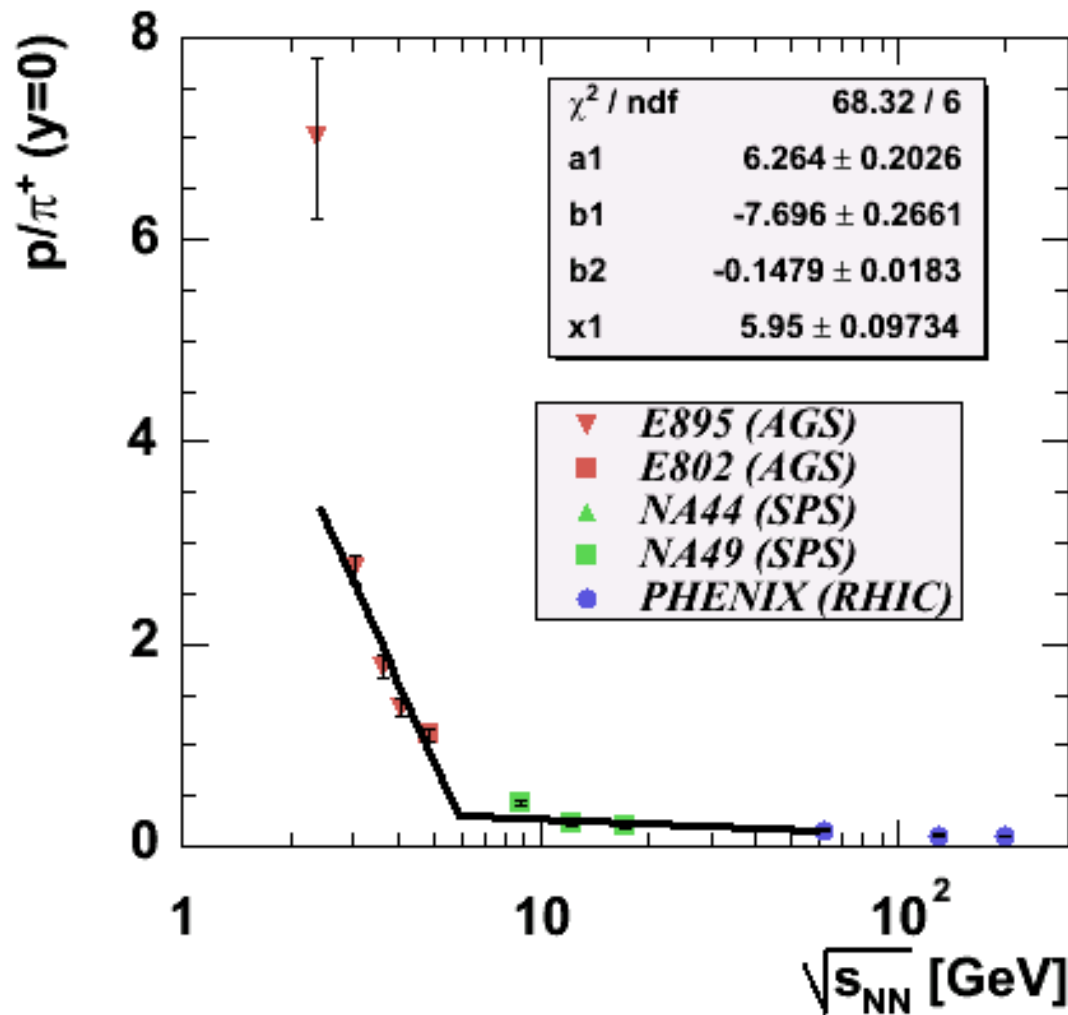
Minimum at $s^{1/2}=7.0$

3rd-order polynomial:

FAIL.

Turn-over=5.0

p/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 85.8/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

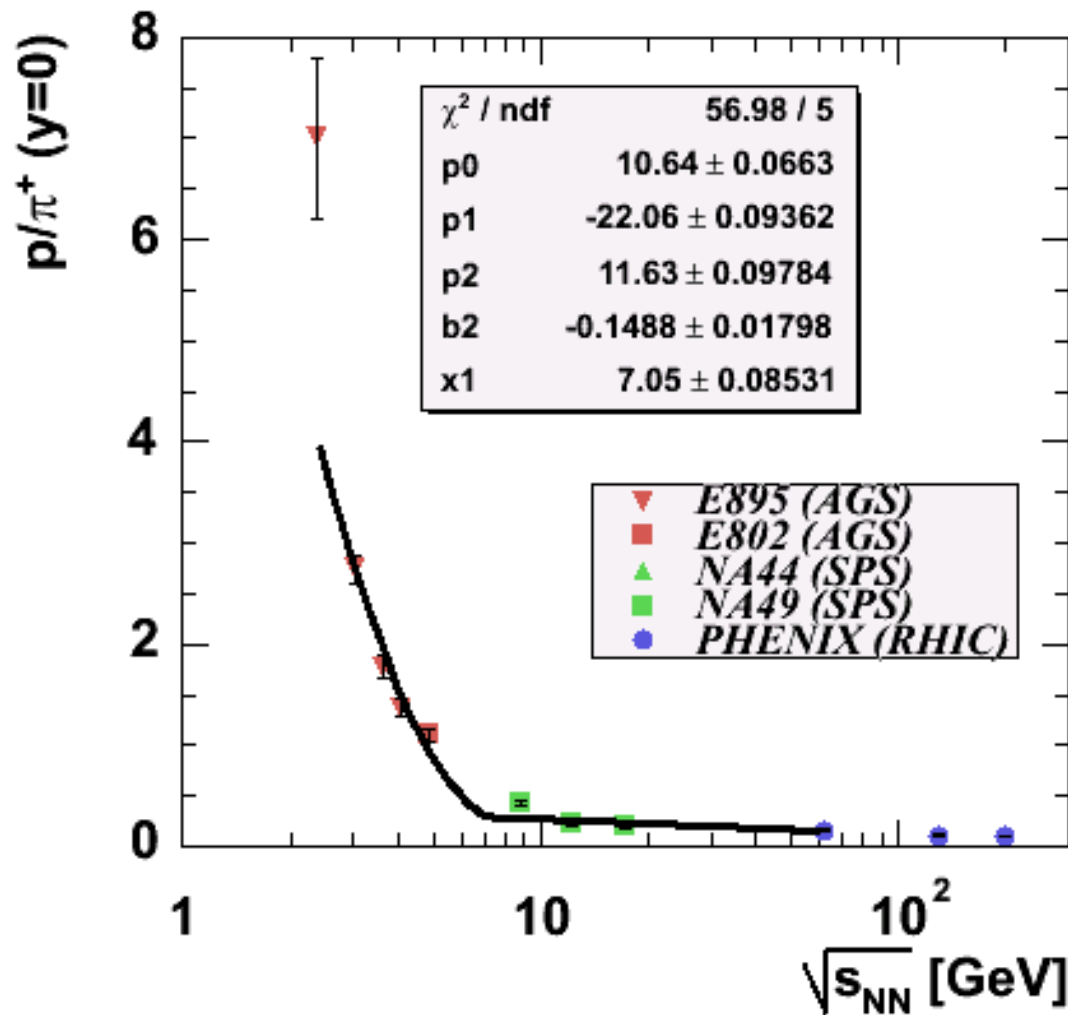
Minimum at $s^{1/2}=7.0$

3rd-order polynomial:

FAIL.

Turn-over=5.0

p/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 85.8/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

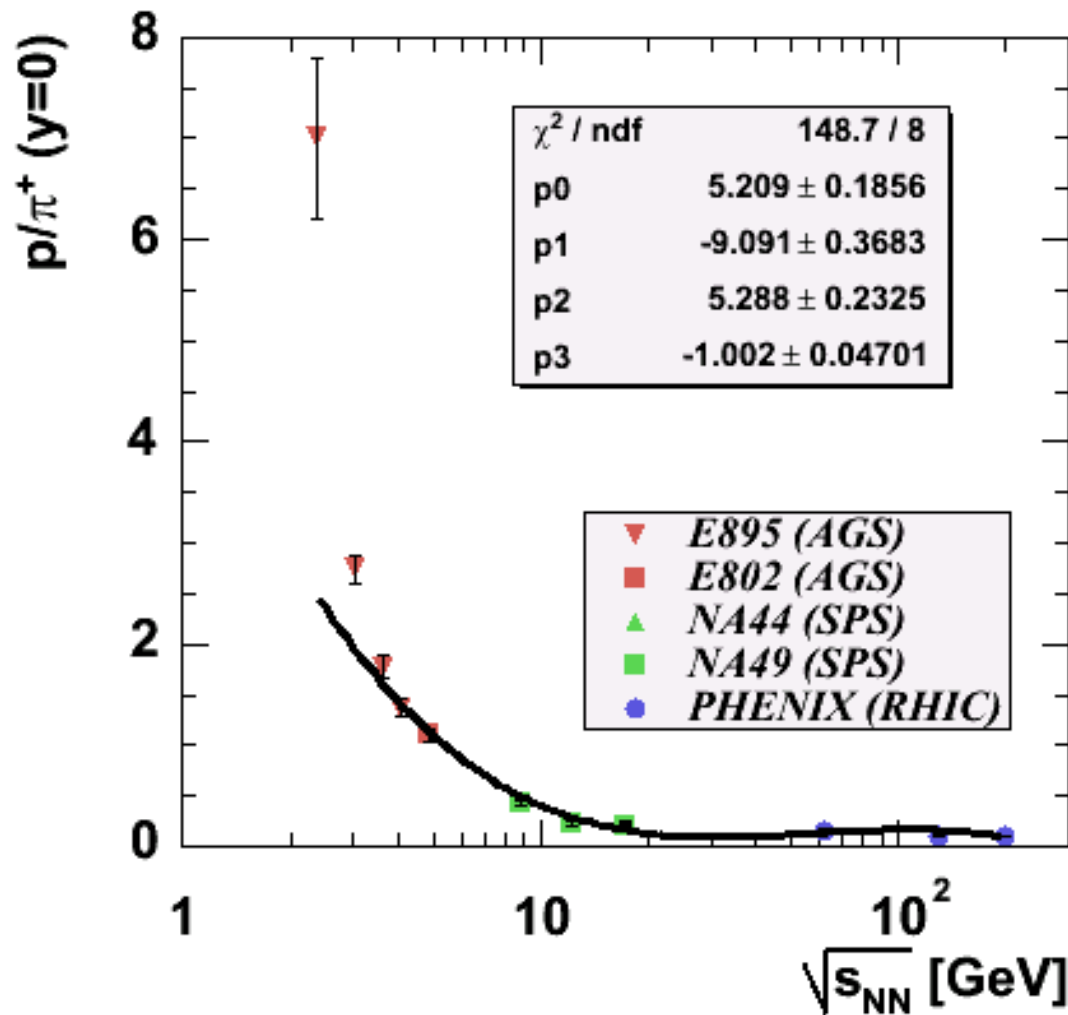
Minimum at $s^{1/2}=7.0$

3rd-order polynomial:

FAIL.

Turn-over=5.0

p/π^+ Ratio



Linear Fit:

FAIL. $\chi^2 = 85.8/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

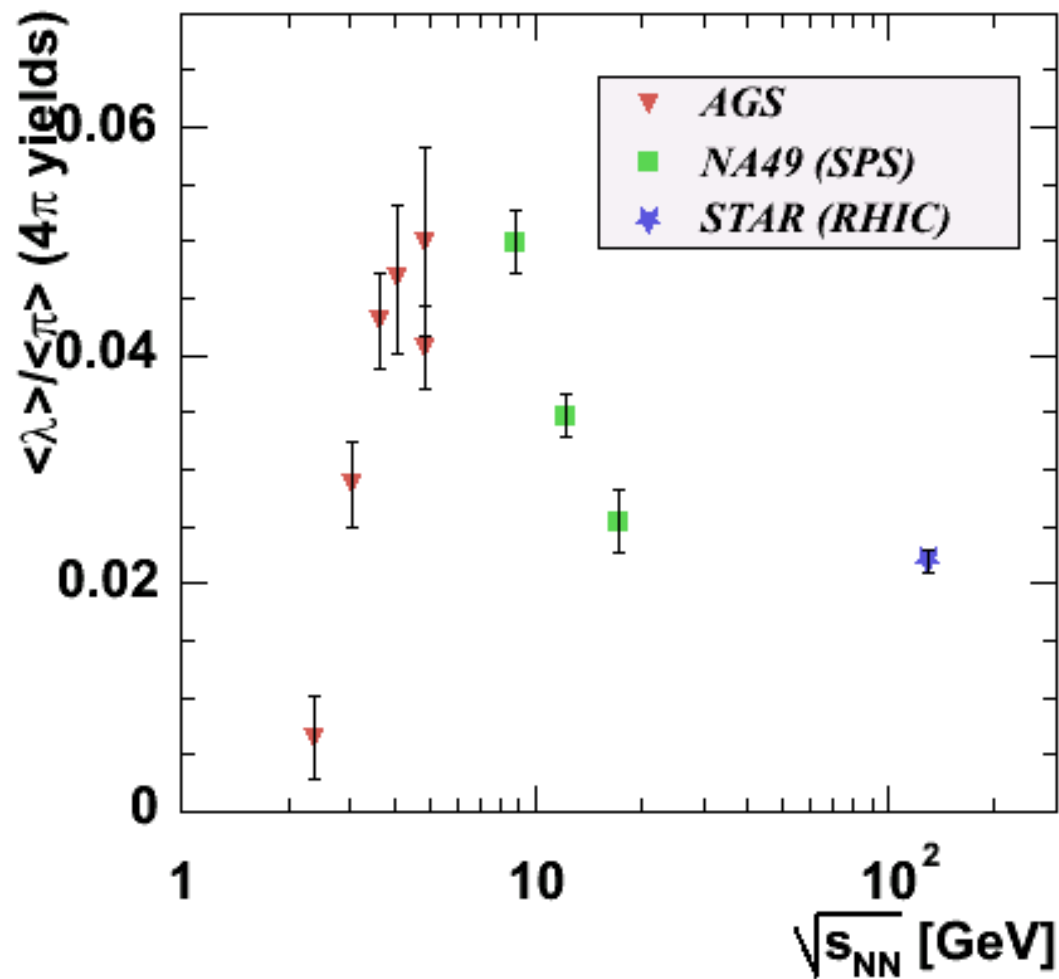
Minimum at $s^{1/2}=7.0$

3rd-order polynomial:

FAIL.

Turn-over=5.0

Λ/π Ratio



Linear Fit:

FAIL. $\chi^2 = 131.9/8$

Line+Line Fit:

C.L.=1%.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

C.L.=10%. [7.0,+]

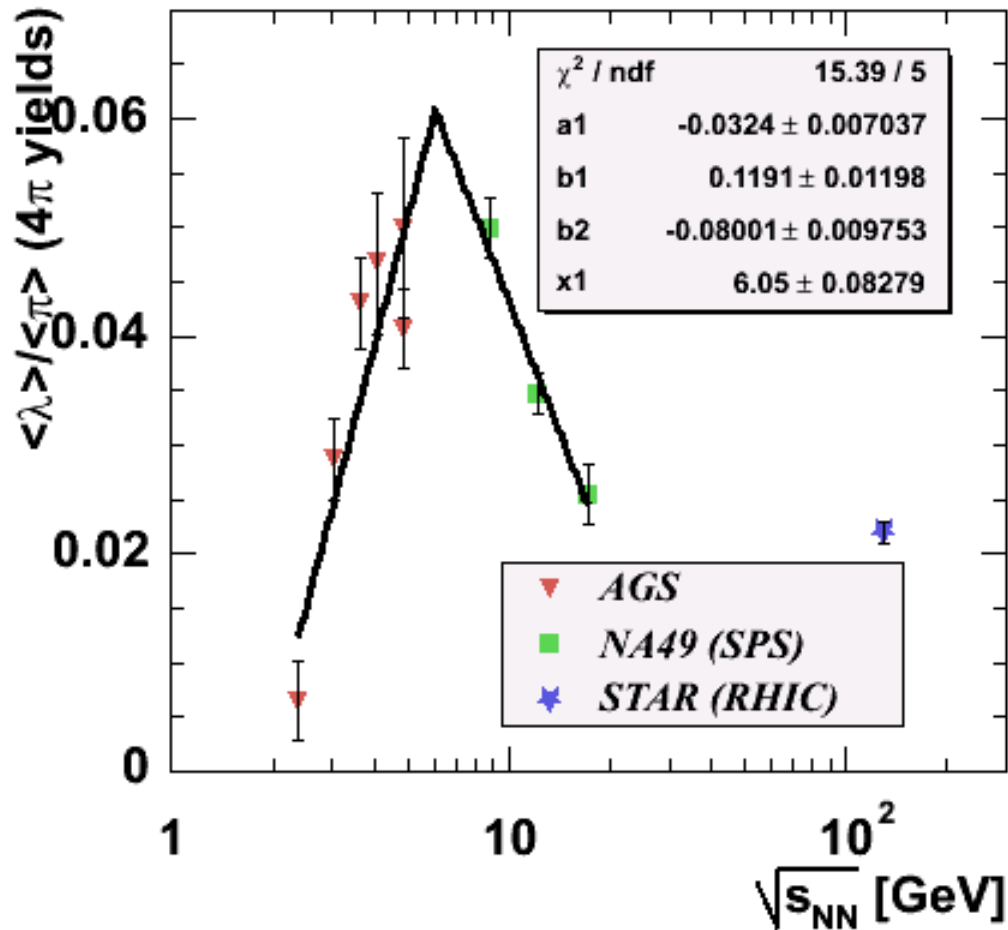
Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

PASS w/ C.L.=25%.

Turn-over=5.3

Λ/π Ratio



Linear Fit:

FAIL. $\chi^2 = 131.9/8$

Line+Line Fit:

C.L.=1%.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

C.L.=10%. [7.0,+]

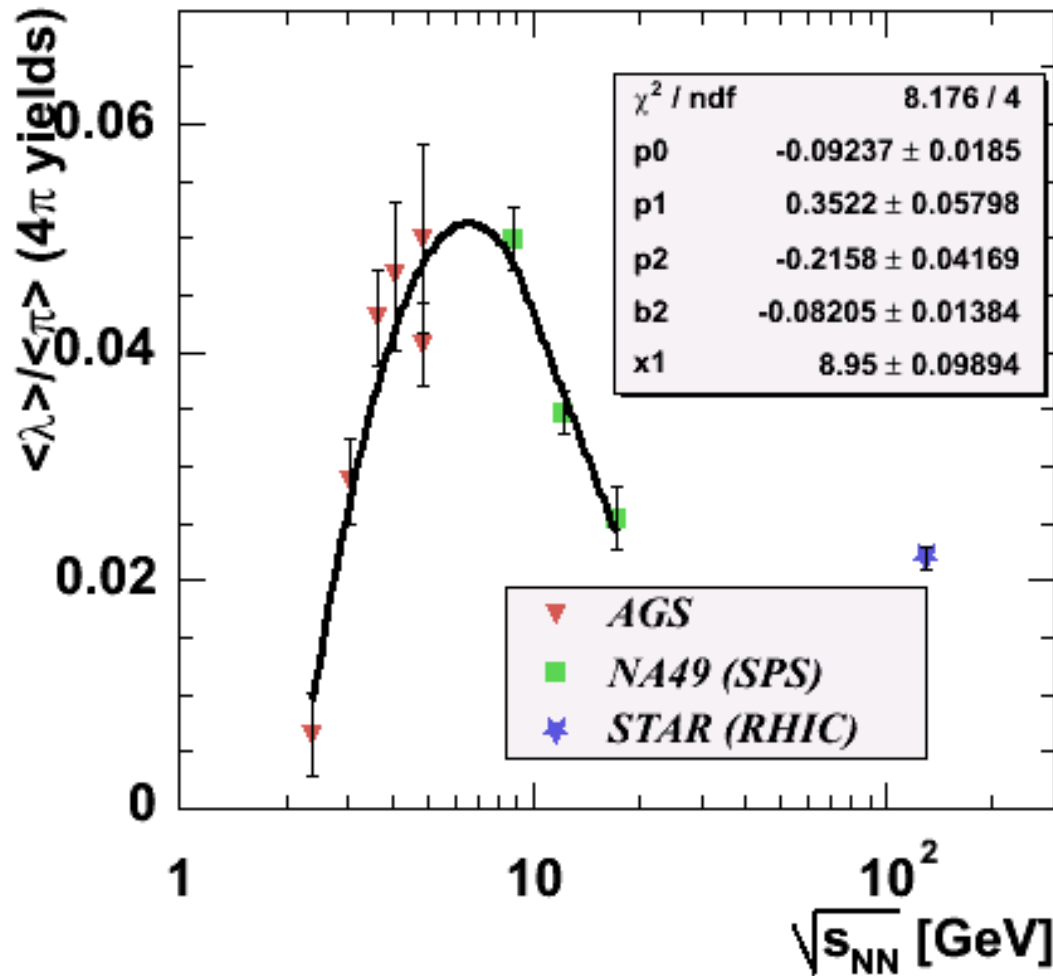
Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

PASS w/ C.L.=25%.

Turn-over=5.3

Λ/π Ratio



Linear Fit:

FAIL. $\chi^2 = 131.9/8$

Line+Line Fit:

C.L.=1%.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

C.L.=10%. [7.0,+]

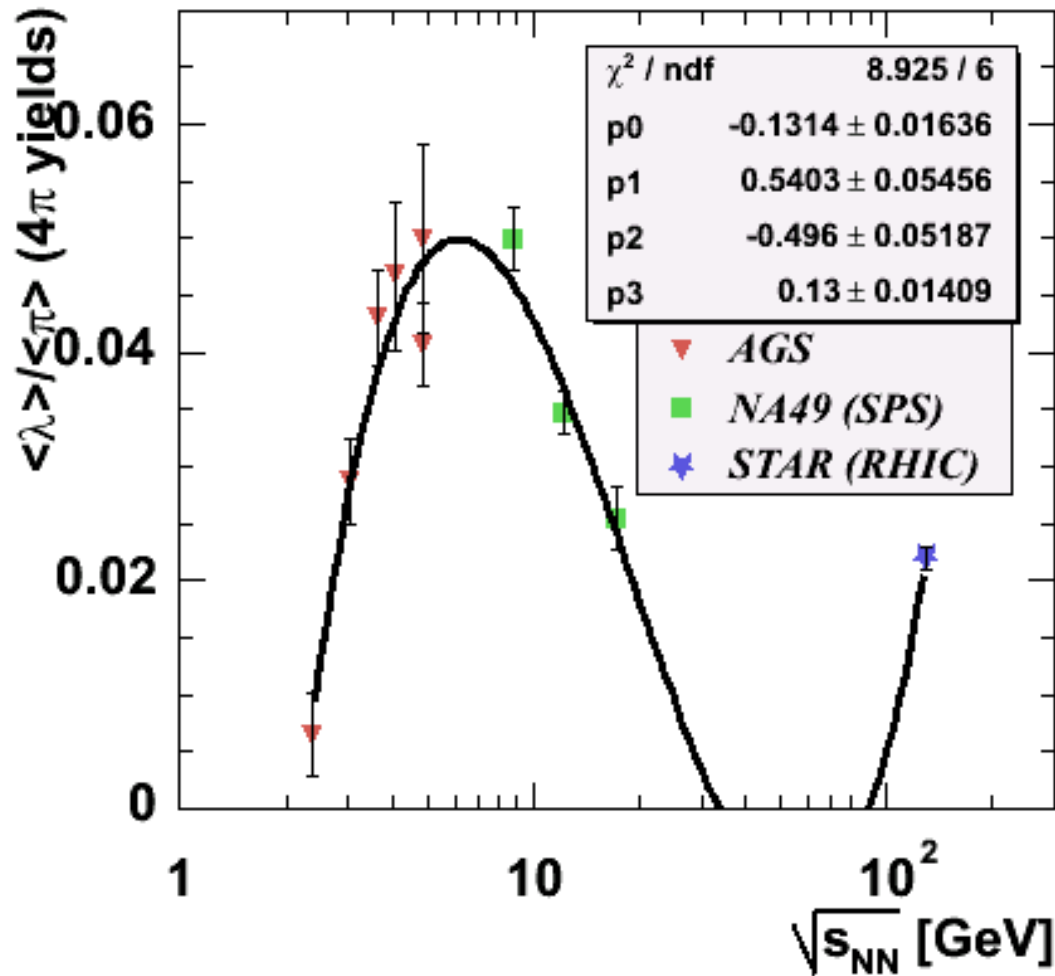
Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

PASS w/ C.L.=25%.

Turn-over=5.3

Λ/π Ratio



Linear Fit:

FAIL. $\chi^2 = 131.9/8$

Line+Line Fit:

C.L.=1%.

Minimum at $s^{1/2}=6.0$

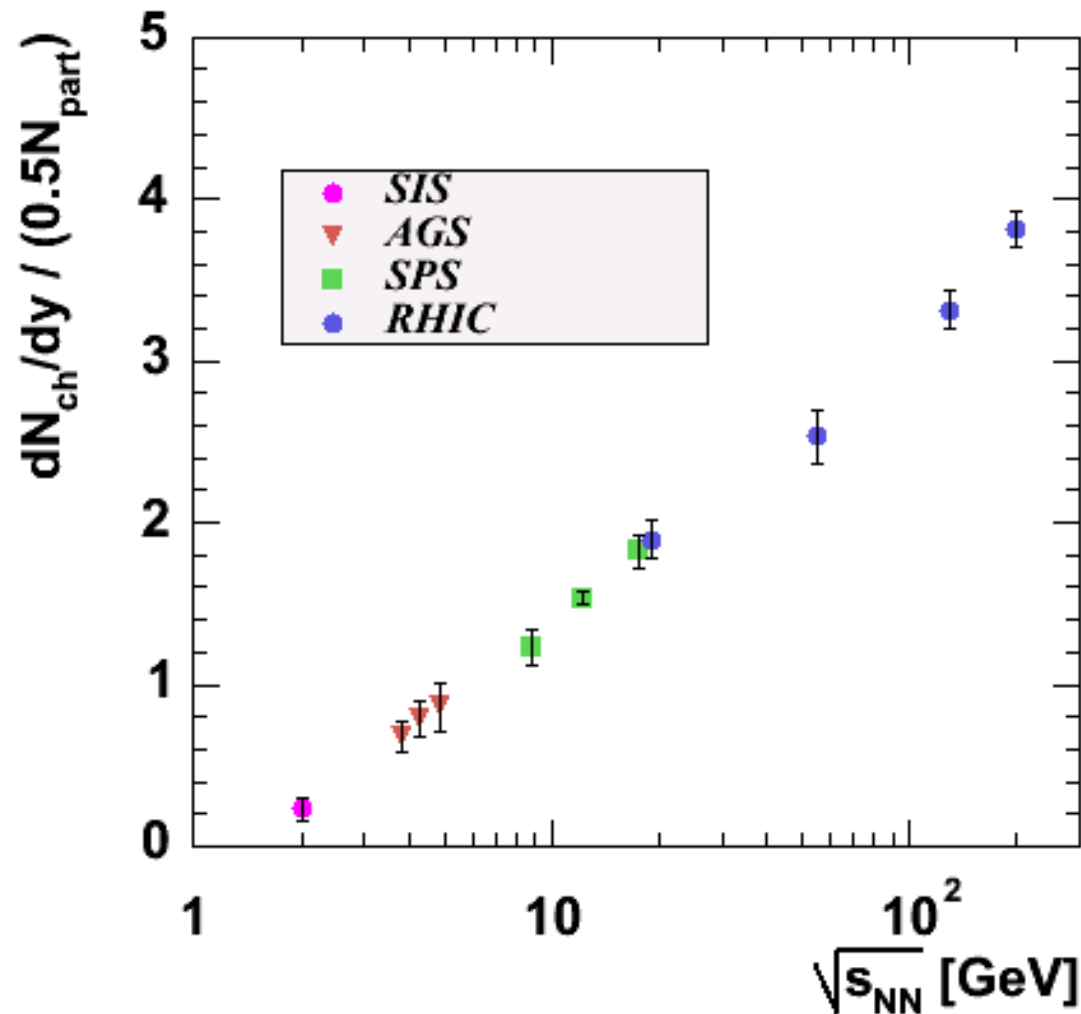
Poly+Line Fit:

C.L.=10%. [7.0,+]

Minimum at $s^{1/2}=8.0$

3rd-order polynomial:
PASS w/ C.L.=25%.
Turn-over=5.3

Charged Particle dN/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

PASS. $\chi^2 = 3.87/9$

Line+Line Fit:

C.L.=99%. [full range]

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

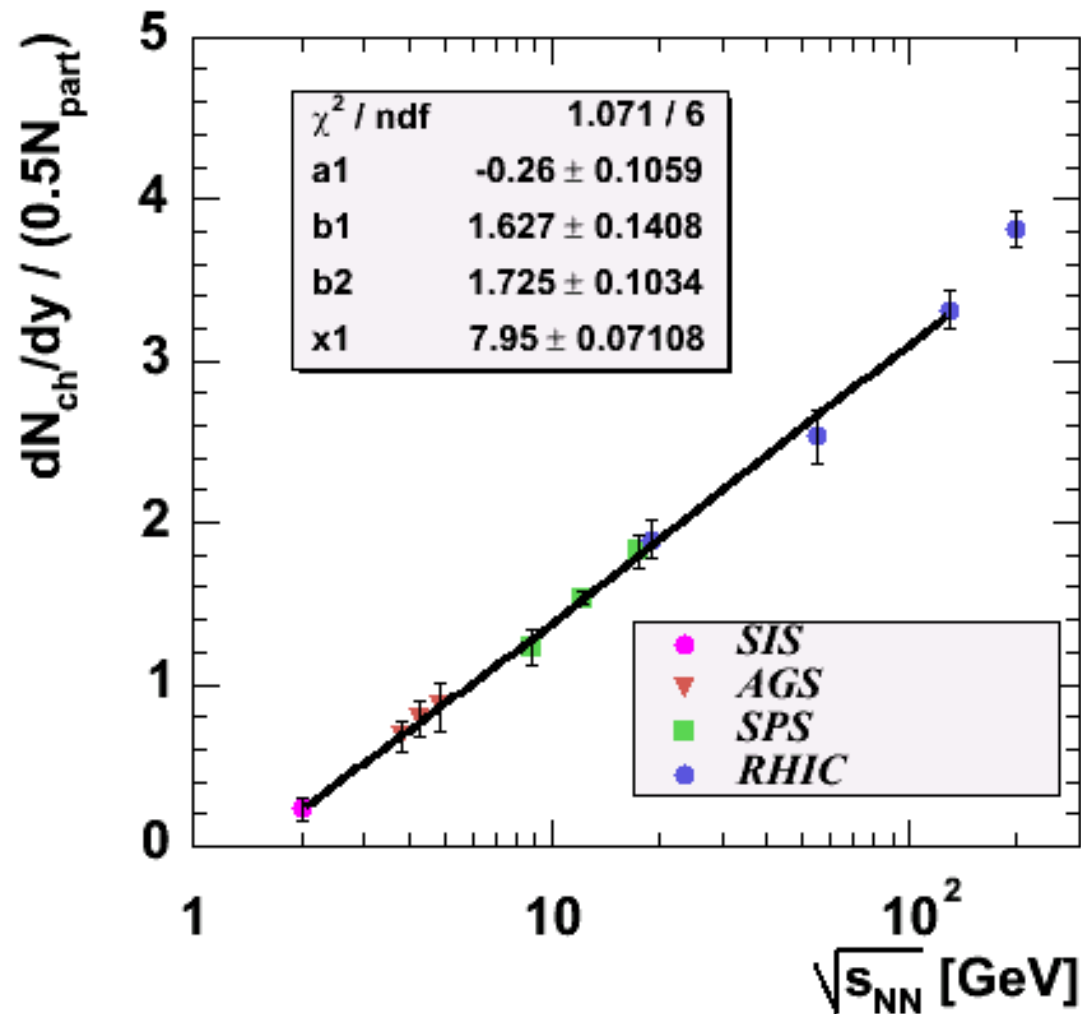
C.L.=97%. [full range]

Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

No turn-over.

Charged Particle dN/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

PASS. $\chi^2 = 3.87/9$

Line+Line Fit:

C.L.=99%. [full range]

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

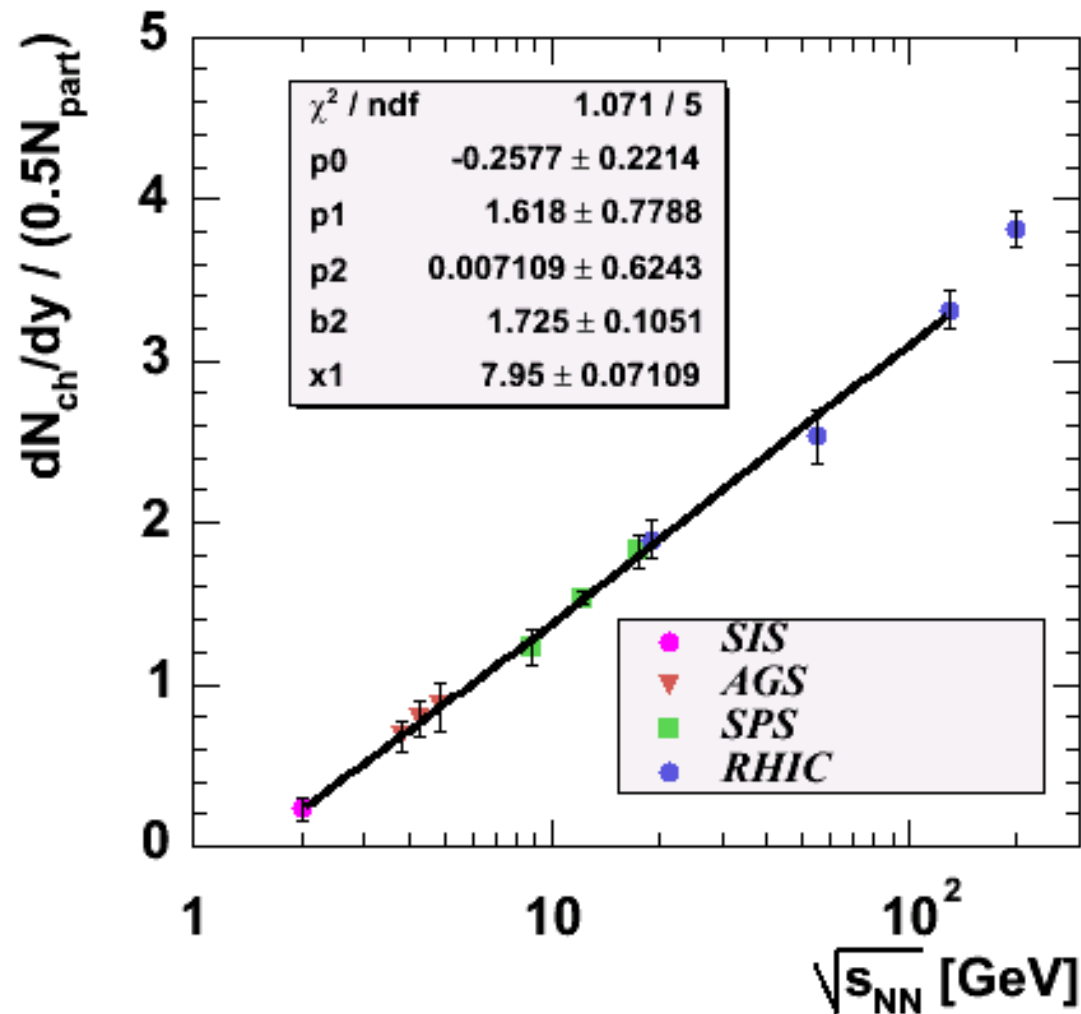
C.L.=97%. [full range]

Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

No turn-over.

Charged Particle dN/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

PASS. $\chi^2 = 3.87/9$

Line+Line Fit:

C.L.=99%. [full range]

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

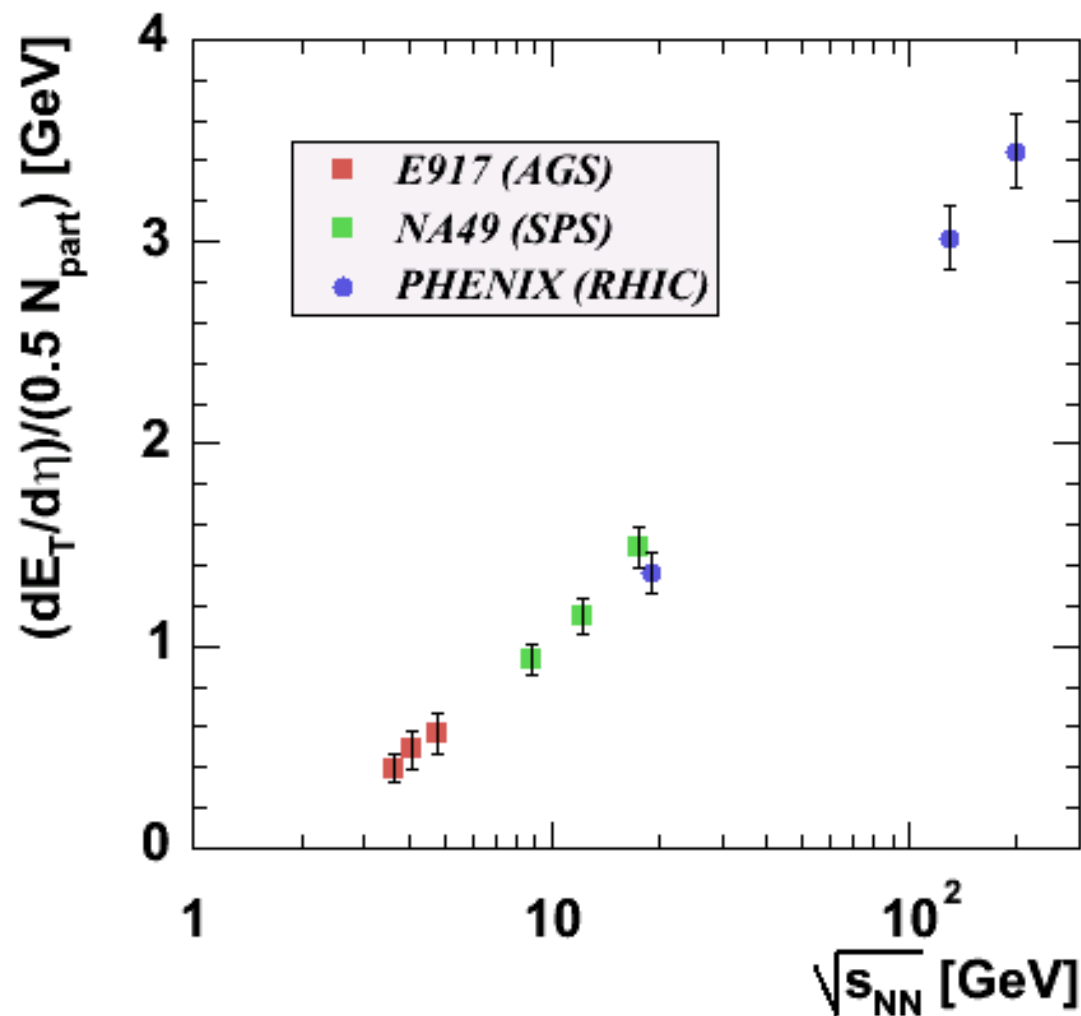
C.L.=97%. [full range]

Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

No turn-over.

dE_T/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

PASS. $\chi^2 = 7.09/7$

Line+Line Fit:

C.L.=50%. [full range]

Minimum at $s^{1/2}$ =None

Poly+Line Fit:

C.L.=50%. [full range]

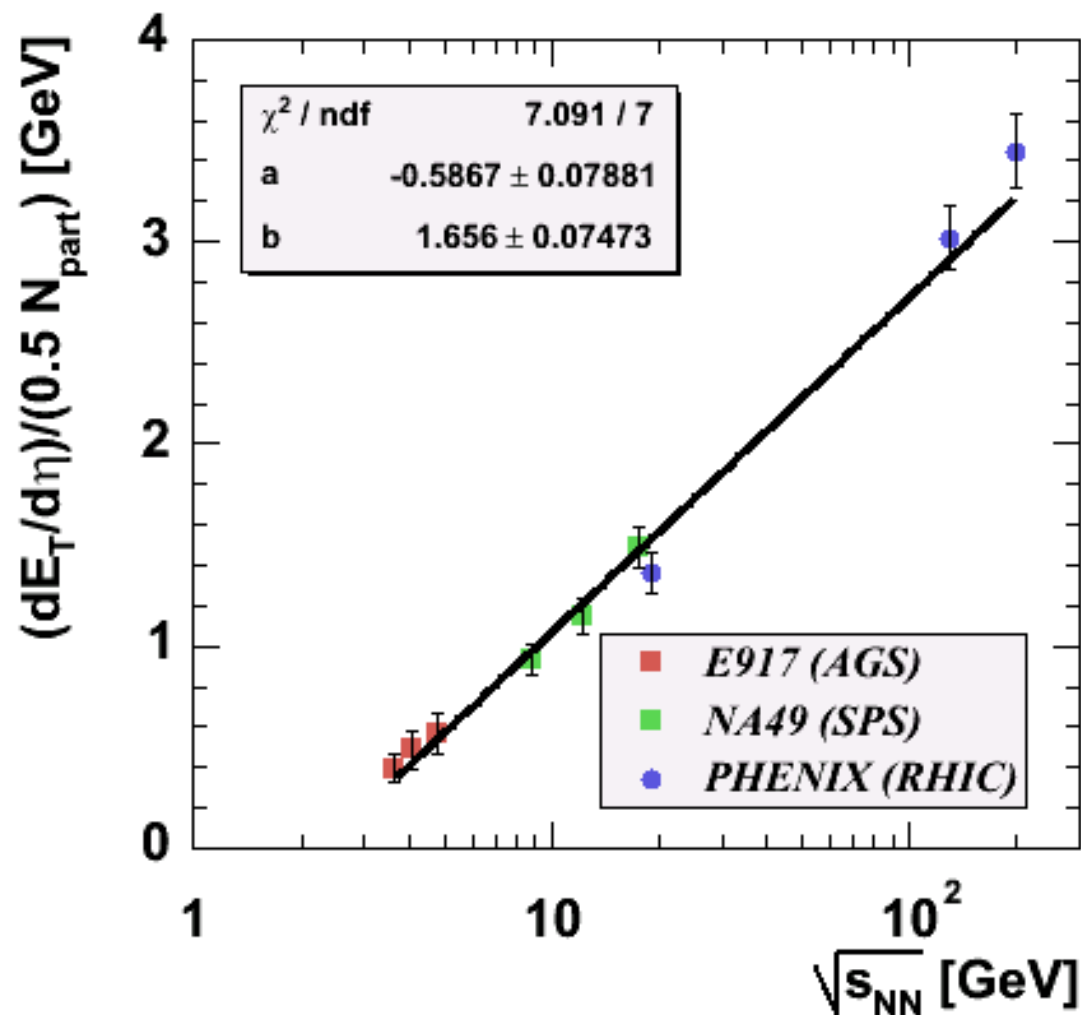
Minimum at $s^{1/2}$ =None

3rd-order polynomial:

PASS w/ C.L.=90%.

Turn-over=20.1

dE_T/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

PASS. $\chi^2 = 7.09/7$

Line+Line Fit:

C.L.=50%. [full range]

Minimum at $s^{1/2}$ =None

Poly+Line Fit:

C.L.=50%. [full range]

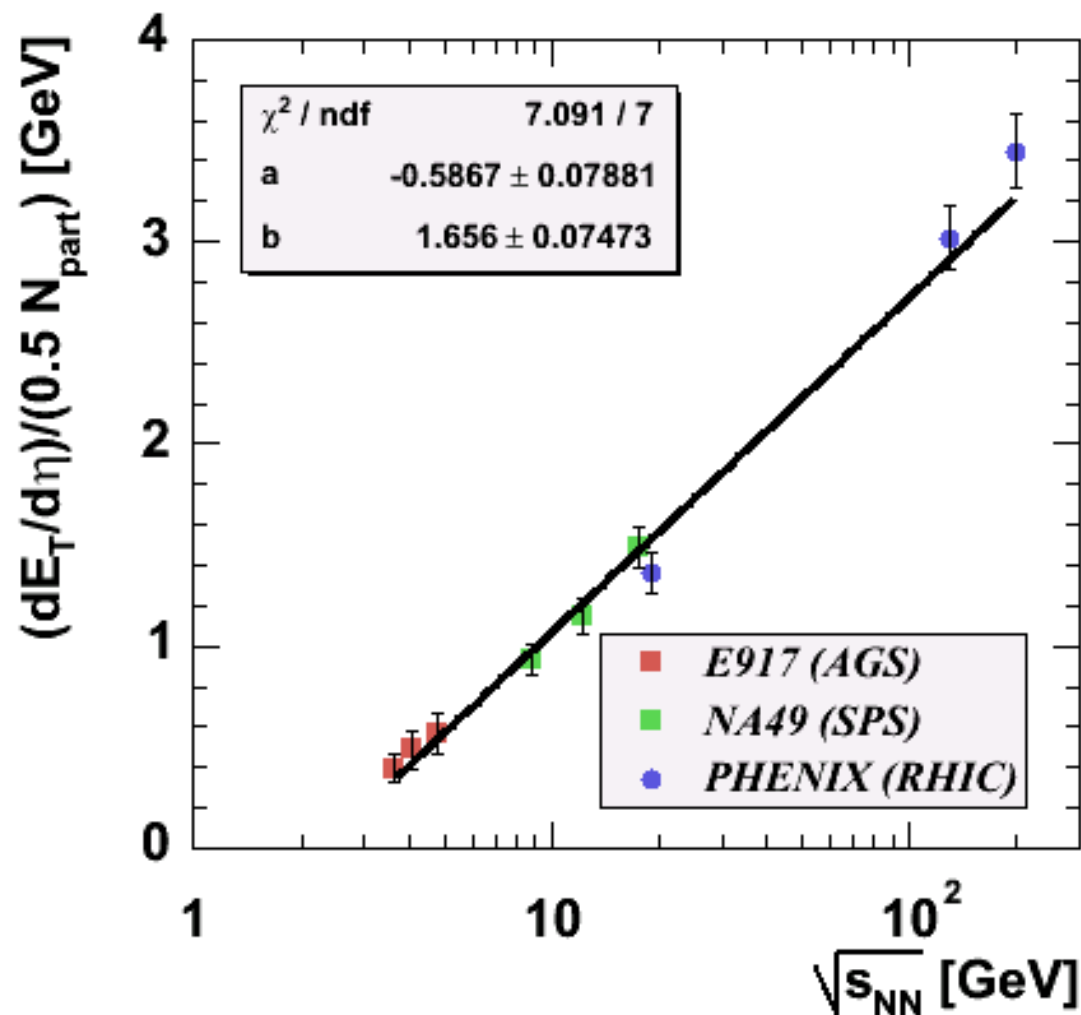
Minimum at $s^{1/2}$ =None

3rd-order polynomial:

PASS w/ C.L.=90%.

Turn-over=20.1

dE_T/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

PASS. $\chi^2 = 7.09/7$

Line+Line Fit:

C.L.=50%. [full range]

Minimum at $s^{1/2}$ =None

Poly+Line Fit:

C.L.=50%. [full range]

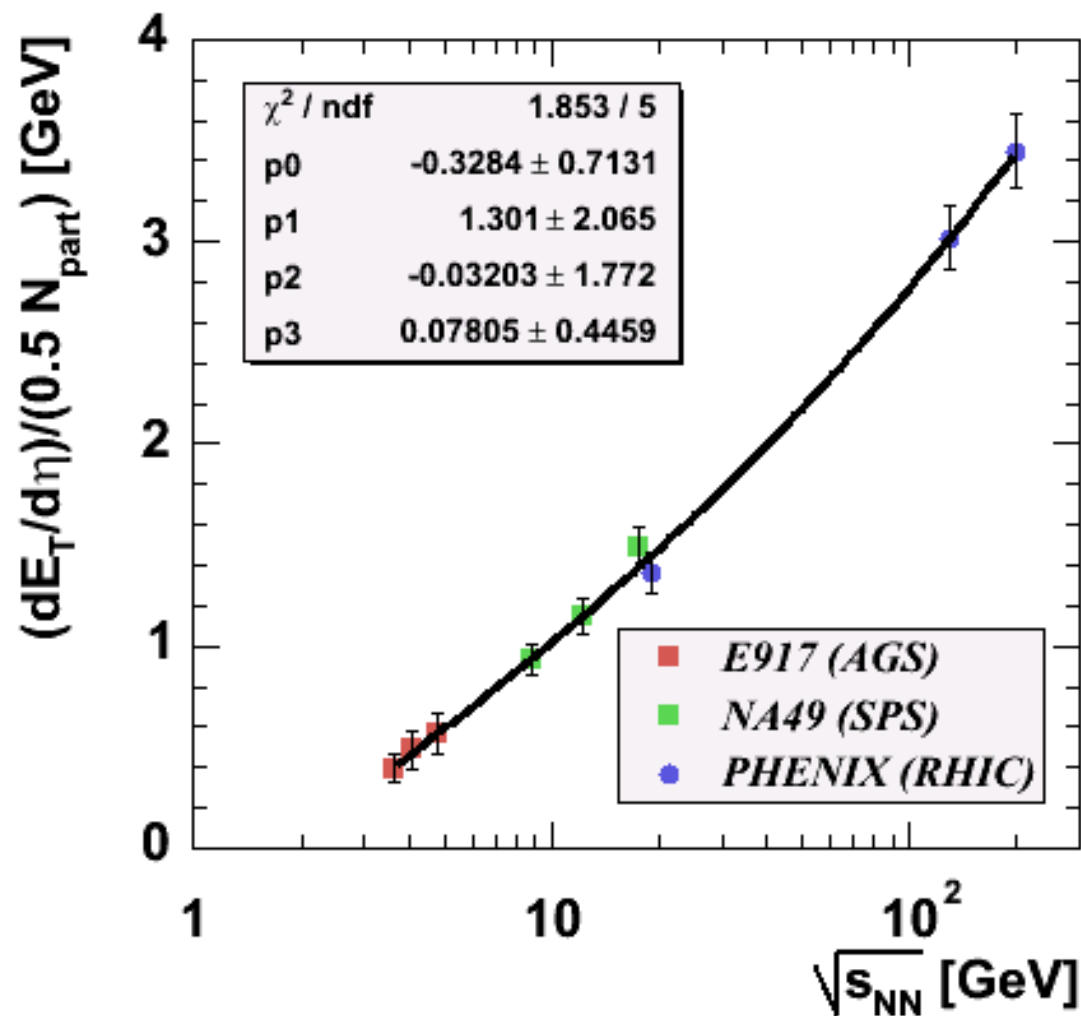
Minimum at $s^{1/2}$ =None

3rd-order polynomial:

PASS w/ C.L.=90%.

Turn-over=20.1

dE_T/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

PASS. $\chi^2 = 7.09/7$

Line+Line Fit:

C.L.=50%. [full range]

Minimum at $s^{1/2}$ =None

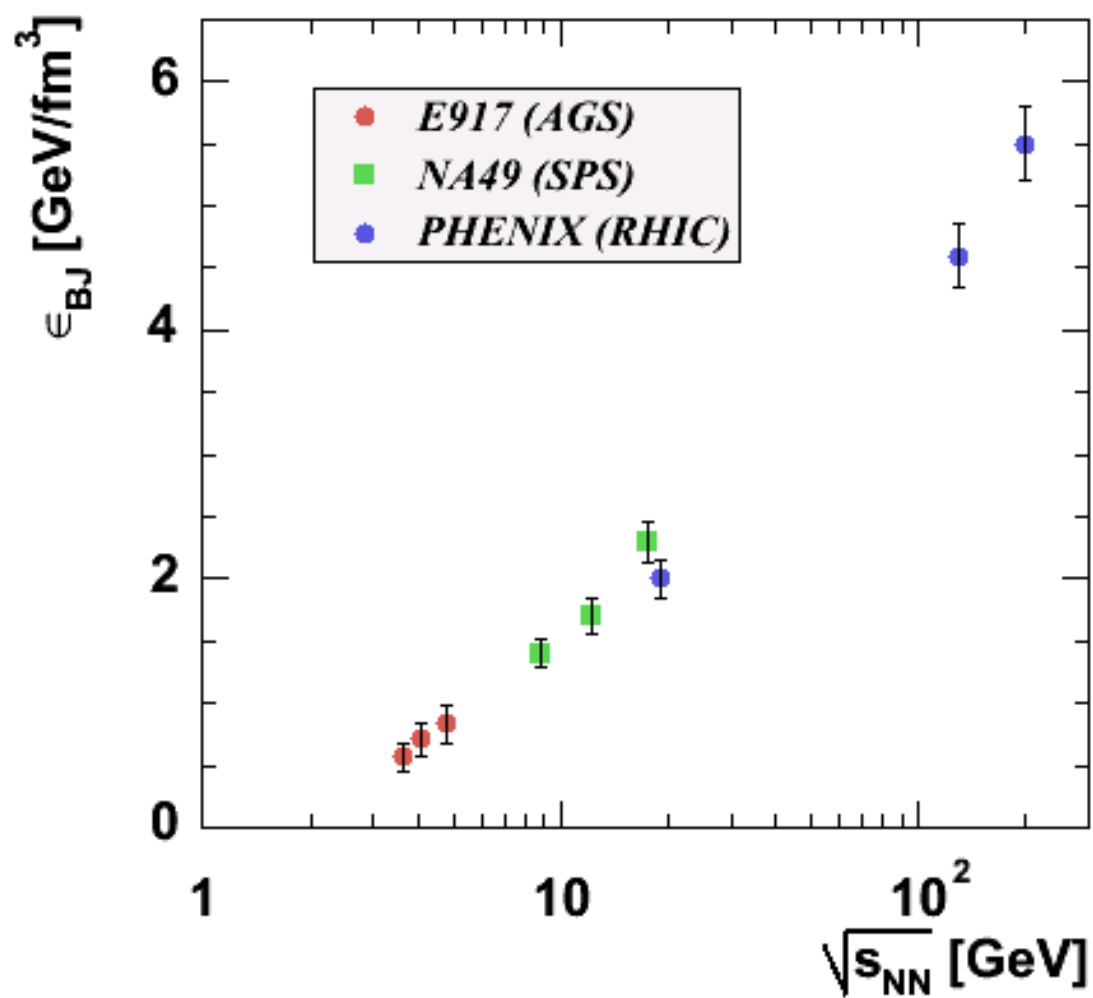
Poly+Line Fit:

C.L.=50%. [full range]

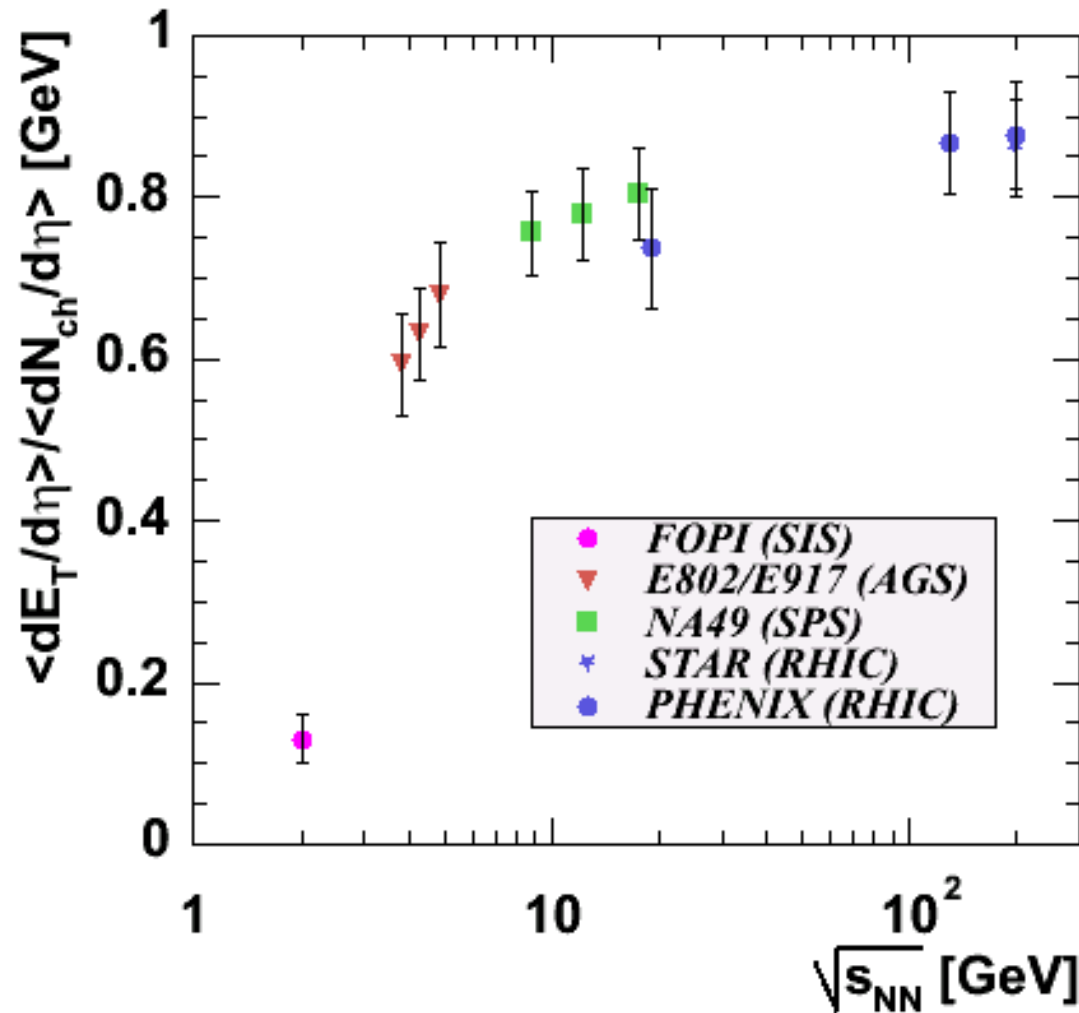
Minimum at $s^{1/2}$ =None

**3rd-order polynomial:
PASS w/ C.L.=90%.
Turn-over=20.1**

$\epsilon_{\text{Bjorken}}$



E_T / N_{charged}



Linear Fit:

FAIL. $\chi^2 = 119.6/9$

Line+Line Fit:

C.L.=95%. [3.0,7.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=97%. [3.0,12.0]

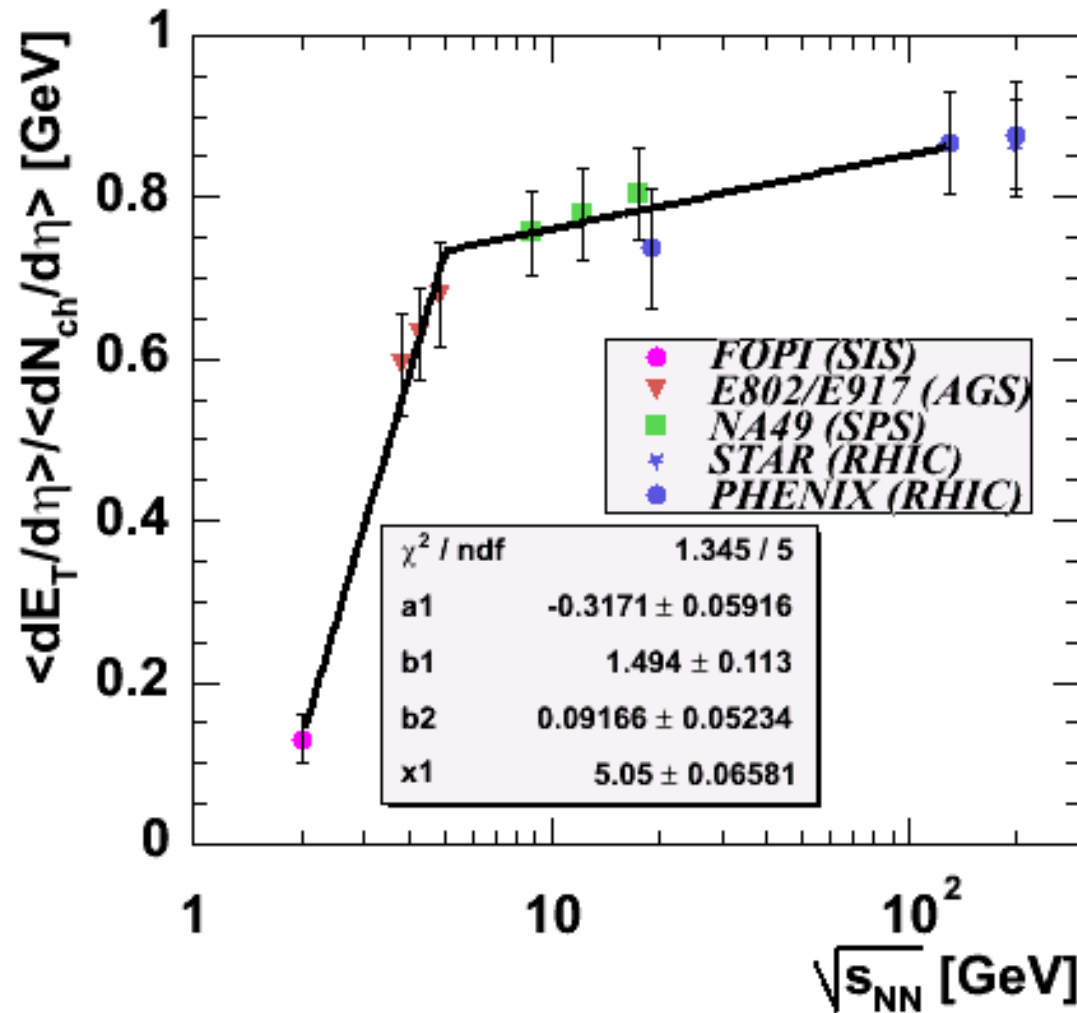
Minimum at $s^{1/2}=7.0$

3rd-order polynomial:

PASS w/ C.L.=90%.

Turn-over=7.4

E_T / N_{charged}



Linear Fit:

FAIL. $\chi^2 = 119.6/9$

Line+Line Fit:

C.L.=95%. [3.0,7.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=97%. [3.0,12.0]

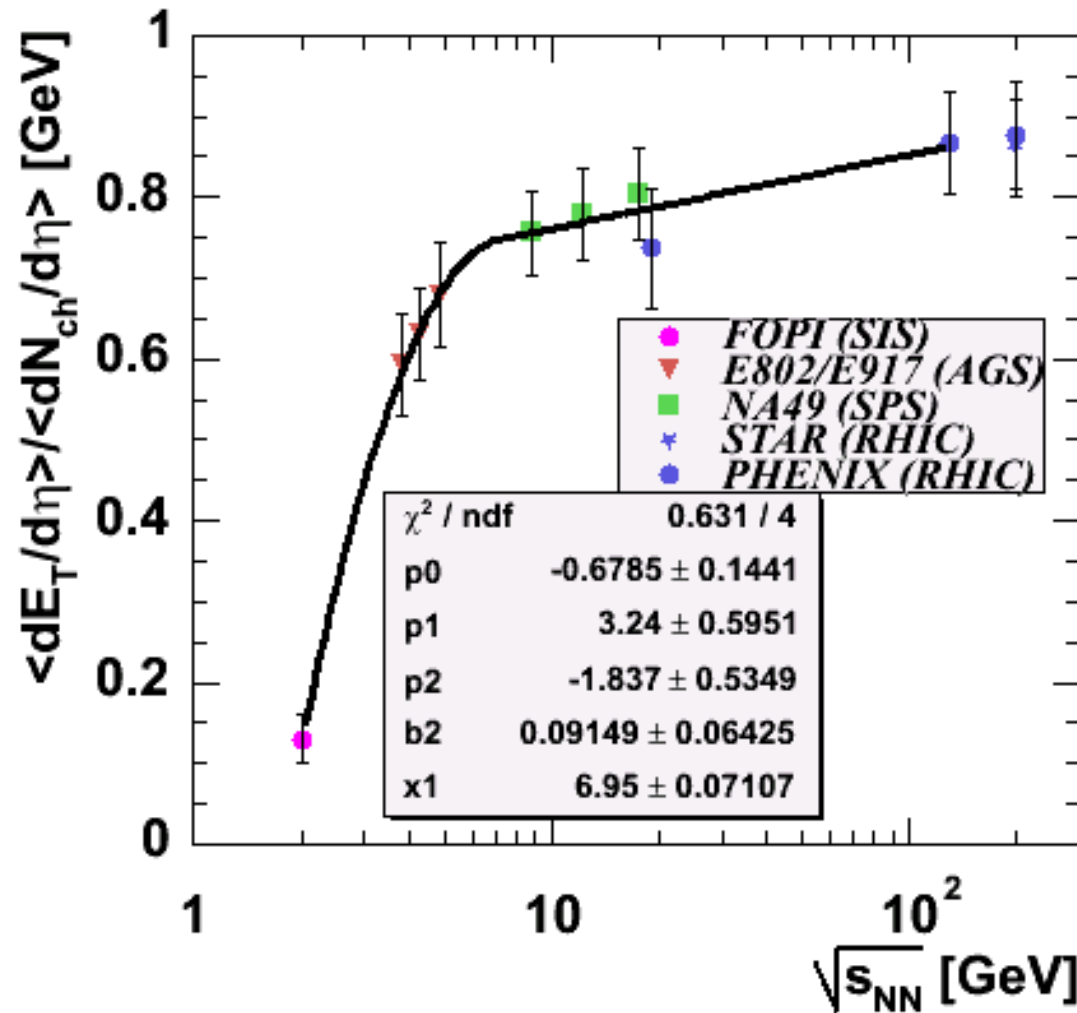
Minimum at $s^{1/2}=7.0$

3rd-order polynomial:

PASS w/ C.L.=90%.

Turn-over=7.4

E_T / N_{charged}



Linear Fit:

FAIL. $\chi^2 = 119.6/9$

Line+Line Fit:

C.L.=95%. [3.0,7.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=97%. [3.0,12.0]

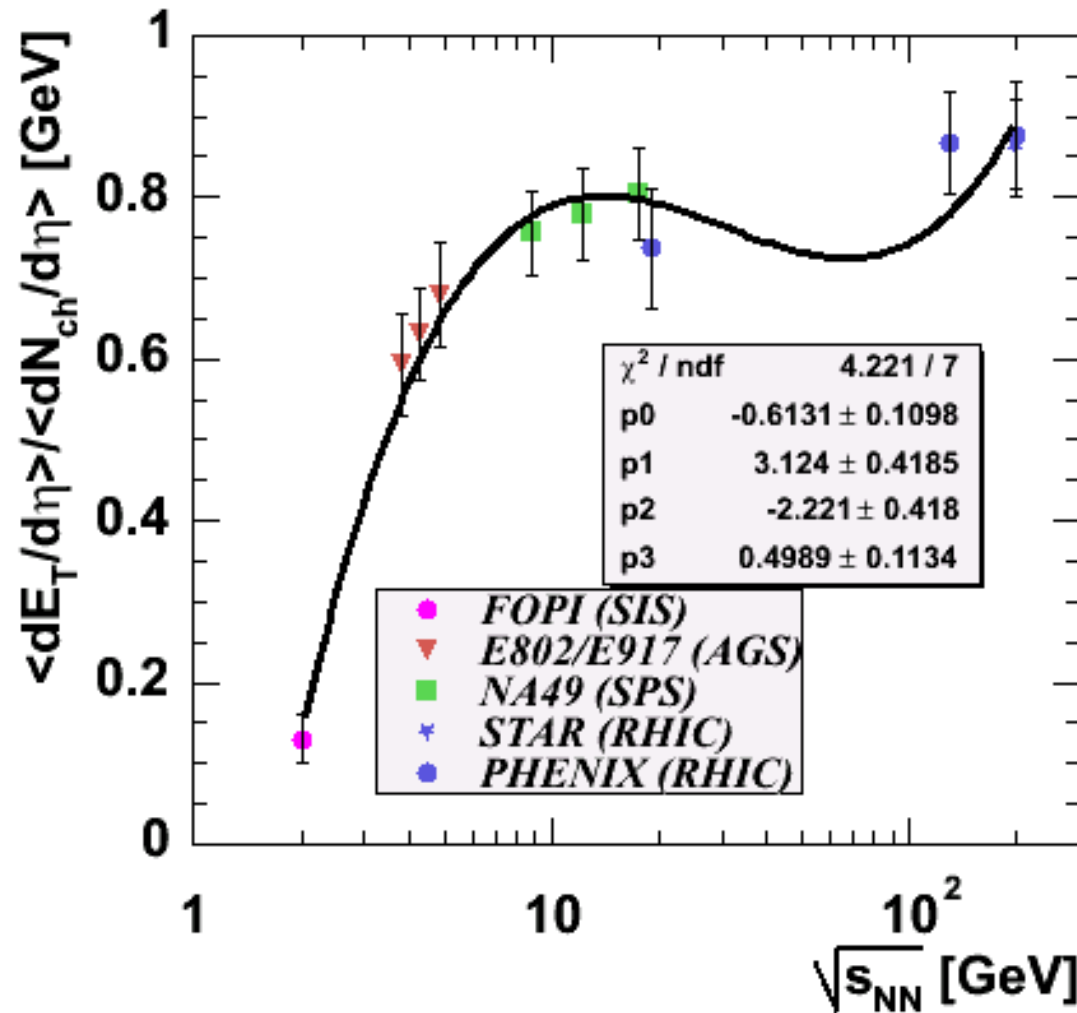
Minimum at $s^{1/2}=7.0$

3rd-order polynomial:

PASS w/ C.L.=90%.

Turn-over=7.4

E_T / N_{charged}



Linear Fit:

FAIL. $\chi^2 = 119.6/9$

Line+Line Fit:

C.L.=95%. [3.0,7.0]

Minimum at $s^{1/2}=5.0$

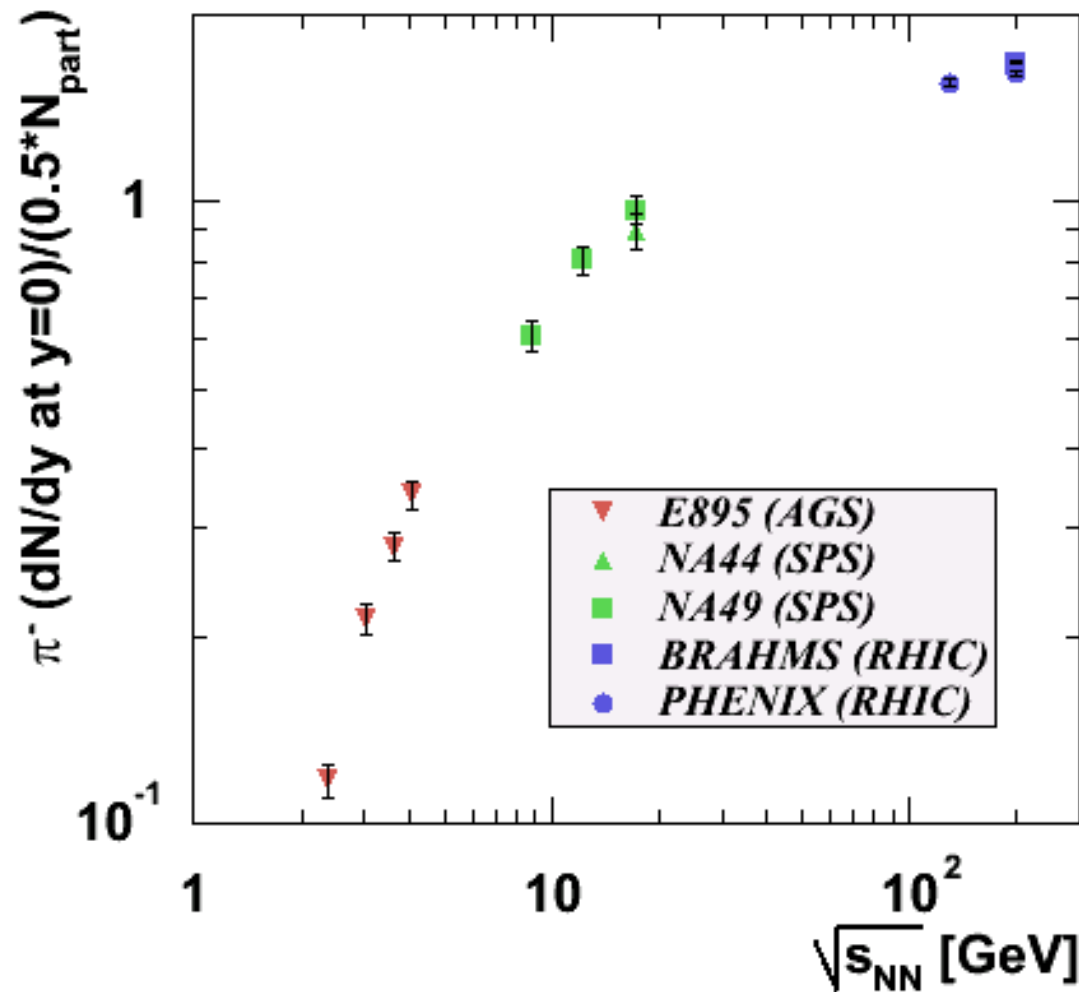
Poly+Line Fit:

C.L.=97%. [3.0,12.0]

Minimum at $s^{1/2}=7.0$

**3rd-order polynomial:
PASS w/ C.L.=90%.
Turn-over=7.4**

π^- dN/dy at $y=0$ / $0.5 N_{\text{part}}$



Linear Fit:

FAIL. $\chi^2 = 451.7/9$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

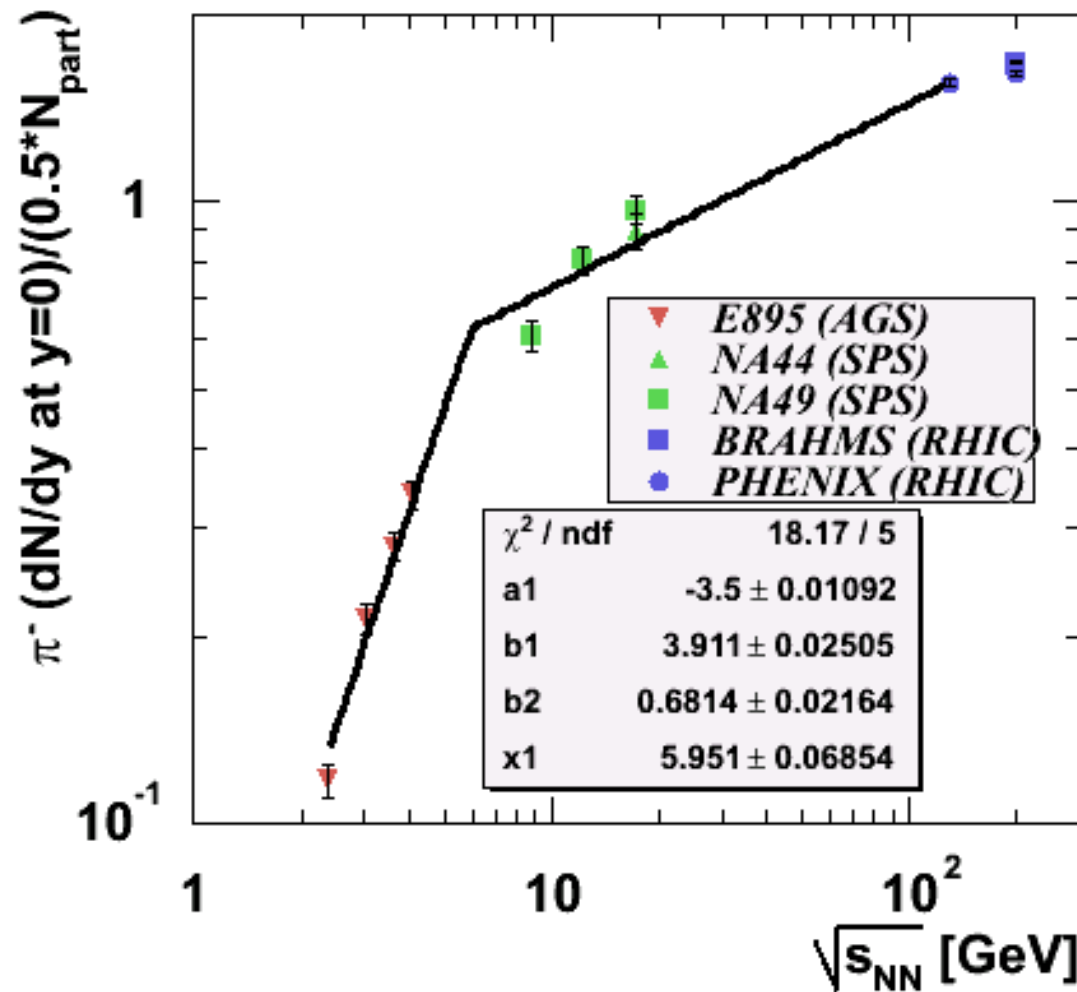
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=4.9

π^- dN/dy at $y=0$ / $0.5 N_{\text{part}}$



Linear Fit:

FAIL. $\chi^2 = 451.7/9$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

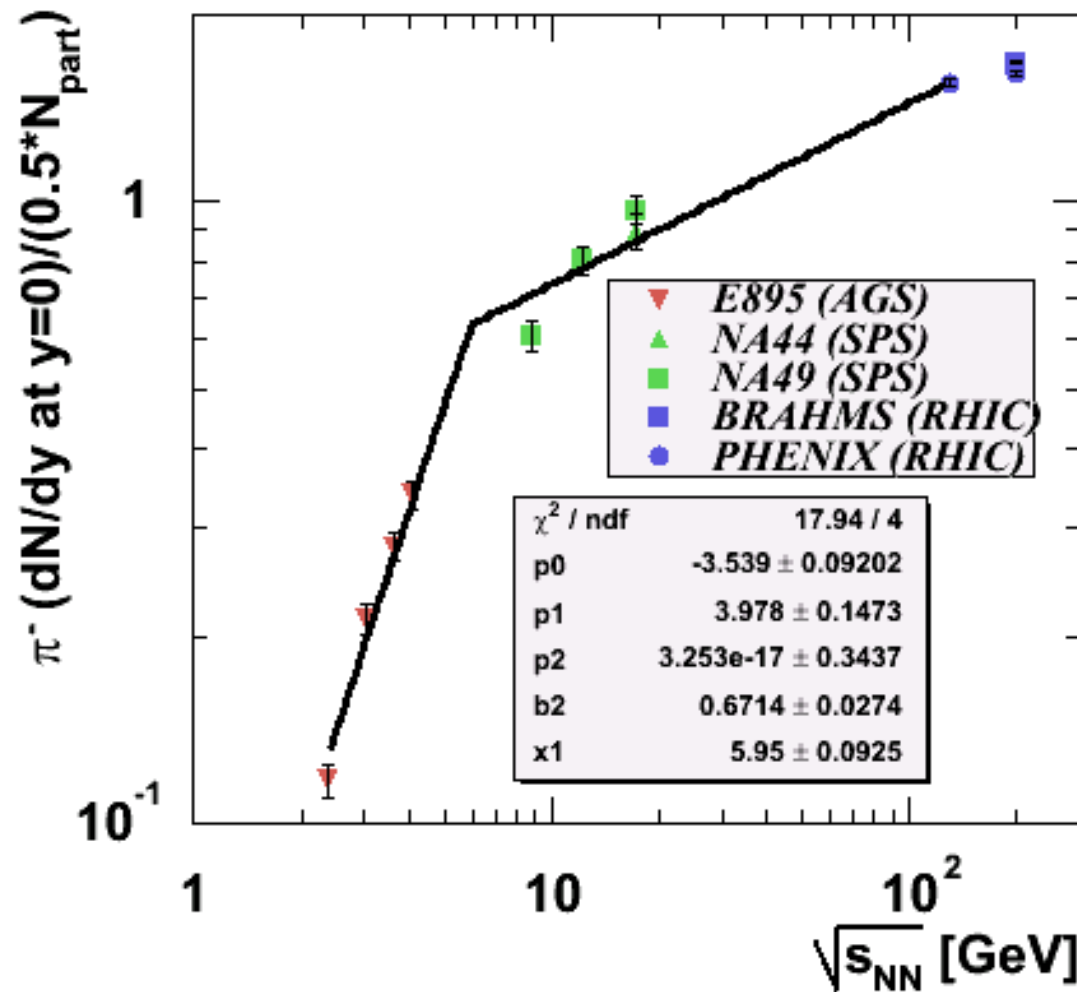
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=4.9

π^- dN/dy at $y=0$ / $0.5 N_{\text{part}}$



Linear Fit:

FAIL. $\chi^2 = 451.7/9$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

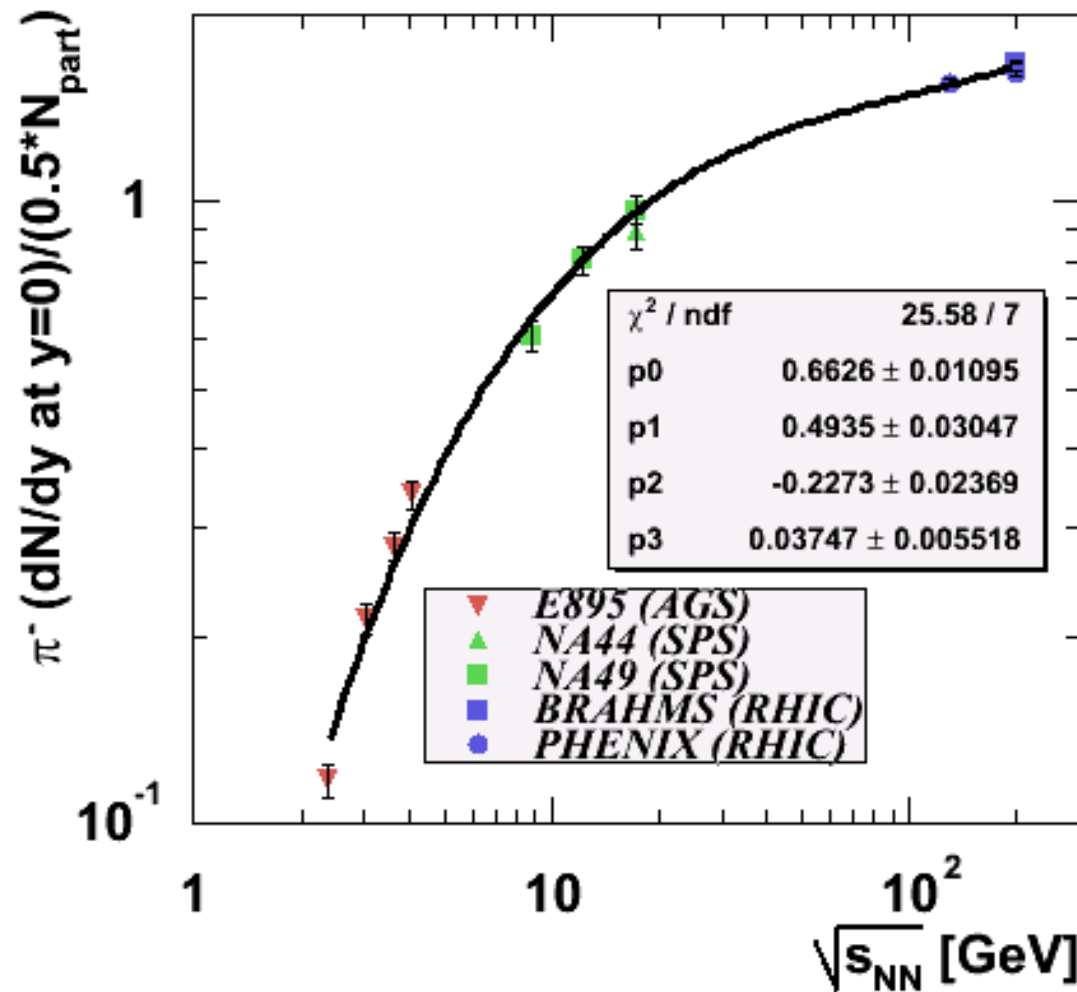
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=4.9

π^- dN/dy at $y=0$ / $0.5 N_{\text{part}}$



Linear Fit:

FAIL. $\chi^2 = 451.7/9$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

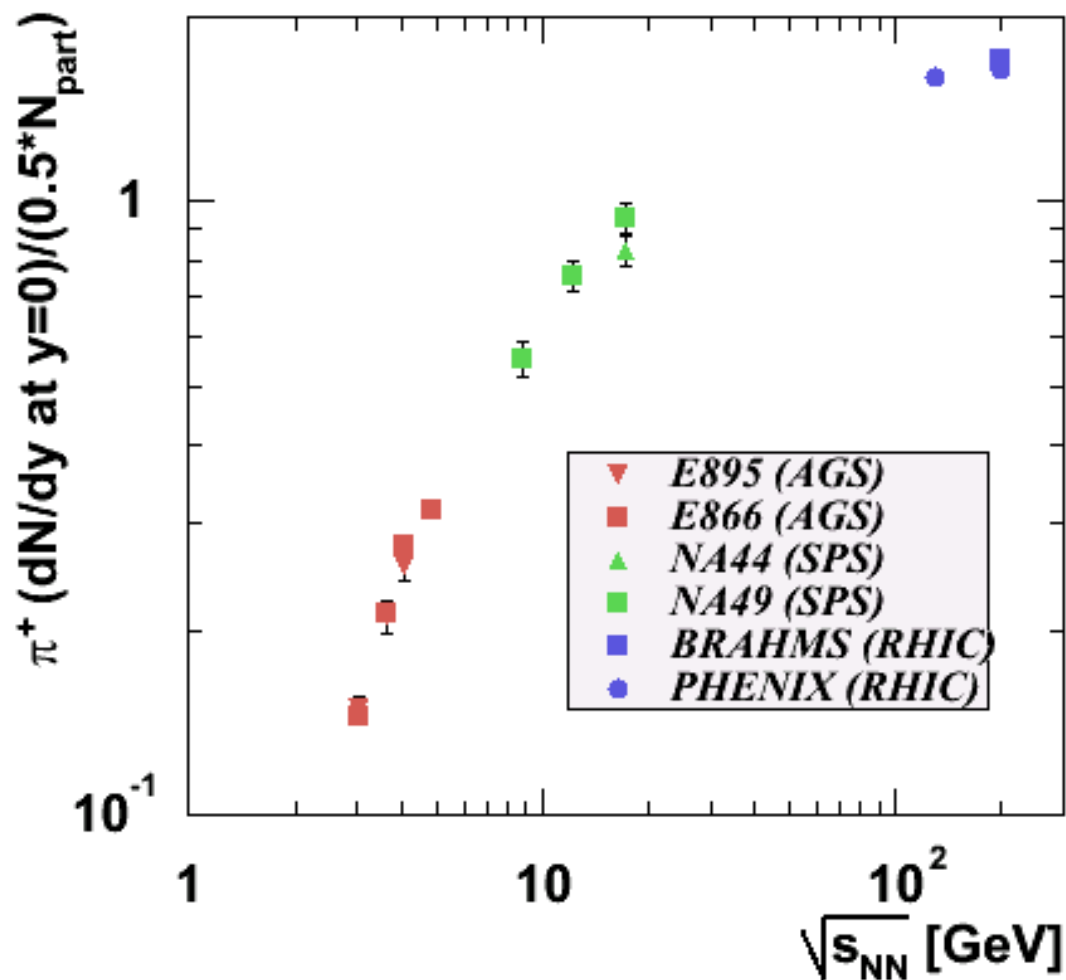
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

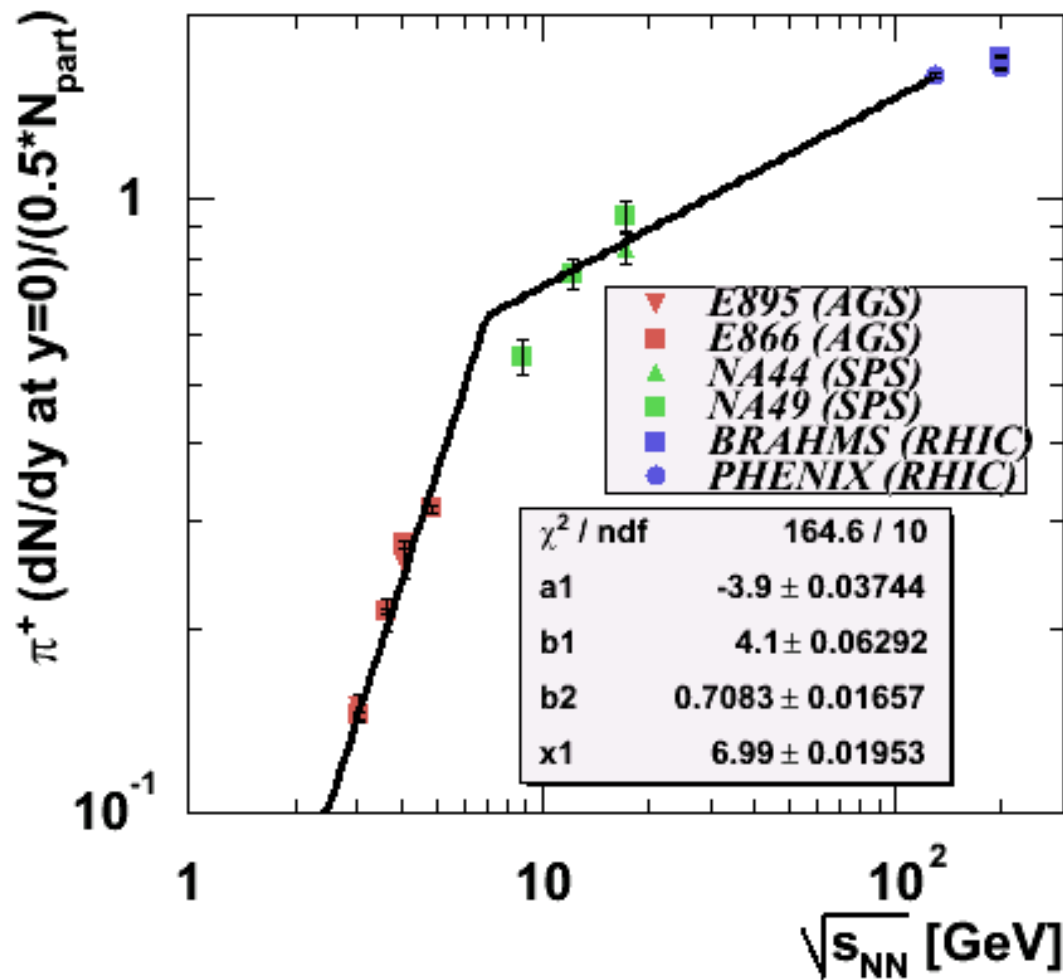
FAIL.

Turn-over=4.9

π^+ dN/dy at $y=0$ / $0.5 N_{\text{part}}$



π^+ dN/dy at y=0 / 0.5 N_{part}



Linear Fit:

FAIL. $\chi^2 = 2376/14$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=7.0$

Poly+Line Fit:

FAIL.

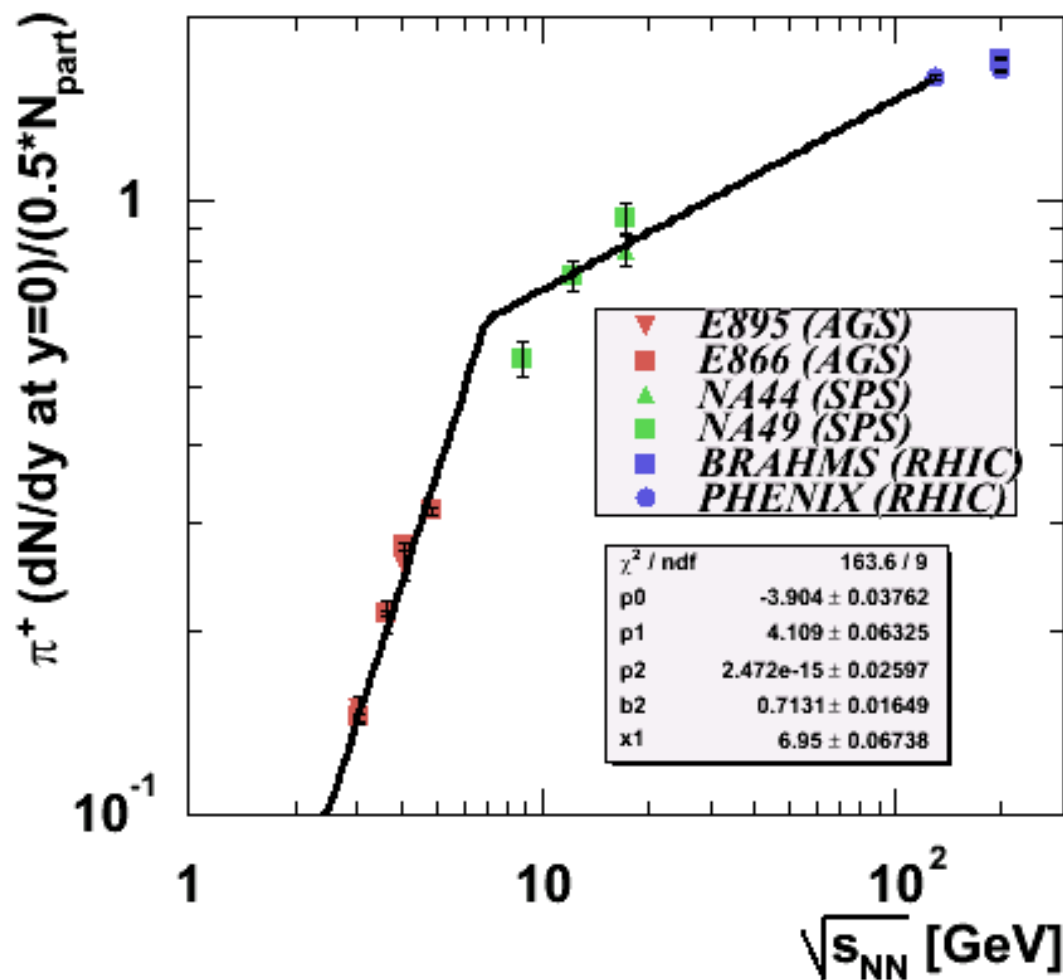
Minimum at $s^{1/2}=7.0$

3rd-order polynomial:

FAIL.

Turn-over=6.5

π^+ dN/dy at y=0 / 0.5 N_{part}



Linear Fit:

FAIL. $\chi^2 = 2376/14$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=7.0$

Poly+Line Fit:

FAIL.

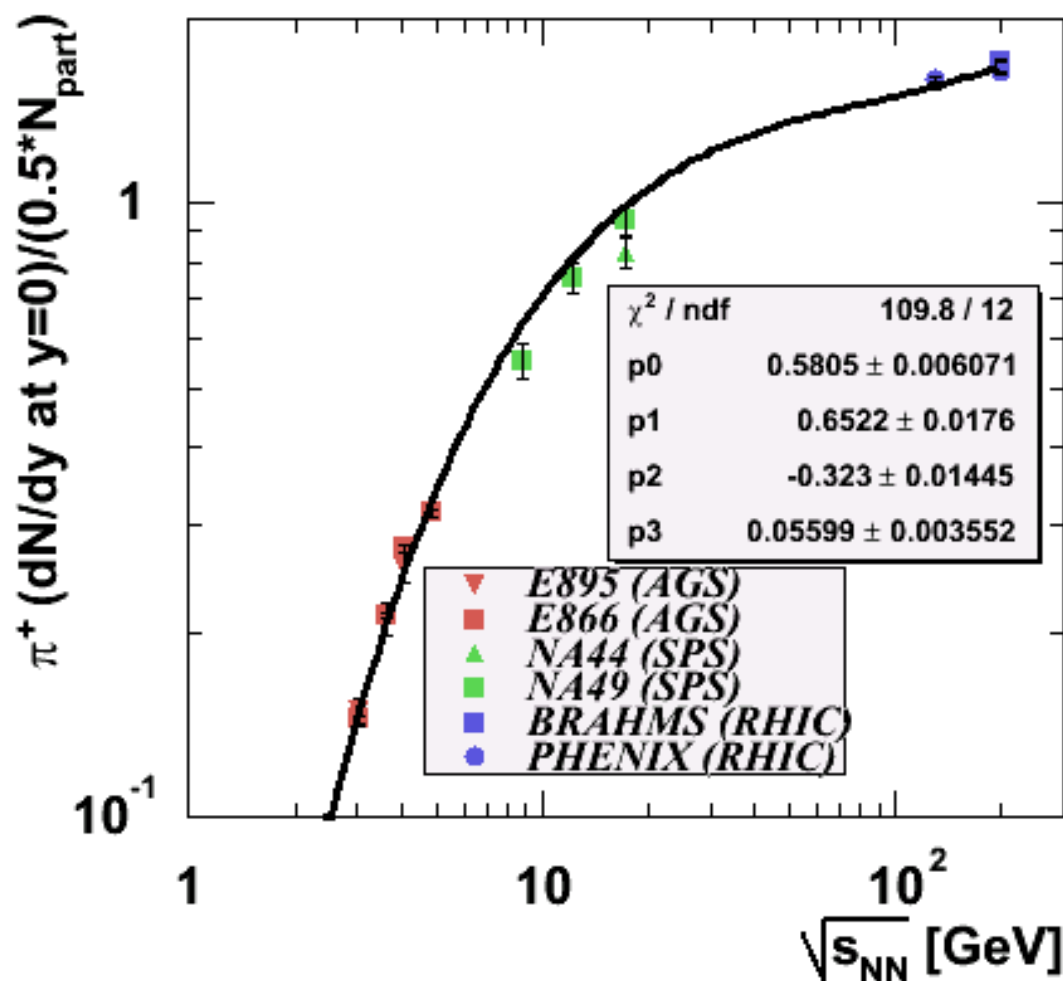
Minimum at $s^{1/2}=7.0$

3rd-order polynomial:

FAIL.

Turn-over=6.5

π^+ dN/dy at y=0 / 0.5 N_{part}



Linear Fit:

FAIL. $\chi^2 = 2376/14$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=7.0$

Poly+Line Fit:

FAIL.

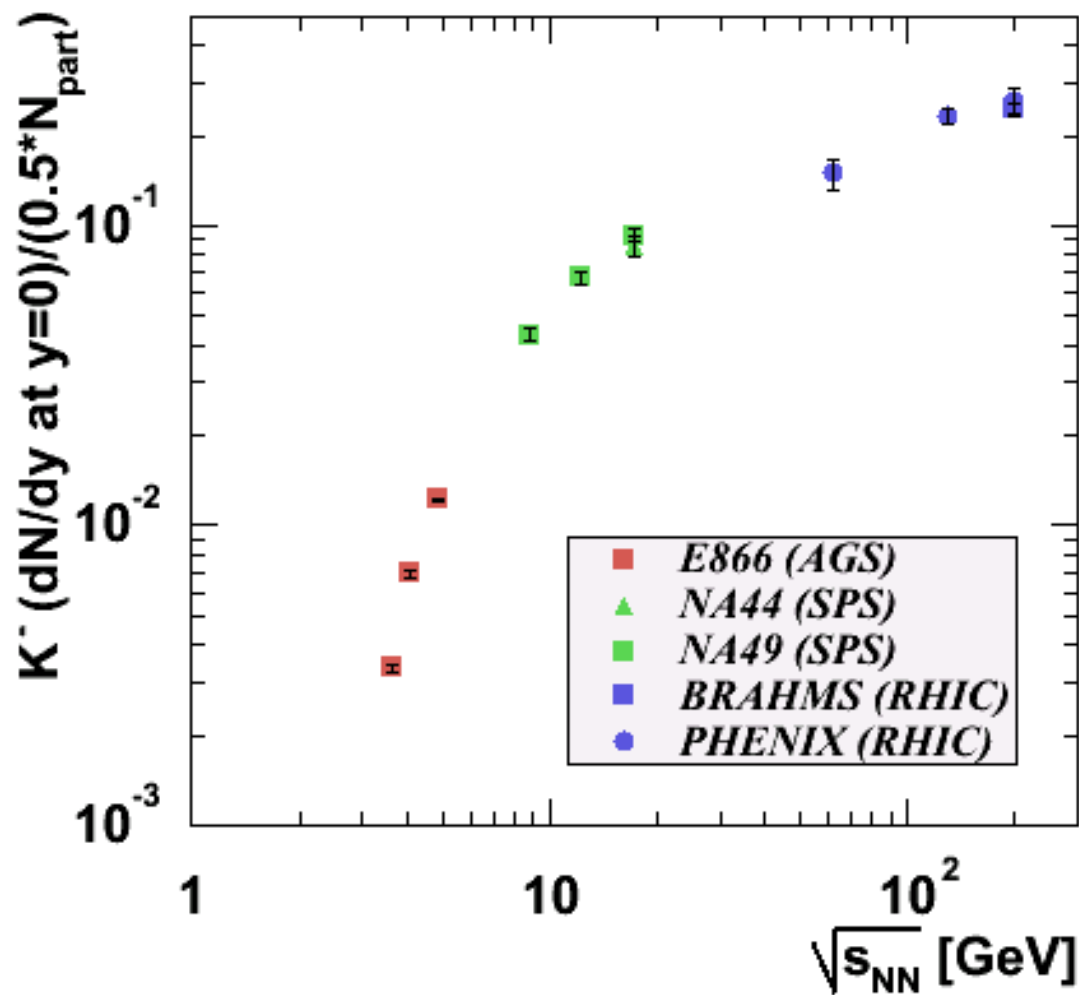
Minimum at $s^{1/2}=7.0$

3rd-order polynomial:

FAIL.

Turn-over=6.5

$K^- \frac{dN}{dy} \text{ at } y=0 / 0.5 N_{\text{part}}$



Linear Fit:

FAIL. $\chi^2 = 4867/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

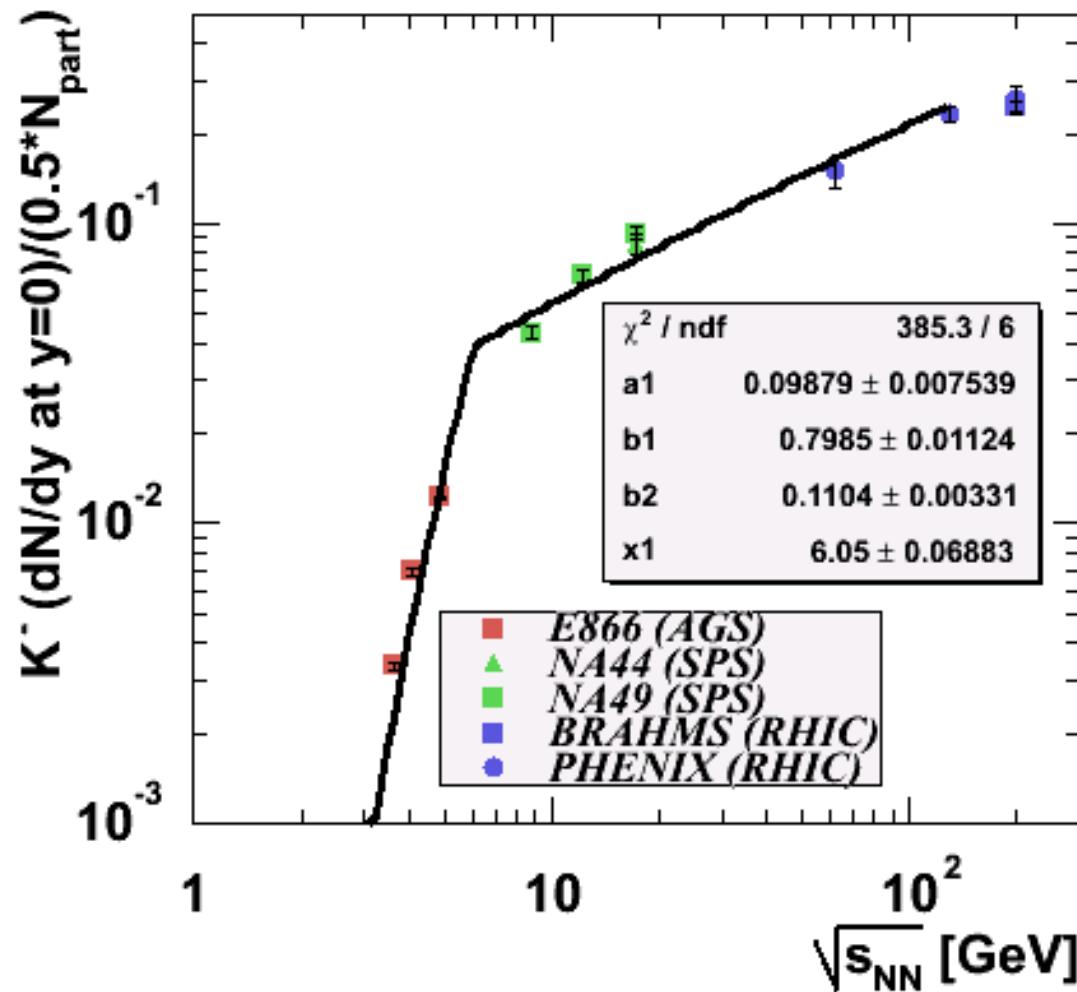
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=9.7

K⁻ dN/dy at y=0 / 0.5 N_{part}



Linear Fit:

FAIL. $\chi^2 = 4867/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

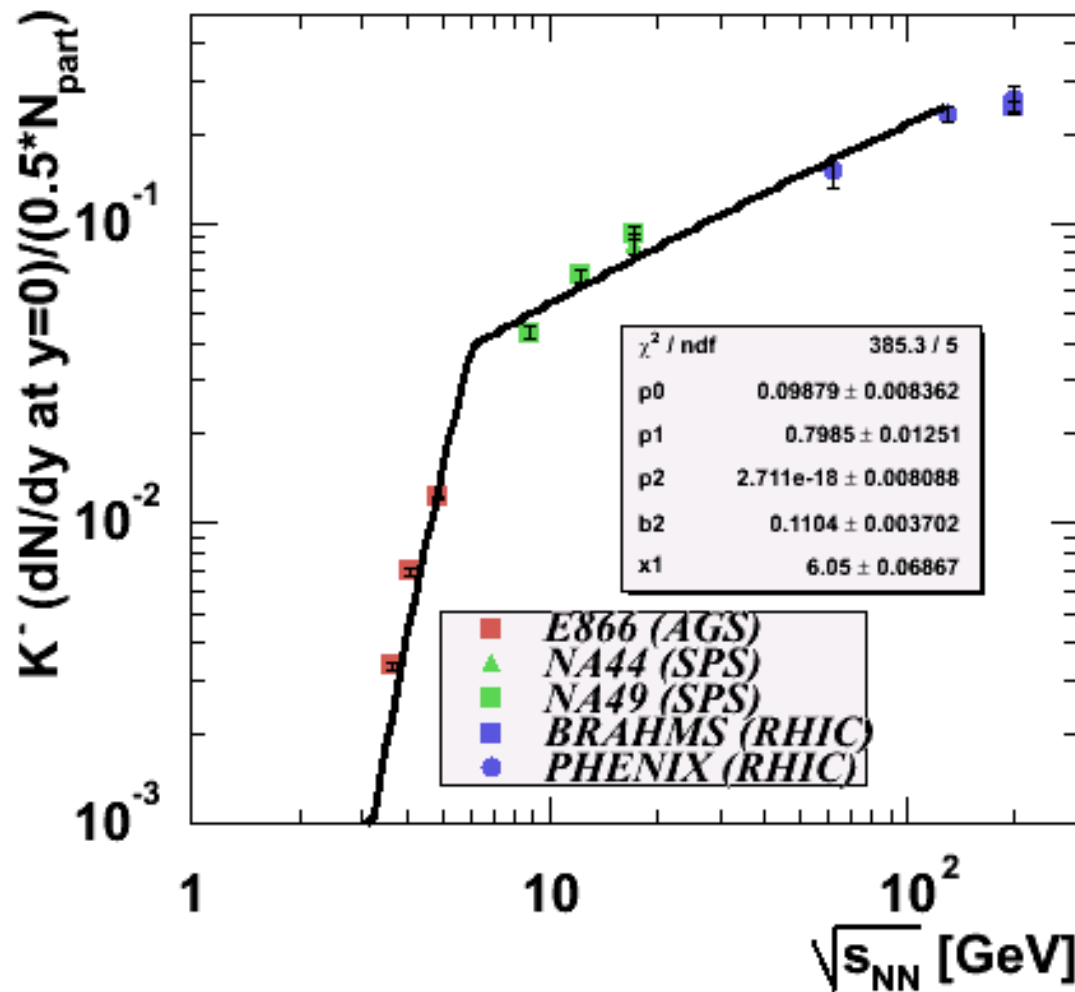
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=9.7

K⁻ dN/dy at y=0 / 0.5 N_{part}



Linear Fit:

FAIL. $\chi^2 = 4867/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

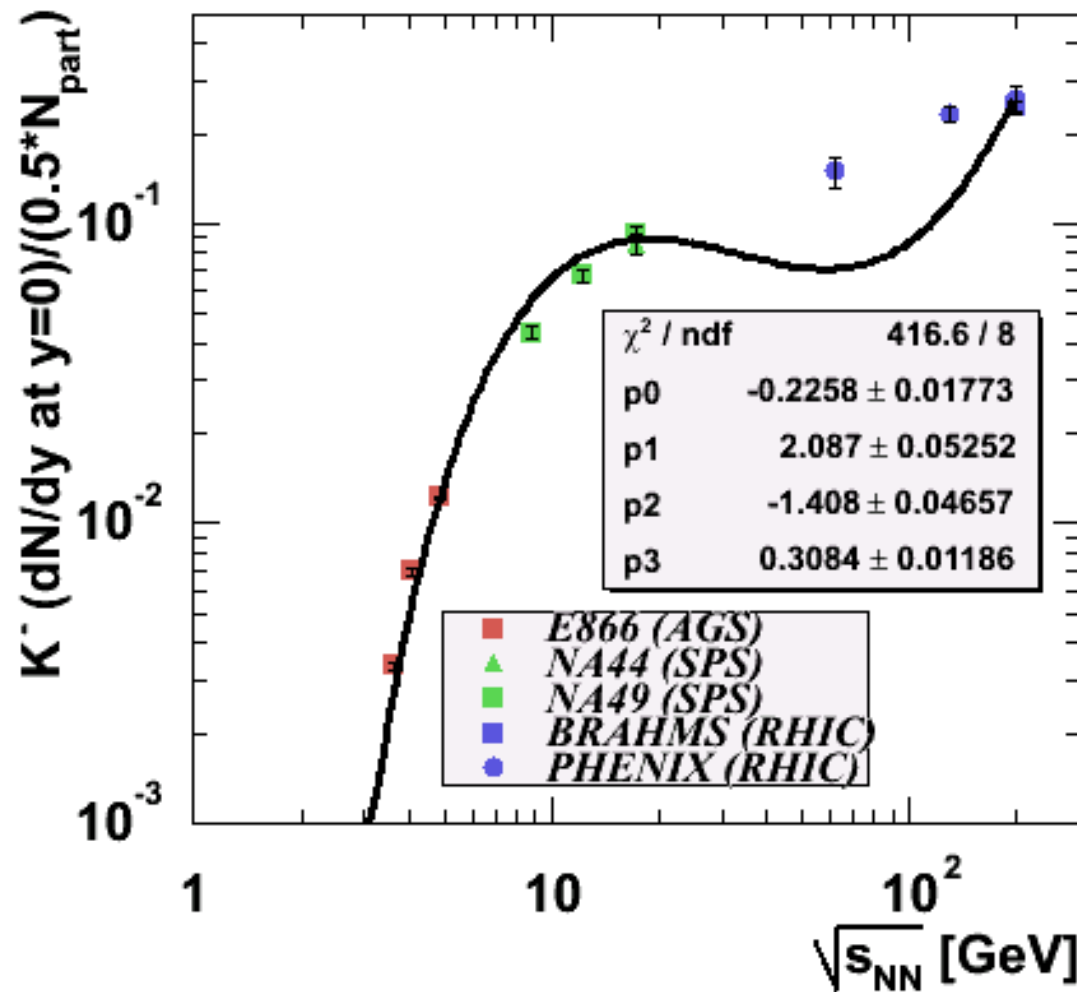
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=9.7

K^- dN/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

FAIL. $\chi^2 = 4867/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=6.0$

Poly+Line Fit:

FAIL.

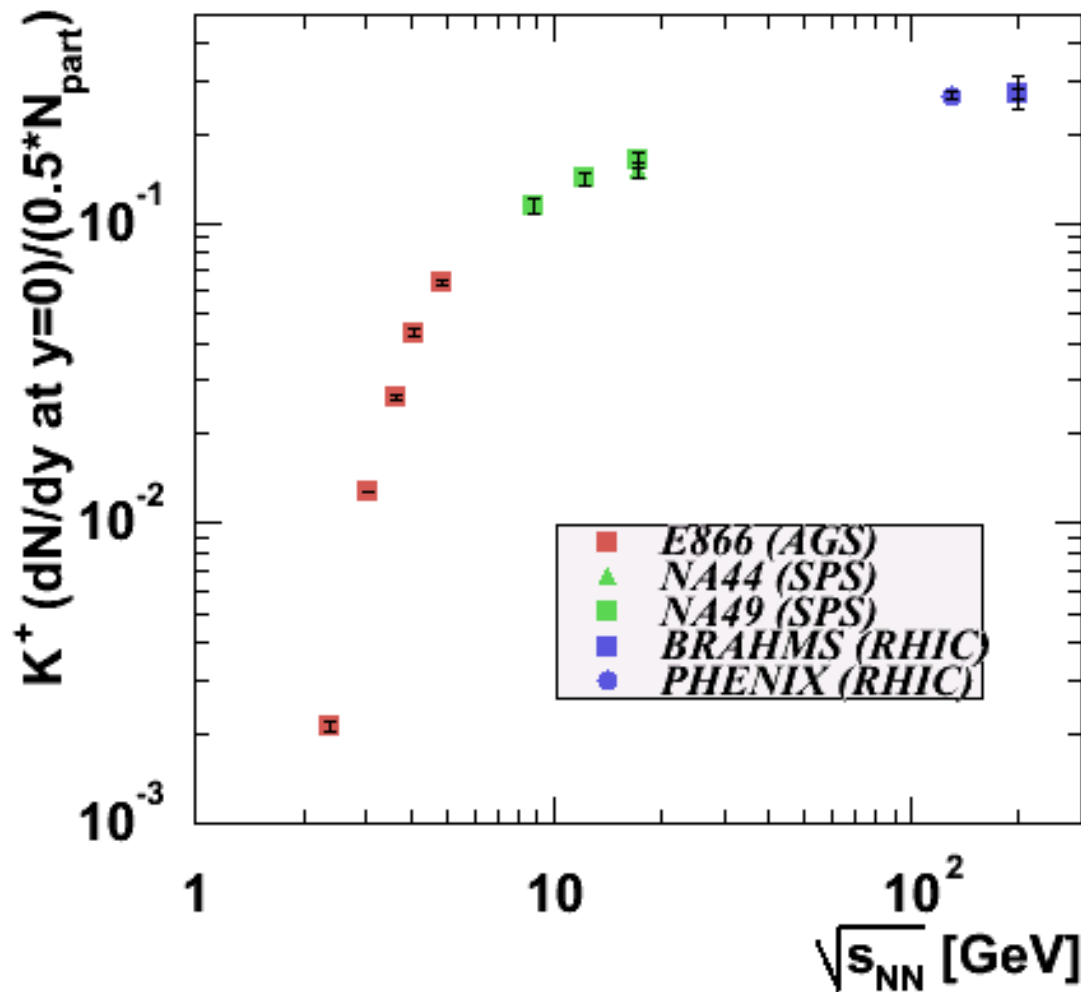
Minimum at $s^{1/2}=6.0$

3rd-order polynomial:

FAIL.

Turn-over=9.7

K^+ dN/dy at $y=0$ / $0.5 N_{\text{part}}$



Linear Fit:

FAIL. $\chi^2 = 1.1e4/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

FAIL.

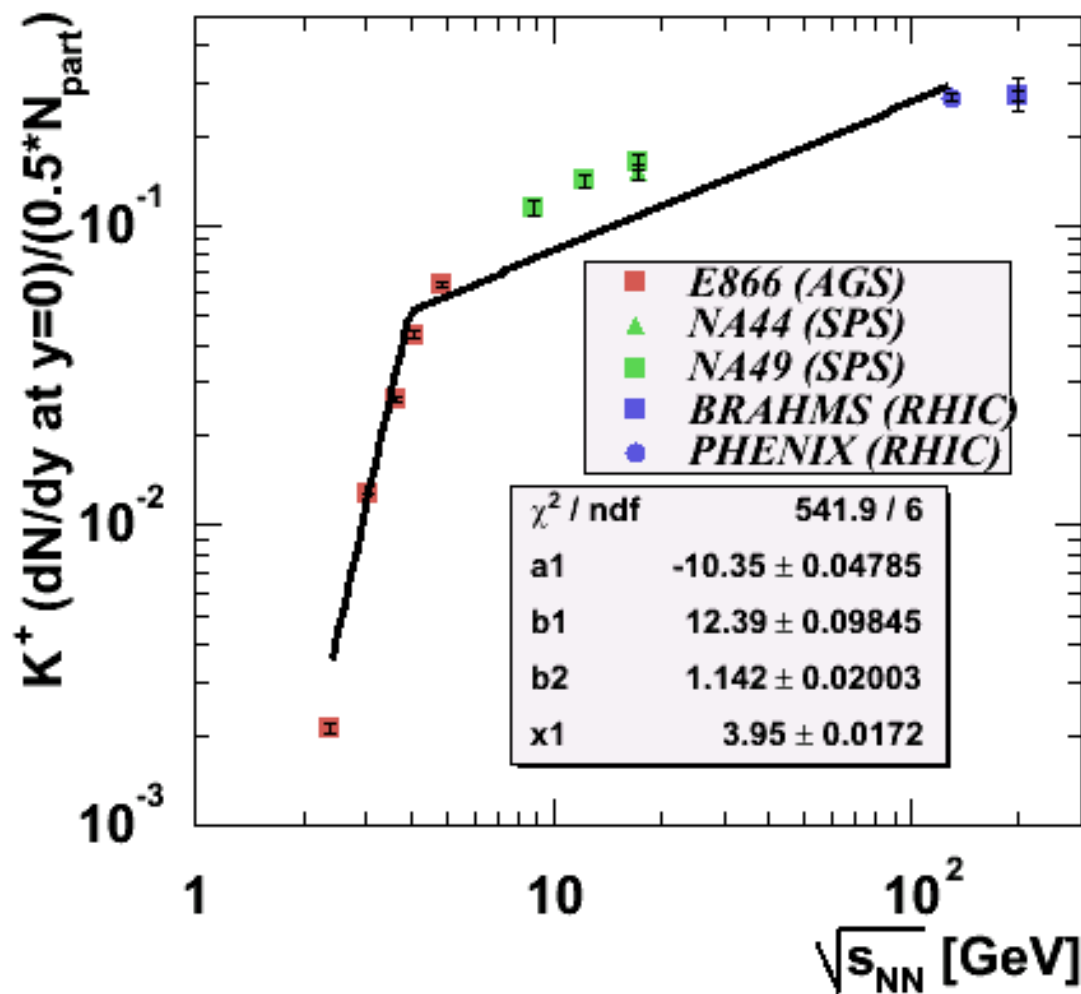
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

FAIL.

Turn-over=7.1

K^+ dN/dy at $y=0$ / $0.5 N_{\text{part}}$



Linear Fit:

FAIL. $\chi^2 = 1.1\text{e}4/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

FAIL.

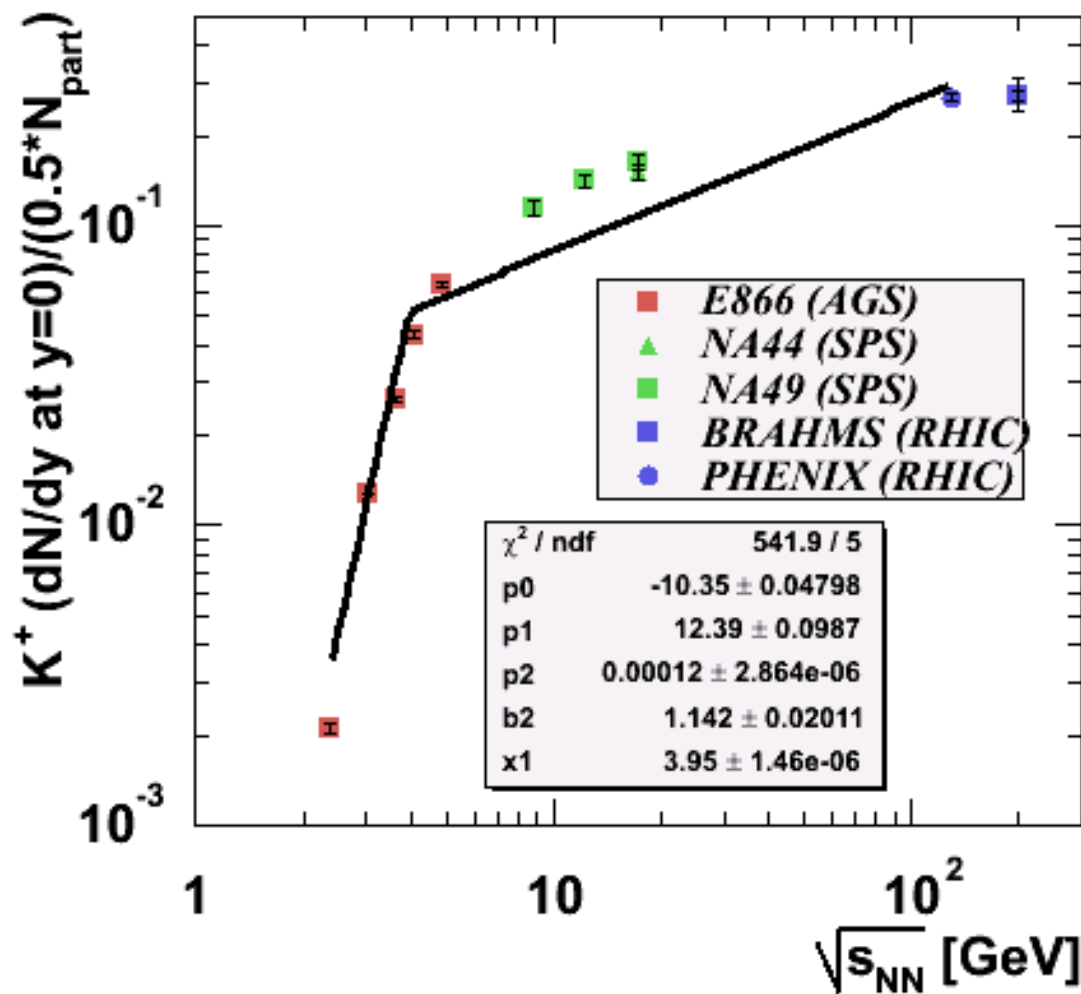
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

FAIL.

Turn-over=7.1

K^+ dN/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

FAIL. $\chi^2 = 1.1e4/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

FAIL.

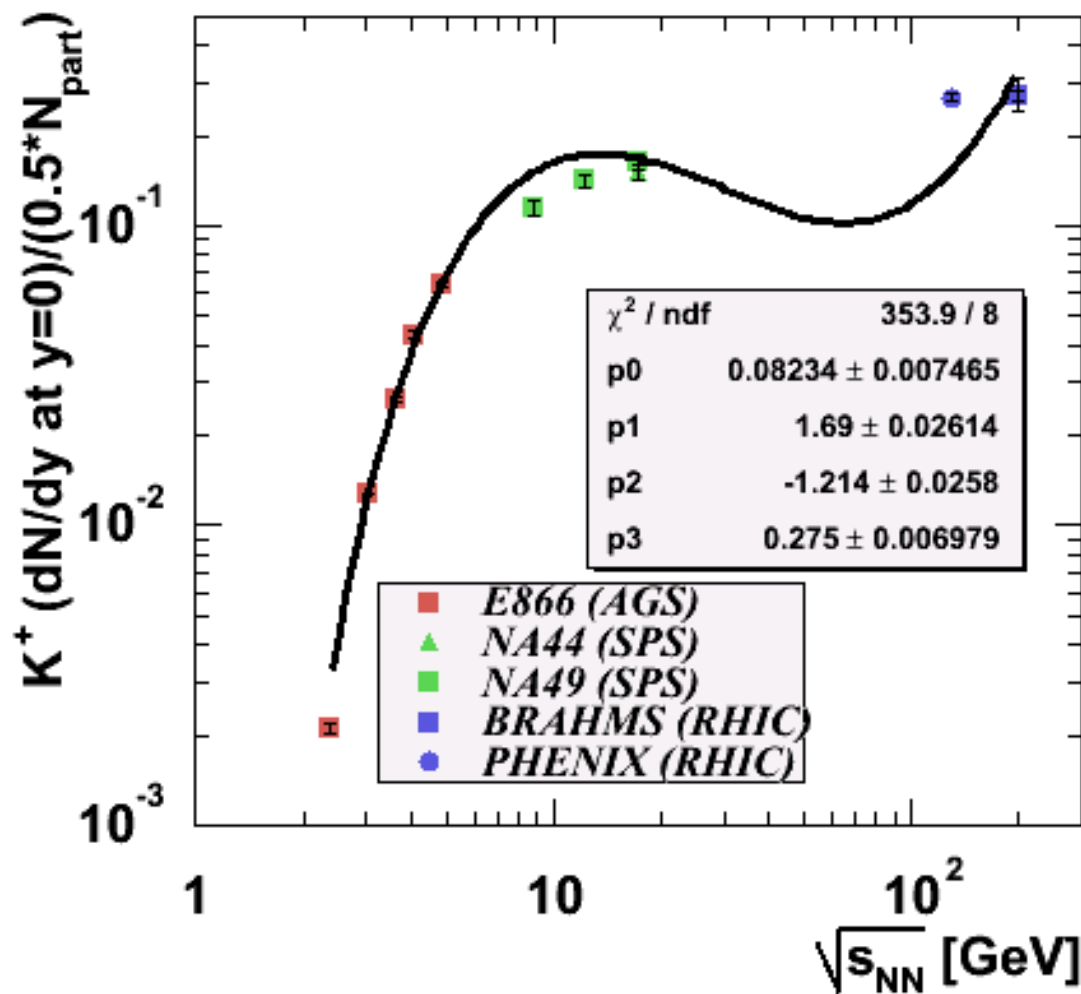
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

FAIL.

Turn-over=7.1

K^+ dN/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

FAIL. $\chi^2 = 1.1e4/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

FAIL.

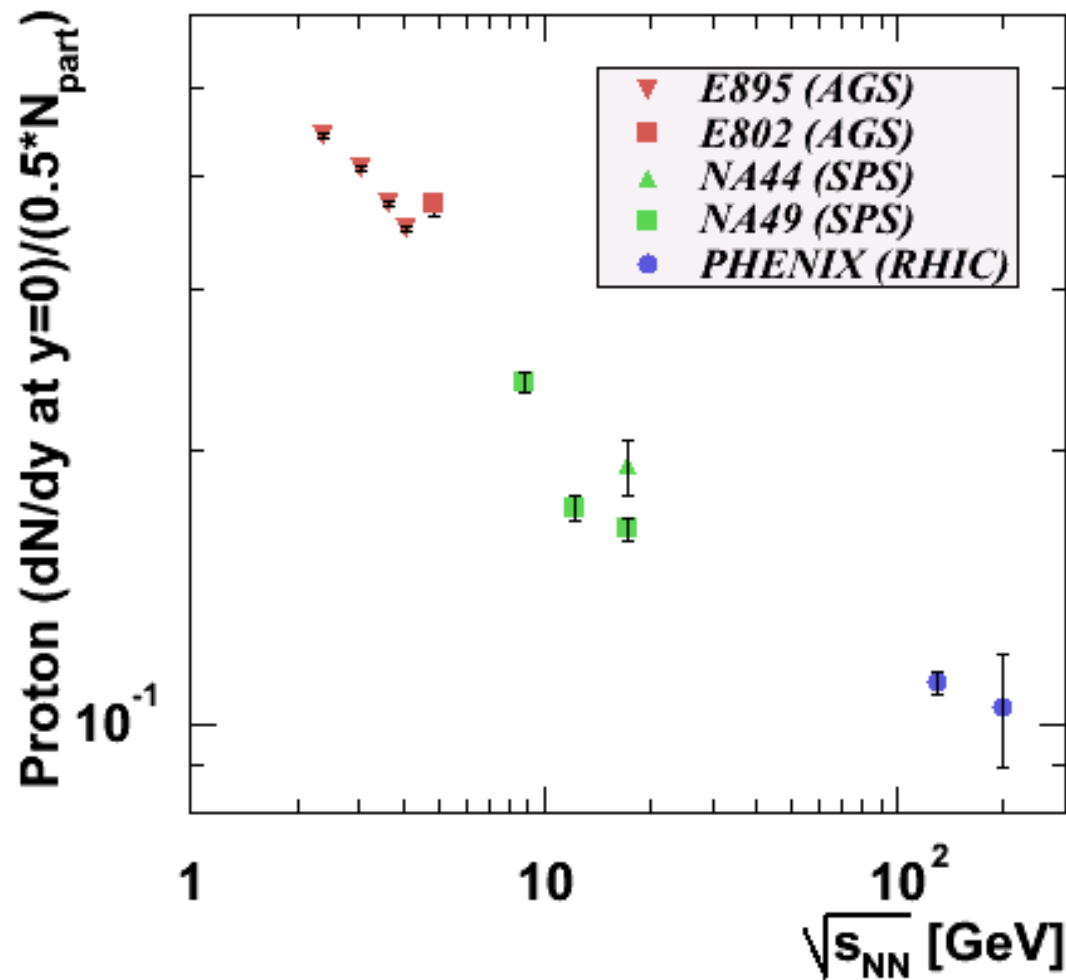
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

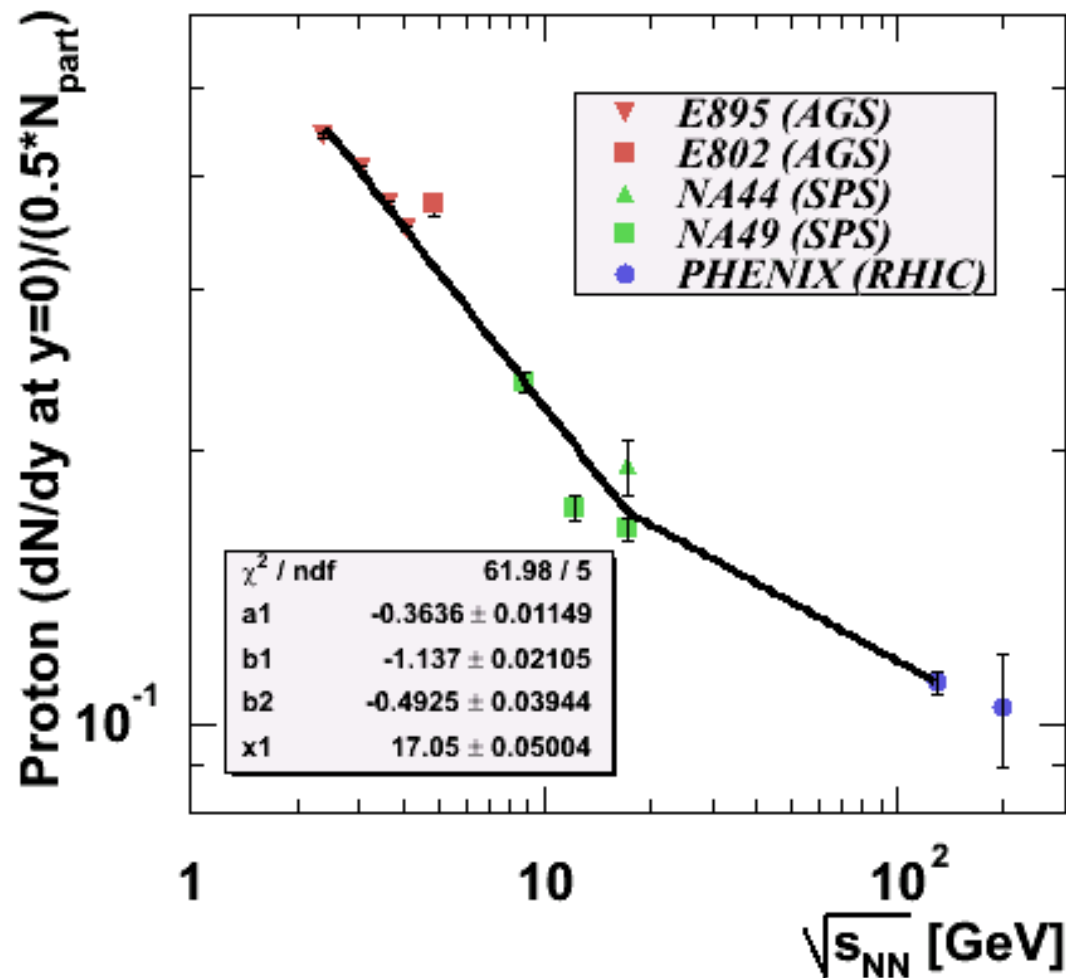
FAIL.

Turn-over=7.1

Proton dN/dy at $y=0$ / $0.5 N_{part}$



Proton dN/dy at $y=0$ / $0.5 N_{\text{part}}$



Linear Fit:

FAIL. $\chi^2 = 203.5/8$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=17.0$

Poly+Line Fit:

FAIL.

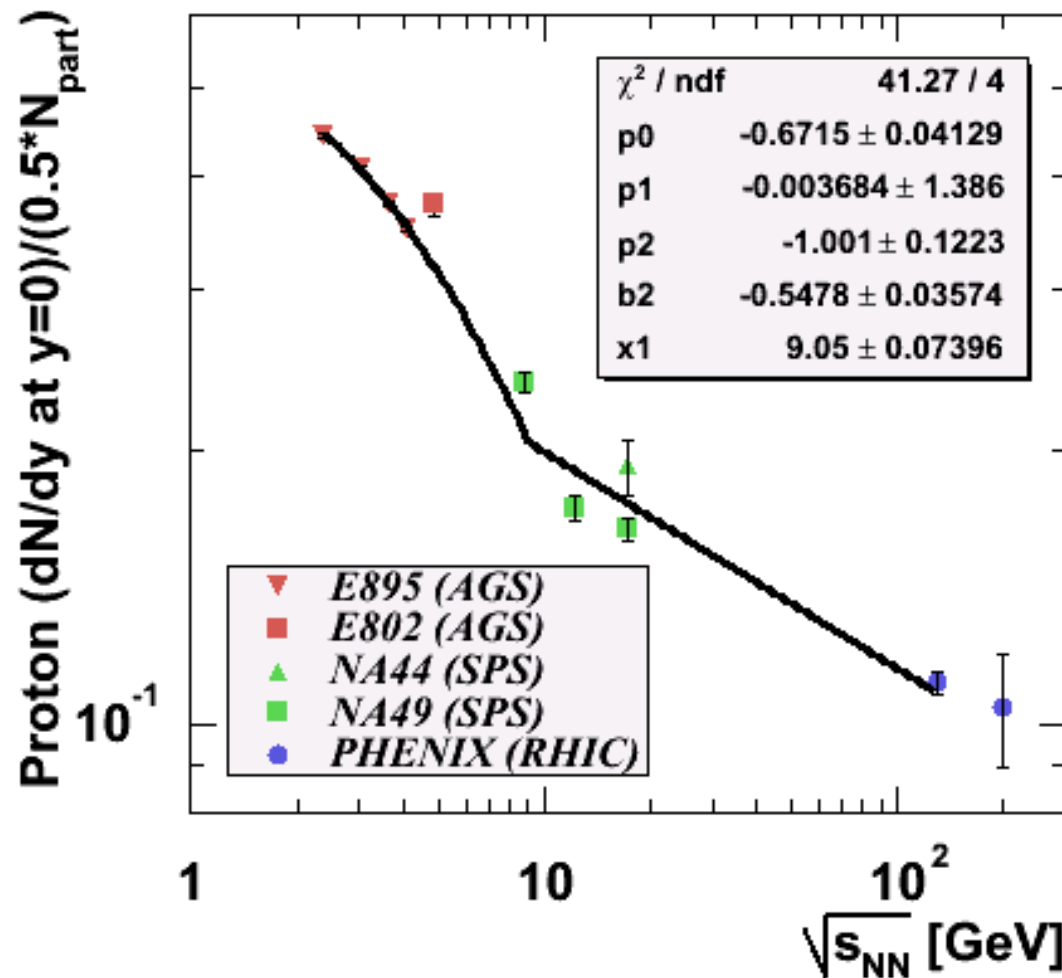
Minimum at $s^{1/2}=9.0$

3rd-order polynomial:

FAIL.

Turn-over=None

Proton dN/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

FAIL. $\chi^2 = 203.5/8$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=17.0$

Poly+Line Fit:

FAIL.

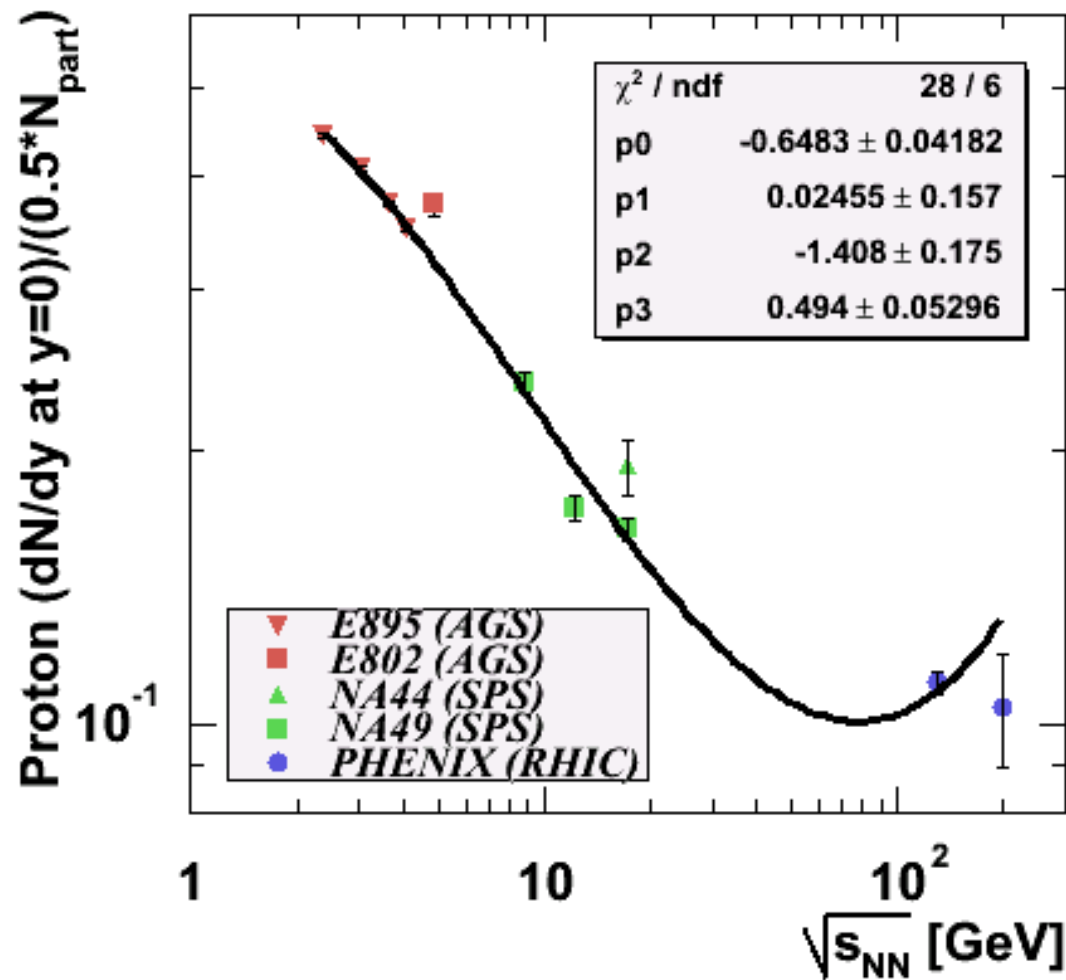
Minimum at $s^{1/2}=9.0$

3rd-order polynomial:

FAIL.

Turn-over=None

Proton dN/dy at $y=0$ / $0.5 N_{part}$



Linear Fit:

FAIL. $\chi^2 = 203.5/8$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=17.0$

Poly+Line Fit:

FAIL.

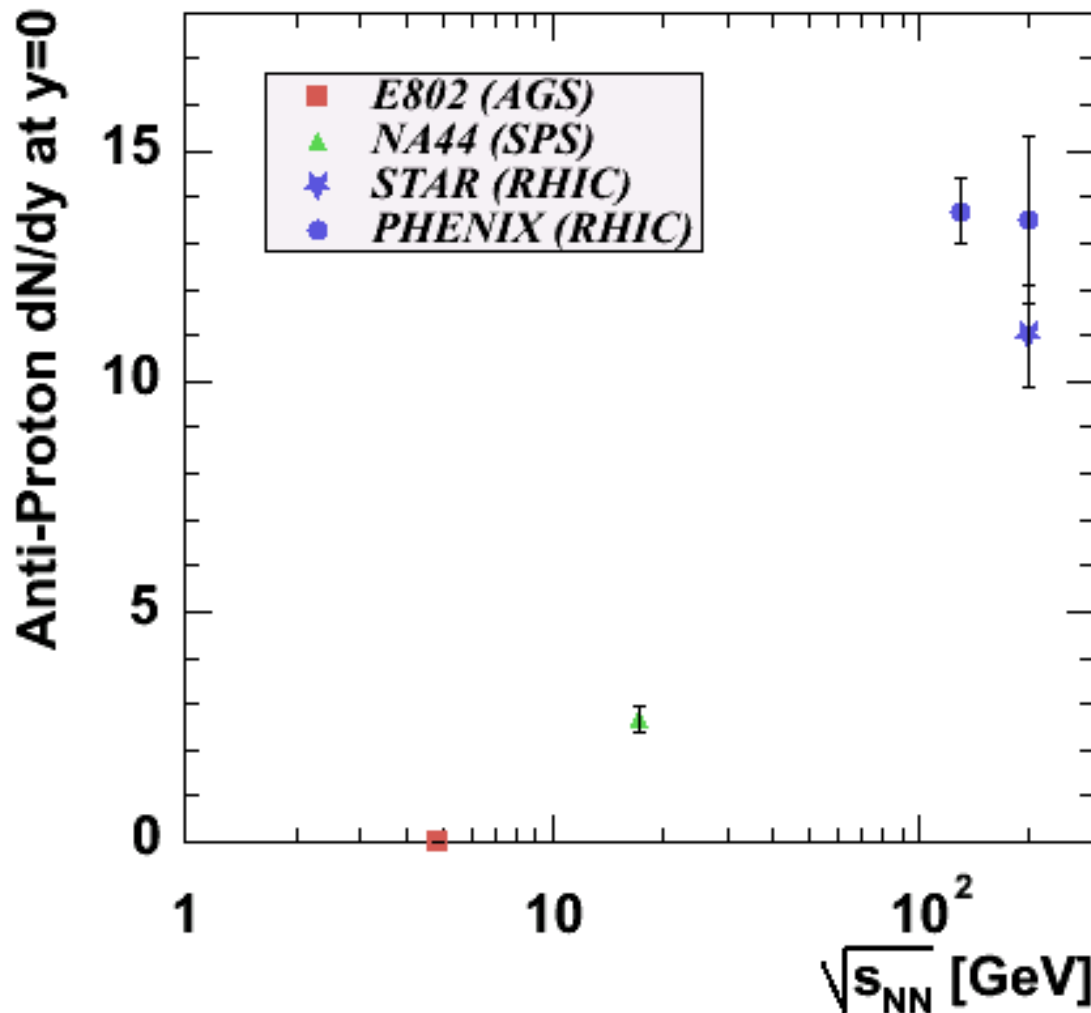
Minimum at $s^{1/2}=9.0$

3rd-order polynomial:

FAIL.

Turn-over=None

Antiproton dN/dy at $y=0$



Linear Fit:

FAIL. $\chi^2 = 49.0/3$

Line+Line Fit:

Not enough points.

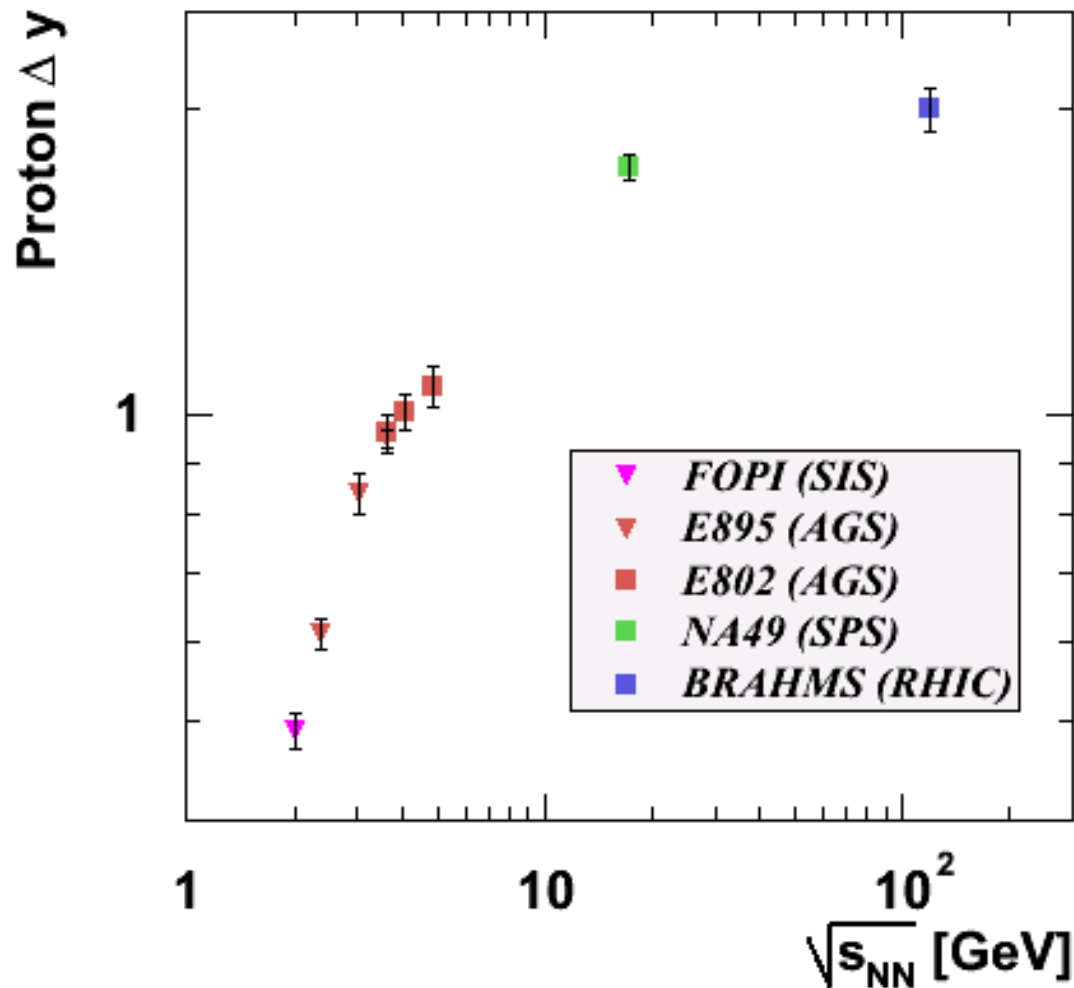
Minimum at $s^{1/2}=?$

Poly+Line Fit:

Not enough points.

Minimum at $s^{1/2}=?$

Proton δy



Linear Fit:

FAIL. $\chi^2 = 281.8/8$

Line+Line Fit:

C.L.=2.5%.

Minimum at $s^{1/2}=7.0$

Poly+Line Fit:

C.L.=2.5%. [7.0,+]

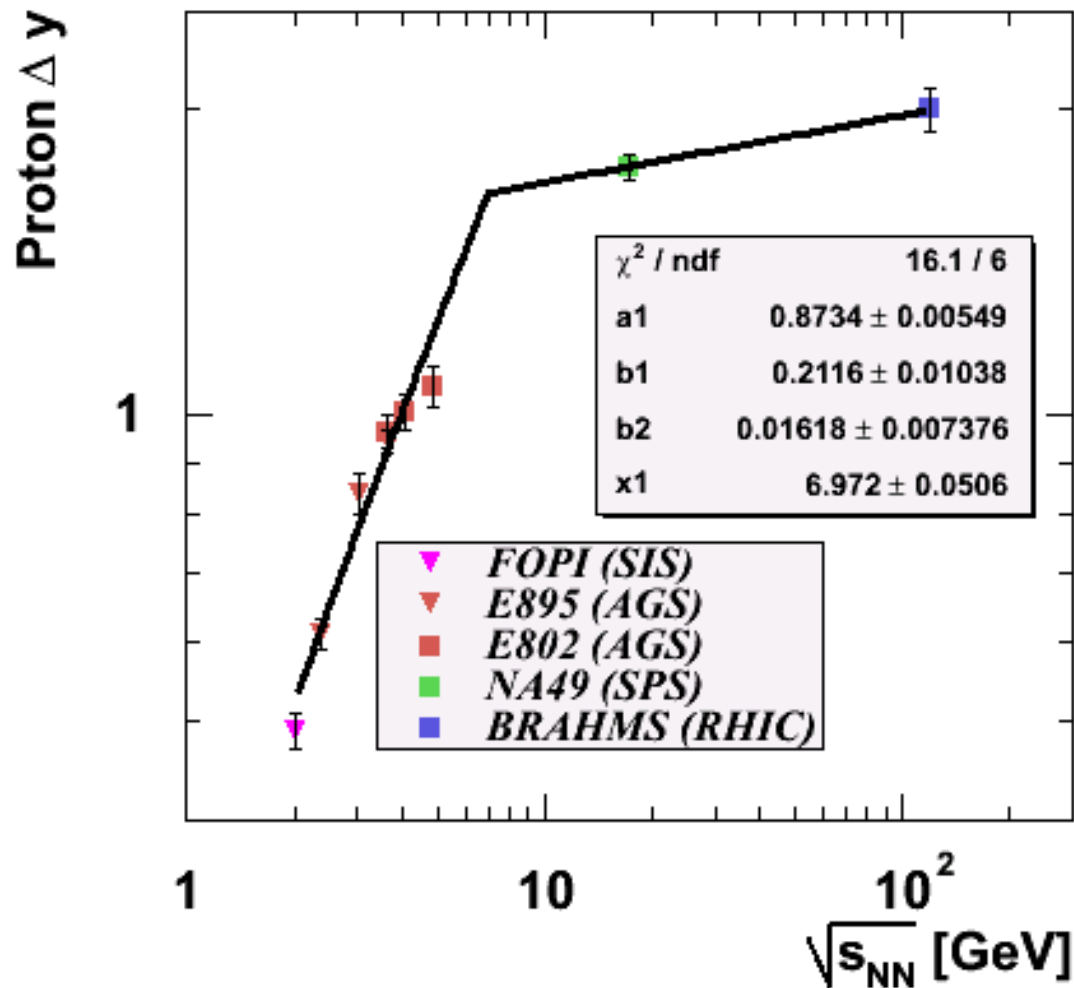
Minimum at $s^{1/2}=\text{None}$

3rd-order polynomial:

PASS w/ C.L.=90%.

Turn-over=9.4

Proton δy



Linear Fit:

FAIL. $\chi^2 = 281.8/8$

Line+Line Fit:

C.L.=2.5%.

Minimum at $s^{1/2}=7.0$

Poly+Line Fit:

C.L.=2.5%. [7.0,+]

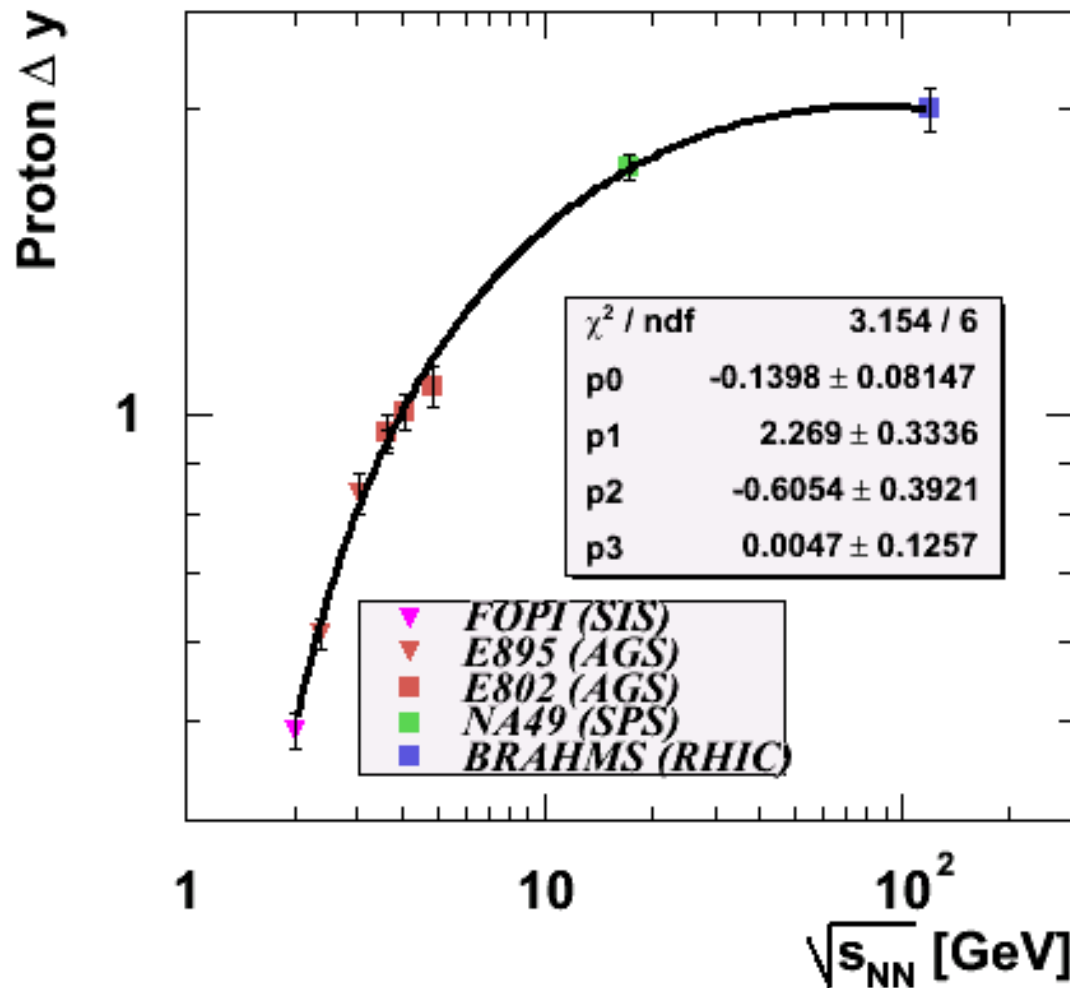
Minimum at $s^{1/2}=\text{None}$

3rd-order polynomial:

PASS w/ C.L.=90%.

Turn-over=9.4

Proton δy



Linear Fit:

FAIL. $\chi^2 = 281.8/8$

Line+Line Fit:

C.L.=2.5%.

Minimum at $s^{1/2}=7.0$

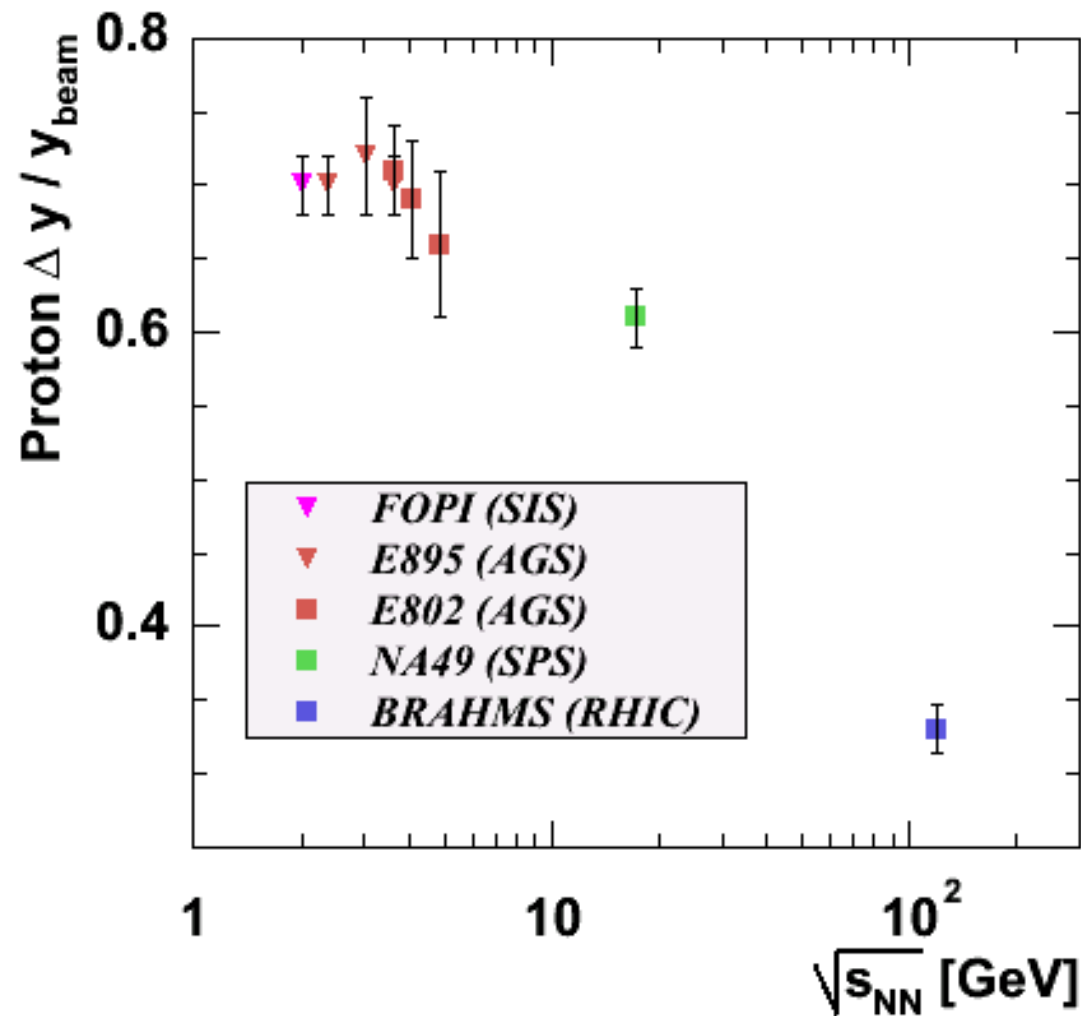
Poly+Line Fit:

C.L.=2.5%. [7.0,+]

Minimum at $s^{1/2}=\text{None}$

**3rd-order polynomial:
PASS w/ C.L.=90%.
Turn-over=9.4**

Proton $\delta y / y_{\text{beam}}$



Linear Fit:

FAIL. $\chi^2 = 22.9/8$

Line+Line Fit:

C.L.=99%. [3.0,+]

Minimum at $s^{1/2}=10.0$

Poly+Line Fit:

C.L.=99%. [3.0,+]

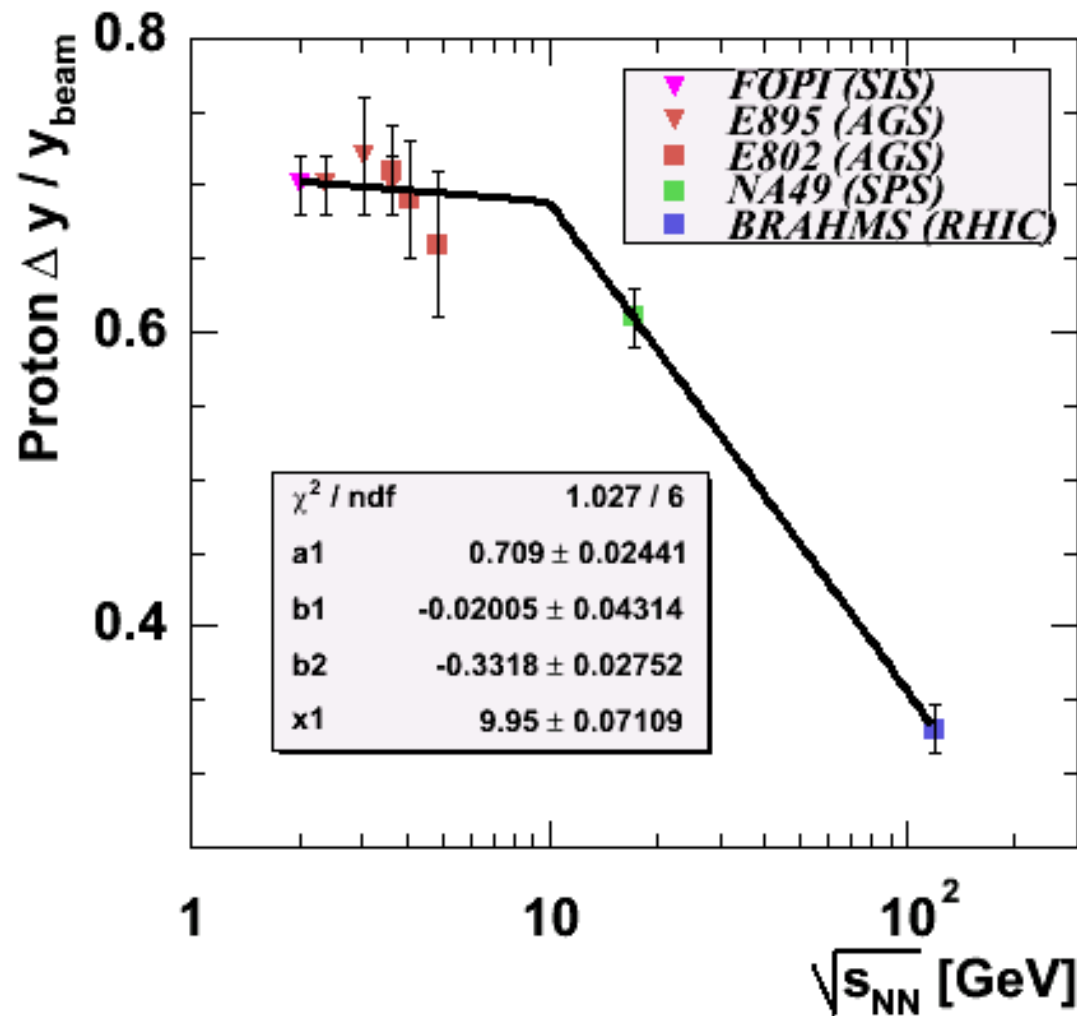
Minimum at $s^{1/2}=\text{None}$

3rd-order polynomial:

Pass w/ C.L.=99.5%.

Turn-over=17.5

Proton $\delta y / y_{\text{beam}}$



Linear Fit:

FAIL. $\chi^2 = 22.9/8$

Line+Line Fit:

C.L.=99%. [3.0,+]

Minimum at $s^{1/2}=10.0$

Poly+Line Fit:

C.L.=99%. [3.0,+]

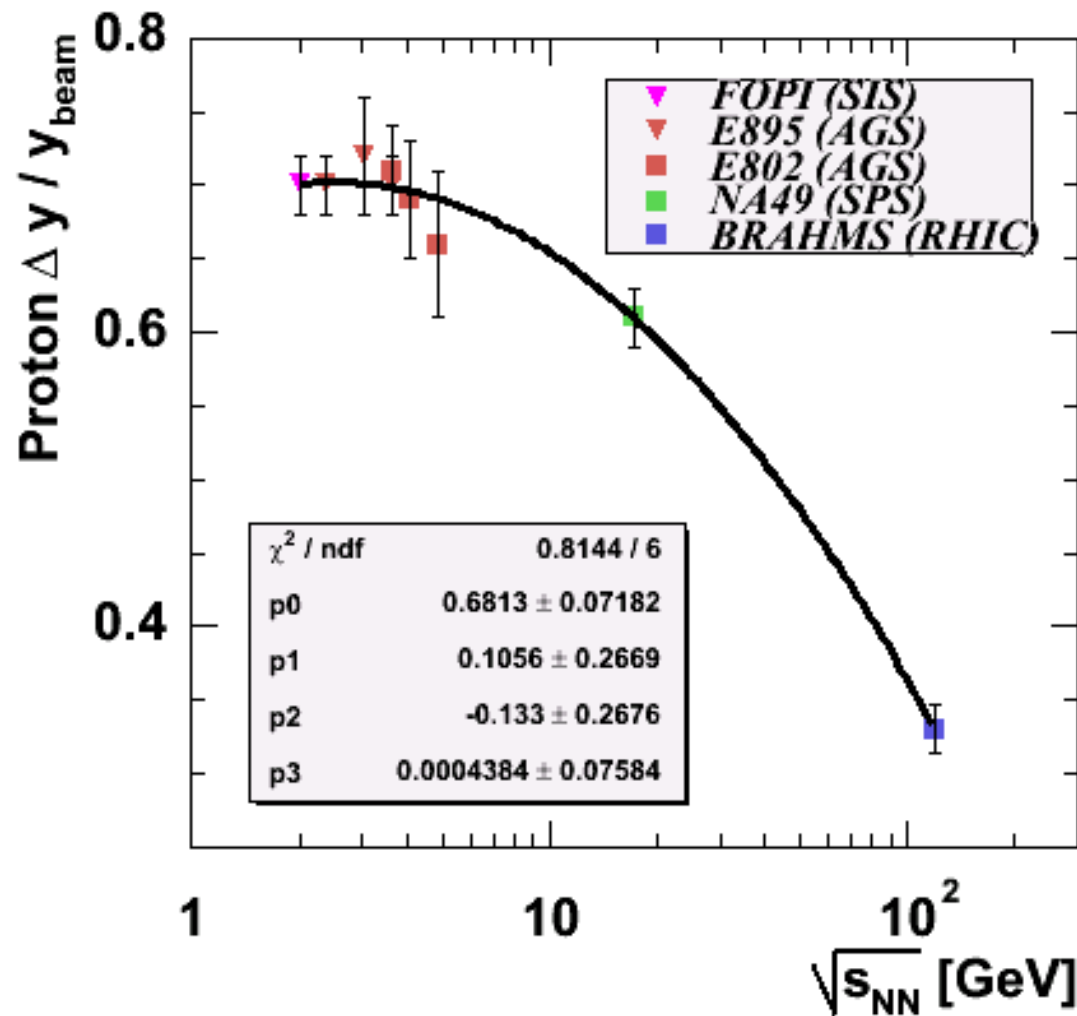
Minimum at $s^{1/2}=\text{None}$

3rd-order polynomial:

Pass w/ C.L.=99.5%.

Turn-over=17.5

Proton $\delta y / y_{\text{beam}}$



Linear Fit:

FAIL. $\chi^2 = 22.9/8$

Line+Line Fit:

C.L.=99%. [3.0,+]

Minimum at $s^{1/2}=10.0$

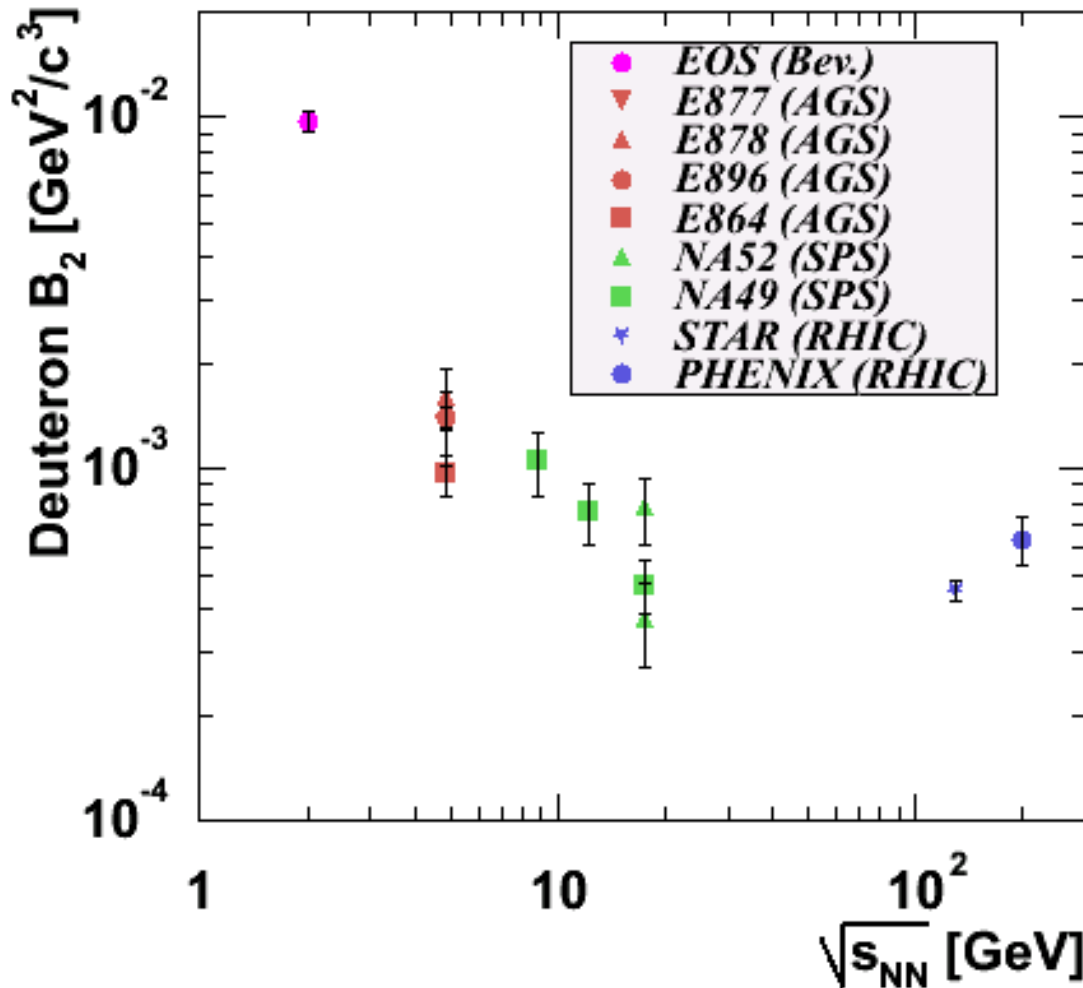
Poly+Line Fit:

C.L.=99%. [3.0,+]

Minimum at $s^{1/2}=\text{None}$

**3rd-order polynomial:
Pass w/ C.L.=99.5%.
Turn-over=17.5**

Deuteron Coalescence



Linear Fit:

FAIL. $\chi^2 = 235/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

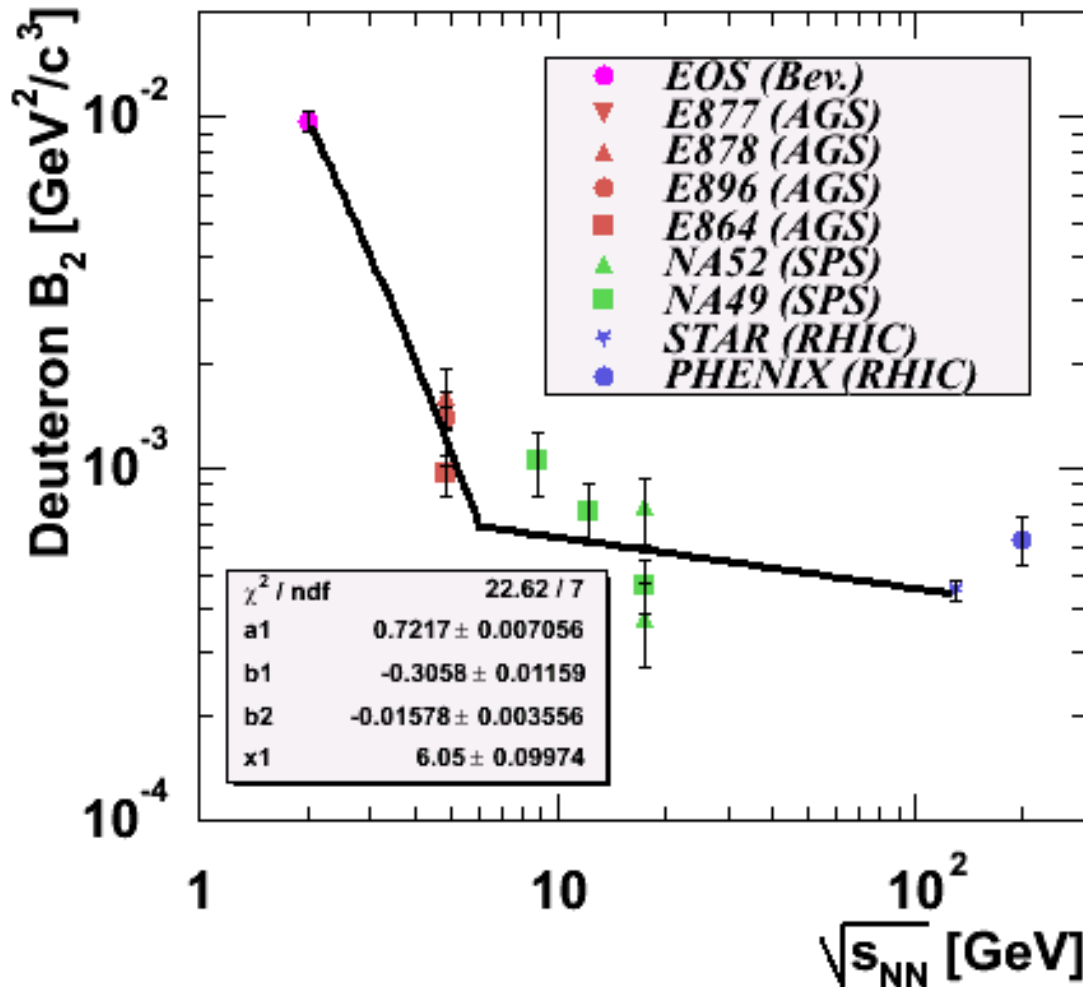
Minimum at $s^{1/2}=10.0$

3rd-order polynomial:

FAIL.

Turn-over=7.3

Deuteron Coalescence



Linear Fit:

FAIL. $\chi^2 = 235/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

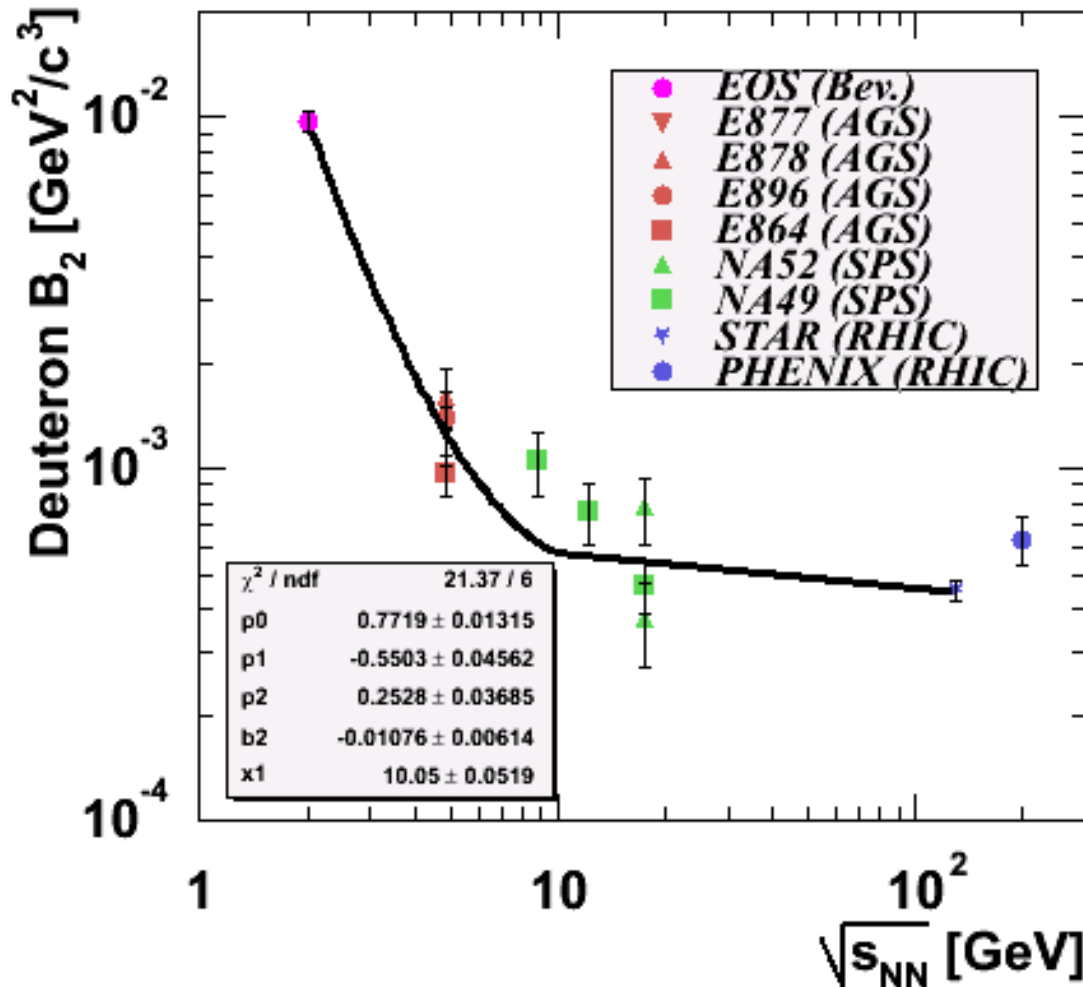
Minimum at $s^{1/2}=10.0$

3rd-order polynomial:

FAIL.

Turn-over=7.3

Deuteron Coalescence



Linear Fit:

FAIL. $\chi^2 = 235/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

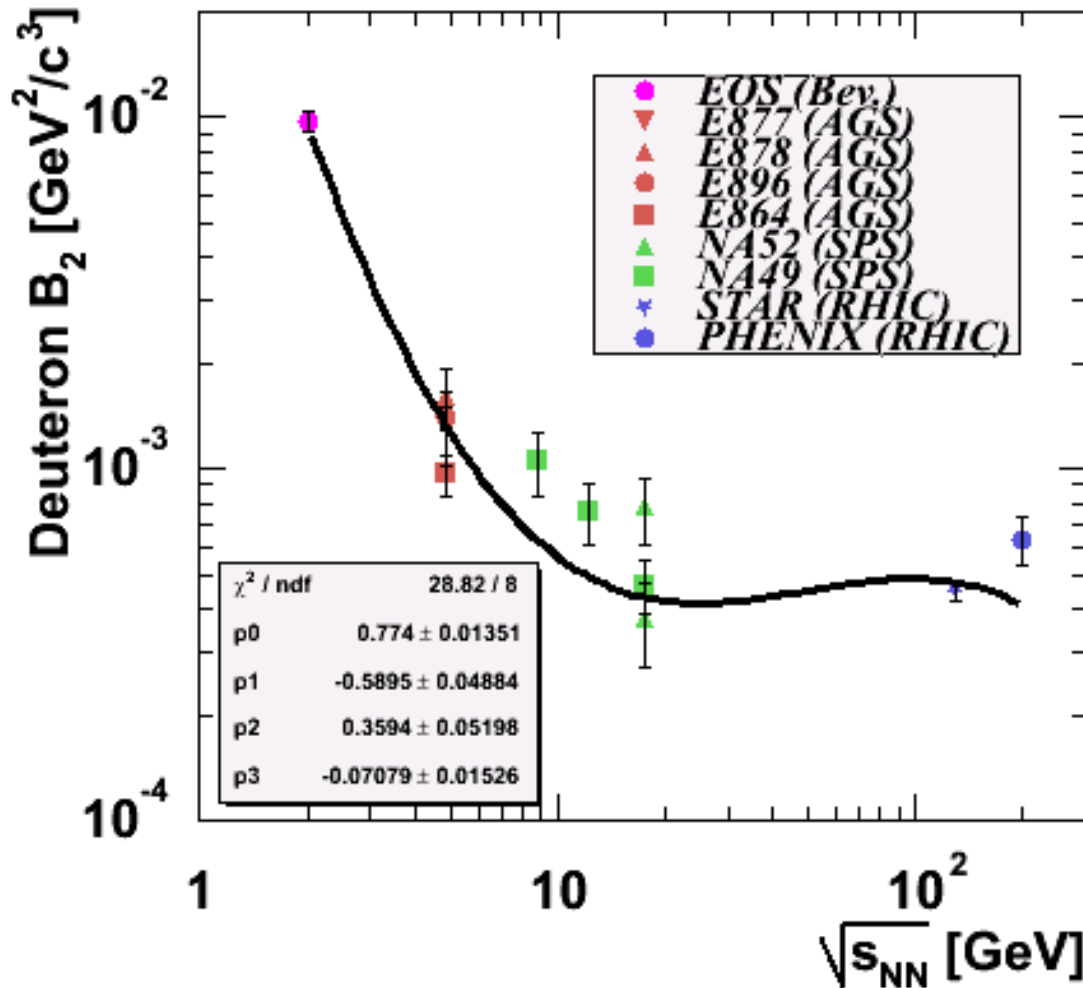
Minimum at $s^{1/2}=10.0$

3rd-order polynomial:

FAIL.

Turn-over=7.3

Deuteron Coalescence



Linear Fit:

FAIL. $\chi^2 = 235/10$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

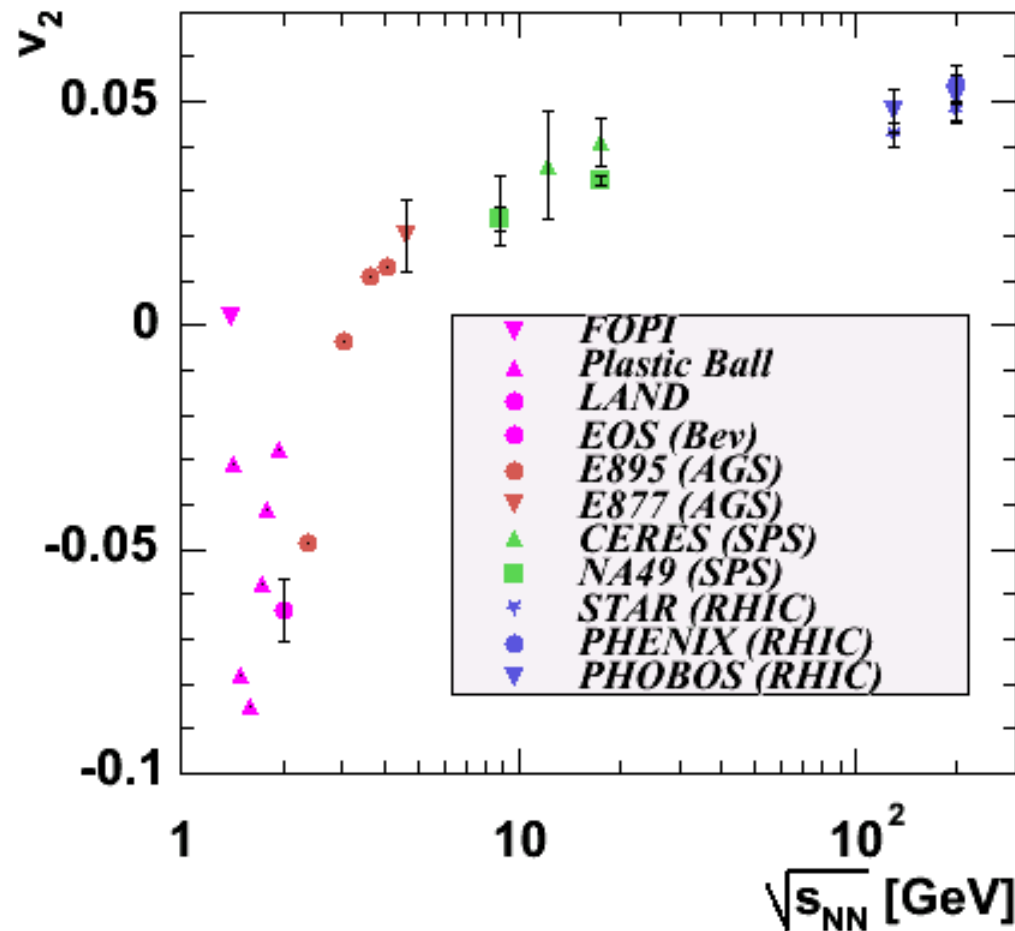
Minimum at $s^{1/2}=10.0$

3rd-order polynomial:

FAIL.

Turn-over=7.3

Elliptic Flow



Linear Fit:

FAIL. $\chi^2 = 648.2/21$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

FAIL.

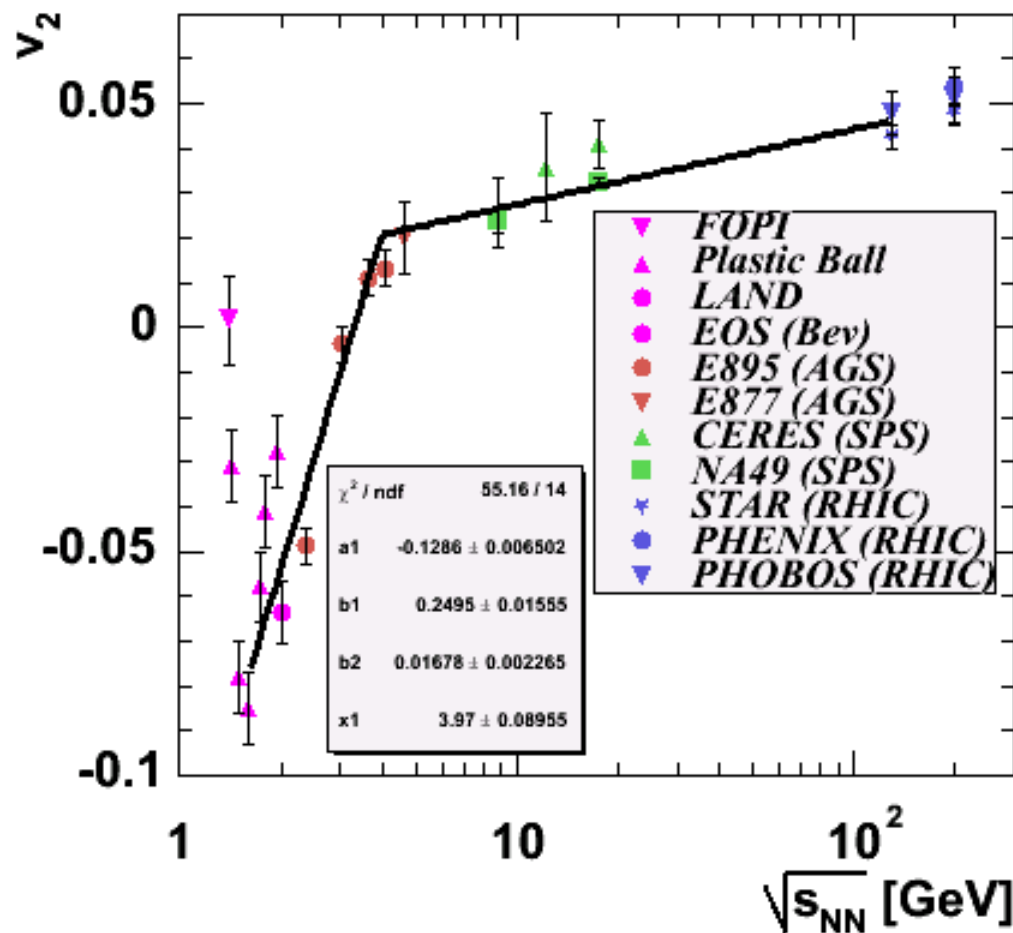
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

FAIL.

Turn-over=6.1

Elliptic Flow



Linear Fit:

FAIL. $\chi^2 = 648.2/21$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

FAIL.

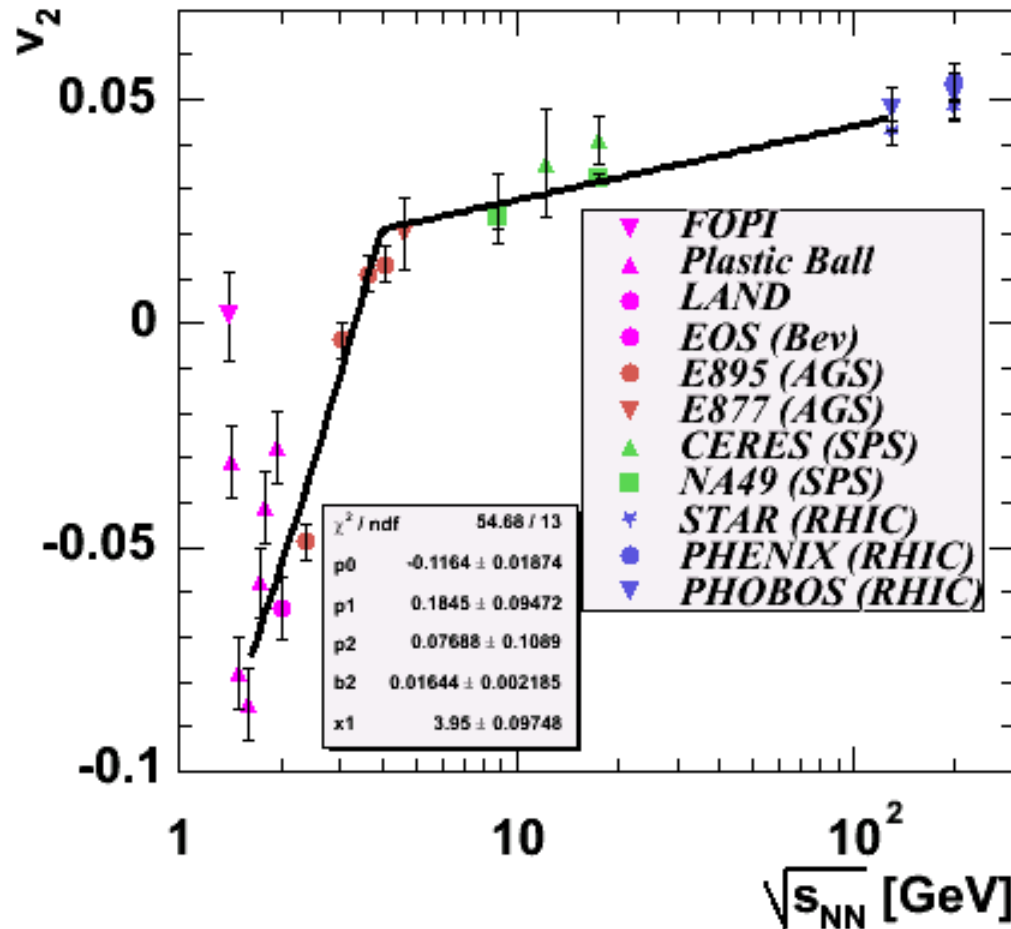
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

FAIL.

Turn-over=6.1

Elliptic Flow



Linear Fit:

FAIL. $\chi^2 = 648.2/21$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

FAIL.

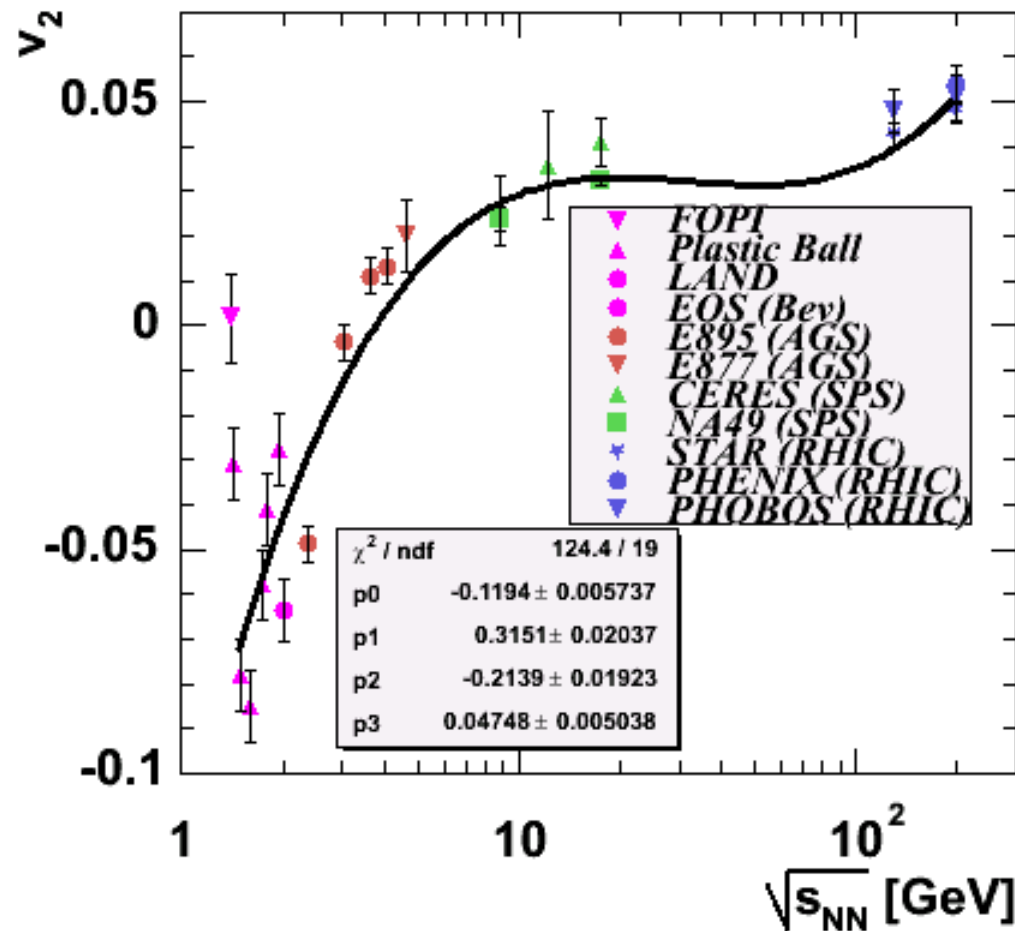
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

FAIL.

Turn-over=6.1

Elliptic Flow



Linear Fit:

FAIL. $\chi^2 = 648.2/21$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

FAIL.

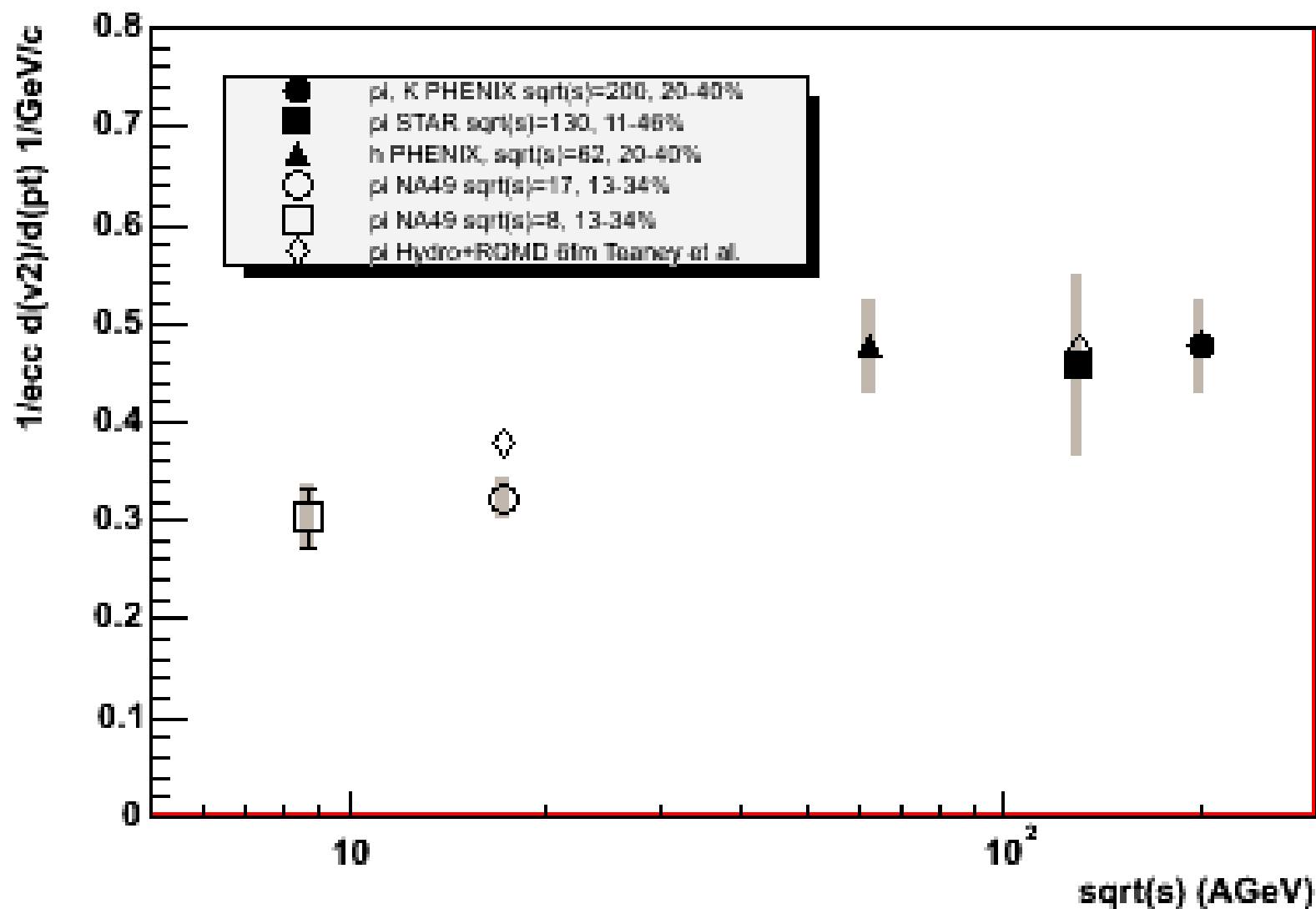
Minimum at $s^{1/2}=4.0$

3rd-order polynomial:

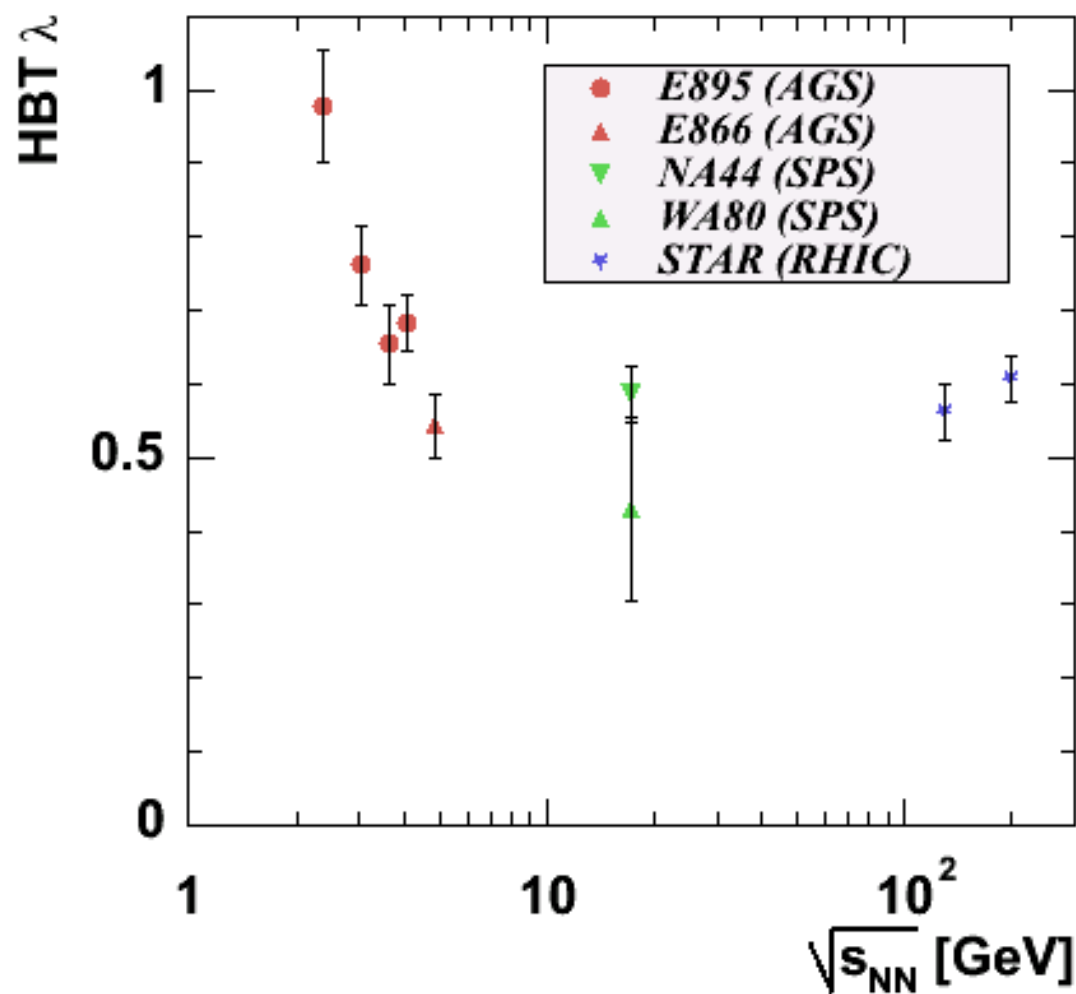
FAIL.

Turn-over=6.1

Elliptic Flow: v_2 vs. p_T



HBT λ



Linear Fit:

FAIL. $\chi^2 = 31.7/7$

Line+Line Fit

C.L.=50%. [4.0,6.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=25%. [4.0,9.0]

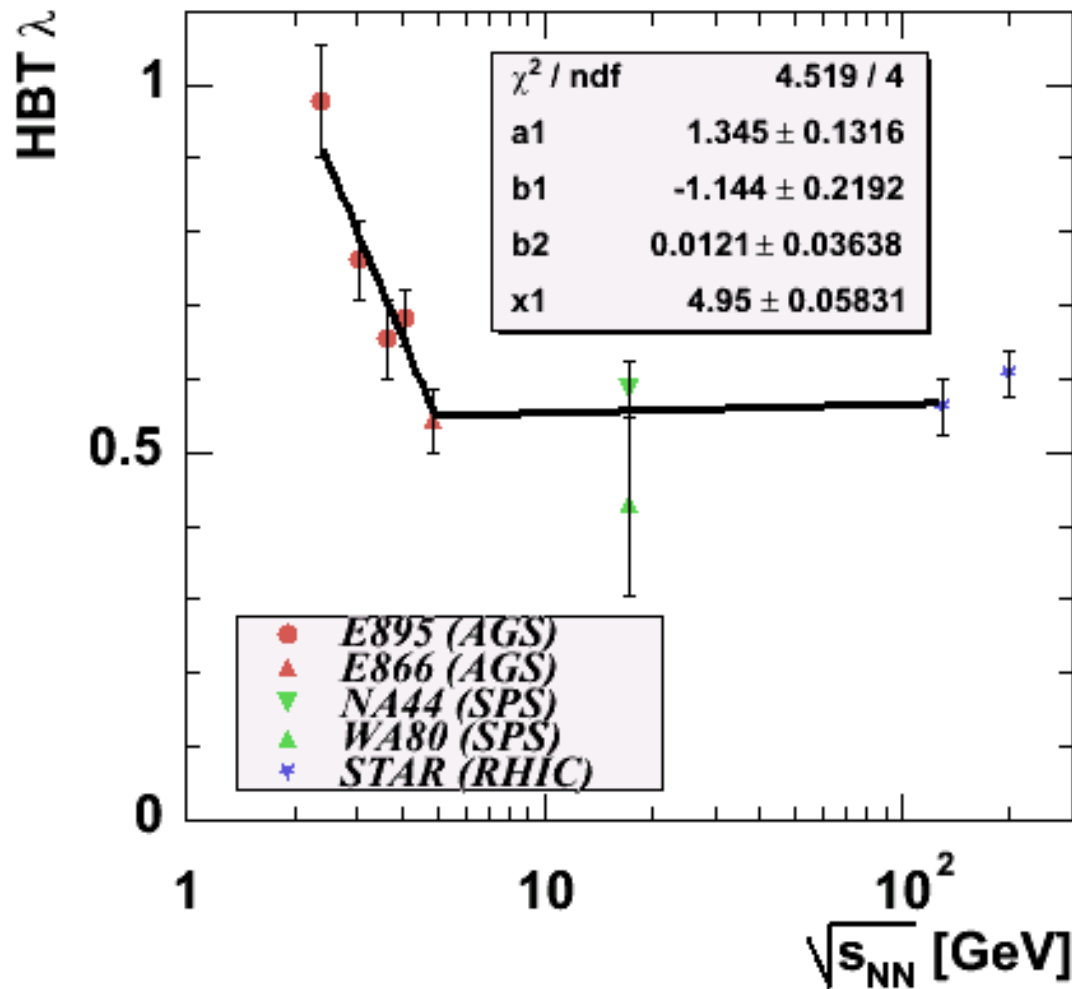
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

Pass w/ C.L.=5%.

Turn-over=5.5

HBT λ



Linear Fit:

FAIL. $\chi^2 = 31.7/7$

Line+Line Fit

C.L.=50%. [4.0,6.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=25%. [4.0,9.0]

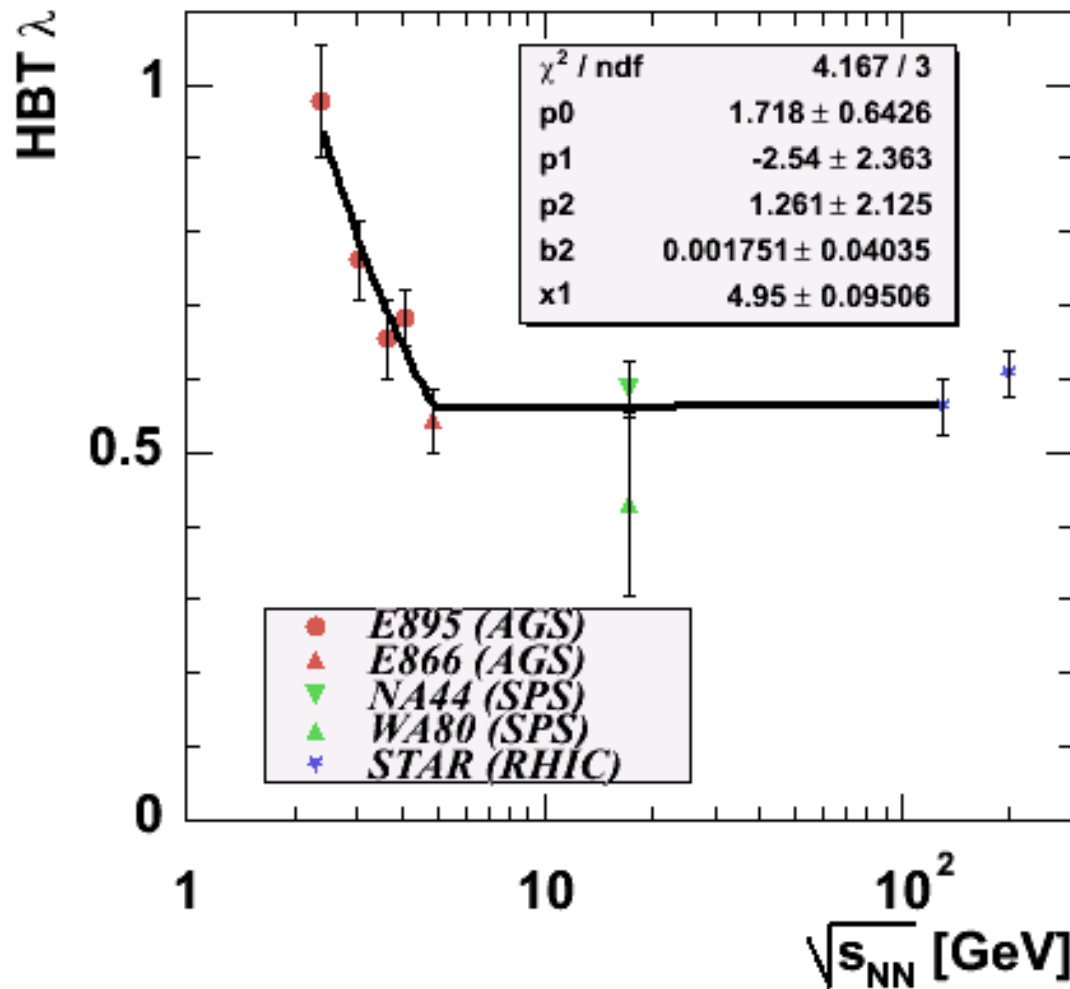
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

Pass w/ C.L.=5%.

Turn-over=5.5

HBT λ



Linear Fit:

FAIL. $\chi^2 = 31.7/7$

Line+Line Fit

C.L.=50%. [4.0,6.0]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=25%. [4.0,9.0]

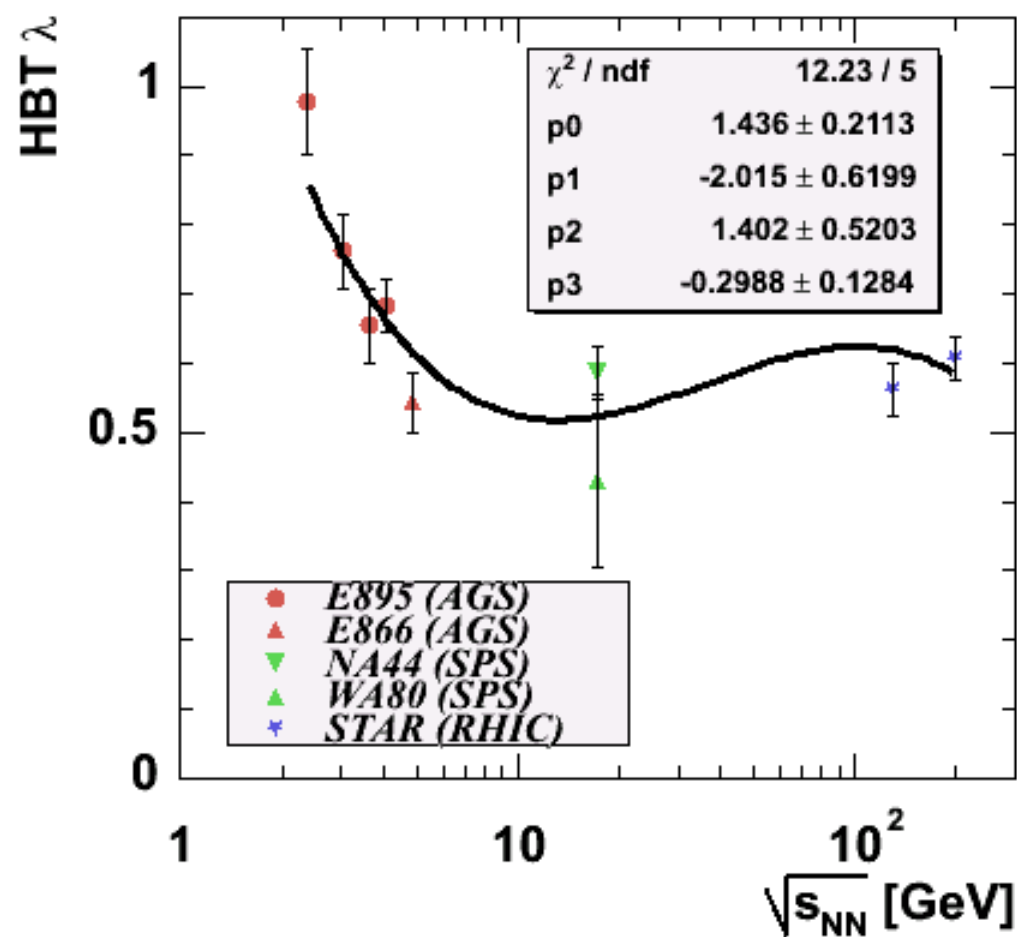
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

Pass w/ C.L.=5%.

Turn-over=5.5

HBT λ



Linear Fit:

FAIL. $\chi^2 = 31.7/7$

Line+Line Fit

C.L.=50%. [4.0,6.0]

Minimum at $s^{1/2}=5.0$

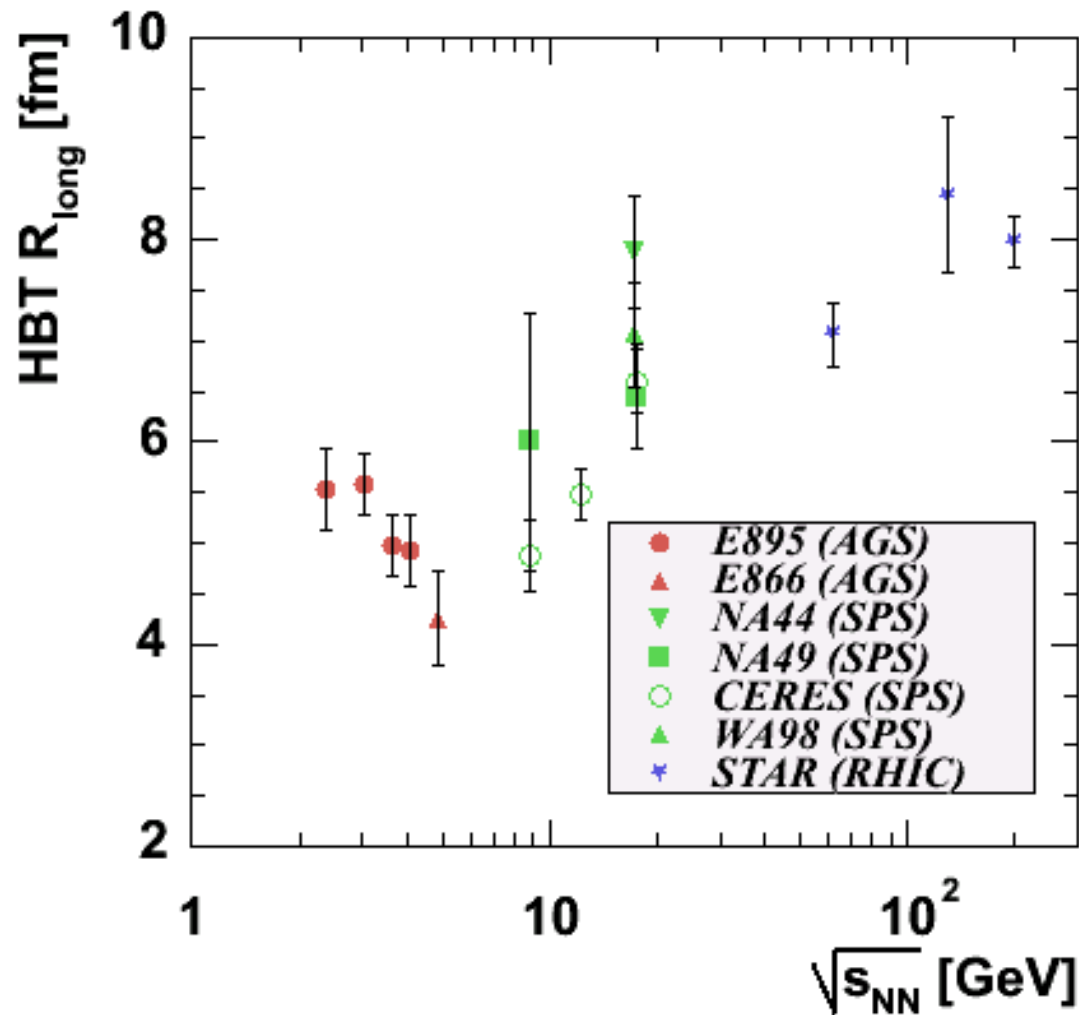
Poly+Line Fit:

C.L.=25%. [4.0,9.0]

Minimum at $s^{1/2}=5.0$

3rd-order polynomial:
Pass w/ C.L.=5%.
Turn-over=5.5

HBT R_{long}



Linear Fit:

FAIL. $\chi^2 = 37.3/13$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

FAIL.

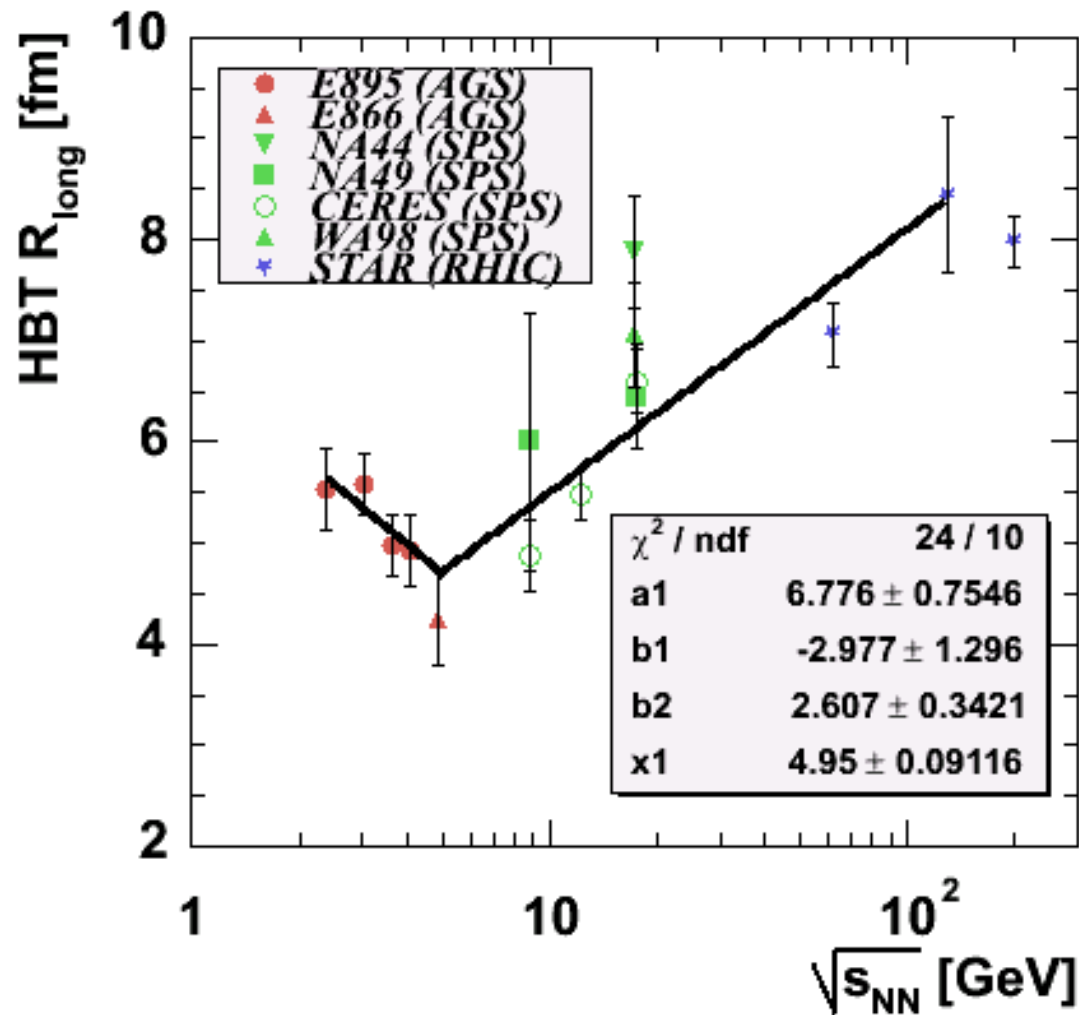
Minimum at $s^{1/2}=4.4$

3rd-order polynomial:

FAIL.

Turn-over=None

HBT R_{long}



Linear Fit:

FAIL. $\chi^2 = 37.3/13$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

FAIL.

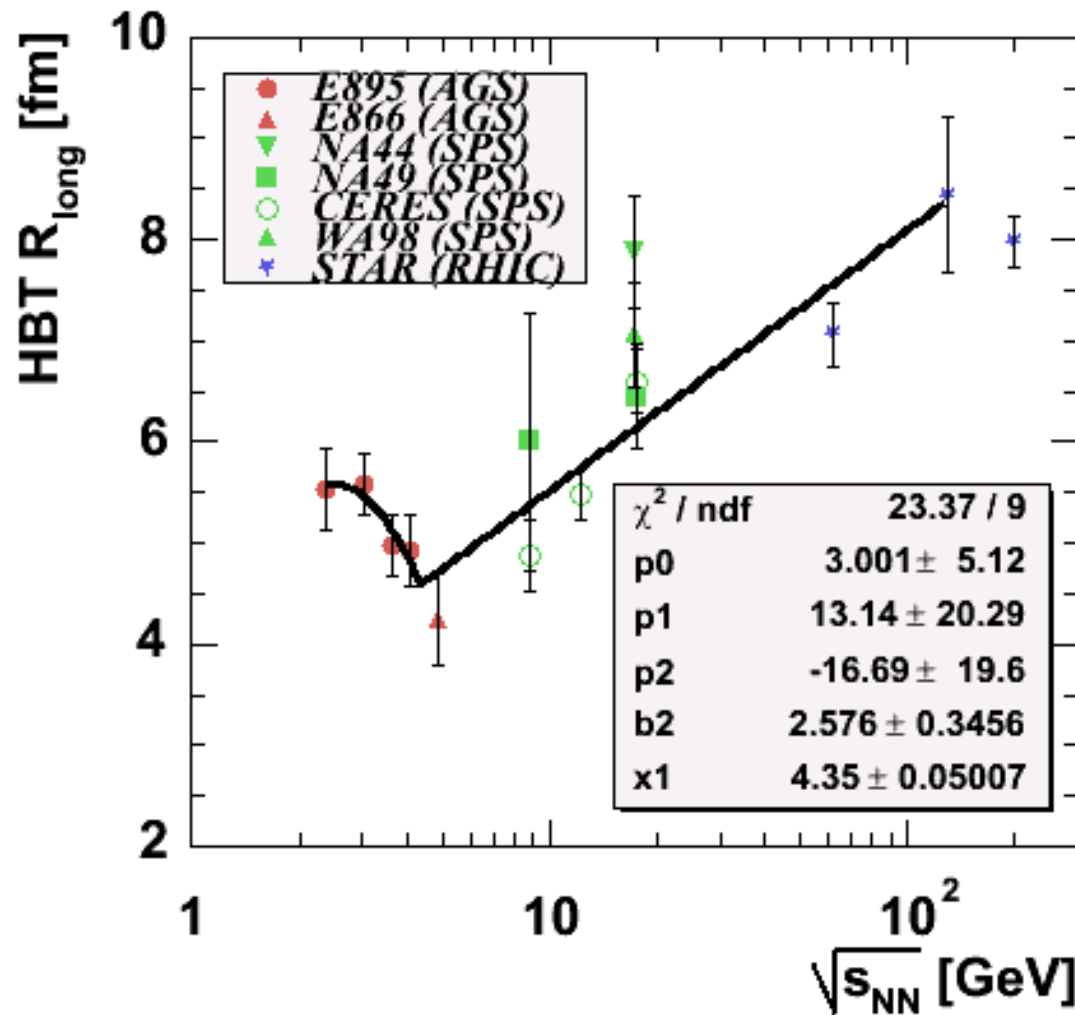
Minimum at $s^{1/2}=4.4$

3rd-order polynomial:

FAIL.

Turn-over=None

HBT R_{long}



Linear Fit:

FAIL. $\chi^2 = 37.3/13$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

FAIL.

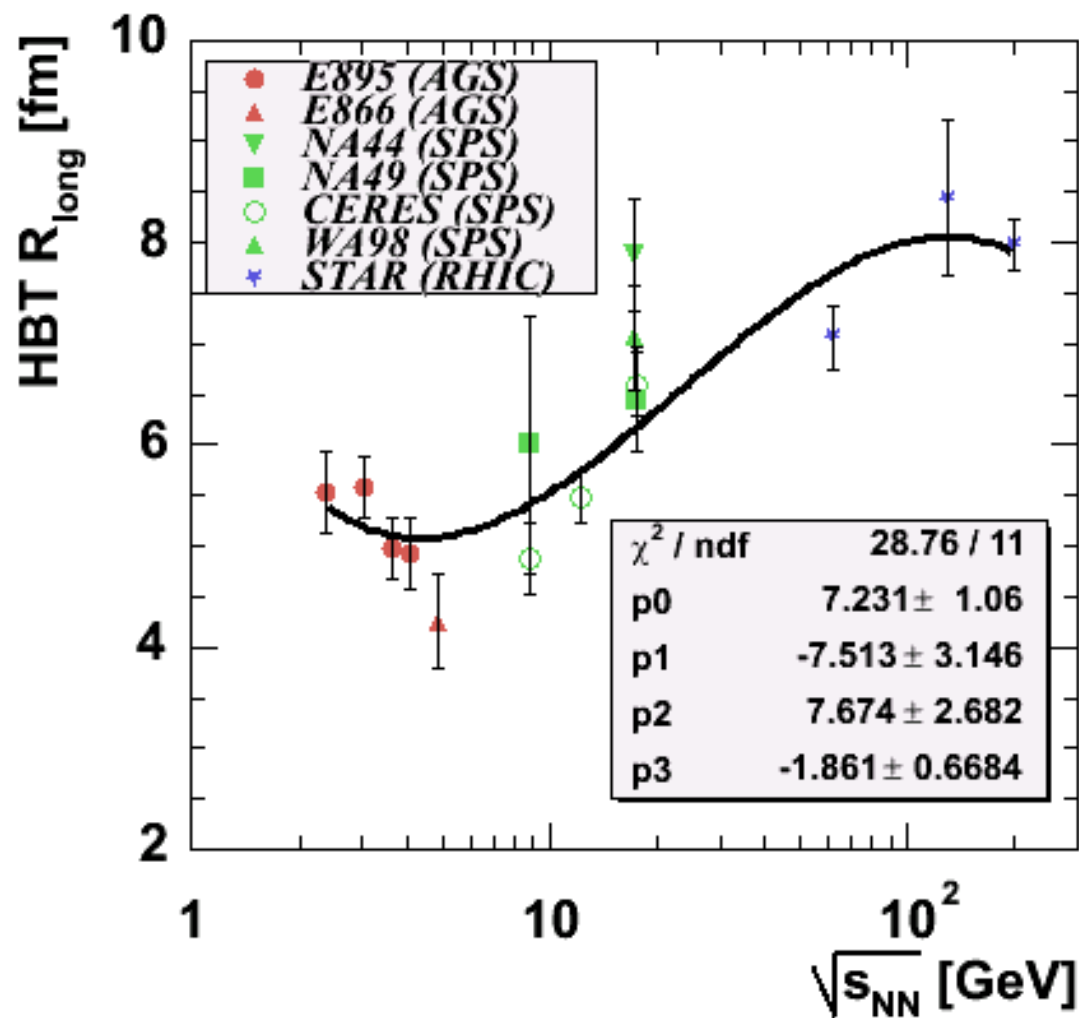
Minimum at $s^{1/2}=4.4$

3rd-order polynomial:

FAIL.

Turn-over=None

HBT R_{long}



Linear Fit:

FAIL. $\chi^2 = 37.3/13$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

FAIL.

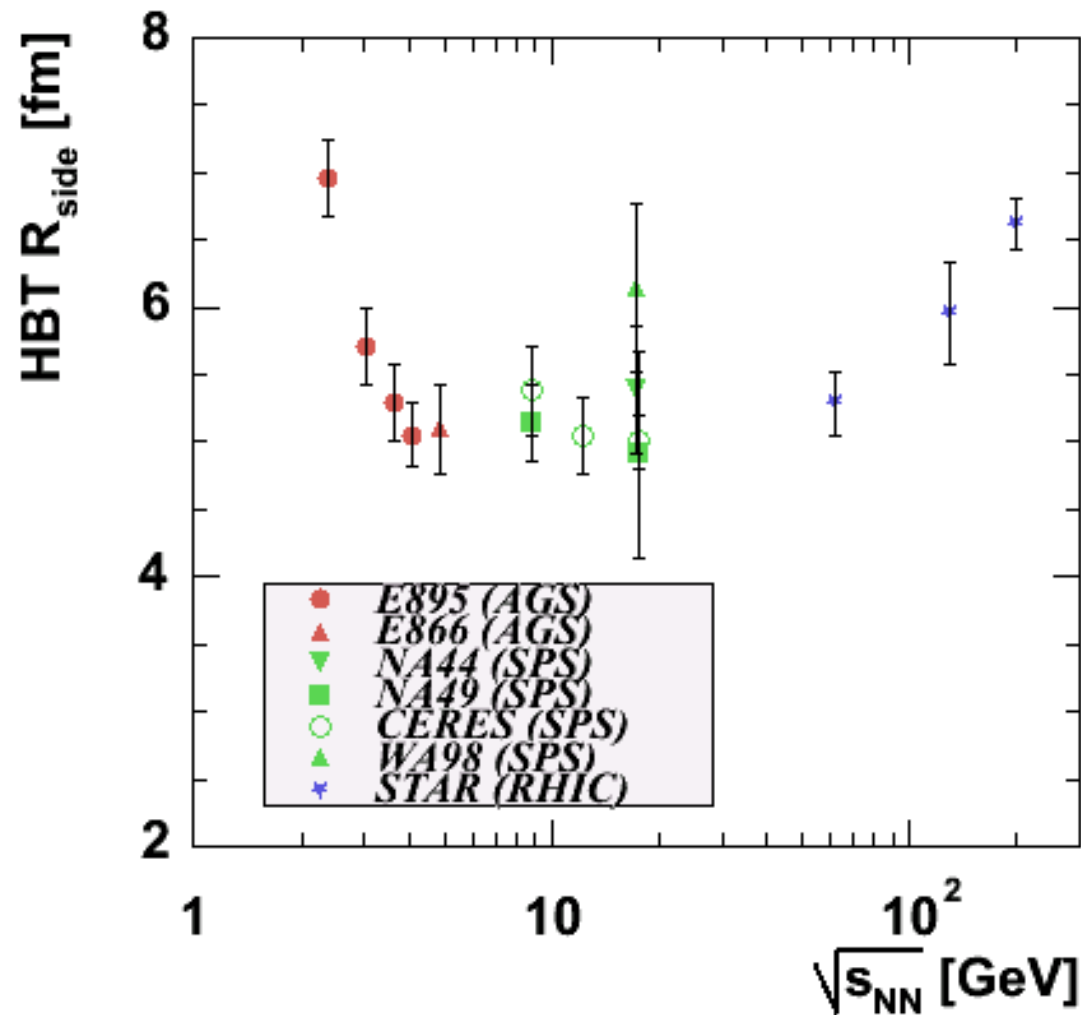
Minimum at $s^{1/2}=4.4$

3rd-order polynomial:

FAIL.

Turn-over=None

HBT R_{side}



Linear Fit:

FAIL. $\chi^2 = 69.9/14$

Line+Line Fit:

C.L.=90%. [3.0,6.0]

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

C.L.=90%. [3.0,27.0]

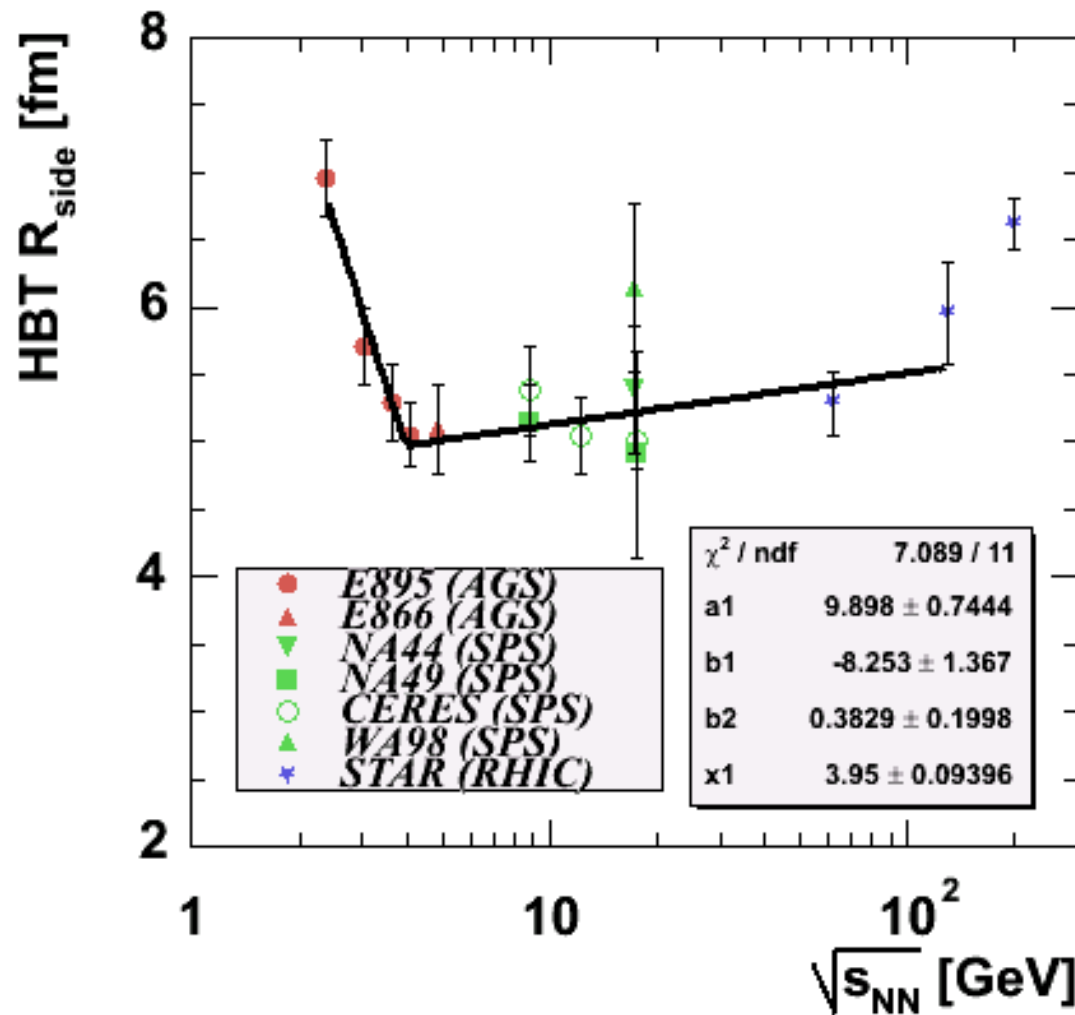
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

Pass w/ C.L. 5%.

Turn-over=4.0

HBT R_{side}



Linear Fit:

FAIL. $\chi^2 = 69.9/14$

Line+Line Fit:

C.L.=90%. [3.0,6.0]

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

C.L.=90%. [3.0,27.0]

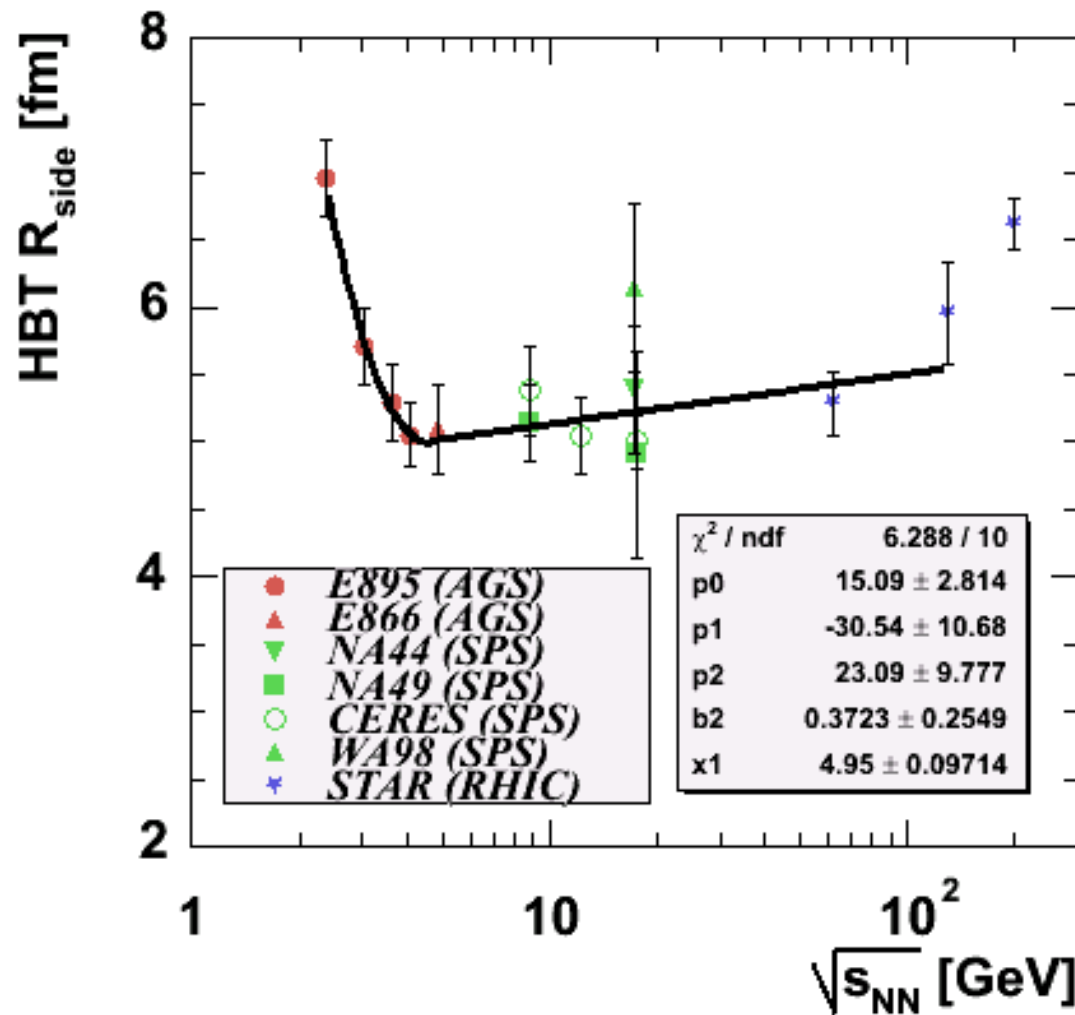
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

Pass w/ C.L. 5%.

Turn-over=4.0

HBT R_{side}



Linear Fit:

FAIL. $\chi^2 = 69.9/14$

Line+Line Fit:

C.L.=90%. [3.0,6.0]

Minimum at $s^{1/2}=4.0$

Poly+Line Fit:

C.L.=90%. [3.0,27.0]

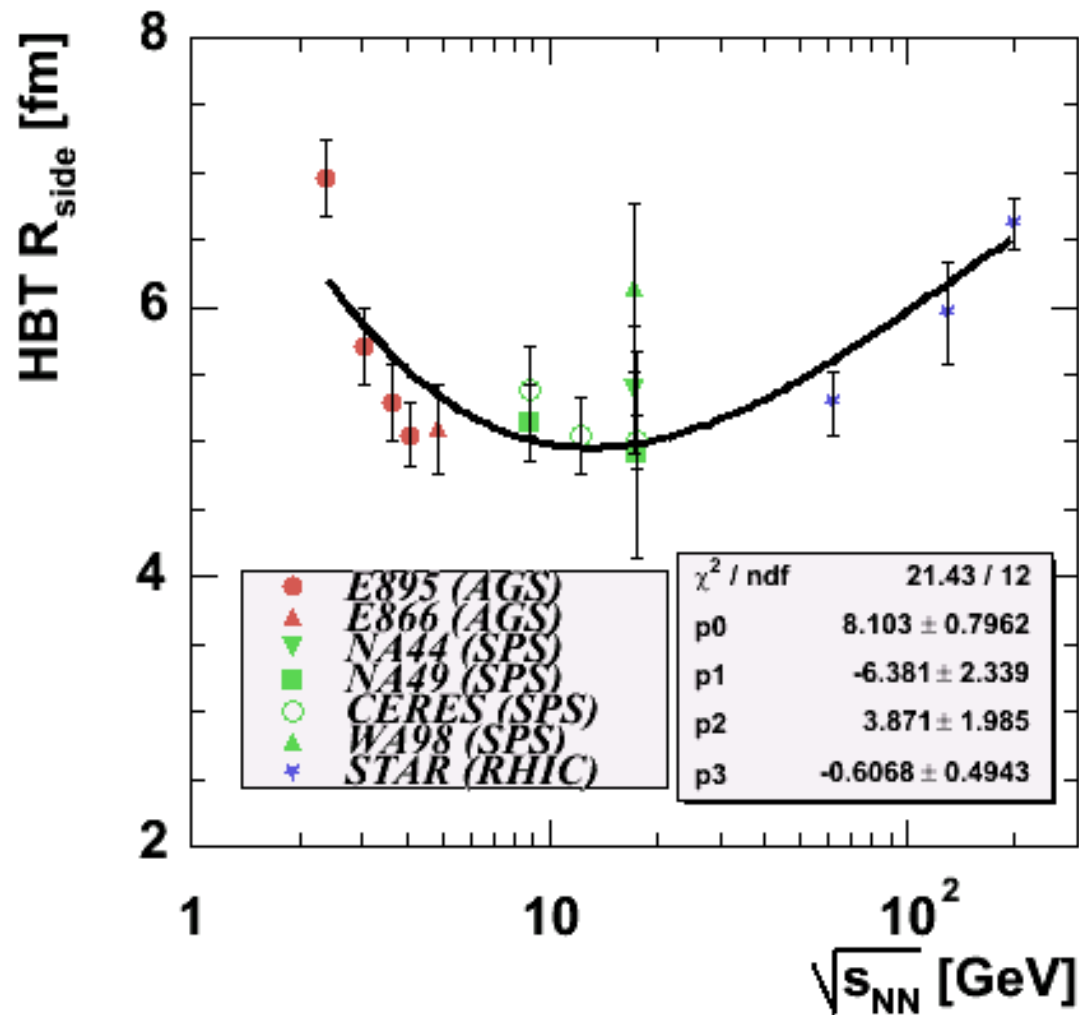
Minimum at $s^{1/2}=5.0$

3rd-order polynomial:

Pass w/ C.L. 5%.

Turn-over=4.0

HBT R_{side}



Linear Fit:

FAIL. $\chi^2 = 69.9/14$

Line+Line Fit:

C.L.=90%. [3.0,6.0]

Minimum at $s^{1/2}=4.0$

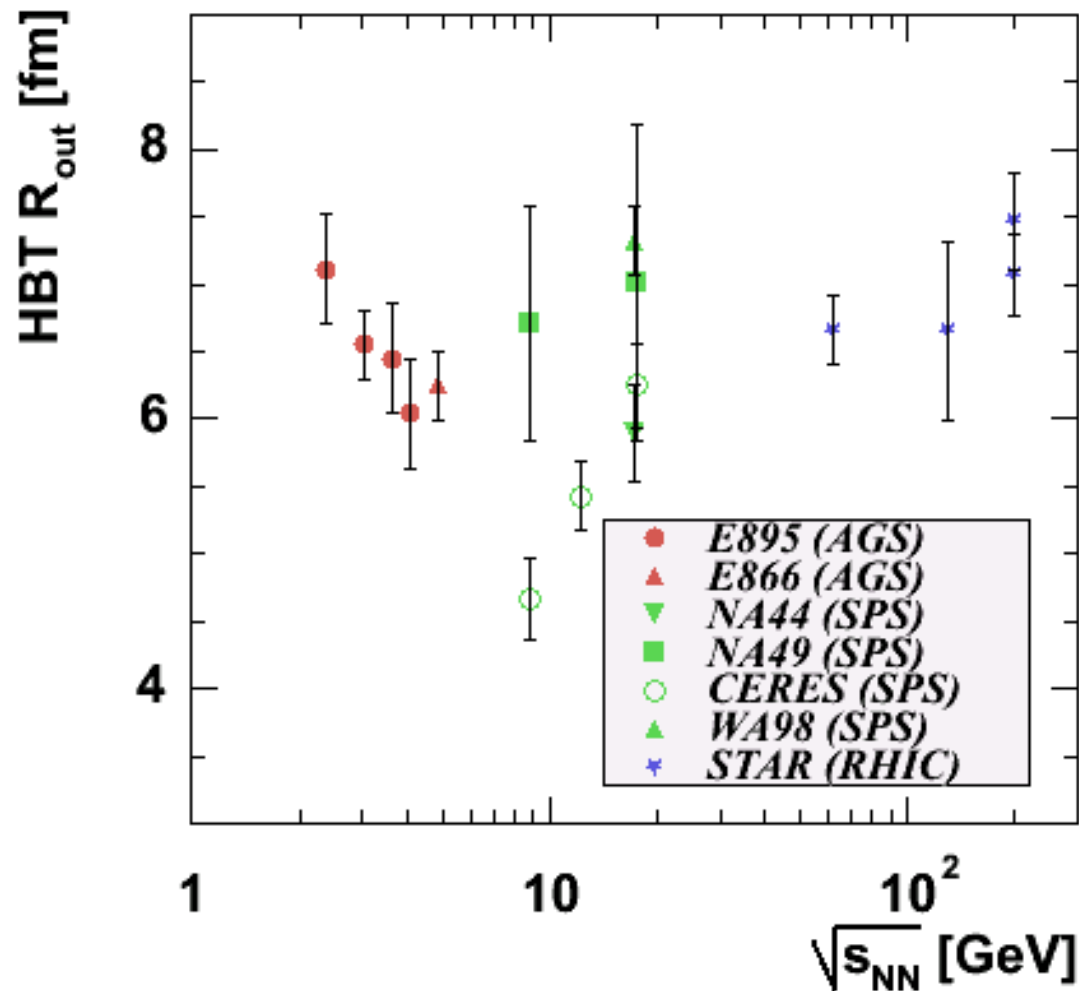
Poly+Line Fit:

C.L.=90%. [3.0,27.0]

Minimum at $s^{1/2}=5.0$

**3rd-order polynomial:
Pass w/ C.L. 5%.
Turn-over=4.0**

HBT R_{out}



Linear Fit:

FAIL. $\chi^2 = 70.9/14$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

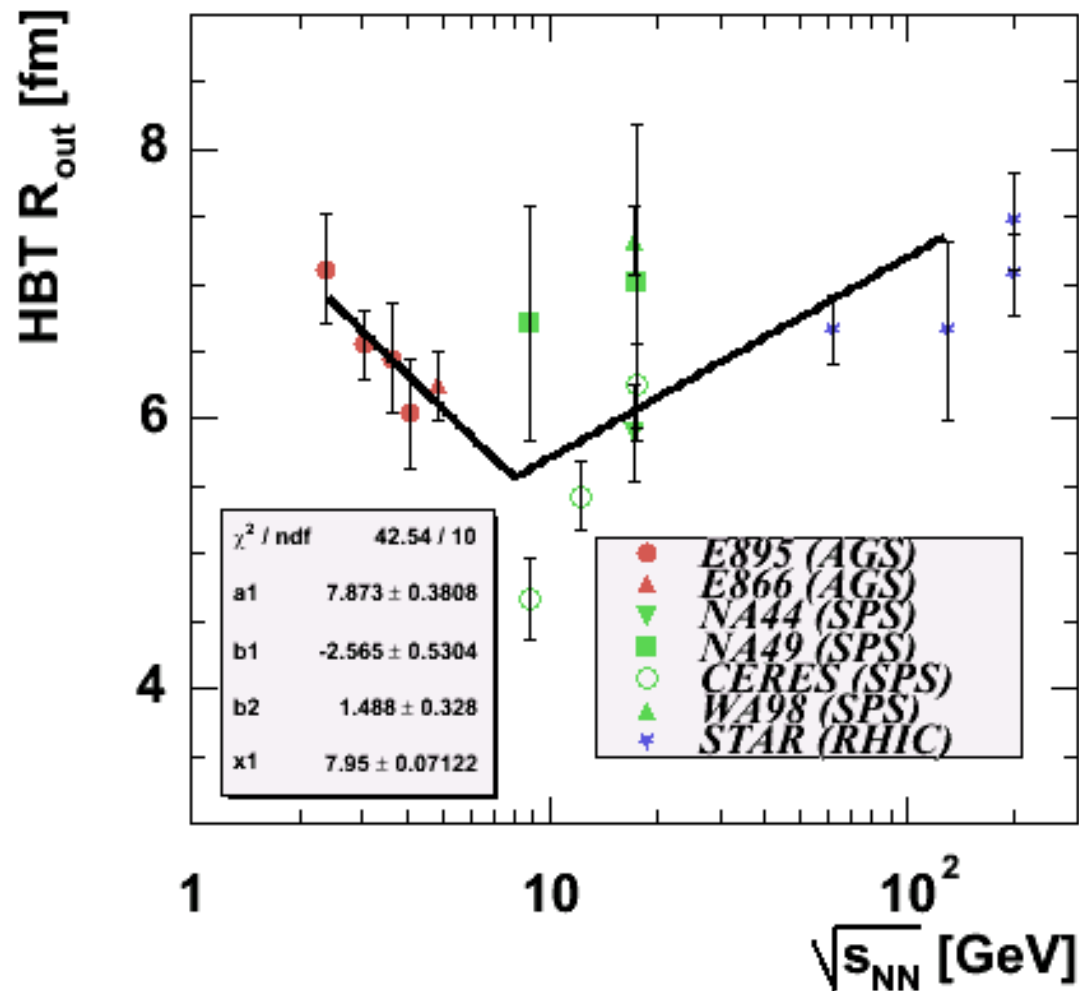
Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

FAIL.

Turn-over=4.1

HBT R_{out}



Linear Fit:

FAIL. $\chi^2 = 70.9/14$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

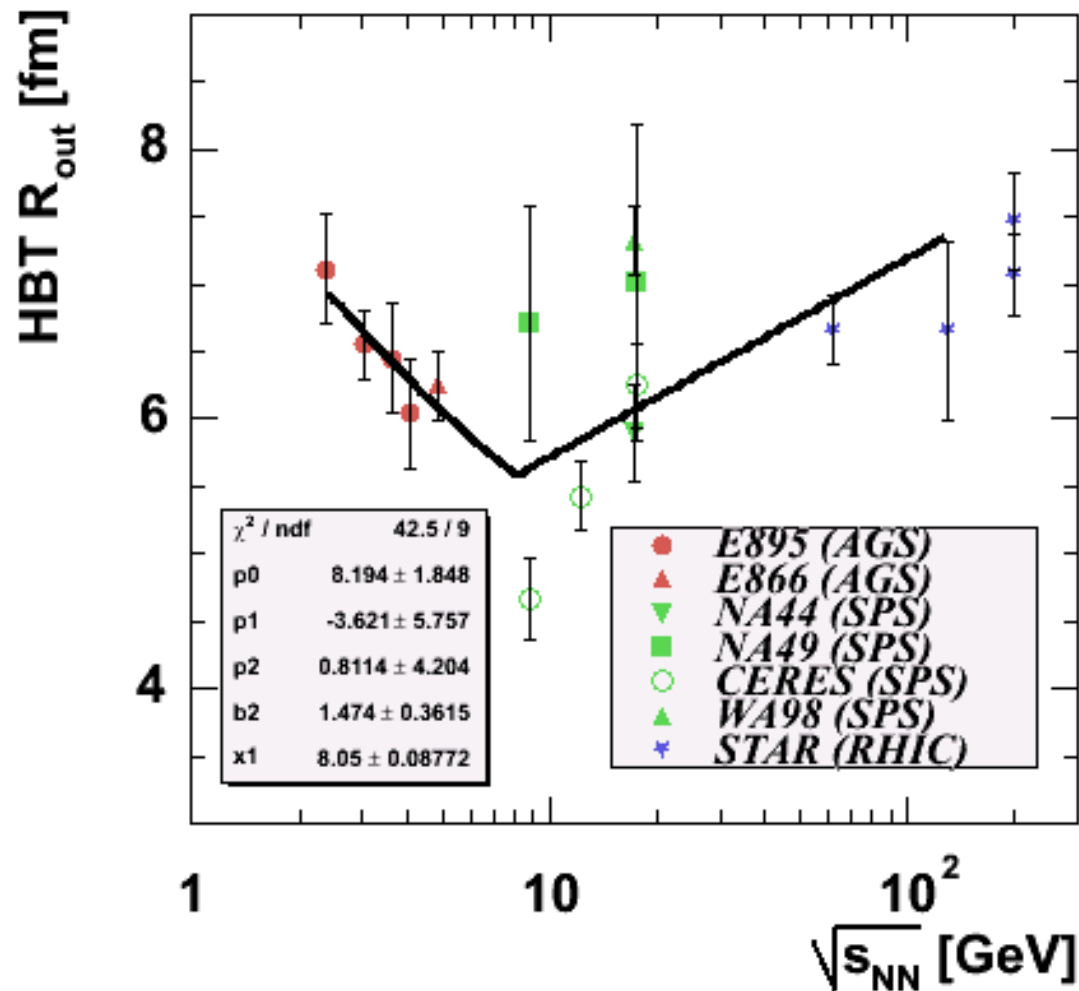
Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

FAIL.

Turn-over=4.1

HBT R_{out}



Linear Fit:

FAIL. $\chi^2 = 70.9/14$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

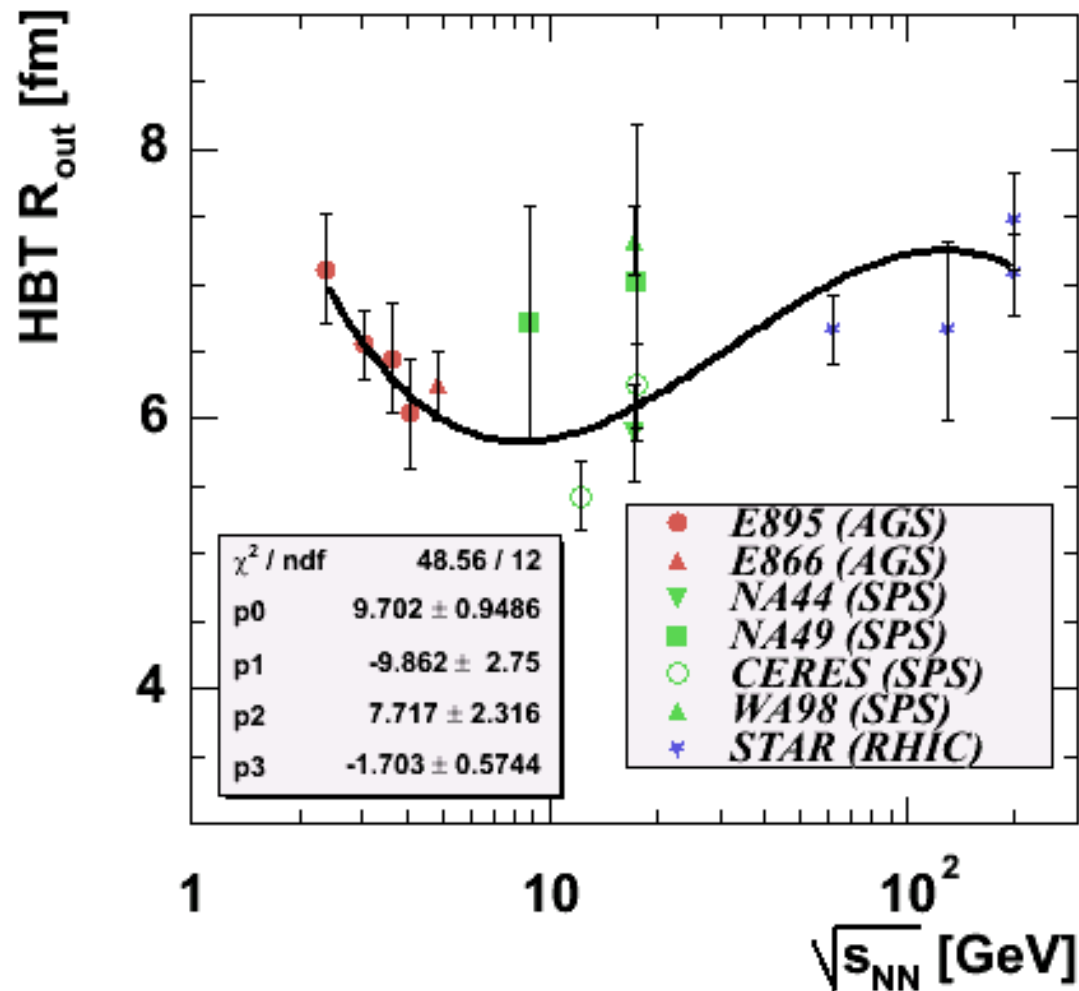
Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

FAIL.

Turn-over=4.1

HBT R_{out}



Linear Fit:

FAIL. $\chi^2 = 70.9/14$

Line+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

Poly+Line Fit:

FAIL.

Minimum at $s^{1/2}=8.0$

3rd-order polynomial:

FAIL.

Turn-over=4.1

Universal pion freeze-out

- CERES proposed a simple ansatz to investigate if critical mean free path for pions λ_f drives freeze-out
 - Mean free path can be estimated from these two relations:

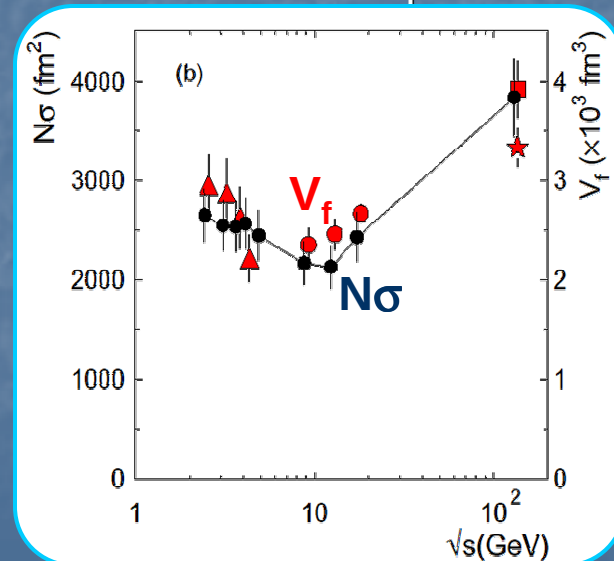
$$\lambda_f = \frac{\rho_f}{\sigma} = \frac{V_f}{N \sigma} \Rightarrow \sim 1 \text{ fm}$$

- Use HBT radii to estimate freeze-out volume V_f

$$V_f \equiv (2\pi)^{3/2} R_{\text{long}} R_{\text{side}}^2$$

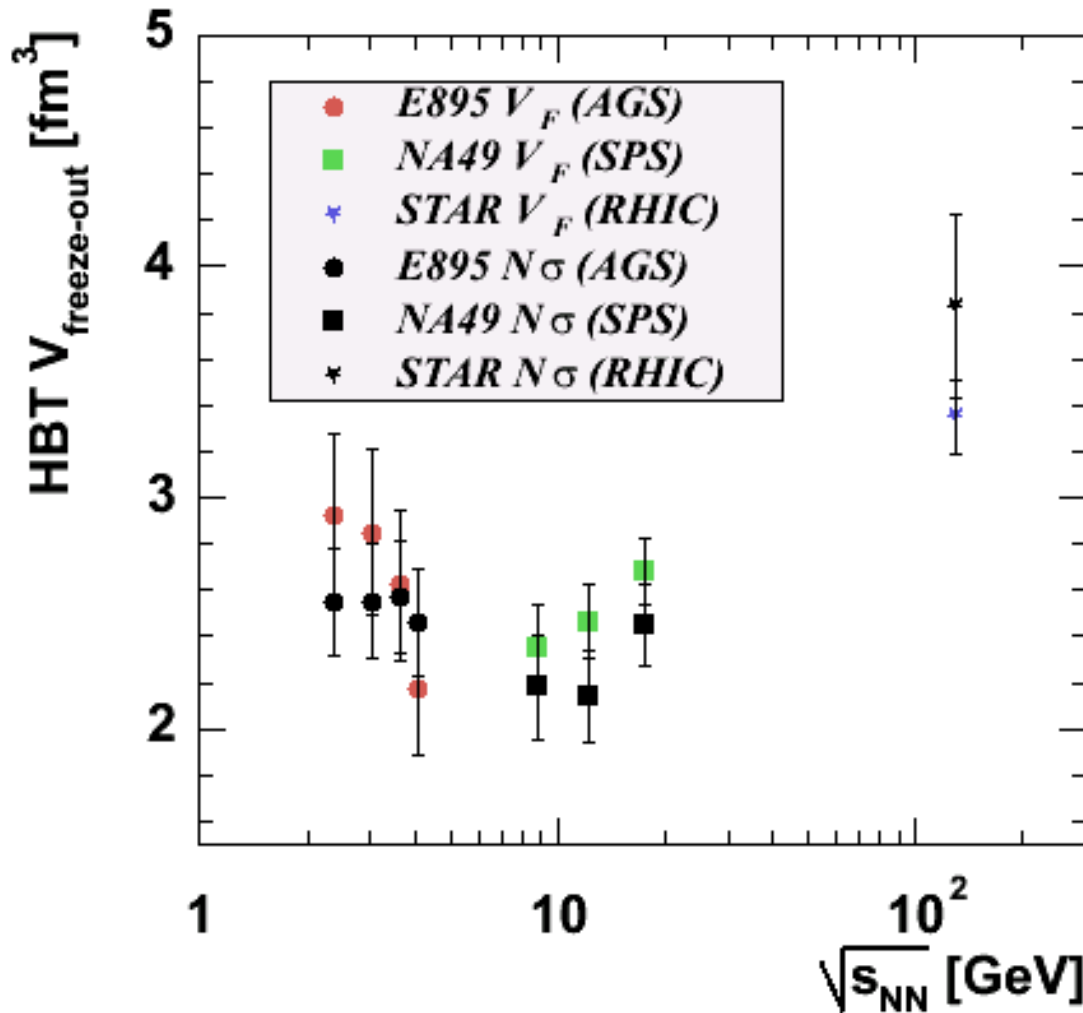
- Fold π - π and π -N cross sections with experimentally-measured dN/dy 's

$$N\sigma \equiv \sum_i N_i \sigma_{\pi i} = N_N \sigma_{\pi N} + N_\pi \sigma_{\pi\pi}$$



CERES, PRL 90 (2003) 022301

HBT $V_{\text{freeze-out}}$



Linear Fit:

PASS. $\chi^2 = 10.5/6$

Line+Line Fit:

C.L.=95%. [full range]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=97%. [full range]

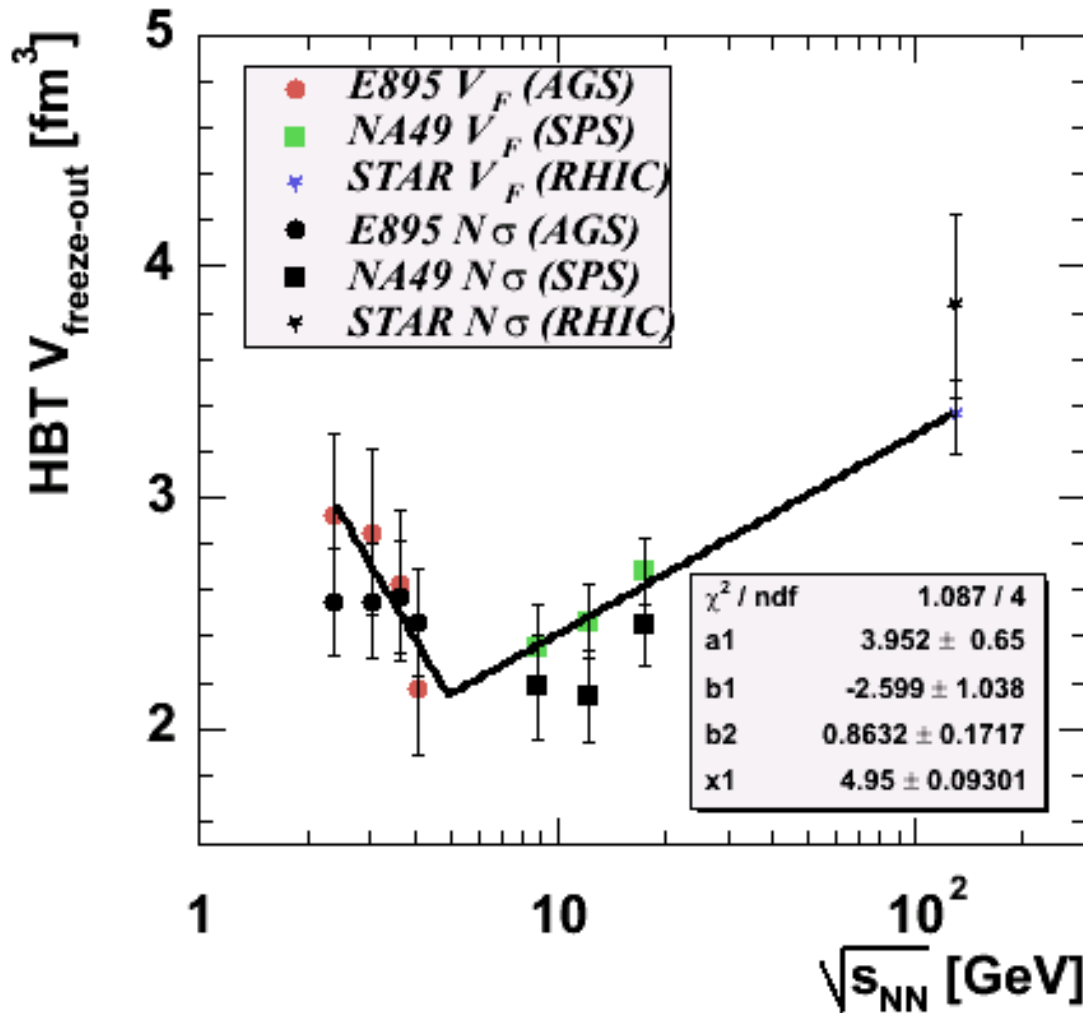
Minimum at $s^{1/2}=4.2$

3rd-order polynomial:

Pass w/ C.L.=90%.

Turn-over=4.4

HBT $V_{\text{freeze-out}}$



Linear Fit:

PASS. $\chi^2 = 10.5/6$

Line+Line Fit:

C.L.=95%. [full range]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=97%. [full range]

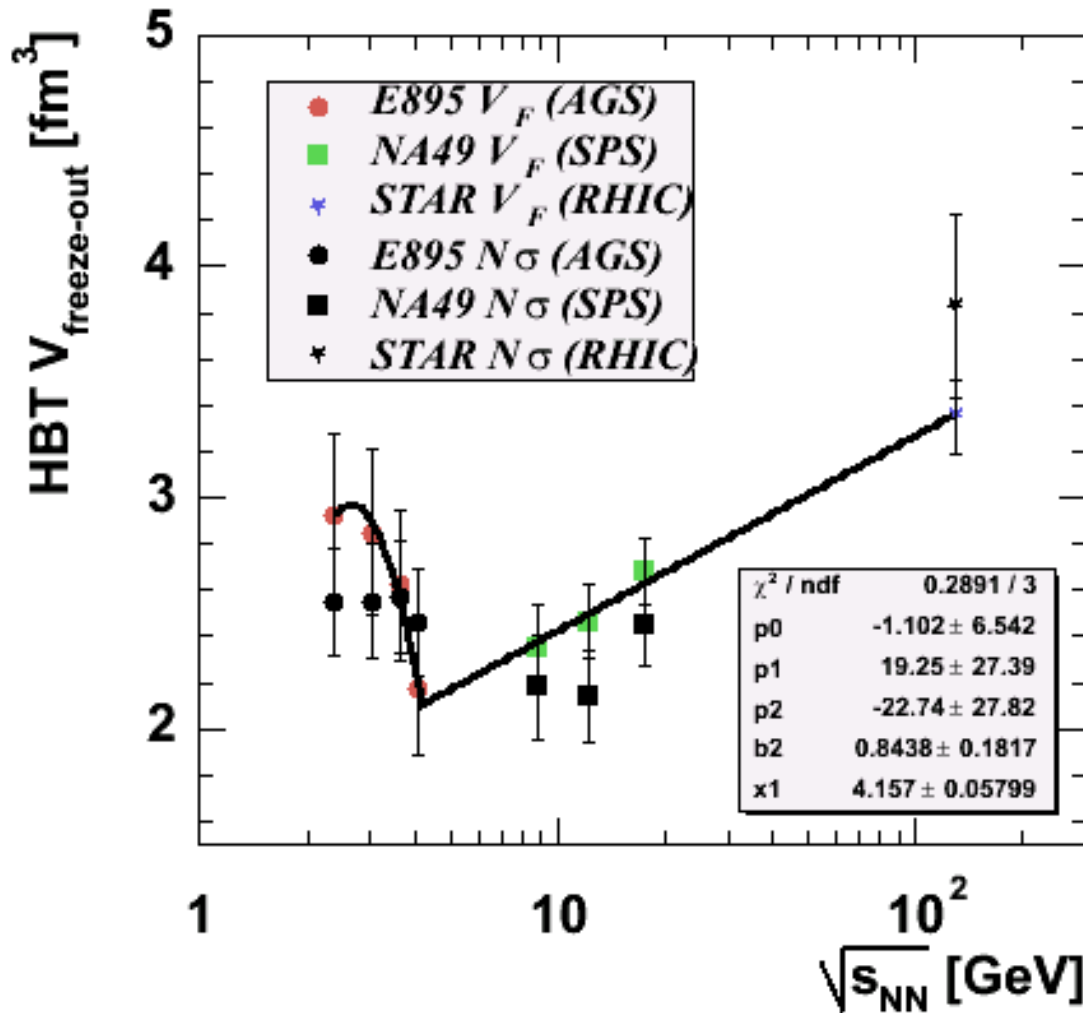
Minimum at $s^{1/2}=4.2$

3rd-order polynomial:

Pass w/ C.L.=90%.

Turn-over=4.4

HBT $V_{\text{freeze-out}}$



Linear Fit:

PASS. $\chi^2 = 10.5/6$

Line+Line Fit:

C.L.=95%. [full range]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=97%. [full range]

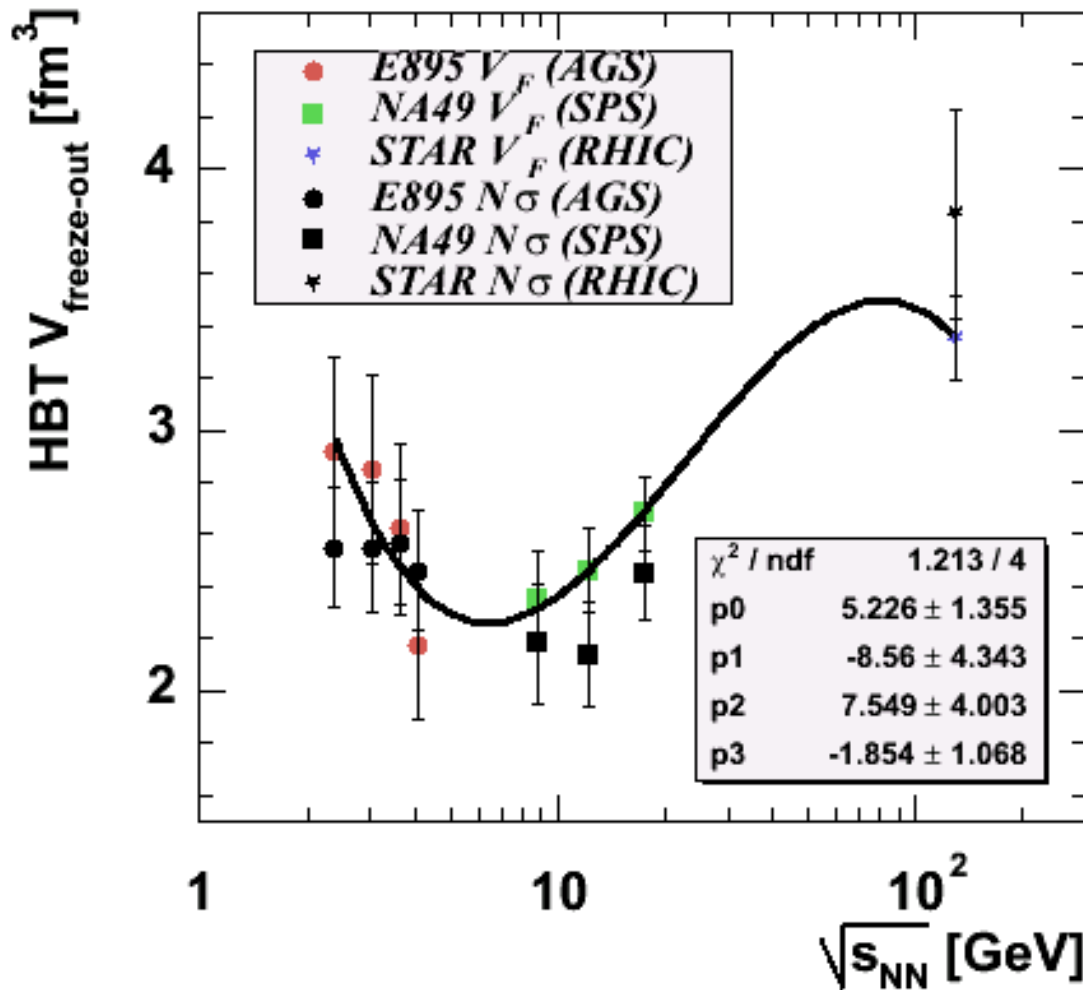
Minimum at $s^{1/2}=4.2$

3rd-order polynomial:

Pass w/ C.L.=90%.

Turn-over=4.4

HBT $V_{\text{freeze-out}}$



Linear Fit:

PASS. $\chi^2 = 10.5/6$

Line+Line Fit:

C.L.=95%. [full range]

Minimum at $s^{1/2}=5.0$

Poly+Line Fit:

C.L.=97%. [full range]

Minimum at $s^{1/2}=4.2$

**3rd-order polynomial:
Pass w/ C.L.=90%.
Turn-over=4.4**

R_{AA} – not enough points

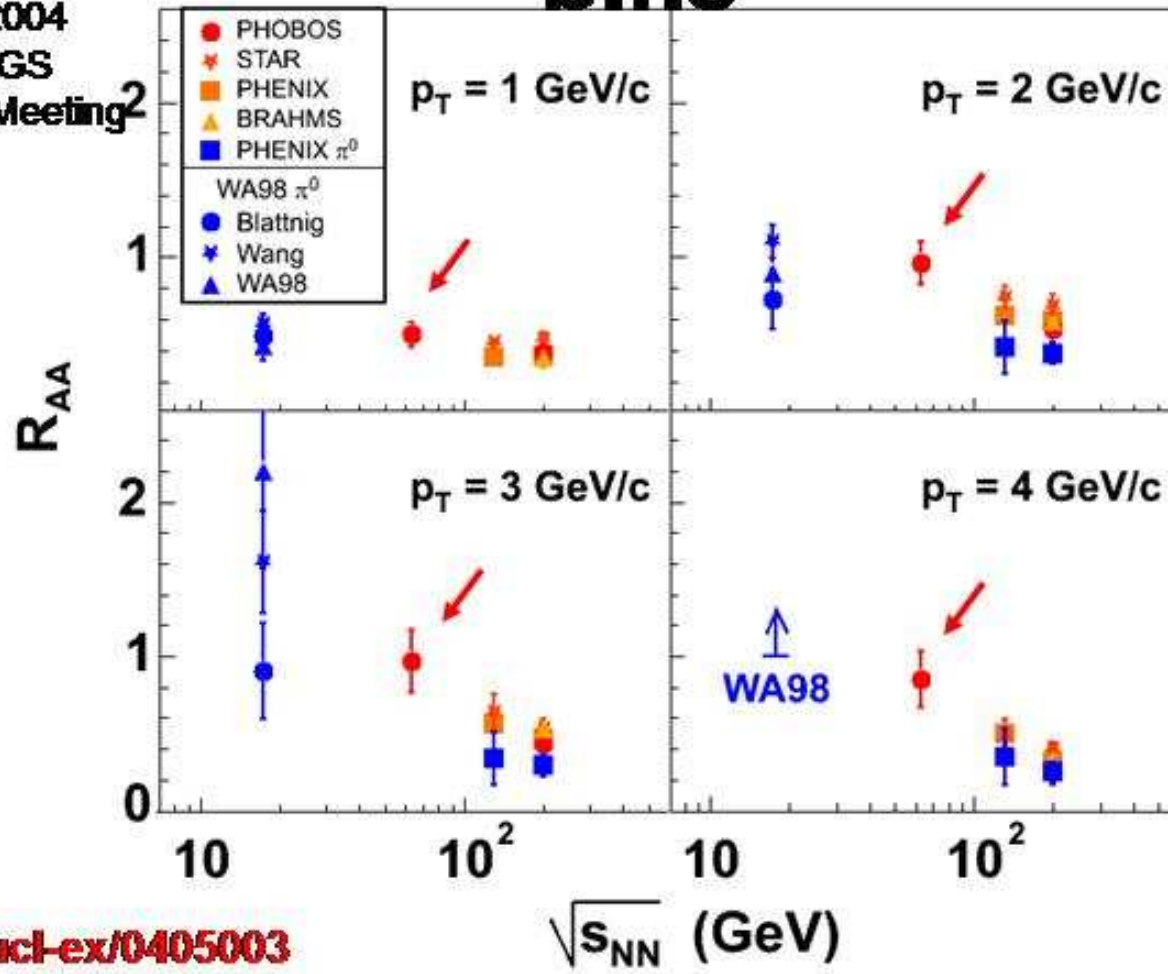
Energy dependence of R_{AA} in p_T bins

From G. Veres

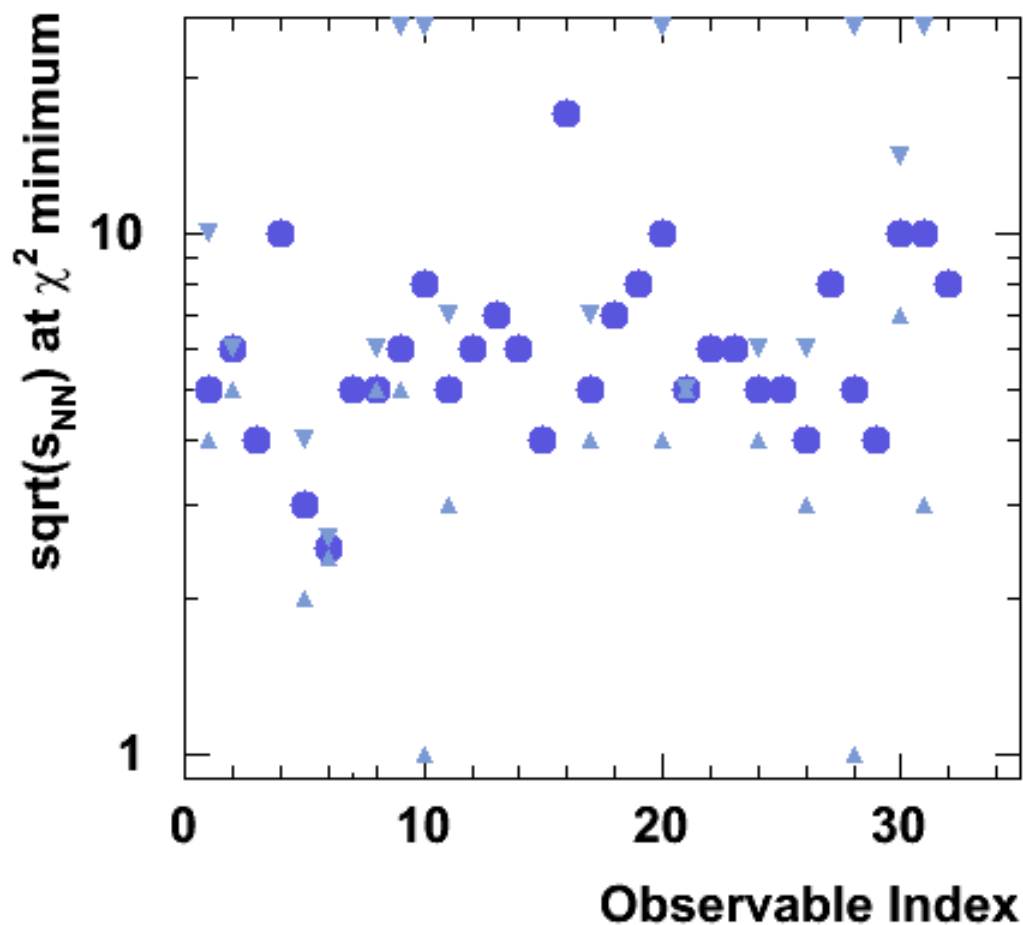
talk at 2004

RHIC/AGS

User's Meeting



Line+line Fit Summary: All Observables



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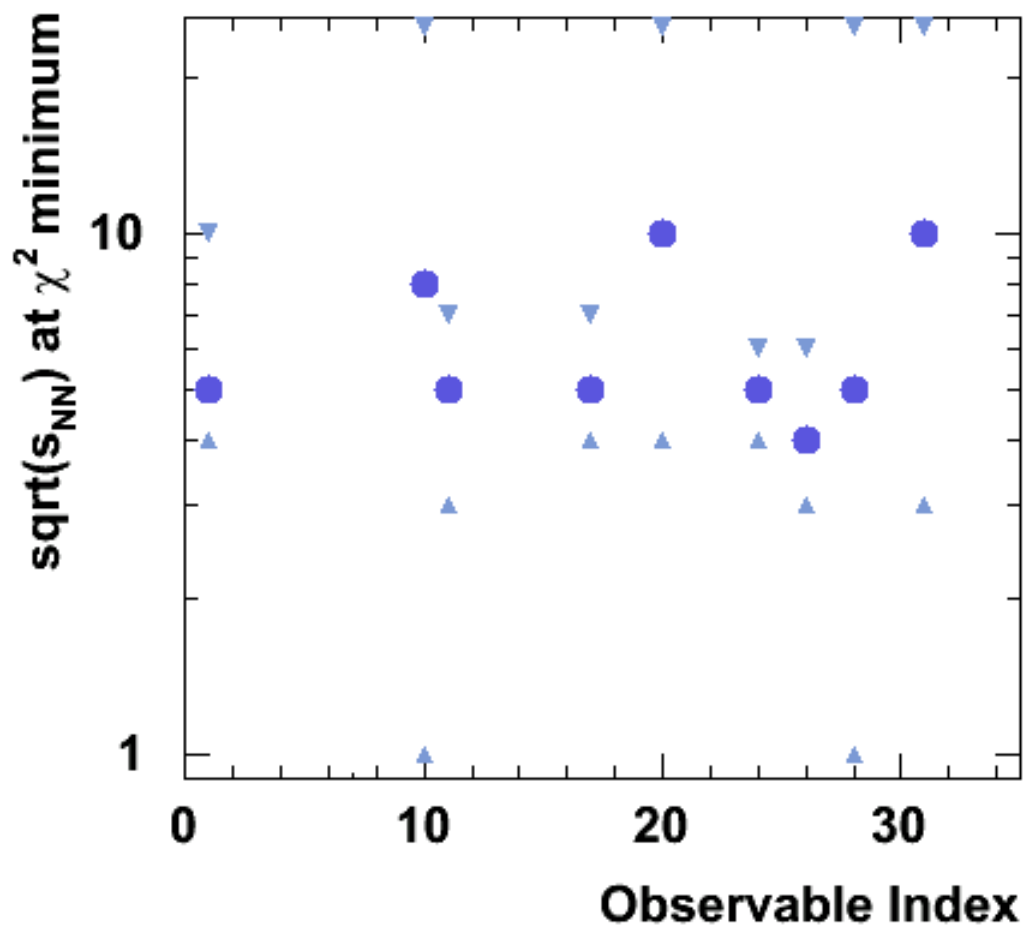
- 1 = pion T_{boltz}
- 2 = K⁻ T_{boltz}
- 3 = K⁺ T_{boltz}
- 4 = p T_{boltz}
- 5 = $T_{\text{freeze-out}}$
- 6 = $\langle b_T \rangle$
- 7 = pion $\langle m_T \rangle - m_0$
- 8 = K⁻ $\langle m_T \rangle - m_0$
- 9 = K⁺ $\langle m_T \rangle - m_0$
- 10 = dN_{ch}/dy
- 11 = E_T/N_{ch}
- 12 = $\pi^- dN/dy$
- 13 = $\pi^+ dN/dy$
- 14 = K⁻ dN/dy
- 15 = K⁺ dN/dy
- 16 = p dN/dy
- 17 = π^-/π^+
- 18 = K⁻/K⁺
- 19 = pbar/p
- 20 = K⁻/ π^-
- 21 = K⁺/ π^+
- 22 = p/ π^+
- 23 = lambda/pi
- 24 = HBT lambda
- 25 = HBT R_{long}
- 26 = HBT R_{side}
- 27 = HBT R_{out}
- 28 = HBT V_f
- 29 = v_2
- 30 = proton dy
- 31 = proton dy / y_{beam}
- 32 = d B_2

Mean = 6.42

Sigma = 2.76

N = 32

Line+line Fit Summary: Passing 50% C.L. Test



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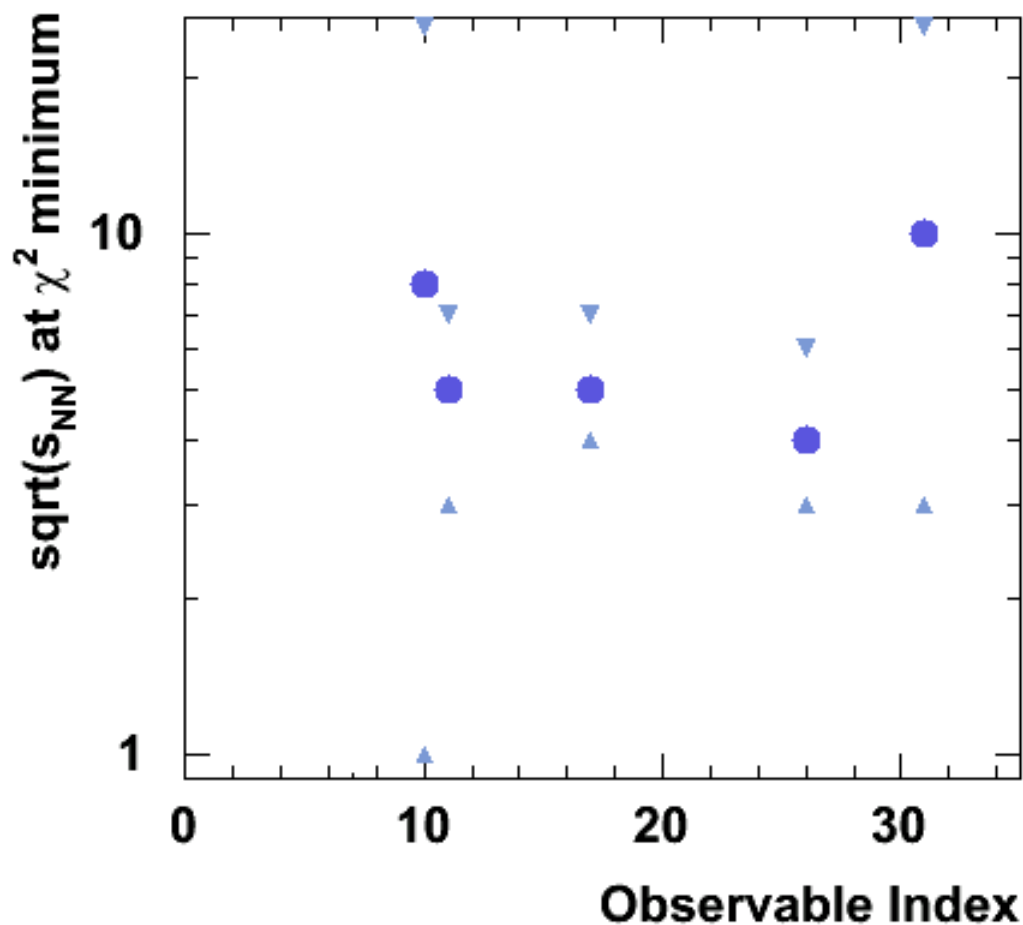
- 1 = pion T_{boltz}
- 2 = K⁻ T_{boltz}
- 3 = K⁺ T_{boltz}
- 4 = p T_{boltz}
- 5 = $T_{\text{freeze-out}}$
- 6 = $\langle b_T \rangle$
- 7 = pion $\langle m_T \rangle - m_0$
- 8 = K⁻ $\langle m_T \rangle - m_0$
- 9 = K⁺ $\langle m_T \rangle - m_0$
- 10 = dN_{ch}/dy
- 11 = E_T/N_{ch}
- 12 = $\pi^- dN/dy$
- 13 = $\pi^+ dN/dy$
- 14 = K⁻ dN/dy
- 15 = K⁺ dN/dy
- 16 = p dN/dy
- 17 = π^-/π^+
- 18 = K⁻/K⁺
- 19 = $\bar{p}/p$
- 20 = K⁻/ π^-
- 21 = K⁺/ π^+
- 22 = p/ π^+
- 23 = λ/π
- 24 = HBT λ
- 25 = HBT R_{long}
- 26 = HBT R_{side}
- 27 = HBT R_{out}
- 28 = HBT V_f
- 29 = v_2
- 30 = proton dy
- 31 = proton dy / y_{beam}
- 32 = $d B_2$

Mean = 6.33

Sigma = 2.21

N = 9

Line+line Fit Summary: Passing 90% C.L. Test



Index

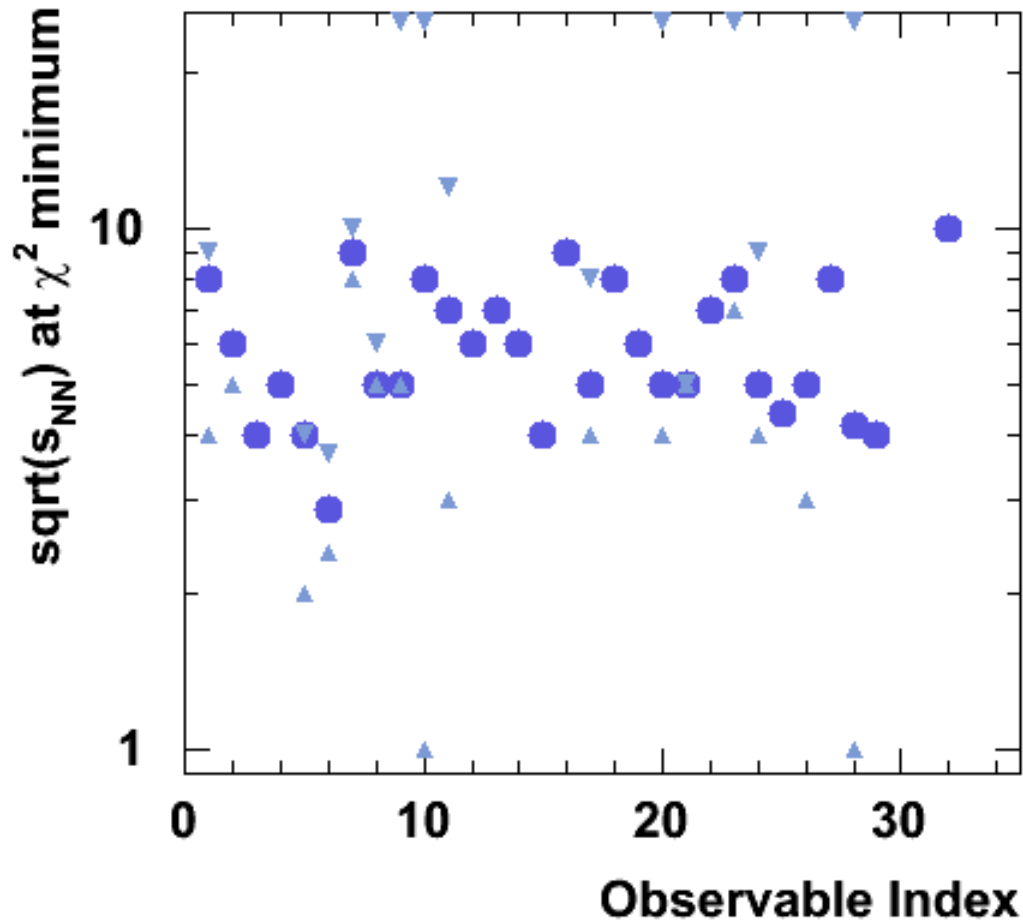
- 1 = pion T_{boltz}
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- 4 = p T_{boltz}
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- 15 = K⁺ dN/dy
- 16 = p dN/dy
- 17 = π^-/π^+
- 18 = K⁻/K⁺
- 19 = $\bar{p}/p$
- 20 = K⁻/ π^-
- 21 = K⁺/ π^+
- 22 = p/ π^+
- 23 = λ/π
- 24 = HBT λ
- 25 = HBT R_{long}
- 26 = HBT R_{side}
- 27 = HBT R_{out}
- 28 = HBT V_f
- 29 = v_2
- 30 = proton dy
- 31 = proton dy / y_{beam}
- 32 = $d B_2$

Mean = 6.40

Sigma = 2.24

N = 5

Line+poly Fit Summary: All Observables



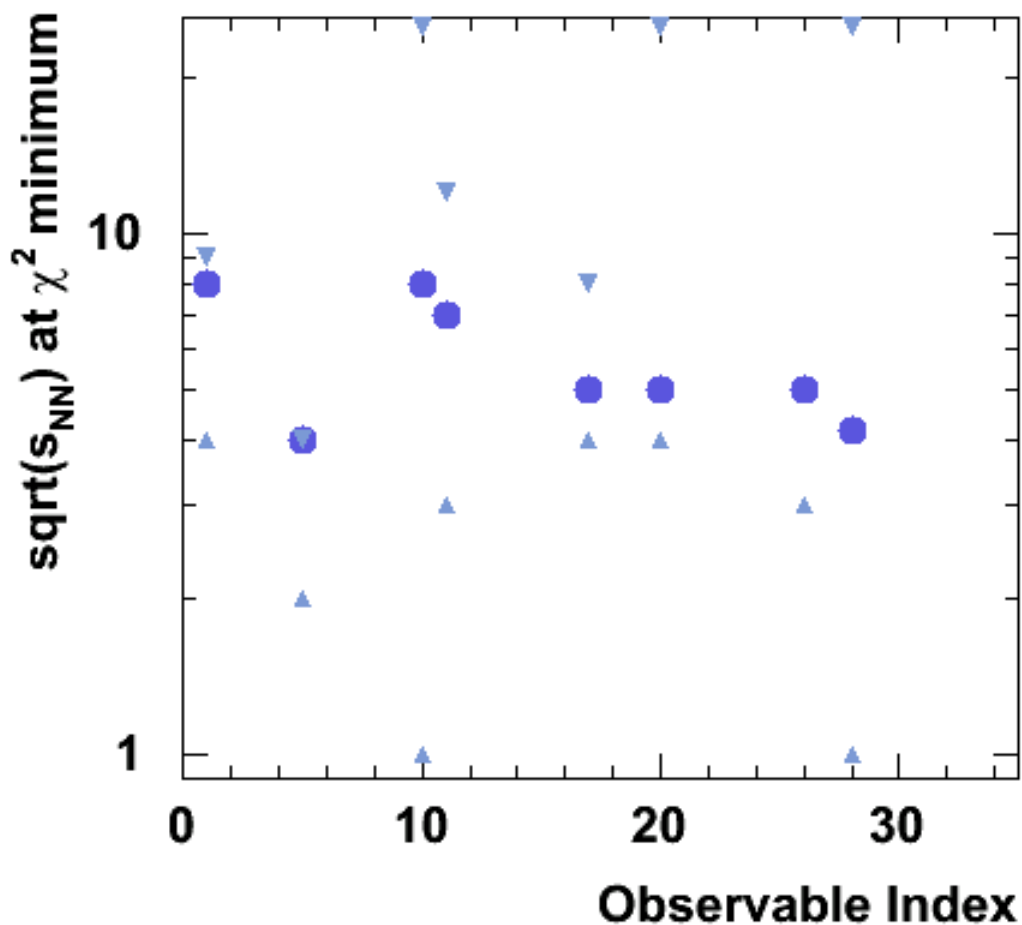
- Index
- 1 = pion T_{boltz}
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 - 3 = K⁺ T_{boltz}
 - 4 = p T_{boltz}
 - 5 = $T_{\text{freeze-out}}$
 - 6 = $\langle b_T \rangle$
 - 7 = pion $\langle m_T \rangle - m_0$
 - 8 = K⁻ $\langle m_T \rangle - m_0$
 - 9 = K⁺ $\langle m_T \rangle - m_0$
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 - 14 = K⁻ dN/dy
 - 15 = K⁺ dN/dy
 - 16 = p dN/dy
 - 17 = π^-/π^+
 - 18 = K⁻/K⁺
 - 19 = pbar/p
 - 20 = K⁻/ π^-
 - 21 = K⁺/ π^+
 - 22 = p/ π^+
 - 23 = lambda/ π
 - 24 = HBT lambda
 - 25 = HBT R_{long}
 - 26 = HBT R_{side}
 - 27 = HBT R_{out}
 - 28 = HBT V_f
 - 29 = v_2
 - 30 = proton dy
 - 31 = proton dy / y_{beam}
 - 32 = d B_2

Mean = 6.02

Sigma = 1.79

N = 30

Line+poly Fit Summary: Passing 50% C.L. Test



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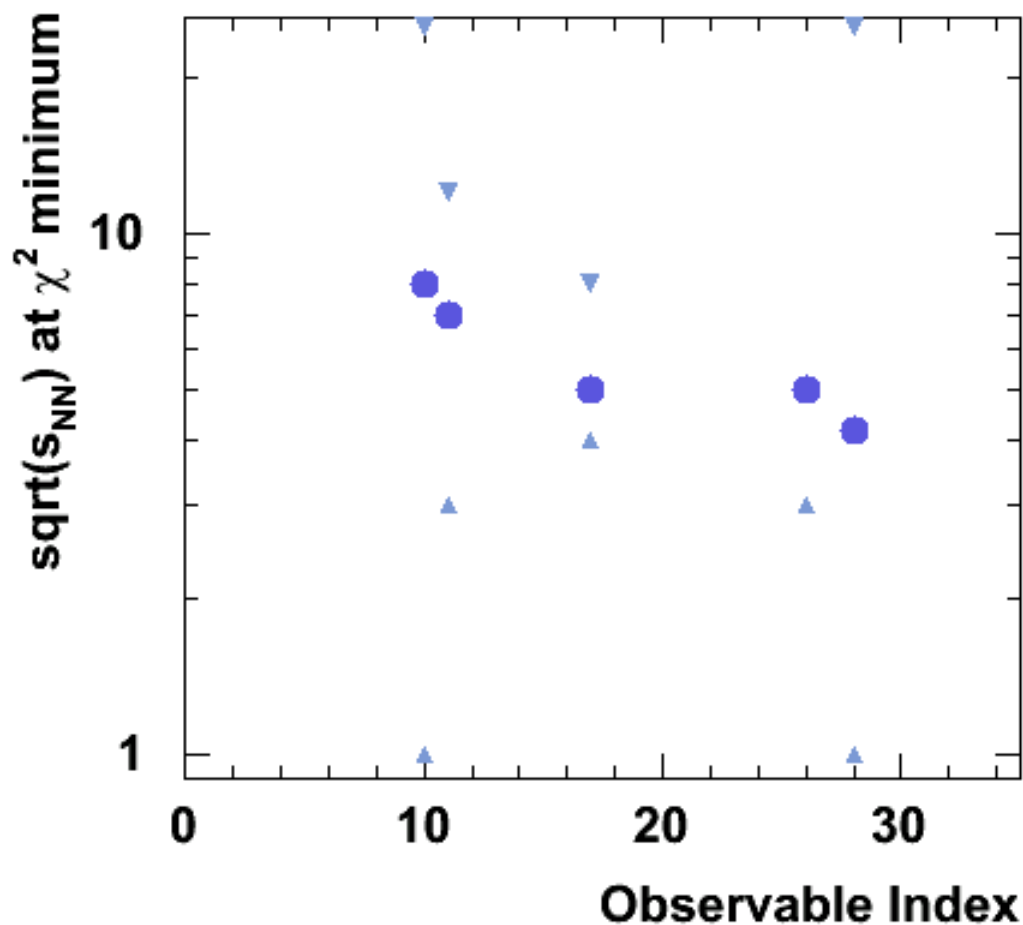
- 1 = pion T_{boltz}
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- 3 = K⁺ T_{boltz}
- 4 = p T_{boltz}
- 5 = $T_{\text{freeze-out}}$
- 6 = $\langle b_T \rangle$
- 7 = pion $\langle m_T \rangle - m_0$
- 8 = K⁻ $\langle m_T \rangle - m_0$
- 9 = K⁺ $\langle m_T \rangle - m_0$
- 10 = dN_{ch}/dy
- 11 = E_T/N_{ch}
- 12 = $\pi^- dN/dy$
- 13 = $\pi^+ dN/dy$
- 14 = K⁻ dN/dy
- 15 = K⁺ dN/dy
- 16 = p dN/dy
- 17 = π^-/π^+
- 18 = K⁻/K⁺
- 19 = $\bar{p}/p$
- 20 = K⁻/ π^-
- 21 = K⁺/ π^+
- 22 = p/ π^+
- 23 = λ/π
- 24 = HBT λ
- 25 = HBT R_{long}
- 26 = HBT R_{side}
- 27 = HBT R_{out}
- 28 = HBT V_f
- 29 = v_2
- 30 = proton dy
- 31 = proton dy / y_{beam}
- 32 = $d B_2$

Mean = 5.77

Sigma = 1.53

N = 8

Line+poly Fit Summary: Passing 90% C.L. Test



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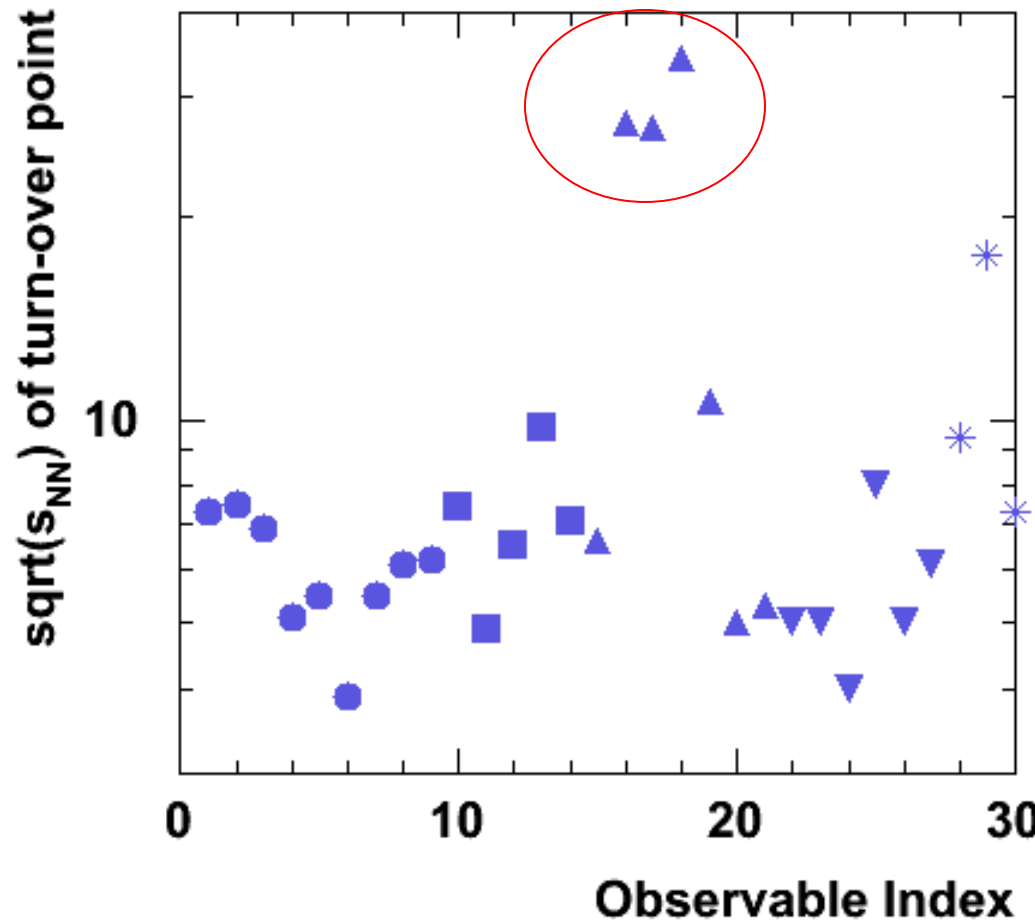
- 1 = pion T_{boltz}
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- 3 = K⁺ T_{boltz}
- 4 = p T_{boltz}
- 5 = $T_{\text{freeze-out}}$
- 6 = $\langle b_T \rangle$
- 7 = pion $\langle m_T \rangle - m_0$
- 8 = K⁻ $\langle m_T \rangle - m_0$
- 9 = K⁺ $\langle m_T \rangle - m_0$
- 10 = dN_{ch}/dy
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- 15 = K⁺ dN/dy
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- 17 = π^-/π^+
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- 19 = $\bar{p}/p$
- 20 = K⁻/ π^-
- 21 = K⁺/ π^+
- 22 = p/ π^+
- 23 = λ/π
- 24 = HBT λ
- 25 = HBT R_{long}
- 26 = HBT R_{side}
- 27 = HBT R_{out}
- 28 = HBT V_f
- 29 = v_2
- 30 = proton dy
- 31 = proton dy / y_{beam}
- 32 = $d B_2$

Mean = 5.84

Sigma = 1.42

N = 5

3rd-order polynomial turn-over point summary



Index
1 = pion T_{boltz}
2 = K ⁻ T_{boltz}
3 = K ⁺ T_{boltz}
4 = p T_{boltz}
5 = $T_{\text{freeze-out}}$
6 = $\langle b_T \rangle$
7 = pion $\langle m_T \rangle - m_0$
8 = K ⁻ $\langle m_T \rangle - m_0$
9 = K ⁺ $\langle m_T \rangle - m_0$
10 = dN_{ch}/dy
11 = E_T/N_{ch}
12 = $\pi^- dN/dy$
13 = $\pi^+ dN/dy$
14 = K ⁻ dN/dy
15 = K ⁺ dN/dy
16 = p dN/dy
17 = π^-/π^+
18 = K ^{-}/K^+}
19 = $\bar{p}/p$
20 = K ^{-}/\pi^-}
21 = K ^{+)/\pi^+}
22 = p/ π^+
23 = λ/π
24 = HBT λ
25 = HBT R_{long}
26 = HBT R_{side}
27 = HBT R_{out}
28 = HBT V_f
29 = v_2
30 = proton dy
31 = proton dy / y_{beam}
32 = $d B_2$

Mean = 8.24

Sigma = 5.77

N = 30

Without
outliers:

Mean = 6.83

Sigma = 2.65

N = 27

Conclusion

- The results of the statistical analyses all come up with the same basic conclusion:
 - There is statistically significant critical behavior occurring in many observables at $\sqrt{s_{NN}} \sim 5.8\text{-}6.8$ GeV!
 - This corresponds to the energy range not covered - between the highest AGS and the lowest SPS energies!
 - I submit this as proof that RHIC is exploring a new state of nuclear matter!