Light Nuclei Production in Heavy-ion Collisions in STAR at RHIC BES Energies

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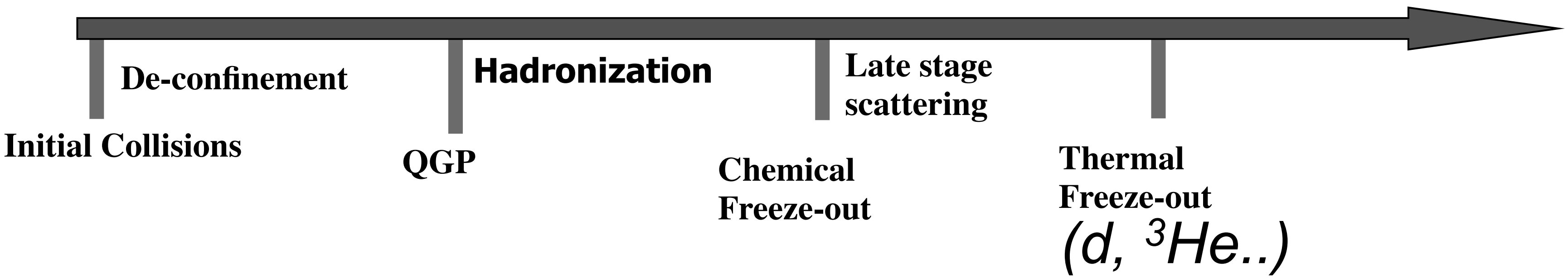
Outline

- Introduction and Motivation
- Experimental setup – STAR
- Particle identification method
- Transverse momentum spectra
- Results: energy and centrality dependence of dN/dy, $<p_T>$, B_3
- Summary

Motivation

- Light nuclei - expected to form at a later stage of the evolution
  - a probe for understanding the final freeze-out



- Mechanism of formation: direct production or coalescence of nucleons
- The nuclear invariant yield is related to invariant yield of baryon as

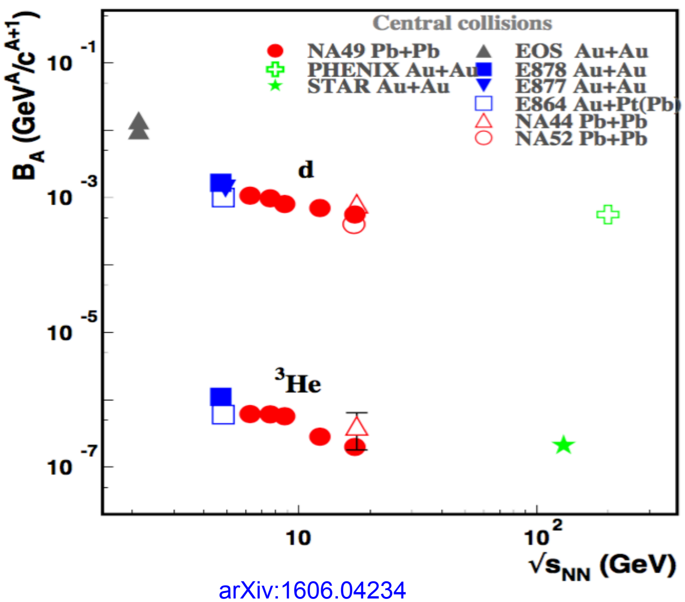
$$E_A \frac{d^3N_A}{d^3p_A} = B_A \left(E_p \frac{d^3N_p}{d^3p_p} \right)^Z \left(E_n \frac{d^3N_n}{d^3p_n} \right)^{A-Z}$$

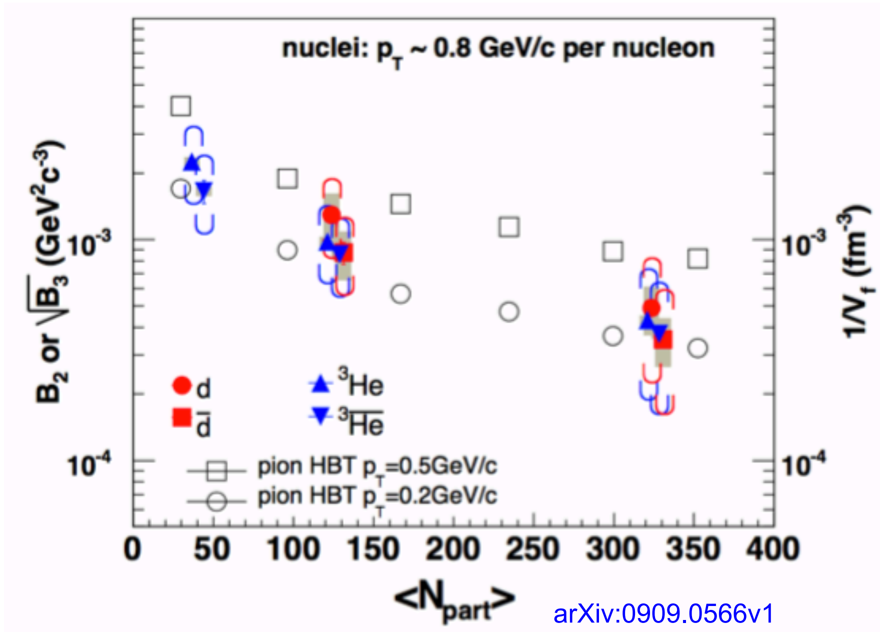
B_A is coalescente parameter and relatad to the freeze-out (source) volume $B_A \propto 1/V_f^{\,A-1}$

H. H. Gutbrod et al., Phys. Rev. Lett. 37, 667 (1976).

- Study of light nuclei provides information about freeze-out properties, such as particle density and source volume.

Motivation for B_A



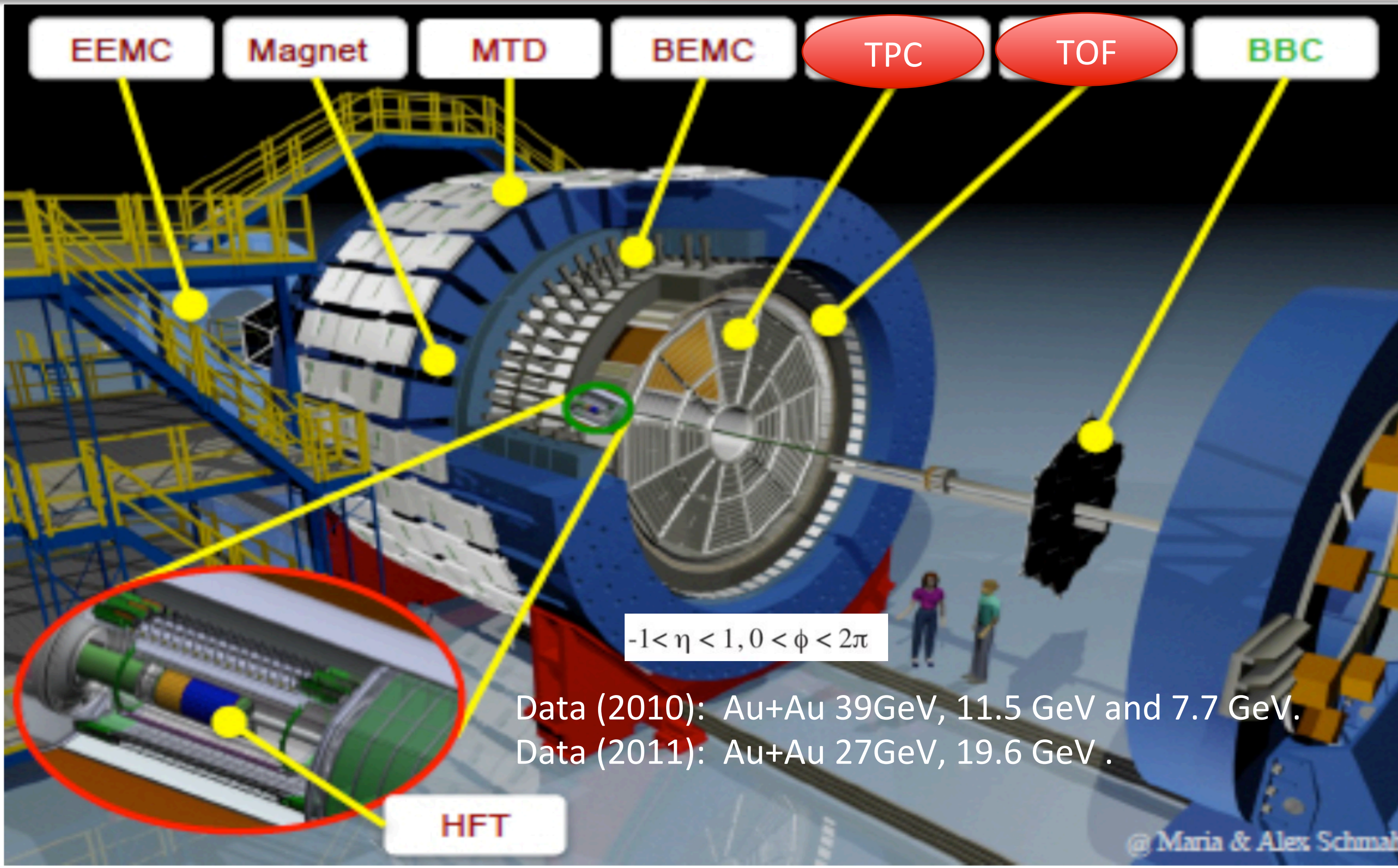


Coalescence parameters B_2 and B_3, can be derived from p, d, and ^{3}He spectra

$$E_A \frac{d^3 N_A}{d^3 p_A} = B_A \left(E_p \frac{d^3 N_p}{d^3 p_p} \right)^Z \left(E_n \frac{d^3 N_n}{d^3 p_n} \right)^{A-Z} \qquad B_2 \propto \sqrt{B_3}$$

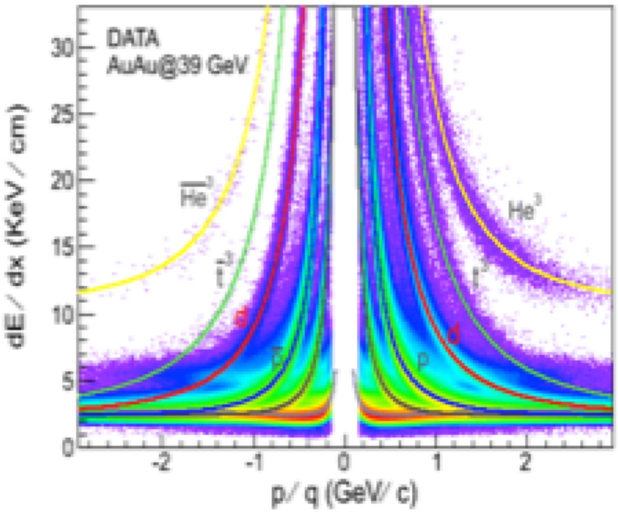
Measurement of B_A in BES energies will help to understand the particle production mechanism via coalescence.

The Solenoidal Tracker At RHIC (STAR)



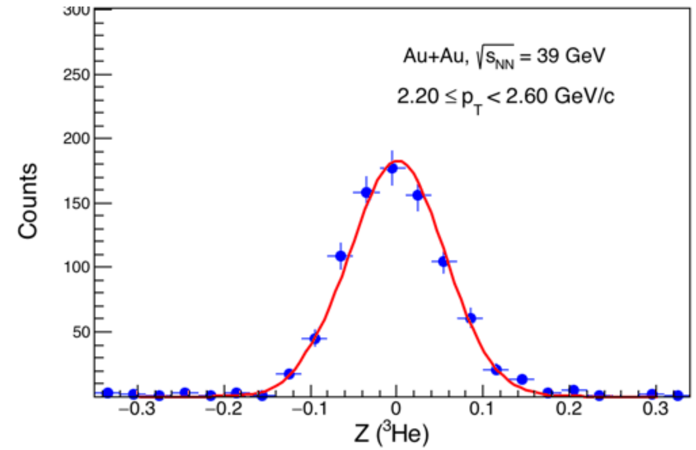
Data (2010): Au+Au 39GeV, 11.5 GeV and 7.7 GeV.
Data (2011): Au+Au 27GeV, 19.6 GeV .

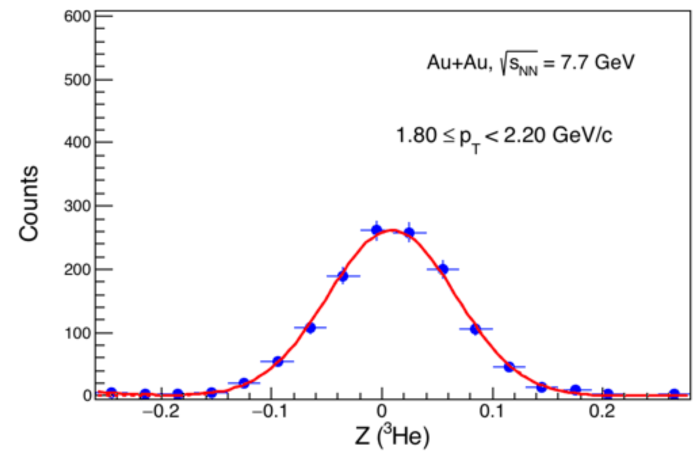
Particle Identification



TPC

$$z = \log\left(\frac{(dE/dx)_{meas.}}{(dE/dx)_{theory}}\right)$$

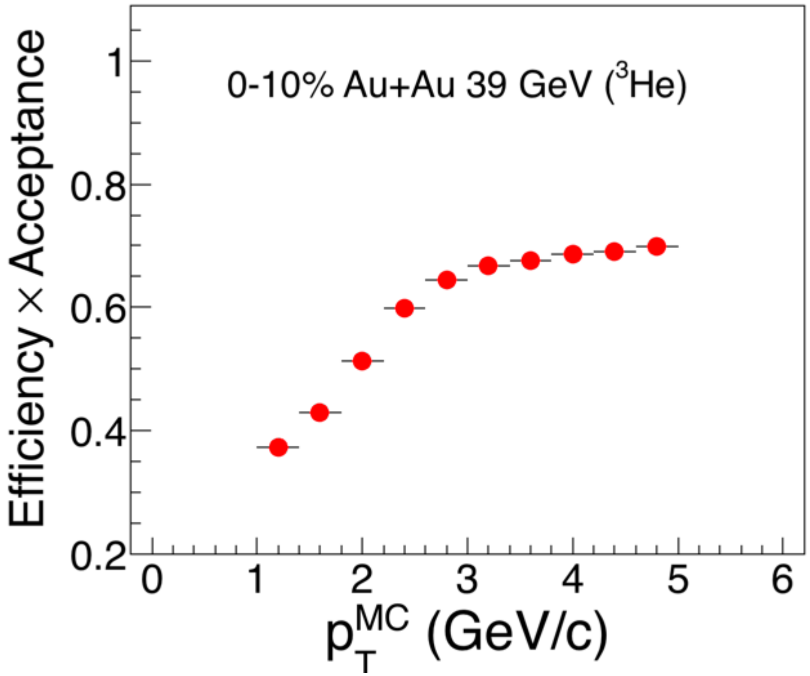


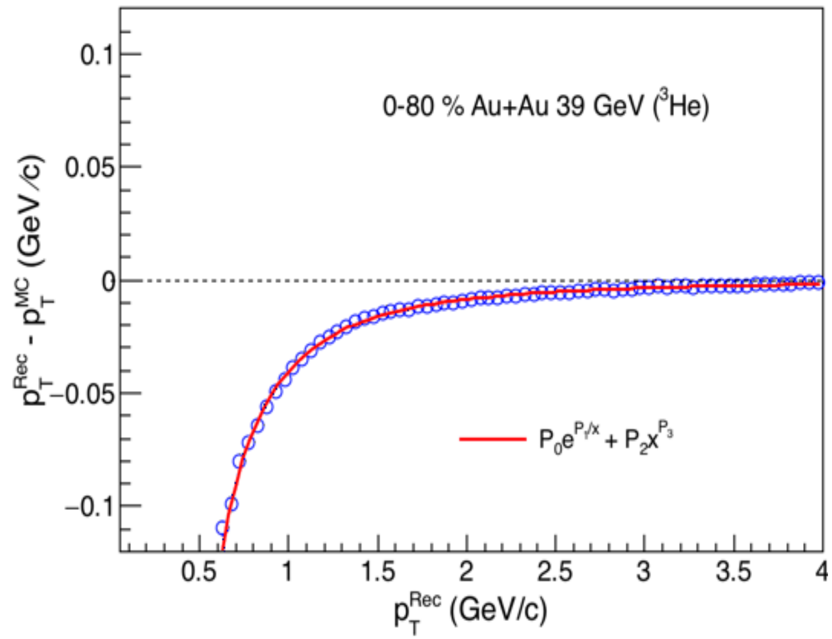


$\sqrt{s_{NN}}$ (GeV)	MB events
39	~ 112 M
27	~ 38 M
19.6	~ 19 M
11.5	~ 10 M
7.7	~ 3 M

Types	Values
$\lvert V_z \rvert$	< 40/50 cm
$\lvert V_r \rvert$	< 2 cm
p_T	> .2 GeV/c
$\lvert y \rvert$	< 0.5
$\lvert \eta \rvert$	< 1.0
DCA	<= 1.0 cm
nHitsfit ratio	>= .52
nFitPoints	>= 20
nHitsdEdx	>= 10

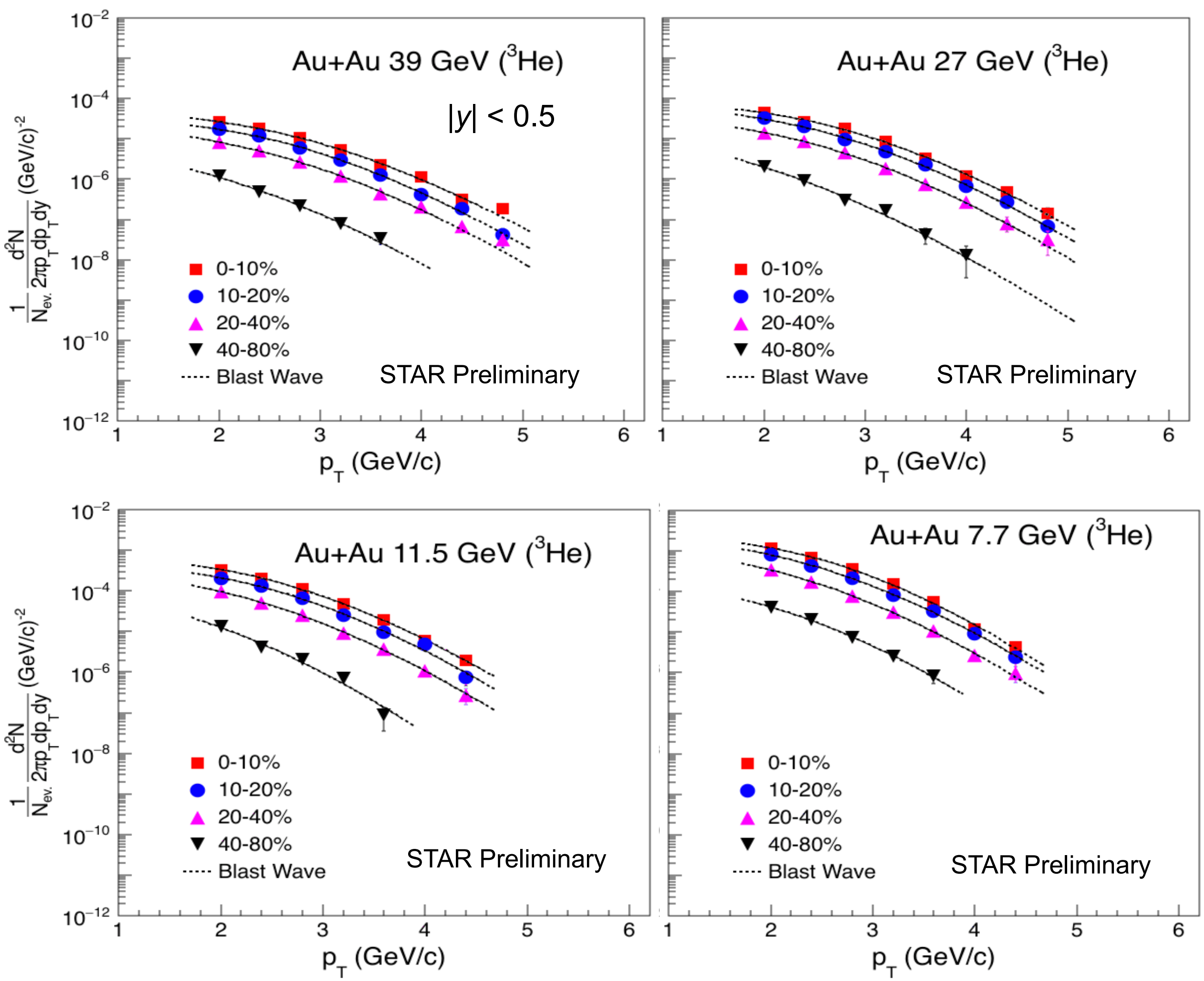
Correction Factors





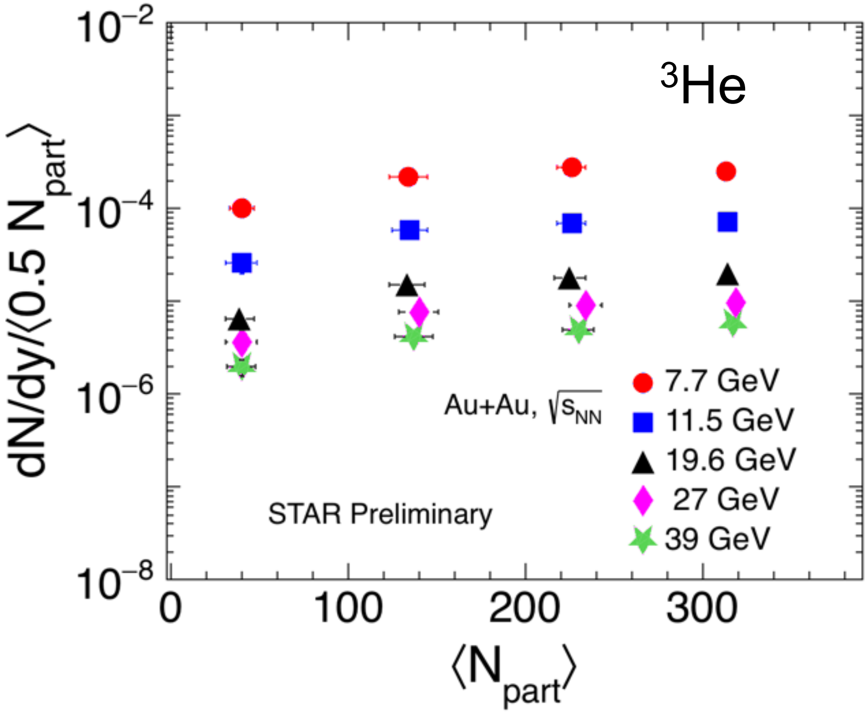
- Tracking efficiency and acceptance correction
- Momentum correction

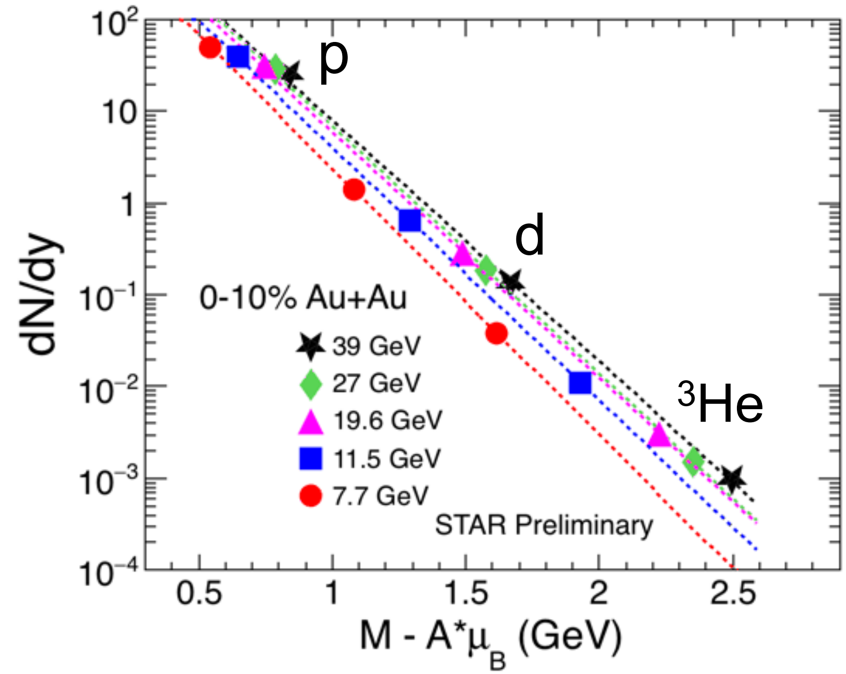
Transverse Momentum Particle Spectra (^3He)



Errors are statistical

dN/dy



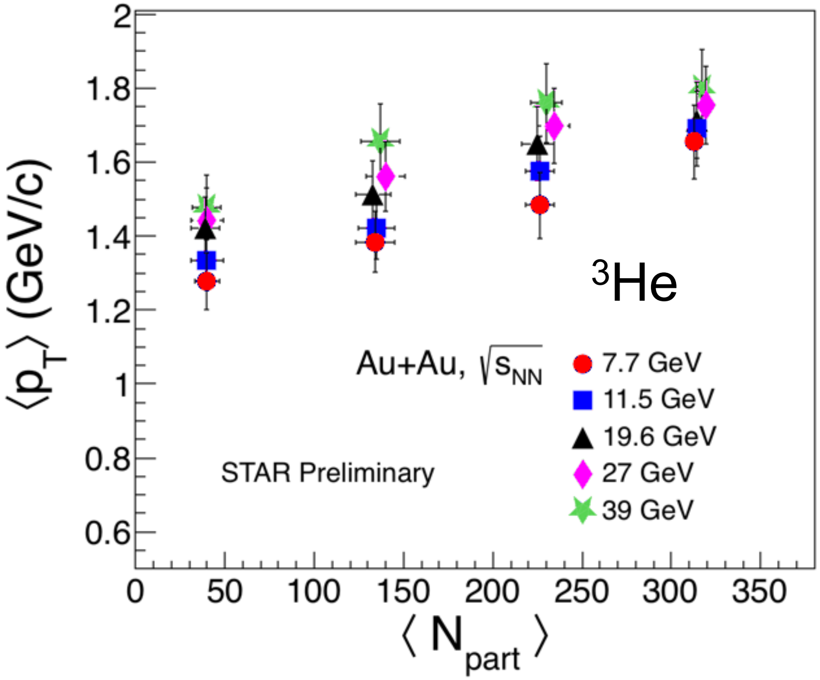


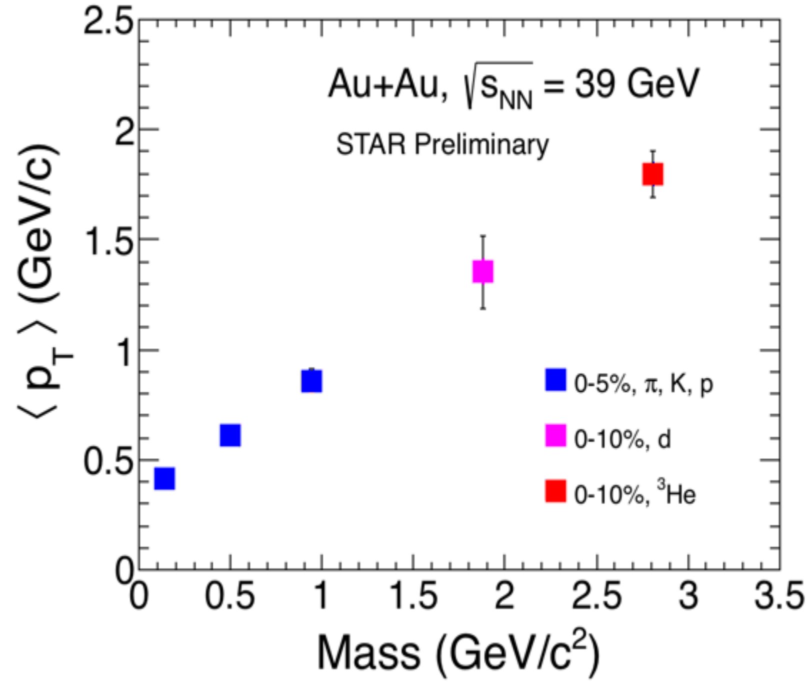
statistical

- dN/dy increases with decrease of collision energy
- dN/dy shows an exponential decrease with increase of mass of the particle. Similar behavior also observed in lower and higher collision energies.

J. Barrette et al., Phys. Rev. **C 50,**1077–1084 (1994) , R. Arsenescu et al., New J. Phys. **5** (2003) 150. H. Agakishiev et al., Nature **473** (2011) 353,
J. Adam et al. (ALICE Collaboration) Phys. Rev. C 93, 024917

$\langle p_T \rangle$

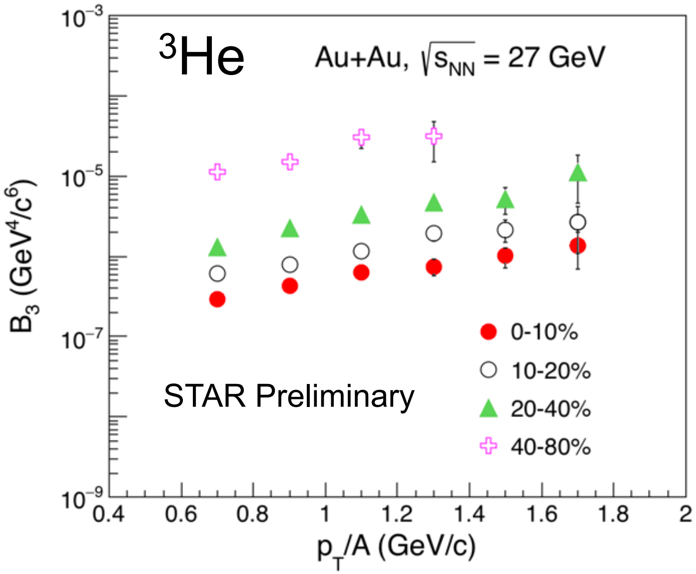


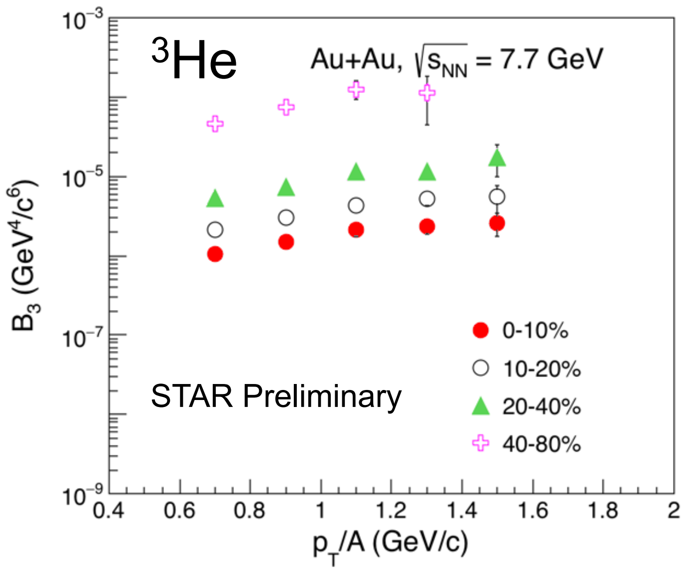


Errors are statistical

- $\langle p_T \rangle$ increases with centrality: collectivity increases with centrality
- $\langle p_T \rangle$ increases with increase of mass of the particle which confirms the particle production from a radially expanding source.

B_3 vs p_T/A

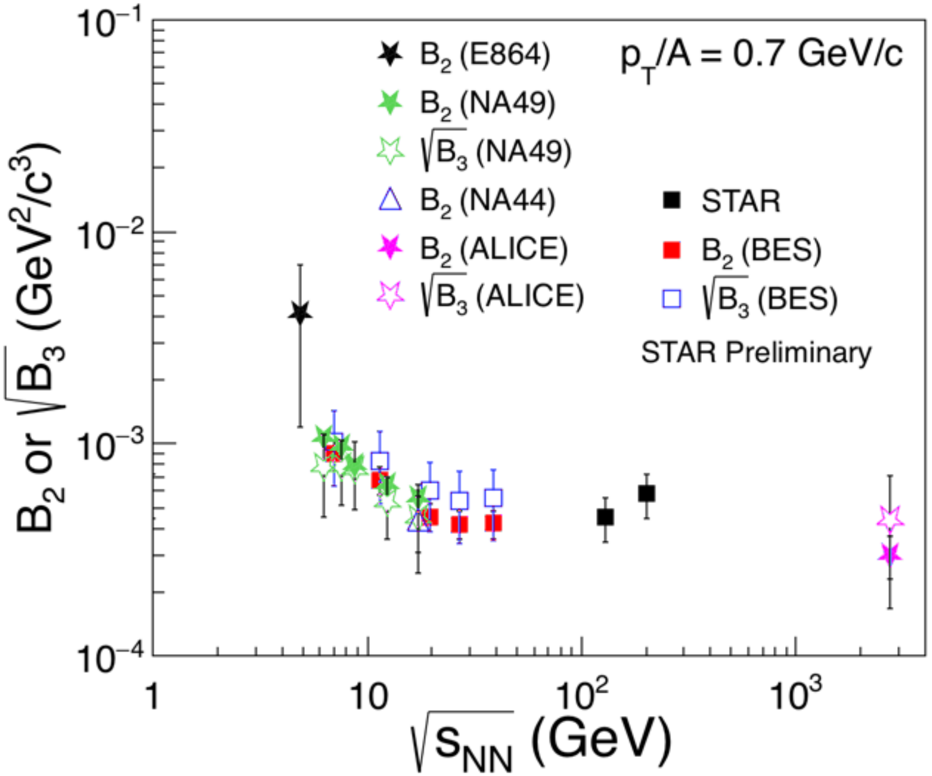




Errors are statistical

- B_3 increases with p_T/A and also from central to peripheral as $B_A \propto 1/V_f^{\,A-1}$, V_f = freeze-out volume
- Small B_3 values in central collisions imply freeze-out volume at thermal freeze-out is larger than for peripheral collisions

B_A vs $\sqrt{S_{NN}}$



- B_A found to be decreasing with increase of collision energies which corresponds to an increase in freeze-out volume

Summary

- ✓ New results on ^{3}He production have been presented in Au+Au collisions at $\sqrt{s_{NN}}$ = 39, 27, 19.6, 11.5 and 7.7 GeV.
- ✓ Centrality and energy dependence of particle yields, $\langle p_T \rangle$ and B_3 are presented.
- ✓ Comparison of B_2 and B_3 vs. energy.

- With decreases of collision energies dN/dy increases
- As the collision energy increases, the values of $\langle p_T \rangle$ increase and the extracted B_3 decrease => collective expansion in the Au+Au collisions

Thank you

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