The effect of baryon conservation and nucleon-nucleon correlation on the light nuclei production at $\sqrt{S_{NN}} = 3$ GeV

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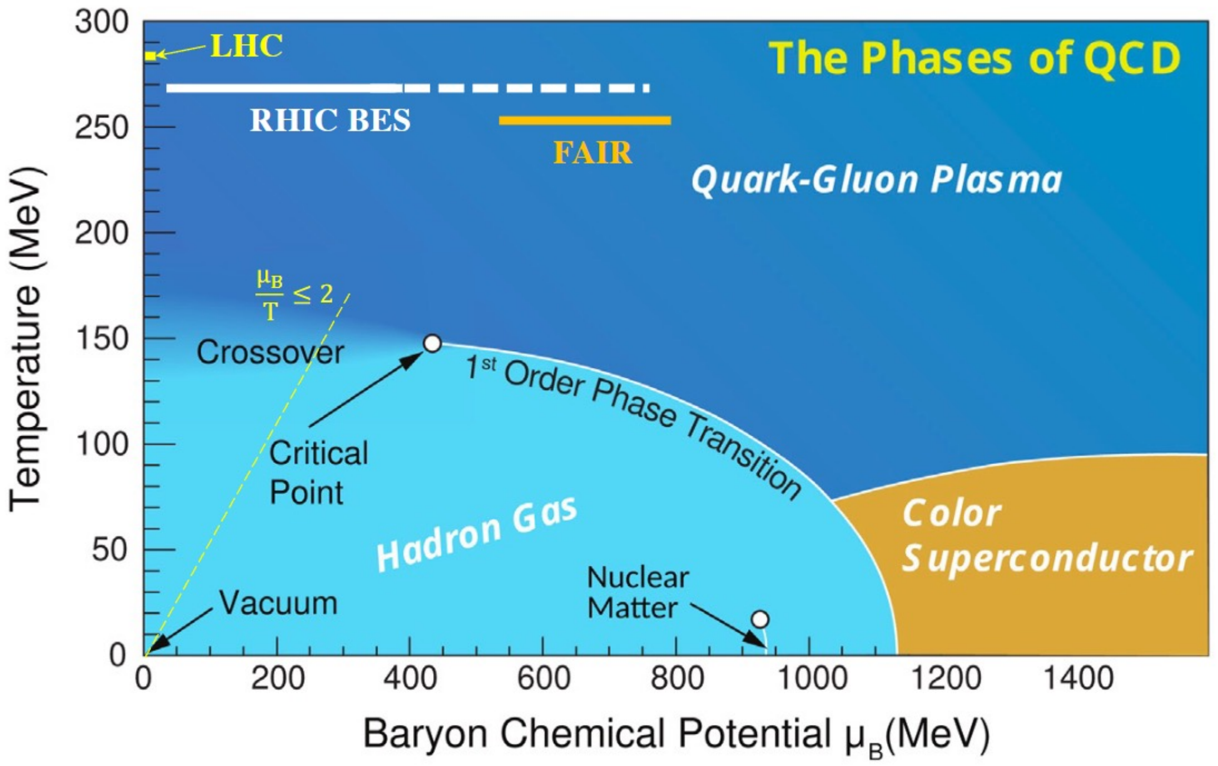
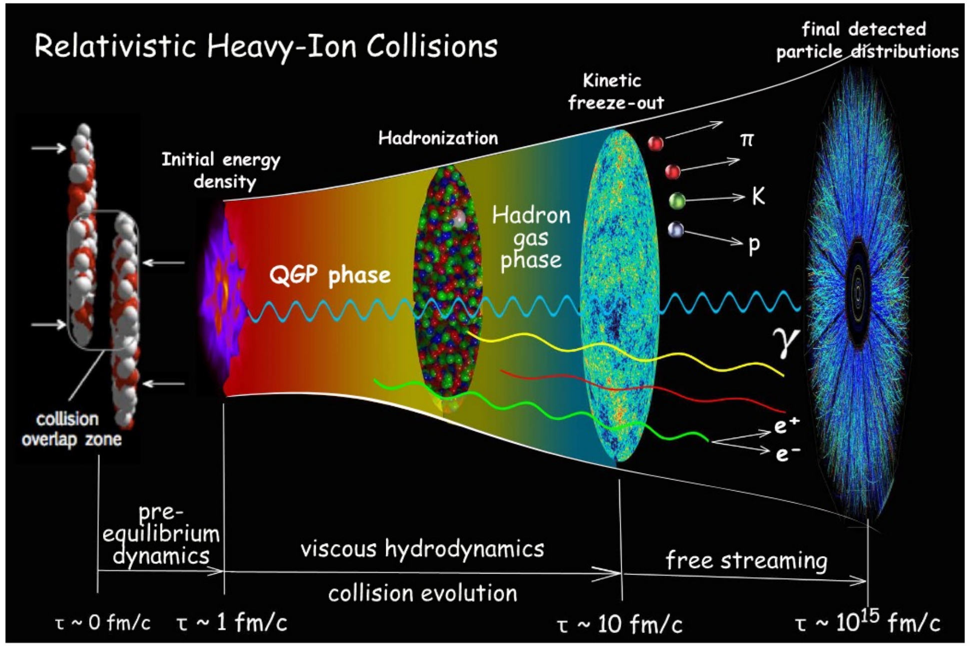
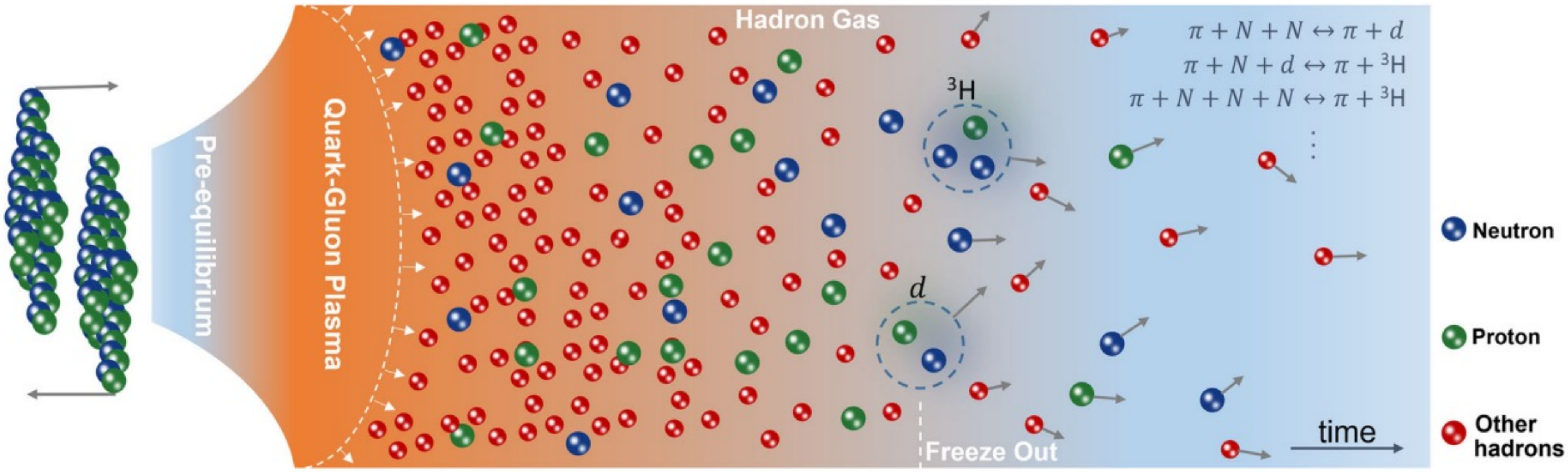
Introduction: The relationship of CEP and light nuclei





Nucl.Phys.A 1047 (2024) 122874

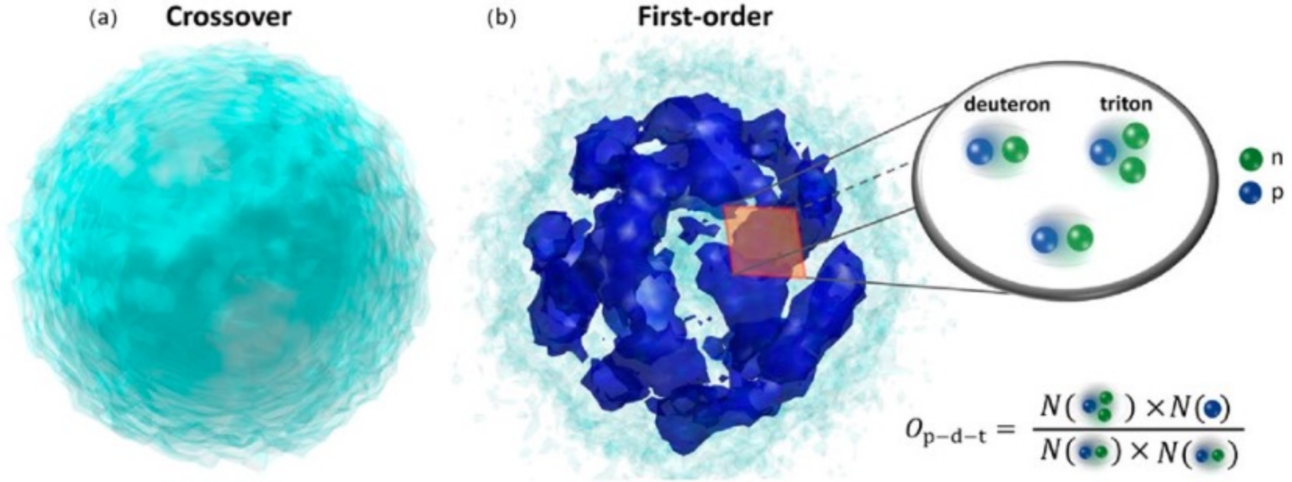
Light nuclei



Nature Commun. 15 (2024) 1, 1074

- Light nuclei carry information about local baryon density fluctuations.
- Light nuclei provide an effective probe for studying the boundary of the first-order phase transition and the QCD critical point.

Double ratio $\frac{N_t \times N_p}{N_d^2}$ and wigner function



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Density Matrix Formulation:

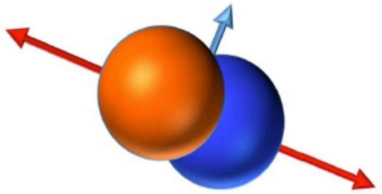
$$N_A = Tr(\hat{\rho}_S \hat{\rho}_A) = g_c \int d\Gamma\ \rho_s\ (\{x_i, p_i\}) \times W_A\ (\{x_i, p_i\})$$

Wigner function:

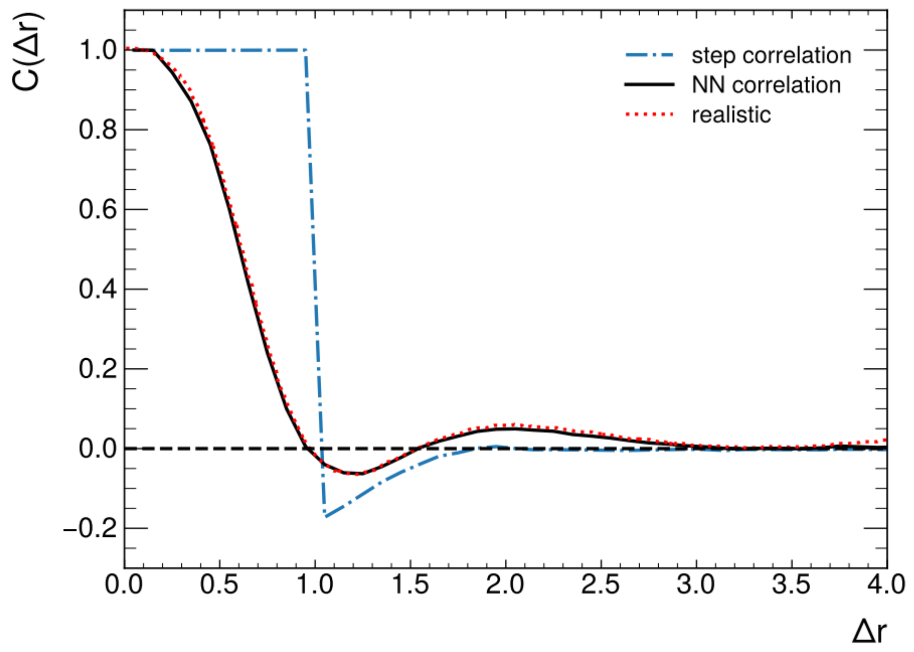
$$\frac{dN_A}{d^3 P_A} = \frac{g_A}{Z!N!} \int \prod_{i=1}^{Z} p_i^{\mu} \frac{d^3 p_i}{E_i} f_{p/\bar{p}}(x_i, p_i, t_i) \times \int \prod_{j=1}^{N} p_j^{\mu}\ d^3\sigma_{j\mu} \frac{d^3 p_j}{E_j} f_{n/\bar{n}}(x_j, p_j, t_j) \times f_A(\rho, \lambda, \dots, p_\rho, p_\lambda, \dots) \times \delta^{(3)}(P_A - \sum_{i=1}^{Z} P_i - \sum_{j=1}^{N} P_j)$$

Correlation

Position-space



Momentum-space

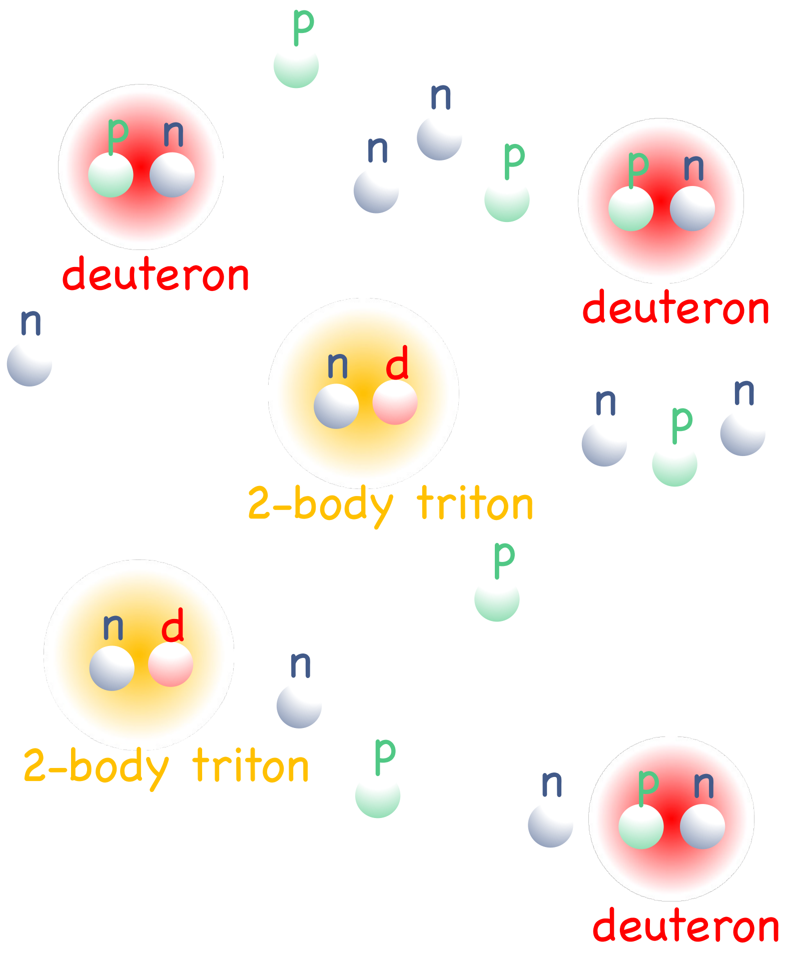


Consider the correlation effects through the mean field model to see if they are more apparent.

- $C(\Delta r) = 1 - \rho_C^{(2)}(\Delta r)/\rho_U^{(2)}(\Delta r)$
  where $\Delta r = |r_1 - r_2|$

Phys.Lett.B 680 (2009) 225-230
and poster by Yu-Jing Huang

Yield ratio

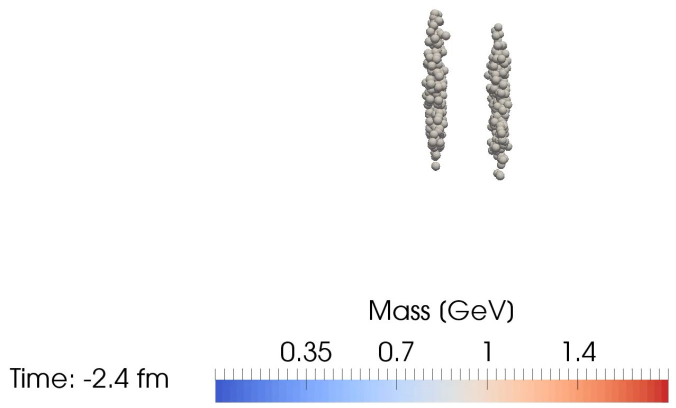


$$\frac{N_t N_p}{N_d^2} = \frac{N_{t_2} N_p}{N_{d-t_2}^2}$$

Method: Model and set up

- Model: SMASH

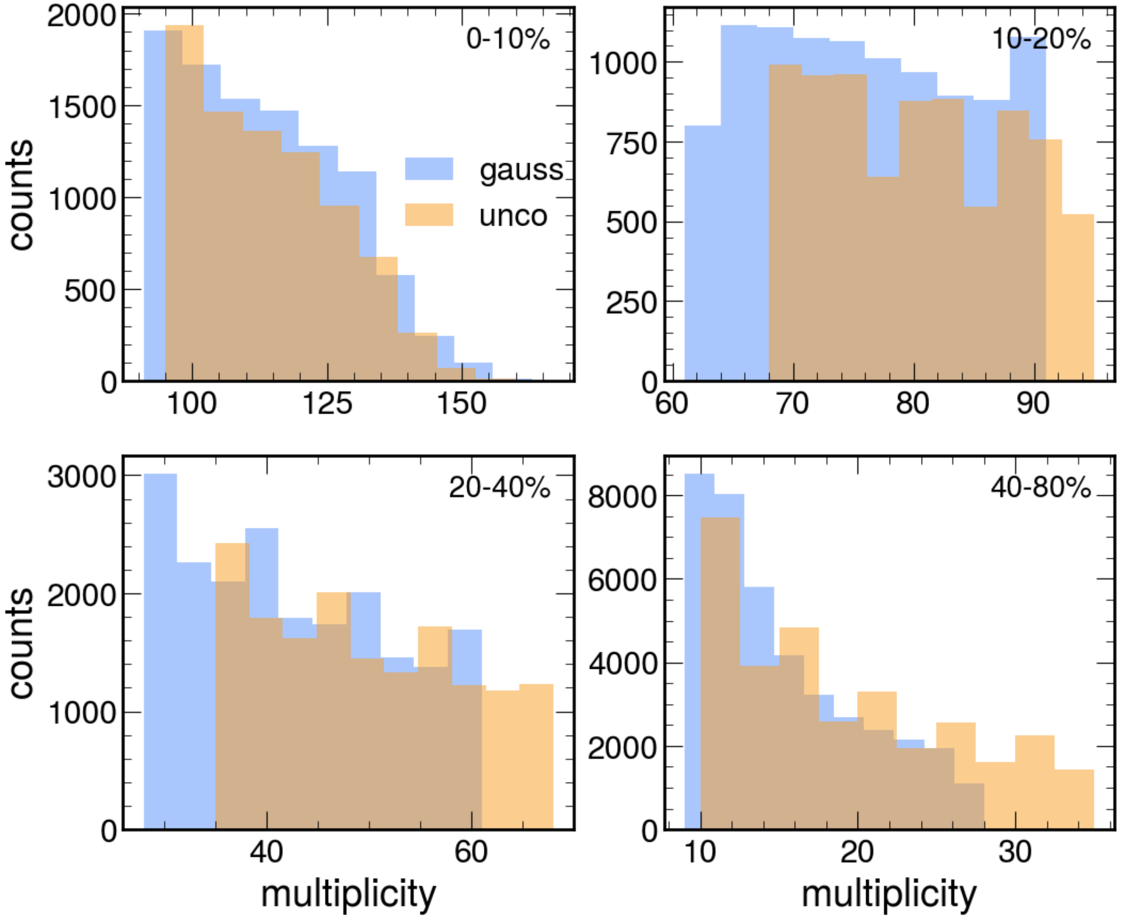
- Modes:
  - mean field + no correlation
  - mean field + NN correlation



- Collision system: Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV

- Events: 100,000 events per mode

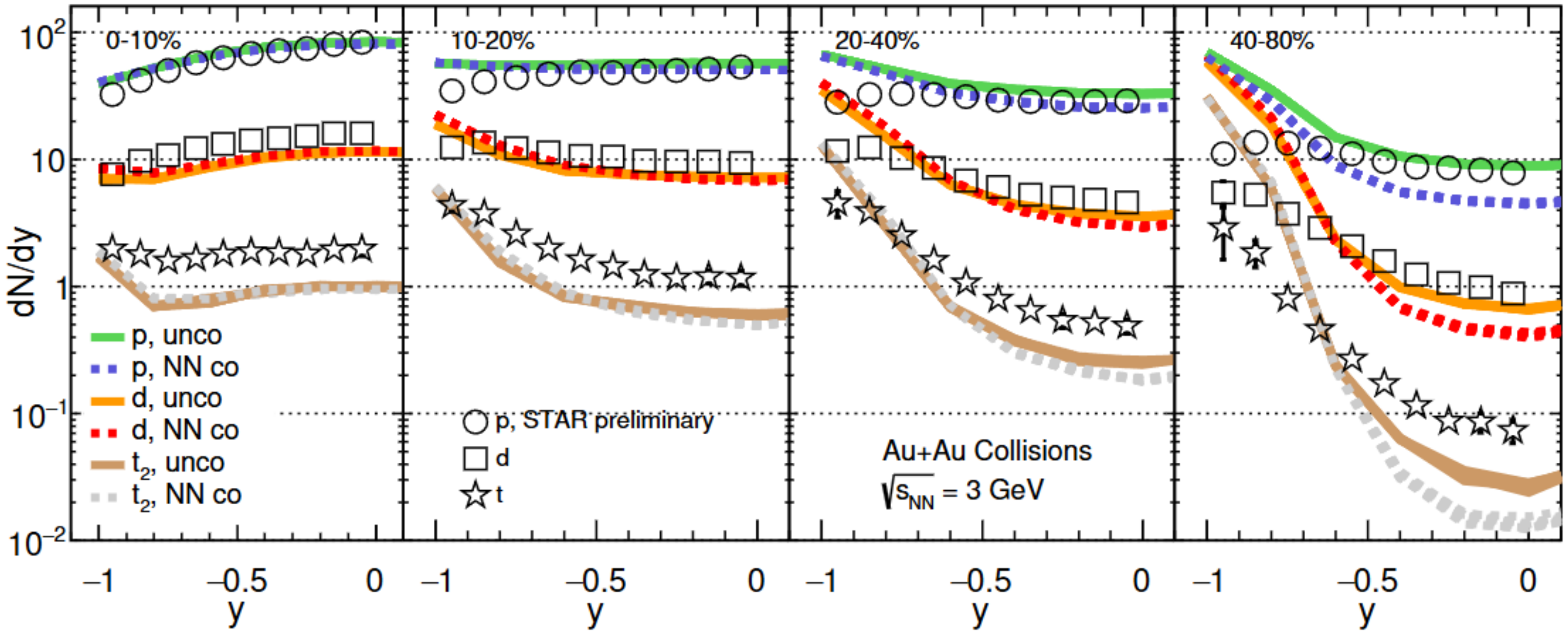
Results: Centrality division



- Collision centralities were determined by dividing the charged-particle multiplicity (FXTMult), measured within the pseudo-rapidity range $0 < \eta < 2$, by the $p_T > 0.4$.

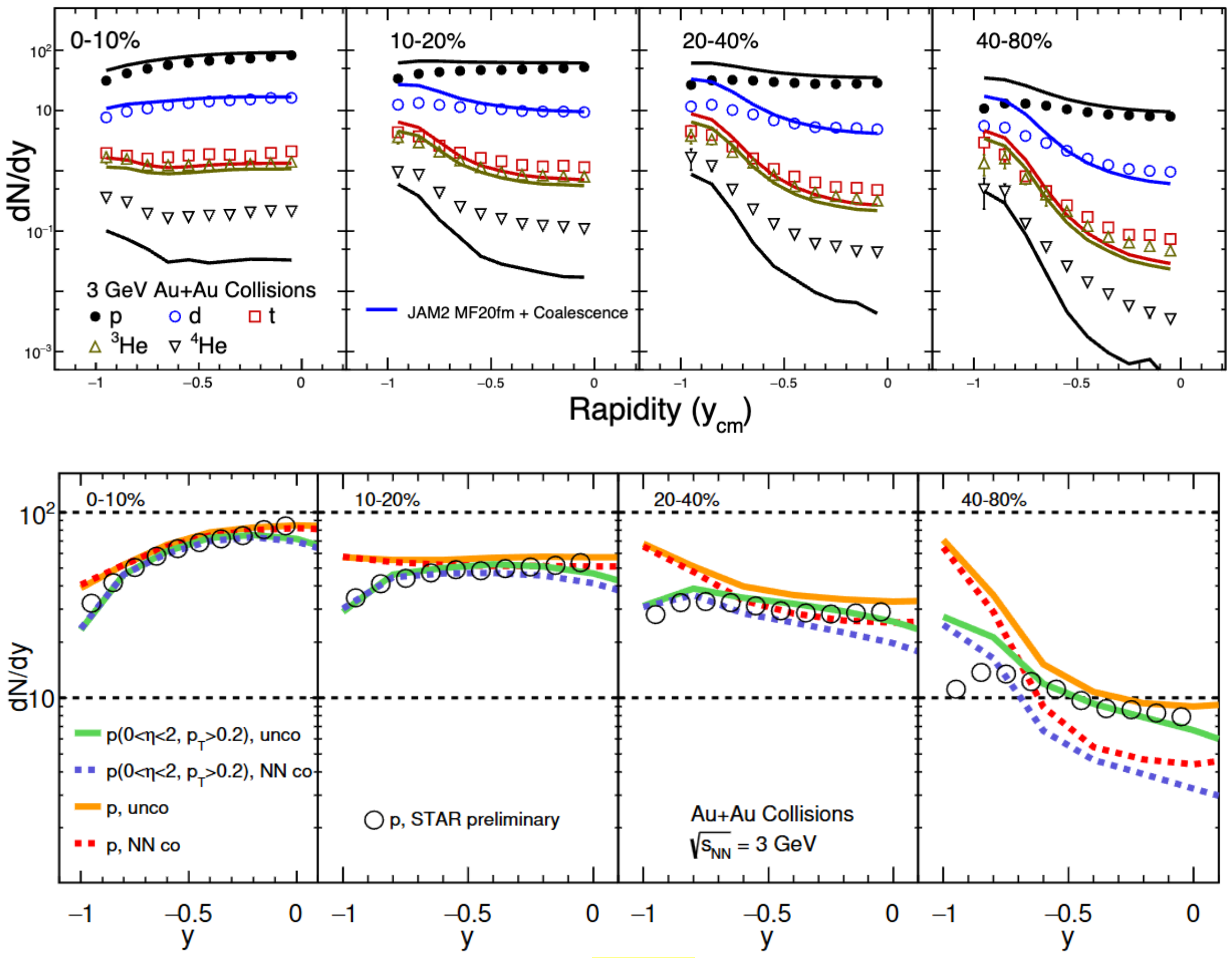
Method

Light nuclei production



- Incorporating nucleon-nucleon correlations into the SMASH simulation will result in a visible difference in the yield ratio of light nuclei during peripheral collisions.

Spectator effect



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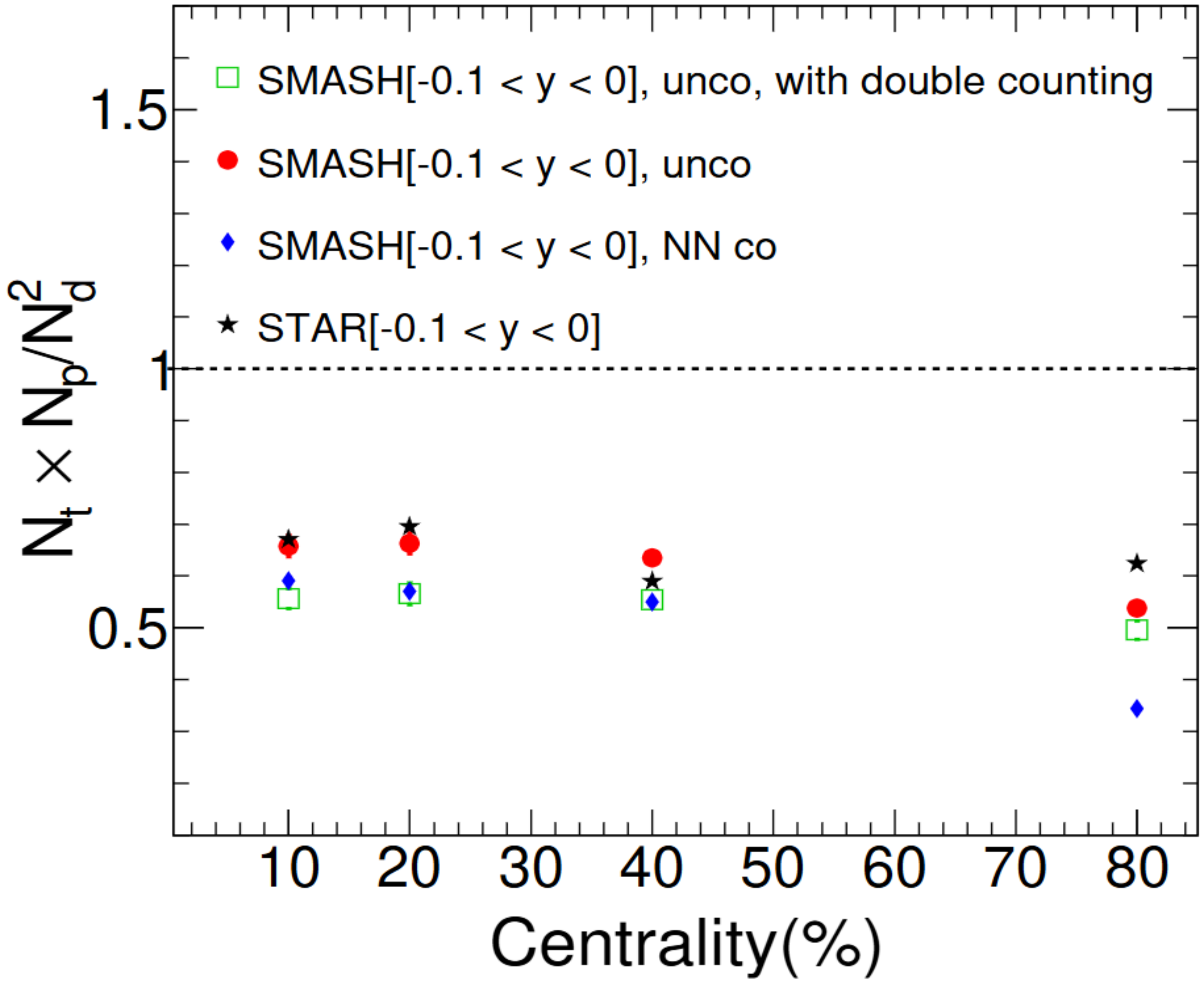
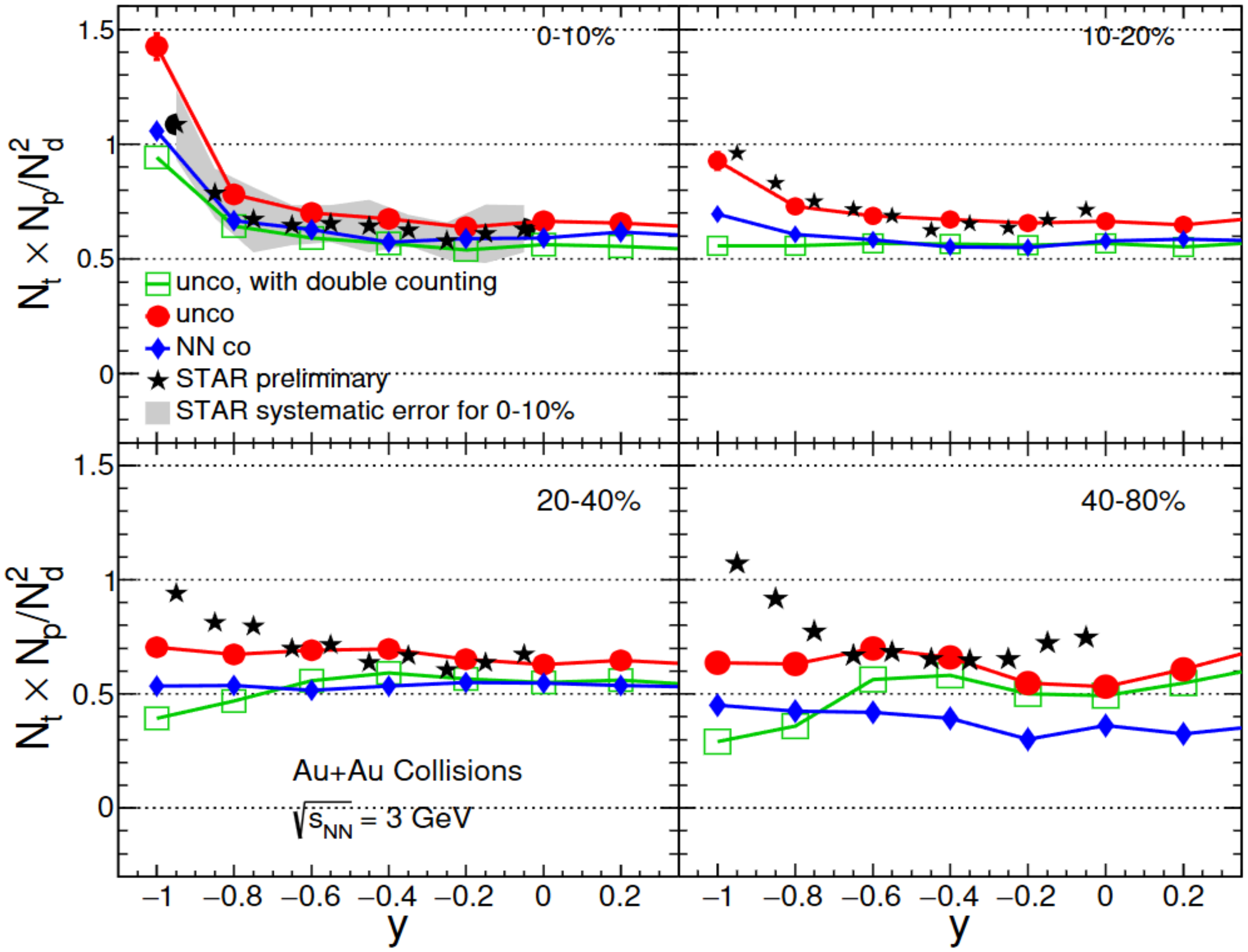
Results

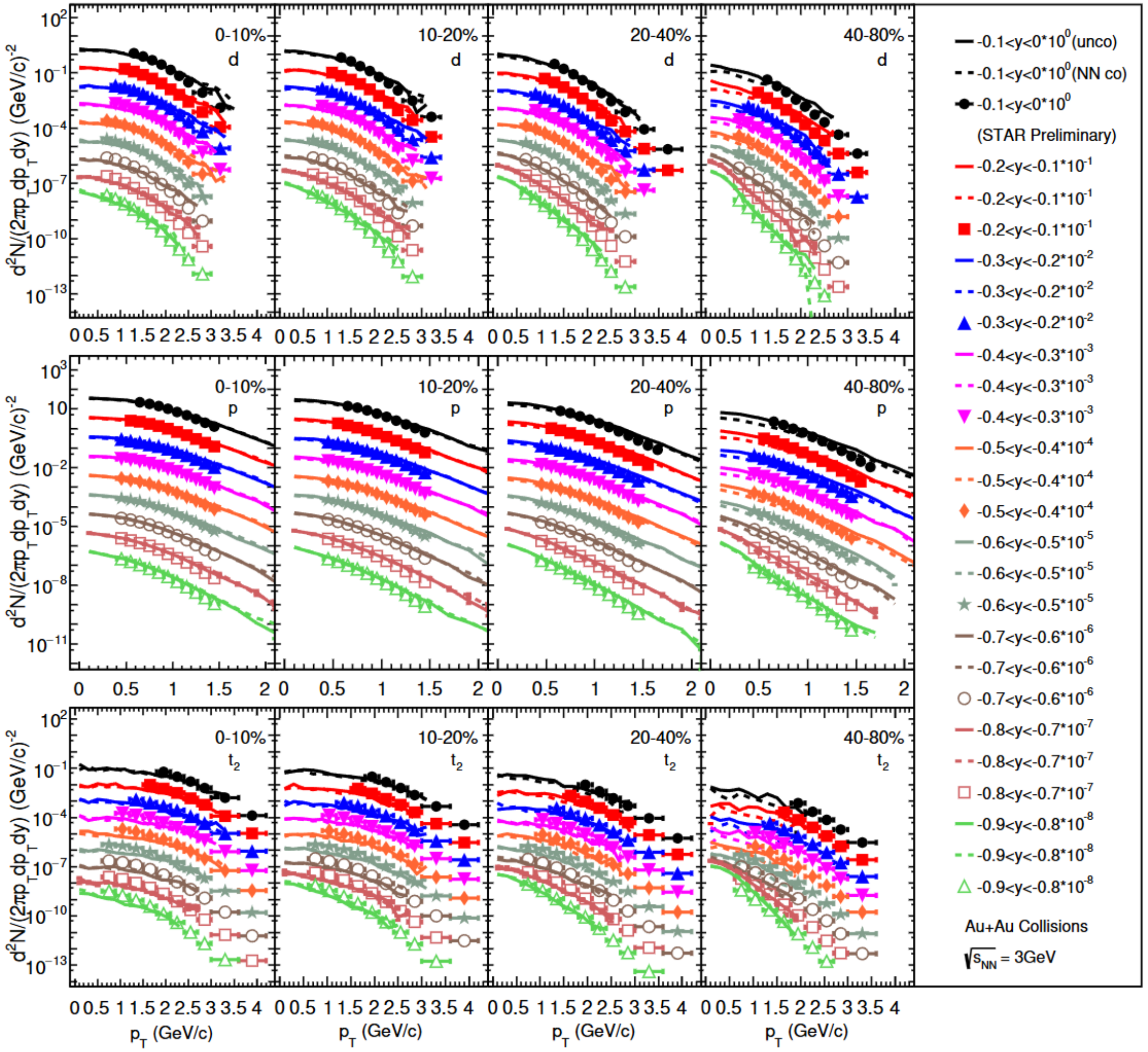
$\frac{N_t N_p}{N_d^2}$ vs centrality



$\frac{N_t\, N_p}{N_d^2}$ vs rapidity

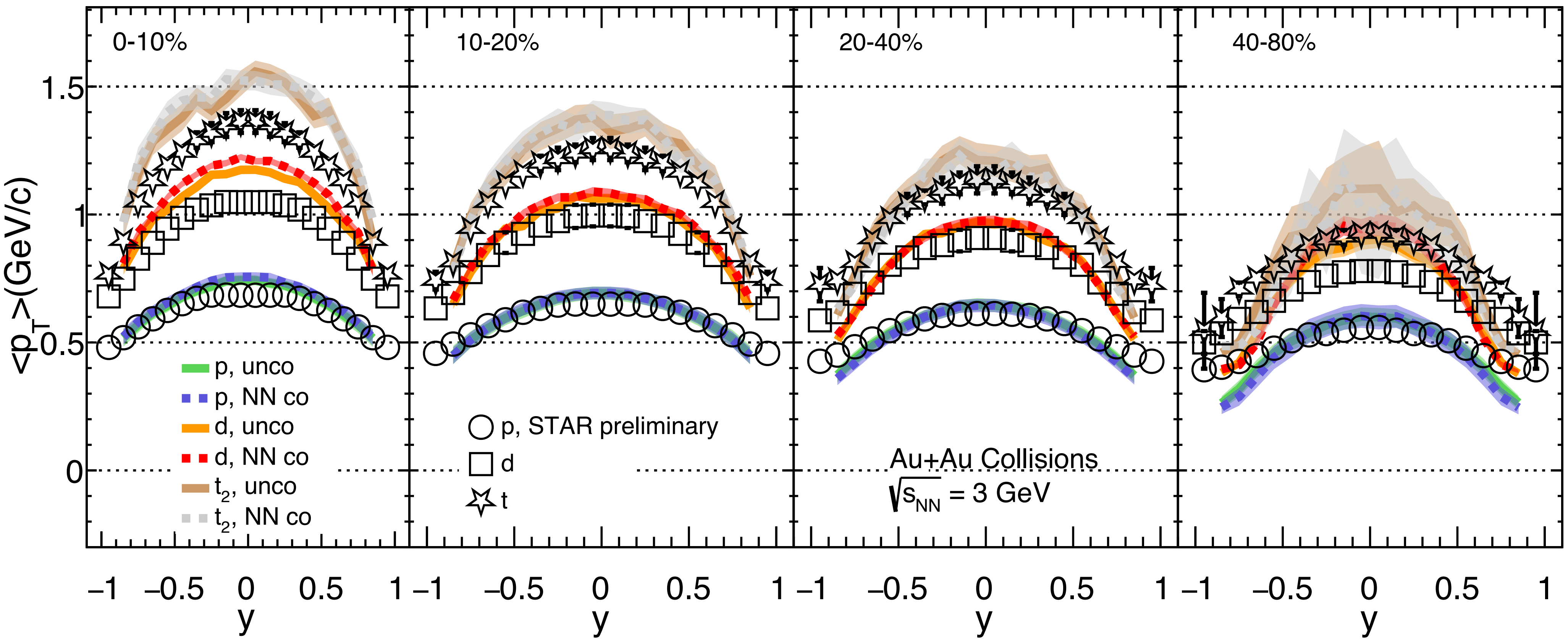


p_T spectra



Results

Mean p_T



0-10%
10-20%
20-40%
40-80%
<p_T>(GeV/c)
y
p, unco
p, NN co
d, unco
d, NN co
t2, unco
t2, NN co
p, STAR preliminary
d
t
Au+Au Collisions
√sNN = 3 GeV

Summary

- We made a baryon conservation correction for deuteron production. By deducting the deuteron used to generate triton, we have improved the value of $\frac{N_t\, N_p}{N_d^2}$, thus bringing it into better agreement with experimental results.
- We introduced spatial correlation between nucleons at the initial stage of the nuclear collision. This led to a reduction in the multiplicity of particles after the introduction of correlation, which in turn reduced the production of light nuclei, with a more significant impact on triton, thereby in the noticeably suppressing the value of $\frac{N_t\, N_p}{N_d^2}$.
- The yield ratio of light nuclei in heavy-ion collisions may serve as a reliable probe for nucleon-nucleon correlations within nuclear structures.