中国科学技术大学硕士学位论文答辩

5.2 GeV金核金核碰撞中超氚的实验测量与轻核产生的系统依赖模型研究

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2025.10.19

Outline

- Experimental measurement of ${}^{3}_{\Lambda}\mathrm{H}$ of AuAu fxt 5.2 GeV at STAR
  - ⇨ Introduction
  - ⇨ Experimental Setup
  - ⇨ Yield Analysis, Results and Discussion
- Models calculation about system dependence of light nucleus generation
  - ⇨ Motivation
  - ⇨ Results
- Summary and Outlook

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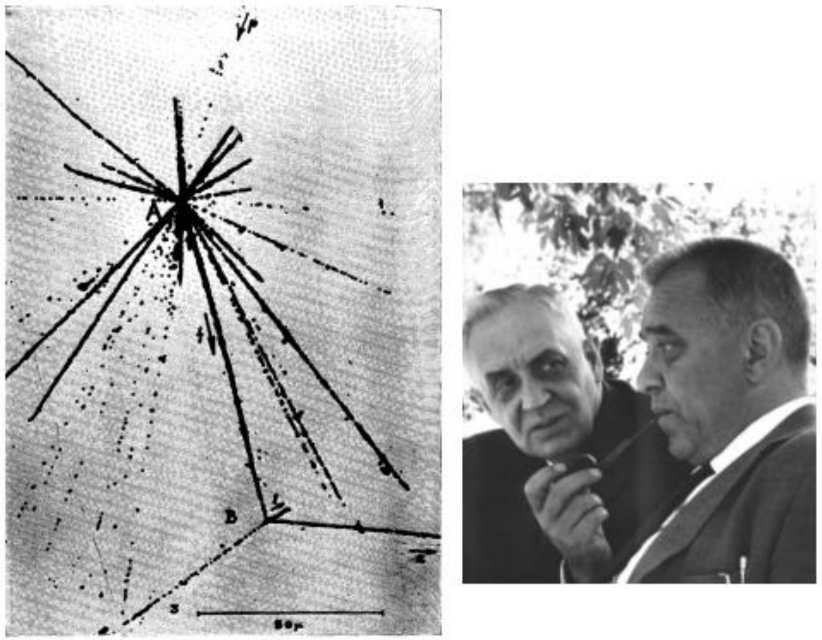
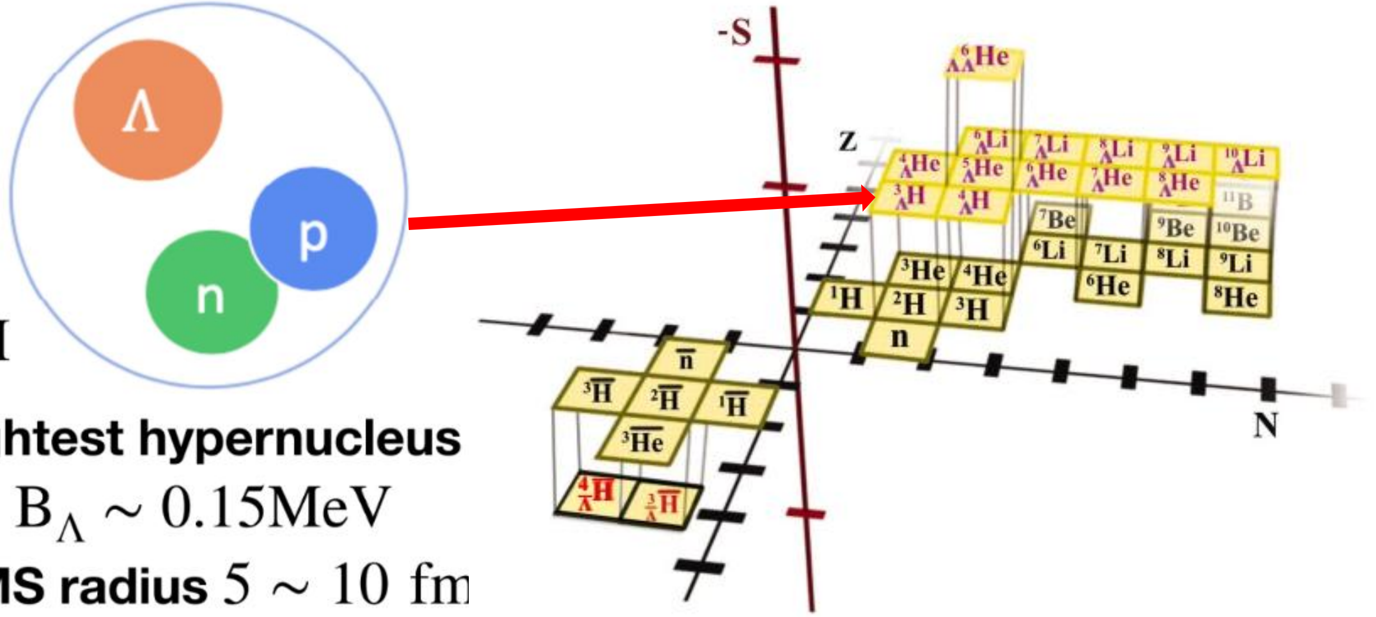
Introduction : hypernuclei

- Hypernuclei : bound nuclear systems of non-strange and strange baryons
  - **-Natural hyperon-baryon correlation system**



The first discovery of hypernucleus by Marian Danysz (right) and Jerzy Pniewski (left) in 1952

M. Danysz, J. Pniewski, Philos. Mag. 44 (1953) 348.



$^{3}_{\Lambda}H$

lightest hypernucleus

$B_{\Lambda} \sim 0.15MeV$

RMS radius $5 \sim 10$ fm

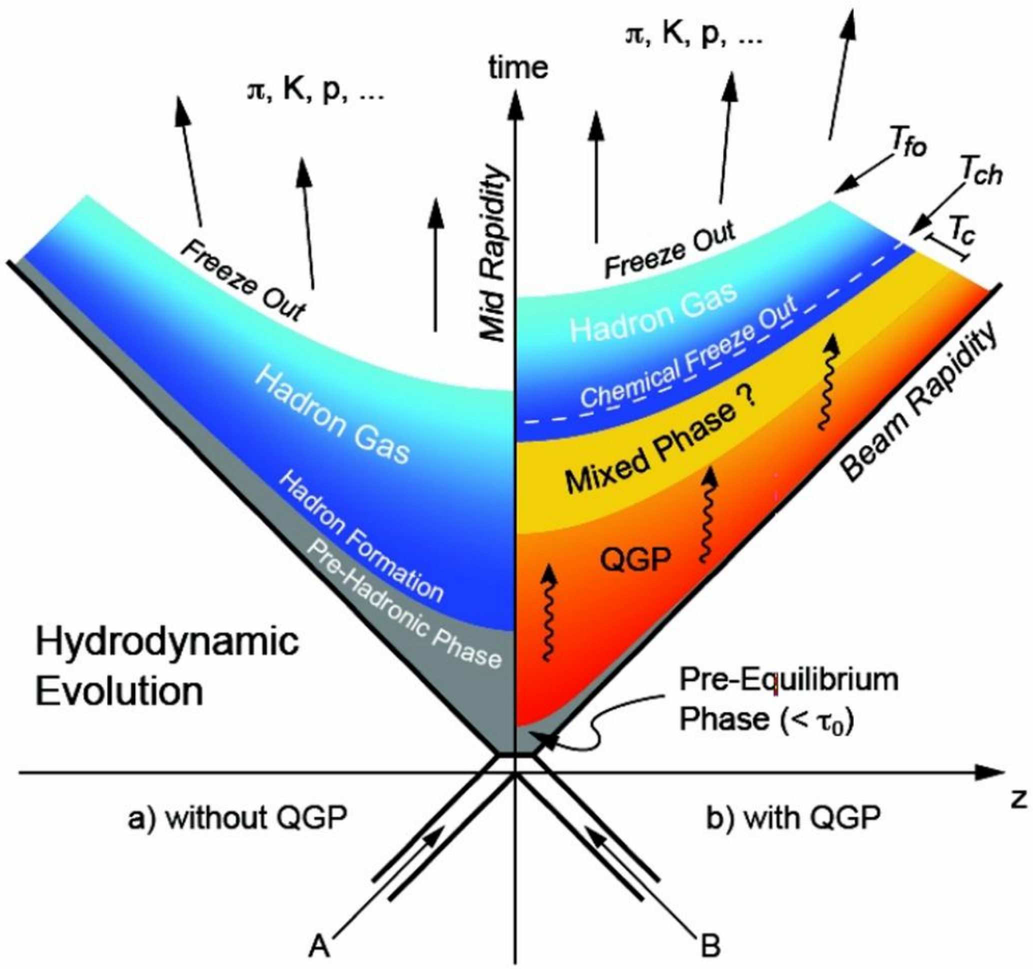
Introduction : hypernuclei

Production mechanism of hypernuclei in nature is still not well understood.

- In low- and intermediate-energy nuclear physics ,hypernuclei produced via strangeness exchange reaction.

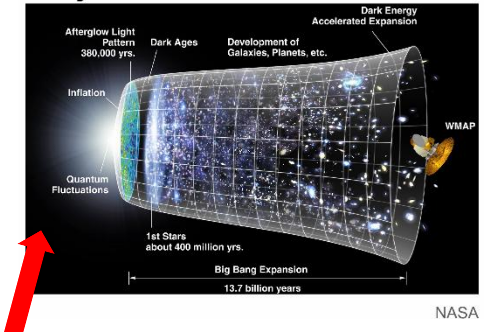
- In high-energy heavy ions ➡ microcosm

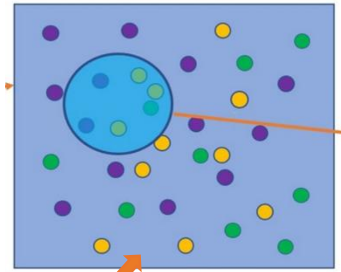
How such a loosely bound state as a super-nucleus can be formed and survive in high-energy heavy ions remains unknown.

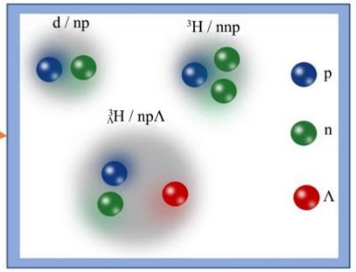


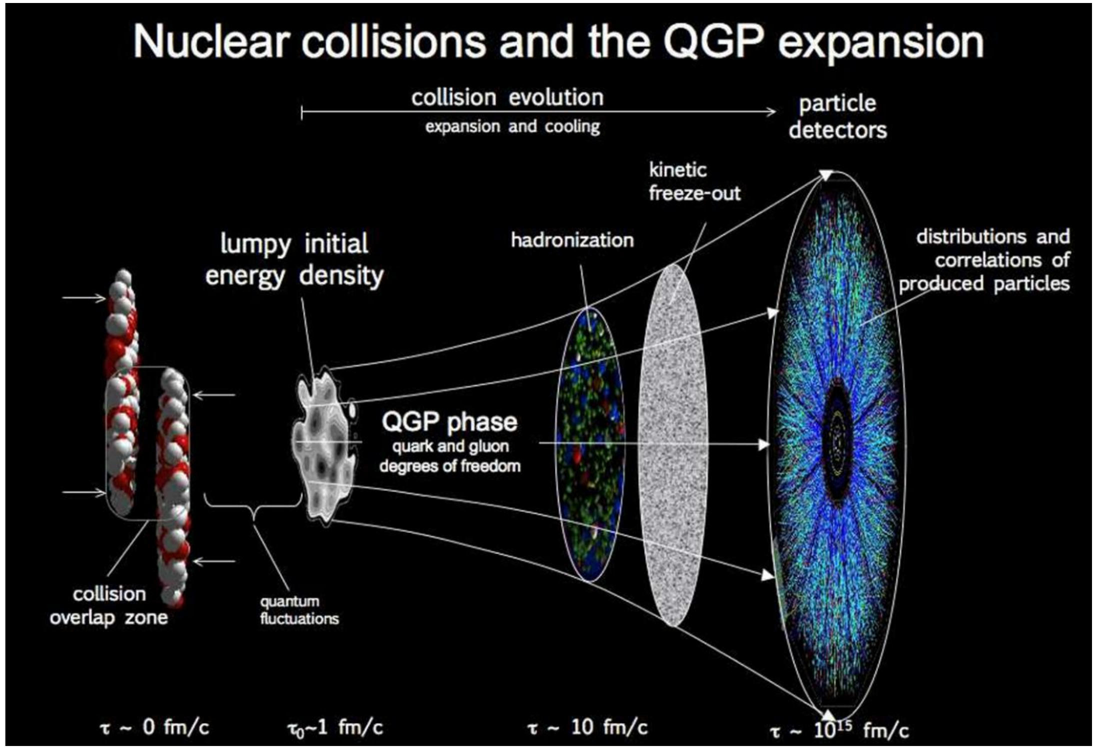
Introduction : HI collisions and QCD Phase Diagram

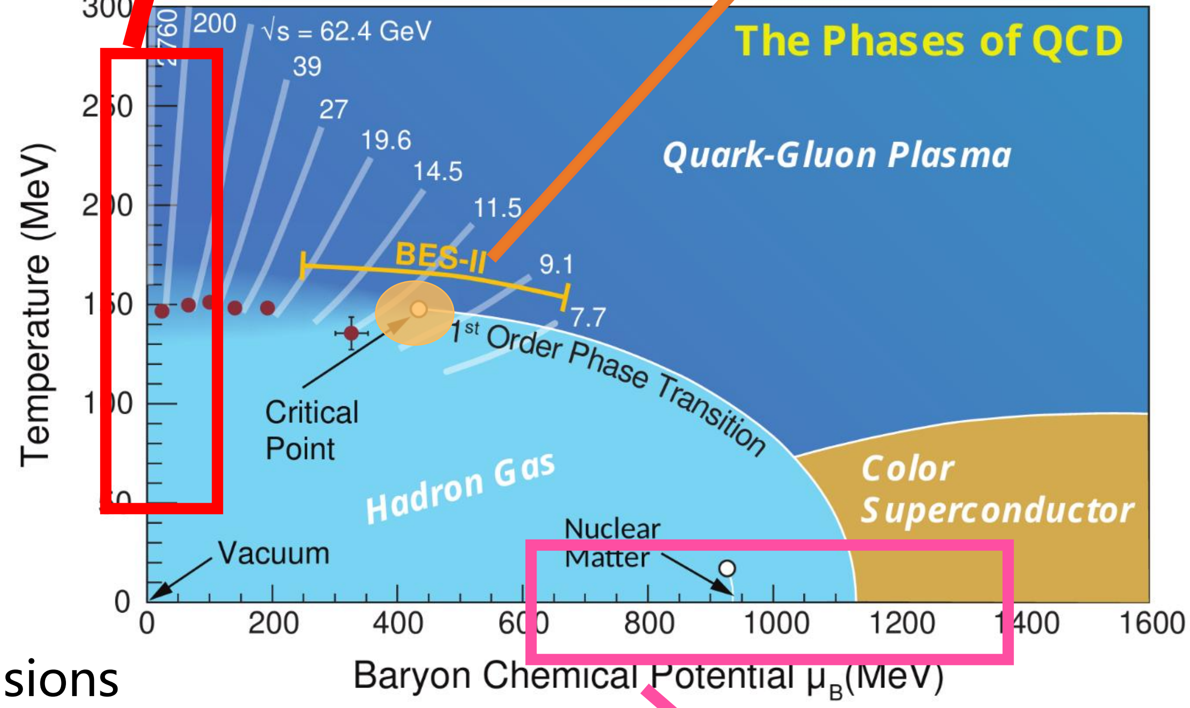
Early Universe



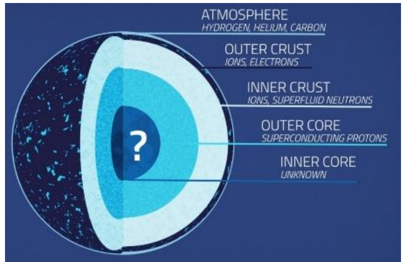








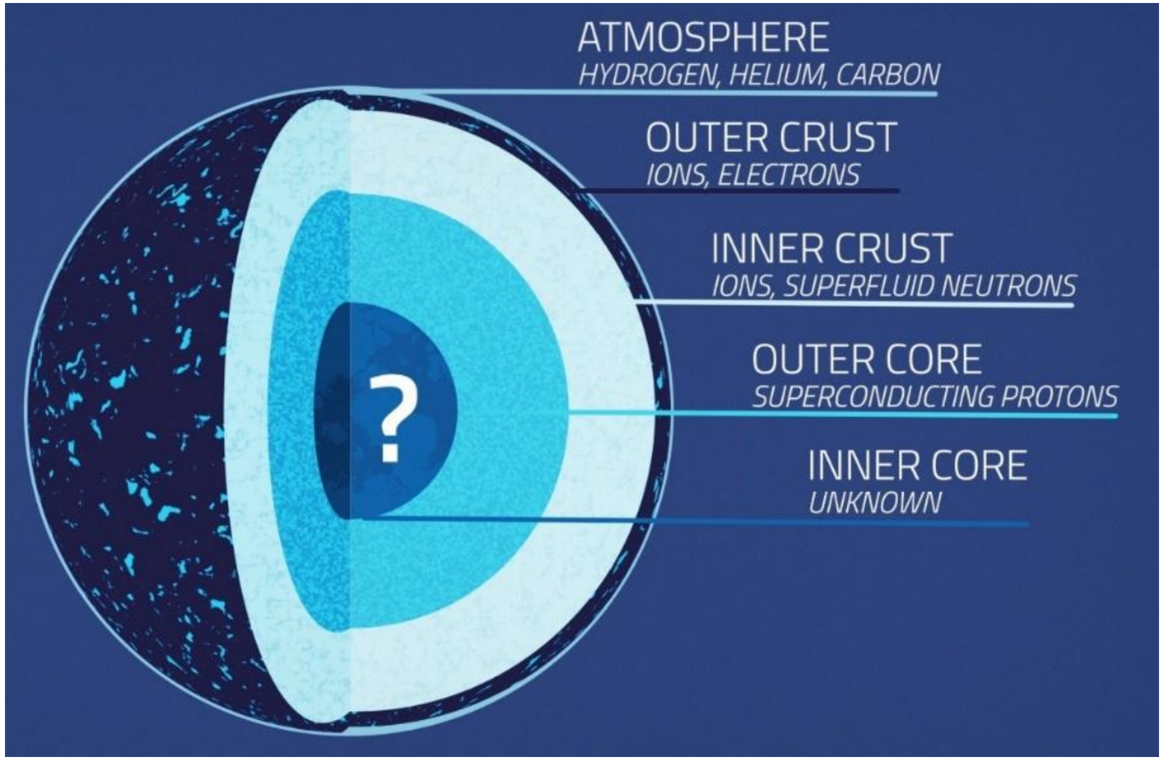
Varying centre-of mass energy of heavy-ion collisions

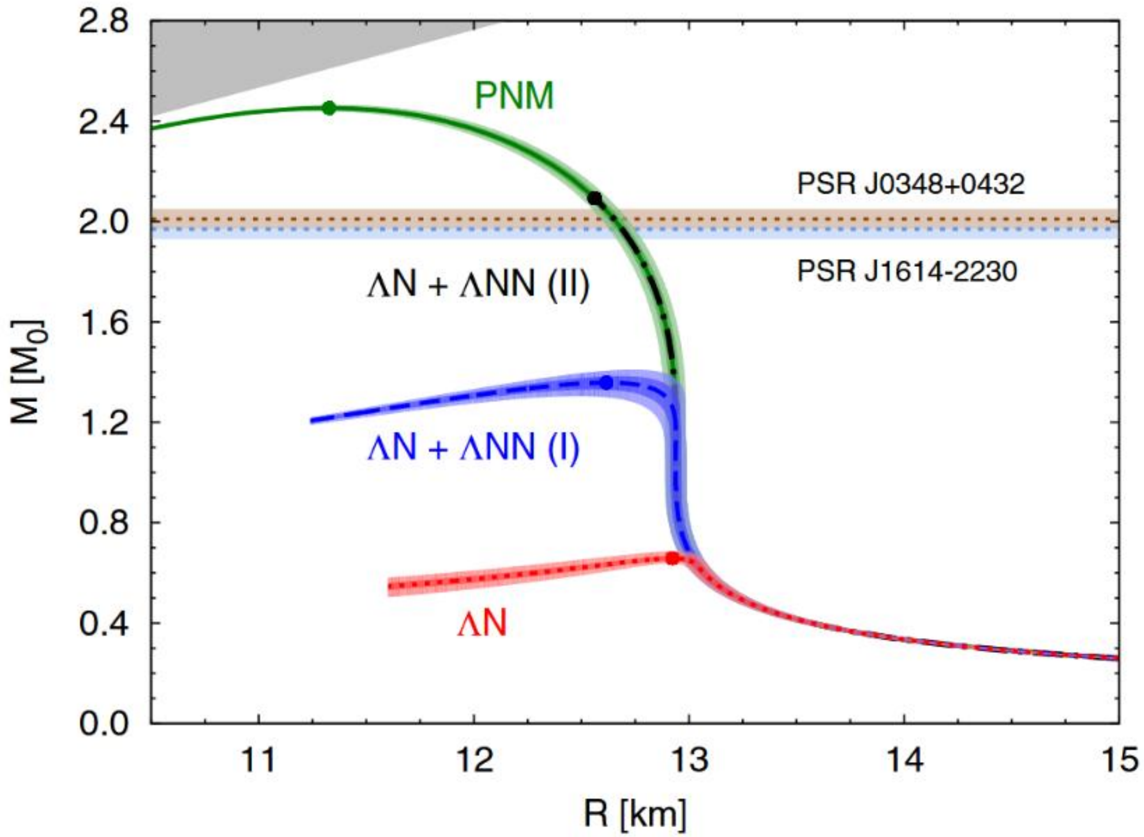


Introduction : Y-N interaction in dense matter

- **Hyperon puzzle**: do hyperons exist in the dense inner core of neutron stars?

- Hypernuclei serve as a laboratory to study the hyperon−nucleon (YN) interaction





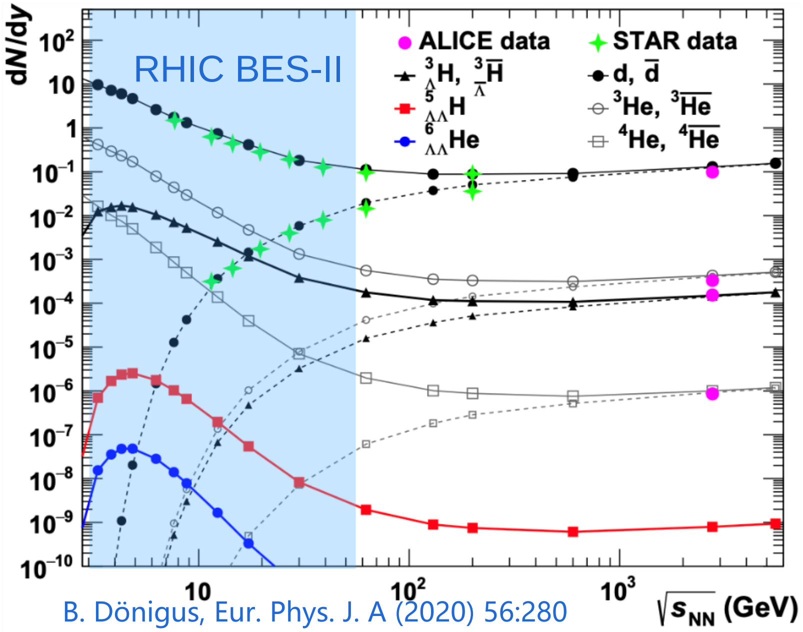
Introduction : hypernuclei in HI collisions

Production mechanism of hypernuclei is still not well understood.

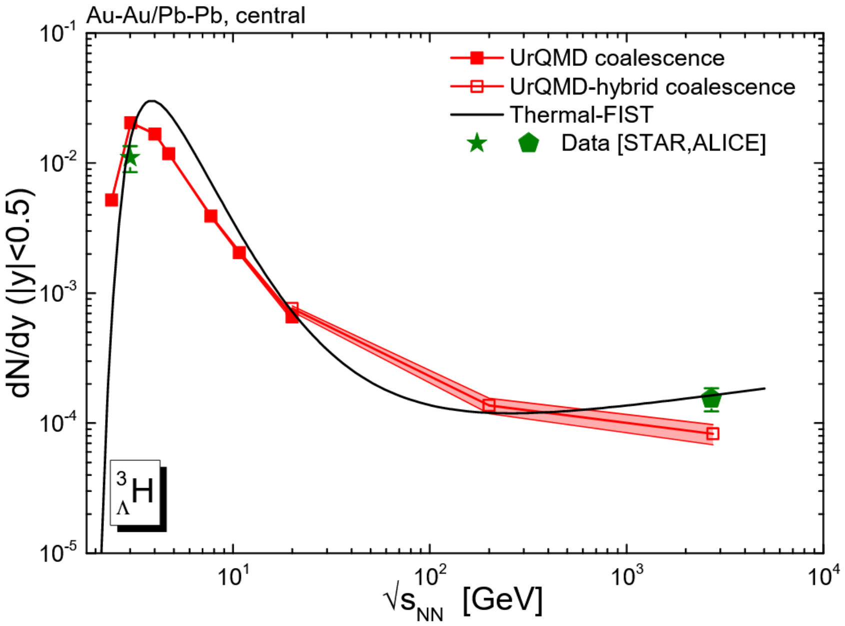
Hypernuclei formation process in relativistic heavy-ion (HI) collisions can be studied through measurements related to **spectra and** collective flow.

- Thermal model and UrQMD+coalescence

- At **low beam energies**, both in thermal model and UrQMD+coalescence model, hypernuclei production is expected to be **enhanced**



B. Dönigus, Eur. Phys. J. A (2020) 56:280
A. Andronic et al. PLB (2011) 697:203–207



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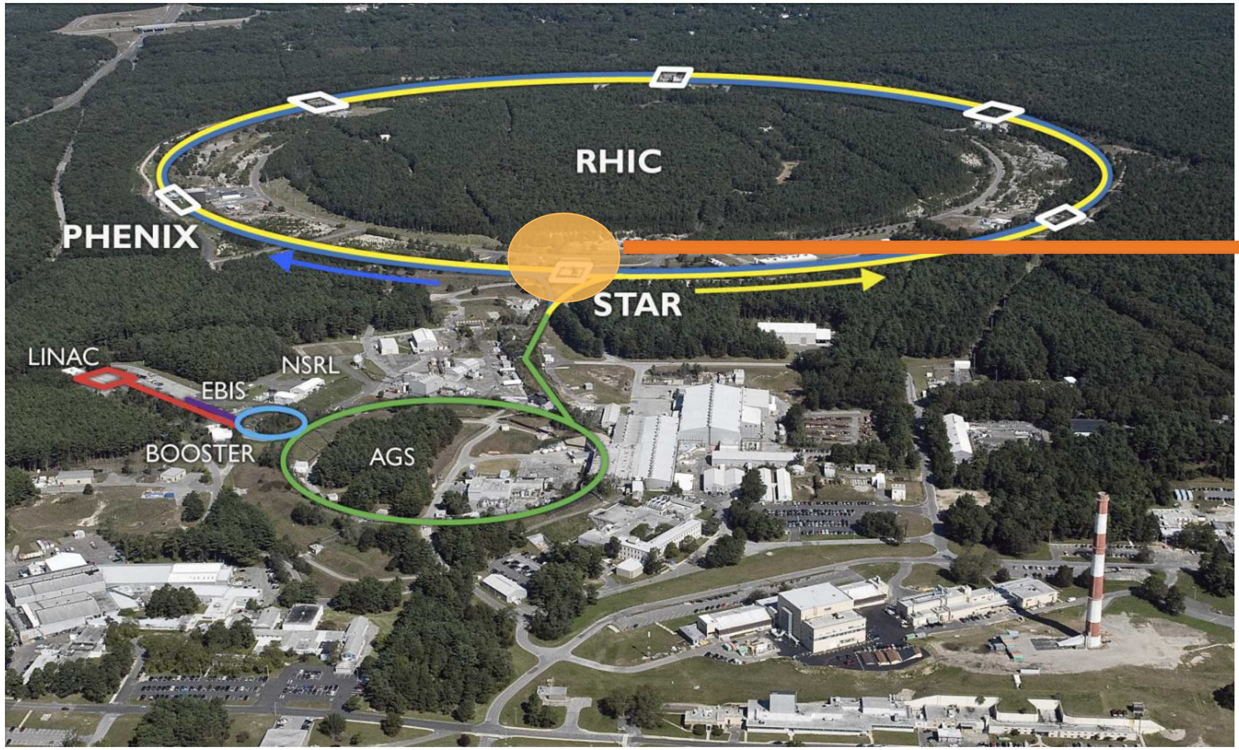
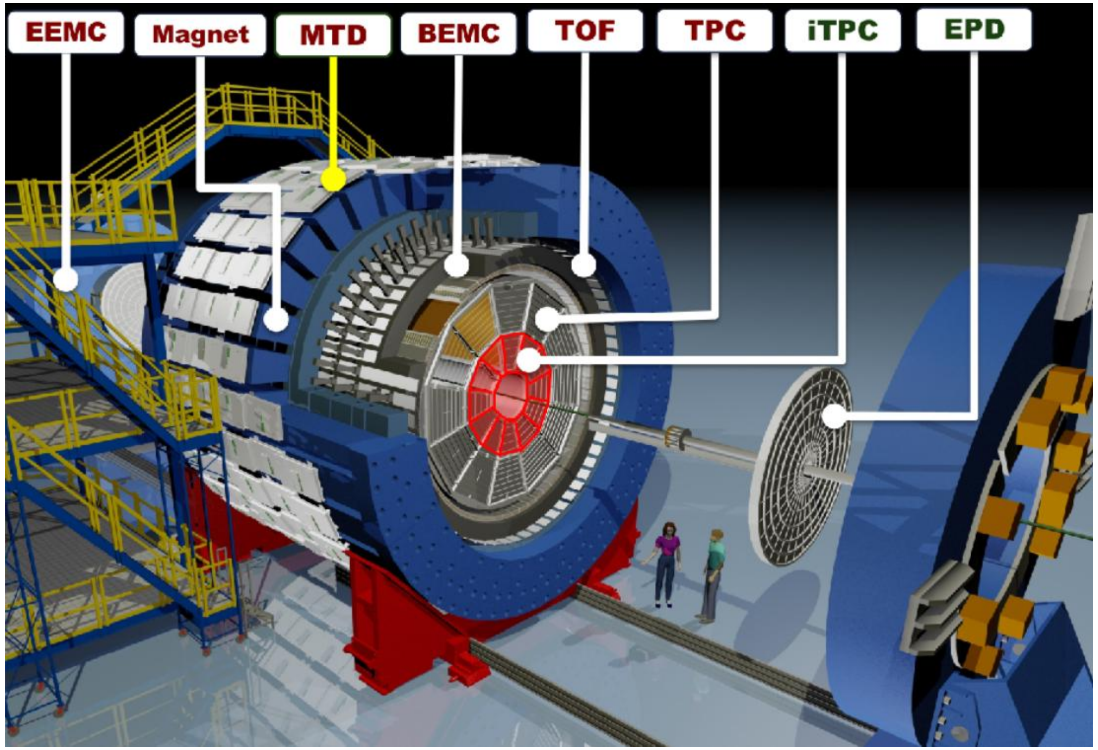
Experimental Setup : Relativistic Heavy Ion Collider (RHIC)





- Collide ion from p, d, He to Cu, Au, Zr, Ru, U
- Central-of-mass energy for Au+Au collisions 3—200 GeV

- Wide and uniform acceptance, full azimuthal coverage, excellent PID capability
- TPC(Time Projection Chamber)+TOF (Time of Flight): particle identification

$$n_\sigma = R^{-1} \ln \frac{\langle (dE/dx)_{\mathrm{exp}} \rangle}{\langle (dE/dx)_{\mathrm{th}} \rangle} \qquad \beta = \frac{L}{ct} \qquad \frac{m^2}{q^2} = \frac{p^2}{q^2}\left(\frac{1}{\beta^2} - 1\right)$$

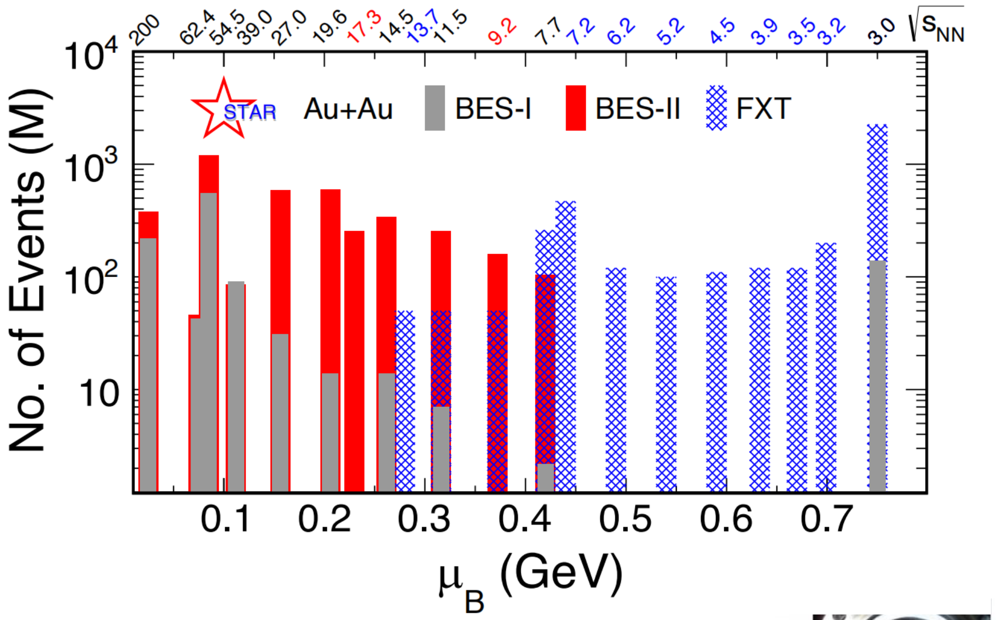
Experimental Setup : RHIC BES-II

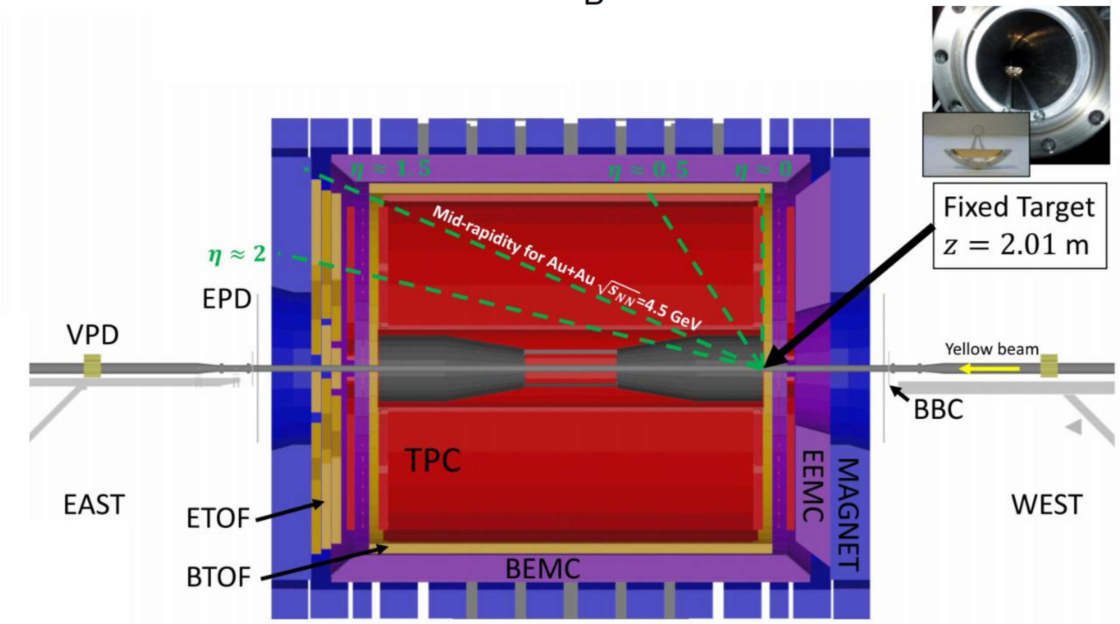
- RHIC beam energy scan Phase II (BES-II)
  - Specific focus on low $\sqrt{s_{NN}}$

    Include fixed target (FXT) mode extends down to 3.0 GeV, increase μ_B range from ~400 MeV to ~700 MeV

  - High statistics data
  - Improve systematics
    - Detector upgrade: iTPC, EPD, eTOF

Enhances the capability of various measurements with excellent precision





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Yield Analysis Flow

Particle Identification

⇩

Reconstruct $^{3}_{\Lambda}H$ candidates in different and rapidity ranges

⇩

Calculate efficiency

⇩

Correct the raw signal counts with efficiency

⇩

Differential p_T spectra

⇩

dN/dy and $\langle p_T \rangle$

⇩

Uncertainty Estimations

⇩

Uncertainty Estimations

Dataset and event selections

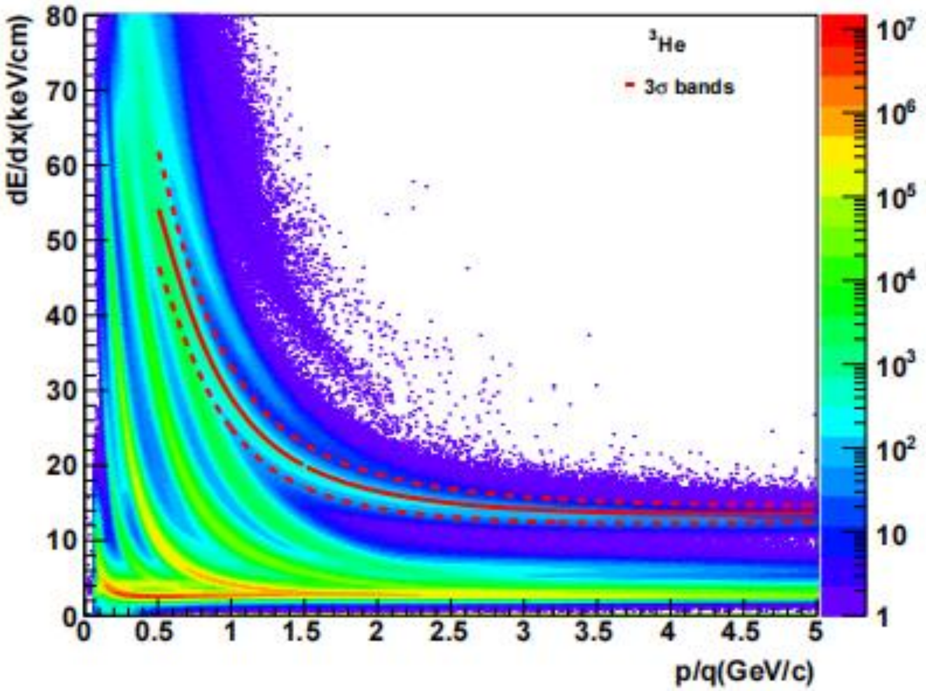
	information
Dataset	Data: production_13p5GeV_fixedTarget_2020 Star Library:P21id
Trigger	750000
Badrun	21034002,21034007 https://drupal.star.bnl.gov/STAR/pwg/common/bes-ii-run-qa/FXT-datasets
Rapidity convention	y = -1*($y_{lab} - y_{\mathrm{beam}}$), y_{beam} = -1.68 at FXT 5.2 GeV
Vertex cuts	198 < Vz < 202 cm $\sqrt{(Vx+0.3)^2+(Vy+2)^2} < 2$
Centrality definition& pileup rejection	https://drupal.star.bnl.gov/STAR/system/files/2023_0718_AuAu5p2Cent.pdf
Number of events	~ 89M good events(0-80% centrality)
Embedding request id	0223001
Track Cuts	pion p_T >0.1 GeV/c He3 p >0.4 GeV/c nHitsFit>15 nHitsDedx>5 nHitsFit/nHitsMax ⩾ 0.52

PID based on TPC dE/dx

$^{3}_{\Lambda}H \rightarrow ^{3}_{2}He + \pi^{-}$

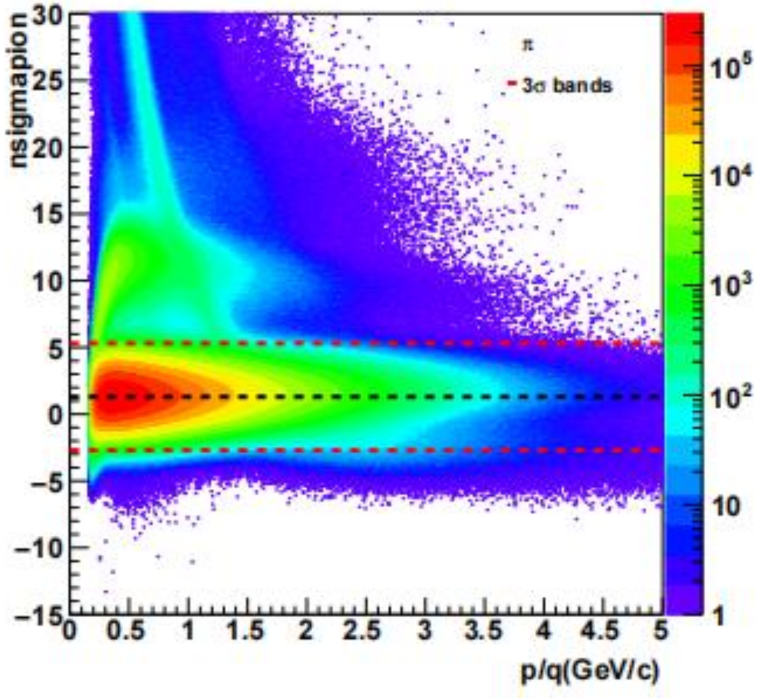
- He3

  ⇨ p/|q|>0.4GeV/c: ±3σ dE/dx band



- Pion:

  ⇨ $|n\sigma_{\pi}$-mean $|<3\ \sigma$



$$n\sigma_{\pi} = \frac{1}{(\frac{dE}{dx})_{error}} ln \frac{< dE/dx >}{(dE/dx)_{bichsel}}$$

Reconstruct ${}^{3}_{\Lambda}H$ candidates

- Reconstructed by KFParticle package

⁎ XY. Ju et al. Nucl.Sci.Tech. 34 (2023) 10, 158

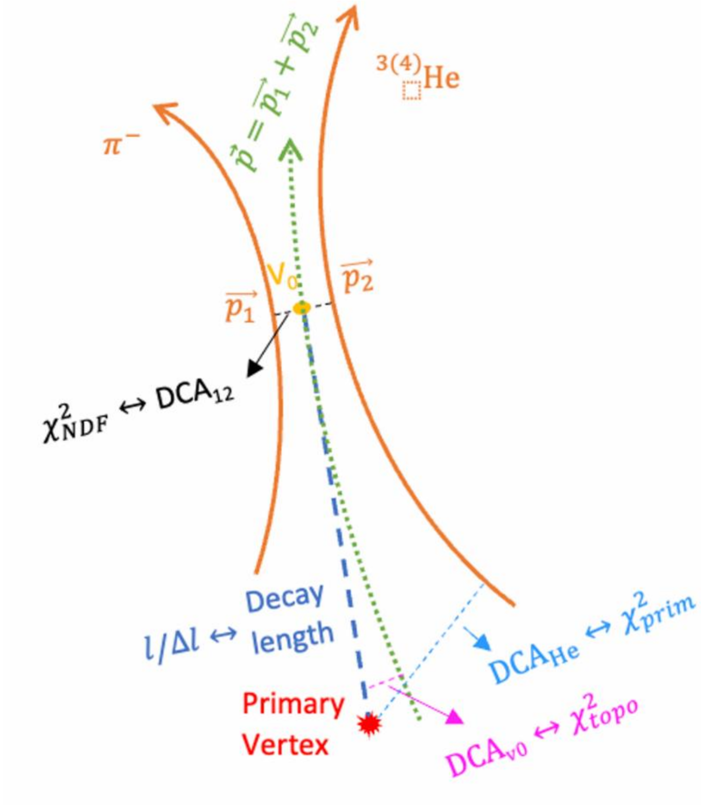
- Background reconstruction

⇨Rotate He3 10°~350° randomly, 20 times statistics

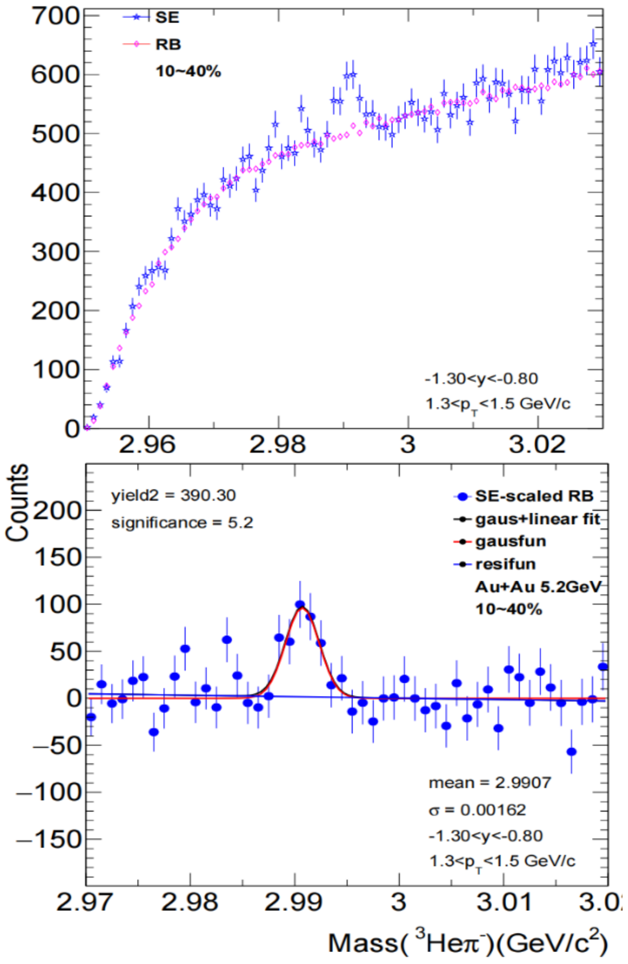
- Topological cuts

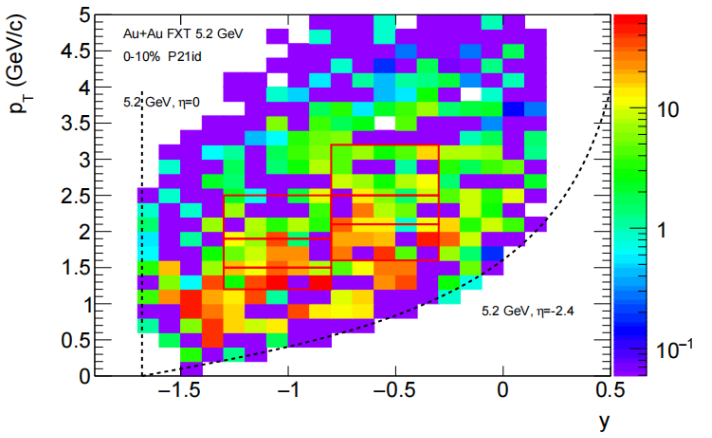
0~10%
l>1
l/dl>6
chi2topo<10
chi2ndf<2.2
chi2primary_pi>5

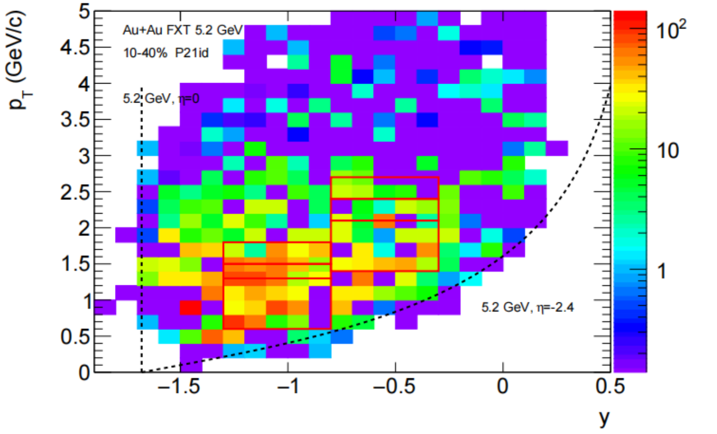
10~40%
l>1
l/dl >1,
chi2topo<10
chi2ndf<4
chi2prim_pi>11



$${}^{3}_{\Lambda}H \rightarrow {}^{3}_{2}He + \pi^-$$

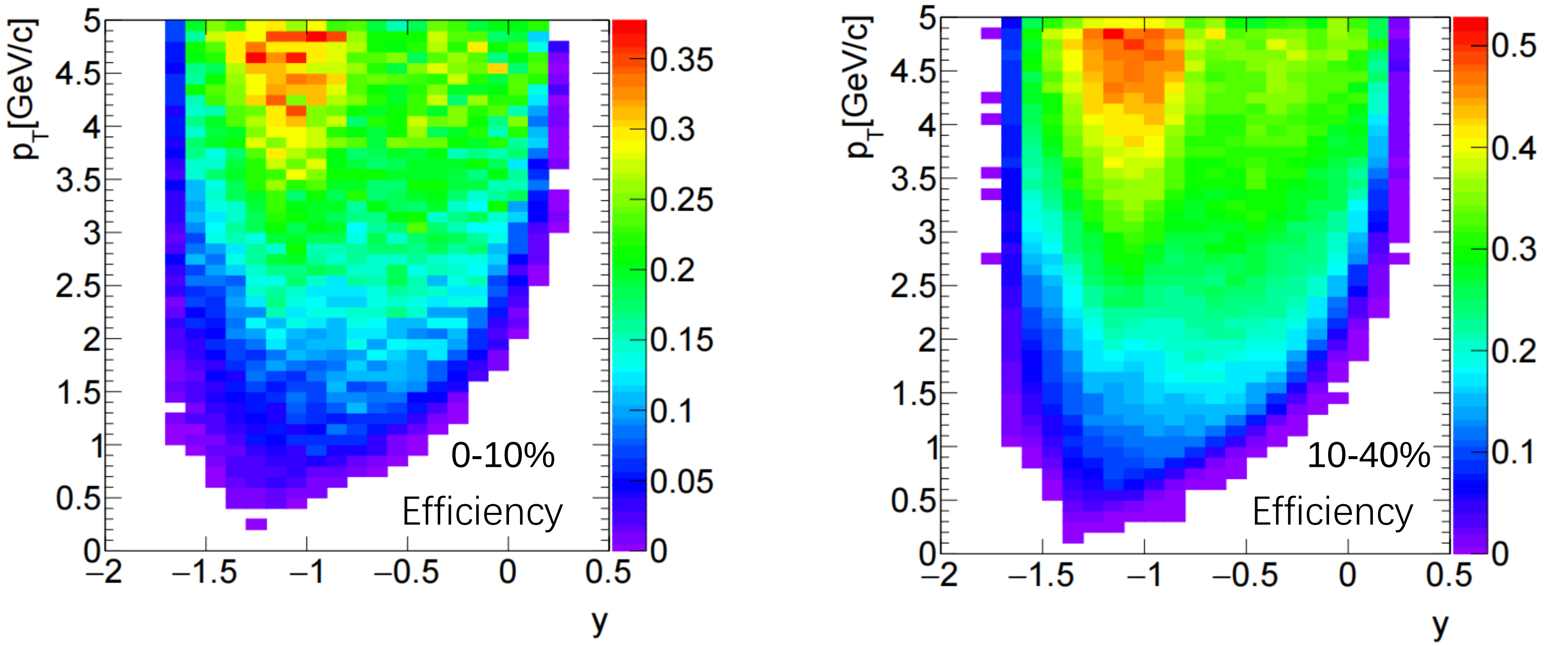




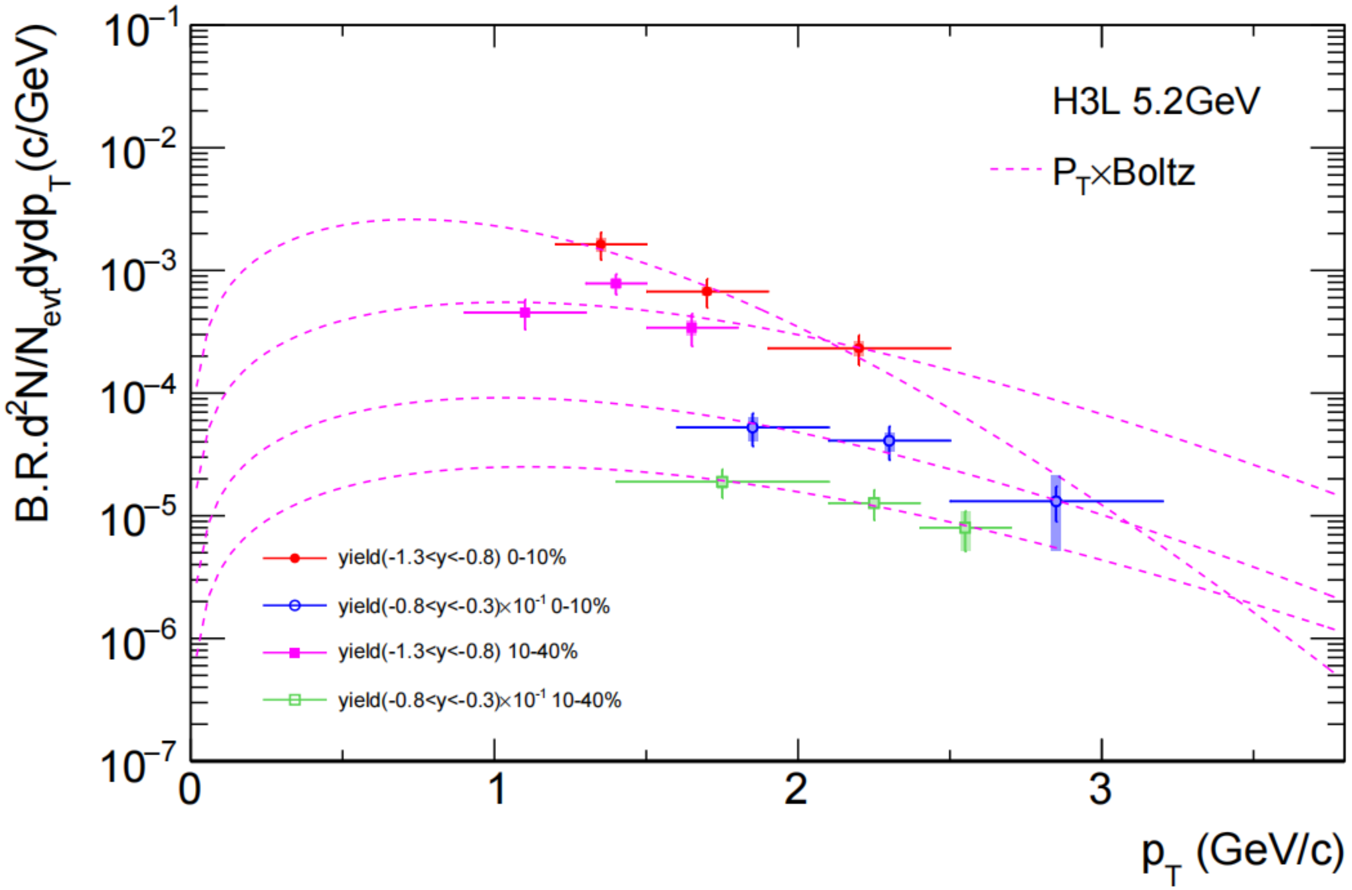


Efficiency calculation

- Reconstructing the embedded H3L signals via the same procedure as data
- To make a fair comparison, weights are added to the embedding simulations
- Calculate efficiency



${}^{3}_{\Lambda}\mathrm{H}$ differential p_T spectra 0-10% and 10-40%



•p_T spectra in 0~10% and 10~40.

Differential p_T spectra:

- Corrected p_T spectra:

$$\frac{1}{2\pi p_T}\frac{d^2N}{dp_T dy} \propto = \frac{N^{Raw}/(\epsilon^{reco} \times \epsilon^{PID})}{2\pi p_T \Delta p_T \Delta y}$$

dN/dy and $\langle p_T \rangle$:

dN/dy:

- Sum of yields in measured p_T region + unmeasured p_T region from function extrapolation
- Stat error: measured region $*$ Fraction, Fraction = Integral(p_T>0)/Integral(measured p_T range) from fitting function

$\langle p_T \rangle$:

$$\langle p_T \rangle = \frac{\int p_T \cdot \frac{d^2N}{dp_T dy} dp_T}{\int \frac{d^2N}{dp_T dy} dp_T}$$

Systematic uncertainty sources

- NHitsFit: nHitsFit>15, 17, 13
- Global average lifetime: H3L= 228.3±12.5 [ps]
- Raw count extraction
- Extrapolation function
- The topological cuts

- for default,var1,var2

⇨sys.err = (max-min)*0.5

(max: maximum value of default,var1,var2)

(min: minimum value of default,var1,var2)

- Total sys.err added quadratically

- Vary raw count extraction

⇨ Vary the Gaussian+Linear fitting range

[2.97,3.02] , [2.97,3.01] , [2.96,3.02]

- Vary the topological cuts

0-10%

l >0,1, 3

chi2topo<8,10,12

chi2ndf<1.5,2.2, 3.5

chi2primary_pi>3,5,7

10-40%

l>0,1, 3

chi2topo<8,10,12

chi2ndf<3,4,5

chi2prim_pi>8,11,15

- Vary extrapolation function

⇨ function styles:

$C \cdot m_T exp(-\frac{m_T}{T})$ boltzmann(default)

$C \cdot exp(-\frac{m_T}{T})$ m_T exp

$C \cdot exp(-\frac{{p_T}^2}{\mu})$ p_T Gaus

$C \cdot exp(-\frac{p_T^{3/2}}{\mu})$ $p_T^{3/2}$ exp

$\int_0^R rdrm_T I_0(\frac{p_T sinh\rho(r)}{T_{kin}}) * K_1(\frac{m_T cosh\rho(r)}{T_{kin}})$ blast wave

⇨ function parameters： Bootstrap

Red denotes cuts variations in systematic uncertainty study

Systematic Uncertainties of dN/dy and $\langle p_T \rangle$

Dataset	Au+Au collisions at $\sqrt{s_{NN}}$ = 5.2 GeV	
Centrality	0 – 10%	10 – 40%
Tracking efficiency	10%	10%
${}^{3}_{\Lambda}$H lifetime	5%	2%
Topological cuts	11%	8%
Raw count extraction	10%	0%
Extrapolation	30%	14%

在$\sqrt{s}$NN =5.2GeV时，目标速度$-1.3<y<-0.8$时，Au+Au碰撞中dN/dy的 相对系统不确定度

Dataset	Au+Au collisions at $\sqrt{s_{NN}}$ = 5.2 GeV	
Centrality	0 – 10%	10 – 40%
Tracking efficiency	11%	10%
${}^{3}_{\Lambda}$H lifetime	3%	0%
Topological cuts	12%	0%
Raw count extraction	0%	0%
Extrapolation	27%	18%

在$\sqrt{s}$NN =5.2GeV时，目标速度$-0.8<y<-0.3$时，Au+Au碰撞中dN/dy的 相对系统不确定度

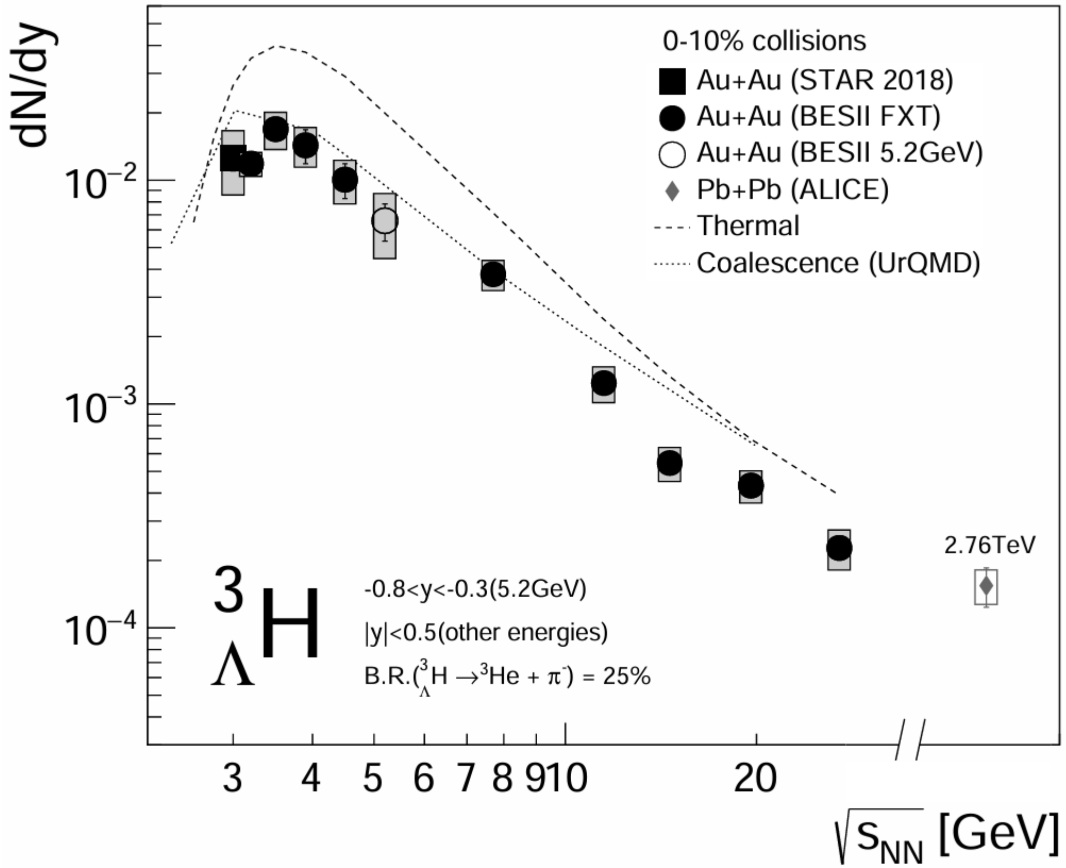
Dataset	Au+Au collisions at $\sqrt{s_{NN}}$ = 5.2 GeV	
Centrality	0 – 10%	10 – 40%
Tracking efficiency	0%	0%
${}^{3}_{\Lambda}$H lifetime	0%	1%
Topological cuts	4%	6%
Raw count extraction	0%	0%
Extrapolation	6%	4%

在$\sqrt{s}$NN =5.2GeV时，目标速度$-1.3<y<-0.8$时，Au+Au碰撞中$\langle p_T \rangle$的 相对系统不确定度

Dataset	Au+Au collisions at $\sqrt{s_{NN}}$ = 5.2 GeV	
Centrality	0 – 10%	10 – 40%
Tracking efficiency	0%	0%
${}^{3}_{\Lambda}$H lifetime	0%	0%
Topological cuts	3%	5%
Raw count extraction	0%	1%
Extrapolation	4%	2%

在$\sqrt{s}$NN =5.2GeV时，目标速度$-0.8<y<-0.3$时，Au+Au碰撞中$\langle p_T \rangle$的 相对系统不确定度

Energy dependence of ${}^{3}_{\Lambda}H$ production

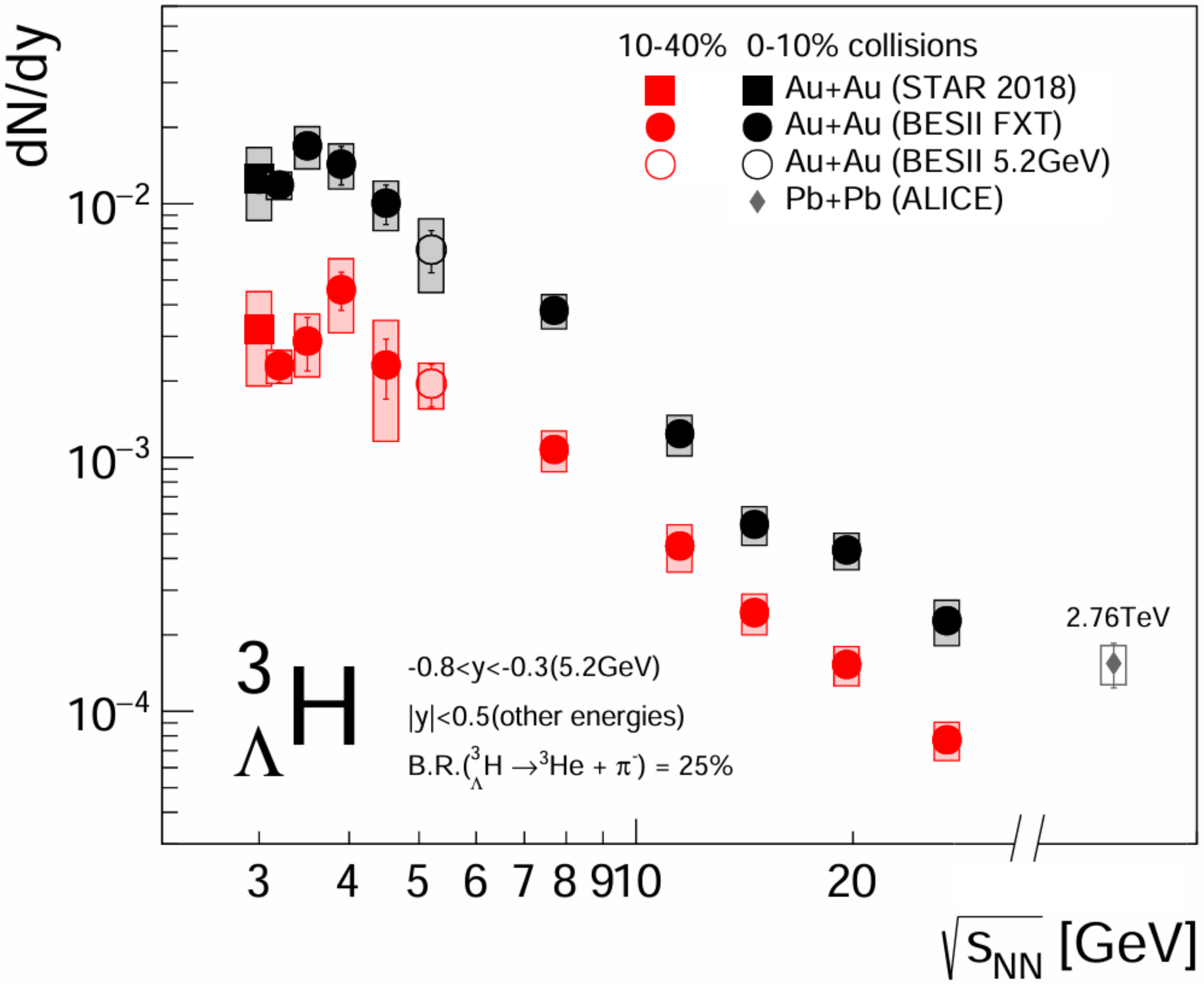


- Yields increase strongly from $\sqrt{s_{NN}} = 27$ GeV to ~4GeV
- Peak at 3-4 GeV
- Hadronic transport + coalescence models qualitatively describe the data
- Thermal model overestimates the data

First energy dependence of ${}^{3}_{\Lambda}H$ production yields in the high-baryon-density region

STAR, PRL 128 (2022) 202301
ALICE, PLB 754 (2016) 360
T. Reichert, et al, PRC 107 (2023) 014912

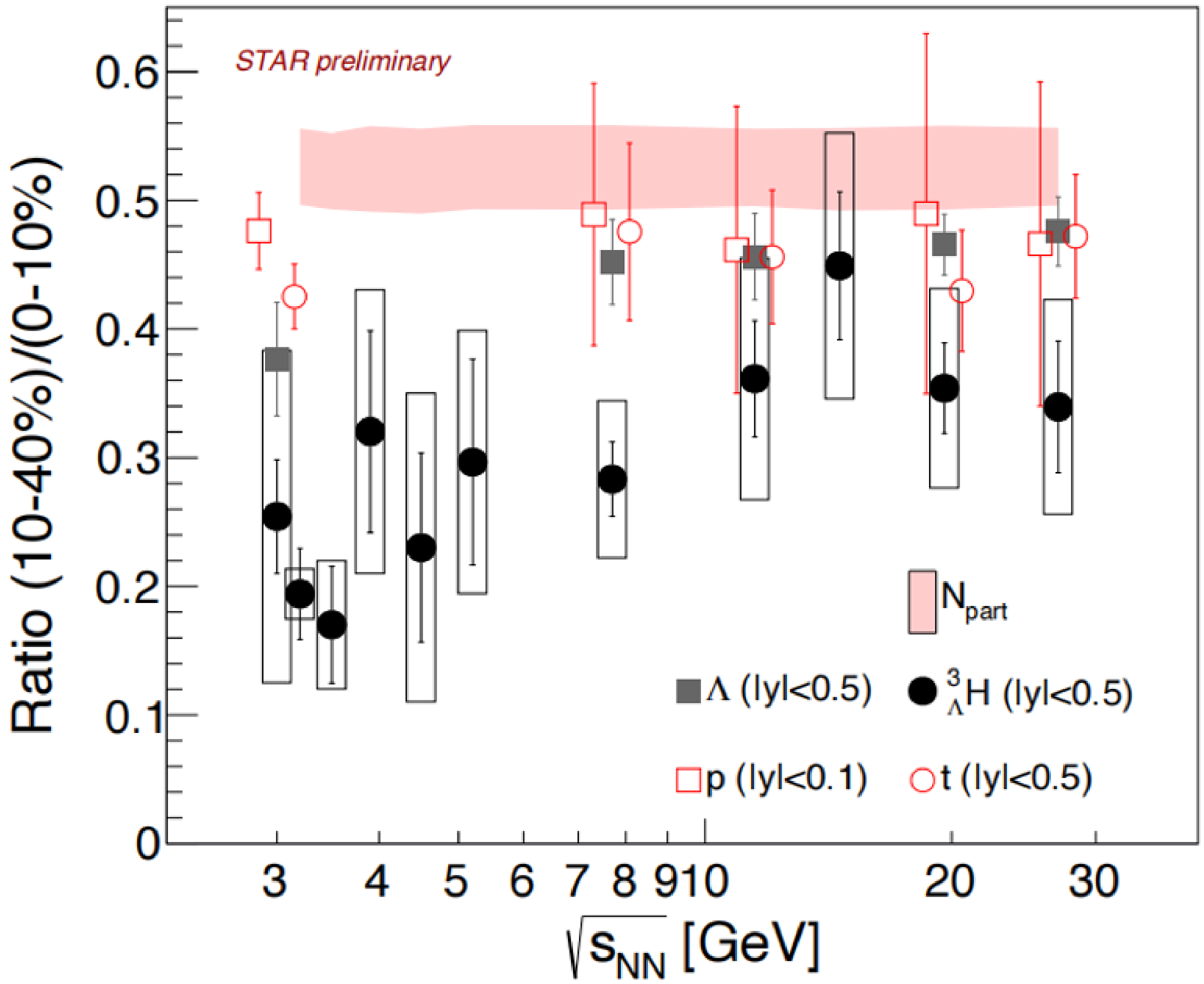
Centrality dependence of $^{3}_{\Lambda}H$ production



- Similar trend in central (0-10%) and mid-central (10-40%) collisions

STAR, PRL 128 (2022) 202301
ALICE, PLB 754 (2016) 360

Centrality dependence of ${}^{3}_{\Lambda}\mathrm{H}$ production

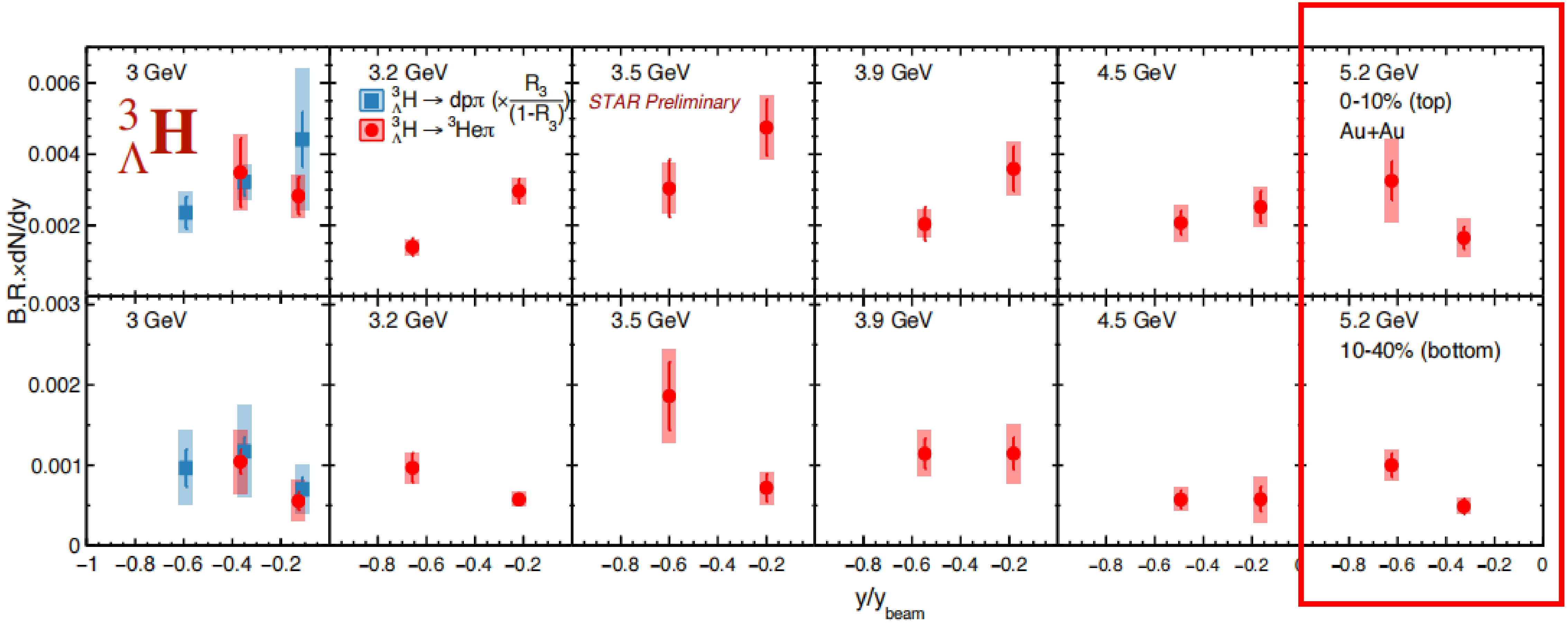


- For ${}^{3}_{\Lambda}\mathrm{H}$, a significant depression conpared to was observed compared to the Npart result and it was more pronounced where the system collision energy was less than 7.7 GeV.

This might imply that the hypernucleus yield is related to the geometry of the system.

STAR, PRL 128 (2022) 202301
ALICE, PLB 754 (2016) 360

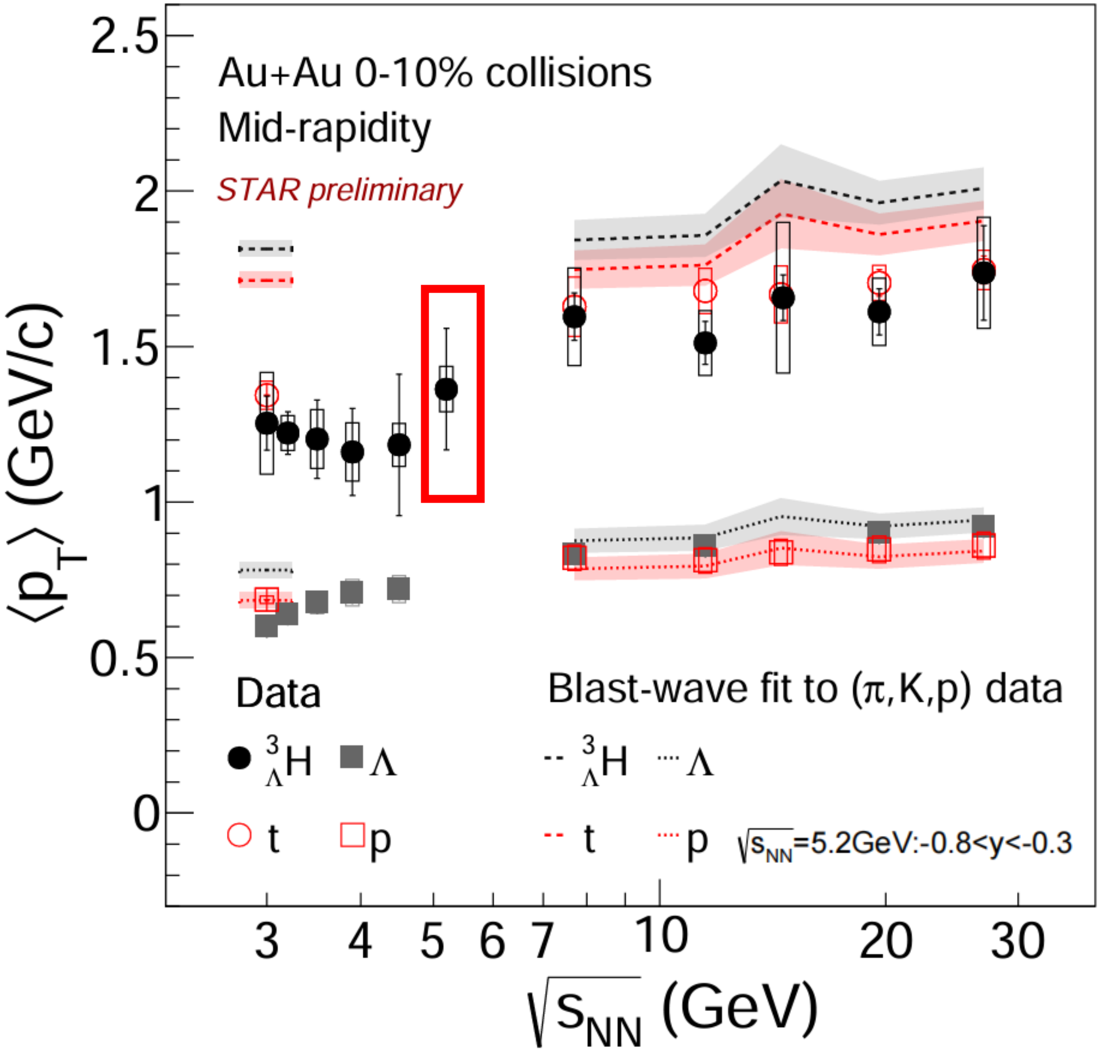
${}^{3}_{\Lambda}H$ rapidity dependence



- The yields at 5.2 GeV and other energies are comparable.

⇨ The tendency rapidity dependence of ${}^{3}_{\Lambda}H$ yields at 5.2 GeV is similar to those of other energies in 10-40%.

Energy dependence of ${}^{3}_{\Lambda}\mathrm{H}$ $\langle p_T \rangle$



- Similar $\langle p_T \rangle$ for ${}^{3}_{\Lambda}\mathrm{H}$ and t
- Hint of ${}^{3}_{\Lambda}H$ and t $\langle p_T \rangle < \langle p_T \rangle^{BW}$ especially >7.7GeV

Blast-wave expectation calculated using measured kinetic freeze-out parameters from light hadrons (π, K, p)spectra

${}^{3}_{\Lambda}\mathrm{H}$ and t might do not follow same collective expansion as light hadrons. Can be interpreted as ${}^{3}_{\Lambda}\mathrm{H}$ and t decoupling at different times compared to light hadrons

- Different trend around $\sqrt{S_{NN}} = 4.5$ GeV

  ⇒ This might imply the existence of a critical point between them or suggest different expansion dynamics?

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Motivation

- UrQMD combined coalescence model can give a good description of $^{3}_{\Lambda}\mathrm{H}$ yields
- The yield ratio of $^{3}_{\Lambda}\mathrm{H}$ at different centers was significantly lower than that of the hadron, indicating that the production of loosely bound $^{3}_{\Lambda}\mathrm{H}$ is related to the system geometry
- Looking forward to using this model to conduct a collision system-dependent model study on light nuclei under different collision systems (Ru+Ru, Zr+Zr system and Au+Au collision system)

UrQMD via phase-space coalescence

(i) During the evolution of the system, we follow theprotons and neutrons until their individual space-timepoints of last interaction.

(ii) For each p-n pair, the momentum and position of proton and neutron is boosted to the two-particle rest frame of this p-n pair.

(iii) We calculate the relative momenta $\Delta p = |\vec{p}_1 - \vec{p}_2|$and the relative distances $\Delta r = |\vec{x}_1 - \vec{x}_2|$ | of the p-n pair in the two-particle rest frame at equal times. The yield of deuteron candidates is then given by the condition of $\Delta p < \Delta p_{max}$ and $\Delta r < \Delta r_{max}$. Here we use the parameter set of Δp_{max} = 0.285 GeV/c and Δr_{max} = 3.575 fm

(iv) the chosen p-n pair is marked as a deuteron and its constituent nucleons are removed from the phase-space distribution. PHYSICAL REVIEW C 99, 014901 (2019)

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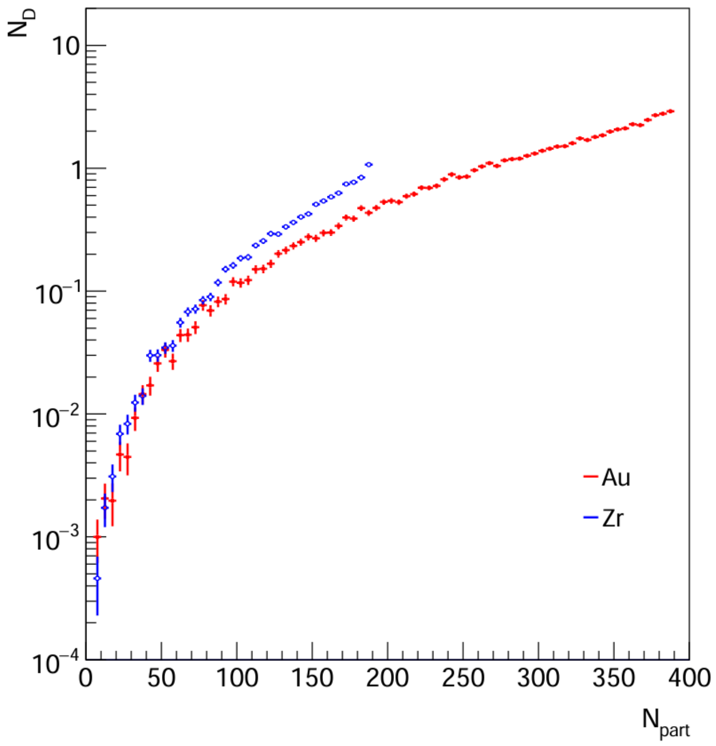
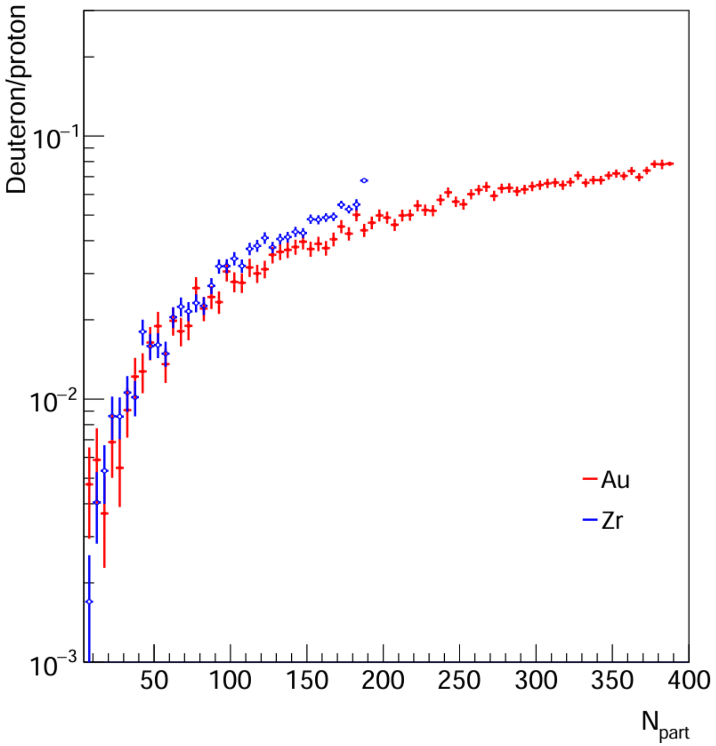
Deuteron and Deuteron/Proton vs Npart

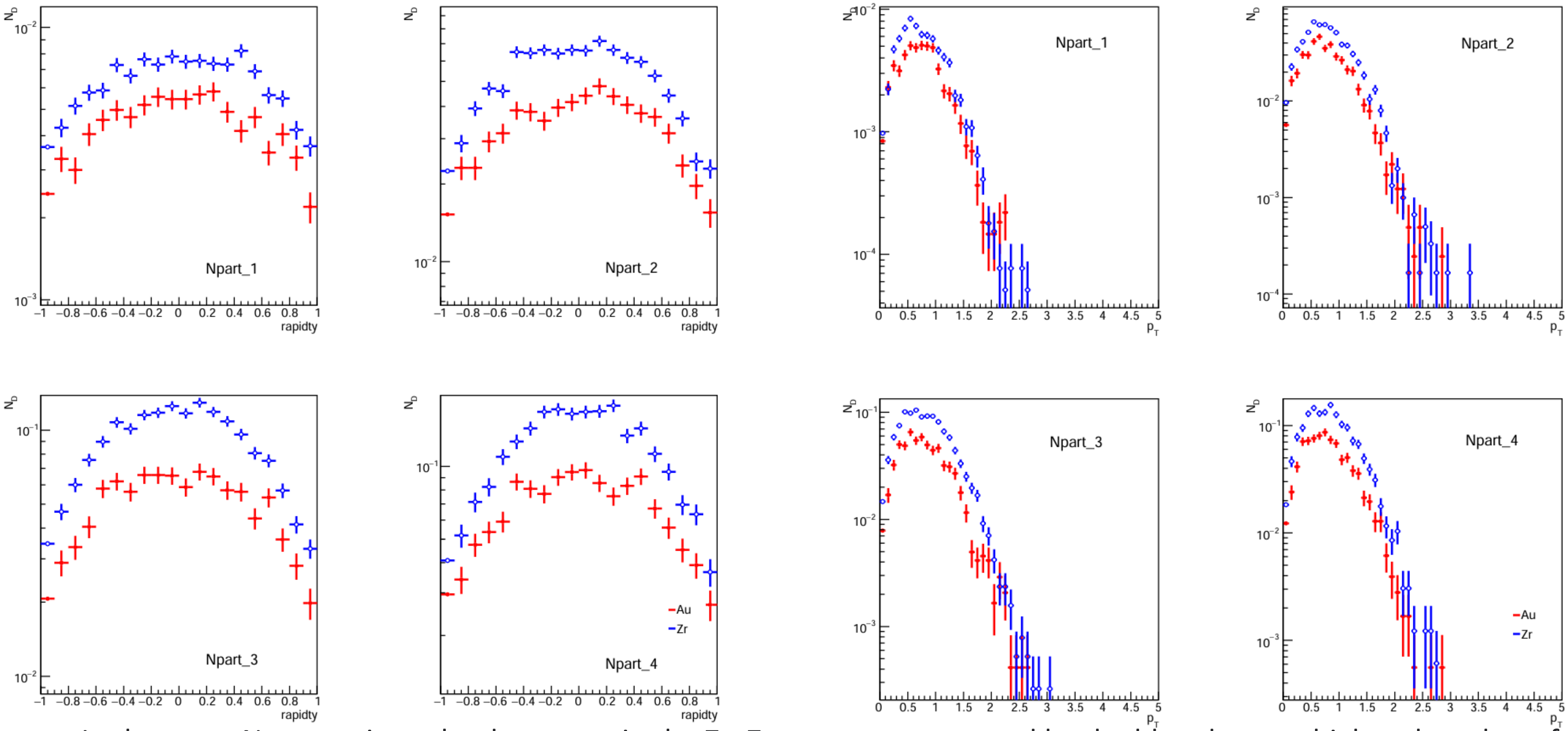




- In the high Npart region , the deuterons in the Zr+Zr system represented by the blue dots under the same Npart are higher than that of the Au+Au system represented by the red dot.

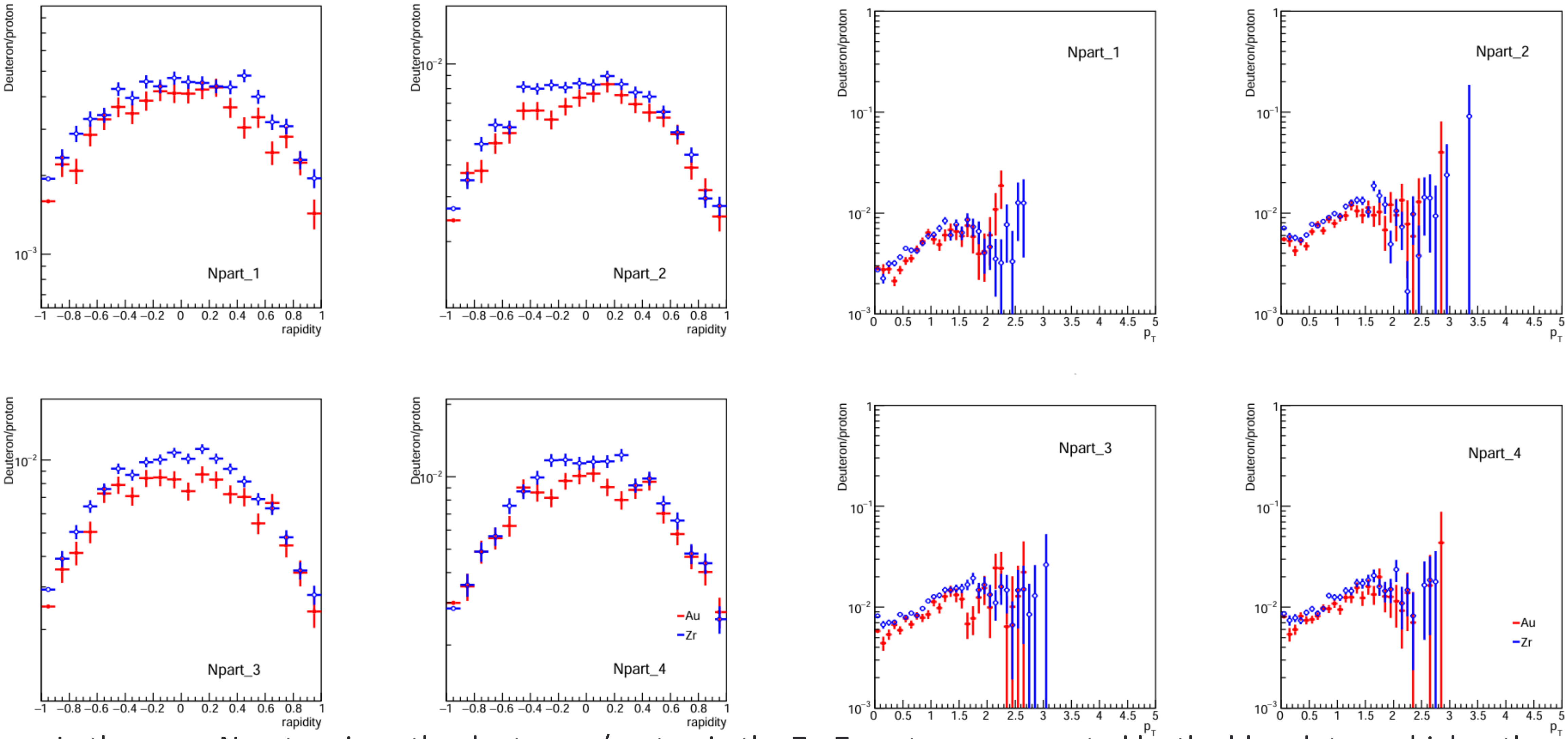
Deuteron vs rapidity and $\langle p_T \rangle$

Npart_1 (0, 112), Npart_2 (112, 149), Npart_3 (149, 173), Npart_4 (173, 192)



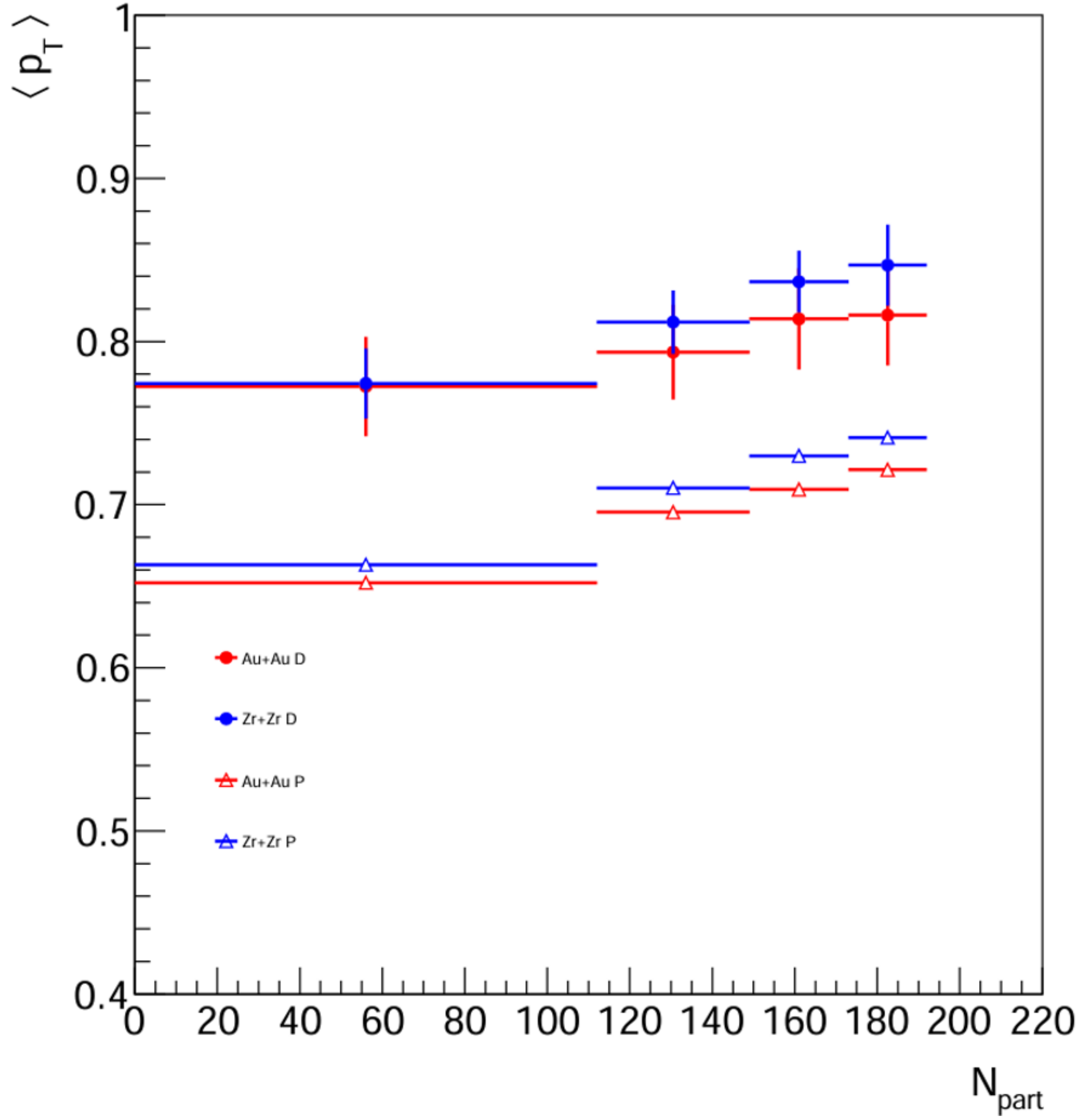
- In the same Npart region, the deuterons in the Zr+Zr system represented by the blue dots are higher than that of the Au+Au system represented by the red dot.

Deuteron/Proton vs rapidity and $\langle p_T \rangle$



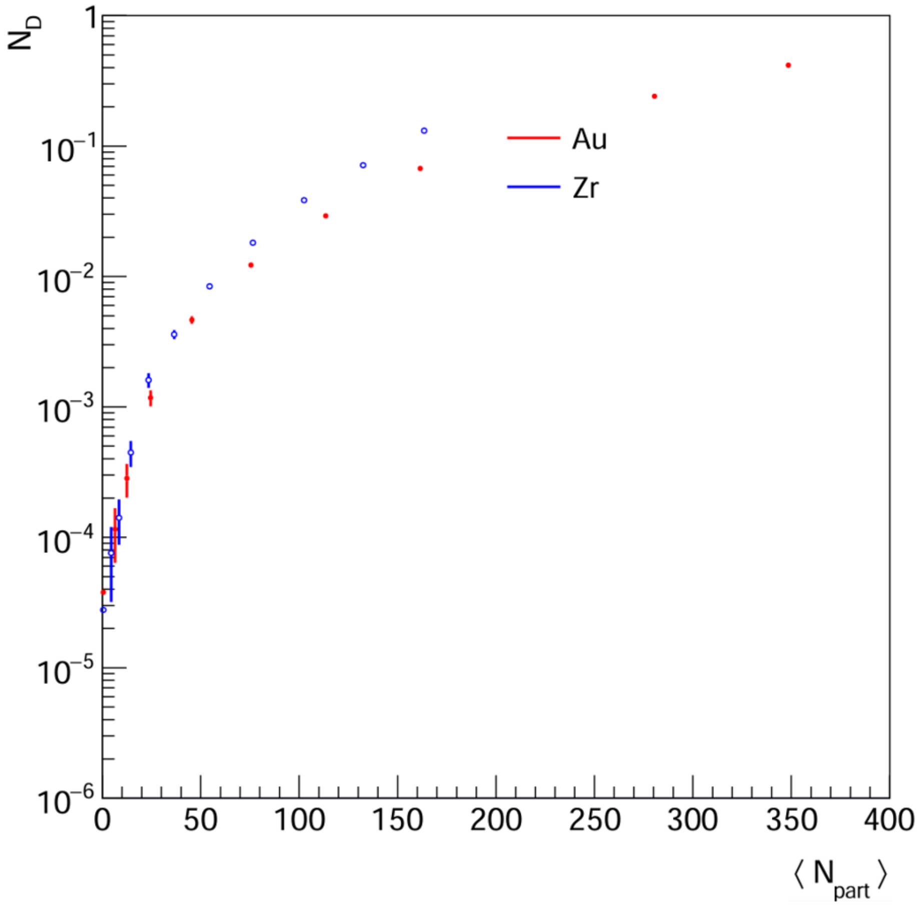
- In the same Npart region , the deuterons/proton in the Zr+Zr system represented by the blue dots are higher than that of the Au+Au system represented by the red dot.

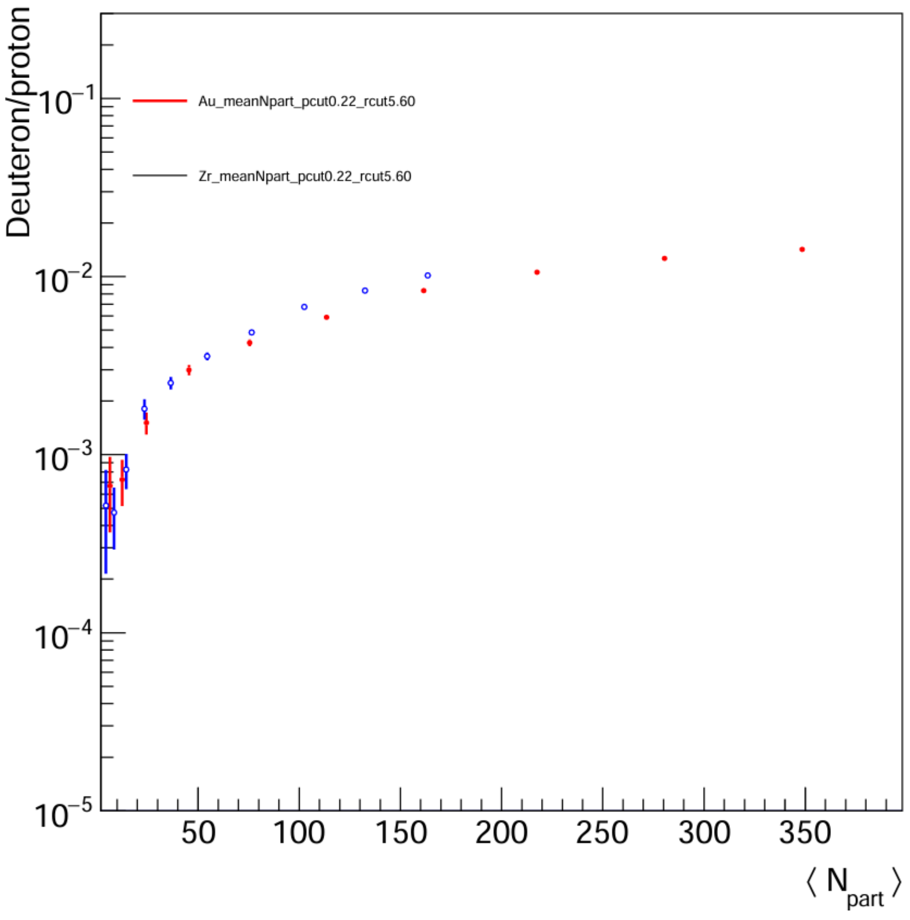
⟨p_T⟩ vs Npart



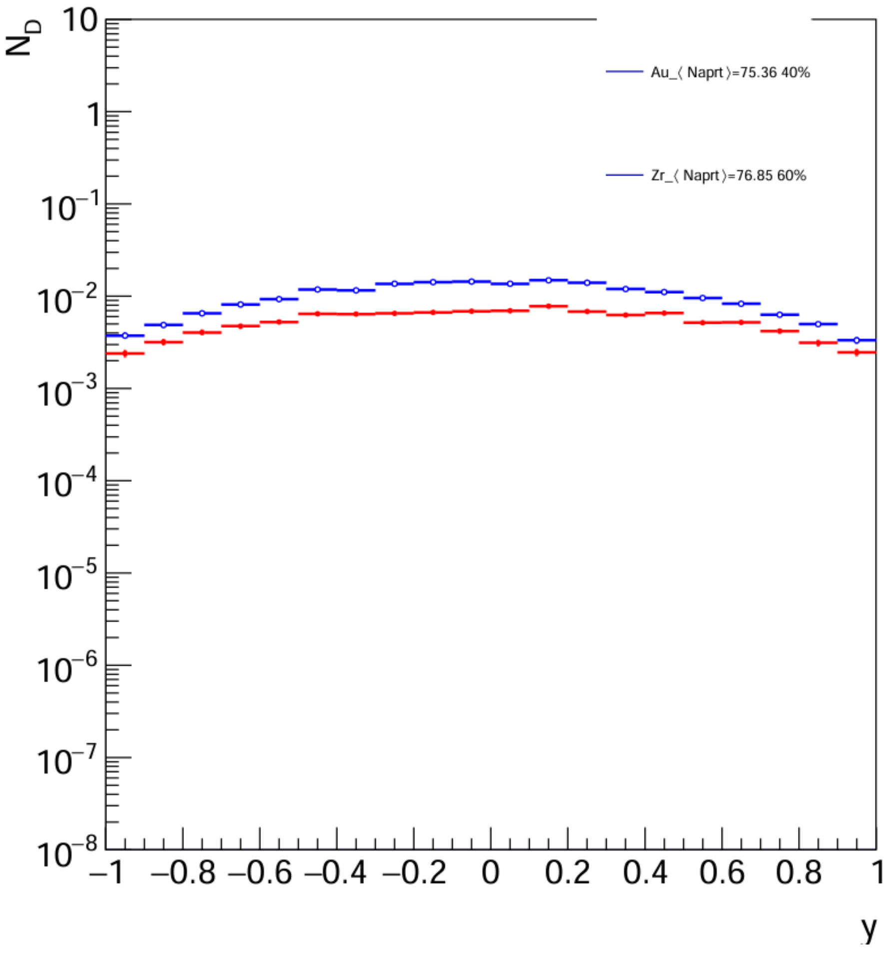
yulou

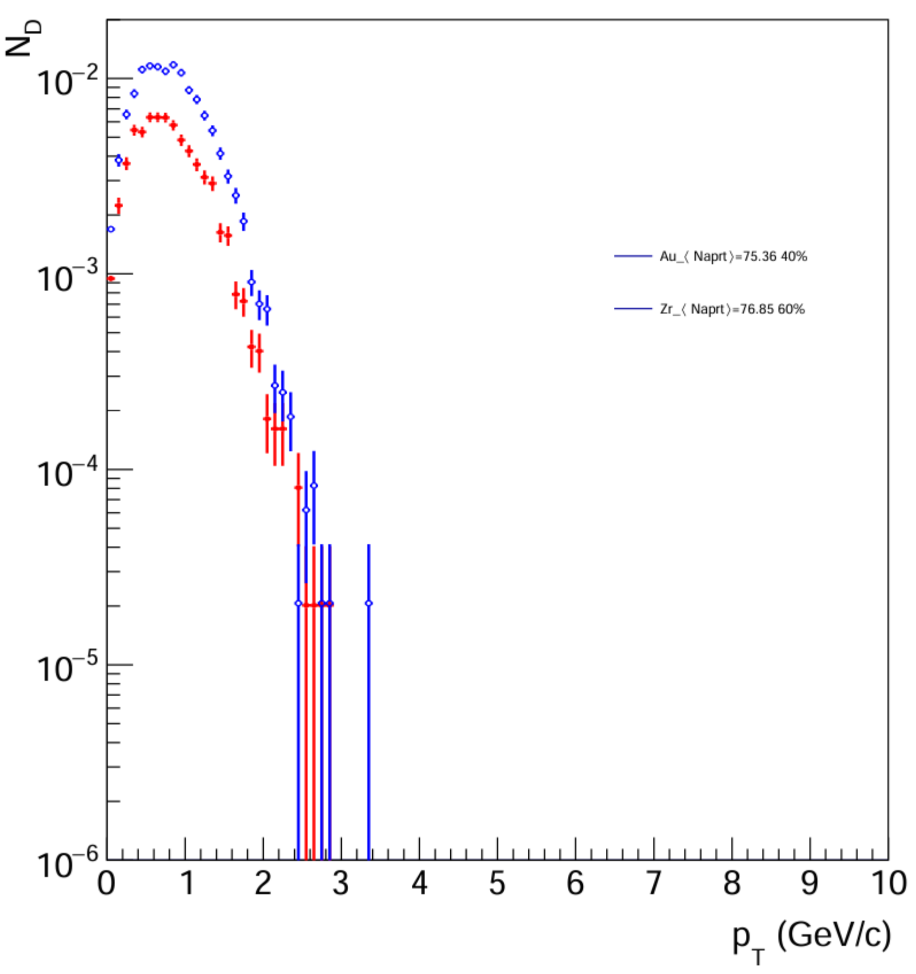
Deuteron and Deuteron/Proton vs ⟨Npart⟩





Deuteron vs rapidity and $\langle p_T \rangle$





Outline

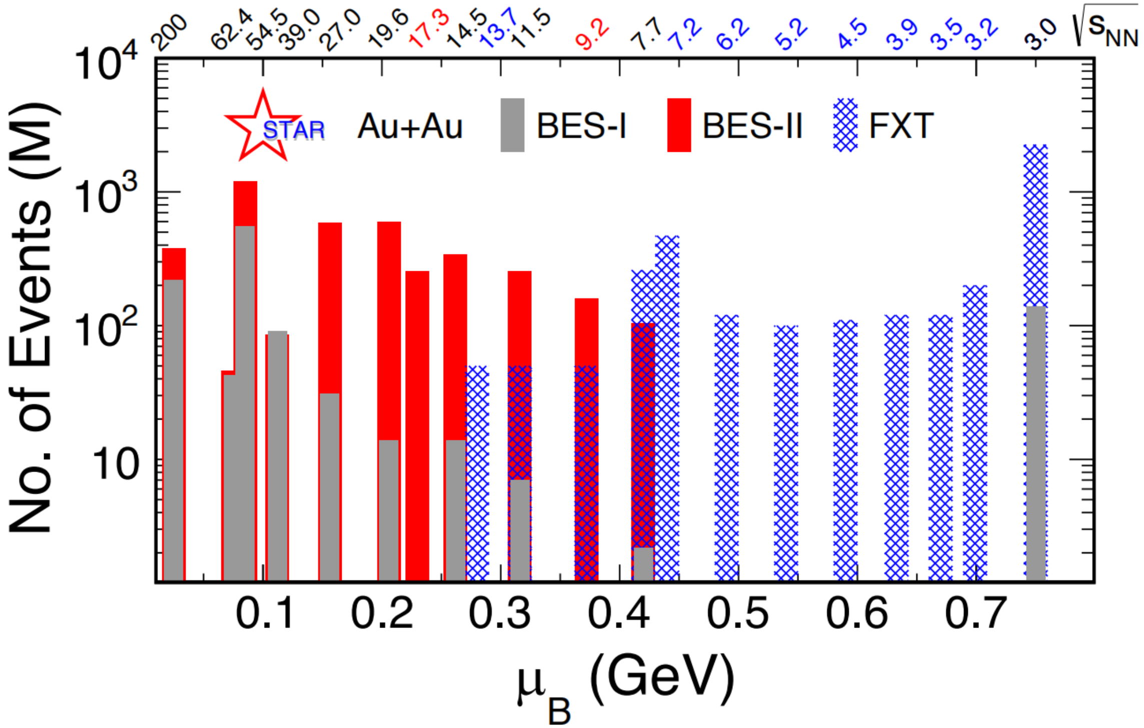
- Experimental measurement of ${}^{3}_{\Lambda}\mathrm{H}$ of AuAu fxt 5.2GeV at STAR
  - ⇨Introduction
  - ⇨ Experimental Setup
  - ⇨ Yield Analysis, Results and Discussion
- models calculation about system dependence of light nucleus generation
  - ⇨ Motivation
  - ⇨Results
- Summary and Outlook

Summary

- This paper presents the yield measurement results of ${}^{3}_{\Lambda}\mathrm{H}$ in a fixed-target Au+Au collision with an energy of $\sqrt{S_{\mathrm{NN}}}$ =5.2 GeV in 2020
  - ➢ The results at 5.2 GeV follows the trend of dN/dy varying with energy from 3 GeV to 27 GeV
  - ➢ Combined with other energy points, they present first measurement of ${}^{3}_{\Lambda}\mathbf{H}$ energy dependence in the high-baryon-density region
    - ✓ Yield of ${}^{3}_{\Lambda}\mathbf{H}$ increases rapidly as the collision energy decreases and peaks around 3-4 GeV
    - ✓ The yields ratios of ${}^{3}_{\Lambda}\mathbf{H}$ between different centralities of 10-40% and 0-10% is significantly smaller than the result of ⟨Npart⟩ especially $\sqrt{S_{\mathrm{NN}}}$ <7.7GeV seems imply that hypernucleus yield is related to the geometry of the system
    - ✓ UrQMD+ coalescence model show a better description than thermal statistical model
    - ✓ ${}^{3}_{\Lambda}\mathrm{H}$ $\langle p_T \rangle$ seems in contradiction to that freeze out at the same time as light hadrons
    - ✓ Different ${}^{3}_{\Lambda}\mathrm{H}$ $\langle p_T \rangle$ trend around $\sqrt{S_{NN}} = 4.5$ GeV seems imply the existence of a critical point or different expansion dynamics

- models calculation about system dependence of light nucleus generation
  - ➢ The same number of participant nucleons (Npart or ⟨Npart⟩) ,the deuteron yields and deuteron/proton ratios in Zr+Zr collisions are higher than those in Au+Au collisions
    - ✓ the large radius of loosely bound nuclei may make their yields possibly related to the geometry of the emission source

Outlook



- Huge datasets enable precision hypernuclei measurements
  - **Run 21, Au+Au 3 GeV, ~2 billion events**
  - Run 18, Isobar 200 GeV, ~6 billion events
- Opportunities for heavier hypernuclei: $\boldsymbol{^4_\Lambda H}$, $\boldsymbol{^4_\Lambda He}$, $^5_\Lambda He$, $^6_\Lambda H$, $^A_{\Lambda\Lambda}H$, $^A_{\Lambda\Lambda}He$
- For the model research of light nuclei, attempt to change the nuclear density distribution for further exploration

Publications and Presentations

- Publications

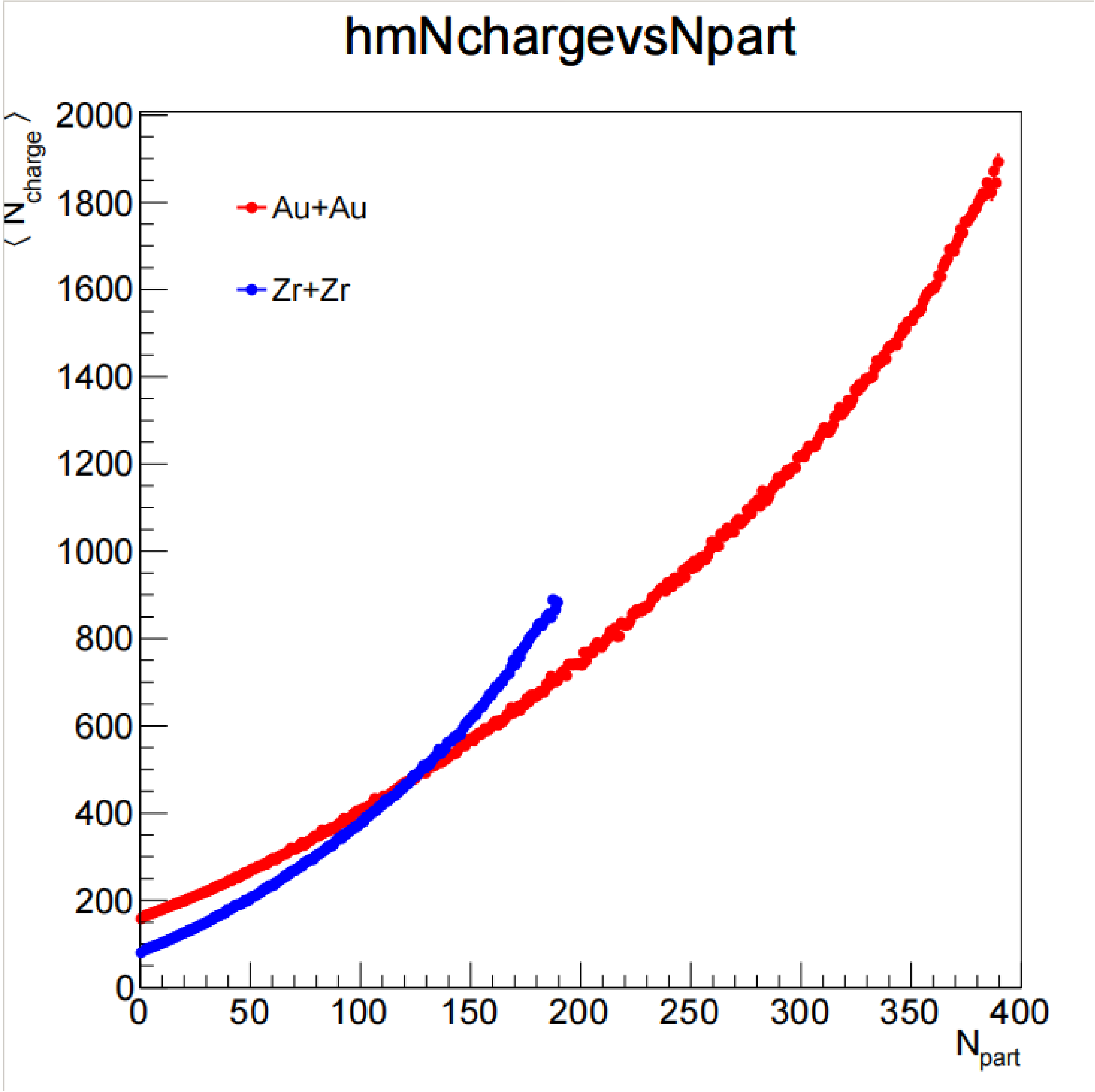
  Analysis Note: Hypertriton production in FXT Au+Au collisions at $\snn$=5.2GeV, PSN=0864,
  https://drupal.star.bnl.gov/STAR/starnotes/private/PSN0864

  Prepare to publish:
  Collision energy dependence of H3L production in Au+Au collisions at RHIC (Principal Author, under STAR GPC review)

- Presentations

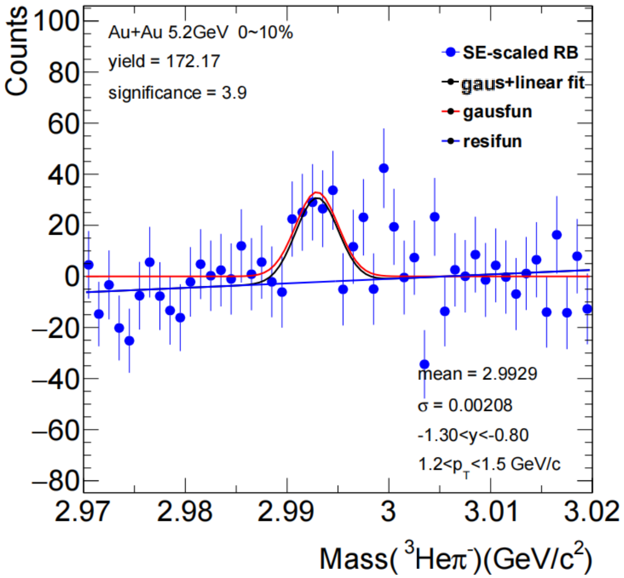
  1. Talk, “Collision Energy Dependence of Hypertriton Production in Au+Au Collisions at RHIC”，中国物理学会高能物理分会第十四届全国粒子物理学术会议,2024,08, Qingdao, China (talk)

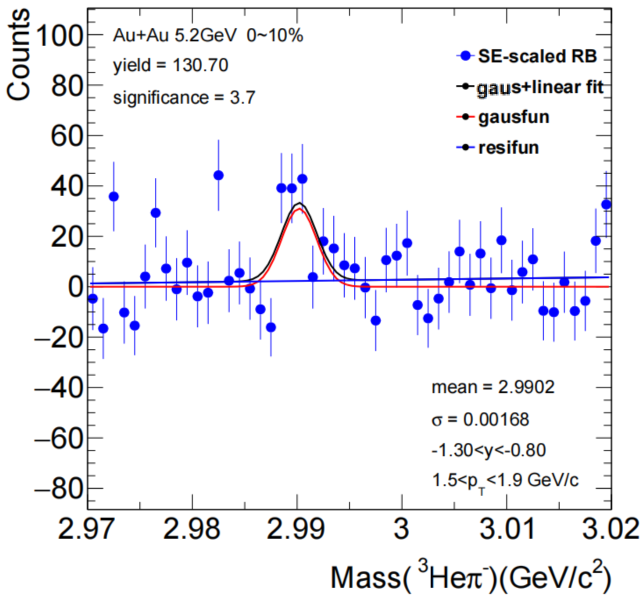
Back up

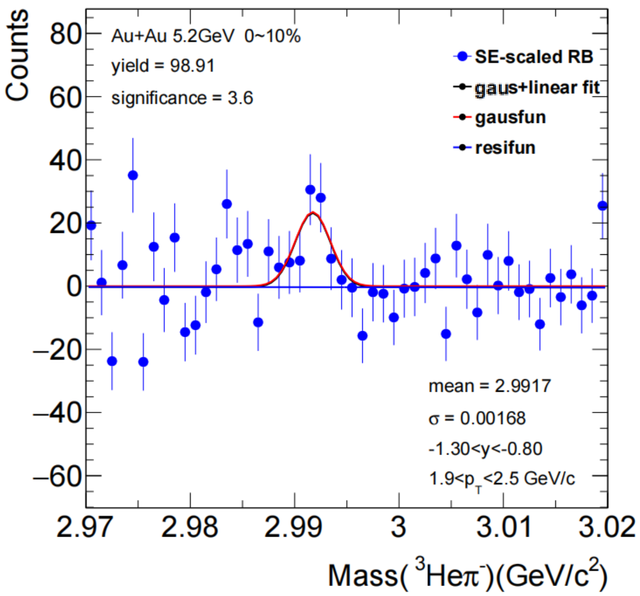


hmNchargevsNpart
Au+Au
Zr+Zr
⟨ N_charge ⟩
N_part
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
50
100
150
200
250
300
350
400

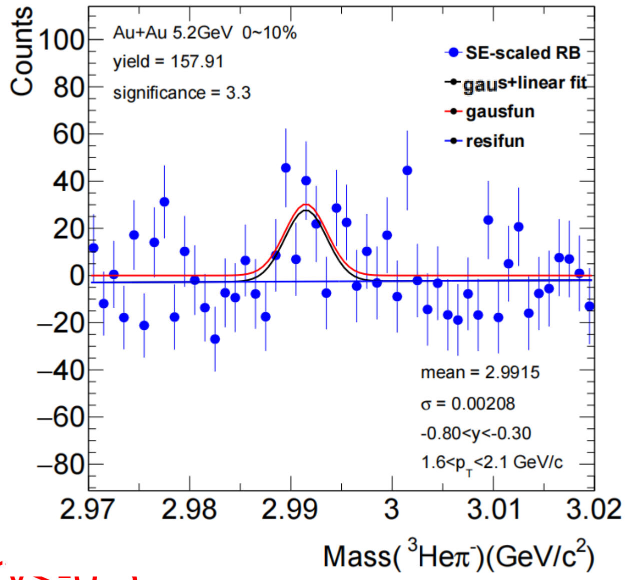
Signals extraction 0-10% (Run2020 5.2 GeV)

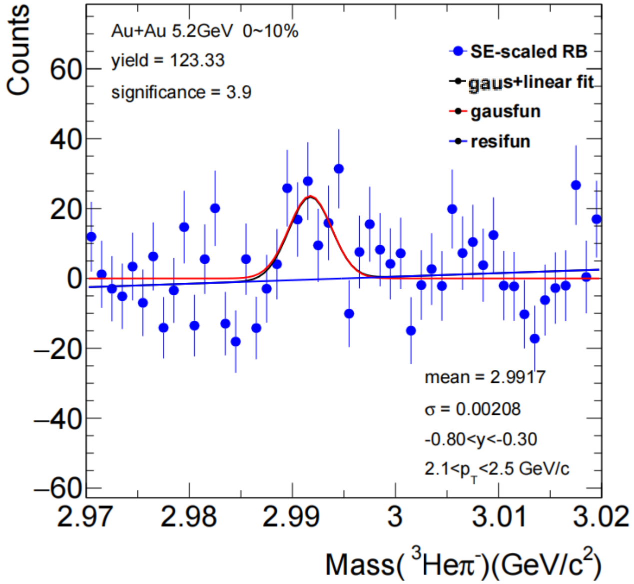


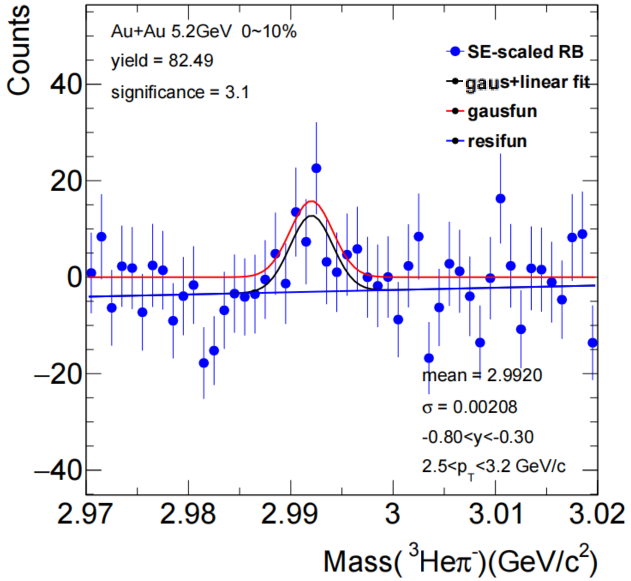




-1.3<y<-0.8

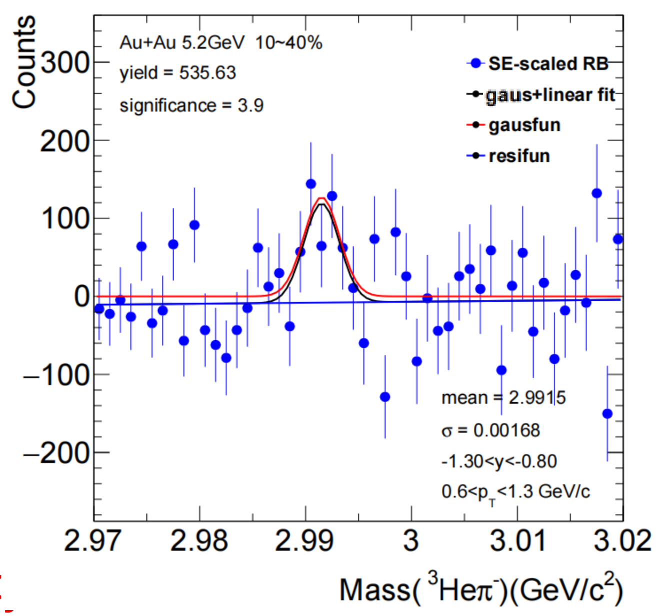


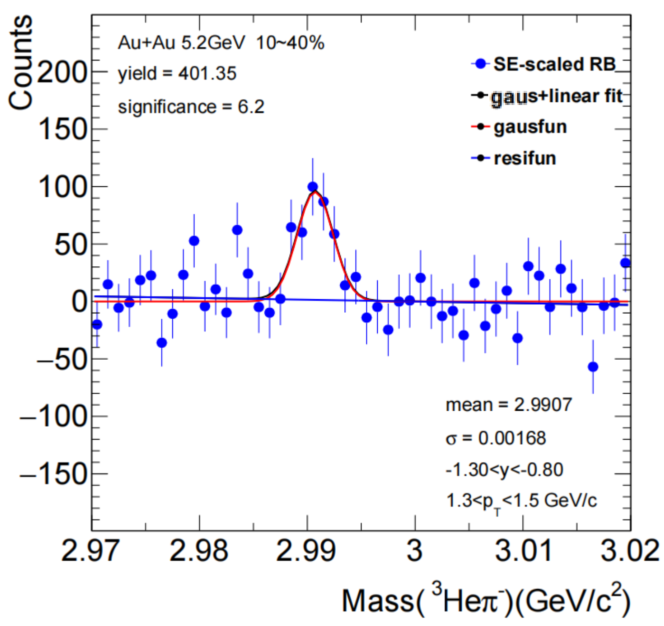


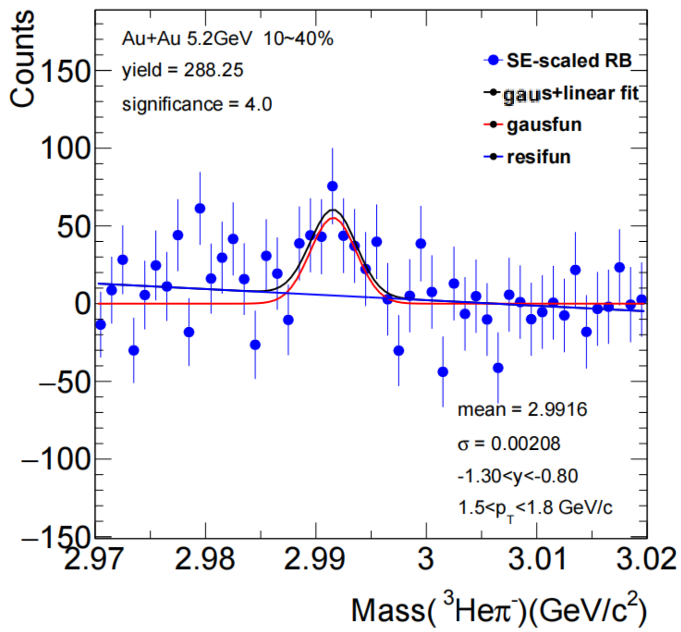


-0.8<y<-0.3

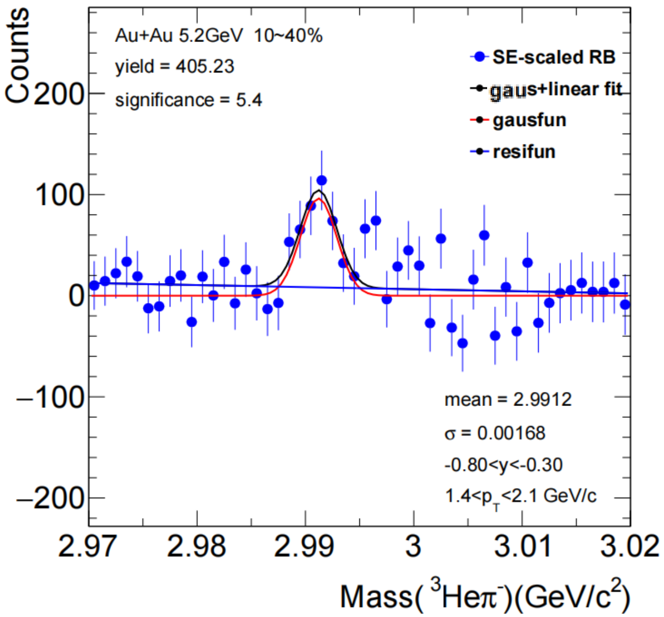
Signals extraction 10-40% (Run2020 5.2 GeV)

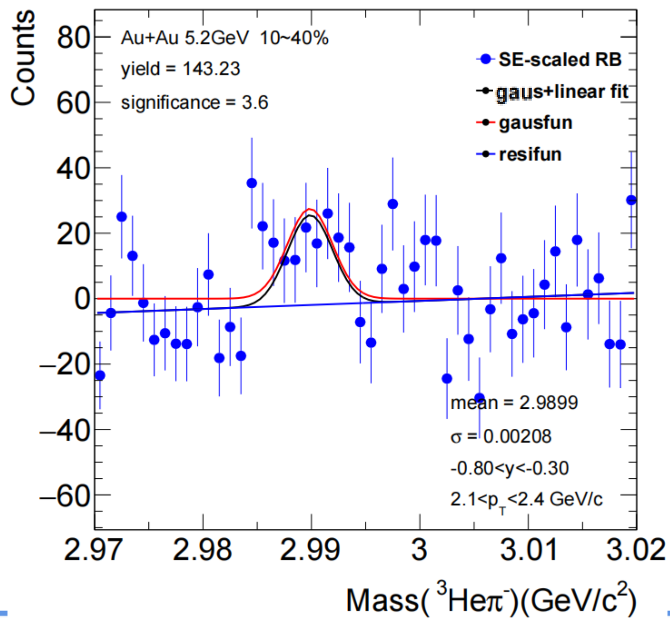


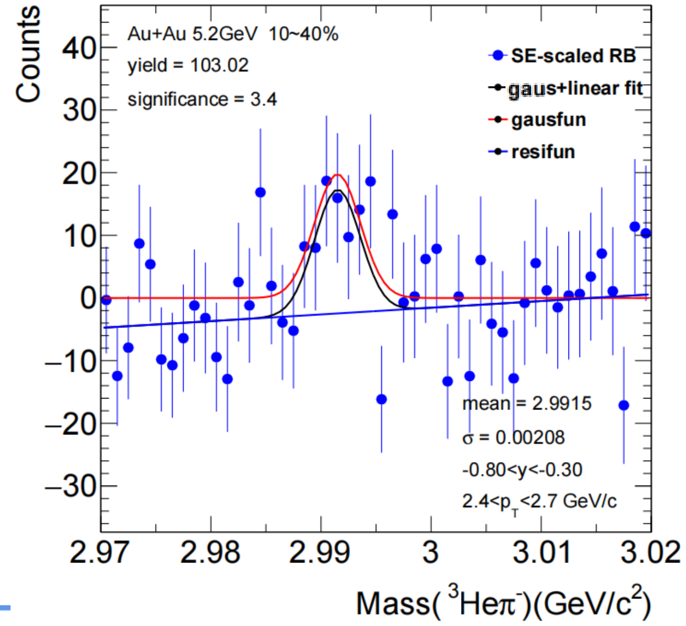




-1.3<





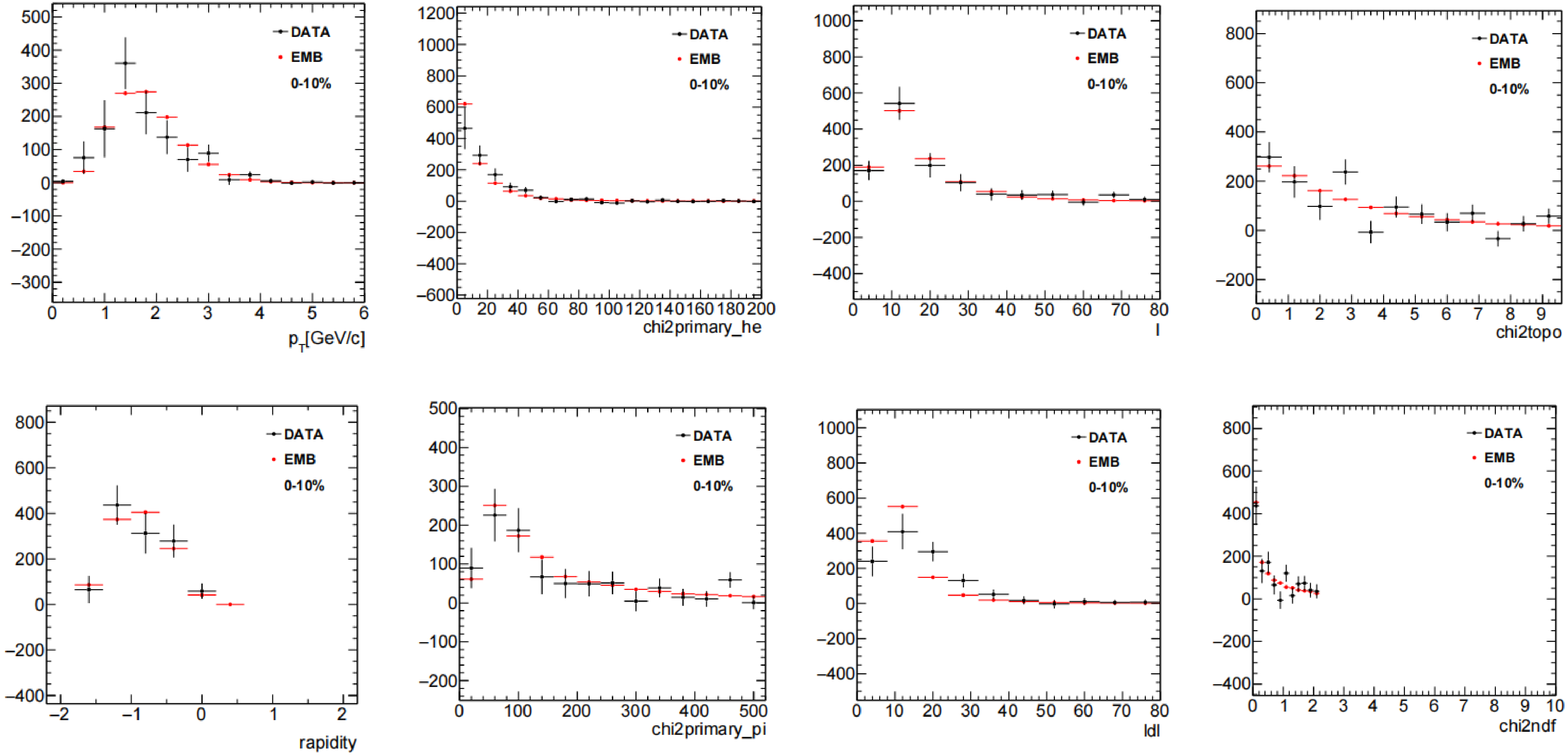


-0.8<

Back up Analysis procedure

- 3.2 GeV(2019) H3L embedding: https://drupal.star.bnl.gov/STAR/starsimrequests/2022/Jul/30/hypernuclei-FXT-AuAu-32-GeV

Using integrated p_T and rapidity range; after weighting of p_T distribution



Embedding data comparison

Back up Analysis procedure

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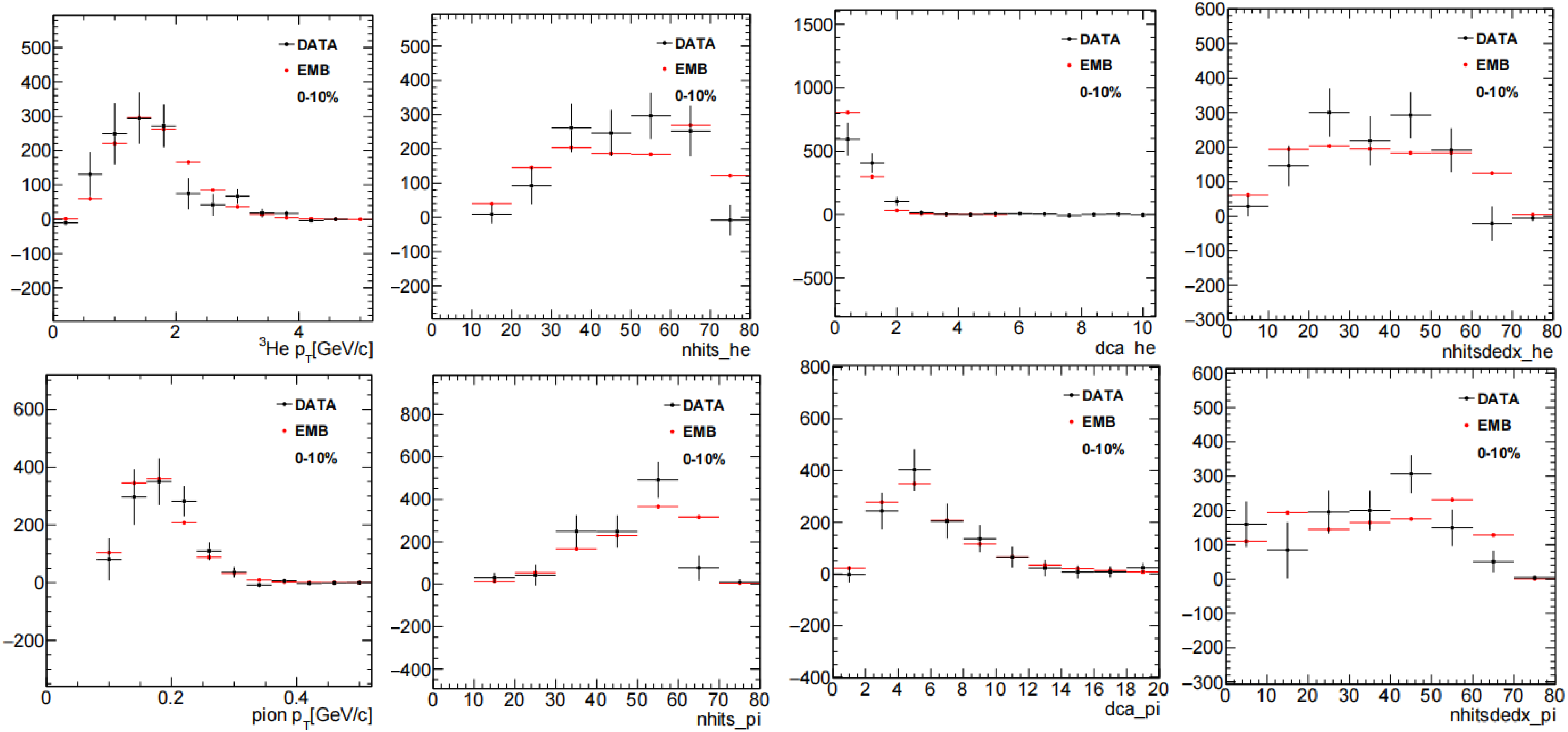
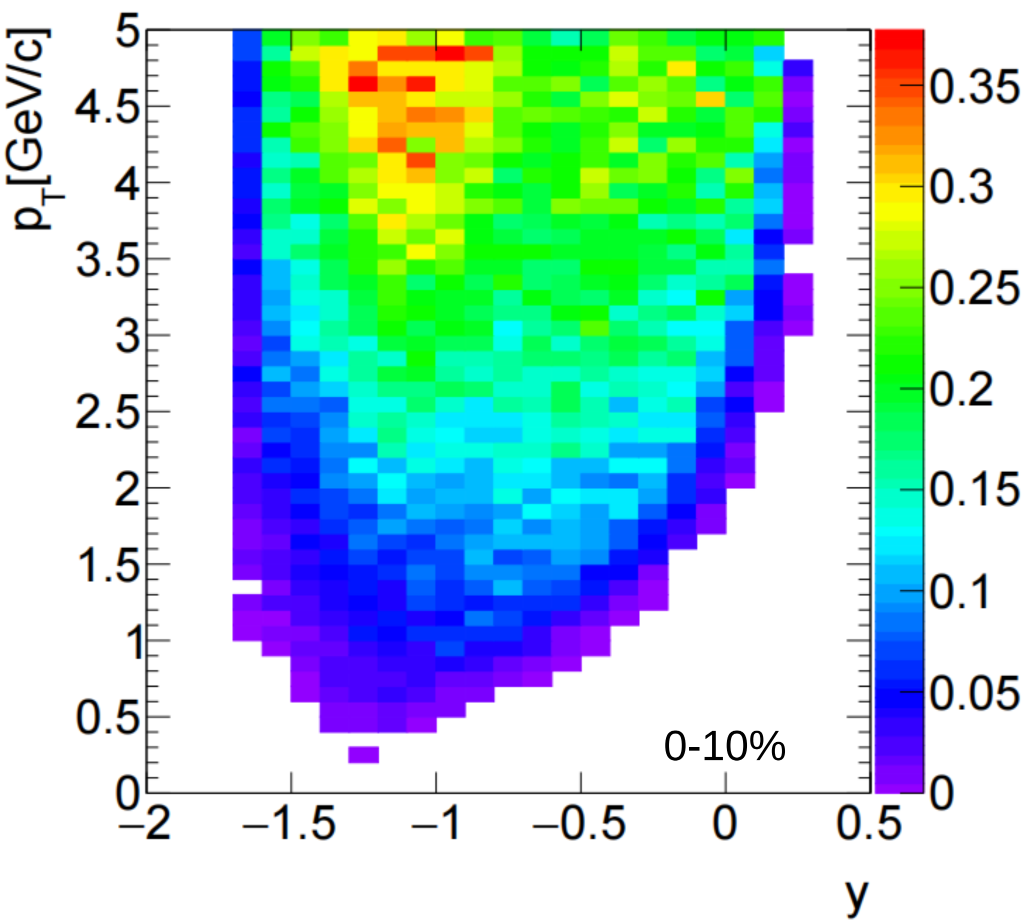
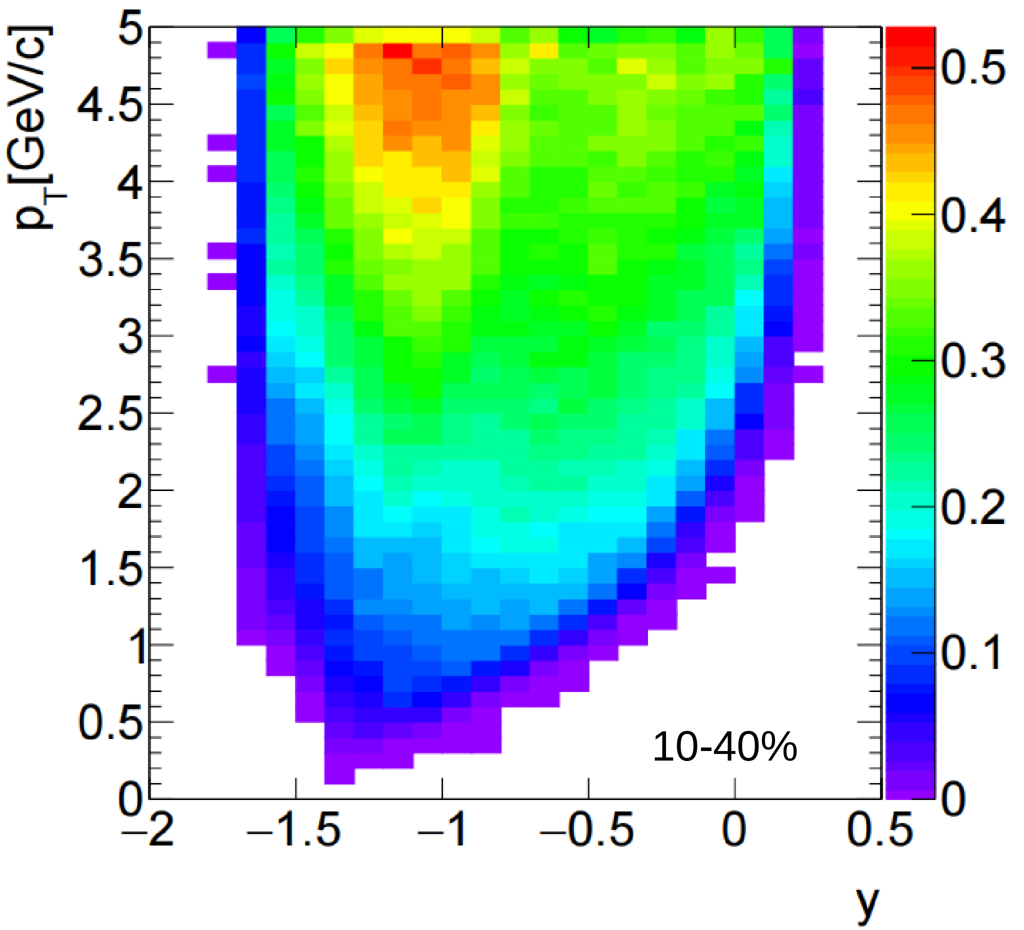


Embedding data comparison

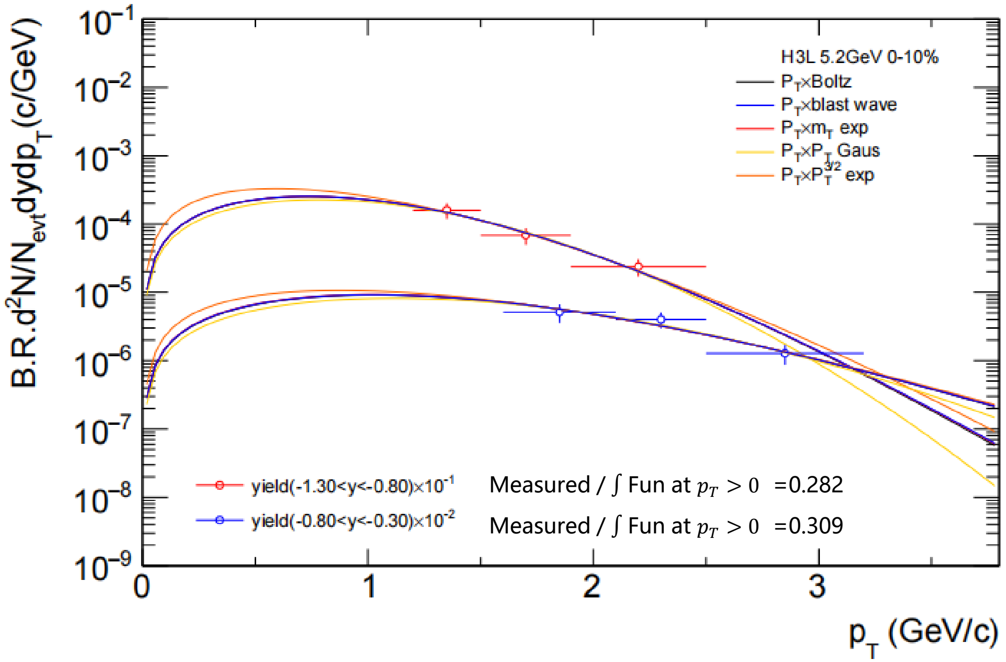
Reconstuction efficiency

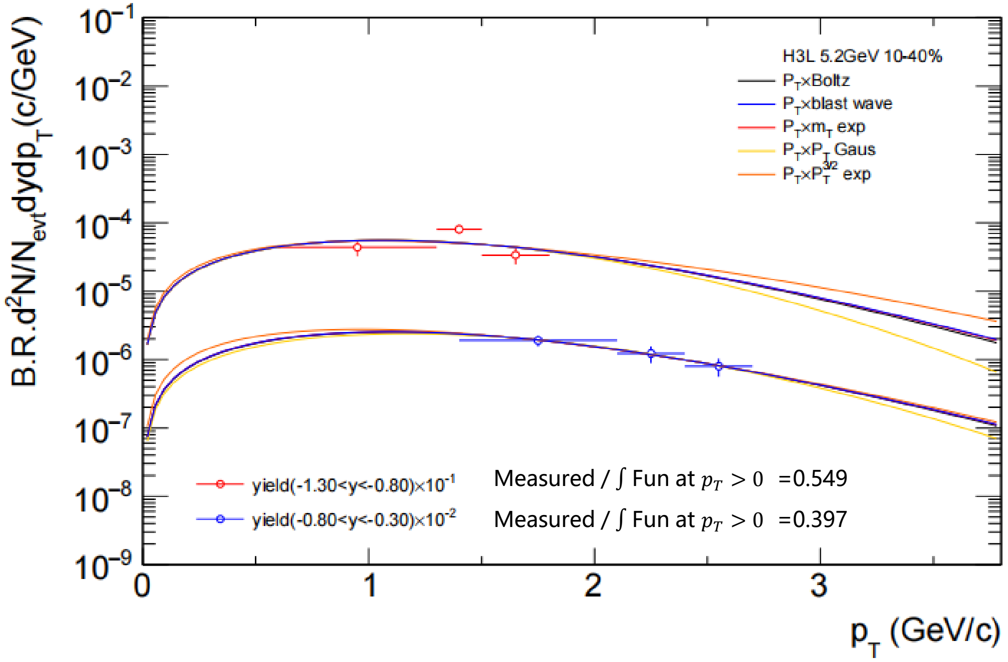




- MC particles' p_T distribution is weighted with an boltzmann function
- MC particles' y distribution is weighted with a quadratic function
- Lifetime is weighted to H3L world average lifetime 228.3ps

H3L spectra and yield 0-10% and 10-40%





$$\frac{1}{2\pi p_T}\frac{d^2N}{dp_T dy} = \frac{N^{Raw}/(\epsilon^{reco} \times \epsilon^{PID})}{2\pi p_T \Delta p_T \Delta y} \propto$$

$C \cdot m_T exp(-\frac{m_T}{T})$ boltzmann(default)

$C \cdot exp(-\frac{m_T}{T})$ m_T exp

$C \cdot exp(-\frac{{p_T}^2}{\mu})$ p_T Gaus

$C \cdot exp(-\frac{p_T^{3/2}}{\mu})$ $p_T^{3/2}$ exp

$\int_0^R rdrm_T I_0(\frac{p_T sinh\rho(r)}{T_{kin}}) * K_1(\frac{m_T cosh\rho(r)}{T_{kin}})$ blast wave

- When fitting, option “I” is added.(fit range:0-4GeV/c)
- dN/dy

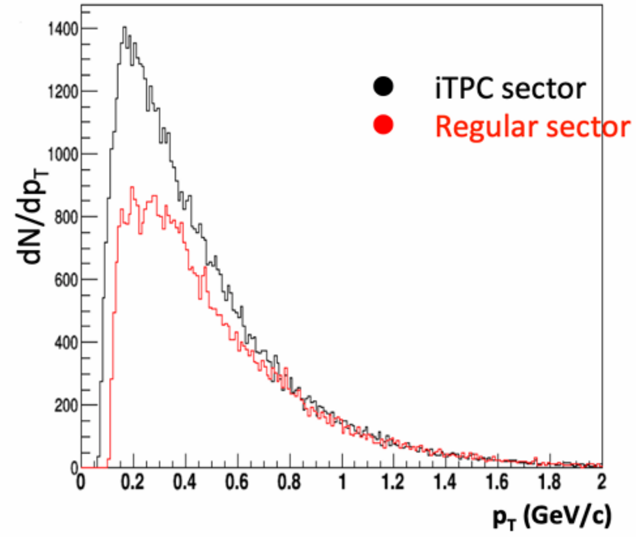
⇨Sum of yields in measured p_T region + unmeasured region p_T from function extrapolation.

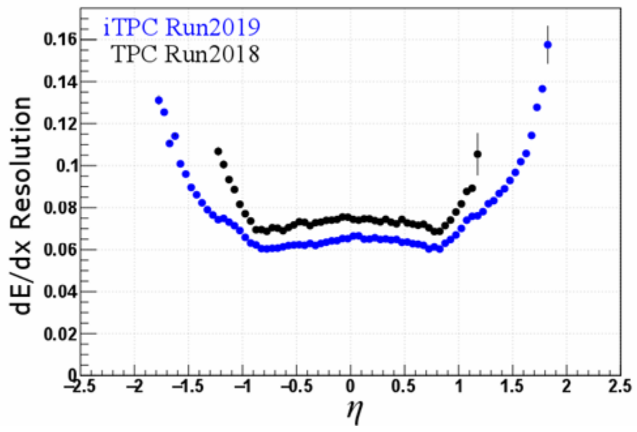
⇨ Stat error: measured region * Fraction,
Fraction = Integral(p_T>0)/Integral(measured p_T range) from fitting function.

STAR iTPC Upgrades

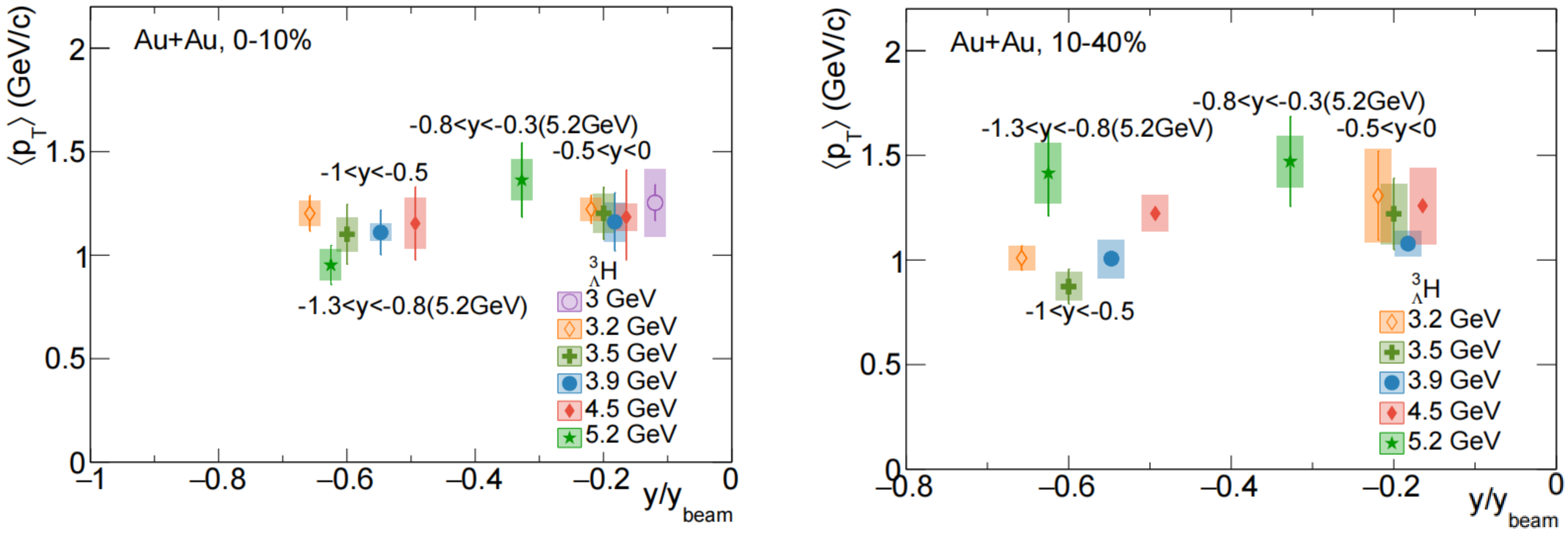
- Rebuild the inner sectors of the TPC (iTPC)
  - Fully installed in 2019
  - Continuous coverage
  - Improve dE/dx
  - Extends η acceptance from 1.0 to 1.5
  - Lower p_T cut-off

Nucl. Phys. A, 2021, 1005: 121758



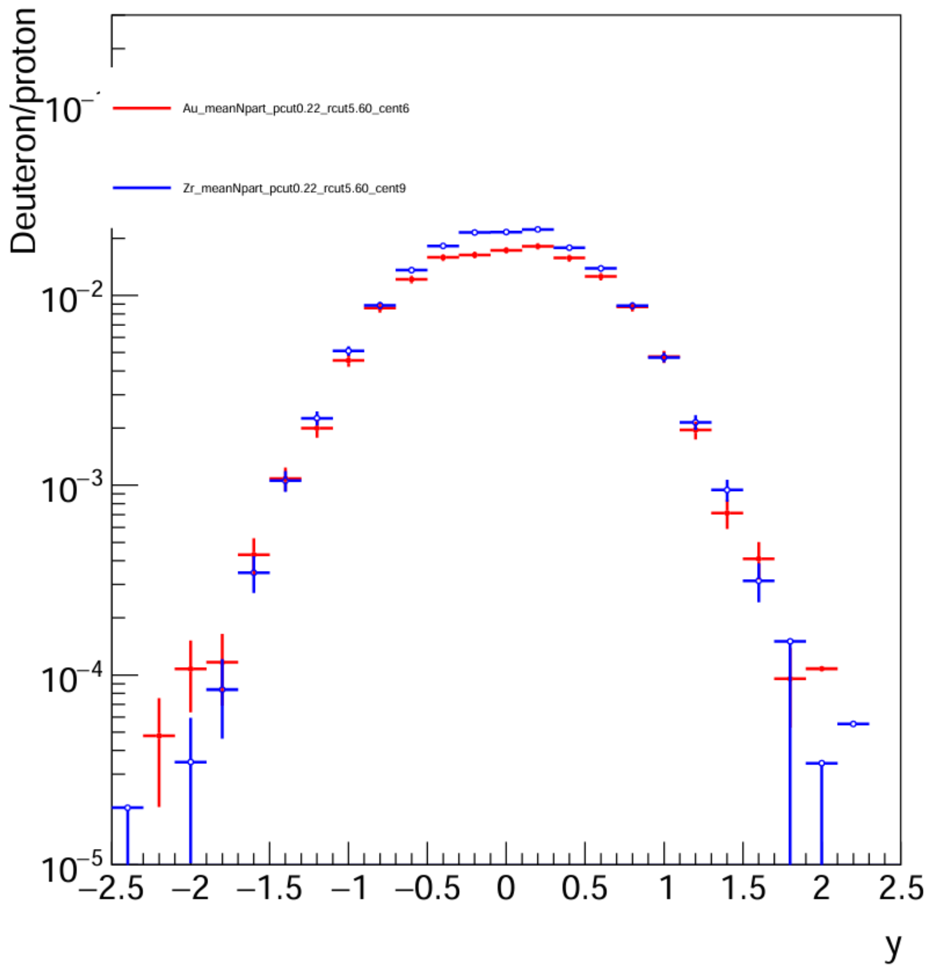


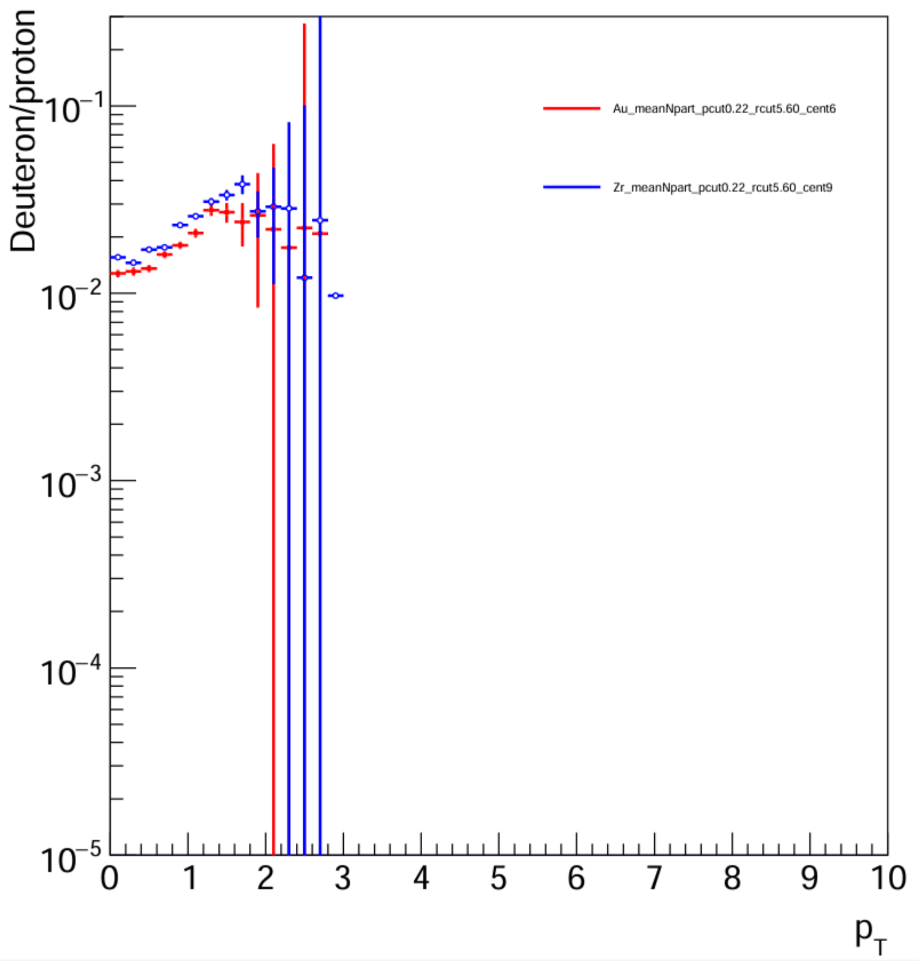
$< p_T >$ vs rapidity



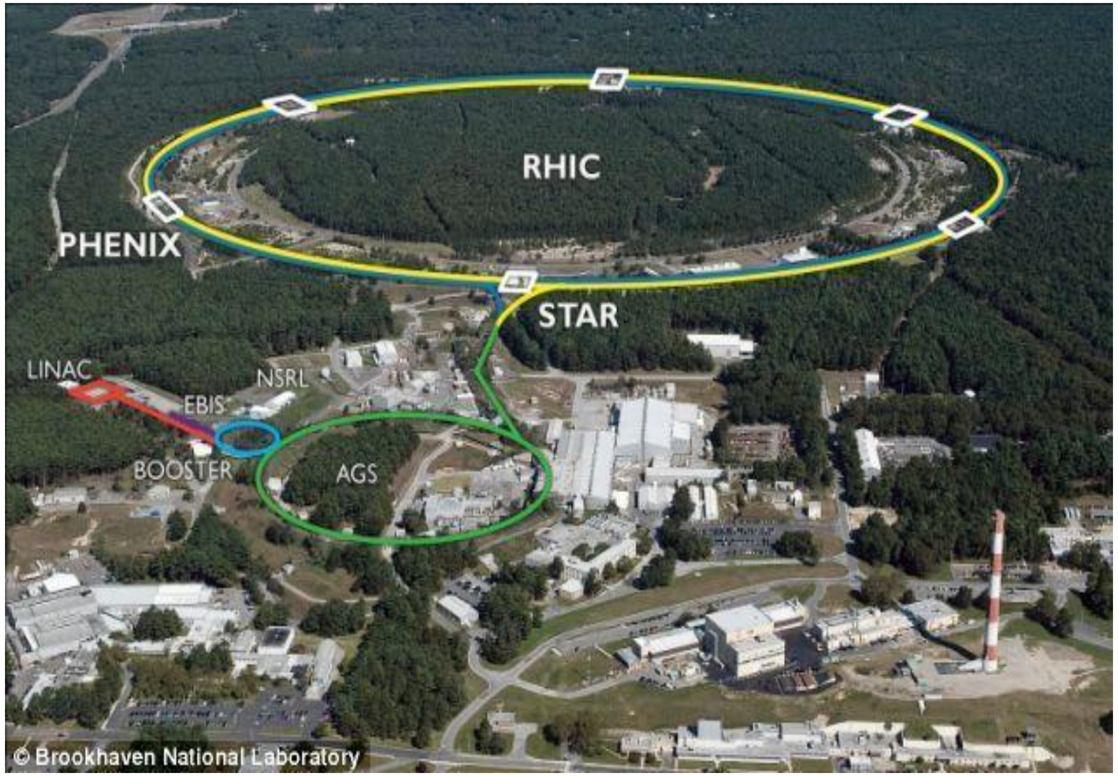
- The $\langle\, p_T \,\rangle$ at 5.2 GeV and other energies are comparable

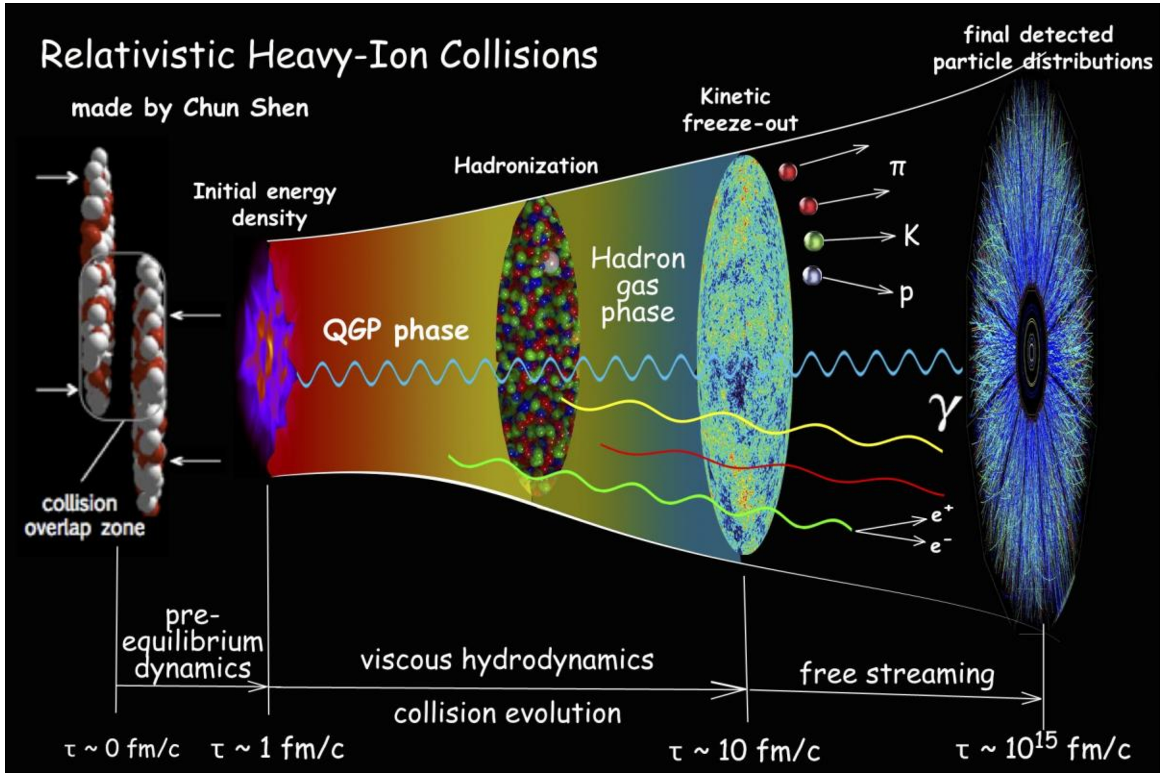
Deuteron/Proton vs rapidity and $\langle p_T \rangle$





Motivation : RHIC BES-II





High temperature and high baryon number density

decay

Relativistic heavy ion collisions → Hypernuclei → Hardons

reconstruct

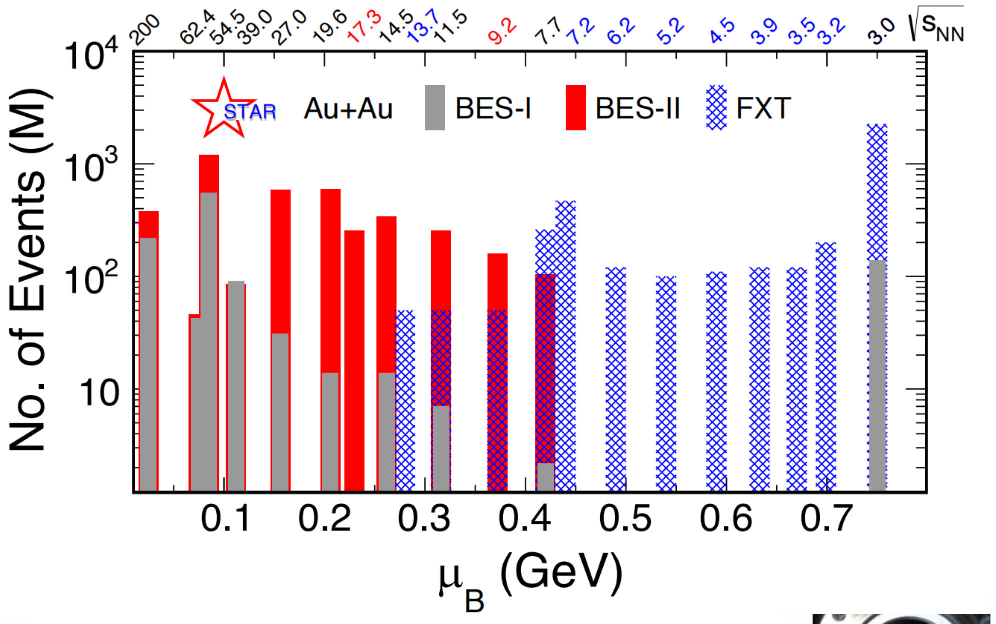
We can measure directly

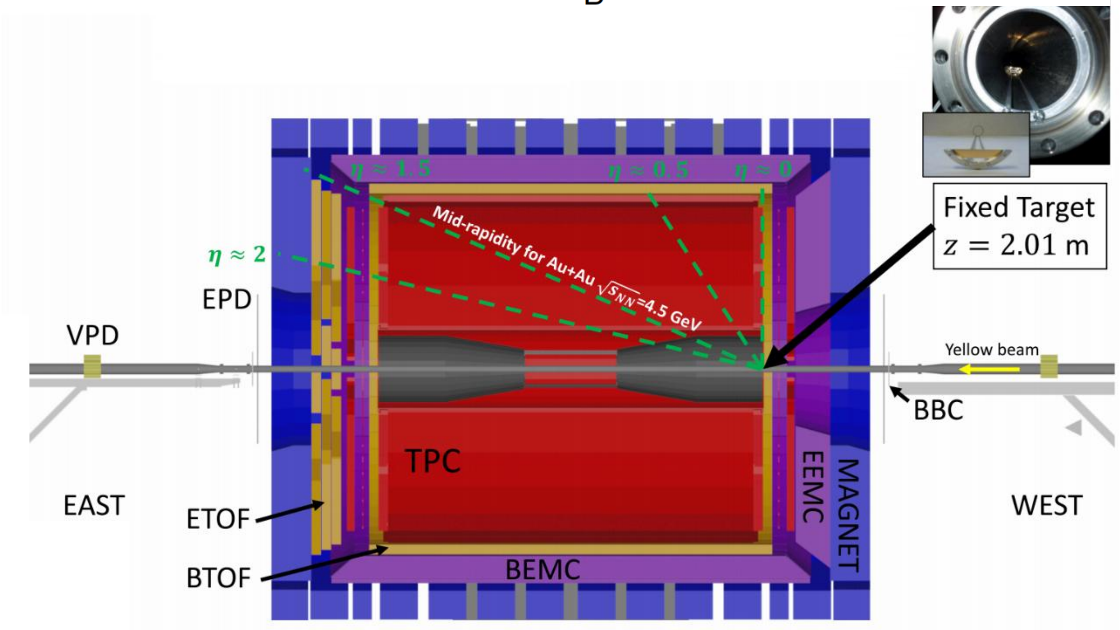
Motivation : RHIC BES-II

- RHIC beam energy scan Phase II (BES-II)
  - Specific focus on low $\sqrt{s_{NN}}$

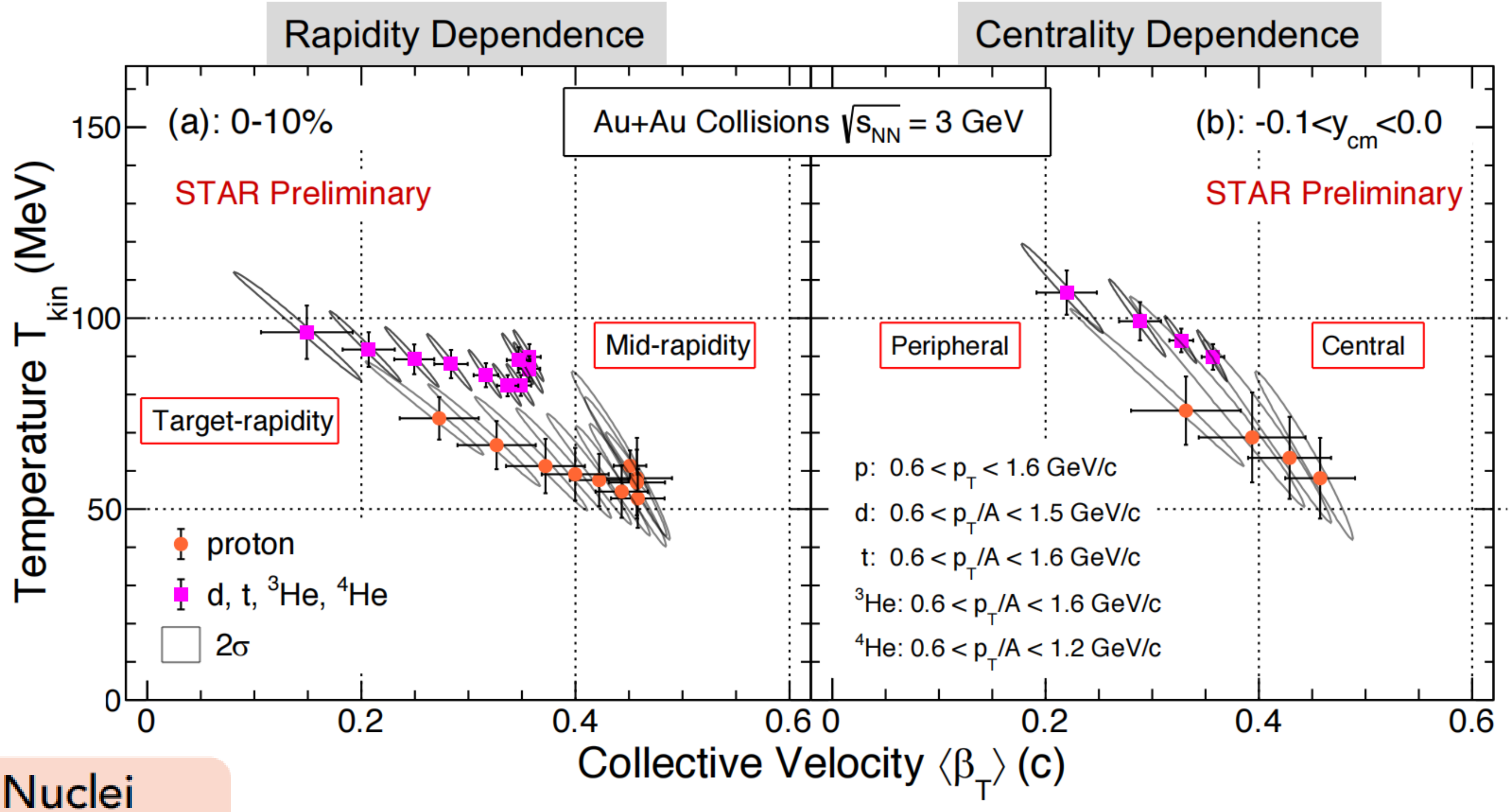
    Include fixed target (FXT) mode extends down to 3.0 GeV, increase μ_B range from ~400 MeV to ~700 MeV
  - High statistics data
  - Improve systematics
    - Detector upgrade: iTPC, EPD, eTOF

Enhances the capability of various measurements with excellent precision





Kinetic Freeze-out Dynamics at 3 GeV



Light Nuclei freeze out earlier?

J. Adams et al. [STAR Collaboration] Nucl.Phys.A 757 (2005) 102-183

- The kinetic freeze-out parameters (T_{kin} and $\langle\beta_T\rangle$) show rapidity and centrality dependence
- The freeze-out parameter (T_{kin}) of the light nuclei is systematically higher than that of the protons

Hui Liu, QM2022 @ Krakow, Poland

Summary

- First measurements of ${}^{3}_{\Lambda}\mathrm{H}$ yields vs. energy at high baryon density region presented, consistent with coalescence model

- Suppression of ${}^{3}_{\Lambda}\mathrm{H}$ in 10-40% collisions at low collisions energies observed

- ${}^{3}_{\Lambda}\mathrm{H}$ $\langle p_T \rangle$ overestimated by Blast-wave fit parameterization from light hadrons

  ⟹ ${}^{3}_{\Lambda}\mathrm{H}$ are likely formed at or decouples from the system at a different time compared to the light hadrons