

${}^3_{\Lambda}H$ production in Run2020 FXT Au+Au 5.2 GeV

Yulou Yan

- Motivation
- The process of analysis
 - ⇒ Dataset and event selections
 - ⇒ PID recalibration
 - ⇒ Signal reconstruction
 - ⇒ Reconstuction efficiency
- Results
 - ⇒ H3L p_T spectra and p_T -integrated yield
 - ⇒ Systematic uncertainty
 - ⇒ H3L yields vs $\sqrt{s_{NN}}$

Motivation

- Hypernuclei production in heavy ion collisions

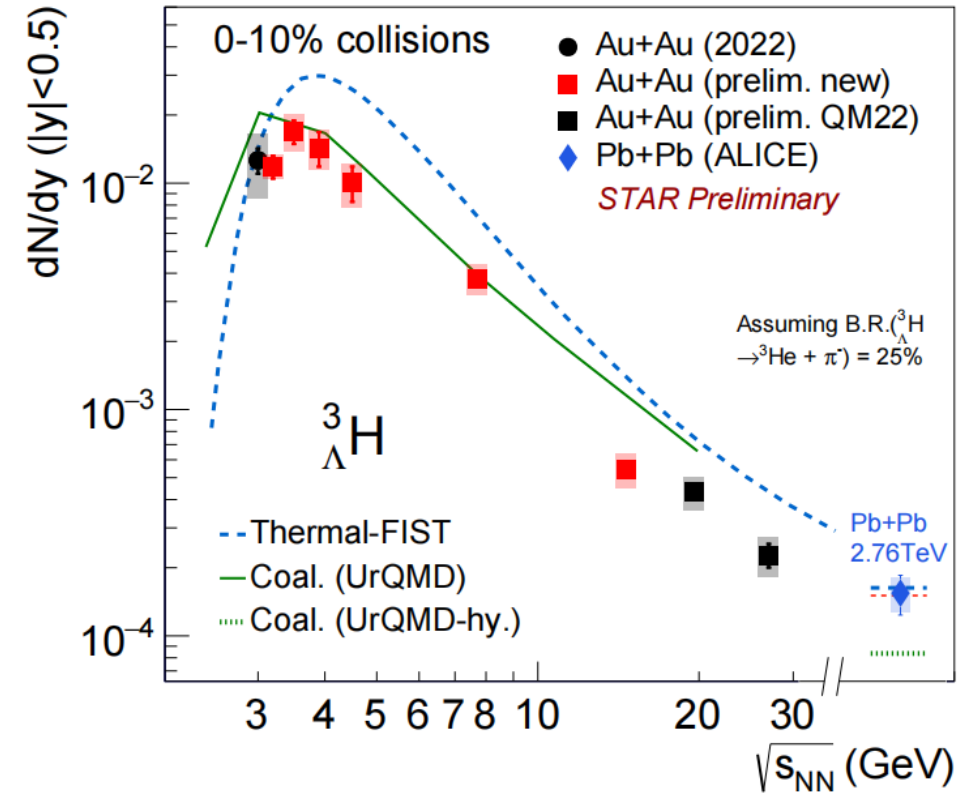
- ⇒ Y-N interaction
- ⇒ EOS of compact stars

- Production mechanism

- ⇒ Thermal model
- ⇒ Coalescence model

- Observables:

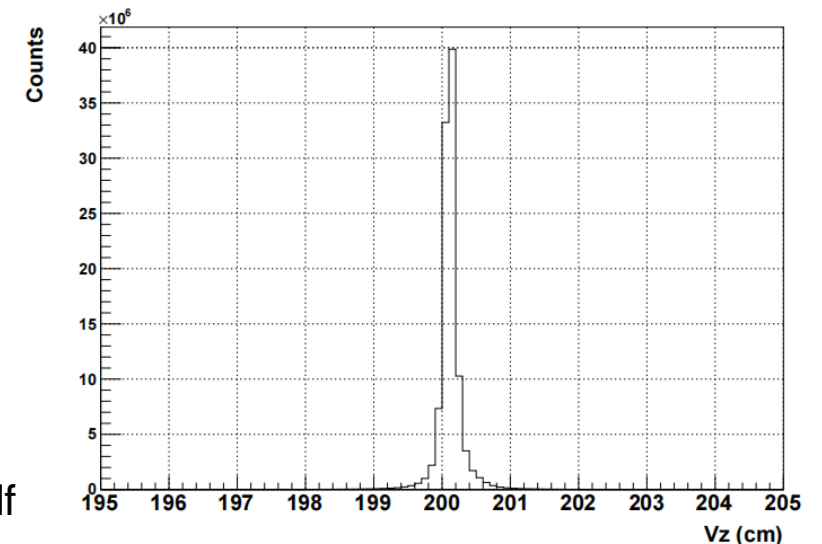
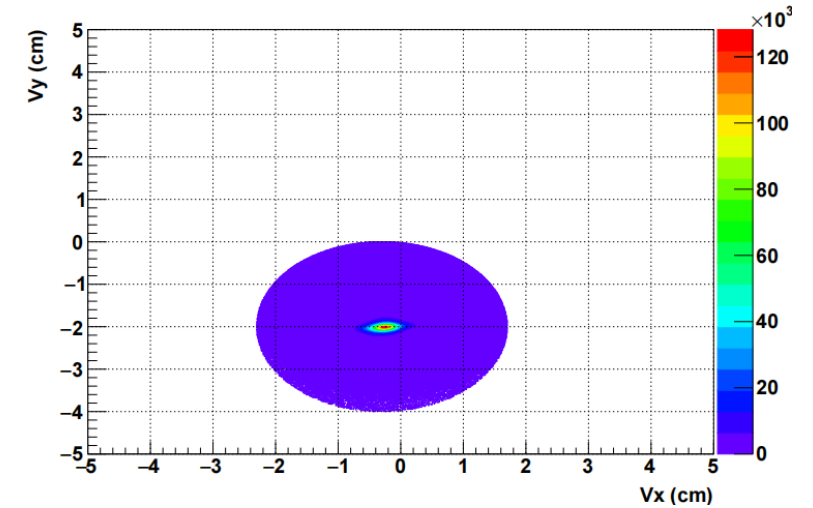
- ⇒ Energy dependence of hypernuclei yields at mid-rapidity
- ⇒ Rapidity dependence of hypernuclei yields



- First time systematically measuring the energy dependence of hypernuclei production

Dataset and event selections

- Run 2020 FXT Au+Au 5.2 GeV
 - production_13p5GeV_fixedTarget_2020
- Trigger: 750000 (epde-or-bbce-or-vpde-tof1)
- Badrun:21034002,21034007
<https://drupal.star.bnl.gov/STAR/pwg/common/bes-ii-run-qa/FXT-datasets>
- Rapidity convention: $y = -1*(y_{lab}-y_{cm})$,
 $y_{cm} = -1.68$ at FXT 5.2 GeV
- Vertex cuts:
 $198 < Vz < 202$ cm,
$$\sqrt{(Vx + 0.3) * (Vx + 0.3) + (Vy + 2) * (Vy + 2)} < 2$$
- Centrality definition& pileup rejection(From STAR centrality definition team):
https://drupal.star.bnl.gov/STAR/system/files/2023_0718_AuAu5p2Cent.pdf
- 0-80% centrality: ~ 89M good events

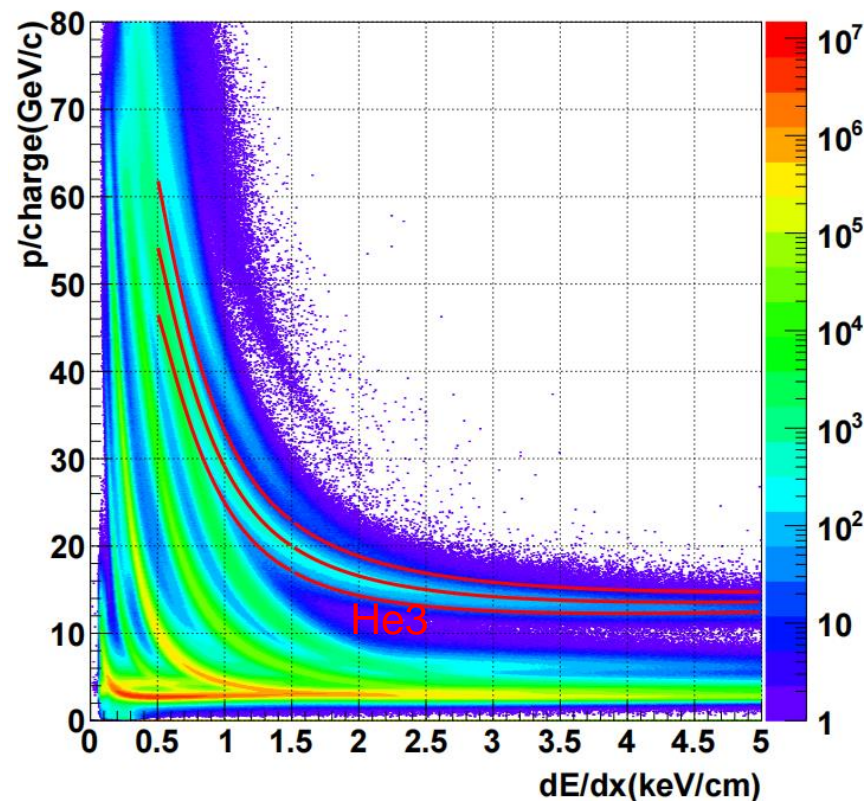


PID recalibration

- Using TPC information ${}^3_1H \rightarrow {}^3_2He + \pi^-$

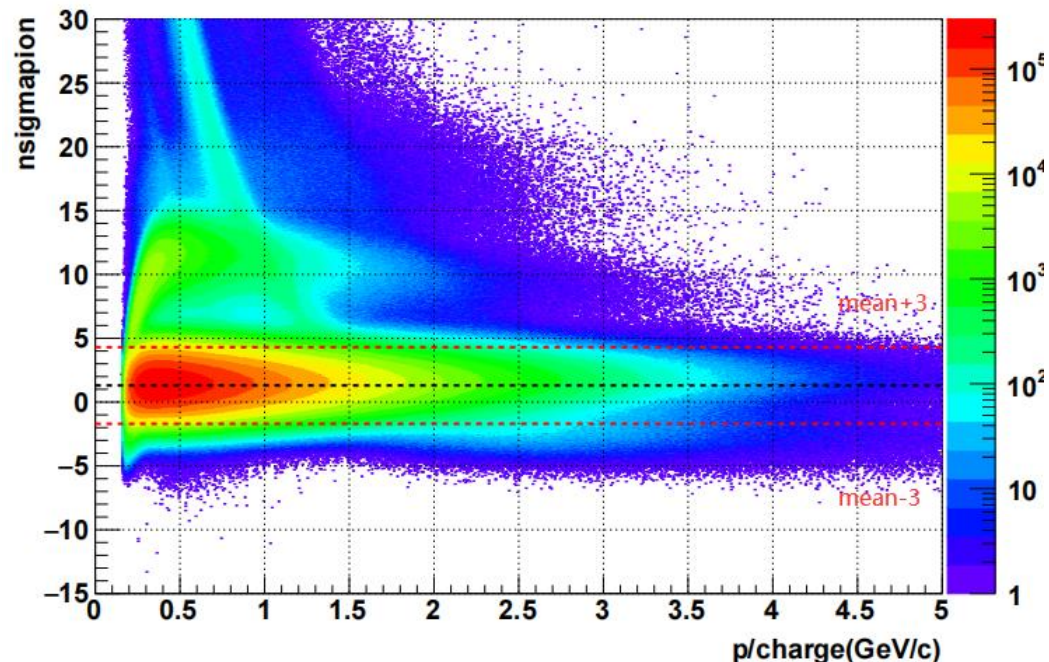
- He3

$\Rightarrow p/|q| > 0.4 \text{ GeV}/c: \pm 3\sigma \text{ dEdx band}$



- Pion:

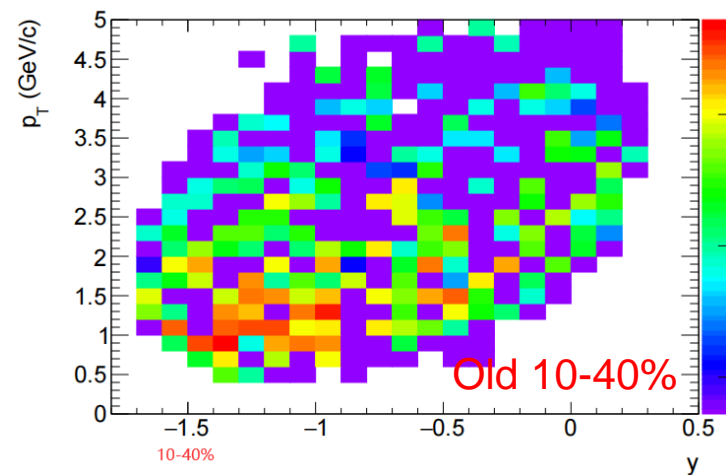
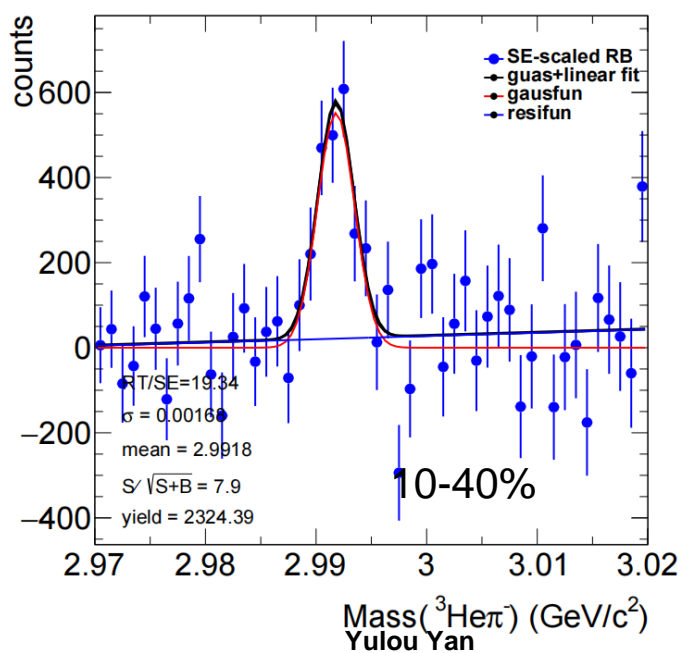
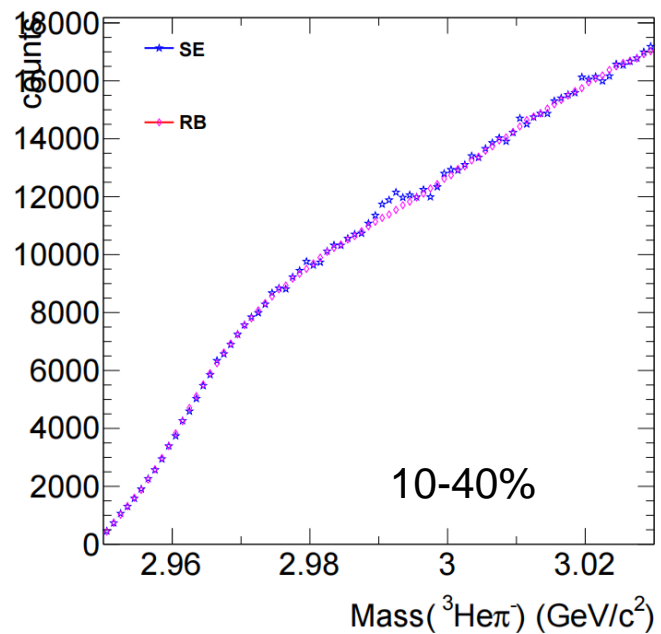
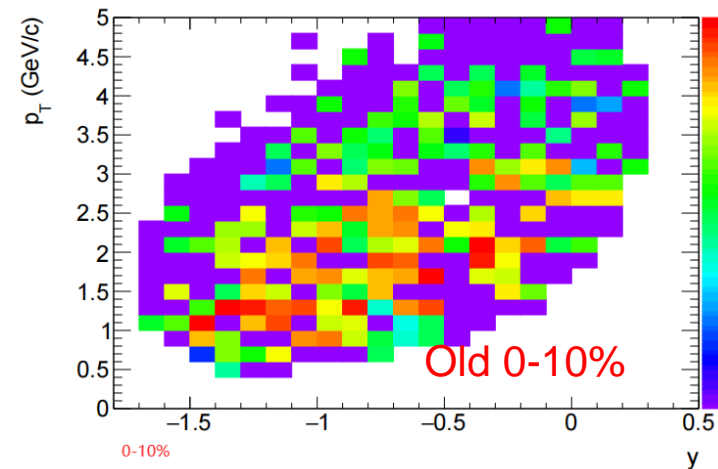
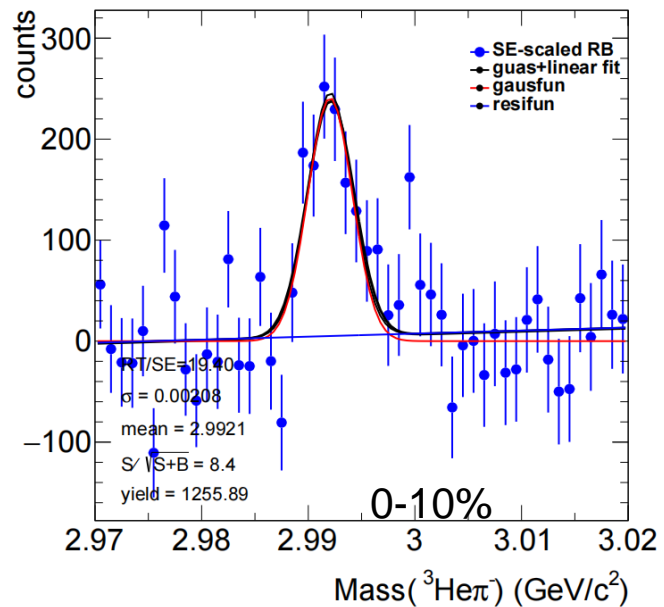
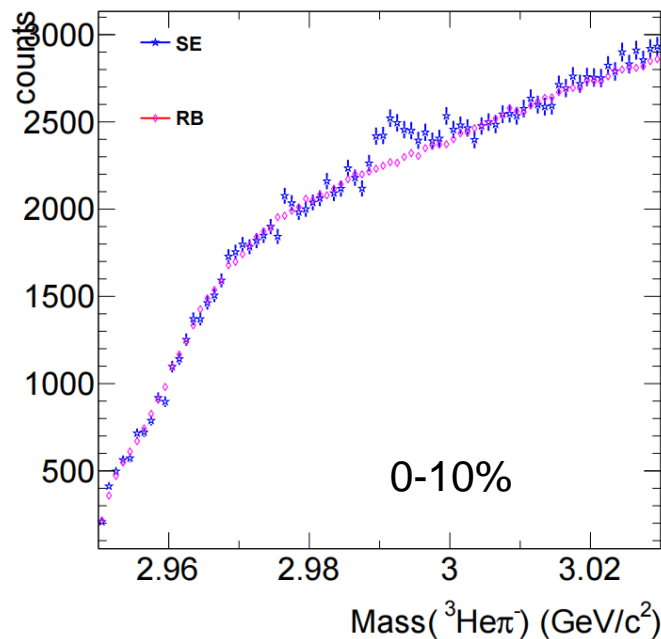
$\Rightarrow |dEdXPULL_{\text{pion}}(n\sigma_{\pi}) - \text{mean}| < 3\sigma$



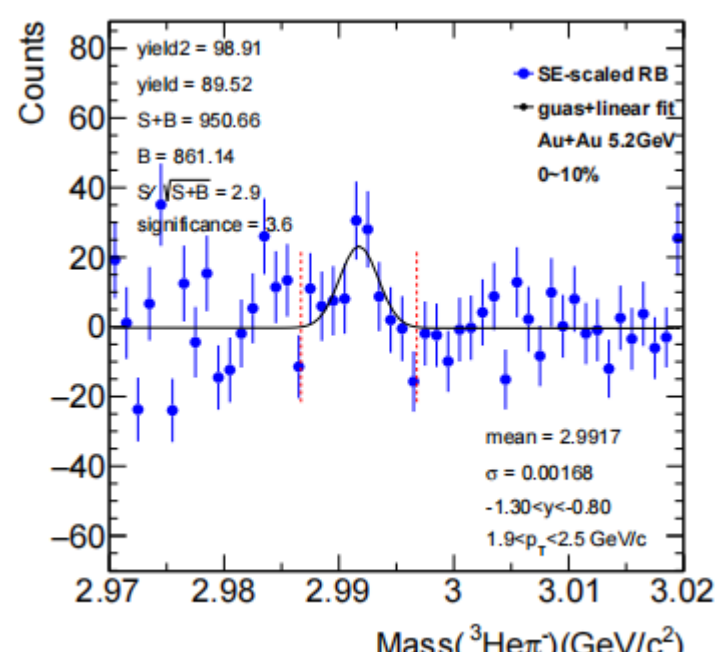
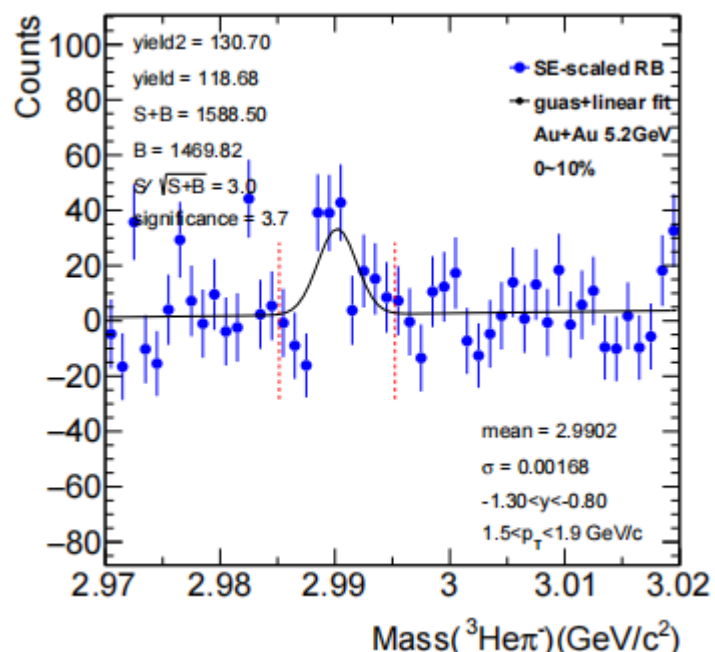
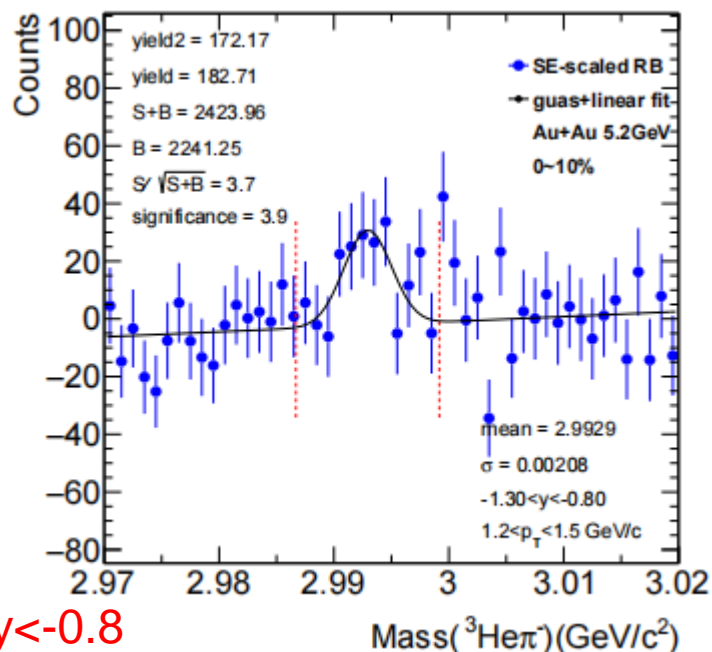
$$dEdXPULL = \frac{1}{\left(\frac{dE}{dx}\right)_{\text{error}}} \ln \frac{\langle dE/dx \rangle}{(dE/dx)_{\text{bichsel}}}$$

gTrack->dEdxPull([Particle_Mass], fdEdXMode, 1) 5

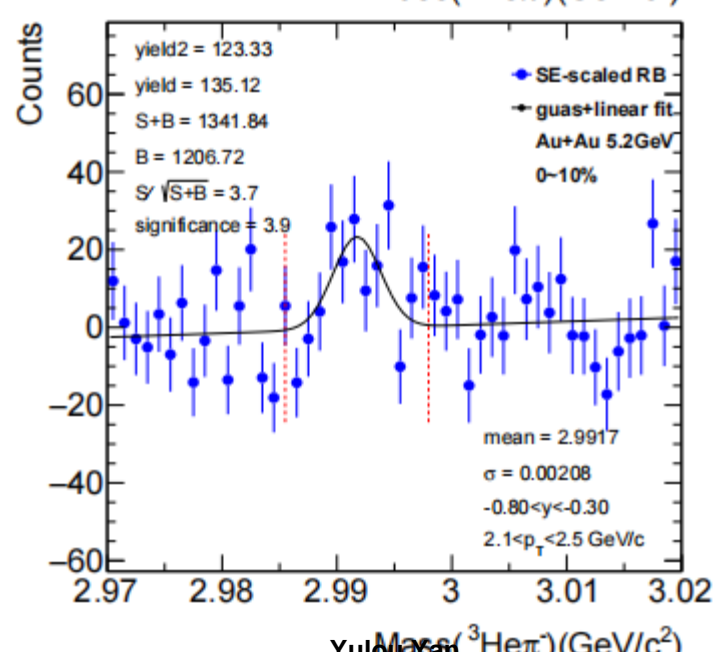
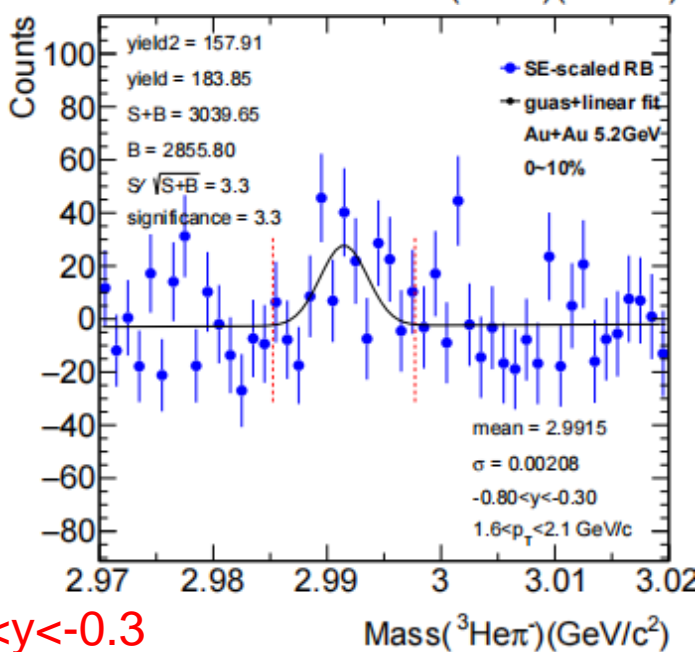
Signals extraction 0-10% (Run2020 5.2 GeV)



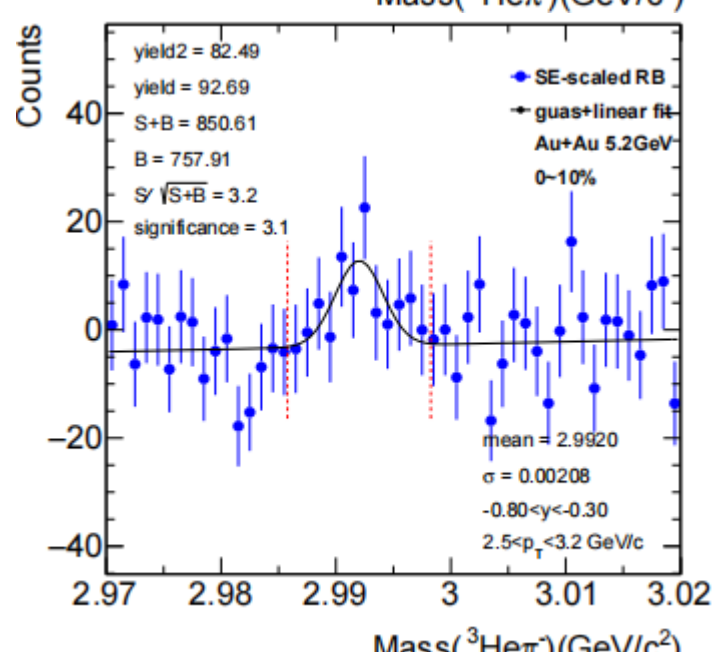
Signals extraction 0-10% (Run2020 5.2 GeV)



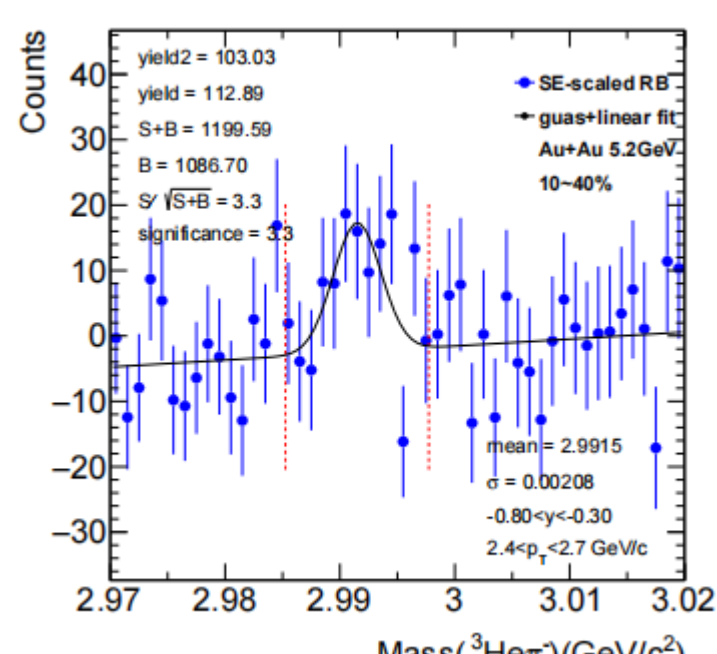
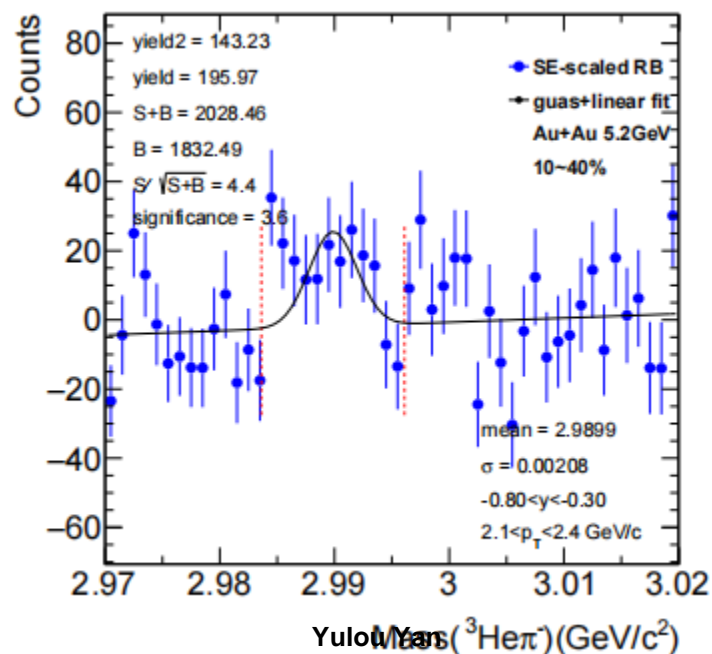
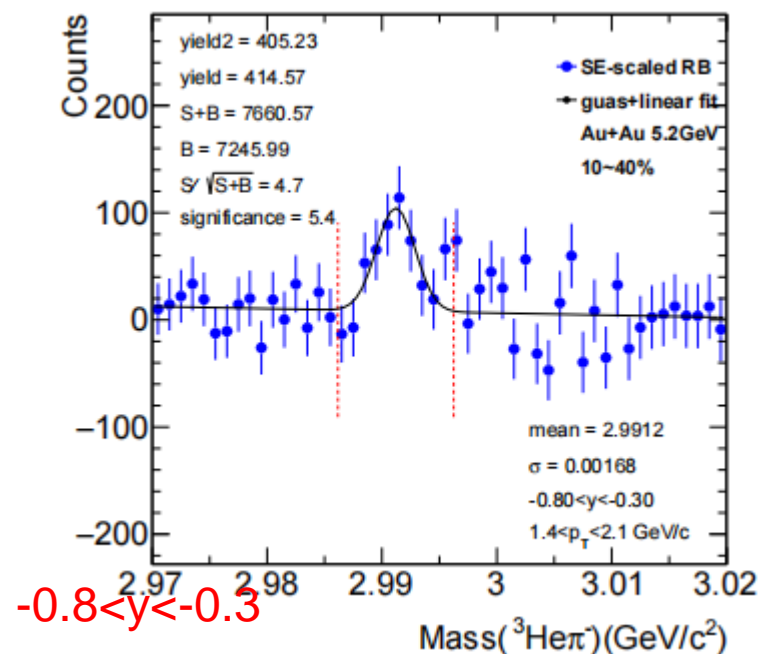
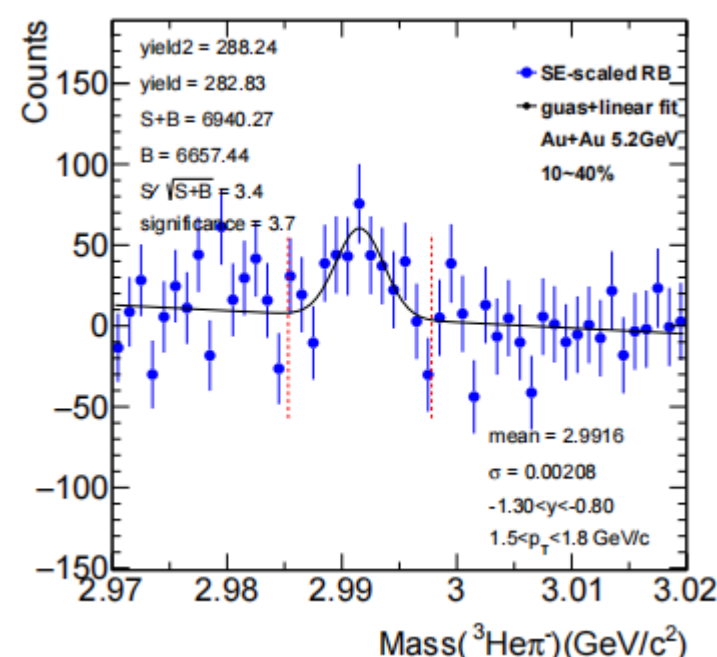
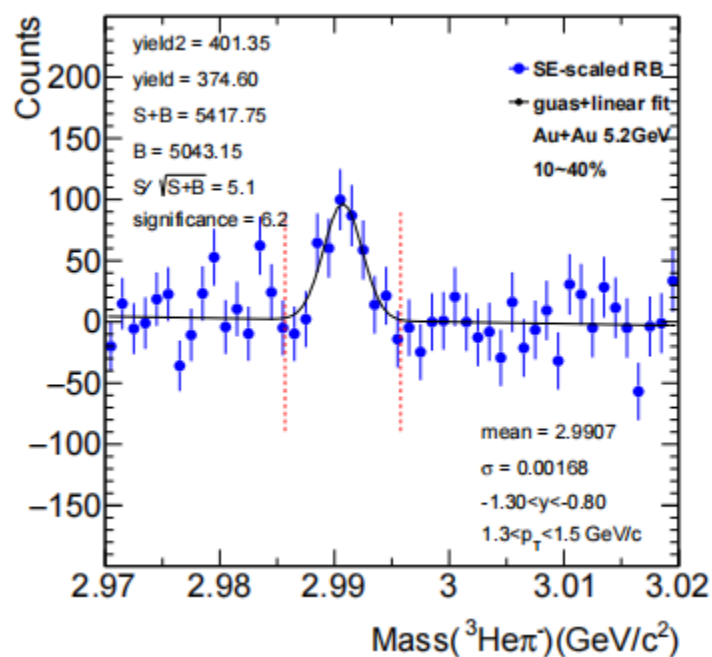
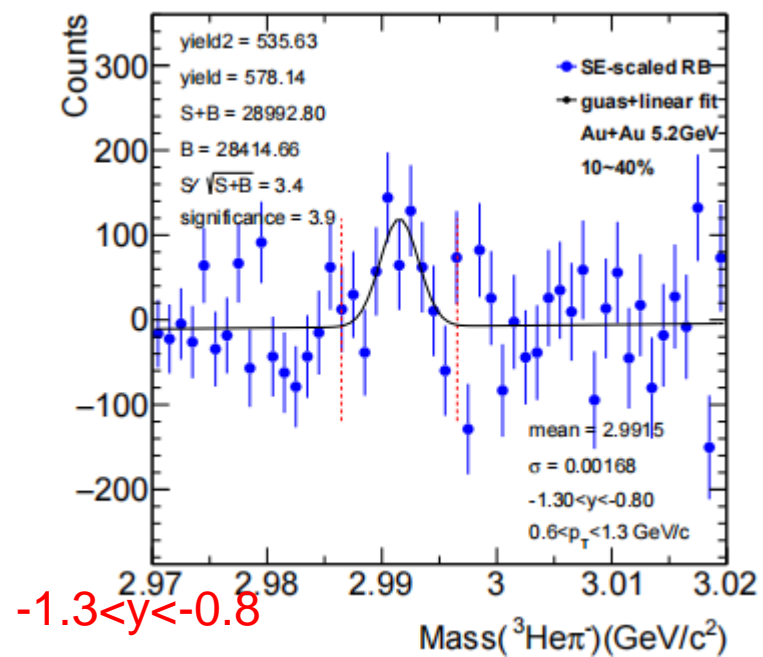
-1.3 < y < -0.8

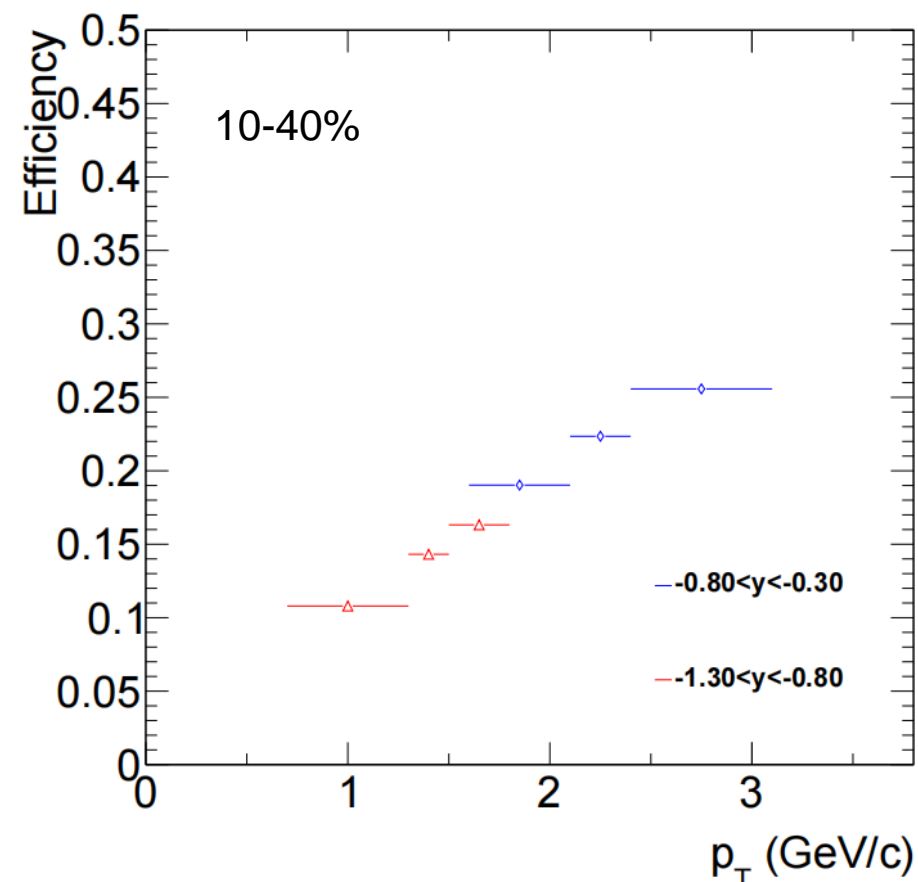
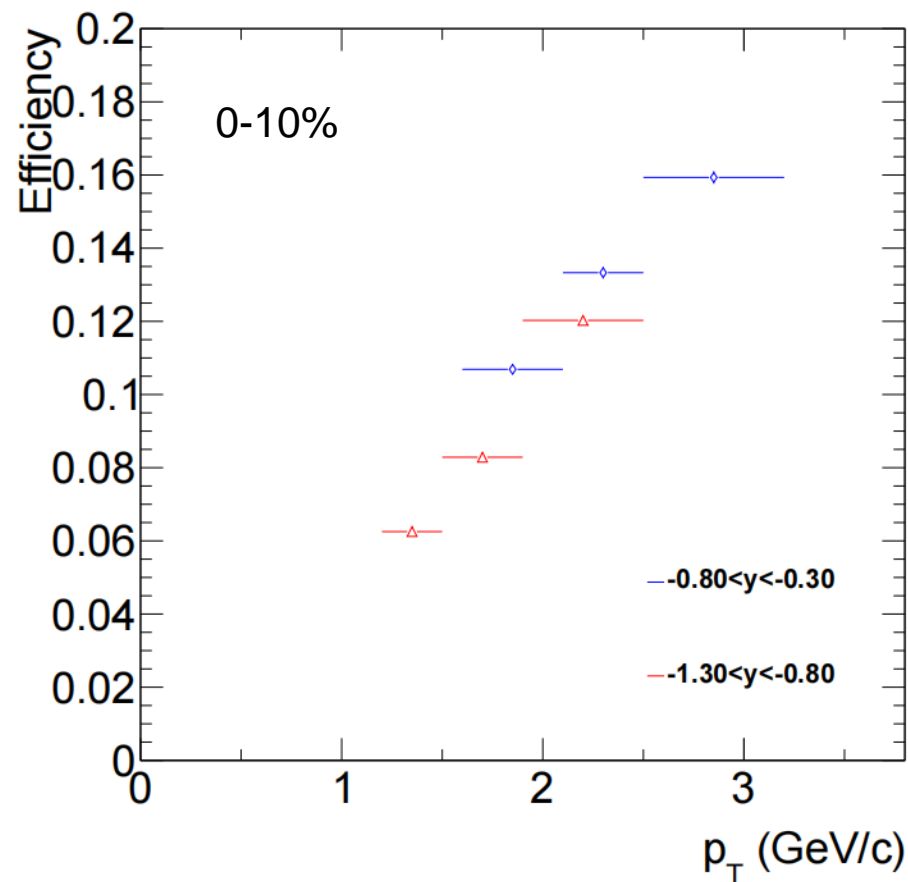


-0.8 < y < -0.3



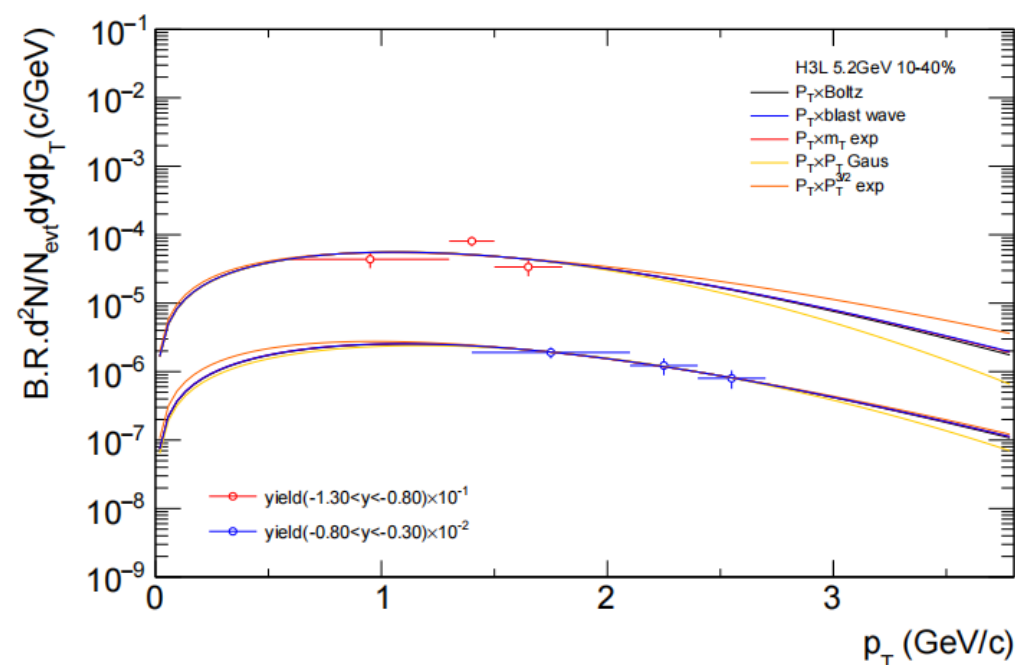
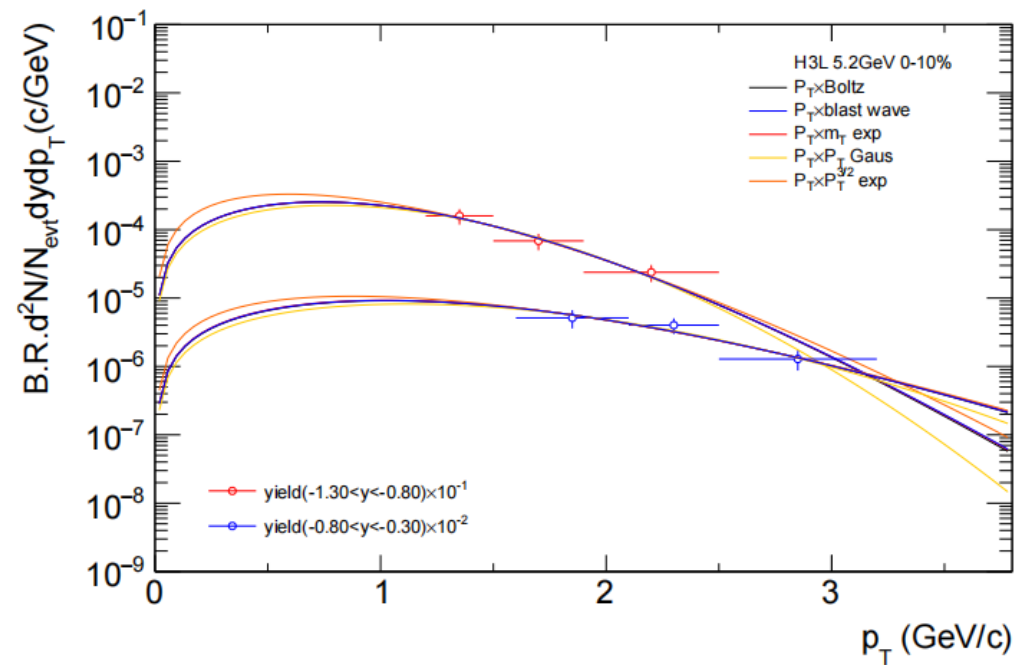
Signals extraction 10-40% (Run2020 5.2 GeV)





- MC particles' p_T distribution is weighted with an m_T exponential function that fit to data (iteration)
- 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%



$$\frac{1}{2\pi p_T} \frac{d^2N}{dp_T dy} \propto C \cdot m_T \exp\left(-\frac{m_T}{T}\right) \text{ boltzmann(default)}$$

$$= \frac{N^{Raw} / (\epsilon^{reco} \times \epsilon^{PID})}{2\pi p_T \Delta p_T \Delta y} \quad C \cdot \exp\left(-\frac{m_T}{T}\right) \quad m_T \exp$$

$$C \cdot \exp\left(-\frac{p_T}{\mu}\right) \quad p_T \text{ Gaus}$$

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

$$\int_0^R r dr m_T I_0\left(\frac{p_T \sinh \rho(r)}{T_{kin}}\right) * K_1\left(\frac{m_T \cosh \rho(r)}{T_{kin}}\right) \quad \text{blast wave}$$

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•When fitting, option “I” is added.

•dN/dy

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

⇒ Stat error: measured region * Fraction,
 Fraction = $\text{Integral}(p_T > 0) / \text{Integral}(\text{measured } p_T \text{ range})$
 from fitting function.

Systematic uncertainty

- Vary nHitsFit: nHitsFit>15, 17, 13
- Vary global average lifetime: H3L= 228.3±12.5 [ps]
- Vary raw count extraction
- Vary extrapolation function
- Vary the topological cuts

- If {default,var1}
⇒ sys.err = |default-var1|
- If {default,var1,var2}
⇒ sys.err = (max-min)*0.5
- Total sys.err added quadratically

- Vary the topological cuts

0-10%

$l > 1, 0, 3$

$\text{chi2topo} < 8, 12, 10$

$\text{chi2ndf} < 2.2, 3, 4$

$\text{chi2primary_pi} > 3, 5, 7$

10-40%

$l > 1, 0, 3$

$\text{chi2topo} < 8, 12, 10$

$\text{chi2ndf} < 3, 4, 5$

$\text{chi2prim_pi} > 8, 11, 15$

- Vary raw count extraction

⇒ Vary mass range used for the rotation backgrounds scaling
[3.008,3.018] , [3.016,3.026], [3.006,3.016]

⇒ Vary the Gaussian+Linear fitting range
[2.97,3.02] , [2.97,3.01] , [2.96,3.02]

Red denotes cuts variations in systematic uncertainty study

Summary of uncertainties

	dndy(cen:0-10%;-1.3~-0.8)
Tracking efficiency	10.01%
H3L Lifetime	6.51%
Topological cuts	9.33%
Raw count extraction	9.26%
Extrapolation	30.12%
	dndy(cen:0-10%;-0.8~-0.3)
Tracking efficiency	11.66%
H3L Lifetime	5.68%
Topological cuts	12.40%
Raw count extraction	3.96%
Extrapolation	27.74%

	100%(cen:10-40%;-1.3~-0.8)
Tracking efficiency	10.35%
H3L Lifetime	3.47%
Topological cuts	8.91%
Raw count extraction	1.80%
Extrapolation	11.81%
	100%(cen:10-40%;-0.8~-0.3)
Tracking efficiency	10.07%
H3L Lifetime	2.95%
Topological cuts	9.91%
Raw count extraction	2.30%
Extrapolation	16.17%

⇒ 0-10%

$$dN/dy = 0.0127164 \pm 0.00212993 \text{ (stat)} \pm 0.004445726 \text{ (sys)} \quad -1.3 < y < -0.8$$

$$dN/dy = 0.00653931 \pm 0.00117625 \text{ (stat)} \pm 0.002176037 \text{ (sys)} \quad -0.8 < y < -0.3$$

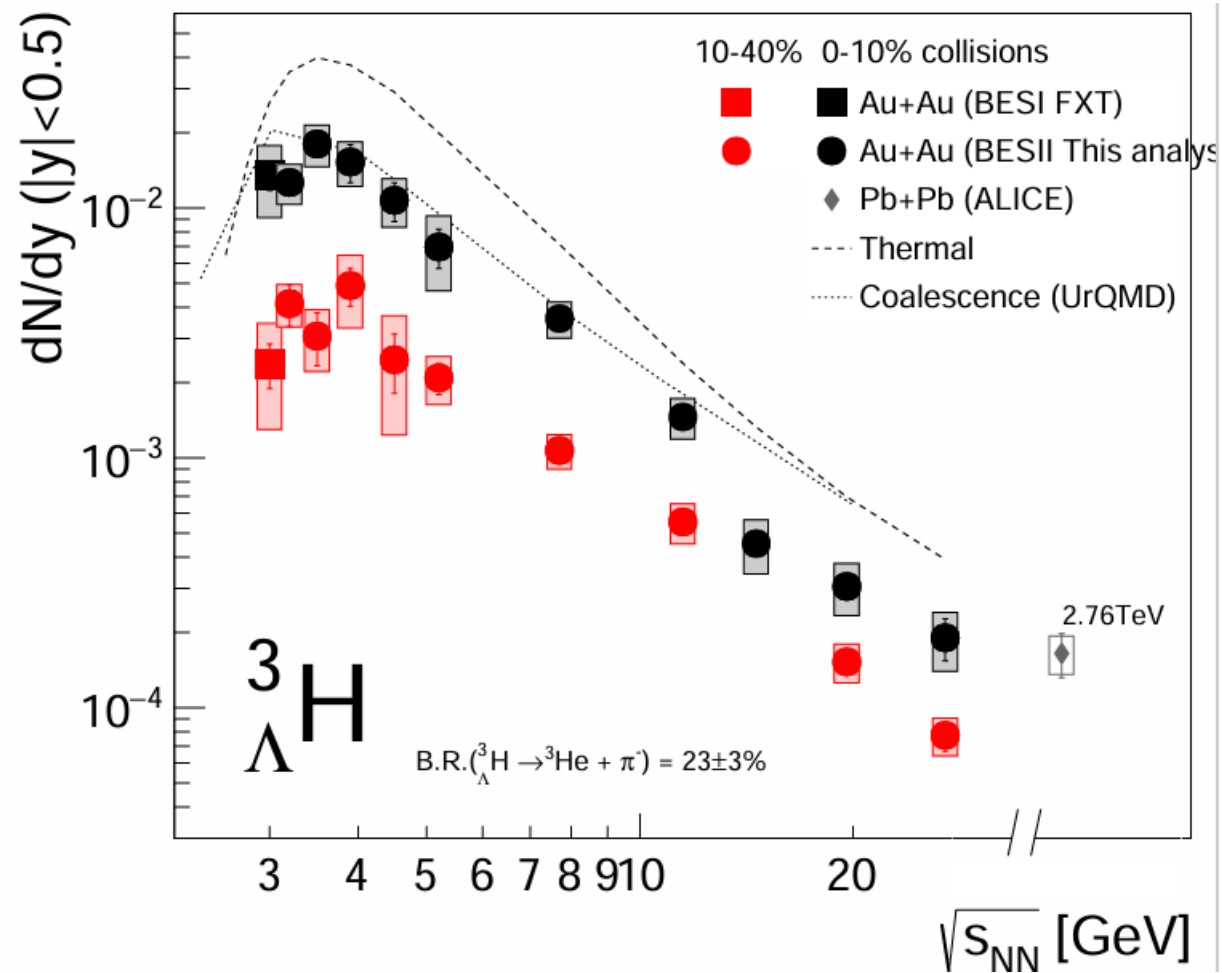
⇒ 10-40%

$$dN/dy = 0.00400137 \pm 0.000602911 \text{ (stat)} \pm 0.000739257 \text{ (sys)} \quad -1.3 < y < -0.8$$

$$dN/dy = 0.00215088 \pm 0.000279149 \text{ (stat)} \pm 0.000426624 \text{ (sys)} \quad -0.8 < y < -0.3$$

⇒ Assuming B.R. = 25%

https://drupal.star.bnl.gov/STAR/system/files/H3L_branchingratio.pdf



- The dN/dy in 5.2GeV follows the trend of dN/dy vs energy

Summary of uncertainties

	meanpt(cen:0-10%;-1.3~-0.8)
Tracking efficiency	0.24%
H3L Lifetime	0.64%
Topological cuts	5.19%
Raw count extraction	2.79%
Extrapolation	11.39%
	meanpt(cen:0-10%;-0.8~-0.3)
Tracking efficiency	1.58%
H3L Lifetime	1.08%
Topological cuts	6.06%
Raw count extraction	1.23%
Extrapolation	13.82%

	meanpt100%(cen:10-40%;-1.3~-0.8)
Tracking efficiency	2.49%
H3L Lifetime	0.89%
Topological cuts	7.45%
Raw count extraction	2.46%
Extrapolation	15.66%
	meanpt100%(cen:10-40%;-0.8~-0.3)
Tracking efficiency	0.12%
H3L Lifetime	0.70%
Topological cuts	7.70%
Raw count extraction	2.44%
Extrapolation	3.02%

⇒0-10%

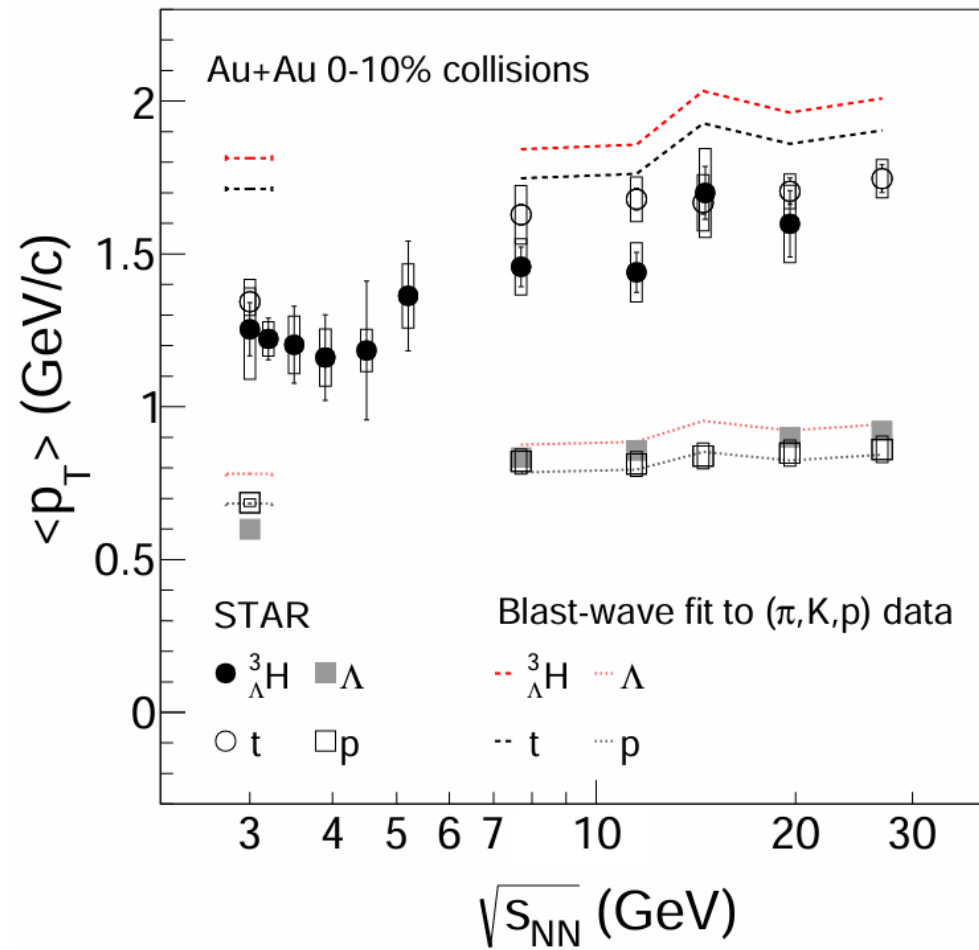
meanpt= 0.952788 ± 0.0943583 (stat) ± 0.077844019 (sys) $-1.3 < y < -0.8$

meanpt = 1.3628 ± 0.179604 (stat) ± 0.104793252 (sys) $-0.8 < y < -0.3$

⇒10-40%

meanpt = 1.41513 ± 0.144311777 (stat) ± 0.204977 (sys) $-1.3 < y < -0.8$

meanpt = 1.471 ± 0.122105261 (stat) ± 0.204977 (sys) $-0.8 < y < -0.3$



- Get H3L p_T spectra in 0-10% and 10-40% of Run2020 FXT Au+Au 5.2 GeV
- Get p_T -integrated yields in $-0.8 < y < -0.3$ of 0-10% and 10-40% at Run2020 FXT Au+Au 5.2 GeV
 - ⇒ It follows the trend of dN/dy vs energy

To do list

- Barlow test
- Analysis note
- Waiting for reproduced data