The measurement of $p-\Xi^-$ Correlation function in Au + Au collisions at $\sqrt{s_{NN}}$ = 3.5 GeV(P23ie)

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The analysis @ 3.5GeV(P21id):
https://drupal.star.bnl.gov/STAR/system/files/yingjie_pXicf_BESII_fxt_sys.pdf

The analysis @ 3.2GeV:
https://drupal.star.bnl.gov/STAR/system/files/Measurement_pXiCF_3p2.pdf

Outline

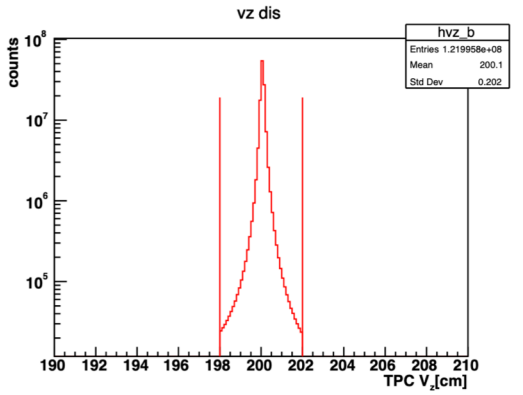
- Data set and event, track selection
- Proton candidate selection
- Ξ^- candidate reconstruction
- $p-\Xi^-$ correlation function calculation
- Summary and Outlook
- The comparison between the dataset at P23ie and P21id are shown in the backup

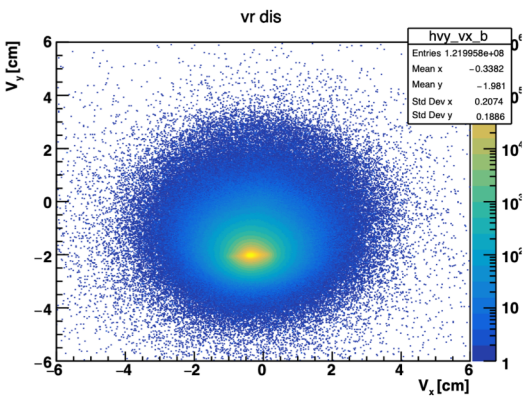
Data set and event, track selection

- $\sqrt{s_{NN}}$ = 3.5 GeV (Run 20 Fixed target Au + Au 5.75 GeV data)

Data form: production_5p75GeV_fixedTarget_2020 (P23ie)

Energy ($\sqrt{s_{NN}}$ GeV)	Trigger ID	Total Events(M)	V_z (cm)	V_r ((0, 2)cm)	Good Events(M)
3.5	720000	~122	[198, 202]	$\sqrt{(V_x)^2 + (V_y+2)^2} < 2$	~119

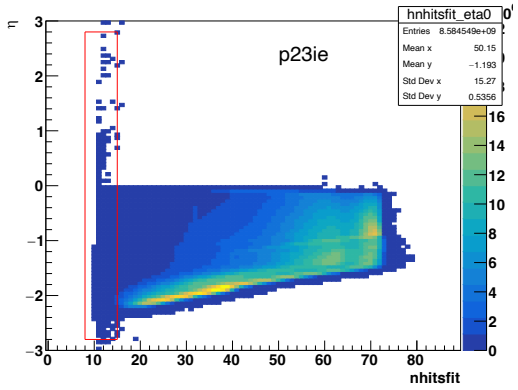


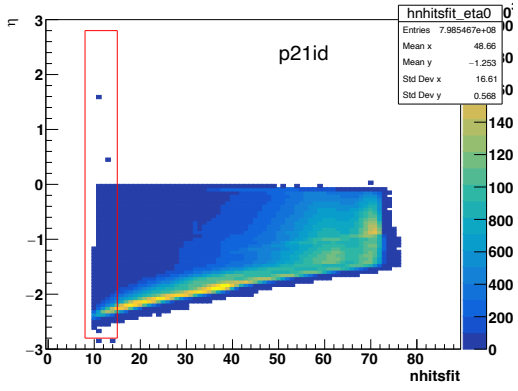


Bad run list, Centrality definition and Pile-up:

https://drupal.star.bnl.gov/STAR/system/files/Centrality_Determination_for_3_5_GeV_Production_0.pdf

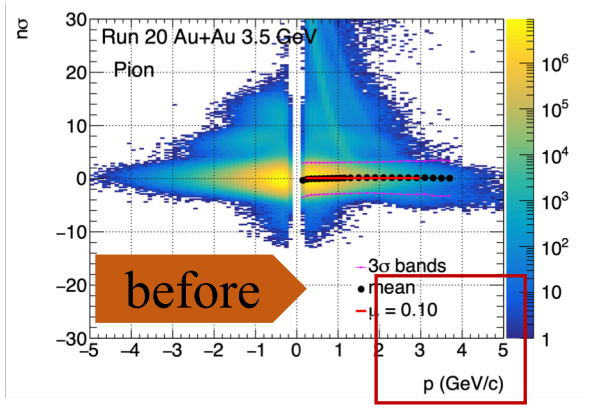
Track cuts	p_T	nHitsFit	nHitsFit / nHitsMax	nHitsdEdx
	>=0.15	>=15	>=0.52	>= 5

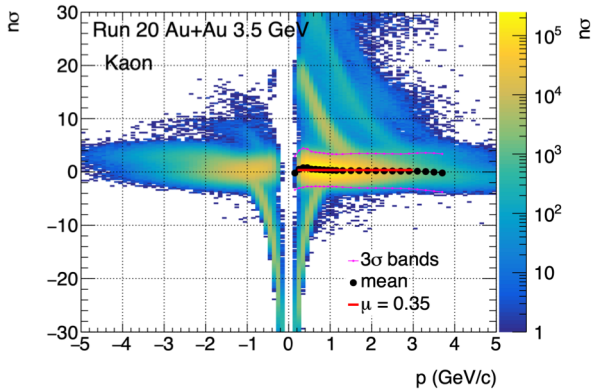


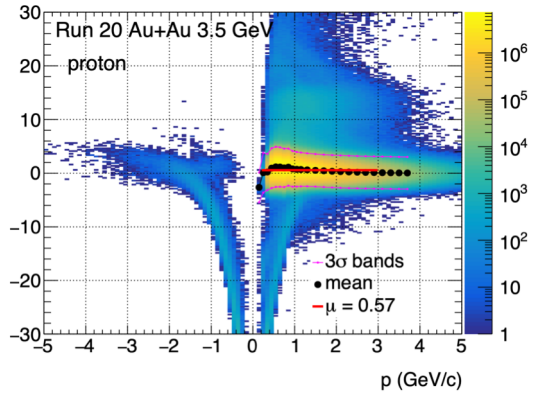


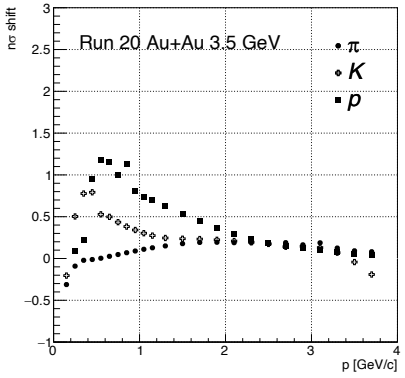
Particle Identification Recalibration

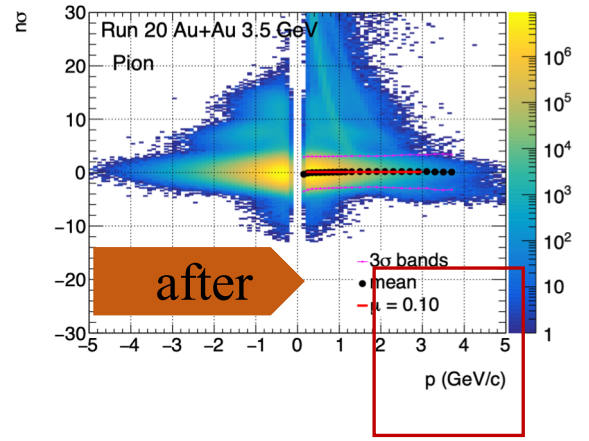
Particle Identification recalibration of π^- , k and p

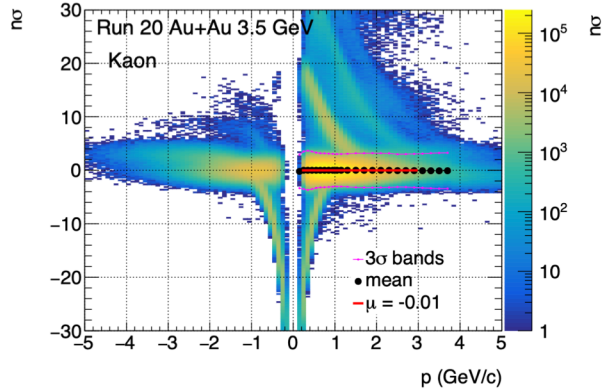


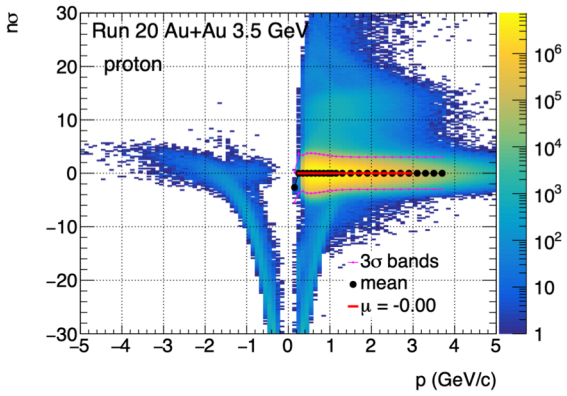








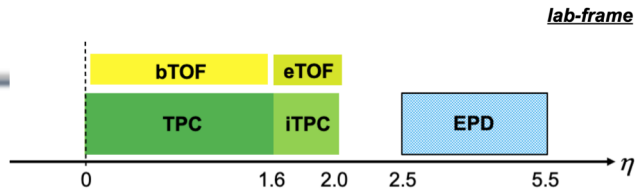




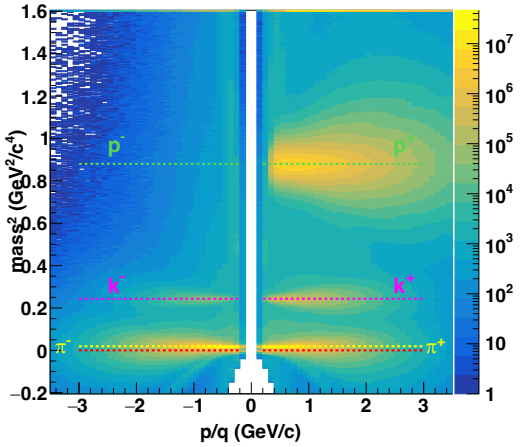
- Using the gaussian function to fit the $n\sigma$ distribution in narrow momentum bin and determine the mean of $n\sigma$

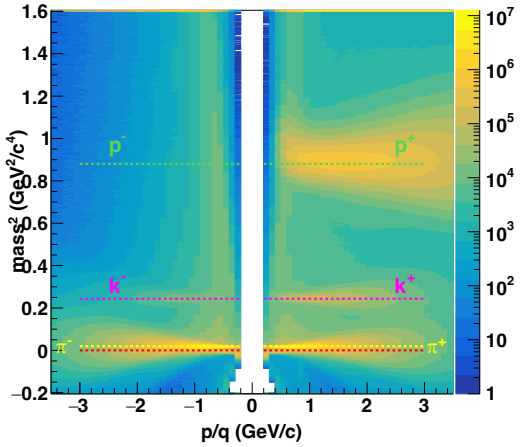
- $n\sigma$ (recalibration) = $n\sigma$ – mean

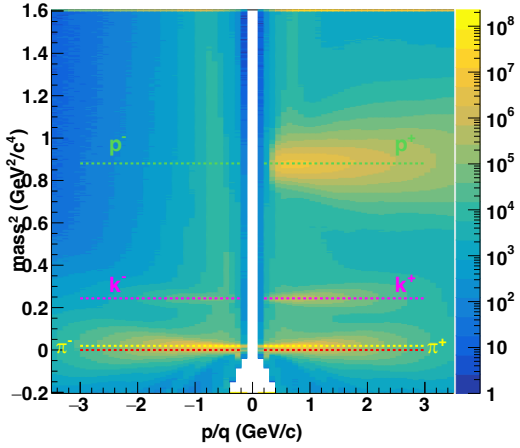
Add the eTOF



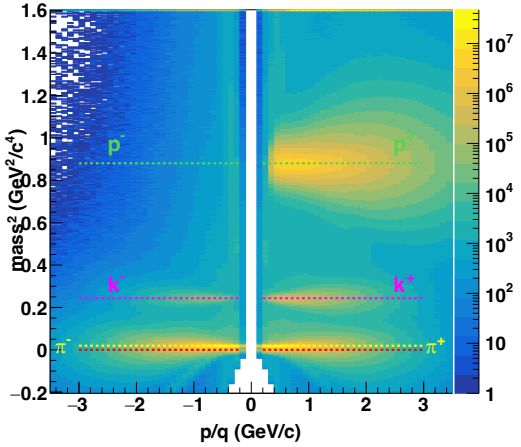
W/O T0 recalibration

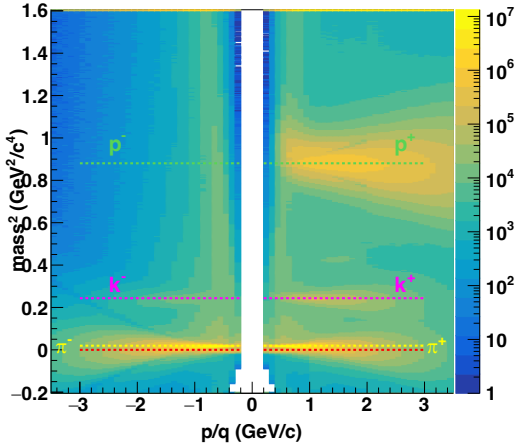


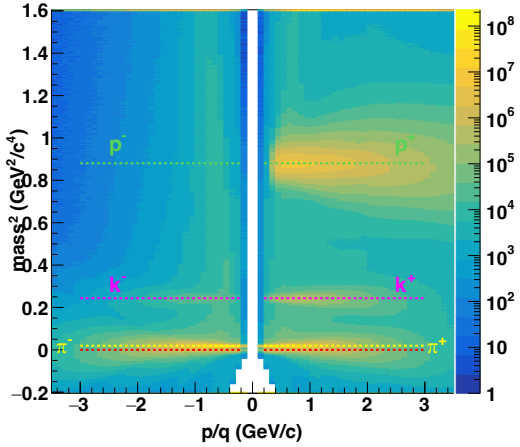




W/ T0 recalibration





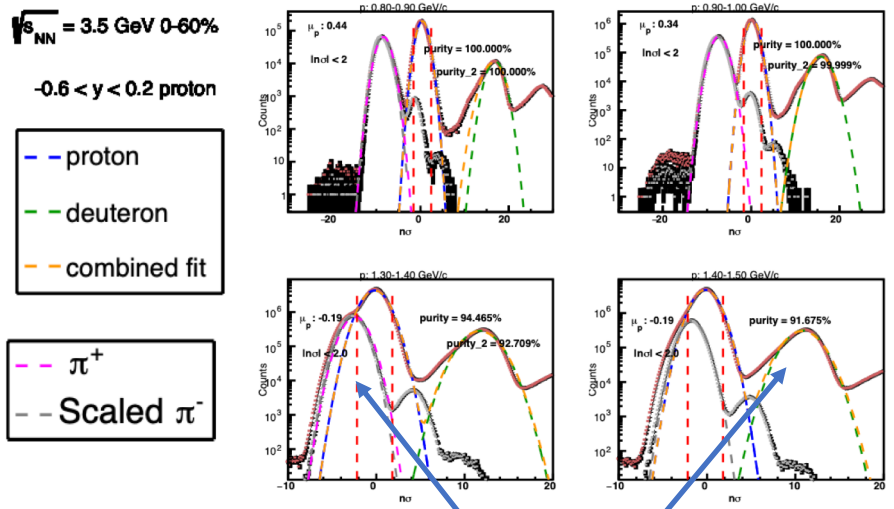


bTOF

eTOF

Mix bTOF + eTOF

Proton purity calculation



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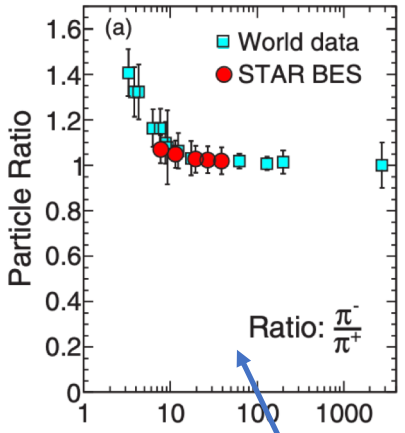


FIG.1

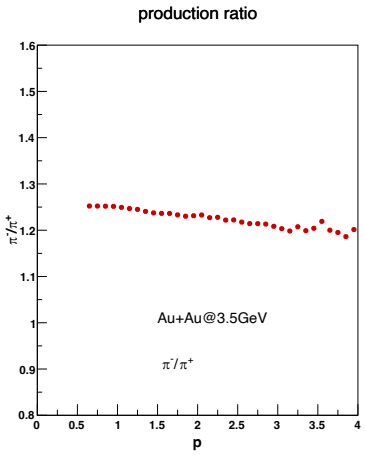


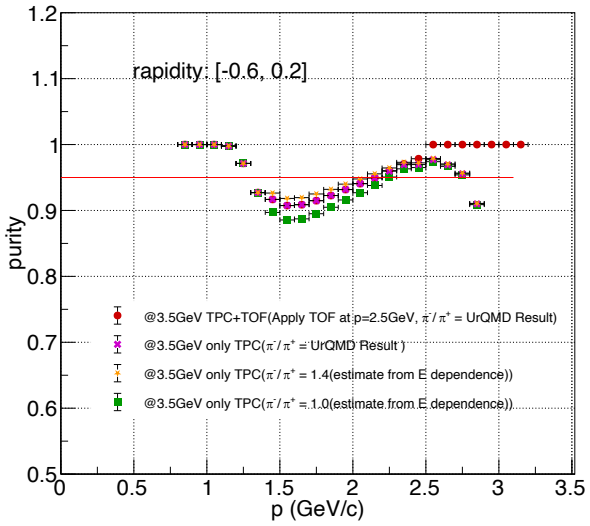
FIG.2

FIG.1: The energy dependence of π^-/π^+ particle ratio from world data

FIG.2: Particle ratio of π^-/π^+ from UrQMD model

Proton purity estimation in two methods:

- p ∈ [0, 1.4]GeV/c, Using the three gaussian functions to fit the π^+, p, d in each momentum bin with determined mean/width of each particle's $n\sigma$ distribution
- p ∈ [1.4, 3.0]GeV/c, Using the π^- to estimate the π^+ (refer the particle ratio of π^-/π^+) , combine with the p, d (fitted by the two gaussian functions) to calculate the purity of proton
- Purity = total- π^+- d / total



Ξ^- reconstruction

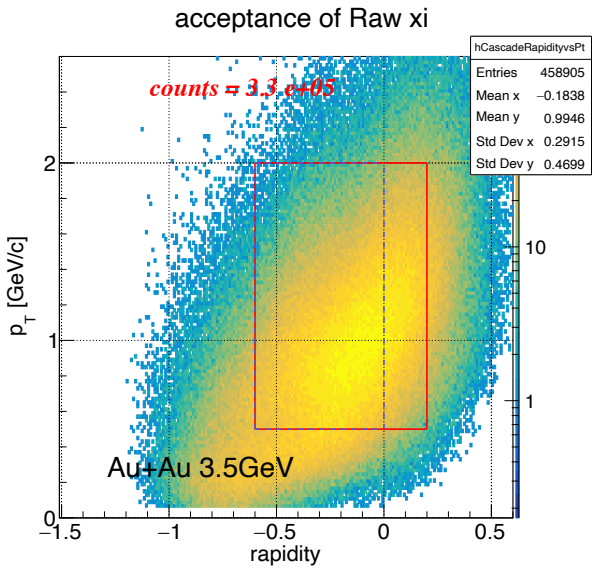
- According to the significance, purity and signal counts, we tuning the topological variables cuts to get the Ξ^- with the higher quality from wide step to the narrow step and wider region :

https://drupal.star.bnl.gov/STAR/system/files/20230329_Xi_bkg.pdf

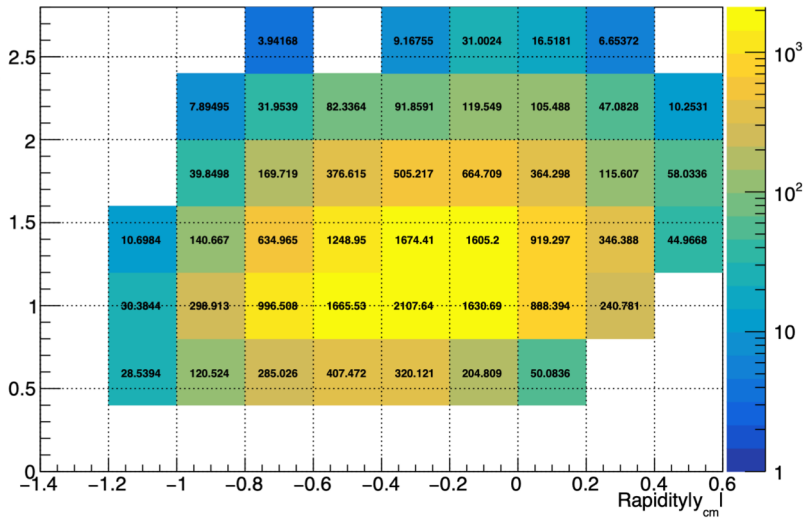
Remove the fake Ξ^-				**|fake mass – 1.1157| > 0.00504**			
Topological cuts	3GeV	$LdL_{\Xi^-} > 6$	$\chi^2_{NDF} < 10$	Ξ^- decay length < Λ ($\leftarrow \Xi^-$)			$L_{\Xi^-} > 1$cm
		$DCA_{\Lambda-\pi^-}$ < 0.8 cm	$DCA_{p-\pi^-}$ < 0.8 cm	$\chi^2_{prim\_proton} > 10$	$\chi^2_{prim\_pion} > 10$	$\chi^2_{prim\_pion(bach)} > 10$	$\chi^2_{topo} < 10$
	3.2GeV	$LdL_{\Xi^-} > 6$	$\chi^2_{NDF} < 10$	Ξ^- decay length < Λ ($\leftarrow \Xi^-$)			$L_{\Xi^-} > 3$cm
		$DCA_{\Lambda-\pi^-}$ < 0.8 cm	$DCA_{p-\pi^-}$ < 0.8 cm	$\chi^2_{prim\_proton} > 7$	$\chi^2_{prim\_pion} > 10$	$\chi^2_{prim\_pion(bach)} > 14$	$\chi^2_{topo} < 4.3$
	3.5GeV	$LdL_{\Xi^-} > 6$	$\chi^2_{NDF} < 10$	Ξ^- decay length < Λ ($\leftarrow \Xi^-$)			$L_{\Xi^-} > 3$cm
		$DCA_{\Lambda-\pi^-}$ < 0.9 cm	$DCA_{p-\pi^-}$ < 1.0 cm	$\chi^2_{prim\_proton} > 7$	$\chi^2_{prim\_pion} > 10$	$\chi^2_{prim\_pion(bach)} > 17$	$\chi^2_{topo} < 4.3$

Centrality region	**p_T region**	**Rapidity region**
0-60%	$0.5 < p_T < 2.0$	$-0.6 < y < 0.2$

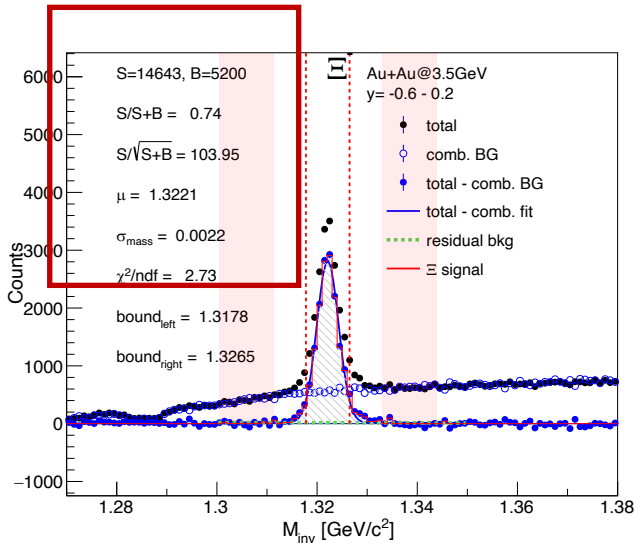
Acceptance and signal extraction



Acceptance of Ξ^-



Acceptance of Ξ^- with deducting the background



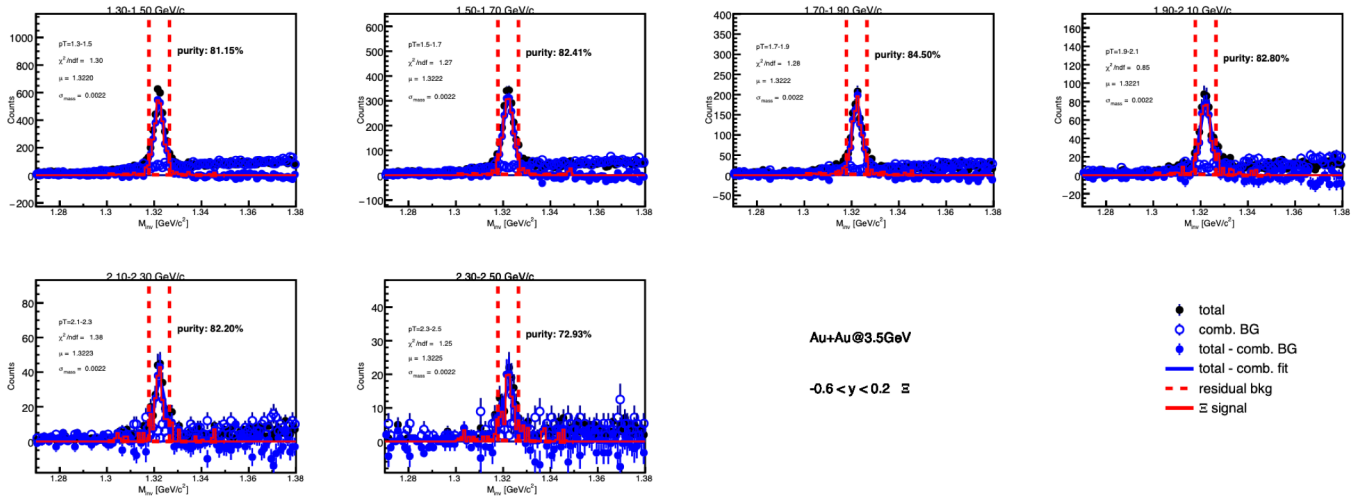
Extracting the signal

- Raw signal: Using the KF-Particle package to reconstruct the Ξ^- with tuning topological cuts and veto mass cut
- Background(Rotation background): Rotate π^- by (150, 210)°
- Signal bin counts region : [1.3178, 1.3265] (mass window is $\mu \pm 2\sigma$)

Ξ^- purity calculation

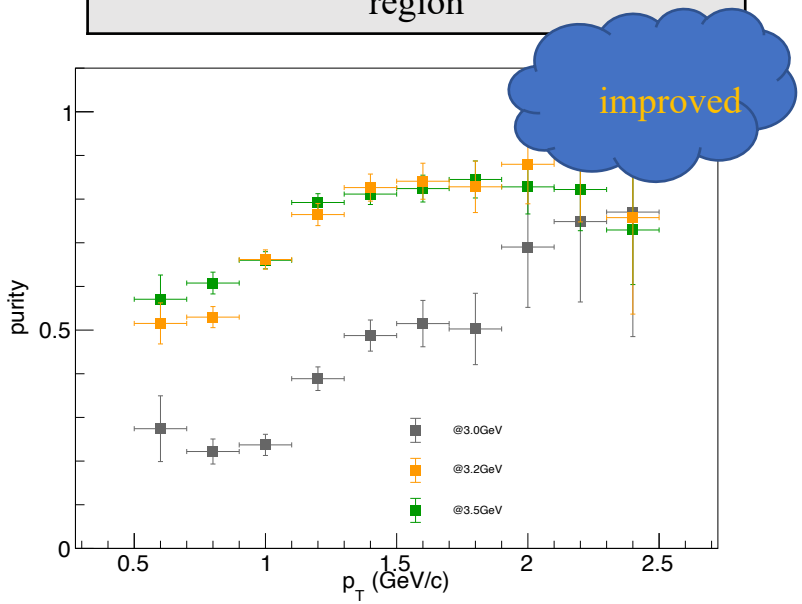
CENTRAL CHINA NORMAL UNIVERSITY

Calculate the purity of Ξ^- in small p_T region



Acceptance and centrality region same as proton

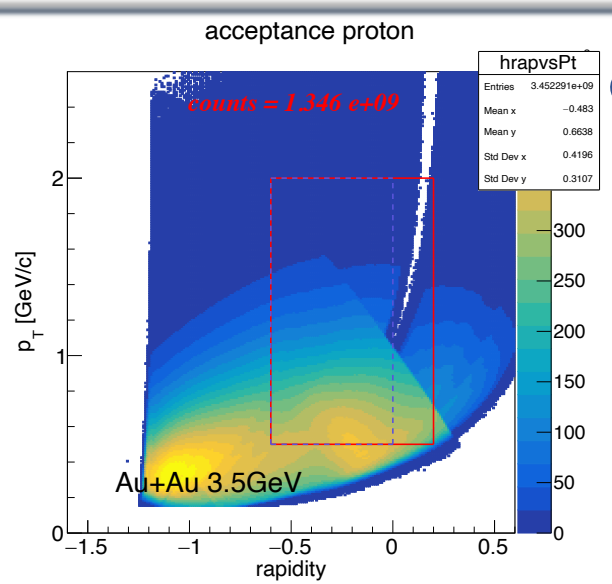
0-60%(centrality)
-0.6 < y < 0.2
the region of $\mu \pm 2\sigma$ is fixed as total p_T region

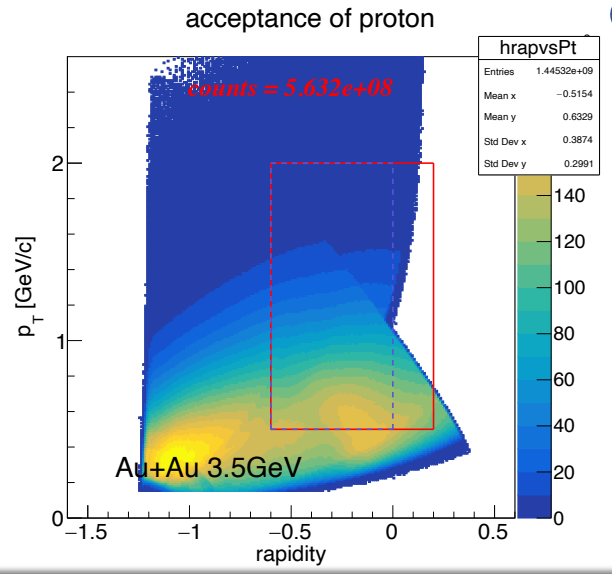


Proton purity estimation in two method:

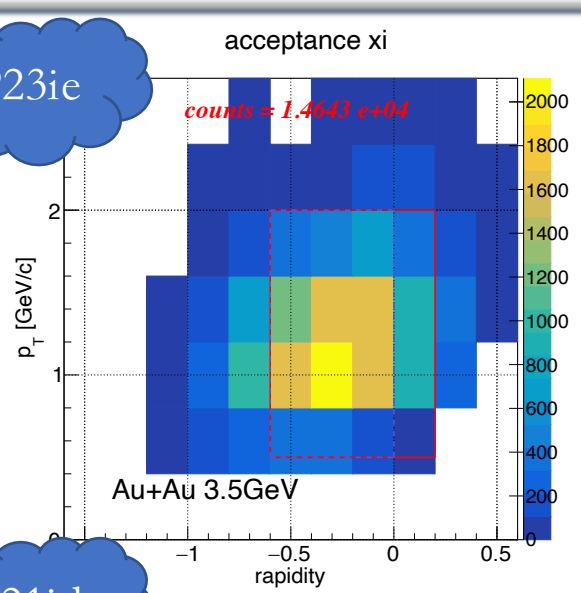
- After subtraction of the rotation background , use the gaussian and linear function to fit signal in small p_T region
- Purity = $\dfrac{\text{total counts} - \text{rotation bkg counts} - \text{residual bkg counts}}{\text{total counts}}$

comparison

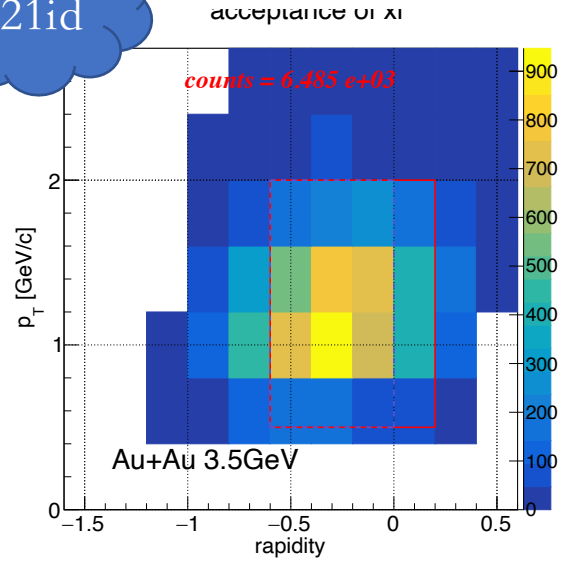




P23ie



P21id



	Good Events	Ξ^- counts	Proton counts
P23ie (eTOF)	119.262M	14643	1.346 e+09
p21id	52.827M	6485	5.632 e+08
ratio	~ 2.2576	~ 2.2579	~ 2.3899

Applying the eTOF improve the statistics of primary proton

Raw correlation function

Derivation of p-Ξ^- experimental correlation function:

$$C(p_1, p_2) = \frac{P(p_1, p_2)}{P(p_1)P(p_2)}$$

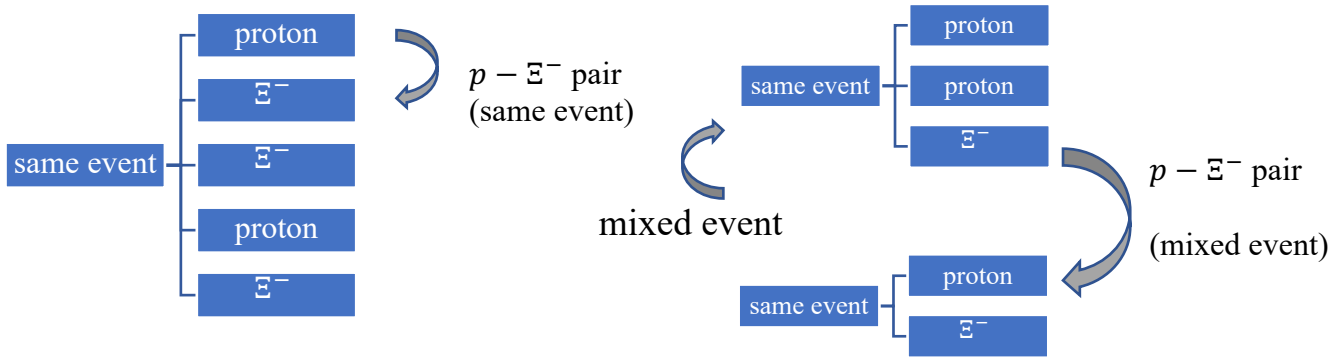
$$k^* = \frac{1}{2}|p_1^* - p_2^*|$$

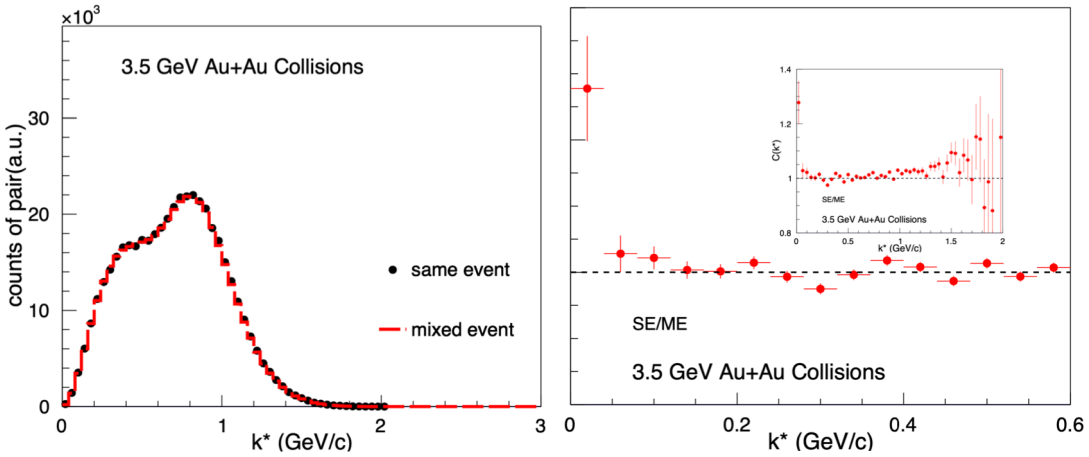
$$C(k^*) = N\frac{A(k^*)}{B(k^*)} = \frac{\text{counts of same event}}{\text{counts of mixed enent}}$$

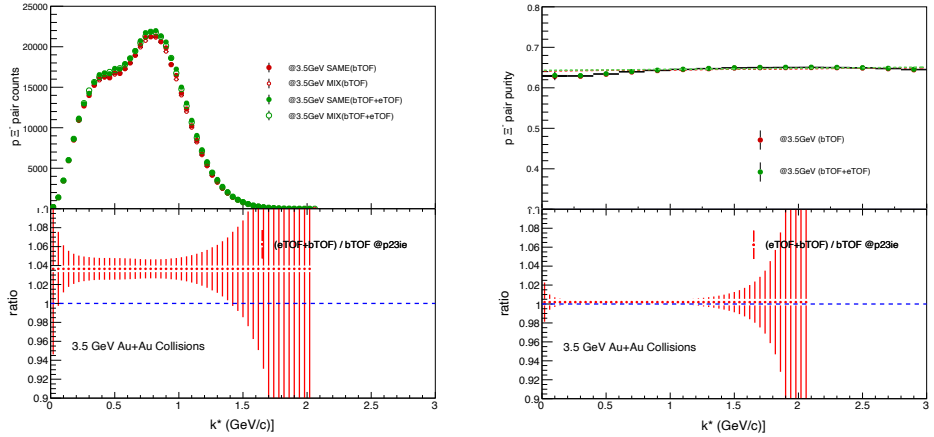
Normalization region is: $k^*\epsilon[0.3, 0.5]$

signal region is [0.000, 0.0044] ($|\mu \pm 2\sigma|$)

Proton id ≠ Ξ^- daughters id



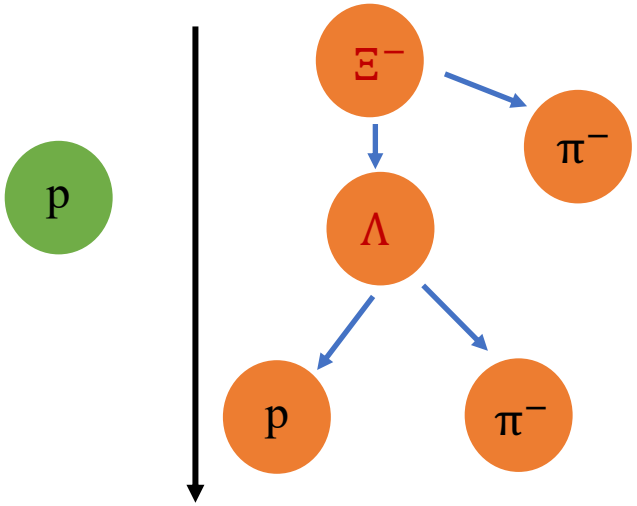




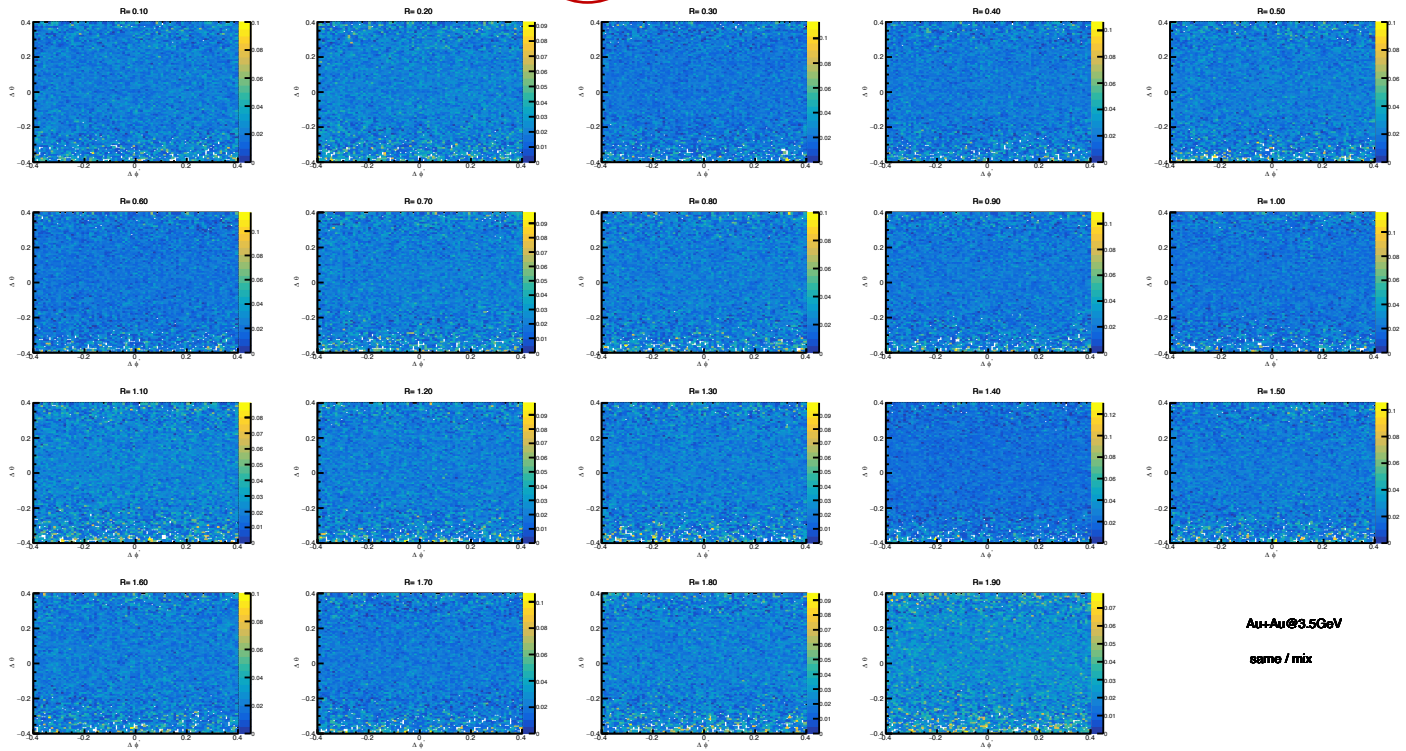
Track merging and splitting check

$p + \Xi^- \rightarrow \Lambda(\rightarrow p + \pi^-) + \pi^-$

$\Delta\theta$ v.s $\Delta\phi^*$



R = 0.1 - 1.9



https://drupal.star.bnl.gov/STAR/system/files/Preliminary_request_KK_HBT_3p2to3p9_Bijun_230810_v2.pdf

- There are no track merging and splitting effect between primary proton and proton(decayed from Λ)
- Same method using to check the track-merging effect between the π^- (decayed from Ξ^-) and π^- (decayed from Λ), positive and negative particle daughters, and get the same conclusions

Decomposition of the Correlation Function

$p - \Xi^-$ signal is diluted with contributions from the two aspects :

- First, particle misidentifications due to the experimental techniques and the experimental setup:
  - Misidentified Ξ^- （After being identified by TPC and TOF detectors， the proton purity ~ 1, can be ignored)
- Second, weakly decaying resonances :
  - Decays of the Ξ(1530) resonance $(\Xi^-(1530) \rightarrow \Xi^- + \pi^-)$

The correlation functions stemming from resonances or impurities of the sample are weighted with the so-called λ parameters and the correlation function can be described as :

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$$C(k^*) = 1 + \lambda_{\text{genuine}} \cdot [C_{\text{genuine}}(k^*) - 1] + \sum_{..} \lambda_{ij}[C_{ij}(k^*) - 1],$$

$$\lambda_{i,j}(XY) = \mathscr{P}(X_i) f(X_i) \mathscr{P}(Y_j) f(Y_j).$$

$$\rightarrow \quad C_{\text{Raw}}(k^*) = \lambda_{\text{gen}} C_{\text{gen}} + \lambda_{\text{bkg}} C_{\text{bkg}} + \lambda_{\text{feed}} C_{\text{feed}} + \cdots$$

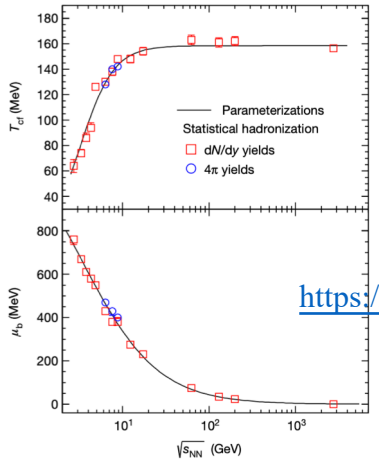
genuine　misidentifications　feed-down

where the i, j denote all possible impurity and feed-down contributions.

Particle channel fraction and λ_{ij} parameter

Using the Thermal-FIST (Thermal, Fast and Interactive Statistical Toolkit) model to obtain the composition of the contribution of resonances to the yield of Ξ^- baryons and proton primordial fraction :

Fig. 3 | Energy dependence of chemical freeze-out parameters T_{cf} and μ_b. The results are obtained from the statistical hadronization analysis of hadron yields (at mid-rapidity, dN/dy, and in full phase space, 4π) for central collisions at different energies. The parameterizations shown are: $T_{cf} = T_{cf}^{lim}/\{1+\exp[2.60-\ln(\sqrt{s_{NN}})/0.45]\}$ and $\mu_b = a/(1+0.288\sqrt{s_{NN}})$, with $\sqrt{s_{NN}}$ in gigaelectronvolts, T_{cf}^{lim} =158.4 MeV and a = 1,307.5 MeV. The uncertainty of the limiting temperature T_{cf}^{lim}, determined from the fit of the five points that represent the highest energies, is 1.4 MeV.



When $\sqrt{S_{NN}}$ = 3.5 GeV :

$T_{cf} \approx 86.4$ MeV

$\mu_b \approx 651$ MeV

https://github.com/vlvovch/Thermal-FIST

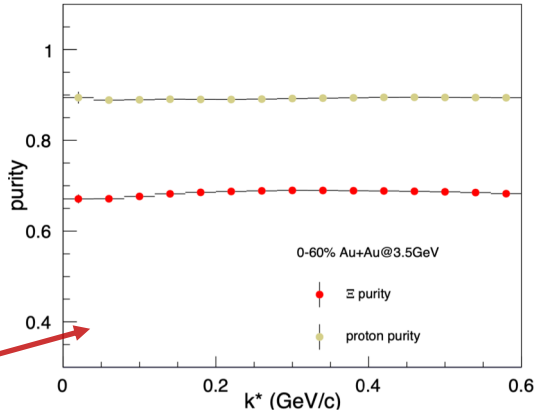
Nature 561, 321 (2018)

Production of Xi-
Primordial density = 2.13994e-05 fm^{-3}
Primordial yield = 0.0458944
Total yield = 0.0551354
Primordial + strong decays = 0.0551354
Primordial + strong + EM decays = 0.0551354
Primordial + strong + EM + weak decays = 0.0551752

Source	Multiplicity	Fraction (%)
Primordial	0.0458944	83.2394
Decays from primordial Xi(1530)0	0.00566825	10.2806
Decays from primordial Xi(1530)-	0.00319793	5.80014
Decays from primordial Xi(1690)0	0.000172307	0.312515
Decays from primordial Xi(1690)-	0.000100598	0.182456
Decays from primordial Xi(1950)0	4.74195e-05	0.0860055
Decays from primordial Xi(1950)-	2.76851e-05	0.0502129
Decays from primordial Omega(2012)	1.17849e-05	0.0213745
Decays from primordial Sigma(2030)-	8.02627e-06	0.0145574
Decays from primordial Sigma(2030)0	3.43689e-06	0.00623355
Decays from primordial Lambda(2100)	2.40801e-06	0.00436746
Decays from primordial Omega(2250)	1.15506e-06	0.00209496

Production of p
Primordial density = 0.0138019 fm^{-3}
Primordial yield = 29.6003
Total yield = 35.9929
Primordial + strong decays = 35.9929
Primordial + strong + EM decays = 35.9929
Primordial + strong + EM + weak decays = 38.1076

Source	Multiplicity	Fraction (%)
Primordial	29.6003	82.2393
Decays from primordial Delta(1232)++	2.48245	6.89707
Decays from primordial Delta(1232)+	1.93245	5.36898
Decays from primordial Delta(1232)0	1.12799	3.13393
Decays from primordial N(1520)0	0.0923308	0.256525
Decays from primordial N(1440)+	0.0887602	0.246605
Decays from primordial N(1440)0	0.0859461	0.238787
Decays from primordial N(1520)+	0.0673591	0.187146
Decays from primordial Delta(1600)++	0.0596456	0.165715
Decays from primordial Delta(1600)+	0.050377	0.139964
Decays from primordial N(1535)+	0.0427554	0.118789
Decays from primordial Delta(1600)0	0.0363271	0.100929
Decays from primordial N(1675)+	0.0238499	0.0662628
Decays from primordial N(1535)0	0.0229506	0.0637643
Decays from primordial N(1680)0	0.0200127	0.0556019

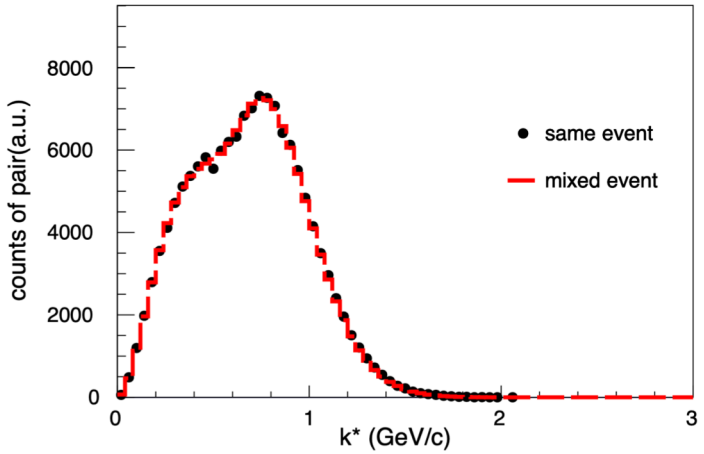


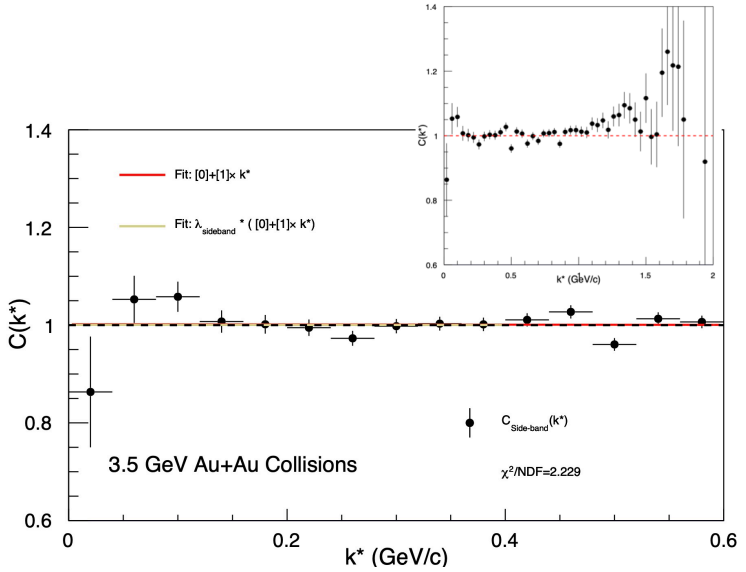
- The primordial fraction of Ξ^- : 83.2394% The primordial fraction of proton: ~ 99%
- The pair purity and mis-identification pair purity(proton paired with the side-band Ξ^-) extracted from the data.

$\lambda_{ij}\ \left(p\Xi^-_{\Xi^-_{(1530)}}\right)$ = proton purity * Ξ^- purity * proton primordial fraction(0.99) * Ξ^- (from the $\Xi^-_{(1530)}$)fraction (1-0.832) = 0.1073

λ_{ij} (misid) = proton purity * Ξ^- impurity * proton primordial fraction(0.99) * Ξ^- primordial fraction (0.832) = 0.2019

Mis-identification correction



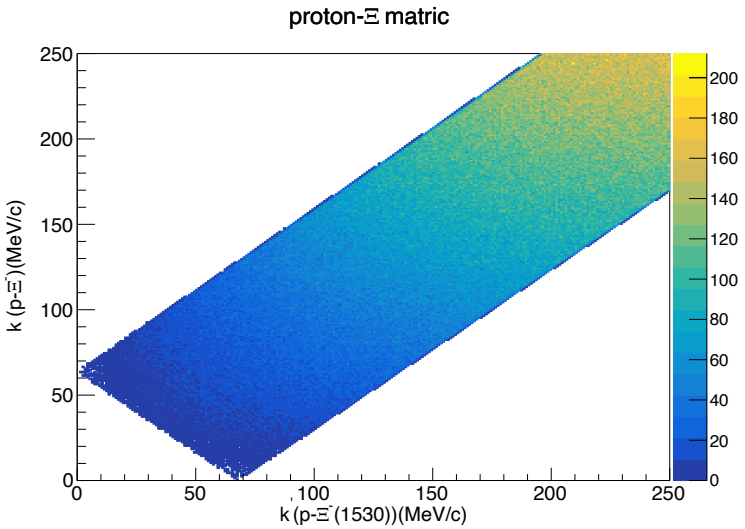


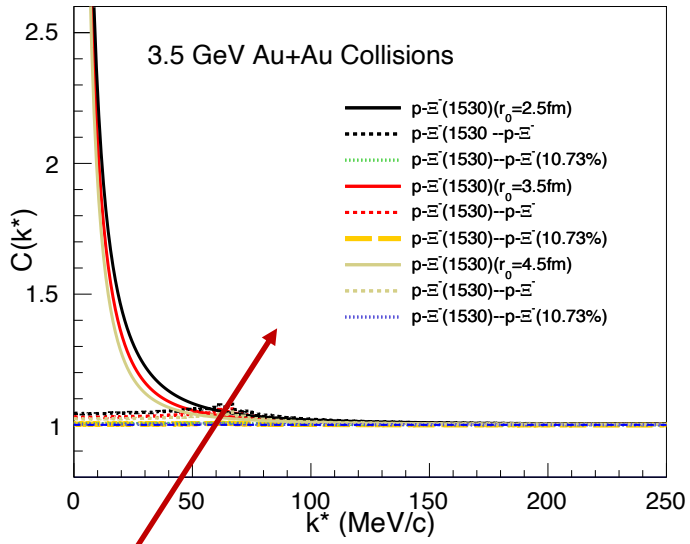
- Nor-zero probability to misidentify the particles of interest:
  - proton paired with the side-band Ξ^-
  - Side-band region: [0.011, 0.0176] ([$|\mu \pm 5\sigma|$, $|\mu \pm 8\sigma|$])
  - The fit function (which to fit the background correlation function) is defined as a polynomial of first order.

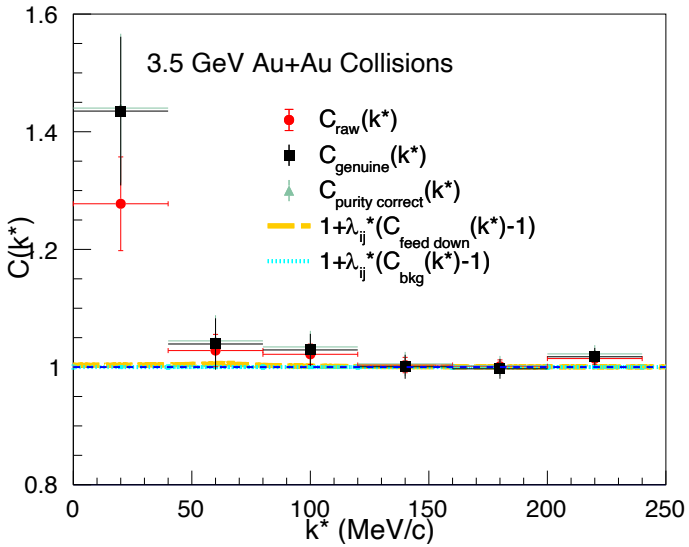
$$C_{geniune}(k^*) = 1 + \frac{C_{raw}(k^*)}{\lambda_{genuine}} - \frac{(1+\lambda_{bkg}(C_{bkg}(k^*)-1)}{\lambda_{genuine}} - \frac{(1+\lambda_{feed\ down}(C_{feed\ down}(k^*)-1)}{\lambda_{genuine}}$$

~ 1

Feed down correction





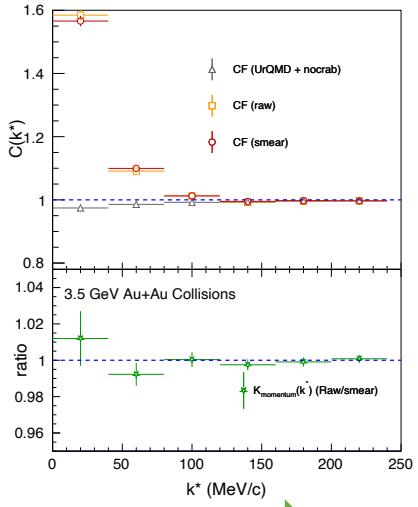


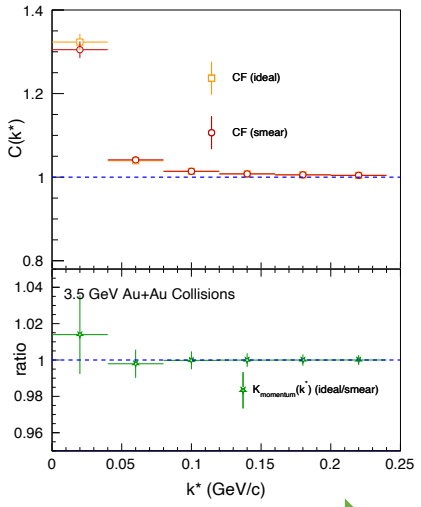
- Feed-down to the particles of interest:
  - Secondaries with $c\tau \geq 20$ fm, eg: weak decays or electromagnetic decays, or $\Xi(1530) \rightarrow \Xi^- + \pi^{\pm}$ with $c\tau \sim 20$ fm
  - Only Coulomb interaction is considered for p- $\Xi(1530)$ correlation function
  - Feed-down matrix, converting the initial p- $\Xi(1530)$ $k'$to the measured k^* of the p- Ξ^- pair
  - Check the influence of different source size to p-Xi(1530) correlation function(Source size : 2.5fm, 3.5fm, 4.5fm)

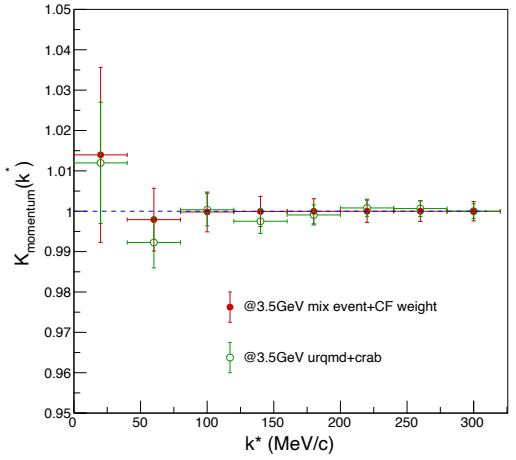
$$C_{geniune}(k^*) = 1 + \frac{C_{raw}(k^*)}{\lambda_{genuine}} - \frac{(1+\lambda_{bkg}(C_{bkg}(k^*)-1)}{\lambda_{genuine}} - \frac{(1+\lambda_{feed\ down}(C_{feed\ down}(k^*)-1)}{\lambda_{genuine}}$$

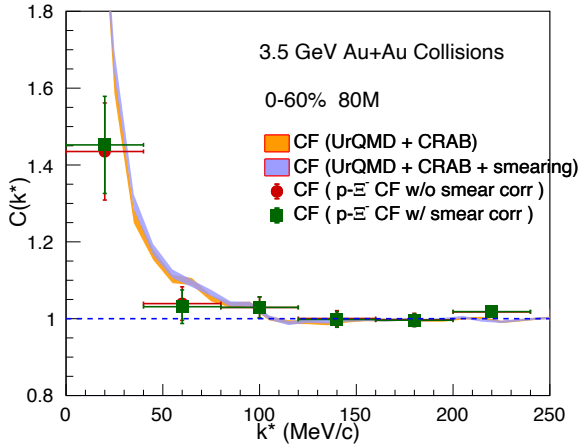
~1 ~1

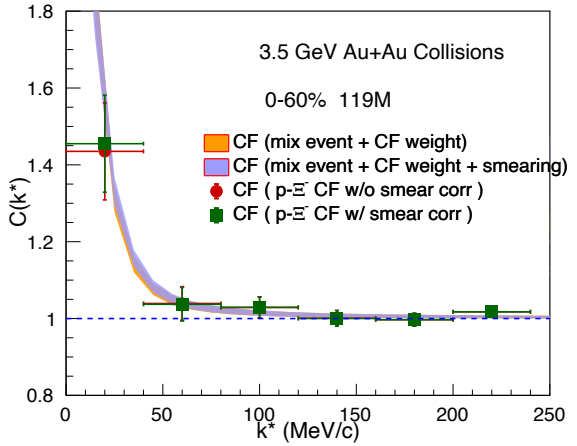
Momentum resolution correction











UrQMD+CRAB → **Mix event+CF weight**

The first point	Mix	UrQMD+CRAB
@3.5GeV	~1.014	~1.012

- We can also use the UrQMD data to instead of mix event data, and use the CRAB (v3.0b) to add the final state interactions(Coulomb + Strong interaction)
- The results by mix event + CF weight and UrQMD + CRAB are basically consistent

systematic error estimate

The systematic uncertainty source in Proton candidates selection:

Single track efficiency : nhitsfit > (15 19, 23)	DCA < (1, 0.5, 1.5)	nσ < (2, 2.5, 3)	production ratio(π^-/π^+) : 1.0, 1.23, 1.4

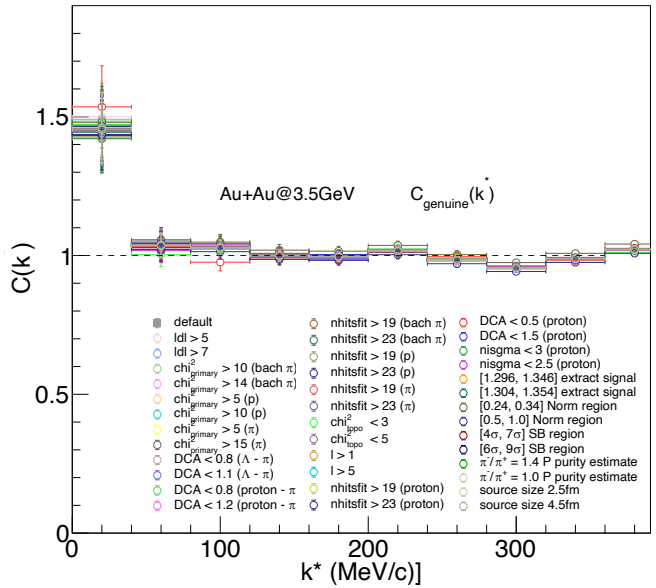
The systematic uncertainty source in Ξ^- candidates reconstruction:

<table>
<tr><td colspan="3">Remove the fake Ξ^-</td><td colspan="4">|fake mass – 1.1157| > 0.00504</td></tr>
<tr><td colspan="3">Single track efficiency (daughter particles): nhitsfit > (15 19, 23)</td><td colspan="4">Signal extraction: $\Xi^-_{\mathrm{invM}} \in$ ([1.300, 1.350] [1.296, 1.346], [1.304 1.354])</td></tr>
<tr><td rowspan="2">Topological cut</td><td>LdL_{Ξ^-} > (5, 6, 7)</td><td>χ^2_{NDF} < 10</td><td colspan="3">Ξ^- decay length < Λ ($\leftarrow \Xi^-$)</td><td>L_{Ξ^-} > 3cm</td></tr>
<tr><td>$DCA_{\Lambda-\pi^-}$ < (0.8, 0.9, 1.1) cm</td><td>$DCA_{p-\pi^-}$ < (0.8, 1.0, 1.2) cm</td><td>$\chi^2_{prim\_proton}$ > (5, 7, 10)</td><td>$\chi^2_{prim\_pion}$ > (5, 10, 15)</td><td>$\chi^2_{prim\_pion(bach)}$ > (10, 14, 17)</td><td>χ^2_{topo} < (3, 4.3, 5)</td></tr>
</table>

The systematic uncertainty source in Correlation function calculate:

Side-band mass window: [$\lvert\mu \pm 4\sigma\rvert$, $\lvert\mu \pm 7\sigma\rvert$], [$\lvert\mu \pm 5\sigma\rvert$, $\lvert\mu \pm 8\sigma\rvert$], [$\lvert\mu \pm 6\sigma\rvert$, $\lvert\mu \pm 9\sigma\rvert$]	Normalization region in same event/mix event: k* ∈ [0.24, 0.34], [0.3, 0.5], [0.5, 1.0]	Source size in feed-down correction: 2.5fm, 3.5fm, 4.5fm

correlation function in different systematic source



Genuine correlation function

- Calculate the statistical uncertainty:

$$statistical\ uncertainty = \sqrt{\left|statistical\ error_{def}^2 - statistical\ error_{sys}^2\right|}$$

- Calculate the systematic difference:

$$systematic\ difference = \left|C(\mathrm{k}^*)_{def} - C(\mathrm{k}^*)_{sys}\right|$$

- Calculate the final systematic error of one cut variable:

$$\sqrt{\left|C(\mathrm{k}^*)_{def} - C(\mathrm{k}^*)_{sys}\right|^2 - \left|stat\ error_{def}^2 - stat\ error_{sys}^2\right|}$$

- Barlow test: if $\left|C(\mathrm{k}^*)_{def} - C(\mathrm{k}^*)_{sys}\right|^2 - \left|stat\ error_{def}^2 - stat\ error_{sys}^2\right| < 0$, systematic uncertainty = 0
- For multiple variations of a variable, quotes the average of the maximum and minimum of the variations as its systematic uncertainty: $(C(\mathrm{k}^*)_{max} - C(\mathrm{k}^*)_{min})/2$
- The final systematic error is to add all systematic sources in quadrature:

$$systematic\ uncertainty = \sqrt{error_{sys1}^2 + error_{sys2}^2 + \dots}$$

Genuine CF with systematic error bars

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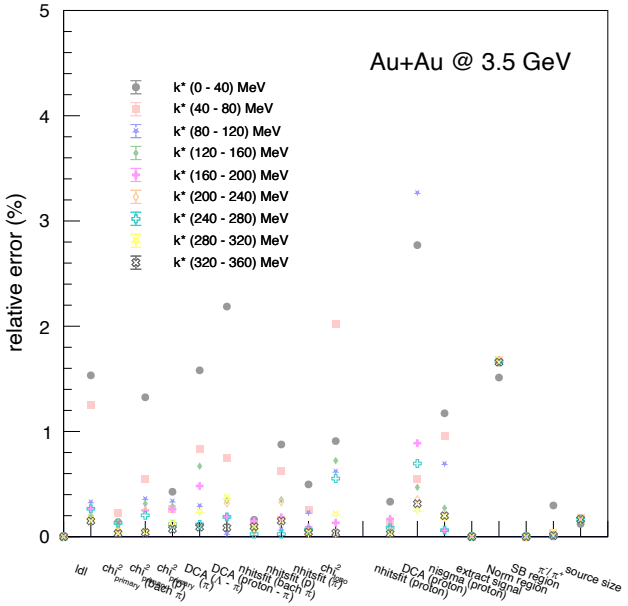
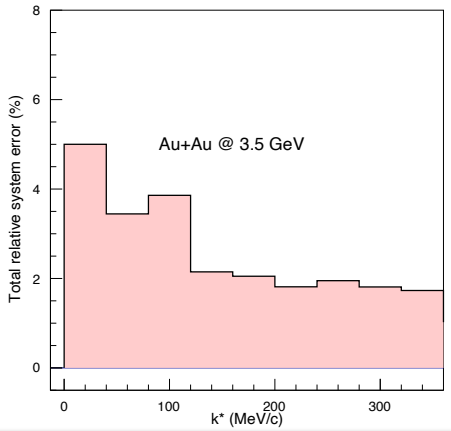
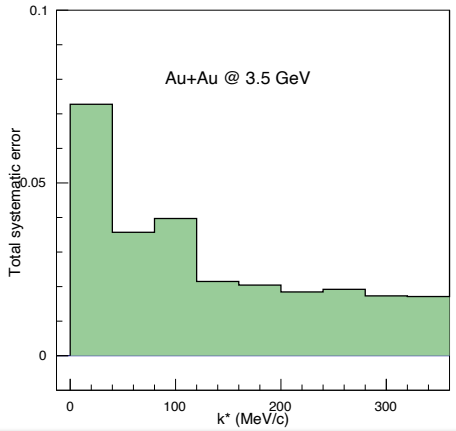
No Barlow test



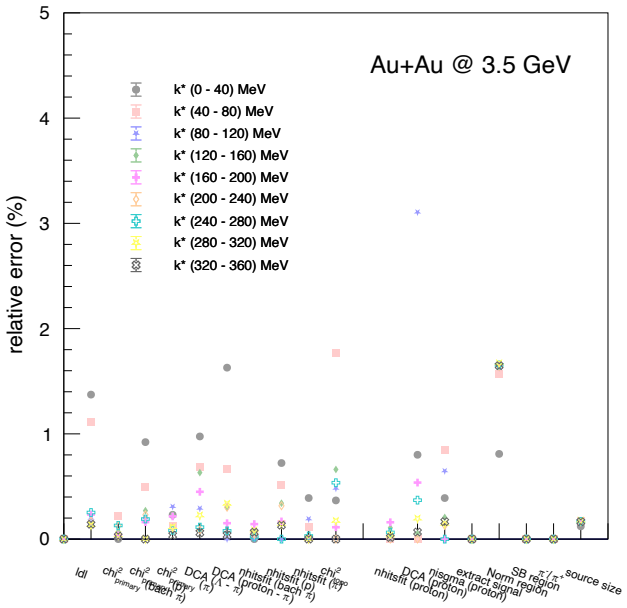
add all systematic sources in quadrature:

$$\sqrt{error^2_{sys1} + error^2_{sys2} + \cdots}$$



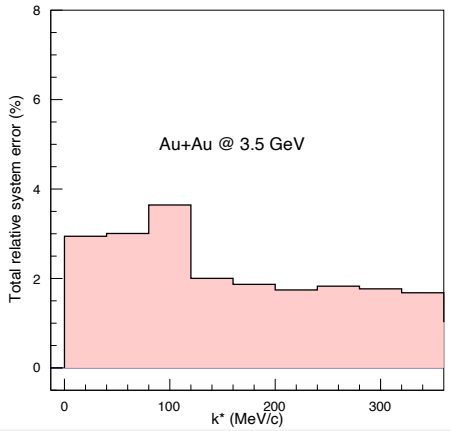


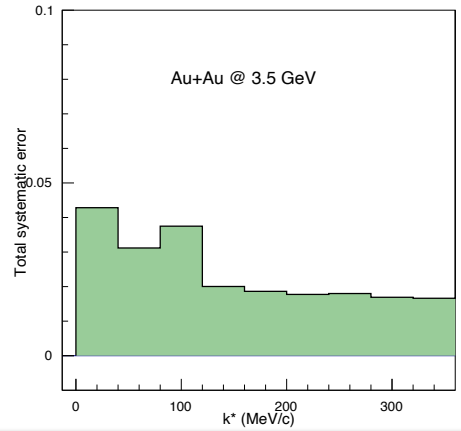
With Barlow test



add all systematic sources in quadrature:

$$\sqrt{error^2_{sys1} + error^2_{sys2} + \cdots}$$





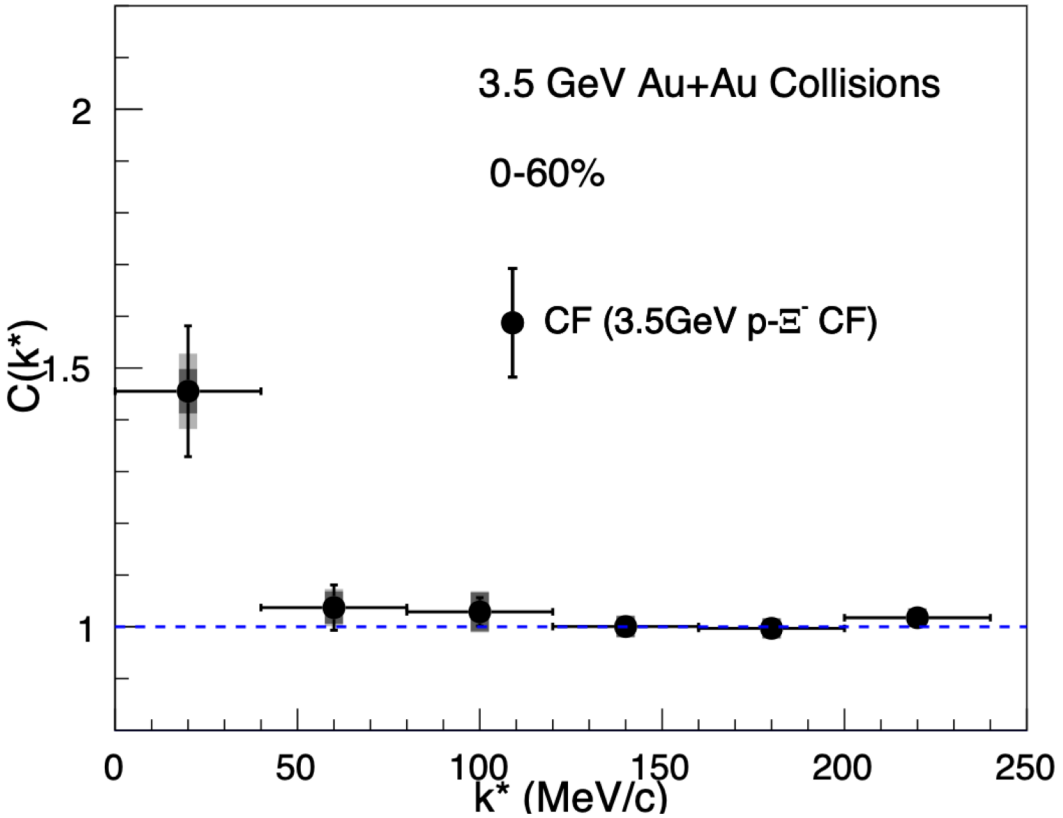
systematic error

k^* ∈[0, 40] MeV/c

	Systematic error source	3.5 GeV (%) (barlow test)	3.5 GeV (%)
Systematic source for Ξ selection	Ldl	1.3729	1.53315
	chi2_primary(bach π)	0	0.137823
	chi2_primary(proton)	0.921501	1.32475
	chi2_primary(π)	0.230758	0.427215
	DCA(Λ-π)	0.97535	1.58089
	DCA(p-π)	1.62901	2.18683
	nhitsfit(bach π)	0	0.16093
	nhitsfit(proton)	0.722764	0.876625
	nhitsfit(π)	0.39039	0.497024
	chi2_topo	0.367561	0.908876
	extract signal range	0	0.00837038
Systematic source for proton selection	DCA(proton)	0.801163	2.7705
	nhitsfit(proton)	0	0.33296
	Sigma (proton)	0.390149	1.17292
	production ratio between the π^- and π^+	0	0.296981
Systematic source of the correlation function	Normal region	0.809572	1.51233
	SB region	0	0
	source size	0.12145	0.12145
Total	Total	~ 2.94387	~ 5.001

Genuine CF

Check the systematic error w/o Barlow test



- The dark box :

systematic error with Barlow test

- The light box :

systematic error without Barlow test

Summary and outlook

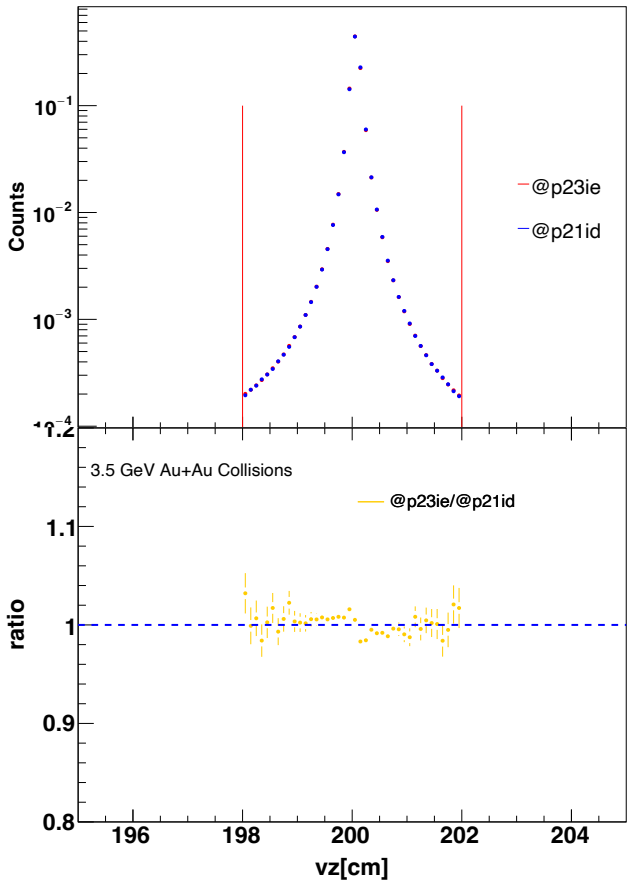
Summary:

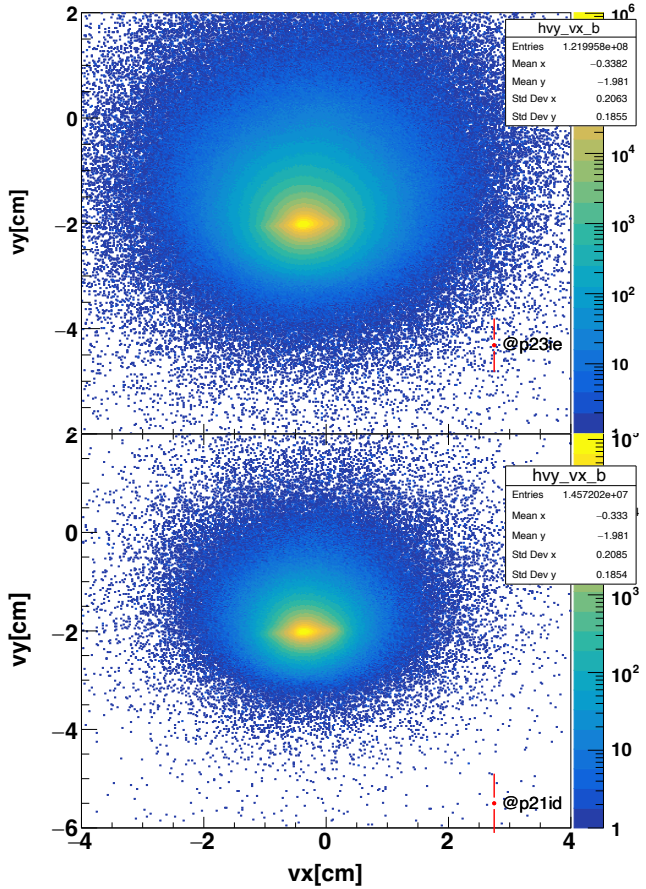
- Measured the proton- Ξ^- raw correlation function in Au + Au collision at $\sqrt{s_{NN}}$ = 3.5 GeV
- Track merging and splitting checking has been done
- The mis-identification, feed down and momentum smearing correction have been done
- Calculated the systematic error of proton- Ξ^- correlation function

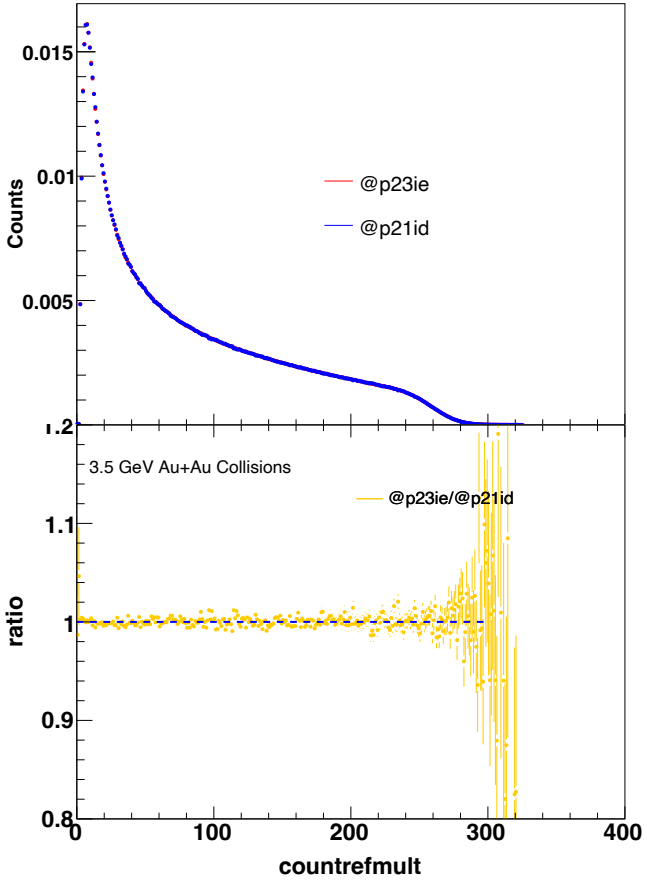
To do list:

- Model calculations via the UrQMD plus CRAB afterburner
- the CF calculation based on Lednicky-Lyuboshitz model

Data QA (event level)

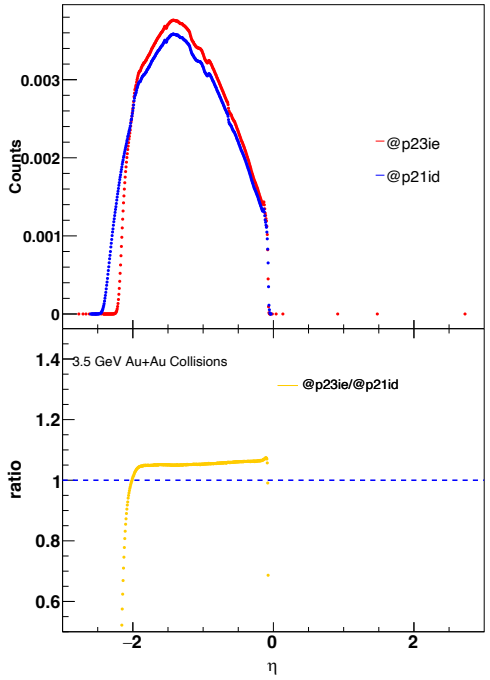


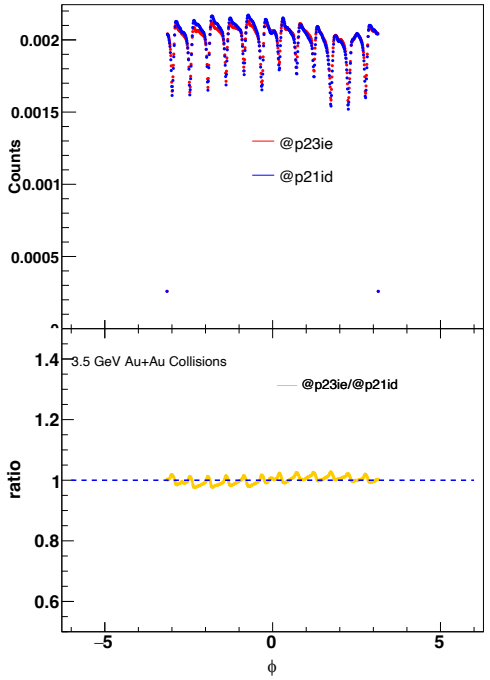


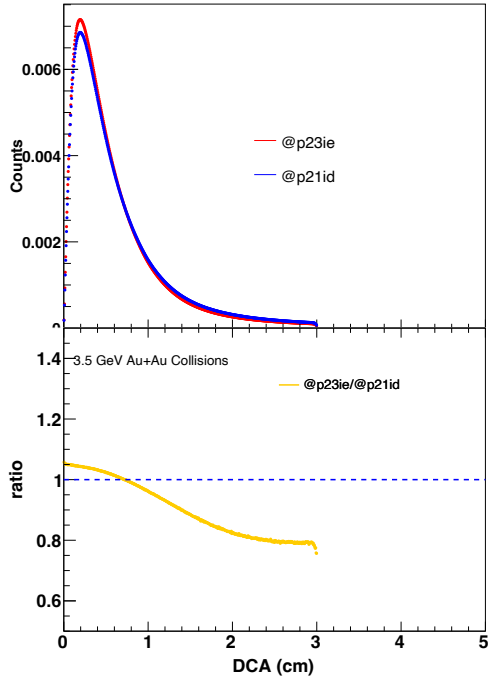


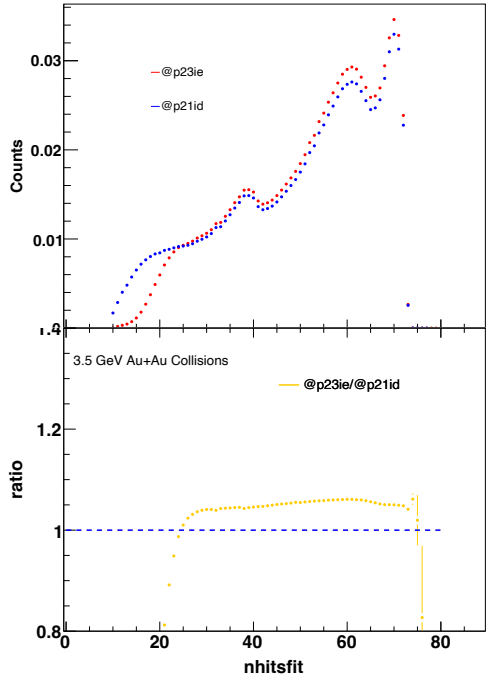
We may apply the official centrality definition(p21id) into new dataset(p23ie)

Data QA (track level)

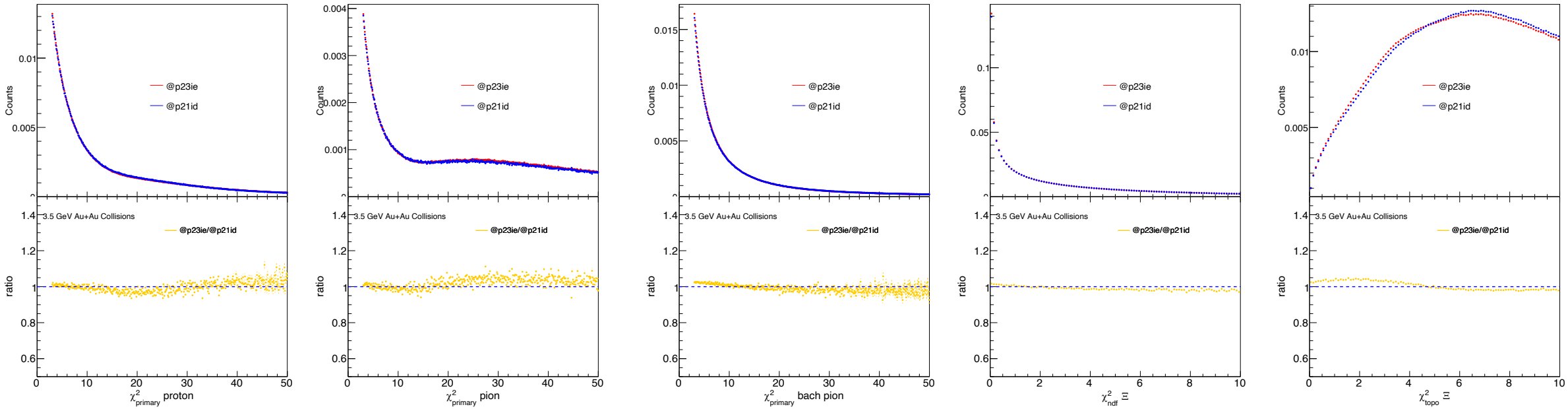




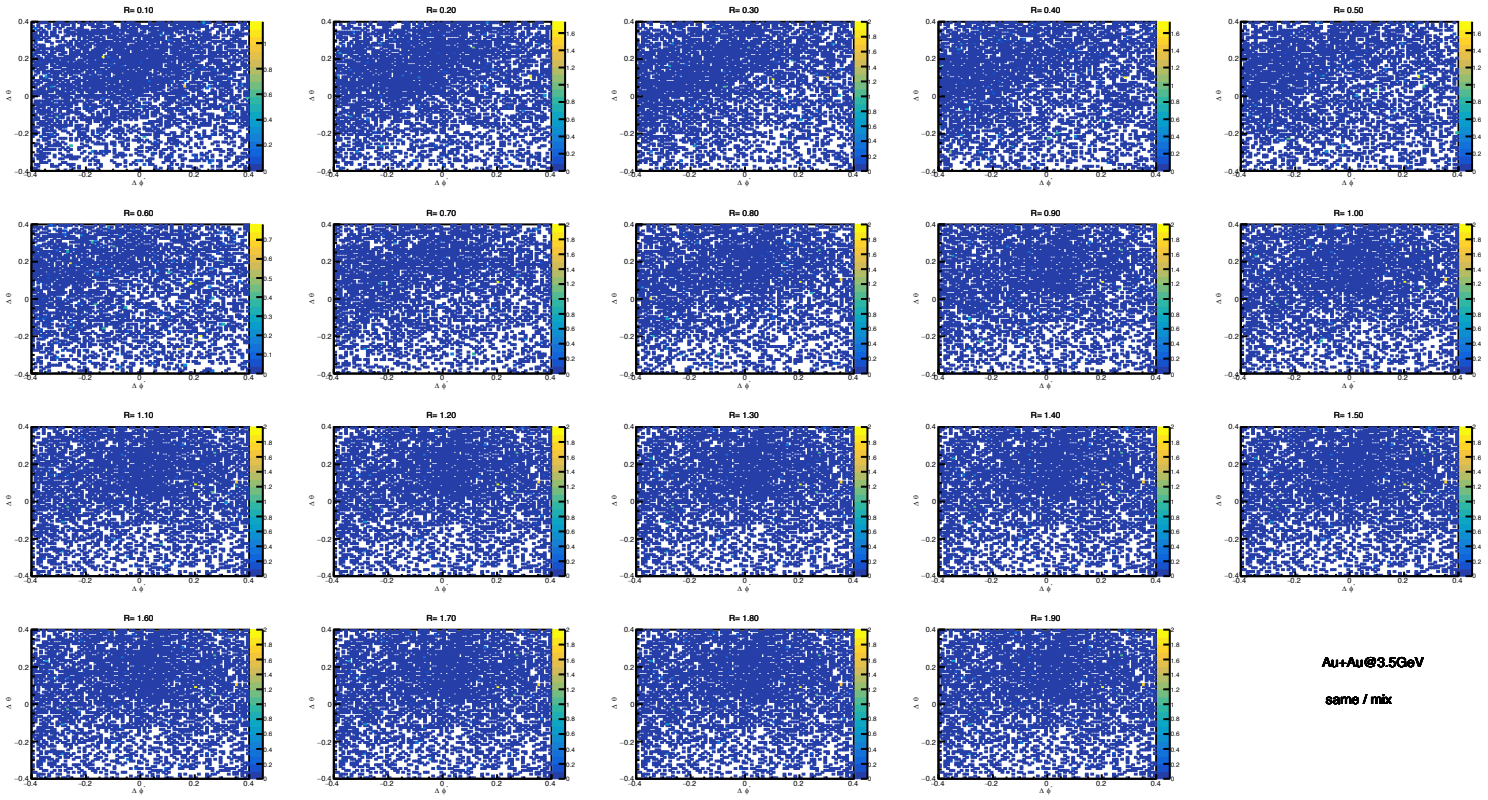




Data QA (topological variables of Ξ^-)

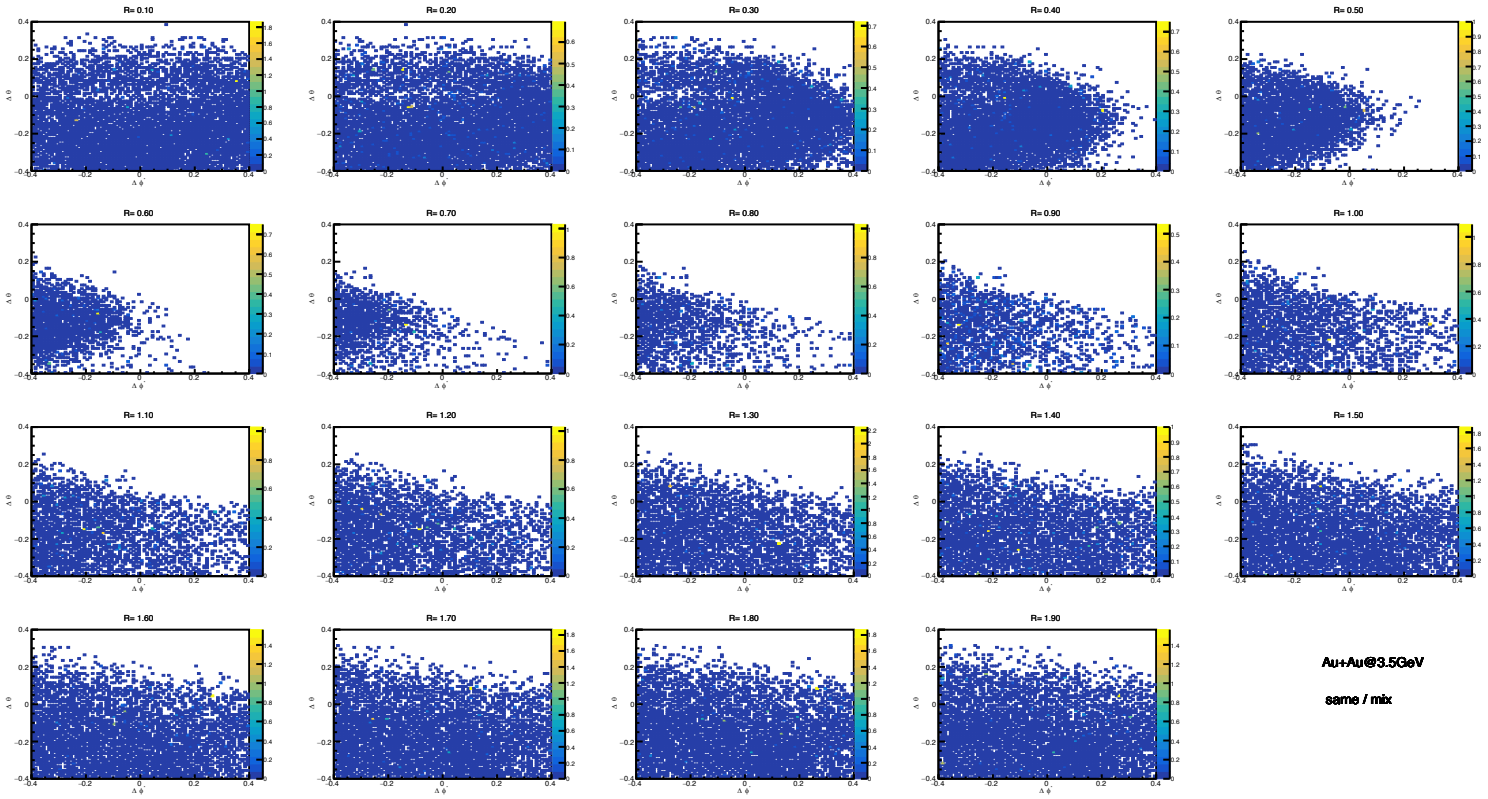


Check track merge($\pi(\Xi^-)$ - $\pi(\Lambda)$)



- There are no track merging effect between pion(decayed by Ξ^-) and pion(decayed by Λ)

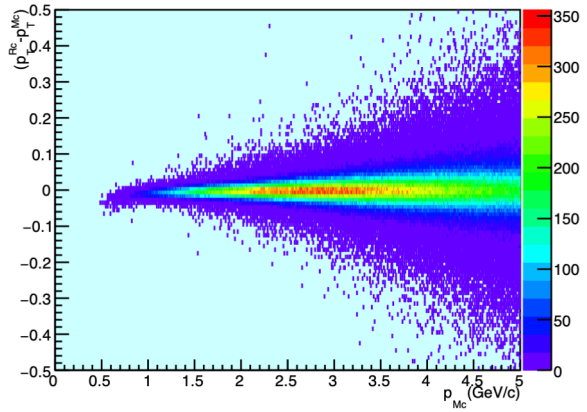
Check track merge(proton(Λ) - π(Λ))



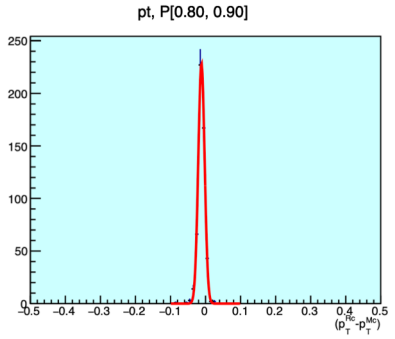
- There are no track merging effect between proton(decayed by Λ) and pion(decayed by Λ)

Momentum resolution of Ξ^-

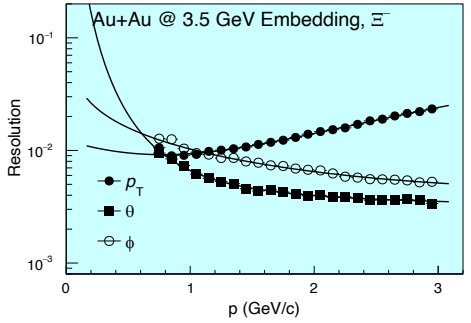
- Embedding request ID: Ξ^- 20231202 proton 20221601 (at 3.2 GeV)

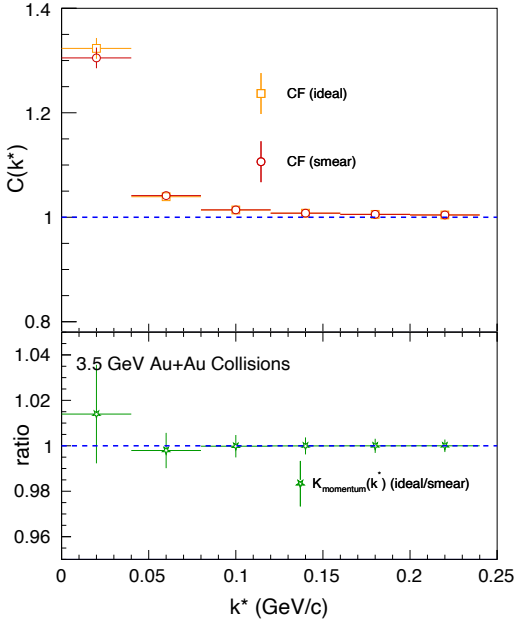


gaussian function fitting



Fit function: $p[0] + p[1]x^{p[2]} + p[3]x$





- Using the gaussian sampling to get the p_x^s, p_y^s, p_z^s

$$p_T^s = \text{gRandom} \rightarrow \text{Gaus}(p_T, \sigma_{p_T}) \qquad p_x^s = p_T^s \times \cos(\phi^s)$$

$$\theta^s = \text{gRandom} \rightarrow \text{Gaus}(\theta, \sigma_\theta) \qquad p_y^s = p_T^s \times \sin(\phi^s)$$

$$\phi^s = \text{gRandom} \rightarrow \text{Gaus}(\phi, \sigma_\phi) \qquad p_z^s = p_T^s \,/\, \tan(\phi^s)$$

- Using the k* under the Mix event to estimate the real correlation function

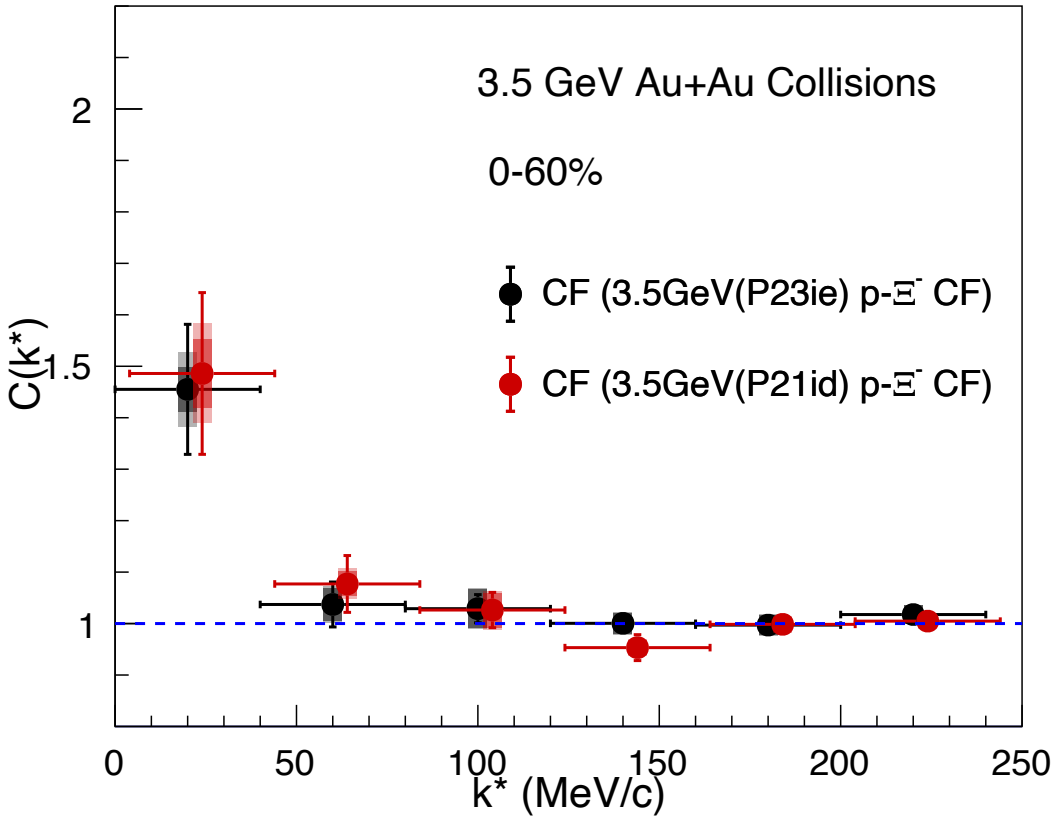
$$K = \text{CF}^{\text{mix}}_{\text{ideal}} / \text{CF}^{\text{mix}}_{\text{smeared}} = \frac{A(\vec{p}_{1,ideal}, \vec{p}_{2,ideal})}{B(\vec{p}_{1,ideal}, \vec{p}_{2,ideal})} \Big/ \frac{A(\vec{p}_{1,smear}, \vec{p}_{2,smear})}{B(\vec{p}_{1,smear}, \vec{p}_{2,smear})}$$

$$\text{CF}^{Data}_{\text{real}} = \text{CF}^{Data}_{\text{smeared}} \times K$$

→ Each pair in the numerator is weighted by data correlation function

Comparison

Check the systematic error w/o Barlow test



- The dark box :

systematic error with Barlow test

- The light box :

systematic error without Barlow test

The Correlation function at P23ie is consistent with the result at P21id