(Anti-)H3L Yield in Isobar Collisions at 200 GeV

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STAR collaboration meeting Feb. 2023

Outline

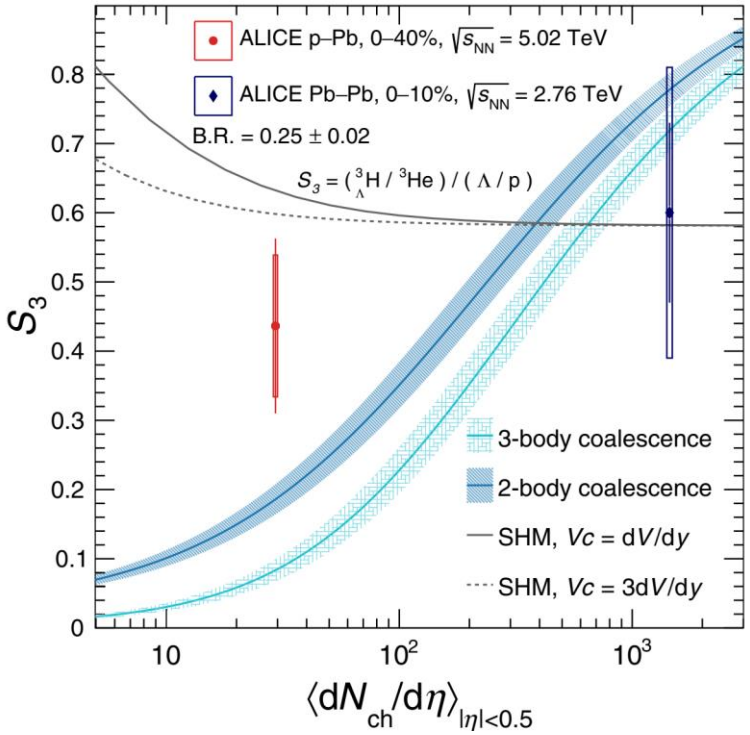
- Introduction
- Data Set, Event and Track Selection
- (Anti-)H3L Reconstruction
- Signal Extraction
- Embedding Tuning and Checks
- Efficiency, Yield and Particle Ratios
- Summary and Outlook

Introduction

- Hypernuclei production mechanism is not well understood
  - Thermal model
  - Coalescence

- Multiplicity dependence of S3 may help distinguish different models(behavior in peripheral cases are very crucial)
  - $S_3 = \frac{^3_\Lambda\mathrm{H}/\ ^3\mathrm{He}}{\Lambda/\mathrm{p}}$
  - Lack of statistics for ALICE results

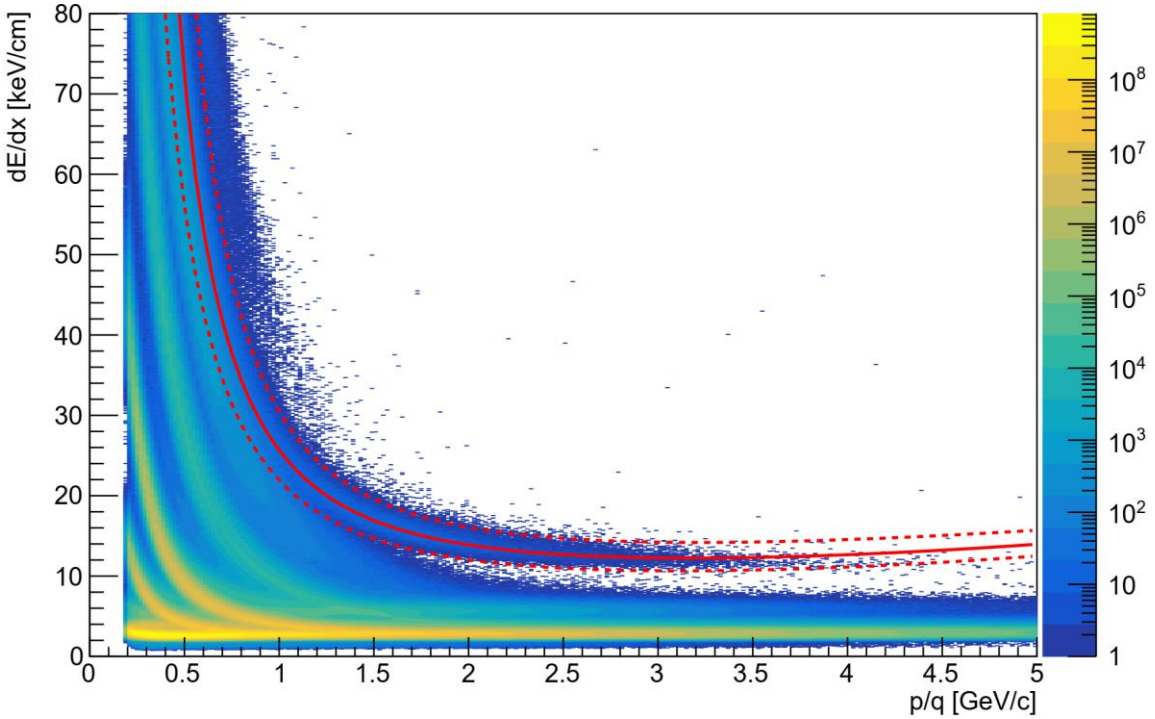
- Isobar data with high statistics offers an opportunity
  - ~4 billion events available



PRL 128, 252003 (2022)

Data Set, Event and Track Selection

- Data set: Run18 Isobar (Ru+Ru & Zr+Zr 200 GeV, SL20c)
- Trigger ID: 600001, 600011, 600021, 600031
- Official badrun list and centrality definition
- Decay channel: ${}^{3}_{\Lambda}\mathrm{H} \rightarrow \pi^{-} + {}^{3}\mathrm{He}$, ${}^{3}_{\Lambda}\overline{\mathrm{H}} \rightarrow \pi^{+} + {}^{3}\overline{\mathrm{He}}$
- Event selection cuts: -35 < Vz < 25 (cm), Vr < 2 cm
- Track selection cuts:
  - NHits ≥ 15, nHitsFit/nHitsPoss ≥ 0.52, 0.12 ≥ dEdxError ≥ 0.04
  - $p_{\mathrm{T}} \geq 0.1$, $|\eta| \leq 1.5$
  - PID:
    - He3: dEdx selection
      - 2.5-sigma for lower limit
      - 3-sigma for higher limit
    - Pion: |nsigma_pi| < 3

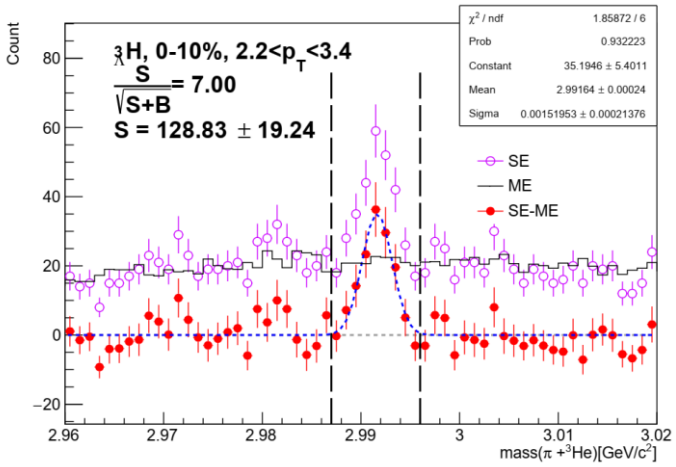


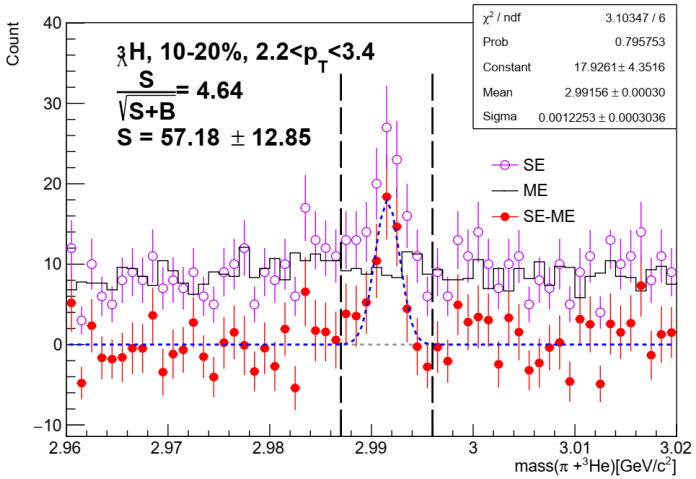
(Anti-)H3L Reconstruction

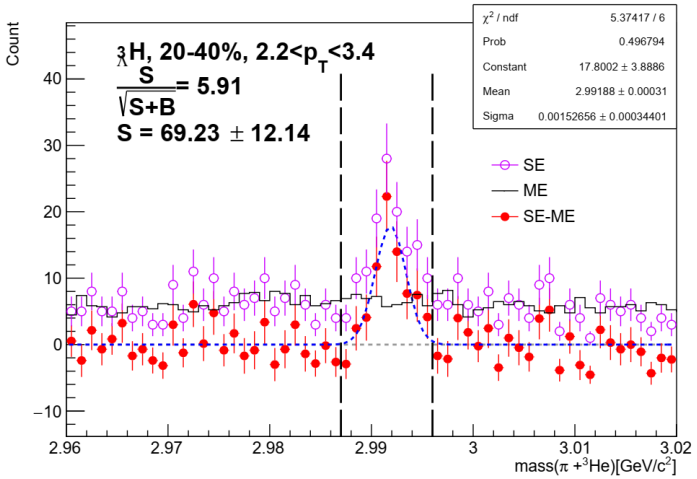
- (Anti-)H3L is reconstructed in different centralities (0-10%, 10-20%, 20-40%, 40-80% and 0-80%) with the KFparticle package
- Topological cuts for (Anti-)H3L reconstruction
  - Chi2primary_pi > 10, Chi2primary_He3 < 2000
  - Chi2ndf < 5, Chi2topo <2
  - Decay length (l) > 3.4 cm, ldl >3.5
  - He3 DCA <1, p > 2 GeV

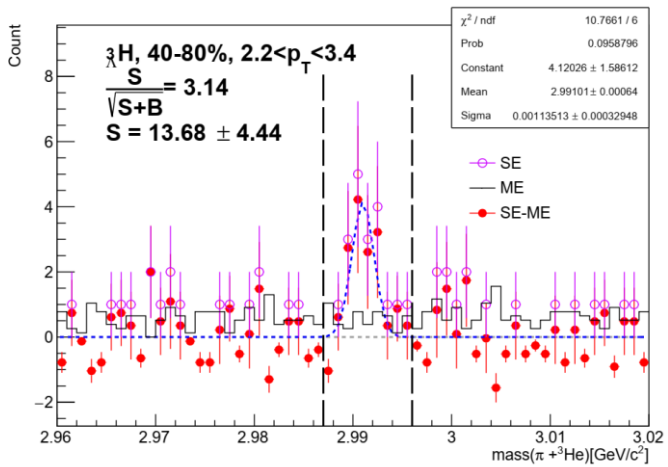
  Topo cuts from Junlin's anti-H4L analysis
  https://drupal.star.bnl.gov/STAR/system/files/Analysis_note_for_anti_HyperH4_ver4.pdf
- Background reconstruction (Mix Event):
  - Mix current event with 5 similar events (within same centrality bin) in buffer
  - ~10 times statistics
  - ME describes the background well

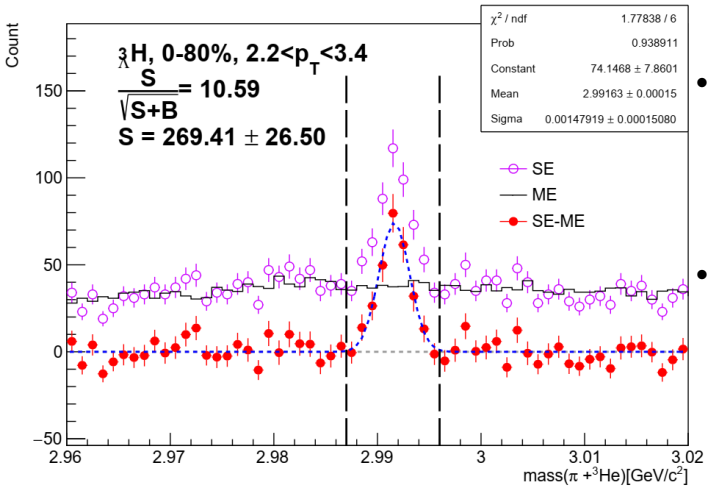
(Anti-)H3L Reconstruction





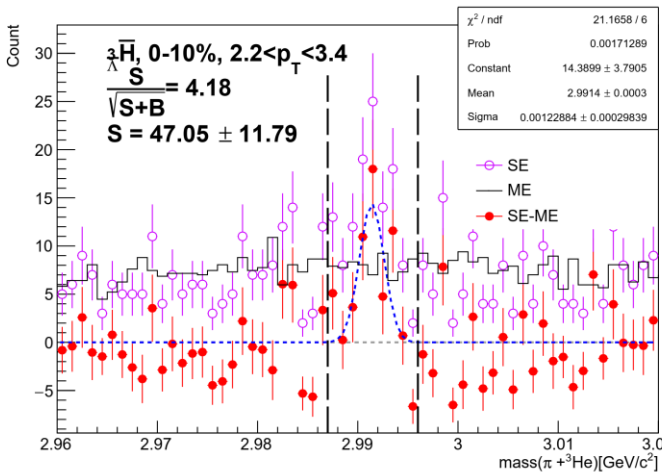


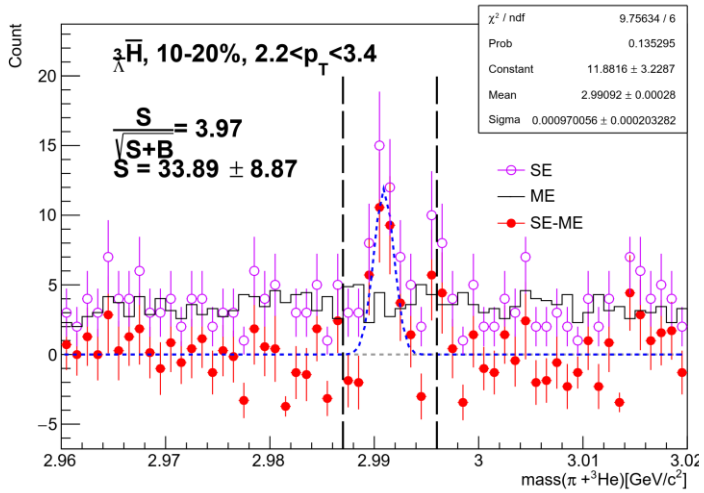


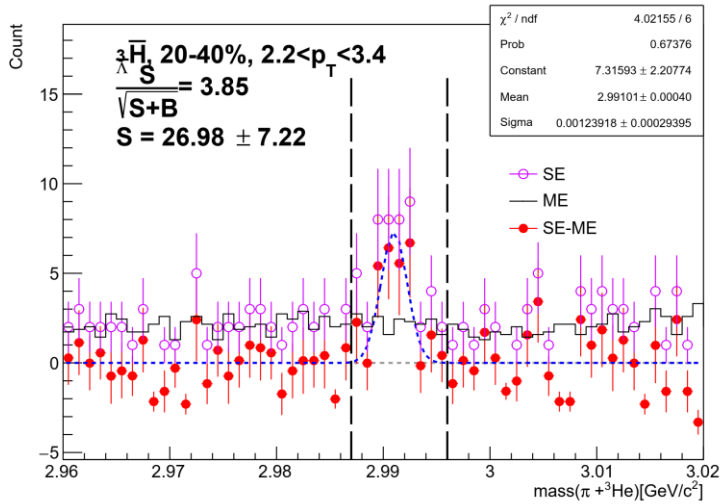


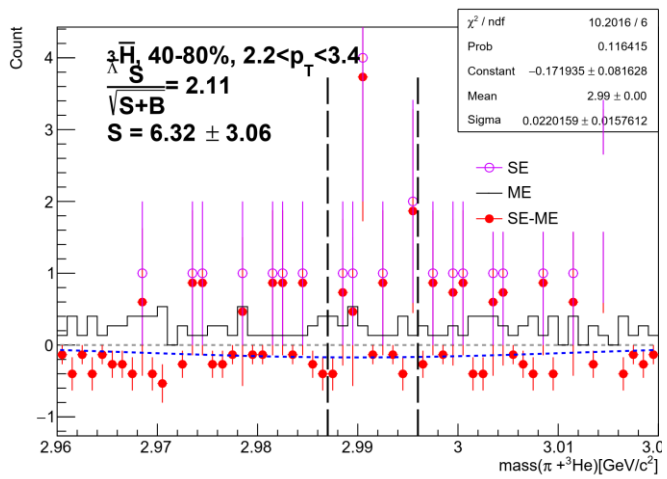
- ROI: 2.2 < pT < 3.4
  - later compare with analysis on He3 by Yun Huang (CCNU) and calculate a ratio
  - Mass window (3-sigma): 2.987~2.996
- High significance in peripheral collisions
  - ~3-sigma for H3L in 40-80%
  - ~2-sigma for Anti-H3L In 40-80%
  - ~4-sigma for H3L combined with Anti-H3L in 40-80% (check Backup slides)

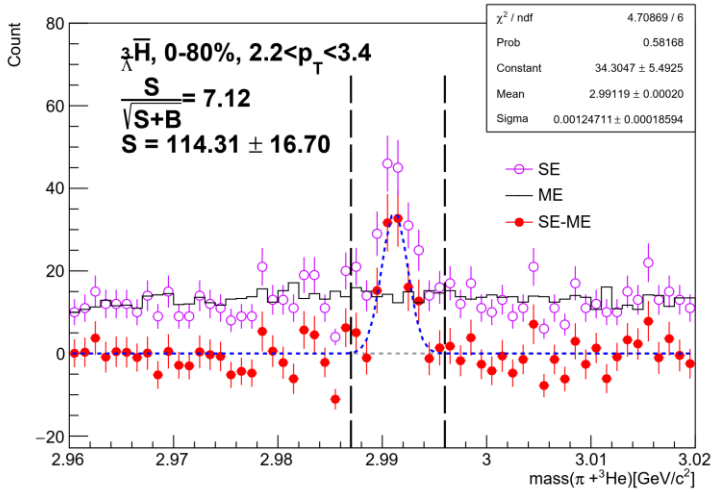
(Anti-)H3L Reconstruction











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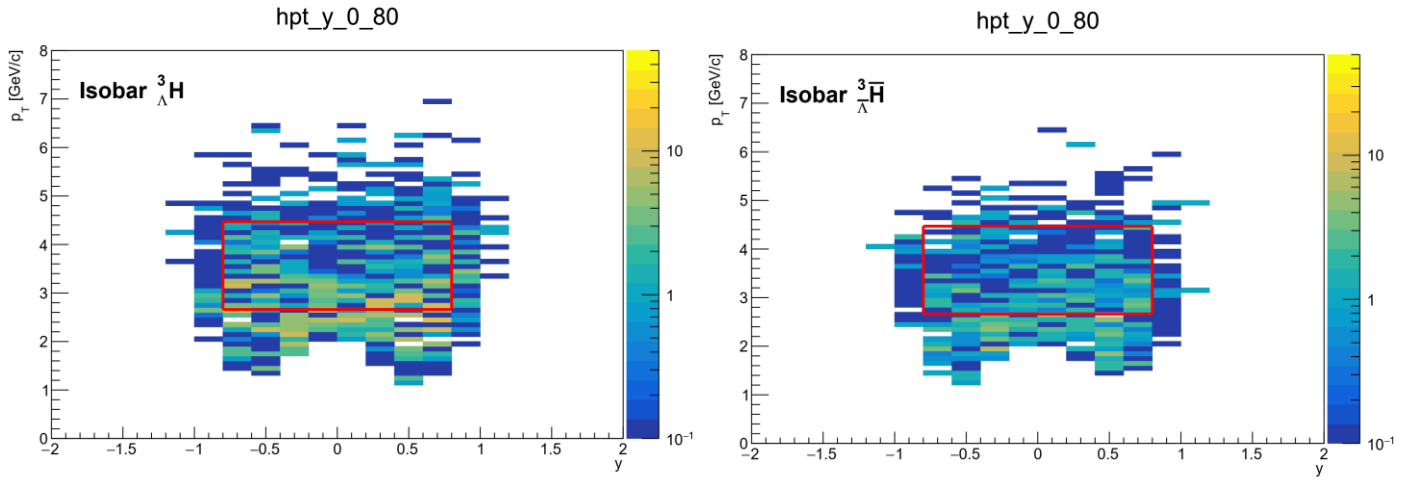
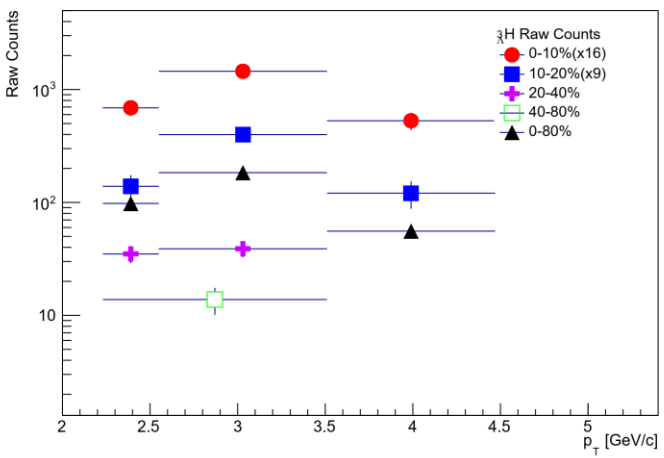
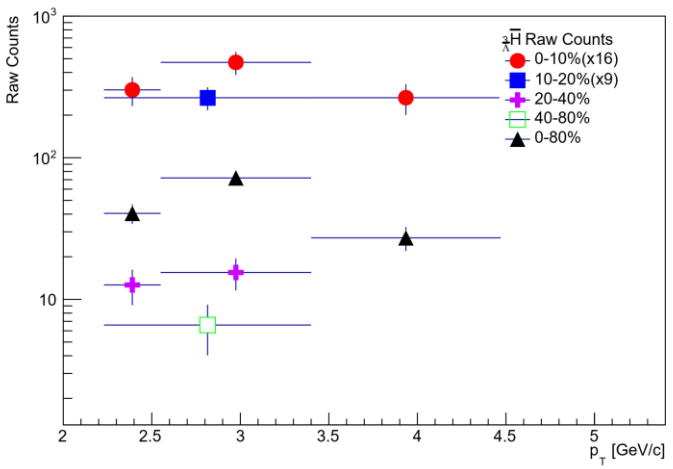
Signal Extraction

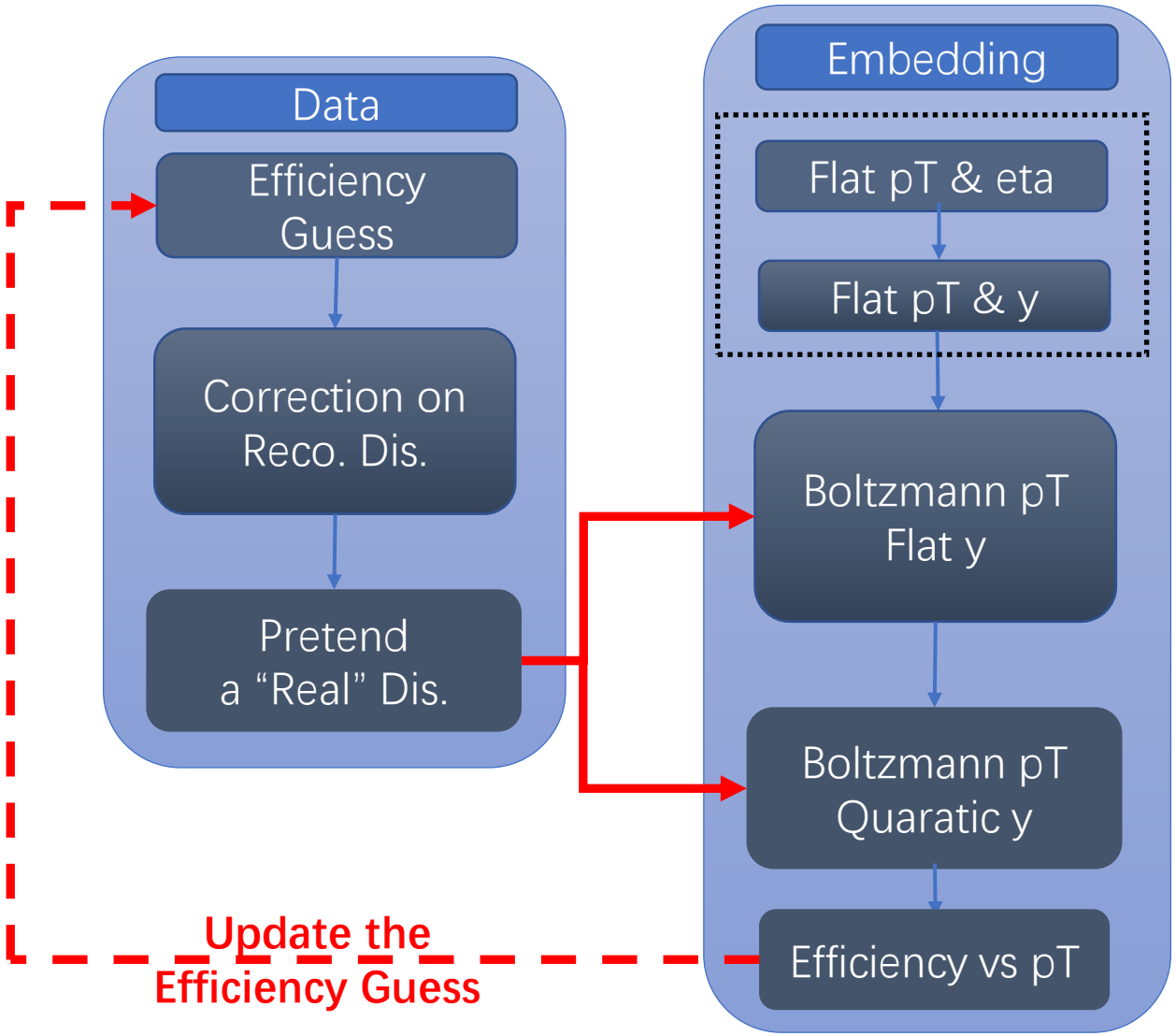






- (Anti-)H3L acceptance and selected phase space (red line)
  - |y| < 0.8 && 2.2 < pT < 4.2 for (Anti-)H3L
- pT windows for bin counting:
  - designed to be consistent with Yun's He3 results (pT/m binning matched)
  - bins with significance less than 2-sigma are not included

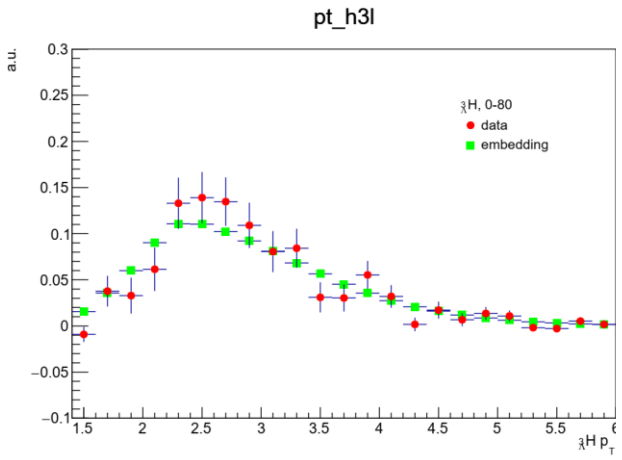
Embedding Tuning and Checks

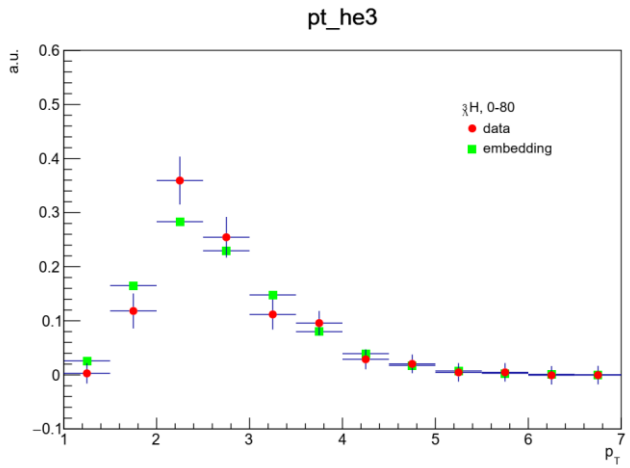


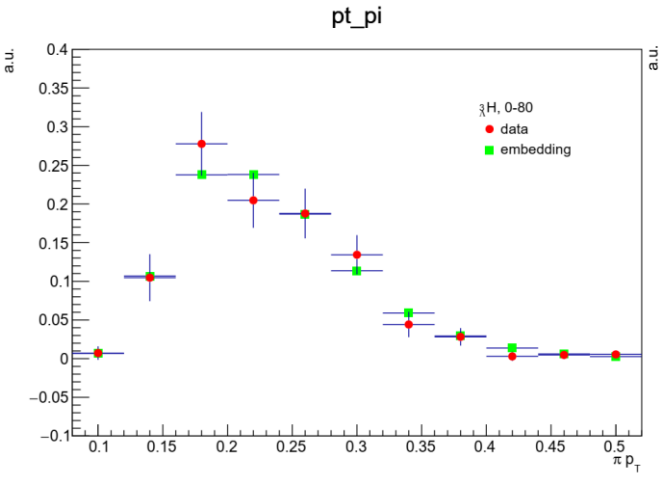
- To calculate efficiency, tune the embedding to match data:
  - Target: consistent distribution of topological variables for reco data and embedding
  - Respectively apply weights on pT & y distribution in each centrality
- Iteration workflow
  - pT & y weights as output
  - Stabilized after 3-4 iterations
  - Need to check topological variables
  - Sometimes Fit( ) fails due to lack of statistics (then apply weights of nearby centrality)
  - Temperatures in Boltzmann function for different centralities are summarized

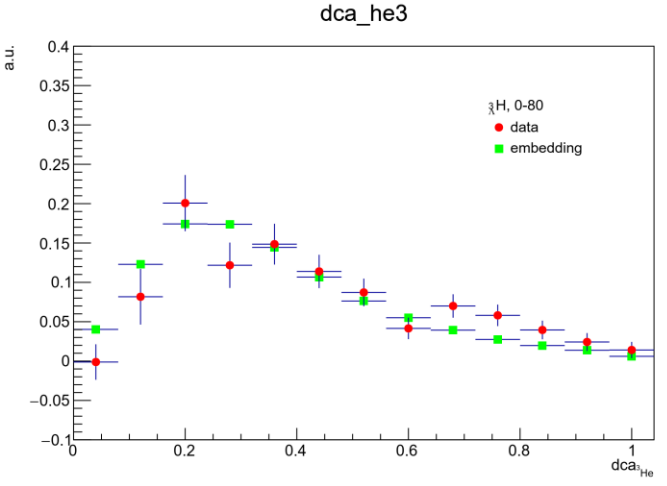
Cent. / T(GeV)	0-80%	0-10%	10-20%	20-40%	40-80%
T(H3L)	0.41	0.45	0.43	0.42	0.42
T(Anti-H3L)	0.39	0.47	0.43	0.39	0.13

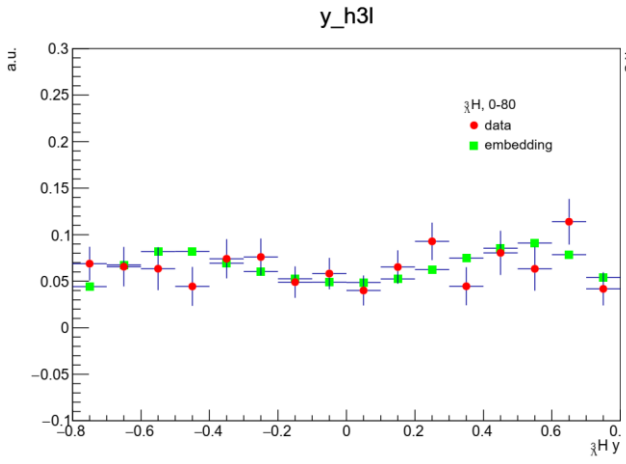
Embedding Tuning and Checks

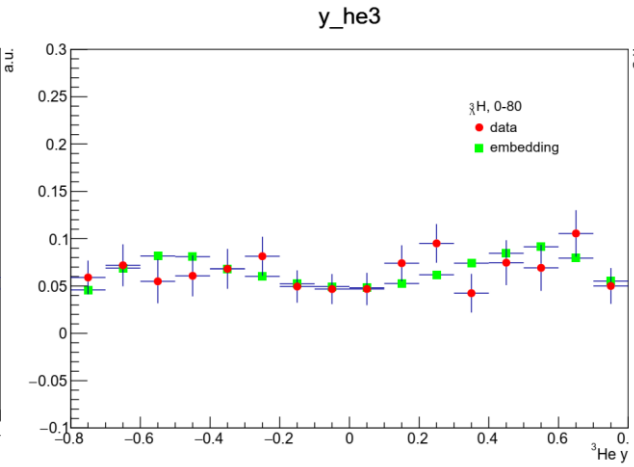


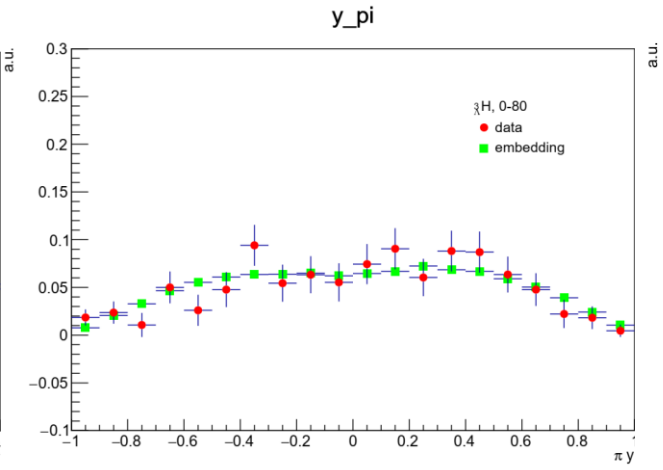


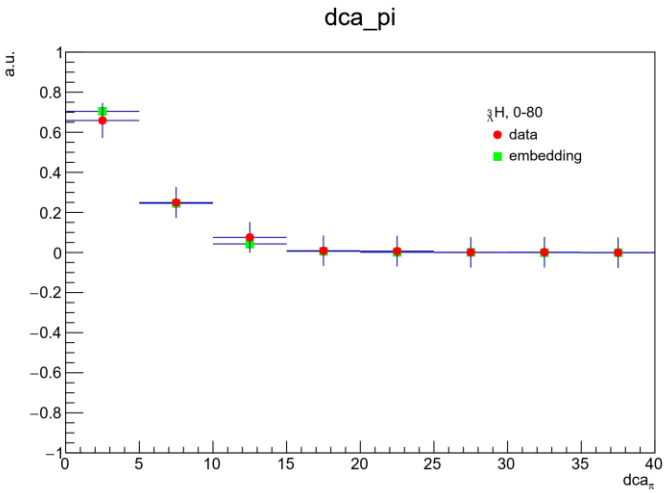




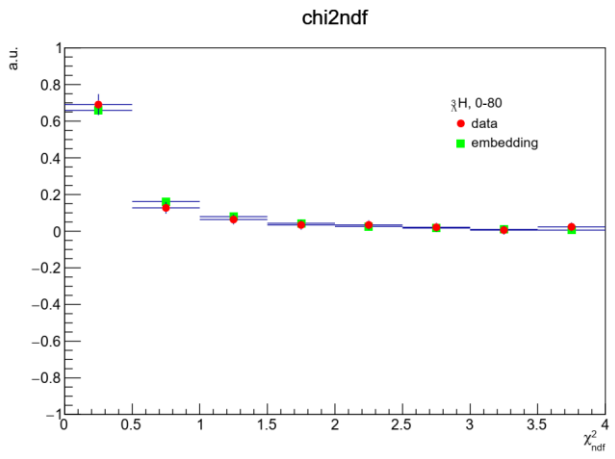


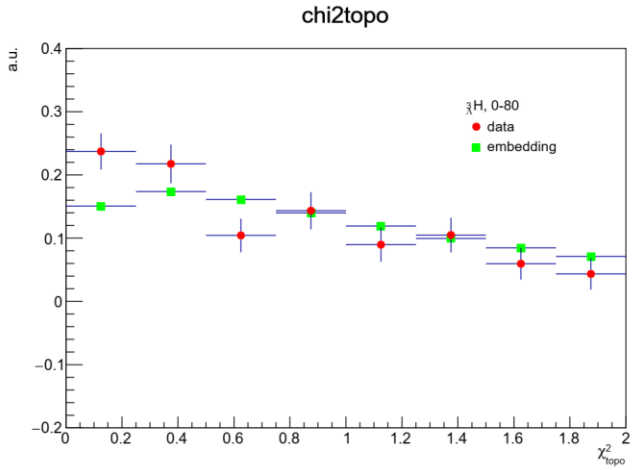


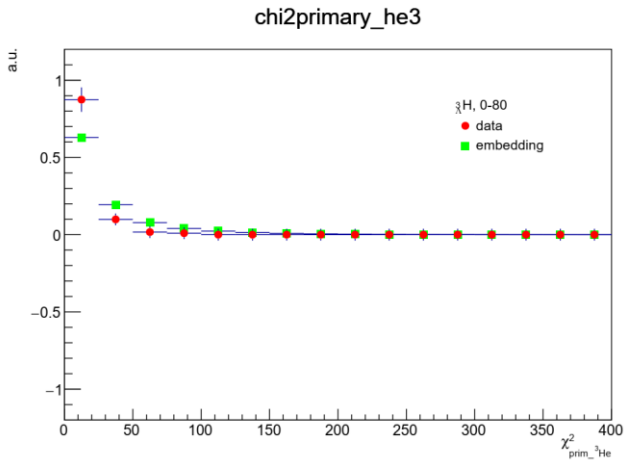


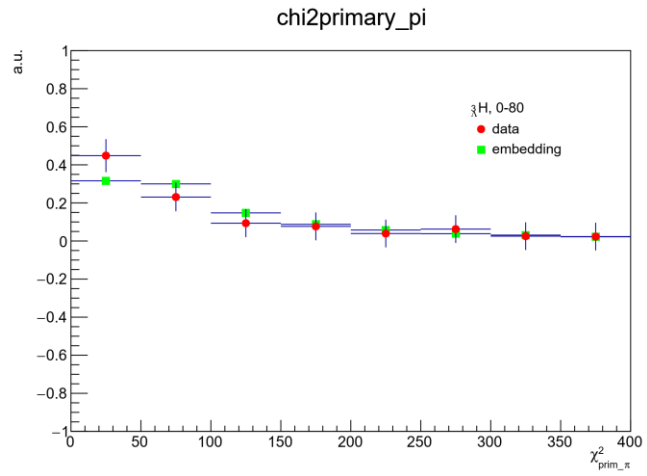


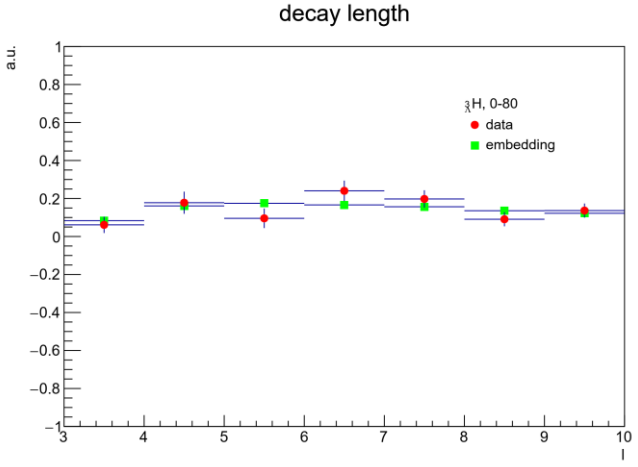
Embedding Tuning and Checks

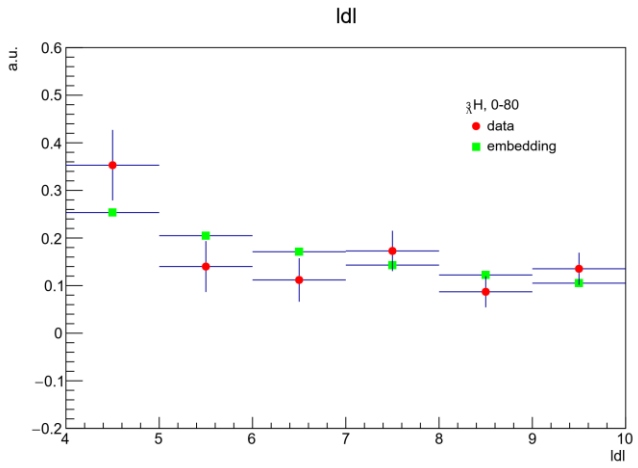


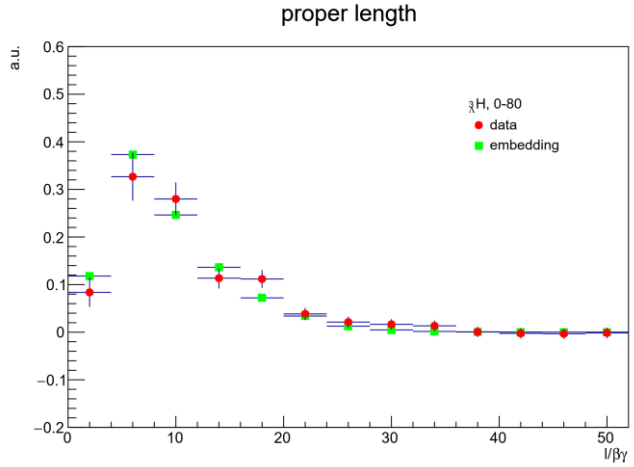








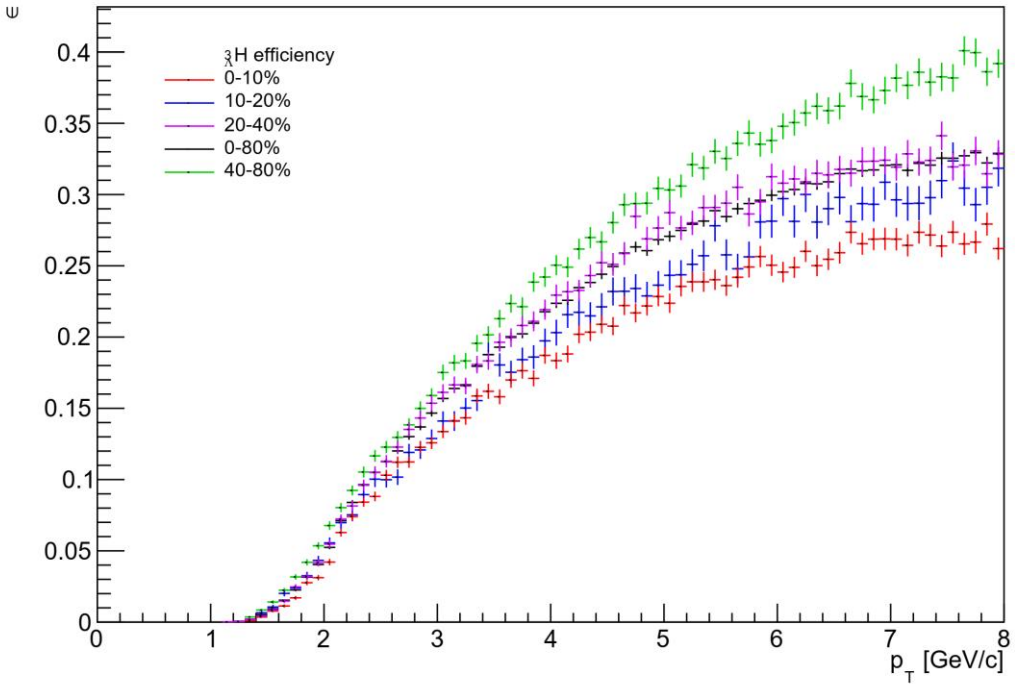


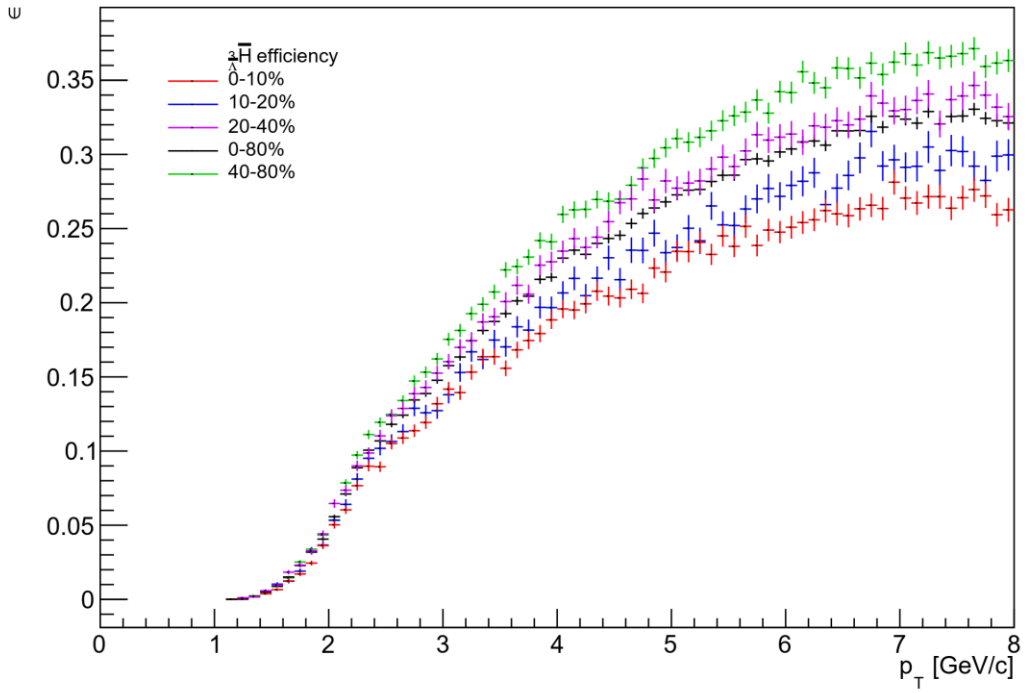


- 0-80% as an example
- Iteration steps reasonably weights the embedding
- Can calculate an efficiency

Efficiency, Yield and Particle Ratios

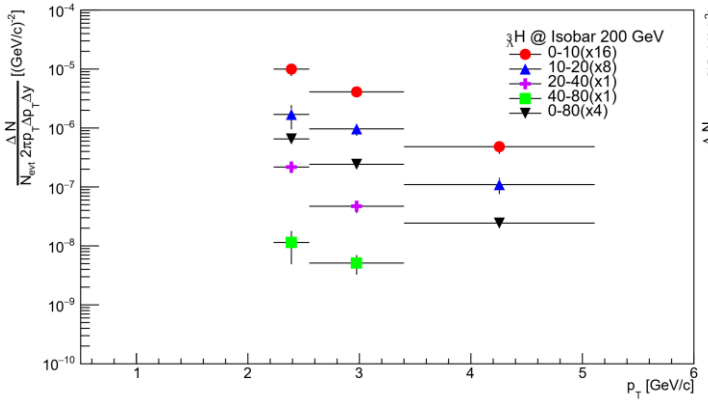
- Efficiency
  - From embedding: Tracking × Reconstruction efficiency
  - From PID: folded into the calculation as a weight
  - Higher efficiencies in the peripheral cases

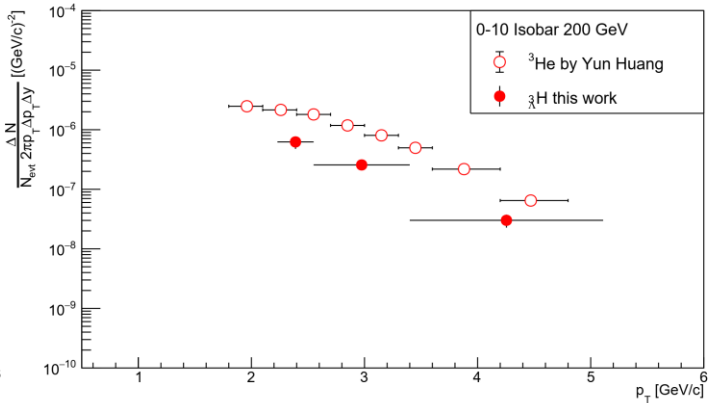


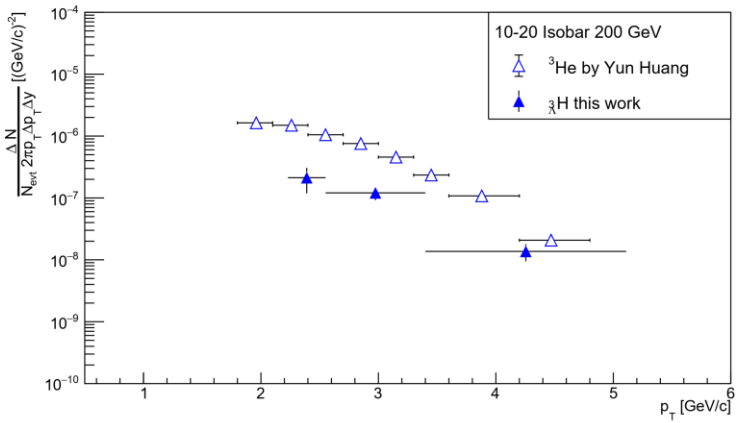


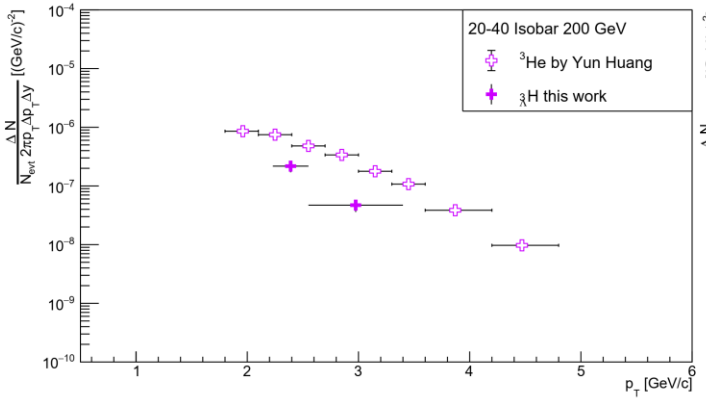
Efficiency, Yield and Particle Ratios

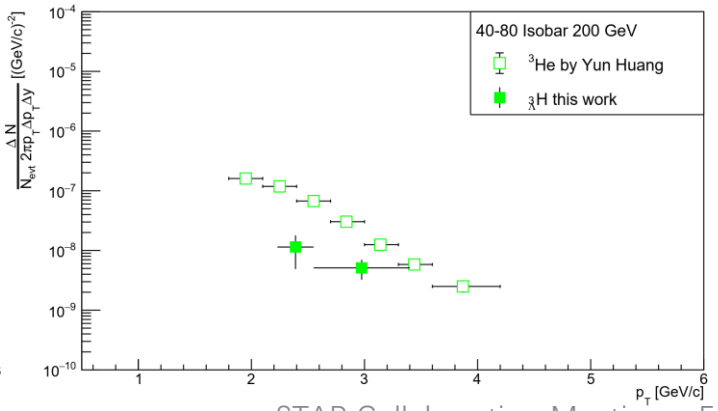
- Corrected Yield for (Anti-)H3L
  - Corrected invariant yield = $\frac{\text{Raw Counts}}{\text{B.R.} \times \text{Efficiency} \times 2\pi \times p_T^{center} \times \Delta p_T \times \Delta y}$
  - Compare with Yun's (Anti-)He3 results
  - Systematic uncertainties are not studied yet

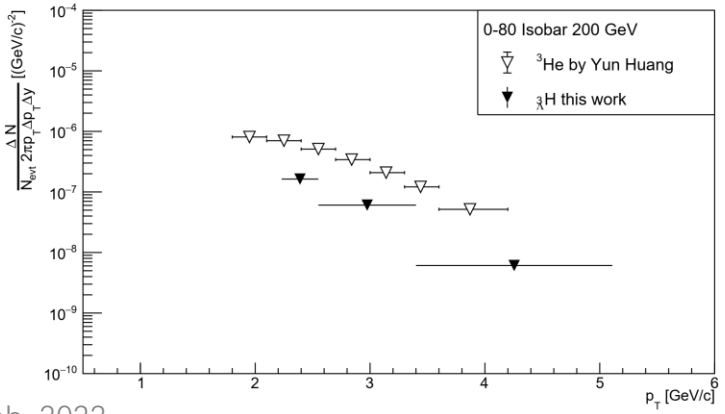












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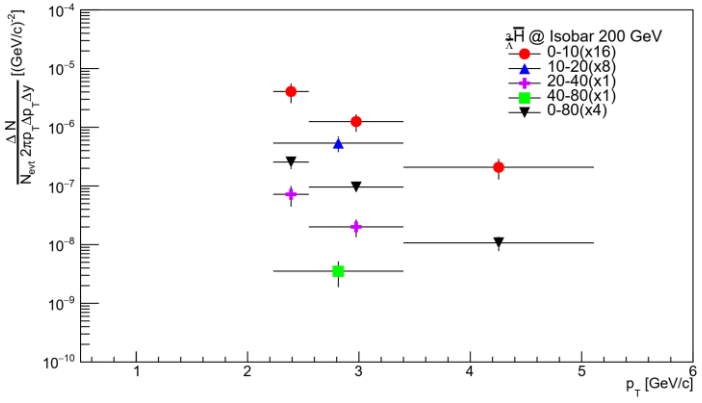
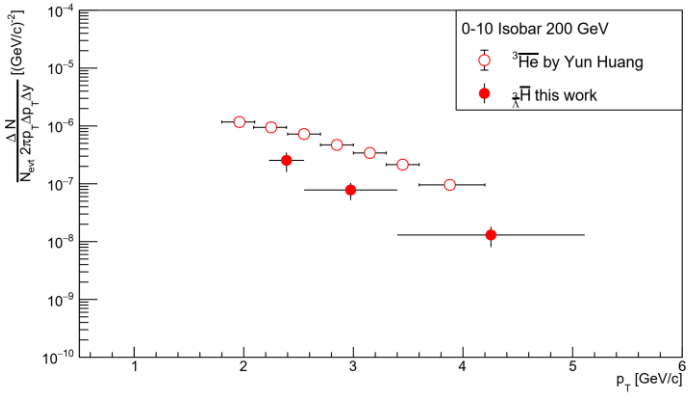
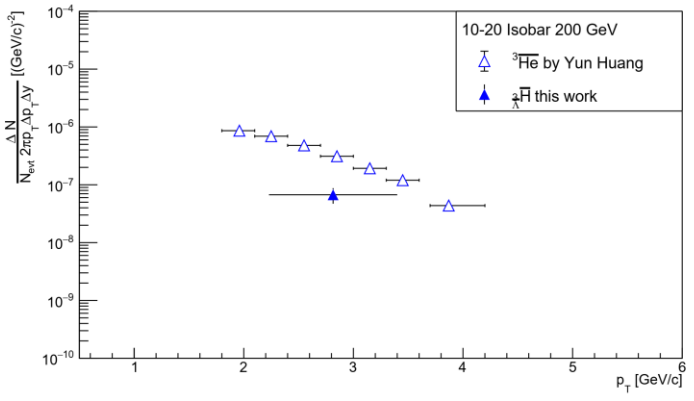
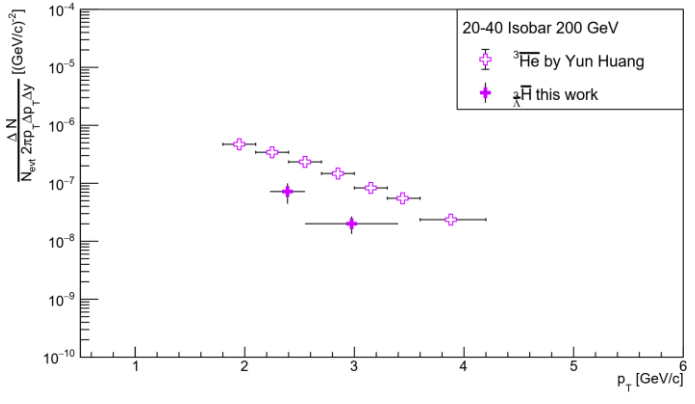
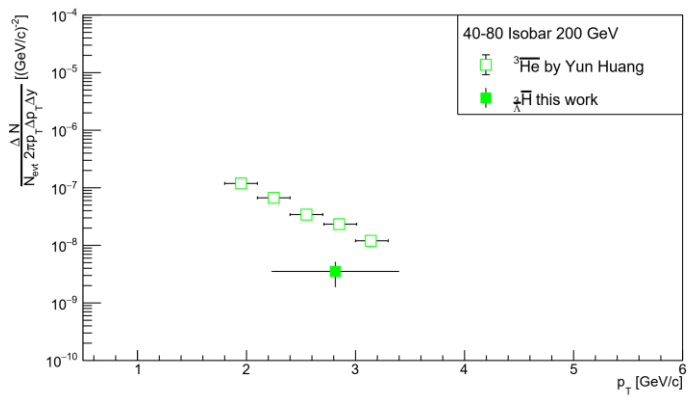
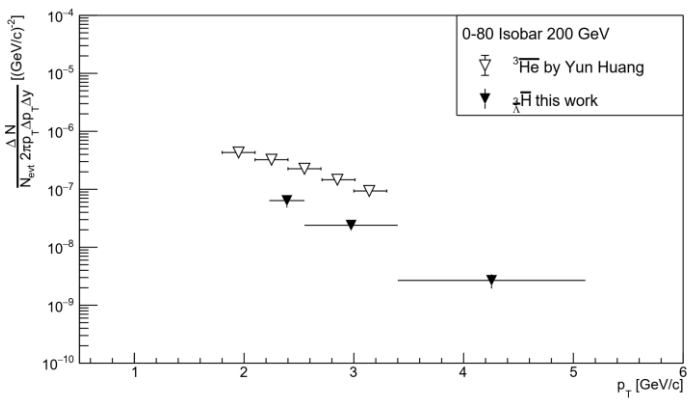






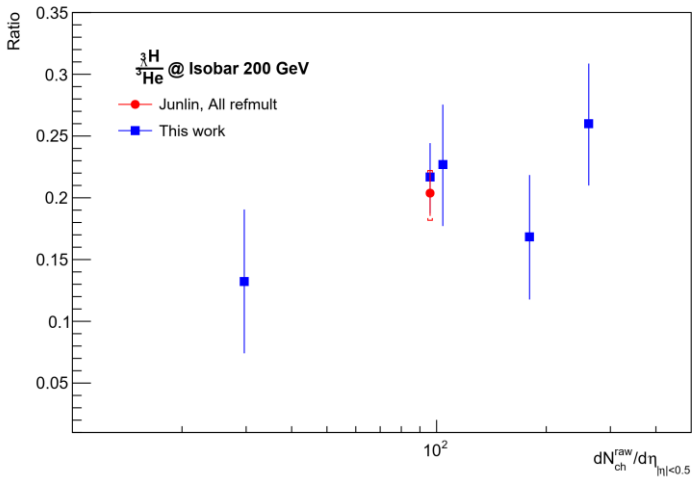


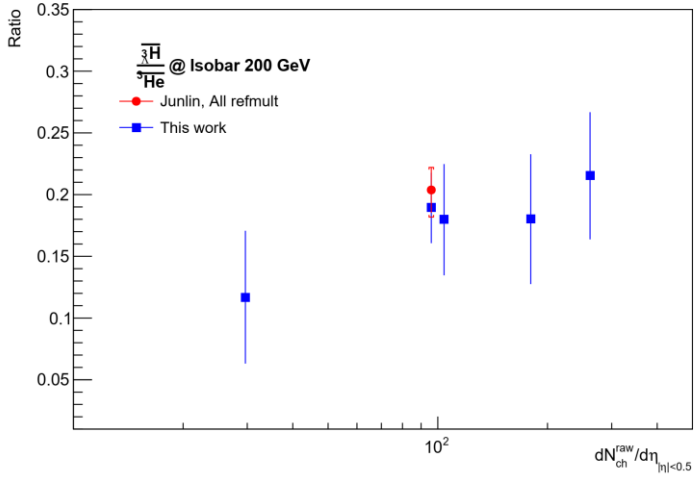


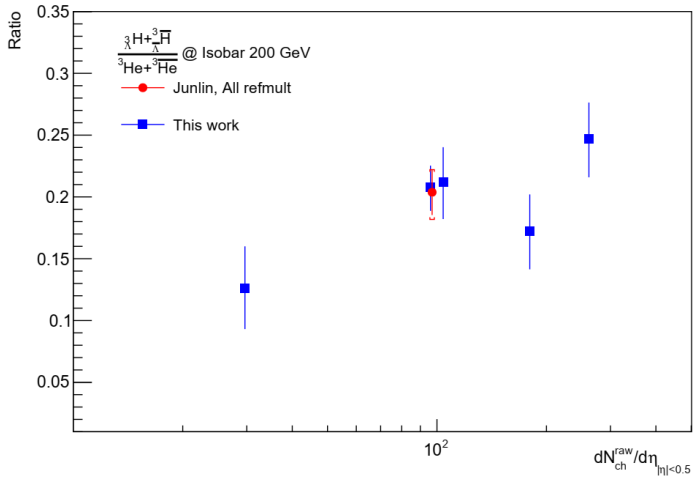


Efficiency, Yield and Particle Ratios

- H3L/He3 & Anti-H3L/Anti-He3 ratios
  - Divide H3L yield (this work) by He3 yield (Yun) within same pT/m range: 0.7~1.2. For H3L, this corresponds to a pT range of 2.2~3.4
  - dN_ch/deta for corresponding centralities are not available for Isobar, the efficiency uncorrected TPC multiplicity is shown as a substitute
  - Consistent with Junlin's all-refmult result
  - Particle & anti-particle ratios consistent within uncertainties

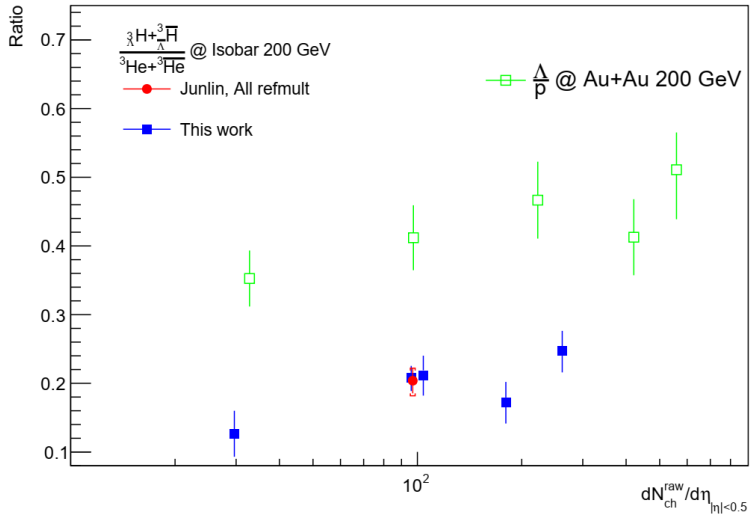


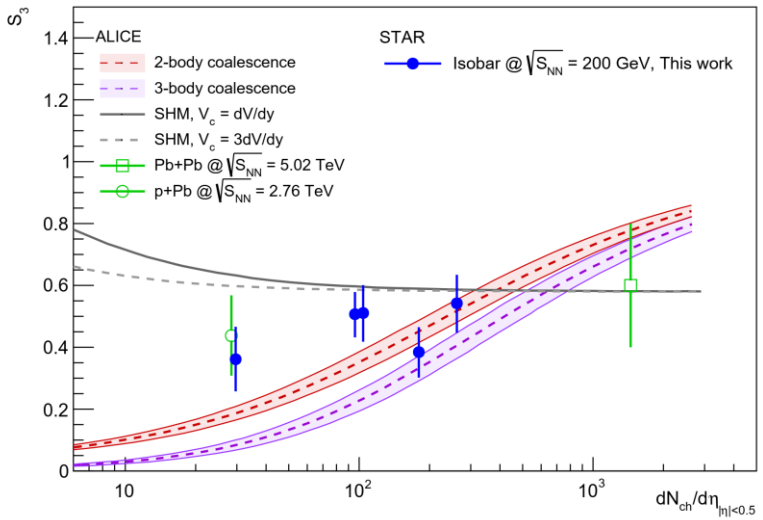




Efficiency, Yield and Particle Ratios

- $S_3 = \frac{^3_\Lambda\mathrm{H}/\,^3\mathrm{He}}{\Lambda/\mathrm{p}}$
  - Numerator
    - Use a combined ratio of particle and anti-particle
  - Denominator
    - Estimated with Au+Au 200 GeV results.
    - Lambda dNdy: **PRL 98, 062301 (2007)**
    - Proton dNdy: **PRC 79, 034909 (2009)**
  - Large uncertainty on S3, no obvious dN_ch/deta dependence
    - Lambda/p relative uncertainty comparable with H3L/He3
    - Planning to measure Lambda in Isobar (lack of embedding now)





Relative Uncertainty \ Point	1st(40-80%)	2nd(0-80%)	3rd(20-40%)	4th(10-20%)	5th(0-10%)
$\sigma(\Lambda/\mathrm{p})$	0.115	0.116	0.115	0.118	0.121
$\sigma(^3_\Lambda\mathrm{H}/\,^3\mathrm{He})$	0.267	0.093	0.140	0.179	0.127

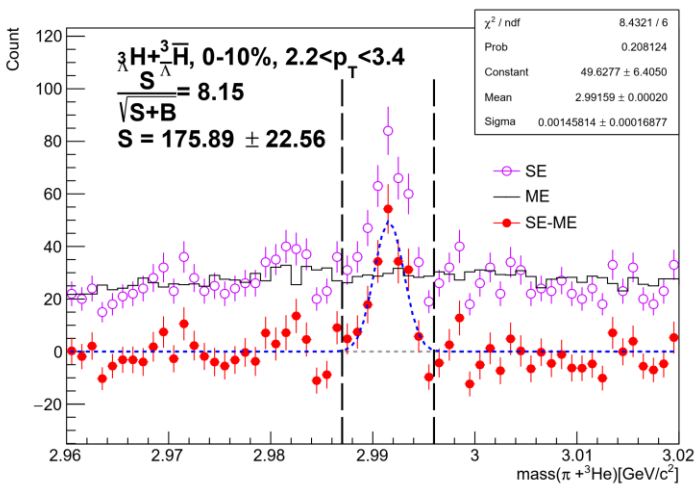
Summary and Outlook

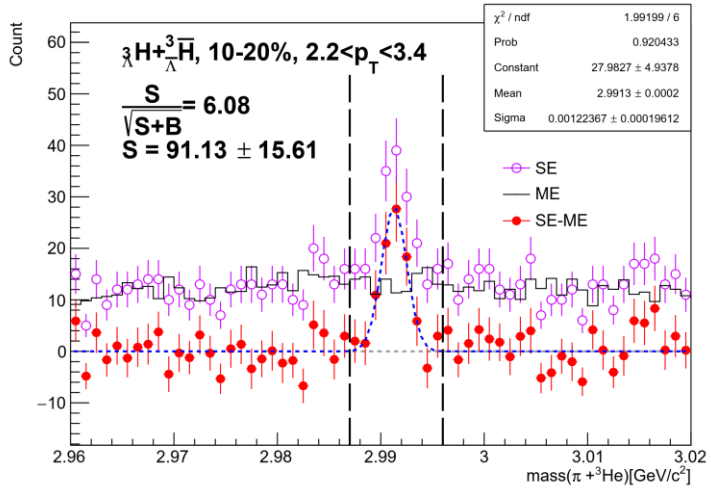
- Summary
  - We report the pT spectra of (Anti-)H3L in Isobar collisions at 200 GeV
  - Particle ratios including H3L/He3 and S3 are calculated. We observe no significant S3 dependence on dN_ch/deta due to large uncertainty

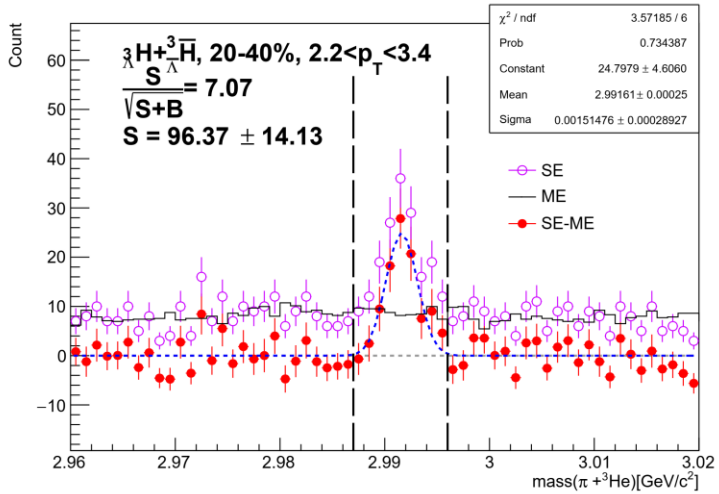
- Outlook
  - Study systematic uncertainty of (Anti-)H3L yield
  - Measure Lambda yield in Isobar collisions and improve precision on S3

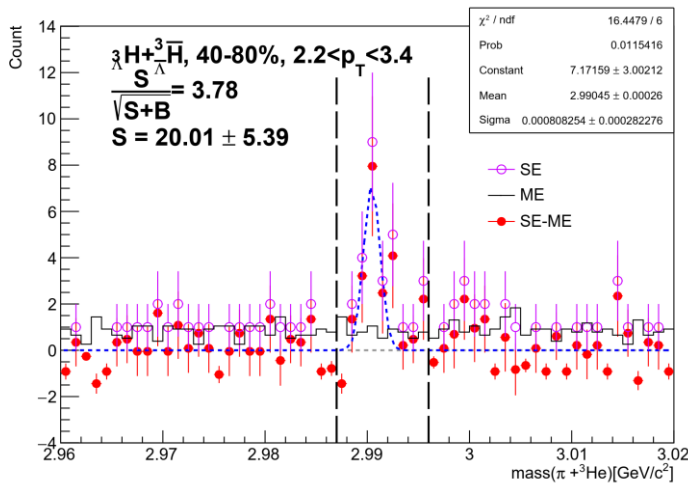
BACK UP

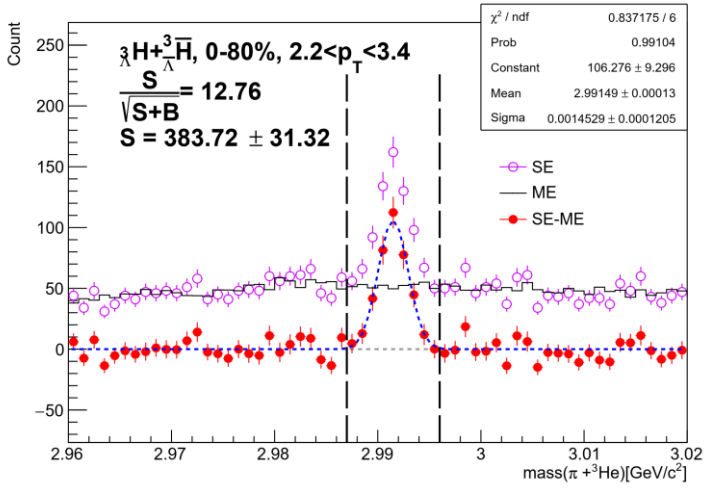
(Anti-)H3L Reconstruction



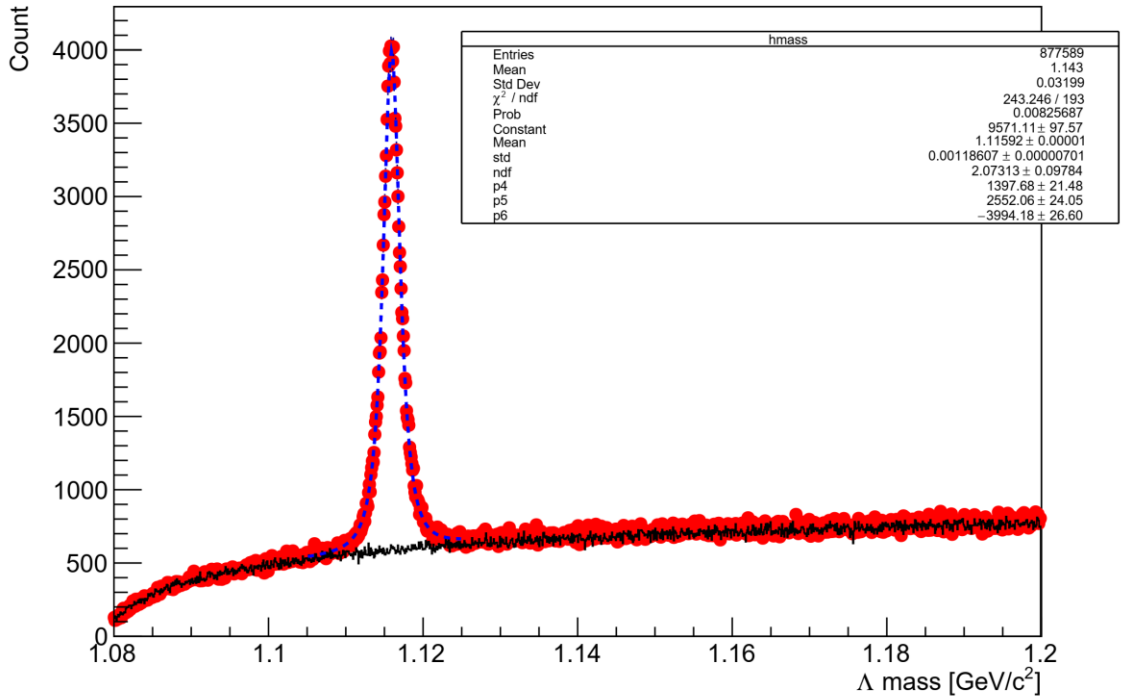


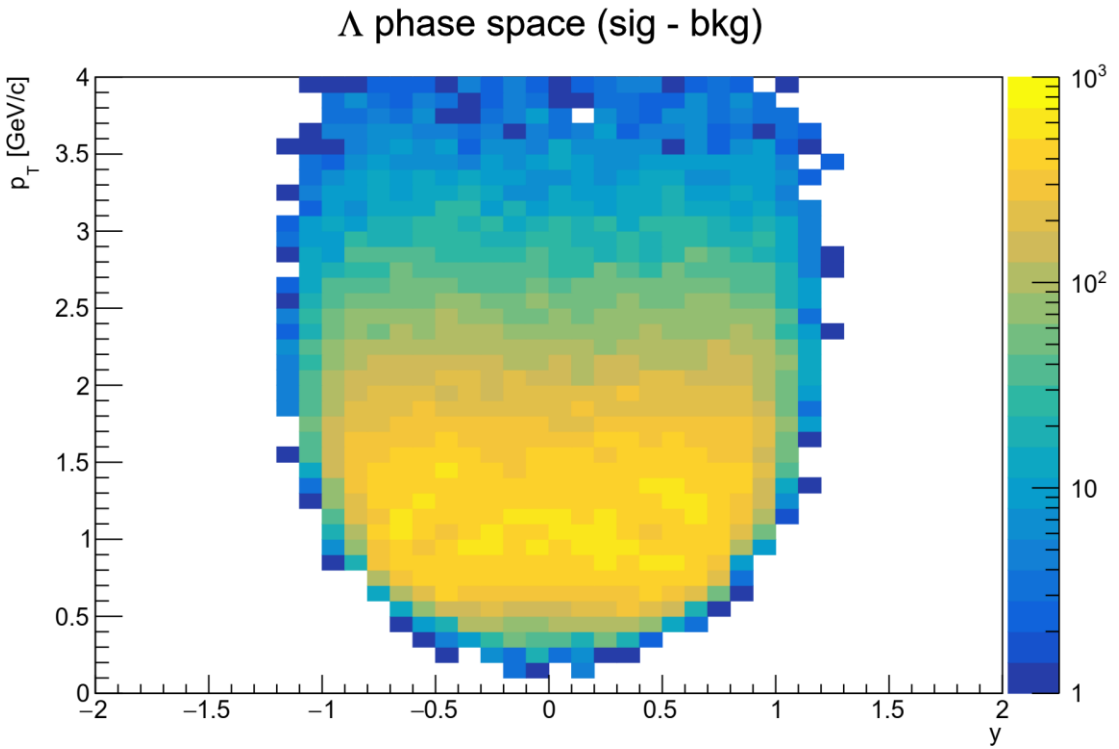






Lambda Reconstruction





~20% statistics

But we don't have Lambda embedding for Isobar now