Status of hypernuclei reconstruction in Xe run

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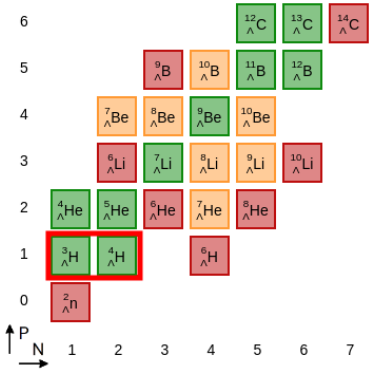
Analysis and Detector Meeting of the BM@N Experiment at NICA
Dubna, Russia

04/03/25

What are hypernuclei?



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

$^{4}_{\Lambda}$H

$^{4}_{\Lambda}$He

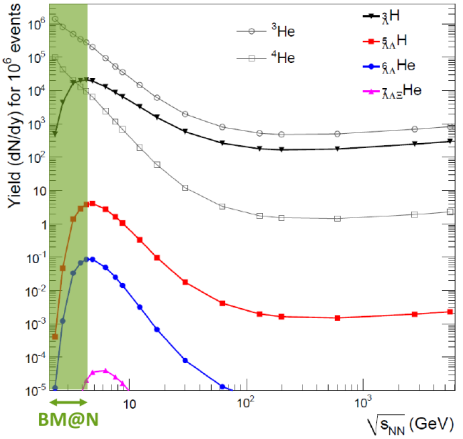
Charged particle decays

$$^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-}$$
$$^{4}_{\Lambda}\mathrm{H} \rightarrow {}^{4}\mathrm{He} + \pi^{-}$$

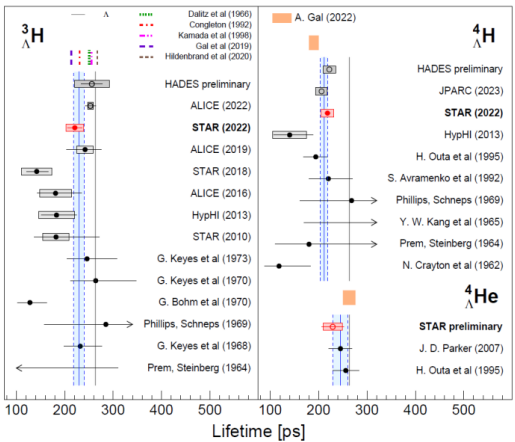
$$^{3}_{\Lambda}\mathrm{H} \rightarrow \mathrm{d} + \mathrm{p} + \pi^{-}$$
$$^{4}_{\Lambda}\mathrm{H} \rightarrow \mathrm{t} + \mathrm{p} + \pi^{-}$$

Why hypernuclei are interesting?

Sigh of phase transform



Lifetime puzzle



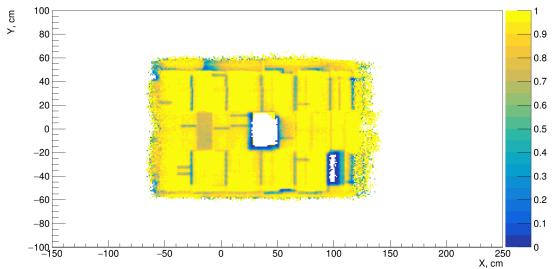
Remarks

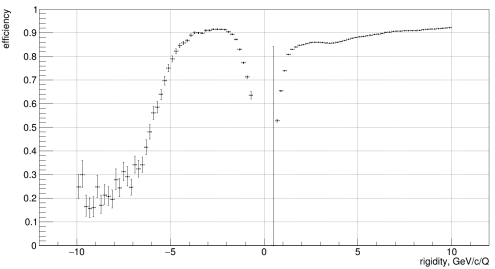
- Current report is an update from the last collaboration meeting
- Only mesonic decay of hypertritium is observed: ${}^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-}$
- Main updates: TOF-700, dE/dx, Statistics

New TOF-700 hits

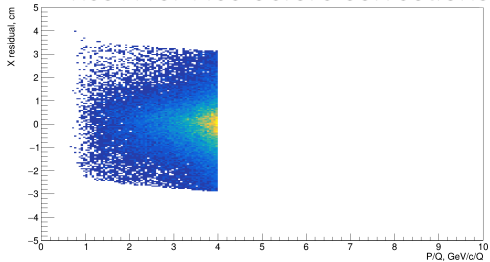
- BmnTOF701Hit branch in DST tree
- Much better efficiency (number of reconstructed hits)
- Still some problems with module 30

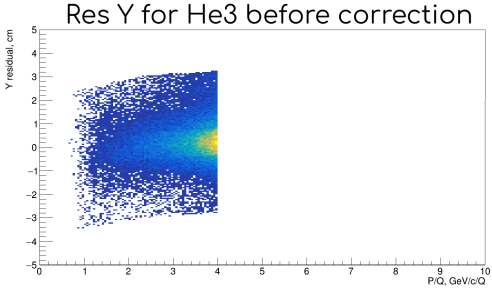
Efficiency related to FSD+GEM+LCSC

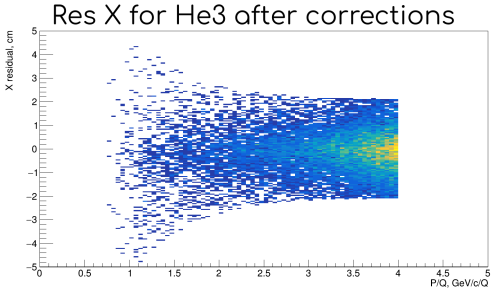


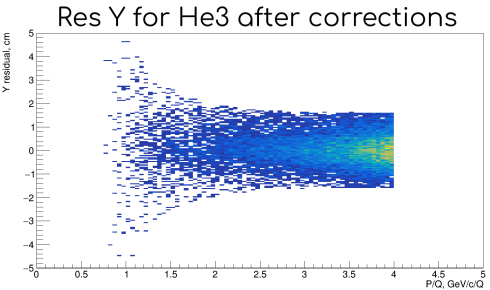


Momentum-dependent alignment of TOF-700

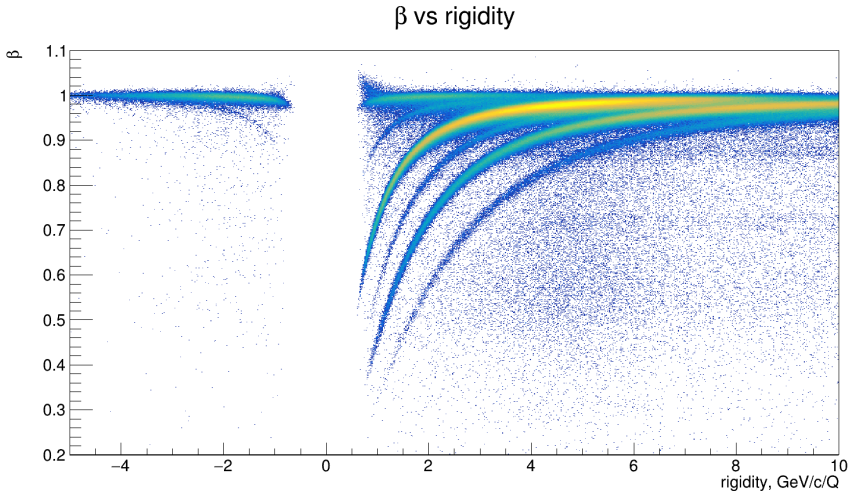








PID plot after corrections

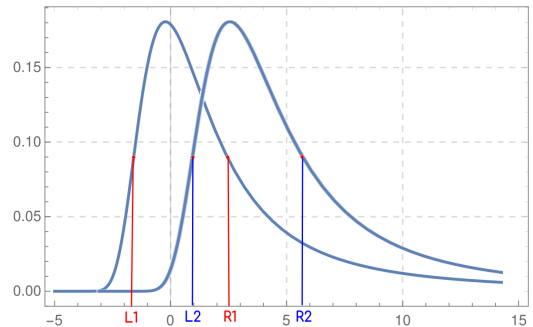


GEM dE/dx

Cluster signal in GEM detectors is proportional to energy loss and could be used to separate helium

GEM signal scaling

The goal: to equalize distributions in the horizontal direction



Linear transformation:

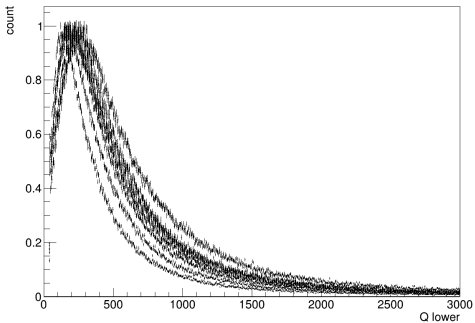
$$L_1 = a \cdot L_2 + b$$

$$R_1 = a \cdot R_2 + b$$

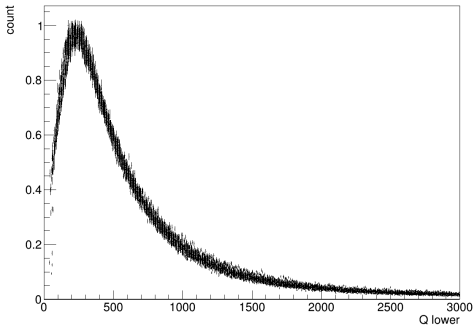
dE/dx in GEM

Signals from 7 GEM detectors

before scaling



after scaling

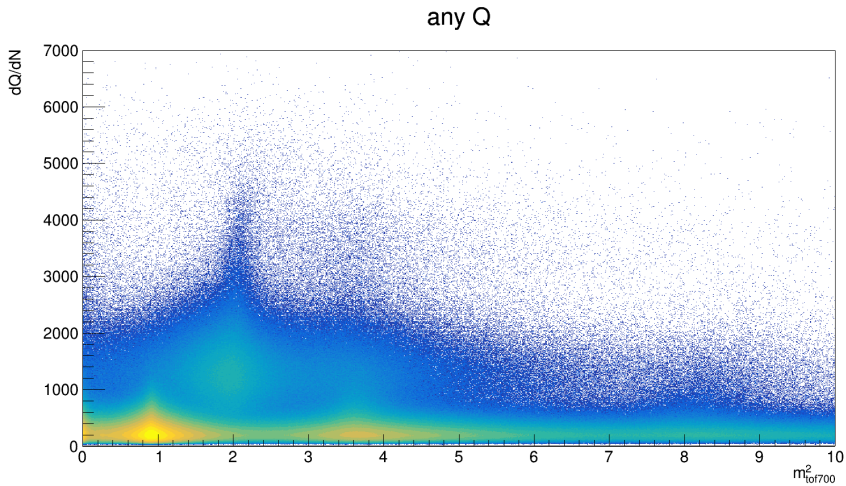


dE/dx in GEM

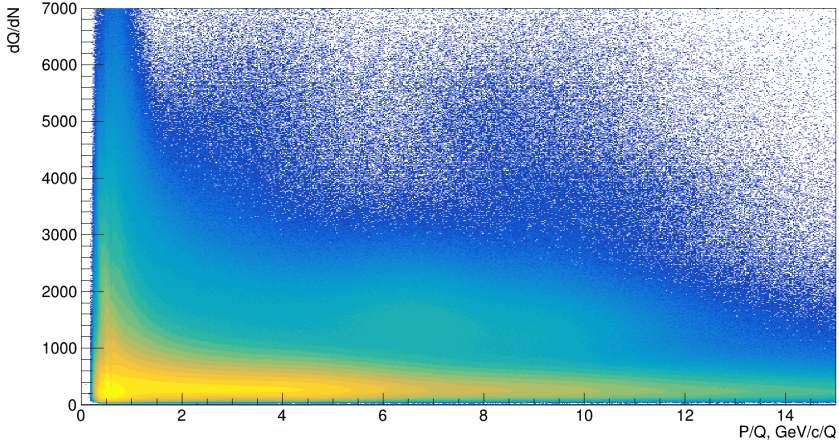
- It was 7 GEM stations in run 8. Only tracks with 3+ GEM hits were taken into account.
- dE/dx has Landau distribution, so the mean value is shifted by the reason of long “tail“.
- The truncated mean was used for analysis (40% hits with maximal signal were removed).

Number of GEM hits	3	4	5	6	7
Used hits	2	2	3	4	4
In percent	67	50	60	67	57

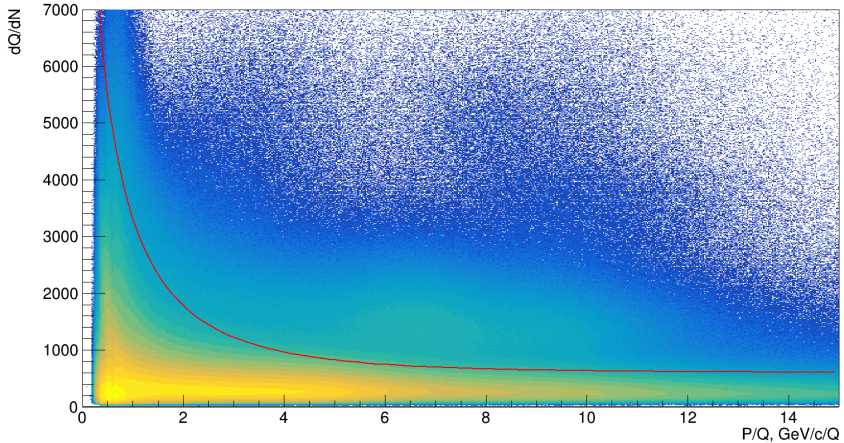
GEM dE/dx vs mass



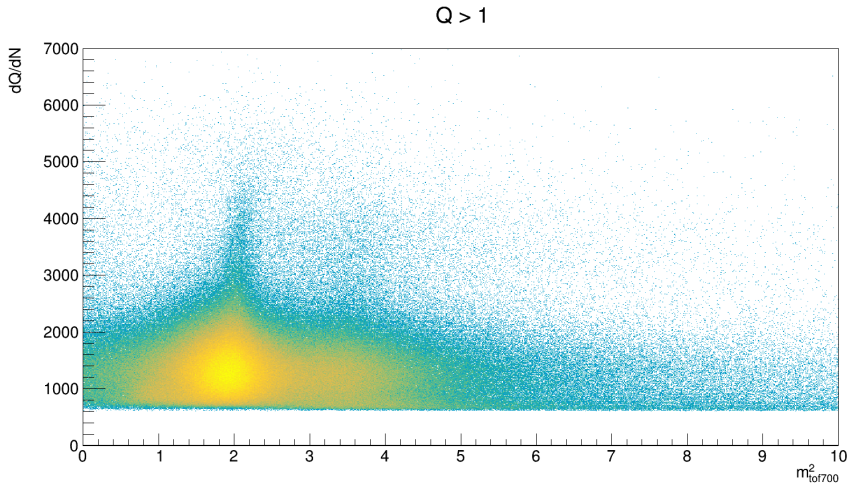
GEM dE/dx vs Momentum



GEM dE/dx vs Momentum



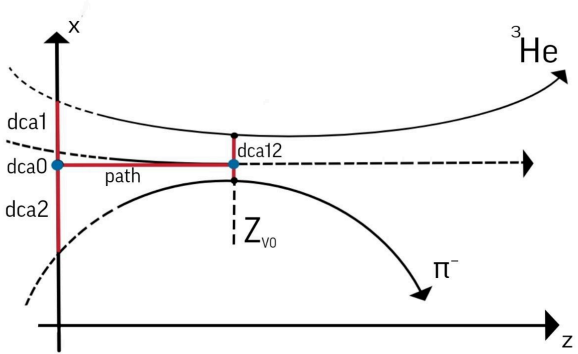
GEM dE/dx vs mass after cut implemented



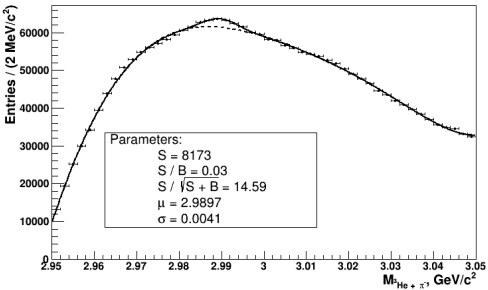
Experimantal data for analysis

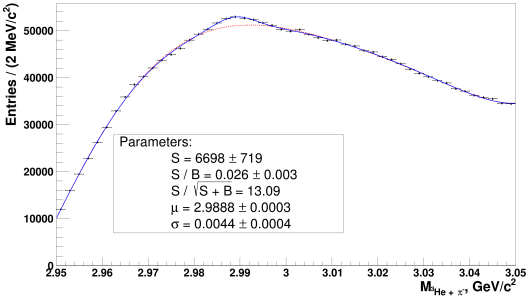
- Beam energy 3.8 AGeV
- Physics trigger (Mixed/CCT1/CCT2/MBT)
- Statistics $\approx (450 - 480) \cdot 10^6$ events
- CsI target
- Primary vertex (MpdVertex with 2+ tracks) in ranges:
  $\sqrt{(x - 0.4)^2 + (y - 0.15)^2} < 1.2$,
  $-0.5 < z < 0.5$
- Each track in pair-candidate has at least 4 hits
- Positive track in pair-candidate has at least 3 hits in GEM detectors (for dE/dx)

Scheme of ${}^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-}$ decay



Invariant mass of $^3H_\Lambda$





Cuts:

- 3.9 < path < 16.0
- 2.0 < dca2 < 30.0
- 0.0 < dca12 < 2.2
- 350 < dedx < 5000
- $1.6 < m^2_{He} < 2.6$
- $0.0 < P_{He} < 8.0$
- $0.3 < P_\pi < 0.8$
- 0.0 < dca0 < 1.1
- $P_{He}/P_\pi > 7.0$

Cuts:

- 3.2 < path < 16.0
- 0.0 < dca12 < 5.2
- $1.6 < m^2_{He} < 2.6$
- $\text{dedx} > 20000 \cdot e^{-2.0 \cdot \sqrt{P_{He}}} + 600.0$
- 0.0 < dca0 < 1.8

Summary

- New TOF-700 production gives much better efficiency
- dE/dx makes it possible to separate fragments with Q > 1
- The of signal of $^{3}H_{\Lambda}$ increased significantly

Next steps

- Further geometrical cuts optimization
- dEdx cut improvement
- Cuts efficiency estimation and comparison with MC case

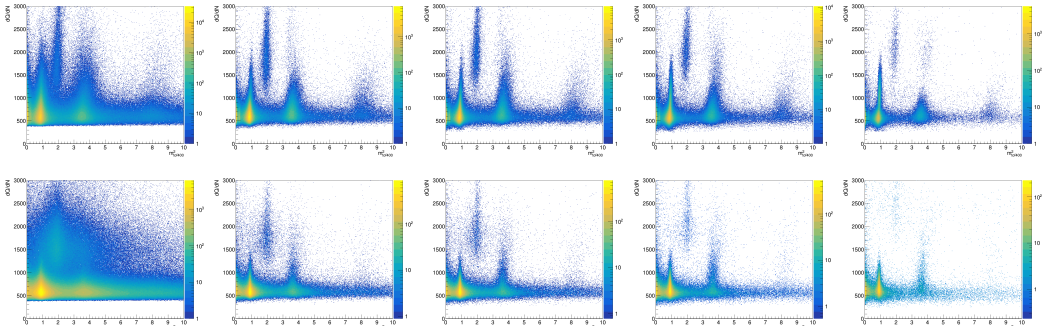
Thank you!

Backup

FSD affection

TOF-400

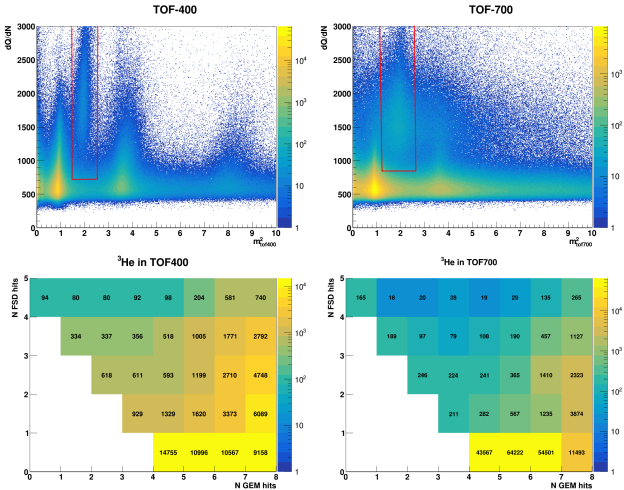
0 FSD | 1 FSD | 2 FSD | 3 FSD | 4 FSD



0 FSD | 1 FSD | 2 FSD | 3 FSD | 4 FSD

TOF-700

^{3}He hit composition



Experimantal data for analysis (OLD: collab.meet)

- Beam energy 3.8 AGeV
- Physics trigger (Mixed/CCT1/CCT2/MBT)
- Statistics $\approx 3 \cdot 10^8$ events
- CsI target
- Primary vertex (MpdVertex with 2+ tracks) in ranges:
  $-5.0 < x < 5.0$, $-5.0 < y < 5.0$, $-1.0 < z < 1.0$
- Each track in pair-candidate has at least 4 hits
- Positive track in pair-candidate has at least 3 hits in GEM detectors