Status of hypernuclei signal reconstruction in Xe+CsI Collisions in the BM@N experiment

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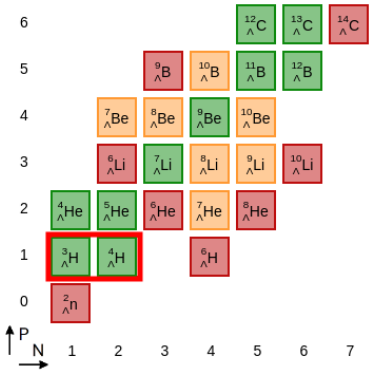
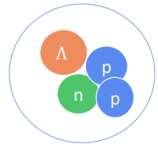
What are hypernuclei?



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

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



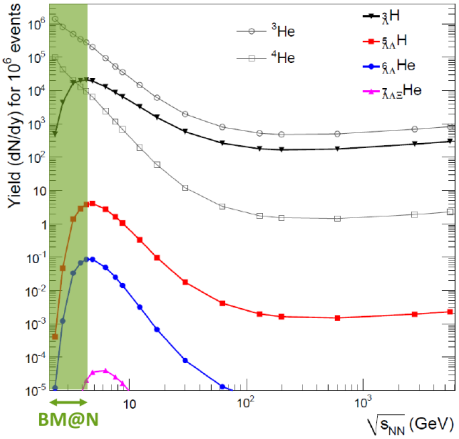
$^{4}_{\Lambda}$He

Charged particle decays

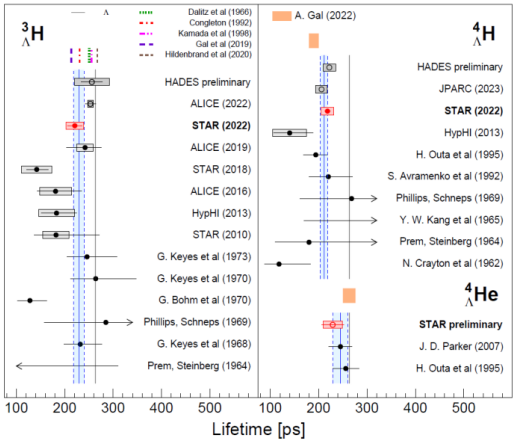
$$^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-} \qquad ^{3}_{\Lambda}\mathrm{H} \rightarrow \mathrm{d} + \mathrm{p} + \pi^{-}$$

Why hypernuclei are interesting?

Sign of phase transform



Lifetime puzzle



Content

- About analysed data
- dE/dx estimation to select double-charged ions
- Helium-3 selection by mass in TOF-700
- Results on experimental and MC data

Data for analysis

Production 24.12.0

Condition	Number of events	Percentage
Energy 3.8 AGeV	652 479 072	100.0%
Target CsI	588 802 961	90.2%
Magnetic Field	586 351 128	89.9%
Type “Physics”	543 509 433	83.3%
CCT2 bit is 1	442 250 571	67.8%
2+ tracks in vertex	307 472 876	47.1%
Vertex in “target”	265 413 702	40.7%

Target region:
$\sqrt{(x-0.4)^2+(y-0.15)^2} < 1.2$,
$-0.5 < z < 0.5$
Conditions for tracks in pair-candidates:

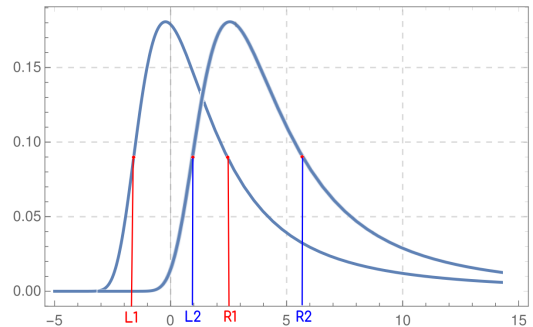
- Each track has at least 4 hits
- Positive track has at least 3 hits in GEM detectors (for dE/dx)

dE/dx in GEM

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:

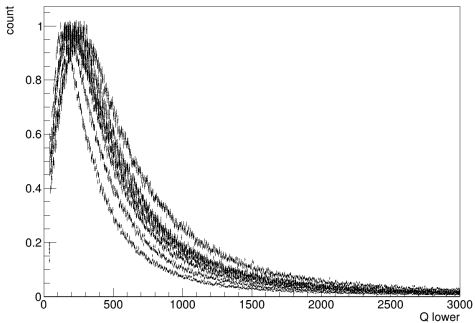
$$L_1 = a \cdot L_2 + b$$

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

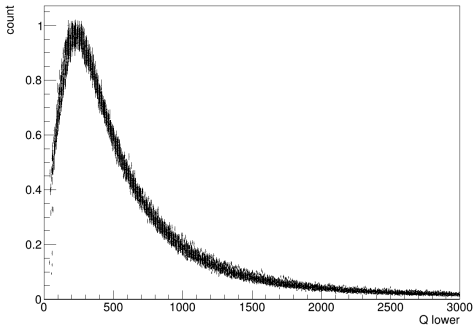
dE/dx in GEM

Signals from 7 GEM detectors

before scaling



after scaling



dE/dx in GEM

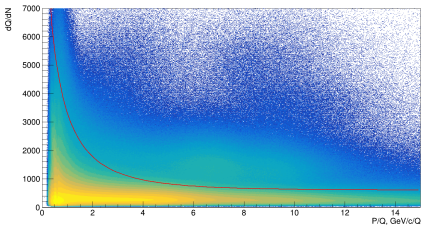
- It was 7 GEM stations in run 8. Only tracks with 3+ GEM hits were taken into account.
- dE/dx has Landau distribution, so the mean value is shifted by the reason of long “tail“.
- The truncated mean was used for analysis (40% hits with maximal signal were removed).

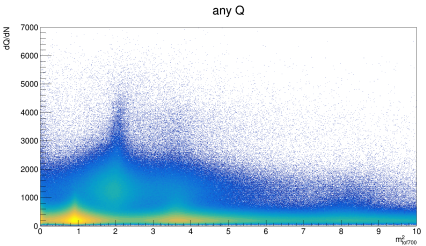
Number of GEM hits	3	4	5	6	7
Used hits	2	2	3	4	4
In percent	67	50	60	67	57

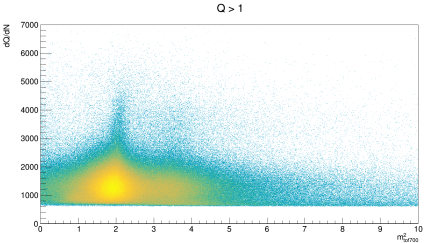
dE/dx in GEM

Simple cut to separate double-charged ions was implemented:

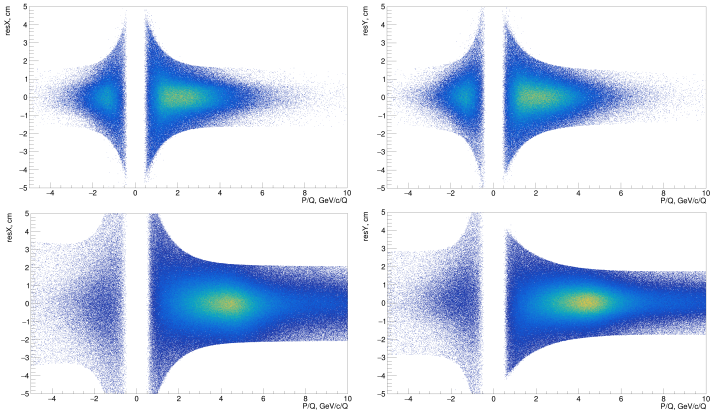
$$20000 \cdot e^{-2.0 \cdot \sqrt{\rho}} + 600.0$$







Momentum dependent corrections of TOF



- Implemented in 25.04.0 production
- Room for improvement: to implement corrections for each module

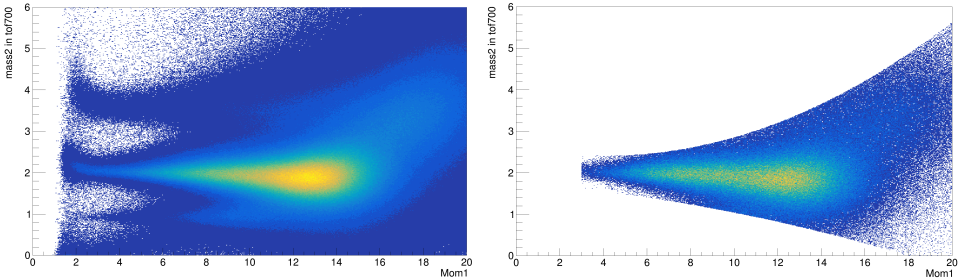
by Stanislav Goyda (SPbSU student)

He-3 selection

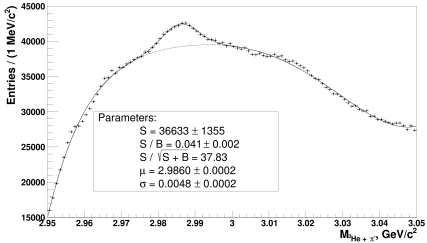
Updates:

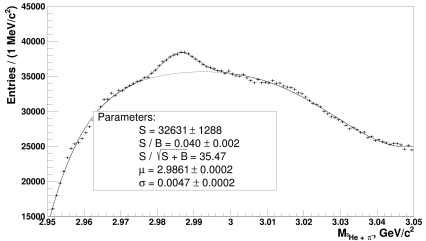
- The problem of low efficiency of TOF-700 reconstruction was solved
- Matching algorithm was updated
- He3 momentum dependent corrections were added

Selection by ToF-700 after dE/dx cut was implemented



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



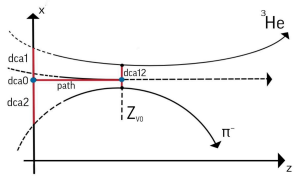


Two cases were observed:

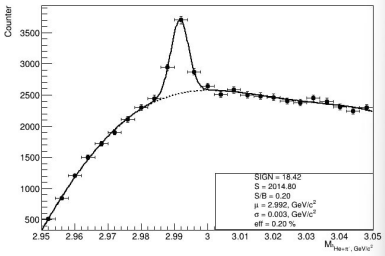
- All experimental events [≈22000 files]
- Events from run 7772 (roughly the beginning of the "golden"runs) [≈11000 files]

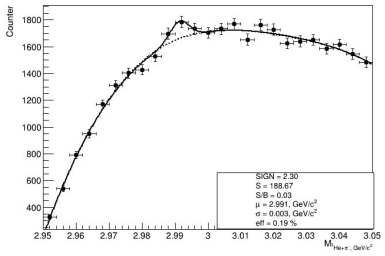
Cuts:

- 4 < path < 14
- 2 < dca2 < 20
- 0 < dca12 < 20
- 0 < dca0 < 10
- 0 < P_{He} < 20
- 0.2 < P_{π} < 20
- 14 < P_{He} / P_{π} < 20



${}^{3}_{\Lambda}\mathrm{H}$ on Monte Carlo Data





Two sets of MC was generated by DCM-SMM model:

- 1e6 events with ${}^{3}_{\Lambda}\mathrm{H}$ included in each event
- 1e6 events with ${}^{3}_{\Lambda}\mathrm{H}$ included in one in ten event

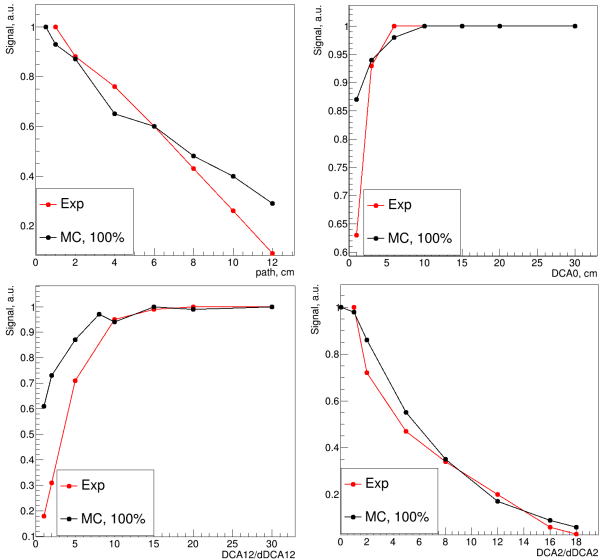
Cuts:

- $0.5 < \mathrm{path} < 50.0$
- $0.01 < \mathrm{dca2} < 100.0$
- $0.0 < \mathrm{dca12} < 8.0$
- $0.0 < \mathrm{dca0} < 1.8$
- $2.0 < P_{He} < 10.0$
- $0.2 < P_{\pi} < 1.6$
- $4.0 < P_{He} / P_{\pi} < 21.0$

Geometrycal cuts efficiency

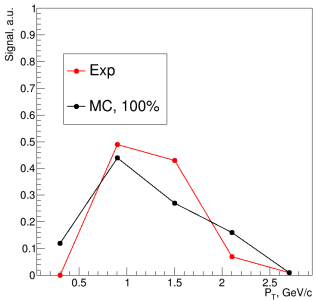
- Observed cut was scanned (other cuts fixed)
- Signal for each case was evaluated
- Results were scaled by maximum signal

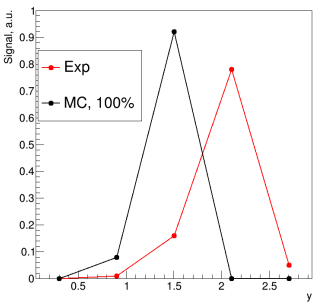
For MC data we need higher statistics. After that values of the cuts will be comparable through their efficiencies.

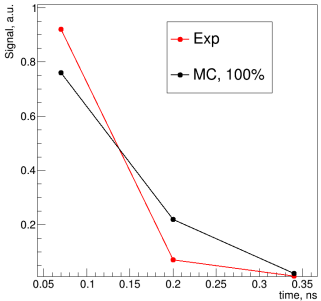


Towards physics analysis

The first attempt to compare physics characteristics of MC and Experimental data hypertritium signal.







Need more corrections for both MC and Exp. data.

Next steps

- Find source of the signal shift (magnetic field, algorithm, ...).
- Increase statistics of MC.
- Detailed comparison MC and Experimental Data.
- Estimate physics characteristics.
- Start to analyze ${}^{4}_{\Lambda}\mathrm{H}$
- Start to analyze three body decay

Thank you!