Hypernuclei signal observation in the BM@N experiment

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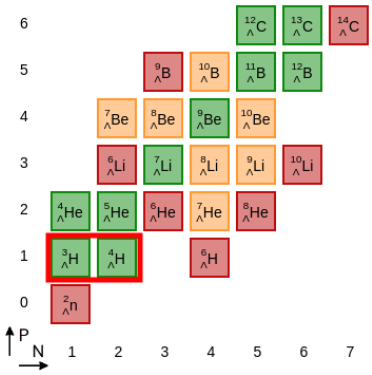
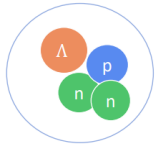
13th Collaboration Meeting of the BM@N Experiment at the NICA Facility
Dubna, Russia

09/10/24

What are hypernuclei?



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



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

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

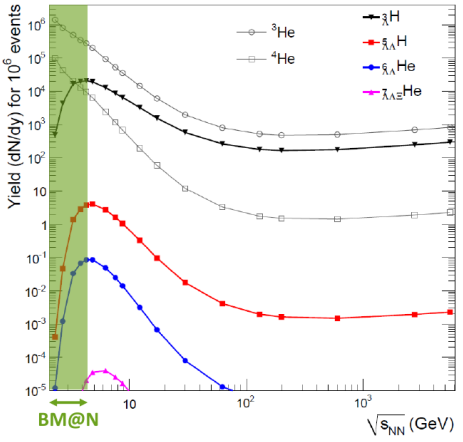
Charged particle decays

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

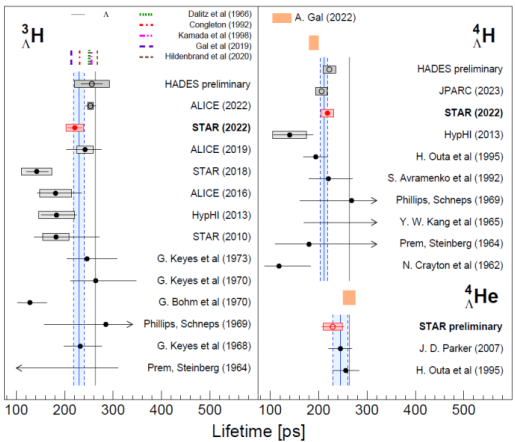
$$^{3}_{\Lambda}\mathrm{H} \rightarrow \mathrm{d} + \mathrm{p} + \pi^{-}$$
$$^{4}_{\Lambda}\mathrm{H} \rightarrow \mathrm{t} + \mathrm{p} + \pi^{-}$$

Why hypernuclei are interesting?

Sigh of phase transform

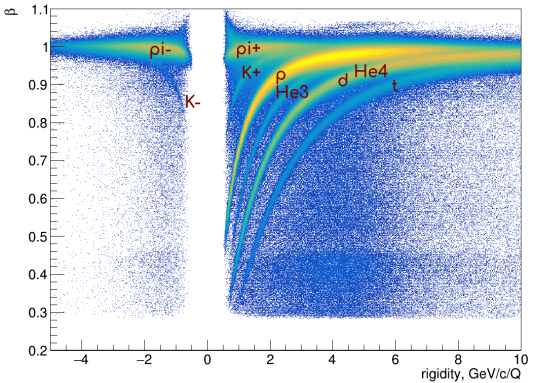


Lifetime puzzle



Two particle decay

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

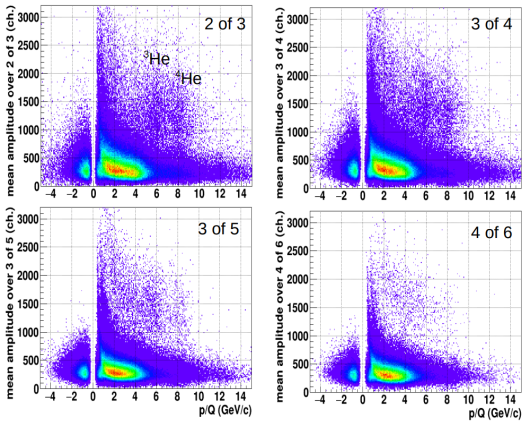


It's not enough to have a time-of-flight technique to identify helium

GEM dE/dx

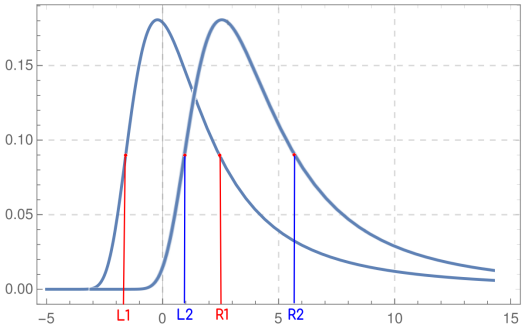
Cluster signal in GEM detectors is proportional to energy loss and could be used to separate helium

As it was in Argon data (2018):



GEM signal scaling

The goal: to equalize distributions in the horizontal direction



Linear transformation:

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

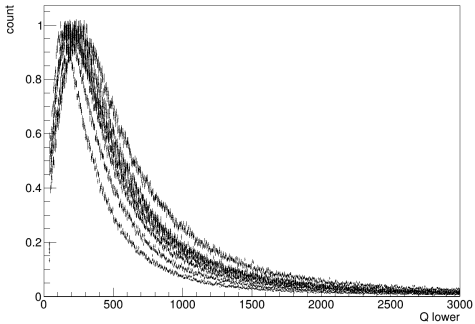
$$R_1 = a \cdot R_2 + b$$

`Proposal of I.Rufanov`

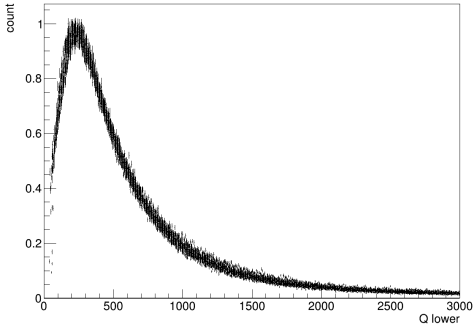
dE/dx in GEM

Signals from 7 GEM detectors

before scaling



after scaling

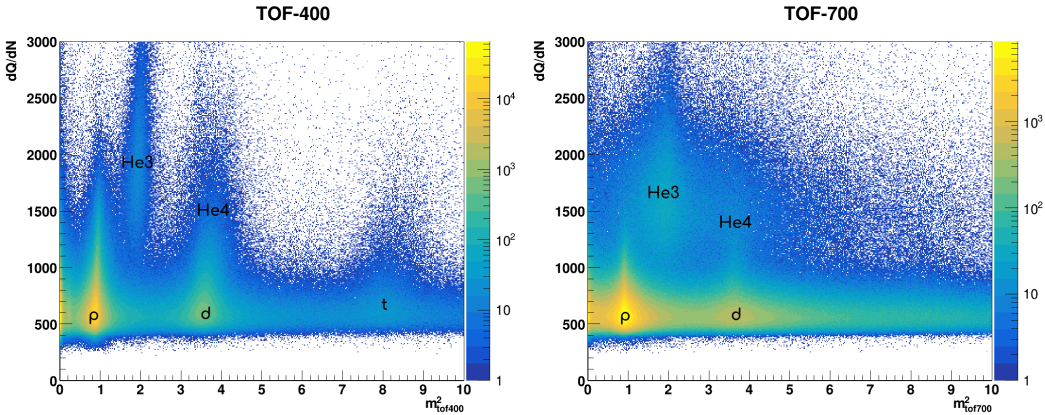


dE/dx in GEM

- 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

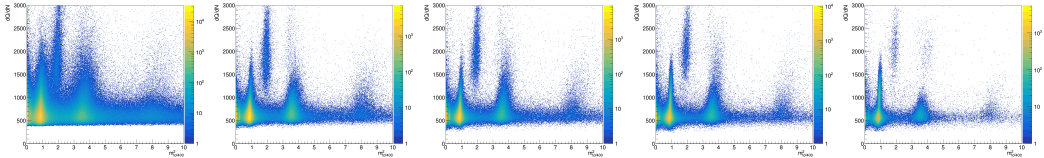
GEM dE/dx vs mass



FSD affection

TOF-400

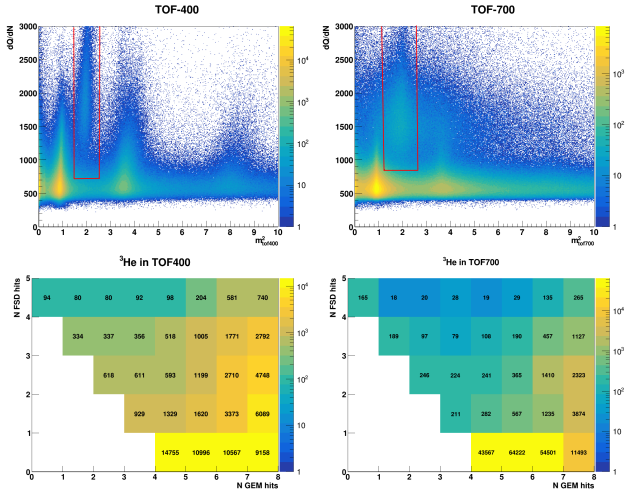
0 FSD | 1 FSD | 2 FSD | 3 FSD | 4 FSD



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

TOF-700

^{3}He hit composition

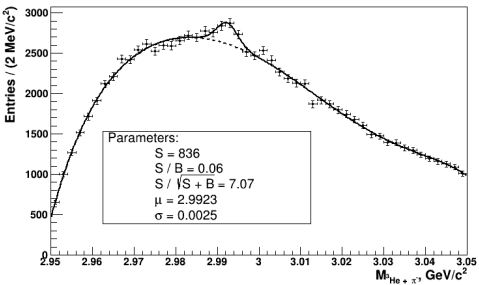


Experimantal data for analysis

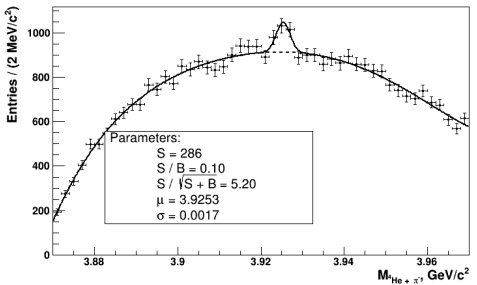
- Beam energy 3.8 AGeV
- Physics trigger (Mixed/CCT1/CCT2/MBT)
- Statistics $\approx 3 \cdot 10^8$ events
- CsI target
- Primary vertex (MpdVertex with 2+ tracks) in ranges:
  $-5.0 < x < 5.0$, $-5.0 < y < 5.0$, $-1.0 < z < 1.0$
- Each track in pair-candidate has at least 4 hits
- Positive track in pair-candidate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

Experimantal data

$^{3}H_{\Lambda}$

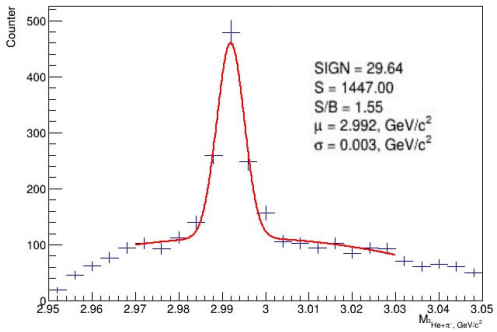


$^{4}H_{\Lambda}$

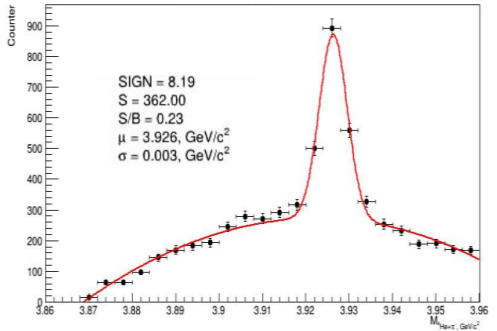


MC data

$^3H_\Lambda$



$^4H_\Lambda$



by E.Konstantinova during summer school

Conclusion

The main positive result

- The first stable signals of $^{3}\mathrm{H}_{\Lambda}$ and $^{4}\mathrm{H}_{\Lambda}$ observed in the BM@N experiment

Steps for signal improvement

- New production with better TOF-700 efficiency (factor 2-3)
- More accurate analysis of dE/dx in GEM for the separation of $^{4}\mathrm{He}$ from deuterons
- Standalone matching of STS tracks and TOF hits to reduce background