Hypernuclei signal observation in the BM@N experiment

E.Konstantinova (ISU), S.Merts (JINR)

Mathematical Modeling and Computational Physics
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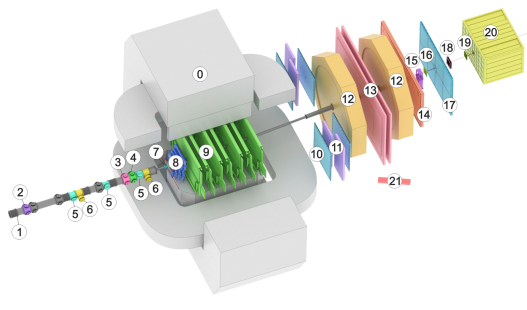
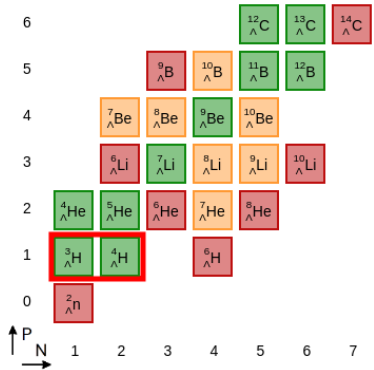
Baryonic Matter at Nuclotron (BM@N)

- The first working experiment at the NICA complex
- Fixed target facility
- 8 runs were carried out
- The first physics run with heavy ions was in Dec,2022 - Jan,2023: Xe + CsI @ 3.8 AGeV



What are hypernuclei?



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

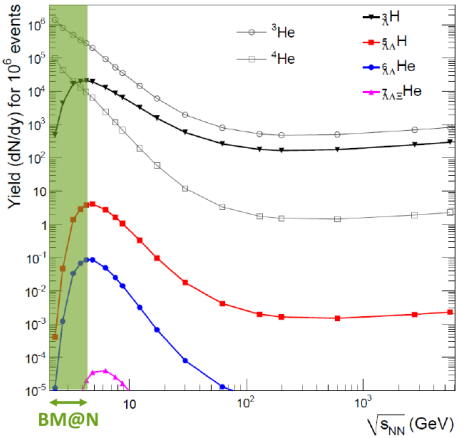
$^{4}_{\Lambda}$H

In current work two-particle decays only

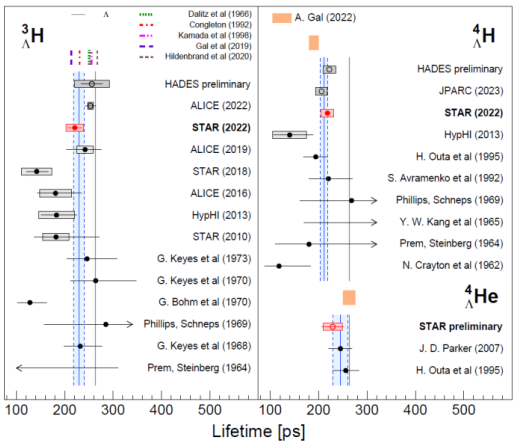
$$^{3}_{\Lambda}\mathrm{H} \rightarrow {}^{3}\mathrm{He} + \pi^{-} \qquad ^{4}_{\Lambda}\mathrm{H} \rightarrow {}^{4}\mathrm{He} + \pi^{-}$$

Why hypernuclei are interesting?

Sigh of phase transform



Lifetime puzzle

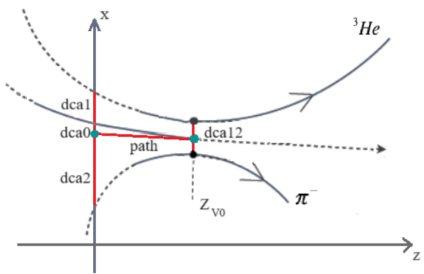


Two directions of research

Simulated data

- Helps to develop, test and tune algorithms
- Gives algorithm efficiency

Decay scheme

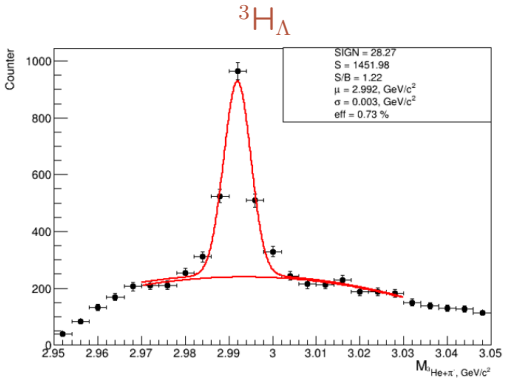


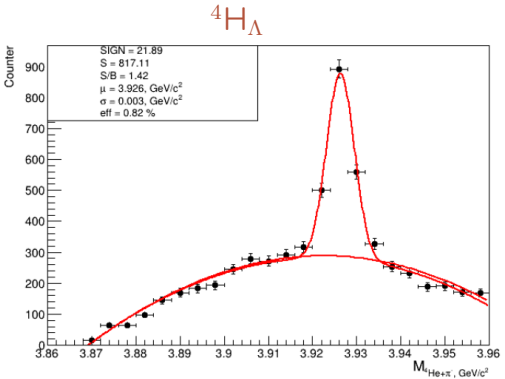
Experimental data

- The main goal of research
- Analysis of hypernuclei production, lifetime estimation etc

Simulated data

- Full realistic geometry of experimental setup used.
- The birth of hypernuclei is a rather rare process.
- So in current MC production the mixture of background events (DCM-SMM model) and signal events (Single hypernuclei) was used in proportion 1:1
- Used statistics: 10^5 events





Experimantal data

- Xe + CsI @ 3.8 AGeV
- Physics trigger (Mixed/CCT1/CCT2/MBT)
- Used statistics $\approx 3 \cdot 10^8$ events

Two particle decay

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

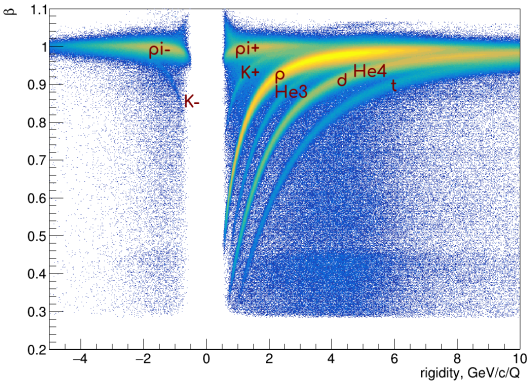
$$^{4}_{\Lambda}\mathrm{H} \rightarrow {}^{4}\mathrm{He} + \pi^{-}$$

Problems:

- ^{3}He could be selected in momentum range ≈ 0.5 - 3.5 GeV/c
- Impossible to separate ^{4}He from deuterons

It's not enough to have a ToF technique to identify helium

ToF identification plot



dE/dx in GEM

Let's try to use GEM detectors for dE/dx extimation

- It was 7 GEM stations in the last experimental run.
- Each track has 1-7 GEM hits, so the energy loss could be estimated as

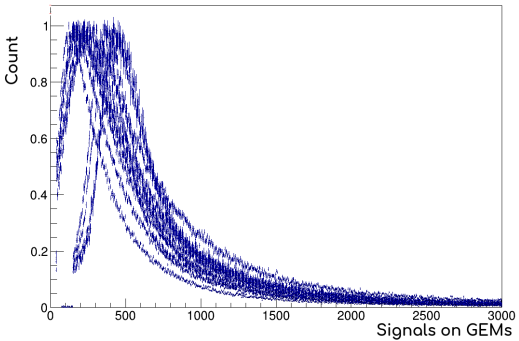
$$\langle \frac{dE}{dx} \rangle = \frac{\sum_{i=1}^{N} q_i}{N}, \text{ where } N > 3, q_i - \text{hit signal}$$

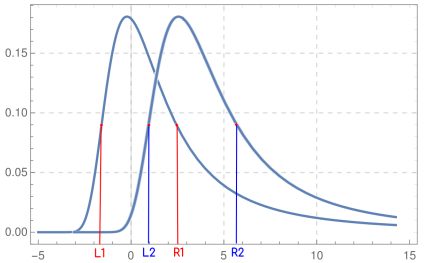
- dE/dx has Landau distribution, so the mean value is shifted by the reason of long "tail".
- The truncated mean was used for analysis (40% hits on track with maximal signal were removed).

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

GEM signal scaling

The goal: to equalize distributions in the horizontal direction





Linear transformation:

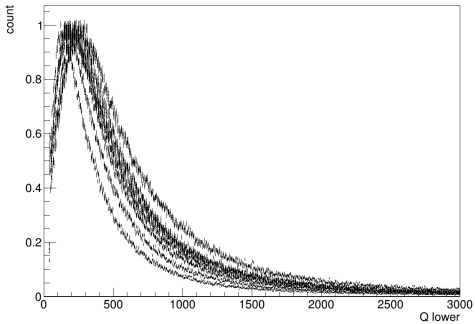
$$L_1 = a \cdot L_2 + b$$

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

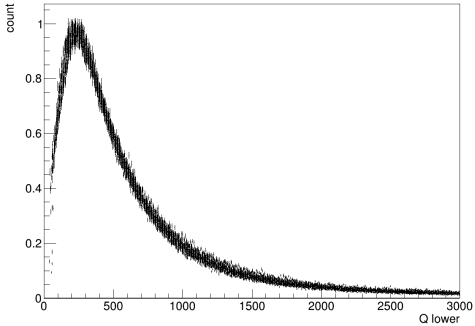
dE/dx in GEM

Signals from 7 GEM detectors

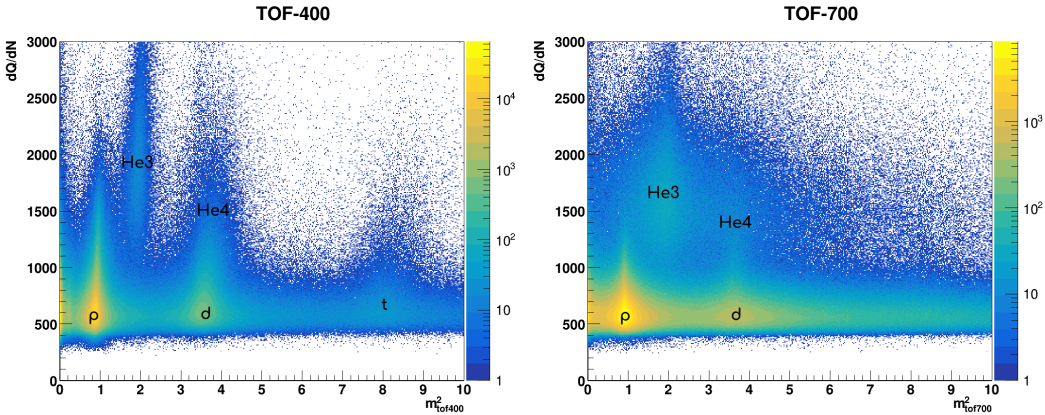
before scaling



after scaling

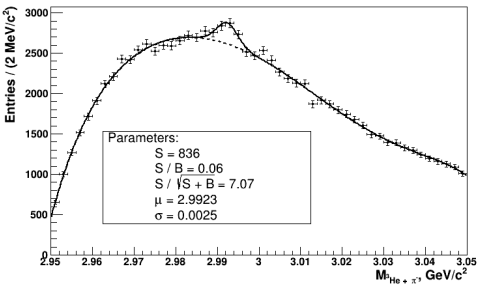


GEM dE/dx vs mass

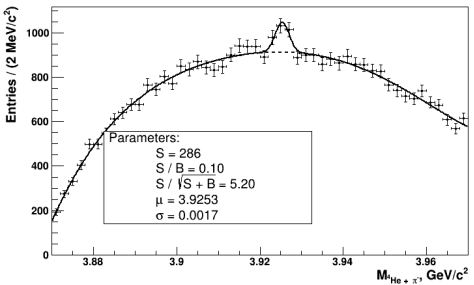


Experimantal data

$^{3}H_{\Lambda}$



$^{4}H_{\Lambda}$



Summary

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 increasing

- 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
- Reduction of geometric cuts number (now 11 cuts used)

Thank you!