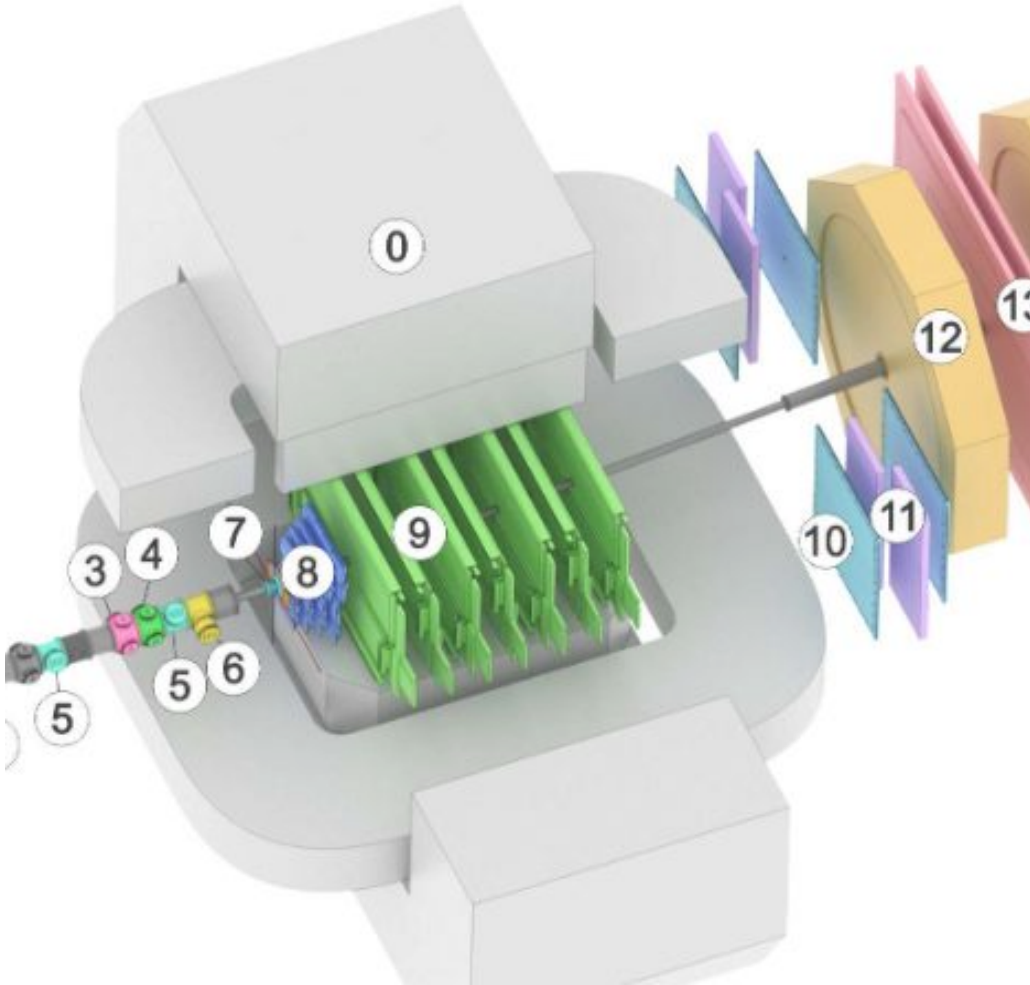
Analysis of hypernuclei in simulated data of the BM@N experiment

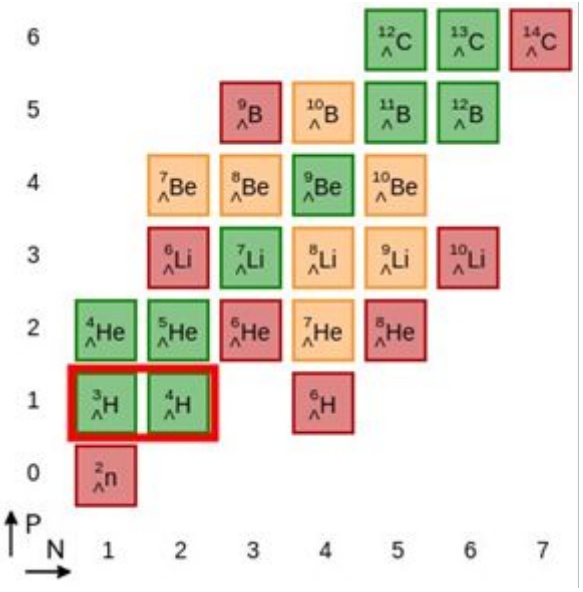
Konstantinova Elizaveta(ISU),
Dr. Sergei Merts (JINR)

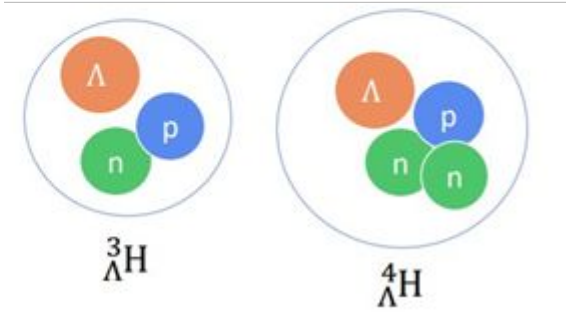
AYSS
Dubna, 29.10.2024



The aim of this work is to reconstruct the hypernuclei signal in the invariant mass distribution for simulated data for the BM@N experiment.

In the report algorithm of geometrical parameters selection for both decays presented. Estimation of reconstruction efficiency in phase space {pt, y} done.





$^{3}_{\Lambda}H$ $^{4}_{\Lambda}H$

$$^{3}H_{\Lambda} \rightarrow \pi^{-} + {}^{3}He$$

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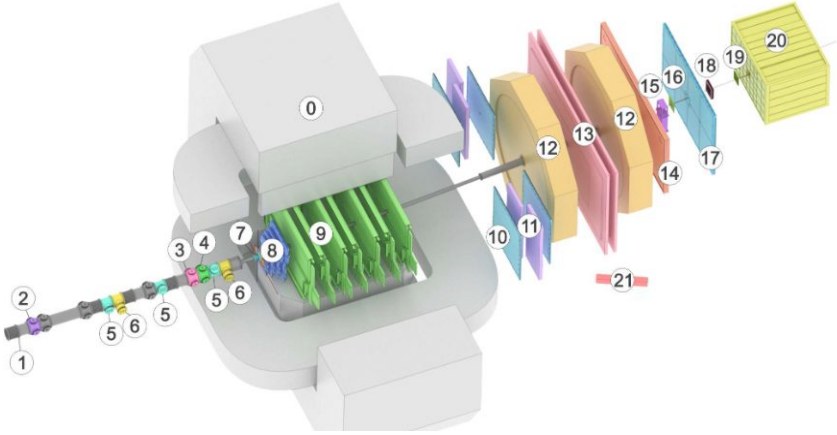
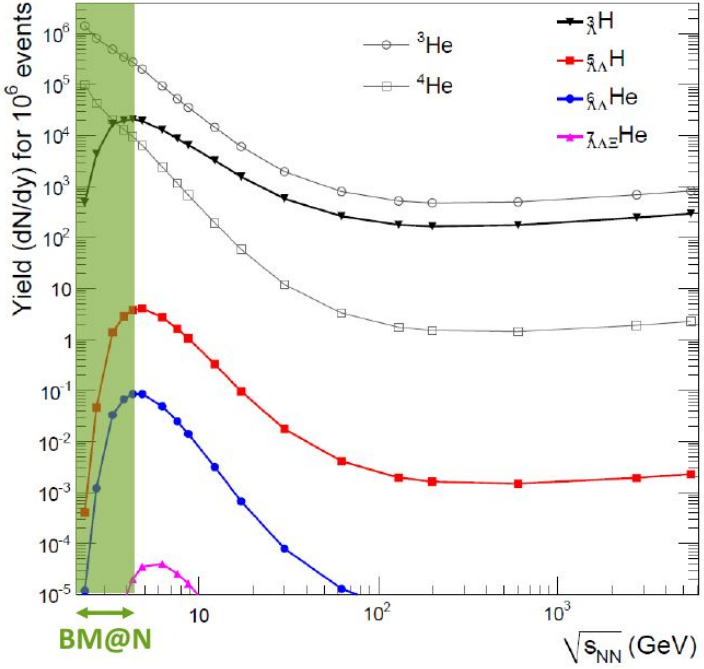
Hypernuclei contain at least one hyperon (a particle with non-zero strangeness) in addition to protons and neutrons.

BM@N at NICA

The BM@N is aimed at studying collisions of relativistic ions with a fixed target.

The experiment has had **8 sessions** at the Nuclotron from 2015 to 2023. The last of the sessions was in 2022-2023 on a xenon beam and a CsI target at 3.8 GeV/nucleon.





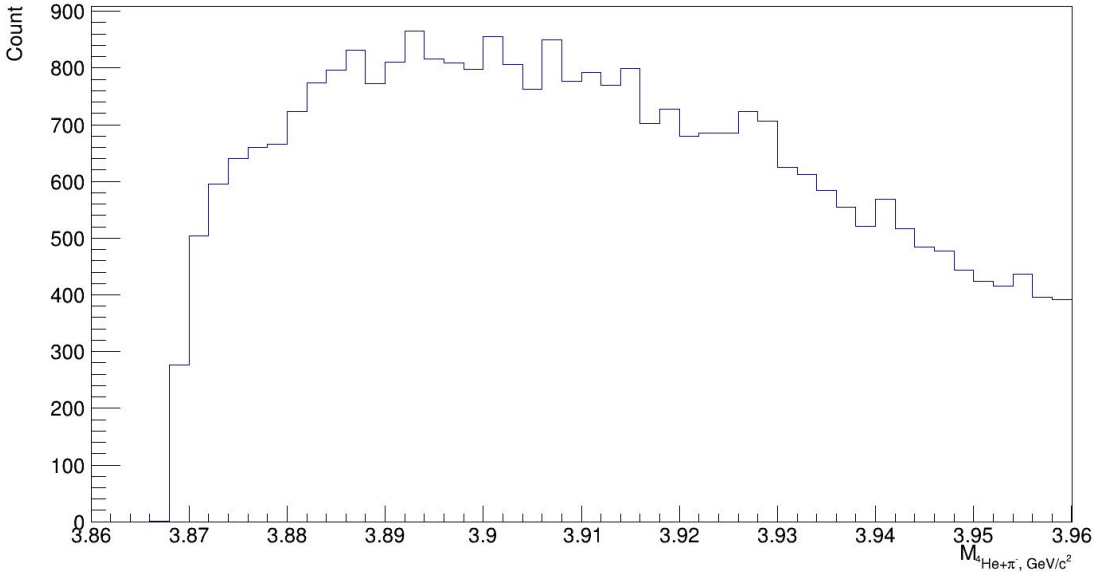
One of the main aim of the experiment is to study hypernuclei

Simulation and Reconstruction

A detailed realistic geometry of the experimental setup was used for simulation. At the first stage, the events of a Xe+CsI collisions were simulated by DCMSMM model. In collisions of heavy ions, hypernuclei are born quite rarely, so it became necessary to model 10^5 events, each of which has an artificially added hypernucleus.

Tracks were reconstructed using the standard tools of the BmnRoot package based on the Kalman filter.

Data analysis

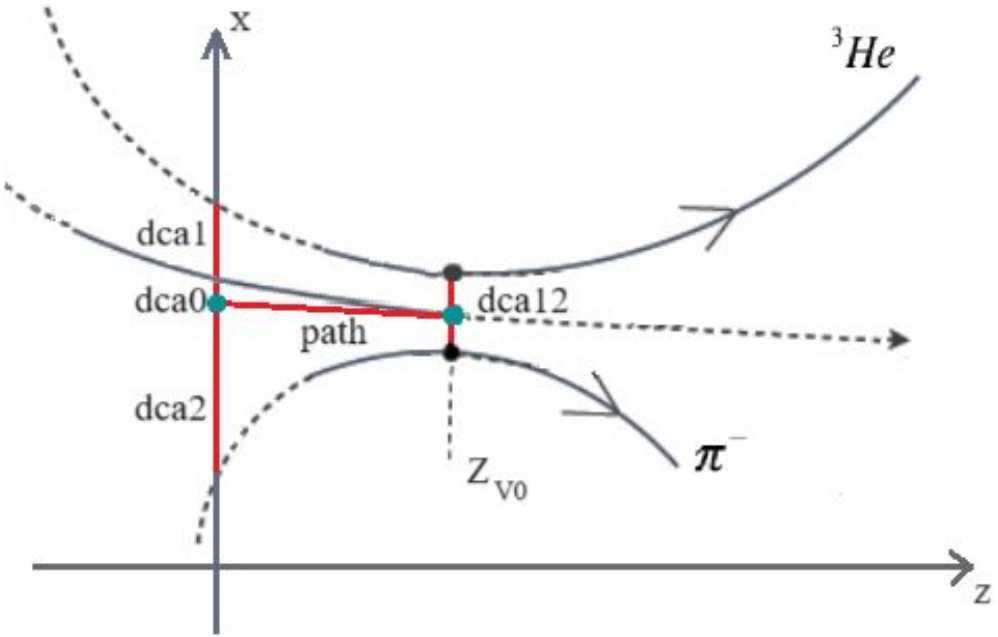


Example of $^{4}H_{\Lambda}$ invariant mass distribution with unsuppressed background

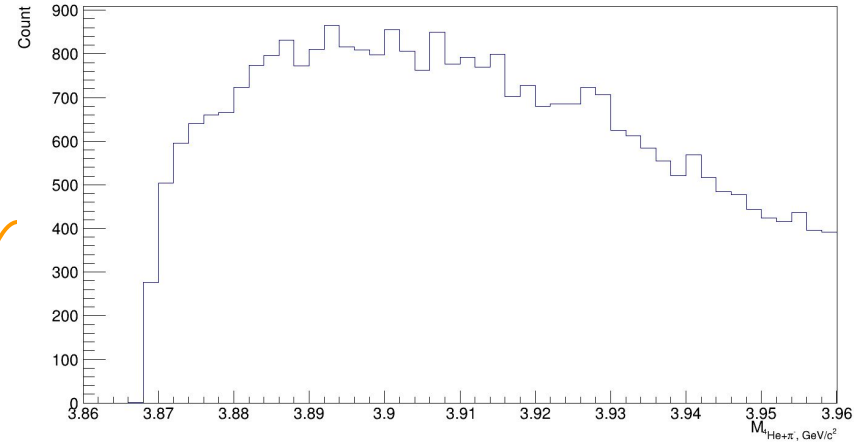
The final step of the data preparation procedure is the creation of candidate pairs of hypernuclear decay products. Among the reconstructed tracks, the macro selects pairs of positive and negative particles, where all negative particles are considered pi-minus, and helium is identified by mass in the tof detector system. Selection is then performed by momentum, vertex, and other parameters. Having constructed the pairs, it is necessary to select decays by the necessary channel under conditions of a large combinatorial background.

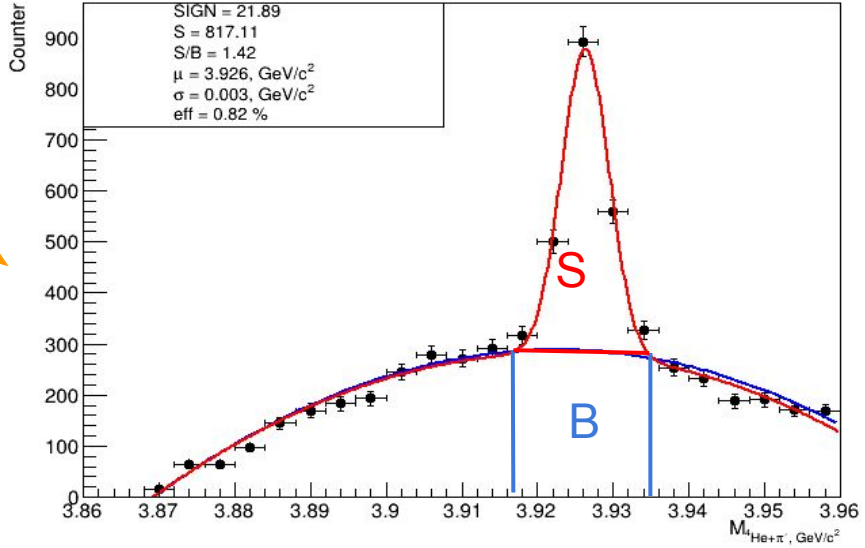
The varying parameters

- **dca12** - the minimum distance between the trajectories of two particles from the pair under consideration,
- **dca1** - distance from the primary vertex to the trajectory of the positive particle in the plane of the primary vertex,
- **dca2** - distance from the primary vertex to the trajectory of the negative particle in the plane of the primary vertex,
- **path** - distance from the primary vertex to the decay point V_0
- **dca0** - distance from the primary vertex to the momentum projection in the plane of the primary vertex.



*The parameters dca2 and dca12 are considered in χ^2-space, i.e. after normalization by the corresponding parameter errors.





Data analysis

The main parameters for the analysis:

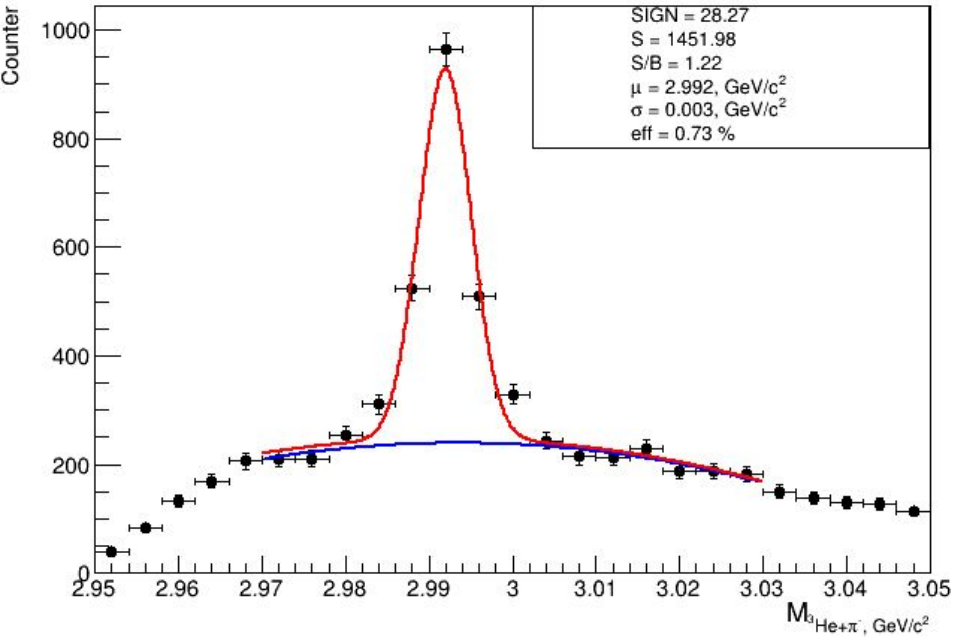
- Signal (S) corresponds to the area under the plot in range ± 3 σ around the center of the peak above the background
- Background (B) corresponds to the area under the plot in the same range without the signal peak.

The algorithm for finding the best geometric constraints was based on combinatorial search in the space of all constraints.

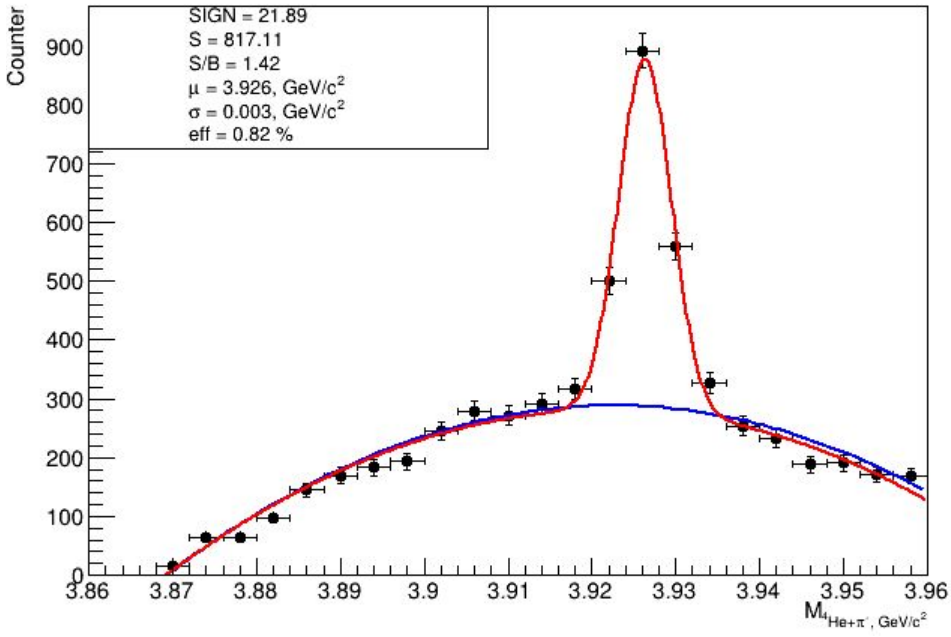
$$sign = \frac{S}{\sqrt{S+B}} \rightarrow max$$

Significance of signal

H3L



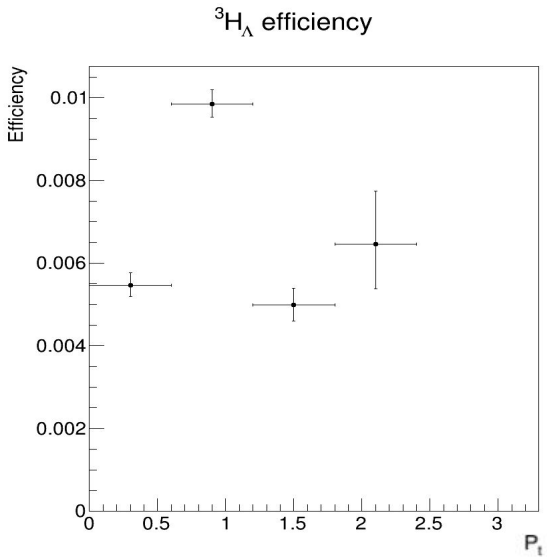
H4L

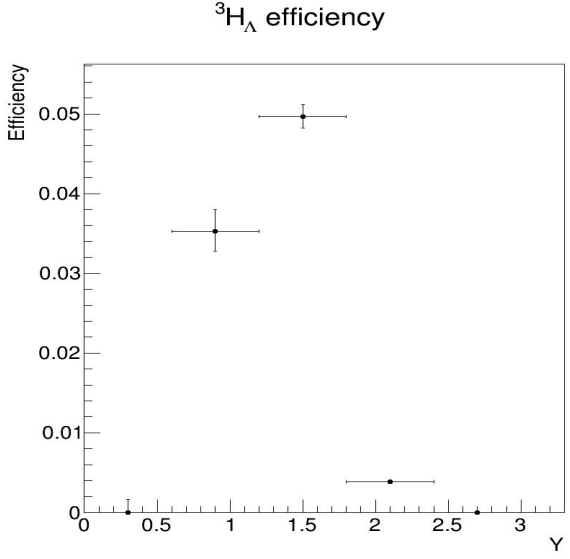


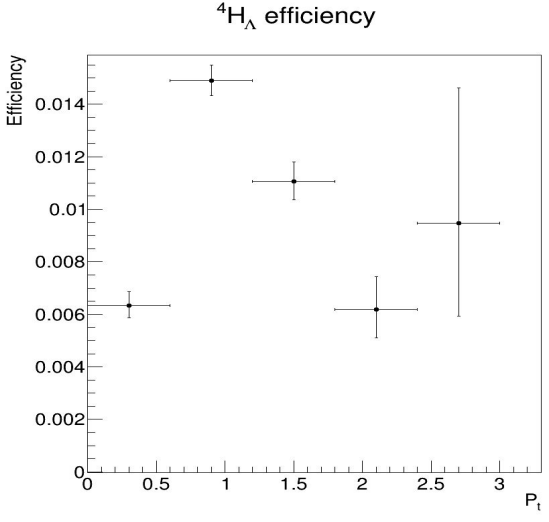
Efficiency

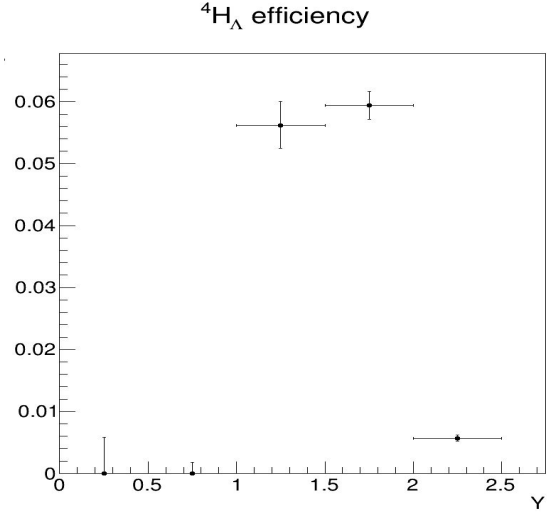
$eff=S/N_{sim}$

S - signal(number of reconstructed hypernuclei)
N_{sim} - number of simulated hypernuclei





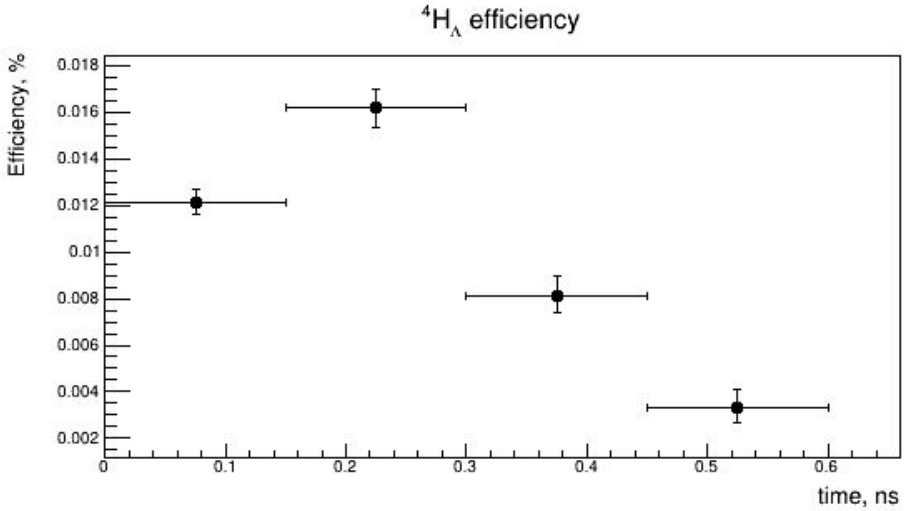


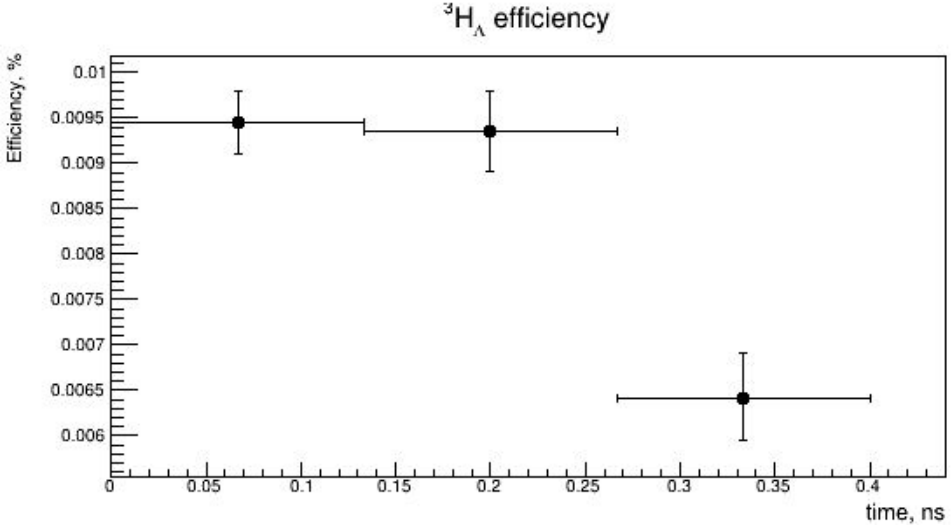


Conclusions and future work

Finally:

- A combinatorial background suppression algorithm is presented
- The efficiency of hypernucleus reconstruction is evaluated in Pt, Y and time bins





In future work, it is planed to simulate more data to improve lifetime and efficiency estimations, analyze three-particle decay channels, and start working with experimental data.

Thank you for your attention