Heavy fragments (^{3}He and ^{4}He) identification using the energy loss method in the STS detector of the CBM experiment

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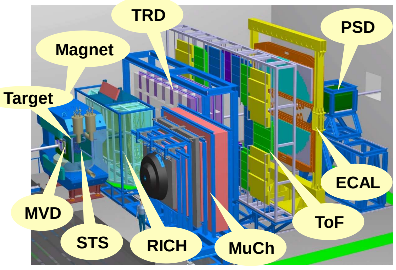
(for the CBM Collaboration)

Compressed Baryonic Matter experiment at FAIR

CBM Heavy-ion Experiment



- CBM is a future fixed-target heavy-ion experiment at FAIR
- observables include very rare (or extremely rare) probes
- very high interaction rates of up to 10 MHz
- up to 1000 charged particles/collision

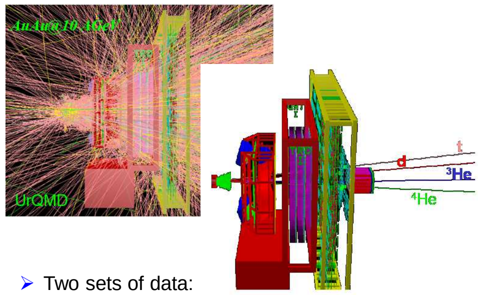
Motivation

One of the aims of the experiment is to study the production of hypernuclei. Theoretical models predict that single and even doubly strange hypernuclei are produced in heavy-ion collisions with a maximum yield in the region of SIS100 energies. The discovery and the investigation of new (doubly strange) hypernuclei will shed light on hyperon-nucleon and hyperon-hyperon interactions. In order to accurately measure the yields of hypernuclei and their lifetime, one should identify their decay products including ^{3}He and ^{4}He.

PID detectors: TOF, TRD, STS

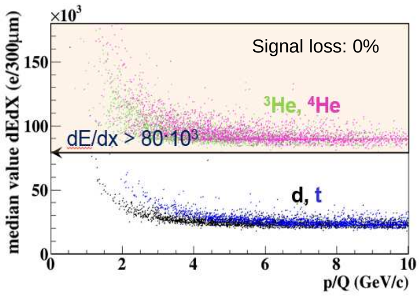
Goal: to study the possibility of using the STS detector for particle identification in addition to the dedicated PID detectors.

Input for simulation

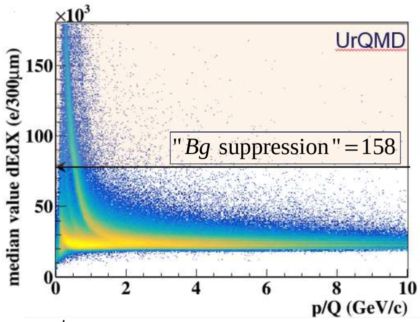


- Two sets of data:
  - Siganl: ^{3}He, ^{4}He, d, t (simulated according to the thermal distribution)
  - background events (UrQMD)
- central AuAu collisions at 10 AGeV
- sis100_electron setup without MVD

dE/dx calculation in STS



1. to reconstruct a track;
2. for each cluster dE is defined as a total cluster charge;
3. to estimate dx:
   - 3.1 the track is assumed to be a straight line between the current hit and the hit in the next station;
   - 3.2 the track inclination is calculated;
   - 3.3 dx is calculated from the track inclination.
4. to take a median value of dE/dx over the remaining clusters.



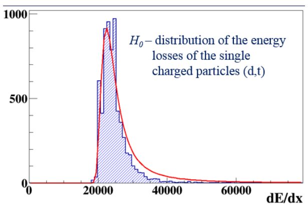
Perfect separation between single- and double-charged particles for the whole momentum range

ω_n^k criterion for particle identification in STS

Each track is associated with a set of measurements of particle energy losses. With the help of ω^k_n, one should determine to which distribution (signal or background) these losses are related.

$$\omega_n^k = -\frac{n^{k/2}}{k+1}\sum_{j=1}^{n}\left\{\left[\frac{j-1}{n}-\phi(\lambda_j)\right]^{k+1}-\left[\frac{j}{n}-\phi(\lambda_j)\right]^{k+1}\right\},$$

where k is the criterion degree, n is the sample size (the number of dE/dx values), $\phi(\lambda)$ is the Landau distribution function (which describes H_0) with a new variable λ

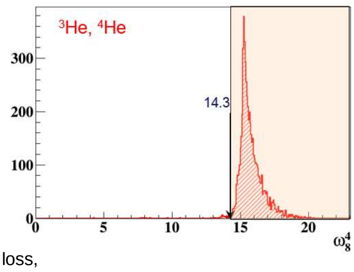


$$\lambda_i = \frac{\Delta E_i - \Delta E^i_{mp}}{\xi_i} - 0.225, \qquad i = 1,2,\ldots,n$$

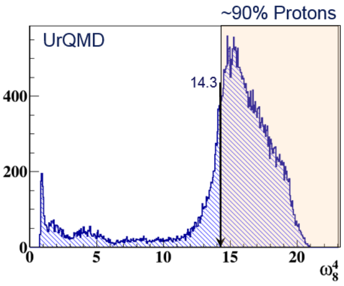
ΔE_i – the energy loss in the i-th STS "layer",

ΔE^i_{mp} – the value of the most probable energy loss,

ξ_i =1/4.02 FWHM of distribution of the energy losses for H_0.

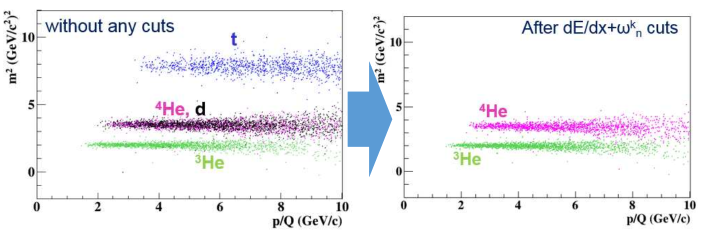


Signal loss: 1%

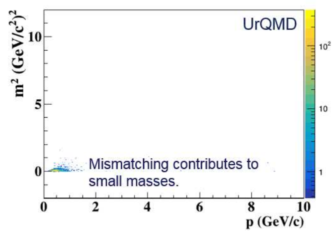


"Bg suppression" = 1.3

Particle identification in TOF



TOF+STS allow one to significantly suppress the background and clearly highlight ^{3}He and ^{4}He.



Conclusions

1. The ω^k_n criterion has been successfully adapted for the STS detector. It allows one to separate doubly charged particles from single ones.
2. The combination of the dE/dx cut and the ω^k_n criterion has shown a high level of the background suppression. ω^k_n gives the additional background suppression 1.3.
3. The combination of TOF+STS allows one to separate ^{3}He and ^{4}He from the deuteron background.

Plans

1. To analyze the additional background suppression for TOF identified tracks using dE/dx and ω^k_n in STS.
2. To apply the proposed procedure to the hypernuclei reconstruction.

References

[1] B. Friman, P. Senger et al. *Lecture Notes in Physics*, (2011) Vol. 814, 1st Edition 960 pp.

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[3] P.V. Zrelov and V.V. Ivanov, *Nucl. Instr. and Meth. in Phys. Res.*, A310 (1991) pp. 623-630.

*This work was supported by the Grant for young scientists JINR 19-602-02