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ПЛОВДИВСКИ УНИВЕРСИТЕТ •ПАИСИЙ ХИЛЕНДАРСКИ•

Evaluation study of reconstruction and production of Hypernuclei at NICA/MPD

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Outline

- Motivation
- Analysis details
- Event reconstruction and detector preformance
- Model predictions
- Study of hypernuclei production

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

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

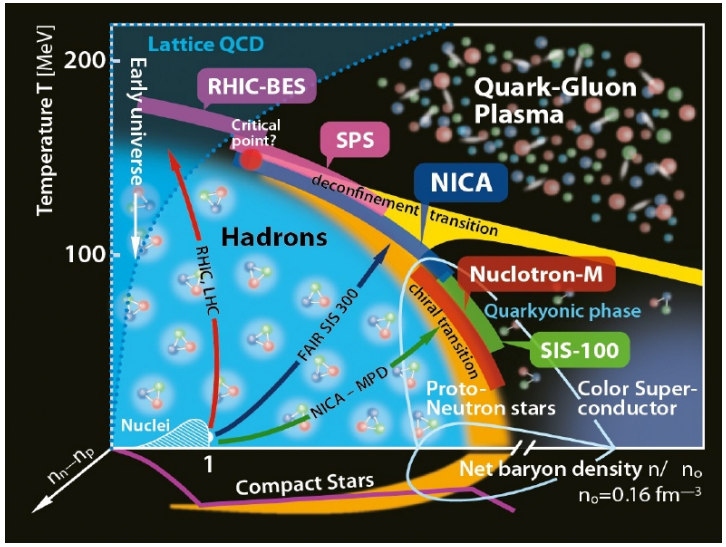
  $^{3}_{\Lambda}H \rightarrow p + d + \pi^{-}$

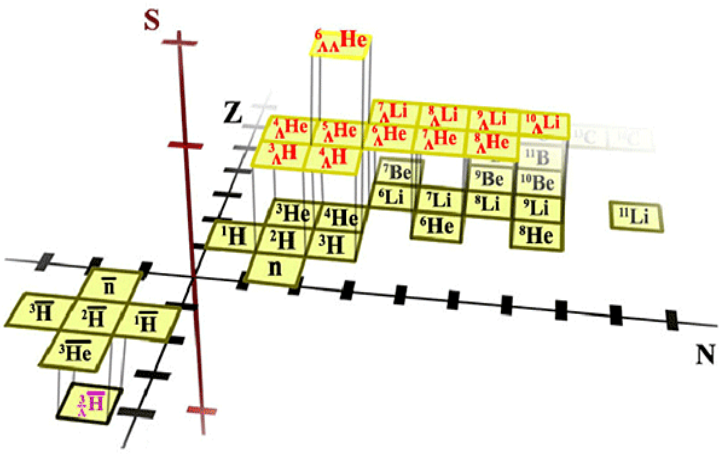
  $^{4}_{\Lambda}H \rightarrow {}^{4}He + \pi^{-}$

- Summary

Physics motivation

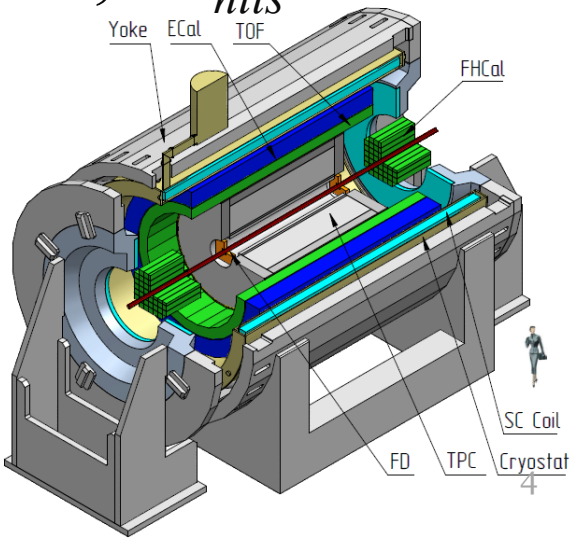
- Hyperon-nucleus and hyperon-hyperon interaction can be investigated through hypernuclei.
- Study of all populated regions in the three-dimensional chart of the nuclides.
- Understanding production mechanism of exotic objects such as multi-hypernuclei
- Provide info on EOS of neutron stars.



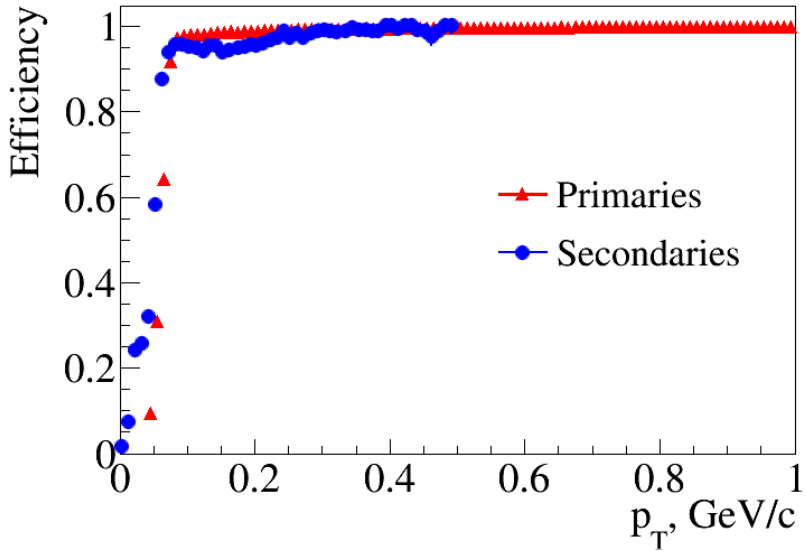


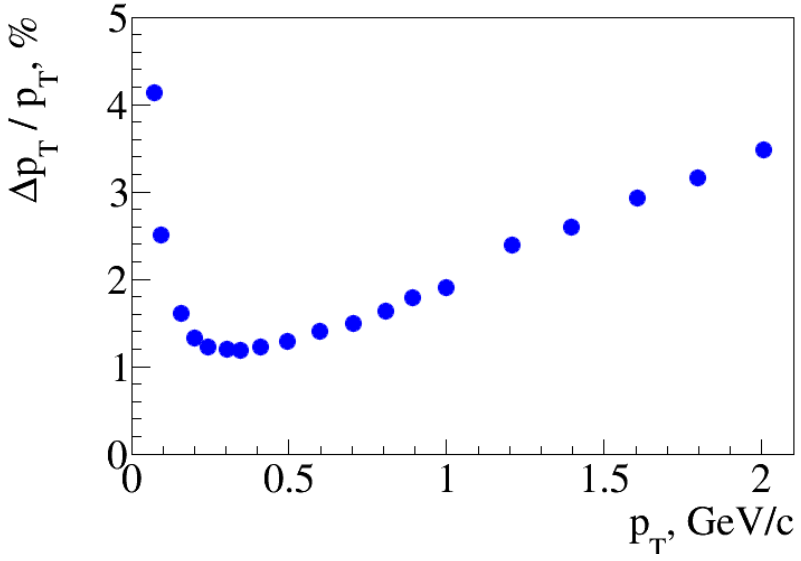
Event generators and data sets

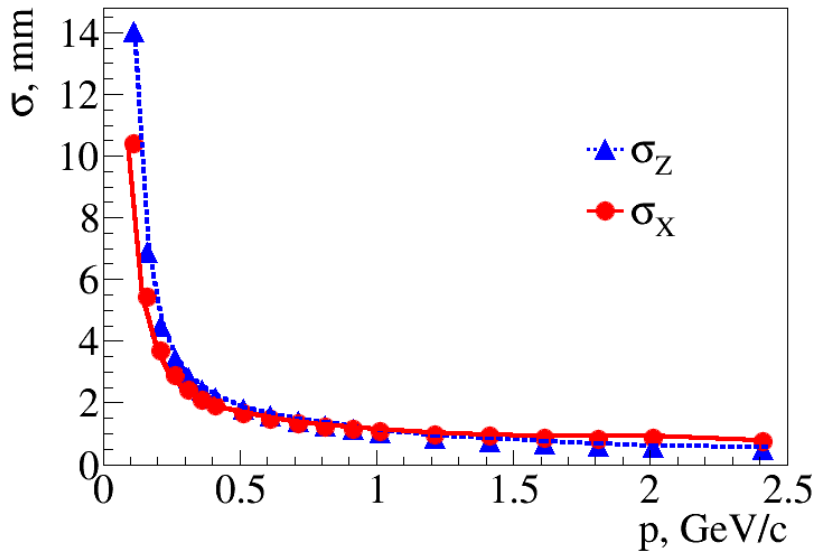
- **Generator:** DCM-QGSM, Au+Au @ 5A GeV central (0-3 fm), 6.1x10^7 evens
- **Detectors:** start version of MPD (TOF, TPC, ECAL, FHCal,FD)
- Track acceptance criterion: $|\eta| < 1.3$, $N_{hits} \geq 10$
- Particle identification
- Maximization of significance

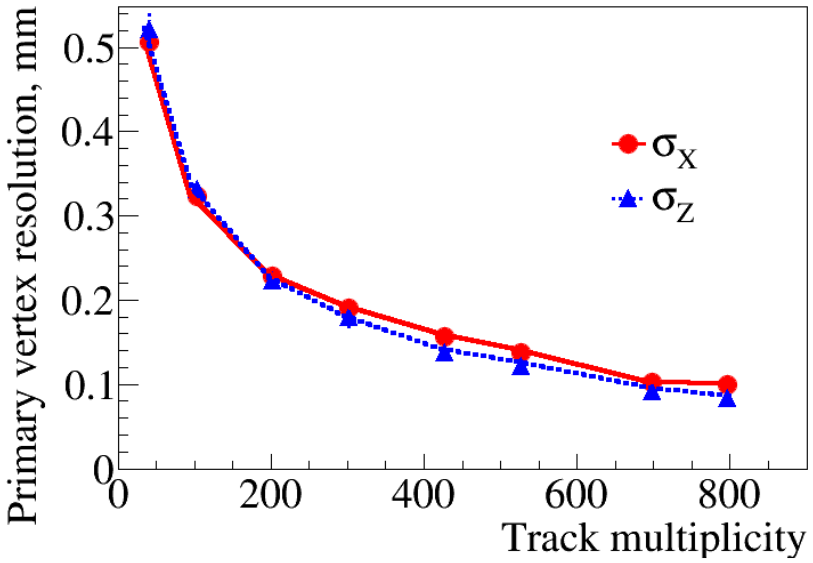


Track Reconstruction and Detector Performance







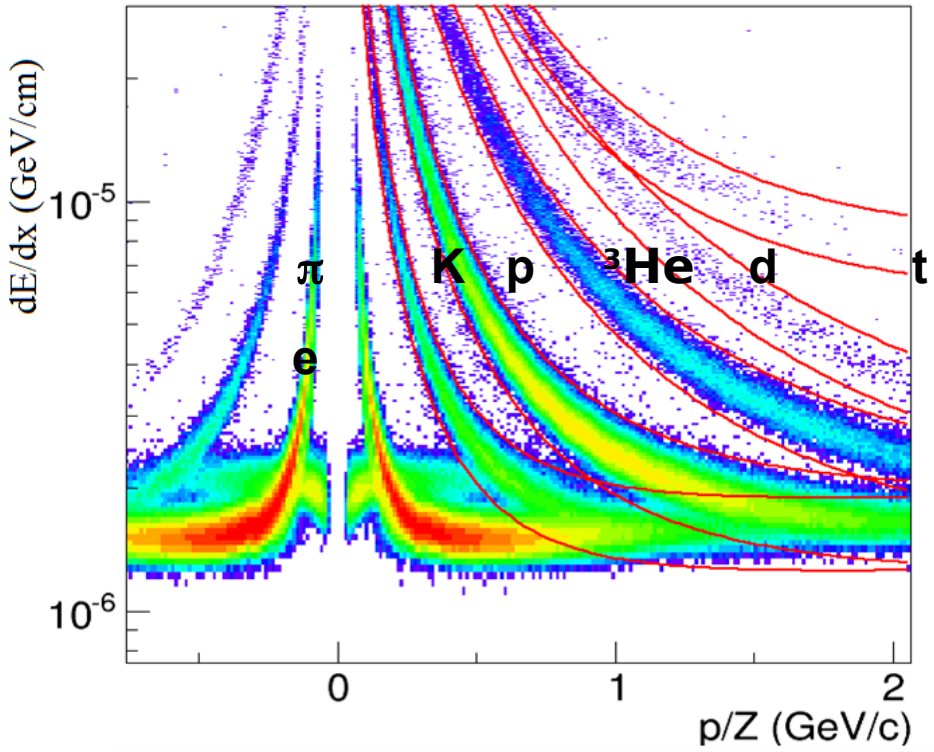


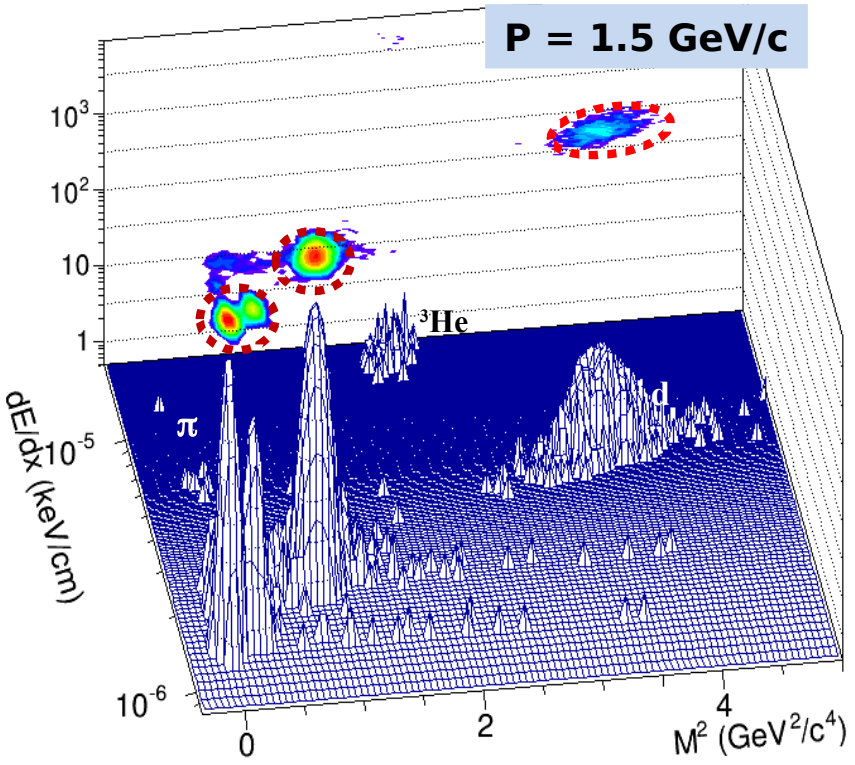
MPD Particle Identification (PID)

PID is achieved by dE/dx (TPC) and time-of-flight (TOF) measurements

Mass square calculated using the measurements of momentum (p), time-of-flight (T) and trajectory length (L)

$$m^2 = p^2\left(\frac{c^2T^2}{L^2} - 1\right)$$



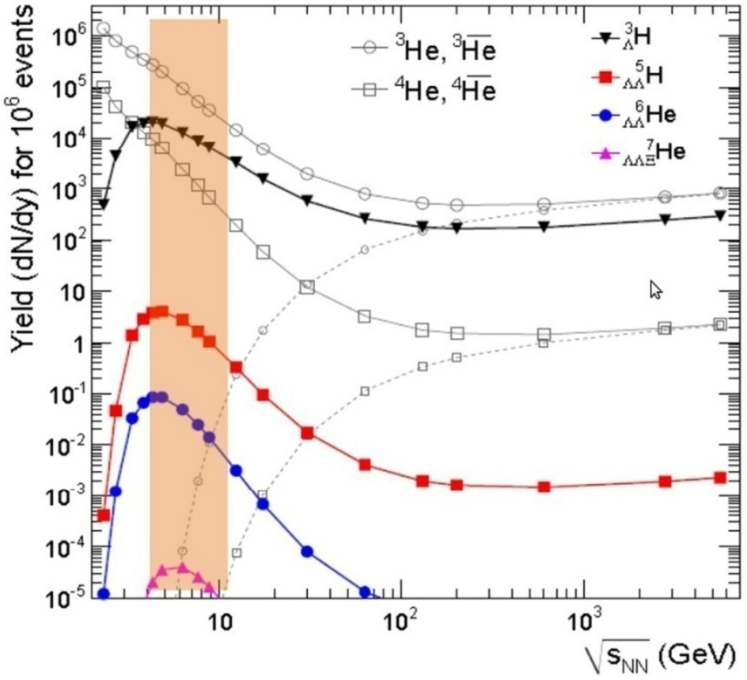


Particles are selected within 3σ cuts in 'dE/dx vs p' (1) or 'dE/dx vs m²' space in momentum bins (2)

Model predictions

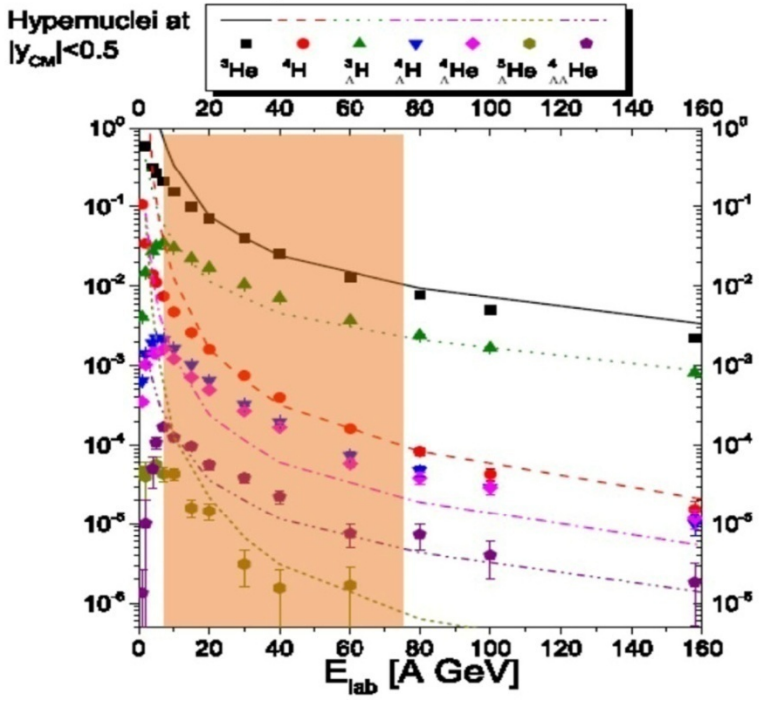
Statistical hadronization model

A.Andronic, P.Braun-Munzinger,
J.Stachel, H.Stocker



DCM-QGSM

J.Steinheimer, K.Gudima, A.Botvina,
I.Mishustin, M.Bleicher, H.Stocker

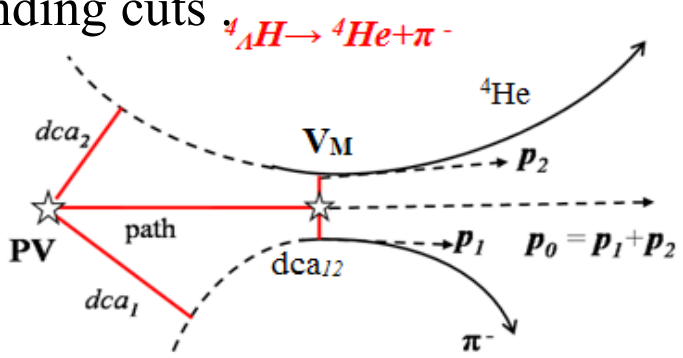


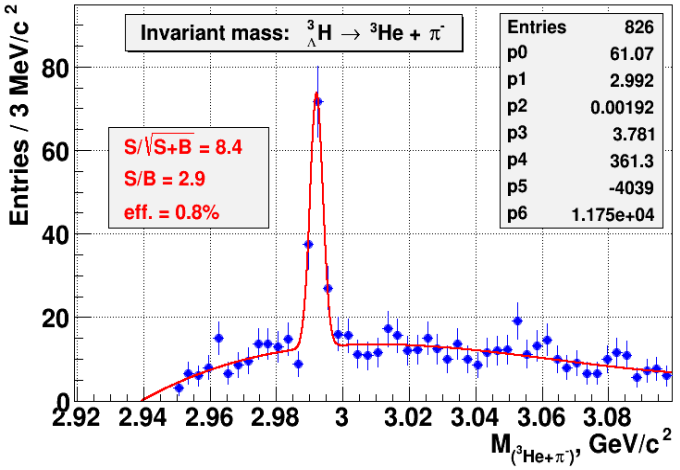
- **In heavy-ion reactions:** production of hypernuclei through coalescence of Λ with light fragments.
- **Maximal yield** predicted for √s=4-5A GeV (stat. model) (interplay of Λ and light nuclei excitation function).

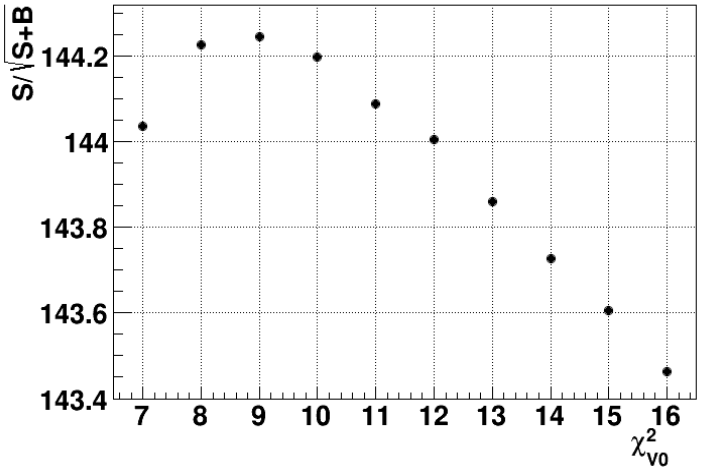
➔ **NICA energy range is ideally suited for the search of (double) hypernuclei**

Maximization of significance

1. Significance is defined as $S/\sqrt{(S+B)}$
2. Set of 6-8 cuts, for hypernuclei selection: χ^2_{π} (dca_{π}), χ^2_{p} (dca_2), χ^2_{3He} (dca_1), dca_M, dca_{VM}, path, angle between ***p*** and ***r*** of *Y*.
3. Variation of all cuts with small steps and production of invariant mass distributions for each set of cuts.
4. Fitting to the sum of Gaussian and polynomial functions and computing the significance.
5. Selection of maximum significance with corresponding cuts .



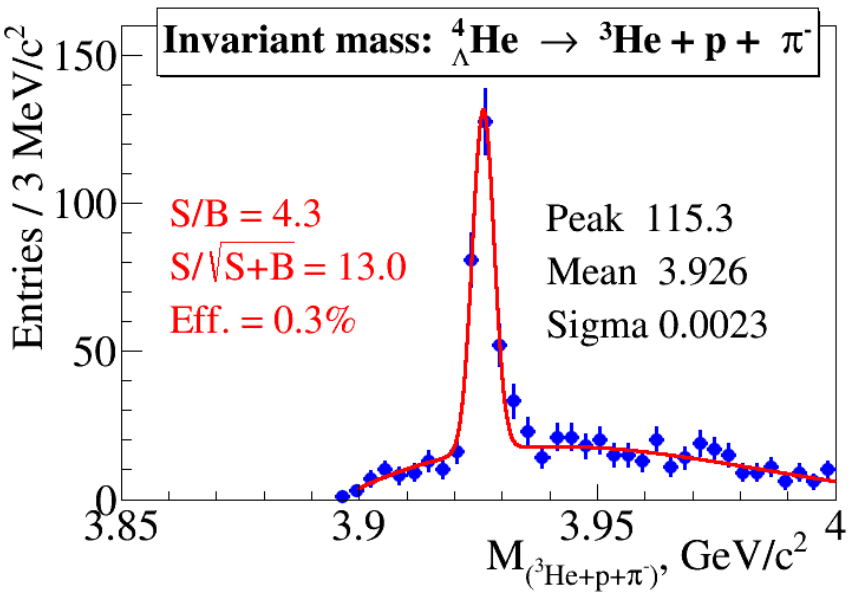


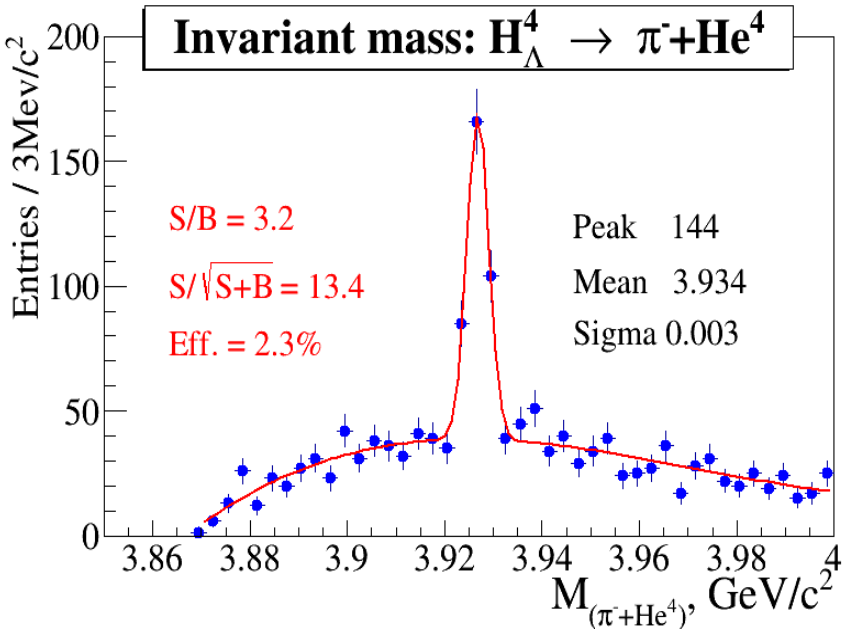


Invariant mass at max. significance:

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

DCM-QGSM, Au+Au @ 5A GeV, central (0-3 fm), 6.1×10^7 events
~61 hours @6 kHz.





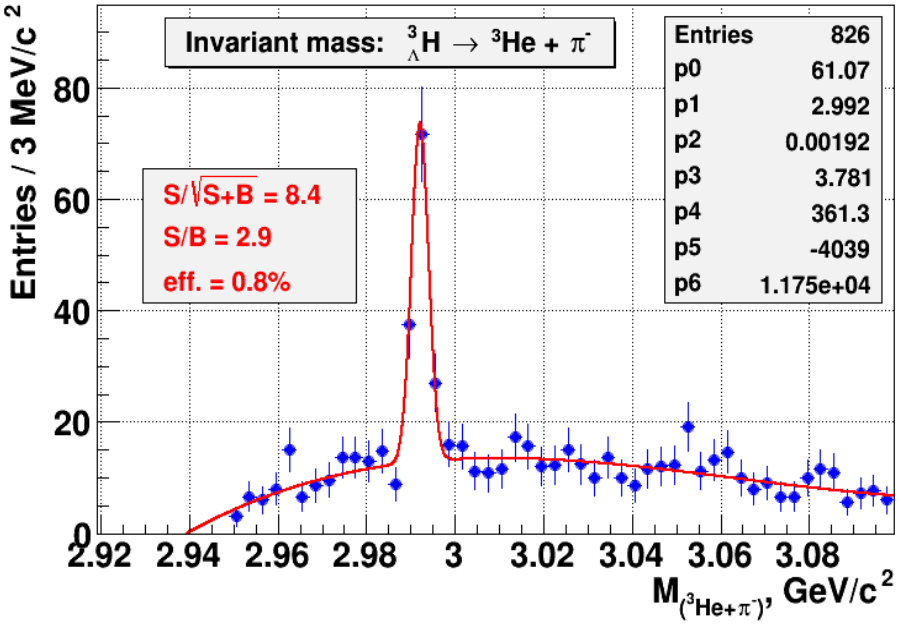
Expected yield of $^4_\Lambda He$: for MPD (10 weeks) @ 5A GeV: $1.4*10^5$

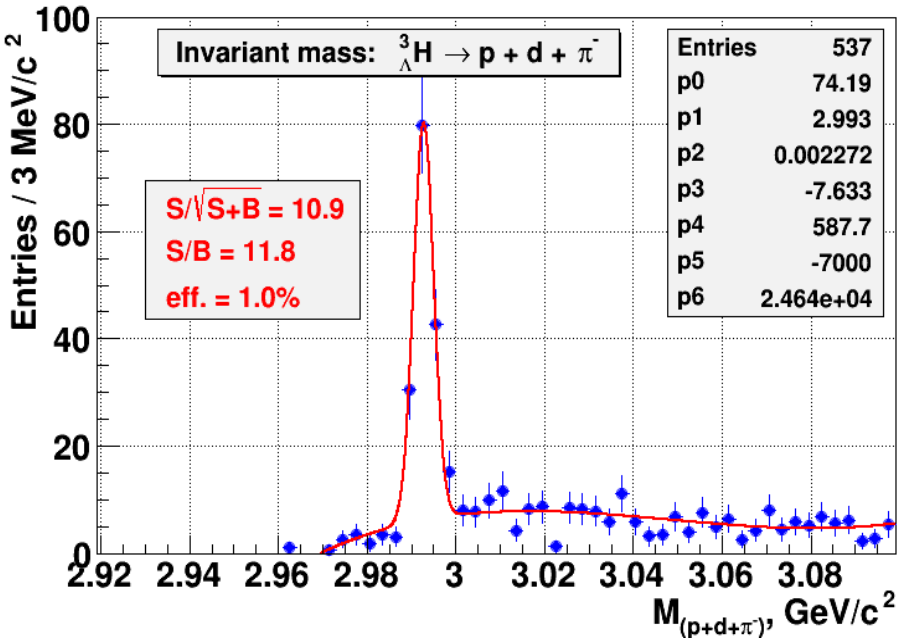
Expected yield of $^4_\Lambda H$: for MPD (10 weeks) @ 5A GeV: $1.9*10^5$

Invariant mass at max. significance:

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

DCM-QGSM, Au+Au @ 5A GeV, central (0-3 fm), 5x10^5 events - 30 minutes @6 kHz. PID in TPC & TOF





Expected yield of $^{3}_{\Lambda}H$: for NICA (10 weeks) @ 5A GeV: **8.1*10^5**

Efficiency vs detector acceptance cut

Factor	**Eff,%** $^{3}_{\Lambda}H$ **2-prong**	**Eff,%** $^{3}_{\Lambda}H$ **3-prong**	**Eff,%** $^{4}_{\Lambda}H$	**Eff, %** $^{4}_{\Lambda}He$
Branching ratio	24.6	36.4	75.0	32.0
$\|\eta\| < 1.3$	14.9	19.8	48.9	28.1
$\|\eta\| < 1.3,\ p_T > 0.05$ GeV/c	14.2	15.7	48.3	25.3
$\|\eta\| < 1.3,\ p_T > 0.1$ GeV/c	8.9	6.2	35	16.4
$\|\eta\| < 1.3,\ p_T > 0.2$ GeV/c	0.7	0.1	4.0	0.18
Reconstructed $\|\eta\| < 1.3$	7.9	8.3	27.7	9.4
Maximum significance	0.8	1.0	2.3	0.3

Summary

- MPD start version will provide a good opportunity for a study of the hypernuclei production at NICA.
- Procedures for reconstruction of different species hypernuclei have been developed.
- Mass resolution of 3 MeV/c^2 has been achieved.

Thank you for your attention!