Prospects of studying the production of hypernuclei in heavy-ion interactions at the NICA collider at JINR

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Introduction

A new accelerator complex **NICA (Nuclotron-based Ion Collider facility)** for the study of the collisions of heavy ions and polarized particles is under construction at **JINR (Dubna, Russia)**. The main goal of the NICA physics program is the experimental investigation of the strongly interacting matter phase diagram in the poorly explored region of the maximal baryon density. One of the main goals of the NICA project is to study the nucleon-hyperon and hyperon-hyperon interactions by **the measurement of the production of hypernuclei.**

In order to better understand the dynamics of hot and dense hadronic matter, in particular, the strangeness production mechanism, the **Multipurpose Detector (MPD)** experiment at the NICA collider will provide new precise experimental data on the total yields, rapidity, transverse momentum and azimuthal angle distributions of strange particles, including (anti)-hyperons and hypernuclei.

More information on the physics program and technical details of the NICA and MPD projects you can find here:

https://nica.jinr.ru/ **http://mpd.jinr.ru/**

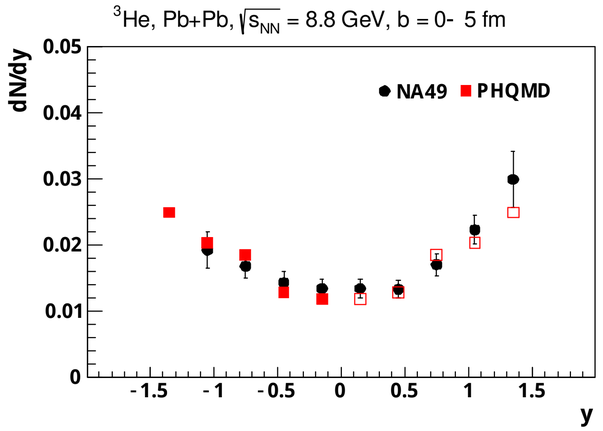
PHQMD

The **Parton-Hadron-Quantum-Molecular-Dynamics (PHQMD)** extends the established **PHSD [1]** transport approach by replacing the mean-field propagation by density dependent two body interactions in a similar way as in the **Quantum Molecular Dynamics [2]** models – this allows for a dynamical description of cluster and hypernuclei formation. The clusters are identified with the **Minimum Spanning Tree** or the **Simulated Annealing Clusterization Algorithm [3]** which generates the most bound configuration of nucleons and clusters.

The PHQMD approach can be used in different modes for the hadron propagation: the mean-field based PHSD mode and the QMD mode with different equations-of-state (EoS).

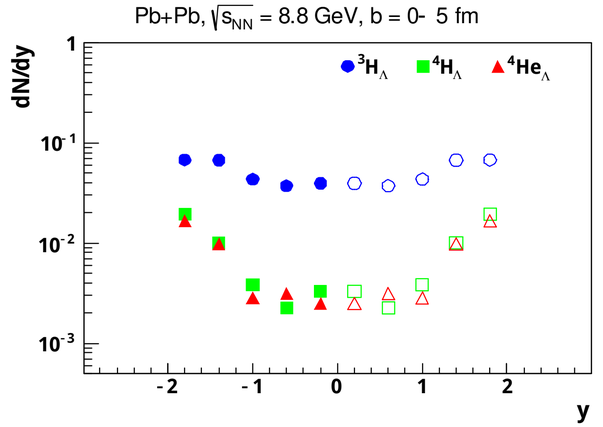
This allows to study the sensitivity of observables on the different descriptions of the potential interactions among nucleons.

1. E.L. Bratkovskaya, W. Cassing, Nucl.Phys. A856 (2011) 162-182.
2. J. Aichelin, Phys Rep. 202 (1991) 233
3. R. K. Puri, J. Aichelin, J.Comput.Phys. 162 (2000) 245-266
4. T. Anticic et al. (NA49), Phys. Rev. C94, 044906 (2016),

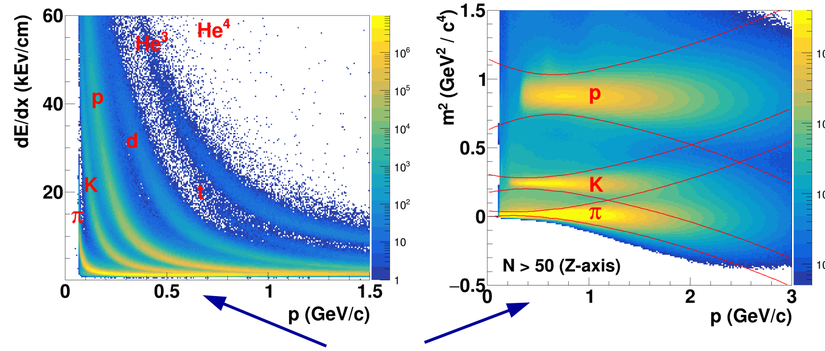


The rapidity distribution of ^{3}He from Pb+Pb central collisions at $\sqrt{s_{NN}}$=8.8 GeV. The dots indicate the experimental data from the NA49 Collaboration [4], the red squares show the PHQMD results taken at the physical time t=$t_0$cosh(y) for t_0 = 67 fm/c.

PHQMD shows a good agreement with the experimental data over the whole rapidity range.

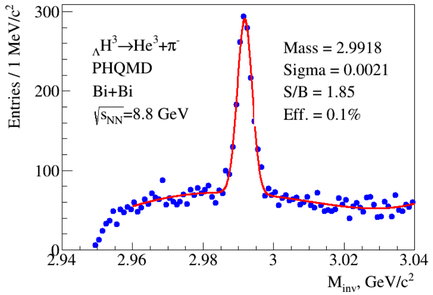


The rapidity distribution of $^3H_\Lambda$, $^4H_\Lambda$ and $^4He_\Lambda$ from central Pb+Pb collisions at $\sqrt{s_{NN}}$=8.8 GeV calculated at the physical time t=$t_0$cosh(y) for t_0= 53 fm/c.

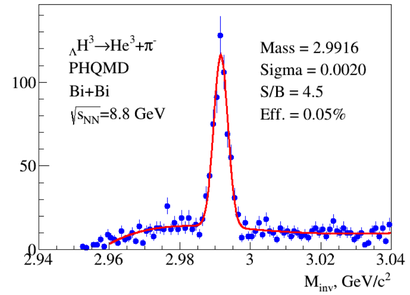


Combined PID (dE/dx+TOF) and topological cut

Reconstructed invariant mass spectra of $_\Lambda$H^3: 2-prong decay mode.



Soft cuts, large contamination of misidentified daughters mainly from spallation reactions in the material



Strong cuts, better PID and lower contamination of wrongly identified specie, but lower efficiency

Summary

- **Future NICA experiments are designed for the study of HIC at the strangeness threshold energies and maximal net baryon densities.**
- **MPD offers good opportunities for studies of heavy strange probes at the NICA facility.**
- **The PHQMD is a microscopic n-body transport approach for the description of heavy-ion dynamics and cluster formation which may provide the theory for the hypernuclei formation in the hot and dense matter of NICA experiments (good agreement with the existing data!).**

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