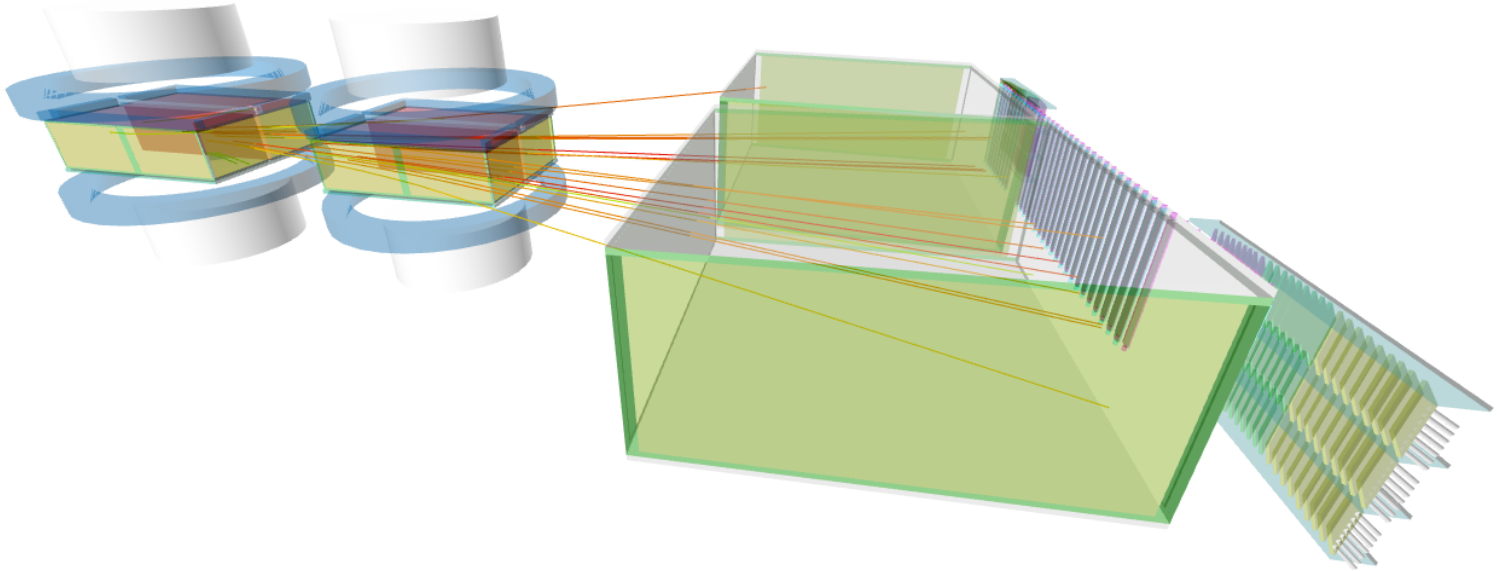


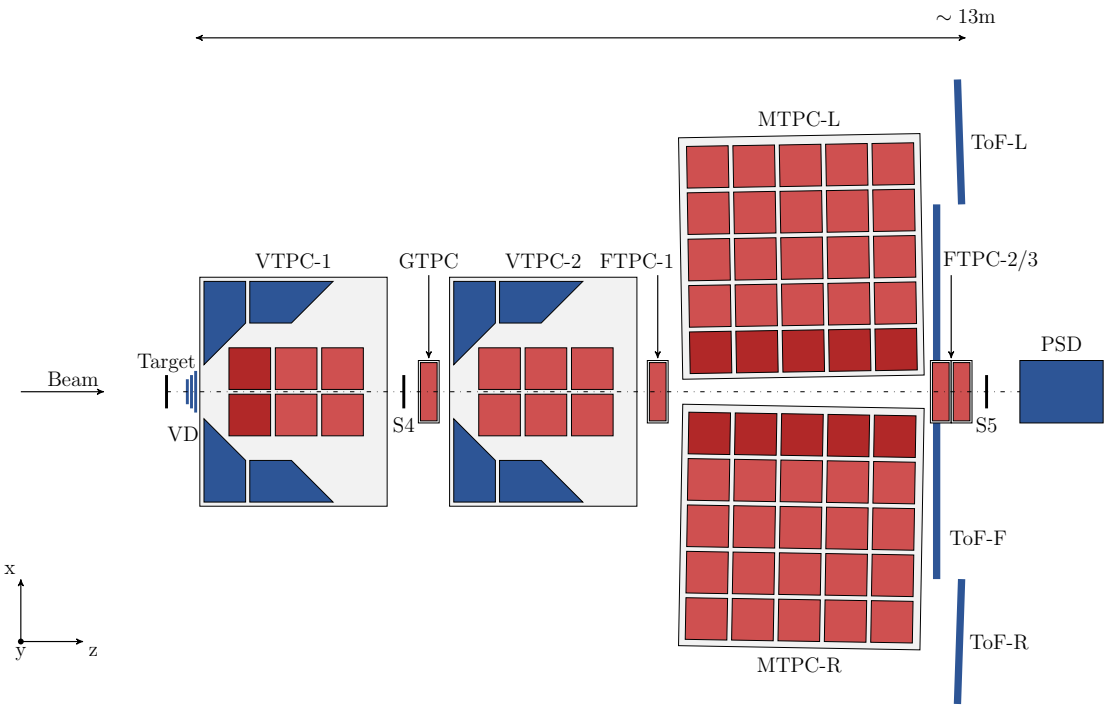
d, $\bar{p}$ and $\bar{d}$ production cross-section studies for nucleus-nucleus collisions at the NA61/SHINE experiment.

Michał Naskręt

WFiA UWr, UH Manoa,
NA61/SHINE collaboration

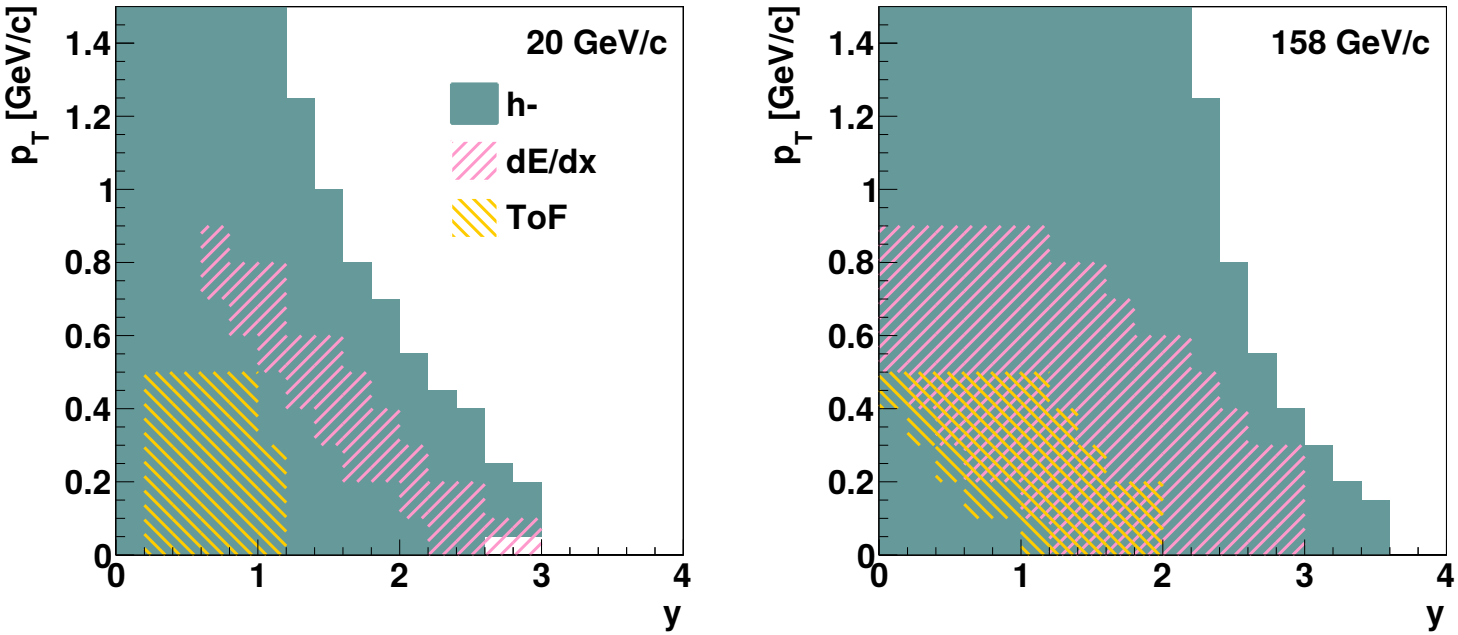
March 28, 2019

The NA61/SHINE detector



- **Fixed target** experiment,
- Located **at the SPS** accelerator,
- **Large acceptance** spectrometer – coverage of the full forward hemisphere, down to $p_T = 0$.

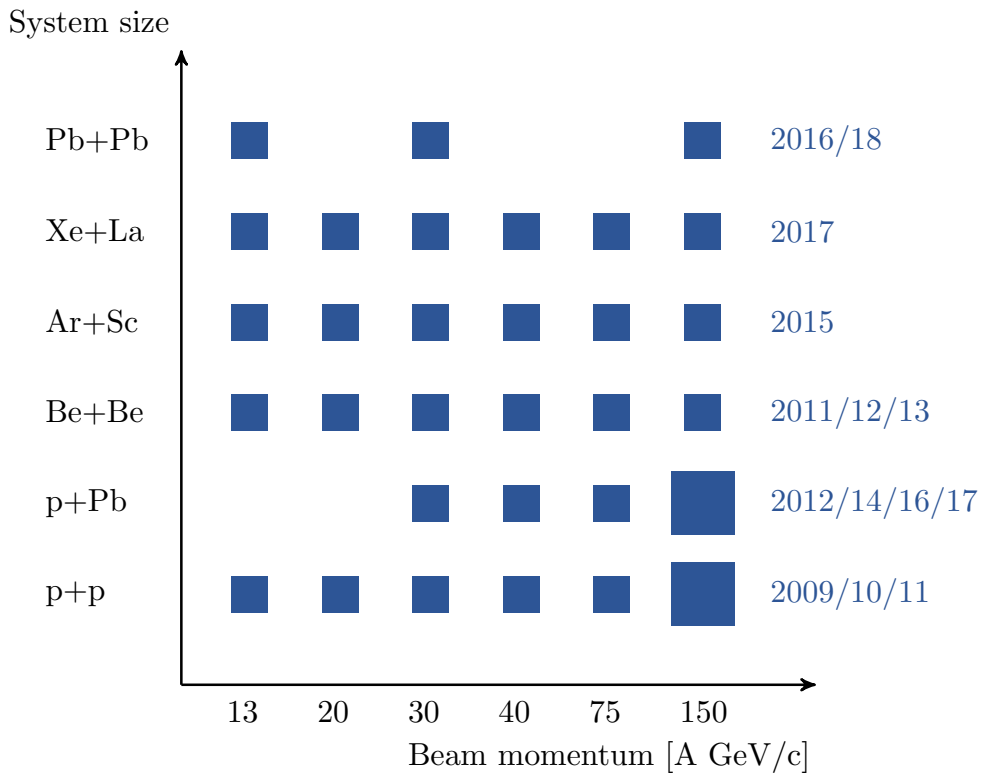
PID methods in NA61/SHINE



- dE/dx method estimates multiplicities of hadrons using **energy loss measurements** in TPCs,
- tof-dE/dx method estimates multiplicities of hadrons using **energy loss and particle time of flight measurements** in ToFs,
- h^- method estimates multiplicities of π^- based on the fact that **the majority of negatively charged hadrons produced in p+p and A+A collisions are π^-.**

Physics program at NA61/SHINE

The NA61/SHINE performs a 2D **scan over system size and collision energy** to study the phase diagram of strongly interacting matter in **temperature and baryon density**.



- Data taken,
- Large statistics data taken.

Only strong interaction program datasets marked.

Study of hadrons and light nuclei

This versatile data which was taken by the NA61/SHINE experiment allows for a **study of low momentum hadrons and light (anti)nuclei production** in a variety of collisions at different energies.

The goal of my analysis is to use different collision systems measurements and a simplified dE/dx PID to study:

- Production cross-sections of different hadrons and light (anti)nuclei,
- Coalescence parameters for deuterons and antideuterons,
- Thermal model predictions,
- Uncertainties in indirect dark matter searches.

Coalescence and thermal models

Production of light nuclei.

Coalescence model

- Nucleons emitted from a fireball with small relative momenta **form a nucleus due to attractive nuclear forces**.

$$E_A \frac{\mathrm{d}^3 N_A}{\mathrm{d}^3 P_A} = B_A \left(E_\mathrm{p} \frac{\mathrm{d}^3 N_\mathrm{p}}{\mathrm{d}^3 p} \right)^Z \left(E_\mathrm{n} \frac{\mathrm{d}^3 N_\mathrm{n}}{\mathrm{d}^3 p} \right)^{A-Z}$$

where N_A invariant yield of clusters with charge Z and mass number A, N_p and N_n proton and neutron yields, $p = P_A/A$ and B_A is the coalescence parameter.

Coalescence and thermal models

Production of light nuclei.

Thermal model

- The ratios of particles' yields depend on the **fireball's temperature and baryon chemical potential at the chemical freeze-out**,
- The model **does not describe production mechanism**.

$$N_C = \frac{gV}{\pi^2} m^2 T K_2(m/T) exp\left(\frac{B\mu_B + q\mu_q}{T}\right)$$

where N_C is cluster abundance, g degeneracy factor, q charge, B baryon number, V source volume, K_2 Bessel function of the second kind, μ_B and μ_q baryochemical and charge potential.

Previous analyses - NA49

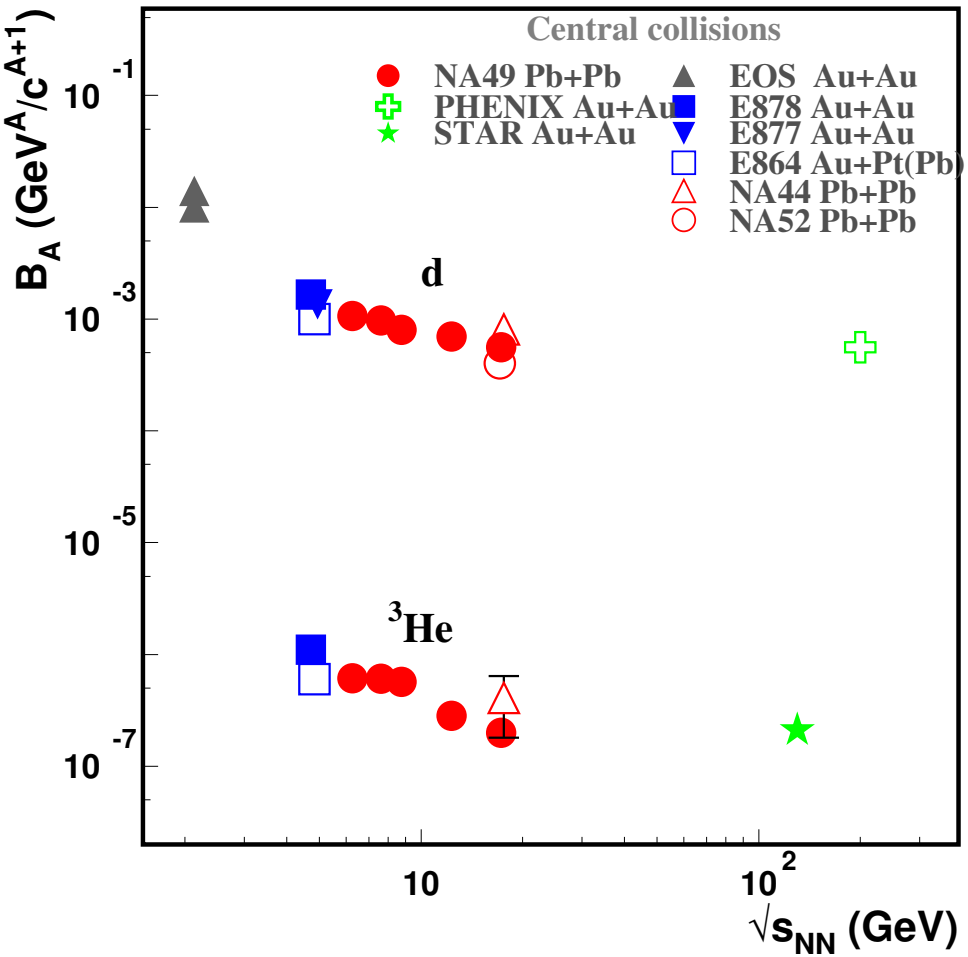
Phys. Rev. C, 94:044906, Oct 2016

The NA49 (NA61/SHINE predecessor) experiment published a similar analysis on Pb+Pb collisions at 20*A*-158*A* GeV/c.

The contents of the paper:

- PID and yields of d, t and ^{3}He,
- Study of isospin asymmetry with $t/^3$He ratio,
- Agreement with thermal model of clusters formation,
- **Derivation of coalescence parameter** B_A energy dependence.

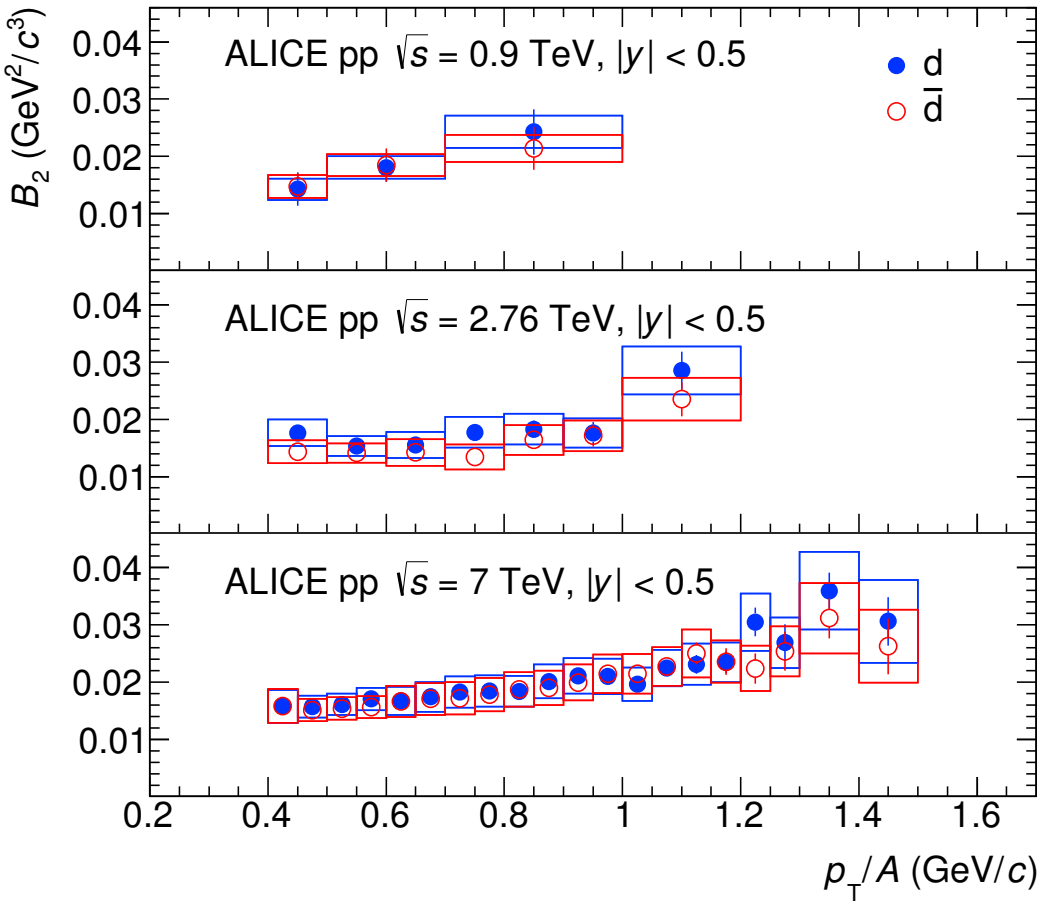
Previous analyses



Coalescence parameter B_A from central A+A collisions as a function of collision energy - shows **energy dependence**.

Other experiments - ALICE

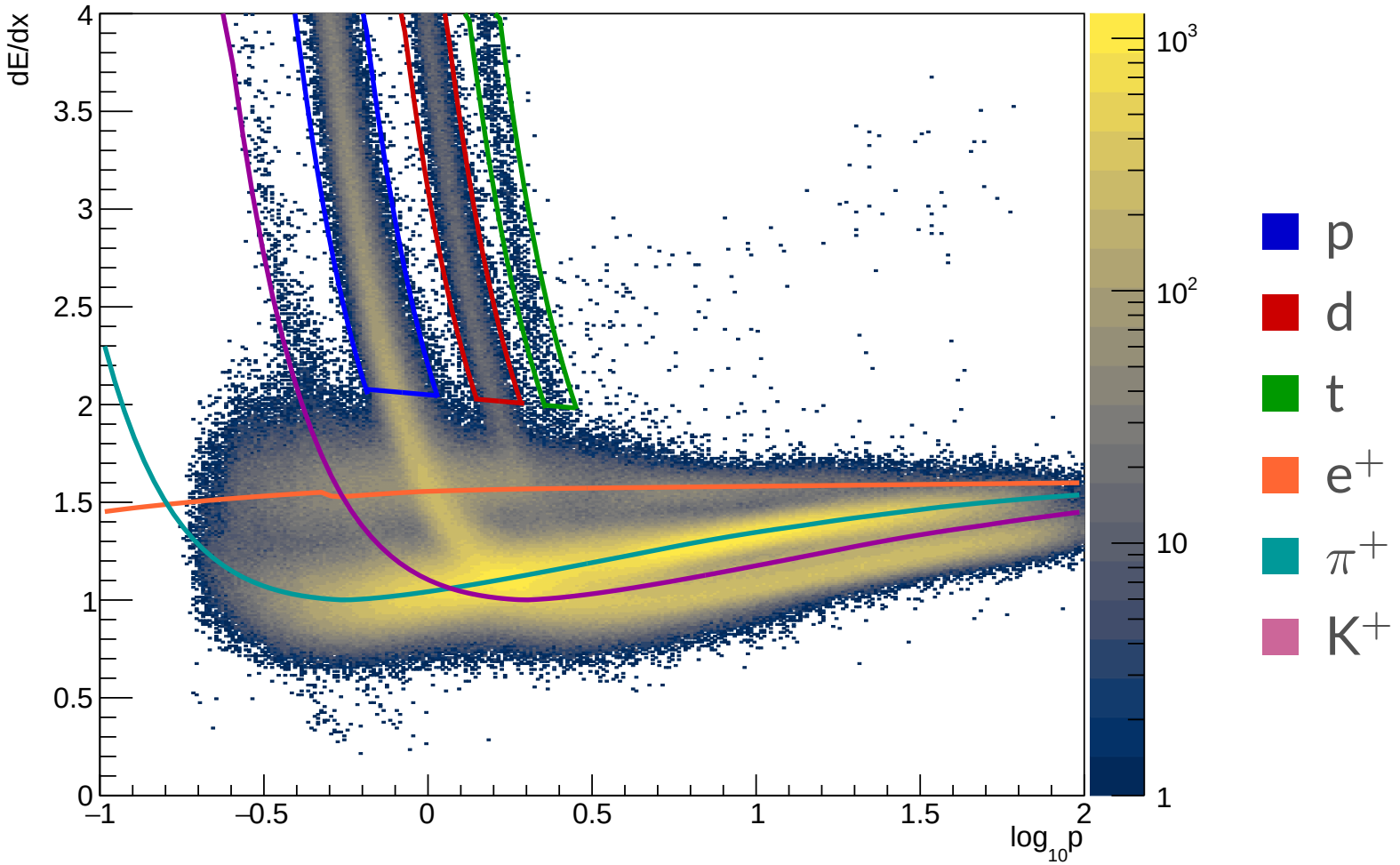
Phys. Rev. C, 97:024615, Feb 2018



Coalescence parameter (B_2) of deuterons and antideuterons as a function of p_T per nucleon in inelastic pp collisions at $\sqrt{s}$ = 0.9, 2.76, and 7 TeV.

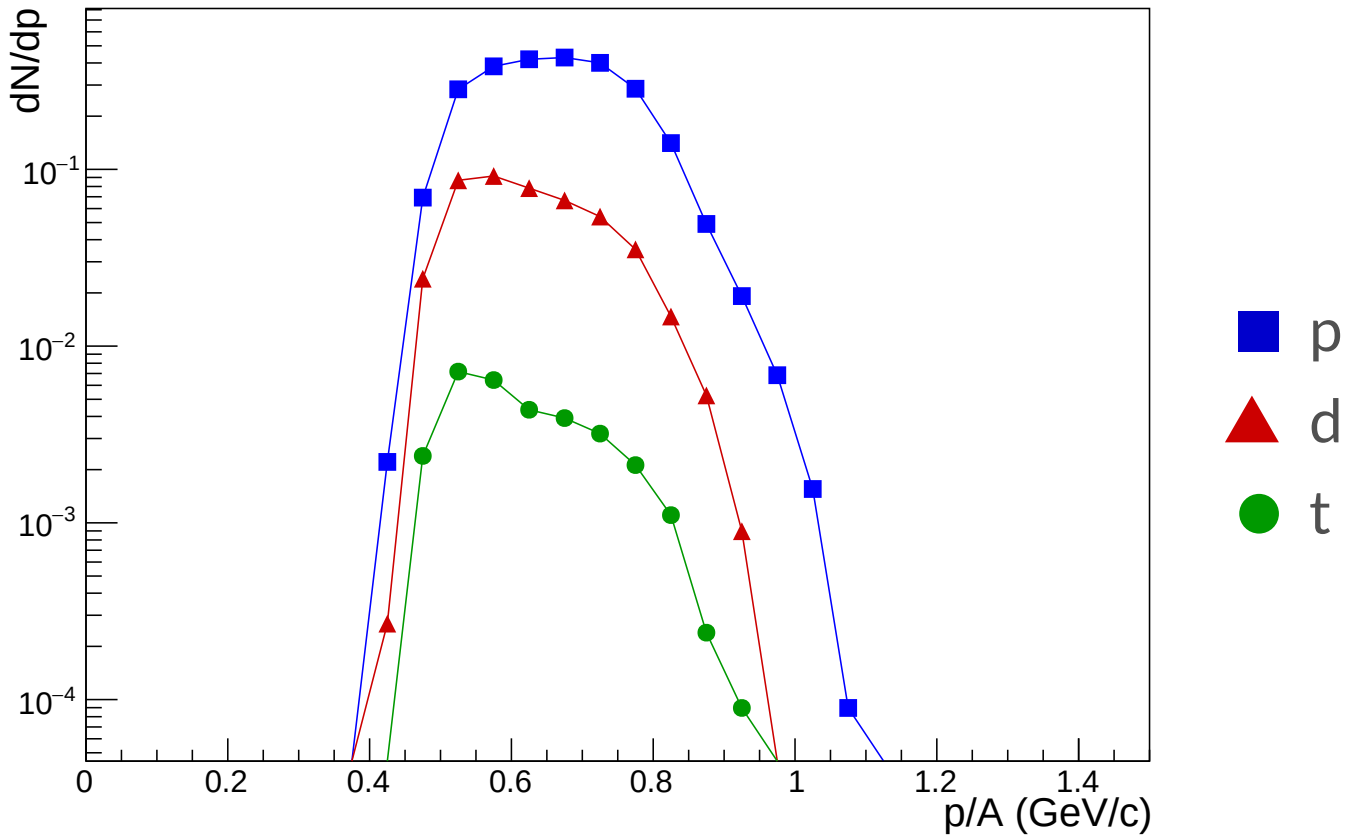
Simplified dE/dx method

p+Pb @158 GeV/c



Clear deuteron and triton signals.

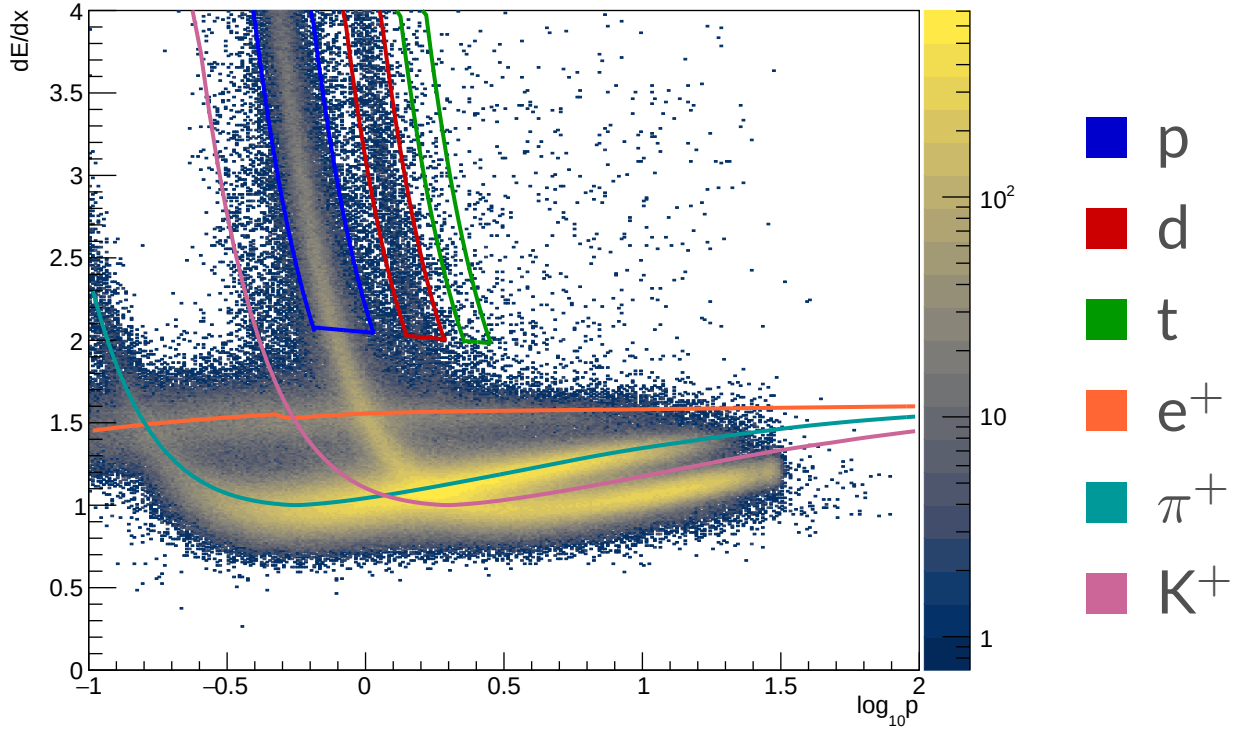
Future steps



- Employ a coalescence afterburner for EPOS MC event generator,
- Introduce a MC correction for experiment acceptance and reconstruction efficiency,
- Calculate production cross-sections,
- Confront results with coalescence and thermal models.

Other systems

p+C @31 GeV/c



A preliminary analysis has been conducted on measurements of other systems:

- p+C@31 GeV/c - 5.4 M events,
- π+C@350 GeV/c - 5 M events,
- Be+Be@158*A* GeV/c - 2.7 M events,
- Ar+Sc@150*A* GeV/c - 2 M events.

Summary

- The NA61/SHINE experiment is a valuable and abundant source of data on low momentum hadrons and light (anti)nuclei production,
- MC corrections are a priority focus,
- Studies of other systems are ongoing.

Thank you for your attention.