Study of Clusters and Hypernuclei production with NICA/MPD and BM@N experiments

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OUTLINE

- Motivation
- Light nuclei and hypernuclei productions within PHSD+SACA models
- NICA
- MPD hypertriton feasibility study
- Summary

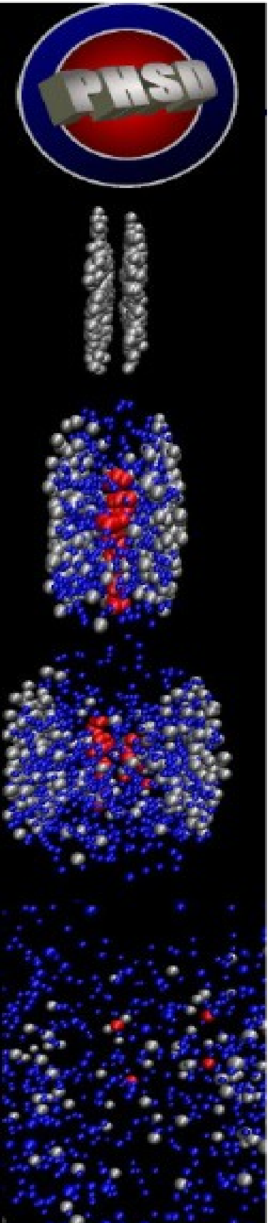
MOTIVATION

- It is important to have the robust modeling of hypernuclei and cluster formation in order to study the detector replica and to have the possibility to optimize the experimental setup for the best efficiency.

- Modeling of the clusters formation is a complicated problem, there are very few transport models that can provide it.

PHSD - basic concepts

E.L. Bratkovskaya, W. Cassing, Nucl.Phys. A856 (2011) 162-182.



Initial A+A collisions – HSD: string formation and decay to pre-hadrons

Fragmentation of pre-hadrons into quarks: using the quark spectral functions from the **Dynamical QuasiParticle Model** (DQPM) approximation to QCD

DQPM: Peshier, Cassing, PRL 94 (2005) 172301;
Cassing, NPA 791 (2007) 365: NPA 793 (2007)

Partonic phase: quarks and gluons (= ‚dynamical quasiparticles') with off-shell spectral functions (width, mass) defined by DQPM

elastic and inelastic parton-parton interactions: using the effective cross sections from the DQPM

- ✓ q + qbar (flavor neutral) <=> gluon (colored)
- ✓ gluon + gluon <=> gluon (possible due to large spectral width)
- ✓ q + qbar (color neutral) <=> hadron resonances

Hadronization: based on DQPM - massive, off-shell quarks and gluons with broad spectral functions hadronize to off-shell mesons and baryons:
gluons → q + qbar; q + qbar → meson (or string);
q + q +q → baryon (or string) (strings act as ‚doorway states' for hadrons)

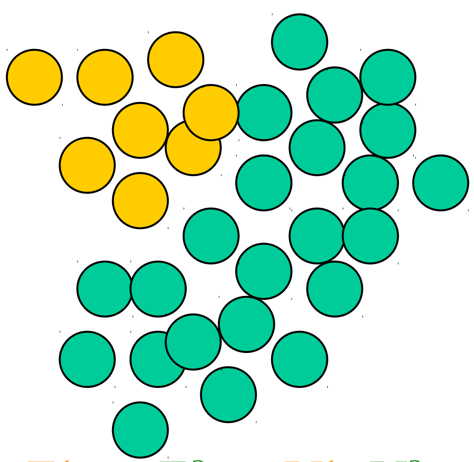
Hadronic phase: hadron-string interactions – off-shell HSD

Simulated Annealing Clusterisation Algorithm

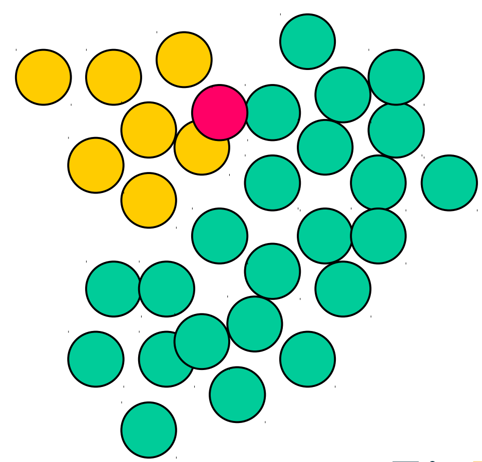
R. K. Puri, J. Aichelin, J.Comput.Phys. 162 (2000) 245-266

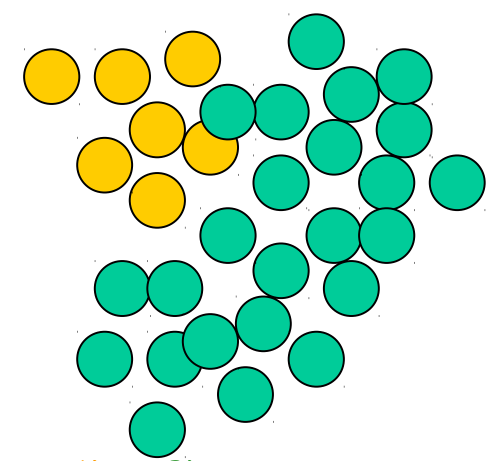
1) Pre-select good «candidates» for fragments according to proximity criteria: real space coalescence = Minimum Spanning Tree (MST) procedure.

2) Take randomly 1 nucleon out of one fragment



3) Add it randomly to another fragment





$E=E^1_{kin}+E^2_{kin}+V^1+V^2$

$E'=E^{1'}_{kin}+E^{2'}_{kin}+V^{1'}+V^{2'}$

If $E' < E$ take the new configuration

If $E' > E$ take the old with a probability depending on E'-E

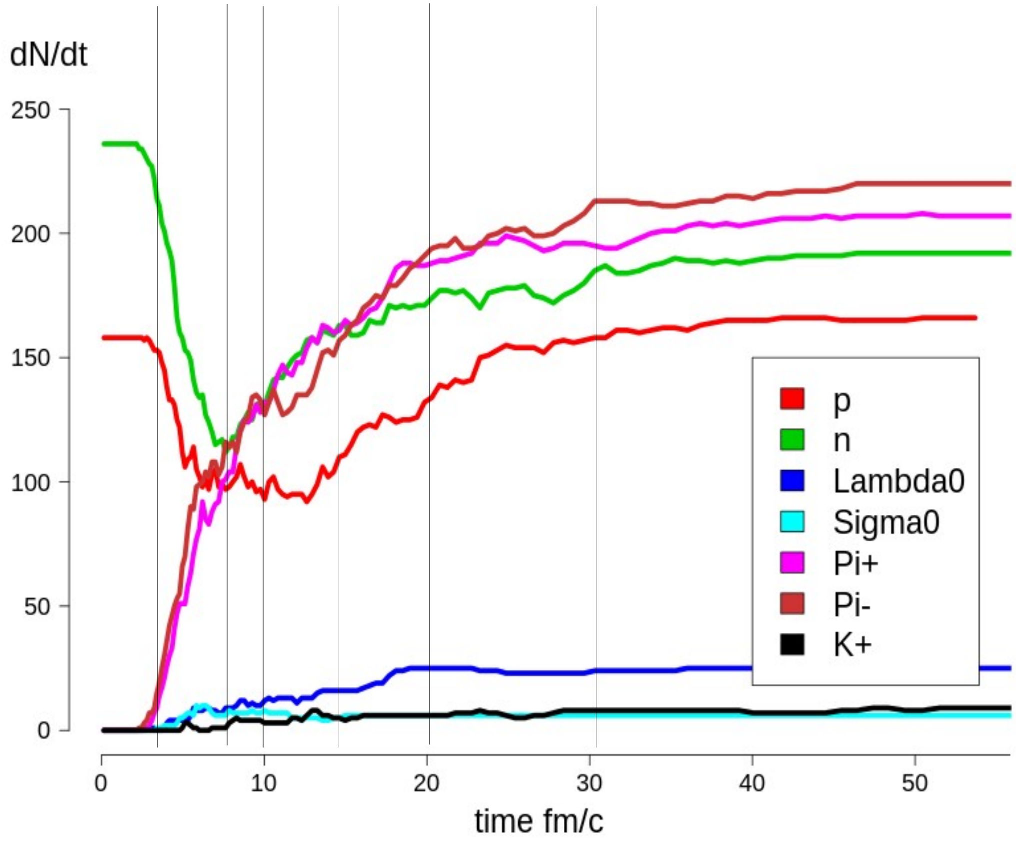
Repeat this procedure very many times...

It leads automatically to the most bound configuration.

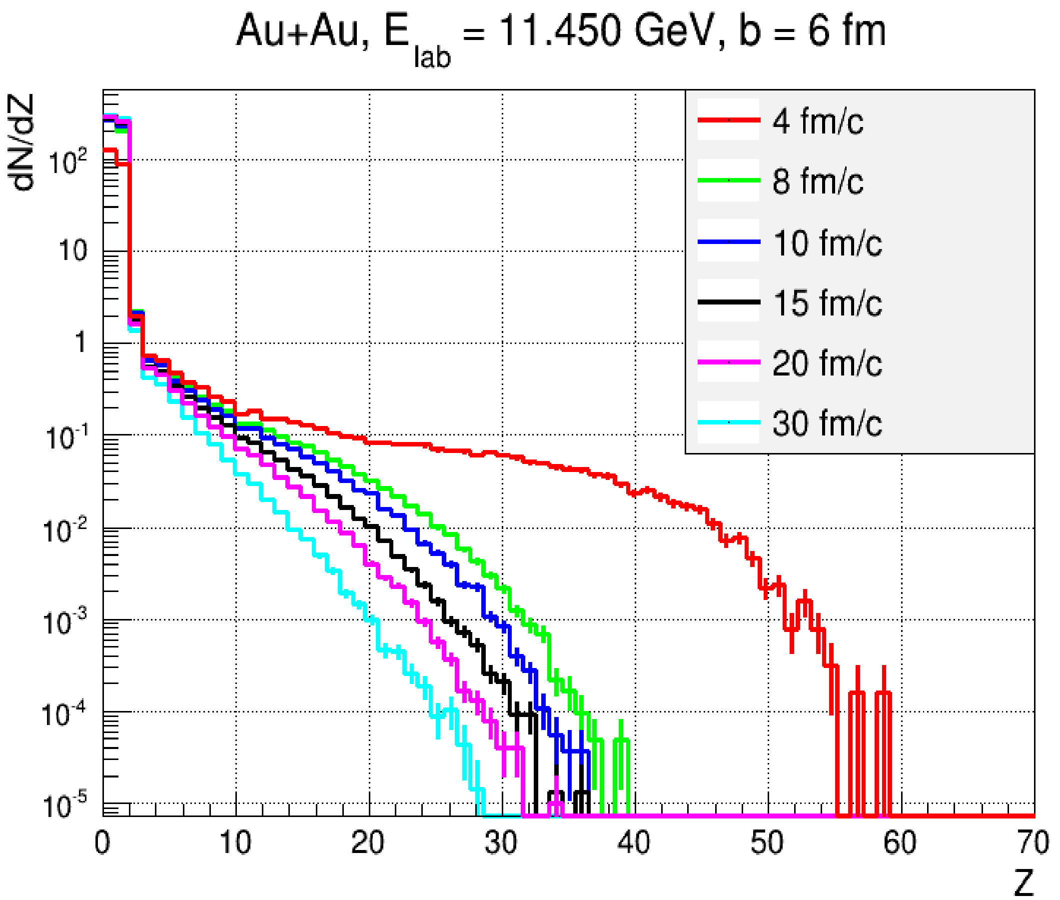
Searching clusters with PHSD+SACA model

(GSI & NANTES & JINR & FIAS collaboration)

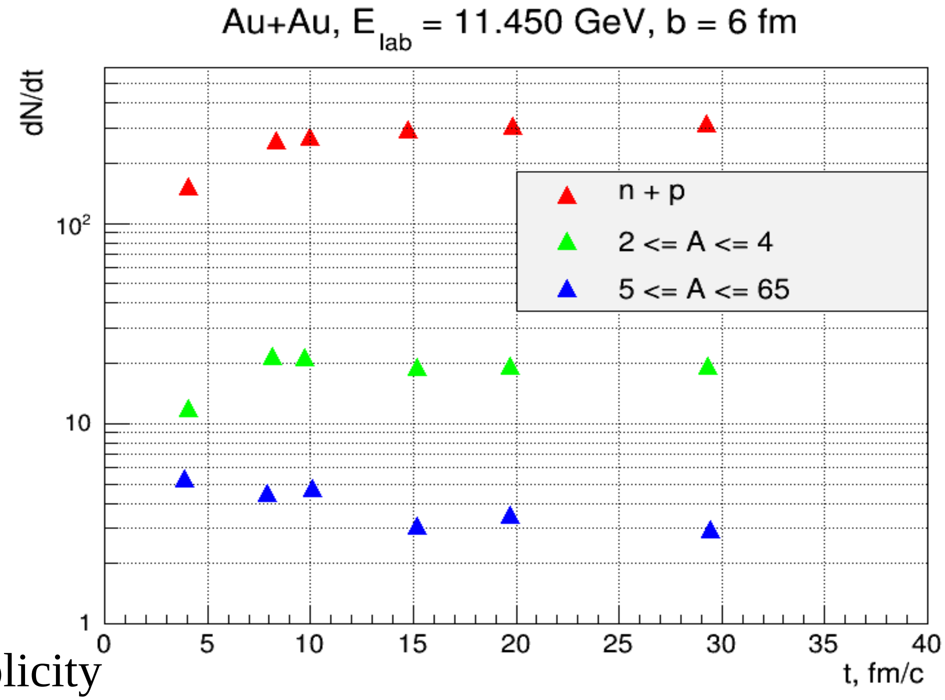
It is very important to choose a good starting time for clusterisation algorithm



Particles multiplicity per step of PHSD evolution time

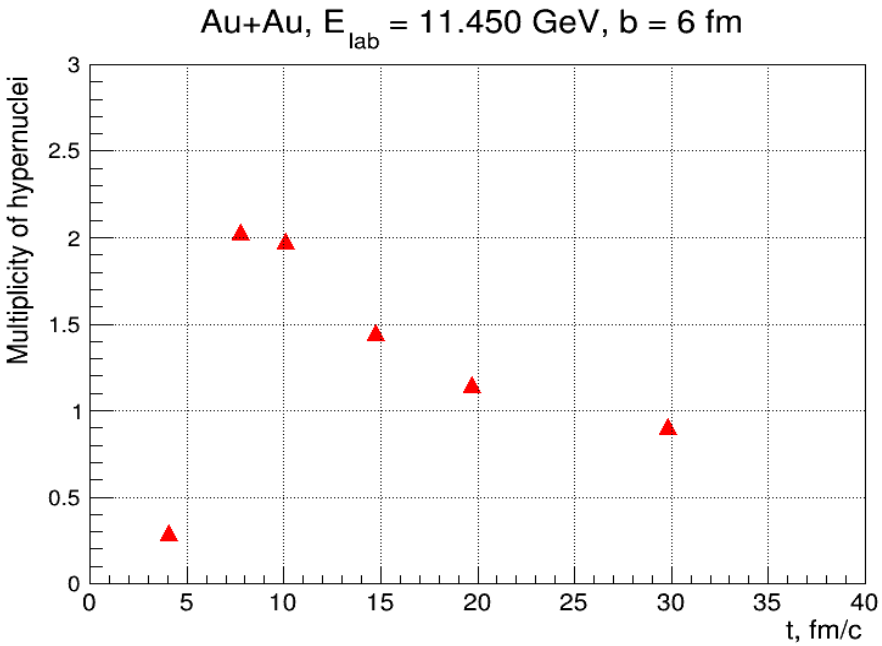


Charge distribution for different SACA starting times. (Red line here — passing time without interaction, for reference only)

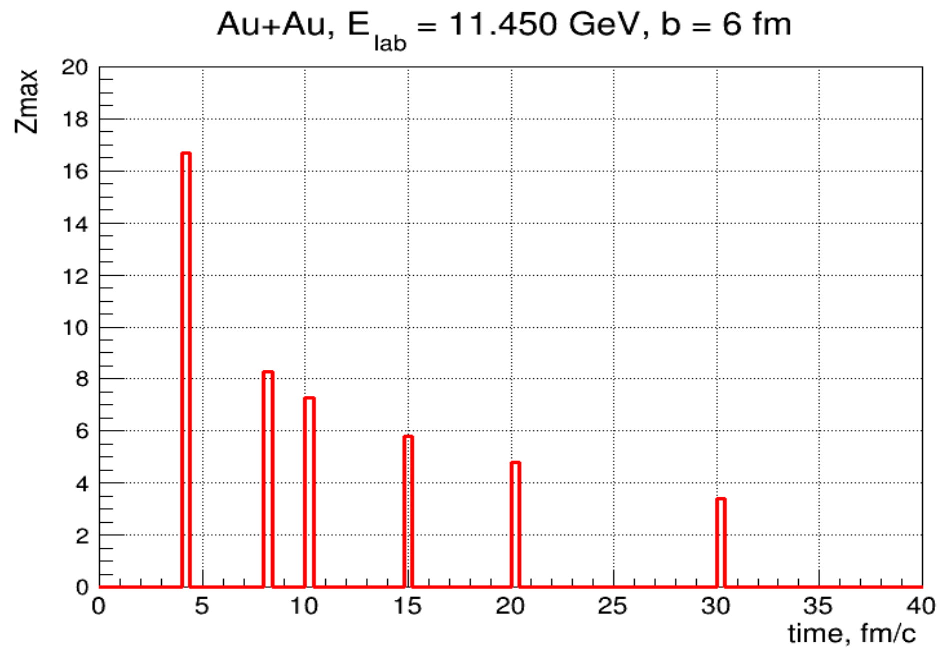


Multiplicity of different kind of particles and fragments

Hypernuclei multiplicity



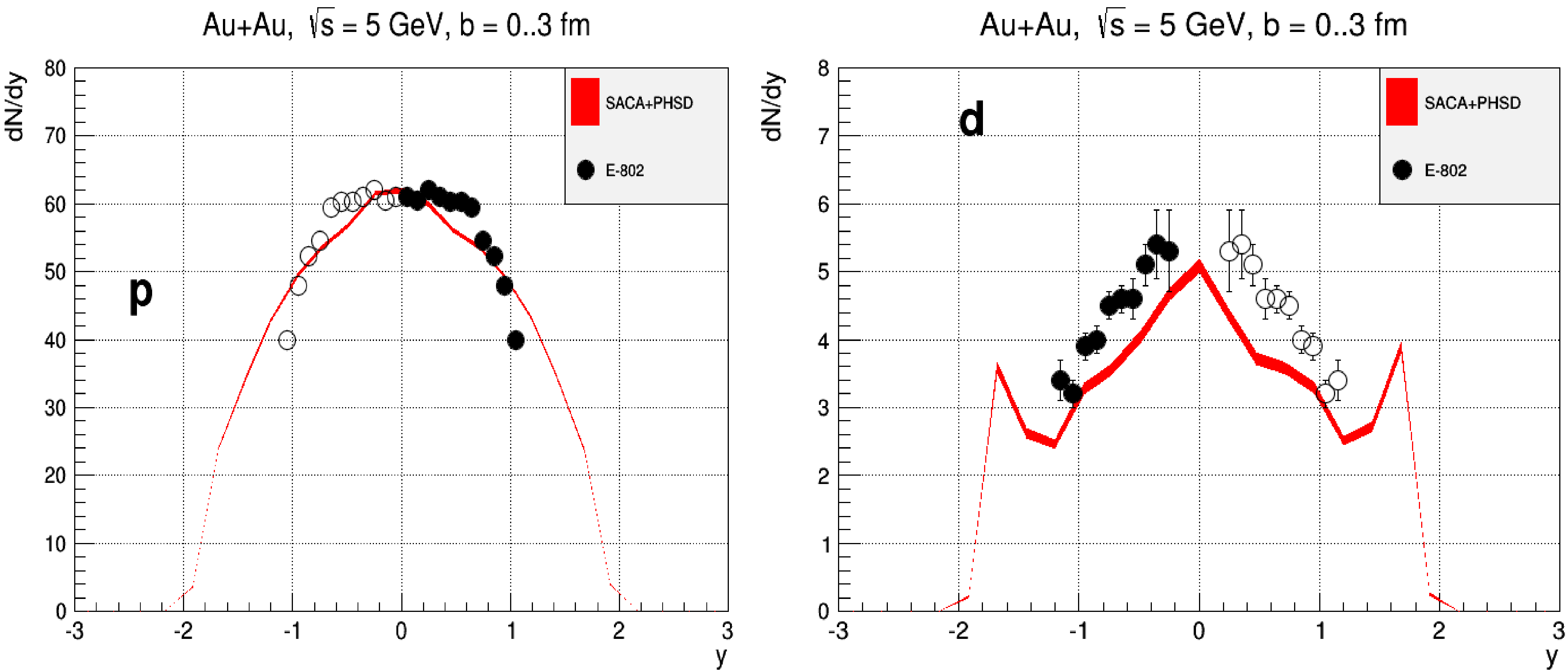
<Zmax> versus formation time



t = 15 fm/c has been chosen to start SACA simulations at 11.45 GeV

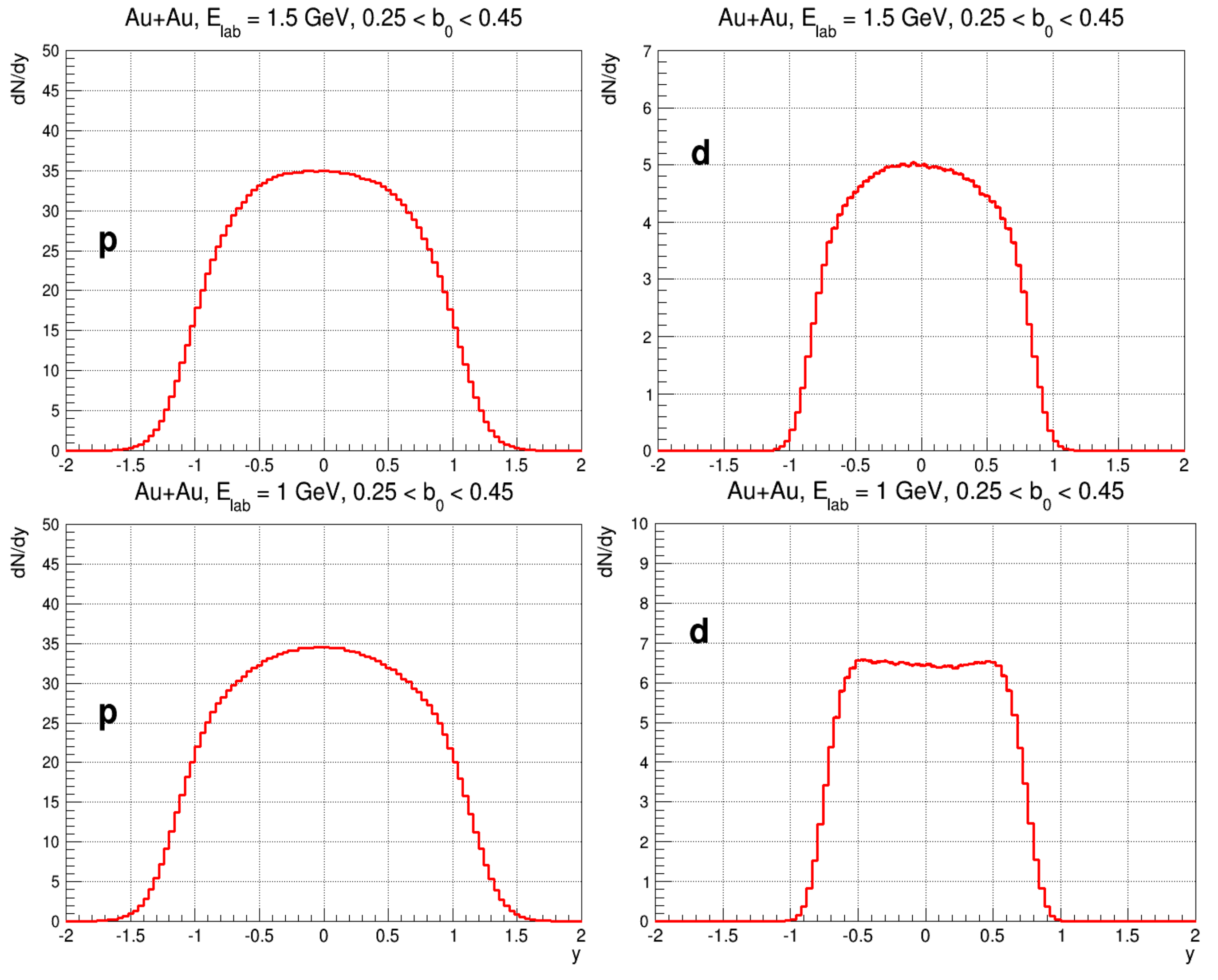
SACA comparison with E-802 experimental data 11.45 GeV

«Proton and deuteron production in Au+Au reactions at 11.6A GeV/c» Phys. Rev. C, 60 064901



Model reproduce experimental data dN/dy distributions for protons and deuterons

SACA particles production for low enegry (BM@N and FOPI)

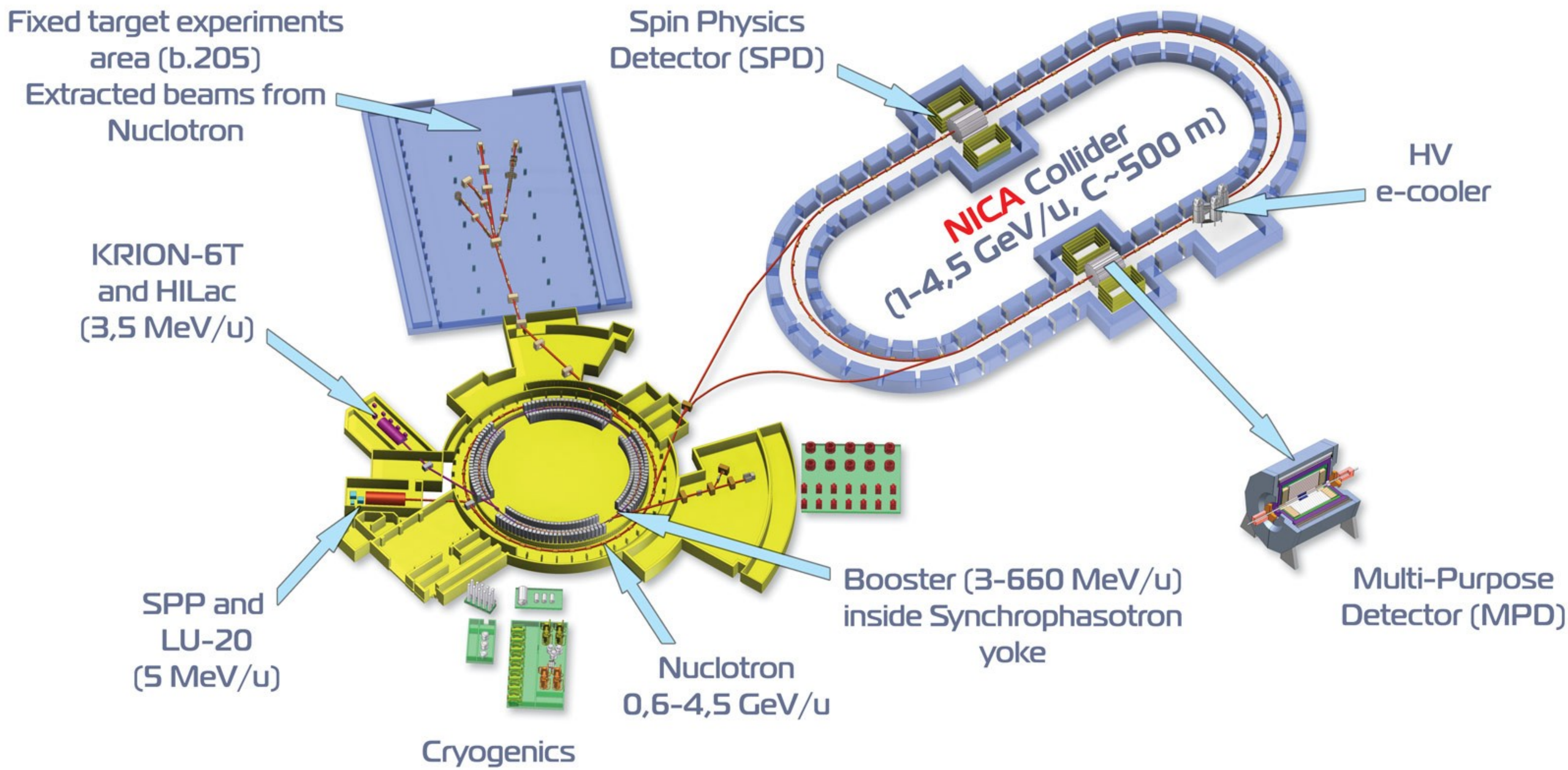


$b_0 = b / b_{max}$

$b_{max} = 12.8$ fm

Rapidity distribution of protons and deuterons for 1.5 and 1 GeV

Superconducting accelerator complex NICA
(Nuclotron based Ion Collider fAcility)



NICA parameters:

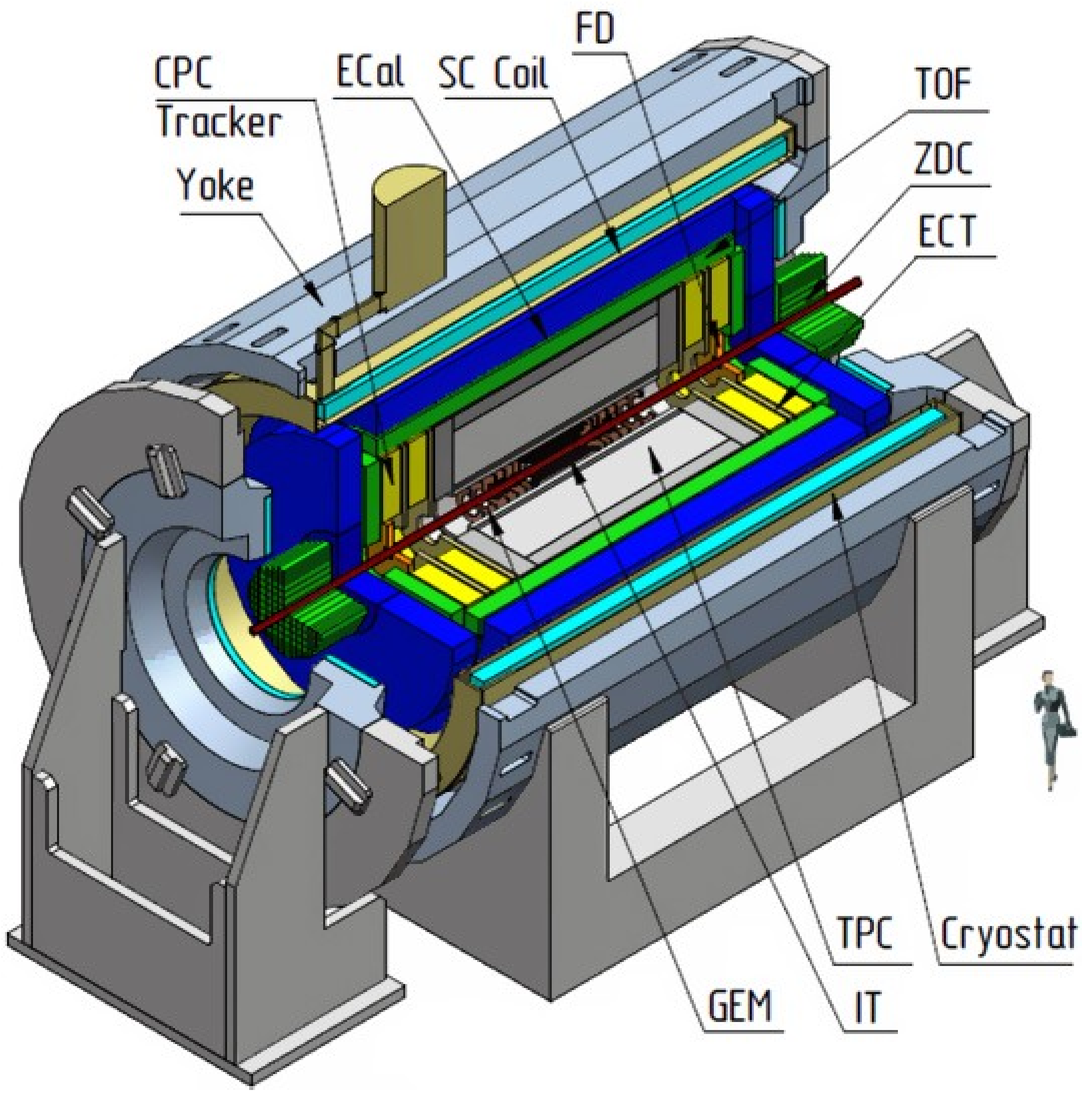
Energy range: $\sqrt{s_{NN}}$ = 4-11 GeV

Beams: from p to Au

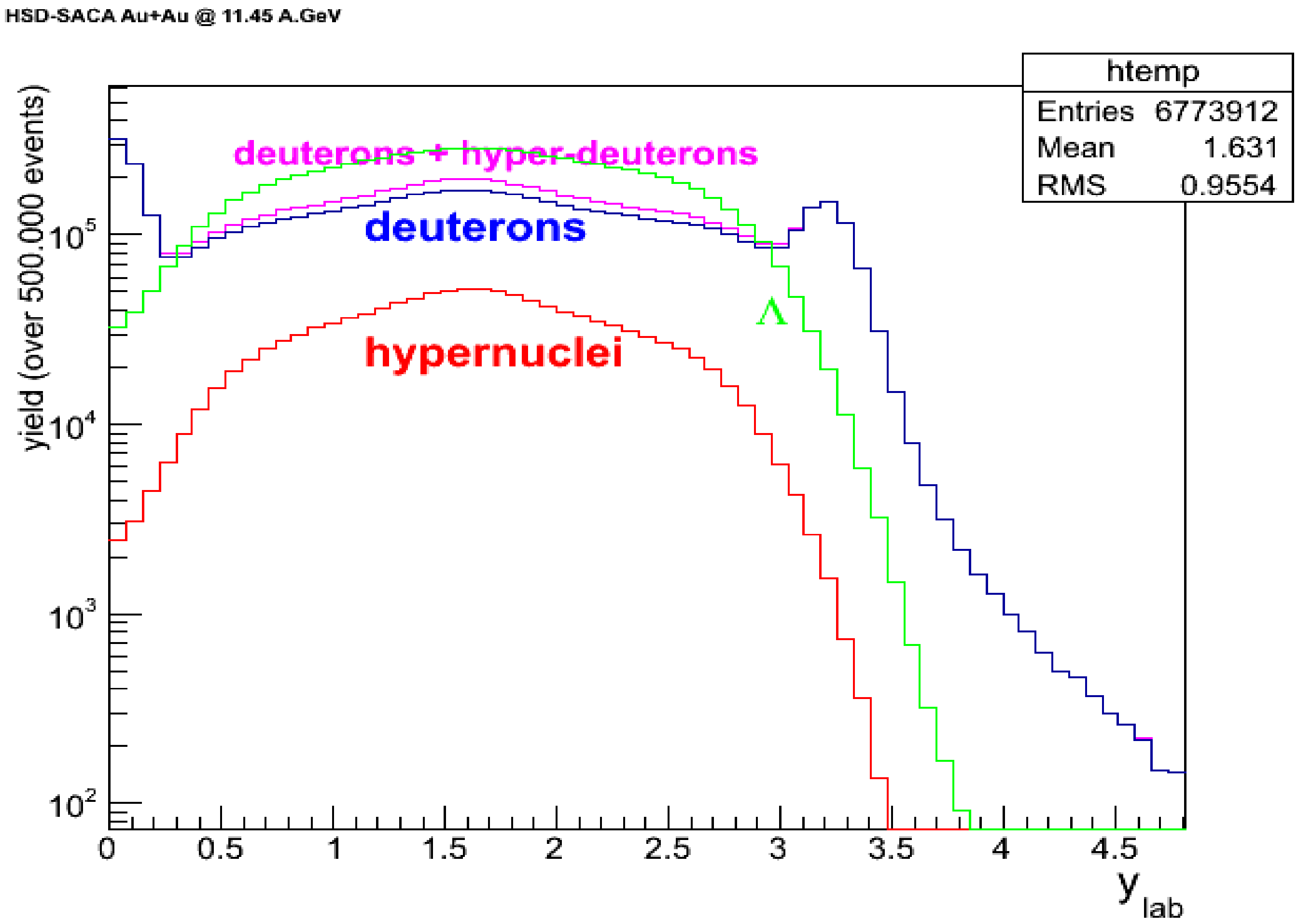
Luminosity: L~10^{27} (Au), 10^{32} (p)

Detectors: MPD (ions), SPD (spin physics)

Multi-Purpose Detector general view



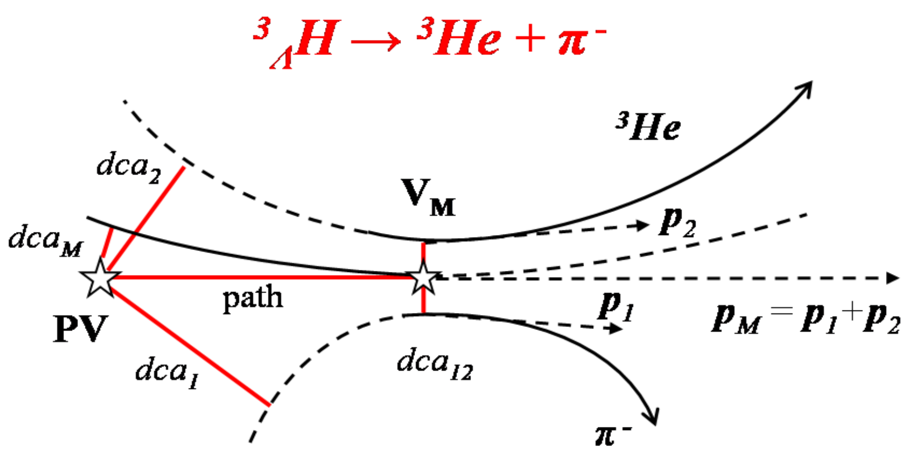
SACA hypernuclei production



SACA produce a lot of different hypernuclei, the largest amount is taked by LP and LN correlations.

The next step of our work is to disable this kind of short-lived correlations ans see if there will be some difference in hypernuclei production.

MPD hypertriton feasibility study



Event topology of two-particle decay of the particle:

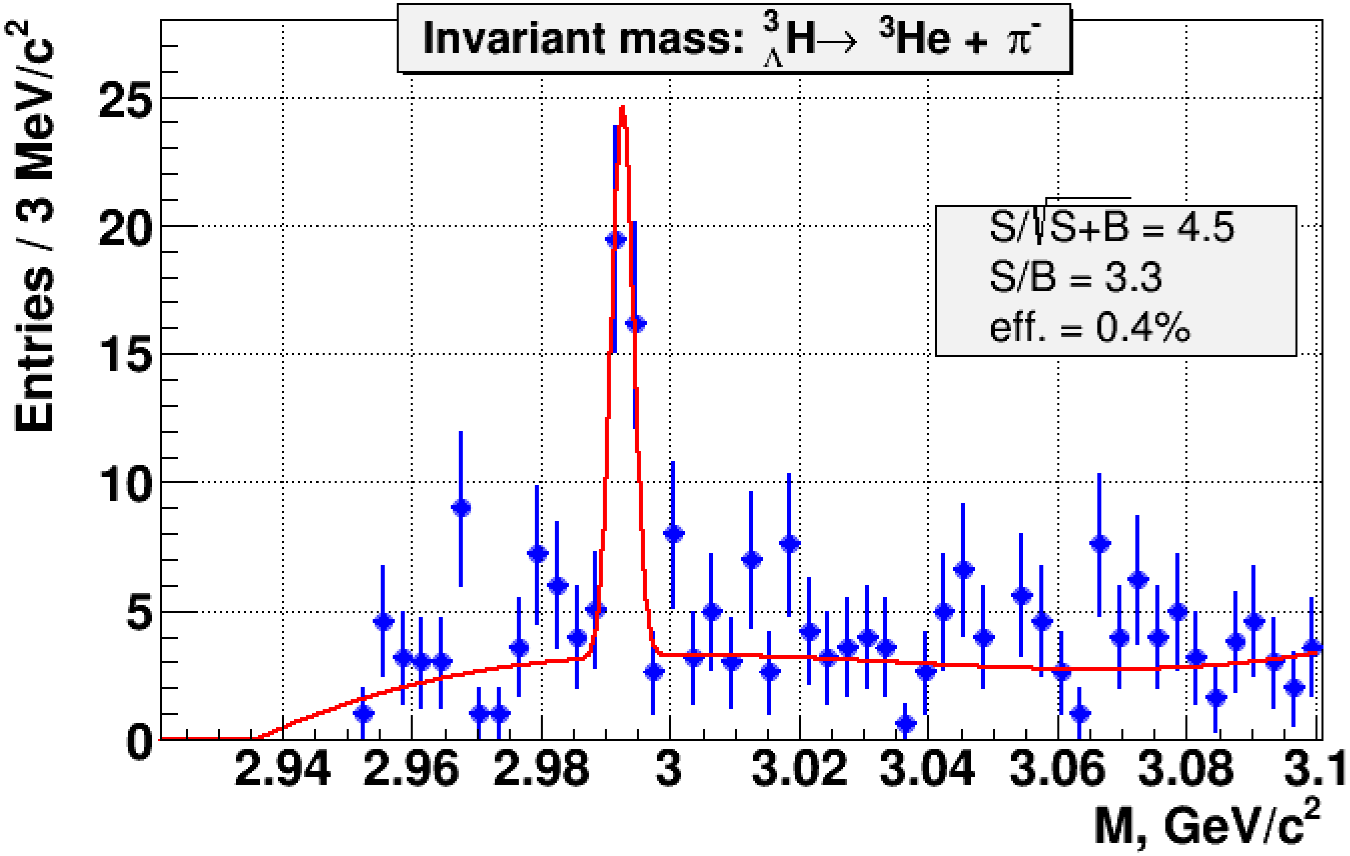
- ✓ PV – primary vertex
- ✓ V_M – vertex of $^3_\Lambda H$ decay
- ✓ dca – distance of the closest approach
- ✓ path – decay length

Dataset:

500 000 events, Au+Au, b = 0..3 fm, 5 A GeV (11.45 GeV in lab frame)

M. Ilieva (JINR) — 19.09.2014 at 16:00

MPD hypertriton feasibility study



H3L is identified with S/B ratio = 3.3 and efficiency about 0.4%.

SUMMARY

- PHSD+SACA can produce clusters and hypernuclei;
- These predictions have been used for MPD performance studies;
- PHSD+SACA model reproduce experimental data for 11.45 GeV;
- Model is actively developing, there is some of polishing work to do.