

Simulation of NICA/MPD with THESEUS as an attempt to investigate effects of a QCD phase transition in the EoS on HIC observables

P. Batyuk

on behalf of the MPD collaboration

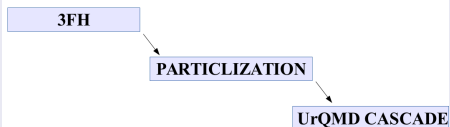
pavel.batyuk@jinr.ru
VBLHEP, JINR

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Outline:

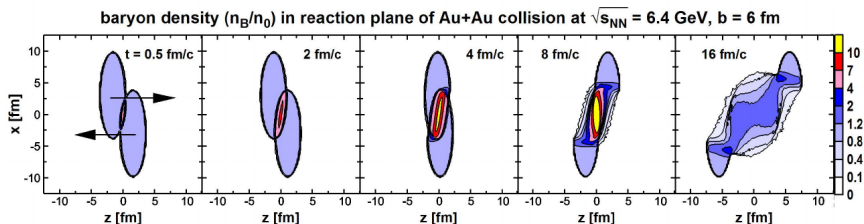
- **Three-fluid Hydrodynamics-based Event Simulator**
Extended by UrQMD final State interactions (THESEUS)
- **NICA Complex, NICA/MPD, MPDROOT ...**
- **First results on baryon stopping power and direct flow as a result of MC simulation of NICA/MPD**

Three-fluid Hydrodynamics-based Event Simulator Extended by UrQMD final State interactions (THESEUS)



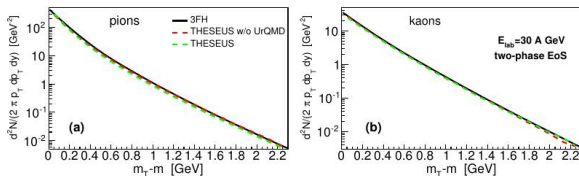
- The simulation was performed with the crossover EoS without freeze-out.
- Very high baryon densities are reached in the central region of the colliding system.

3FH-model:



Test of the particlization and cascade routines

p_T -spectra:

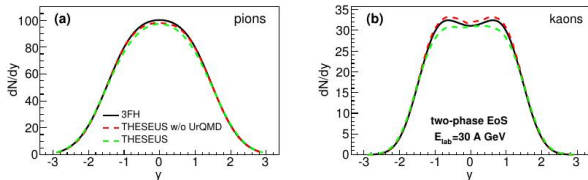


AuAu @ 30 AGeV,
 $b = 2\text{fm}$, 2-phase
EoS

UrQMD hadronic rescattering:

- leads to a slight steepening of the pion p_T -spectrum.
- smears the double-peak structure in the kaon rapidity spectrum.

Rapidity distribution:



NICA Complex

General characteristics:

Beams - $p, d \dots {}^{197}\text{Au}^{79+}$

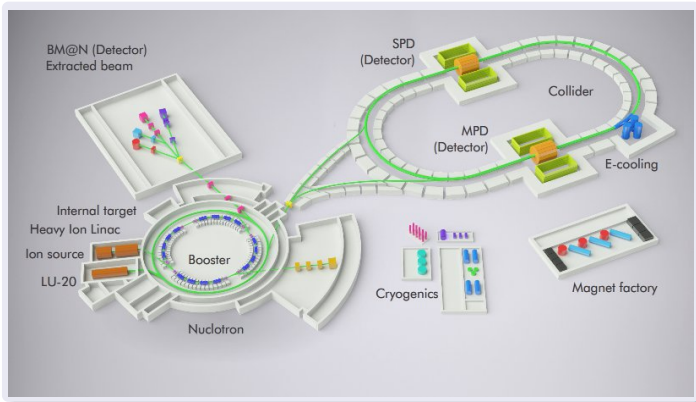
Collision energy:

$$\sqrt{s_{NN}} = 4 - 11 \text{ GeV} \quad E_{lab} = 1 - 6 \text{ AGeV}$$

Luminosity: $10^{27} \text{ cm}^{-2} \text{ s}^{-1}$ (Au), 10^{32} (p)

Experiments:

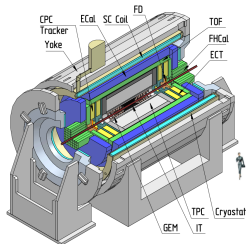
- 2 interaction points - **MPD** and **SPD**
- Fixed target experiment - **BM@N**



- **2017:** extracted beams of heavy ions are available within the BM@N experiment
- **2019:** a first configuration of the MPD setup available.
- **2023:** commissioning of the fully designed NICA-complex is foreseen.

MultiPurpose Detector (MPD) for $A + A$ collisions @ NICA

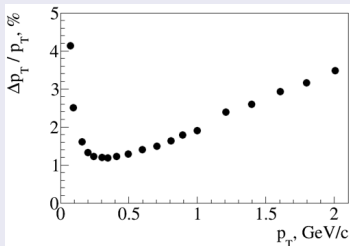
Layout:



Benefits:

- Hermeticity, 2π -acceptance in azimuth
- 3D-tracking (TPC, ECT)
- Vertex high-resolution (IT)
- Powerful PID (TPC, TOF, ECal)
 - π, K up to 1.5 GeV/c
 - K, p up to 3 GeV/c
 - γ, e from 0.1 GeV/c up to 3 GeV/c
- Precise event characterization (FHCAL = ZDC) (centrality determination, reaction plane ...)
- Fast timing and triggering (FFD)
- Low material budget
- High event rate (up to 7 kHz)

Momentum resolution:



Simulation Framework for MPD (MPDROOT)

MPDROOT

SIMULATION AND ANALYSIS FRAMEWORKS FOR MPD AND BM@N AT NICA

GENERAL

DOCUMENTS

COMPUTING

REFERENCES

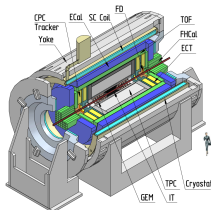
FORUM

BM@N SHIFTS

MPDROOT home
web-page:

<http://mpd.jinr.ru>

- News
- Software repositories
- Software tests
- Forums
- Database for physics run
- E.t.c.



Physics models available:

- UrQMD / Hybrid UrQMD / vHLLE + UrQMD
- QGSM / LAGQSM
- HSD / PHSD
- **THESEUS**

Benefits:

- Inherits basic properties from FairRoot, C++ classes
- Extended set of event generators for heavy-ion collisions
- Detector composition and geometry; particle propagation by GEANT3/4
- Advanced detector response functions, realistic tracking and PID included
- Event display for Monte-Carlo and experimental data

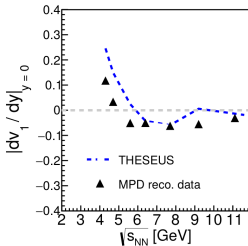
**All main macros
to be used for sim
& reco have been
adopted for
THESEUS input**

Direct flow of protons, dv_1/dy

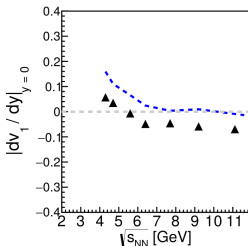
Phys. Rev. C 94, 044917 (2016)

THESEUS:

2-phase EoS, $b = 6$ fm

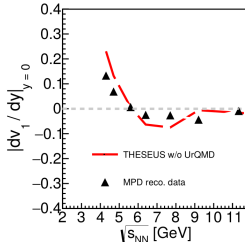


crossover EoS, $b = 6$ fm

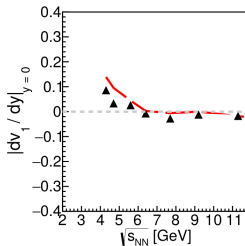


THESEUS w/o UrQMD:

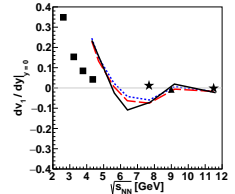
2-phase EoS, $b = 6$ fm



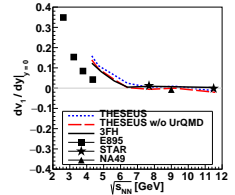
crossover EoS, $b = 6$ fm



2-phase EoS, $b = 6$ fm



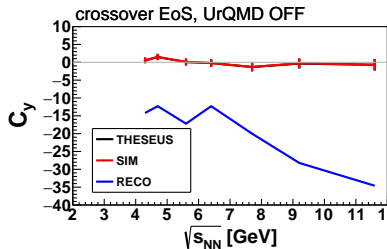
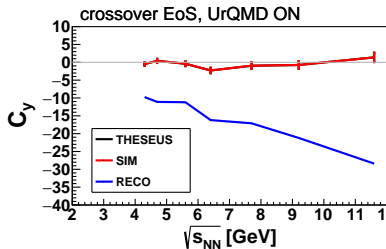
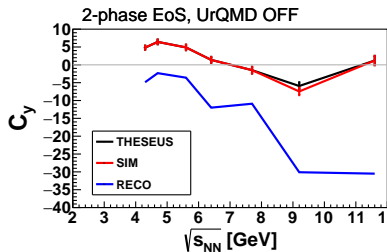
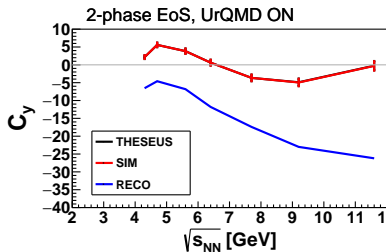
crossover EoS, $b = 6$ fm



Real PID used:

recoTrack->GetPidProbProton() > 0.9

Baryon stopping signal for a first-order phase transition



Conclusion