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Application of the Three-fluid hydrodynamic Event Generator THESEUS to CBM

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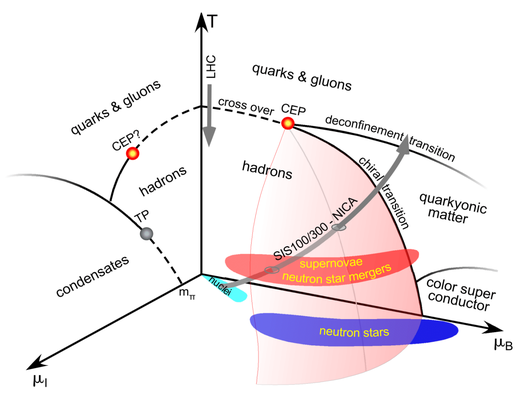
QCD Phase Diagram

At high temperature and/or large baryon density, a phase transition may occur to a state, where quarks and gluons become the correct degrees of freedom. This state is called quark-gluon plasma



Phase diagram

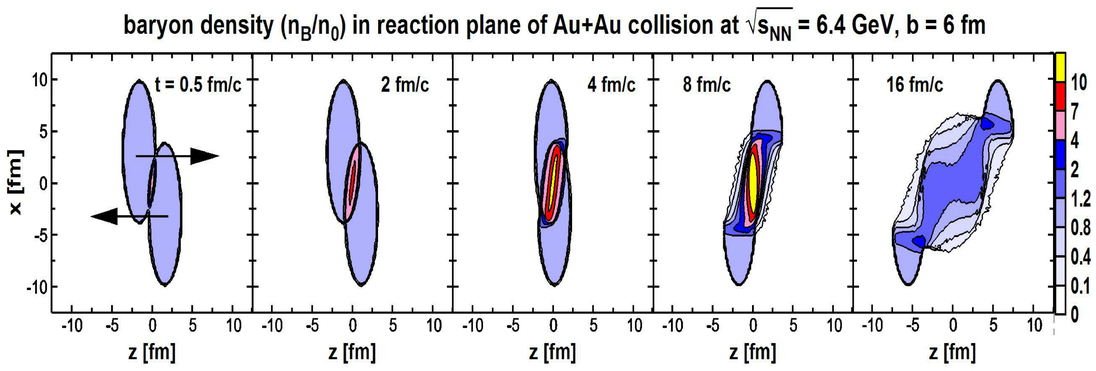
In nature, this state has occurred in the early universe and might, at high baryon density and low temperature, exist in the interior of neutron star.

In the course of neutron star mergers, as recently observed by gravitational wave astronomy, transient matter at moderate temperates (T=20-50 MeV) and high baryonic density is formed.

This matter can be probed by heavy-ion collision at 10-30 AGeV, were maximal baryon densities are reached[1].

Heavy-Ion Collisions

It's expected that conditions, sufficient to produce a QGP, may be reached in laboratory in heavy-ion reactions already at relatively modest energies, i.e. the order of 10–30 AGeV laboratory projectile energy.



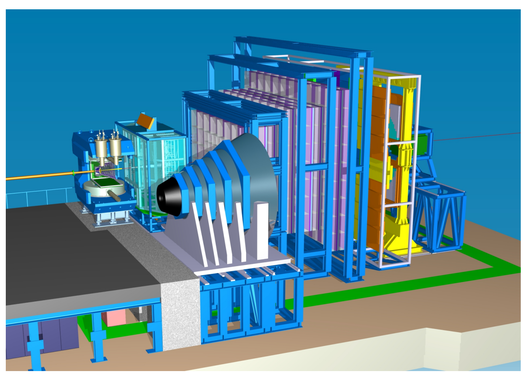
The evolution of high density matter created in heavy-ion collisions can be described by hydrodynamics.

We present the simulation employing a three-fluid 3D hydrodynamic model, THESEUS[2], which incorporates the evolution of three baryon-rich fluids: a target and projectile fluid, and a fluid describing the hot fireball of participant matter.

THESEUS is a new event generator, which based on the three-fluid hydrodynamics approach for the early stage of the collision, followed by a particlization at the hydrodynamic decoupling surface to join to a microscopic transport model, UrQMD, to account for hadronic final state interactions. The first results of comparing this two models is shown on the figure below.

CBM

The Compressed Baryonic Matter experiment (CBM) at FAIR will measure nucleus-nucleus collisions at beam energies up to 14AGeV. The key objective of CBM is to investigate the QCD phase diagram in the region of the highest net-baryon-densities[3].

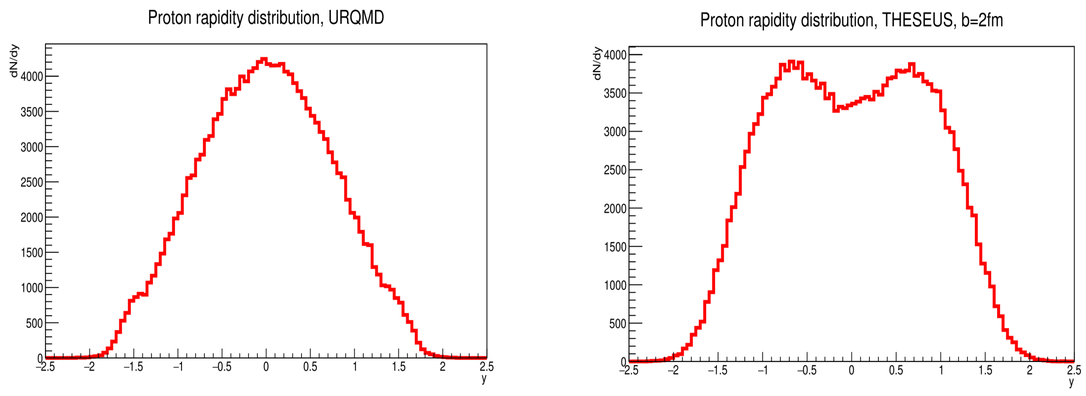


CBM experiment [3]

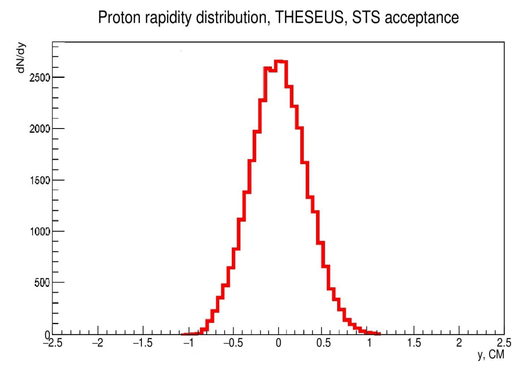
- Micro-Vertex Detector (MVD)
- Silicon Tracking System (STS)
- Cherenkov Detector(RICH)
- Muon Chamber System
- Transition Radiation Detector
- Timing Multi-gap Resistive Plate Chambers(MRPC)
- ECAL
- Projectile Spectrator Detector

Results

As a first result of our application of THESEUS we show a rapidity spectrum of protons obtained from 10 AGev Au+Au collisions, sampled for an impact parameter b= 2 fm; right figure. The distribution is compared to UrQMD events with b=0 fm; left figure.



Proton rapidity distributions URQMD and THESEUS generators.
Central Au+Au collisions for 10 AGeV



Proton rapidity distributions after STS detector response simulation

As a next step the events are subjected to the detector acceptance of the CBM experiment. A corresponding rapidity distribution (UrQMD) is shown in the lower figure. As can be seen the spectrum is modified due to acceptance effects

Outlook

- Integration of THESEUS into CBMRoot
- Investigation of flow and other observables for different equation of states (EOS)
- full simulation of the CBM detector response

References

- [1]W. Florkowski «Phenomenology of Ultra-Relativistic Heavy-Ion Collisions»
- [2] P. Batyuk, D. Blaschke at all. ArXiv 1608.00965 (2016)
- [3] Technical Design Report for the CBM (2012)