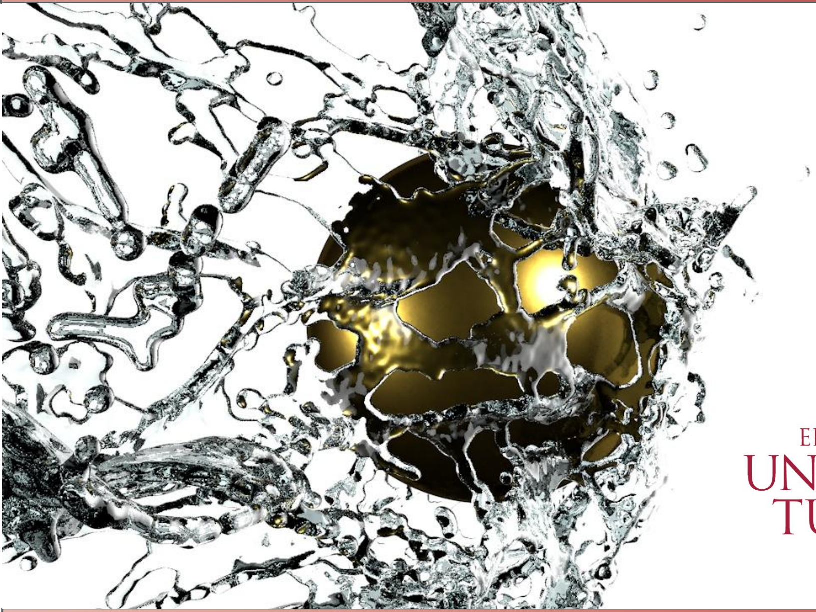
Proton y-p_T spectra reconstruction of THESEUS data in CBM experiment



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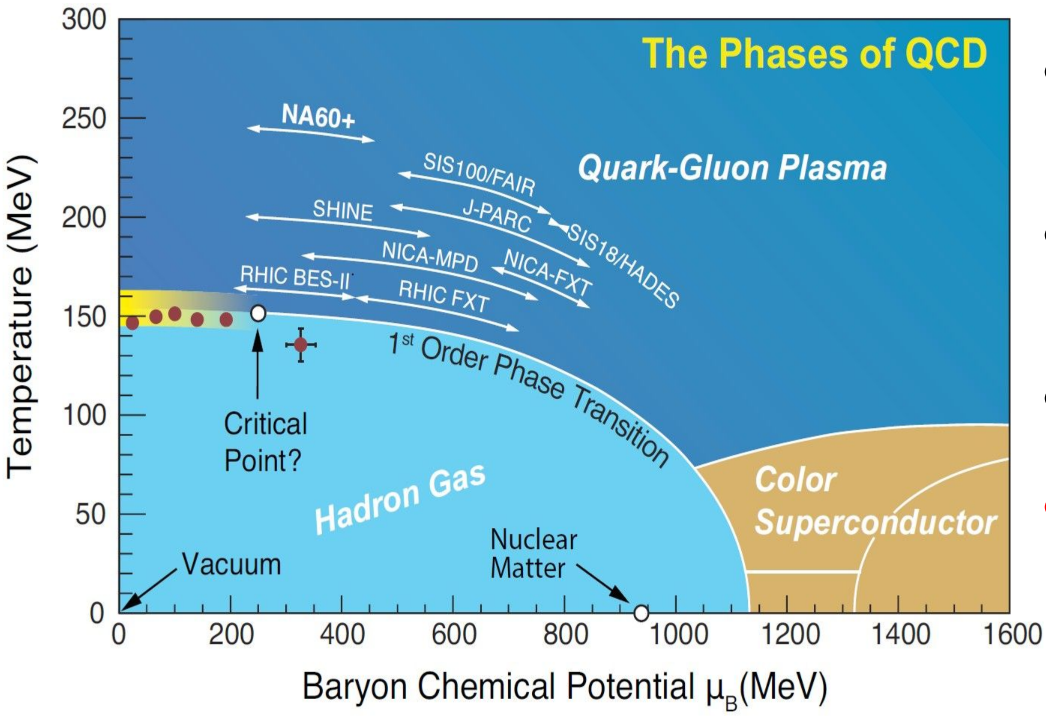
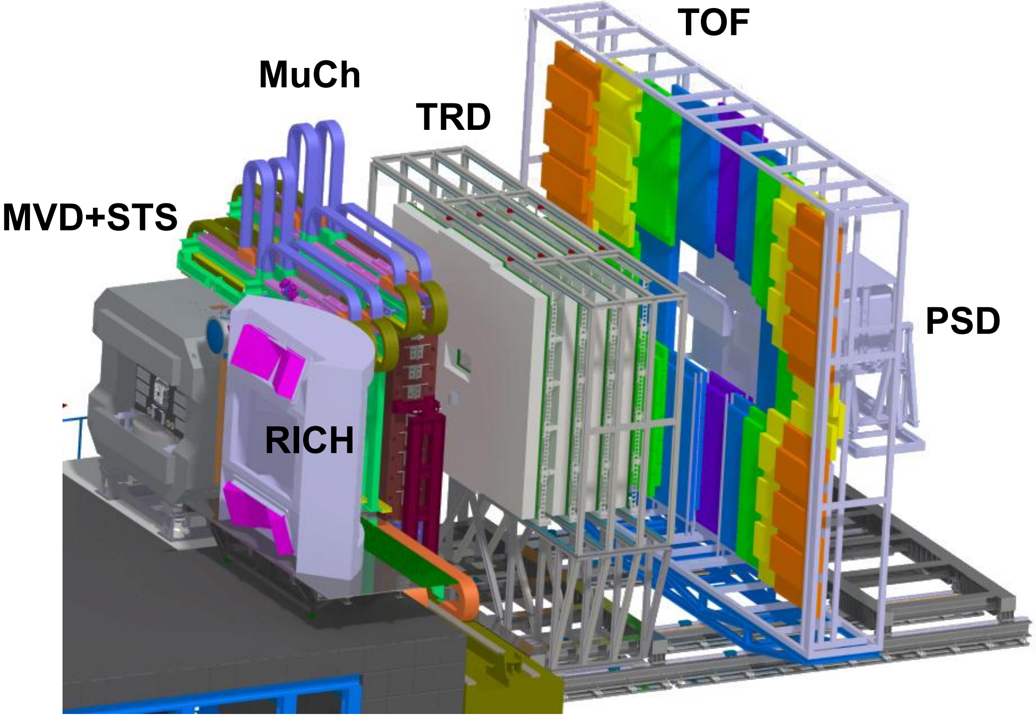


- THESEUS generator has been developed to simulate heavy-ion collisions at CBM energies.
- Generator based on dynamic of 3 ideal fluids: projectile, target and fireball nucleons.
- THESEUS consists of fluid dynamic, particlization and rescattering.
- Generator has 3 Equation of States(EoS): 1st order phase transition, crossover and hadron gas.



MVD

Micro Vertex Detector*

STS

Silicon Tracking System*

* *inside magnetic field*

MuCh or RICH

Muon Chamber System /

Ring Imaging Cherenkov Detector

TRD

Transition Radiation Detector

ToF

Time-of-Flight Detector

PSD

Projectile Spectator Detector

ECal

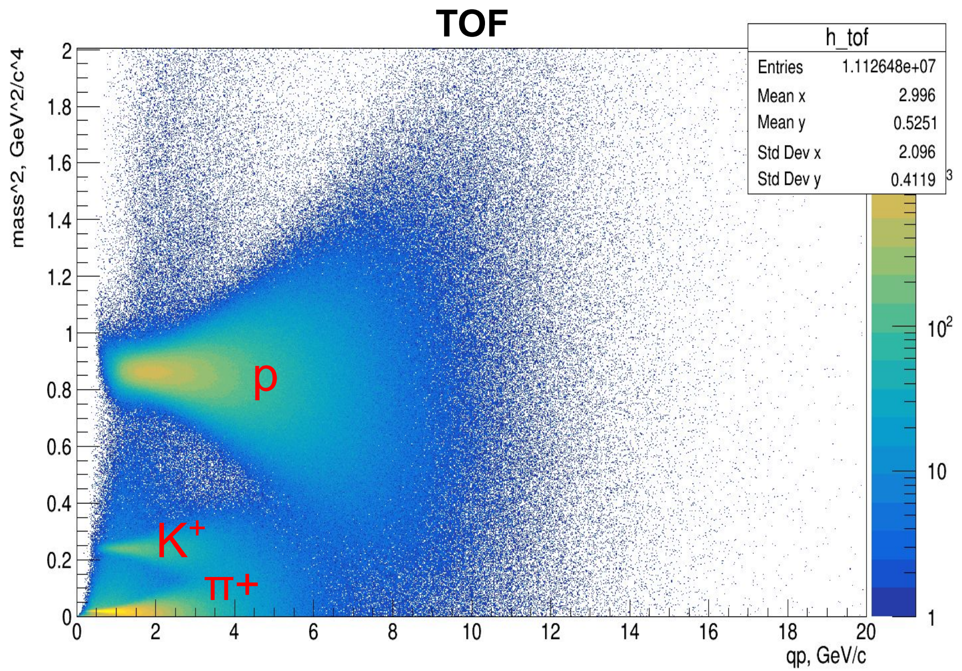
Electromagnetic Calorimeter

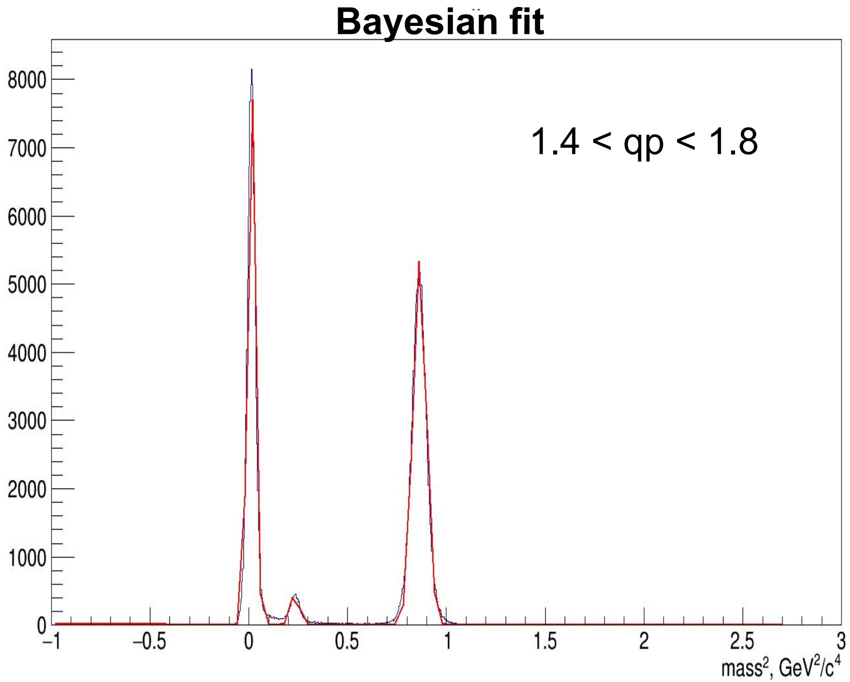
CBM simulation

Generator (THESEUS, UrQMD, etc.) → **CBMRoot** Apr21 → reconstructed tracks → *AnalysisTree and PID* → particles, momentum, energy

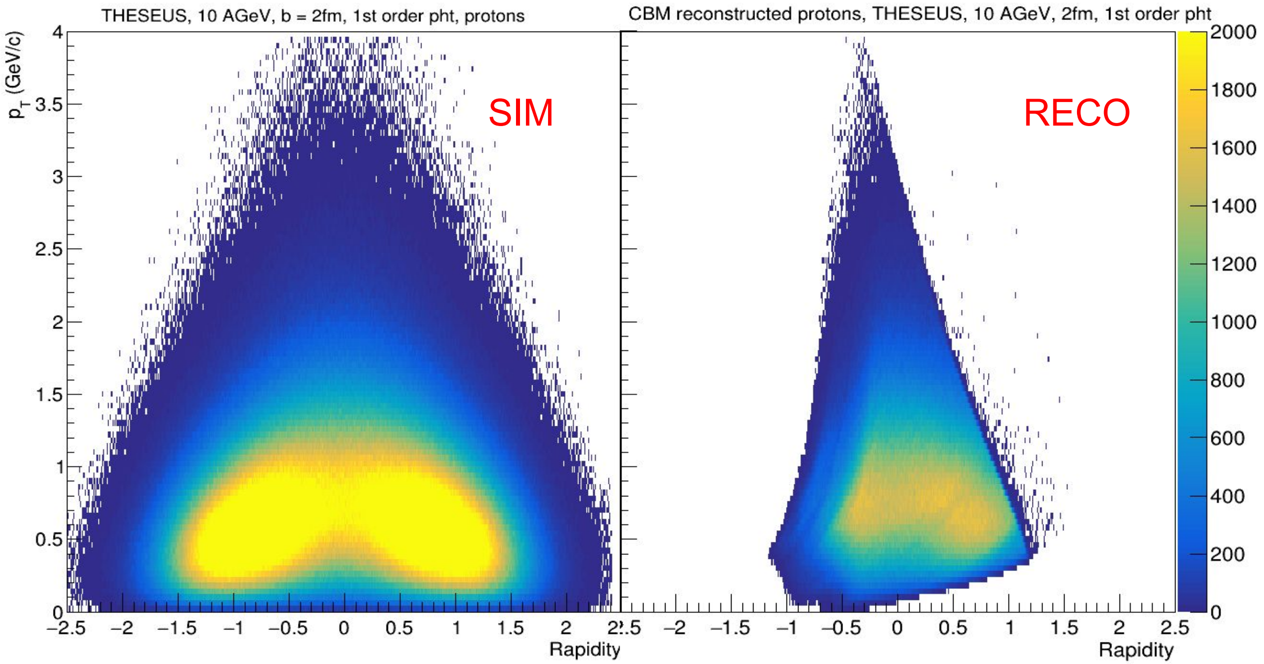
CBM TOF hadron identification

Generator (THESEUS, UrQMD, etc.) → CBMRoot Apr21 → reconstructed tracks → *AnalysisTree and PID* → particles, momentum, energy



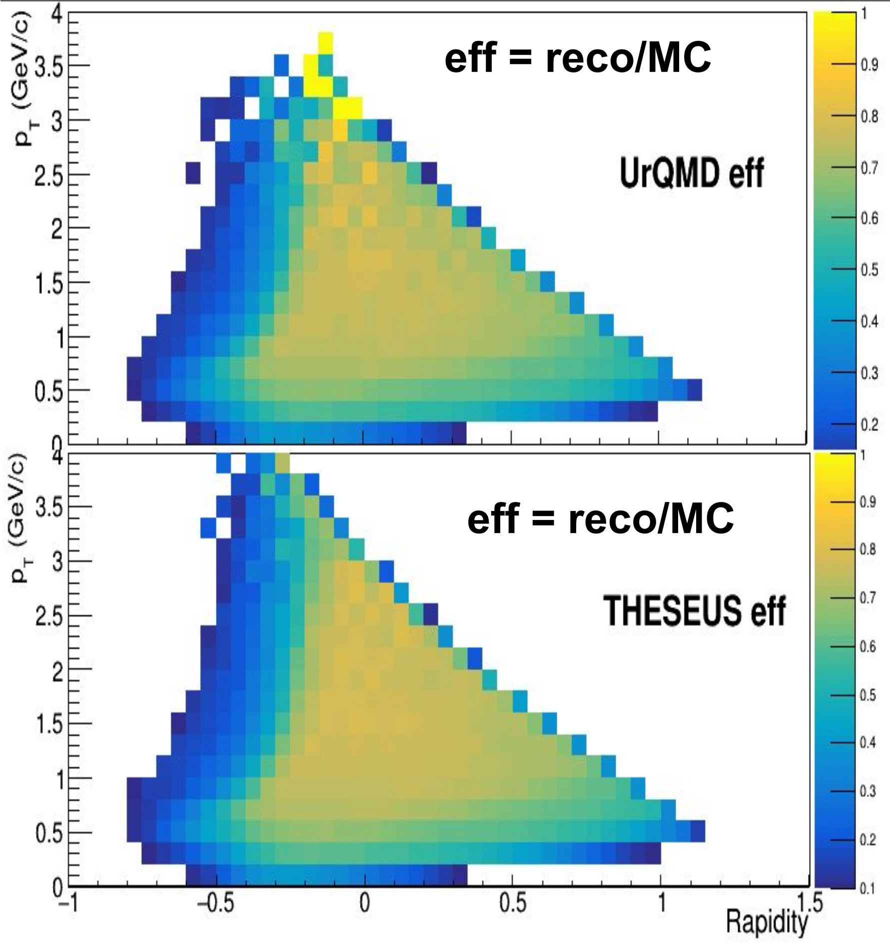


Generator (THESEUS, UrQMD, etc.) → CBMRoot Apr21 → reconstructed tracks → *AnalysisTree and PID* → particles, momentum, energy



Characteristic dip shape at midrapidity reducts after CBM acceptance.

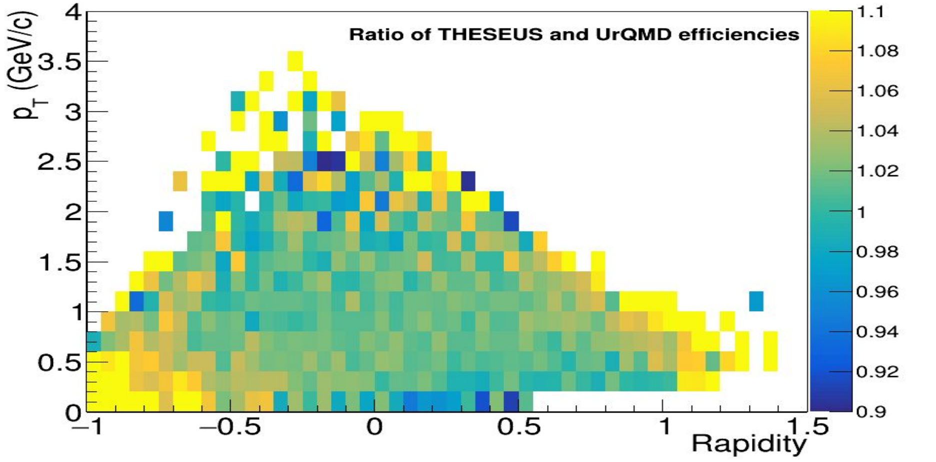
Proton reconstruction efficiency



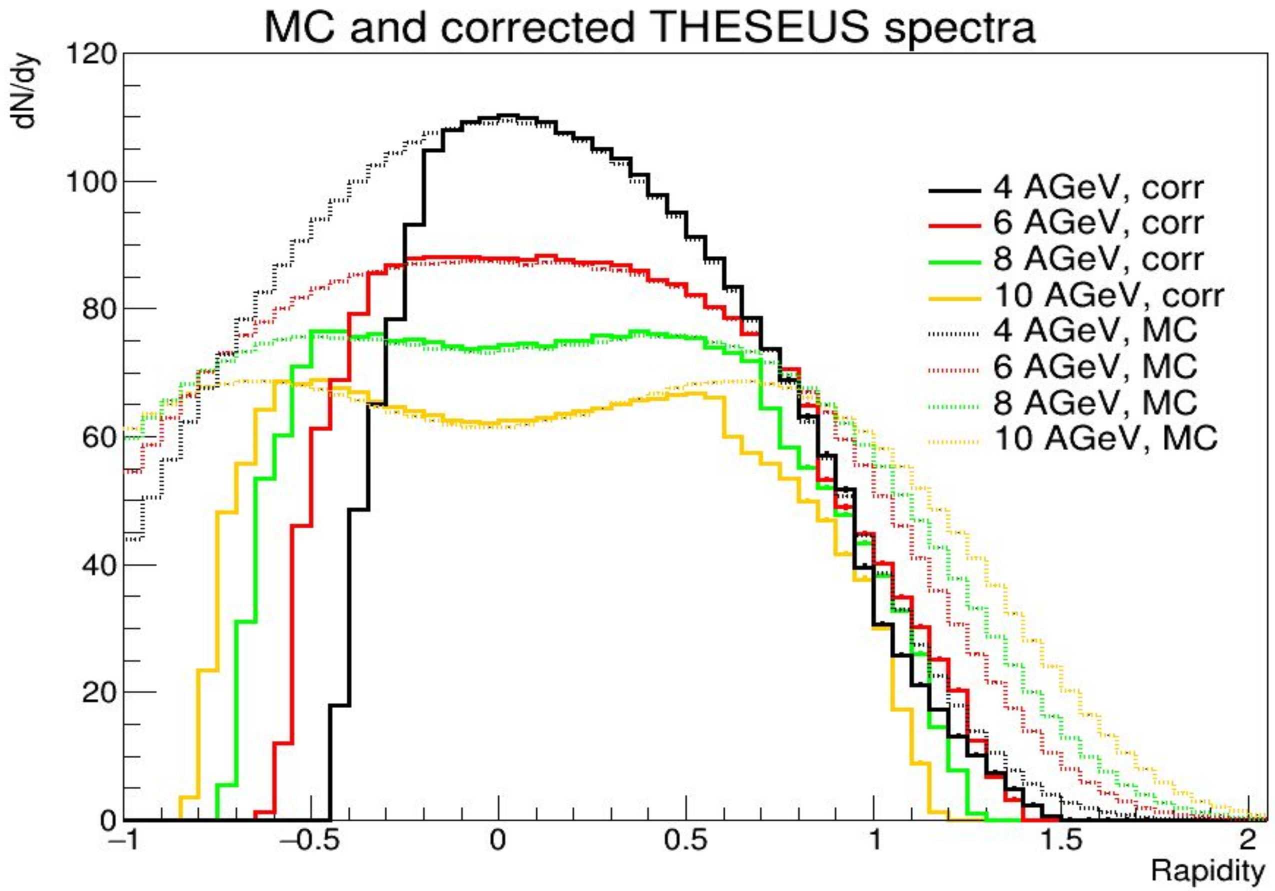
- We assume that we don't know reconstruction efficiency for THESEUS model.
- To correct reconstructed distribution, we use efficiency that has been calculated using UrQMD model.

corrected spectra = $reco_{THESEUS}/eff_{UrQMD}$

Ratio of UrQMD and THESEUS efficiencies:



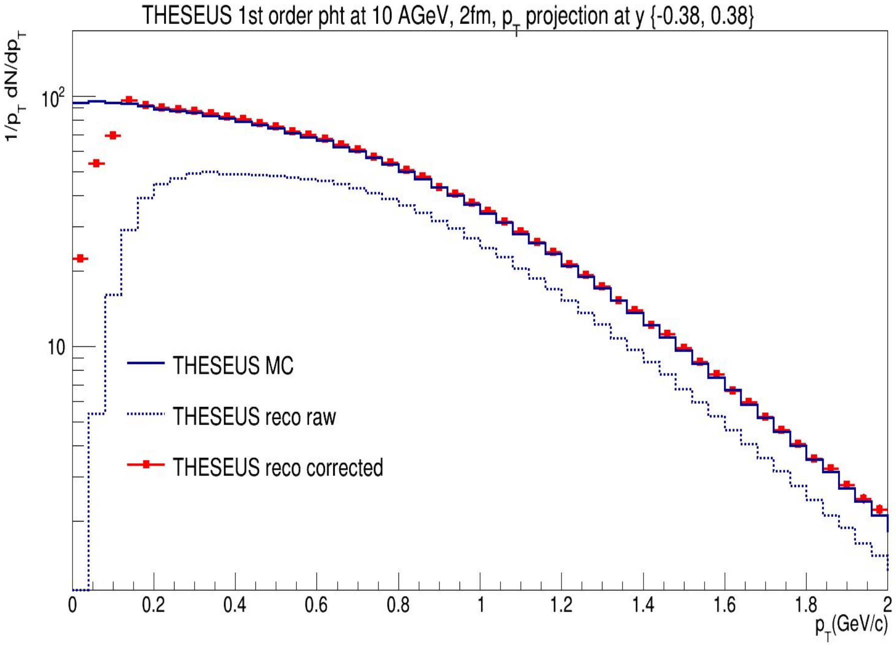
Rapidity window

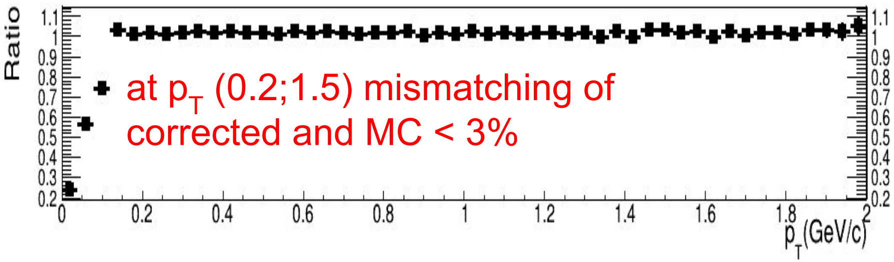


In accordance with corrected and MC spectra ratio and width of rapidity distribution, midrapidity windows have been selected to be:

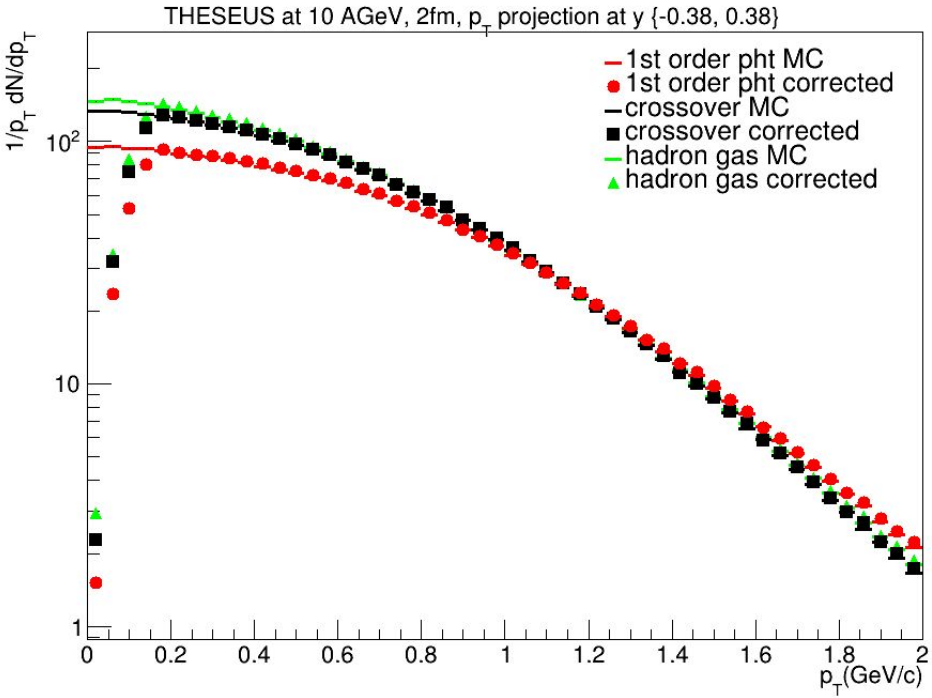
for 4AGeV **(0;0.3)**
for 6AGeV **(-0.33;0.33)**
for 8AGeV **(-0.36;0.36)**
for 10AGeV **(-0.38;0.38)**

p_T projection





at p_T (0.2;1.5) mismatching of corrected and MC < 3%



$$\frac{1}{p_T}\frac{dN}{dp_T} \propto \int_0^R r dr m_T I_0\left(\frac{p_T \sinh\rho}{T_{kin}}\right) K_1\left(\frac{m_T \cosh\rho}{T_{kin}}\right)$$

Fit parameters:

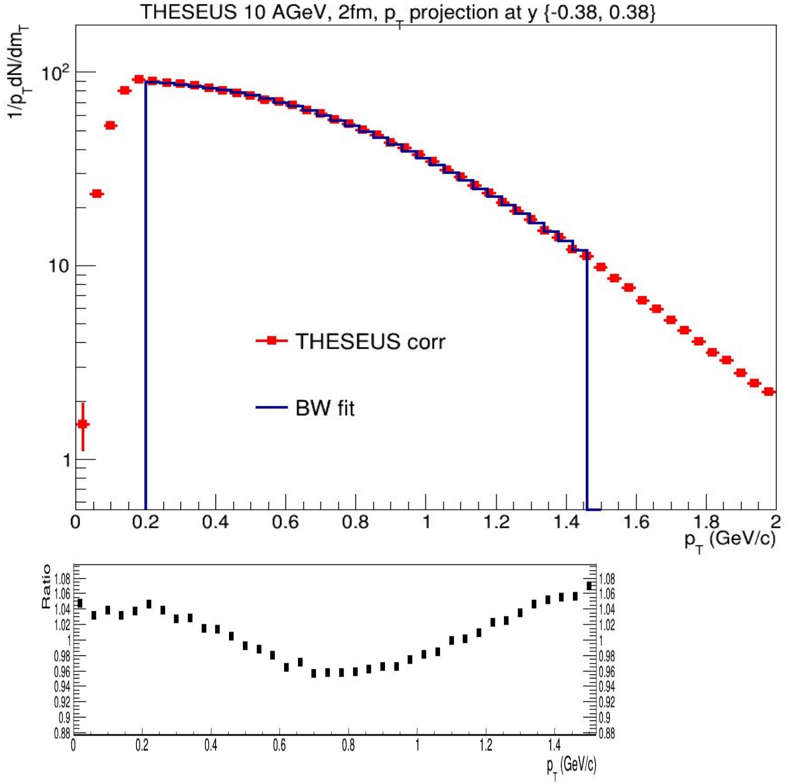
- $\mathbf{T_{kin}}$ is the temperature at which kinetic freeze out occurs
- ρ is the velocity profile given by

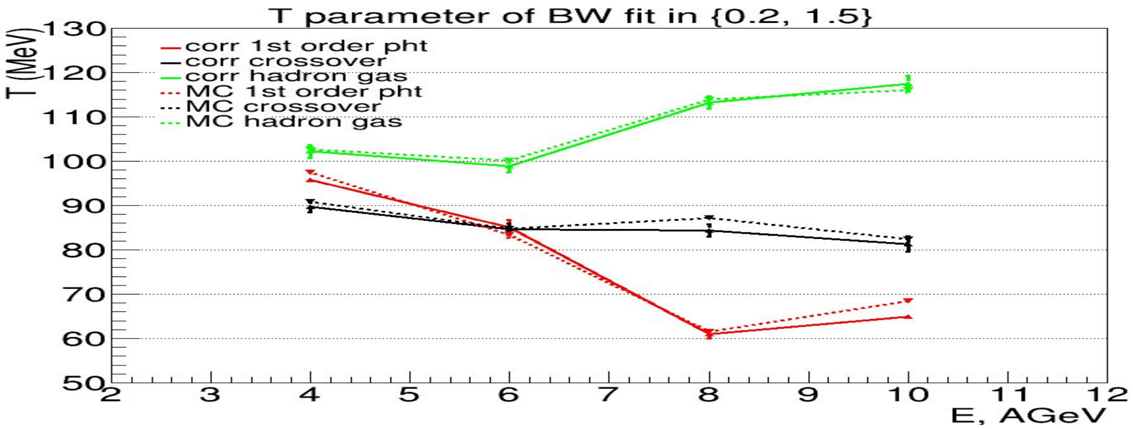
$$\rho = \text{arctanh}\,\beta_T$$

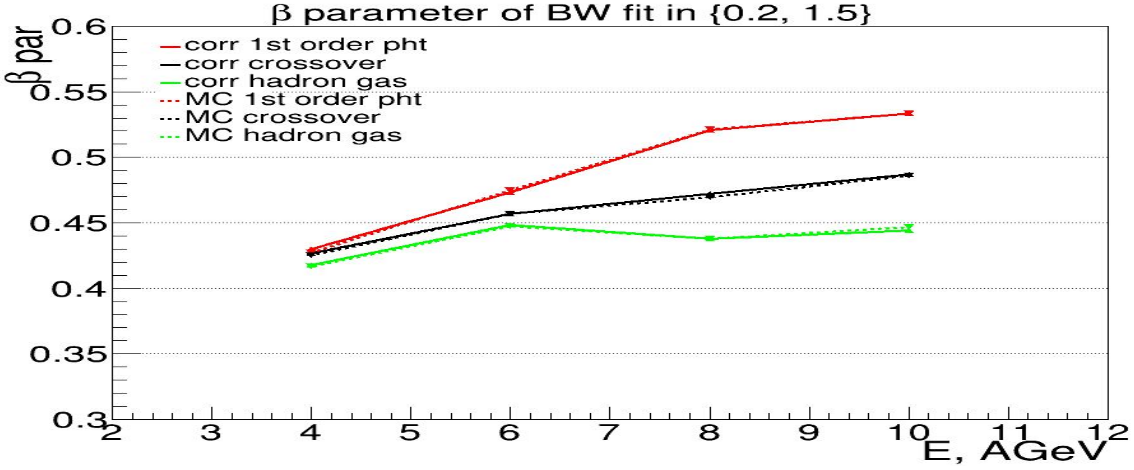
We assume the transverse velocity β_T (in units of c) to increase linearly from 0 at the centre to $\boldsymbol{\beta_{max}}$ at the surface.

$\beta_T = \beta_{max}(r/R)^n$ $\langle\beta\rangle = 2\beta_{max}/2+n$

- n = 1
- Scale







-proton pT slope is reconstructed with ~8% uncertainties

-CBM is sensitive to the difference within EoS's in THESEUS model

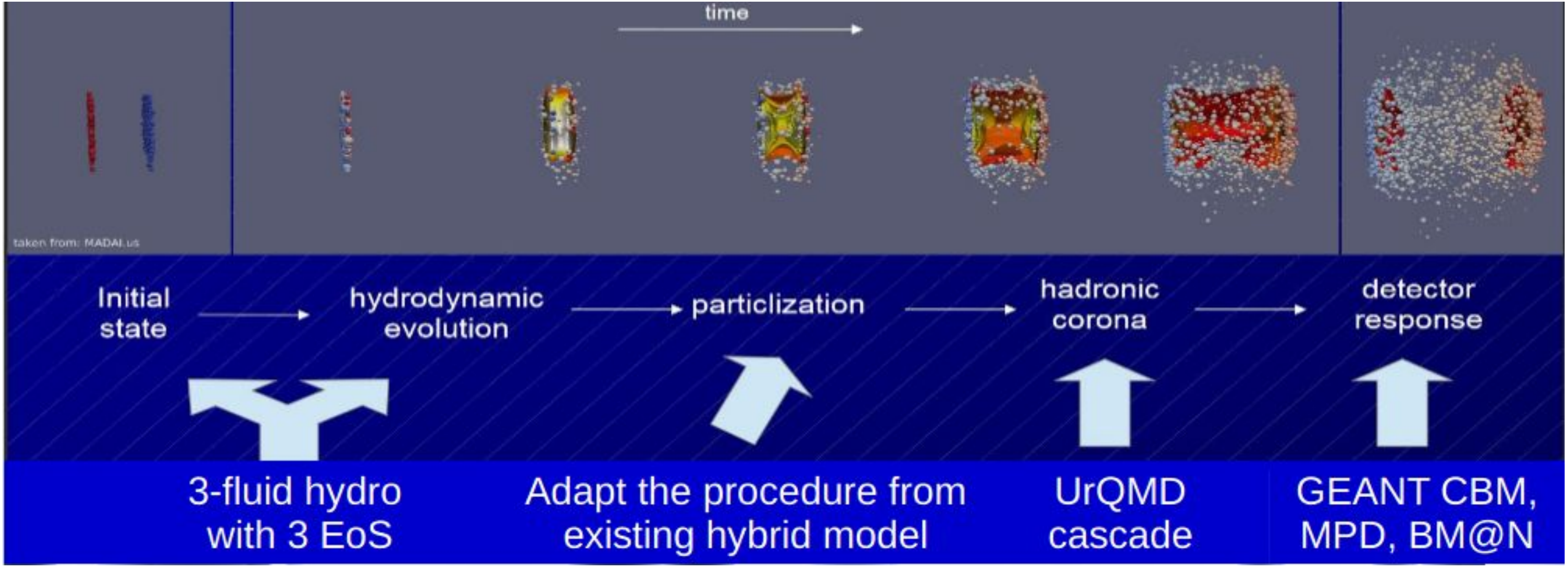
Conclusion

- At SIS100 energies, we can distinguish all 3 EoS by Blast Wave fit of p_T spectra.
- UrQMD correction procedure reconstruct proton y-pT spectra at midrapidity and p_T (0.2; 1.5) with < 3% divergence with MC.
- BW fit has ~5% systematic error for T par and ~1% systematic error for β.
- Freeze-out temperature from BW fit has ~8% uncertainties

Thank you!

Backup

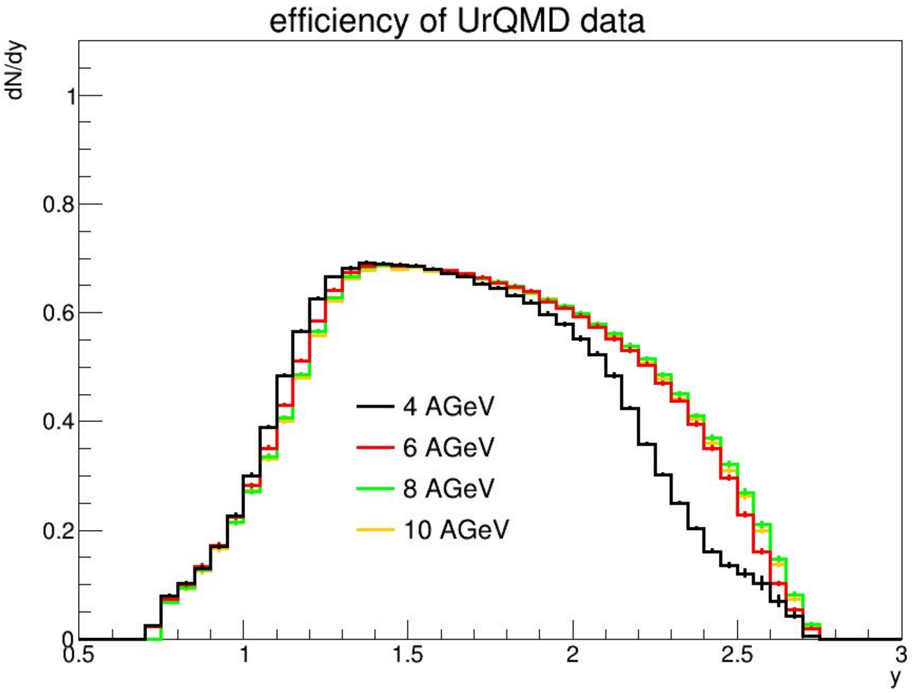
THESEUS

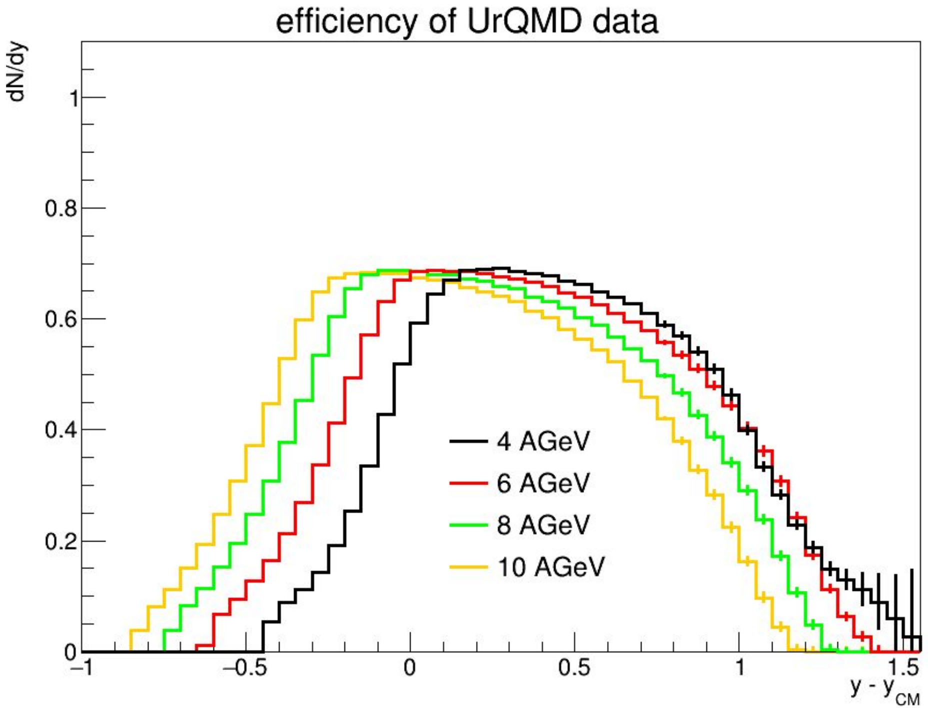


$$E\frac{\mathrm{d}N}{\mathrm{d}p^3} = \int_\sigma \mathrm{d}\sigma_\mu p^\mu f(x,p) \approx \sum_\sigma \Delta\sigma_\mu p^\mu f(x,p)$$

-p(x, p) is particle distribution
-σ is surface where one applies the Cooper-Frye formula

1D Efficiency as a function of rapidity





The Blast Wave Model

The blast-wave model assumes all hadrons decouple simultaneously from the QGP, which gives rise to a transverse 2-dimensional blast-wave that boosts particles according to their mass. The transverse mass spectrum of particles radiated from a thermal source at temperature T is given by

$$\frac{1}{m_T}\frac{dN}{dm_T} = \frac{V}{2\pi^2} m_T K_1\left(\frac{m_T}{T}\right)$$

where N is the particle yield, V is the volume of the source and K_1 is the modified Bessel function of the second kind.

After the transverse flow and the longitudinal expansion corrections:

$$\frac{1}{p_T}\frac{dN}{dp_T} \propto \int_0^R r dr m_T I_0\left(\frac{p_T \sinh\rho}{T_{kin}}\right) K_1\left(\frac{m_T \cosh\rho}{T_{kin}}\right)$$