Application of the 3-Fluid Hydrodynamic Event Generator THESEUS to CBM
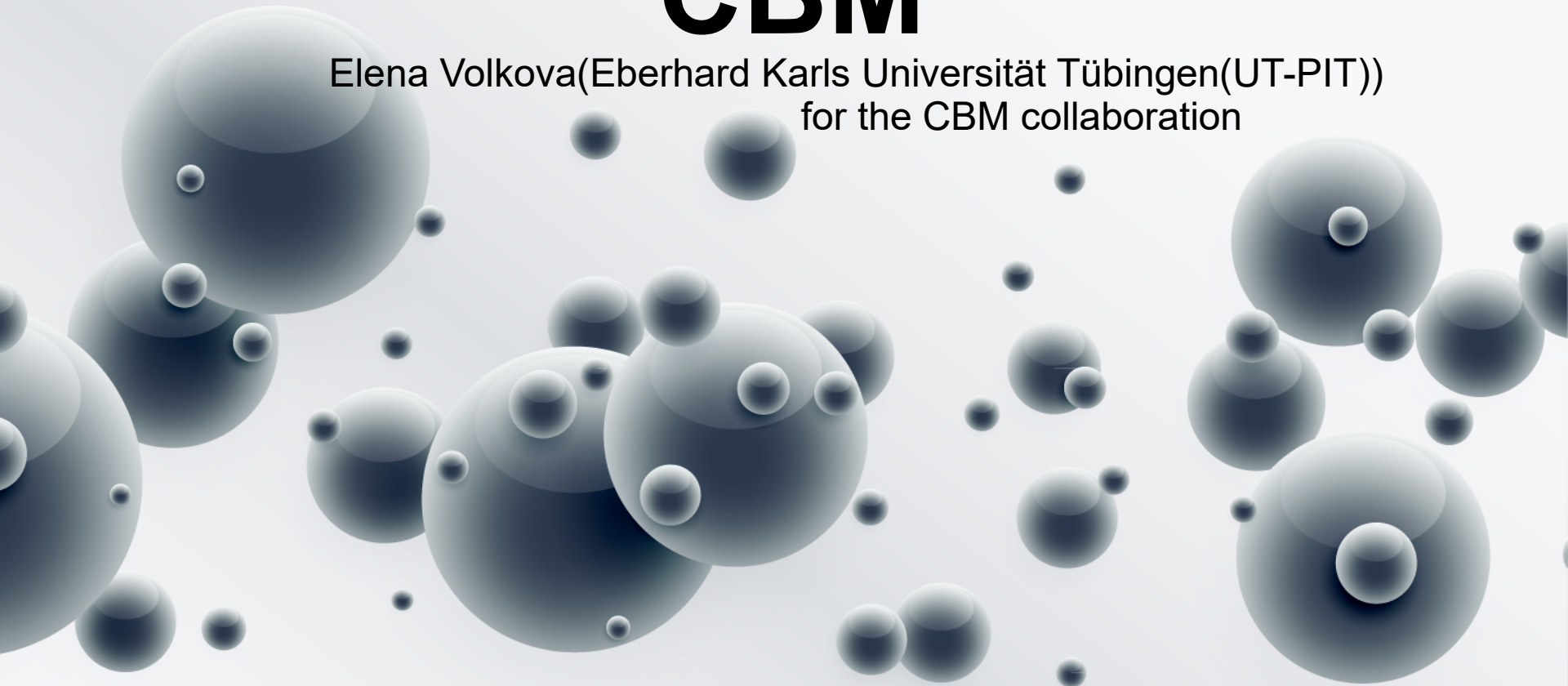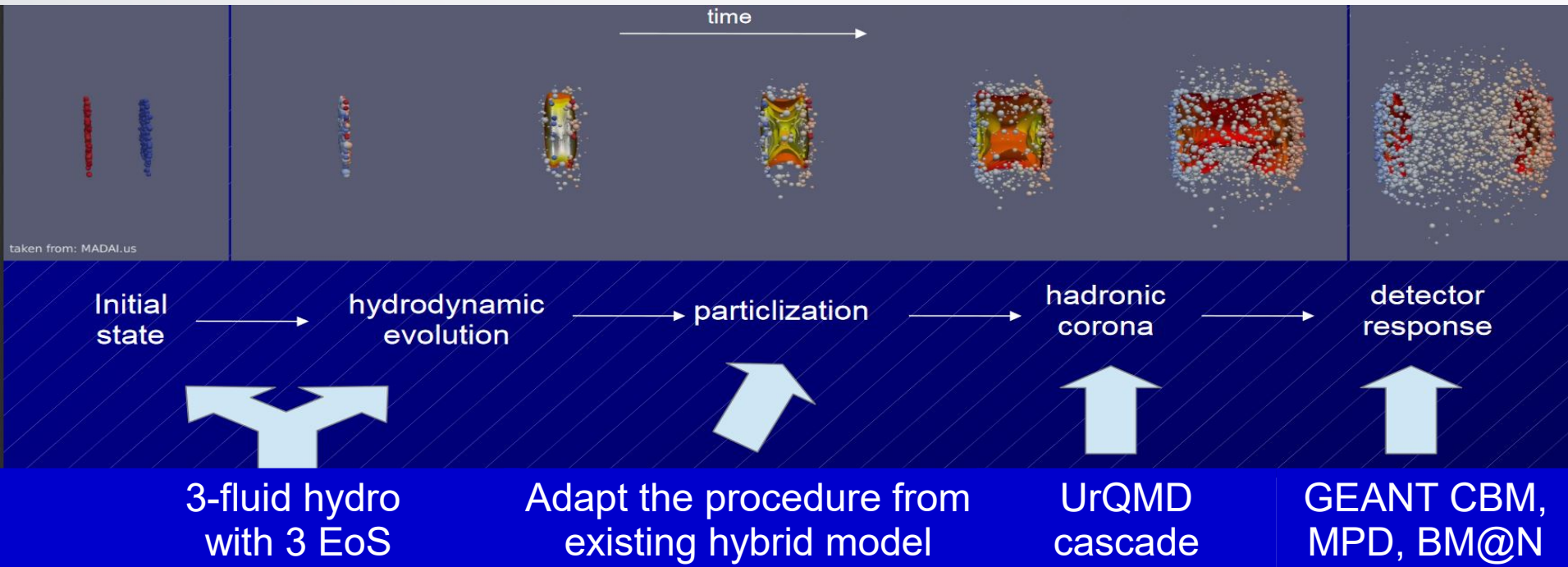
Elena Volkova(Eberhard Karls Universität Tübingen(UT-PIT))
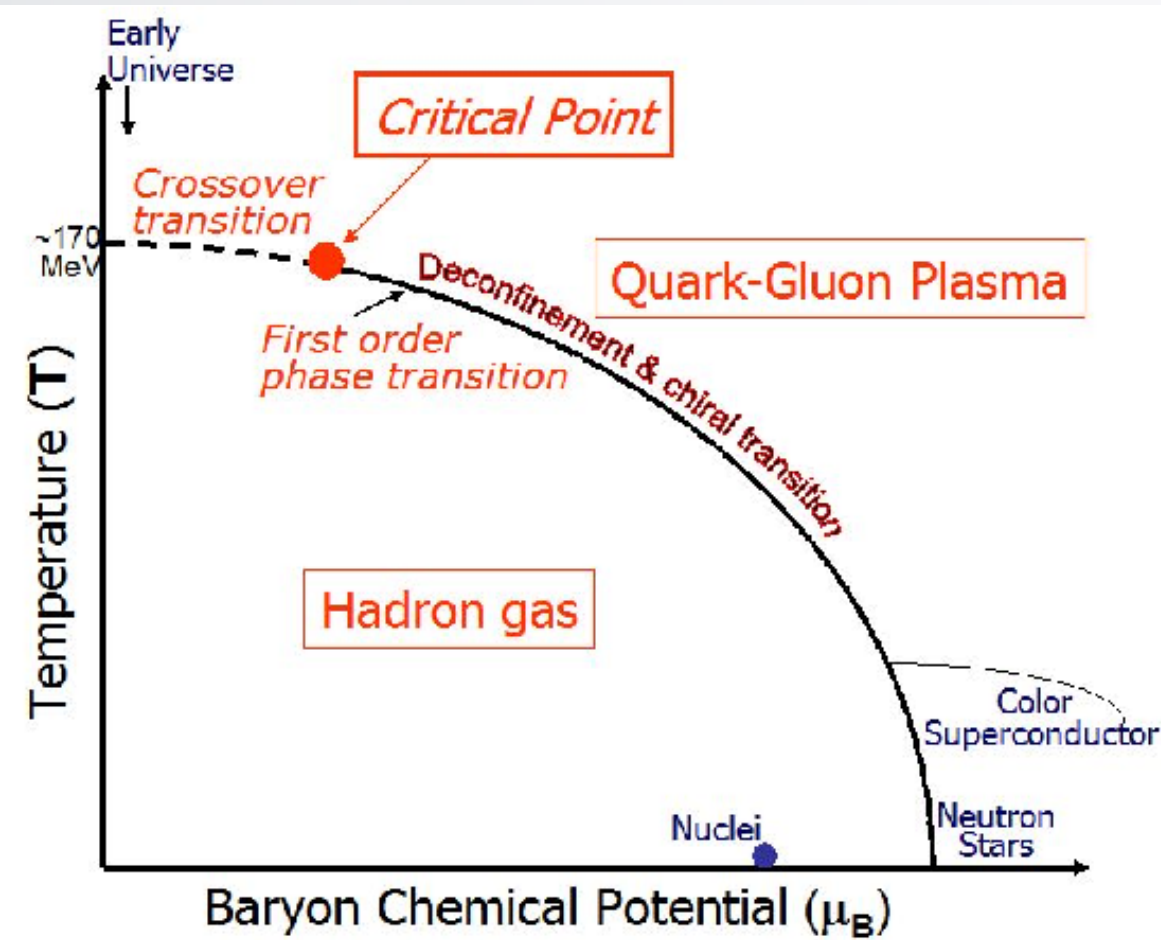for the CBM collaboration

THESEUS

- Three-fluid hydrodynamics (3FH) was developed to simulate heavy-ion collisions at moderately relativistic energies.
- 3 ideals fluids: projectile, target and fireball nucleons
- Particlization is the process of changing from a fluid to a particle description. It allows to apply experimental cuts to particle distributions
- Final state hadronic rescattering processes are simulated using the UrQMD code.

taken from: MADAI.us

Initial state	hydrodynamic evolution	particlization	hadronic corona	detector response
3-fluid hydro with 3 EoS	Adapt the procedure from existing hybrid model		UrQMD cascade	GEANT CBM, MPD, BM@N

Exploring QCD phase diagram

Where is critical point?

Is there phase transition between Hadron gas and QGP?

If yes, which type?

# THESEUS EoS and rapidity distributions

3 different equations of state:
purely hadronic, 1st order phase transition (2-phase) EoS with deconfinement and crossover EoS with deconfinement
Will we see the difference after CBM acceptance cuts?
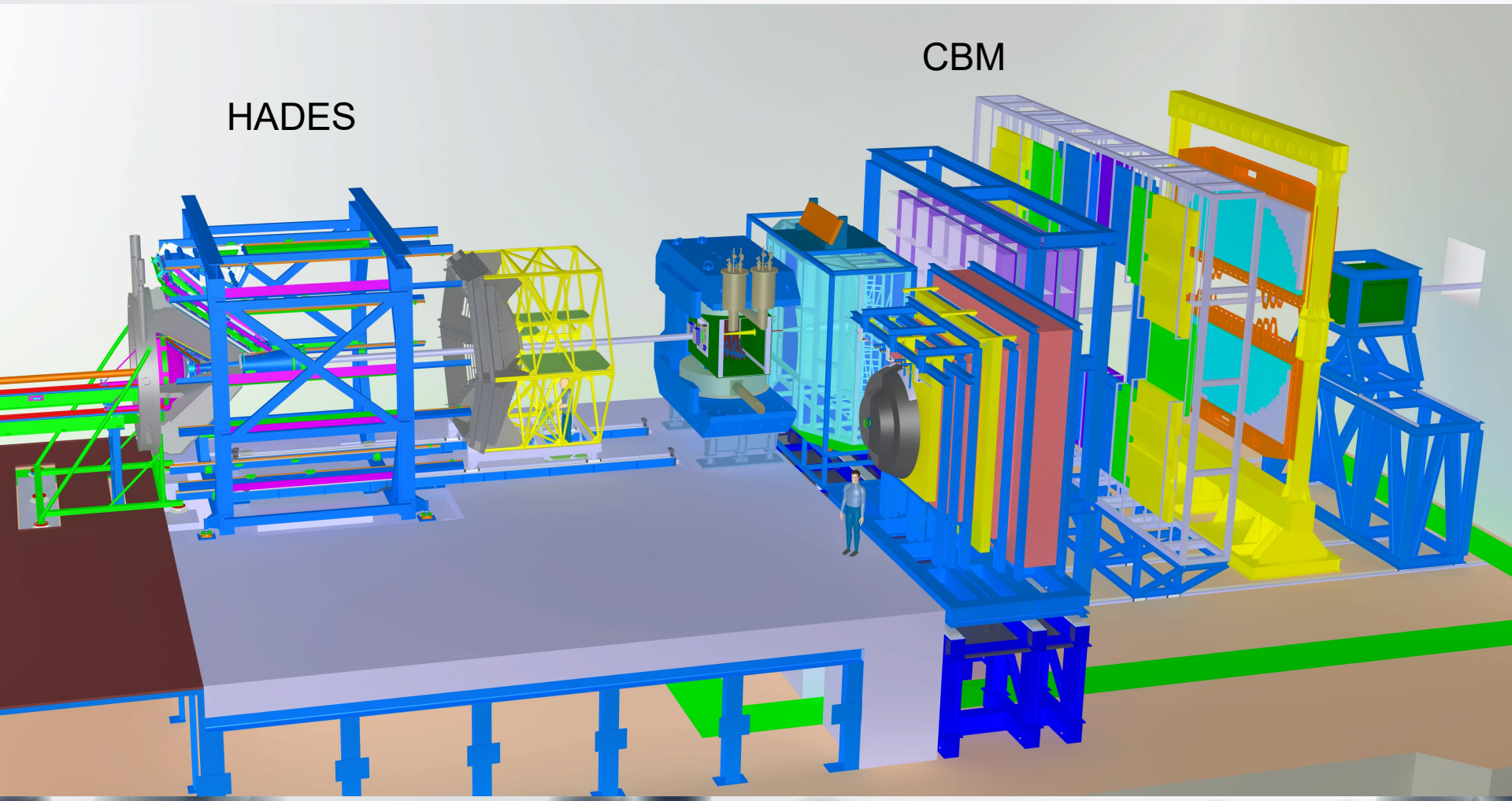
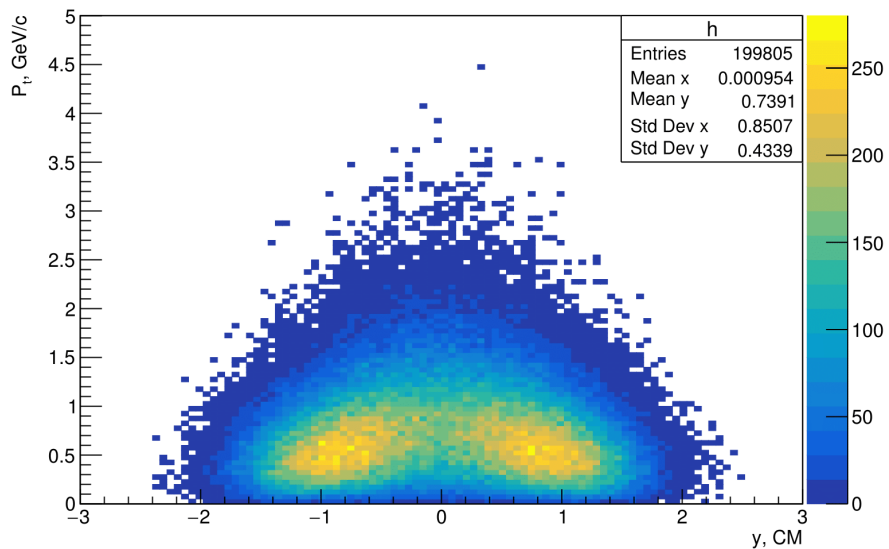Rapidity distribution of THESEUS output

THESEUS, 10 AGeV, b=2fm, proton

Legend:
— hadron gas
— 1st oder phase transition
— crossover

$y-y_{beam}$, CM

dN/dy
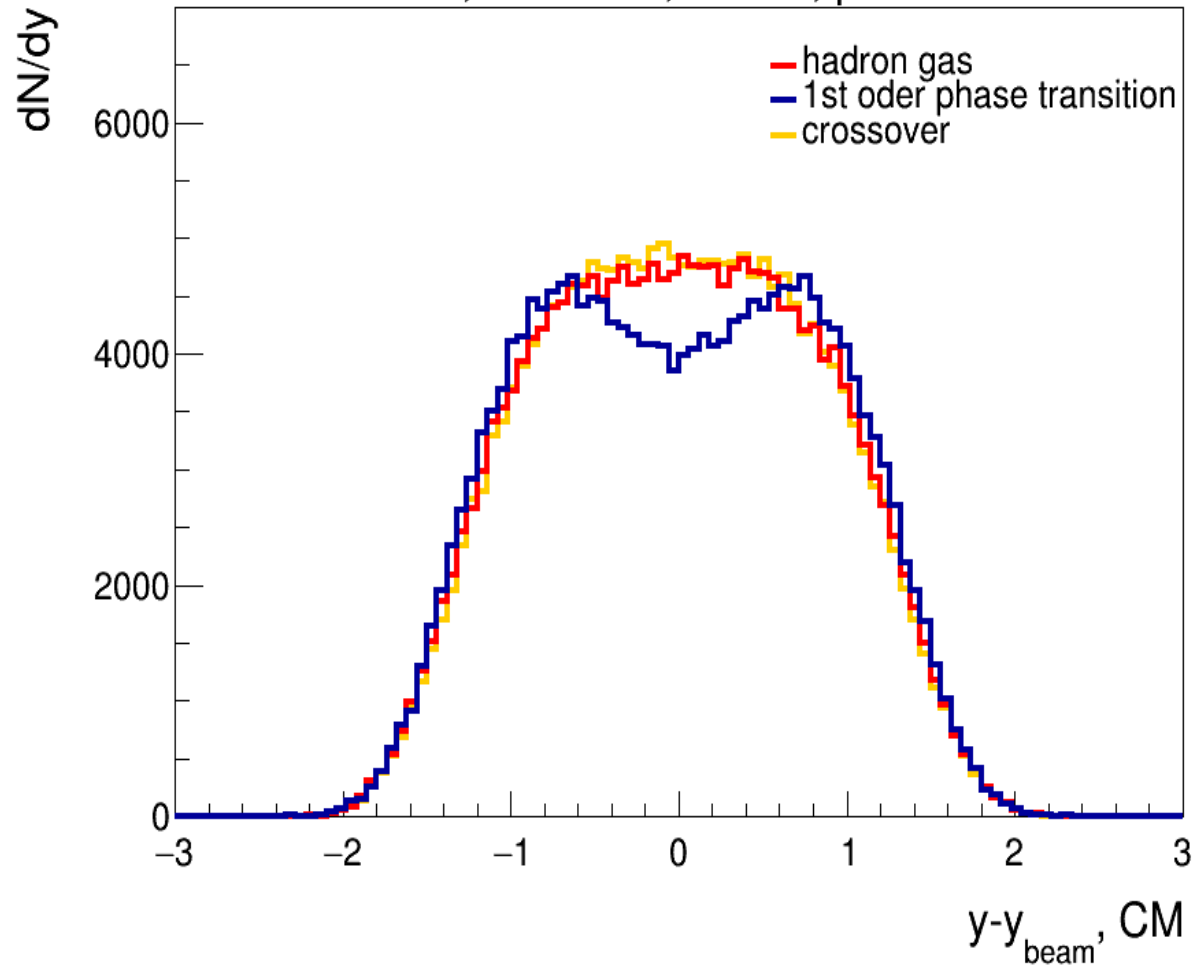
CBM setup

CBM is fixed target experiment with a polar angle acceptance between 2.5^o — 25°
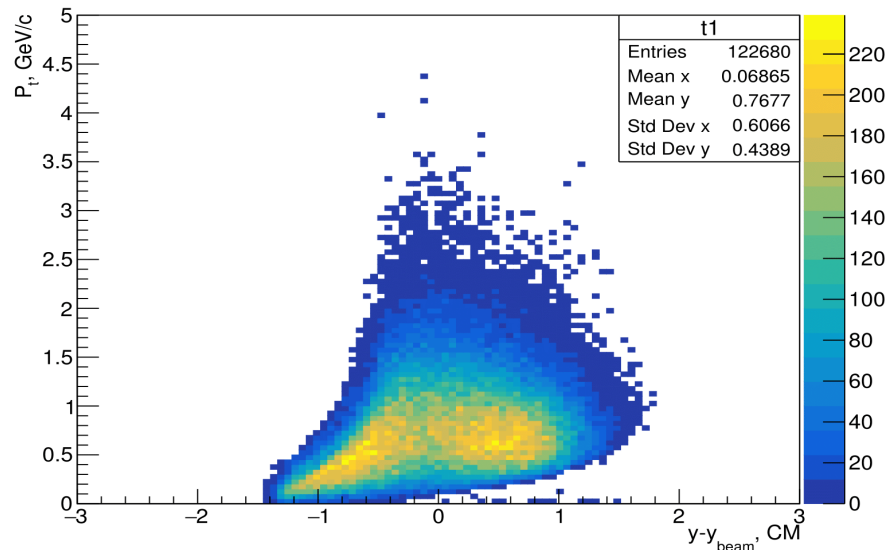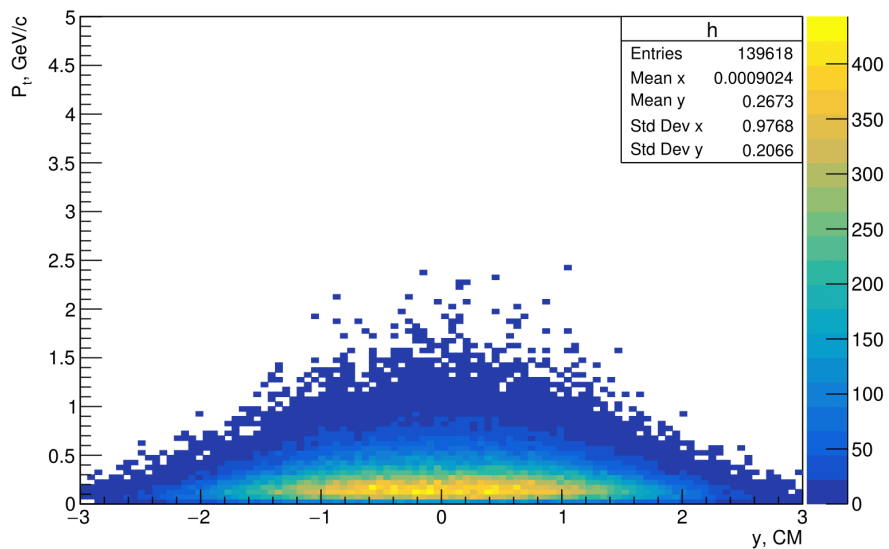Energy range: 2-10 AgeV at SIS100 for AuAu collisions

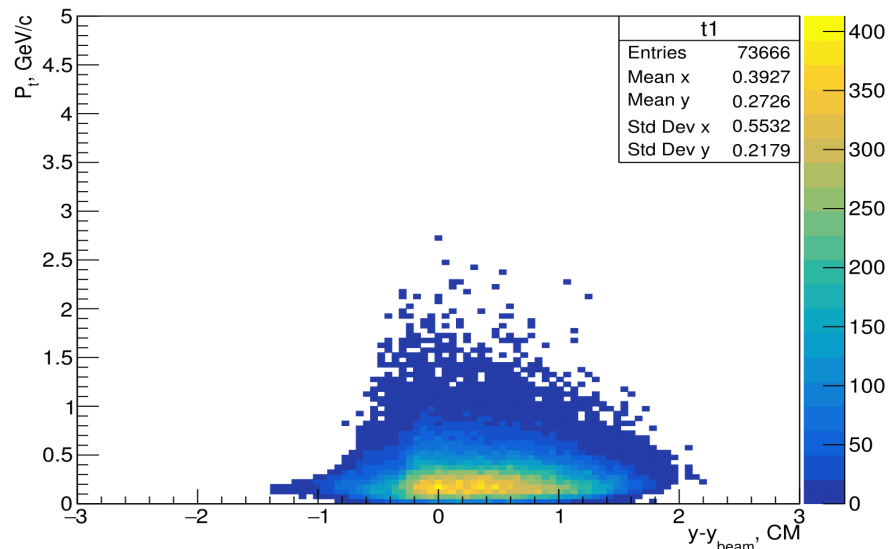# Effect of CBM acceptance cuts

THESEUS, b=2fm, 1st order pht, p
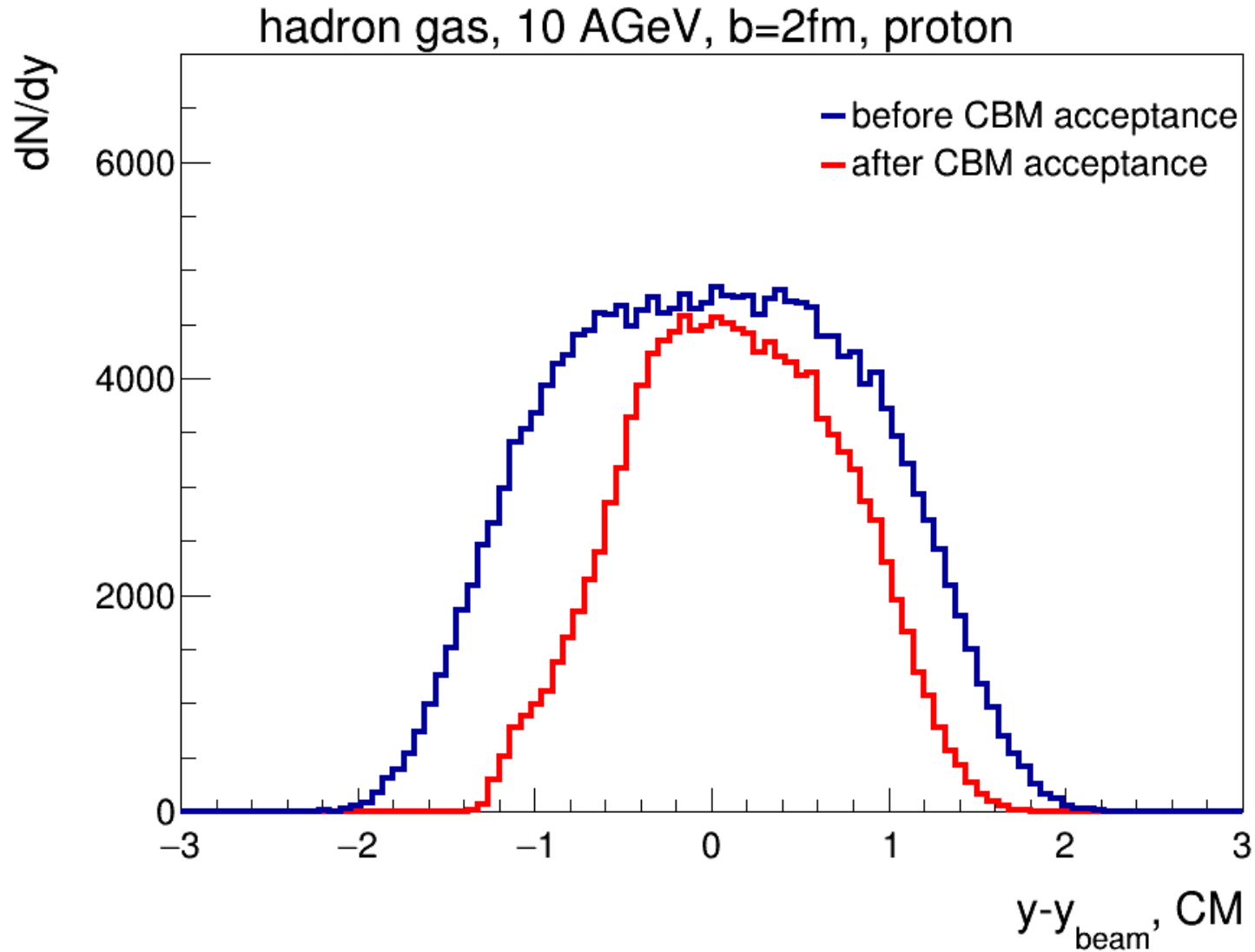
THESEUS + CBM, 10 AGeV, b=2fm, 1st order thp, p

THESEUS, b=2fm, 1st order pht, π^-

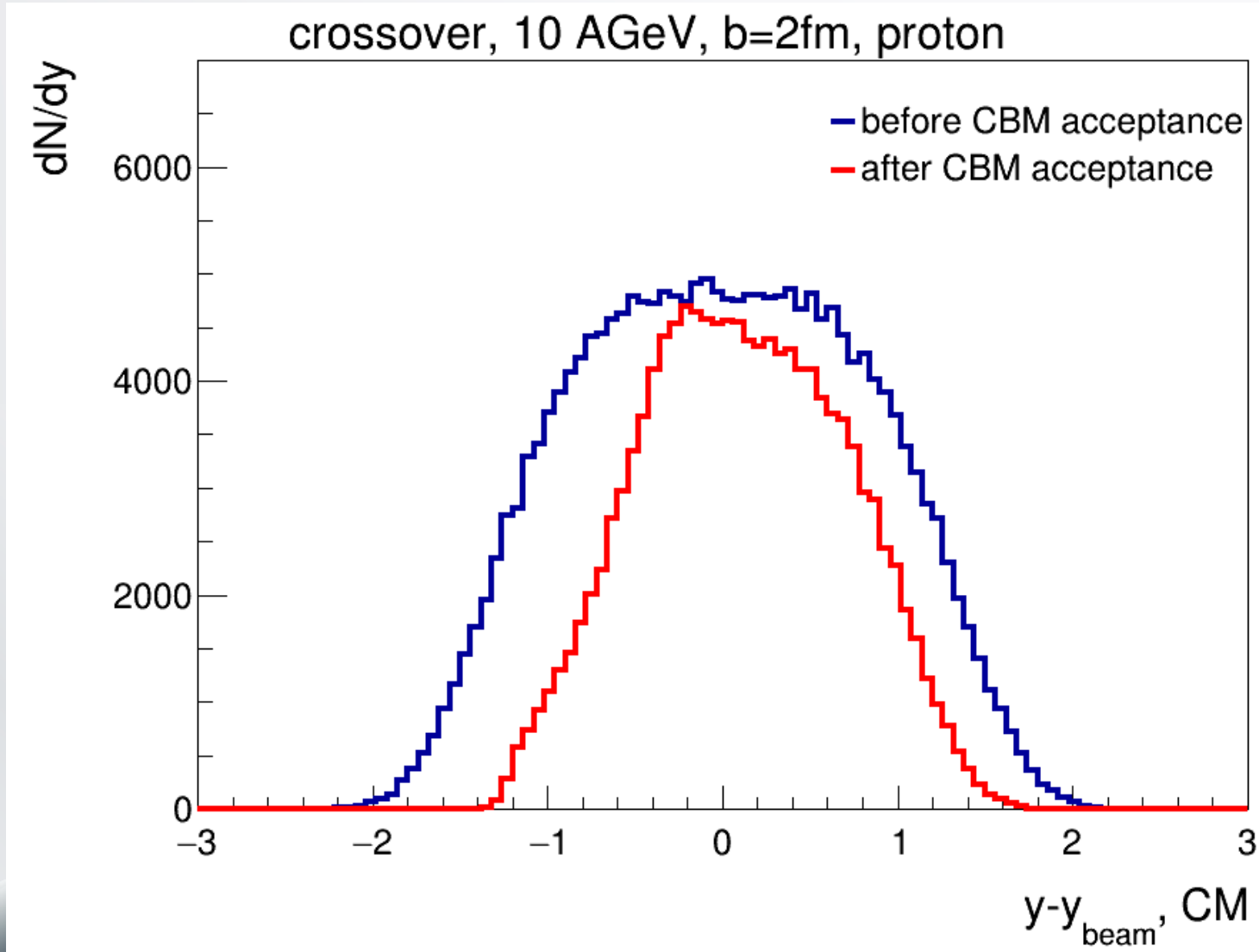THESEUS + CBM, 10 AGeV, b=2fm, 1st order pht, π^-

# Rapidity distribution for hadron gas before and after CBM

hadron gas, 10 AGeV, b=2fm, proton

— before CBM acceptance
— after CBM acceptance

Rapidity distribution for crossover before and after CBM

crossover, 10 AGeV, b=2fm, proton

before CBM acceptance
after CBM acceptance

$y-y_{beam}$, CM

Rapidity distribution for 1ˢᵗ order pht before and after CBM

1st order phase transition, 10 AGeV, b=2fm, proton

— before CBM acceptance
— after CBM acceptance
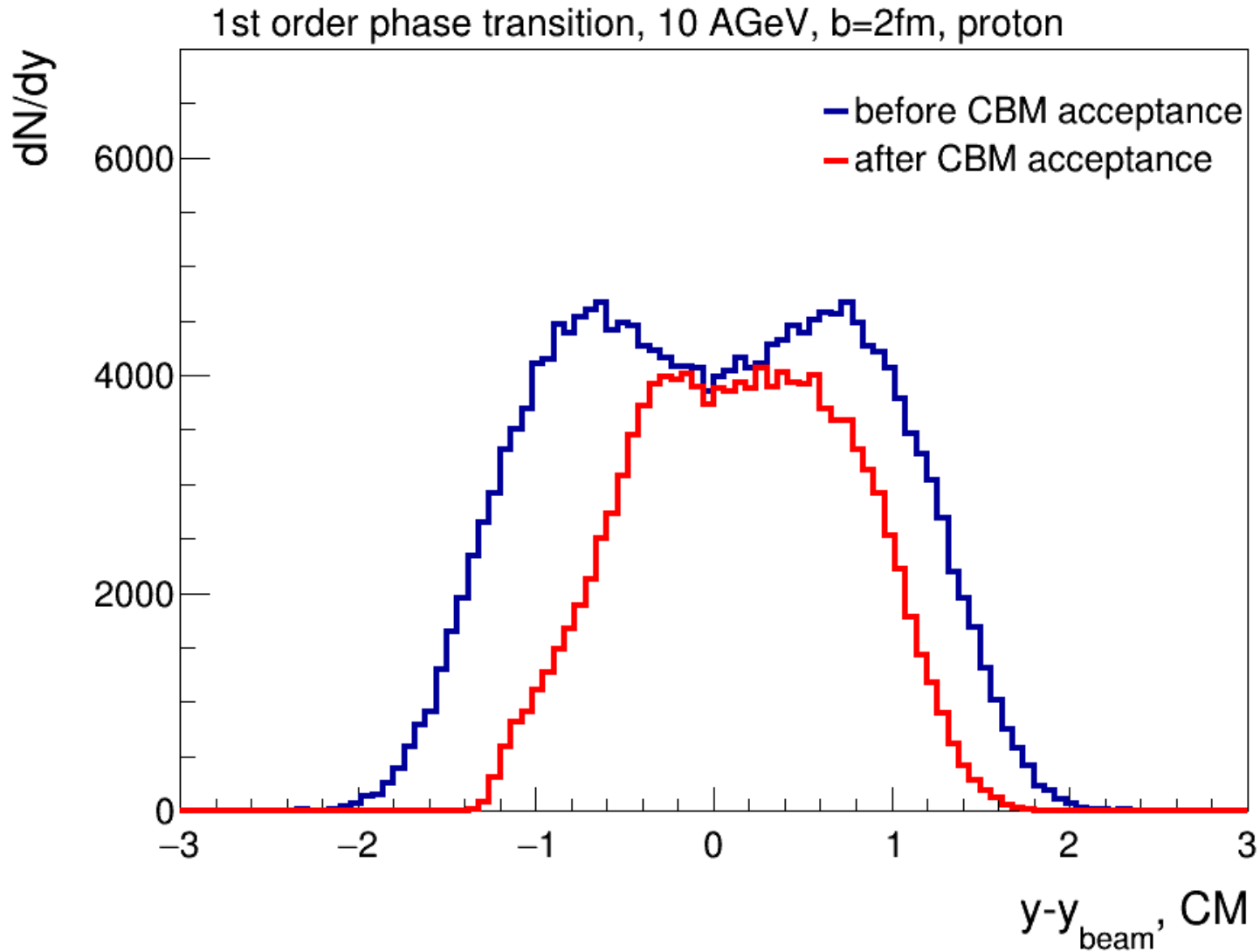
Rapidity distribution for different EoS at 10 AGeV after CBM

THESEUS + CBM, 10 AGeV, b=2fm, proton

- hadron gas
- 1st oder pht
- crossover

dN/dy

$y-y_{beam}$, CM
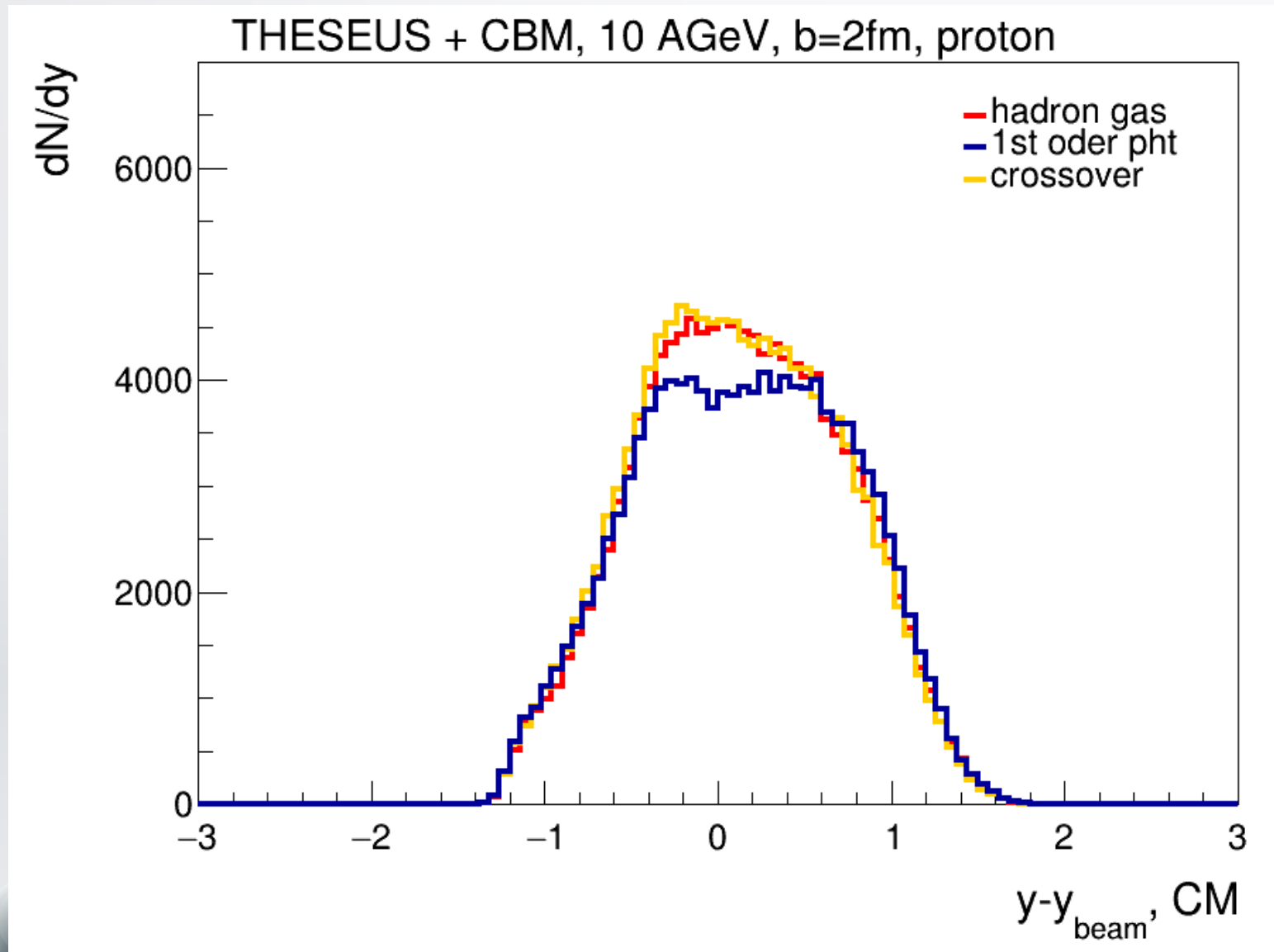
Rapidity distribution for different EoS at 8 AGeV after CBM

THESEUS+CBM, 8 AGeV, b=2fm, proton
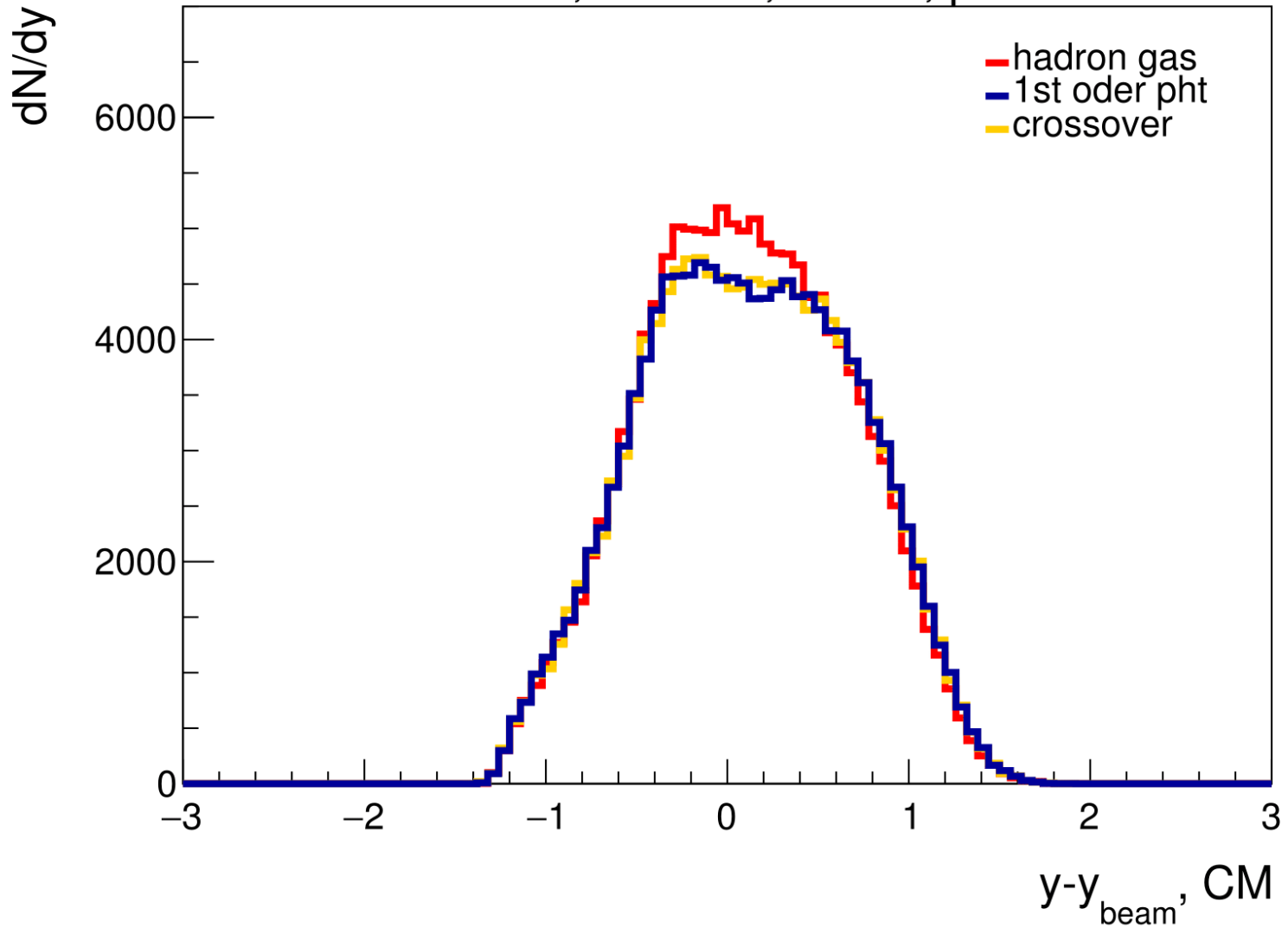
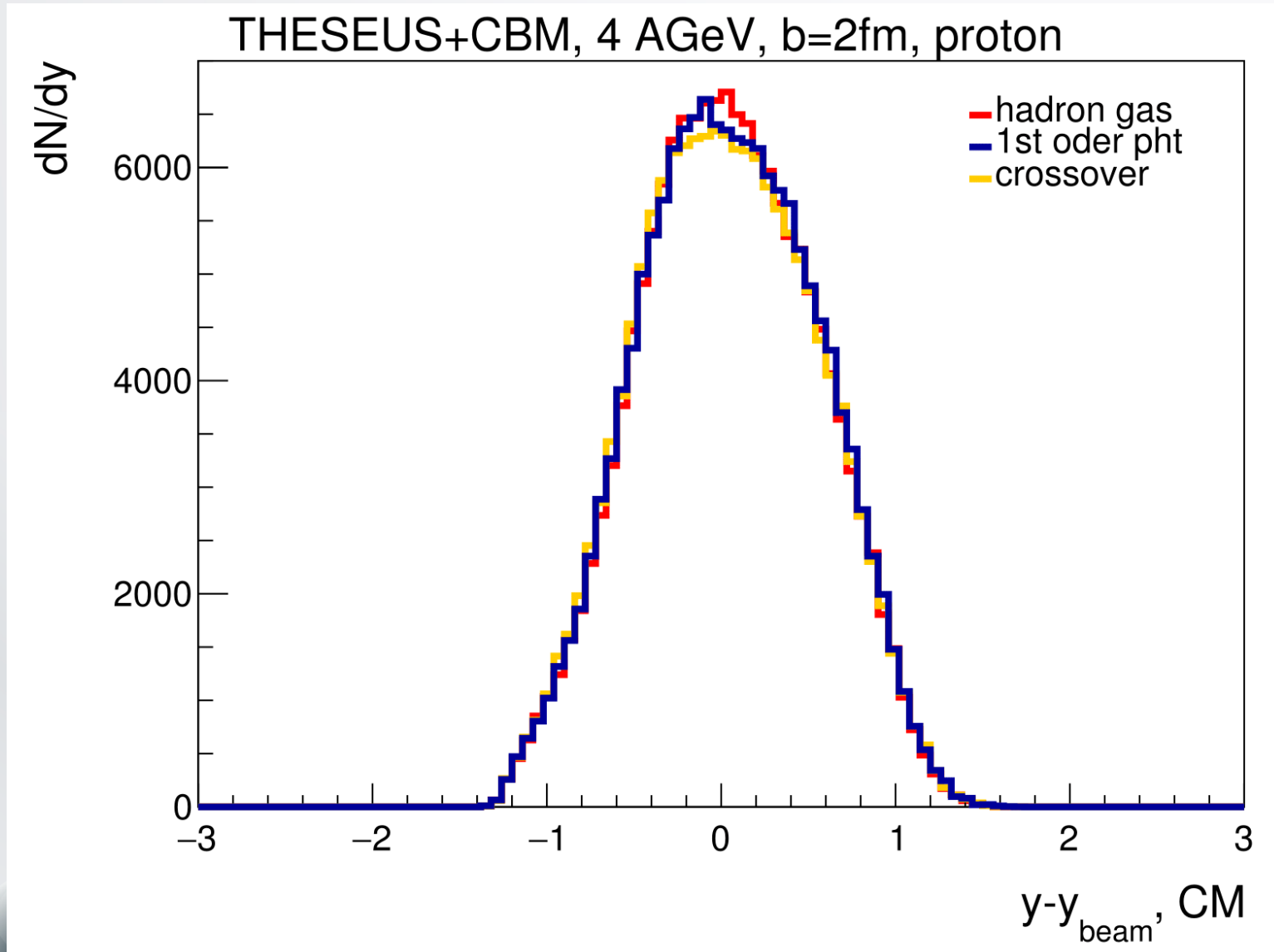# Rapidity distribution for different EoS at 4 AGeV after CBM

THESEUS+CBM, 4 AGeV, b=2fm, proton

Legend:
- hadron gas
- 1st oder pht
- crossover

Y-axis: dN/dy

X-axis: $y-y_{beam}$, CM

# Quantitative analysis of rapidity distributions

Rapidity distribution can be analyzed quantitatively by looking at the curvature at mid-rapidity for different energies.

$$C_y \equiv \left(y_{cm}^3 \frac{d^3N}{dy^3} \right)_{y=y_{cm}} \bigg/ \left(y_{cm} \frac{dN}{dy} \right)_{y=y_{cm}}$$

THESEUS, 1st order pht, proton rapidity, 10 AGeV

2-phase EoS, b = 2 fm

(a)

crossover EoS, b = 2 fm

- THESEUS
- THESEUS w/o UrQMD
- 3FH
- E866, E895, E917
- NA49, Pb+Pb

(b)
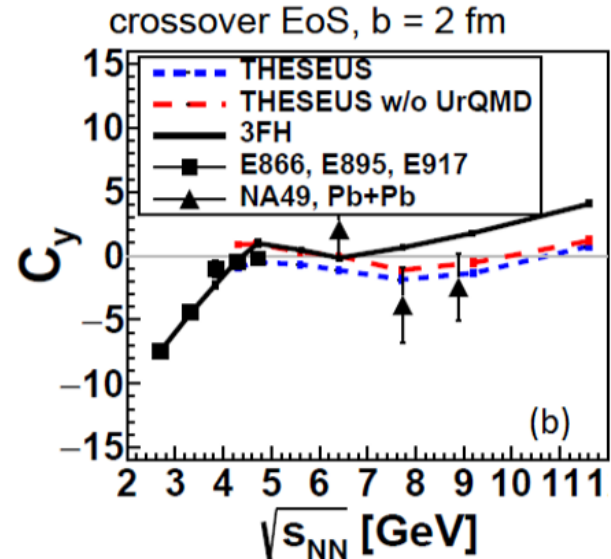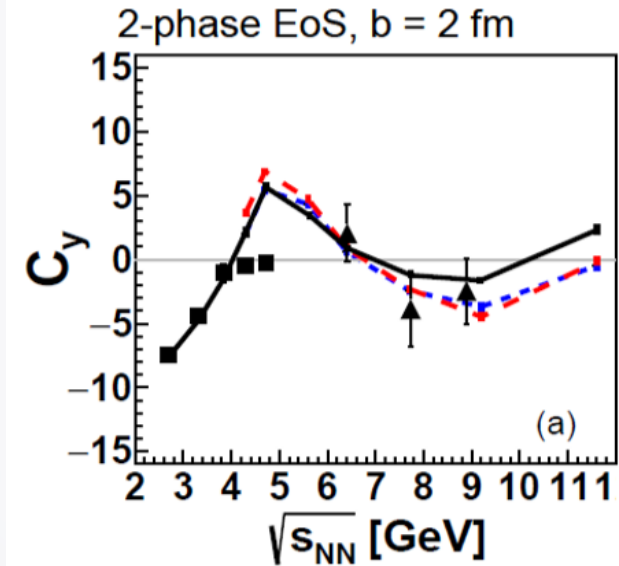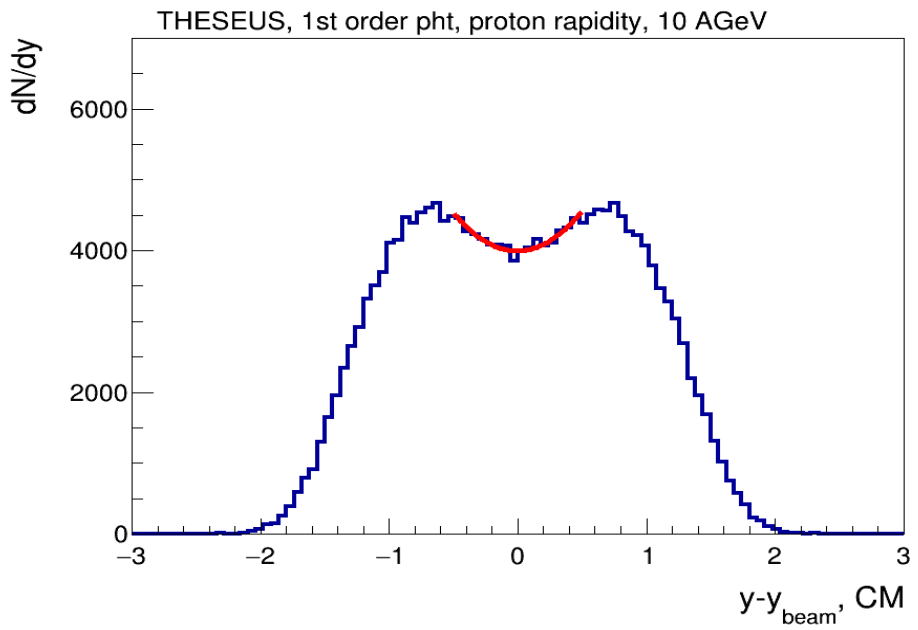
Conclusions

- Features of different EoS are (partly) presented in this talk;
- Rapidity distributions allows in principle to distinguish 1st order phase transition EoS and crossover with gas EoS;
- This features are preserved to some extend also with CBM acceptance cuts.
- The midrapidity shape can be measured by its «curvature»;
- Energy scan for the curvature C_y of the net proton rapidity distribution is observable for differentiation EoS. («Event simulation based on three-fluid hydrodynamics for collisions at energies available at the NICA and at the FAIR» P.Batyuk, D.Blaschke,Yu. B.Ivanov, Iu.Karpenko)
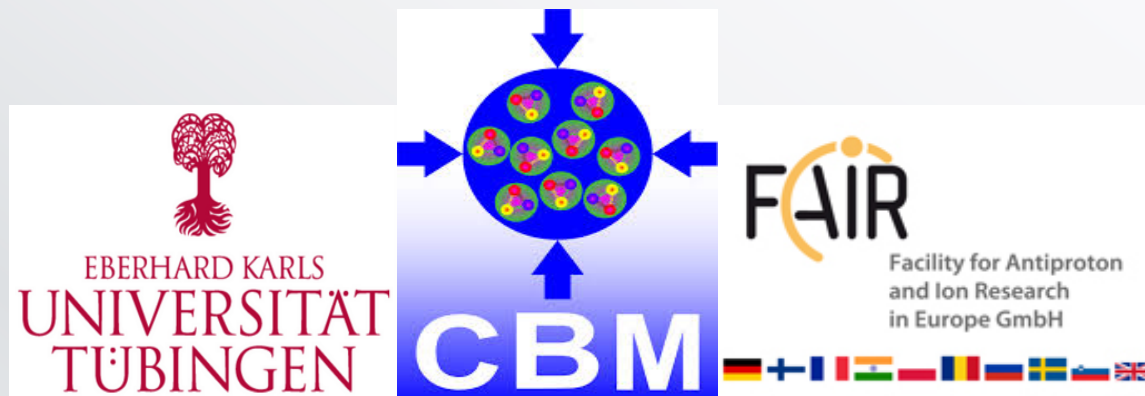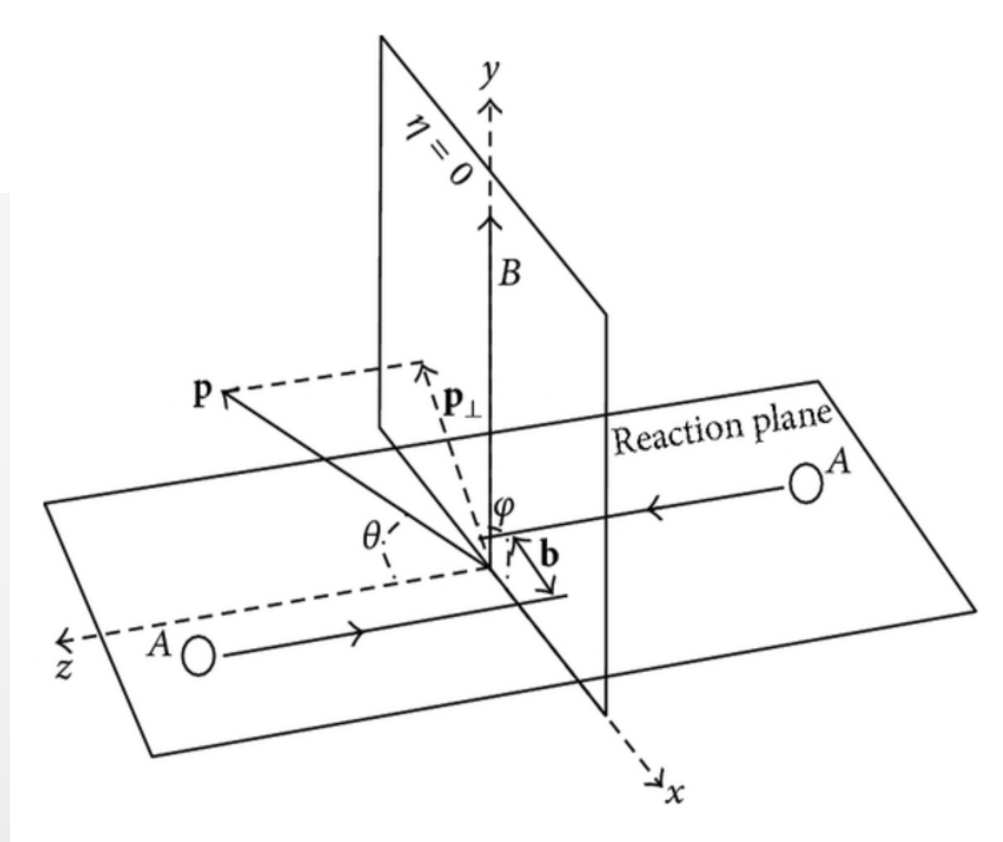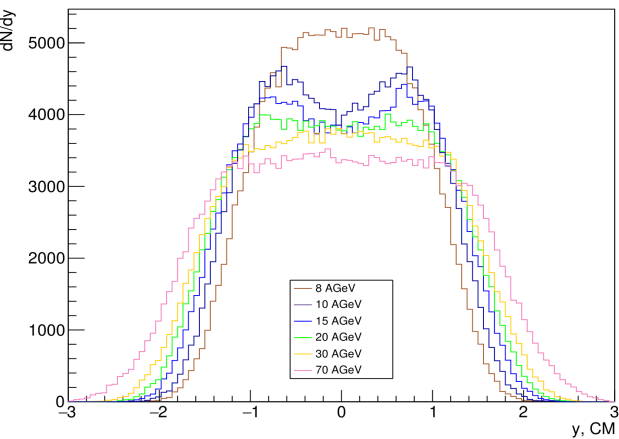
Backup

$$Y = \frac{1}{2} \ln(E+pz/E-pz)$$

$$C_y \equiv \left(y_{cm}^3 \frac{d^3 N}{dy^3} \right)_{y=y_{cm}} \Big/ \left(y_{cm} \frac{dN}{dy} \right)_{y=y_{cm}}$$
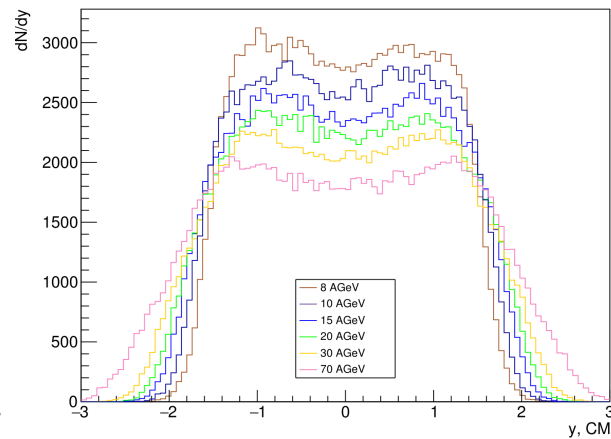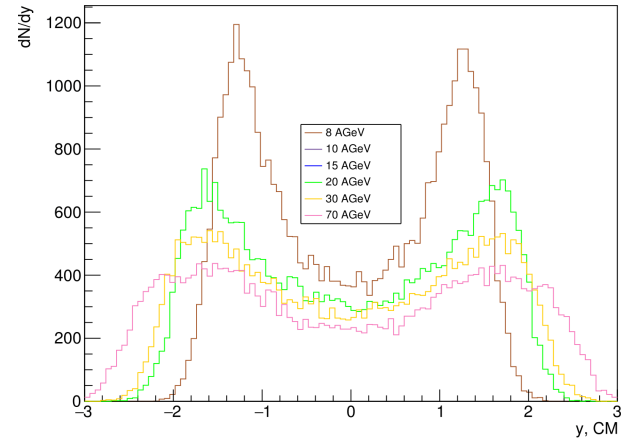
Rapidity evolution with energy