Perspectives of correlation femtoscopy studies at NICA and STAR BES energies.

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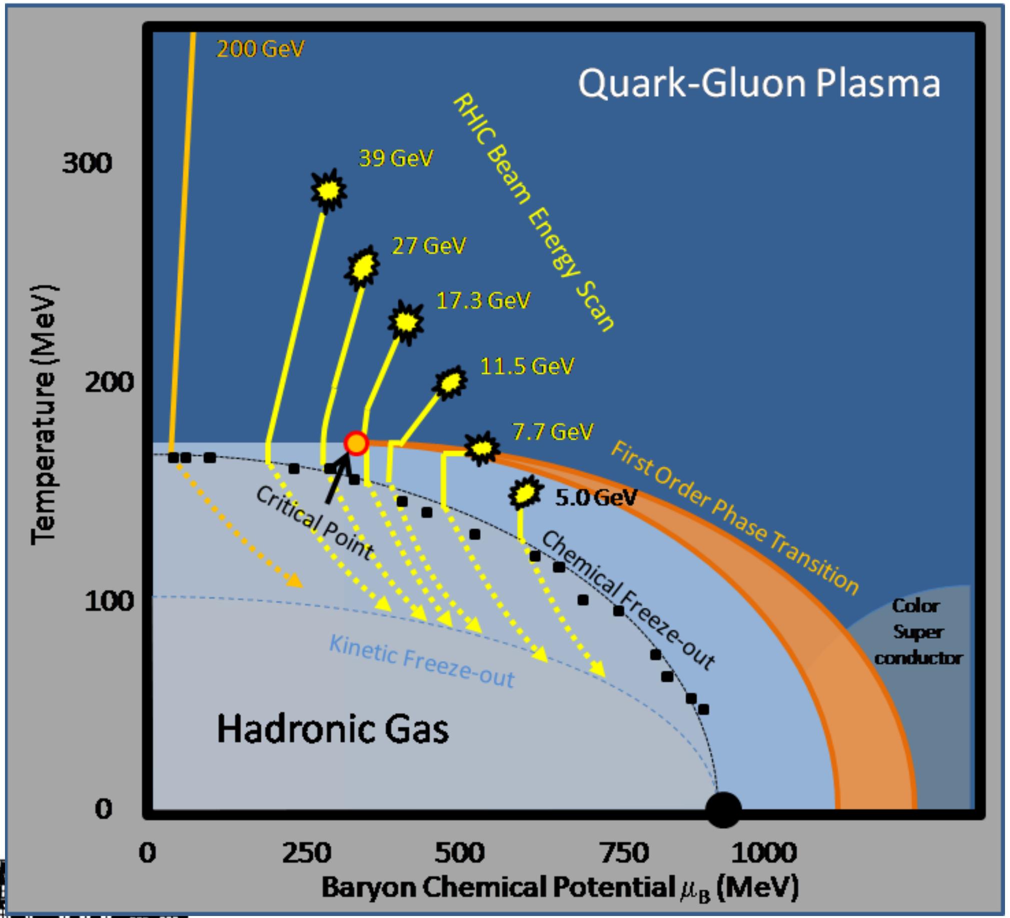
Phase diagram



1st order PT –> latent heat -> Longer emission duration and lifetime of system -> bigger R_{out}, R_{long}

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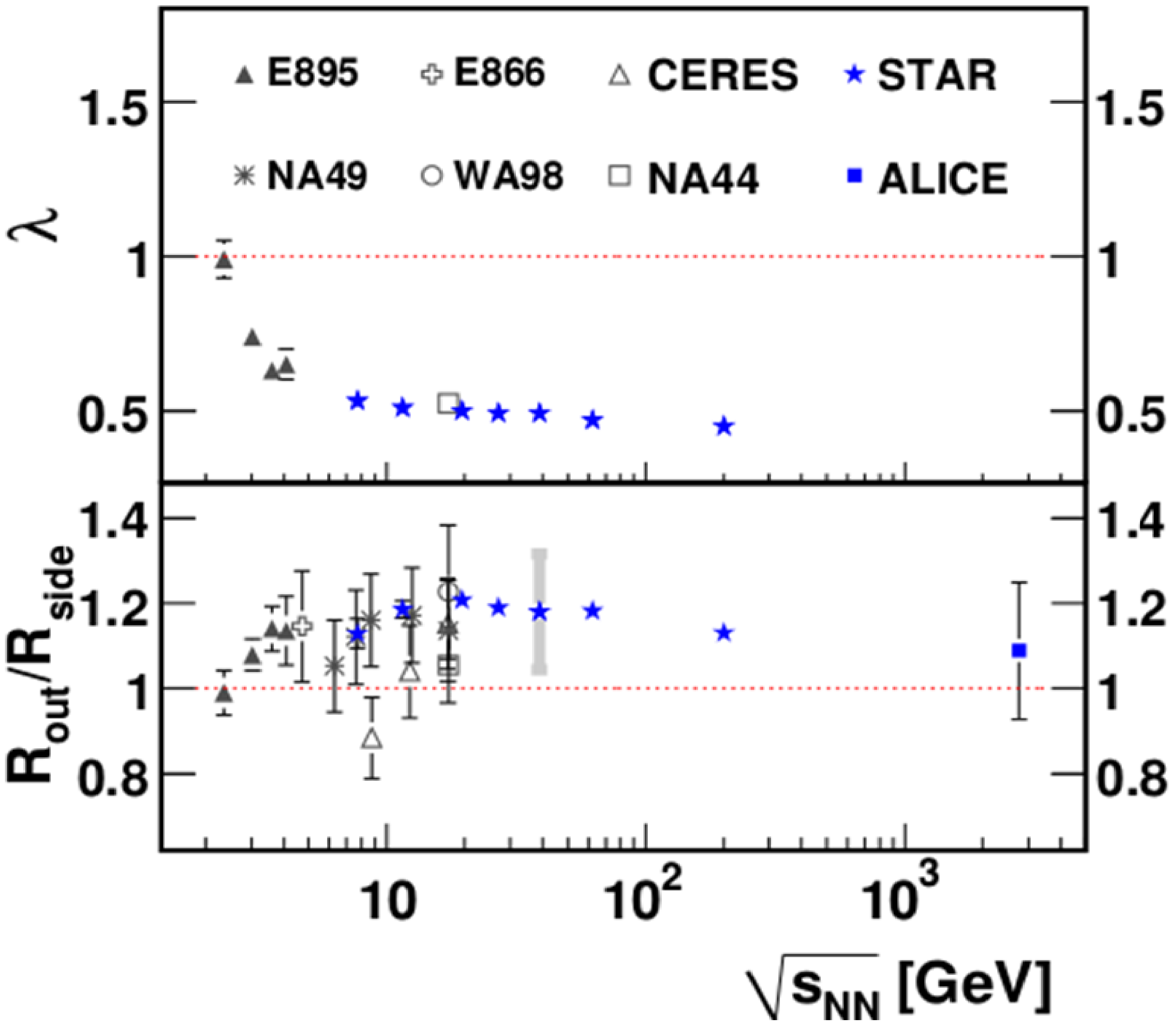
STAR Results

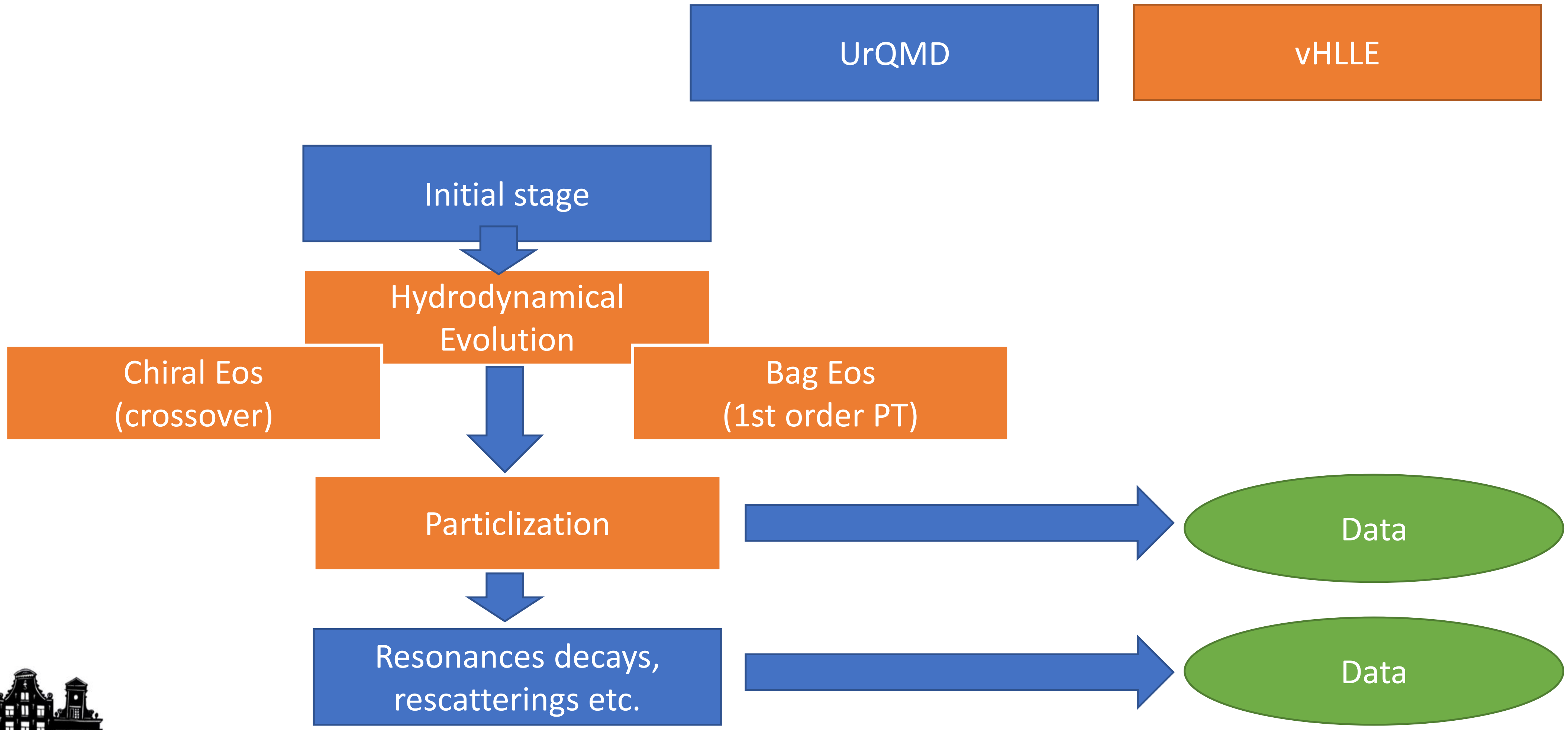
No clear signal!
Only „wide maximum ~20 GeV”
- but few times smaller than systematic uncertainties!



STAR Results

- No clear signature observed
  - small effect?
  - suppression after hadronization?
  - other?

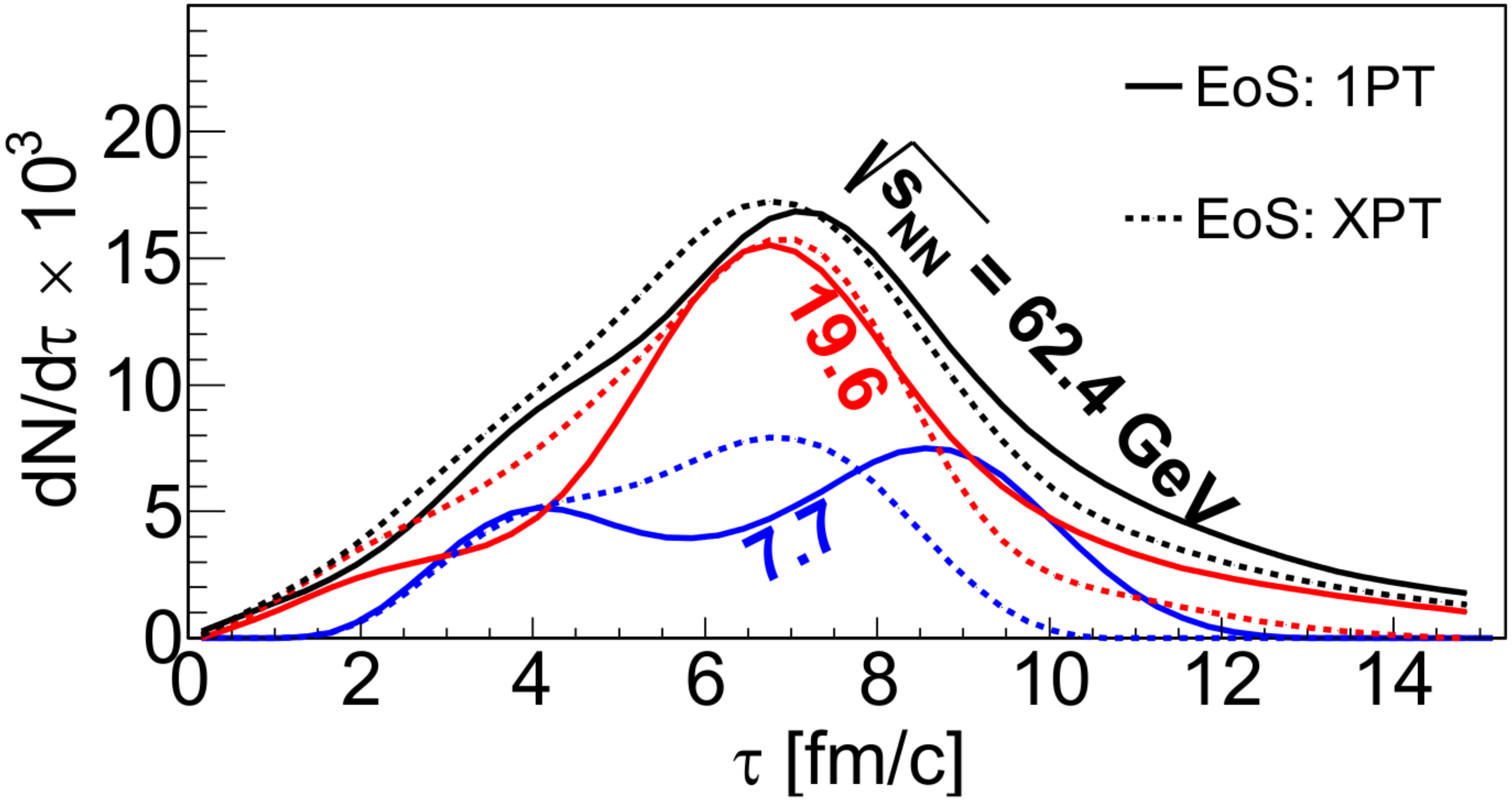
vHLLE+UrQMD


UrQMD
vHLLE
Initial stage
Hydrodynamical Evolution
Chiral Eos (crossover)
Bag Eos (1st order PT)
Particlization
Data
Resonances decays, rescatterings etc.
Data

vHLLE+UrQMD

- Designed for BES energies
- Parameters of model used for preparing this presentation– tuned for spectra, yields, elliptic flow, no „HBT tuning”
- more in Iu. Karpenko talk (Wednesday)

Particlization proper time



1PT = 1st order PT
XPT = crossover transition

$$\tau = \sqrt{t^2 - z^2}$$

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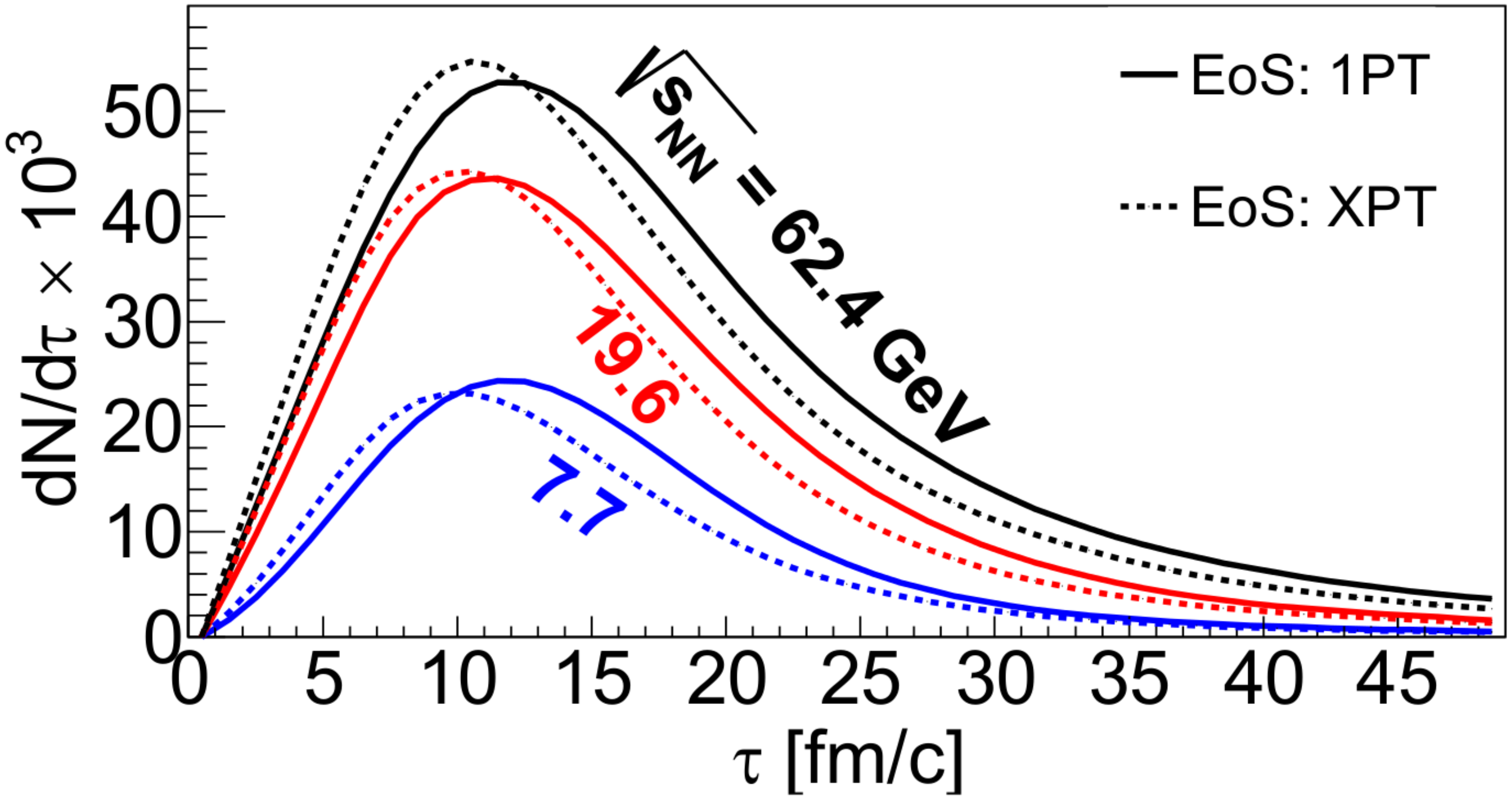
Last interaction proper time



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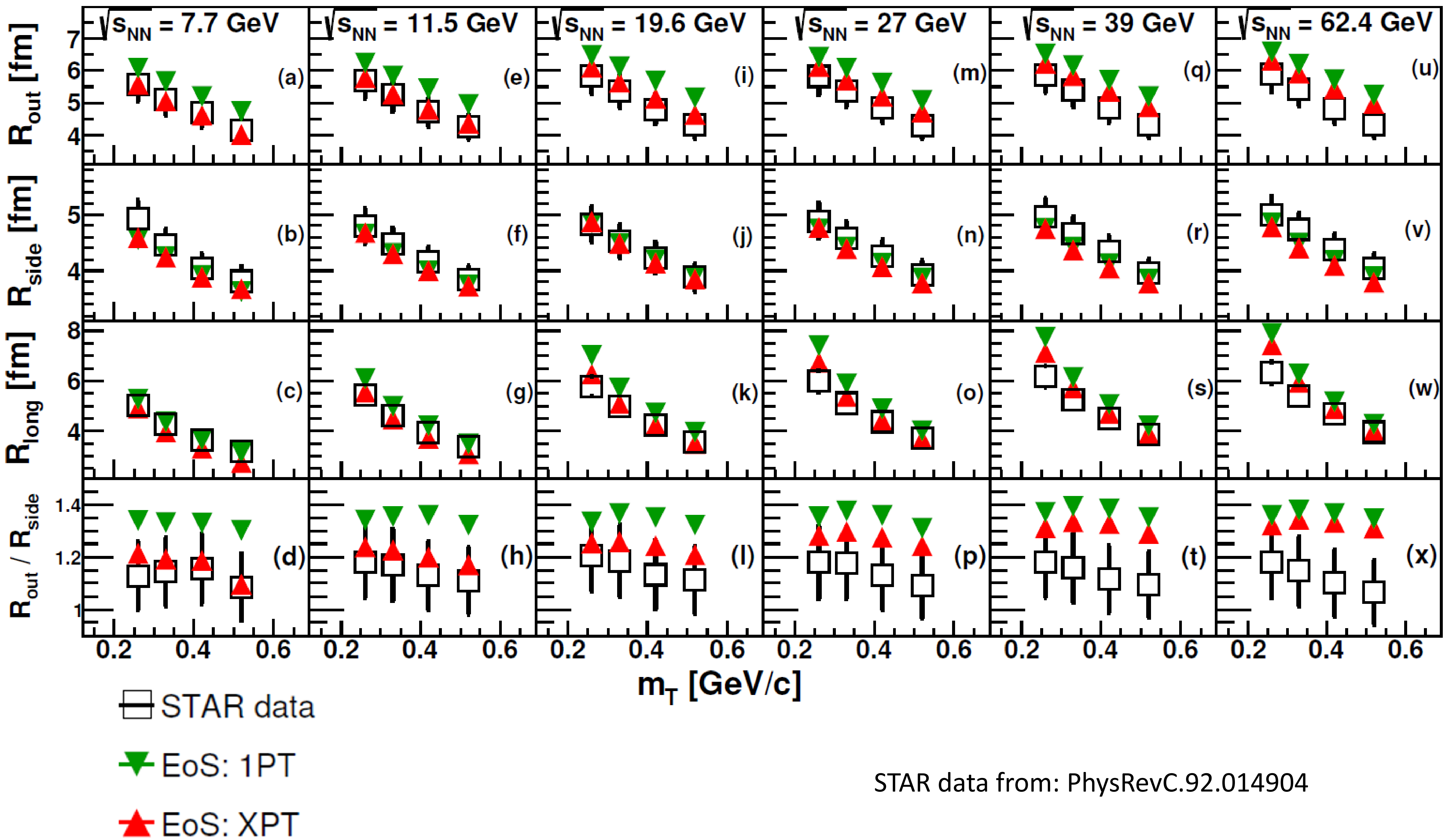
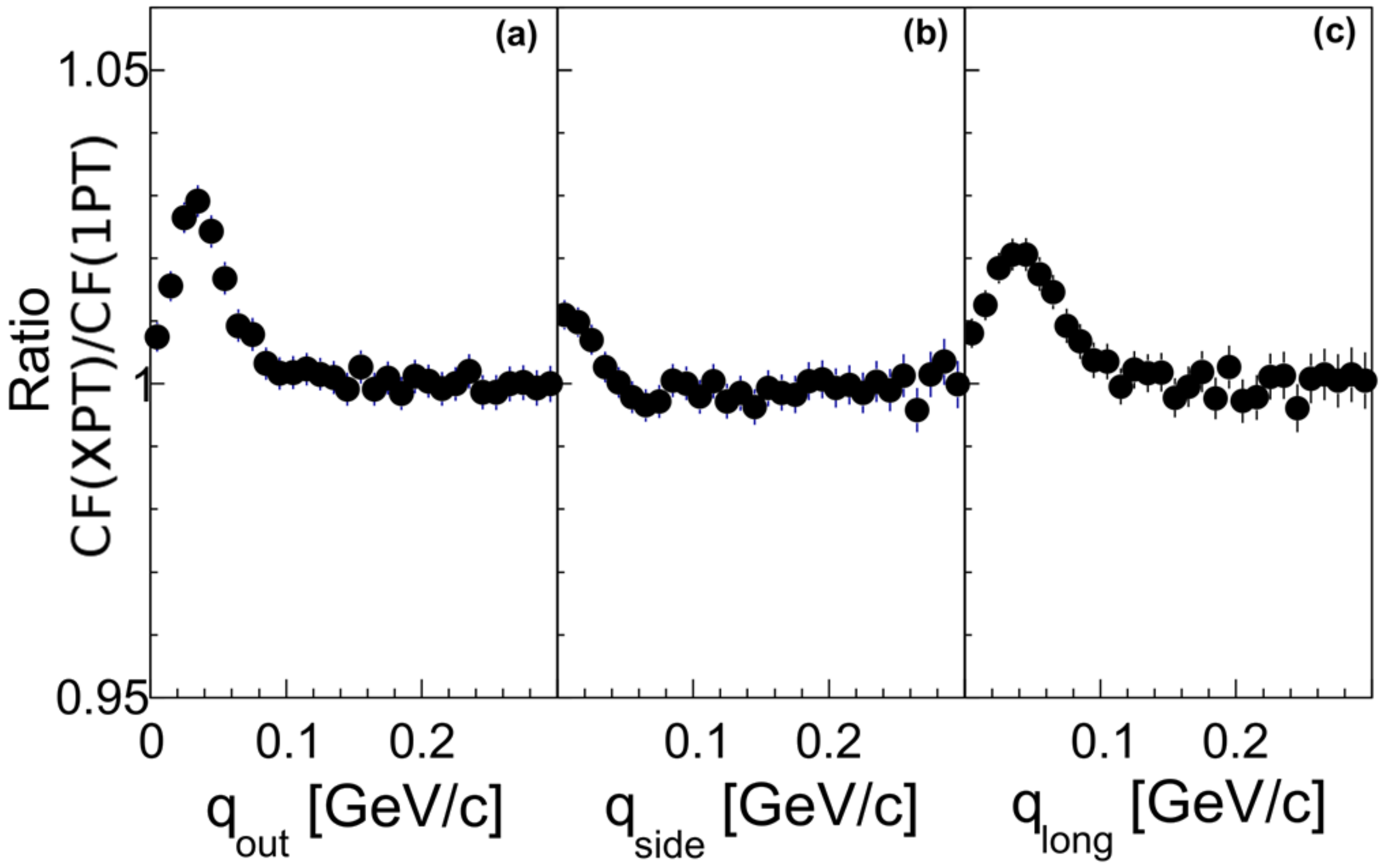


STAR data from: PhysRevC.92.014904

Femtoscopic measurements

Crossover transition

1st order PT
Correlation Functions ratio
at 7.7 GeV



Femtoscopic measurements

- R_{out} – modified by EoS (increased emission duration)
- R_{long} – modified by EoS (increased emission time)
- R_{side} – not modified by EoS
- Bigger difference between both scenarios at lower energy
- Difference comparable to systematic errors reported by STAR experiment

Femtoscopic measurements

- Systematic errors during fitting in STAR $\pi^{\pm}\pi^{\pm}$ system:

Source	R_{out}	R_{side}	R_{long}	ε_F
Coulomb	4%	3%	4%	0.004
Fit Range	5%	5%	5%	0.002
FMH	7%	3%	3%	0.003
Total	9.5%	6.5%	7%	0.005

FMH – Fraction of Merged Hits

from: PhysRevC.92.014904

Source emission function

- Gaussian shape $S_g = Ne^{-\left(\frac{r_x}{2R_x}\right)^2 - \left(\frac{r_y}{2R_y}\right)^2 - \left(\frac{r_z}{2R_z}\right)^2}$
- 2-gaussian shape $S_{g2} = N\left[\lambda_1\, e^{\left(\frac{r_x}{2R_{xl}}\right)^2 + \left(\frac{r_y}{2R_{yl}}\right)^2 + \left(\frac{r_z}{2R_{zl}}\right)^2} + \lambda_2\, e^{\left(\frac{r_x}{2R_{xs}}\right)^2 + \left(\frac{r_y}{2R_{ys}}\right)^2 + \left(\frac{r_z}{2R_{zs}}\right)^2}\right]$
- Humpian shape

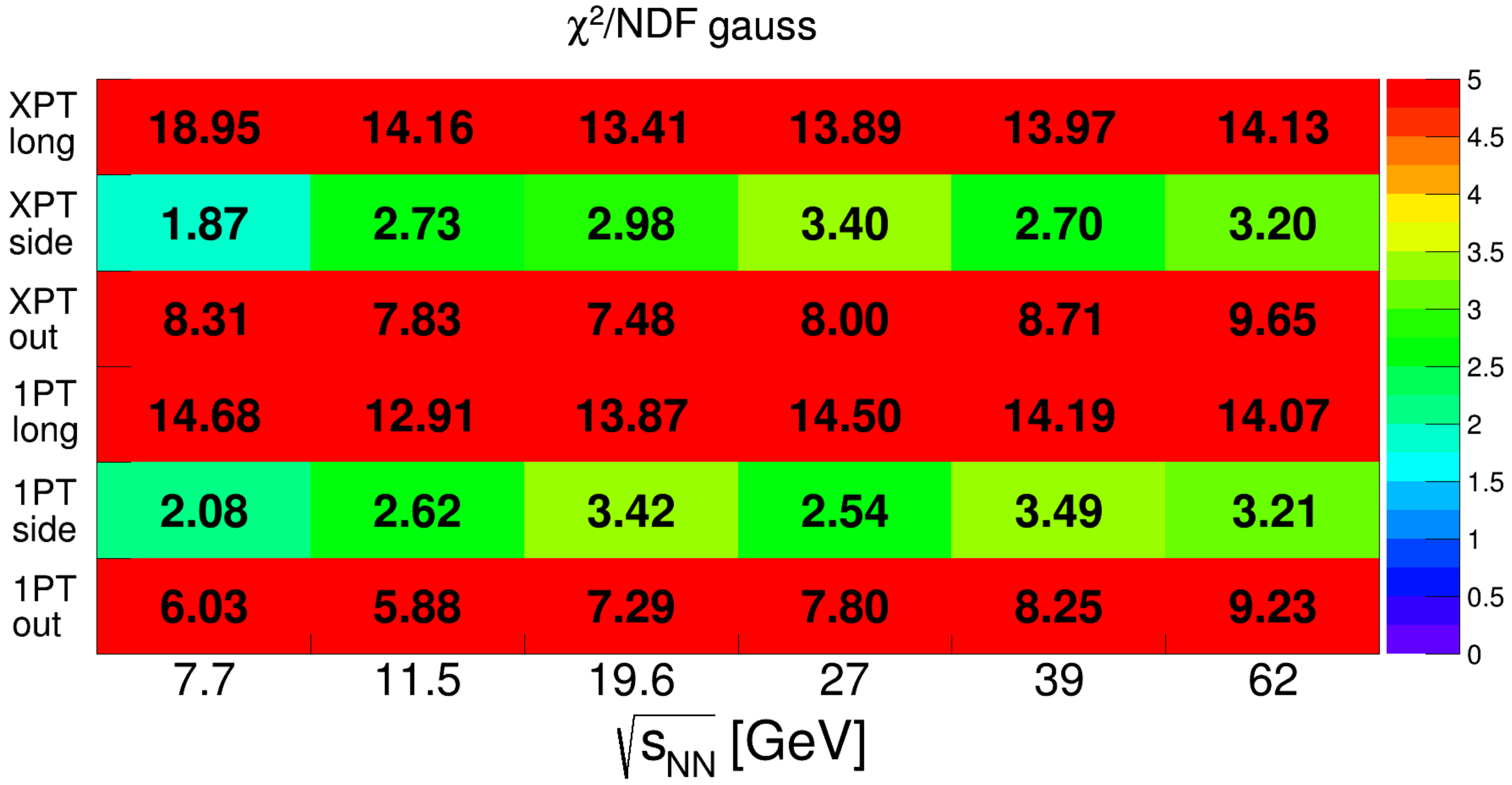
$$S^H(r_x, r_y, r_z) = e^{-F_s\left[\left(\frac{r_x}{2R_{xs}}\right)^2 + \left(\frac{r_y}{2R_{ys}}\right)^2 + \left(\frac{r_z}{2R_{zs}}\right)^2\right] - F_l\left[\left(\frac{r_x}{2R_{xl}}\right)^2 + \left(\frac{r_y}{2R_{yl}}\right)^2 + \left(\frac{r_z}{2R_{zl}}\right)^2\right]}$$

$$F_s = \frac{1}{1 + (r/r_0)^2}, \quad F_l = 1 - F_s$$

Source emission function

Gaussian fit

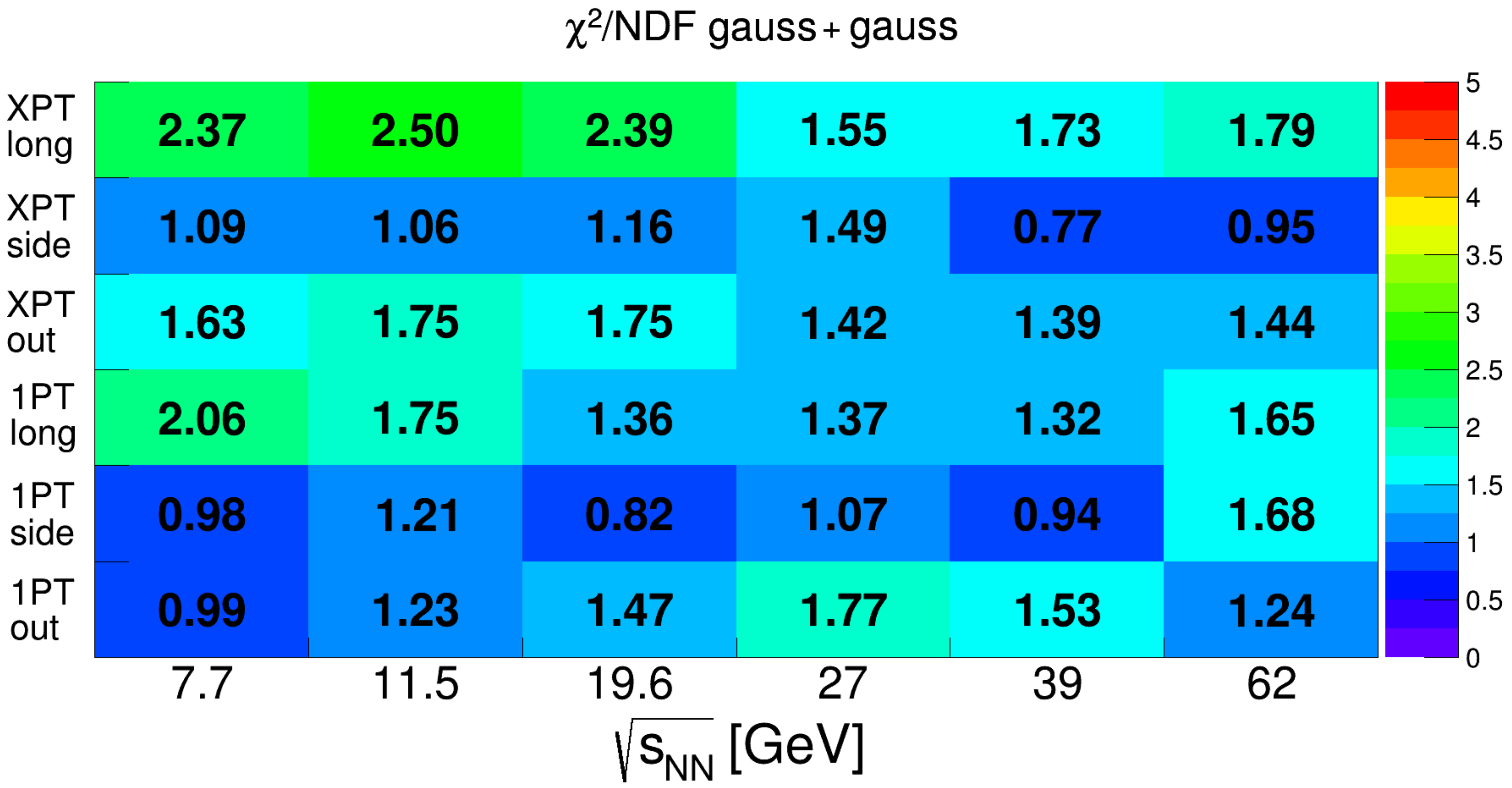
Good for „out”
bad for other
directions



Source emission function

- 2-gaussian fit

Quite good for all directions



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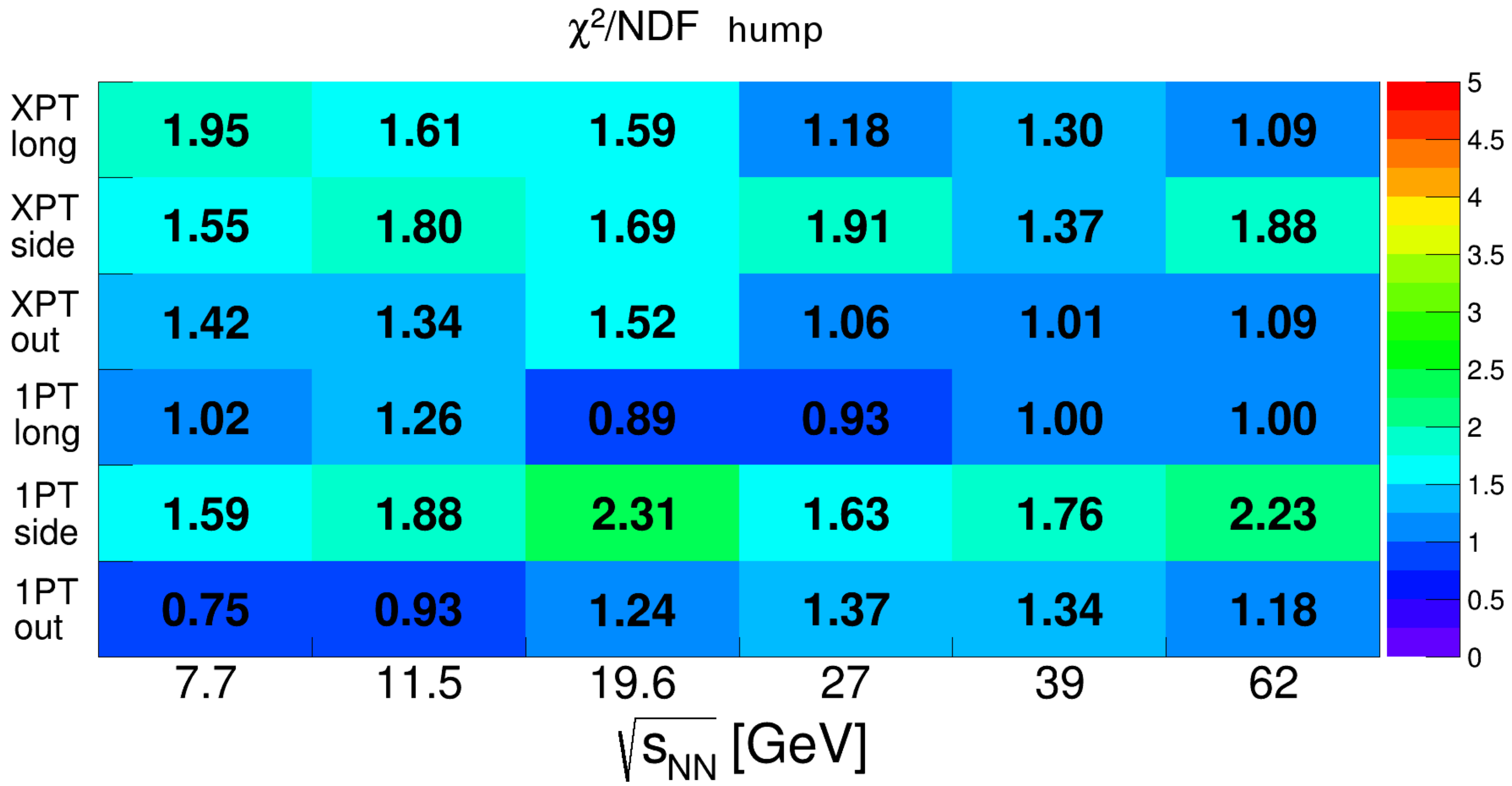
Source emission function

- Humpian fit

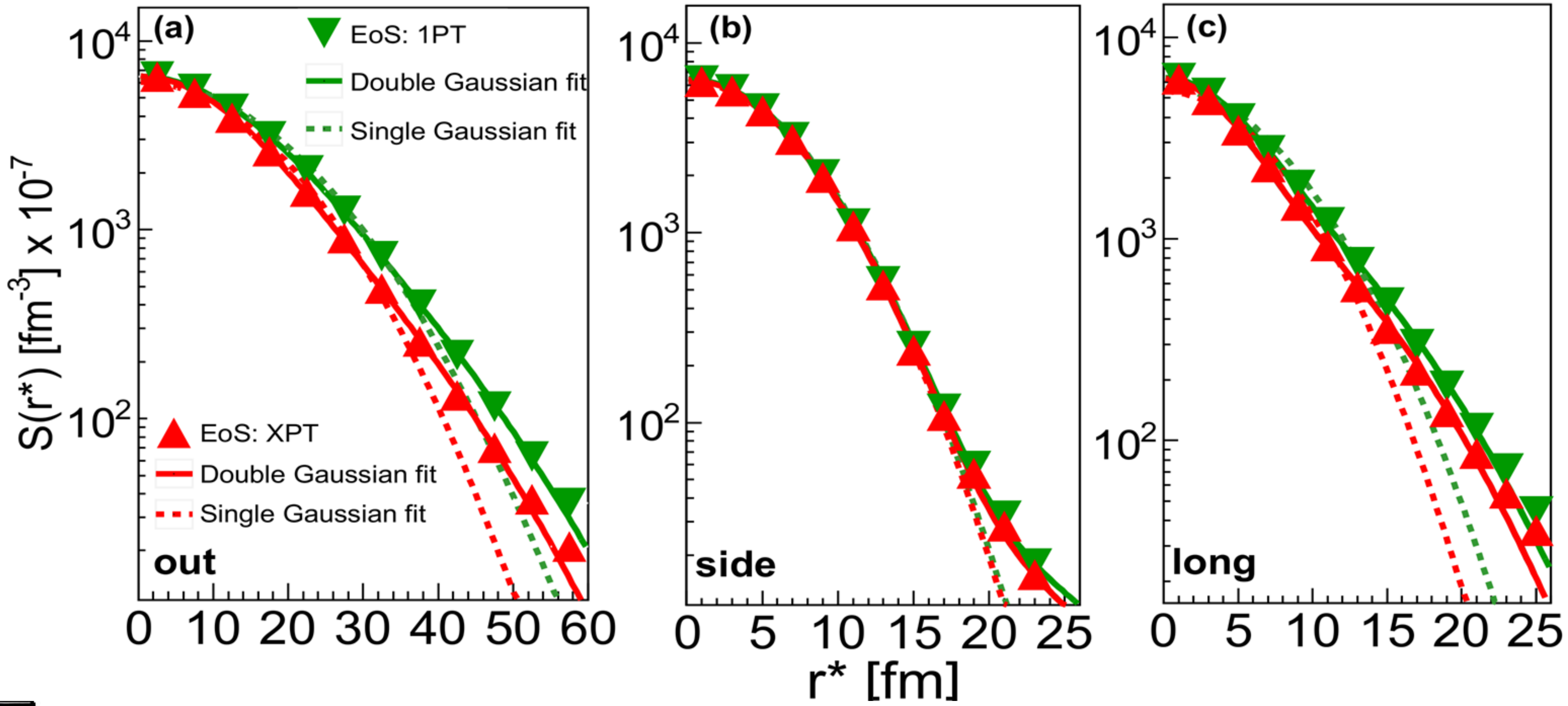
Better in „long” and „out”



Source emission function

- Hump function advantages
  - Slightly better description of shape
- Two-gaussian fit advantages
  - Clear interpretation of parameters
  - Much easier to fit
    - Stable
    - Core parameters can be obtained from single gaussian fit
  - Analytical form of Correlation Function

Source emission function (7.7 GeV)



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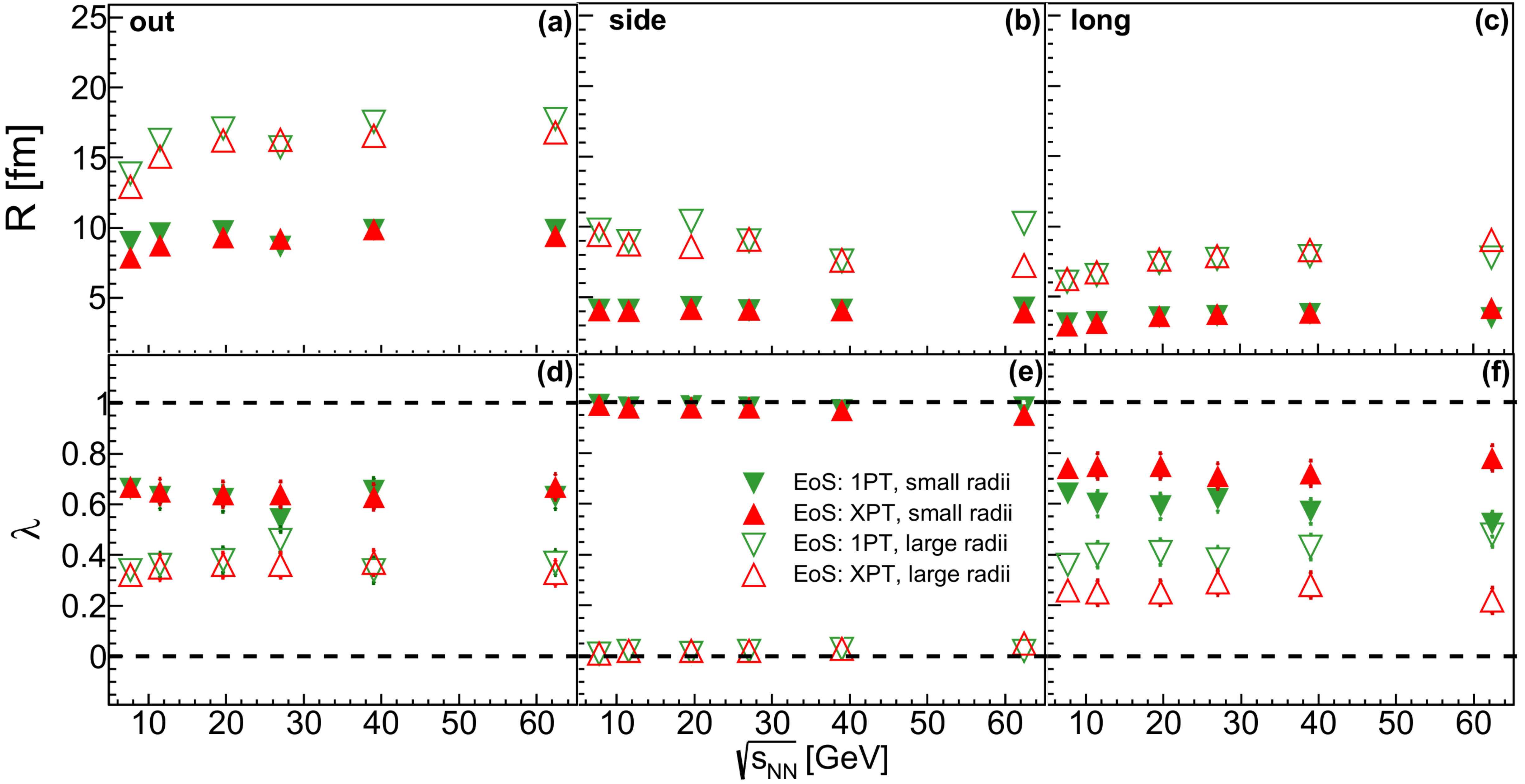
Source function



Source function

- Comparable influence of tails in „long” and „out” direction
- No one of tested functions can describe shape of source in entire considered range (0-100 fm)

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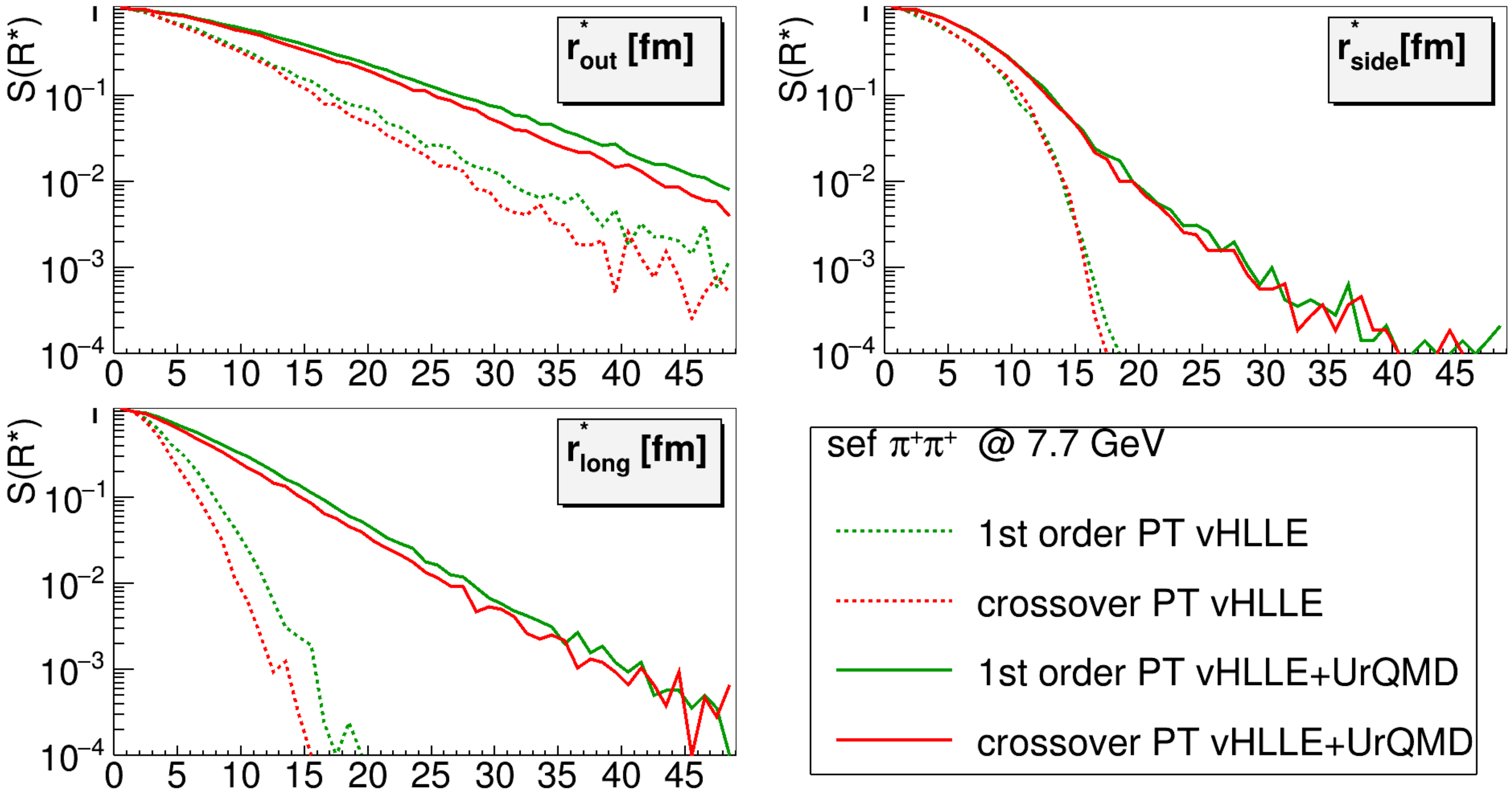
Source function



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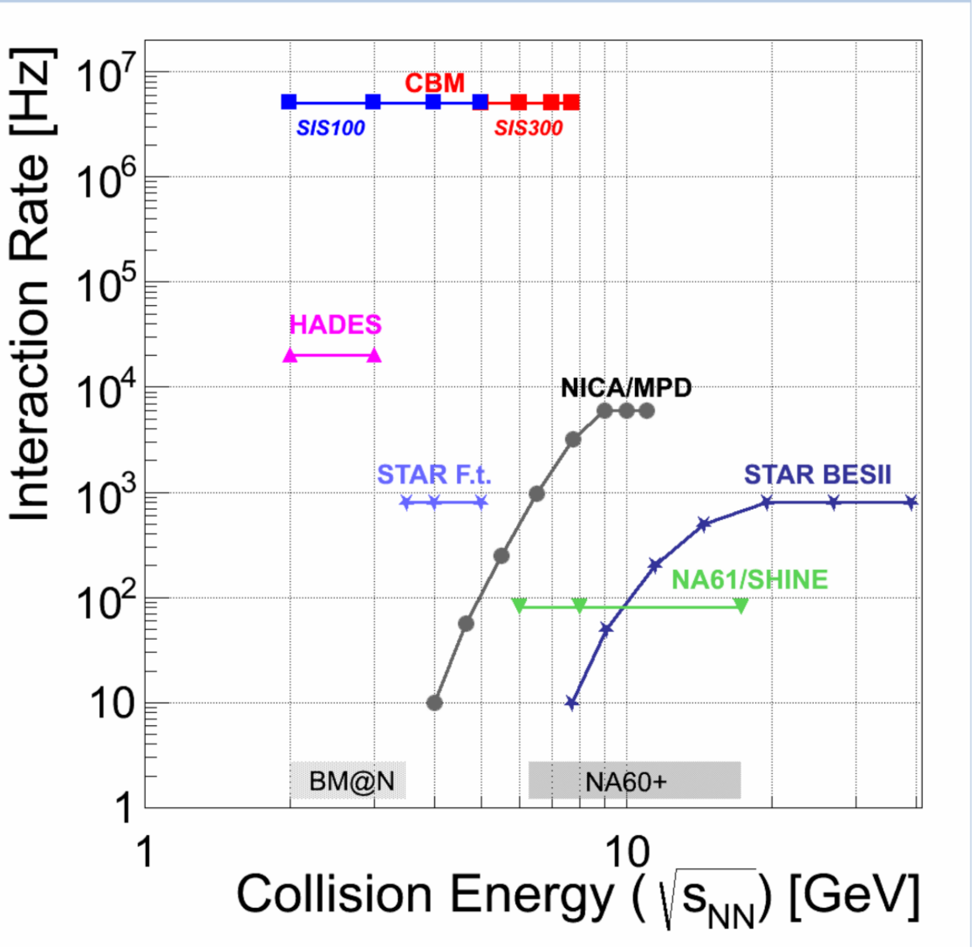
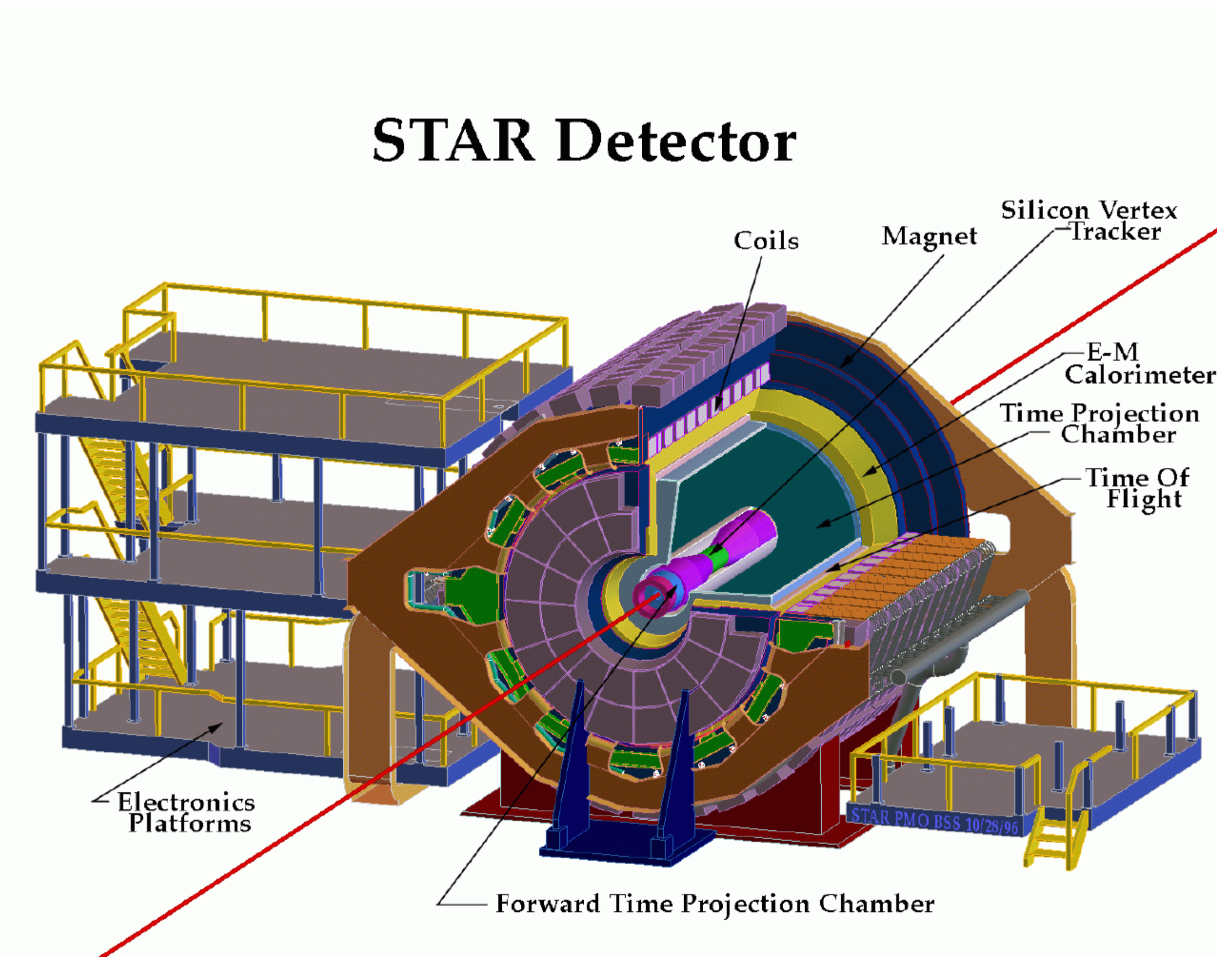
NICA & STAR/BES

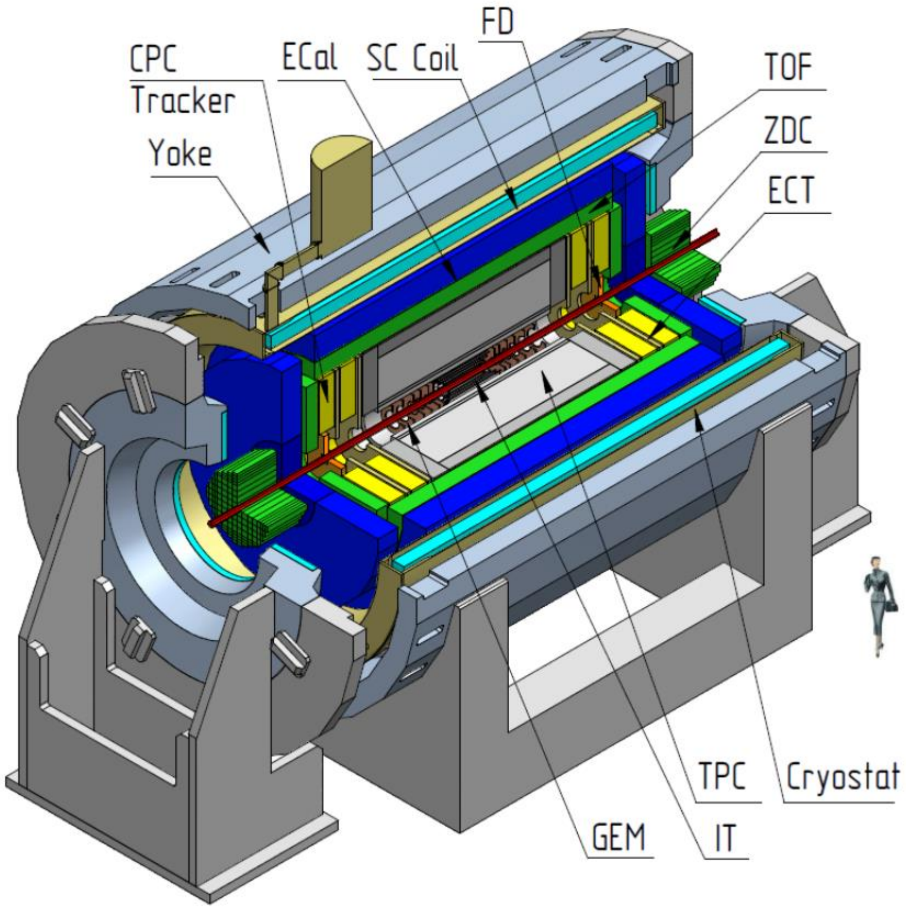
- BES $\sqrt{s_{NN}} = 7.7 - 62.4\ GeV$
- NICA $\sqrt{s_{NN}} = 4 - 11\ GeV$

NICA & STAR/BES



BES NICA





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To do list

- Simulations with MPD detector
- Checking more sophisticated methods (kaon-kaon correlations, azimuthal correlations)
- Studies with THESEUS – model dedicated for NICA energies

Summary

- The differences between both EoS's exist in femtoscopic observables
- Standard pion-pion femtoscopy based on the single-gaussian fits is only weakly sensitive to see them, leading to ~10% difference between the fitted gaussian radii.
- More sophisticated methods (beyond single-gaussian CF parametrization) may be useful to study phase transition phenomena at studied energy range

Thank you for your attention