Femtoscopy at NICA with vHLLE+UrQMD

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Outline

MPD experiment

Phase transition phenomena

vHLLE+UrQMD

NicaFemto

Correlation functions

Source emission functions

Imaging technique

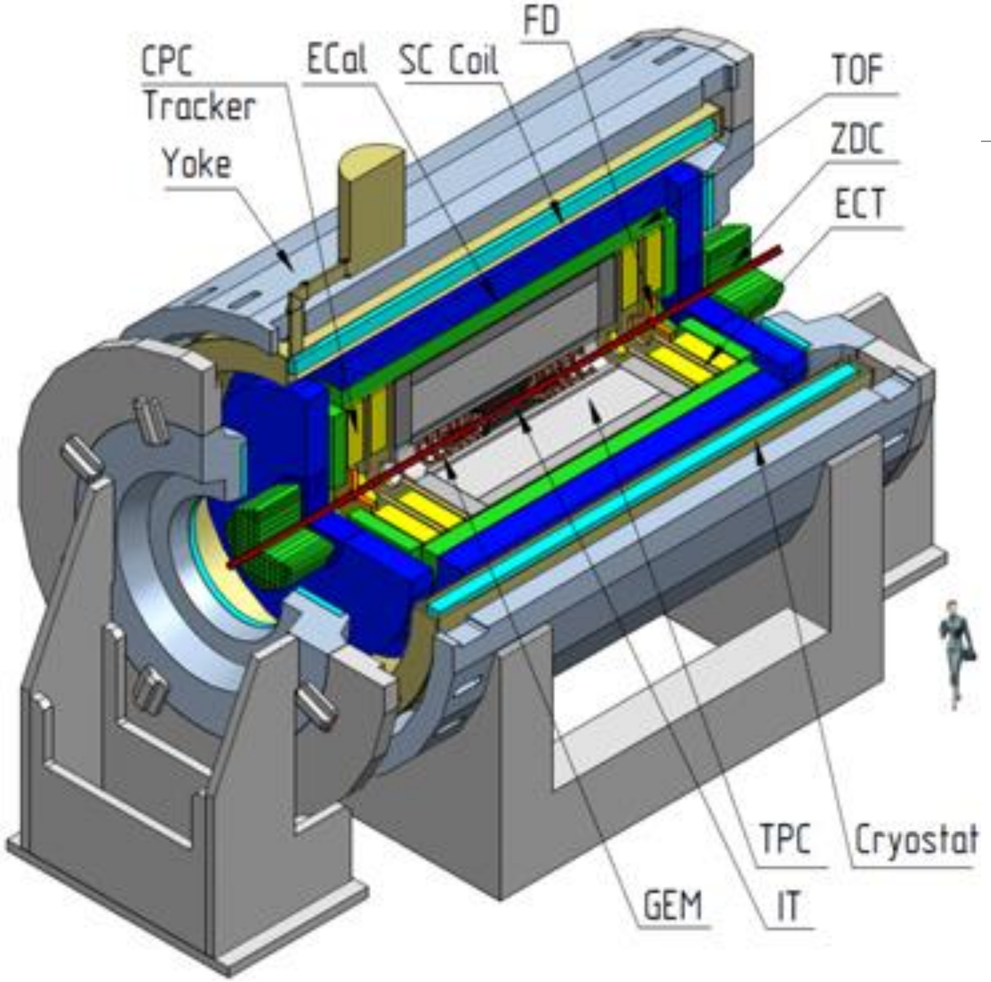
Summary and plans

MPD experiment

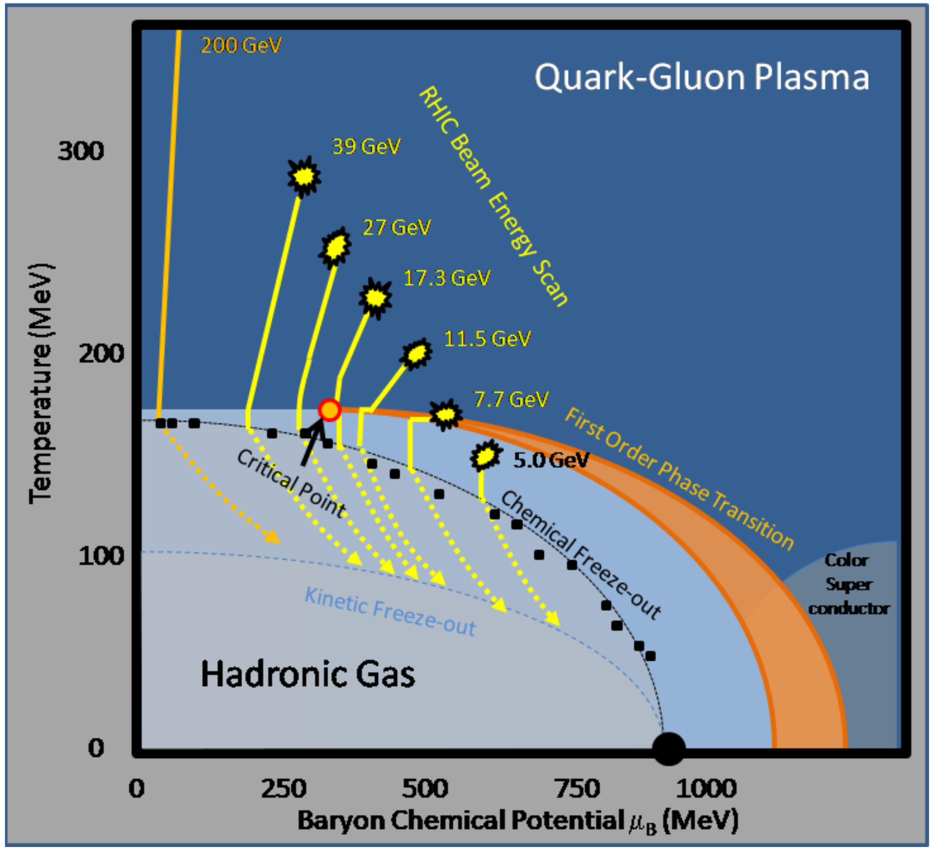
Collider experiment at NICA

Study HIC at 4-11 GeV

Study hot and dense matter phenomena



Phase transition phenomena



Phase transition phenomena

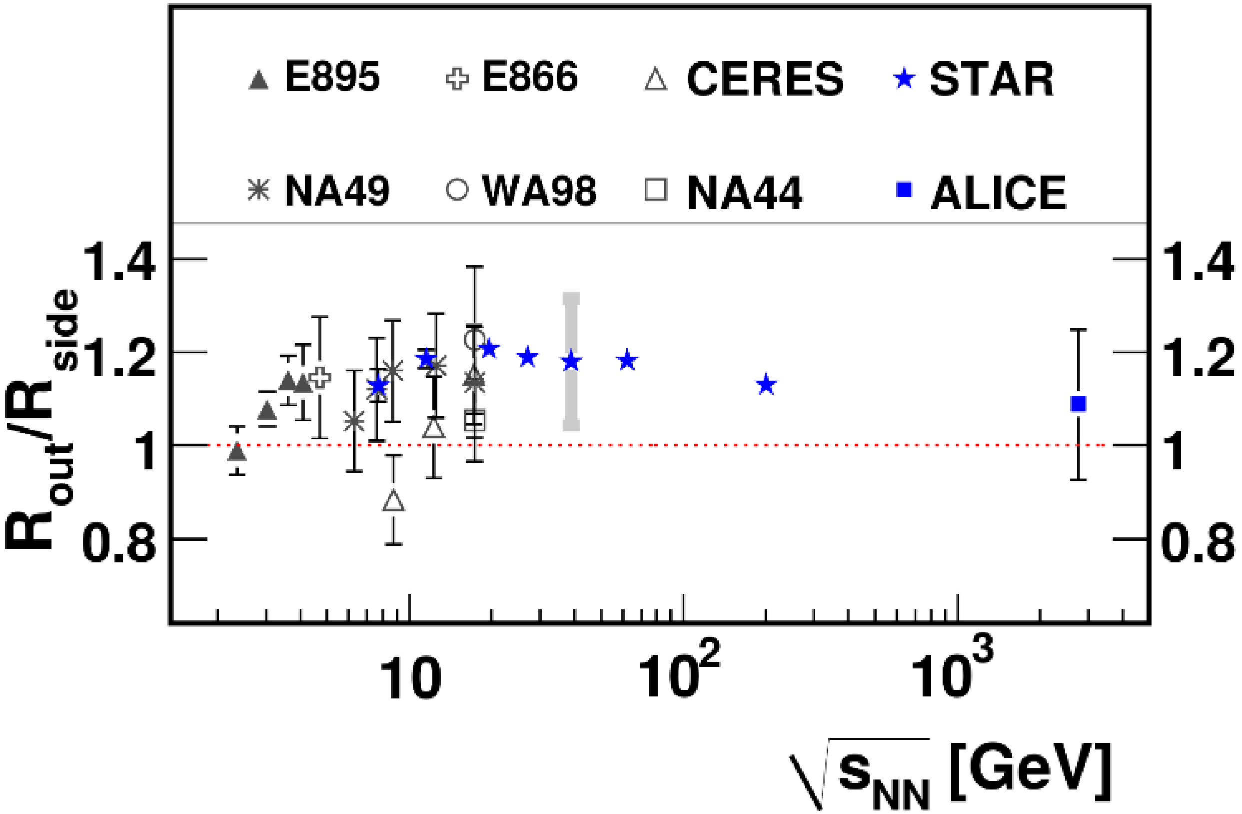
1st order PT - latent heat, system lives longer than for crossover PT

longer lifetime - bigger R_{long}

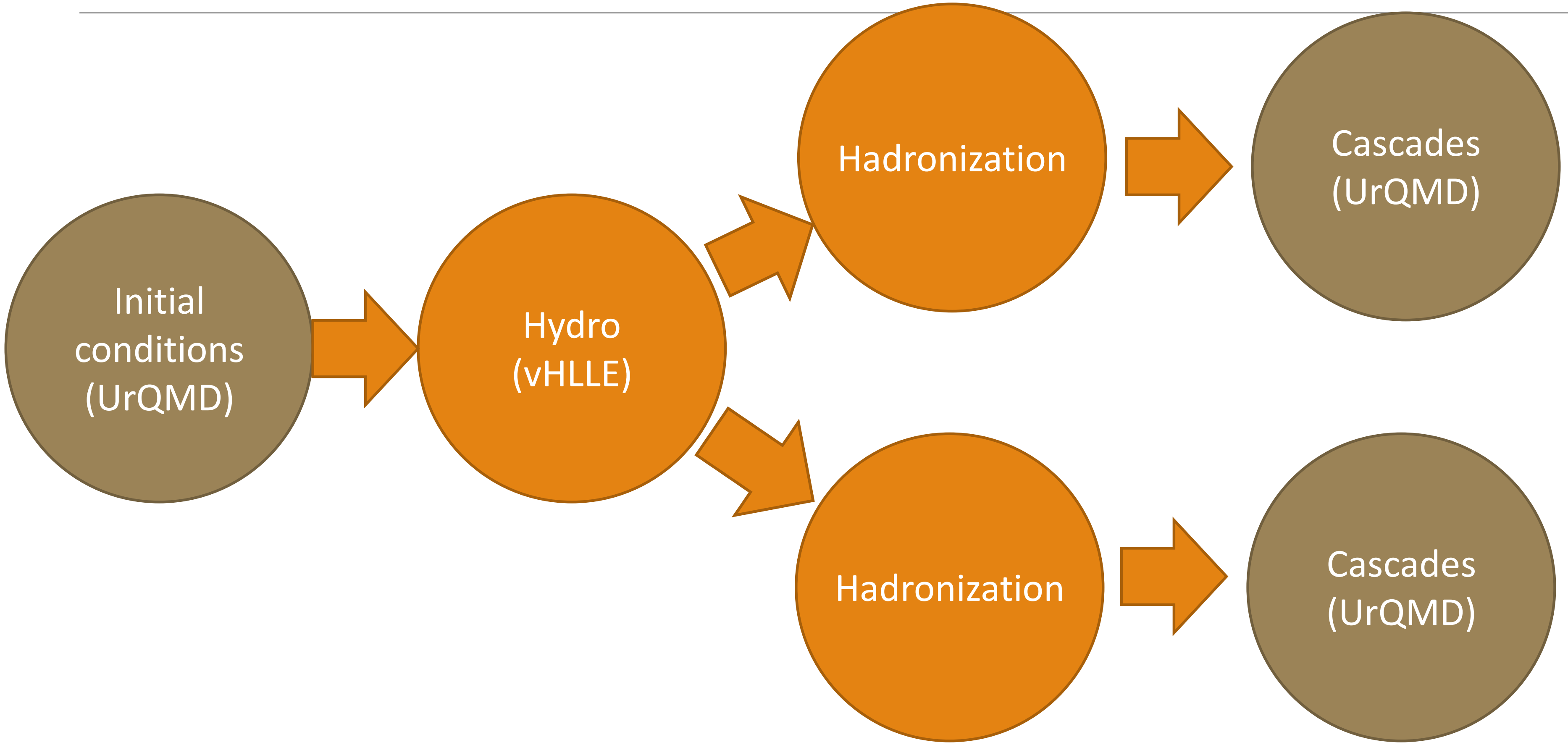
longer emission duration - bigger R_{out}

no direct effect on transversal size - generally

R_{out}/R_{side} ratio as signature of PT



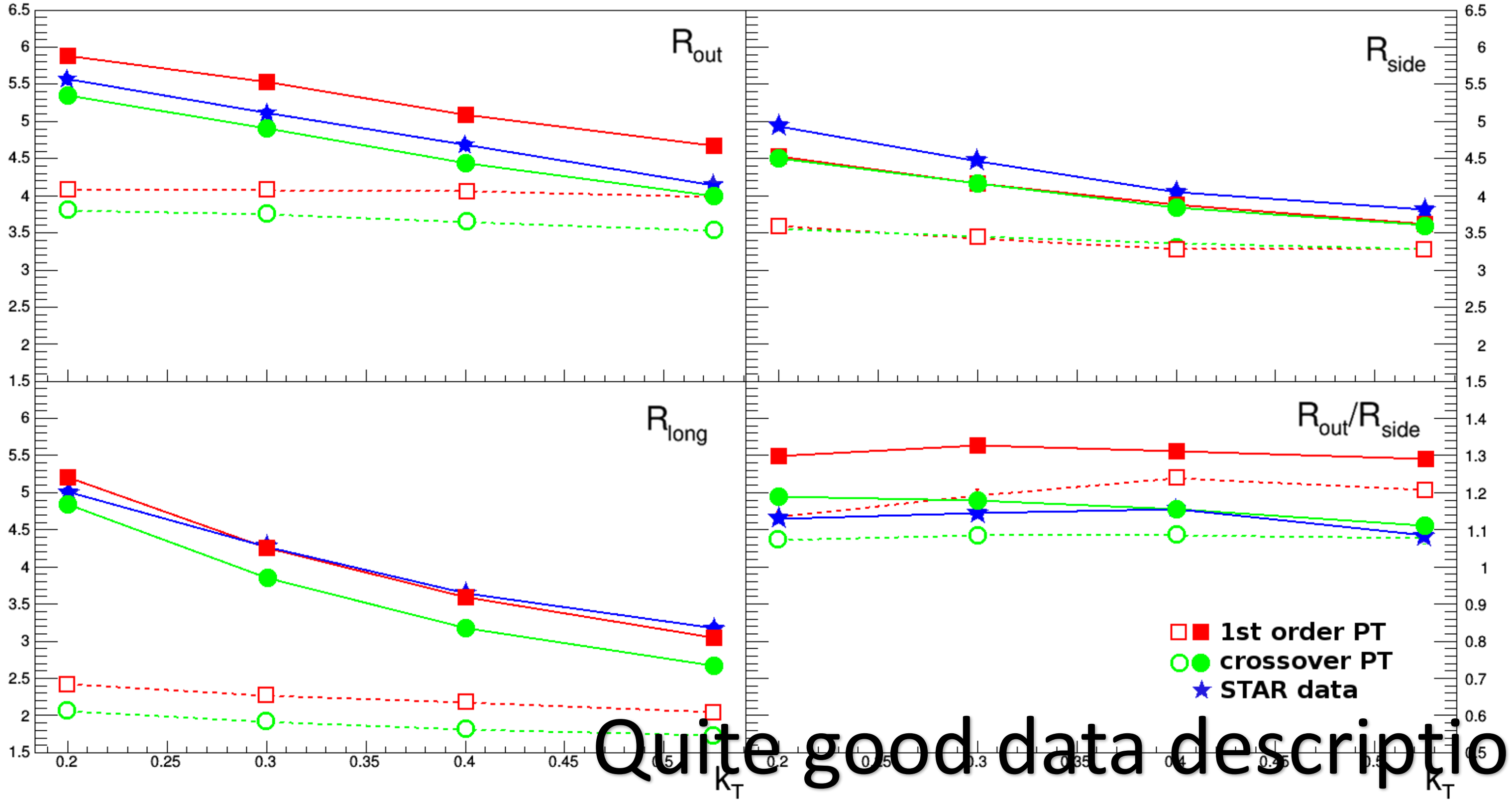
vHLLE+UrQMD


Initial conditions (UrQMD)
Hydro (vHLLE)
Hadronization
Cascades (UrQMD)
Hadronization
Cascades (UrQMD)

vHLLE+UrQMD

- designed for BES energies at RHIC (what means also upper energies of NICA)
- parameters tuned for STAR data (spectra)
- support EoS for 1st order PT and crossover PT - possibility of study critical point phenomena
- can call few hadronizations/cascades per single hydro simulation - possibility of use oversampling technique to increase statistic

vHLLE+UrQMD (7.7 GeV)



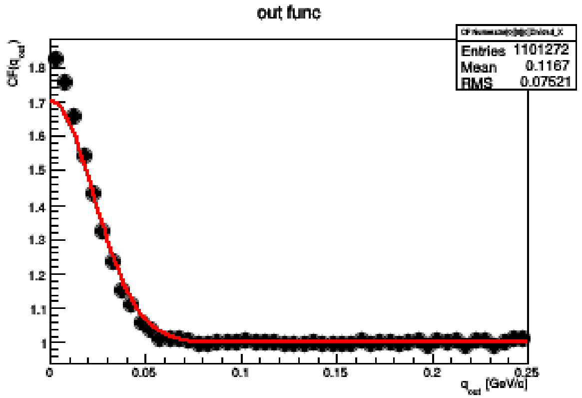
Quite good data description!

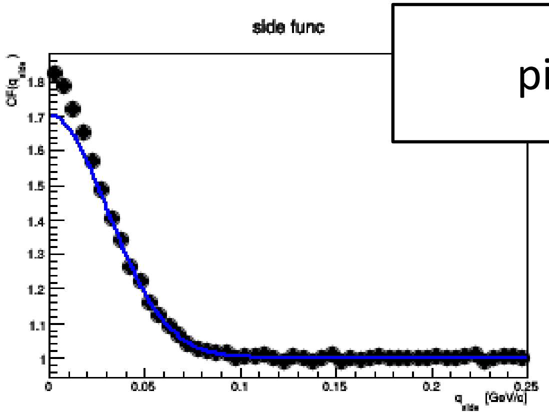
Strong influence of cascades

NicaFemto

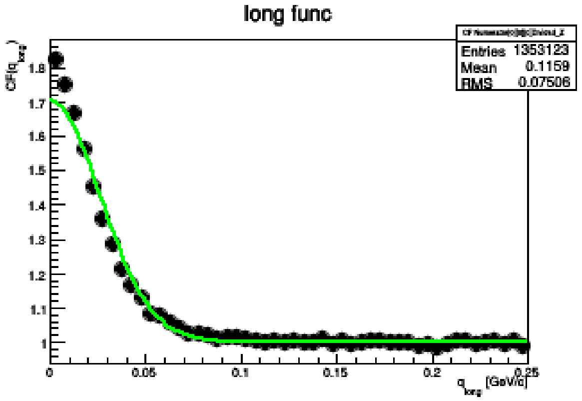
- Software for performing simple flow, spectra and femtoscopic analysis
- Flexible - can be transferred between experiments that use FairROOT framework
- Still under development
- Used to obtain plots in this talk

Correlation functions for 7.7 GeV





pions



3D Corrfit

R_{out} 6.028±0.008

R_{side} 4.515±0.006

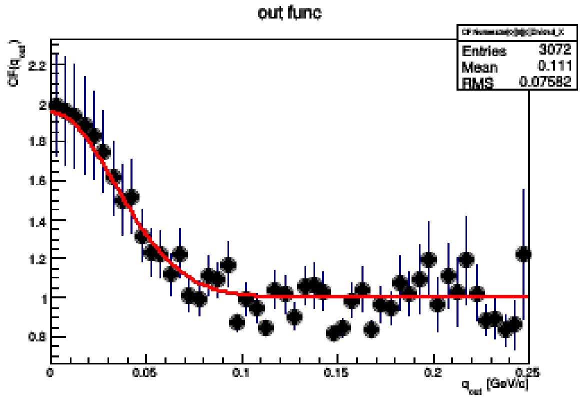
R_{long} 5.254±0.008

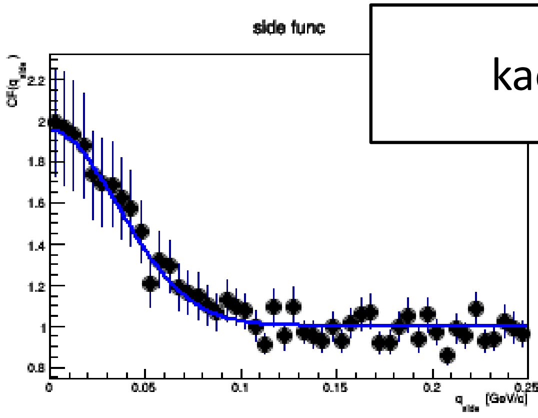
λ 0.703±0.001

N 1.000(fixed)

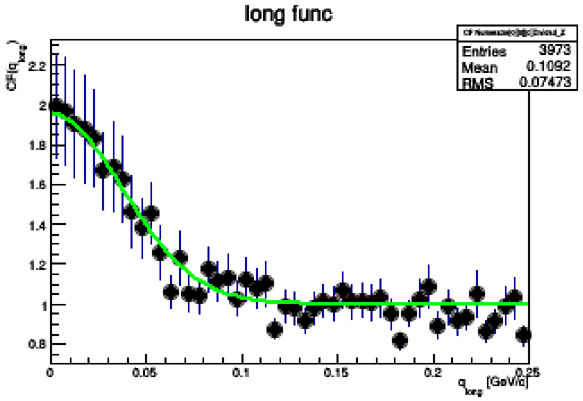
χ^2/NDF 1.1 (145618.4/132647)

Correlation functions for 7.7 GeV





kaons



3D Corrfit

R_{out} 4.069±0.043

R_{side} 3.812±0.039

R_{long} 3.664±0.040

λ 0.949±0.013

N 1.000(fixed)

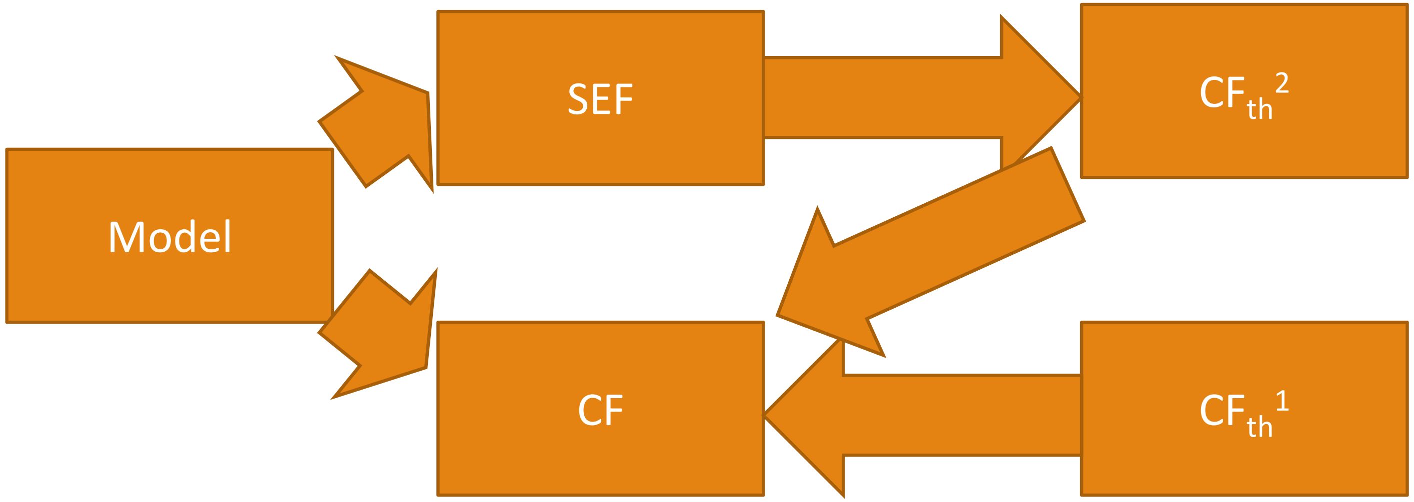
χ^2/NDF 10.1 (1344710.5/132647)

Source emission function

Problems with correlation functions

- during fit we assume some shape of source, if we don't "guess" this shape we can have problem with obtaining reasonable results

Solution

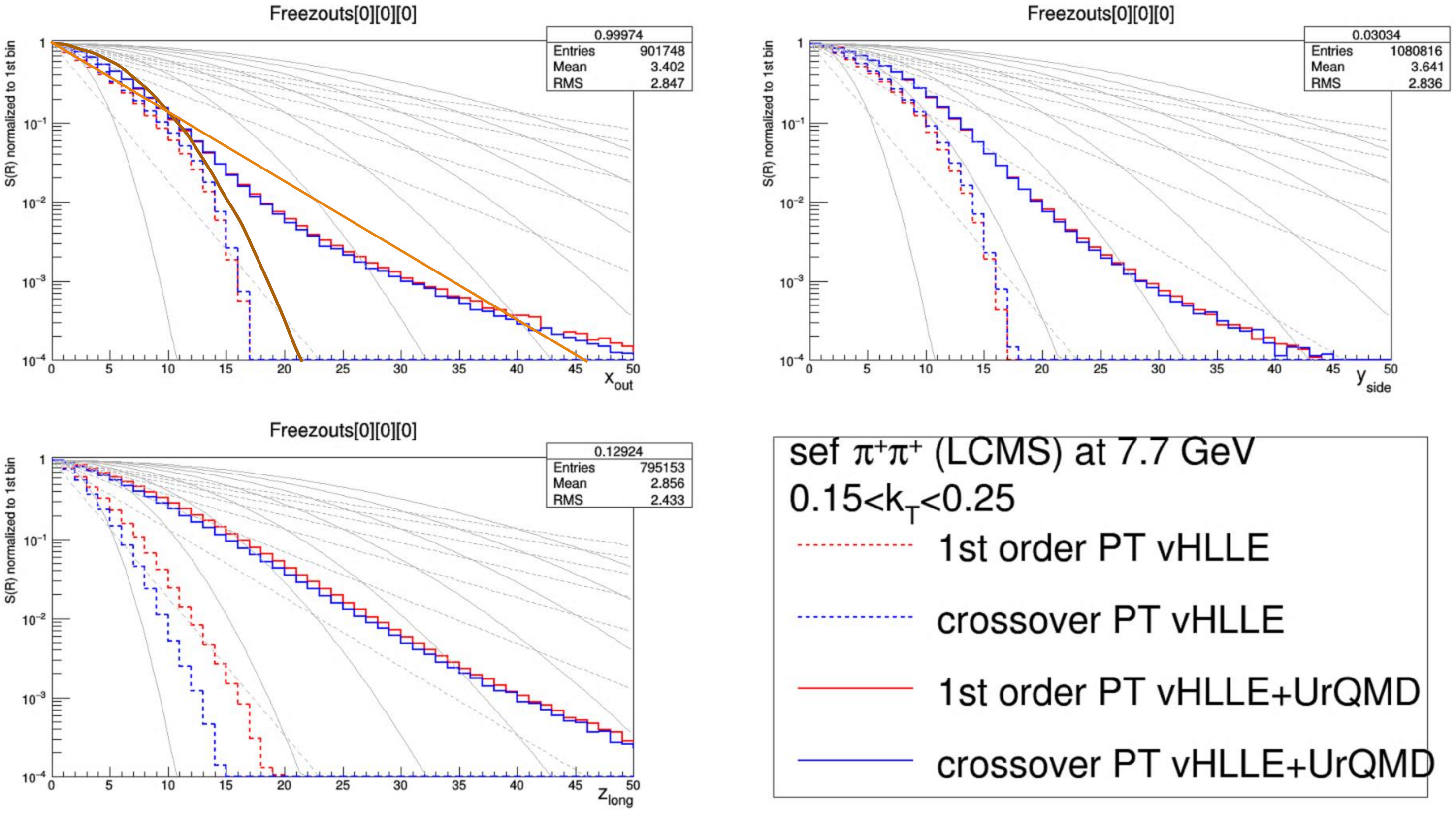


Source emission function

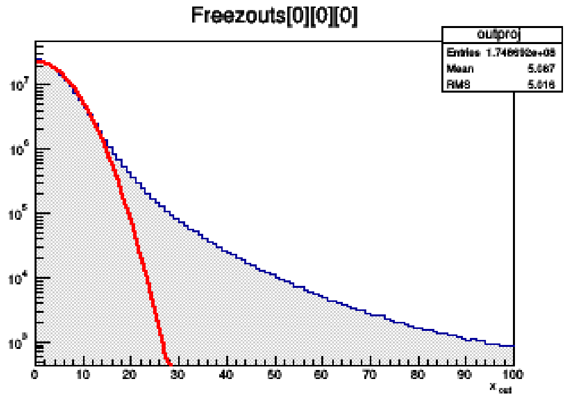
Obtained in following way

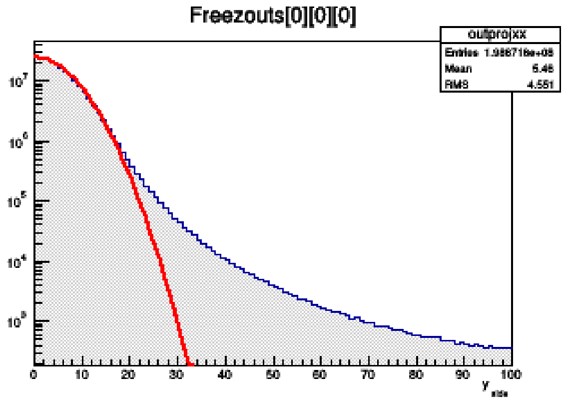
- making pairs
- if pair relative momentum is higher than given value - skip pair
- otherwise fill histogram with calculated values of femtoscopic radii

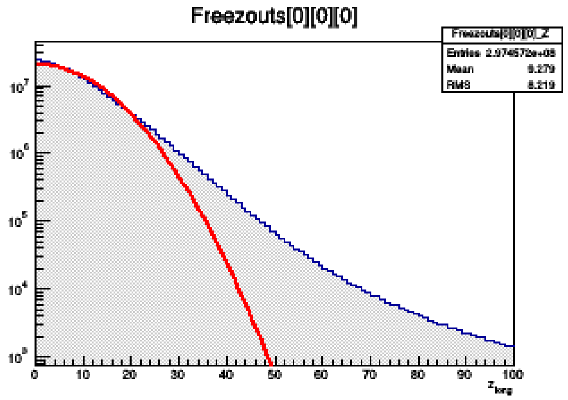
Radii distribution



Radii distribution



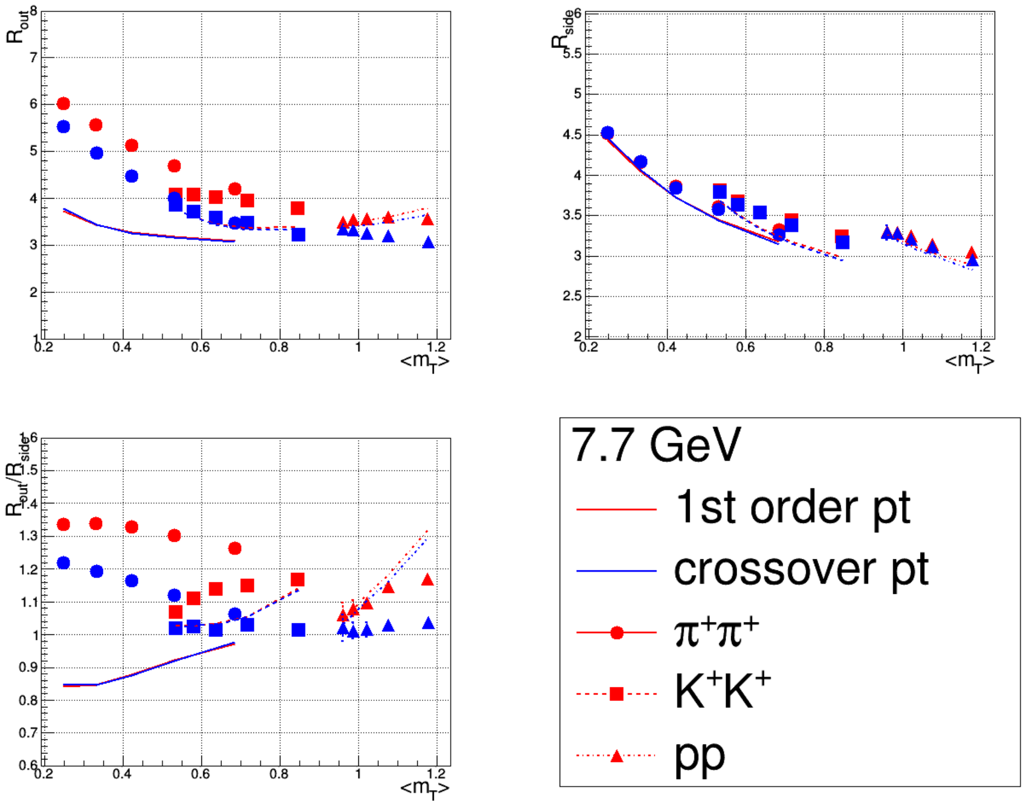




Fit for pions, one parameter – norm is set, later gaussian fit is made

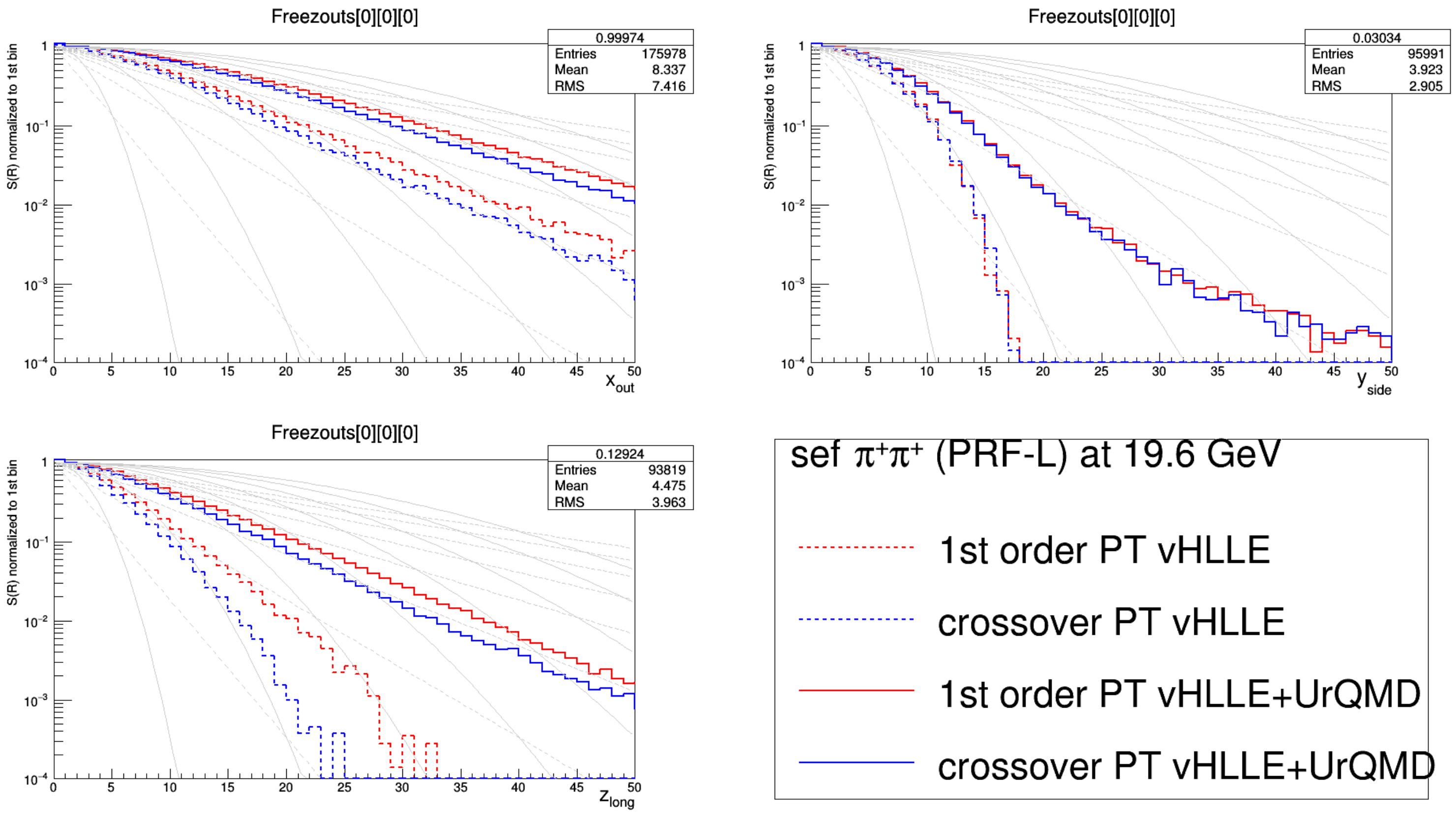
$R=\sigma/\sqrt{2}$

CF & SEF for vHLLE+UrQMD particle



Line – direct fit from radii distribution
Point – fit from CF

Source emission function



Imaging technique

What about SEF in realistic data?

Imaging technique

For correlation function we can write*:

$$CF(\boldsymbol{q}) = \int S(\boldsymbol{r},\boldsymbol{q})(1+\cos(\boldsymbol{qr}))\boldsymbol{dr}$$

$$CF(\boldsymbol{q}) = 1 + \int S(\boldsymbol{r},\boldsymbol{q})\cos(\boldsymbol{qr})\boldsymbol{dr}$$

For 1D case we can write:

$$CF(q) = 1 + \underbrace{\int S(r,q)\cos(qr * cos(\theta))\, dr d\theta}_{R(q)}$$

If assume no momentum-position correlations then CF can be expressed as

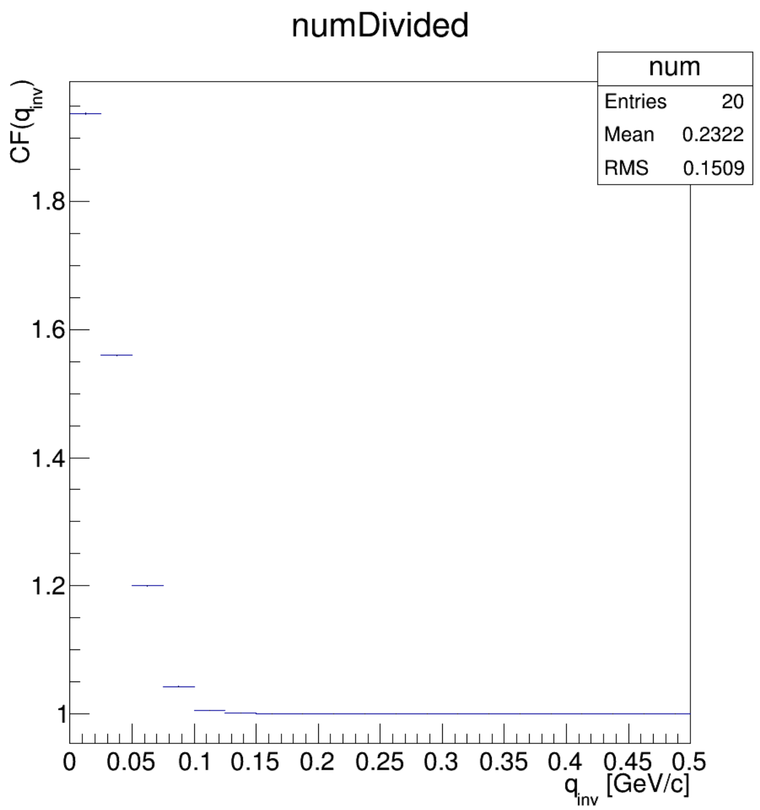
$$R(q) = \int S(r,q)\sin(qr)/qrdr$$

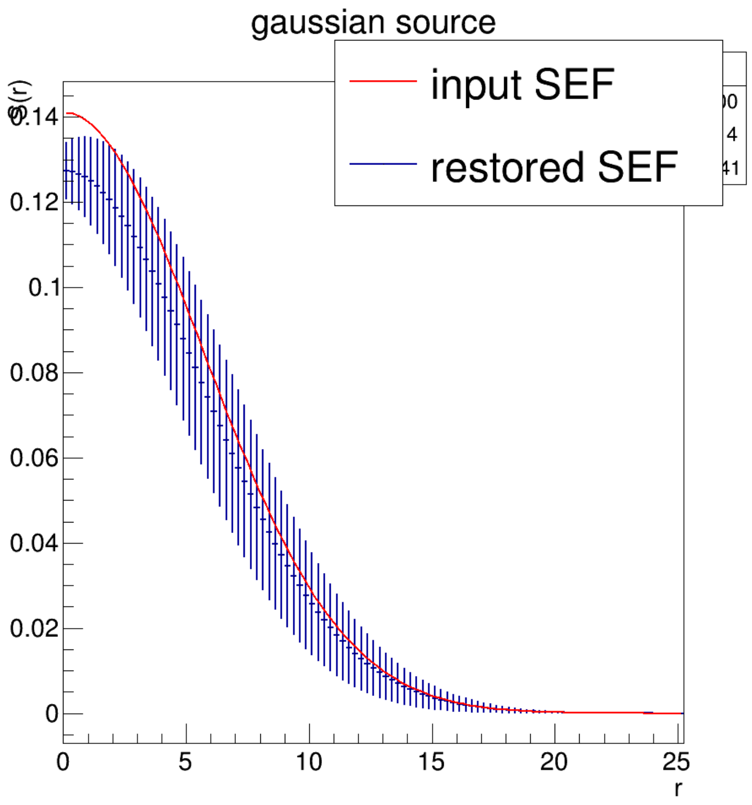
$$R(q) = \frac{1}{q}\int \frac{S(r,q)}{r} * \sin(qr)\, dr$$

arXiv:nucl-th/0010108

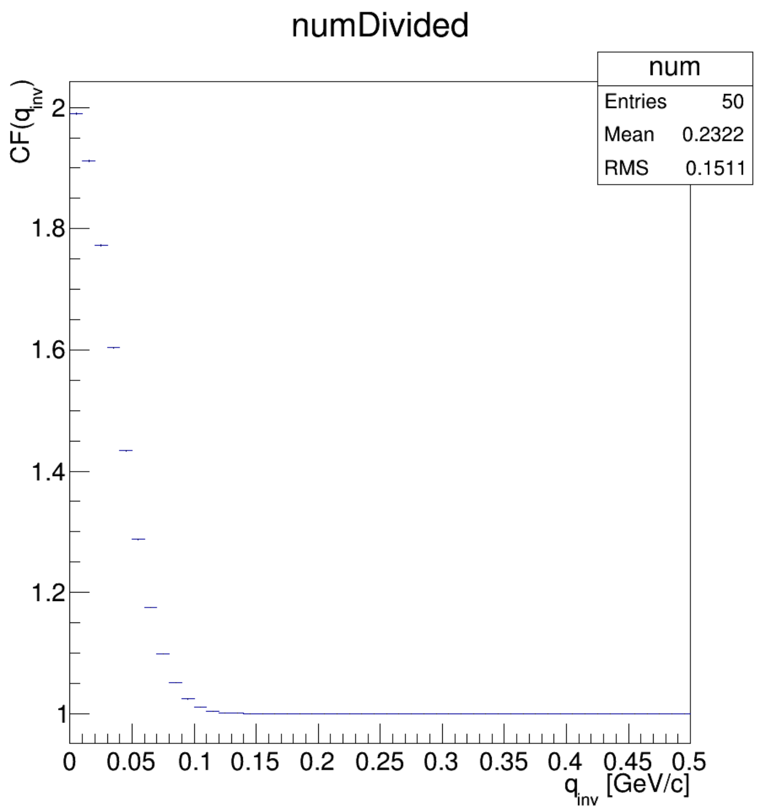
* Identical bosons without FSI

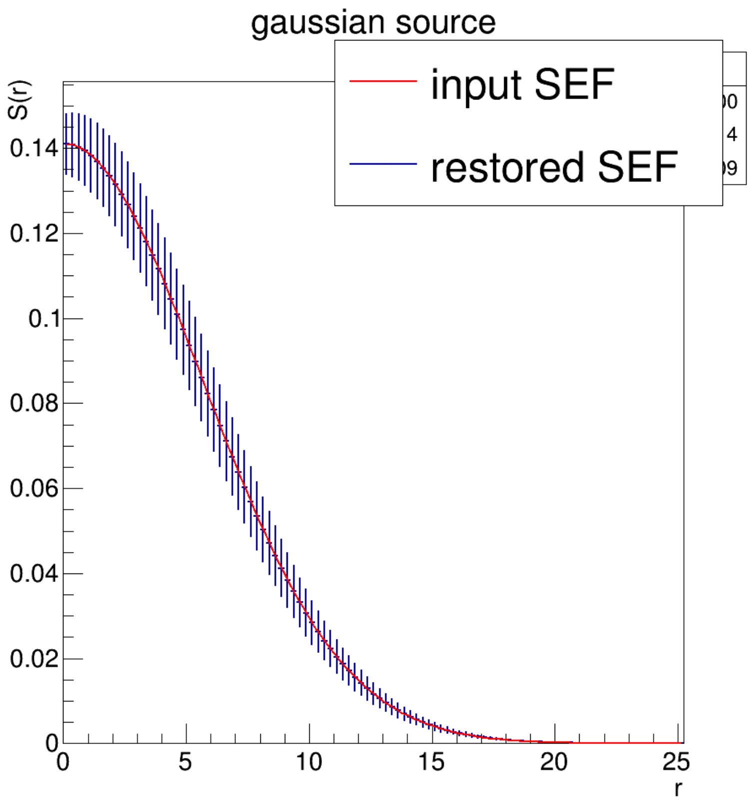
Imaging technique



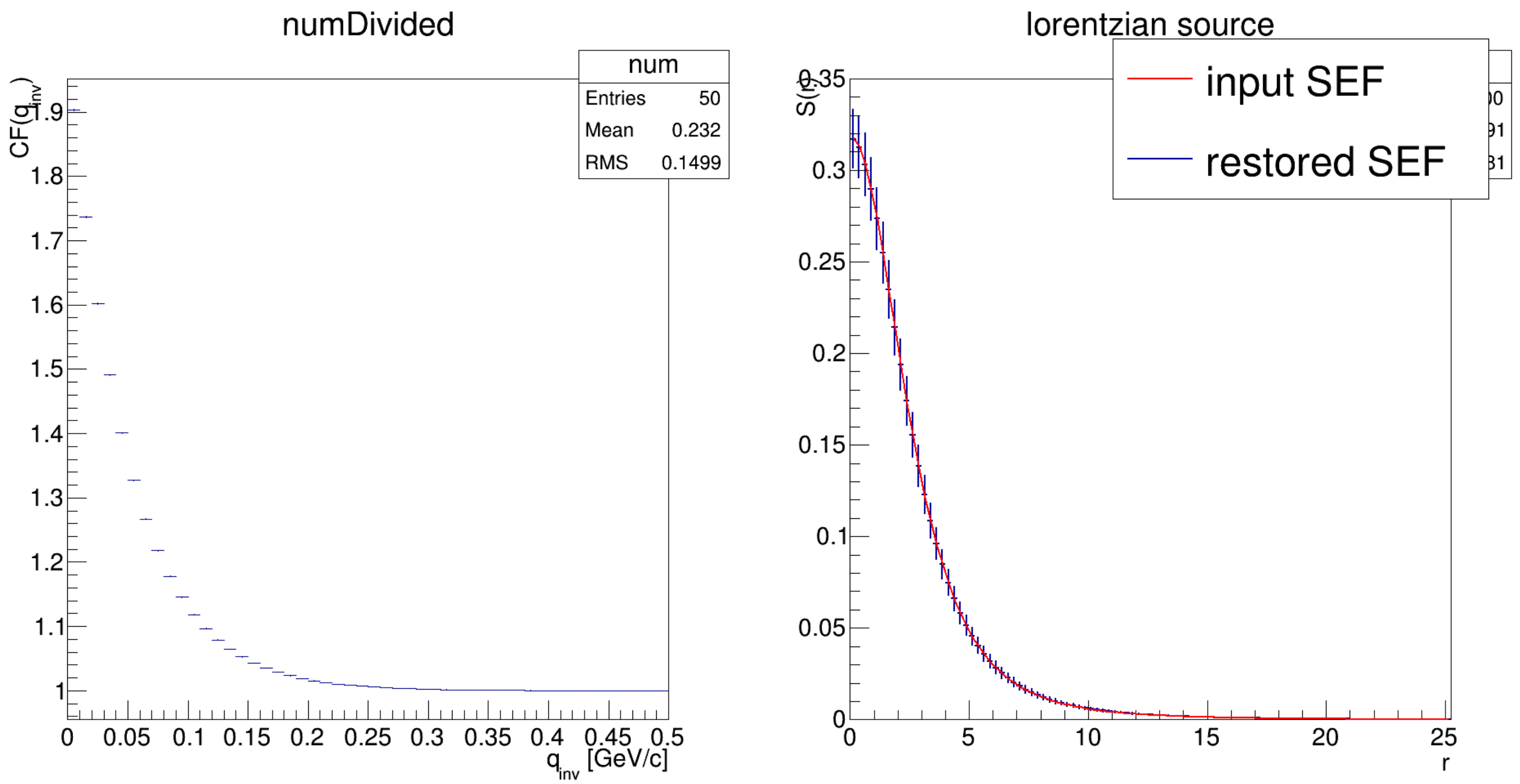


Imaging technique

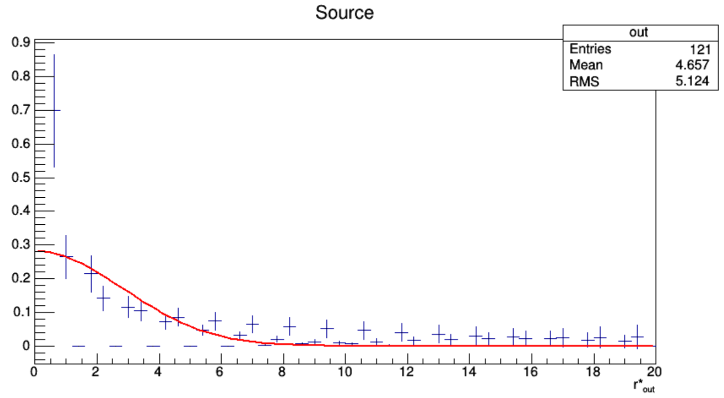


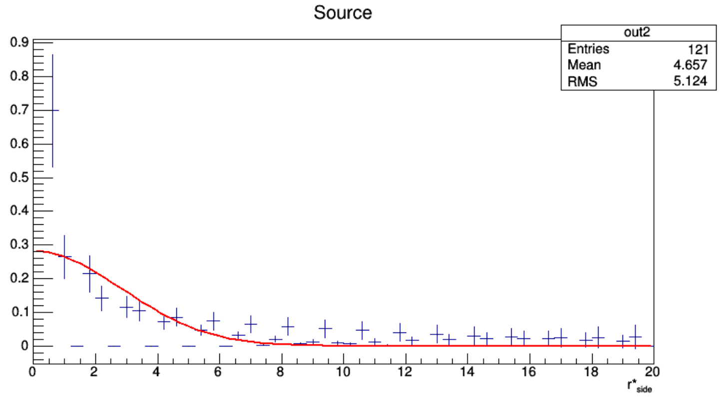


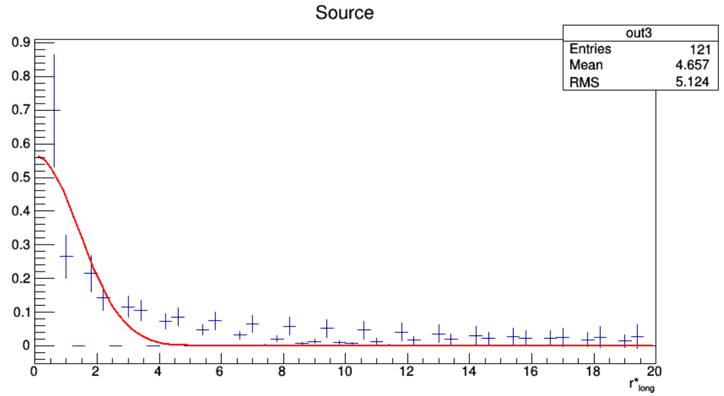
Imaging technique



Imaging technique







doesn’t work for 3D !

Imaging

Both methods are implemented in NicaFemto, but it seems that 3D is not be very useful

Possible solution:

- Use cubic harmonic decomposition
- Do imaging on those 1D histograms – fourier transform in 1D is not a problem
- Add images from those histograms to obtain shape of the source

To do: check this method by using current ALICE code for Spherical Harmonics analysis

Summary

Basic femtoscopic observables has been calculated

Source emission function has been calculated

We showed that PT phenomena affects femtoscopic observables

However there is no clear method to define PT type

Imaging procedures are still under development

Still experimental effects must be taken into account

Thank you for your attention