Fitting the correlation function with the Lednicky-Lyuboshitz model

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General expression (for p-p)

Theoretical expression:

$$C_{pp}(k^*) = \frac{1}{2}\sum_{S=0}^{1}\frac{2S+1}{(2s_p+1)^2}\int d^3\vec{r}S(\vec{r})\,|\psi^S_{-\vec{k}}(\vec{r}) + (-1)^S\psi^S_{\vec{k}}(\vec{r})|^2$$

$$S(r) \sim exp(-\frac{r^2}{4R^2_{inv}})$$

— assuming Gaussian source

Experimental CF:

$$C_{exp}(k^*, R_{inv}) = 1 + \lambda\left(C_{pp}(k^*, R_{inv}) - 1\right)$$

Wave function (s-wave approximation)

General expression (assuming that protons are primary: pp->pp scattering):

$$\psi_{\vec{k}}(\vec{r}) = e^{i\delta_c(\eta)}\sqrt{A_c(\eta)}\left[e^{i\vec{k}\vec{r}}F(-i\eta,1,i\xi) + \frac{f(k)}{A_c(\eta)}\frac{\tilde{G}(kr,\eta)}{r}\right]$$

$\eta = \frac{1}{ka}$, $\quad a$ – *Bohr radius* $\qquad A_c(\eta) = \frac{2\pi\eta}{e^{2\pi\eta}-1}$ – *Gamov factor (Coulomb penetration factor)*

$\xi = kr - \vec{k}\vec{r}$

$\delta_0(\eta) = arg[\Gamma(1+i\eta)]$ – *Coulomb s-wave phase shift*

$f(k^*)$ – *scattering amplitude*

$\tilde{G}(kr,\eta) = \sqrt{A_c(\eta)}\left(G_0(kr,\eta) + iF_0(kr,\eta)\right)$

$F_0(kr,\eta)$ – *regular s-wave Coulomb function*

$G_0(kr,\eta)$ – *singular s-wave Coulomb function*

This formalism was used in ALICE paper for p-p femtoscopy (Run1):

PHYSICAL REVIEW C 92, 054908 (2015)

Coulomb wave equation

Equation for the wave function (s-wave):

$$\vec{\nabla}^2 \psi_{\vec{k}}(\vec{r}) + \left(k^2 - \frac{2\mu}{\hbar^2}\frac{e^2}{r}\right)\psi_{\vec{k}}(\vec{r}) = 0$$

Coulomb wave equation:

$$\frac{d^2\psi}{d^2\rho} + \left(1 - \frac{2\nu}{\rho} - \frac{l(l+1)}{\rho^2}\right)\psi = 0$$

General solution:

$$\psi = AF_l(\eta, \rho) + BG_l(\eta, \rho)$$

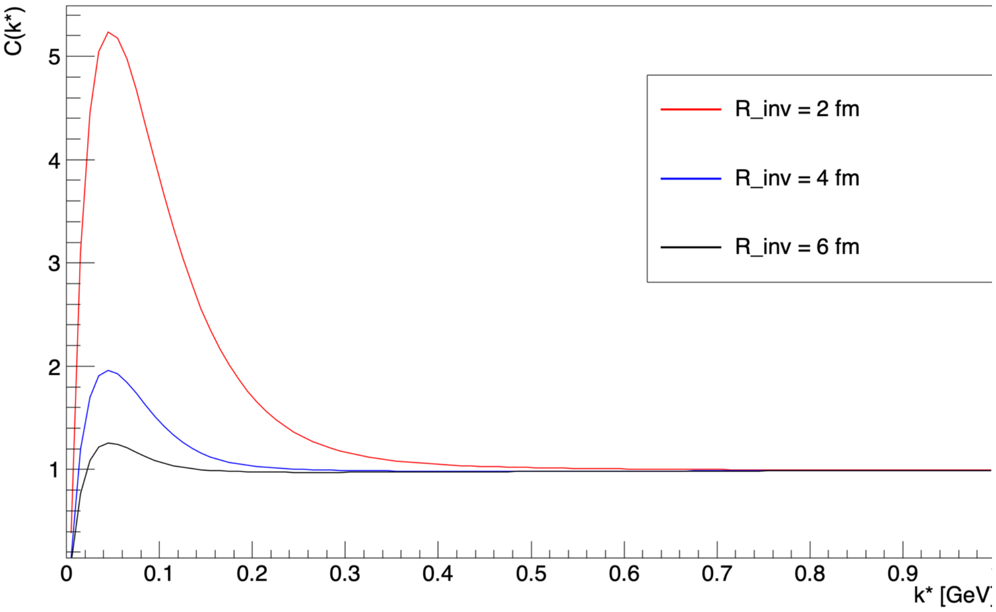
Wave function (s-wave & small source approximation)

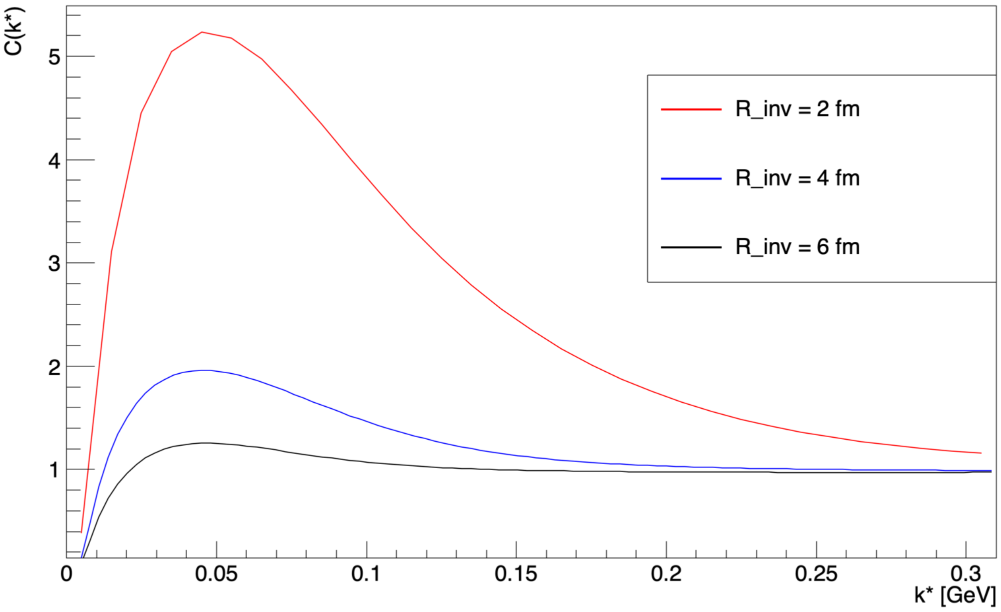
$$if \;\; r << |a|; \;\; kr \lesssim 1$$

$$\psi_{\vec{k}}(\vec{r}) = e^{i\delta_c(\eta)}\sqrt{A_c(\eta)}\left[e^{i\vec{k}\vec{r}} + \frac{f(k)}{A_c(\eta)}\frac{cos(kr) + iA_c(\eta)\,sin(kr)}{r}\right]$$

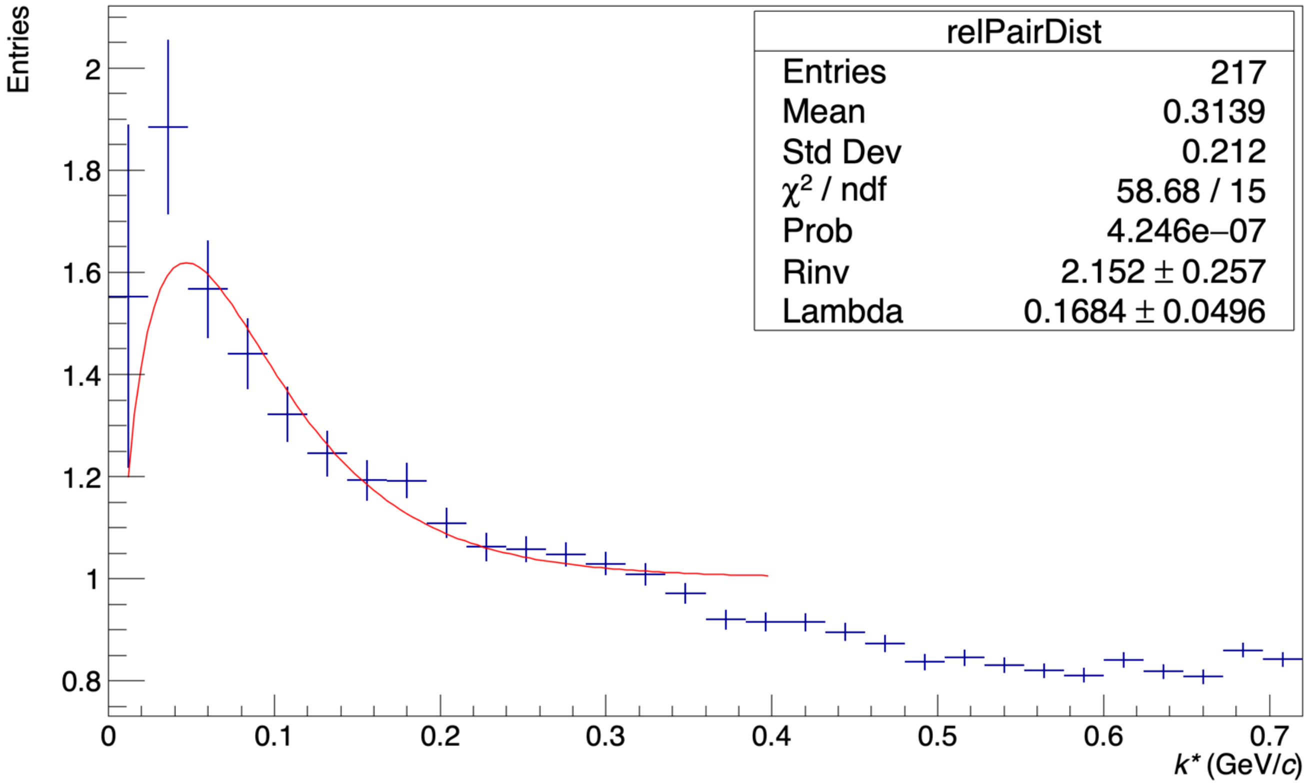
I used this to obtain an analytical expression for fit

Result

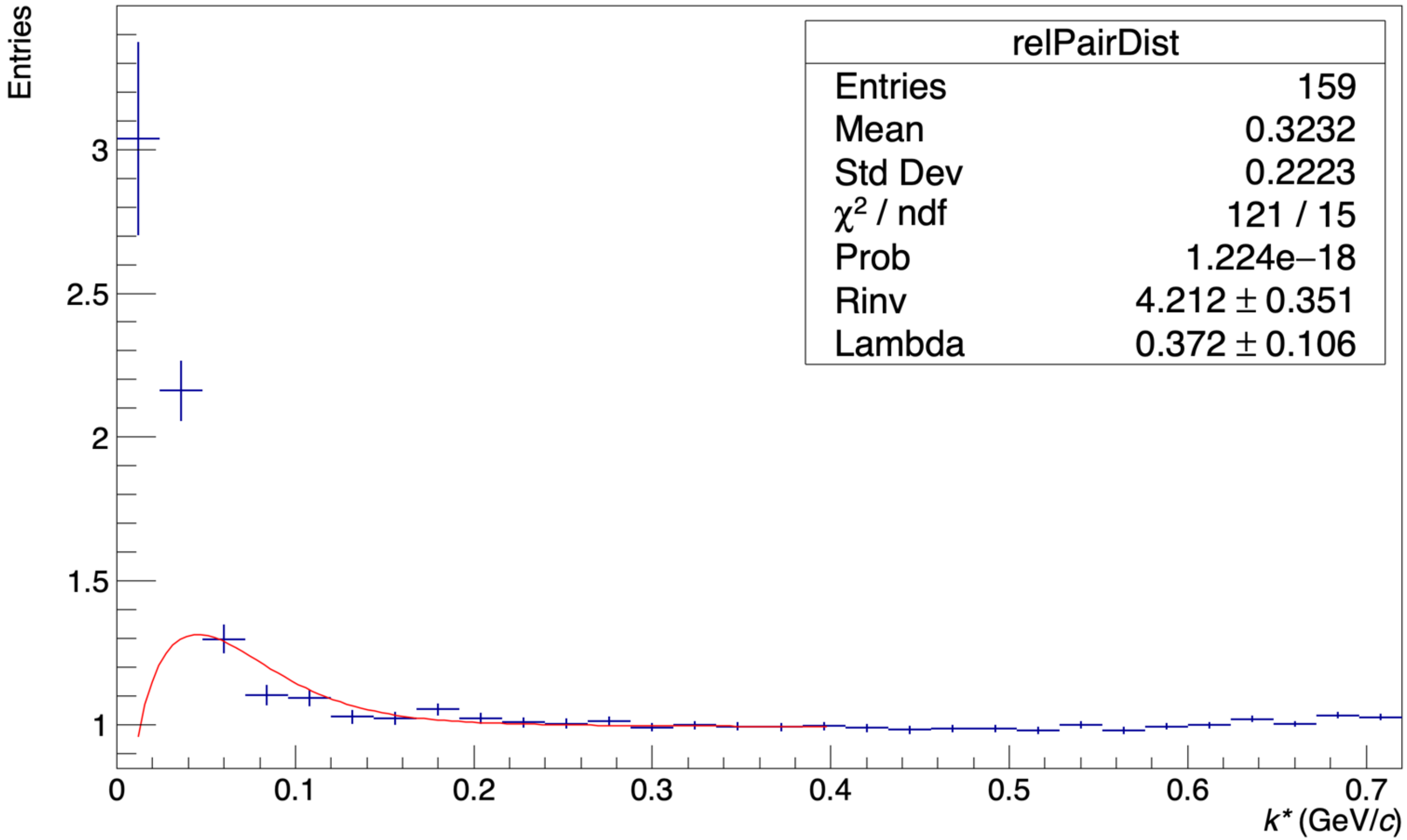

C(k*)
5
4
3
2
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
k* [GeV]
R_inv = 2 fm
R_inv = 4 fm
R_inv = 6 fm


C(k*)
5
4
3
2
1
0
0.05
0.1
0.15
0.2
0.25
0.3
k* [GeV]
R_inv = 2 fm
R_inv = 4 fm
R_inv = 6 fm

Trying to fit (pilot beam 900 GeV)



Trying to fit (LHC22f_pass2)



LHC22f_pass2 & Pilot beam