Proton-proton correlations in Au+Au collisions measured by STAR at RHIC

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Outline

Baryon correlations:

- Interactions present in baryon correlations
- Identical vs. nonidentical (anti)proton combinations
- The contribution of Residual Correlations + their estimation
- The fraction of pure p -p correlation
- Results of correlation functions
- m_T dependence (validity of flow description checked)
- Conclusions

Proton- (anti)proton correlations

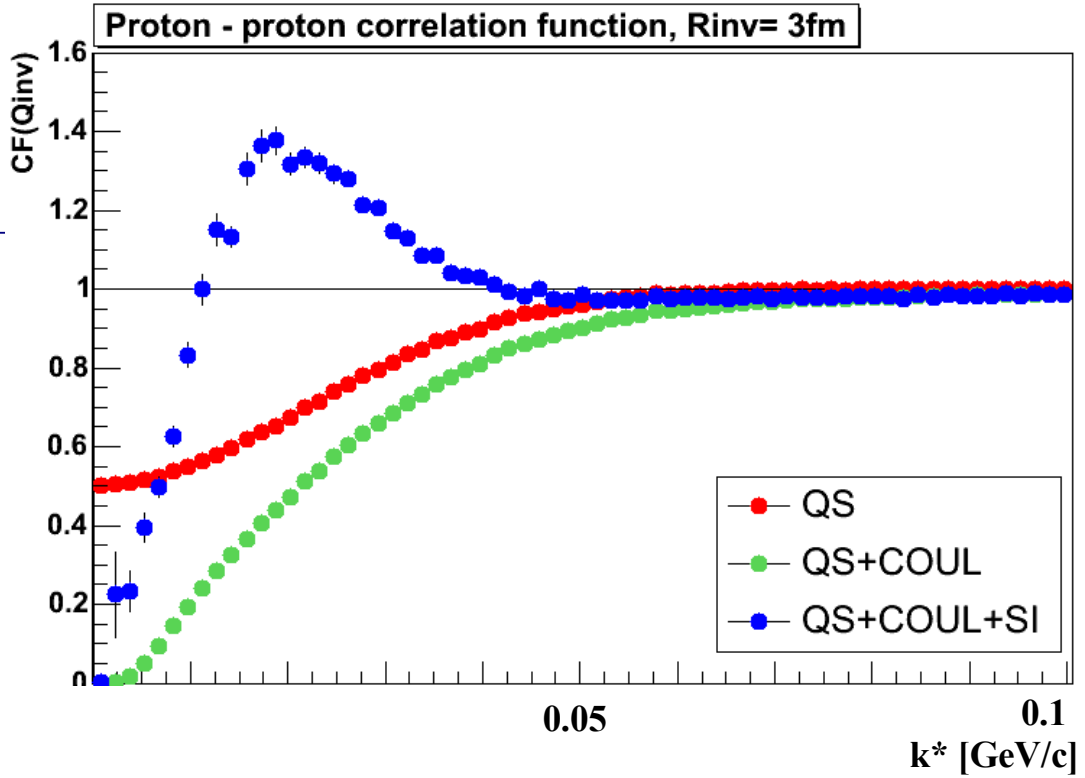
Identical baryon- baryon

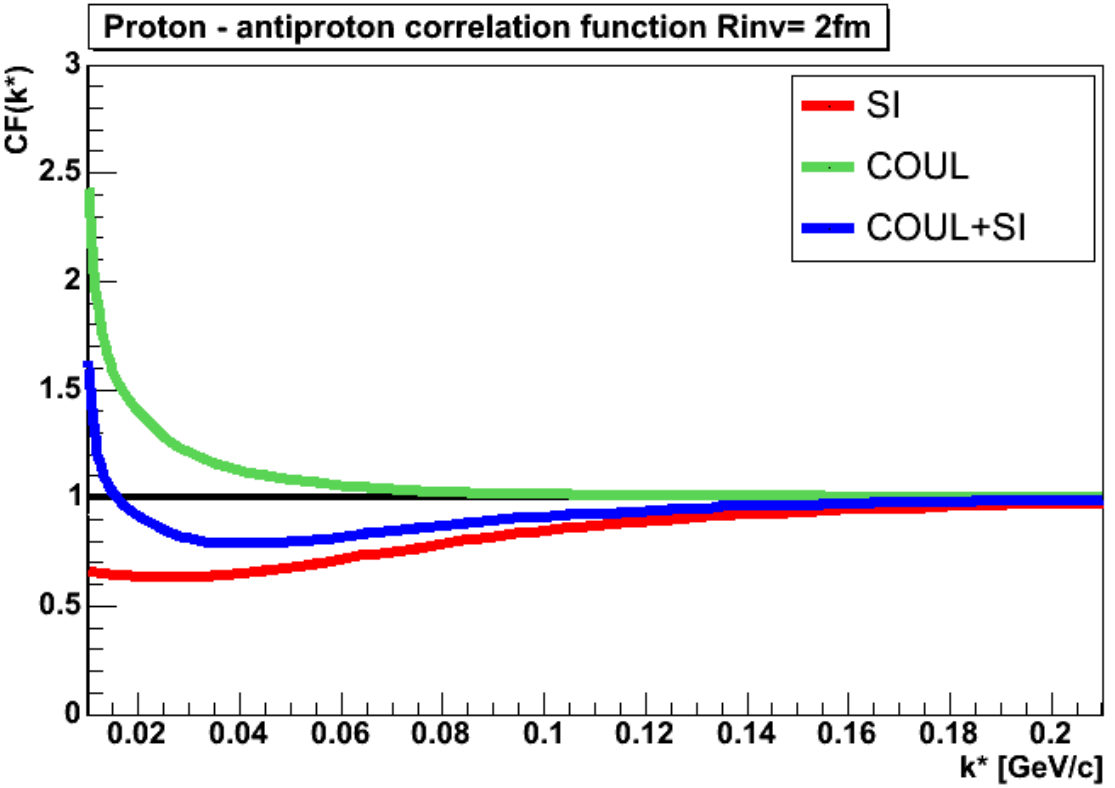
- Quantum Statistics- **QS**

- Final State Interactions- **FSI**
  - **Coulomb**
  - **Strong**

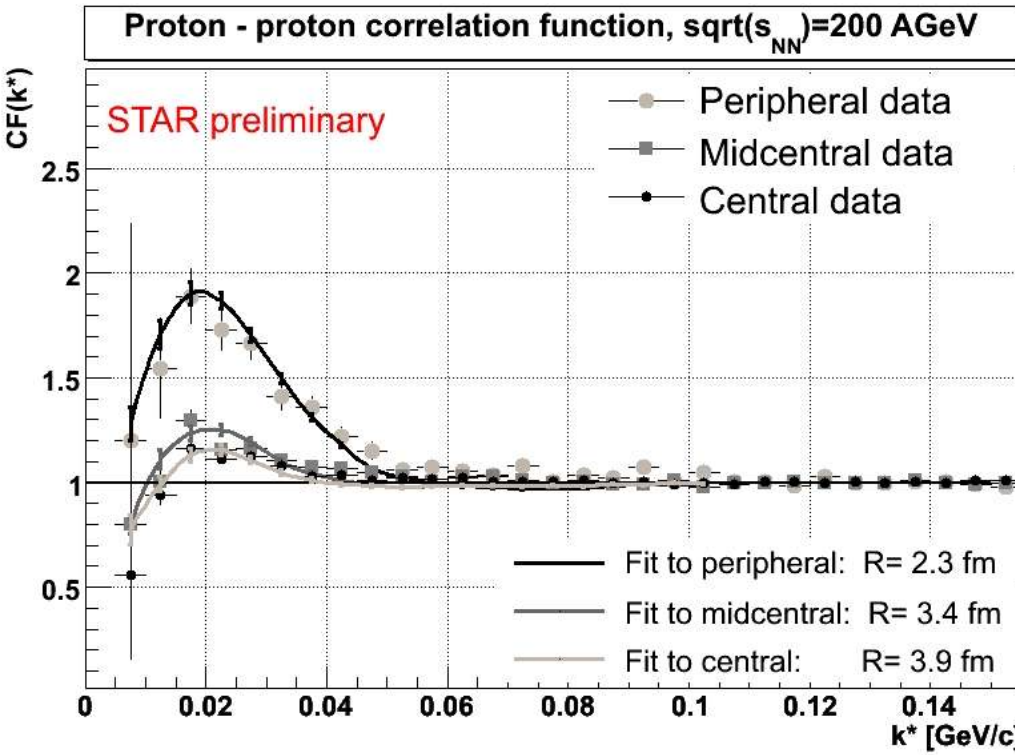
Nonidentical baryon- (anti)baryon

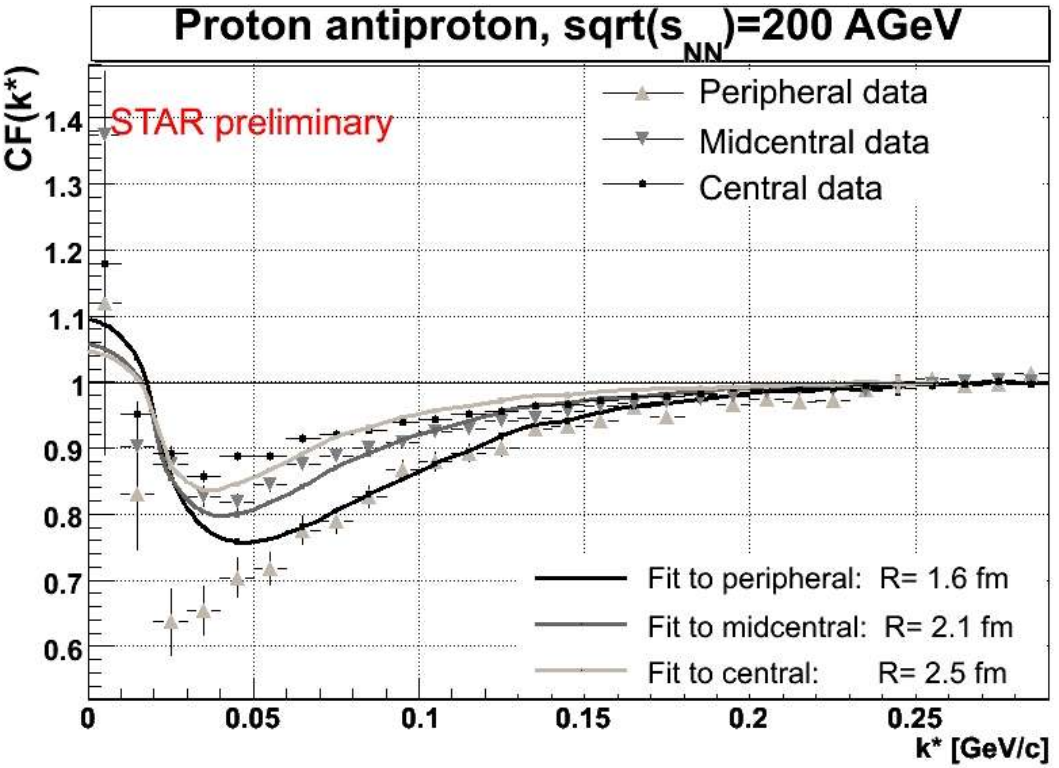
- Final State Interactions- **FSI**
  - **Coulomb**
  - **Strong**





Baryon-baryon: Quark Matter 2005 status





	$p-p$	$\bar{p}-\bar{p}$	$p-\bar{p}$
peripheral	$2.3^{+0.1}_{-0.1}$ *fm*	$2.4^{+0.1}_{-0.2}$ *fm*	$1.6^{+0.1}_{-0.1}$ *fm*
midcentral	$3.4^{+0.1}_{-0.1}$ *fm*	$3.5^{+0.1}_{-0.1}$ *fm*	$2.1^{+0.1}_{-0.1}$ *fm*
central	$3.9^{+0.2}_{-0.1}$ *fm*	$4.5^{+0.1}_{-0.1}$ *fm*	$2.5^{+0.1}_{-0.2}$ *fm*

2 different sizes!

2 different sources?

The input

- 10 000 events generated (central collisions) using
  THERMal heavy IoN generATOR
  (Broniowski, Florkowski, Kisiel, Tałuć: nucl-th/0504047)
- Access to information: unique id, pid, space-time coordinates, mass, momentum four-vector, identification number of father

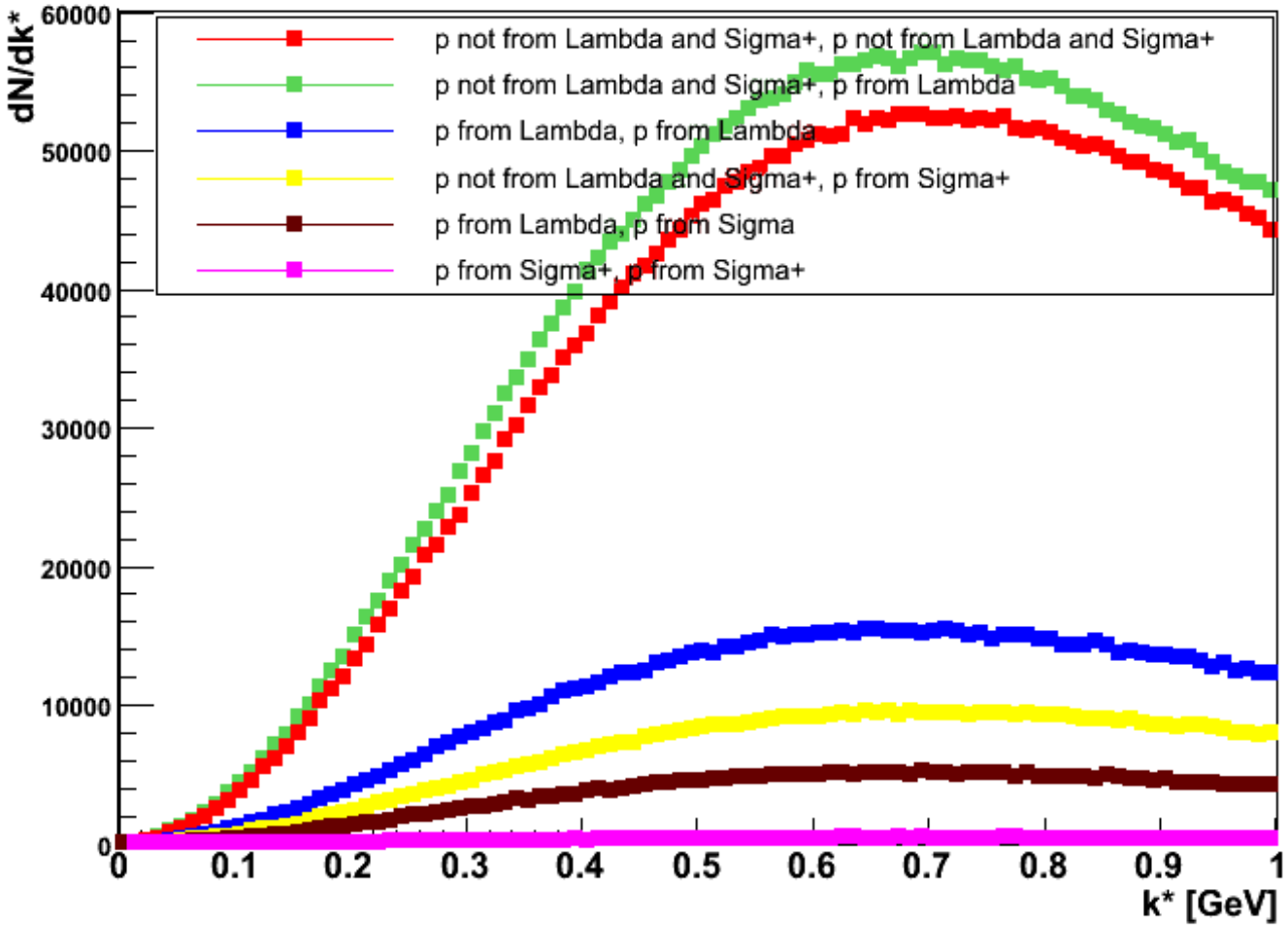
- weak decay channels of interest:

$\Lambda \rightarrow p + \pi^-$, $\Lambda_{bar} \rightarrow p_{bar} + \pi^+$

$\Sigma^+ \rightarrow p + \pi^0$, $\Sigma^+_{bar} \rightarrow p_{bar} + \pi^0$

Contribution to measured correlation function

$$CF_{true}(k_{star}) = CF_{p-p}(k_{star})F_{p-p}(k_{star}) + CF_{p-\Lambda}(k_{star})F_{p-\Lambda}(k_{star}) + CF_{\Lambda-\Lambda}(k_{star})F_{\Lambda-\Lambda}(k_{star}) + CF_{p-\Sigma}(k_{star})F_{p-\Sigma}(k_{star}) + CF_{\Sigma-\Sigma}(k_{star})F_{\Sigma-\Sigma}(k_{star}) + CF_{\Lambda-\Sigma}(k_{star})F_{\Lambda-\Sigma}(k_{star})$$



$$F_{p-p}(k_{star}) = \frac{f_{p-p}(k_{star})}{\sum f(k_{star})}$$

$$F_{p-\Lambda}(k_{star}) = \frac{f_{p-\Lambda}(k_{star})}{\sum (k_{star})}$$

$$F_{\Lambda-\Lambda}(k_{star}) = \frac{f_{\Lambda-\Lambda}(k_{star})}{\sum (k_{star})}$$

$$F_{p-\Sigma}(k_{star}) = \frac{f_{p-\Sigma}(k_{star})}{\sum (k_{star})}$$

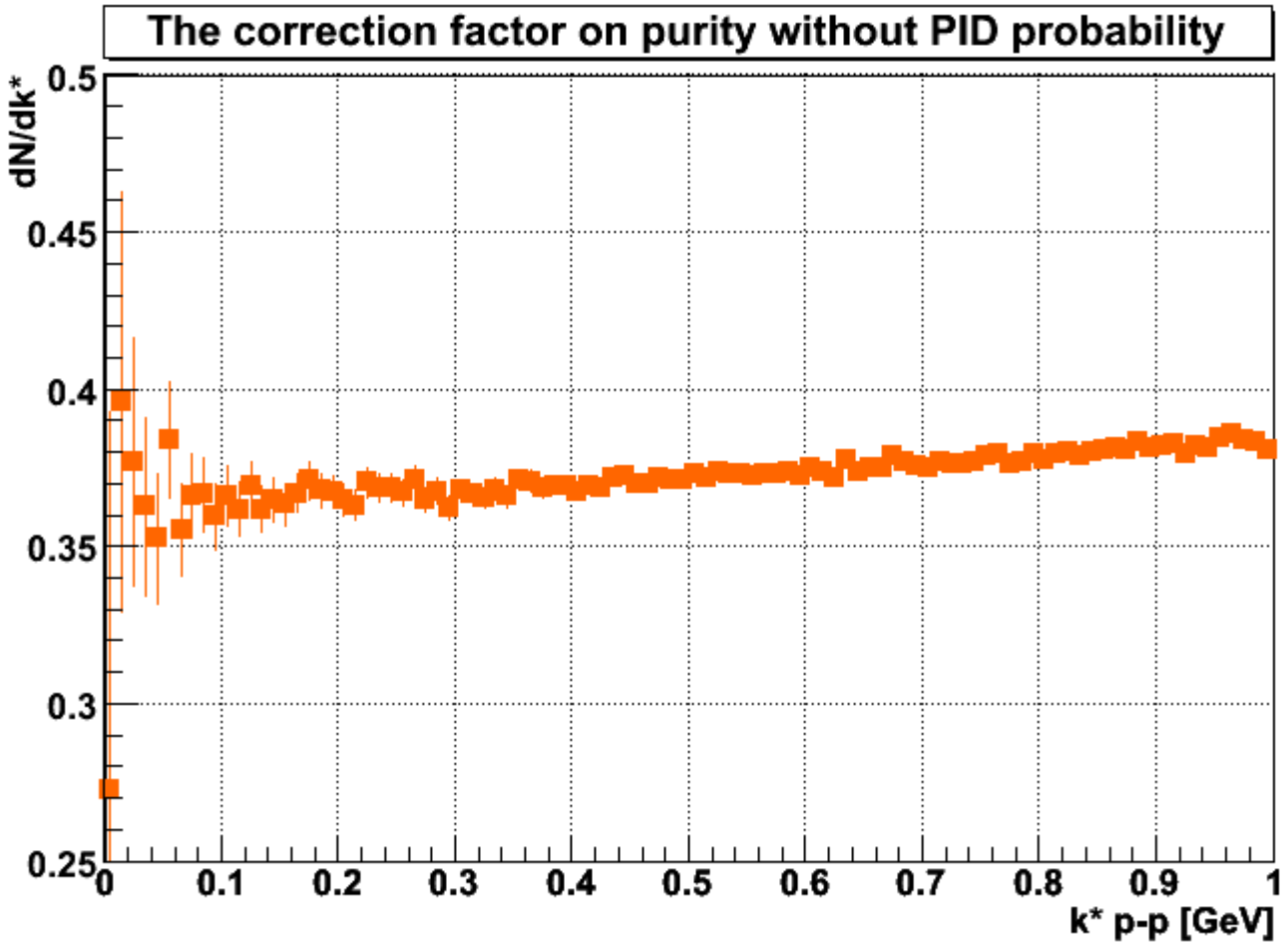
$$F_{\Sigma-\Sigma}(k_{star}) = \frac{f_{\Sigma-\Sigma}(k_{star})}{\sum (k_{star})}$$

$$F_{\Lambda-\Sigma}(k_{star}) = \frac{f_{\Lambda-\Sigma}(k_{star})}{\sum (k_{star})}$$

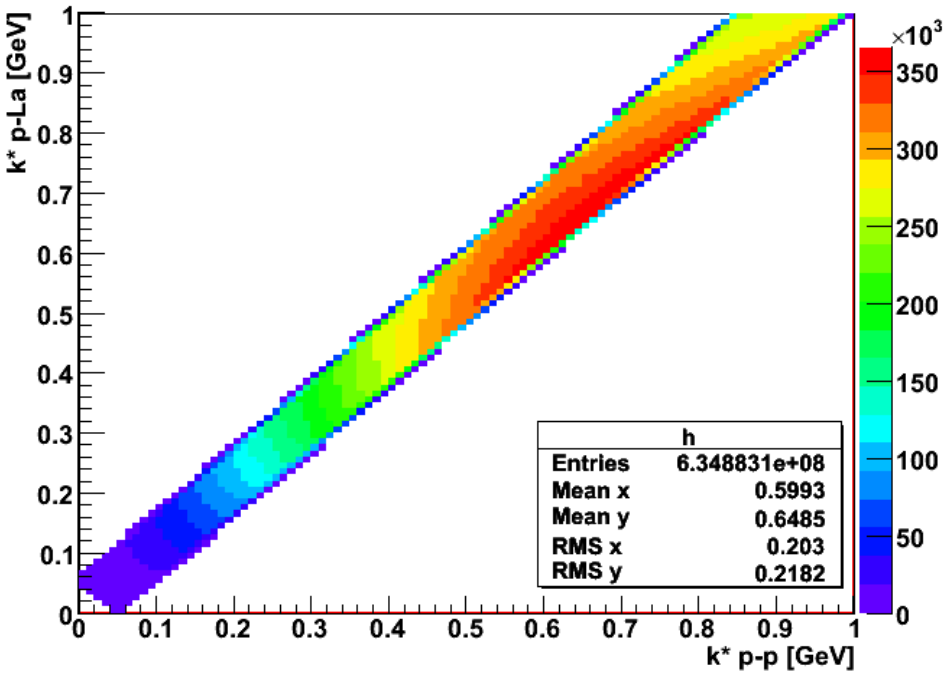
$$\sum f(k_{star}) = f_{p-p}(k_{star}) + f_{p-\Lambda}(k_{star}) + f_{\Lambda-\Lambda}(k_{star}) + f_{p-\Sigma}(k_{star}) + f_{\Sigma-\Sigma}(k_{star}) + f_{\Lambda-\Sigma}(k_{star}) \quad 6$$

The fraction of proton-proton pairs

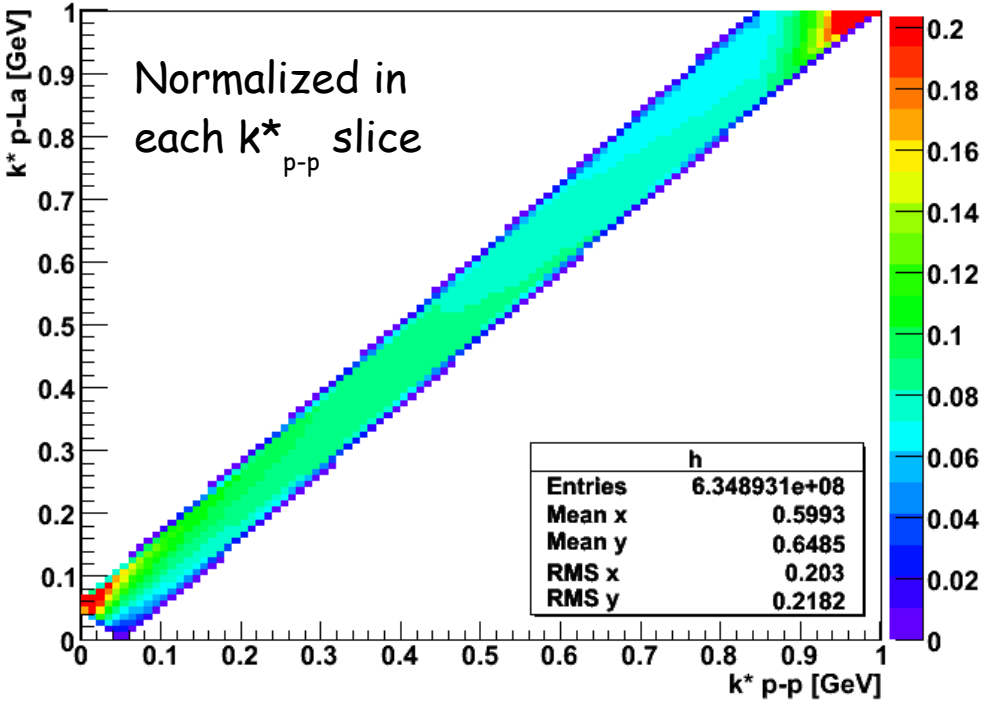
$$F_{p-p}(k_{star}) = \frac{f_{p-p}(k_{star})}{all(k_{star})}$$

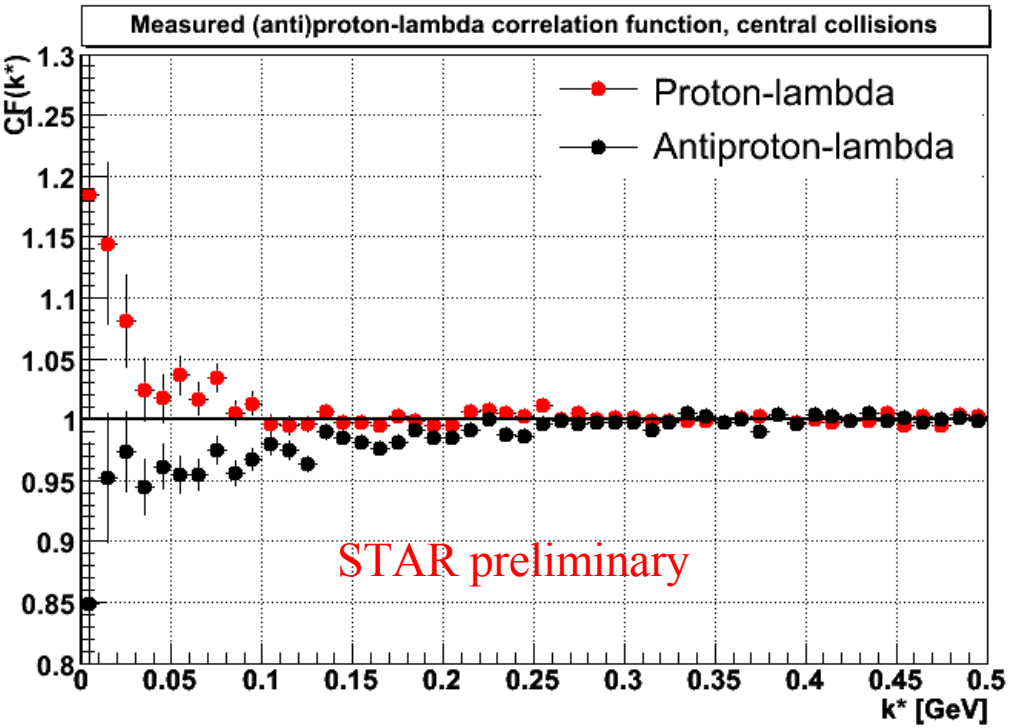


The estimation of p-Λ residual correlation

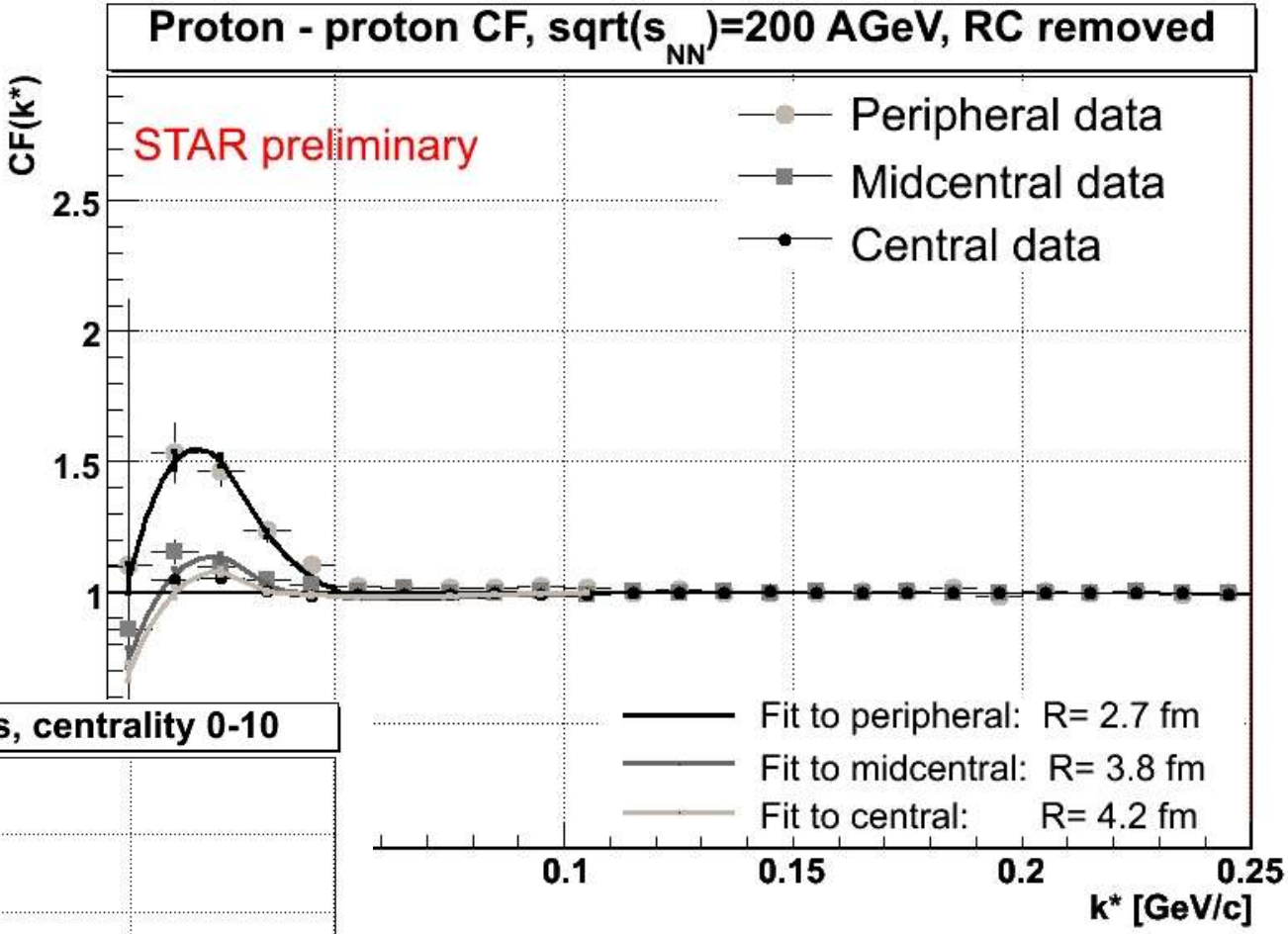


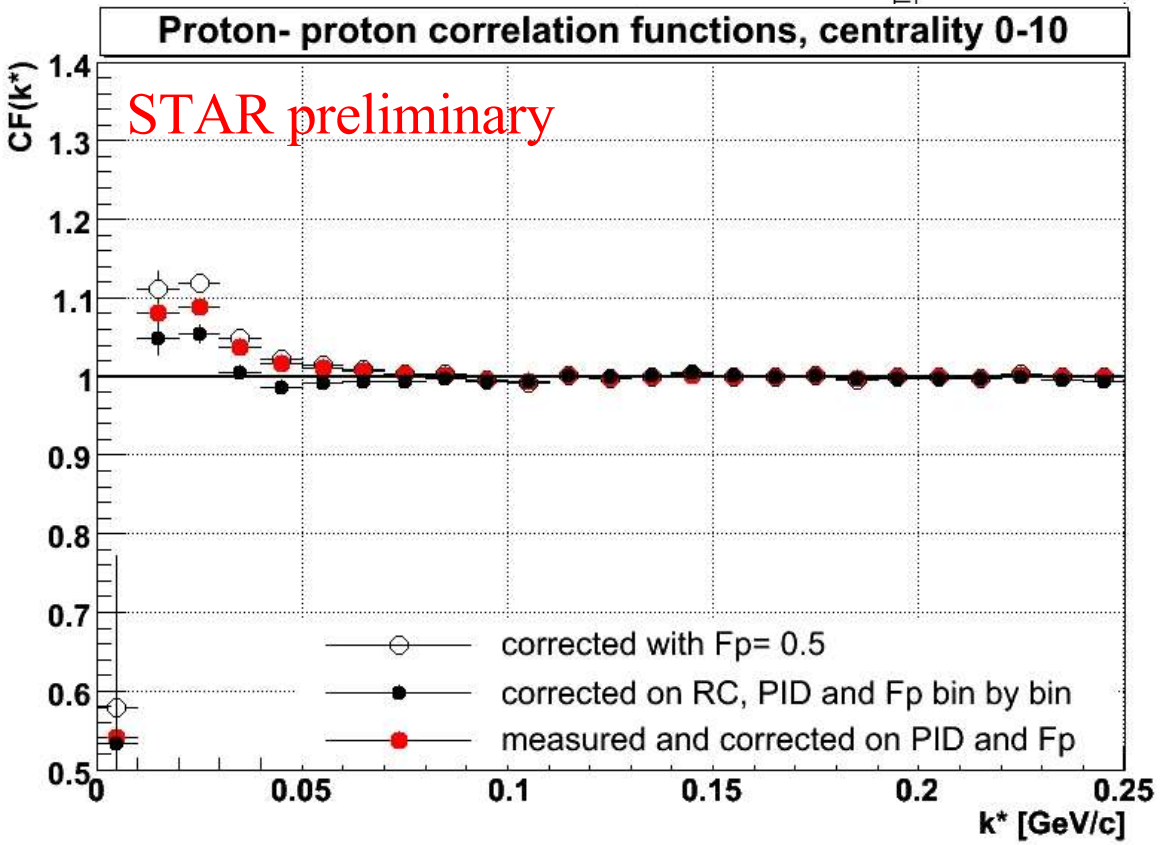
$$CF_{p-\Lambda}(k^{star}_{p-p}) = \sum_{k^{star}_{p-\Lambda}} CF^{meas}_{p-\Lambda}(k^{star}_{p-\Lambda})\, W(k^{star}_{p-p}, k^{star}_{p-\Lambda})$$



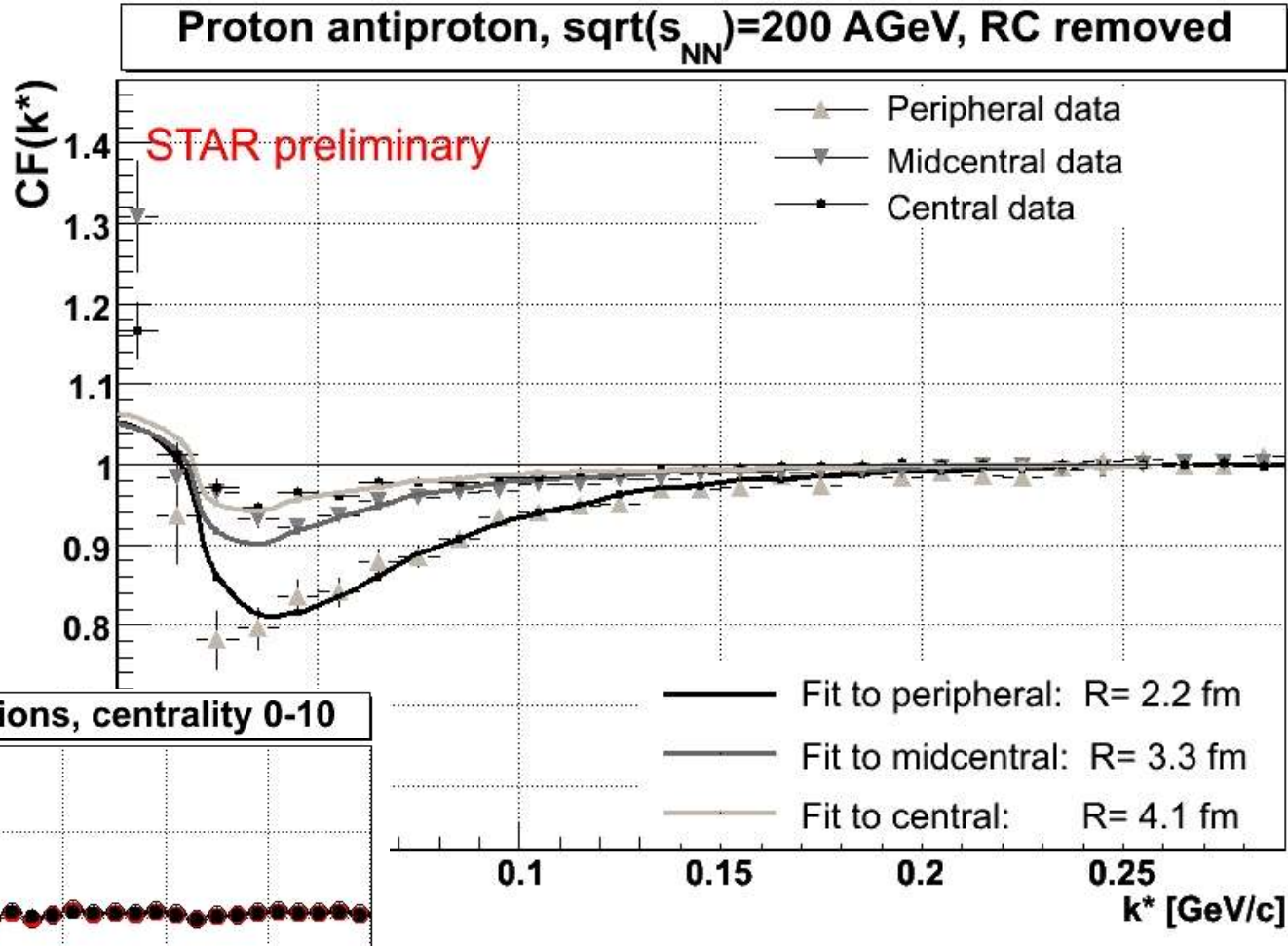


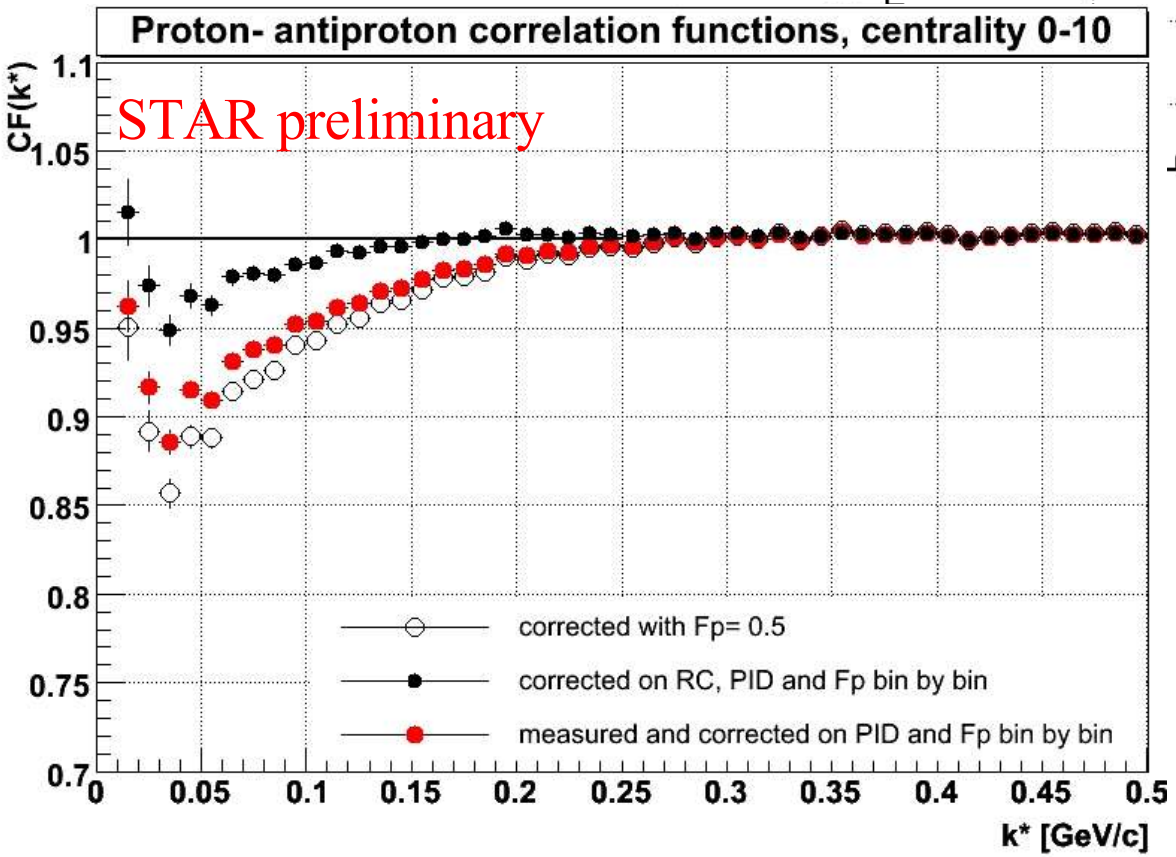
Proton-proton correlations



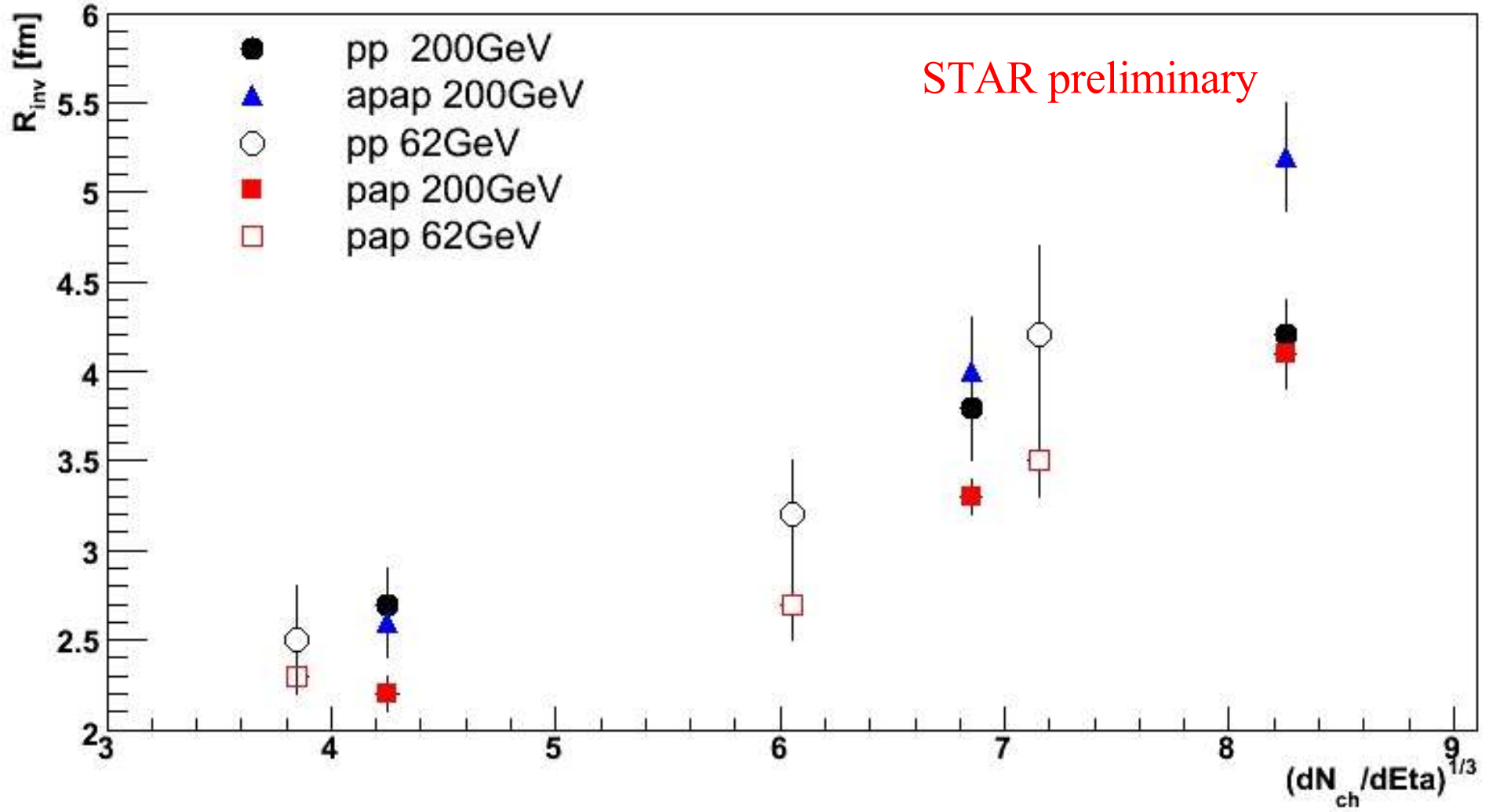


Proton-antiproton correlations

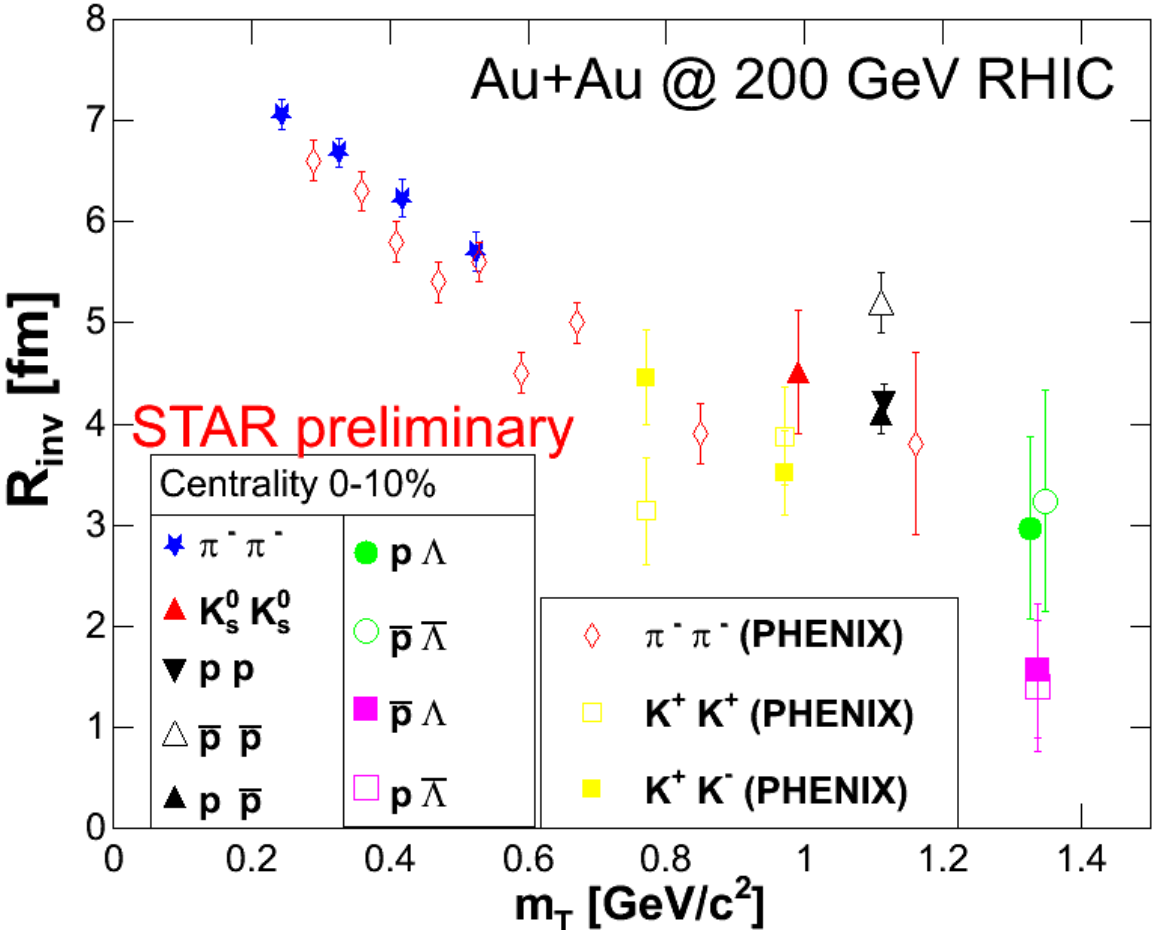


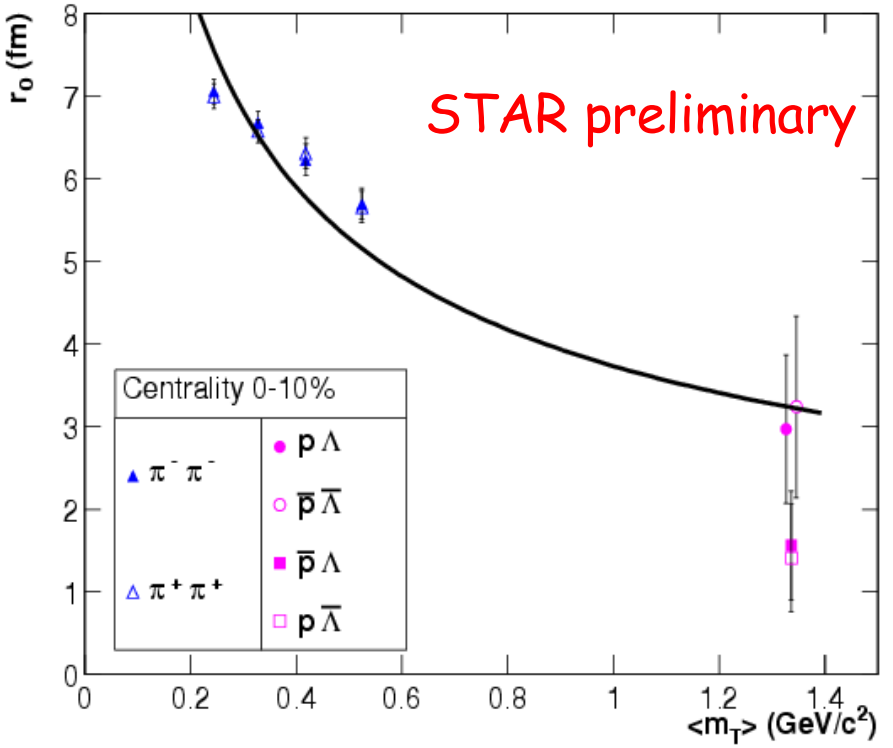


Proton-proton, antiproton-antiproton, proton- antiproton



m_T dependence





Not taking into account the residual correlations- may lead to the misunderstanding of results!

System	*r_0 (fm)*
$\bar{p}-\Lambda+p-\bar{\Lambda}$	$1.50+0.05^{+0.10}_{-0.12}$
$p-\Lambda+\bar{p}-\bar{\Lambda}$	$3.09+0.30^{+0.17}_{-0.25}$

Conclusions – part II

- Proton-proton, antiproton-antiproton, proton-antiproton correlations for Au+Au @ 200GeV and 62 GeV are shown
- Proton femtoscopy is a new insight into baryon production and interaction processes thanks to the large STAR data collections
- It allows to extract proton and antiproton source size parameters with a very good accurancy
- Preliminary results indicate that the residual correlations play a crucial role in baryon systems
- Residual correlations affect non-id systems more
- We record a very good agreement between the experimental results and the theoretical predictions
- After removing RC- there are still small discrepancies (according gaussian parametrization of source)
- Systematic uncertainty studies are underway
- Proton source sizes scales as predicted by flow

The End

Few words about femtoscopy

Single- and two- particle distributions

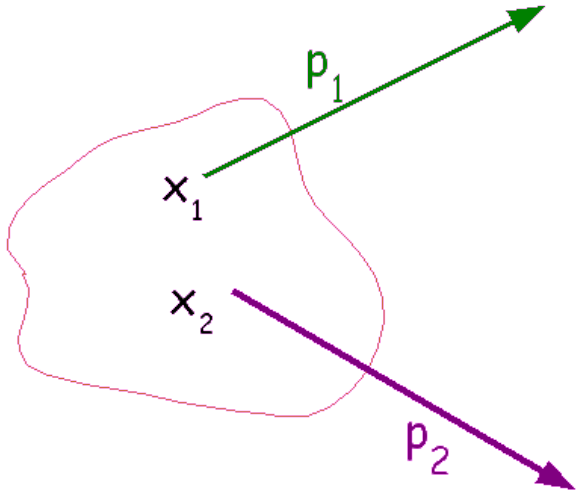
$$P_1(p) = E\frac{dN}{d^3p} = \int d^4x\, S(x,p)$$

S(x,p) – emission function: the distribution of source density probability of finding particle with x and p

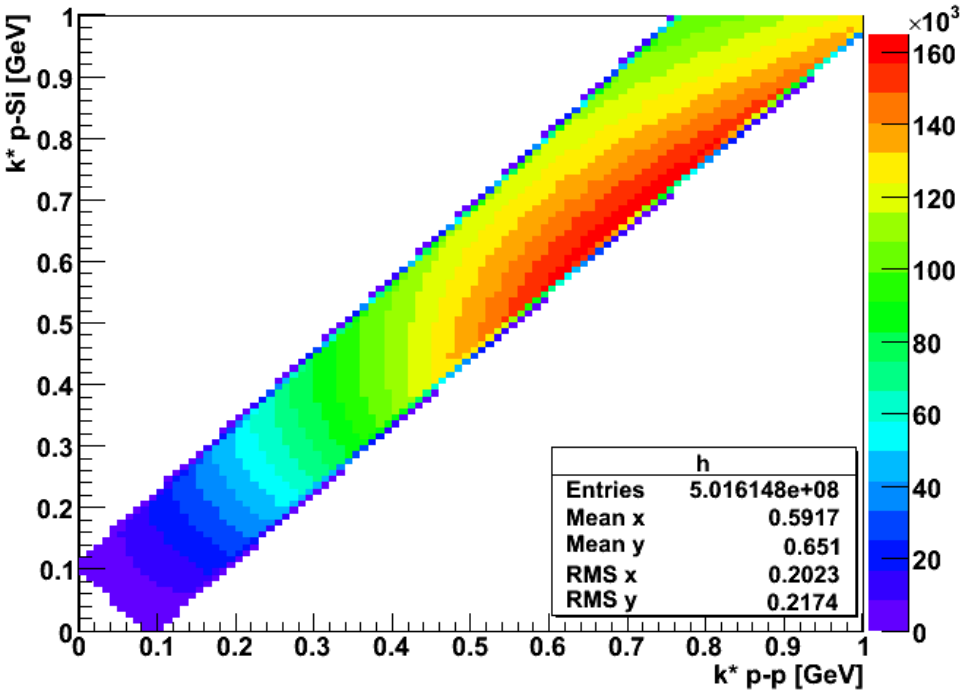
$$P_2(p_1, p_2) = E_1 E_2 \frac{dN}{d^3p_1\, d^3p_2} = \int d^4x_1 S(x_1, p_1) d^4x_2\, S(x_2, p_2) \Phi(x_2, p_2 | x_1, p_1)$$

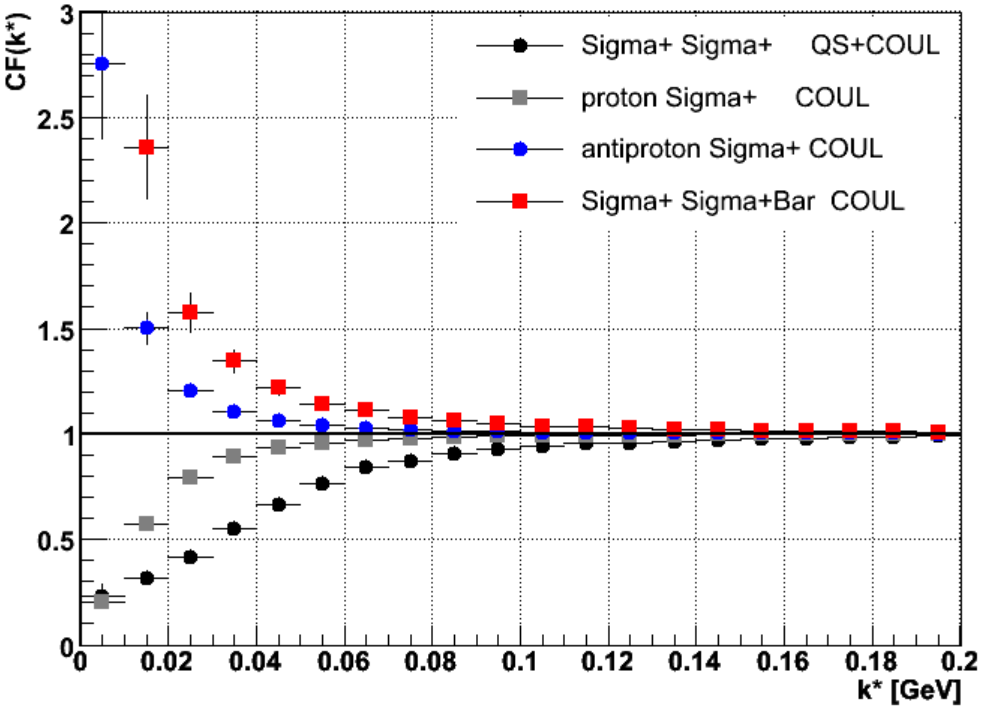
The correlation function

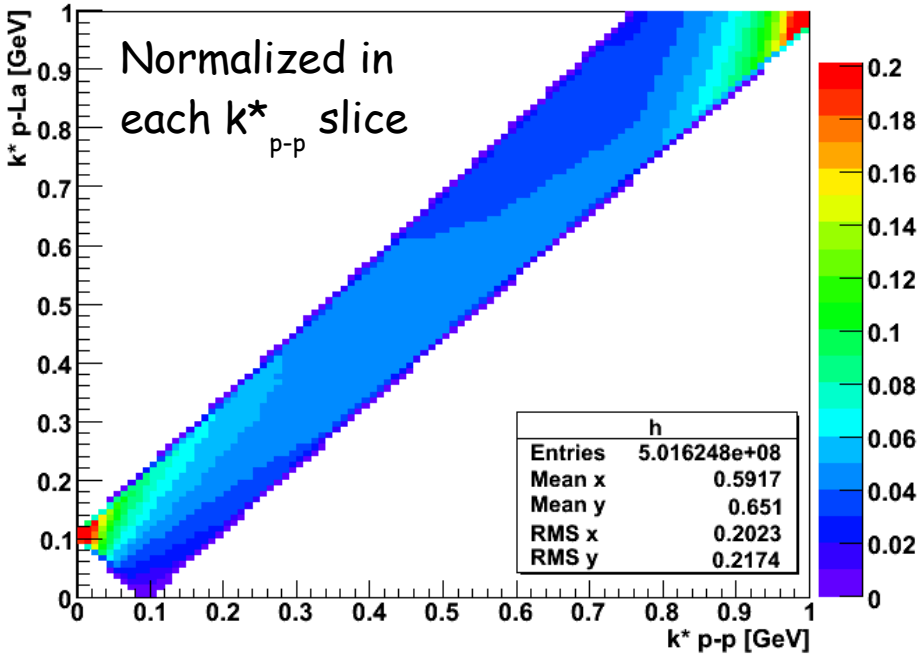
$$C(p_1, p_2) = \frac{P_2(p_1, p_2)}{P_1(p_1) P_1(p_2)}$$



The estimation of p-Σ residual correlation



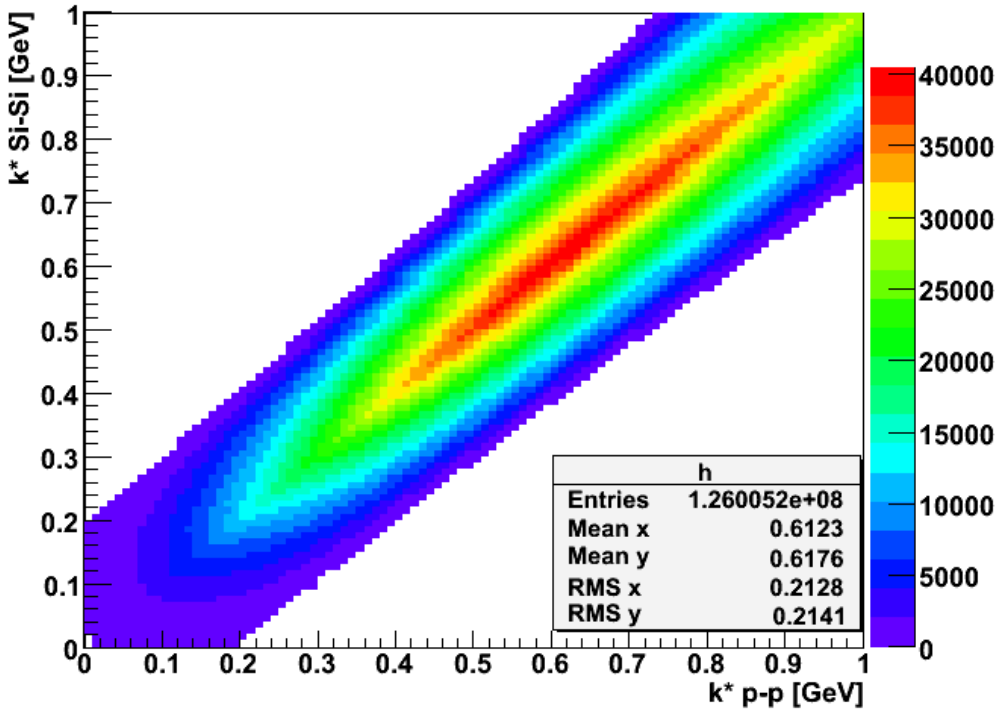


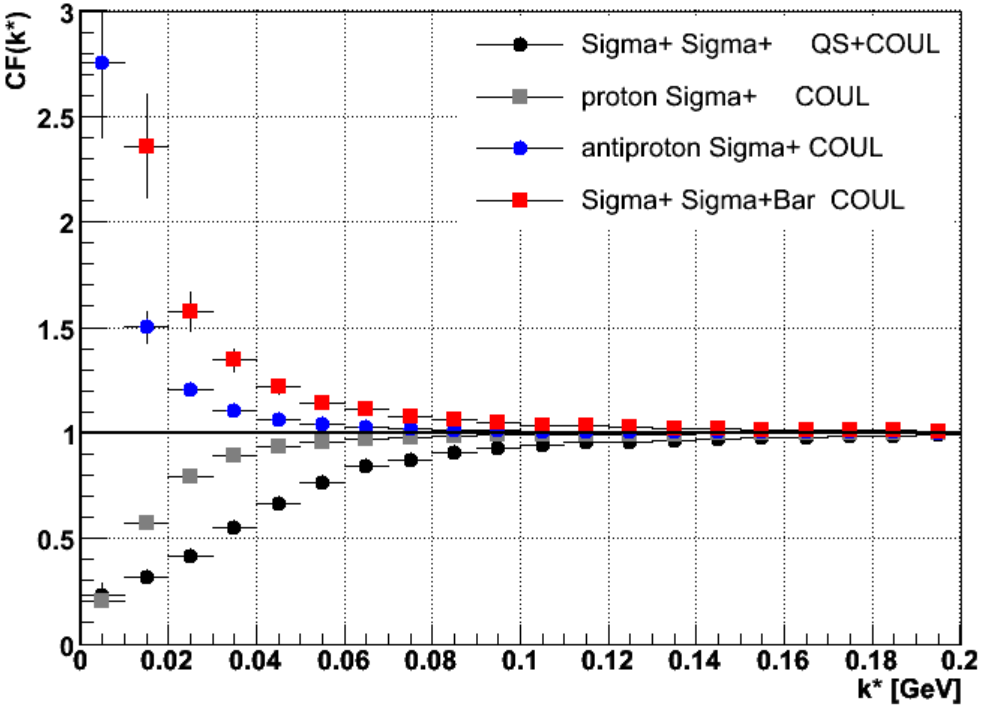


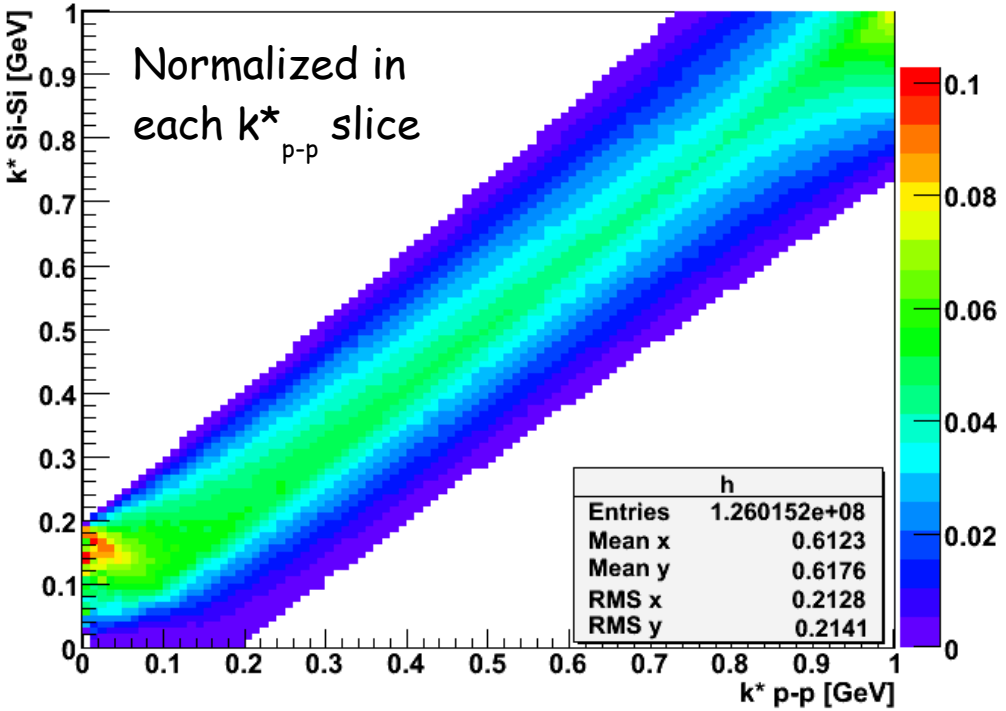
$$CF_{p-\Sigma}(k^{star}_{p-p}) =$$

$$= \sum_{k^{star}_{p-\Sigma}} CF^{fsim}_{p-\Sigma}(k^{star}_{p-\Sigma})\, W(k^{star}_{p-p}, k^{star}_{p-\Sigma})$$

The estimation of Σ-Σ residual correlation



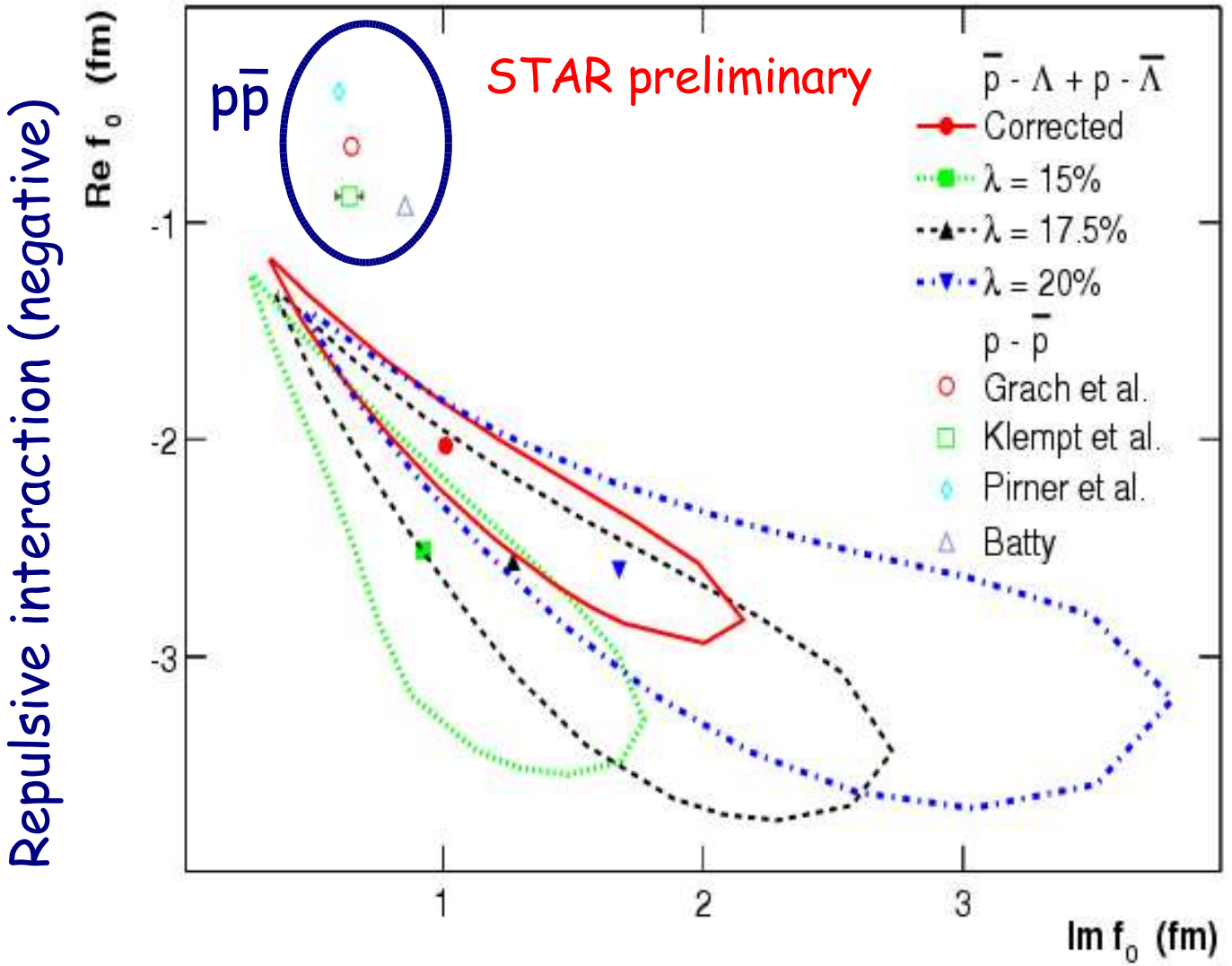




$$CF_{\Sigma-\Sigma}(k^{star}_{p-p}) =$$

$$= \sum_{k^{star}_{\Sigma-\Sigma}} CF^{fsim}_{\Sigma-\Sigma}(k^{star}_{\Sigma-\Sigma})\, W(k^{star}_{p-p}, k^{star}_{\Sigma-\Sigma})$$

The scattering lengths



Annihilation