$K^0_s K^0_s$ correlations in 7 TeV proton+proton collisions from the ALICE experiment at the LHC

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Motivation for studying $K^0_sK^0_s$ correlations in ALICE

- K^0_s is a different kind of boson -> complements $\pi\pi$ and charged KK studies and extends k_T to higher values

- K^0_s is uncharged so no final-state Coulomb effects

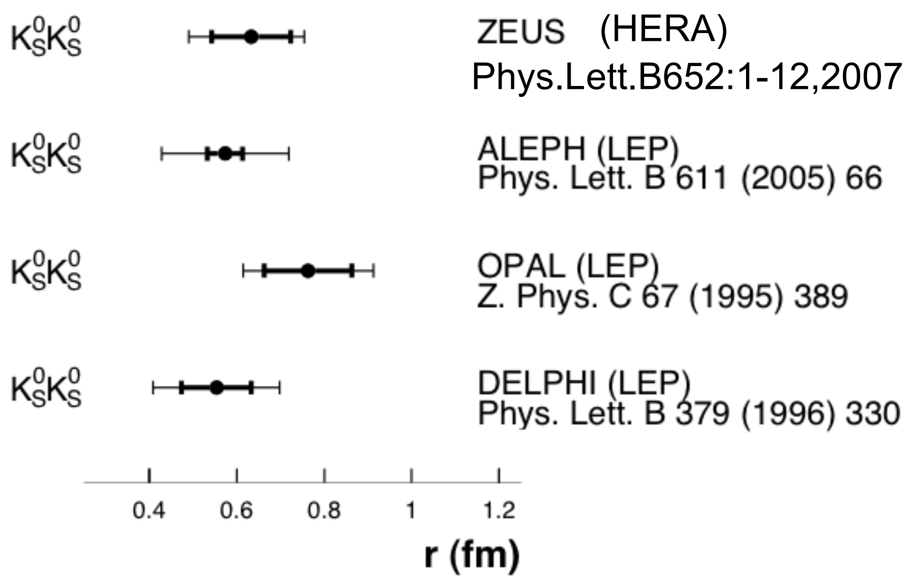
- previous $K^0_sK^0_s$ studies suffered from a lack of statistics
  -- in ALICE, high energy and long running periods allow better statistics

- $K^0_sK^0_s$ state is interesting:
  $$|K^0_sK^0_s\rangle = 1/2\,(|K^0K^0\rangle + |\bar{K}^0\bar{K}^0\rangle + |K^0\bar{K}^0\rangle + |\bar{K}^0K^0\rangle)$$

Symmetric due to BE — Only symmetric part contributes to $K^0_sK^0_s$

Results from other experimental $K^0_s K^0_s$ Bose-Einstein studies

* e^+e^- and $e^{\pm}p$ collisions (figure from Phys.Lett.B652:1-12,2007)



* Au+Au collisions at sqrt(s_{NN}) = 200 GeV (RHIC)

STAR $K^0_s K^0_s$ $R_{inv} = 4.09 \pm 0.46 \pm 0.31$ fm , $\lambda = 0.92 \pm 0.23 \pm 0.13$

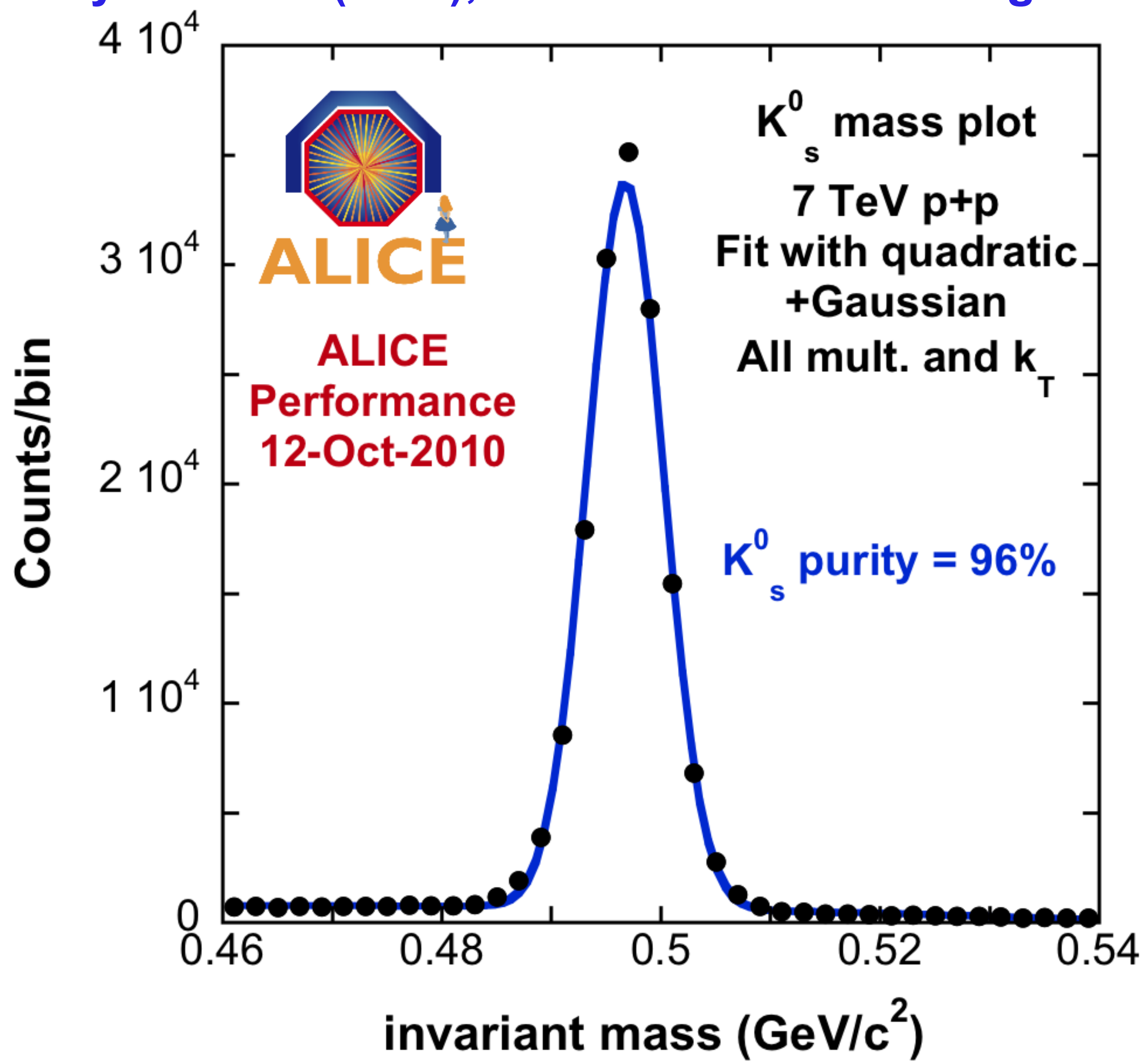
Phys. Rev. C74:054902 (2006)

→The present $K^0_s K^0_s$ study is the first to show source parameters for p+p collisions and for different multiplicity and k_T bins

K^0_s identification (from V_0 ➔ h^+h^-)

Fit a Quadratic + Gaussian to the K^0_s mass peak and take the Quadratic to represent the background

Purity ➔ P = G/(Q+G), calculated in the range 0.49 < mass < 0.504 GeV

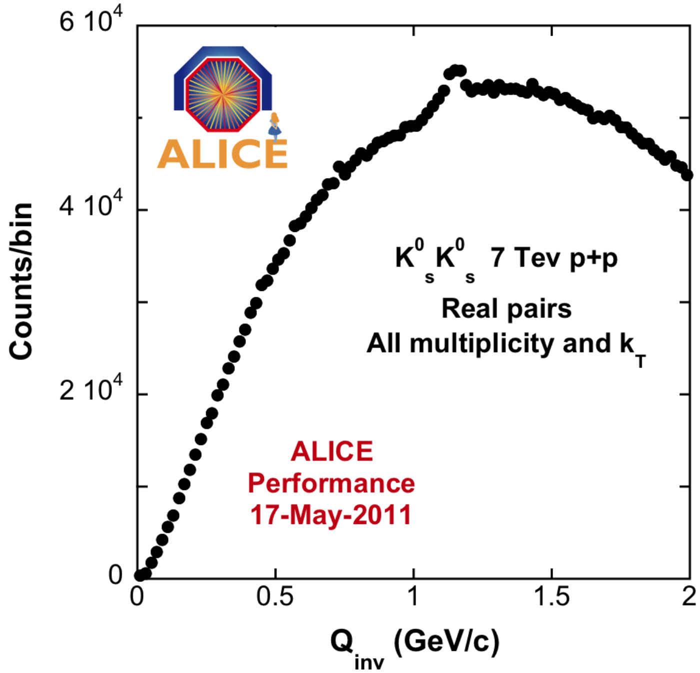


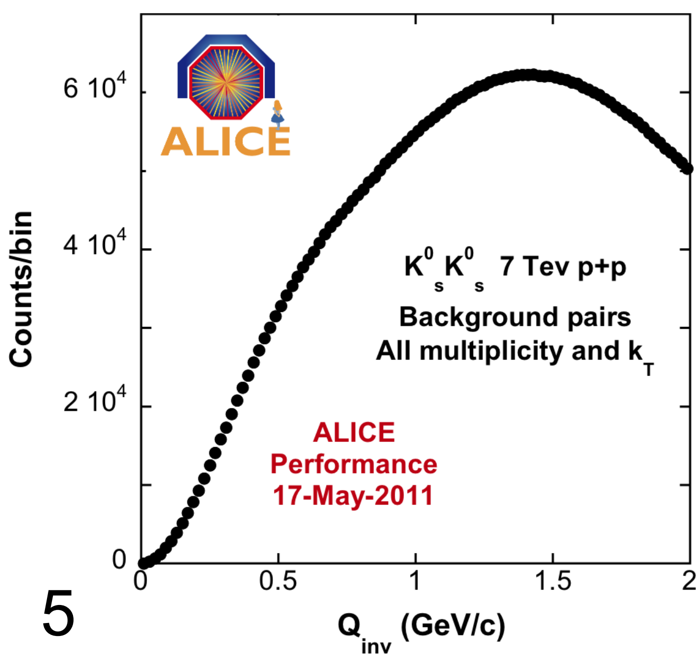
K^0_s Cuts used:

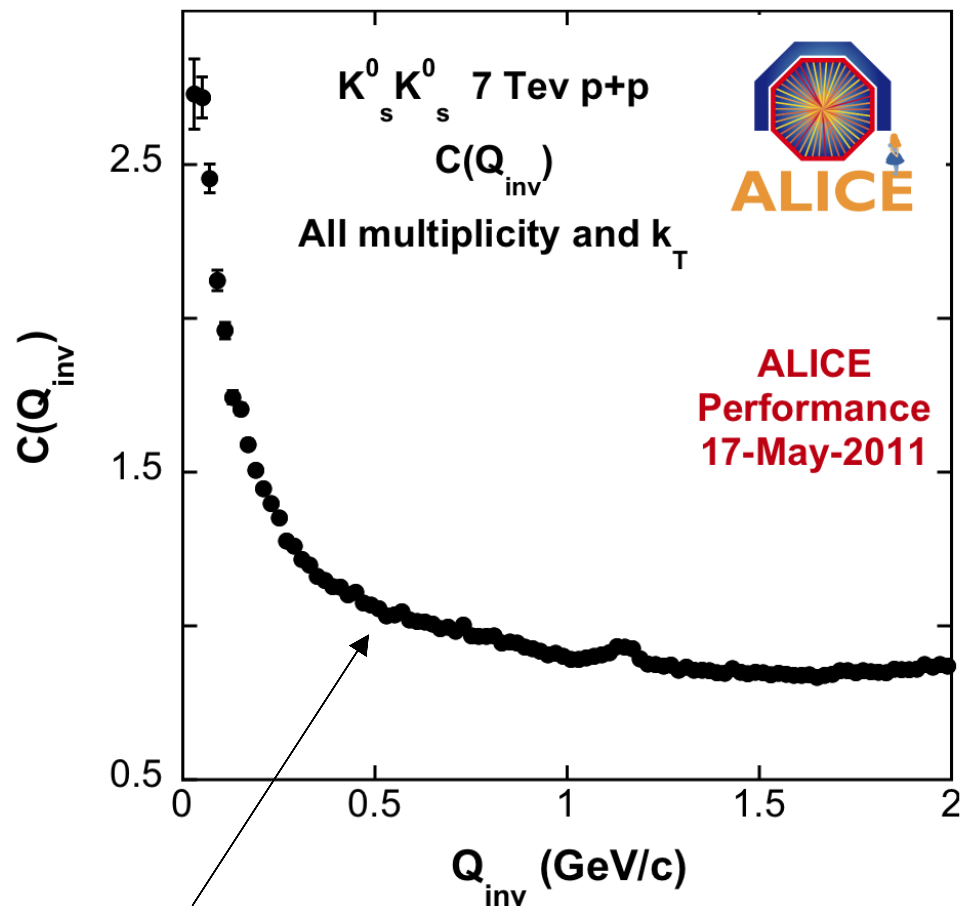
$|\eta| < 0.8$

$0.4 < p_T < 3.5$ GeV/c

$K^0_sK^0_s$ Real and Background pairs distributions and $C(Q_{inv})$ All multiplicity and k_T

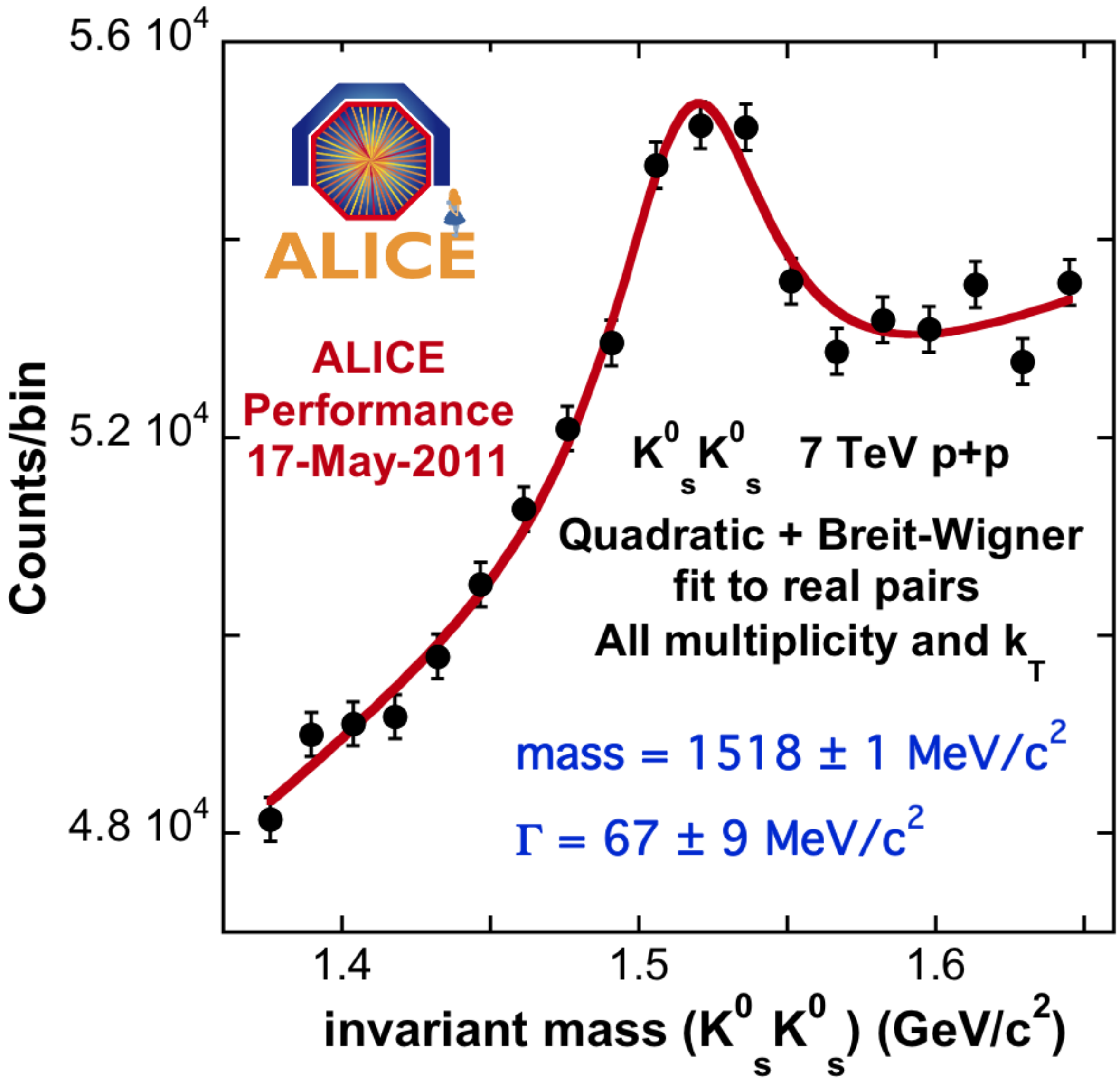






Non-flat baseline as in ππ for 7 TeV p+p

Identity of the "mystery peak" in $K^0_s K^0_s$ real distribution



From PDG: **$f_2'(1525)$**

mass =1525 ± 5 MeV/c²
Γ = 73 ± 6 MeV/c²

Main decay mode

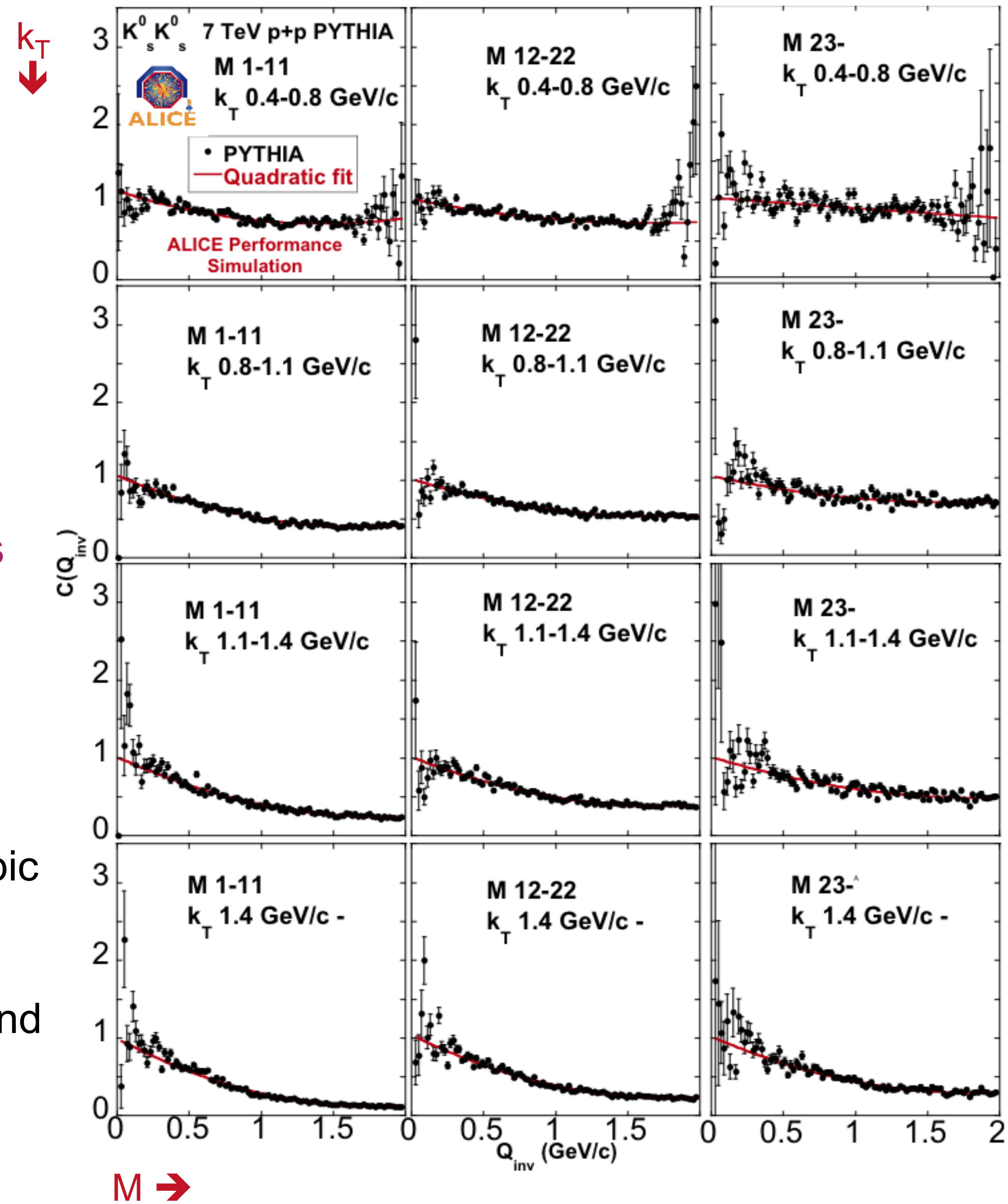
$f_2'(1525) \rightarrow K\bar{K}$ (89%)

Use PYTHIA with the Perugia-0 tune to model the baseline for $K^0_sK^0_s$ $C(Q_{inv})$ as was done for ππ (apply ±10% syst. error)

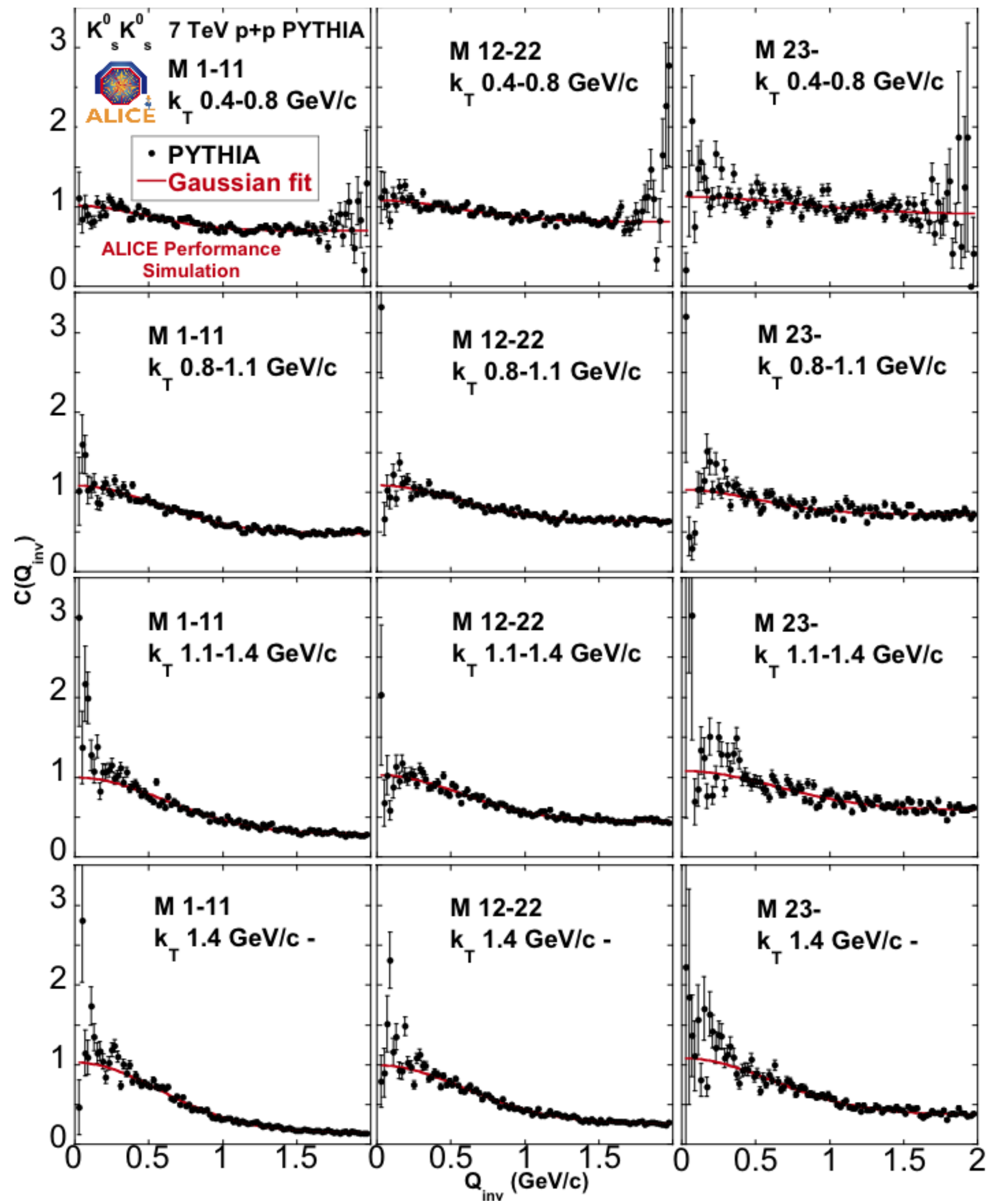
Quadratic fits to PYTHIA to extract baseline parameters for $C(Q_{inv})$

$$C(Q_{inv}) = N\{1 + aQ_{inv} + bQ_{inv}^2\} \times F(Q_{inv})$$

where $F(Q_{inv})$ is the femtoscopic part containing, in general, quantum statistics and strong interaction effects which depend on R_{inv} and the λ parameter.



k_T ↓



M →

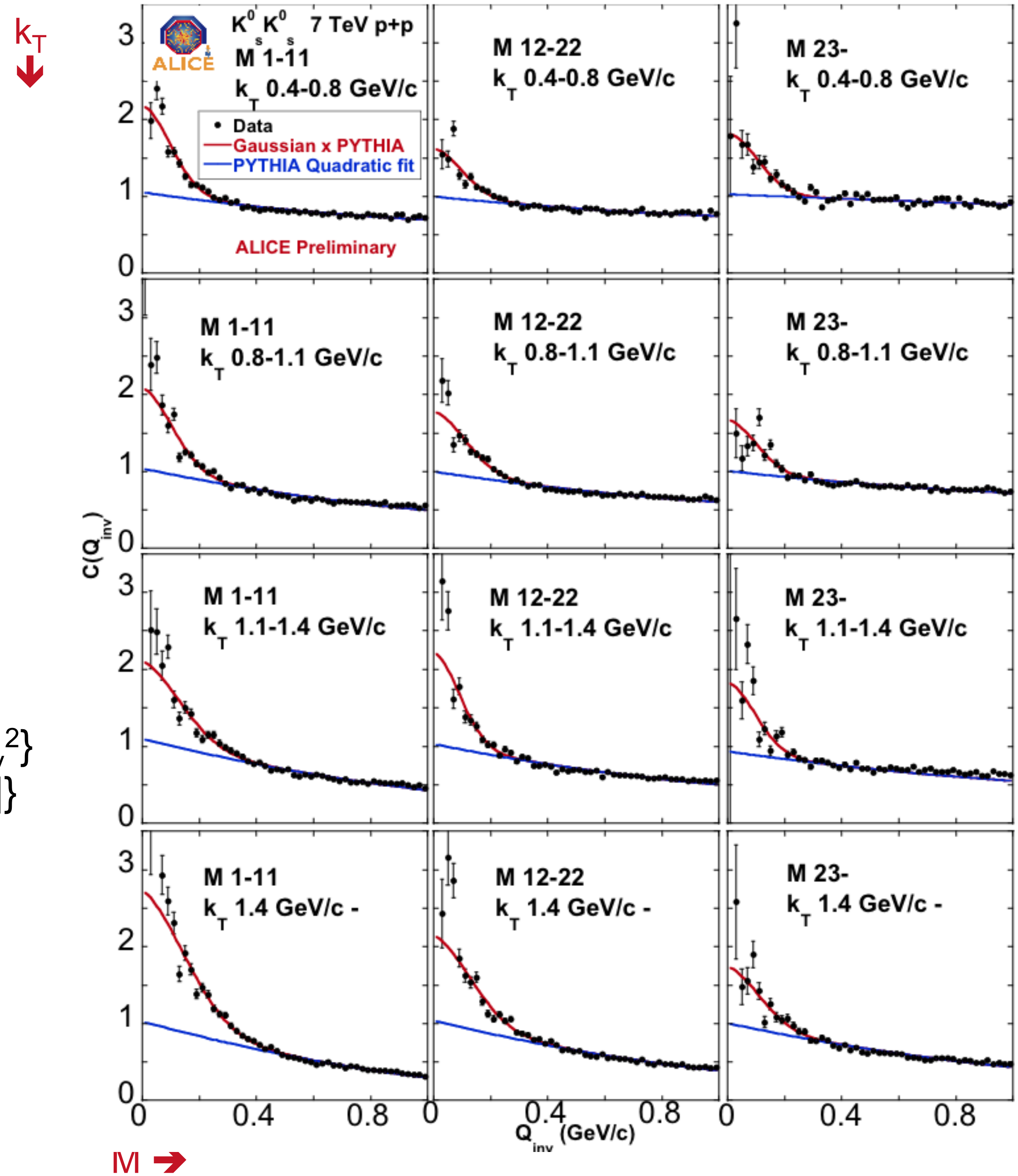
Gaussian fits to PYTHIA to extract baseline parameters for $C(Q_{inv})$

$$C(Q_{inv}) = N\{1 + a \exp[(bQ_{inv})^2]\} \times F(Q_{inv})$$

ALICE data
7 TeV p+p

Gaussian fits to data $C(Q_{inv})$ with Quadratic PYTHIA baseline

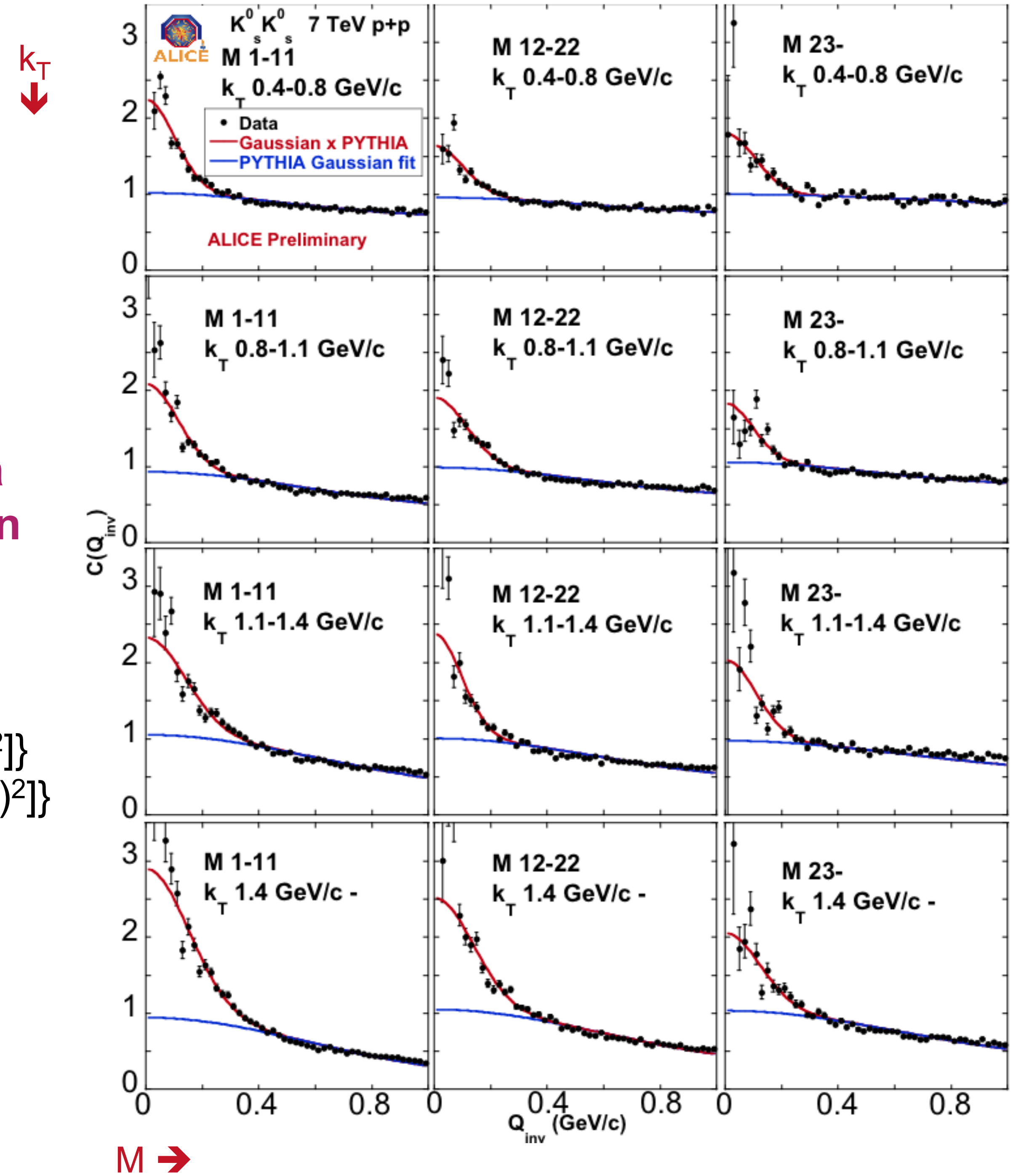
$$C(Q_{inv}) = N\{1 + aQ_{inv} + bQ_{inv}^2\} \times \{1 + \lambda \exp[-(Q_{inv}R_{inv})^2]\}$$



ALICE data
7 TeV p+p

Gaussian fits to data $C(Q_{inv})$ with Gaussian PYTHIA baseline

$$C(Q_{inv}) = N\{1 + a \exp[(bQ_{inv})^2]\} \times \{1 + \lambda \exp[-(Q_{inv}R_{inv})^2]\}$$



Lednicky fit to data to take into account the a_0/f_0resonance in $K^0\overline{K^0}$ channel

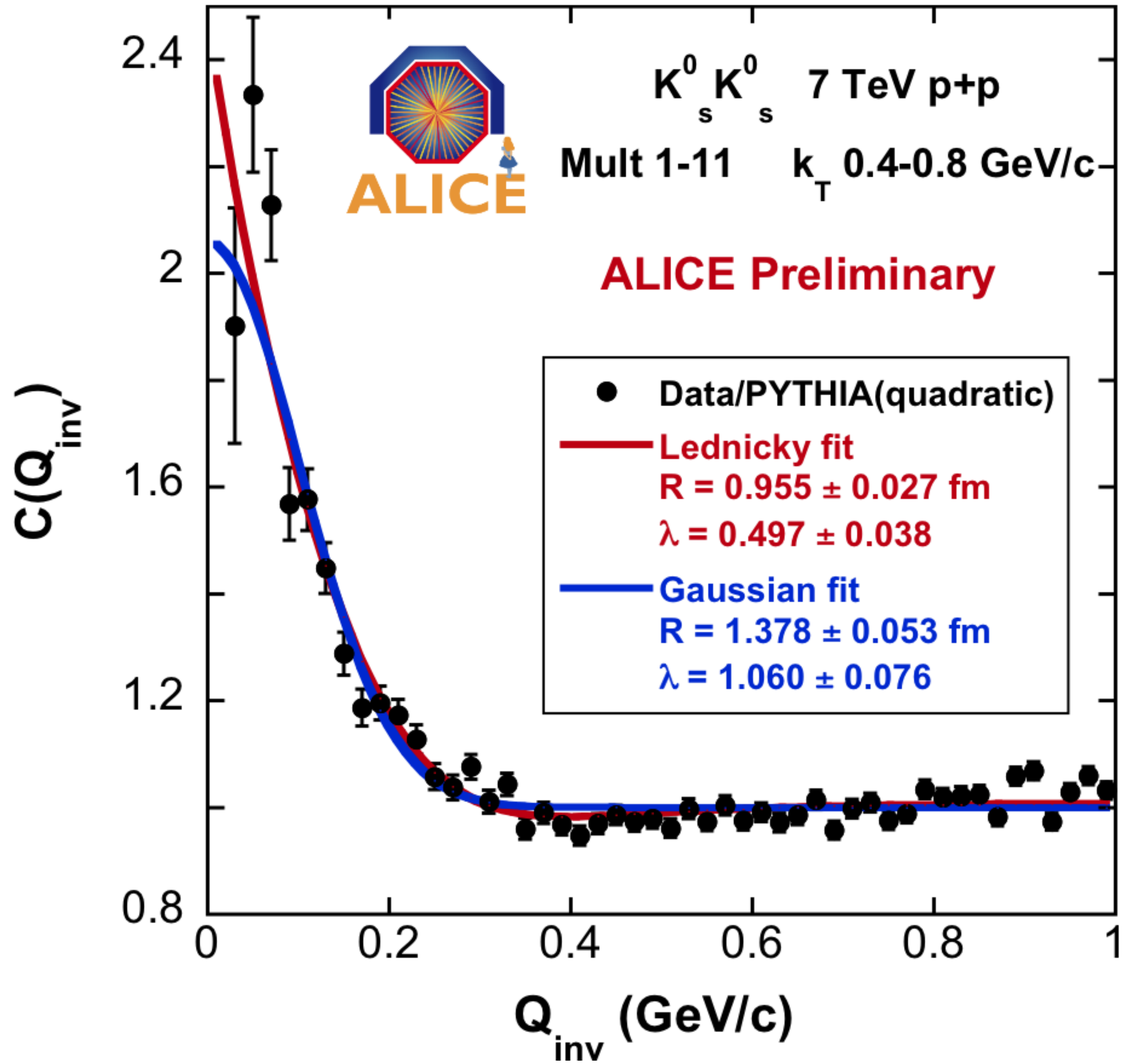
* A strong final-state interaction has an important effect on neutral kaon correlations due to the $f_0(980)$ and $a_0(980)$ resonances which contribute to the K^0K^0-bar channel.

* Use the Lednicky & Lyuboshitz analytical model and code to take into account this strong FSI assuming s-wave scattering:
(R. Lednicky and V.L. Lyuboshitz, Sov.J.Nucl.Phys. 35,770 (1982))

* The code assumes a Gaussian distribution of the K^0 source points, and so one fits the model to the experimental correlation function to extract the Gaussian R and λ parameters from both quantum statistics and strong FSI.

* STAR used this method to fit their $K^0_sK^0_s$ correlation function from RHIC Au+Au collisions (Phys.Rev.C74:054902,2006).

Example of Lednicky fit to data with quadratic baseline model divided out

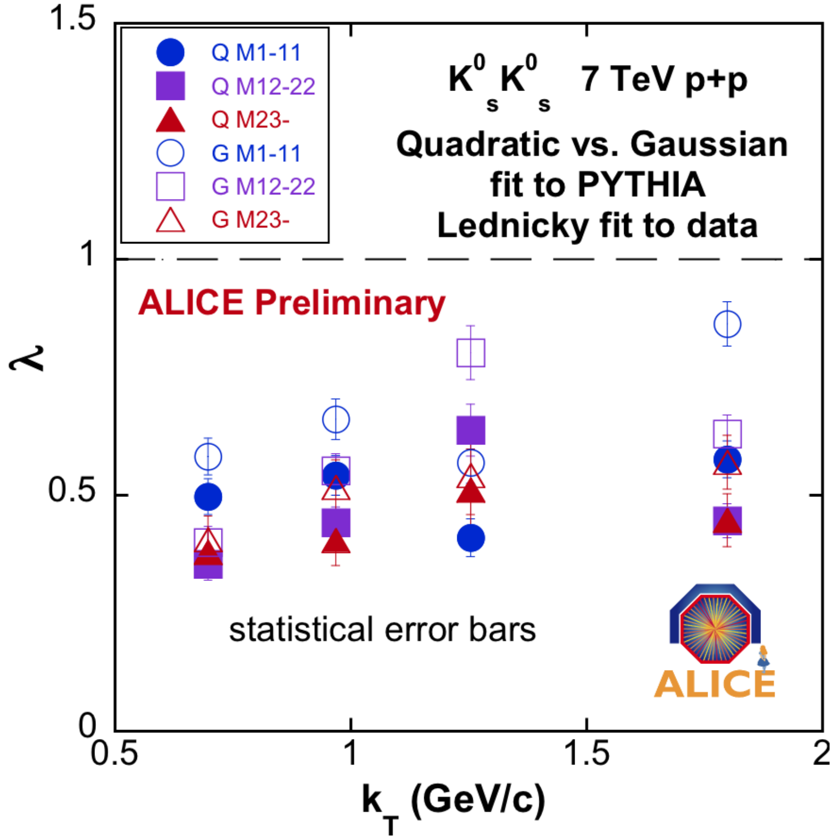


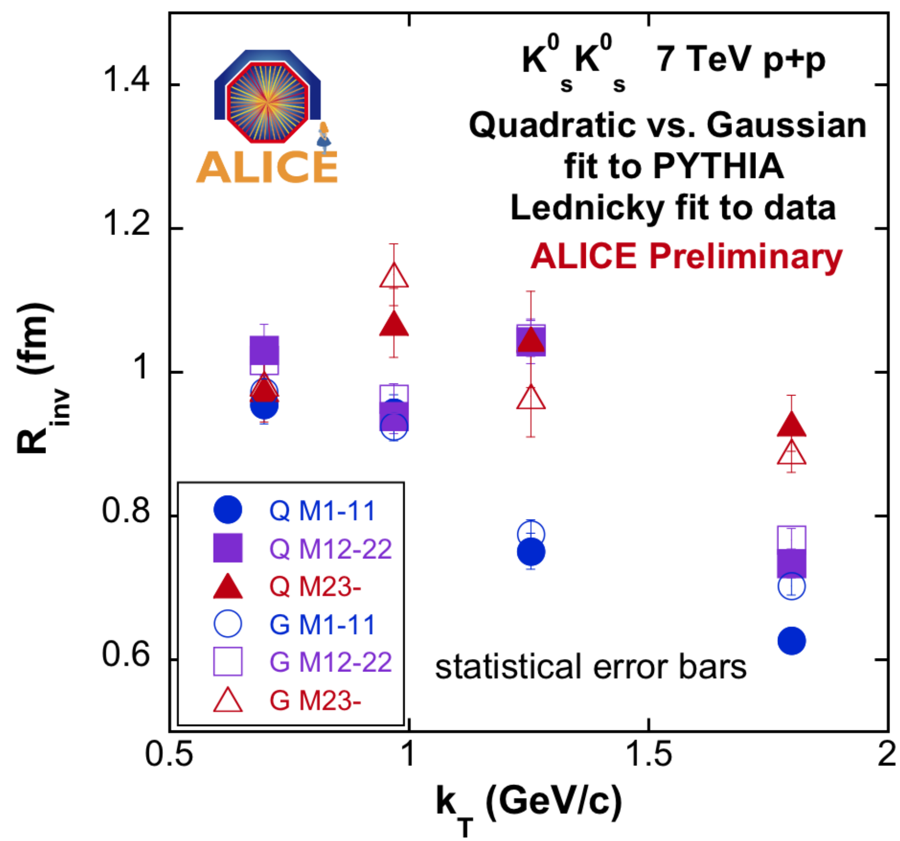
Big effect!

~30% reduction for R and ~50% for λ

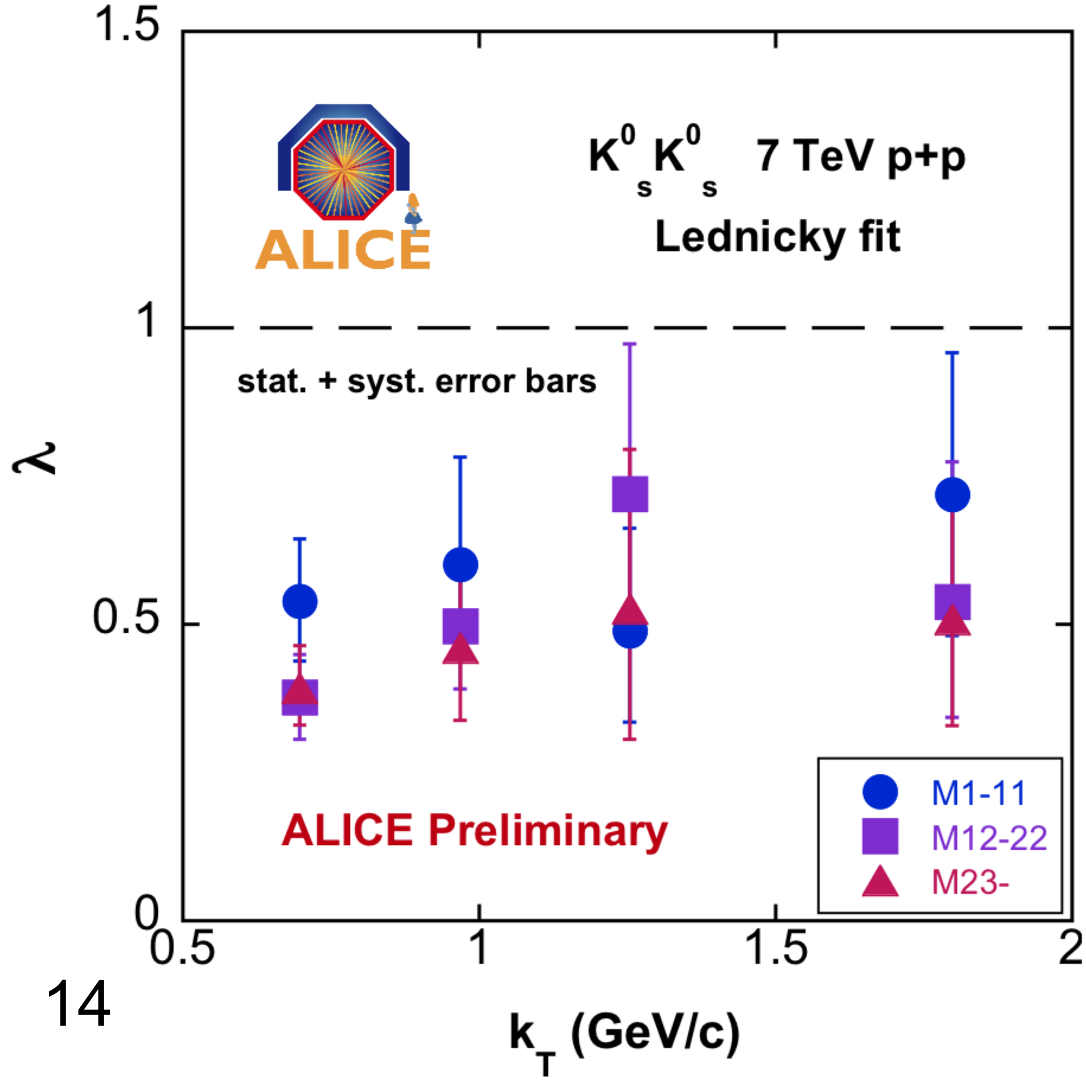
STAR saw a ~20% reduction in R and λ for Au+Au collisions.

R_{inv} and λ from Lednicky fits to data for the 12 multiplicity-k_T bins and for Quadratic vs. Gaussian fits to PYTHIA for the baseline statistical error bars



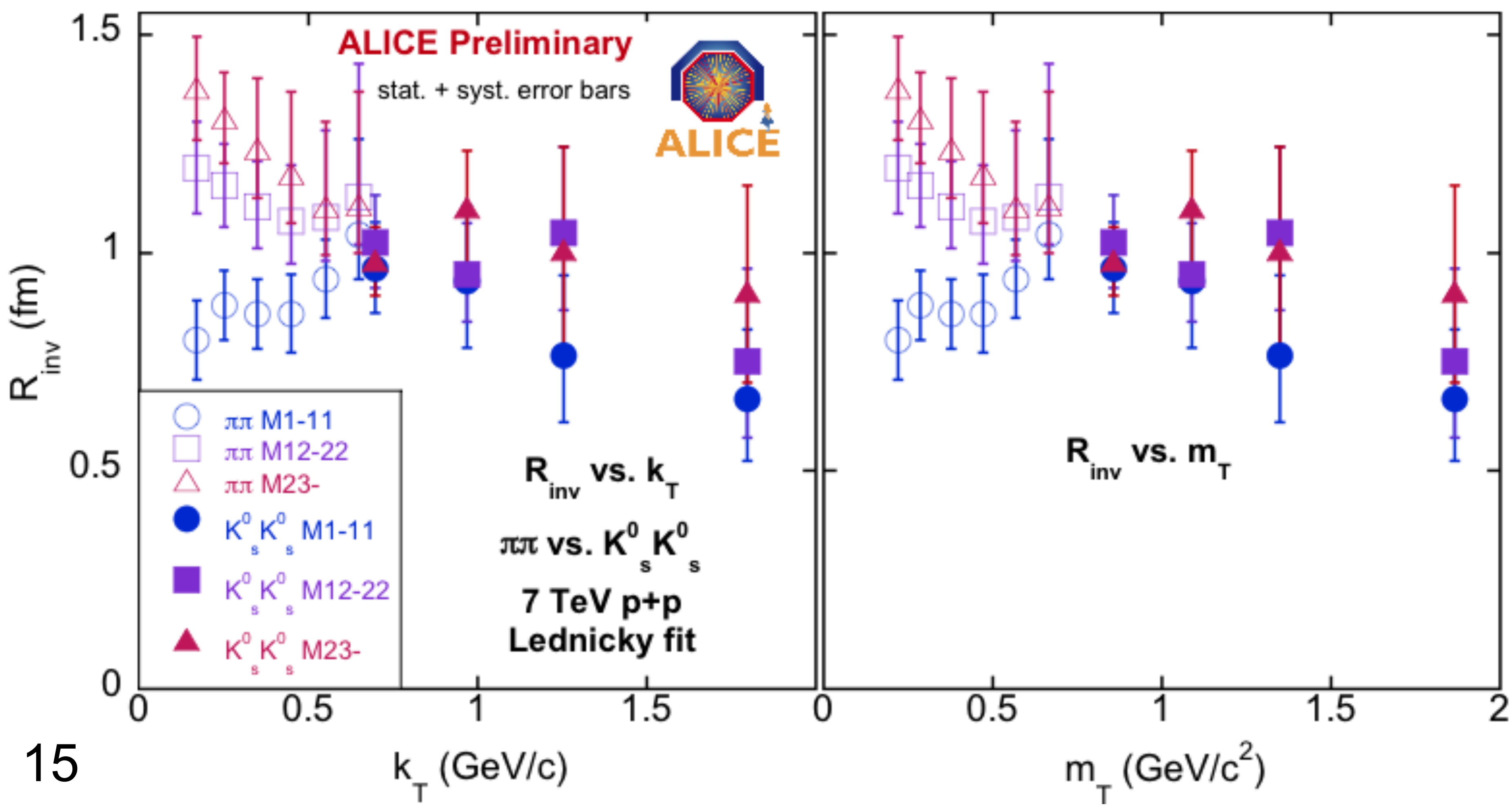


Averaged λ parameters vs. k_T and multiplicity bin from Lednicky code fits statistical + systematic error bars (including ±10% shift in baseline parameters)



λ shows a mostly flat k_T dependence and is at an overall level of ~ 0.5-0.6 similar to ALICE ππ results

Averaged R_{inv} vs. k_T , m_T and multiplicity bin from Lednicky code fits compared with ALICE ππ correlation data statistical + systematic error bars (including ±10% shift in baseline parameters)



Summary for $K^0_sK^0_s$ 7 TeV p+p analysis

* The present $K^0_sK^0_s$ study is the first to show source parameters for p+p collisions and for different multiplicity and k_T bins.

* The $K^0_sK^0_s$ results for the λ parameter show a mostly flat k_T dependence which is at an overall level of ~ 0.5 - 0.6, similar to that seen in the ALICE $\pi\pi$ results for 7 TeV p+p.

* The $K^0_sK^0_s$ results for R_{inv} suggest a slight tendency for R_{inv} to decrease with increasing k_T and to increase for increasing event multiplicity bin as also seen in the ALICE $\pi\pi$ results for 7 TeV p+p and in heavy-ion collisions.

* Comparing with $\pi\pi$, the $K^0_sK^0_s$ results for R_{inv} extend the covered range of k_T to ~2 GeV/c (3 × larger than $\pi\pi$). No discontinuity for the k_T dependence of R_{inv} is seen between $\pi\pi$ and $K^0_sK^0_s$.

see L. Malinina poster on charged KK correlations in 7 TeV p+p, Tuesday Poster Session

Backup slides

Details of the analysis: 7 TeV p+p ➔ $K^0_s K^0_s$

K^0_s Cuts:

* $|\eta| < 0.8$, $0.4 < p_T < 3.5$ GeV/c
* Identification: K^0_s ➔ $\pi^+\pi^-$ (V_0 ➔ h^+h^-)
* $0.490 <$ Reconstructed V_0 mass < 0.504 GeV/c^2
* DCA of V_0 daughters < 0.1 cm

Correlation function:

* $C(Q_{inv}) = R(Q_{inv})/B(Q_{inv})$
  R ➔ real pairs per event, B ➔ pairs from 10 mixed events
* Form in 3 event multiplicity x 4 k_T bins

Fits used to extract R and λ from $C(Q_{inv})$:

* $C(Q_{inv}) = N\{1 + aQ_{inv} + bQ_{inv}^2\} \times \{1 + \lambda \exp[-(Q_{inv}R_{inv})^2]\}$
* $C(Q_{inv}) = N\{1 + a \exp[(bQ_{inv})^2]\} \times \{1 + \lambda \exp[-(Q_{inv}R_{inv})^2]\}$
* $C(Q_{inv})$ = N{ baseline } × { Lednicky code with a_0/f_0 resonance decay }
  where the baseline parameters a and b are fixed by fits to **PYTHIA with the Perugia-0 tune.**

R and λ from data using the various fitting functions and for several multiplicity bins