Non-identical particle correlations in 130 and 200 AGeV collisions at STAR

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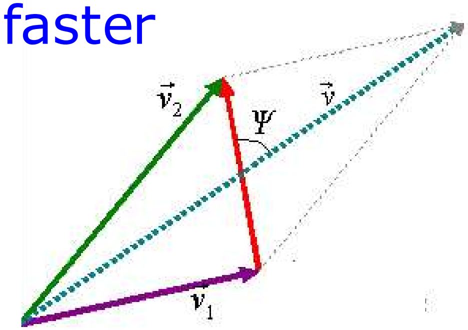
for the **STAR experiment**

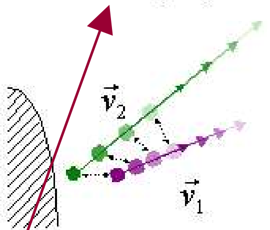
Outline

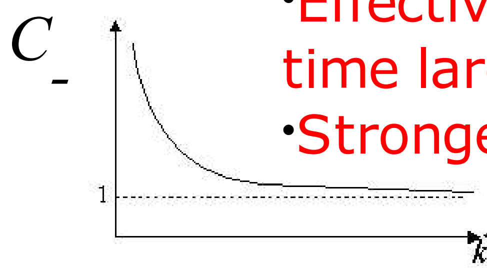
- Physics motivation
  - Emission asymmetry measurement
  - Measuring flow as space-momentum correlations
  - Measuring unknown interaction potentials
- Current results
  - 130 AGeV data
  - 200 AGeV data
- Flow in models
  - Blast-wave parameterization
  - RQMD – transport model
- Exotic correlation functions
  - Proton-Lambda and antiproton-Lambda
  - Pion-Cascade

The asymmetry analysis

Heavier particle faster



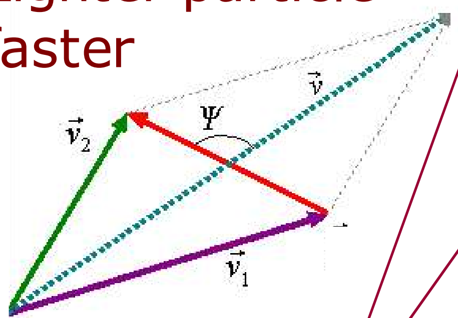


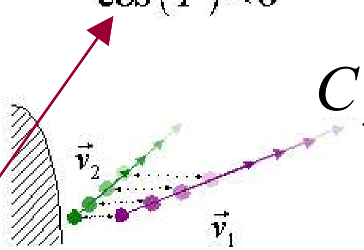


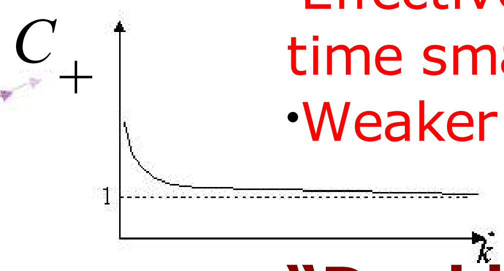
Catching up

- Effective interaction time larger
- Stronger correlation

Lighter particle faster



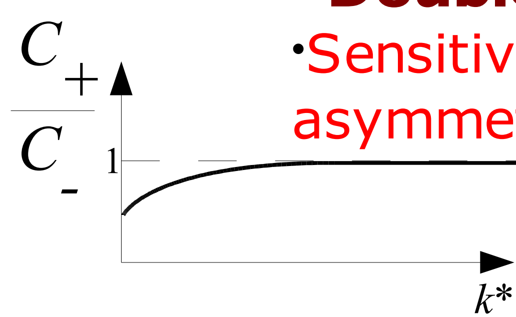




Moving away

- Effective Interaction time smaller
- Weaker correlation

"Double" ratio



- Sensitive to the space-time asymmetry in the emission process

Kinematics selection along some direction
e.g. k_{Out}, k_{Side}, cos(v,k)

R.Lednicky, V. L.Lyuboshitz, B.Erazmus, D.Nouais, Phys.Lett. B373 (1996) 30.

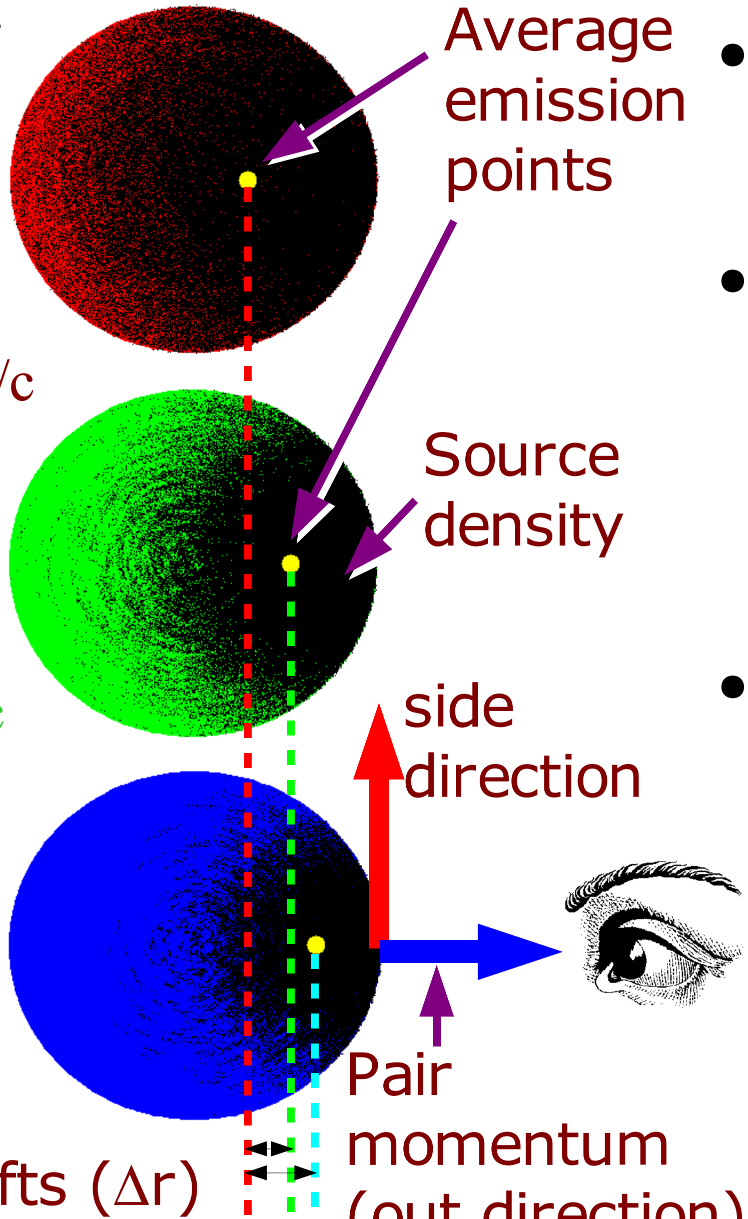
Flow in the transverse plane

nucl-th/0312024
F. Retiere,
M. Lisa

Pion
$\langle\beta_t\rangle = 0.7$
$p_t = 0.15$ GeV/c

Kaon
$\langle\beta_t\rangle = 0.7$
$p_t = 0.5$ GeV/c

Proton
$\langle\beta_t\rangle = 0.7$
$p_t = 1.$ GeV/c



- Flow produces emission asymmetries in space Δr
- Observed asymmetry r* can come from emission time difference Δt

$$\langle r^* \rangle = \gamma(\langle \Delta r \rangle - \beta_T \langle \Delta t \rangle)$$

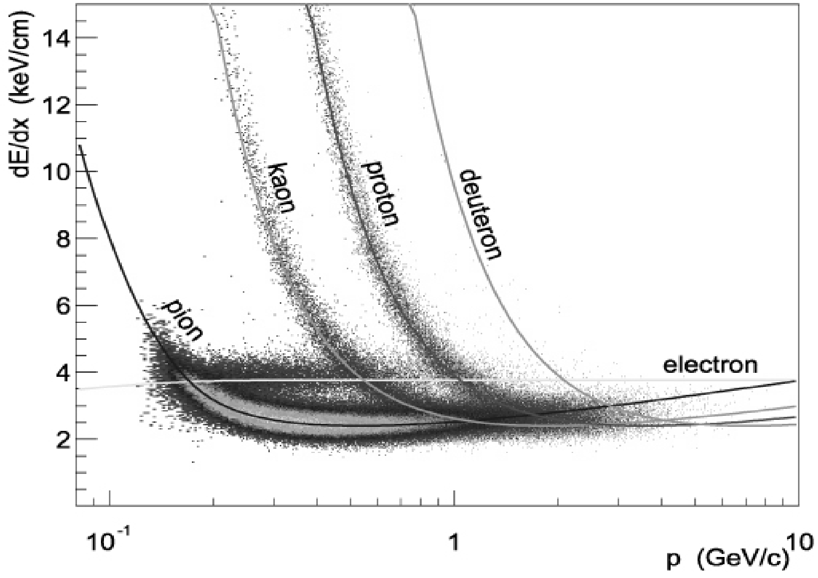
- We expect asymmetry in "out" direction, but not in "side", which is used as cross-check

S.Voloshin, R.Lednicky, S. Panitkin, N.Xu, Phys.Rev.Lett.**79**(1997)30

R. Lednicky, nucl-th/0305027

Data sample

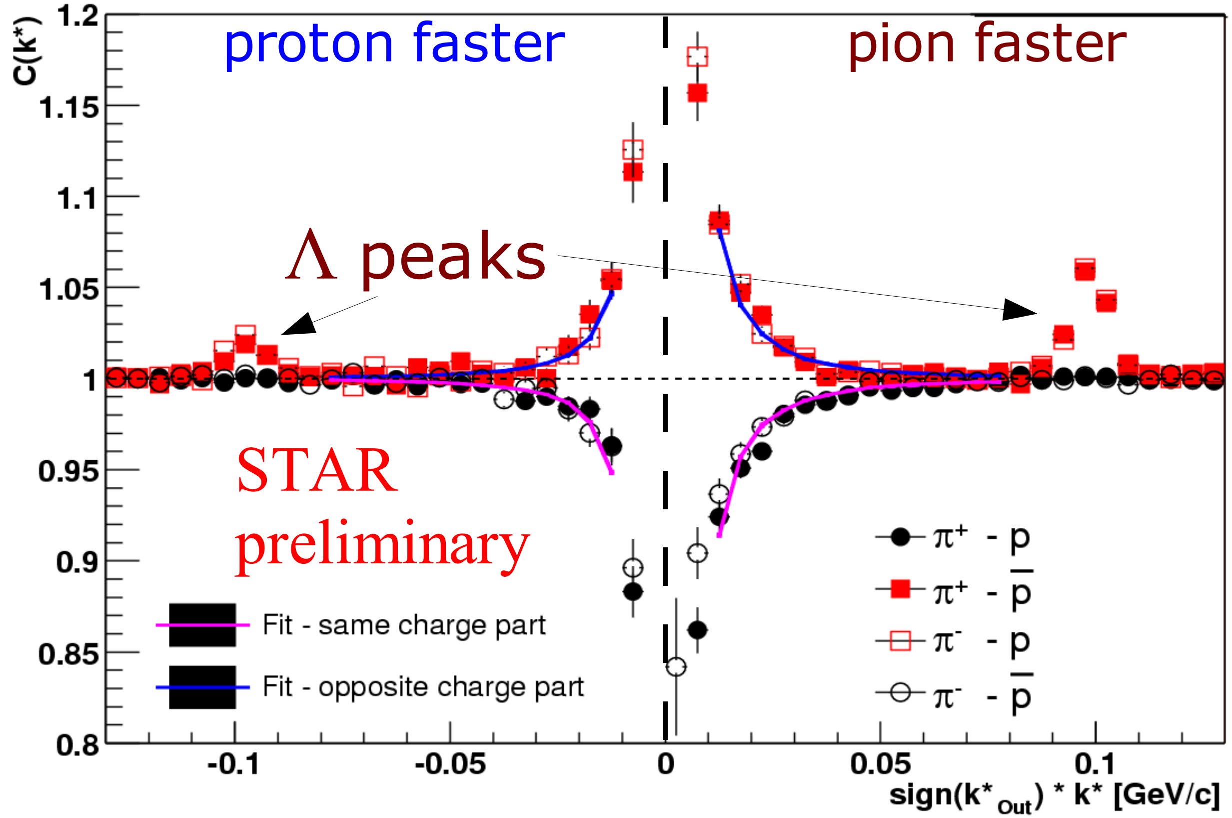
- Central AuAu collisions
  - 130 AGeV – 0.7 Mevents
  - 200 AGeV – 2.2 Mevents
- Identification probability from dE/dx in STAR TPC
  - Purity cuts on particle level
  - $\gamma \rightarrow e^+e^-$ removal on pair level



- Midrapidity data |y|< 0.5
- Momentum range [GeV/c]
  - Pions (0.13, 0.5)
  - Kaons (0.3, 1.0)
  - Protons (0.4, 1.2)
- Detector corrections
  - Two-track effects:
    - elimination of pairs possibly sharing hits in the TPC
  - Particle purity
    - PID probabilty (all), estimation of contamination from weak decay (pions, protons)
  - Momentum resolution

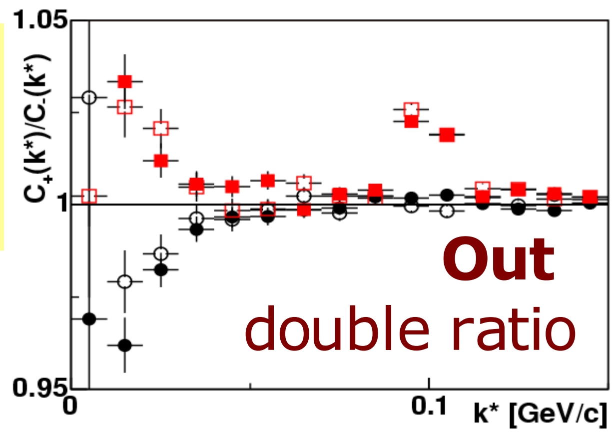
Pion-Proton 130 AGeV

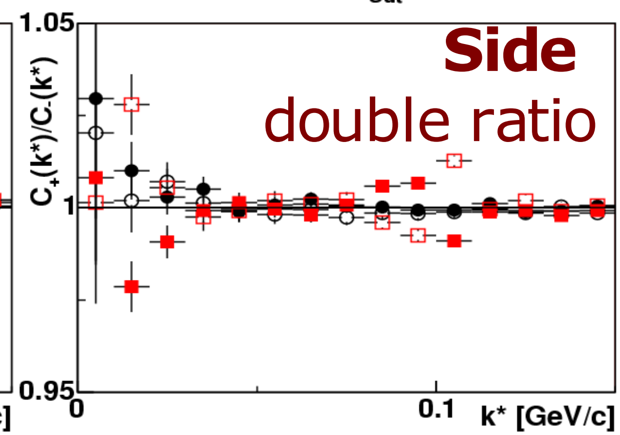
- We observe Lambda peaks at $k^* \sim m_{inv}$ of Λ
- Good agreement for identical and non-identical charge combinations



Sigma: $\mathbf{15.1 \pm 0.4}\ ^{+1.0\ \text{syst.}}_{-1.5\ \text{syst.}}$ fm

Mean: $\mathbf{-7.4 \pm 0.9}\ ^{+1.9\ \text{syst.}}_{-3.4\ \text{syst.}}$ fm





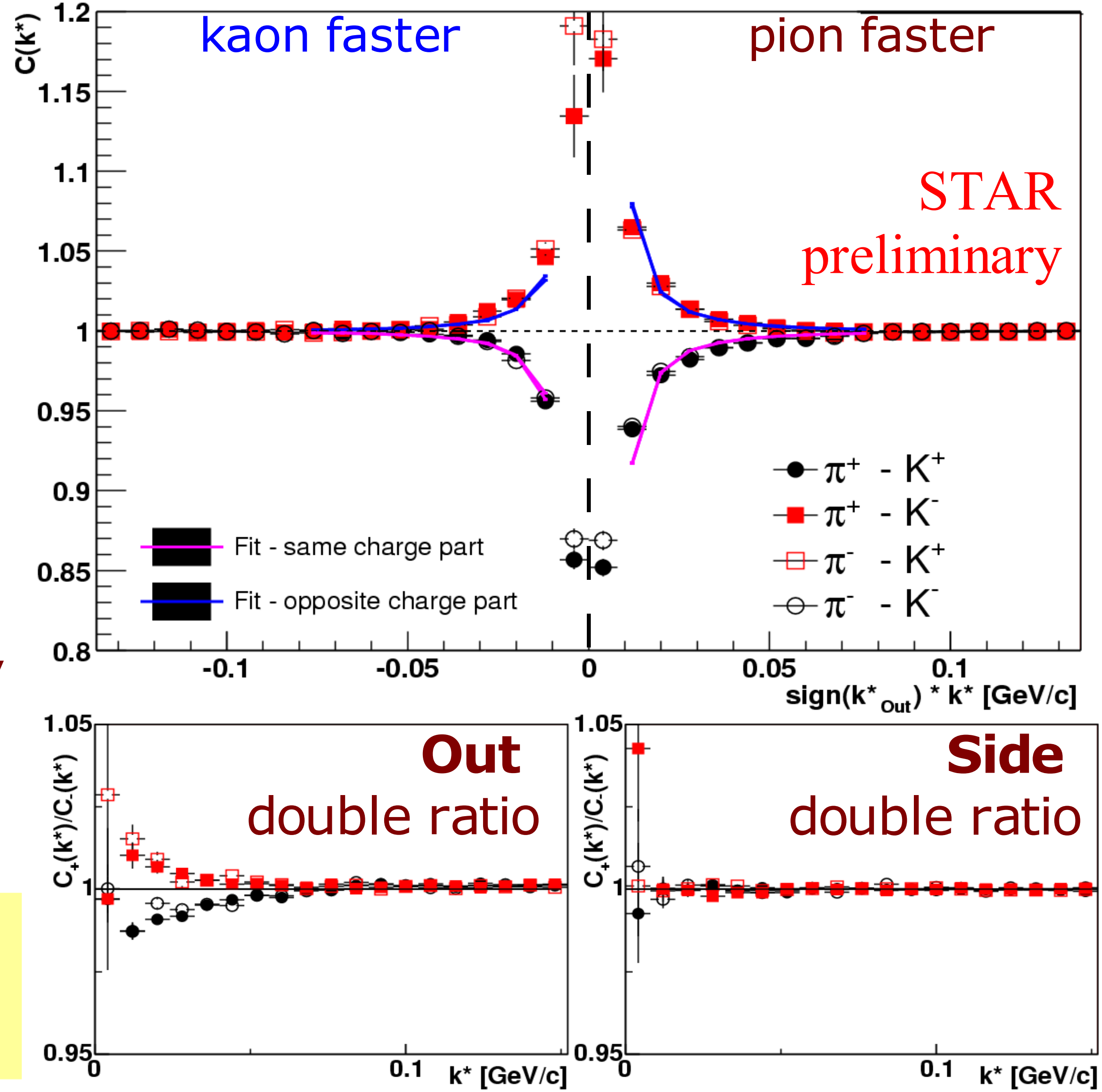
Fit assumes source is a gaussian in r^*_{out}

Pion-Kaon at 200 AGeV

- Good agreement for same-charge combinations
- Clear emission asymmetry signal
- Systematic error under study – influenced by purity and fits to all CFs separately

Sigma: **17.3 ± 0.8** $^{+0.9\ \text{syst.}}_{-1.6\ \text{syst.}}$ fm

Mean: **-7.0 ± 1.2** $^{+6.1\ \text{syst.}}_{-4.0\ \text{syst.}}$ fm

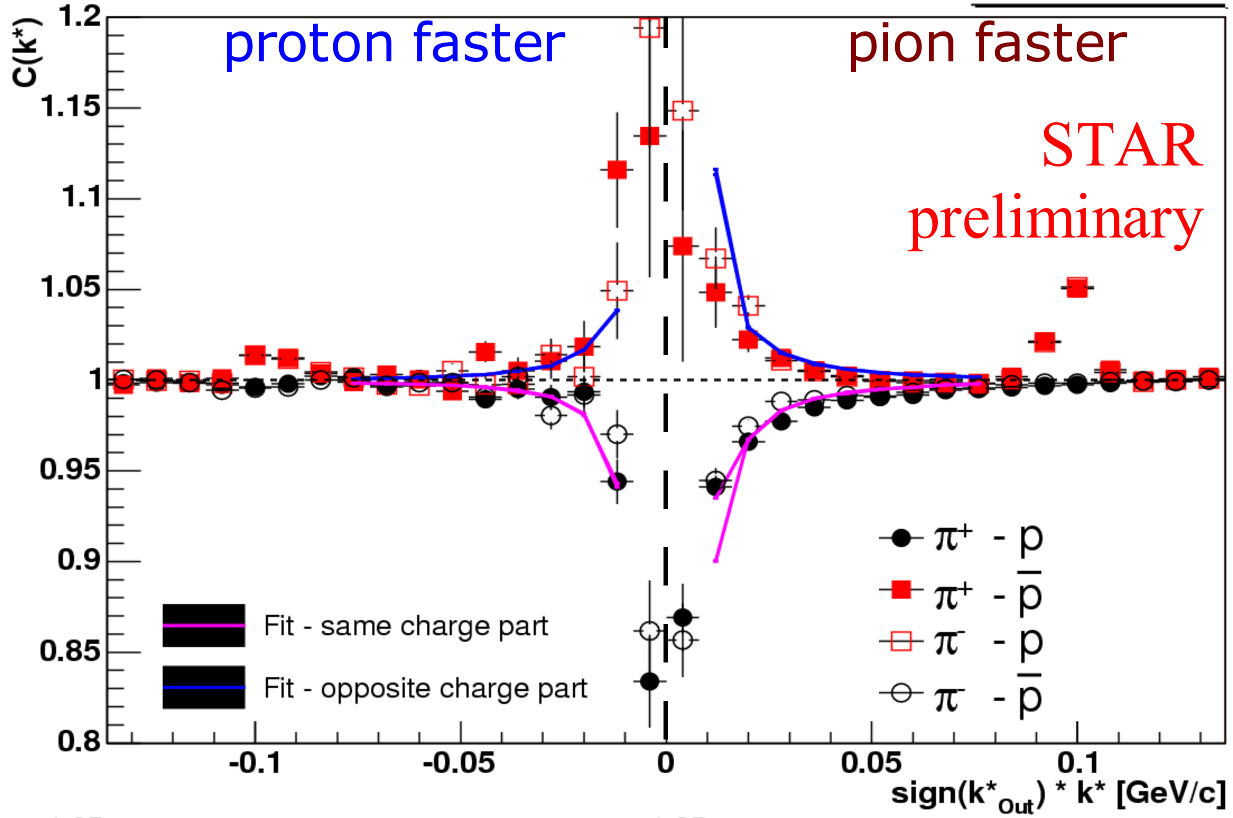


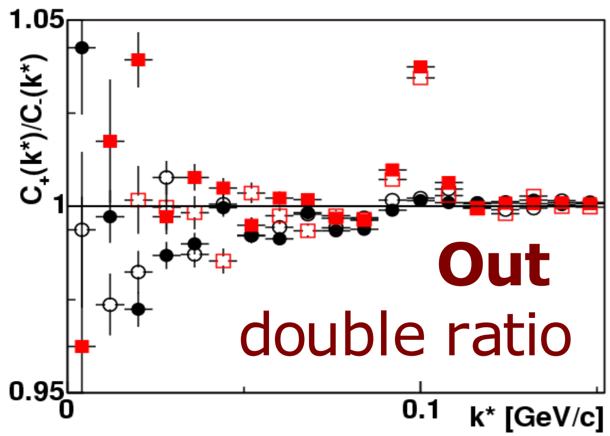
Pion – Proton at 200 AGeV

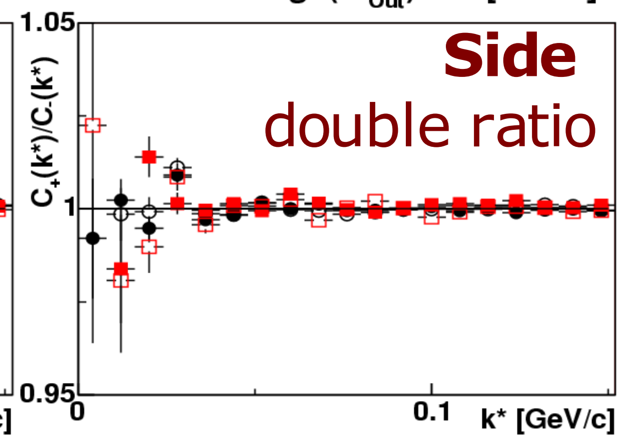
- Good agreement for same-charge combination pairs
- Double ratios influenced by e^+e^-
- Systematic error limited by the knowledge of pi-p interaction

Sigma: **14.8 ± 0.5** $^{+4.0\ \text{syst.}}_{-3.0\ \text{syst.}}$ fm

Mean: **-6.0 ± 1.5** $^{+3.0\ \text{syst.}}_{-5.5\ \text{syst.}}$ fm





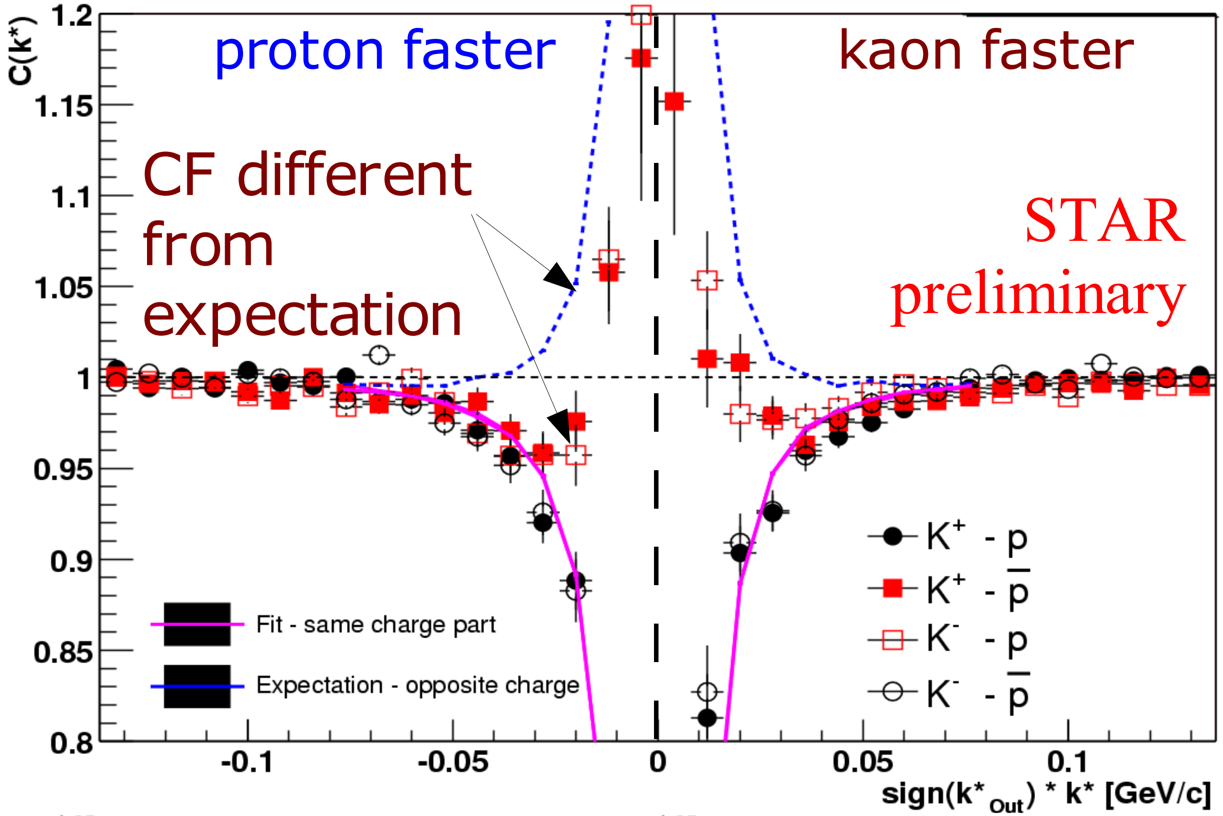


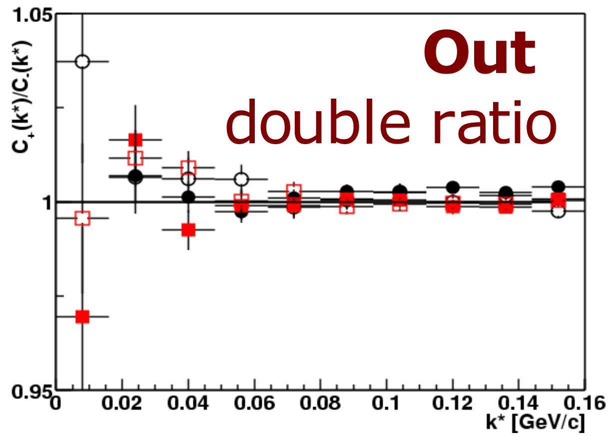
Kaon-Proton at 200 AGeV

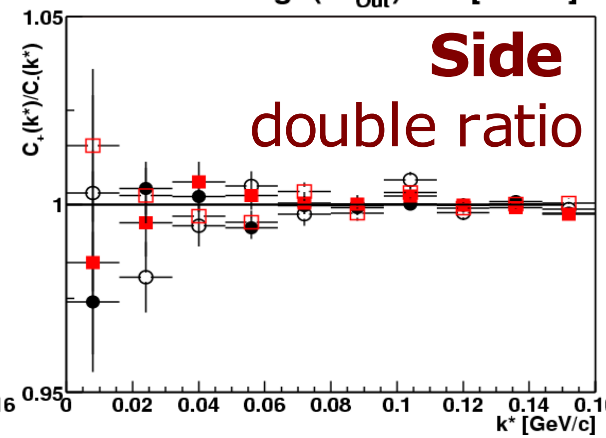
- Only like-sign data well described by theory and fitted
- Surprising correlation shape for unlike-sign – a question to theorists
- Mean shift opposite to pi-K and pi-p

Sigma: **10.6** ± **0.6** $^{+1.4\ \text{syst.}}_{-2.1\ \text{syst.}}$ fm

Mean: **0.7** ± **1.5** $^{+1.6\ \text{syst.}}_{-0.6\ \text{syst.}}$ fm







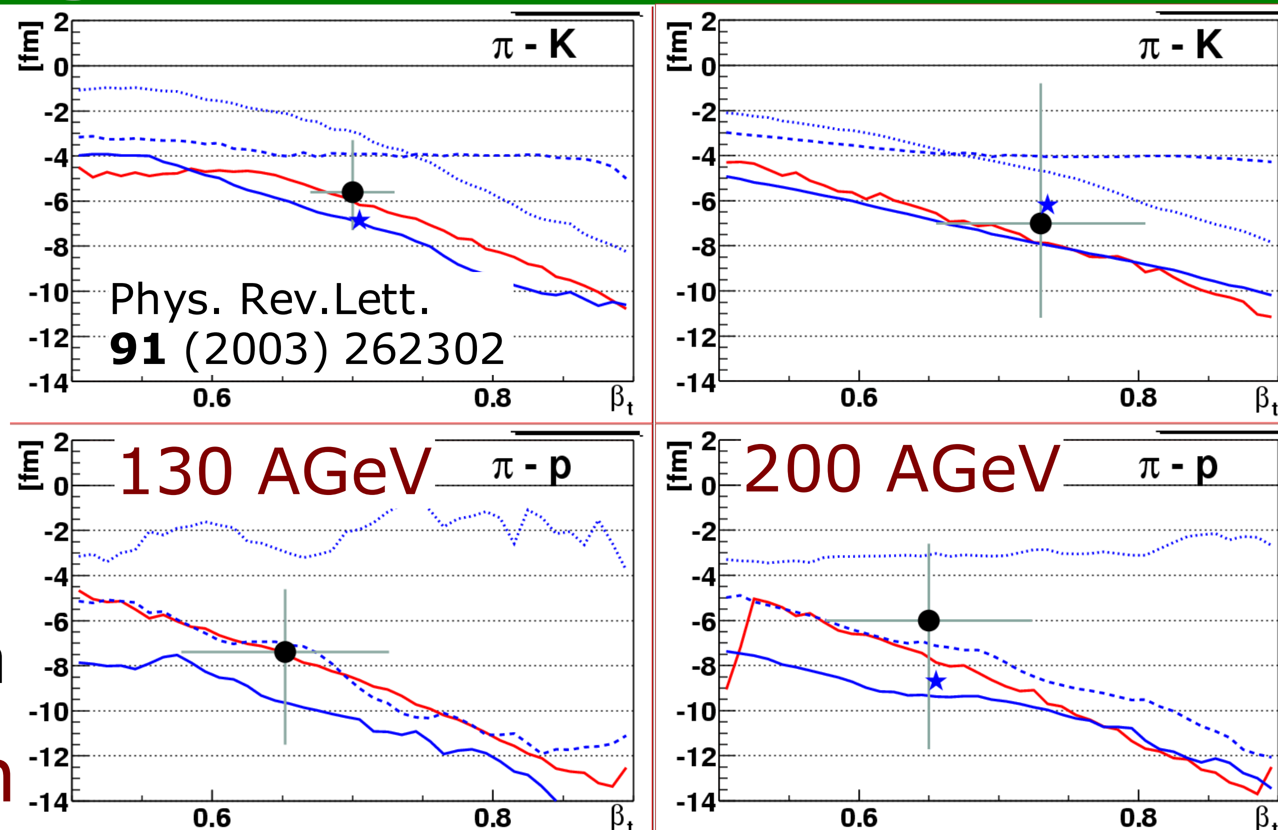
Modeling the emission asymmetry

- Are we measuring time shifts, space shifts (flow) or both?
- Is the flow hypothesis consistent with the data?
- How do we compare theory and experiment?

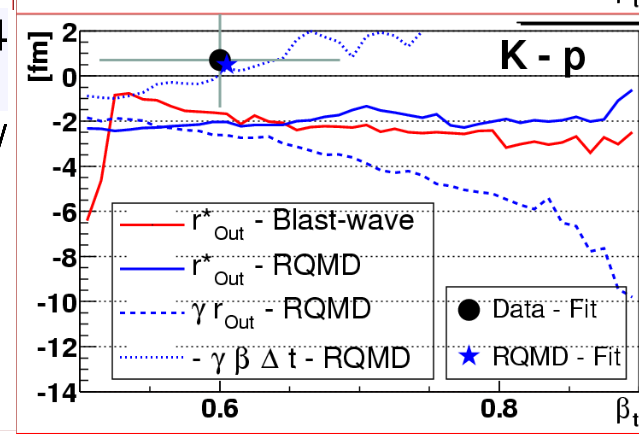
- Need models producing strong transverse radial flow:
  - Blast-wave – hydro-like flow
  - RQMD – flow through interactions

Comparing models to data

- We do see space-momentum correlations:
  - Data and blast-wave consistent
  - RQMD needs flow to reproduce data
- Time difference can explain K-p
- Fair comparison: same fitting for RQMD and data

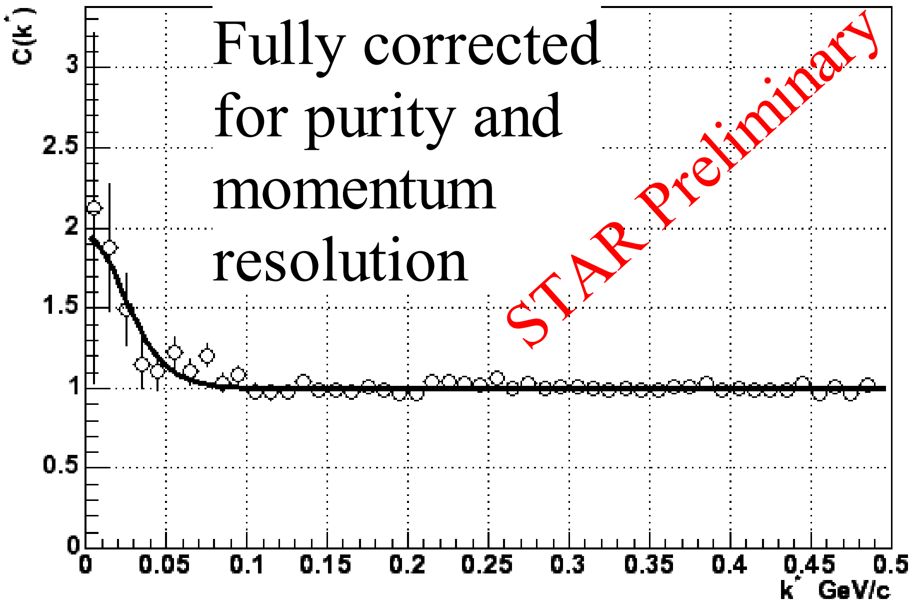


Blast-wave: nucl-th/0312024
F. Retiere, M. Lisa



	130 AGeV	200 AGeV
Temperature	104 MeV	100 MeV
Flow intensity	0.9 .	1.0 .
System radius	12.9 fm	13.0 fm
Evolution time	8.9 fm/c	10.0 fm/c
Emission duration	0.002 fm/c	3.5 fm/c

Proton – Lambda at 200 AGeV

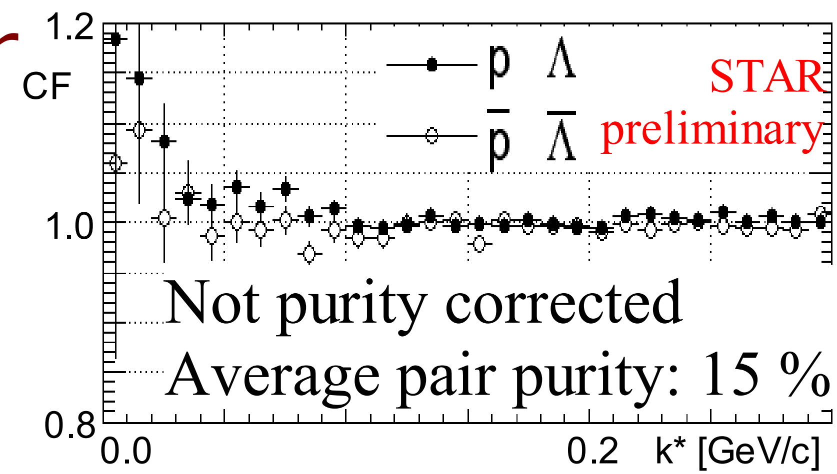


- Fit using analytical model of proton-lambda correlation:
  $R_{inv} = 2.8 \pm 0.3\ (+1.0\ -1.4)\ fm$
  (see poster by S. Bekele)

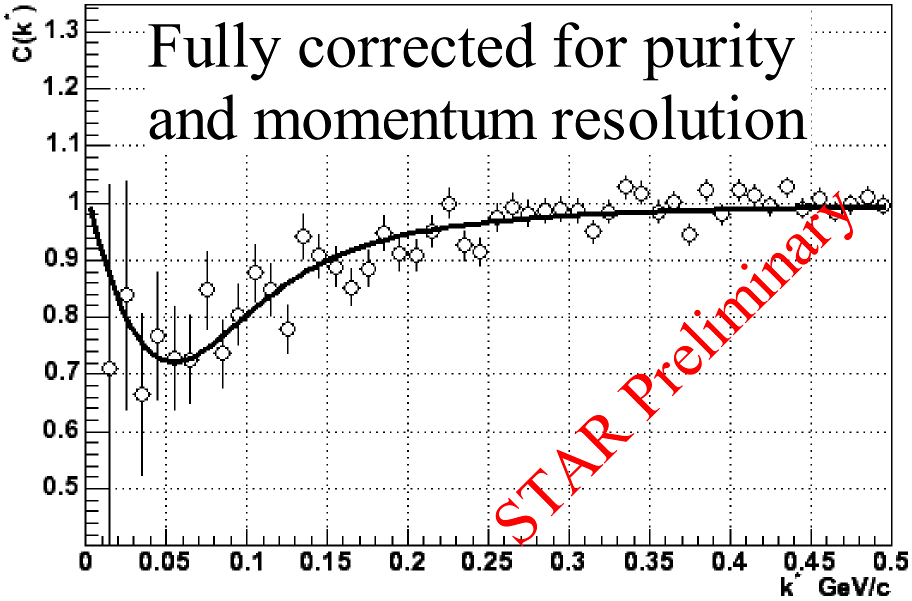
Proc. CORINNE 90 Nantes, France, 1990 (ed. Ardouin, World Scientific) p.42

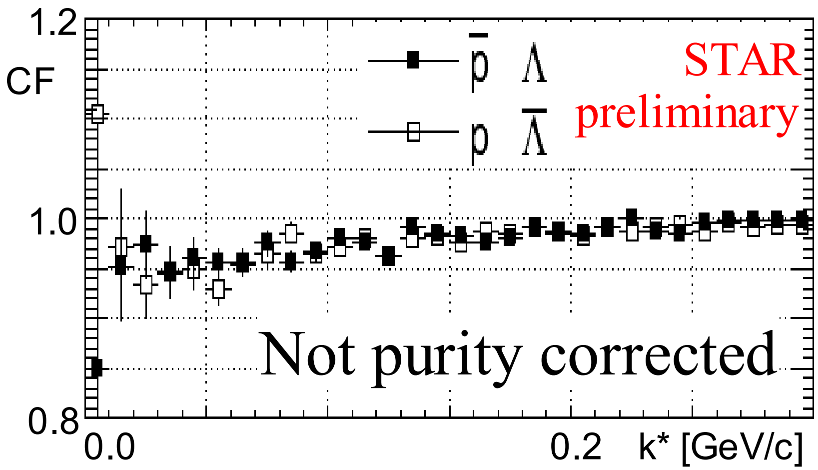
- Main challenge is particle purity, feed-down from from Lambda-Lambda accounted for
- Good agreement between proton-lambda ans anti-proton anti-lambda correlation functions

Phase shifts from:
F. Wang, S. Pratt, Phys. Rev. Lett. 83 (1999) 3138-3141



Anti-Proton Lambda at 200 AGeV

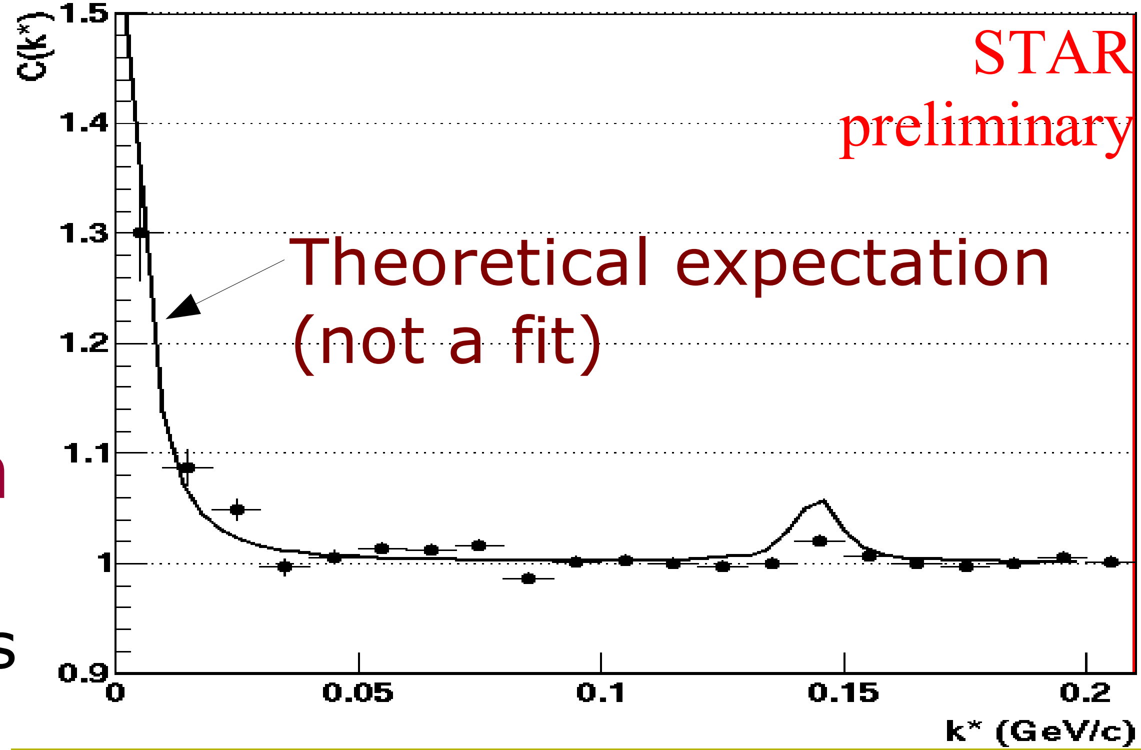




- First time measurement of anti-proton lambda CF
- Fit with the same analytical model as pΛ– interaction parameters now unknown
  $R_{inv} = 1.5 \pm 0.07\ (+0.5\ -0.9)\ fm$
- Early drop of correlation fuction signals significant annihilation
- A new way to extract scattering lenghts

Pion – Xi at 200 AGeV

- Also a first time measurement
- Will enable to address the question of Ξ flow
- Theoretical expectation with assumptions:
  - Source size as for pions
  - Significant Ξ flow
  - Coulomb + strong interaction
  - Gives input onto cross-sections similar to proton-lamdba case



Calculation using S.Pratt's code
Combined π^+-Ξ^- and π^--Ξ^+
Purity assumed = 50%±25%
No momentum resolution correction

Summary and outlook

- Measured correlations for πK, πp and Kp pairs at 130 and 200AGeV AuAu collisions
  - Clear asymmetry of emission observed for all pairs
  - Space-momentum correlations from transverse radial flows present a consistent description of emission asymmetries for all systems
  - Emission time differences found to be important, but not enough to explain the data
- New way to measure system interactions: $p\Lambda$, *anti*-$p\Lambda$, Kp (unlike sign), $\pi\Xi$
- $\pi\Xi$ function promises new information in future
- New, non-HBT size estimation method for $p\Lambda$, *anti*-$p\Lambda$