Pion-kaon femtoscopy in Au+Au collisions at STAR

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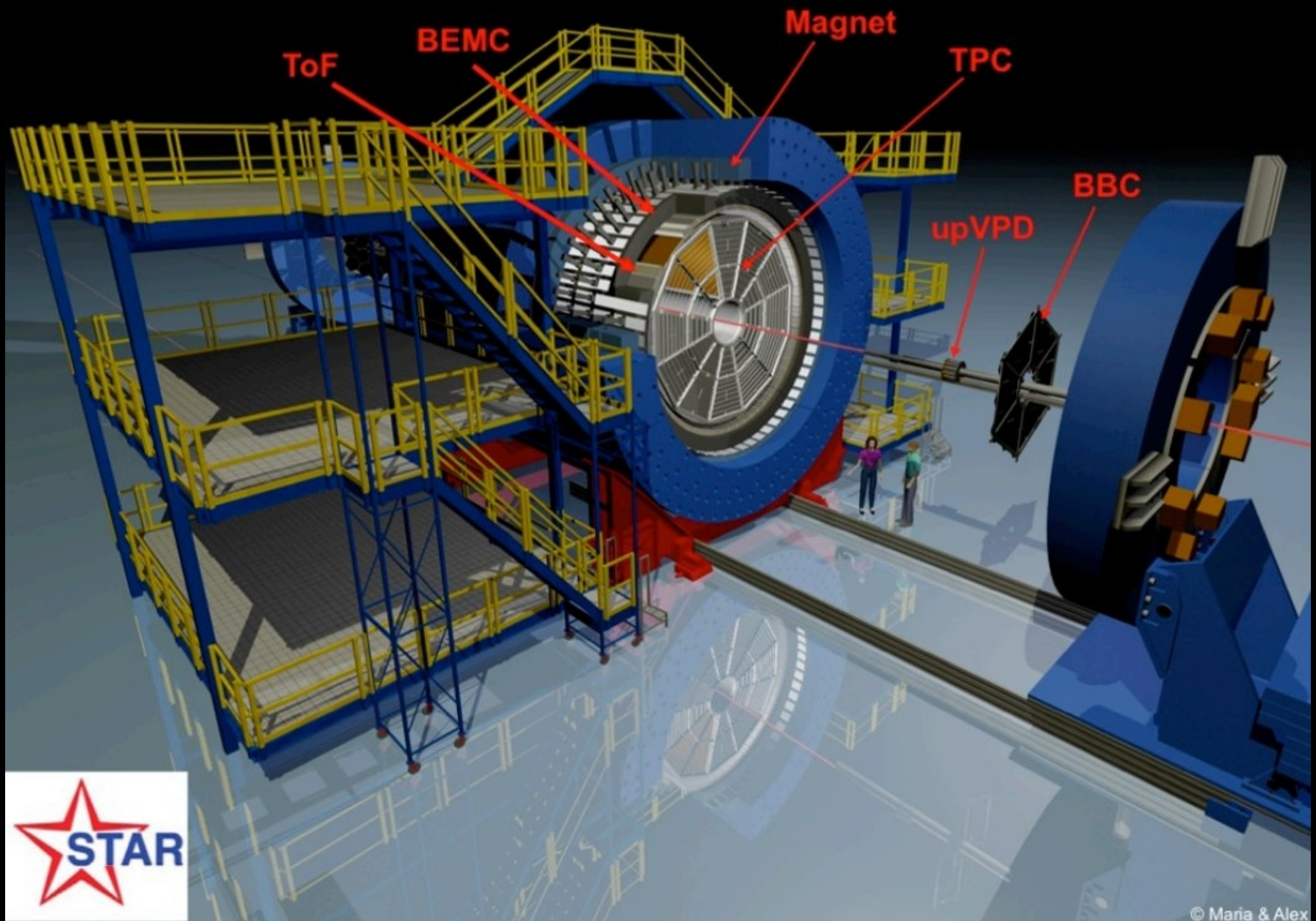
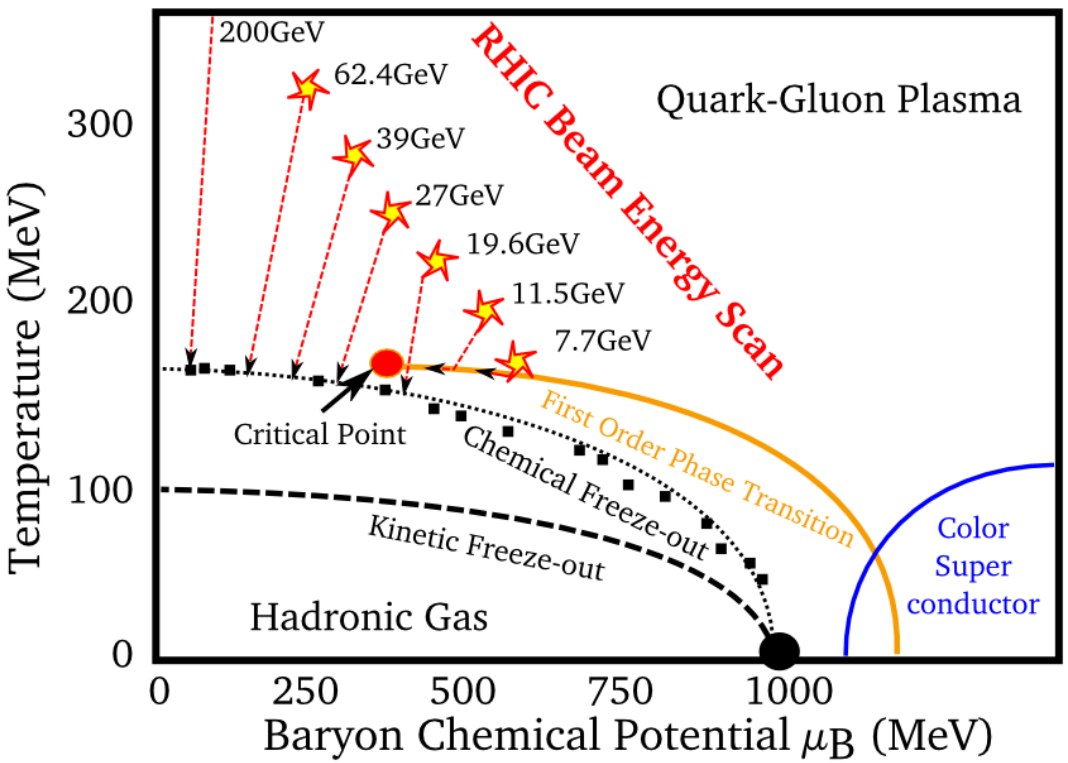
Outline

- Motivation
- Space-time asymmetry
- Data selection
- Comparison of correlation functions for $\sqrt{s_{NN}} = (130, 39, 7.7)\, GeV$
- Comparison of asymmetry for $\sqrt{s_{NN}} = (130, 39, 7.7)\, GeV$
- Summary

The Solenoidal Tracker At RHIC (STAR)



Motivation



Analyze all Beam Energy Scan (BES) energies and find answers:

If or how pion-kaon source changes with energy?

If or how pion-kaon asymmetry in emission process looks for all BES energies?

If or how the flow affects the pion-kaon system, consisting of particles of different masses?

Space-time asymmetry

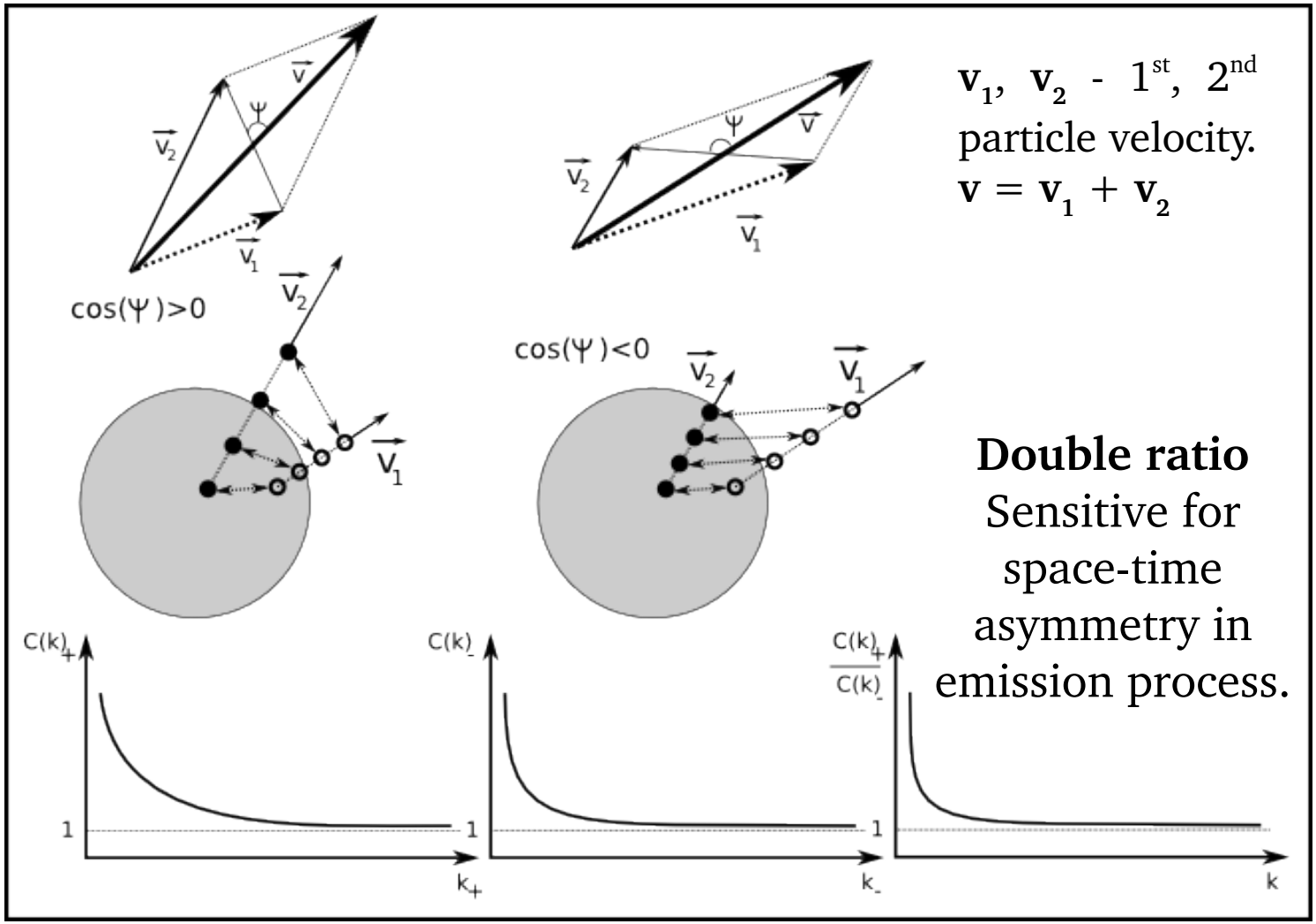
$$C(\mathbf{p}_1, \mathbf{p}_2) = \frac{P_2(\mathbf{p}_1, \mathbf{p}_2)}{P_1(\mathbf{p}_1) P_1(\mathbf{p}_2)}$$

$P_2(\mathbf{p}_1, \mathbf{p}_2)$ – the probability of observing two particles with momentum p_1, and p_2 at the same time and the same place.

$P_1(\mathbf{p}_1)$, $P_1(\mathbf{p}_2)$ – the probability of observing two particles with momentum p_1, and p_2 separately.

cos(Ψ)>0
Catching up
Long time of effective interaction. Strong correlation.

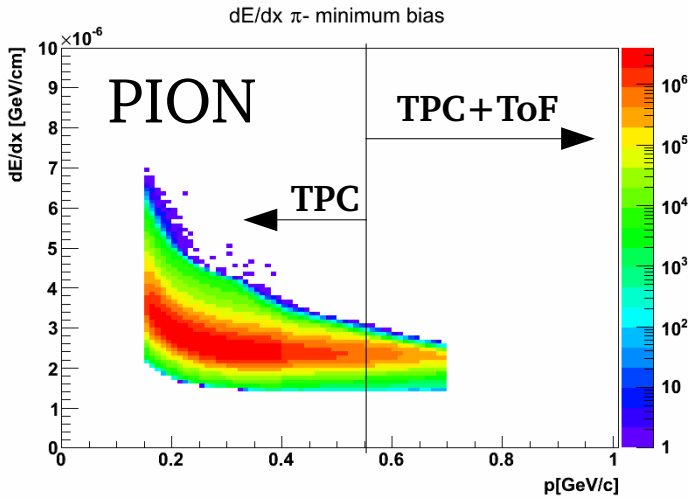
cos(Ψ)<0
Run away
Short time of effective interaction. Weak correlation.

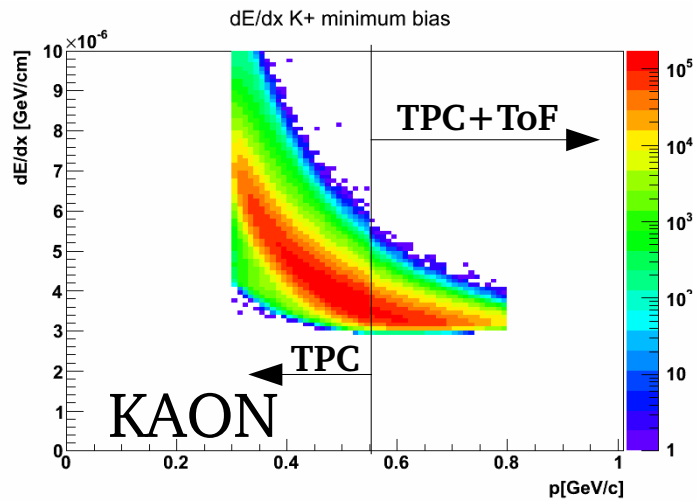


$\mathbf{v}_1$, $\mathbf{v}_2$ - 1st, 2nd particle velocity.
$\mathbf{v} = \mathbf{v}_1 + \mathbf{v}_2$

Double ratio
Sensitive for space-time asymmetry in emission process.

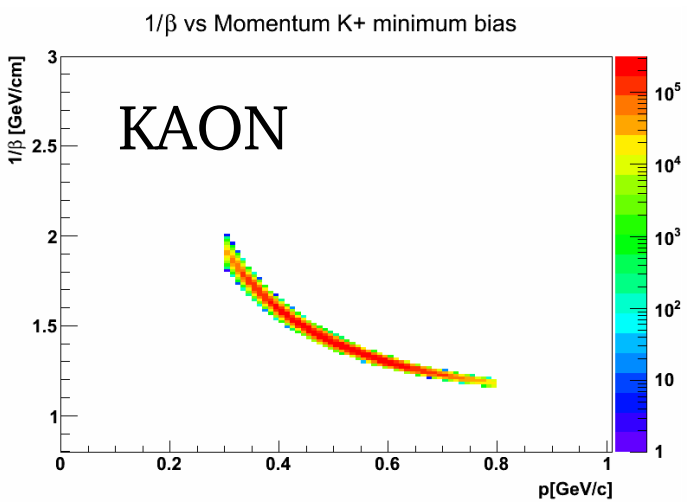
Data selection

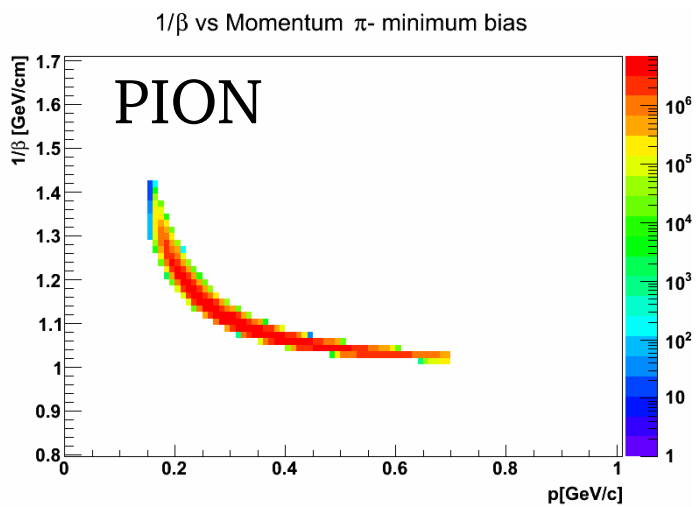




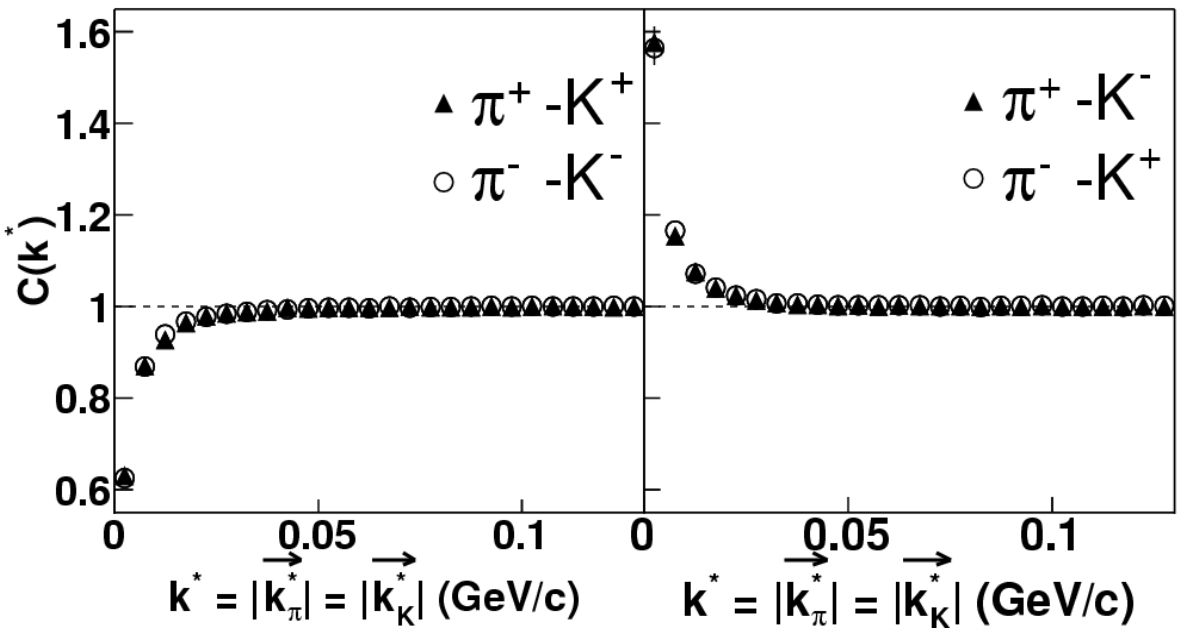
	7.7 GeV	39 GeV
analyzed	5.7 mln events	91.2 mln events
π momentum	[0.1, 1.2] GeV/c	[0.15, 0.7] GeV/c
K momentum	[0.1, 1.2] GeV/c	[0.3, 0.8] GeV/c
N σ for π and K	< 3.0	< 3.0
π m^2	[0.0176, 0.022] GeV^2/c^4	[0.017, 0.026] GeV^2/c^4
K m^2	[0.23, 0.26] GeV^2/c^4	[0.22, 0.27] GeV^2/c^4
|η|	< 0.5	< 0.5
DCA	< 3cm	< 3cm

Centrality deffinition:
central: 0-10%
minimum bias: 0-80%





Comparison of Au+Au data for $\sqrt{s_{NN}}=130\text{GeV}$ and $\sqrt{s_{NN}}=39\text{GeV}$



Au+Au collision at $\sqrt{s_{NN}}=130\text{GeV}$ (central)

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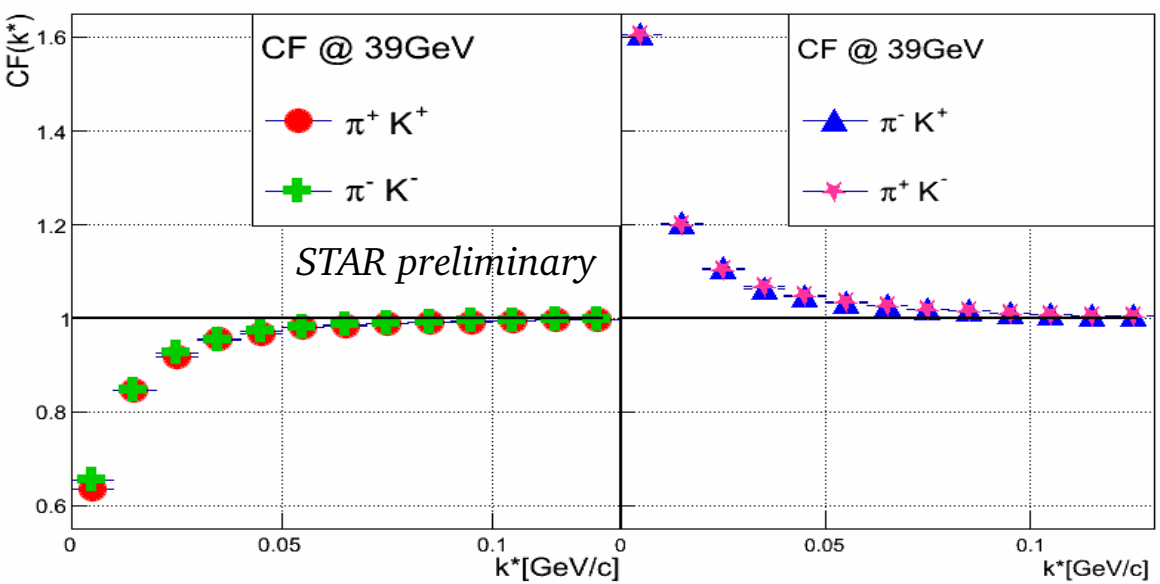

Au+Au collision at $\sqrt{s_{NN}}=39\text{GeV}$ (central)

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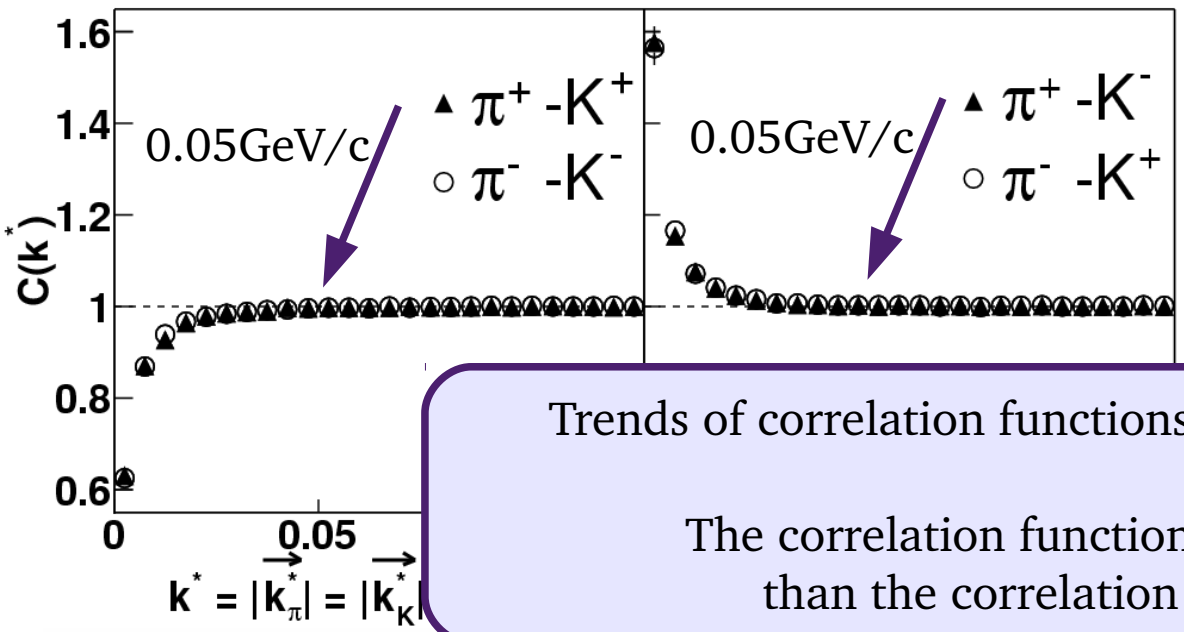
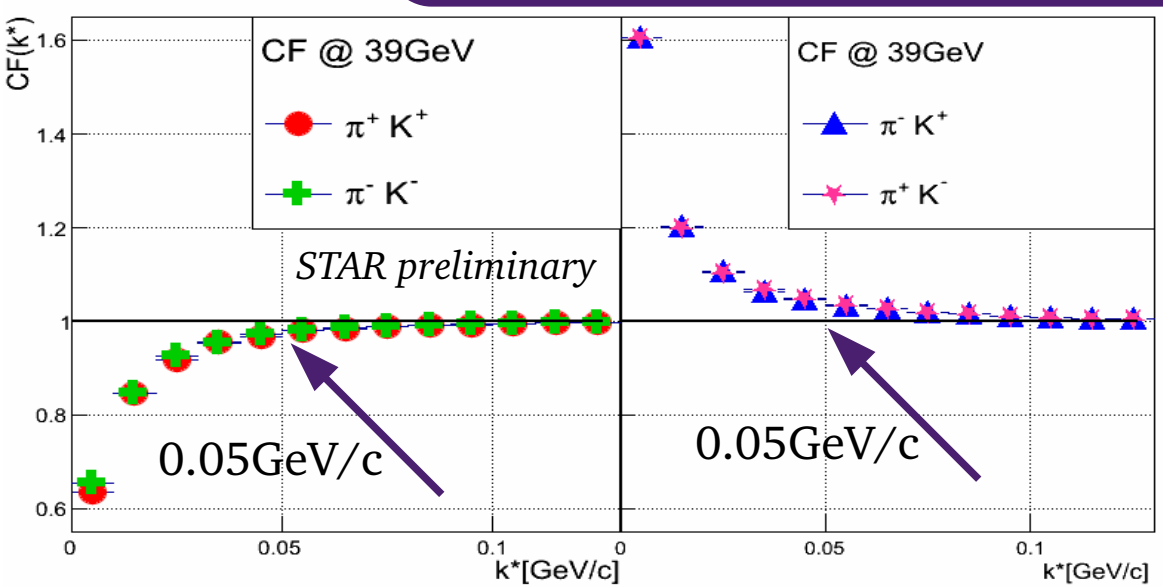


Au+Au collision at $\sqrt{s_{NN}}=130\text{GeV}$ (central)

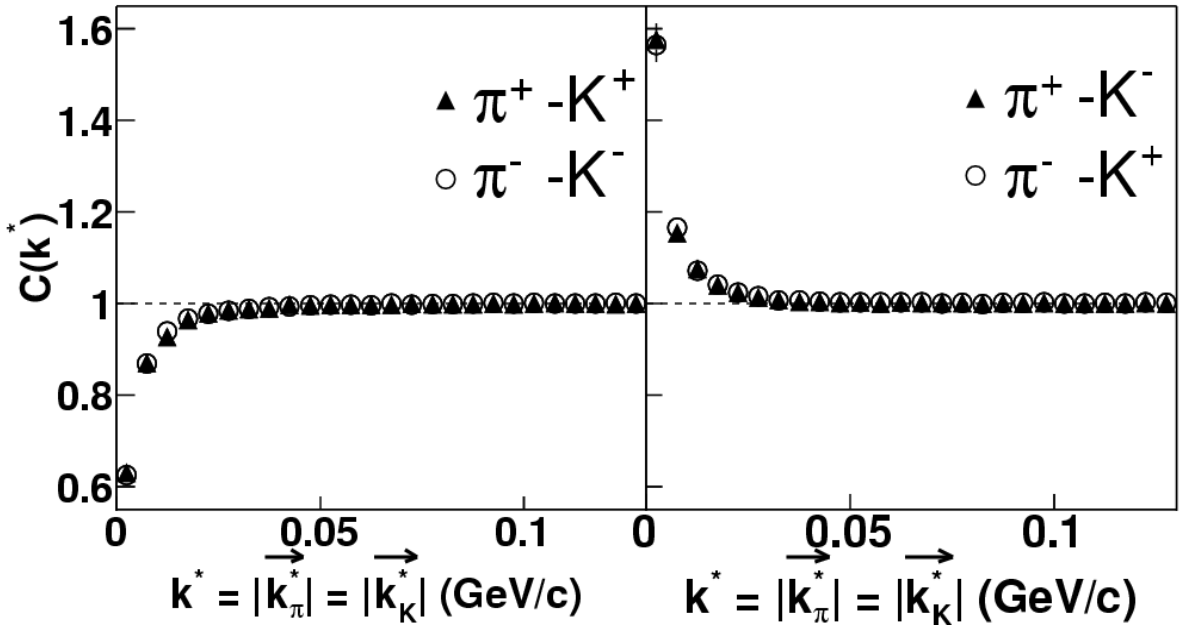
Trends of correlation functions for both energies are the same.

The correlation functions for 39GeV are stronger than the correlation functions for 130GeV.



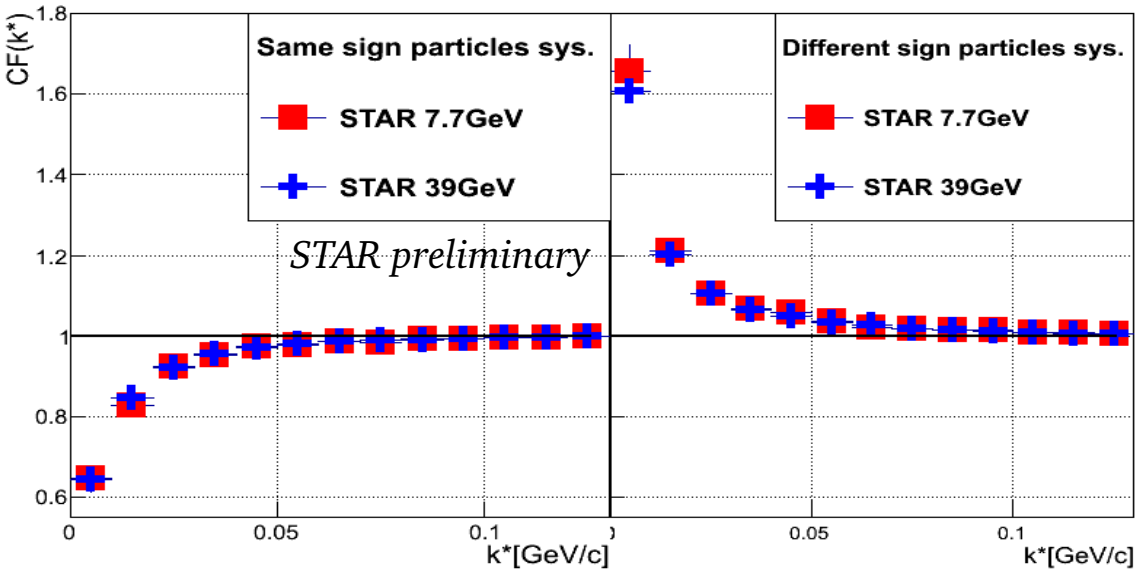
Au+Au collision at $\sqrt{s_{NN}}=39\text{GeV}$ (central)

Comparison of Au+Au data for $\sqrt{s_{NN}} = (130, 39, 7.7)\,GeV$



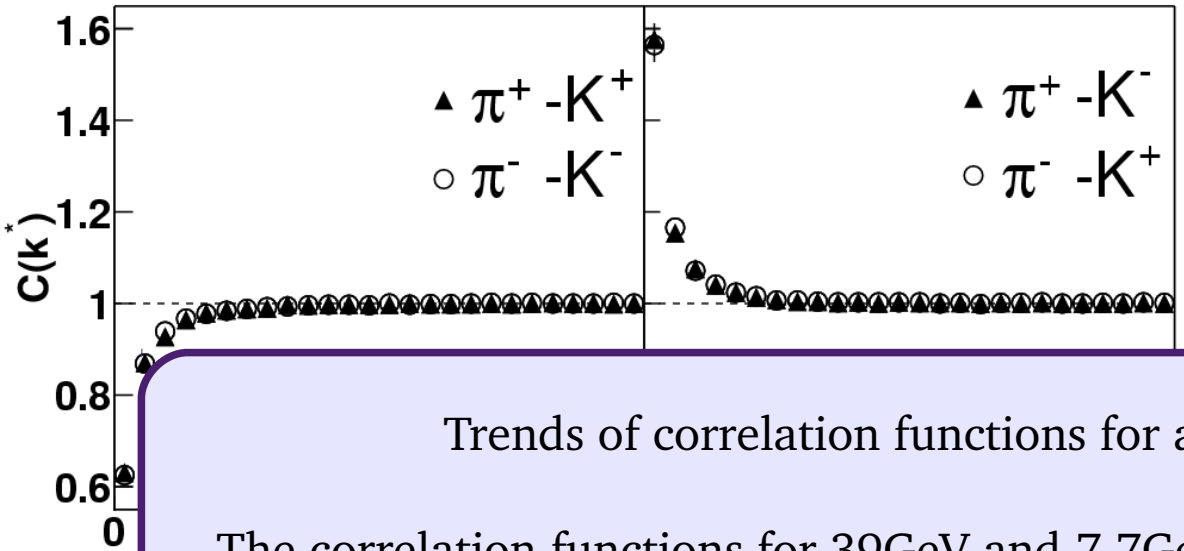
Au+Au collision at $\sqrt{s_{NN}} = 130\text{GeV}$ (central)

Phys. Rev. Lett. 91 (2003) 262302



Au+Au collision at $\sqrt{s_{NN}} = 39\text{GeV}$ and $\sqrt{s_{NN}} = 7.7\text{GeV}$ (minimum bias)

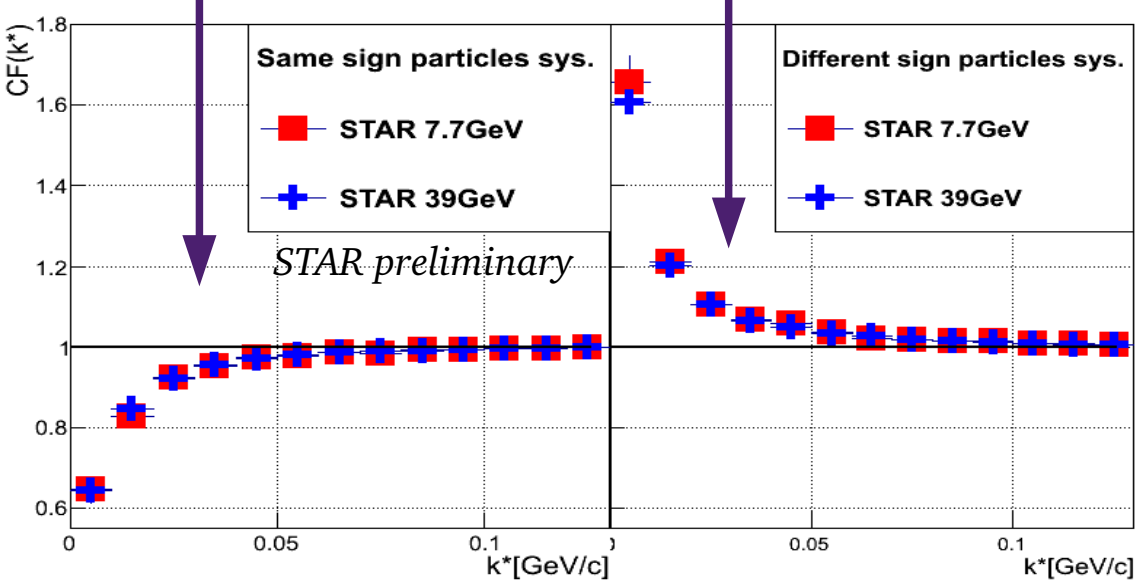
Comparison of Au+Au data for $\sqrt{s_{NN}} = (130, 39, 7.7)\,GeV$



Au+Au collision at $\sqrt{s_{NN}} = 130\text{GeV}$ (central)

Trends of correlation functions for all energies are the same.

The correlation functions for 39GeV and 7.7GeV looks the same within error bars.



Au+Au collision at $\sqrt{s_{NN}} = 39\text{GeV}$ and $\sqrt{s_{NN}} = 7.7\text{GeV}$ (minimum bias)

Comparison of Au+Au data for $\sqrt{s_{NN}}=130\text{GeV}$ and $\sqrt{s_{NN}}=39\text{GeV}$

Au+Au collision at $\sqrt{s_{NN}}=130\text{GeV}$ (central)

Au+Au collision at $\sqrt{s_{NN}}=39\text{GeV}$ (central)

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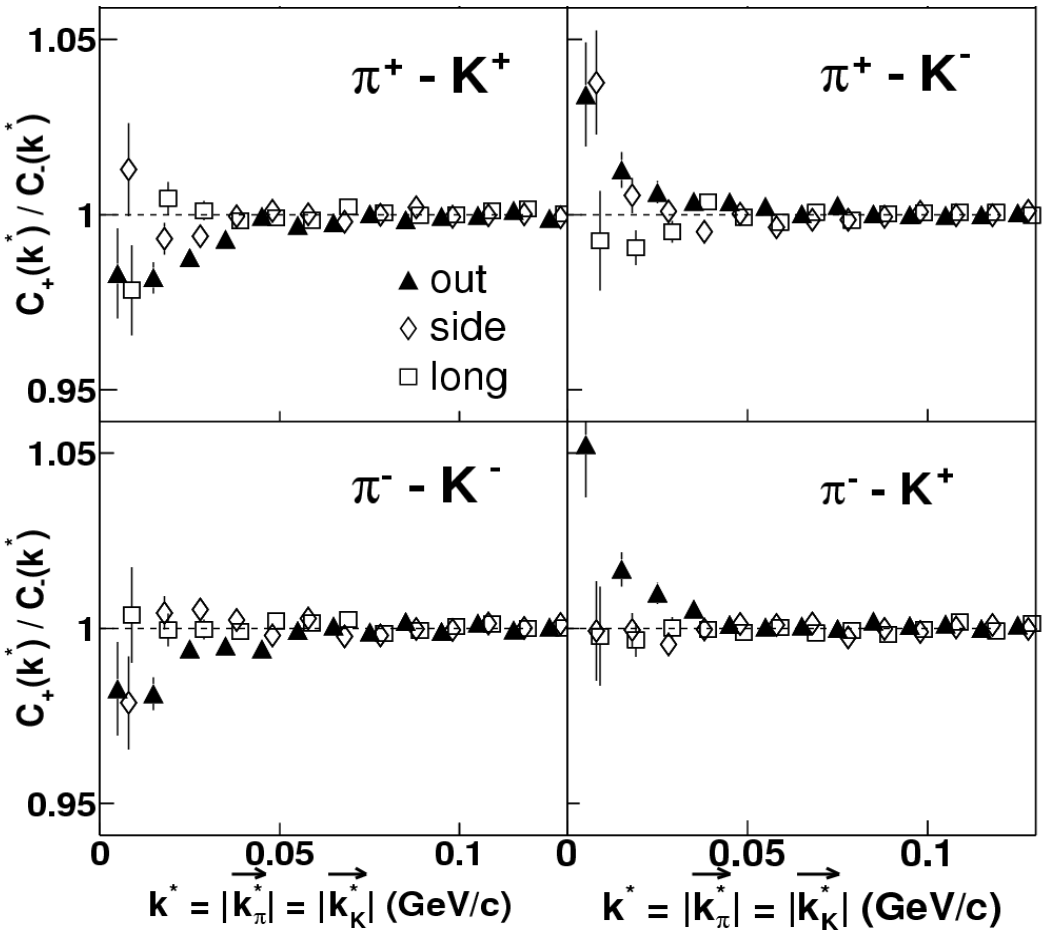

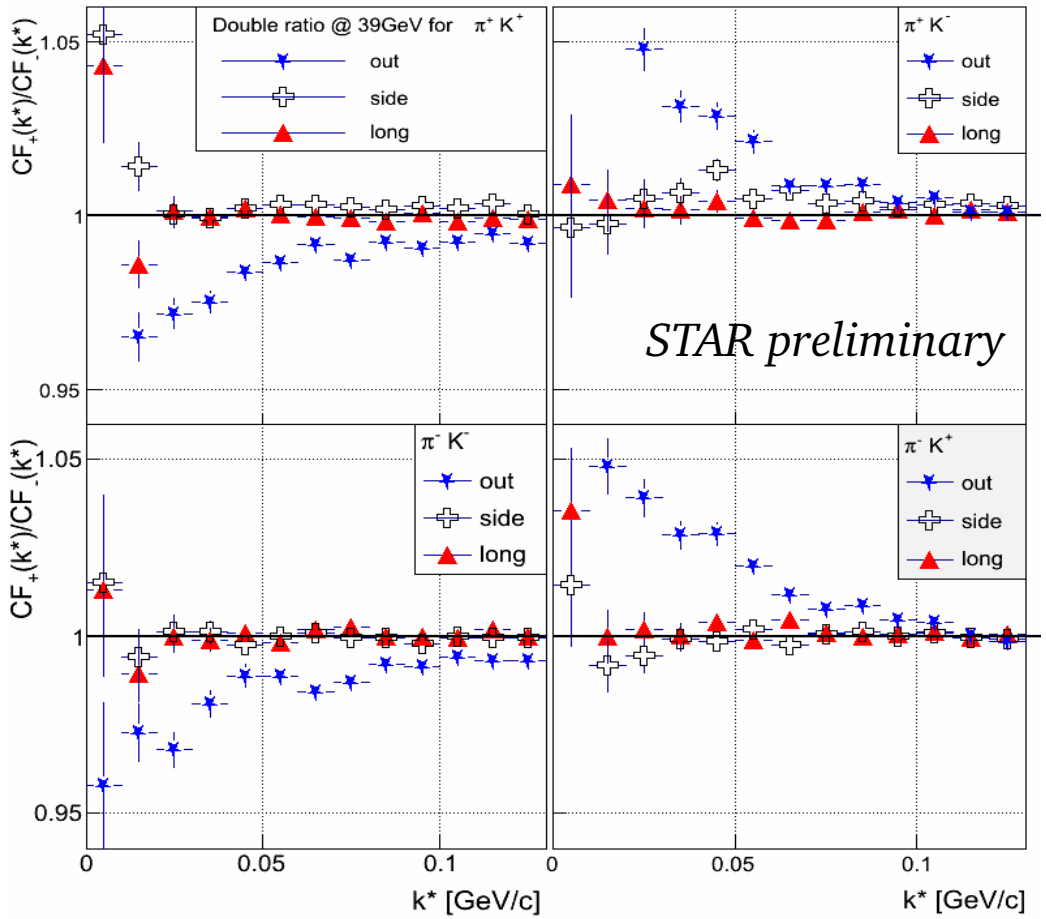

Comparison of Au+Au data for $\sqrt{s_{NN}}=130\text{GeV}$ and $\sqrt{s_{NN}}=39\text{GeV}$

Au+Au collision at $\sqrt{s_{NN}}=130\text{GeV}$ (central)

Au+Au collision at $\sqrt{s_{NN}}=39\text{GeV}$ (central)

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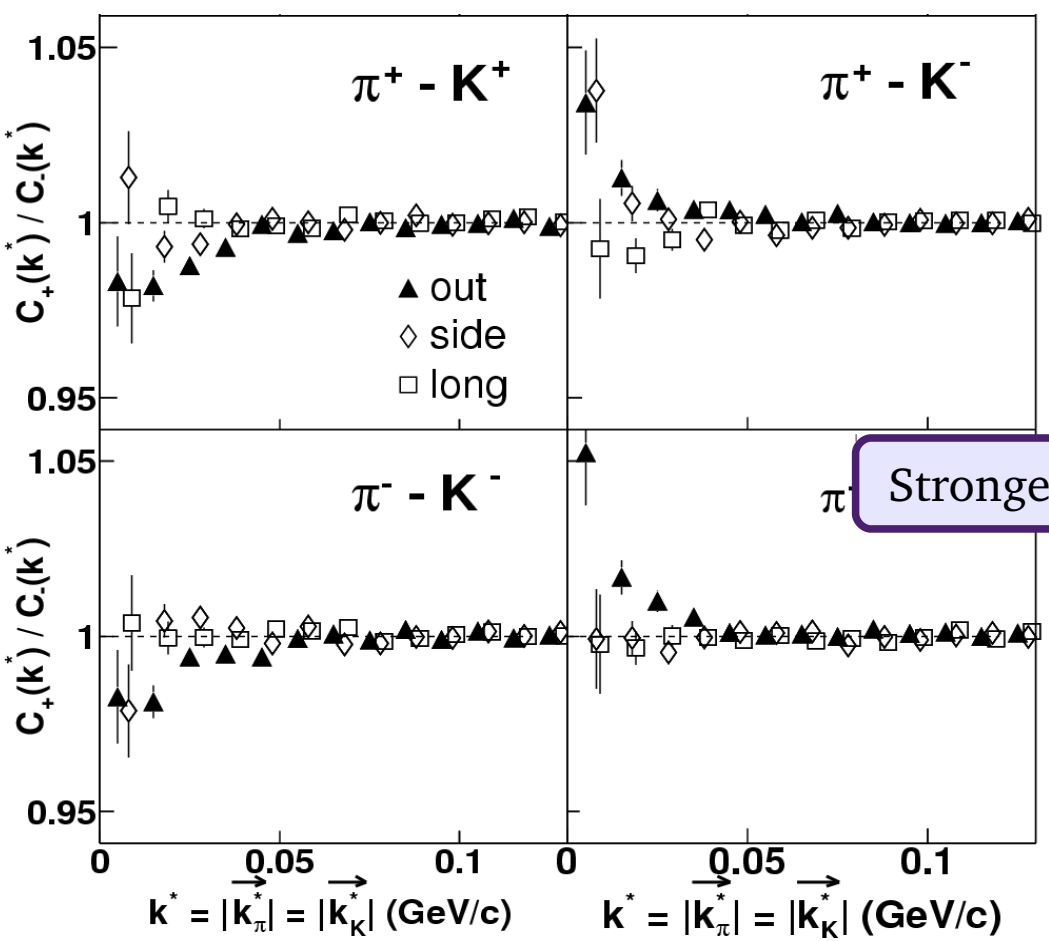
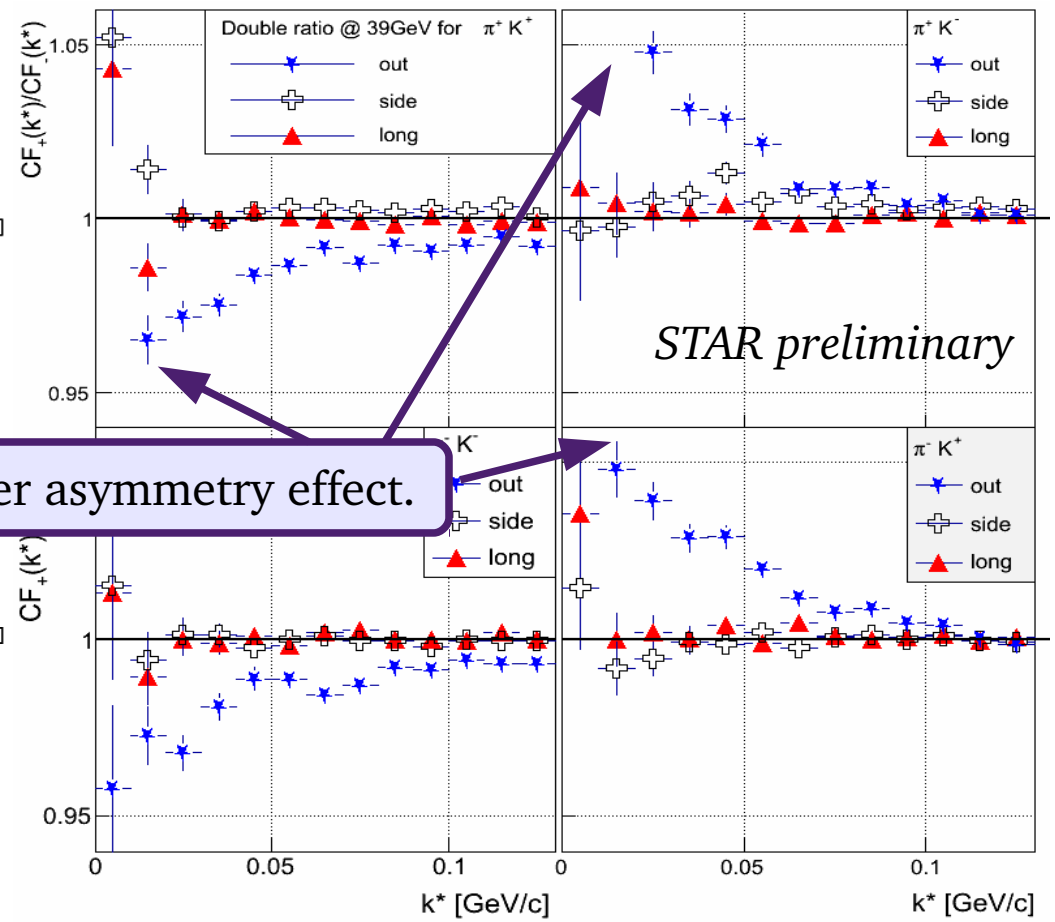
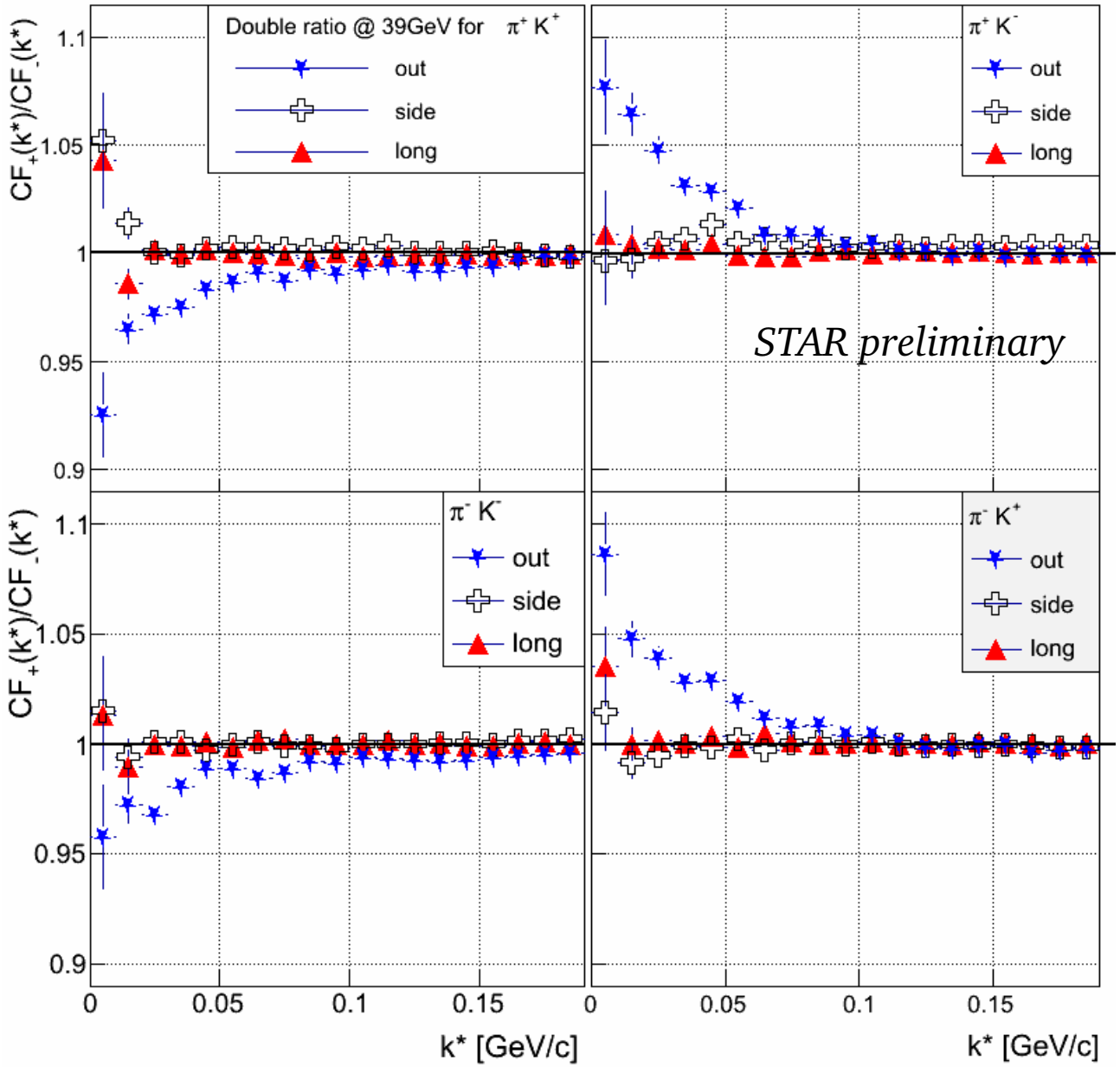


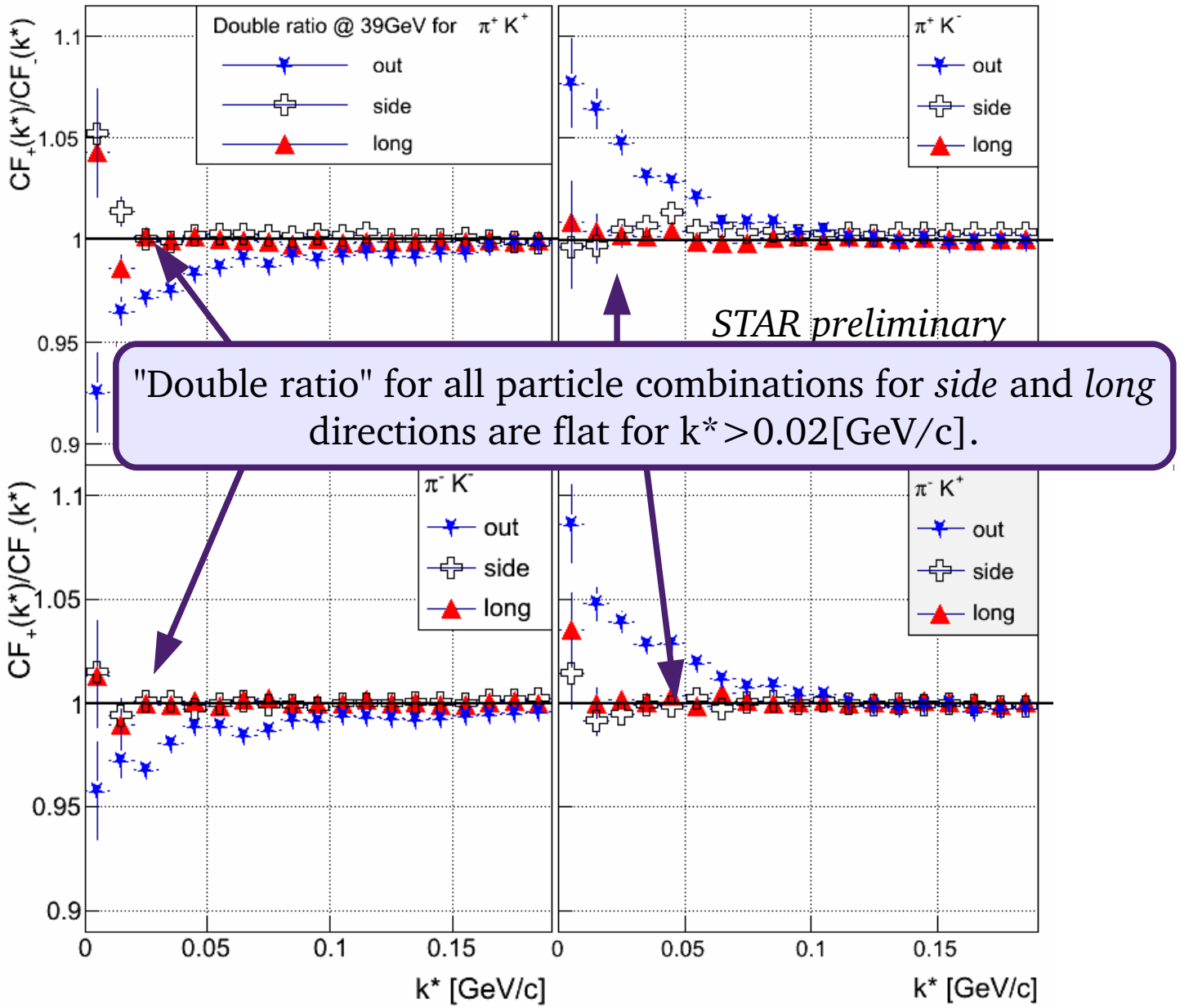


Stronger asymmetry effect.

Asymmetry for Au+Au collisions at $\sqrt{s_{NN}}=39\text{GeV}$

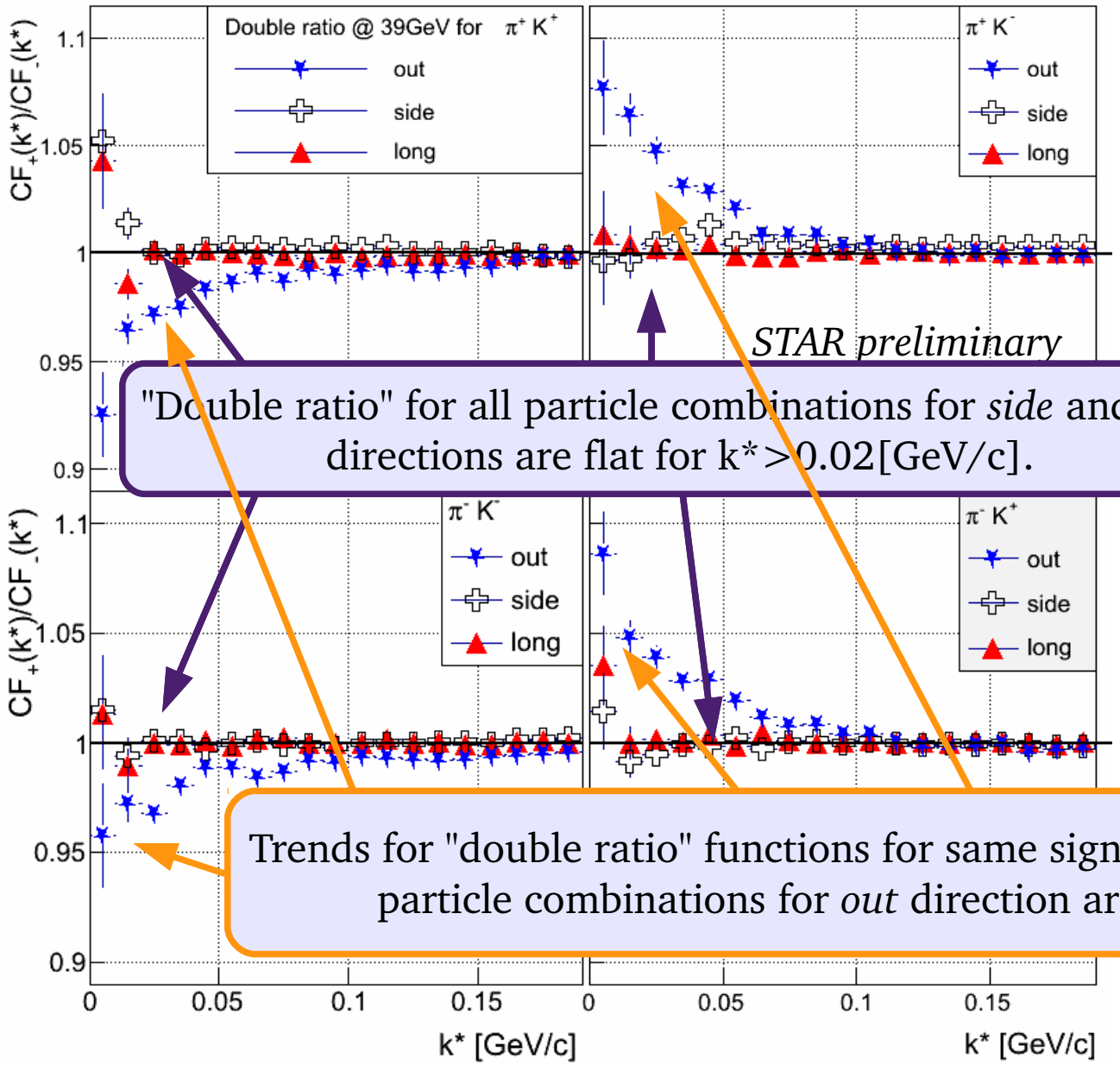


Asymmetry for Au+Au collisions at $\sqrt{s_{NN}}=39\text{GeV}$



"Double ratio" for all particle combinations for *side* and *long* directions are flat for k*>0.02[GeV/c].

Asymmetry for Au+Au collisions at $\sqrt{s_{NN}}=39\text{GeV}$

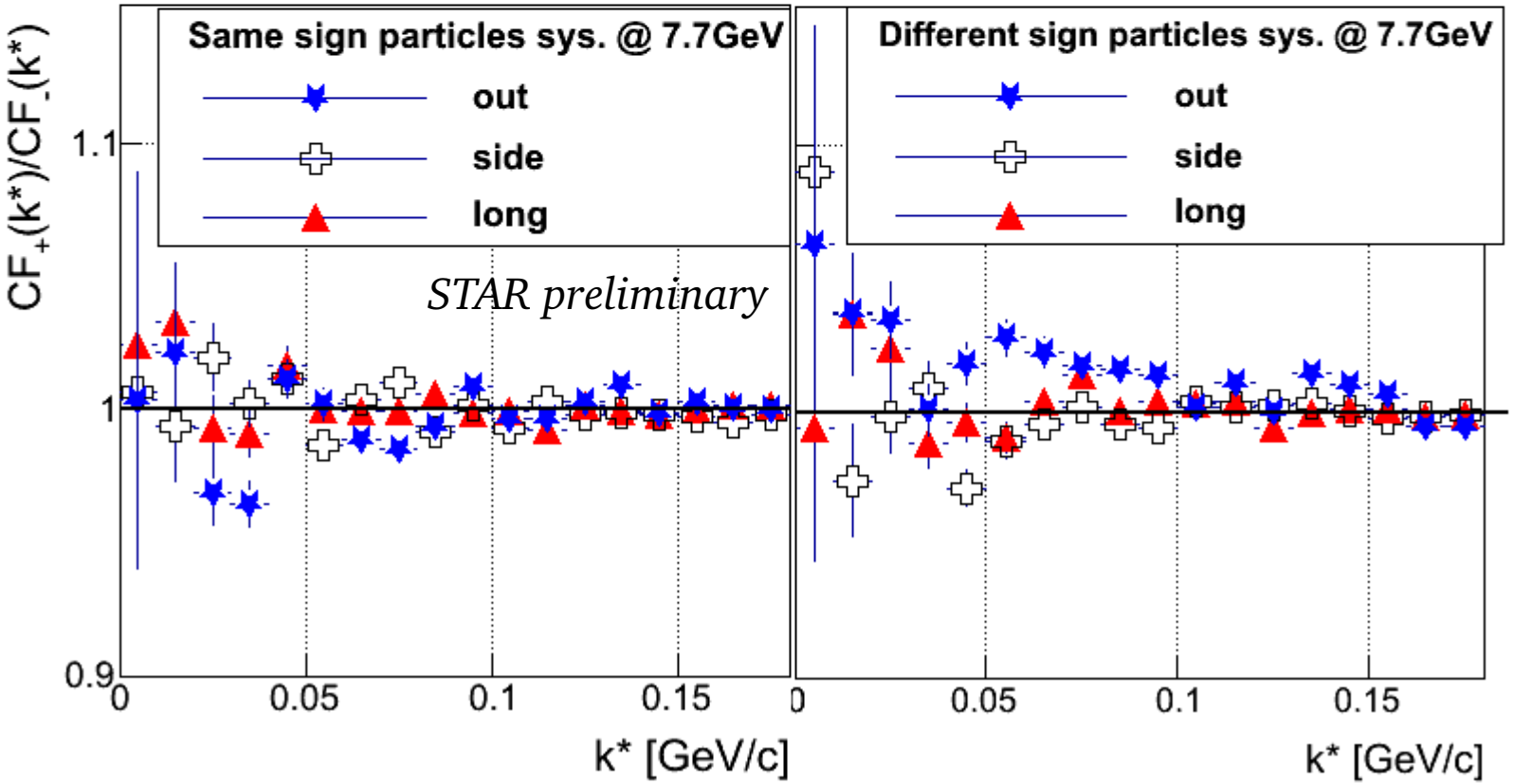


"Double ratio" for all particle combinations for *side* and *long* directions are flat for k*>0.02[GeV/c].

Trends for "double ratio" functions for same sign (different sign) particle combinations for *out* direction are similar.

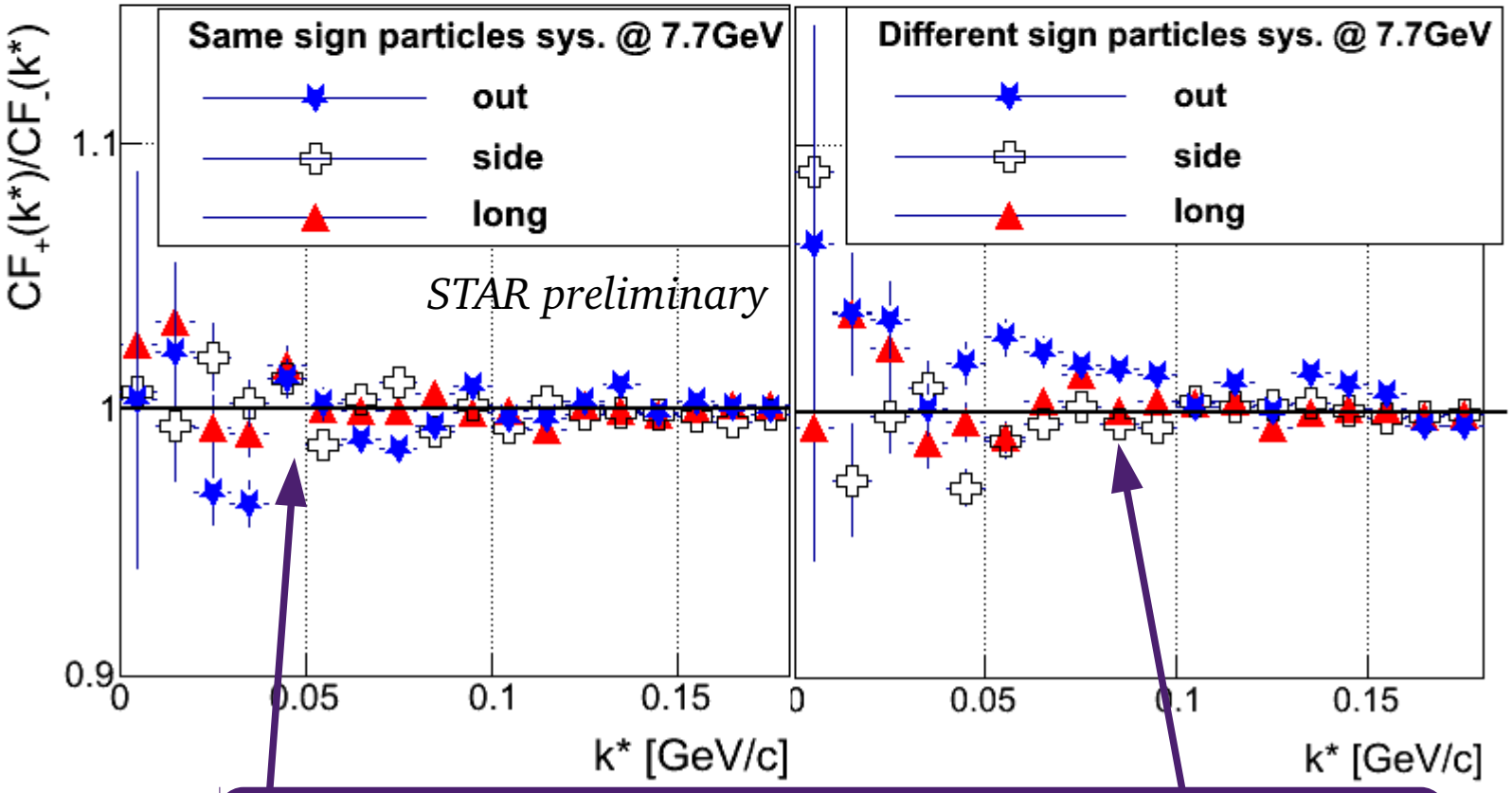
Asymmetry for Au+Au collisions at $\sqrt{s_{NN}}$=7.7GeV

Minimum bias data.



Asymmetry for Au+Au collisions at $\sqrt{s_{NN}}$=7.7GeV

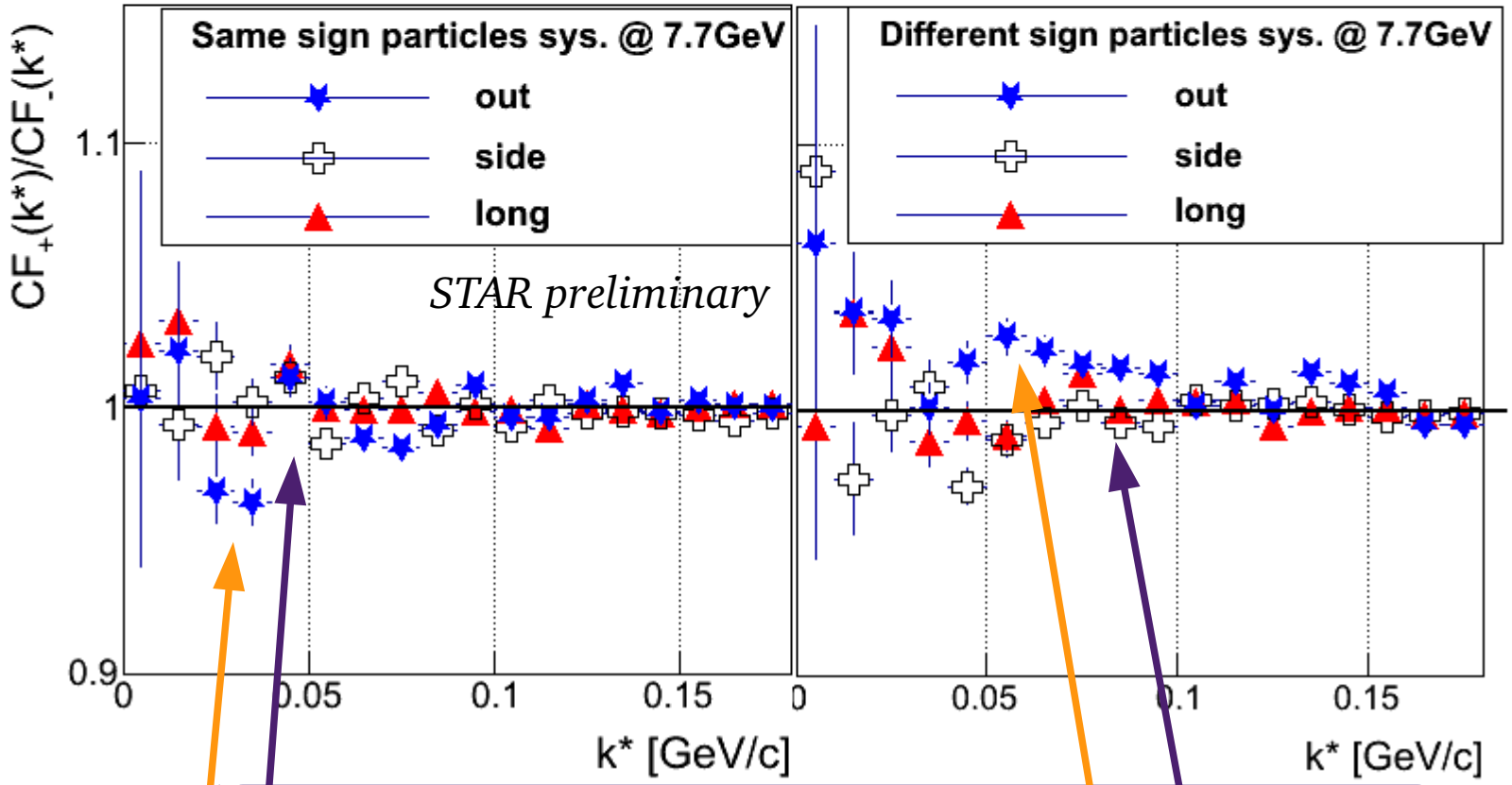
Minimum bias data.



"Double ratio" for all particle combinations for *side* and *long* directions are flat in respect of error bars.

Asymmetry for Au+Au collisions at $\sqrt{s_{NN}}$=7.7GeV

Minimum bias data.

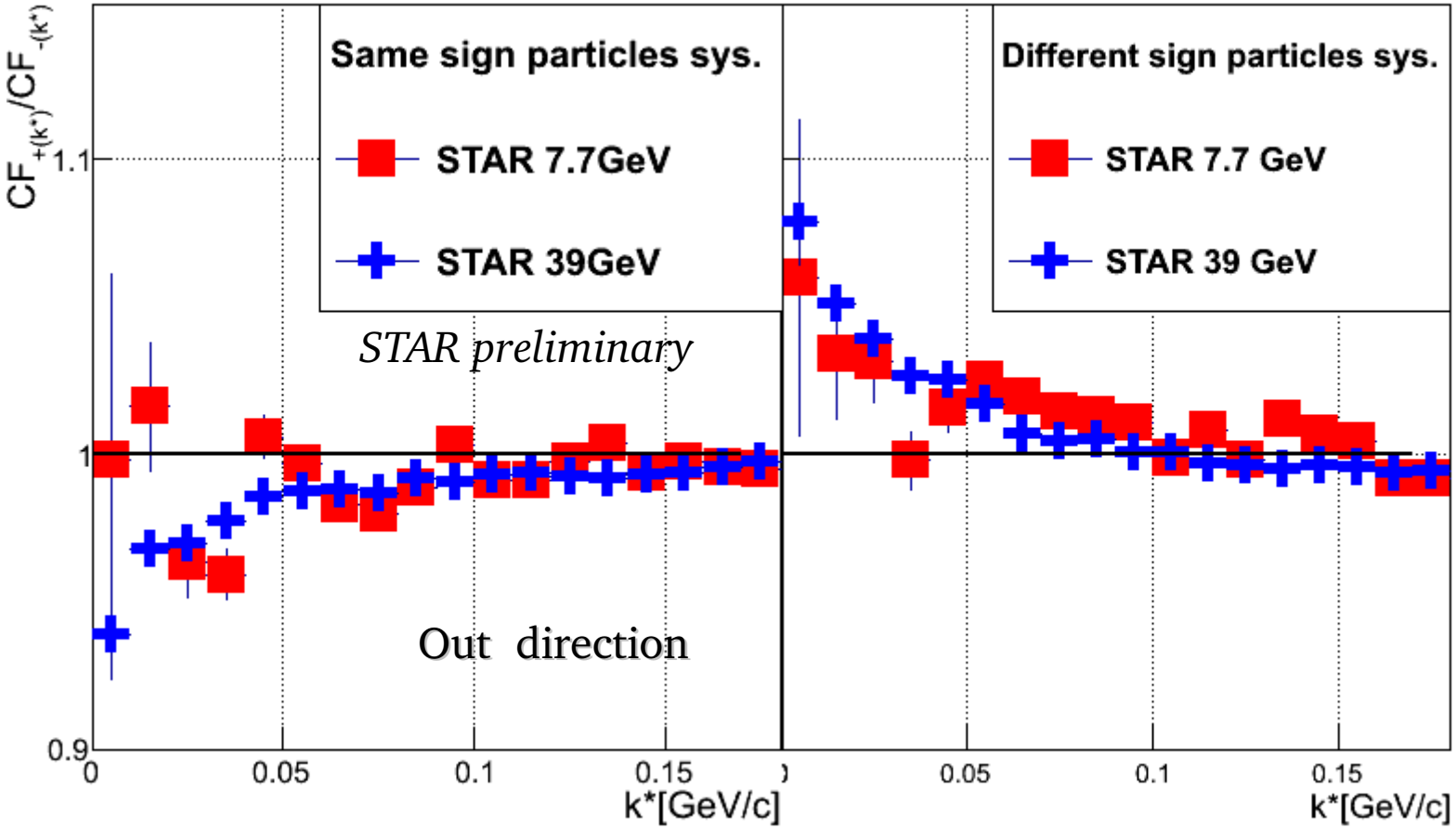


"Double ratio" for all particle combinations for *side* and *long* directions are flat in respect of error bars.

Trends for "double ratio" functions for same sign (different sign) particle combinations for *out* direction deviated from the unity – we observe the asymmetry.

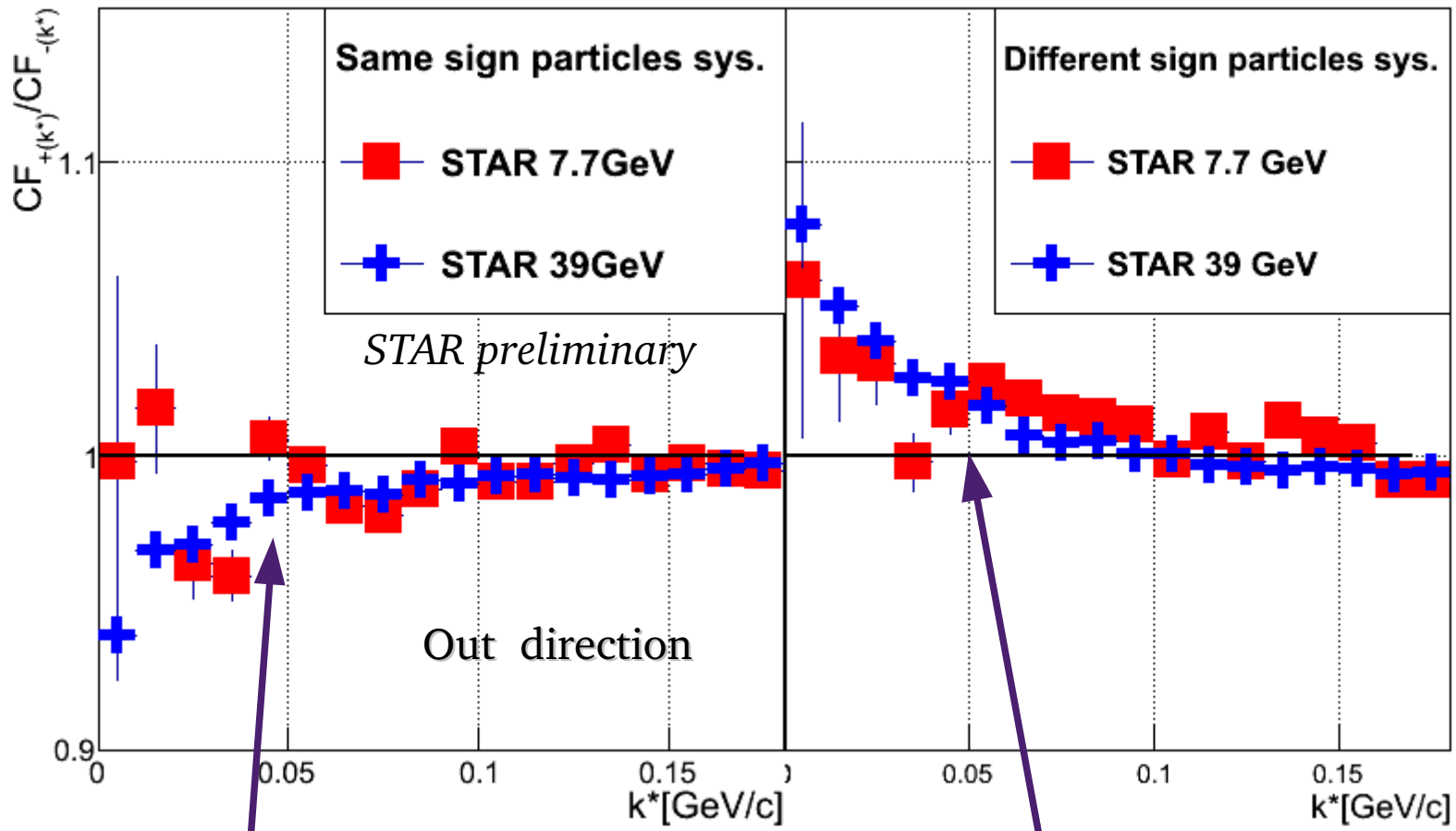
Comparison of Au+Au data for $\sqrt{s_{NN}}=39\text{GeV}$ and $\sqrt{s_{NN}}=7.7\text{GeV}$

Minimum bias data.



Comparison of Au+Au data for $\sqrt{s_{NN}}=39\text{GeV}$ and $\sqrt{s_{NN}}=7.7\text{GeV}$

Minimum bias data.



We observe the same tendency in asymmetry for 7.7 GeV as for 39 GeV.

Summary

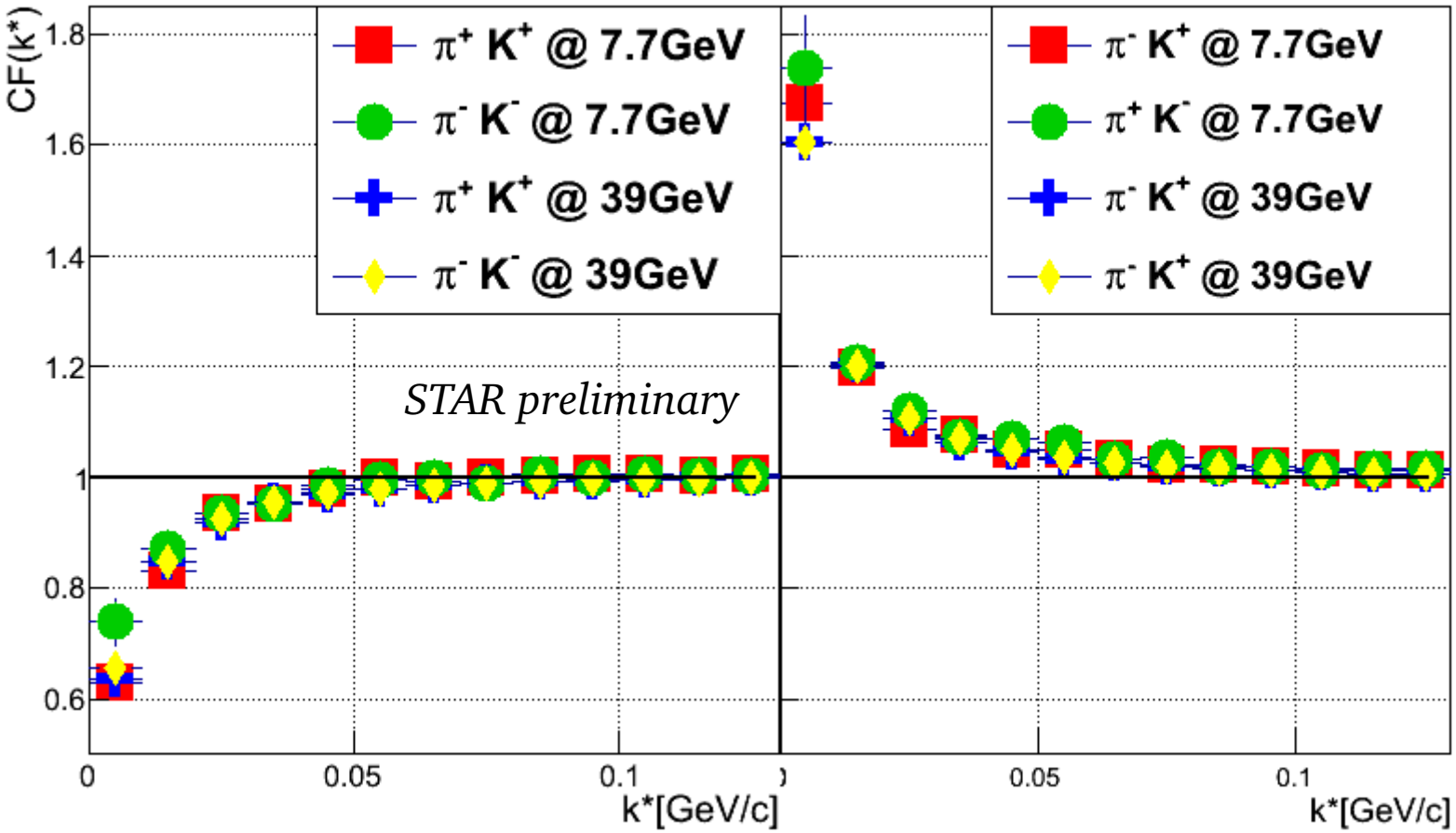
- Correlation functions and “double ratio” functions for minimum bias Au+Au collisions at 39GeV and 7.7GeV are calculated.
- Trends of correlation functions and “double ratio” functions for Au+Au collisions at 39GeV, 7.7GeV and 130GeV are the same.
- Pions are emitted closer to the system's center or/and later than kaons in systems created in collisions for 7.7GeV, 39GeV and 130GeV.
- Source size is bigger in Au+Au collisions at 130GeV than at 39GeV and 7.7GeV.
- The asymmetry in emission process in “double ratio” functions for 39GeV are stronger than for 130GeV.
- The correlation functions for 39GeV and 7.7GeV are stronger than the correlation functions for 130GeV.
- Due to small statistics we can only say, that source size in Au+Au collision at 7.7GeV are close to source size in Au+Au collision at 39GeV.

Thank you for your attention!

Back up

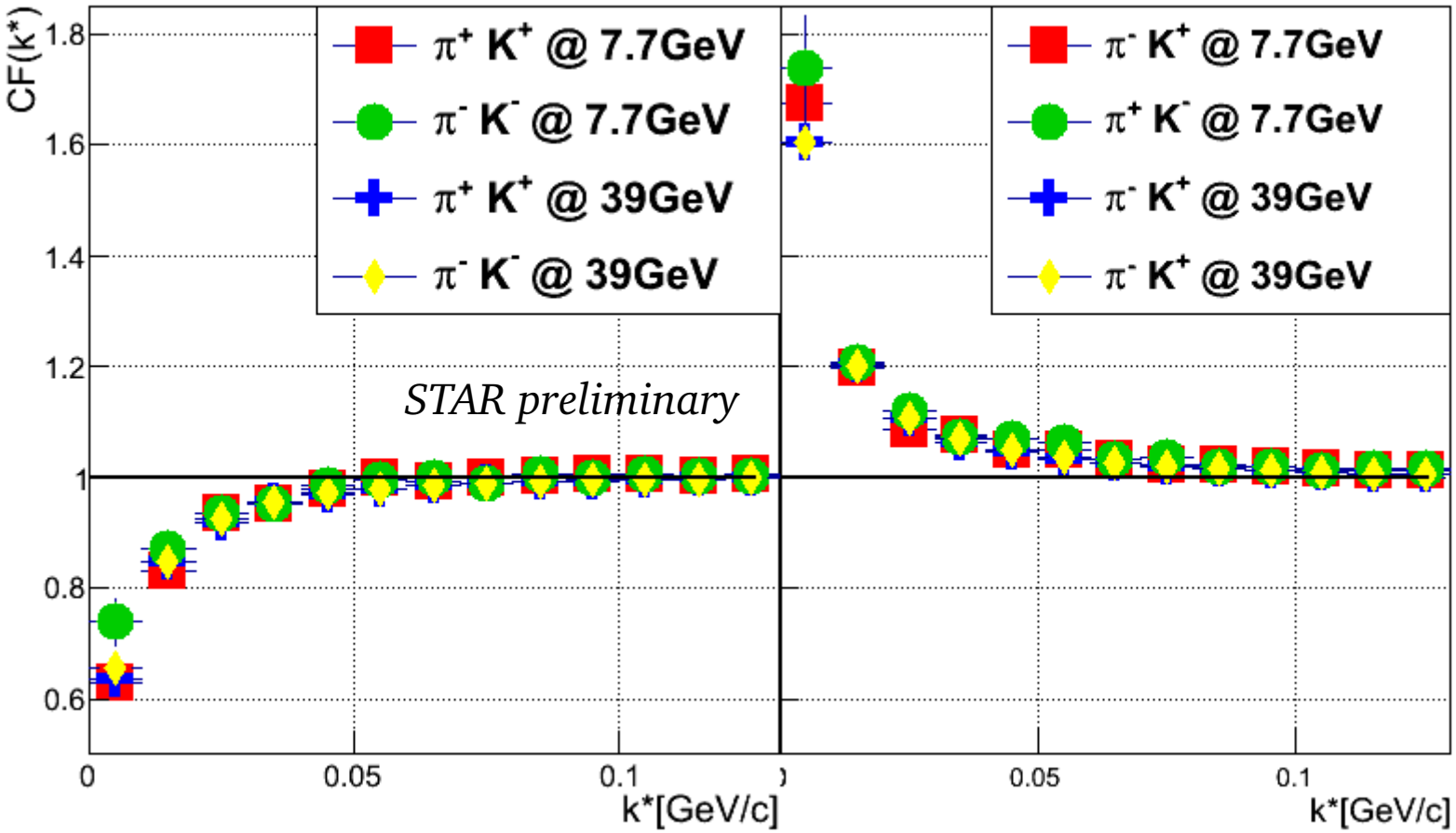
Comparison of Au+Au data for $\sqrt{s_{NN}}=39\text{GeV}$ and $\sqrt{s_{NN}}=7.7\text{GeV}$

Minimum bias data.



Comparison of Au+Au data for $\sqrt{s_{NN}}=39\text{GeV}$ and $\sqrt{s_{NN}}=7.7\text{GeV}$

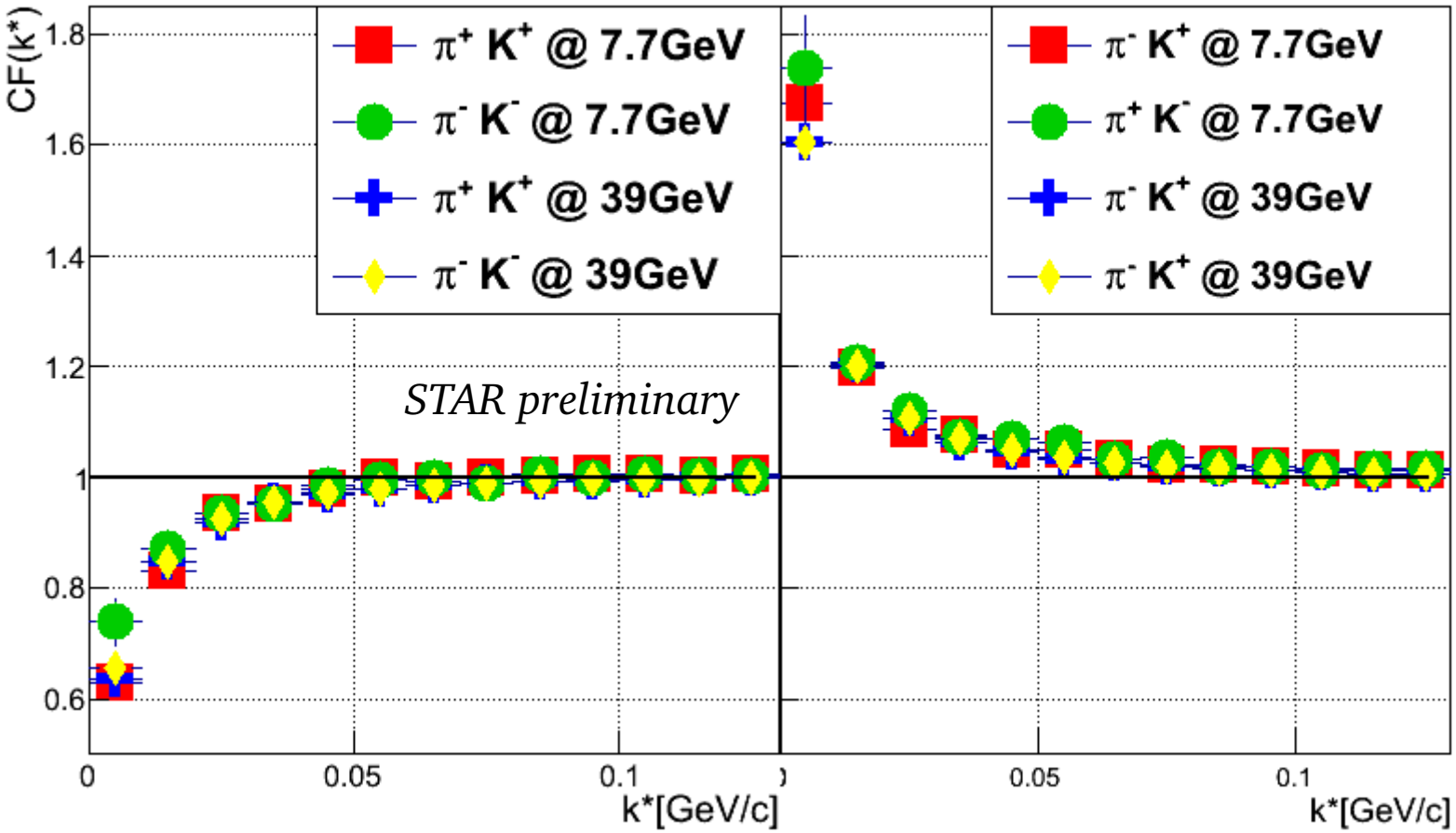
Minimum bias data.



The data from 39GeV and 7.7GeV Au+Au collisions are consistent within errors

Comparison of Au+Au data for $\sqrt{s_{NN}}=39\text{GeV}$ and $\sqrt{s_{NN}}=7.7\text{GeV}$

We cannot devide data into 4 systems



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