HBT correlations in Au+Au collisions at AGS energy

QM96

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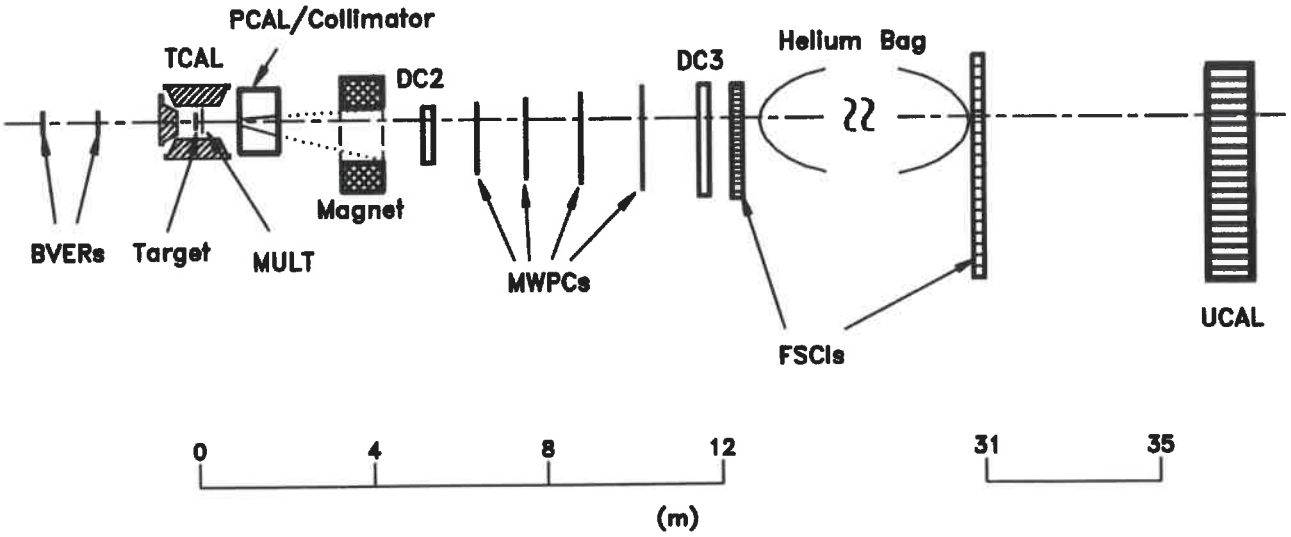
for
E877 Collaboration

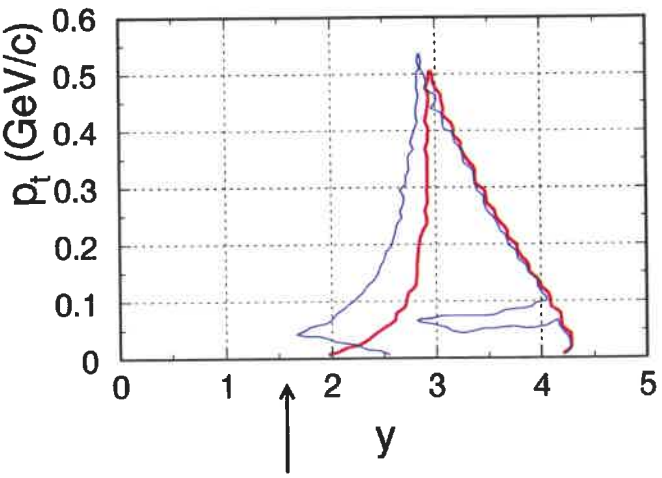
Outline:

- **E877 setup**
- **Analysis**
- **1-dim correlations (π, K, p)**
  ...and comparison to RQMD
- **3-dim correlations (π)**
  ...and phase space density
- **4-dim correlations (π)**
  ...and source velocity
- **Summary**

(Late) E877 setup at the AGS

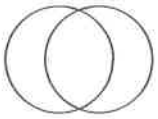


- **Beam detectors** – event selection, TOF start
- **Calorimeters** – centrality, reaction plane
- **Forward spectrometer** – pions, kaons, protons, deutrons identified, $\Delta p/p \approx 3\%$



π^+ and π^- acceptance

Experiment

- ^{197}Au + ^{197}Au at 10.8 GeV/c per nucleon
- Central trigger (14% σ_g) 
- Beam intensity 10^5 per spill

- Fall 1993 – 2 M central events
  (100 k-200 k identical pion pairs)
- Fall 1994 – 10 M central events
- Fall 1995 – 50 M central events

Data analysis

- Select good central events
- Select good pion tracks
- Combine pions into pairs → signal
- Use event mixing → background
- Correlation = signal : background
- Fit correlation

Special attention required:

- Two track efficiency
- Track order in event
- Combination of different measurements
- Normalization
- Singles distortion
  - -multiparticle effects
  - -distortion of the single particle acceptance by the two-particle trigger
- Maximum Likelihood and not Least Squares
- Coulomb "correction"

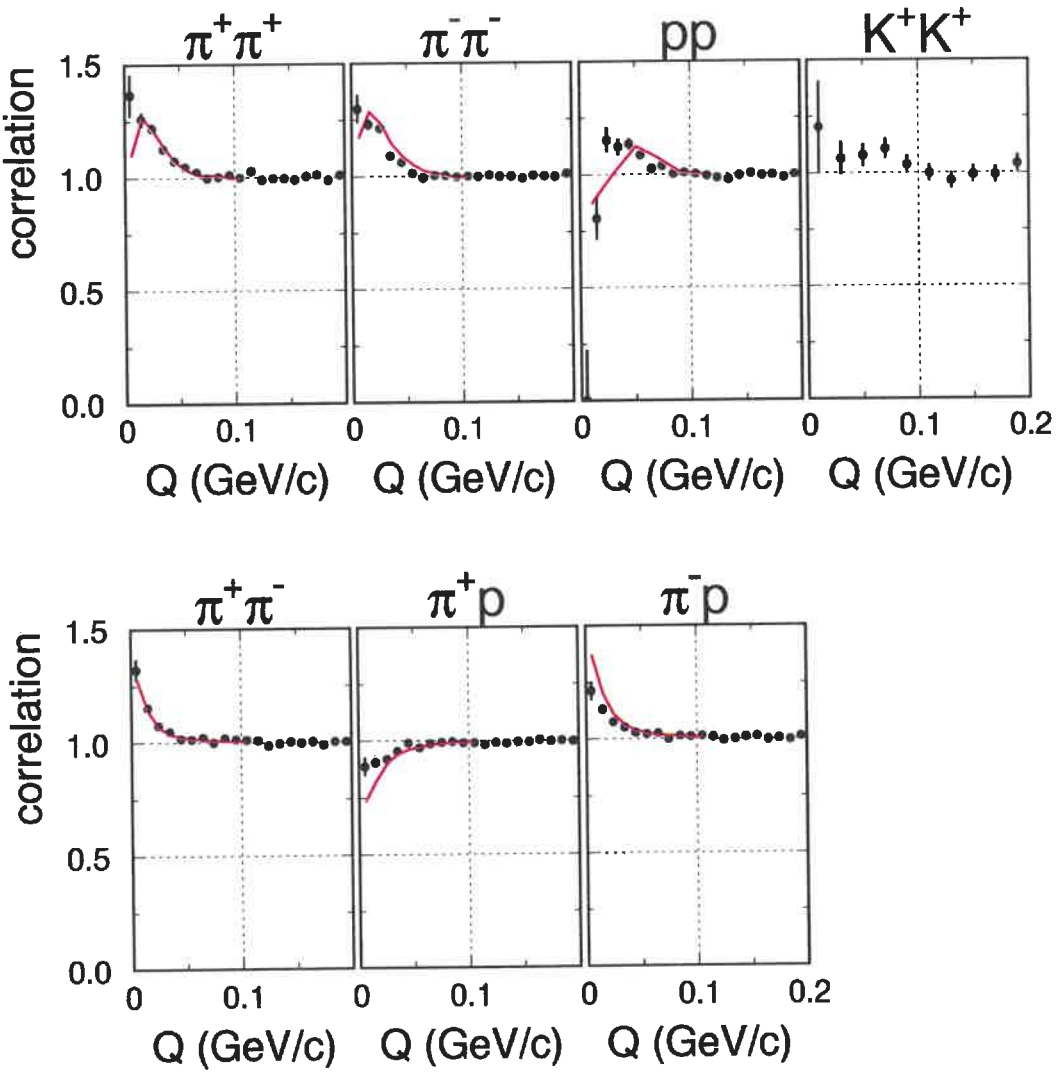
Source lifetime from out-side-long

$$R_{out}^2 = R_{side}^2 + \beta_{out}^2 \tau^2$$

$3.3\ \mathrm{fm/c} < \tau < 7.4\ \mathrm{fm/c}$ for π^+

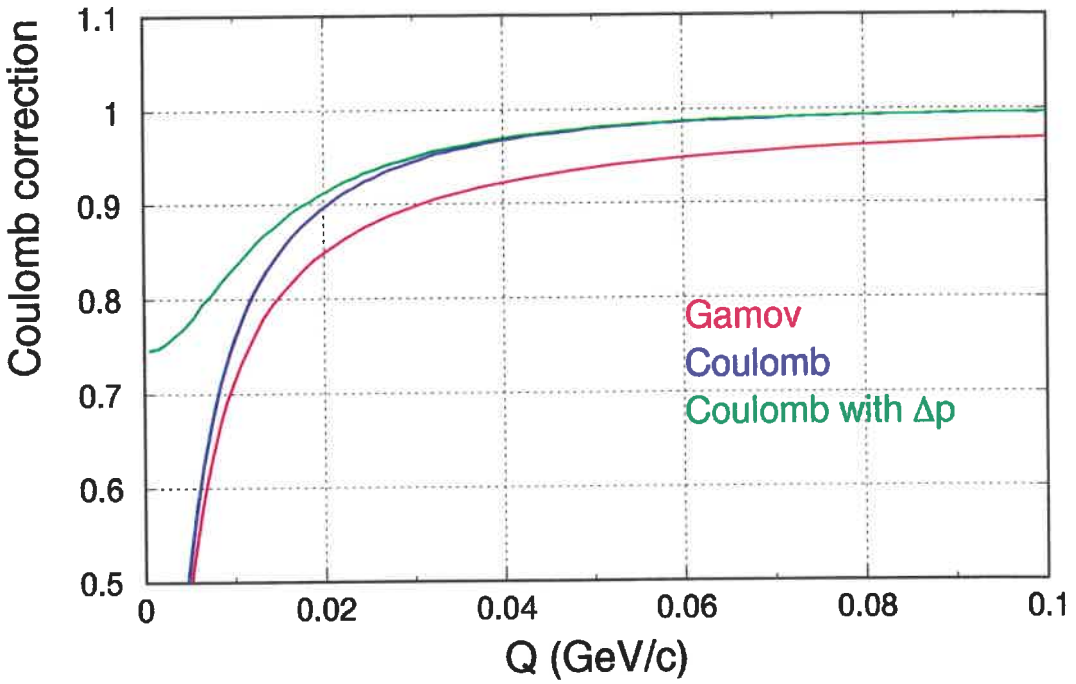
$\tau < 7.0\ \mathrm{fm/c}$ for π^-

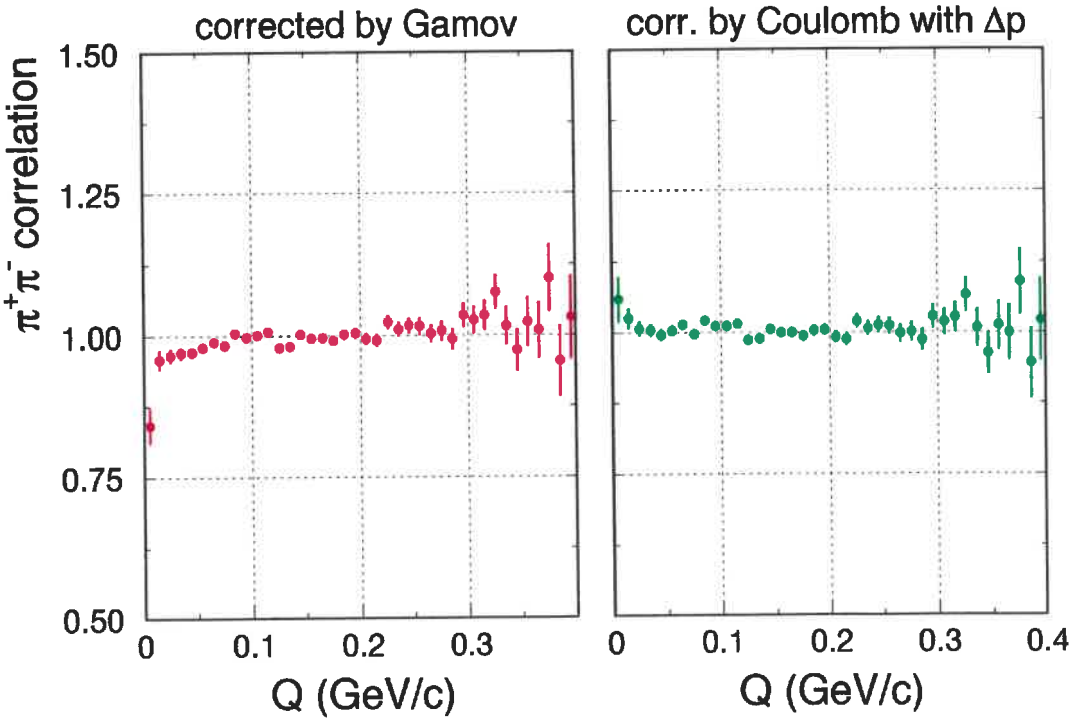
1-dim raw correlations



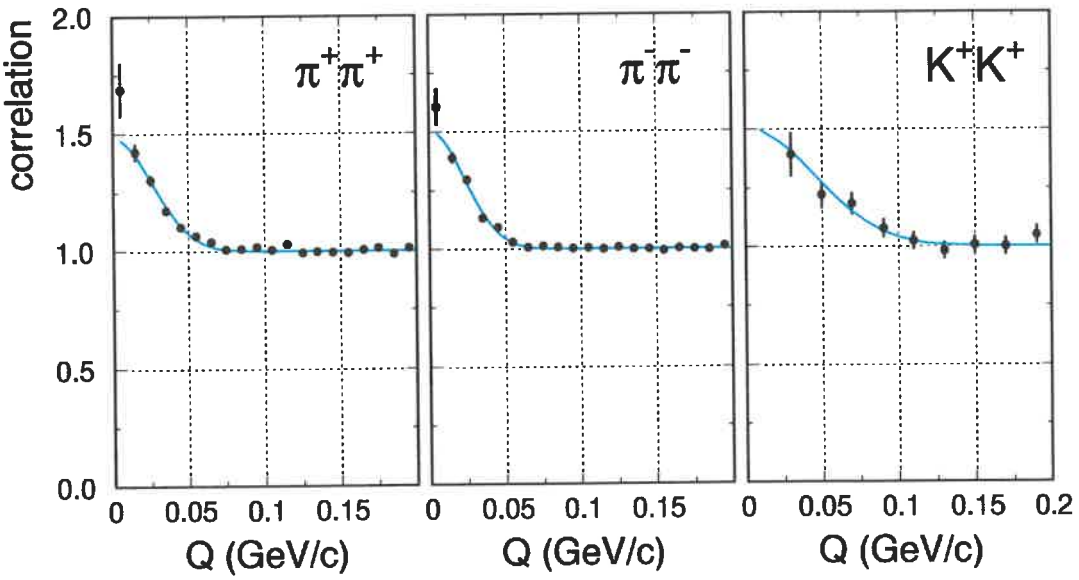
RQMD + SUBATECH

Coulomb correction





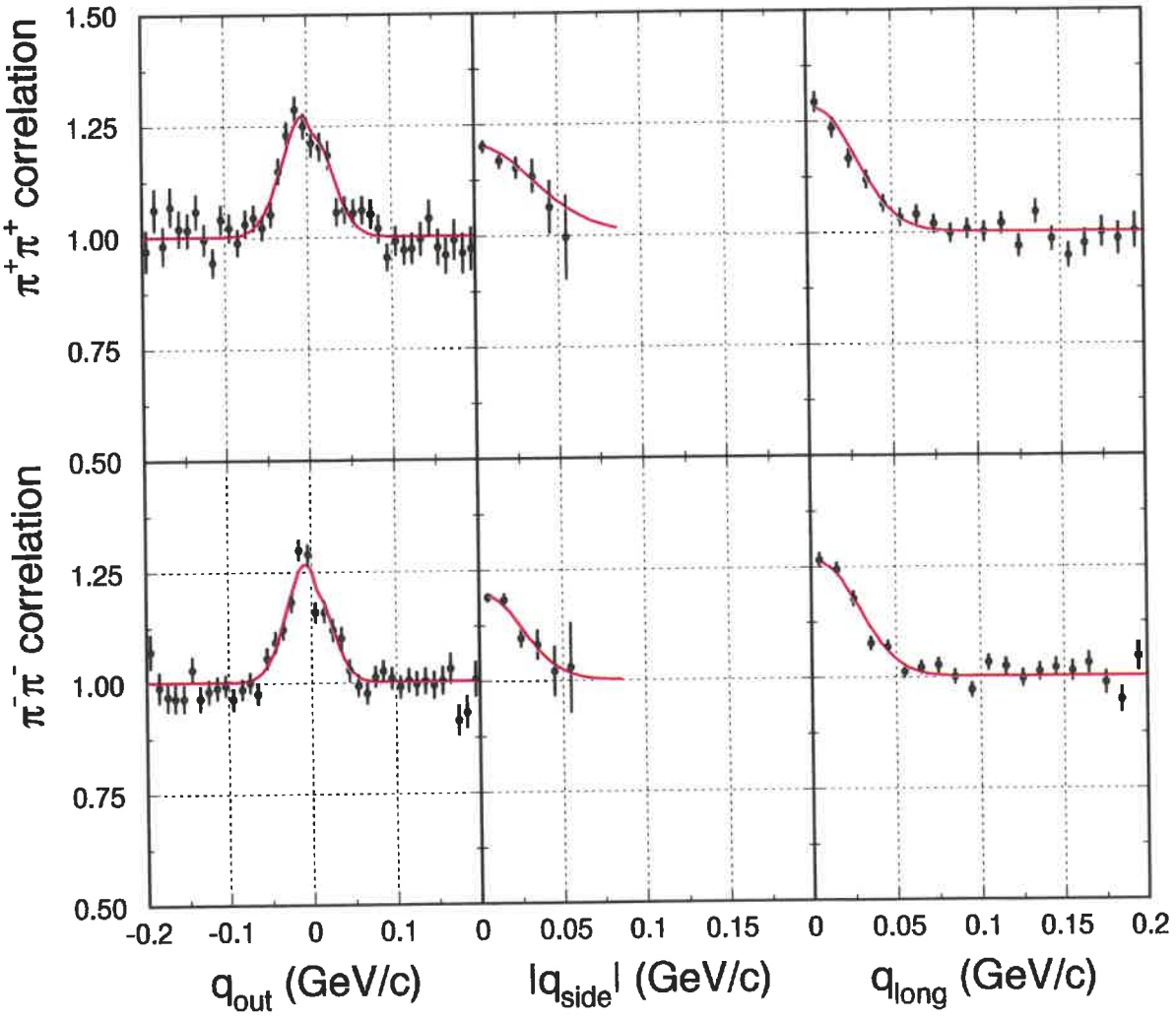
Gaussian fit to 1-dim correlations



$$1 + \lambda \exp(-Q^2 R^2)$$

	λ	R (fm)
$\pi^+\pi^+$	0.48±0.04	5.4±0.3
$\pi^-\pi^-$	0.51±0.03	6.2±0.2
K^+K^+	0.51±0.13	3.1±0.5

Out-side-long fit



Fit function:

$$C(q_{out}, q_{side}, q_{long}) = 1 + \lambda \exp(-R_{out}{}^2 q_{out}{}^2 - R_{side}{}^2 q_{side}{}^2 - R_{long}{}^2 q_{long}{}^2 - 2|R_{ol}|R_{ol} q_{out} q_{long})$$

Fit results:

	λ	R_{out}(fm)	R_{side}(fm)	R_{long}(fm)	R_{ol}(fm)
$\pi^+\pi^+$	0.50±0.04	5.1±0.4	3.8±0.7	5.5±0.4	2.3±0.6
$\pi^-\pi^-$	0.53±0.03	5.9±0.3	5.8±0.6	6.0±0.3	3.7±0.4

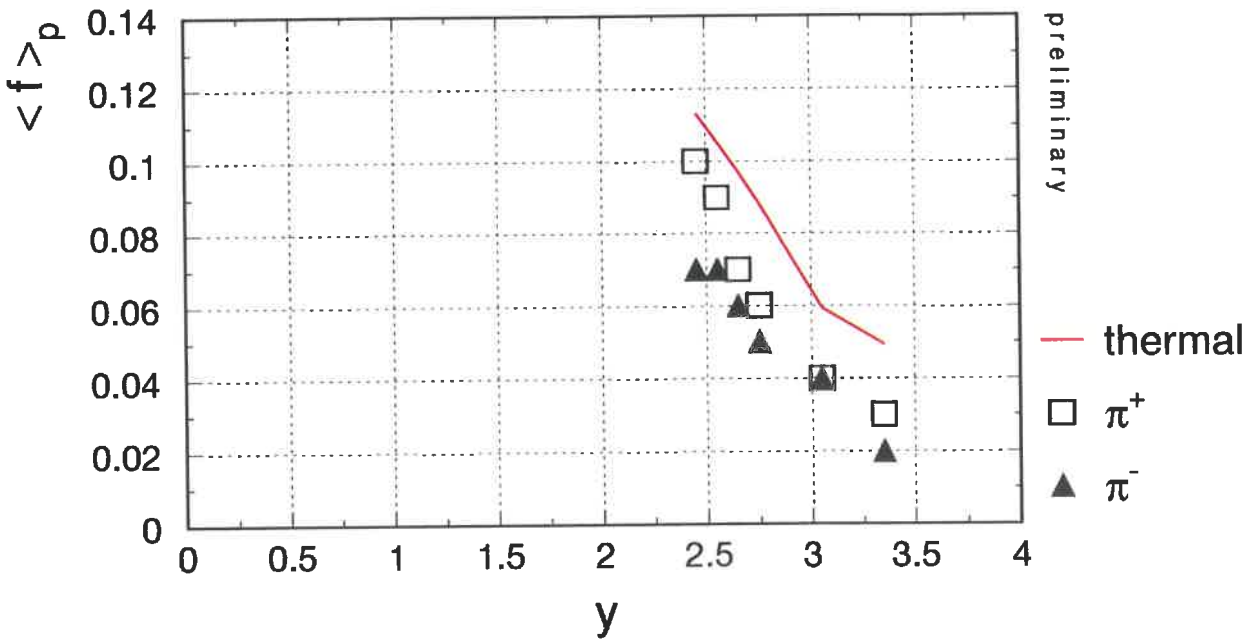
Phase space density from out-side-long

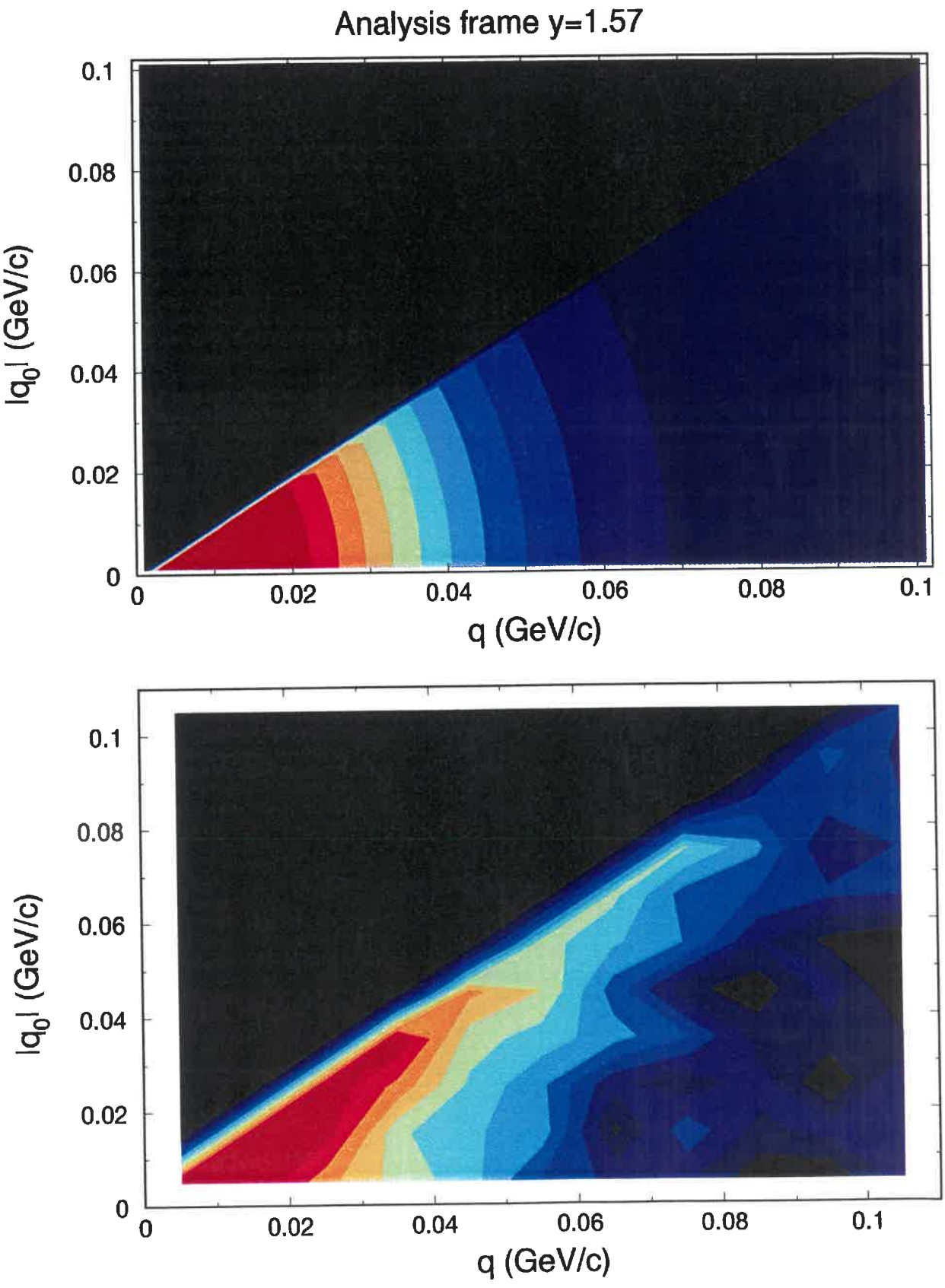
G. Bertsch, Phys.Rev.Lett. 72(1994)2349

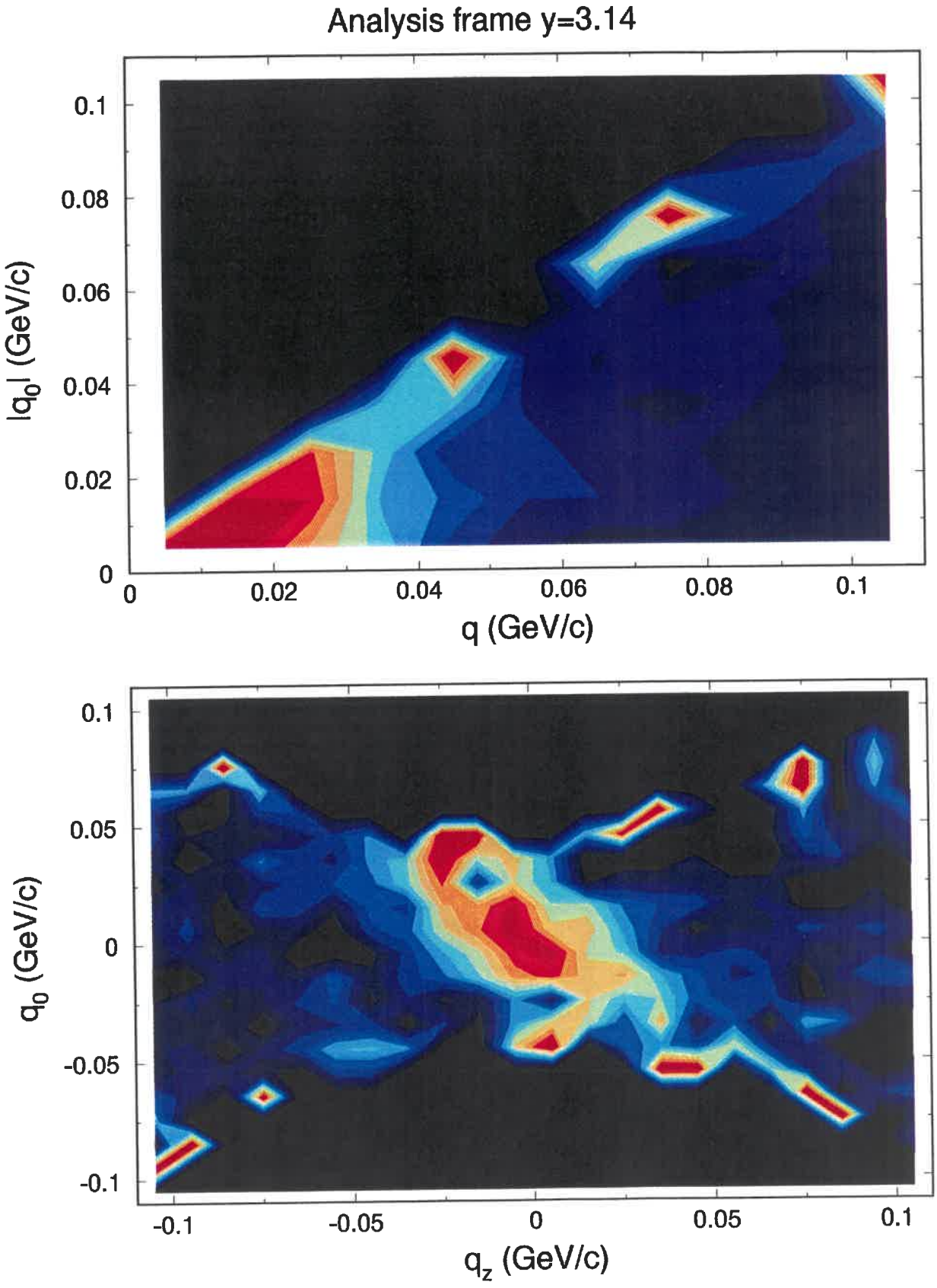
$$< f >_p = \left(\frac{d^3n}{d^3p}\right)^{-1} \cdot \int d^3q \left[\frac{d^6n}{d^3p_1 d^3p_2} - \frac{d^3n}{d^3p_1}\frac{d^3n}{d^3p_2}\right],$$

$$where \;\; \vec{q} = (q_{out}, q_{side}, q_{long})$$

$$< f >_p = \left(\frac{d^3n}{d^3p}\right) \cdot \frac{\pi^{3/2}\,\lambda}{R_{out}R_{side}R_{long}}$$




Analysis frame y=1.57
0.1
0.08
0.06
0.04
0.02
0
$|q_0|$ (GeV/c)
0
0.02
0.04
0.06
0.08
0.1
q (GeV/c)
0.1
0.08
0.06
0.04
0.02
0
$|q_0|$ (GeV/c)
0
0.02
0.04
0.06
0.08
0.1
q (GeV/c)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0.06
0.04
0.02
0
$|q_0|$ (GeV/c)
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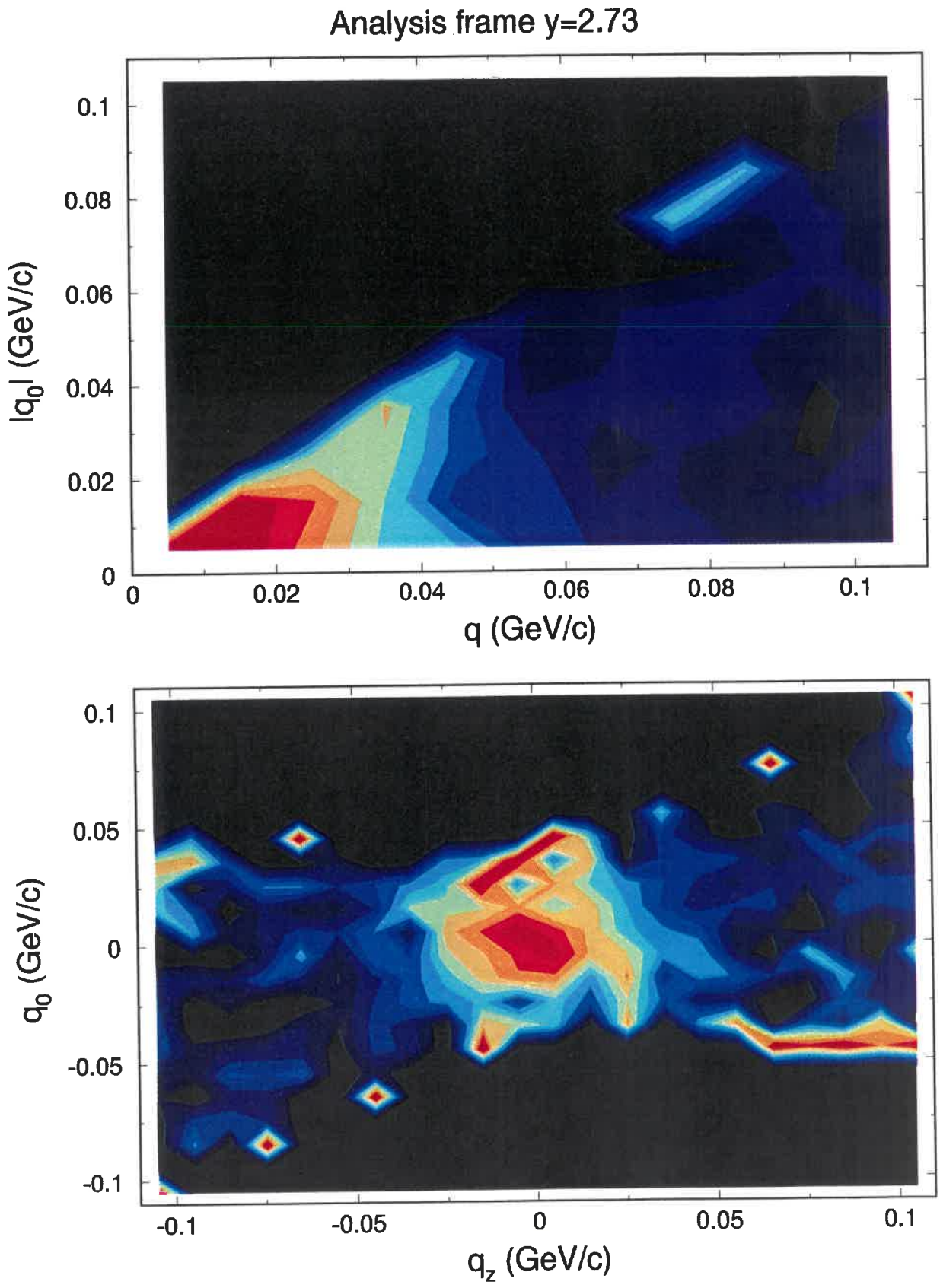
0.02
0.04
0.06
0.08
0.1
q (GeV/c)
0.1
0.05
0
-0.05
-0.1
q_0 (GeV/c)
-0.1
-0.05
0
0.05
0.1
q_z (GeV/c)


Analysis frame y=2.73
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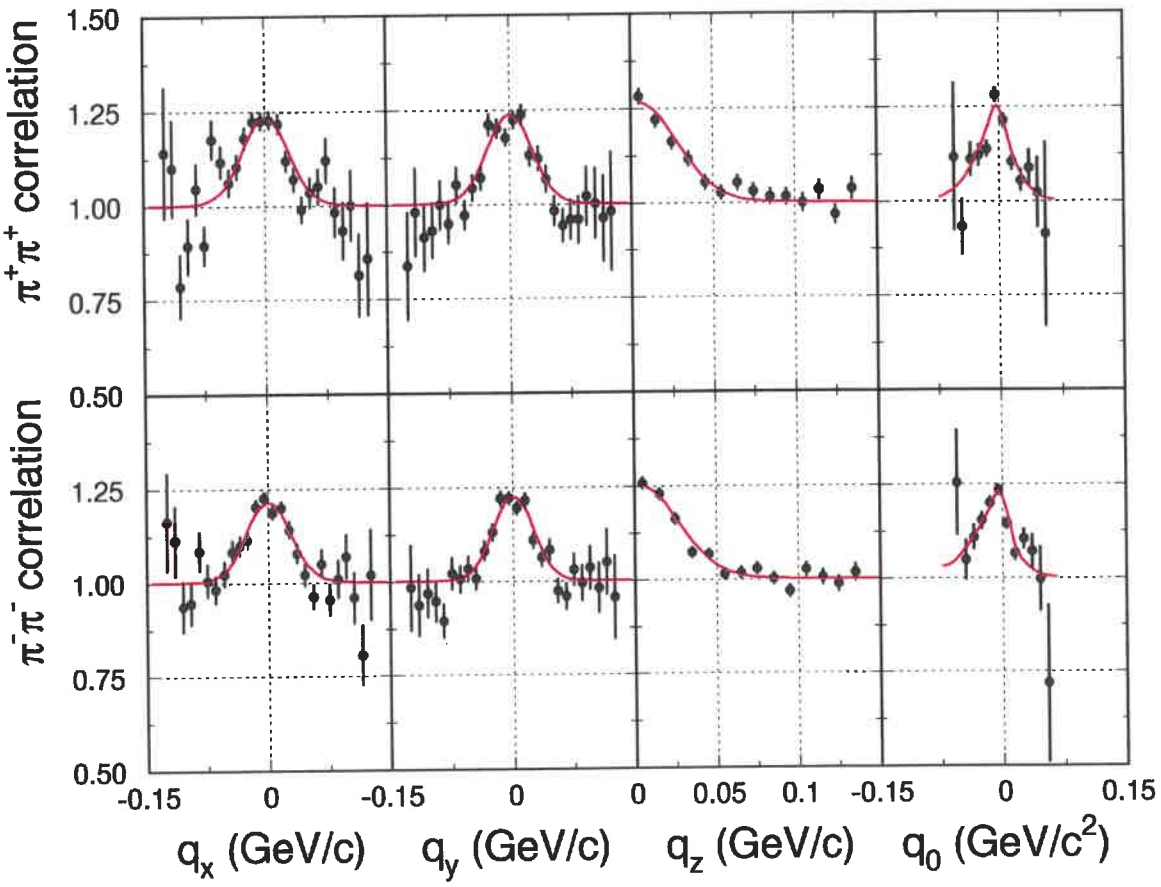
0.08
0.06
0.04
0.02
0
$|q_0|$ (GeV/c)
0
0.02
0.04
0.06
0.08
0.1
q (GeV/c)
0.1
0.05
0
-0.05
-0.1
q_0 (GeV/c)
-0.1
-0.05
0
0.05
0.1
q_z (GeV/c)

Moving Gaussian source analysis



Fit function:

$$C(q_x, q_y, q_z, q_0) =$$
$$1 + \lambda \exp(-R_x{}^2 q_x'^2 - R_y{}^2 q_y'^2 - R_z{}^2 q_z'^2 - \tau^2 q_0'^2),$$

where (q_x', q_y', q_z', q_0') are (q_x, q_y, q_z, q_0) boosted by $(\beta_x, 0, \beta_z)$.

Fit results:

	λ	R_x	R_y	R_z	τ	β_x	$y(\beta_z)$
π^+	0.52(4)	4.6(5)	4.8(4)	5.3(4)	3.2(21)	-0.07(12)	2.9(1)
π^-	0.50(3)	4.9(4)	5.5(4)	5.3(4)	0.0(15)	-0.10(9)	2.5(1)

Summary:

- Two-pion correlation functions reproduced by RQMD+SUBATECH
- Gamov correction is wrong
- Average pion phase-space density consistent with thermal
- Pion longitudinal source velocity y=2.5-2.9

Outlook:

- Out-side-long analysis with cuts on (pt,y,ψ)
- Moving-Gauss analysis with cuts on (pt,y,ψ)
- Centrality dependence