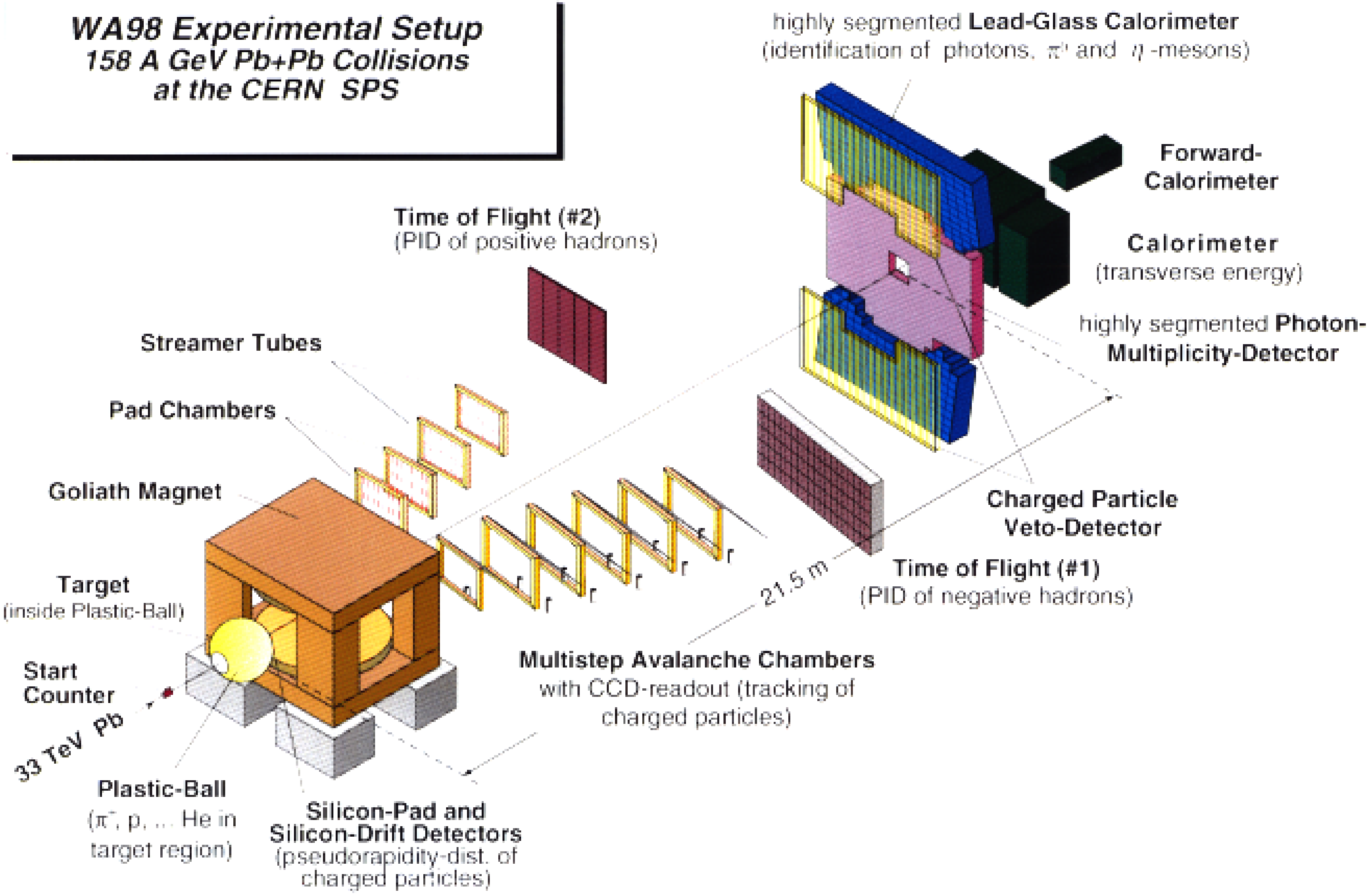
One-, Two- and Three-Particle Distributions from Central Pb+Pb Collisions at 158A GeV/c

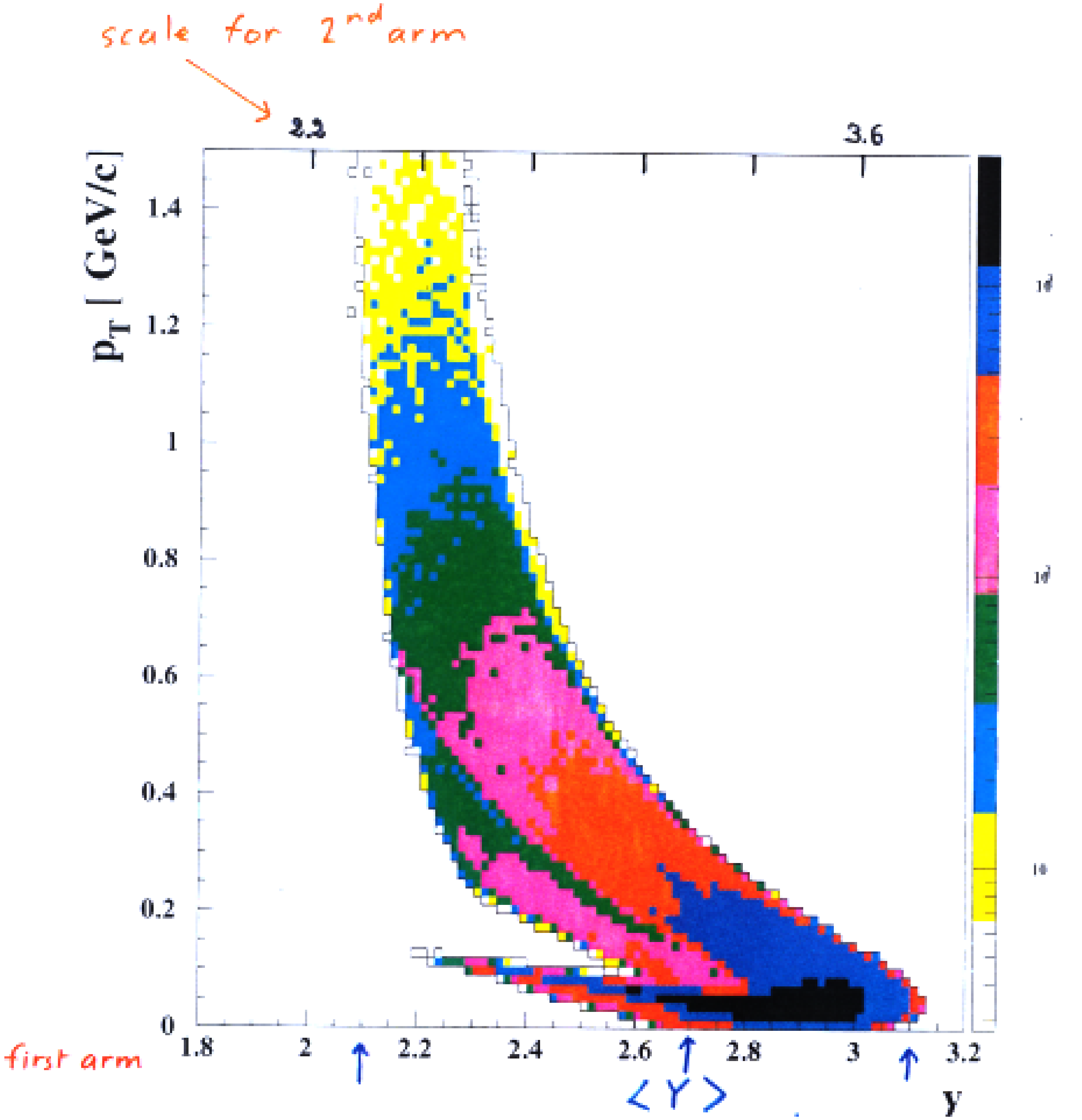
Laurent Rosselet for the WA98 Collaboration

WA98 Experimental Setup
158 A GeV Pb+Pb Collisions at the CERN SPS



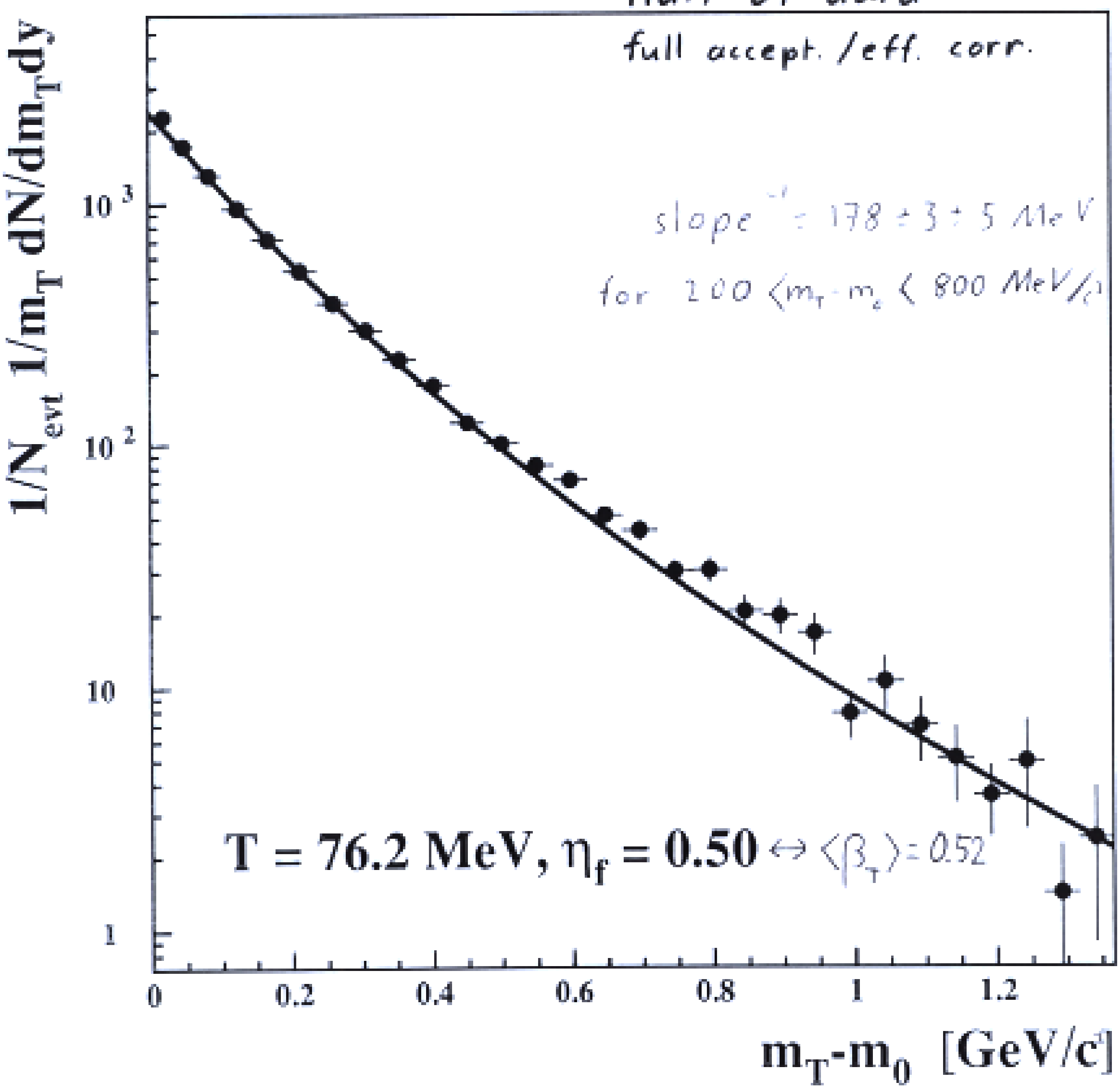
p_T - rapidity acceptance for π

identified by T. o. F. (resol. 120ps and 90ps.



π^- central triggers firstarm

half of data



fit from a hydrodynamical model

U. A. Wiedemann and U. Heinz, Phys. Rev C56, 3265 (1997)

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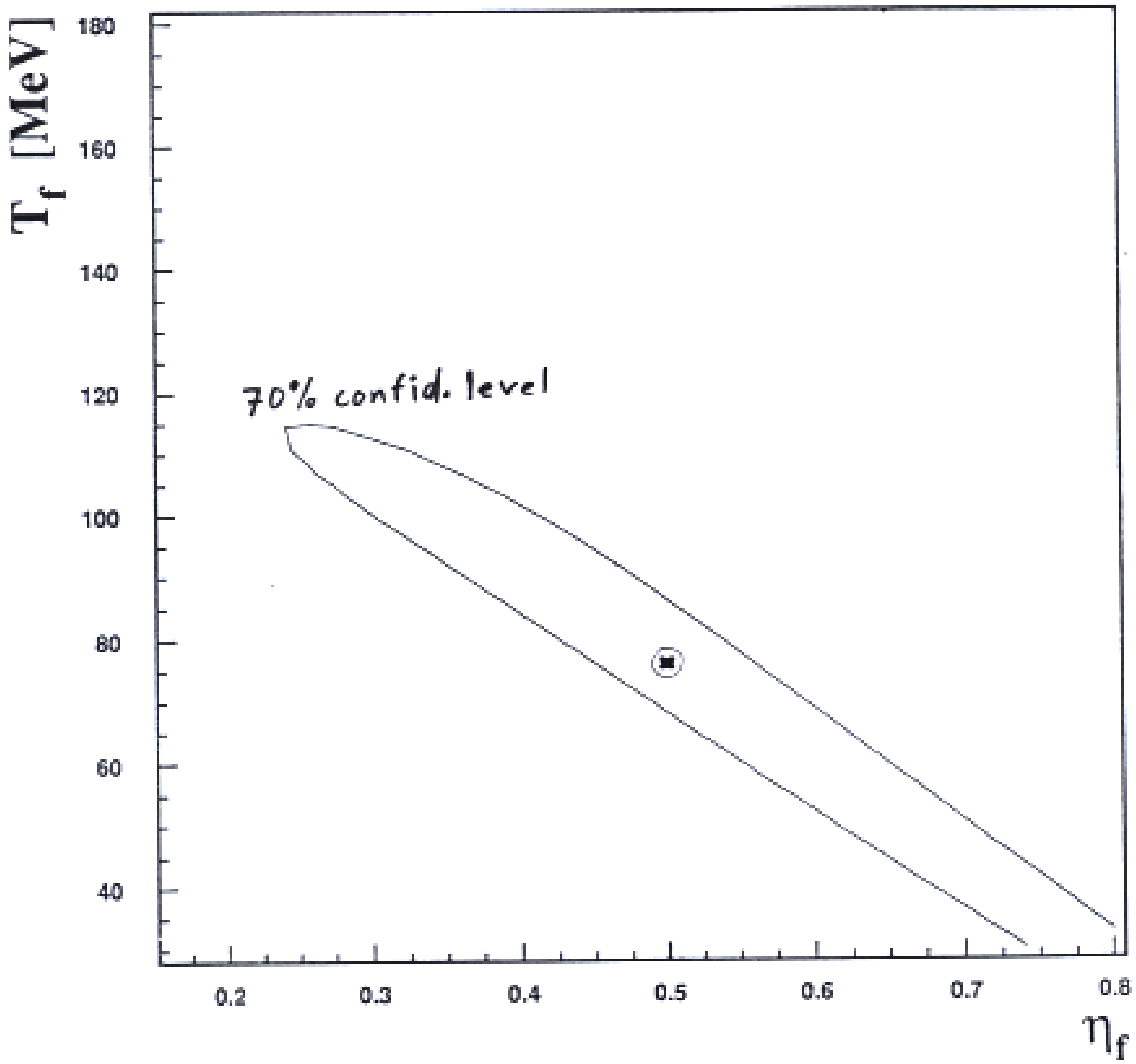
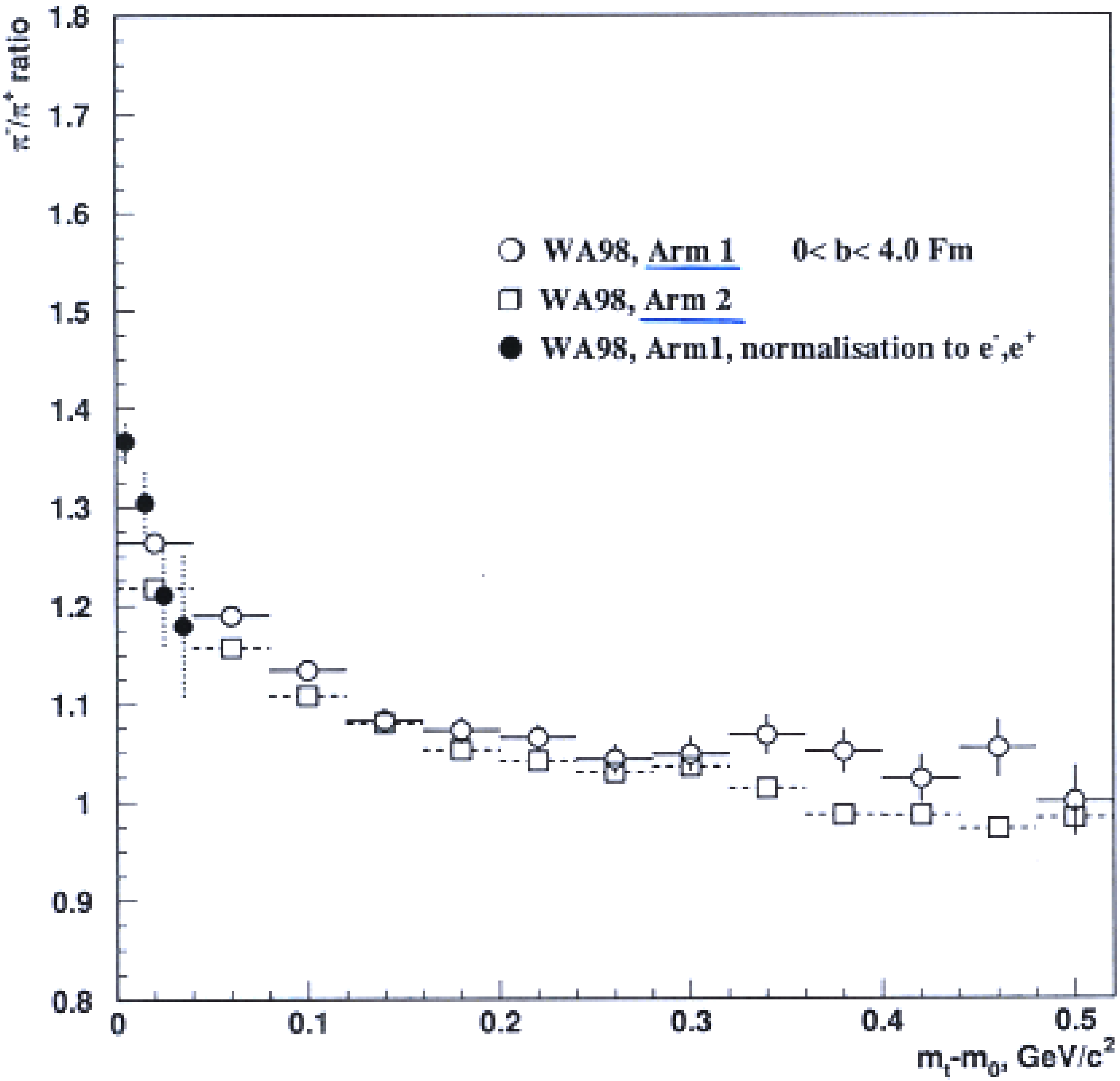


Similar m_T distribution for π^- and π^+...

...extraction of T_f is delicate

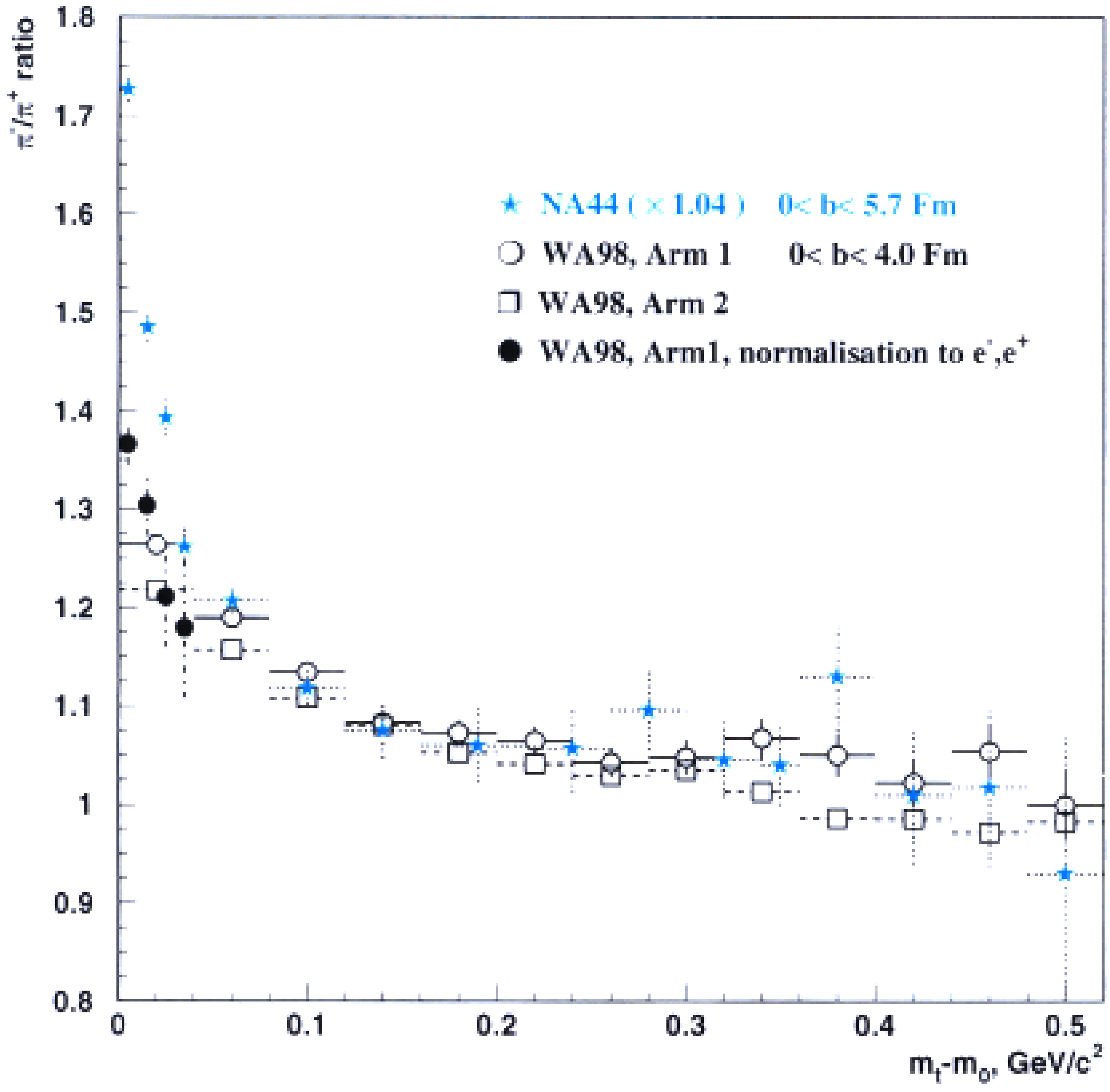
π^- / π^+ ratio:



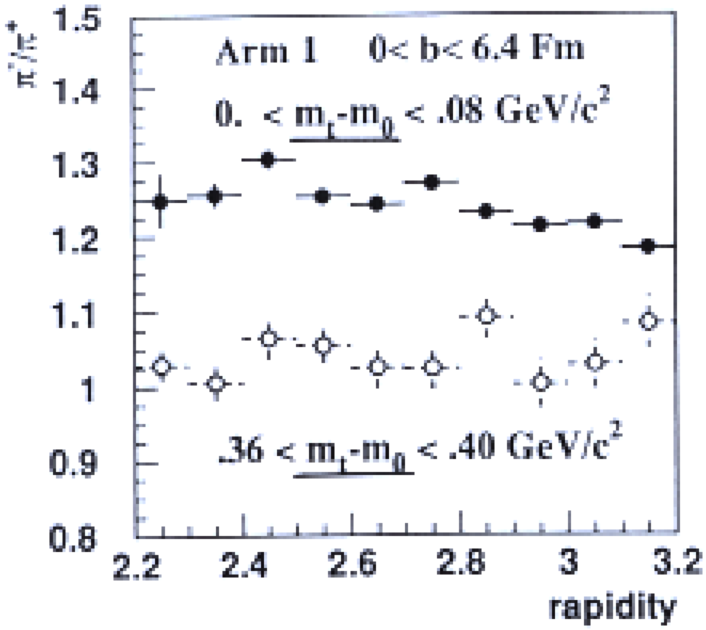
each arm is treated as a separate exp.

using normal and reverse field ...

excess at small m_t

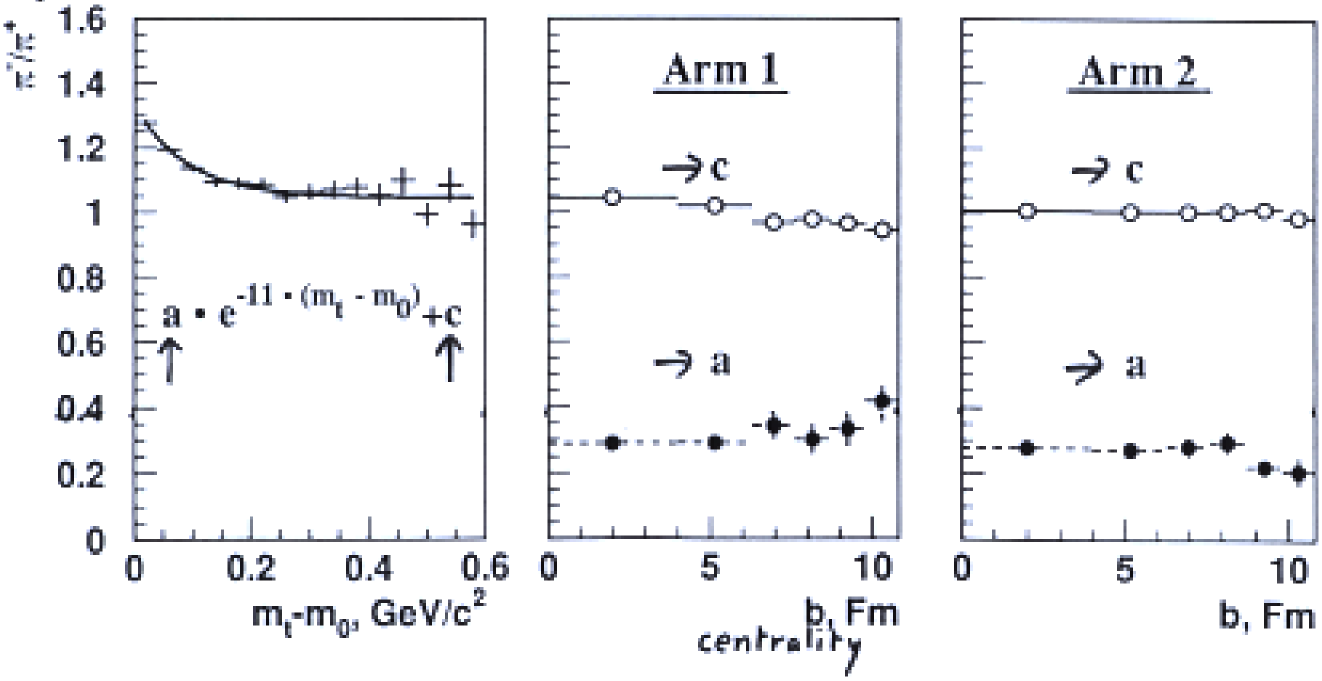


excess smaller than measured by NA44



⇒ ratio cte within acceptance range

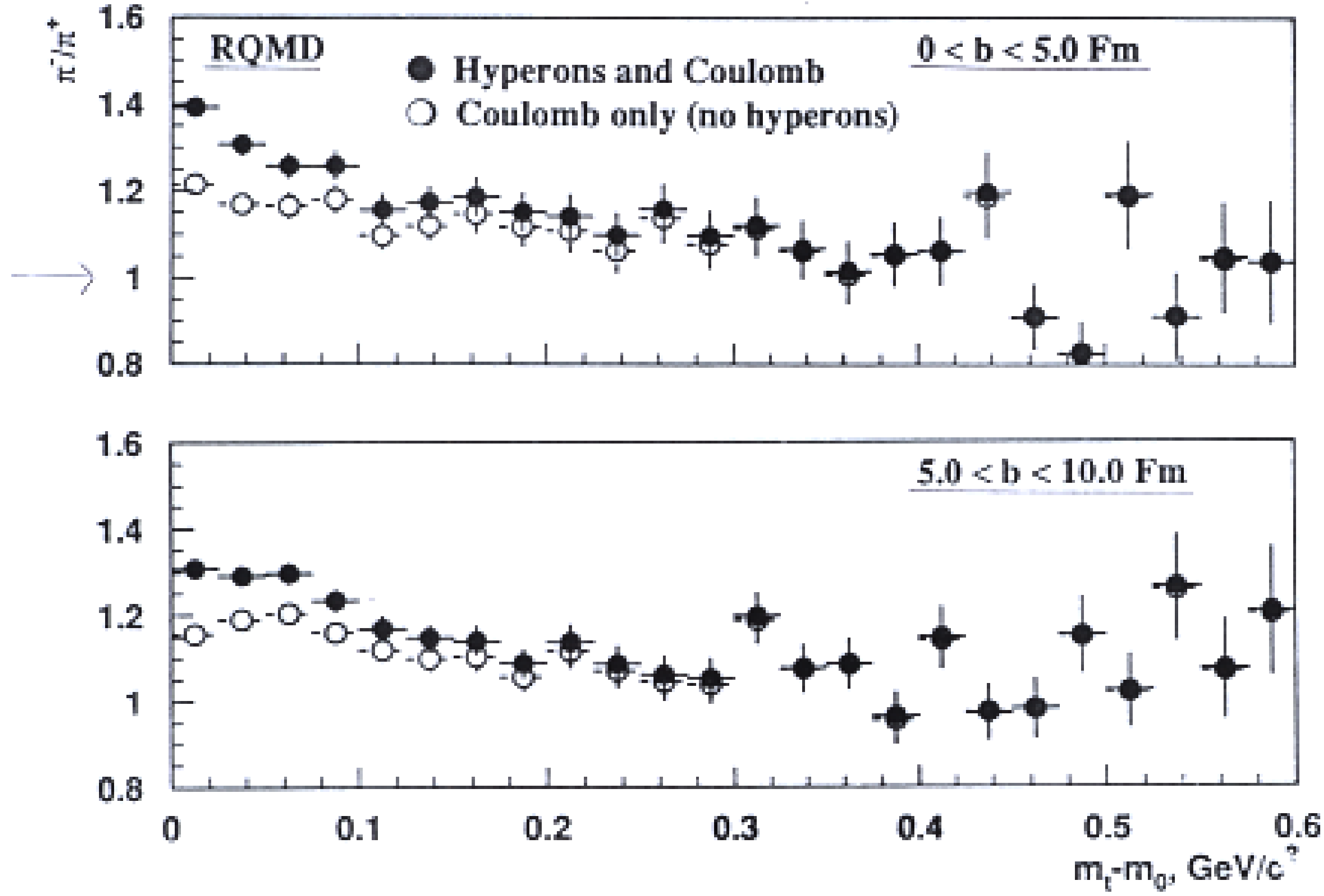
fit to



⇒ ratio cte for b < 10 fm

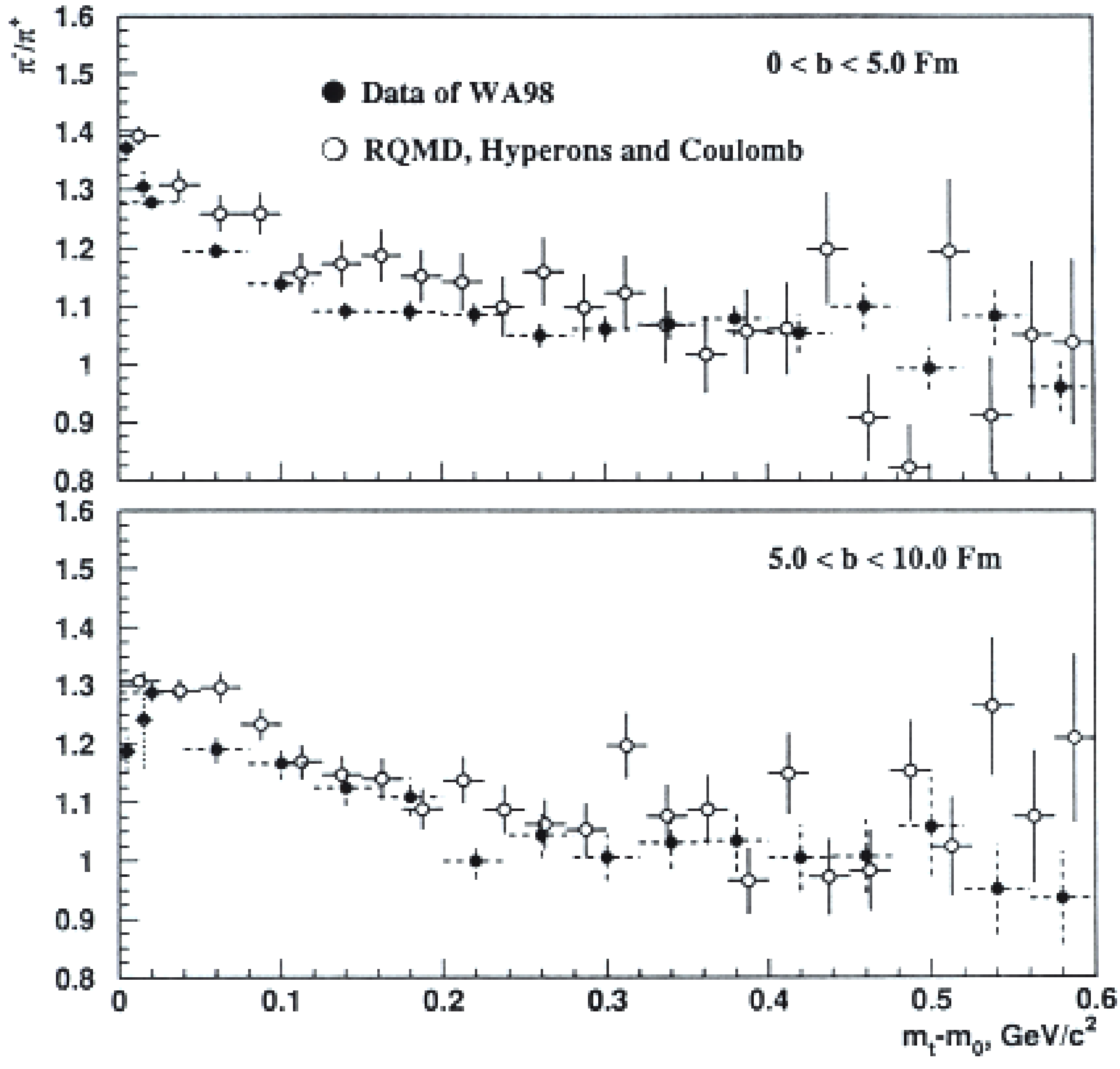
no data for b > 10 fm

Monte-Carlo study



∴ half effect Coulomb

half effect hyp. decays

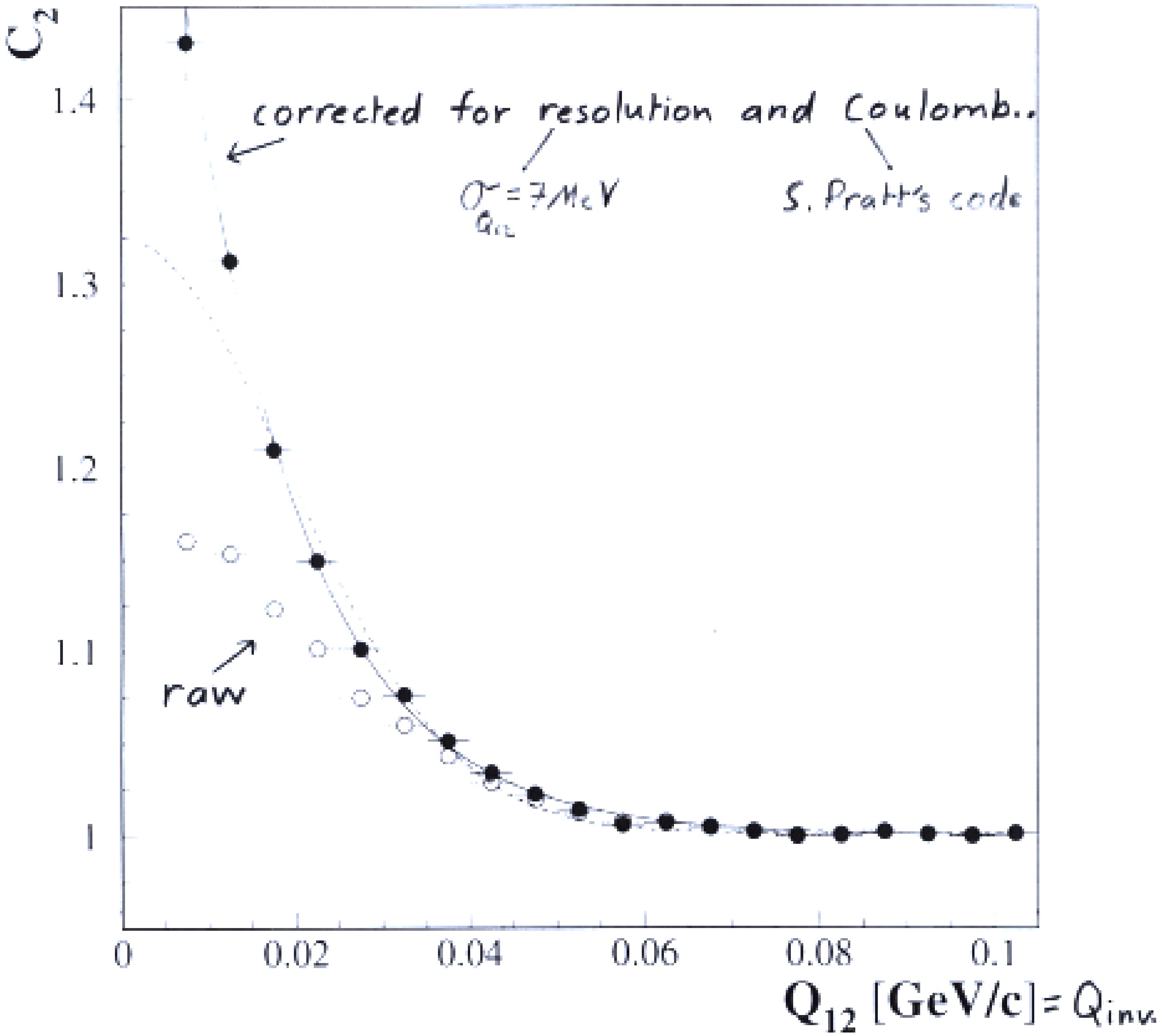

0 < b < 5.0 Fm
Data of WA98
RQMD, Hyperons and Coulomb
5.0 < b < 10.0 Fm
π⁻/π⁺
m_t-m_0, GeV/c²
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0
0.1
0.2
0.3
0.4
0.5
0.6

$\pi^- \pi^-$ correlation

Central triggers: 10% of min. bias cross section

13.7×10^6 pairs

full data set...

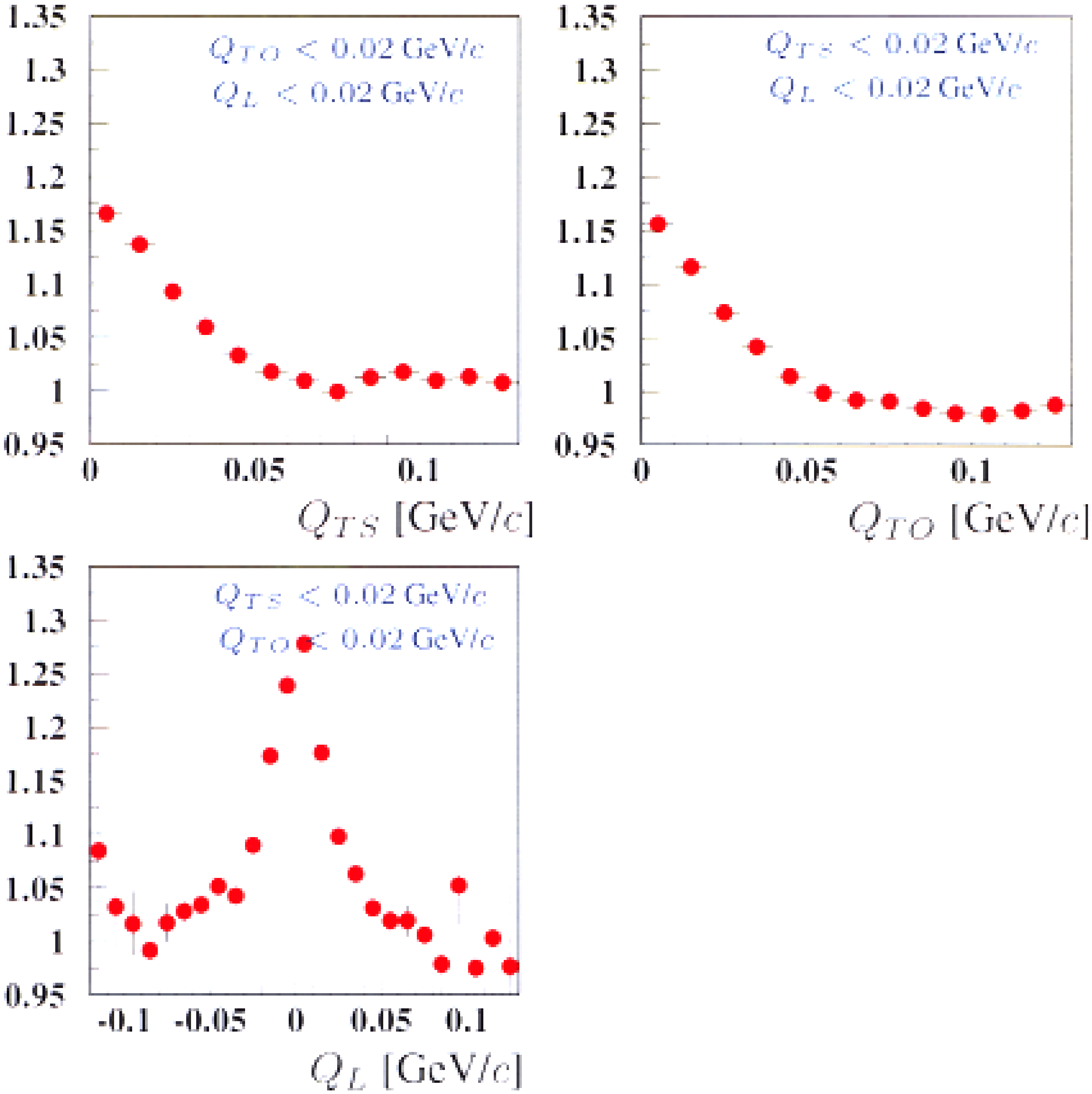


Clearly exponential $C_2 = 1 + \lambda e^{-2 Q_{12} \cdot R}$ with $R = 7.33 \pm 0.08$ fm

$\lambda = 0.785 \pm 0.009$

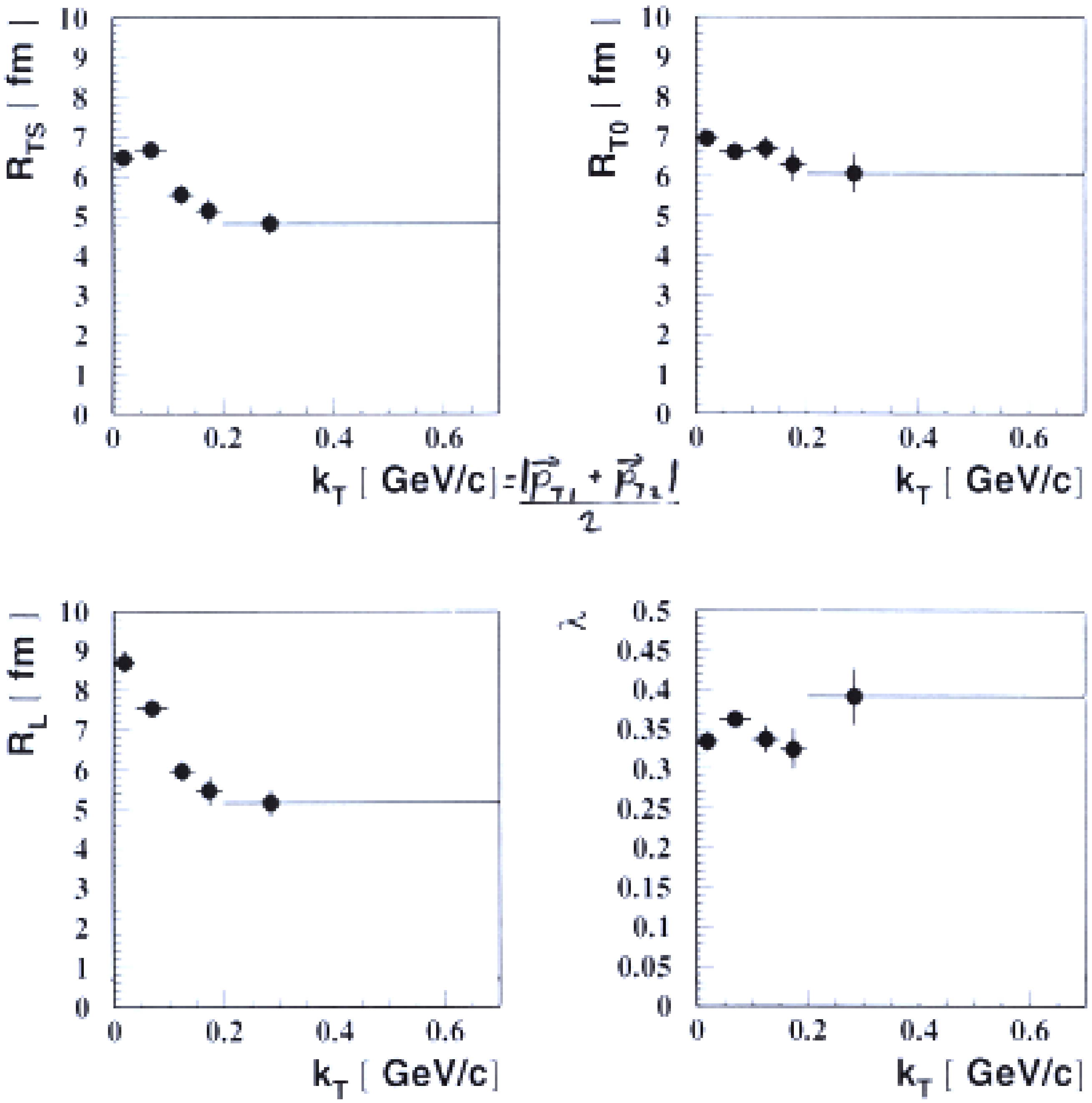
...

Slice distributions for the Q_{TS}, Q_{TO} and Q_L variables



Pratt-Bertsch parameterization in the LCMS

fit includes cross-term

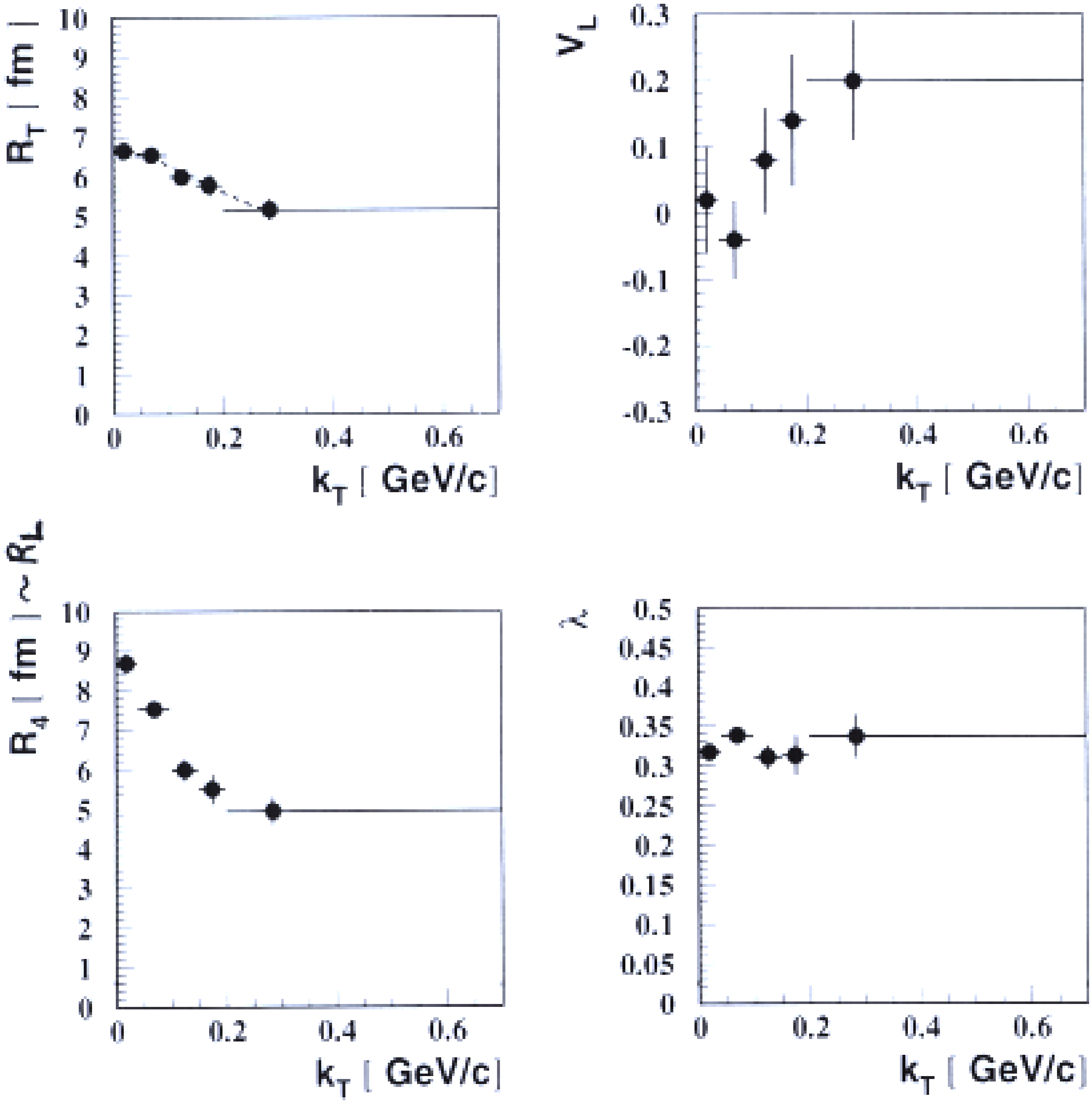


... transverse flow < longitudinal flow

Yano-Koonin parameterization

connects Y-K frame to LCMS ...

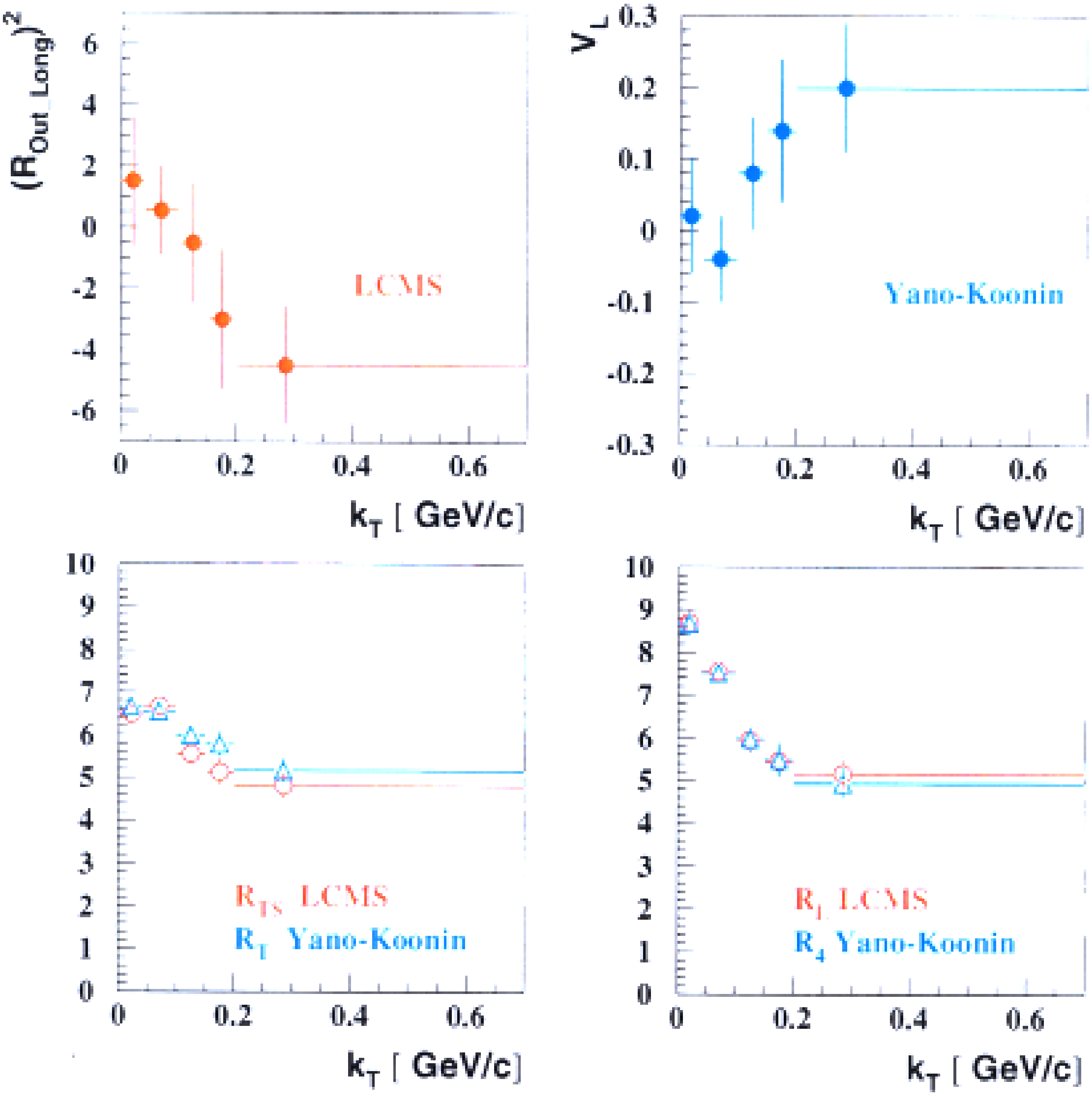
$\Rightarrow$ not fully boost invar.



... $R_o \sim \Delta\tau \sim 0$ at all k_T

duration of emission

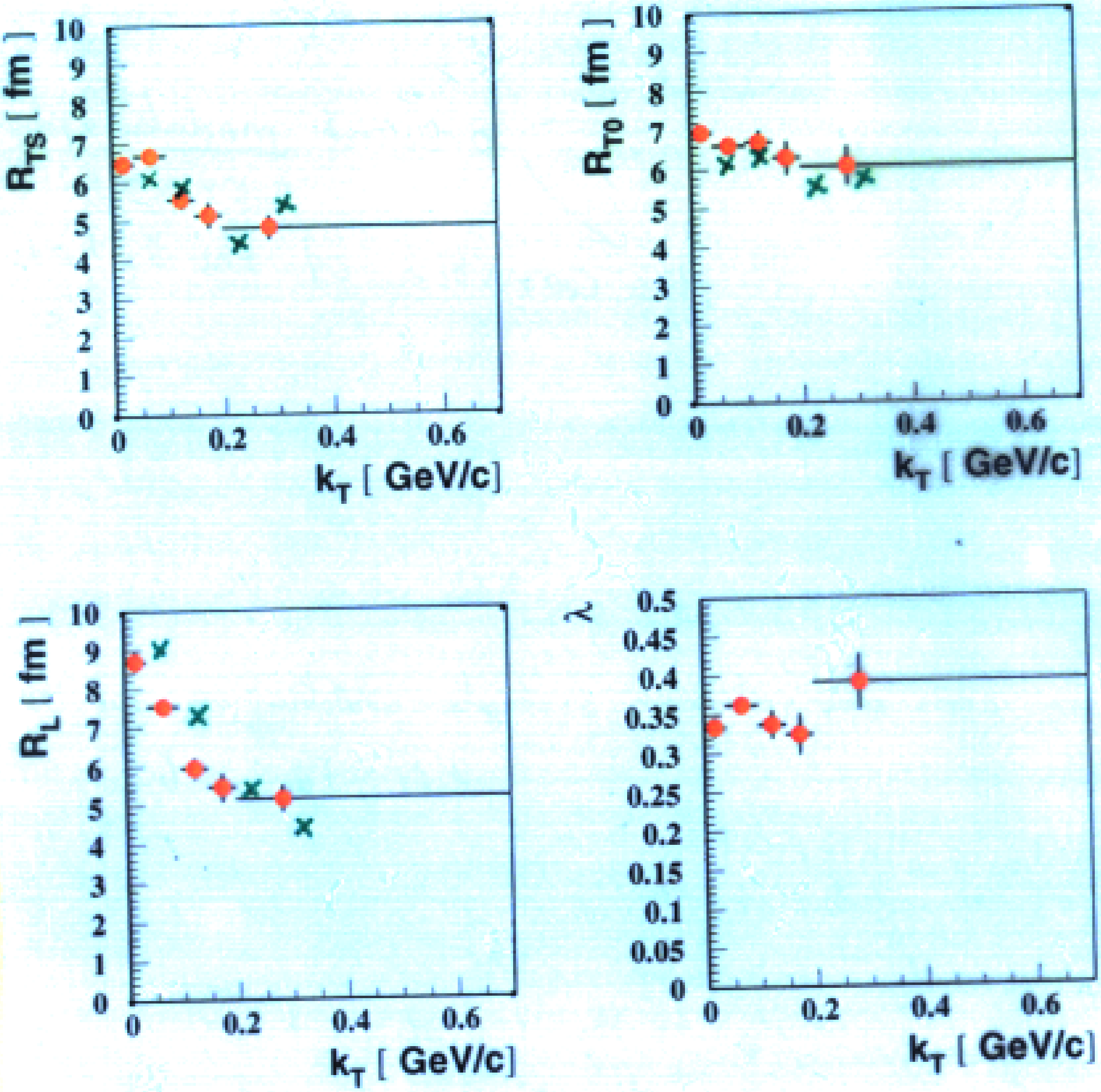
Comparison Pratt-Bertsch and Yano-Koonin param.

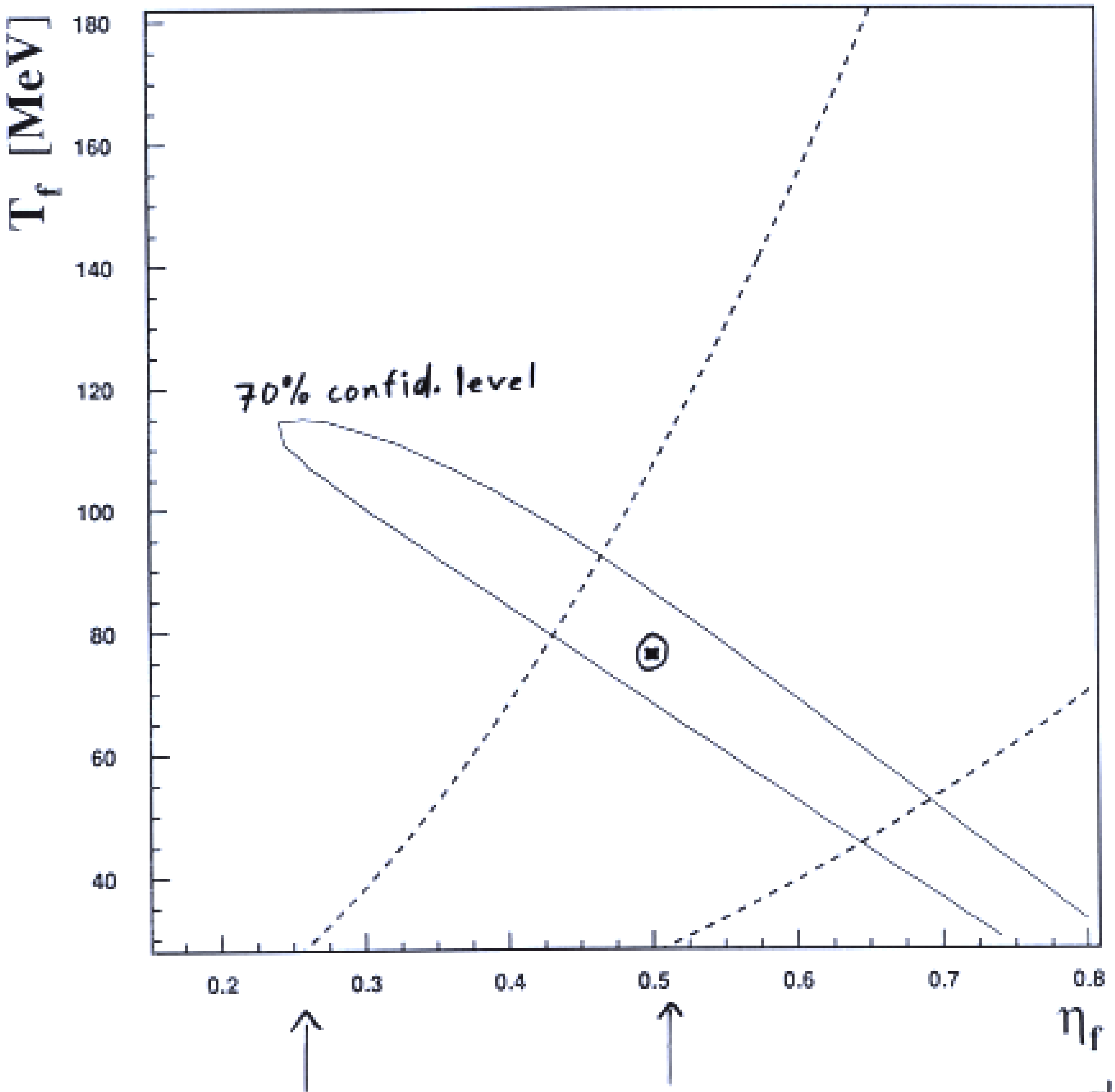


good agreement

WA98 $\pi^- \pi^-$ with $\langle y_{\pi^-\pi^-} \rangle = 2.70$

NA49 $h^- h^-$ with $\langle y_{h^-h^-} \rangle = 3.2$





±1 σ HBT constraint from fit $R_T = R_G \left[1 + m_T \cdot \frac{\eta_f^2}{T_f}\right]^{-1/2}$

<u>from WA98</u> – same data

with $m_T = \sqrt{m_\pi^2 + k_T^2}$

. . .

3 identical boson correlation:

if source fully chaotic: $C_2 = 1 + |F_{12}|^2$

$$C_3 = 1 + |F_{12}|^2 + |F_{23}|^2 + |F_{31}|^2 + 2\,\mathrm{Re}\{F_{12}F_{23}F_{31}\}$$

genuine 3-body correlatio

with $F_{ij} \equiv |F_{ij}|e^{i\phi_{ij}}$: $2|F_{12}||F_{23}||F_{31}| \cdot W$

and $W = \cos(\phi_{12} + \phi_{23} + \phi_{31})$

$|W| < 1$ $\quad < 2|F_{12}||F_{23}||F_{31}|$

with $Q_3^2 \equiv Q_{12}^2 + Q_{23}^2 + Q_{31}^2$: $2\lambda^{3/2} e^{-R^2 Q_3^2/2}$ or $2\lambda^{3/2} e^{-R(Q_{12}+Q_{23}+Q_{31})}$

Gaussian C_2 — expon. C_2

R obtained by $C_2 \Rightarrow$ access to the phase W of F.T. of source function
{. asymmetry of the source
if $W=1 \leftrightarrow$ F.T. real $\leftrightarrow$ symmetrical

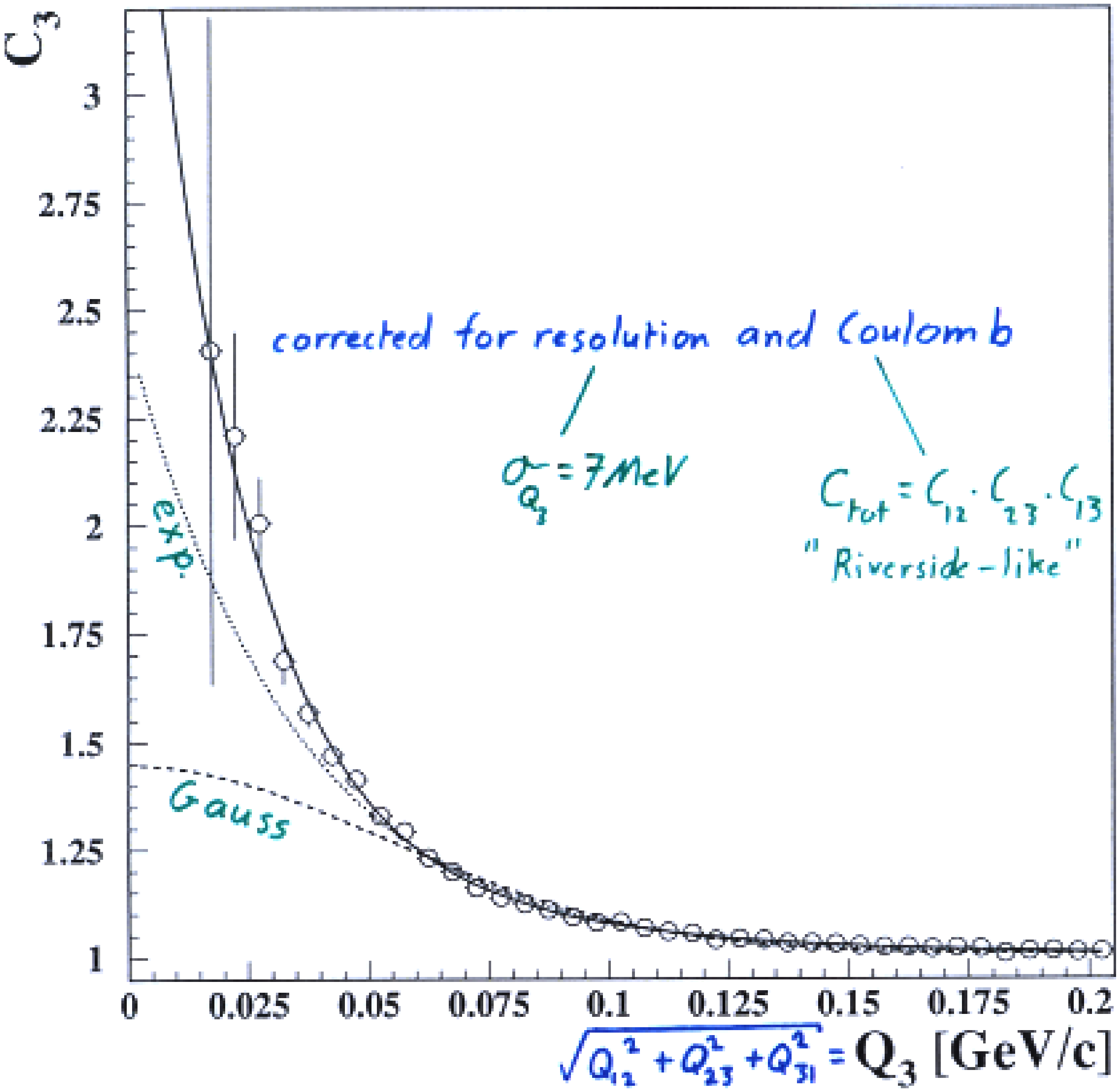
...

If source not fully chaotic, . W is the strength of true 3-body corre

if $W \neq 1 \longleftrightarrow$ coherency

$\pi^- \pi^- \pi^-$ correlation

central triggers
8.2×10^6 triplets

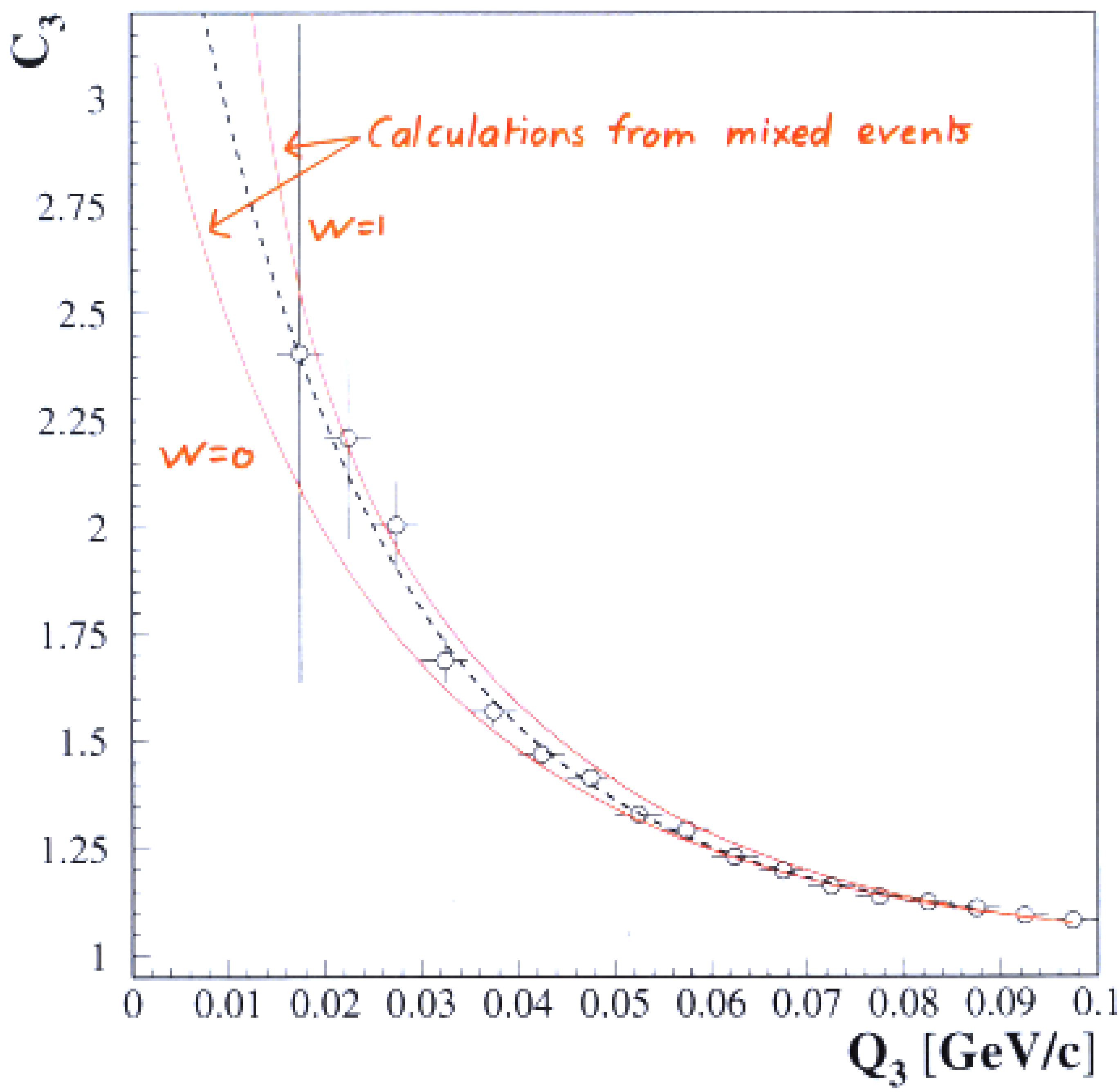


$$C_3 = 1 + \lambda_1 \exp[-2 Q_3 R_1] + \lambda_2 \exp[-2 Q_3 R_2]$$

$R_1 = 5.01 \pm 0.38$ $R_2 = 1.72 \pm 0.12$

$\lambda_1 = 2.79 \pm 0.32$ $\lambda_2 = 0.343 \pm 0.072$

$\chi^2/\text{d.o.f.} = 0.88$ intercept at $Q_3 = 0$: 4.13 ± 0.37 < 6


C3
Calculations from mixed events
w=1
w=0
Q3 [GeV/c]
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
1 1.25 1.5 1.75 2 2.25 2.5 2.75 3

$$W = \frac{(C_3(Q_3)-1) - (C_2(Q_{12})-1) - (C_2(Q_{23})-1) - (C_2(Q_{31})-1)}{2\sqrt{(C_2(Q_{12})-1)(C_2(Q_{23})-1)(C_2(Q_{31})-1)}}$$

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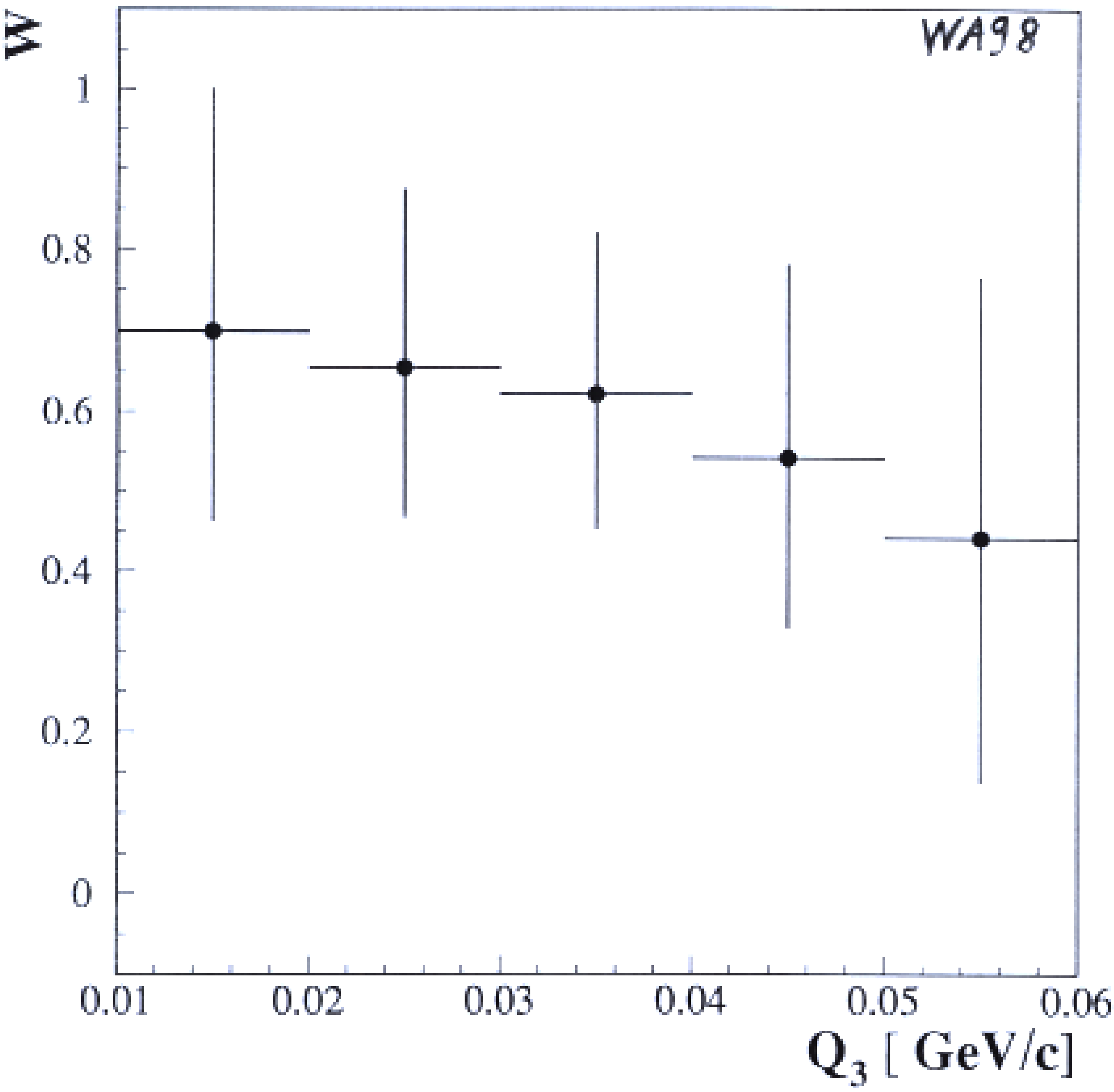
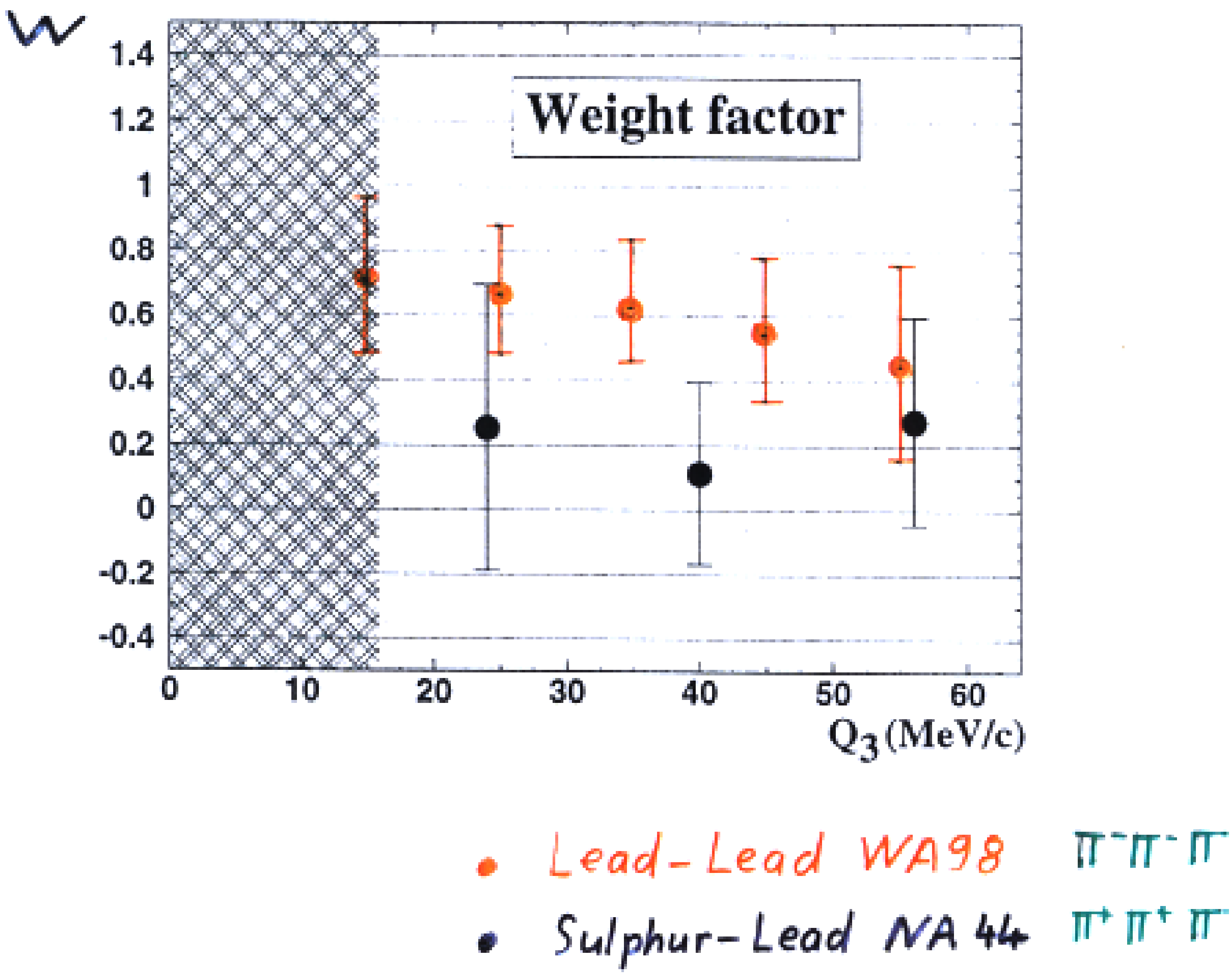


statistical + systematical errors

weighted mean $\langle w \rangle = 0.606 \pm 0.005 \pm 0.179$



W
Weight factor
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
10
20
30
40
50
60
Q_3 (MeV/c)
Lead-Lead WA98 $\pi^-\pi^-\pi^-$
Sulphur-Lead NA 44 $\pi^+\pi^+\pi^-$

Summary:

π^- : hydrodynamical model on single distrib. (W.-H.)
favor low T and high transverse flow

π^-/π^+: enhancement at small m_T

indep. of Y between 2.2 and 3.2

~ indep. of centrality for $b < 10$ fm

~ equal contribution from Coulomb and hyp. decays

$\pi^-\pi^-$: 2 analysis of the full data as a f. of K_T

- duration of emission short ↔ no long-lived intermediate phase
- longitudinal expansion not strictly boost inv.
- " " > lateral expansion

$\pi^-\pi^-\pi^-$: substantial contribution of the genuine 3-pion correlation, for the first time in central Pb-Pb collisions

$\langle w \rangle = 0.606 \pm 0.005 \pm 0.179$

larger than in S-Pb from NA44

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