SEPARATION BETWEEN SOURCES OF PIONS AND PROTONS IN CENTRAL AU+AU AT AGS

(E877)

DARIUSZ MIŚKOWIEC, GSI

CRIS 98
CATANIA

OUTLINE

- EXPERIMENT
- DATA ANALYSIS
- CORRELATION FUNCTIONS
  ASYMMETRIC PEAK IN
  PION-PROTON CORRELATIONS

} OBSERVATION

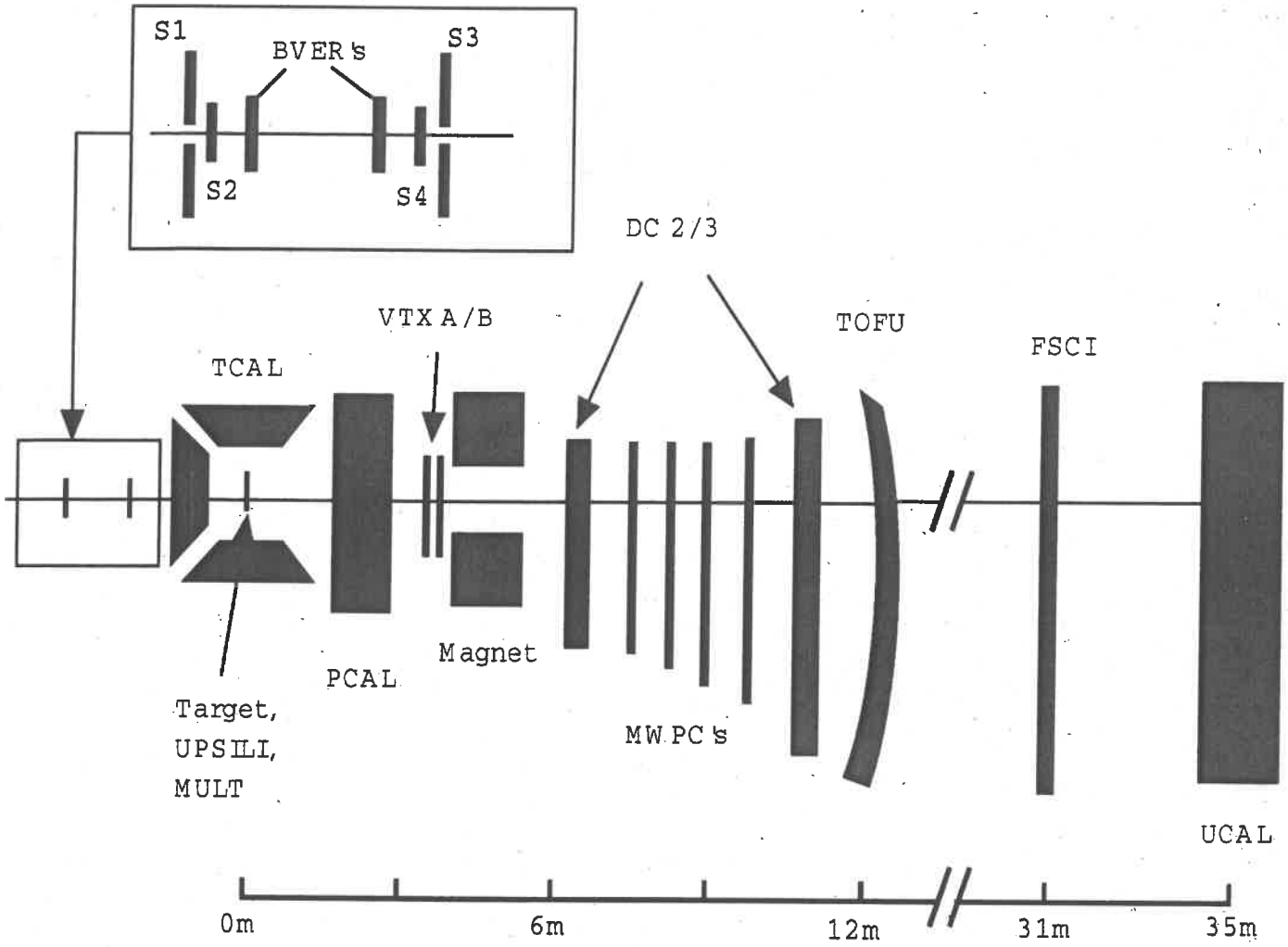
- CALCULATION
  SEPARATION NEEDED TO
  EXPLAIN ASYMMETRY

} INTERPRETATION

- ESTIMATION OF FREEZE-OUT
  TIME AND SIZE

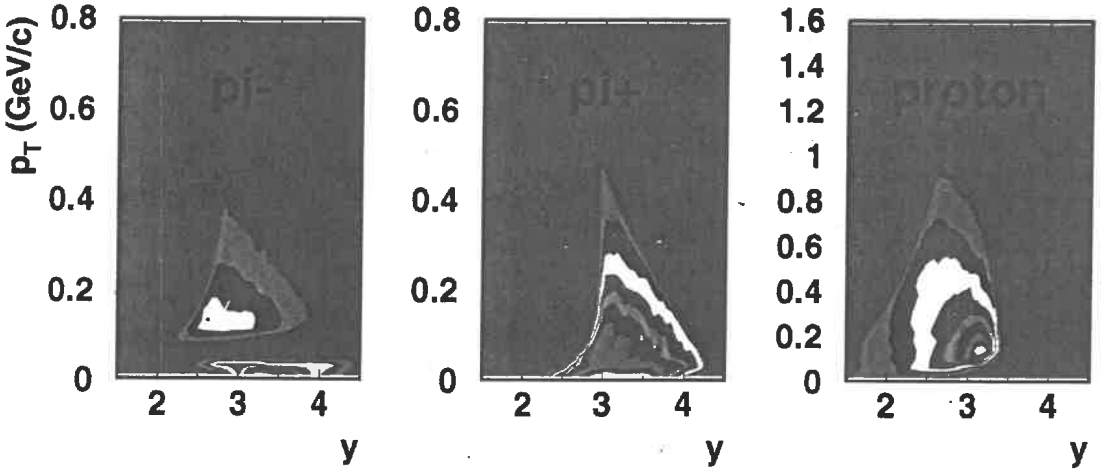
} SPECULATION

E877 setup at the AGS

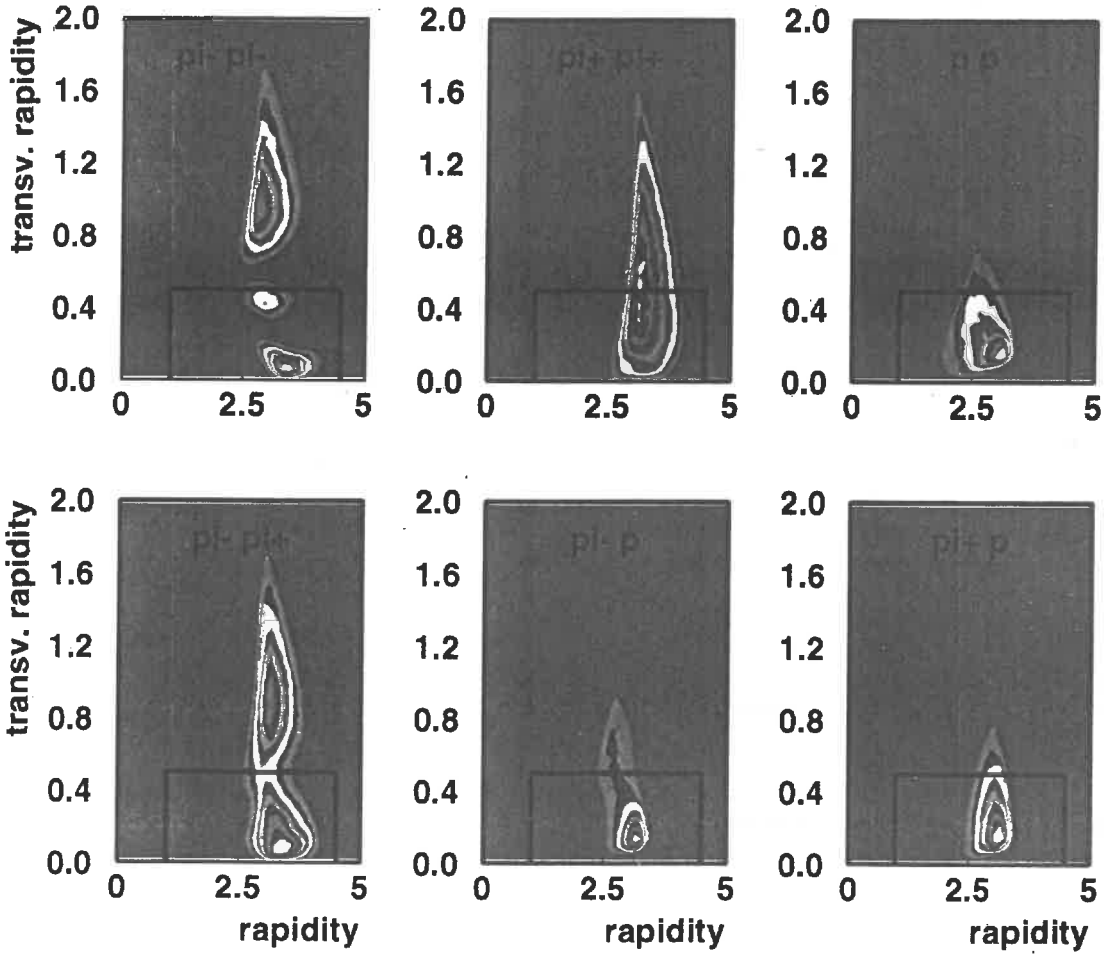


1994 E877 run:
5 million central Au+Au collisions
at 11 GeV/nucleon

Analyzed particles



Analyzed pairs



RAPIDITY := $\frac{1}{2}$ LOG$\left(\frac{E+P_z}{E-P_z}\right)$

TRANSV. RAPIDITY := $\frac{1}{2}$ LOG$\left(\frac{E^*+P_\perp}{E^*-P_\perp}\right)$, $E^* := \sqrt{E^2-P_z^2}$

CORRELATION FUNCTION

$$C(\vec{p}_1, \vec{p}_2) := \frac{\frac{d^2N}{d\vec{p}_1\, d\vec{p}_2}}{\frac{dN}{d\vec{p}_1} \cdot \frac{dN}{d\vec{p}_2}}$$

EMISSION FUNCTION

$$S(\vec{x}, t, \vec{p}) := \frac{dN}{d\vec{x} \cdot dt \cdot d\vec{p}}$$

$$C \longleftarrow S$$

DATA ANALYSIS

1. SELECT GOOD EVENTS
2. SELECT GOOD TRACKS
3. COMBINE IN PAIRS
4. SELECT GOOD PAIRS

↓

SIGNAL

5. SAME WITH EVENT MIXING, (MIX ONLY EVENTS WITH SAME CENTRALITY AND ϕ)

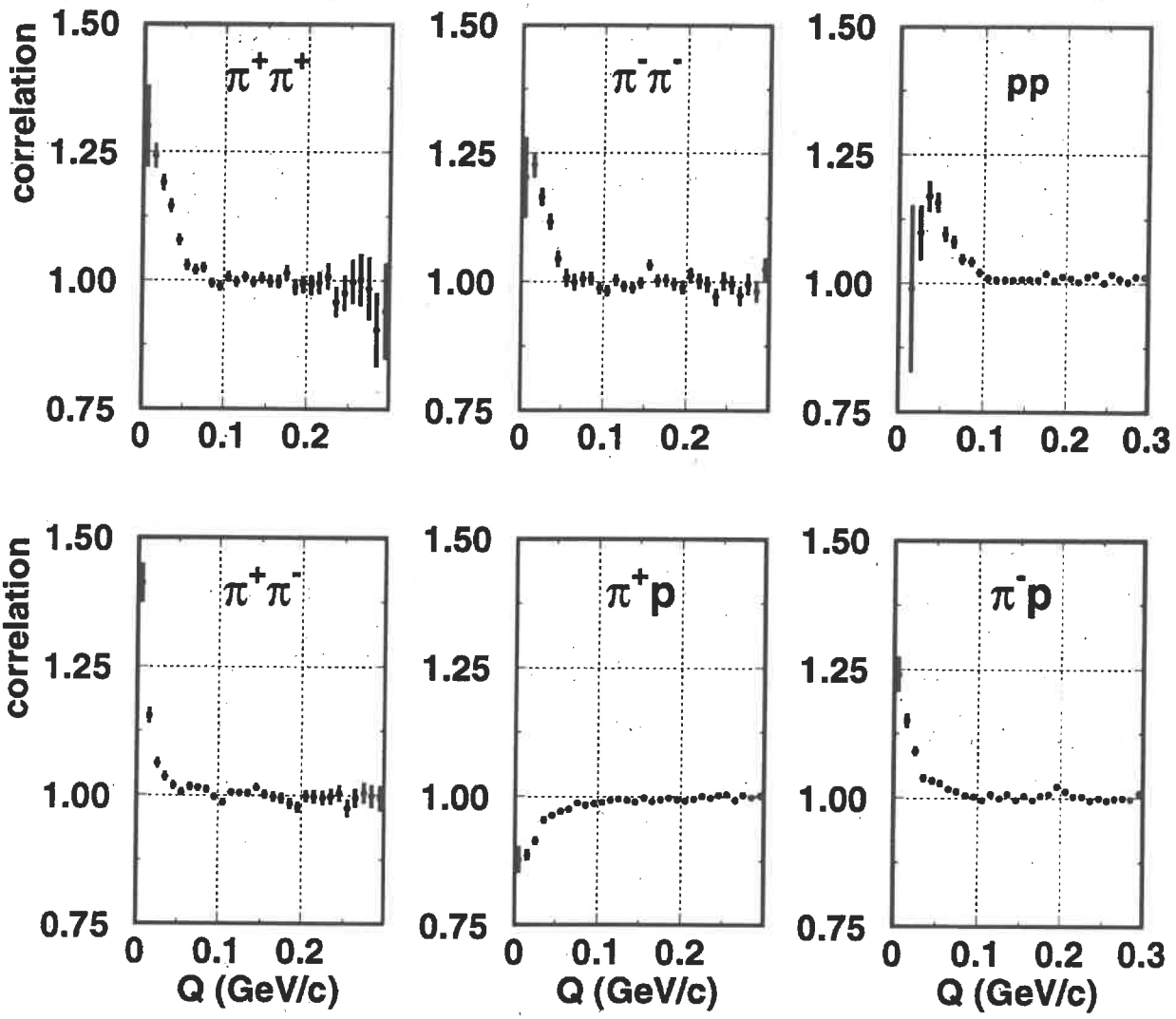
↓

BACKGROUND

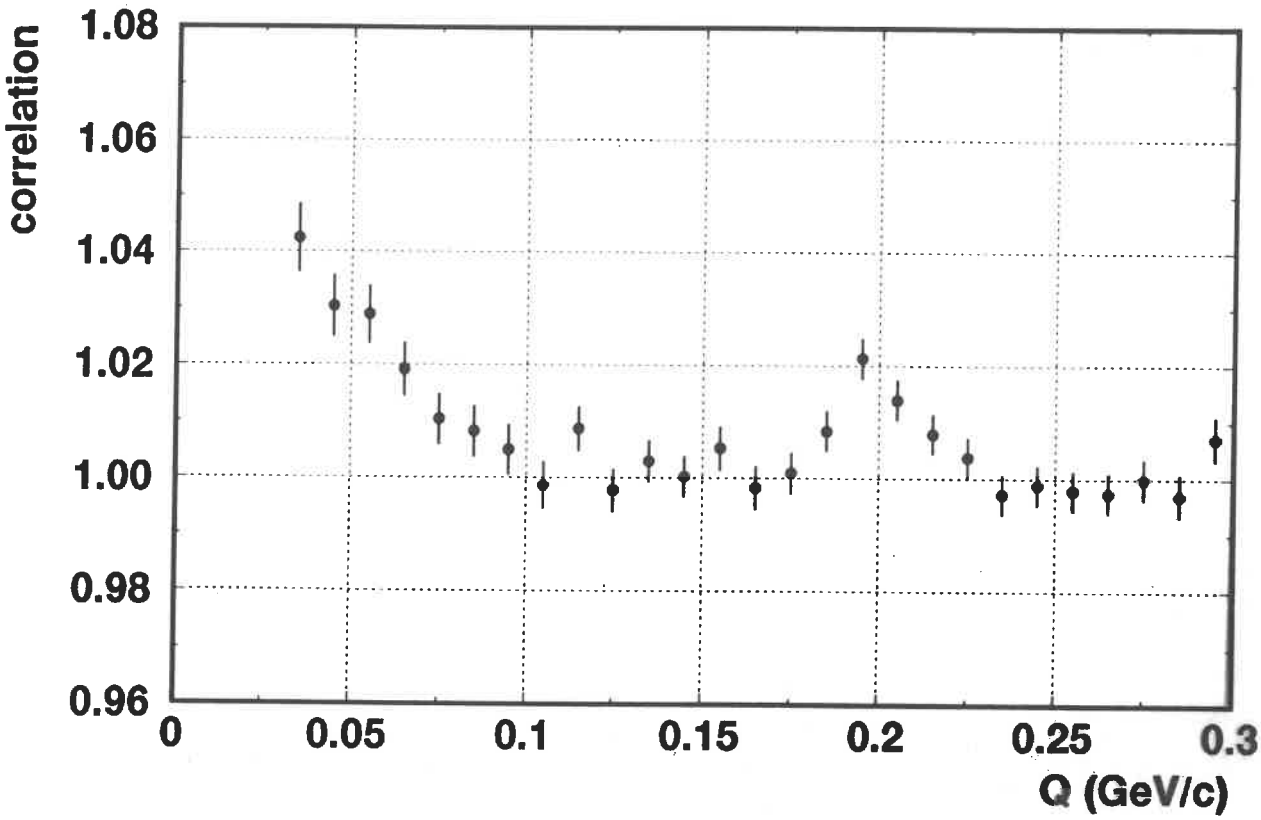
6. NORMALIZE: FLAT PART = 1.0
7. DIVIDE SIGNAL/BACKGROUND → C

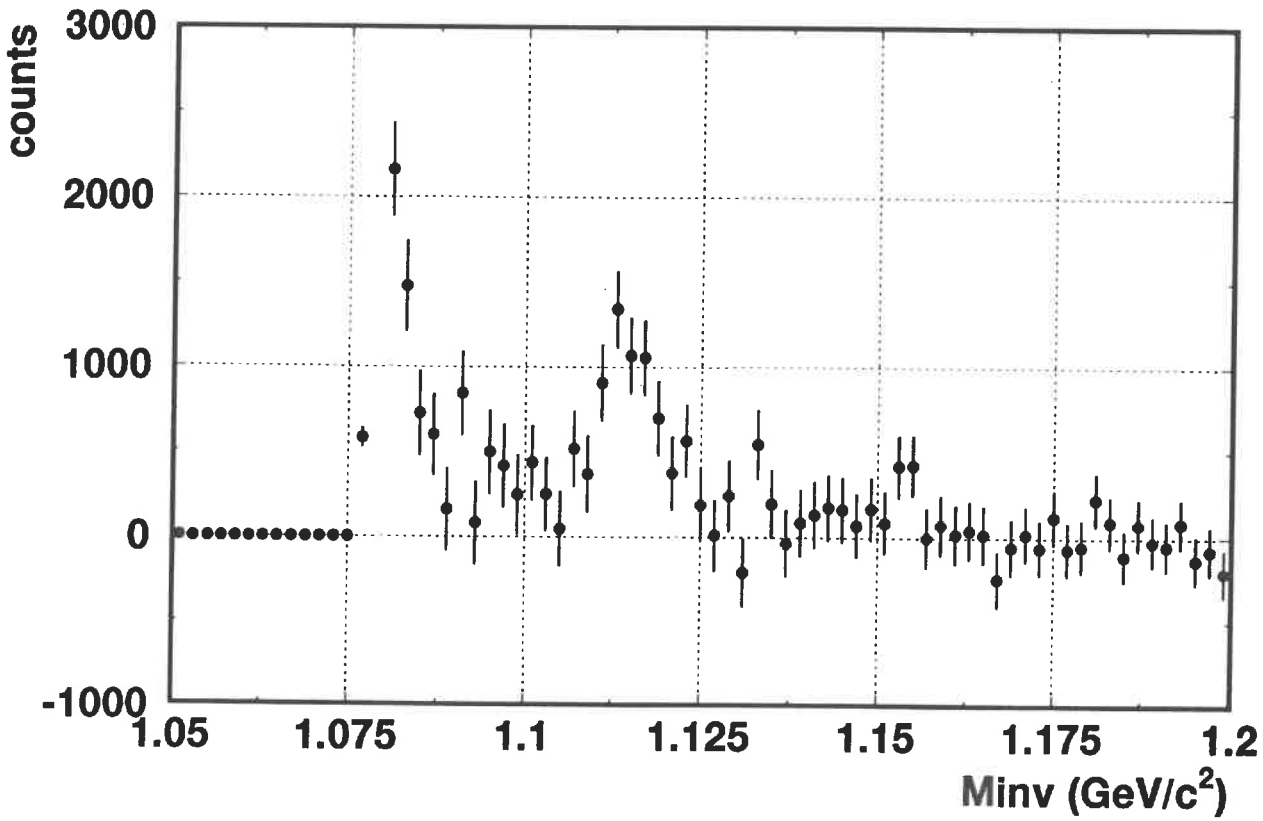
SPECIAL:
- PAIR C.M.S.
- X, Y, Z INSTEAD OF OUT, SIDE, LO
- NO COULOMB CORR. ETC.

One-dimensional correlation functions

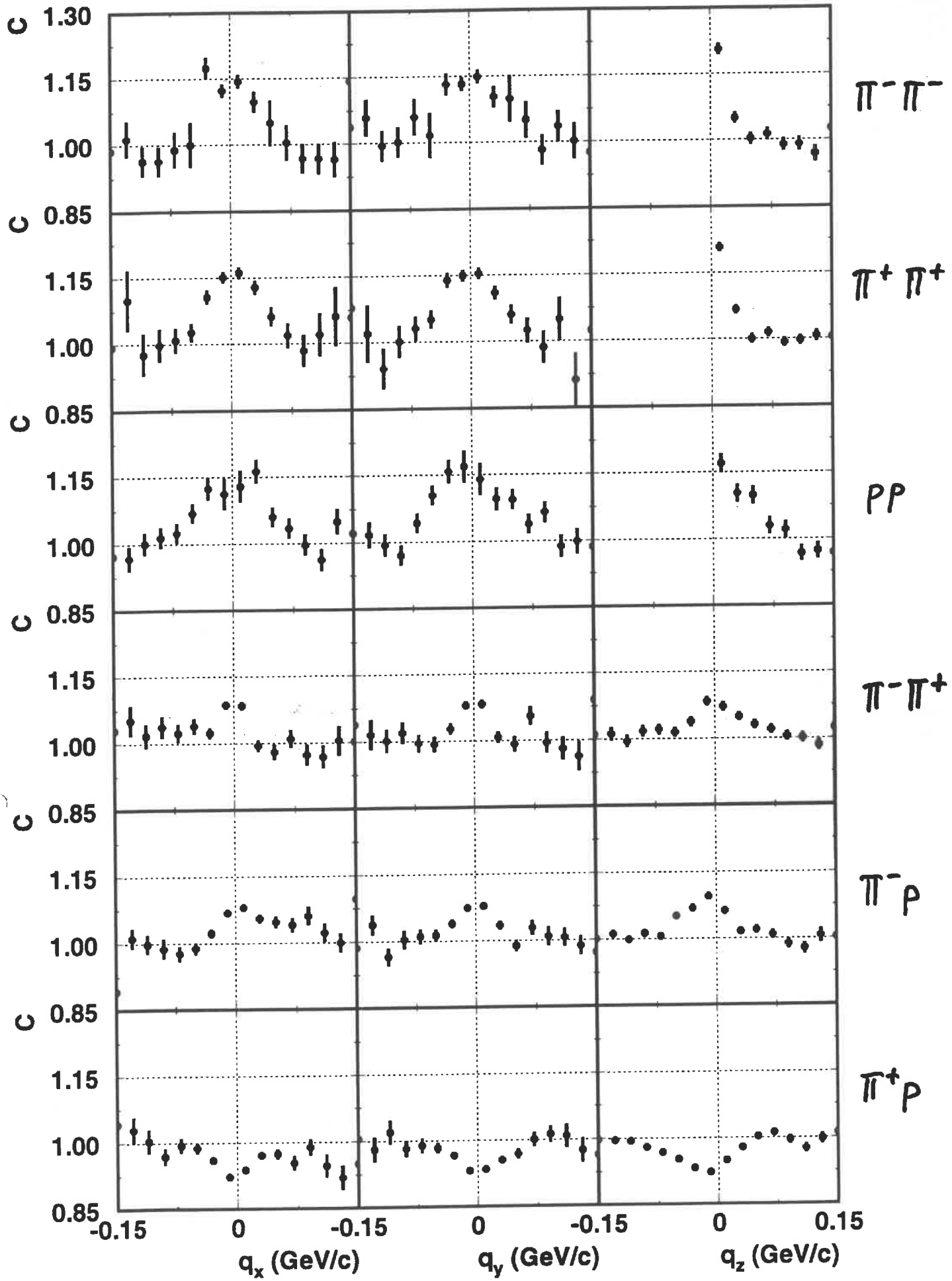


Lambda peak in π^--proton correlation





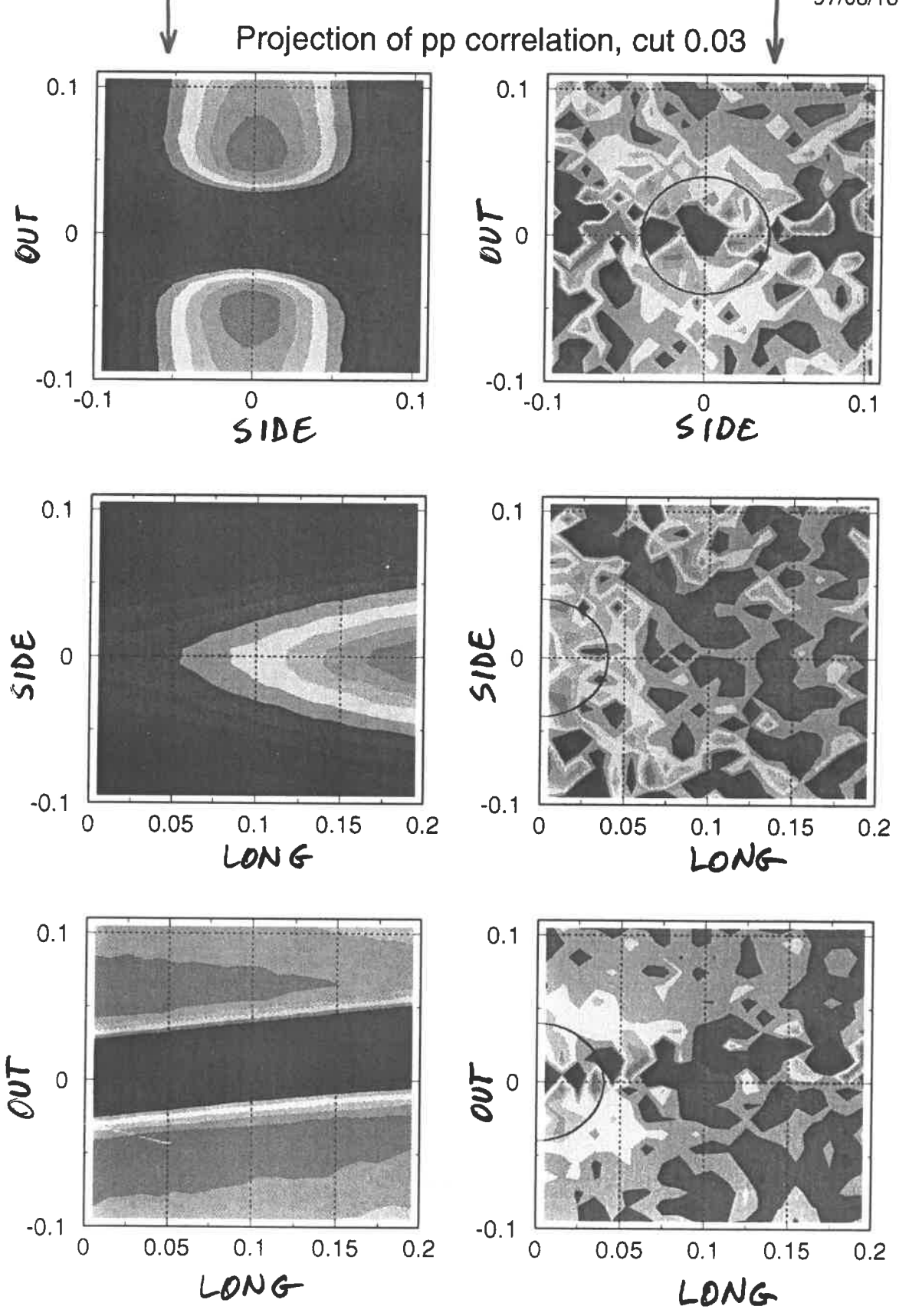
3-DIM CORRELATION FUNCTIONS



PAIR DISTRIBUTION

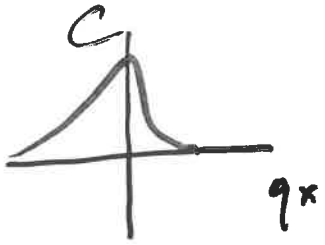
CORRELATION

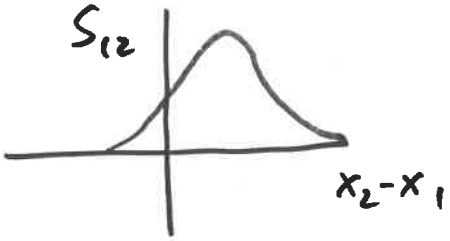
97/08/18 17.27

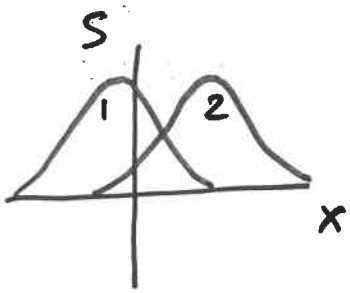


AXIS: Q IN GeV/c

LEDNICKY ET AL.:







SIMPLE EXPLANATION:

$q_x < 0$	$p_2 < p_1$	$x_1 \xrightarrow{p_1}$ $x_2 \xrightarrow{p_2}$	STRONG
$q_x > 0$	$p_1 < p_2$	$x_1 \xrightarrow{p_1}$ $x_2 \xrightarrow{p_2}$	WEAK

CALCULATION

GENERATE X_1, X_2

GENERATE $\vec{P}_1$, $\vec{P}_2$

CALCULATE WEIGHT

MOMENTUM RESOLUTION

2-TRACK RESOLUTION

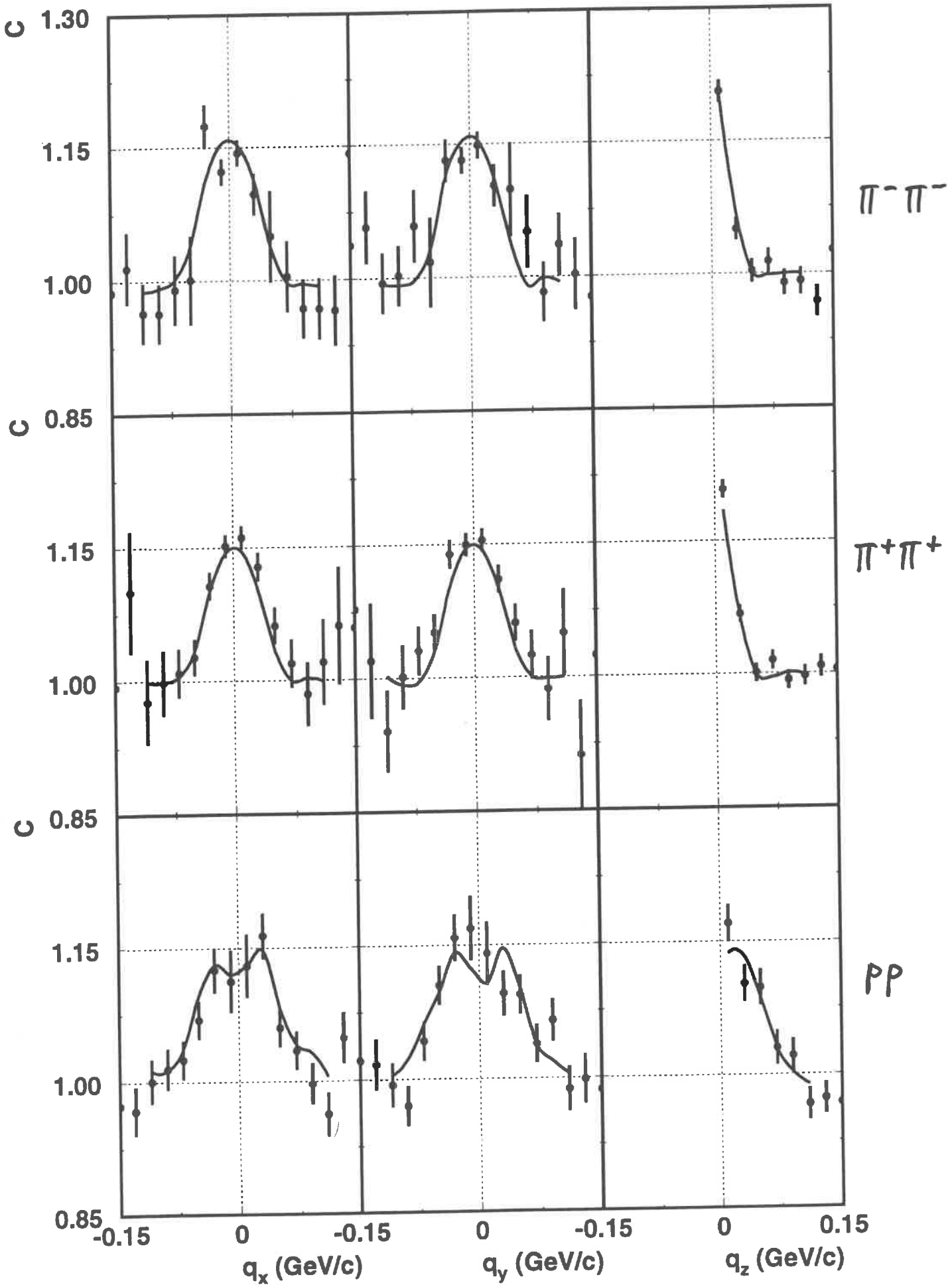
ANALYZE PAIR

EXPERIMENTAL DIST.

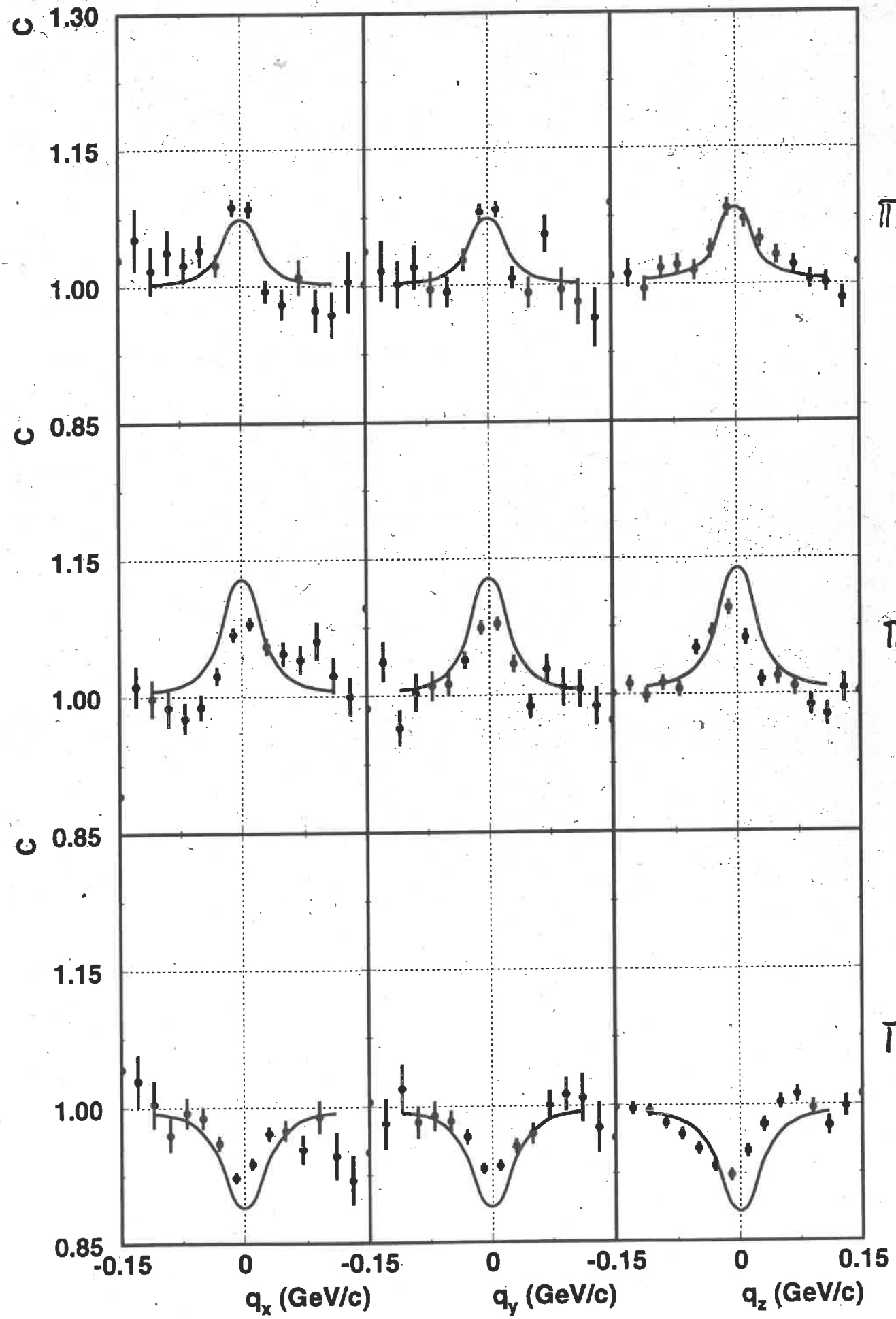
LEDNICKY CODE

SAME ANALYSIS AS FOR EXPERIMENTAL DATA

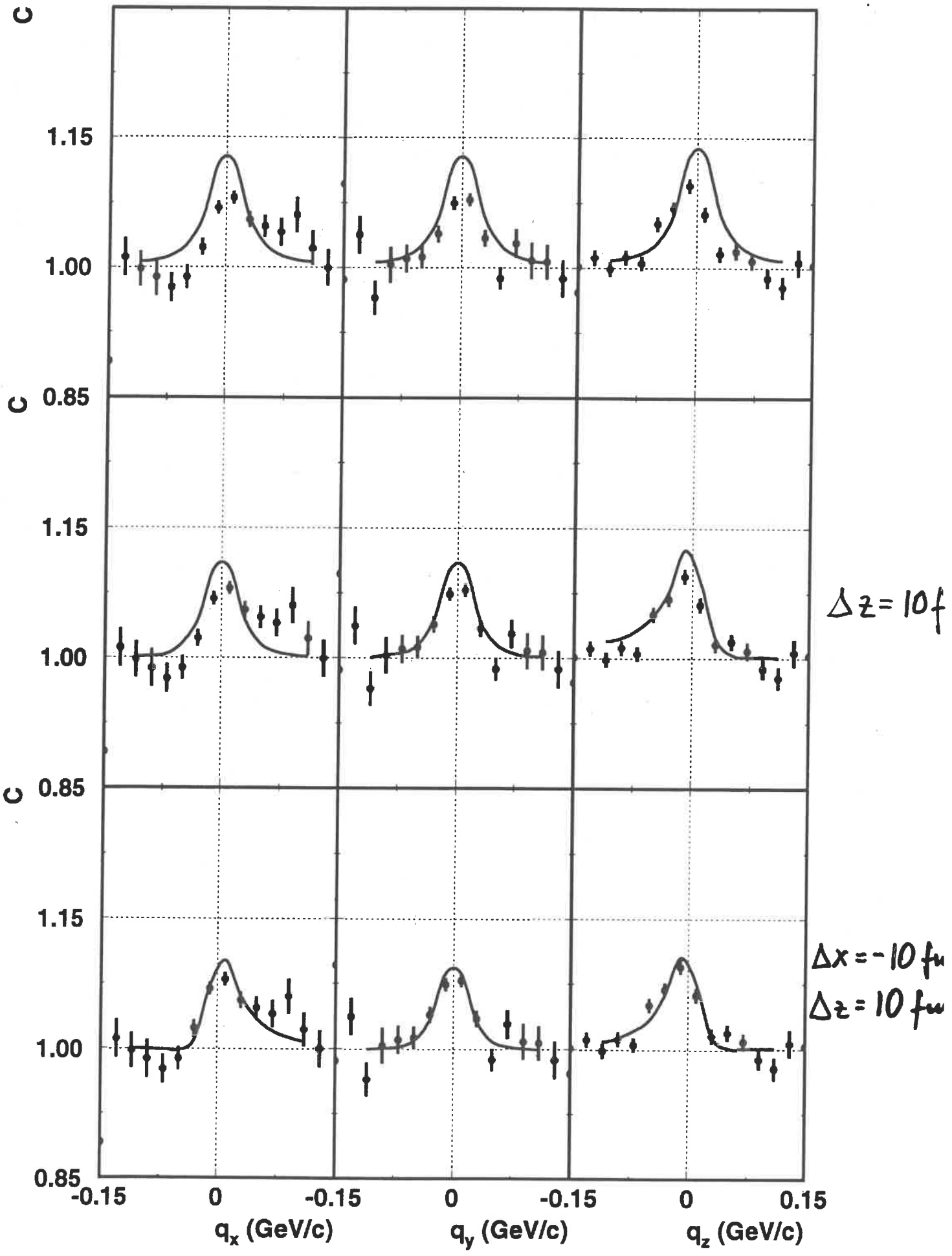
IDENTICAL PARTICLE CORRELATIONS



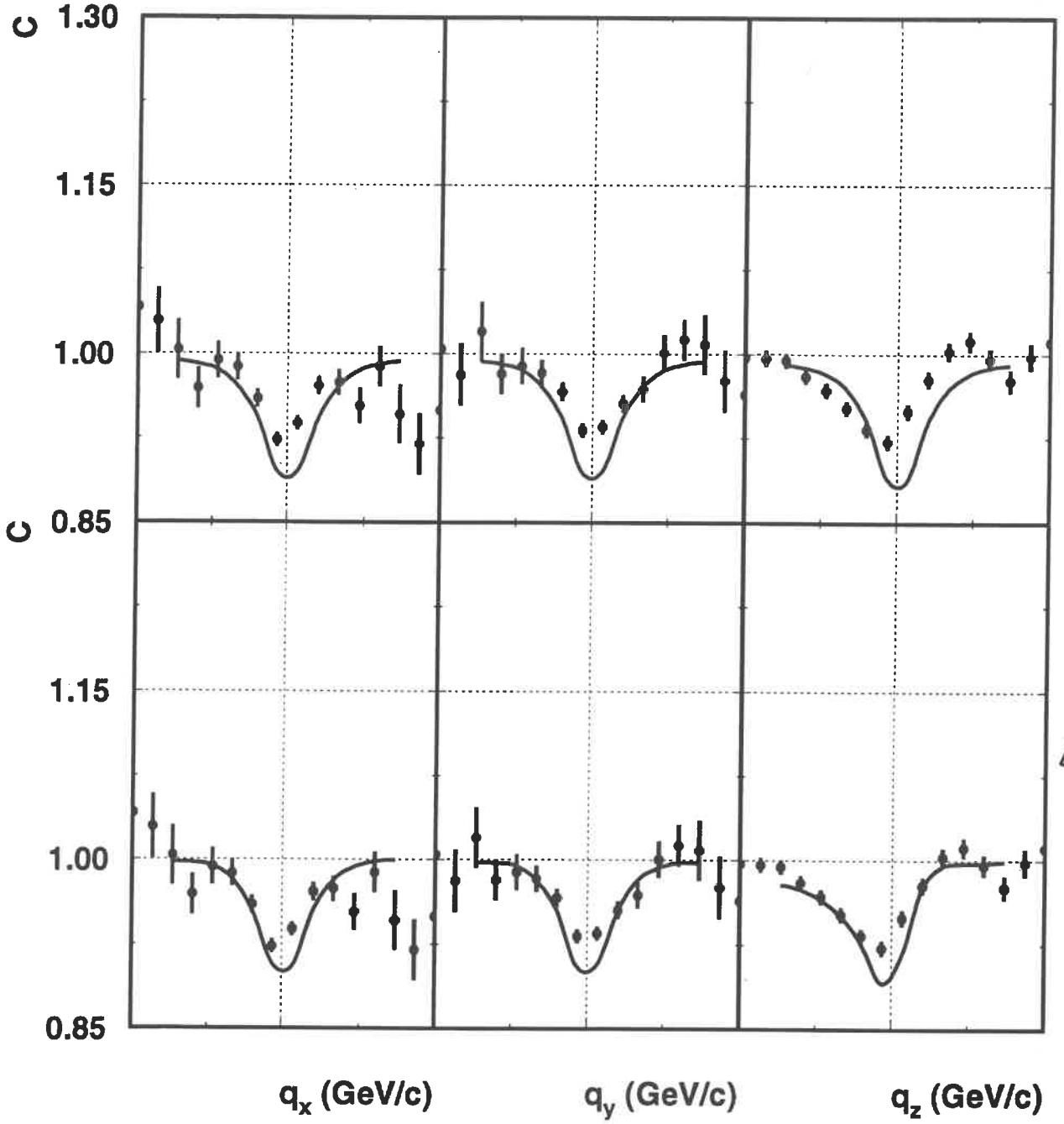
NON-IDENTICAL PARTICLES CORRELATIONS



$\pi^- - p$ CORRELATION



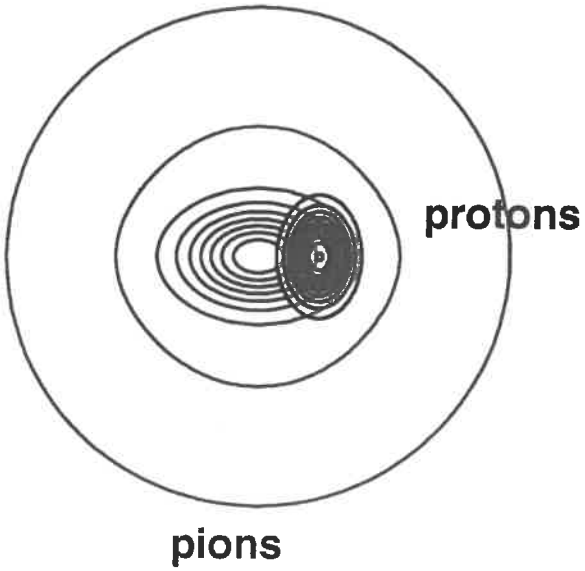
π^+ - p CORRELATION



$\Delta z = 10$ fm

Source parameters used in calculation

	pions	protons
f	0.72	—
R_T (fm)	5	4.75
R_L (fm)	7.8	3.25
τ (fm/c)	0	0
R_{halo} (fm)	30	—
τ_{halo} (fm)	0	—



SPECULATION

$\Delta z = 10$ fm

y_s (PIONS) $\simeq$ 2.5 - 2.9 YKP

y_s (PROTONS) = 3.0 JUST ASSUMED

$\Downarrow$

$\tau_f \simeq 20 - 100$ fm/c

$L = 2 \underbrace{\sinh\left(\frac{y_B}{2}\right)}_{2.4} \cdot \tau_f \gtrsim 100$ fm

SUMMARY

FACT: PION-PROTON CORRELATION FUNCTIONS ARE ASYMMETRIC

INTERPRETATION:

SPATIAL SEPARATION BETWEEN SOURCES OF PIONS AND PROTONS

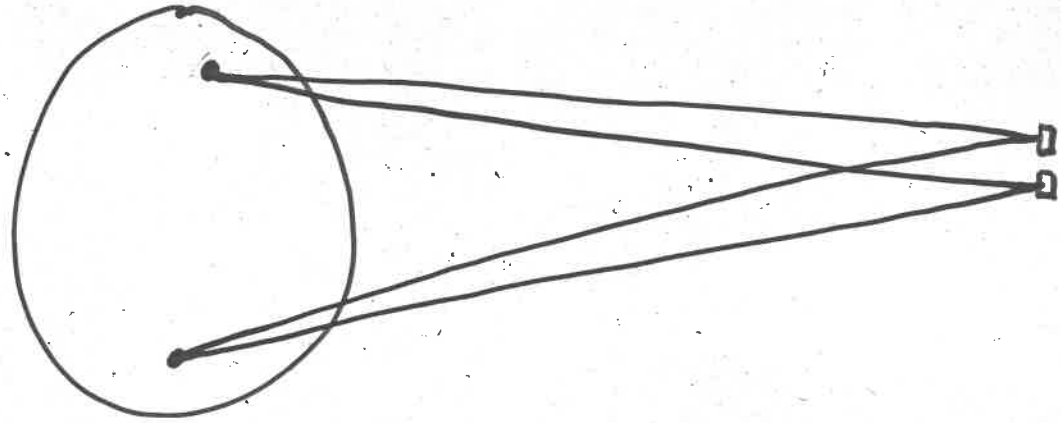
OUTLOOK:

THE SEPARATION SHOULD BE RELATED TO THE FREEZE-OUT TIME

ASTRONOMY

STAR: P_1, P_2

DETECTORS: X_1, X_2

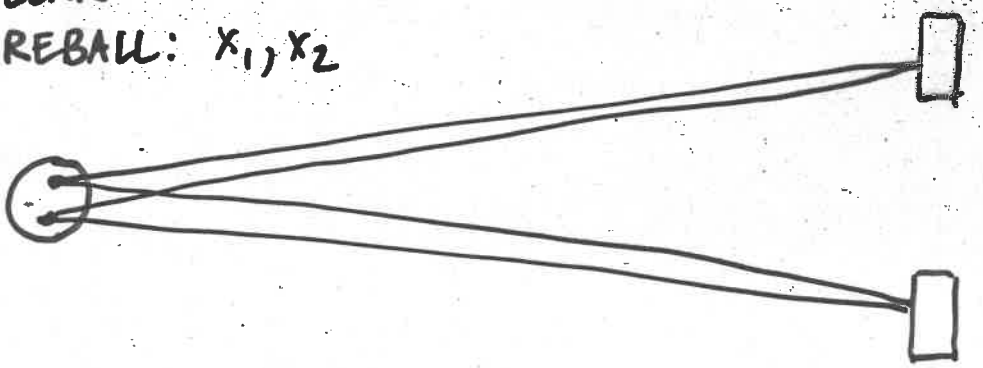


NUCLEAR PHYSICS

~~STA~~

NUCLEAR FIREBALL: X_1, X_2

DETECTORS: P_1, P_2



NORMALIZATION OF THE TWO-PARTICLE CORRELATION FUNCTION

(MIŚKOWIEC, VOLOSHIN, NUCL-EX/9704006, REJECTED BY PHYS. REV. C)

THEORETICAL PAPERS:

$$C_1(p_1,p_2) := \frac{\frac{d^6n}{d^3p_1\,d^3p_2}}{\frac{d^3n}{d^3p_1}\,\frac{d^3n}{d^3p_2}}$$

$$C_2(p_1,p_2) := \frac{\langle n\rangle^2}{\langle n(n-1)\rangle}\,\frac{\frac{d^6n}{d^3p_1\,d^3p_2}}{\frac{d^3n}{d^3p_1}\,\frac{d^3n}{d^3p_2}}$$

$C = 1 + |f(p_1,p_2)|^2$ INCONSISTENT WITH DEF. 2.

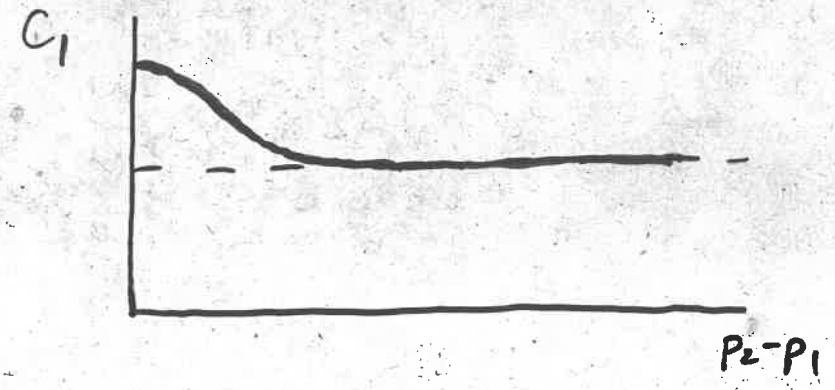
PROOF:

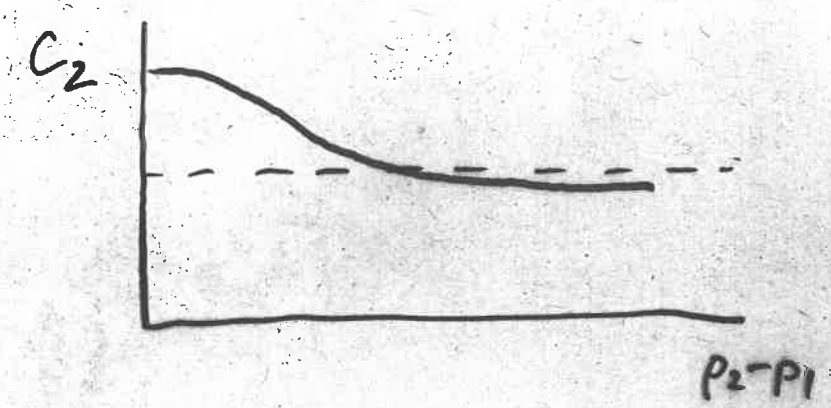
$$C_2(p_1,p_2) = 1 + |f(p_1,p_2)|^2$$

$$\frac{1}{\langle n(n-1)\rangle}\frac{d^6n}{d^3p_1\,d^3p_2} = \frac{1}{\langle n\rangle^2}\frac{d^3n}{d^3p_1}\frac{d^3n}{d^3p_2}\left(1 + |f(p_1,p_2)|^2\right)$$

$$1 = 1 + \frac{1}{\langle n\rangle^2}\int d^3p_1\,d^3p_2\,\frac{d^3n}{d^3p_1}\frac{d^3n}{d^3p_2}\,|f(p_1,p_2)|^2$$

$$f(p_1,p_2) \equiv 0$$


C_1
$P_2 - P_1$


C_2
$P_2 - P_1$

EXPERIMENT: NORMALIZE TO UNITY FLAT PART

BUT, IN PRINCIPLE, ABSOLUTE NORMALIZATION, BASED ON C_1, IS POSSIBLE.

$$C_1(p_1, p_2) := \frac{\frac{d^6u}{d^3p_1\, d^3p_2}}{\frac{d^3u}{d^3p_1}\,\frac{d^3u}{d^3p_2}}$$

FOR EVERY 100 EVENTS USED FOR NUMERATOR USE 100 EVENT PAIRS FOR DENOMINATOR.