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New Results on Exclusive Production From Nuclei*

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Three new experiments concerning coherent production from nuclei are discussed. Evidence is presented from the Carnegie Mellon-Illinois-Northwestern-Rochester collaboration regarding coherent production of A_2 mesons in collisions of 23 GeV/c π^- with nuclear targets (C, Al, Cu, Ag). The coherent A_2 cross section which vanishes in the forward direction is typically ~2% that of the A_1. A neutron dissociation experiment conducted at BNL (Rochester-BNL collaboration) has studied the process $n \to p\pi^-$ occurring coherently on nuclei. Using the optical model of Kolbig-Margolis a 30-40 mb cross section was extracted for the scattering of low-mass $p\pi^-$ systems on nucleons for momenta of ~13 GeV/c. A similar experiment conducted at FERMILAB (FNAL, University of Massachusetts, Northwestern, Rochester Collaboration) has indicated that at high energies (~200 GeV/c) Coulomb excitation of the neutron accounts for the major part of the reaction $n + Pb \to (p\pi^-) + Pb$. While $p\pi^-$ production on C is dominated through Pomeranchukon exchange.

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Coherent Production of A_2 Mesons

One of a series of coherent-production experiments performed at Brookhaven Laboratory by the Carnegie-Mellon, Northwestern, Rochester Collaboration, involved a study of the dissociation of 23 GeV/c π^- mesons into $\pi^-\pi^+\pi^-$ systems using nuclear targets. Using the Illinois analysis techniques[1], the 1^+ S-wave and 2^+ D-wave contributions to the three-pion mass spectrum near 1.3 GeV were examined as a function of t'.[2] The results of this analysis indicate that there is a sizeable coherent component in the A_2 production cross section off nuclear targets. This coherent enhancement is clearly seen in the peaks observed in Fig. 1 for the 2^+ spin-parity component for $t' < 0.05$. The fall of the A_2 cross section at $t' = 0$ is due to the helicity-flip nature of the production process. This result, taken together with the known weak energy dependence for A_2 production in hydrogen[1], speaks for a Pomeranchukon-exchange mechanism in A_2 production.

Neutron Dissociation Using Nuclear Targets

Figure 2 displays the t' spectra measured in a study of neutron dissociation into $p\pi^-$ systems at Brookhaven Laboratory. Typical mass spectra obtained in this Rochester-BNL experiment are shown in Fig. 3.[3] Using the Kolbig-Margolis optical model[4], the authors have performed fits to the ratios of the observed $p\pi^-$ production cross sections on various nuclei and extracted a 30-40 mb value for scattering of the

($p\pi^-$) system of ~1.4 GeV mass on nucleons. These results are similar to those obtained previously for the scattering of unstable-particle systems in nuclear matter[5], in that the cross section extracted for the scattering of a produced system is essentially the same as that for the incident hadron.

Neutron Dissociation at FERMILAB

To give a flavor for how a difference in incident momentum affects the coherent excitation of the neutron in its dissociation into ($p\pi^-$) systems on nuclear targets, I provide in Figs. 4 and 5 preliminary results from the FERMILAB, University of Massachusetts, Northwestern, Rochester Collaboration at FNAL.[6] The data are for neutrons in the momentum range of 170-230 GeV/c. The ($p\pi^-$) mass spectra in Fig. 4 are for production on a C and a Pb target. The Pb data are qualitatively different from the low energy results shown in Fig. 3 in that a large excess is observed in the $\Delta(1236)$ mass region. This excess is due entirely to the large Coulomb production cross section at high energy, which is dominated through $\Delta^\circ(1236)$ production. A Pb-C subtraction is shown at the bottom of Fig. 4 and compared to the shape of the $p\pi^-$ mass spectrum expected from a simple Primakoff production formula.[7] It is seen that the difference between production in Pb and in C can be largely accounted for by the Z^2 dependence of the Coulomb production cross section. Figure 5 illustrates the fact that the $\Delta^\circ(1236)$ signal is due to the low-t Coulomb excitation process. Because Coulomb production is an understood process,[7] it is intended to use the $\Delta(1236)$

signal as a normalization so as to study in detail the nuclear excitation of the neutron which is thought to proceed through Pomeranchukon exchange.

References

1. G. Ascoli et al. Phys. Rev. D7, 669 (1973).
2. U. E. Kruse et al, Phys. Rev. Letts. 32, 1328 (1974).
3. W. C. Carithers et al, paper submitted to the London Conference (1974).
4. K. Kolbig and B. Margolis, Nucl. Phys. B6, 85 (1968).
5. C. Bemporad et al, Nucl. Phys. B59, 106 (1973)and references given therein.
6. R. Ruchti et al, Bull. Am. Phys. Soc. 19, 439 (1974).
7. See, for example, G. Fäldt, Nucl. Phys. B43, 591 (1972) and references given therein.

Figure Captions

1. Momentum transfer dependence of the $J^P = 1^+S$ and 2^+D waves in $\pi^- \rightarrow (\pi^-\pi^+\pi^-)$ dissociation on nuclear targets at 23 GeV/c. The three-pion mass interval is 1.2 - 1.4 GeV.

2. Momentum transfer dependence of the dissociation of neutrons into $p\pi^-$ systems of ~1.4 GeV mass for neutron momenta near 13 GeV/c. The curves are calculations using an optical model.

3. Mass spectra for coherently produced $(p\pi^-)$ systems in C and Pb targets at ~13 GeV/c.

4. Mass spectra for coherent excitation of $n \rightarrow (p\pi^-)$ at ~200 GeV/c. The difference between the shapes of the C and Pb data at small masses can be attributed to Coulomb excitation of the neutron in Pb.

5. Evidence showing that the low-mass excess in high-Z material is due to the large Coulomb excitation process at high energies for small values of t.

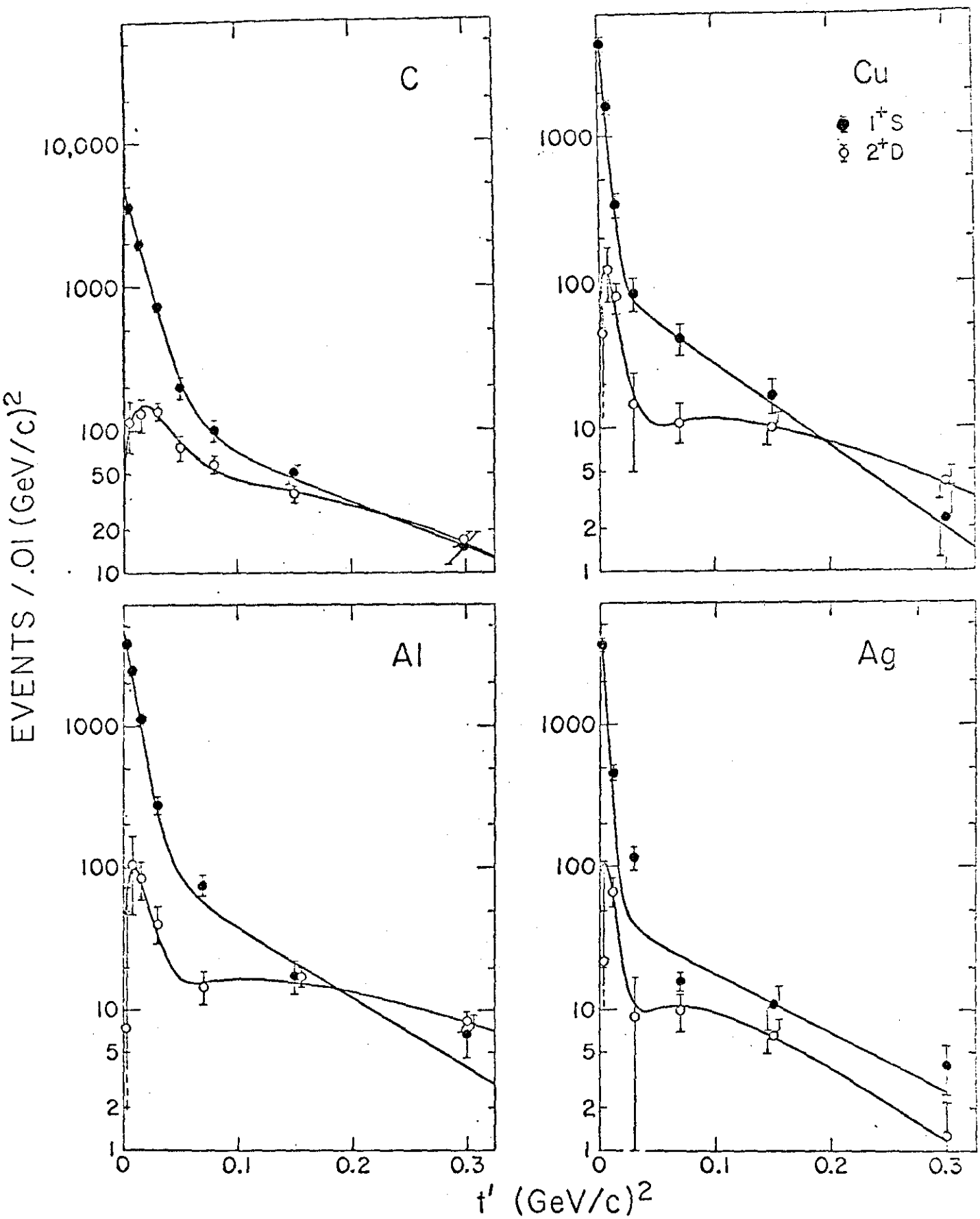
C
Cu
Al
Ag
1+S
2+D
EVENTS / .01 (GeV/c)2
t' (GeV/c)2
10,000
1000
100
50
20
10
5
2
1
0
0.1
0.2
0.3

Fig. 1

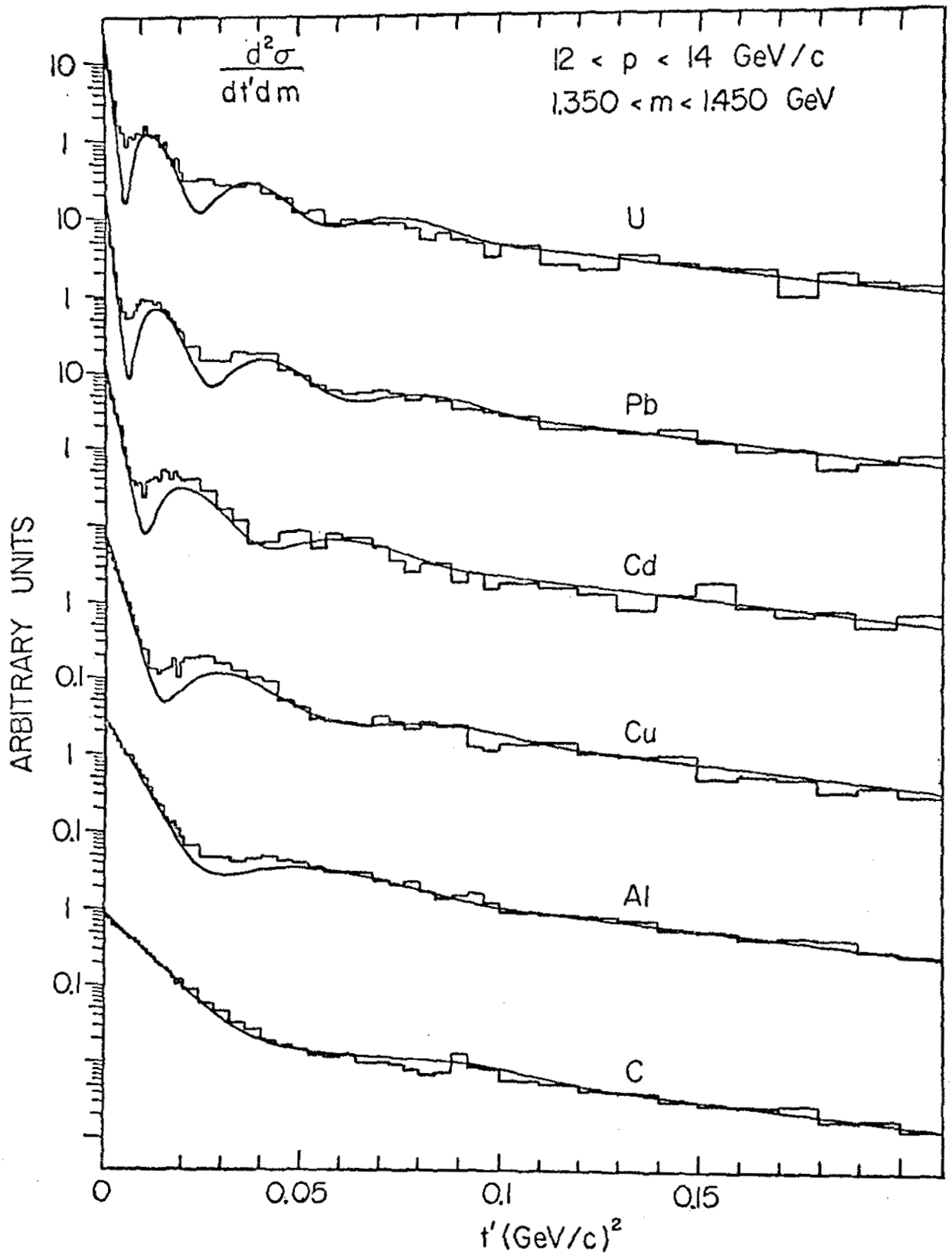
$\frac{d^2\sigma}{dt'dm}$
12 < p < 14 GeV/c
1.350 < m < 1.450 GeV
U
Pb
Cd
Cu
Al
C
ARBITRARY UNITS
10
1
10
1
10
1
1
0.1
1
0.1
1
0.1
0
0.05
0.1
0.15
t' (GeV/c)²

Fig. 2

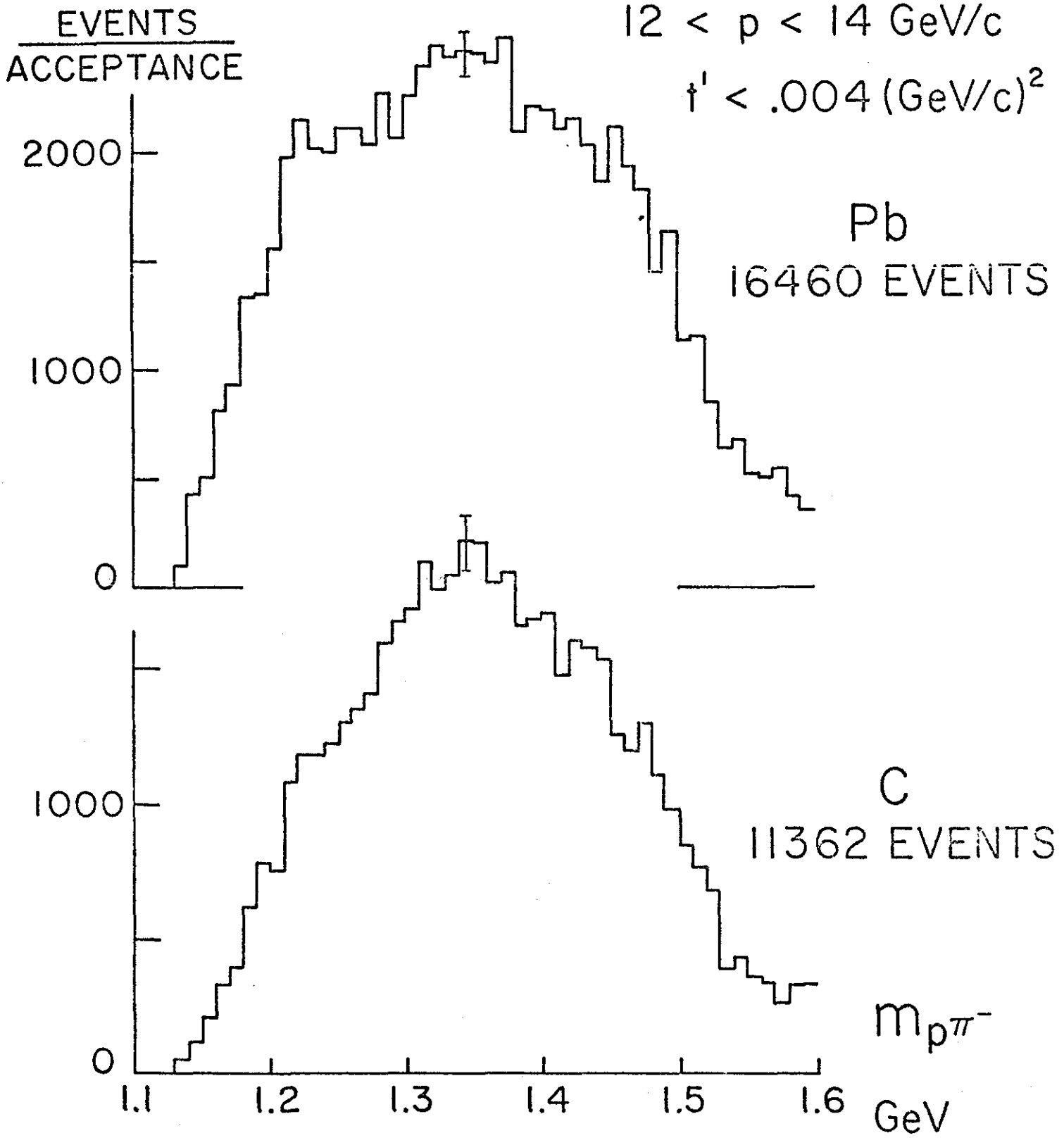
EVENTS
ACCEPTANCE
12 < p < 14 GeV/c
t' < .004 (GeV/c)²
2000
1000
0
Pb
16460 EVENTS
1000
0
C
11362 EVENTS
1.1
1.2
1.3
1.4
1.5
1.6
GeV
$m_{p\pi^-}$

Fig. 3

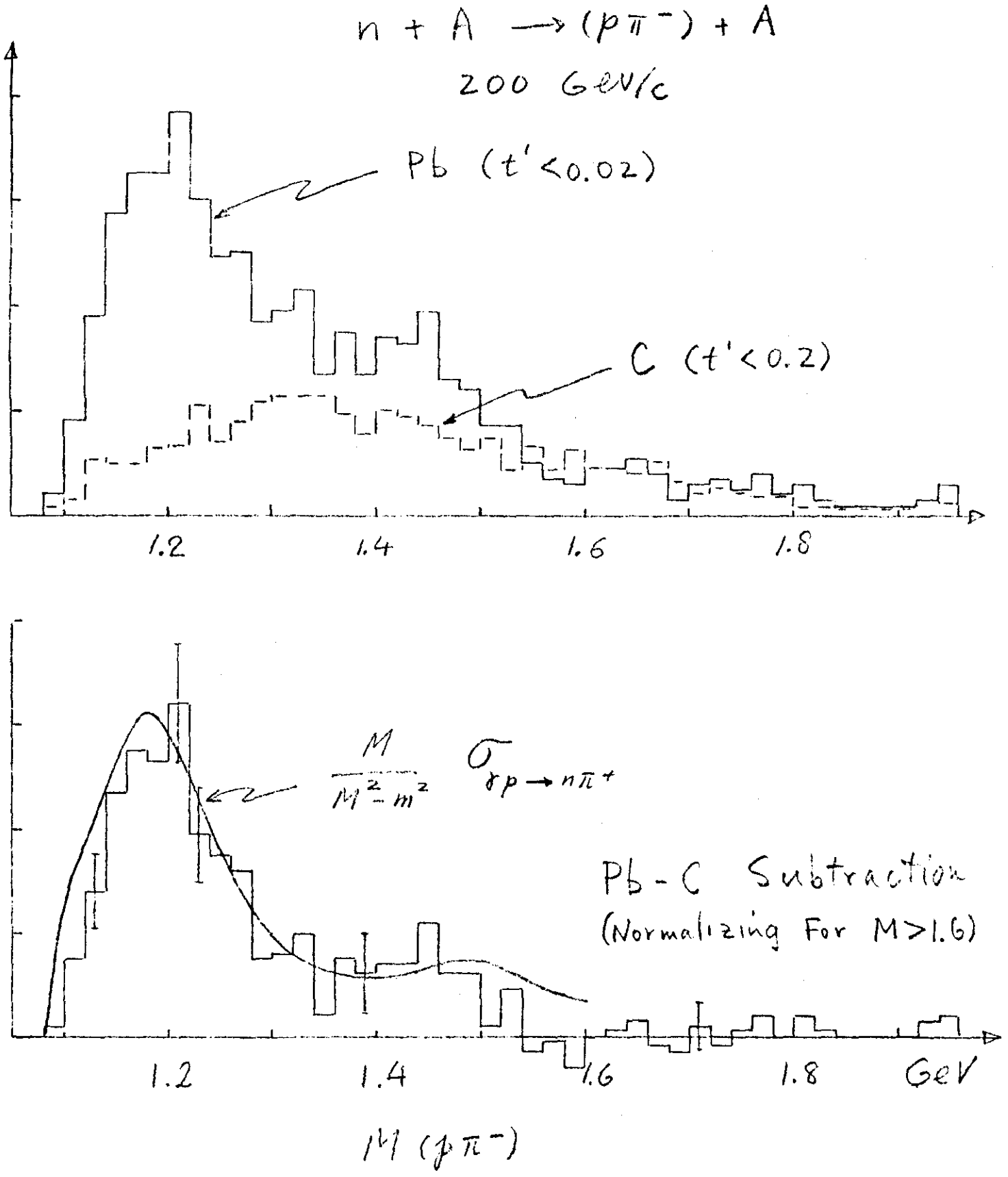
n + A → (pπ⁻) + A
200 GeV/c
Pb (t'<0.02)
C (t'<0.2)
1.2
1.4
1.6
1.8
M / (M² − m²)
σ γp → nπ⁺
Pb - C Subtraction
(Normalizing For M>1.6)
1.2
1.4
1.6
1.8
GeV
M (pπ⁻)

Fig. 4

$n + A \longrightarrow (p\pi^-) + A$

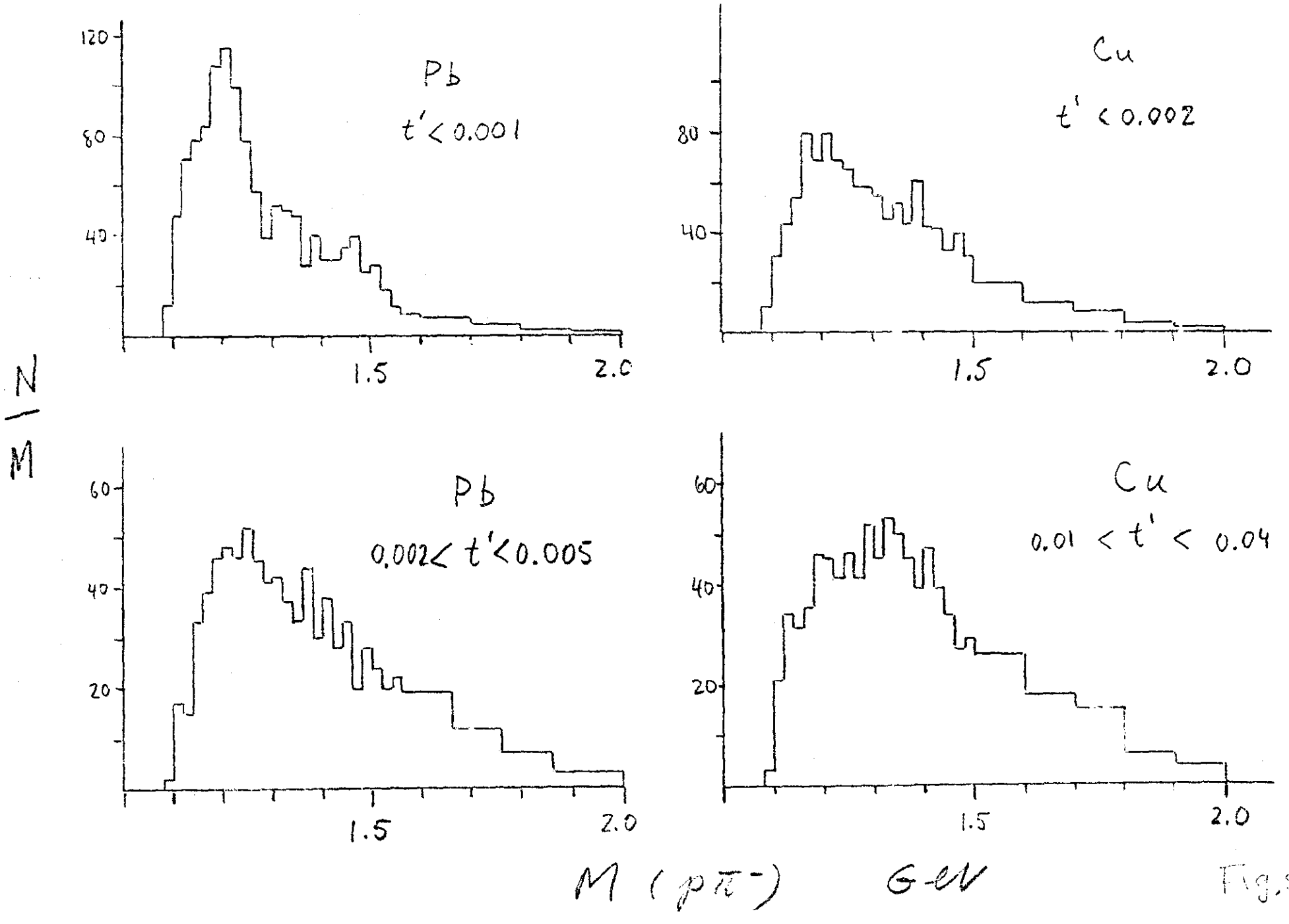

Fig.5