copies c/o Winzeler

CERN/TC/PHYSICS 64-14
30.4.1964

Production of neutral particles in π^+-d interactions at 6 GeV/c and I-spin of f_0

F. Bruyant, M. Goldberg[i)], M. Holder[ii)], M. Krammer[ii)], J.V. Major[iii)], G. Vegni[iv)], and H. Winzeler
CERN, Geneva

P. Fleury, J. Huc, R. Lestienne, G. de Rosny and R. Vanderhaghen
Ecole Polytechnique, Paris

About 70,000 pictures from the Saclay 81cm bubble chamber filled with deuterium and exposed with 6.07 GeV/c π^+ mesons have been examined. In this letter we present evidence for even I-spin of the f_0 from a study of the reaction

a) $\pi^+ + d \longrightarrow p + p + X^0 \longrightarrow$ neutrals

When interpreting these data we shall also make use of preliminary results from a study of the reactions

b) $\pi^+ + d \longrightarrow p + p + \pi^+ + \pi^-$ + neutrals

The protons have been selected by ionisation criteria after determination of dip and momentum. Their identification was reliable up to momenta of about 1.3 GeV/c. Ionisation measurements on a large sample indicated that only few events have a proton in the momentum range 1.3 - 1.6 GeV/c. This observation is supported by the general trend of the proton momentum distribution. The protons with higher momenta which have been found were included in the present data.

Spectator protons were often too slow to be observed. We did not measure events producing tracks shorter than 1 mm in projection. The experimentally determined loss below this cut-off was 67 o/o. The calculation of cross-sections took this into account.

Figure 1) shows the frequency distribution of 388 events as function of their (mesonic) missing mass. The total cross-section for reaction a) is 810 $\pm$ 80 μ barn. Figure 2) shows the corresponding distributions as determined by pure phase-space* for $2\pi^0$ + 5 o/o ($K^0 \bar{K}^0$) and $3\pi^0$. By comparing these distributions with the observed one in regions which should be relatively free from resonances, one might obtain

---

i) On leave of absence from Institut de Radium, Laboratoire Curie, Paris

ii) Students at the University of Tübingen (M.H.) and Graz (M.K.)

iii) On leave of absence from the University of Durham

iv) On leave of absence from the University and Section of INFN of Milan

* In the phase-space calculations the 'Fermi-motion' of the neutron has been taken into account.

PS/4368/jc

a rough feeling for the upper limit of their proper contributions. The experimental distribution clearly shows a structure different from phase-space. One observes two big accumulations, the first one is at low mass values, the second one is centered around 1250 MeV. Besides these peaks we observe a slight enhancement in the region between 3 and 4 GeV^2.

The low-mass accumulation corresponds to a cross-section of the order of 150 μ barn. It is difficult to distinguish between π^o and η^o - production (or other low-mass resonances). The shape of the peak analyzed by ideogram techniques indicates that π^o production predominates over η^o - production; however, a significant contribution of π^o to this peak would not be compatible with the upper limit for charge exchange cross-section of π^- p at 6 GeV/c $\sigma \leqslant 14\mu$ barn given by Bellini et al[(1)].

Now we discuss the enhancement at 1250 MeV. With a tentative estimate of the background (interpolation from both sides of the peak) this gives a cross-section of 115 $\pm$ 20 μ barn and a full width at half maximum $\Gamma \leqslant 180$ MeV*.

In the mass region of 1250 MeV 3 pionic resonances are known by their charged decay modes: f_o, B and A[(2)].

The A, recently reported by Goldhaber et al. has been observed as a $\rho\pi$ resonance. If it decays only via $\rho\pi$ the A^o cannot have a neutral decay mode**. In any case, our rather narrow peak could not be due to the A which is very broad and has a different structure.

The B^o cannot decay via strong interactions into any number of neutral pions***, but it could contribute to the peak via the known electromagnetic decay mode of the ω :

$$B^o \longrightarrow \omega^o + \pi^o$$
$$\omega^o \longrightarrow \pi^o + \gamma$$

which ammounts to about 1/5 of the charge ω^o decay[(3)]. The cross-section for B^o production would be of the order of at least 600 μ barn if the whole neutral peak were due to B^o. Preliminary results with the 4-prong events of type b) give an upper limit for the production of B^o of 80 μ barn, which excludes thus any appreciable

---

* The error quoted for the cross-section is the pure statistical one. The width, obtained by fitting a Gaussian curve, is larger than the estimated experimental resolution.

** The strong decay of ρ^o into 2 π^o is forbidden and the decay of A^o into $\rho^o + \pi^o$ is also forbidden if it has I-spin=1. In fact, the observation of this decay mode would be a rigorous test for I-spin=2 of the A.

*** G and C considerations imply that B^o cannot lead to any number of π^o.

contribution from B^o in the neutral peak. Therefore, if we assume that the mass region between 1100 and 1400 MeV contains no other pionic resonances than B, f_o and A, we are led to interpret this peak as mainly due to the neutral decay of f_o.

In the 4 - prong events we find a similar order of magnitude for the cross-section of f_o production leading to the charged decay (Figure 3) thus suggesting a main contribution from the strong decay $f_o \dashrightarrow 2\,\pi^o$. This implies an even value* of its I - spin and excludes the hypothesis of Frazer et al[4] on the identity of f_o and B^o. This result is also in agreement with those obtained by other authors with 3 different experiments[5, 6, 7].

We are grateful to the CERN MPS and TC Divisions and the Saclay bubble chamber group for their work in providing the photographs. We also wish to thank Drs. D. Morrison and F. Muller for their continuous interest in the various stages of this work and especially Drs. G. Kellner and W. Koch for their invaluable help in handling detailed questions of programming and computations.

* At the present stage our statistics with the 4-prong events is too weak to exclude I=2 assignment.

1) G. Bellini, E. Fiorini and A. Orkin-Lecourtois, Phys. Lett. 4, 164 (1963).

2) G. Goldhaber, J.L. Brown, Sulamith Goldhaber, J.A. Kadyk, B.C. Shen and G.H. Trilling, Phys. Rev. Lett. 12, 336 (1964).

3) 'Evidence for $\omega \dashrightarrow \pi^0 + \gamma$ decay', V.V. Barmin, A.G. Dolgolenko, Yu. S. Krestinikov, A.G. Meshkovskij, Yu. P. Nikitin and V.A. Shebanov, Report 161 (1963) State Committee for the use of atomic energy, Moscow.

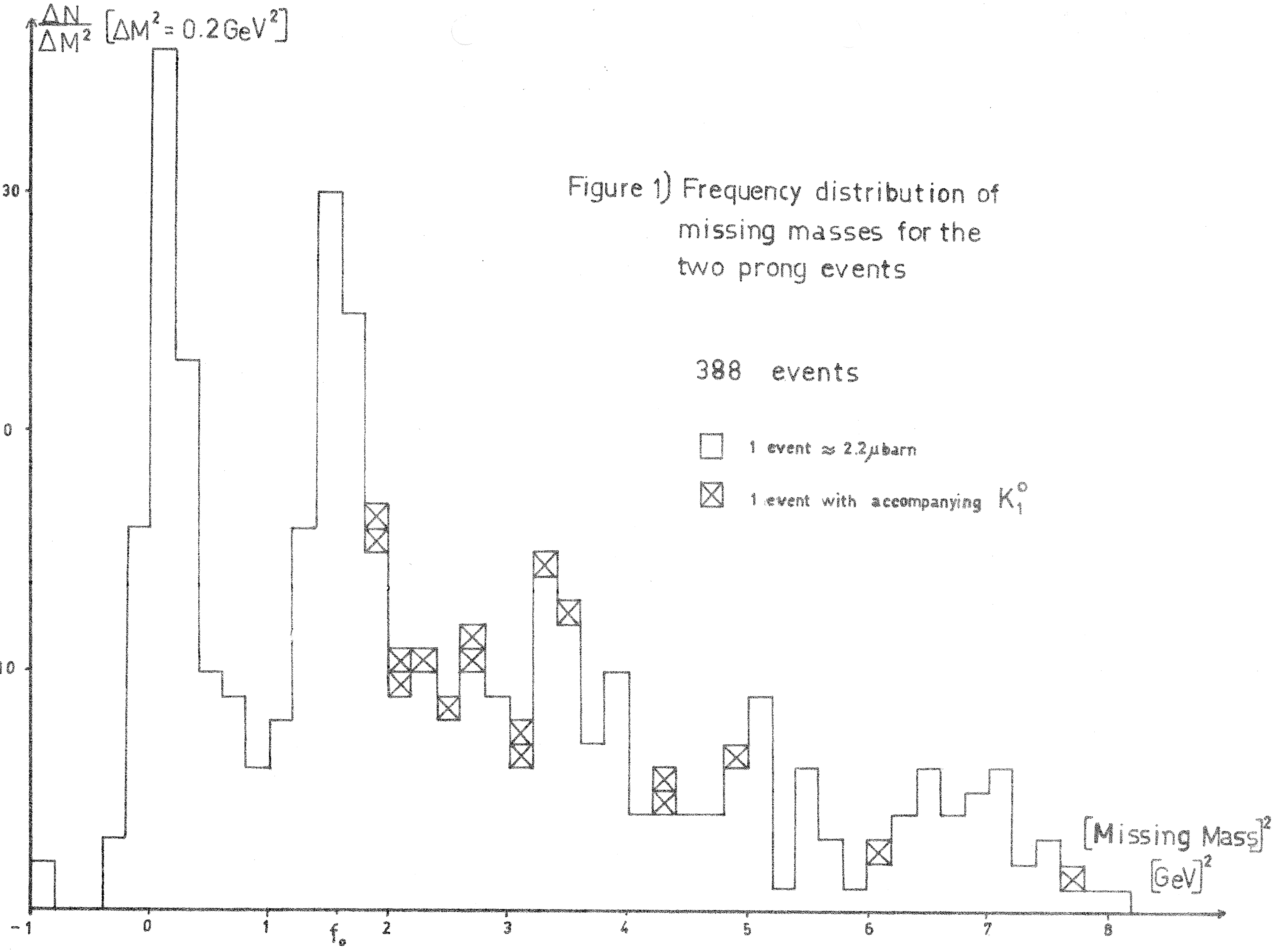
4) W.R. Frazer, S.H. patil and N.H. Xuong, Phys. Rev. Lett. 12, 178 (1964).

5) Y.Y. Lee, B.P. Roe, D. Sinair and J.C. Vander Velde, Phys. Rev. Lett. 12, 342 (1964).

6) Aachen-Berlin-Birmingham-Bonn-Hamburg-London-München Collaboration: 'The Iso-Spin and neutral decay of f_0'. Preprint 1964.

7) 'Observation of $f_0 \dashrightarrow 2\pi^0$', L. Sodikson, M. Wahlig, I. Monelli, D. Frisch and O. Fackler, Preprint MIT (1964).

PS/4368/jc



ΔN/ΔM² [ΔM² = 0.2 GeV²]
30
20
10
Figure 1) Frequency distribution of missing masses for the two prong events
388 events
1 event ≈ 2.2 μbarn
1 event with accompanying K_1^o
[Missing Mass]²
[GeV]²
-1
0
1
f_o
2
3
4
5
6
7
8

PS/4368

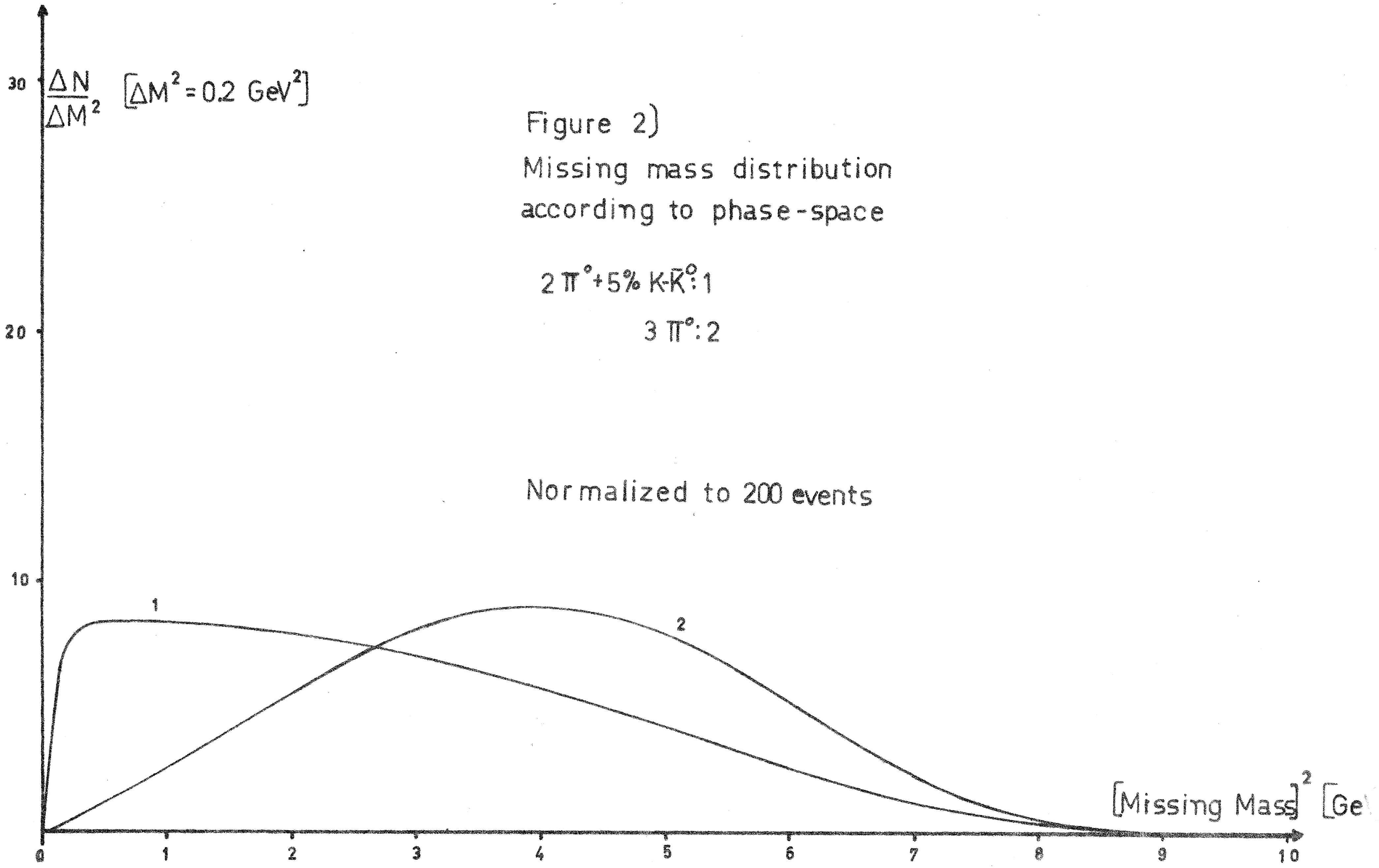
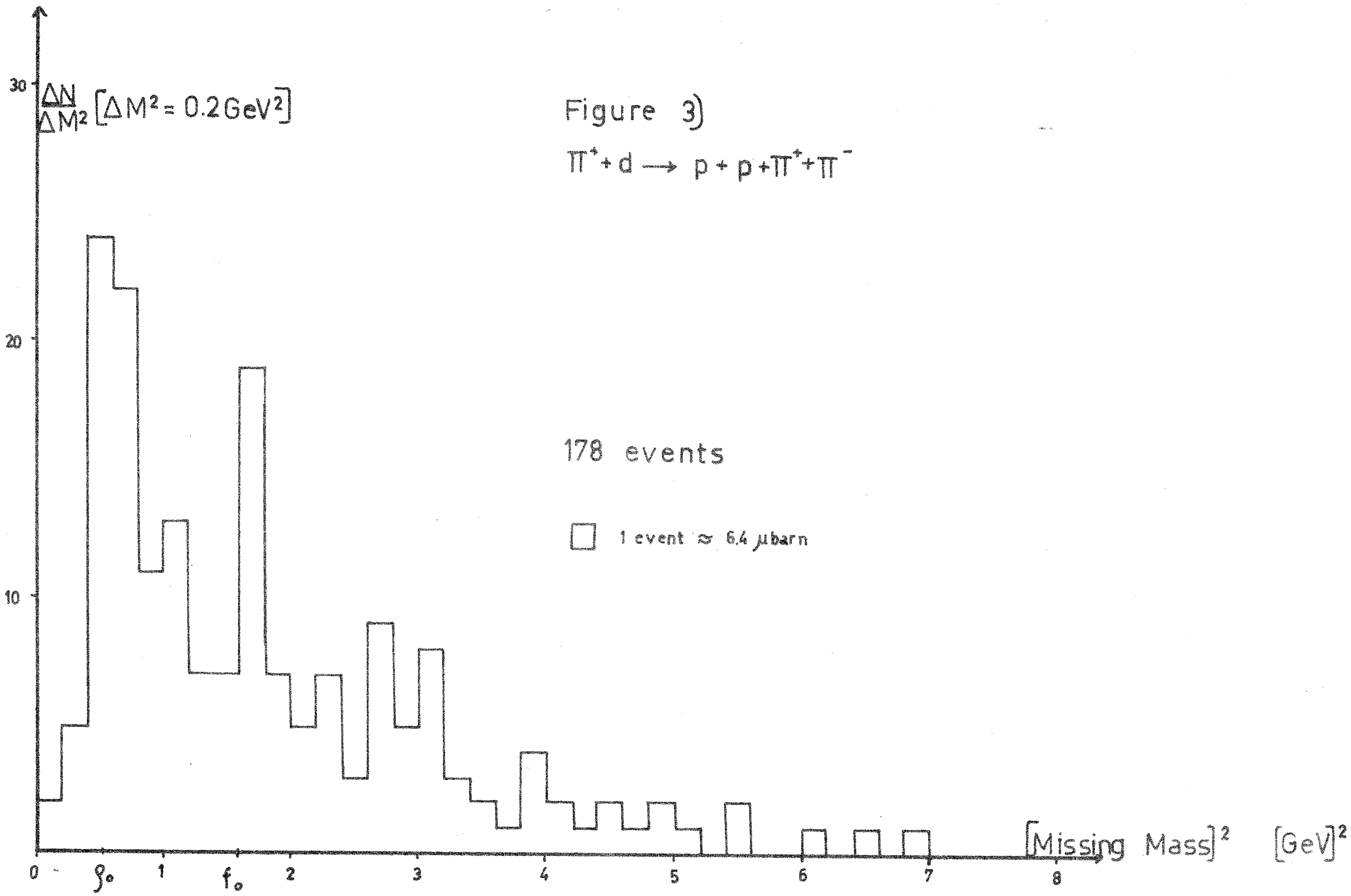


Figure 2)
Missing mass distribution according to phase-space

$2\pi^0 + 5\% \; K\text{-}\bar{K}^0$: 1
$3\pi^0$: 2

Normalized to 200 events

ps/4368



30
20
10
$\frac{\Delta N}{\Delta M^2}$ [$\Delta M^2 = 0.2 GeV^2$]
Figure 3)
$\pi^+ + d \rightarrow p + p + \pi^+ + \pi^-$
178 events
1 event ≈ 6.4 μbarn
[Missing Mass]^2 [GeV]^2
0
ρ_o
1
f_o
2
3
4
5
6
7
8

PS/4368