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Search for Narrow $\bar{N}N$ States in $\bar{p}d$ Annihilation

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A missing mass experiment in $\bar{p}d \to NX$ was performed at the Brookhaven alternating-gradient synchrotron. The invariant mass of the system X ($\bar{p}p$ or $\bar{p}n$) was determined at incident beam momenta of 500 and 610 MeV/C by measuring the angle and time of flight of the recoiling nucleon. Possible radiative transitions in $\bar{p}d \to NX\gamma$ were also investigated with a large NaI crystal.

The layout of the apparatus is shown in fig. 1. Antiprotons from production target (P) were transported to a 1 m long liquid deuterium target (T). Pions were suppressed by two electrostatic separators (E1 and E2) and a mass slit (M). A counter telescope ($S_0S_1S_2$) defined the incident beam on the target. Pulse height analysis in S_1 and S_2 and time of flight between S_0 and S_2 reduced the pion contamination to an acceptable level. A set of three multiwire proportional chambers ($W_1W_2W_3$) and the last dipole magnet determined the trajectory and momentum of individual antiprotons. The annihilation vertex was obtained by measuring the inter-

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section of the incident track with the tracks of the annihilation products detected in two pairs of wire chambers (L) located above and below the target. A plastic counter array (A) detected recoil nucleons. The energy of the recoil was determined by time of flight and the recoil angle by measuring the detection point along the counter.

The main contribution to the missing mass resolution was the time of flight resolution ($\pm$ 500ps). Other contributions arose from uncertainties in the antiproton momentum ($\pm$ 0.3%), in the vertex position ($\pm$ 1.5cm) and in the recoil angle ($\pm$ 2^{o}).

The NaI detector (N) was 10 radiation lengths deep by 75 cm diameter. The aperture was limited by a lead collimator (R) sandwiched between two large veto counters (V). The detector was shielded by borax and iron. The crystal was calibrated with 130 MeV protons from $\pi^{-}p$ radiative capture and in a 800 MeV electron beam. The resolution was 9 % and 3 % FWHM respectively. Only photons associated with a valid recoil nucleon from $\bar{p}d$ annihilation were recorded so that full kinematics could be reconstructed and the photon energy computed in the center of mass frame of the missing mass system.

Data at 500 MeV/c have been subdivided into annihilation in flight and at rest. Results for $\bar{p}d \to (\bar{p}p)n$ and $\bar{p}d \to (\bar{p}n)p$ have been presented earlier (ref. 1). We have not observed any narrow $\bar{N}N$ state. For annihilations at rest we find a 4-standard-deviation upper limit of 0.3 % for the production of narrow bound states. For annihilations in flight the limit is 2 mb in the mass interval 1650 to 1930 MeV/c^2 assuming isotropic production in the $\bar{p}d$ center of mass system.

Results for $\bar{p}d \rightarrow (\bar{p}p)n$ at 610 MeV/c incident momentum are shown in fig. 2. The dashed curve gives the background contribution mainly due to accidental coincidences with ambient slow neutrons. Missing mass resolutions are given at the top of the figure. The rapid rise of the distribution at large masses is suitably described by the pick up mechanism while the tail has been attributed to initial and final state interactions(2). No significant deviation from a smooth curve is observed. In particular we fail to observe the 1794 MeV bound states reported earlier(3). The 4-standard deviation upper limit for the production of states narrower than the experimental resolution is 1 mb in the mass interval 1600 to 1960 MeV/c^2.

Figure 3 shows the energy distribution of phtons for annihilations at rest and in flight below 500 MeV/c. The photon energy is evaluated in the center of mass frame of the annihilating $\bar{N}N$ system. The fast rise below 50 MeV is due to ambient slow neutrons. The spectrum is similar to that of Ref. 4 shown to be consistent with that expected from π^o decay. No significant enhancement is observed. The 4-standard-deviation upper limit on the fraction of photon transitions associated with a state of width smaller than the resolution is 4 % in flight and 2 % at rest. The mean number of photons per annihilation is 2.6 $\pm$ 0.3 in agreement with a neutral to charged pion ratio of 0.5 predicted by charge independence, assuming a mean charged multiplicity of three(5).

References: (1) C. Amsler et al., Phys. Ref. Lett. 44 (1980) 853

(2) D. Zemany et al., Phys. Rev. Lett. 38 (1977) 1443

(3) L. Gray et al., Phys. Rev. Lett. 26 (1971) 1491

(4) P. Pavlopoulos et al., Phys. Lett. B72 (1978) 415

(5) T. E. Kalogeropoulos and G. S. Tzanakos, Proceedings of the Third European Symposium on $\bar{N}N$ Interactions, Pergamon Press, 1977, page 33.

Figure captions:

Fig. 1 Layout of apparatus. For explanation see text.

Fig. 2 ($\bar{p}p$) missing mass distribution for $\bar{p}d$ annihilation in flight at an incident antiproton momentum of 610 MeV/c. The dashed line shows the contribution from background. Resolutions are given at the top of the figure.

Fig. 3 Photon energy distribution for annihilations at rest and in flight below 500 MeV/c. Resolutions are given in the figure. Lines are eyeball fits to the data.

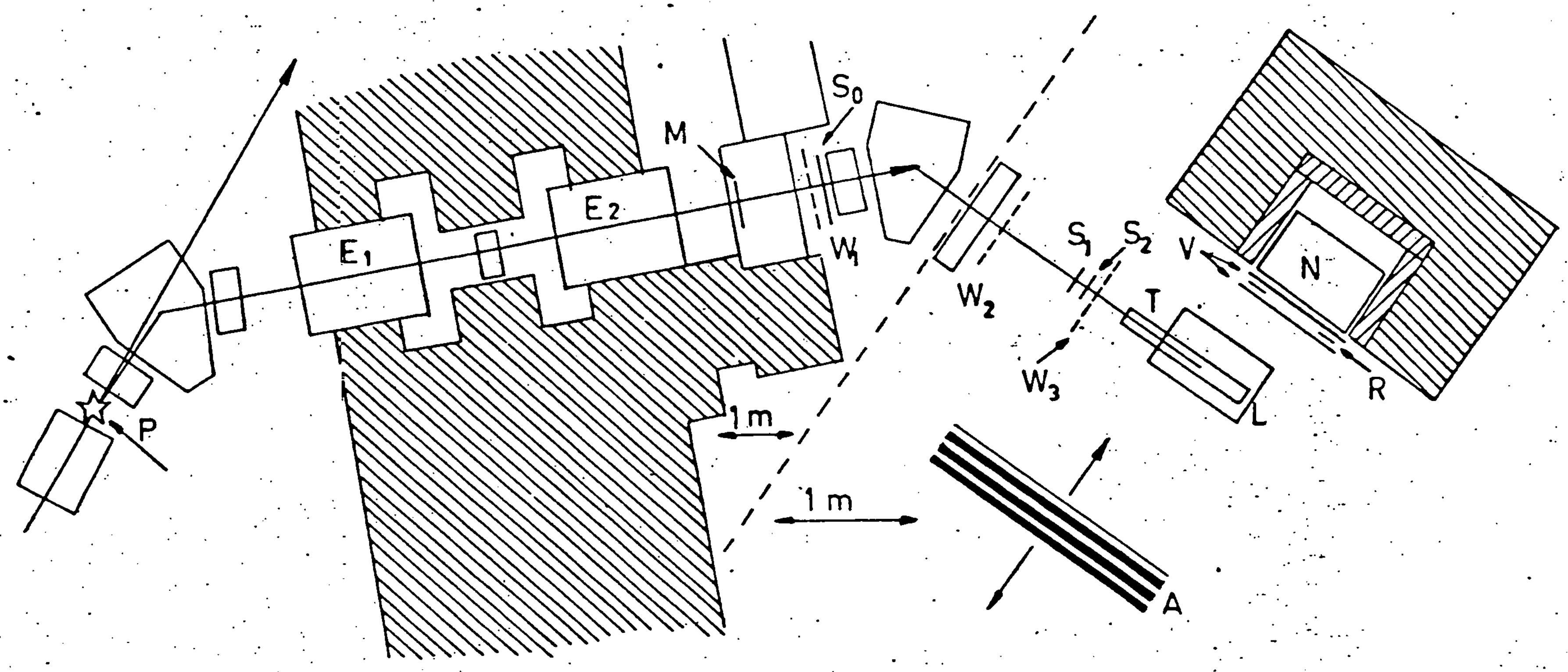


Fig. 1

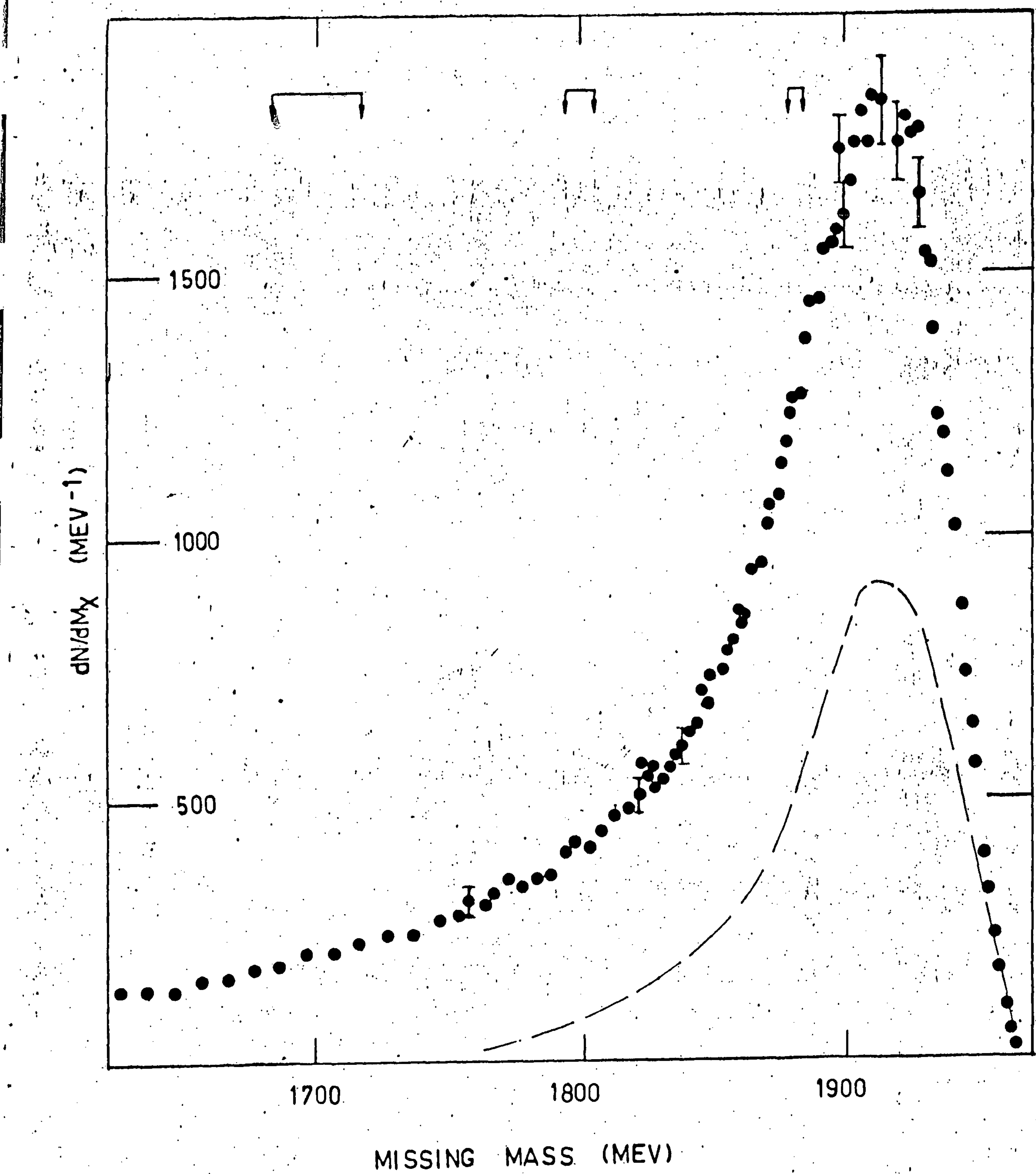
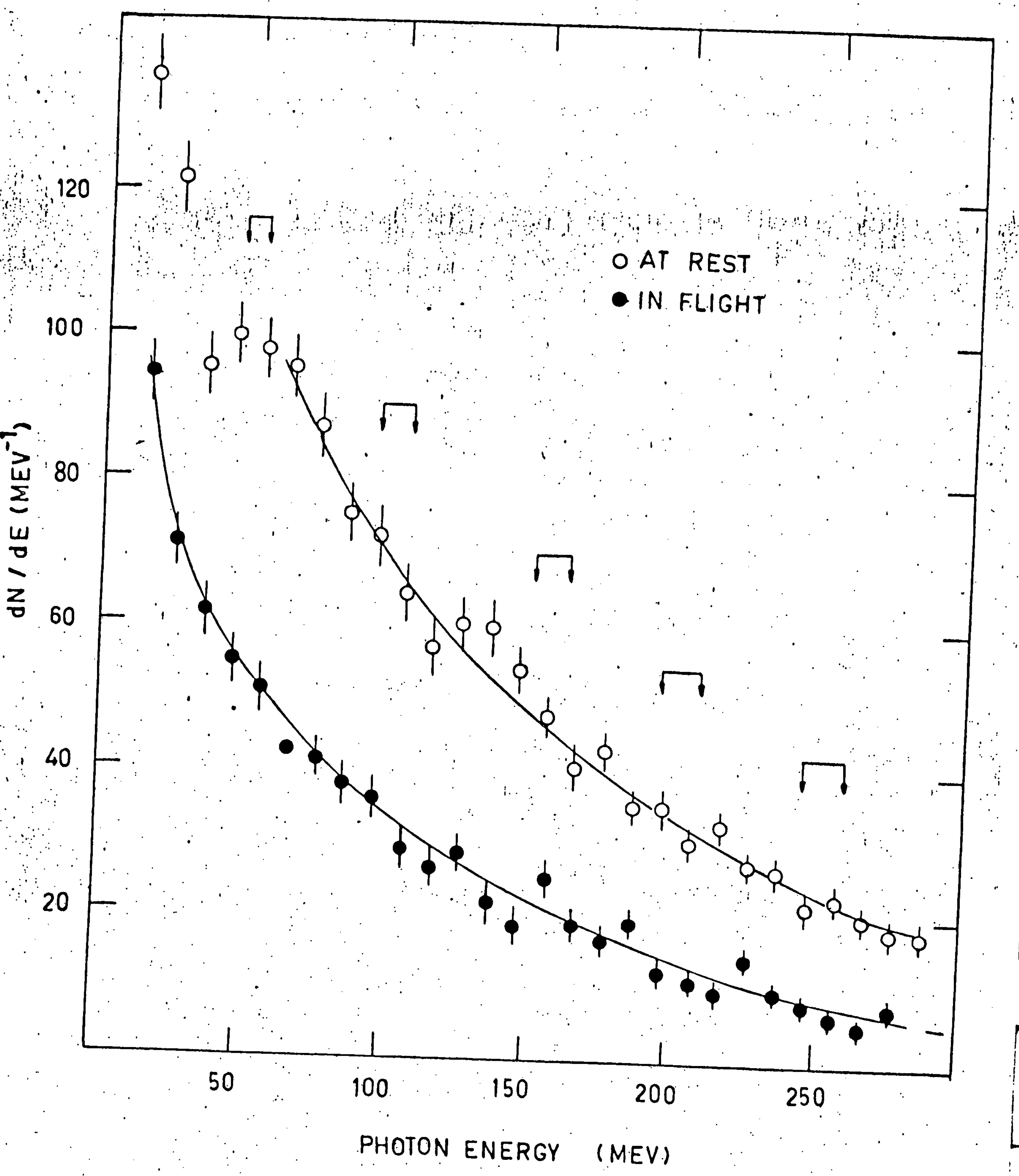


Fig. 2.



O AT REST
● IN FLIGHT
dN / dE (MEV⁻¹)
20
40
60
80
100
120
50
100
150
200
250
PHOTON ENERGY (MEV)