

MEASUREMENT OF CHARGED PION YIELDS FROM NUCLEI IN THE (p, π^+) REACTION FROM
2-13 MeV ABOVE THRESHOLD

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Proton induced positive pion production differential cross sections have been measured for various nuclei utilizing the DD pion spectrometer. The DD spectrometer has made possible the measurement of positive pion cross sections closer to threshold than previously reported by other groups. Pions with laboratory energies as low as 2 MeV and differential cross sections as low as 1 nb/sr have been observed.

The energy and A dependence of the positive pion production process is being studied using ^{10}B , ^{13}C , ^{16}O , ^{40}Ca , and ^{90}Zr targets. Complete angular distributions have been obtained for pion production to the ground states of ^{11}B , ^{14}C , and ^{17}O at $T_p = 155$ MeV ($T_{\pi\text{c.m.}} = 10, 10$ and 8 MeV respectively), ^{11}B and ^{14}C at $T_p = 151$ MeV ($T_{\pi\text{c.m.}} = 7$ MeV), ^{41}Ca at $T_p = 144$ and 140 MeV ($T_{\pi\text{c.m.}} = 7.8$ and 3.8 MeV) and ^{91}Zr at $T_p = 144$ MeV ($T_{\pi\text{c.m.}} = 8$ MeV). The energy dependence of the differential cross sections ($\theta_{\text{lab}} = 25$ deg) for the production of ^{11}B ground state pions has been extended down to $T_{\pi\text{c.m.}} = 1.7$ MeV (2.2 MeV above threshold).

The detector stack used consisted of 3 to 5 elements. The 5 element stack consists of a 100 μm Al absorber and a 10 mil NE 102 plastic scintillator followed by a silicon detector stack consisting of a $200 \rightarrow 500$ $\mu\text{m} \times 150$ mm^2 ΔE , 5000 $\mu\text{m} \times 100$ mm^2 stopping detector and a 500 $\mu\text{m} \times 450$ mm^2 veto detector. This stack is suitable for detecting pions in the

4 to 14 MeV range. The three element stack does not include either the ΔE silicon or the Al absorber and the 10 mil scintillator is replaced by a 5 mil scintillator. The 3 element stack is suitable for detecting pions with energies greater than 1.5 MeV. In addition to the energy loss information obtained from the detectors, TOF between the cyclotron's RF and the plastic scintillator and pulse shape discrimination in the 5mm stopping detector were used. In order to observe cross sections of the order of 1 nb/sr in the forward direction (high background region) a further requirement was made that the positron from the muon's decay be observed. This requirement reduces the detector stack's efficiency by a varying factor of 2 or 3 but reduces the background events by more than an order of magnitude and completely eliminates the high energy tail in the summed energy spectra due to the decay positrons. Fig. 1 shows an example of the data obtained in the 144 MeV calcium run with all appropriate background cuts applied. The plots show summed energy (includes 4.1 MeV from the $\pi \rightarrow \mu + \nu$ decay) vs. ΔE and the relative RF TOF. The ground state and 2 MeV doublet of ^{41}Ca are clearly observed as well as a few pions from higher excited states. The cross section for the production of the ground state pions shown in Fig. 1 is approximately 8 nb/sr.

Figures 2 and 3 display samples of the angular distributions (preliminary) obtained with the DD. Figure 3 also includes the angular distribution taken with the QDDM spectrograph at $T_p = 160$ MeV (Ref. 1). Figures 4 and 5 show the excitation function for calcium and boron and include points taken with the QDDM at IU as well as points derived from Uppsala data (Ref. 2 and 3). The Uppsala data points are multiplied by a factor of 1.8 to normalize their data to that of IUCF (Ref. 4).

These data combined with higher energy data from other groups should provide a severe test of competing pion production models.

- 1) R.D. Bent, P.T. Debevec, P.H. Pile, R.E. Pollock, R.E. Marrs, and M.C. Green, *Physical Review Letters* **40** (1978) 495.
- 2) S. Dahlgren, P. Grafström, B. Høistad, and A. Åsberg, *Nuclear Physics* **A227** (1974) 245.
- 3) S. Dahlgren and P. Grafström, *Physica Scripta* **10** (1974) 104.
- 4) R.D. Bent, P.T. Debevec, R.E. Marrs, P.H. Pile, R.E. Pollock, M. Tsangarides, and J.G. Wills. Contribution to the 7th International Conference on High-Energy Physics and Nuclear Structure, Zürich, Switzerland, Aug. 1977.

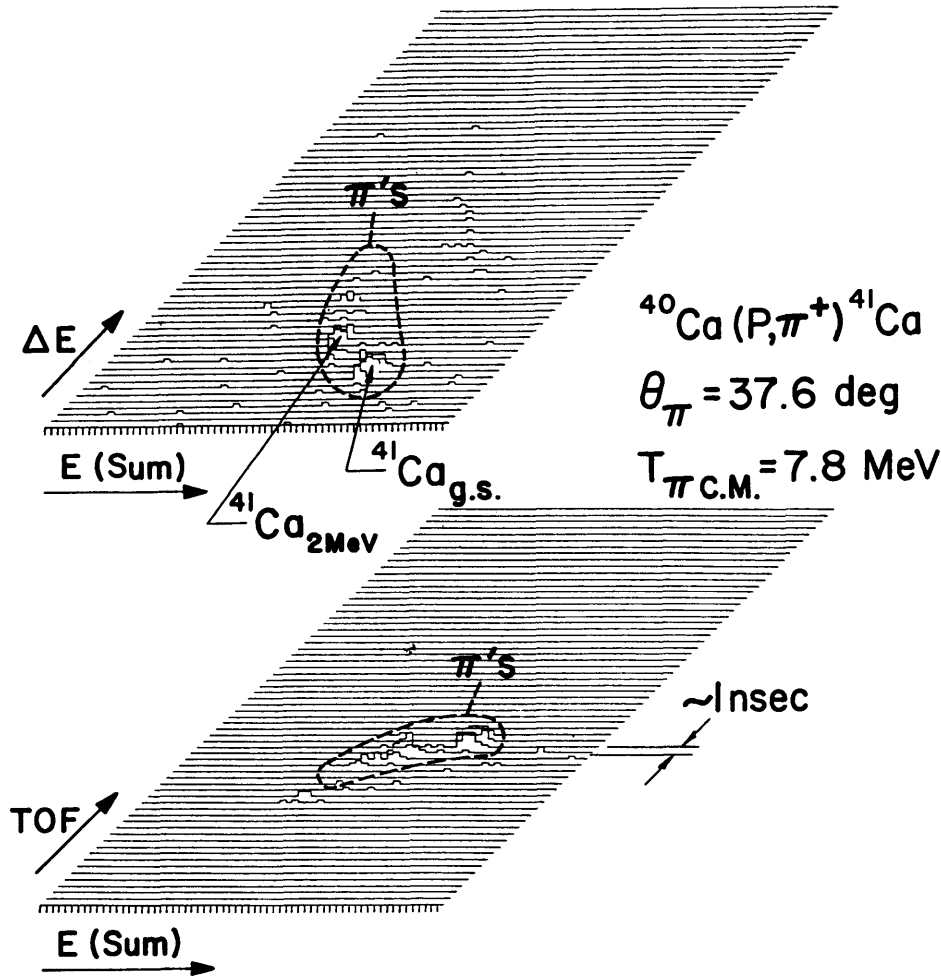


Figure 1.

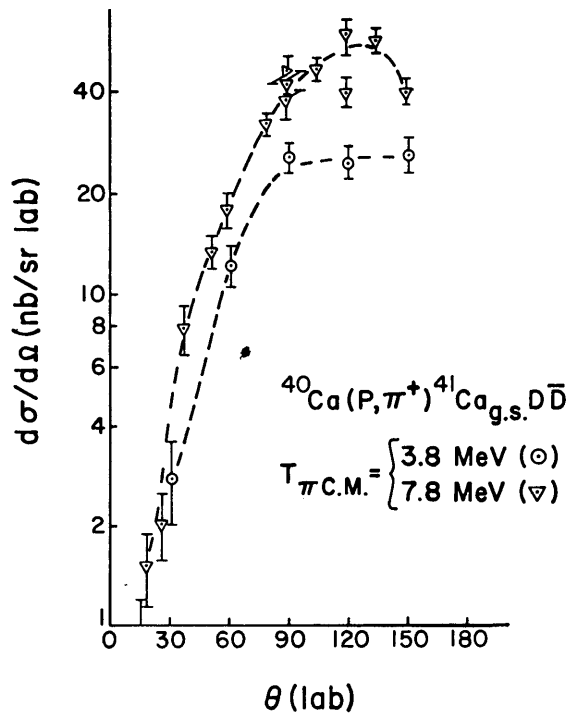


Figure 2

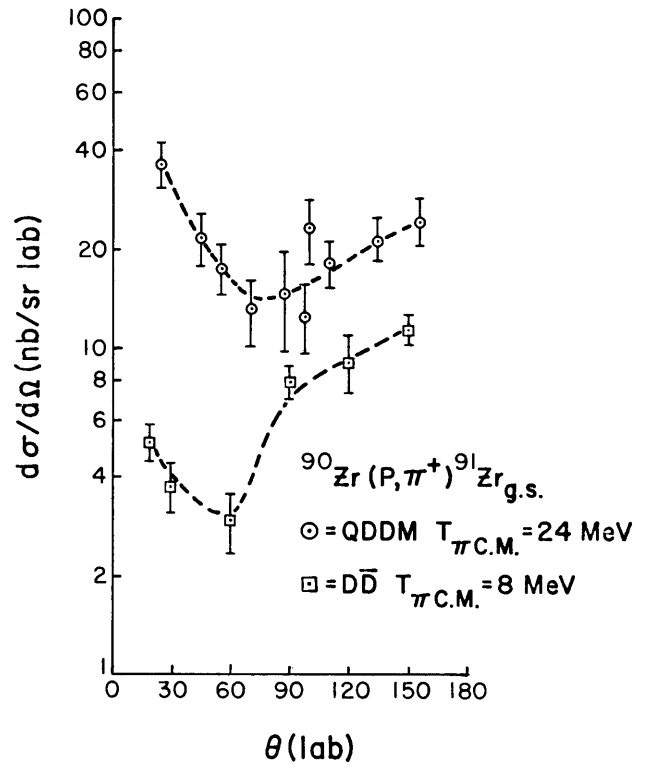


Figure 3

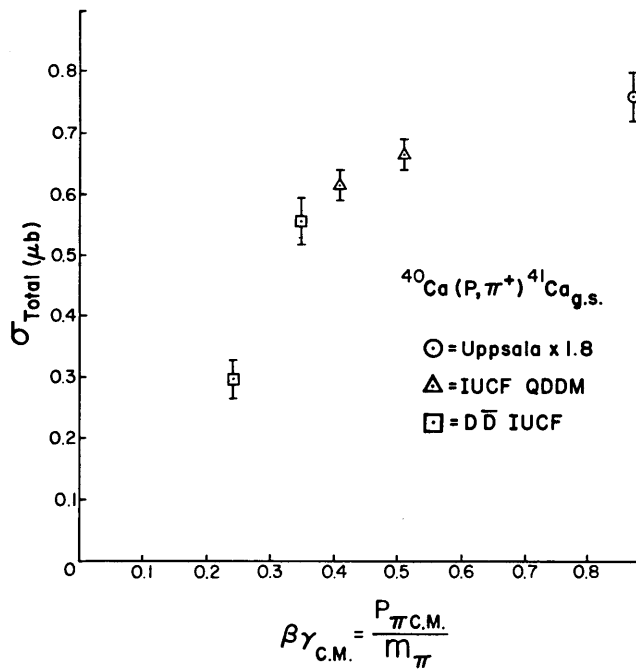


Figure 4

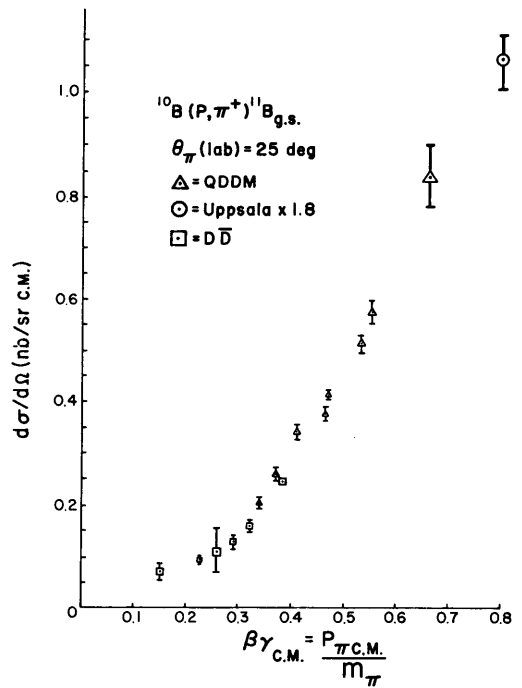


Figure 5