

CHARGED PION PRODUCTION IN PROTON-NUCLEUS COLLISIONS NEAR THRESHOLD

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Charged pions produced in proton-nucleus collisions have been measured using the QDDM magnetic spectrograph facility shown in Fig. 1. The focal-plane detector array consisted of a helical multiwire proportional chamber followed by 1/8" and 1/2" thick scintillators separated by a distance of 30 cm. Pions were identified by multiparameter computer analysis of the  $\Delta E_1$  (1/8" scintillator),  $\Delta E_2$  (1/2" scintillator), two time-of-flight (RF  $\rightarrow \Delta E_1$  and  $\Delta E_1 \rightarrow \Delta E_2$ ) and two position (helix and  $\Delta E_2$  scintillator) signals. Beam currents up to 100 na were used, and pion event rates ranged from 0.5/second for  $^{10}\text{B}$  to 0.2/minute for  $^{208}\text{Pb}$ . A background level of  $\sim 1$  nb/sr was achieved.

Examples of data are shown in Fig. 2. The  $^{40}\text{Ca}$  spectrum shows 90 pion events obtained in a 90 minute run with an average beam current of 20 na. For  $^{208}\text{Pb}$ , 30 pions were observed in a 3 1/2 hr run with an average beam current of 50 na.

Table 1 summarizes the reactions that have been measured so far. For  $^{10}\text{B}(p, \pi^+)^{11}\text{B}_{\text{gs}}$  at 154 MeV, measurements were made at laboratory angles of 25, 45 and 60 degrees. For all other cases  $\theta_\pi$  (lab) = 25 degrees.

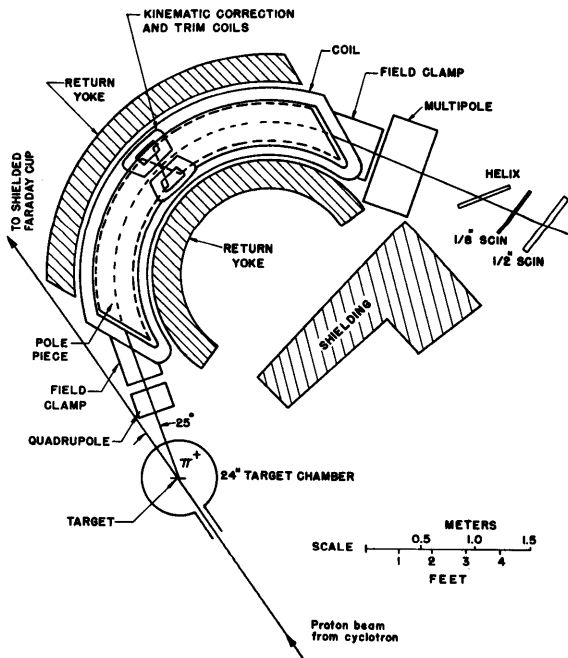
Table 1. Summary of (p,  $\pi$ ) Reactions Measured with the QDDM Magnetic Spectrograph

Reaction	Bombarding Energies (MeV)				
	152	154	156	160	164
$^9\text{Be}(p, \pi^-)^{10}\text{C}_{\text{gs}}$					?
$^{10}\text{B}(p, \pi^+)^{11}\text{B}_{\text{gs}}$	x	*	x	x	*
$^{11}\text{B}_{2.12}$				x	
$^{12}\text{C}(p, \pi^+)^{13}\text{C}_{\text{gs}}$			x	x	
$^{40}\text{Ca}(p, \pi^+)^{41}\text{Ca}_{\text{gs}}$	x	*	x	x	*
$^{51}\text{V}(p, \pi^-)^{52}\text{Mn}_{\text{gs}}$		*			
$^{90}\text{Zr}(p, \pi^+)^{91}\text{Zr}_{\text{gs}}$		*			
$^{208}\text{Pb}(p, \pi^+)^{209}\text{Pb}_{\text{gs}}$					?
$^{209}\text{Pb}_{1.42}$			?	x	*

x 3-5 September 1976 Run (40 hrs)

\* 18-20 December 1976 Run (48 hrs)

Cross sections extracted from our  $^{10}\text{B}$  and  $^{40}\text{Ca}$  data are about 5 and 1.7 times larger than those obtained at Orsay<sup>1)</sup> and Uppsala,<sup>2)</sup> respectively.



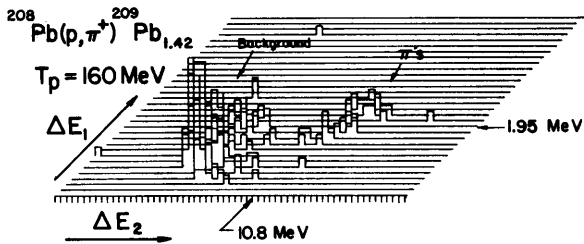
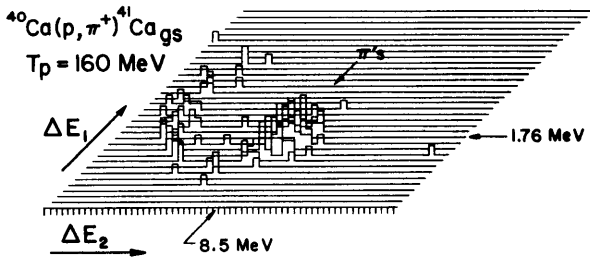


Figure 2.

Preliminary analyses of the  $^{10}\text{B}$  and  $^{40}\text{Ca}$  ( $p, \pi^+$ ) data have been carried out within the framework of the pionic stripping model using a plane-wave code written by J.G. Wills.<sup>3)</sup> The point of the plane-wave analysis was to determine qualitatively the extent to which data of this type can establish the importance of the one-nucleon (stripping) mechanism near threshold as well as the non-relativistic form of the  $\pi$ -N interaction. A DWBA code for ( $p, \pi$ ) reactions is currently being developed at Indiana by Tsangarides and Wills.<sup>4)</sup>

Positive pion production on targets heavier than  $^{40}\text{Ca}$  at bombarding energies below 200 MeV and negative pion production at bombarding energies as low as 154 MeV have not been reported previously. The  $^{208}\text{Pb}(p, \pi^+)^{209}\text{Pb}_{1.42}$

reaction was observed at IUCF to have a cross section of  $\sim 30$  nb/sr at  $25^\circ$  and 160-MeV bombarding energy.<sup>3)</sup> Preliminary cross sections for the  $^{90}\text{Zr}(p, \pi^+)^{91}\text{Zr}_{gs}$  and  $^{51}\text{V}(p, \pi^-)^{52}\text{Mn}_{gs}$  reactions at  $25^\circ$  and 154-MeV bombarding energy are  $24 \pm 10$  nb/sr and  $1.5 \pm 1$  nb/sr, respectively.<sup>5)</sup>

- 1) Y. Le Bornec, B. Tatischeff, L. Bimbot, I. Brissaud, J.P. Garron, H.D. Holmgren, F. Reide and N. Willis, Phys. Lett. 49B, 434 (1974).
- 2) S. Dahlgren and P. Grafstrom, Physica Scripta, Vol. 10 (1974) 104; S. Dahlgren, P. Grafstrom, B. Hoistad and A. Asberg, Nuc. Phys. A227, 245 (1974); S. Dahlgren, Priv. Comm. (1976).
- 3) Positive Pion Production by 148- to 160-MeV Protons on  $^{10}\text{B}$ ,  $^{40}\text{Ca}$  and  $^{208}\text{Pb}$ . R.D. Bent, P.T. Debevec, P.H. Pile and R.E. Pollock, Bull. Am. Phys. Soc. 22, 80 (1977).
- 4) M. Tsangarides and J.G. Wills, Priv. Comm. (1976).
- 5) Positive and Negative Pion Production by 154- and 164-MeV Protons on  $^9\text{Be}$ ,  $^{10}\text{B}$ ,  $^{40}\text{Ca}$ ,  $^{51}\text{V}$ ,  $^{90}\text{Zr}$  and  $^{208}\text{Pb}$ . P.H. Pile, R.D. Bent, P.T. Debevec and R.E. Pollock, Washington Meeting of the American Physical Society, 25-28 April, 1977.