

The calculation is for 1 m length and neutron energy of 100 MeV. The three curves are for scintillations at the front, middle, and back of the scintillator.

The curve for the back starts later because the difference in light paths for different emission angles is less. Figure 13b shows how the time origins of the light pulses can be made to coincide by tilting the scintillator. Compensation for the variations in rise time is then achieved with quadratic extrapolated zero timing that makes use of the approximately parabolic shape of the pulses near their origins.

The best time resolution that has been achieved in real neutron spectra at IUCF is about 0.8 ns FWHM and this has been achieved with tilted detectors, mean timing, and small detectors alike.

Two techniques were used to measure the detector efficiency at energies near 100 MeV. In one measurement neutrons from ${}^7\text{Li}(p,n){}^7\text{Be}$ were counted during proton bombardment of a fresh target with $E_p = 120$ MeV. Afterwards, the number of ${}^7\text{Be}$ nuclei created was inferred from an absolute gamma count of the ${}^7\text{Be}$ in the target. The angular distribution was measured separately. In another measurement neutrons from ${}^{12}\text{C}(p,n){}^{12}\text{N}(g.s.)$ were counted. The cross section was calculated from a measurement of ${}^{12}\text{C}(p,p'){}^{12}\text{C}(15.1 \text{ MeV})$ and the assumption of isospin conservation. Both methods yielded the result that the effective solid angle of the tilted detector is equivalent to that subtended by an area of 32% of cross sectional face (15 cm x 15 cm).

*Collaborative effort by outside user groups: C. Goodman (ORNL); B. Anderson, A. Baldwin, J. Knudson, R. Madey and T. Witten (Kent State Univ.); D. Bainum and J. Rapaport (Ohio Univ.); C. Goulding and M. Greenfield (Florida A&M Univ.); D. Lind and C. Zafiratos (Univ. of Colo.); S. Schery (Texas A&M Univ.); C. Foster (IUCF).

- 1) C.D. Goodman, J. Rapaport, D.E. Bainum, and C.E. Brient, accepted for publication in Nucl. Inst. and Meth.
- 2) C.D. Goodman, J. Rapaport, D.E. Bainum, M.B. Greenfield, and C.A. Goulding, IEEE Trans. on Nucl. Sci. NSS-25, NO. 1, Feb. 1978.

Development of Future Facilities

QQSP Pion Spectrograph

In order to increase the efficiency of data collection in reactions which produce charged pions, H. Enge of Deuteron Inc. was commissioned to design a spectrograph of modest energy resolutions with large solid angle, large momentum bite, and short flight path. The spectrograph system (QQSP) consisting of two quadrupole magnets and a split dipole magnet is shown schematically in Figure 14. The basic properties of the system are summarized in Table 8.

A contract has been awarded to Alpha Scientific, Inc. of Hayward, Ca. to carry out the engineering design and fabrication of the magnets. Delivery of the system is anticipated for the end of summer, 1978. Installation of the system in the target room shared with the 64" scattering chamber (see Figure 3) will then take place in the last quarter of 1978.

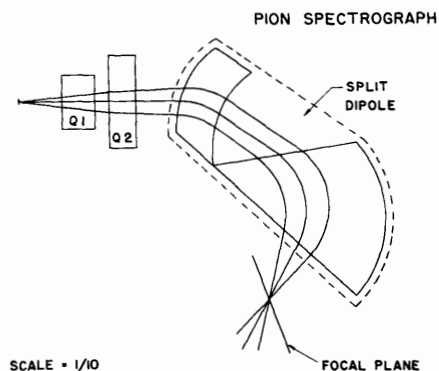


Figure 14. Schematic representation of the QQSP pion spectrograph

Table 8. Basic parameters of the QQSP pion Spectrograph.

1. Orbit radius	46.8 cm max 28.8 cm min
2. Angular range	25° to 135° continuously 0° to 10° fixed setting
3. Angular acceptance	± 100 mr horizontally ± 100 mr vertical
4. Solid angle	35 msr low momentum to 16 msr high momentum
5. Magnet gap	5.76 cm
6. Magnetic field strength	1.0 to 16.0 kG
7. Momentum range (pmax/pmin)	1.625
8. Maximum pion energy (at 16 kG)	125 MeV
9. Focal plane angle	40°
10. Dispersion along focal surface (cm/% mom)	1.1
11. Resolution ($\Delta E/E$) @ full solid angle	.2% (with ray tracing)
12. Horizontal magnification	0.3
13. Horizontal angular magnification	3.2
14. Vertical angular magnification	0.3 to 0.4
15. Vertical image at full solid angle	4.0 cm max

Beam Swinger for Neutron Time-of-Flight Experiments

The beam swinger facility described in the last annual report was relocated in the planning stages farther to the north in the accelerator building as shown in Figure 3. This places the beam dump outside the building and allows for a future experimental

station and dump associated with the QDDM spectrograph room. This move was stimulated by the rapid development of high efficiency time compensated detectors for neutron time-of-flight measurements with high energy neutrons (see P. 21 of this report). The counting rates achieved with such large volume good time resolution detectors allow experiments to be contemplated over larger angular ranges and with longer flight paths than would have been possible with the earlier floor plan. Table 9 gives the basic properties of the beam swinger system. A photograph of the main beam swinger magnet is shown in Figure 15.

Construction of the beam swinger facility was delayed somewhat by the relocation studies and funding constraints. It is now proceeding on a schedule designed to result in an operating beam line and facility by mid-summer 1978. An active group of researchers await this facility; at the December, 1977 program advisory committee meeting six proposed experiments were approved.

As part of the construction of the beam swinger facility, the old time-of-flight facility, which is made up of a target chamber, dump magnet, wall dump and slotted shielding wall, will be removed. This facility has served well in this initial operating period as techniques and detectors for doing (p,n) experiments at high energies (eventually up to 200 MeV) have been developed and refined while some rather interesting data was taken.

Table 9. Properties of the Beam Swinger for Neutron Time-of-Flight Experiments

1. Angular Sweep 0° to 26°
2. Max Particle Energies 200 MeV P's at 14.1 kG
(Designed for 900 Kg -inch in Hp)
3. Spot sizes for 200 MeV P's (Adjusting only last two quads in swinger beam line)

Swing Angle	Horizontal Waist	Vertical Waist
0	2.66 mm	3.17 mm
12.5°	2.59 mm	3.16 mm
25°	1.24 mm	2.80 mm

4. Three Magnet Systems

Entrance Magnet (40 V at 750 A) 31° bend
 Main Magnet (100V at 500 A) 26° bend
 Dump Magnet (23 V at 650 A) $\pm 13^\circ$ bend
 4" gap 14" circular pole tip

5. Five Stations covering 26° swing

- | | |
|--------------------------|---|
| (1) $0^\circ/26^\circ$ | 60 meters at present - 100 meters planned-space reserved for 200 m. |
| (2) $24^\circ/50^\circ$ | 60 meters at present - 100 meters planned-space reserved for 200 m. |
| (3) $48^\circ/74^\circ$ | 60 meters planned - 150 m reserved. |
| (4) $74^\circ/100^\circ$ | 50 meters |
| (5) $98^\circ/124^\circ$ | 30 meters |

6. 60 meter flight path with the expected time resolution $\Delta t_m = 0.5$ nsec results in an energy resolution of 800 keV for 200 MeV neutrons, 450 keV for 150 MeV neutrons and 250 keV for 100 MeV neutrons.

Figure 15. The main beam swinger magnet for the neutron time-of-flight facility being unloaded at IUCF in March 1977. This magnet is on loan to IUCF from Oak Ridge National Laboratory.

