ACTIVATION MEASUREMENTS OF THE $^7Li(p,n)^7Be$ REACTION FROM 60-480 MeV

T.E. Ward and C.C. Foster
Indiana University Cyclotron Facility, Bloomington, Indiana 47405

J. D'Auria, M. Dombsky, L. Moritz, T. Ruth and G. Sheffer
TRIUMF, University of British Columbia, Vancouver, B.C. V6T 2A3 Canada

J.W. Watson and B.D. Anderson
Department of Physics, Kent State University, Kent, Ohio 44242

J. Rapaport and T.N. Taddeucci
Department of Physics, Ohio University, Athens, Ohio 43701

Activation measurements of the $^7Li(p,n)^7Be$ (g.s. + 0.43 MeV) total reaction cross section has been made at proton energies of 60 - 480 MeV. This reaction is of some interest since it is often used to produce copious quanities of nearly monoenergetic secondary neutron beams and is used to calibrate large volume neutron time-of-flight detectors. Theoretically the extent to which the trivial 1/E dependence continues to energies above 200 MeV depends upon the cancellation of energy dependent terms in the t-matrix element and the energy dependence of the optical potential in DWIA analysis.[1]

Watson et al.[2] have noted most recently that a comparison of methods for determining neutron detector efficiencies at medium energies using the "isospin Clebsch-Gordon Ratio" and "Monte-Carlo" calculational code disagree with the "Lithium Activation" (LiA) results of Ref. 1 in the 100-160 MeV region by 10-20%. The blame for this discrepancy has been placed on the targets chosen for the Li activation in Ref. 1. They used ^7LiCl composite targets without knowing that chlorine would contribute substantially at the higher energies (>120 MeV). To be sure, a cascade code calculation would have predicted a negligable $Cl(p,x)^7Be$ contribution at all energies below 200 MeV. The salt targets were used since they could be stored without vacuum over long periods of time.

The total production cross section for the $^7Li(p,n)^7Be$ (g.s. + 0.43 MeV) reaction was measured by observing the 478 keV γ-ray following the 10.4 ± 0.1% electron capture (EC) branch of the decay of ^7Be (53.29d). The targets used for the present study were isotopically pure (99.999%) ^7Li metal discs (dia.=2cm) with target thicknesses of 10-100 mg/cm^2. In addition, at IUCF ^7LiCl targets (~40 mg/cm^2) and KCl targets (~100 mg/cm^2) were also irradiated and the ^7Be yields measured at energies of 60, 135, 160 and 190 MeV. Irradiations at IUCF were performed in the neutron-time-of-flight facility (NTOF) and in the isotope production area using an external Faraday cup to monitor the beam. Irradiations at the TRIUMF cyclotron were made at proton energies of 190-480 MeV using beam current integration by the simultaneous production of ^{24}Na in thin (≈2 mg/cm^2) aluminum catchers.

The results of the present experiment are given in Table I where we show a comparison of the ^7Li metal and ^7LiCl results. The differences were shown to be due to the production of ^7Be in the $Cl(p,x)^7Be$ reaction which has a strongly increasing excitation function between 60 and 200 MeV. At 200 MeV the $Cl(p,x)^7Be$ reaction contributes about 20% to the $^7LiCl(p,x)^7Be$ total cross section. This was substantiated by irradiation of KCl targets and measurement of the ^7Be production cross section between 60 and 190 MeV. Counter experiments by Viola et al.[3] have been investigating this unusual reaction process; however, the reaction mechanism is little understood.

In Fig. 1. we show our results plotted along with the previous Li activation results of Ref. 1 and the results of Ref. 2 up to an energy of 200 MeV. The values for Ref. 2 were obtained by integrating the differential cross section for comparison. The LiA, ICGR, and calculated Monte-Carlo code efficiencies now agree at all energies up to 200 MeV to within ±10% uncertainty. The predictable energy dependence and measurement of the LiA cross section up to 480 MeV now enables one to calibrate large volume neutron detectors up to that energy. Measurements of the $^7Li(p,n)^7Be$ total reaction cross-section are planned at 800 MeV at LAMPF in 1984.

Table I. $^7Li(p,n)^7Be$ Total Cross Sections

Ep(MeV)	σ(mb) Metal	^7LiCl
60	12.02±1.02	12.00
62		11.28
69		10.78
79		8.09
80	7.96±0.80	
89		7.46
100		7.29
119		5.29
120	4.88±0.41	
135	4.30±0.43	5.31
144		4.97
157		4.56
160	3.77±0.40	4.52
175		3.50
190	3.01±0.24	3.50
191	2.85±0.21	
199		
252	2.58±0.30	3.46
301	1.74±0.14	
349	1.41±0.26	
400	1.51±0.31	
480	1.11±0.13	

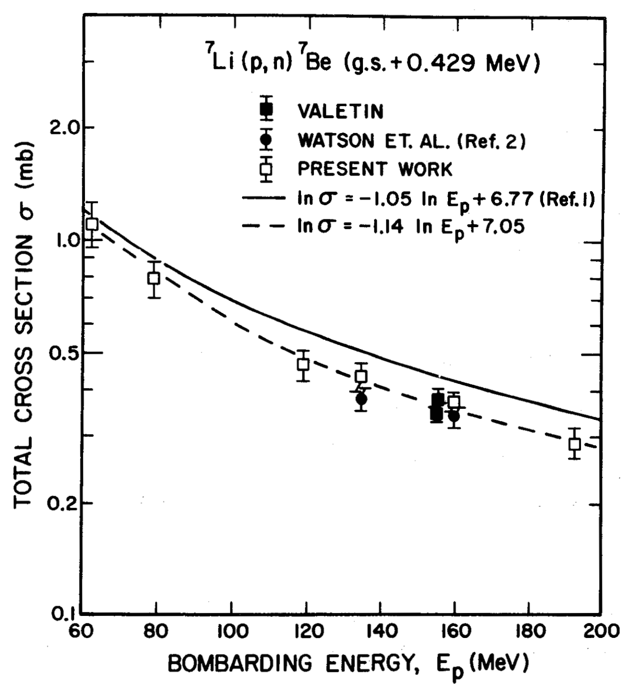

Figure 1. Comparison of $^7Li(p,n)^7Be$ total cross section in the energy range 60-200 MeV. The solid line fits the previous ^7LiCl results (Ref. 1) and the dashed curve is fit to present work.

1) T.E. Ward et al., Phys. Rev. C 25, 762, (1982).

2) J.W. Watson et al., Nucl. Inst. Methods (1984).

3) V.E. Viola, Jr., Nucl. Chem. Annual Report (1983).