The formation of light mass fragments with $A \leq 6$ produced in interactions of protons with a variety of light to heavy target elements is of much interest due to the uncertainty of the reaction mechanism. Recent studies at IUCF and TRIUMF have been investigating production of light elements with intermediate energy proton reactions on targets of Al, Si, and Ag respectively. These counter studies have obtained high quality differential cross section data and energy spectra. Green, Korteling and Jackson have studied the reaction $Ag(p,IMF)X$ at energies of 210-480 MeV, where IMF refer to intermediate mass fragments. They found that the fragment spectra were little affected (except in overall magnitude) with changes in the incident proton energy. Furthermore, a majority fraction of the IMF yield (> 75% for Li and > 98% for Oxygen) was non-evaporative and could be described in terms of an isotropic emission process in the rest frame of the
moving source. They found that the total isobaric cross sections could be fit to a power law of the form \( A^p = \) in the fragment mass with \( p = 3.71 \). In the study of Kwiatkowski, et al.\(^1\) the reaction \( \text{Al}(p,\text{IMF})X \) was studied at \( E_p = 180 \text{ MeV} \) and compared with INC calculations. The data at 180 MeV exhibit many similarities with data at 2.1 and 4.9 GeV proton bombardments of \( ^{27}\text{Al} \). The INC comparison at 180 MeV describes peripheral, quasifree processes adequately but is unable to account for the light fragment yields or their angular distributions, in particular, no significant yield for \( A = 7 \) was predicted although substantial yields were observed. It was noted that these data are of considerable interest relating to studies of cosmic-ray origins and propagation.\(^5\)\(^-\)\(^7\)

Irradiations were performed in the isotope production facility at IUCF at proton energies of 60, 100, 135, 160, 190 and 200 MeV. Targets consisted of natural Si metal discs (77 mg/cm\(^2\)) and KCl discs (~100 mg/cm\(^2\)). Similarity at TRIUMF thin Al foils (~2 mg/cm\(^2\)) were irradiated at proton energies of 300, 400 and 480 MeV. Following irradiation the \( \gamma \)-ray spectra of the targets was analysed for the production of \( ^7\text{Be}(53.3\text{d}) \) by observing the 478 keV \( \gamma \)-ray in the 10.4\% EC decay to \( ^7\text{Li} \).

The activation measurements of the \( \text{Si}(p,^7\text{Be})X \) and \( \text{KCl}(p,^7\text{Be})X \) reactions made at IUCF are displayed in Fig. 1 along with data on Si by Rayudu.\(^7\)\(^,\)\(^8\) A global set of data for the reaction \( ^{27}\text{Al}(p,^7\text{Be})X \) is shown in Fig. 2 for the energy range of 30 MeV to several GeV including our recent measurements conducted at TRIUMF. In the region of 60 MeV - 1 GeV the energy dependence of the IMF excitation function for Si follows a power law of the form \( \sigma(E) = c_0 E^{0.74} \) with the slope little changed by either \( A \)-fragment or \( A \)-projectile. The contribution of
\(^7\text{Be}\) to the total mass 7 isobaric yield has been measured in counter experiments (for example Ref. 1 and 2) and found to be approximately 15%. At \(E_p=180\ \text{MeV}\) on \(^{27}\text{Al}\) the \(^7\text{Be}\) yield is 1.4 mb, a value in good agreement with the global data set. Using the extensive set of excitation function data for the production of \(^7\text{Be}\) from various targets ranging from \(^{12}\text{C}\) to \(^{197}\text{Au}\), the target mass-energy dependence was determined. The cross sectional data were fit to a power law of the form

\[ A_{\text{prod}} \propto W^{-1} \text{where } W = (E_0 - E_p) \text{ in MeV}. \]

The parameters \(a = 2.65 \times 10^{-3} \text{MeV}^{-1}\) and \(E_0 = 931\ \text{MeV}\) were found to fit the low energy (65-335 MeV) data very well. Above 1 GeV the experimental slope approaches zero and at \(E_p > 2\ \text{GeV}\) the slope becomes positive and constant (Slope=1.8). The constant value is in keeping with concepts of limiting fragmentation at relativistic energies.

Further work on the \(A(\alpha, ^7\text{Be})X\) and \(A(^3\text{He}, ^7\text{Be})X\) reactions at 200 and 270 MeV, respectively are in progress and will be reported at a later date.

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7) G. Rayudu, JINC 30, 2311 (1968).