

DECAY OF HIGHLY EXCITED NUCLEI

CONTINUUM SPECTRA OF H AND He IONS FROM IN THE 156-MeV $p+^{27}\text{Al}$ REACTION

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Complete continuum spectra of H and He isotopes have been measured at IUCF for the 156-MeV $p+^{27}\text{Al}$ reaction. The primary goals of this study were: (1) to examine pre-equilibrium decay models for complex fragment emission, and (2) to provide calibration data to be used in the evaluation of bit upsets caused by nuclear reactions in microelectronic components when exposed to both natural and man-made radiation.

Spectra of ^1H , ^2H , ^3H , ^3He and ^4He ions were measured over the angular range 10° to 165° with a time-of-flight/particle-identification telescope consisting of silicon elements of thickness $75\mu\text{m}$, $400\mu\text{m}$, and 5mm , respectively and a 10-cm NaI crystal. Time-of-flight mass identification was used to identify particles which stopped in the first detector element. With this arrangement all H and He ions above 2 MeV in energy were identified.

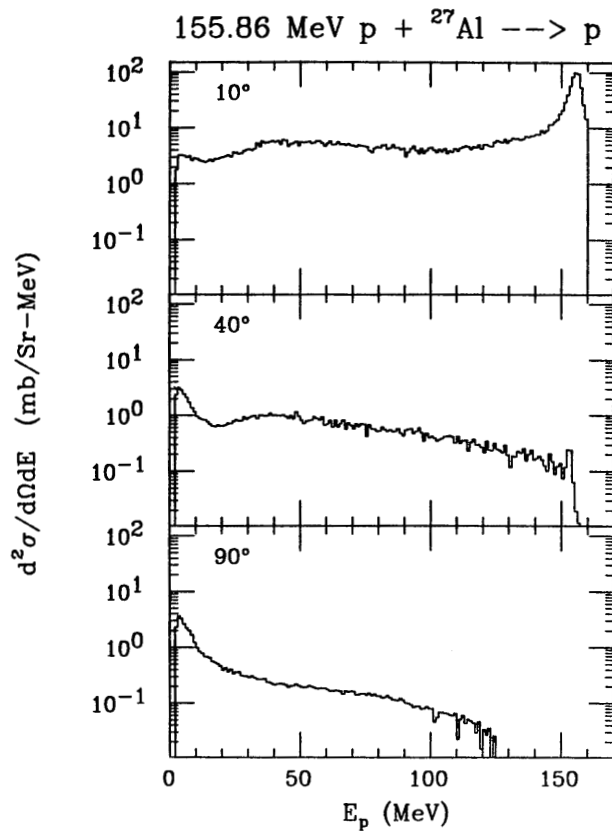
In Fig. 1(a) and (b) energy spectra for proton and alpha-particle ejectiles are shown for representative angles. The proton spectra shown in Fig. 1(a) exhibit the well-known features consisting of an evaporation peak at low energies, elastic scattering at the maximum energies, and a broad, nearly flat distribution between these extremes. With increasing angle an exponentially-decreasing slope appears in the spectra.

The ^4He spectra shown in Fig. 1(b) are characterized by an evaporation peak at low energy and an exponentially-falling pre-equilibrium distribution which decreases in slope rapidly with increasing emission angle. The angular distributions for all H and He isotopes are shown in Figs. 2(a) and (b). The H isotope yields all decrease exponentially in the forward hemisphere, but are essentially isotropic beyond 90° . The He spectra are peaked near 25° – 30° and then undergo a gradual exponential decrease with increasing emission angle. Total cross sections are given in Table I. The large cross sections for ^4He ions, combined with the peaking of the spectra at low fragment energies, makes this component of the spectra particularly important for radiation damage studies; i.e., these ejectiles exhibit the largest cross-section-weighted dE/dx values. Fits to these data with the IBM cascade code¹ are presently underway at IBM Corp.

Table I

Ejectile	^1H	^2H	^3H	^3He	^4He
cross section (mb)	960	84	18	20	160

(1a)



(1b)

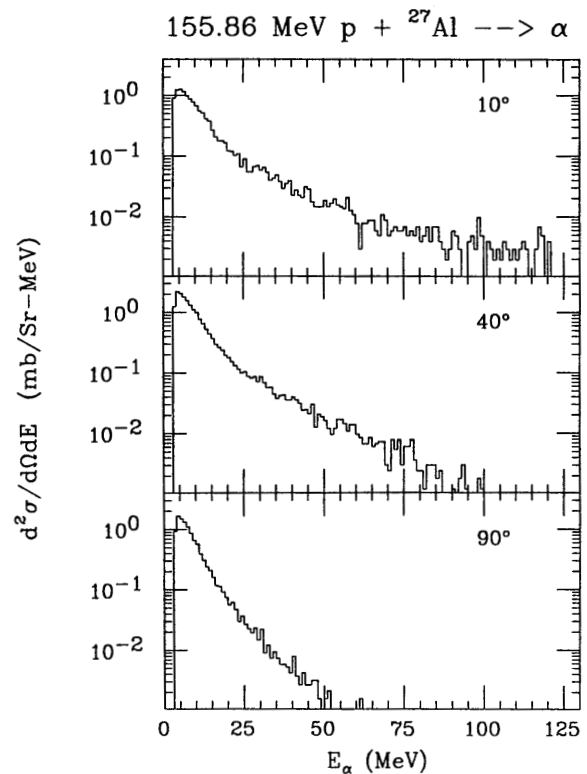


Figure 1. Kinetic energy spectra for (a) protons and (b) alpha particles emitted from the 156-MeV p + ^{27}Al reaction at angles of 10°, 40° and 90°.

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1. H. Tang, N. Azziz, and G. Srinivasan, submitted to Phys. Rev. C.

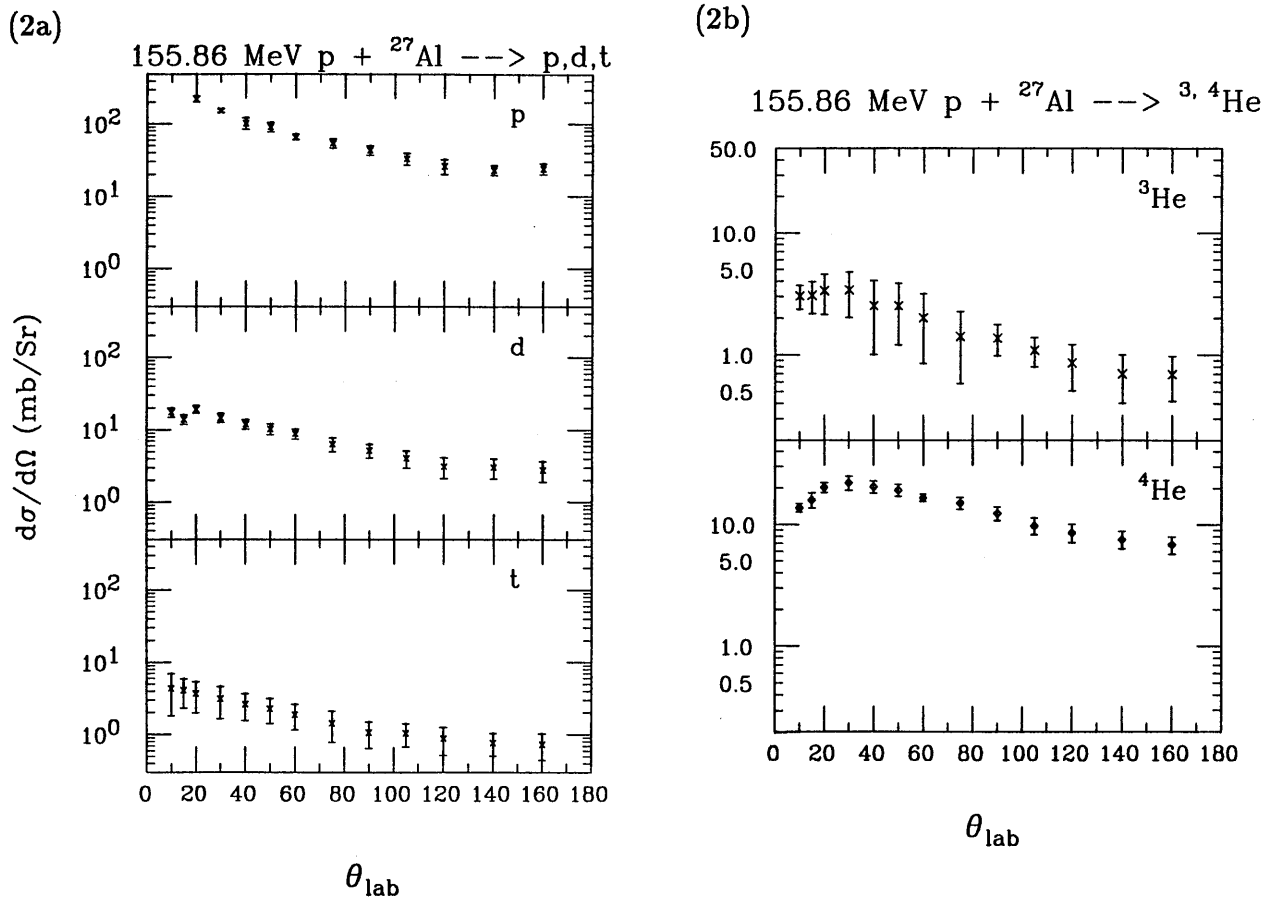


Figure 2. Angular distributions for (a) hydrogen isotopes and (b) helium isotopes produced in the 156-MeV p + ^{27}Al reaction.

ISOTOPIC SIGNATURES OF COMPLEX FRAGMENT EMISSION MECHANISMS

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Isotopic yields of Z- and A-identified intermediate-mass fragments (IMF: $3 \leq Z \lesssim 15$) have been examined in order to investigate non-equilibrium mechanisms responsible for the formation of these ejectiles in intermediate-energy collisions. From previous studies¹ it is known that IMF yields at forward angles are dominated by non-equilibrium processes, as deduced from strongly forward-peaked angular distributions and kinetic energy spectra much more energetic than predicted for emission from an equilibrated compound nucleus. The elemental yields follow a power-law dependence, $\sigma(Z) \propto Z^{-\tau}$, where τ is typically 2-5.