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Very-High Energy ($E \rightarrow E_{beam}$) Light Particle Production Near 0° in Heavy-Ion Collisions, $E/A \leq 40$ MeV/u.

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Studies of heavy-ion collisions at $E/A \sim 10$ MeV/u to 20 MeV/u with the production of nucleons and other particles at forward angles with velocities several times that of the projectile have been observed by many groups (TAM, ORNL, MSU, HMI). This is usually attributed to projectile fragmentation with Fermi motion of the light particle[1,2] which is often described by a source temperature T_s, accounting for the additional velocity component. However, experiments reported by Borcea *et al.*[3] and those done[4] at the Hahn-Meitner Institute (VIKSI) have suggested that high-energy alpha particles observed near $\theta = 0°$ in ^{20}Ne-induced collisions, $E/A \leq 20$ MeV/u, may arise from mechanisms such as cluster transfer reactions. Here we report observation of a similar phenomenon with a variety of projectiles ($Z \geq 8$), $E/A = 9$ to 40 MeV/u.

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The projectiles and bombarding energies studied are shown in Table I. Most of the data presented here were taken using a 50 mm diameter by 150 mm long BGO scintillator situated 0.5 m to 1 m behind a tantalum target which also served as a beam stop and permitted measurements at $\theta = 0°$. Additional detectors (NaI), were situated at angles $\theta \geq 0°$. The BGO detector could stop protons up to about 400 MeV and α particles up to 1.5 GeV. Particles were identified in the BGO using time-of-flight (TOF) while those in the NaI($T\ell$) were identified with a combination of pulse-shape discrimination (PSD) and TOF. In addition to thick-target measurements at $\theta = 0°$ we have also recently utilized a thin/thick target scheme with TOF used to separate the thin target spectra from the thick target spectra. This allows us to take spectra at $\theta = 0°$ with a well-defined beam energy (unlike the thick target stopped-beam data).

Some of the light particle spectra observed at $\theta = 0°$ are displayed in Figures 1 and 2. They typically peak at an energy near that corresponding to the projectile velocity (although the spectra shown are cut off by lower discriminators), then fall off as $\sim \exp - E_L/T_L$ (where E_L is the fragment's lab energy and T_L is a slope parameter) and finally turn over and reach some end-point energy, E^0_{max}. This type of spectrum is typical of a 3-body phase-space with some threshold Q value determining E^0_{max}, *i.e.* the kinematic energy limit at $\theta = 0°$. In the case of the ^{16}O projectiles (Fig. 1), the α spectra near $\theta = 0°$ extend out to

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