Inelastic scattering of alphas on ^{24}Mg as a surrogate for stellar carbon burning

J.M. Munson,[1] E.B. Norman,[1] J.T. Burke,[2] R.J. Casperson,[2] E. McCleskey,
M. McCleskey, R. Hughes,[2] S. Ota, [2] A. Czeszumska,[1]
A. Saastamoinen, and A. Spiridon
[1]*University of California-Berkeley, Berkeley, California*
[2]*Lawrence Livermore National Laborator, Livermore, California*

The carbon burning nuclear reactions ^{12}C(^{12}C,α)^{20}Ne, ^{12}C(^{12}C,p)^{23}Na, and ^{12}C(^{12}C,n)^{23}Mg are important during supernova explosions as well as in the later stages of evolution for larger stars. The Gamow window for these reactions is typically around 1.5 MeV, however direct measurements at energies in this range are very diffcult due to the large coulomb barrier. A surrogate measurement was made by inelastically scattering alpha particles on ^{24}Mg. This allows the relative reaction rate for each reaction channel to be investigated in an energy region inaccessible to direct measurement.

The final measurement for this project was made at the TAMU Cyclotron Institute using the K150 Cyclotron and the STARLiTeR target chamber and detector system. This run, not including setup, ran from November 11, 2014 until November 18, 2014. A 40 MeV alpha beam was directed at a thin enriched ^{24}Mg target, and the emitted particles and gammas were detected by two "S2" type silicon detectors and six "Clover" germanium detectors respectively.

Fig.1 is the result of coincidence measurements in the silicon detectors for the scattered alpha and the ejected particle. Horizontal bands indicate states in the daughter nuclei. For excited states of the daughter the coincident emitted gamma was used in the identification of an event as well.

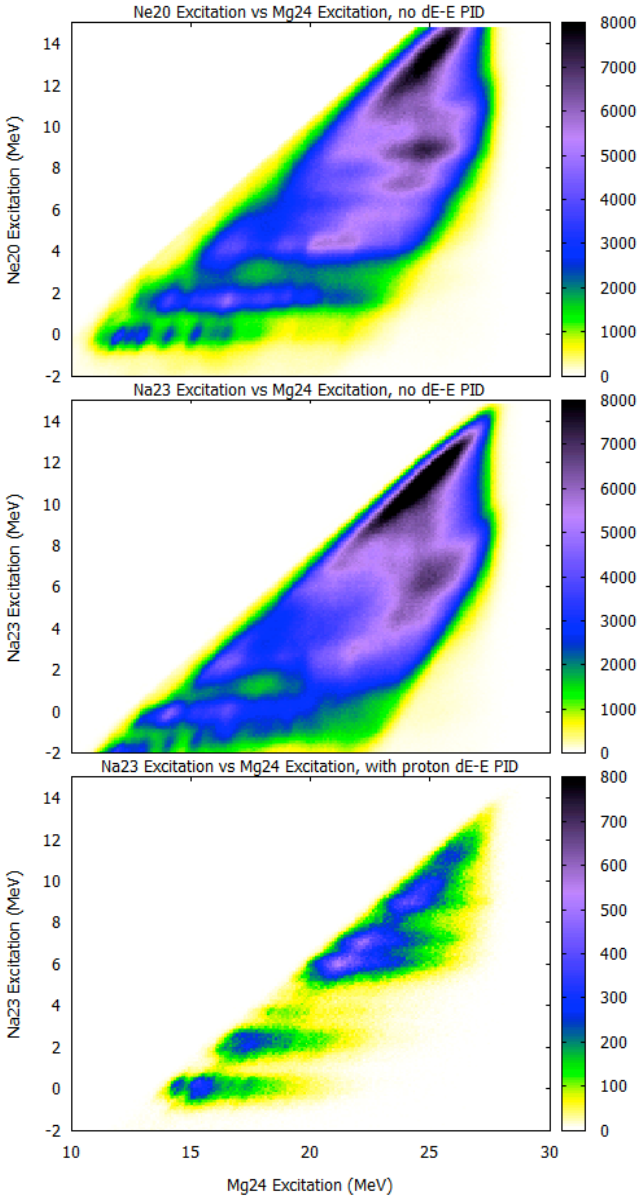

FIG. 1. ^{24}Mg and product nucleus excitation.

The alpha and proton branching ratios, including separate branches for the ground and excited states of the resulting ^{20}Ne and ^{23}Na, as well as the neutron channels populating the first state of ^{23}Mg were successfully measured for the excitation range of interest for a ^{12}C+^{12}C compound nucleus in stellar environments. These measurements are shown in Fig. 2. The

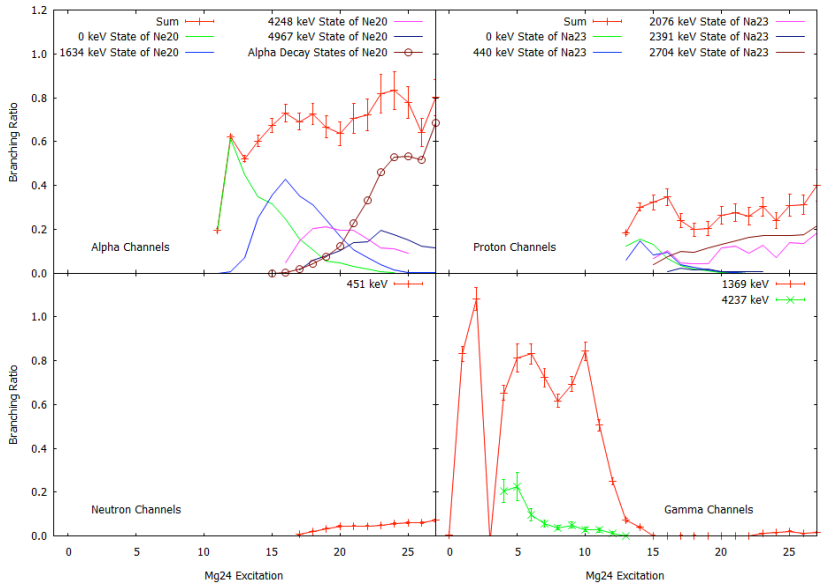

FIG. 2. Branching Ratios.

summed branching ratios for the alpha,

proton, and neutron channels are show in in Figure 3, and are normalized such that the total of all measured branches is 1. Prior to normalization, the sum of all branching ratios in the energy range of interest was close to 1.

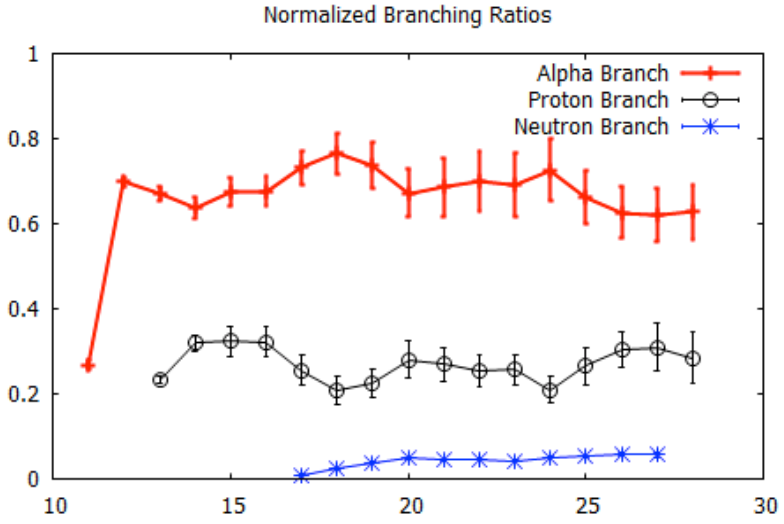

FIG. 3. Normalized Branching Ratios.

Additionally, angular scattering cross sections for a 40 MeV beam on ^{24}Mg were determined for several excited states using the same data. These measurements are shown in Fig.

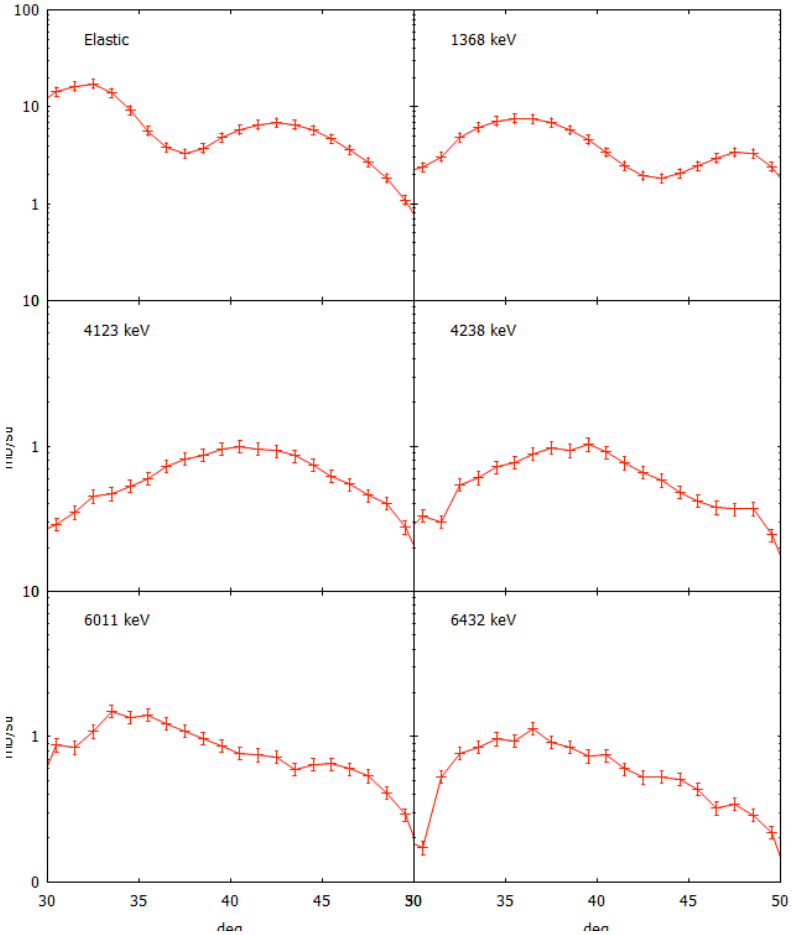

FIG. 4. Scattering Partial Cross Sections.

4.