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EMMA: The Electromagnetic Mass Analyser

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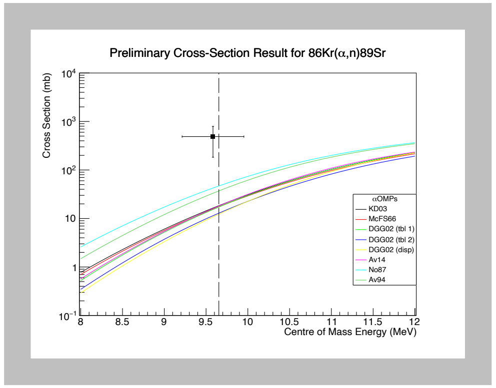
Overview

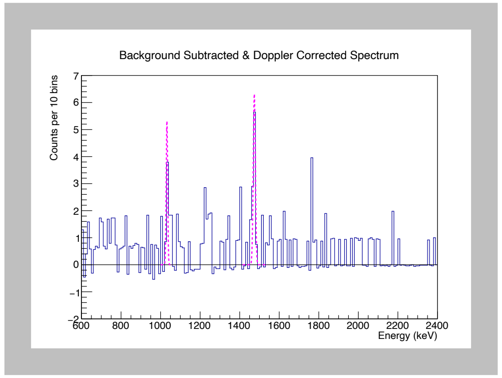
Based in the ISAC-II facility at TRIUMF, EMMA is designed to separate and identify different nuclei as they recoil from reactions induced by a beam on a target. It can be used to study reactions that are important for nuclear astrophysics. Most recently, an experiment to measure the cross section of the ^{86}Kr(α,n)^{89}Sr reaction was conducted. This reaction is important for nucleosynthesis in core-collapse supernovae.



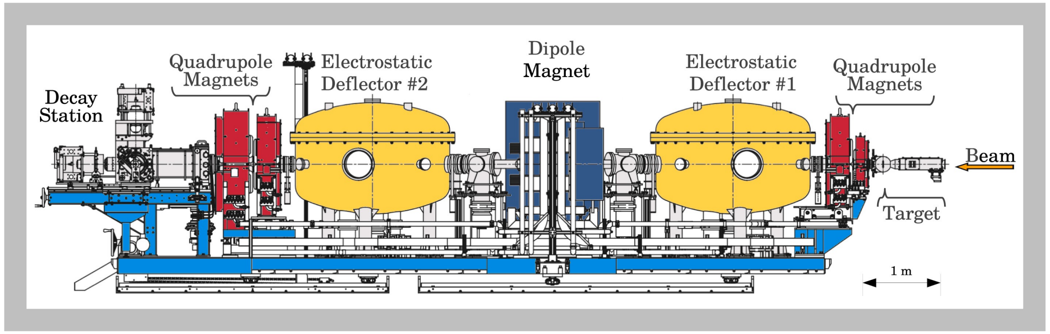
Preliminary results from the ^{86}Kr(α,n)^{89}Sr measurement. The dashed line indicates the upper limit for the astrophysical energy range and the coloured lines are Hauser-Feshbach cross section predictions made using different models of alpha optical potential.

The Weak *r*-process and ^{86}Kr(α,n)^{89}Sr

The weak r-process in core-collapse supernovae is a possible site of nucleosynthesis for the lighter heavy elements ($26 < Z < 45$). There are few available cross section measurements for (α,n) reactions at temperatures of $2 < T_9 < 5$. Models must rely on Hauser-Feshbach theory to predict cross sections; this introduces a significant source of uncertainty into the nucleosynthesis calculations. Thus, it is necessary to measure these cross sections experimentally and ^{86}Kr(α,n)^{89}Sr was selected as it has a significant impact on the final nucleosynthesis predictions. EMMA was coupled to TIGRESS, a gamma ray spectrometer, to allow detection of gamma rays in coincidence with recoiling nuclei.



Part of the ^{89}Sr gamma ray spectrum after coincidence gating by EMMA. Coloured lines are fits of known gamma rays.



A labelled diagram of EMMA. The recoils enter from the right after a reaction and are stopped at the focal plane on the left (labelled as the Decay Station).

Separating Recoils

Nuclei recoiling from induced reactions pass through a series of electric and magnetic fields which deflect their trajectories. The magnitude of this deflection depends upon the mass-to-charge ratio (m/q) of the recoils. The recoils are detected at the focal plane, the position of their detection depends on each recoil's m/q ratio and is measured by a multi-wire proportional chamber (MWPC). When the m/q value is not enough to distinguish different isotopes, ΔE-E is provided by an ionisation chamber and silicon detector behind the MWPC.

Conclusion & Future

EMMA is a recoil separator, able to identify different nuclei based on their m/q values. Together with TIGRESS, EMMA has studied several important reactions, most recently the cross section of ^{86}Kr(α,n)^{89}Sr at energies relevant for the weak r-process. The data analysis of this experiment is ongoing.

Work is progressing to build SHARC-II, a development of SHARC which will to couple to EMMA and TIGRESS and will allow the simultaneous measurement of ejected (charged) particles and gamma rays as well as the recoiling nuclei measured by EMMA.

Discovery, accelerated