Production of Nuclei on the Proton Dripline

{ Isaiah Richardson and Dr. Brian Roeder } Texas A&M University, Cyclotron Institute

Introduction

Exotic radioactive beams are of interest in a multitude of fields in physics such as Nuclear Astrophysics. In order to study the properties of these beams they must be created in a laboratory. Using the K500 cyclotron and the Momentum Achromat Recoil Spectrometer (MARS) at Texas A&M we can produce and separate particular exotic beams of interest [1].

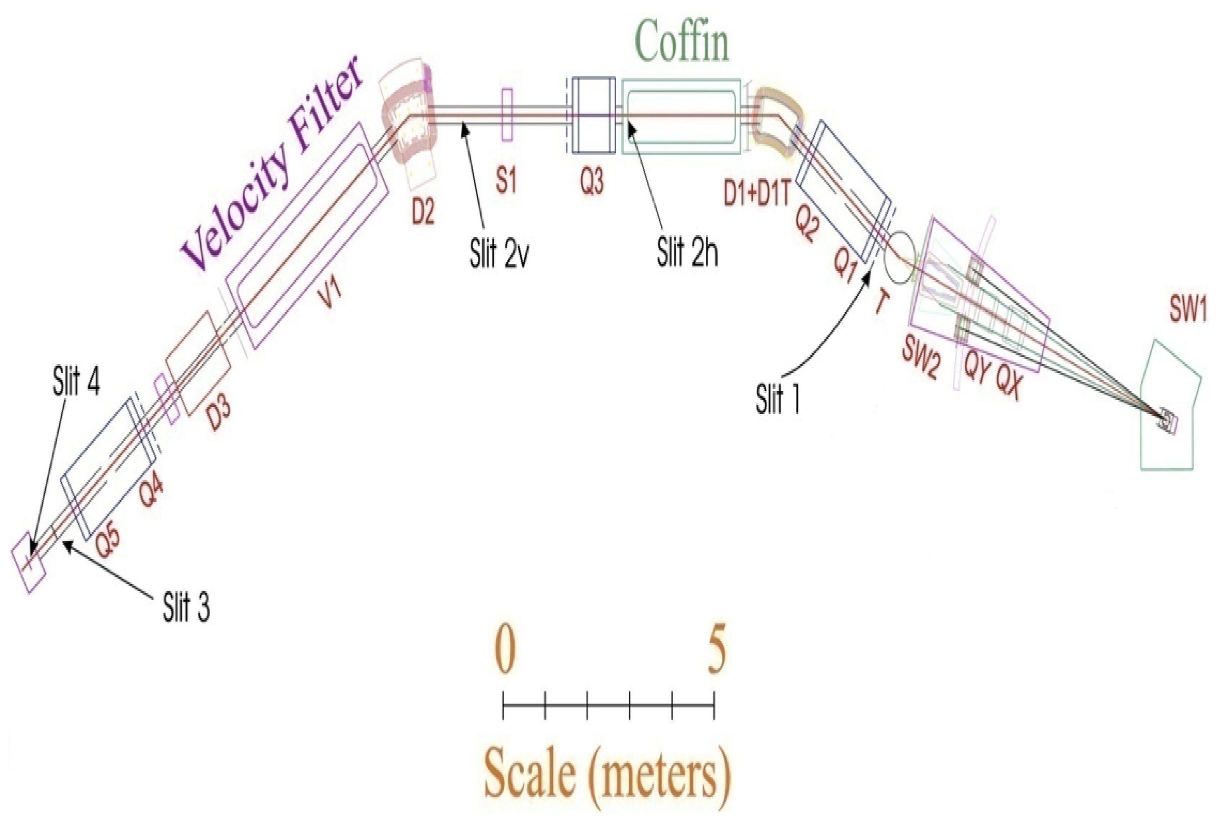

Figure 1: Schematic of the Momentom Achromat Recoil Spectrometer at Texas A&M.

The goal for this experiment is to determine how much ^{35,36}Ca we can make with a ^{40}Ca beam at 40 MeV/u on 100μm Ni, 254μm Al, and 456μm Be targets. We then take the production rates from experiment and compare it to the production models in our spectrometer simulator, LISE++ [2].

Method

We use the parameters LISE++ predicted to determine how to tune MARS for the experiment. A beam from the K500 cyclotron travels into MARS which impinges upon a target. The products then are separated by magnetic rigidity, and the primary beam is blocked by a graphite faraday cup in the coffin which reads the beam current. The products are further filtered by the velocity filter which seperates isotopes by their charge to mass ratio. The products are detected by our ΔE vs. E Si telescope which is read as an electronic signal and recorded by our DAQ setup. Particles can then be identified based on their vertical position and energy loss in the Si telescope [3].

Particle Identification

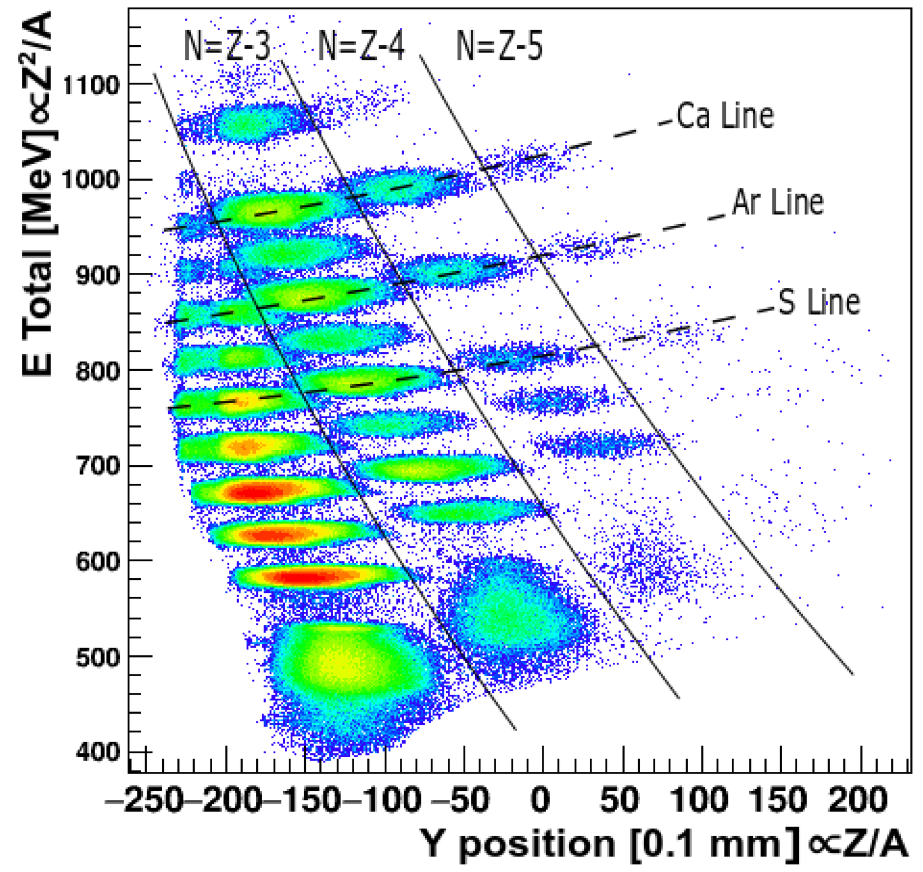

Figure 2: Particles Identified for the ^{40}Ca beam on Ni target with MARS tuned for ^{35}Ca.

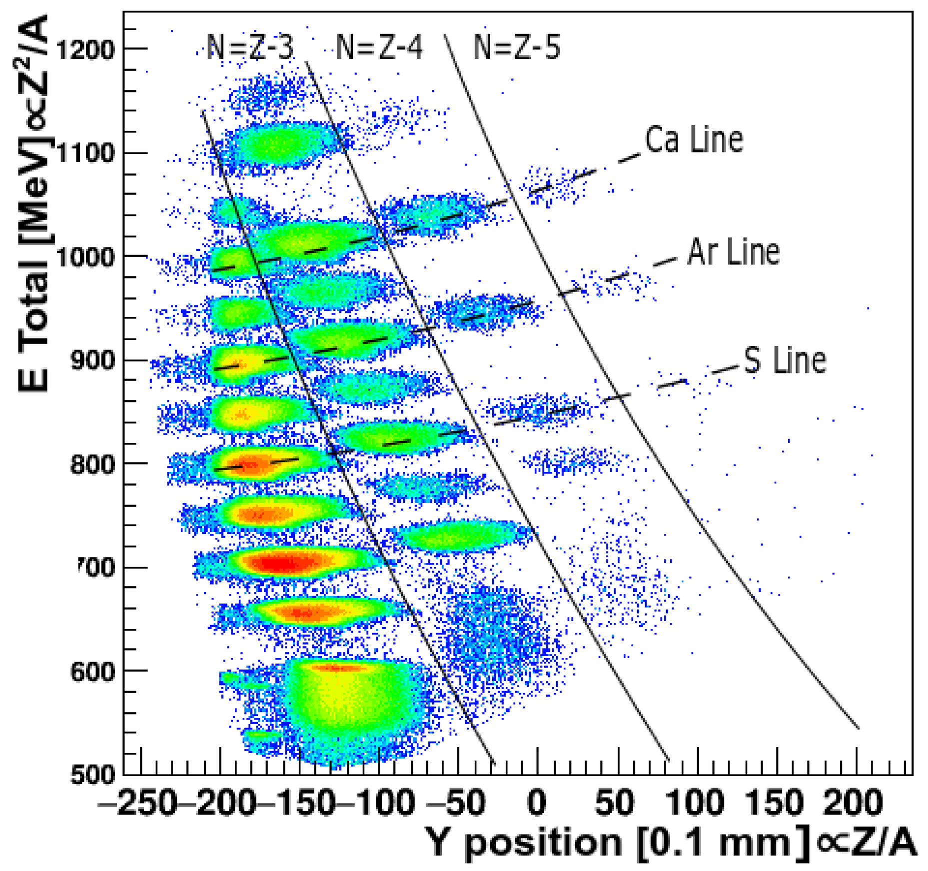

Figure 3: Particles Identified for the ^{40}Ca beam on Al target with MARS tuned for ^{35}Ca.

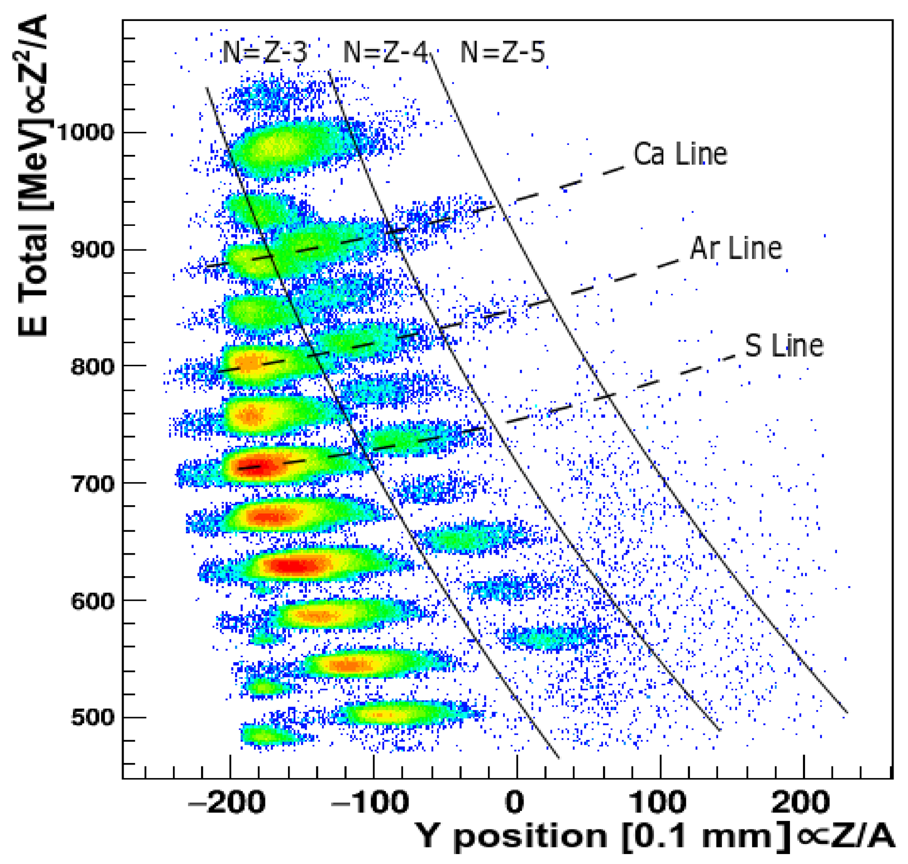

Figure 4: Particles Identified for the ^{40}Ca beam on Be target with MARS tuned for ^{35}Ca.

Results

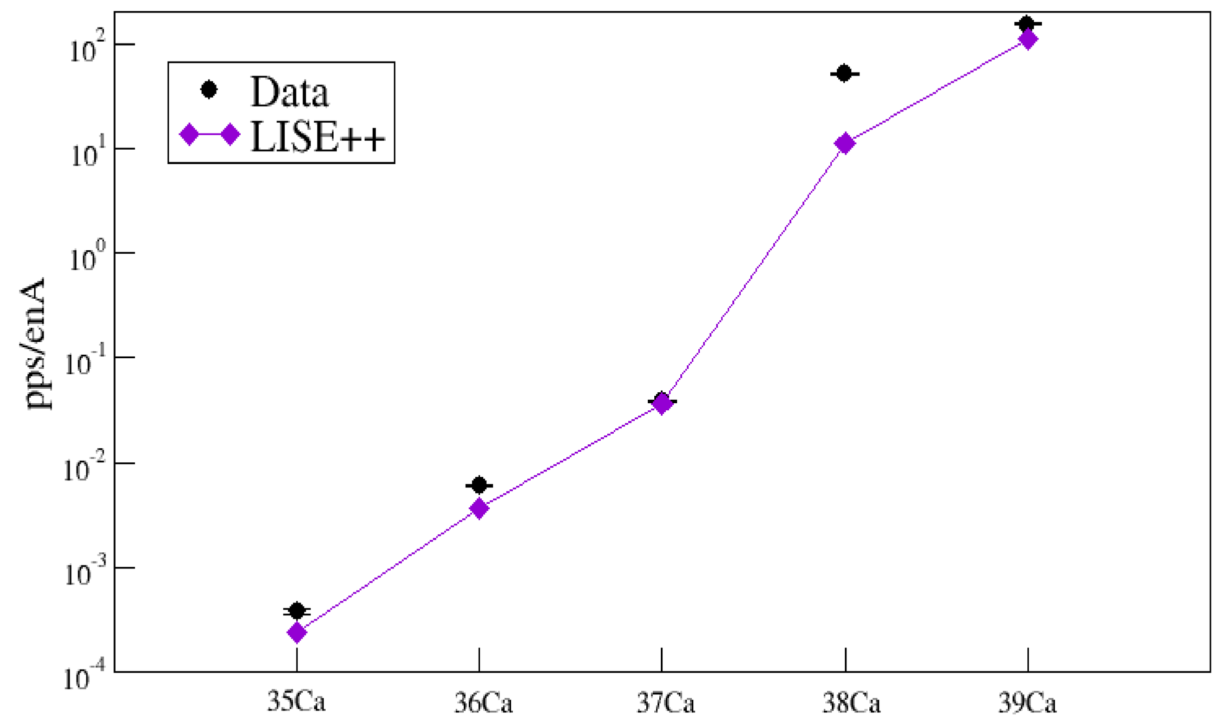

Figure 5: Yields for ^{40}Ca+Ni reaction compared to LISE++ predicted rates using the projectile fragmentation reaction mechanism. The particles per second per enA when multiplied by the beam current gives the production rates for ^{35,36}Ca.

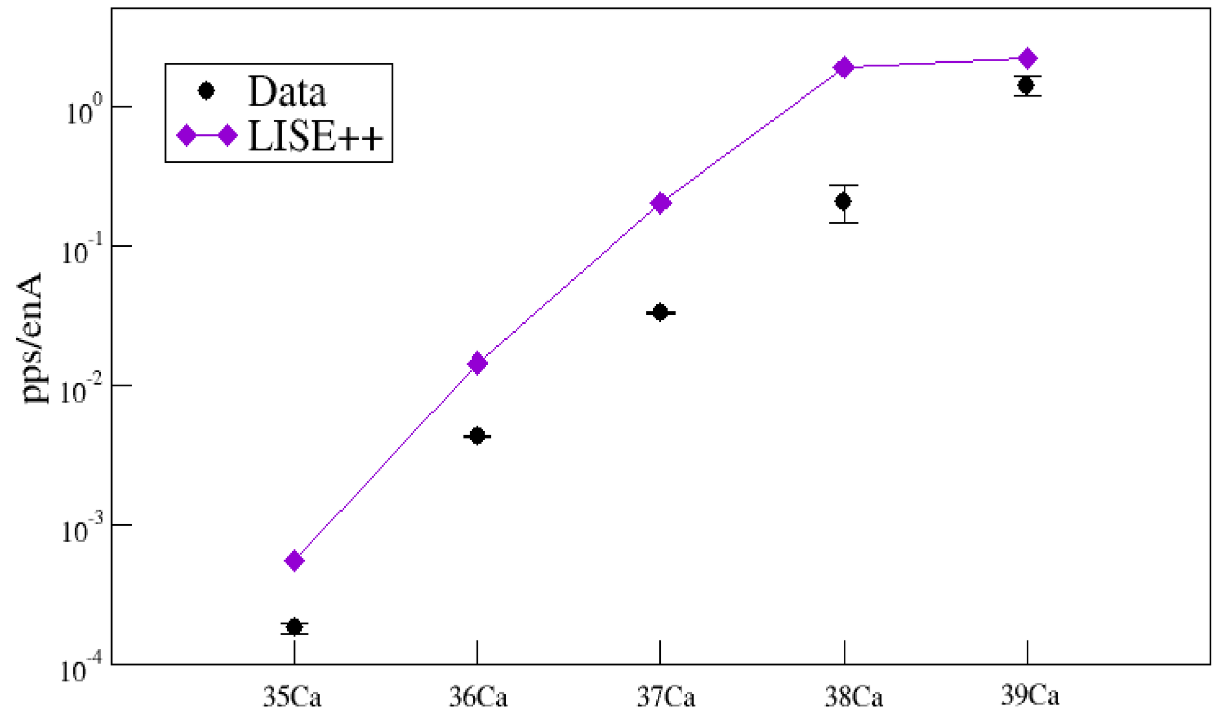

Figure 6: Yields for ^{40}Ca+Al reaction compared to LISE++ predicted rates using the projectile fragmentation reaction mechanism. The particles per second per enA when multiplied by the beam current gives the production rates for ^{35,36}Ca.

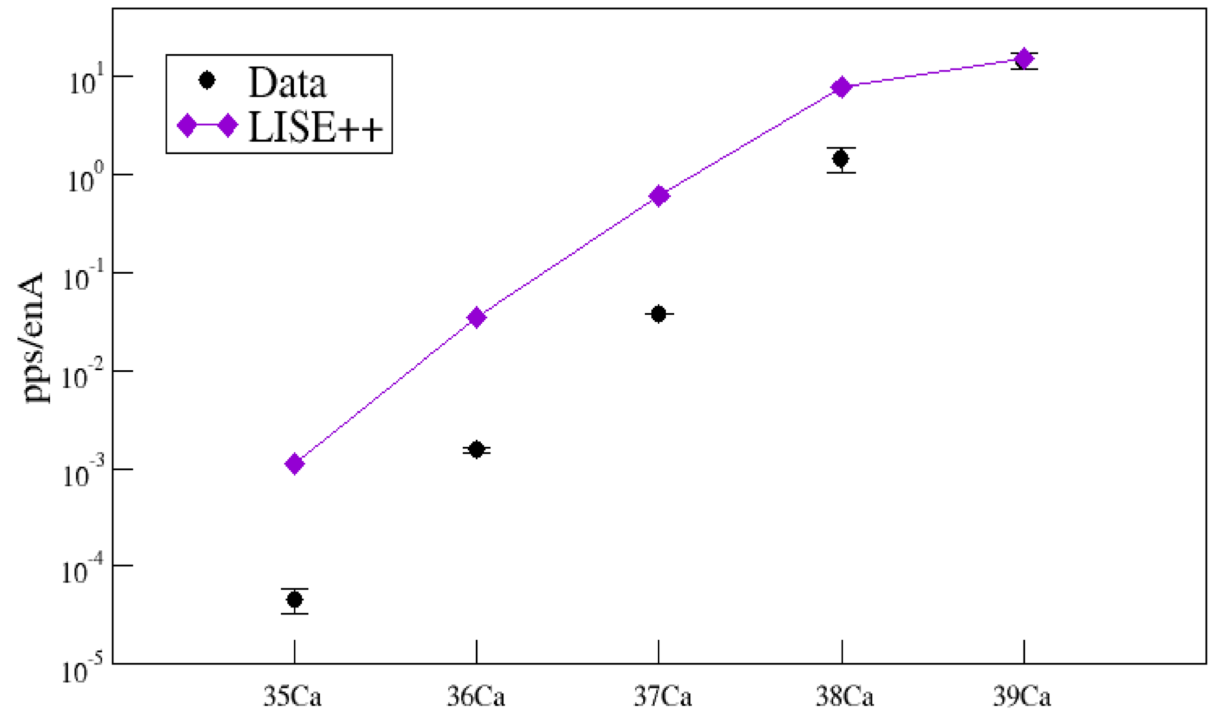

Figure 7: Yields for ^{40}Ca+Be reaction compared to LISE++ predicted rates using the projectile fragmentation reaction mechanism. The particles per second per enA when multiplied by the beam current gives the production rates for ^{35,36}Ca.

Conclusion

From this experiment we found that the Ni target has a higher production rate for ^{35,36}Ca than what LISE++ predicted at this energy. The amount of beam available was ∼60 enA which allows us to calculate production rates from each reaction. The ^{40}Ca+Ni reaction produced was ∼82 ^{35}Ca per hour and ∼1295 ^{36}Ca per hour. The Al and Be targets not only underperform in comparison to the LISE++ predictions, but produces less ^{35,36}Ca than the Ni target. The ^{40}Ca+Al reaction made ∼40 ^{35}Ca,∼933 ^{36}Ca per hour, and the ^{40}Ca+Be reaction made ∼10 ^{35}Ca,∼328 ^{36}Ca per hour.

Future Research

We wish to further explore what isotopes on or near the proton dripline Texas A&M is able to produce for various future experiments. The creation of a ^{35}Ca beam allows for the study of its β-delayed proton/2-proton emission which can give interesting information such as a measurment of the half-life of ^{35}Ca, and decay modes of daughter nuclei from the decay [4].

Acknowledgements

I would like to thank Dr. Brian Roeder and Dr. Antti Saastamoinen for their mentorship throughout this project, Dr. Mike Youngs for taking the overnight shift to collect data for the Ni target, and the Cyclotron Institute for granting me an opportunity to learn and work with nuclear physics for the summer. This project was funded by the NSF REU Grant (PHY-1659847).

References

[1] R.H. Burch R.E. Tribble and C.A Gagliardi. Nucl. Instrum. Methods Phys. Res. A285:441, Dec. 1989.

[2] O.B. Tarasov and D. Bazin. Nucl. Instrum. Methods Phys. Res. B266:4657, Oct. 2008.

[3] J.F. Ziegler, J.P. Biersack, and U. Littmark. *The Stopping and Range of Ions in Solids*. Stopping and ranges of ions in matter. Pergamon, 1985.

[4] M. Lewitowicz et al. Beta-Decay of Light Nuclei Close to the Proton Drip-Line: ^{40}Ti and ^{35}Ca. *Nuovo Cim.*, 111A:835, 1998.