Production of Radioactive Beams on the Proton Dripline using MARS

Rebekah Roundey

Texas A&M Cyclotron Institute

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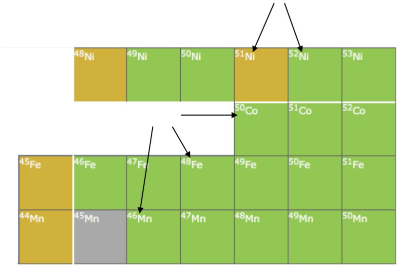
Motivation

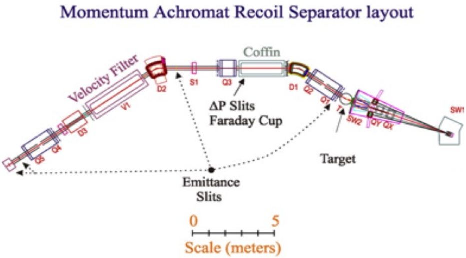
- Properties of nuclei on proton dripline important to study of r-p process
- Must produce nuclei to study these properties
- Ni+Ni reaction previously used at high energies (74.5 MeV/u) to produce nuclei on dripline
- Projectile fragmentation is dominating reaction mechanism at these energies

Purpose

- Determine which isotopes can be produced at available energies
- Calculate production rates
- Compare targets, stripper foil for optimum production rates
- Compare products and rates to simulation program LISE++
- Products of interest: $^{52}\mathrm{Ni}$, $^{51}\mathrm{Ni}$, $^{50}\mathrm{Co}$ $^{48}\mathrm{Fe}$, and $^{46}\mathrm{Mn}$



MARS Spectrometer



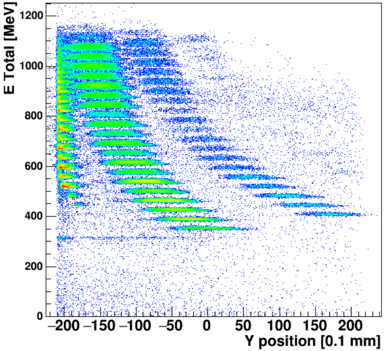
- Momentum Achromat Recoil Separator
- Filters particles by magnetic rigidity and velocity
- Separates products by charge/mass ratio in y-position on detector
- Can be tuned for magnetic rigidity of individual isotopes.

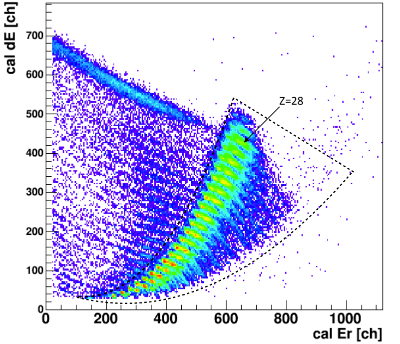
Methods

- Ni (100µm) and Be (304µm) targets used
- Carbon stripper foil (.44µm) after target–should create higher production rates
- $^{58}\mathrm{Ni}$ beam at 36 MeV/u used
- Two Si detectors used at end of MARS
- For each target tuned for both $^{53}\mathrm{Ni}$ and $^{52}\mathrm{Ni}$

Particle Identification

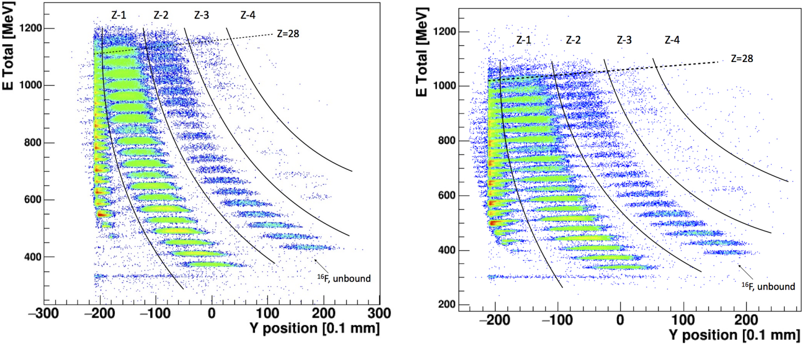
Data gate to eliminate background ($^{53}\mathrm{Ni}$)





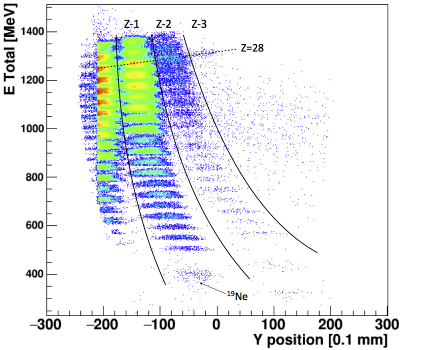
Particle Identification

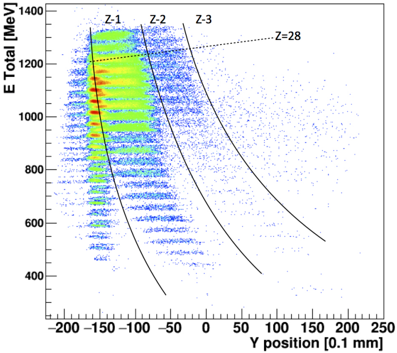
Nickel target, tuned for ^{53}Ni on left and ^{52}Ni on right



Particle Identification

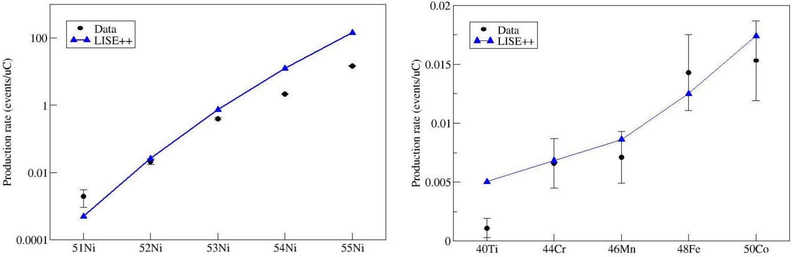
Beryllium target, tuned for ^{53}Ni and ^{52}Ni





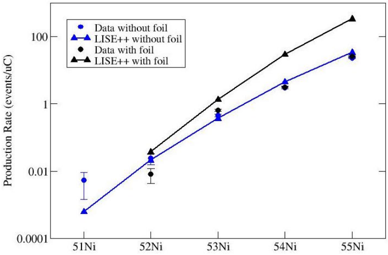
Results

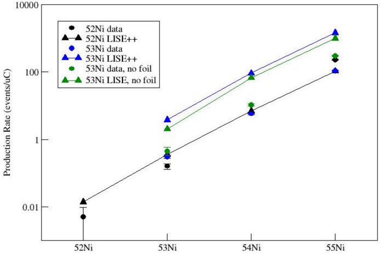
Tuned for $^{52}\mathrm{Ni}$



Results

Nickel target tuned for $^{53}\mathrm{Ni}$ and Beryllium target





Results

Comparison of Beryllium and Nickel targets (production rates in events/μC)

		Be target		Ni target	
		LISE	data	LISE	data
^{52}Ni tuning	^{51}Ni	.0002	0	.0005	.002
	^{52}Ni	.014	.005	.0259	.0211
	^{53}Ni	.354	.159	.731	.3956
	^{54}Ni	6.92	6.173	12.3	2.14
	^{55}Ni	105	232	141	14.7
		LISE	data	LISE	data
^{53}Ni tuning	^{52}Ni	.008	0	.037	.008
	^{53}Ni	3.81	.305	1.32	.656
	^{54}Ni	91.9	5.66	29.1	3.161
	^{55}Ni	1440	109	330	25.5

Summary

- Able to populate predicted isotopes on the dripline with Ni target
- Carbon foil failed to improve production rates
- Accurate LISE++ predictions for set rigidity
- Production rates for Nickel target higher, more consistent with prediction than Beryllium target.

Future Work

- Produce isotopes along dripline from similar reactions such as $^{54}\mathrm{Fe}$ beam on Ni target.
- Study β-delay proton emission from nuclei in this region

References and Acknowledgements

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Stripper Foil and Charge States

Predicted distribution of charge states without foil (on left) and with foil (on right)