

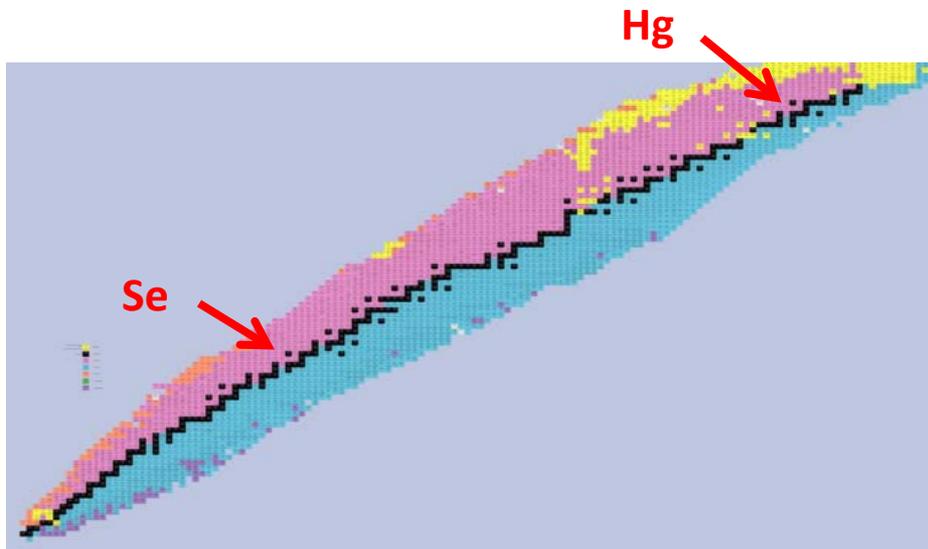


A γ -Summing NaI (SuN) Detector for p-process Reactions

Stephen Quinn
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Background

- *p-nuclei* – 35 stable proton-rich isotopes located between Se and Hg
- *p-process* – the synthesis of *p-nuclei*
- existing nucleosynthesis models do not accurately reproduce the abundances of *p-nuclei*
- need to identify and study important reactions in the *p-process* to improve these abundance calculations
- many of the estimated important reactions involve unstable nuclei*



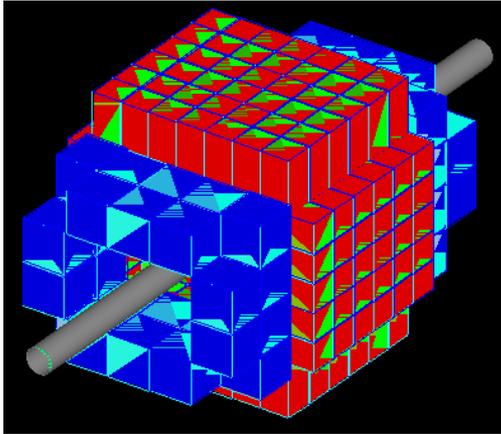


Our Research

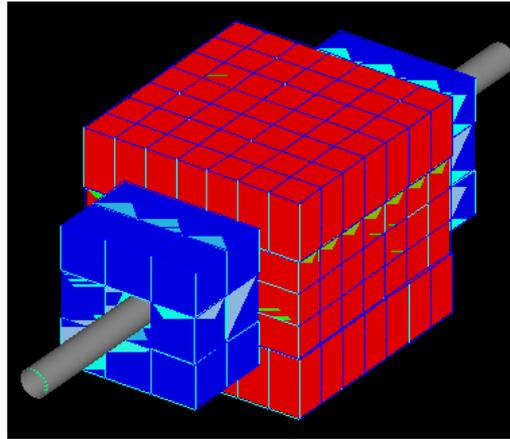
- Improve the understanding of the production of p-nuclei by placing constraints on nucleosynthesis reactions
- Perform cross-section measurements at energies corresponding to a supernova explosion where p-process reactions take place
- Develop new methods to study reactions involving unstable nuclei
- With ReA3 we have radioactive ion beams at relevant energies, now we just need a detector...

CAESAR

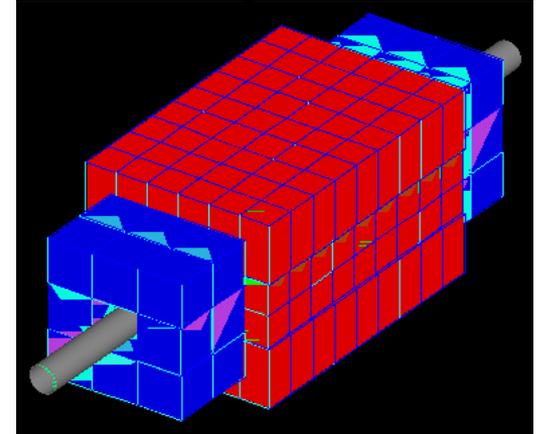
CAESAR



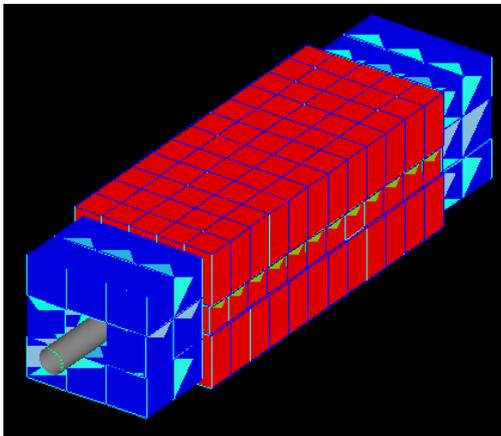
reconfiguration 1



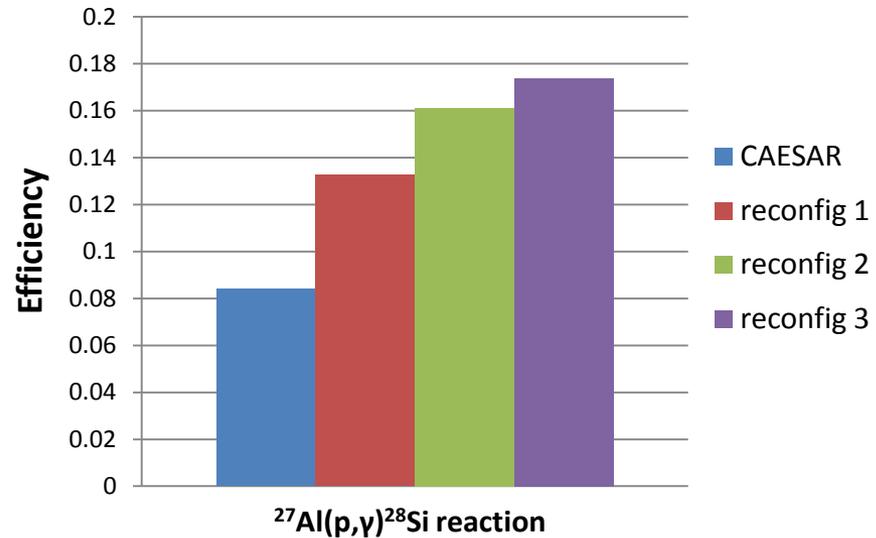
reconfiguration 2



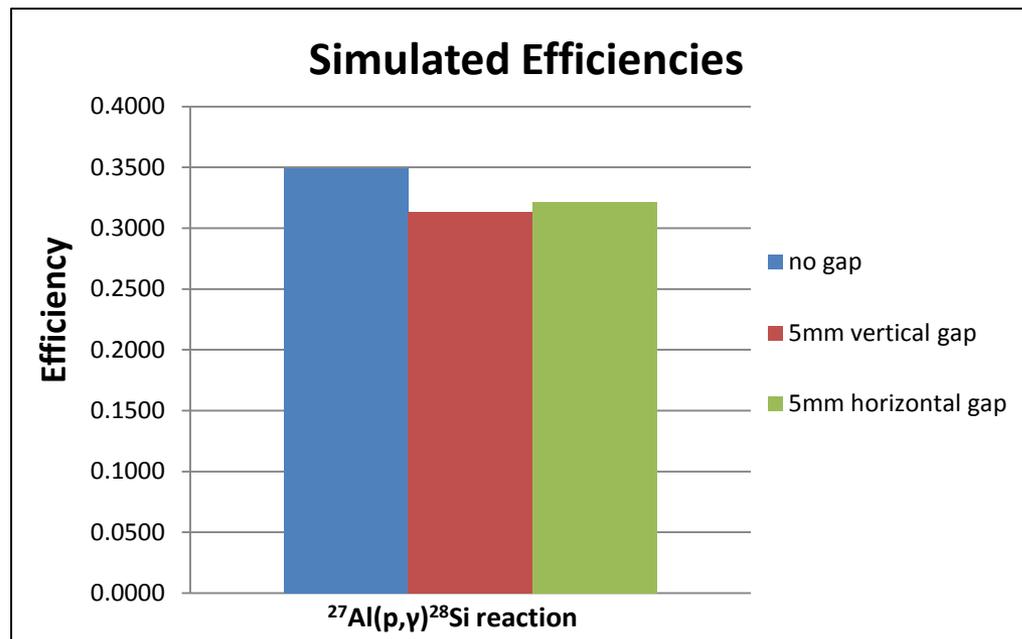
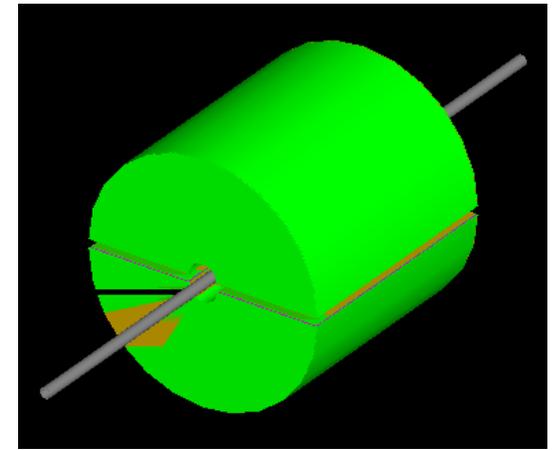
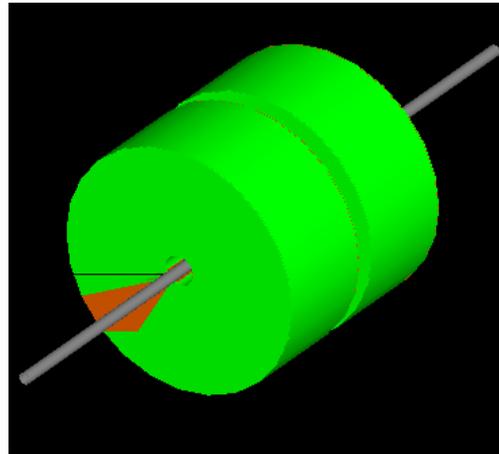
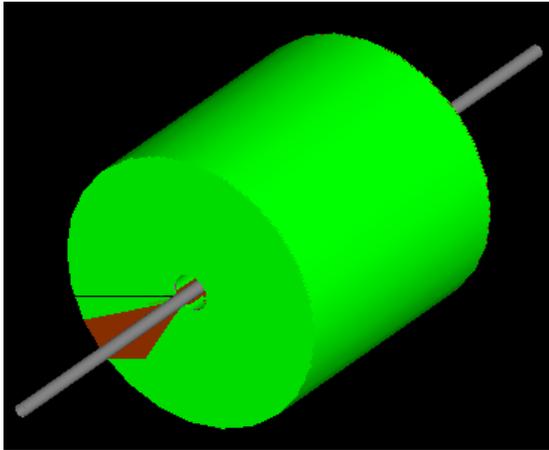
reconfiguration 3



Simulated Efficiencies



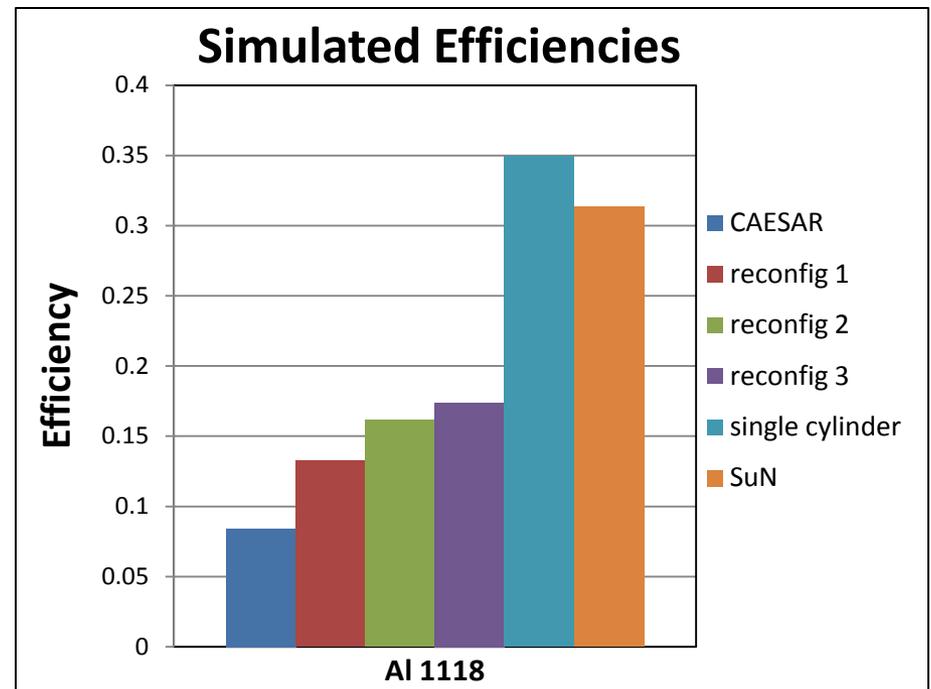
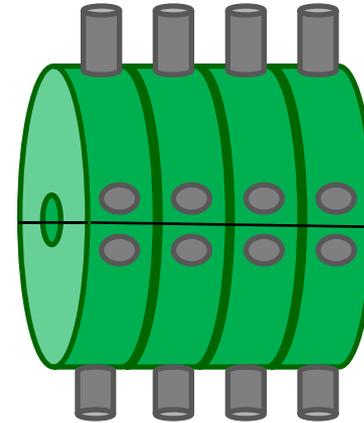
Cylindrical Detectors



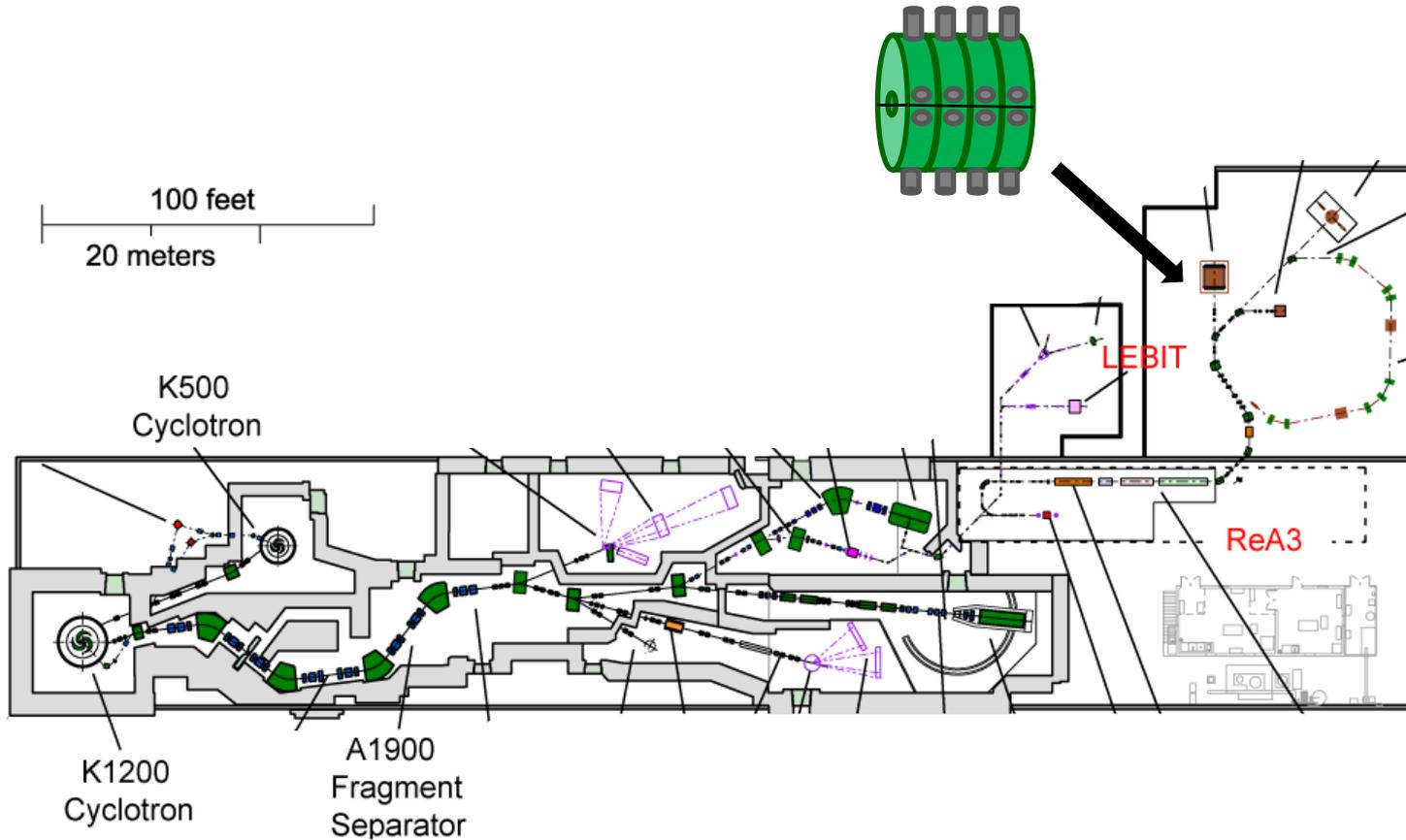
γ -Summing NaI Detector (SuN)

Features:

- 16" (40.6cm) in length
- 16" (40.6cm) in diameter
- 4.5cm borehole
- divided into top and bottom
- 8 segments of NaI crystal
- 3 PMTs per segment
- aluminum casing

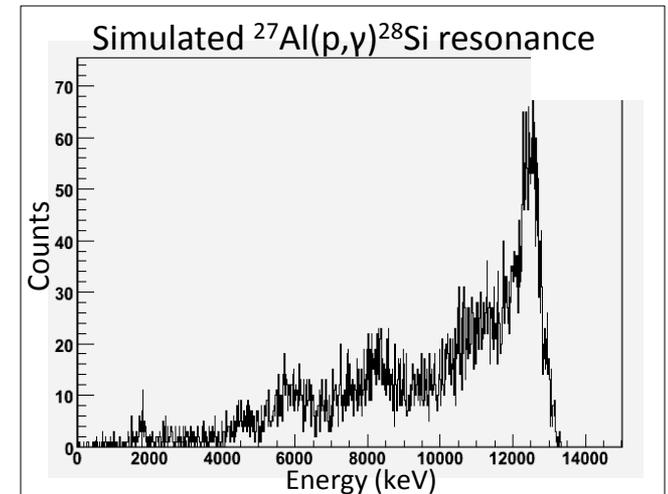
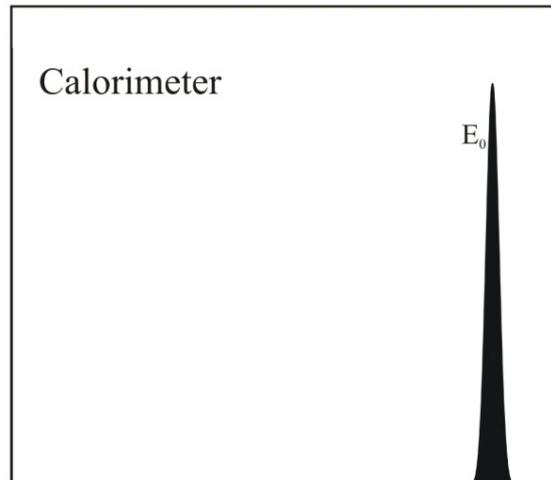
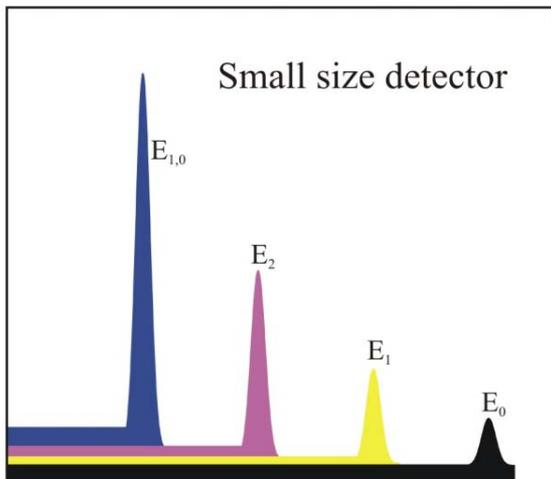
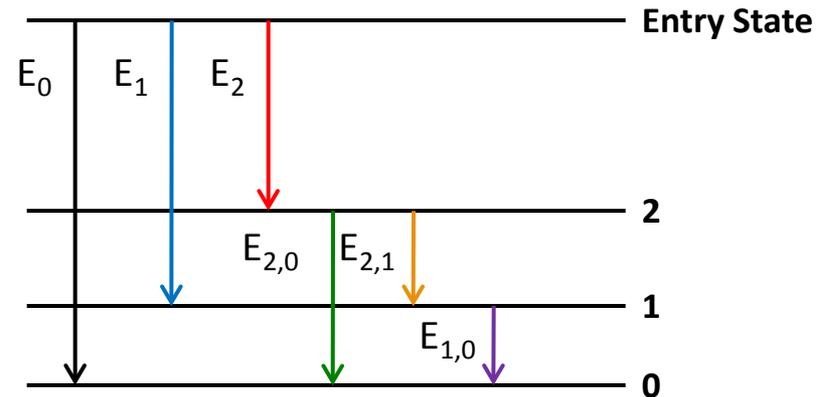


Experimental Setup



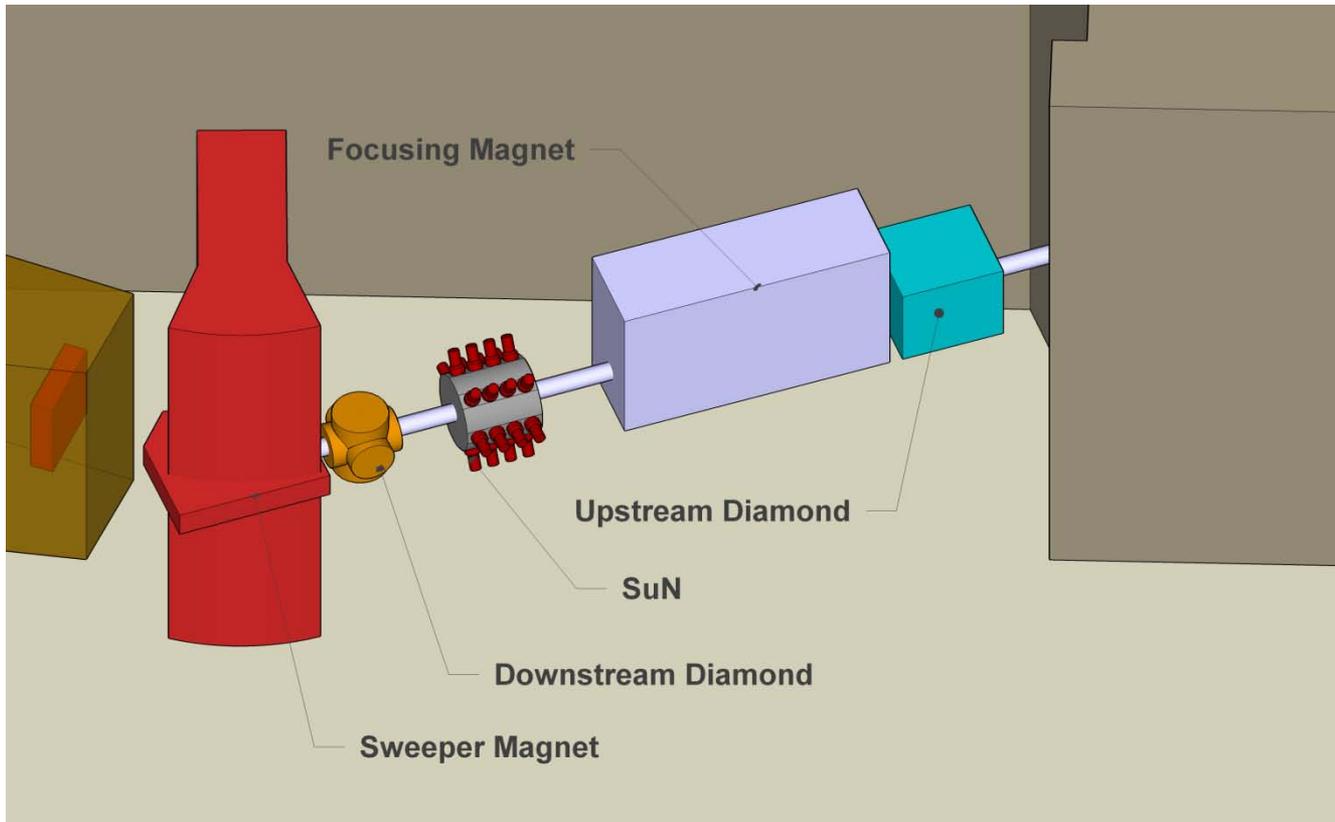
The γ -Summing Method

- Use a large volume γ -ray detector so that the emitted photon is totally absorbed
- Result is one common peak equal to the sum of the individual peaks
- Only need to analyze one γ peak



First Experiments

- $^{78}\text{Kr}(p,\gamma)^{79}\text{Rb}$
- $^{77}\text{Br}(p,\gamma)^{78}\text{Kr}$
- $^{118}\text{Te}(\alpha,\gamma)^{122}\text{Xe}$





Summary

- The SuN detector will be arriving at the NSCL soon as part of the effort to develop new techniques to study radioactive nuclei in the p-process
- Its primary use will be studying these reactions to improve nucleosynthesis models
- Its design allows for improved efficiency over existing detectors, as well as a method to correct for Doppler effects
- A possible first experiment is $^{78}\text{Kr}(p,\gamma)^{79}\text{Rb}$

Acknowledgements

- Artemis Spyrou
- Benjamin Stefanek



Radioactive Nuclei and the p process

SELECTED (γ, p) OR (n, p) REACTIONS

Reactions

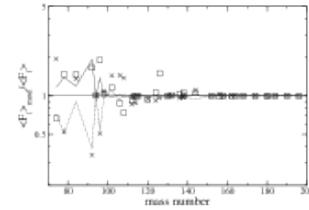
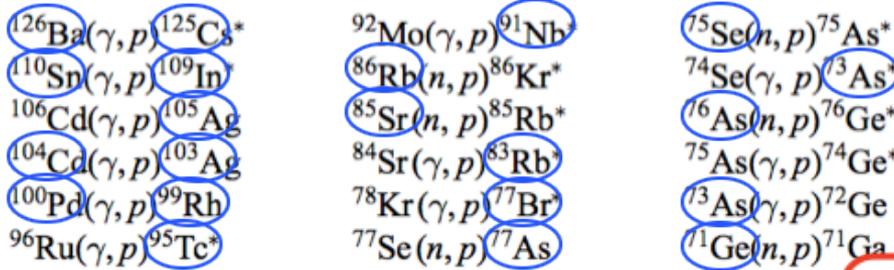


Fig. 11—Same as Fig. 10, but modifying only the (γ, p) rates of all p-nuclei and their rates (γ, p) rates by factors of 1.7 (solid line) and 3 (dashed line).

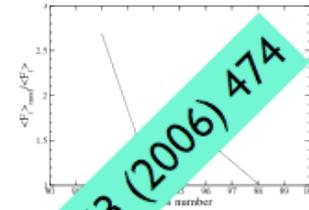


Fig. 12—Same as Fig. 10, but modifying only the (γ, p) rates of all p-nuclei and their rates (γ, p) rates by factors of 1.7 (solid line) and 3 (dashed line).

near the $N = 50, 82$ closed neutron shells, where the (γ, p) reaction flow changes into a (γ, p)-dominated reaction flow pattern. In addition, the weak sensitivity of the p -abundances to the individual feeding and depleting processes of p -nuclei typically occur on odd N -nuclei with lower Q -values. These p -nuclei have higher rates compared to neighboring (γ, p) reactions on even N -nuclei. They are therefore not expected to be equally important bottlenecks in the p -process.

In the case of (γ, p) dissociation reactions, the impact on the abundances of p -nuclei in the p -process is based on inverse processes, a modification of the rates of these reactions based on the modified rates to those based on the original rates. The squares

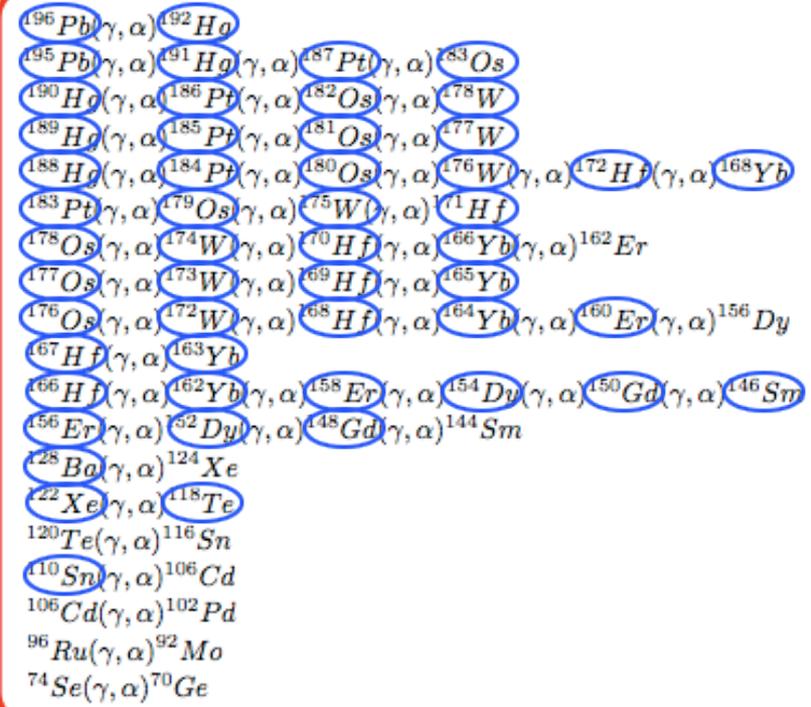
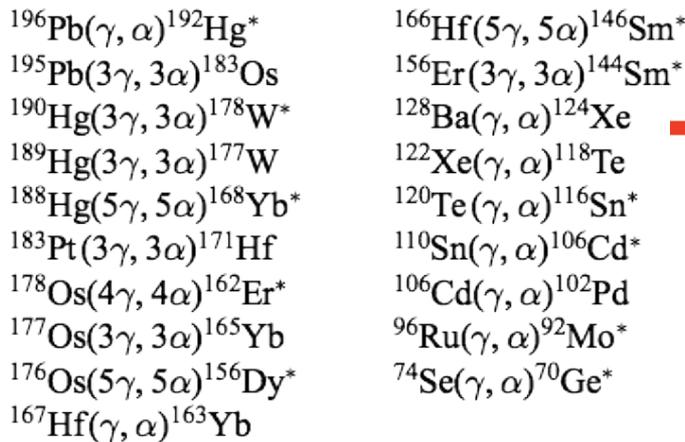
of the overproduction factors for the p -nuclei in the main region of the p -process are shown in Figure 13. The overproduction factors for the p -nuclei in the main region of the p -process are shown in Figure 13. The overproduction factors for the p -nuclei in the main region of the p -process are shown in Figure 13.

Figure 13 compares the overproduction factors for the p -nuclei in the main region of the p -process based on the modified rates to those based on the original rates. The squares of the overproduction factors for the p -nuclei in the main region of the p -process are shown in Figure 13.

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SELECTED (γ, α) REACTION CHAINS

Reaction Chains



Nucleosynthesis Paths

