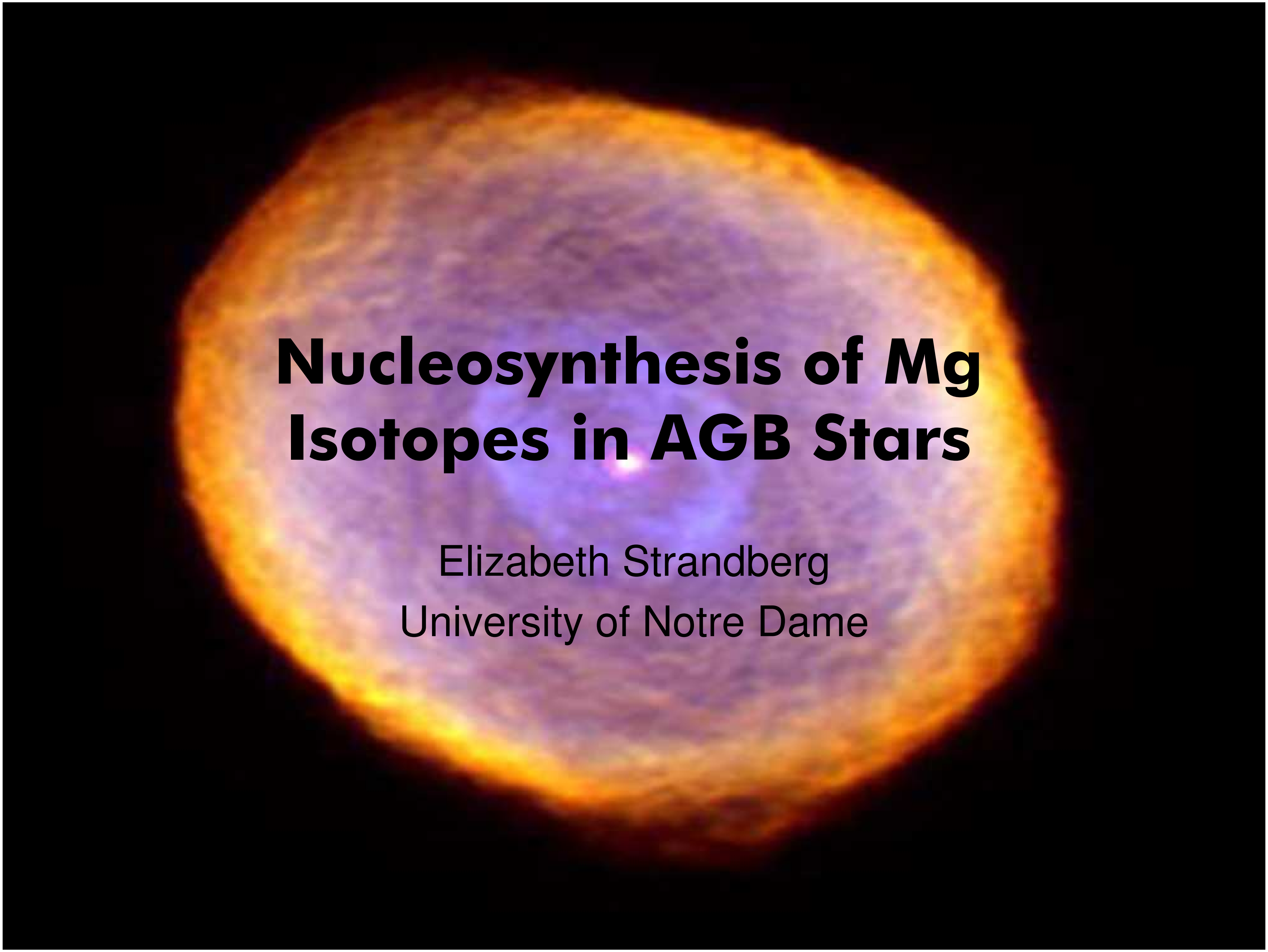
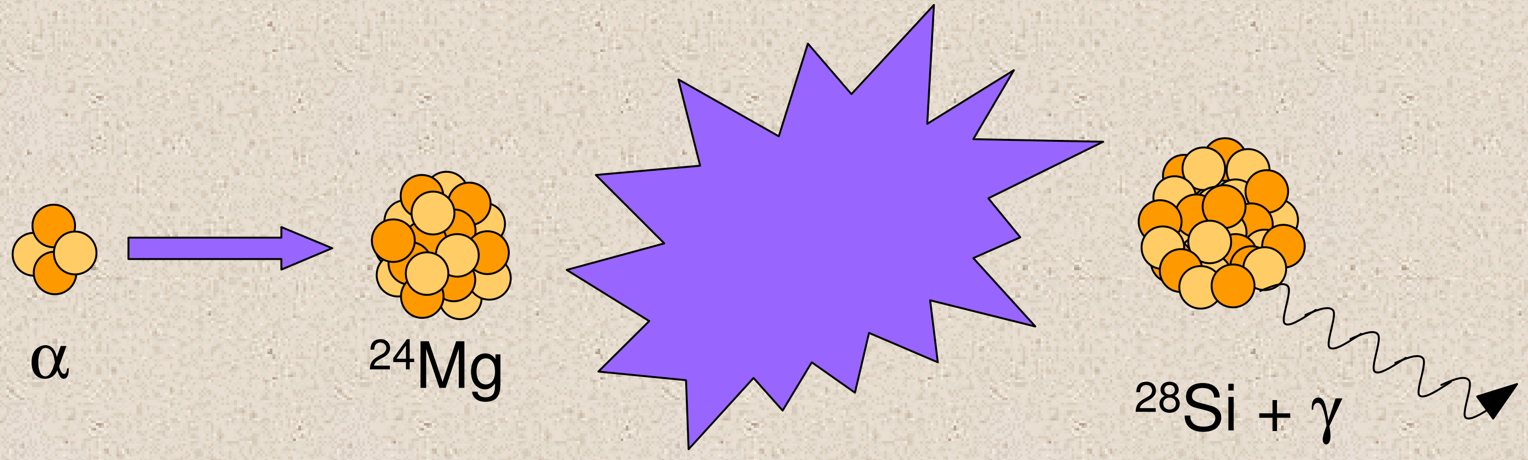


Nucleosynthesis of Mg Isotopes in AGB Stars

Elizabeth Strandberg
University of Notre Dame

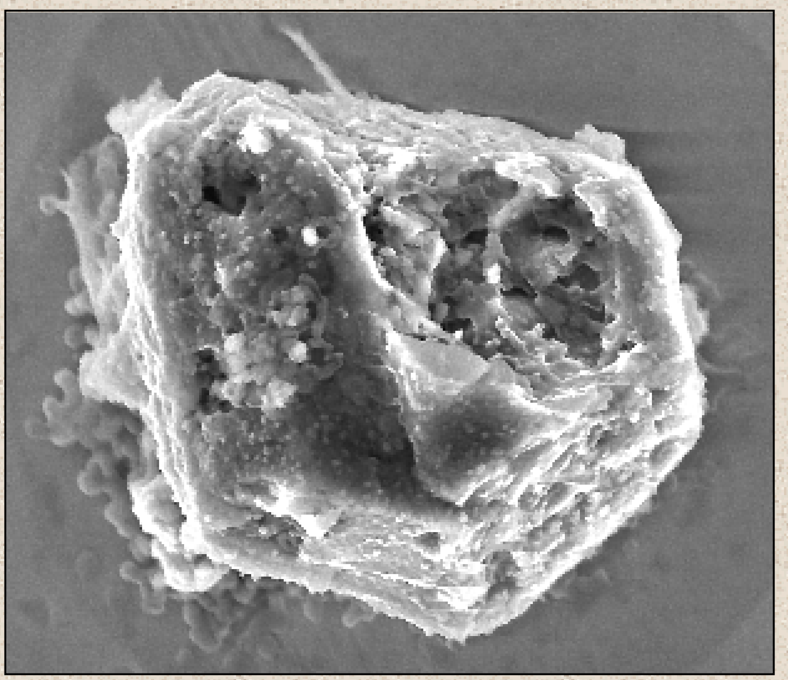
Project: $^{24}Mg(\alpha,\gamma)^{28}Si$



Goal: Find new resonances and determine resonance parameters

Astrophysical Motivation: SiC Grains

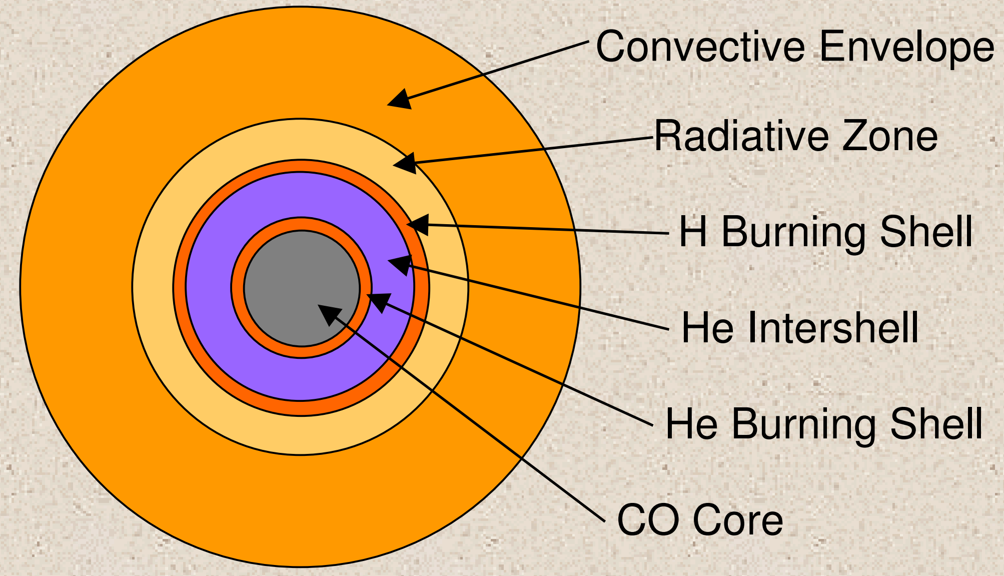
- Grains expelled from previous generations of AGB stars are found in meteorites in our solar system
- These grains can contain pristine material from the cloud out of which the solar system formed
- These grains contain anomalously large amounts of the neutron-rich Si isotopes



SiC meteorite grain (L. Nittler)

Astrophysical Motivation: AGB Stars

AGB stars have an onion-like structure, with nuclear burning occurring the hydrogen and helium shells



In the later part of the AGB phase, the He-shell undergoes thermal pulses, during which many nuclear reactions can take place:

$^{24}Mg(\alpha,\gamma)^{28}Si$

$^{12}C(p,\gamma)^{13}N(\beta^{+}\nu)^{13}C(\alpha,n)^{16}O$

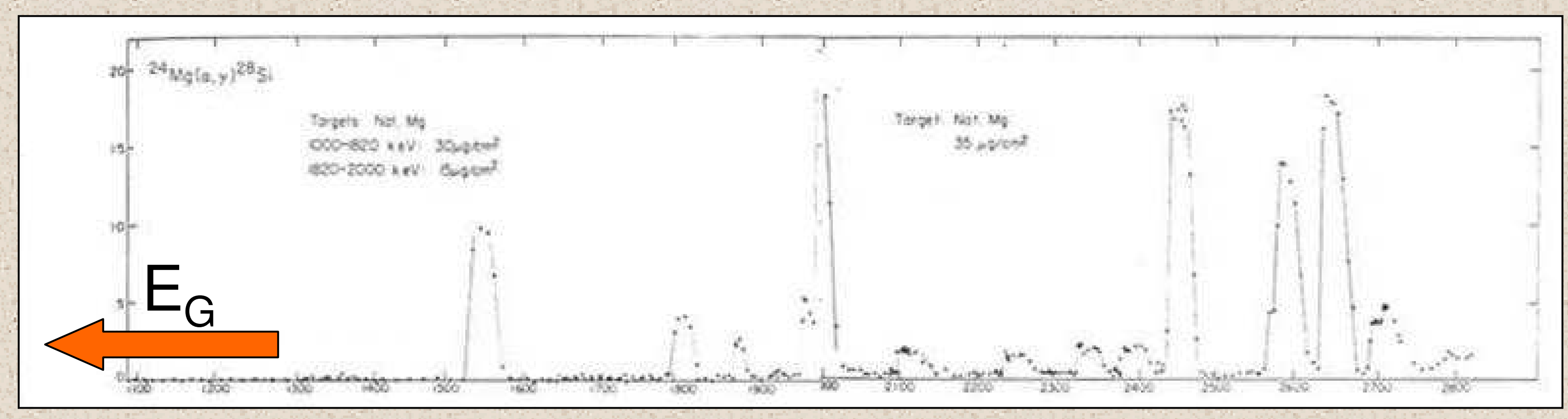
$^{22}Ne(\alpha,n)^{25}Mg(\alpha,n)^{28}Si$

$^{24,25,26}Mg(n,\gamma)$

$^{28,29,30}Si(n,\gamma)$

Previous Work

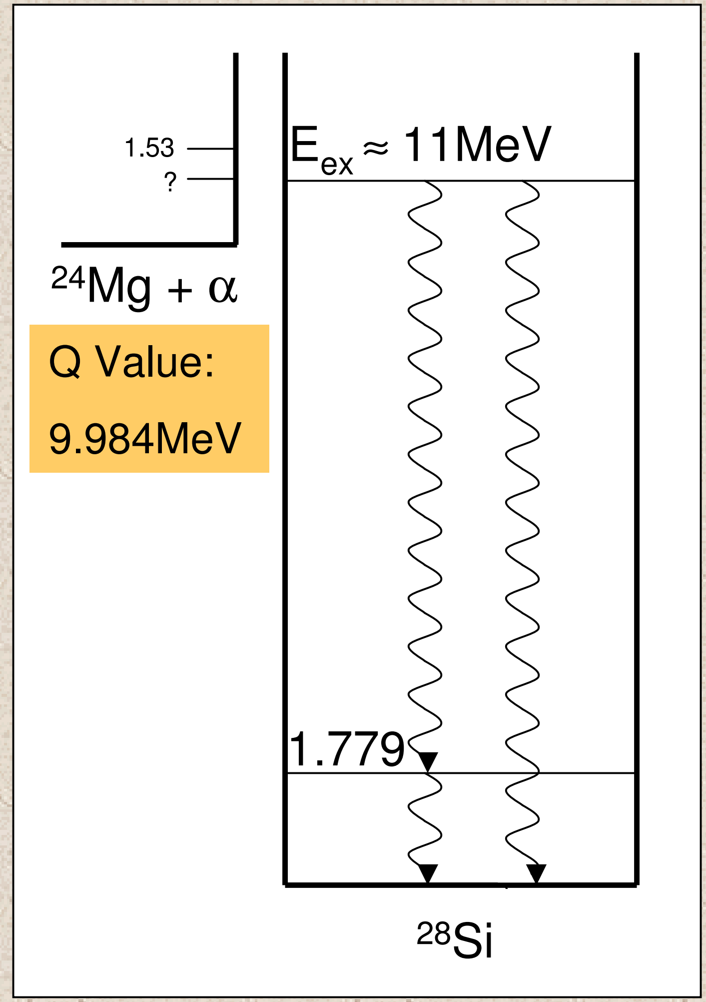
The lowest energy resonance published for this reaction occurs at E_α = 1358 keV, but the Gamow window is around 500keV



P.B. Lyons, Nucl. Phys. A130 (1969) 25

There are several states in the ^{28}Si compound nucleus that are favorable for formation by alpha capture in the E_α = 1.0 to 1.5 MeV range

Level Scheme

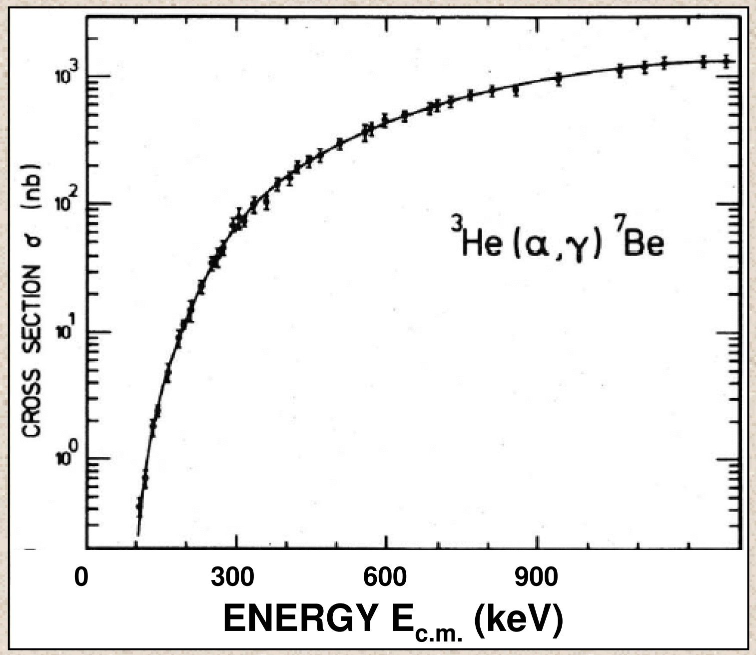


Alpha capture on a J = 0 nucleus such as ^{24}Mg must lead to a natural parity state in the compound nucleus

J^π	E_{ex} (MeV)	E_α (lab) (keV)
2^+	10.916	1087
2^+	10.944	1120
2^+	10.951	1130
	10.994	1178
$2\text{-}4^+$	11.079	1277

Experimental Challenges

The cross section decreases exponentially with decreasing projectile energy



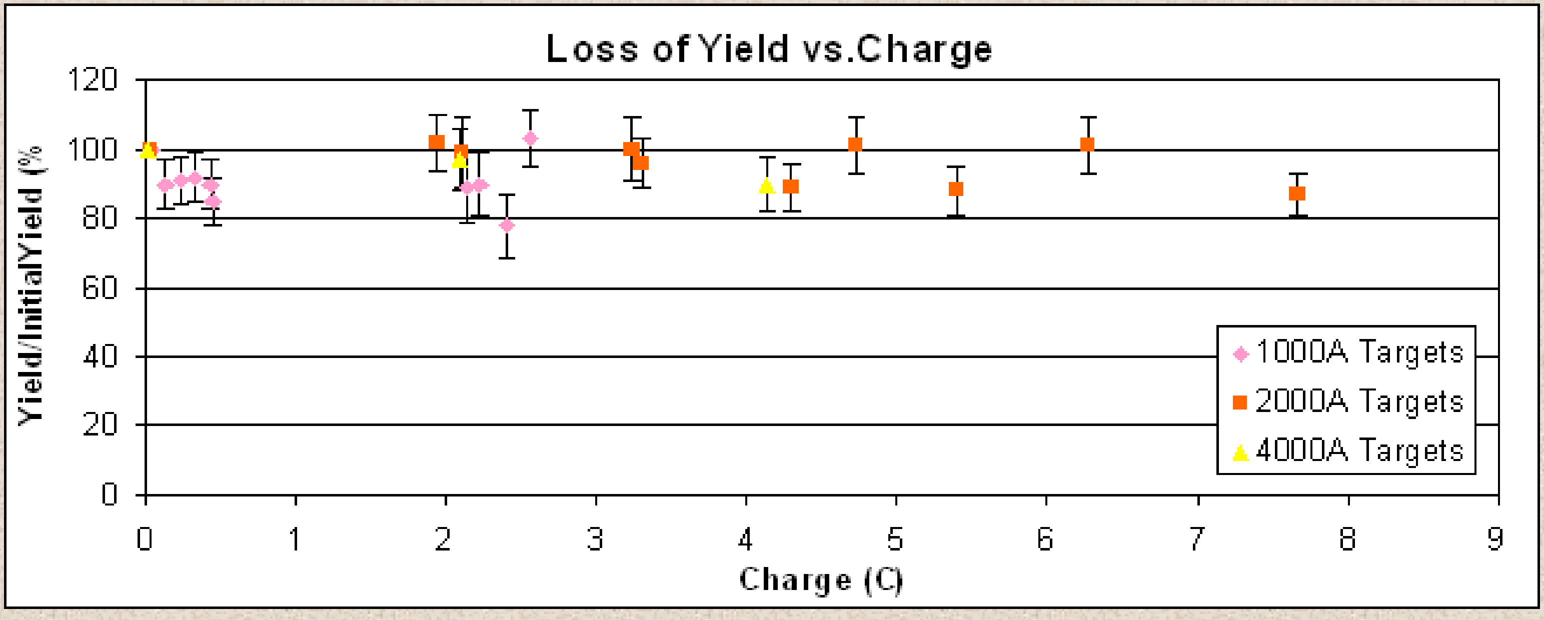
H. Kräwinkel et.al., Z. Phys. A304 (1982) 307

To find new resonances, we need

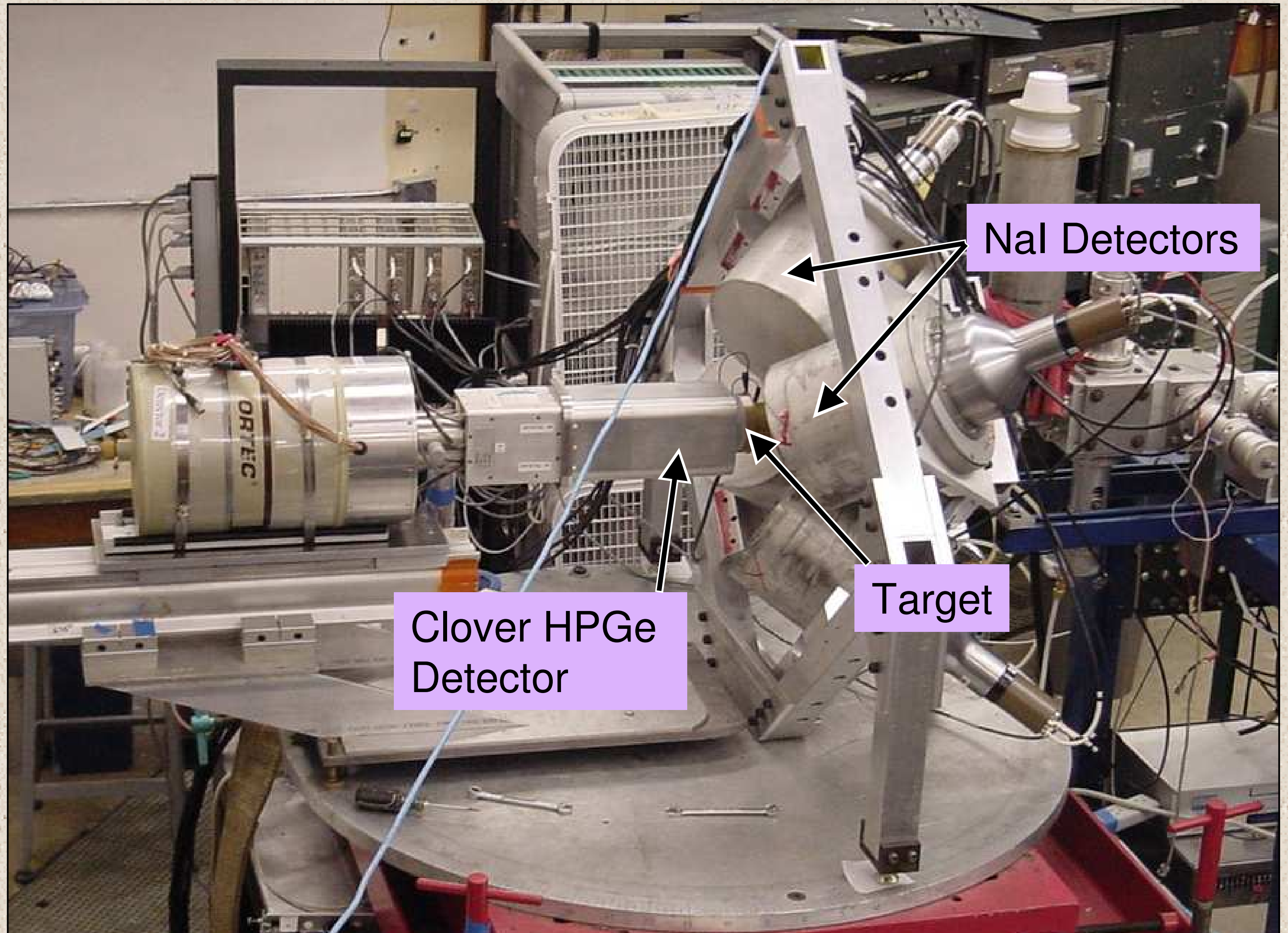
1. Durable targets with as much ^{24}Mg as possible
2. An efficient detection system

Target Development

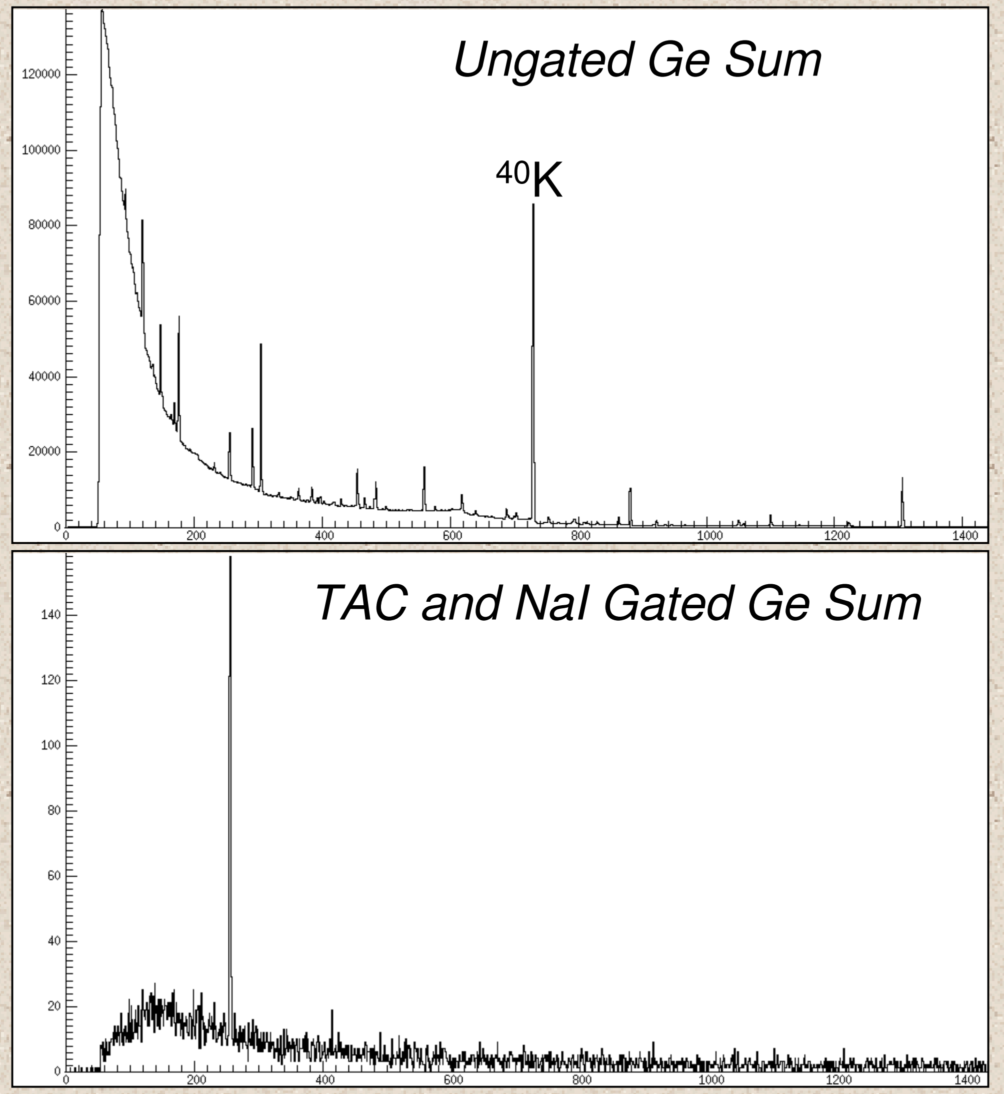
1. Mg implanted on tantalum backing
   Mg/Ta ratio was not satisfactory
2. Mg evaporated on tantalum backing
   Yield was high, but backing was blistered by beam
3. Mg evaporated on copper backing
   Yield was high and target showed no damage



Detection System



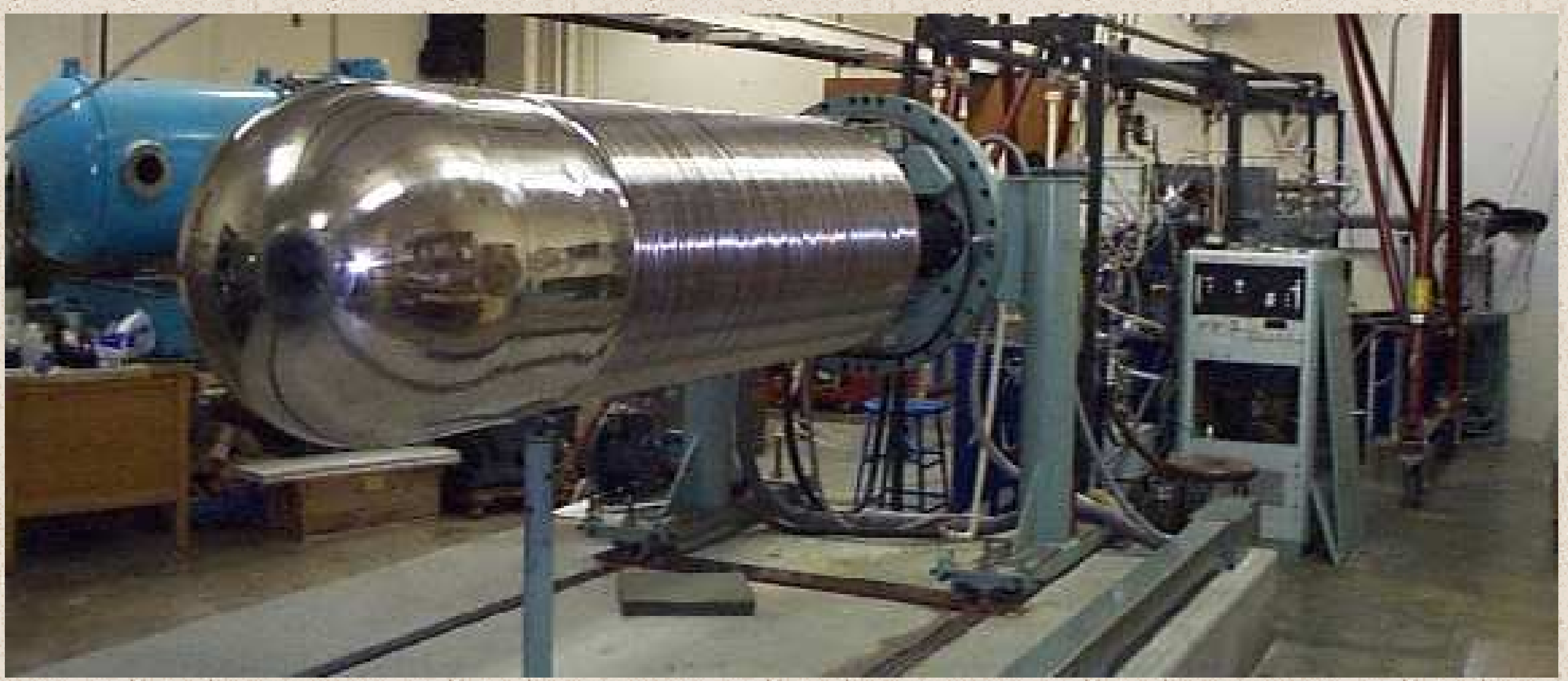
Coincidence Mode



By operating the detection system in coincidence mode, the room background is reduced by ~3 orders of magnitude!

KN Accelerator

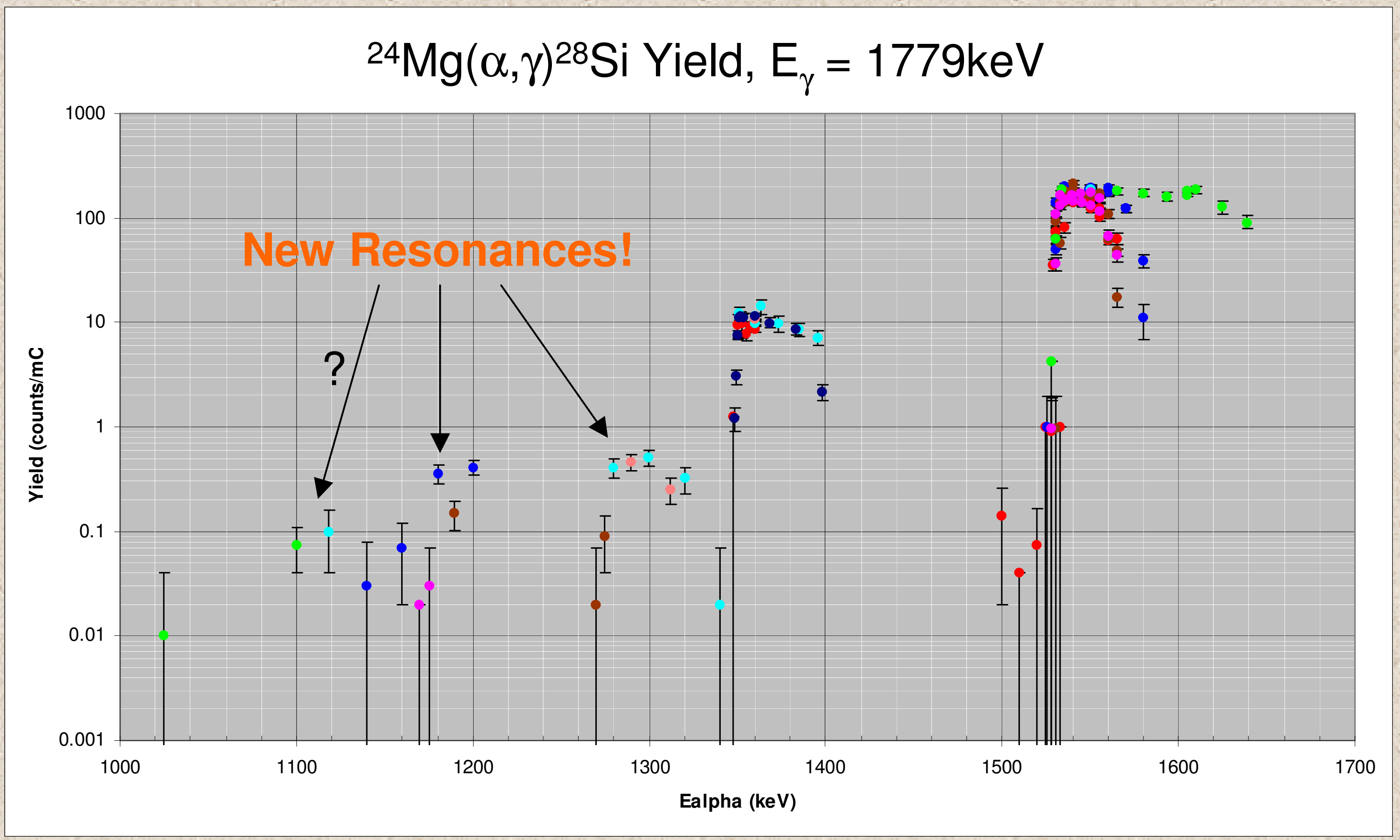
The alpha beam was produced by the 4MV KN Van de Graaff accelerator at Notre Dame



We ran for two weeks with alpha beam currents up to 55μA

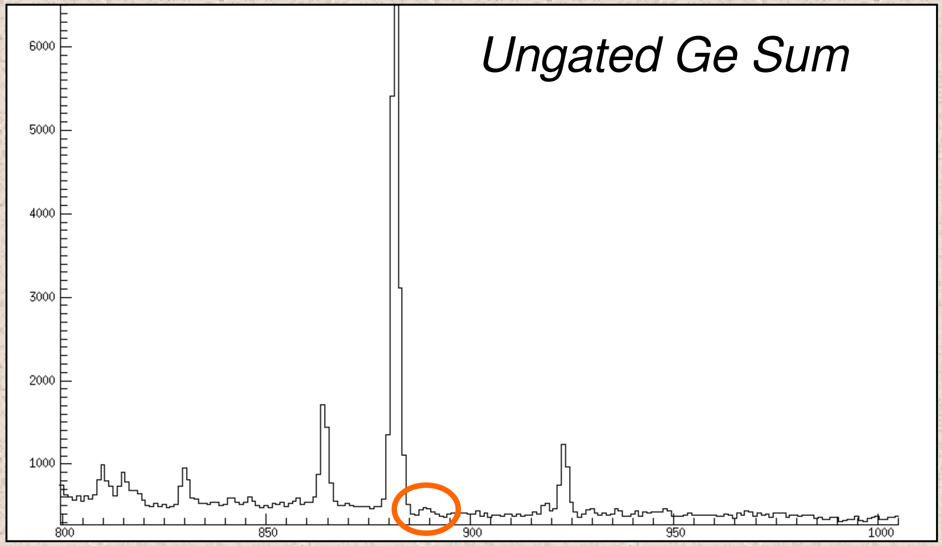
Results of Experimental Run

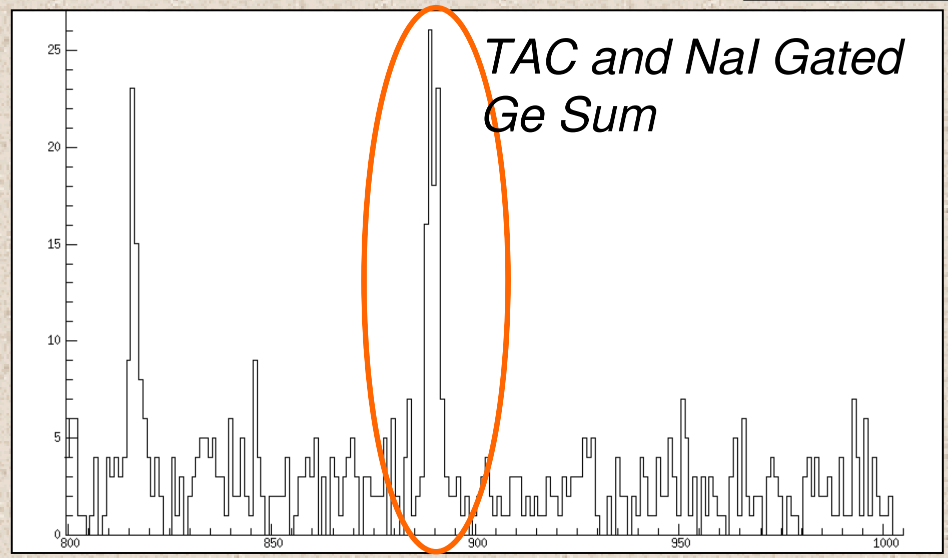
Yield curve mapped using transition from first excited state to ground state in ^{28}Si



Verification of Coincidence Mode

Without the coincidence gate, the gamma ray of interest is barely seen





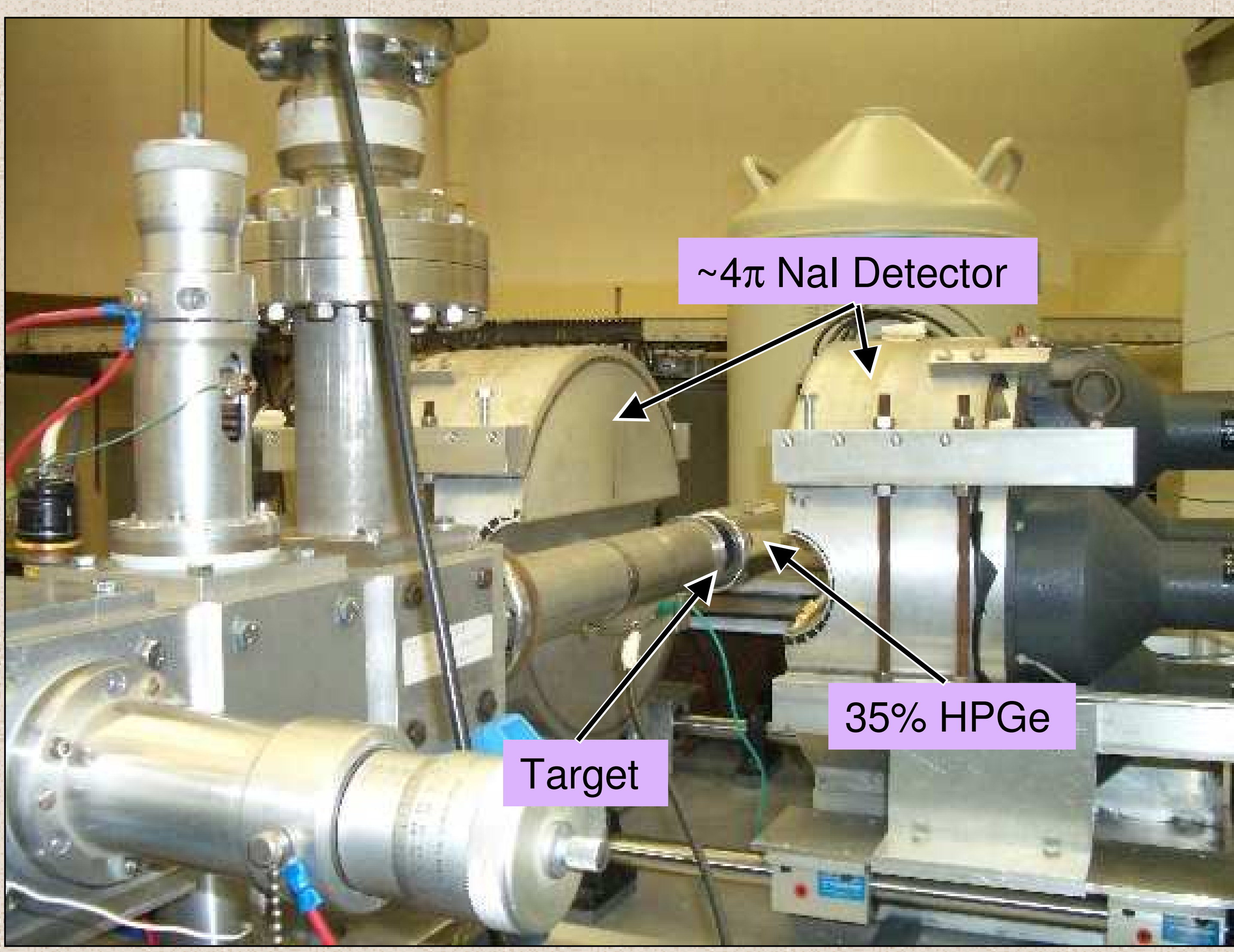
With the appropriate gates, background lines disappear and the reaction gamma ray is clearly visible

Resonance Strength $\omega\gamma$

E_α (keV)	Current $\omega\gamma$ (lower limit)	Previous Experiments
1350	1.3 ± 0.3 meV	1.9 ± 0.6 meV (Lyons 1969)
1277	56 ± 12 μeV	No previous value
1178	45 ± 10 μeV	200 ± 60 μeV (Buchmann, unpublished)

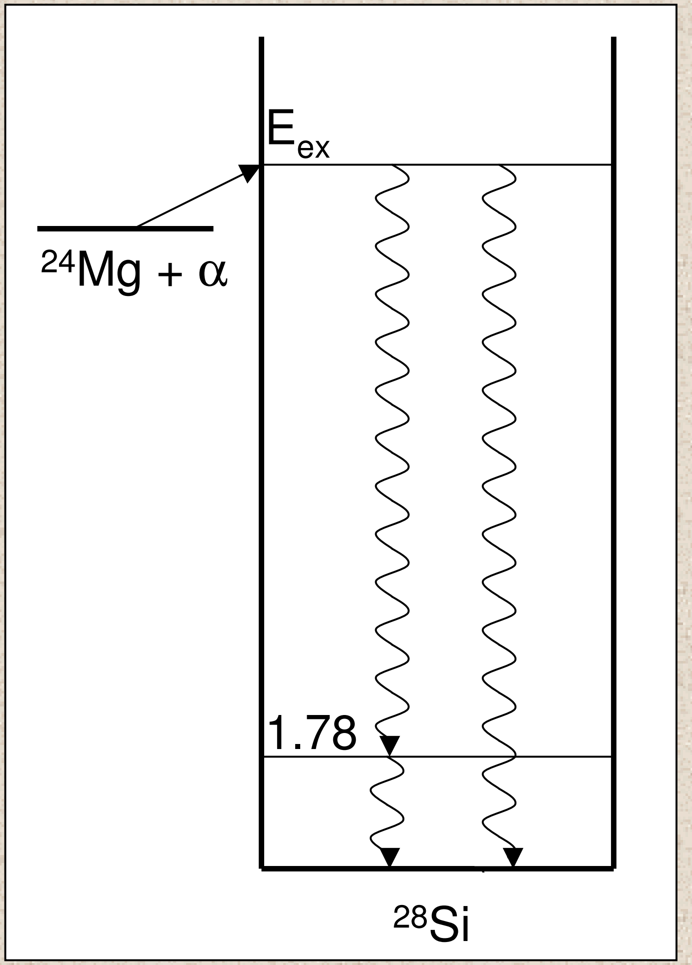
Since branching ratios are not yet known, $\omega\gamma$ was calculated by assuming all decays include the 1779keV gamma, thus we arrive at a lower limit

Future Plans: Second Experimental Run



4π NaI + 35% HPGe Setup

The ~4π NaI detector can be used as a Compton shield. With this setup, we will observe the transition from E_{ex} to the ground state.



This will compliment the previous experiment, in which we observed the transition from the first excited state to the ground state.

Collaborators

Advisors:

Michael Wiescher and Joachim Görres

Notre Dame Students, Postdocs and Staff:

Mary Beard, Aaron Couture, Michael Lamey, PJ LeBlanc, Hye Young Lee, Shawn O'Brien, Annalia Palumbo, Barbara Truett, Claudio Ugalde, Manoel Couder, Wolfgang Rapp, Wanpeng Tan, Larry Lamm, Brad Mulder, Ed Stech

Other Collaborators:

Kent Scheller (University of Southern Indiana)

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