Establishing the deformation characteristics of ^{66}Ge

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P-531

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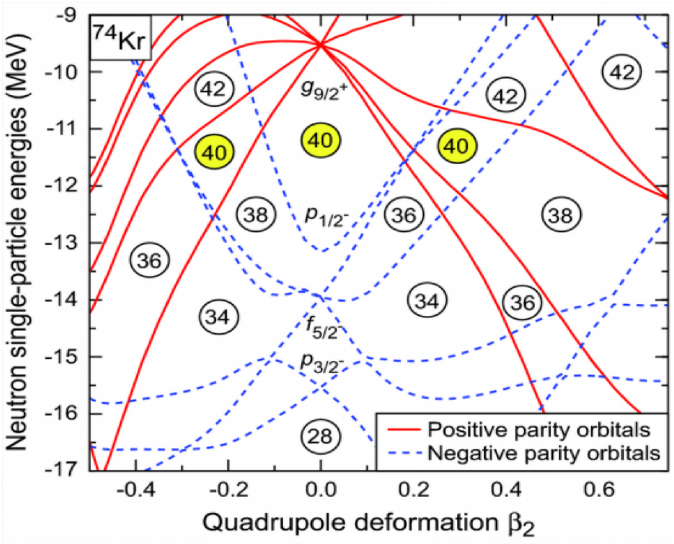
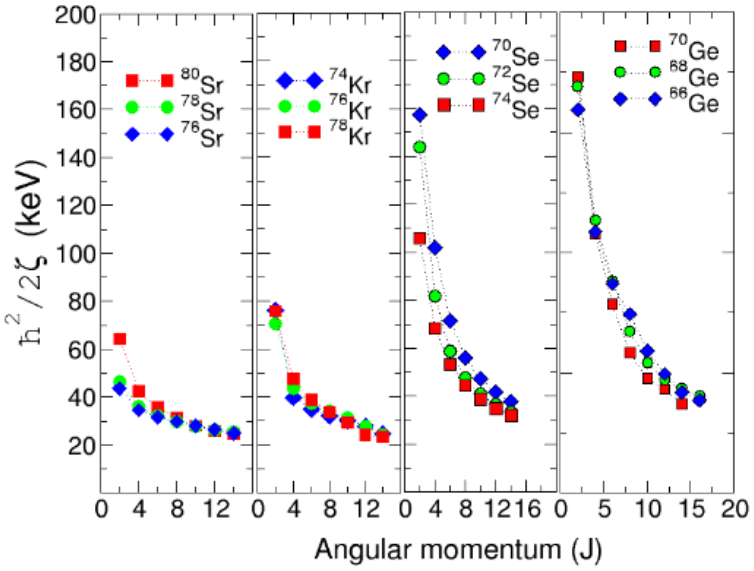
Motivation

- ^{66}Ge expected to lie on boundary of γ-soft and triaxial shapes [1]
- Valence particles in *fpg* shell challenge theoretical models
- Low-excitation structure not understood
- Post-accelerated beams only available at HIE-ISOLDE (July 2017)

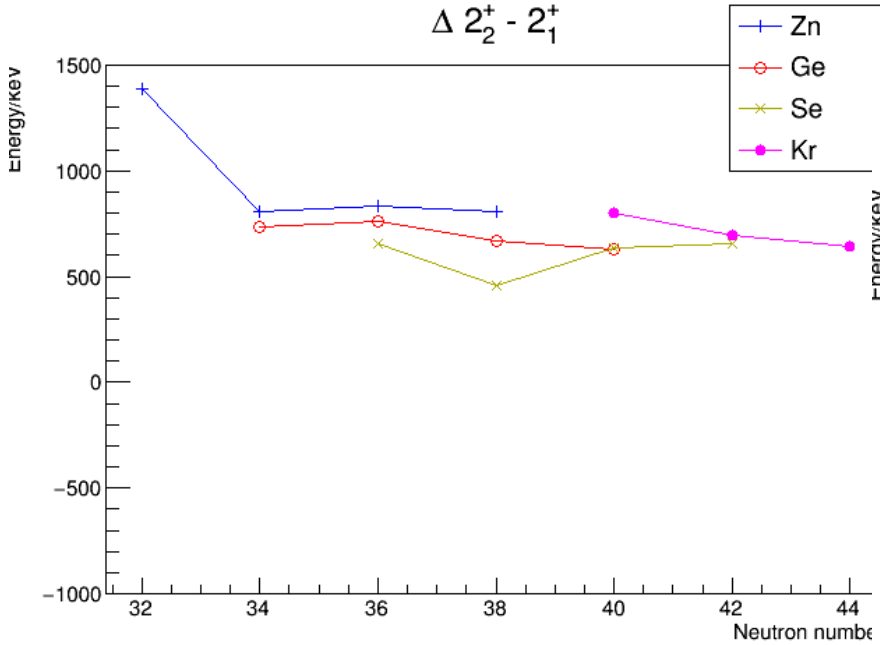
[1] Kris Heyde and John L Wood, *Shape coexistence in atomic nuclei*, Rev. Mod. Phys. 83(4):1467, 2011

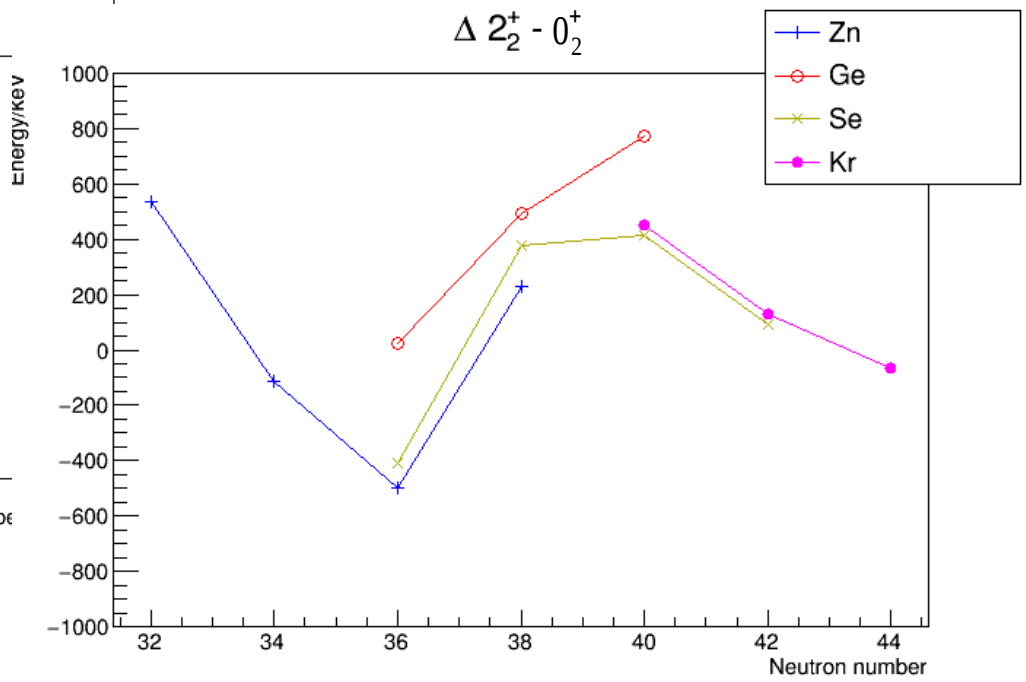




Motivation

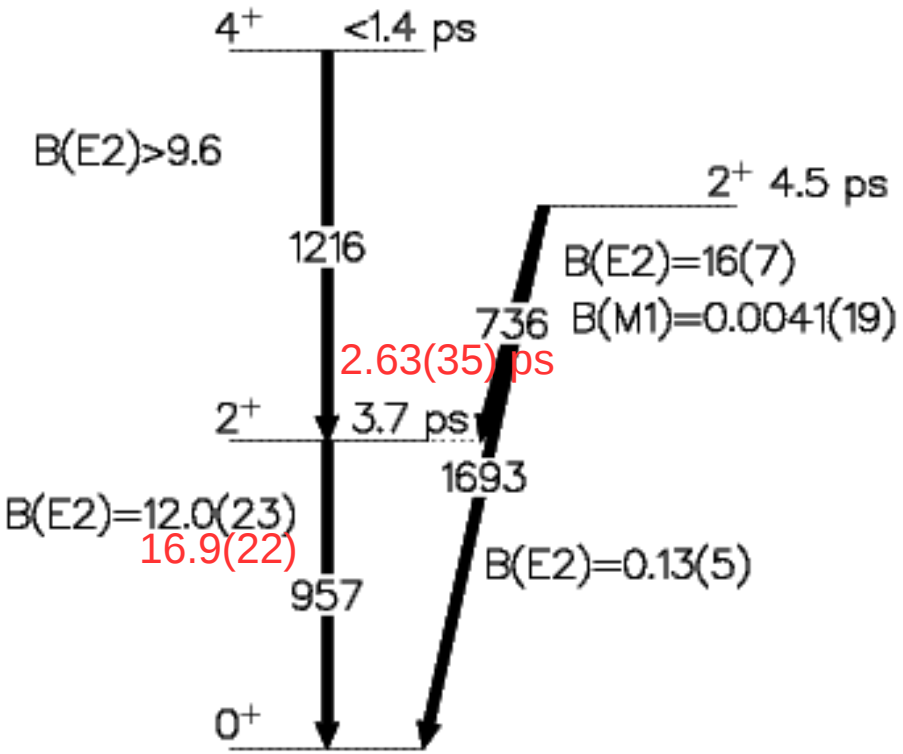
- $\Delta(2_2^+ - 2_1^+)$ relatively constant
- $\Delta(2_2^+ - 0_2^+)$ decreasing in energy
- Implies intruder orbital into the γ band
- Few measurements of 0_2^+ near N=Z with unstable nuclei



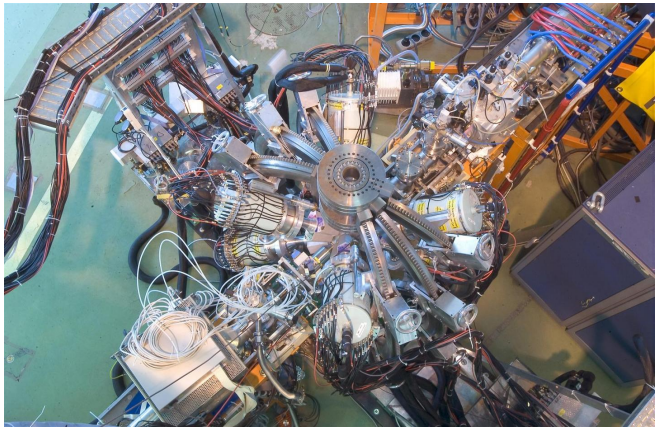


Current Situation

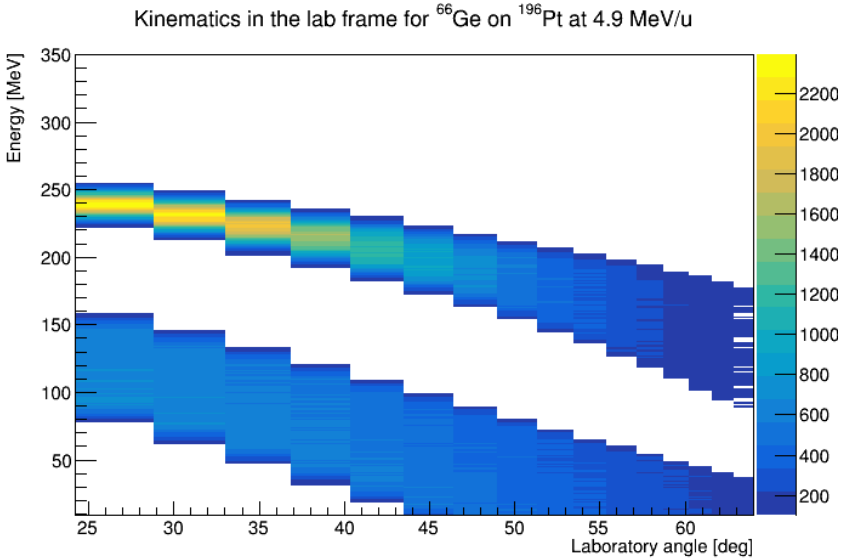
- Level scheme well known
- Shapes are not
- Effect of mid-shell effects outside valley of stability between N, Z=28-50 unclear

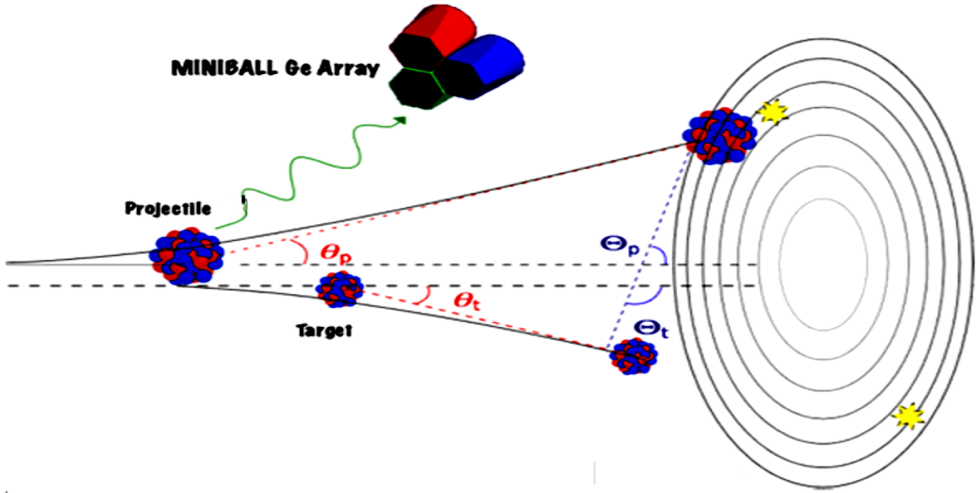


Method



- Safe Coulomb excitation (4.9 MeV/u)
- De-excitations detected using MINIBALL
- Reorientation effect employed
- ^{196}Pt (4.0 mg/cm^2) target for normalisation
  - No γ rays in regions of interest
  - Well-measured B(E2) values
- CD placed 26 mm downstream (any MINIBALL chamber)





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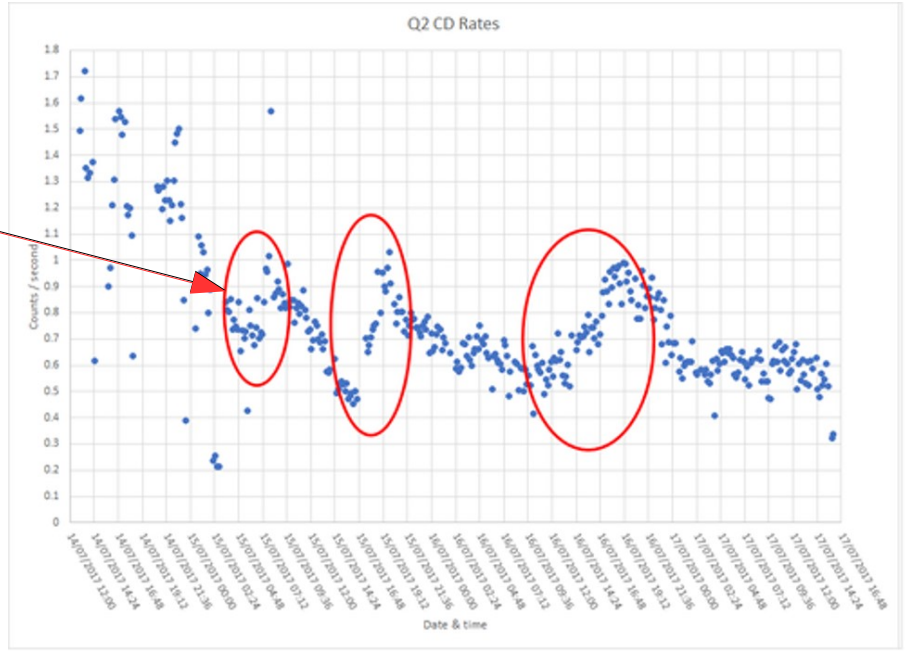
Beam Production

- ^{66}GeS can be enhanced with direct sulphur injection [1]
- Relatively clean beams with high yields extracted as molecule [2]
- Broken apart in EBIS
- ^{34}S enriched preferred to reduce possible ^{70}SeCO

[1] Ulli Koester et al., *Progress in ISOL target–ion source systems*, NIM B 266(20):4229, 2008

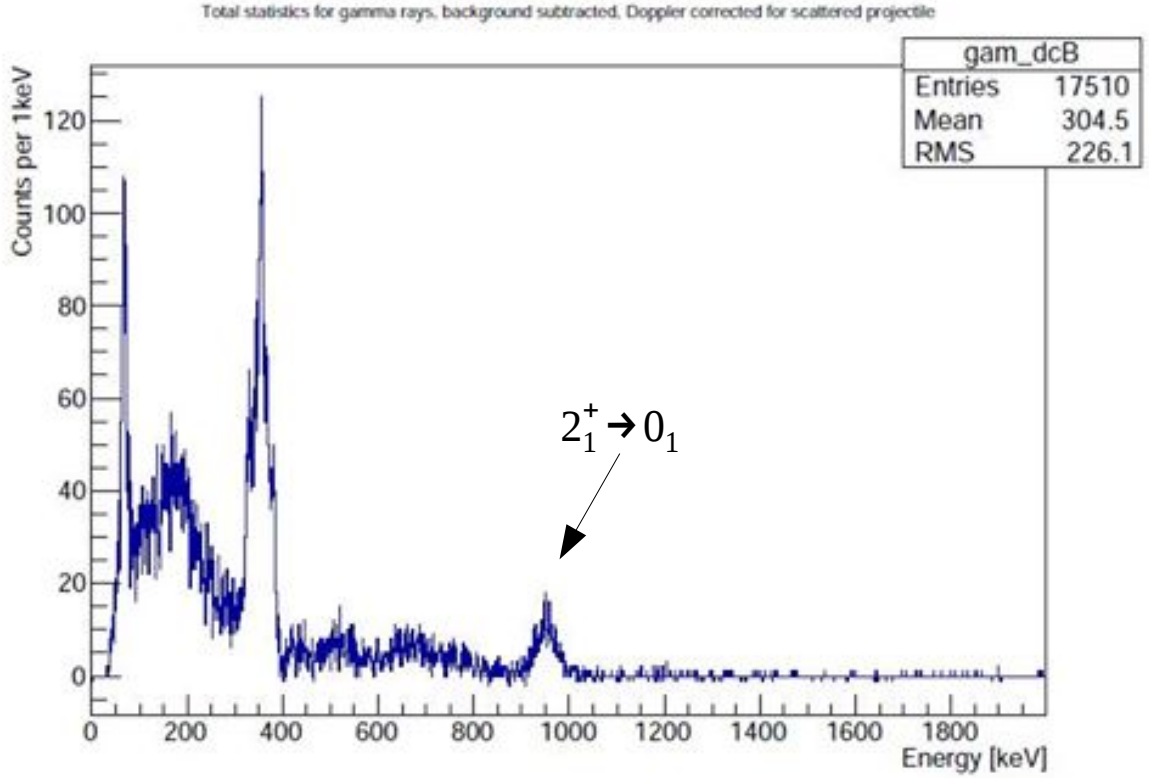
[2] Ulli Koester, Private Communication

Target heating

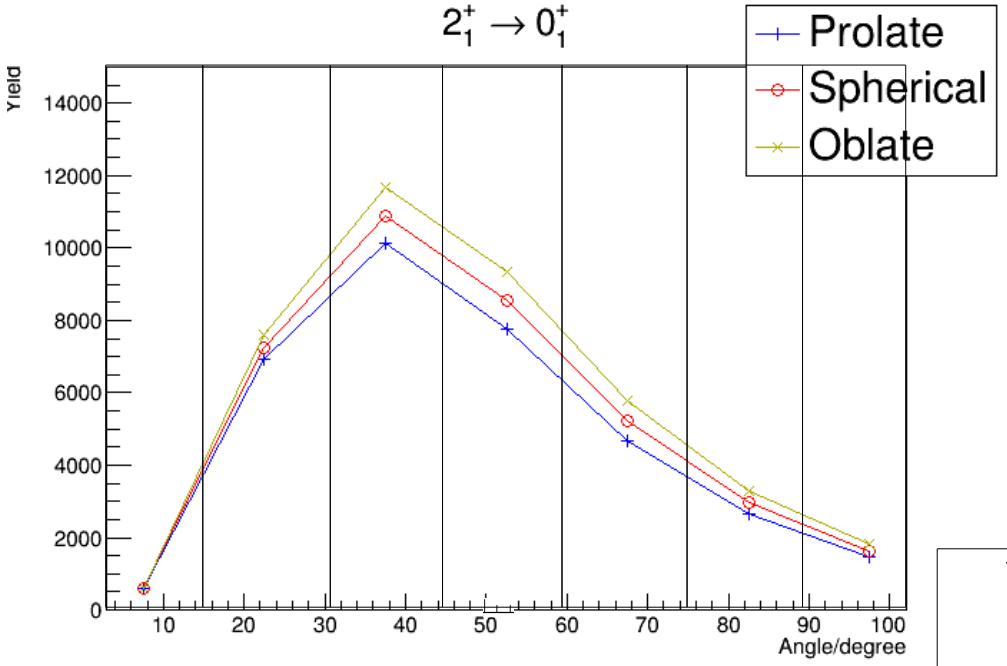


Previous Experiment

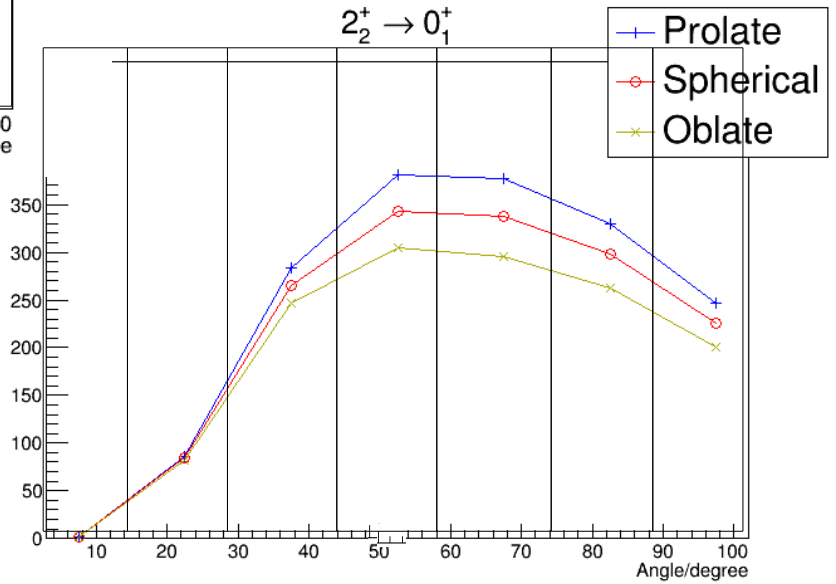
- ^{66}Ge (4.395 MeV/u) data taken over 60 hours in summer 2017
- First time post-accelerated
- Intention was to perform ^{70}Se study (IS569); little yield obtained
- Yields of ^{66}Ge on the order of 10^3 pps
- Decays from first 2^+ state observed



GOSIA Calculations



- Per shift:
  - $2_1^+ \rightarrow 0_1^+ = 2460$
  - $2_2^+ \rightarrow 0_1^+ = 106$
  - $2_2^+ \rightarrow 2_1^+ = 19$
  - $4_1^+ \rightarrow 2_1^+ = 186$
- Oblate = +10%
- Prolate = -10%



- $2_2^+ \rightarrow 0_1^+ \geq 200$ counts in each angular range to get $Q_s(2_2^+)$
- Shifts requested: 15

Experiment Outline

- Mid-shell effects and underlying shape of ^{66}Ge unknown
- Measurement only possible at ISOLDE
- Yields can be greatly enhanced compared to July 2017
- Production enhanced with sulphur contained within primary target
- Broken apart in EBIS
- Determination of sign & magnitude of quadrupole moment for 1st, 2nd 2^{+}
- Matrix element for 1st 4^{+}
- Search for 2nd 0^{+}

[1] J. Ballof, Private Communication

Production material	ZrO_2
Primary target yields	5.4×10^5 ions/μC [1]
Beam energy	4.9 MeV/u (323.4 MeV)
Charge state	16+
MINIBALL rate	6300 pps/μC
Shifts	15

Collaboration

G. G. O'Neill*[1,2], J. N. Orce[1], K. Abrahams[1], E. Akakpo[1], J. M. Allmond[3], D. T. Doherty[4], R. Dubey[1,2], L. P. Gaffney[5], P. Garrett[1,6], D. G. Jenkins[7], M. Kamil[1], N. Khumalo[1], S. Masango[1], D. Mavela[1], C. Mehl[1], M. Mokgolobotho[1], E. M. Montes[1], C. Ngwetsheni[1], S. Ntshangase[8], J. Ondze[1], B. Rebeiro[1], B. Singh[1], S. Triambak[1,2], R. Wadsworth[7], M. Zielińska[9]

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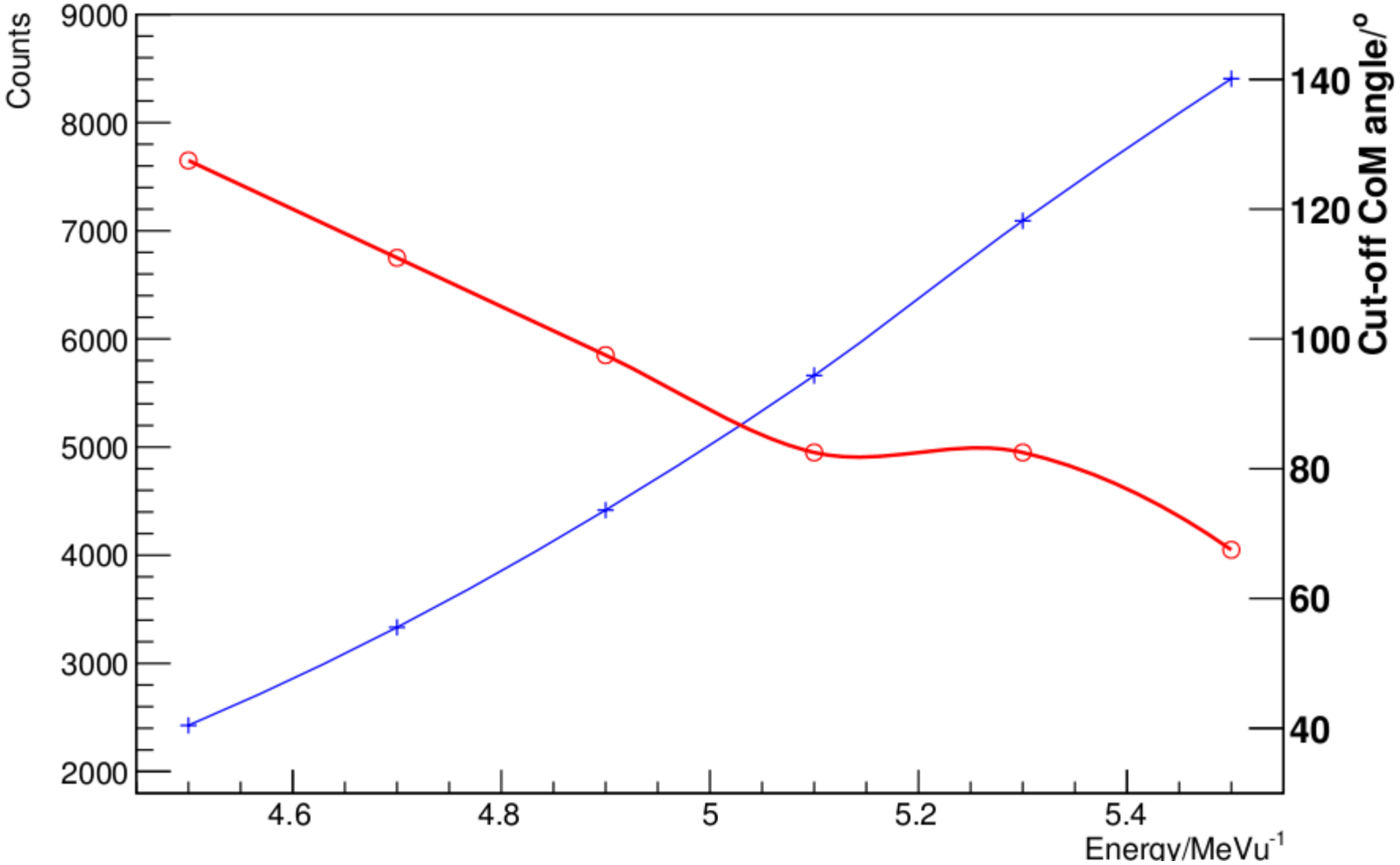
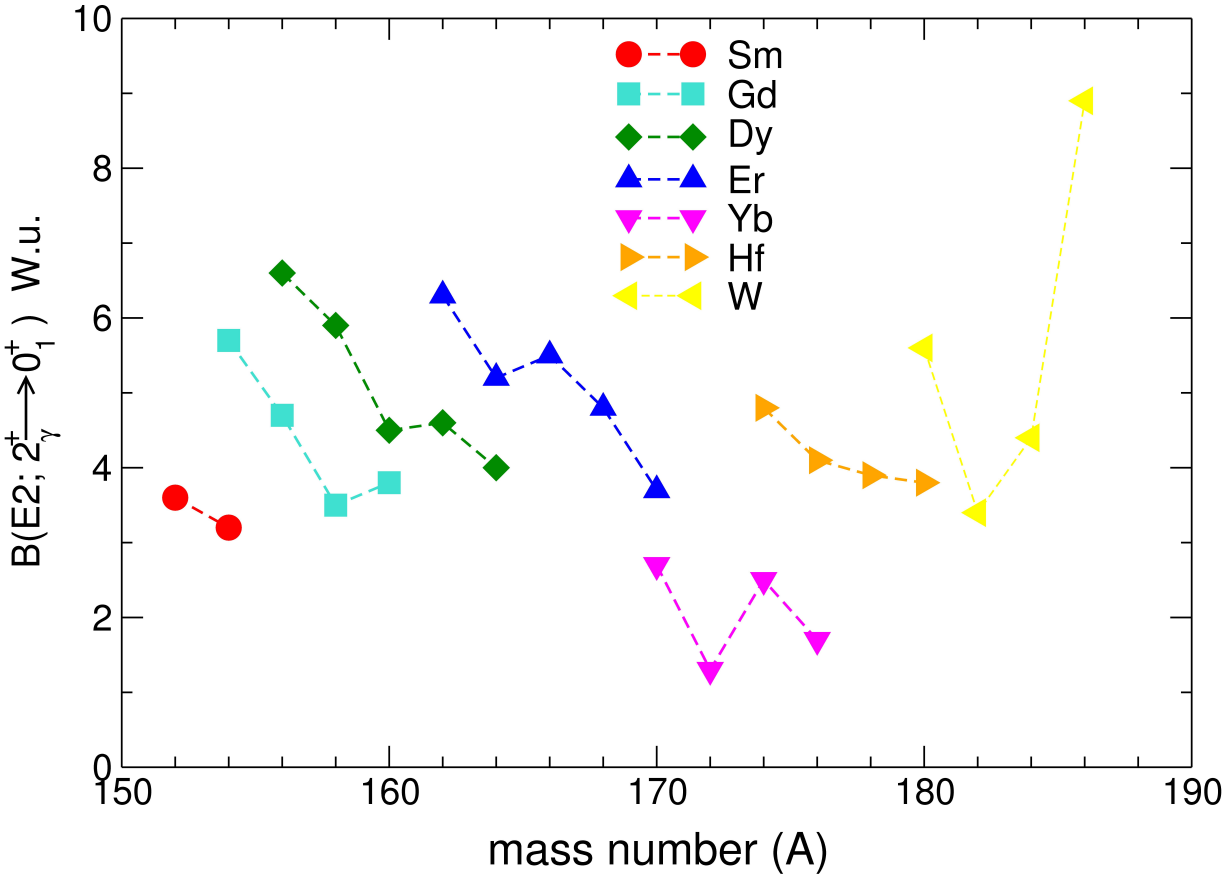
[9]: CEA Saclay, IRFU/SPhN, Gif-sur-Yvette, France

Yield as a function of energy



Coulomb Excitation Parameters

- Most target particles available
- CoM angle safe until 96°
- Sommerfeld parameter $\eta = 177$ (GOSIA valid)
- Adiabacity parameter $\xi = 0.315$ (2^+) (3 MeV excitations)


Sm
Gd
Dy
Er
Yb
Hf
W
B(E2; $2^+_\gamma \rightarrow 0^+_1$) W.u.
mass number (A)
0
2
4
6
8
10
150
160
170
180
190

Kinematics

- Detection of forward-focused particles includes most target particles
- High-energy projectile particles detected
- Further detection of ^{66}Ge possible by detection of target