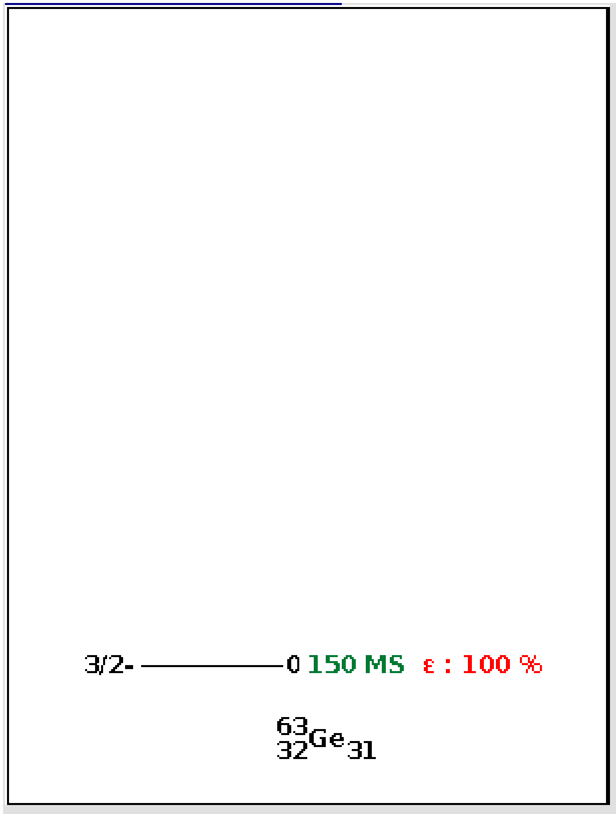
The discovery of excited states in very neutron-deficient ^{63}Ge nucleus

G. Jaworski & A. Fijałkowska

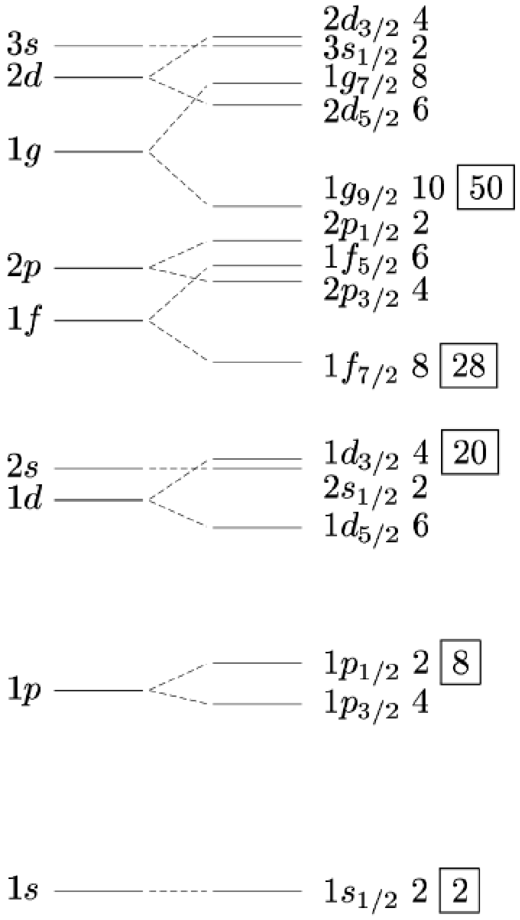
Heavy Ion Laboratory, University of Warsaw, Poland
Faculty of Physiscs, University of Warsaw, Poland

^{63}Ge



^{63}Ge

60Ge > 110 ns εp ε	61Ge 44 ms ε = 100.00% εp ≈ 62.00%	62Ge 129 ms ε = 100.00% εp	63Ge 150 ms ε = 100.00%	64Ge 63.7 s ε = 100.00%
59Ga P?	60Ga 70 ms ε = 100.00% εp = 1.60% εα < 0.02%	61Ga 167 ms ε = 100.00% εp < 0.25%	62Ga 116.121 ms ε = 100.00% εp	63Ga 32.4 s ε = 100.00%
58Zn 86 ms ε = 100.00% εp < 3.00%	59Zn 182.0 ms ε = 100.00% εp = 0.10%	60Zn 2.38 min ε = 100.00%	61Zn 89.1 s ε = 100.00%	62Zn 9.186 h ε = 100.00%
57Cu 196.3 ms ε = 100.00%	58Cu 3.204 s ε = 100.00%	59Cu 81.5 s ε = 100.00%	60Cu 23.7 min ε = 100.00%	61Cu 3.339 h ε = 100.00%
56Ni 6.075 d ε = 100.00%	57Ni 35.60 h ε = 100.00%	58Ni STABLE 68.077%	59Ni 7.6E+4 y ε = 100.00%	60Ni STABLE 26.223%



^{63}Ge and the rp-process

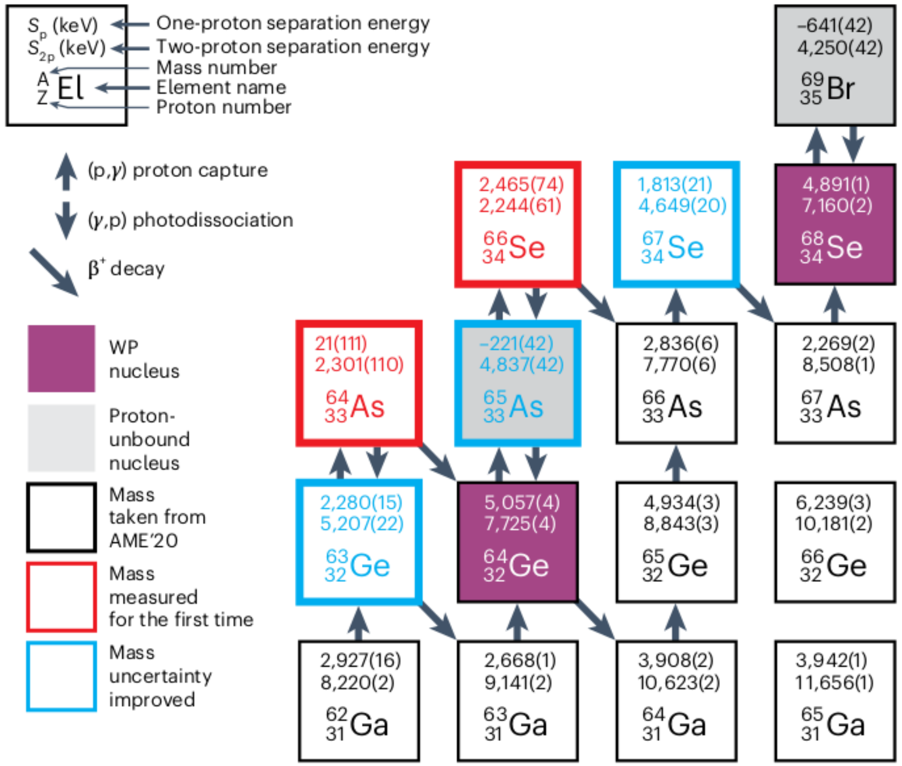
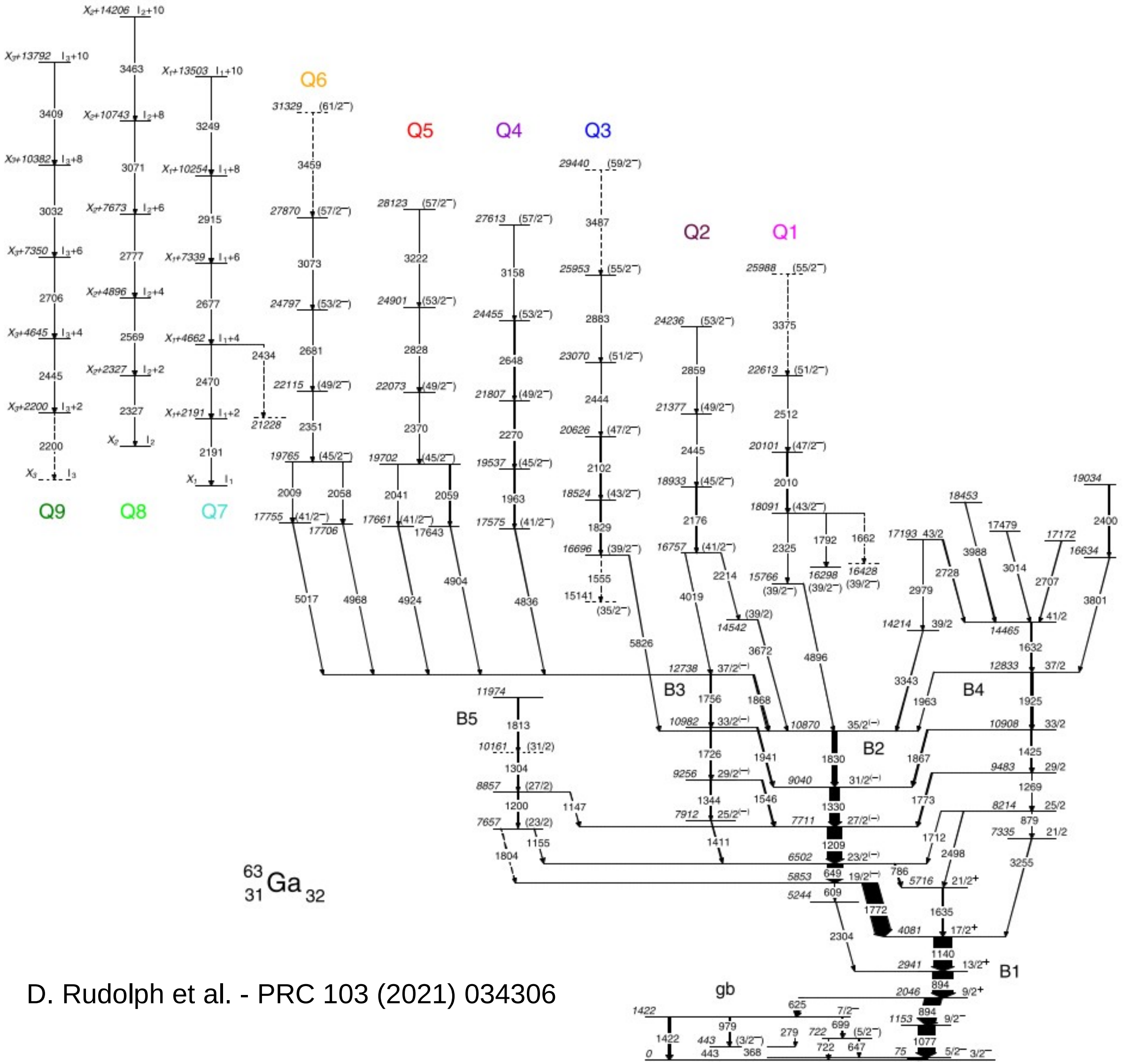


Fig. 1 | Nuclear chart around the rp process WP ^{64}Ge. The nuclides are organized according to neutron (horizontally) and proton (vertically) numbers. Nuclides whose masses were taken from the latest AME'20 database[36], whose masses were experimentally determined or whose mass uncertainties were improved in this work are indicated in black, red and blue colours, respectively. The one-proton (S_p) and two-proton (S_{2p}) separation energies (values expressed in keV) follow the same colour code. The pathway of the rp process nucleosynthesis is shown with the black arrows. The legend provides more details.

X. Zhou et al. - Nature Physics 19 (2023) 1091

^{63}Ga – mirror nuclei of ^{63}Ge



D. Rudolph et al. - PRC 103 (2021) 034306

^{63}Ge – the aims of the experiment

Observation of excited states in ^{63}Ge allowing to reckon:

→ proton and neutron spe,

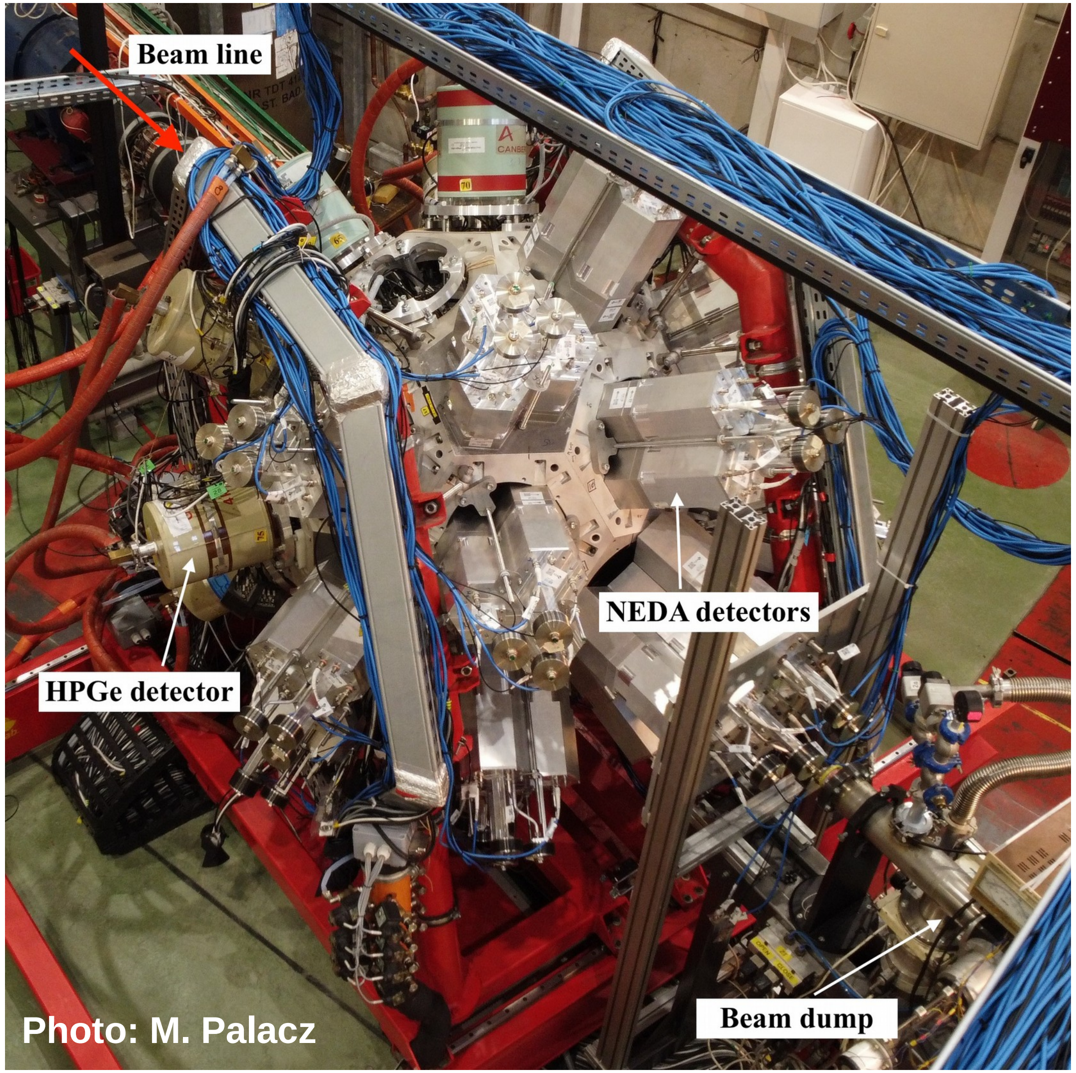
→ core excitations,

→ ^{63}Ga – isospin symmetry within the states of *2p3/2, 1f5/2, 2p1/2* shells,

→ ? collective octupole effects due to *p3/2–g9/2* correlations – observed in ^{65}Ge,

→ possibly astro-physical significance.

Setup



EAGLE:

$\varepsilon(\gamma)$ = 1.4% @ 1.3 MeV

DIAMANT:

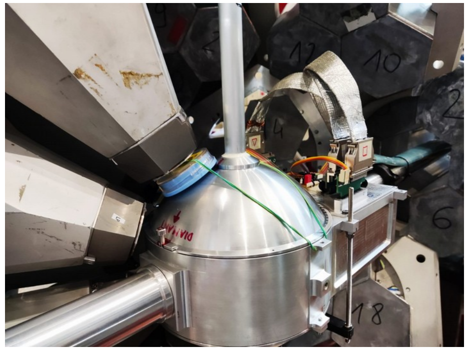
$\varepsilon(p) = 60\%$

$\varepsilon(\alpha) = 40\%$

NEDA:

$\varepsilon(n) = 30\%$

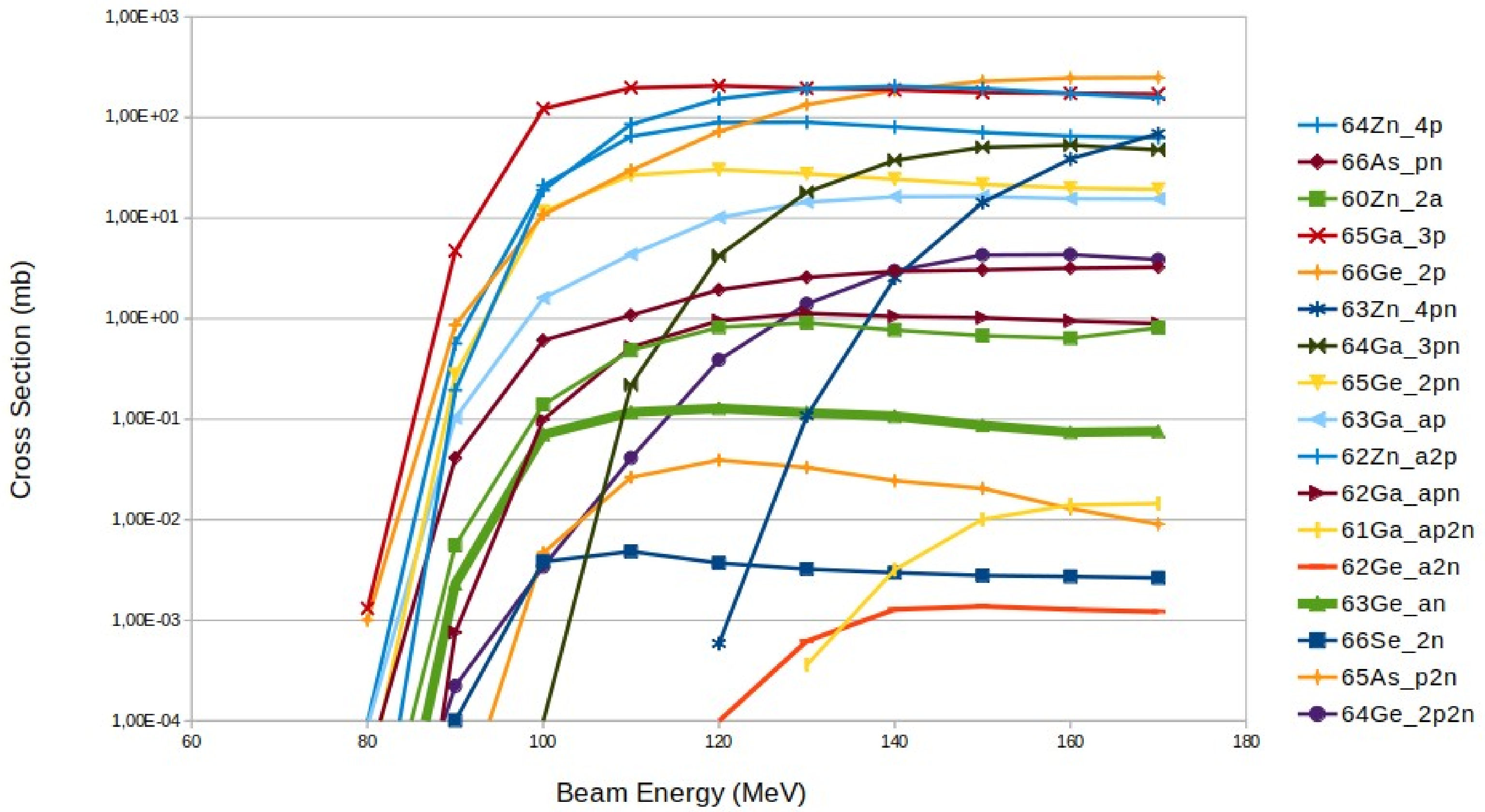
6xCaen V1725S(B) – xdaq
5xNumexo – Narval



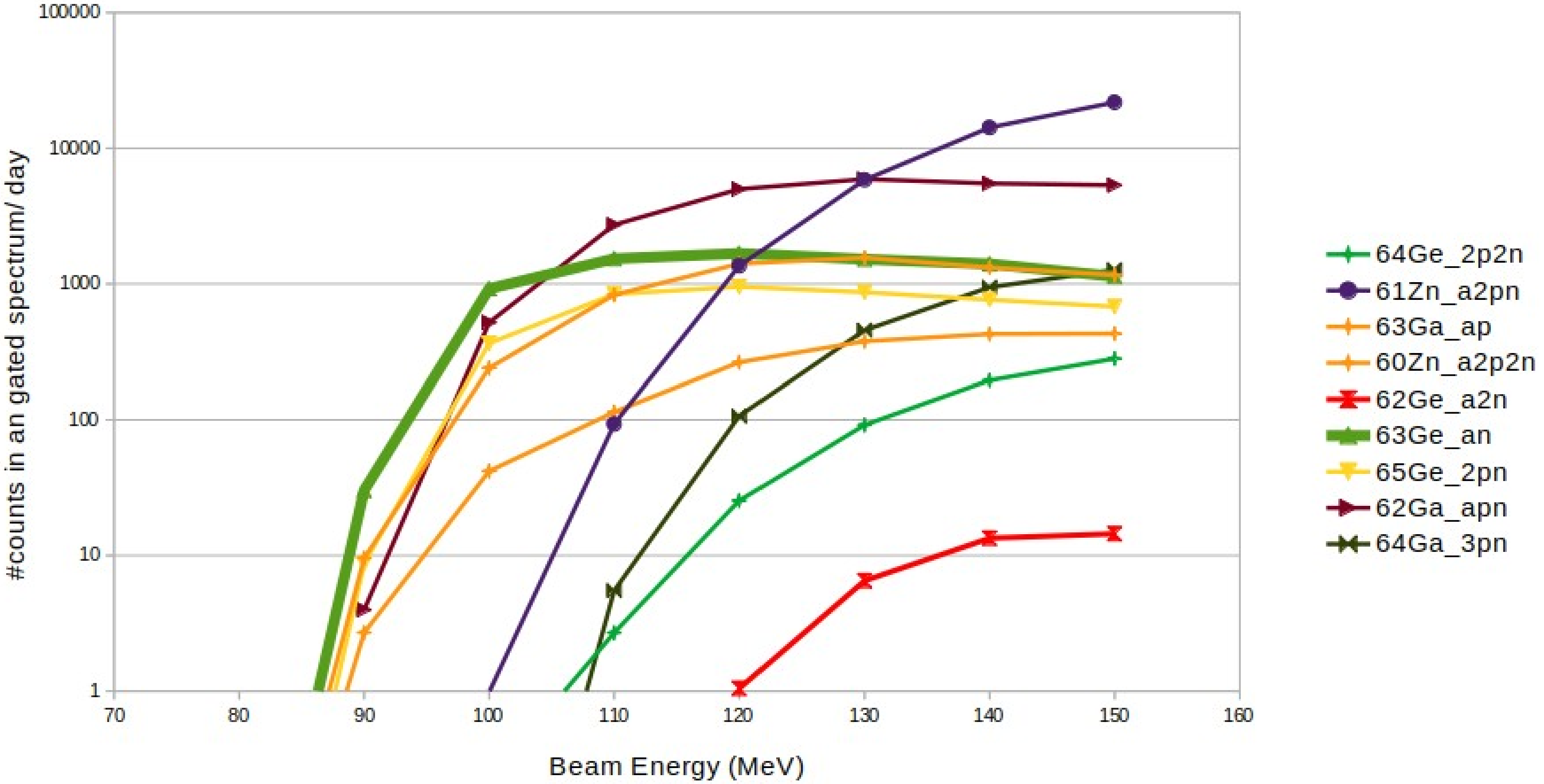
Reactions and x-secs

^{40}Ca + ^{28}Si → ^{78}Se → ^{63}Ge + αn (^{40}Ca @ 105 MeV) ^{63}Ge x-sec: ~0.1 mb (HIVAP)

^{36}Ar + ^{32}S → ^{78}Se → ^{63}Ge + αn (issue: ~60 k€ cost for ^{36}Ar bottles)



Needi selectivity & beam-time



Expected data collection:

- αn-gated g.s. γ/day: 1000

We ask for 15 days of the beam on the target to collect:

- αn-gated γ-γ: 150 counts

Summary

We aim to obtain for the first time the information on excited states in the ^{63}Ge nucleus.

And thus:

→ explore single-particle states in the upper *fp* shell region,

→ investigate levels associated with the collective excitation od the N=Z=28 core,

→ acquire experimental data on the isospin symmetry breaking in the upper *fp* shell region.

We ask for 15 days of beam on the target.

Project supported by NCN grant 2020/39/D/ST2/00466

Collaboration

The discovery of excited states in very neutron-deficient ^{63}Ge nucleus

G. Jaworski[1], A. Fijałkowska[2], E. Ahlgren Cederlöf[3], M. Araszkiewicz[2], A. Astier[4], T. Bäck[3], M. Ciemała[5], N. Cieplicka-Oryńczak[5], G. Colucci[1], A. Courbe[4], J. Darai[6], Y. Fang[7], F. Galtarossa[8], A. Goasduff[9], J. Grębosz[5], V. Guadilla[2], S. Guo[7], K. Hadyńska-Klęk[1], C. Hiver[4], Y. Hrabar[10], P. Jodidar[4], M. Kisieliński[1], M. Kmiecik[5], M. Komorowska[1], A. Korgul[2], M. Kowalczyk[1], A. Krakó[6], B. Kruzsicz[6], I. Kuti[6], B.F. Lv[7], A. Maj[5], A. Malinowski[1], M. Matejska-Minda[5], N. Marchini[11], D. Mengoni[8], K. Miernik[2], J. Molnár[6], A. Nałęcz-Jawecki[12], A. Nannini[11], J. Nyberg[13], M. Palacz[1], G. Pasqualato[4], C. Petrache[4], I. Piętka[1], W. Poklepa[14], J. Samorajczyk-Pyśk[1], M. Rocchini[11], P. Sekrecka[1], D. Sohler[6], K. Solak[2], M. Stepaniuk[2], K. Szlęzak[2], A. Špaček[1], J. Timár[6], N. Toniolo[9], A. Tucholski[1], K. Wrzosek-Lipska[1], F. Wu[15], K.K. Zheng[7]

[1] *Heavy Ion Laboratory, University of Warsaw, Poland*
[2] *Faculty of Physics, University of Warsaw, Poland*
[3] *Department of Physics, Royal Institute of Technology (KTH), Stockholm, Sweden*
[4] *IJClab, Université Paris-Saclay, CNRS-IN2P3, Orsay, France*
[5] *Institute of Nuclear Physics Polish Academy of Sciences, PL-31342 Krakow, Poland*
[6] *HUN-REN Institute for Nuclear Research (ATOMKI), Debrecen, Hungary*
[7] *Institute of Modern Physics, Chinese Academy of Science, Lanzhou, China*
[8] *Faculty of Physics, University of Padova & INFN Sec. Padova, Italy*
[9] *LNL INFN, Legnaro, Italy*
[10] *Lund University, Sweden*
[11] *INFN Sec. Firenze, Italy*
[12] *National Centre for Nuclear Research, Warsaw, Poland*
[13] *Department of Physics and Astronomy, Uppsala University, Sweden*
[14] *GSI Helmoltzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany*
[15] *Simon Fraser University, Burnaby, Canada*

Thank you for your attention