Coulomb excitation of ^{66}Ge

Or How I Learned to Stop Worrying and Love Ge

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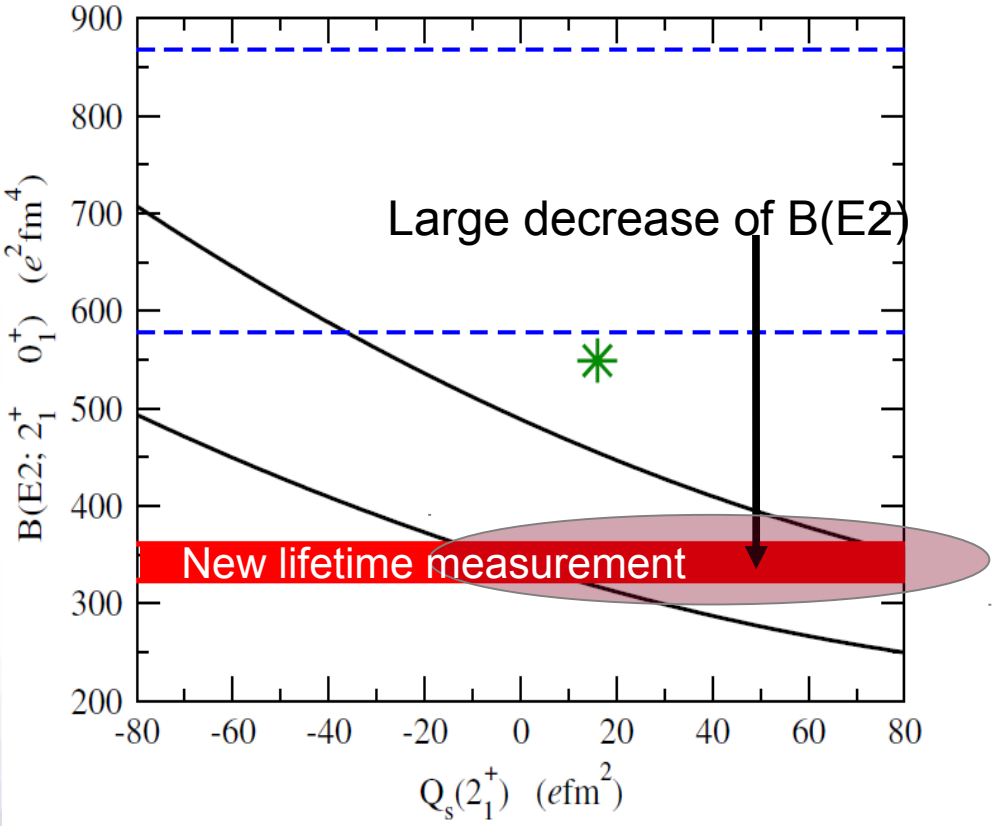
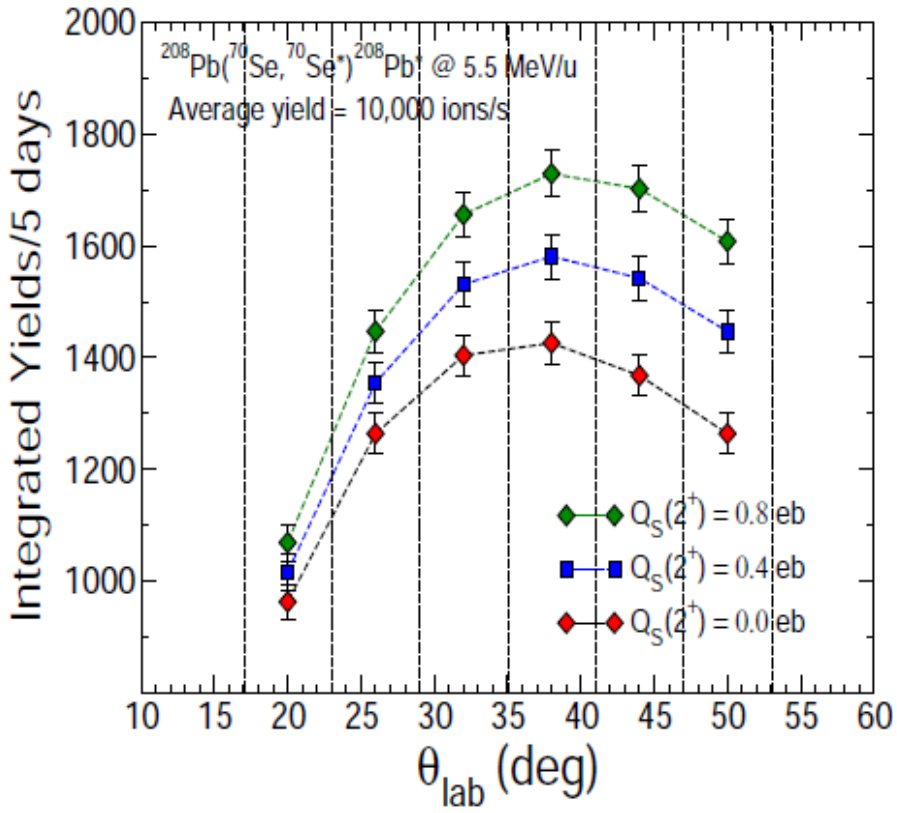
Overview

- Shape Conundrum in ^{70}Se (IS569)
- Beam profile favours ^{66}Ge
- Experiments carried out during 13-17 July 2017
- Data analysis
- Conclusions

In the books: Shape Conundrum in ^{70}Se (IS569)

Reorientation-effect measurement
using full potential @



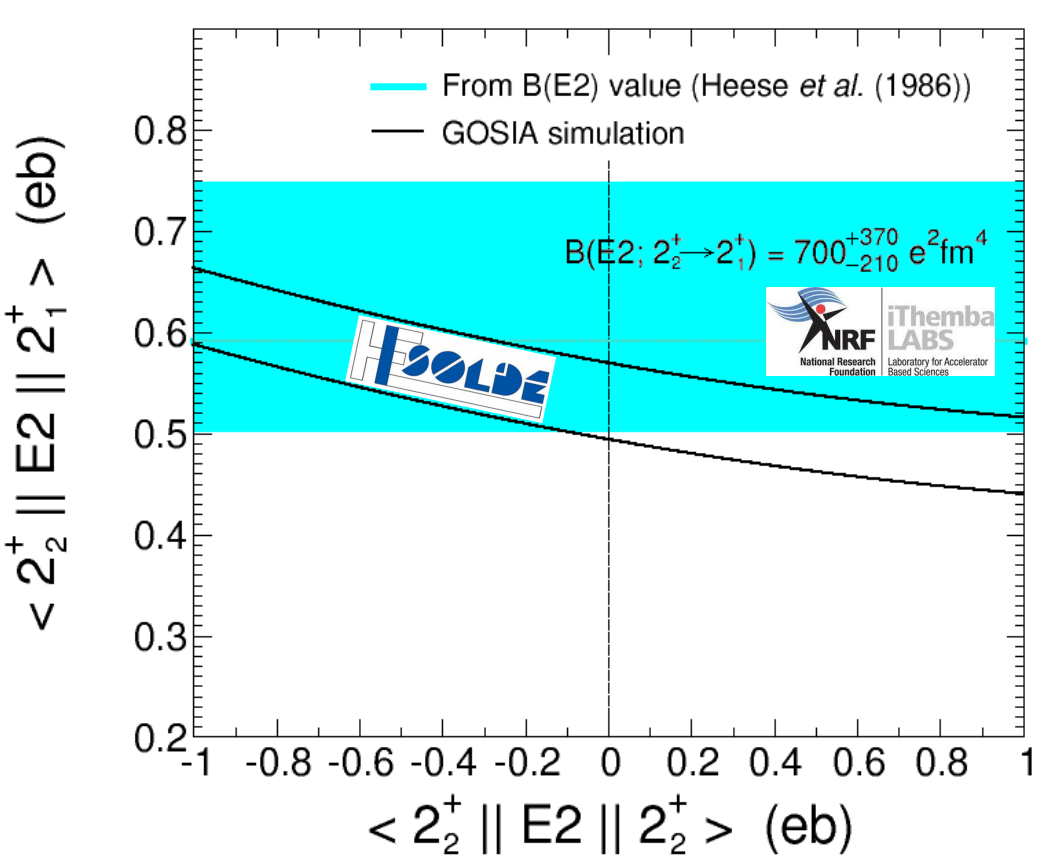


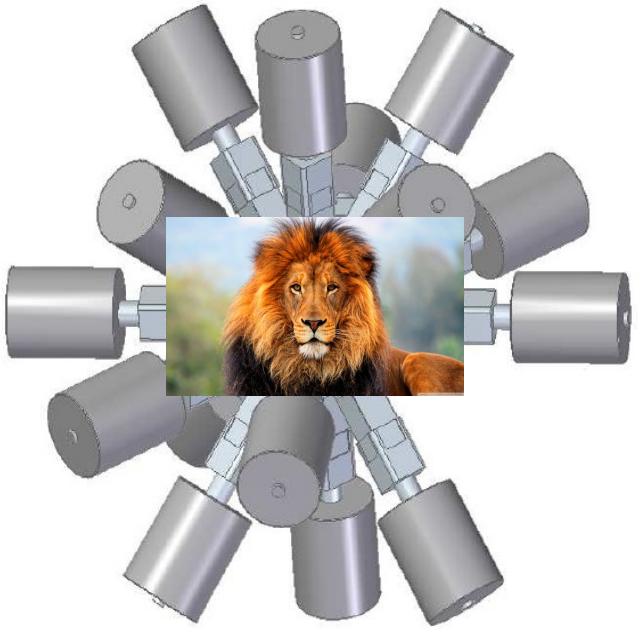
Angular distribution would tell us precisely static quadrupole moment of the first 2$^+$

J. Ljungvall *et al.*, Phys. Rev. Lett. **100**, 102502 (2008)
A. Hurst *et al.*, Phys. Rev. Lett. **98**, 072501 (2007)

Shape Coexistence in ^{70}Se: **What about the second 2$^+$?**

Enough statistics (~100-200 counts) @ HIE-ISOLDE to determine the sign of $Q_s(2^+)$ with complementary measurements @ iThemba LABS



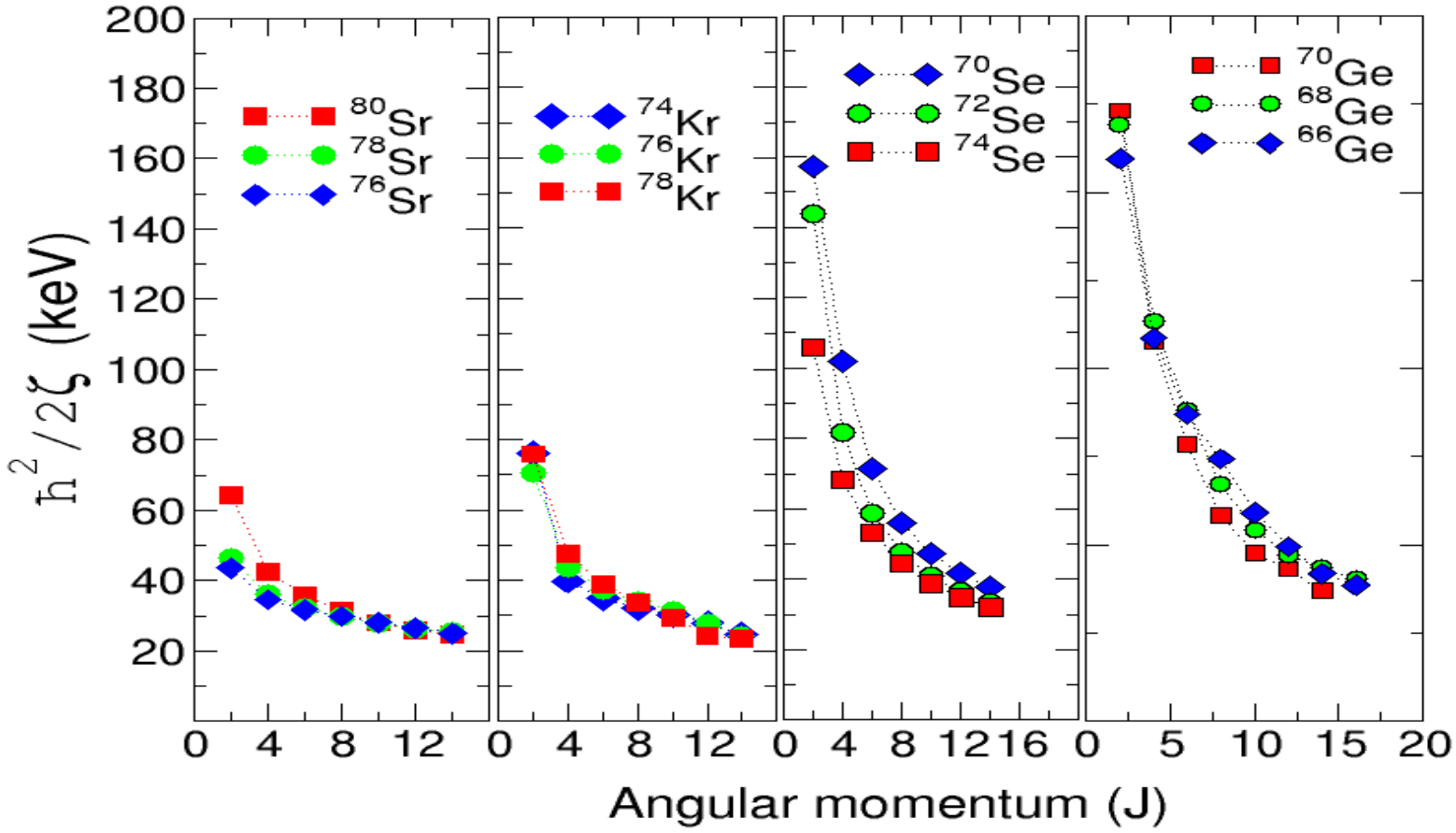


GAMKA (the Lion):
R35M just funded by the NRF
One possible combination:
18 clovers + 8 large $LaBr_3$

Lifetime and mixing-ratio measurements for 2nd 2$^+$ @ iThemba LABS using the GAMKA array
e.g., ^{58}Ni(^{14}N,pn) reaction at 39 MeV (Heese *et al* 1986) to avoid yrast population

Shape coexistence in the neutron deficient region A ~ 70

^{66}Ge and ^{70}Se present a very similar “anomalous” behaviour

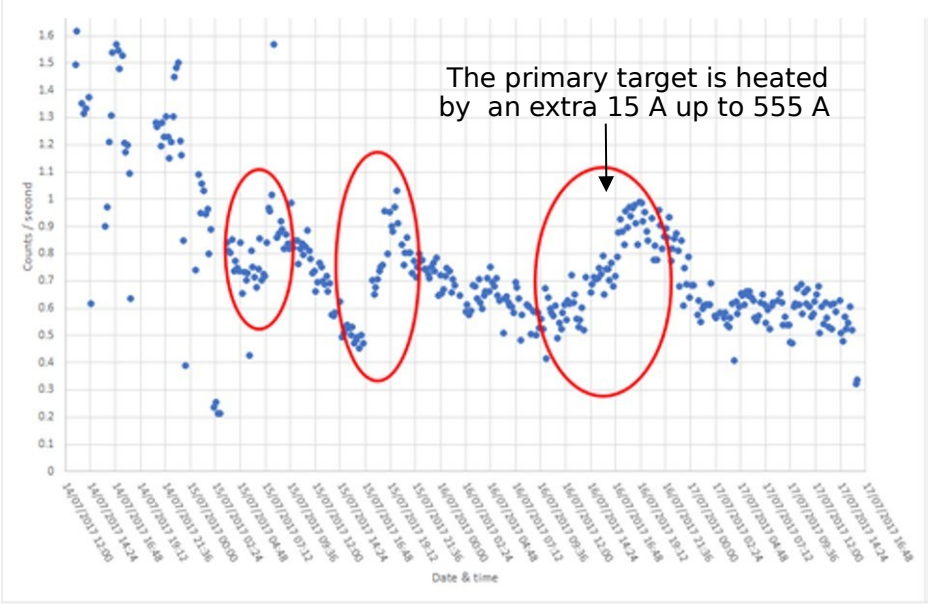


Mixing of 0^+ states leads to anomalous rotational behaviour of first 2^+ state.
Tentative 2^{nd} 0^+ state @ 2010.3 keV in ^{70}Se.
No 2^{nd} 0^+ state in ^{66}Ge (new proposal by G. O’Neill et al)

Beam profile: sulfur in ZrO_2 target # 612

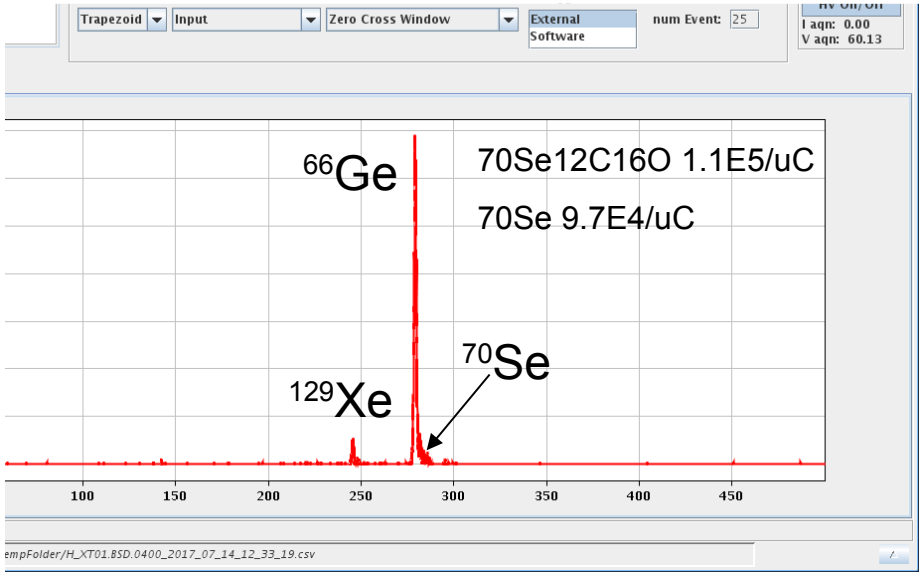
The original Physics goal changed by the existing sulfur in the ZrO2 target, which allowed for the production of ^{66}GeS molecules in greater proportion than ^{70}SeCO molecules.

Particle hits on Q2 quadrant in MINIBALL as a function of time (similar pattern in all quadrants)



The beam current decreased very rapidly over time despite efforts from the accelerator group.

Beam composition from CD upstream: **estimated ^{70}Se/^{66}Ge~0.1**



Implantation data under analysis to estimate beam compostion.

The good news: first time an unstable Ge isotope is accelerated!

Experiments carried out during 13-17 July 2017

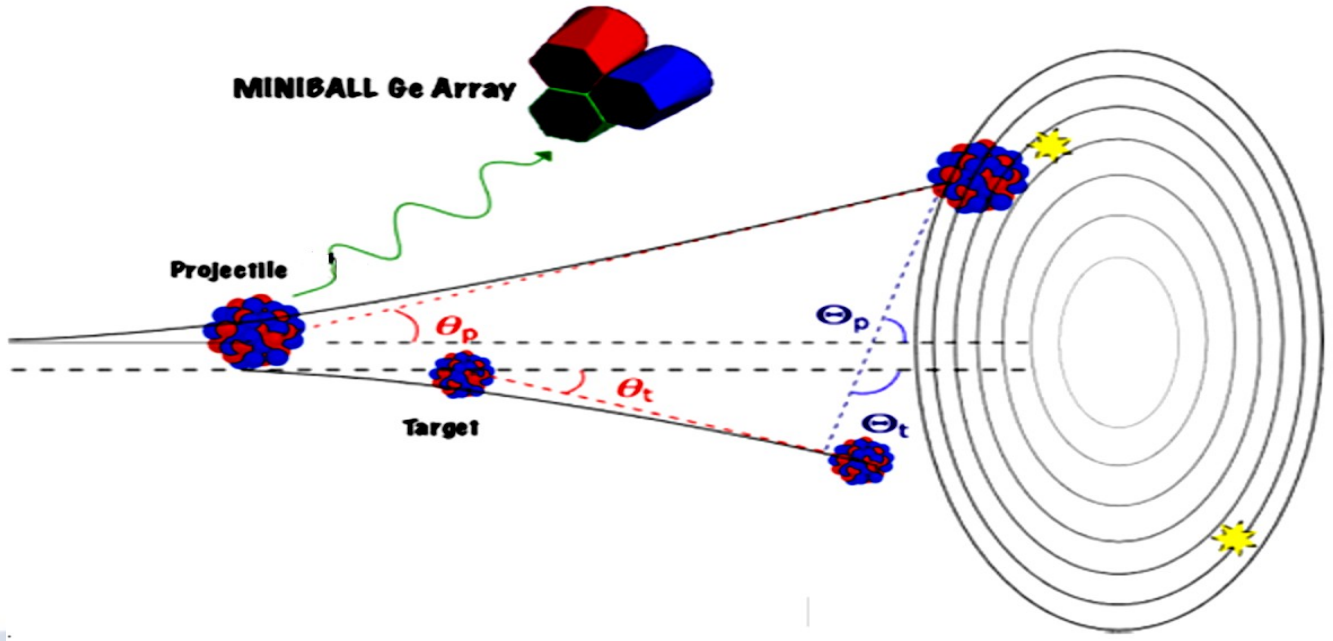
- d(^{22}Ne,^{23}Ne)p @ 4.48 MeV/u to determine MINIBALL crystal angles
  N. Warr *et al.*, Eur. Phys. J. A **49** (2013) 40
- ^{66}Ge(^{196}Pt, ^{196}Pt*)^{66}Ge* Coulomb excitation reaction @ 4.395 MeV/u

- ^{66}Ge beam in the ionization chamber downstream the MINIBALL array to estimate beam energy losses and ^{196}Pt target thickness.

- Implantation and beta decay to study the beam composition and nuclear structure of daughter nuclei (C. Mehl PhD thesis)

$^{66}Ge(^{196}Pt, ^{196}Pt^{*})^{66}Ge^{*}$ Coulomb excitation reaction @ 4.395 MeV/u

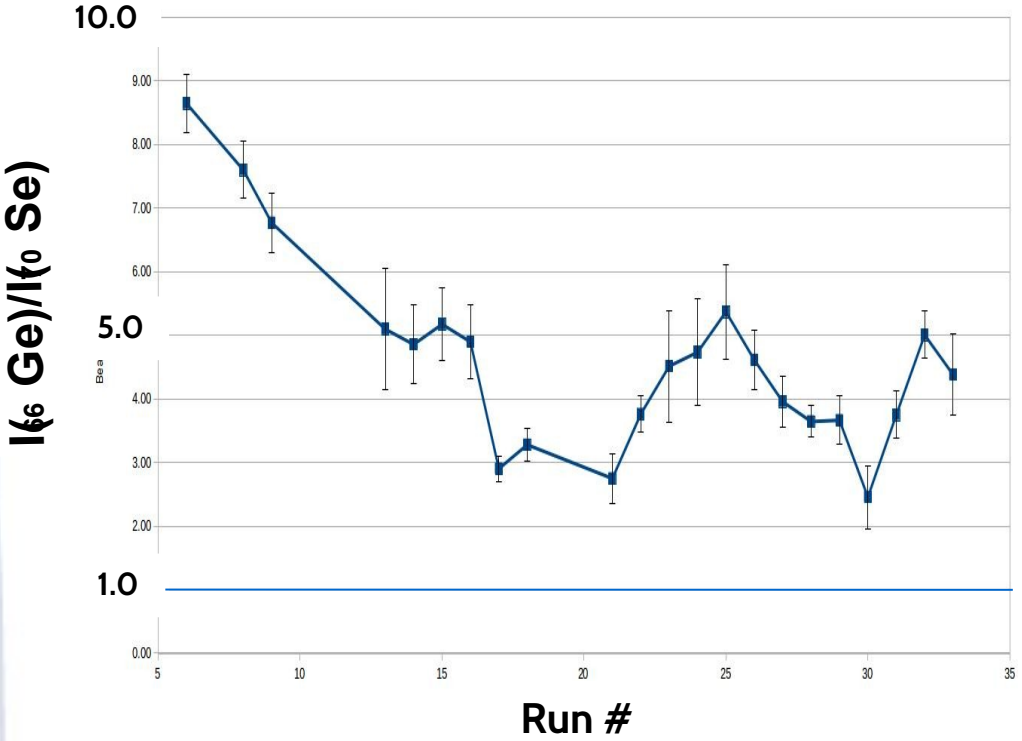
- Eight MINIBALL detectors + double-sided CD detector
- ^{66}Ge beam bombarded onto a ^{196}Pt target (97.25% enriched)
- ^{196}Pt target thickness = 4 mg/cm^2 @ Heavy Ion Laboratory, Warsaw
- Starting $^{70}Se^{12}C^{16}O$ yield = 1.1E5/uC (free of isobars?) vs 70Se 9.7E4/uC
- Actually, it was mostly ^{66}GeS!
- Beam energy = 4.395 MeV/u
- Target - CD distance = 27.4 ± 0.3 mm
- CD angular coverage: [18.2^o, 56.2^o] in the lab frame



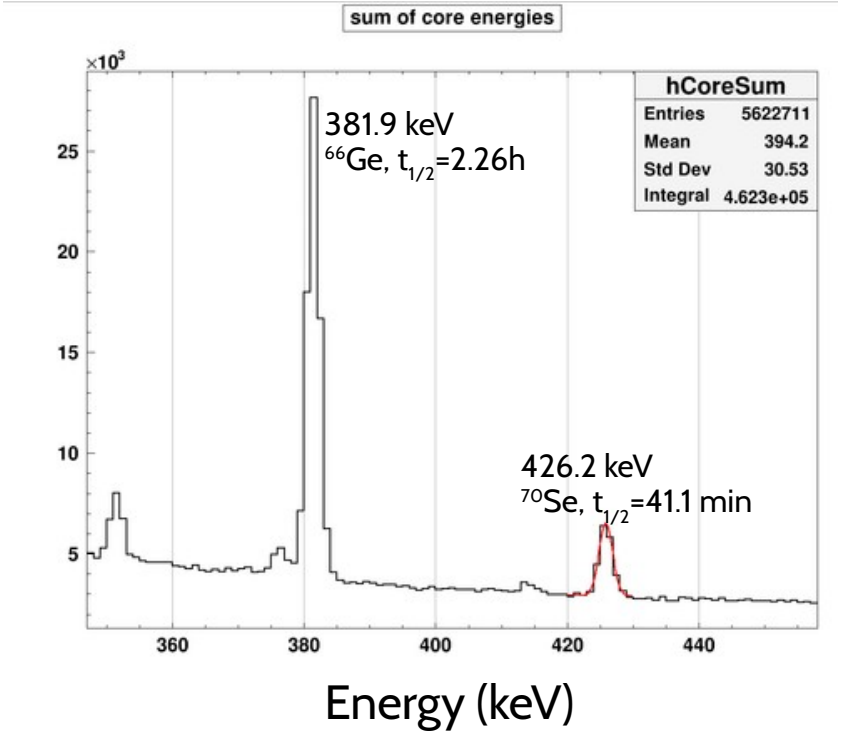
Beam composition from in-beam γ-ray data: I(⁶⁶Ge)/I(⁷⁰Se)

The composition of ^{66}Ge is stronger than ^{70}Se,
as agreed by the accelerator group.

Beam ratio vs Run #

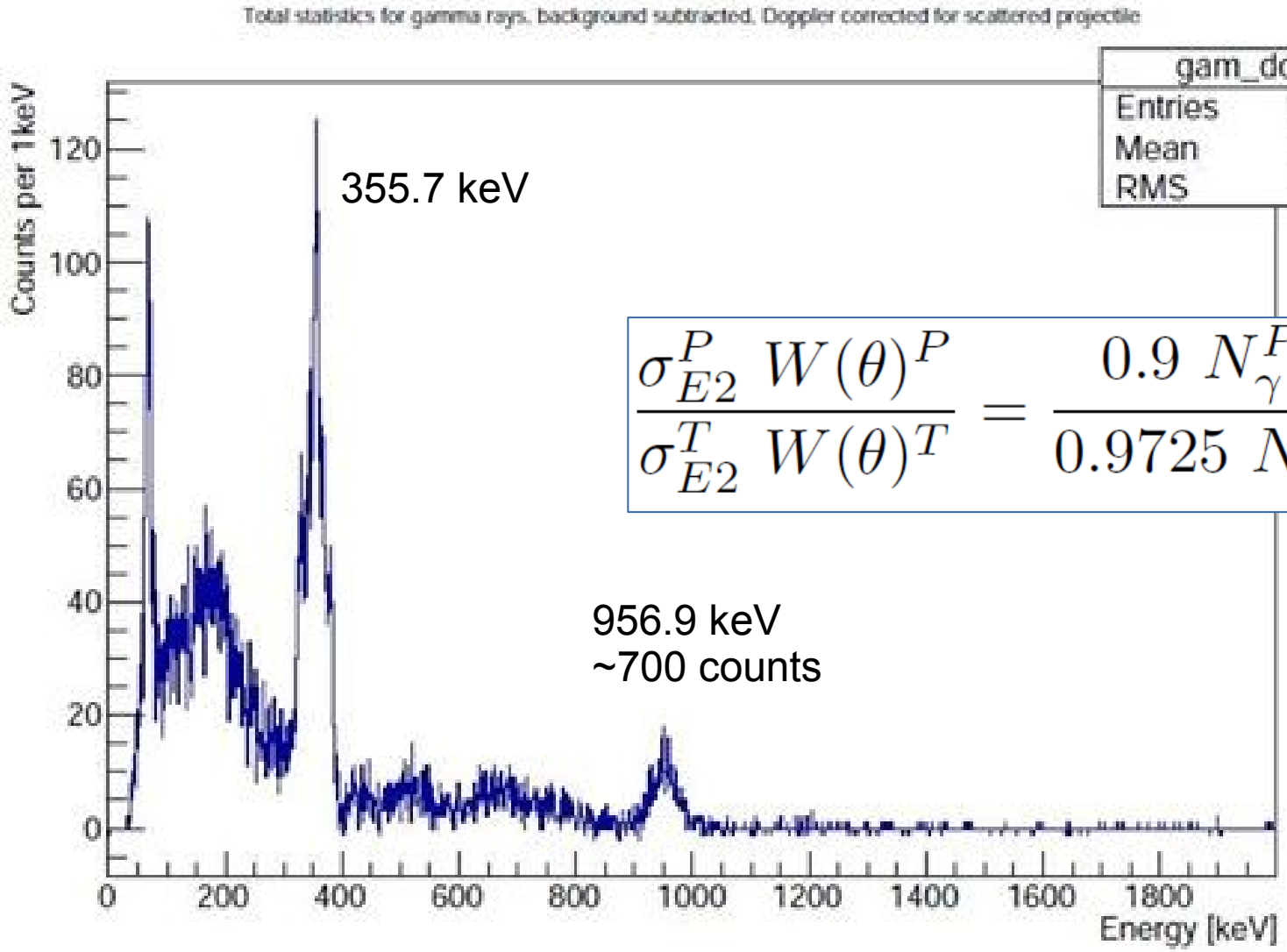


In-beam γ-ray spectrum



Data are, however, not conclusive as there is a decay/time dependence in the γ–ray peaks. The activation/decay data will confirm the beam composition.

Preliminary Doppler-corrected γ–ray spectrum

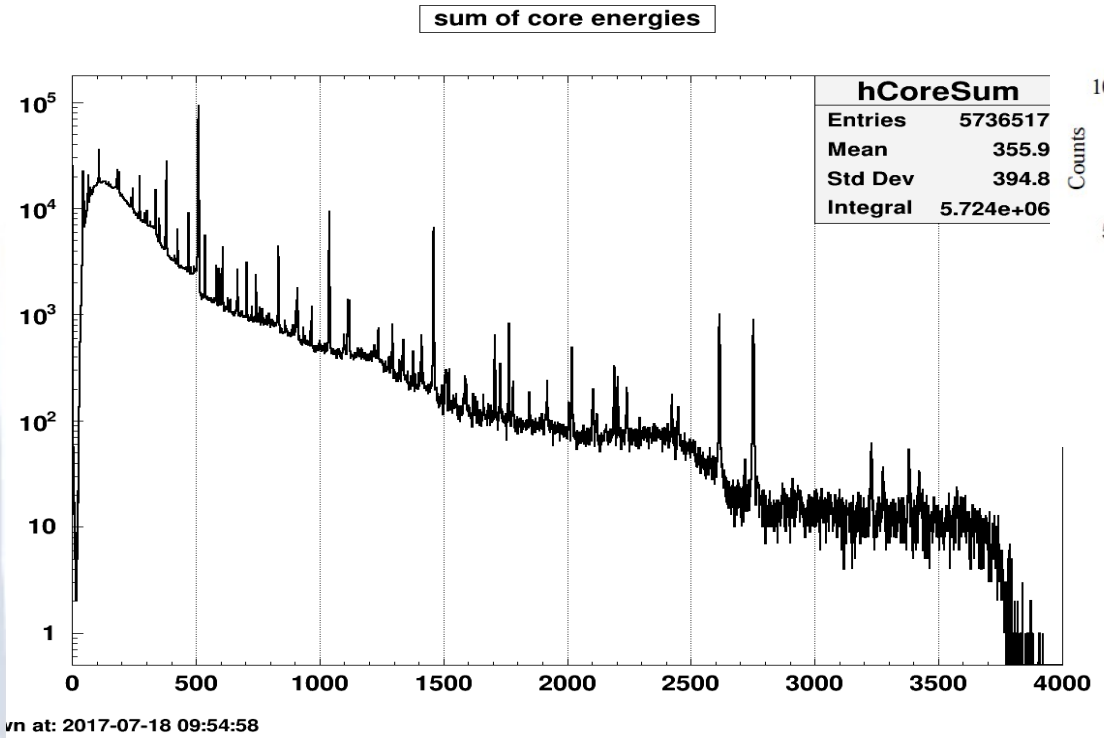


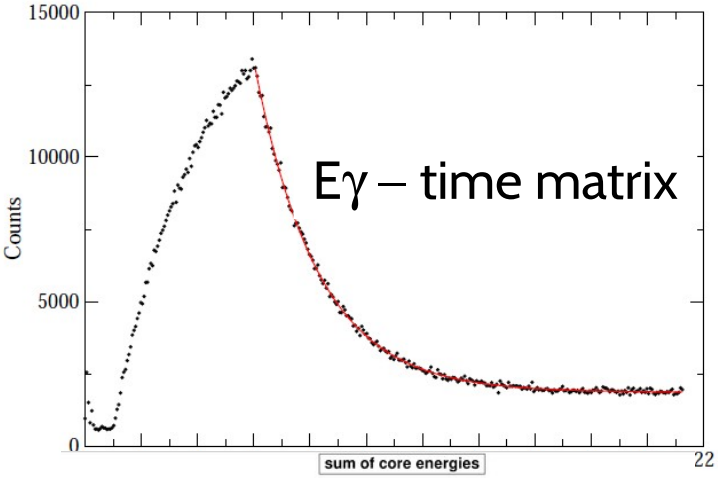
$$\frac{\sigma_{E2}^{P}\ W(\theta)^{P}}{\sigma_{E2}^{T}\ W(\theta)^{T}} = \frac{0.9\ N_{\gamma}^{P}}{0.9725\ N_{\gamma}^{T}}\frac{\varepsilon_{\gamma}^{T}}{\varepsilon_{\gamma}^{P}}$$

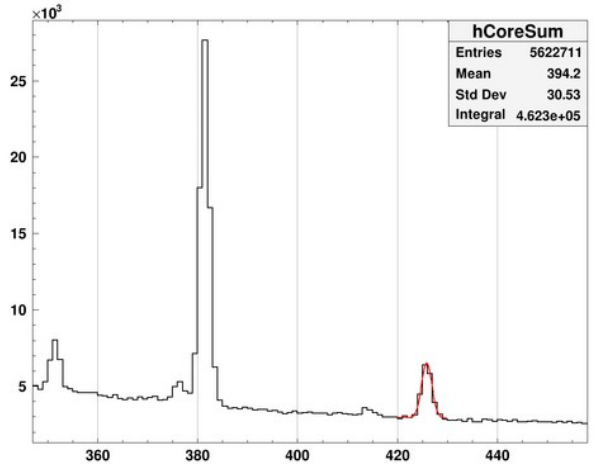
Enough statistics to determine $Q_s(2^+)$ from normalization method

Implantation + beta decay study

beam composition + nuclear structure







A promising data set collected with 10^6 γ–γ coincidences (C. Mehl, PhD Thesis)
Eγ – time matrix + pile up + dead time (ongoing analysis)

CONCLUSIONS

- Efficiencies and Calibration of the clusters and CD detector
- Geometry characterisation
- In-beam composition supports a larger ^{66}Ge/^{70}Se beam composition
- Static quadrupole moment with be determined using the Normalization technique
- Beam composition under analysis from activation+beta decay data collected at the end of the experiments
- A new proposal to study shape coexistence in ^{66}Ge wil be submitted to the next INTC + we expect to run ^{70}Se (IS569).
- Beam development is required to study the ^{66}Ge/^{70}Se beam profile and enhance production for either of them.

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