Naomi Marchini

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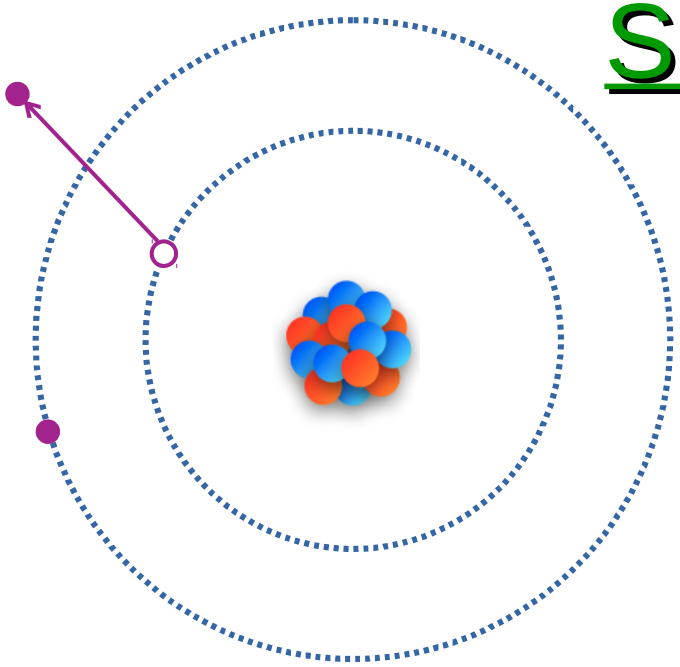
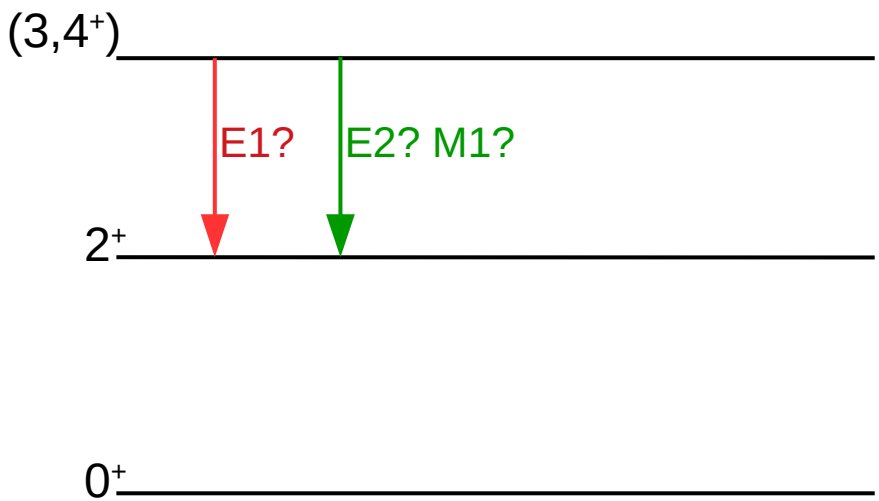
Internal Conversion Electron Spectroscopy @LNL



Internal Conversion Coefficients

- Experimentally we obtain: $$\alpha_K(\Omega L) = \frac{I_K(\Omega L)}{I_\gamma(\Omega L)} \cdot \frac{\eta_\gamma^{abs}}{\eta_e^{abs}}$$

- Compare the experimental $\alpha_K(\Omega L)$ value with the theoretical $\alpha_K(\Omega L)$ values for different multipolarities to find a correct parity of the level



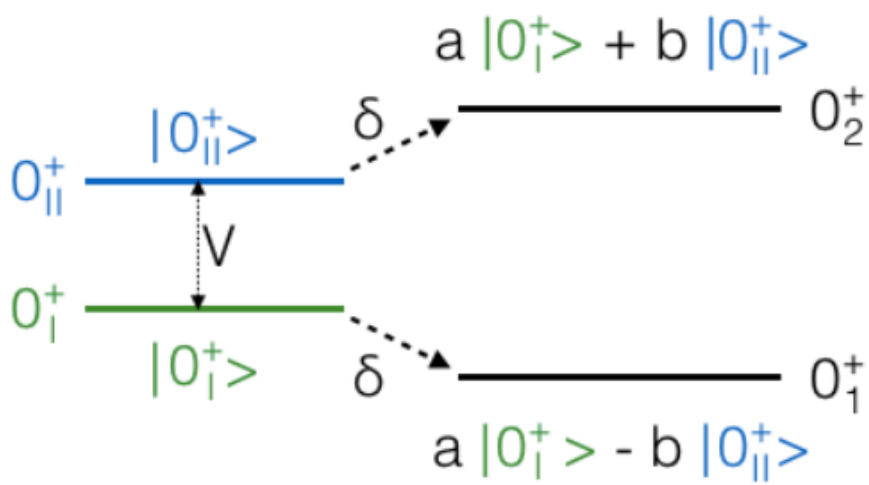
Assign level parity

Electric Monopole Transitions (E0) ΔJ=0

- E0 Transition Probability: $$B\left(E0; J \longrightarrow J'\right) = \frac{1}{2J+1}\left|\langle J' \| E0 \| J\rangle\right|^2$$

- Monopole Transition Strength: $$\rho^2\left(E0; J \longrightarrow J'\right) = \frac{\left|\langle J' \| E0 \| J\rangle\right|^2}{e^2 R^4}$$

Simple two levels model:

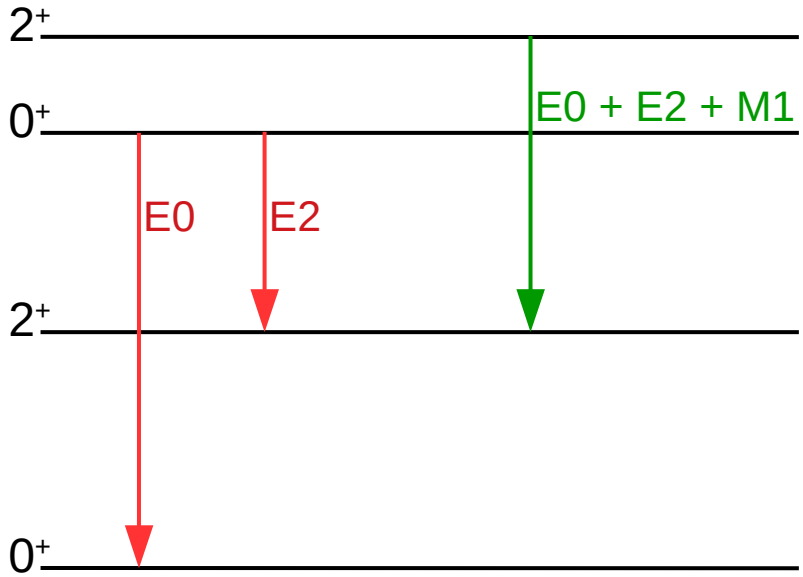


$$\rho^2(E0) = \frac{Z^2}{R^4} a^2 b^2 \left(\Delta \left\langle r^2 \right\rangle\right)^2$$

Shape of excited states and mixing between them

Electric Monopole Transitions (E0) ΔJ=0

- Experimentally we obtain: $$q_K^2(\mathrm{E0/E2}) = \frac{I_K(\mathrm{E0})}{I_K(\mathrm{E2})}$$



- For $J_i=J_f=0$

$$q_K^2(\mathrm{E0/E2}) = \frac{I_K(\mathrm{E0})}{I_K(\mathrm{E2})}$$

- For $J_i=J_f\neq 0$

$$\alpha_K = \frac{\alpha_K^{th}(M1) + (1+q_j{}^2{}_{if})\cdot\delta^2\cdot\alpha_K^{th}(E2)}{(1+\delta^2)}$$

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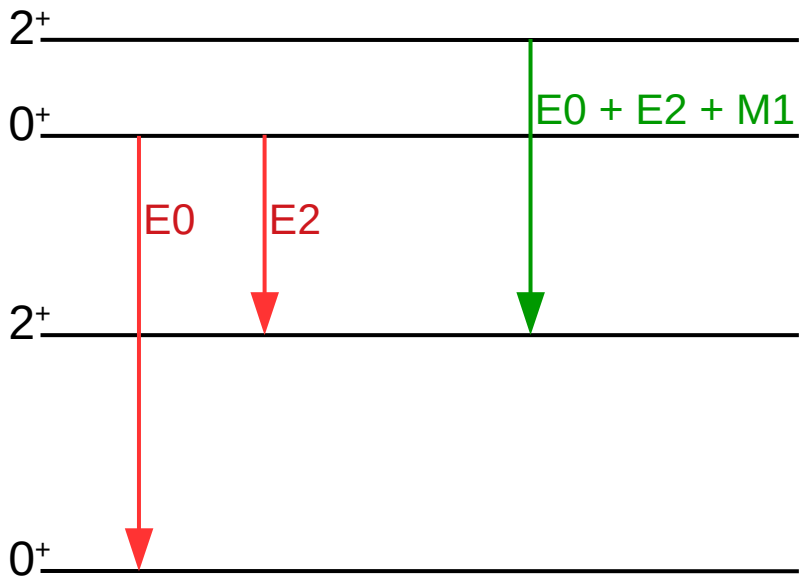

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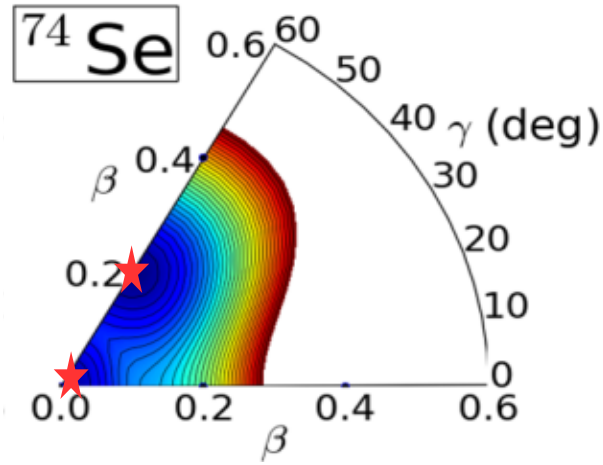
$$\alpha_K = \frac{\alpha_K^{th}(M1) + (1+q_j{}^2{}_{if})\cdot\delta^2\cdot\alpha_K^{th}(E2)}{(1+\delta^2)}$$

- If the E2 transition rate is known: $$\rho^2(\mathrm{E0}) = q_K^2(\mathrm{E0/E2}) \times \frac{\alpha_K(\mathrm{E2})}{\Omega_K(\mathrm{E0})} \times W_\gamma(\mathrm{E2})$$

^{74}Se Recent Investigations

- K. Nomura et al., Phys. Rev. C 95, 064310 (2017) in the IBM framework predicted coexistence between spherical and oblate shapes



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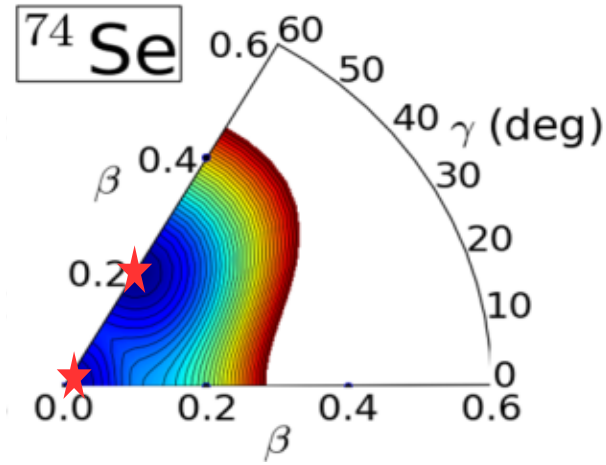
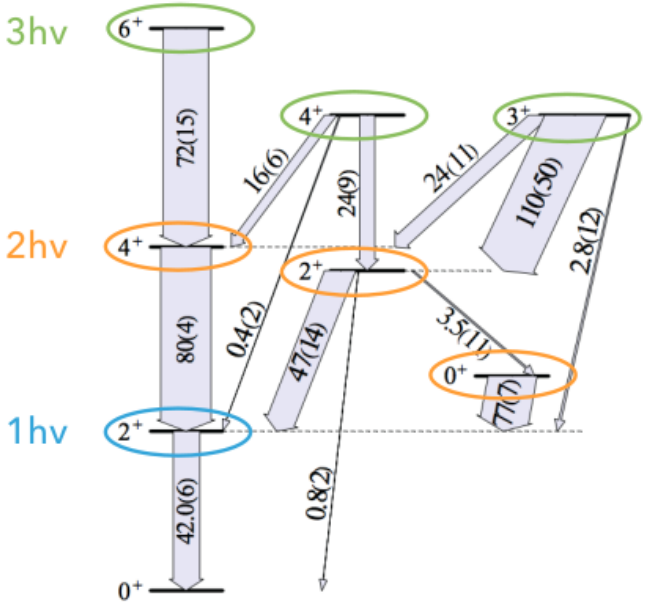
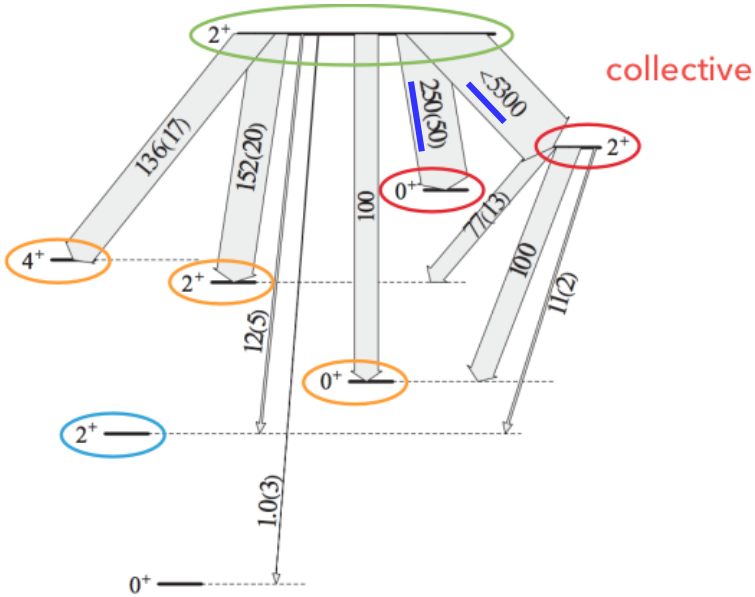


- In E. A. McCutchan et. al, Phys.Rev. C 87, 014307 (2013) the low-lying states are described as a set of near-spherical vibrational levels mixing strongly with a spectrum of prolate states



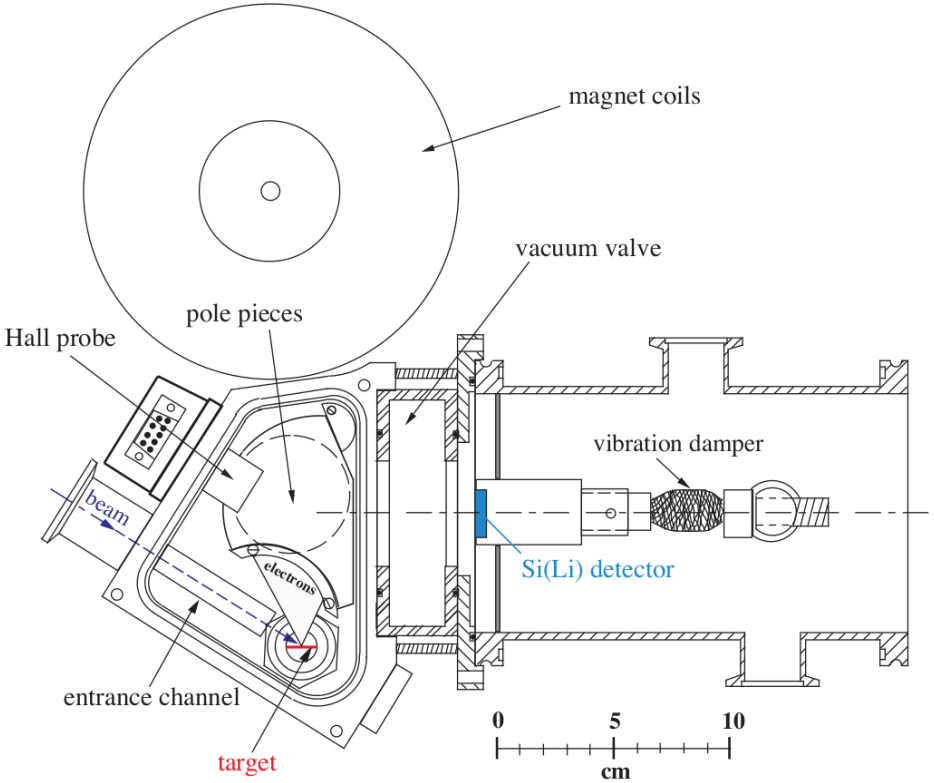


^{74}Se Experiment

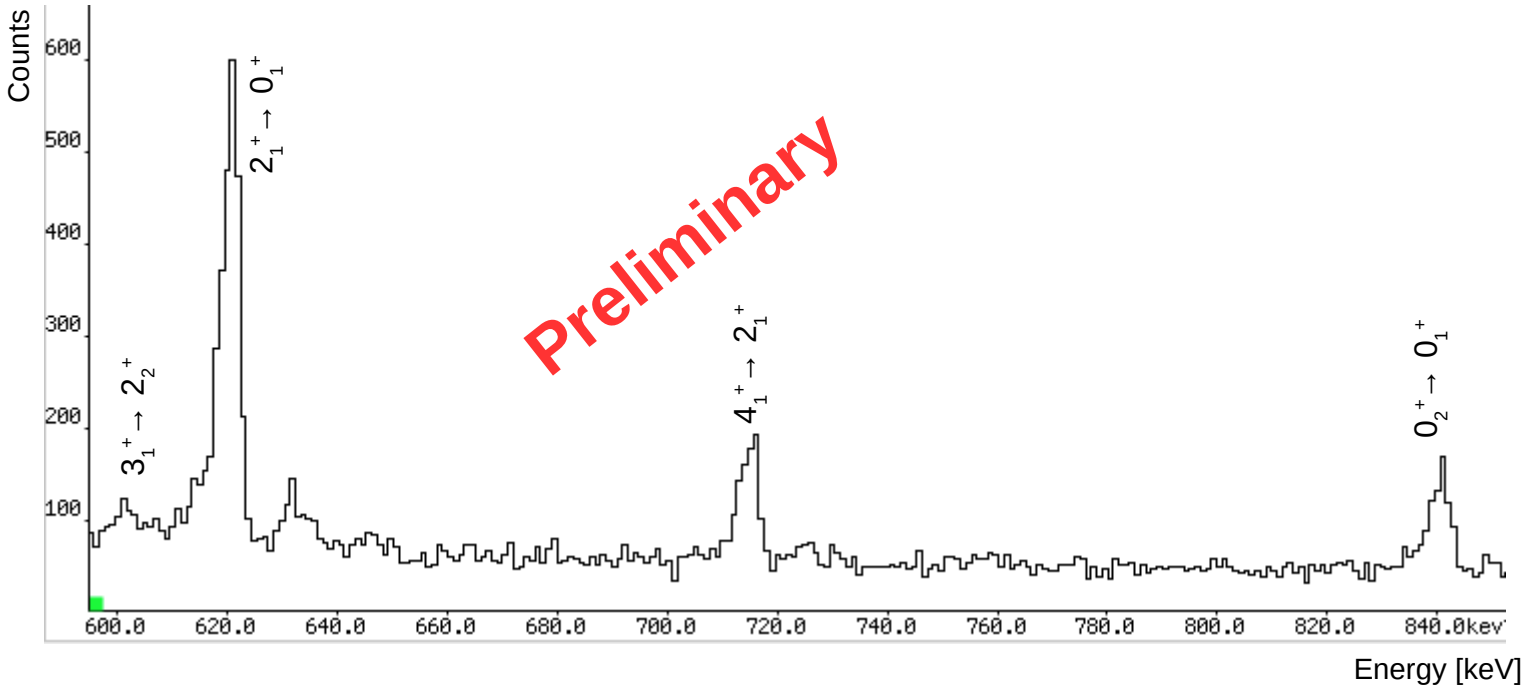
- Performed at Legnaro National Laboratory last year
- Levels of interest were populated in the EC/β^+ decay of ^{74}Br produced via the fusion evaporation ^{60}Ni(^{16}O,pn)^{74}Br reaction
- The ground state of ^{74}Br has a half-life of 24.5 m and the isomeric state a half-life of 46 m
- Off-line acquisition: activation and measurement time of 31 min
- Bombarding and measurement cicles were controlled by our acquisition system

^{74}Se Experimental Setup

- One HPGe detector
- Magnetic electron spectrometer
  - Magnetic coils
  - Si(Li) detector
  - Spectrometer efficiency is constant from 150 keV to 1600 keV (~ 1%)
  - Spectrometer trasmission Δp/p ~ 18%



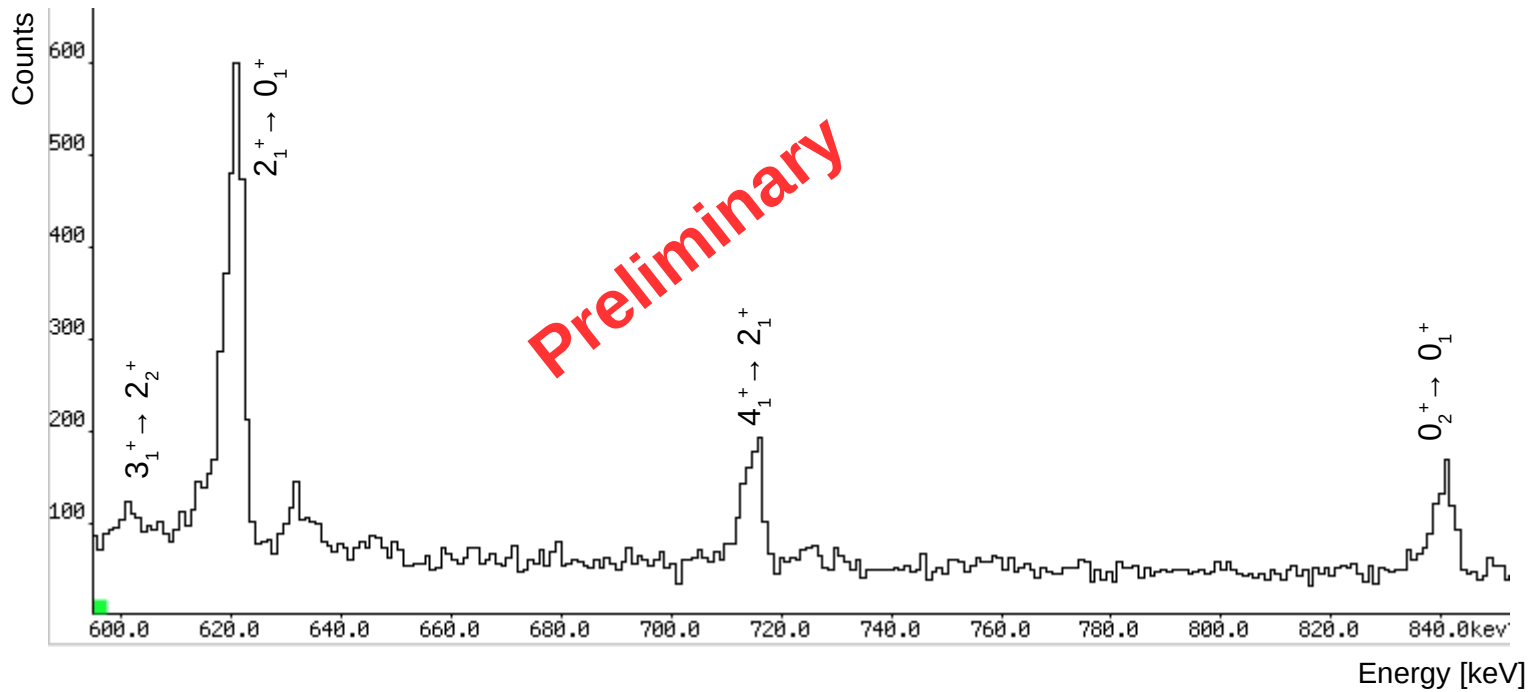
^{74}Se Experiment



- E0 transitions ⟶ Mixing between 0^+ states and between 2^+ states

- α_K ⟶ Assign levels parity

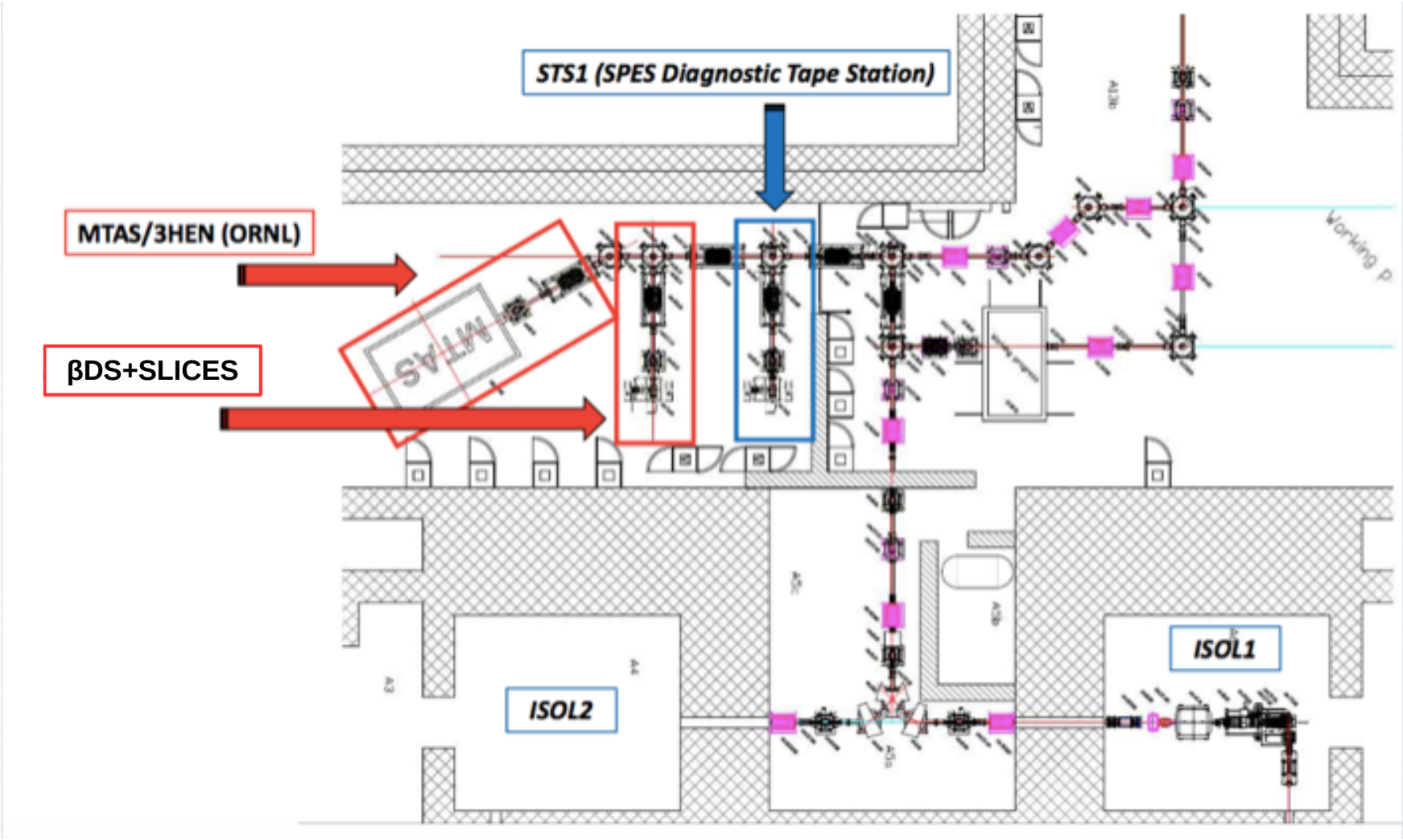
^{74}Se Experiment



- E0 transitions ⟶ Mixing between 0^+ states and between 2^+ states
  - $q^2(0_2^+ \rightarrow 0_1^+) = 0.28(8)$ ($q^2 = 0.203(14)$)

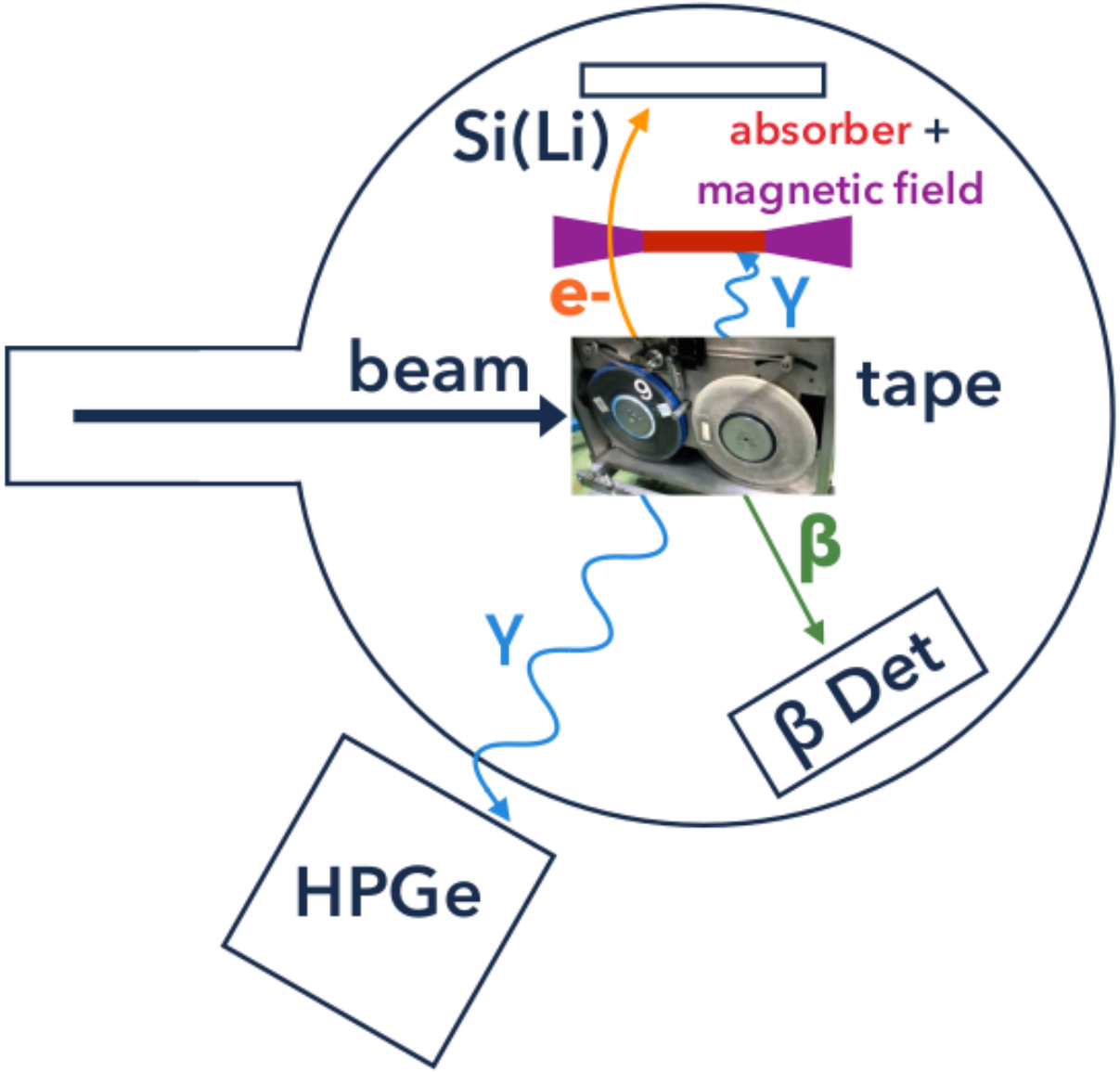
- α_K ⟶ Assign levels parity
  - $\alpha_K(4_1^+ \rightarrow 2_1^+) = 0.00080(6)$ ($\alpha_K = 0.000830(12)$)

Spes Experimental Room

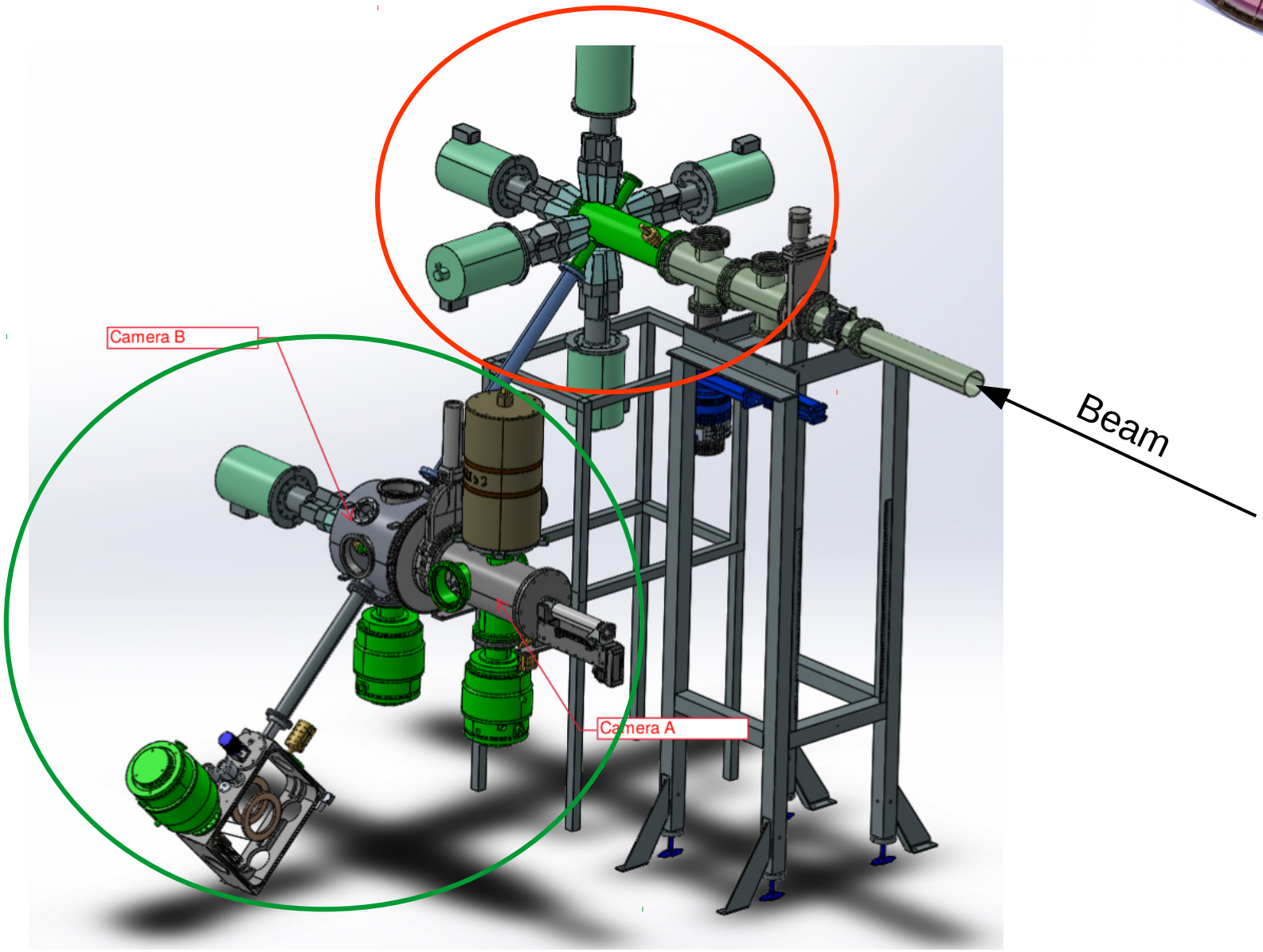


SLICES (Spes Low-energy Internal Conversion Electrons Spectrometer)

- Si(Li) detector
- HPGe detector
- Moving tape
- Plastic Scintillator
- Magnetic transport system



SLICES



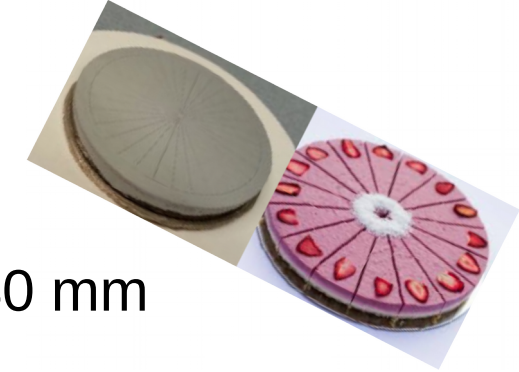
SLICES Si(Li) detector

- Development in collaboration with the Jülich (Germany) research center
- Diameter = 70 mm (active area ~ 3900 mm^2)
- Thickness = 6.8 mm
- Segmented in 32 independent sectors
- Requested FWHM(@~1MeV) ~ 3 keV

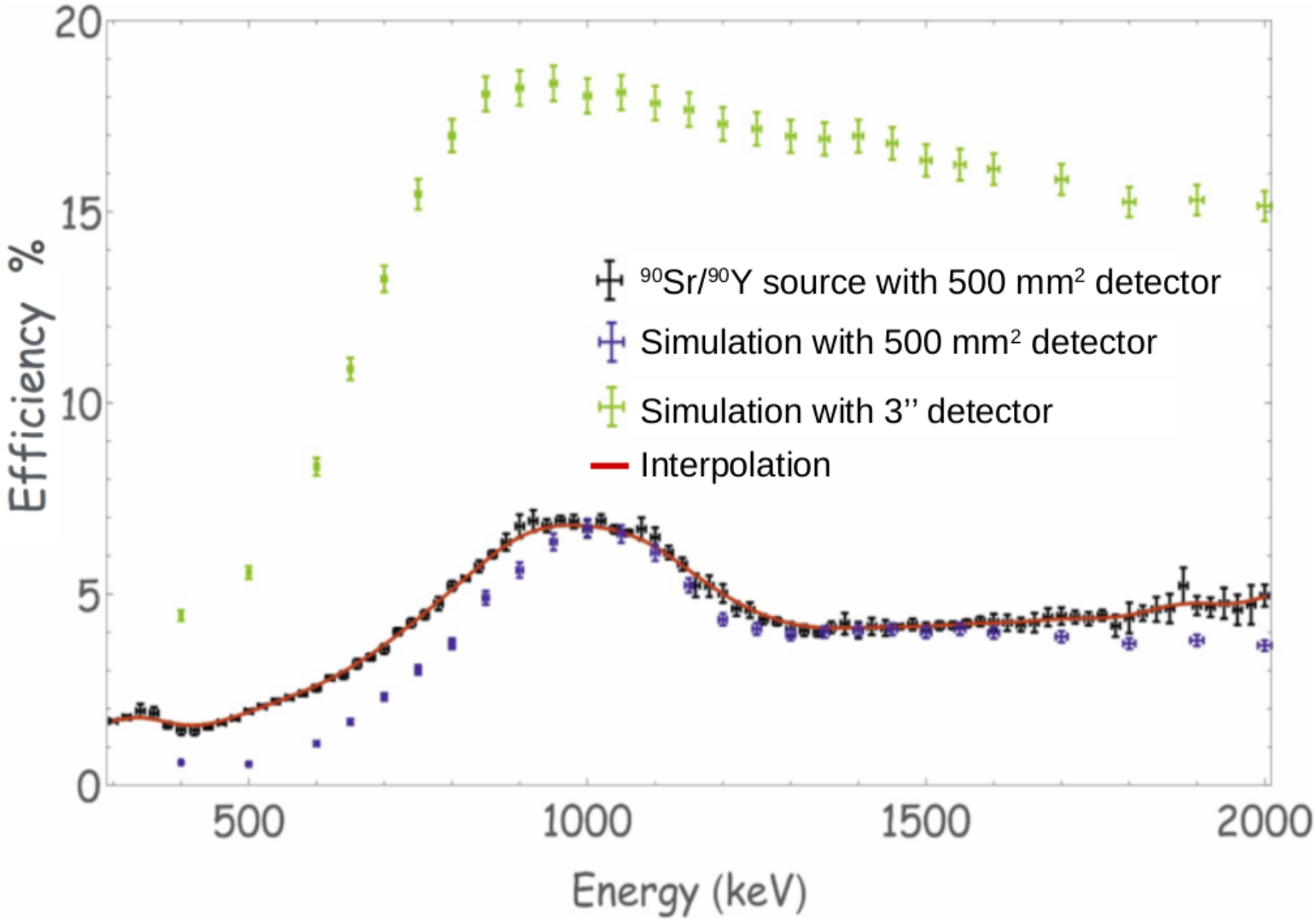
SLICES Si(Li) detector

- Deve ... ich (Gerı
- Diam ... m²)
- Thick
- Segr
- Requ

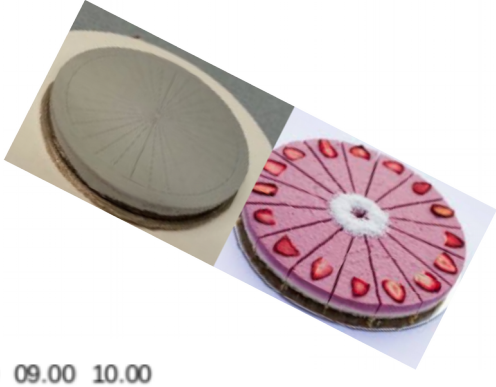
SLICES Efficiency

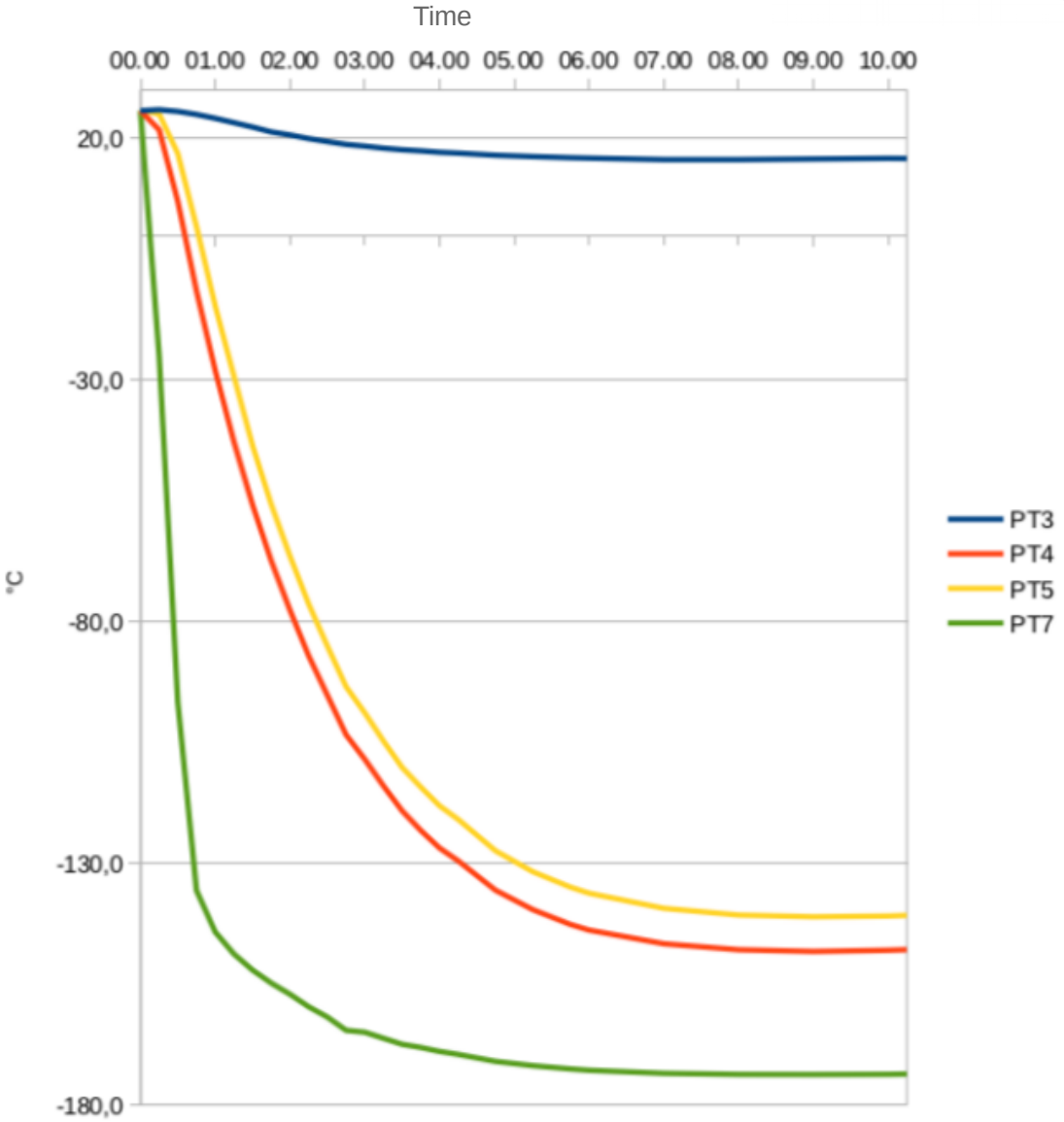


Distances: Source-Magnets = 50 mm, Magnets-Detector = 40 mm



SLICES Tests





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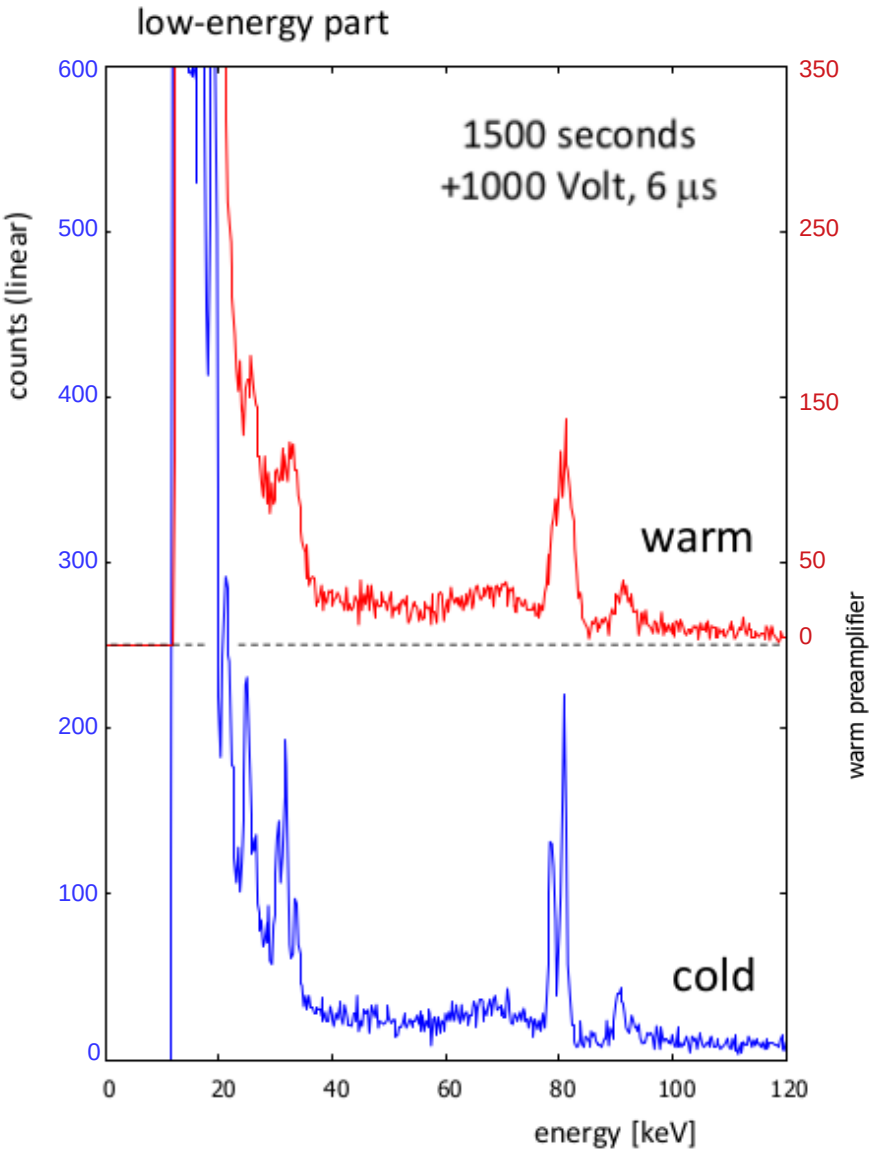

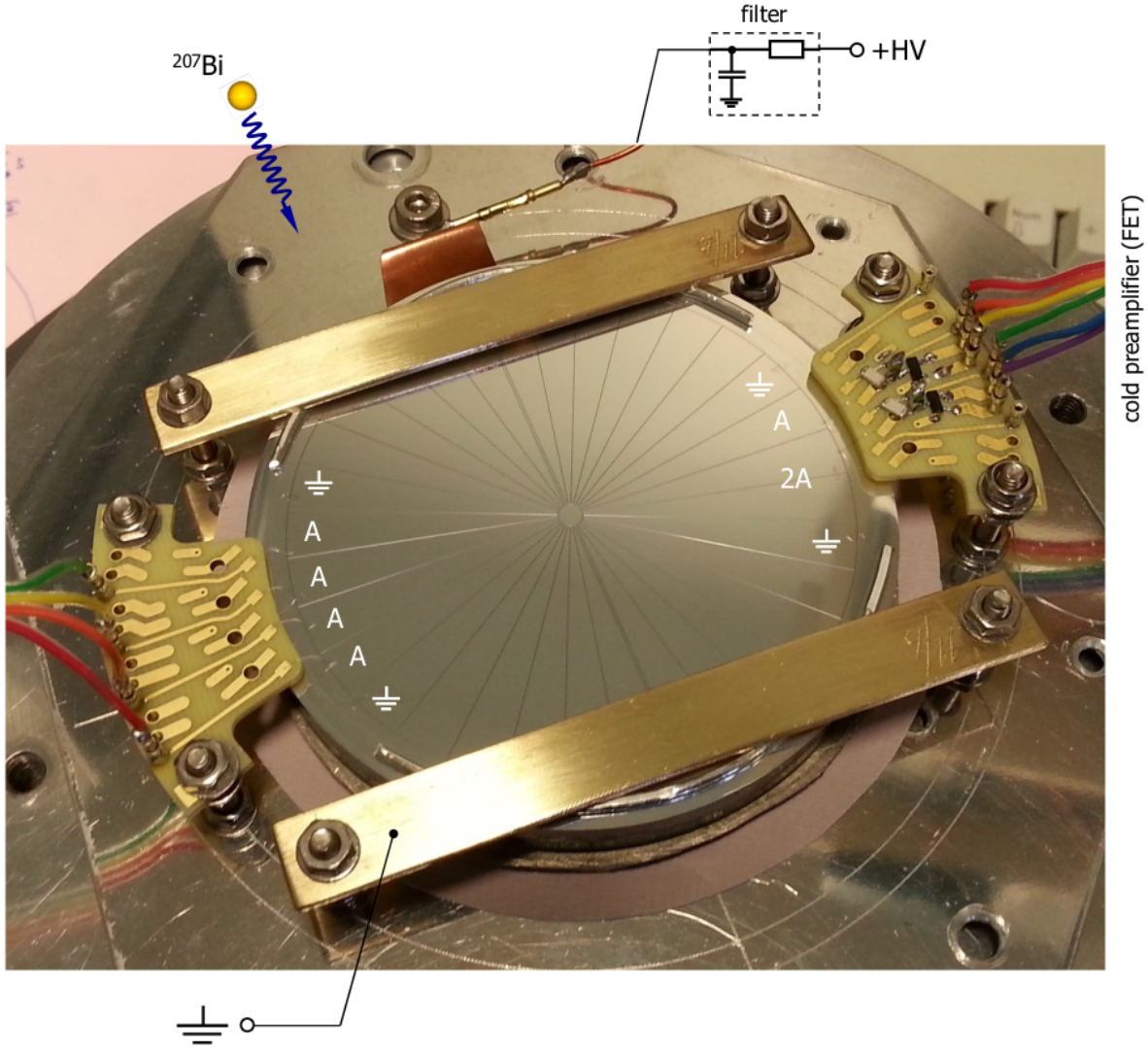

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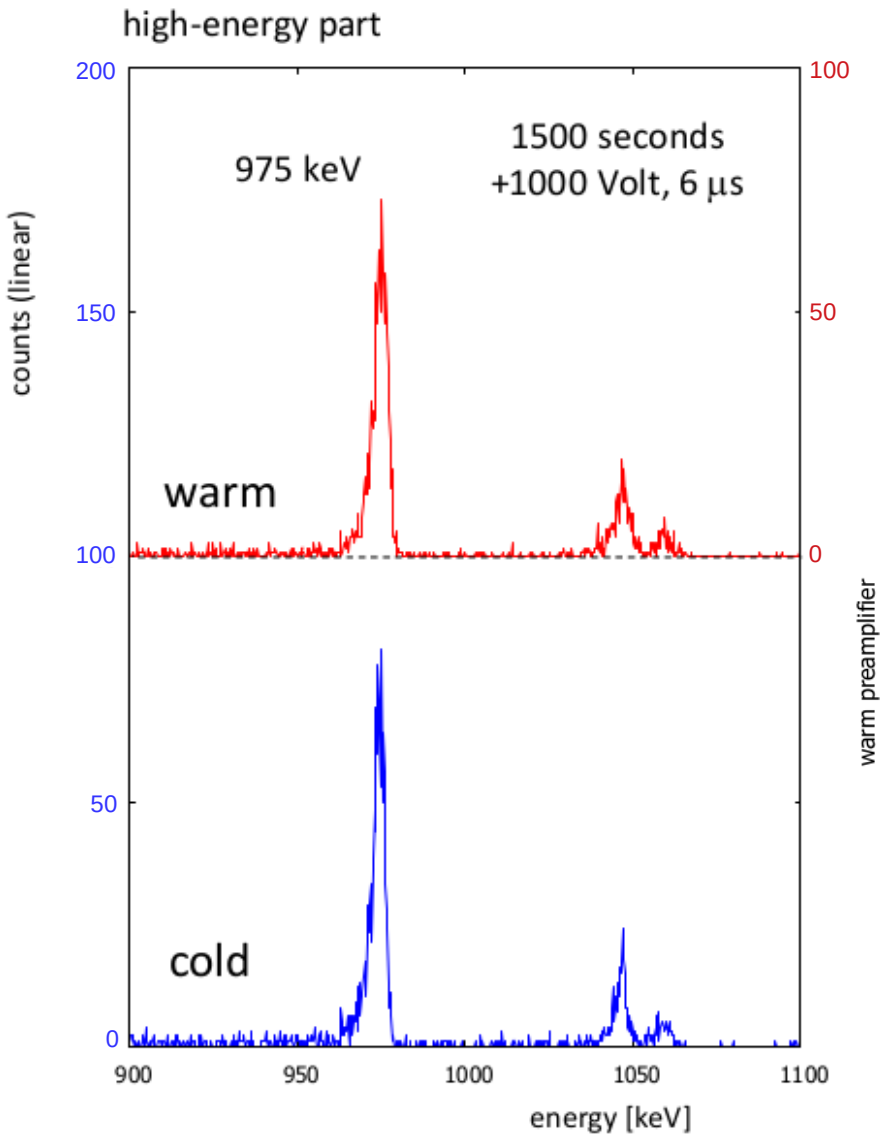

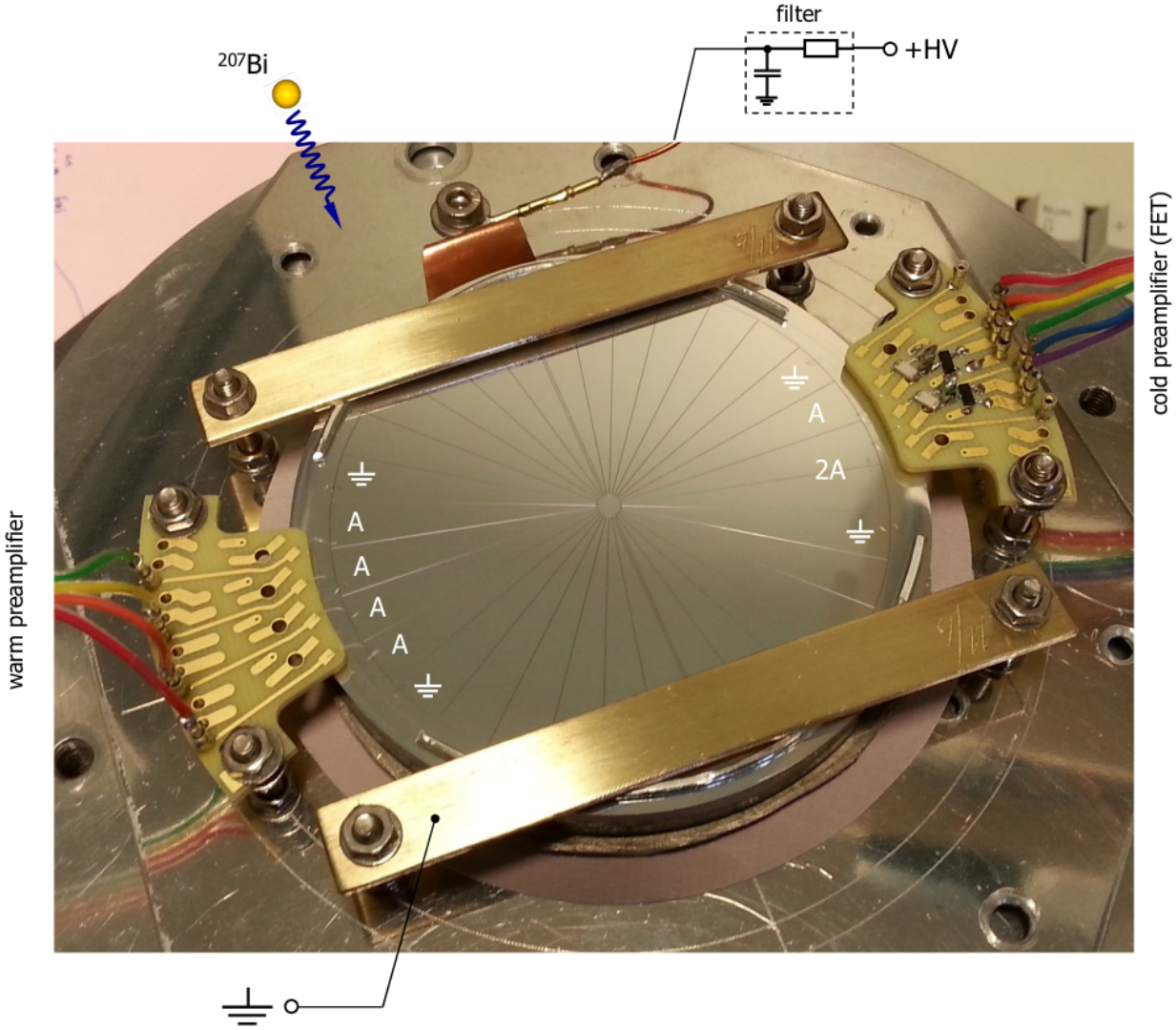

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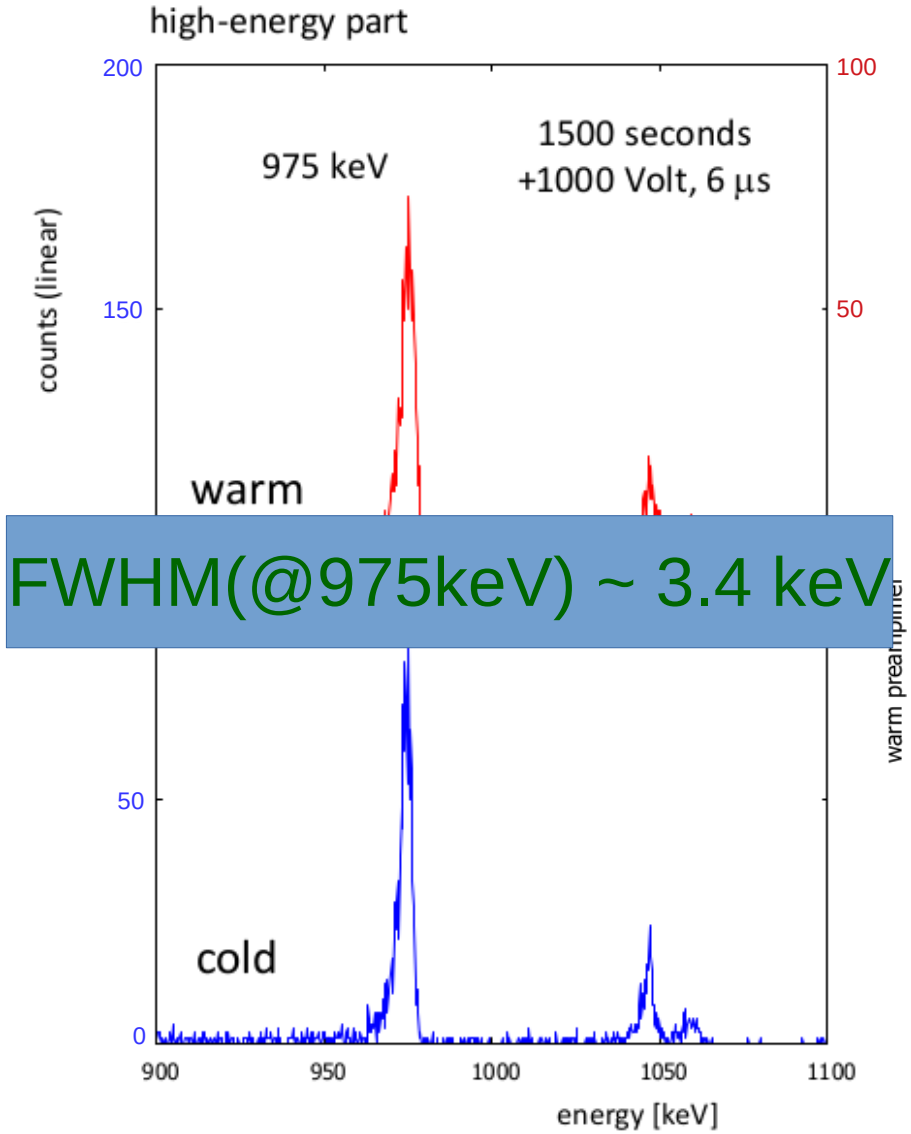
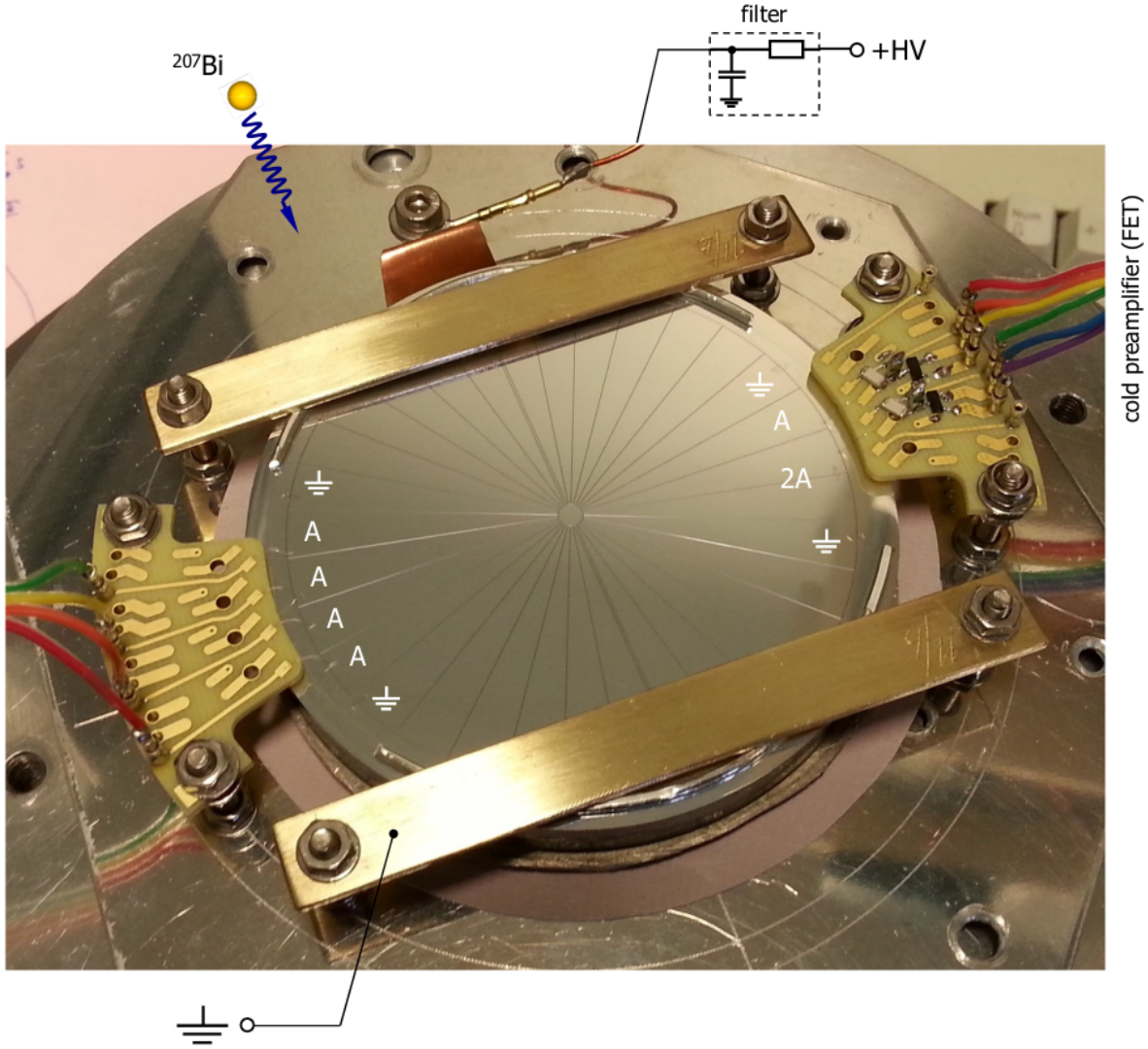
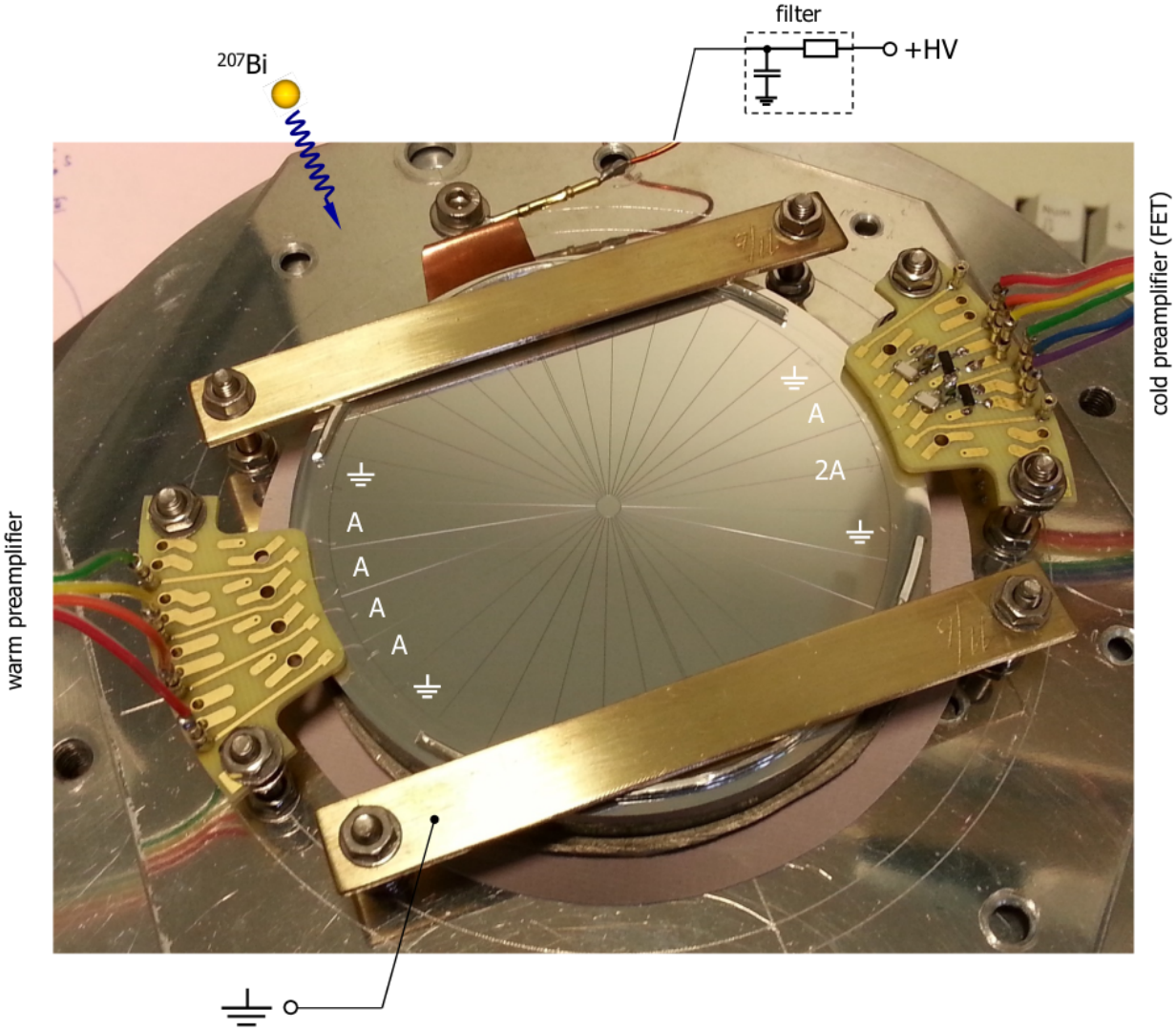


FWHM(@975keV) ~ 3.4 keV

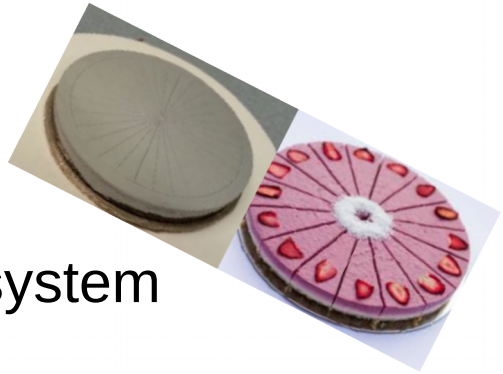


SLICES Tests

Strips	Live Time	τ	FWHM (@975 keV)
2A	1500s	6μs	3.4keV
A	1500s	6μs	3.7keV
A	1500s	3μs	2.4keV



To Do List



SLICES

- Finalize the cooling system
- Finalize the mechanical structure design
- Test completed detector with proper sets of magnet
- Commissioning @LABEC in Florence
- Study the first SPES low-energy beams (the most intense expected beams are Cs, Rb, Sr, Br, ...)

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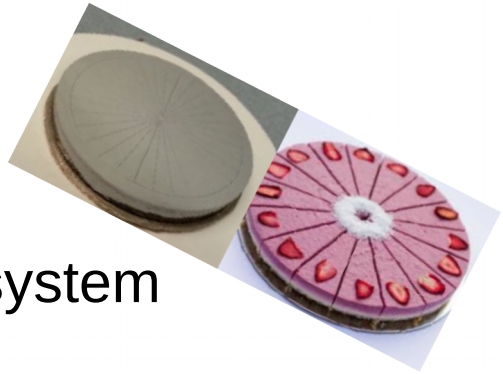

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^{74}Se

- Finalize the analysis

Obtain $\rho^2(E0)$ values

Obtain α_K coefficients

Thank you for the attention

^{74}Se Collaboration

A. Nannini[1], N. Gelli[1], N. Marchini[1,2], M. Ottanelli[1], A. Perego[1,3], M. Rocchini[1], G. Benzoni[4], D. Brugnara[5], A. Buccola[1,3], G. Carozzi[5], A. Goasduff[5], E.T. Gregor[6], D. Mengoni[5], F. Recchia[5], D. Rosso[6], A. Saltarelli[2,7], M. Siciliano[6], J.J. Valiente-Dobon[6], I. Zanon[5].

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[2] *Division of Physics, School of Science and Technology, Università di Camerino, Camerino (Macerata), Italy.*
[3] *Università degli Studi di Firenze, Firenze, Italy.*
[4] *INFN, Sezione di Milano, Milano, Italy.*
[5] *Dipartimento di Fisica e Astronomia and INFN, Sezione di Padova, Padova, Italy.*
[6] *INFN, Laboratori Nazionali di Legnaro, Legnaro (Padova), Italy.*
[7] *INFN, Sezione di Perugia, Perugia, Italy.*

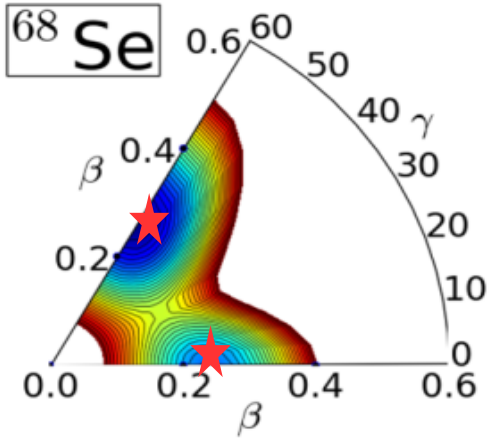
SLICES Collaboration

N. Marchini[1,2], A. Nannini[1], M. Ottanelli[1], M. Rocchini[1], A. Saltarelli[2,3], G. Benzoni[4], A. Goasduff[5], T. Krings[6], A. Gottardo[7], J.J. Valiente-Dóbon[7]

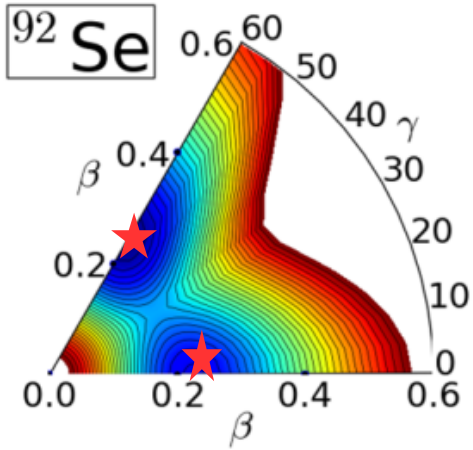
[1] *INFN, Firenze Division*
[2] *University of Camerino*
[3] *INFN, Perugia Division*
[4] *INFN, Milano Division*
[5] *University of Padova*
[6] *Inst. fur Kernphysik, Forschungszentrum Jülich*
[7] *INFN, LNL Division*

Selenium Isotopes (Z=34)

- Several theoretical investigations confirm:
  - For Z~N Se isotopes an oblate shape for the ground state with a strong configuration mixing for the low-lying excited levels, coexisting with a exited prolate configuration



  - For the heavier Se isotopes a prolate ground state is expected to coexist with an excited oblate configuration



K. Nomura et al., Phys. Rev. C 95, 064310 (2017)

Why Electron Spectroscopy?

- Obtain the $\alpha_K(\Omega L)$ Internal Conversion Coefficients

↓

Assign level Parity

- Study of Electric Monopole Transitions (E0)

↓

Study the possible Shape Coexistence
and level Mixing