COMBINED COULOMB EXCITATION AND CONVERSION ELECTRON SPECTROSCOPY OF ^{182,184,185}HG

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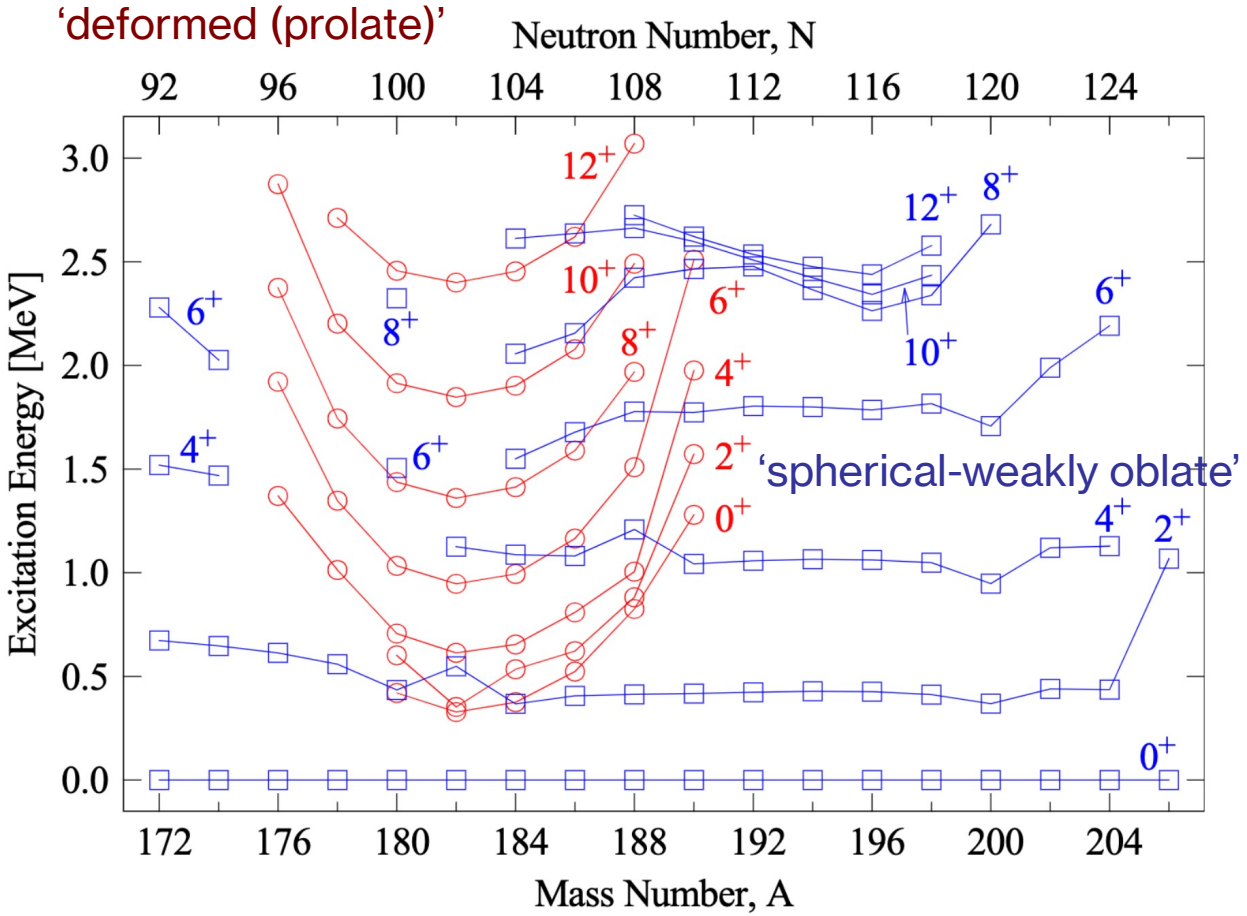
PDRA
University of Liverpool
On behalf IS563 and IS699

SPECTROMETER
ELECTRON
DETECTION

MINI BALL

Motivation

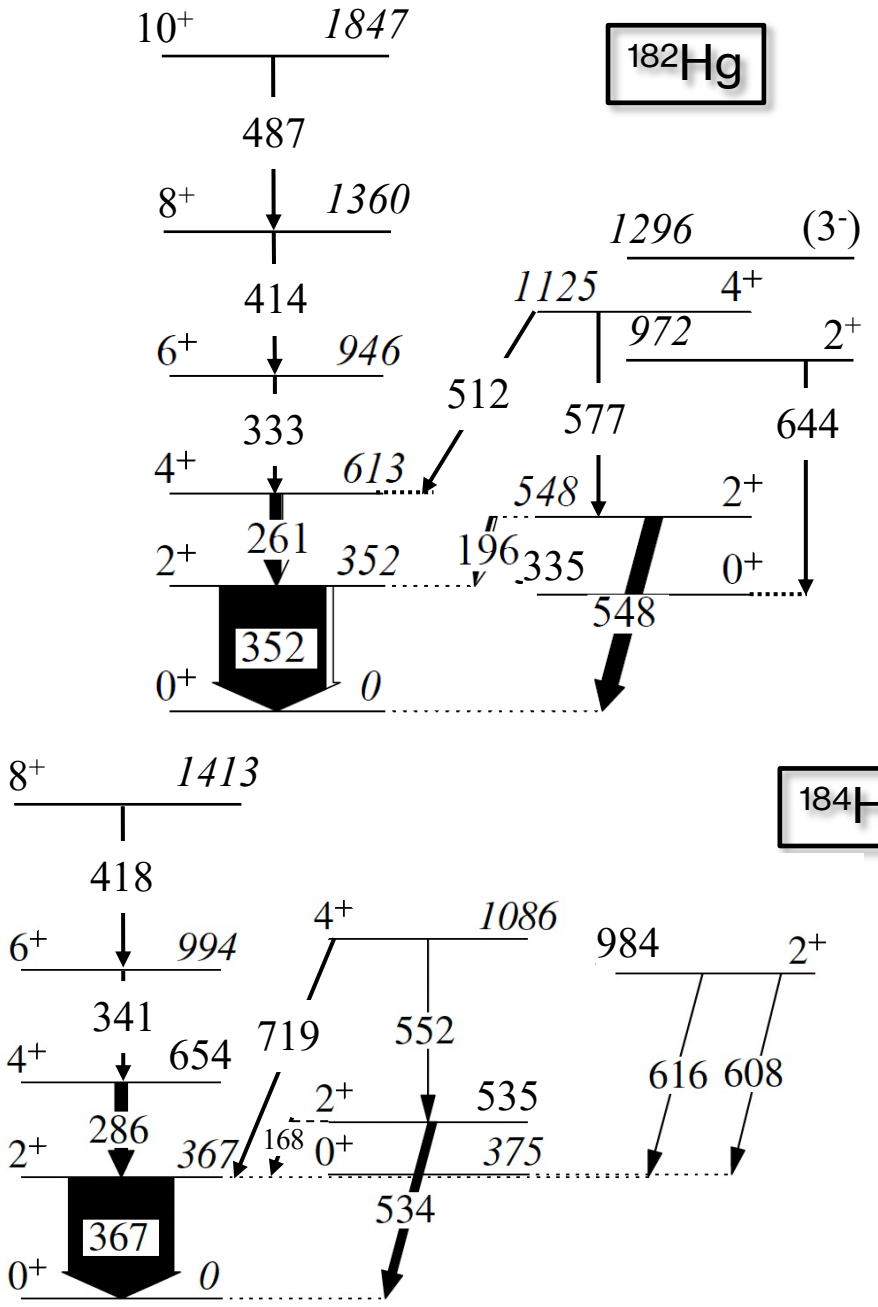
- Study the shape coexistence of neutron-deficient Hg near neutron mid-shell N~104.
- Prolate (Oblate) structure is associated 4p-4h (2p-2h) proton excitation



L. P. Gaffney, et al., PRC **89** 024307 (2014)

IS563

- Coulomb excitation experiment ^{182,184}Hg
- Experiment setup: Miniball+SPEDE
- The beam energy: 4 MeV/u
- ^{120}Sn was used as a target
- Objective:
  1. Reduce errors of diagonal matrix elements of 2^+ states to a level where negative, zero and positive quadrupole moments can be distinguish
  2. Deduce transitional matrix elements for higher lying non-yrast states



Previous experiment

- Based on the results for diagonal E2 matrix element, it was not possible to draw conclusions the structures of ^{182,184}Hg
- The large uncertainty related to the E0 component of the $2_2^+ \rightarrow 2_1^+$ transition in ^{182,184}Hg was also the issue which needed to be solved

Eur. Phys. J. A (2019) **55**: 130
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THE EUROPEAN PHYSICAL JOURNAL A

Regular Article – Experimental Physics

Electromagnetic properties of low-lying states in neutron-deficient Hg isotopes: Coulomb excitation of ^{182}Hg, ^{184}Hg, ^{186}Hg and ^{188}Hg

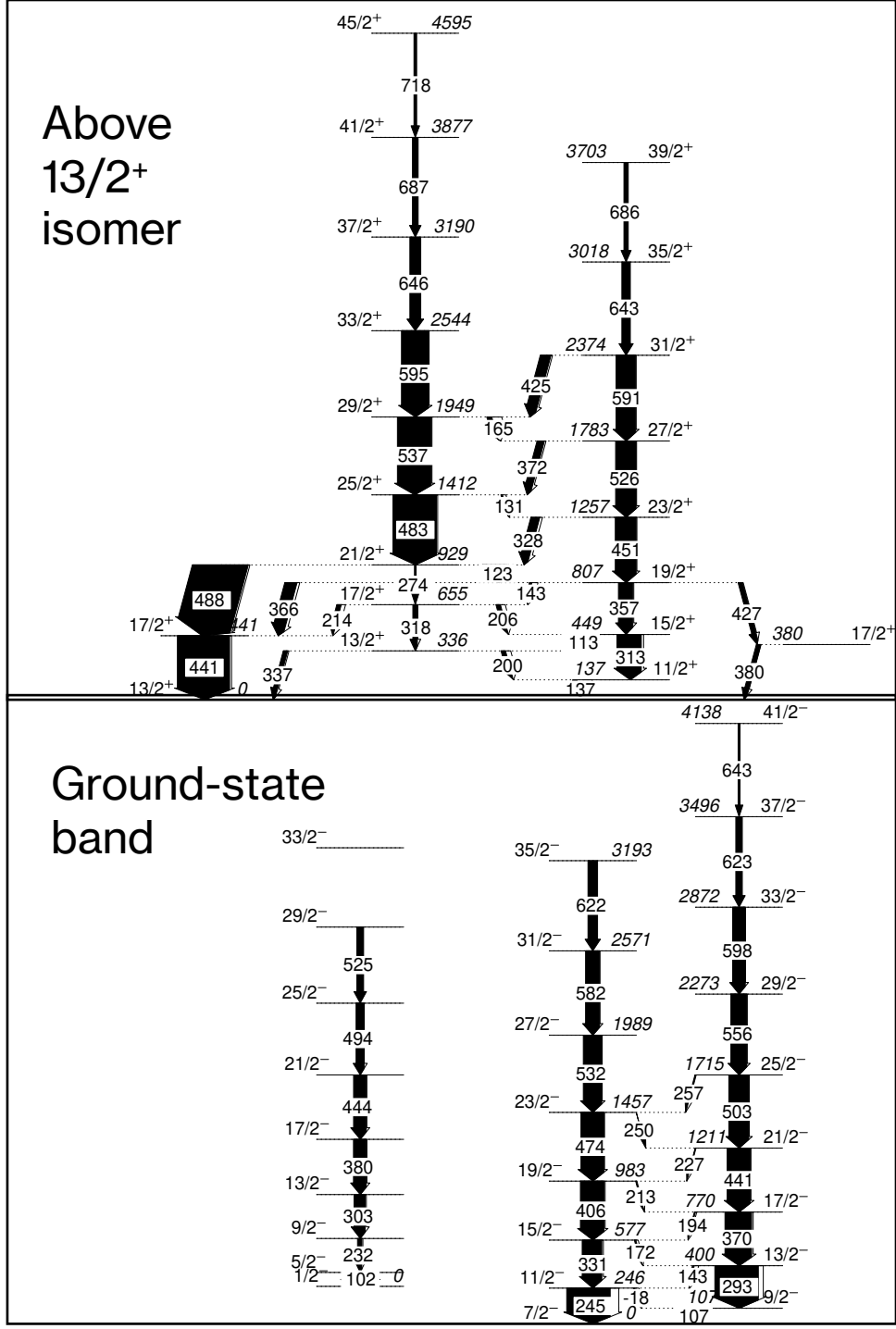
$\langle I_i \| E2 \| I_f \rangle$ (eb)	^{182}Hg	^{184}Hg
$\langle 0_1^+ \| E2 \| 2_1^+ \rangle$	1.29(4)	1.27(3)
$\langle 2_1^+ \| E2 \| 4_1^+ \rangle$	3.70(6)	3.31(6)
$\langle 0_1^+ \| E2 \| 2_2^+ \rangle$	$-0.6(1)$	0.348(14)
$\langle 0_2^+ \| E2 \| 2_1^+ \rangle$	$[-2.2, 0.9]$	$-1.2^{+0.3}_{-0.2}$
$\langle 0_2^+ \| E2 \| 2_2^+ \rangle$	$-1.25(30)$	$0.93^{+0.20}_{-0.25}$
$\langle 2_1^+ \| E2 \| 2_2^+ \rangle$	$-2.0(3)$	$1.64^{+0.14}_{-0.16}$
$\langle 2_2^+ \| E2 \| 4_1^+ \rangle$	3.3(4)	$[-3, 0]^\star$
$\langle 2_1^+ \| E2 \| 2_1^+ \rangle$		
$\langle 2_2^+ \| E2 \| 2_2^+ \rangle$		

K. Wrzosek-Lipska et al., Eur. Phys. J. A **55:130**
N. Bree et al.., Phys. Rev. Lett. 112, 1627011
N. Bree, PhD Thesis KU Leuven 2014

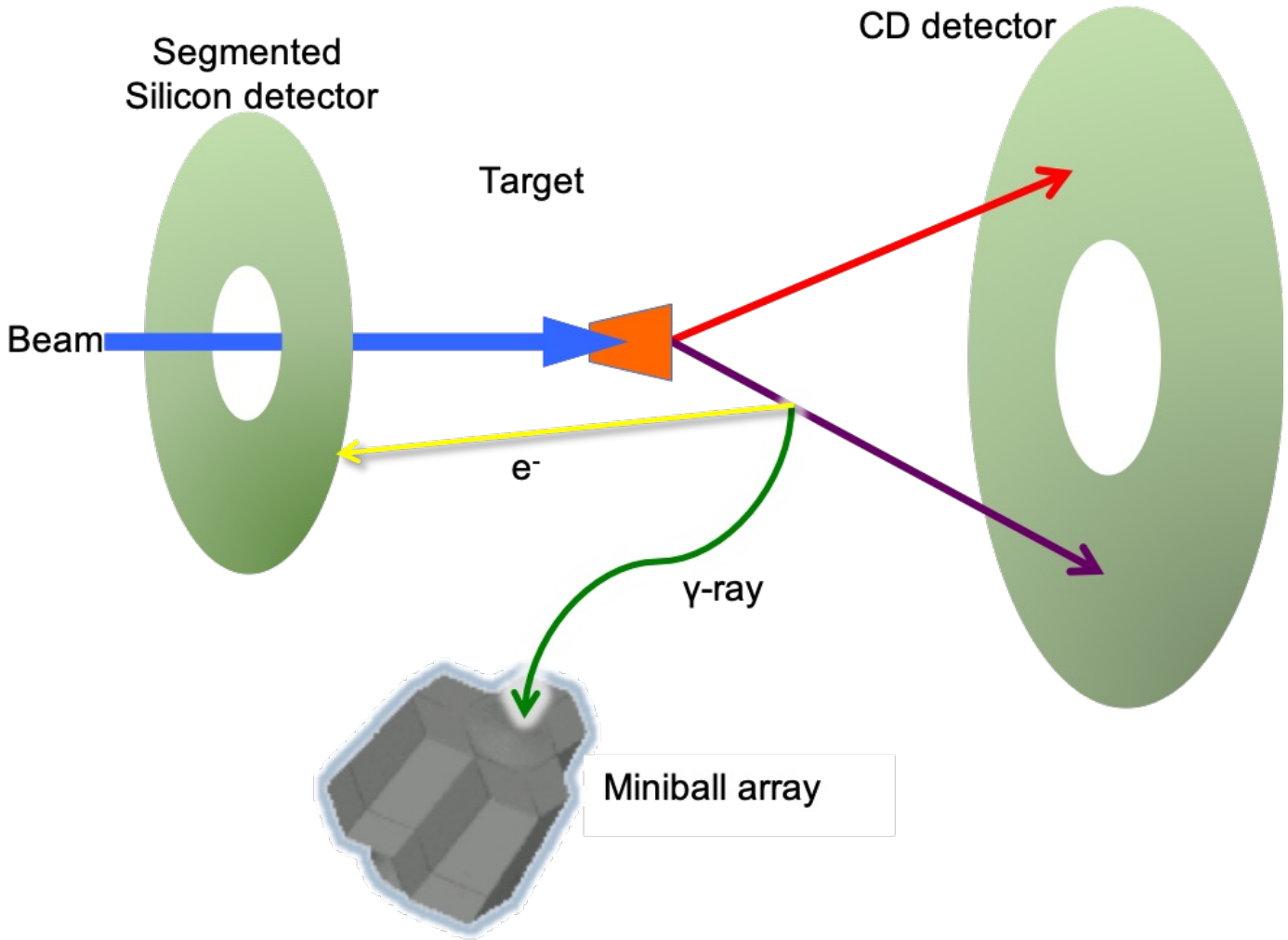
IS699

- Coulomb excitation experiment ^{185}Hg
- Experiment setup: Miniball+SPEDE
- The beam energy: 4 MeV/u
- ^{120}Sn and ^{48}Ti were used as a target
- Objective: To extract quadrupole moments for states in the rotational bands built of the ground state and on isomer

Courtesy Janne Pakarinen

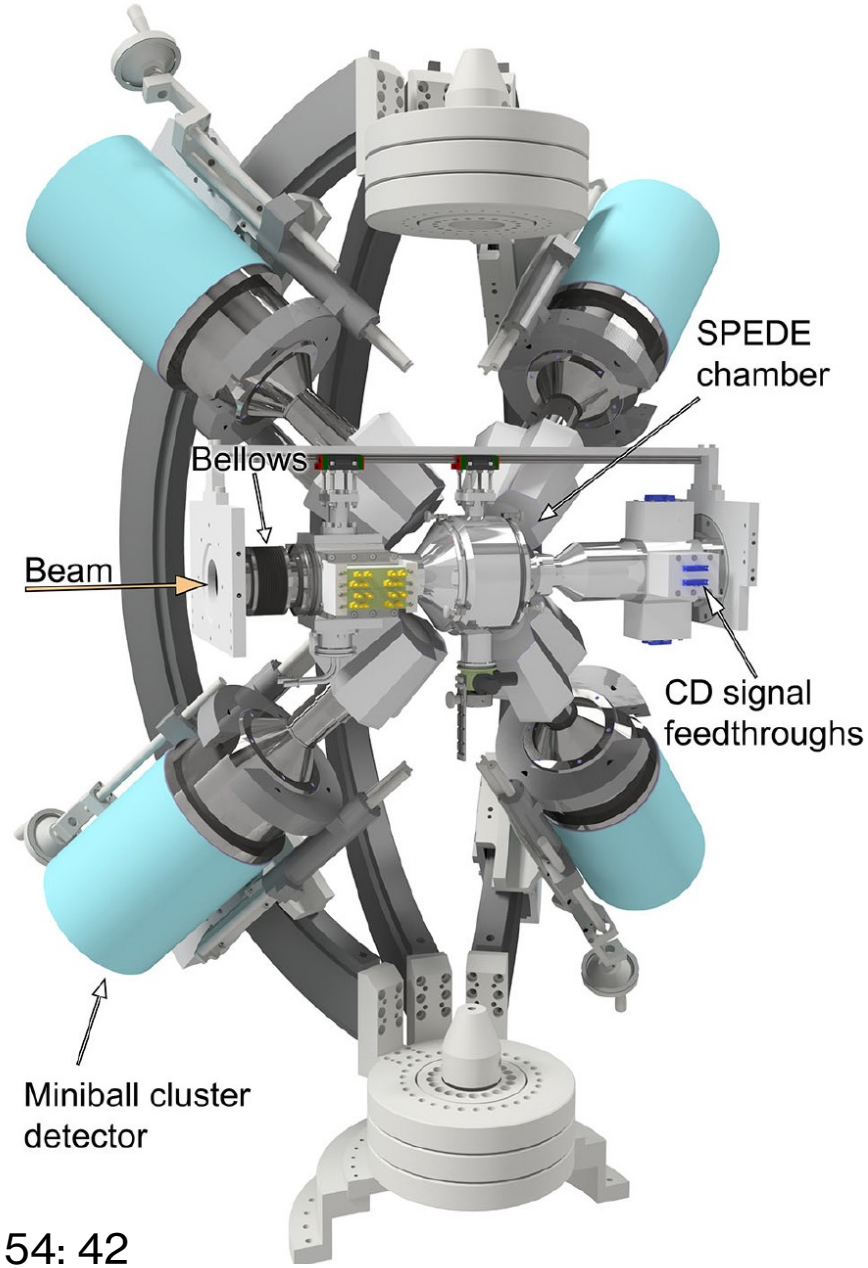


The SPEDE concept



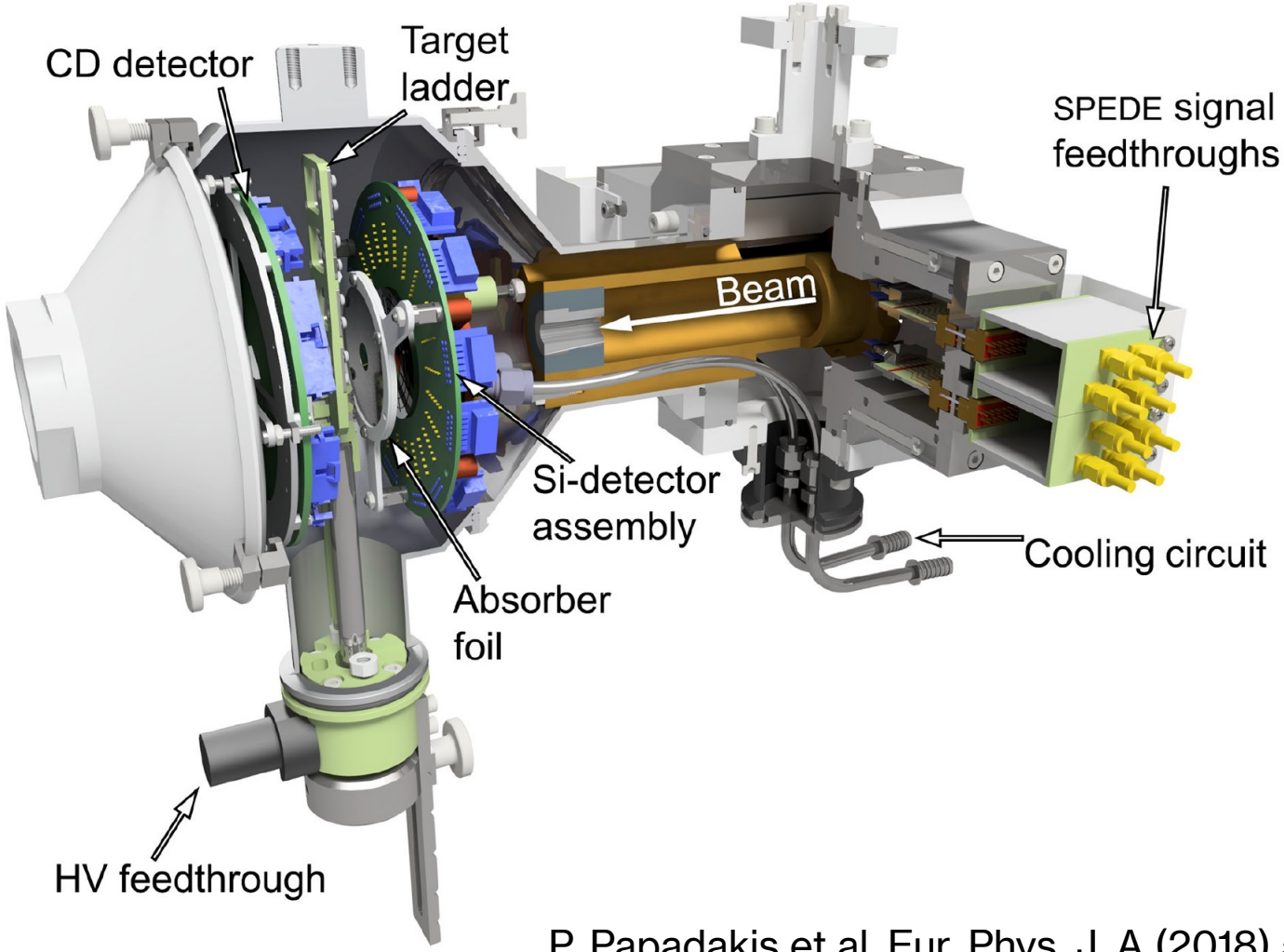
The SPEDE spectrometer

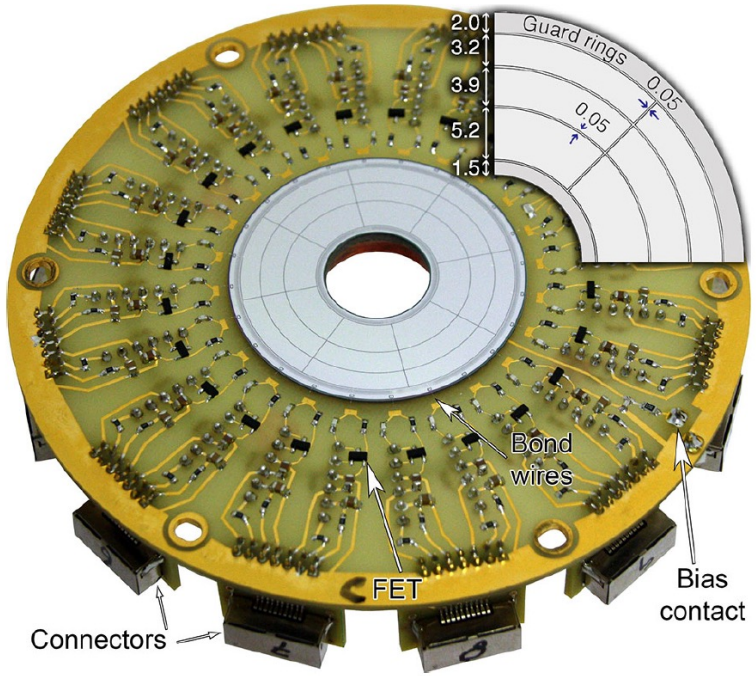
- Conversion electron spectrometer
- Used in conjunction with the MINIBALL germanium array and CD detector
- Allows simultaneous γ-ray and conversion electron spectroscopy using radioactive beam
- Target chamber designed for the SPEDE spectrometer



P. Papadakis et al. Eur. Phys. J. A (2018) 54: 42

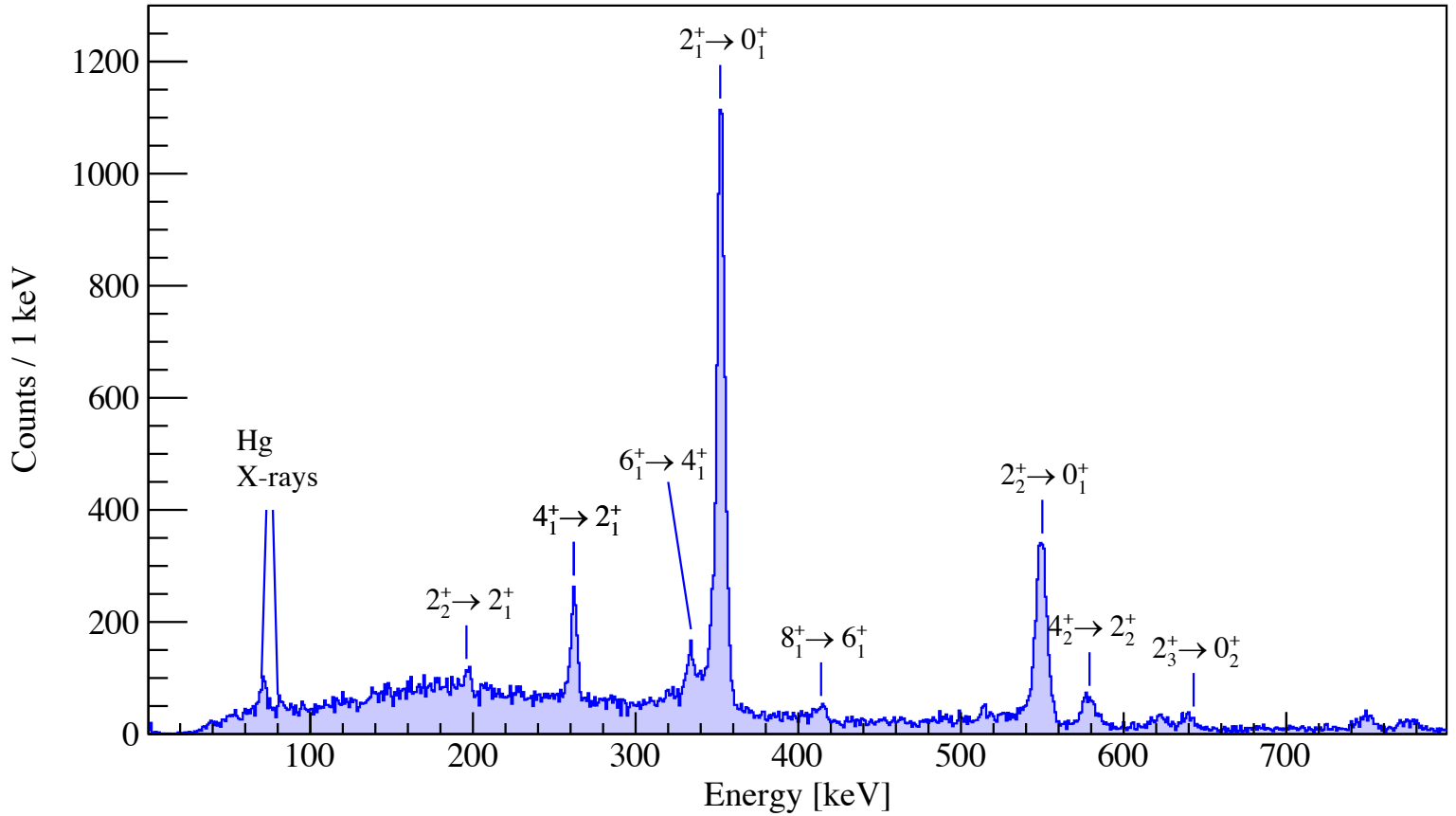
The SPEDE spectrometer

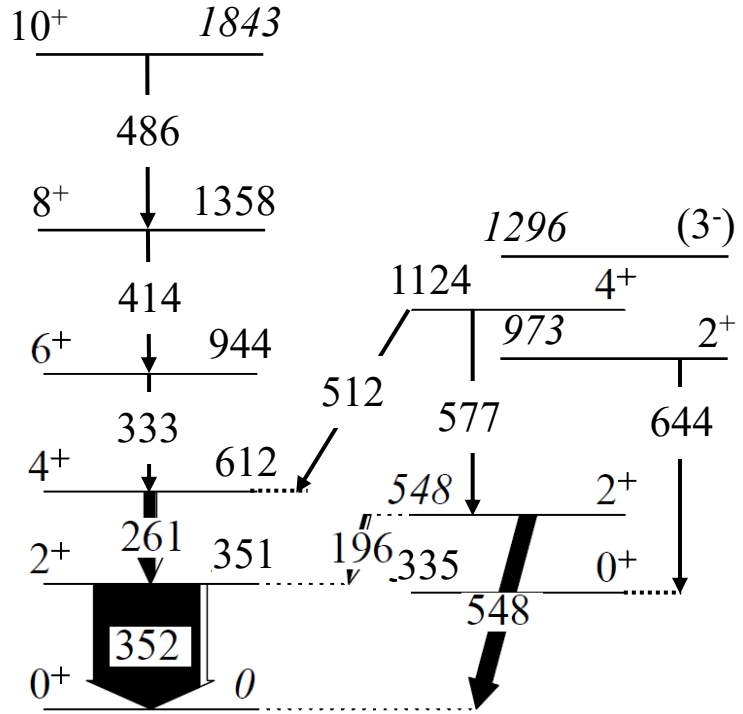




P. Papadakis et al. Eur. Phys. J. A (2018) 54: 42

IS563: ^{182}Hg γ-ray energy spectrum





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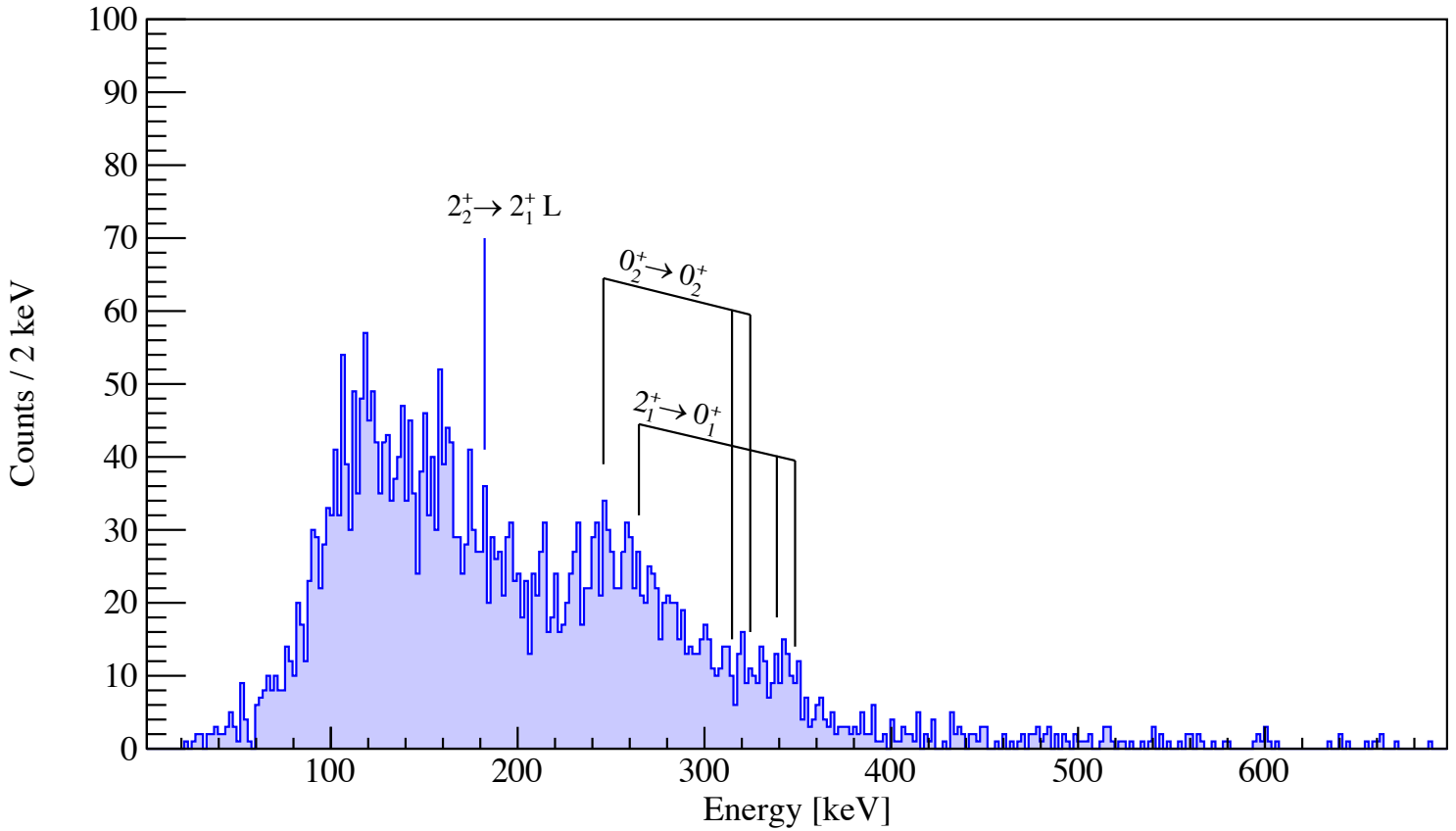
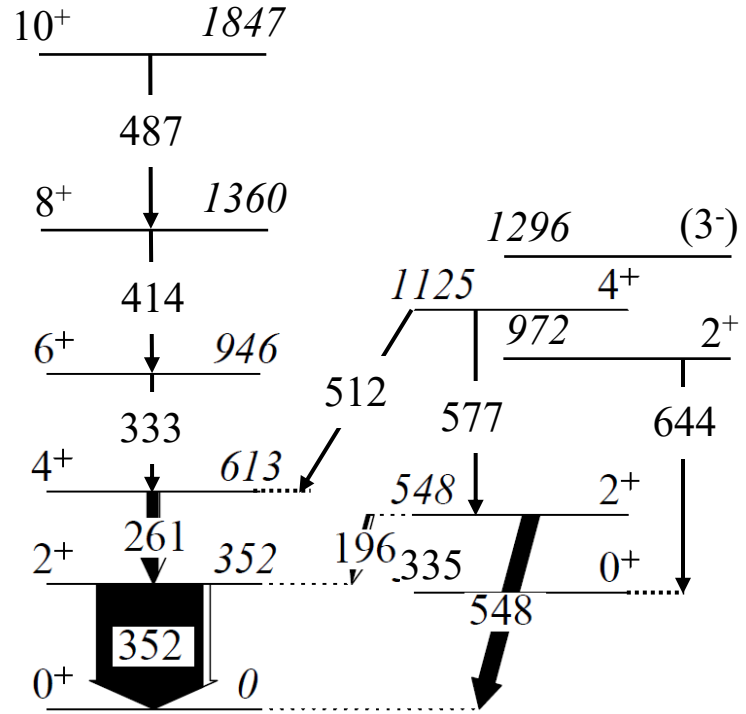
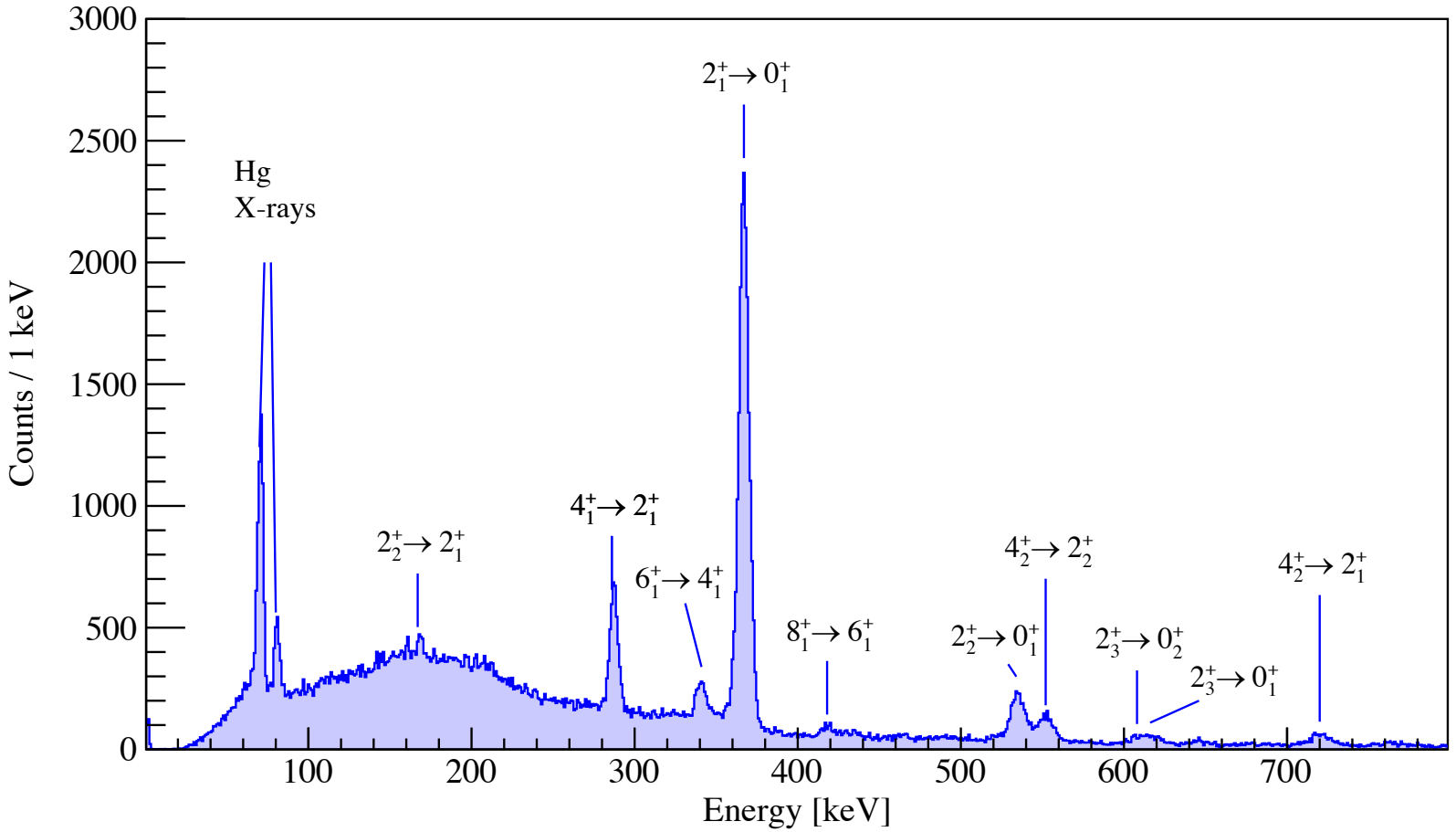
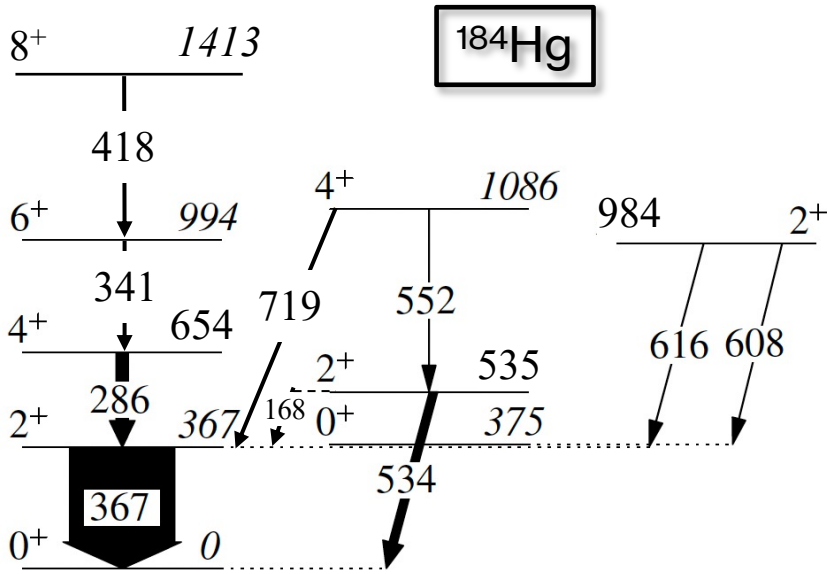




IS563: ^{184}Hg γ-ray energy spectrum





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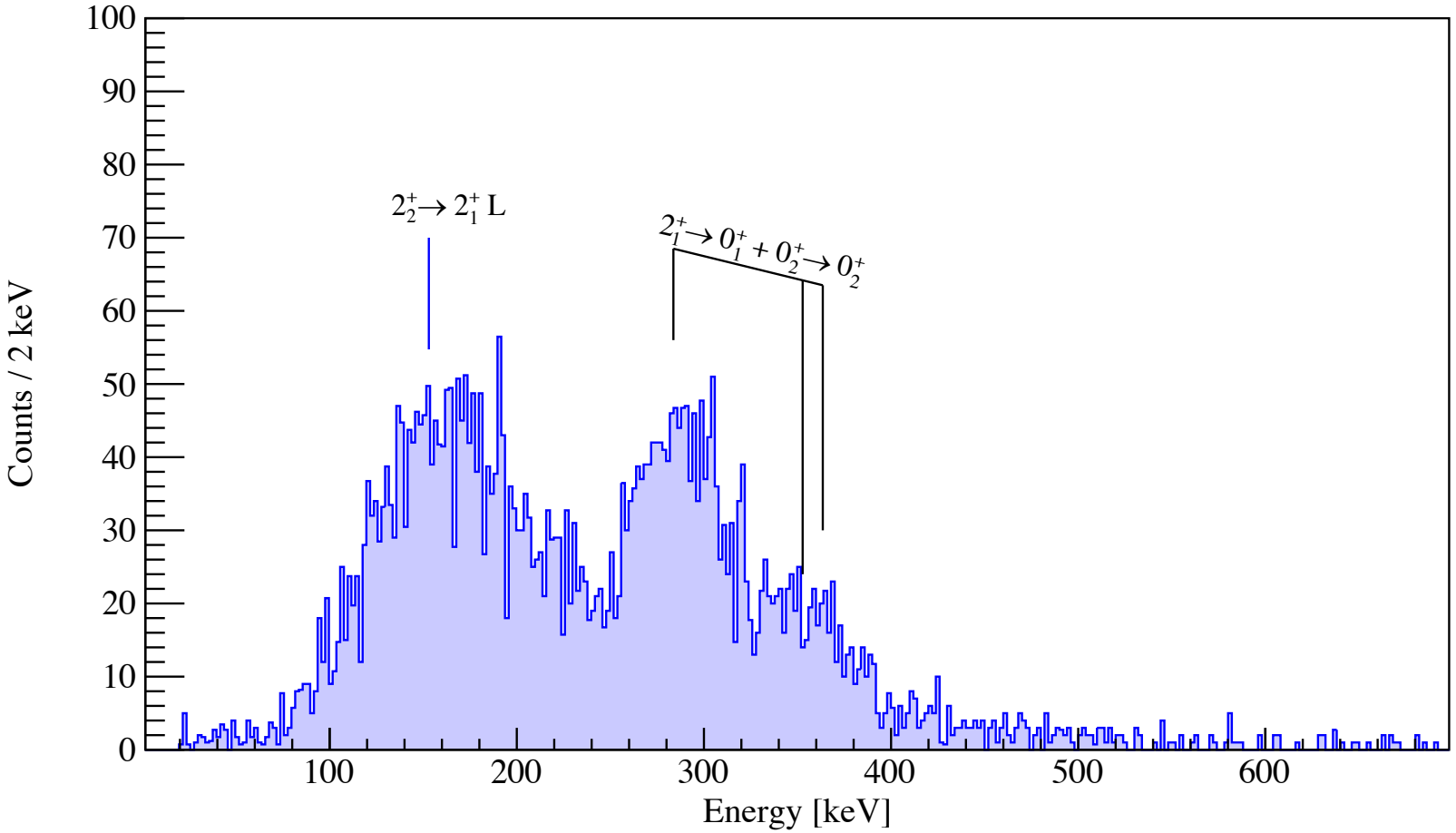

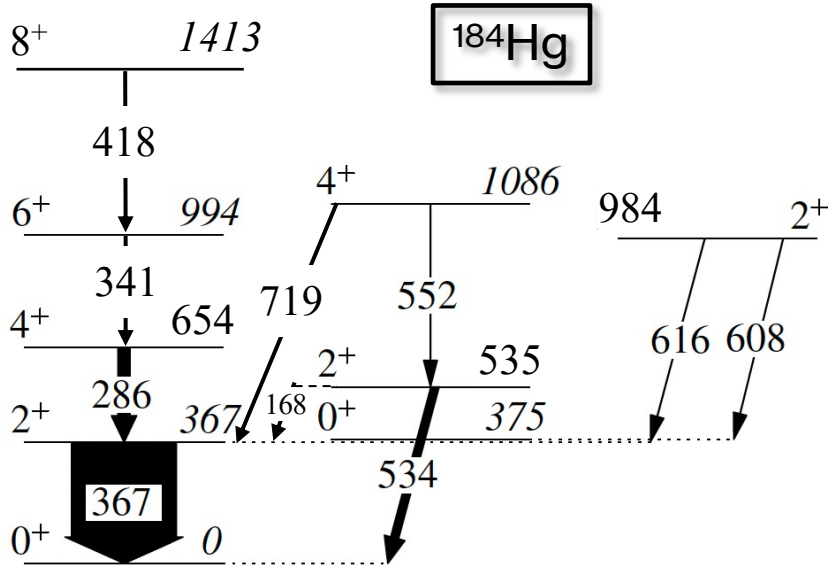

IS563: ^{184}Hg electron spectrum

PHYSICAL REVIEW C **108**, 014308 (2023)

Simultaneous γ-ray and electron spectroscopy of ^{182,184,186}Hg isotopes

M. Stryjczyk,[1,2,*] B. Andel,[1,3,†] J. G. Cubiss,[4,5,†] K. Rezynkina,[1,6,†] T. R. Rodríguez,[7,8] J. E. García-Ramos,[9,10] A. N. Andreyev,[5,11] J. Pakarinen,[2,12] P. Van Duppen,[1] S. Antalic,[3] T. Berry,[13] M. J. G. Borge,[14,4] C. Clisu,[15] D. M. Cox,[16] H. De Witte,[1] L. M. Fraile,[8] H. O. U. Fynbo,[17] L. P. Gaffney,[4,18] L. J. Harkness-Brennan,[18] M. Huyse,[1] A. Illana,[19,2,8] D. S. Judson,[18] J. Konki,[4] J. Kurcewicz,[4] I. Lazarus,[20] R. Lica,[15,4] M. Madurga,[4,21] N. Marginean,[15] R. Marginean,[15] C. Mihai,[15] P. Mosat,[3] E. Nacher,[22] A. Negret,[15] J. Ojala,[2,12] J. D. Ovejas,[14] R. D. Page,[18] P. Papadakis,[18,20] S. Pascu,[15] A. Perea,[14] Zs. Podolyák,[13] L. Próchniak,[23] V. Pucknell,[20] E. Rapisarda,[4] F. Rotaru,[15] C. Sotty,[15] O. Tengblad,[14] V. Vedia,[8] S. Viñals,[14] R. Wadsworth,[5] N. Warr,[24] and K. Wrzosek-Lipska[23]
(IDS Collaboration)

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IS563: ^{184}Hg electron spectrum

PHYSICAL REVIEW C **108**, 014308 (2023)

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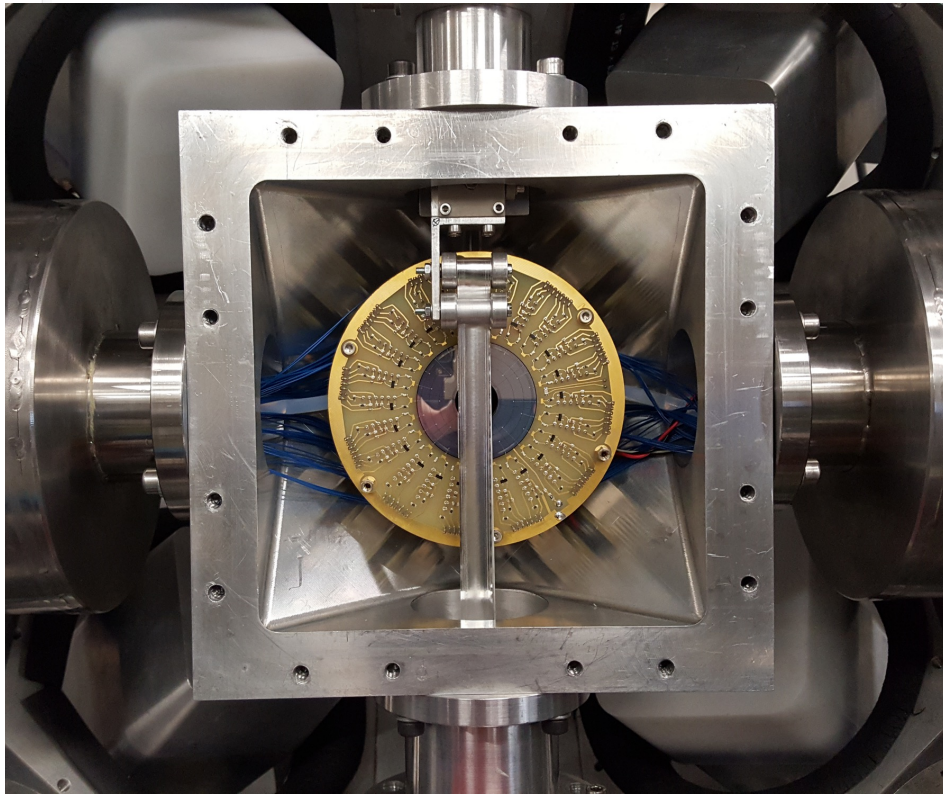

IS699: ^{185m}Hg γ-ray energy spectrum

- Before carrying on...

Complementary measurement of ^{185m}Hg with SAGE

Single particle properties in the neutron-deficient Hg region: in-beam γ-ray and electron spectroscopy of ^{185}Hg.

A. Illana, J. Ojala, J. Pakarinen, K. Auranen, T. Grahn, P. Greenlees, H. Jutila, J. Louko, M. Luoma, P. Rahkila, P. Ruotsalainen, M. Sandzelius, J. Sarén, H. Tann, J. Uusitalo and G.L. Zimba
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D.M. Cox
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M. Stryjczyk
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P.A. Butler and L.P. Gaffney
Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom.

K. Wrzosek-Lipska
Heavy Ion Laboratory, University of Warsaw, Warsaw, Poland.

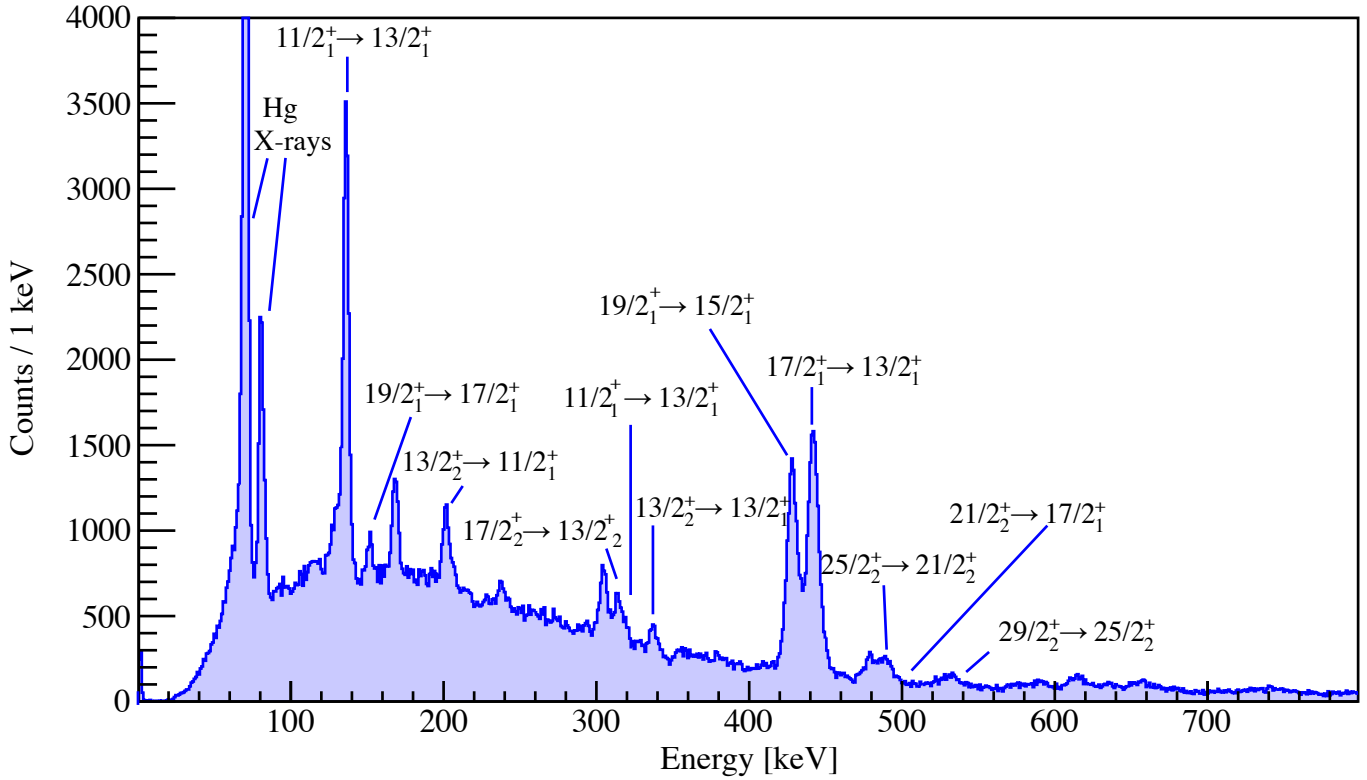
L.M. Fraile, J. Benito, J.R. Murias and J. de la Riva
Universidad Complutense, Grupo de Física Nuclear and IPARCOS, CEI Moncloa, Madrid, Spain.

Spokespersons: A. Illana, J. Ojala, J. Pakarinen
Contact person: A. Illana, J. Ojala

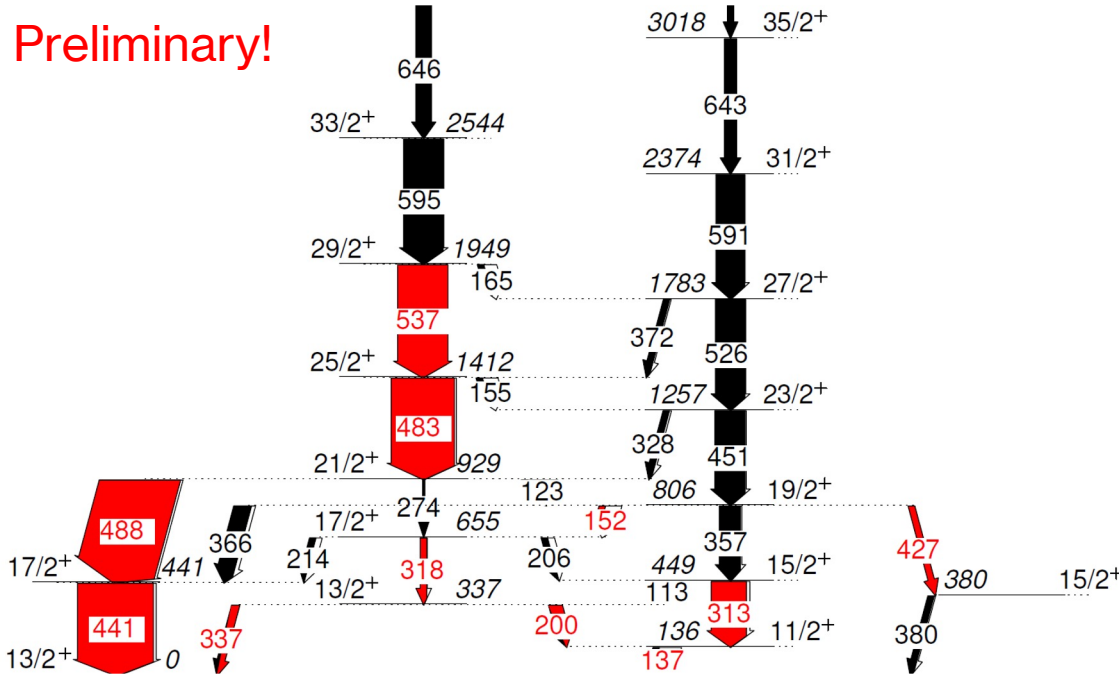
Abstract:

The aim of this proposal is to study shape coexistence in the neutron-deficient Hg nuclei as a continuation to the previous experiments performed for the even-even nuclei in this region.We propose to perform a simultaneous in-beam γ-ray and conversion electron spectroscopy experiment in order to pin down the influence of the neutron occupation of the $i_{13/2}$ intruder orbital and to clarify properties of the low-lying yrast and non-yrast excited states. For this purpose, the SAGE spectrometer in conjunction with the MARA separator will be employed. This combination will allow us to investigate the inter-band transitions and to shed light on properties of the low-spin states reported earlier for the ^{185}Hg nucleus.

IS699: ^{185m}Hg γ-ray energy spectrum

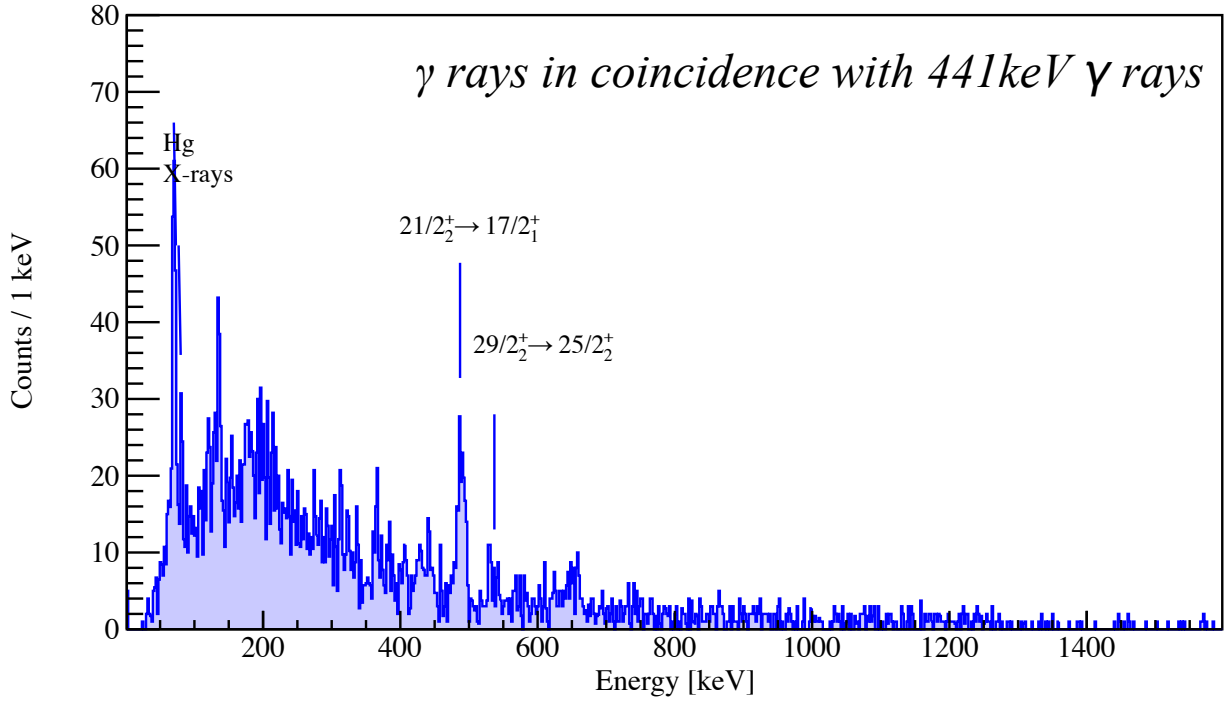


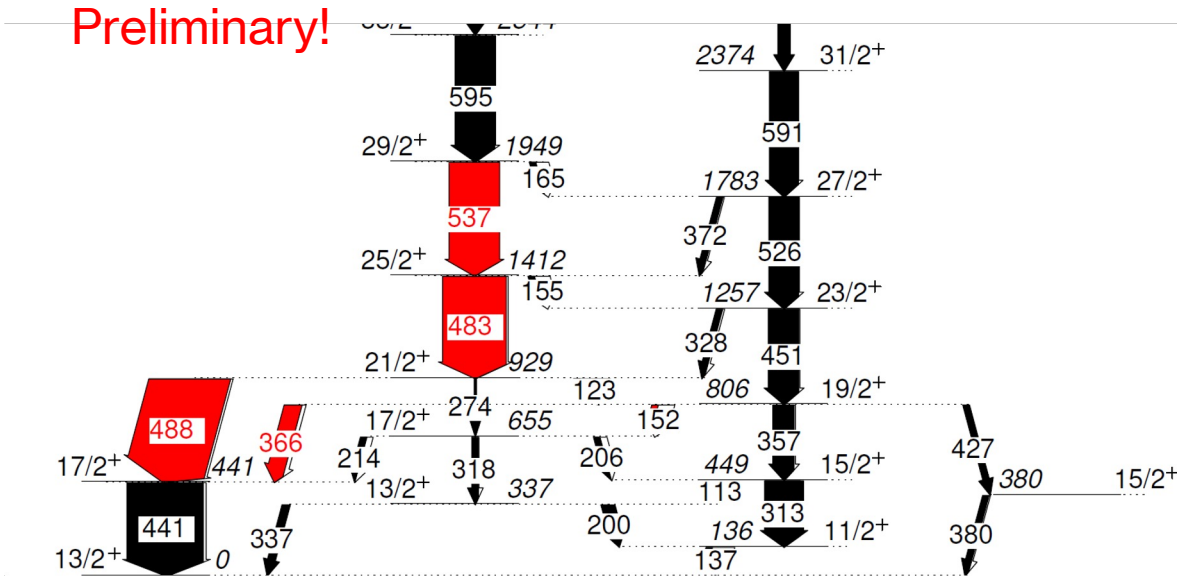
Preliminary!



Courtesy Janne Pakarinen

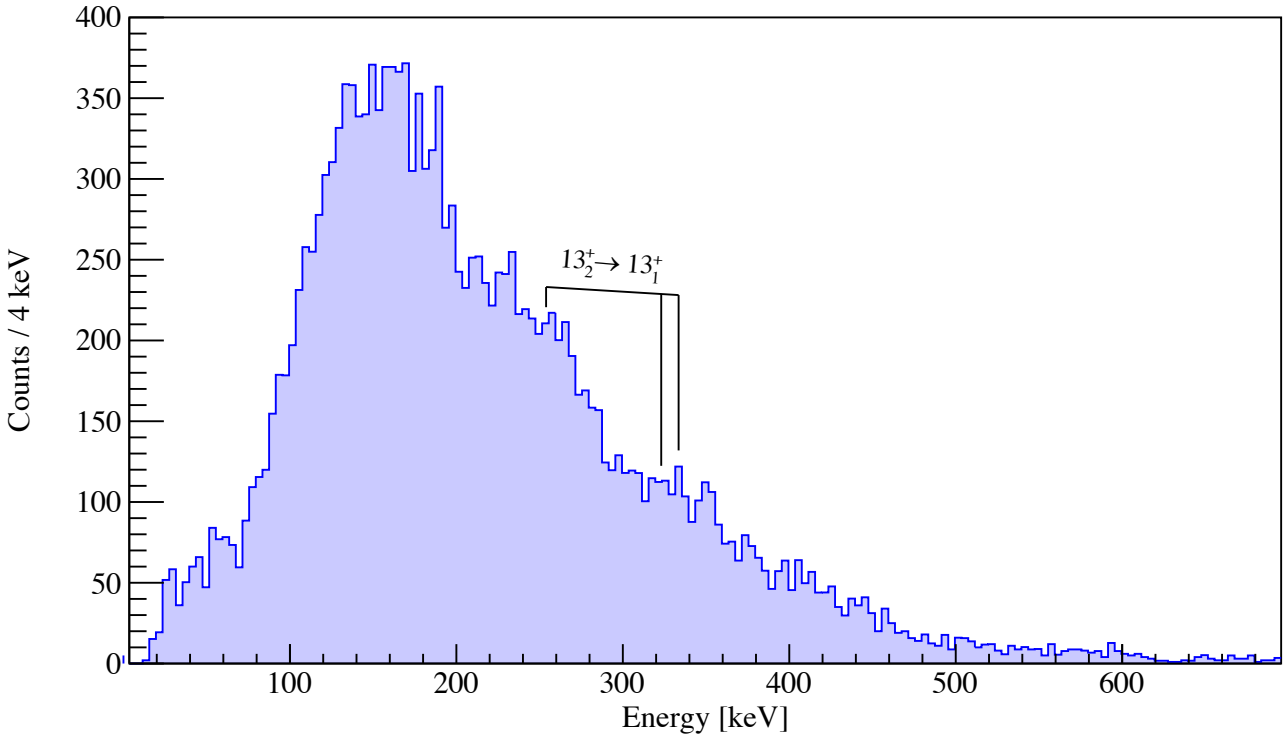
IS699: ^{185m}Hg γ-ray energy spectrum





Courtesy Janne Pakarinen

IS699: ^{185m}Hg electron energy spectrum



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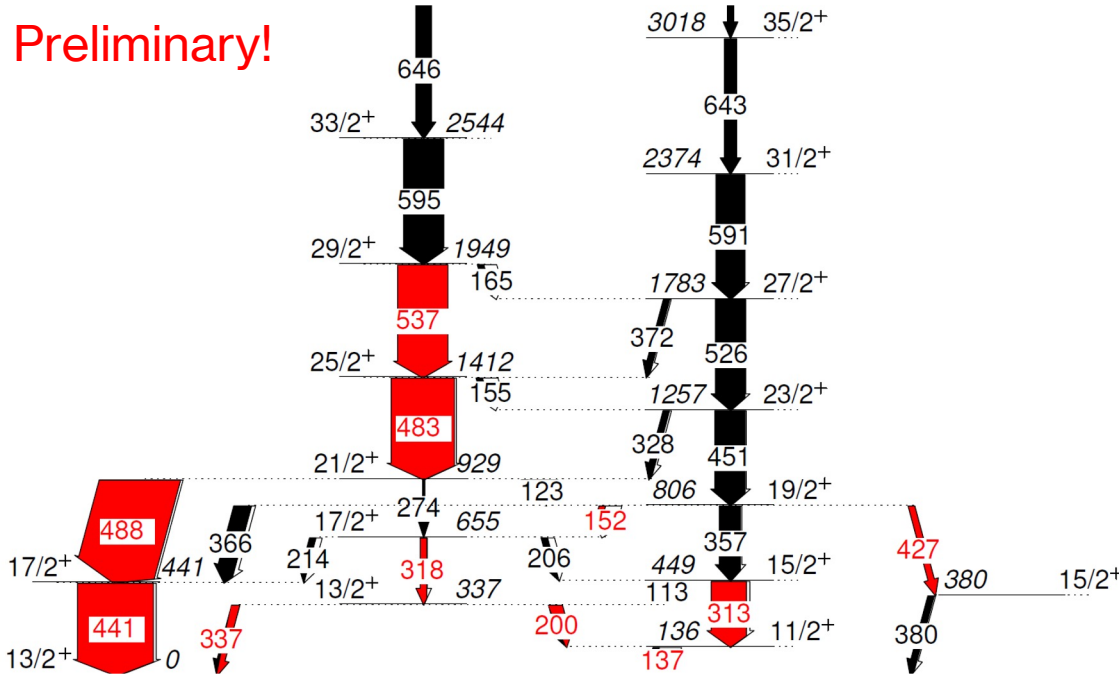
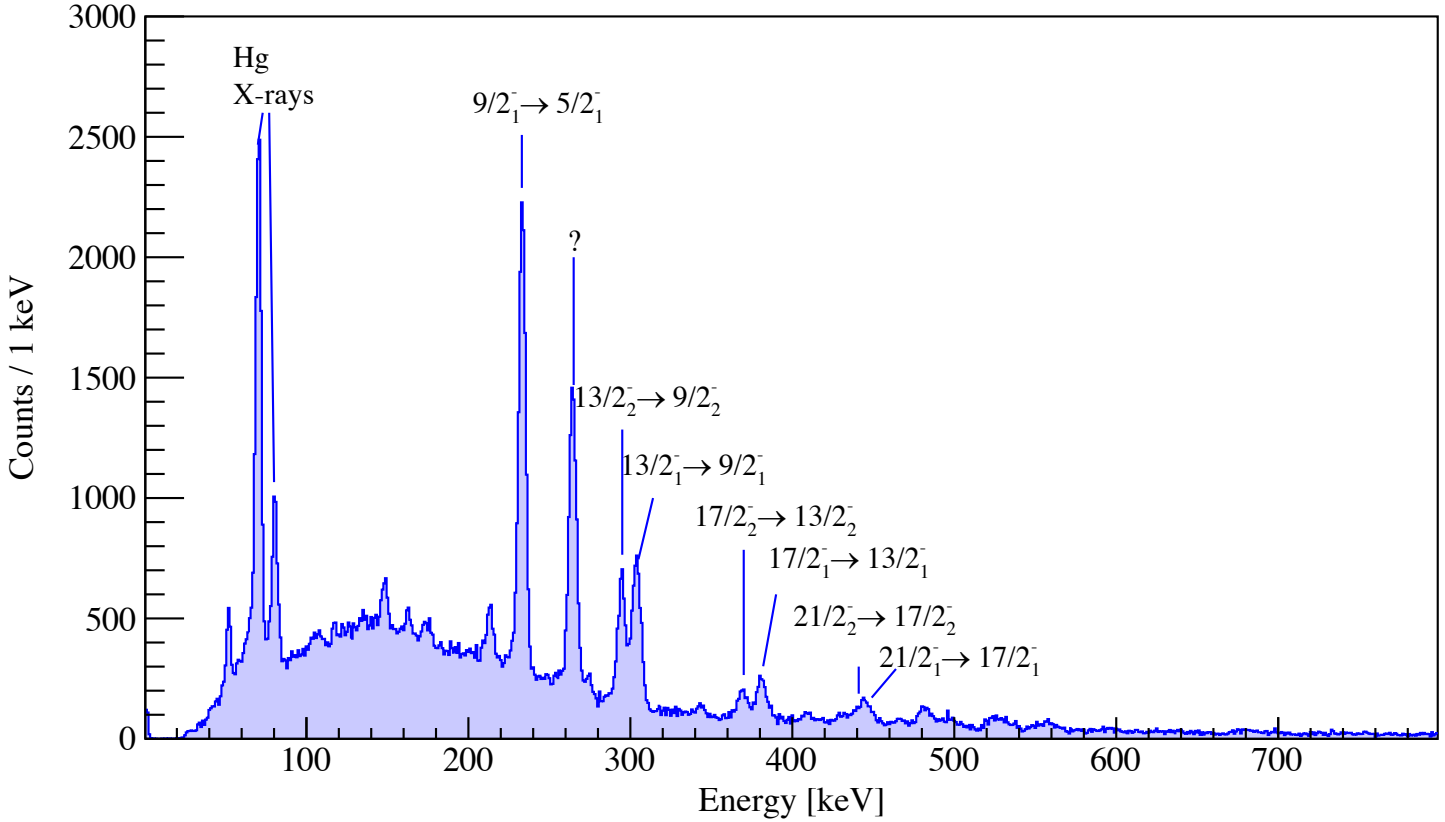
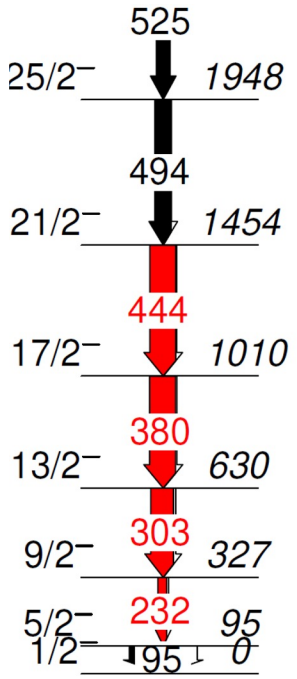
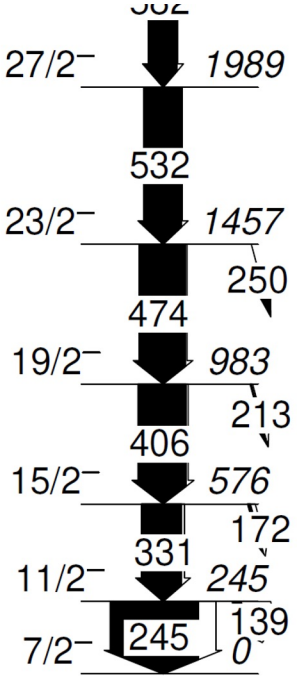


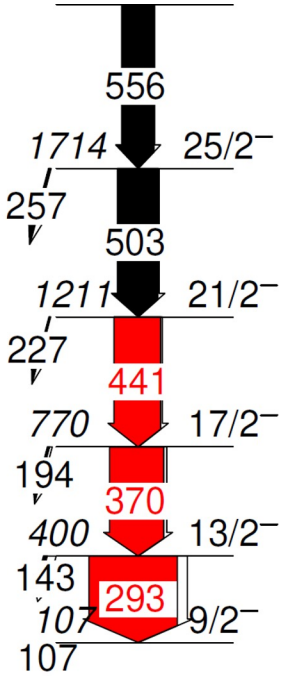
Courtesy Janne Pakarinen

IS699: ^{185g}Hg γ-ray energy spectrum









SUMMARY

- The results for ^{182,184,185}Hg look promising. There is still a need for proper analysis of this data set. A new PhD student started to work on this at Liverpool!
- SPEDE was used for the first time for a radioactive ion beam experiment at MINIBALL

UNIVERSITY OF LIVERPOOL

HIL
Heavy Ion Laboratory

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

KU LEUVEN

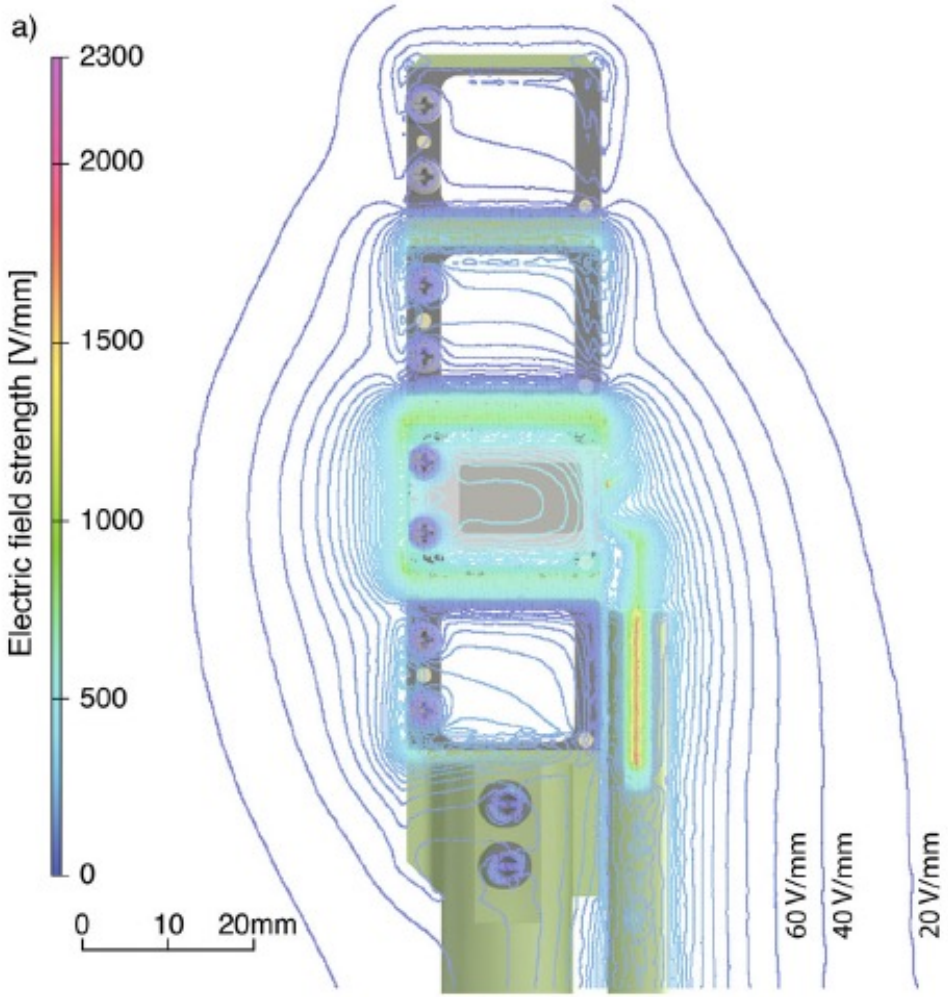
ISOLDE

Research Council of Finland

EURO-LABS
EUROPEAN LABORATORIES FOR ACCELERATOR BASED SCIENCES

Suppressing delta electrons

- It is essential to suppress low-energy delta electrons
- 5000 V high voltage is applied to the target ladder
- The absorber foil (12 μm mylar coated with 0.5 μm aluminium) prevents low-energy electrons and scattered particles from hitting the detector



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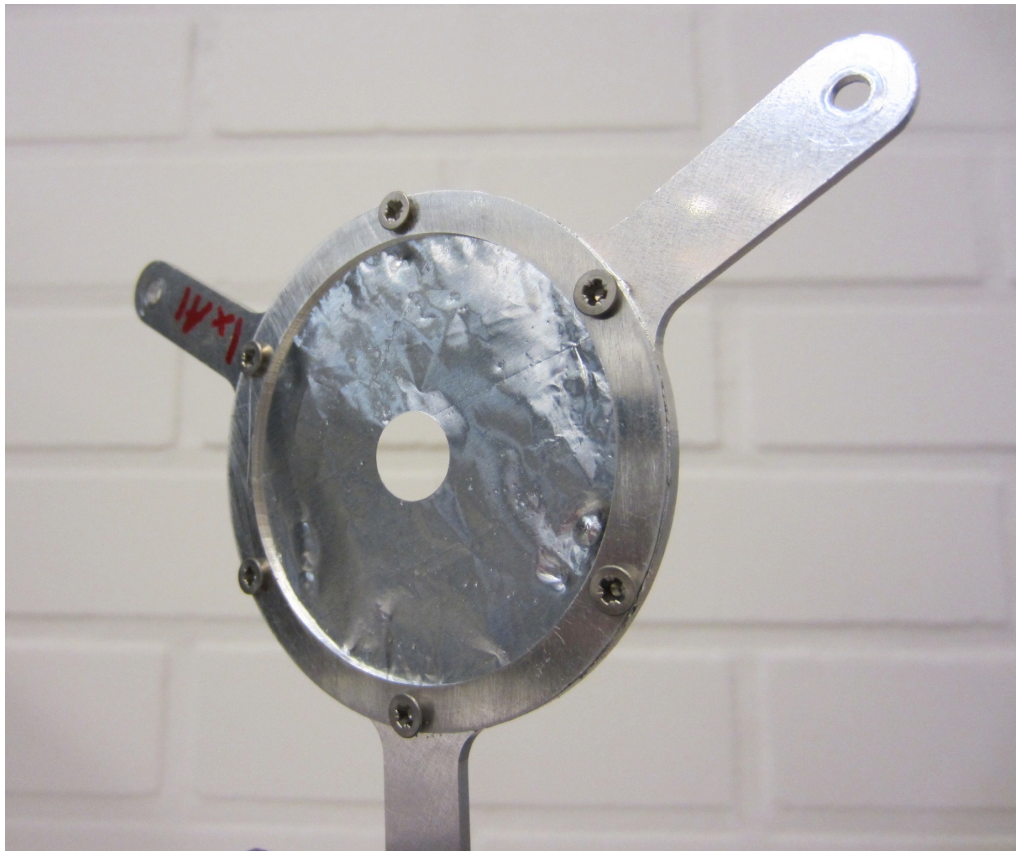

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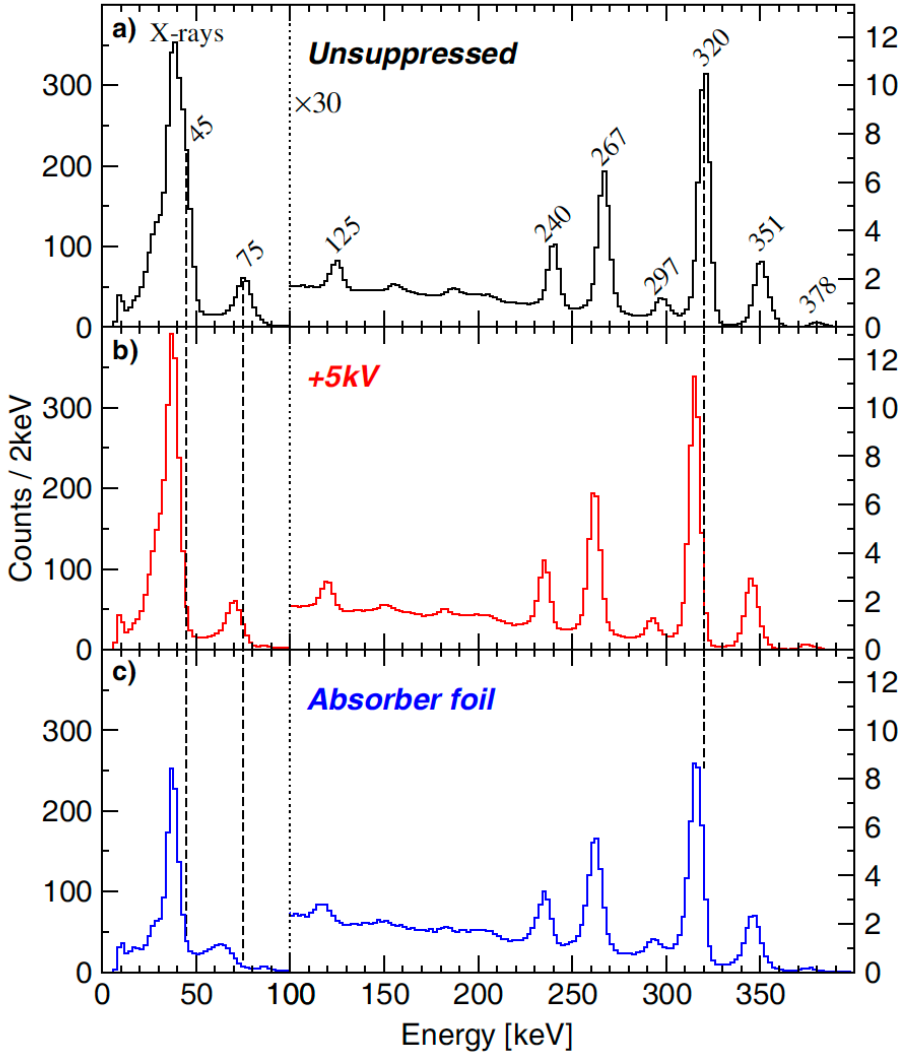
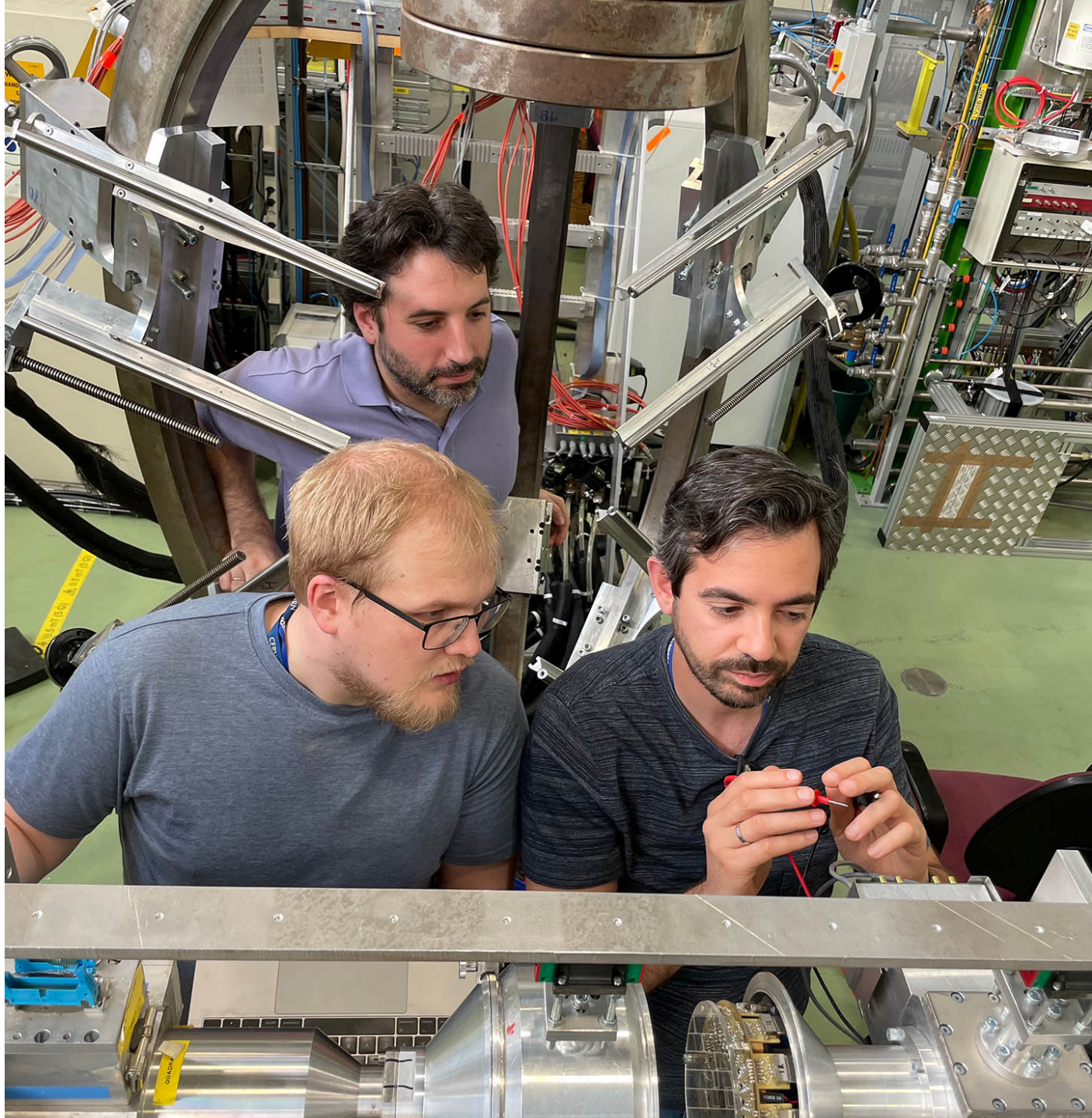


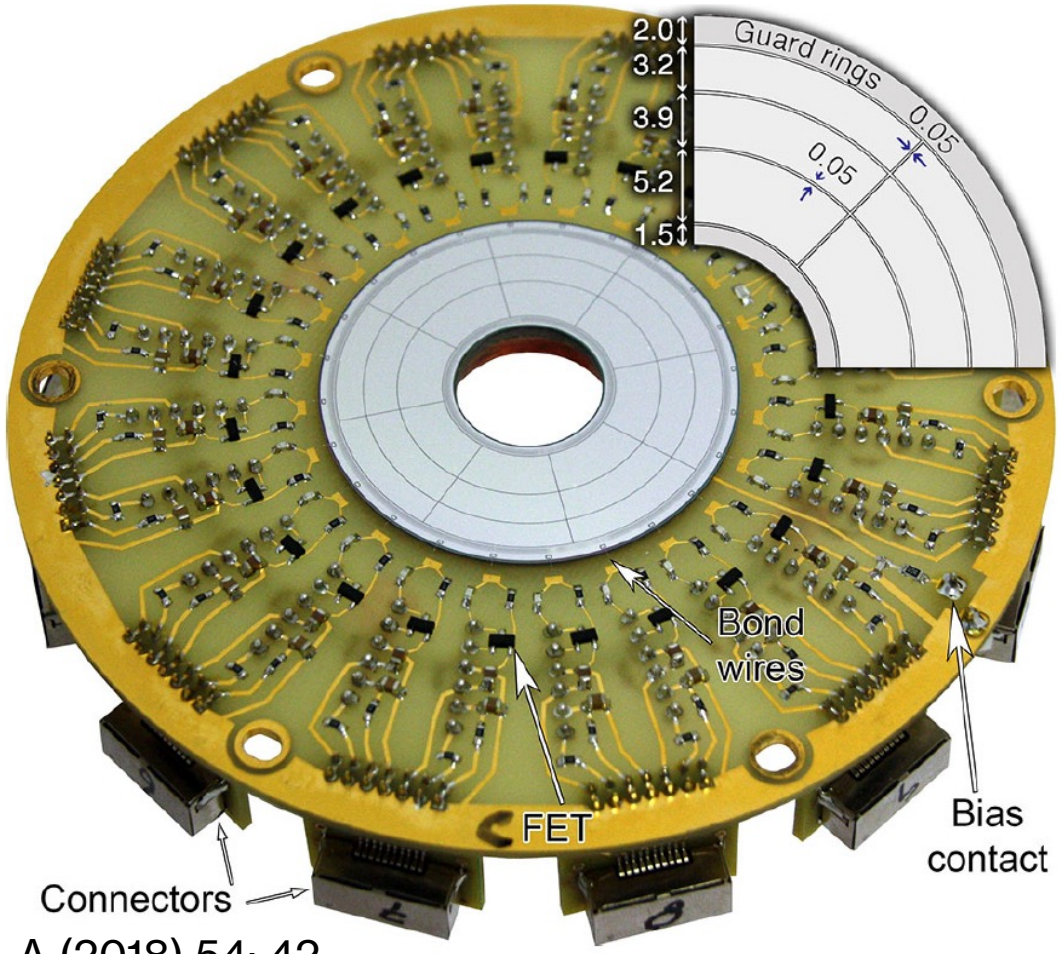
SPEDE Installation summer 2022

- Installation started May 2022
- Setting up electronics/devices (HV, Preamps, DOS-Cards, Julabo)
- Alignment of the target chamber
- Prepare the MINIBALL array
- New DAQ @MINIBALL



The SPEDE silicon detector

- 24 pixels
- Silicon design is decided based on the simulations
- Thickness 500 μm
- AMPTEK A250F/NF used as preamplifiers
- Silicon is cooled down with ethanol near -5 ℃ temperature
- A typical bias voltage is +90 V



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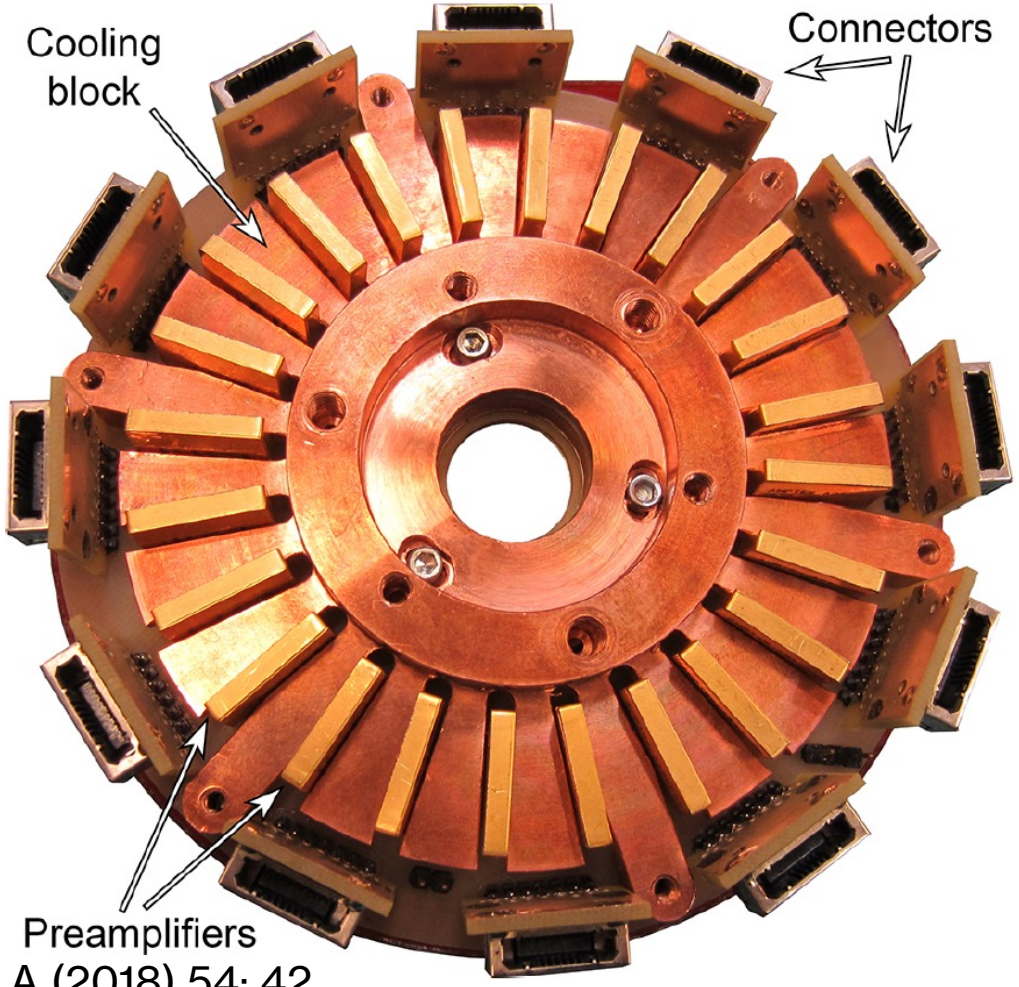

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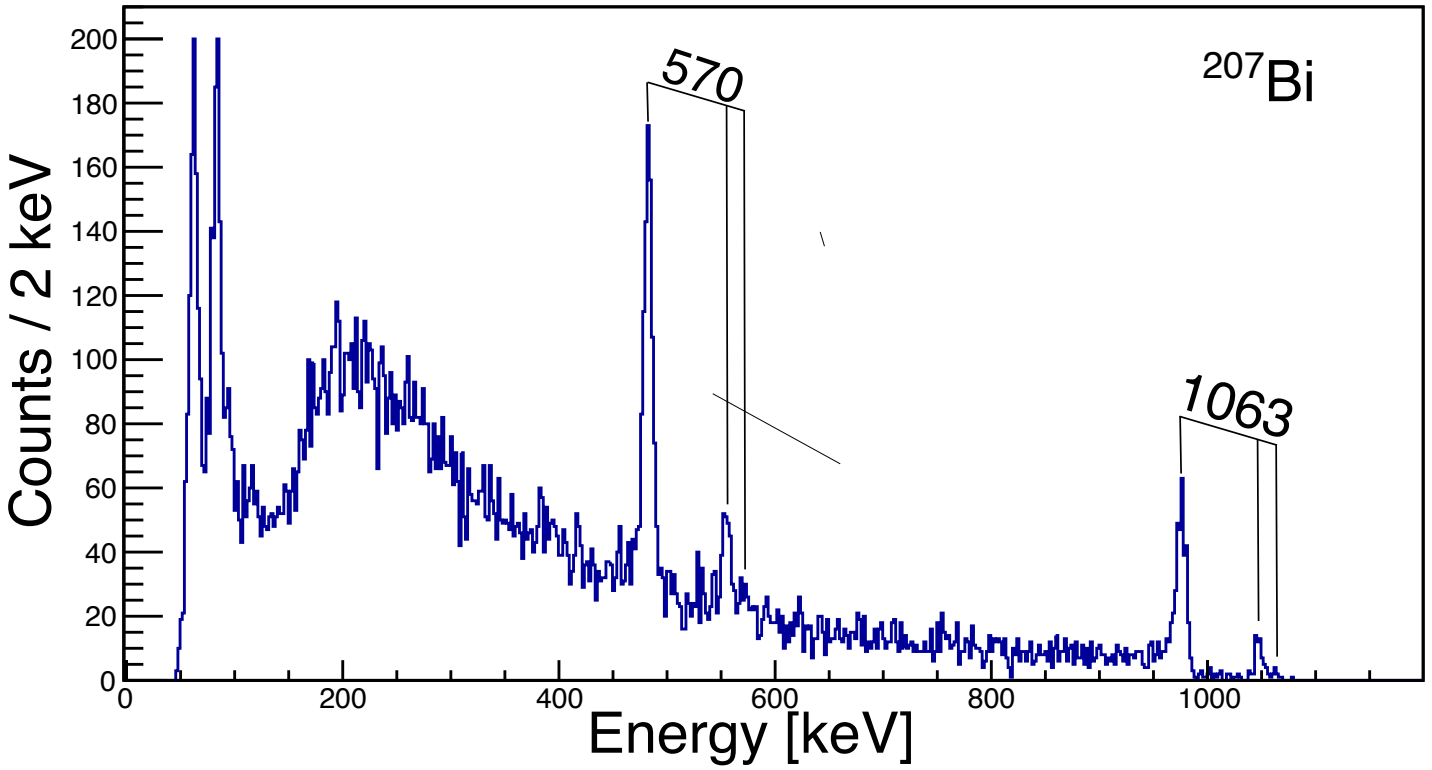
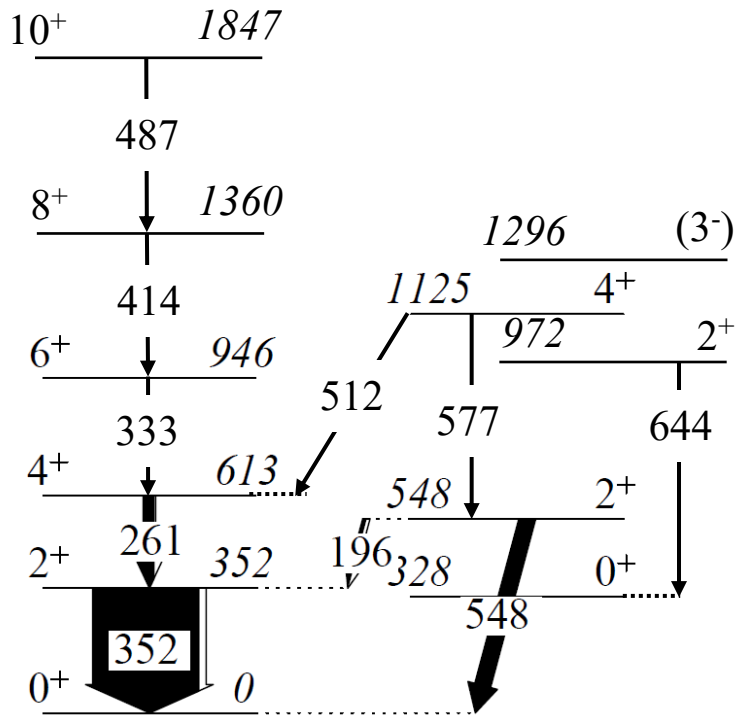
SPEDE Installation summer 2022

- FWHM @ 482 keV : ~8 keV (MCA)
- FWHM @ 482 keV : ~10 keV (DAQ)
- Due to preamp signal shape, the resolution depends on the DAQ
- Efficiency @ 482 keV : ~4%
- There is a clear need for a ^{133}Ba electron source for efficiency below 400 keV!



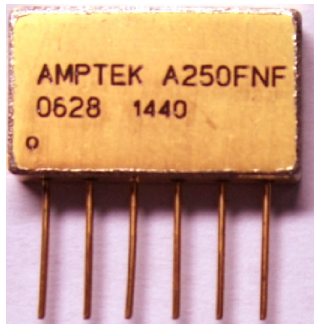
IS563: ^{182}Hg Coulex experiment

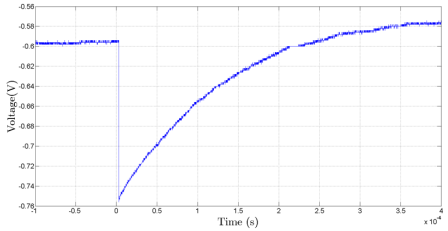
- Beam:^{182}Hg beam,
- Target:^{120}Sn
- The first radioactive ion beam experiment with SPEDE!!
- Objective: Reduce errors of diagonal matrix elements of 2^+ states to level where negative, zero and positive quadrupole moments can be distinguish
- SPEDE can be used to assess the intensity of E0 $2^+ \rightarrow 2^+$ transition



Electronics

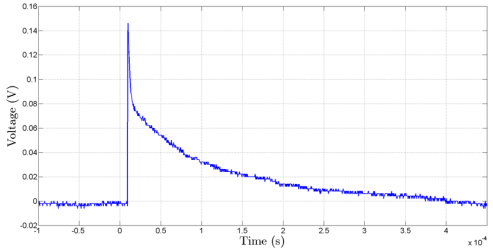
- Preamp power, Mesytec MNV-4
- Gain-offset (GO) unit
- Differential to single ended (DOS) cards
- FEBEX: DAQ cards
- Bias voltage supply (+90V), Mesytec MHV-4, for the detector
- HV supply, ISEG SHR, for a target ladder





SPEDE preamp

GO Box



DOS-Cards

FEBEX