SAGE Spectrometer

Combining γ-ray and conversion electron spectroscopy; The first results

P. Papadakis, J. Sorri, P.T. Greenlees, R.-D. Herzberg, P.A. Butler, D.M. Cox, P.J. Coleman-Smith, J.R. Cresswell,P. Jones, R. Julin, J. Konki,
I.H. Lazarus, S.C. Letts, A. Mistry, J. Pakarinen, V.F.E. Pucknell, P. Rahkila, M Sandzelius, , D.A. Seddon, J. Sampson, J. Simpson, J. Thornhill, D. Wells

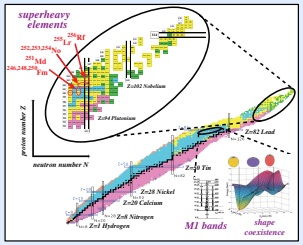
UNIVERSITY OF LIVERPOOL · erc · UNIVERSITY OF JYVÄSKYLÄ · Science & Technology Facilities Council

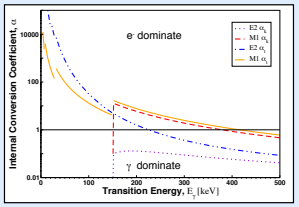
What does SAGE do?

- Combines in beam γ-ray and internal conversion electron spectroscopy.
- Employs the RITU gas-filed recoil separator and the GREAT focal-plane spectrometer to enable recoil-decay tagging studies and measure recoils and their decay at the focal plane.

Why does it do it?

- Study superheavy nuclei to get indications on the position of the next spherical proton shell closure and provide valuable guidance for theory.
- Study shape coexistence where the properties of low-lying 0^+ states and the inter-band transitions between the same spin-parity can be investigated via simultaneous conversion electron and γ-ray spectroscopy.



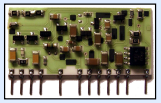


Internal conversion coefficients for ^{254}No.

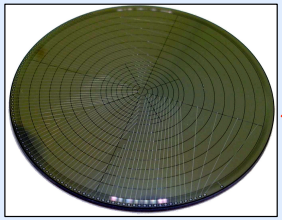
- Conversion electron and γ-ray emission compete strongly in heavy nuclei.
- Spectroscopy using electron and γ spectrometers separately provides only part of the picture.
- E0 transitions only occur via internal conversion.

How does it do it?

Preamplifiers:
- Custom-made C.A.E.N A1422 charge-sensitive hybrid preamplifiers.
- Gain 400mV/MeV.

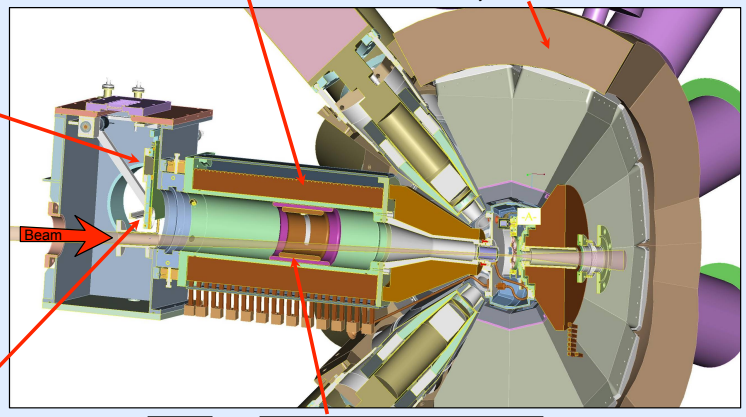


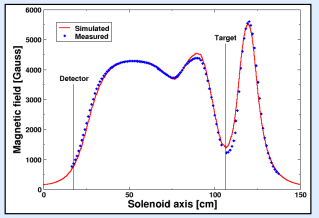
Silicon detector:
- 90 segments
- 48mm diameter, 1mm thick
- Higher segmentation in the center to cope with high count-rates.



Solenoid coils:
To transport the conversion electrons to the silicon detector.

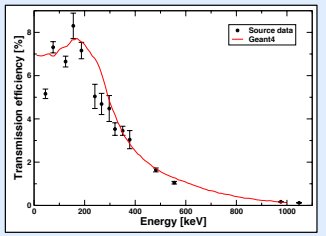
JUROGAM II germanium array
- 24 Clover & 10 Phase I Compton-suppressed germanium detectors.
- 5.5% efficiency at 1332 keV.



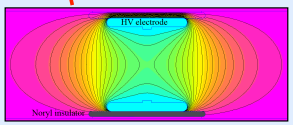


Measured & simulated magnetic field on solenoid axis with 700A current through the coils

Measured & simulated electron transmission efficiency with 800A current and 0kV on the HV barrier



196 channels of **fully digital electronics**.

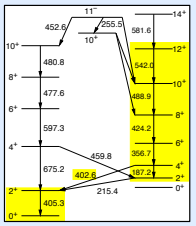


High Voltage barrier:
- Up to -50 kV
- Reduces the flux of low-energy delta electrons.

How well does it do it?

Study of ^{186}Hg through the ^{150}Sm+^{40}Ar reaction

- Part of the first experimental campaign with SAGE.
- First published data from SAGE.
- The measured K- and L-conversion electron ratios confirmed the stretched E2 nature of several transitions of the yrast band.
- Obtained additional information on the E0 component of the $2_2^+ \rightarrow 2_1^+$ transition.
- Data helped to identify possible electronic and mechanical upgrades for SAGE.

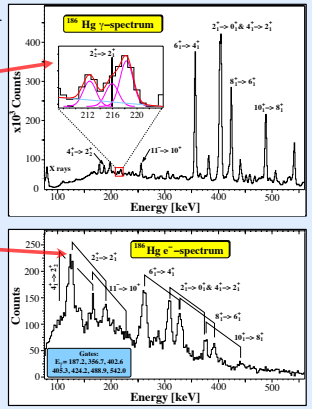


W.C. Ma *et al.*, Phys. Rev. C **47**, 1 (1993)

Projection of the γγ matrix.

The $2_2^+ \rightarrow 2_1^+$ transition forms a multiplet with other peaks and cannot be deconvoluted easily.

The K and L components of the $2_2^+ \rightarrow 2_1^+$ transition are clearly seen.

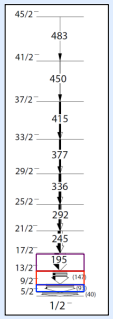


e⁻ spectrum created by gating on the highlighted γ transitions from the γe⁻ matrix.

M. Scheck *et al.*, Phys. Rev. C **83**, 037303 (2011)

Study of ^{251}Md through the ^{205}Tl+^{48}Ca reaction

- Extended published level scheme through γγ coincidences.
- Observed highly converted low-energy transitions with electron measurements.
- Used intensities of electron peaks belonging to the same transition to define multipolarities.



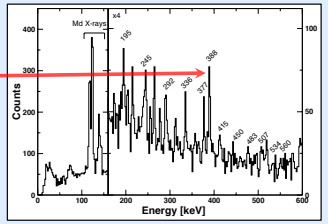
A. Chatillon, PhD Thesis (2007)

Highlighted transitions observed in the electron spectrum.

Raw γ-ray spectrum.

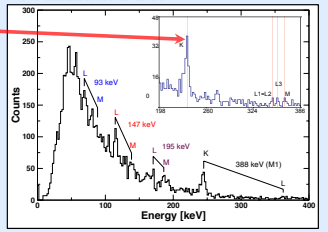
388keV transition not yet placed in the level-scheme.

Indicated transitions belong to the 1/2⁻[521] band.



PRELIMINARY courtesy of F. Dechery

388keV transition identified as M1 from conversion electron ratios.



Raw electron spectrum.

Summary

- With SAGE we have:
  - Measured γ-rays and conversion electrons simultaneously.
  - Performed cross-coincidence analysis between γ rays and conversion electrons.
  - Extracted internal conversion coefficients from ratios of γ rays and conversion electrons from the same transition.
- Successfully coupled with RITU and GREAT, allowing:
  - Detection of recoils and their subsequent decays at the focal plane [fission, α, e⁻, γ].
  - Use of the Recoil Decay Tagging technique.
- Use digital electronics for germanium and silicon detectors:
  - Allows high count rates (45 kHz/Ge detector).
  - Linear throughout the energy range.
- JUROGAM efficiency increased from 4.2% to 5.5% @ 1332keV.
- Improved operation of SAGE after commissioning.
- First campaign:
  - Study of shape coexistence in ^{184,186}Hg M. Scheck *et al.*, Phys. Rev. C **83**, 037303 (2011)
  - Study of shape coexistence in ^{202,204}Rn, ongoing analysis
- Second campaign:
  - Study of ^{251}Md
  - Study of ^{253}No
  - Study of ^{255}Lr
  - Study of ^{188}Pb
  - Study of ^{152,154}Sm

  } Ongoing analysis
- Next experimental campaign scheduled for the following year.