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^{177,178}Yb ground-state lifetimes

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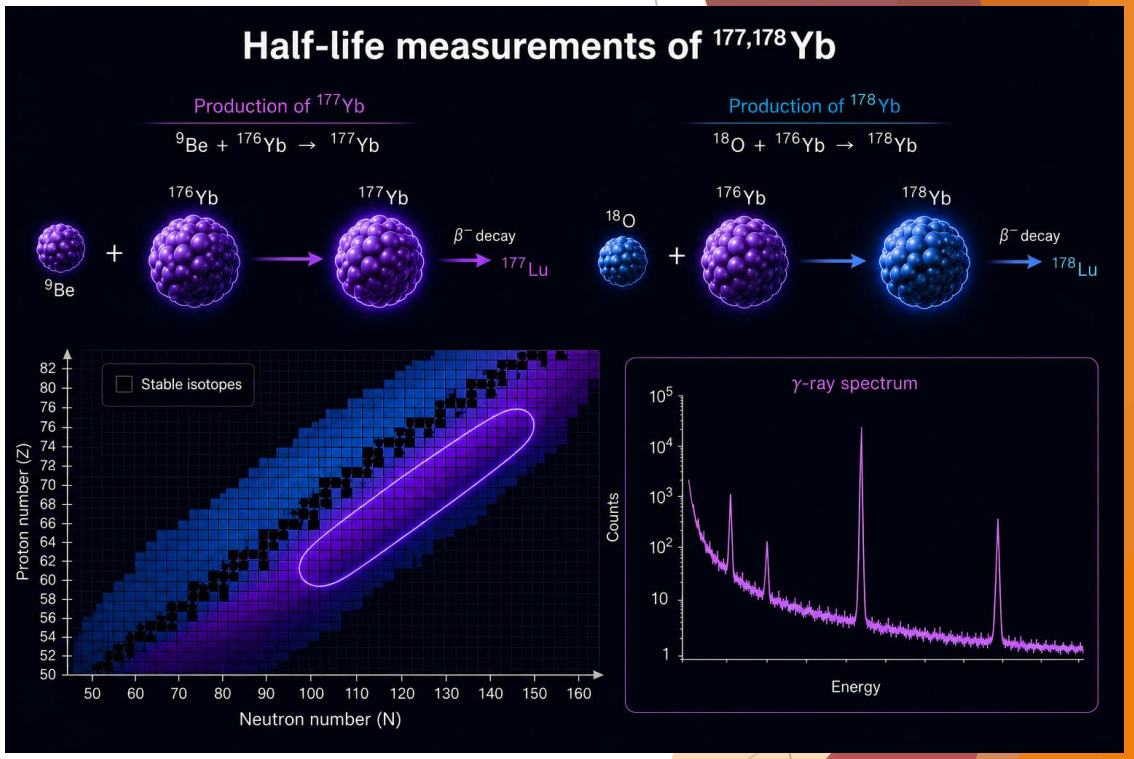
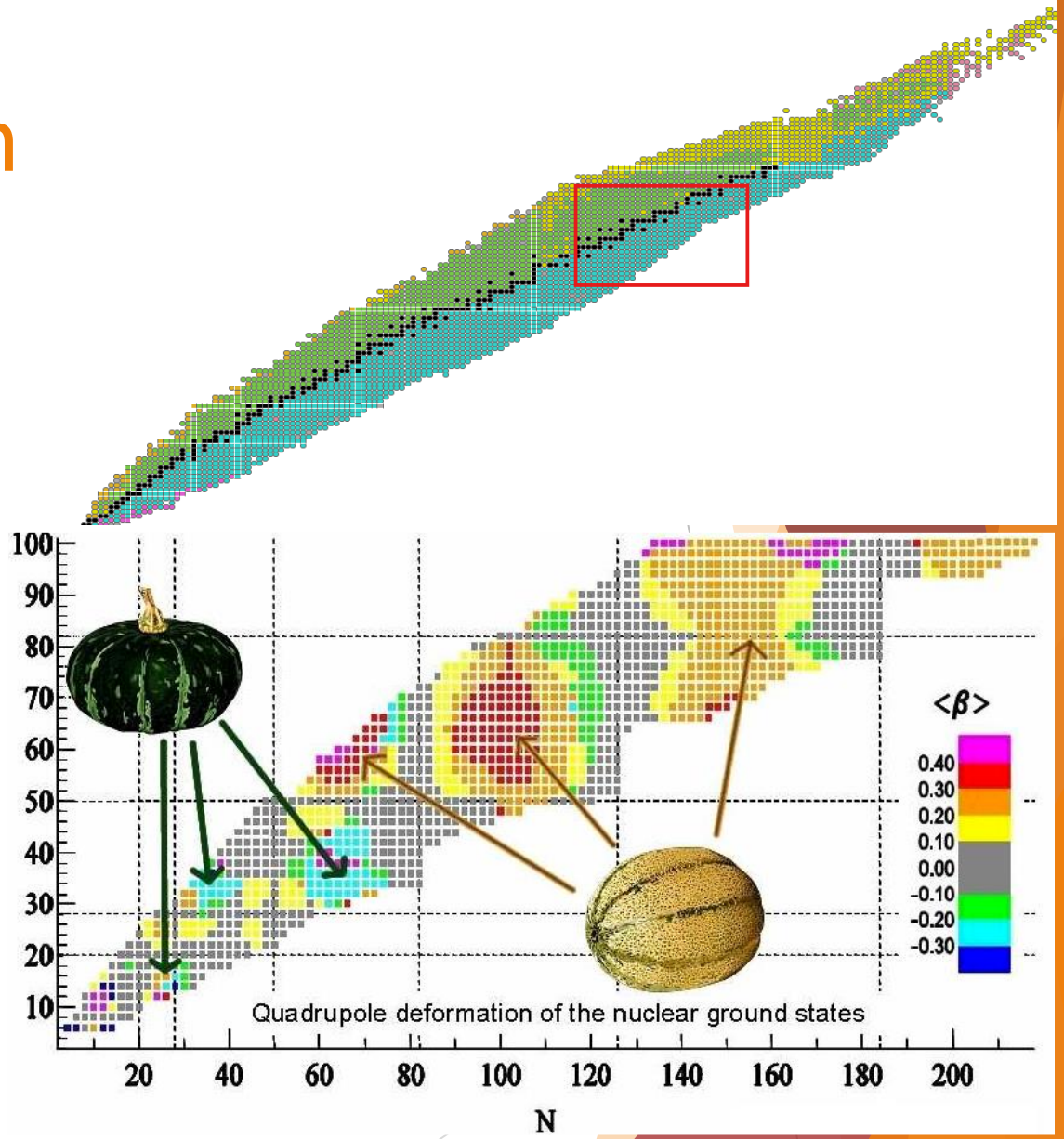
Outline

- Introduction & Motivation
- Activation Method
- Experimental Setups
  - ROSPHERE array at IFIN-HH
  - CATHEDRAL spectrometer at IKP Cologne
- Experimental Results
  - Half-life result for ^{177}Yb
  - Half-life result for ^{178}Yb
- Summary and Outlook



Introduction and Motivation

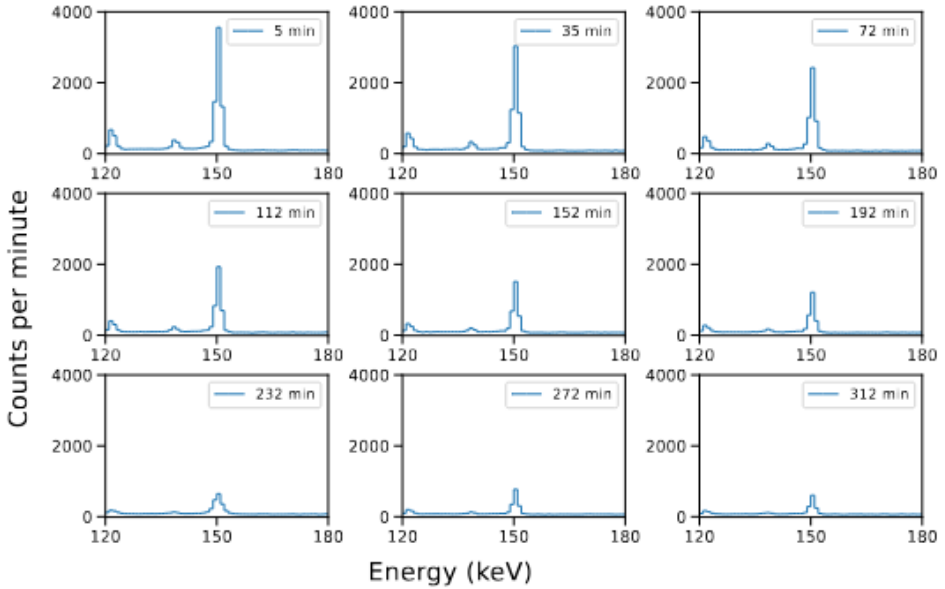
- The mass region around A=180 is important for studying nuclear structure and decay lifetimes
- Yb isotopes are important for both nucleosynthesis and medical applications, especially throught the production of ^{177}Lu
- ^{178}Yb shows strong deformation and rotational behavior
- **The half-life data for ^{177}Yb and ^{178}Yb are outdated, so new measurements were performed using modern activation technique**

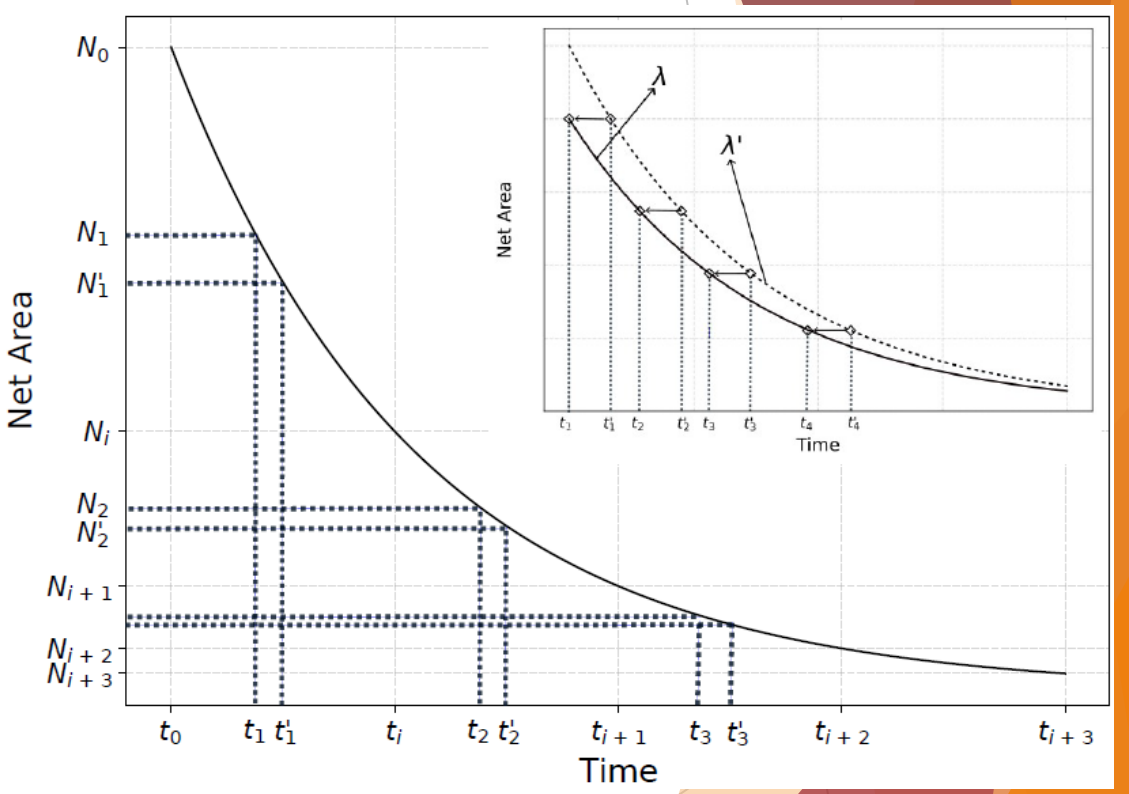


Activation Method

Decay Time Correction Procedure

- Irradiation: The sample is irradiated for 5–6 half-lives to ensure measurable activity post-beam.
- Time Assignment: Each data point is initially placed at the midpoint of its acquisition window.
- Uncertainty: This midpoint approximation introduces significant timing error (±½ duration).





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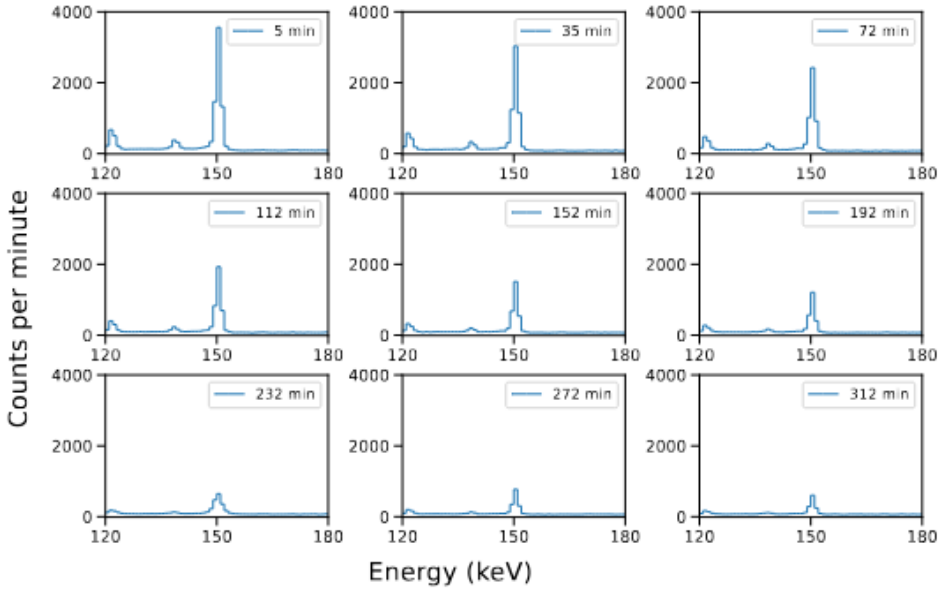

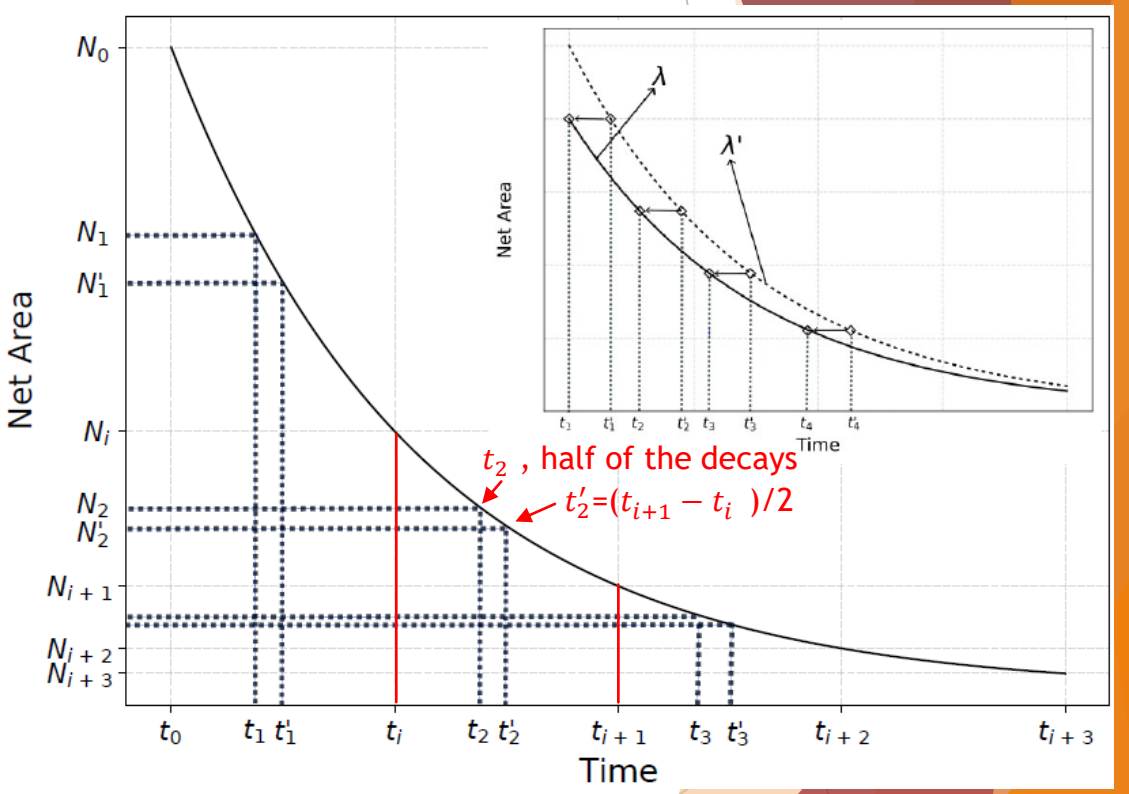

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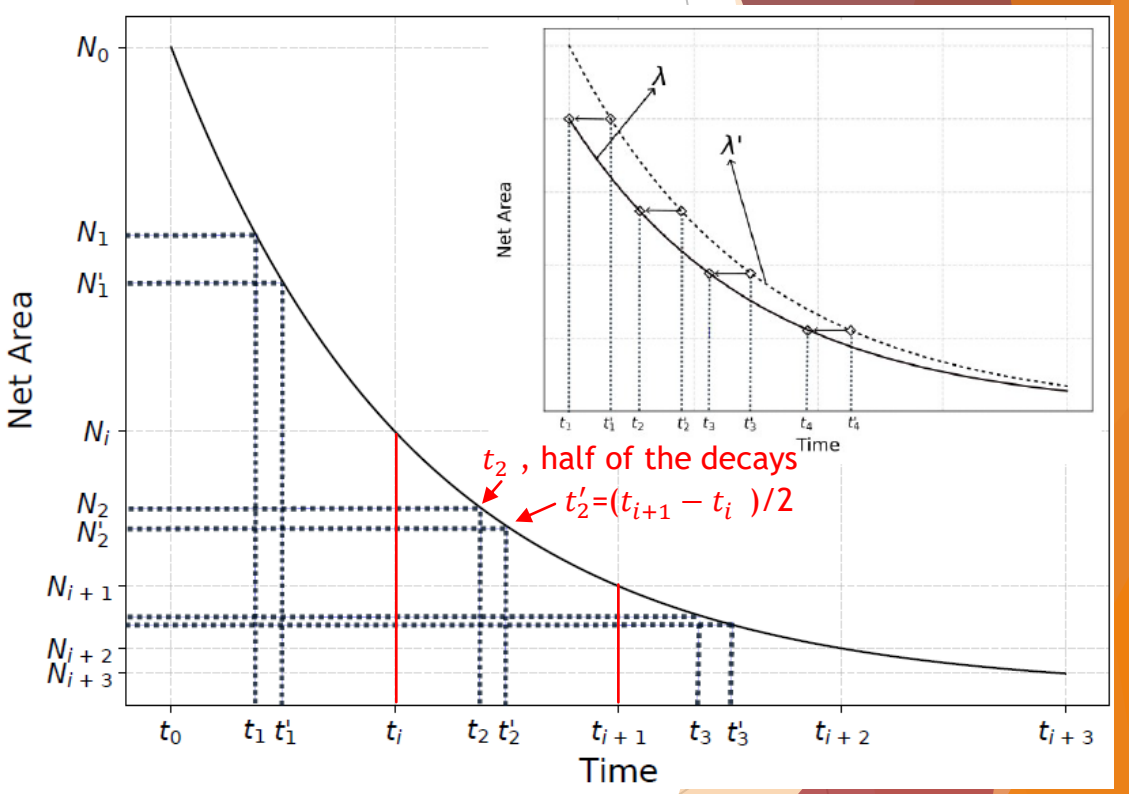
- Time Assignment: Each data point is initially placed at the midpoint of its acquisition window.
- Uncertainty: This midpoint approximation introduces significant timing error (±½ duration).
- Initial Fit: A first estimate of the decay constant (λ') is obtained by fitting the decay using midpoint times.
- Timing Correction: Accurate timing is calculated by solving:

$$t = -\frac{1}{\lambda'} \cdot \ln\left(\frac{e^{-\lambda' t_{i+1}} + e^{-\lambda' t_i}}{2}\right)$$

- Error Refinement: Updated time uncertainties account for λ and the interval endpoints via error propagation.
- Final Result: The corrected decay curve shifts slightly earlier, yielding a more accurate half-life.



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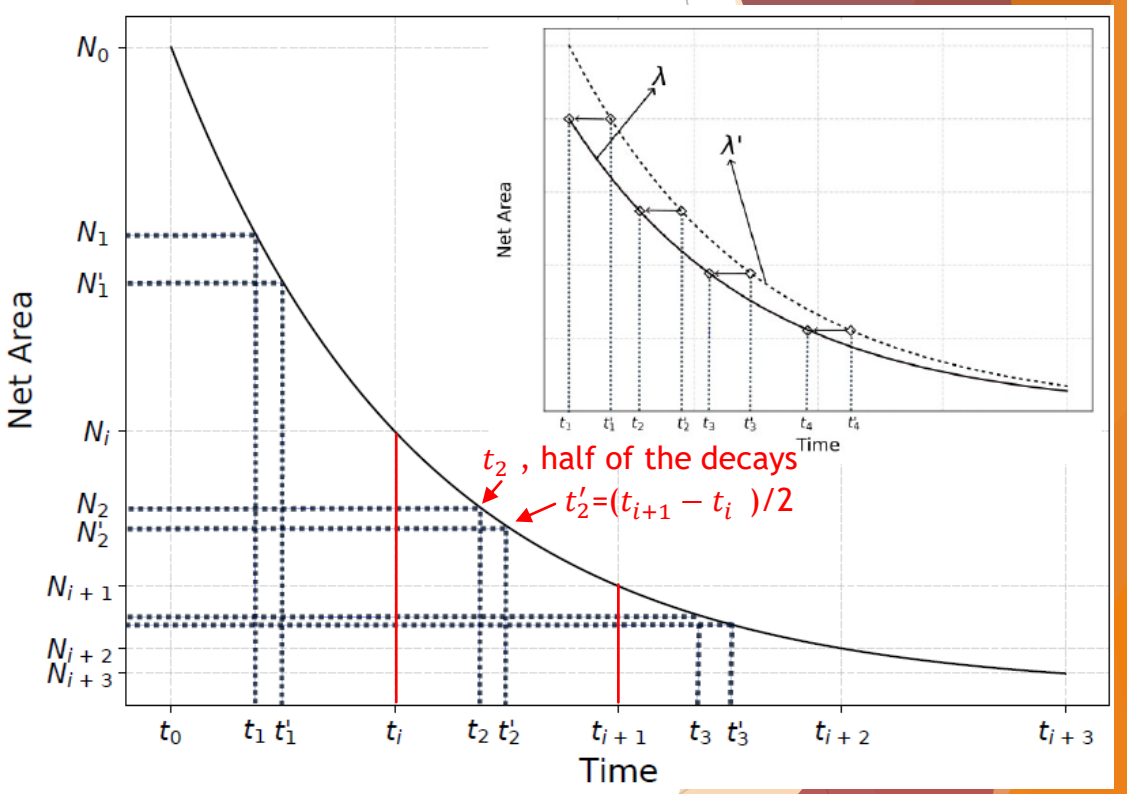

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Experiments

Lifetime measurement following the decay of ^{177}Yb

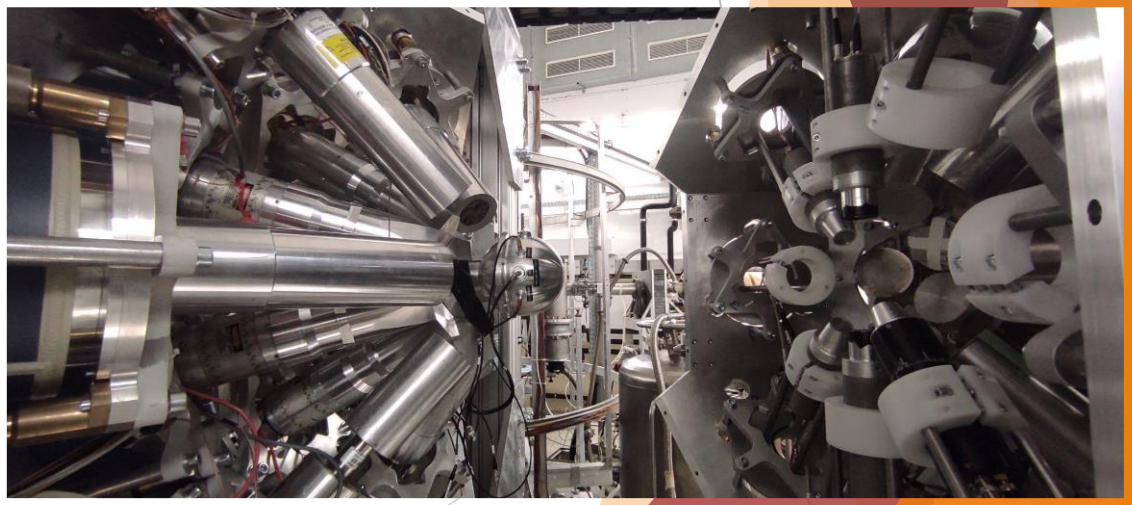
Setup and measurements

- 9 MV Tandem accelerator at the Horia Hulubei National Unstitute of Physics and Nuclear Engineering IIFIN-HH) In Romania
- Target: ^{176}Yb (thickness 10 mg/cm^2, 96% enrichment)
- 1n-transfer reaction : $^{176}Yb(\ ^{9}Be,\ ^{8}Be)^{177}Yb$
- Beam Energy: 38 MeV
- ROSPHERE array:
  - 10 HPGe detectors (2 rings)
- SORCERER: 6 Si particle detectors for charged particle detection
- Irradiation time ~ 10 days
- Counting time ~ 7 hours
  - 44 runs of 10 min duration

Lifetime measurement following the decay of ^{178}Yb

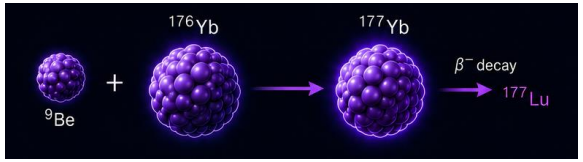
Setup and measurements

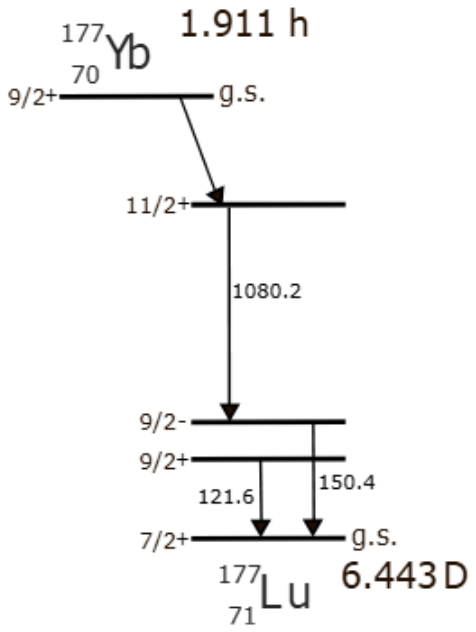
- 10 MV FN-Tandem accelerator at Institute for Nuclear Physics in Cologne, Germany
- Target: ^{176}Yb (thickness 10 mg/cm^2, 96% enrichment)
- 2n-transfer reaction: $^{176}Yb(^{18}O, ^{16}O)^{178}Yb$
- Beam Energies: 74 MeV
- CATHEDRAL Spectrometer array:
  - 24 HPGe detectors (4 rings in 30°, 55°, 125° and 150° in relation to the beam direction)
- 6 Solar cells for charged particle detection
- Irradiation time ~ 110 hours
- Counting time ~ 15 hours
  - 29 runs of 1 min duration
  - 88 runs of 10 min duration

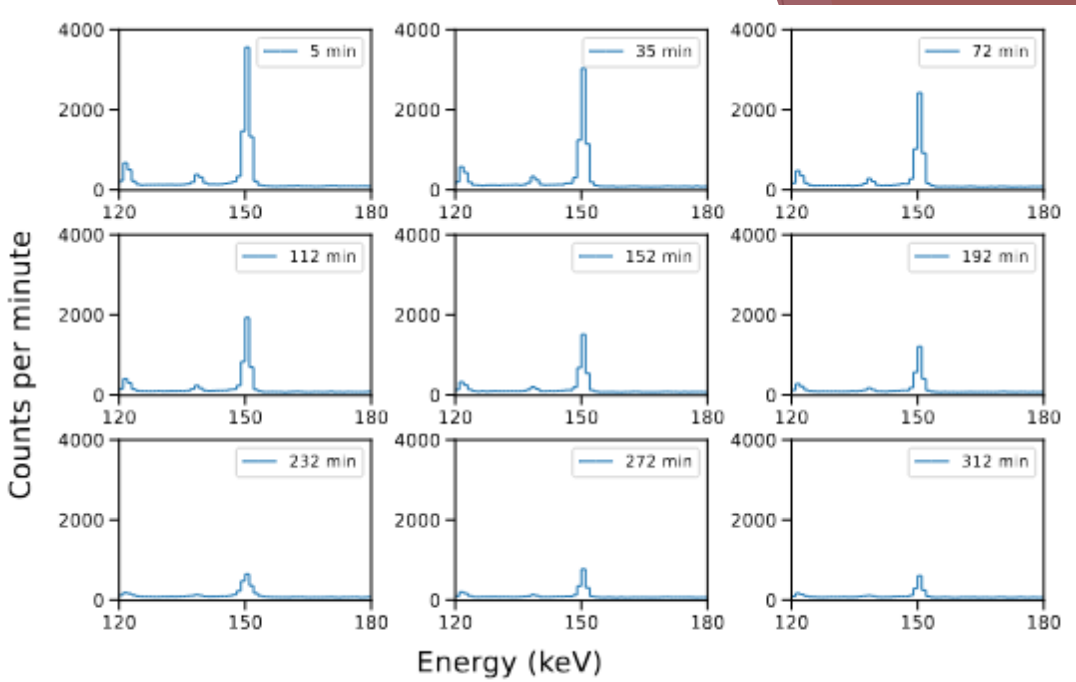


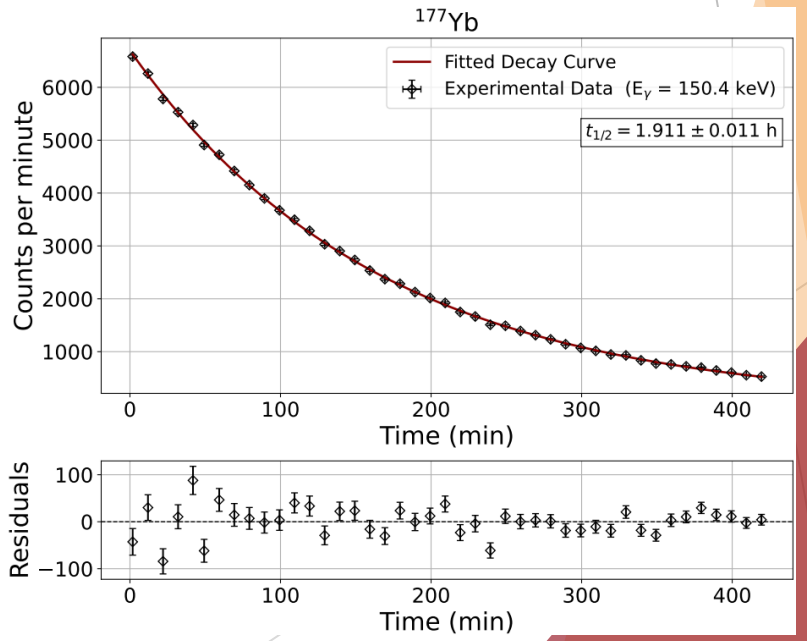
Experimental Results

Half-live result for ^{177}Yb



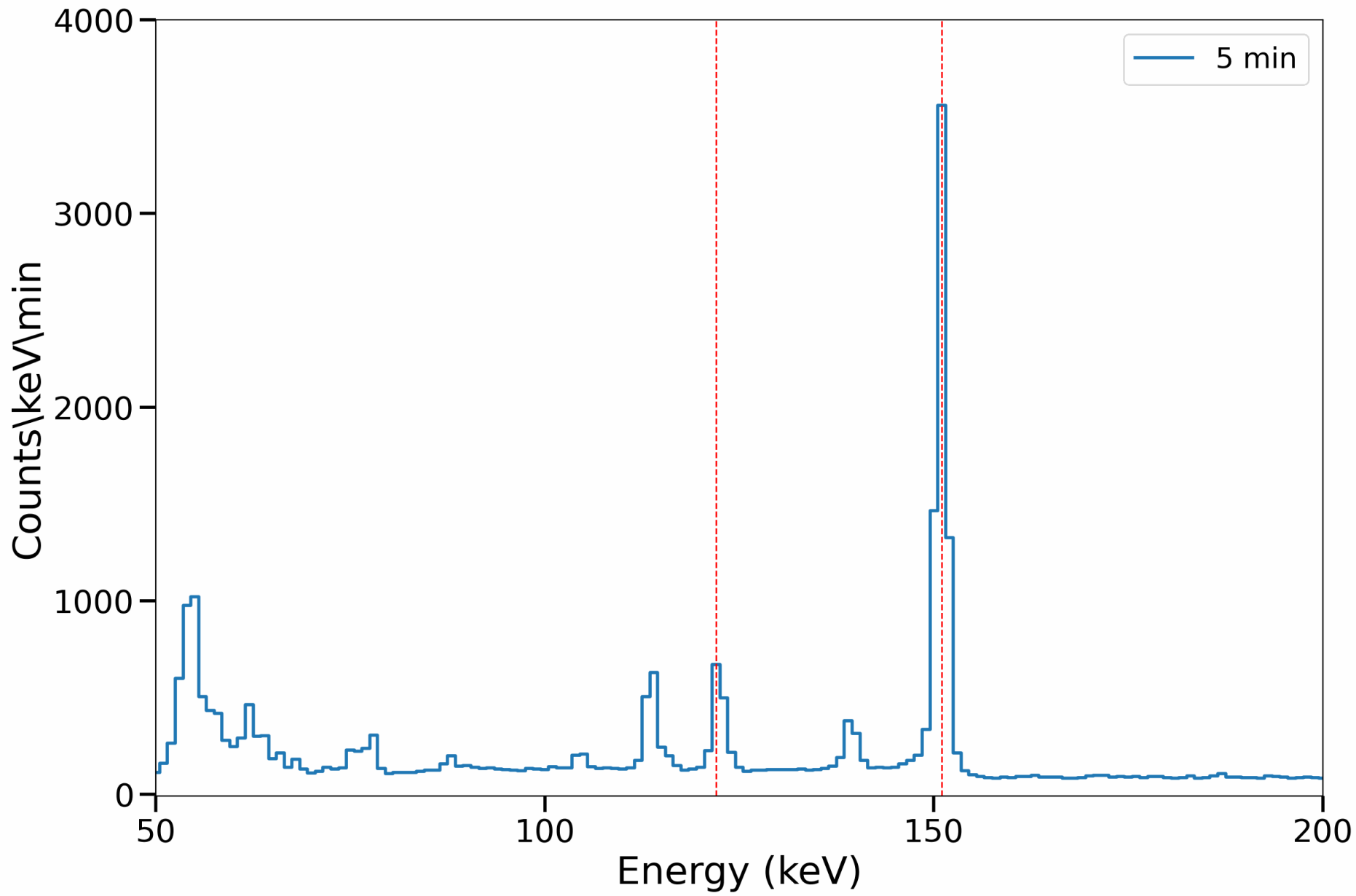


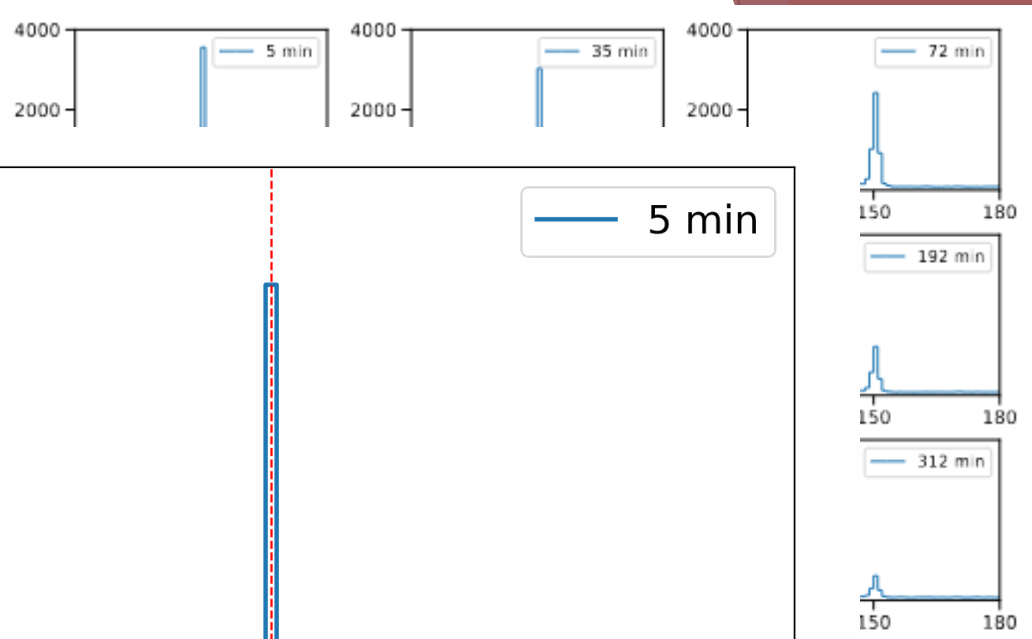


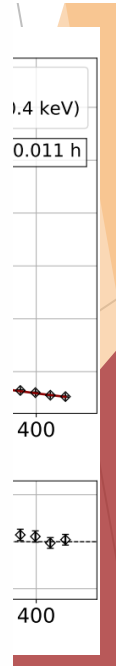


Isotope	This work	Adopted (from Ref. [9])	Literature	Ref.	Proposed Weighted Average
^{177}Yb	1.915(10) h	1.911(3) h	1.88(10) h	[40]	1.911(3) h
			1.911(3) h	[41]	
			1.8(1) h	[42]	
			1.9(1) h	[43]	

Half-live result for ^{177}Yb



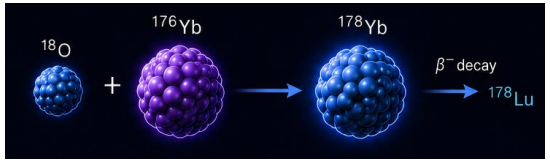


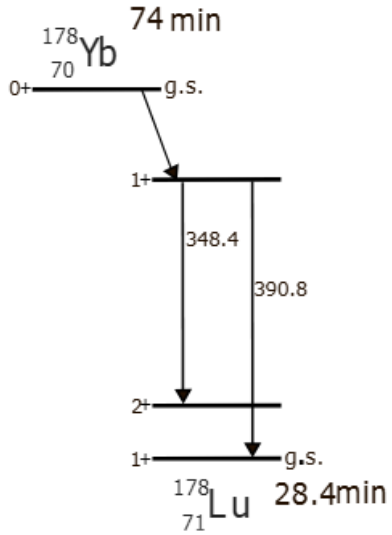


Isotope

^{177}Yb

Half-live result for ^{178}Yb





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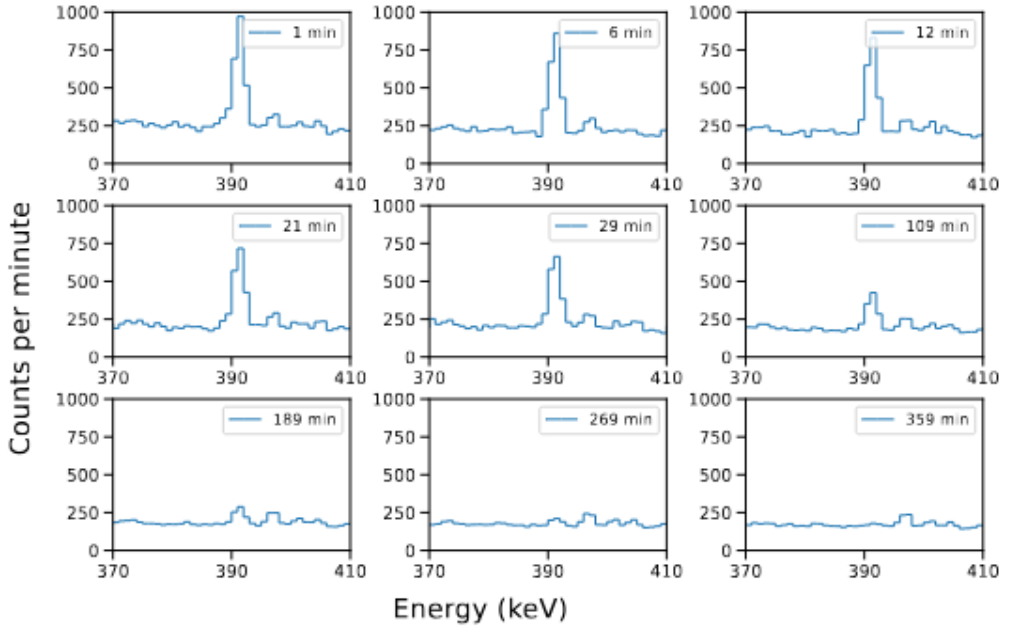
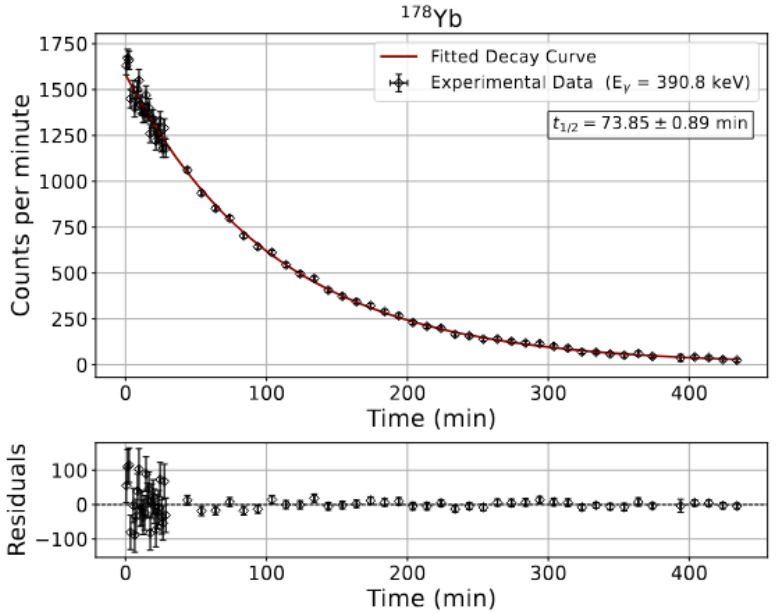
^{178}Yb	73.52(72) min	74(3) min	74(3) min	[45]	73.55(70) min





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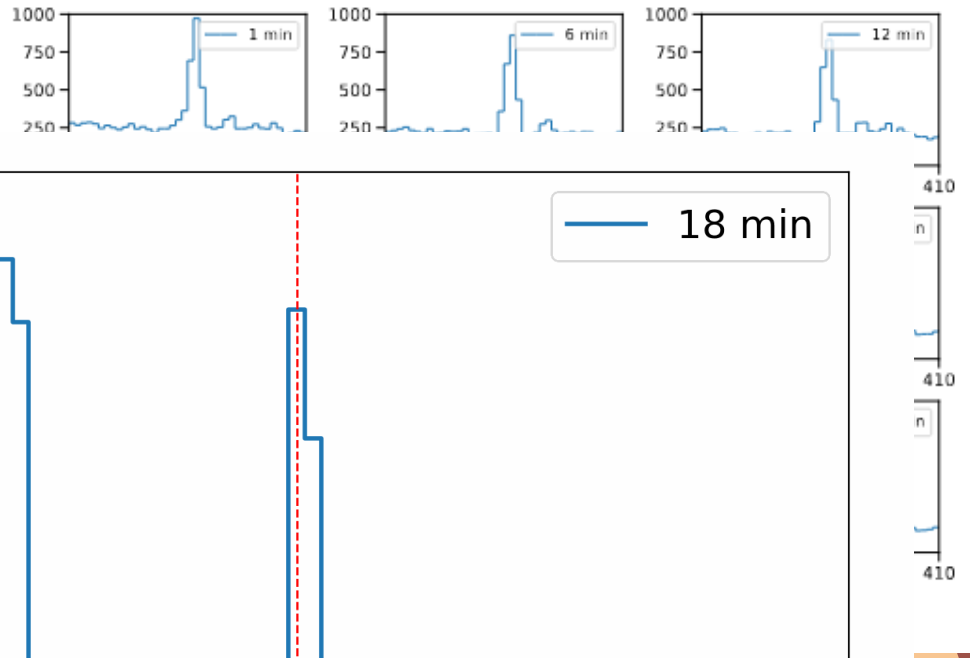

Isotope	Tl
^{177}Yb	1.9
^{178}Yb	73.5

Summary & Outlook

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- The method seems to work well for the cases of interest
- For the lifetime of ^{177}Yb our measurement is in a good agreement with the literature value
- For the lifetime of ^{178}Yb the value deduced in the present work shows significantly improved precision compared to the adopted value, >77% reduction in uncertainty vs adopted value
- Under review: manuscript submitted, reviewer response received
- **As a future plan, we aim to apply this analysis method to the data obtained from the experiment we recently performed, with the goal of investigating the $^{171,172}Er$ isotopes.**

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Isotope g.s.	E_{lvl} (keV)	Suggested Weighted Average (min)		NNDC (min)
^{117}Te g.s.	719.7(7)	63.85(99)	▼67%	62(3)
^{117}Sb g.s.	158.6(15)	170.97(50)	▼17%	168.0(6)
^{115}Sb g.s.	497.3(8)	31.94(14)	▼53%	32.1(3)

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Thank you for the attention!

M. Efstathiou[1], P. Koseoglou[1], T.J. Mertzimekis[1], P. Vasileiou[1,3], A. Blazhev[6], R. Borcea[2], A. Chalil[1,5], C. Costache[3], A. Esmaylzadeh[6], J. Fischer[6], N. Florea[3], S.T. Florian[2], C. Fransen[6], H. Mayr[2], J. Jolie[6], C.-D. Lakenbrink[6], R. Lica[3], N. Marginean[3], C. Mihai[3], R.E. Mihai[3,4], C. Nickel[2], A. Turturica[3], V. Werner[2], A. Zyriliou[1]

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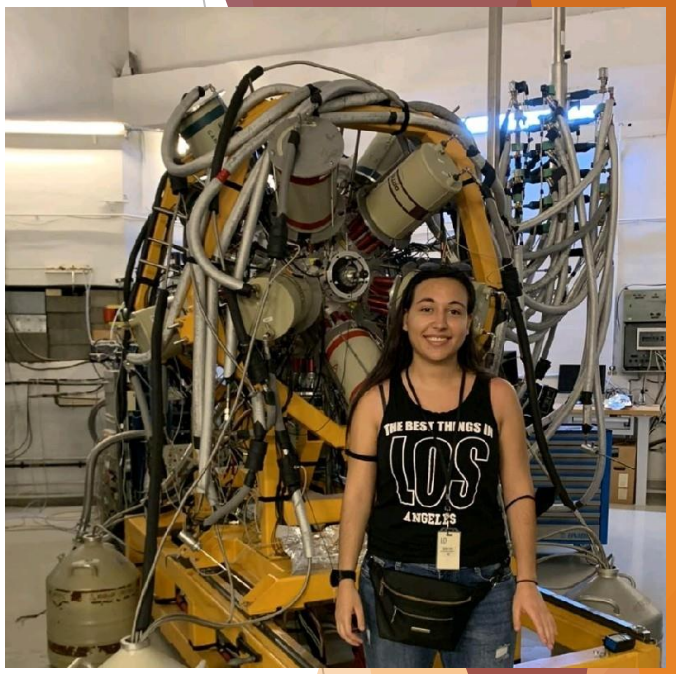
[3] *Horia Hulubei National Institute of Physics and Nuclear Engineering, Magurele, R-77125, Romania*
[4] *Institute of Experimental and Applied Physics, Czech Technical University in Prague, Husova 240/5, Prague 1, 110 00, Czech Republic*
[5] *CEA, DES, IRESNE, DTN, Nuclear Measurement Laboratory, Saint Paul-lez-Durance, 13108, France*
[6] *Institut für Kernphysik, Universität zu Köln, Cologne, 50937, Germany*



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NUSTRAP Nuclear Structure, Reactions & Applications

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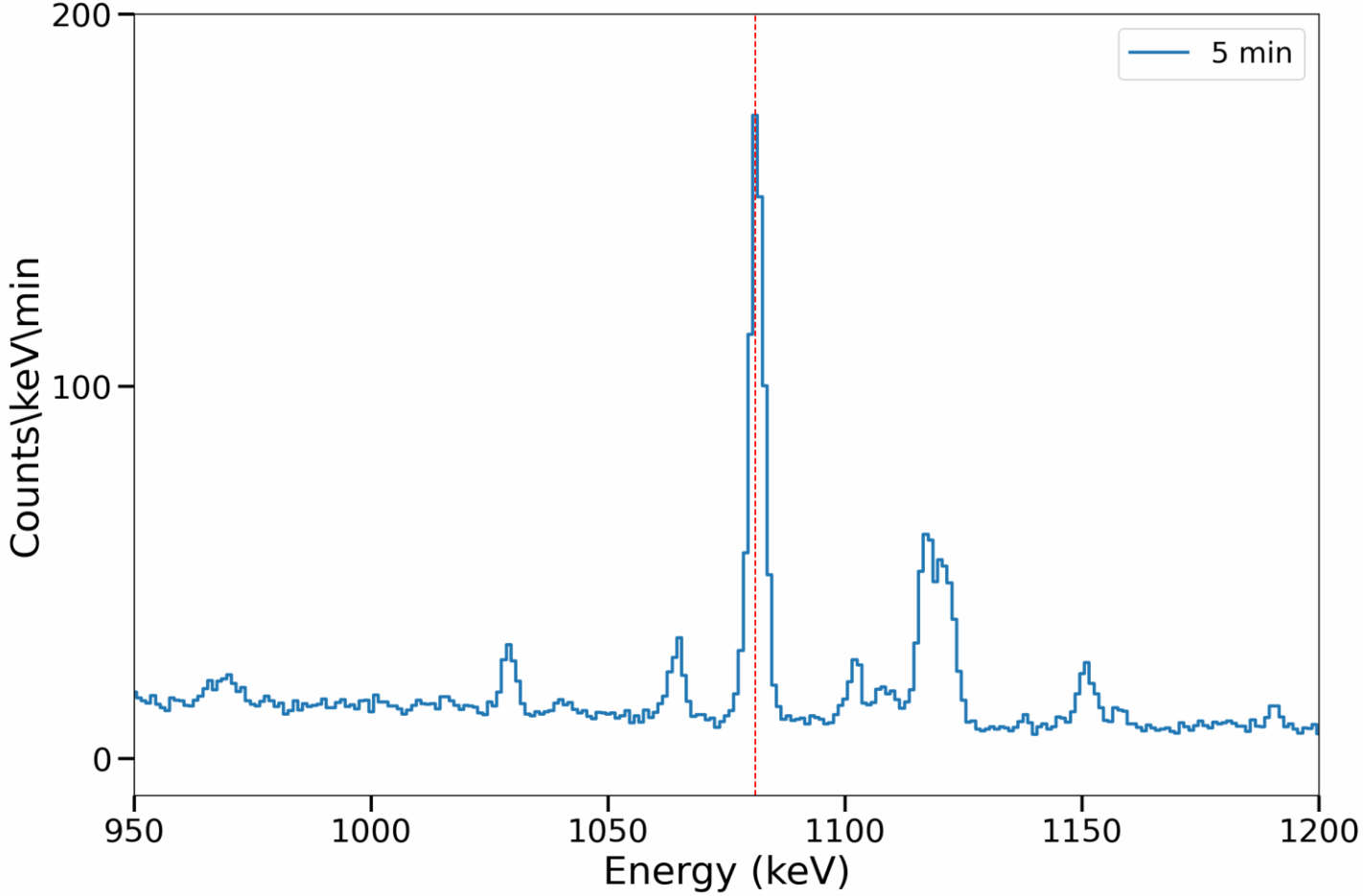
EURO-LABS EUROPEAN LABORATORIES FOR ACCELERATOR BASED SCIENCES

Walter Benjamin-Programm DFG Deutsche Forschungsgemeinschaft

Back-up slides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