KU LEUVEN

The structure of the low-lying excited states in ^{182,184,186}Hg studied through β^+/EC decay of ^{182,184,186}Tl at IDS

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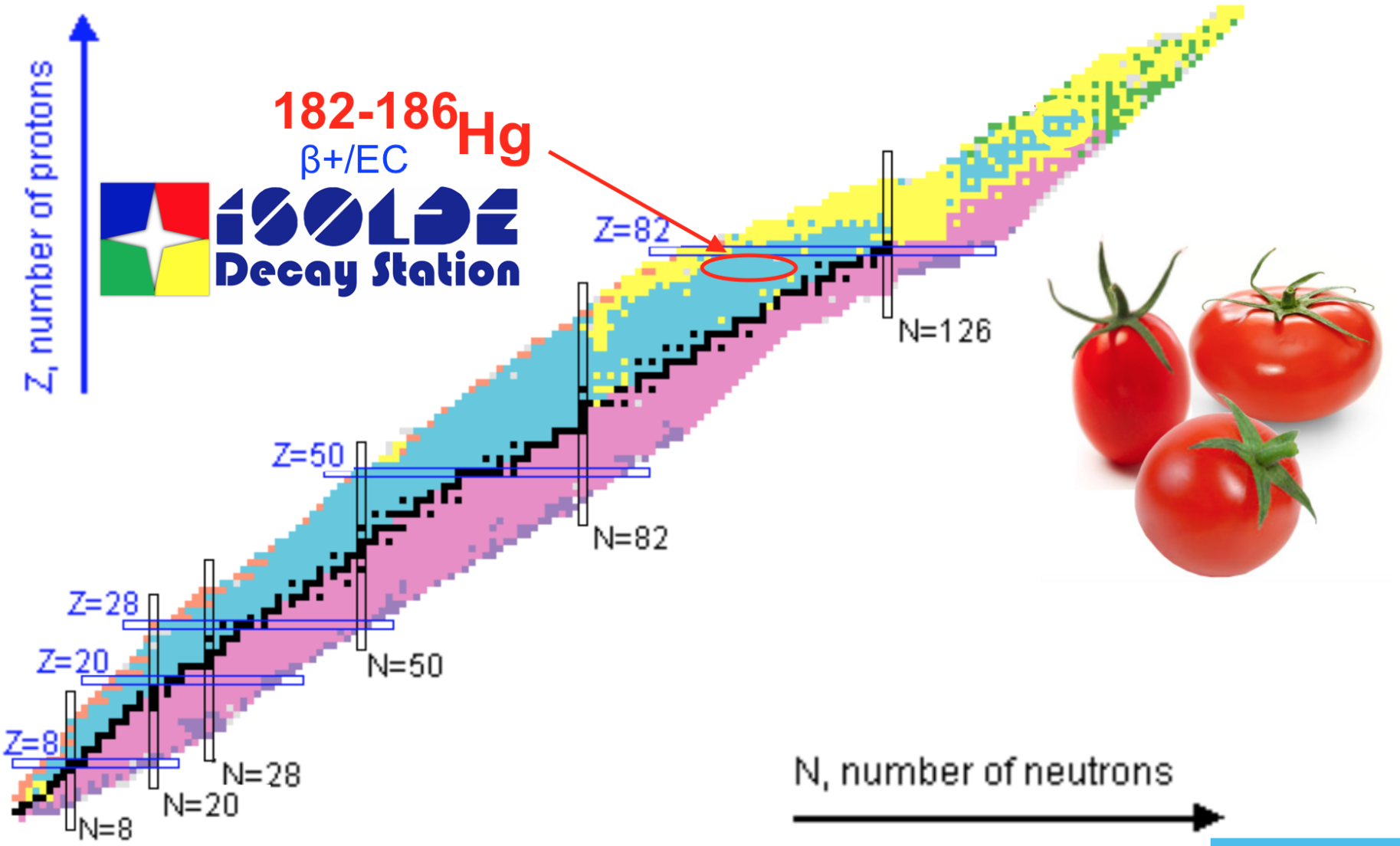
56th Meeting of the INTC

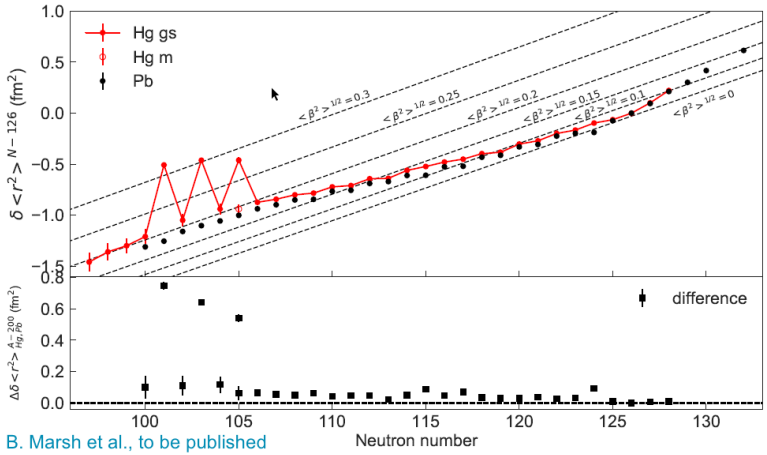
June 28, 2017

1. Shape coexistence in Hg isotopes
2. Goals
3. Experimental setup
4. Beam request



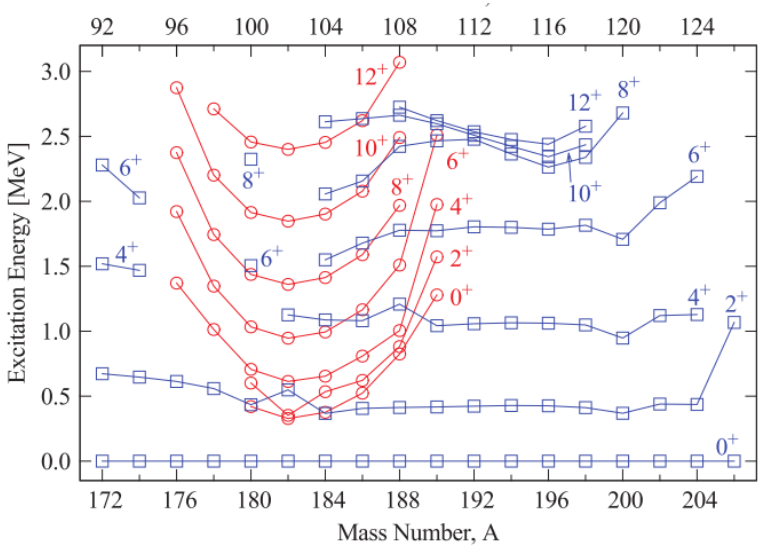
courtesy of J. Cubiss

- "Shape-staggering" in $^{181-185}$Hg



B. Marsh et al., to be published

- "Shape-staggering" in $^{181-185}$Hg
- Intruder states come down and mix with the g.s. band



L.P. Gaffney et al., Phys. Rev. C 89, (2014) 024307

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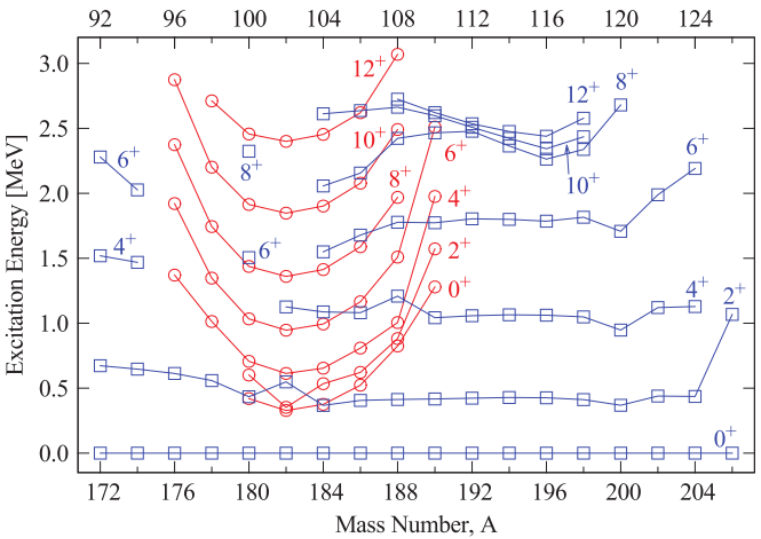
- Intruder states come down and mix with the g.s. band
- **In the even $^{182-186}$Hg**:
  - ⋆ The $2_1^+ \rightarrow 0_1^+$ and **B(E2)** often used to trace the evolution of nuclear structure
  - ⋆ However, **the energy and the B(E2) of the 2^+ remain surprisingly constant** between ^{182}Hg and ^{188}Hg

  (N. Bree et al., Phys. Rev. Lett. 112, 16 (2014), 162701)
  - ⋆ Between ^{182}Hg and ^{184}Hg, the mixing with the prolate band varies drastically
  - ⋆ $\Rightarrow$ **comparison to theory: BMF, IBM, GBH, first Monte-Carlo Shell model (T. Otsuka et al.)**



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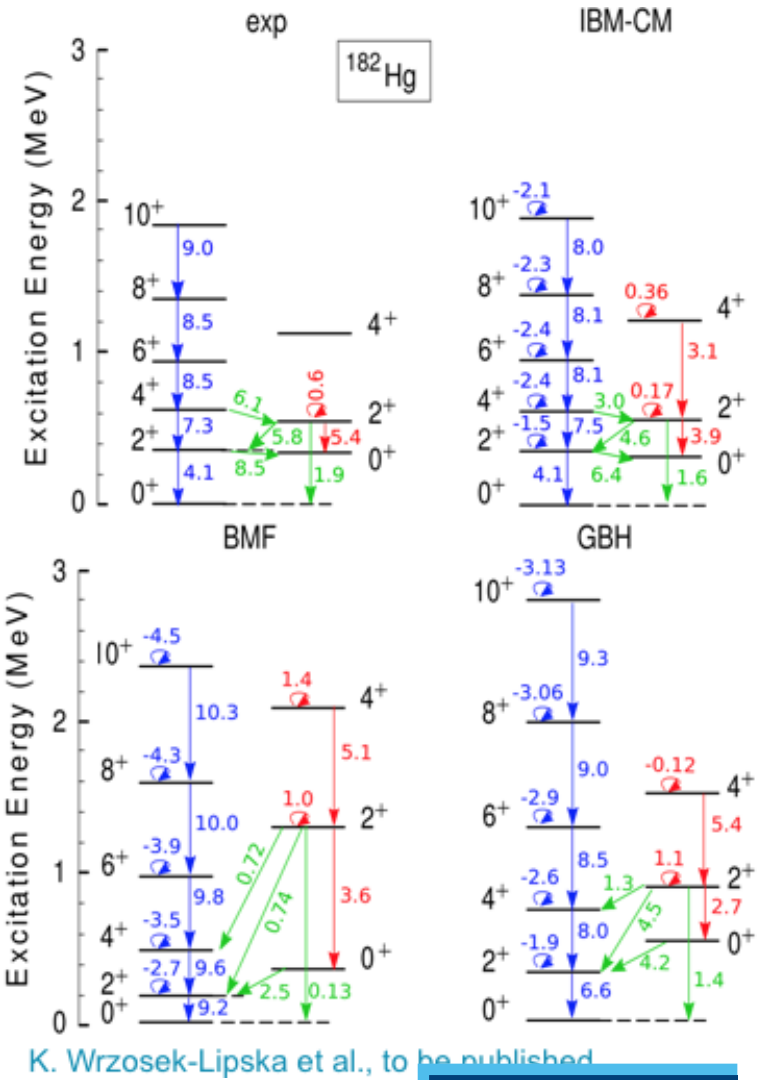
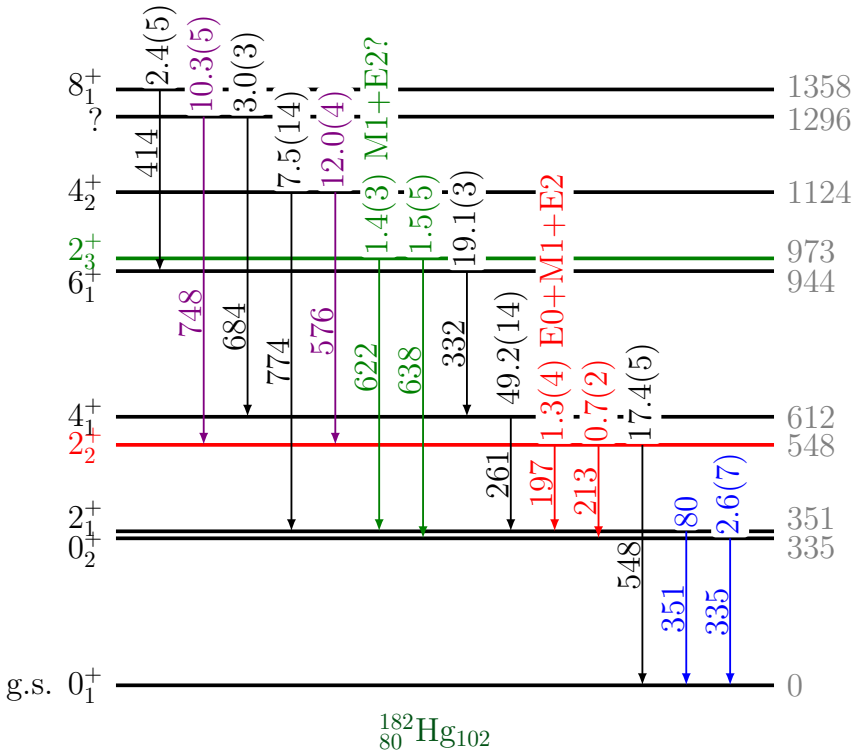


- **coulex** data (REX-ISOLDE: IS452, HIE-ISOLDE: IS563) ⇒ **transitional matrix elements**, **quadrupole moments** and their signs
- **Crucially need accurate BR, ICC , δ** to extract the ME
  the non-yrast levels will be populated in the HIE-ISOLDE experiment
- **this experiment + coulex** ⇒ precise monopole transition strenghts $(2^+ \rightarrow 2^+)$ and quadrupole moments that can be compared to theory

		$\lvert Q_t \rvert$[eb] / Q_s [eb]			
Isotope		Experiment	IBM	BMF	GBH
^{182}Hg	$2_1^+ \rightarrow 0_1^+$	$4.09\ ^{+0.13}_{-0.09}$	4.11	9.18	6.63
	$4_1^+ \rightarrow 2_1^+$	7.34 (12)	7.51	9.58	7.96
	$6_1^+ \rightarrow 4_1^+$	8.5 (3)[a]	8.13	9.77	8.55
	$8_1^+ \rightarrow 6_1^+$	8.4 (5)[a]	8.13	9.99	8.97
	$10_1^+ \rightarrow 8_1^+$	9 (1)[a]	8.04	10.27	9.34
	$2_2^+ \rightarrow 0_1^+$	1.93 (9)	1.64	0.13	1.37
	$0_2^+ \rightarrow 2_1^+$	$8.5\ ^{+0.5}_{-0.4}$	6.39	2.46	4.21
	$2_2^+ \rightarrow 0_2^+$	5.4 (6)	3.87	3.65	2.73
	$2_2^+ \rightarrow 2_1^+$	5.84 (106)	4.59	0.74	4.54
	$4_1^+ \rightarrow 2_2^+$	6.1 (6)	2.96	0.72	1.31
	$2_1^+ \rightarrow 2_1^+$	$-0.03\ ^{+0.98}_{-1.06}$	-1.53	-2.71	-1.89
	$2_2^+ \rightarrow 2_2^+$	$0.6\ ^{+0.8}_{-0.6}$	0.17	1.0	1.1

2 – Decay of the 2_2^+ level in ^{182}Hg



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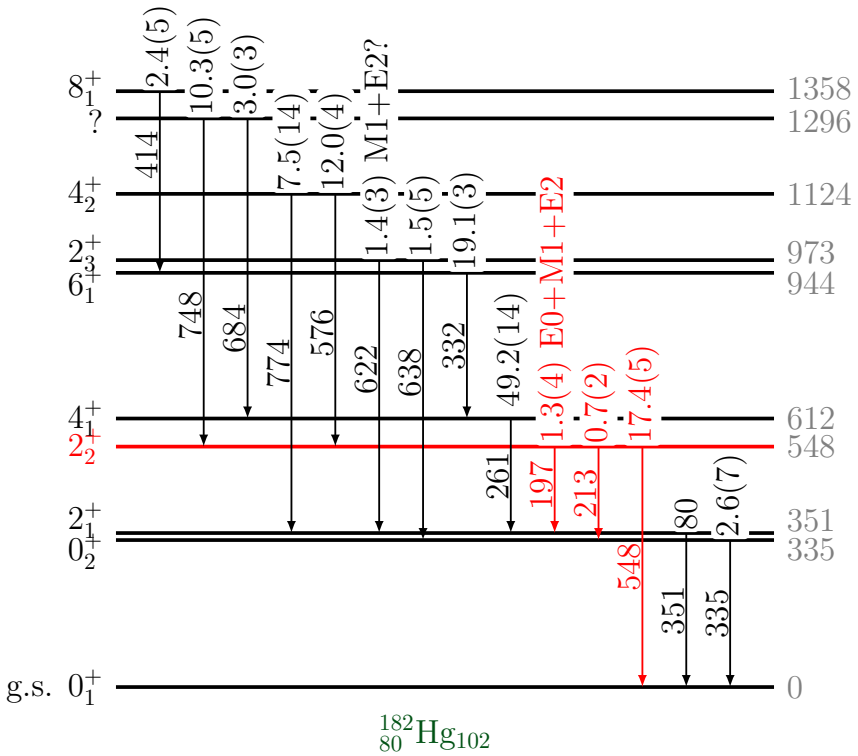

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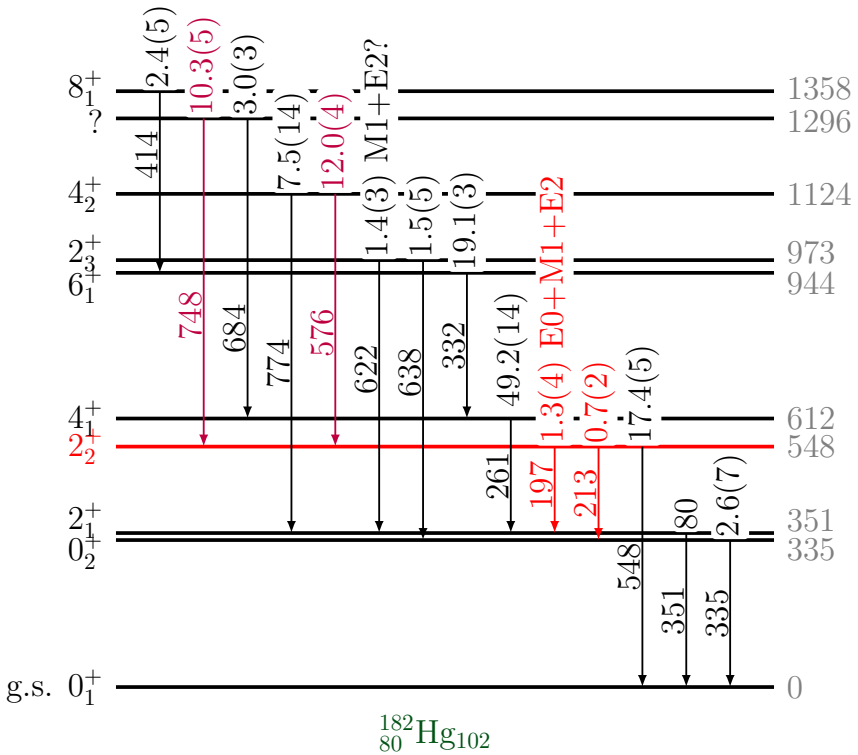

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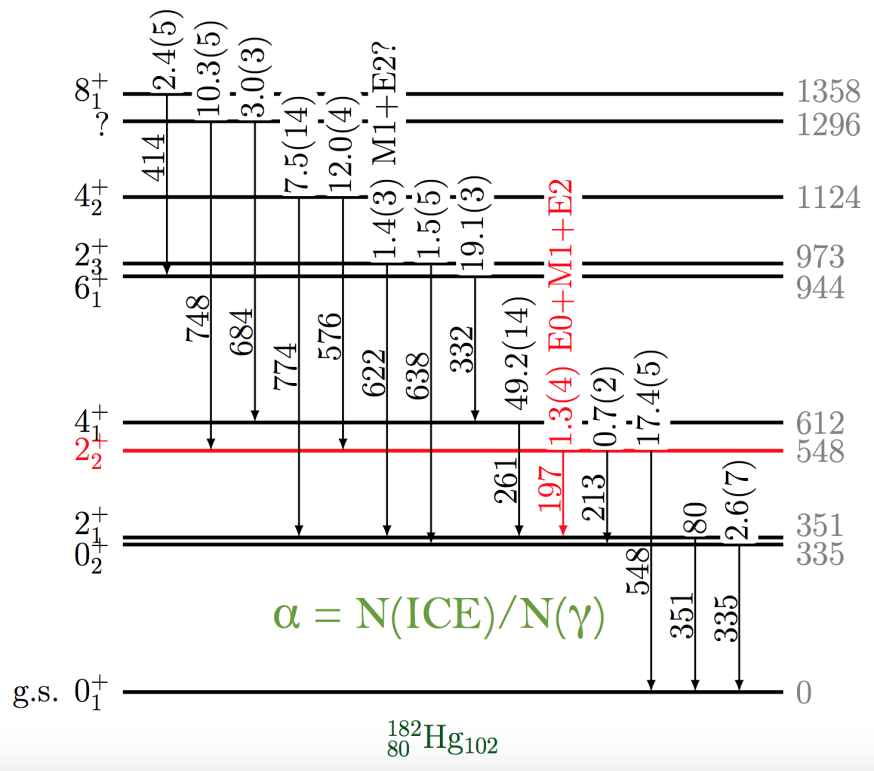

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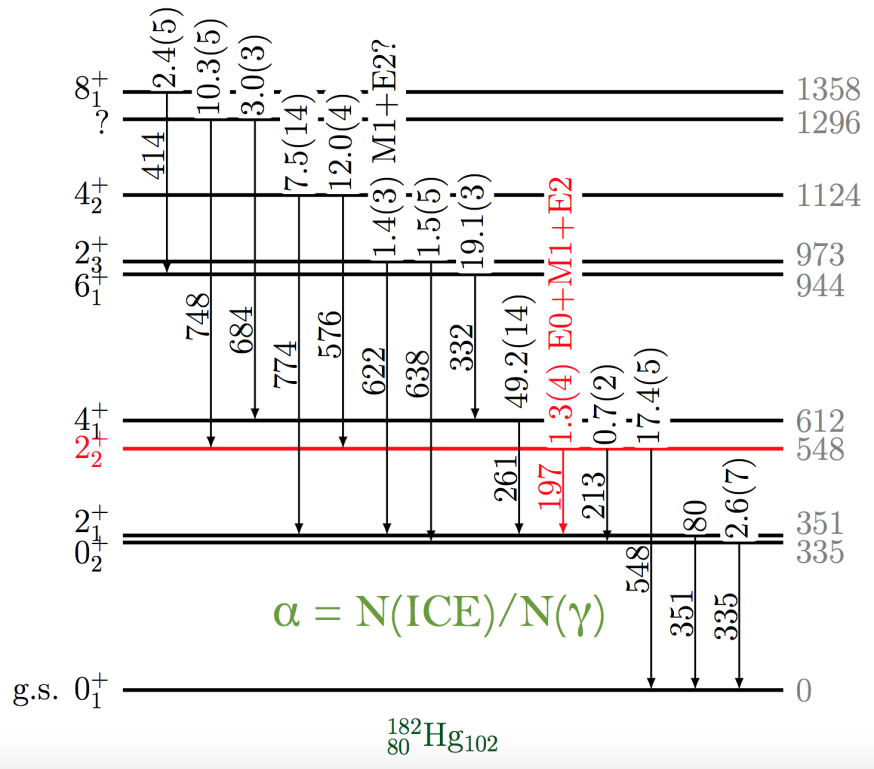

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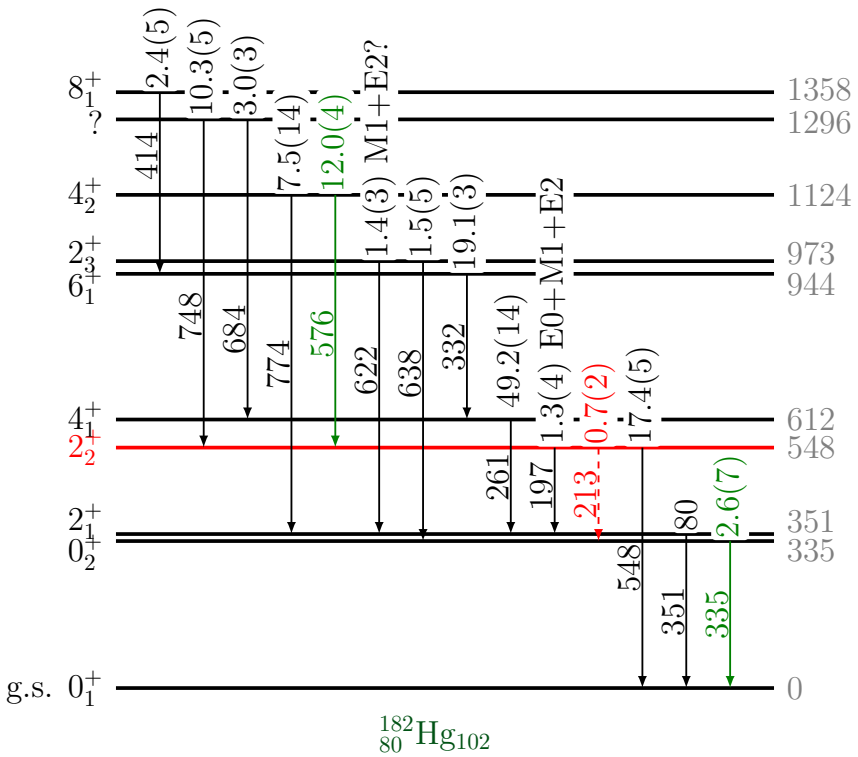

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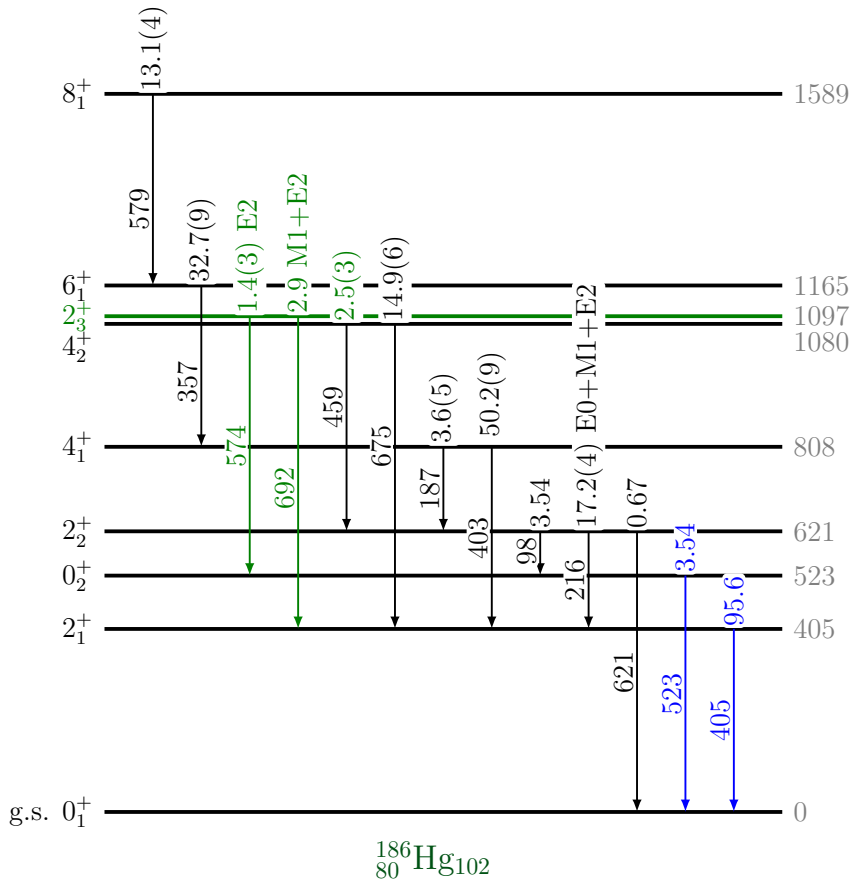
- ICC through the K-X-rays for cross-check
- 213 keV transition was not observed directly

2 – 2_3^+ supposed band-head of a γ-vibrational band

- Built on prolate-deformed states, enhanced B(E2) $\Rightarrow$ **measure of deformation**
- This excited states will be populated with HIE-ISOLDE
- Decay pattern observed in ^{182}Hg, ^{184}Hg, ^{186}Hg: **$2_3^+ \rightarrow 2_1^+$ & $2_3^+ \rightarrow 0_2^+$**
- In ^{186}Hg the $2_3^+ \rightarrow 2_1^+$ is **mixed** $\delta(M1/E2) = 3.4^{+6.1}_{-1.8}$ [a]
- **no δ was measured for ^{182}Hg and ^{184}Hg**
- we will put stringent limits on the BR to the 2_2^+ and the g.s.



[a] J.P.Delaroche et al., Phys. Rev. C 50 (1994) 5

- ^{182}Tl: broad band laser mode;
- ^{184}Tl: narrow-band laser ionisation to **enhance** the relative **production of (2$^-$)** level by reducing the (10$^-$) production;
- ^{186}Tl: same as ^{184}Tl

$$SI : x_s(2^-) + y_s(7^+) + z_s(10^- \rightarrow 7^+)$$

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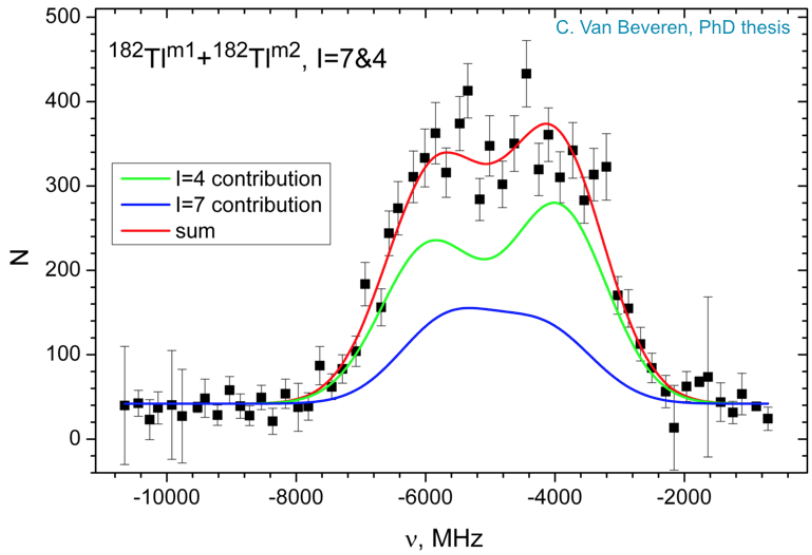

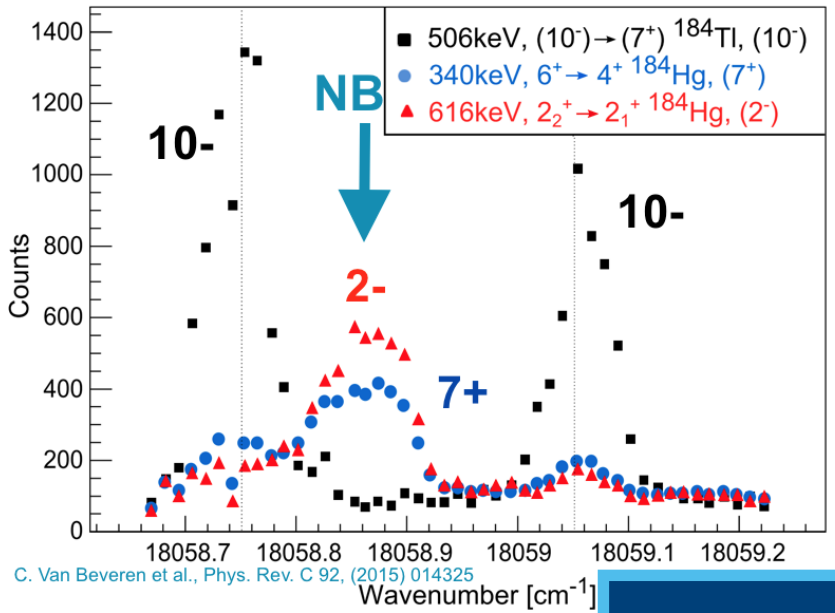

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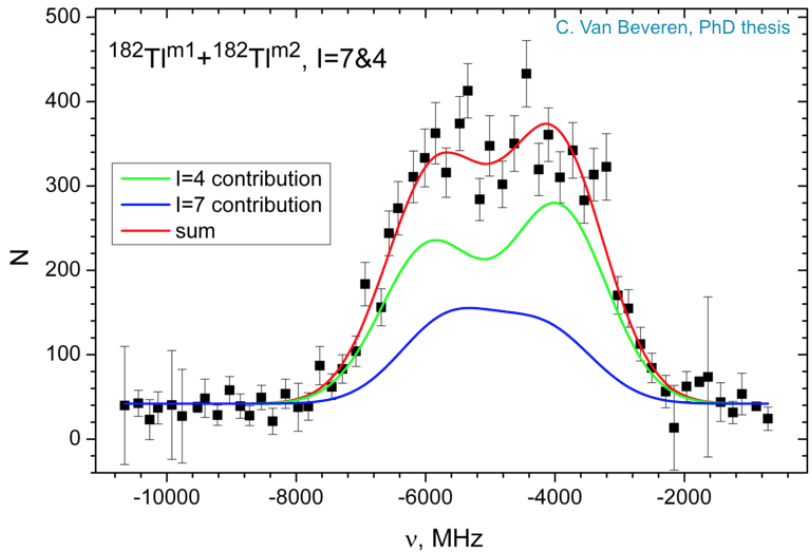

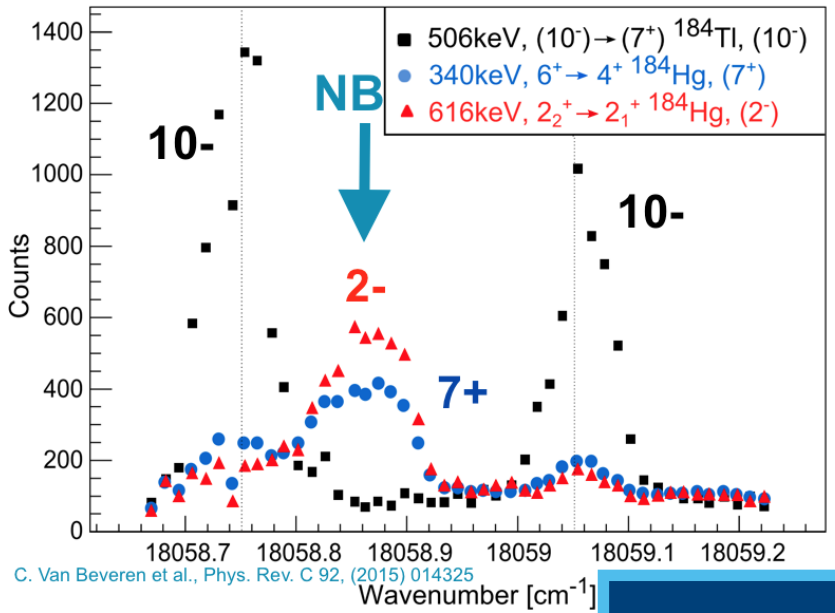

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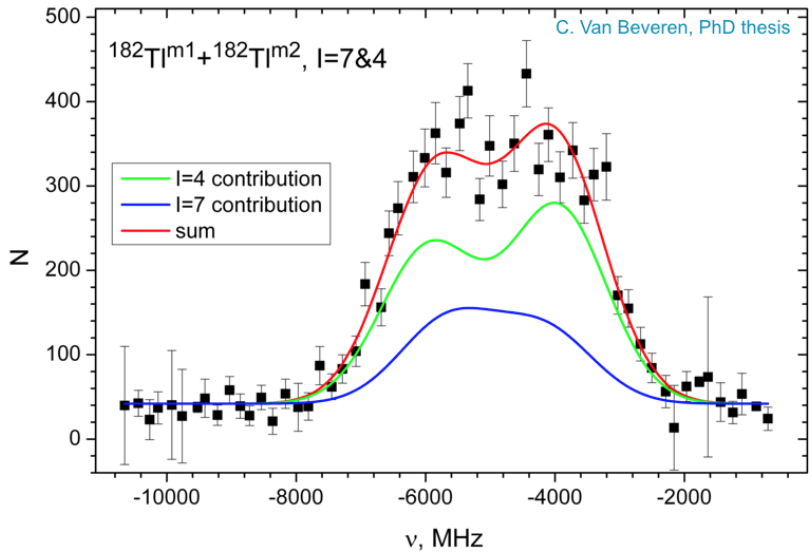
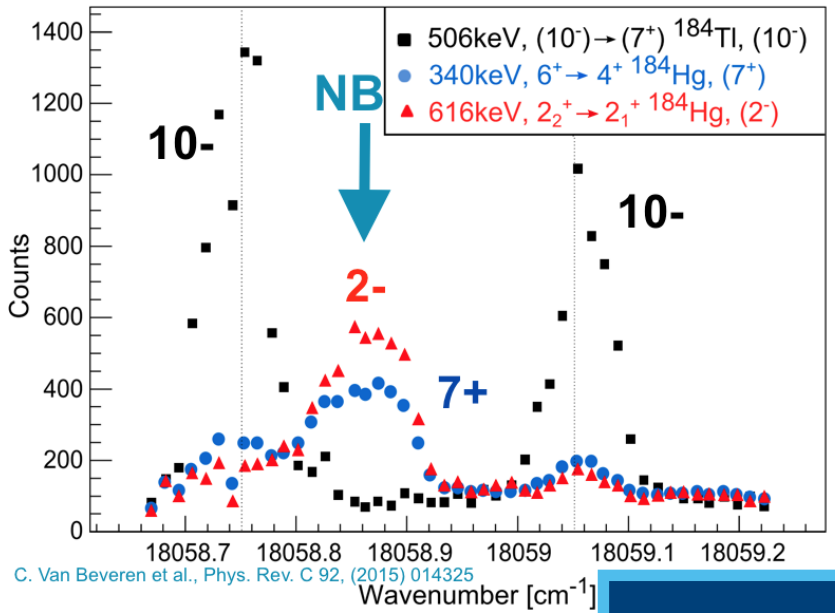
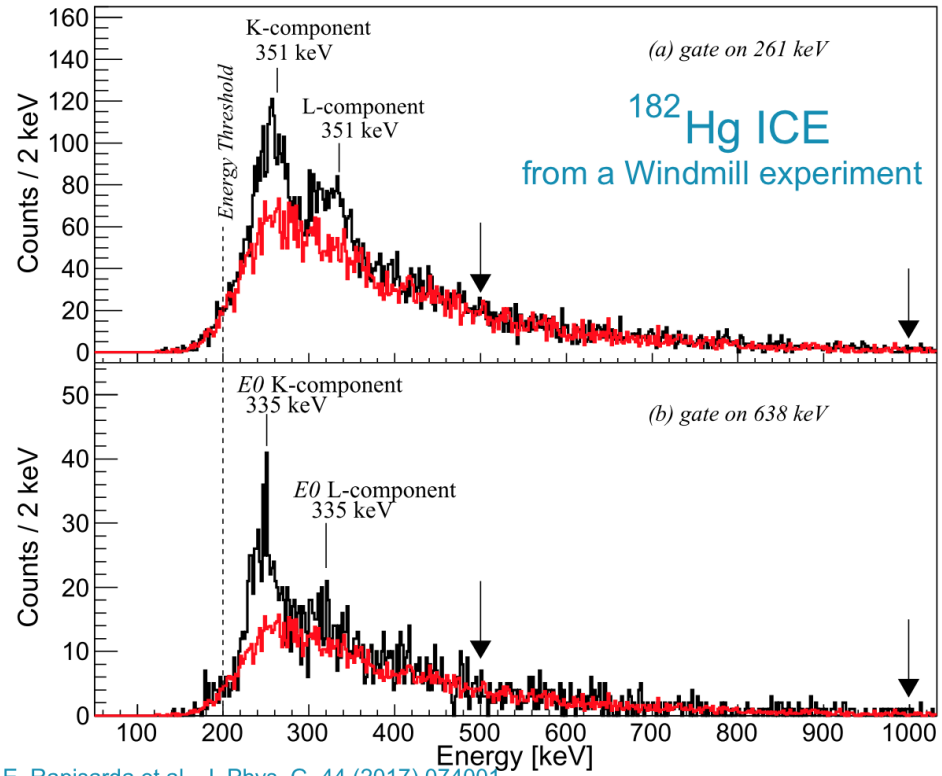
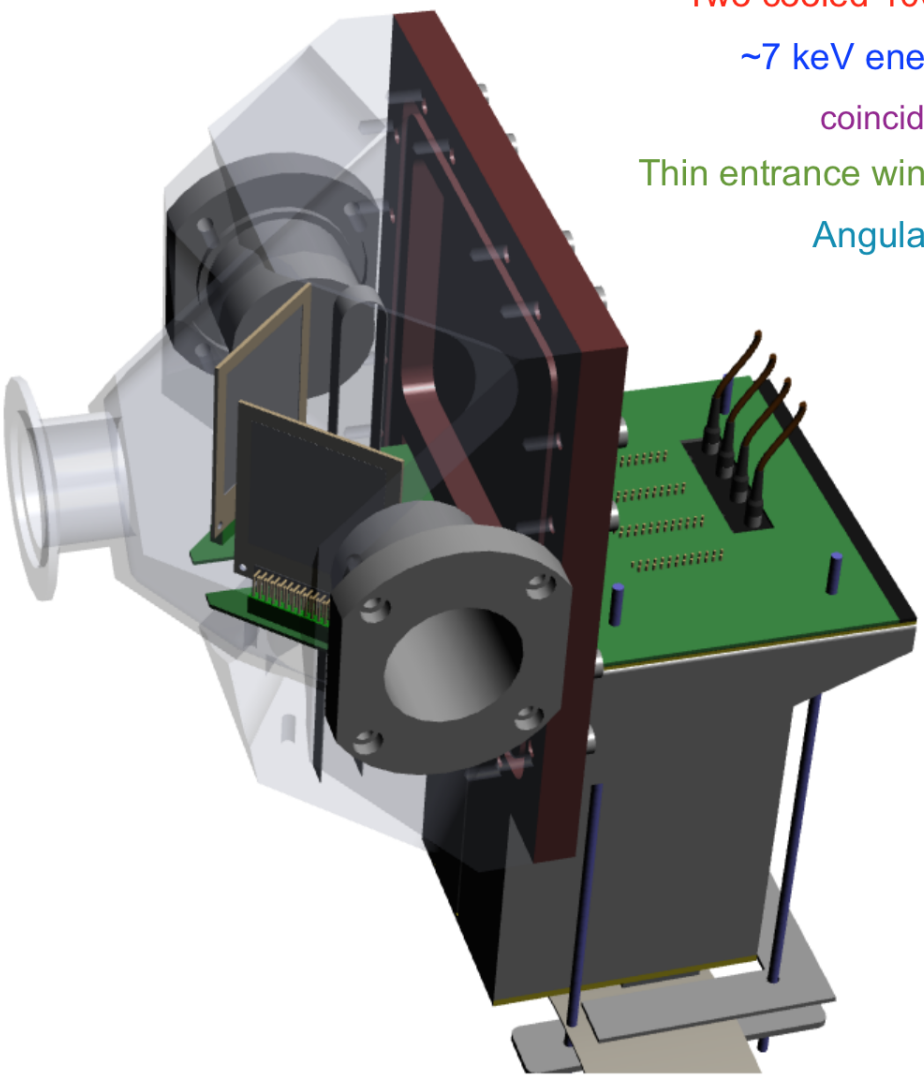




- β background under the lines of interest;
- low energy resolution;
- high energy thresholds;
- γ-ray summing:
  - efficiency reduced;
  - systematic uncertainties on the intensity determination



E. Rapisarda et al., J. Phys. G, 44 (2017) 074001



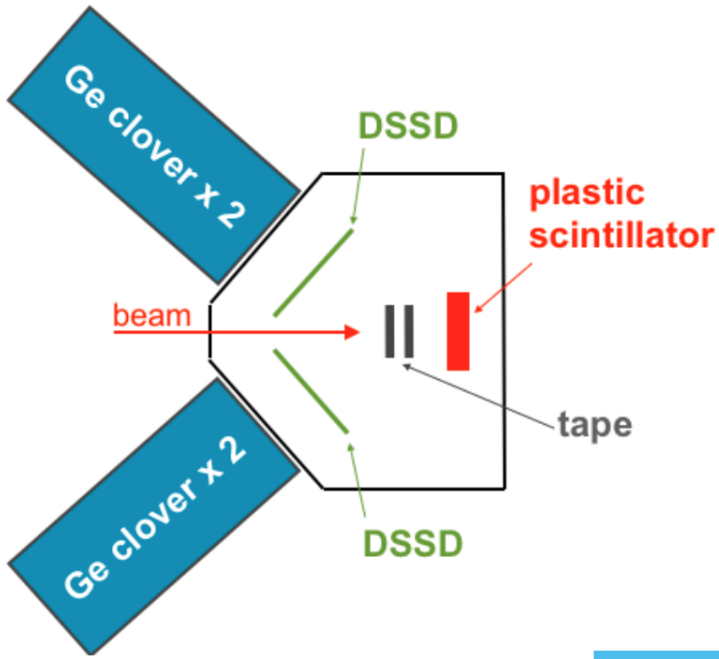
Two cooled 1000 um thick, 5x5 cm, 16x16 strips DSSDs to detect the ICE

~7 keV energy resolutions to distinguish between the ICE lines

coincidence with the plastic to reduce the β background

Thin entrance windows for the Ge detectors: high efficiency at low energy

Angular coverage: ~10% for DSSDs, ~30% for plastic
Ge efficiency: 7.5% @ 1 MeV



Isotope	Yield, ions/μC	BR$_{\beta^+/\mathrm{EC}}$	Rate at IDS, ions/s
^{182}Tl	$3.2{\cdot}10^4$	99.51%	$2.8{\cdot}10^4$
^{184}Tl	$1.7{\cdot}10^6$	98.78%	$1.5{\cdot}10^6$
^{186}Tl	$3.3{\cdot}10^7$	99.4%	$2.9{\cdot}10^{6\,*}$

In total we request **5 shifts**:
2.5 shifts for ^{182}Tl
1 shift ^{184}Tl
0.5 shift ^{186}Tl
1 shift for the beam tunning

UC$_x$ target, RILIS ion source

Latest IDS experiment (IS608):
transmission 30-70%
$\Rightarrow$ we take **50%** as a safe estimate

Thank you!