New observation of α decay of ^{190}Pt to the first excited level of ^{186}Os

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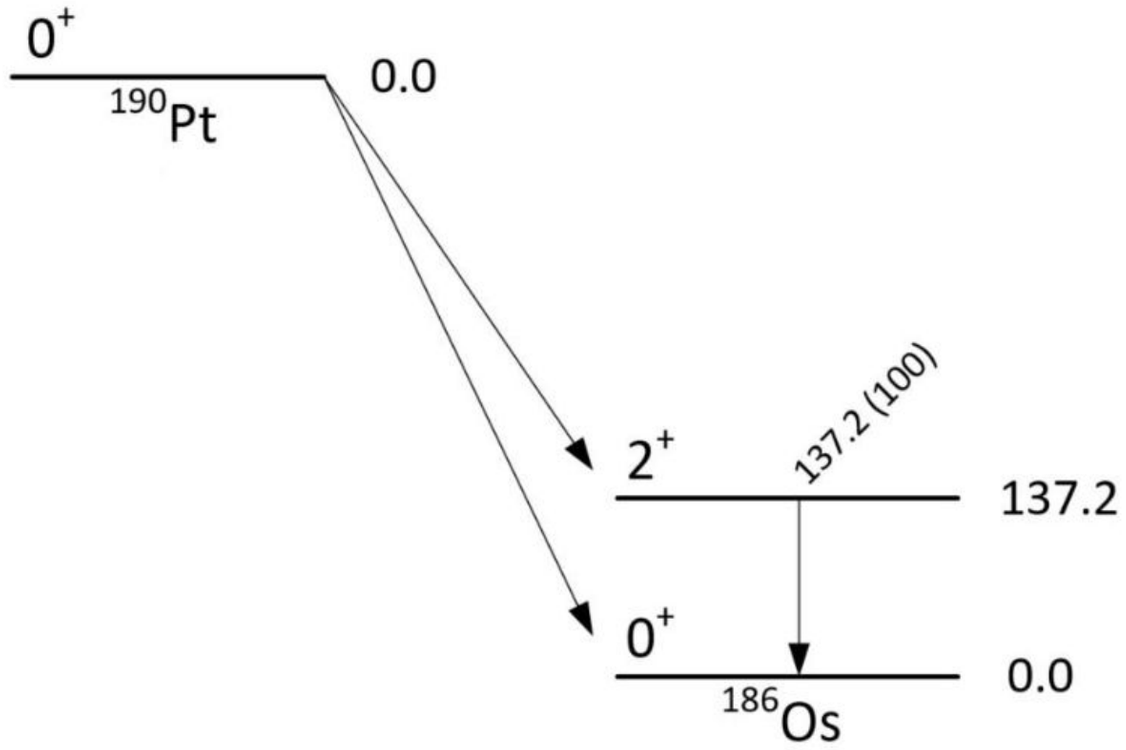
- In the investigation of long-living rare nuclear decays the improvements in the experimental techniques have led to the enhancement of sensitivity and to the discovery of new α decays that were never observed previously because of the extra-long half-lives of the decaying nuclides
- All the six naturally occurring isotopes of platinum are potentially unstable in relation to α decay
- ^{190}Pt is of particular interest with the biggest energy release of Q_α = 3268.6(6) keV

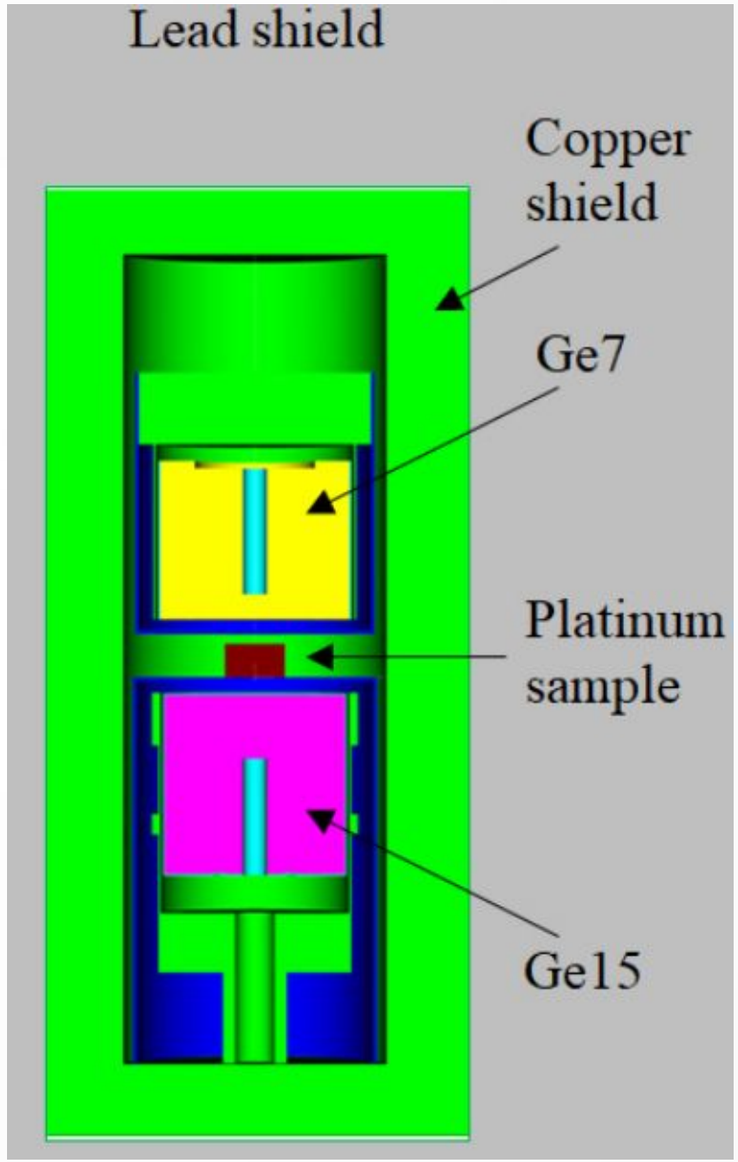
(M. Wang et al., CPC 45(2021)030003)

$$T_{1/2}[^{190}\mathrm{Pt} \rightarrow {}^{186}\mathrm{Os}(2_1^+, 137.2\ \mathrm{keV})] = 2.6^{+0.4}_{-0.3}(\mathrm{stat.}) \times 10^{14}$$

P. Belli et al., Phys. Rev. C 83 (2011) 034603



Experimental ultralow-background set-up with two HPGe detectors and a platinum sample



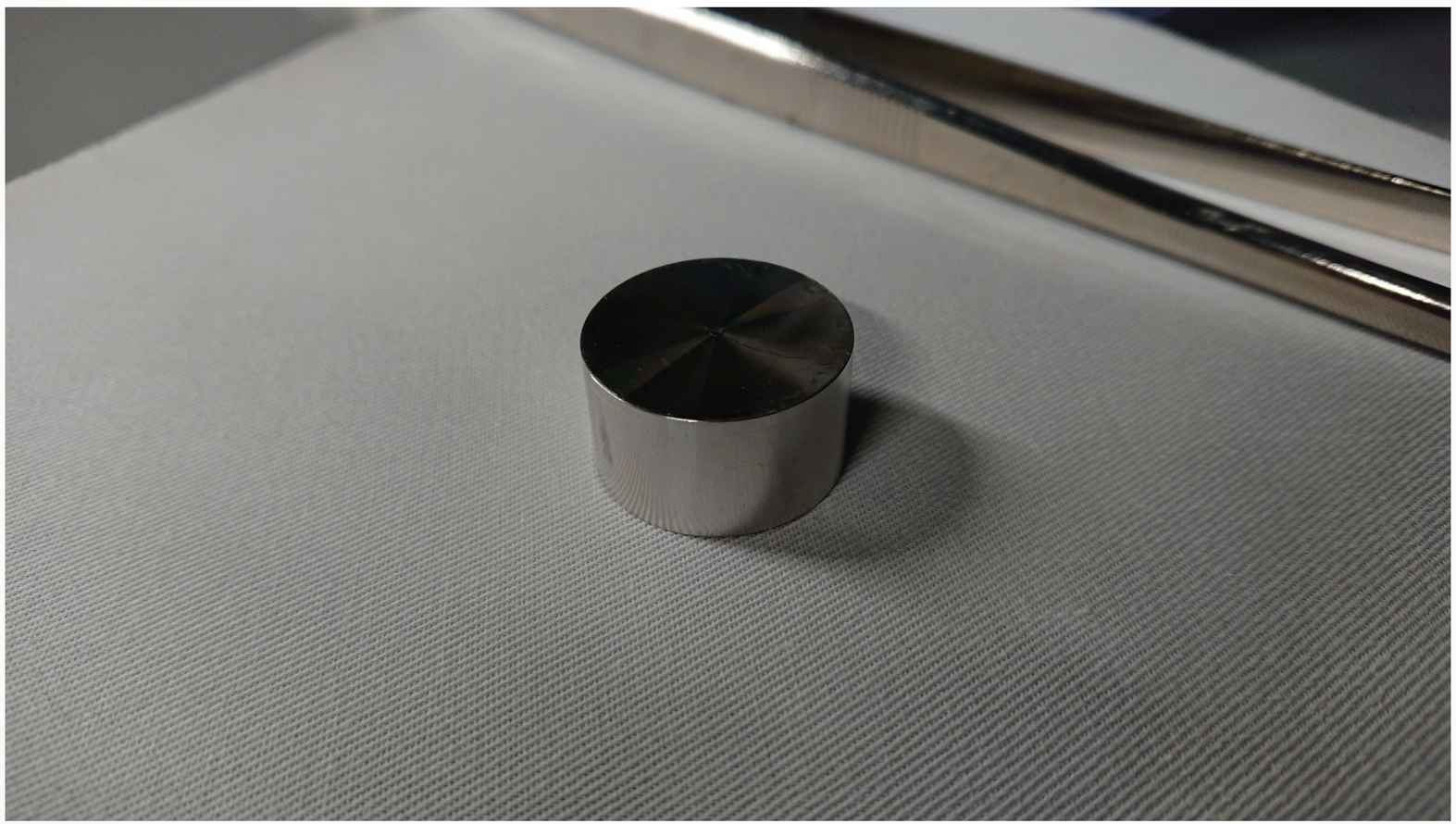
Properties of the HPGe-detectors

FWHM denotes the full width at half of maximum of γ-ray peak measured with a ^{60}Co gamma-ray source

	Ge7	Ge15
Energy resolution (FWHM) at 1333 keV	2.2 keV	1.8 keV
Relative efficiency	90%	85%
Crystal mass	1778 g	1840 g
Endcap / Window material	HPAl / HPAl	HPAl / HPAl
Dead layer (front)	0.3 μm	0.3 μm

HPAl = High Purity Aluminum

Platinum sample



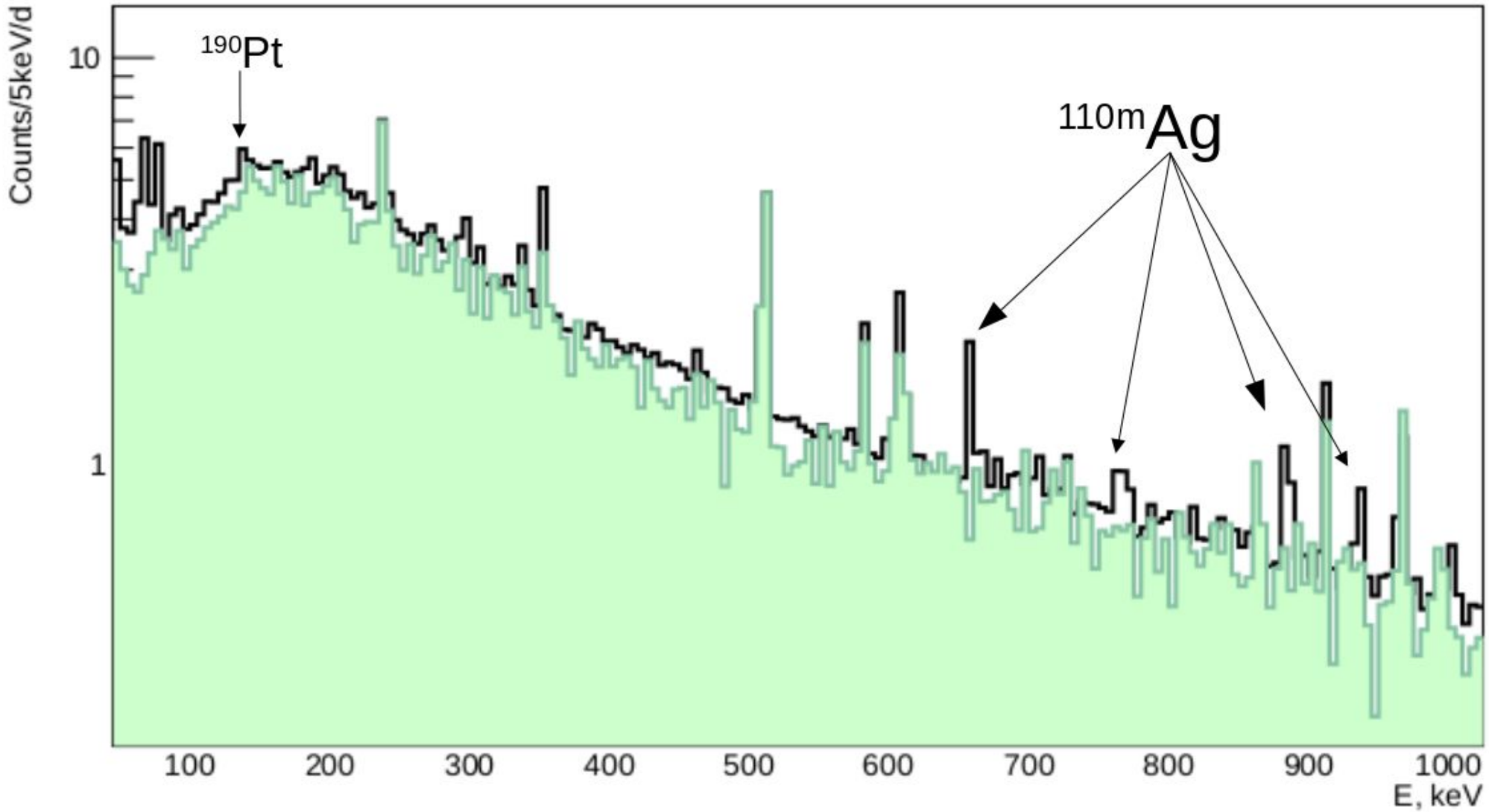
diameter 25.04(1) mm, thickness 14.07(2) mm, mass 148.122(1) g,
purity grade is 99.95%

Isotopic composition (δ) of the platinum in the sample

Isotope	δ (%) IUPAC [1]	δ (%) this work	Number of nuclei in the sample
^{190}Pt	0.012(2)	0.0127(1)	$5.81(5) \times 10^{19}$
^{192}Pt	0.782(24)	0.7759(16)	$3.548(7) \times 10^{21}$
^{194}Pt	32.864(410)	32.6511(522)	$1.4929(24) \times 10^{23}$
^{195}Pt	33.775(240)	33.6884(526)	$1.5403(24) \times 10^{23}$
^{196}Pt	25.211(340)	25.5376(419)	$1.1677(19) \times 10^{23}$
^{198}Pt	7.356(130)	7.3343(115)	$3.353(5) \times 10^{22}$

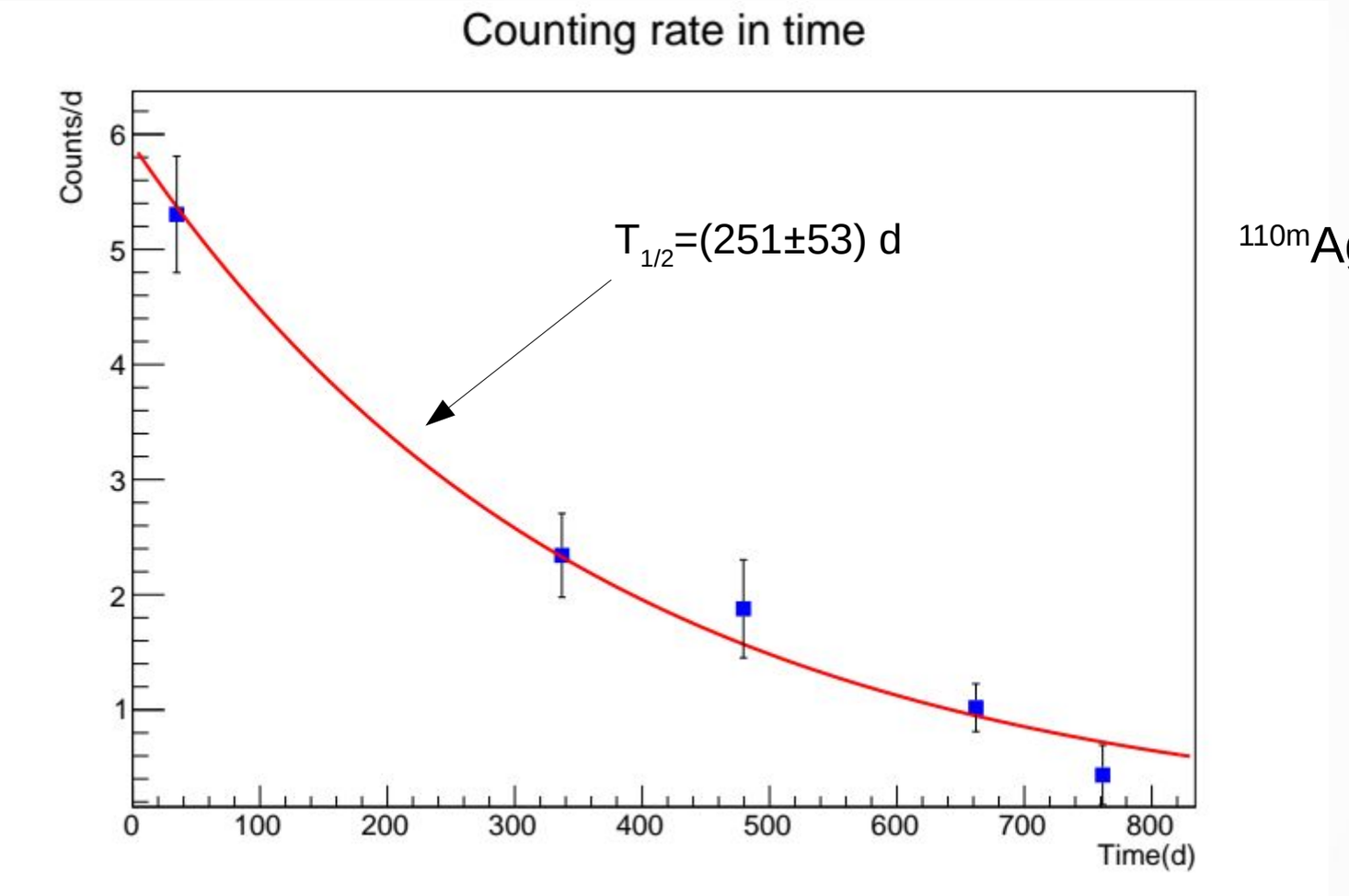
Pt isotopic measurements were acquired using a sector field Inductively coupled plasma mass spectrometer (ICP-MS) ELEMENT XR (Thermo Scientific) at the John de Laeter Centre for Isotope Research, Curtin University (Australia)

[1] J. Meija et al.,Pure Appl. Chem. 88 (2016) 293



Energy spectra in the energy intervals 50 − 1000 keV measured with the platinum sample over 373 d (black line) and without sample over 28 d (filled green) both normalized to time (d)

Behaviour in time of the counting rate in the 657.8 keV *y* peak of ^{110m}Ag



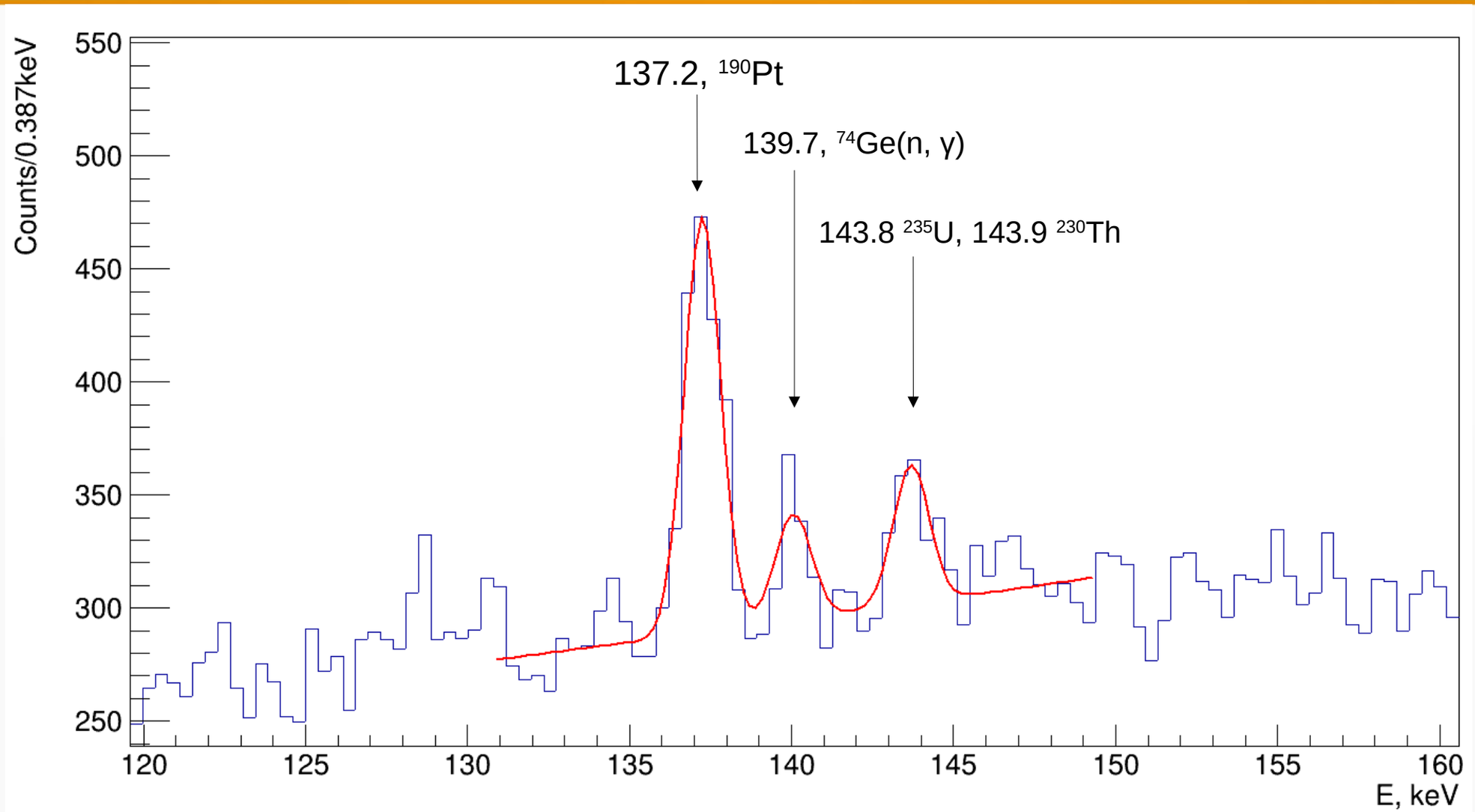
^{110m}Ag: $T_{1/2}$=249.950(24) d

Meija, Juris; et al. (2016)

The massic activities of the detected radionuclides. The upper limits are given at 90% confidence level (C.L.), the reported uncertainties are the combined standard uncertainties. The reference date is the start of the measurement (February 6th, 2018)

Chain	Nuclide	Massic activity (mBq/kg)
	^{22}Na	≤ 0.5
	^{26}Al	≤ 0.6
	^{40}K	≤ 13
	^{54}Mn	≤ 0.9
	^{60}Co	≤ 0.8
	^{137}Cs	≤ 0.4
	^{110m}Ag	9.2 ± 0.4
^{232}Th	^{228}Ra	≤ 5.7
	^{228}Th	10.8 ± 1.3
^{235}U	^{235}U	≤ 16
	^{231}Pa	≤ 81
^{238}U	^{234}Th	247 ± 134
	^{234m}Pa	≤ 89
	^{226}Ra	6.8 ± 0.9
	^{210}Pb	2600 ± 570

The partial half-life of ^{190}Pt for the alpha decay to the first excited level of ^{186}Os



Energy spectra measured with the 148.122 g platinum sample over 8946 hours around the 137-keV region

The partial half-life of ^{190}Pt for the alpha decay to the first excited level of ^{186}Os

$$T_{1/2}[^{190}\mathrm{Pt} \rightarrow {}^{186}\mathrm{Os}(2_1^+, 137.2\,\mathrm{keV})] = \frac{\ln 2 N_{190} \varepsilon t}{S(1+\alpha)},$$

N_{190} = 5.81(5)×10^{19},

S = 666 ± 51,

α =1.29, (C.M. Baglin, Nucl. Data Sheets 99 (2003) 1)

t = 373 d

Preliminary result, the data analysis is in progress:

$$T_{1/2} = \left(2.28^{+0.19}_{-0.16}\right) \times 10^{14}\ yr$$

$$T_{1/2} = \left[2.28^{+0.19}_{-0.16}\,(stat.) \pm 0.09\,(syst.)\right] \times 10^{14}\ yr$$

in agreement with the data of two previous measurements:

$$T_{1/2} = \left[2.6^{+0.4}_{-0.3}\,(stat.) \pm 0.6\,(syst.)\right] \times 10^{14}\ yr$$ P. Belli et al., PRC 83(2011)034603;

$$T_{1/2} = \left[2.59 \pm 0.04\,(stat.) \pm 0.24\,(syst.)\right] \times 10^{14}\ yr$$ S. Nagorny et al., JINST 16(2021)P03027

Summary and conclusions

- The partial half-life of ^{190}Pt for the alpha decay to the first excited level (E_{exc} = 137.2 keV) of ^{186}Os was measured using an ultralow-background HPGe-detector system located 225 m underground in the HADES underground laboratory (Belgium)
- A sample of high purity platinum (the purity grade is 99.95%) with a mass of 148.122 g was used and measured during 373 days
- The istopic composition of the Pt sample was measured using a sector field Inductively coupled plasma mass spectrometer (ICP-MS) ELEMENT XR (Thermo Scientific) at the John de Laeter Centre for Isotope Research, Curtin University (Australia). The measurements allowed to reduce the uncertainty of 190Pt nucley by 20 times
- Preliminary, the partial half-life of ^{190}Pt is estimated as

$$T_{1/2} = \left[2.28^{+0.19}_{-0.16} (stat.) \pm 0.09 (syst.) \right] \times 10^{14}\, yr$$

Acknowledgments

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BACKUP

Systematic uncertainties

3.3 % registration efficiency
0.9 % number of the ^{190}Pt nuclei
1.9 % approximation interval

Summed in quadrature
3.9 %

$$T_{1/2}[\rightarrow] = \left[2.3^{+0.19}_{-0.16}(stat.) \pm 0.09(syst.)\right] \times 10^{14}\, yr$$

The energy dependence of the energy resolution in the sum energy spectrum measured with the Pt sample by the detectors Ge7 and Ge15

$$\mathrm{FWHM(keV)} = 1.08(12) + 0.020(8)\sqrt{E_\gamma}$$

for the low energy region (65−352 keV)

$$\mathrm{FWHM(keV)} = 0.55(8) + 0.049(4)\sqrt{E_\gamma}$$

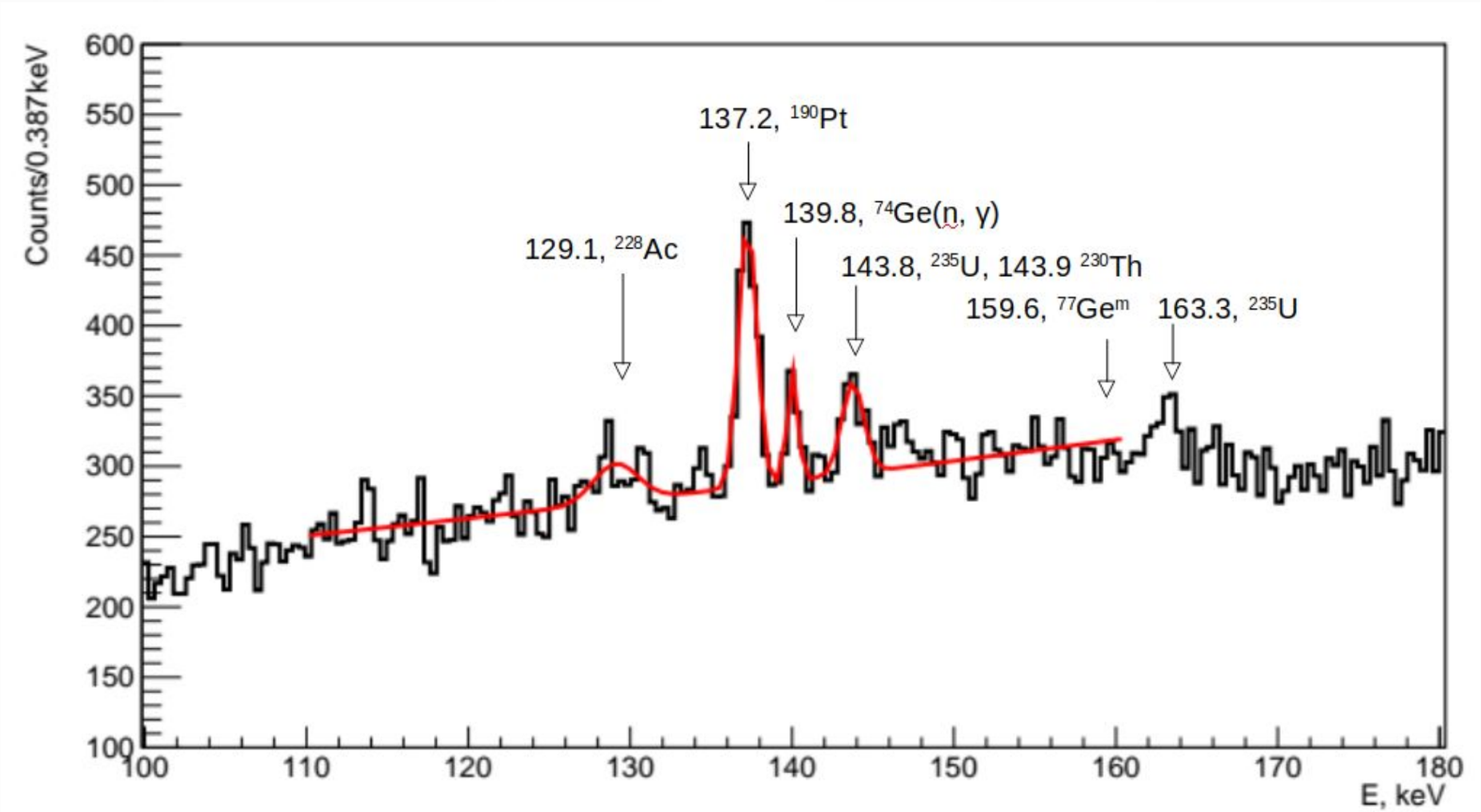
for the energies above 352 keV

$$A = (S_{sample}/t_{sample} - S_{bg}/t_{bg})/(\epsilon \cdot \eta \cdot m)$$

massic activity,

where ϵ is the γ-ray emission intensity of the corresponding transition; η is the full energy peak efficiency; m is the sample mass

The partial half-life of ^{190}Pt for the alpha decay to the first excited level of ^{186}Os



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