^{193}Pt Electron Capture Spectra with Microcalorimeters

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Context

Neutrino mass measurements using calorimetry require:

- High resolution
- Lots of counts!
- Well-understood theory

Why study ^{193}Pt?

- Minimal sample preparation or deposition
- Nearly perfect absorber—entire absorber is single element aside from impurities
- Independent check on the theoretical calculations

Irradiation

A 10 mg sample of ^{192}Pt-enriched Pt was irradiated for approximately 7 days with a predicted production of 2.8 Bq of ^{193}Pt per µg of platinum.

Figure 1. The ^{192}Pt-enriched Pt foil (left), placed within a polyethylene tube (upper right), was irradiated at the MIT reactor (lower right), exposing it to a high thermal flux to create ^{193}Pt.

Theoretical Spectrum

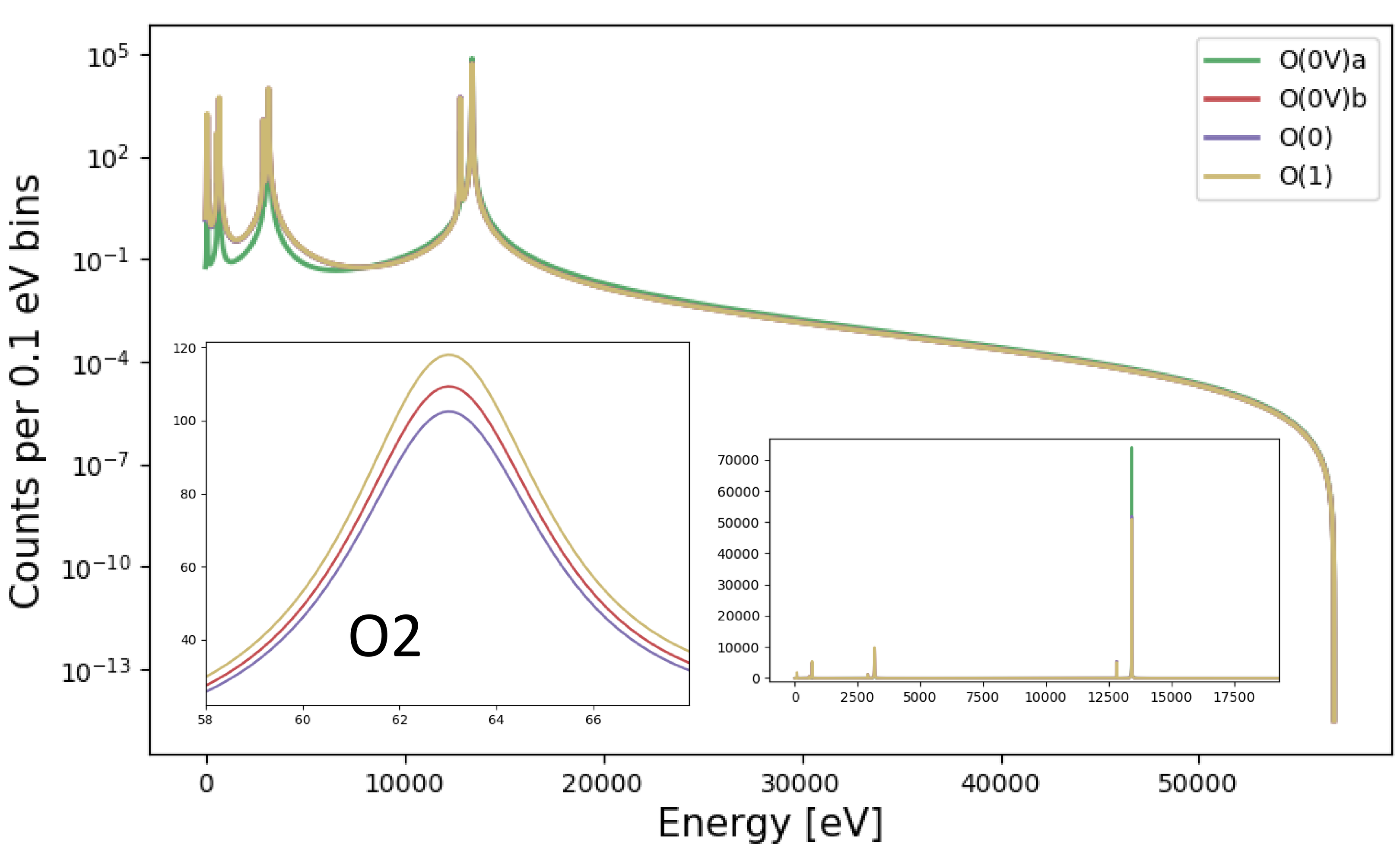


Figure 3. A ^{193}Pt 1-hole spectrum with 10^7 counts, showing varying levels of fidelity in the atomic overlap calculation. Left inset shows model dependencies of peak heights. Right inset shows spectrum in linear scale.

The theoretical spectrum for ^{193}Pt has never before been published. The spectrum shown above in Figure 3 shows the differences in a single-hole spectrum with varying levels of fidelity in the atomic overlap calculation. The wavefunctions used to the build the spectra are calculated with DFS atomic structure codes.

Model details:

- O(N) indicates N orbital overlap factors with unmatched quantum numbers
- V indicates Vatai approximation for the atomic overlap
- a indicates wavefunction evaluated at r = 0 au
- b indicates wavefunction evaluated at r = 1.365×10^{-4} au

Gamma Spectroscopy

HPGe spectra were used to identify isotopes created within the foil and their activities. The activity of the sample as of 4 July 2017 is dominated by ^{192}Ir (18.6 Bq/µg). Its short half life (74 days) means that in a year this impurity will decay to a more favourable 0.7 Bq/µg, the same activity as ^{193}Pt.

*Activity inferred, rather than measured directly

Isotope	Activity [Bq/10mg]
^{192}Ir	186000
^{193}Pt*	7460
^{46}Sc	897
^{192m2}Ir*	864
^{51}Cr	577
^{182}Ta	77.8
^{65}Zn	23.6
^{60}Co	22.5

Table 1. Activities as of 4 July 2017.

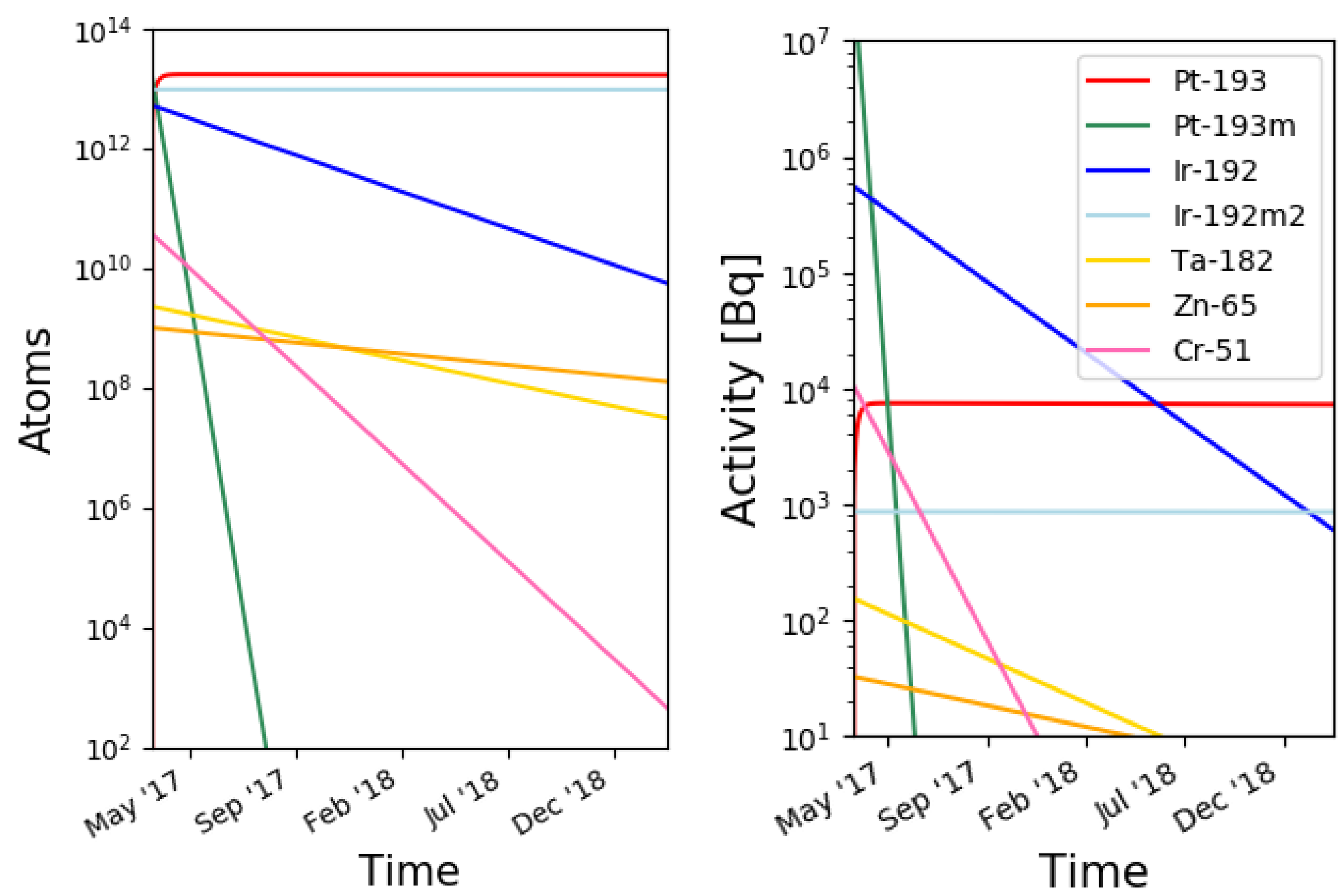


Figure 2. The isotopes present in the platinum foil as determined through gamma spectroscopy. The total number of Pt atoms is ~10^{19}. By July 2018, ^{193}Pt will be the most active isotope in the sample.

Experimental Calorimetric Spectrum

A small piece (≈0.04 µg) was cut from the irradiated foil and incorporated into a microcalorimeter detector. Shown in Figure 4 is the first experimental calorimetric electron capture spectrum of ^{193}Pt.

TES details:

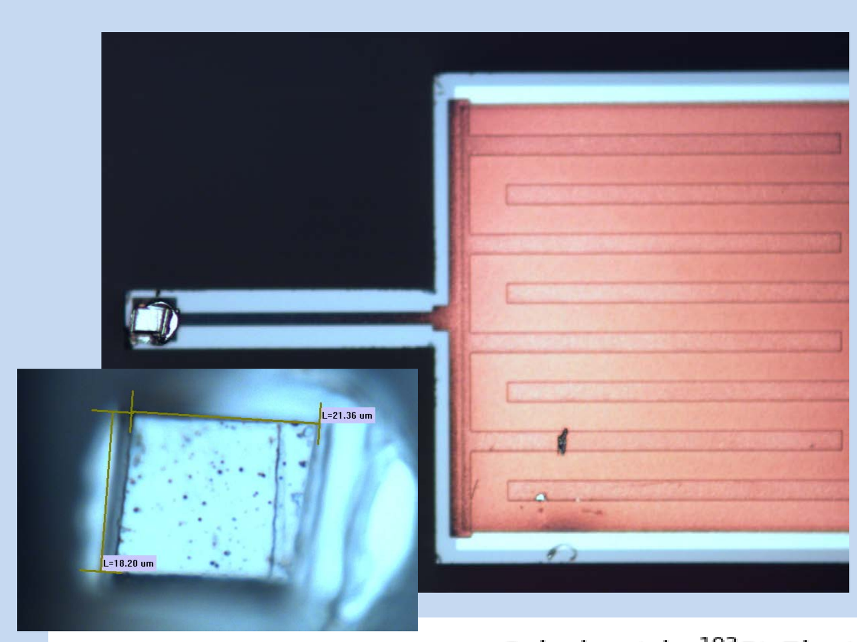
- 350 µm square Mo-Cu bilayer
- Transition temperature near 110 mK

Further analysis:

- External energy calibration
- Identify unknown peaks
- Quantify activity of ^{193}Pt
- Direct comparisons with theory

Observations:

- Observed electron capture lines for ^{192}Ir and ^{193}Pt
- Unknown peaks between M- and L-clusters
- Comparable electron capture rates for ^{192}Ir and ^{193}Pt



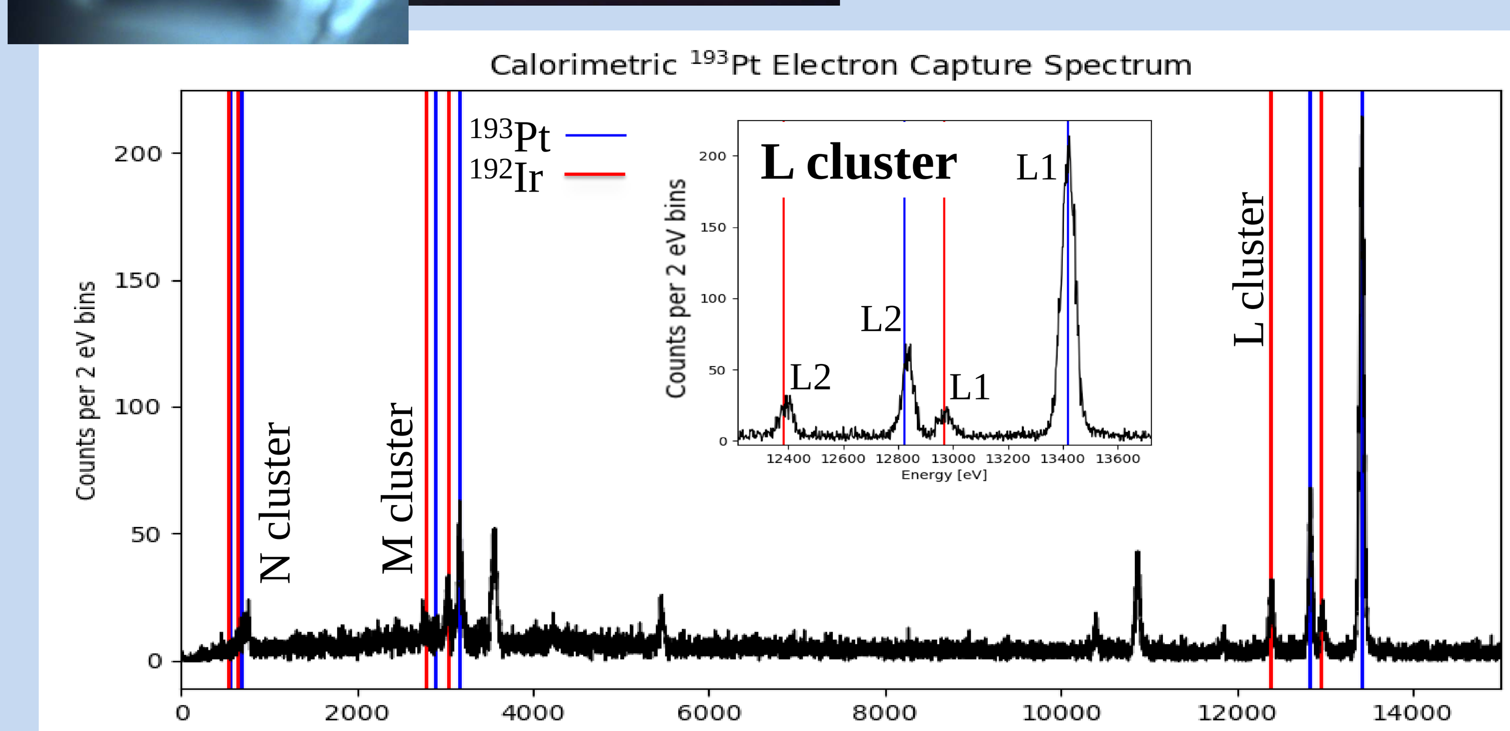


Figure 4. (Top) A small piece was cut from the irradiated foil and attached to a TES. (Bottom) Preliminary calorimetric measurement of platinum foil. Electron capture peaks from ^{193}Pt and ^{192}Ir are visible. Some peaks are yet to be identified.