A Further Measurement to Test Electron Conversion Theory: ^{116}In Measurement for Detector Calibration

By Sondra N. Miller

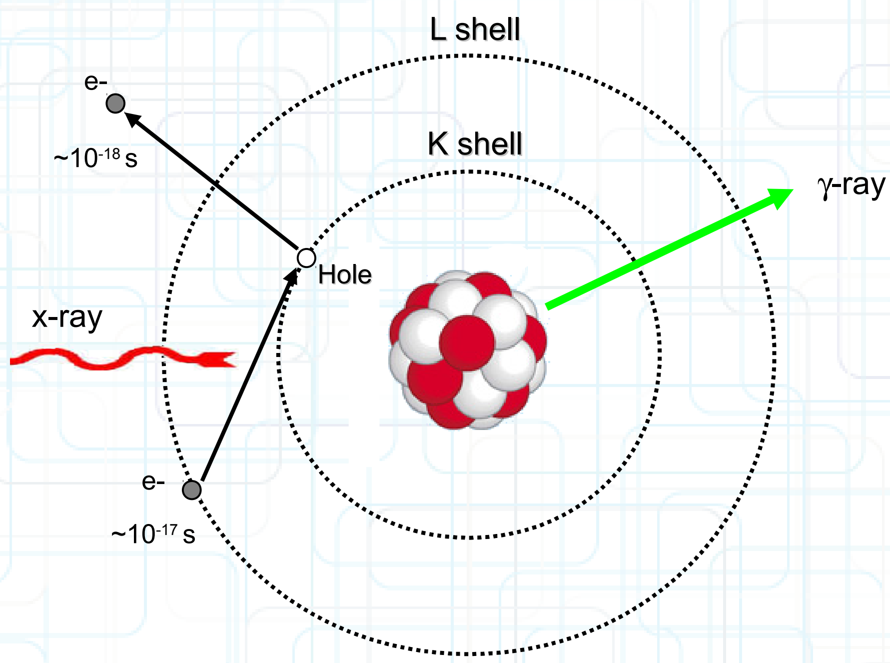
Cyclotron Institute
Texas A&M University

Overview

- Internal Conversion
- ^{119m}Sn Measurement
- Purpose of measuring ^{116}In
- Data Collection
- Spectral analysis
- Preliminary Results
- Conclusion
- Acknowledgements

Internal Conversion

- Nuclear transition
  - Competition between γ-ray emission or electron emission



Internal Conversion

- Internal Conversion Coefficient (ICC)
  - Number of electrons emitted : Number of γ-rays emitted
  - Can be expressed for each shell

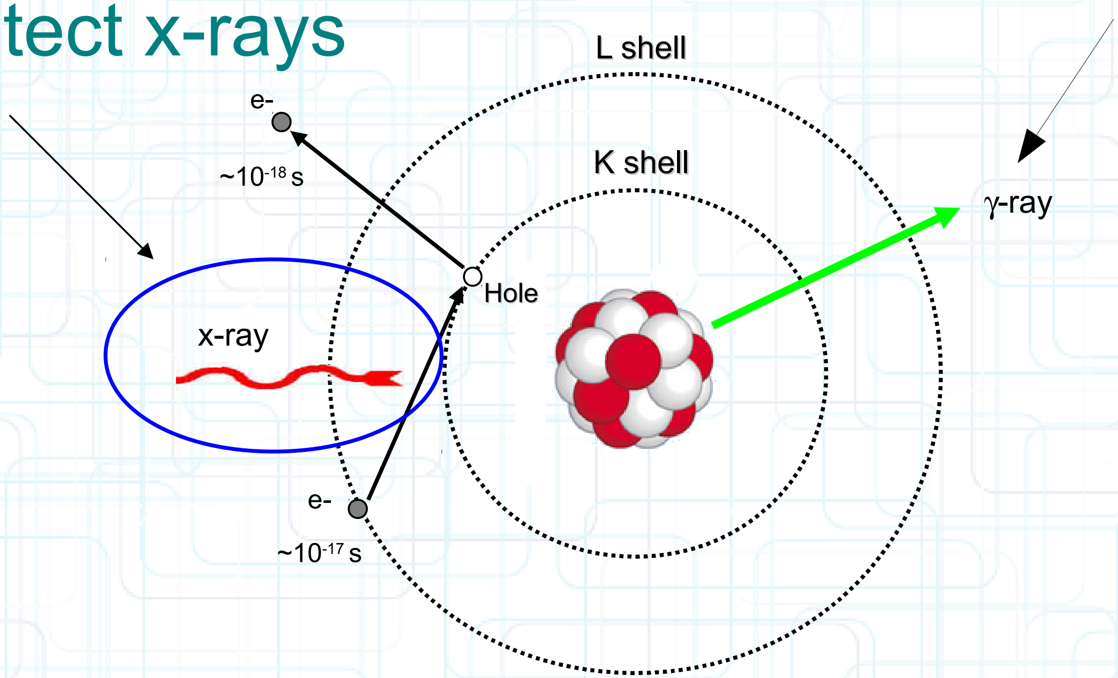
$$\alpha = \frac{N_{electrons}}{I_{\gamma}}$$

$$\alpha = \sum_i \alpha_i = \alpha_K + \alpha_L + \alpha_M + \ldots$$

Internal Conversion

We detect x-rays

And γ rays



Internal Conversion

- Internal Conversion Coefficient (ICC)
  - Number of electrons ejected : Number of γ-rays emitted
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$$\alpha = \sum_i \alpha_i = \alpha_K + \alpha_L + \alpha_M + \ldots$$

  - Fluorescence yield
    - Relates number of x-rays emitted to number of electrons emitted

$$\alpha_K = \left(\frac{1}{\omega_K}\right)\left(\frac{I_{Kx}}{I_\gamma}\right)$$

Internal Conversion

- ICC crucial for nuclear decay schemes
  - Transition rates
  - Spin and parity designations
  - Branching Ratios
- Few available precise data
  - ~10 measurements available with error <1%
- Experimental data to test theoretical calculations
  - Determine valid ICC modeling method

Internal Conversion

- Two main theoretical models:
  - 1) Accounts for the hole left behind by the departing electron.
  - 2) Regards the hole left behind by the departing electron as negligible (filled quickly)

ICC of Interest

Decay of ^{119m}Sn

Te114 15.2 m 0+ EC	Te115 5.8 m 7/2+ * EC	Te116 2.49 h 0+ EC	Te117 62 m 1/2+ * EC	Te118 6.00 d 0+ EC	Te119 16.03 h 1/2+ * EC	Te120 0+ 0.096	Te121 16.78 d 1/2+ * EC	Te122 0+ 2.603	Te123 1E+13 y 1/2+ * EC 0.908	Te124 0+ 4.816	Te125 1/2+ * 7.139
Sb113 6.67 m 5/2+ EC	Sb114 3.49 m 3+ EC	Sb115 32.1 m 5/2+ EC	Sb116 15.8 m 3+ * EC	Sb117 2.80 h 5/2+ EC	Sb118 3.6 m 1+ * EC	Sb119 38.19 h 5/2+ * EC	Sb120 15.89 m 1+ * EC	Sb121 5/2+ 57.36	Sb122 2.7238 d 2- * EC,β-	Sb123 7/2+ 42.64	Sb124 60.20 d 3- * β-
Sn112 0+ 0.97	Sn113 115.09 d 1/2+ * EC	Sn114 0+ 0.65	Sn115 1/2+ 0.34	Sn116 0+ 14.53	Sn117 1/2+ * 7.68	Sn118 0+ 24.23	Sn119 1/2+ * 8.59	Sn120 0+ 32.59	Sn121 27.06 h 3/2+ * β-	Sn122 0+ 4.63	Sn123 129.2 d 11/2- * β-
In111 2.8047 d 9/2+ * EC	In112 14.97 m 1+ * EC,β-	In113 9/2+ * 4.3	In114 71.9 s 1+ * EC,β-	In115 4.41E+14 y 9/2+ * β- 95.7	In116 14.10 s 1+ * EC,β-	In117 43.2 m 9/2+ * β-	In118 5.0 s 1+ * β-	In119 2.4 m 9/2+ * β-	In120 3.08 s 1+ * β-	In121 23.1 s 9/2+ * β-	In122 1.5 s 1+ * β-
Cd110 0+ 12.49	Cd111 1/2+ * 12.80	Cd112 0+ 24.13	Cd113 9.3E+15 y 1/2+ * β- 12.22	Cd114 0+ 28.73	Cd115 53.46 h 1/2+ * β-	Cd116 0+ 7.49	Cd117 2.49 h 1/2+ * β-	Cd118 50.3 m 0+ β-	Cd119 2.69 m 3/2+ * β-	Cd120 50.80 s 0+ β-	Cd121 13.5 s (3/2+) * β-

ICC of Interest

$^{119m}_{50}\mathrm{Sn}_{69}$

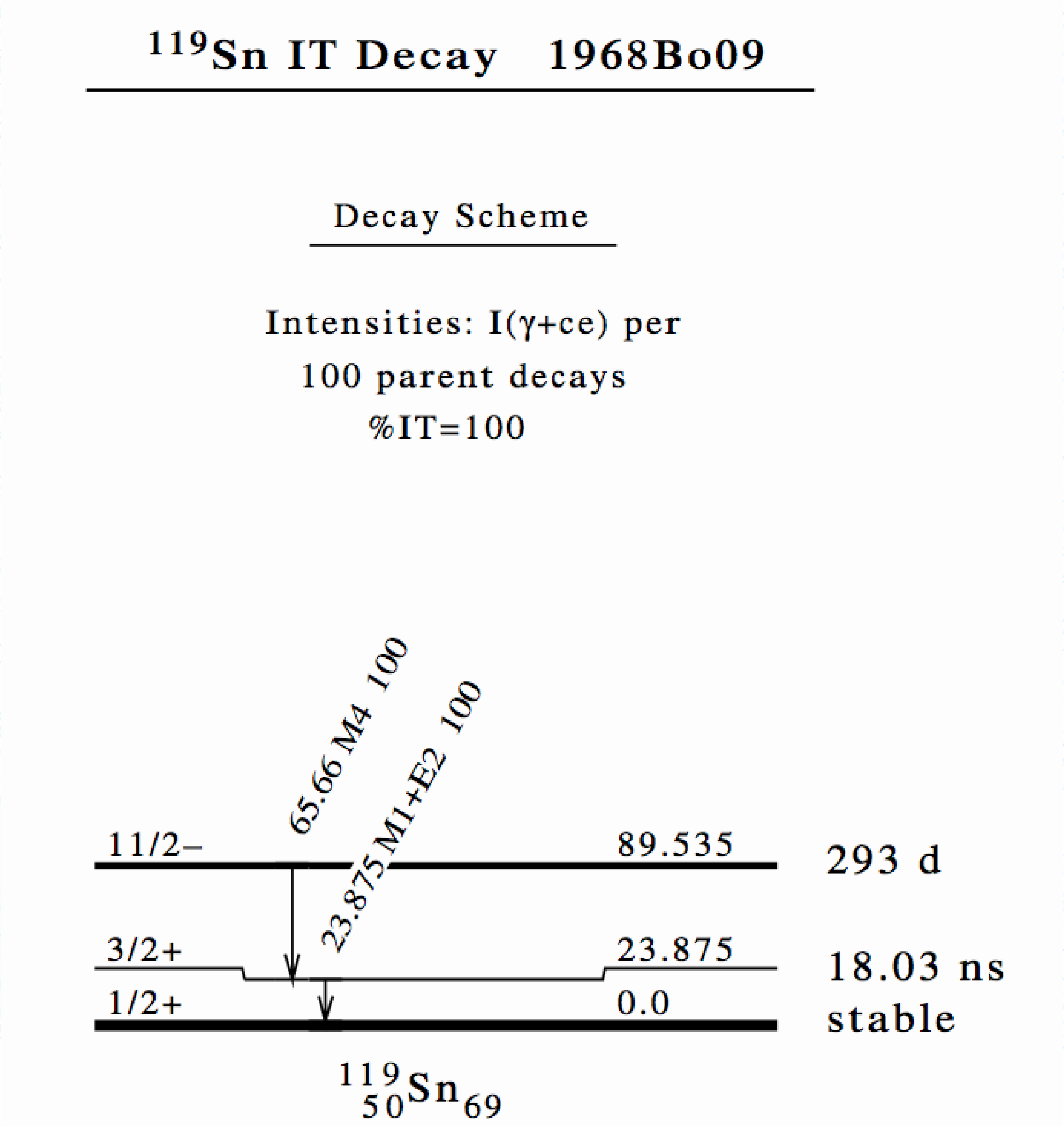
Half life:	293.1 d *7*
E(level):	89.531 *13* keV
Jp:	11/2-
S_n (keV):	6485.4 *14*
S_p (keV):	10126 *8*
Prod. mode:	Fast neutron activation Thermal neutron activation
ENSDF citation:	NDS 67,327 (1992)
Literature cut-off date:	1-May-1991
Author(s):	K. Kitao, M. Kanbe and K. Ogawa
References since cut-off:	^{119}Sn decay from 1991-98 (NSR)

Decay properties:

Mode	Branching (%)	Q-value (keV)	References
IT	100		68Bo09

Source: Lund/LBNL Nuclear Data Search; WWW Table of Radioactive Isotopes

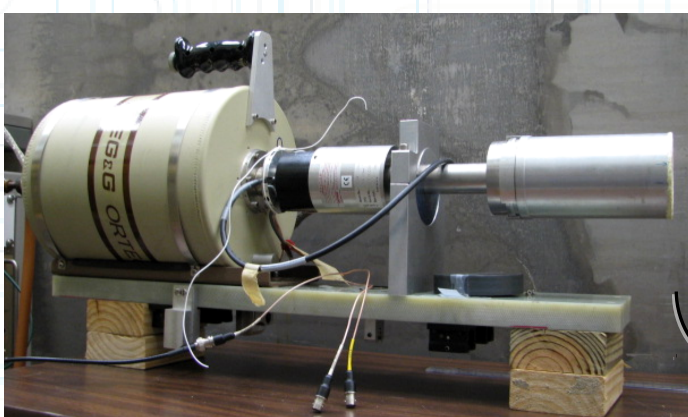
ICC of Interest

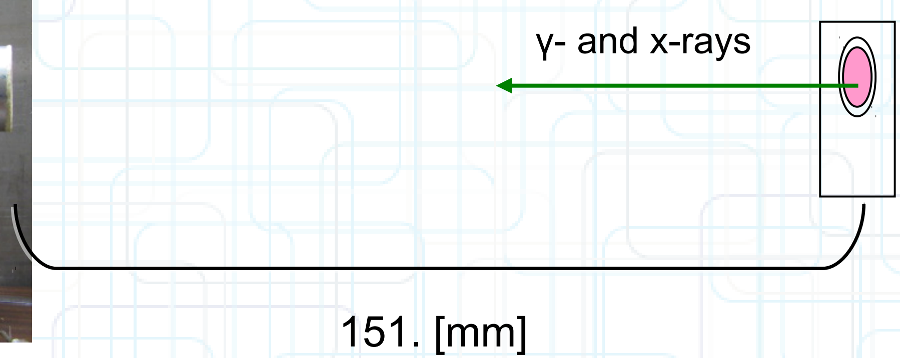


Source: National Nuclear Data Center; Evaluated Nuclear Structure Data File

Measuring ICC of Interest

- Hyper pure germanium detector, Cyclotron Institute, Texas A&M University
  - Relative photopeak efficiencies calibrated to 0.15% above 50 [keV] at 151.[mm]

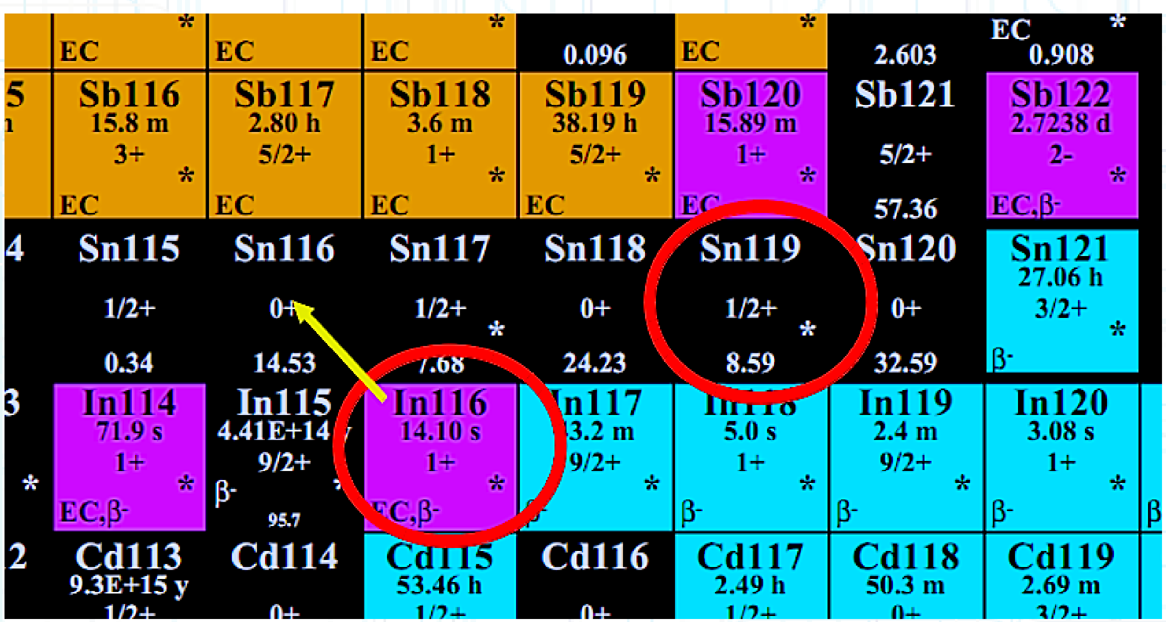




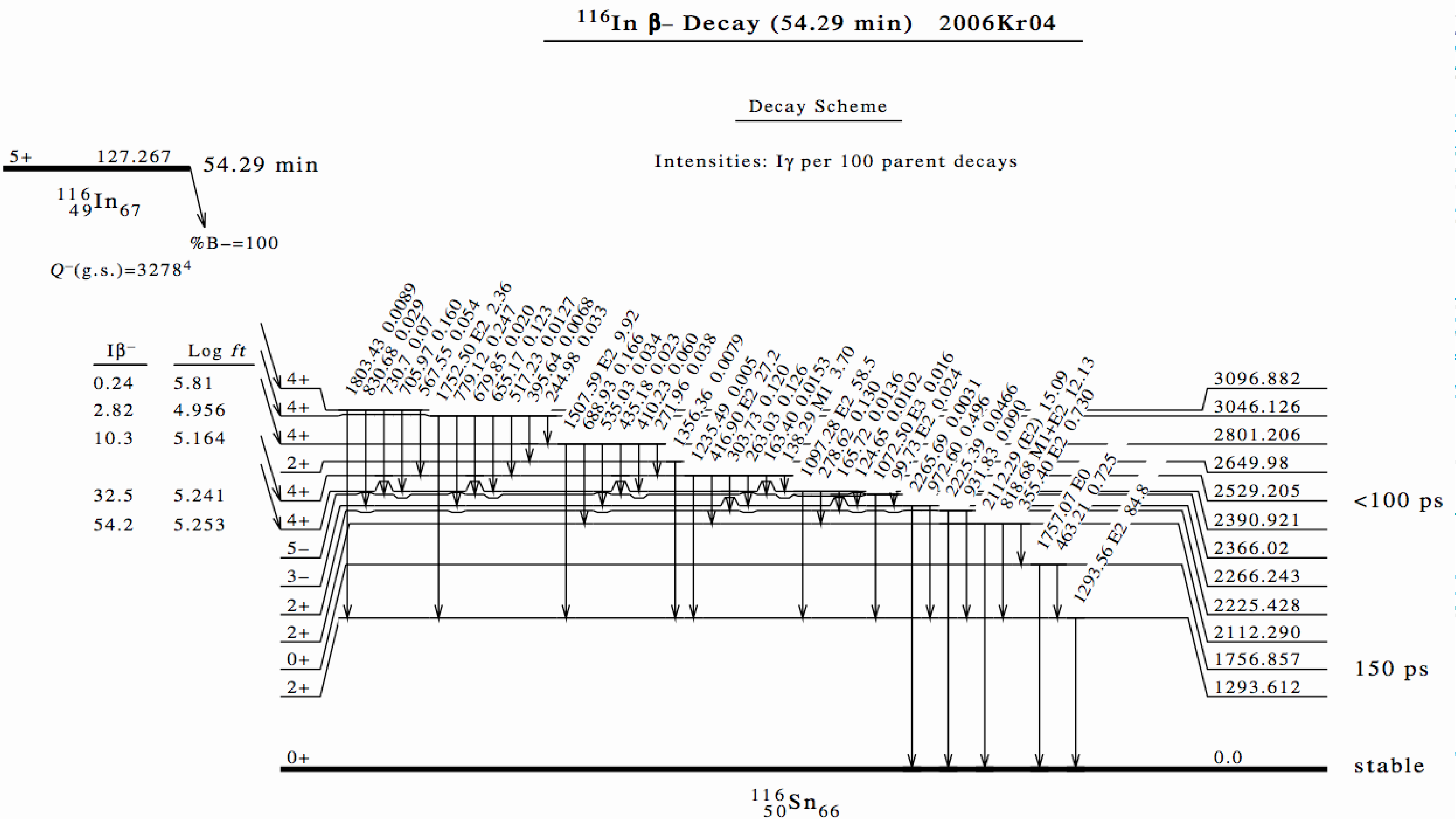
ICC of Interest: ^{116}In

Emission of Sn x-rays following the β decay of ^{116}In

- ^{116}In β- decays to ^{116}Sn
  - 138 [keV] and 418 [keV] γ rays
  - Sn x-rays
- Values of α_k are in agreement
- Used to calibrate detector at range of Sn x-rays

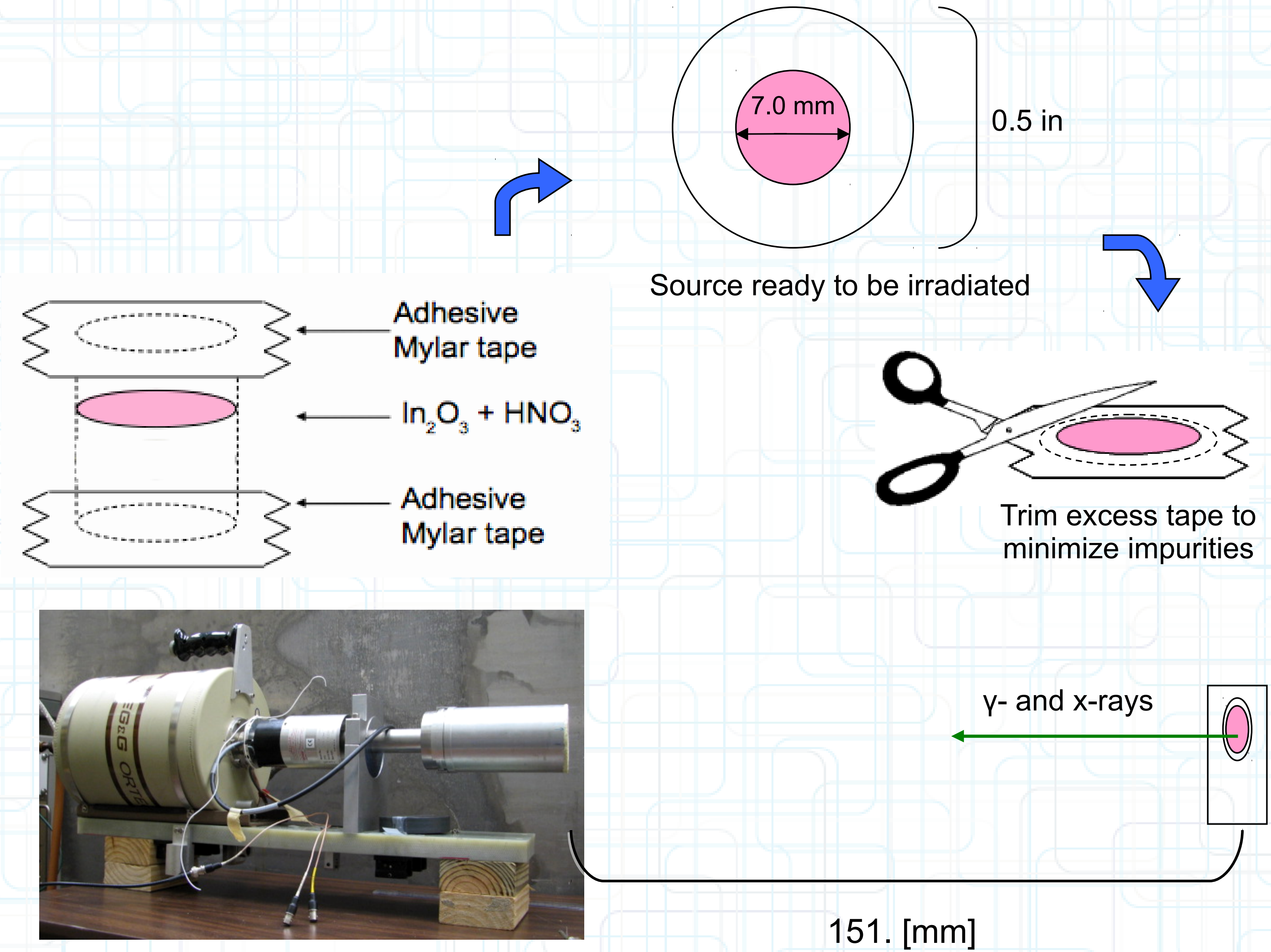


ICC of Interest: ^{116}In



Source: National Nuclear Data Center; Evaluated Nuclear Structure Data File

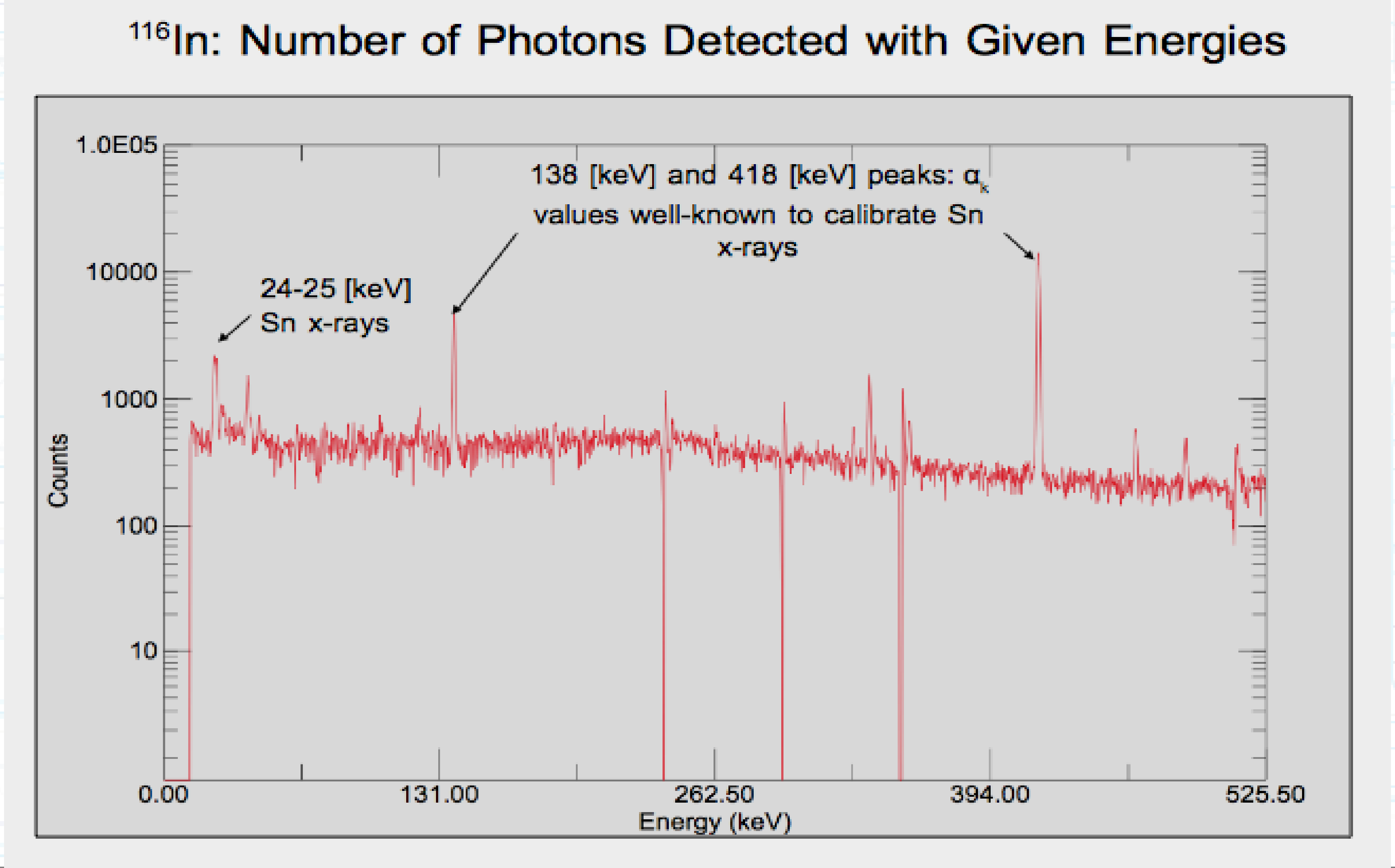
Data Collection



Spectral Analysis

Source: June 2011 ^{116}In, spectrum 4

~8 hour measurement



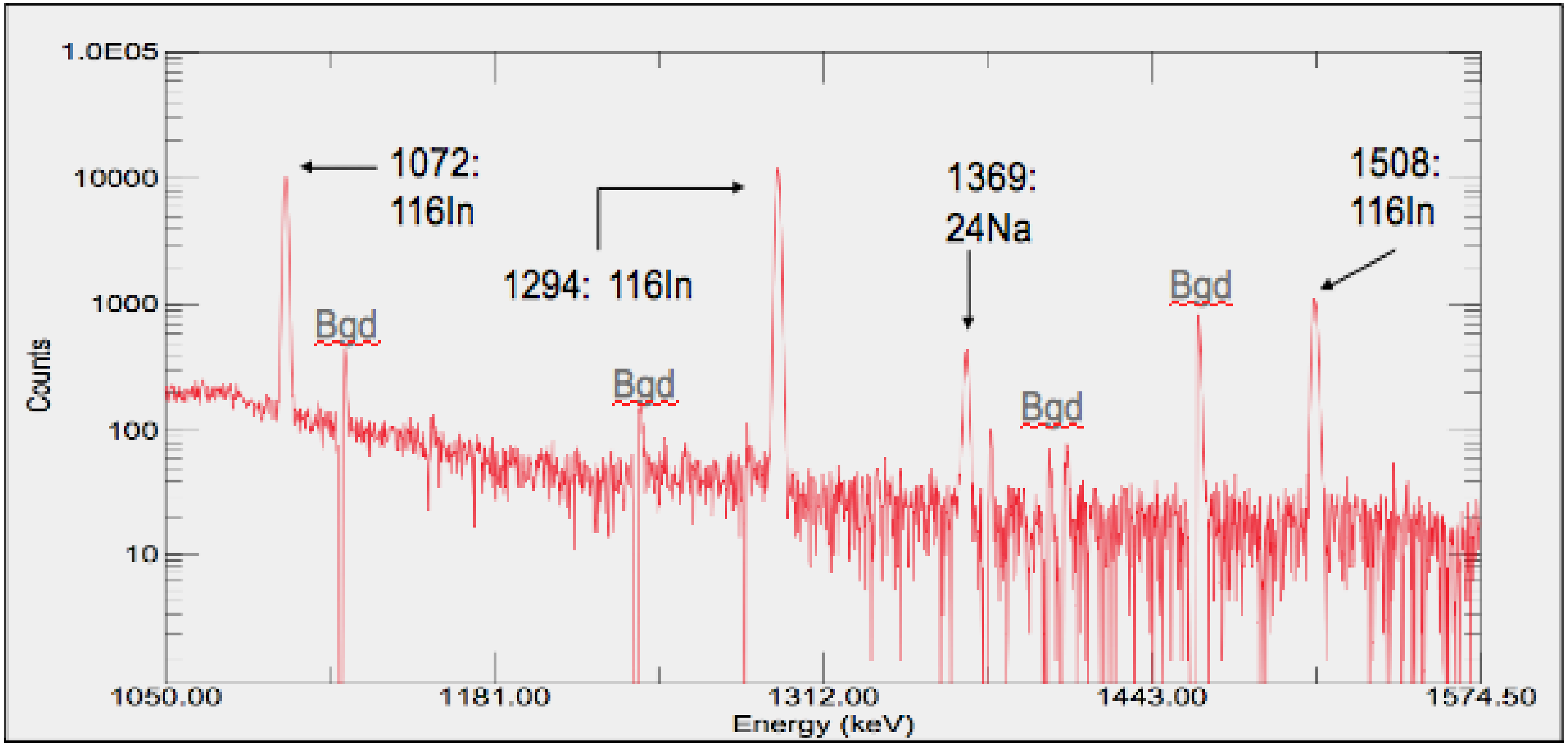
Radiation Spectra

- Impurity criteria:
  - Energy and intensity of γ rays
- Likely impurities:
  - Activated varieties of other isotopes in the source
  - Elements with nearby Z values
  - Activated nuclei of mounting material
- Additional spectra analyzed
  - ^{119m}Sn spectrum
  - ^{182}Ta spectrum

Radiation Spectra

Source: June 2011 ^{116}In, spectrum 4
~8 hour measurement

116In: Number of Photons Detected at Given Energies; Source Nuclei of Peaks Labeled



Preliminary Results

- Impurities identified:
  - ^{122}Sb
  - ^{124}Sb
  - ^{140}La
  - ^{24}Na
  - ^{115}In (from fast neutrons)
- Using calibration from ^{116}In:
  - ^{119m}Sn: α_k = 1601(40) - PRELIMINARY
    - α_k (no hole) = 1544
    - α_k (hole) = 1618

Summary

- Obtained preliminary detector calibration at Sn x-ray range
- Analyzed Sn and Ta spectra for impurities
- Successfully analyzed 4 In spectra for impurities
- Performed impurity subtraction
- Calculated preliminary values for α_k for ^{119m}Sn
- More detailed analysis of x-rays needed
    - Analysis is ongoing
- Produce new source without fast neutrons in activation channel

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