KERNTECHNIK

Activity Determination of Co-60 and Cs-137 Radiation Sources

Daniel Hackl

Executed at the TRIGA Center Atominstitut

TU WIEN TECHNISCHE UNIVERSITÄT WIEN Vienna | Austria

TRIGA CENTER Atominstitut

Supervised by:

Dieter Hainz, BSc
Ing. Monika Veit

Dipl.-Ing. Dr. techn. Andreas Musilek

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Motivation

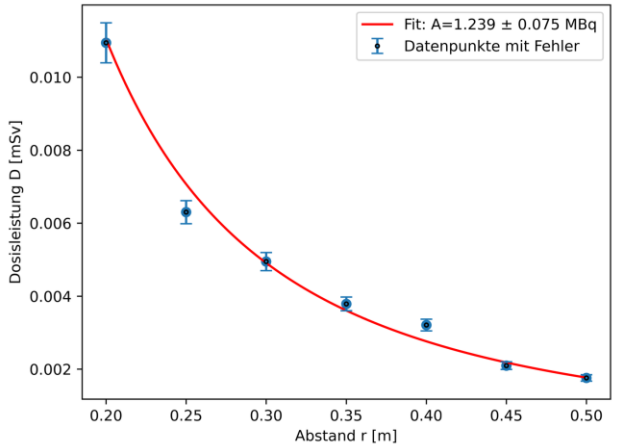
- Inventory of historical radiation sources at the Triga Center Atominstitut
- Historically missing certificates
- Precise characterization required for proper disposal by NES GmbH
- Measurement methods/detectors used:
  - Dose rate meter (Thermo FH 40 G-10)
  - Geiger-Mueller-Counter
  - Activimeter (ISOMED 2010)
  - HPGe-Gammaspectrometer

Dose Rate Meter

- Measurement of the dose rate D at various measuring points
- Activity A can be determined using the square law of distance [1]:

$$A = \frac{(D_{Source} - D_{Bkgd}) \cdot \Gamma}{r^2} = \frac{D_{net} \cdot \Gamma}{r^2}$$

- Correction of the dose rate for Co-60 necessary
- Python script determines curve fit using the ODR method and returns activity A



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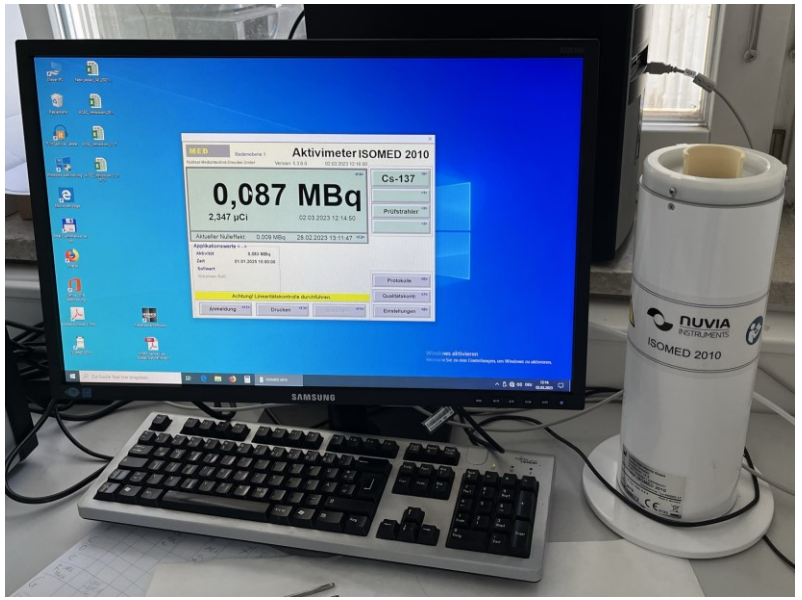
Activimeter

- ISOMED 2010 from the manufacturer NuviaTech Healthcare for medical applications
- Multiple measurements in different measurement angles



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Geiger-Mueller-Counter

- Measurement at a fixed distance of 8.5 cm
- Determination of detector efficiency using two reference sources:

Isotope	Energy (keV)	I_γ	η (8.5 cm)
Co-60	1252,86	0,9992	$1,01 \cdot 10^{-4}$
Cs-137	661,655	0,8505	$2,09 \cdot 10^{-5}$

- Average activity (three measurements each) [2]:

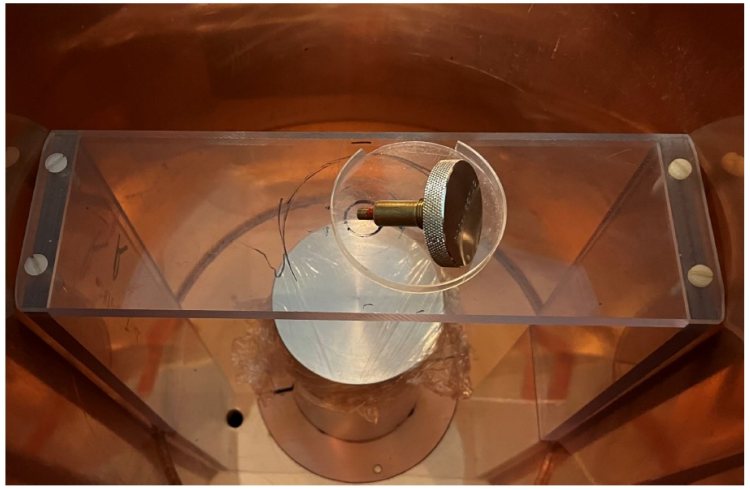
$$\bar{A} = \frac{\bar{n}}{\eta(E_\gamma) \cdot t_{meas} \cdot I_\gamma} \qquad \sigma_{\bar{A}} \approx \frac{\sqrt{\bar{n}}}{\sqrt{N} \cdot \eta(E_\gamma) \cdot t_{meas} \cdot I_\gamma}$$

Gammaspectroscopy

- High purity Germanium detector
- Co-60 has two γ-peaks, activity calculated with equation [3]:

$$A = \sum_i \frac{I_i(E_\gamma)}{t_{real} \cdot \eta(E_\gamma) \cdot R_t \cdot I_\gamma}$$

- Efficiency for different geometries and isotopes calculated with reference sources



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Results

Source	Calc. A	Dose Rate	Activ.	γ-Spectr.	Geiger-C.
Nr. 2 (Co-60)	3,621	3,224	3,685	-	3,221
Nr. 3 (Co-60)	1,254	1,239	1,337	-[1]	-[2]
Nr. 4 (Co-60)	0,276	0,782	0,941	0,837	0,860
Nr. 5 (Co-60)	0,001	-	-	0,002	-
Nr. 6 (Co-60)	0,041	-	0,008	0,015	-
T 15/4 (Cs-137)	-	-	0,052	0,041[3]	-
OTL 99 R004	-	0,544	0,518	0,508	-
OTL 99 R005	-	0,534	0,535	-[4]	-
FL 90/1975	0,110	0,097	0,100	0,096	-
automess 6706	0,126	0,134	0,106	0,098	-
T25-20	-	4,757	4,502	-[5]	4,584
T 3/4	0,091	-	0,087	0,057	-
Nr. 7	0,220	0,137	0,145	0,135	-
Nr. 8	58,127	48,317	45,418	37,702	-[6]
Nr. 30	0,316	0,291	0,309	0,262	-

Discussion

- **Dose Rate Meter**: Precise values for a wide range of activities
- **Activimeter**: Not consistent, high error if below minimum acitvity value
- **Geiger-Mueller-Counter**: Suitable for activities > 0.8 MBq
- **γ-Spectroscopy**: Not consistent (efficiency), not suitable for high acitivities, best results for activity range 1 kBq – 550 kBq

References

[1] M. Tschurlovits, A. Leitner und G. Daverda, »Dose Rate Constants for New Dose Quantities,« Radiation Protection Dosimetry, Jg. 42, Nr. 2, p. 77-82, Aug. 1992.

[2] N. Tsoulfanidis und S. Landsberger, Measurement and Detection of Radiation. CRC Press, Taylor & Francis Group, 2015, ISBN: 9781482215496.

[3] »Praktikum aus Neutronenphysik: Aktivierung von Gold- und Indiumfolien,« 2022.