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INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

INTERCOMPARISON EXERCISE FOR ACTIVATION MEASUREMENT OF 14 MEV NEUTRON IRRADIATED NI FOILS

An exercise carried out as a part of the IAEA Co-ordinated Programme on "Measurement and analysis of 14 MeV neutron nuclear data needed for fission and fusion reactor technology" and the Interregional Project INT/1/018 on "Nuclear Data Techniques and Instrumentation"

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H. Vonach (IRK, Vienna)
Pavlik (IRK, Vienna)
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December 1985

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

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Background

During the first Research Co-ordination Meeting (RCM-I) of the Co-ordinated Research Programme (CRP) on "Measurement and analysis of 14 MeV neutron nuclear data needed for fission and fusion reactor technology" held at Gaussig, GDR in November 1983, the Working Group WGB(A) on Activation and other off-line methods recommended that an intercomparison exercise should be carried out between the laboratories who are participating in the CRP and the Interregional Project INT/1/018 on Nuclear Data Techniques and Instrumentation and who are planning to carry out 14 MeV neutron cross section measurements using activation techniques to provide an appropriate reference level to intercompare and normalise all the measurements carried out under this programme.

The exercise involved irradiation of Nickel foils processed and prepared at IRK-Vienna and irradiated by 14 MeV neutrons from the RTNS neutron source at Lawrence Livermore Laboratory, and distributed to the participating laboratories by the Nuclear Data Section of the Agency.

Twenty seven irradiated foils were distributed to sixteen laboratories during 1984 (some laboratories were given more than one foils - Appendix I). A letter from Dr. Haight giving the details of the irradiation and suggestion for the measurements (Appendix II) was distributed along with the foils. The results from twelve laboratories involving measurement of $^{57,59,60}Co$ activities produced under 14 MeV neutron irradiation were reported and discussed at the Second Research Co-ordination meeting (RCM-II) held at Chiang Mai, Thailand during 4-8 February 1985. Subsequently detailed intercomparison analysis was carried out at IRK - Vienna which is reported here and shown in Fig. 1. The analysis includes results on twenty three foils from twelve laboratories. Results for two more foils were received after the analysis was performed and so are not used in fitting the curve but are subsequently plotted on the graph (points for foil nos. 112 and 116). It can be seen that these points are consistent with the fitted straight line and their inclusion in the fitting procedure would not have changed any of the conclusion drawn from the analysis.

Evaluation and Analysis

To evaluate the results of the nickel foil intercomparison a linear decrease of the neutron fluence was assumed along the stack of irridiated samples. This is justified because the decrease in fluence between the first and last foil is only about 15% and thus any reasonable function describing the fluence dependence within the stack can be approximately linearized within this range.

Therefore linear functions (number of cobalt atoms per gram nickel versus foil number) were fitted on the measured data. As the isotopes ^{57}Co, ^{58}Co and ^{60}Co were produced in the same samples during the same irradiation the fitted functions

$$f_i(n) = k_i n + d_i$$

f_i ... number of atoms of the isotope i ($i = {}^{57}Co, {}^{58}Co, {}^{60}Co$) per gram nickel

n ... foil number

have to fulfill the condition

$$\frac{f_{57}(n_1)}{f_{57}(n_2)} = \frac{f_{58}(n_1)}{f_{58}(n_2)} = \frac{f_{60}(n_1)}{f_{60}(2)}$$

for every pair of foils (n_1,n_2).

This condition leads to the two independent constraints

$$k_{57}d_{58} = k_{58}d_{57}$$

$$k_{57}d_{60} = k_{60}d_{57}$$

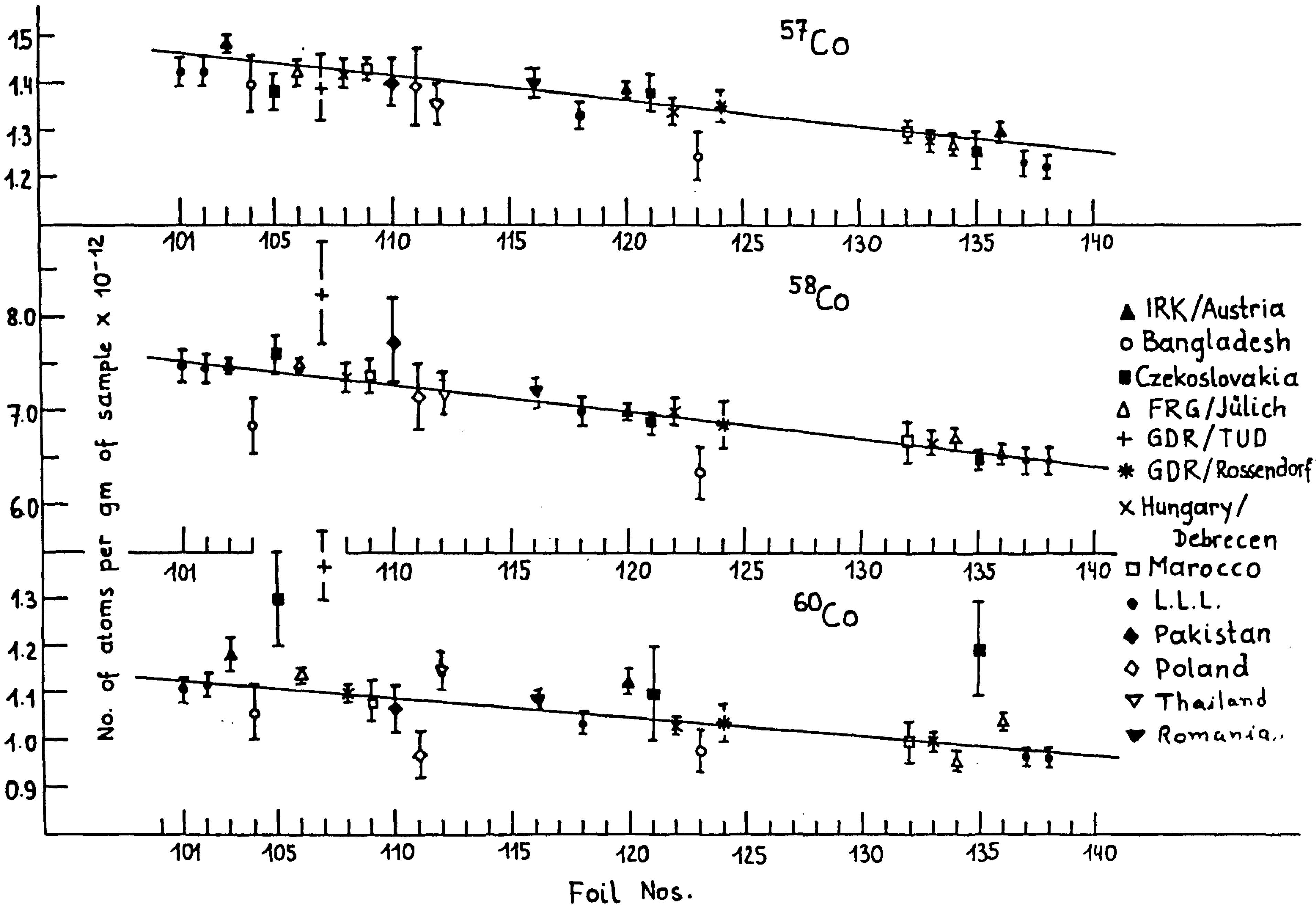
The evaluation was done in two steps using generalized least square procedures. In the first step a linear function was fitted for every cobalt isotope. The squares of the uncertainties reported were taken as diagonal elements of the covariance matrices. To get the off-diagonal elements of the covariance matrices, correlation coefficients were estimated from the error analyses on the experimental dtails reported if several data points were provided by one laboratory. Measurements of different laboratories were assumed to be independent. The uncertainties of the parameters k_i and d_i of the fitted functions were calculated from the experimental uncertainties using the error propagation lane (internal error). In the case of ^{60}Co to the resulting uncertainties were increased due to the wider scattering of the experimental data (external error).

In a second step the parameters k_i and d_i of the fitted functions were evaluated under the constraints mentioned above. The constraints were linearly approximated by expansions around the results of the first step.

Fig. 1 shows the final result of this procedure. This result was essentially already obtained in the first step of the fitting procedure. The necessary adjustments due to the imposed condition of equal relative slope for all 3 straight line fits caused only changes less .5 %.

Conclusions

Thus the over all result is an excellent consistency of the reported results from all three radioisotopes for both ^{57}Co and ^{58}Co the X^2 per degree of freedom is well below one, only for ^{60}Co it amounts to 2.0. However, also in this case the problem seems not to be associated with measurements from developping countries but probably with the measurements reported by the IRK Vienna and TUD, Dresden which seem systematically too high. The Vienna measurements were very carefully rechecked but no reason for the discrepancy could be indentified.



^{57}Co
^{58}Co
^{60}Co
No. of atoms per gm of sample × 10^{-12}
Foil Nos.
1.5
1.4
1.3
1.2
8.0
7.0
6.0
1.3
1.2
1.1
1.0
0.9
101
105
110
115
120
125
130
135
140
▲ IRK/Austria
o Bangladesh
■ Czekoslovakia
Δ FRG/Jülich
+ GDR/TUD
✱ GDR/Rossendorf
× Hungary/ Debrecen
□ Marocco
● L.L.L.
◆ Pakistan
◇ Poland
▽ Thailand
▼ Romania

Figure 1

	foil nos.
Prof. H.K. Vonach Institut für Radiumforschung und Kernphysik Boltzmanngasse 3 A-1090 Wien	nos. 103, 120, 136
Dr. Nurul Islam Molla Atomic Energy Research Establishment G.P.O. Box 3787 Ganakbari, Savar, Dhaka Bangladesh	nos. 104, 123
Dr. I. Ribanksy Department of Nuclear Physics Institute of Physics of the Slovak Academy of Sciences Dubravska Cesta CS-842 28 Bratislava Czechoslovakia Dr. P. Oblozinsky Department of Nuclear Physics Institute of Physics of the Slovak Academy of Sciences Dubravska Cesta CS-842 28 Bratislava Czechoslovakia	nos. 105, 135, 121
Dr. Syed M. Qaim Institut f. Chemie 1 (Nuklearchemie) Kernforschungsanlage Juelich G.m.b.H. Postfach 1913 D-5170 Juelich 1 FRG	nos. 106, 134
Dr. K. Seidel Sektion Physik Technische Universität Dresden Mommsenstrasse 13 DDR-8027 Dresden	nos. 107, 124
Prof. J. Csikai Institute of Experimental Physics of Kossuth Lajos University P.O. Box 105 H-4001 Debrecen Hungary	nos. 108, 133, 122
Prof. M. Berrada Department of Nuclear Physics Faculty of Science Mohammed-5 University B.P. 1014 Rabat, Morocco	nos. 109, 132

	foil nos.
Dr. K. Gul Head, Neutron Physics Group Pakistan Institute of Nuclear Science and Technology P.O. Nilore Rawalpindi, Pakistan	no. 110
Dr. A. Marcinkowski Department P-I Institute of Nuclear Studies (IPJ) ul. Hoza 69 PL-00-681 Warsaw Poland	no. 111
Prof. Thiraphat Vilaithong Nuclear Physics Laboratory Department of Physics Chiang Mai University Chiang Mai, Thailand	no. 112
Dr. D. Miljanic Nuclear Physics Department Institut Ruder Boskovic P.O. Box 1016 YU-41001 Zagreb Yugoslavia	no. 113
Dr. Hoang Dac Luc Head, Nuclear Physics Laboratory National Science Research Centre Institute of Physics of the Academy of Science Hanoi, Viet Nam	no. 114
Dr. Sukiman Sarmani Acting Dean, Faculty of Physical & Applied Sciences Universiti Kebangsaan Malaysia (National University of Malaysia) Bangi Selangor, Kuala Lumpur Malaysia Prof. Ananda Mohan Ghose School of Physics Universiti Sains Malaysia (University of Science Malaysia) Minden, Penang, Malaysia	no. 115
Dr. I. Garlea Central Institute of Physics P.O. Box MG-6 R-7000 Bucharest Romania	no. 116

Lawrence Livermore National Laborator

October 26, 1984

Dr. M. K. Mehta
Nuclear Data Section
International Atomic Energy Agency
Wagramerstrasse 5
P. O. Box 100
A-1400 Vienna
AUSTRIA

Dear Dr. Mehta:

The samples of nickel foil, provided by you through Prof. Vonach, were irradiated at our intense 14-MeV neutron source, RTNS-II, during the period October 8, 1984 (begin 12:49 p.m. Pacific Daylight Time (PDT)) through October 13 (end 7:15 a.m. PDT). The samples were placed approximately 10 cm from the source and irradiated in a "piggy back" mode with the principal experiment, a test of radiation damage of heated samples. This principal experiment included an oven and other materials so that the neutrons from the source passed through about 5 cm of various materials in a complicated geometry. The flux reaching the nickel samples consisted of the attenuated 14-MeV flux plus the degraded neutrons. The spectral shape is not known experimentally and would be difficult to calculate because of the complexity of materials and geometry. Niobium dosimetry foils indicated that the neutron fluence was 3.025×10^{15} at the front of the stack and 2.595×10^{15} at the back if we make the gross and clearly incorrect assumption that all the neutrons had an energy of 14.8 MeV.

We are sending you 33 foils for the intercomparison exercise. They were irradiated in numerical order with the lowest number closest to the source. The foils were placed in direct contact with each other so that recoils from one foil would be implanted in the adjacent one. For our part of the exercise, we have kept the irradiated foils 101, 102, 118, 137 and 138. We also are keeping foils 139 and 140 which were not irradiated. The masses of the foils are given on the attached sheet.

I suggest that each laboratory analyze the samples for the following isotopes: ^{57}Co, ^{58}Co, and ^{60}Co. The activity should be reported in atoms of the isotope per gram of sample corrected to the end of the irradiation which is 14:15 GMT on 13 October 1984. I suggest that the half-lives be taken from the latest Table of the Isotopes: 271 days for ^{57}Co, 70.8 days for ^{58}Co, and 5.271 years for ^{60}Co.

Sincerely,

Robert C. Haight

Robert C. Haight

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MASSES OF NICKEL FOILS

Foil number	mass (g)	number	mass
101	0.11358	121	0.11499
102	0.11286	122	0.11402
103	0.11406 X	123	0.11556
104	0.11486	124	0.11317
105	0.11390	125	0.11432
106	0.11617	126	0.11423
107	0.11429	127	0.11349
108	0.11392	128	0.11481
109	0.11400	129	0.11373
110	0.11432	130	0.11355
111	0.11317	131	0.11367
112	0.11459	132	0.11345
113	0.11327	133	0.11497
114	0.11240	134	0.11535
115	0.11433	135	0.11481
116	0.11478	136	0.11309
117	0.11389	137	0.11311
118	0.11517	138	0.11495
119	0.11441	139	0.11329 X
120	0.11434 X	140	0.11386

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