



SAFEGUARDS AND PHYSICS MEASUREMENTS: NEUTRON ACTIVATION ANALYSIS WITH k_0 -STANDARDISATION

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Background

Neutron Activation Analysis (NAA) is a sensitive and accurate tool for element analysis, complementary to non-nuclear analytical techniques. The combination of our gamma spectrometry laboratory and the neutron irradiation facilities at the BR1 reactor constitutes an excellent framework for the application of NAA.

Objectives

- to further develop the k_0 -standardisation method for NAA, in close collaboration with scientific partners;
- to fully exploit the inherent qualities of NAA such as accuracy, traceability and multi-element capability, to ensure its position as a competitive routine chemical analysis technique;
- to acquire technical spin-off to our nuclear measurements services, enhanced support possibilities to other internal projects and be a stimulus for professional contacts with the international scientific community.

Programme

- to improve the standardisation method and the neutron field characterisation
- to improve the statistical control on neutron activation analysis

Achievements

In k_0 -NAA, the normalisation of the analytical result is based on so-called k_0 -factors associated with each gamma line in the activation spectrum, and the neutron flux characterisation is usually based on the Au-Zr triple bare monitor method. An original method has been presented to determine Au-burn up effects by γ -ray spectrometry of the ^{198}Au and ^{199}Au decay lines, hence allowing the utility of gold as a flux monitor at high neutron fluxes. SCK•CEN contributed, in international collaboration, to a re-determination of the k_0 -parameters associated with the activation of Zr and also Rh, the first being an important monitor for epithermal flux, the latter presenting an interesting but complex activation scheme leading to short-lived isotopes. By participating to the EUROMET project 428 on "Transfer of Ge detectors efficiency calibration from point source geometry to other geometries", some evaluation was done of the semi-empirical method used to calculate the detec-

tion efficiency of a High Purity Germanium (HPGe) γ -ray detector set-up for cylindrical geometries.

Fundamental research was done on nuclear counting statistics, which deviate from Poisson distributions in the presence of significant count loss in the spectrometer. From renewal process theory, new counting uncertainty formulas were derived for the basic types of count loss: extending dead time, pulse pileup and non-extending dead time. Separate expressions are presented, valid before and after count-loss compensation respectively. Also the particular case of Wilkinson ADC's is scrutinised, taking into account the channel dependence of the characteristic dead time. Particular attention was paid to the statistical properties of "loss-free counting" and the "Gedcke-Hale live-time correction method", which are two important pulse-loss correction methods for nuclear spectrometry. Finally, statistical control was achieved for most of the commonly applied γ -ray spectrometry techniques in neutron activation analysis.

Scientific Partners

Institute for Reference Materials and Measurements (IRMM), Universiteit Gent (UG), Atomic Energy Research Institute of the Hungarian Academy of Sciences (KFKI), DSM Research BV, National Institute of Standards and Technology (NIST), École Polytechnique Montreal.

Thesis

S. Pommé, "On the applicability of k_0 -NAA in extreme conditions", PhD Chemistry, University of Gent, Analytical Chemistry Lab, (1999), 270 pages

Publications

F. De Corte, S. Van Lierde, A. Simonits, D. Bossus, R. van Sluijs, S. Pommé, "A re-evaluation of k_0 and related nuclear data for the 555.8 keV gamma-line emitted by the ^{104m}Rh - ^{104}Rh mother-daughter pair", *Appl. Rad. Isot.* 51 (1999), 701-706

C. Ingelbrecht, J. Ambeck-Madsen, K. Teipel, P. Robouch, G. Arana, S. Pommé, "Electrodeposited ^{149}Sm targets for (n, α) studies", *Nucl. Instr. and Meth.* A438 (1999), 36-39

S. Pommé, J-P Alzetta, J. Uytendhove, B. Denecke, G. Arana, P. Robouch, "Accuracy and Precision of Loss-Free Counting in γ -ray Spectrometry", *Nucl. Instr. and Meth.* A422 (1999), 388-394

S. POMMÉ, B. DENECKE, J-P ALZETTA, "Influence of pileup rejection on nuclear counting, viewed from the time-domain perspective", Nucl. Instr. and Meth. A 426 (1999), 564-582

S. POMMÉ, "How pileup rejection affects the precision of loss-free counting", Nucl. Instr. and Meth. A 432 (1999), 456-470

S. POMMÉ, "Time-interval distributions and counting statistics with a non-paralysable spectrometer", Nucl. Instr. and Meth. A437, (1999), 481-489

S. VAN LIERDE, F. DE CORTE, D. BOSSUS, R. VAN SLUUIS, S. POMMÉ, "Determination of k_0 and related nuclear data for short-lived radionuclides to be used in KAYZERO-NAA at DSM Research", Nucl. Instr. and Meth. A422, (1999) 874-879

S. POMMÉ, "Is loss-free counting under statistical control?", Biol. Trace Element Res. 71-72 (1999), 415-422.

Presentations

M.C. LÉPY, T. ALZITZOGLOU, D. ARNOLD, F. BRONSON, R. CAPOTE NOY, M. DECOMBAZ, F. DE CORTE, R. EDELMAIER, S. KLEMOLA, M. KORUN, H. NEDER, T. NOVOTNY, S. POMMÉ, O. SIMA, F. UGLETVEIT, L. VAN VELZEN, "Efficiency transfer software intercomparison", 12th International Conference on Radionuclide Metrology and its Application, ICRM'99, Prague, Czech Republic, June 7-11, 1999

S. POMMÉ, A. SIMONITS, R. LINDSTROM, F. DE CORTE, P. ROBOUCH, "Determination of burnup effects in $^{197}\text{Au}(n,g)^{198}\text{Au}$ prior to reactor neutron field characterisation", MTAA-10: Modern Trends in Activation Analysis, Bethesda, Maryland, USA, April 19-23, 1999.

S. POMMÉ, P. ROBOUCH, G. ARANA, M. EGUSKIZA, M.I. MAGUREGUI, "Is it safe to use Poisson Statistics in Nuclear Spectrometry?", MTAA-10: Modern Trends in Activation Analysis, Bethesda, Maryland, USA, April 19-23, 1999.

S. POMMÉ, G. KENNEDY, "Pulse loss and counting statistics with a digital spectrometer"

12th International Conference on Radionuclide Metrology and its Application, ICRM'99, Prague, Czech Republic, June 7-11, 1999.

P. ROBOUCH, G. ARANA, M. EGUSKIZA, S. POMMÉ, N. ETXEBARRIA, "Uncertainty budgets for k_0 -NAA", MTAA-10: Modern Trends in Activation Analysis, Bethesda, Maryland, USA, April 19-23, 1999.

A. SIMONITS, F. DE CORTE, S. VAN LIERDE, S. POMMÉ, "THE k_0 and Q_0 values for the Zr-isotopes: a re-investigation", MTAA-10: Modern Trends in Activation Analysis, Bethesda, Maryland, USA, April 19-23, 1999.

Reports

S. POMMÉ, P. WILLEBORTS, "Neutron Activation Analysis of Al-Au alloy for certification", SCK•CEN External contract report, IRMM order 90127 CCR 290357, 1999, pp.8.

P. ROBOUCH, G. ARANA, S. POMMÉ, "As, Br, Cl, Cd, Cr and Hg in CRM-680 and 681: the k_0 -NAA contribution to the PERM certification", Internal Report IRMM, GE/R/RM/04/99, 1999, pp.8.

P. ROBOUCH, G. ARANA, M. EGUSKIZA, S. POMMÉ, " k_0 -NAA and Bronzes: the IMMACO certification", Internal Report IRMM, GE/R/RM/05/99, 1999, pp.17.

P. ROBOUCH, M. EGUSKIZA, M.I. MAGUREGUI, S. POMMÉ, "CRM-600 and k_0 -NAA: Homogeneity, Stability and Certification analysis", Internal Report IRMM, GE/R/RM/06/99, 1999, pp.13.