The true coincidence summing correction method at STUK, Finland

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STUK gamma spectrum analysing program including summing correction

- Original STUK analysing program GAMMA-81: coincidence summing correction subroutine CSUM based on the general equations presented by Andreev et al. (1972) and McCallum and Coote (1975)
- In 1985 CSCOR program: the effect of X-rays (following internal conversion or decay by EC) by Debertin and Schötzig (1979)
- CSCOR can be run also separately
Input data

- Full-energy peak efficiency
- Total efficiency
- Detailed/modified decay scheme data including conversion coefficient data

| symbol, half-life, type of decay (β, EC) |
| symbol, half-life, type of decay (β, EC) |
| energy of KX-ray, fluorescence yield, numbers of energies (n), excitation levels, protons and neutrons |
| initial and final excitation levels of the transition, gamma-ray intensity, total internal conversion coefficient, K-conversion coefficient, intensity of decay to the initial level |

| Cs-134 | 2.0648 | Y | B- |
| 32.9  | 0.877  | 9 | 5  | 55 | 79 |
| 4 2   | 475.36 | 1.465 | 1.00E-2 | 1.00E-2 | 0.0248 |
| 2 1   | 563.227 | 8.38  | 5.7E-3  | 5.7E-3  | 0.0045 |
| 5 3   | 569.315 | 15.43 | 7.8E-3  | 7.8E-3  | 0.274 |
| 1 0   | 604.699 | 97.56 | 5.03E-3 | 5.03E-3 | 0.00008 |
| 3 1   | 795.845 | 85.44 | 2.63E-3 | 2.63E-3 | 0.7011 |
| 5 2   | 801.932 | 8.73  | 2.69E-3 | 2.69E-3 | 0.274 |
| 4 1   | 1038.571 | 1.00  | 1.73E-3 | 1.73E-3 | 0.0248 |
| 2 0   | 1167.938 | 1.805 | 1.18E-3 | 1.18E-3 | 0.0045 |
| 5 1   | 1365.152 | 3.04  | 8.2E-4  | 8.2E-4  | 0.274 |
Cs-134

EKX=32.90  OMK= 0.877  EPX=8.788E-02  ETX=1.2595E-01

<table>
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<tr>
<th>TRANSITION ENERGY</th>
<th>CORRECTION COEFFICIENT</th>
<th>N(I)</th>
<th>D(I,K)</th>
<th>M(K)</th>
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</table>
References

- Debertin K., Schötzig U. Coincidence Summing Corrections in Ge(Li)-Spectrometry at Low Source-to-Detector Distances Nuclear Instruments and Methods 158 (1979), 471-477.
Gamma Laboratories

3 counting rooms:
  2 in Helsinki, 1 in Rovaniemi

• Special concrete and mortar with low abundance of natural radionuclides
  
  Ra-226  6.2 Bq/kg
  Th-232  4.3 Bq/kg
  K-40    70.0 Bq/kg

• Controlled access

• Special designs for air conditioning to decrease background radiation due to 1) radon, 2) severe fallout

• Separate counting and operator/computer rooms

• Pipelines for LIN supply

• UPS + reserve power generator
14 Spectrometers

- coaxial HPGe
- vertical cryostat
- 13 p-type, 1 n-type
- rel. eff. 20-100%
- 12-14 cm Pb BG-shielding Cu+Cd lined
- DSP + NIM electronics, MCB
- control: local PC or LAN workstations
Beakers

cylindrical:
0-30 ml, free sample height
0-100 ml, free sample height

Marinelli:
0.5 l, fixed sample height

New measuring geometries can be calibrated using DECCA-programme
Software

• Measurement control: **MAESTRO** from ORTEC
• Spectrum analysis: **GAMMA-99** from STUK
  • originally Gamma-81 (Fortran 5)
    • sample height and density correction
  • cascade summing correction since 1983! (Andreev, 1981)
  • DOS-version 1990 (Fortran 77)
  • Windows-version 1997
    • automatic and interactive operation modes
• Efficiency calibration calculation: **DECCA**
  • efficiency transfer method (Moens et al, 1981)
  • programmed in co-operation w. NRPA Norway in 1990
  • validated in ICRM and Euromet projects
Accreditation

- 1996: Gamma spectrometry as a pilot project, 1st draft of quality manual
- 1997: STUK Quality system (TQM): basis for laboratory manuals
- 1998-1999: Preparation of the laboratory manuals
- Feb 1999: Main documentation to FINAS
- 17.12.1999: Accreditation certificate
- 2003: Renewed accreditation acc. ISO/IEC 17025
Fields and volume

• Surveillance of environmental radiation
  • Radioactive substances in outdoor air, deposition, surface water, drinking water, milk, foodstuffs and in the Baltic Sea

• Research, radioecological studies
  • Artificial radionuclides: fallout, NPP discharges, ...
  • Natural radionuclides: eg. wood ash, sediment dating, ...

• Contracted service
  • Industry NPP environmental monitoring, national and international organisations and institutes

• Emergency preparedness, method development, QA

• Total volume of gammalaboratories: 5000 anal./year
Procedure

- Sample collection & preparation not included in the method
- Optimisation of sample flow
  - right sample (amount), right detector (type and efficiency), right counting time
- Spectrum acquisition (counting’, measurement’)
- Computer analysis
- Evaluation of analysis report, re-analysis if needed
- All stages (to be) integrated to LIMS with advanced handling of uncertainties
Intercomparisons

+ Successful participation in intercomparisons: the best way of proving good quality
+ One of the ways to validate a new method
  – The procedure → results not always comparable with routine work
  – The results often only available after a long time, even years

![Graph showing Cs-137 levels over years](image-url)
Special Intercomparisons

Fresh fission and activation products in NPP primary coolant water

- Inspection of power plant laboratory extended to intercomparison between 6 gamma spectrometry laboratories in Finland since 1994
- ‘age’ of the sample 3-5 h → possible to analyse nuclides with half-lives < 1 h
- typically results of 30 nuclides

Use of Synthetic Spectra
to test and demonstrate

- software capability and quality
- emergency preparedness
- personnel competence

Reaktorivesivertailu 2003
The summing of gamma- and X-ray peaks + Ge-escape peaks

case: $^{111}\text{In}$

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Energy [keV]