Gamma-ray Spectrometry

Training Workshop on
Applications of Gamma-ray Spectrometry
to Environmental Samples

Computer Codes

Tim Vidmar, PhD

SCK.CEN, Belgian Nuclear Research Centre, Boeretang 200, Mol, Belgium

Tim.Vidmar@sckcen.be

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Computer codes for Efficiency Transfer and Coincidence Summing Corrections

- Add-ons by major manufacturers
- General Monte Carlo packages
- Specialized gamma-ray spectrometry programs

Major manufacturers

- Well integrated with the main Acquisition and Analysis package
- Support many types of detectors and sample geometries
- Tested and certified
- Short run time
- Sufficient accuracy?
- CANBERRA: ISOCS and LABSOCS
- ORTEC: ANGLE, part of GammaVision

Canberra's LABSOCS

Canberra's replacement for Efficiency Transfer

- All possible sample geometries and materials
- Detector characterization required
- No calibration required whatsoever
- Detector model validity over time?
- Coincidence summing corrections very advanced
  - No peak-to-total calibration necessary
  - Scattering in the sample taken into account
  - Summing with X-rays
  - Very comprehensive ENSDF library
  - Generic detector models available

ORTEC's Angle

Efficiency Transfer code that works with virtual total efficiencies

- Fully integrated with the spectrum analysis
- Well tested
- Planar, coaxial and well-type detectors
- Cylindrical, rectangular and Marinelli samples
- Improvements planned – coincidence summing corrections
- http://angle.dlabac.com

ORTEC's experimental calibration approach uses the method of Blaauw

General purpose packages

- **Written for large experiments in particle physics, medical physics, shielding applications, criticality calculations**
  - Mostly require programming, quite complex to use
  - Track various kinds of particles
  - Perform full Monte Carlo calculations
  - Can handle arbitrary geometries – unusual objects
  - Run times between minutes and hours
  - Variance reduction techniques available
  - Most work across platforms (Linux, Windows, Unix, (VMS))

MCNP5

- Grand-daddy of Monte Carlo codes, development started with the Manhattan project
- No programming required, uses input cards
- Complicated and rich I/O formats
- Neutrons transport strongest, but all types of particles available
- Tracking electrons can slow the calculation by a factor of 10
- Rich selection of variance reduction techniques
- Radionuclide decay module available, based on the ENSDF database (A.N. Berlizov, V.V. Tryshyn, Journ. Radioanal. Nucl. Chem. 264, 2005, p. 169-174)
- License has to be obtained
- Expensive, but excellent courses
- http://mcnp-green.lanl.gov/

PENELOPE

- Photon and electron transport
- Very precise and advanced treatment of electron transport
- Uses an input geometry description file
- Complete quadric geometry, variance reduction techniques available
- The main program in Fortran 77
- Simplified version for cylindrically symmetric setups
- Course available through the OECD NEA
- Popular with gamma-spec practitioners, many research articles
- Code available through the NEA data bank:

  http://www.oecd-nea.org/
- Principal developed F. Salvat, University of Barcelona

GEANT4

- CERN collaborative development
- Available free of charge
- Many users and purposes, forums and support
- C++ programming required, complex class structure
- Incredibly versatile
- Special low-energy electromagnetic interaction module
- Radionuclide decay engine available
- http://geant4.cern.ch/
- S. Hurtado, M. Garcia-Leon, R. Garcia-Tenorio. GEANT4 code for simulation of a germanium gamma-ray detector and its application to efficiency calibration. Nuclear Instruments and Methods in Physics Research A 518 (2004) 764–774.
- Courses available at various levels

EGSnrc

- Electron Gamma Shower, 1 keV to 1 GeV
- Popular with dosimetry calculations and in medical physics
- Fortran 77
- Latest in a long series of EGS codes
- http://irs.inms.nrc.ca/software/egsnrc/
- Works on Unix, Linux, Windows and, to some extent, on Mac OS X
- Freely downloadable
- Many publications, courses organized occasionally
- Main authors I. Kawrakow and D. W. O. Rogers

Specialized codes

- Specifically aimed at gamma-ray spectrometry
- No programming, user friendly interfaces
- Various approaches
  - Full Monte Carlo
  - Virtual total efficiencies – Effective solid angle
- Run much quicker than general packages
- Limited geometry
- Not (yet) integrated with major manufacturer's platforms

GESPECOR

- Very sophisticated, high precision
- Efficiency Transfer, Coincidence Corrections and Transmission measurements
- Commercial product
- Pure calculation, full Monte Carlo
- All usual detector types and sample geometries (including Marinelli)
- Used by primary laboratories
- Many variation reduction techniques implemented – still, not very fast
- Graphical user interface
- Constantly maintained and improved, in existence for more than a decade
- The most accomplished gamma-ray spectrometry code available
- No direct integration with major gamma-spec platforms
- http://gespecor.com/
- Well documented in research literature

ETNA

- (Efficiency Transfer for Nuclide Activity measurements)
- Efficiency Transfer and Coincidence Corrections
- Developed by the French Laboratoire National Henri Becquerel
- Available freely on request (Marie-Christine.Lepy@cea.fr)
- Efficiency transfer
  - Effective solid angle method (Moens)
  - Cylindrically symmetric geometries (disk, point, Marinelli)
- Coincidence corrections
  - Input of efficiencies required
  - ET values can be used
  - Direct use of the NUCLEIDE database!
- XCOM attenuation data can be used
- User friendly graphical interface
- Experimentally validated (M-C. Lepy et al., ARI 64, 2006, p. 1340-1345)
- ASCII export of results

DETEFF

- Efficiency Transfer or Direct Computation of Efficiencies
- Full Monte Carlo
- Nai, CsI, Ge and Si detectors
- Cylindrical, rectangular and Marinelli type sources
- Developed by the Center for Hygiene and Radiation Protection, Havana, Cuba, and the Physics Department of the University of Extremadura, Spain
- Available freely on request (ncfoton@hotmail.com and mjv@unex.es)
- All important photon interactions considered, including Ge fluorescence
- Simplified electron transport for greater speed
- Can produce a spectrum
- Full-energy-peak and total efficiencies computed, one energy at a time
- Experimentally validated (N. C. Diaz, M. J. Vargas, NIM A586, 2008, p. 204-210)
- Can be used for in-situ calibration!

TrueCoinc

- Coincidence Summing Correction factors
- Requires input of full-energy-peak and total efficiencies
- Uses the point-source approximation
- ENSDF database of decay schemes
- Full treatment of X-rays
- Author S. Sudar, Institute of Experimental Physics, University od Debrecen
- Described in IAEA-TECDOC-1275

Nucleonica site

- www.nucleonica.com
- Basic functionality free (registration required)
- Advanced features available commercially
- Spectrum Generator (basic and Pro versions)
- Cambio - spectrum file converter
- WESPA - Web-based Gamma Spectrum Analyser
- Many other functions related to dosimetry, decay, shielding …