THE EFFECTIVE SOLID ANGLE CONCEPT AND ANGLE v3.0 COMPUTER CODE FOR SEMICONDUCTOR DETECTOR GAMMA-EFFICIENCY CALCULATIONS – APPLICABILITY TO IN-SITU CHARACTERIZATION OF CONTAMINATED SITES*

S. JOVANOVIC, A. DLABAC, N. MIHALJEVIC
University of Montenegro,
Centre for Nuclear Competence and Knowledge Management,
G. Washington Str. 2,
MNE-81000 Podgorica,
Montenegro
E-mails: bobo_jovanovic@yahoo.co.uk, aleksandar@dlabac.com

ANGLE software for semiconductor detector efficiency calculations in its various forms has been in use for 15 years now in numerous gamma-spectrometry based analytical laboratories all around. Its purpose is to allow for the accurate determination of the activities of gamma spectroscopic samples for which no "replicate" standard exists, in terms of geometry and matrix. ANGLE employs a semi-empirical "efficiency transfer" approach, which combines advantages of both absolute (Monte Carlo) and relative (traceable-source-based) methods to determine sample activity by gamma-spectrometry, while reducing the practical limitations of the latter methods and minimizing potential for systematic errors in the former. The physical model behind is the concept of the effective solid angle – a parameter calculated upon the input data on geometrical, physical and chemical (composition) characteristics of (i) *the source* (incl. its container vessel), (ii) *the detector* (incl. crystal housing and end-cap) and (iii) *counting arrangement* (incl. intercepting layers between the latter two).The program can be applied to practically all situations encountered in gamma-spectrometry practice, e.g. for environmental monitoring, radioactivity control, NAA, scientific research applications, etc. Point, disc, cylindrical or Marinelli samples, small or large, of any matrix composition, measured on coaxial, planar or well-type detectors, HPGe or Ge(Li) can be treated. No standards are required, but a start-up "reference efficiency curve" must be obtained, generally as a one-time procedure. Latest ANGLE v3.0 version is presented. Besides its (i) wide range of applicability, (ii) high accuracy, (iii) ease-of-use, (iv) short computation times, (v) flexibility in respect with input parameters and output data, (vi) easy communication with another software and (vii) suitability for teaching/training purposes, ANGLE architecture offers potential for (viii) accommodating other efficiency calculation methods of semi-empirical or absolute (Monte Carlo) type and for (ix) expanding its current scope of applicability to further/particular user's needs and/or fields of interest. A key aspect and difference from other approaches, which greatly enhances practicality, is that (x) no "factory characterization" of the detector response is required – any detector may be used as long as some basic knowledge concerning its construction is available. Besides the years of practical utilization, accuracy of the software is recently successfully tested in an IAEA-organized intercomparison exercise – ANGLE scored 0.65% average deviation from the exercise mean for $E_\gamma > 20$keV energies. Applicability of ANGLE to in-situ radioactivity measurements, including surface and in-depth contamination, is straightforward. It goes simply about defining "counting geometry" as either (i) *an infinite slab*, when detector is placed above the surface, or (ii) *an infinite Marinelli source*, when put into a hole dug in the soil, so as to increase detection efficiency and reduce counting times. ANGLE is commercially distributed by AMETEK/ORTEC, U.S.A.

* Published in part in: S. Jovanovic et al., Nucl. Instr. and Meth. A (2010), doi:10.1016/j.nima.2010.02.058, in press