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1. Name of Code: Monte Carlo Program 15-2 (NMPO No. 648)
2. Computer and Programming System: IBM 7090 and 7094—FAP
3. Nature of Code: Program 15-2 calculates the energy spectrum and angular distribution of gamma rays at a point detector due to single and multiple scattering in air from a monoenergetic, monodirectional point source. The single-scattering contribution to the detector energy-angle distribution is computed by numerical integration. Second- and higher-order scattering is determined using Monte Carlo techniques.

   First-collision points for the Monte Carlo calculation are obtained using systematic sampling. Subsequent collision points are determined randomly. A quota sampling scheme is used to allow a more intensive study of those histories that contribute the most error to the problem. Scoring is done at second- and higher-order collision points using a statistical estimation technique. Optional variance reduction techniques are: biased sampling of the scattering angle from an isotropic distribution with weighting according to the Klein-Nishina relationship; and exponential transformation depending on the energy, position and direction of the gamma ray with respect to the detector.
4. Restrictions: Number of detector energy intervals ≤ 30
   Number of detector polar-angle intervals ≤ 30
   Number of detector azimuthal-angle intervals ≤ 4
   Number of multiple collisions per history ≤ 50
5. Machine Requirements: 32-K core memory, 2 magnetic-tape units.
6. Typical Running Time: Computation times are quoted in DC 60-10-150 for preliminary calculations with an earlier version of this code on an IBM 704.
7. Status: Production. Code package CCC-4 is available from Radiation Shielding Information Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
8. *References*:

[1]N. R. Baumgardt, A. Trampus and J. E. MacDonald, "Program 15-2, Monte Carlo Calculation of Gamma Ray Scattering in Air," XDC 61-5-1.

[2]M. A. Capo, "Determination of Suitable Parameters for Compiling Gamma Ray Air Scattering Probabilities," DC 60-10-150, (October, 1960).

N. R. Baumgardt
J. E. MacDonald

Nuclear Materials and Propulsion Operation
General Electric Company
Cincinnati, Ohio

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1. Code Name: Point Kernel Programs 14-0, 14-1 and 14-2 (NMPO Nos. 69, 70 and 71)
   Data Check Program 14-3 (NMPO No. 128)
2. Computer and Programming System: IBM 7090 and 7094—FAP
3. Nature of Problem Solved: Programs 14-0, 14-1 and 14-2 evaluate point kernels and integrate trapezoidally over source regions to perform reactor-shield penetration calculations for neutrons and gamma rays. Neutron and gamma-ray fluxes, spectra, and dose and energy absorption rates can be optionally computed by Programs 14-0 and 14-1 for positions in and around complex shields containing multiple sources described in a cylindrical-coordinate system. Program 14-2 can be used for sources described in a rectangular-coordinate system. Reactor-shield weight can also be computed.

   Reactor and shield geometries are described by combinations of regions formed by rotation of rectangles and trapezoids about the reactor-shield axis or parallel axes or by translation of convex quadrilaterals parallel to any axis of the rectangular-coordinate system. Compositions are expressed as volume fractions for each material in the assembly. Source density distributions are described in Program 14-0 by either cosine or exponential functions. Source densities are described in Programs 14-1 and 14-2 by tabular input.

   Program 14-3 performs an extensive check of input data to Programs 14-0, 14-1 and 14-2 for range of values, sign, sequencing and completeness.
4. Method of Solution: A modification of the Albert-Welton theory of neutron attenuation is

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used for fast-neutron flux or dose-rate calculations in hydrogenous materials. Buildup factors computed by empirical expressions are used in conjunction with exponential attenuation to compute gamma-ray fluxes and dose and energy absorption rates. Bivariant polynomial functions are used for computation of differential spectra.

5. Restrictions: Enough physical and source-description capability is provided that nuclear analysis of reactor-shield assemblies, which contain sources that can be described in cylindrical- or rectangular-coordinate systems, should involve little uncertainty except that associated with the point kernels.
6. Machine Requirements: 32-K core memory and 2 magnetic-tape units for each.
7. Typical Running Time: Program 14-0, 14-1 and 14-2 computation time depends on the complexity of the source-shield description and the output requested; it varies from short to long. Program 14-3 running time is short.
8. Status: Code packages CCC-1 (14-0 and 14-3), CCC-2 (14-1 to 14-3), and CCC-3 (14-2 and 14-3) are available from Radiation Shielding Information Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
9. *References:*

[1]J. T. Martin, J. P. Yalch and W. E. Edwards, "Shielding Computer Programs 14-0 and 14-1, Reactor Shield Analysis," XDC 59-2-16, (January 1959).

[2]J. T. Martin, J. P. Yalch and W. E. Edwards, "Shielding Computer Program 14-2, Reactor Shield Analysis," XDC 50-6-173, (June 1959).

[3]M. C. McDonald, "Shielding Computer Program 14-3, Data Check for Shielding Computer Programs 14-0, 14-1 and 14-2," XDC 59-3-52, (December 1958).

J. P. Yalch
W. E. Edwards

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1. Code Name: Gamma Single-Scattering Program 05-0 (NMPO No. 59)
   Neutron Single-Scattering Program 09-0 (NMPO No. 64)
2. Computer and Programming System: IBM 7090 and 7094–FAP
3. Nature of Code: Programs 05-0 and 09-0 calculate the dose rate at any specified, unshielded point detector due to single-scattered gamma rays and fast neutrons, respectively, in an infinite, homogeneous medium from an anisotropic point source. The source energy spectrum may be approximated by ten discrete values of the energy. Exponential attenuation may be considered on either scattering leg as desired. The dose rate is determined by trapezoidal integration for each source energy, and the total dose rate is obtained by summation over all source energies.
4. Machine Requirements: 32-K core memory.
5. Typical Running Time: Less than one minute per receiver point.
6. Status: Production. Code packages CCC-25 (05-0) and CCC-26 (09-0) are available from Radiation Shielding Information Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
7. *References:*

[1]J. J. Loechler, J. E. MacDonald and H. M. Van Valkenburg, "704 Program Report, Aircraft Nuclear Propulsion Shielding Program 05-0," XDC 59-8-218, (July 1959).

[2]J. W. Haffner, J. J. Loechler and J. E. MacDonald, "IBM 704 Program Report, Aircraft Nuclear Propulsion Shielding Program 09-0," APEX 533, (December 1958).

J. E. MacDonald

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