# Computer Code Abstract

## CYLTRAN

1. Program Identification: CYLTRAN, a cylindrical geometry, multimaterial electron/photon Monte Carlo transport code.[1]

2. Description of Physical Problem Solved: CYLTRAN describes the generation and transport of the electron/photon cascade from several MeV down to 1.0 keV for electrons and 10.0 keV for photons, respectively, for multimaterial geometries that are invariant with respect to rotations about some line (axis of symmetry). Source particles may be either electrons or photons; monoenergetic or source spectra are allowed; and source angular distributions may be monodirectional, cosine law, or isotropic. The most important output data are (a) charge and energy deposition profiles, (b) integral energy and number escape coefficients for both electrons and photons, and (c) escape coefficients for electrons and photons that are differential in energy, in angle, and in both energy and angle.

3. Method of Solution: The CYLTRAN code combines condensed-history electron Monte Carlo[2] with conventional single-scattering photon Monte Carlo. The electron transport includes energy-loss straggling, elastic scattering, and the production of knock-on electrons, continuous bremsstrahlung, characteristic x rays, and annihilation radiation. Photon transport includes the photoelectric, Compton, and pair-production interactions, along with the production of the corresponding secondary particles. Electron cross sections and sampling distributions are obtained from DATAPAC-4 and LIBRARY TAPE 2 of the ETRAN Monte Carlo code system.[3] Photon cross sections are the analytical fits of Biggs and Lighthill.[4] Although the material geometry is two-dimensional, trajectories are fully three-dimensional. CYLTRAN is a user-oriented code in the sense that it was designed to provide both experimentalists and theorists with a method for the routine, but sophisticated, solution of basic transport problems. For example, as a consequence of automated subzoning and boundary-crossing logic, only eight input cards are required to obtain two-dimensional charge and energy deposition profiles in a single material for a monoenergetic source. On the other hand, the completeness with which CYLTRAN describes the radiation transport and the flexibility of its construction make it possible for the user to extend its capabilities significantly through relatively simple updates. Examples of these extended capabilities are (a) energy spectrum and spatial distribution of the internal flux, (b) spectrum of absorbed energy (pulse-height distribution without electronics distortion) for selected active regions of the material geometry, (c) azimuthal dependence of escaping particles, (d) forcing of photon collisions, (e) biasing of bremsstrahlung and characteristic x-ray production, and (f) zone-dependent electron cutoff energies. Every output quantity is followed by the best estimate of its statistical standard error. By storing the five largest cross-section arrays in Extended Core Storage (ECS) instead of Central Memory, the Central Memory requirement has been reduced more than 50 000 decimal locations. Further reductions are possible at little or no increase in running time whenever such fast peripheral access is available.

4. Related Material: CYLTRAN contains much of the same logic found in the TIGER (Ref. 5) and ETRAN (Ref. 3) codes, which are appropriate for simpler material geometries. Comments, suggestions, and/or consultation are welcomed by the authors.

5. Restrictions: The problem configuration is limited to no more than 100 material or void zones. A problem may not involve more than 5 unique homogeneous materials, each of which contain no more than 20 elements. The method is more accurate at higher energies, with a less rigorous description of the particle cascade at energies where the shell structure of the transport media becomes important. The only shell effects considered are ionization of, fluorescence of, and Auger emission from the K-shell of the highest-atomic-number element in each material.

6. Computer: CDC 6600.

7. Running Time: So many parameters affect the problem run time that it is not possible to estimate a "typical" machine time. However, run times do vary almost linearly with the number of histories. The average time per history in the calculation of the argon laser two-dimensional energy deposition profile shown in Fig. 7 of Ref. 1 was ~0.1 s.

8. Programming Languages: The code is written in FORTRAN IV. A major effort was made to remove nonstandard and installation-dependent usages.

9. Operating System: The code runs under the SCOPE 3.3 system with the FTN (OPT = 2) compiler.

10. Machine Requirements: Four input/output files (two input cross-section files and two scratch files) and two system input/output files are required. The central memory storage requirement is 156 000 (octal) words. In addition, 245 000 (octal) words of ECS are required. Data are transmitted to and from ECS in blocks of variable size, so that with some program modifications, disk, drum, or tape storage can be substituted for ECS.

11. Material Available: Source deck, cross-section files, test problems, results of executed test problems, and the reference document[1] are available from the Oak Ridge Radiation Shielding Information Center.

12. *Acknowledgment*: This work was supported by the U.S. Energy Research and Development Administration.

13. *References*:

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[2]M. J. BERGER, "Monte Carlo Calculation of the Penetration and Diffusion of Fast Charged Particles," *Methods in Computational Physics*, Vol. 1, Academic Press, New York (1963).

[3]M. J. BERGER and S. M. SELTZER, "ETRAN Monte Carlo Code System for Electron and Photon Transport Through Extended Media," CCC-107, Radiation Shielding Information Center, Computer Code Collection, Oak Ridge National Laboratory (1968).

[4]F. BIGGS and R. LIGHTHILL, "Analytical Approximations for X-Ray Cross Sections II," SC-RR-71 0507, Sandia Laboratories (1971); F. BIGGS and R. LIGHTHILL, "Analytical Approximations for Total Pair-Production Cross Sections," SC-RR-68-619, Sandia Laboratories (1968).

[5]J. A. HALBLEIB, Sr. and W. H. VANDEVENDER, *Nucl. Sci. Eng.*, **57**, 94 (1975).

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