# Computer Code Abstract

## TIGER

1. Program Identification: TIGER, a one-dimensional, multilayer electron/photon Monte Carlo transport code.[1]

2. Description of Physical Problem Solved: TIGER describes the generation and transport of the electron/photon cascade in multislab geometries from several MeV down to 1.0 keV for electrons and to 10.0 keV for photons. Source particles can be either electrons or photons; monoenergetic or source spectra are allowed; and source angular distributions can be monodirectional, cosine law, or isotropic. The most important output data are (a) charge and energy deposition profiles; (b) integral energy and number transmission and reflection coefficients for both electrons and photons; and (c) transmission and reflection coefficients for electrons and photons that are differential in energy, in angle, and in both energy and angle.

3. Method of Solution: The TIGER 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 radiation, 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] TIGER 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, only ten input cards are required for monoenergetic particle sources. On the other hand, the completeness with which TIGER 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. Every output quantity is followed by the best estimate of its statistical standard error. Although CDC 6600 central memory is sufficient without it, central memory has been reduced more than 50 000 decimal locations by storing the three largest electron cross-section arrays in extended core storage (ECS). Further reductions are possible at little or no increase in running time wherever such fast peripheral access is available.

4. Related Material: The TIGER code contains ETRAN-15 (Ref. 3) as a subset and, insofar as possible, the logic of the latter has been preserved. Comments, suggestions, and/or consultation are welcomed by the authors.

5. Restrictions: The problem configuration is limited to no more than 50 material layers. A problem cannot involve more than 5 unique homogeneous materials, each of which contains 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 aluminum/gold energy deposition profile shown in Fig. 5 of Ref. 1 was ~ 0.1 sec.

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 202 000 (octal) words. In addition, 213 000 (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 United States Atomic Energy Commission.

13. *References*:

[1]J. A. HALBLEIB, Sr. and W. H. VANDEVENDER, "TIGER: A One-Dimensional, Multilayer Electron/Photon Monte Carlo Transport Code," SLA-73-1026, Sandia Laboratories (1974).

[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 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); also F. BIGGS and R. LIGHTHILL, "Analytical Approximations for Total Pair-Production Cross Sections," SC-RR-68-619, Sandia Laboratories (1968).

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