Computer Code Abstracts

MECC-3

A Monte Carlo Intranuclear-Cascade Code for Medium-Energy (<3500 MeV) Particle-Nucleus Collisions

1. Names of Programs: MECC-3 and associated analysis code I4C.

2. Computers for Which Programs are Designed: IBM 360/75 and 360/91.

3. Nature of Physical Problem Solved: MECC-3 calculates the results of nuclear reactions caused by the collision of medium- to high-energy particles with nuclei. The incident particles may be protons or neutrons with energies from 1 to 3500 MeV or charged pions with energies from 1 to 2500 MeV. Target nuclei may be any element from ^{4}He to ^{239}Pu. MECC-3 writes a history tape containing data on the properties of the particles escaping from the nucleus as a result of the particle-nucleus collision. The data consist of the types of escaping particles, and their energies and angles of emission. The associated analysis code I4C utilizes the data on the MECC-3 history tape to calculate particle multiplicities and various cross sections, such as the nonelastic cross section or the doubly differential cross section for energy-angle correlated distributions. I4C also carries the nuclear reaction through an additional phase, that of evaporation, and calculates evaporation residual nuclei (radiochemical) cross sections and the particle multiplicities and energy spectra of particles "boiled off" from the nucleus after the cascade has stopped.

4. Method of Solution: MECC-3 is based on the assumption that nuclear reactions involving high-energy particles can be described in terms of particle-particle collisions within the nucleus. The life history of each individual particle is traced as the incident particle and the subsequent generations of particles involved in collisions wind their way through the nucleus. The point of collision, the type of collision, the momentum of the struck nucleon, and the scattering angles for each collision are determined by statistical sampling techniques. Free-particle experimental data are used whenever cross-section data are required. Cross sections and distributions resulting from the nuclear reactions are calculated in the associated analysis code I4C by taking the average value of many results. For example, the doubly differential cross section for an energy-angle correlated distribution of a particular type of particle is calculated by counting the number of times a particle is emitted in the specified energy range and into the specified angular interval, dividing this number by the energy range, angular interval, and number of incident particles, and multiplying by the geometric cross section.

5. Restrictions on the Complexity of the Problem: The range of validity of MECC-3 is from about 100 to 2500 MeV for incident nucleons and from about 100 to 1500 MeV for incident pions on targets heavier than carbon. The maximum possible number of incident-particle histories is $< 10^{6}$.

6. Typical Running Time: The approximate running times on the IBM 360/75 per 1000 incident particles range from ~1 min for a 1-GeV particle on oxygen to 10 min for the same energy particle on lead, and from 1.5 min for a 2.5-GeV particle on oxygen to 20 min for the same energy particle on lead. The I4C analysis code with all options takes approximately one-fifth of the MECC-3 running time.

7. Unusual Features of the Program: MECC-3 uses an exact sampling technique to determine the collision site and the types of particles in the reaction.

8. Related and Auxiliary Programs: The Nuclear Configuration Code creates a new input tape for MECC-3 with changed nuclear-configuration data. In MECC-3, three nuclear regions are used to approximate a continuous nucleon-density distribution in the nucleus. The radii of these regions may be changed by using the Nuclear Configuration Code.

9. Status: MECC-3 and I4C have been in production use on the IBM 360/75 and 360/91 computers at the Oak Ridge National Laboratory Computing Center.

10. Machine Requirements: MECC-3 requires ~470K of core and I4C requires ~1030K of core. Both codes require two nine-track tape drives in addition to the standard I/0 devices.

11. Programming Languages Used: Both programs are written in FORTRAN IV except for random-number generating subroutines, which are in assembly language.

12. Operating System or Monitor under Which Programs are Executed: IBM 360 System/Operating System, Level 18, FORTRAN H.

13. Other Programming or Operating Information or Restrictions: MECC-3 has 75 subroutines and ~6000 source cards. I4C, with 36 subroutines and ~4500 source cards, uses an overlay structure with 3 overlay segments.

14. Material Available: The codes and documentation may be obtained through the Radiation Shielding Information Center (RSIC) at the Oak Ridge National Laboratory.

15. *Acknowledgment*: This work was partially funded by the National Aeronautics and Space Administration, Order No. H-38280A, under Union Carbide Corporation's contract with the U. S. Atomic Energy Commission.

16. *References*:

H. W. BERTINI, M. P. GUTHRIE, and O. W. HERMANN, "Instructions for the Operation of Codes Associated with MECC-3, a Preliminary Version of an Intranuclear-Cascade Calculation for Nuclear Reactions," ORNL-4564, Oak Ridge National Laboratory (1971).

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VIXEN

1. Name of Program: VIXEN.
2. Computer for Which Program is Designed: CDC-6600. The code also executes on the CDC-7600 and IBM-360 computers.
3. Nature of the Problem Solved: Checks are made on the ENDF photon production files (12-15) for format syntax, consistency, and physical realism. Some typical checks made are (a) comparing the photon energies and their corresponding nuclear level energies, (b) checking total photon energy released against reaction energetics, and (c) verifying the normalization of the continuous photon energy probability distributions. Quantities useful to the cross-section evaluators and reviewers are also printed on the output listing. One such quantity is the total photon energy released at each tabulated neutron energy. Suspected errors are flagged on the output listing.
4. Method of Solution: Most operations are Boolean (logical tests).
5. Restrictions on the Complexity of the Problem: The total number of discrete-energy photons plus photon continua is restricted to be <500.
6. Typical Running Times: 1 min (CDC-6600); 13 sec (CDC-7600).
7. Unusual Features of the Program: None.
8. Related and Auxiliary Programs: VIXEN replaces an earlier code, PHOXE. VIXEN input is independent of other codes, but all ENDF data should be checked for syntax errors by the CHECKER code before being processed by VIXEN.
9. Status: In use on CDC-6600, CDC-7600, and IBM-360.
10. Machine Requirements: Two scratch files (disk, drum, extended core storage, or tapes) in addition to three system input/output units (card reader, magnetic tape unit, and printer).
11. Programming Language Used: FORTRAN IV, with only three IF(EOF)i,j statements (end-of-file checks) peculiar to the CDC-6600 and CDC-7600 systems.
12. Operating System or Monitor Under Which Program is Executed: CDC-6600 Scope 3.1.2 (locally modified to LASL 3.05).
13. Other Programming or Operation Information or Restrictions: None.
14. Material Available: A code package identified as PSR-30/VIXEN is available from the Radiation Shielding Information Center at Oak Ridge National Laboratory. The package contains (a) a FORTRAN deck, (b) a sample problem (an ENDF evaluation for silicon) input and output, and (c) an INDEX (cross reference) listing of the code. A report[1] describing the code is available.
15. *Acknowledgment*: This work was performed under the auspices of the U. S. Atomic Energy Commission.
16. *References*:

[1]DONALD J. DUDZIAK and JOHNNY M. ROMERO, "VIXEN, a Physical Consistency Checking Code for Photon Production Data in Revised ENDF Format," LA-4739 (ENDF-155), Los Alamos Scientific Laboratory (1971).

DONALD J. DUDZIAK, Ed., "ENDF Formats and Procedures for Photon Production and Interaction Data," LA-4549 (ENDF-102, Rev., Vol. II), Los Alamos Scientific Laboratory (1971).

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