momentum or kinetic energy of 3 in either frame, and angle of 3 in either frame.

KINE essentially generates tables of kinematic and dynamic variables. Depending on the input, its output consists of the kinetic energies, momenta, and angles of particles 3 and 4 in both frames, as well as their η, β, and $d\Omega_{\mathrm{LAB}}/d\Omega_{\mathrm{c.m.}}$. In addition, the η, β, and γ of the center of mass; the relative velocity, phase space, and total opening angle of the final-state particles; and the threshold energy and momentum of the incident particle are calculated.

This program is available in deck form from the author and a full write-up has been prepared [W. P. TROWER, "FORTRAN Program KINE: Calculating Kinematical and Dynamical Quantities for Particle Interactions and Decays," Report UCRL-11650. Lawrence Radiation Laboratory, September (1964) (unpublished)].

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A Fortran Subroutine for Calculating the Range-Energy Relation of Charged Particles in Chemical Elements[1]

A problem inseparable from any experimental particle physics is that of determining the energy loss of a charged particle as it passes through matter. We have constructed a computer program to easily give useful and accurate solutions to this problem. The program is constructed basically to evaluate the Bethe-Bloch equation for all charged particles except electrons and positrons. At low energies shell corrections are applied. At high energies density-effect corrections are applied.

[1] Work performed under the auspices of the U.S. Atomic Energy Commission; AEC Contract No. W-7405-eng-48.

Since the Bethe-Bloch equation yields the differential energy loss of the particle in millielectron volts per centimeter, we can obtain the range of the particle by direct integration, using low-energy proton experimental ranges to initiate the integration. The range of a particle is given as a function of energy or momentum in terms of three units: centimeters, gram-centimeters^2, and moles of electrons per centimeters^2. This calculation is made for any homogeneous target material that is a chemical element. Using the results of element calculations, we can readily compute the energy loss and range in chemical compounds and mixtures [1].

The results of representative calculations have been checked with experimental results and have been found to be in good agreement. Figure 1 displays both calculated and experimental range results for protons in copper in the energy interval of 1 MeV to 100 BeV [2–5].

The user must specify the charge of the target atom, the charge and

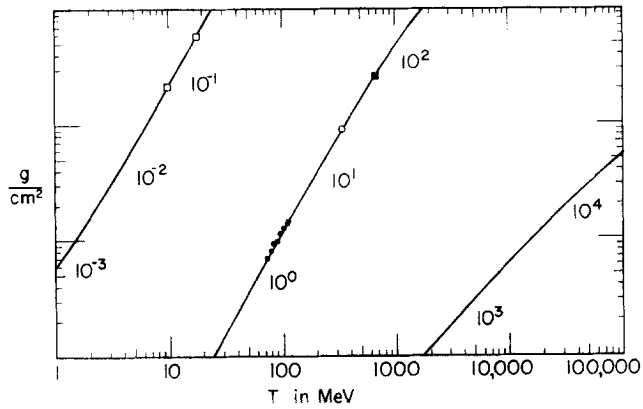

FIG. 1. Graph of proton range in copper generated by program RANGE ($I = 322$ eV). Points plotted according to data of Bloembergen and Van Heerden [3] (●); Bichsel [2] (□); Mather and Segrè [4] (○); and Zrelov and Stoletov [5] (■). (——) Calculated from RANGE ($I = 322$ eV).

mass of the particle, and the energy range of his interest. He may, in addition, specify the atomic number, mean ionization potential, and density of the target material if he wishes to override the internally stored data of the program with that of his choice.

This program is available in deck form from the author. A full write-up, which includes a listing of the source program as well as fixed data, has been prepared [W. P. TROWER, "FORTRAN Subroutine RANGE:

Calculating the Range-Energy Relation for Charged Particles in Chemical Elements," Report UCRL-11643. Lawrence Radiation Laboratory, September (1964) (unpublished)].

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