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CALOR As A Single Code Including A Modular Version of HETC

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Abstract

The major components of CALOR are HETC, MORSE, EGS4, EGS4PREP, and SPECT, working sequentially on calorimeter detector for high energy physics, experimental analysis, or shielding studies. An effort to combine the components into a single code is described. The new code is modular in nature. For example, one may run only HETC and MORSE. In addition, HETC itself has become modular and may be run in three energy options - up to 2.5 GeV, 15 GeV, and 20 TeV. The size of the low-energy option of HETC is less than 40% of the original HETC. A great advantage of the new code is the elimination of three huge files for passing information from one component to another.

1. Introduction

CALOR [1] is a system of Monte Carlo particle transport codes designed primarily for the determination of calorimeter parameters for high-energy particle detectors [2], experimental analysis, or high-energy radiation shielding problems [3].

The major components of CALOR are HETC [4,5,6,7], MORSE [8,9,10], EGS4 [11], EGS4PREP [1], and SPECT [1]. An effort to combine them into a single code is described in this report. The new CALOR reads in the geometry input only once, shares many inputs and subroutines common to the components, uses the same set of random number utilities, and eliminates the need for writing three huge files to pass information from one component to another.

The new CALOR is modular in nature. For example, one may run HETC and MORSE as a single code for neutron activation analysis. In the KEK proton accelerator beam dump experiments [3], activation detectors were designed to cover the energy range from 1 eV to 500 MeV. Some detectors are sensitive to MORSE only (less than 20 MeV), some to HETC only (above 20 MeV), and some to both. When HETC and MORSE are run as a single code, one gets all the results at once. This calculation is used as one of the sample problems.

The modular version of HETC starts with the most recent version [6] that includes a pre-equilibrium model [7] to bridge the existing intranuclear-cascades and evaporation models. The modular version of HETC may be run in three energy options - up to 2.5 GeV, 15 GeV, and 20 TeV. The low-energy option of the code is less than 40% of the original HETC and the user of this option does not need to compile and load the other 60%. Using the low-energy option of HETC, plus savings due to the sharing of many subroutines, the size of the new CALOR is smaller than the original HETC.

Dynamic dimensionings of arrays have been introduced to the new CALOR for the parts of the dimensions that can be determined from the input file. For example, many

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dimensions containing the total number of incident particles can be set in the beginning of the code.

2. The Sequential CALOR

The original CALOR and its components are shown in Fig. 1. One starts with HETC, the hadron transport code. All events, including particle productions, boundary crossings, etc., are written onto a file (HETC file). From this file, SPECT extracts the information it needs for hadron analysis. EGS4PREP reads the HETC file to prepare the electromagnetic source (EGS4PREP file) to be read by EGS4. MORSE reads the HETC file to extract the low-energy neutrons for neutron transport and photon production. MORSE writes a photon file (MORSE file) to feed EGS4 for photon transport. The four independent results - from SPECT, HETC-EGS4, MORSE, and MORSE-EGS4 - are combined for final analysis.

The input preparation codes, LIGHT for saturation curves and PEGS for EGS4 cross sections, stay unchanged and will not be disussed further.

Detailed descriptions of the sequential CALOR can be found in ref [2] and references therein. Reference [2] described analyses of several liquid-argon calorimeter experiments for incident electrons and pions in the energy range between 5 and 100 GeV. Since then, many improvements have been made to HETC - the most important is an addition of a pre-equilibrium model, described below.

3. The Modular Version of HETC

HETC is composed of several particle production models. A recent addition to these models is CEM95 developed by Mashnik [7] that includes intranuclear-cascade, pre-equilibrium, and evaporation models. CEM95 cannot do hydrogen and may not be better than the Bertini model [4] for target mass numbers less than 16. Therefore, CEM95 in HETC is an addition rather than a replacement. The upper energy limit for both Bertini and Mashnik is 3.5 GeV for nucleons and 2.5 GeV for pions. These models form the low energy (2.5 GeV) option of CALOR.

For energies higher than 3.5 GeV for nucleons and 2.5 GeV for pions, HETC uses the scale model [4] to bridge the Bertini-Mashnik model and the fragmentation model developed by Ranft and Ritter [12] and modified extensively [5] for its use in HETC. The energy (usually 15 GeV) separating the scale model and the fragmentation model is an input to HETC.

Adding the scale model to the low-energy option, one gets the 15-GeV option. Adding both the scale and the fragmentaion models, one returns to the original HETC or the 20-TeV option. This energy is the highest used by HETC.

An immediate use of the modular version of HETC is its application for the design of the target and target room of the Spallation Neutron Source [13]. The incident proton energy is 1 GeV, suitable for the low-energy option of HETC - a much smaller code to compile and load.

4. CALOR as a Single Code

As a single code, all components of CALOR become subroutines. The main program sets the dimensions for many large arrays using dynamic dimensioning by scanning the input file. Some dimensions can be set exactly, such as those depending on the number of incident particles and the number of detectors. Some others can be estimated wisely, such as those proportional to the energy of the incident particles. Needless to say, similar dimensions used by the components are now unified. The main program calls HETC which calls SPECT, MORSE, and EGS4PREP. MORSE calls EGS4 to transport secondary photons produced in MORSE and EGS4PREP calls EGS4 to transport electrons, positrons, and photons produced in HETC. One gets SPECT, HETC-EGS4, MORSE, and MORSE-EGS4 results in one run.

An advantage to run CALOR as a single code is the elimination of the three huge files described in Section 2: HETC file, EGS4PREP file, and MORSE file. The HETC file, extremely large for certain applications, has in the past been a limiting factor for how many incident particles one could run without getting into storage problems.

The geometry input needs to be read and processed only once in the single-code version instead of four times in the sequential version - by HETC, MORSE, HETC-EGS4, and MORSE-EGS4.

The new CALOR combines the required inputs of the components into one file without redundent information. Many subroutines common to the components are shared. The outputs of the components are written into one file with unified formats.

CALOR as a single code is modular in nature. By adding a few extra subroutines to the package, one obtains other options: (1) HETC, MORSE, and EGS4 as stand-alone codes, (2) HETC and MORSE, (3) HETC and EGS4, (4) HETC and SPECT. Makefiles to generate the executables for these options are provided.

Two sample problems have been chosen. For the new CALOR and all other options, a CsI calorimeter for the SLAC BaBar detector has been tested. The other sample problem, the KEK beam dump analysis [3] already mentioned in the introduction, is intended as an additional one for the HETC and MORSE combination. This combination is expected to be the most characteristic for shielding application and demonstrates the generation of neutron fluxes at desired locations.

A user's manual is in preparation and will include a detailed explanation of the subroutines a user has to modify for a special application. One cannot appreciate the power of the present package without a full understanding of these subroutines. For example, in former calculations with the old CALOR pachage the authors ran EGS4 for incident electrons and coupled the secondary photon tracks with a photo-hadron library to generate a secondary hadron file and a low-energy neutron file. HETC read the hadron file and transported the secondary hadrons and wrote another low-energy neutron file. The two low-energy neutron files were combined for a fourth file as input to MORSE. With the new CALOR package, it is not difficult to generate a single code to run the EGS4, HETC, and MORSE sequence all at once, without having to create the four particle files.

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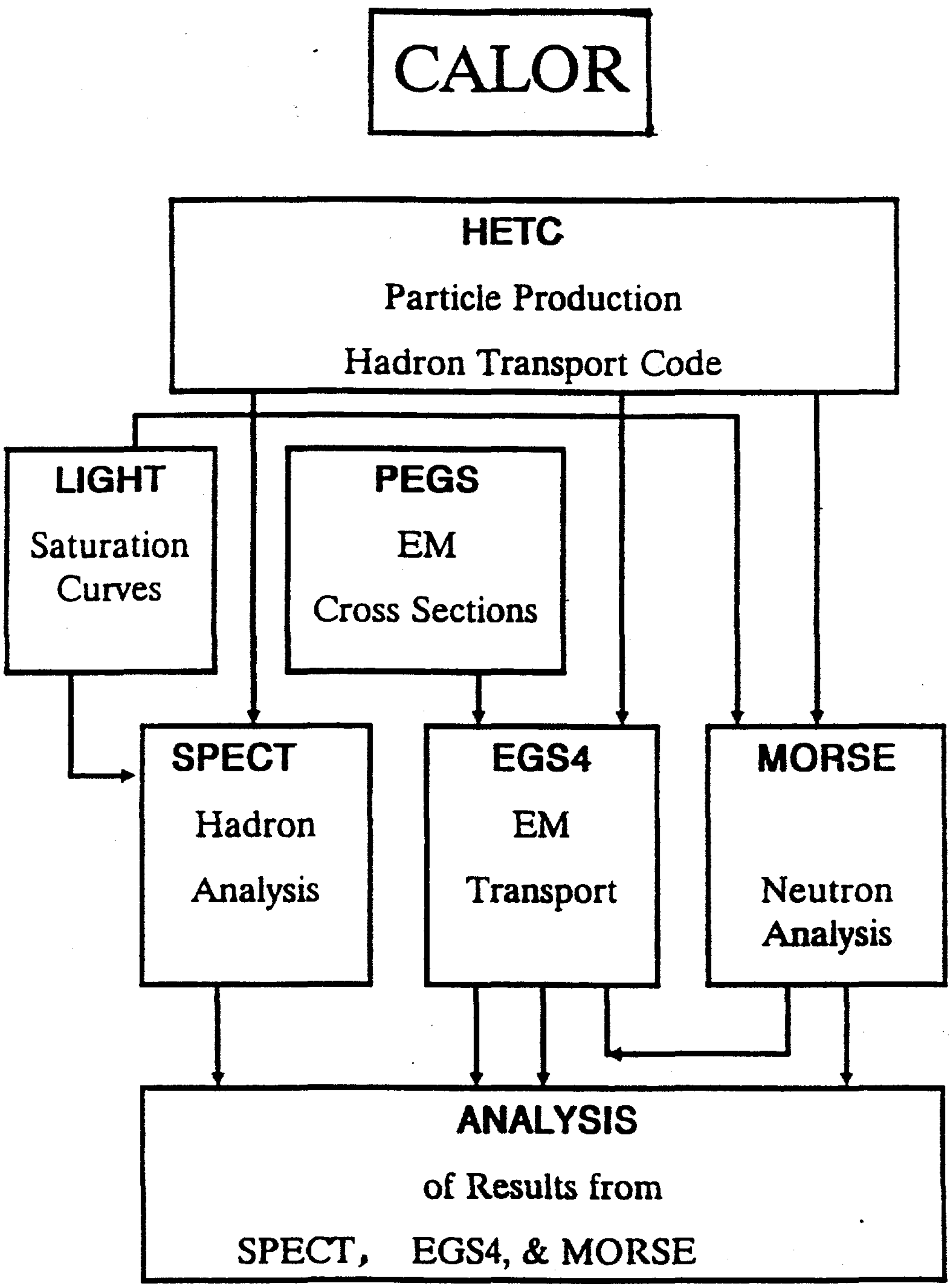

Fig. 1 Components of CALOR