

BNL-104705-2014-TECH

AGS/AD/Tech Note No. 287;BNL-104705-2014-IR

CASIM on VAX

A. J. Stevens

August 1987

Collider Accelerator Department Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No.DE-AC02-76CH00016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Alternating Gradient Synchrotron Department BROOKHAVEN NATIONAL LABORATORY Associated Universities, Inc. Upton, New York 11973

Accelerator Division Technical Note

AGS/AD/Tech. Note No. 287

August 25, 1987

A. J. Stevens

CASIM on VAX

I. Introduction

This note describes some aspects of the Fortran Monte Carlo code CASIM which is now available on the VAX network at BNL. $CASIM^{1\ 2}$ is a hadron CAscade SIMulation program which can be used to study problems (energy deposition, instantaneous dose, induced activity) associated with beam loss in accelerators. This note makes no attempt to explain the model and methodologies of CASIM, but is more in the line of a "users' guide." The interested reader is referred to Refs. 1 and 2 for more detail.

II. An Important Physics Restriction

At the current time, CASIM propagates only protons, neutrons, and pions through matter and stops propagation at a threshold momentum which, although user specified, should be set at 0.3 GeV/c. CASIM considers all particle, nucleus cross-sections to be constant, which is drastically incorrect below this value for the threshold.

Although the threshold energy presents no problems as concerns energy deposition, deducing quantities related to radiological hazards requires some approximations and a certain degree of craftiness. The user is referred to Section VI of Ref. 1 for more detail. Examples of the use of CASIM in this context are given in two recent Booster reports. 3 ⁴

III. CASIM Input Data

In the simplest use of CASIM, the user interacts with CASIM through input data and a subroutine named HITORM. Although many methods of running the program are possible, this note describes a command file submitted as a batch job. Figure 1 shows a sample command file.

The first line sets the default directory to whatever directory the user desires. CASIM reads, in addition to the input parameters described in this section, a file whose name is RLST.DAT, assumed to be in the user's directory (see Section VI). CASIM reads (except for the RLST.DAT file) from unit 5 and writes on unit 6. As shown, these are assigned to the system I/O streams.

The example also shows a logical file name (SETUP) assigned to a file name SETUP.DAT. This is explained below in connection with the first input line.

The LINK operation shows, in addition to the object module HITORM, an object module for something called CASIMMAIN. This is a dummy main program (CALL CASIM, END) which the user must also supply.

The remainder of this section describes the input stream data illustrated by an example shown in Fig. 1.

Line 1: ITM, IFORCE, ISTOP, IPRESET

ITM is a user supplied elapsed time limit in seconds. If ITM = 0, no time limit is enforced, and the program will (or should) end on a specified number of incident particles (see line 3) or certain conditions specified by values of ISTOP or IPRESET.

IFORCE is a parameter which, if equal to 1, will cause CASIM to force the primary to interact at its starting point. This turns out to be a convenient option at times.

ISTOP is a parameter which, if equal to 1, causes CASIM to stop after drawing a printer representation of the geometry. The drawing is discussed below in connection with the last lines of the input. This option is useful to check that the subroutine HITORM, described in the next section, is properly coded.

IPRESET is a parameter controlling CASIM initialization, which can often be a lengthy procedure, consuming a substantial fraction of a CASIM run. If IPRESET = 0, CASIM executes the initialization, which is a function of the incident and threshold momenta and the materials present, and proceeds to the Monte Carlo. If IPRESET = 1, CASIM executes the initialization procedure, writes the file 'SETUP' (assigned in our example to have the file name SETUP.DAT) and stops. If IPRESET = 2, CASIM skips the initialization, reading the initialization results from the previously prepared file. In the example shown, IPRESET is 2, implying that [MYDIR] SETUP.DAT already exists--having been created in a previous run where IPRESET was 1.

Line 2: IBMCODE, XSZ, YSZ, XOF, YOF, XDV, YDV

The beam is nominally incident along the +Z direction in CASIM. IBMCODE determines the transverse beam shape. If IBMCODE = 1, the initial X and Y are sampled from Gaussian distributions with 1 σ values of XSZ and YSZ. If IBMCODE = 2, the initial X and Y are sampled uniformly in a rectangle with half-widths XSZ and YSZ. Any other value of IBMCODE results in a uniform sampling in a circle with radius XSZ. XOF and YOF are offsets and XDV and YDV are initial values of dx/dz and dy/dz. Note all length units are in cm.

Line 3: ITYPE, P, PTR, CLMU, NUMP

ITYPE is a code for incident particle type, 1 for proton, 2 for neutron, 3 for pion. (Although, in principle, 3 is the code for π^+ and 4 for π^- , CASIM has, currently, a bug which causes π^- to be treated as π^+). P is the incident momentum in GeV/c and PTR is the threshold momentum. As indicated above, PTR should not be set lower than 0.3 <u>CLMU</u> is something called the collision length multiplier. Normally (as in the example), the user should set CLMU = 1.0. For studies involving very deep penetrations, CLMU can be set to larger values. See Ref. 2 for more detail. NUMP is the number of incident particles desired.

Line 4: IEDEP, ISB, ISEED, WECO, CSTEP, RSTEP

IEDEP is an important control parameter. If IEDEP = 0, CASIM calculates star densities only; if IEDEP = 1, CASIM calculates star densities and energy densities; if IEDEP = 2, CASIM calculates energy densities only. Before defining ISB, some explanation of CASIM standard output is required. CASIM obtains energy and/or star densities in a cylinder of dimensions specified by the user (line 7 below). The cylinder is divided into 50 bins in both Z and R. If ISB =1, CASIM further divides the first radial bin into 10 finer regions; this feature is sometimes useful for observing details smaller than the transverse beam size in the same calculation that relatively large values of the transverse distance (R) are also considered. ISEED is the starting value for the random number generator. WECO is the weight cut-off as discussed in Ref. 2; values of 10^{-6} or so are small enough for energies likely to be encountered at BNL. CSTEP and RSTEP are step sizes for cascade and recording particles, explained in Ref. 2. The "proper choice" of these step sizes is a rather subtle problem depending on the characteristics of the specific problem being considered. In the example shown, the cascade step size is comparable to the Z bin size (see below). In general, the recording particle step size can be larger than the cascade step size.

Line 5: INUM

INUM is the number of materials in the problem, which cannot exceed 5. The following INUM lines of input describe each material. Each material is assigned a number in order of occurrence.

Line 6: Z,A,RHO,VIP,RALG,RFM,SIGL

Each material is described by the following properties: atomic number and weight, density in g/cc, ionization potential (VIP) in ev, radiation length (RALG) in cm., nuclear radius (RFM) in Fermis, and nuclear elastic scattering cross section (SIGL) in barns. Line 7 (example): ZLIM, RLIM, ZSTART

ZLIM and RLIM are the dimensions of the cylinder mentioned above, ZSTART is the initial Z value of the incident particle.

Line 8 (example): INUMZ, INUMY

As mentioned above, one of the first outputs of CASIM is a printer plot of the geometry. <u>INUMZ</u> and <u>INUMY</u> are the number of plots at constant Z (X,Y projections) and the number of plots at constant Y (X,Z projections) desired. Up to 10 of each are allowed.

Line 9 (example): XMIN, XMAX, YMIN, YMAX, ZMIN, ZMAX

This line is the "frame" used for the printer plots. For example, the constant Z plots appear on a printer page scaled such that a page of output spans the region between XMIN and XMAX (vertically) and YMIN and YMAX (horizontally). The fact that the same frame is used in all plots is a shortcoming of the current version.

Line 10 (example): ZSL

The next INUMZ lines contain the constant Z values at which X,Y projections are produced. The plots themselves consist only of the material number--0 is vacuum and an asterisk is "out-of-bounds."

Line 11 (example): YSL

The next INUMY lines contain the constant Y values at which X,Z printer plots are produced.

IV. Subroutine HITORM

A sample HITORM is shown in Fig. 2. As shown, it has 9 arguments and the common block /GEOMETRY/. The meaning of ZLIM and RLIM have already been explained. RLIS is simply the square of RLIM.

It is basically the function of HITROM to return the material index number (N) given the input coordinates X.Y,Z. However, complications arise. The integer M is a flag to the calling routines that indicates the presence (or absence if M = 0) of a magnetic field. The "output" coordinates of HITORM must be set; although the input coordinates to HITORM are always specified in a fixed rectangular reference frame, material is specified in a frame chosen by the user. This feature is useful in calculations involving magnetic fields; a further explanation is given in Section VI below.

The sample HITORM is a simple one--a solid cylindrical block. Note that material index 99 corresponds to "out-of-bounds."

V. CASIM Output

CASIM standard output is reasonably self-explanatory. The user will first see the input parameters echoed with explanatory remarks. If printer plots of the geometry were requested, these appear next with "out-of-bounds: regions marked with an asterisk. Next appears calculated parameters related to the materials. The final output before the Monte Carlo begins is information related to the "SETUP" file in case IPRESET is not 0.

A series of de-bugging lines appears during the Monte Carlo execution. Each of these lines begins with "C" or "R" and is intended for "experts" only.

The first line of output after the Monte Carlo is over is misleadingly entitled "Number of Interacting Particles." In fact it is the number of incident particles. The next output is a table giving the fractional energy balance. This is important; if energy is not balanced to within 5 or 6% given several hundred incident particles, it is likely that CASIM has encountered difficulties. The next output gives summary information related to the Cascade and Recording stars and the total energy deposited. (The total energy deposited is NOT simply related to the energy balance categories.)

The next outputs are the star and/or energy density tables--as a function of R and Z. In some cases (depending on the IEDEP selection), tables of "Relative Error" will appear. These are estimates of the 1- σ error of a bin's contents divided by the bin value. It is believable for relative errors of less than ~ 0.3, but highly dubious if greater than ~ 0.7.⁵

The final output consists of tables of radially and longitudinally integrated star and/or energy densities and logarithmic plots which are self-explanatory.

VI. Additional Requirements/Options/Advice

As mentioned above, CASIM reads a file called RLST.DAT. This file should be copied into the user's directory; it is available from BNLCL1:: \$2\$DUA14: [STEVENS.CASIM].

If transport through the magnetic field is desired, the user must supply SUBROUTINE FIELD (XM,YM,ZM,M,BX,BY,BZ). Calls to this subroutine are made immediately following the call to HITORM when M (see HITORM discussion) is not zero. This routine must return the components of the magnetic field (BX,BY,BZ) in KG. in the original fixed coordinate system. The idea here (apparently) is that HITORM uses M to designate and distinguish between different regions of fields-dipole, quad, etc.

•.	
	\$! TEST JOB FOR FIRST STANDARD VERSION
•	\$ SET DEFAULT EMYDIR]
· 1	* ASSIGN SYS#INPUT FORCOS
1	\$ ASSIGN SYSTOUTPUT FORCOG
	* ASSIGN SETUP. DAT SETUP
•	\$ LINK/NOMAP/EXE=CASIM.EXE CASIMMAIN.OBJ
	HITORM. OBJ, BNLCL1:: \$2#DUA14: LETEVENS. CASIMICASIMLIB. DLB/LIB
- 1	# RUN CASIM
·. —	50000, 0, 0, 2/TIME LMT, FORCE FLG, STOP FLG, IPRESET
	1.0.5.0.5.0.0.0.0.0.0.0.0.0/CODE, SIZE, OFFSET, D1VG (X.Y PAIRS)
• •	1, 100., 0. 3, 1., 500/TYPE, P. PTR, CLMU, NUM PART
 	2, 0, 371213, 1. 0E-07, 5., 10. / IEDEP, SMALL BINS, RAN SEED, WECO, STEPS
	17 NUM MATERIALS
· · ·	<u>26.,56.,7.9,285.,1.77,5.35,.420/IRDN</u>
~	200., 50., . 01/2LIM, RLIM, ZSTART
	1, 1/NUM Z, Y GEOM PRINTER PLOTS
• N	-60., 60., -60., 60., -50., 250. /XMIN, XMAX, ETC.
•	10. /Z SLICE
	0./Y BLICE
••	

Fig. 1

1	-
	SUBROUTINE HITORM (X, Y, Z, N, M, K) XM, YM, ZM)
	COMMON/GEUMETRY/ZLIM, RLIM, RLIS
1	N=77
	A Mar A
	IFILLE. V. HALIVAN DD-VRVLVRV
	Le Christen Miller and Franker and the States of States and States
	TE/KT OF 60001THEM
	WRITE(6, 1001)
	1001 FORMAT(' HITORM CALLS EXCEEDED ')
	RETURN
	C
	C THE ABOVE FROM STANDARD HITORM GEOMETRY GOLS HERE
	① 物格集集整整整整
	RETURN

Fig. 2