SIMULNEC

Version 1.0

The algorithm for nuclear-electromagnetic cascade simulation in the atmosphere for emulsion chamber experiments

This algorithm uses the so-called MC0 model of hadron - nucleus interactions based on quark-gluon string model (QGSM) and described in detail elswere [1]. The language used is Microsoft FORTRAN 5.0.

In order to begin simulations of the nuclear-electromagnetic cascade (NEC) in the atmosphere it is necessary to produce a group of files, which have the same group name (arbitrary chosen by you) and different extensions. The name must have not more than 8 characters. For example, you choose the name "SIMUL001". In this case first you must produce two following files:

SIMUL001.BAT and

SIMUL001.DAT

These files must contain the following information.

File "SIMUL001.BAT"

The file SIMUL001.BAT has really only one line (and arbitrary number of commentaries, of course):

SIMULNEC.EXE < SIMUL001.DAT

This means that the program uses the file SIMULNEC.EXE (used in all simulations) and reads information from the file "SIMUL001.DAT".

File "SIMUL001.DAT"

The file SIMUL001.DAT must contain the following information (see the list of items given lower in the file SIMUL001.BAT):

1. NAME OF FILE GROUP FOR INFORMATION SAVING (CH*8)
2. TEMPORARY DISK (CH*1)
3. MINIMAL AND MAXIMAL PRIMARY PARTICLE CODE
   (1=p, 2=Alpha, 3=Li(A=7), 4=C, 5=O, 6=Mg(A=24), 7=Si(A=28), 8=VH(A=52), 9=Fe, 63=e+, 64=e-, 69=GAMMA)
4. IS CASCADE SAMPLED ? MINIMAL AND MAXIMAL PRIMARY ENERGY (TEV) (T/F,R*4,R*4)
5. MINIMAL AND MAXIMAL ZENITH ANGLES (RAD) (R*4,R*4)
6. TOTAL NUMBER OF CASCADES ?
   CASCADE NUMBER BETWEEN DISPLAYS OF CASCADE AND FAMILY NUMBERS ?
   CASCADE NUMBER BETWEEN INFORMATION SAVINGS ? (I*4,I*4,I*4)
7. OBSERVATION LEVEL (g/cm^2) (R*4)
8. ENERGY THRESHOLD FOR ELECTROMAGNETIC PARTICLES (TeV) (R*4)
9. ENERGY THRESHOLD FOR STABLE HADRONS (TeV) (R*4)
10. IS ELECTROMAGNETIC CASCADE SAMPLED ? (T/F)
11. IS DIFFRACTION CROSS-SECTION INCREASED? HOW MUCH? (T/F, R*4)
12. IS DOUBLE DIFFRACTION with LARGE Pt taken into account ?
    Which probability ? Which additional Qt ? Which Pt-sampling channel ?
    Which Mxmin ? (T/F,R*4,R*4,I*4,R*4)
13. IS GENERATION OF NEW SUPERHEVY QUARKS taken into account ?
    IS SUPERHEAVY-HADRON GENERATION taken into account ?
    Which probability ? Which channel ? (T/F,T/F,R*4,I*4)
14. IS Kinel BEHAVIOR QGSM-STANDARD ? Which kind of change [1-4] ? (T/F,I*4)
15. IS EARTH'S MAGNETIC FIELD TAKEN INTO ACCOUNT ? (T/F)

16. IS CLOUD ELECTRIC FIELD taken into account ?
    VERTICAL [1] or HORIZONTAL [2] ?
    HORIZONTAL DIMENSION of ELECTRIC FIELD (cm) ?
    MAXIMUM POTENTIAL of ELECTRIC FIELD (GV) ? (T/F,I*4,R*4,R*4)
17. IS HALO DEVELOPMENT TAKEN INTO ACCOUNT ?
    THRESHOLDS for Gammas and Hadrons [TeV] ? (T/F,R*4,R*4)
18. DOES THRESHOLD (TEV) for Gammas DEPEND ON DEPTH ?
    PARAMETER value [0. - 1.] ? (T/F,R*4)
19. IS EACH CASCADE SIMULATION FREE [1] OR DETERMINED BY A KNOWN INTEGER NUMBER [2] ? (I*4)
20. FIRST and LAST NUMBERS of cascades with total information ? (I*4,I*4)
21. INTEGER numbers determining EACH cascade simulation (it is necessary only if "2" is inputed in no.19)

The real file, i.e., "SIMUL001.DAT", must be the following:

```
SIMUL001
D
2,9
T,10.,10000.
0.,0.75
1000,10,100
594.
5.
10.
T
F,2.
T,0.2,0.,2,10.
F,F,0.1,1
T,3
T
T,1,1.E5,1.
F,1.,1.
F,.0
1
0,0
```

It means that

1. The group name of files is SIMUL001.
2. The logical disk used to record temporary information during cascade simulation is D: (the virtual disk is recommended to be used)
3. The primary spectrum consists of nuclei from α-particles to Fe.
4. The simulation uses the primary-energy interval from 10 TeV to 10 PeV. At that, minimal energy of nucleus, heavier than most light component (here, α-particles), really used in cascade simulations is proportional to square root from the atomic weight.
5. A zenith angle of primaries can be between 0 and 0.75 radian.
6. The number of simulated cascades (primary particles) is 1000.
7. The observation level is 594 g/cm^2.

8. The energy threshold for electromagnetic particles E = 5 TeV.
9. The energy threshold for stable hadrons E = 10 TeV.
10. Electromagnetic cascades initiated by γ- quanta are sampled ("T").
11. Usual diffraction cross-section is not increased ("F"). (in the "T" case it would be two times larger).
12. Double diffraction with large Q_t transfer is taken into account ("T") with the probability 0.2 (it is a formal parameter only, whereas the real probability is lesser). Additional value added to sampled values of Q_t is zero. Sampling values of secondaries' normal-to-string p_t channel occur via 2nd channel ($\langle p_t \rangle \approx 0.2$ GeV/c. Minimal mass M_x^{min} of clusters in such processes is 10 GeV/c.
13. Generation of new superhevy quarks and superheavy-hadron generation is not taken into account.
14. Behavior of $\langle K_{inel} \rangle$ is QGSM-standard. (In opposite case it would change via 3rd channel).
15. The Earth's magnetic field is taken into account.
16. Possible influence of cloud's vertical electric field is taken into account.
17. Halo development is not taken into account, i.e., thresholds for γ's and hadrons in large EPhC is standard.
18. The threshold for γ's does not depend on depth. The parameter value determining the used dependence is 0..
19. The integer number initiating each cascade simulation is determined only as a result of simulation of the previous cascade.
20. No print of total information.

If you have these two files you must create the other files. For that it is necessary to execute file "CREATE.EXE" to create group of "SIMUL001...." files before simulation beginning.

File "CREATE.EXE"

This program during its working will ask you :

FILE GROUP NAME ? (CH*8)

You must input the chosen name (SIMUL001). After that the program will ask you again:

WILL FAMILY INFORMATION BE WRITTEN ? (T/F)

You must input an answer, i.e. "T"(true) or "F" (false). It is necessary to take into account that term "family" means any event of interest, which is a result of the individual cascade development. It can consist of one particle at the observation level, or it may be a high-energy γ-quantum at a high altitude without observable particles. It depends on your choice. If you choose "T", the program ask you:

MINIMUM FAMILY ENERGY (TEV) ?

After obvious answer it asks

MINIMUM FAMILY PARTICLE NUMBER ?

Obviously, this number can vary in a wide range from 1 to very large value. The following question is

WILL INTERACTION INFORMATION BE WRITTEN ? (T/F)

If you input "T" (true), the program would write some information on interactions generating detected particles. It will be described in detail lower. After that the program will ask you

DOES PROGRAM CHECK LEADER HADRON ? (T/F)

If you input "T" (true), the program controls the cascade development and writes information on families with registered hadrons having energy higher than E_{leader}. Its value must be inputted as the answer to the following question:

THRESHOLD FOR LEADER HADRON (TEV) ? (R*4)

The program can not only simulate electromagnetic cascades, but record high-energy γ-quanta with energy larger than E_{thr} without the following cascade simulation also. This possibility could be realized by the program if you would input "T" as the answer to the following question:

WILL HIGH-ENERGY GAMMA INFORMATION BE WRITTEN? (T/F)

and a value of E_{thr} as the answer to the following question:

THRESHOLD FOR HIGH ENERGY GAMMAS (TEV) ? (R*4)

If you want to analyze muons also you must answer "T" to the following answer:

WILL MUON INFORMATION BE WRITTEN ? (T/F)

or "F" if muons are not of interest for you. The following answer is:

WHICH MAXIMUM FAMILY NUMBER CAN BE WRITTEN IN FILE ?

The program controls the recorded family number and stopped the simulation if their number would be as large as the value input by you.

In order to have possibility to break simulations in any moment and begin it again it is necessary to input "T" as the answer to the question:

WILL SPECTRUM INFORMATION BE PERIODICALLY SAVED? (T/F)

If you, by mistake, input "F" to questions about both family and spectrum information writing, the program will ask:

FAMILY AND SPECTRUM INFORMATION WILL NOT BE WRITTEN !

DO YOU WANT TO WRITE SOMETHING ? (T/F)

Of course, it is necessary to input "T" if you really would like to simulate cascades and have some results. After that all the above questions will be repeated.

The last question is:

INITIAL VALUE FOR RANDOM NUMBER SEQUENCES ? (I*4)

You must input integer number (101, for example), which is named in the program as IY0, determining sequences of random numbers in the first simulation run. In the case of the break of the simulation process the algorithm automatically begins the new simulation run with a new value of IY0, i.e.

IY0 = IY0 + 10.

As a result, the following files will be created by the program "CREATE.EXE" in the same subdirectory in addition to the files 1)"SIMUL001.BAT" and 2) "SIMUL001.DAT" :

3) SIMUL001.CAS
4) SIMUL001.FAM
5) SIMUL001.CON
6) SIMUL001.SAV

ATTENTION ! The algorithm creates virtual files SIMUL001.TMI, SIMUL001.TMI and SIMUL001.TMP during the simulation and deletes them after the end of its work. It is better to use the electronic disk for that. Its name (E:, D:,...etc) is determined in the file SIMUL001.DAT in the second line.

Files "SIMUL001.CON" and "SIMUL001.SAV"

The "SIMUL001.CON" keeps the unformatted-type information and the answers to the questions of the program "CREATE.EXE", in part, the random number for each simulation run, the number of recorded families, kind of recorded information and so on. It is used for saving spectra of primary particles and single particles of different kinds at the observation level.

SIMUL001.SAV keeps the same information and is necessary for a case of "SIMUL001.CON" destroying.

File "SIMUL001.FAM"

The file "SIMUL001.FAM" is used for unformatted recording the information on each event (a family, satisfying to chosen criteria, and/or high energy quanta etc.)

First record of file "SIMUL001.FAM" contains six logical words
KEYFAW, KEYINW, KEYGMW, KEYCHL, KEYMUW, KEYT01,

Here

KEYFAW	=.TRUE.(.FALSE.)	means that family information is (NOT) written
KEYINW	=.TRUE.(.FALSE.)	means that interaction information is (NOT) written
KEYGMW	=.TRUE.(.FALSE.)	means that information on high-energy γ-quanta is (NOT) written
KEYCHL	=.TRUE.(.FALSE.)	means that the program (DO NOT) controls the hadron leader
KEYMUW	=.TRUE.(.FALSE.)	means that muon information is (NOT) written
KEYT01		is not used in this variant.

The family information follows the above record. First, the variables
JFAMIL,JNUM0,E0T,COSTET,PHI,JFT,JT,JGAM0,IY00T

are recorded. Here

Integer*2	JFAMIL	= number of the family
Integer*2	JNUM0	= code of primary particle (1=proton etc)
Real*4	E0T	= energy of primary particle (TeV)
Real*4	COSTET	= Cosine (theta) of primary particle
Real*4	PHI	= Azimuthal angle of primary particle (radian)
Integer*2	JFT	= number of particles in the family
Integer*2	JT	= number of interactions generating observed particles
Integer*2	JGAM0	= number of high-energy quanta in the cascade
Integer*4	IY00T	= initial random number

After that JFT records with particle information follow. Each record consists of 7 numbers:
ET,XPT,YPT,JTYPT,JGT,JDECT,IGENT.

Here

Real*4	ET	= energy of particle (TeV)
Real*4	XPT	= X-coordinate of particle (mm)
Real*4	YPT	= Y-coordinate of particle (mm)
Integer*2	JTYPT	= type of particle
Integer*2	JGT	= number of interaction creating the particle
Integer*2	JDECT	= type of a parent particle creating the particle through decay
Integer*4	IGENT	= history of the particle (types of preliminary interactions etc.)

After that JT records with information on interactions follow. Each record consists of four numbers:
JGT,ITYINT,TEPT,PPT.

Here

Integer*2	JGT	= number of interaction giving detected particles
Integer*4	ITYINT	= history of interaction (type of parent particle, preliminary interactions etc.)
Real*4	TEPT	= energy of parent particle (TeV)
Real*4	PPT	= interaction's depth in the atmosphere (g/cm^2)

After that JGAM0 records with information on high - energy γ-quanta follow. Each record consists of 11 numbers:
ET,CLG,CMG,CNG,XPT,YPT,XP0,YP0,ZP0,JGT,IGENT.

Here

Real*4	ET	= energy of γ-quantum (TeV)
Real*4	CLG	= γ's directing cosine (TeV) (to X-axis)
Real*4	CMG	= γ's directing cosine (TeV) (to Y-axis)
Real*4	CNG	= γ's directing cosine (TeV) (to Z-axis)
Real*4	XPT	= X-coordinate of γ's direction crossing with observation plane
Real*4	YPT	= Y-coordinate of γ's direction crossing with observation plane
Real*4	XP0	= X-coordinate of high-energy $\gamma \to e + e$-pair creation
Real*4	YP0	= Y-coordinate of high-energy $\gamma \to e + e$-pair creation
Real*4	ZP0	= Z-coordinate of high-energy $\gamma \to e + e$-pair creation
Integer*2	JGT	= number of interaction creating the quantum
Integer*4	IGENT	= γ's history (types of preliminary interactions etc.)

File "SIMUL001.CAS"

The "SIMUL001.CAS" after each simulation run gives readable information on previous and new statistics of single particles and previously recorded families. It gives some information on main parameters of NEC simulation.

First it informs on the names of a lightest and a heaviest nuclei from the chemical composition used in the simulation. For the above mentioned conditions it have the following view.

PRIMARY PARTICLES = Alpha - Fe

The following information for the above mentioned conditions is listed further. It does not need comments, in fact. Let us note that information on lines, marked as !!!, is defined in internal program subroutines. It can be changed, but it is necessary to now the program structure for this action. If below you see dots (i.e., ...) in the end of a line, it means that a real information is cut. But this is not of important for your understanding.

PRIMARY SPECTRUM IS SAMPLED
LL1= 1 LL2= 1000
EMIN= 40.0 TEV EMAX= 50000. TEV E0T= 400.00 TEV
NUMMIN= 2 NUMMAX= 9 NAT0T= 2
MINIMAL ZENITH ANGLE=TETMIN=0. MAXIMAL ZENITH ANGLE=TETMAX=0.75
ENERGY INTERVALS FOR DIFFERENT PRIMARIES

PARTICLE	MINIMUM E0(TEV)	MAXIMUM E0(TEV)
Alpha	10000.	1000000.
Li	13229.	1000000.
C	17321.	1000000.
O	20000.	1000000.
Mg	24495.	1000000.
Si	26458.	1000000.
HL	35355.	1000000.
FE	37417.	1000000.

OBSERVATION LEVEL =OBSLEV= 594.0 G/CM**2
ENERGY THRESHOLD FOR GAMMA-RAYS=ETHA = 5.000 TEV
ENERGY THRESHOLD FOR STABLE HADRONS=ETHAD = 10.000 TEV

ELECTROMAGNETIC CASCADE IN THE ATMOSPHERE	IS	SIMULATED
	WITH	CONSTANT CROSS-SECTION
HALO DEVELOPMENT IN THE AIR	IS	TAKEN INTO ACCOUNT
ENERGY THRESHOLD FOR GAMMA-RAYS=1.000 TEV		
ENERGY THRESHOLD FOR HADRONS =1.000 TEV		
! THRESHOLDS DEPEND ON DEPTH !		
GAMMA-QUANTUM PHOTONUCLEAR INTERACTION	IS	TAKEN INTO ACCOUNT
MUON PAIR CREATION IN ELECTROMAGNETIC CASCADE	IS NOT	TAKEN INTO ACCOUNT
EARTH MAGNETIC FIELD	IS	TAKEN INTO ACCOUNT
CLOUD ELECTRIC FIELD	IS	TAKEN INTO ACCOUNT
NUCLEUS ELECTROMAGNETIC DISSOCIATION	IS NOT	TAKEN INTO ACCOUNT
REMNANT NUCLEUS ROTATION	IS NOT	TAKEN INTO ACCOUNT
DOUBLE DIFFRACTION WITH LARGE PT	IS NOT	TAKEN INTO ACCOUNT
		WITH PROBABILITY =0.2
NEW SUPERHEAVY QUARK GENERATION	IS	TAKEN INTO ACCOUNT
(Q6-baryon life time=1.00E-08 s)		
		WITH PROBABILITY =1.0
Mx min (Q6 → Diffractive cluster)= 402.0 GeV		
Kinel QGSM-STANDARD BEHAVIOR	IS	CHANGED
⇒ Kinel (E) decreases vs. E		
DECAY OF BACK DIFFRACTION CLUSTER	IS NOT	TAKEN INTO ACCOUNT

In the case of increase of usual diffraction cross-section values (by 2 times, for instance) the following information will be typed:

! SINGLE-DIFFRACTION CROSS SECTION IS INCREASED 2.0 TIMES !

The following information is defined in the subroutine DEFINC. It lists a dependence of energy thresholds for electromagnetic particles E_{THRESH} on the depth *DEPTH* in the atmosphere. This dependence is defined by the value of the parameter FNTH (the smaller FNTH the weaker dependence). As FNTH=0 in this case, any dependence is absent.

FNTH= .000 !!!

DEPENDENCE OF EM-PARTICLE THRESHOLD (TEV) ON DEPTH (C.U.) IN THE ATMOSPHERE:

DEPTH	E THRES	DEPTH	E THRES	DEPTH	E THRES	DEPTH	E THRES ...
36.7	5.0	73.3	5.0	110.0	5.0	146.6	5.0 ...
256.6	5.0	293.3	5.0	329.9	5.0	366.6	5.0 ...
476.5	5.0	513.2	5.0	549.9	5.0	586.5	5.0 ...
696.5	5.0	733.1	5.0	769.8	5.0	806.5	5.0 ...

The following numbers define the connection between the geometrical coordinates and the depth in the atmosphere. They are defined also in the internal subroutines.

CB=5.26 CBI=.190 CHB=.752 CT00=4430800 C00=640000 P0B=229.6 P0S=1030

Further, there is the information on the slopes and relative intensities of assuming primary integral spectrum components.

BETO is the index at energies E¿1 TeV for all components.

DB0 is the value of the index increase at E ¿ 50 TeV for a component with the nuclear charge Z.

DB1 is the value of the index increase at E ¿ EP*Z for a component with the nuclear charge Z. EP is the point of the proton spectrum steepening.

DB2 is the value of the index decrease at E¿ 1000*EP*Z. The nuclear charge marked as 10**6 means an electromagnetic component.

NUCLEAR CHARGE	1	2	3	6	8	12	14	24	26	10^6
INTENSITY	.370	.200	.010	.050	.050	.050	.050	.020	.200	.00
BETO	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65
DB0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
DB1	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
DB2	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10

EP (PROTON SPECTRUM BREAK POINT)= 3000. TEV

ZE0 (IRON SPECTRUM BREAK POINT)= 50. TEV

PRIMARY SPECTRUM RELATIVE INTENSITY I(> *E* MIN)/I(>1 TEV)= .644E-06

Further, there is the information on parameters of nucleus excitation in the case of simulation of rotation of the noninteracting part of a projectile nucleus.

REMNANT NUCLEUS EXCITATION IS DEFINED BY PARAMETERS:

A=-.800000 A1= .076900 B=1.000000 B1=-.060000 G= .108000

The following information is connected with electromagnetic cascade simulation in the atmosphere.

INVERSE RADIATION LENGTH = .0273 CM**2/G

RADIATION LENGTH = 36.657 G/CM**2

The following information on event selection criteria are listed below.

INFORMATION ON FAMILIES IS WRITTEN
IF SUM E> 100. TEV AND N TOT>= 3
INFORMATION ON LEADER IS UNDER CONTROL
THRESHOLD FOR LEADER IS 50.0 TEV

INFORMATION ON HE GAMMAS IS WRITTEN
THRESHOLD FOR HE GAMMAS IS 300. TEV
MAXIMUM FAMILY NUMBER, WHICH BE WRITTEN,NFAMAX=100
INFORMATION ON MUONS IS NOT WRITTEN
INFORMATION ON SPECTRA IS WRITTEN
FIRST RAND CALL: IY0 = 131

FIRST RECORD OF FILE "*.FAM" CONTAINS:
KEYFAW=T KEYINW=T KEYGMW=T KEYCHL=T KEYMUW=F KEYT01=F
It means that the program writes family information if family energy is equal or more than 100 TeV, and particle number is equal or more than 3.

In addition to this criteria the program checks events for leaders and energy threshold for hadrons to be leader is equal to 50 TeV. If there is not a hadron, satisfying to this criterion, between both recorded particles and particles in memory, which must be analyzed by program during cascade simulation, the program ends simulation of the recent cascade and begins the next one.

Events could be recorded also if in stage of cascade simulation one high-energy (¿300 TeV, e.g.) γ-guantum was created. The program writes information about it, i.e. energy, coordinates of places of first pair creation and crossing of its axis with observation level, number of interaction etc (see below). Electromagnetic cascades initiated by these quanta are not sampled.

One hundred events could be written in this files (more exactly, in the file "SIMUL001.FAM").

The program does not record information on muons, however it periodically saves statistic information on single-particle spectra.

The random number sequence is defined by integer value 131.

Last two lines inform about values of logical variables defined by the program CREATE.

The following information informs on results of previous simulation runs, namely, about the number of families written during all previous runs; on initial value of random number sequence; the number, the differential and integral spectra of all the primary particles with various atomic weights used in this simulation, i.e. α-particles, Li,...Fe and summary particle spectrum (ALL). Spectra of primaries begin from the energy E=EMIN.

First, for each type of primary particle the differential spectrum F(E) are listed. For instance, below, numbers .0000095-.00000 under the value 40.00 means differential intensity of a-particles in 40-63.4 TeV - interval in the units (m**2*hour*ster*GeV)**(-1).

Lower, the integral spectrum F($> E$) in the units (m**2*hour*ster)**(-1) is given.

!!

FAMILY NUMBER WRITTEN IN PREVIOUS RUNS= 100

!!

****

**** INFORMATION ON PREVIOUS RUN ****

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INITIAL VALUE FOR RANDOM NUMBER SEQUENCES IY0= 101
PRIMARY PARTICLE NUMBER= 1000
PRIMARY SPECTRUM
SPECTRA ARE NORMALIZED TO INTENSITIES:
DIFFERENTIAL: DI/DE(1 TEV)= 568.800 (M**2*HOUR*STER*GEV)**(-1)
INTEGRAL: I(>1 TEV)= 400.00 (M**2*HOUR*STER)**(-1)

E,TEV	40.00	63.4	100.5	159.2
			ALPHA	
F(E)	.0000095-.00000	.0000028-.00000	.0000008-.00000	.0000002-.00000000
F($> E$)	.2960734-.01640	.1398629-.01127	.0662986-.00776	.0326952-.00545000
			LI	
F(E)	.0000005-.00000	.0000002-.00000	.0000000-.00000	.0000000-.00000000
F($> E$)	.0154394-.00374	.0072656-.00257	.0018164-.00128	.0018164-.00128000

			C	
F(E)	.0000019-.00000	.0000007-.00000	.0000003-.00000	.0000001-.00000000
F($> E$)	.0681150-.00787	.0363280-.00574	.0190722-.00416	.0063574-.00240000
			O	
F(E)	.0000022-.00000	.0000007-.00000	.0000001-.00000	.0000000-.00000000
F($> E$)	.0635740-.00760	.0281542-.00506	.0099902-.00301	.0045410-.00203000
			MG	
F(E)	.0000024-.00000	.0000009-.00000	.0000003-.00000	.0000001-.00000000
F($> E$)	.0853709-.00881	.0463182-.00649	.0236132-.00463	.0108984-.00315000
			SI	
F(E)	.0000027-.00000	.0000007-.00000	.0000002-.00000	.0000001-.00000000
F($> E$)	.0790135-.00847	.0345116-.00560	.0172558-.00396	.0090820-.00287000
			HL	
F(E)	.0000007-.00000	.0000002-.00000	.0000000-.00000	.0000000-.00000000
F($> E$)	.0227050-.00454	.0108984-.00315	.0045410-.00203	.0027246-.00157000
			FE	
F(E)	.0000094-.00000	.0000025-.00000	.0000006-.00000	.0000002-.00000000
F($> E$)	.2779094-.01589	.1226071-.01055	.0572166-.00721	.0317870-.00537000
			ALL	
F(E)	.0000293-.00000	.0000087-.00000	.0000024-.00000	.0000008-.00000000
F($> E$)	.9082006-.02872	.4259461-.01967	.1998041-.01347	.0999021-.00953000

The following information informs on the differential and integral spectra (per 1 cascade from primary particles with energies E > EMIN) of different particle types arriving on the observation level. One line, beginning from F(E) (F($> E$)), lists an differential (integral) intensity value and second one, beginning from +-, lists statistical errors.

PARTICLE SPECTRA ON OBSERVATION LEVEL (PER 1 CASCADE)

E,TEV	5.00	7.9	12.6	19.9	31.5	50.0
			P			
F(E)	.000000000	.000019418	.000010482	.000003693	.00000144	.000000308
+-	.000000000	.000002047	.000001195	.000000563	.00000012	.000000031
F($> E$)	.243000000	.243000000	.153000000	.076000010	.03300000	.013000000
+-	.015588460	.015588460	.012369320	.008717799	.00574433	.003605552
			AP			
F(E)	.000000000	.000000647	.000000136	.000000086	.00000000	.000000000
+-	.000000000	.000000374	.000000136	.000000086	.00000000	.000000000
F($> E$)	.005000000	.005000000	.002000000	.001000000	.00000000	.000000000
+-	.002236068	.002236068	.001414214	.001000000	.00000000	.000000000
			NE			
F(E)	.000000000	.000019418	.000011163	.000004037	.00000122	.000000479
+-	.000000000	.000002047	.000001233	.000000589	.00000044	.000000128
F($> E$)	.264000000	.264000000	.174000000	.092000010	.04500000	.023000000
+-	.016248080	.016248080	.013190910	.009591663	.00670844	.004795832
			ANE			
F(E)	.000000000	.000000216	.000000000	.000000086	.00000000	.000000034
+-	.000000000	.000000216	.000000000	.000000086	.00000000	.000000034
F($> E$)	.003000000	.003000000	.002000000	.002000000	.00100000	.001000000
+-	.001732051	.001732051	.001414214	.001414214	.00100000	.001000000
			L0			
F(E)	.000000000	.000000000	.000000136	.000000172	.00000000	.000000000
+-	.000000000	.000000000	.000000136	.000000121	.00000000	.000000000

F($> E$)	.003000000	.003000000	.003000000	.002000000	.00000000	.000000000
+-	.001732051	.001732051	.001732051	.001414214	.00000000	.000000000
			PI+			
F(E)	.000000000	.000001079	.000001497	.000000687	.00000000	.000000034
+-	.000000000	.000000482	.000000451	.000000243	.00000130	.000000034
F($> E$)	.037000000	.037000000	.032000000	.021000000	.01300000	.007000000
+-	.006082763	.006082763	.005656855	.004582576	.00360500	.002645751
			PI-			
F(E)	.000000000	.000000863	.000001497	.000000429	.00000000	.000000068
+-	.000000000	.000000432	.000000451	.000000192	.00000000	.000000048
F($> E$)	.030000000	.030000000	.026000000	.015000000	.01000000	.007000000
+-	.005477226	.005477226	.005099020	.003872984	.00316200	.002645751
			K+			
F(E)	.000000000	.000000000	.000000545	.000000000	.00000000	.000000034
+-	.000000000	.000000000	.000000272	.000000000	.00000000	.000000034
F($> E$)	.006000000	.006000000	.006000000	.002000000	.00200000	.002000000
+-	.002449490	.002449490	.002449490	.001414214	.00141400	.001414214
			K-			
F(E)	.000000000	.000000000	.000000000	.000000000	.00000000	.000000034
+-	.000000000	.000000000	.000000000	.000000000	.00000000	.000000034
F($> E$)	.001000000	.001000000	.001000000	.001000000	.00100000	.001000000
+-	.001000000	.001000000	.001000000	.001000000	.00100000	.001000000
			KS			
F(E)	.000000000	.000000000	.000000408	.000000000	.00000000	.000000000
+-	.000000000	.000000000	.000000236	.000000000	.00000000	.000000000
F($> E$)	.005000000	.005000000	.005000000	.002000000	.00200000	.002000000
+-	.002236068	.002236068	.002236068	.001414214	.00141400	.001414214
			KL			
F(E)	.000000000	.000000216	.000000272	.000000000	.00000000	.000000034
+-	.000000000	.000000216	.000000193	.000000000	.00000000	.000000034
F($> E$)	.005000000	.005000000	.004000000	.002000000	.00200000	.001000000
+-	.002236068	.002236068	.002000000	.001414214	.00141400	.001000000
			SG-			
F(E)	.000000000	.000000000	.000000000	.000000000	.00000000	.000000000
+-	.000000000	.000000000	.000000000	.000000000	.00000000	.000000000
F($> E$)	.001000000	.001000000	.001000000	.001000000	.00100000	.000000000
+-	.001000000	.001000000	.001000000	.001000000	.00100000	.000000000
			E+-			
F(E)	.000002736	.000000000	.000000136	.000000000	.00000000	.000000000
+-	.000000967	.000000000	.000000136	.000000000	.00000000	.000000000
F($> E$)	.009000001	.001000000	.001000000	.000000000	.00000000	.000000000
+-	.003000000	.001000000	.001000000	.000000000	.00000000	.000000000
			GAMM			
F(E)	.000013678	.000003452	.000000817	.000000344	.00000000	.000000239
+-	.000002163	.000000863	.000000333	.000000172	.00000000	.000000090
F($> E$)	.077000010	.037000000	.021000000	.015000000	.01100000	.009000001
+-	.008774965	.006082763	.004582576	.003872984	.00331600	.003000000
			MU+			
F(E)	.000000342	.000000216	.000000000	.000000000	.00000000	.000000000
+-	.000000342	.000000216	.000000000	.000000000	.00000000	.000000000
F($> E$)	.002000000	.001000000	.000000000	.000000000	.00000000	.000000000
+-	.001414214	.001000000	.000000000	.000000000	.00000000	.000000000
			MU-			
F(E)	.000000342	.000000216	.000000000	.000000000	.00000000	.000000000

+-	.000000342	.000000216	.000000000	.000000000	.00000000	.000000000
F(> E)	.002000000	.001000000	.000000000	.000000000	.00000000	.000000000
+-	.001414214	.001000000	.000000000	.000000000	.00000000	.000000000

The following information informs on the summary differential and integral spectra (per 1 cascade) of all the particles (ALL), nucleons (NUCL), charged pions (PI+-), kaons (K+-0) and strange barions (B(S)) arriving on the observation level.

SUMMARY HADRON SPECTRA

E,TEV	5.00	7.9	12.6	19.9	31.5	50.0
			ALL			
F(E)	.000000000	.000041856	.000026137	.000009190	.00000222	.000001026
+-	.000000000	.000204587	.000161669	.000095867	.00005300	.000032029
F(> E)	.603000000	.603000000	.409000000	.217000000	.11000000	.057000000
+-	.024556060	.024556060	.020223750	.014730920	.01048800	.007549834
			NUCL			
F(E)	.000000000	.000039698	.000021781	.000007902	.00000200	.000000821
+-	.000000000	.000199244	.000147583	.000088894	.00004700	.000028647
F(> E)	.515000000	.515000000	.331000000	.171000000	.07900000	.037000000
+-	.022693610	.022693610	.018193410	.013076700	.00888500	.006082762
			PI+-			
F(E)	.000000000	.000001942	.000002995	.000001117	.00000000	.000000103
+-	.000000000	.000044065	.000054725	.000033416	.00002200	.000010128
F(> E)	.067000000	.067000000	.058000000	.036000000	.02300000	.014000000
+-	.008185353	.008185353	.007615773	.006000001	.00479500	.003741658
			K+-0			
F(E)	.000000000	.000000216	.000001225	.000000000	.00000000	.000000103
+-	.000000000	.000014688	.000035002	.000000000	.00000700	.000010128
F(> E)	.017000000	.017000000	.016000000	.007000000	.00700000	.006000000
+-	.004123106	.004123106	.004000000	.002645751	.00200000	.001800000
			B(S)			
F(E)	.000000342	.000000216	.000000000	.000000000	.00000000	.000000000
+-	.000000342	.000000216	.000000000	.000000000	.00000000	.000000000
F(> E)	.002000000	.001000000	.000000000	.000000000	.00000000	.000000000
+-	.001414214	.001000000	.000000000	.000000000	.00000000	.000000000

The following information lists different parameters of interaction simulation. It could be useful in a case of the interaction model change. The first line is important only as it gives the integer IY0 value, determining a consequence of random numbers used in THIS simulation run. Second line informs the cross - section of diffraction processes used in this simulation.

FIRST RAND CALL (IY0= 15)
SIGMA DIFFR = 40.0*(.94634+ .01025*LN S), MBARN
FOLLOWING HADRON INTERACTION PROBABILITY DEPENDS ON ALF= .25
PT(JET)MIN(REAL)= 1.800 K01=1.00 GEV
PARAMETERS FOR Y(JET)-SAMPLING: A=.25 A1= 4.0 C= 1.62(AYJ= .750000 YJ=.100)
JET PT SAMPLING IS WITH PARAMETERS: ALF= 2.00 BET= 5.00 ADDITIONAL DY= .0
AT SAMPLING OF LEADER'S X 1-ST and 2-ND EXCHANGE PROBABILITIES INCREASE 1 TIMES
RESONANCE CREATION PROBABILITIES AT EXCHANGE= .50

FOR LEADER SPECTRUM OF (1-X)**B TYPE B = B0*(.2900+ .136*LN(S)
AND FOR AIR IS MULTIPLIED BY FF=1.25
IN SOFT PROCESSES BPT0= .110*(1-4*M/SQRT(S)
AT SAMPLING OF LEADER'S X B01= .350 CXL= .125 C= .150
MINIMAL B01= .300

The following information informs on results of the last simulation run. It begins from following head:
****
*****   INFORMATION ON NEXT RECORD   *****
****
and has the same view as above.

In the end of file there is information about maximal values of cascade particles NM MAX, interactions in one cascade branch NI MAX and particles generated in one interaction N PART MAX which occurs during the last simulation run.

NM MAX=100 NI MAX=10 N PART MAX=150

Finally, there is information about the total family number written on file "SIMUL001.FAM" during all the runs of simulation.

!!!
TOTAL FAMILY NUMBER WRITTEN ON FILE "SIMUL001.FAM = 100
!!!

Thus, if all these files are ready you can begin your simulations. It is necessary to executethe file "SIMUL001.BAT" for this goal.

PARAMETER CHANGES

Primary spectrum change. It is defined in subroutine DEFINC. Relative intensities of different primaries at E=1 TeV are determined by values of array AZ (10). Positions of this values corresponds to codes of primaries. Slopes of primary spectra and their changing are determined by arrays BETO0 (10), DB00 (10), DB10 (10), DB20 (10). (see also the corresponding information on the file "SIMUL001.CAS").

Fast protonuclear cross-section energy dependence. It is defined in subroutine GAMINT in the line

IF (NUMSTR.EQ.2) SIGSTR=DS*E**0.25.

and can be changed here. The variable NUMSTR is defined in subroutine ORIGIN. It can be equal to 1 or 2 only. The case

NUMSTR=1

corresponds to weak logarithm energy dependence.

NUMSTR=2

will correspond to the changed case.

Proton-target-like interactions of hadrons. It is possible to simulate cascades with hadron interactions like to collisions with proton. To make this choice it is necessary to put the variable

KEYAIR=.FALSE

in subroutine ORIGIN. In this case the following information

ALL INTERACTIONS ARE SIMULATED AS IN HADRON-PROTON CASE !!!

will be typed in the file "SIMUL001.CAS" after information

PARTICLE ALIGNMENT IN STRONG INTERACTIONS .... TAKEN INTO ACCOUNT !!!

Bibliography

[1] Fedorova, G.F. and Mukhamedshin, R.A. , Bull. Soc. Sci. Lettr. Lodz, Ser. Rech. Def. (1994), vol. XVI, pp. 137-152.