Major Atmospheric
Gamma Imaging
Cerenkov Telescope

MAGIC-TDAS 12-06

Monte Carlo Production Strategy for MAGIC-II two-telescope system

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Abstract

In this small document we outline the latest changes which have been done by Abelardo Moralejo and the strategy adopted for the MAGIC Monte Carlo production. More details will be made available in the webpage which is under construction (http://wwwmagic.mppmu.mpg.de/workgroups/mc/index.html).

1 Modifications in CORSIKA and Reflector

Monte Carlo Simulations for MAGIC-I were based on CORSIKA code version 6.019 which used the EGS4 code for electromagnetic shower generation, VENUS for high energy hadronic interactions, GHEISHA for low energy hadronic interactions and US Standard atmosphere. In 2006, we decided to make a few changes in the generation of showers (both CORSIKA and Reflector) .

- We have a new version CORSIKA-6.501 (Dorota converted it to MMCS6500)
- Hadronic Interactions have been changed to FLUKA for low energy interactions and QGS-JETII model for higher energy hadronic interactions
- New input cards for both gammas and protons have been added
- The wavelength has been extended to 850 nm in the reflectivity.dat file and in the absorption routines
- New Atmospheric profiles which have been provided by Marijke Haffke are now implemented in the absorption routines of the reflector code. This included eliminating the last remaining fortran file in the package, which was translated to a C-program (see later for more details)
- We changed the telescope coordinates to match the true relative positions of MAGIC and its clone. The former coordinates were wrong. We still do not have z coordinate though.
- Many modifications in the Reflector code have been done in the past months which now allows us to make multiple use of hadronic showers (see Abelardo's talk in Collaboration meeting at Tenerife for details, 14^{th} October 2005). This will allow us to generate hadronic showers upto an impact parameter of at least 800 m at low zenith angle. Also, it is possible to run each event with several different (random) orientations of the telescope with respect to the shower axis.
- The feature which will allow us to 'refocus the telescope' at the camera simulation level has been tested. The direction cosines stored per each photon (see TDAS note 02-11) stored in the reflector outputs are those of the direction of the photon at the moment of arriving at the camera. Formerly they were the original photon direction before the reflection on the mirror.
- The PSF of individual mirror tiles is now simulated in a more proper way : spread is now introduced in the photon orientations, and not directly on the impact position on the camera plane.

2 A note on Atmopsheric Model and Effect on Lateral Distribution

By comparing the atmopsheric models used in MAGIC (US Standard atmosphere) with NRLMSISE-00 [1] on the basis of total mass density as a function of height, one can see a significant deviations upto 14%. The emperical models of MSISE are based on data from satellites and rocket probes and include both latitude and longitude and time (for example, in our case, co-ordinates of MAGIC and the first day of each month is used). To calculate a tabulated atmopshere of MAGIC to be used in CORSIKA, the mass density was averaged over 6 months : MagicSummer and MagicWinter. Comparing NRLMSISE-00 with the generated Magic atmospheres, we get a deviation of about 2%. (see Figure 1 and Figure 2)

Lateral distribution plots were made to compare the photon densities on the ground at La Palma. About 10-15% decrease in photon densities has been observed compared to the US Standard atmosphere model. (see Figure 3)

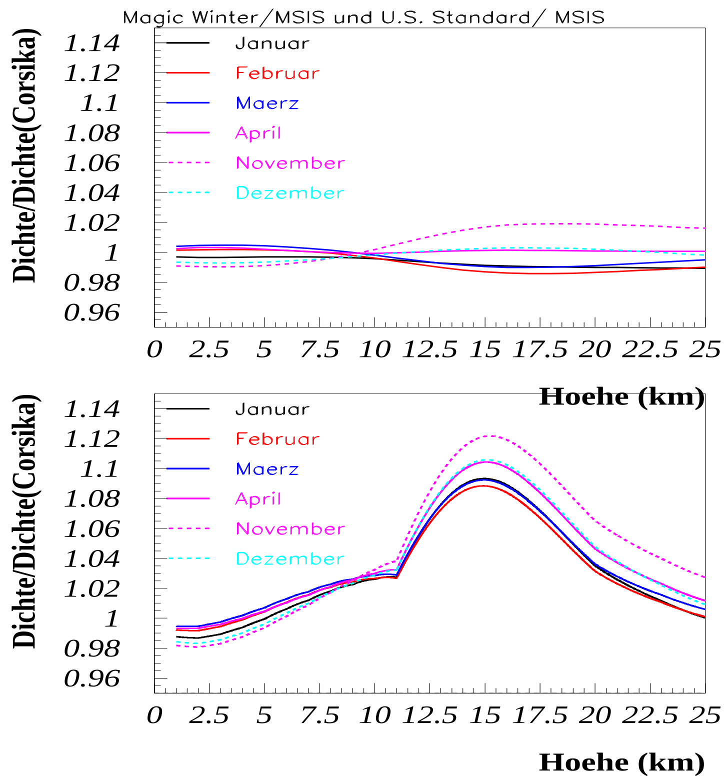

Figure 1: Comparison of density profiles for MagicWinter and US Standard

In the Reflector input card, one can choose different models for atmospheric absorption. To use the new MAGIC atmospheres, a parametrised version of MagicSummer and MagicWinter was calculated using ROOT and implemented into the Reflector code.

[1] for details see http://uap-www.nrl.navy.mil/models_web/msis/msis_home.htm

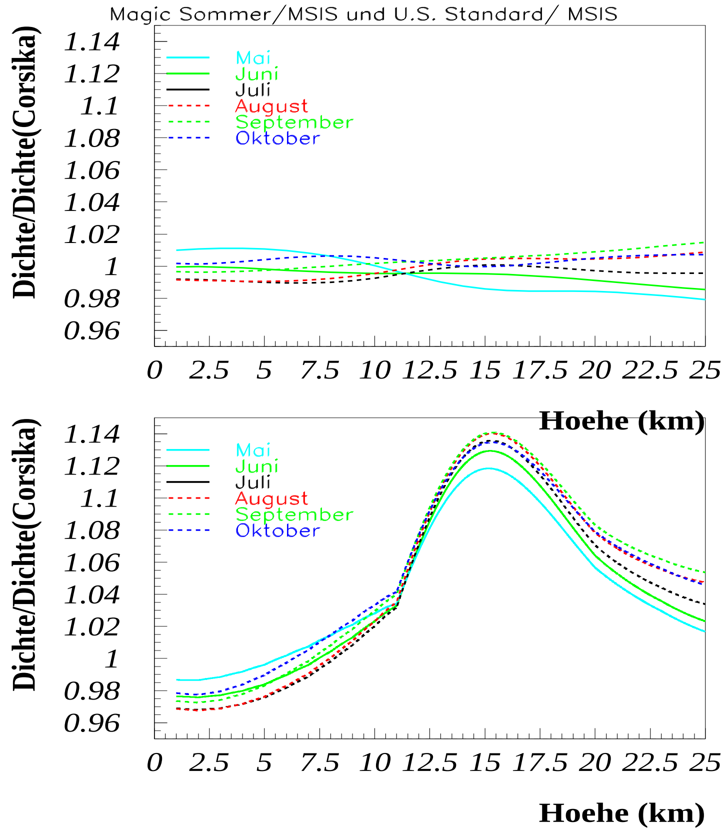

Figure 2: Comparison of density profiles for MagicSummer and US Standard

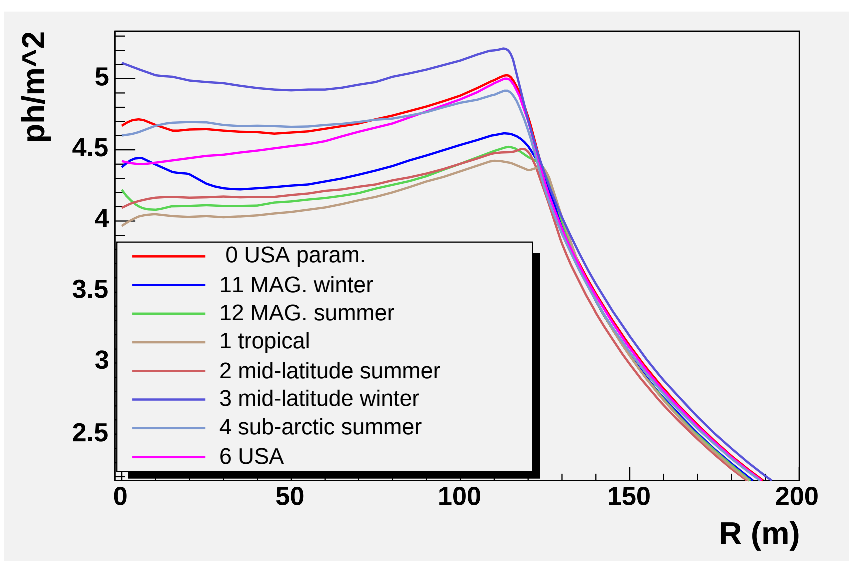

Figure 3: Lateral distribution of Cerenkov photons for 50 GeV gammas

3 Installation of MonteCarlo Packages

To download the full MC package (remember, the new CVS is at PIC, no longer at IFAE):

Here we remind you how to checkout software packages from CVS at PIC
export CVSROOT=":ext:username@cvsmagic.pic.es/CVS" (bash)
setenv CVSROOT :ext:username@cvsmagic.pic.es/CVS (csh)

where "username" should be your username *AT PIC*

If you do not have an account at PIC please ask for it (follow http://magic.pic.es/howto.htm)
Once you have an account in PIC, you can can checkout MC packages by

cvs checkout MonteCarlo
This will download all the necessary stuff for Corsika, Reflector and Camera.
To install MMCS (CORSIKA) please follow the instructions on
MagicSoft/Simulation/Corsika/Mmcs6500/README_MMCS6500 to install it.

- Create directory fluka2006_3 (wherever you want, for instance under MagicSoft/Simulation/Corsika/Mmcs6500)
- Move fluka2006.3-linuxAA.tar.gz to directory fluka2006_3
- Go to directory fluka2006_3 and uncompress the file:

  cd fluka2006_3
  tar xvzf fluka2006.3-linuxAA.tar.gz

- Define environment variable FLUPRO in your ~/.bashrc or ~/.cshrc. Examples:

  export FLUPRO='/home/magic/MagicSoft/Simulation/Corsika/Mmcs6500/fluka2006_3' (bash)

  setenv FLUPRO /home/magic/MagicSoft/Simulation/Corsika/Mmcs6500/fluka2006_3 (csh)

  (then do "source ~/.bashrc" or "source ~/.cshrc")

  PROGRAM NEEDS FLUPRO TO WORK PROPERLY!

- Go to directory with main program mmcs6500, i.e.:

cd MagicSoft/Simulation/Corsika/MMcs6500/

- Uncompress qgsdat-II-03.gz :

  gunzip qgsdat-II-03.gz

- Compile the program:

  make all SYSTEM=LINUX

- Have lots of fun with simulations

To install Reflector:
cd MagicSoft/Simulation/Detector/ReflectorII
refl-install

The example input cards for Reflector are also available :
MagicSoft/Simulation/Detector/ReflectorII/rfl_proton.inp
MagicSoft/Simulation/Detector/ReflectorII/rfl_gamma.inp
MagicSoft/Simulation/Detector/ReflectorII/rfl_gamma_wobble.inp

The basic details of the input card are explained in the TDAS note 0211, but that note is valid for MAGIC-I configuration. Some changes had to be made for MAGIC-II simulations, the most important of them being the telescope_position. The user must make sure that the telescope location positions are consistent with the locations specified in the MMCS input card around which the Cerenkov photons are saved to the disk. We write first the coordinates of all the telescopes in the first system, then all those of the second system, and so on. The order is important. The relative locations of the different telescopes in each system must also be the same, for instance: the first telescope of each system is always the one on the SW, then the one in NE. In the case of a system of two telescopes, the first one is MAGIC-1, the second is the MAGIC clone, which is placed 70 m south and 48 m west of the first one, that is, delta_x = -70 m, delta_y = +48 m Also the user should remember that one will have to run the reflector program twice on Cerenkov output files for Non-wobble and wobble positions respectively. Another important point which the user should remember to check is that we have chosen for the time being MagicWinter as the atmospheric model (atm_model ATM_MagicWinter).

To install camera ,
you need to have ROOTSYS and LD_LIBRARY_PATH defined, and have ROOTSYS/bin in the PATH as camera needs to compile Mars first. So, one has to define all that is required to compile Mars. Then:
cd MagicSoft/Simulation/Detector/Camera
camera_install

4 Production Strategy

The example Corsika input cards for protons and gammas are in in the package
MagicSoft/Simulation/Corsika/Mmcs6500/card_proton.inp
MagicSoft/Simulation/Corsika/Mmcs6500/card_gamma.inp

It should be noted that there are a few things which the producers will have to change

- The run number
- The output directory
- The first number in the three SEED commands

Three production sites which are foreseen in near future are Munich (production site label 3), Zurich (production site label 5) and Udine(production site label 9). CORSIKA requires three different seeds for random number generation. It was also decided that for mass production, the seeds for the random number generation will be chosen as follows :

SEED_A=runnumber*100 + ProductionSiteNumber (for example, 9 for Udine)
SEED_B=SEED_A+1
and SEED_C=SEED_B+1

The output files from the Reflector will look like, for example,

GA_za00to30_9_9*****_ct1_w0.rfl
where the first 9 is the production site label and the run number will be 9*****, always starting with the site label and w0 signifies non-wobble mode. For wobble mode, w0 should be replaced by w+. [2]

Concerning the checking of CORSIKA outputs, Ciro Bigongiari suggested that many queuing systems return a exit status value. Otherwise there is a weird system Ciro found a lot of time ago : [3]

tail -1 mycerfile — grep RUNE >& /dev/null

> status is 0 if the cerfile is completed, 1 otherwise.

More detailed checks of reflector files can be performed with the 'repsime' code which is in the repsime subdirectory of the ReflectorII directory. This program turns the .rfl reflector output files into root files where one can check all the relevant quantities. Some more subsequent systematic checks can be defined in future.

[2]For Protons GA is to be replaced by PR, and for other particles, HE for alpha, MU for muons ....etc

[3]however, one should note that many systems may not have this facility

Appendix A

Abelardo has run a proton and a gamma test files, with the standard input cards. The file sizes are the following (please note that they may vary widely since a few high E showers make up for most of the photons!):

cer file, gamma: 1.3 GB
cer file, proton: 1.7 GB

rfl files, gamma: $\sim$ 300 MB
rfl files, proton: $\sim$ 1.0 GB

This means that runs of 1000 events may be a bit dangerous because we may exceed the limit of 2 GB in the cer file. The producers should take of this while testing in their respective centres and it is recommended that the number of showers in each file be made 500.

Corsika execution times in a desktop, a 3.2GHz pentium4 (again, please expect quite some variations from run to run due to large events!)
1000 gammas: $\sim$ 30 h
1000 protons $\sim$ 66 h

Reflector execution time for gammas is negligible, for protons it is 3 hours per 1000 events.

To get 10^6 events of each we will need then a total of 10^5 CPU hours ($\sim$ 4100) CPU days, which is just $\sim$ 21 days assuming we have 200 CPUs. One should note that since the spectral index is raised by +1 w.r.t. the old production, with 10^6 events of these we can do as much as with 10^7 of the old ones.

The reflector files from these 2×10^6 events will be around 1.3 TB, from simple extrapolation of the above numbers.