

Simulation of the 6NM-64 neutron monitor

Application manual

Authors: Pavlos Paschalis and Helen Mavromichalaki

Affiliation: National and Kapodistrian University of Athens / Physics Department / Cosmic Ray Group

email: ppaschalis[at]phys[dot]uoa[dot]gr, emavromi[at]phys[dot]uoa[dot]gr

Description

The application aims to the determination of the 6NM-64 detection efficiency for various beams.

Two main operations are provided (**TOTAL – SPATIAL**) and one supporting mode (**GEOMETRY**):

Mode	Description	Beam characteristics	NM position
TOTAL	Determination of the NM detection efficiency as a whole	<ul style="list-style-type: none">• Monoenergetic particles of the same type• Two types of beam• Beam 1: originates 1cm above the NM surface (ideal for low energy particles)• Beam 2: originates 2m above the NM centre• Vertical beam• Positions of particles form a grid with defined distance among particles• Beam illuminates all the NM	<ul style="list-style-type: none">• Beam 1: NM cannot be rotated• Beam 2: NM can be rotated according to zenith and azimuth angles
SPATIAL	Determination of the detection efficiency for a specific NM region	<ul style="list-style-type: none">• Monoenergetic particles of the same type• Beam originates 1cm above the NM surface• Vertical beam• Positions of particles form a grid with 1cm distance among particles• Beam illuminates specific region of the NM	NM cannot be rotated
GEOMETRY	Graphical representation of the simulation geometry	<ul style="list-style-type: none">• One particle• Originates 2m above the NM layer	NM can be rotated according to zenith and azimuth angles

Dependencies

The simulation is based on the Geant4 simulation toolkit, thus it requires:

- the libraries of Geant4 that can be downloaded from <http://geant4.cern.ch/>
- the datasets used by the physics lists of Geant4

The graphical representation of the simulation geometry (GEOMETRY mode) is exported in .heprep format that can be viewed by the HepRep browser.

Input data

The application requires a set of parameters that are entered as input according to the following table:

Modes	Parameters
TOTAL	<ul style="list-style-type: none">• Particle Name• Particle Energy (GeV)• Beam type (type 1 / type 2)• Distance between particles (cm)• NM zenith angle (deg)• NM azimuth angle (deg)• NM counter resolving time (μs)• NM electronics dead time (μs)• Physics list• Secondary neutrons spectrum (YES/NO)
SPATIAL	<ul style="list-style-type: none">• Particle Name• Particle Energy (GeV)• NM region (1 to 24 or A to D)• NM counter resolving time (μs)• NM electronics dead time (μs)• Physics list• Secondary neutrons spectrum (YES/NO)
GEOMETRY	<ul style="list-style-type: none">• Particle Name• Particle Energy (GeV)• NM zenith angle (deg)• NM azimuth angle (deg)• Physics list

Remarks:

- The particle names and the physics lists are the ones used by the Geant4 toolkit. For the application, three additional physics lists have been developed, the QGSP_BIC_HP_TS, QGSP_BERT_HP_TS and FTFP_BERT_HP_TS. The QGSP_BIC_HP_TS is considered as the optimal one for the application.
- Typical resolving and dead time for the NM-64 is 5μ s and 20μ s respectively.
- The distance between the particles is an integer.
- The "Secondary neutrons spectrum" flag is used for the recording of the secondary neutrons energies.
- In the case of TOTAL mode, it is suggested to the user to select the beam type 1 (1cm), when the beam consists of unstable low energy particles, in order to avoid the decay of particles before their entrance in the neutron monitor.
- Referring to the SPATIAL mode, the regions of the NM are 25x25cm blocks, identified by the numbers 1-24 and letters A-D according to figure 1:

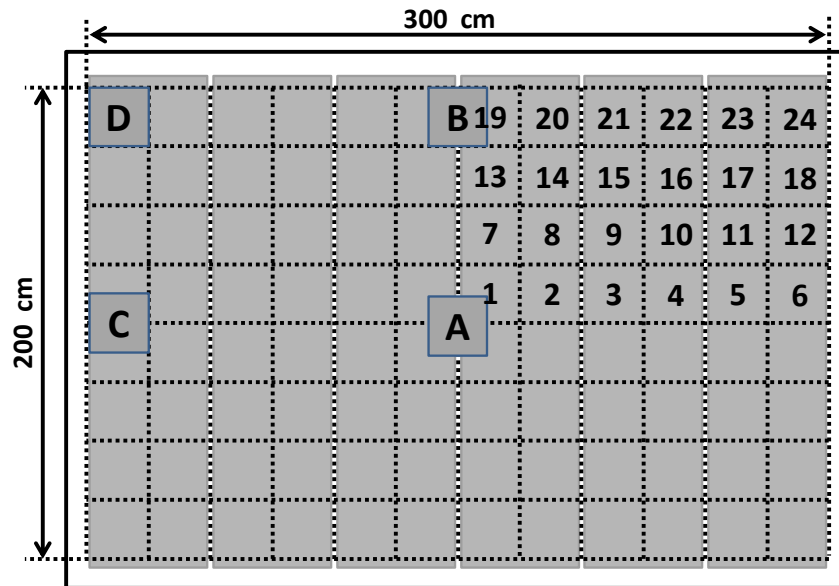


Figure 1: Regions of the NM, used in SPATIAL mode

Output data

The output of the application is appended in results.csv file in the following format:

- PARAMETERS OF THE APPLICATION
- SECONDARY NEUTRONS NUMBER
- NEUTRON CAPTURES OF COUNTER 1
- NEUTRON CAPTURES OF COUNTER 2
- NEUTRON CAPTURES OF COUNTER 3
- NEUTRON CAPTURES OF COUNTER 4
- NEUTRON CAPTURES OF COUNTER 5
- NEUTRON CAPTURES OF COUNTER 6
- COUNTS OF COUNTER 1
- COUNTS OF COUNTER 2
- COUNTS OF COUNTER 3
- COUNTS OF COUNTER 4
- COUNTS OF COUNTER 5
- COUNTS OF COUNTER 6

Moreover:

- The geometry is exported in .heprep format that can be read by the HepRep browser.
- In the case that the "Secondary neutrons spectrum" is selected, a .txt file is generated, in which the application writes the energy (in eV) of each neutron that is generated in the neutron monitor.

Installation and environmental variables

- The application has been compiled by using the Visual Studio 2010 and the executable file is provided for Windows systems. The user should provide the compiled Geant4 library. This can be done either by compiling the Geant4 source (by using the Visual Studio) or by downloading the precompiled library provided by the Geant4 webpage. The current version of the application uses the Geant4.9.6 that can be downloaded from <http://geant4.web.cern.ch/geant4/support/source/lib4.9.6.p03/WIN32-VC100-7.zip> .
- The physics lists of Geant4 require the presence of datafiles, containing cross sections information of the interactions. The datasets for the Geant4.9.6 can be downloaded from the links of the table 3 and should be extracted into the same folder.
- Before the execution of the application the user should set
 - the folder containing the Geant4 DLLs in the windows PATH
 - the environmental variables, pointing to the Geant4 datasets, according to the following table:

Environmental Variable	Description	Download Link
G4LEDATA	path to the G4EMLOW6.32 dataset	http://geant4.web.cern.ch/geant4/support/source/G4EMLOW.6.32_permissions.tar.gz
G4LEVELGAMMADATA	path to the PhotonEvaporation2.3 dataset	http://geant4.web.cern.ch/geant4/support/source/G4PhotonEvaporation.2.3.tar.gz
G4NEUTRONHPDATA	path to the G4NDL4.2 dataset	http://geant4.web.cern.ch/geant4/support/source/G4NDL4.2.tar.gz http://geant4.web.cern.ch/geant4/support/source/G4NDL4.2.TS.tar.gz
G4NEUTRONXSDATA	path to the G4NEUTRONXS1.2 dataset	http://geant4.web.cern.ch/geant4/support/source/G4NEUTRONXS.1.2.tar.gz
G4PIIDATA	path to the G4PII1.3 dataset	http://geant4.web.cern.ch/geant4/support/source/G4PII.1.3.tar.gz
G4RADIOACTIVEDATA	path to the RadioactiveDecay3.6 dataset	http://geant4.web.cern.ch/geant4/support/source/G4RadioactiveDecay.3.6.tar.gz
G4REALSURFACEDATA	path to the RealSurface1.0 dataset	http://geant4.web.cern.ch/geant4/support/source/RealSurface.1.0.tar.gz
G4SAIDXSDATA	path to the G4SAIDDATA1.1 dataset	http://geant4.web.cern.ch/geant4/support/source/G4SAIDDATA.1.1.tar.gz

6NM64Assist

For simplicity reasons, the application is provided with the **6NM64Assist_Generator.bat** file which asks for the folders of the Geant4 DLLs (bin folder of the compiled library) and Geant4 datasets. After that, a new batch file is generated, called **6NM64Assist.bat**. The user can use the application simply by double clicking 6NM64Assist.bat which checks and sets the windows PATH and the environmental variables only for the current session.

References

- Agostinelli S., Allison J., Amako K., Apostolakis J. et al. for the Geant4 collaboration, "Geant4 - a simulation toolkit", NIM A, Volume 506, Issue 3, pp. 250-303, 2003
- Allison J., Amako K., Apostolakis J., Araujo H. et al. for the Geant4 collaboration, "Geant4 developments and applications", IEEE Transactions on Nuclear Science, vol.53, no.1, pp. 270-278, 2006
- Clem, J.M. and Dorman, L.I., "Neutron Monitor Response Functions", Space Science Review, vol. 93, pp. 335-359, 2000
- Paschalis, P., Mavromichalaki, H., Dorman, L.I., "A quantitative study of the 6NM-64 neutron monitor by using Geant4: 1. Detection efficiency for different particles", NIM A, 729, 877-887, 2013

Useful Links

Geant4 toolkit, <http://geant4.cern.ch>

Archived library of Geant4, http://geant4.web.cern.ch/geant4/support/source_archive.shtml

HepRep Browser, <http://www.slac.stanford.edu/~perl/heprep/index.html>