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HF Radiation Project

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ABSTRACT:

This project aims to estimate the Total Ionizing Dose (TID), and fluence of neutrons and charged hadrons in the front-end electronics of the HCAL Forward system (HF) in CMS detector.

The simulation was made using FLUKA **[1]** based on the CMS geometry file provided by Moritz Guthoff **[2]**.

1. Definitions:

1.1 Primary: It's one event that initiates a FLUKA simulation **[3]**. For this project, a "primary" means one proton-proton collision.

1.2 Absorbed dose: Dose is a measure of the energy deposited in a medium by ionizing radiation per unit mass **[4]**. It can be expressed by GeV/g or by Grays (Gy)

$$1 \text{ GeV/g} = 1.60217646\text{E-}7 \text{ Gy}$$

1.3 Fluence: It's the total number of particles that intersect a unit area in a specific time interval of interest. It has units of m^{-2} or cm^{-2} **[5]**.

1.4 Luminosity: It´s a measurement of the number of collisions that can be produced per unit area and per second. The bigger is the value of L, the bigger is the number of collisions.

1.5 Integrated luminosity: It's the luminosity integrated by the time. It has units of $AREA^{-2}$ or $barn^{-1}$. Given the integrated luminosity, we can calculate the number of events if the cross section of the colliding particles is known:

$$\#\text{events} = (\text{cross section}) \times (\text{integrated luminosity})$$

2. Project settings:

2.1 Beam:

- p-p collisions at energy of 14 TeV, 7 TeV per beam
- $\sigma_z = 5.0\ cm$
- lab momentum x-component for hadrons: 0.42 GeV/c

2.2 Measurements:

- All the measurements (dose and fluence) were made at R= 260 cm and z=1310 cm from the interaction point.
- Dose was measured in air, aluminum and silicon blocks.
- Neutron fluence and charged hadron fluence were measured using several energy ranges:
    - Whole energy range
    - > 1 MeV
    - > 10 MeV
    - > 20 MeV

2.3 FLUKA estimators:

- USRBIN card used to get **Dose**.
- USRTRACK card used to get **Neutron and Charged Hadrons fluence** as a function of their energy.

3. Simulation:

- Ran in LXPLUS (Scientific Linux CERN 5.8 x86_64)
- Fluka2011.2
- 98900 primaries simulated

4. Results:

4.1. Dose

4.1.1. Dose per primary:

	Dose [Gy/prim]	%Err
Dose in air	1,03E−16	26,23
Dose in aluminum	5,49E−17	14,02
Dose in Silicon	3,07E−17	33,73

Table 4.1.1.

4.1.2. Total dose. Dose normalized by 3000 fb^{-1}

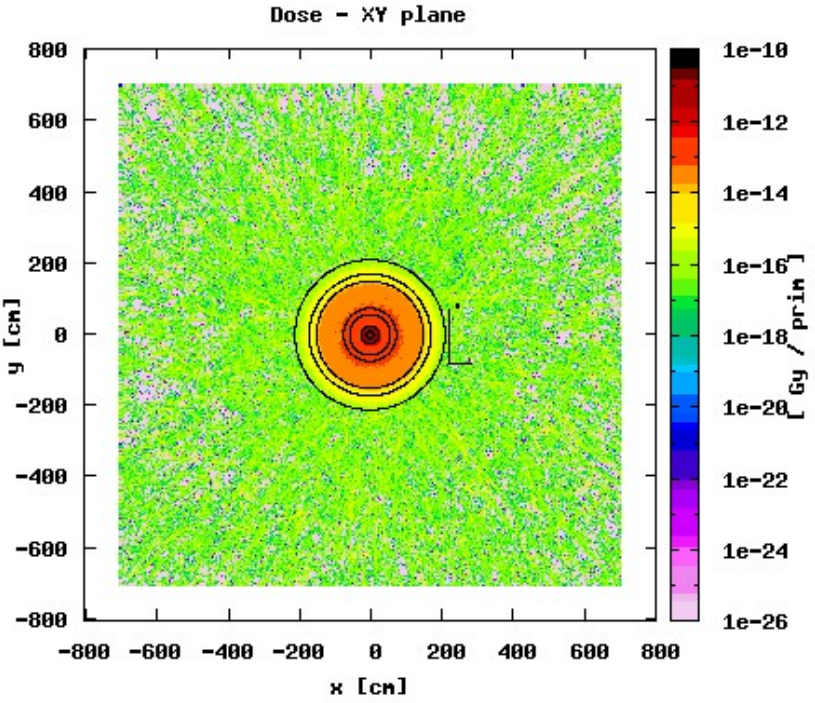
Using : #events = (cross section) X (integrated luminosity)

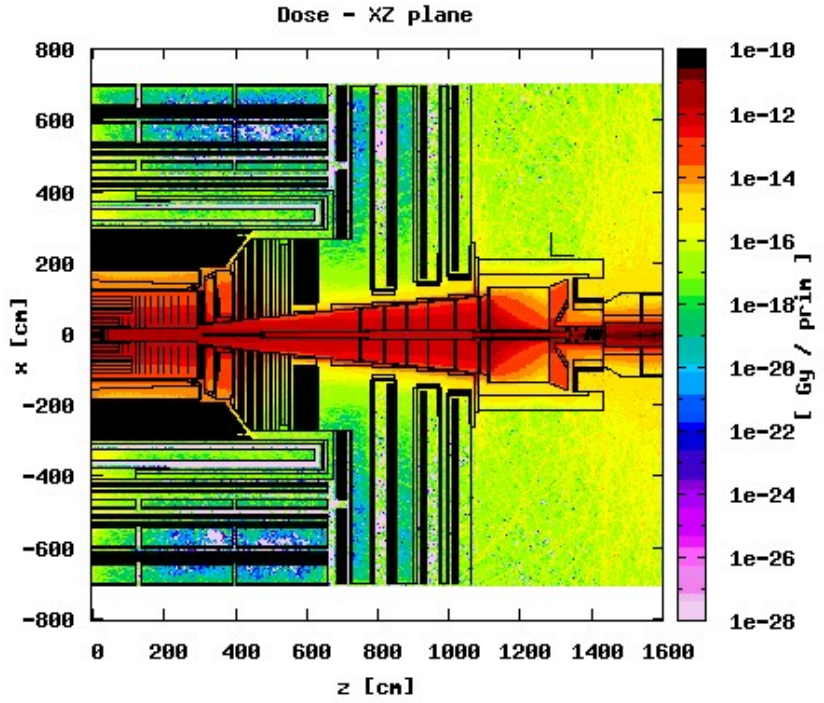
$$primaries = \sigma_{(14\,TeV)} * 3000\,fb^{-1}$$
$$primaries = 76\,mb * 3000\,fb^{-1}$$
$$primaries = 2.28\,E17$$

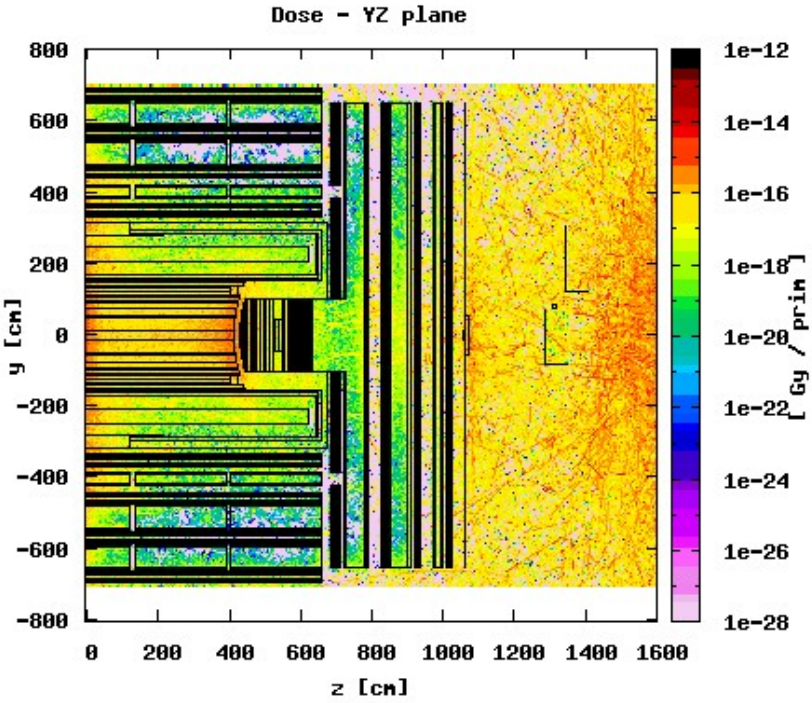
	Dose [Gy]	%Err
Dose in air	2,35E+01	26,23
Dose in aluminum	1,25E+01	14,02
Dose in Silicon	7,01E+00	33,73

Table 4.1.2.

4.1.3. Dose plots







4.2. Fluence

4.2.1 Fluences per primary

	Whole energy range	%Err	> 100 KeV	%Err	> 1 MeV	%Err	> 10 MeV	%Err	> 20 MeV	%Err
Neutrons [part/(cm2*prim)]	6,07E-06	1,5	2,89E-06	2,1	2,06E-06	2,4	1,15E-06	3,1	1,00E-06	3,3
Charged Hadrons [part/(cm2*prim)]	1,89E-08	24,0	1,88E-08	24,0	1,88E-08	24,1	1,68E-08	25,0	1,58E-08	26,2

Table 4.2.1.

4.2.2 Fluences integrated by 3000 fb^{-1}

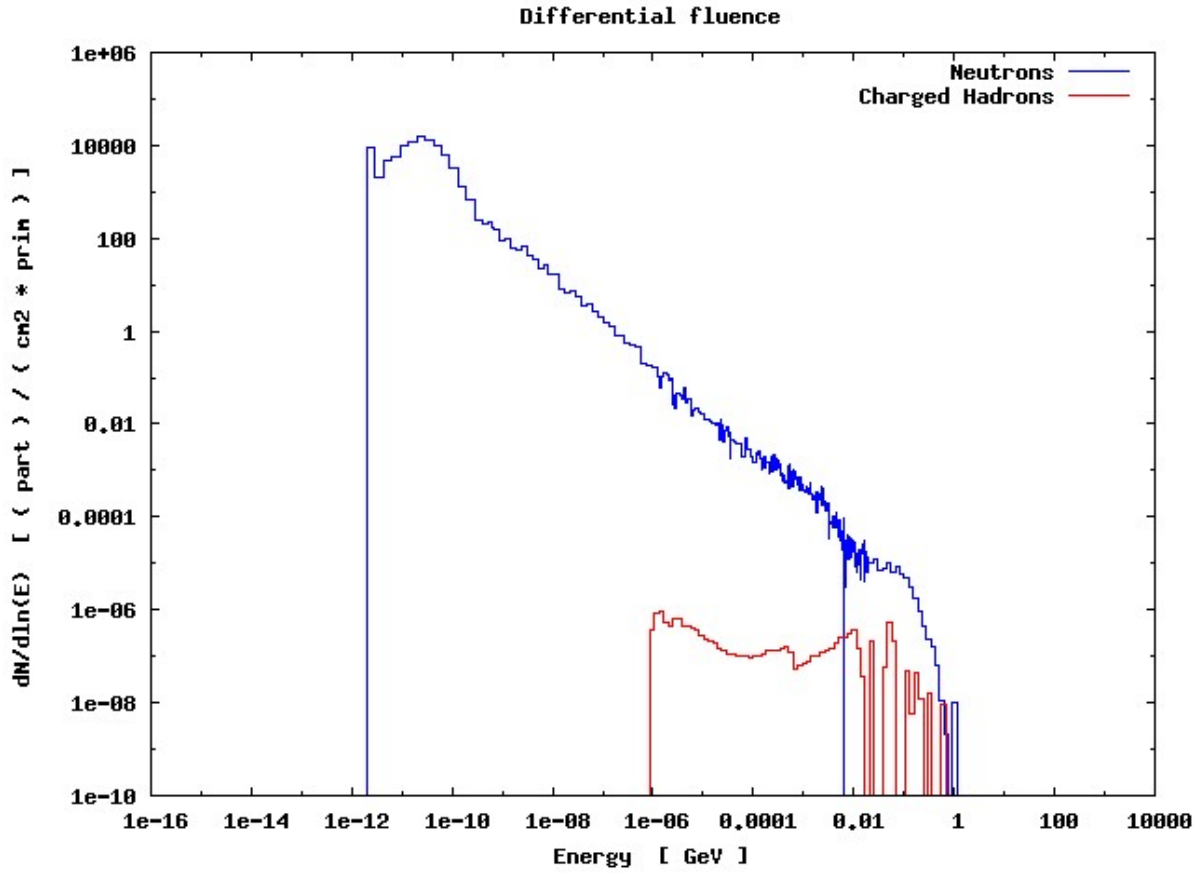
Using : #events = (cross section) X (integrated luminosity)

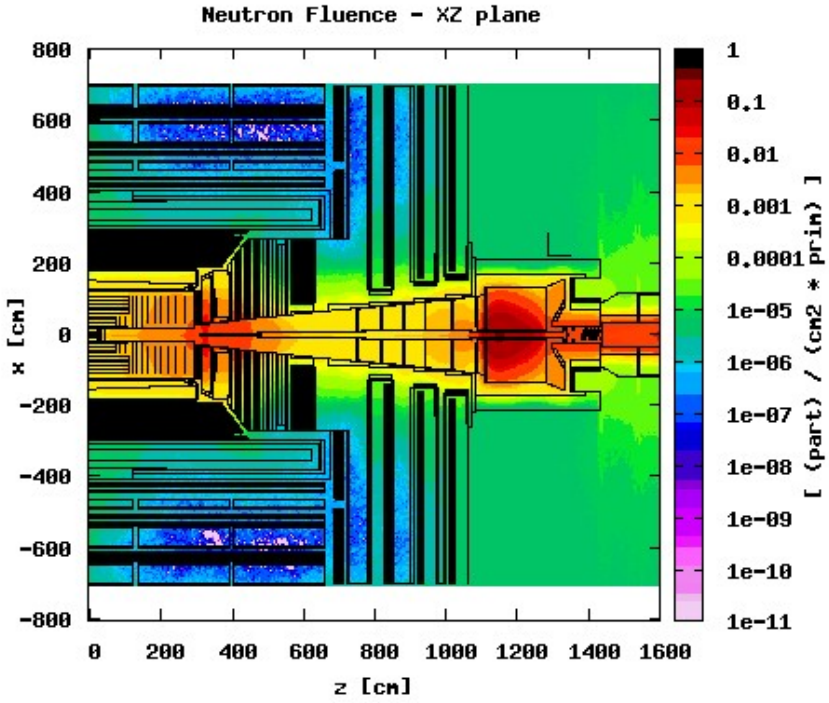
$$primaries = \sigma_{(14\,TeV)} * 3000\,fb^{-1}$$
$$primaries = 76\,mb * 3000\,fb^{-1}$$
$$primaries = 2.28\,E17$$

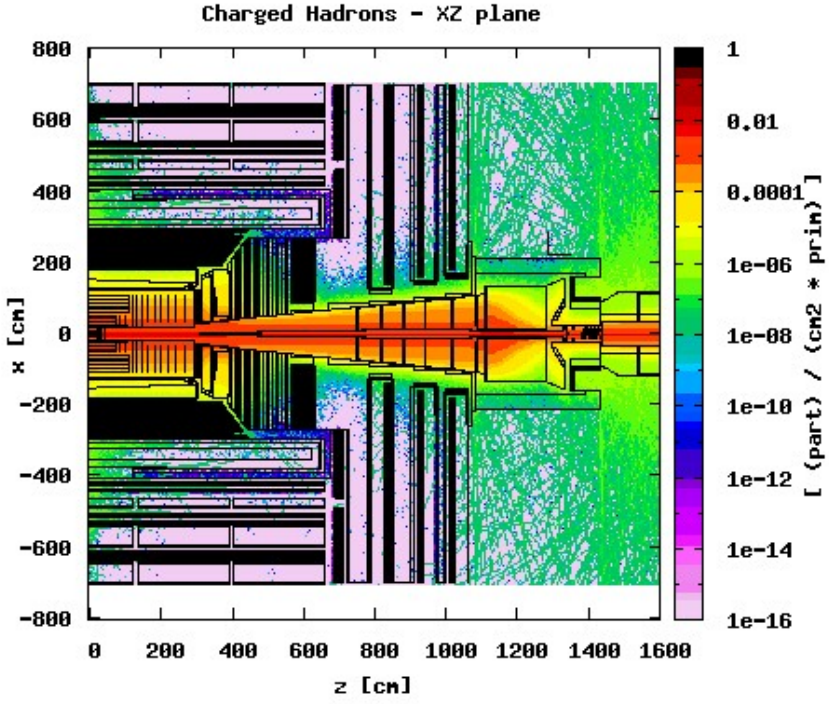
	Whole energy range	%Err	> 100 KeV	%Err	> 1 MeV	%Err	> 10 MeV	%Err	> 20 MeV	%Err
Neutrons [part/cm2]	1,38E+12	1,5	6,58E+11	2,1	4,69E+11	2,4	2,62E+11	3,1	2,28E+11	3,3
Charged Hadrons [part/cm2]	4,30E+09	24,0	4,30E+09	24,0	4,28E+09	24,1	3,82E+09	25,0	3,60E+09	26,2

Table 4.2.2

4.2.3 Fluence plots




Neutron Fluence - XZ plane
x [cm]
z [cm]
[(part) / (cm2 * prin)]
800
600
400
200
0
-200
-400
-600
-800
0
200
400
600
800
1000
1200
1400
1600
1
0.1
0.01
0.001
0.0001
1e-05
1e-06
1e-07
1e-08
1e-09
1e-10
1e-11


Charged Hadrons - XZ plane
x [cm]
z [cm]
[(part) / (cm2 * prin)]
800
600
400
200
0
-200
-400
-600
-800
0
200
400
600
800
1000
1200
1400
1600
1
0.01
0.0001
1e-06
1e-08
1e-10
1e-12
1e-14
1e-16

4.3 Fluence for silicon using special FLUKA estimators

4.3.1 Fluence per primary for silicon

Hadrons (> 20 MeV)	7,80E-07	34,45
Silicon 1 MeV-equivalent flux	2,09E-06	28,21

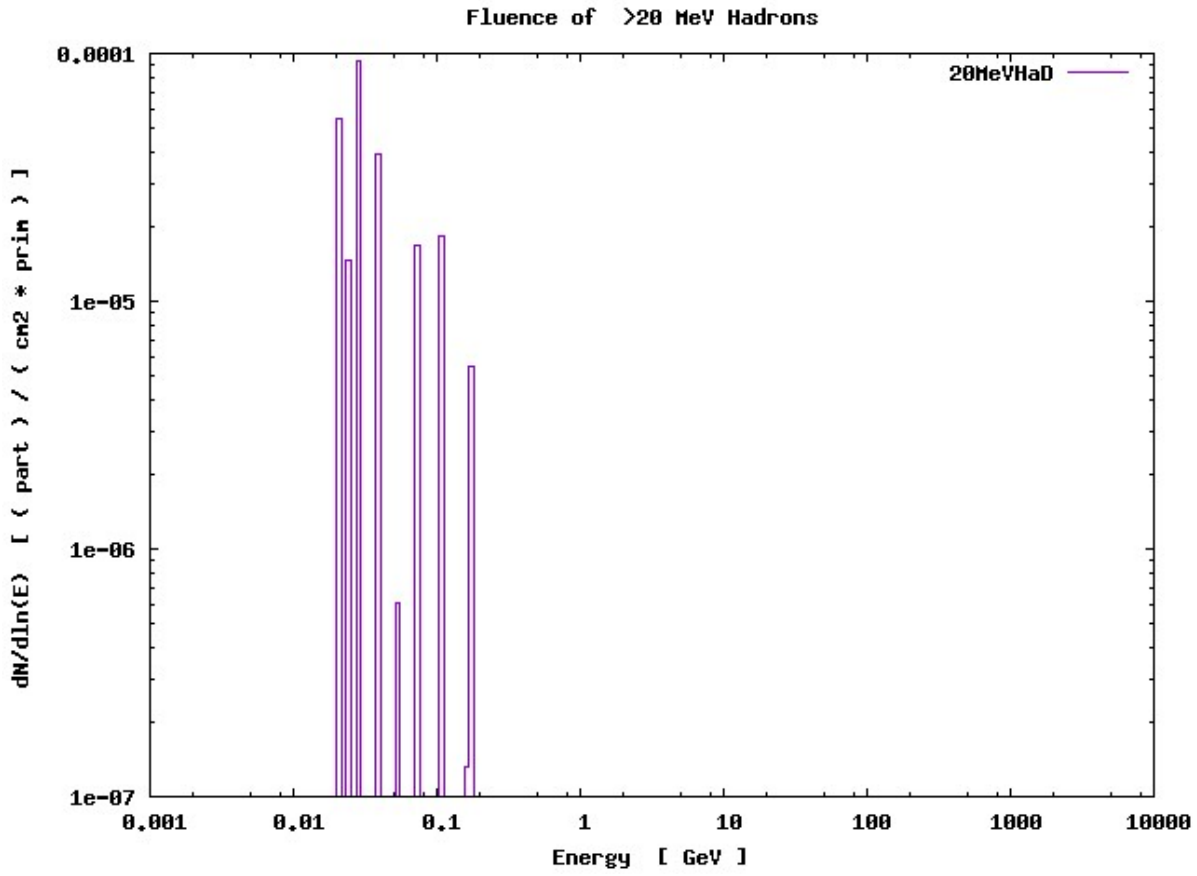
Table 4.3.1

4.3.2 Total fluence for silicon integrated by 3000 fb^{-1}

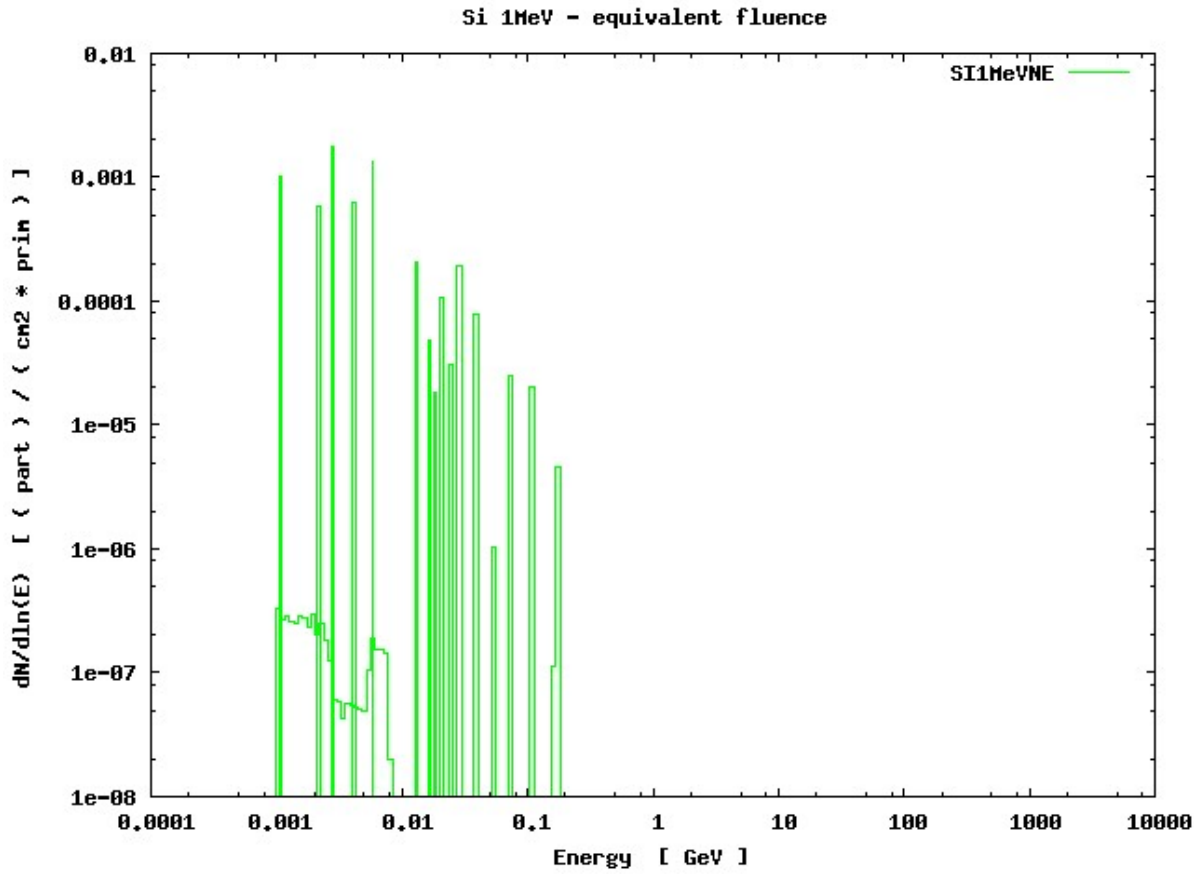
Fluence in Si cube	[part/cm2]	%Err
Hadrons (> 20 MeV)	1,78E+11	34,45
Silicon 1 MeV-equivalent flux	4,77E+11	28,21

Table 4.3.2

4.3.3 Plot of fluence for silicon using HADGT20M estimator



4.3.4 Plot of fluence for silicon using SI1MEVNE estimator



5. References:

1: www.fluka.org
2: https://twiki.cern.ch/twiki/bin/view/Sandbox/HCALRadiationProject
3: http://www.fluka.org/fluka.php?id=man_onl&sub=4
4: http://en.wikipedia.org/wiki/Absorbed_dose
5: http://en.wikipedia.org/wiki/Fluence