

HF Radiation Project

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Objectives

- Estimate the number of residual nuclei produced per pp collision in the region of the HCAL Forward (HF).
- Start FLUKA simulations for the activation studies.

Description of the simulation

- **Description of software parameters**

The software used for making this simulation was FLUKA. Based on the CMS geometry file share by Moritz Guthoff with HCAL Ecuadorian Group.

The RESNUCLE FLUKA card was used to estimate the number of residual nuclei produced in inelastic interactions on the rows at HF after a proton-proton collision in the CMS experiment. The type of products to be scored were:

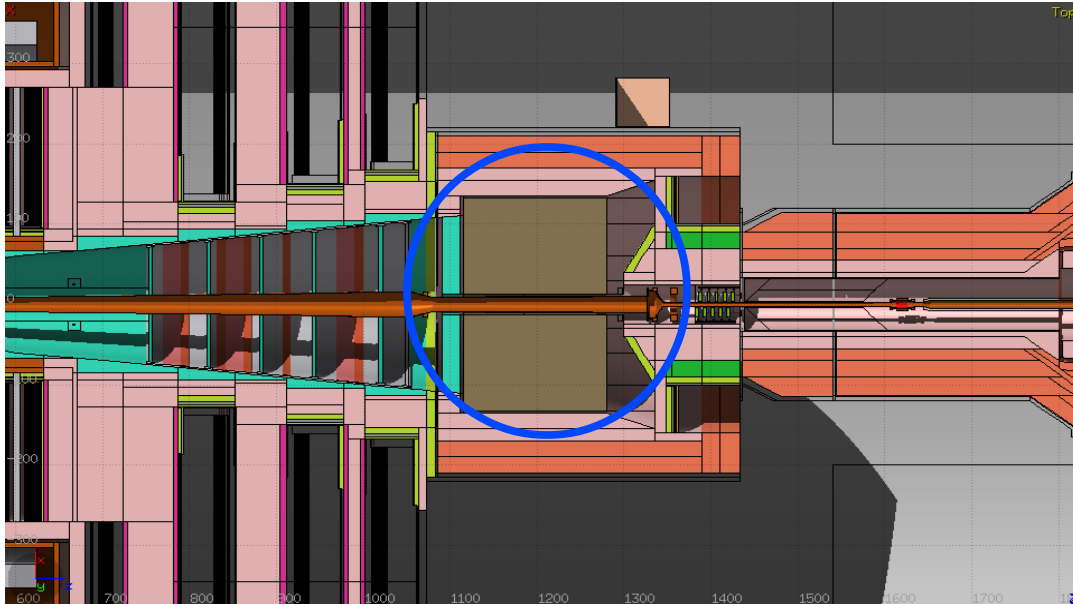
- Spallation products (all inelastic interactions except those induced by neutrons below the threshold for multigroup treatment).
- Low energy products, i.e. those produced by neutron below the threshold for multigroup treatment.

The CMS geometry file was modified in order to define a region which unites the regions R243, R244, R245, R246, R238, R239, R240, R241, R233, R234, R235, R236, R230, R231 at HF in one. The reason is that RESNUCLEI is a REGION card, that is to say, we just can make studies in a single defined region in FLUKA.

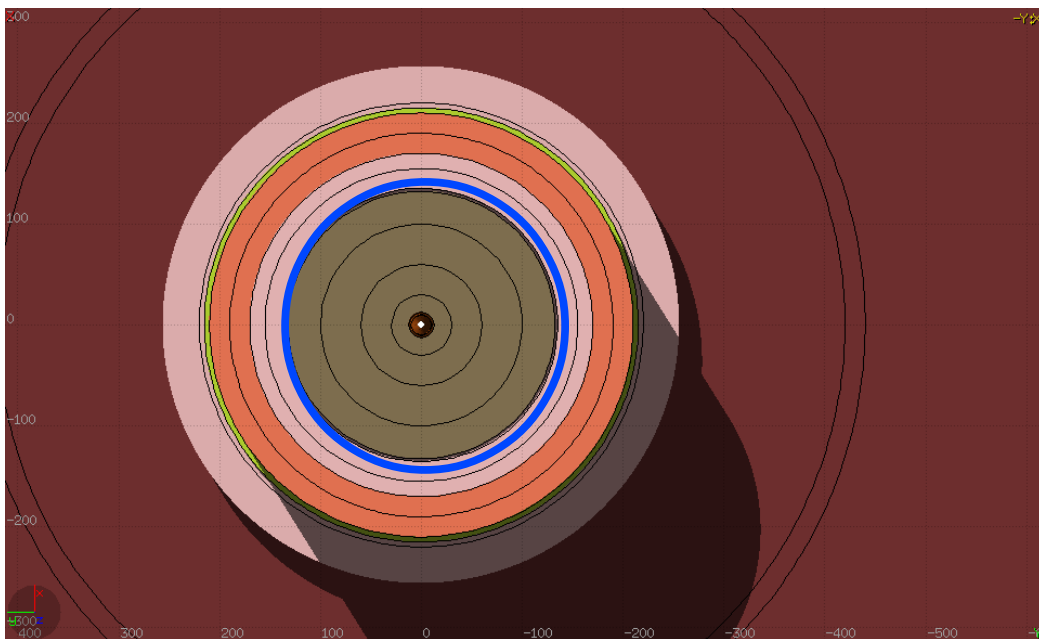
- **Description of physics parameters**

- The center of mass of the pp collision was 14 TeV.
- Lab momentum x-component equal to 0.42 G/eV and a $\sigma_z=5$.

- **Graphic description of the region where was made the count of residual nuclei in the simulation.**



Picture 1. Region of the rows in HF for testing residual nuclei.



Picture 2. Region studied in the HF

Results

1. Total Residual Nuclei

The total response was that the number of residual nuclei per cm³ and per primary are:

$$5.77048515E-04 \text{ +/- } 0.663871527 \%$$

out of which the unstable ones are:

$$5.8716796E-05 \text{ +/- } 0.662116587 \%$$

The volume of the region studied was 9019513. cm³, then we have that the number of residual nuclei produced per primary are:

$$5204.69678 \text{ +/- } 0.663871527 \%$$

and the unstable ones :

$$529.596924 \text{ +/- } 0.662116587 \%$$

2. Isotope Yield as a function of Mass Number

A	nuclei / cmc / pr	Uncert. [%]	A	nuclei / cmc / pr	Uncert. [%]	A	nuclei / cmc / pr	Uncert. [%]
1	9.3186056E-05	0.66	24	1.7718795E-07	0.88	46	1.5973239E-06	0.68
2	6.5418553E-06	0.67	25	1.7456006E-07	0.82	47	1.4363627E-06	0.69
3	2.8820547E-06	0.67	26	2.0670588E-07	0.79	48	2.1985779E-06	0.67
4	2.1249753E-05	0.66	27	3.0841250E-07	0.78	49	2.5852736E-06	0.67
6	5.6720309E-08	1.17	28	1.1842556E-06	0.67	50	4.2741539E-06	0.66
7	4.9885139E-08	1.22	29	3.5575006E-07	0.76	51	4.5115288E-06	0.66
8	8.1959574E-09	2.03	30	1.7757610E-07	0.84	52	7.1174507E-06	0.66
9	2.6104816E-08	1.46	31	2.1373736E-07	0.79	53	9.0808711E-06	0.67
10	4.1019942E-08	1.20	32	1.4375272E-07	0.83	54	2.0098464E-05	0.66
11	1.1276245E-07	0.93	33	1.6068449E-07	0.84	55	2.8672609E-05	0.66
12	4.0899479E-07	0.74	34	2.3403318E-07	0.76	56	1.8996578E-04	0.66
13	2.1986760E-07	0.80	35	2.1002531E-07	0.84	57	1.6166404E-04	0.67
14	9.4483283E-08	0.93	36	2.7976011E-07	0.78	58	5.1471193E-06	0.68
15	3.0100624E-07	0.75	37	2.3956556E-07	0.77	59	1.8083887E-06	0.68
16	5.7129884E-07	0.72	38	3.8275612E-07	0.77	60	4.0681306E-07	0.73
17	2.2834464E-08	1.58	39	3.1377088E-07	0.76	61	5.3894332E-07	0.71
18	2.4623565E-08	1.45	40	4.5680974E-07	0.69	62	1.2106549E-07	0.93

19	1.1510925E-08	2.07	41	3.9969235E-07	0.75	63	4.5265153E-07	0.73
20	6.5175039E-08	1.02	42	5.2678546E-07	0.74	64	3.4322636E-07	0.76
21	5.2151631E-08	1.13	43	4.2000155E-07	0.73	65	1.1777729E-07	0.92
22	8.2383427E-08	0.99	44	7.8242617E-07	0.69	66	9.0815849E-08	0.97
23	8.1107409E-08	1.01	45	9.2276577E-07	0.69	67	4.4615990E-12	99.0

3. Isotope Yield as a function of Atomic Number

Z	nuclei / cmc / pr	Uncertainty [%]
1	1.0153245E-04	6.61E-01
2	2.2330486E-05	6.61E-01
3	8.9829835E-08	1.03E+00
4	5.5270289E-08	1.17E+00
5	1.1044688E-07	8.96E-01
6	6.7610180E-07	7.18E-01
7	3.1415904E-07	7.42E-01
8	6.6777646E-07	7.17E-01
9	3.5492020E-08	1.27E+00
10	1.5820384E-07	8.32E-01
11	1.2952022E-07	9.19E-01
12	4.6364491E-07	7.37E-01
13	5.2985504E-07	7.44E-01
14	1.6236919E-06	6.69E-01
15	2.8310631E-07	7.53E-01
16	4.3582684E-07	7.10E-01
17	5.4878561E-07	7.37E-01
18	6.7741797E-07	7.14E-01
19	7.5550934E-07	7.03E-01
20	1.3996527E-06	6.82E-01
21	1.5852240E-06	6.64E-01
22	4.0913934E-06	6.69E-01
23	5.6512399E-06	6.65E-01
24	1.3910284E-05	6.61E-01
25	2.6062444E-05	6.63E-01
26	3.8770435E-04	6.65E-01
27	7.0777915E-07	7.12E-01

28	3.2125789E-06	6.74E-01
29	8.4706582E-07	7.12E-01
30	5.0416069E-10	8.64E+00
31	8.9231980E-12	7.06E+01

3. Isomers

A	Z	Nuclei/cmc/pr	Uncertainty[%]
24	11	7.19E-09	2.0
24	13	7.84E-11	16.3
26	13	4.22E-08	0.9
34	17	2.00E-08	1.2
38	17	7.48E-09	1.9
38	19	8.51E-09	1.8
42	21	1.62E-08	1.3
44	21	2.12E-07	0.7
45	21	2.82E-07	0.7
46	21	1.42E-07	0.8
46	23	1.67E-08	1.3
50	21	1.30E-10	13.1
50	25	1.67E-08	1.4
52	25	9.22E-07	0.7
52	26	3.95E-08	1.0
53	26	4.15E-07	0.7
53	27	6.27E-11	18.4
54	27	3.81E-09	2.5
58	25	9.56E-10	5.1
58	27	1.23E-07	0.8
60	25	4.48E-12	70.6
60	27	6.98E-09	1.8
62	27	3.96E-10	7.7

4. Plots

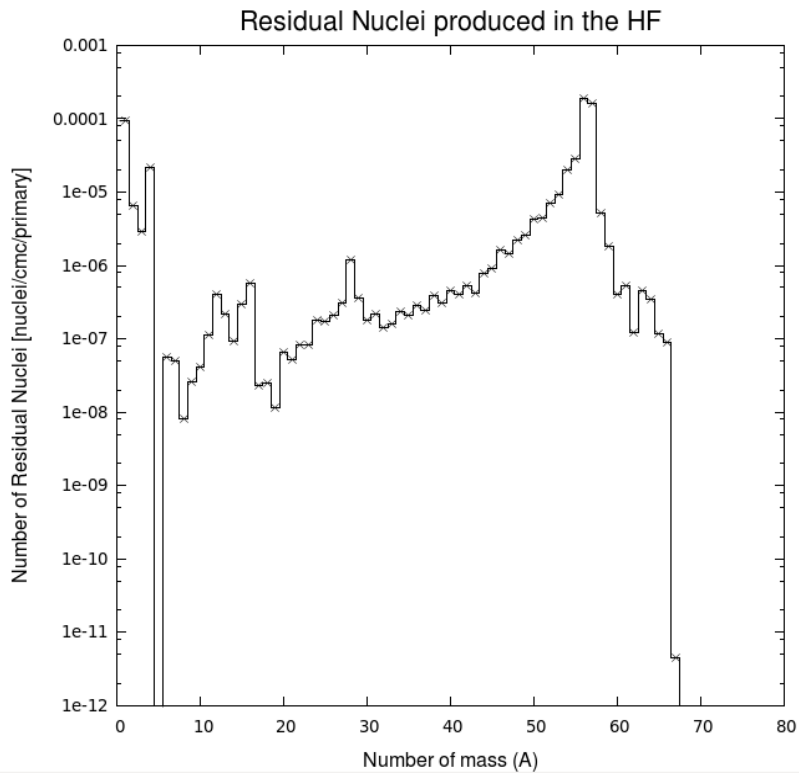


Figure 3. Number of residual nuclei produce per pp collision as a function of the Number of Mass (A).

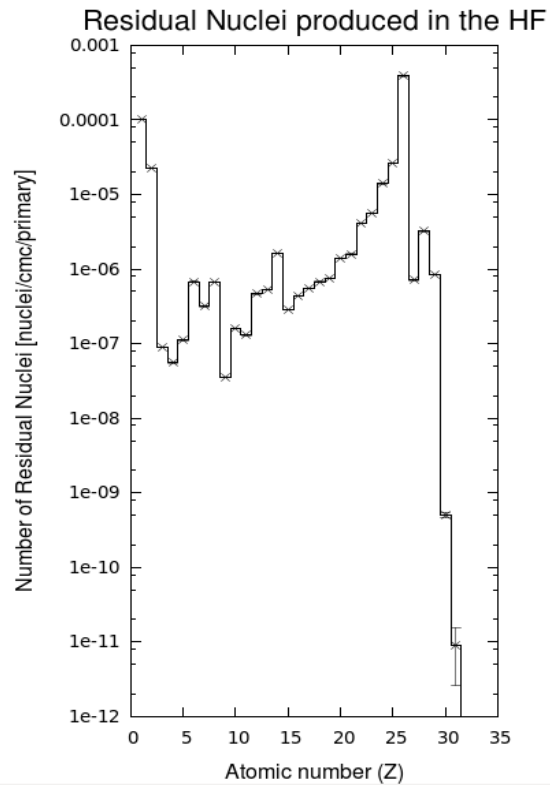


Figure 4. Number of residual nuclei produce per pp collision as a function of the Number of Mass (A).

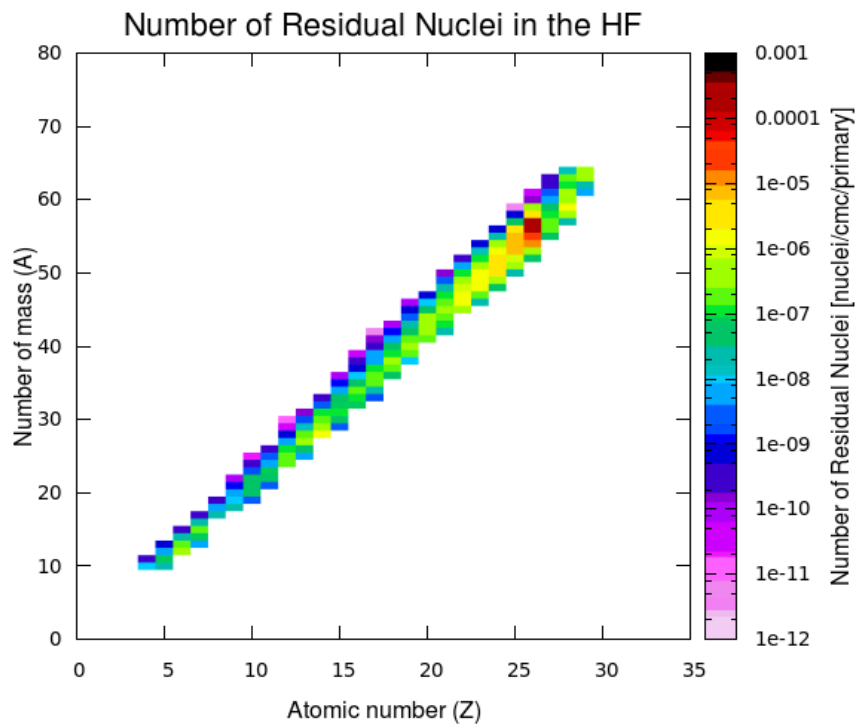


Figure 5. Number of residual nuclei produce per pp collision as a function of the Number of Mass (A) and Atomic number (Z).

REFERENCES

[1] FLUKA Online Manual

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[2] Induced Radioactivity. 7th FLUKA Course

<http://www.fluka.org/content/course/NEA/lectures/Activation.pdf>

[3] Fluka 2006 calculations in CMS.

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