Simulation by FLUKA of the self-activation of a cyclotron IBA Cyclone® 18

Simone Manenti[1,2], **Francesco Broggi**[2], **Riccardo Calandrino**[3], **Flavia Groppi**[1,2]

[1] Department of Physics, Università degli Studi di Milano, Milano, Italy

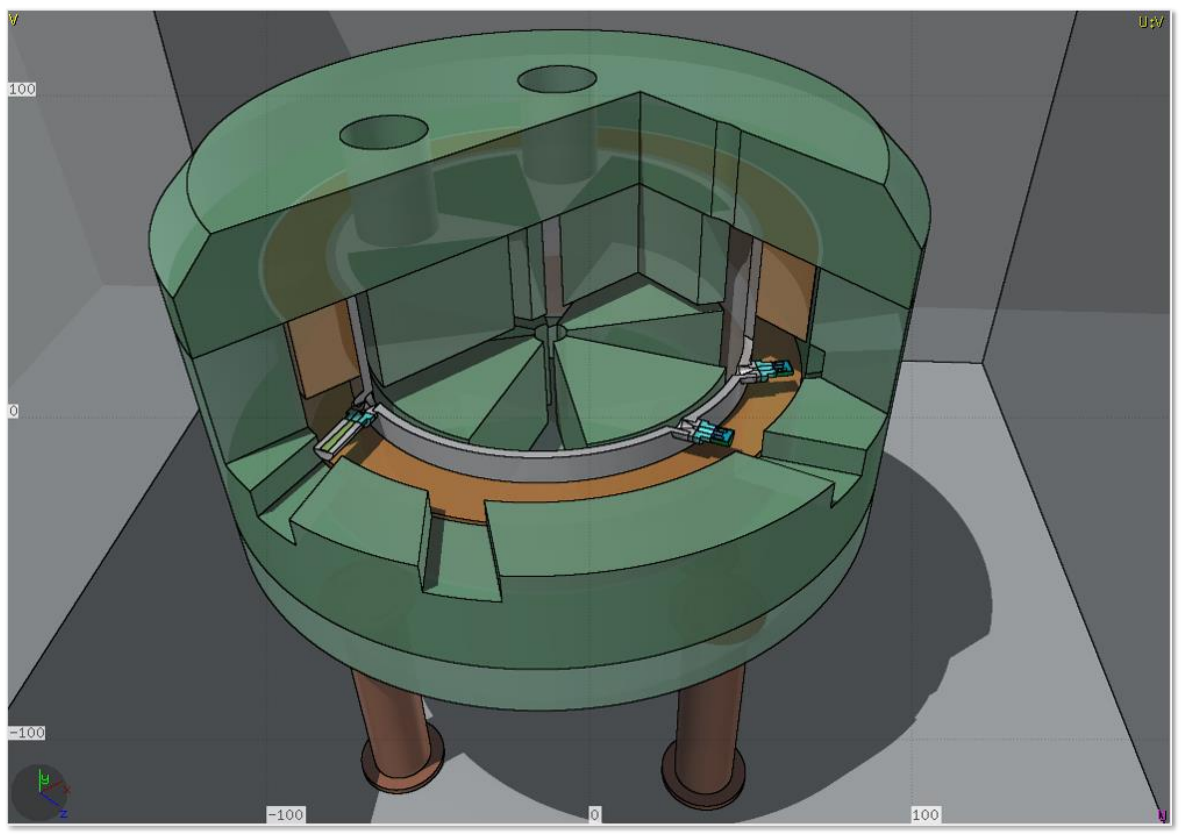
[2] INFN/Milano, Milano, Italy

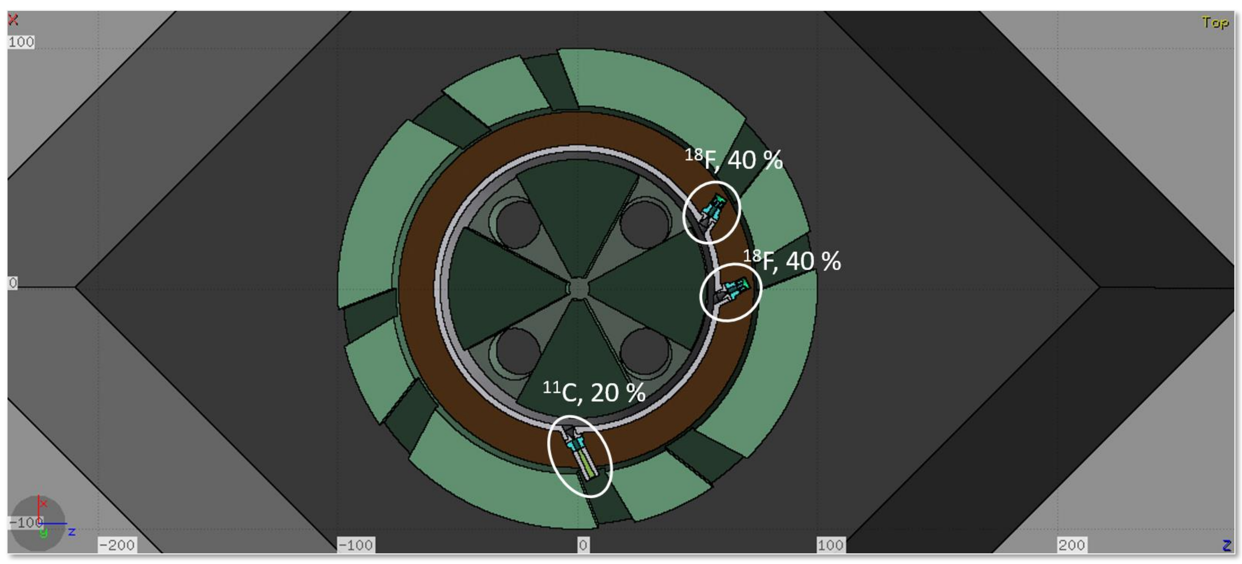
[3] Medical Physics, San Raffaele Scientific Institute, Milano, Italy

Radioprotection in the use of medical cyclotrons involves many aspects both in the routine use and for the decommissioning of a site. In this work we present the self-activation results obtained through the simulation by FLUKA of the cyclotron IBA Cyclone®18 that was installed in San Raffaele Hospital.

The cyclotron object of the simulation has been stopped two years ago and it is useful to detail the today average radionuclide composition for the various macro-regions (coils, main yoke, return yoke, dees).

The geometry and the materials constituting respectively the cyclotron and the targets have been reconstructed starting from technical drawings, from private communications and from confidential technical documents.

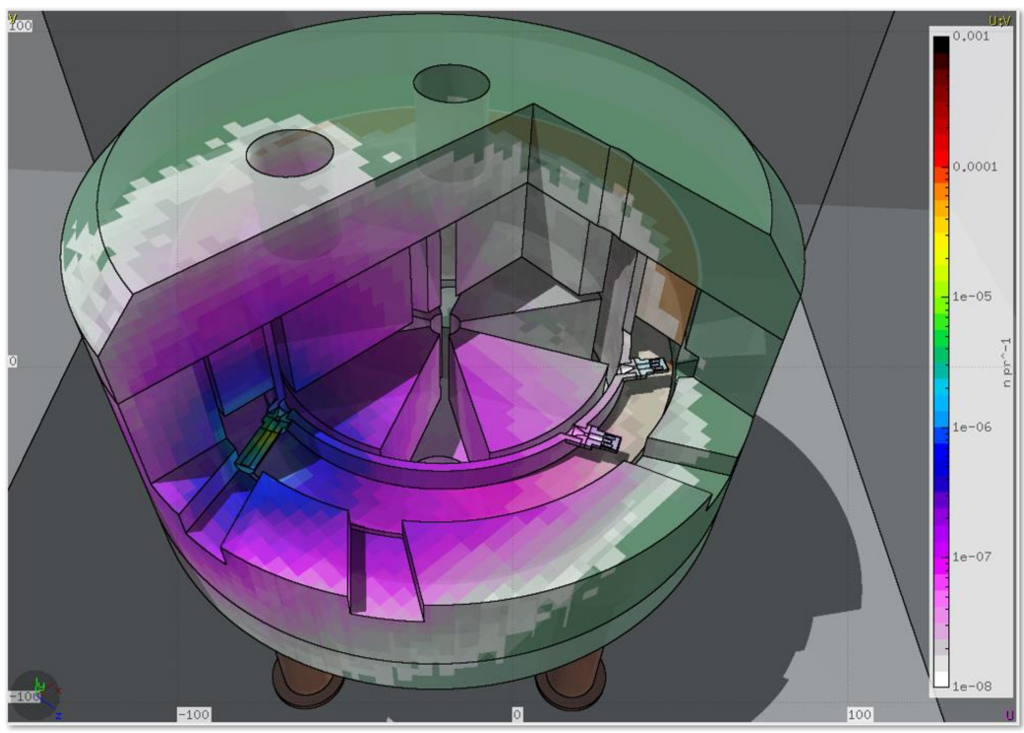


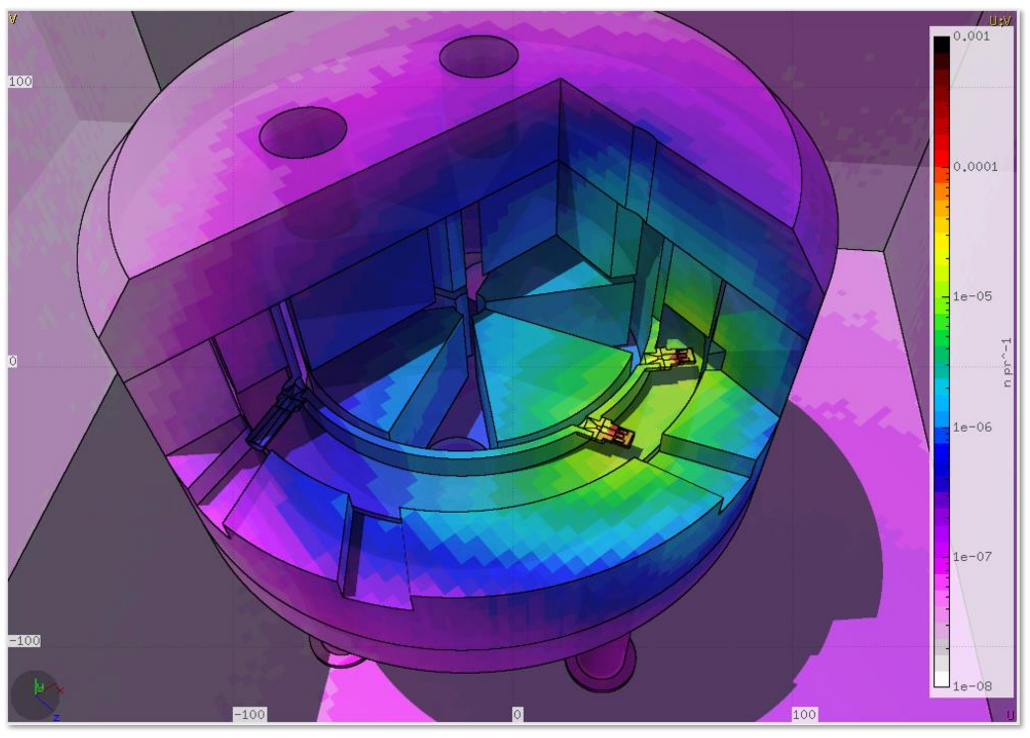


Through FLUKA it was possible to reconstruct the entire working life of the cyclotron: from the operating characteristics (1000 μA·week for 20 years), a constant beam has been imposed for 630’720’000 seconds.

The residual radioactivity is due to secondary neutrons produced by the reactions on targets containing:

$^{14}N_2$ at high pressure for the production of ^{11}C;

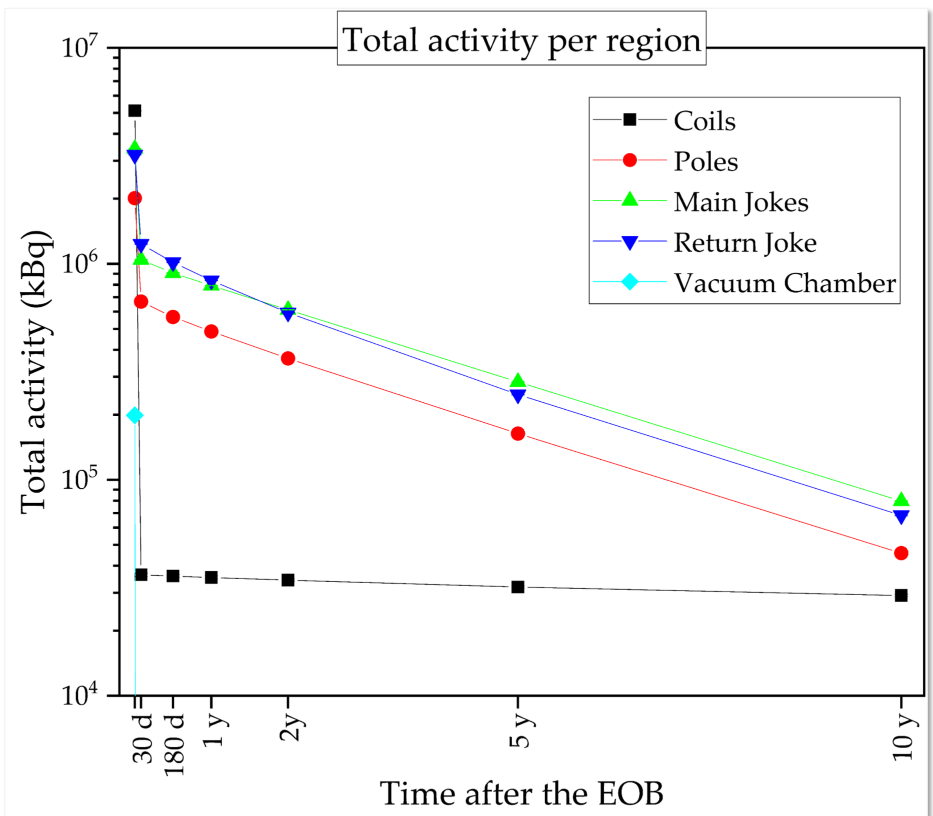




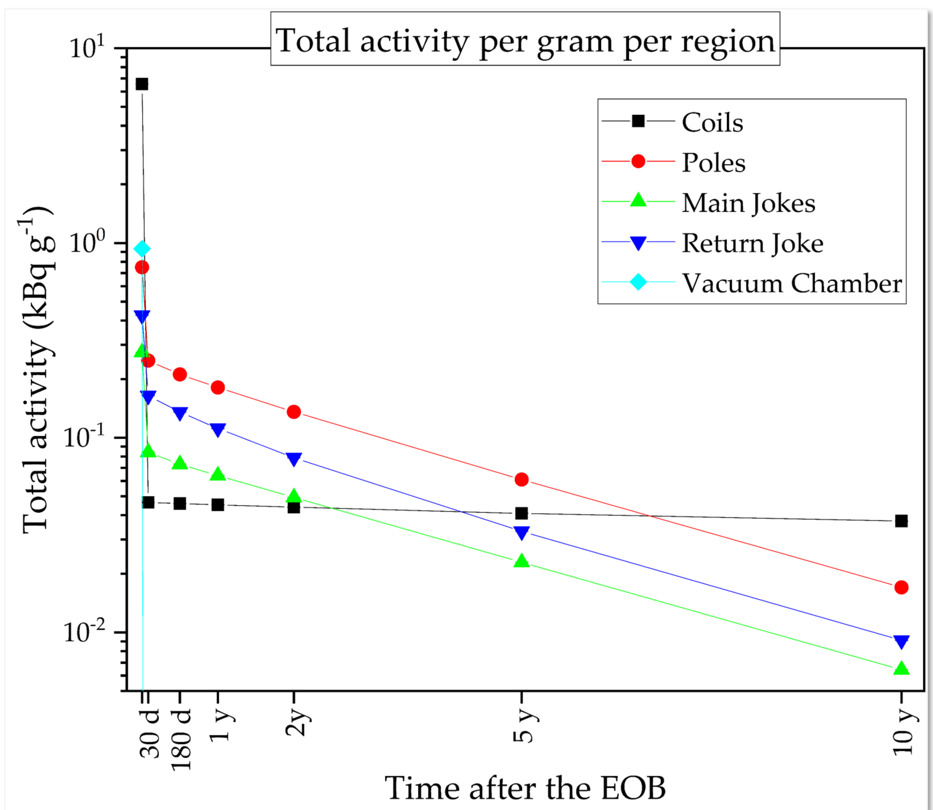
$H_2{}^{18}O$ for the production of ^{18}F.

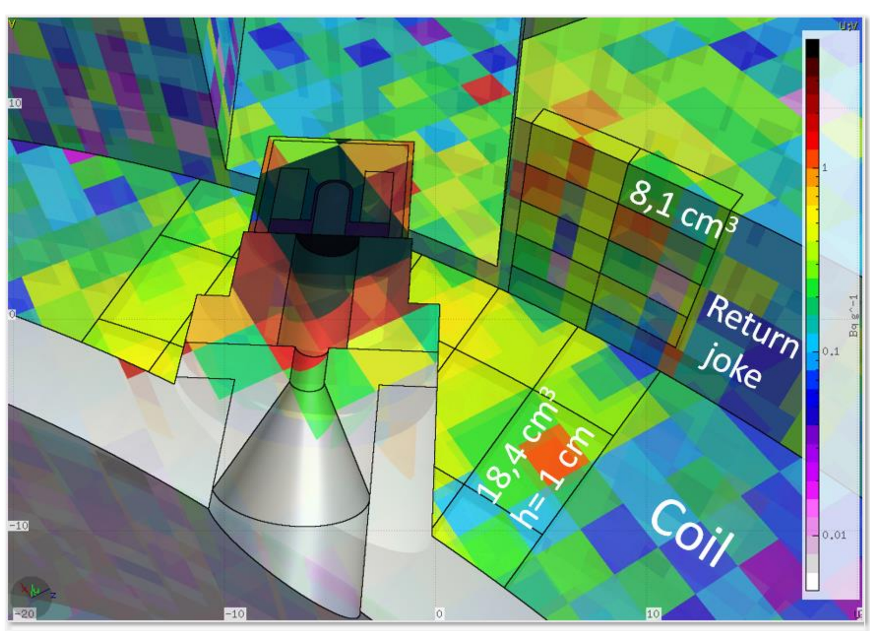
The cyclotron has been divided into macro-regions:

- the Coils;
- the Vacuum Chamber;
- the poles of the magnet (Poles);
- the Main Yoke;
- the Return Yoke.



For each of these areas the total radioactivity (*top*) was estimated and the average value per unit of mass (*bottom*) was calculated based on the time elapsed since the last irradiation (EOB i.e. End Of Bombardment).





After **two years**, the residual radioactivity is given by ^{54}Mn ($t_{1/2}$=312.2 d), ^{55}Fe ($t_{1/2}$=2.73 a), ^{60}Co ($t_{1/2}$=5.272 a) and ^{63}Ni ($t_{1/2}$=100 a).
The maximum local activity is from:

- ^{60}Co (~2.1 kBq g^{-1}) and ^{63}Ni (~0.7 kBq g^{-1}) in the coils;
- ^{55}Fe (~1.8 kBq·g^{-1}) and ^{54}Mn (~1.4 kBq·g^{-1}) in the return yoke.

The results of this work will have to be confirmed by ongoing experimental measurements.

Contact:
simone.manenti@mi.infn.it

OSPEDALE SAN RAFFAELE MILANO

INFN MILANO Istituto Nazionale di Fisica Nucleare Sezione di Milano

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