

# Modeling Cyclotron CYRCE on OpenGATE10

CYRCÉ is a TR24 cyclotron at the Institut Pluridisciplinaire Hubert Curien, in Strasbourg, France. This cyclotron allows both isotope production ( $^{18}\text{F}$ ,  $^{64}\text{Cu}$  and  $^{89}\text{Zr}$ ) for Positron Emission Imaging (PET) markers as well as sample irradiation (both biological and nuclear instrument) with protons between 16 and 25 MeV and intensities up to 500  $\mu\text{A}$  [1], [2].



*Figure 1. CYRCE cyclotron casemate*

Numerical modelling of an irradiation beam line, using Monte Carlo simulation software for radiation-matter interactions, is a very important tool both for preparing irradiation experiments and for comparing the results with theoretical calculations. This internship in the DeSIs team at IPHC proposes to model the CYRCÉ cyclotron beam line using the latest version of the Geant4/GATE Monte Carlo software (v10.0.3). Geant4 is a Monte Carlo simulation toolkit developed at CERN to model particle interactions with matter. Initially created for high-energy and nuclear physics experiments, it offers a comprehensive framework for simulating complex geometries, materials, and a wide range of physical interactions across different energy scales. GATE (Geant4 Application for Tomographic Emission) is an extension of Geant4 designed explicitly for medical physics and radiation protection applications, including medical imaging, hadron therapy, and dosimetry simulations. It features a user-friendly interface and specialized tools for conducting Monte Carlo simulations in this field.

Previous modelling of the CYRCÉ beam line has been done in GATE version 9 (v9) in the context of a thesis [5]. GATE v9 was based on C++ Geant4 commands. However, with the rise of machine learning and the increasing use of Python for computer science, GATE has been upgraded this year to a Python-based version, called GATE10 which is [3], [4]. The main objective of the internship will be to develop a model of the CYRCÉ platform's irradiation line using GATE version 10 software. The internship work will also focus on validating the model through experimental measurements (beam energy, dosimetry, etc.). Moreover, as a secondary activity during the internship, some development of new features for the new version of GATE10 may be necessary depending on modelling requirements

**Skills:**

- basic knowledge of radiation-matter interactions
- basic knowledge of radiation detection
- basic knowledge of radiation protection and dosimetry
- experience in Python programming

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