Free Software Tools in Computational Neutronics: Introduction

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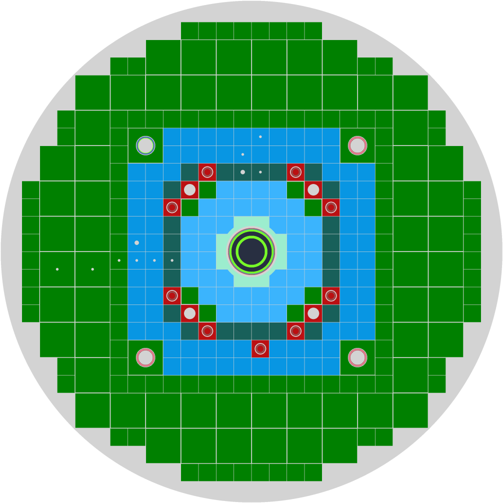
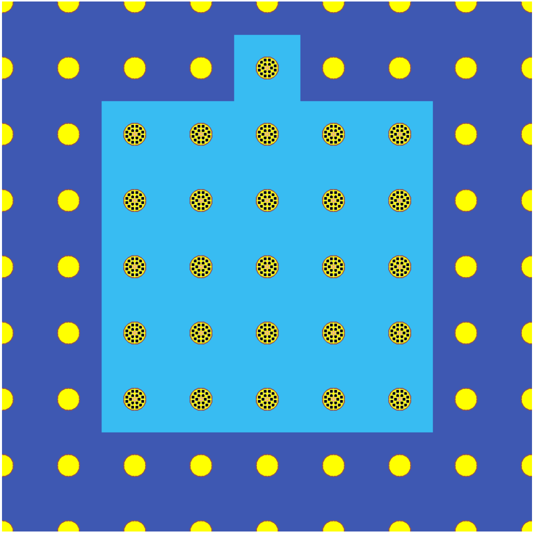
At the end of this course you will be able to calculate nuclear reactors and other systems with software tools that have no usage restrictions.

Some examples:

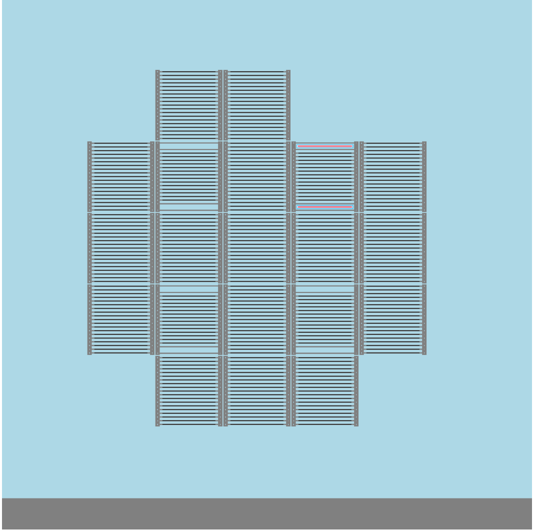


Horizontal cut of the IGR nuclear reactor core - Benchmark HEU-COMP-THERM-016

Some examples:

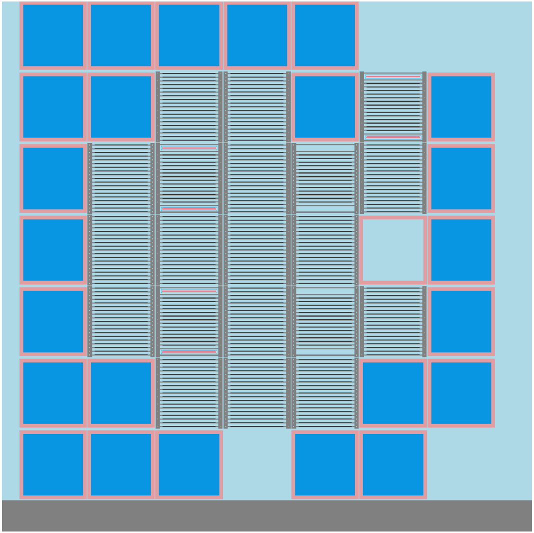


Horizontal cut of a RBMK type reactor core - Benchmark LEU-COMP-THERM-060



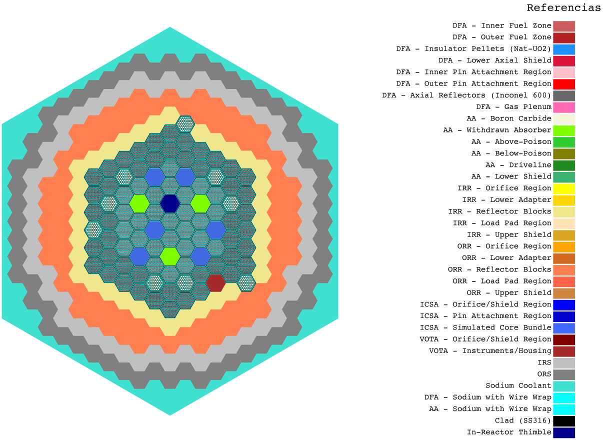
Horizontal cut of the RA-6 reactor core - Benchmark IEU-COMP-THERM-014
(Author: Jaime Romero Barrientos)

Some examples:

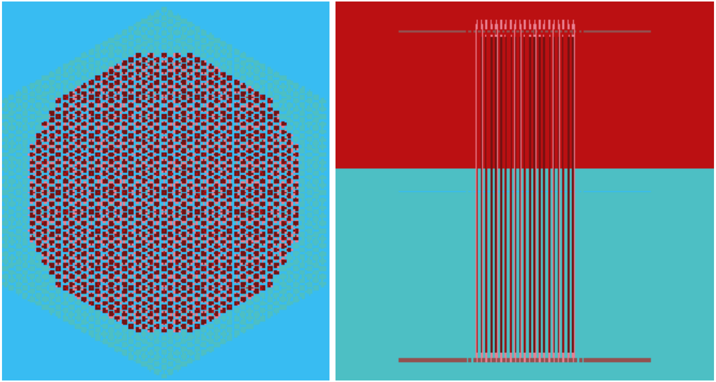


Horizontal cut of the RA-6 reactor core - Benchmark IEU-COMP-THERM-014 (first reflected core)
(Author: Jaime Romero Barrientos)

Some examples:



Horizontal cut of the FFTF reactor core - Benchmark FFTF-LMFR-RESR-001
(Author: Norberto Schmidt)



Horizontal and vertical cuts of ZR-6 reactor core - Benchmark
LEU-COMP-THERM-075
(Author: Pablo Octaviano)

The students will obtain a basic understanding of a set of free software tools available for neutronics:

- GNU/Linux as a base,
- Python as interface language to OpenMC, and for data pre- and post-processing,
- OpenMC for neutron transport, and
- NJOY2016 for neutron cross section data processing.

These are not the only tools that are available (and we are lucky!). In Reactor Physics you might have used Milonga, a core calculation code developed by Germán Theler. There is also DRAGON/DONJON/TRIVAC, from Polytechnique Montréal, and OpenMOC from CRPG (the group that started the development of OpenMC).

Objectives:

- The purpose of this group is to present a series of tools that are useful for solving problems in computational neutronics.
- One common characteristics of the tools we will see in this course is that they are free software. What does it mean? That we as users have the freedom to do four things:
  0. The freedom to run the program as you wish, for any purpose.
  1. The freedom to study how the program works, and change it so it does your computing as you wish.
  2. The freedom to redistribute copies so you can help your neighbor.
  3. The freedom to distribute copies of your modified versions to others.

These freedoms (in my opinion) are fundamental in the academic field, because they allow us to learn tools that do not imply any dependency. And on the other hamd, in the professional field, accessing the source code without restrictions allows us to really understand what a program does to avoid using it as a black box.

- Introduction to GNU/Linux (8 hs):
  GNU/Linux systems, filesystem structure, file management commands. Text file processing with GNU tools: grep, awk, sed. Connection to remote servers using SSH. Version control with git.
- Introduction to the Python language (8 hs):
  Basic concepts, scripts and iPython/Jupyter notebooks. Data types. Flow control and loops. Functions and modules.

- OpenMC (24 hs):
  Review of radiation transport. Monte Carlo method for neutron transport. Generation of simple geometries: definition of surfaces, regions, cells and universes. Definition of materials. Definition of external sources and eigenvalue calculations. Generation of repeated structures: lattices.
- NJOY2016 (8 hs):
  Review of neutron interaction with matter: nuclear reactions and cross sections. ENDF-6 format and evaluated nuclear data files (ENDF/B, JEFF). Reconstruction and linearization of cross section. Temperature treatment: Doppler broadening and thermal scattering libraries. Generation of ACE libraries for Monte Carlo codes.
- Final project (16 hs):
  Description of the system. Benchmark problems (ICSBEP/IRPHEP/SINBAD). Solution and analysis. Presentation of the final project.

Online version of the course:

- For the online version of the course we will use Google Colaboratory.
- This allows us to use Python (and Python based tools, such as OpenMC) without the need to install anything in our computers.
- All the examples that we will see in the course are based on data in the public domain. The examples are available to be modified by the students.
- In case you do not have a Google account or you do not want to use Google Colaboratory, the Jupyter notebooks can be downloaded to be run locally..

Coordination with other courses:

Recommended prerequisites at Instituto Balseiro:

- Modern Physics for Nuclear Engineering.
- Neutron Physics.
- Reactor Physics.

Courses that cover in more details topics seen in this course:

- Monte Carlo Method Applied to Neutron Problems.
- Introduction to the Python Language with applications to Engineering and Physics.
- Calculation and Analysis of Reactors.