Graphical User Interface for the n_TOF Transport Code

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Abstract

n_TOF is a neutron time-of-flight facility at CERN where high accuracy neutron-induced reaction cross-section measurements, of great interest for Astrophysics, Nuclear Technology, Basic Physics and Medical Physics, can be performed. In order to prepare and analyze such high accuracy measurements, several calculations have to be performed, such as reaction rates or the alignment between neutron beam and sample. Those calculations are done via Monte Carlo simulations. The aim of this project is to create a tool to allow users a convenient and consistent way to perform those simulations, including setting up the parameters for a simulation, launching it on CERN’s computing grid, check the running status and plot the results.

1 Introduction

The neutron time-of-flight facility (n_TOF) at CERN makes use of the 20 GeV/c protons delivered by the Proton Synchrotron to produce neutrons through spallation induced by protons impinging on a lead target [1]. The resulting neutrons are directed to two experimental areas: experimental area 1 (EAR1), a horizontal beam line located 185 m from the lead target, and experimental area 2 (EAR2), a vertical beam line located 20 m from the target. There, the neutron-sample interaction is measured, in order to investigate properties of isotopes relevant to various fields of research such as nuclear astrophysics, technology or medicine. Neutrons energies, determined by the time-of-flight method, range from meV up to GeV with a high intensity ($10^5$ neutrons/pulse in EAR1, $10^7$ neutrons/pulse in EAR2 [2]). The broad neutron spectrum, the energy resolution and its high instantaneous neutron flux make n_TOF one of the world leading facilities for measuring neutron-induced reaction cross sections.

1.1 Monte-Carlo Simulation

One of the main tools in research is the Monte-Carlo simulation, which imitates the physical process in the experiment and produces theoretical predictions, i.e. count rates and cross sections, in order to compare them with measured results.

At n_TOF, the spallation process is simulated with FLUKA [3], a fully integrated particle physics Monte-Carlo simulation package. Neutrons and photons are recorded in scoring planes close to the spallation target facing the two experimental areas.

In a second stage, neutrons and photons are projected from the scoring plane to the two experimental areas, taking into account the collimation system and interactions with materials. This part of the
simulation, called the transport code, is capable of producing various types of histograms such as the fluence, count rates, resolution function and the spatial profile of the beam.

A schematic description of the simulation process is given in figure 1.

The goal of this project is to create a graphical user interface (GUI) for the transport code to allow users a consistent and convenient way of performing those simulations.

2 GUI DESCRIPTION

The GUI consists of three functions:

1. **Launch Simulation** – set up the parameters for a new simulation and launch it.
2. **Check Status** – check if a simulation is still running.
3. **Create Plots** – create a ROOT histogram from the outputs and plot it.

2.1 Implementation Details

The GUI was implemented in Python, using the default GUI package Tkinter. It runs on LXPLUS (Linux Public Login User Service), CERN’s interactive logon service. When launching the simulation, the input parameters are saved into a bash script and submitted to HTCondor, CERN’s distributed batch service. The simulation is divided into different jobs, one job per each source file. The jobs run on HTCondor in parallel, and write their output in ASCII format to a directory defined by the user. When the jobs are done, the user is able to combine and average the ASCII output files and convert it to a ROOT histogram for easy plotting using the "Create Plots" tool.
2.2 Launch Simulation

This function allows the user to set up the parameters for a simulation and launch it. The following parameters should be provided by the user:

- Source files - output of spallation simulation, generated by FLUKA or FLUKA + MCNP
- Alignment of collimators
- Particle type - neutrons or photons
- Flight path length
- Target shape - circular or rectangular
- Resampling cutoffs for the histogram, e.g. energy or time of flight
- Sample material (optional)
- Support layers (optional)
- Output directory

The GUI includes a configuration wizard that helps the user navigate through all the input parameters and fill them. An example for a page from the configuration wizard is shown in figure 2.

Moreover, the GUI assists the user to select the desired histogram type, out of the following:

- Energy - fluence or yield (1D)
- Time of flight - fluence or yield (1D)
- Energy vs Time of flight (2D)
- Resolution function vs Energy (2D)
- Resolution function vs Time of flight (2D)

Figure 2: Example for a page from the configuration wizard.
• Spatial profile (2D)

In addition, another tool was developed to assist the user calculate the number of atoms per barn in the sample and support layers, given a material chosen from a database or defined manually by its chemical (isotopic) composition.

2.3 Check Status

After launching the simulation, the user is able to check its running status using this tool. For each job (see section 2.1), the status is one of the following:

1. **Done** – the job finished and created an output file.
2. **Running** – the job is still running on HTCondor.
3. **Dead** – the job is not running anymore, but the output file was not found. The job might have been killed by the user, or failed for another reason.

The user is also able to use the tool to kill the running jobs. The tool is shown in figure 3.

![Check Status tool](image)

**Figure 3:** Check Status tool

2.4 Create Plots

When the simulation is done, the outputs are written as ASCII files to an output directory defined by the user. This tool is used to aggregate all the outputs into one file, convert it to a ROOT histogram and plot it. See some examples for different outputs defined in the configuration wizard in figure 4.
Figure 4: Plots examples: (a) neutrons energy (b) spatial profile (c) resolution function

3 Summary

This report describes the main features of the GUI for the transport simulation. The GUI eases the use of the transport code, allowing new users to run simulations easily and plot their results quickly. In addition, the interactive interface reduces the amount of potential errors in setting and calculating the input parameters. Furthermore, a user manual was written to help the user navigate through the GUI. In fact, the GUI is already in use by n_TOF, for example in the comparison between the two spallation simulations, FLUKA and FLUKA + MCNP.

References

