3 (h) Neutron Raytracing

1 Determine guide coating with neutron raytracing

In this exercise, we assume we have optimized a guide system using m=6 mirror coating. Now we want to find out where in the guide we can use a lower coating without loosing flux on the sample. We don't want to use a high coating to reflect a lot of neutrons that get lost somewhere else in the system, or contribute to background! Therefore, we use raytracing to select the neutrons we want, and then choose the coating appropriate to transport them.

The guide system we use here consists of a short linear focusing part followed by a kinked ballistic guide; we use linear focusing here so we can build the different guide parts out of one piece each in oder to save simulation time in this exercise. For the same reason, instead of a chopper at the focal point at approx. 6 m we use a slit representing a chopper opening window.

1. Load *Ex3h_Raytracing.gui*, and `Check` wether you have all required input files available. You might have to change the name of the reflectivity file, or create one[1] if you haven't done so in previous exercises. The moderator file is the standard cold ESS moderator (available in `FILES/moderators/ESS`).

2. In a first simulation run, we select neutrons that reach a 2x2 cm^2 sample with a divergence no larger than $\pm 0.5°$: add a `writeout`, set position and divergence filter values and simulate. Look at the transmitted position and divergence in monitors.

3. In the source file, put the name of the writeout output file as *raytracing file* and select *only trace trajectories*. Remove the writeout. When you start the simulation again, the same neutrons as before will be generated in the source (all of them). Their ID is compared to the ones found in the raytracing file (first column), and neutrons not written there are discarded, so only the neutrons found in this file are treated and sent to the next module. So raytracing does NOT work if you

   - change the random number between the two simulations
   - use a module that changes neutron IDs (e.g. samples can do that when multiplying trajectories)

   Run the simulation again and confirm by the monitors that you selected the right neutron subset.

4. Now you can investigate those neutrons you use, e.g. you can see what part of the moderator is actually seen in your experiment by putting a

[1] To create a reflectivity file, start the tool `Generate Mirror Files`, choose quadr. Swiss Neutronics description ("yes") and give desired m value and filename.

position monitor directly at the source (you need to choose *by virtual window* for that)

5. In order to see what coating is needed in the **first guide**, give Filenames in *Reflection list options* and *Reflection plot options*. You only need one of them, but here we want to create both so you can choose which method you prefer. Read the according explanations in the guide helper file. Note that these reflection files can become quite large if you have too many trajectories!
   The reflection list creates an output file similar to the writeout module, with a list of all neutrons and their properties including the coating necessary for a successful reflection. This is a lot of information, taking up a lot of space! The reflection plot option creates an output similar to a monitor file with the chosen parameters on the x and y axes, but still containing other information; choose "position x" and "m" for our purpose, weighted with the probability. Give guide length as maximum X and plot the coating up to m=6. Run the simulation.

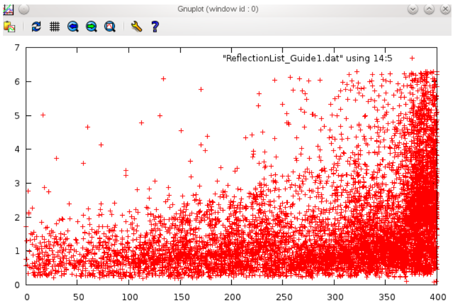
6. Compare the file size of the created reflection list and reflection plot files. Look at their content.

   - With the reflection list, you can plot anything against anything now by reading in the respective columns in your favourite evaluation tool. Gnuplot example for the m-value vs. guide x position: *plot "ReflectionList_Guide1.dat" using 14:5*. Figure 1 shows example plots produced with `gnuplot` or `root`. You could also plot the reflection angle, the reflectivity etc.
   - In the reflection plot, the data is already binned to save disk space. Figure 1(b) shows an example from guplot.

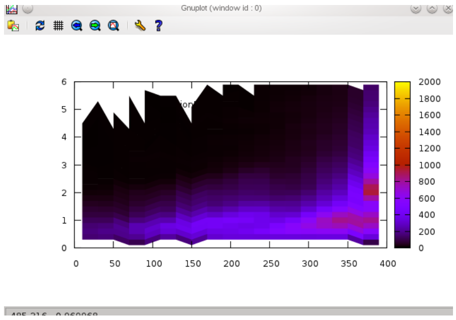
7. Use your favourite method to investigate the coating needed in the last guide part. Notice that neutrons reflected in this part of the guide only contribute to background!

8. Select background neutrons in a similar way as signal neutrons before: use a beamstop to cut out the sample position, and the filter option in monitor1D together with *exclusive counts* to select the divergence[2]. Compare the m values for signal and background neutrons in guide no. 4, i.e. the 20 m long kinked part. You should see something like shown in figure 2.

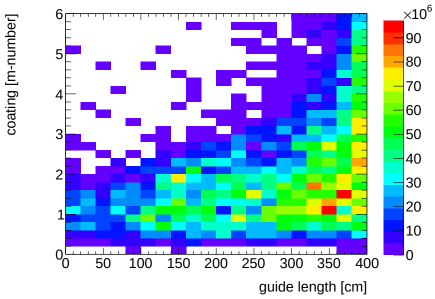
[2]There is a dedicated filter module since VITESS version 3.1, however the "OR" option which we need here does not work correctly.



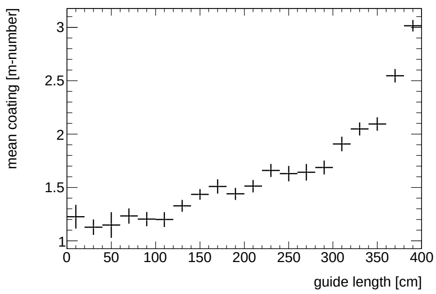
(a) Gnuplot example: trajectories in x-m-space from refl. list



(b) Gnuplot example: trajectories in x-m-space from refl. plot

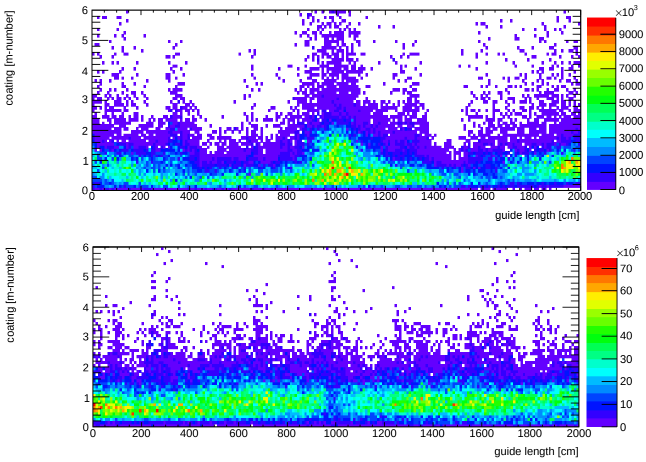


(c) root example: intensity in x-m-space from refl. list



(d) root example: mean m as function of x from refl. list

Figur 1: Example plots showing needed m value at different positions x in guide 1.



Figur 2: m value needed for signal (upper) and background (lower) neutrons at different position in the kinked guide part. Note that neutrons contributing to background are primarily reflected at the beginning of this guide, while signal neutrons are reflected in the center and end section!