Preliminary Results of the Monte Carlo Simulation of the Neutron and Gamma Background in a Second Experimental Area for Fission Measurements at nTOF

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Introduction

The suitability, in terms of neutron and neutron-induced gamma background, of a design [1] for the second experimental area is being investigated by means of Monte Carlo simulations with MCNPX [2]. This short note reports on the current status and preliminary results of the ongoing simulations.

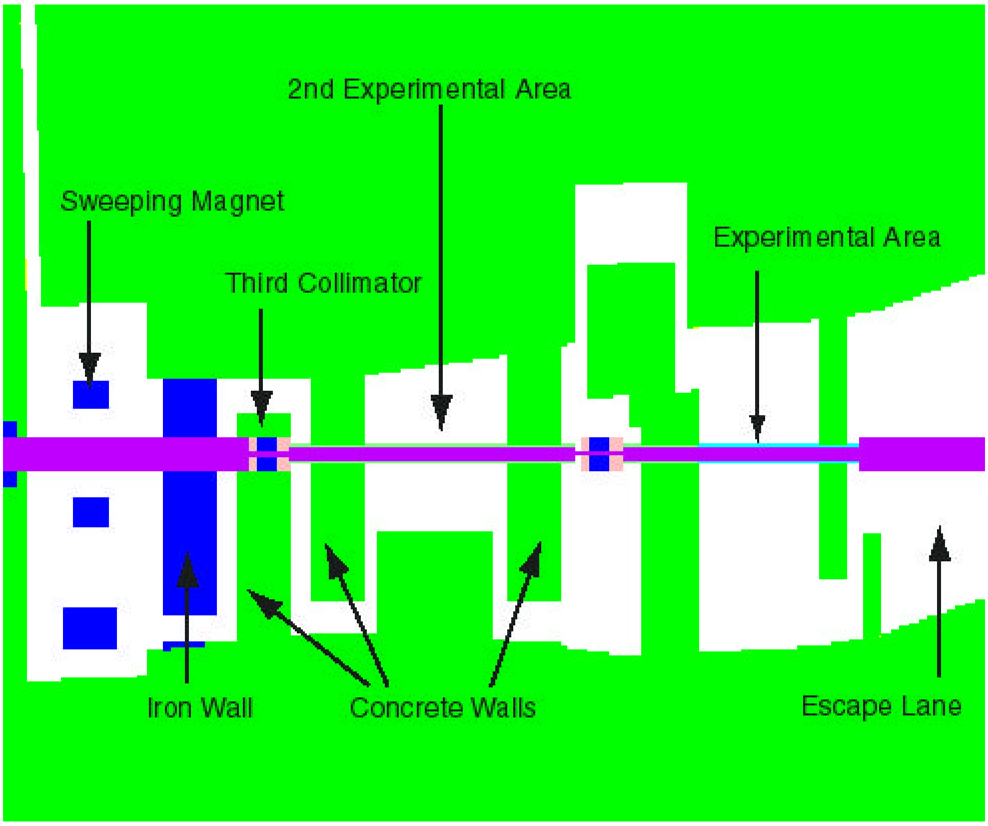

Figure 1. View of the geometry of the proposed 2nd experimental area and main experimental area as defined for MCNPX. Notice that the vertical (x) and horizontal (z) axes are not in the same scale.

A fully detailed geometry of the complete nTOF tunnel, from the spallation target up to the escape lane, has been modelled for MCNPX. It also includes the design proposed for the second area for fission measurements located at 165 m TOF. The relevant part of the geometry is shown in Fig.1. It also includes a third collimator of 5 cm inner radius with the same geometrical design as the 2nd collimator currently in use: 50 cm of borated polyethylene, 125 cm of Fe and 75 cm of borated polyethylene.

Preliminary Results

Due to the excessively time consuming simulation of the complete spallation process, a realistic neutron source (with the correct spatial and energy distribution) has been modelled alternatively. However, it is being verified in parallel that the contribution of the spallation process to the secondary area in terms of neutron and neutron-induced background can be really neglected with the improved version of the shielding. The background produced by the interaction of charged particles coming from the Pb-target is also not considered and should be the subject of a separate study.

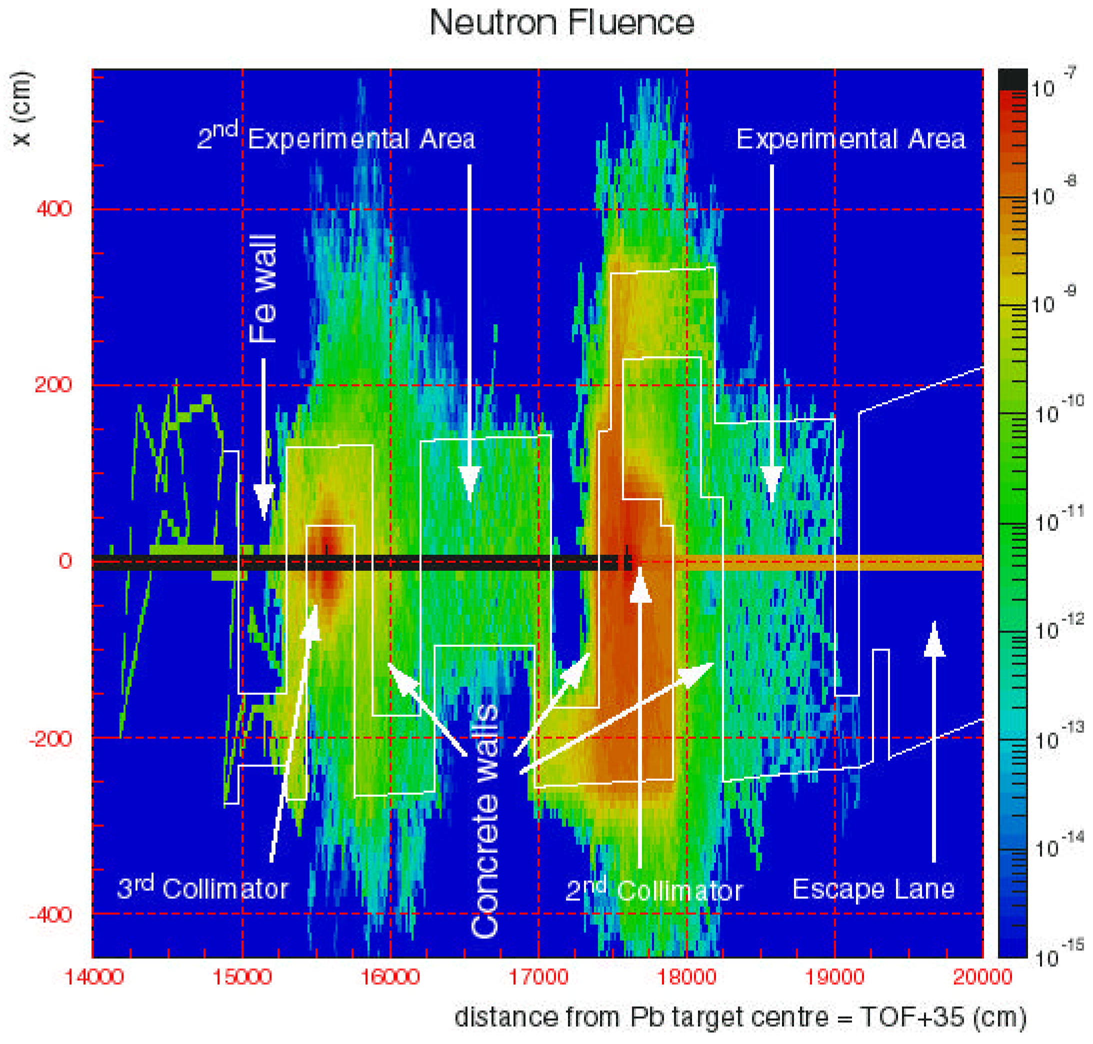

Figure 2. Neutron fluence distribution along the last 60 metres of the tunnel. The figure represents a bird's-eye view of the nTOF tunnel. Both horizontal (beam axis) and vertical (horizontal tunnel x-axis) axes have been divided in 10 cm substeps. The perpendicular axis (not seen in the plot) corresponds to one single bin between –500 and 500 cm which includes the floor and ceiling of the nTOF tunnel.

The neutron and neutron-induced gamma background have been tallied at several regions of interest along the tunnel. The next figures show the results obtained with 10^6 primary neutron events. The absolute magnitude (i.e. normalisation) of the neutron and gamma fluences is not defined. Therefore, only the ratio with respect to the neutron beam shown in Fig. 6 should be taken into account.

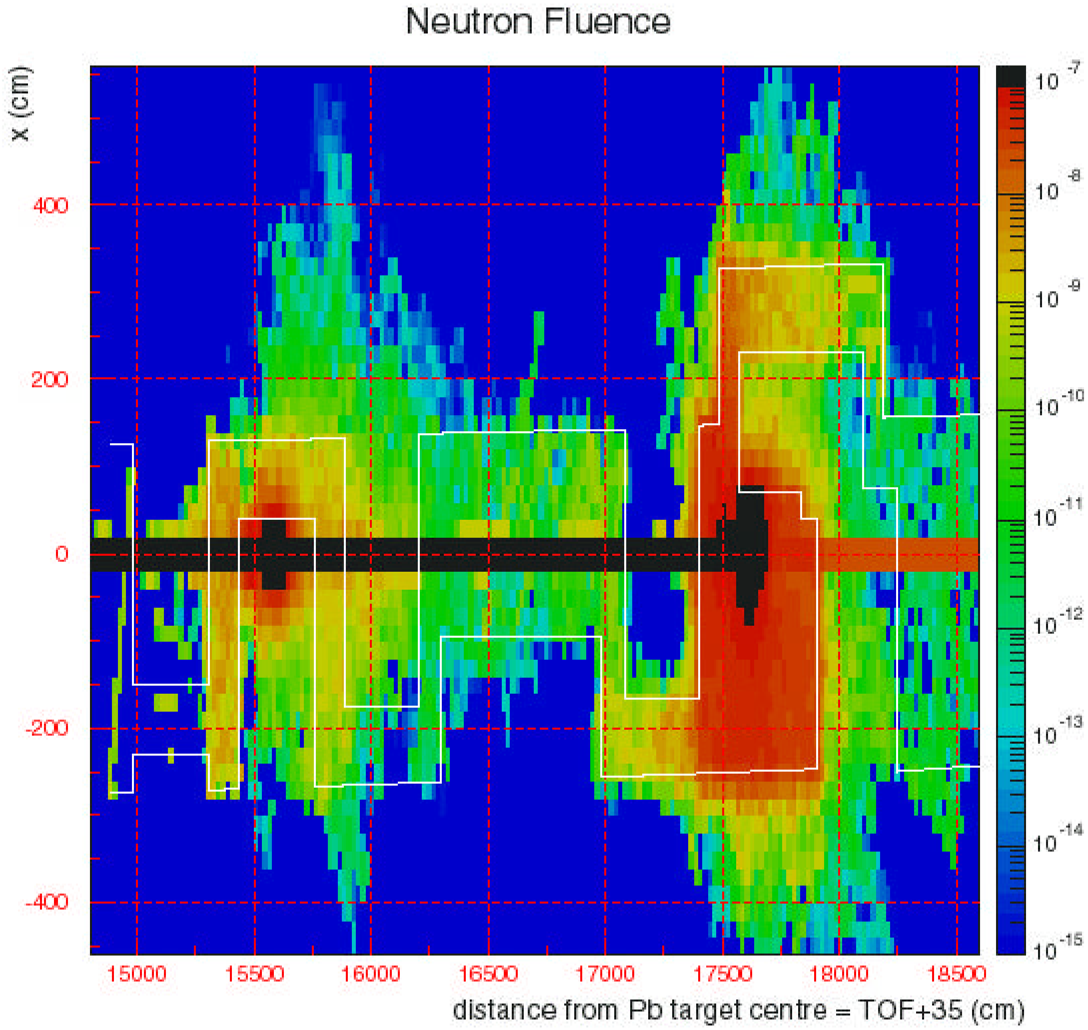

Figure 3. Neutron fluence distribution between 140 and 186 metres from the centre of the Pb target. The distribution corresponds to a cut on the vertical axis above and below the nTOF tube which neither includes the floor nor the ceiling.

Figure 2 shows the neutron fluence distribution in the last 60 metres of the nTOF tunnel, including both second and main experimental areas. The horizontal (beam axis) and vertical (horizontal tunnel axis) axes of the figure have been segmented in 10 cm bins. However, one single bin was defined along the perpendicular axis of the tunnel including also the floor and the celing. Therefore, Fig.2 does not show the real neutron fluence observed by the fission detectors placed in beam at 165 m, since it also accounts for the extra fluence of neutrons hitting the floor and the ceiling of the tunnel. It only illustrates which are the strongest sources of background near the possible new fission station.

The real neutron background fluence observed by a fission detector is shown in Fig.3, which corresponds to the neutron fluence inside a region 20 cm above and 80 cm below the pipe and including the neutron beam.

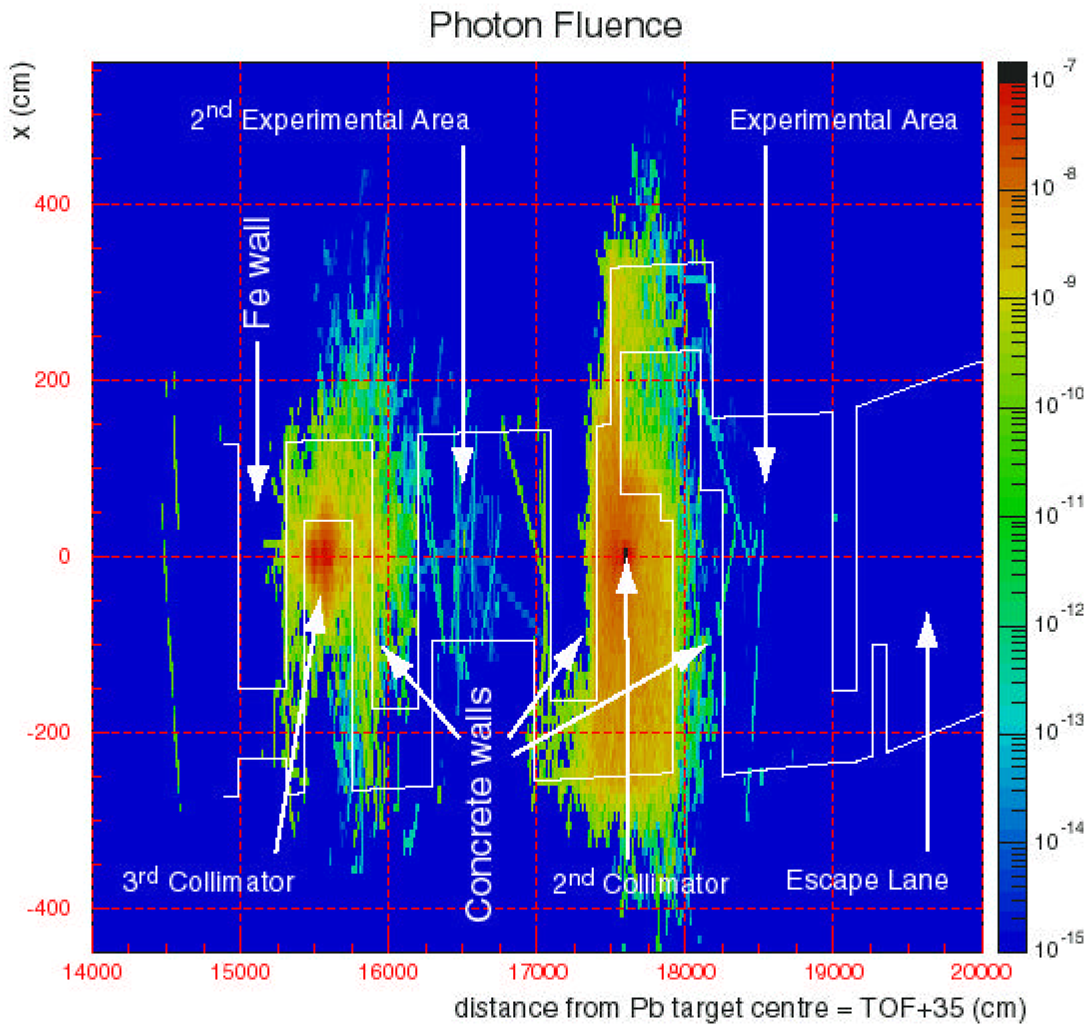

Figure 4. Neutron-induced gamma fluence distribution along the last 60 metres of the tunnel. The figure represents a bird's-eye view of the nTOF tunnel. Both horizontal (beam axis) and vertical (horizontal tunnel x-axis) axes have been divided in 10 cm substeps. The perpendicular axis (not seen in the plot) corresponds to one single bin between –500 and 500 cm which includes the floor and ceiling of the nTOF tunnel.

Fig.4 and Fig.5 are similar to Fig.2 and Fig.3, respectively, but showing the neutron-induced gamma fluence distribution in the last part of the nTOF tunnel. It can be seen that the current statistics should be improved at least by a factor of 10 in order to extract any reliable conclusion.

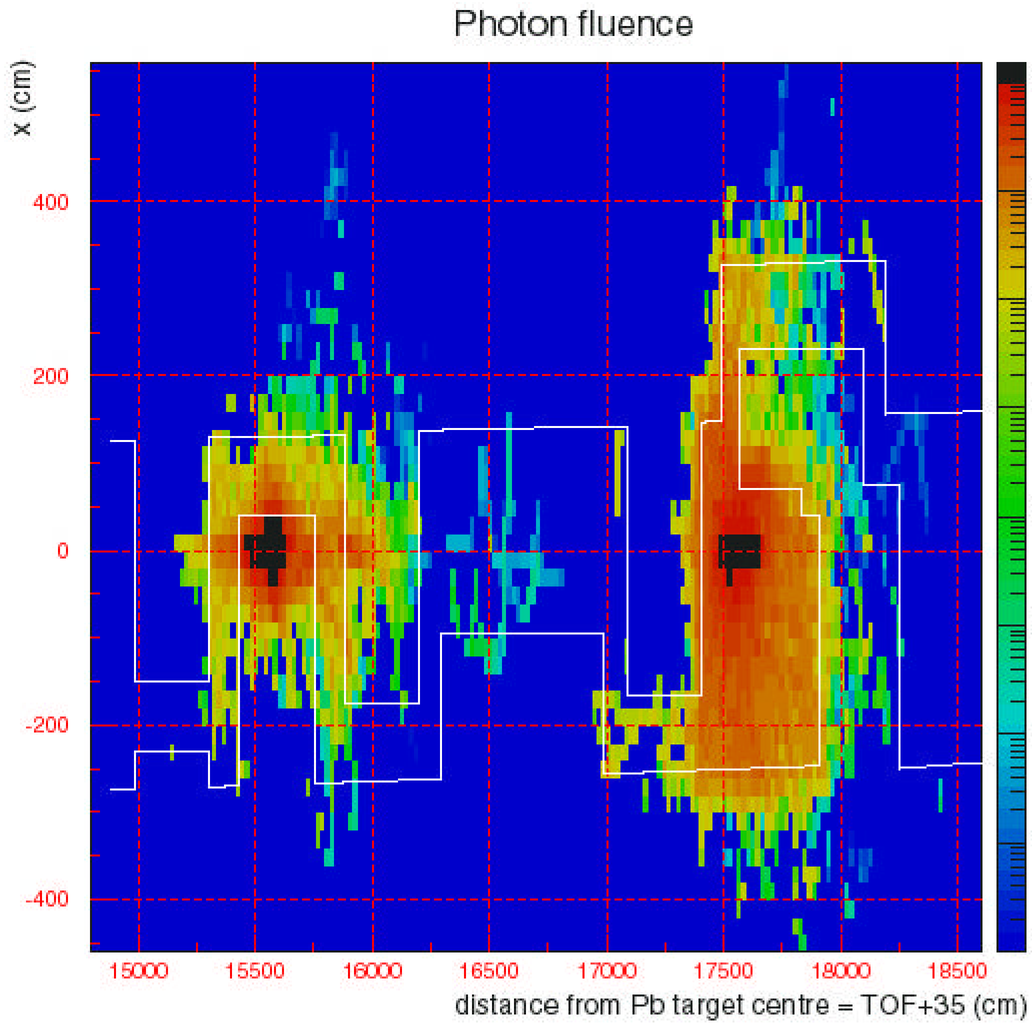

Figure 5. Neutron-induced gamma fluence distribution between 140 and 186 metres from the centre of the Pb target. The distribution corresponds to a cut on the vertical axis above and below the nTOF tube which neither includes the floor nor the ceiling.

Fig. 6 shows the neutron beam radial profiles at the second area (black curve) and the main experimental area (red curve). It can be seen that the background in the main experimental area remains after the insertion of the extra shielding 6-7 orders of magnitude with respect to the neutron beam there. It is also shown that the neutron background at the second experimental area is 5-6 orders of magnitude below the neutron beam fluence.

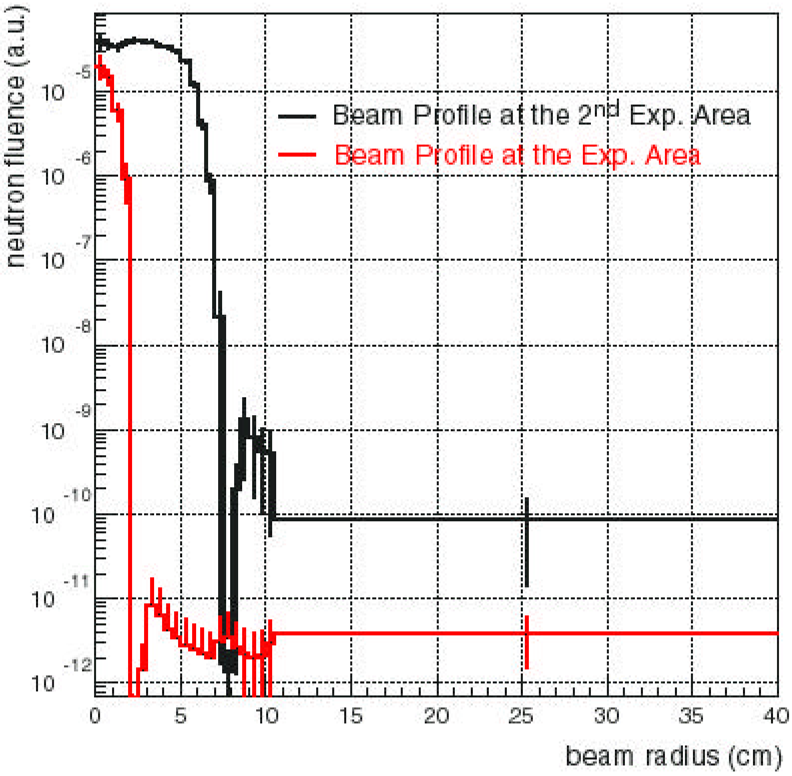

Figure 6. Radial beam profile distributions at the the 2nd experimental area (in black) and main experimental area (in red).

Summary and Conclusions

- A fully detailed and realistic geometry of the nTOF tunnel has been modelled for the MCNPX Monte Carlo code.
- A simulation for calculating the neutron and neutron-induced gamma background in a possible second experimental area for fission is in progress.
- The background produced by the charged particles remains as a separate study.
- The preliminary results for 10^6 primary neutron events are presented.
- The neutron background fluence at the second experimental area is 5-6 orders of magnitude lower than the neutron beam fluence at the same place.
- The neutron background fluence at the main experimental are stays by 6-7 orders of magnitude below the neutron beam fluence at the same place.
- No reliable conclusion can be extracted on the neutron-induced gamma background with the present statistics.

References

[1] I. Durán, C. Stephan. Private Communication.

[2] H.G. Hughes, R.E. Prael and R.C. Little, MCNPX – The LAHET/MCNP Code Merger, XTM-RN(U)97-012, LA-UR-97-4891, Los Alamos National Laboratory (April 1997)