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Comparisons between MCNPX and MARS with or without magnetic field

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I. Introduction and simulation setup

This note is report on the comparisons in the dose simulations for the same shielding condition using MCNPX (version 2.7.0) and MARS (version 15.12) software packages that N. Mokhov updated a couple months ago (with and without the magnetic field).

Figure 1 shows the plan view of the geometry used in both simulation packages. The middle cylindrical piece is like the DX magnet in RHIC and is surrounded by concrete of 1 foot thick about 10 feet from the center. The beam axis is the z-axis (+ve direction being from left to right), y-axis points vertically towards the sky (in the +y direction) and the x-axis is fixed by the right-handed rule. In the simulations, protons at 250 GeV hit the center of the magnet at the coordinate (-8.5, 0, 235.35), which thus breaks the cylindrical symmetry of the entire setup, and we look at the neutron doses along the –x side (between x=-355 cm and x=-345 cm). The volumes of measurements are indicated Figure 1 as cells 11 to 24.

Efforts have been made to make sure that the settings in both simulation packages are as close as possible. In MCNPX, we have used the “F4” tallies (in the above-mentioned cells) to measure the fluxes and doses. In MARS, we used XYZ histogramming for the same volume to measure the same quantities.

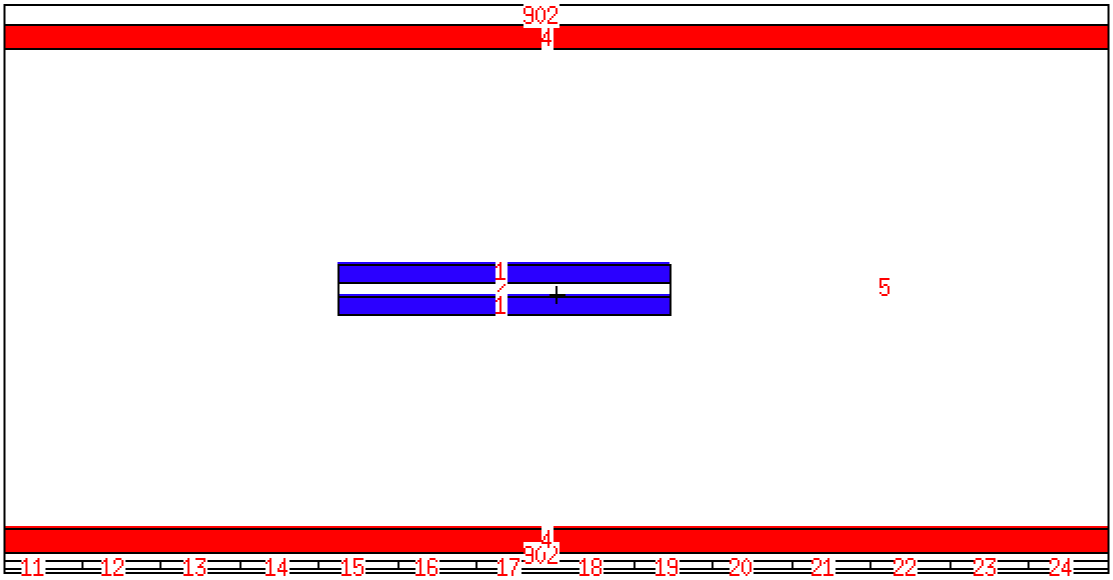

Figure 1: The geometry used in the simulations as viewed from the sky is shown. The magnet (in blue) in the middle is surrounded by concrete of 1 foot thick about 10 feet away from the center. The detecting volumes were marked in this figure as numbers 11 to 24.

II. Results

3 sets of simulations have been performed to measure the doses outside the concrete shielding, ie. using MCNPX, using MARS with no magnetic field and using MARS with magnetic field in the DX magnet.

Figure 2 shows the doses (rem per proton) corresponding to the above-mentioned 3 sets of simulations.

Figure 3 shows the ratio of doses, MCNPX / MARS(no magnetic field) and MARS(with magnetic field) / MARS(no magnetic field).

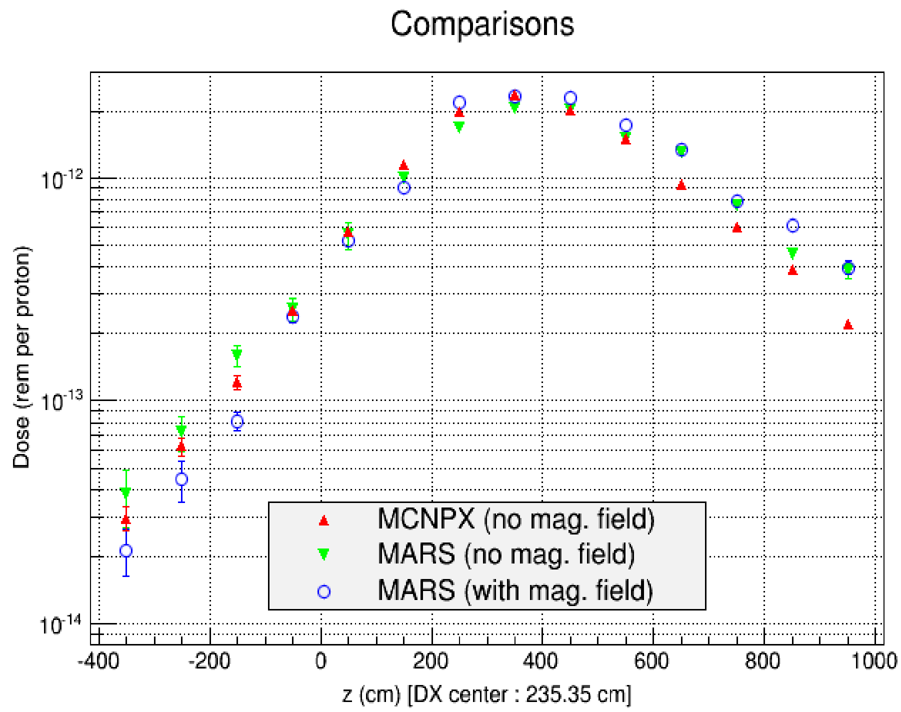

Figure 2: Doses (rem per proton) for 3 sets of simulations, MCNPX, MARS without magnetic field and MARS with magnetic field in the DX magnet are shown.

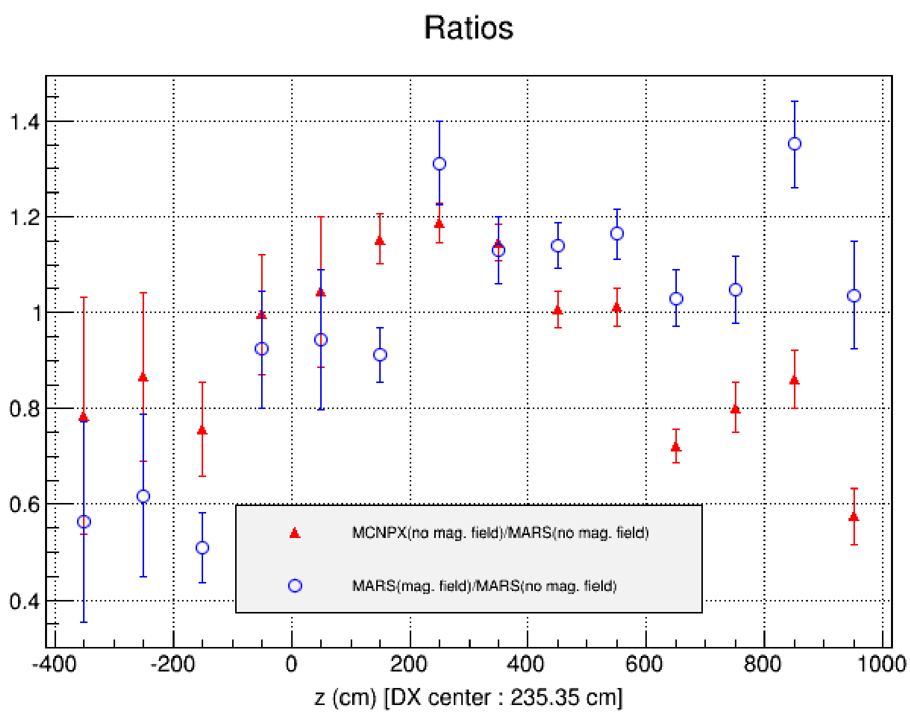

Figure 3: The ratio of the doses from the MCNPX simulation to the doses from MARS simulation without magnetic field, and the ratio of doses from the MARS simulation with magnetic field in the DX magnet to the doses from MARS simulation without magnetic field, are shown.

For the flux-to-dose conversion, the author has used the“ic=40” in MCNPX (which is the column of H*(10/Φ) in Table A.42 of the ICRP Publication 74) as Henry Kahnhauser has instructed and the default setting in MARS (which uses the conversions in Table 3 of Cossairt & Vaziri [1]). [1]

The MARS simulation has been run in a mode that uses MCNP4c for neutron transport (IND(5) = T). The author has also used its thick-shielding setting (IND(6) = T and IND(15) = T), which is the mode the author would use very frequently for shielding simulations.

[1] Those “ICRP 74” flux-to-dose conversions rise with energy to its maximum at 20 MeV and then fall with energy, and stop at 201 MeV; whereas the conversions of Cossairt & Vaziri increase monotonically to 10 TeV. Experimenting a bit of different conversions, the author has found no major difference in the dose results because the vast majority of the neutrons outside the shielding are of low energies. (Otherwise, for example at 1 TeV , the conversions of Cossairt & Vaziri are 61 times of the “ICRP 74” conversion).

III. References

[1] J.D. Cossairt and K. Vaziri, Health Phys. 2009 Jun;96(6):617-28. [Fermilab-PUB-08-244-ESH-REV (Dec.2008)]