HEBT soil cap boundary

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This note describes how the capping boundary for the new HEBT (High Energy Beam Transfer) beam stop has been determined.

1. Assumptions and parameters

We have used the simulation software MCNPX (with the newest version 2.6f at this time) to determine the extent of the cap needed in order to maintain the 5% drinking water standard. In the usual BNL SMBS formulation, ^{22}Na is the limiting isotope that determines the extent of the soil cap. The SBMS limit for ^{22}Na created in the soil for a single year operation is 1.065×10^{6} atoms/cc per year. Therefore,

$$\mathbf{1.065 \times 10^{6} = \frac{\phi}{\lambda} \times 0.02 \times N_p} \qquad \textbf{Equation 1}$$

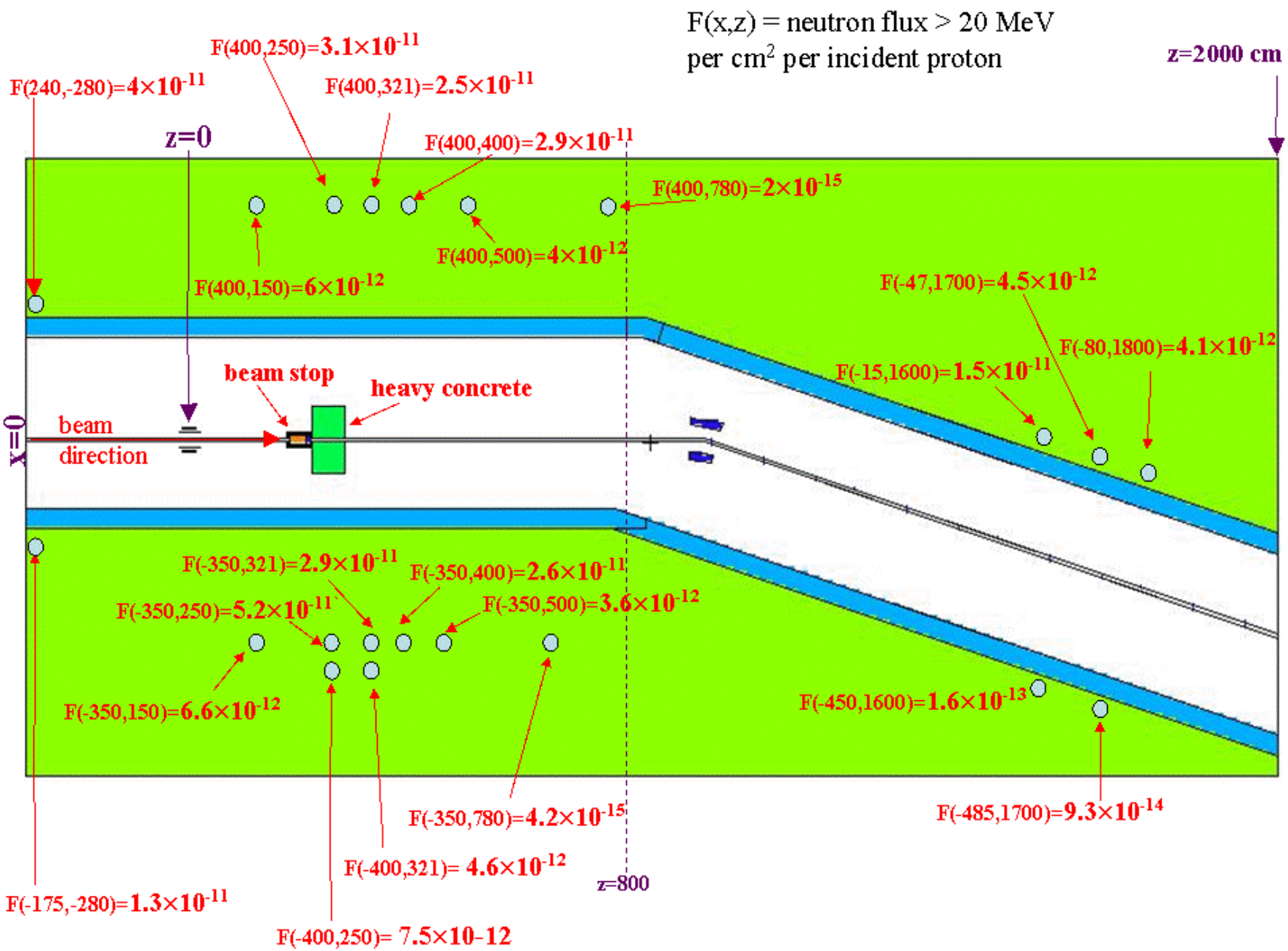
where ϕ is the hadronic (neutron) flux allowed, λ the soil interaction length (39 cm), N_p the number of protons hitting at the beam stop which is 4×10^{19} per year and we have assumed 0.02 ^{22}Na created per nuclear interaction as in the SBMS. Equation 1 then gives us $\mathbf{5.2\times10^{-11}\ cm^{-2}}$ per incident proton.

The geometry of the HBET tunnel is provided by A. Javidfar and the drawings used for the beam-stop are D25-794-5, D25-795-5 and D25-796-5 as informed by B. Briscoe. The heavy concrete shielding (2 feet) is suggested by A. Pendzick. There is no gap between the beam pipe and the heavy concrete (as also suggested by A. Pendzick).

2. Results

The fluxes at various locations of the HEBT tunnel are shown in the figure below. In which, the basic geometry of the HEBT from MCNPX was made at beam height (y=) and therefore the complicated shapes and geometry of individual components are not shown. The fluxes shown define the minimal cap boundary such that the flux everywhere would not be higher than the limit of 5.2×10^{-11} cm^{-2}.

The civil engineer A. Javidfar and I use the information in the figure below to finalize the final soil cap size which is always bigger than the figure below shown. The boundary of the soil cap in the forward and backward directions are set by the points next to the wall where the fluxes area below the limit of 5.2×10^{-11} cm^{-2}. In principle, the cap at those extreme forward and backward directions only needs to end at those points. But as cutting the cap into certain triangular shape would justify the cause, the final cap coverage is somewhat larger in a rectangular shape.


F(x,z) = neutron flux > 20 MeV
per cm^2 per incident proton
z=2000 cm
z=0
x=0
F(240,-280)=4×10^{-11}
F(400,250)=3.1×10^{-11}
F(400,321)=2.5×10^{-11}
F(400,400)=2.9×10^{-11}
F(400,780)=2×10^{-15}
F(400,500)=4×10^{-12}
F(400,150)=6×10^{-12}
F(-47,1700)=4.5×10^{-12}
F(-80,1800)=4.1×10^{-12}
F(-15,1600)=1.5×10^{-11}
beam stop
heavy concrete
beam
direction
F(-350,321)=2.9×10^{-11}
F(-350,400)=2.6×10^{-11}
F(-350,250)=5.2×10^{-11}
F(-350,500)=3.6×10^{-12}
F(-350,150)=6.6×10^{-12}
F(-450,1600)=1.6×10^{-13}
F(-350,780)=4.2×10^{-15}
F(-485,1700)=9.3×10^{-14}
F(-400,321)= 4.6×10^{-12}
z=800
F(-175,-280)=1.3×10^{-11}
F(-400,250)= 7.5×10-12