Carbon Therapy X-Y Scanner Magnet Analysis

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Introduction

A new Carbon Ion cancer particle therapy treatment center has been proposed at Argonne National Lab. This system would need a scanner magnet system to be able to steer the beam into a 40cm X 40cm square to cover all tumor sizes and shapes. This action coupled with the deposition nature of the charged particles (Bragg Peak feature) and the ability to vary the energy from a linac accelerator will enable for 3D "painting" of a tumor and less collateral damage to healthy tissue.

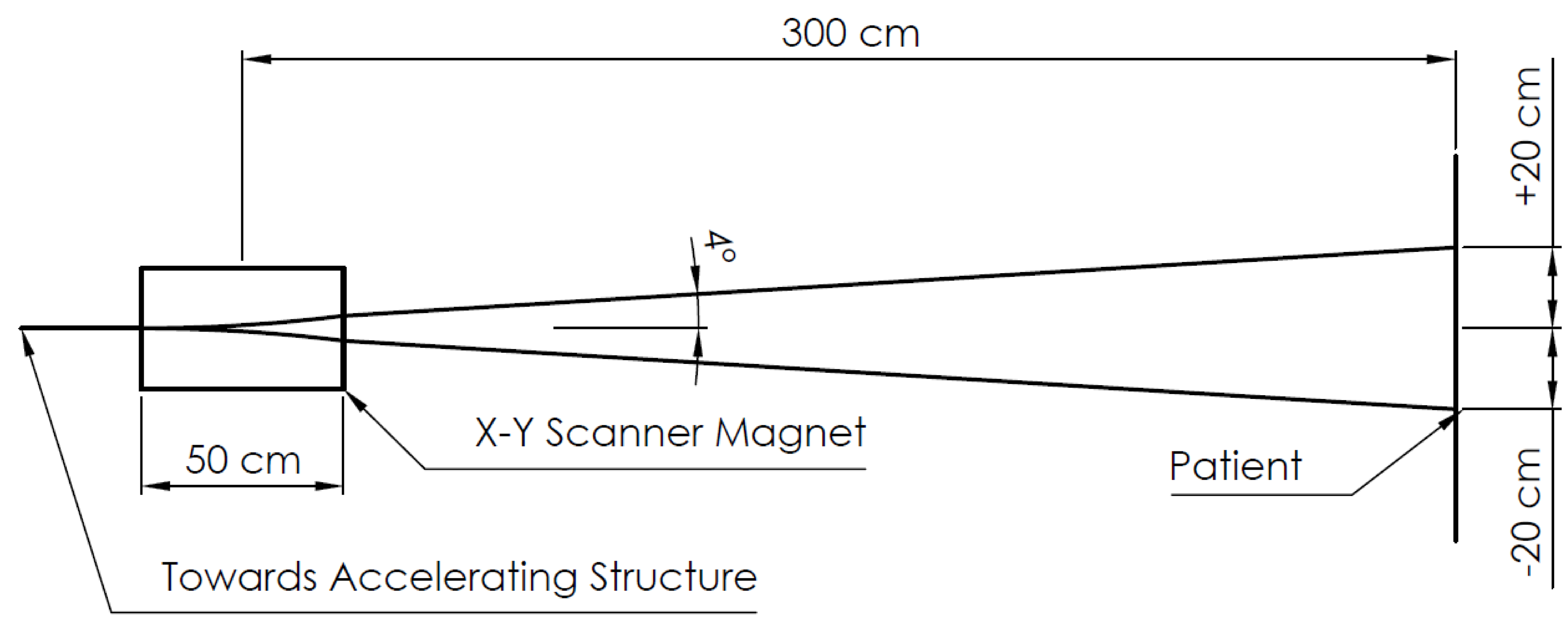


Figure 1: The layout of the scanner magnet.

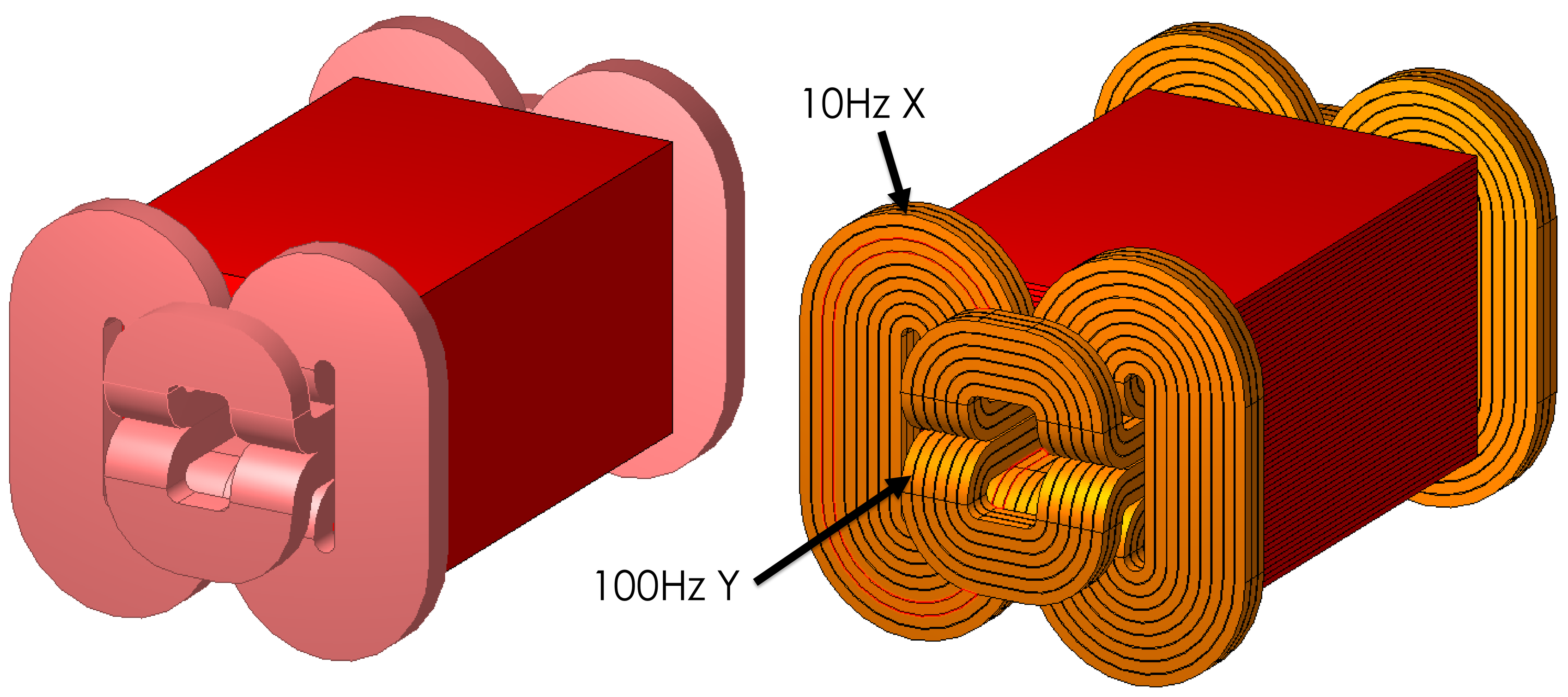


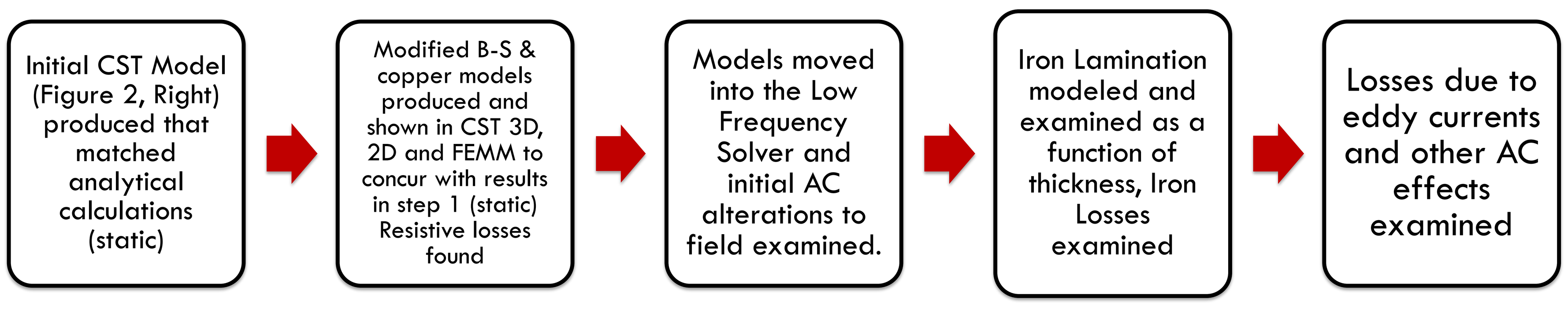
Figure 2: The Idealized initial Biot Savart (B-S) model at left and the copper stranded model with a laminated yoke at right. Modified B-S is not shown but appears identical to the copper.

System Requirements

As seen in figure 1 the magnet will need to be able to bend the 450 MeV/u carbon coverage beam 4° to allow for a 40cm X 40cm area. This means that this magnet must have a B_x & B_y of ≈0.8T. The inner coils will run at 100Hz while the outer at 10Hz. Losses due to AC and resistive loading must be examined as well as iron saturation effects.

Magnet Model

The two main models produced were the *modified Biot-Savart* and the *copper* model. Also modeling of the laminated iron yoke was done to examine those effects. Issues in establishing current in the copper model made it difficult at all steps to model.

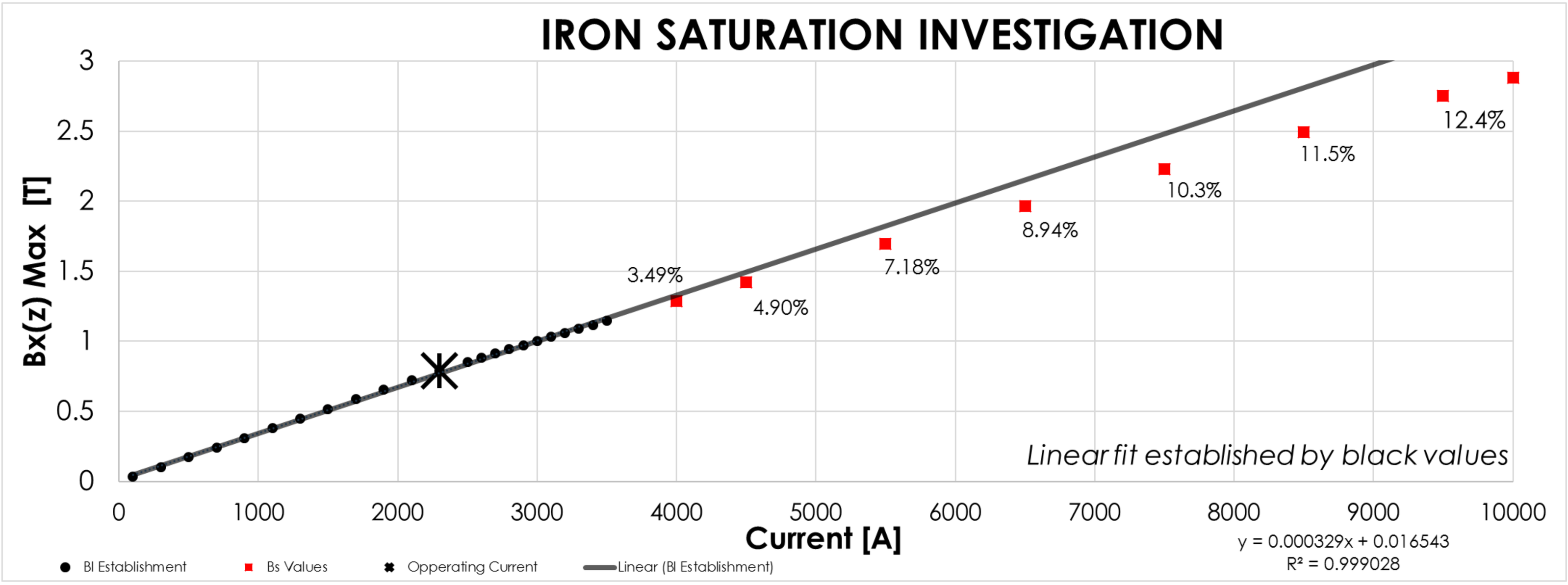


Methods

Using CST 3D molder (with verification from CST 2D and FEMM) models were produced across the various platforms to observe potential differences between the FEA programs. When the programs agreed a model would be allowed to move into the next analysis step. This was done to increase confidence in the results obtained.

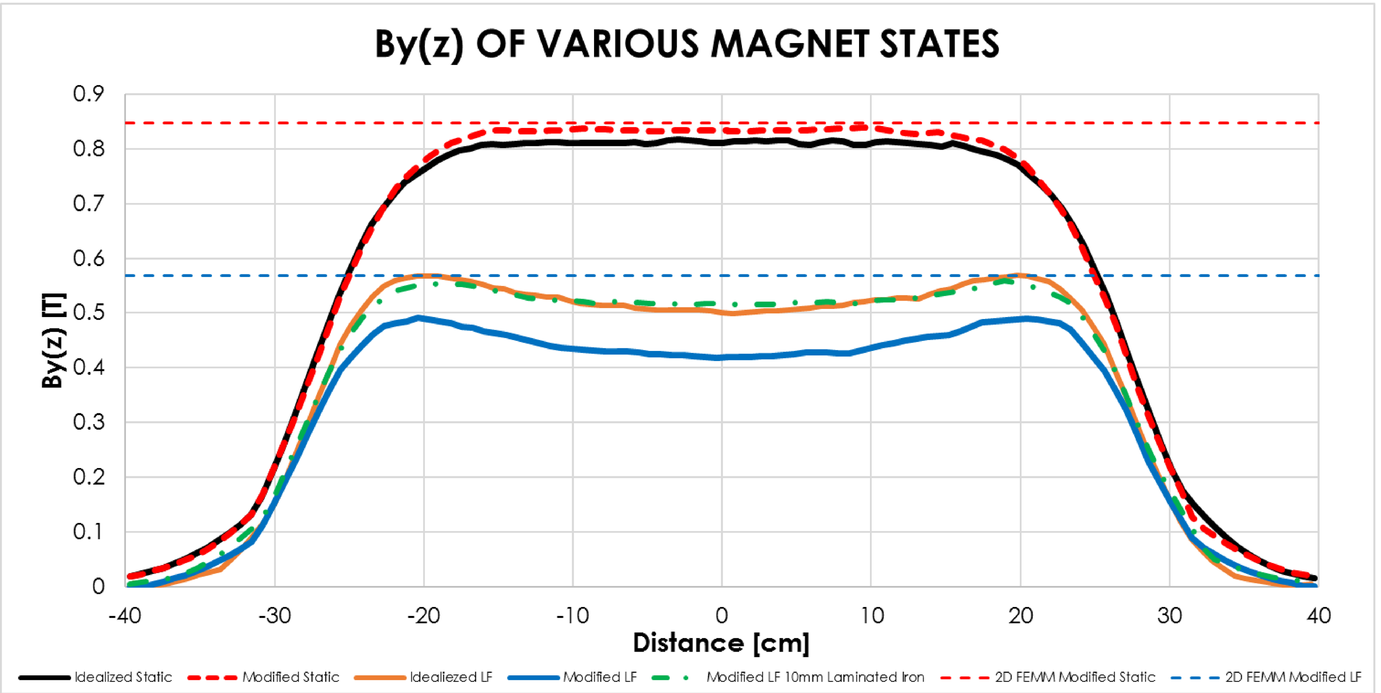
Magnetostatic Results

The copper model produced viable results. From that model it was determined that resistive power losses will be about 155kW. Also in the static model we found that the magnet is about 1000 A away from the iron saturation point (*chart below*).



Preliminary Low Frequency Results

AC losses within the iron have been found and as expected as lamination thickness decreases they also decrease. Also, as can be seen in the chart below the dramatic alterations to the field due to AC effects must be accounted for.



Future Work

Next is to find the losses due to eddy currents induced within the conductors themselves and to optimize the magnet with the minimization of those losses as the goal.

Acknowledgments

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