Purpose: To achieve real-time tumor tracking, our group is integrating a 6 MV in-line linac with an MR imager, where the linac is placed on the MR magnet's central axis to create a linac-MR system. Because of the linac's location, it experiences large fringe magnetic fields parallel to the electron trajectories in the waveguide. To minimize the adverse affects of these fields on the linac, both passive and active magnetic shielding was investigated.

Methods: COMSOL was used to model 3D fringe magnetic fields from a 0.5T PARAmed openMRTM magnet with and without magnetic shielding in place. These fields were added to our electron gun model (created previously using OPERA/SCALA-3D), and to our waveguide model (created previously using COMSOL and PARMELA) to optimize both passive and active shielding.

Results: The unshielded linac electron gun experiences up to a 0.011 T longitudinal field. The injection electron beam's rms-emittance increases from 0.299pi mm-mrad at 0 T to 2.834pi mm-mrad at 0.011 T. This non-laminar beam results in a decreased target current to 84% of nominal. A 5 mm thick and 141.5 mm long passive steel shield reduces the beam's rms-emittance to 0.450pi mm-mrad. In this configuration, >99% of the target current is recovered. With an optimized active shield (two current rings) in place, the rms-emittance was reduced to 0.308pi mm-mrad and the target current was recovered to 100.2% of nominal. Homogenous fringe magnetic field strengths up to 0.2 T were also modeled to test the passive shielding under larger-field conditions. A 5 mm thick passive shield is sufficient to magnetically shield the linac at 0.04 T at which the target current decreased to only 97.6%.

Conclusions: Both passive and active magnetic shielding can be used in our linac-MR system to recover any beam loss resulting from MR fringe magnetic fields.