AbstractID: 8827 Title: Investigation of alpha particle beam therapy as a lower neutron dose alternative to proton beams

Purpose:
Secondary neutron production is a serious issue in ion-beam radiotherapy. As ion therapy becomes more popular, this issue must be addressed. In this study, we investigated whether alpha-particle beam therapy would have an advantage over proton beam therapy in lowering neutron flux.

Methods and materials:
Simulations were performed using the Geant4.9.1.p01 Monte Carlo toolkit for alpha-particle and proton beams. Fluxes and spectra were modeled for neutrons produced in a 40cm cubic water phantom and in a 50mm thick Lucite plastic range shifter for several beam energies.

Results:
Alpha particles have four times the stopping power than protons for similar speeds. For equal depth penetration, they must carry four times the energy. Per beam particle, alpha particles produce more secondary neutrons than do protons, but only 1/4 the beam flux is required.

Monte Carlo calculations show that, for comparable beam dose, alpha-particle beams produce lower neutron fluxes than proton beams at lower treatment energies (~100MeV protons, ~400MeV alpha-particles). This is observed both in water and in Lucite. For higher energy beams, neutron spectra and fluxes are comparable between alpha particles and protons.

For all cases, the proton-induced neutron flux falls off at lower neutron energy than does the alpha-induced neutron flux. For higher energy beams, with otherwise similar neutron spectra, this differential drop-off means a higher integrated neutron energy using alpha particles. For the lower energy primary beams, this is more than compensated for by the lower total integrated neutron energy.

Conclusion:
Calculations suggest that for lower energy treatment beams, alpha particles produce fewer secondary neutrons with a lower integrated energy than do proton beams. This is significant for depths of $\leq$80mm in a water phantom, which is good for juvenile patients where a reduced neutron dose is paramount. There is less benefit seen using higher energy alpha-particle beams.