AbstractID: 3741 Title: Activation Induced by Proton Interactions in a Multileaf Collimator in Proton Therapy

Purpose: The design of a computer-controlled multileaf collimator (MLC) for use in a proton radiotherapy beamline requires investigation of issues of neutron and radioactive isotope production due to activation, which result in an increase of dose to patients and personnel.

Methods and Materials: Materials such as tungsten (W), tungsten-copper (10%) alloy (WCu10), iron (Fe), low-carbon steel (LCS), medium-carbon steel (MCS), and brass have been studied to explore proton-induced radiation activation and generation of neutrons under proton bombardment of energy up to 250 MeV. Analysis was based on a wide variety of experimental and nuclear reaction simulation data. Neutrons generated will induce additional radioactivity in the MLC, in other materials in the treatment room, and will deposit undesirable dose in the patient. The size and cost of the materials need to be considered as well.

Results: The probability of neutron production per 25 MeV energy interval of incident protons has been calculated for the selected materials as the proton stop. Furthermore, the probability for generation of radioactive products has been studied. The predominate radioactive nuclides with half-lives greater than 1 hour generated in three materials were as follows. For Fe: ${}_{27}Co^{58,57,56,55}$,${}_{26}Fe^{55,53,52}$, ${}_{24}Cr^{51,58}$, ${}_{25}Mn^{54,52,51}$, and ${}_{23}V^{49,48,47}$. For brass: ${}_{29}Cu^{64,62,61}$, ${}_{30}Zn^{65,63,62}$, ${}_{31}Ga^{68,67,66,65,64}$, ${}_{27}Co^{60,58}$, ${}_{82}Pb^{203,202,201}$, ${}_{83}Bi^{203,204,205,206,207}$, ${}_{81}Tl^{204,201}$, ${}_{80}Hg^{203}$. For W: ${}_{74}W^{185,181,179,178}$, ${}_{75}Re^{186,184,183,182,181}$, ${}_{73}Ta^{183,182,179,177,176}$, ${}_{72}Hf^{184,181,179,178,177,175,172,173}$. In terms of neutron production W has three times higher neutron multiplicity compared to Fe; however, W density is also 2.5 times as high to Fe and because of the higher atomic number may have better self-shielding properties.

Conclusions: These results are being used to select an optimal material, not only for an MLC, but also for other patient devices used in proton therapy.