Beam properties of an in-room proton therapy accelerator

The Mevion S250™ (nee Still River Systems) is a proton therapy treatment machine with many unique properties. Among these is the fact that the beam exits the accelerator aimed directly at isocenter. Other commercial systems use a remote accelerator and a series of bending magnets to deliver the beam to the treatment room. Such systems limit the beam emittance, so that even systems which employ degraders deliver nearly discrete beams ranging from about 70 to 250 MeV.

The Mevion, however, always delivers a 250 MeV beam in the treatment room. The effect of degraders is simply to shift the range of the beam, but other properties remain similar. The difference between these two approaches is demonstrated in Figure 1. Bragg peaks from the Mevion system are nearly identical in shape regardless of the range. Bragg peaks from other systems get progressively sharper as the range is reduced. Figure 1 shows measured Bragg peaks from the M.D. Anderson facility, but they are similar to other commercial systems.

A consequence of this design is that many beam properties (virtual SAD, effective source size, and effective SAD) can be determined accurately from very few measurements and interpolation based on the range of the beam. In addition, the shape of the Bragg peak can be accurately described using Bortfeld’s analytical approximation. The fit parameters (R₀, σ and ε) show a slow, smooth dependence on the Bragg peak range as well. Highly accurate Bragg peaks can be predicted by interpolating between fit parameters extracted from very few measurements. Fig. 2 shows σ and ε from 7.8 to 20 cm in range.

These results were based on 576 virtual commissioning measurements, calculated with MCNPX prior to installation of the accelerator. The significance of these findings is that a greatly reduced set of measurements is needed to accurately commission a treatment planning system.

References:
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