Purpose: To examine the various processes involved and to assess their effects on the accuracy in proton therapy.

Methods: Proton therapy involved several processes: (1) Beam commissioning. (2) CT scan of patient. (3) Contouring. (4) Treatment planning. (5) Output factor measurements for each field. (6) Patient setup verification with image guidance. (7) Dose delivery. (8) Neutron dose and proton RBE at the distal edge. Within each step, there are several sub-processes that each may contribute to the uncertainty in the treatment. By analyzing each of the sub-processes within each process, based on measurements or published data, we estimated a % uncertainty to each sub-process and/or a distance uncertainty (in millimeter) on the proton range. A total uncertainty in proton therapy is estimated.

Results: The uncertainties assessed for the various processes are: (1) Â±1.5%; (4) Â±3.0%, and 1-3mm; (5) Â±2.0%; (6) Â±2 mm; (7) Â±2.0%, Â±2mm. The uncertainties in (2) CT, (3) contouring and neutron dose in (8) strongly depend on the location and type of the tumor. On the other hand, the proton RBE at the distal edge in (9) is still debatable and may affect the dose uncertainty from 0-20% depending on which value we want to accept. Thus the overall uncertainty in proton therapy is at least Â±4.5% and Â±4 mm (by adding the various uncertainties in quadrature), without consideration of processes (2), (3) and (8), and the RBE effect.

Conclusions: Due to the complexity in proton therapy and the various factors that may affect the accuracy in proton therapy, it is far more complicated to assess the accuracy in proton therapy. Our preliminary study showed that the accuracy in proton therapy is at least Â± 4.5% in dose delivered to a tumor with an uncertainty of Â±4mm to the distal edge of the SOBP.