Even simple proton beam arrangements can deliver precise and conformal dose distributions to complex targets while avoiding nearby critical structures. Proton treatment planning is, however not simple and more sensitive to uncertainties compared to photon therapy due to uncertainties related to physics, the patient, the machine and radiobiology. The accuracy required for proton beam commissioning is atypical compared to conventional measurement practices in radiotherapy. Individual pristine Bragg peak depth dose distributions have to be quantified accurately to achieve in the order of 1% dosimetric accuracy in standard geometries and to allow an accurate comparison between treatment planning systems derived and measured dose distributions composed of numerous individual Bragg peaks. During dosimetric commissioning a comparison of the depth dose profiles and beam profiles generated by the treatment planning system with the measured data for various fields has to be performed. In addition, Monte Carlo methods are needed to both generate and validate measured and computed results.

In the non-dosimetric part of commissioning data transfers, tools and features of the treatment planning system have to be tested. The CT calibration curve, dose perturbations from immobilization devices, and treatment device accuracies (compensator boluses, aperture/ MLC positions) has to be evaluated as well. In addition, treatment site-specific procedural validation is required in order to mitigate site-specific uncertainties.

The range uncertainty is unique uncertainty to proton therapy and a consequence of the uncertainty in patient and tissue specific determination of relative stopping power from CT number. This requires beam orientation specific PTVs as described in ICRU78 and complicates the simple use of the PTV as in IMRT. Uncertainty management is therefore an integral part of the planning process and impacts all beam parameters.

Proton beams have a finite rage and therefore spare distal tissue just as an aperture provides lateral tissue sparing. Whereas photon beams are often employed in opposing and overlapping beam directions, proton beams are not and allow for more flexibility in the use of non coplanar beams. In proton therapy it is critical, however, to choose beam directions that avoid passing through complex heterogeneities, that overcome the lack of skin sparing and that achieve the maximum lateral separation between target and critical structures.

The use of CT imaging is absolute in the design of proton treatments plans. Typically proton plans require less number of beams than photons in order to achieve a clinically acceptable plan. Besides beam matching, proton beam patching can be employed with passive scattering techniques and may be considered to be a simple form of IMRT. IMRT and IMPT are the most advanced forms of photon and proton therapy delivery. While the physics of IMPT is simpler than IMRT, IMPT is computationally more demanding due to the additional dimension of range modulation.

Immobilization and imaged guided alignment based on bony anatomy or fiducials is routinely employed in proton therapy. Volumetric imaging is required to further improve treatment accuracy and monitor volume changes. Overall proton therapy treatment planning requires attention to detail.

1. Proton beam delivery techniques - SOBP fields (scattered or uniform scanning) and PBS / IMPT fields
2. Treatment Planning Commissioning and Implementation
3. Differences between photons an protons treatment planning
4. Managing uncertainties in proton therapy.