The MedAustron proton gantry nozzle
Design recommendations


1Christian Doppler Laboratory for Medical Radiation Research for Radiation Oncology, Medical University of Vienna, Austria
2Department of Radiotherapy, Comprehensive Cancer Center, Medical University of Vienna / AKH Vienna, Austria
3EGF MedAustron GmbH, Marie Curie-Straße 5, A-2700 Wiener Neustadt, Austria
4CREATIS, Université de Lyon, CNRS UMR5220, Inserm, INSA-Lyon, Université Lyon 1, Centre Léon Bérard, 69007 Lyon, France
5Department of Physics and Chemistry, University of Palermo, Viale delle Scienze, Edificio 18, 90128 Palermo, Italy

Objective

MedAustron is equipped with one vertical and three horizontal fixed beam lines and one proton gantry based on the PSI gantry 2 design for patient treatments. This work focuses on design considerations for the proton gantry nozzle, derived from Monte Carlo simulations, allowing an optimization of beam delivery properties at isocenter.

Material & Methods

Design considerations were based on the use of similar components as in the other beam lines, including beam monitoring system. Furthermore, a static beam monitoring system should be used.

The impact of different gantry nozzle design approaches on the spot size was evaluated by Monte Carlo simulations employing Gate 7.1 alongside Geant4 release 10.0 patch 02:

• Different gas fillings (air, helium) and vacuum
• Extendable snout (see Fig. 1)
• Compact nozzle: shifting all components towards the nozzle exit, consequently reducing the nozzle dimension in beam direction

Simulations were performed for 5 representative energies (62, 96.5, 157.4, 205, and 252.3 MeV) covering the clinical available energy range. The impact of beam modifying devices such as a range shifter (RS) and a ripple filter (RFi) [1] were investigated. Gas fillings (Air, Helium) and vacuum of the nozzle were studied by introducing a gas filled volume, as the beam monitoring system required standard environmental conditions.

Nozzle designs were based on the MC model of the MedAustron fixed beam line nozzle, which was verified with measurements at isocenter for 20 representative energies.

Results

The influence of the gantry nozzle filling with vacuum or helium (as used in some commercial systems) was found to have only a minor impact on spot size (<2%). Compacting all nozzle elements closer together, thereby reducing the nozzle dimension in beam direction by 25% lead to a reduction of the spot size of up to 20%, depending on the initial energy as depicted in Fig. 2 and 3.

Using higher energies in combination with range shifter also decreased the delivered spot size for shallow seated tumors, as already demonstrated in other studies [2].

Discussion

Most of the components could not be modified, therefore only a limited change of scattering material in the beam path could be achieved. Therefore, the distance of the scattering components from the isocenter was found to be the dominant factor. Consequently, large amount of scattering material, such as range shifter or ripple filter, should be placed on an extendable snout, allowing a close positioning to the patient, reducing scattering distance.

Conclusion

The optimum in terms of spot size at isocenter can be reached if all nozzle elements are as close as possible to the nozzle exit as a reduction in distance to the isocenter proved very effective. Therefore, MedAustron will focus on a compact nozzle design with retractable snout.

References