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DOSIMETRY WITH THE SCANNED PROTON BEAM ON THE PSI GANTRY

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The irradiation facility at PSI is designed for the treatment of deep seated tumours with a proton beam energy of up to 270 MeV [1]. The spot scanning technique, which uses a proton pencil beam applied to the patient, is performed on a compact isocentric gantry. An optimal three-dimensional conformation of the dose distribution to the target volume can be realized. A fast steering system and a redundant interlock system are in operation.

The dose delivery is controlled by a parallel plate transmission chamber, which is calibrated in terms of number of protons per monitor unit. The therapy planning is based on an empirical model, which takes into account attenuation of primary protons and losses outside the primary beam through secondary products. The therapy plan predicts an absolute dose.

The calibration of the primary monitor is done using a reference thimble ionization chamber inside a homogeneous geometrical dose volume. The reference system is calibrated in a cobalt field at the national office of metrology in terms of absorbed dose to water. The dosimetry protocol used up to last year was based on the ICRU Report Nr. 59, we have switched to the IAEA Code of Practice starting this beam period. Data on the monitor calibration for various energies and using two different reference systems will be shown.

The calibration of the beam monitor using a Faraday Cup in the static pencil beam results in a good agreement with the ionization chamber measurements, with a deviation of less than 1%.

Following the daily setup of the machine, an extensive quality control and safety check of the whole system is performed. The daily dosimetry quality assurance program includes:
- measurement of dose rate and monitor ratios
- check of the beam position monitors
- measurement of a depth dose curve
- dose measurement in a regular dose field

The doses measured daily in a regular scanned field show a standard deviation of about 1 %. Further daily checks results, which illustrate the precision and reproducibility of the dose application, independent of the gantry angle and the beam energy, will be presented.

Before the first delivery of a new field to the patient, the dose distribution is checked by using a water phantom with an array of ionization chambers. A qualitative 3d check is done in addition through irradiation of a stack of films. The routine dosimetry with ionization chambers agree well with the expected dose from the therapy plan. The overall dose error for one year is +- 0.03 Gy (S.D.). Some systematic effects, due to reactions in the range-shifter plates, have been found for small fields. Data to illustrate the dose verification will be shown.

For our quality control and for the further refinement of the application technique we use a CCD dosimetry system. A scintillating screen is viewed by a CCD camera and a mirror. This 2d dosimetry device has an excellent position resolution and shows a very good reproducibility of the beam delivery.

Further developments with the aim of realizing a 3D dosimetry system for the measurement of intensity modulated fields, which have a high spatial resolution, are under way.

REFERENCES

[1] E. PEDRONI ET AL.: "The 200-MeV proton therapy project at the Paul Scherrer Institute: conceptual design and practical realization". Med. Phys. 22(1), January, 37-53, 1995.