DEVELOPMENT AND TEST OF ONE AND TWO DIMENSIONAL ALGORITHMS FOR
ONLINE BEAM MONITOR IN PROTONTHERAPY TREATMENTS, USING A PIXEL
IONISATION CHAMBER

Director: prof. Maria Itala Ferrero
Advisors: dr. Gianni Perno
prof. Roberto Cirio
Candidate: dr. Alberto Boriano

Within the “Leonardo” project of the University of Torino, in the period between September and December 2007, I stayed at the “Institut Curie-Centre de Protonthérapie d'Orsay” (ICPO). At the ICPO 200 MeV protons are used to treat, with a passing scanning system, intracranial and ophthalmologic tumors. In the 2004 and 2006 two pixel chambers, designed and built by the INFN group of Torino, have been mounted on the two treatment rooms, with the aim of perform a more precise and fast kind of beam check.

In these three months of permanence I have collected the data given by the detectors, both in beam reference and treatment conditions. The main goal of this work has been the off line data analysis, developing 1D and 2D algorithms in order to use the pixel chambers as on line beam monitor. Both the defined parameters (the 1D parameter is called Symmetry, the 2D one \( \gamma \)) work in a “relative” way, comparing the on line computed results with a reference one. The necessity of a comparison between the data and a gold standard is due to the position of the pixel chamber on the optical bench. A set of fixed and variables collimators are placed between the detector and the isocenter: non linear effects can thus modify the beam shape at the two different positions. Each treatment day the tuning of the beam is performed at isocenter in an absolute way, and, in the right conditions, the reference value for Symmetry and \( \gamma \), for the pixel chambers, are computed.

At isocenter the check of the beam is performed acquiring the vertical and horizontal profiles, using an ionization chamber mounted in a motorized water phantom.

Results show that the relation between the Symmetry (pixel chamber) and the standard reference parameter (at isocenter) is linear: both are computed on the same beam profile, in a mono dimensional way.

The absence of a two dimensional beam quality control parameters is, in this case, probably the main difficulty in the use of the pixel chamber as a real two dimensional detector. To define a threshold value of \( \gamma \) for the beam acceptance, a comparison between the \( \gamma \) and the reference parameters at isocenter has been performed. As expected, the relation found is not linear, and this leads more uncertainty in the threshold acceptance definition.

On the other side, a two dimensional analysis of the beam shape leads a stronger quality assurance: there are no blinded zones, and the higher number of pixels involved in the computation guarantee a better statistical analysis. Comparisons between Symmetry and \( \gamma \) show an agreement in case of big beam variations, while a big spread of data exists in the relation between the two parameters at little beam modifications.

The comparison among the single treatment fractions highlights the necessity of a parameters characterization in function of the modulator wheel and binary filter. Each treatment fraction shows a fixed Symmetry and \( \gamma \) value with a superimposed fluctuation. The beam dimension analysis confirms that a beam dimension variation exists between the reference and treatment conditions, and among different fractions.

Different acceptance values and thresholds have to be defined in function of the modulators, in order to be as accurate as possible, reducing the uncertainty in every fractions.

The use of the pixel chamber as on line beam monitor is clearly dependent on the kind of algorithm for the data analysis: at this level of the study the best solution is probably the combined use of 2D and 1D algorithms. The first to safety detect the beam fluctuations, the second for an easy tuning of the beam.