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In recent years the introduction of novel techniques in radiation treatment such as beamlet based Intensity Modulated Radiation Therapy (IMRT), Image-Guided Radiation Therapy (IGRT), Tomotherapy, Cyberknife and Gamma Knife, has lead to the reduction of the treatment field sizes to a sub-centimeters scale. In particular, Stereotactic Radiosurgery (SRS) rely on very small field sizes on the order of a few millimeters to treat tumours. IMRT is based on the superposition of several beamlets with a very narrow size and pronounced penumbra. The dosimetry of small beams has several issues to take into account: the lack of charge particle equilibrium (CPE), associated with the range of secondary particles that is comparable with these field sizes, the availability of small detectors and the related choice of the most suitable dosimeter, the increased penumbra innarrow beams, the presence of perturbation effects in the dosimeter cavity. The common way of comparing measurements made with several detectors and to take the one which shows the highest output factors or to take the average response among the detectors, does not take into account the possible perturbation and correction factors to be applied to the response of the detectors. The knowledge of these correction factors, as provided by the standard dosimetry protocols, is limited to a certain number of dosimeters, and, above all, doesn’t take into account all the perturbation effects of the radiation field in presence of the detectors. Also the method of comparing Monte Carlo simulation with measurements has some drawback: in fact it is not correct to compare simulation in water with the response of the detector. Instead, a direct simulation of the detector together with the simulation of the treatment head should be made. In this way the correct parameters which characterize the source, i.e. the radial distribution and the energy of the electron beam incident on the target, that are not usually known, can be found in a univocal way.

This lecture will provide an overview of the issues related to the small beam dosimetry and the deviation from the standard cavity theory, usually applicable in condition of electronic equilibrium. Furthermore, it will be shown the method used to determine the correction factors necessary for different commercially available dosimeters (2 microchambers, a diode, and a diamond) by using Monte Carlo simulation. In particular, it will be shown the application of the method to the dosimetry of small collimators of the Cyberknife. It will be also shown how this method can be generalized to other dosimeters and different linear accelerators. Finally, a short indication on the problem of small field dosimetry in the presence of low Z inhomogeneities will be given.

Educational Objectives:

1. Understand the issues related to the dosimetry when the electronic equilibrium condition is not achieved.
2. Understand the issues related to the application of Monte Carlo for the determination of correction factors of detectors.
3. Discussion of low z in small fields