COMMISSIONING OF OPERATIONAL RADIATION PROTECCIÓN IN COMPACT PROTON THERAPY CENTERS (CPTC) WITH SMALL ACELERATORS

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Important and preliminary note:
The main author and other contributors of the work are members of the SEPR (Spanish Society for Radiation Protection), an institution that is part of the IRPA. In this way, membership of the IRPA is fulfilled by membership of the SEPR. (The author GARCÍA FERNÁNDEZ, GONZALO FELIPE is the member number 1292 of SEPR).

Proton therapy is in continuous ever evolving to improve its performance in cancer treatments. Some prominent current trends involve small accelerators, cutting-edge delivery methods, or building compact proton centers. New developments have a direct impact in radiation protection of proton facilities and actions should be developed continuously with the aim that new centers meet all the requirements. The study of radiation protection in multi-room centers has been widely studied elsewhere, however, Compact Proton Therapy Centers (CPTC) have specific features that pose a challenge in radiation protection, and the present work suggest different contributions to the body of knowledge in these compact facilities: Their main element are small and medium-sized accelerators, they usually have one single room, small footprint and a standard configuration, higher radiation density (Sv/m^2), using the most advanced equipment and machinery to reduce their size, the delivery mode of protons is Pencil Beam Scanning (PBS), and there is a mix of professional exposed workers (clinical and technical staff) in these centers.

The present work is framed into the multinational project *Contributions to operational radiation protection and neutron dosimetry in compact proton therapy centers* (CPTC), developed by nine researchers from seven institutions in five different countries, which is focused on assessing the impact of these innovations on the operational radiation protection and commissioning of these compact facilities. Thus, several tasks have been carried from 2108, as comparing ambient dose equivalent of compact proton centers using different small accelerators (superconductor synchrocyclotron, conventional compact synchrotron and superconductor isocyclotron), checking and evaluation of shielding, comparing ambient dose equivalent of several CPTC, analysing activation with different types of concrete, and activation in accelerators, beamline, air and water of the facility, characterizing wide range rem-meters and neutron area monitors to measure neutron fields, studying new proton delivery techniques and their neutron fields, or assessing personal dosemeters, among others. The aim of this work was to present a commissioning process of the operational radiation protection of Compact Proton Centers, summarized in ten main recommendations, achieved in the activities mentioned, and lined up with the requirements of the Nuclear Authority:

(1) Select a suitable site and location for facility
(2) Design barriers and shielding against neutron and gamma radiation
(3) Use Monte Carlo simulations and check with analytical methods
(4) Choose appropriate materials in barriers
(5) Review the impact of radiation on environment
(6) Anticipate changes in assumptions and future developments
(7) Place the right radiation monitor in the right place of the facility
(8) Pick suitable personal dosemeters
(9) Assume uncertainties
(10) Carry out experimental measurements

Finally, the development of more efficient radiation protection measures could significantly reduce the thickness of the barriers, reducing the cost and size required to implement a proton therapy center. Considering topics as new methods of application of dose in development (proton arc therapy, flash-therapy with protons), new materials for barriers and shielding or recent radiation monitoring equipment, future works must be carried out to study their impact on operational radiation protection and recommendations such as, IAEA Technical Report series 283 *Radiological safety aspects of the Operation of Proton Accelerators*, or ICRP Publication 127, *Radiological Protection in Ion Beam Radiotherapy*, should be updated periodically taking into account the new methods and technologies developed.