Contribution ID: **72** Type: **not specified**

Measurement of stray neutron radiation within a proton therapy facility

Tuesday, 29 April 2014 16:40 (25 minutes)

Proton therapy is an advanced radiation treatment that destroys cancer cells with high accuracy. Proton treatment beams can be fine-tuned to deposit most of their energy at a specific depth within the patient, keeping irradiation of adjacent organs and healthy tissue to a minimum. However, proton interactions with materials in the beam line and with patient's tissue create secondary neutrons with energies from thermal to several tens or hundreds of MeV. These secondary neutrons may increase the risk of a second cancer significantly, and should be taken seriously.
Dosimetry measurements around medical proton accelerators are very complex due to heterogeneous radiation fields, for this reason the use of well proved and well known measurement systems is necessary. In 2013, organised by EURADOS Working Group 9 (Radiation Protection Dosimetry in Medicine) a large set of intercomparison measurement was carried out in the IBA (230 MeV) active-scanning proton beam therapy facility in Trento, Italy. Several types of active detectors and dosemeters were used: Bonner Sphere Spectrometers (BSS), HAWK TEPC, several REM-counters such as WENDI-II, Berthold, RadEye, NM2B, and new HMGU electronic dosemeters. The proton beam was directed into a water phantom (30 x 30 x 60 cm3) with a 1 liter (10 x 10 x 10 cm3) target volume, simulating the patient. The isocenter of the beam was in depth of 15 cm inside the water phantom. Neutron ambient dose equivalents, H*(10), were measured at several positions inside the treatment room at four angles: 0°, 45°, 90°, and 135° with respect to the beam line direction, and at different distances.*
A generally good agreement among H(10) values within 30% was observed for the different types of used detectors. The highest neutron H*(10) value of about 60 µSv/Gy was measured along the beam axis at distance of 1.15 m from isocenter. However, the lowest neutron H*(10) value measured in the treatment room was about 1.1 µSv/Gy at distance of 4.25 m, and at 90° with respect to beam line.
Measurements with BSS provided valuable information on the spectral energy distribution of secondary neutrons and H*(10) at 4 different angles around the water phantom. Secondary neutron spectra generated by a proton beam impinging a water phantom were also calculated using Monte Carlo simulation with the GEANT4 code.
Dosimetry measurements in the phantom included different passive detectors (RPL, several types of TLDs and CR-39). Their future analysis will give insight in dose contributions from different radiation types depending on the position in the phantom and distance from the target volume.
The results of this large set of intercomparison measurements and Monte Carlo simulations may be valuable for medical physicists and radiation protection officers.

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Session Classification: Session 4. Medical Accelerators, Convener: Vladimir Mares