

BUREAU NATIONAL DE MÉTROLOGIE
Laboratoire National Henri Becquerel (BNM-LNHB)

DOSIMETRY OF PHOTONS AND CHARGED PARTICLES

Progress Report 2001-2002

F. Delaunay

Preliminary remark:

Due to (i) a significant staff turnover these last years (-6.5 and +7 on a total of 17 (summed primary and secondary activities)), (ii) the expansion of our study field (brachytherapy, radiodiagnostic), (iii) the new quality systems (ISO 17025 and 9001:2000) and its extension to all the measurements capabilities and laboratory calibrations as required by the MRA, and (iv) the according responsibilities redistribution, some studies did progress slowly.

Graphite Calorimetry

The building of the new graphite calorimeter is in progress.

The new measurements in the 20 MV beam (2001) of the LNHB accelerator aimed at the realisation of new references in terms of absorbed dose are 0.06% far from the previous ones (1999), showing an excellent reproducibility of the present calorimeter. The same measurements have been done in the 6 and 12 MV beams in 2002 with respective differences of 0.13 % and 0.06 %. It has been verified that the measuring thermistor answer was the same under irradiation or electrical calibration in these 3 photon accelerator beams and in a cobalt-60 beam.

Some measurements were conducted with the new cobalt-60 source to calibrate it in absorbed dose to graphite.

A new temperature regulation principle is tested. The absorber is heated continuously to maintain it at the same temperature whatever the outside conditions (irradiation, electrical calibration, no irradiation). The thermal transfers should be the same.

The vacuum gap correction factor was measured in the 18 MeV electron beam of the accelerator in order to prepare the realisation of a reference of absorbed dose to graphite at that energy.

Water calorimetry

The building of the water calorimeter is going-on, but this study has been slowed down due to lack of staff. Some heat transfer calculations were done with CASTEM.

Ionization Chambers

Some new primary air-kerma ionization chambers are being built. Preliminary tests on a prototype give good results.

A new small home-made ionization chamber (0.35 cm³) intended to measure absorbed dose to water is being tested.

Fricke dosimetry

Some preliminary measurements in the 18 MeV electron beam have been done in 2001, for preparing the realisation of a reference of absorbed dose to water.

New measurements in the water and graphite phantoms in the 20 MV photon beam have been done in 2002 and are part of the transfer procedure to derive the absorbed dose to water from the absorbed dose to graphite.

The reproducibility of measurements carried out with Fricke solution glass ampoules sealed using laser heating is under study. The stability of the response in function of storage time will be also examined. This study is aimed at providing (i) Fricke dosimeters to be sent by mail for on site measurements or (ii) dosimeters storable and readily usable for internal needs of the laboratory.

TLD FLi dosimetry

The study of the performance of TLD FLi was initiated some years ago in the frame of a project of national control of radiotherapy beams, for which the laboratory would calibrate the laboratories in charge of this control. The reading repeatability of such measurements using FLi powders from one day to the other is of the order of 1 % and very difficult to reduce. The unhomogeneous heating (via different cupels) of the unhomogeneous powder seems to be the cause. Some testing has been done with GR 200 chips. The results are better (max discrepancy 0.5 %) except one tenth of the readings which are randomly very wrong (5 %).

Monte-Carlo calculations

MCNP4C was used to compute the 18 MeV accelerator beam electron energy spectrum.

The vacuum gap correction factor of the graphite calorimeter was calculated in the 18 MeV beam.

The photon energy spectrum of the gamma-cell IBL-460, the new cobalt-60 radiotherapy dose-rate source and the caesium-137 source were also calculated.

Some spectra calculations were also done for the ambient dose equivalent in cobalt-60.

New versions of Monte Carlo codes, PENELOPE 2001 and EGSNRC_V2 were tested.

The HDR Iridium-192 spectrum and the ionization chamber wall effect were calculated.

Some new calculations were done for the determination of the wall effect for the air kerma standard ionization chamber of the laboratory in a cobalt-60 beam.

Some calculations were done for determining the suitability of free-air ionisation chambers to radiodiagnostic studies.

Air-kerma rate in cobalt-60 beam

Measurements in the new cobalt-60 source (radiotherapy dose-rate) were done in 2002. The new reference using the Monte Carlo calculations for the spectrum and the wall effect should be ready in 2003. The resulting value will still have to be compared with the new primary ionization chambers results.

Absorbed dose to water in high-energy X-ray beams

References, based on graphite calorimetry measurements and transfer to water using Fricke dosimeters, were realised for 6, 12 and 20 MV photon beams in 1999 and 2000. New measurements at 20 MV were performed again in 2001 and 2002. The results of Fricke dosimetry and calorimetry will permit to determine the variation of the radio-chemical yield G in function of beam quality. The final report has been delayed.

Absorbed dose to water in high-energy electron beams

A first series of provisional references (9, 12 and 18 MeV) obtained using NACP and Roos chambers and applying the IAEA protocol TRS 398 should permit to offer calibration possibilities to customers at the beginning of 2004.

Ambient dose equivalents

Direct determinations of ambient dose equivalents are being carried out in cobalt-60 and caesium-137 beams, using a cavity chamber calibrated in absorbed dose to water for ^{60}Co gamma photons and a sphere of 30 cm diameter filled with water. The measurements were carried out in 2001 and 2002.

Standards for brachytherapy

The laboratory is equipped now with a MicroSelectron HDR source projector.

The study of new standards for brachytherapy (iridium 192, high rate) is in good progress. As the measurement is done near the source and the dose gradient is steep in this area, the precise measurement of the source-ionization chamber distance is important. It is determined by rotating the ionization chamber around the source.

A comparison with ADCL (Wisconsin University) is programmed in 2003.

Standards for radiodiagnostic

A building is in construction at Saclay to receive medium- and low-energy X-rays and radiodiagnostic reference beams.

A GEMS MPH65+ MAXI RAY 100 generator was installed at the LCIE site and beams were characterised.

A free-air ionisation chamber well suitable for radiodiagnostic measurements was studied and tests were satisfactory.

PUBLICATIONS

Comparison of dosimetric standards of Canada and France for photons at cobalt-60 and higher energies, K.Shortt et al, Phys. Med. Biol. 46 (2001) 1-24

Calculation of perturbation correction factors for some reference dosimeters in high-energy photon beams with the Monte carlo code PENELOPE; J. Mazurier et al, Phys. Med. Biol. 46 (2001) 1707-1717