BNM-LNHB/LMD Actions Completed in 2003-2004

Highlights

The past two years have seen the creation and transmission to users of new references in Ir-192 HDR brachytherapy and in high-energy e^- beams. They were also marked with the completion of the building extension for brachytherapy, radiology, low and medium X-rays irradiation rooms and ESR reading laboratory.

Beam calibrations

With numerous sources changed those last years, the laboratory had to focus on the new beams calibrations:

_ Ionometric calibration of a radiotherapy cobalt-60 beam (« 1C ») in air kerma with the primary standard

_ Ionometric calibration of a radiotherapy cobalt-60 beam (« 2C ») in air kerma with the primary standard and absorbed dose to water by transfer from the old source (« 2B »)

_ Ionometric calibration of a radiotherapy cobalt-60 beam (« 3A ») in absorbed dose to water and air kerma by transfer from another cobalt-60 beam (« 2C »)

_ Ionometric calibration of ^{192}Ir HDR sources in air kerma strength

_ Calibration in absorbed dose to water of reference ionisation chambers for the LinAc at 9, 12 and 18 MeV electron beams using TRS 398

_ Determination of the air kerma calibration coefficients of one reference ionisation chamber (free air chamber) for radiology X-rays up to 150 kV (irradiation time > 100 ms) and one reference ionisation chamber (free air chamber) for mammography

Comparisons

_ Air kerma, absorbed dose to water and absorbed dose to graphite in cobalt-60 beam comparison with the BIPM

_ EuroMet project 739: absorbed dose rate to tissue in ^{147}Pm, ^{90}Sr-^{90}Y and ^{85}Kr sources

_ Air kerma strength in iridium-192 with ADCL (Wisconsin University)

Equipment

_ Atmospheric conditions monitoring and recording of the building extension irradiation rooms (QA)

_ Fixed the detector support device on the LinAc instead of the ground (easier handling of the phantoms)

_ Implementation of calibration facilities for our own measurement devices in temperature, voltage and resistance (for saving money)

_ Acquire low and medium X-ray generators (used in pulsed mode for medical applications and continuous mode for industry applications)

ESR

_ Found an external laboratory to prepare the dosimeters in order to provide QA tests for radiotherapy beams

Graphite calorimetry

_ Studied the new constant-temperature operating mode (J. *Daures et al*, 2003): electrical calibration done at the same time than the measurements, better accuracy, better measurements rate

Abstract: The present graphite calorimeter is the reference for absorbed dose at BNM-LNHB. Although reproducibility and accuracy are excellent, some improvements can be implemented concerning the flexibility in use and, to some extent, accuracy. The usual operating mode of this calorimeter is based on a thermal feedback between the core and the jacket, corresponding to a quasi-adiabatic mode. When a core-jacket temperature difference is detected, a commercially available PID (Proportional, Integral, Derivative) controller sends to the jacket an electrical power to reduce this difference. The core and jacket temperatures increase with irradiations and electrical calibrations. The new constant-temperature mode consists in maintaining the core and the jacket at fixed temperatures. First, the power applied to the core without irradiation is measured. Secondly, under irradiation, the power needed to maintain the assigned temperature in the core is reduced proportionally to

the heat generated by ionizing radiation. This residual electrical power is carefully measured too. The core temperature is maintained at the set-value using a PID regulator developed at the laboratory on PC LabView. This regulator is versatile and particularly well suited for calorimetry purposes. The quality of this type of measurements is strongly dependent upon the quality of the core and jacket thermal control. The value of the dose rate of the beam is quite simply proportional to the difference of the powers without and with irradiation. Preliminary measurements in a cobalt 60 beam have shown no significant difference (< 0.09 %) between the two operating modes, with an equivalent reproducibility (1 σ < 0.06 %). When the gaps are opened to air, only the new constant-temperature operating mode gives reasonably good results (no difference on the mean value but 1 σ < 0.4 %). These encouraging results will be followed by complementary measurements.

Ionometry

_ Review of the ionisation currents and correction factors uncertainty analysis in cobalt-60 and caesium-137 beams

MC calculations

_ Future Air kerma primary standards wall effect calculations (EGS NRC & PENELOPE) in a cobalt-60 beam

_ Vacuum gap correction for the graphite calorimeter in a 18 MeV beam

_ Choice of thermal regulation copper plates positions for the water calorimeter

Quality

_ ISO 9001:2000 (CEA/DRT) certification renewal in 2003, surveillance audit in 2004

_ ISO 17025 (national laboratory): accreditation renewal in 2003, surveillance audit in 2004

_ Writing of 31 LNHB reports (2 on unusual calibrations, 13 describing operating procedures, 5 on new beams references or comparisons, 11 on developments or new kind of references)

Sources

_ Replacement of one cobalt-60 source (“1C”)

_ Replacement of the beta sources: ^{90}Sr-^{90}Y, ^{85}Kr, ^{147}Pm (“BSS2”): problems with shutter (locked), with the measurement of the source-detector distance (accuracy) and the lack of information about the codes and addresses to control the irradiation

_ Replacement of 3 cobalt-60 and 3 caesium-137 radioprotection sources to cover a wider dose rate range

Staff

_ May 2005: 17 permanents (15 Full Time Equivalents) + 4 trainees + 1 PhD student

TLD

_ Studied the repeatability and reproducibility measurements with LiF pellets with the PCL3 reader (1 % of uncertainty (k = 1) for absorbed dose to water measurements for radiotherapy)

Usual dosimeter calibrations or irradiations

_ Air kerma, dose equivalents and absorbed dose to water in cobalt-60 beams

_ Air kerma, dose equivalents in caesium-137 beams

_ Absorbed dose to tissue and dose equivalents in ^{147}Pm, ^{90}Sr-^{90}Y and ^{85}Kr beams

_ Air kerma strength in ^{192}Ir beams (since 2003)

_ Absorbed dose in water in 6 – 20 MV photon beams

_ Absorbed dose in water in 9 – 18 MeV electron beams (since 2004)

_ Air kerma in air in mammography beam

Some projects in progress (2005 - …)

Beam calibrations

_ Determination of air kerma references with the new reference ionisation chambers (Co-60, Cs-137)

_ Determination of the absorbed dose to water references based on graphite calorimetry measurements (+ transfer by MC, ionometry and Fricke solutions) (Co-60, HE e^-, HE photons)

_ To complete the calibration of the beta sources

_ Determination of air kerma strength references with the new reference ionisation chamber (I-125, Pd-103)

_ Determination of the X-ray generators air kerma references

Comparisons

_ To finish the comparison in Co-60 air kerma with the BIPM

_ To publish the results of the Ir-192 air kerma strength comparison with ADCL (accepted for publication)

_ Euromet 813: comparison on Co-60 air kerma and absorbed dose to water

_ Euromet 814: comparison in Ir-192 air kerma strength with NPL

Equipment

_ To finish to build the X rays generator rooms facilities

ESR

_ To finish the testing of the new dosimeters and improve the knowledge about the free radicals

Ionometry

_ To build, and check the new cavity air kerma reference standards (Co-60 and Cs-137)

_ To build an ionisation chamber to calibrate I-125 and Pd-103 brachytherapy sources

Quality

_ To continue to describe all our operating procedures

Sources

_ To change one caesium-137 source

TLD

_ To continue the study of the repeatability and reproducibility measurements with LiF pellets and study of the fading

Usual dosimeter calibrations or irradiations

_ To calibrate users dosimeters for radiology applications and industrial X-rays applications

Publications (2003 – 2004)

"Artificial optical bleaching of the aluminium center in quartz implications to ESR dating of sediments", *P. Voinchet, C. Falguères, M. Laurent, S. Toyoda, J.-J. Bahain, J.-M. Dolo*, Quaternary Science Reviews, 2003, 22, 1335-1338

« Guide SFPM : Utilisation des références métrologiques nationales de dose absorbée dans l'eau et application du protocole de dosimétrie AIEA TRS n° 398 aux faisceaux de photons de haute énergie », *B. Chauvenet, F. Delaunay, J.-M. Dolo, G. Le Roy, A. Bridier, P. Francois, R. Sabattier,* (document site Internet SFPM, mai 2003)

"BNM-LNHB graphite calorimeter: a new constant-temperature operating mode for absorbed dose rate measurements", *J. Daures, A. Ostrowsky,* Proceedings Workshop on Recent Advances in Absorbed Dose Standards, Melbourne - Australia – August 2003

"ESR dating of quartz extracted from quaternary sediments: Application to fluvial terraces system of northern France", *P. Voinchet, J.-J. Bahain, C. Falguères, M. Laurent, J.-M. Dolo, J. Despriée, Gageonnet R.,C. Chaussé,* Quaternaire, 15, 2004, 135-141

"EPR study of gamma induced radicals in amino acid powders", *S. Talbi, J. Raffi, S. Aréna, J. Colombani, P. Piccerelle, P. Prinderre, J.-M. Dolo*, Spectrochimica Acta Part A, 60, 2004, 1335-1341

Publications (2005 – …)

"Comparison of dosimetric standards of USA and France for HDR brachytherapy", *G. Douysset, J. Gouriou, F. Delaunay, L. De Werd, K. Stump, J. Micka*, Phys. Med. Biol., 2005, 50, 1961-1978

New constant temperature operating mode for graphite calorimeter at BNM LNHB; *J. Daures, A. Ostrowk*y, to be published in Phys. Med. Biol.,

Métrologie des rayonnements ionisants au service de la santé : diagnostic et radiothérapie. *J.-M. Bordy, M. Denoziere, G. Douysset,* congrés international de métrologie, Lyon, France, juin 2005.