THE BIPM ABSORBED-DOSE GRAPHITE CALORIMETER

A primary calorimetric standard to measure the absolute absorbed dose of ionizing radiation in ^{60}Co and megavoltage medical accelerator photon beams has been developed in the Ionizing Radiation Department at the BIPM. This standard is used for comparisons of NMI standards for absorbed dose to water.

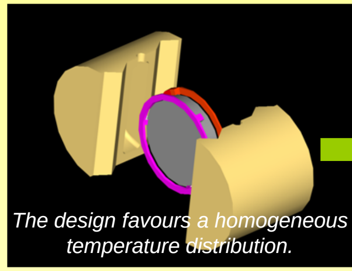
The absorbed dose D is determined using the relation

$$D = E\,/\,m = c_p\,\Delta T.$$

The temperature rise in the calorimeter core is measured with an accuracy of a few µK.

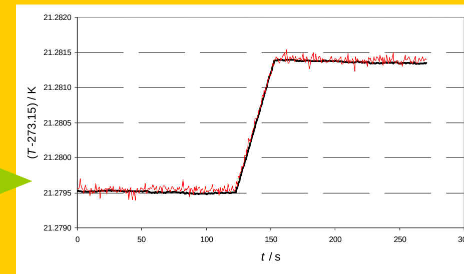
The specific heat capacity c_p of a particular graphite sample has been determined with an uncertainty of 1 part in 10^3.

The calorimeter in its vacuum chamber.

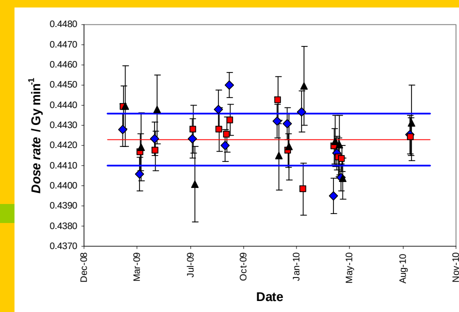


The design favours a homogeneous temperature distribution.

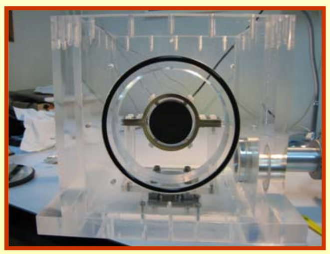
The calorimeter was designed to minimize the temperature difference between the core and jacket, and to reduce as far as possible heat exchange, notably radiative heat transfer, between the jacket and its surroundings. Non-graphite materials were kept to a minimum to reduce their effect on the temperature rise.



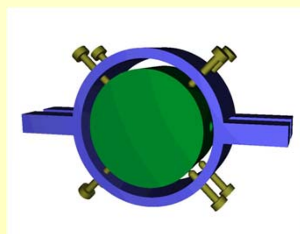
Temperatures measured before, during and after irradiation of the calorimeter in a 6 MV accelerator beam, demonstrating quasi-adiabatic behaviour. The black curve represents the temperature of the calorimeter core using two thermistors in opposite arms of a d.c. Wheatstone bridge, while the red curve shows the temperature of the jacket. The jacket is measured using a single thermistor and an ohm-meter and the signal is therefore noisier than that of the core.



Decay-corrected data for the absorbed-dose rate to graphite in the BIPM Co-60 reference beam from January 2009 until November 2010. The red squares and the blue diamonds represent two of the three resistance bridges, each with two thermistors. The black triangles represent the third resistance bridge containing only one thermistor. The red and blue lines represent, respectively, the mean value and the standard uncertainty of the distribution of 3 parts in 10^3.



Calorimeter seen from the front, without the graphite window….



…and as a component of the Monte Carlo geometry constructed using the PENGEOM code of PENELOPE [1].

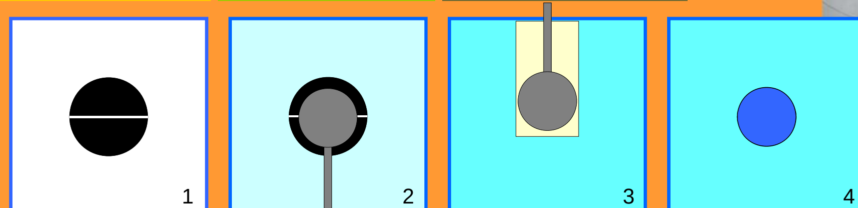
The absorbed dose to water, D_w, in a high-energy photon beam is determined through three different measurements in the beam (1–3), combined with Monte Carlo calculations modelling these experimental configurations (1-3) and also the ideal configuration (4).

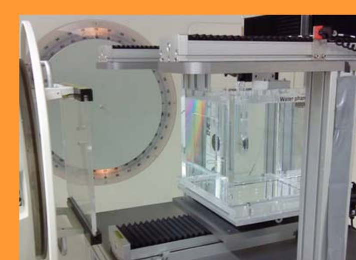
$$D_w = D_c \frac{I_w}{I_c} C_{w,c}$$

Calorimetric measurement in vacuum with the graphite core in the graphite jacket.

Ionometric measurement where the core is replaced by a parallel-plate ionization chamber.

Ionometric measurement with the parallel-plate ionization chamber placed in a water phantom.





Ionization chamber in graphite jacket …and water phantom.

[1] Salvat F, Fernandez-Varea J M, Acosta E and Sempau J 20083 PENELOPE, - a code system for Monte Carlo simulation of electron and photon transport *Electronic manual supplied with PENELOPE 2008.*

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