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BEV PROGRESS REPORT 2005-2007
ON RESEARCH ACTIVITIES IN RADIATION DOSIMETRY STANDARDS AND FACILITIES

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Standards for Radiation Therapy

The ^{60}Co source of the teletherapy irradiation unit was changed at the end of 2004. The actual values for air kerma and absorbed dose to water for ^{60}Co were set in 2005.

In 2005 a new BEV research project was initiated for field characterisation and calibration of photon and electron accelerators in Austrian hospitals by BEV. The project started with measurements at the BEV dosimetry laboratory with ^{60}Co and calibration of 2 therapy dosimeters with 6 ionization chambers as secondary standards for high energy photon and electron beams at METAS. An important part of this project is the energy range and application enhancement of the primary standard graphite calorimeter used at BEV, to allow measurement of absorbed dose to water in high energy photon and electron beams used for medical applications in practice. An essential part of the project is covered by a PhD theses (A. Baumgartner, Univ. of Technology Vienna).

Milestones finished:
- Measurements at accelerators using the secondary standards to verify calculation methods based on ^{60}Co-calibration such us the new Austrian standard OENORM S 5234-3 [1] and the new German standard Draft DIN 6800-2 [2].
- Reestablishment of the graphite calorimeter including revision, replacement of hardware components and development of a new evaluation program with automatic non-linear drift extrapolations created in LabView®
- Determination of the absorbed dose to graphite and conversion in absorbed dose to water using photon fluence scaling theorem based procedures. We will use two parallel procedures - conversion by calculation and conversion with an transfer ionisation chamber
- Verification of the calorimeter response by electric calibrations for the complete temperature working range
- Measurements in the beam of the ^{60}Co teletherapy unit and comparison with our primary ionisation chamber standards has showed good agreement within declared measurement uncertainties

Milestones in progress:
- Calculation of application specific correction factors for the graphite calorimeter using Monte Carlo code system *PENELOPE 2006* for ^{60}Co radiation and high energy radiation qualities (photons and electrons) used in medicine. Following correction factors are taking into account: correction for the effect of the vacuum gaps around the core, correction for the deviation of the graphite phantom from the scaling requirements, air attenuation correction, correction for the effective measurement depth in graphite
- Modelling of the BEV ^{60}Co teletherapy unit using *PENELOPE 2006 – penmain*, to achieve the energy spectrum for the use as an input parameter within the simulations regarding the application specific correction factors
- Measurements at accelerators using the graphite calorimeter to verify the simulation results
- Comparison of the results of measurements with secondary standard chambers and graphite calorimeter on the one hand, on the other hand comparison with the calculated results using the transfer standard chambers

First results will be presented at the Workshop on "Absorbed Dose and Air Kerma Primary Standards" Paris, 9-11 May, 2007.

Standards for Diagnostic Radiology

In this field BEV continued the development of a national air kerma standard for diagnostic X-rays by further particularization of basic parameters of the standard free air chamber PKM.
Optimizing the aperture shape has significantly decreased by *PENELOPE* calculation stated correction factor k_{sa} for scatter in aperture even for energy 150 kV (Qualities RQA10 and RQR10). While using the original cylindrical aperture, k_{sa} value has reached 7,8 %. After its reconstruction and new design k_{sa} decreased to 2,4 %. Internal comparison of the BEV PKG standard free air chamber and new PKM standard has been done with satisfactory agreement within declared measurement uncertainties for above mentioned diagnostic qualities (Figure 1).

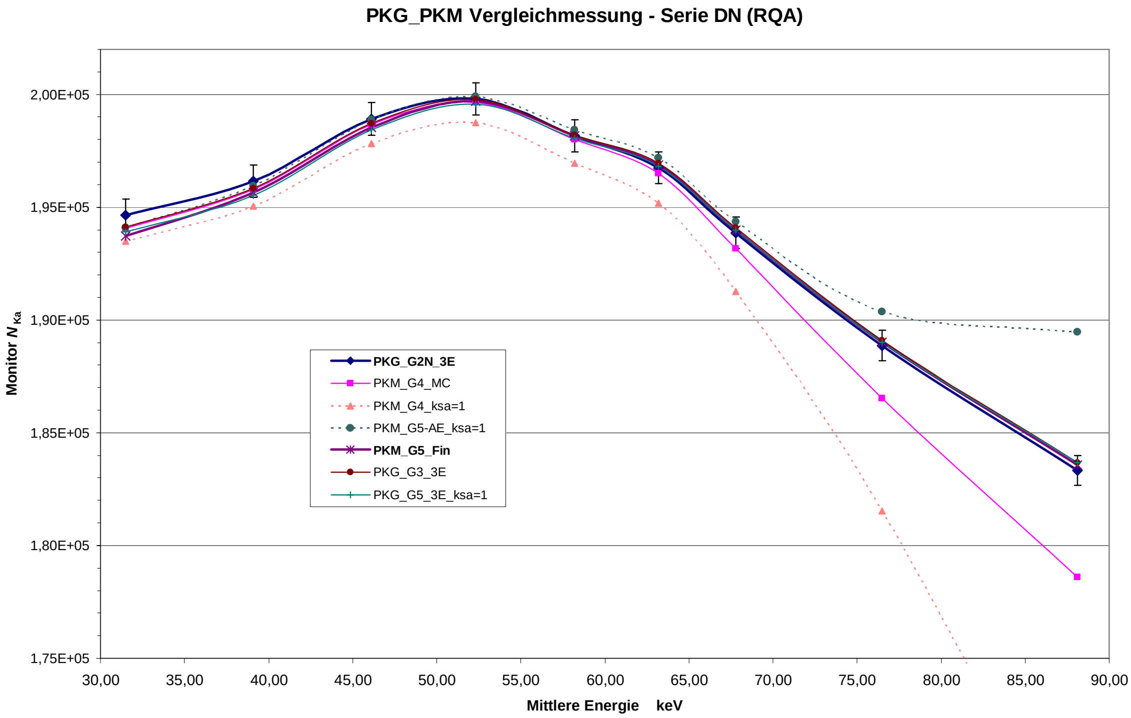

Figure 1 PKM aperture optimization process with final comparison PKM/PKG (PKM_G5 Final aperture design was compared with PKG_G2N_3E and PKG_G3_3E measurements)

Ion recombination in the PKM has been investigated according to M Boutillon [3]. The parameter m^2 has been stated by a set of measurements for both X-ray quality series – Figure 2.

Analysing measurement results as well as uncertainty sources, we have obtained that there is relatively high dependence of the final m^2 value on the precision of the chamber voltage measurement which was previously not adequately taken into account. For usual measurement with ionizing chamber, the stability of voltage is crucial but uncertainty of its setting is not critical. The change of the measured value of chamber voltage in a range of 1% for this purpose could cause the change of m^2 parameter value in the same range, and in the worst case 2,5 %. That's why we've done all further voltage measurements using well calibrated high voltage divider with accurate voltmeter.

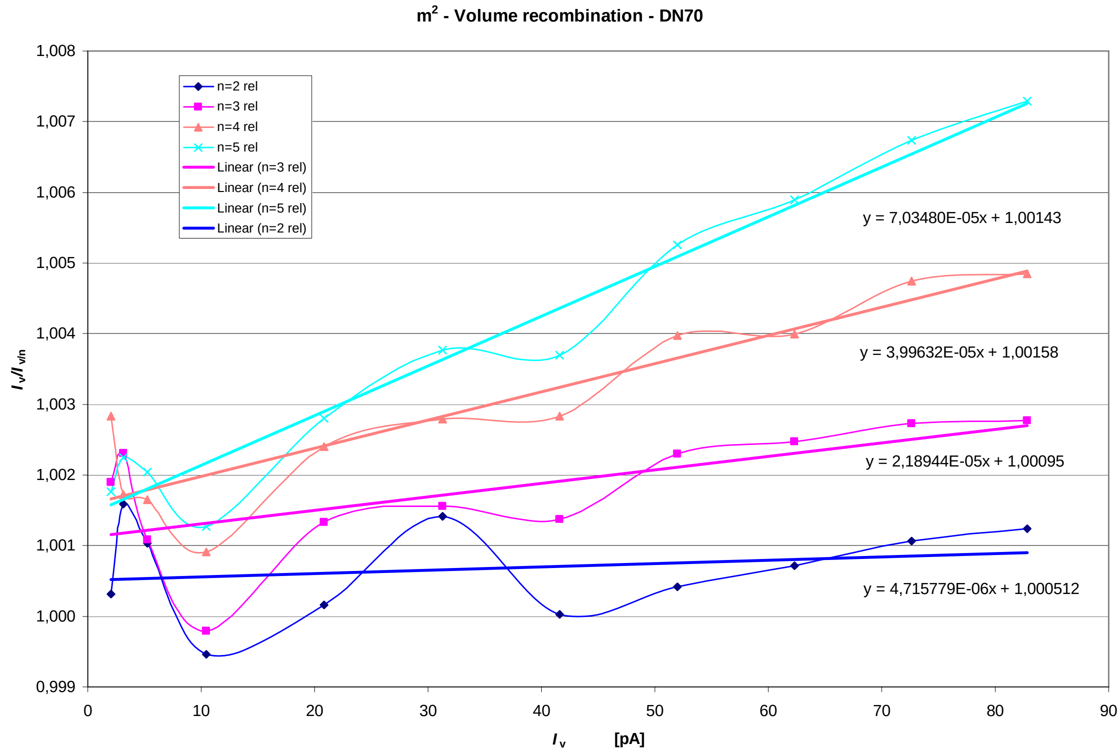

Figure 2. Ratio of the ionization currents I_V and I_V/n measured in PKM chamber with voltages V and V/n respectively, as a function of I_V, for several n values

Therefore we suppose that uncertainty stated by M Boutillon was slightly underestimated and this piece of knowledge could perhaps explain relatively high spread of published m^2 values. Stated arithmetic mean of our measurements $m^2 = 4{,}30\cdot10^{14}$ s m^{-1}C^{-1}V^2 with s = 2,3 % is within a set of values given by other authors in published data. Final saturation correction factor $k_s = 1 + k_{init} + k_{vol}\, I_V$ has been calculated for our PKM chamber at the end and its mean value $k_s = 1{,}0004_8$ is in a very good agreement with the value stated according to W Hübner [4], $k_s = 1{,}0004_6$.

Results will be published after further verification.

Participation in Euromet 813 Project

In 2006 the dosimetry laboratory of the BEV took part in the project EUROMET 813 - *Comparison of air kerma and absorbed dose to water measurements of Co-60 radiation in radiotherapy* – pilot laboratory is the OMH, project leader Istvan Csete.

Our laboratory has calibrated the transfer chambers with transfer electrometers according to the project program and has finished its measurements in January 2007. For air kerma rate measurements, our cylindrical graphite 1 cm^2 primary chamber has been used as a reference standard. For absorbed dose to water we have used our graphite calorimeter and graphite ionizing chamber as reference.

Cooperation with IAEA

BEV dosimetry laboratory periodically performs reference irradiations for the IAEA/WHO postal dose quality audit service for ^{60}Co therapy level as well as for ^{137}Cs radiation protection level.

References

[1] OENORM S 5234-3:2001-05: Clinical dosimetry – Ionization chamber dosimetry

[2] Draft DIN 6800-2:2006-12: Procedures of dosimetry with probe-type detectors for photon and electron radiation – Part 2: Ionization chamber dosimetry of high energy photon and electron radiation

[3] M Boutillon, Phys.Med.Biol. 43 (1998) 2061-2072

[4] W Hübner, Fortschritte auf dem Gebiete der Röntgenstrahlen und der Nuklearmedizin, 89 (1958), S.764