sheet of shielding material and by a further factor of three when two sheets were used. In the practical neurosurgical environment, a further reduction in dose rate was obtained using a 'plug' of bone.

Conclusion: The dose rates measured, without any local shielding in place show that it is not feasible to use this equipment straight out of the box. Although the X-ray energy is low the dose rates at the treatment site are in the region of 0.5Gy/min. Adequate shielding for the operator and anaesthetist is provided by 2mm Lead Equivalent screens. Judicious positioning of the screens also provides protection for adjacent rooms. The use of local shielding at the treatment site is essential in order to reduce the dose rate in adjacent areas to acceptable levels. Control of access to the theatre is required, as with any radiological equipment. Prior planning with the theatre staff and surgical team is invaluable.

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Relative dosimetry of high-energy electron beams with radiographic film

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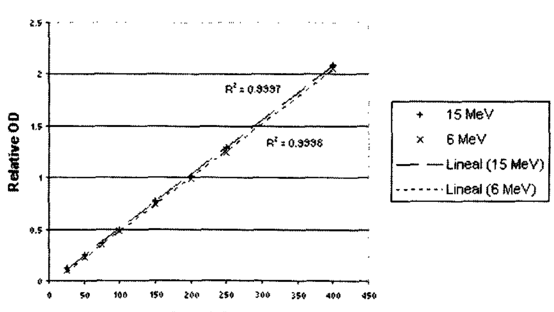
Film dosimetry of high-energy (HE) electron beams is a handy procedure in a periodic quality control of relative dosimetry (depth dose and profiles), due to the availability in most medical physics departments and relatively high spatial resolution, wide linearity range and signal-noise ratio.
In this paper, we address a calibration procedure and relative dosimetry verification with Kodak EDR2 radiographic film in HE electron beams of a Siemens PRIMUS linear accelerator. Gerbi et al. [1] suggests this film must be used with care due it response with electrons, although bad performance has not been shown in our results.
Films have been processed in a Microtek ScanMaker 9800XL CCD digitiser with a transparency adapter and Densirad software from Tecnicas Radiofisicas S.L. (Zaragoza, Spain). For scanned grey levels (GL) to optical density (OD) calibration, a 21-step AGFA sensitometer strip have been digitaized. It has been found that linearity deteriorate as optical density increase. A practical upper limit around 1.8 OD has been established in order to keep a good performance.



Kodak EDR2 have been irradiated at measurement depths of IAEA TRS-398 protocol in a PTW RW3 laminar solid water phantom with nominal electron energies of 6 and 15 MeV and a circular aplicator of 5 cm diameter. Doses of 25, 50, 75, 100, 150, 200, 250 and 400 cGy were delivered to develop the characteristic curve for the EDR2 film for each beam energy. Calibration procedure shows a OD to dose linnear response using both digitaiser and a X-RITE desk densitometer.
Relative dosimetry verification is show through depht doses comparison between parallel-plane ionization chamber in water phantom and film measurements in the RW3 phamton. Film have been irradiated in it ready pack to make method as simple as possible. We have been able to maintain good results except first milimeters in depth. Maximum differences of 1 mm have been found for d_{max}, d_{80} and d_{50} depths.
EDR2 film is a good choice in periodic QA of high-energy electron beams.

[1] B. J. Gerbi and D. A. Dimitroyannis: "Kodak EDR2 film response for electron beams", Med. Phys. 30, 2703-2705 (2003)

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Conversion factors for reference dosimetry of 6 MV narrow photon fields using a PTW-31014 Pinpoint ion chamber

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Introduction: Intensity Modulated Radiation Therapy (IMRT) has evolved towards the use of multiple small radiation fields, "*beamlets*", whose dosimetry requires ionization chambers having sensitive volumes smaller than about 0.1 cm^3. These are generally used for dose verification of IMRT treatments. Very narrow photon beams are also employed in radiosurgery. Existing protocols for dosimetry in reference conditions are based on relatively large fields (10x10 cm^2) where electronic equilibrium conditions exist. The dosimetry of narrow photon beams pertains to the so-called non-reference conditions for beam calibration. The use of ion chambers for such narrow beams remains questionable due to lack of lateral electron equilibrium. As an extension of the work by Doblado *et al* (PMB 2003) this work aims at calculating by Monte Carlo (MC) simulation the conversion factor necessary to determine directly the absorbed dose to water using a **PTW-31014** "Pinpoint" ion chamber in 6 MV narrow radiation fields.
Materials and Methods: Detailed MC simulations of a **PTW-31014** ion chamber were carried out. The chamber has an active volume of 0.015 cm^3, and a central electrode made of aluminium; it was positioned at 5 cm depth in water, perpendicular to the beam axis (as recommended by the manufacturer for reference dosimetry) and SSD=100 cm. The required 6 MV phase-spaces for a Siemens Primus linac were calculated with BEAMnrc to model the linac treatment head and its multileaf collimator. Dose calculations were carried out for several irradiation fields, including the reference 10x10 cm^2 and a series of decreasing beams from 5x5 cm^2 down to 0.7x0.7 cm^2. The dose to the air cavity and to water were calculated using an EGSnrc-based user code (CAVRZsp), developed from the well-known cylindrical CAVRZ code, which includes semi-spherical bodies for ion chamber simulations. The dose to the air cavity (D_{air}) was determined in the MC simulation as the energy deposited in the air chamber volume (excluding the electrode) divided by its mass. The absorbed dose to water (D_{water}) was derived as the energy deposited in a 1 mm^3 water cylinder, centered at the reference point. The electron and photon transport cut-off energy in the volume surrounding the ion chamber were 1 keV, and 100 keV in the rest of the water phantom.
Results and Conclusions: Following Sempau *et al* (PMB 2004), factors $f_{c,Q}$ to convert the absorbed dose to air into dose in water for the 6 MV beams were calculated directly as D_{water}/D_{air}. For the reference field the calculated factor was 1.11±0.01. This value was nearly constant within the stated uncertainty for field sizes down to 2x2 cm^2. For smaller fields the factor increases monotonically by 4%, 6% and 12% over the reference value for fields of 1.5x1.5, 1.0x1.0 and