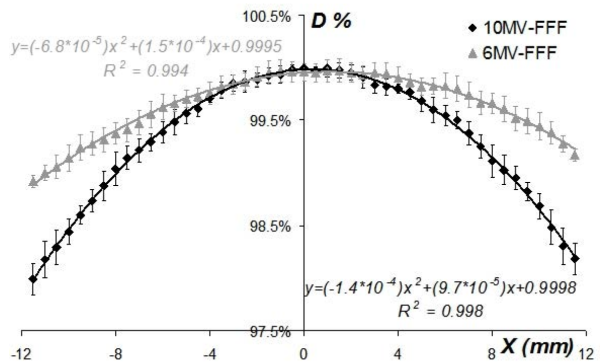
Finally, *P_fl* equal to 1.0021 (0.0004) for 6 MV-FFF, and to 1.0033 (0.0005) for 10 MV-FFF, respectively, were computed.
Figure 1. Average transverse dose profiles of the (10x10) cm^2 field, for 6 MV (gray) and 10 MV (black) FFF photon beams from a TrueBeam™ (Varian Inc.) linac, scanned, along *L*= 24 mm with 0.5 mm step, by a shielded p-diode (T60016™, PTW) at 10 cm of depth in water with SSD= 90 cm. (±1sd)-error bars (<0.1 %) refer to four sessions of measurements spanning about six months.



Conclusion: The factor *K_icdg*, which can be approximated by *P_vol* within 0.1 %, corrects for a dose error up to -0.6 % in reference dosimetry of the 10 MV-FFF photon beam when a Farmer ionization chamber is used.

EP-1484

The dosimetric property of TLD2000 thermoluminescent dosimeter

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Purpose or Objective: To study the dosimetric properties of TLD2000 thermoluminescent dosimeter (TLD), including repeatability, linearity of dose response, energy response and dose rate effect.

Material and Methods: 1300 TLD2000 TLDs were read out after exposure to a dose of 1 mGy of 65 keV x-ray, then were sorted out to have the same sensitivity within ±3.0%. TLDs were irradiated to a dose of 120 MU using 6 MV x-ray, then irradiated to the same dose after 24 h. TLDs were irradiated with two I-125 seeds with the same activity for 24 h, and the interval time was 24 h, to study the repeatability of TLDs for 6 MV x-ray and I-125 seed. TLDs were irradiated to different doses using Cs-137 (662 keV γ-ray), I-125 seed and 6 MV x-ray, to study the dose response of the TLDs. TLDs were irradiated to a dose of 1 mGy using Cs-137, 48 keV, 65 keV, 83 keV, 118 keV and 250 keV x-rays, to study the energy response of the TLDs. TLDs were irradiated to a dose of 120 MU using 6 MV x-ray with different dose rates of 37 MU/min, 75 MU/min, 150 MU/min, 300 MU/min and 600 MU/min; TLDs were irradiated to the same dose using three 125I seeds with different activities of 0.739 mCi, 0.675 mCi and 0.559 mCi, and the irradiated time were 24 h, 26h 17 min and 31 h 48 min, respectively, to study the dose rate effect of TLDs for 6 MV x-ray and 125I seed.

Results: 350 TLD2000 TLDs were selected with the sensitivity within ±3.0%. The maximum deviations of the repeatability were 2.7% and 4.0% for 6 MV x-ray and I-125 seed, respectively. The dose response of TLDs for Cs-137 and I-125 seed were linear. For 6 MV x-ray, the linear response range were 0.74 Gy-10.0 Gy, beyond 10.0 Gy the dose response became supralinear but proportional to the absorbed dose to TLD. The energy response for 48 keV, 65 keV, 83 keV, 118 keV and 250 keV x-rays, relative to the energy response of Cs-137, were 1.25, 1.08, 0.99, 0.91 and 0.96, respectively. There were no dose rate effects in the dose rate range of 37 MU/min to 600 MU/min for 6 MV x-ray and 0.66 cGy/h to 0.87 cGy/h for I-125 seed.

Conclusion: TLD2000 TLD has good repeatability and linear dose response for Cs-137, I-125 seed and 6 MV x-ray without dose rate effect, but the dose response is energy dependent.

EP-1485

Characterization and performance of the MR compatible Delta4 patient QA system in a hybrid MRI-Linac

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Purpose or Objective: At our institute a prototype of a MRI-Linac (MRL) has been installed combining imaging (MRI, Philips) with treatment (Linac, Elekta). However before starting patient treatments, extensive machine quality assurance (QA) must be investigated including QA of treatment-plans. Standard electronic equipment is not MR-safe so patient-specific QA systems have had to be re-designed, and the performance of a new system in a 1.5 T magnetic field must be tested. The purpose of this study was to examine and characterize the performance of the newly developed MR-compatible Delta4 phantom in a transverse 1.5 T magnetic field.

Material and Methods: A prototype MR-compatible version of the Delta4 QA phantom (ScandiDos AB) was used in these measurements. To characterize this QA-system, the short-term reproducibility, dose linearity, field size dependence, dose rate dependence, dose-per-pulse dependence and angular dependence were evaluated on a conventional linac (B0=0, Elekta, 6MV Flattened (FF) and 6MV Flattening Filter Free(FFF) beam, SAD of 100 cm) and the MR-linac (B0 = 1.5 T, Elekta 6 MV FFF beam, SAD of 142.7 cm). All measurements were normalized to the readings of an ionization chamber. The performance of the MR-compatible Delta4 was also compared to that of a commercially-available clinical version in use in our department.

Results: The maximum differences between the clinical and the MR-compatible Delta4 measurements on a conventional linac are represented in the table below:

	FF-beam (B_0=0)	FFF-beam (B_0=0)
Short term reproducibility	0.05%	0.21%
Dose linearity	0.59%	0.64%
Fieldsize dependency	0.36%	0.38%
Dose rate dependency	0.25%	0.36%
Dose-per-pulse dependency	0.43%	0.47%
Angular dependency	---	0.89 %

Measurements are currently being performed on the 1.5 T research-prototype MRL. Analysis of the preliminary data show similar behavior to the measurements performed without magnetic field. Final results will be presented.

Conclusion: The characteristics and performance of the MR-compatible Delta4 have been investigated. There are no significant differences found between the clinical phantom and the MR-compatible phantom. The preliminary results at the MR-linac are consistent with those from the clinical linac.

EP-1486

Evaluation of detectors response for small field output factor measurement using Gafchromic film

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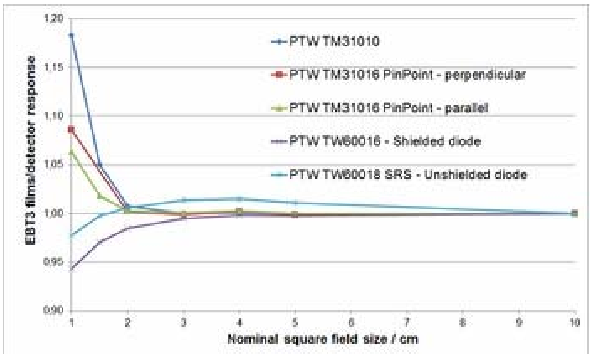
Purpose or Objective: Most irradiation technics require dose computing from TPS. Calculation accuracy highly depends on the measurements used for beam modeling. Depending on their characteristics, available detectors may be best suited for specific field sizes when measuring Output Factors (OF). Recent studies compare several active with passive detectors and MonteCarlo calculation. The goal of our study is to evaluate the response of several active detectors exposed to 6 MV X-ray beams of different sizes, down to 1x1 cm^2, while considering EBT3 Gafchromic films as reference.

Material and Methods: Eight EBT3 films were irradiated with field sizes ranging from 1x1 to 10x10 cm2. Measurements were done in a homemade RW3 solid water phantom. Multichannel film dosimetry was used for film opacity-to-dose conversion. All films (including background) were irradiated and scanned simultaneously using the efficient protocol described by D. Lewis *et al.* Among available active detectors, two ionization chambers and two diodes were studied. Measurements were carried out in a water phantom. OF measurements were also done by placing both chambers in the solid water phantom, in the same condition as the films. Results were compared to measurements done in water in order to verify scattering components correspondence for all field sizes. This allows active detectors irradiated in water to be compared to the films in RW3 slabs.

Results:



OF obtained with the ionization chambers placed in the water and solid water phantom are identical for field sizes smaller than 15x15cm2. As described in H. Benmakhlouf publication, active detector response for each field size was normalized with respect to the reference data. Figure 1 shows results. Concerning ionization chambers, the influence of partial volume averaging is similar to the published results. The three major effects mentioned for the diodes also appear in our results : the charged particles equilibrium between detector material and water, the over-response of the unshielded diode in broad beams and the partial volume averaging.

Conclusion: Our study confirms that partial volume averaging is not the only undesirable effect for OF measurement. Thus, the detector having the best spatial resolution is not systematically the best suited for small fields OF measurements.

EP-1487

Dosimetric properties of a new formula PRESAGE with tin metal catalyst

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Purpose or Objective: Metal compounds in the fabrication of new radiochromic polymer gel dosimeters based on polyurethane resin act as catalyst to accelerate the polymerization of the dosimeter precursors. Tin-base catalyst is one of the widely used catalysts in polyurethane technology. The main purpose of this study is an evaluation of effect of tin-metal catalyst in new formula of PRESAGE response and radiological properties of it.

Material and Methods: : A very little amount of dibutyltin dillaurate (0.07 wt%) was used as catalyst in the fabrication of the new PRESAGE which components were: 93.93 wt% polyurethane , 5 wt% tetrachloride and 1 wt% Leucomalachite green. Radiochromic response and post-irradiation response of new PRESAGE were determined. Radiological characteristics of new PRESAGE such as mass density, electron density, mass attenuation coefficient and mass stopping power in different photon energies were assessed and compared with water and a commercial PRESAGE® radiochromic.

Results: Absorption peak of new PRESAGE with metal was seen unchanged. Sensitivity of new PRESAGE was relatively two times higher than commercial PRESAGE® and stability of new PRESAGE after one hour was seen constant. Mass attenuation coefficient in energy less than 0.1 MeV was 10% more than water, whereas the mass stopping power difference was only 2%.

Conclusion: Tin catalyst with very low weight fraction can be used in fabrication of radichromic polymer gel in order to fabricate a gel with high sensitivity and stability as well as good radiological properties in the megavoltage photon beam.

EP-1488

Estimation of the RBEs of two miniature x-ray devices, I-125, Ir-192 and Co-60 BT-sources

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Purpose or Objective: Today over 300 miniaturized x-ray devices (MXD) from the companies Carl Zeiss Meditec AG (Intrabeam®) and Xoft (Axxent®) are applied in clinics worldwide for radiation therapy treatment (RTT) of breast cancer. Both devices emit an x-radiation field where the energy distribution is given by a continuous Bremsstrahlung-spectrum with a maximum energy of 50 keV and characteristic fluorescence lines induced by the material of the electron target and the materials in the pathway of the emitted photons. Low-energy x-rays are known to have a higher relative biological effectiveness (RBE) than higher energy photons such as the gamma rays from Ir-192 and Co-60. In this work the RBEs of the MXDs and of I-125, Ir-192 and Co-60 BT-sources at several points within a hemispherical water-phantom are estimated by calculational techniques based on both micro- and nanodosimetry.

Material and Methods: Spectra of both devices were obtained by measurements with an HPGe-Detecor and applying the sophisticated data evaluation procedures already presented at the 2nd ESTRO-Forum. For the photon transport-calculations the respective source is located 4 cm below the spherical surface and spectra are calculated at several points along the axis through the centre of the hemisphere. The first approach is based on a comprehensive biological study of the α-dic variation by E. Schmid (GSF, Munich) in the photon energy range from 1 keV to 1.3 MeV. The yield coefficient α-dic represents the linear or α-component of the yields of dicentric chromosomes and is considered to be strongly correlated with the RBE. A strong dependence of α-dic on the photon energy was thereby revealed with a maximum of RBE = 8 at 7 keV in comparision with Co-60. Based on this experimental data microdosimetric calculations were performed to obtain an energy dependend function α-dic(E) (D. Harder, W. Friedland et al). The RBE for a given source in a given point is obtained by a convolution of the respective spectrum with α-dic(E). For the second approach each of the calculated spectra is taken as a starting point for simulations with Geant4-DNA to obtain the track structure of the ionising radiation. The track structure is characterised by the frequency distribution of the ionisation