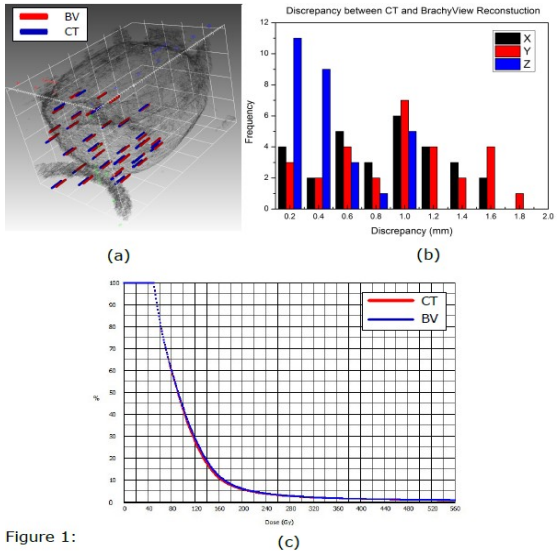

Figure 1:

Conclusion: The reconstructed seed positions measured by the BV probe demonstrate excellent agreement with seed positions calculated using CT data with a maximum discrepancy of 1.78 mm. It was observed that 75% of seed positions were reconstructed within 1 mm of their nominal location. The DVH study was performed to evaluate the effect of reconstructed seed locations on estimated dose delivered. V100 showed a discrepancy of 0.604 cm3 between CT and BV-derived 3D seed distribution. The BV technique has proven to be an effective tool for quality assurance during LDR brachytherapy, providing anatomical and seed positioning information without need for external irradiation for imaging.

OC-0253

A high sensitivity plastic scintillation detector for in vivo dosimetry of LDR brachytherapy

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Purpose or Objective: There are multiple challenges behind developing an *in vivo* dosimeter for LDR brachytherapy. The dose rates are orders of magnitudes lower than in other therapy modalities, the detectors are known to be energy-dependent, and introducing materials that are not tissue-equivalent may perturb the dose deposition. The goal of this work is to develop a high sensitivity dosimeter based on plastic scintillation detectors (PSDs) that overcomes those challenges and to validate its performance for *in vivo* dosimetry.

Material and Methods: The effect of the energy dependence of PSDs on dosimetry accuracy was studied using GEANT4 Monte Carlo (MC) simulations adapted from the ALGEBRA source code developed for brachytherapy. The photon energy distribution at different positions around a modeled I-125 source was obtained and convoluted to a typical PSD response. The effect of the different materials composing the PSD was also investigated.
To measure dose rates as low as 10 nGy/s, the selection of each single element composing a typical PSD dosimetry system was revisited. A photon-counting photomultiplier tube (PMT) was used in combination with an optical fiber designed to collect more light from the scintillator. A spectral study was performed to determine the best combination of scintillator and optical fiber to use.
Finally, doses up to a distance of 6.5 cm from a single I-125 source of 0.76U (0.6 mCi) held at the center of a water phantom were measured. The PSD was moved at different radial and longitudinal positions from the source using an in-house computer-controlled device developed for this study and allowing for sub-mm positioning accuracy. The measurements were compared to the expected values from the updated Task-Group 43 formalism.

Results: The change in the energy distribution with position around the I-125 source was shown from MC simulations to have a limited impact on the PSD's accuracy over the clinically relevant range (<1.2%). Therefore, the energy-dependence can be neglected, as long as the PSD is calibrated using the same isotope. The effect of the different materials on the photon energy distribution was also shown to be limited (<0.1%). The different improvements made to the PSD dosimetry system are presented in Table 1. Those led to a 44 times better signal-to-noise ratio than for a typical PSD. Measurements with the PSD around a single I-125 source were shown to be in good agreement with the expected values (see Fig.1). The uncertainty was shown to be a balance between positioning uncertainty near the source and measurement uncertainty as the detector moves farther away from the source.

Improvements		Factor
Cooling PMT (reduction in dark noise)		1.6
Selection of scintillator + Shorter fiber		5.7
Using a Mylar reflector		2
NA = 0.6 vs. NA = 0.5	collected light	1.44
	increase in OPL	0.996
Scintillator length (5 mm vs 3 mm)		1.67
Total		**43.75**

Table 1. Summary of the different improvements made to the PSD dosimetry system (PMT: Photomultiplier Tube, NA: Numerical aperture, OPL: optical path length).

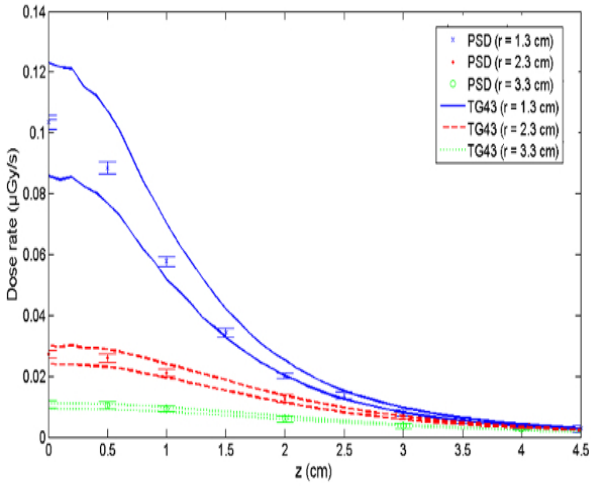

Figure 1. Measured dose-rate with the PSD as a function of position along the longitudinal axis of the source (z) for different radial distances (r) in comparison to the expected values (TG43). The TG43 values (lines) account for uncertainties in source-to-detector positioning of ±1 mm along the x- y- and z-axes.

Conclusion: This optimized PSD system was shown to be capable of accurate in-phantom dosimetry around a single LDR brachytherapy seed, which confirms the high sensitivity of the detector as a potential *in vivo* dosimeter for LDR brachytherapy applications.

OC-0254

MR compatibility of fiber optic sensing for real-time needle tracking

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Purpose or Objective: The development of MR-guided HDR brachytherapy has gained an increasing interest for delivering a high tumor dose safely. However, the update rate of MR-based needle localization is inherently low and the required image interpretation is hampered by signal voids arising from blood vessels or calcifications, which limits the precision of the needle steering.
This study aims to assess the potential of fiber optic sensing for real-time needle tracking during MR-guided intervention. For this, the MR compatibility of a fiber optic tracking system and its accuracy are evaluated.

Material and Methods: *Fiber optic tracking device*: The device consists of a flexible stylet with three optic fibers embedded along its length, a broadband light source, a spectrum analyzer and a PC with Labview application. Along each fiber, Bragg gratings are evenly spaced at 20 mm intervals. To reconstruct the shape of a needle, the stylet is inserted inside the lumen of the needle. This set-up placed in the 1.5T MR-scanner provides real-time measurement of the needle profile, without adverse imaging artefacts since no ferromagnetic material is involved.
MRI-acquisition protocol: 3D MR-images were acquired with a 1.5T MR-scanner, using a 3D Spectral Presaturation with Inversion Recovery (SPIR) sequence (TR=2.9ms, TE=1.44ms, voxel size= 1.2×1.45×1mm^3, FOV=60×250×250mm^3).
Experimental evaluation: The two following experiments were conducted:

1. A needle was placed inside the MR-bore and its shape was imposed by a specially designed plastic mold with different known paths (see Fig. 1a). For path 1, 2 and 3, the shape of the needle was measured by fiber optic tracking during MR-imaging along 4 orientations (i.e 0°, 90°, 180°, 270°), by rotating the needle along its longitudinal axis.
2. Four plastic catheters were introduced in an agar phantom. The corresponding catheter shapes were measured with fiber optic sensing during simultaneous MR imaging (see Fig. 1d, phantom shifted out of scanner for photograph). The MR-based needle shape stemmed from a segmentation step followed by a polynomial fitting (order 5). A rigid registration of the obtained MR-based needle model and the fiber optic tracking was then performed.

Assessment of the fiber optic tracking: The fiber optic needle tracking accuracy was quantified by calculating the Euclidian distances between: the gold-standard shapes and fiber optic based measurements (Experiment #1); MR- and fiber optic based measurements (Experiment #2).

Results: For all tested needle shapes, the maximum absolute difference between the fiber optic based and the gold-standard values was lower than 0.9mm (Experiment #1, Fig. 1b and 1c). Over the 4 tested catheters, the maximal absolute difference between MR- and fiber optic based measurements was lower than 0.9mm (Experiment #2, Fig. 1e, 1f and 1g).

Conclusion: This study demonstrates that the employed fiber optic tracking device is able to monitor the needle bending during MR-imaging with an accuracy and update rate eligible for MR-guided intervention.

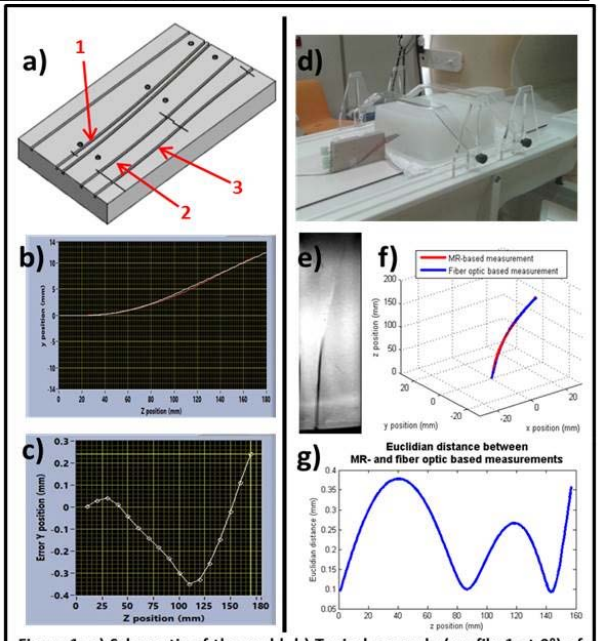

Figure 1: a) Schematic of the mold. b) Typical example (profile 1 at 0°) of fiber optic based measurement (red) and golden standard shape (white). c) Euclidian distance between the gold-standard shape and fiber optic based measurements. d) Experimental setup of catheter in agar phantom. e) Sagittal MR image of one catheter. f) MR- and fiber optic based measurements. g) Euclidian distance between MR- and fiber optic based measurements. The update time of the fiber optic based measurements was 100ms.

OC-0255

Correction function for MOSkin readings in realtime in vivo dosimetry in HDR prostate brachytherapy

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Purpose or Objective: MOSkin detectors coupled to a trans-rectal ultrasound (TRUS) probe were used to perform in vivo dosimetry (IVD) on the rectal wall surface during US-based HDR prostate brachytherapy (BT). The system, called dual purpose probe (DPP), has proven to be an accurate tool to measure in vivo the integral dose, however discrepancies between planned and measured doses from each single catheter can be much higher than the overall discrepancies. In this work, three HDR prostate BT sessions were studied to find a possible distance and angle dependence correction function (CF) to be applied in real time to each single catheter, and data with and without the application of the obtained CF were compared.

Material and Methods: The DPP can be sketched as follows: four MOSkin dosimeters are firmly attached to TRUS rectal probe and are connected to a multichannel reader which provides measurements of the voltage shifts (proportional to the dose) in the MOSkin sensitive layer caused by radiation exposure. A dedicated software plots and records the measured dose with each MOSkin as a function of time, allowing the identification of the dose contribution of each single catheter in real time. Based on the treatment plan data (i.e. planned source strength, dwell times and positions) a software was implemented in the Matlab environment to compute the dose contribution to the MOSkin from each catheter based on TG-43 algorithm. The software reports also the weighted average distance of source to MOSkin for each catheter and the resulting weighted polar angles. IVD data were acquired on three patients treated between June and