

Characterization of a detector system for on-line verification in IMRT

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PURPOSE: IMRT requires a dedicated procedure to verify the correct delivery of the treatment plan of each patient consisting in the comparison before treatment of the dose distribution calculated by the TPS with the one measured with an independent dosimeter. On-line dosimetry completes this procedure by monitoring the delivered dose during the patient treatment.

The aim of this work is to verify the performances of the CompassTM system designed both for patient pre-treatment verification and for on-line dosimetry.



MATERIAL and METHODS

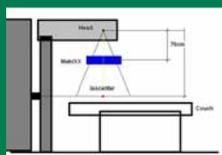
The CompassTM system consists of a dedicated control and analysis software interfacing two possible detectors mounted at the head of the Linac with the appropriate holder: a 2D transmission detector (T2D), with 1600 pixels arranged in a 40x40 matrix, or the 2D ionization chamber MatrixXXTM. The system, which can be used for QA and online dose verification in IMRT, has been tested with treatment plans of increasing complexity. The 2D ionization chamber MatrixXXTM, mounted at the head of the Linac as Compass Detector gives an independent evaluation of fluences. From the fluences measured by the detector at the head of the Linac, and the DICOM files (patient's CT images, structures, and treatment plan), the software uses a Linac "beam model" and a forward dose computation algorithm to reconstruct the dose distribution in patient geometry taking into account the attenuation of the transmission chamber, which has been measured independently in an anthropomorphic phantom with use of microchambers. A series of square fields, dynamic fields and an IMRT plan have been used to test the calibration of the reconstructed dose, the ability of the system to measure fields with high dose gradients and its ability to reconstruct 3D dose distributions in complex geometries for a clinical intensity modulated plan. Cross comparisons have been performed between theoretical dose distributions (TPS), Compass dose distributions and independent measurements, all analysed with the gamma method (3% relative difference and 3mm DTA)

	MatrixXX	T2D
Distance to Source	76 cm	65 cm
pitch	7.6 mm	6.5 mm
# of pixels	1020 (32x32)	1600 (40x40)
single chamber size	4.5 (Ø) x 5 (h) mm, volume: 0.08 cm ³	3.8 (Ø) x 2 (h) mm, volume: 0.02 cm ³
charge resolution	0.1 pC/count	0.1 pC/count

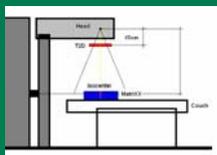
Varian 600 C/D DMLC Millennium 120 6MV photons at IRCC

Experimental Set-up

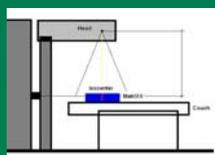
a) MatrixXX at 76 cm DTS as Compass detector



b) T2D as Compass detector + MatrixXX (anthropomorphic phantom) on the couch



c) MatrixXX as anthropomorphic phantom on the couch

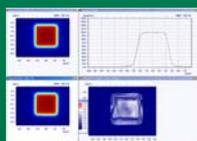


Fields

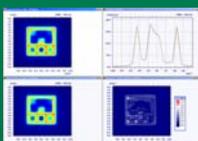
- 3 x 3, 5 x 5, 10 x 10 (cm x cm)
- 1 Gy at MatrixXX surface
- 8 Dynamic Fields gantry at 0 deg
- IMRT prostate plan

RESULTS: The 3D dose distributions reconstructed by the CompassTM Software are exported as dose cubes. The plan at the isocentre level is selected and imported in Omnipro 1mRTTM software where the gamma analysis has been performed for the comparison of TPS vs Compass reconstructed dose.

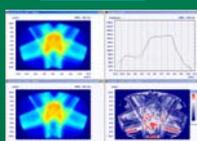
Square fields



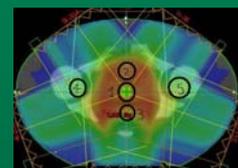
Dynamic fields



IMRT Plan



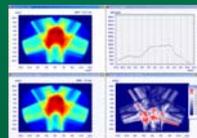
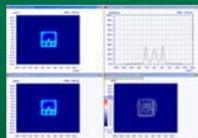
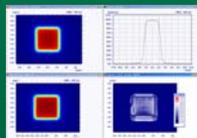
Measurements in Anthropomorphic Phantom



A micro-ionization chamber has been used for measurements in the five inserts of the CIRSTM phantom for the IMRT plan. The model was ExradinTM A-16 with a sensitive volume of 0.007 cm³. The measurements have been taken with and without the attenuation of the transmission chamber.

Compass with MatrixXX as detector

Compass with T2D as detector



*The dose distributions in this comparison have been normalized to the maximum values.

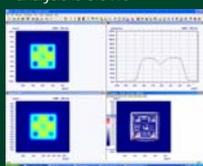
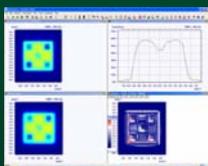
Field (cm x cm)	% of points with gamma index >1	
	Compass with MatrixXX	Compass with T2D
5 x 5	0	0.02
Dynamic	0.02	0
IMRT (Rando)	9.1	8.35

Position	Dose measured by the microchamber (Gy)		
	without T2D	with T2D	Attenuation%
1	1.76	1.722	2.4
2	1.78	1.720	3.2
3	1.01	0.983	2.2
4	1.09	1.048	4.3
5	1.00	0.971	3.3

Attenuation Measurement

Compass dose distribution reconstructed "without the detector in beam" vs MatrixXX on the couch (set-up c). The percentage of failing points in the gamma analysis is 4.1%

Compass dose distribution reconstructed "with T2D in the beam" vs MatrixXX on the couch (set-up b). The percentage of failing points in the gamma analysis is 3.54%



SUMMARY:

• The maximum percentage of failing points for the square and dynamic fields is 0.2%. In the more complex case of the IMRT plan on the anthropomorphic phantom the percentage is 9.1%. This suggests the use of the system in this configuration for a more accurate procedure of quality assurance (QA) because the agreement of the dose distribution is verified for the complete plan over all patient volume, instead of a single surface, field-by-field as in the case of MatrixXXTM

• The results obtained with the transmission chamber shows a substantial agreement with MatrixXXTM measurements: the correctness of dose normalization is shown in the square fields results and the ability of reproducing dose gradients is shown in the dynamic fields. The algorithm that reconstructs the dose distribution in patient's geometry has been tested and gives the same results as in the case when MatrixXXTM is used as CompassTM detector once dose distributions are normalized.

• The attenuation of the transmission chamber has been evaluated by measuring the dose in 5 points in an anthropomorphic phantom: its value results (3.1±0.8)%. This value is correctly implemented in the software since the same results are obtained when dose distributions reconstructed without the detector in the beam are compared to reference measurements and when dose distributions reconstructed taking into account the presence of the detector are compared to reference measurements taken with the transmission chamber at the head of the Linac.