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VERIFYING TOTAL BODY IRRADIATION USING THE INTEGRAL QUALITY MONITOR (IQM) SYSTEM

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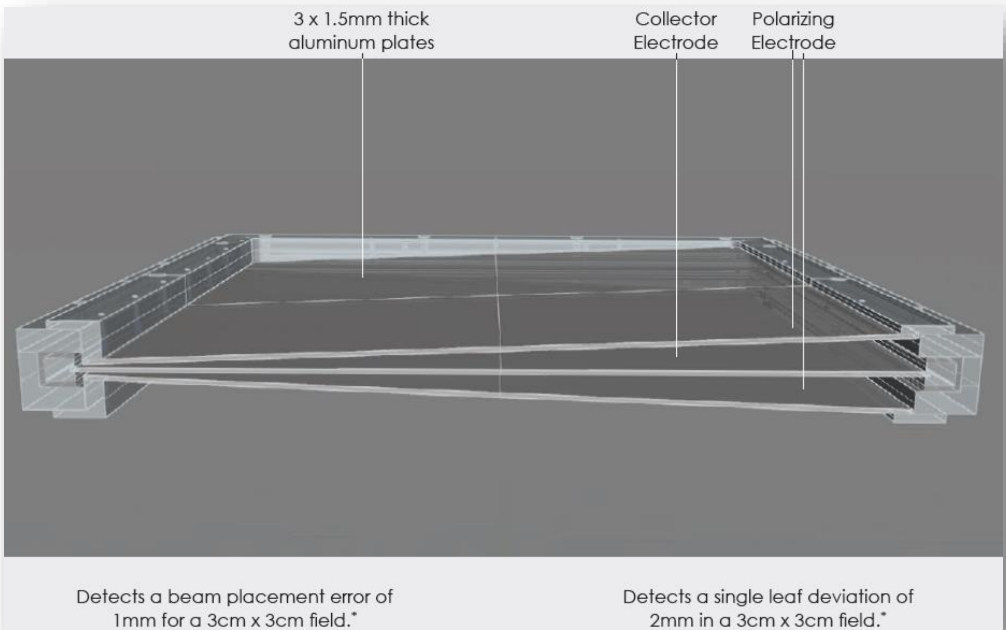
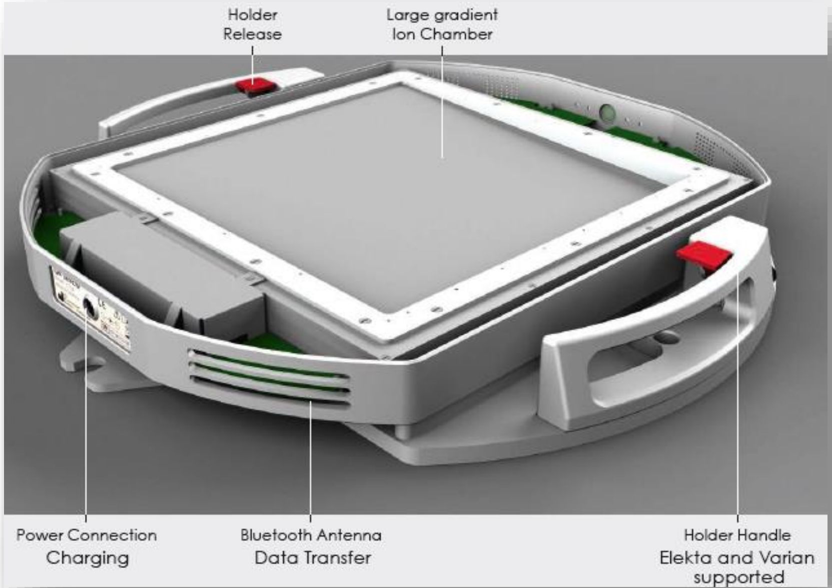
Integral Quality Monitor (*iQM®*)

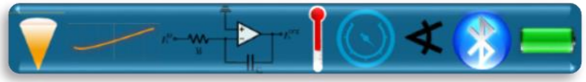
One single detector





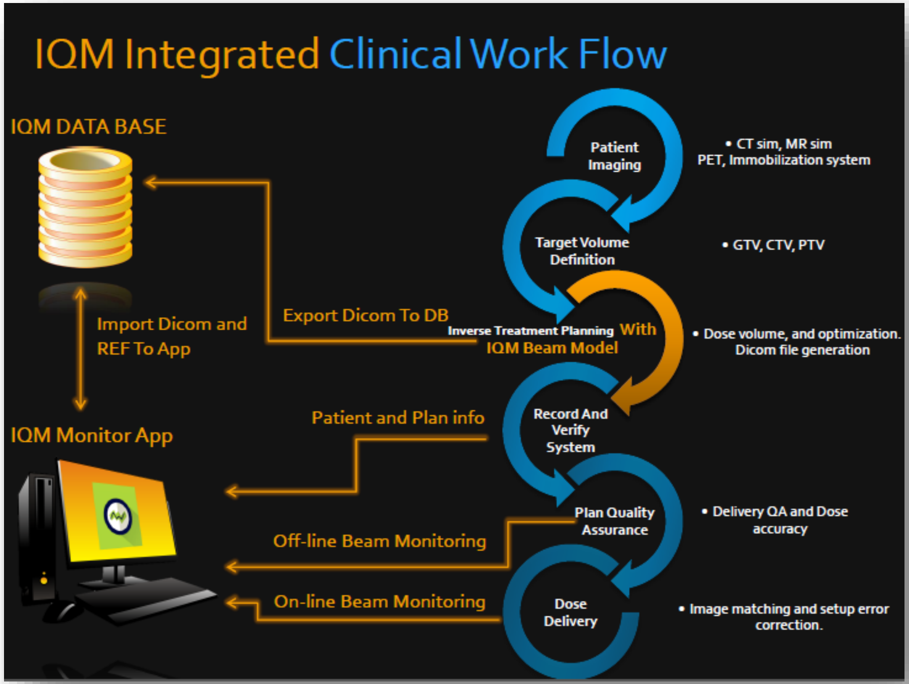
IQM Features

- Spans the entire beam projection area
- 5% /cm intrinsic Gradient
- Built-in 2 channel Electrometer
- 3-Axis MEMS Accelerometer
- Temperature and pressure sensors
- Wireless Bluetooth Communication
- Battery Management system



Improvements

- Intra-fractional verification system
- No user interaction required
- Automated monitoring of every single treatment fraction
- Error prevention instead of error management
- Patient safety improved detecting any deviation from the treatment plan in real-time



Makan Farrokhkish - Princess Margaret Cancer Centre (Toronto)

USES OF THE iQM SYSTEM

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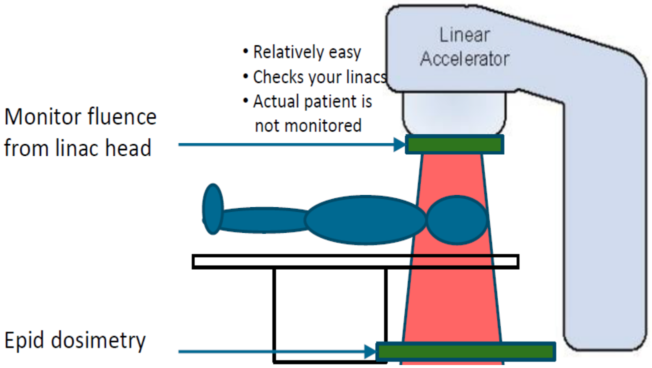
Pre-treatment QA

- Can be run between treatments free time
- RTT can run the test
- Reduces a substantial effort in pre-treatment QA

In vivo treatment monitoring

- Real-time monitoring of beam delivery
- Increased patient safety
- Detect the LINAC behavior per segment/control point



Can we apply same concepts in Total-Body Irradiation?

EXPERIMENTAL SETUP FOR TBI

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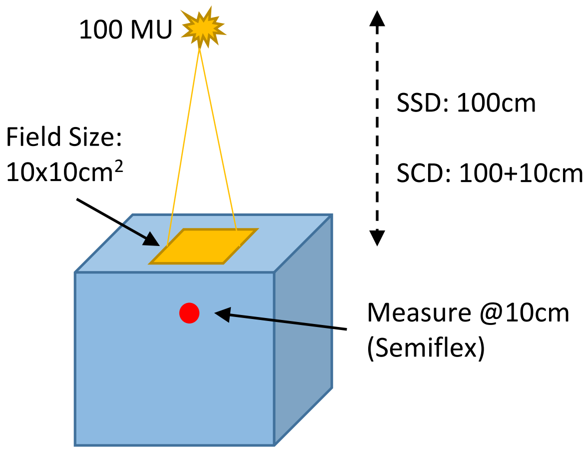
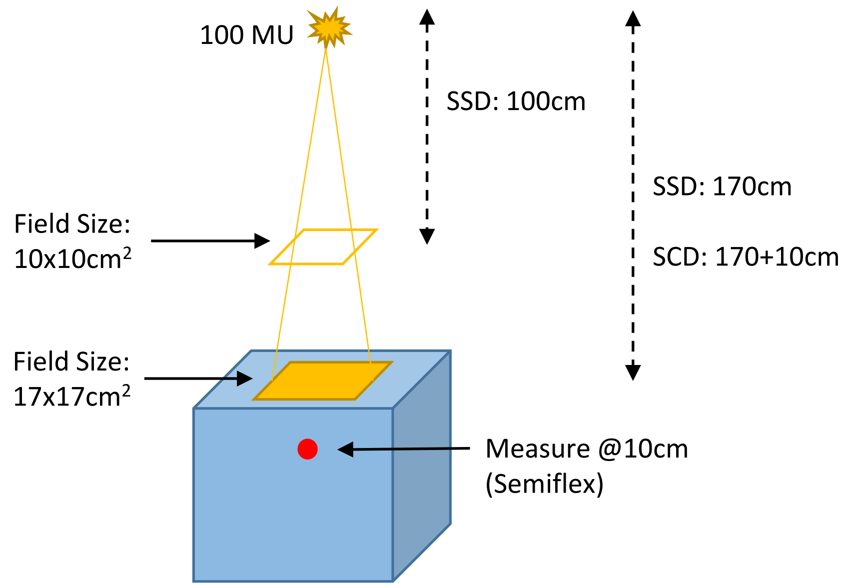
Standard condition



No Standard condition



Field Size (cmxcm) @SSD170cm		Field Size (cmxcm) @SSD100cm
8,5x8,5	≡	5x5
10x10		5,9x5,9
17x17		10x10
34x34		20x20
51x51		30x30
68x68		40x40
68x8,5		40x5
68x17		40x10
68x34		40x20
68x51		40x30

Output factor @10cm depth:

26,97 cGy Elekta Synergy®

25,30 cGy Elekta Synergy® + IQM

PDD profiles

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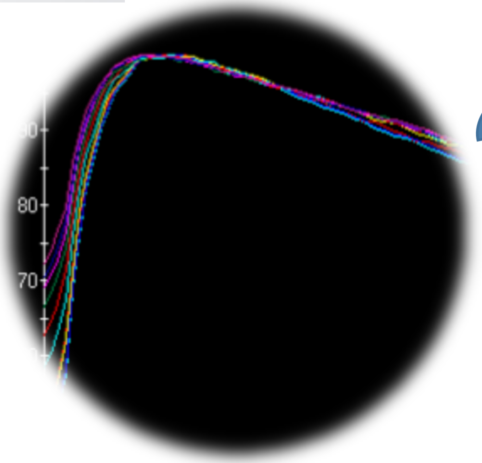
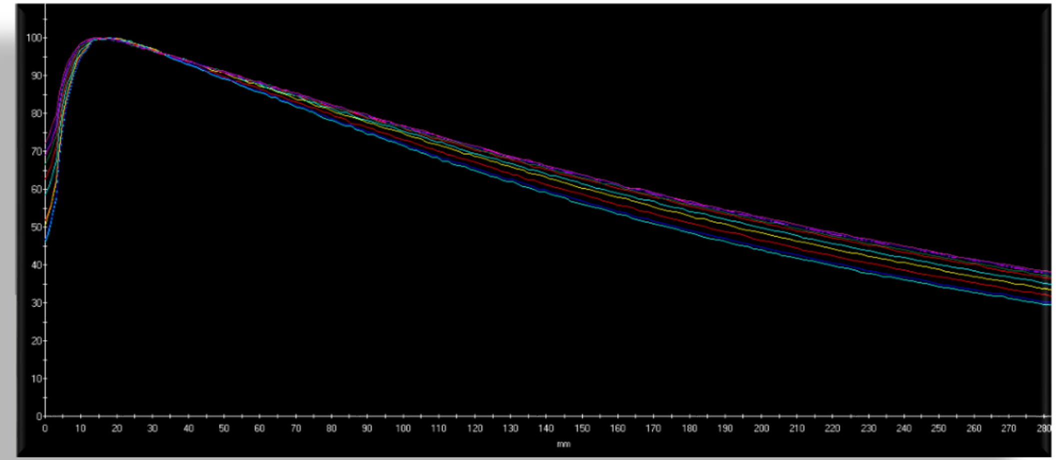
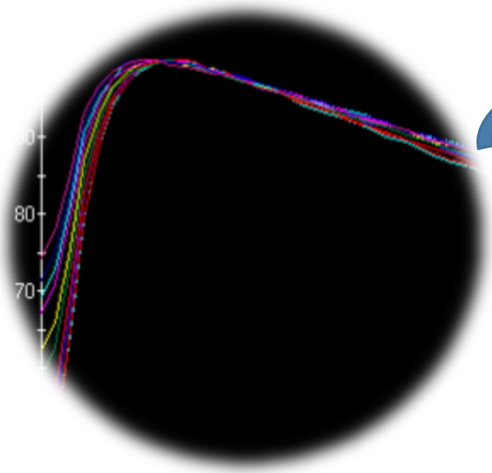
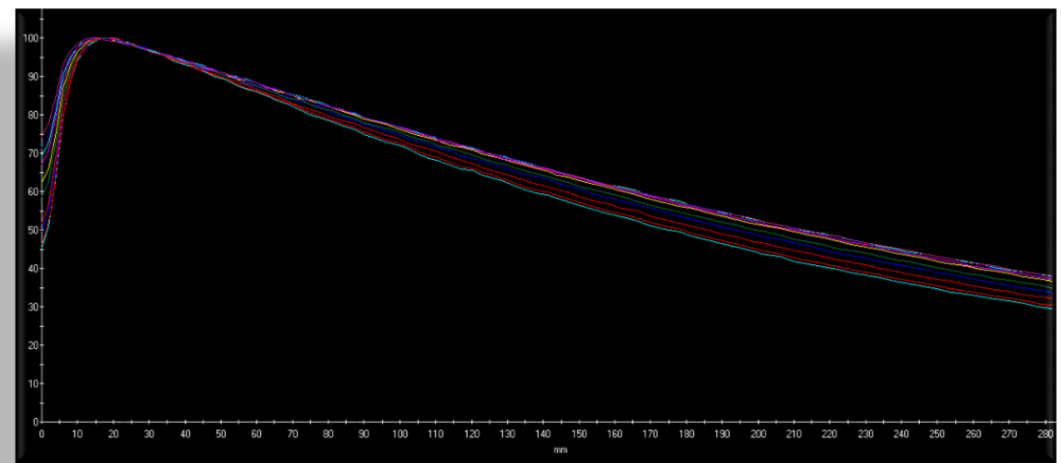
Elekta Synergy®





Elekta Synergy® + IQM





DMax, D10cm, D20cm
IQM vs. No IQM @170cm

	10,0x10,0	17,0x17,0	34,0 x 34,0	51,0x51,0	68,0 x 68,0	8,5x85
R100 mm	-0.96	3.67	1.39	0.00	0.61	-0.98
D100 %	0.46	0.20	0.17	-0.05	-0.12	0.46
D200 %	0.16	0.24	0.10	0.14	0.03	0.18

PENUMBRA PROFILES

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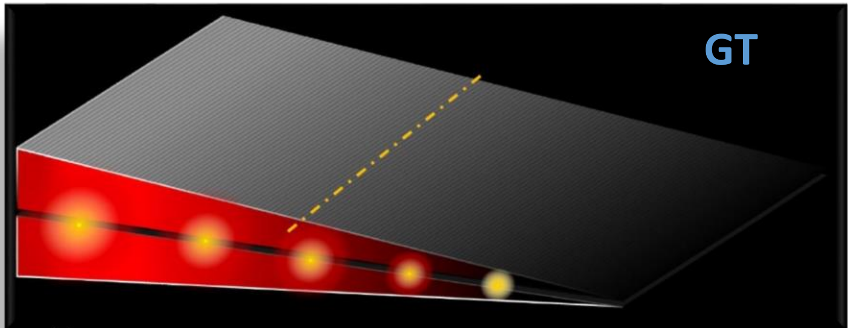
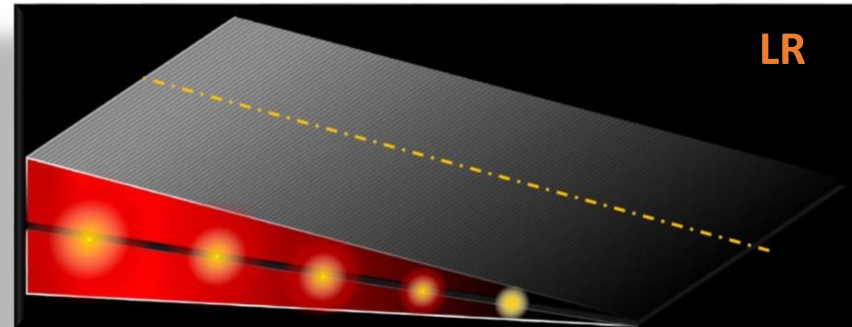
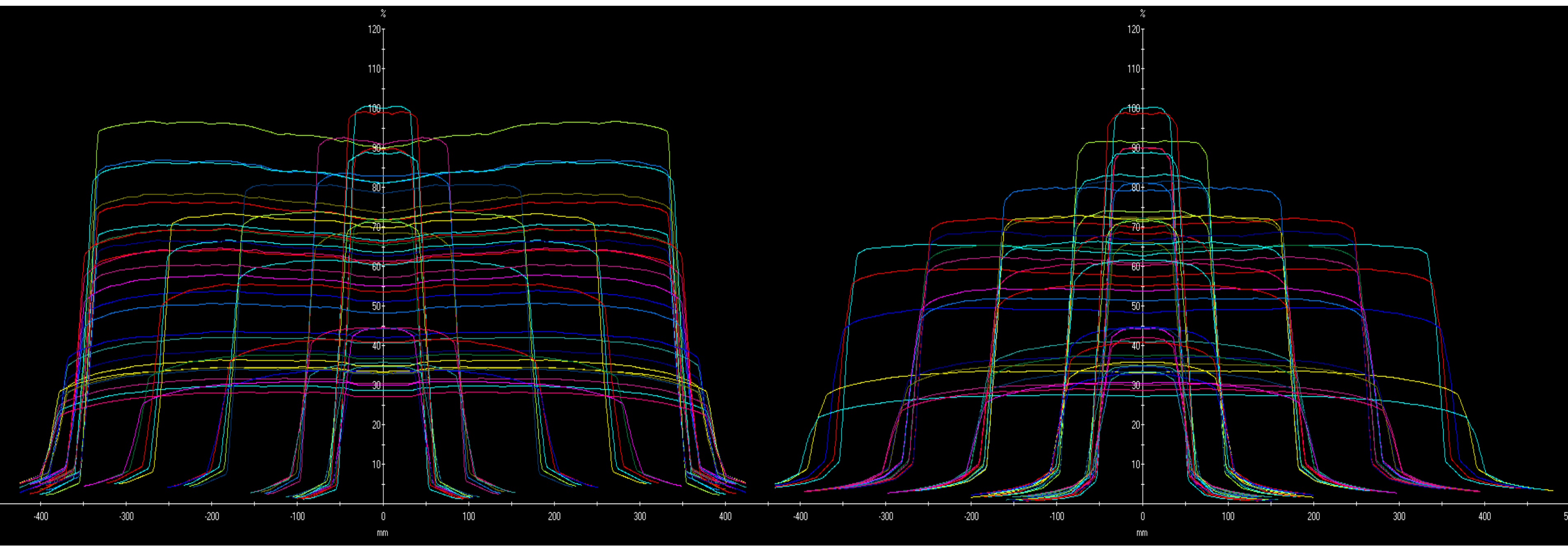
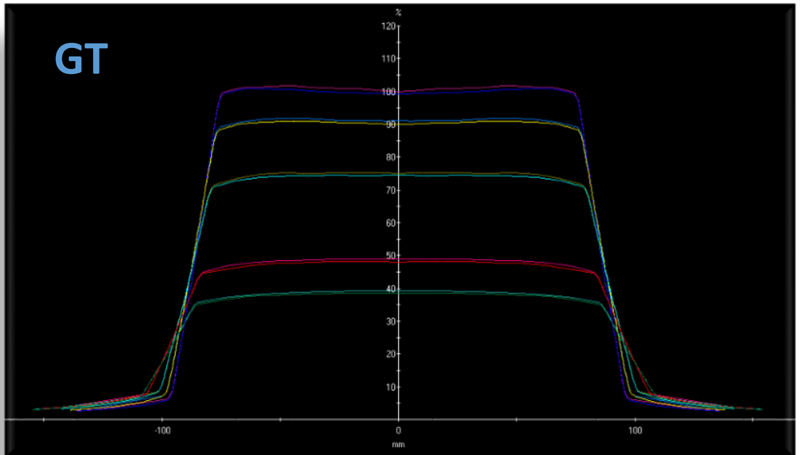






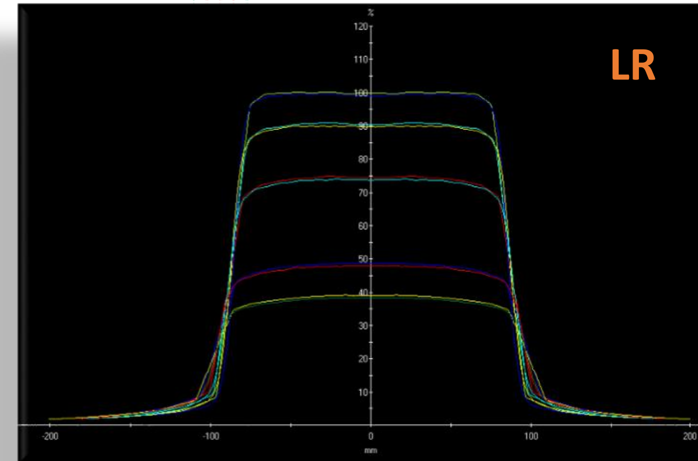
PENUMBRA PROFILES

SERVIZIO SANITARIO REGIONALE

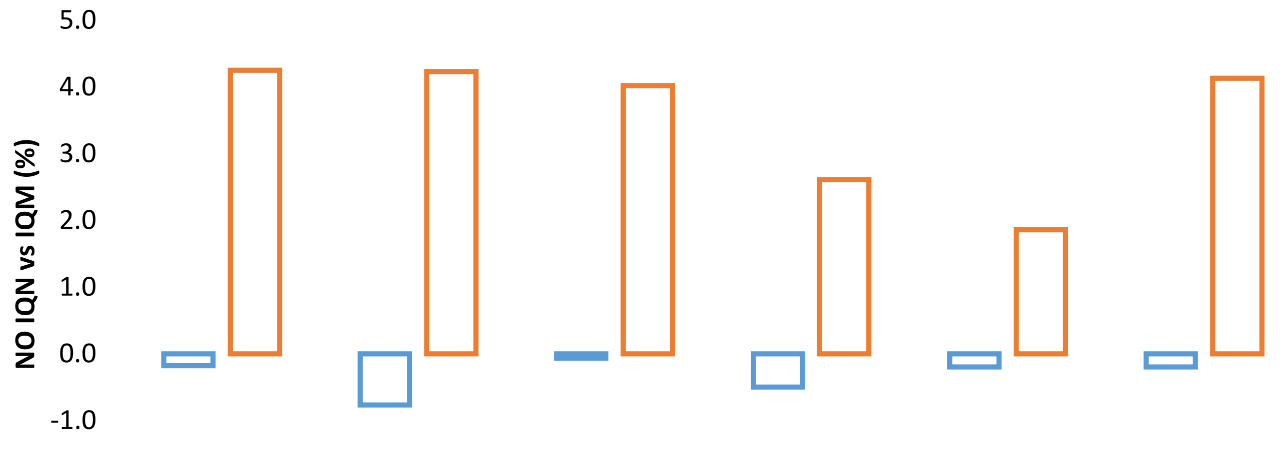


10x10 cm²
IQM *vs* NO IQM

Depth:
18, 50, 100, 200, 250



Penumbra Profiles @SSD170cm IQM vs. NO IQM



	10,0x10,0	17,0x17,0	34,0 x 34,0	51,0x51,0	68,0 x 68,0	8,5 x 8,5
GT	-0.2	-0.8	-0.1	-0.5	-0.2	-0.2
LR	4.3	4.2	4.0	2.6	1.9	4.1

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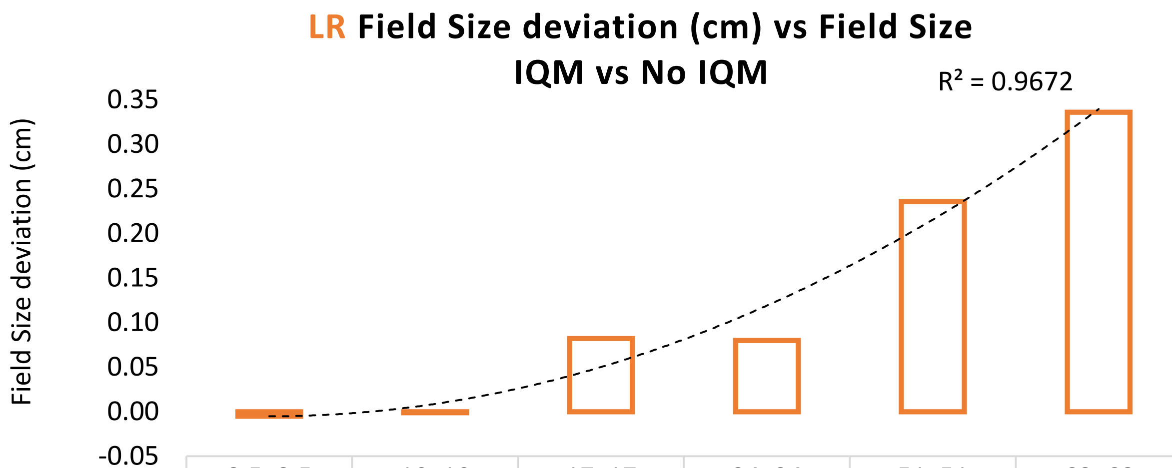
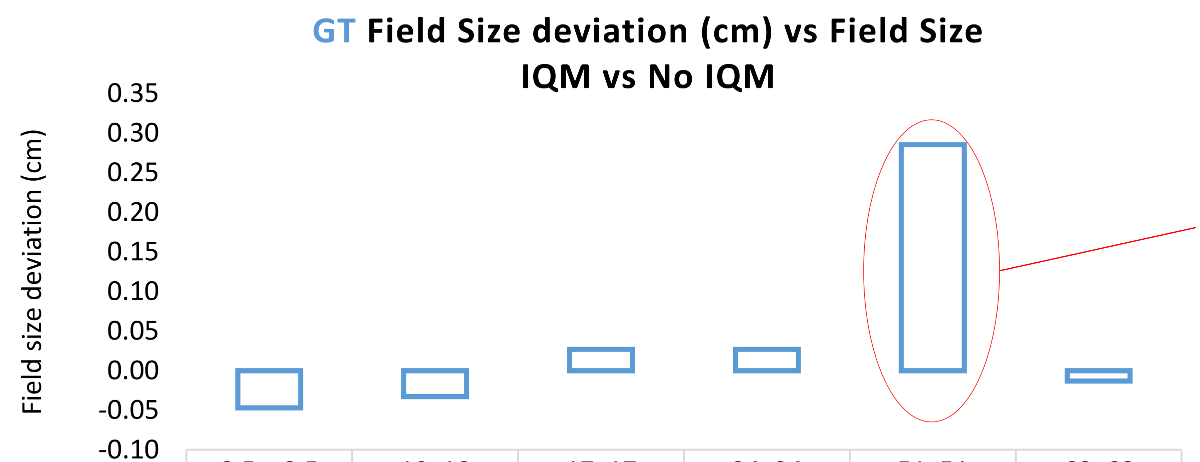


	8,5x8,5	10x10	17x17	34x34	51x51	68x68
Deviation (cm)	-0.005	-0.001	0.082	0.080	0.236	0.336

Suspect increment of the Field Size (Penumbra) along LR direction with the IQM device mounted , using water tank

Possible implication in penumbra modeling, especially in non standard condition

Must investigated!!



	8,5 x 8,5	10x10	17x17	34x34	51x51	68x68
Deviation (cm)	-0.047	-0.033	0.027	0.027	0.285	-0.013

Possible outlier

No iQM vs iQM

TPS Commissioning SHOULD BE PROVIDED!

Supine – TBI
No iQM vs iQM

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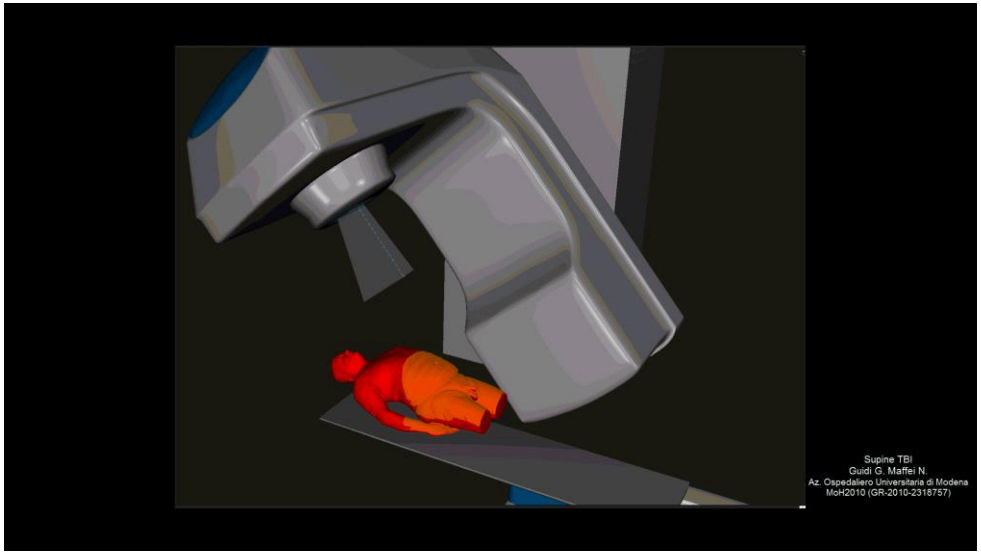
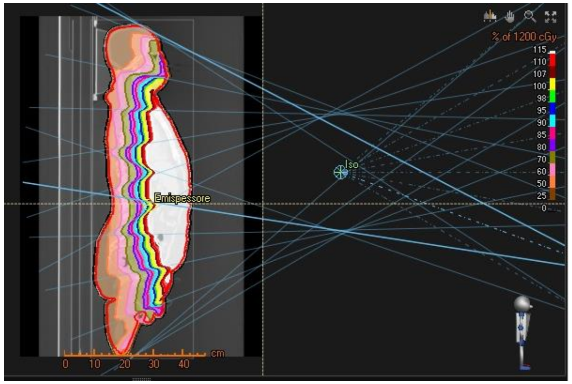
- Treatment Plan: **3DCRT**
- Energy: 6MV
- Dose prescription: 1200cGy
- Fractions: 6
- Gantry angles:
  320° 330° 340° 350° 0° 10° 20° 30°
- Couch angle: 90°





- Treatment Plan: **VMAT**
- Energy: 6MV
- Dose prescription: 1200cGy
- Fractions: 6
- Gantry angles: 330°÷30°
- Couch angle: 90°

3DCRT Supine - TBI

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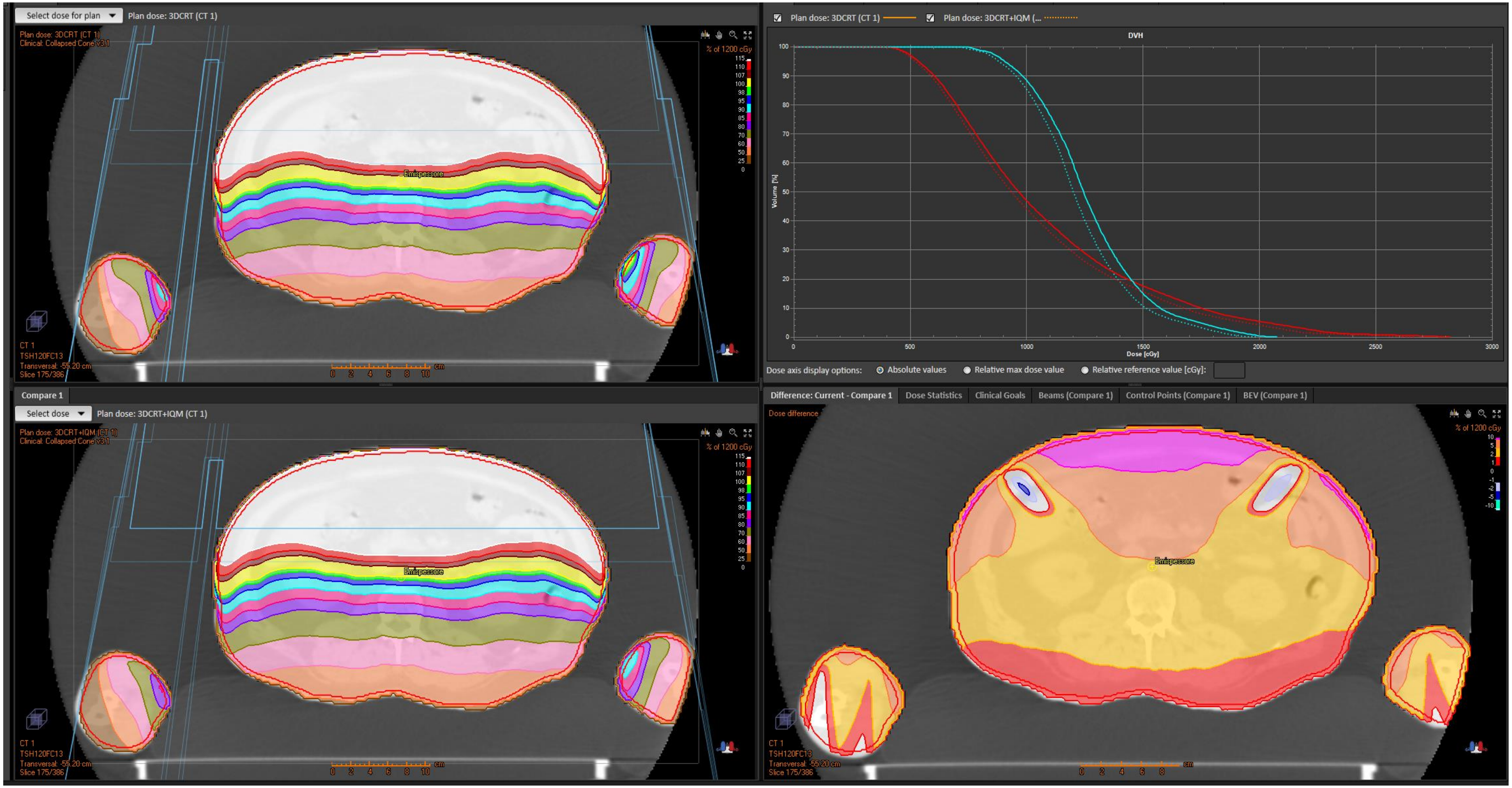
No iQM plan

DVH



iQM plan

Dose Difference

Prone – TBI
No iQM vs iQM

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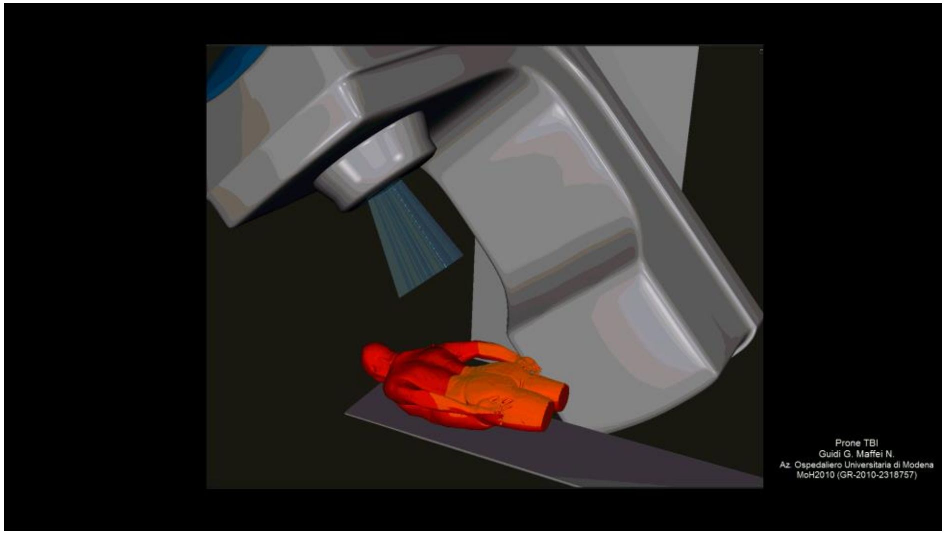
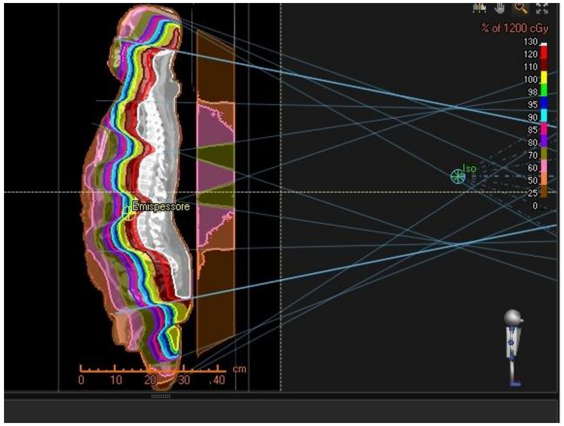
- Treatment Plan: **3DCRT**
- Energy: 6MV
- Dose prescription: 1200cGy
- Fractions: 6
- Gantry angles:
  320° 330° 340° 350° 0° 10° 20° 30°
- Couch angle: 90°





- Treatment Plan: **VMAT**
- Energy: 6MV
- Dose prescription: 1200cGy
- Fractions: 6
- Gantry angles: 330°÷30°
- Couch angle: 90°

VMAT Supine - TBI

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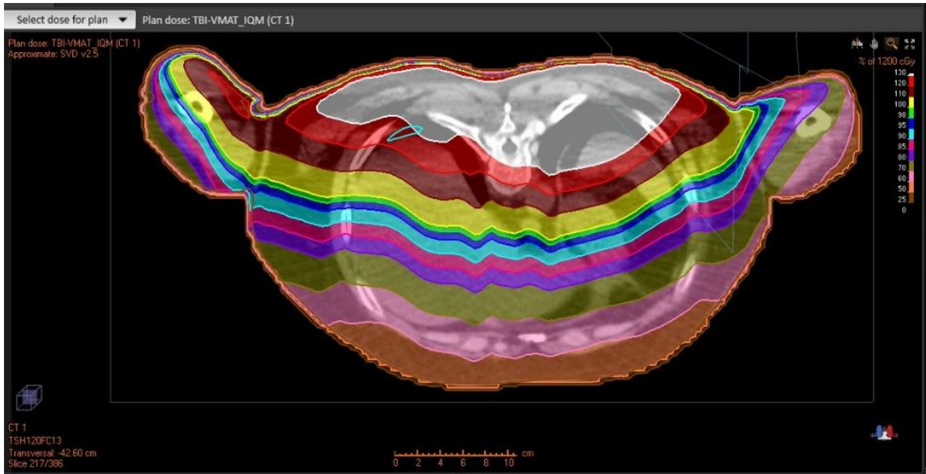
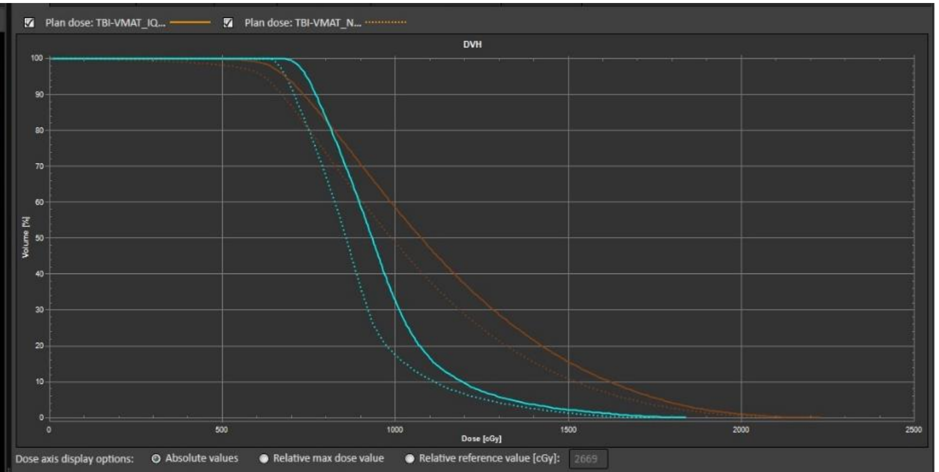
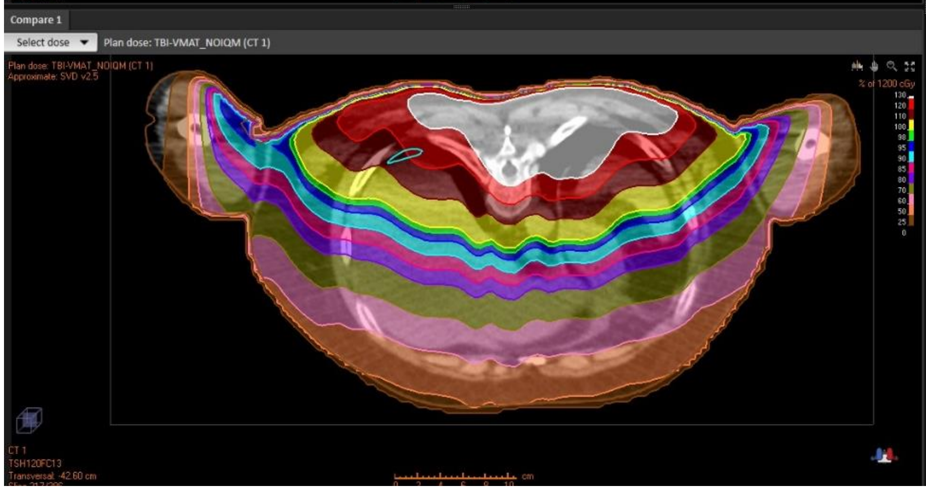
iQM plan



DVH





No iQM plan

Difference: Current - Compare 1 | Dose Statistics | Clinical Goals | Beams (Compare 1) | Control Points (Compare 1) | BEV (Compare 1)

ROI statistics | POI statistics

Dose	ROI	ROI vol. [cm³]	Dose [cGy] D99	D98	D95	Average	D50	D2	D1	% outside grid
Plan dose: TBI-VMAT_IQM (CT 1)	Lungs	2236.96	707	721	745	964	933	1517	1628	0 %
Plan dose: TBI-VMAT_NOIQM (CT 1)	Lungs	2236.96	655	665	684	889	858	1435	1526	0 %
Plan dose: TBI-VMAT_IQM (CT 1)	TBI	89091.42	601	636	682	1130	1075	1906	1990	0 %
Plan dose: TBI-VMAT_NOIQM (CT 1)	TBI	89091.42	376	510	619	1042	989	1842	1928	0 %

Target/OARs statistics

TAKE HOME MESSAGES FOR TBI PURPOSE

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- IQM device should be implemented using TPS commissioning as guidelines require
- IQM Monitor should be investigated for PDD and Profile for penumbra and energy dependency
- The IQM device seems to introduce a penumbra effect, in the LR direction (IQM detector gradient?)
- The IQM device seems to increase skin dose in comparison with the same plan without the IQM (not relevant for TBI purpose)
- Using IQM device + deformable registration + dose summation is feasible the TBI (supine+prone), dose evaluation and complex plans. We can do it…

MULTICENTRIC STUDY

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1529-EP

Thank you!

A REAL-TIME MONITOR SYSTEM FOR QA AND VMAT: SENSITIVITY ANALYSIS IN CLINICAL PRACTICE

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[1]Medical Physics Department Az. Ospedaliero Universitaria di Modena, Italy
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[3]Radiation Oncology Department, Az. Ospedaliero Universitaria di Modena, Italy

OBJECTIVES

The iQM® monitor system was tested to provide a method for treatment field verification using an independent monitor system mounted below the gantry. Real-time monitoring allows delivery errors to be detected during treatment, including record & verify mismatch, calibration errors or malfunctions in multi-leaf collimator (MLC), increasing patient safety.

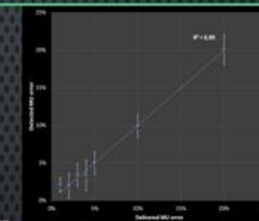
METHODS

The iQM® system consists of a large area ion-chamber with a spatial gradient. The ionization chamber and the data acquisition software system were interfaced to an Elekta Synergy accelerator. During 6 months of VMAT quality assurance (QA) sessions, more than 70 sessions of measurements were carried out to validate the repeatability of the detector as a dedicated QA instrument. To evaluate efficiency in clinical practice, a dummy plan and a Head and Neck (H&N) VMAT plan were delivered and investigated using the system. The dummy plan was composed of 18 segments (17 segments 4x4 cm² and 1 segment 10x10 cm²) and was delivered more than 100 times with constant 50 MU per segments. The VMAT plan was composed of 140 control points delivered by an arc, with low gantry speed, high MU and low dose rate. The sensitivity was then tested by introducing specific dosimetric increases of MU (1%,2%,3%,4%,5%,10% and 20%) in the H&N plan ($VMAT_{Error}$ Plan). Rotational analysis and validation were investigated; correlation with gantry and collimator angles was quantified using SPSS ANOVA analysis.

RESULTS

The dummy plan delivered in standard condition (gantry and collimator angles=0°) revealed a mean variation in signal counts of 0.7±1.0% compared with the commissioning day. Independence of the detector with gantry position were investigated (gantry angle: 0°-90°-180°-270° and collimator angle: 0°-45°-135°-225°-315°). No statistical difference (significance ≈ 1) was detected for all segments, confirming the high quality of the instrument for daily QA. In the H&N plan, a decrease in measured counts was observed in the particular range of gantry angles from 120° through 240°. Statistical analysis showed a mean dose discrepancy of 2.8±1.0% between planned and measured errors for original plan. For the $VMAT_{Error}$ Plan, the system is capable to detect the error introduced with an agreement of 0.2±0.5% (R^2=0.99). No correlation related to collimator angle and delivered MU was detected.

GRAPHS AND TABLES



Gantry angle (°)	MU error						
	1%	2%	3%	4%	5%	10%	20%
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 1 (left) The iQM detector

Figure 2 (right) Comparison between MU delivered with ad hoc errors (1%, 2%, 3%, 4%, 5%, 10%, 20%) and that detected by iQM

Table Detected MU errors vs. gantry angle

CONCLUSIONS

The system was shown to be stable for daily QA and could add many advantages to the patients' safety during treatment. Taking into account all the treatment factors, the detector provides punctual and cumulative output for each beam segment, which is compared in real time to each segment's expected value. The robustness of the measurement results suggests that the system could recognize errors or inadequate MU during the delivery. The significant signal deviation seen at particular gantry rotations could be investigated in order to improve the results obtained.

www.medicalphysicsresearch.weebly.com

Acknowledges

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