Technical and clinical assessment of the Mobetron Autodocking system

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H.U.B.

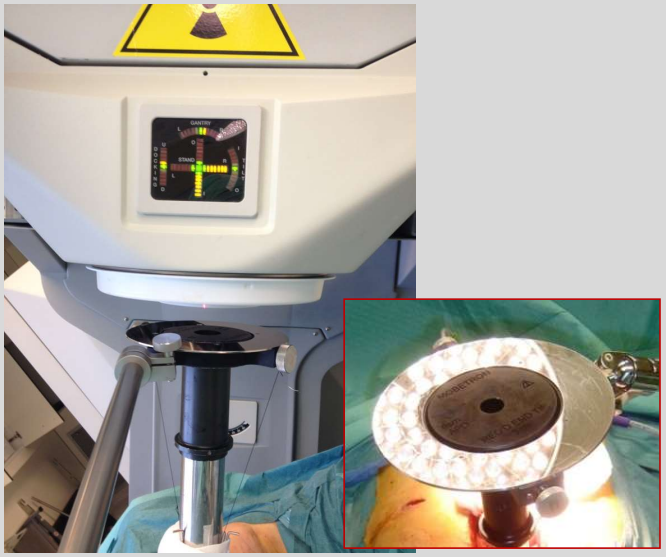
H.U.B

Disclosure

This work was part of a collaborative research agreement between Institut Jules Bordet and Intraop Medical Corporation.

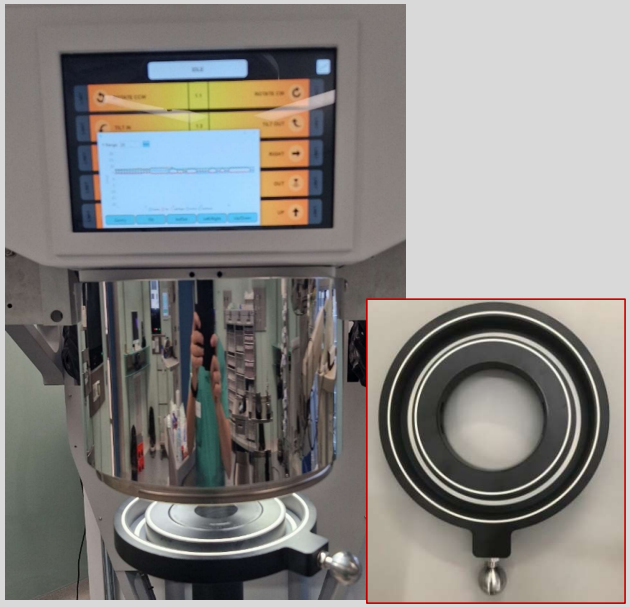
Two Soft docking systems

Laser-Mirror System



Manual alignment only

Camera-target System



Assisted alignment possible :
Autodocking

Camera-Target System

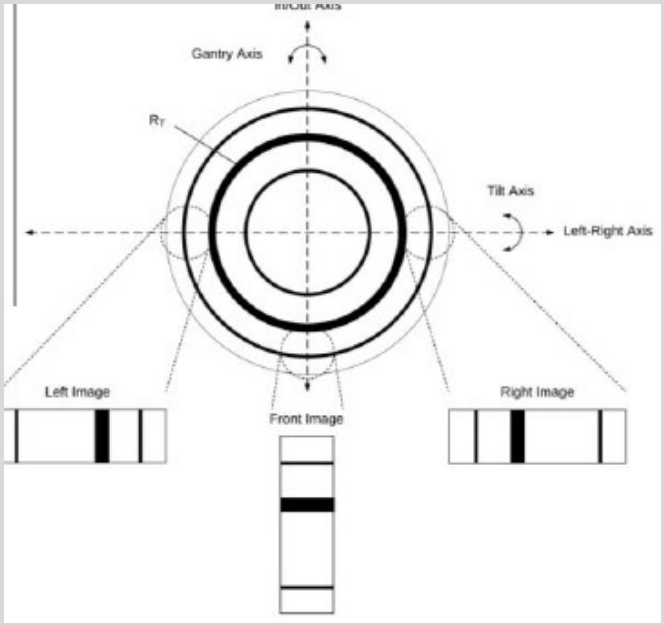
3 embedded cameras in the gantry Left/Right/Front. The system :

- Catches the relative positions of the three white circles in the image

- Computes the alignment deviations for the 5 degrees of liberty

- Displays the deviations as pixel shifts on the monitor

- Triggers beam interlock if deviation > threshold



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0360-3016/00/$–see front matter
PII S0360-3016(00)00456-9

PHYSICS CONTRIBUTION

DESIGN AND DOSIMETRY CHARACTERISTICS OF A SOFT-DOCKING SYSTEM FOR INTRAOPERATIVE RADIATION THERAPY

PETER BJÖRK, M.SC., TOMMY KNÖÖS, PH.D., PER NILSSON, PH.D., AND KURT LARSSON, MED. ENG.

Objective

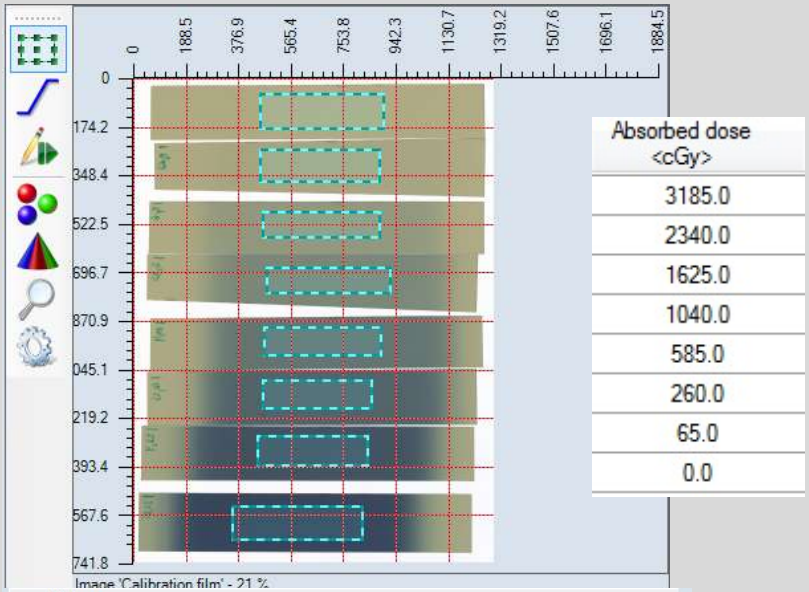
Check if default interlock thresholds are suitable to guarantee the beam quality and the “dockability” of breathing patients with the camera-target docking system.

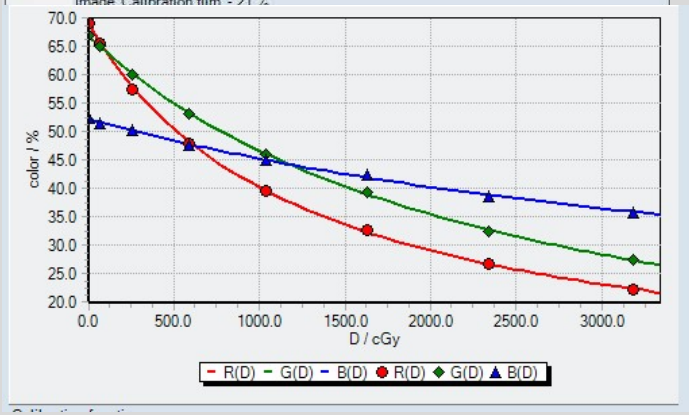
Materiel and Method

Beam energies: 6, 9 & 12 MeV
Applicator: 5 cm dia., flat tip, High Density plastic
EBTXD Gafchromic Films @ Dmax
Solid water slab phantom
Epson V12000 flat scanner
FilmQA Pro Software
Metric micrometer (translation measurement)
Laser Telemeter (SSD measurement)
Digital spirit level (angle measurement)
Anesthesiology Respirator with test balloon (movement generator)

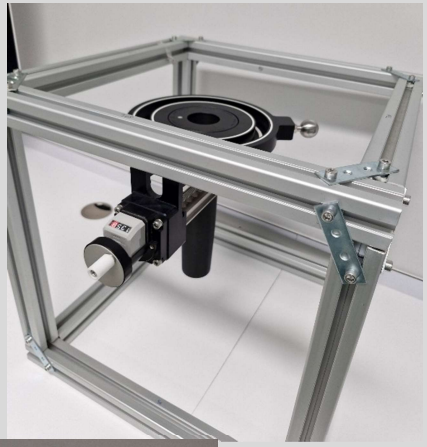
Film measurement

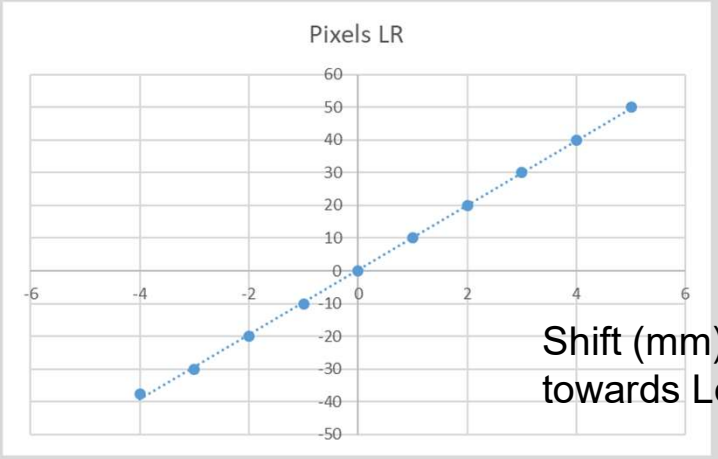
- Film calibrated in a 9 MeV Elekta Versa HD beam
- Dose in geometric progression (0 - 32 Gy)
- 24h post exposure waiting time
- Films centered on the bedscan
- Film Orientation kept constant
- 48 bit color 70-200 dpi + glass compression
- 5 preview scans for warm-up
- Dose profiles smoothed and centered with the Mephysto software (PTW)

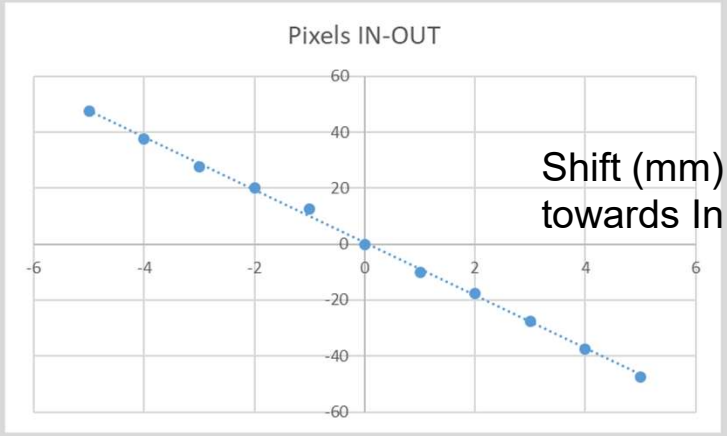




Shift measurements





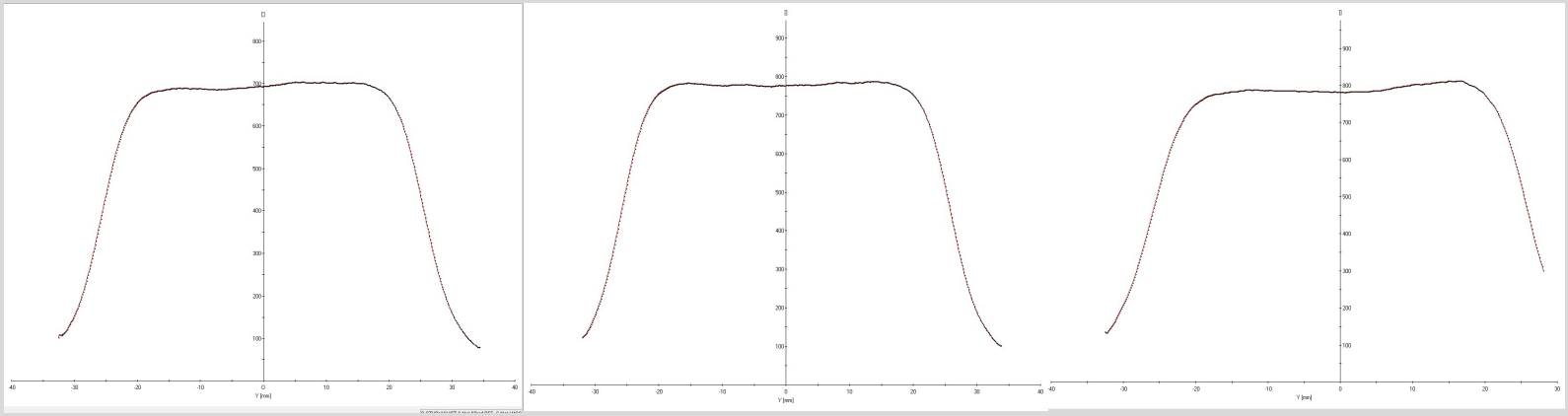


Interlock shift threshold : |0.35| mm

Shift measurements

Profile measurements with shifts: 1x, 2x, 3x, 5x & 10x the interlock shift
500 MU ≈ 7.5 Gy@Dmax

6 MeV | 9 MeV | 12 MeV

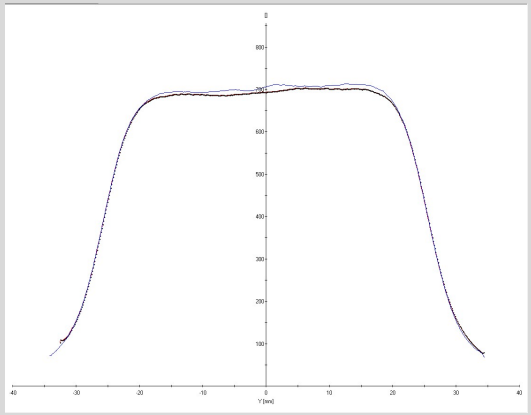


Ref. LR Profile

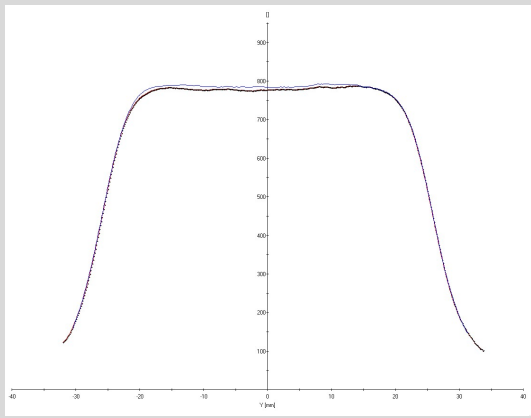
Shift measurements

Profile measurements with shifts: 1x, 2x, 3x, 5x & 10x the interlock shift
500 MU ≈ 7.5 Gy@Dmax

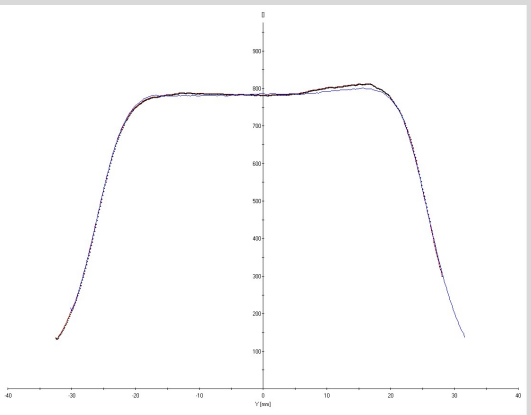
6 MeV



9 MeV



12 MeV

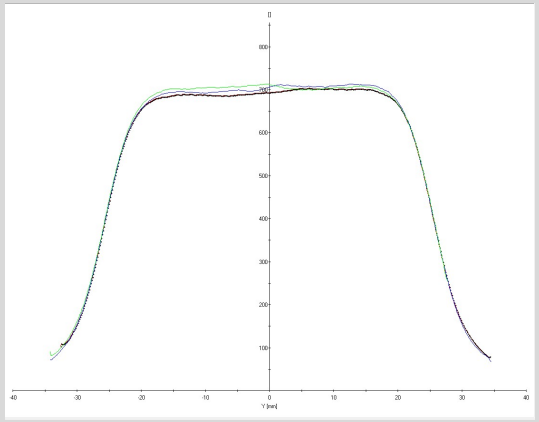


Ref. LR Profile
Shift 0.35 mm

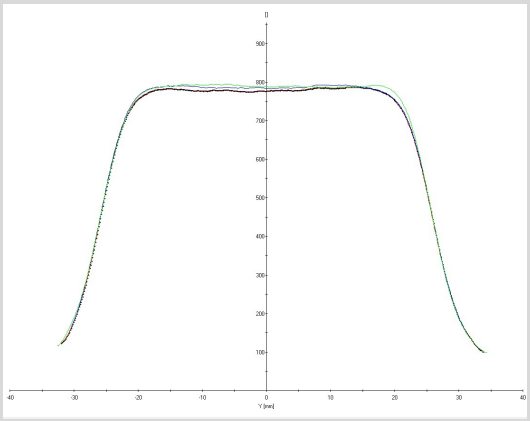
Shift measurements

Profile measurements with shifts: 1x, 2x, 3x, 5x & 10x the interlock shift
500 MU ≈ 7.5 Gy@Dmax

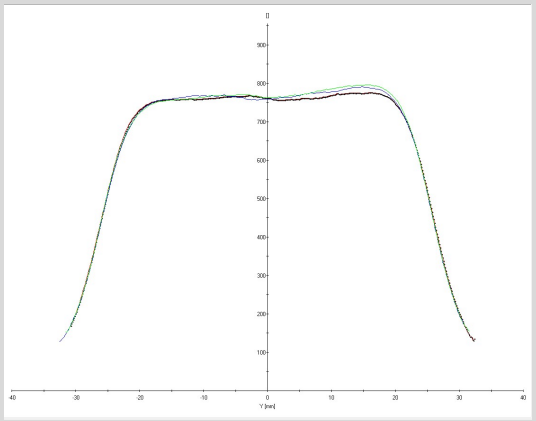
6 MeV



9 MeV



12 MeV

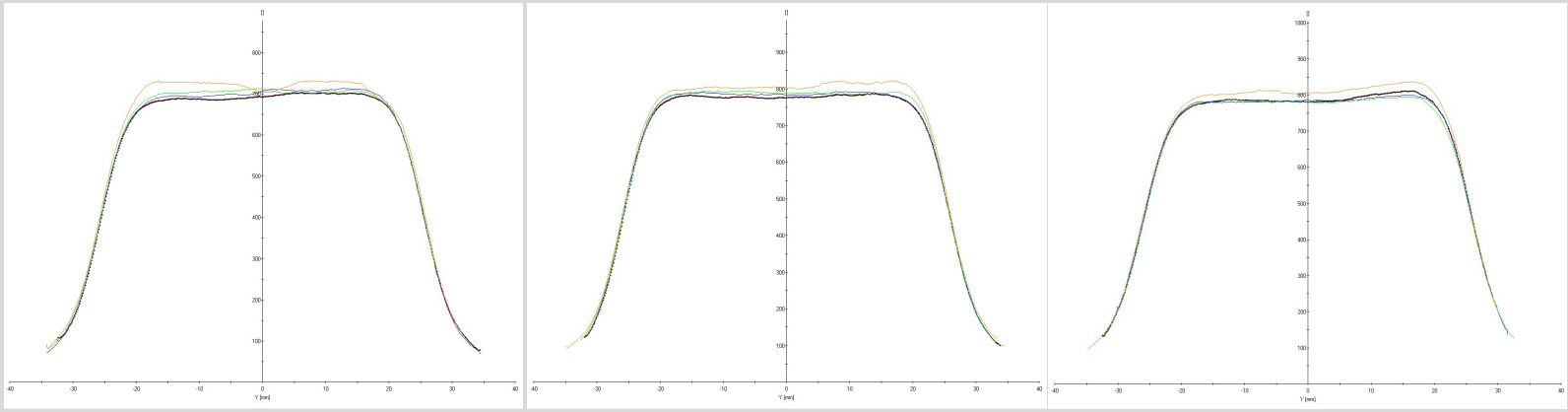


Ref. LR Profile
Shift 0.35 mm
Shift 0.7 mm

Shift measurements

Profiles measurement with shifts: 1x, 2x, 3x, 5x & 10x the interlock shift
500 MU ≈ 7.5 Gy@Dmax

6 MeV | 9 MeV | 12 MeV

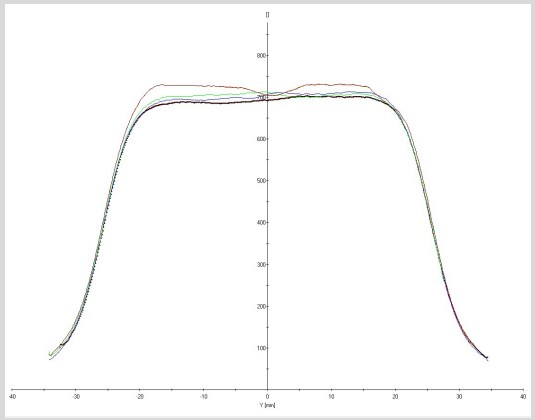


Ref. LR Profile
Shift 0.35 mm
Shift 0.7 mm
Shift 1.05 mm

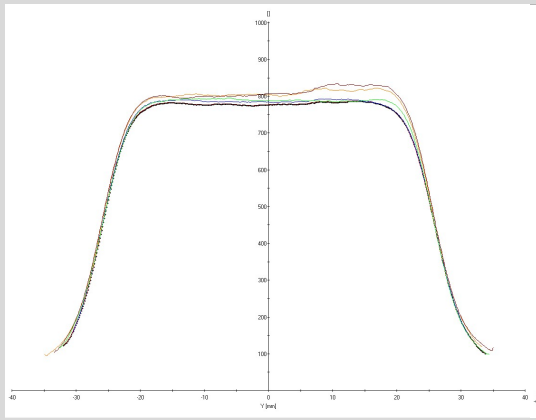
Shift measurements

Profile measurements with shifts: 1x, 2x, 3x, 5x & 10x the interlock shift
500 MU ≈ 7.5 Gy@Dmax

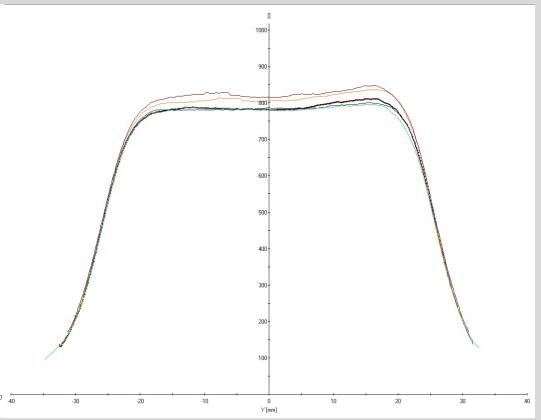
6 MeV



9 MeV



12 MeV

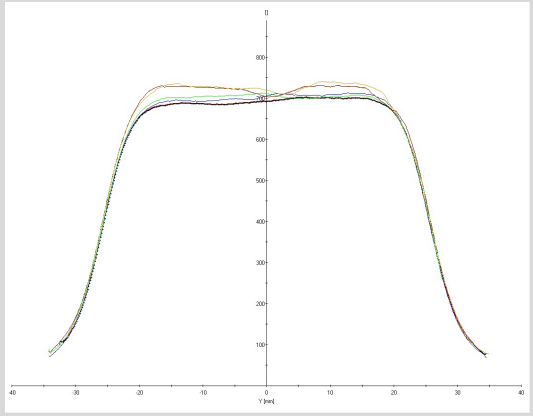


Ref. LR Profile
Shift 0.35 mm
Shift 0.7 mm
Shift 1.05 mm
Shift 1.75 mm

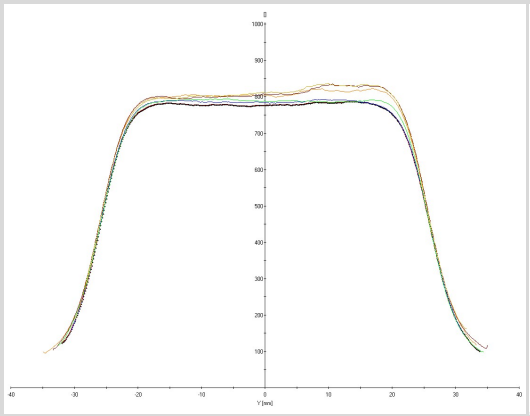
Shift measurements

Profile measurements with shifts: 1x, 2x, 3x, 5x & 10x the interlock shift
500 MU ≈ 7.5 Gy@Dmax

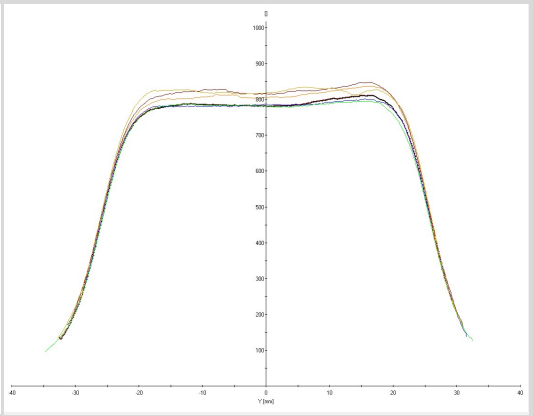
6 MeV



9 MeV

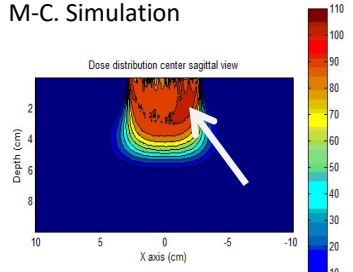


12 MeV



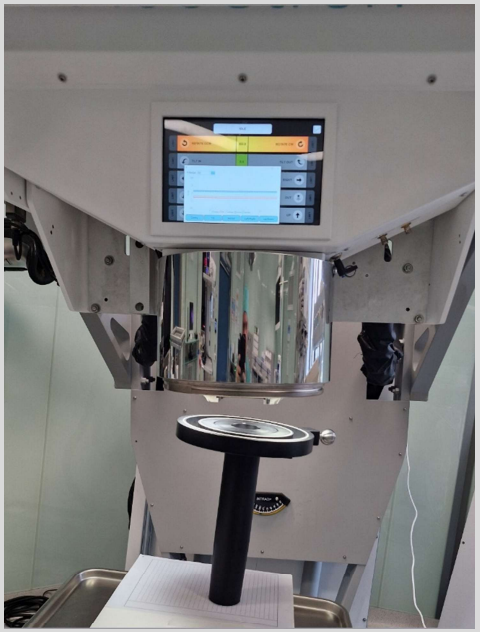
Ref. LR Profile
Shift 0.35 mm
Shift 0.7 mm
Shift 1.05 mm
Shift 1.75 mm
Shift 3.5 mm

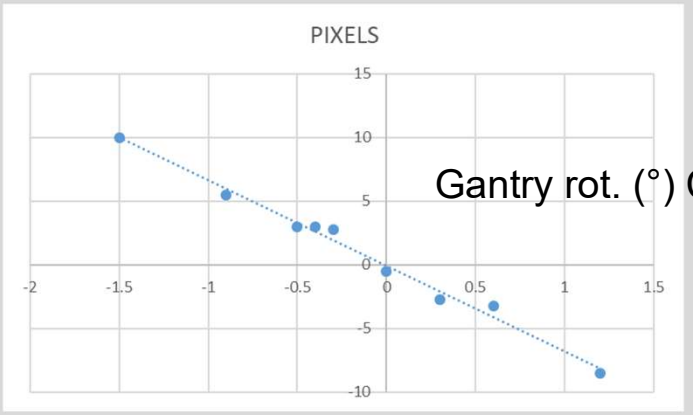
M-C. Simulation



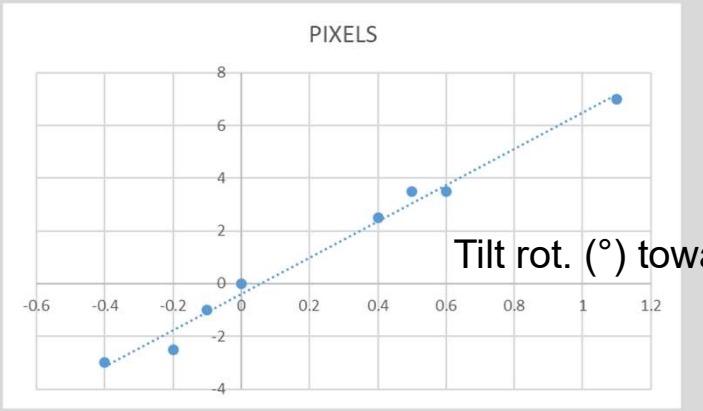
5.5 cm Applicator, 12 MeV,
3mm lateral static misalignment

Rotation measurements





Gantry rot. (°) CCW



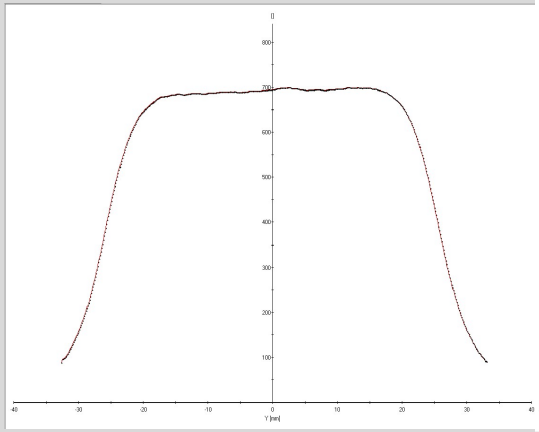
Tilt rot. (°) toward OUT

Interlock rotation threshold : |0.5| degree

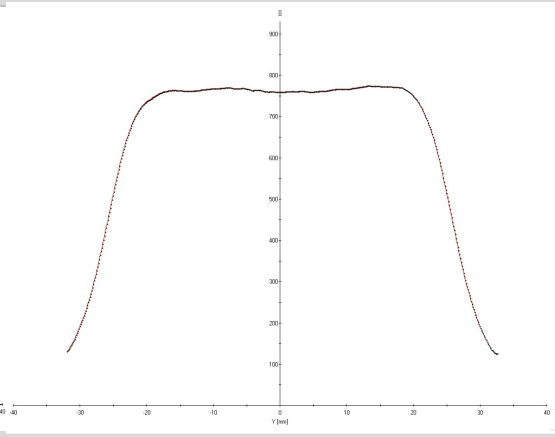
Rotation measurements

Profile measurements with Gantry rotation: 1x, 2x, 3x, 5x & 10x the interlock rotation
500 MU ≈ 7.5 Gy@Dmax

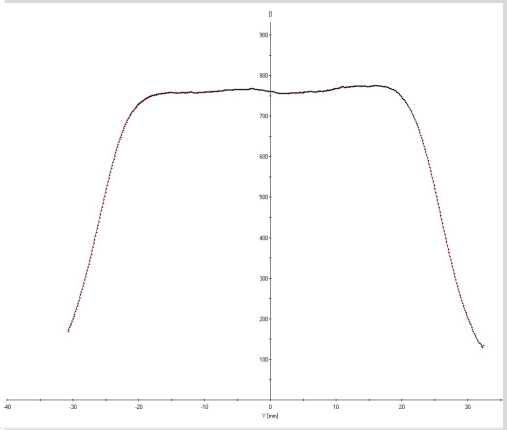
6 MeV



9 MeV



12 MeV

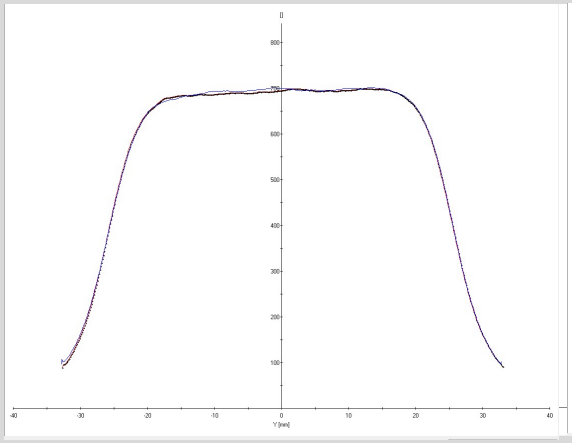


Ref. LR Profile

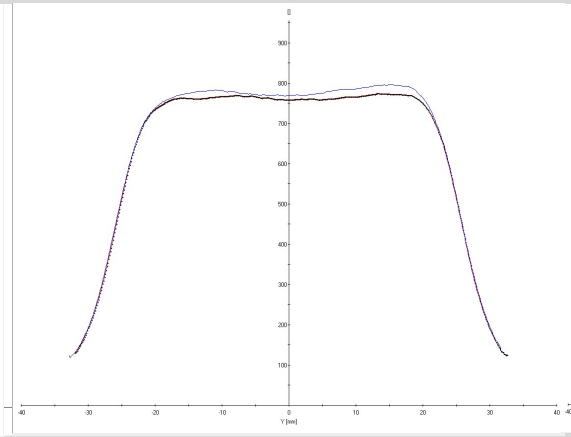
Rotation measurements

Profile measurements with Gantry rotation: 1x, 2x, 3x, 5x & 10x the interlock rotation
500 MU ≈ 7.5 Gy@Dmax

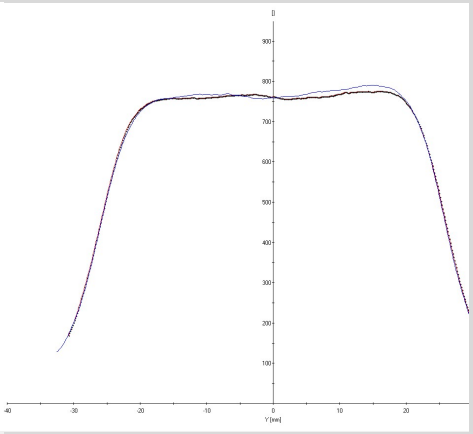
6 MeV



9 MeV



12 MeV

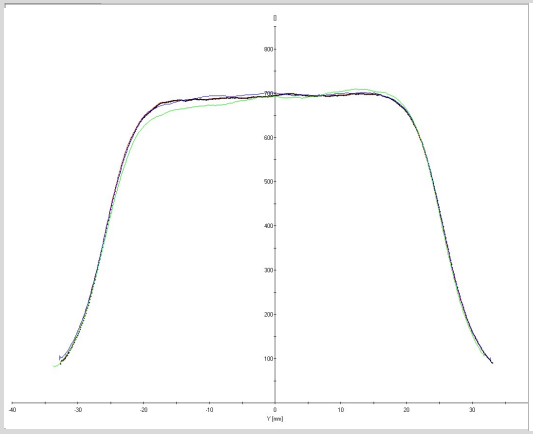


Ref. LR Profile
Rot. Gantry 0.5°

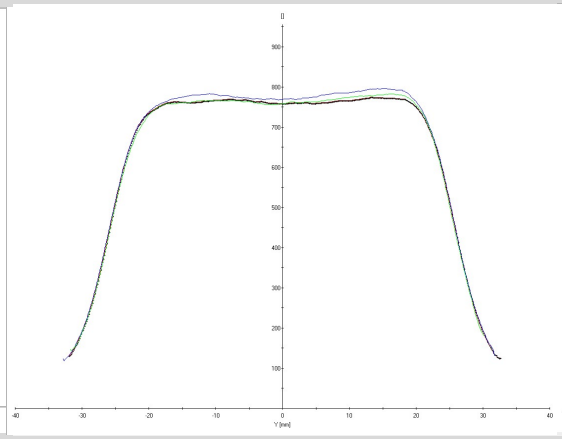
Rotation measurements

Profile measurements with Gantry rotation: 1x, 2x, 3x, 5x & 10x the interlock rotation
500 MU ≈ 7.5 Gy@Dmax

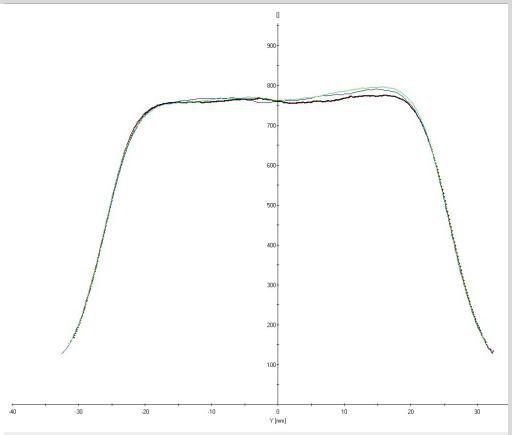
6 MeV



9 MeV



12 MeV

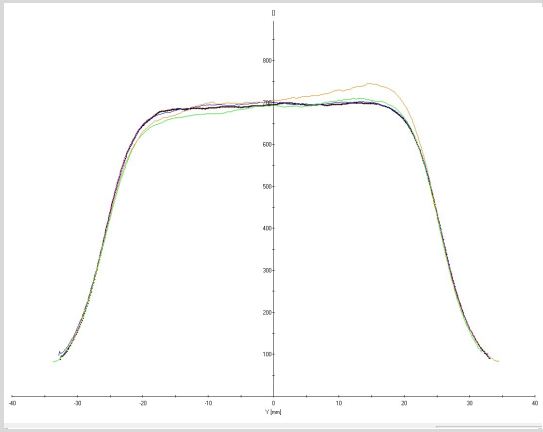


Ref. LR Profile
Rot. Gantry 0.5°
Rot. Gantry 1°

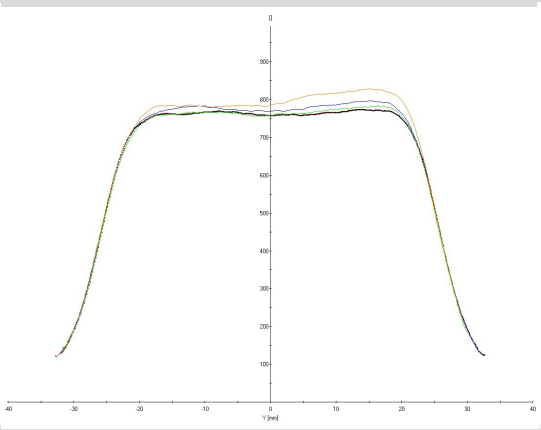
Rotation measurements

Profiles measurement with Gantry rotation: 1x, 2x, 3x, 5x & 10x the interlock rotation
500 MU ≈ 7.5 Gy@Dmax

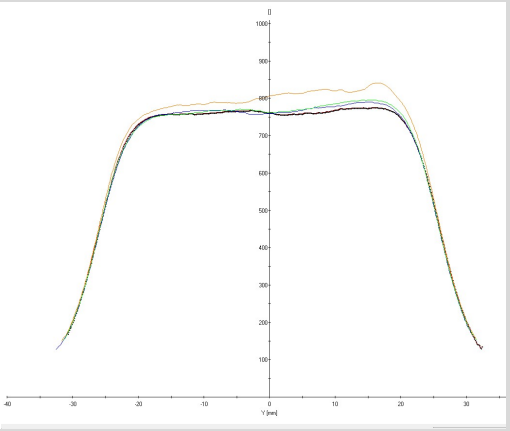
6 MeV



9 MeV



12 MeV

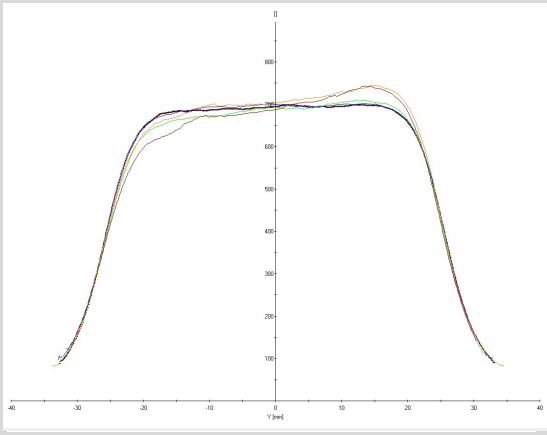


Ref. LR Profile
Rot. Gantry 0.5°
Rot. Gantry 1°
Rot Gantry 1.5°

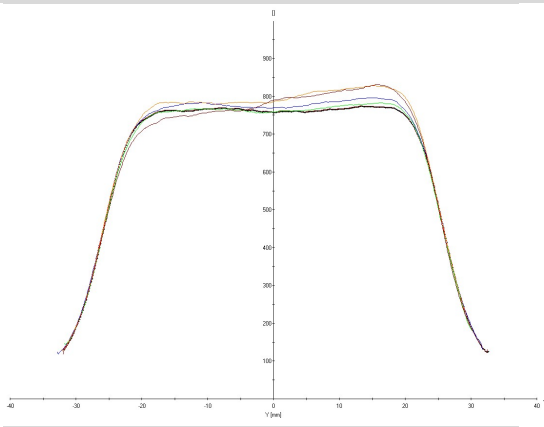
Rotation measurements

Profile measurements with Gantry rotation: 1x, 2x, 3x, 5x & 10x the interlock rotation
500 MU ≈ 7.5 Gy@Dmax

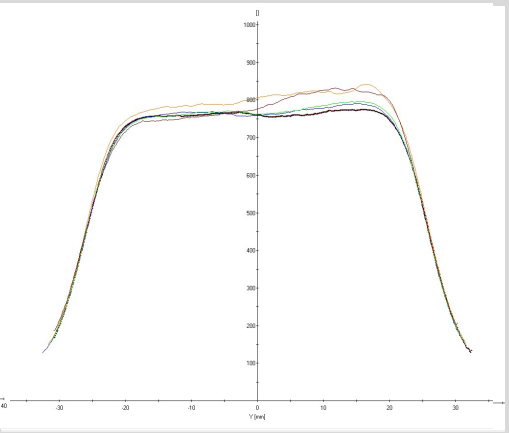
6 MeV



9 MeV



12 MeV

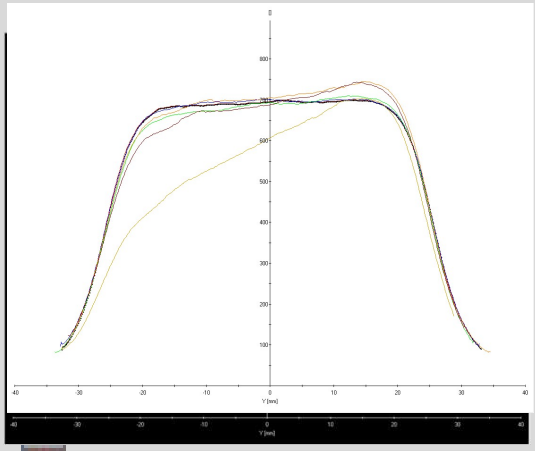


- Ref. LR Profile
- Rot. Gantry 0.5°
- Rot. Gantry 1°
- Rot Gantry 1.5°
- Rot Gantry 2.5°

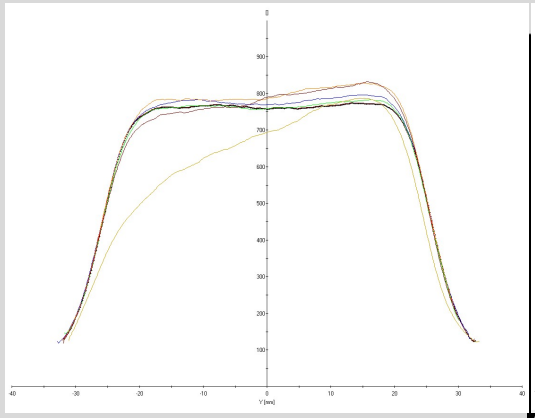
Rotation measurements

Profile measurements with Gantry rotation: 1x, 2x, 3x, 5x & 10x the interlock rotation
500 MU ≈ 7.5 Gy@Dmax

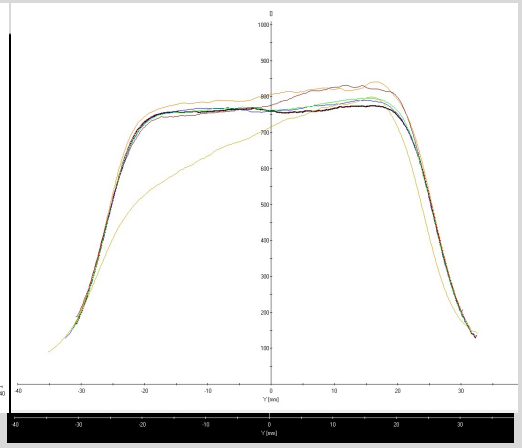
6 MeV



9 MeV

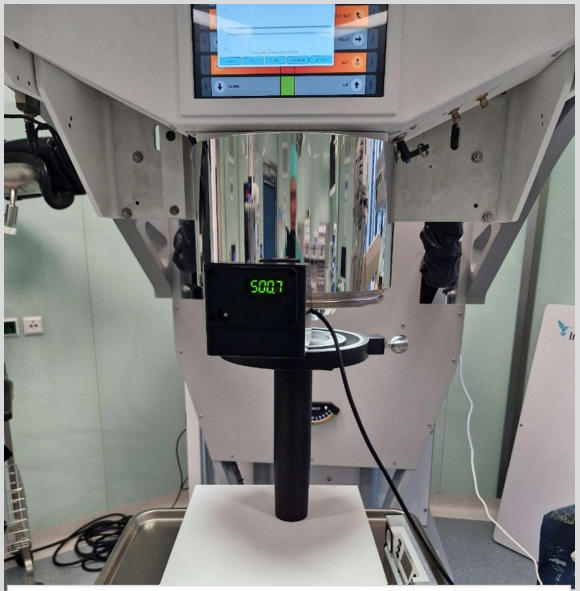


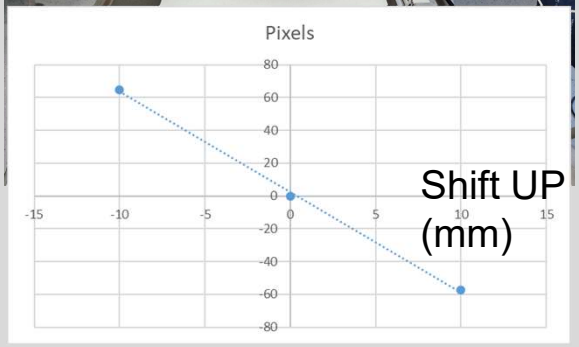
12 MeV



- Ref. LR Profile
- Rot. Gantry 0.5°
- Rot. Gantry 1°
- Rot Gantry 1.5°
- Rot Gantry 2.5°
- Rot Gantry 5°

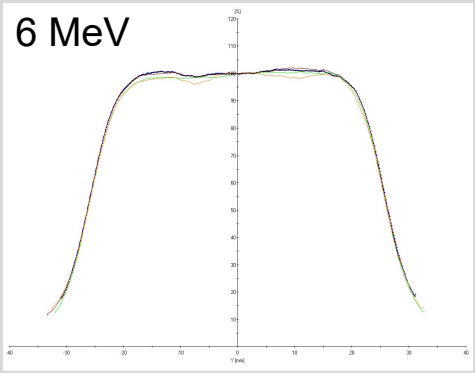
Up/down Shift measurements

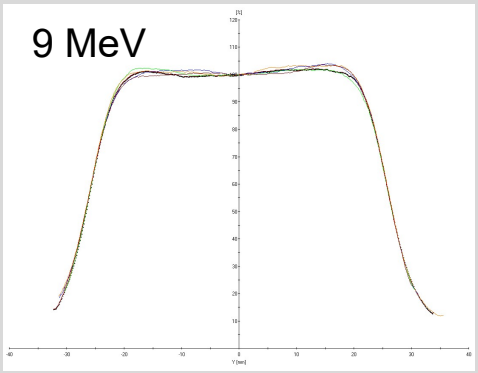


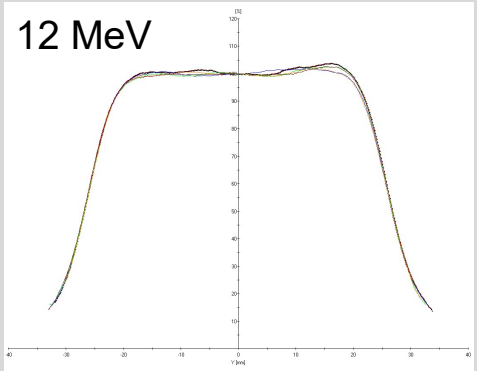


Interlock shift threshold : | 1.0 | mm

NO SSD SHIFT, -1X, +1X, -10X & 10X







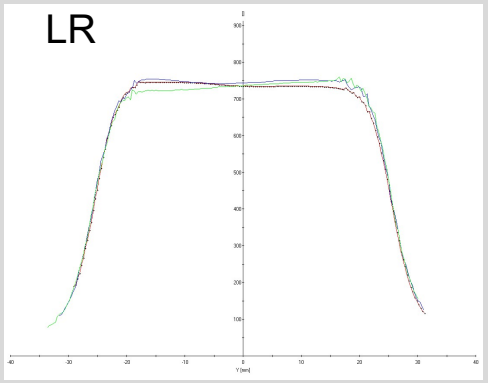
Renormalized LR profiles for different SSD:
The curves are very similar in shape

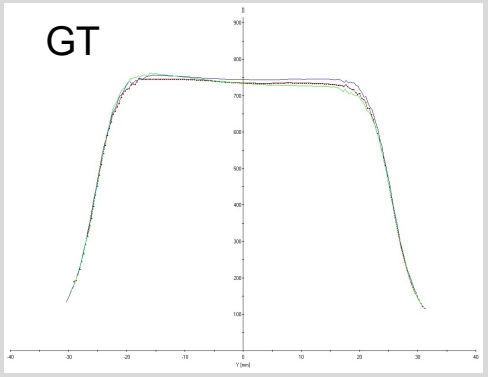
- Ref. LR Profile
- SSD +1 mm
- SSD -1 mm
- SSD +10 mm
- SSD -10 mm

All interlocks activated

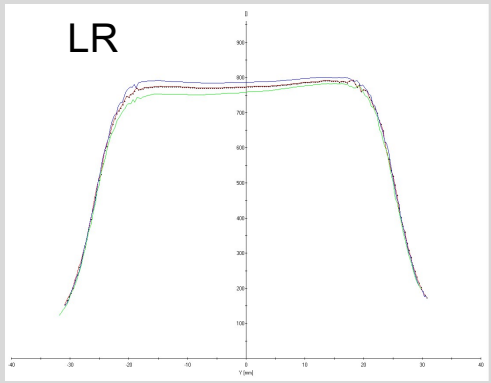
LR and GT profiles when all interlocks are just activated (worse case scenario), in both extreme directions compared to the reference profile

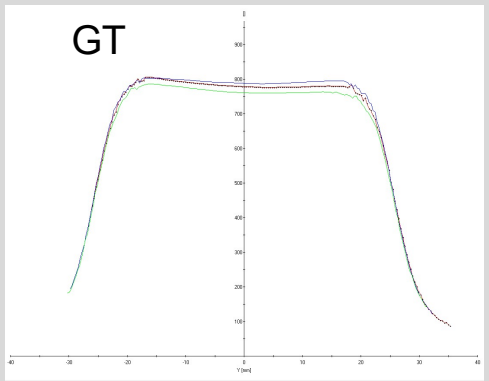
6 MeV



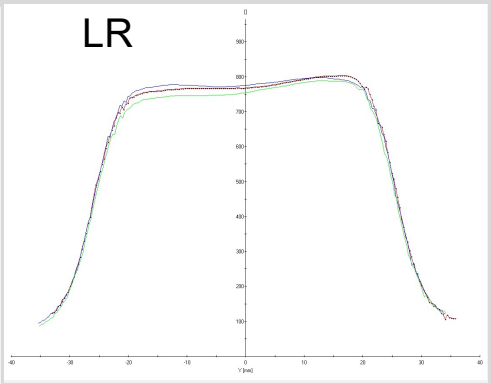


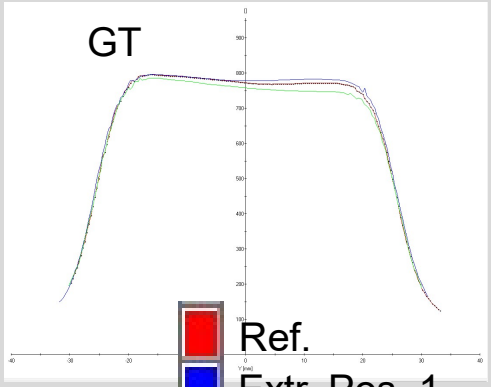
9 MeV

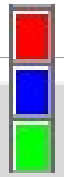




12 MeV







Ref.

Extr. Pos. 1

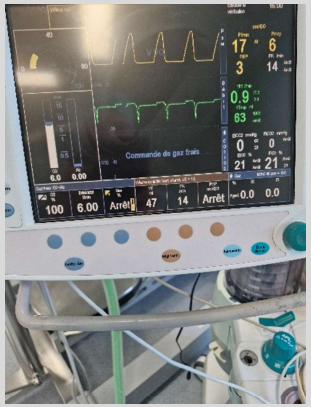
Ext. Pos. 2

Limited but visible deviations up to 3-4 %

Motion activated with respirator

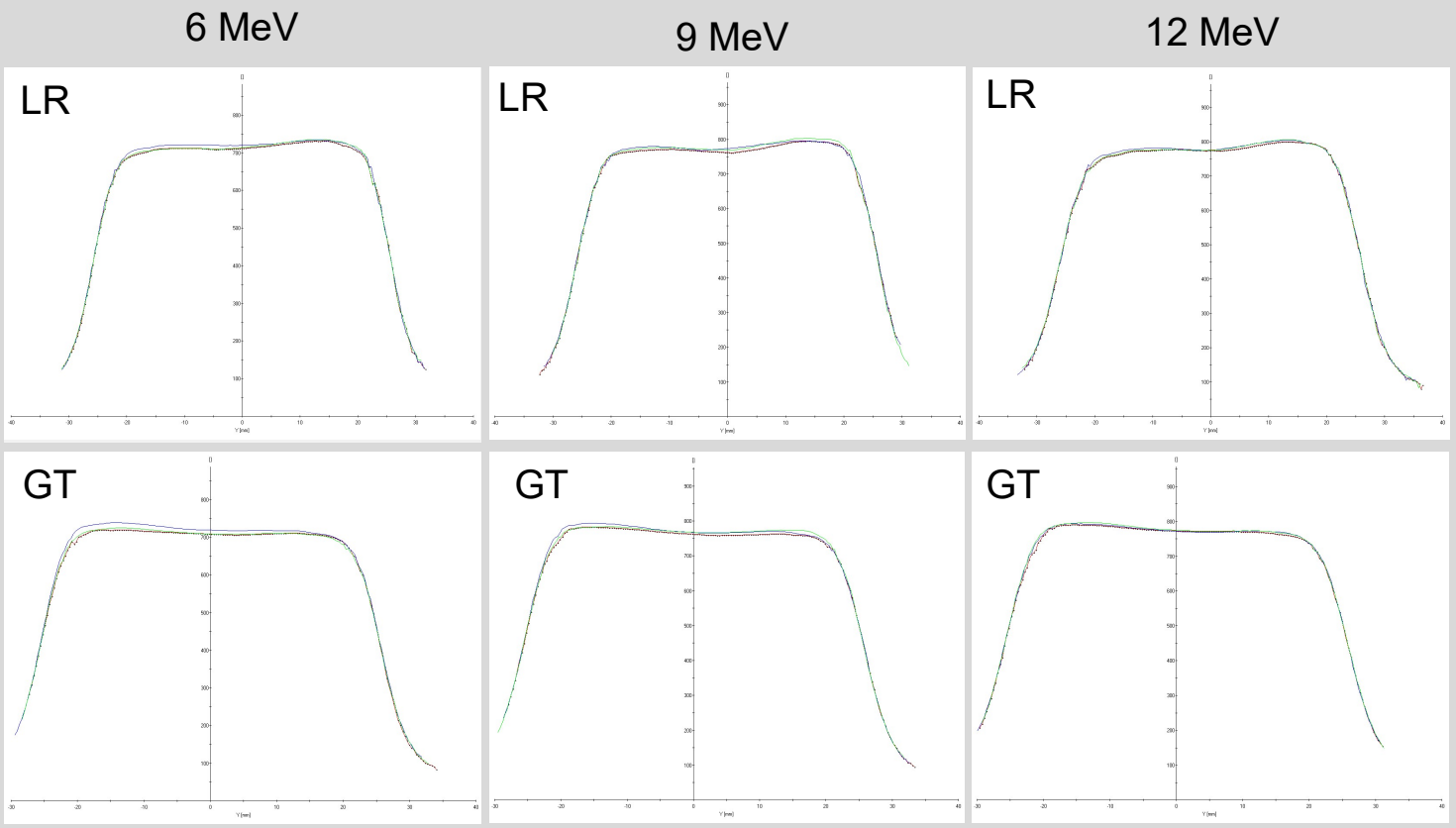
Test balloon placed in position
to maximize GT movements

Air volume sent by the respirator
to a test balloon placed under
the solid water phantom to simulate breathing
movements. The air volume was adjusted
to avoid any interlock. The frequency was
adjusted to match clinical frequencies. The test
balloon was placed in two positions to generate
either mainly GT or mainly LR movements



Breathing settings
on the respirator

Motion activated with respirator



Very limited deviations of 1-2 %

Ref.
Mainly LR movements
Mainly GT movements

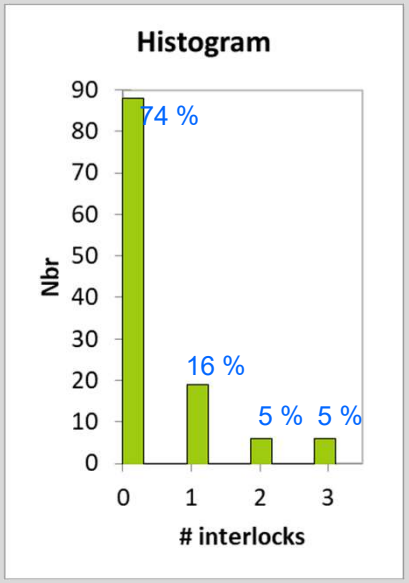
Clinical study

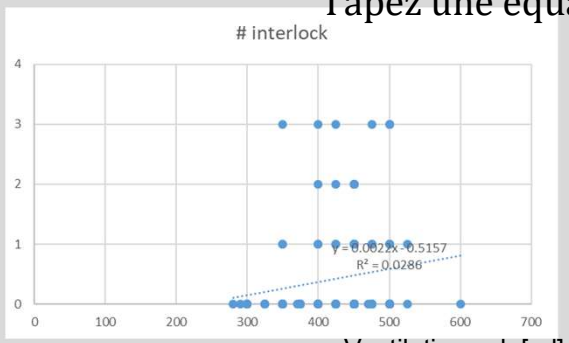
119 unselected breast patients

Data collected :

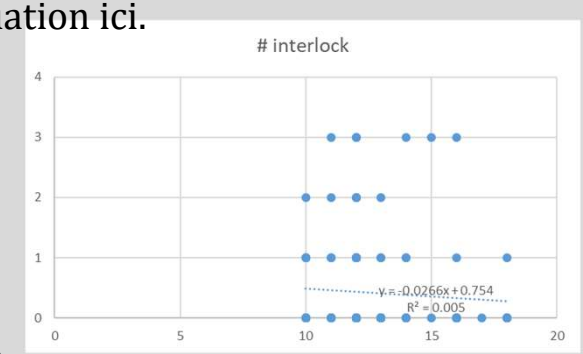
- Nbr of interlocks during treatment
- Breathing volume (Normally 7ml/kg) [280-600 ml]
- Breathing frequency (10-18/min in fct of capnia)

Tapez une équation ici.





Ventilation vol. [ml]



Ventilation Freq. [/min]

74% of treatments without interlock
Time to dock : 1-2 minutes, time to redock: 0.5-1 min
No correlation of interlock events with ventilation volume or frequency
Vast majority of interlocks are due to translations GT-LR

Conclusion

- Default Interlock threshold settings for the Camera-Target Autodocking system are fully acceptable for the beam quality.

- L-R & In-OUT interlock thresholds could be easily relaxed (doubled).

- Rotation interlock thresholds should be kept as they are.

- Most of the breast patient treatments (74%) are docking interlock free. This proportion will be sensibly improved by relaxing the L-R & In-Out interlock thresholds, as those are responsible for almost all interlocks during treatment.

Technical and clinical assessment of the Mobetron Autodocking system

THANK YOU FOR YOUR ATTENTION