Delivery errors detectability with IQM, a system for real-time monitoring of radiotherapy treatments

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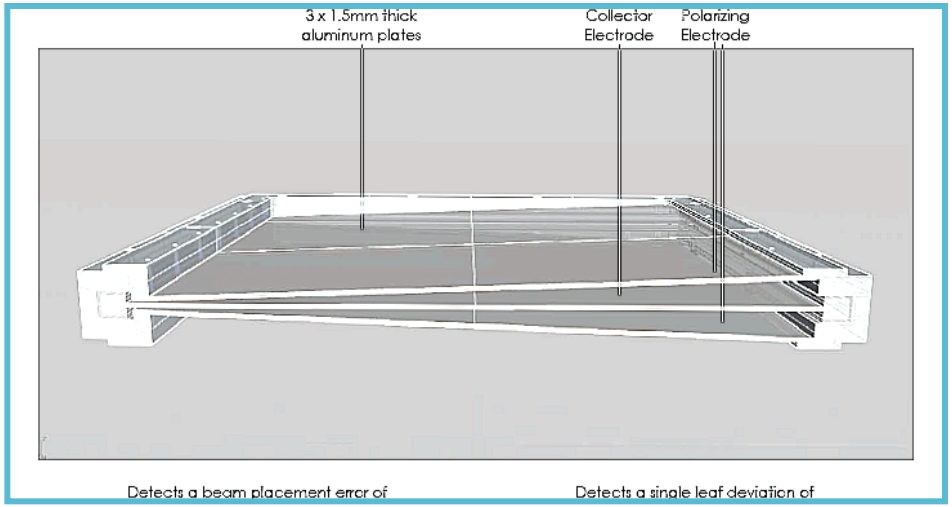
What is IQM (Integral Quality Monitor)?

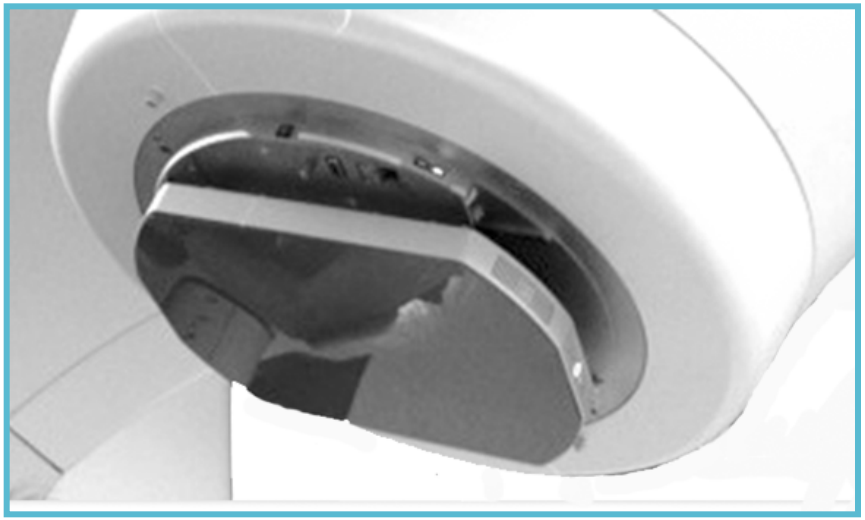


Large area ionization chamber with a gradient in the electrode plate separation (in the axis of MLC motion)

Inclinometer for gantry and collimator angle measurement

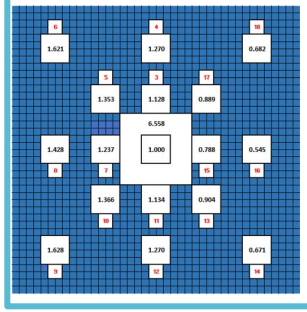
Wireless connection

Monitoring the **accuracy** of the beam delivery as well as the **integrity** of the treatment data transfer from the TPS to the linac **w/o any user interaction**.



Device characterization

Short term repeatability



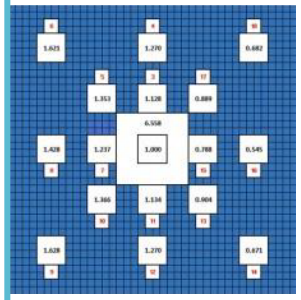
Gantry angle 0°
50 MU per field
17 4x4 cm^2 fields
1 10x10 cm^2 field

Repeatability	Short term σ/M (%)	Long term σ/M (%)		
	Test	Test	Prostate	H&N
Global	0.08	0.96	0.67	0.72
Local (mean±σ)	0.15±0.09	0.15±0.17	0.28±0.54	0.36±0.36

Dose rate dependence

<0.5% @6MV and @10MV 20-400 MU/min

Long term repeatability

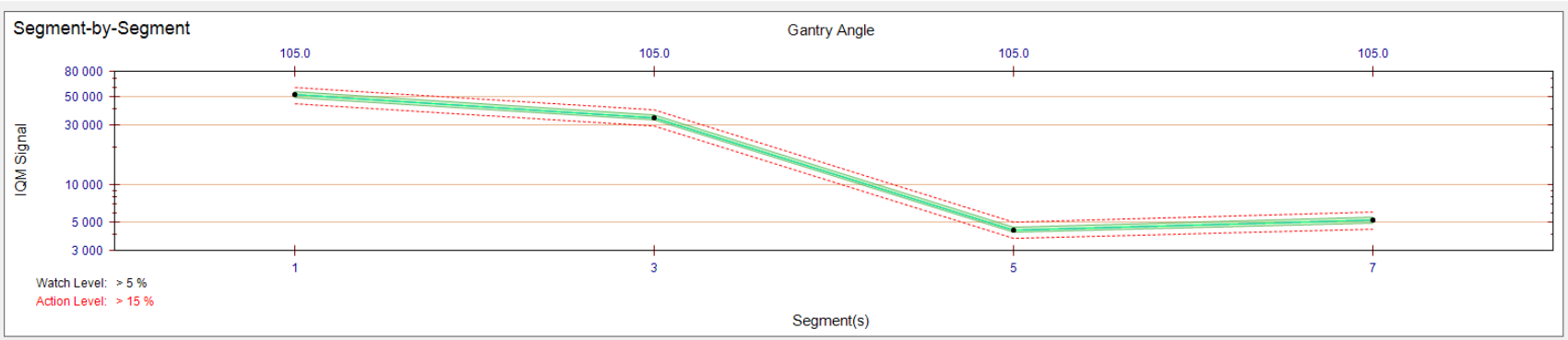


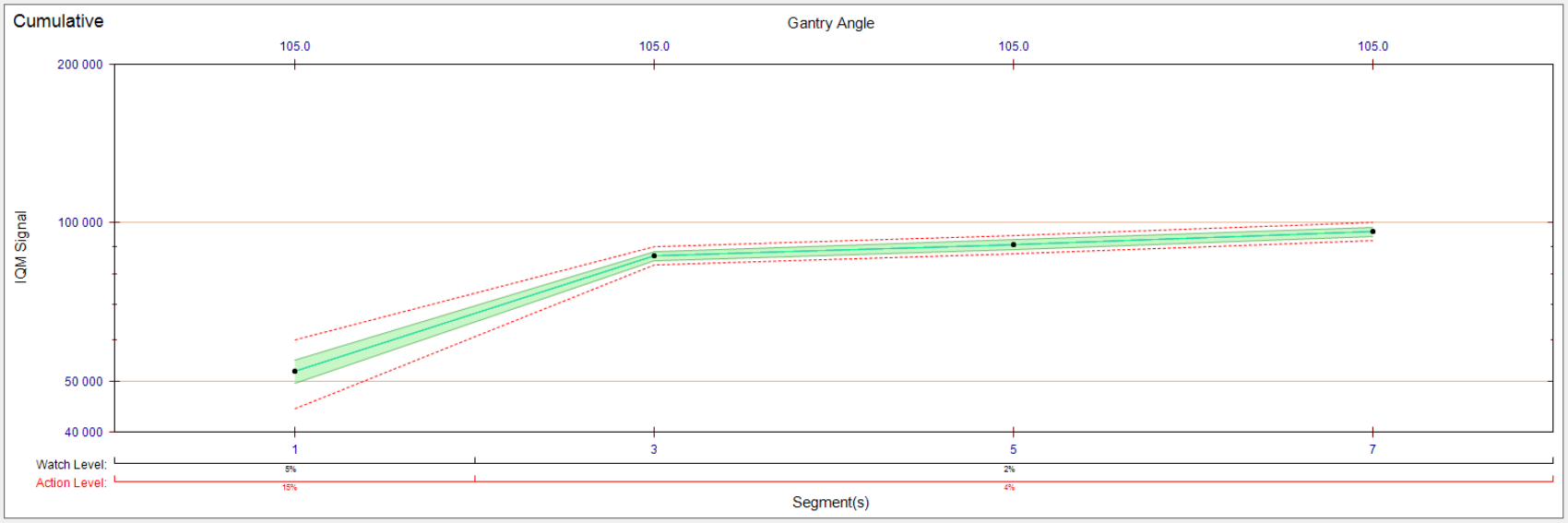
Gantry angle 0°
50 MU per field
17 4x4 cm^2 fields
1 10x10 cm^2 field

Prostate step and shoot IMRT
5 beams
255°, 315°, 45°, 105°, 180°
10 segments per beam

H&N step and shoot IMRT
4 beams
240°, 320°, 0°, 80°
10 segments per beam

IQM output





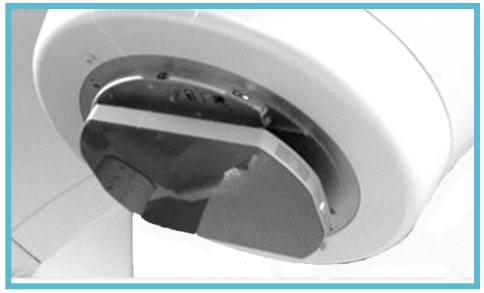
Watch level

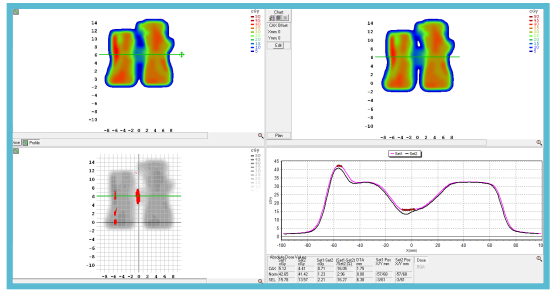
Action level

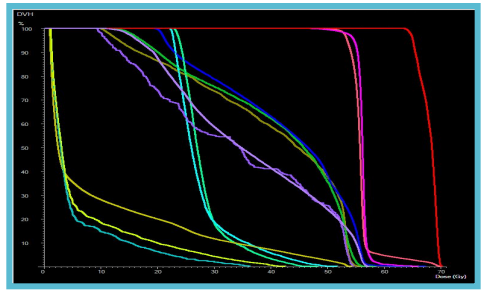
Objectives

- To test the IQM ability of **detecting small delivery errors**

- To evaluate the correlation between the changes in the detector output signal induced by small delivery errors with other metrics, such as the **γ passing rate** and the **DVH variations**



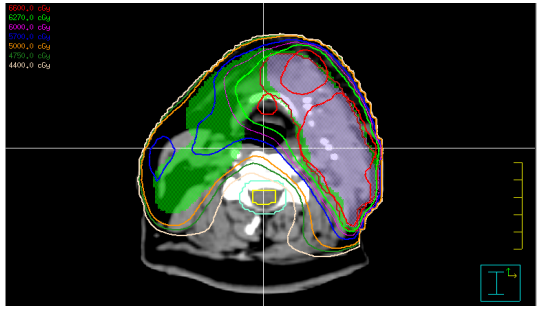


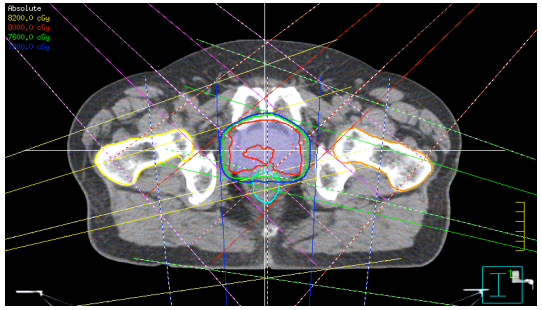


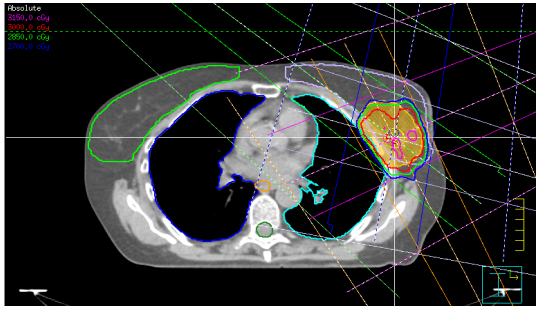
Watch level

Action level

How did we do it?





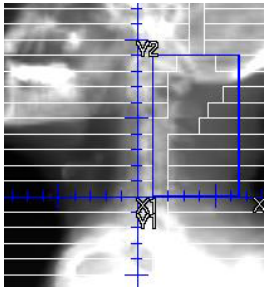


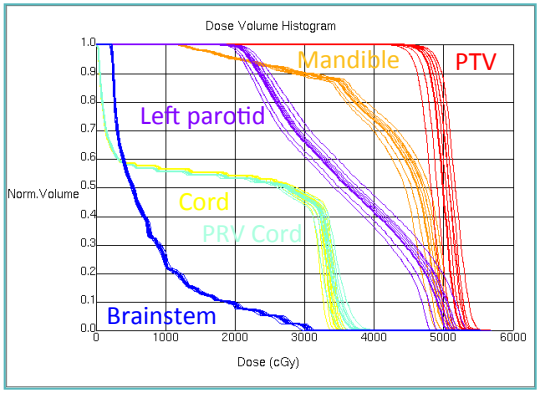
- Delivered MUs (1, 2, 3 MU per beam)

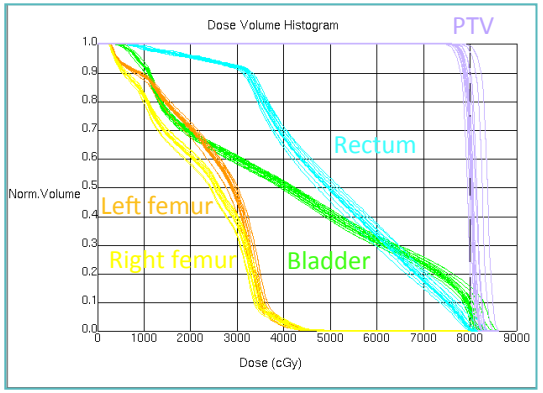
  0,8% - 2,5% (H&N), 1,4% - 4,2% (prostate), 0,4% - 1,3% (APBI)

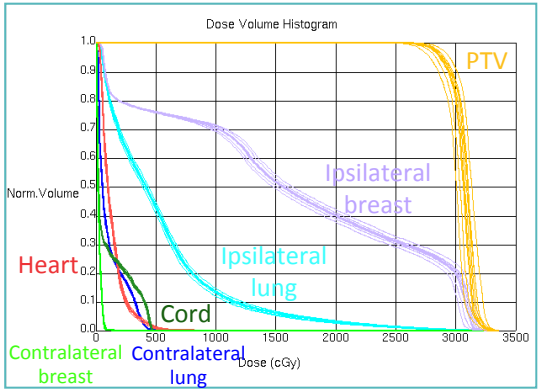
- Small deviations in leaf bank positions

  (1 mm single or both banks in different directions)



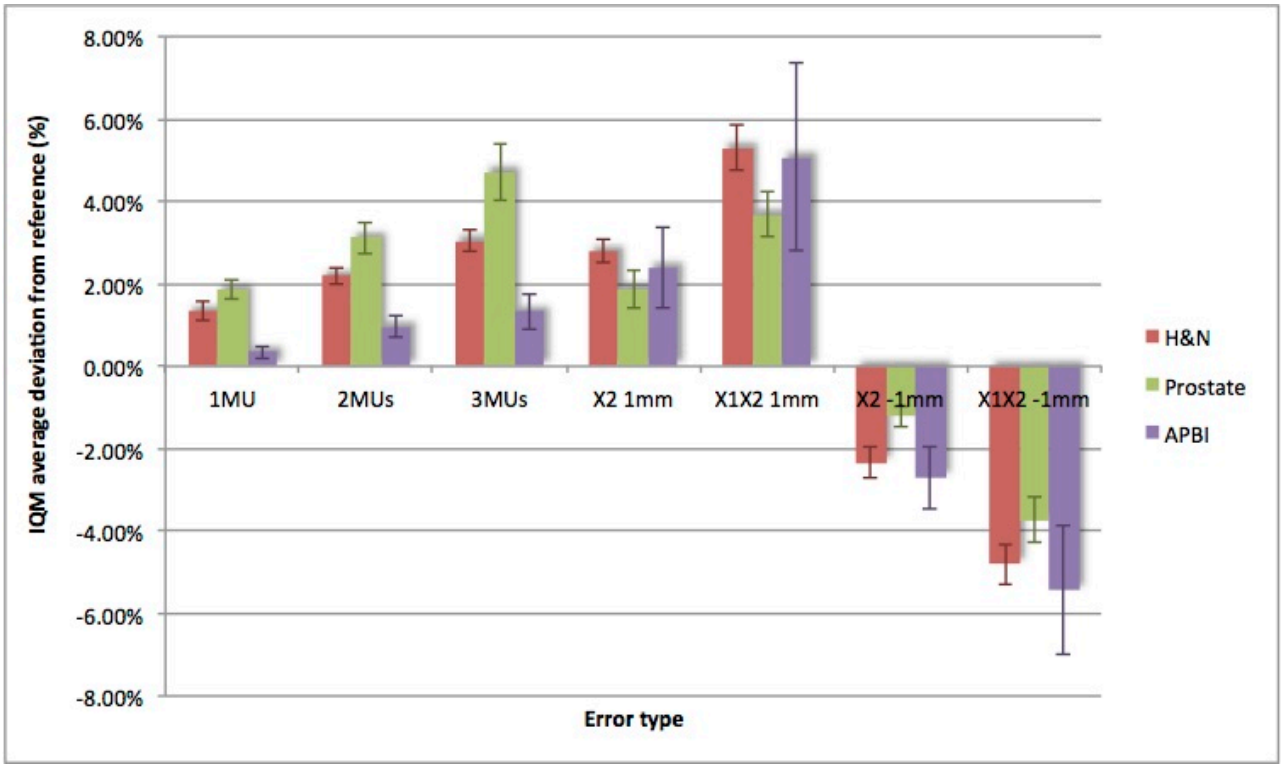


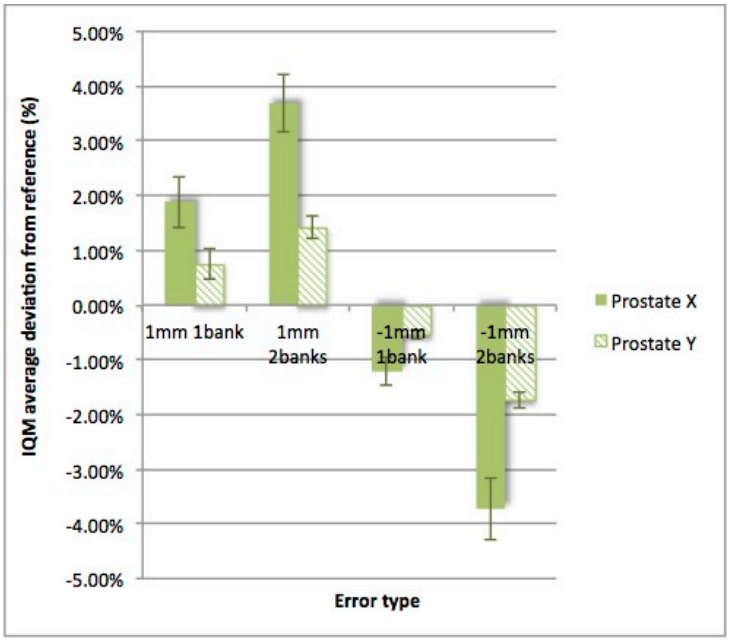




Results

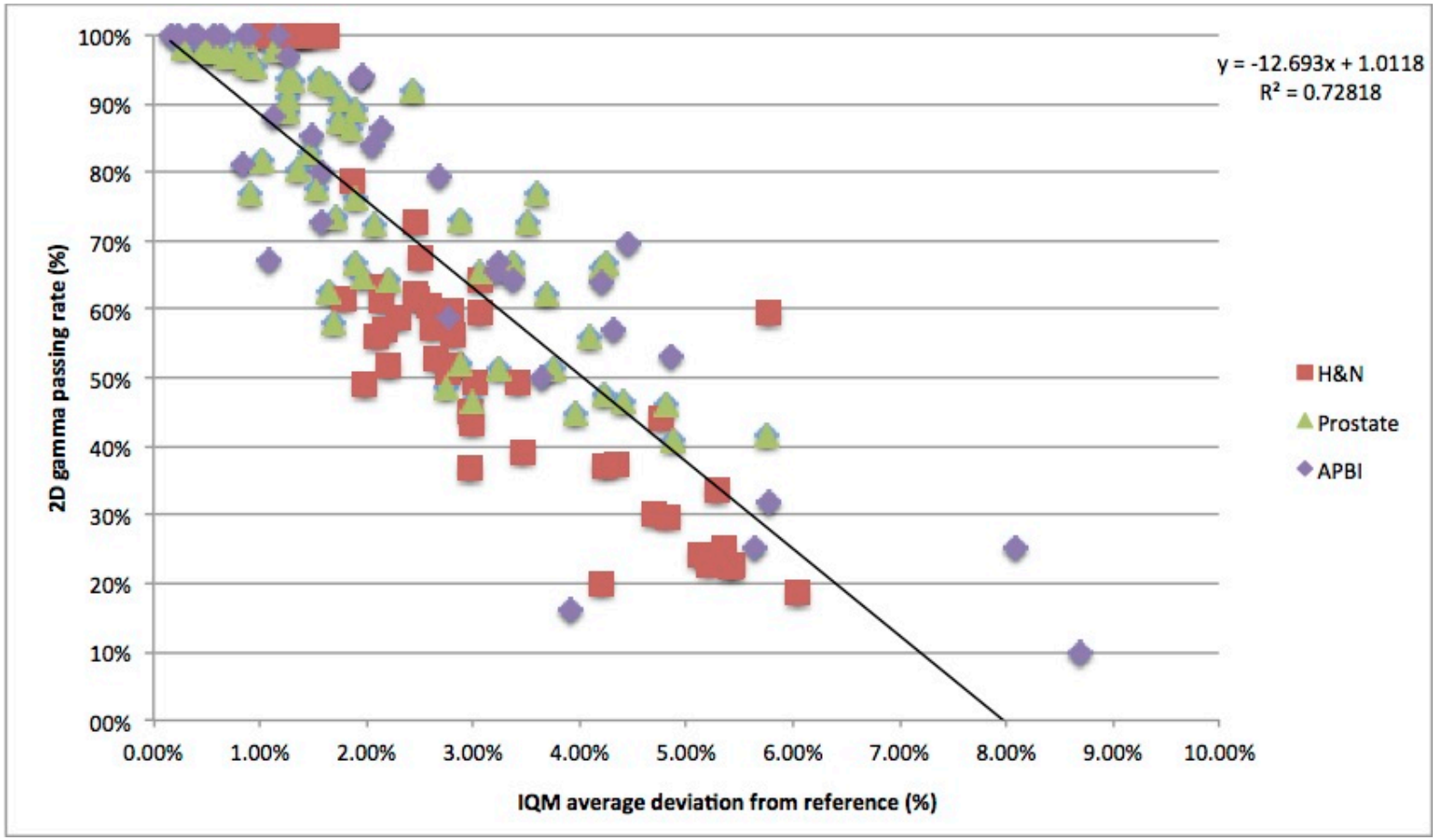
IQM sensitivity in detecting small delivery errors





Results

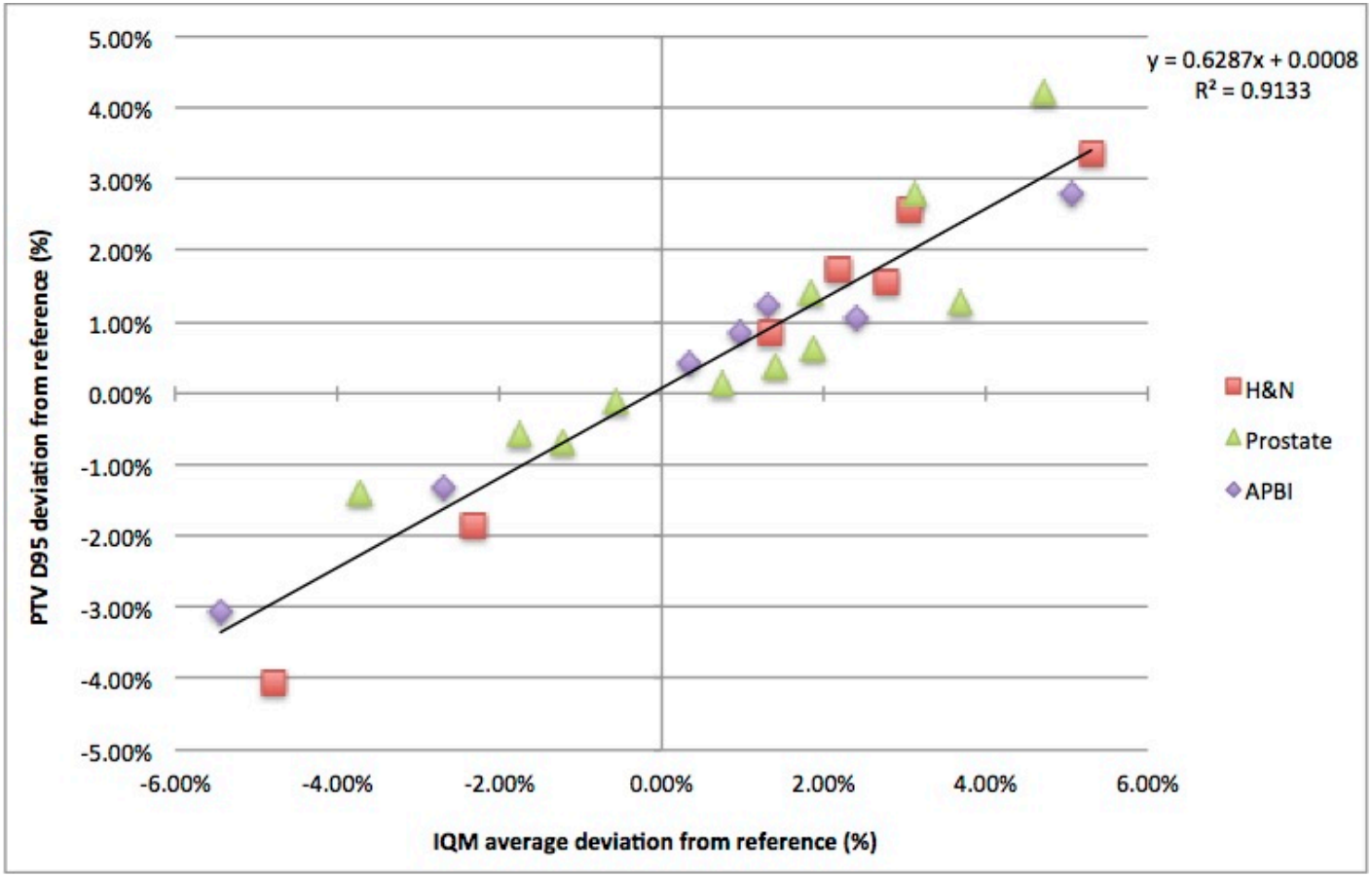
Correlation with **2D gamma** (1%/1mm, 10% th, local approach)

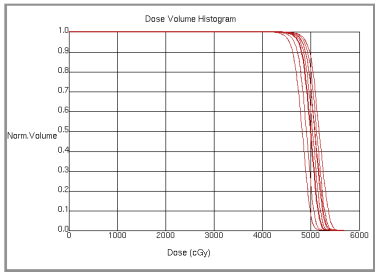


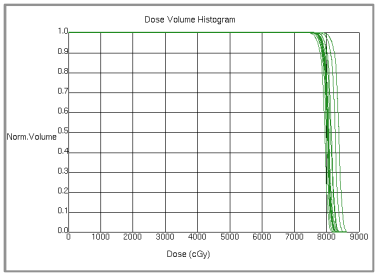
Pearson's r	Adj. R-Square	p
-0,85333	0,7262	<0.01

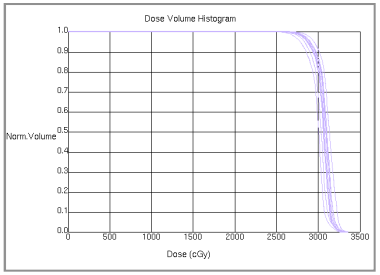
Results

Correlation with **PTV D95**





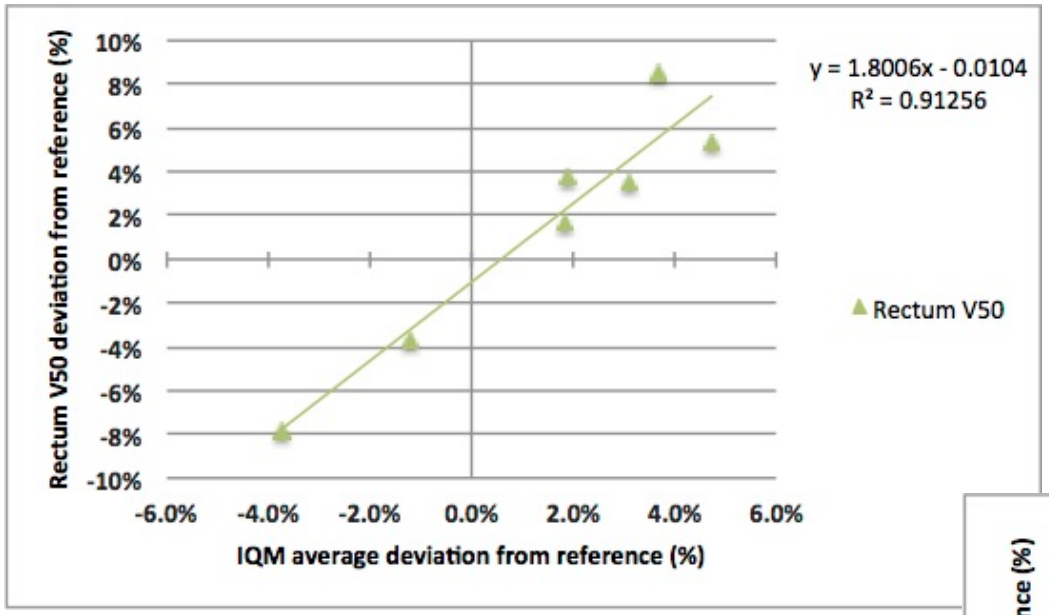


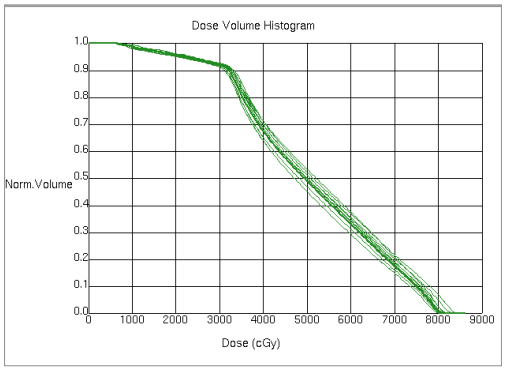


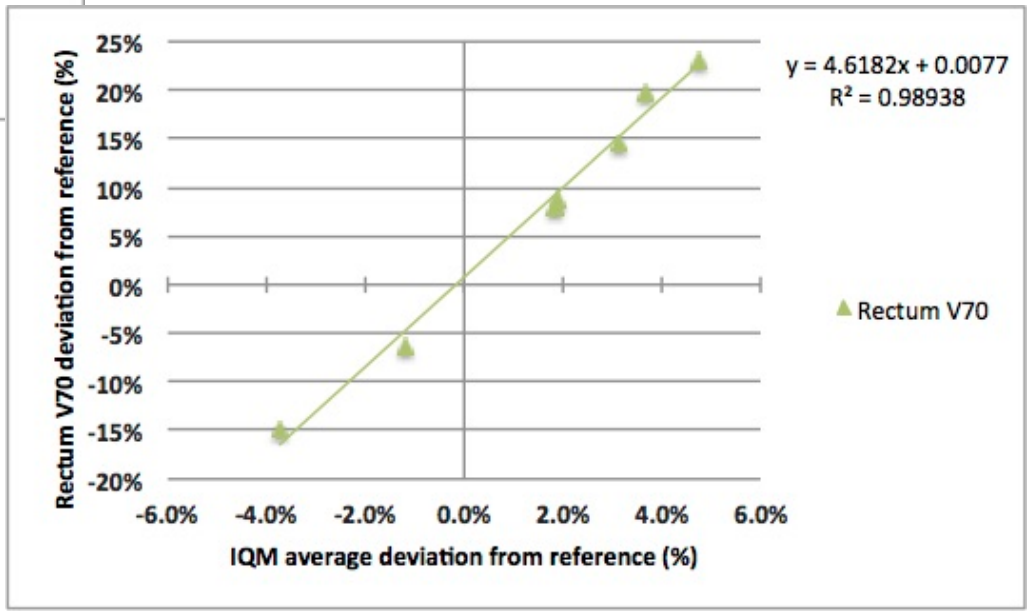
Pearson's r	Adj. R-Square	p
0,95567	0,90953	<0.01

Results

Correlation with **OAR (rectum for the prostate plan)**







	Pearson's r	Adj. R-Square	p
Rectum V50	0.95528	0.89508	<0.01
Rectum V70	0.99468	0.98726	<0.01

Conclusions

IQM is capable of detecting small delivery errors in MU and leaves position and it shows a **sufficient sensitivity** for clinical practice.

IQM exhibits a **good correlation** with other metrics used to quantify the deviations between calculated and actually delivered dose distributions. Such correlations are useful in order to identify the alert threshold associated with this kind of monitoring systems.

Further work will include the system response to **combined errors**.

Thank you for your attention