Using the IQM transmission detector to monitor linac performance

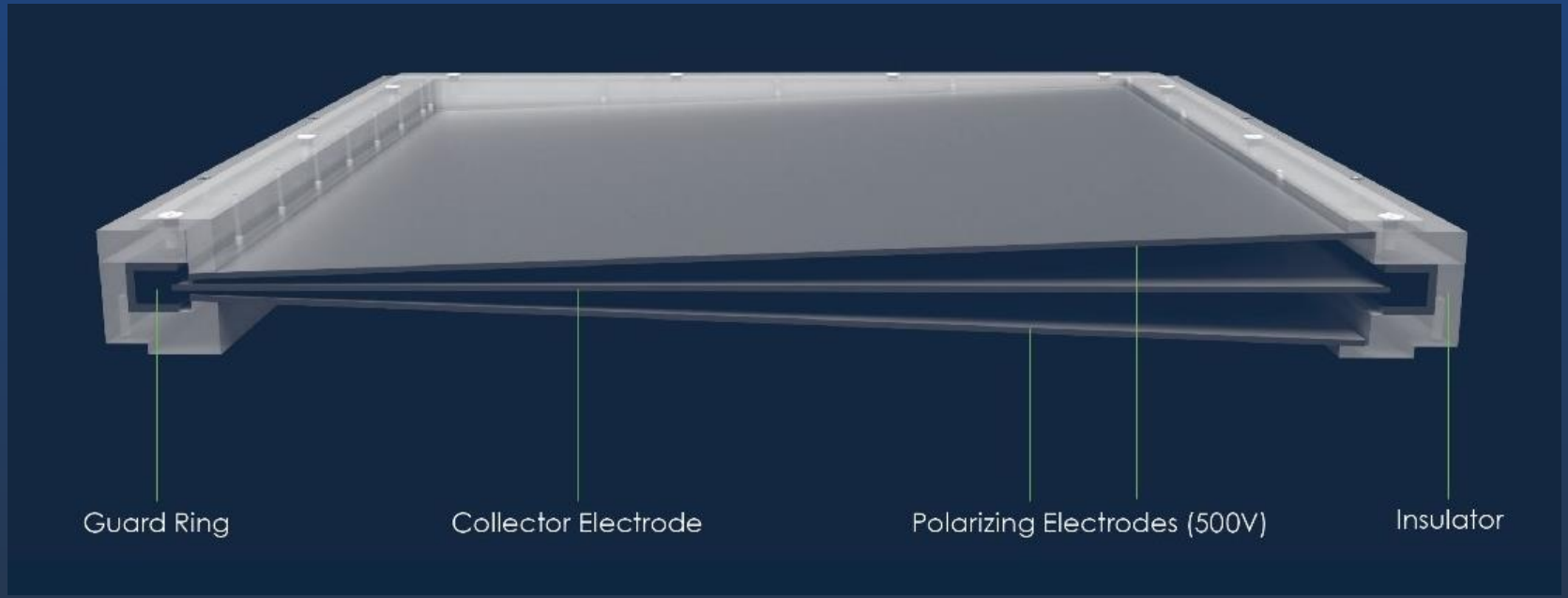
- Dan Pavord
- Chief of Medical Physics
- Allegheny Health Network

AHN

- Conflict of interest

- I have received a grant from Elekta to investigate the use of IQM for patient specific QA.

The IQM device (Integral Quality Monitor) iRT Systems, Koblenz, Germany


Guard Ring
Collector Electrode
Polarizing Electrodes (500V)
Insulator

Patient Specific QA

- Ghafarian, M., Price, M., & Morales-Paliza, M. (2021). Comparison of pretreatment VMAT quality assurance with the integral quality monitor (IQM) and electronic portal imaging device (EPID). Journal of applied clinical medical physics, 22(3), 166-175.

- Saito, M., Sano, N., Shibata, Y., Kuriyama, K., Komiyama, T., Marino, K., ... & Onishi, H. (2018). Comparison of MLC error sensitivity of various commercial devices for VMAT pre-treatment quality assurance. Journal of Applied Clinical Medical Physics, 19(3), 87-93. (Delta4, PTW 2D array, IQM, farmer chamber)

Real Time Monitoring of Treatment Delivery

- Casar, B., Pasler, M., Wegener, S., Hoffman, D., Talamonti, C., Qian, J., ... & Peterlin, P. (2017). Influence of the integral quality monitor transmission detector on high energy photon beams: a multi-centre study. Zeitschrift Für Medizinische Physik, 27(3), 232-242.
- The effects of the IQM detector on photon beam properties were found to be small yet statistically significant. The magnitudes of changes which were found justify treating IQM either as tray factors within the treatment planning system (TPS) for a particular energy or alternatively as modified outputs for specific beam energy of linear accelerators, which eases the introduction of the IQM into clinical practice.

- Arilli, C., Wandael, Y., Galeotti, C., Marrazzo, L., Calusi, S., Grusio, M., ... & Talamonti, C. (2020). Combined use of a transmission detector and an EPID-based in vivo dose monitoring system in external beam whole breast irradiation: a study with an anthropomorphic female phantom. Applied Sciences, 10(21), 7611.
- IQM can detect output and MLC/jaw positioning errors. EPID can detect output and patient positioning errors.

Linac QA

Received: 27 June 2023 | Revised: 9 December 2023 | Accepted: 14 December 2023

DOI: 10.1002/acm2.14245

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS

RADIATION MEASUREMENTS

Feasibility of using a transmission ion chamber for QA tests of medical linear accelerators

Makan Farrokhkish[1] | Andrew J. Veres[2] | Luis E. Fong de los Santos[2] | John J. DeMarco[3] | Mohammad K. Islam[1,4]

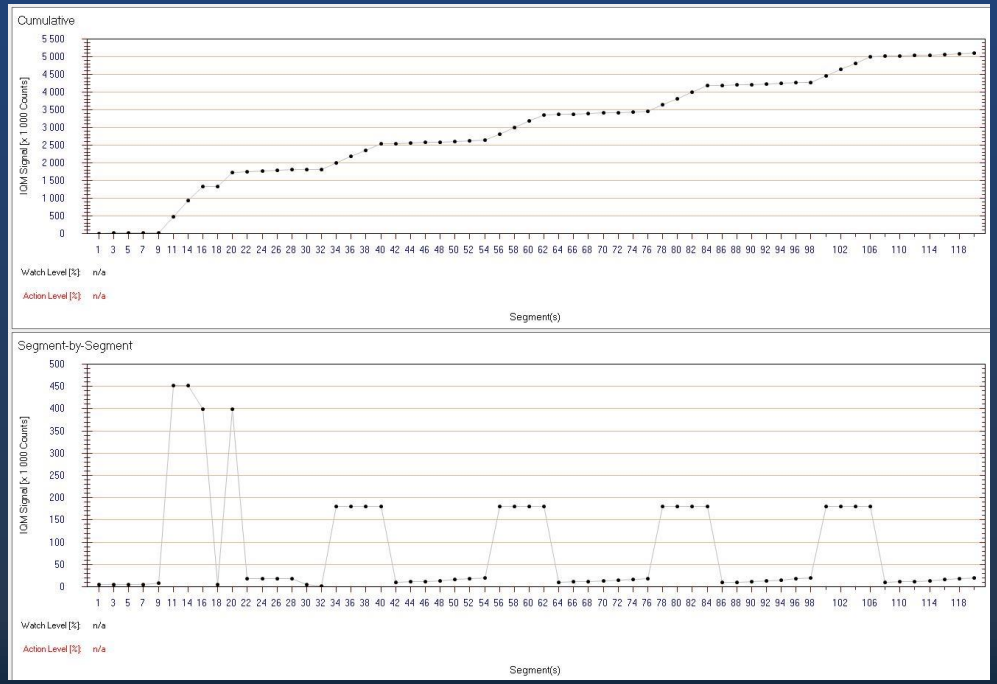
Output
Symmetry
Flatness
MLC position
Dose Rate
MU Linearity

Linac QA, photons

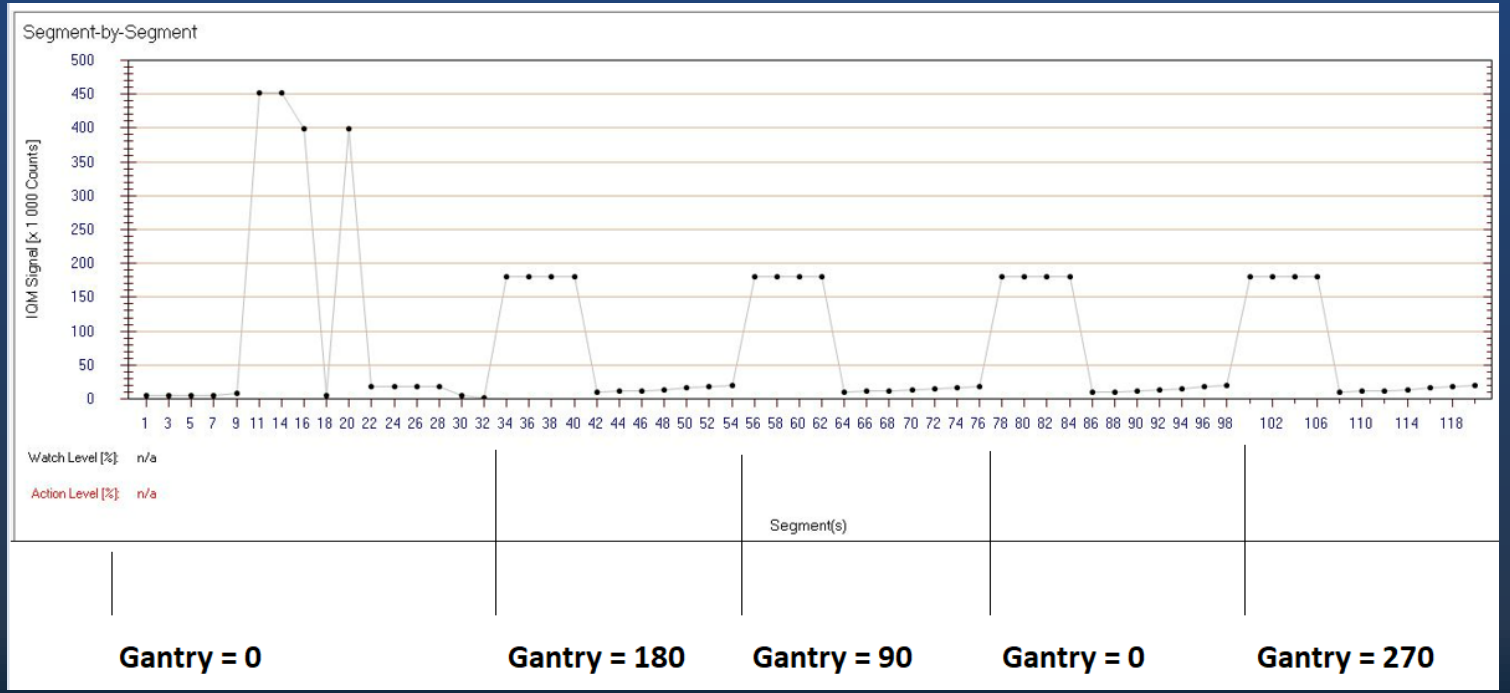
- Add in more checks
  - Energy
  - Jaw Position
  - Wedge Factor
  - Gantry/Collimator Angle
  - Beam Center

Output
Symmetry
Flatness
MLC position
Dose Rate
MU Linearity

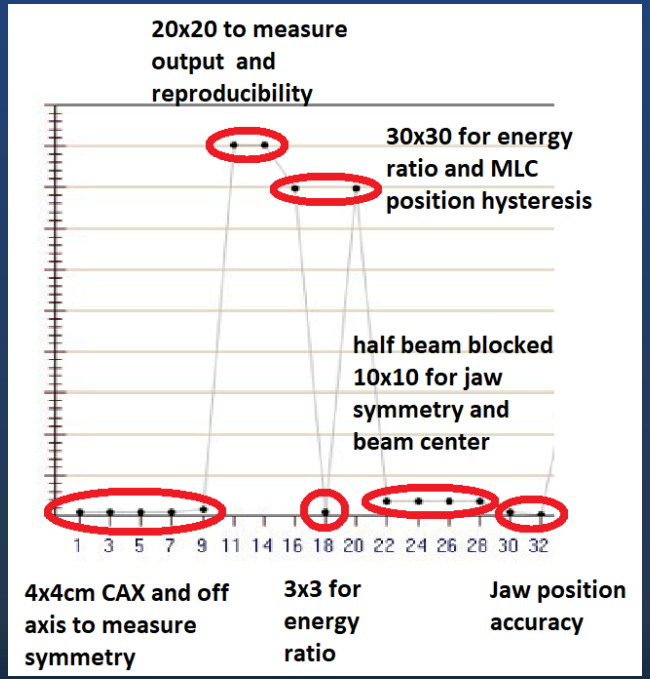
Automated Field Sequence, Elekta Versa HD, 6MV



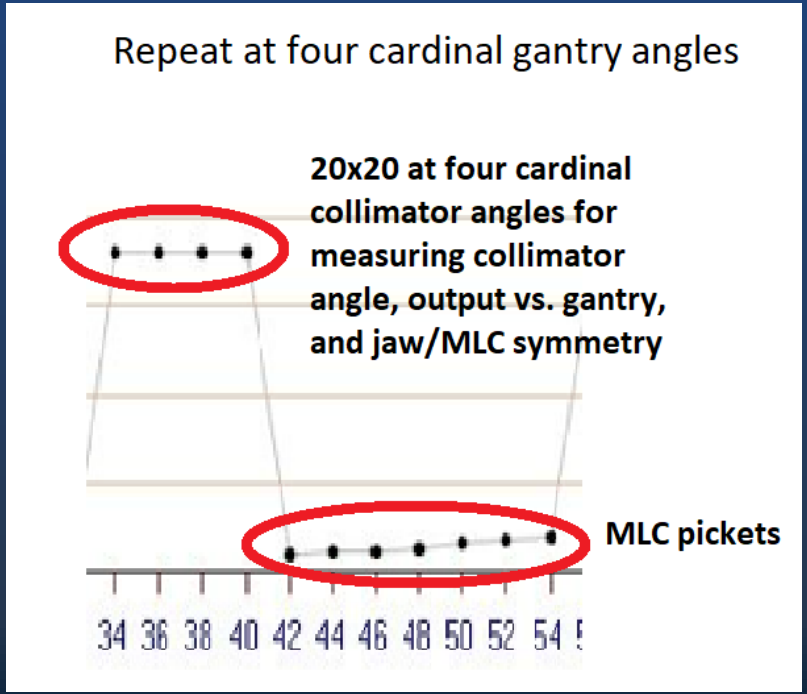
Automated Field Sequence



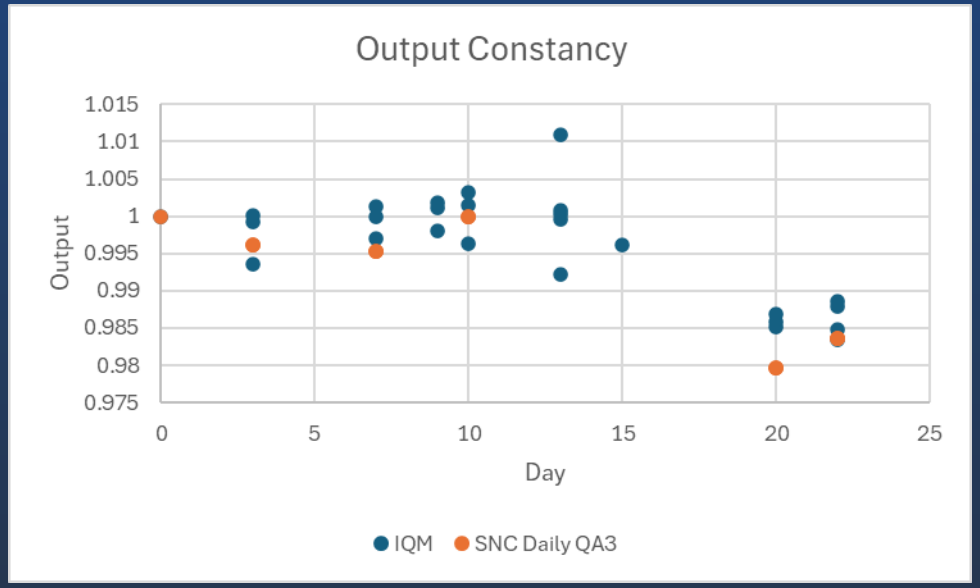
Automated Field Sequence



Automated Field Sequence



Output Constancy

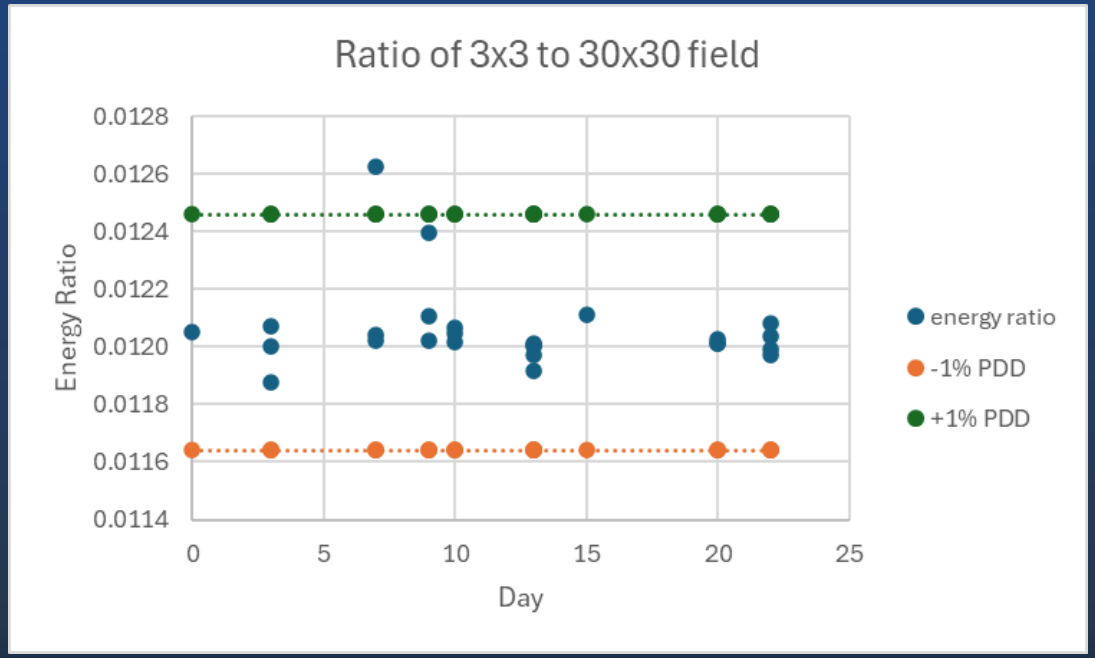


Note: On Day 13 deliberate +/-1% changes made to output.

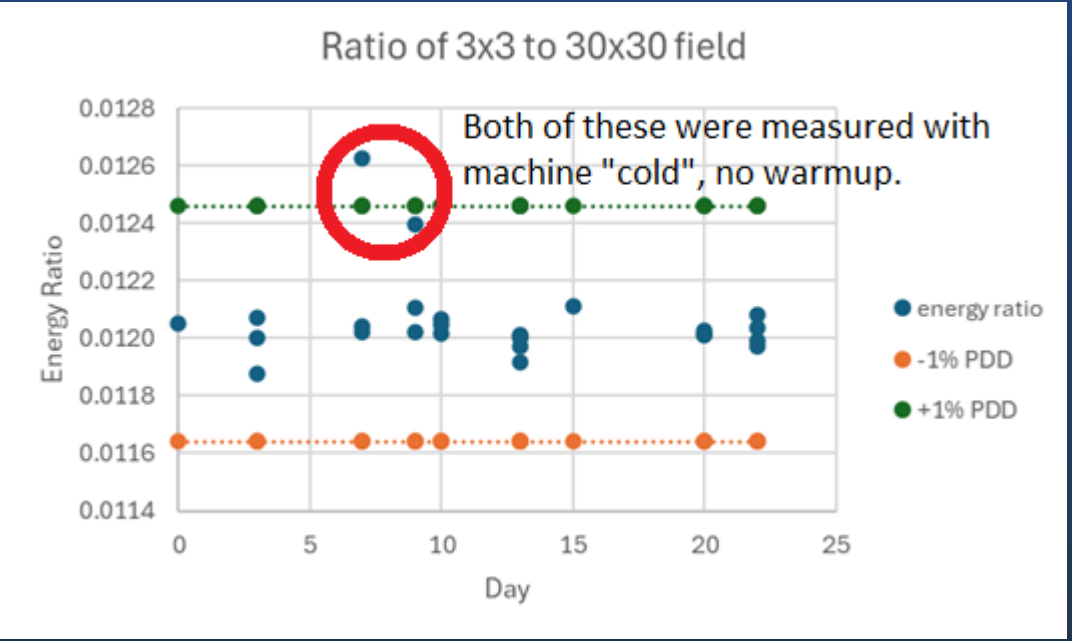
Energy

- Adjusted energy as determined by PDD at 10cm
- Measured resulting change in ratio of small/large field signal with IQM to establish Action Level

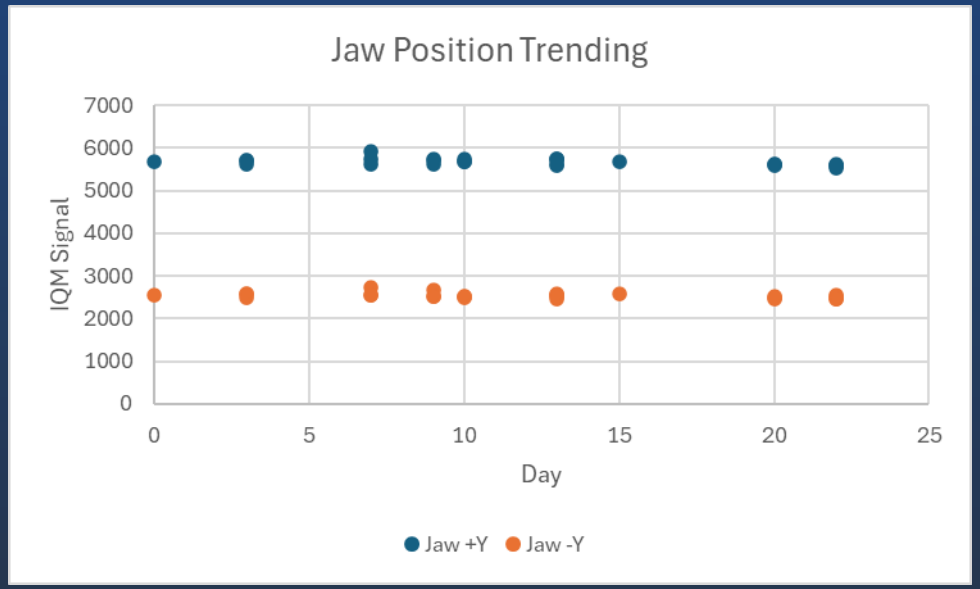
Energy

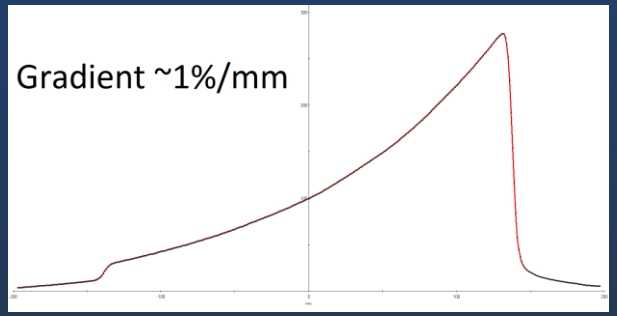

Ratio of 3x3 to 30x30 field
Energy Ratio
0.0128
0.0126
0.0124
0.0122
0.0120
0.0118
0.0116
0.0114
0
5
10
15
20
25
Day
energy ratio
-1% PDD
+1% PDD

Energy

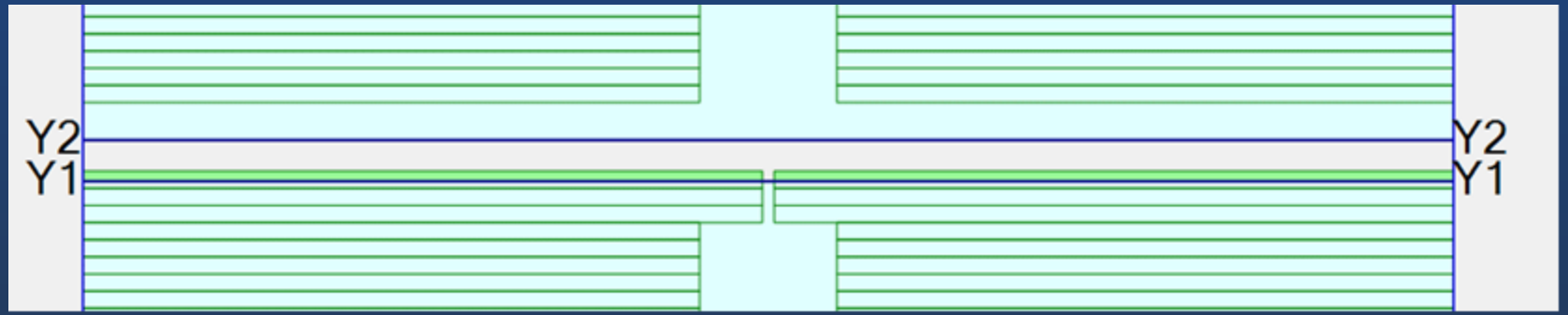

Ratio of 3x3 to 30x30 field
Both of these were measured with machine "cold", no warmup.
Energy Ratio
0.0128
0.0126
0.0124
0.0122
0.0120
0.0118
0.0116
0.0114
0
5
10
15
20
25
Day
energy ratio
-1% PDD
+1% PDD

Jaw Position, use wedge to create gradient





Jaw Position, alternate method of Kilian Michel, iRT



- If Y1 was moved by 1mm it would only affect the IQM signal by less than 1%, because the relating radiation contribution would be absorbed by the closed MLC-pair.
- Similarly, the position/opening of the closed MLC-pair has a negligible effect on the IQM signal because it is half-way covered by Y1.
- However, if Y2 moved, it would have a dramatic effect on the open field size and thereby on the IQM Signal. (preliminary results ~11%/mm)

Wedge Factor

Field	IQM WF	measured
10x10	0.289	0.268
20x20	0.308	0.279

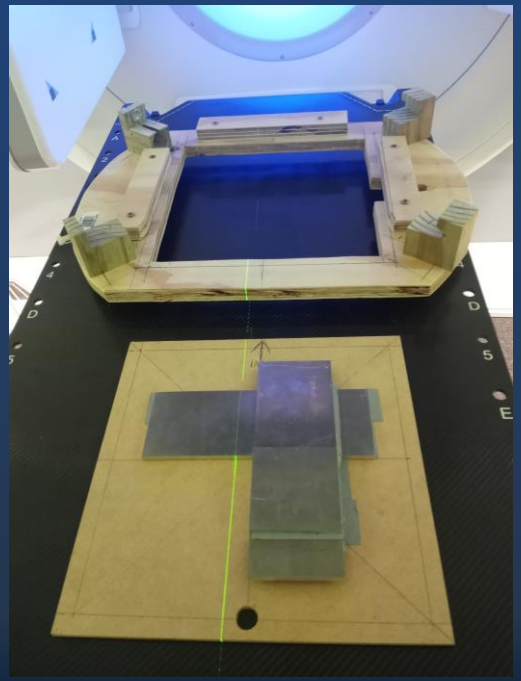
Gantry/Collimator Angle

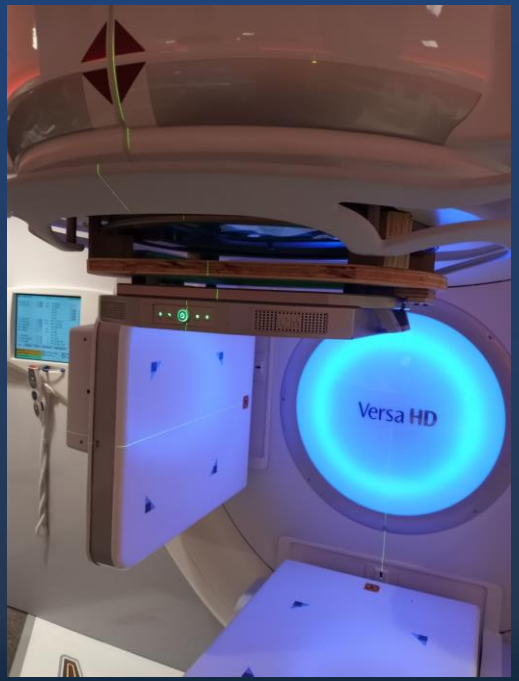
Data easily captured from log files.
All within 0.5 degree of expected angles.

Beam Center

Ratios of +X/-X and +Y/-Y have been very stable (+/- 0.5%). Next step is to purposely steer beam center and see if ratios correlate.

Electrons





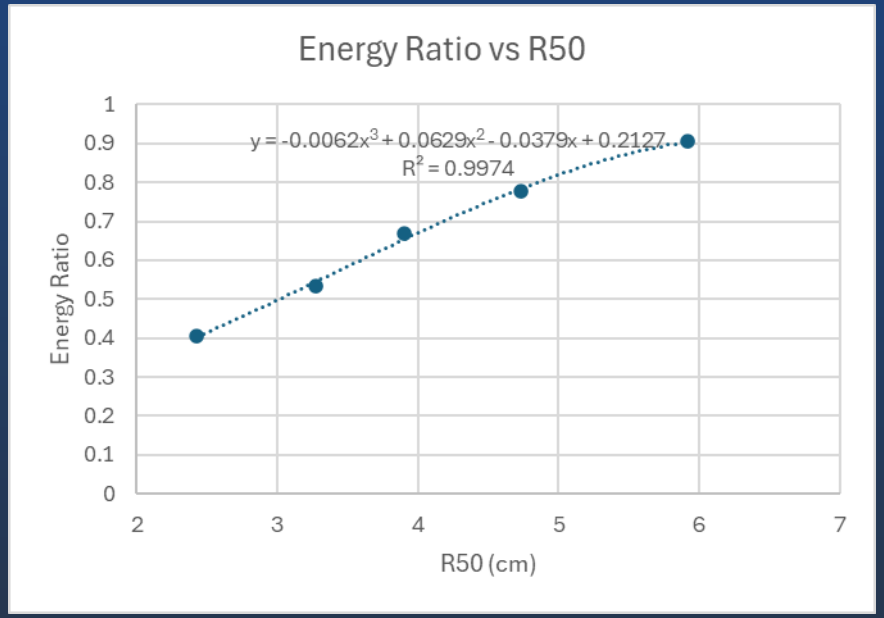
Electrons

- Seven Measurements
  - 20x20 with energy filter
  - 20x20 open
  - 4x4 at CAX
  - Offset field at 4 collimator angles
- Beam analysis
  - 20x20 open for output
  - Ratio 20x20 filter/open for energy
  - Ratios of offset fields to 4x4 CAX for flatness/symmetry

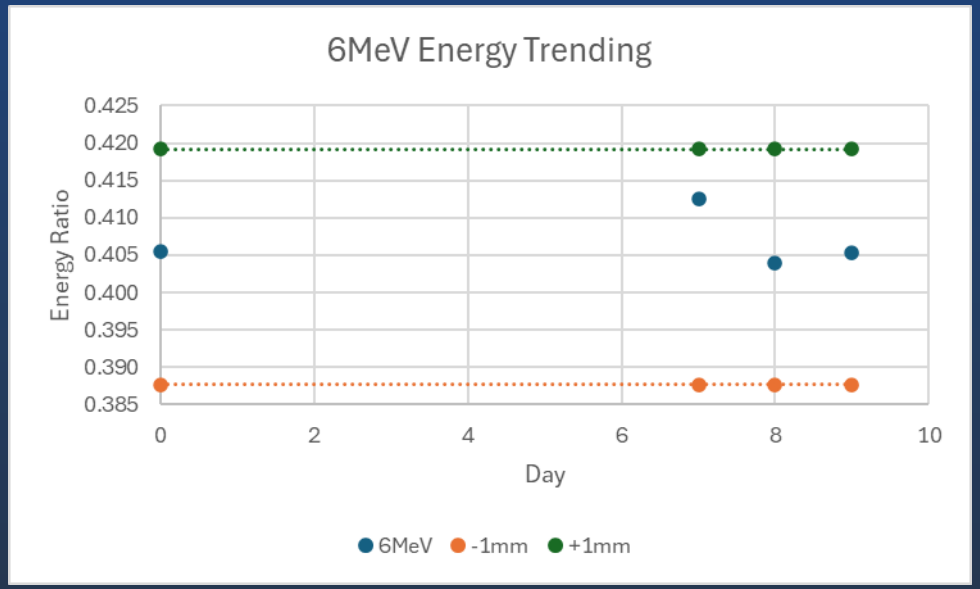
Electrons Energy

	Energy Ratio Measured with IQM				
Day	6MeV	8MeV	10MeV	12MeV	15MeV
0	0.405	0.533	0.668	0.777	0.905
7	0.413	0.537	0.674	0.784	0.913
8	0.404	0.540	0.675	0.784	0.911
9	0.405	0.540	0.674	0.782	0.909

Electrons Energy



Electrons Energy



Time

- Currently about 70 minutes for all tests, photon and electron
- Compares well with 90 minutes using our existing methods

- Acknowledgements

- Alex Solodkin, Elekta
- Jurgen Oellig, iRT Systems
- Will Roestel, iRT Systems
- Kilian Michel, iRT Systems