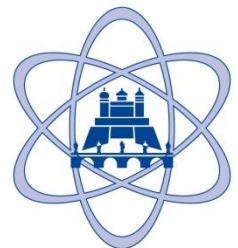


IMRT plan QA with the IQM detector

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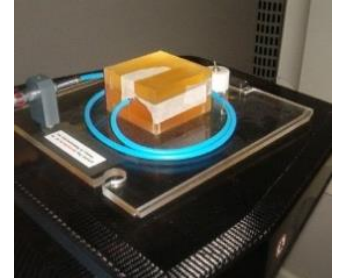


(De-)Motivation for IMRT-QA

► Why we measure every plan

- Mandatory: guidelines, task group reports, DIN
- Finding the one faulty plan in 50 plans¹

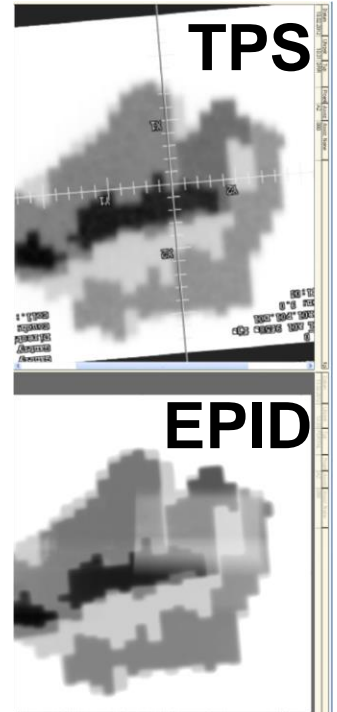
¹Pulliam et al., J. Appl Clin Med Phys.; 15(5):4935



► Why we (sometimes) wish we did not

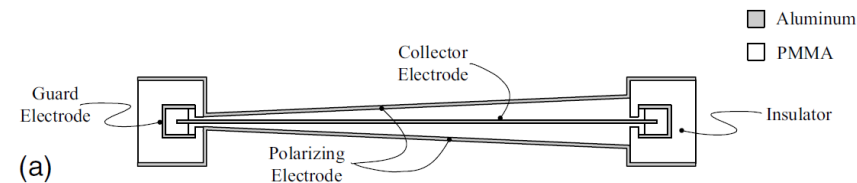
- Finding reasons for deviations is **time-consuming**
- Too many false alarms, often caused by user-error

→ demand for an easy-to-use QA tool

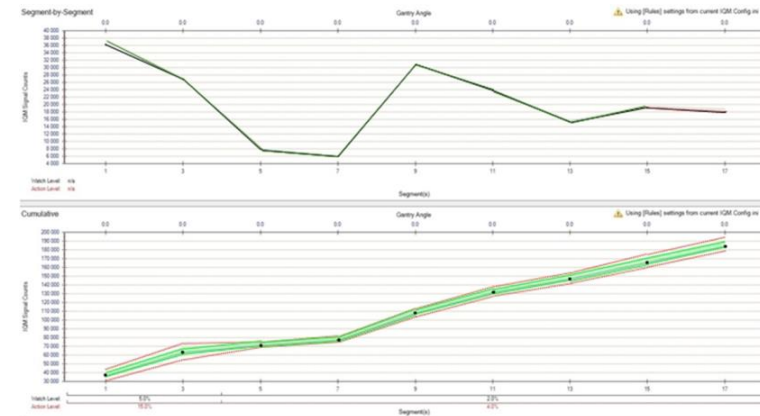


The IQM detector

- ▶ **Position-weighted dose-area product**
 - ▶ inclination in MLC movement direction
 - ▶ Attached to gantry
 - ▶ Includes barometer, thermometer and inclinometer
 - ▶ Bluetooth connection to workstation
-
- ▶ **Signal per segment and cumulative signal per field are compared to calculation**
 - ▶ uses Dicom RTPlan for calculation
 - ▶ detector commissioned using a variety of field sizes and shapes



M. Islam et al., Med. Phys. 2009, 36 (12): 5422

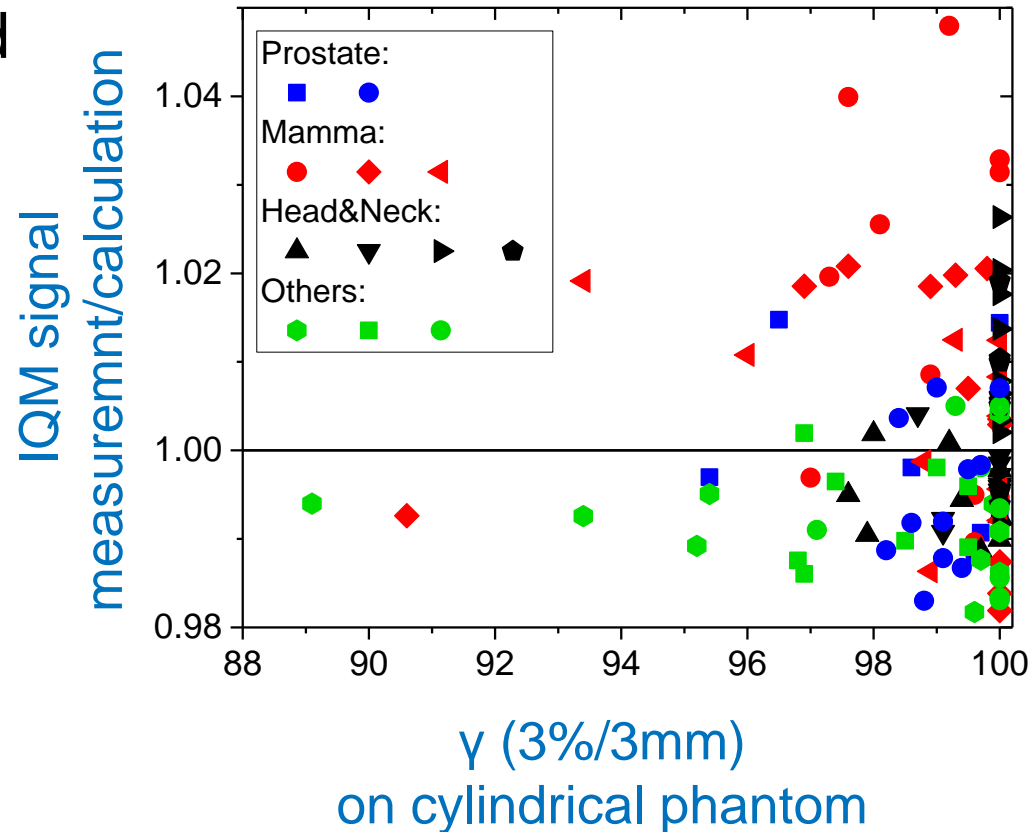


Evaluation of IQM

- ▶ General characterization
- ▶ Influence of transmission detector on beam
 - participation in multi-center study
- ▶ Validation of calculation algorithm for wide spectrum of clinical cases
 - ▶ including plans with long (>26 cm) fields
- ▶ Tests with induced errors
- ▶ Comparison with currently used QA approaches

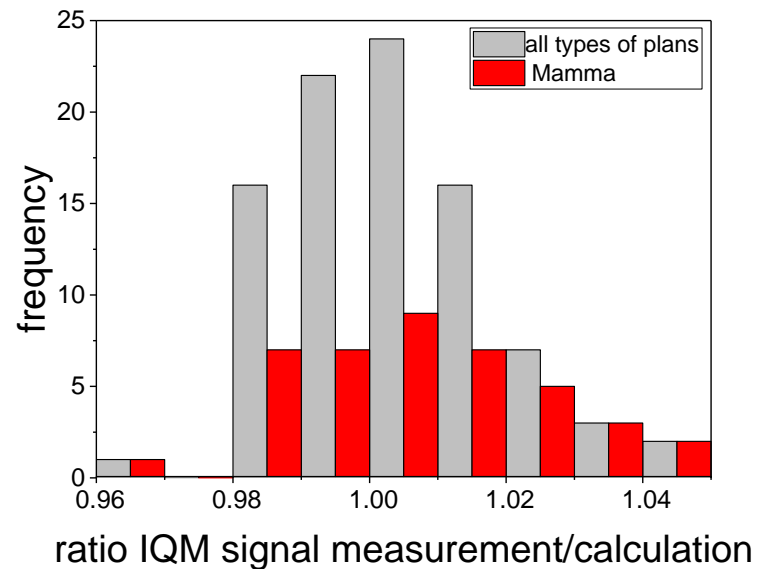
The full spectrum of IMRT fields with IQM

- ▶ Over 100 fields of different plan types were measured and compared against the calculation
- ▶ Agreement with calculation:
-0.2% ($\pm 1.3\%$)
- ▶ Tolerance levels:
3% action
2% warning



Long (>26cm) IMRT fields with IQM

- ▶ Over 100 fields of different plan types were measured and compared against the calculation
- ▶ Mamma results show slightly higher deviation than average plans
- ▶ Agreement with calculation comparable to overall IMRT results: **+0.4% ($\pm 1.4\%$)**



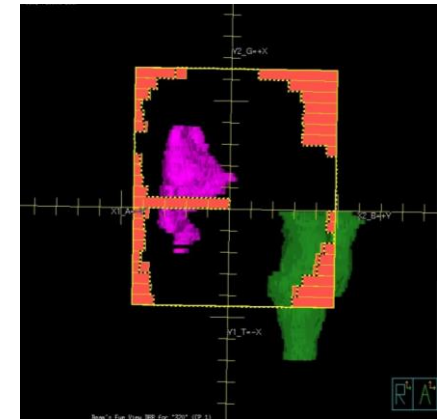
→ IQM can be used for long field IMRT

Induced errors

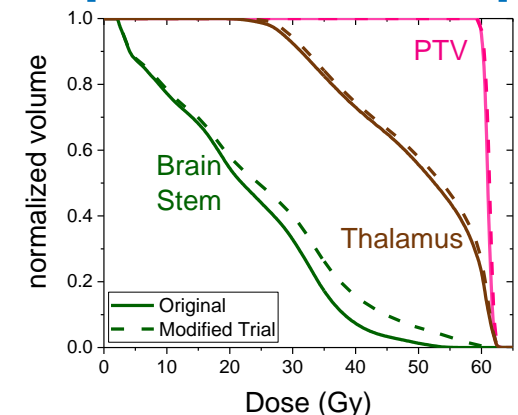
- ▶ 3 clinical plans were modified
- ▶ Errors had a clinical effect: DVH parameters of either the targets or organs at risk changed a few %

Brain	Prostate	Head&Neck
central leaf stuck in field		
energy change from 6 MV to 10 MV		
additional optimization step		
2 mm field shift	one leafbank opened 2 mm	one leafbank opened 2mm + 5.4% MU reduction

leaf error



additional optimization step



Error Detection with IQM

- ▶ Number of deviating fields (9-field plans) for the IQM signal deviation $>3\%$ ($>2\%$)

Type of Error	Brain	Prostate	H&N
leaf	6 (9)	2 (3)	2 (4)
energy	7 (9)	4 (9)	9 (9)
optimization	3 (4)	6 (7)	4 (5)
leafbank shift	0 (0)	9 (9)	0 (0)

field position changed

field size and MU changed

→ Only one undetected error!

- ▶ Remaining error would have been caught with thorough machine QA in addition to plan QA!
- ▶ IQM as a **daily machine QA constancy test?**

Comparison to other QA tools

- ▶ Error plans were also measured with other QA tools
- ▶ IQM error detection superior to other QA procedures!

Type of Error	Brain	Prostate	Head&Neck
leaf	6 (9)	2 (3)	2 (4)
energy	7 (9)	4 (9)	9 (9)
optimization	3 (4)	6 (7)	4 (5)
leafbank shift	0 (0)	9 (9)	0 (0)

IQM
3% (2%)

Type of Error	Brain	Prostate	Head&Neck
leaf	-7,3	-7,9	-0,4
energy	+4,3	+2,9	+4,8
optimization	+0,2	-2,1	+0,3
leafbank shift	0	+1,2	-1.0

ionization chamber
in cube phantom
±3%

Type of Error	Brain	Prostate	Head&Neck
leaf	94.8 (89.9)	96.1 (93.0)	96.9 (93.3)
energy	96.4 (90.6)	99.4 (95.4)	99.8 (98.1)
optimization	99.0 (95.7)	96.0 (86.2)	96.4 (90.7)
leafbank shift	98.7 (95.8)	90.1 (77.4)	97.4 (91.3)

γ evaluation
on cylindrical phantom
3%/3mm>98% (2%/2mm>95%)

Conclusions

- ▶ IMRT signal agreement with calculation:
-0.2% ($\pm 1.3\%$)
- ▶ Long field agreement:
+0.4% ($\pm 1.4\%$)

- ▶ IQM can be used for **field sizes up to 40x40 cm**
- ▶ very limited user-interaction necessary

- ▶ IQM showed a higher error detection rate:
3% action level, **2% warning level**

- ▶ Ongoing projects:
 - Analysis for VMAT is in progress
 - daily constancy test for machine QA with IQM

An aerial photograph of a city, likely Göttingen, Germany, showing a dense urban area with a prominent university campus. The campus features several large, multi-story buildings with red-tiled roofs and a central tower. The city is surrounded by green fields and forests. A major highway with multiple lanes is visible in the foreground, curving around the city. The entire image is overlaid with a semi-transparent blue filter. The text "Thank you for your attention!" is centered in the image in a dark blue, sans-serif font.

Thank you for your attention!