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IMRT plan QA with the IQM detector

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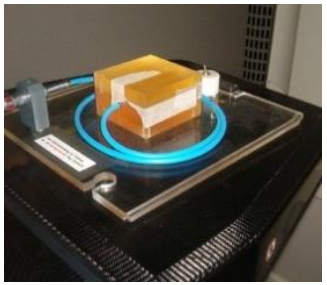
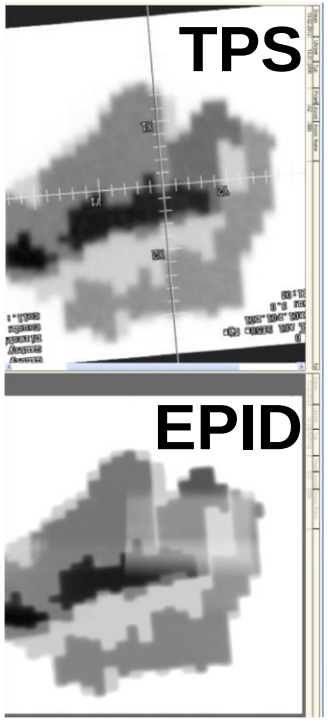
(De-)Motivation for IMRT-QA

- Why we measure every plan
  - Mandatory: guidelines, task group reports, DIN
  - Finding the one faulty plan in 50 plans[1]

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



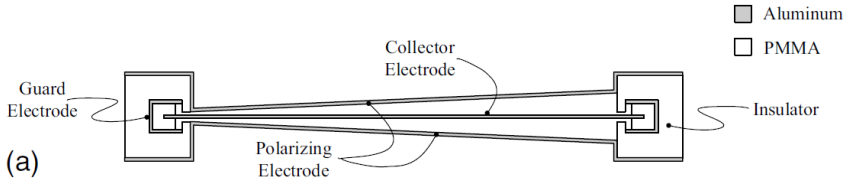
- Why we (sometimes) wish we did not
  - Finding reasons for deviations is **time-consuming**
  - Too many false alarms, often caused by user-error



→ demand for an easy-to-use QA tool

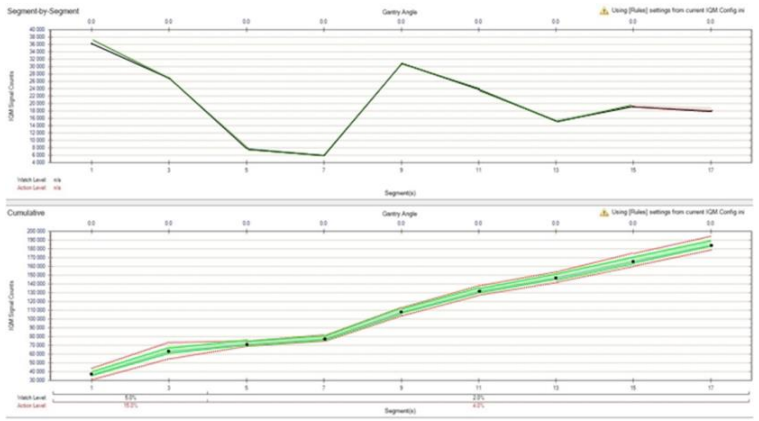
The IQM detector

- **Position-weighted dose-area product**
- inclination in MLC movement direction
- Attached to gantry
- Includes barometer, thermometer and inclinometer
- Bluetooth connection to workstation



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

- **Signal per segment and cummulative signal per field are compared to calculation**
- uses Dicom RTPlan for calculation
- detector commissioned using a variety of field sizes and shapes

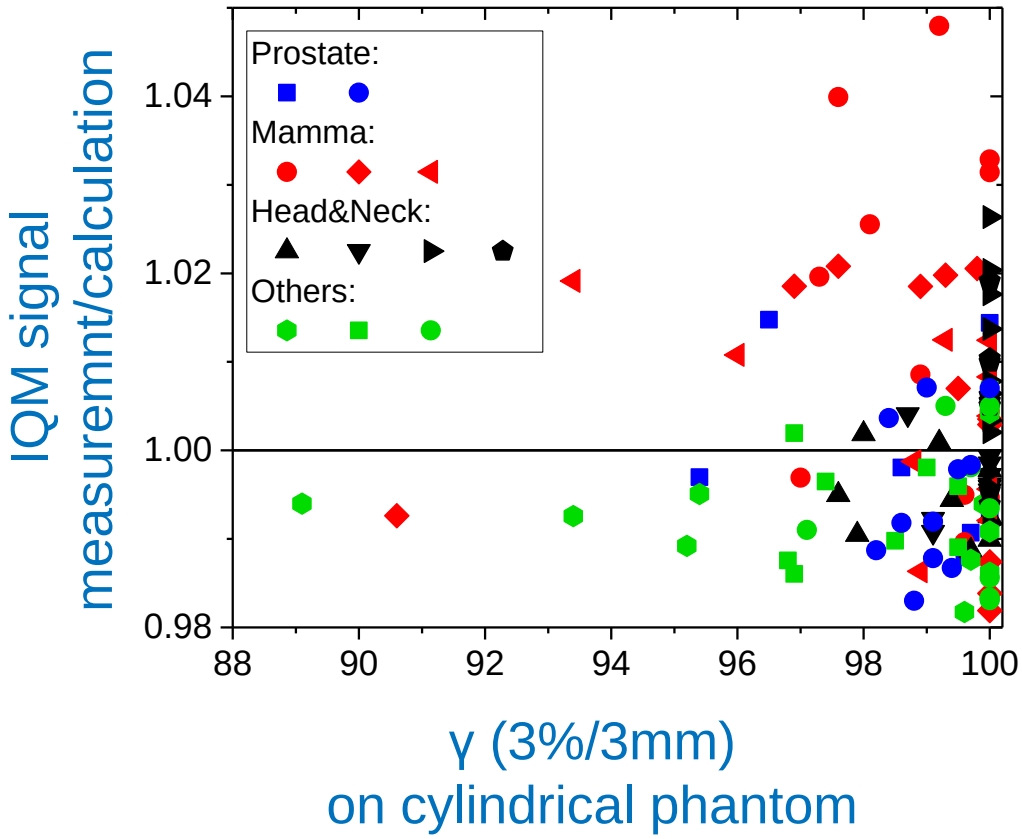


Evaluation of IQM

- 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

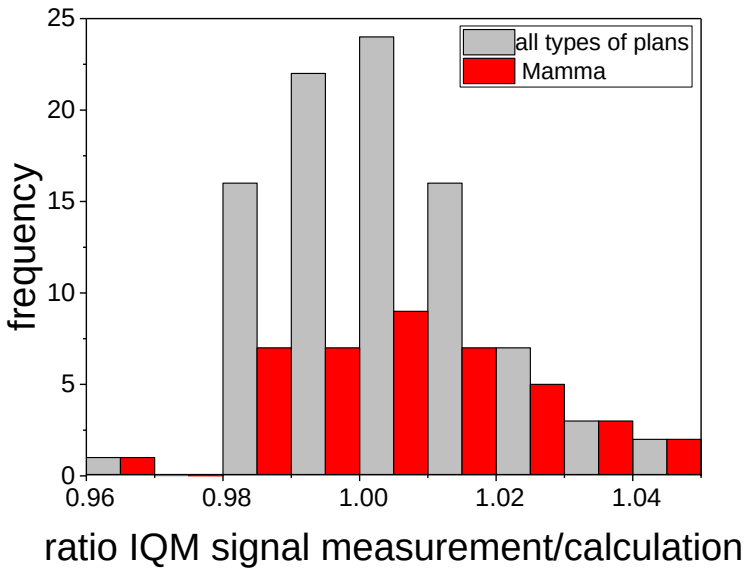
The full spectrum of IMRT fields with IQM

- Over 100 fields of different plan types were measured and compared against the calculation
- Agreement with calculation:
  -0.2% (±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% (±1.4%)**

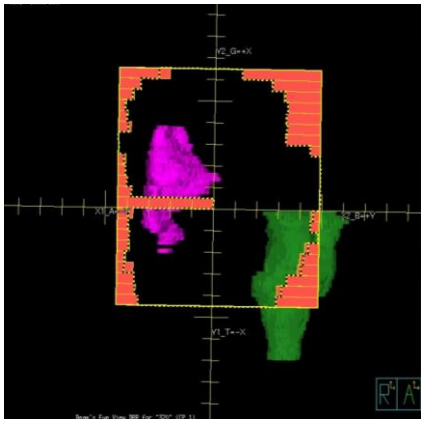
→ IQM can be used for long field IMRT

Induced errors

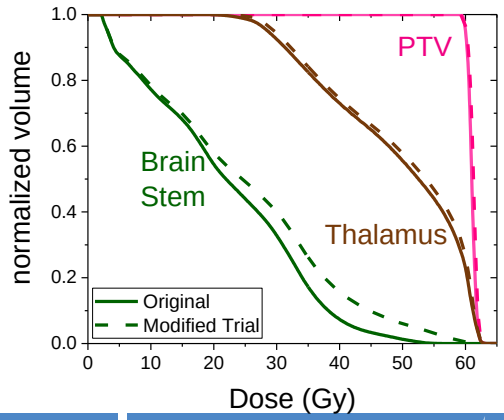
- 3 clinical plans were modified
- Errors had a clinical effect:
  DVH parameters of either the targets or organs at risk changed a few %

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% (±1.3%)
- Long field agreement:
  +0.4% (±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


Thank you for your attention!