IMRT: Patient Specific QA

ICPT School on Medical Physics for Radiation Therapy

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IMRT Patient Specific QA Overview

- Discussed in prior lecture(s):
  - general strategies for verifying patient IMRT & VMAT plans
  - types of detectors & technologies for pre-treatment IMRT & VMAT QA measurements
- To be discussed here:
  - defining an IMRT patient specific QA program
  - independent dose calculations
  - alternative & new verification strategies
  - in vivo verification strategies
    - verification via imaging
    - in-vivo dosimetry
  - QA analysis

Defining an IMRT patient specific QA program

- Determining a pre-treatment verification procedure should be performed as part of IMRT commissioning
- Similar measurement tools can be used as those used to verify dose during IMRT commissioning

Defining an IMRT patient specific QA program

Commissioning: need to determine methods & criteria for per-plan pre-treatment verification

1. what detector & geometry? phantom / air?
    1. is the measurement noise at an acceptably low level?
    2. is the detector & geometry adequately sensitive to dose discrepancies
2. what comparison analysis to be used?
    1. dose difference (1D, 2D, & 3D)
    2. distance to agreement (2D & 3D)
    3. gamma analysis (1D, 2D, & 3D)
    4. others?
3. what acceptance criteria is acceptable / expected?

Review of
Dose Delivery Verification Methods

Phantom based verification:

1. IMRT plan is recalculated on the “phantom” geometry to be used for verification measurements
2. Plan is delivered in phantom geometry & dose measured
3. Planned & delivered dose are compared

- 1D:
  - Point dose & dose profiles measurements
  - Ion chambers
- 2D:
  - Radiographic film
  - Radiochromic film
  - Computed radiography
  - Detector arrays
    - Ion chamber / diode detector arrays
    - EPIDs
- 2D+:
  - Detector arrays in multiple planes
- 3D:
  - Gel dosimeters
  - Polyurethane dosimeters

Point Dose Verification with Ion Chamber: Procedure

1. Measure charge at known conditions (Q_{ref}) (10x10cm field, reference SSD & depth, etc.)
2. Measure charge at point in IMRT plan (Q_{IMRT})
3. $D_{IMRT} = D_{ref} \times Q_{IMRT} / Q_{ref}$
4. Compare measured D_{IMRT} to D_{IMRT} from the TPS

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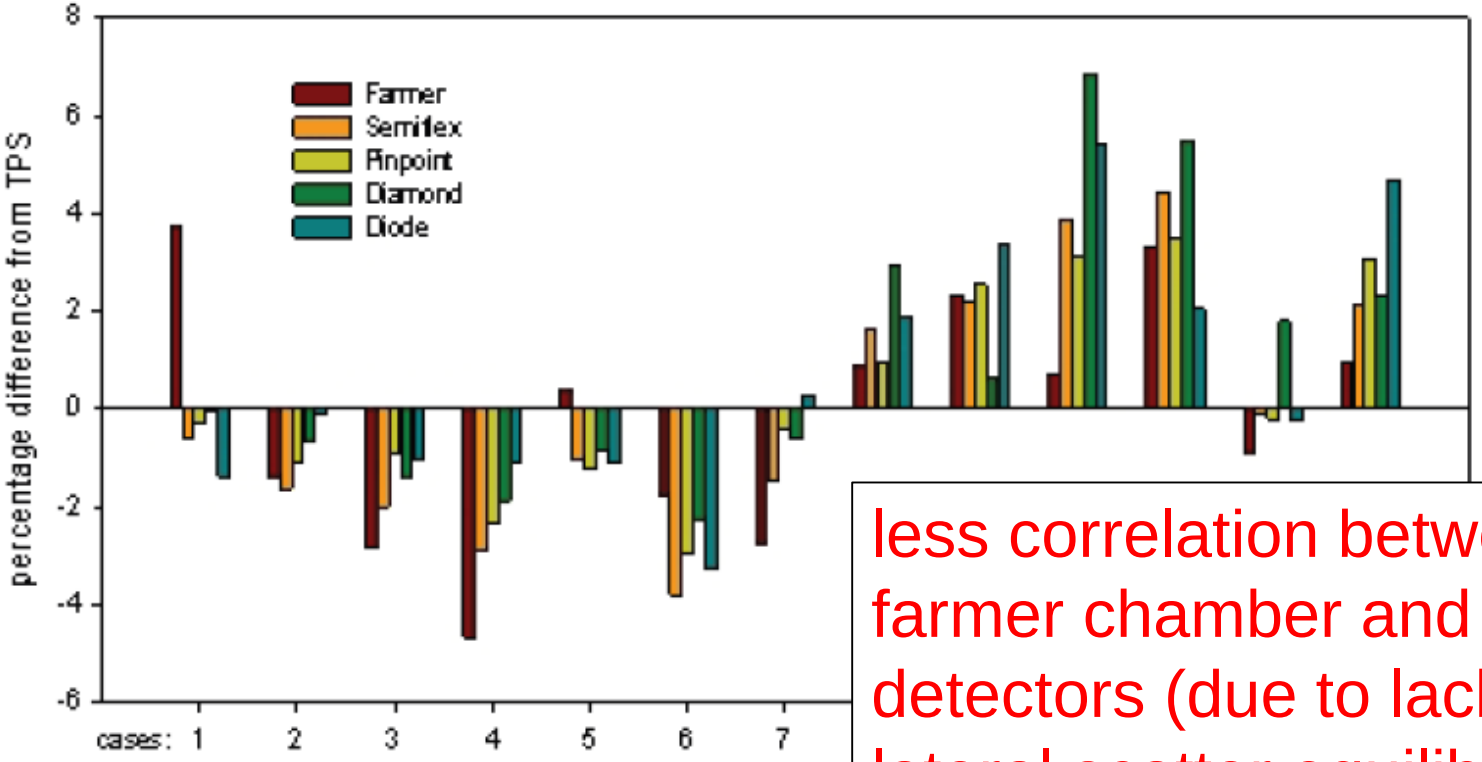
Point dose verification via ion chamber



less correlation between farmer chamber and other detectors (due to lack of lateral scatter equilibrium)

Figure 3.2 Relative differences between dose values measured with various types of detectors and calculations performed with two types of TPS. Cases 1-7 were irradiated with step-and-shoot techniques, while cases 8-13 represent sliding window IMRT treatments

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Point Dose Verification with Ion Chamber: Uncertainties

- Differences in stopping power ratios (between IMRT & reference conditions) can be assumed to be negligible
- Dose differences up to 9% can exist for measurements in penumbra region & small IMRT segments
- Minimize errors by:
  - Using small volume ion chamber
  - calculating dose to a volume rather than a point in the TPS
  - avoid measurement in areas with large dose gradient
- Using a small volume chamber, standard uncertainty is 1.0-1.5%

Point Dose Verification: Other Detector Choices

Solid state detectors:

- energy & dose rate dependence cause uncertainties
- diamond detectors not recommended for IMRT verification due to required pre-irradiation dose

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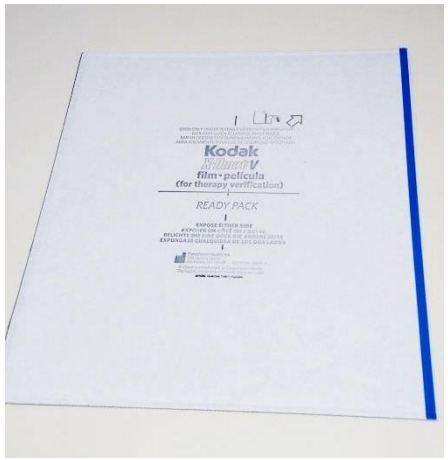
2D Verification: Measurement Options

- Integrating Measurements
  - Radiographic film (silver halide)
  - Radiochromic film (radiation sensitive dye, e.g. diacetylene monomer)
  - Computed radiography
- 2D Arrays
  - Diode / ion chamber arrays
  - Electronic Portal Imaging Devices

2D Verification: Radiographic Film

- High spatial resolution
- EDR2 preferred over XV2 due to increased dose range
  - XV2 saturates above 2Gy
- Uncertainties exist due to lack of water equivalence & energy dependence
  - can be minimized by measuring perpendicular to beam at set depth
- Requires measurement of sensitometric calibration curve



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2D Verification: Radiochromic Film

- Nearly tissue equivalent-> eliminates energy & directional dependence
- Auto processing
- Scanned with flatbed scanner-> maximum absorption in red, hence red channel often used exclusively
- GafChromic EBT dose range: 2-800cGy

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2D Verification: Radiochromic Film

Table 3.1 Working protocol for EBT radiochromic film dosimetry using a flatbed scanner (from Stuertewagen *et al*., 2008).

EPSON scanner protocol	EBT Gafchromic film protocol
Use a positioning frame to position the films on the same place	Use gloves to handle the films
Remove the positioning frame during scanning	Use tight-light envelopes for storage
Perform at minimum 5 successive scans before real measurements	Cut film pieces at minimum one day prior to irradiation
Turn the scanner off between the measurements	Use the films in portrait orientation
Use the same specifications in the EPSON software: professional mode, transparent document type, set 48-bit. colour correction off; select 150 dpi resolution	Scan the films before and after irradiation and use the net optical density for dosimetric evaluation
	After irradiation wait at least 4 hours to scan the films
	Use/select the red colour channel
	Use MatLab software to obtain and process the measured pixel-values; including a 2D correction for scanner inhomogeneities (due to variations in light scattering).

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2D Verification: Radiochromic Film

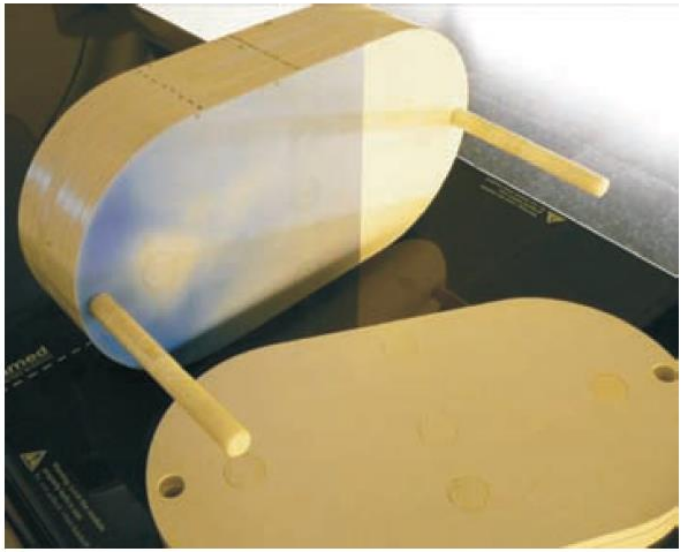

Figure 3.6 QUASIMODO CarPet phantom with Gafchromic EBT film after the delivery of a 5-arc IMAT treatment of an elongated tumour adjacent to the thorax wall.

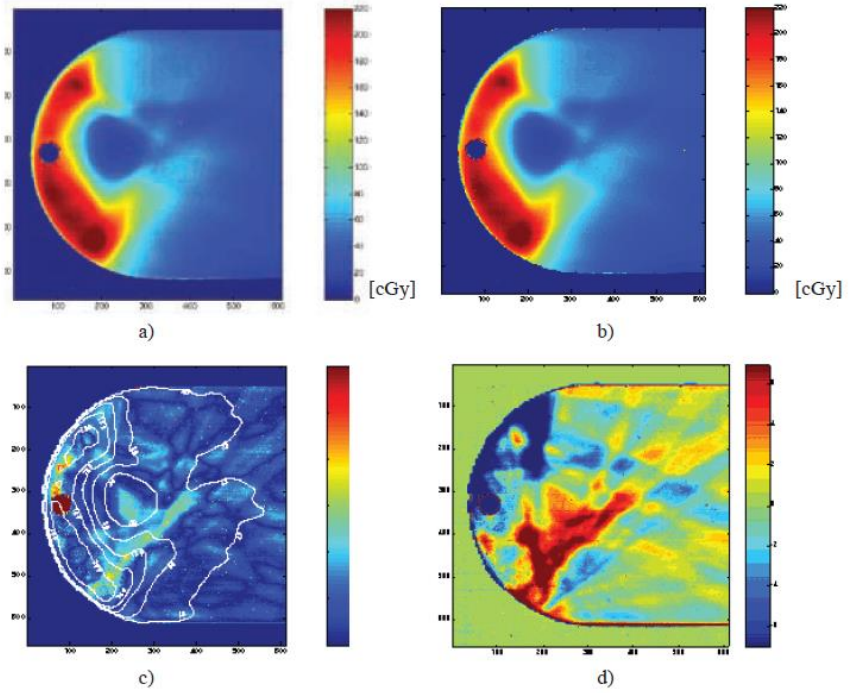

Figure 3.7 Comparison of a) computed and b) measured dose distribution using radiochromic film in the transverse plane through the isocentre. Panel c) shows the distribution of gamma values (3%, 3 mm) on which computed isodose lines have been superimposed. Panel d) shows the film-measured dose (panel b) minus the computed dose (panel a) expressed as a percentage of the reference dose (200 cGy).

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TG69: Radiographic film for megavoltage beam dosimetry (2007)
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Computed Radiography Film

- Active layer: photostimulable phosphor ($BaSrFBr:Eu^{2+}$)
- Inserted in light tight envelope to avoid signal decay from room light exposure
- semi-logarithmic dose response up to 150cGy
- energy dependent leads to over-response of low energy scatter

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2D Arrays:

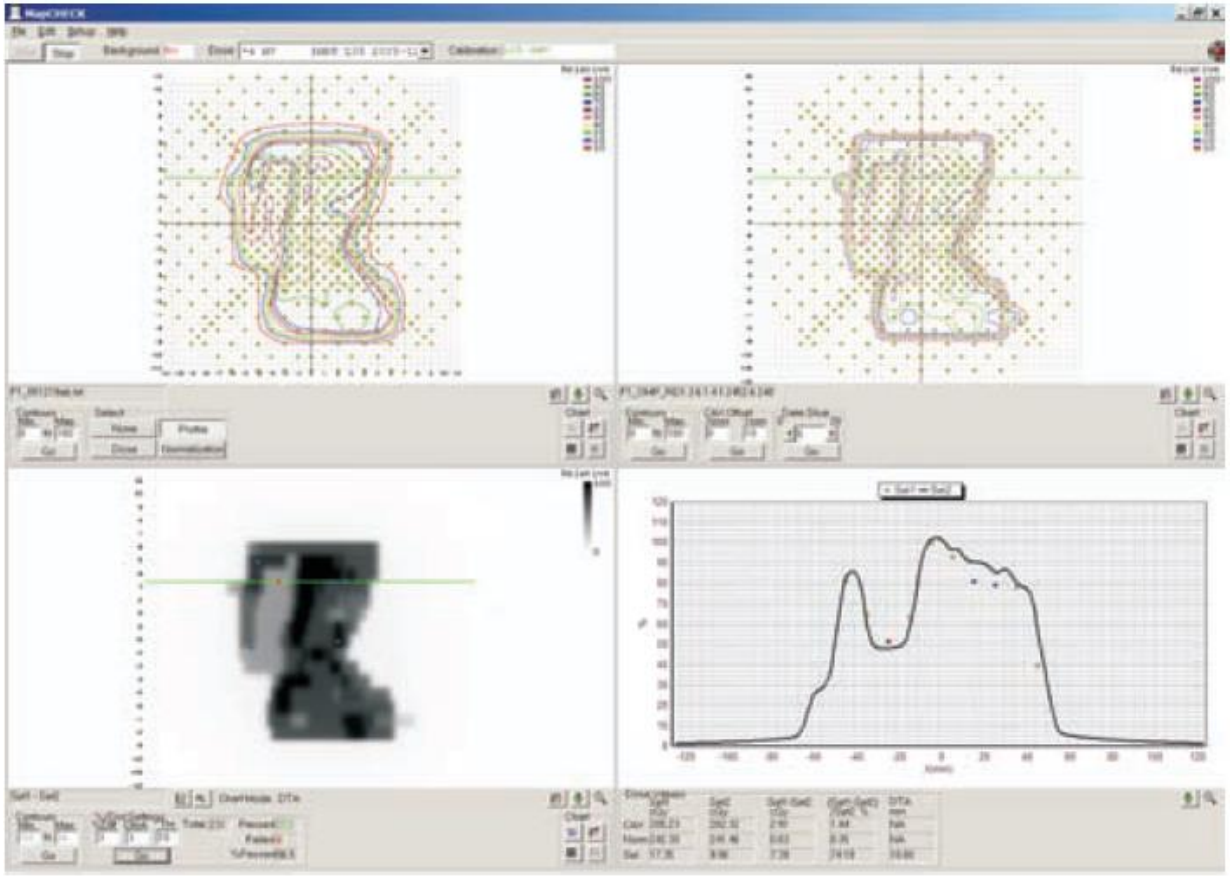

Figure 3.9 Verification of an IMRT treatment using a 2D detector array. Top left: measured isodose lines; top right: isodose lines calculated by the TPS. Bottom left: gamma evaluation of the two dose distributions; bottom right: beam profiles along the horizontal green line. At some points differences between the measured dose and the dose calculated by the TPS can be observed due to the finite spatial resolution of the detector array.

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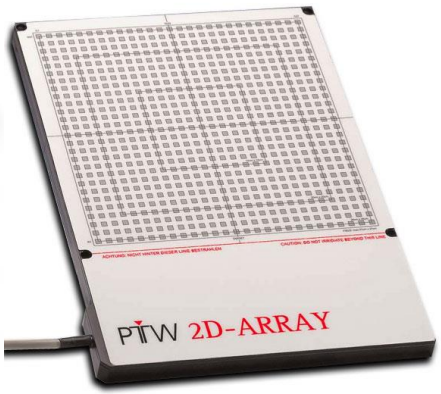
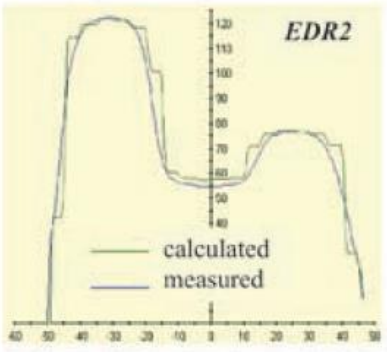
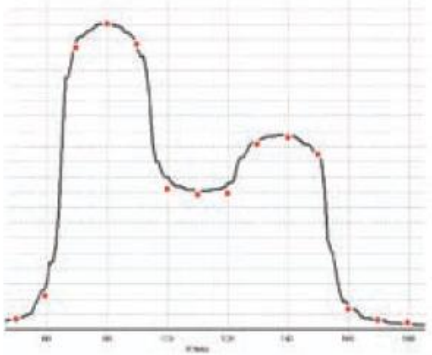
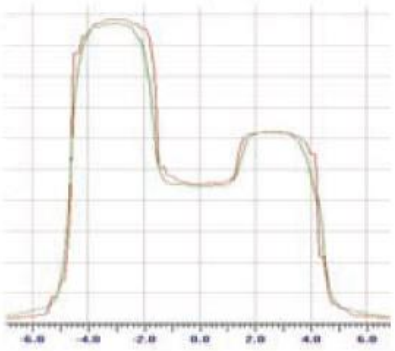
2D Detector Arrays









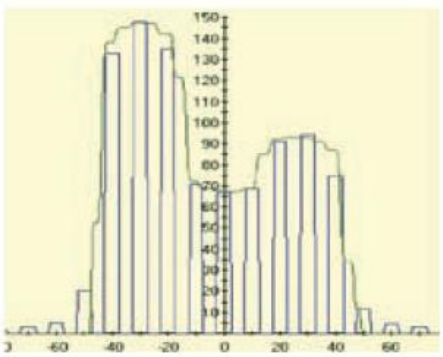


Figure 3.8 Example of an IMRT verification (for the same intensity profile) performed with different commercial 2D detector arrays. All intensity profiles marked as "calculated" refer to IM profiles obtained with the TPS. Measurements were made at 10cm water equivalent depth with radiochromic film (EDR2, left upper), a diode array (Mapcheck, right upper), a scintillation detector (I'mRT, left lower) and an ionisation chamber array (Seven29, right, lower). The 10 cm water equivalent depth included the inherent build-up of the 2D detector arrays. For comparison EDR2 film measurements are shown as well (from Wiezorek *et al.*, 2005).

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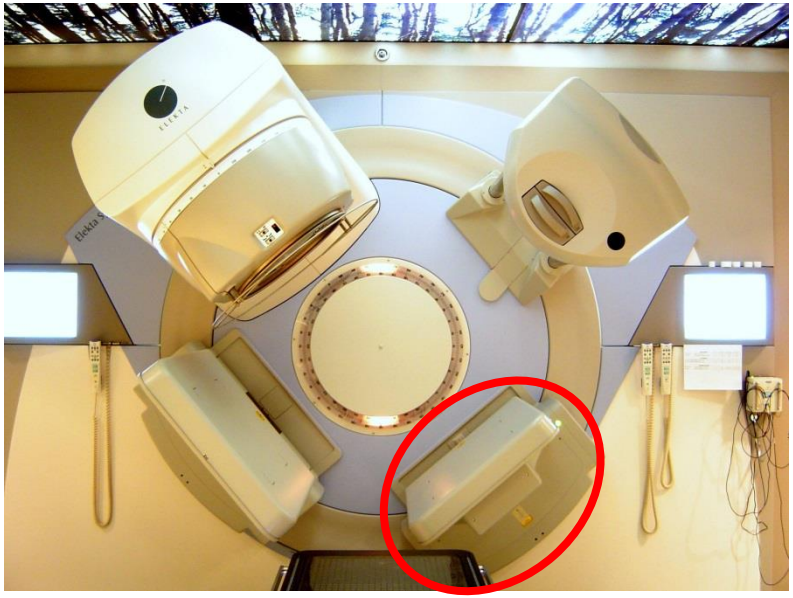
EPIDs

- CCD camera based systems (Philips SRI-100)
- Liquid filled matrix ion chamber (Varian, old design)
- **Amorphous Silicon (a-Si) flat panel**
  - Fast response
  - High spatial resolution
  - Subject to ghosting artifacts
  - Energy dependence



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File Edit View Insert Measure Portal Dosimetry Tools

Portal Dose Images

Plan: * C1_QA/QA_1PRI

Field | Session

- **Field: 1 LPO1**
  - 1 LPO1
  - MV_0_9: Fri 4/3/2015
    - Analysis: Sat 4/4/2015
- **Field: 2 LPO2**
  - 2 LPO2
  - MV_0_4: Fri 4/3/2015
    - Analysis: Sat 4/4/2015
- **Field: 3 LPO3**
  - 3 LPO3
  - MV_0_7: Fri 4/3/2015
    - Analysis: Sat 4/4/2015
- **Field: 4 LAO1**
  - 4 LAO1
  - MV_0_8: Fri 4/3/2015
    - Analysis: Sat 4/4/2015
- **Field: 5 LAO2**
  - 5 LAO2
  - MV_0_5: Fri 4/3/2015
    - Analysis: Sat 4/4/2015
- **Field: 6 LAO3**
  - 6 LAO3
  - MV_0_1: Fri 4/3/2015
    - Analysis: Sat 4/4/2015
- **Field: 7 RAO1**
  - 7 RAO1
  - MV_0_3: Fri 4/3/2015
    - Analysis: Sat 4/4/2015
- **Field: 8 RAO2**

Visibility Configuration

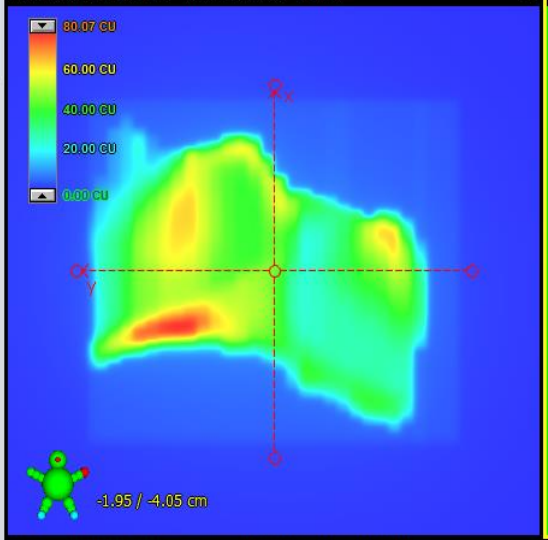
- [ ] Reference Image
- [ ] Graticule
- [ ] Field Outline
- [ ] Isodose Lines

Color Wash

Display Mode

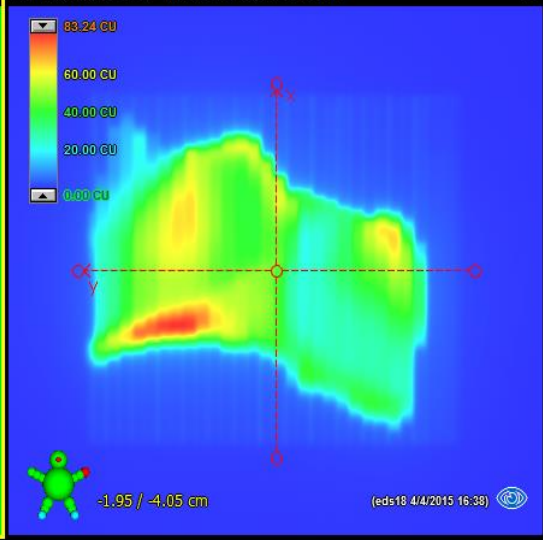
- ○ Predicted and Portal Dose
- ○ Portal Dose only
- ○ Predicted Dose only
- ○ Dose Difference
- ◉ Gamma Evaluation

Predicted Dose: 2 LPO2 - 4/3/2015 12:25 - 0 deg

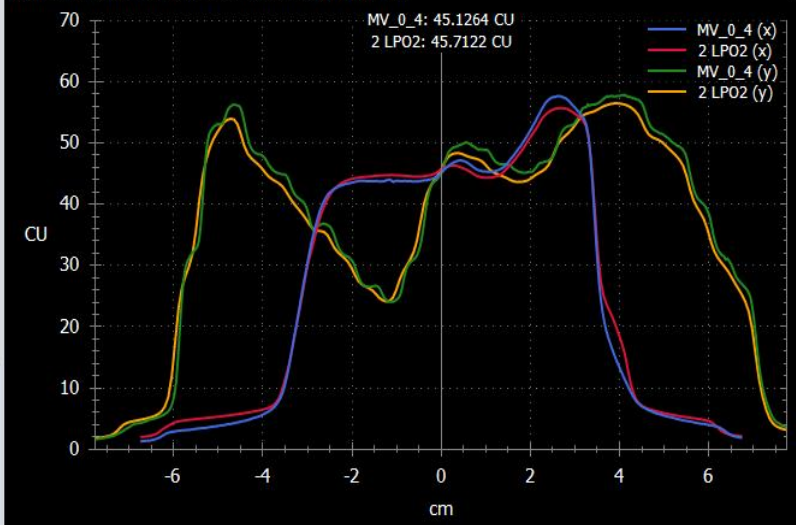


Gamma Evaluation: 2 LPO2 - MV_0_4 - 360 deg

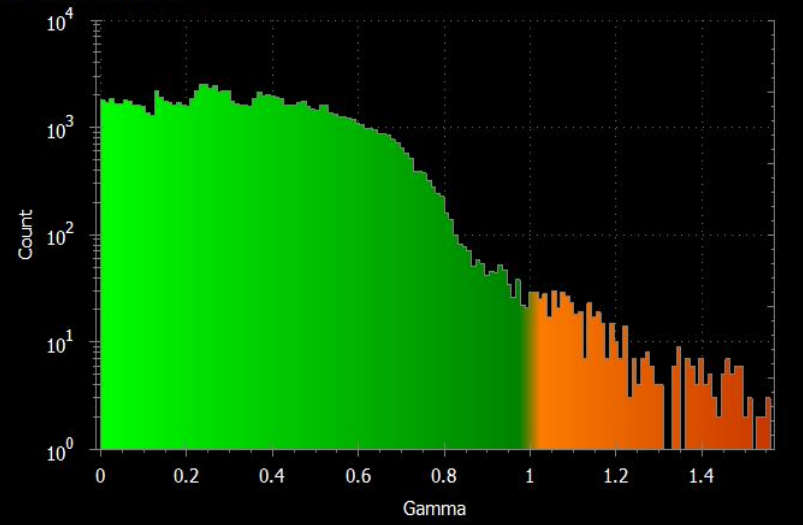
Portal Dose: MV_0_4 - 4/3/2015 21:22 - 360 deg



Profiles along Collimator Axes - Coll Rtn 90 deg (Varian IEC)



Histogram Gamma Evaluation



Gamma (3.0 %, 3.0 mm)	Value	Tol.	Abs. Dose Difference	Value	Tol.
Area Gamma < 1.0	99.5 %		Max. Dose Difference	14.16 ...	
Maximum Gamma	1.56		Avg. Dose Difference	1.47 CU	
Average Gamma	0.34		Area Dose Diff > 0.50 CU	79.7 %	
Area Gamma > 1.0	0.5 %	10.0 %	Area Dose Diff > 0.80 CU	64.8 %	
Area Gamma > 1.2	0.1 %				

Passed

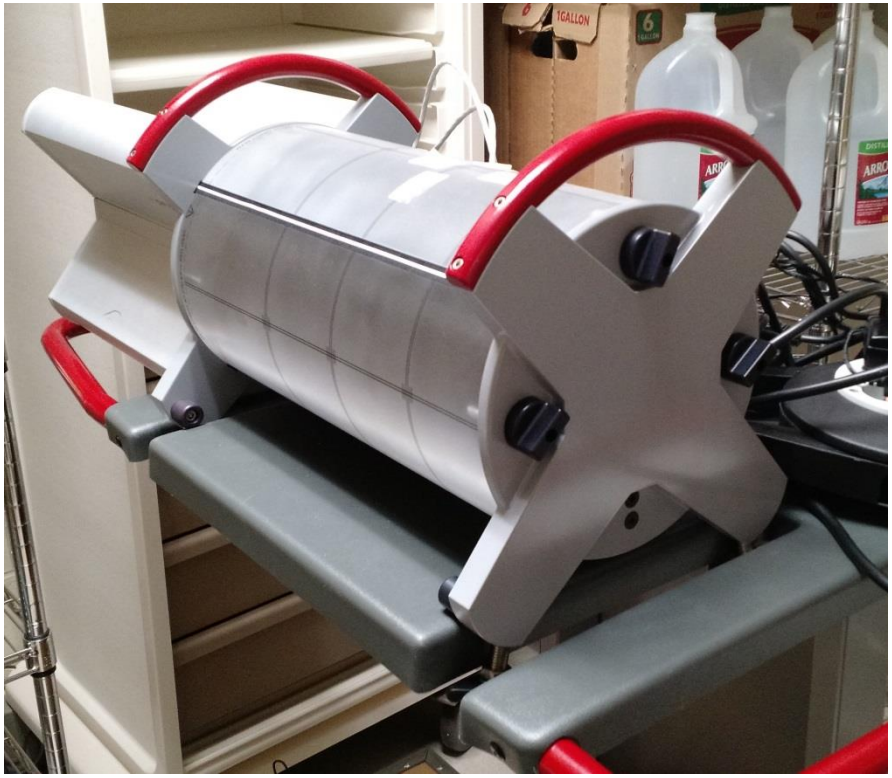
ROI

- ○ None ○ User defined
- ◉ Field +
- ○ MLC CIAO + 1.00 cm Options...
- ☑ Threshold 5.0 % Perform Analysis

Evaluation | Alignment | Normalization

Plan 'QA_1PRI', Field '2 LPO2'
Image 1 of 1

2D+ Arrays:
Detector arrays in multiple axes



Independent Dose Calculation for IMRT

Levels of verification

1. Verification by manufacturer of TPS
2. Verification by individual clinic during acceptance and commissioning
3. Pre-treatment verification per patient

Independent Dose Calculation for IMRT

- 3D treatments are traditionally verified by an independent “hand calculation” of the dose (typically at the prescription point)
- IMRT includes fluence modulation, making a hand calculation difficult or infeasible
- Independent calculation may be made instead using a sophisticated dose calculation algorithm
  - These may range from a simple calculation to Monte Carlo

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Independent Dose Calculation for IMRT

Task Group No. 219 - Independent Dose and MU Verification for IMRT Patient Specific Quality Assurance

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Committee Website | Committee Wiki | **Directory:** Committee | Membership

Email	You may send email to this group now using gmail or outlook. - or - You may save the address *2017.TG219@aapm.org* to your local address book. This alias updates hourly from the AAPM Directory.
Charge	To review and evaluate the algorithms of "independent/second check" of monitor unit calculations for IMRT. In light of the complexities of treatment planning and delivery, the TG will make recommendations on the clinical implementation of calculation programs (e.g., number of points, locations, accuracy, evaluation methods, and heterogeneities). Commissioning and benchmark QA of 2nd MU calculation programs, propose additional measurements, if necessary. Clinical testing and periodic quality assurance of 2nd MU calculation programs and recommendations on test tolerance.
Bylaws:	Not Referenced. **Rules:** Not Referenced.
Approved Date(s)	Start: 5/10/2011 End: 12/31/2017
Committee Keywords:	TG219
Most recent status update:	We will meet to produce a new version of the report during the annual meeting. We have been making slow progress and hopefully to have a reviewable version by the end of the year. - [7/23/2013 by Timothy Zhu] Click to update.

New and Alternative Verification Strategies

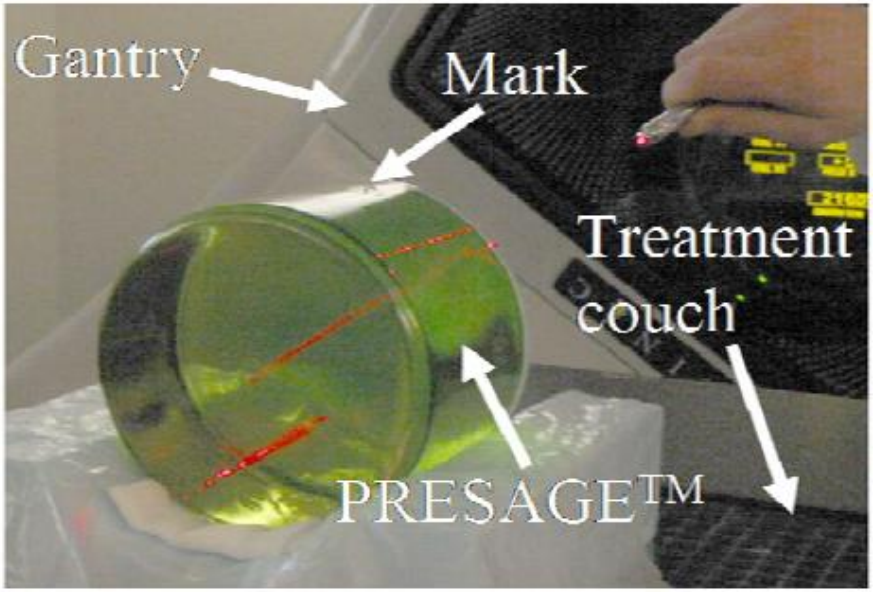
- 3D dosimetry
- In vivo portal dosimetry
- Log file analysis

3D dosimetry technologies

- Micelle hydrogels
- Radiochromic Turnbull Blue gel
- Polymer hydrogels (BANG)
- Radiochromic plastic (PRESAGE™)
  - Leucodyes and halogenated hydrocarbons are dissolved in polyurethane
  - does not exhibit diffusion
  - Optical attenuation rather than optical scatter-> allows for readout with accurate telecentric lens optical CT
- Polymer Gels
  - Dose induces a change in CT Houndsfield units!

Journal of Physics: Conference Series 250 (2010) 012043

3D Dosimetry



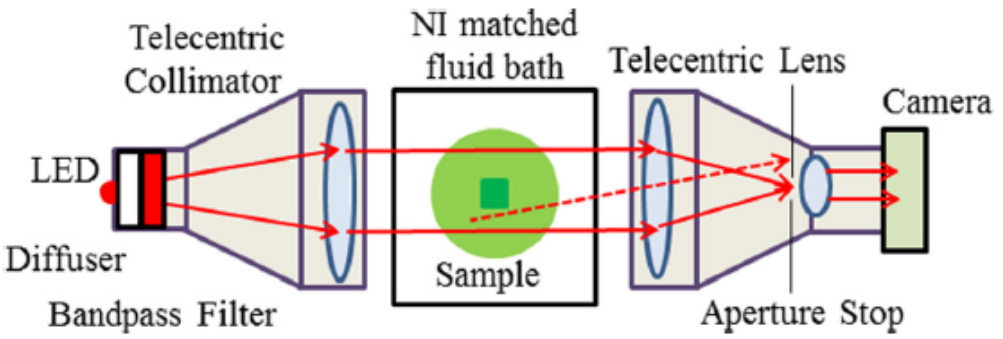


FIG. 1. Duke large field-of-view optical-CT scanner (DLOS). Light is collected by the matched telecentric imaging lens, which forms a precise image only from light rays that are parallel to the optic axis (with a 0.1° tolerance due to the aperture stop). Note rejected light rays due to the aperture such as the dashed scattered line. Each pixel in the image, measures the line-integral of optical attenuation through the dosimeter, with negligible scatter contamination upstream of the imaging lens.

New 3D dosimeters have overcome many of the challenges of prior 3D dosimeters: rigid, high resolution, no signal dispersion, no oxygen dependence

Dose can be read out quickly with new telecentric lens optical CT

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Medical Physics, Vol. 38, No. 8, August 2011

Journal of Physics: Conference Series **56** (2006) 221–224

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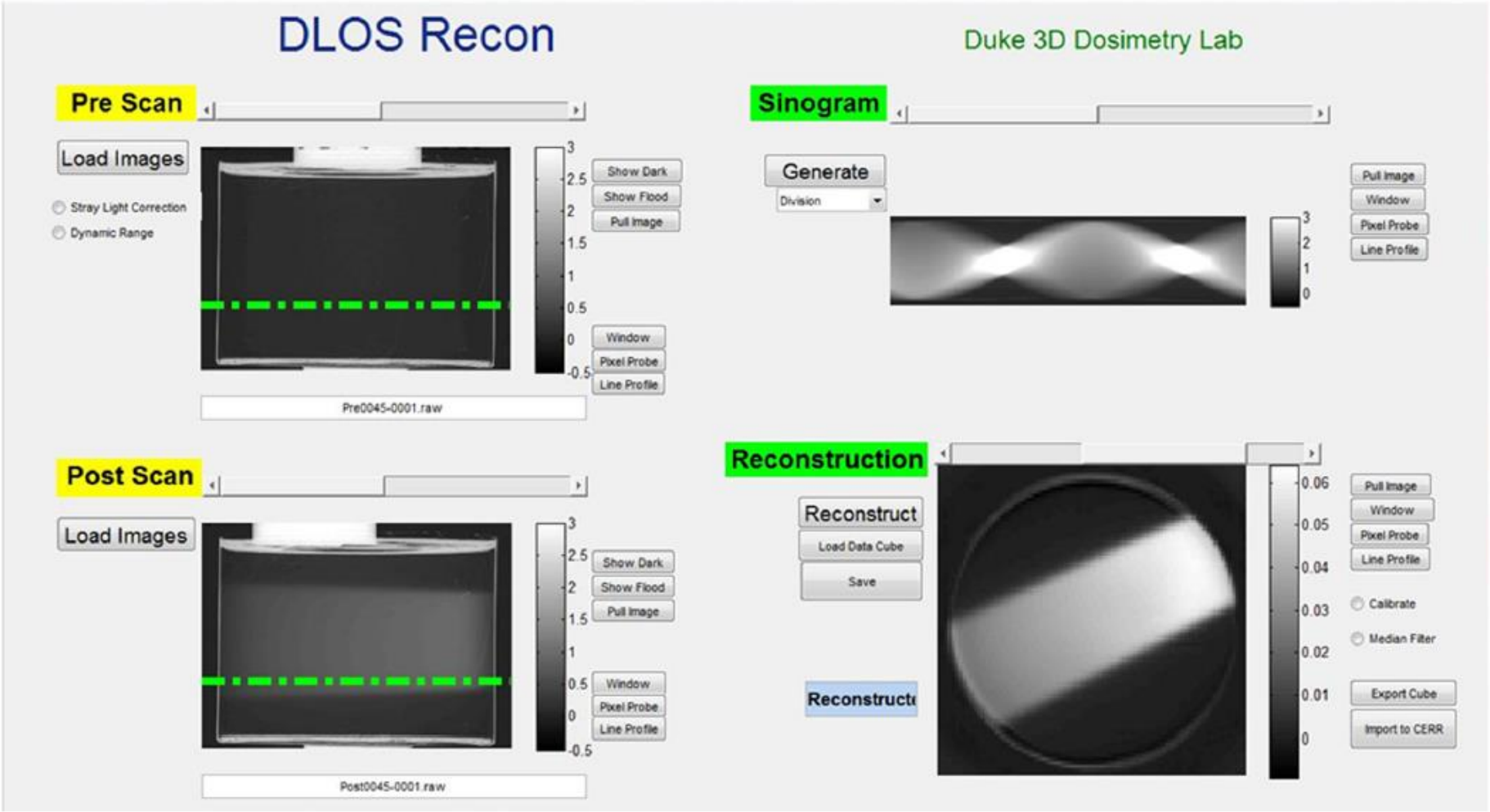
3D Dosimetry



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Medical Physics, Vol. 38, No. 8, August 2011

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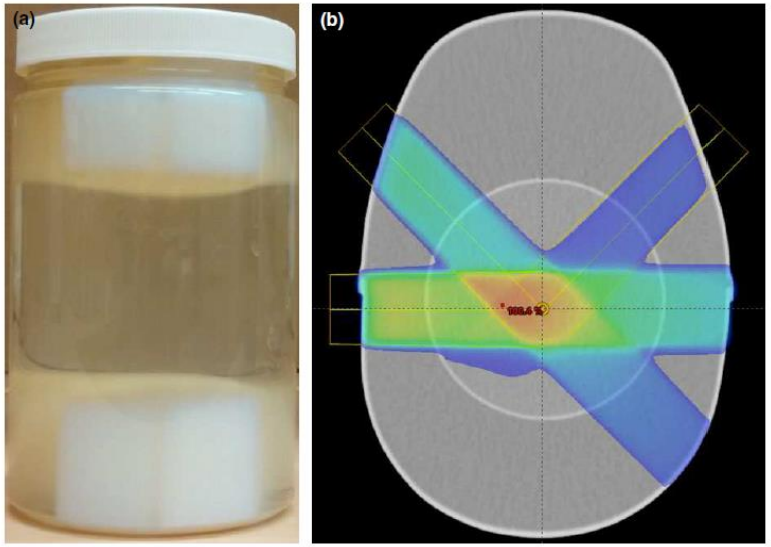
Polymer Gel Dosimeter

- Dose induces a change in CT Houndsfield units
- Can be read out using a standard CT scanner!



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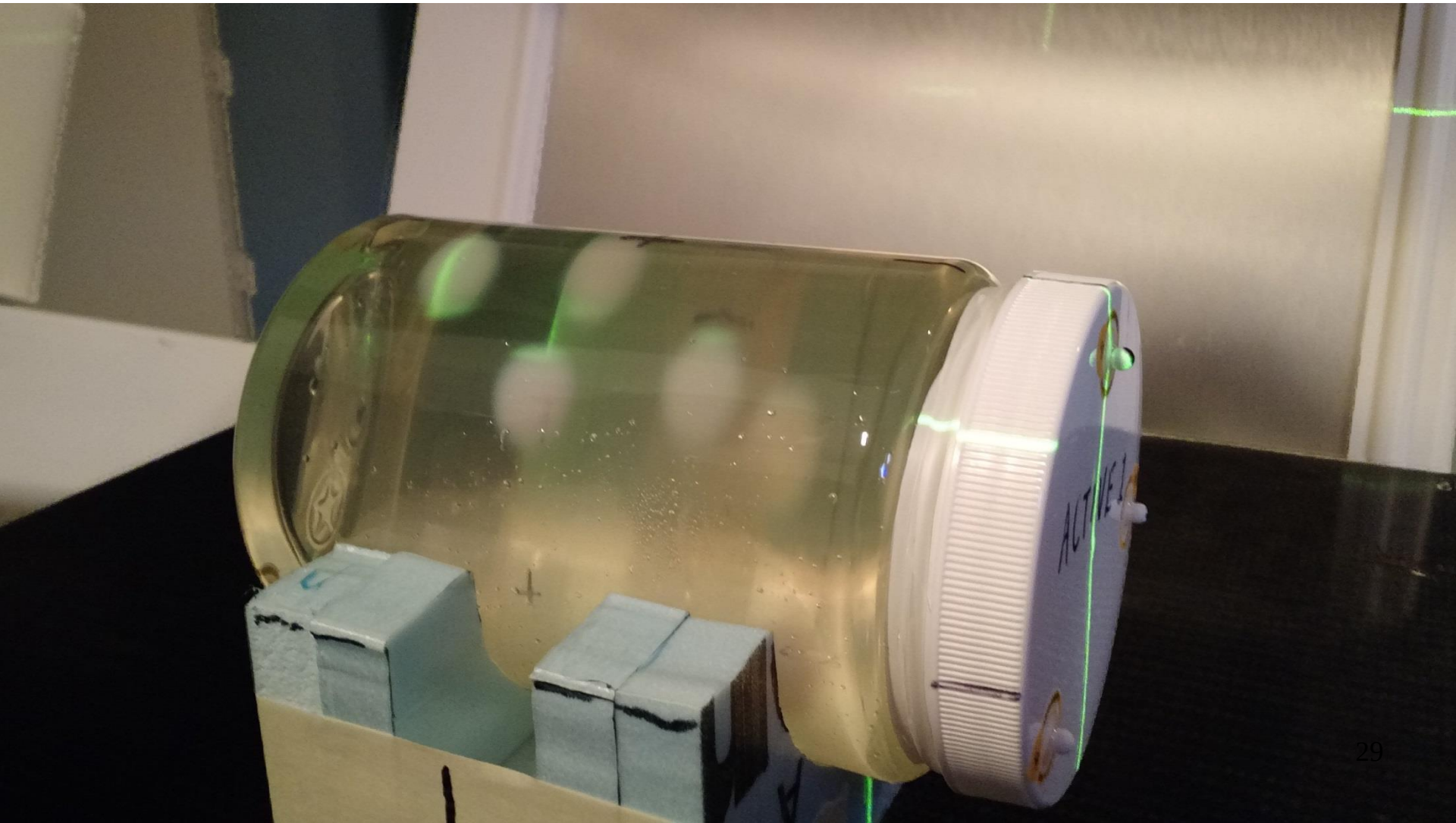
Medical Physics, 44 (2), February 2017

Polymer Gel Dosimeter



3D Dosimetry: Summary

Advantages

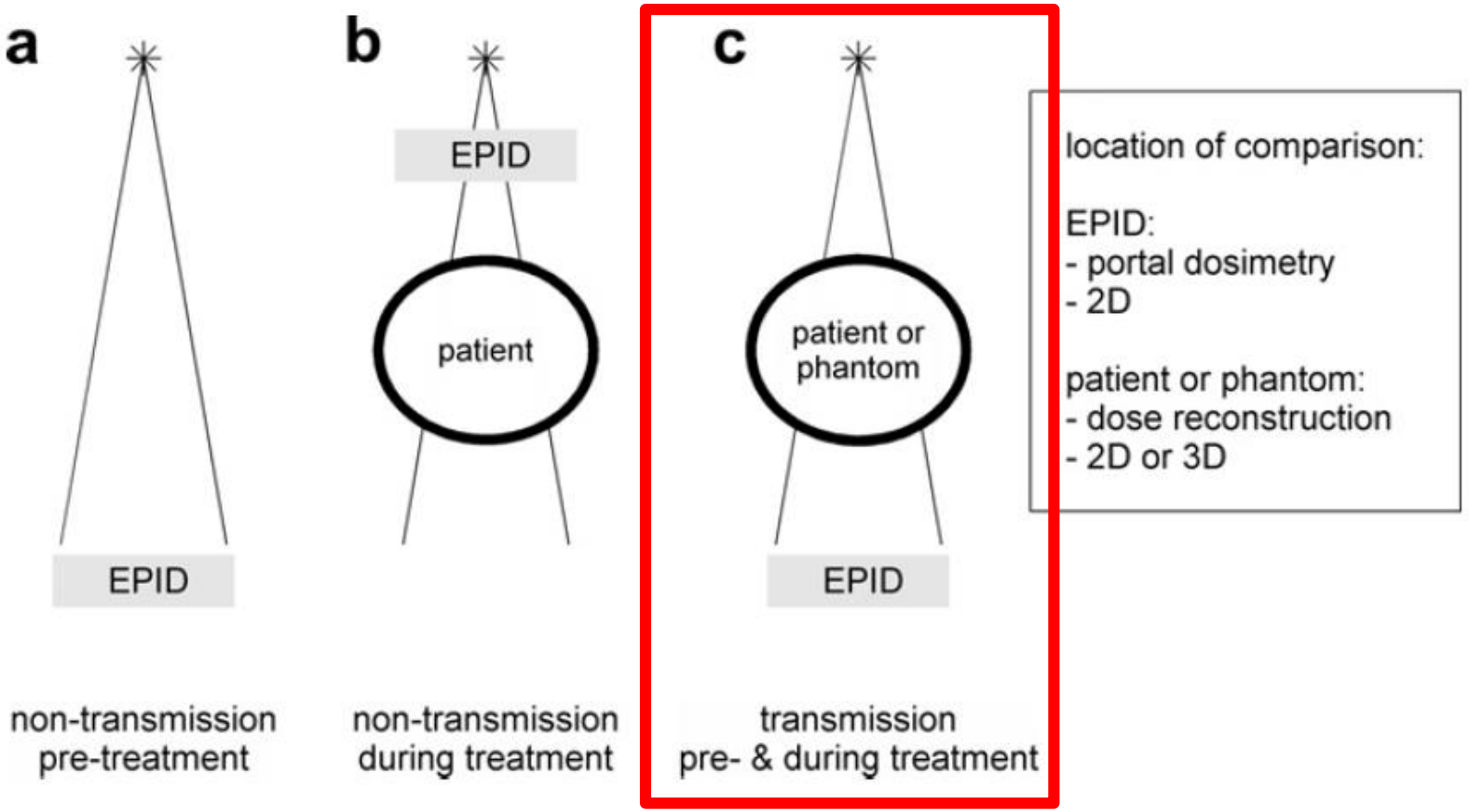
- Very comprehensive
- Often have very high spatial resolution
- Some types of 3D dosimeters can be created “in house”, making it an affordable option

Disadvantages

- Requires a lot of effort
- Can be noisy
- Dose accuracy can be batch dependent- often a measure of relative dose
- Readout usually requires access to either an optical CT system or an MRI
- Analysis often very involved, including registration of measured and delivered dose in independent software

Best use is likely for commissioning, rather than day to day use for every patient

In vivo portal dosimetry



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W. van Elmpt et al. / Radiotherapy and Oncology 88 (2008) 289–309

In vivo portal dosimetry

- Point dose verification
- 2D transit dose verification
  - at EPID level
  - at patient level
- 3D dose verification

In vivo portal dosimetry

Table 3
List of key references on transmission based dose verification methods at EPID level and patient/phantom level, as indicated in Fig. 2

Verification procedure	Position of verification: EPID or patient/phantom	Key references	Objective of verification or subject of the study
Point dose verification	Patient	Pasma [127]	Measured point dose distribution back-projected to the dose in a patient at 5 cm depth
	EPID and patient (in vivo)	Nijsten [128]	Measured point dose verified at EPID level and back-projected to the dose in a patient at 5 cm depth
	Patient/phantom (pre-treatment and in-vivo)	Chang [82], Piermattei [130,131]	Measured point dose back-projected to the dose in a patient at the isocentre
2D transit dose verification at EPID level	EPID	Pasma [132,141], van Elmpt [135]	Predicted transit portal dose distribution using measured beam data and the planning CT scan
	EPID	Kroonwijk [142]	Clinical results for prostate
	EPID	Dahlgren [139,140]	Predicted transit portal dose using the collapsed cone superposition method
	EPID	Spezi [145]	Portal dose image prediction using Monte Carlo calculations
	Extraction of entrance fluence	Hansen [150], Fielding [144], Vieira [143], Spies [148]	Extract entrance energy fluence
	EPID	McCurdy [67,136–138]	Predicted portal dose using Monte Carlo-based scatter kernels
	EPID	McNutt [152], Reich [34], Mohammadi [35,154],	Predicted portal dose using a TPS by adding the EPID to the planning CT scan (''extended phantom'')
2D transit dose verification at patient level	Patient/phantom (in vivo)	Essers [22,126], Kirby [156,157], Boellaard [81,158]	Reconstructed exit dose (3D CRT)
	Patient/phantom (in vivo)	Boellaard [159,160]	Reconstructed 2D midplane dose (3D CRT)
	Phantom (pre-treatment)	Wendling [76]	Reconstructed 2D midplane dose (IMRT)
	Patient/phantom (pre-treatment and in-vivo)	McDermott [161,162]	Clinical results for prostate IMRT
	Phantom (pre-treatment)	Talamonti [77]	2D verification (IMRT)
3D dose verification (dose calculated using a CT scan acquired from the planning stage or acquired 'in room')	Patient (planning CT)	Hansen [39]	Back-projected dose based on transmission EPID images and planning CT scan
	Patient (planning CT)	Jarry [163]	Back-projected energy fluence based on EPID images and a Monte Carlo calculation using the planning CT scan
	Patient (planning CT)	McNutt [123,124]	Combined EPID transit dose measurement and planning CT scan in an ''extended phantom'' using the TPS
	Patient (planning CT)	Louwe [166]	Reconstructed 3D dose distribution (breast)
	Patient (in room CT)	McDermott [167]	Reconstructed in vivo dose for rectal cancer patients using cone-beam CT scan
	Patient (in room CT)	Partridge [164]	Back-projected dose based on transmission EPID images and MV cone-beam CT

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In vivo portal dosimetry

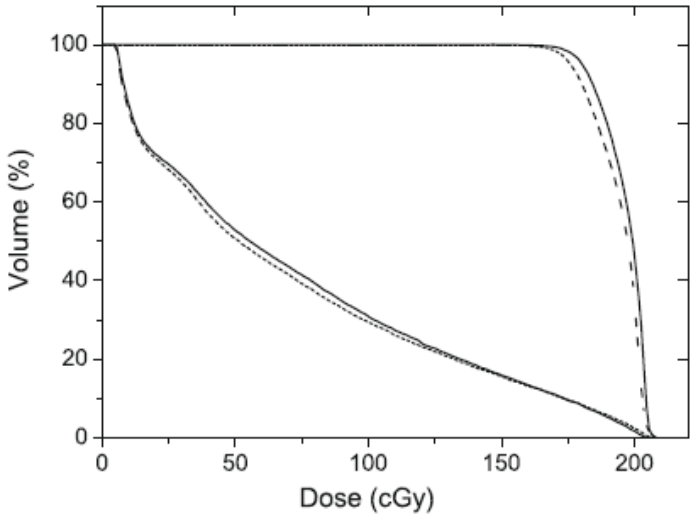

Fig. 5. DVHs of the PTV and the rectal wall from the *in vivo* verification of prostate plan A (Fig. 4). The planned and EPID-reconstructed dose distributions are represented by solid and dashed lines, respectively.

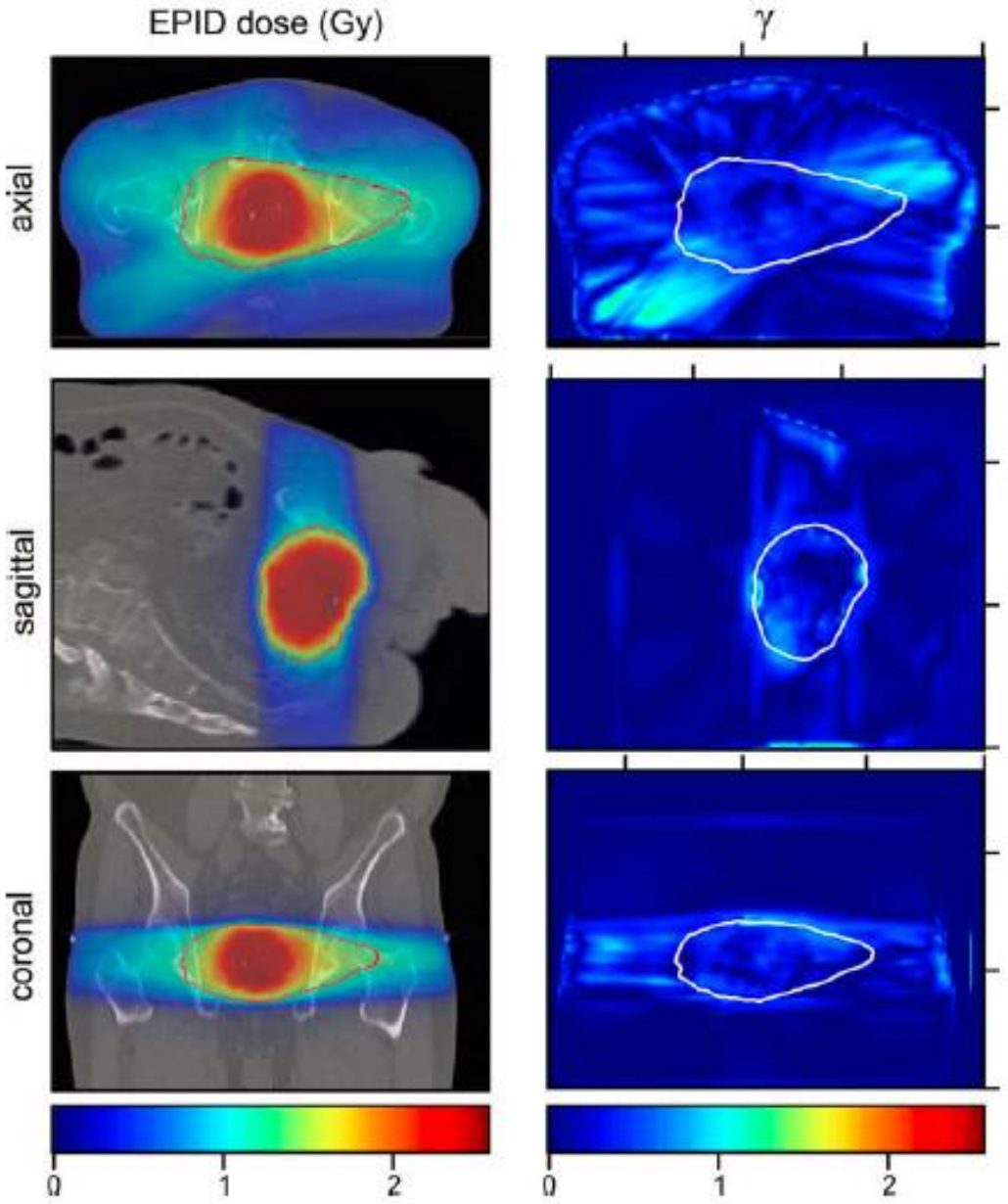

Fig. 4. *In vivo* verification of the first fraction of a VMAT treatment for prostate cancer. Indicated are the EPID-reconstructed dose distribution (left) and the γ-evaluation (right) in three orthogonal planes. The 50% isodose line is shown in red ite) on the dose (γ); the tick marks indicate 10 cm intervals.

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A. Mans et al. / Radiotherapy and Oncology 94 (2010) 181–187

In vivo portal dosimetry

Table 1. Overview of potential and limitations of various quality assurance methods for assessing routine dynamic intensity-modulated radiotherapy

	Suboptimal MLC parameters	Tongue and groove effect	MLC calibration	MLC single leaf delivery error	Inaccuracies in patient dose calculation algorithm	Overly modulated fluence	Patient setup
Ion chamber point dose	+/−	−	+/−	+/−	+	+/−	−
2D field by field							−
Film	++	++	+	++	+	++	
2D array	+	+/−	+/−	+/−	+/−	+	
2D composite plan	+/−	+/−	+/−	+/−	+/−	+/−	−
Phantom 3D array	+	+/−	+/−	+	+	+	−
Portal dosimetry	++	++	+	++	−	++	−
In vivo dosimetry	+/−	−	−	−	+	+/−	++
MU check programme	+/−	−	−	−	+	+/−	−

MLC, multileaf collimator; 2D, two-dimensional; MU, monitor unit.
++ means that the method is very sensitive to the error; + means that the error should mostly be visible with this method; +/− means that the error could be detected in theory but that it is unlikely to be visible in practice; − means that the error not be detected by this method.

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A J Vinall, A J Williams, V E Currie et al

In vivo portal dosimetry

- Can provide some very unique checks
- No extra dose or measurement time-> just use imager during treatment!
- Not widely available
- Analysis may be high maintenance *however*
- Some research papers report automatic 3D dosimetry for all patients!

Log file analysis

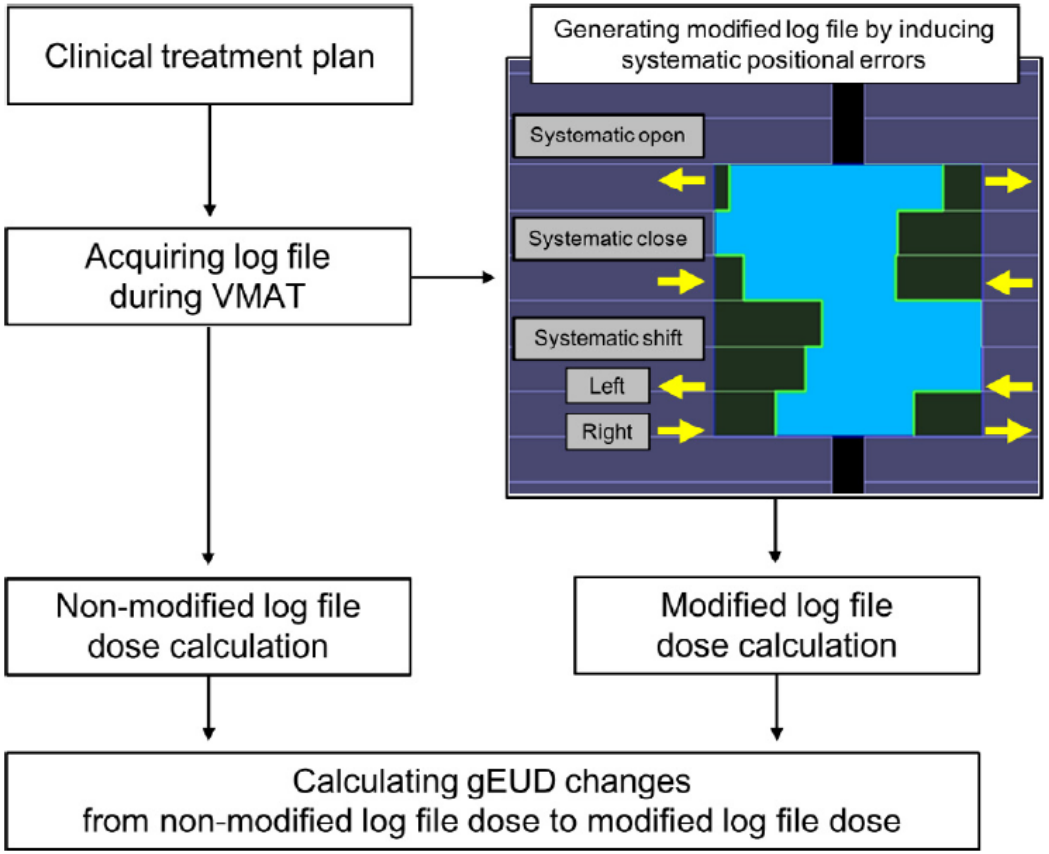

Fig. 2. Flow diagram showing the process of analysis.

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Y. Katsuta et al. / Physica Medica 32 (2016) 701–705

Log file analysis

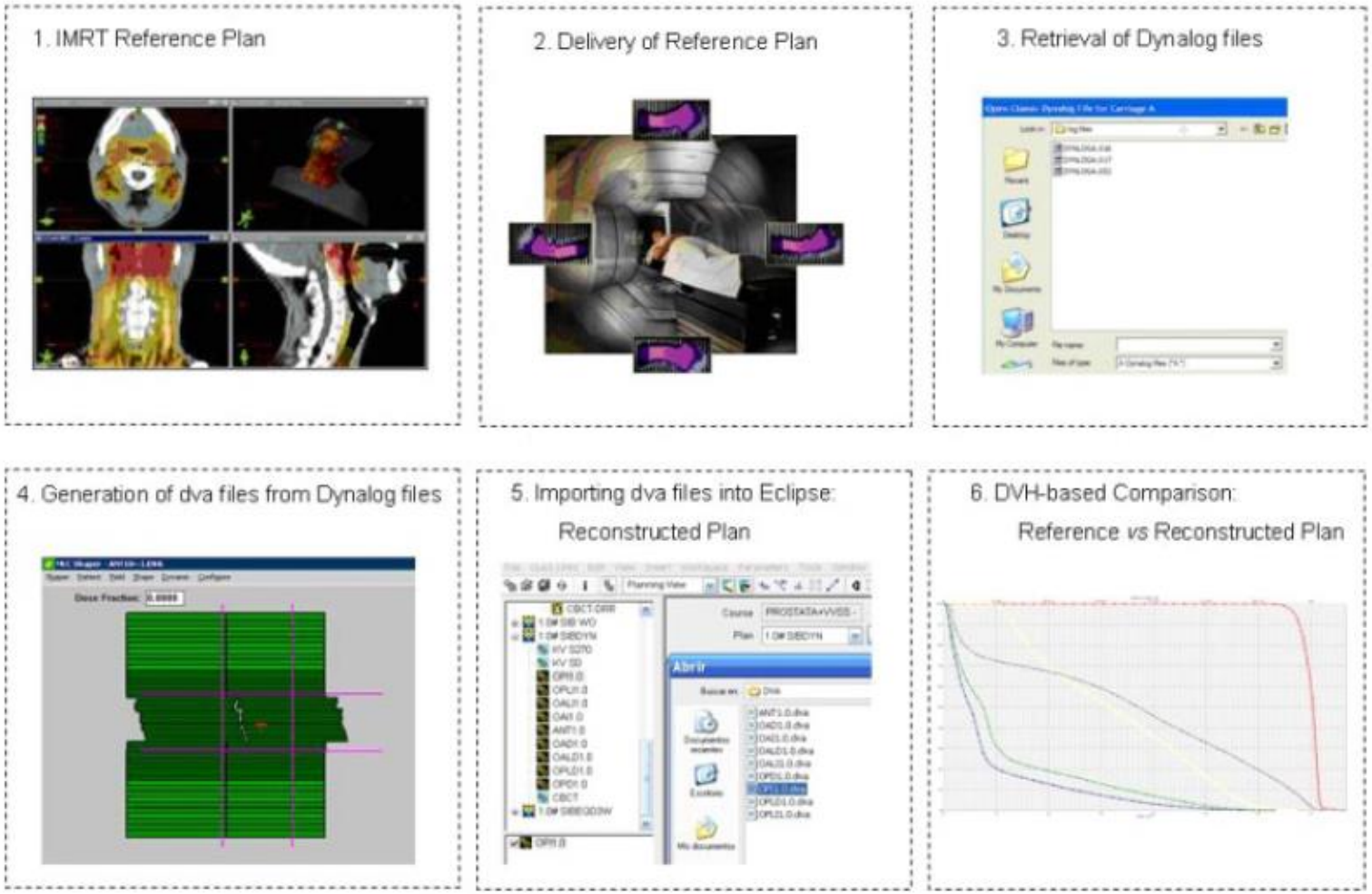


FIG. 1. Workflow of the patient dose-volume histogram–based IMRT QA procedure.

Log file analysis

Monitoring daily MLC positional errors using trajectory log files and EPID measurements for IMRT and VMAT deliveries

A Agnew[1], C E Agnew[1], M W D Grattan[1], A R Hounsell[1,2] and C K McGarry[1,2]

[1] Radiotherapy Physics, Northern Ireland Cancer Centre, Belfast Health and Social Care Trust, Northern Ireland, BT9 7AB, UK
[2] Centre for Cancer Research and Cell Biology, Queen's University Belfast, Belfast, Northern Ireland, BT9 7BL, UK

- Monitored both MLC positions (with EPID) and with log files for 1 year

Over the duration of the study, multiple MLC positional errors were detected using the EPID based software but these same errors were not detected using the trajectory log files. This work shows the importance of increasing linac specific QC when phantom-less methodologies, such as the use of log files, are used to reduce patient specific QC. Tolerances of 0.25 mm have been created for the MLC positional errors using the EPID-based automated picket fence test. The software allows diagnosis of any specific leaf that needs repair and gives an indication as to the course of action that is required.

Phys. Med. Biol. **59** (2014) N49

Log File Analysis: Summary

- Advantages:
  - Requires no extra measurement / hardware-> free additional information!
  - Provides very comprehensive details about machine delivery
  - Logistically relatively easy to convert into a dose / DVH based analysis
- Disadvantages
  - Requires the assumption that recorded values in log file are right (not an independent measurement)
  - Some types of errors may not be caught with log files-> results may be misleading?
  - Usually (but not always) relies on TPS dose calculation
    - tests dose difference due to errors in delivery
    - does NOT test accuracy of dose calculation

QA analysis
(for traditional pre-treatment IMRT QA)

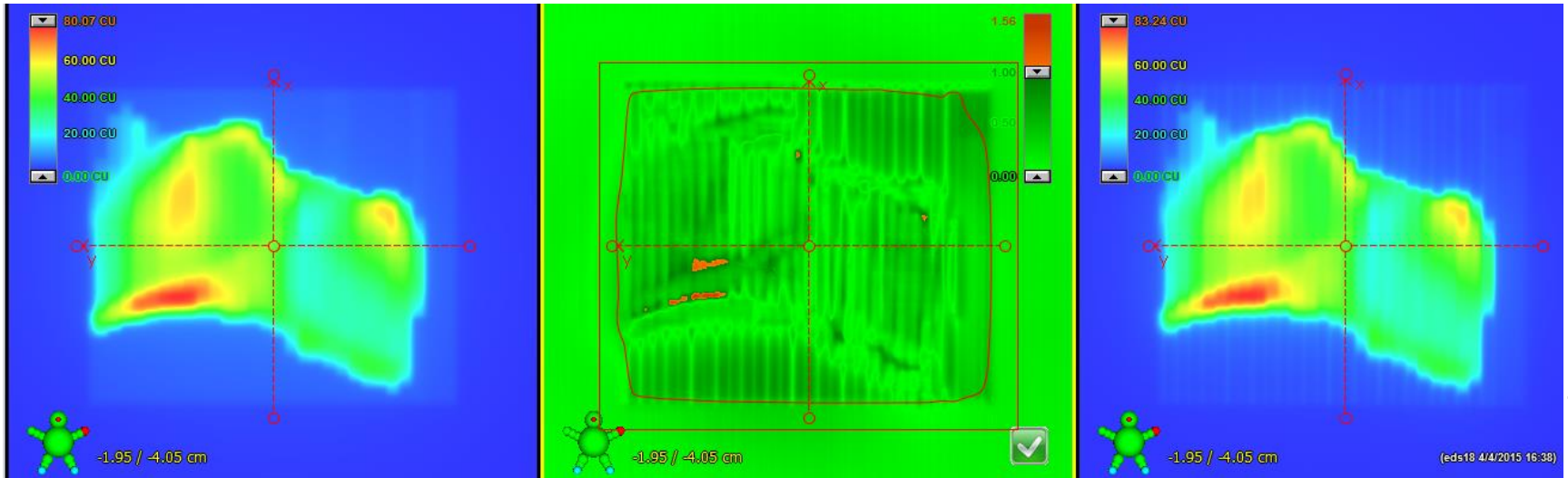
- Most analysis is based on Gamma Index

$$\Gamma = \sqrt{(\Delta d/d_0)^2 + (\Delta x/x_0)^2}$$

  - d is dose, x is distance
- Other alternative exist
  - Dose difference (no spatial component)
  - Distance to agreement (no dose component)

QA analysis
(for traditional pre-treatment IMRT QA)

- Factors to consider when selecting a QA criteria:
  - Limitations of dose calculation algorithm
  - Dose and spatial resolution and noise of detector (what is achievable?)
  - Ultimate dosimetric effect of spatial & dose inaccuracies on treatment plan (what is a reasonable uncertainty to accept based on expected clinical outcome?)



QA Analysis
(for traditional pre-treatment QA)

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 8, NUMBER 3, SUMMER 2007

A survey on planar IMRT QA analysis

Benjamin E. Nelms[1,a] and Jeff A. Simon[2]

TABLE 1. Intensity-modulated radiotherapy quality assurance survey, general methods

Subject/question	Answer options
How often do you use single gantry angle, composite IMRT QA? (i.e. All fields irradiated at normal incidence, added together.)	Never. I always do field-by-field analysis.
	Less than 25% of patients
	25–49% of patients
	50–74% of patients
	75–100% patients
Frequency of absolute dose analysis vs. relative dose analysis	I never use absolute dose analysis.(I always use relative dose analysis.)
	I use absolute dose analysis, but less than 50% of the time.
	I use absolute dose analysis approximately 50–74% of the time.
	I use absolute dose analysis approximately 75–99% of the time.
	I use absolute dose analysis 100% of the time.

IMRT QA Analysis

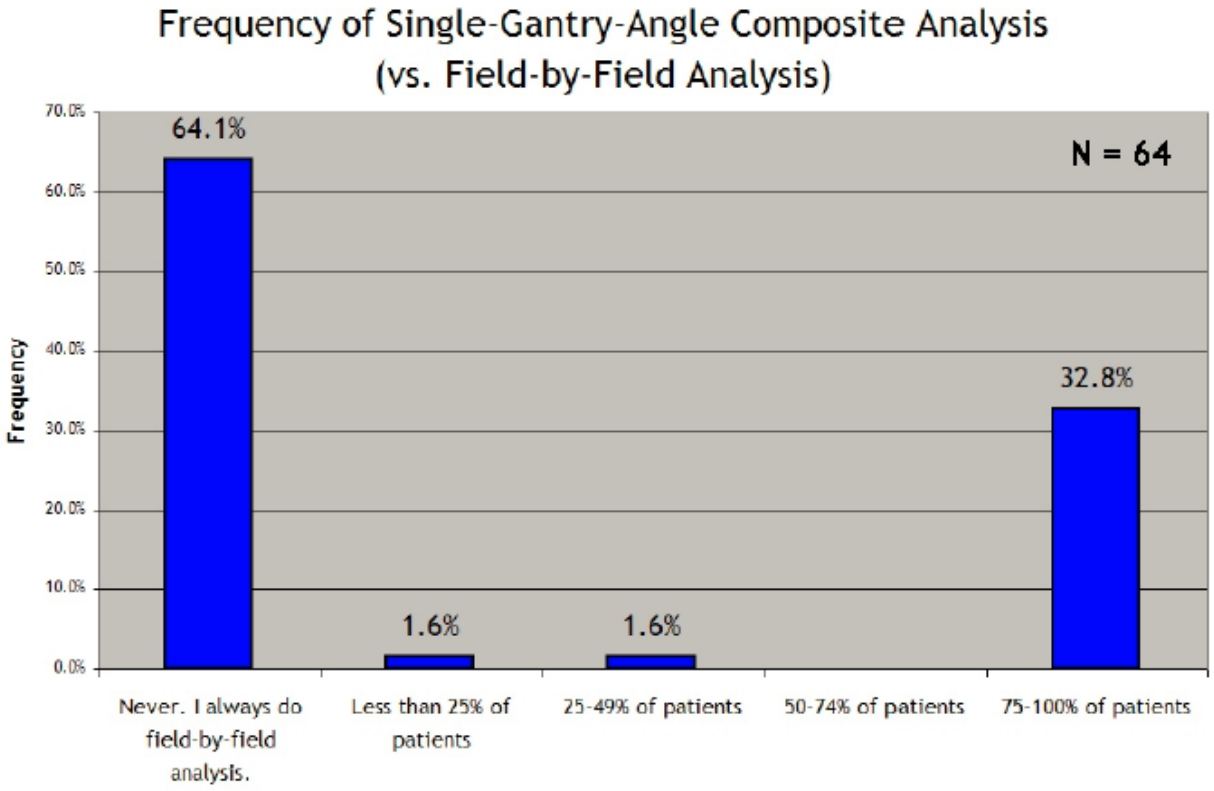


FIG. 1. Response to the survey question "How often do you use single gantry angle, composite IMRT QA? (i.e. All fields irradiated at normal incidence, added together.)"

Journal of Applied Clinical Medical Physics, Vol. 8, No. 3, Summer 2007

IMRT QA Analysis: Survey Summary

- Most physicists used:
  - Field by field analysis
  - Absolute dose analysis
  - 3%, 3mm

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IMRT QA Survey: action upon failing

TABLE 5. Reactions to fields that fail to meet acceptance criteria, multiple responses accepted

Frequency of responses to the question "If the dose analysis for a beam (measured vs. planned) does NOT pass your standard criteria for passing, how do you respond?"

Response	Response frequency (% of N=139)
Examine the field(s) and TPS calculated dose to search for known limitations in the IMRT dose algorithm	71.2%
Examine the other beams in the plan to determine if the magnitude of the error might be significant	61.2%
Change the plan if necessary	51.8%
Examine the delivery records or devices (e.g. machine parameters, log files, physical devices, etc.) for errors	42.4%
Change the criteria to get a higher passing rate and record the justification	39.6%
Change the criteria to get a higher passing rate without recording any justification	6.5%
Not applicable, because my analyses always pass the criteria	2.9%
I do nothing	0.0%
I do something else	59.0%

Journal of Applied Clinical Medical Physics, Vol. 8, No. 3, Summer 2007

IMRT QA Analysis Techniques

Per-beam, planar IMRT QA passing rates do not predict clinically relevant patient dose errors[a)]

Benjamin E. Nelms[b)]
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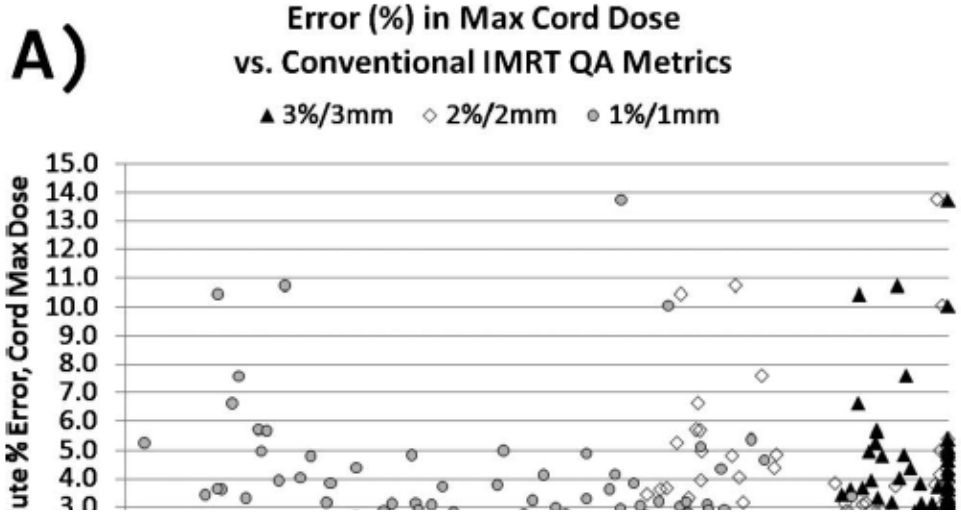
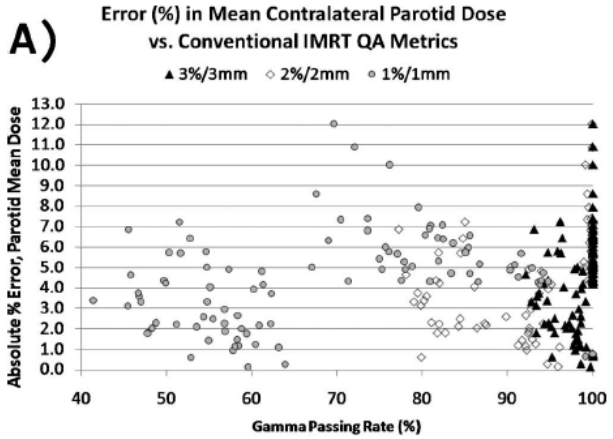
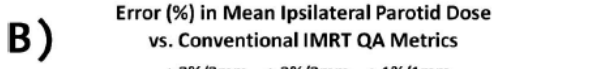
Wolfgang A. Tomé
Departments of Human Oncology, Medical Physics, and Biomedical Engineering, University of Wisconsin, Madison, Wisconsin 53792

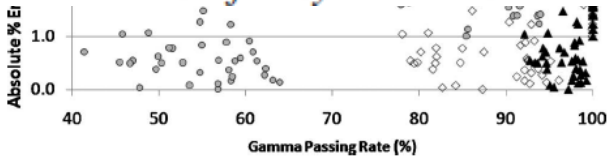
IMRT QA Analysis Techniques







Conclusions: There is a lack of correlation between conventional IMRT QA performance metrics (Gamma passing rates) and dose errors in anatomic regions-of-interest. The most common acceptance criteria and published actions levels therefore have insufficient, or at least unproven, predictive power for per-patient IMRT QA. © *2011 American Association of Physicists in Medicine.*



So what to do?

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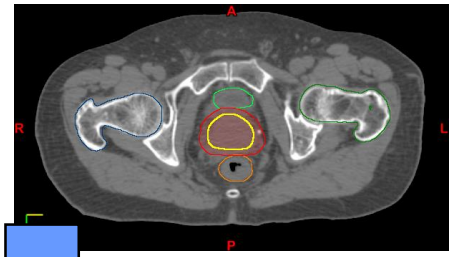
IMRT QA Analysis Technique

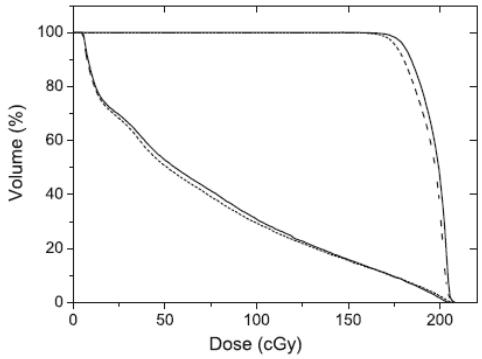
- New idea: transfer results from IMRT QA onto the patient DVH
- Similar to log file analysis, only using input from the IMRT device

QA results

Patient anatomy



DVH



. DVHs of the PTV and the rectal wall from the *in vivo* verification of prostate A (Fig. 4). The planned and EPID-reconstructed dose distributions are ented by solid and dashed lines, respectively.

How this process is carried out depends on the vendor & software system

Moving from gamma passing rates to patient DVH-based QA metrics in pretreatment dose QA

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Conclusions: Gamma passing rate, even if calculated based on patient dose grids, has generally weak correlation to critical patient DVH errors. However, the PDP algorithm was shown to accurately predict the DVH impact using conventional planar QA results. Using patient-DVH-based metrics IMRT QA allows per-patient dose QA to be based on metrics that are both sensitive and specific. Further studies are now required to analyze new processes and action levels associated with DVH-based metrics to ensure effectiveness and practicality in the clinical setting. [DOI: 10.1118/1.3633904]

QA Analysis Summary

- Gamma analysis is a prevalent method of comparing measured and predicted
  - Historically, the most prevalent criteria has been to perform an absolute dose comparison at 3%, 3mm, *however*
  - The criteria used should be selected based on (1) the achievable sensitivity of the measurement and (2) the potential clinical effect within this criteria
  - Not perfect, but certainly useful
- There are many potential actions that can be performed when the passing criteria is low
  - DVH based analysis might be a good follow-up analysis
  - Rigor of how the QA results are mapped to the DVH may vary & should be considered

Thank you!

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