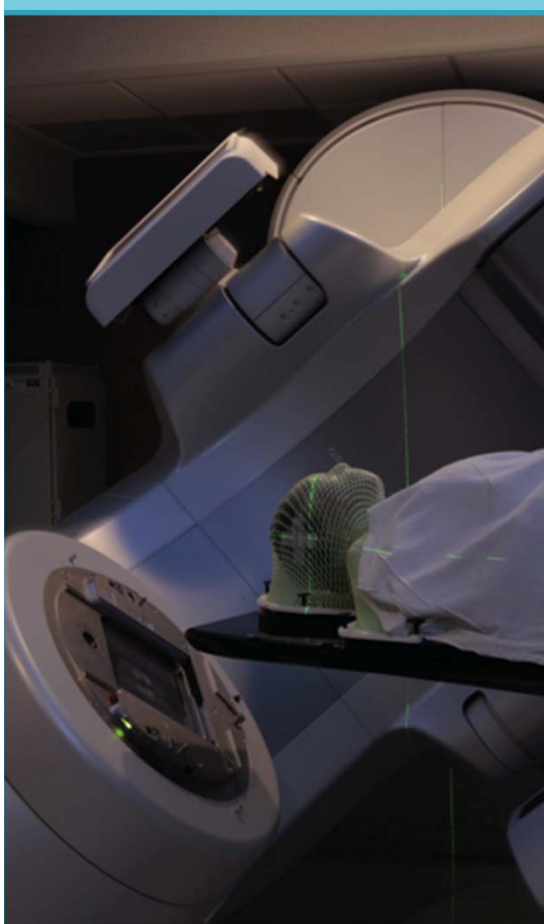




3D Diode Array Commissioning: Building Confidence in 3D QA Technology

Caroline Yount, MS
CONE HEALTH CANCER CENTER





The complex three-dimensional (3D) shapes of intensity modulated radiation therapy (IMRT) dose distributions and the methods for IMRT dose delivery demand that the dosimetry measurement techniques... be reviewed and adapted for the unique challenges posed by IMRT.

TG 120



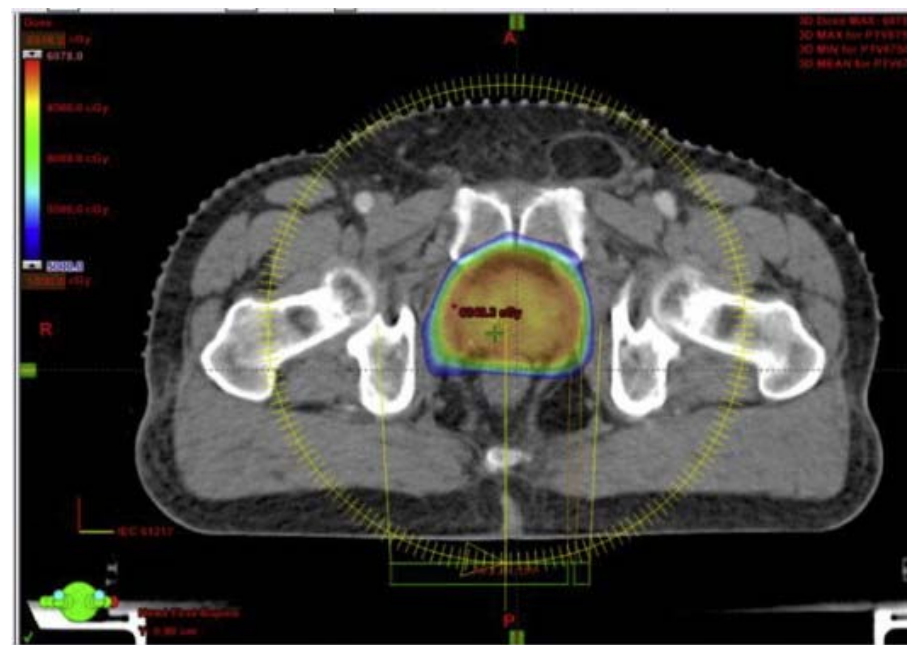
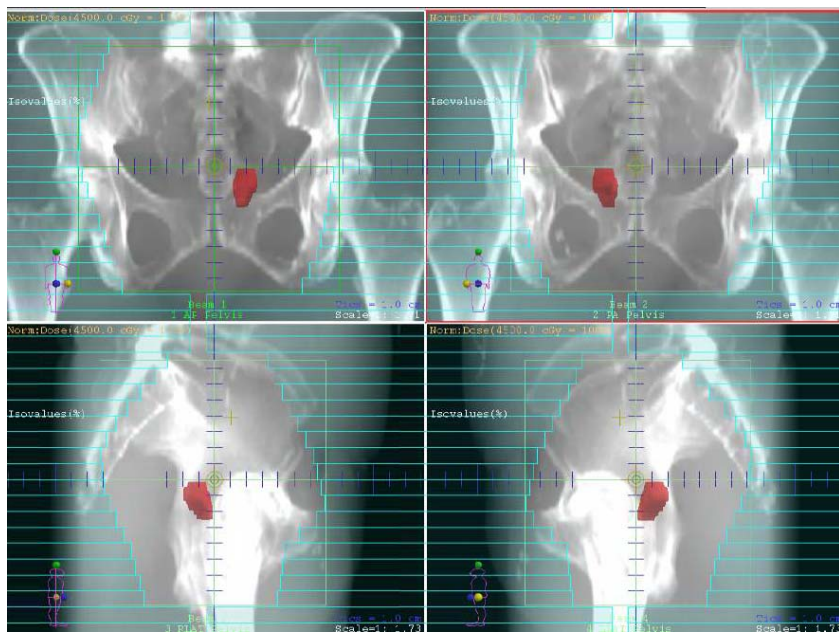


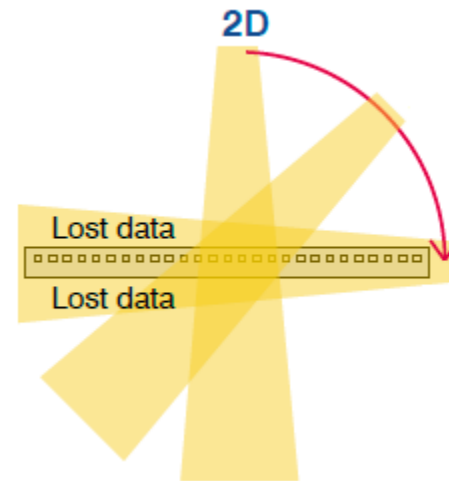
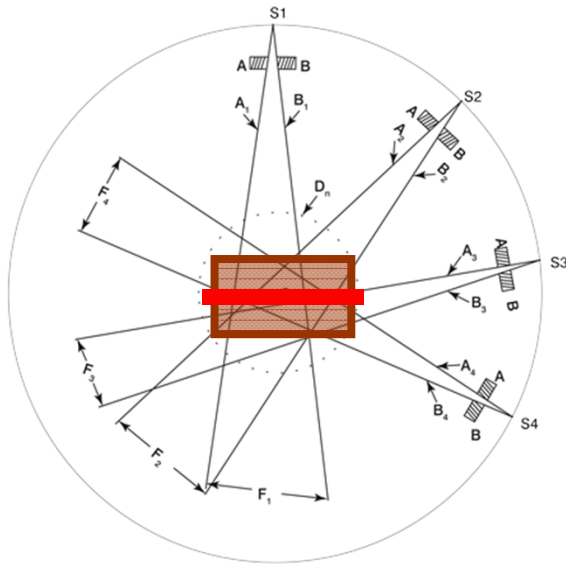
QA Challenges

- Modern technologies are utilizing rotation delivery to speed up treatment time and decrease tissue toxicity
 - ❖ (RapidArc®, VMAT, TomoTherapy®, IMAT, SmartArc)
- Rotational beam delivery creates a challenge for patient specific QA
 - ❖ 360 degrees of delivery



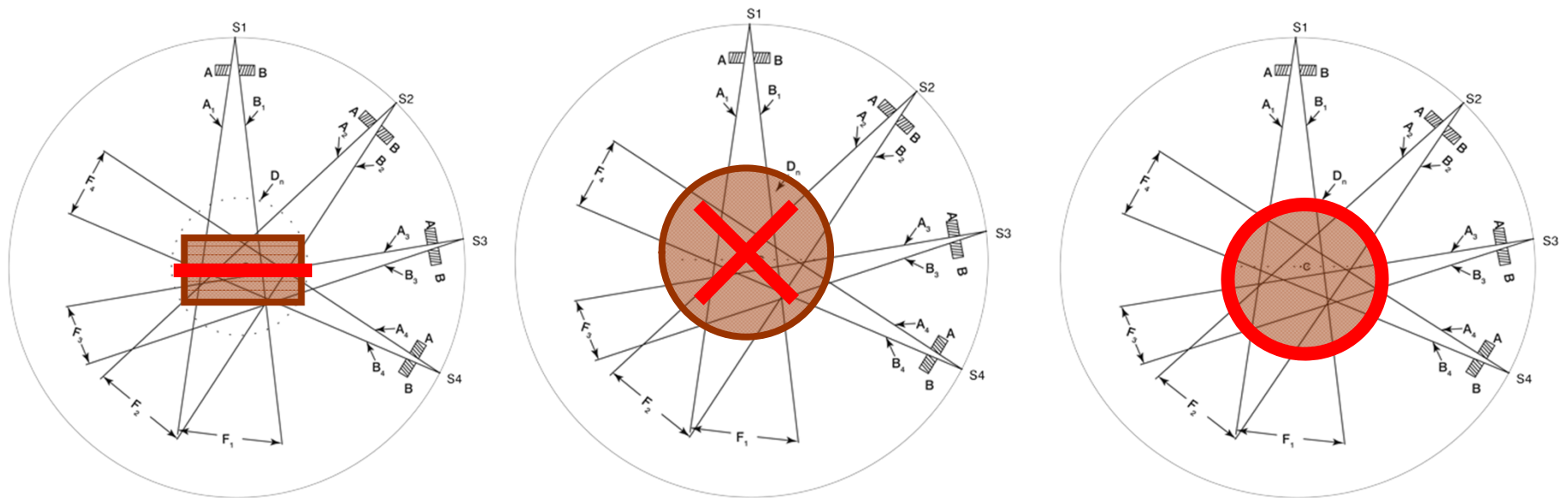
3D QA



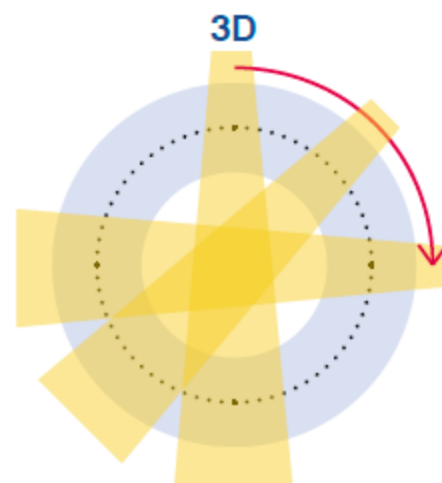
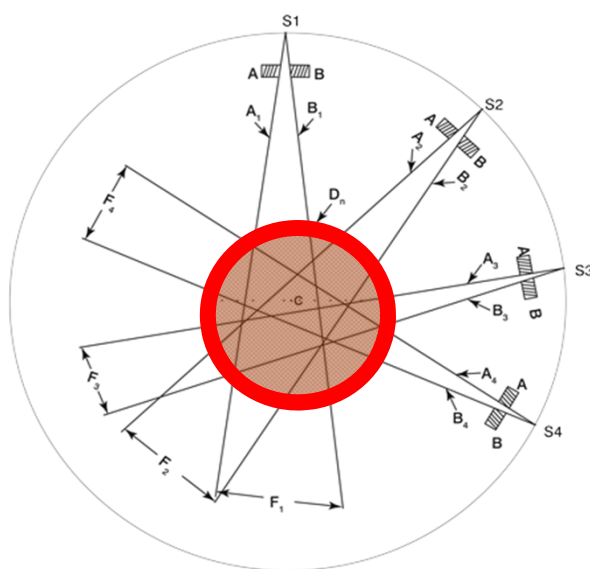




3D QA



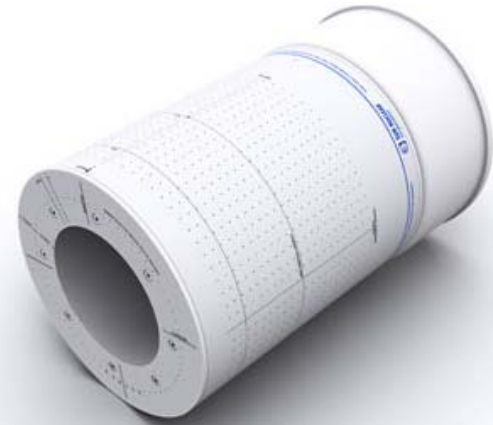
3D QA





ArcCHECK Introduction

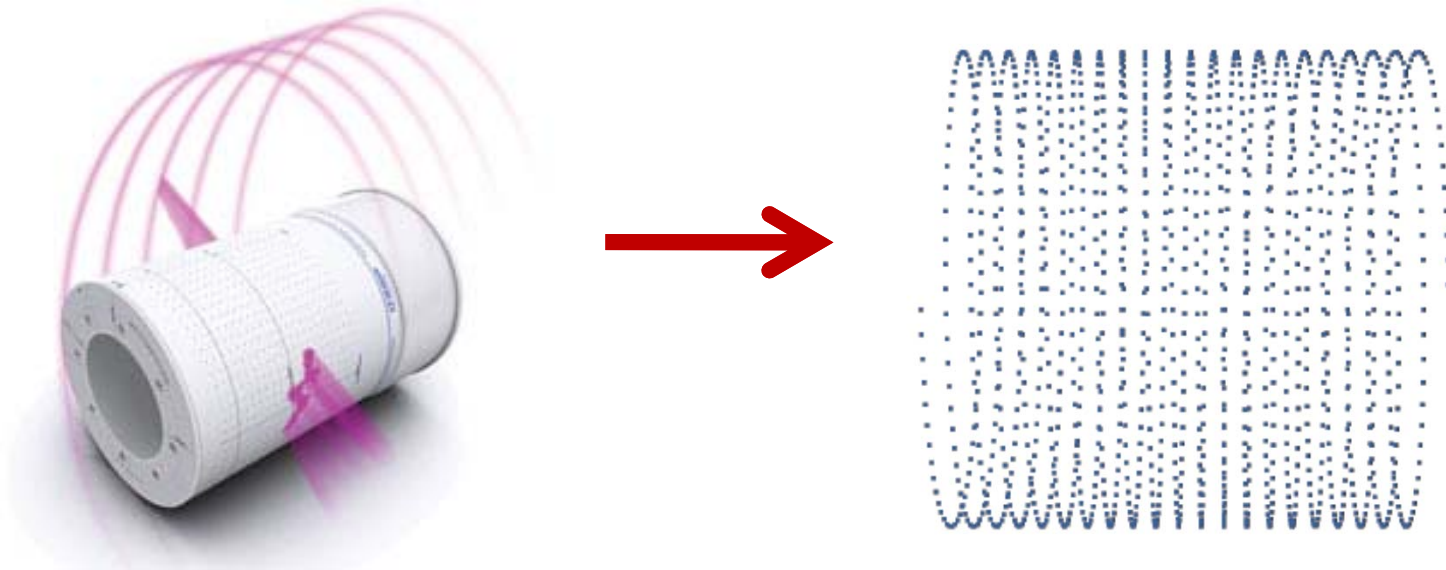
- Designed for Helical & Arc Delivery
- **1386** diodes in a helical geometry
 - ❖ 21cm diameter, 21cm length
 - ❖ 1cm spacing, 3.28cm equivalent depth
 - ❖ 0.64mm² active detector area
- 4th Dimension = Time
 - ❖ **50ms update frequency**
- Optional cavity plug insert with ion chamber holder
 - ❖ **PMMA construction**





Detector Geometry

- Entrance and exit dose are measured
 - ❖ Effectively doubling the detector density in the measurement field.
- Central 10x10 contains approximately 230 detectors
- Detectors are arranged on a HeliGrid™
 - ❖ Increases sampling rate and reduces detector overlap from Beams Eye View (BEV)
- Entrance and exit dose can be correlated to determine gantry angle





Question

“How can I interpret and trust 3D QA?”





Commissioning Measurements

1. Detector spacing
2. Linearity
3. Sensitivity
4. Individual detector response variations
5. Absolute dose accuracy

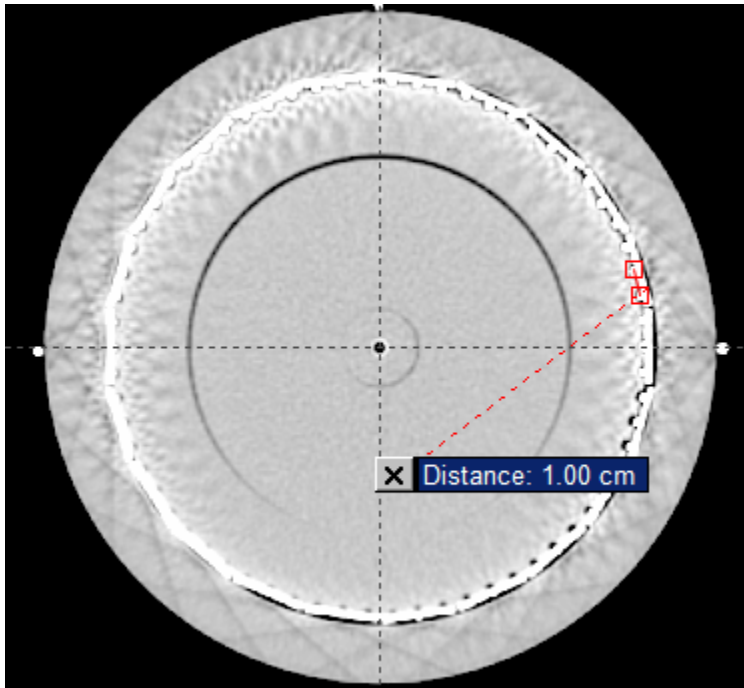
Then... Trend analysis



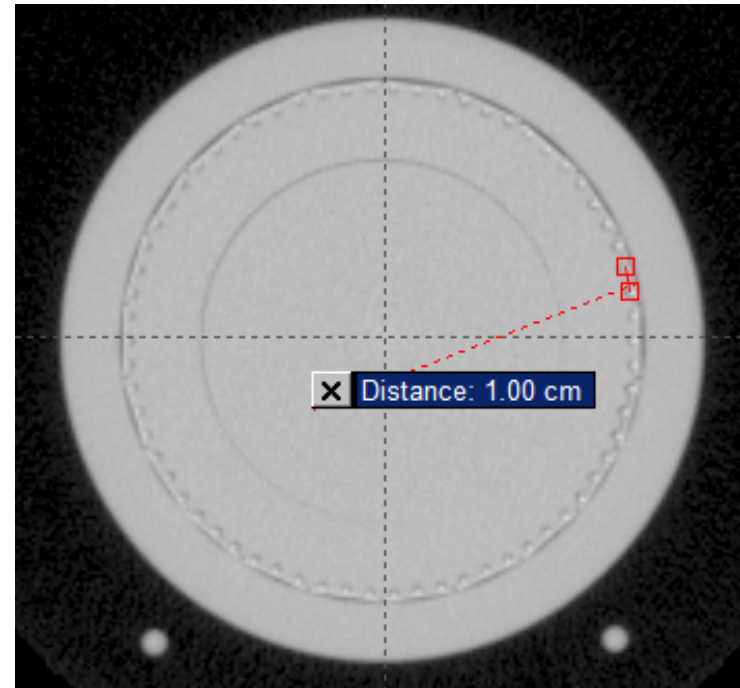


Detector spacing

kVCT



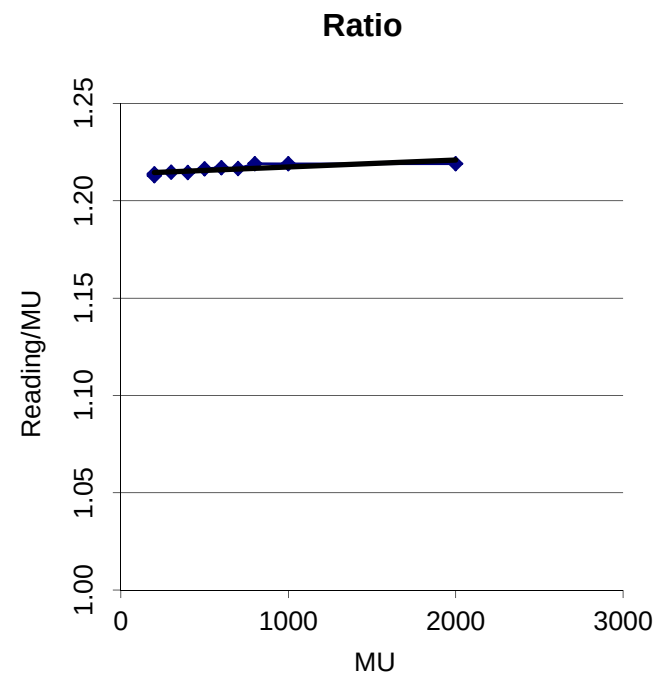
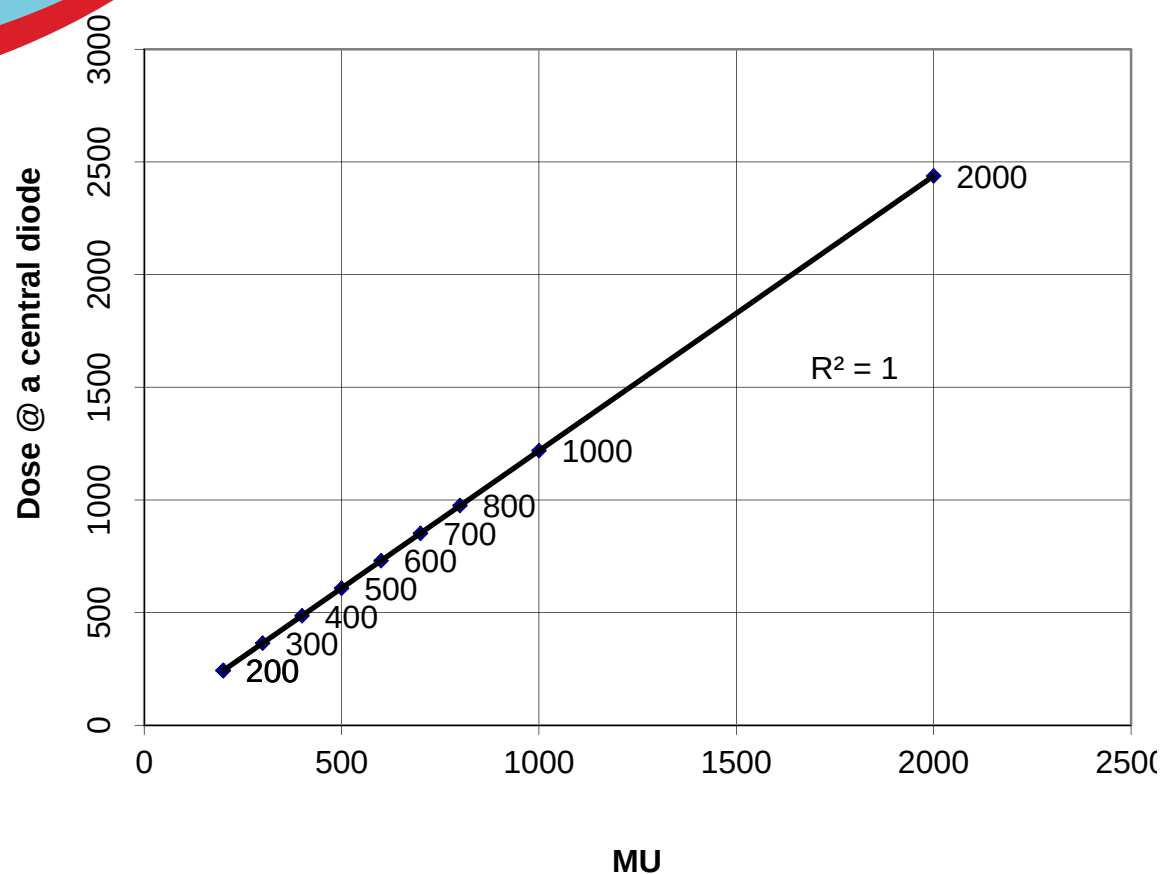
MVCT





Linearity – Conventional Dose Rates

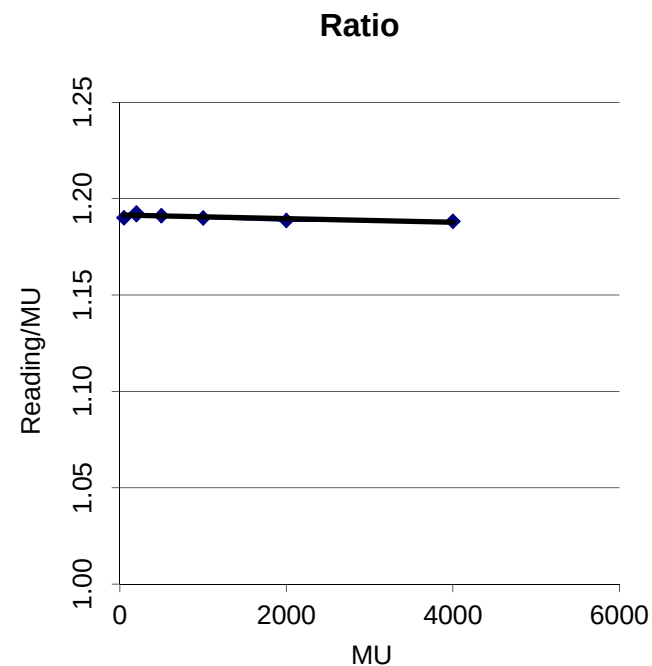
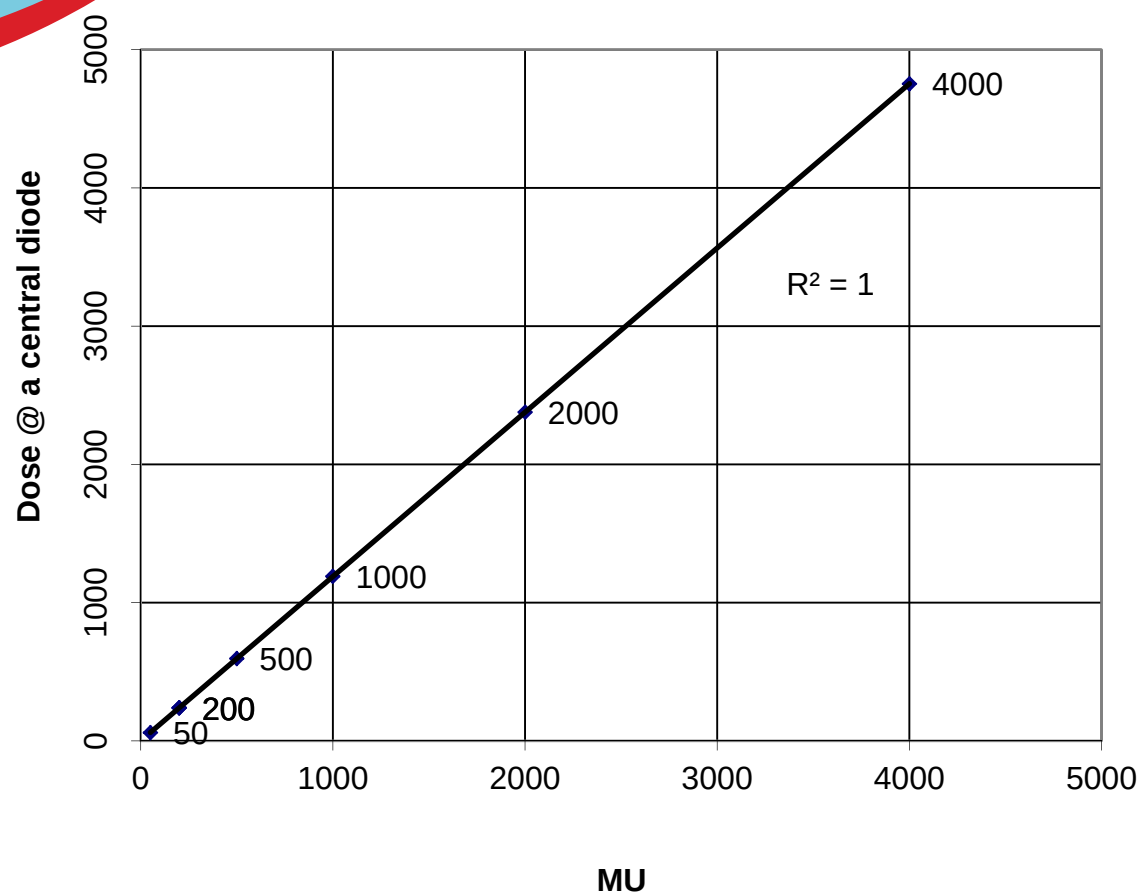
6MV
500MU/min
10x10
100SAD





Linearity – High Dose Rates

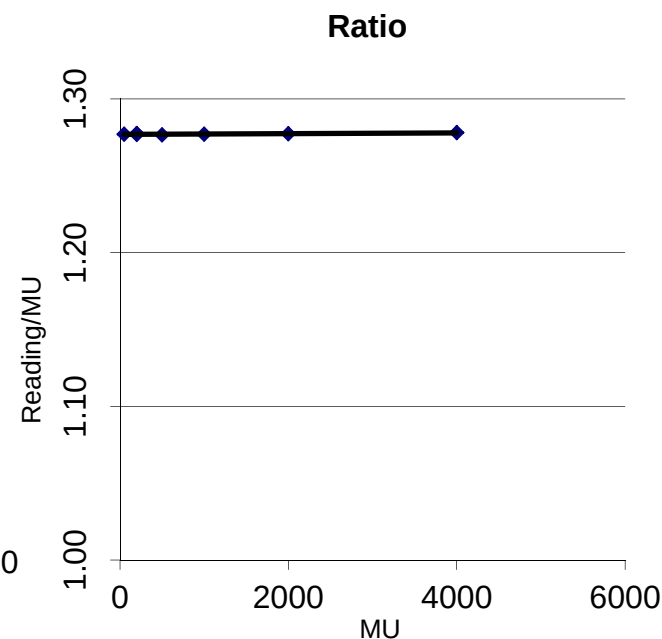
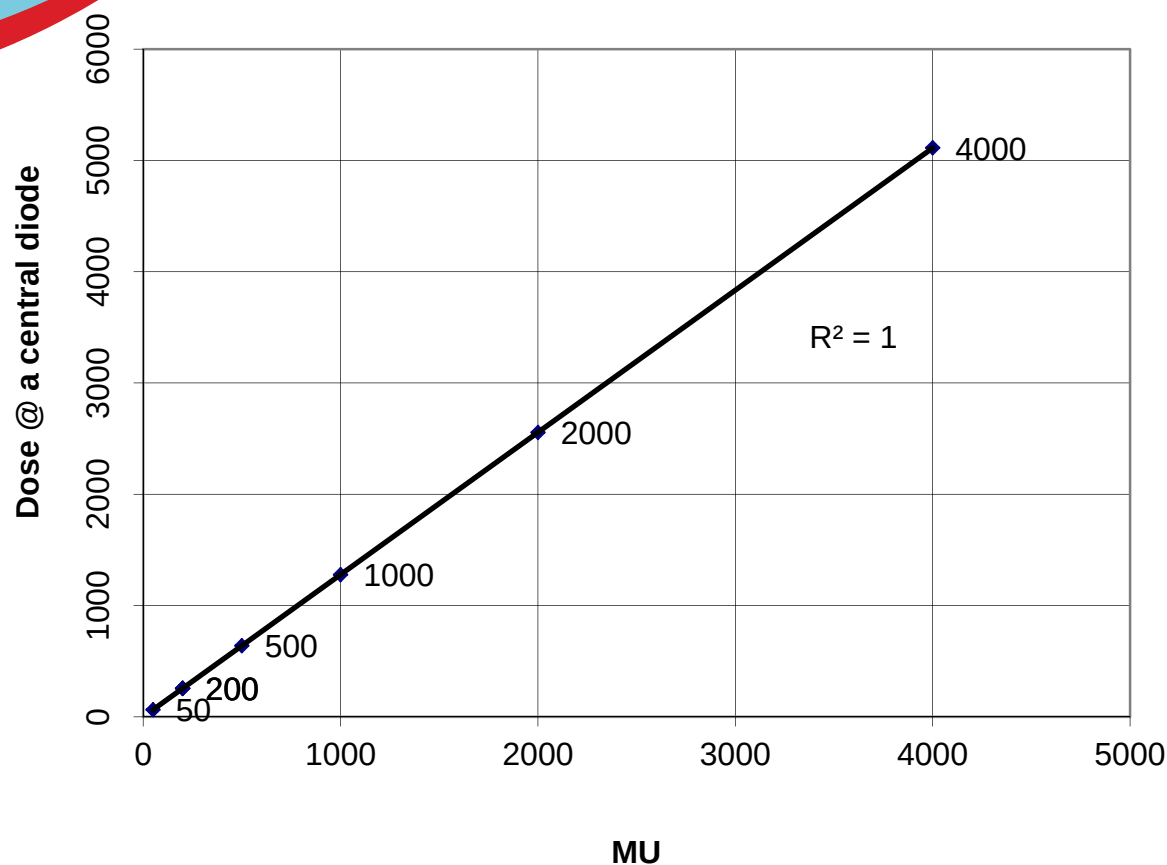
6MV FFF
1400MU/min
10x10
100SAD



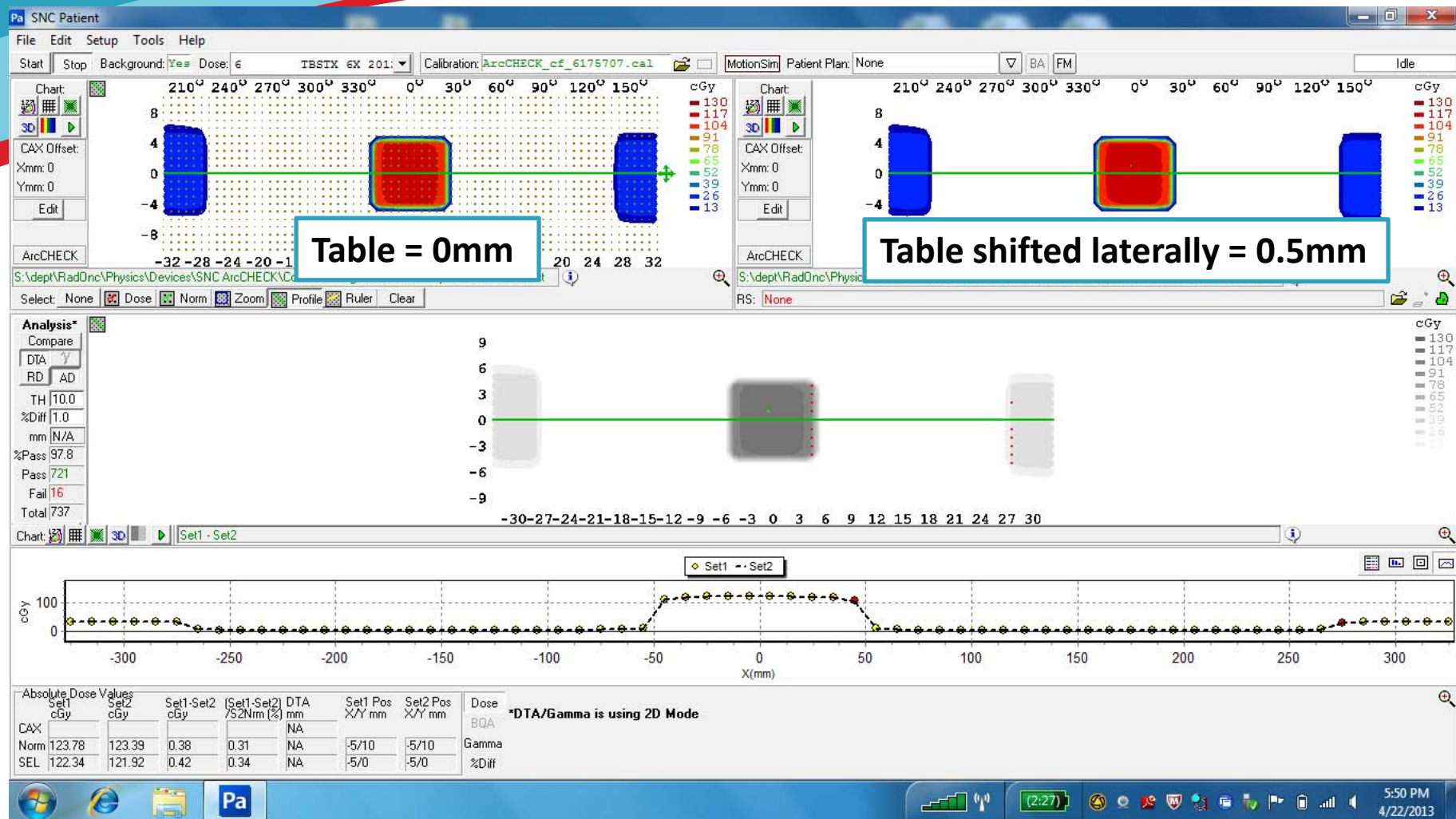


Linearity – High Dose Rates

10MV FFF
2400MU/min
10x10
100SAD

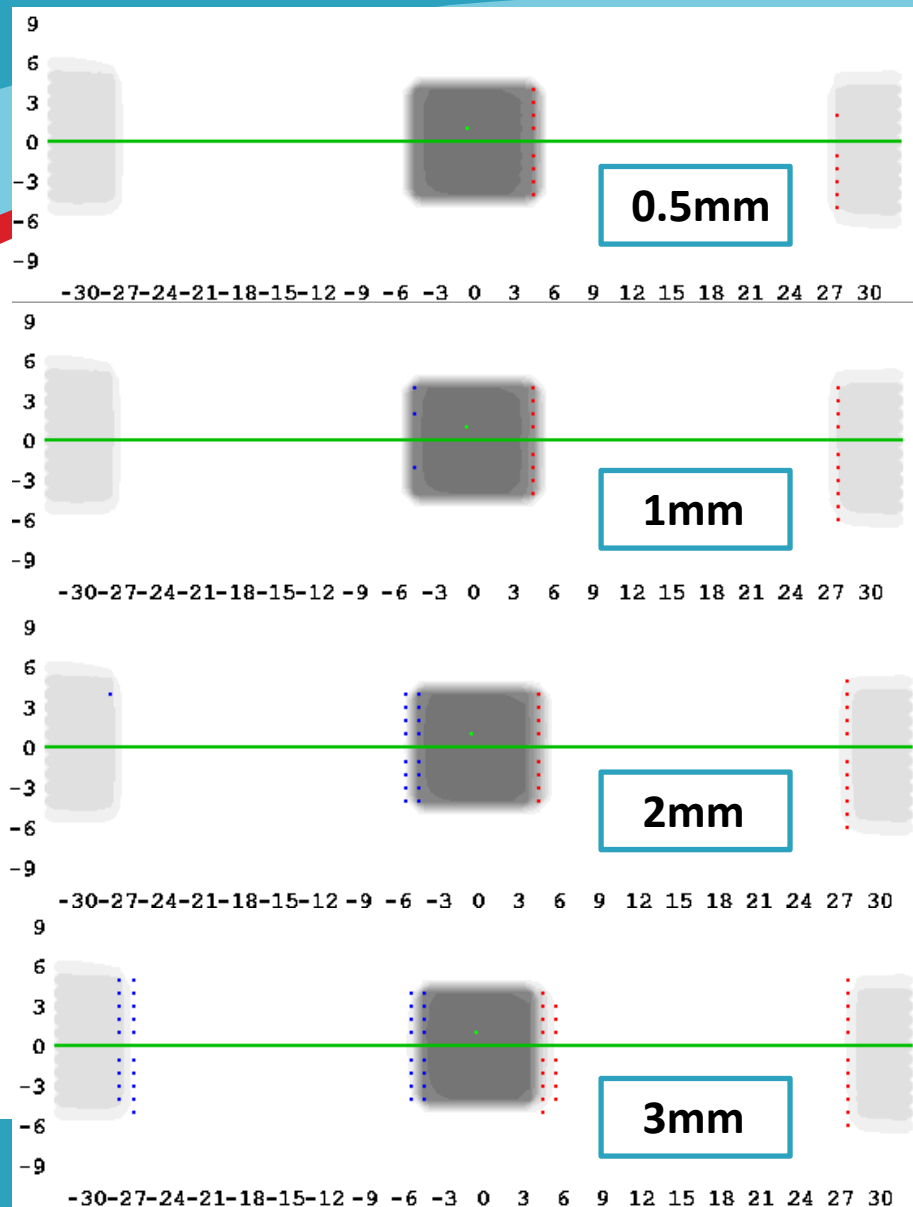


Spatial Sensitivity

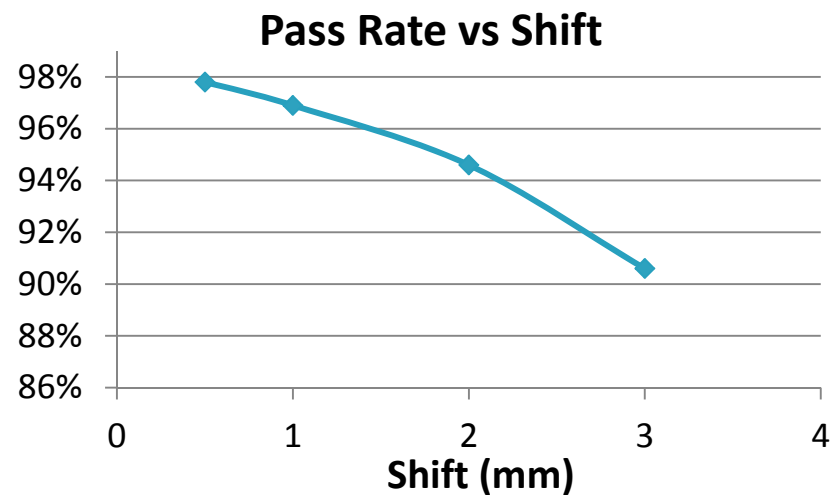




Spatial Sensitivity

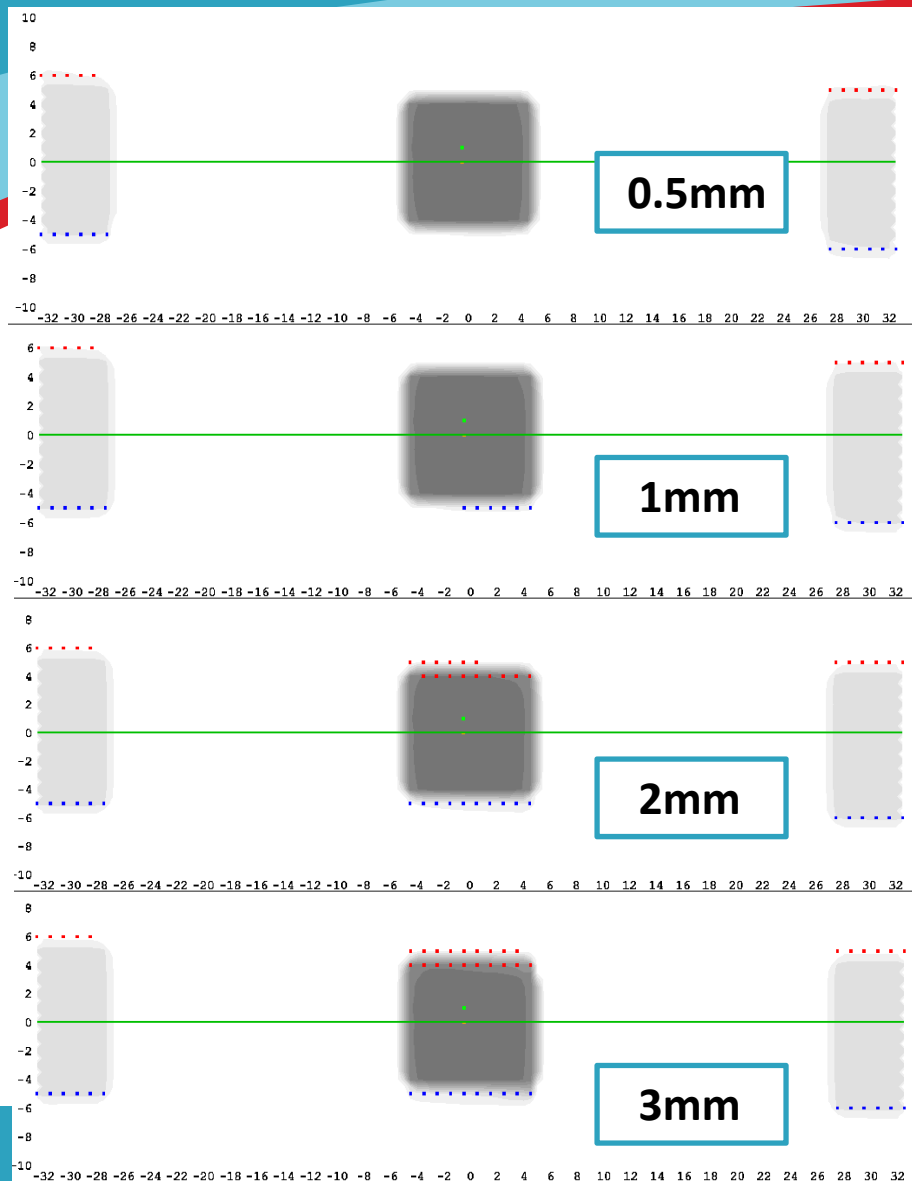


Lateral Table Shifts

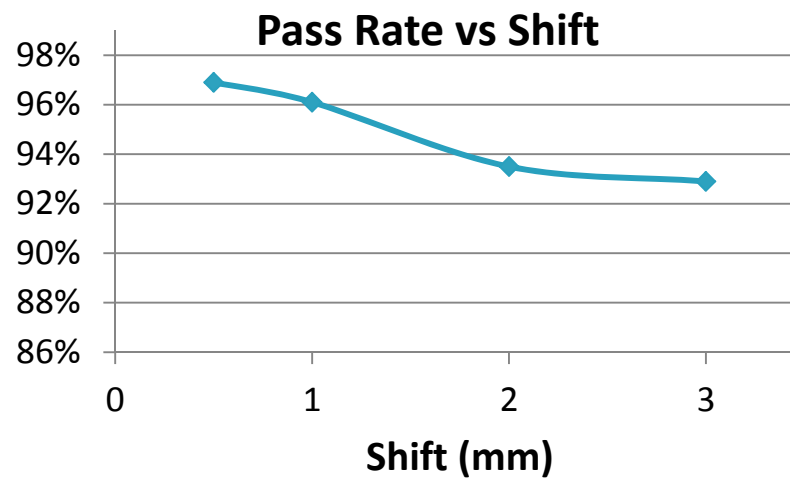




Spatial Sensitivity

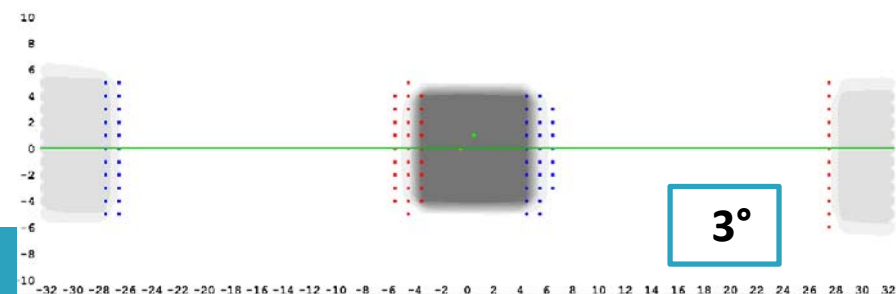
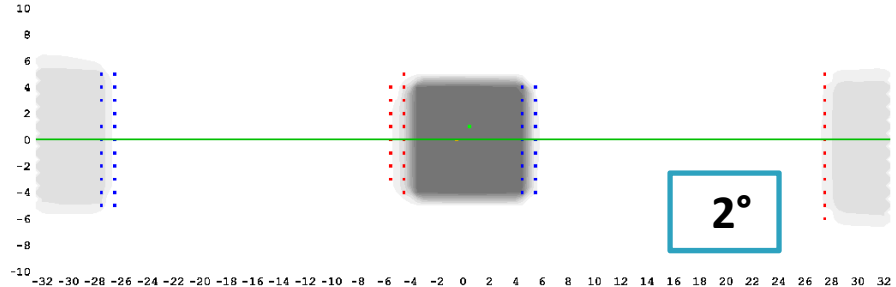
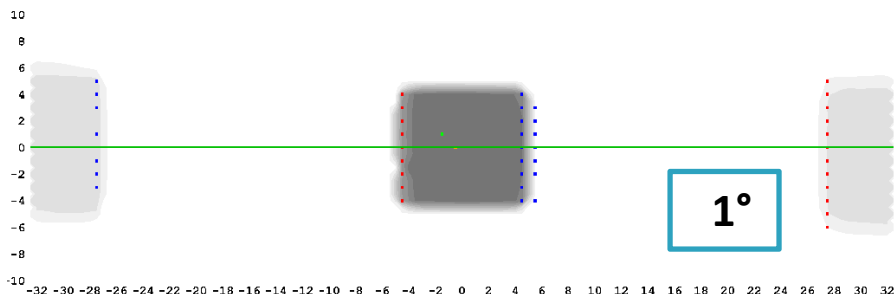
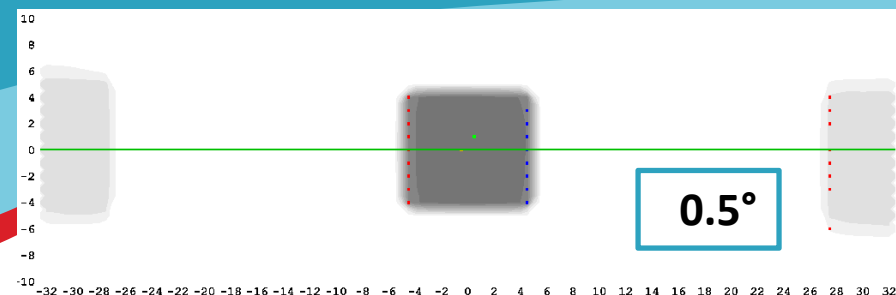


Longitudinal Table Shifts



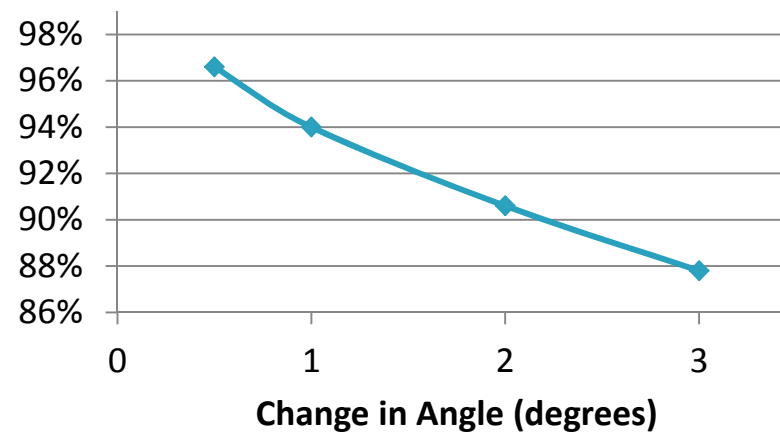


Angular Sensitivity



Gantry Angle Changes

Pass Rate vs Angle Change





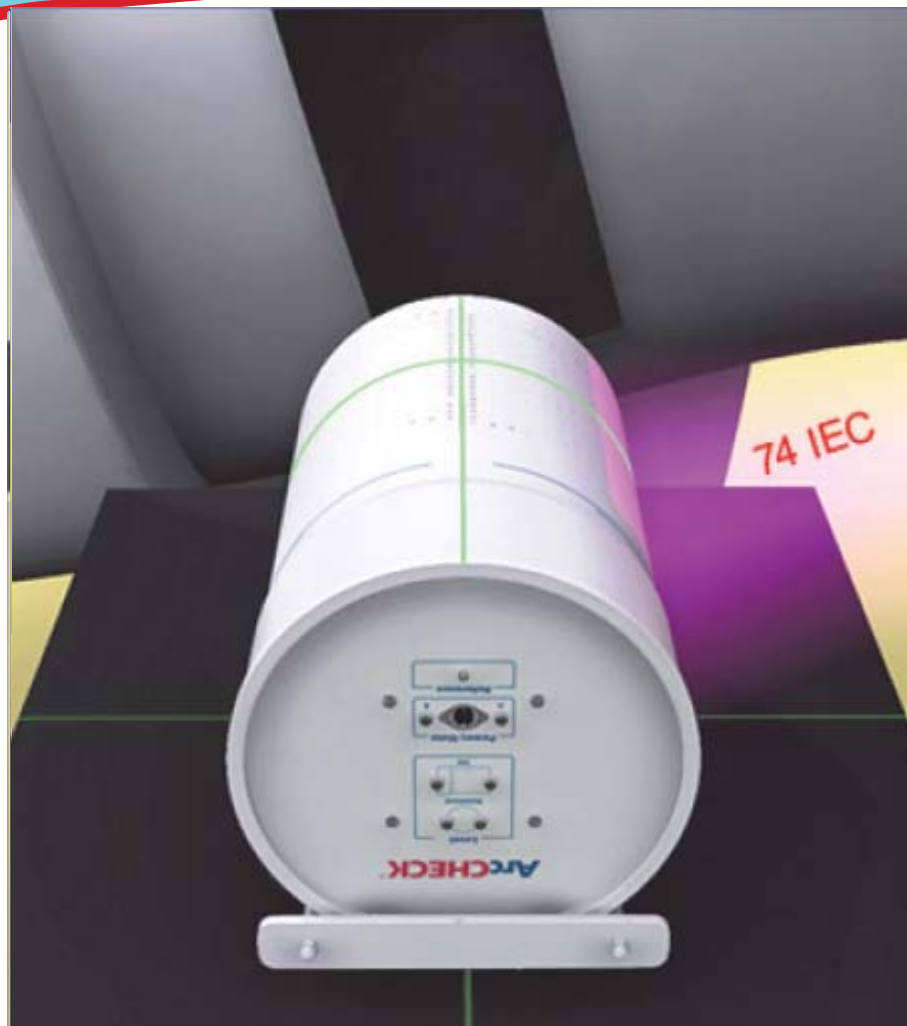
Detector Response Variations

- Sensitivity differences between the ArcCHECK detectors
- These differences can be measured
- Individual correction factors applied to subsequent raw measurements





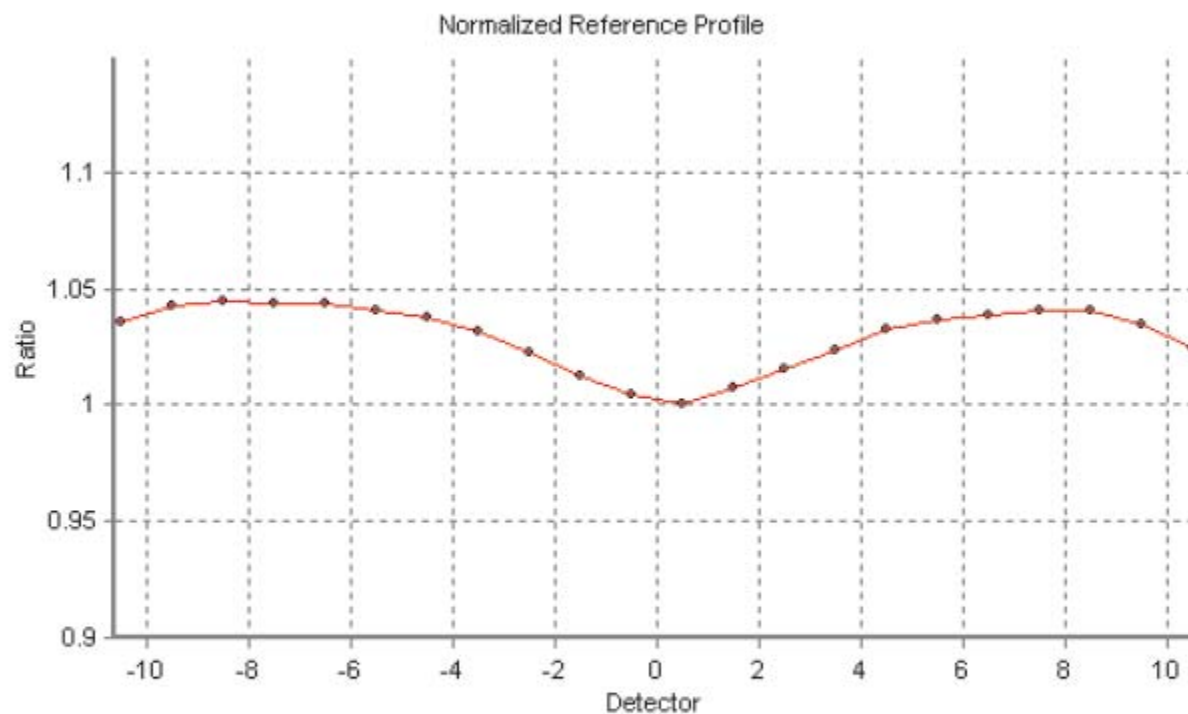
Detector Response Variations





Detector Response Variations

Array Calibration



Apply

Print

Recalibrate

Close





Calibration Validity Check

AP



PA





	To	From
0	0.0000	0.0000
1	0.0000	0.0000
2	0.0000	0.0000
3	0.0000	0.0000
4	0.0000	0.0000
5	0.0000	0.0000
6	0.0000	0.0000
7	0.0000	0.0000
8	0.0000	0.0000
9	0.0000	0.0000
10	0.0000	0.0000
11	0.0000	0.0000
12	0.0000	0.0000
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95	0.0000	0.0000
96	0.0000	0.0000
97	0.0000	0.0000
98	0.0000	0.0000
99	0.0000	0.0000

[illegible]



New In-house array calibration:

1%

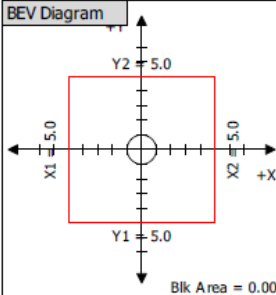
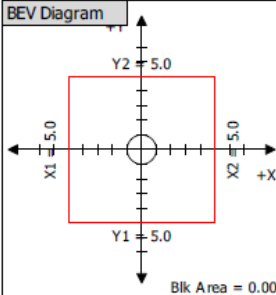
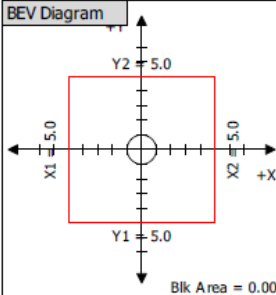
1.5%





ArcCHECK Calibration

- Array calibration on standard linac
- Dose calibration on standard linac SAD hand calc at 3.28 cm depth (water equivalent depth)

Photon Monitor Unit Calc Sheet																			
Patient Name: ArcCHECK, Patient ID#: 0000002																			
Calculation Name: (EZ Photon Calc)																			
Comments:																			
<table border="1"><thead><tr><th>Beam Description</th></tr></thead><tbody><tr><td>Calibration Beam</td></tr><tr><td>Beam ID: 1</td></tr><tr><td>Dose Per Treat.: 246.0 cGy</td></tr><tr><td>Wedge Factor: 1.000</td></tr><tr><td>Sc: 1.000</td></tr><tr><td>ISF: 1.275</td></tr><tr><td>OAF: 1.000</td></tr><tr><td>Sp: 0.996</td></tr><tr><td>TPR: 0.968</td></tr><tr><td>Cal. Factor: 1.000 cGy / MU</td></tr><tr><td>Dose Per MU: 1.230 cGy / MU</td></tr><tr><td>MU: 200.1</td></tr></tbody></table>	Beam Description	Calibration Beam	Beam ID: 1	Dose Per Treat.: 246.0 cGy	Wedge Factor: 1.000	Sc: 1.000	ISF: 1.275	OAF: 1.000	Sp: 0.996	TPR: 0.968	Cal. Factor: 1.000 cGy / MU	Dose Per MU: 1.230 cGy / MU	MU: 200.1	<table border="1"><thead><tr><th>Accelerator: Elekta</th></tr></thead><tbody><tr><td>Energy: RCCx06</td></tr><tr><td>SSD: 86.70 Depth: 3.28</td></tr><tr><td>SSD @ Iso: ---</td></tr><tr><td>Eq. Sq.: 10.00 Blk Eq Sq: 9.00</td></tr></tbody></table>	Accelerator: Elekta	Energy: RCCx06	SSD: 86.70 Depth: 3.28	SSD @ Iso: ---	Eq. Sq.: 10.00 Blk Eq Sq: 9.00
Beam Description																			
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Dose Per MU: 1.230 cGy / MU																			
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SSD: 86.70 Depth: 3.28																			
SSD @ Iso: ---																			
Eq. Sq.: 10.00 Blk Eq Sq: 9.00																			
<table border="1"><thead><tr><th>BEV Diagram</th></tr></thead><tbody><tr><td></td></tr></tbody></table>		BEV Diagram																	
BEV Diagram																			
																			





Dose Accuracy

QA File Parameter

Patient Name : ArcCHECK, MVCT
 Patient ID : Z_ArcCHECK3
 Plan Date : 11/27/2012
 SSD : 86.7
 Depth : 3.3
 Energy : 6x
 Angle : 0

Absolute Dose Comparison

% Diff : 3.0
 Distance (mm) : 3.0
 Threshold : 10.0
 Rotation Angle : 0.0 Degs
 Meas Uncertainty : Yes
 Dose Diff Thresh : 0.0 cGy

Summary (Gamma Analysis)

Total Points : 672
 Passed : 668
 Failed : 4
 % Passed : 99.4
 *DTA/Gamma is using 3D Mode

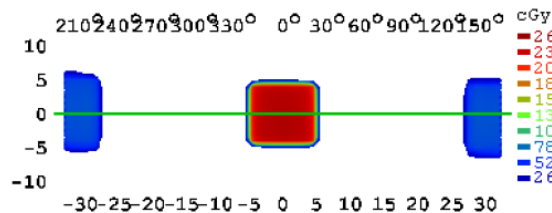
Dose Values in cGy

	Cax	Normal	Picked
Set1	244.66	246.83	
Set2	250.72	252.66	251.08
Set1-Set2	-7.99	-4.24	
% Diff	-3.16	-1.68	
DTA(mm)	NA	0.00	0.00
Coords (y,x) cm	0,0	-3,1.5	0,-0.5

Notes

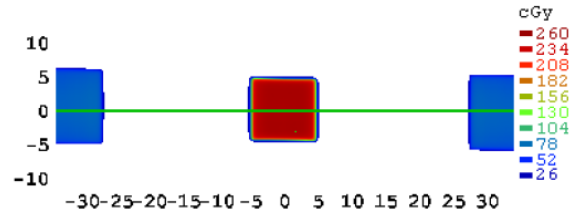
10x10
 500 mu/min
 Factory Array Calibration

Set1



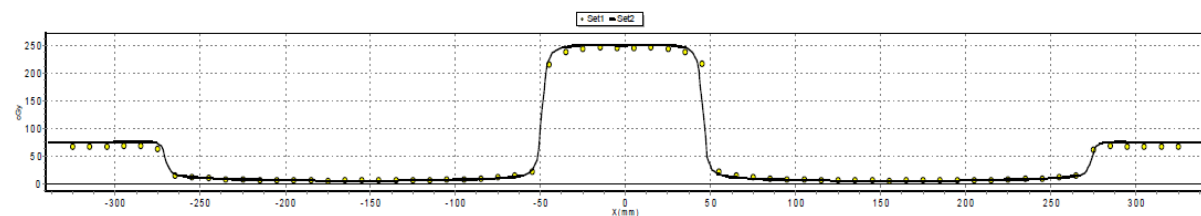
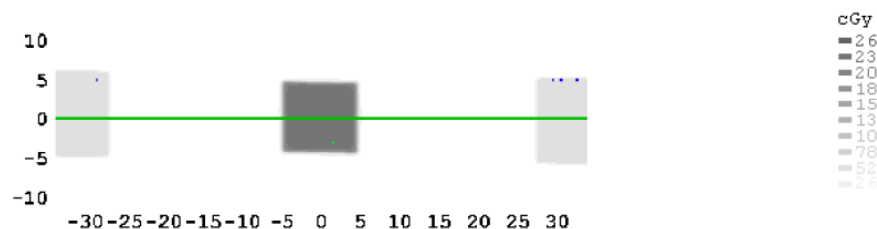
Measured 10x10

Set2



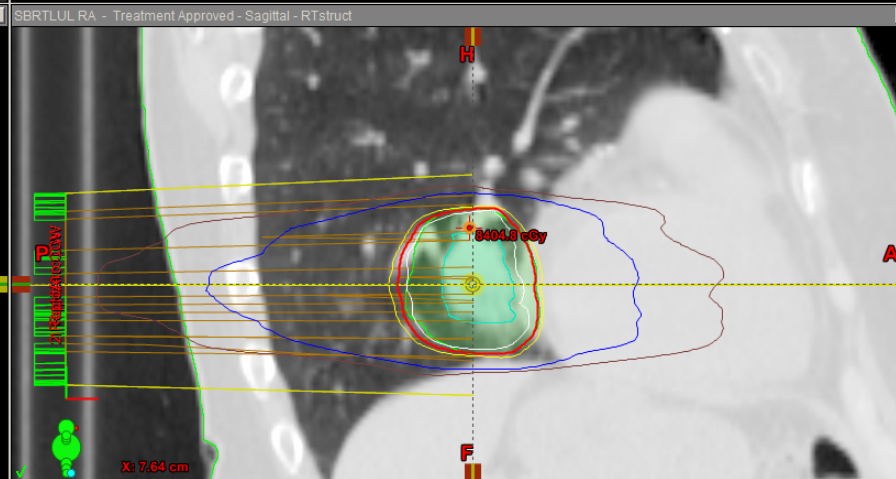
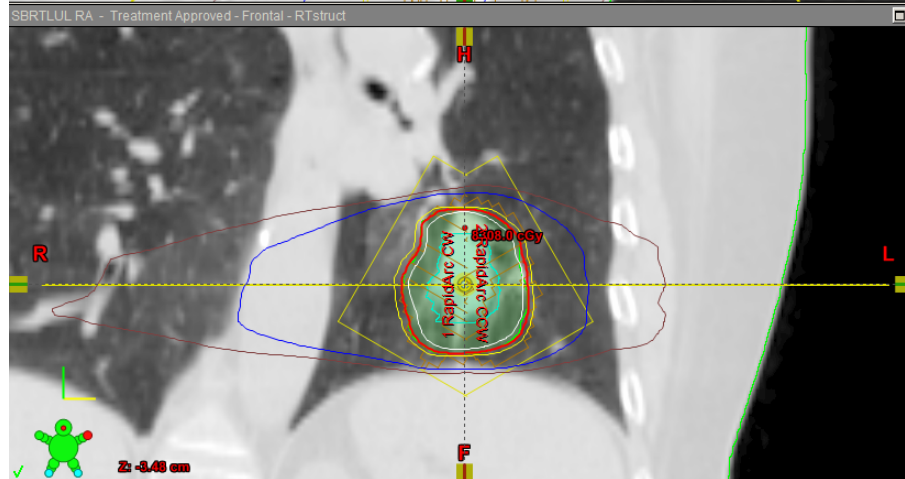
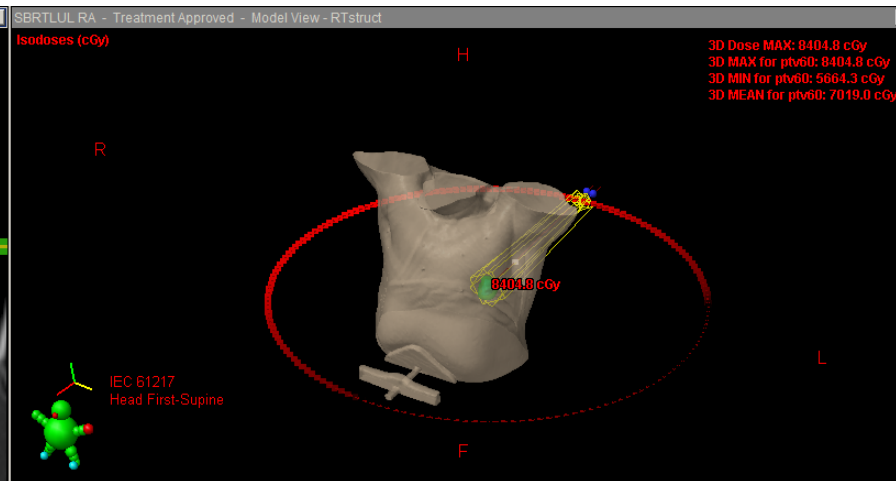
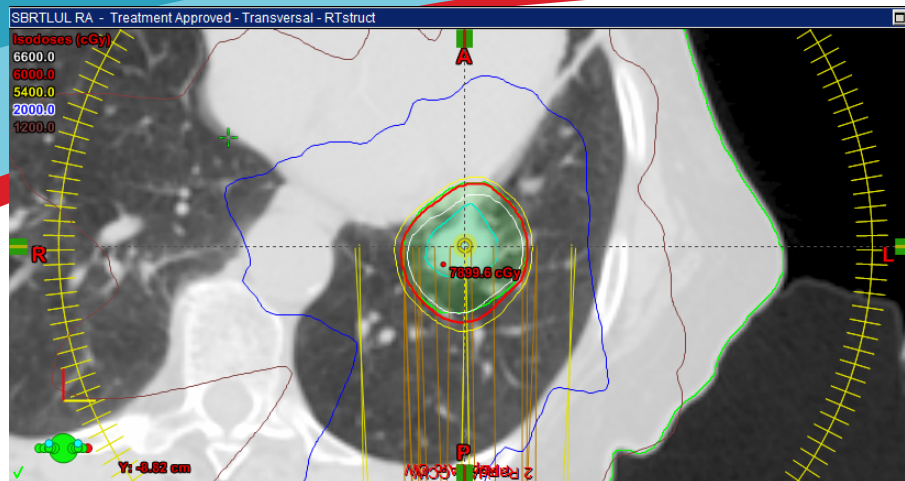
Planned 10x10

Set1-Set2



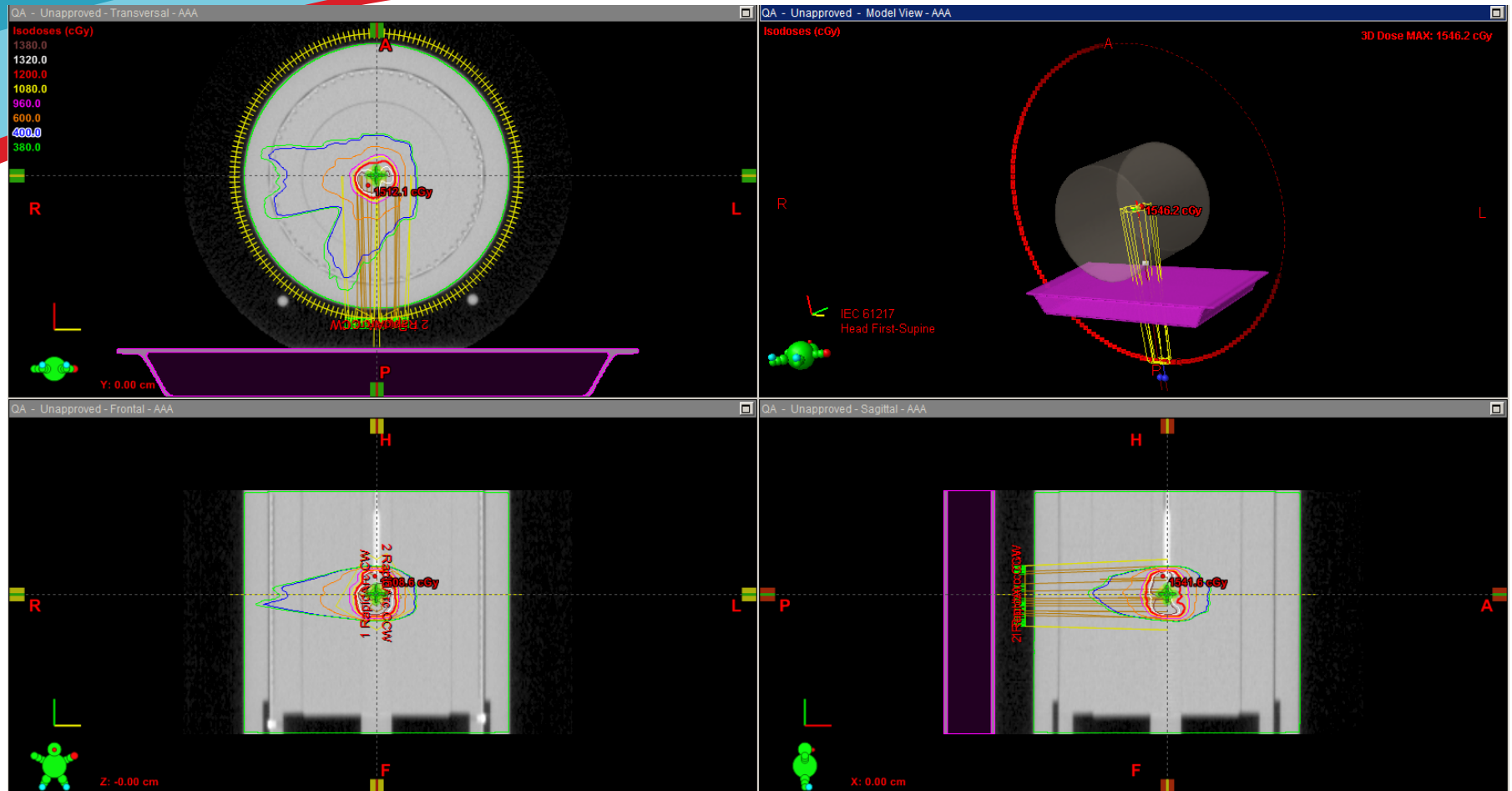


Clinical Example - Chest



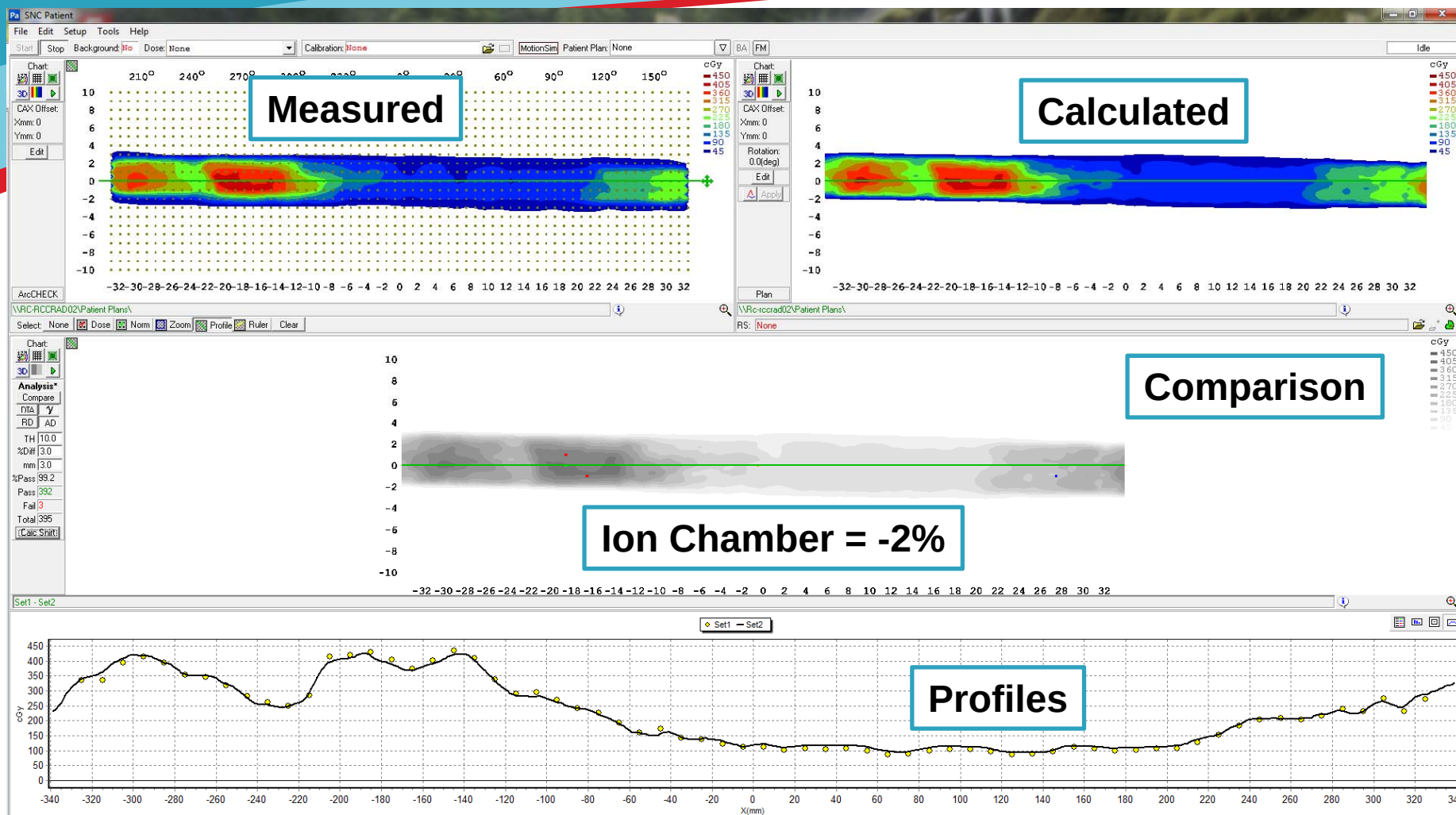


Phantom Plan



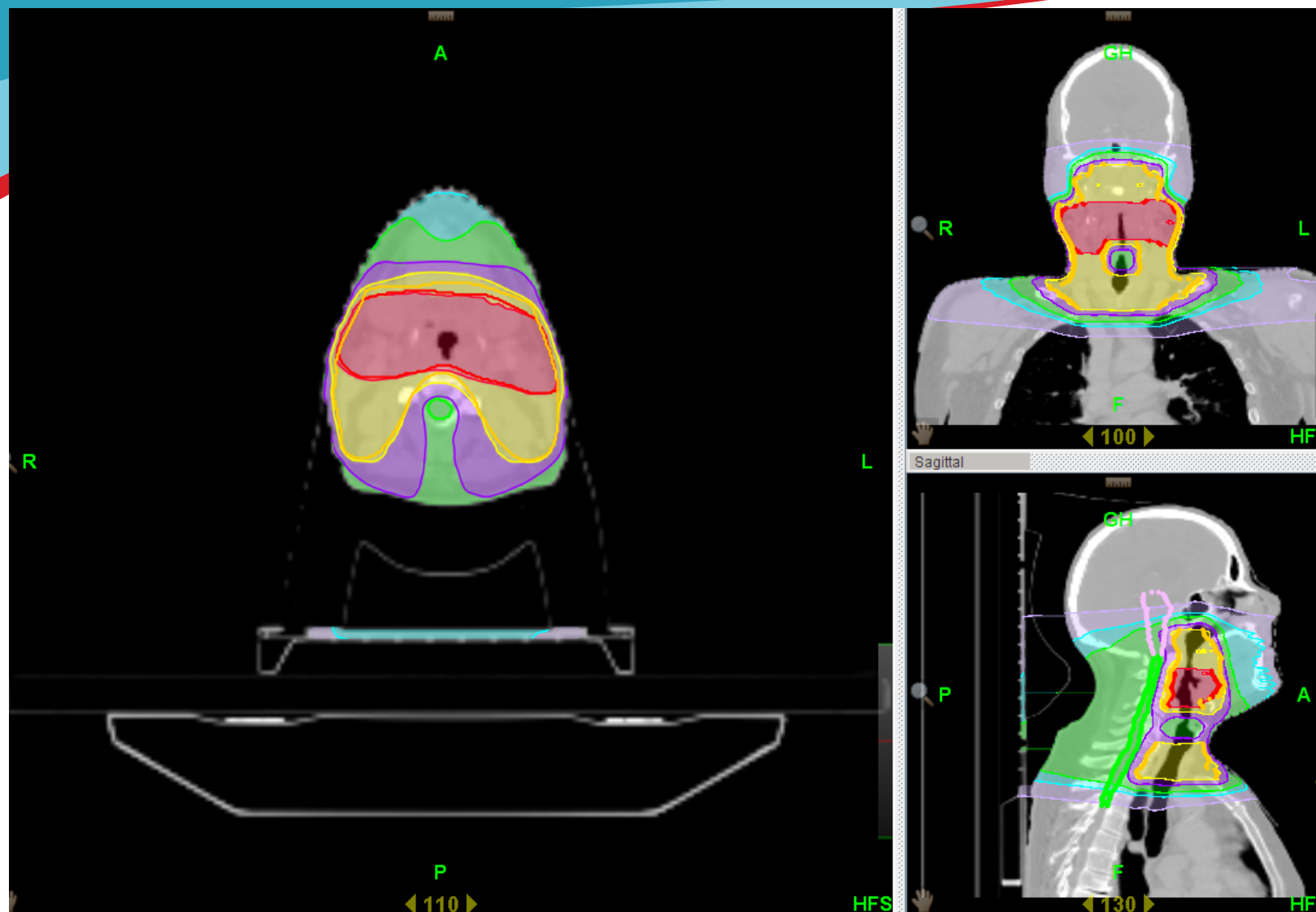


QA Result





Clinical Example – Head & Neck





Phantom Plan

Delivery QA Setup

DQA Plan: Plan_01

Phantom Selector

Retrieve Original Phantom

Change Phantom Couch

Laser Control

☐ View Lasers

☐ Move Lasers

Save Position

Phantom Tools

Restore Position

Move Phantom

Delivery QA Analysis

0210286

Dose Calculation

Calculation Grid: Fine

☐ Save Dose Per Angle

Start

Cancel

Select Delivery QA Fractions

Displayed Image

☐ Patient ☒ Phantom

Isodose Selector

☒ Patient ☐ Plan ☐ Local

Restore From Plan

☐ Phantom

View Phantom Density Image

DQA Plan

IVDT Selector

Dose Display

☒ Isodose

63

60

54

45

30

19.98

4.98

ROI Display

Tumor Settings

Name	Display	Color
ptv5400	☒	Yellow
ptv6000	☒	Red
ptv5400Cropped	☐	Cyan

Sensitive Structure Settings

Name	Display	Color
Cochlea Lt	☐	Purple
Brainstem	☒	Pink
Cord	☒	Green
Body	☐	Brown
Parotid Rt	☐	Cyan
Parotid Lt	☒	Yellow
Mandible	☐	Orange
Larvnx	☐	Orange

Transverse

A

R

L

P

110

HFS

Coronal

GH

R

L

F

97

HFS

Sagittal

GH

P

A

F

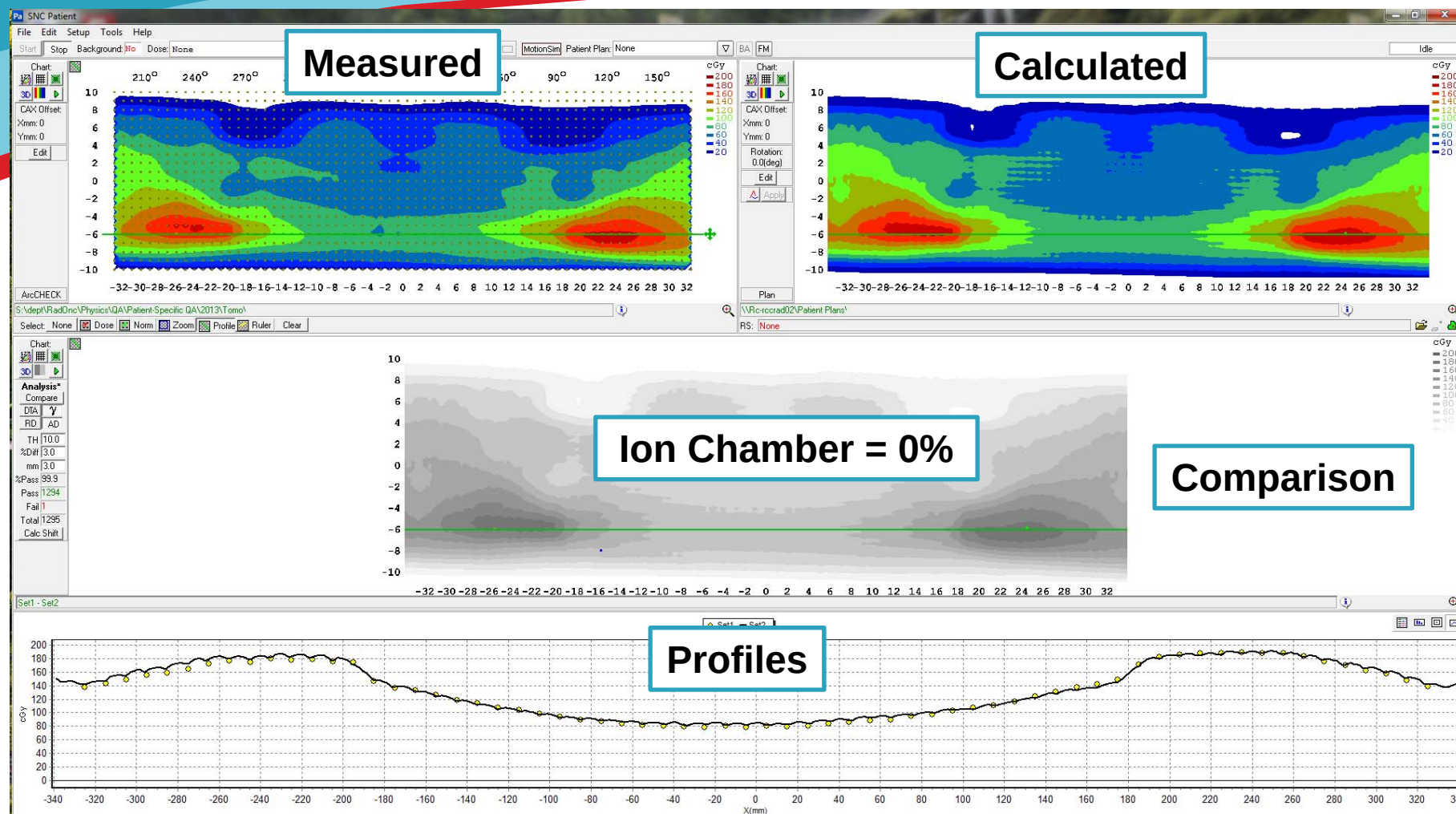
131

HFS



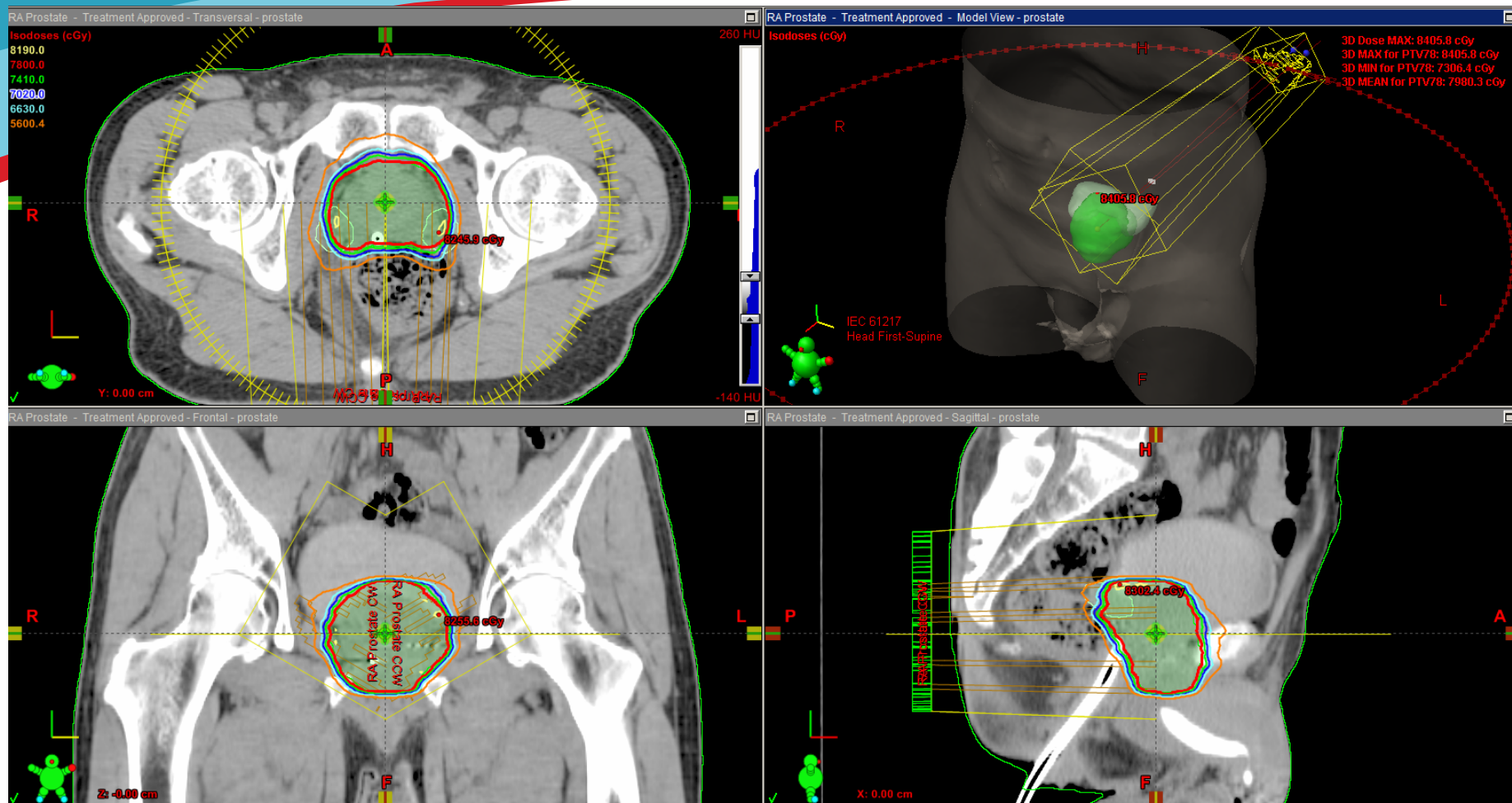


QA Result



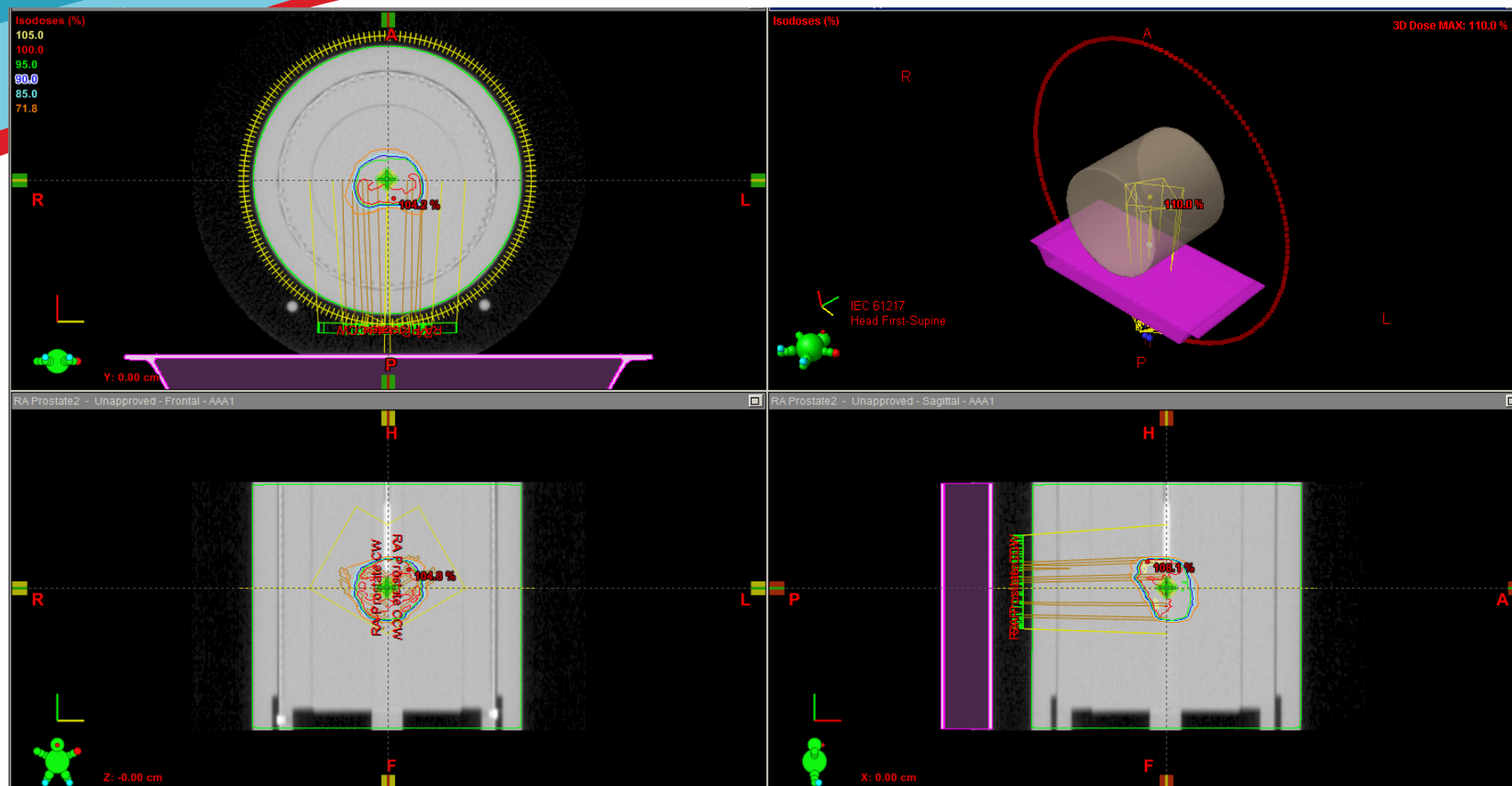


Clinical Example - Prostate



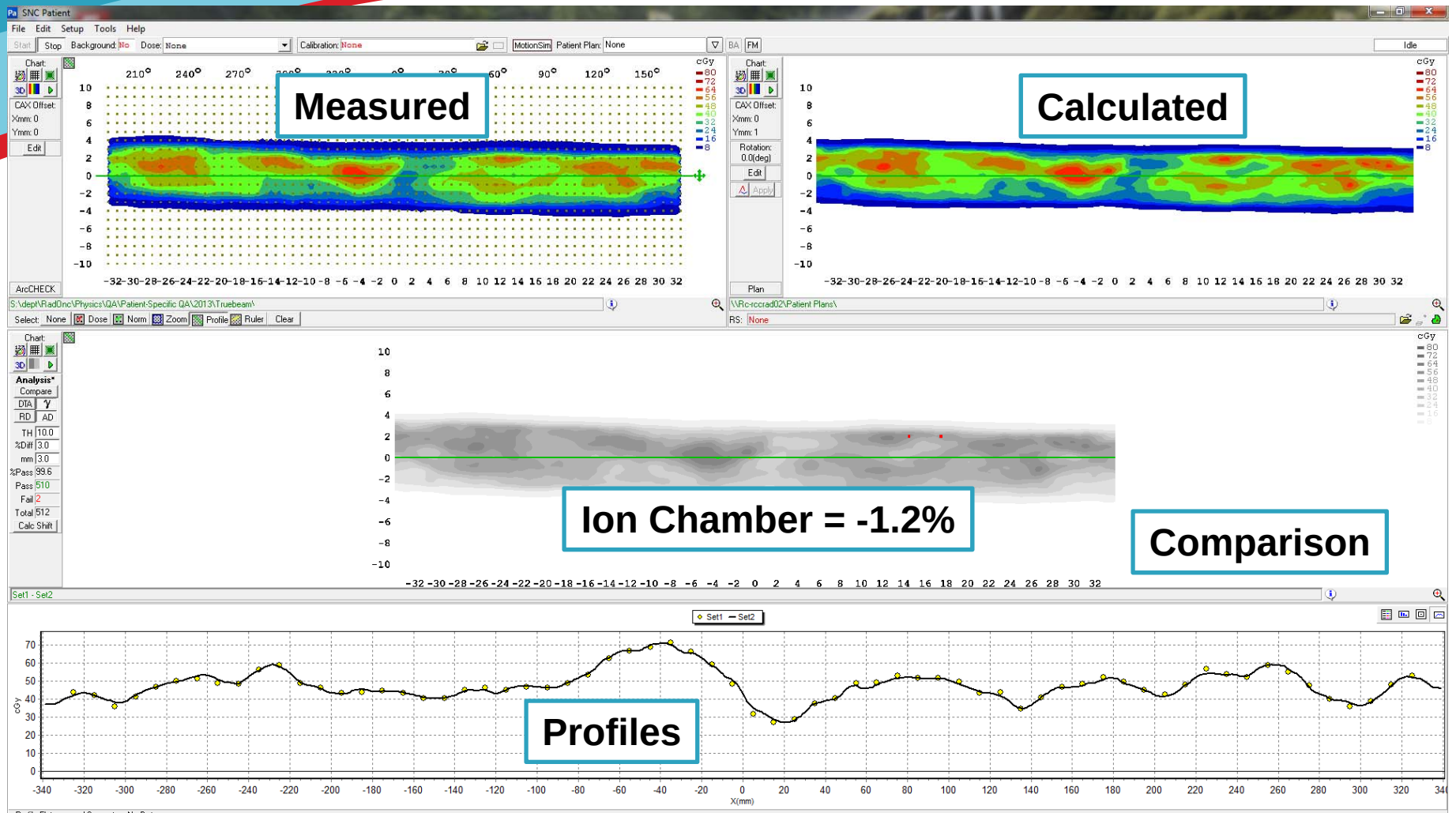


Phantom Plan





QA Result





Trend Analysis

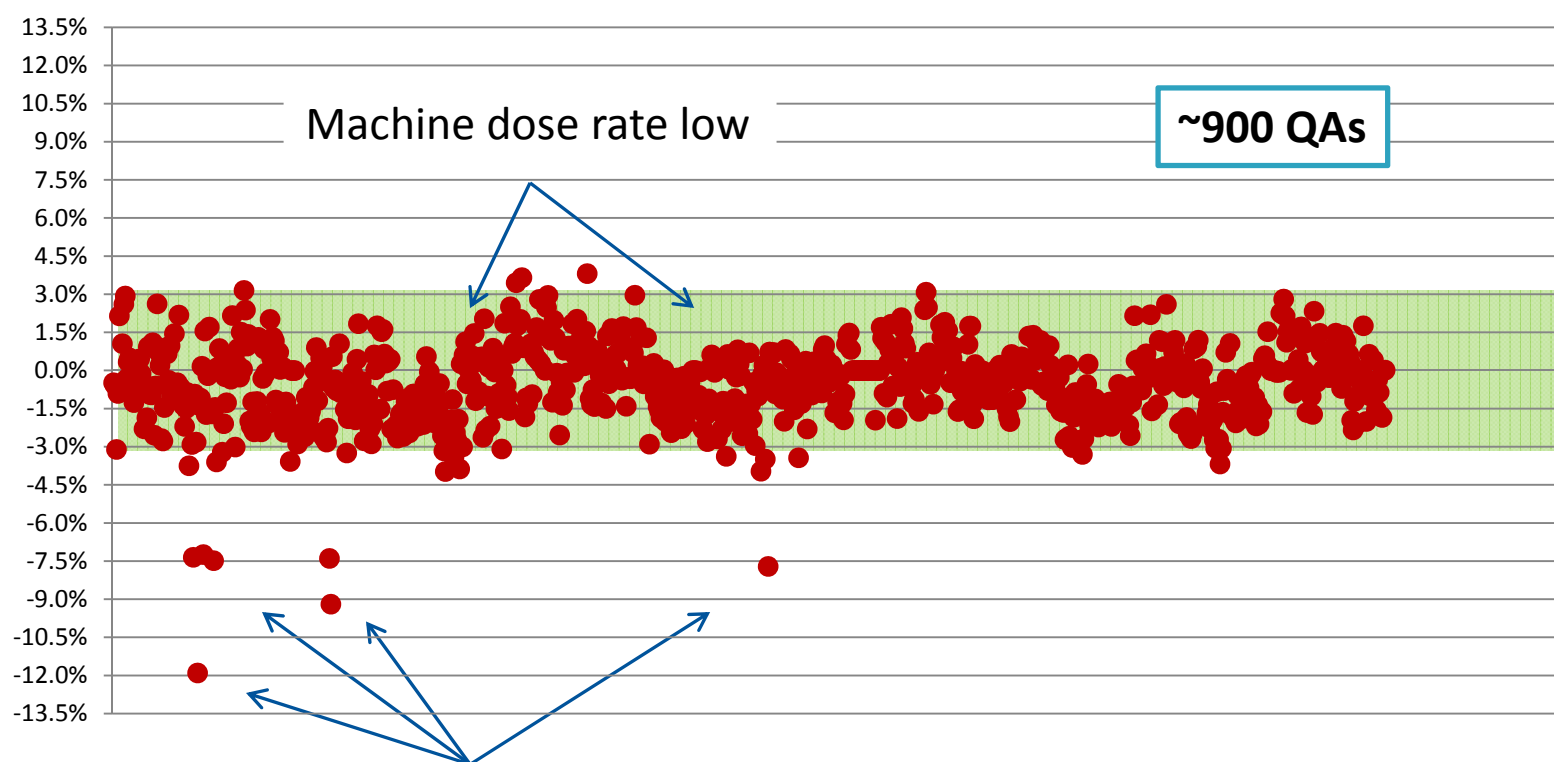
“When did 3D QA indicate clinical issues?”





Trend Analysis

Patient-specific Chamber Readings



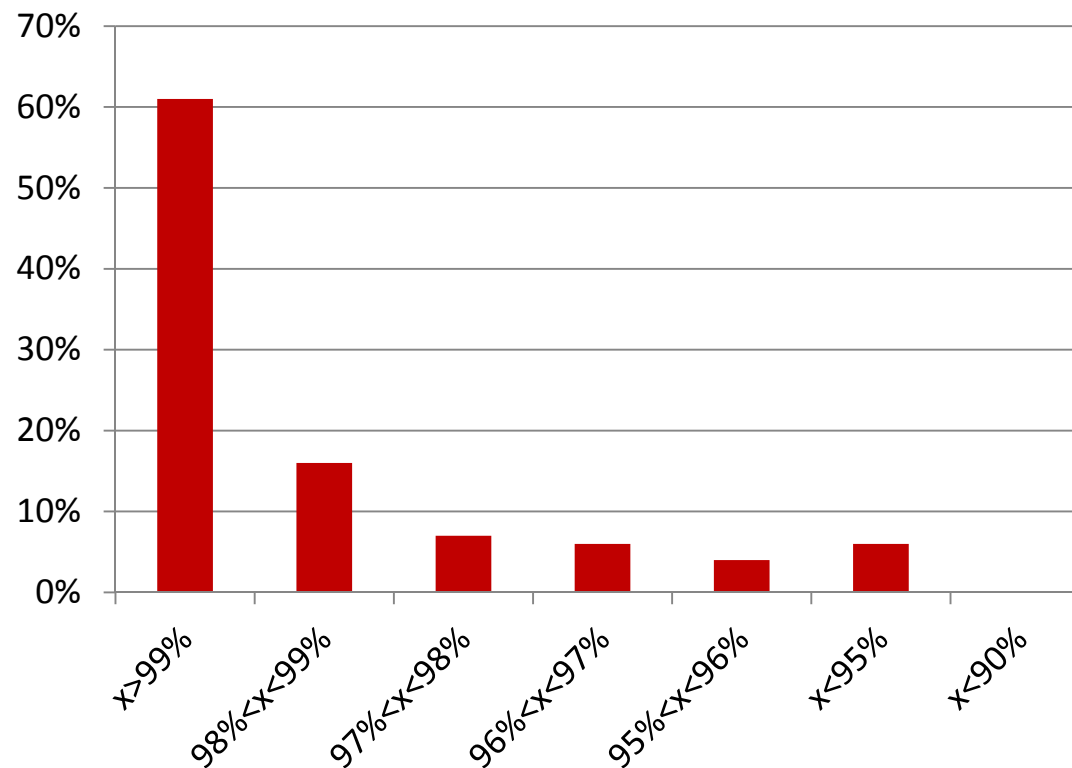
Setup error, high gradients, modulation too high





Trend Analysis

Patient-specific Gamma Pass Rates



Last 100 QAs

Gamma
3%/3mm <1





Future work

1. Better characterization with FFF
2. Higher resolution characterization for SRS
3. Applying results to patient's CT for DVH analysis





Conclusions

1. Commissioning
2. Ongoing Quality Improvement





Thank you!

