



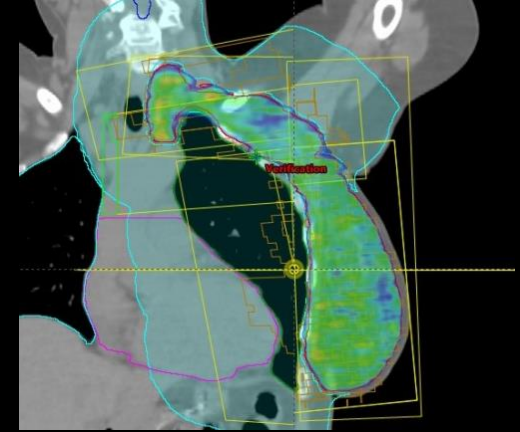
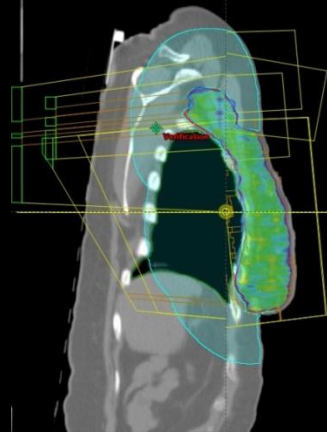
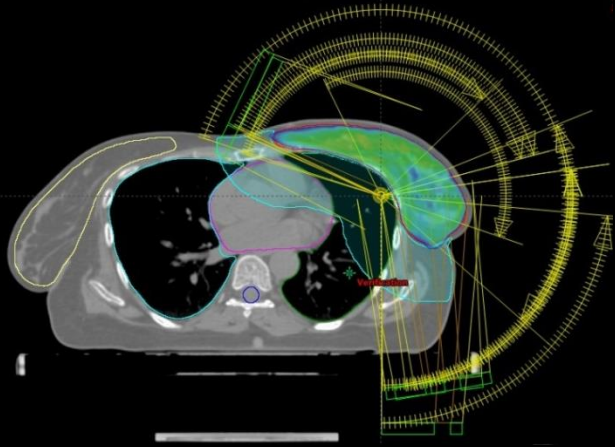
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accept the Challenge

2016 RADIOTHERAPY PLAN COMPETITION

Be the strongest link in the radiotherapy chain



By Saad Aldelaijan

Medical Physicist, Radiation Physics Section
Biomedical Physics Department
King Faisal Specialist Hospital & Research Centre



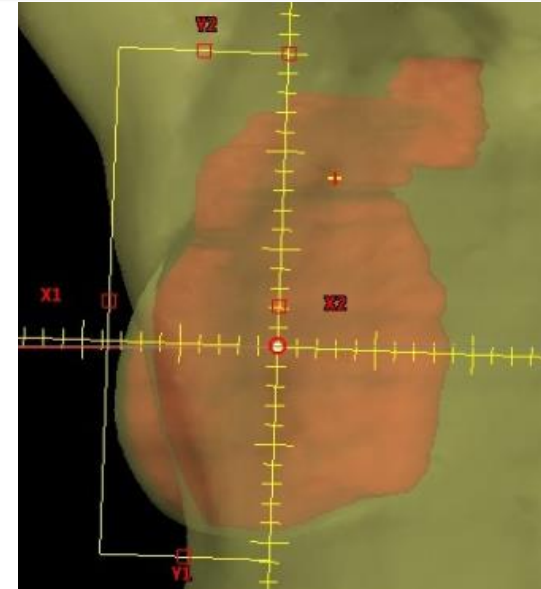
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Agenda

- About the competition
- Contouring stage
- Arc geometry
- Optimization
- Results
- Conclusions

About the competition

- Case selection
 - Peripheral targets
 - Inhomogeneous shape
 - Proximity to organs at risk
- The criteria
 - In general, the criteria is well chosen
 - Constraints on the right side of the patient were difficult to achieve
 - I found that some objectives were easily “over” achieved

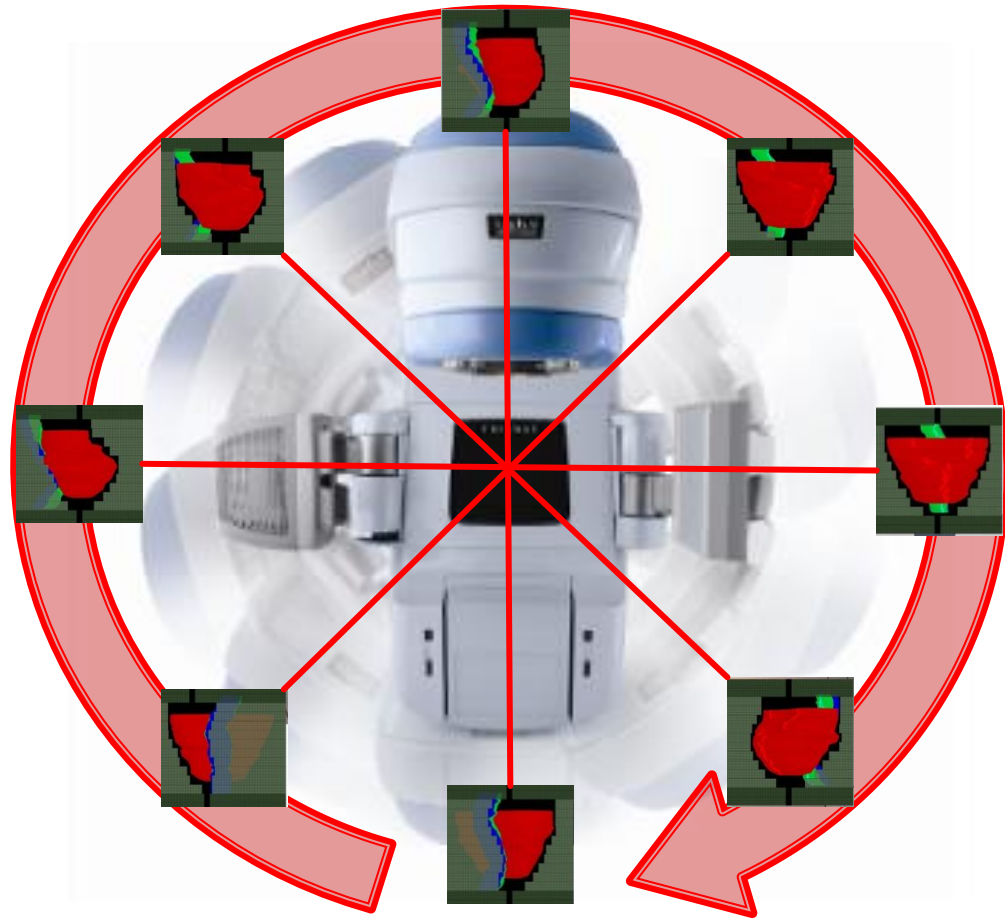


First: understand the criteria

Structure	Points
Target (CI , HI, others)	45
Heart	20
Left lung	19
Right breast	6
Right lung	5
Spinal cord	5
Total:	100

Volumetric Modulated Arc Therapy

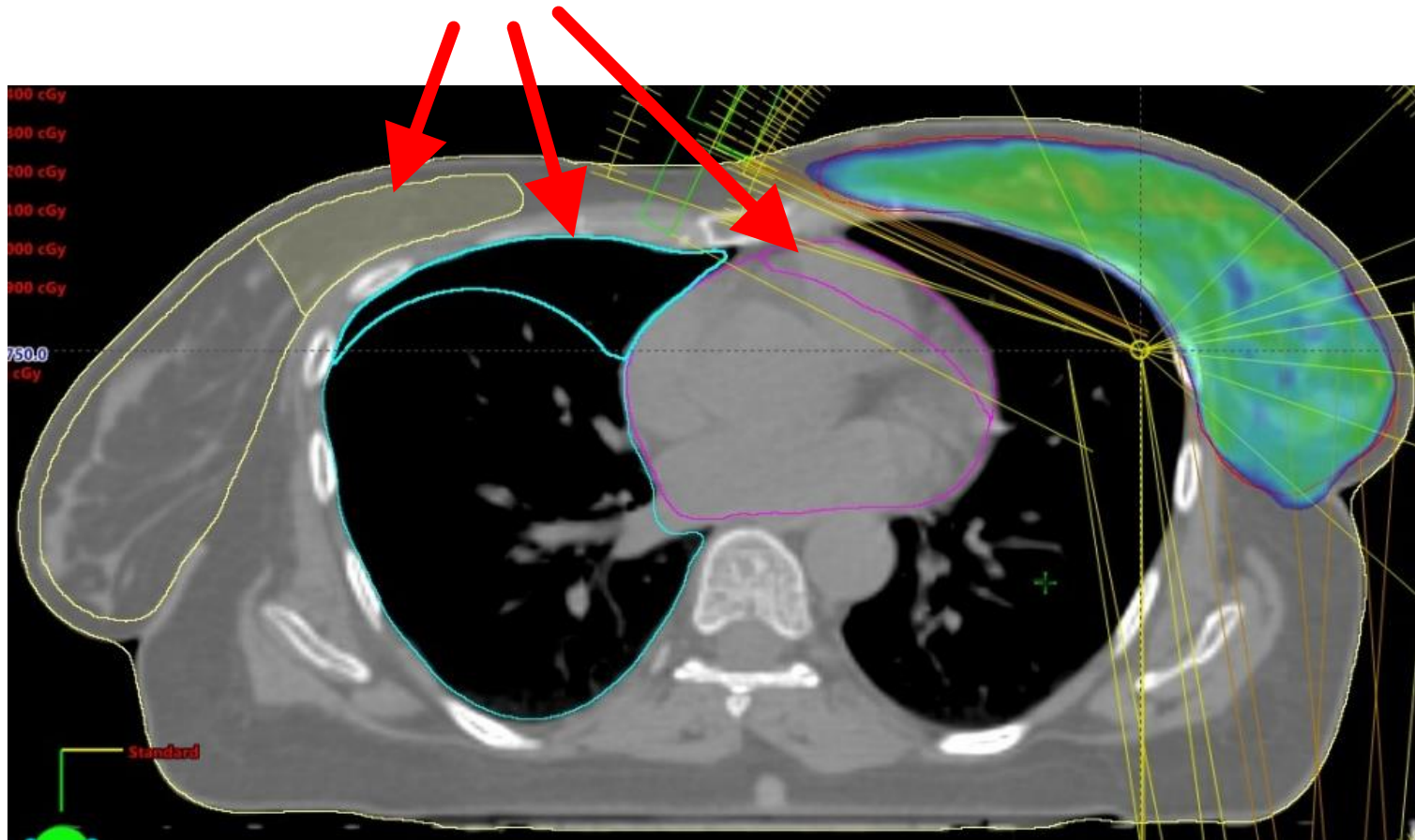
- Intensity modulators:
 - MLC Speed (Max speed 2.5 cm/sec)
 - Dose Rate (0-1400 MU/min)
 - Gantry Speed (~4.8 deg/sec)



Contouring stage

- Made the structures “high resolution”
- Used partially segmented OARs
- Used conformation structures (rings)

Partially segmented OARs



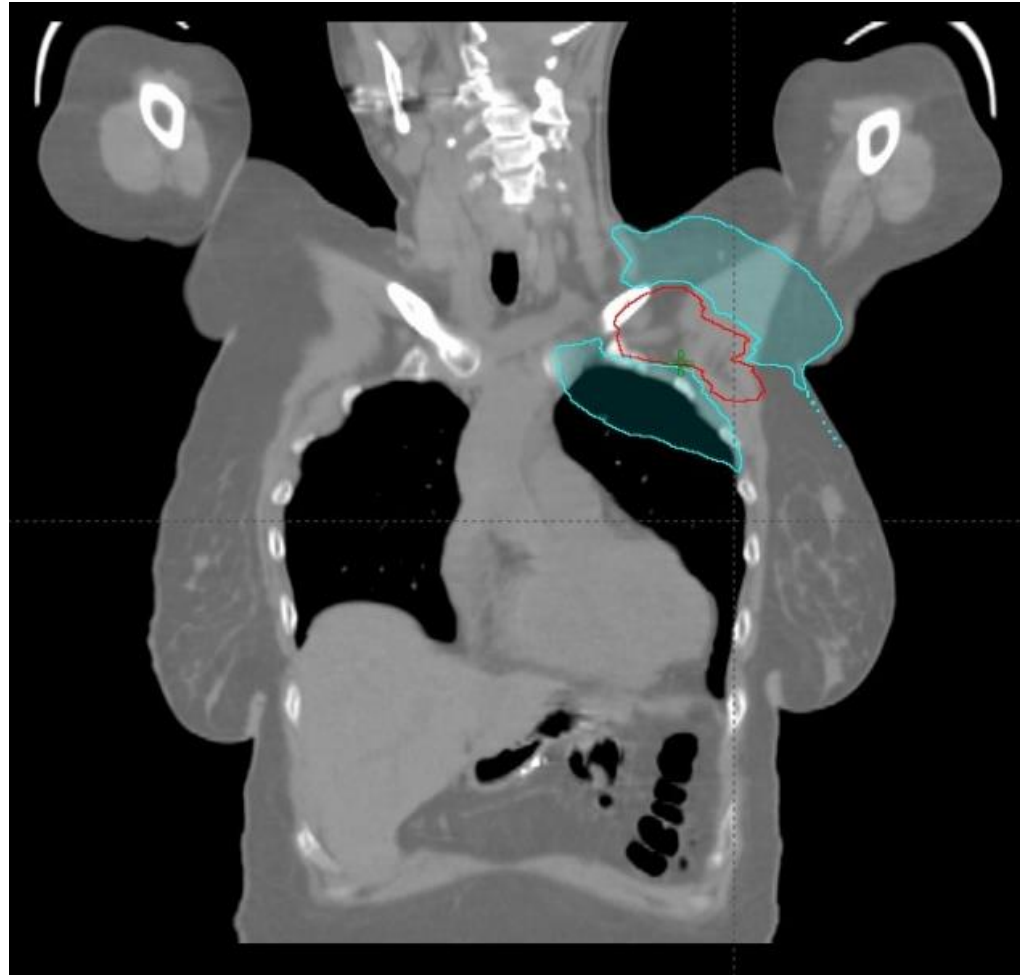
Conformation: Overall ring



Conformation: Supraclavicular ring



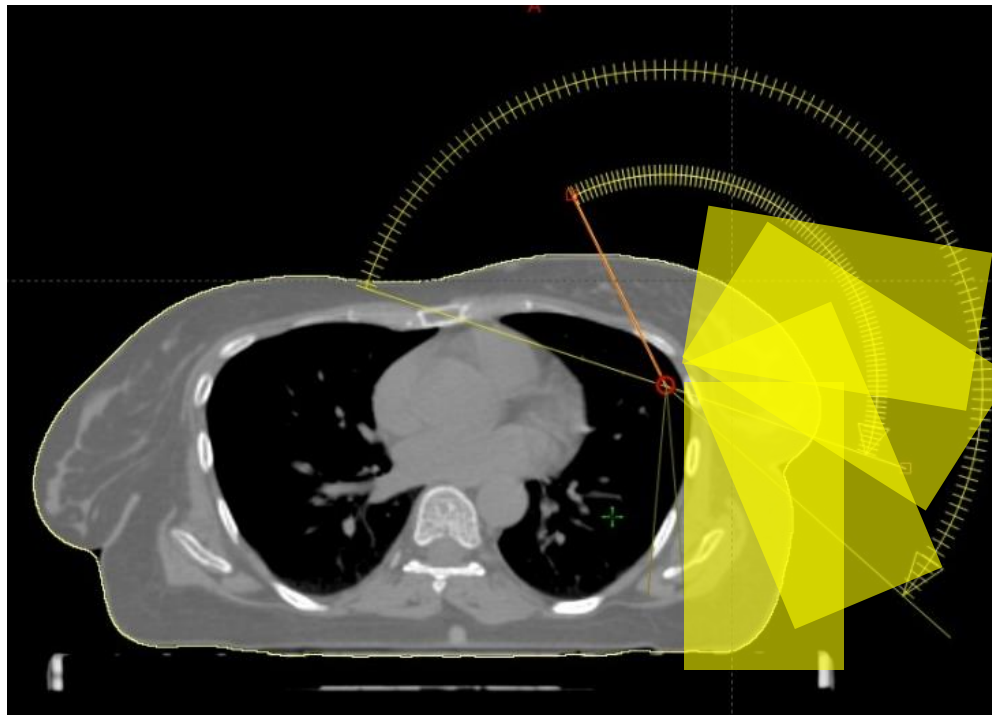
Conformation: Axilla ring



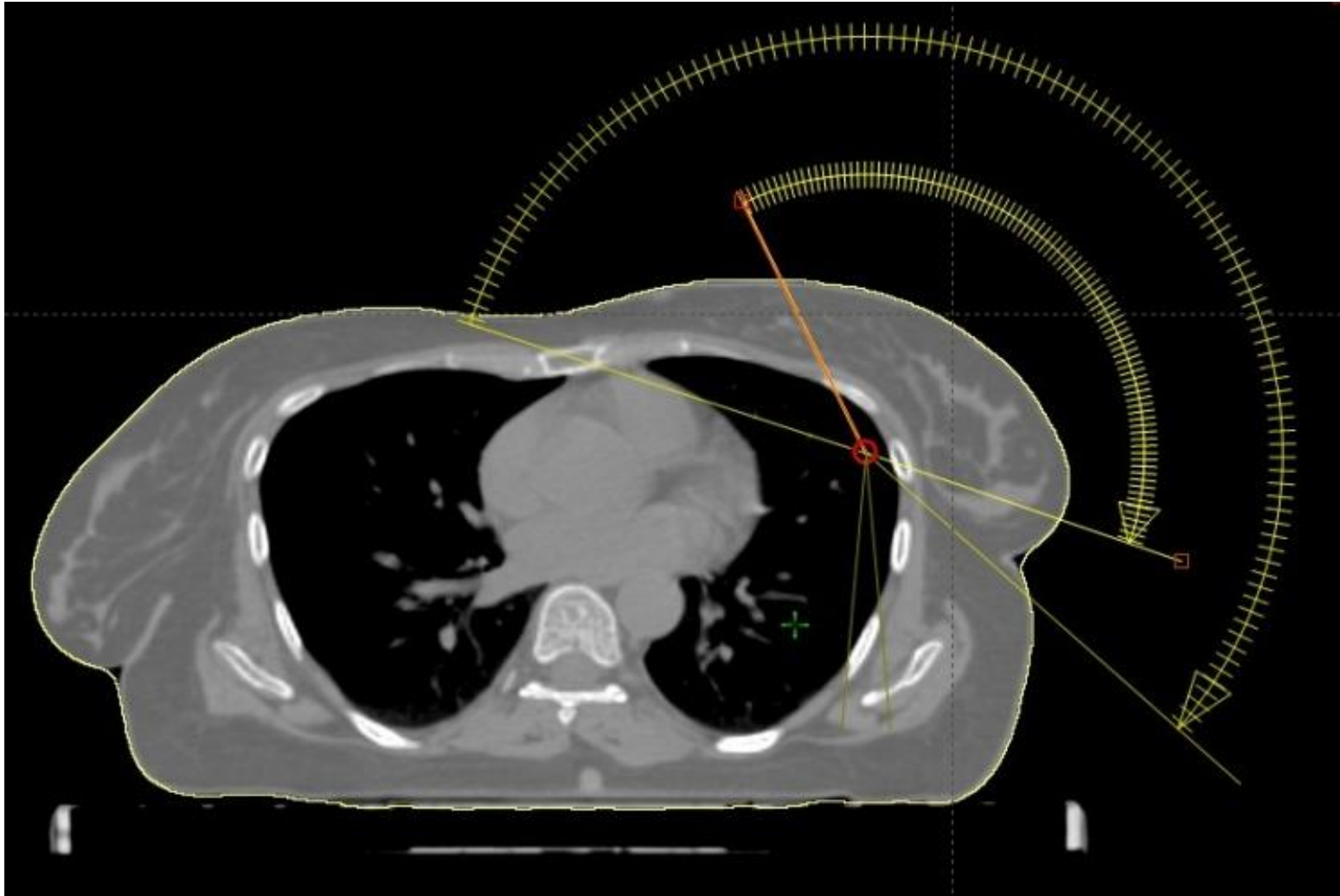
Geometry

- Eclipse Ver 13.6 (AAA 11.0.31, TrueBeam)
- Limitations:
 - Target inhomogeneity → multiple field sizes per target
 - Sparing ipsilateral OARs → isocentre positioning
 - Sparing contralateral OAR's → limiting gantry rotation
 - MLC over-carriage max travel of 14.5 cm
- Therefore, I used all available assets (nine coplanar partial arcs) @ 6 MV FFF

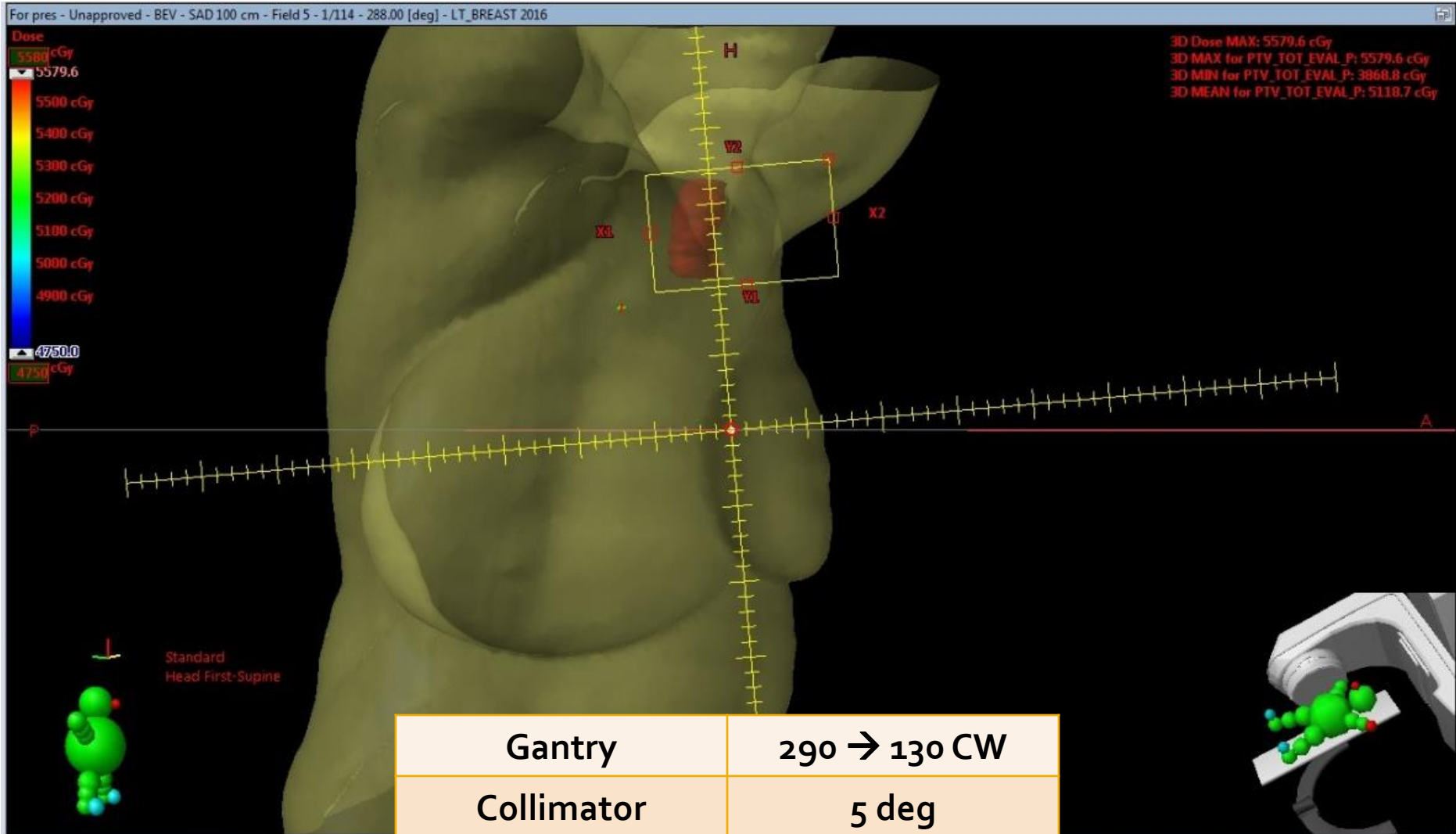
Geometry



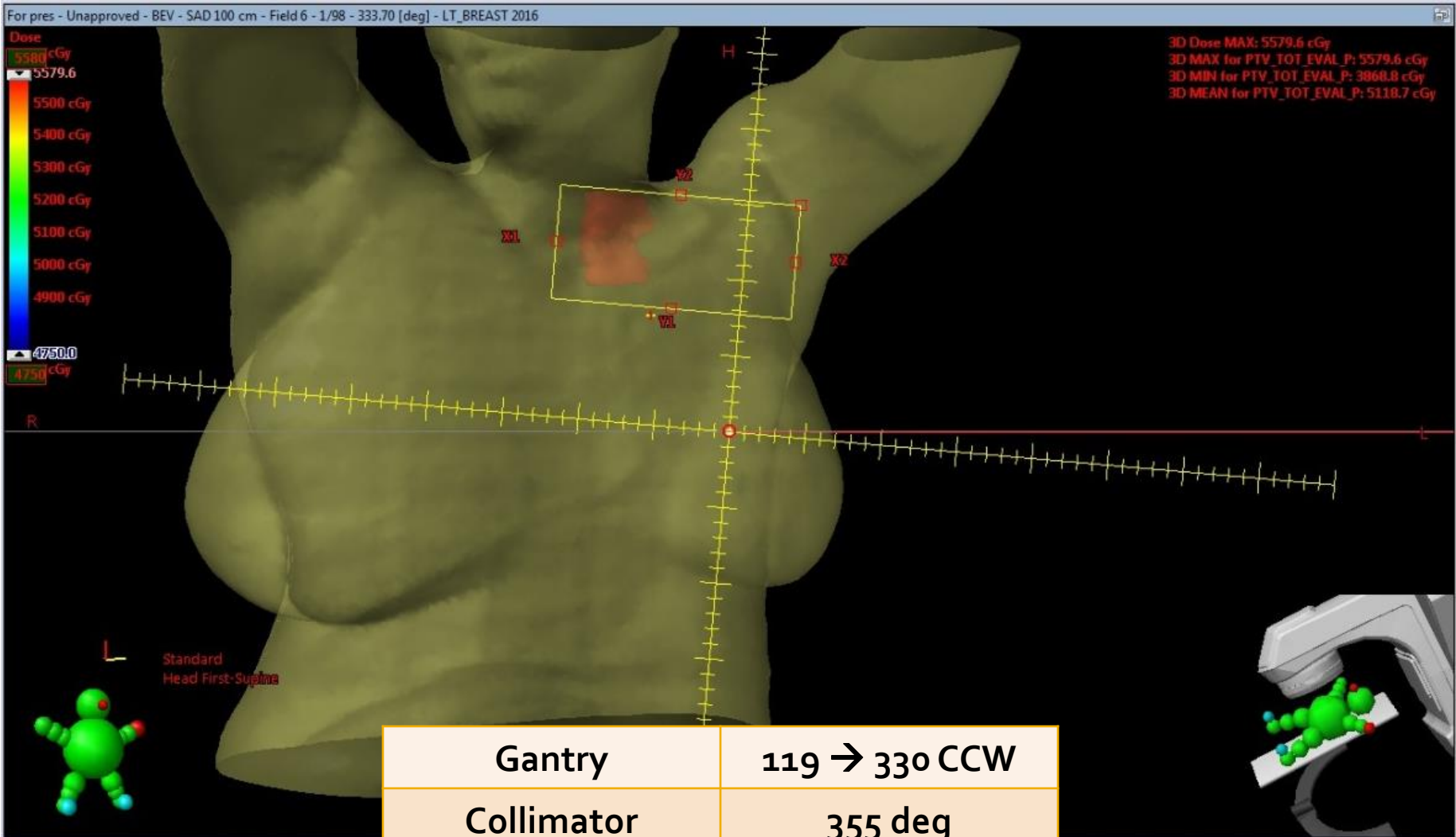
Supraclavicular arcs



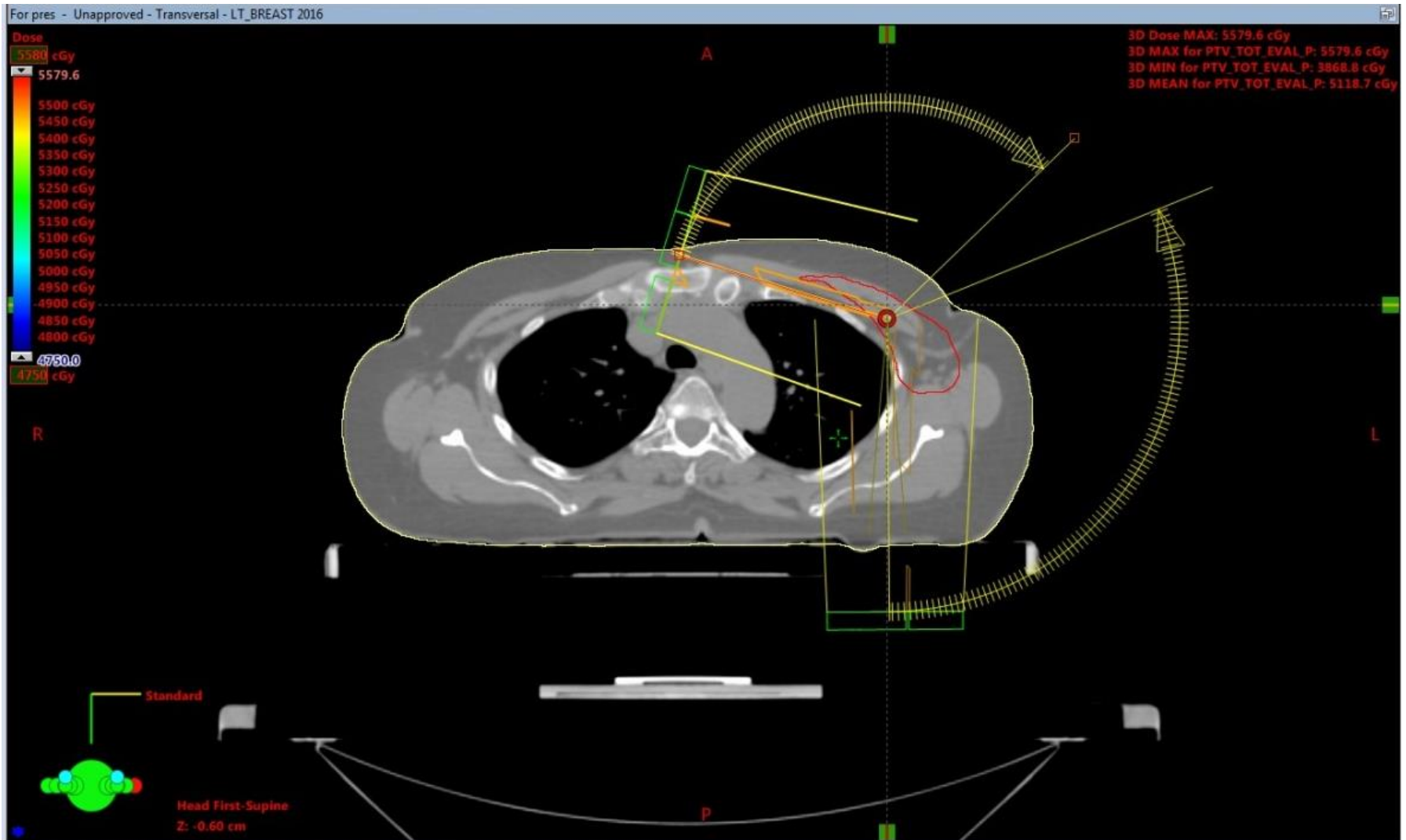
Supraclavicular arc 1



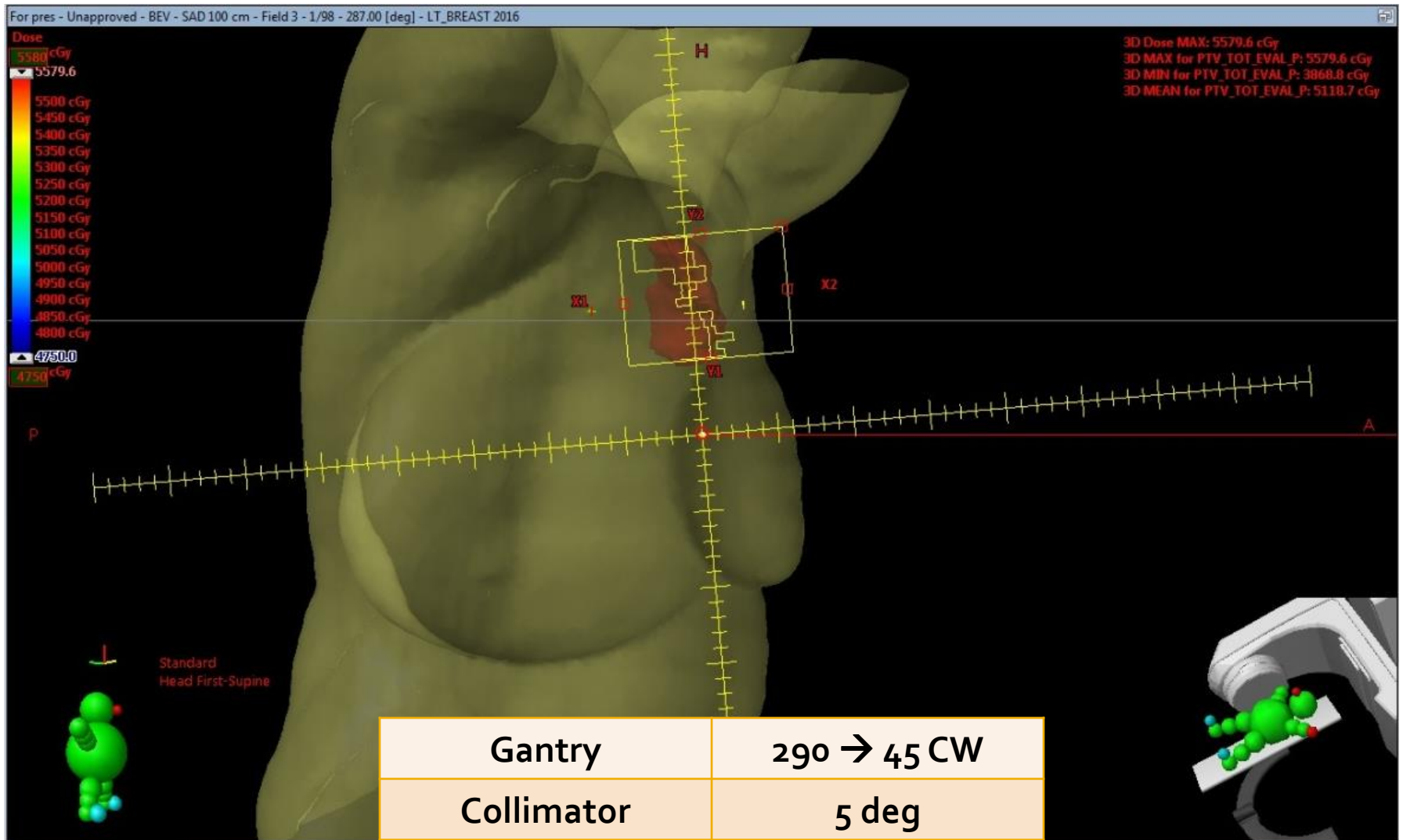
Supraclavicular arc 2



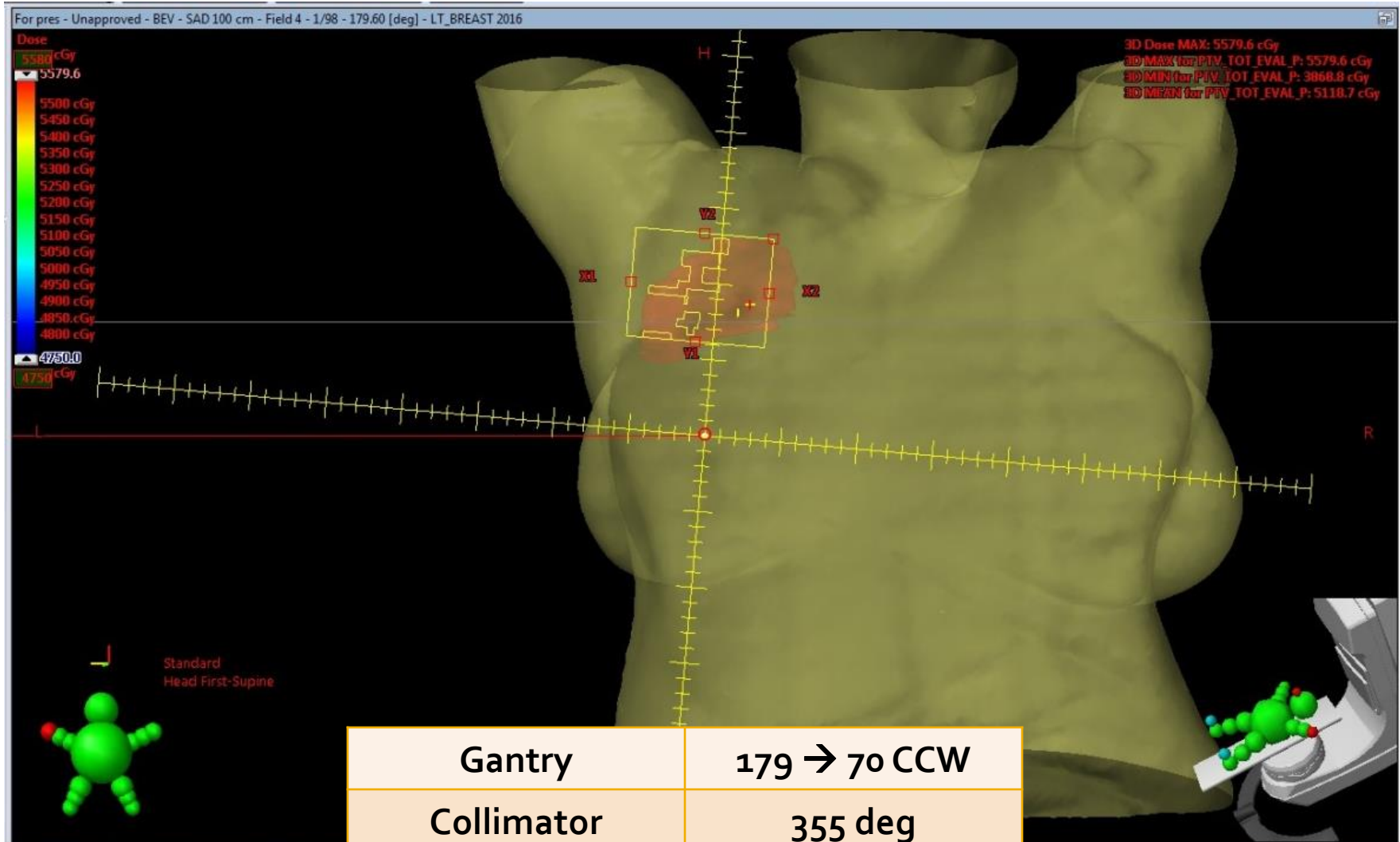
Axilla arcs



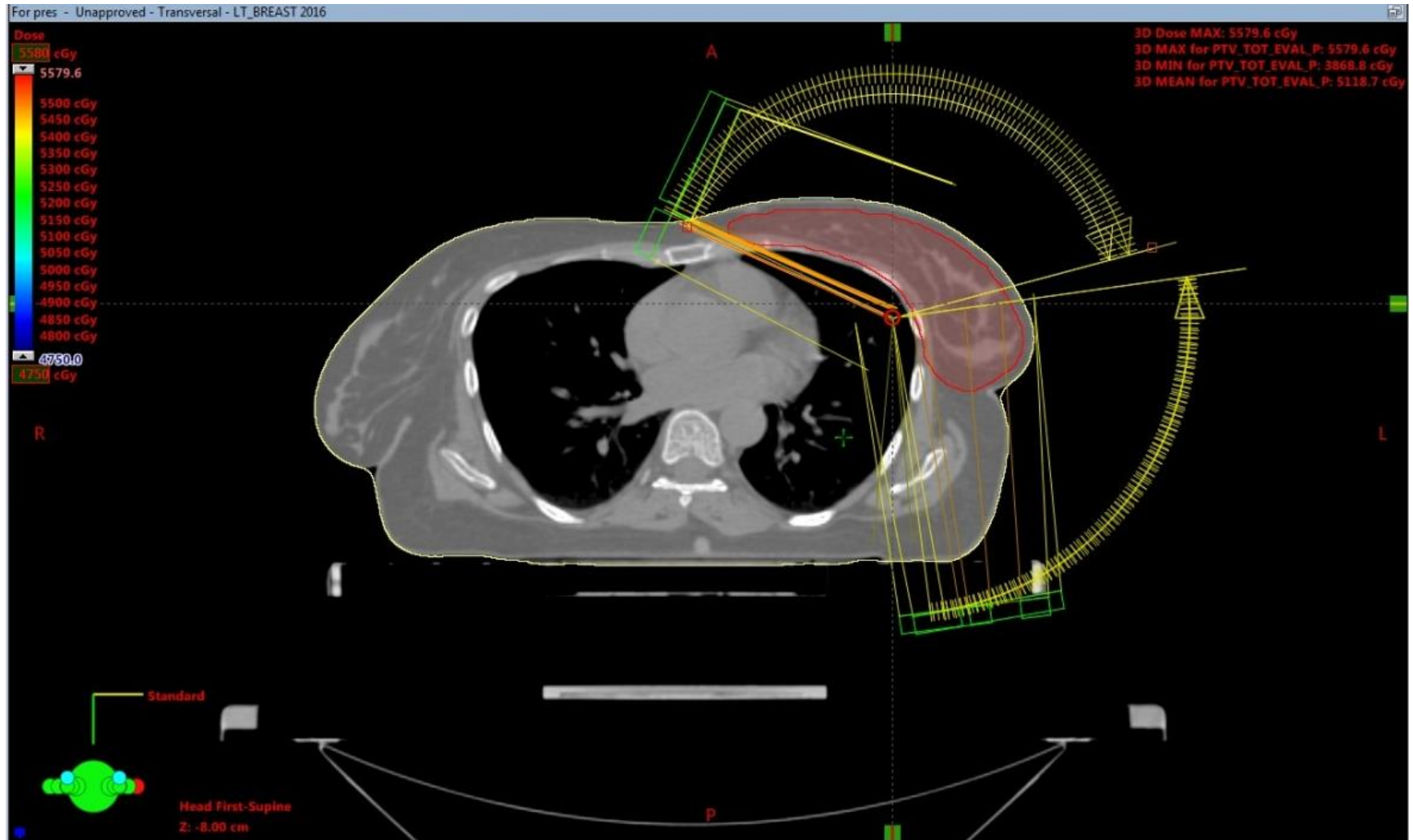
Axilla arc 1



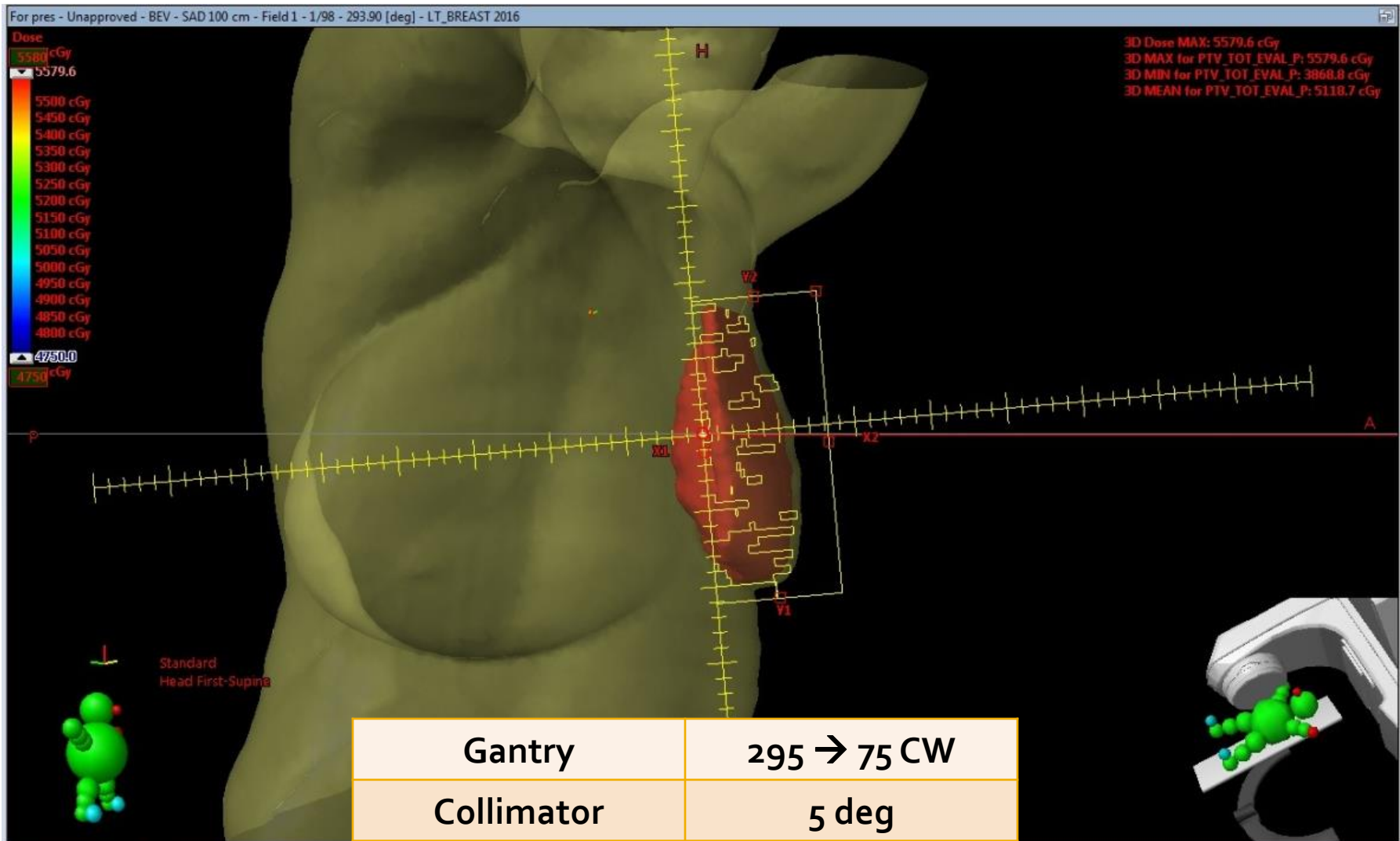
Axilla arc 2



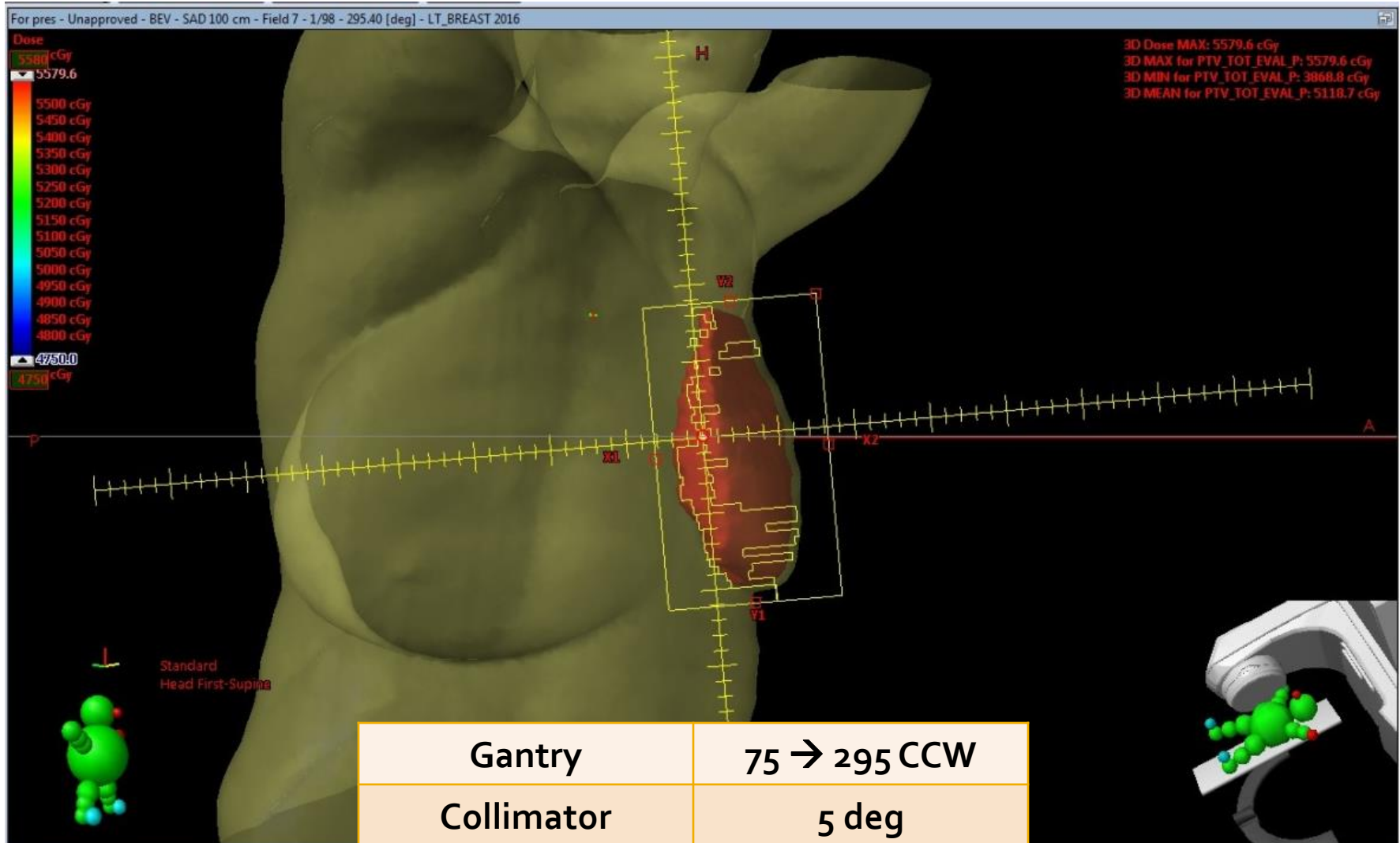
Lt breast arcs



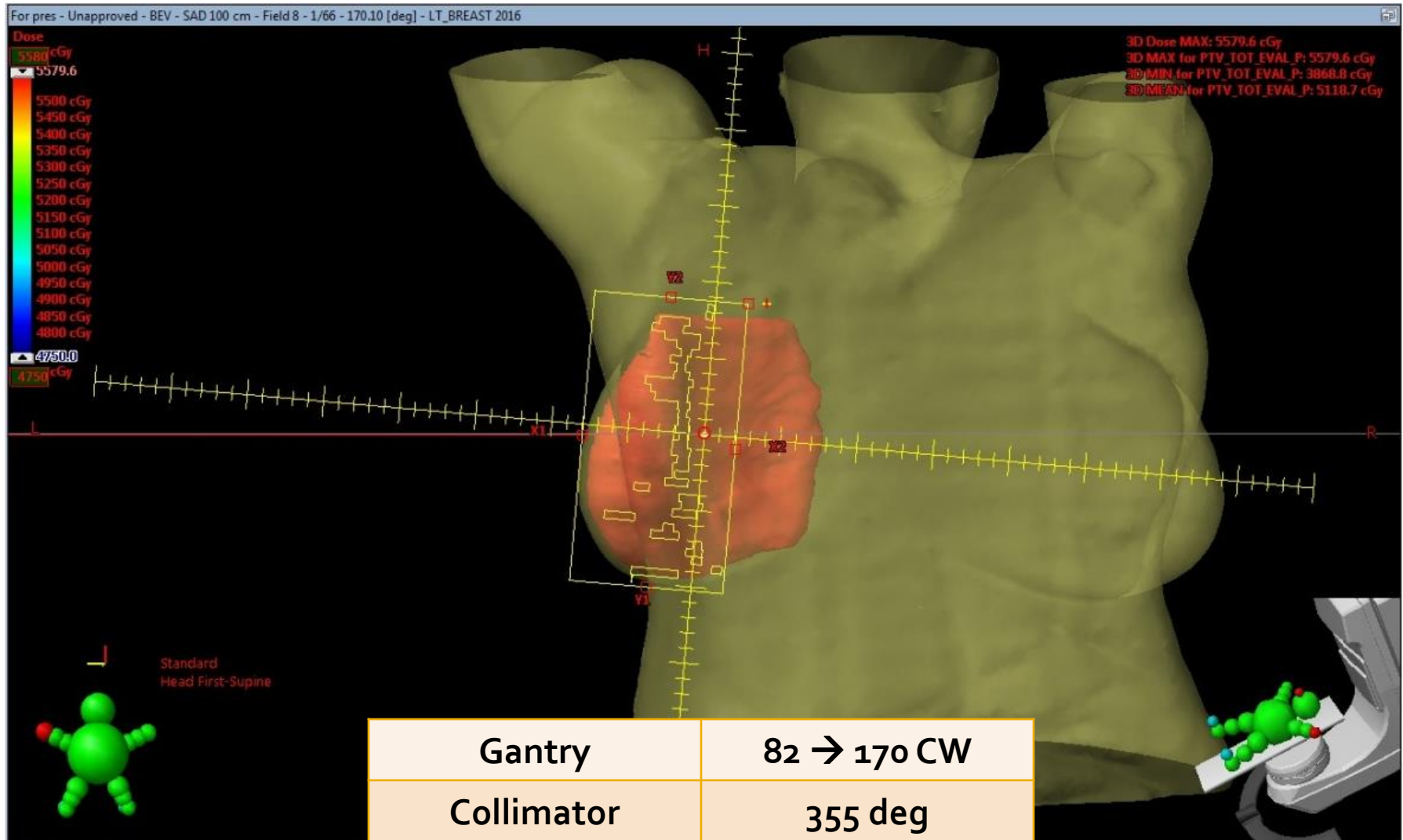
Lt Breast arc 1



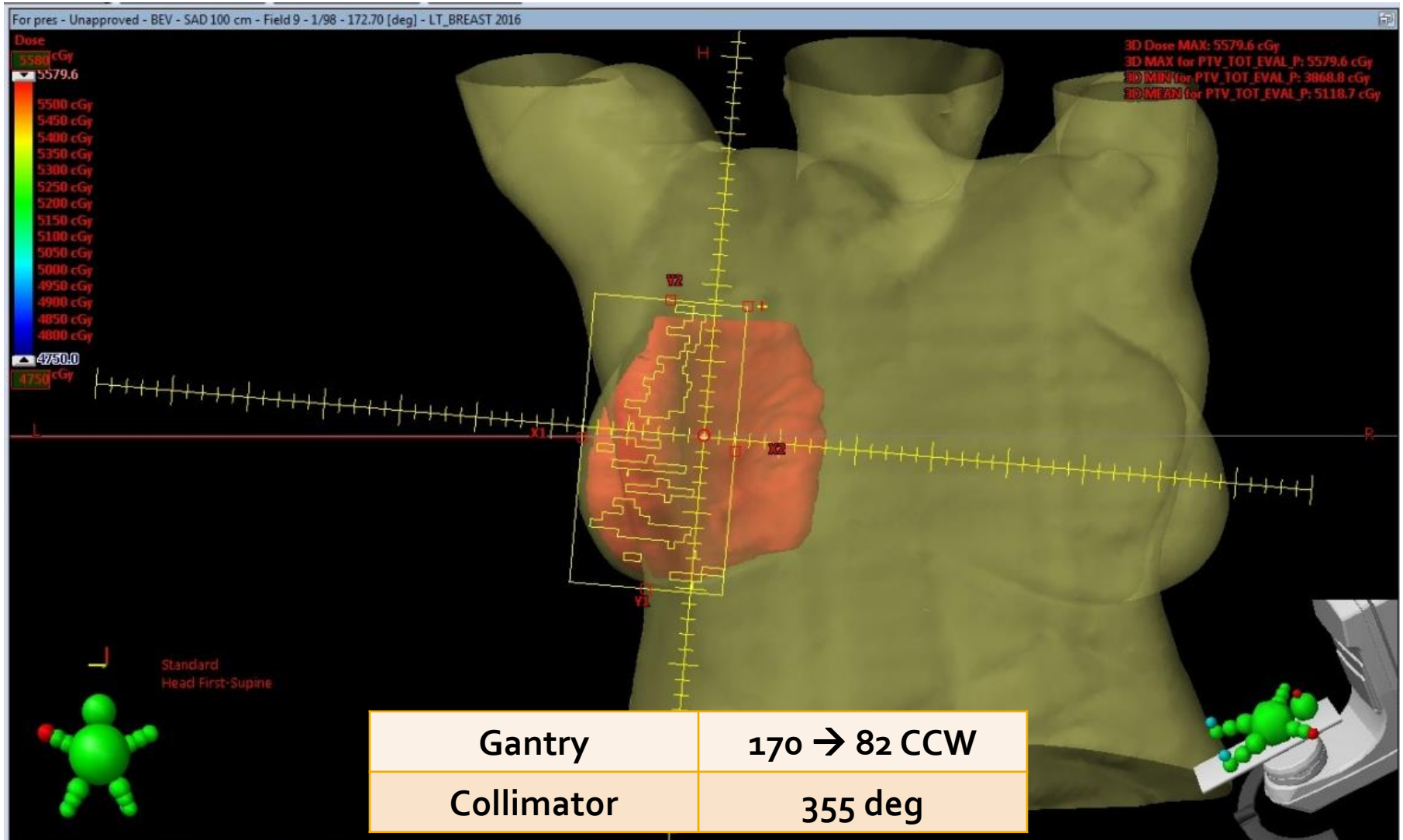
Lt Breast arc 2



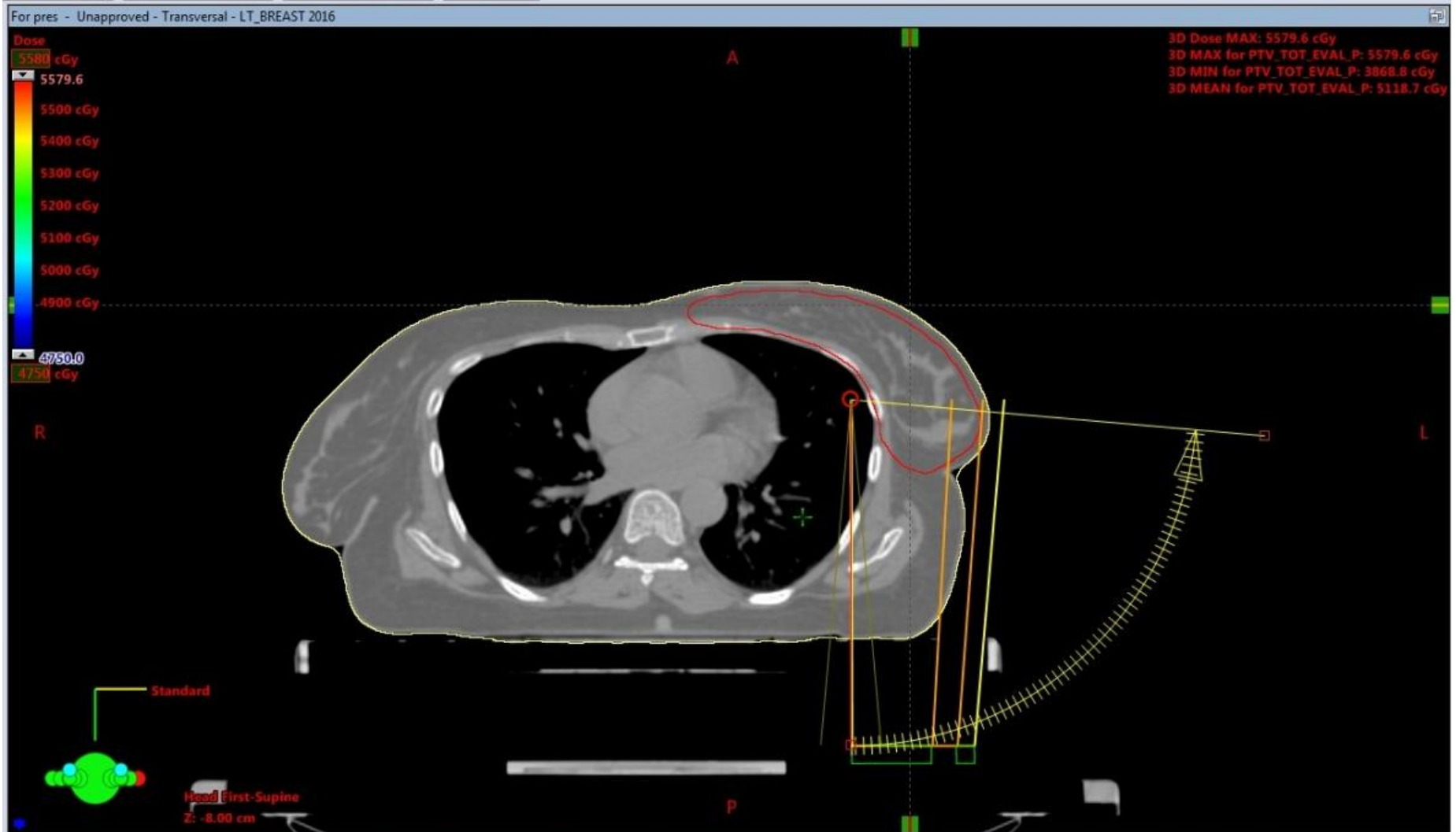
LT Breast arc 3



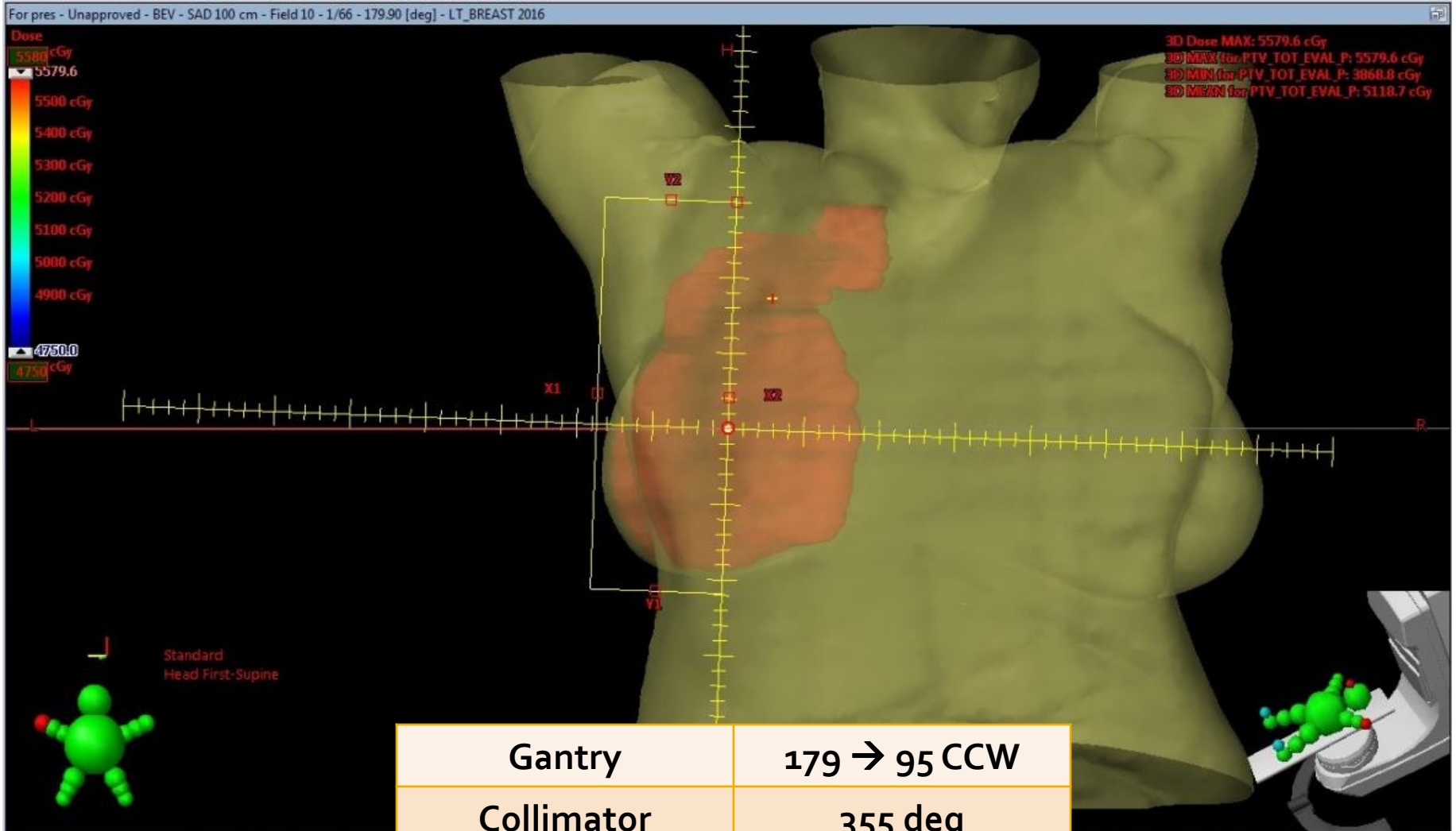
LT Brst arc 4



The "overall" arc



The "overall" arc



Optimization

- Start with targets and rings only:
 - SC + SC ring + overall ring
 - add axilla
 - add breast
 - add OARs
- Try to be patient!

Optimization after 5 min

VMAT Optimization - PlanChallenge, SA (plan 2016)

Structures and Objectives Exclude Structures... (5)

Use Normal Tissue Objective Priority: 100 Define NTO Settings...

Structure	Volume [cc]	Points	Resolution [mm]
BODY_P	27314	269770	4.50
Breast RT GST	225	7503	3.00
BREAST_RIGHT_P	890	29660	3.00
CTV-LUMPECTOMY_P	39	2000	2.60
HEART_P	111	3710	3.00
HEART_P	686	22859	3.00
LUNG_LEFT_P	855	28500	3.00
LUNG_LEFT_P	1177	39229	3.00
LUNG_RT	367	12249	3.00
LUNG_RT	1346	44864	3.00
PTV_AXILL_P	143	4773	3.00
PTV_BREAST_P	873	29108	3.00
PTV_SC_P	41	2000	2.64
PTV_TOT_EVAL_P	1090	36328	3.00
Upper	Volume [%]: 0.0	Dose [cGy]: 5200.0	Priority: 100
Lower	Volume [%]: 100.0	Dose [cGy]: 5000.0	Priority: 100
Ring	Volume [cc]: 4058	Points: 135274	Resolution [mm]: 3.00
Ring_AX	Volume [cc]: 849	Points: 28306	Resolution [mm]: 3.00
Ring_SC	Volume [cc]: 459	Points: 15296	Resolution [mm]: 3.00
SPINAL CORD_P	Volume [cc]: 51	Points: 2000	Resolution [mm]: 2.83

Dose Volume Histogram

Some structures are unapproved or rejected

Base dose plan: Select...

Avoidance Sectors (0 MU) Define Settings...

None

MU Objective

Use Strength: 50

Min MU: 0 Max MU: 2000

Automate Optimization

Continue automatically to final dose calculation

Save all after optimization and dose calculation

Automatic intermediate dose

Progress: Progress bar

Level Hold

MR 1 / 4 STEP 1 / 5 MU: 1008 5m 26s

View as: Line chart Bar chart

OK Cancel Apply

Optimization after 32 min

VMAT Optimization - PlanChallenge, SA (plan 2016)

Structures and Objectives Exclude Structures... (5)

Use Normal Tissue Objective Priority: 100 Define NTO Settings...

Structure	Volume [cc]	Points	Resolution [mm]
BODY_P	27314	269770	4.50
Breast RT GST	225	7503	3.00
BREAST_RIGHT_P	890	29660	3.00
CTV-LUMPECTOMY_P	39	2000	2.60
HEART_P	111	3710	3.00
HEART_P	686	22859	3.00
LUNG_LEFT_P	855	28500	3.00
LUNG_LEFT_P	1177	39229	3.00
LUNG_RT	367	12249	3.00
LUNG_RT	1346	44864	3.00
PTV_AXILL_P	143	4773	3.00
PTV_BREAST_P	873	29108	3.00
PTV_SC_P	41	2000	2.64
PTV_TOT_EVAL_P	1090	36328	3.00
Upper	Volume [%]: 0.0	Dose [cGy]: 5200.0	Priority: 100
Lower	Volume [%]: 100.0	Dose [cGy]: 5000.0	Priority: 100
Ring	Volume [cc]: 4058	Points: 135274	Resolution [mm]: 3.00
Ring_AX	Volume [cc]: 849	Points: 28306	Resolution [mm]: 3.00
Ring_SC	Volume [cc]: 459	Points: 15296	Resolution [mm]: 3.00
SPINAL CORD_P	Volume [cc]: 51	Points: 2000	Resolution [mm]: 2.83

Avoidance Sectors (0 MU)

Define Settings...

None

Jaw Tracking

MU Objective

Use Strength: 50

Min MU: 0 Max MU: 2000

Automate Optimization

Continue automatically to final dose calculation

Save all after optimization and dose calculation

Automatic intermediate dose

Progress:

Dose Volume Histogram

Volume [%]

Dose [cGy]

Some structures are unapproved or rejected

Base dose plan: Select...

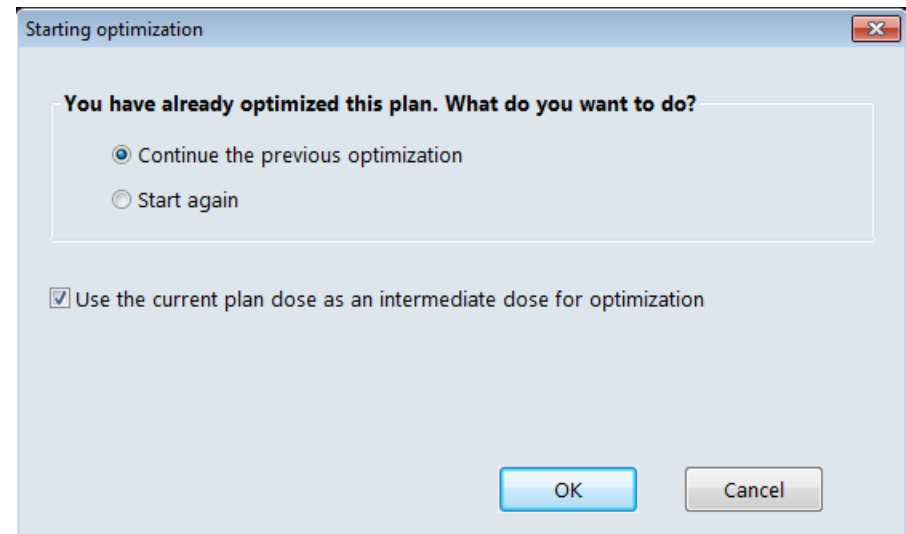
MR 1 / 4 STEP 3 / 5 MU: 1497 32m 23s

Level Hold

View as: Line chart Bar chart

Optimization (in a nutshell)

- Pause the optimizer until the cost function “plateaus”
 - At the “odd number” steps
 - At the beginning of each phase (calc resolution)
- Re-optimize: using the current plan dose as an intermediate dose for optimization



Optimization (in a nutshell)

- If your target priorities are

P: 100%

- Lt Lung:
 - 95 % → 15 % vol max: 2000 cGy
 - 80% → mean: 700 cGy
- Rt Lung:
 - 80 % → 3 % vol max: 500 cGy
 - 50% → mean: 100 cGy
- Rt Breast:
 - 90 % → 5 % vol max: 200 cGy
 - 50% → mean: 75 cGy
- Heart:
 - 35% → mean: 400 cGy
- Spinal cord:
 - 40% → 0% vol max: 600 cGy
 - 40% → mean: 150 cGy

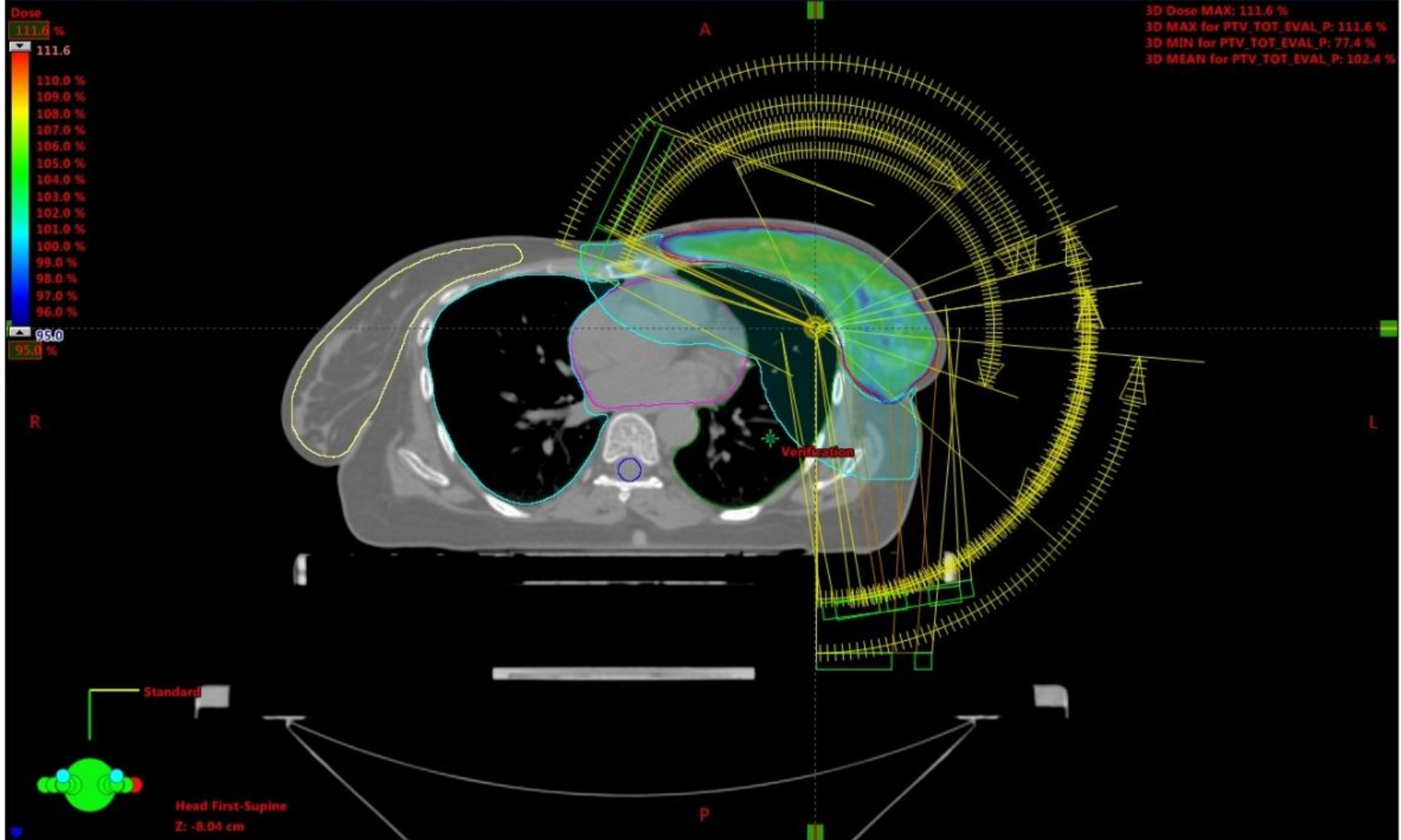
Structures and Objectives

Use Normal Tissue Objective Priority: 100 Exclude Structures... (9) Define NTO Settings...

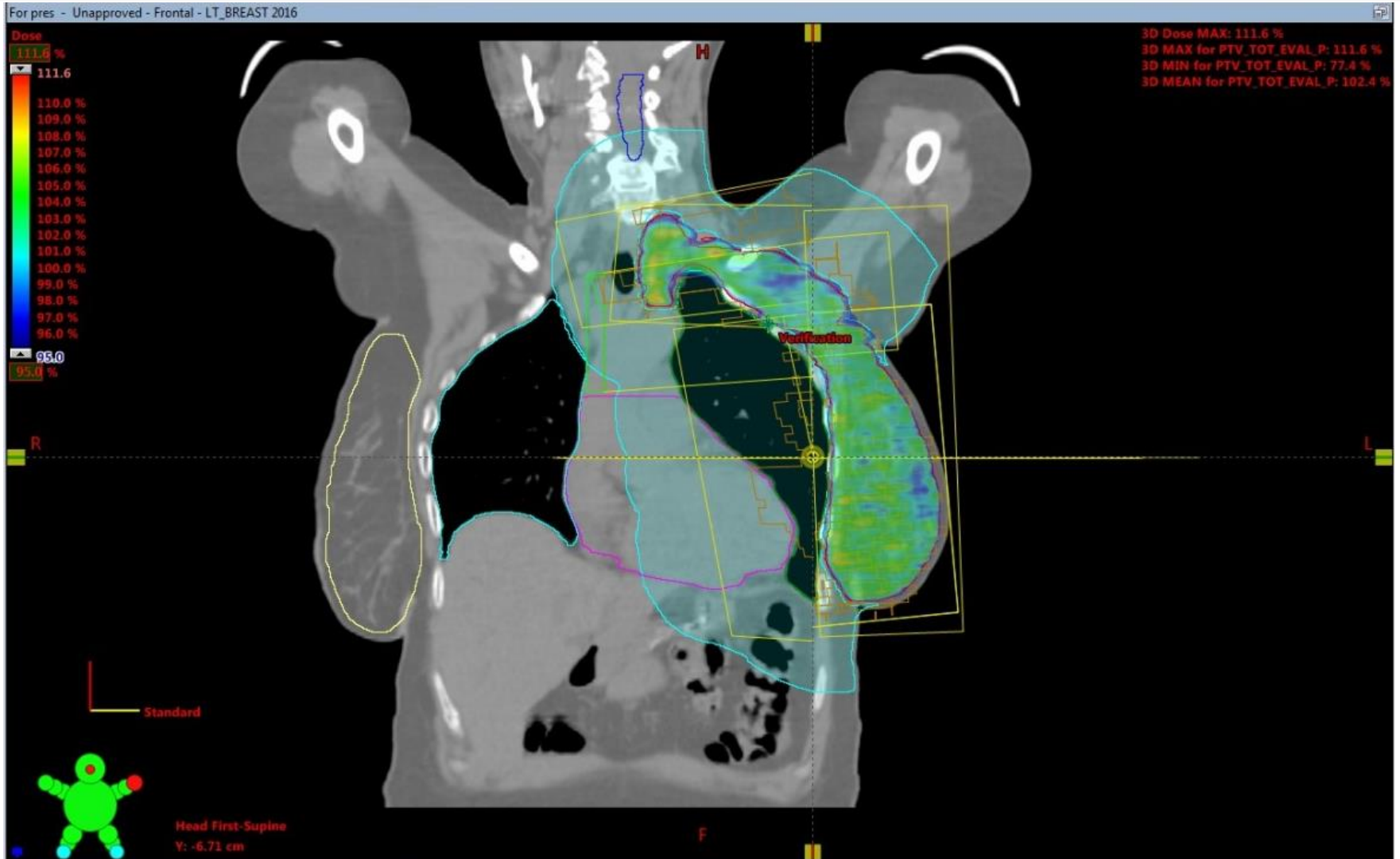
Structure	Type	Volume [cc]	Points	Resolution [mm]	Priority
Breast RT GST	Upper	225	7503	3.00	90
	Mean	5.0	200.0		50
BREAST_RIGHT_P	Upper	890	29660	3.00	90
	Mean	5.0	200.0		50
CTV-LUMPECTOMY_P	Lower	39	2000	2.60	80
	Volume [%]	100.0	5000.0		3.00
HEART_P		111	3710	3.00	35
HEART_P	Mean	686	22859	3.00	35
	Dose [cGy]		400.0		100
LUNG_RT		367	12249	3.00	100
PTV_AXILL_P	Upper	143	4773	3.00	100
	Lower	0.0	5200.0		100
	Volume [%]	100.0	5000.0		3.00
PTV_BREAST_P	Upper	873	29108	3.00	100
	Lower	0.0	5200.0		100
	Volume [%]	100.0	5000.0		105
PTV_SC_P	Upper	41	2000	2.64	105
	Lower	0.0	5200.0		115
	Volume [%]	100.0	5000.0		3.00
PTV_TOT_EVAL_P	Upper	1090	36328	3.00	70
	Lower	0.0	5200.0		60
	Volume [%]	100.0	5000.0		70
Ring	Upper	4058	135274	3.00	50
	Mean	0.0	4600.0		50
	Dose [cGy]		1200.0		70
Ring_AX	Upper	849	28306	3.00	50
	Mean	0.0	4600.0		50
	Dose [cGy]		2300.0		3.00
Ring_SC	Upper	459	15296	3.00	70
	Mean	0.0	4600.0		50
	Dose [cGy]		1900.0		40
SPINAL CORD_P	Upper	51	2000	2.83	40
	Mean	0.0	600.0		40
	Dose [cGy]		150.0		

All fields - Axial

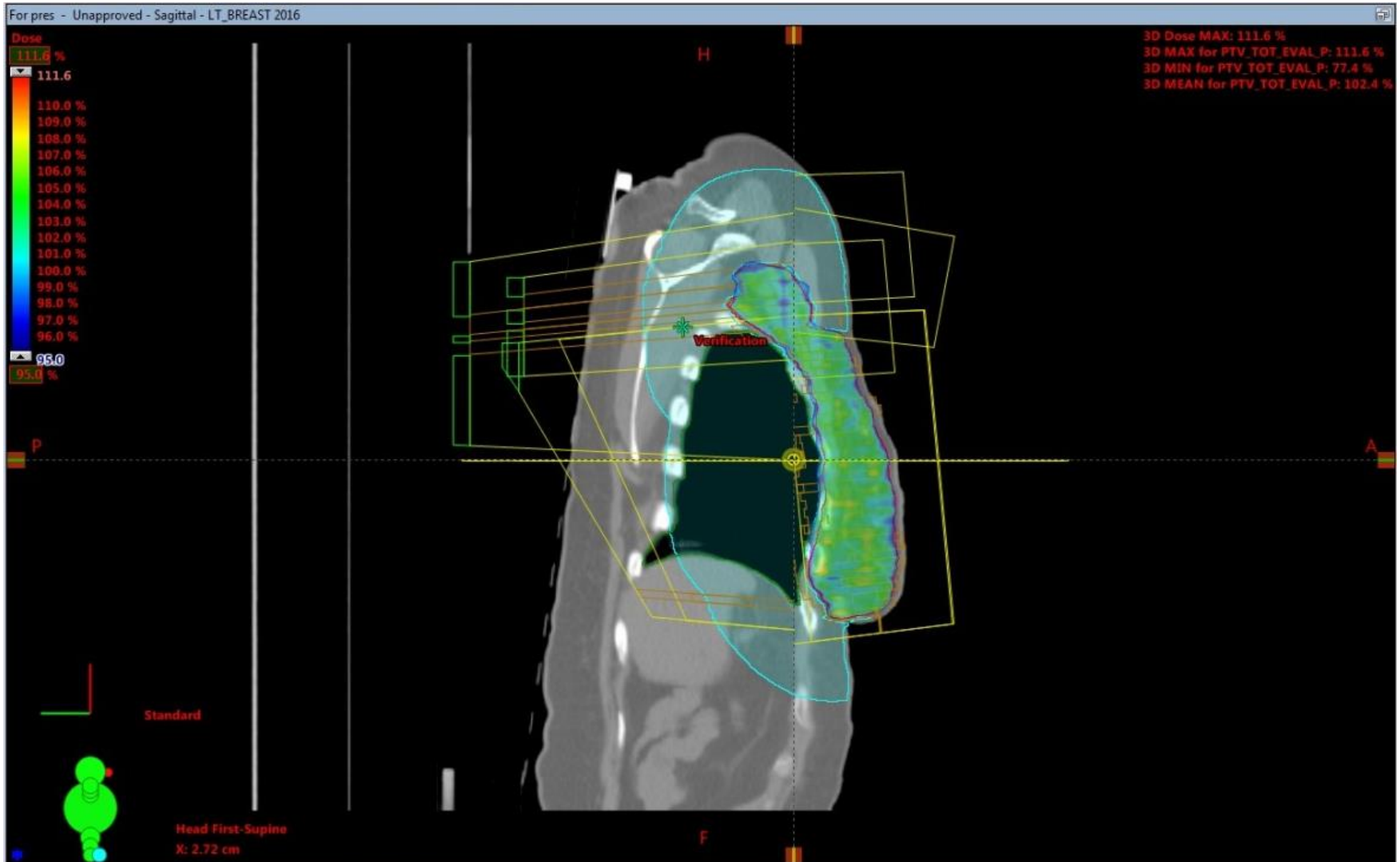
For pres - Unapproved - Transversal - LT_BREAST 2016



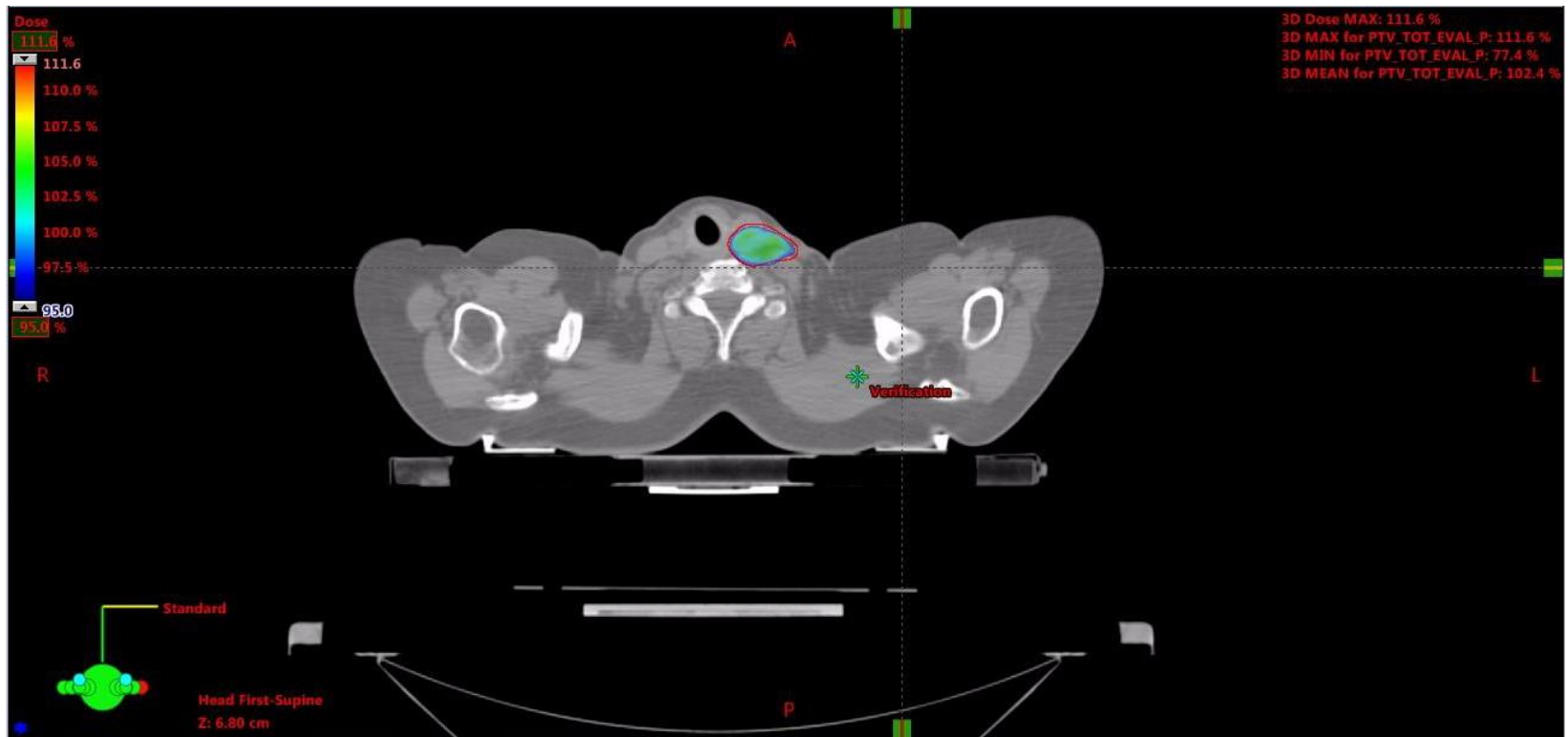
All fields - Coronal



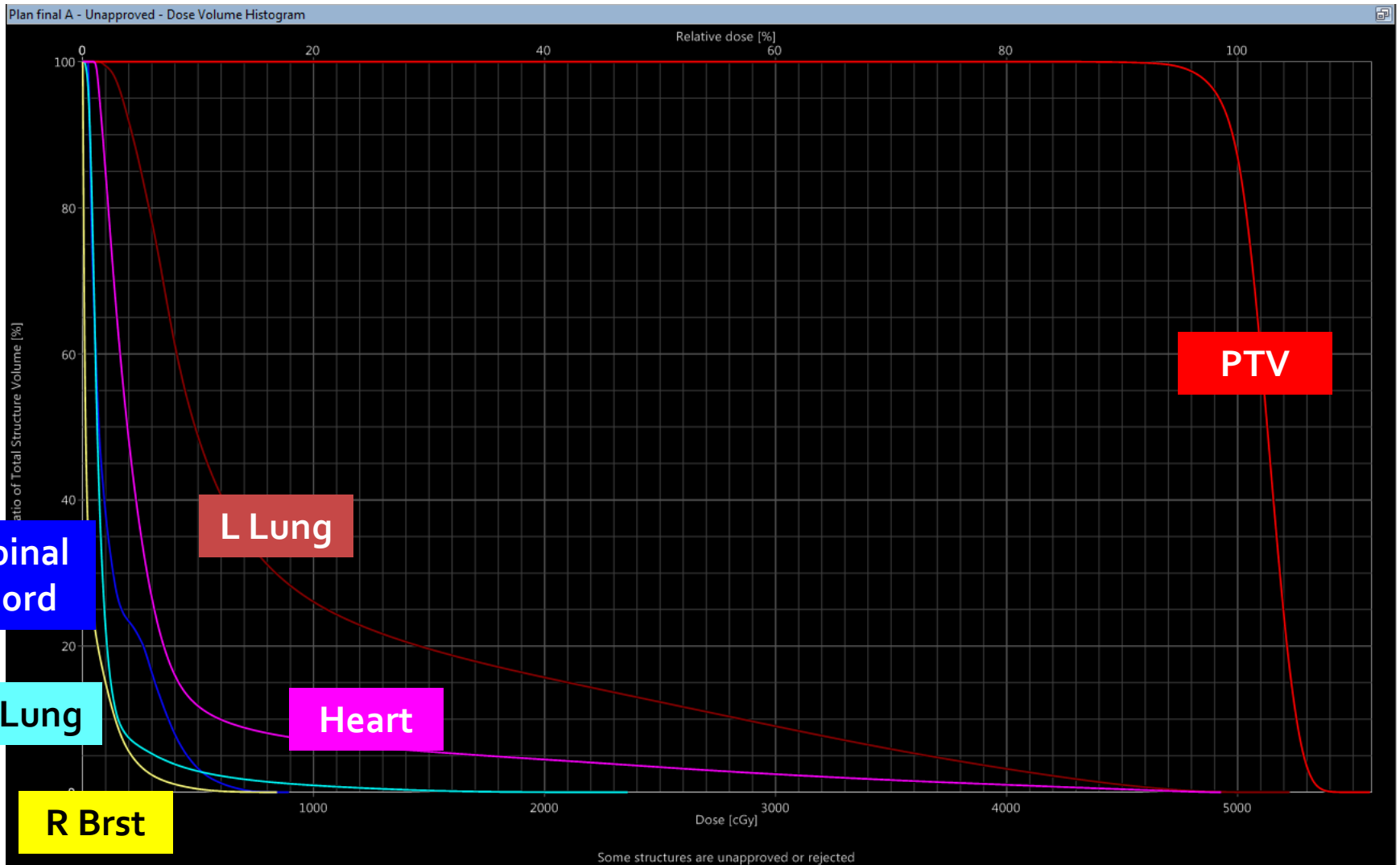
All fields - Sagittal



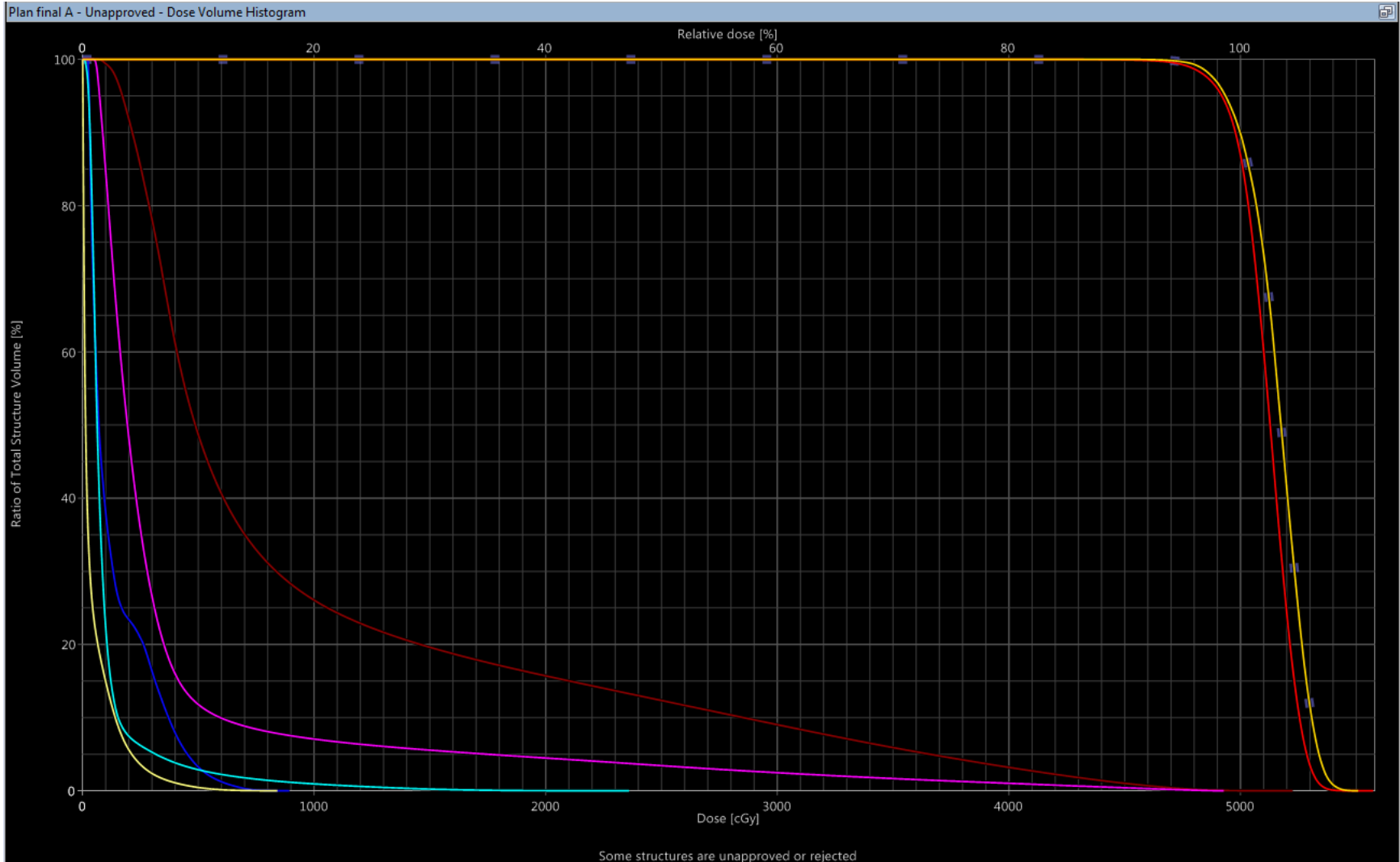
95% dose distribution



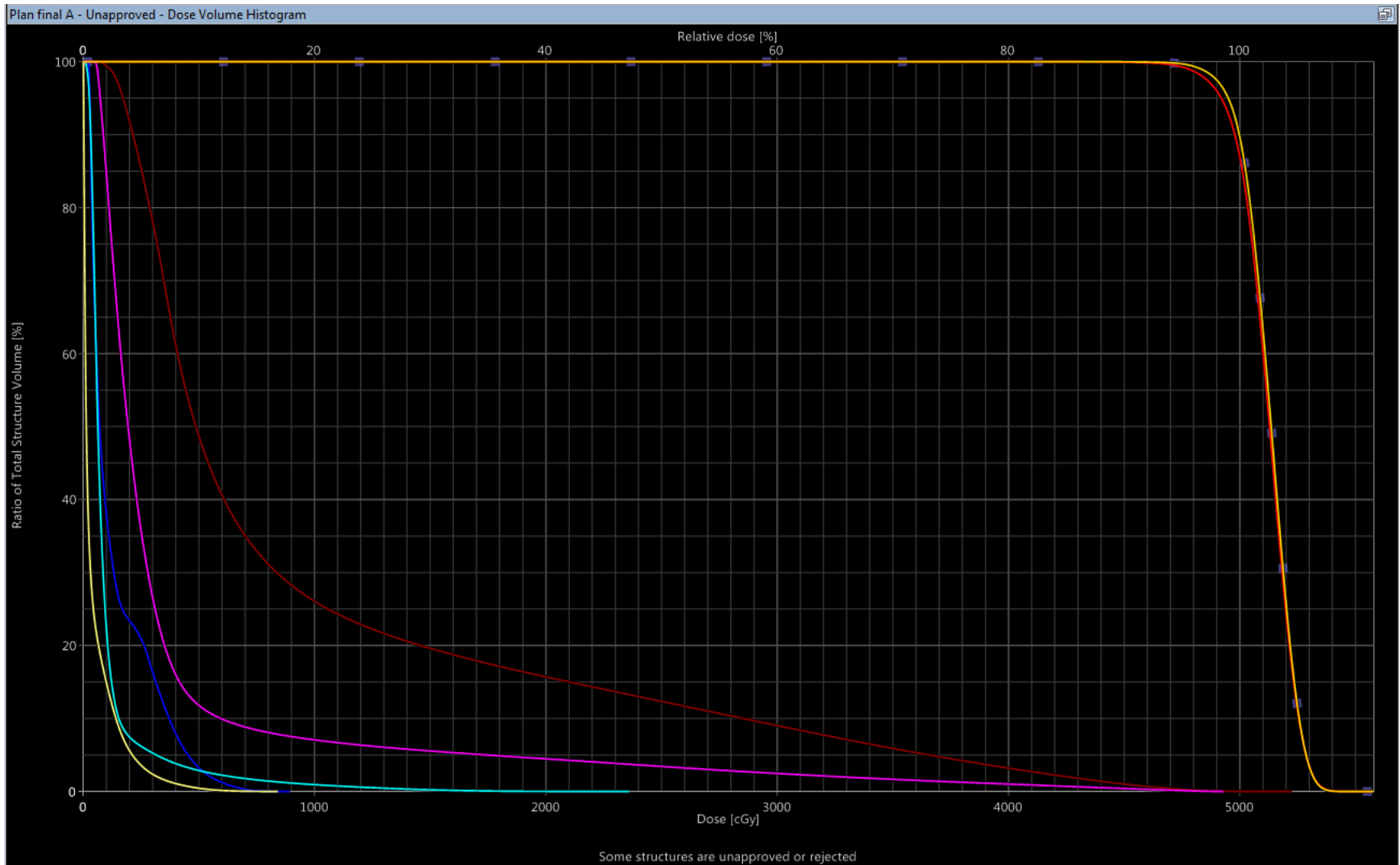
Results: DVHs



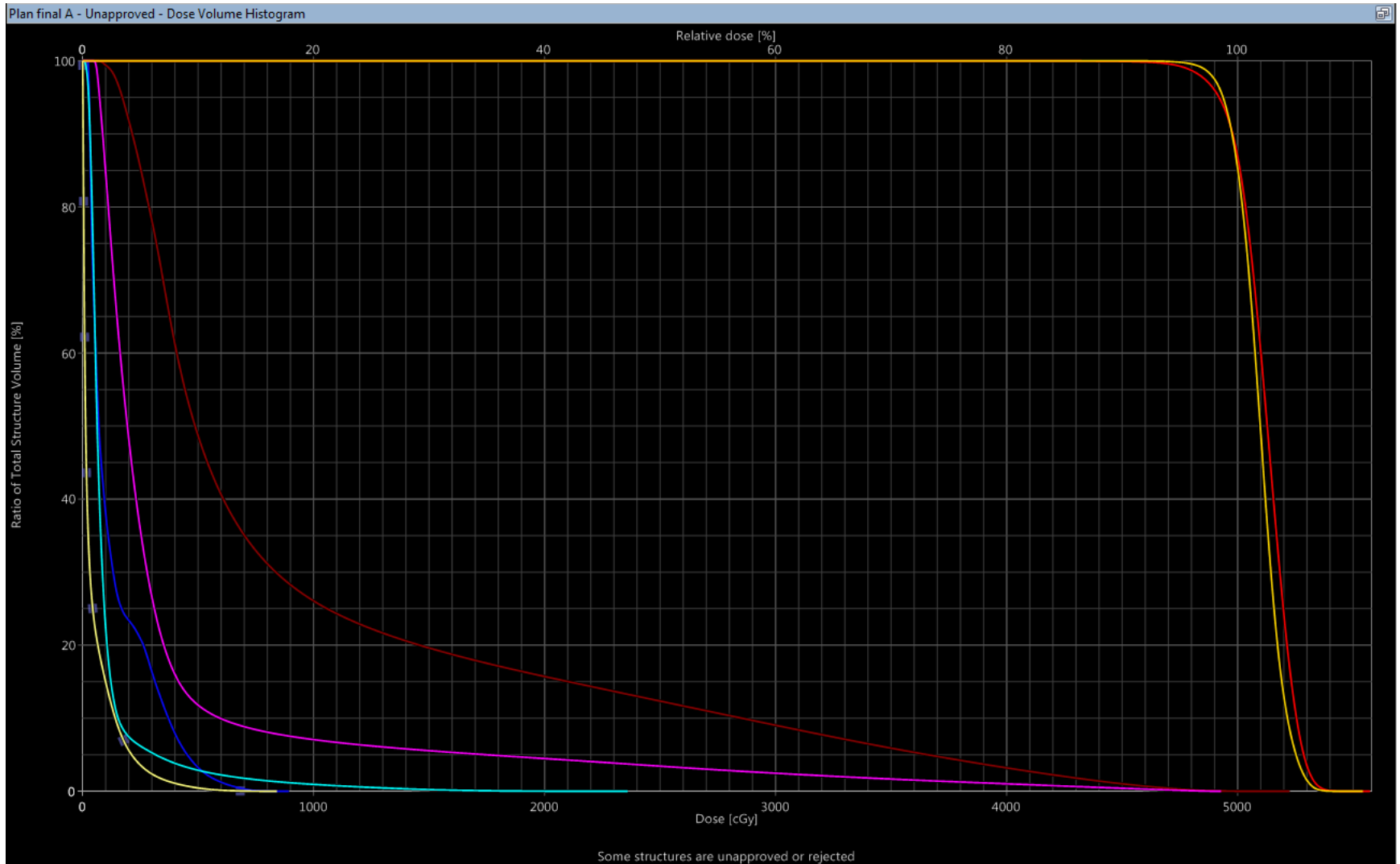
DVH - Supraclavicular



DVH – Lt breast



DVH - Axilla



Results: dose statistics (from TPS)

Structure	Min dose (cGy)	Max dose (cGy)	Mean dose (cGy)
PTV_TOTAL_EVAL	3868.8	5579.6	5118.7
Heart	48.9	4931.7	388.5
Left lung	69.2	5228.1	973.5
Right breast	0.0	847.9	47
Right lung	5.0	2363.0	103.7
Spinal cord	22.2	895.6	139.1

Results: scores

Structure	Available Points	My score
Targets (coverage, conformation, homogeneity, hotspot)	45	42.43
Heart	20	20
Left lung	19	17.62
Right breast	6	3.54
Right lung	5	5
Spinal cord	5	5
Total:	100	93.6

Conclusions

- General:
 - Understand the criteria to score more
 - Make a quick table for points/organ
- Contouring:
 - Use high resolution structures
 - Use conformation structures (rings)
 - Use partially segmented structures for increased OARs sparing
- Geometry:
 - Nine coplanar partial arcs @ 6 MV FFF
 - SC (2), Axilla (2), Breast (4) and (1) "overall"
- Optimization:
 - Start with SC+rings , add axilla, add breast, then the rest
 - Try to be patient!