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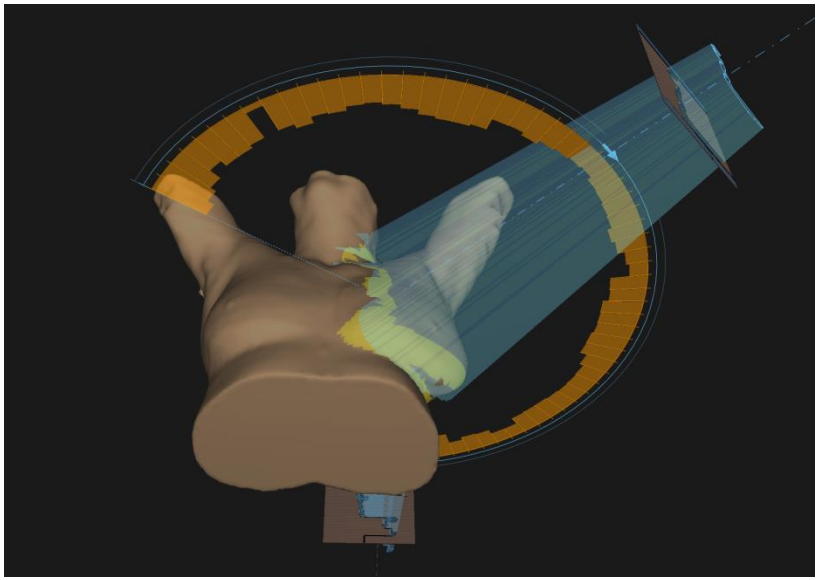
Centre régional de lutte contre le cancer Provence-Alpes-Côte d'Azur
INSTITUT PAOLI-CALMETTES
UNICANCER
CRCM Centre de Recherche en Cancérologie de Marseille
Aix*Marseille université
SIRIC MARSEILLE CANCÉROLOGIE

AGENDA

1. Introduction
2. Material
3. Optimization process
4. Results
5. Comments
6. Conclusion
7. Thanks

INTRODUCTION

- **Plan Competition: opportunity to evaluate our current treatment technique for left sided breast**
  - ✓ VMAT with 2 partial arcs
  - ✓ First patient treated in september 2014

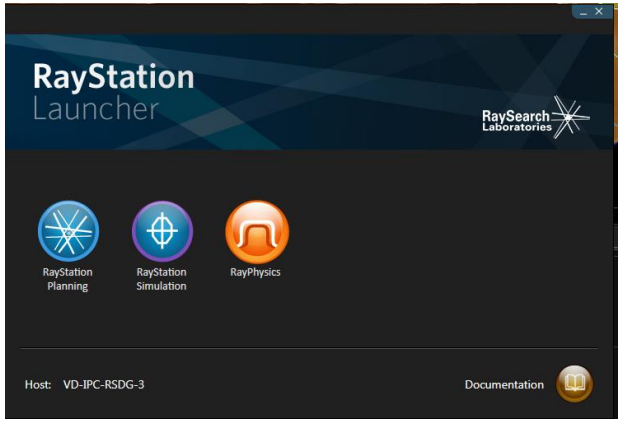


TREATMENT PLANNING SYSTEM

- **RayStation (RaySearch) r.5.0**

  - ✓ Dose calculation for photon beams
    - Collapsed cone convolution superposition algorithm
    - GPU: Fluence + Convolution

  - ✓ Plan Optimization
    - Standard inverse planning
    - Clinical goals



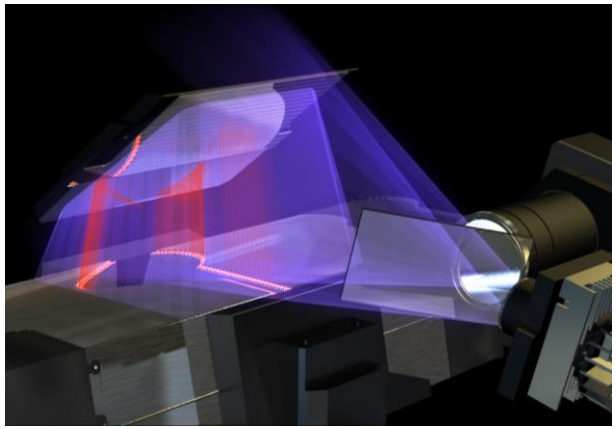
TREATMENT PLANNING SYSTEM

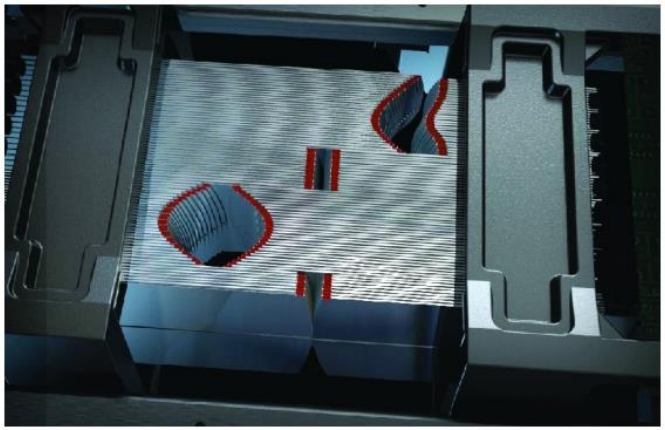
- Clinical goals

Dose	ROI/POI	Clinical goal	Value	Result	% outside grid
Plan dose: Mailleux Hugues 2 (CT 1)	BREAST_RIGHT	At most 2.00 Gy dose at 0.3 cm³ volume	11.31 Gy	!	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	BREAST_RIGHT	At most 2.00 Gy dose at 5.00 % volume	3.26 Gy	!	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	HEART	At most 4.00 Gy average dose	14.91 Gy	!	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	HEART	At most 15.00 % volume at 15.00 Gy dose	39.26 %	!	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	HEART	At most 20.00 Gy dose at 5.00 % volume	34.02 Gy	!	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	LUNG_LEFT	At most 9.00 Gy average dose	22.04 Gy	!	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	LUNG_LEFT	At most 15.00 % volume at 20.00 Gy dose	43.45 %	!	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	LUNG_LEFT	At most 30.00 % volume at 10.00 Gy dose	86.87 %	!	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	LUNG_LEFT	At most 50.00 % volume at 5.00 Gy dose	100.00 %	!	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	LUNG_RIGHT	At most 3.00 % volume at 5.00 Gy dose	12.20 %	!	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	PTV_TOT_EVAL	At least 47.50 Gy dose at 99.00 % volume	48.90 Gy	✓	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	PTV_TOT_EVAL	At least 50.00 Gy dose at 95.00 % volume	49.80 Gy	!	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	PTV_TOT_EVAL	At most 52.00 Gy dose at 50.00 % volume	51.61 Gy	✓	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	PTV_TOT_EVAL	At most 55.00 Gy dose at 0.3 cm³ volume	54.81 Gy	✓	0 %
Plan dose: Mailleux Hugues 2 (CT 1)	SPINAL CORD	At most 8.00 Gy dose at 0.0 cm³ volume	14.08 Gy	!	0 %

ACCELERATOR

- **Versa HD (Elekta)**
  - ✓ Standard 6 MV
  - ✓ MLC Agility



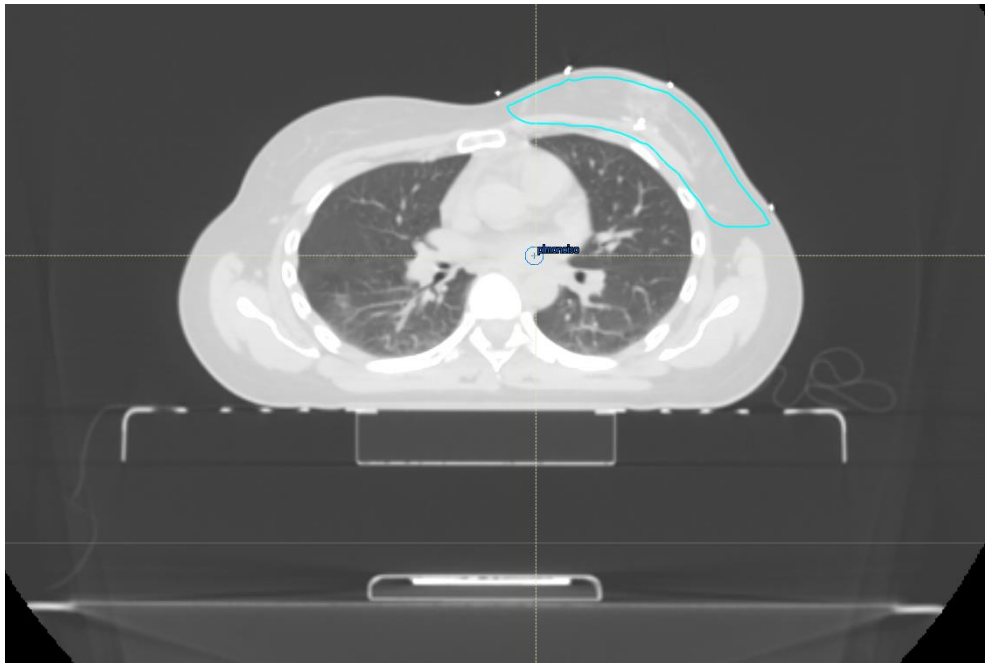


OPTIMIZATION PROCESS

1. Beam geometry

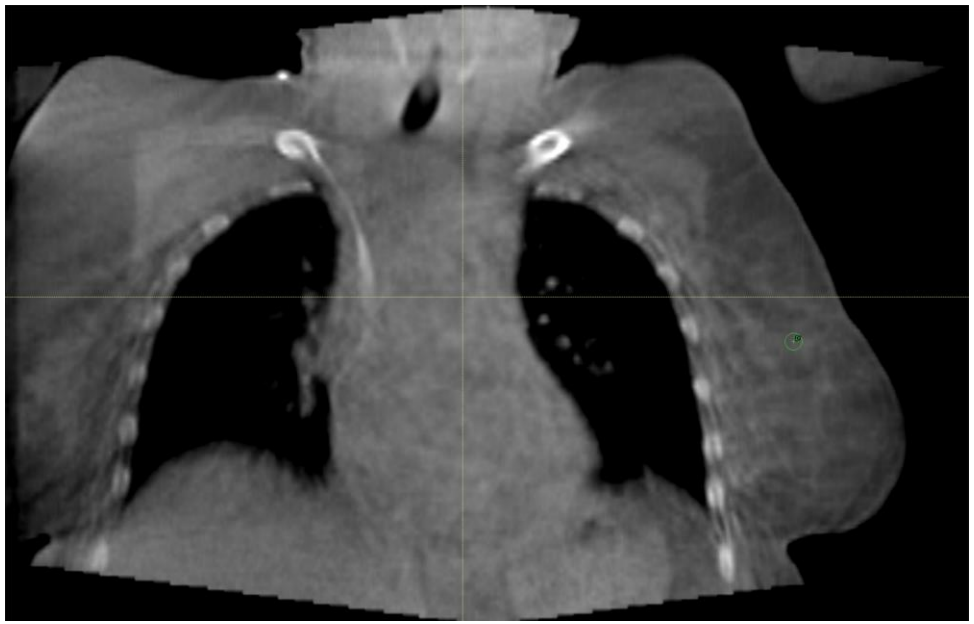
ISOCENTER POSITION

- **Not guided by dosimetric considerations but by technical constraints:**
- **Constraint n°1: CBCT**
  - ✓ The isocenter must be placed to avoid collisions



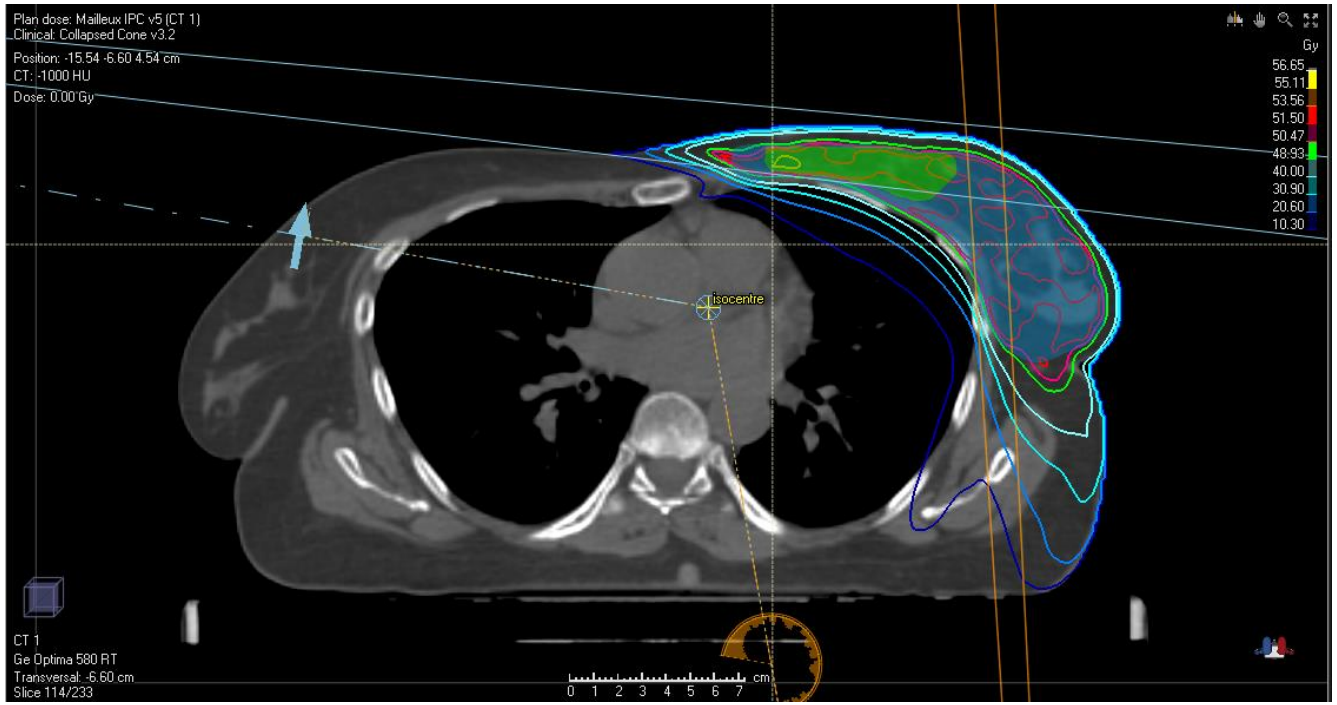
ISOCENTER POSITION

- **Constraint n°2: CBCT**
  - ✓ The isocenter must be placed to get the entire breast inside the field of view



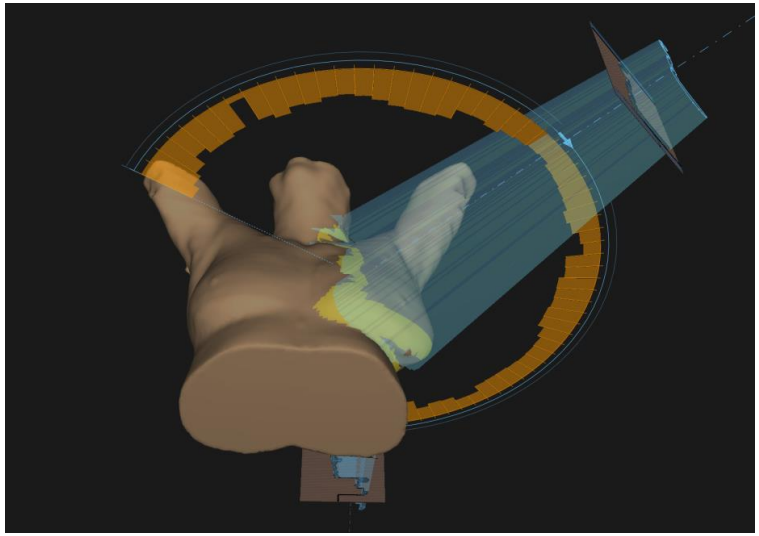
ISOCENTER POSITION

- **Constraint n°3: Jaws and MLC maximum opening**
  - ✓ The isocenter must be placed to cover the entire PTV

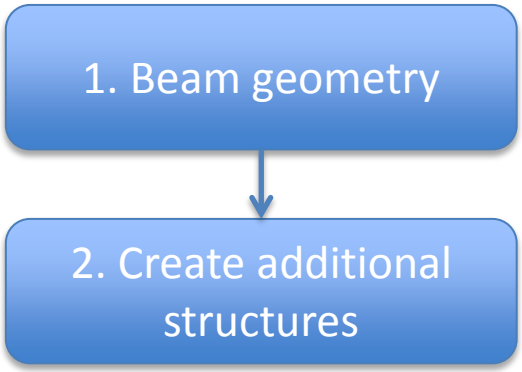


BEAM GEOMETRY

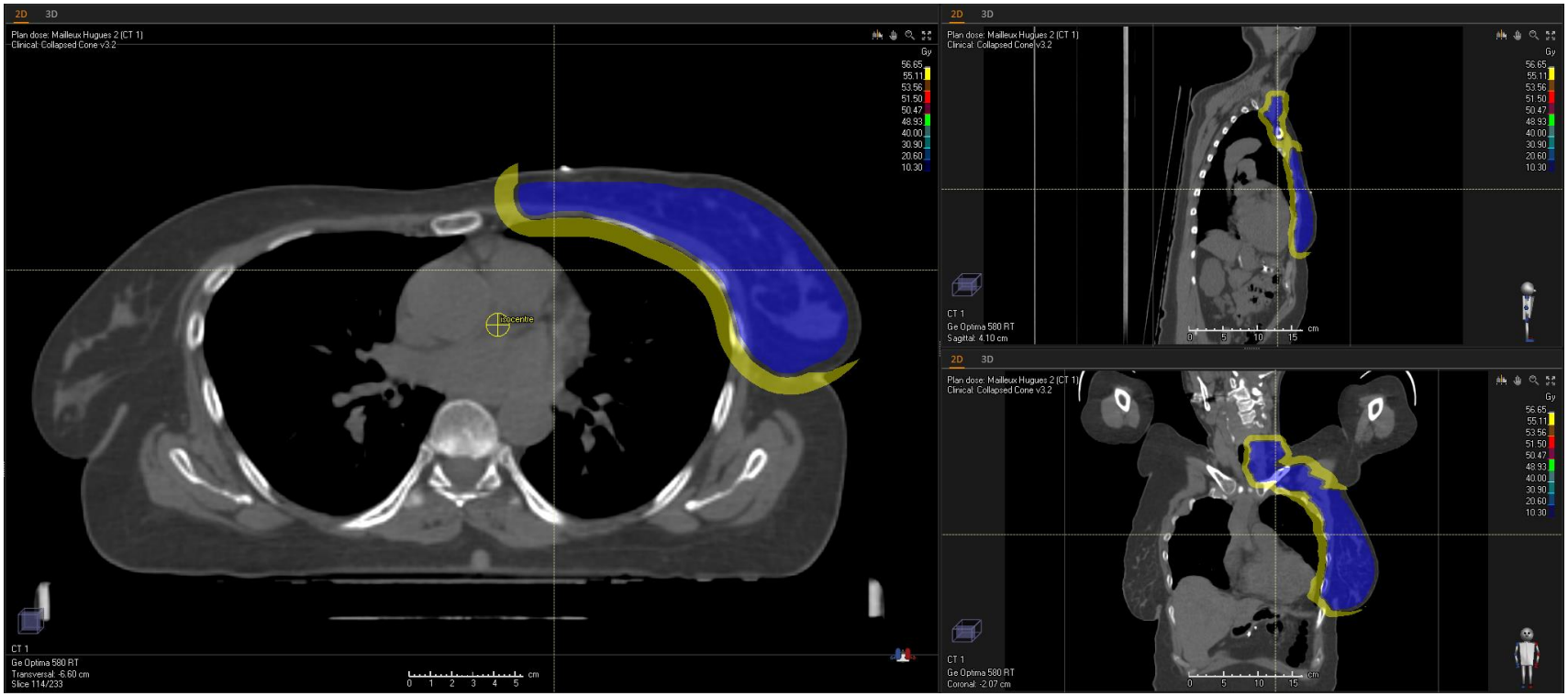
- **No couch rotation**
- **Gantry**
  - ✓ Arc 1: 170° → ~ 300°
  - ✓ Arc 2: ~ 300° → 170°
- **Collimator :**
  - ✓ Arc 1: 5°
  - ✓ Arc 2: 355°
- **Grid size:**
  - ✓ Plan Competition: 1,5 mm
  - ✓ Current practice: 3 mm
- **Gantry spacing between 2 CP: 4°**



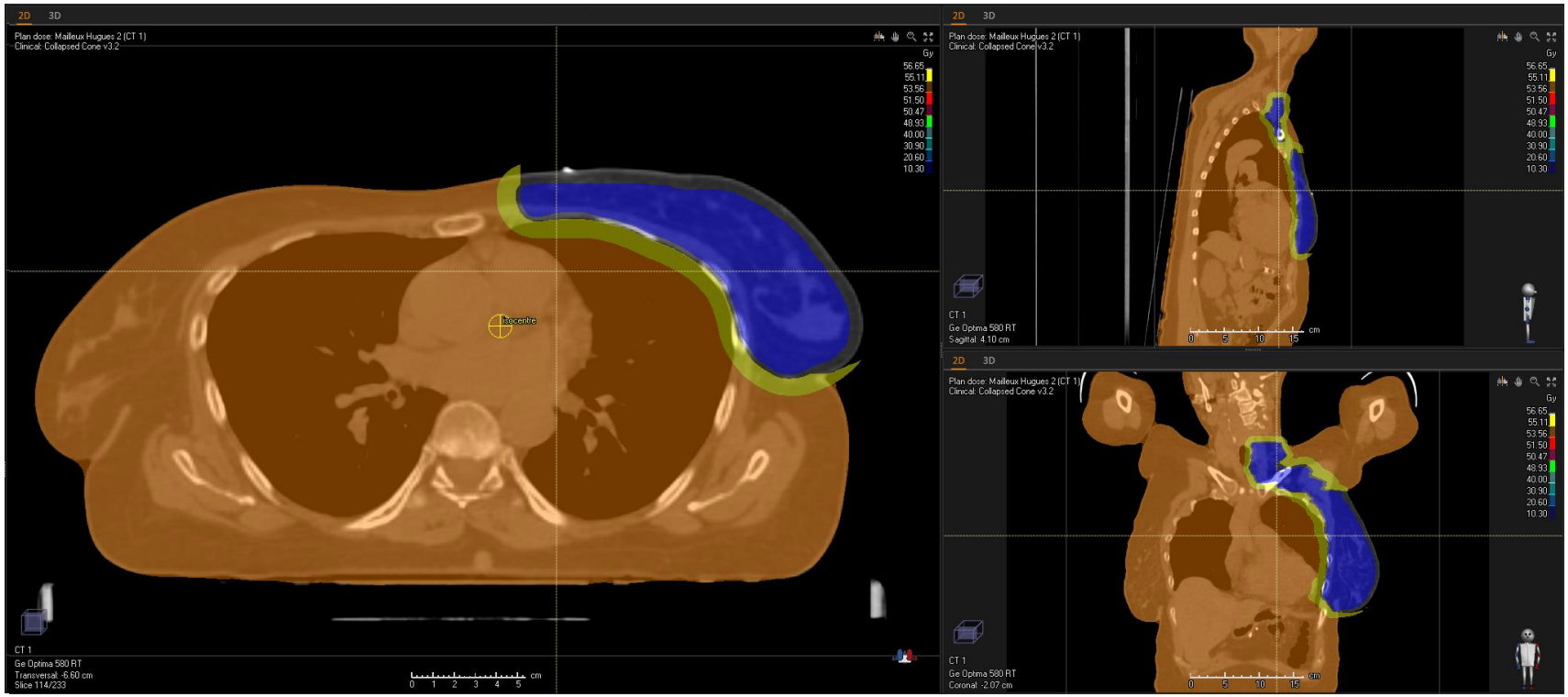
OPTIMIZATION PROCESS



ADDITIONAL OPTIMIZATION STRUCTURES



ADDITIONAL OPTIMIZATION STRUCTURES



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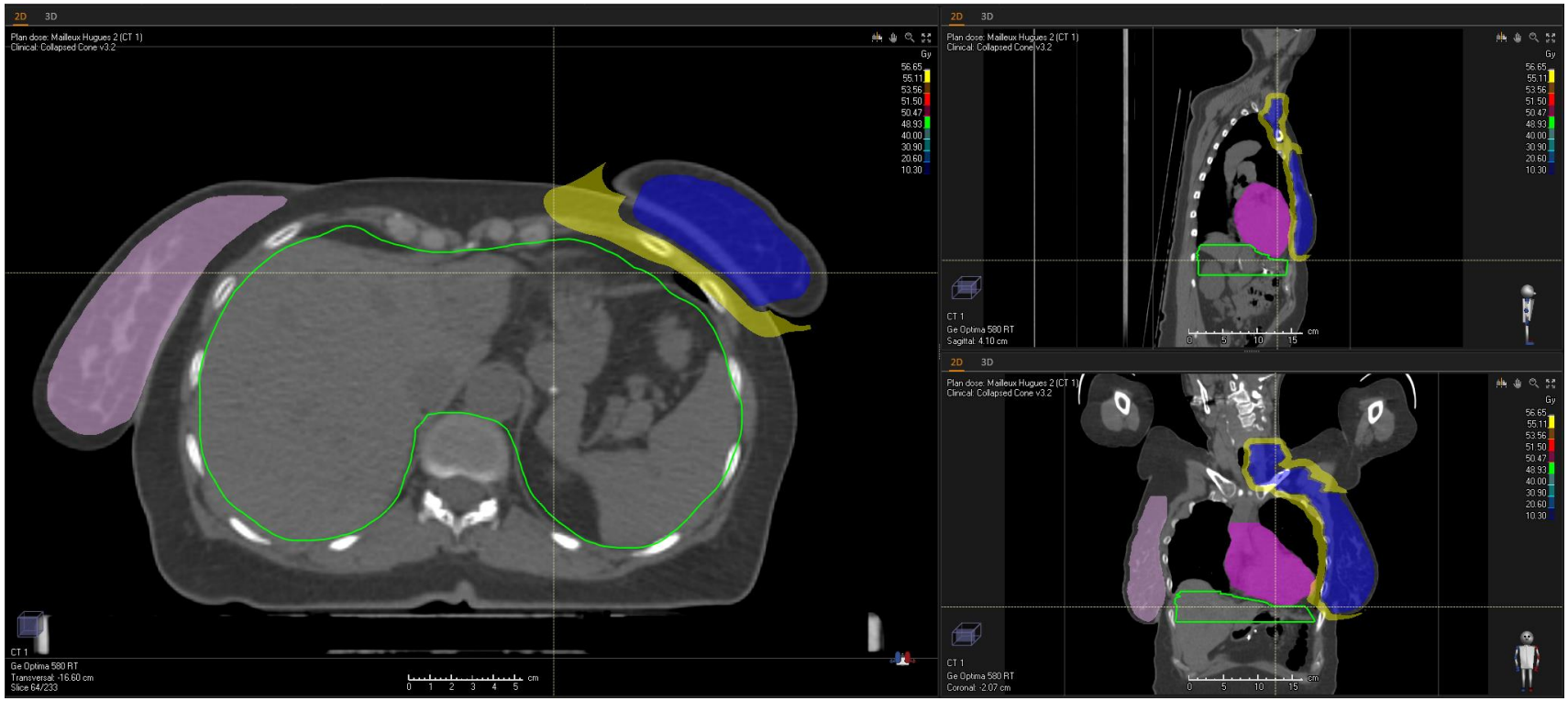
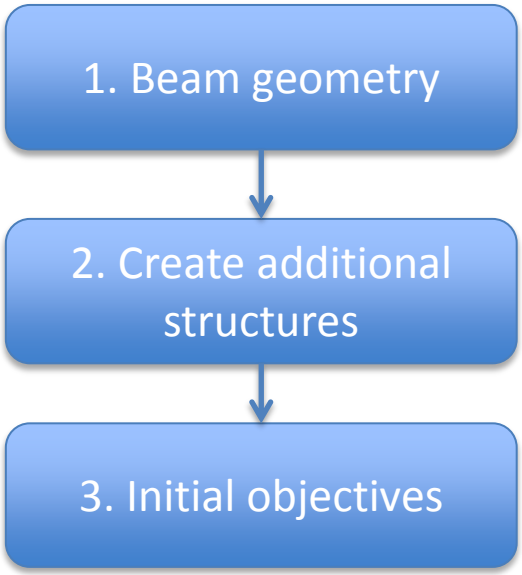


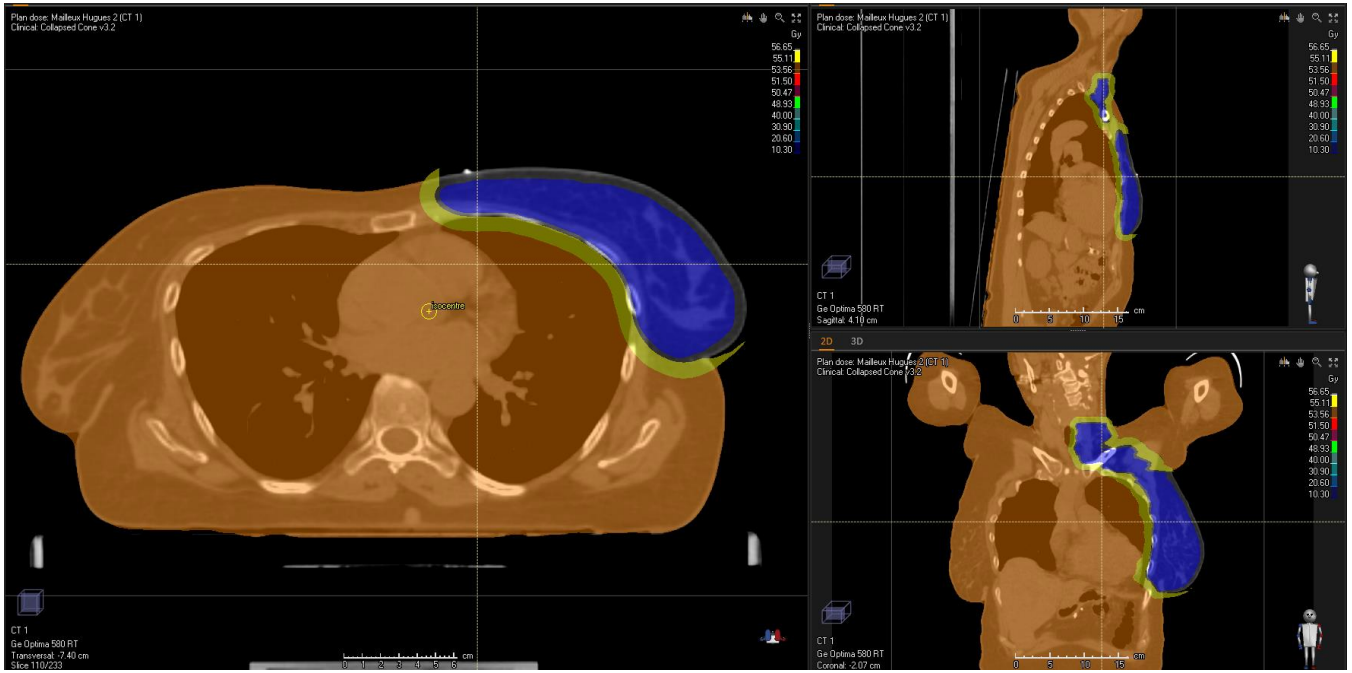
OPTIMIZATION PROCESS



OPTIMIZATION PROCESS

- Initial objectives

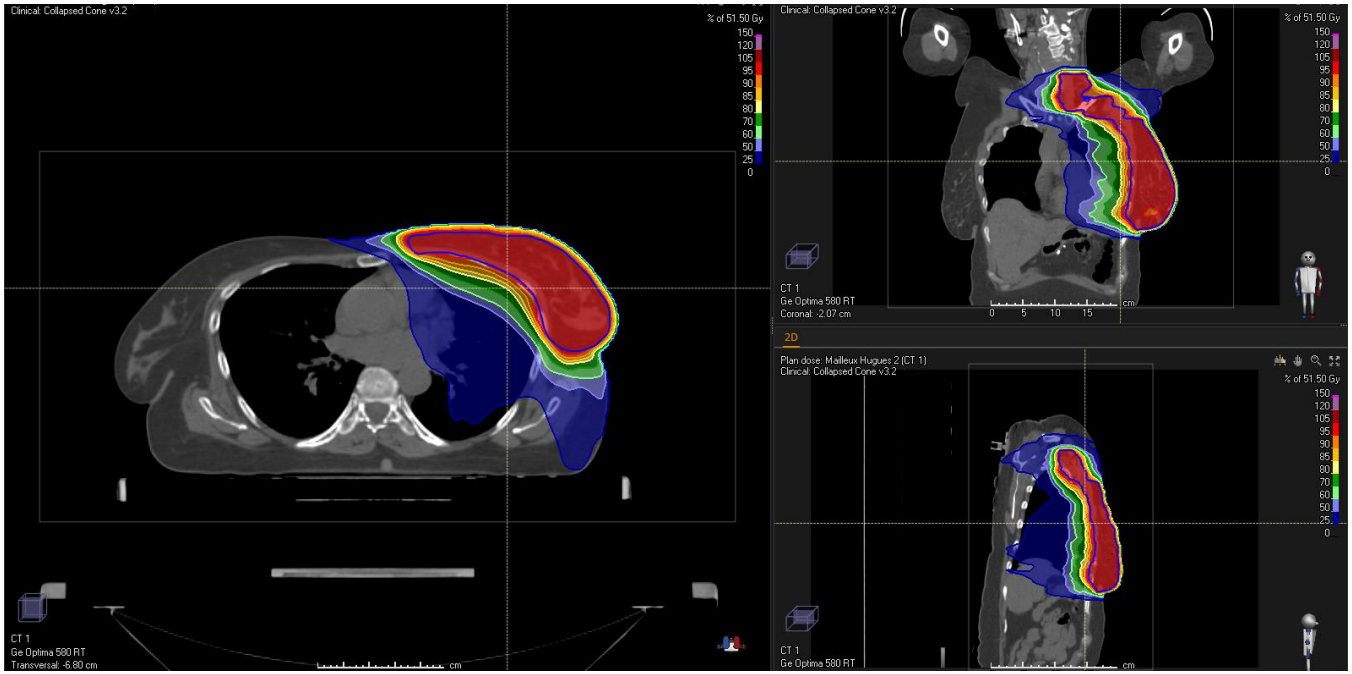
Function	Constraint	Dose	ROI	Description	Robust	Weight
Physical Composite Objective						
Uniform Dose		Plan	PTV_TOT_EVAL	Uniform Dose 50.00 Gy		100
Min Dose		Plan	PTV_TOT_EVAL	Min Dose 49.50 Gy		100
Max Dose		Plan	ring	Max Dose 47.50 Gy		10
Max Dose		Plan	zc	Max Dose 30.00 Gy		10



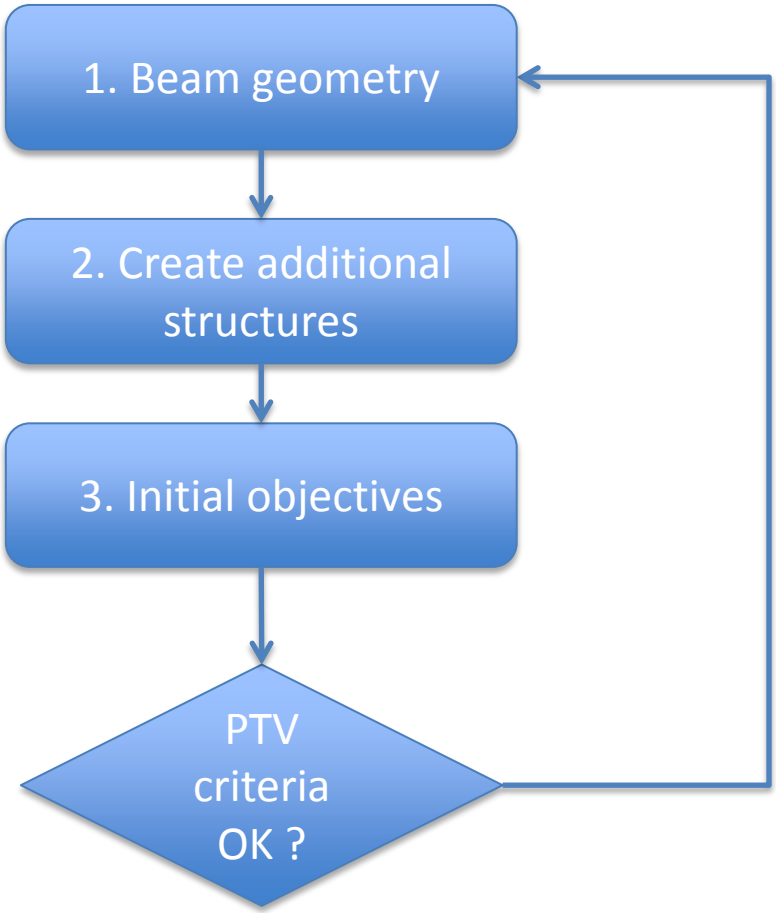
OPTIMIZATION PROCESS

- **Initial objectives**

Function	Constraint	Dose	ROI	Description	Robust	Weight
Physical Composite Objective						
Uniform Dose		Plan	PTV_TOT_EVAL	Uniform Dose 50.00 Gy		100
Min Dose		Plan	PTV_TOT_EVAL	Min Dose 49.50 Gy		100
Max Dose		Plan	ring	Max Dose 47.50 Gy		10
Max Dose		Plan	zc	Max Dose 30.00 Gy		10



OPTIMIZATION PROCESS



INITIAL OBJECTIVES

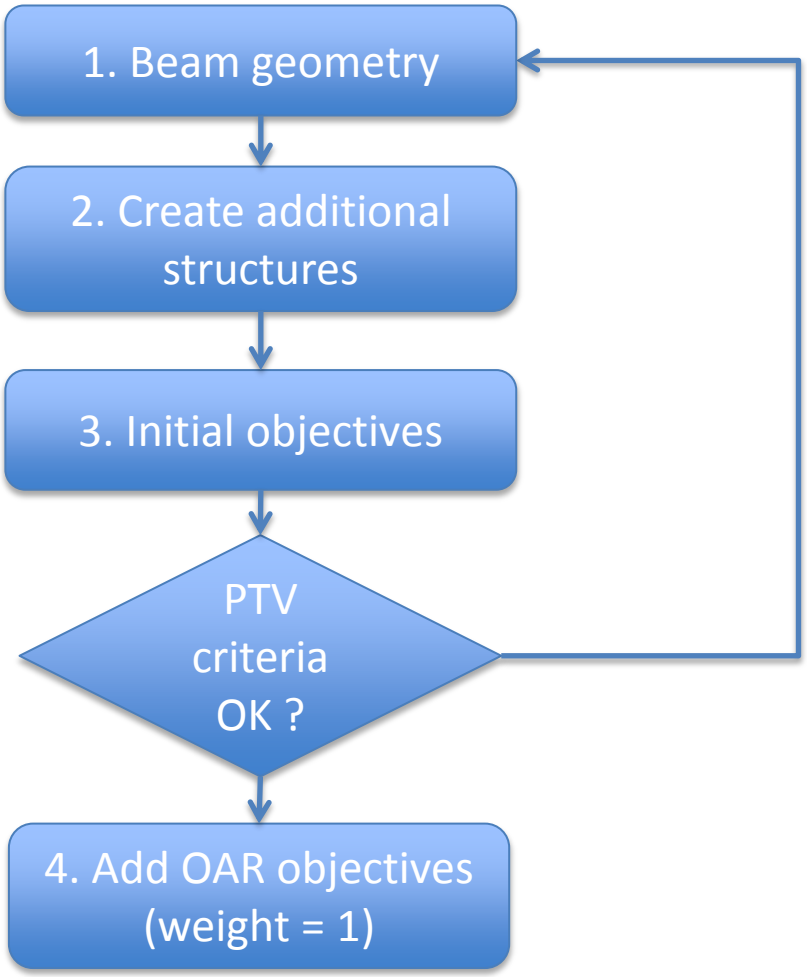
- **Uniform dose and prescription**
  - ✓ Usually: 50 Gy to median dose (ICRU 84)
  - ✓ in this case: 51,5 Gy to median dose

INITIAL OBJECTIVES

Function	Constraint	Dose	ROI	Description	Robust	Weight
Physical Composite Objective						
Uniform Dose		Plan	PTV_TOT_EVAL	Uniform Dose 50.00 Gy		100
Min Dose		Plan	PTV_TOT_EVAL	Min Dose 49.50 Gy		100
Max Dose		Plan	ring	Max Dose 47.50 Gy		10
Max Dose		Plan	zc	Max Dose 30.00 Gy		10

Function	Constraint	Dose	ROI	Description	Robust	Weight
Physical Composite Objective						
Uniform Dose		Plan	PTV_TOT_EVAL	Uniform Dose 51.50 Gy		100
Min Dose		Plan	PTV_TOT_EVAL	Min Dose 51.00 Gy		100
Max Dose		Plan	ring	Max Dose 47.50 Gy		10
Max Dose		Plan	zc	Max Dose 30.00 Gy		10

OPTIMIZATION PROCESS



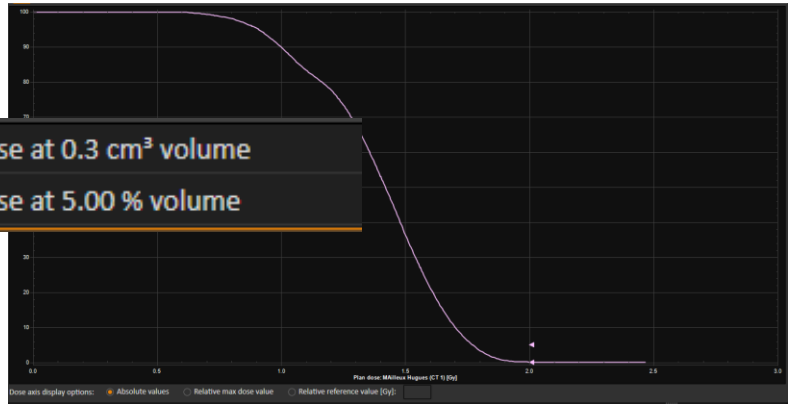
OAR CRITERIA

- **2 types of criteria for OAR:**
  - ✓ maximum dose
    - Rigth breast
    - Spinal cord
  - ✓ Parallel organs
    - Heart
    - Left lung
    - Rigth lung

MAXIMUM DOSE CRITERIA

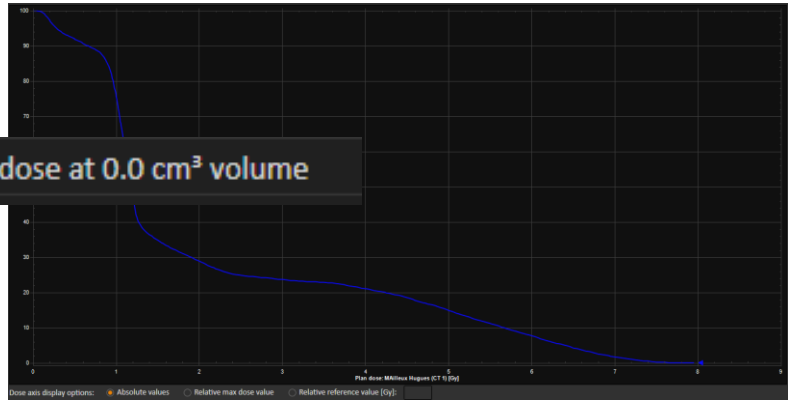
- **Maximum dose:**
  - Rigth breast

BREAST_RIGHT	At most 2.00 Gy dose at 0.3 cm³ volume
BREAST_RIGHT	At most 2.00 Gy dose at 5.00 % volume



  - Spinal cord

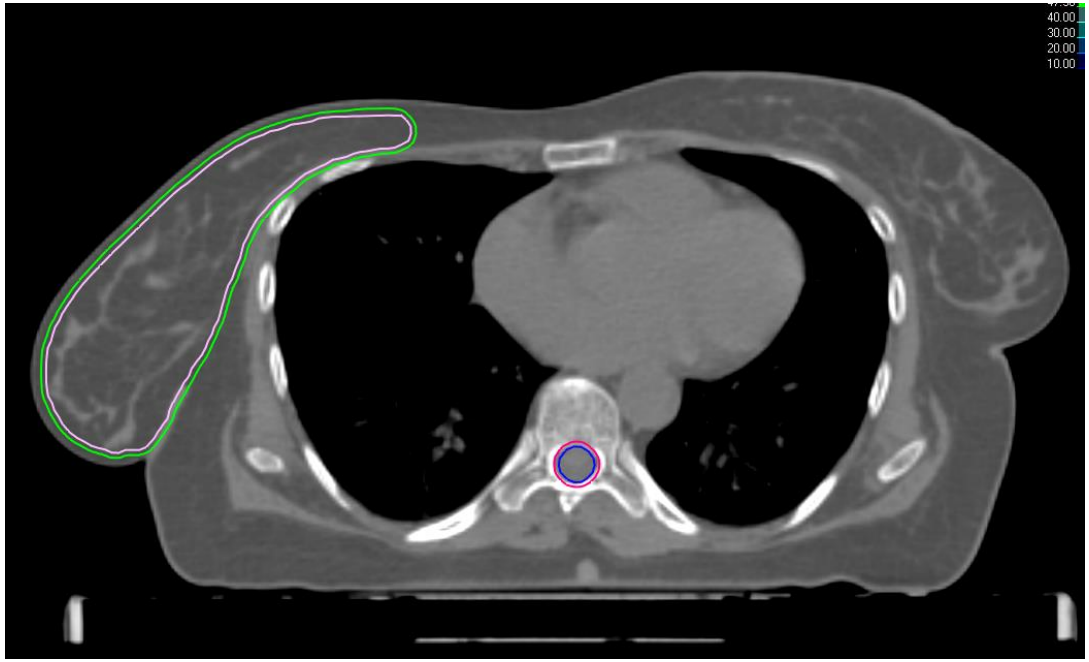
SPINAL CORD	At most 8.00 Gy dose at 0.0 cm³ volume



MAXIMUM DOSE : OAR OBJECTIVES

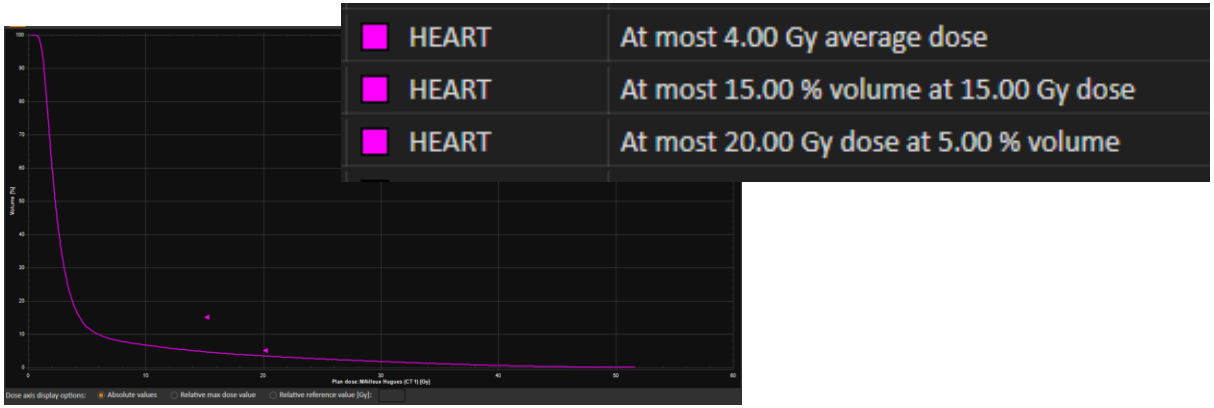
- **Additonal structures**
  - ✓ Breast rigth + 2 mm
  - ✓ Spinal cord + 2 mm

breast rigth + 2mm	Max Dose 1.80 Gy
spinal cord + 2mm	Max Dose 7.80 Gy

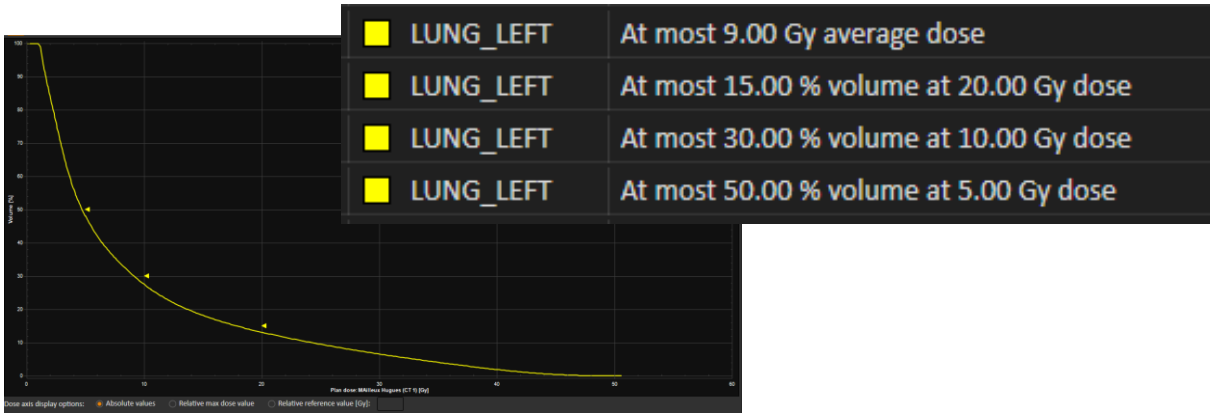


PARALLEL OAR CRITERIA

- **Parallel OAR**
  - Heart

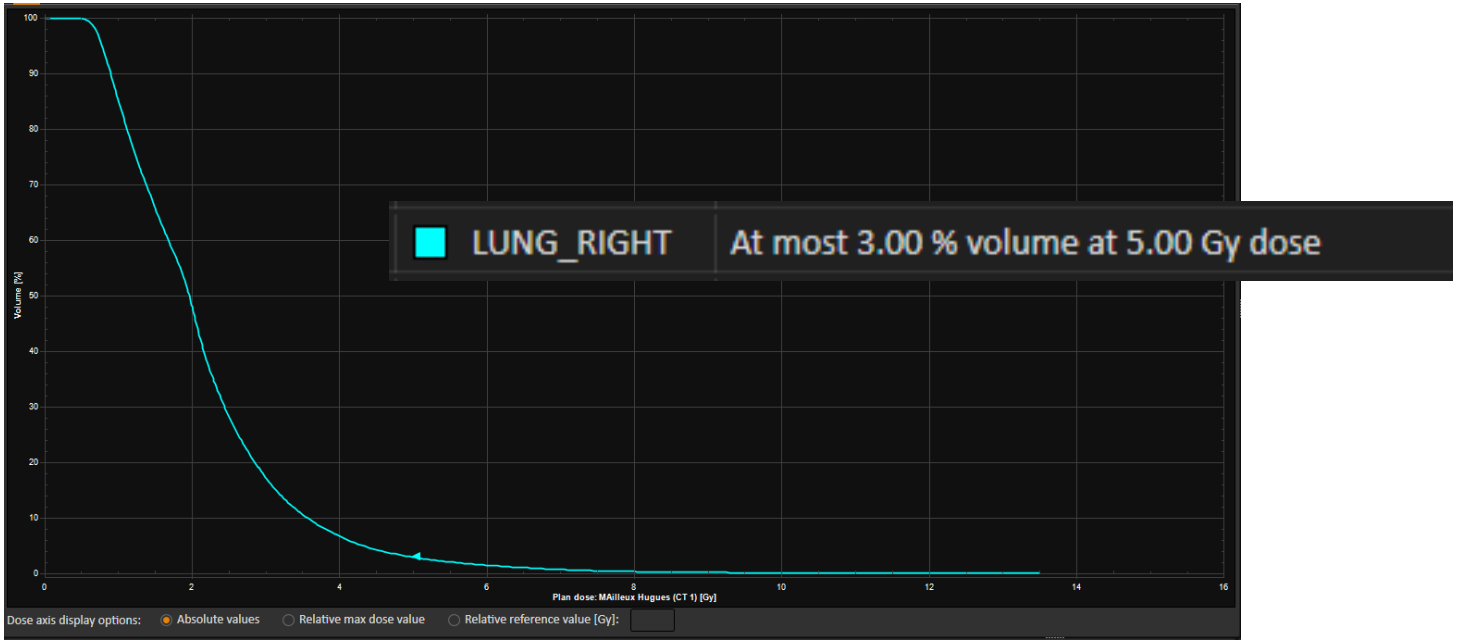


  - Left Lung



PARALLEL OAR CRITERIA

- **Parallel type OAR dosimetric criteria**
  - Rigth Lung:



PARALLEL OAR OBJECTIVES

- Only one objectif by OAR

HEART	Max DVH 4.00 Gy to 12% volume

HEART	At most 4.00 Gy average dose
HEART	At most 15.00 % volume at 15.00 Gy dose
HEART	At most 20.00 Gy dose at 5.00 % volume

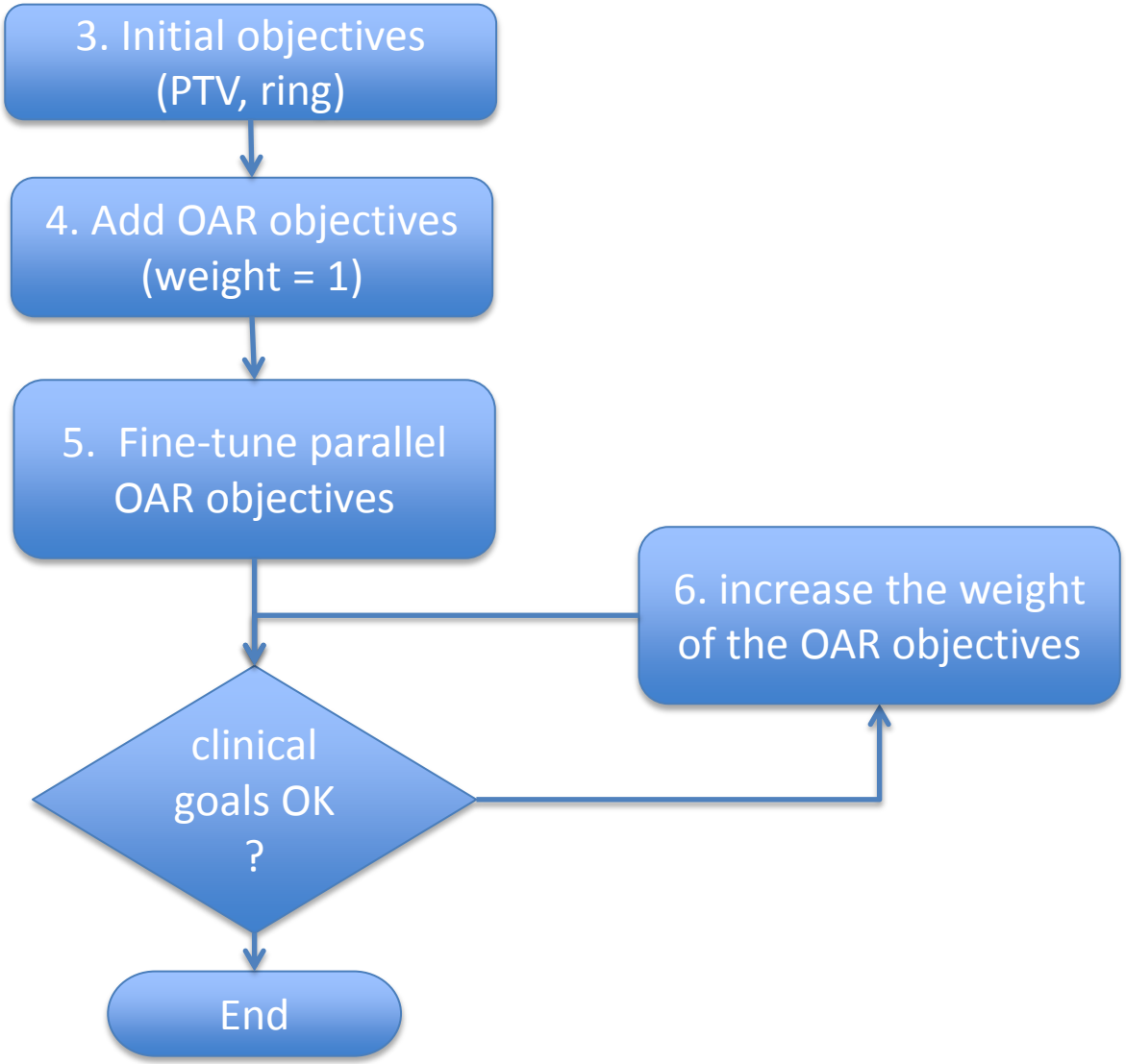
LUNG_LEFT	Max EUD 10.00 Gy, Parameter A 1.95

$$\mathrm{gEUD} = \left(\sum_i v_i D_i^a \right)^{1/a}$$

LUNG_LEFT	At most 9.00 Gy average dose
LUNG_LEFT	At most 15.00 % volume at 20.00 Gy dose
LUNG_LEFT	At most 30.00 % volume at 10.00 Gy dose
LUNG_LEFT	At most 50.00 % volume at 5.00 Gy dose

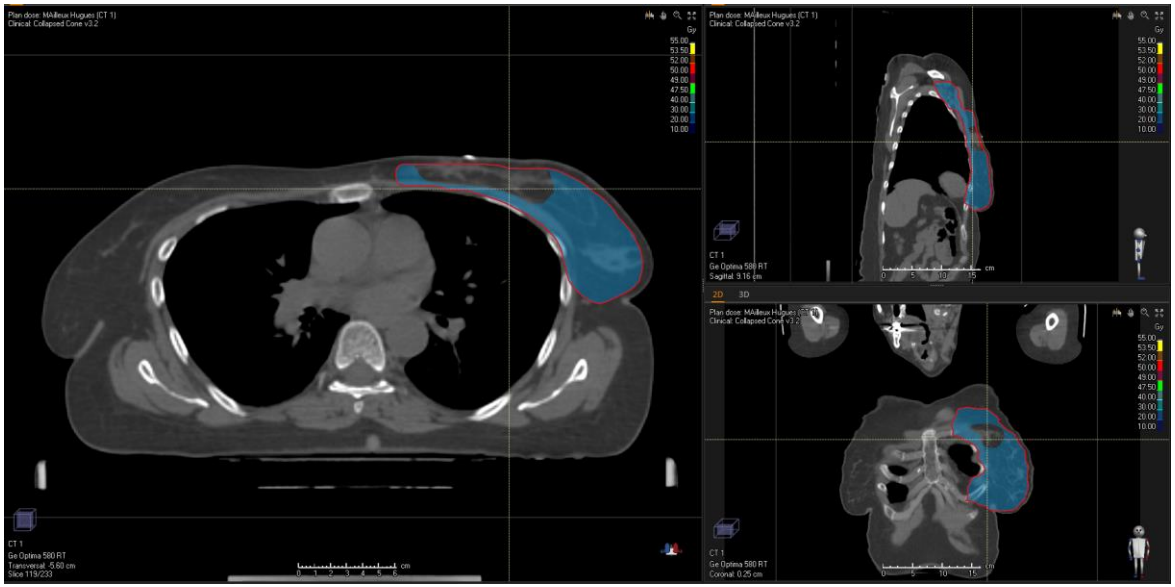
- Initial weight: 1

OPTIMIZATION PROCESS



HOW TO PUT THE MAXIMUM DOSE INSIDE DE CTV-LUMPECTOMY

- **Additional structure:**
  - ✓ PTV – (CTV-LUMPECTOMY)



  - ✓ Add objectives:

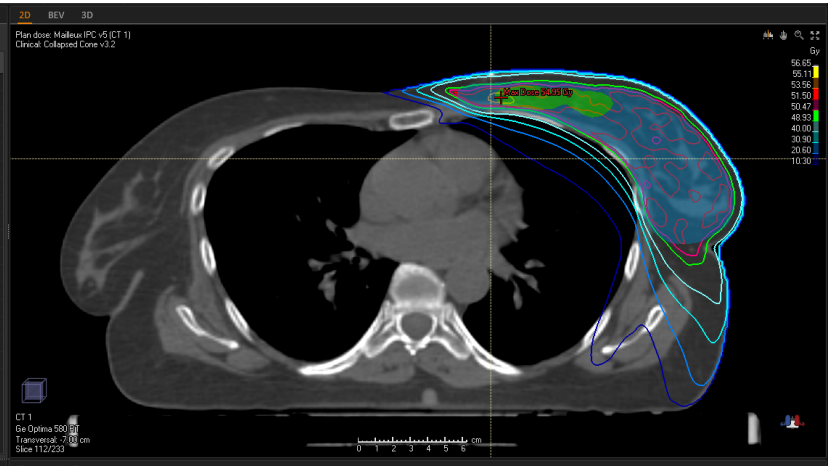
Max Dose		Plan	PTV without CTV-LUMPECTOMY	Max Dose 51.60 Gy
Min Dose		Plan	CTV-LUMPECTOMY	Min Dose 51.40 Gy

RESULTS

DVH | Clinical Goals | Dose Statistics | 2D

Add... | Edit... | Copy | Delete | Load template... | Create template...

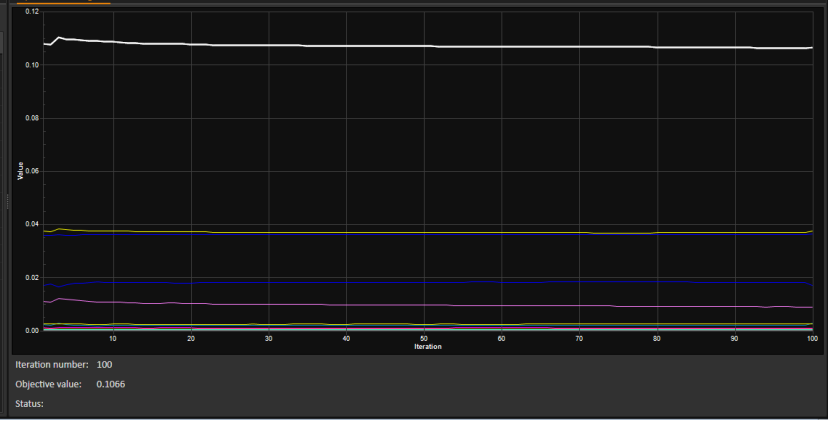
Priority	Dose	ROI/POI	Clinical goal	Value	Result	% outside grid
	Plan dose: Mailleux IPC v5 (CT 1)	BODY	At least 0.0 cm³ volume at 47.50 Gy dose	1319.3 cm³	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	BREAST_RIGHT	At most 2.00 Gy dose at 0.3 cm³ volume	2.08 Gy	!	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	BREAST_RIGHT	At most 2.00 Gy dose at 5.00 % volume	1.77 Gy	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	HEART	At most 4.00 Gy average dose	3.93 Gy	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	HEART	At most 15.00 % volume at 15.00 Gy dose	4.66 %	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	HEART	At most 20.00 Gy dose at 5.00 % volume	13.97 Gy	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	LUNG_LEFT	At most 9.00 Gy average dose	8.94 Gy	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	LUNG_LEFT	At most 15.00 % volume at 20.00 Gy dose	13.08 %	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	LUNG_LEFT	At most 30.00 % volume at 10.00 Gy dose	27.47 %	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	LUNG_LEFT	At most 50.00 % volume at 5.00 Gy dose	48.06 %	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	LUNG_RIGHT	At most 3.00 % volume at 5.00 Gy dose	2.88 %	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	PTV_TOT_EVAL	At least 0.0 cm³ volume at 47.50 Gy dose	1083.5 cm³	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	PTV_TOT_EVAL	At least 47.50 Gy dose at 99.00 % volume	48.20 Gy	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	PTV_TOT_EVAL	At least 50.00 Gy dose at 95.00 % volume	50.00 Gy	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	PTV_TOT_EVAL	At most 52.00 Gy dose at 50.00 % volume	51.54 Gy	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	PTV_TOT_EVAL	At most 55.00 Gy dose at 0.3 cm³ volume	54.50 Gy	✓	0 %
	Plan dose: Mailleux IPC v5 (CT 1)	SPINAL CORD	At most 8.00 Gy dose at 0.0 cm² volume	7.95 Gy	✓	0 %



Objectives/Constraints | Beams | Control Points | Beam Optimization Settings | Beam Weighting

Add... | Edit... | Delete | Load template... | Create template... | Add MCO function

Function	Constraint	Dose	ROI	Description	Robust	Weight	Value
Physical Composite Objective							0.1061
Max EUD		Plan	LUNG_LEFT	Max EUD 10.00 Gy, Parameter A 1.95		1.95	0.0368
Uniform Dose		Plan	PTV_TOT_EVAL	Uniform Dose 51.50 Gy		110	0.0361
Min Dose		Plan	PTV_TOT_EVAL	Min Dose 50.50 Gy		200	0.0184
Max Dose		Plan	breast rigth + 2mm	Max Dose 1.90 Gy		105	0.0086
Max Dose		Plan	ring	Max Dose 47.50 Gy		10	0.0023
Max Dose		Plan	PTV without CTV-LUMPECTOMY	Max Dose 52.00 Gy		80	0.0018
Max DVH		Plan	HEART	Max DVH 4.00 Gy to 12% volume		1	9.5871E-4
Max Dose		Plan	zc	Max Dose 40.00 Gy		10	5.5566E-4
Min Dose		Plan	CTV-LUMPECTOMY	Min Dose 51.00 Gy		40	3.0658E-4
Max DVH		Plan	LUNG_RIGHT	Max DVH 4.30 Gy to 3% volume		2	2.4930E-4
Max Dose		Plan	spinal cord + 2mm	Max Dose 7.80 Gy		22	3.5969E-5
Max DVH		Plan	cav abdo	Max DVH 5.00 Gy to 10% volume		1	0.0000



RESULTS

Function	Constraint	Dose	ROI	Description	Robust	Weight	Value
Physical Composite Objective							0.1061
Max EUD		Plan	LUNG_LEFT	Max EUD 10.00 Gy, Parameter A 1.95		1.95	0.0368
Uniform Dose		Plan	PTV_TOT_EVAL	Uniform Dose 51.50 Gy		110	0.0361
Min Dose		Plan	PTV_TOT_EVAL	Min Dose 50.50 Gy		200	0.0184
Max Dose		Plan	breast rigth + 2mm	Max Dose 1.90 Gy		105	0.0086
Max Dose		Plan	ring	Max Dose 47.50 Gy		10	0.0023
Max Dose		Plan	PTV without CTV-LUMPECTOMY	Max Dose 52.00 Gy		80	0.0018
Max DVH		Plan	HEART	Max DVH 4.00 Gy to 12% volume		1	9.5871E-4
Max Dose		Plan	zc	Max Dose 40.00 Gy		10	5.5566E-4
Min Dose		Plan	CTV-LUMPECTOMY	Min Dose 51.00 Gy		40	3.0658E-4
Max DVH		Plan	LUNG_RIGHT	Max DVH 4.30 Gy to 3% volume		2	2.4930E-4
Max Dose		Plan	spinal cord + 2mm	Max Dose 7.80 Gy		22	3.5969E-5
Max DVH		Plan	cav abdo	Max DVH 5.00 Gy to 10% volume		1	0.0000

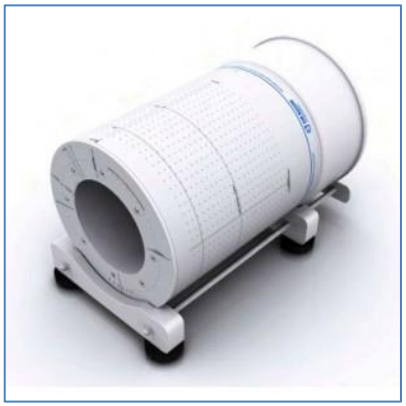
Function	Constraint	Dose	ROI	Description	Robust	Weight	Value
Physical Composite Objective							0.1258
Max EUD		Plan	LUNG_LEFT	Max EUD 8.90 Gy, Parameter A 1.7		2.2	0.0470
Uniform Dose		Plan	PTV_TOT_EVAL	Uniform Dose 51.50 Gy		100	0.0412
Min Dose		Plan	PTV_TOT_EVAL	Min Dose 51.00 Gy		100	0.0223
Max Dose		Plan	breast rigth + 2mm	Max Dose 1.80 Gy		40	0.0060
Max DVH		Plan	HEART	Max DVH 4.00 Gy to 10% volume		1.5	0.0027
Max Dose		Plan	PTV without CTV-LUMPECTOMY	Max Dose 51.60 Gy		30	0.0022
Max Dose		Plan	ring	Max Dose 47.50 Gy		10	0.0018
Max DVH		Plan	LUNG_RIGHT	Max DVH 4.00 Gy to 3% volume		3.5	0.0013
Max Dose		Plan	zc	Max Dose 40.00 Gy		10	7.1477E-4
Min Dose		Plan	CTV-LUMPECTOMY	Min Dose 51.40 Gy		20	4.1151E-4
Max Dose		Plan	spinal cord + 2mm	Max Dose 7.80 Gy		50	1.4472E-4

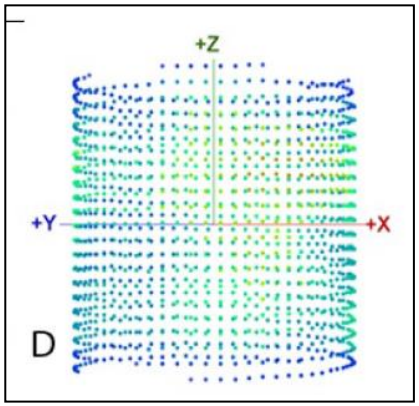
Better !

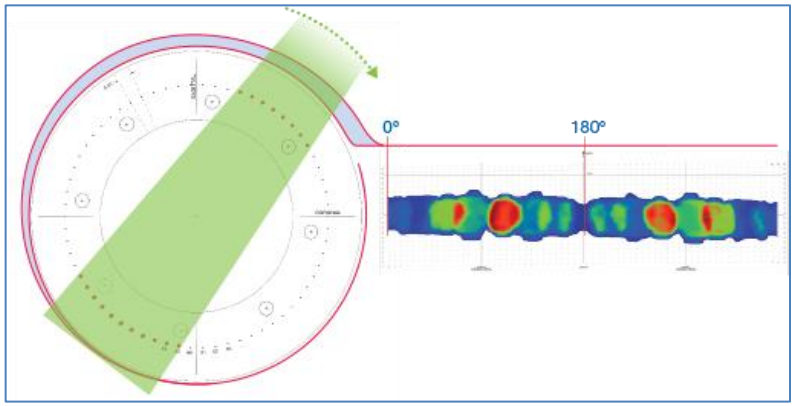
DELIVERY TIME

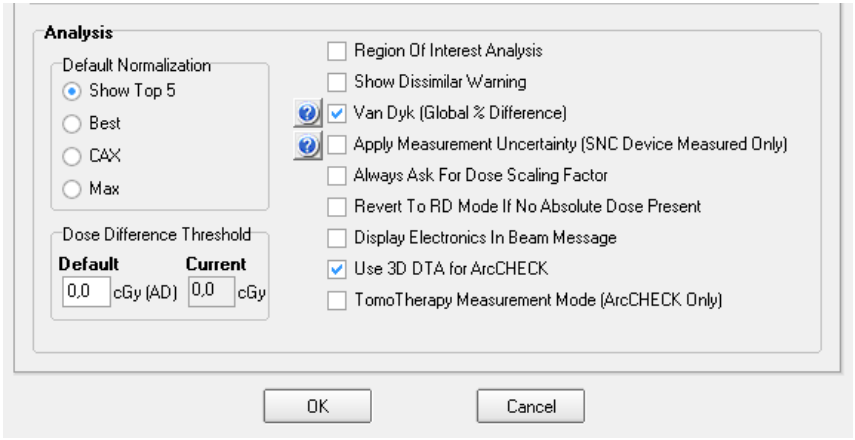
- **Delivery time:**
  - ✓ Arc 1: 1’13”
  - ✓ Arc 2: 1’18”

PATIENT-SPECIFIC QA

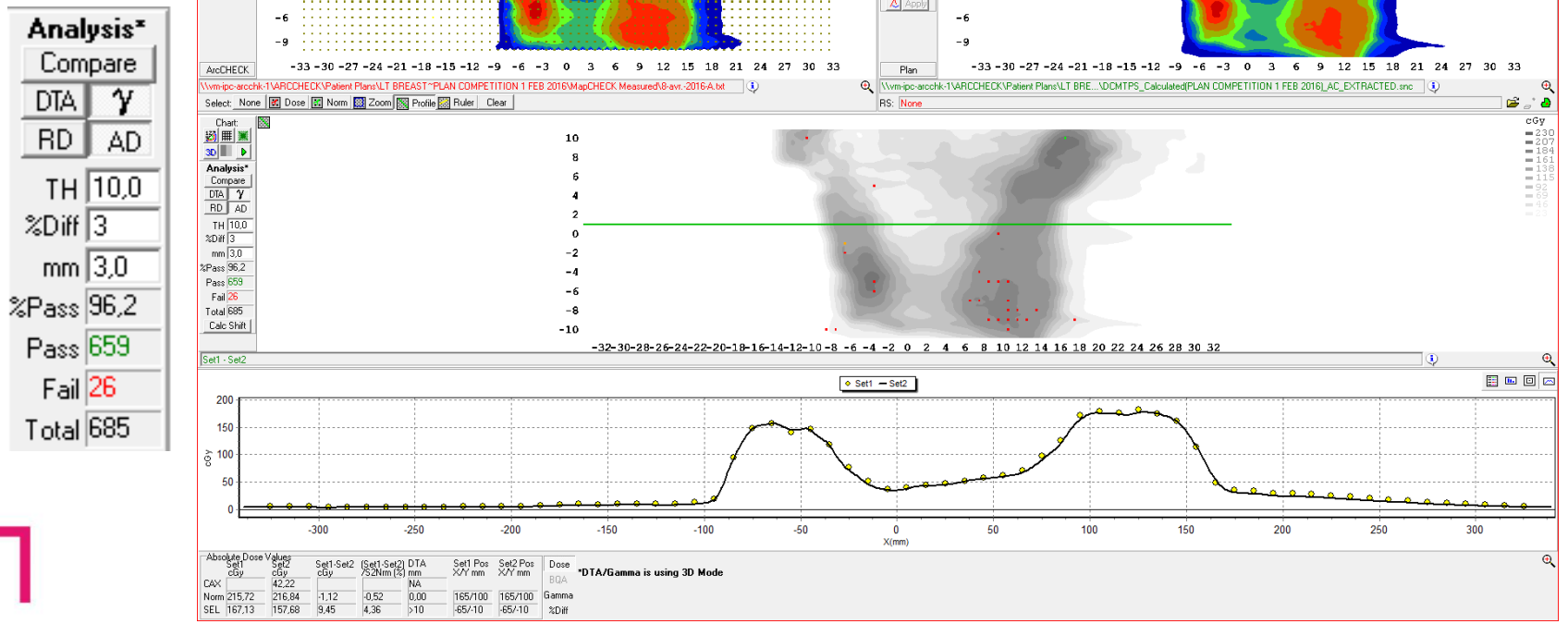








PATIENT-SPECIFIC QA



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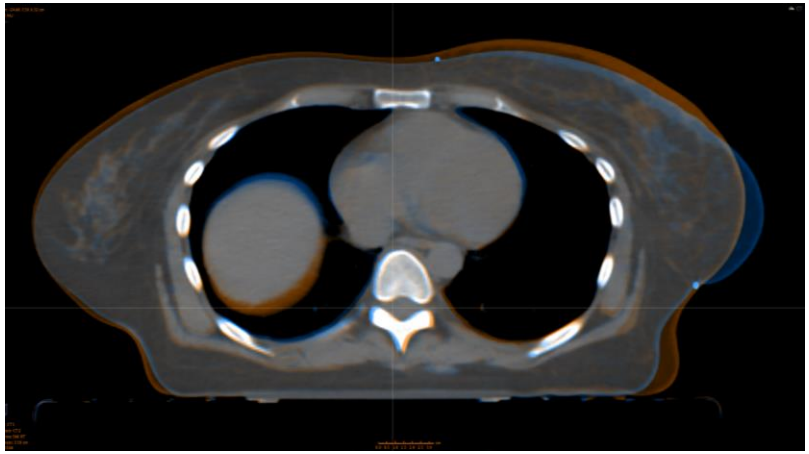
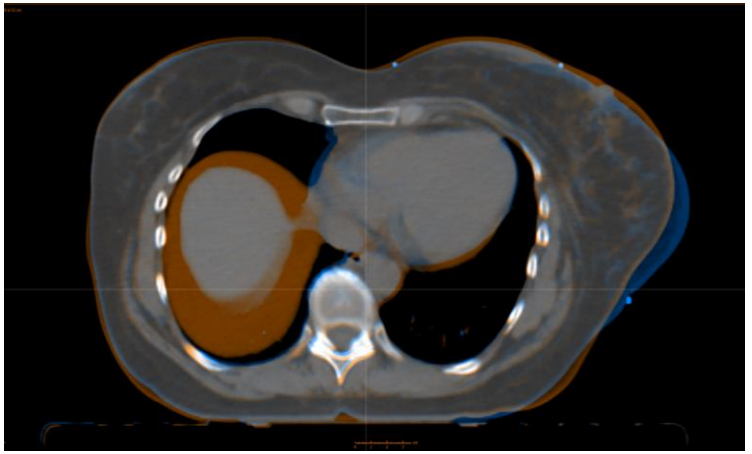
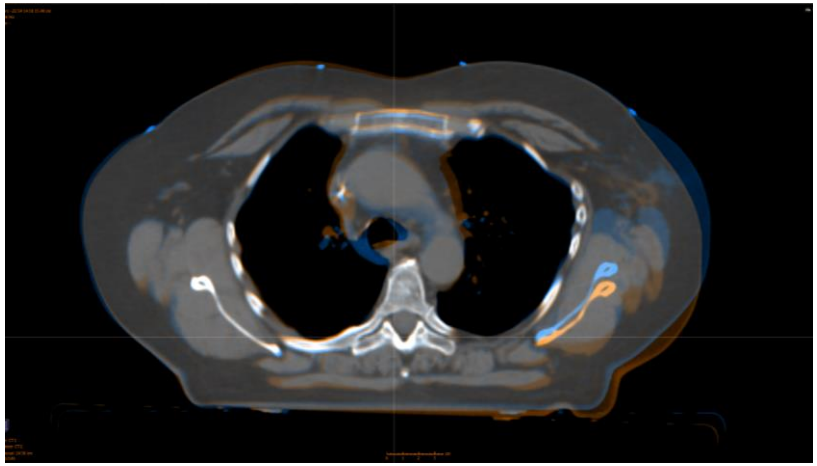
COMMENTS: INTERFRACTION MOVEMENT

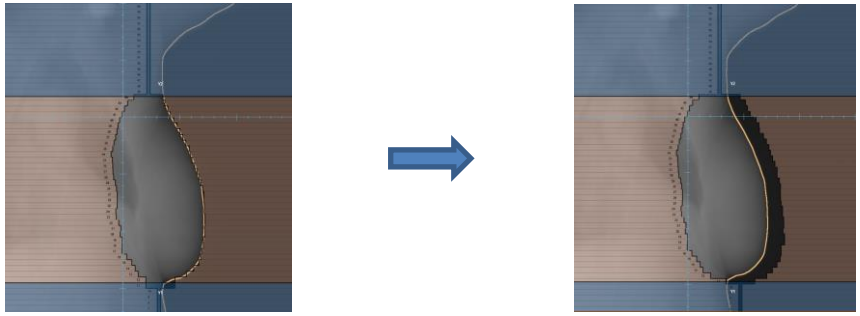




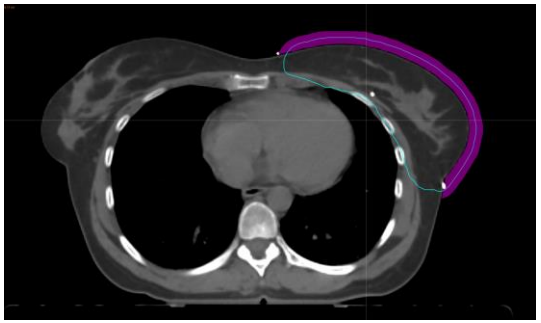


COMMENTS: INTERFRACTION MOVEMENT

- **How to take this into account ?**
  - ✓ For fixed fields: skin flash

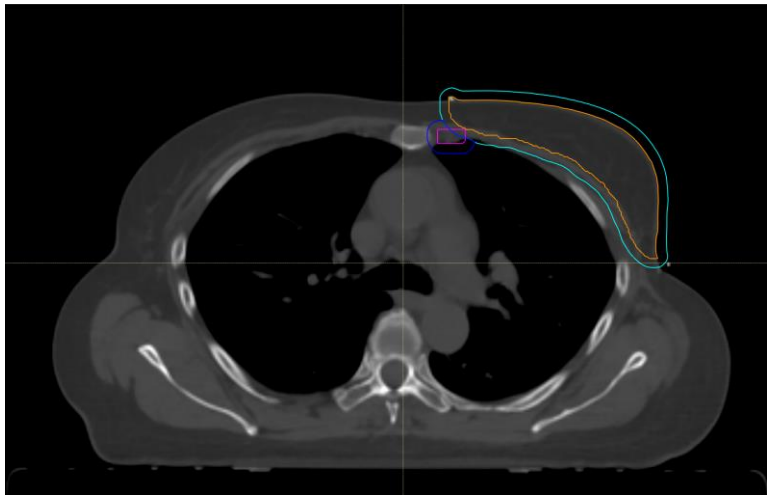


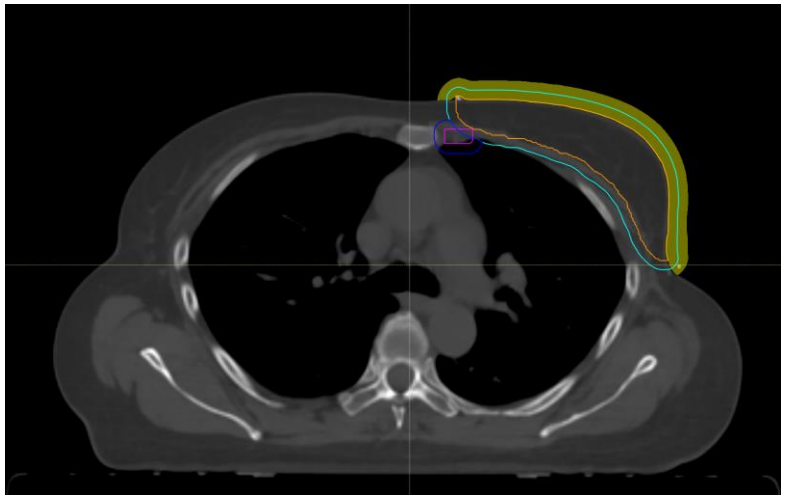
  - ✓ VMAT ?



COMMENTS: INTERFRACTION MOVEMENT

- Virtual bolus

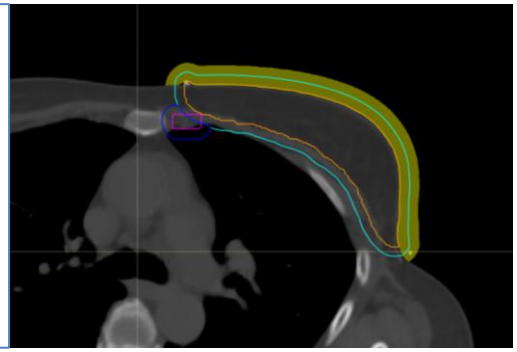




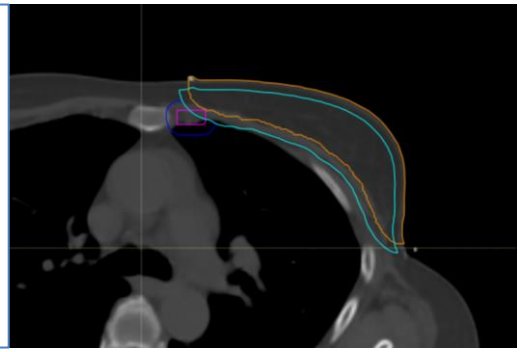
COMMENTS: INTERFRACTION MOVEMENT

- **Optimization: 2 step process**

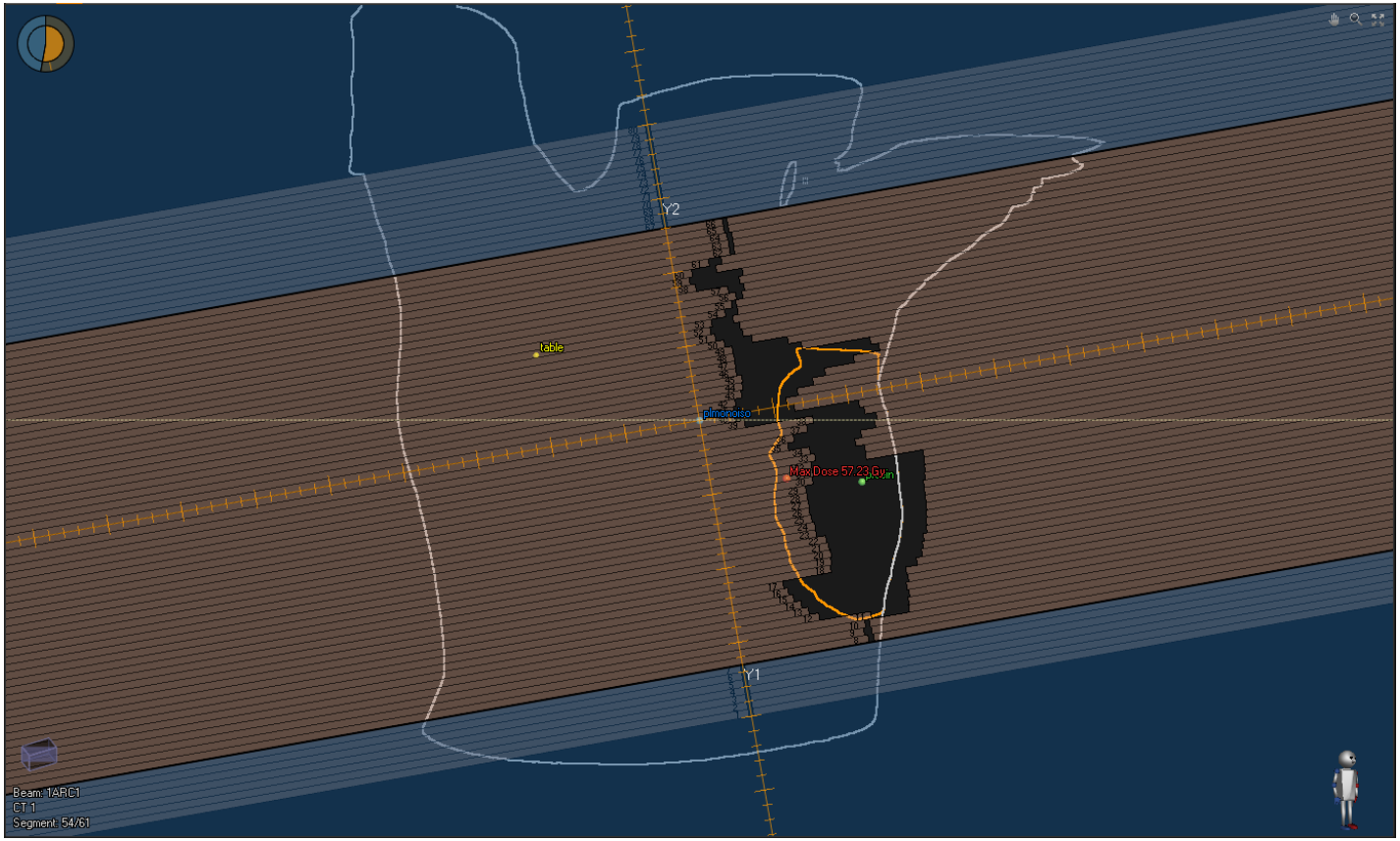
1) With virtual bolus: Optimization on the *PTV OUTSIDE*



2) After having removed the virtual bolus: Optimization on the PTV without modifying the shape of the segments

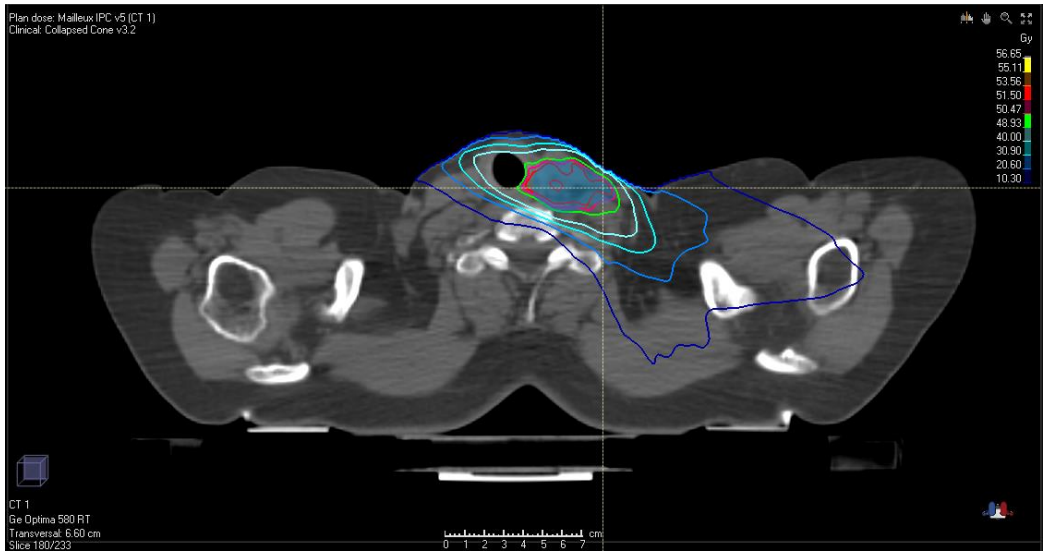


COMMENTS: INTERFRACTION MOVEMENT



COMMENTS

- **In our current technique, we use additional objectives for:**
  - ✓ Larynx
  - ✓ Thyroid
  - ✓ esophagus



CONCLUSION

- **Some (humble) recommendations:**
  - ✓ Well-defined methodology
    - learning curve
    - homogeneity of practices
  - ✓ As simple as possible:
    - 2 arcs
    - No couch rotation
    - As few objectives as possible for optimization
  - ✓ Use of Virtual bolus

THANKS

- ✓ Ahmad Nobah
- ✓ Radiation Oncologists
- ✓ Medical Physics team
- ✓ RaySearch
- ✓ My Family

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