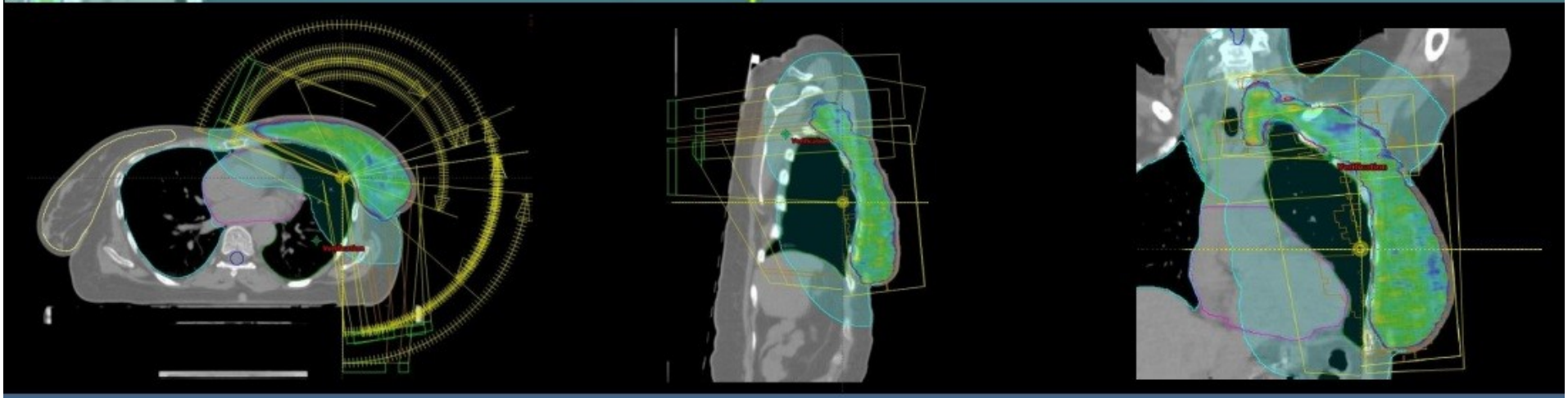
مستشفى الملك فيصل التخصصي و مركز الأبحاث
King Faisal Specialist Hospital & Research Centre
Gen. Org. مؤسسة عامة

accept the challenge

2016 RADIOTHERAPY PLAN COMPETITION

Be the strongest link in the radiotherapy chain



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Agenda

- Competition criteria
- Contouring stage
- Arc geometry
- Optimization
- Results
- Conclusions

Competition criteria

Plan Quality Scoresheet: 2016Competition-BodyMax

This is the Plan Quality results spreadsheet for Plan Quality Algorithm: 2016Competition-BodyMax.

Raw PQM / Max PQM: 94.02 / 100.00 PQM (%): 94.0%

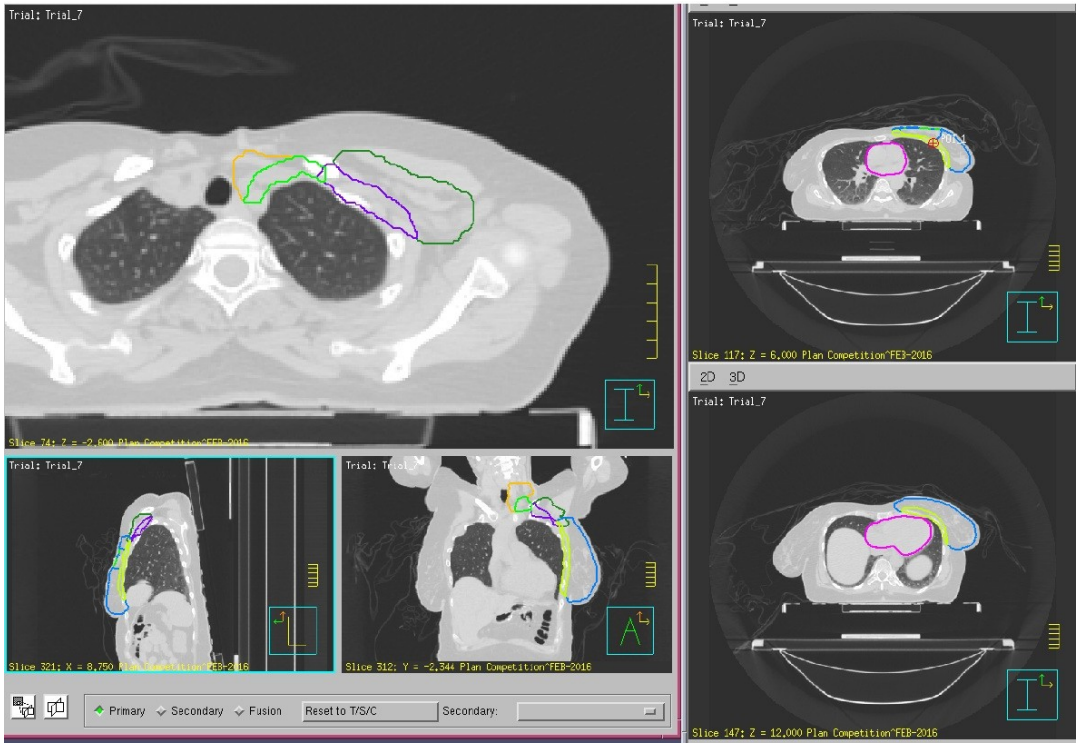
Plan Quality Metric Component	Objective(s)	Max Score
[PTV_TOT_EVAL] D[99.0%] (Gy)	> 45 [≥ 47.5]	15.00
[PTV_TOT_EVAL] D[95.0%] (Gy)	> 45 [≥ 50]	5.00
[PTV_TOT_EVAL] D[50.0%] (Gy)	< 54 [≤ 52]	5.00
[PTV_TOT_EVAL] D[0.3cc] (Gy)	< 57 [≤ 55]	5.00
[HEART] Mean dose (Gy)	< 5 [≤ 4]	10.00
[HEART] V[15.0Gy] (%)	< 20 [≤ 15]	5.00
[HEART] D[5.0%] (Gy)	< 25 [≤ 20]	5.00
[BREAST_RIGHT] D[0.3cc] (Gy)	< 3 [≤ 2]	2.00
[BREAST_RIGHT] D[5.0%] (Gy)	< 3 [≤ 2]	4.00
[SPINAL CORD] D[0.03cc] (Gy)	< 20 [≤ 8]	5.00
[LUNG_RIGHT] V[5.0Gy] (%)	< 6 [≤ 3]	5.00
[LUNG_LEFT] Mean dose (Gy)	< 15 [≤ 9]	5.00
[LUNG_LEFT] V[20.0Gy] (%)	< 20 [≤ 15]	5.00
[LUNG_LEFT] V[10.0Gy] (%)	< 40 [≤ 30]	5.00
[LUNG_LEFT] V[5.0Gy] (%)	< 70 [≤ 50]	4.00
[PTV_TOT_EVAL] Homogeneity Index [50.0Gy]	< 0.2 [≤ 0.08]	5.00
[PTV_TOT_EVAL] Conformation Number [47.5Gy]	> 0.6 [≥ 0.9]	5.00
Global Max Location (ROI)	[BODY]	5.00
Total [18 Metrics]		100.00

Lung left constraints are the most challenging to achieve and give a lot of points. The interface between left lung and PTV is the area where the dose have to be well controled.

Others constraint are more easy to reach.

Contouring stage

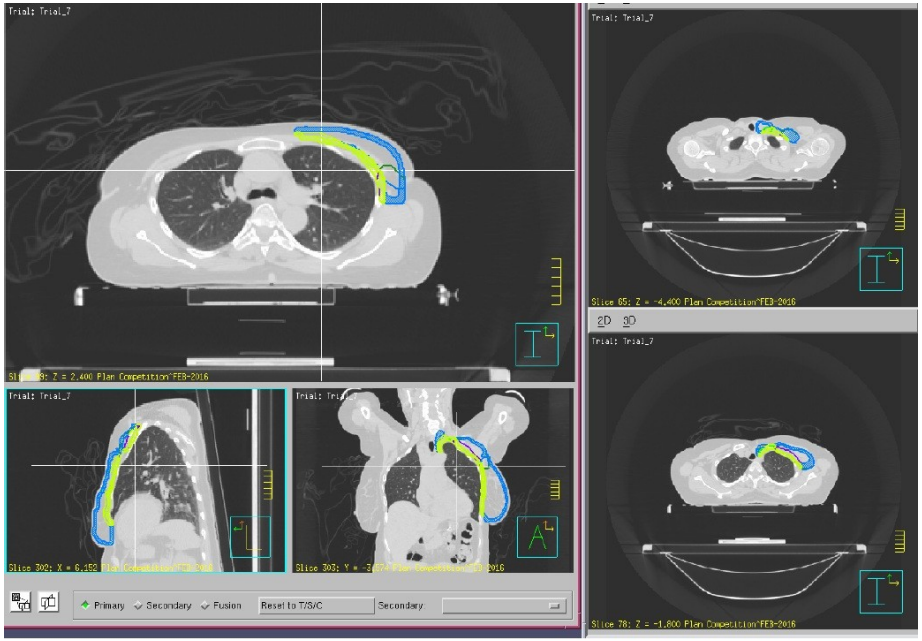
- Create the (Left Lung + 1cm)=(LL+1) ROI and then create the PTVs parts that overlap with it and the parts that do not.



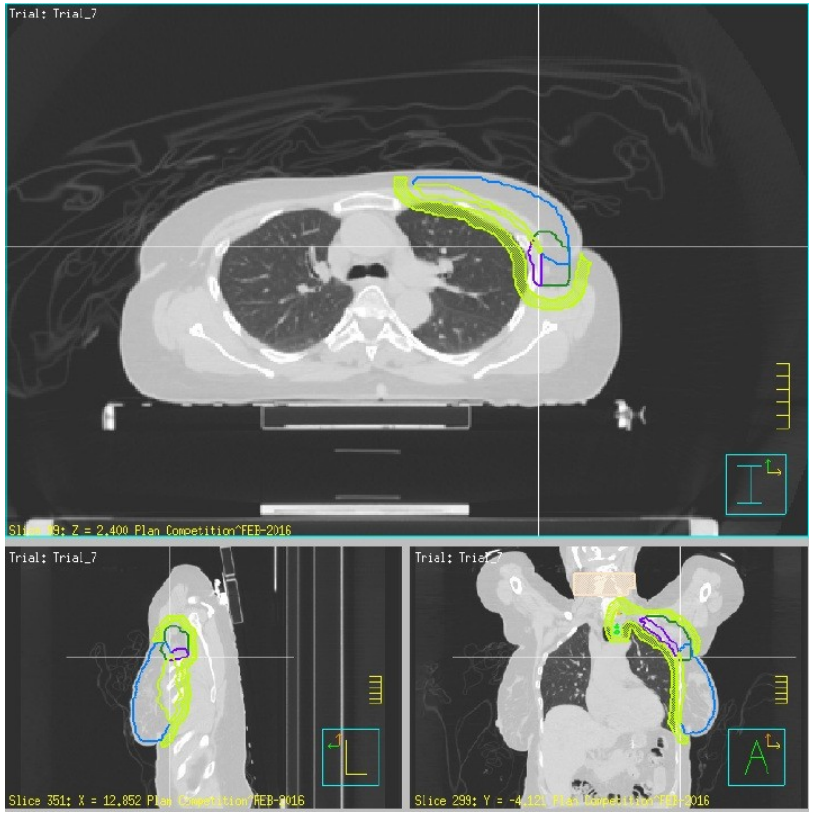
Do this for the PTV_TOT-EVAL and for all the subPTVs. They will all be used for the optimization.

Contouring stage

- Add min dose constraint on a thin internal ring of 4mm inside the PTV. It is divided in two parts, the part that overlaps (LL+1) and the rest. All these parts exclude the CTV-LUMPECTOMY which is treated separately.

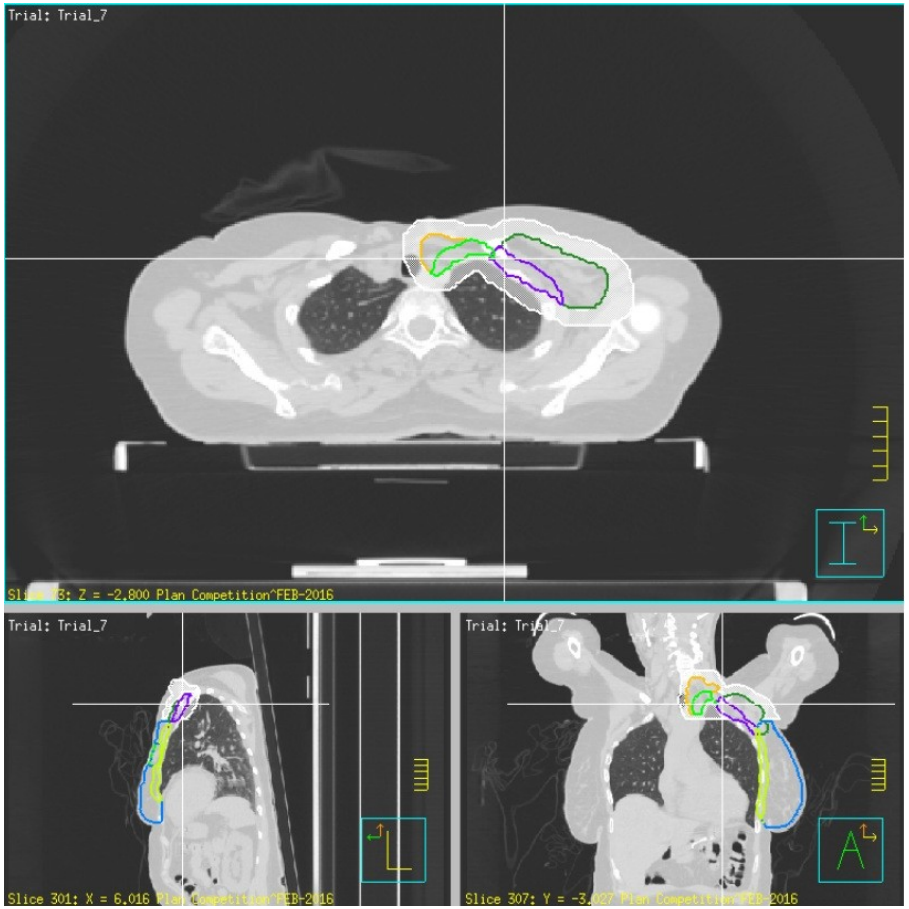


Contouring stage



- Use an external ring of 7mm with 4mm gap between PTV (R1).
- Draw the head of the patient to avoid dose from non-coplanar ARCs.

Contouring Stage

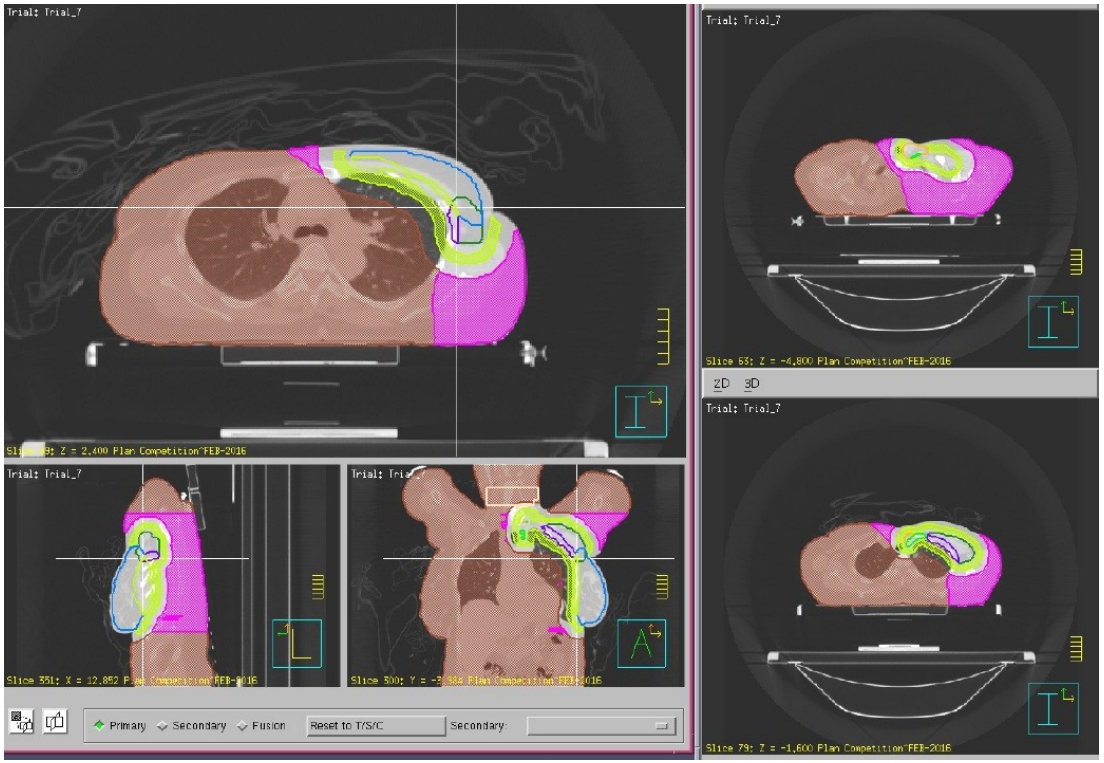


- Add an external ring of 1cm (R2) without gap with PTV in the SC area to increase conformality.

Contouring Stage

- Trace the body with 2,5cm margin from PTV and trim it manually where dose can be higher.

Here in brown : Whole body excluding (PTV+2.5cm) manually trimmed (ZR1).
And in purple the trimmed area (ZR2).

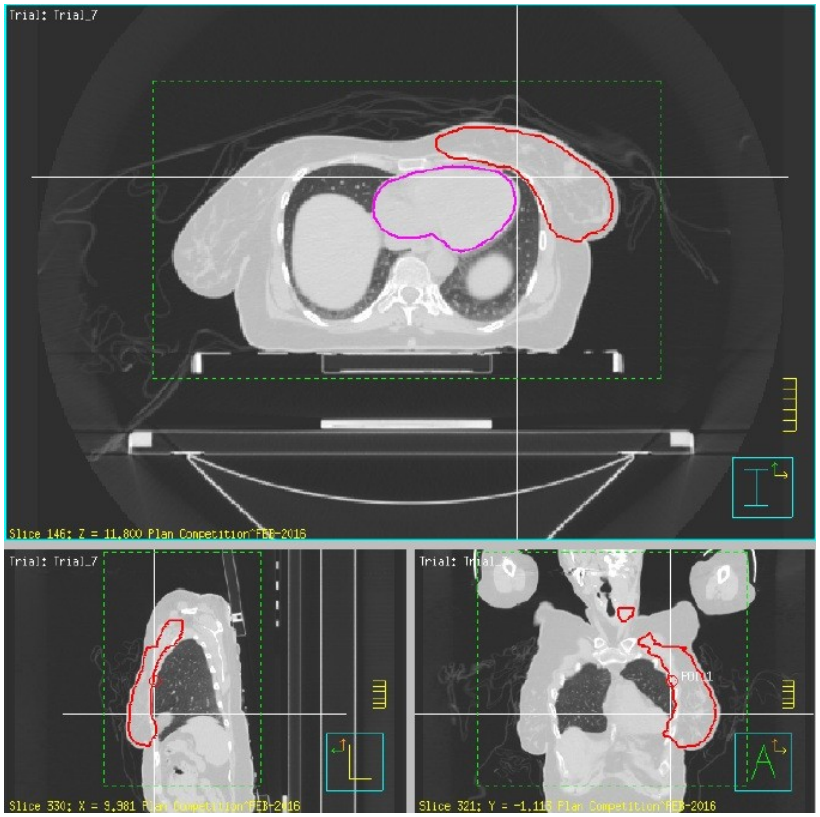


Contouring Stage

- For the Left Lung, use a 4mm gap with the PTV to create an optimisation ROI.
- Create Spine +5mm ROI.
- There is no need to create supplementary ROI for the others OAR.

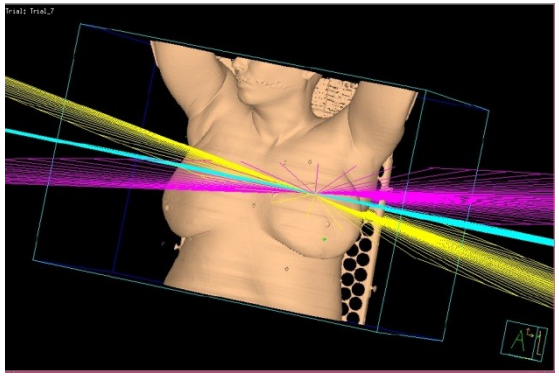
ARC Geometry

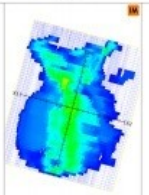
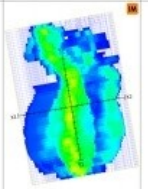
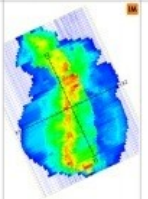
- Isocenter location:
  - on the Y axis: At the middle of the head-foot distance
  - on the XZ plane: At the interface between the heart and the PTV.



ARC Geometry

- 3 non-coplanar beams with different collimator angles to increase the possibilities of modulation.



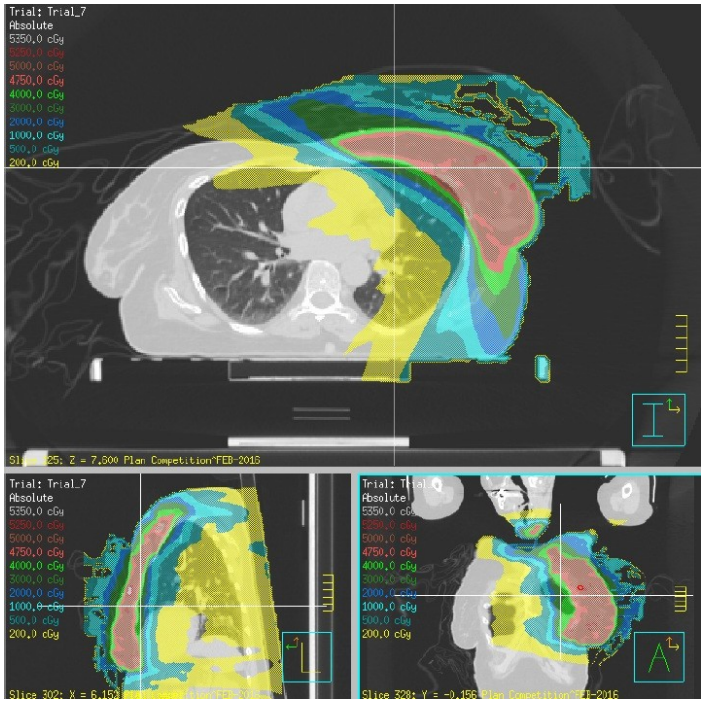
Beam Details	Geometry (IEC)	Modifiers	BEV	# CPs	Meterset
[1] Name: ARC1 [Desc: ARC1] Type: Photon Treatment (VMAT) Machine: VERSA3, Energy: 6 MV # Fractions: 25 (Fx Group 1)	Gantry Motion: CCW Gantry Start-to-End (deg): 180-to-290 Collimator (deg): 345 Couch (deg): 10 Isocenter [DICOM] (mm): (101.6,10.4,-60.0) Isocenter [Couch] (mm): (0.0,0.0,0.0)	[X Jaws*] X1: -111.00 mm, X2: 111.00 mm [Y Jaws*] Y1: -130.00 mm, Y2: 140.00 mm * Max jaw extents (all control points) Multi-Leaf Collimation (X)		64	141.1 MU 46sec
[2] Name: ARC2 [Desc: ARC2] Type: Photon Treatment (VMAT) Machine: VERSA3, Energy: 6 MV # Fractions: 25 (Fx Group 1)	Gantry Motion: CW Gantry Start-to-End (deg): 290-to-180 Collimator (deg): 10 Couch (deg): 350 Isocenter [DICOM] (mm): (101.6,10.4,-60.0) Isocenter [Couch] (mm): (0.0,0.0,0.0)	[X Jaws*] X1: -97.00 mm, X2: 104.00 mm [Y Jaws*] Y1: -130.00 mm, Y2: 160.00 mm * Max jaw extents (all control points) Multi-Leaf Collimation (X)		64	187.9 MU 68sec
[3] Name: ARC3 [Desc: ARC3] Type: Photon Treatment (VMAT) Machine: VERSA3, Energy: 6 MV # Fractions: 25 (Fx Group 1)	Gantry Motion: CW Gantry Start-to-End (deg): 290-to-180 Collimator (deg): 25 Couch (deg): 0 Isocenter [DICOM] (mm): (101.6,10.4,-60.0) Isocenter [Couch] (mm): (0.0,0.0,0.0)	[X Jaws*] X1: -118.00 mm, X2: 103.00 mm [Y Jaws*] Y1: -130.00 mm, Y2: 160.00 mm * Max jaw extents (all control points) Multi-Leaf Collimation (X)		64	239.9 MU 95sec
NOTE: "VMAT" label(s) derived from: 1) usage of MLC and 2) multi-segmented arc.			**Totals:**	**192 CPs**	**568.9 MU**

ARC Geometry

- Limit the gantry rotation to spare controlateral's OARs.
- 6MV FF beams.

Optimisation

- Use 0,05g/cm^{-3} air-patient threshold to allow computation in low density area near the skin.



Optimisation

- Begin with all the target and ring constraints:
  - Targets that overlap with (LL+1) : min dose to 48Gy and max to 50Gy
  - Targets that do not overlap (LL+1) : min dose to 50Gy and max dose to 51,5Gy
  - CTV-LUMPECTOMY: min dose 50,5Gy, uniform dose at 51Gy and max dose at 54Gy
  - PTV_TOT_EVAL part that do not overlaps (LL+1) : uniform dose to 50,5Gy, min dose 50Gy and max dose to 51,5Gy

Optimisation

- PTV_TOT_EVAL part that overlaps (LL+1) : min dose 48Gy and max dose to 50Gy
- PTV_TOT_EVAL : max EUD 52Gy a=1 and min DVH 50Gy on 95%
- ring R1: max dose 47Gy, R2: max dose 51Gy.
- ROI ZR1: max dose 40Gy and ZR2: max dose 45Gy

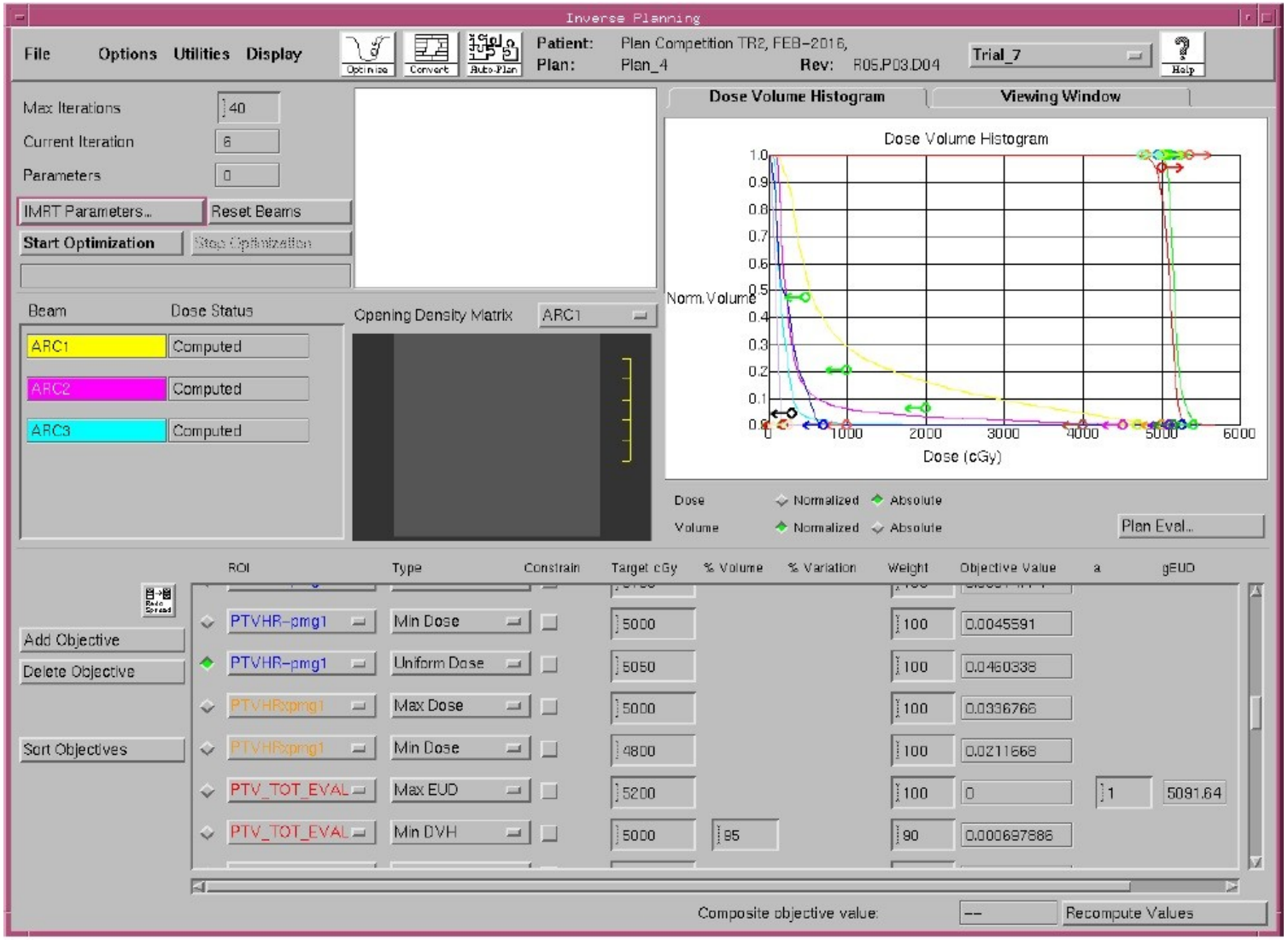
Optimisation

- Begin with SVD calculation to ensure that the constraints are good and then, when the target coverage is sufficient, add the OAR constraints.
- Breast right: max dose 1.8Gy, Heart: max EUD 3.8Gy a=1, and Lung right: max DVH 3Gy 4% and max EUD 6Gy a=5. Those criteria are easy to achieve. So when the criteria is found for these structures, try to gradually decrease the dose to the left Lung until it penalizes the target coverage.

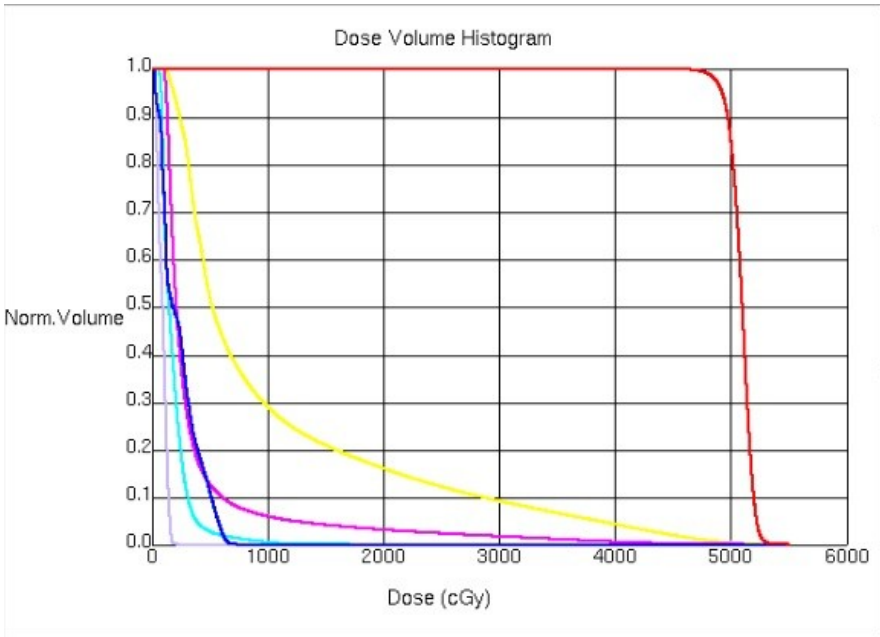
Optimisation

- Left Lung reduced: Max DVH (4.75Gy 47%), (10Gy 20%) and (20Gy 6%).
- When all constraints are optimized, reset the computation and optimize twice with 100 iterations and then 40 iterations.
- Create the hot and cold spots for several computations (7 in my case), add a constraint on them with a strong weight, reset and re-optimize until you get the global max dose point inside the CTV.

Optimisation

- 

Results



DVH Calculation
- Cumulative
- Differential

Dose Axis Display
- Normalized Dose
- Absolute Dose

- Auto-Compute Max
- Specify Max Dose

Volume Axis Display
- Normalized Volume
- Absolute Volume

Tabular DVH...

DVH Tools

Reset

ROI Statistics

Compute

Line Type	ROI	Trial or Record	Min.	Max.	Mean	Std. Dev.	% Outside Grid	% > Max	Generalized EUD
	LUNG_RIGHT	Trial_7	43.2	1702.1	189.2	133.3	0.00 %	0.00 %	--
	LUNG_LEFT	Trial_7	95.3	5253.6	1032.2	1118.4	0.00 %	0.00 %	--
	BREAST_RIGHT	Trial_7	24.6	218.1	93.7	40.2	0.00 %	0.00 %	--
	HEART	Trial_7	102.8	5099.2	377.8	572.2	0.00 %	0.00 %	--
	SPINAL CORD	Trial_7	25.6	733.8	241.8	169.3	0.00 %	0.00 %	--
	PTV_TOT_EVAL	Trial_7	3431.4	5488.4	5089.9	98.3	0.00 %	0.00 %	--

Results

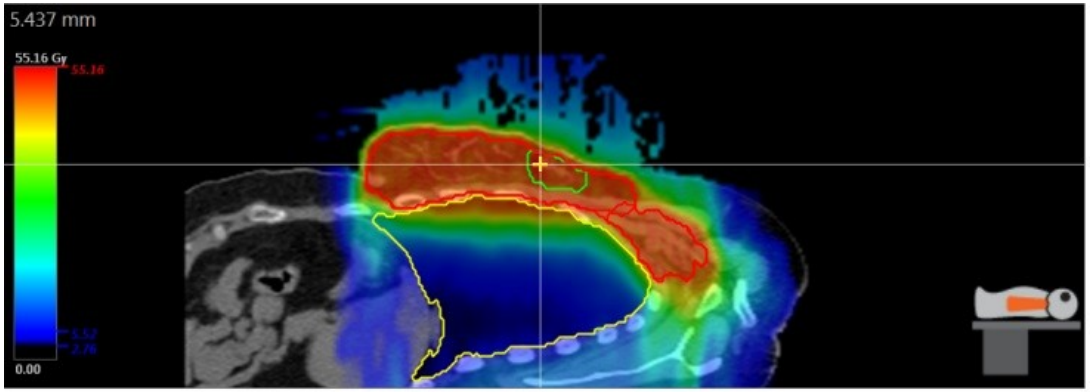
Plan Quality Scoresheet: 2016Competition-BodyMax

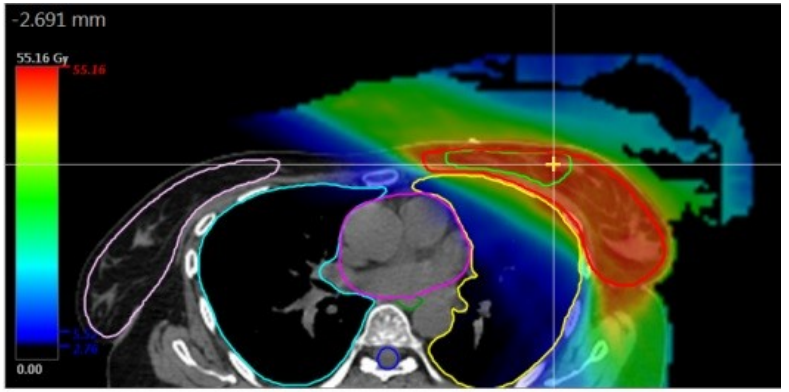
This is the Plan Quality results spreadsheet for Plan Quality Algorithm: 2016Competition-BodyMax.

Raw PQM / Max PQM: 94.02 / 100.00 PQM (%): 94.0%

Plan Quality Metric Component	Objective(s)	Result	Raw Score	Max Score	Performance
[PTV_TOT_EVAL] D[99.0%] (Gy)	> 45 [≥ 47.5]	48.2742	15.00	15.00	100.0%
[PTV_TOT_EVAL] D[95.0%] (Gy)	> 45 [≥ 50]	49.2918	4.29	5.00	85.8%
[PTV_TOT_EVAL] D[50.0%] (Gy)	< 54 [≤ 52]	51.0359	5.00	5.00	100.0%
[PTV_TOT_EVAL] D[0.3cc] (Gy)	< 57 [≤ 55]	54.5638	5.00	5.00	100.0%
[HEART] Mean dose (Gy)	< 5 [≤ 4]	3.7643	10.00	10.00	100.0%
[HEART] V[15.0Gy] (%)	< 20 [≤ 15]	4.0424	5.00	5.00	100.0%
[HEART] D[5.0%] (Gy)	< 25 [≤ 20]	11.8445	5.00	5.00	100.0%
[BREAST_RIGHT] D[0.3cc] (Gy)	< 3 [≤ 2]	1.9574	2.00	2.00	100.0%
[BREAST_RIGHT] D[5.0%] (Gy)	< 3 [≤ 2]	1.5872	4.00	4.00	100.0%
[SPINAL CORD] D[0.03cc] (Gy)	< 20 [≤ 8]	6.7690	5.00	5.00	100.0%
[LUNG_RIGHT] V[5.0Gy] (%)	< 6 [≤ 3]	2.6883	5.00	5.00	100.0%
[LUNG_LEFT] Mean dose (Gy)	< 15 [≤ 9]	10.3627	3.86	5.00	77.3%
[LUNG_LEFT] V[20.0Gy] (%)	< 20 [≤ 15]	16.0776	3.92	5.00	78.4%
[LUNG_LEFT] V[10.0Gy] (%)	< 40 [≤ 30]	28.9782	5.00	5.00	100.0%
[LUNG_LEFT] V[5.0Gy] (%)	< 70 [≤ 50]	52.4144	3.28	4.00	81.9%
[PTV_TOT_EVAL] Homogeneity Index [50.0Gy]	< 0.2 [≤ 0.08]	0.0942	4.29	5.00	85.8%
[PTV_TOT_EVAL] Conformation Number [47.5Gy]	> 0.6 [≥ 0.9]	0.7793	3.38	5.00	67.6%
Global Max Location (ROI)	[BODY]	BODY	5.00	5.00	100.0%
Total [18 Metrics]			94.02	100.00	94.0%

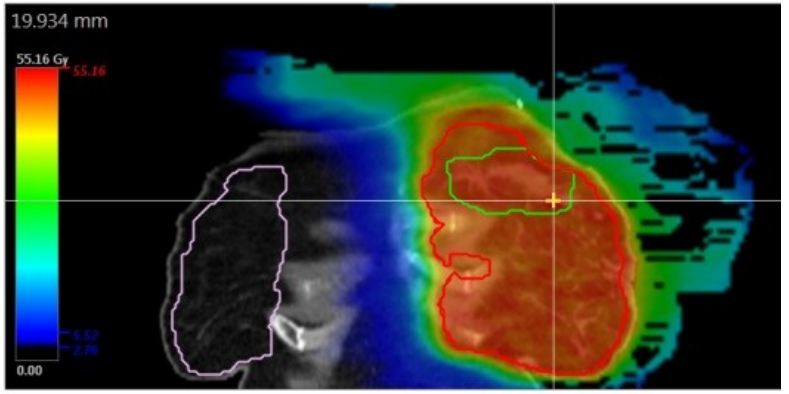
Results





Global Max Dose (Gy): 55.15805
Grid Resolution (mm): 2.90 x 2.90 x 2.90
Grid Range X (mm): -342.563 to 133.037
Grid Range Y (mm): -185.391 to 226.408
Grid Range Z (mm): -188.866 to 89.534
Origin set to DICOM XYZ (mm):
(101.573, 10.366, -60.001)

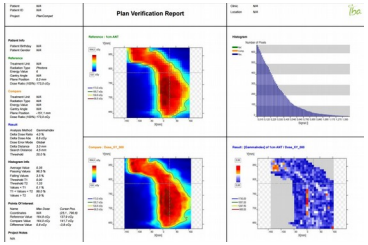
NOTE: This software uses an intuitive "couch coordinate system" (not DICOM) for XYZ points, with the origin set to the first isocenter. +X is couch's lateral "left"; +Y is in towards gantry; and +Z is vertical up from couch.

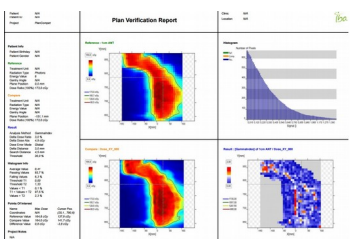


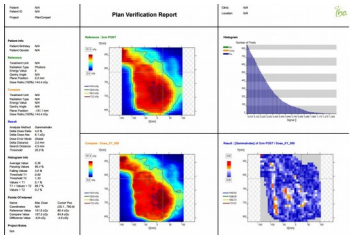
Results

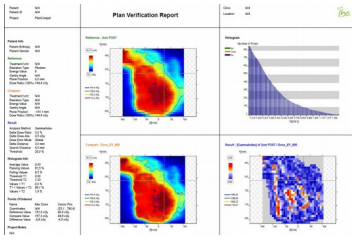
- Patient specific QA:
  - Passing criteria:
    - Gamma index 3%3mm>90%
    - Gamma index 4%3mm>95%
  - Results

Measure	Gamma index criteria 3%3mm	4%3mm
1cm ANT	93.70%	96.50%
2cm POST	91.50%	96.40%









Conclusion

- Isocenter location very important both for target conformality and OAR sparing.
- Segmentation of the target helps to control dose to ipsilateral lung.
- Non-coplanar beams not really nescessary to have a good plan but help to reduce the low dose areas.