Total Marrow and Lymphoid Irradiation (TMLI) 12Gy Model Description

Purpose:

This document describes the context in which the TMLI 12Gy model should be used, as well as how it was configured and validated. All instruction needed to use this model in your clinic can be found when you **read the first 15 pages of this document**.

Applicability:

Note *RapidPlan knowledge-based planning and its models are not intended to replace clinical decisions, provide medical advice, or endorse any particular radiation plan or treatment procedure. The patients' medical professionals are solely responsible for and must rely on their professional clinical judgment when deciding how to plan and provide radiation therapy.*

Note *The performance of the TMLI 12Gy model may vary depending on the contouring and planning guidelines. Each site should validate the model with institution-specific contouring and planning guidelines before clinical use.*

Note *You should validate every DVH estimation model before using it clinically. This applies to any model, whether Varian provided, peer provided or the models you create yourself.*

- TMLI 12Gy model is intended to be used for RapidArc treatment plans on Halcyon or TrueBeam.
- TMLI 12Gy model is meant to be used for treatment plans where the brain and liver are spared.
- Intended use for TMLI, upper body through lower extremities. This includes all OAR sparing, except gender specific organs (model is non-binary, gender specific organs need to be added to the optimizer and spared manually).
- Lower extremities can be treated in the same optimization with VMAT and ESAPI MAAS_TXIhelper as described in Annex A. Or users can select an alternative technique for lower extremities (2D, 3D, IMRT, etc). Such non VMAT techniques for lower extremities are outside the scope of this document.
- An associated dosimetric scorecard is available to evaluate plan quality and for clinical validation.
- The "**Automatic Intermediate Dose**" function of the Photon Optimizer was utilized with **MR3** return and **convergence mode: extended** selected in the calculation options which provide best results. These **settings should be changed prior to starting the optimization or plan quality will be compromised.** (see Annex B)
- The TMLI 12Gy model was referenced and created using the guidelines described below.

  Han, C., Liu, A., Wong, J.
  Target coverage and normal organ sparing in dose-escalated total marrow and lymphatic irradiation: A single institution experience
  Front.Oncol.Vol12-2022
  https://doi.org/10.3389/fonc.2022.946725

Target contouring guidelines:

Standard Name	Description
PTV_LN	Lymph node volume including cervical, supraclavicular, axillary, mediastinal, para-aortic, and inguinal-femoral, with proper margins but cropped from normal organs.
PTV_Ribs	PTV_Ribs includes the rib bones and the chest wall. Typically, a 1 cm margin beyond the chest wall border. Crop back 2 mm from the skin surface if patient anatomy allows. Crop away from kidneys and esophagus by 5 mm.
PTV_Skull	PTV_Skull is obtained by a margin expansion of the skull bone based on setup uncertainty analysis. Crop back from the skin and brain surface.
PTV_SpCord	The spinal cord from C1 to L5.
PTV_Spleen	The spleen volume plus proper margin for respiratory motion.
PTV_VExP (**V**ertebral bodies; **Ex**tremities; **P**elvic bones)	Primary skeletal bone target volume including the vertebral body, upper extremity and superior portion of lower extremity bones, and pelvic bones, with proper margins for setup and intra-fractional motion uncertainties. Larger margins are used in areas with high positioning variability (shoulder, extremities, and spinous process). The ribcage or skull is **not** included.
PTV_VExParms	Helper structures for adequate dose coverage for the upper extremities. It consists of **only** the upper extremity portion of PTV_VExP.
PTV_VExPopti	Helper structure used in plan optimization. PTV_VExP except upper extremities, and overlaps with PTV_Ribs and PTV_LN are **not** part of the structure.
PTV_Lower	Consists of lower extremities **only.** Excludes the upper extremity portion of PTV_VExP

See example DICOM structures, plan and dose in patient DICOM.zip file:

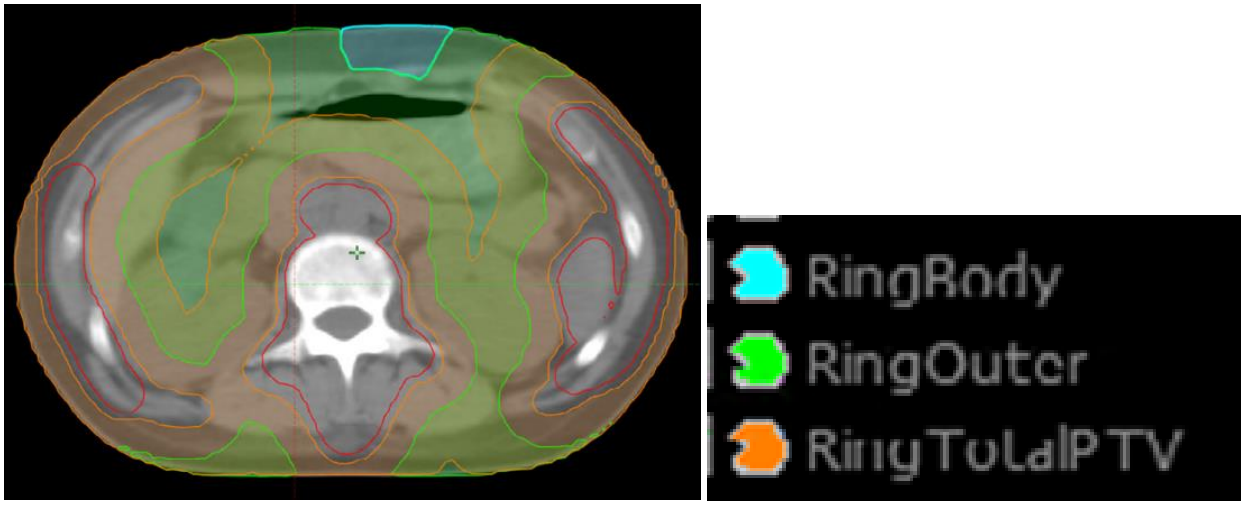
https://medicalaffairs.varian.com/other-tmli-vmat2

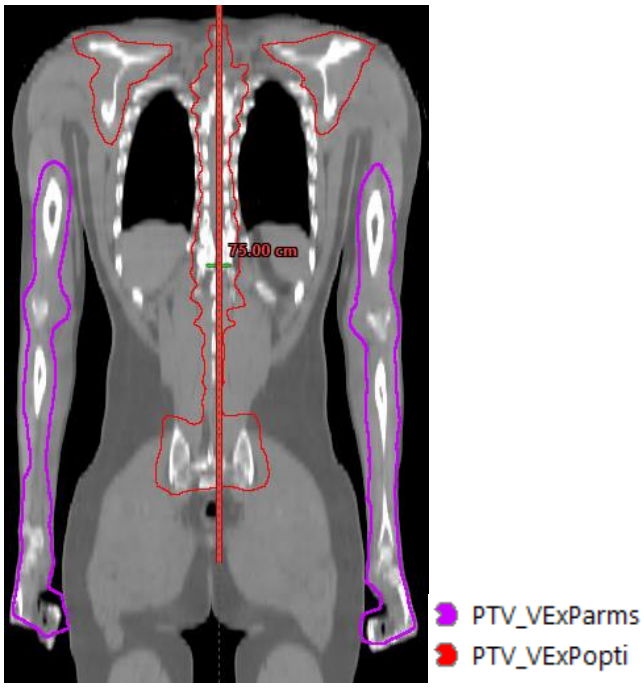
Organ At Risk contouring guidelines:

Standard Name	Description
Body	External patient contour encompassing all patient anatomy with a single contour on each slice.
Brain	Interior to the skull. The inferior border is the lower cerebellum, extending superiorly to the inner apex of the skull.
Bladder	The entire bladder should be contoured as a solid structure
Esophagus	A tubular structure that starts at the bottom of pharynx (cricopharyngeal inlet) and extends to the to the cardiac orifice of the stomach.
Eyes	Soft tissue spherical structure located within the orbital cavity.
GI Lower	All small bowel loops will be outlined on each axial CT slice and treated as solid structures. All large bowel loops including sigmoid will be outlined on each axial CT slice and these organs will be treated as solid structures.
GI Upper	Stomach and duodenum will be outlined on each axial CT slice.
Heart	The heart muscle including the complete pericardia from the lower part of the pulmonic trunk to the apex.
Kidneys	Kidney (left and right).
Larynx	Glottic and supraglottic larynx.
Lenses	Small structure on anterior border of the eye.
Liver	All four lobes: right, left, caudate, and quadrate.
Lungs	Low density structures, contoured together.
OpticN_Chiasm	Includes all optic nerves and optic chiasm. Optic nerves extend from the posterior eye through the skull and connects to the optic chiasm. Optic chiasm extends inferiorly from the eye and then turns superiorly once through the skull and inferiorly from superior border of the sella turcica.
OralCavity	Composite structure posterior to lips consisting of the oral tongue/floor of mouth, buccal mucosa, and superiorly the palate, and inferiorly to the plane containing the tip of the mandible.
Parotids	Defined in their entirety (superficial and deep lobes), the parotid gland is an irregular shaped gland wedged between the ramus of the mandible and the mastoid process.
Rectum	The outer rectal wall will be contoured, and the organ will be considered as a continuous solid structure, and will be defined from the level of the sigmoid flexure to the bottom of the ischial tuberosities.
Thyroid	Has two connected lobes and is located below the thyroid cartilage. It has considerable contrast compared to its surrounding tissues.

Optimization structure guidelines:

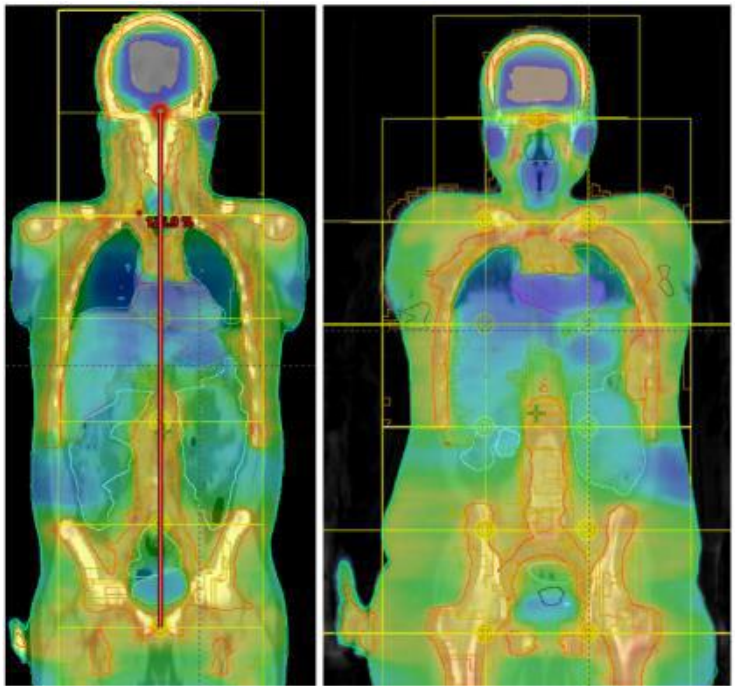
Model Structure	Derived Boolean/Expansion
PTV_VExParms	“{<PTV_VExP> SUB <PTV_VExPopti>}”
PTV_VExPopti	"{<PTV_VExP> SUB <PTV_VExParms>}“
RingTotalPTV	“{<PTVtotal>|+30mm SUB <PTVtotal>|+3mm AND <BODY>}“
RingOuter	“{<PTVtotal>|+50mm SUB <PTVtotal>|+15mm AND <BODY>}”
RingBody (remaining tissue)	“{<BODY> SUB <RingOuter>} | < RingTotalPTV> | < PTVtotal>}”



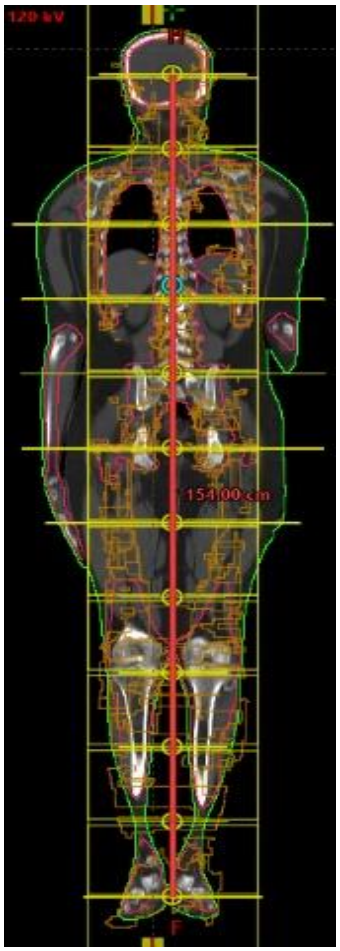


Treatment planning guidelines:

- For Halcyon, multiple isocenter positions, with 2 coplanar arcs per isocenter (collimator 0 and 90 degrees) were placed 14cm apart in the craniocaudal direction. This isocenter spacing maximizes plan deliverability robustness resulting in 28cm total aperture being overlapped, half from the neighboring superior and half from neighboring inferior isocenters (except the most superior and inferior isocenters). When the patient's largest lateral total **BODY** separation was >54cm, two lateral isocenters were placed in the same axial plane, each 7cm from midline otherwise, no lateral offset isocenters are applied. Arcs with alternating clockwise and counterclockwise gantry rotations were used. Each arc included 359.8 degrees of rotation. For irradiating the lower extremities, one VMAT arc per isocenter can be used.
- For TrueBeam VMAT arc option comparisons, refer to Annex C.



Lateral body separation isocenter positions:
<54cm=1 lat. iso. (left); >54cm=2 lat. isos. (right)



Fields in plan 'TMLI12Gy' of course 'C1'

Field ID	Technique	Machine	Energy	Weight	X1 [cm]	X2 [cm]	Y1 [cm]	Y2 [cm]	Gantry Rtn [deg]	Coll Rtn [deg]	Couch Rtn [deg]	X [cm]	Y [cm]	Z [cm]	SSD [cm]	MU
kVCBCT	STATIC-I	RDS3 Ti kV	6X-FFF	0.000	-14.0	+14.0	-14.0	+14.0	0.0	0.0	0.0	0.0	-20.0	-51.6	88.3	Setup field
Field 1	ARC-I	RDS3 Ti kV	6X-FFF	3.559	-14.0	+14.0	-14.0	+14.0	181.0 - 179.0	0.0	0.0	0.0	-20.0	-12.0	90.1	533.9
Field 2	ARC-I	RDS3 Ti kV	6X-FFF	5.086	-14.0	+14.0	-14.0	+14.0	179.0 - 181.0	90.0	0.0	0.0	-20.0	-12.0	90.2	763.0
Field 3	ARC-I	RDS3 Ti kV	6X-FFF	1.799	-14.0	+14.0	-14.0	+14.0	181.0 - 179.0	0.0	0.0	0.0	-20.0	-26.0	93.6	269.8
Field 4	ARC-I	RDS3 Ti kV	6X-FFF	3.311	-14.0	+14.0	-14.0	+14.0	179.0 - 181.0	90.0	0.0	0.0	-20.0	-26.0	93.6	496.7
Field 5	ARC-I	RDS3 Ti kV	6X-FFF	1.420	-14.0	+14.0	-14.0	+14.0	181.0 - 179.0	0.0	0.0	0.0	-20.0	-40.0	90.2	213.0
Field 6	ARC-I	RDS3 Ti kV	6X-FFF	4.748	-14.0	+14.0	-14.0	+14.0	179.0 - 181.0	90.0	0.0	0.0	-20.0	-40.0	90.2	712.2
Field 7	ARC-I	RDS3 Ti kV	6X-FFF	1.807	-14.0	+14.0	-14.0	+14.0	181.0 - 179.0	0.0	0.0	0.0	-20.0	-54.0	90.3	271.1
Field 8	ARC-I	RDS3 Ti kV	6X-FFF	3.630	-14.0	+14.0	-14.0	+14.0	179.0 - 181.0	90.0	0.0	0.0	-20.0	-54.0	90.4	544.5
Field 9	ARC-I	RDS3 Ti kV	6X-FFF	2.328	-14.0	+14.0	-14.0	+14.0	181.0 - 179.0	0.0	0.0	0.0	-20.0	-68.0	90.5	349.1
Field 10	ARC-I	RDS3 Ti kV	6X-FFF	3.263	-14.0	+14.0	-14.0	+14.0	179.0 - 181.0	90.0	0.0	0.0	-20.0	-68.0	90.5	489.4
Field 11	ARC-I	RDS3 Ti kV	6X-FFF	1.370	-14.0	+14.0	-14.0	+14.0	181.0 - 179.0	0.0	0.0	0.0	-20.0	-82.0	89.9	205.6
Field 12	ARC-I	RDS3 Ti kV	6X-FFF	3.312	-14.0	+14.0	-14.0	+14.0	179.0 - 181.0	90.0	0.0	0.0	-20.0	-82.0	89.9	496.9
Field 13	ARC-I	RDS3 Ti kV	6X-FFF	1.354	-14.0	+14.0	-14.0	+14.0	181.0 - 179.0	0.0	0.0	0.0	-20.0	-96.0	93.0	203.1
Field 14	ARC-I	RDS3 Ti kV	6X-FFF	2.293	-14.0	+14.0	-14.0	+14.0	179.0 - 181.0	90.0	0.0	0.0	-20.0	-96.0	93.3	344.0
Field 15	ARC-I	RDS3 Ti kV	6X-FFF	1.007	-14.0	+14.0	-14.0	+14.0	181.0 - 179.0	0.0	0.0	0.0	-20.0	-110.0	93.3	151.1
Field 16	ARC-I	RDS3 Ti kV	6X-FFF	1.192	-14.0	+14.0	-14.0	+14.0	179.0 - 181.0	90.0	0.0	0.0	-20.0	-110.0	93.4	178.7
Field 17	ARC-I	RDS3 Ti kV	6X-FFF	1.920	-14.0	+14.0	-14.0	+14.0	179.0 - 181.0	0.0	0.0	0.0	-20.0	-124.0	-	288.0
Field 18	ARC-I	RDS3 Ti kV	6X-FFF	1.638	-14.0	+14.0	-14.0	+14.0	181.0 - 179.0	90.0	0.0	0.0	-20.0	-138.0	-	245.6
Field 19	ARC-I	RDS3 Ti kV	6X-FFF	1.382	-14.0	+14.0	-14.0	+14.0	179.0 - 181.0	0.0	0.0	0.0	-20.0	-152.0	-	207.3
Field 20	ARC-I	RDS3 Ti kV	6X-FFF	3.235	-14.0	+14.0	-14.0	+14.0	181.0 - 179.0	90.0	0.0	0.0	-20.0	-166.0	87.8	485.3

Beam geometry example with Halcyon 14cm Z direction spacing between isocenters

Target Clinical Goals

The following dose prescription and planning guidelines were used for the cases to train and validate the model.

Standard Target Name	Dose [Gy]	Fraction Size [Gy]	# of fractions	Dose specification technique
PTV_LN	12	1.5	8	>=70% of PTV should receive >=12 Gy
PTV_Ribs	12	1.5	8	>=45% of PTV should receive >=12Gy
PTV_Skull	12	1.5	8	>=70% of PTV should receive >=12Gy
PTV_SpCord	12	1.5	8	>=80% of PTV should receive >=12 Gy
PTV_Spleen	12	1.5	8	>=70% of PTV should receive >=12 Gy
PTV_VExP	12	1.5	8	>=80% of PTV should receive >=12 Gy

OAR Clinical Goals (Han, et al *https://doi.org/10.3389/fonc.2022.946725*)

Name of Structure	Dosimetric Parameter	Per Published Practice Guidelines	Acceptable Deviation
Brain	D80(Gy)	3.7	+/-1.0
	D50(Gy)	6.4	+/-1.1
	D10(Gy)	10.8	+/-0.7
	Mean(Gy)	6.7	+/- 0.9
Liver	D80(Gy)	5.4	+/-0.9
	D50(Gy)	6.6	+/-1.1
	D10(Gy)	10.8	+/-1.2
	Mean(Gy)	7.2	+/- 0.9
Bladder	D80(Gy)	5.6	+/-1.4
	D50(Gy)	7.2	+/-1.8
	D10(Gy)	10.6	+/-1.5
	Mean(Gy)	7.6	+/-1.5
Esophagus	D80(Gy)	3.9	+/-0.7
	D50(Gy)	4.5	+/-0.9
	D10(Gy)	6.9	+/-1.7
	Mean(Gy)	4.9	+/- 0.9

Eyes	D80(Gy)	2.8	+/-1.3
	D50(Gy)	3.9	+/-1.7
	D10(Gy)	5.9	+/-2.2
	Mean(Gy)	4.0	+/-1.6
Heart	D80(Gy)	4.6	+/-1.0
	D50(Gy)	5.7	+/-1.1
	D10(Gy)	8.8	+/-1.2
	Mean(Gy)	6.1	+/-1.0
Lower GI	D80(Gy)	4.2	+/-0.9
	D50(Gy)	5.3	+/-1.0
	D10(Gy)	9.1	+/-1.2
	Mean(Gy)	5.9	+/- 0.9
Upper GI	D80(Gy)	4.0	+/-0.7
	D50(Gy)	4.7	+/-0.9
	D10(Gy)	7.4	+/-1.6
	Mean(Gy)	5.2	+/-0.8

Kidneys	D80(Gy)	4.7	+/-1.3
	D50(Gy)	5.3	+/-1.4
	D10(Gy)	8.5	+/-1.8
	Mean(Gy)	5.9	+/-1.4
Larynx	D80(Gy)	3.4	+/-1.2
	D50(Gy)	4.4	+/-1.5
	D10(Gy)	7.8	+/-1.9
	Mean(Gy)	5.0	+/-1.4
Lenses	D80(Gy)	1.9	+/-0.7
	D50(Gy)	2.2	+/-1.0
	D10(Gy)	2.6	+/-1.4
	Mean(Gy)	2.2	+/- 0.9
Lungs	D80(Gy)	4.6	+/-0.7
	D50(Gy)	5.7	+/-0.4
	D10(Gy)	9.0	+/-0.9
	Mean(Gy)	6.2	+/-0.6
Optic nerves and chiasm	D80(Gy)	5.0	+/-1.3
	D50(Gy)	5.8	+/-1.4
	D10(Gy)	7.4	+/-1.8
	Mean(Gy)	6.0	+/-1.4

Oral cavity	D80(Gy)	2.3	+/-0.6
	D50(Gy)	3.2	+/-0.6
	D10(Gy)	5.0	+/-1.2
	Mean(Gy)	3.2	+/-0.6
Parotids	D80(Gy)	4.0	+/-1.2
	D50(Gy)	4.9	+/-1.3
	D10(Gy)	8.0	+/-1.3
	Mean(Gy)	5.4	+/-1.1
Rectum	D80(Gy)	3.9	+/-0.8
	D50(Gy)	4.3	+/-1.0
	D10(Gy)	6.8	+/-1.9
	Mean(Gy)	4.9	+/-1.0
Thyroid	D80(Gy)	4.6	+/-1.7
	D50(Gy)	5.7	+/-1.8
	D10(Gy)	8.2	+/-1.9
	Mean(Gy)	6.0	+/-1.7

Female breasts	D80(Gy)	7.7	+/-1.2
	D50(Gy)	9.3	+/-1.1
	D10(Gy)	11.8	+/- 0.8
	Mean(Gy)	9.4	+/-1.0
Uterus and ovaries	D80(Gy)	4.8	+/-1.6
	D50(Gy)	5.9	+/-1.9
	D10(Gy)	9.3	+/-2.3
	Mean(Gy)	6.4	+/-1.7

Dosimetric Scorecard overview-points only:

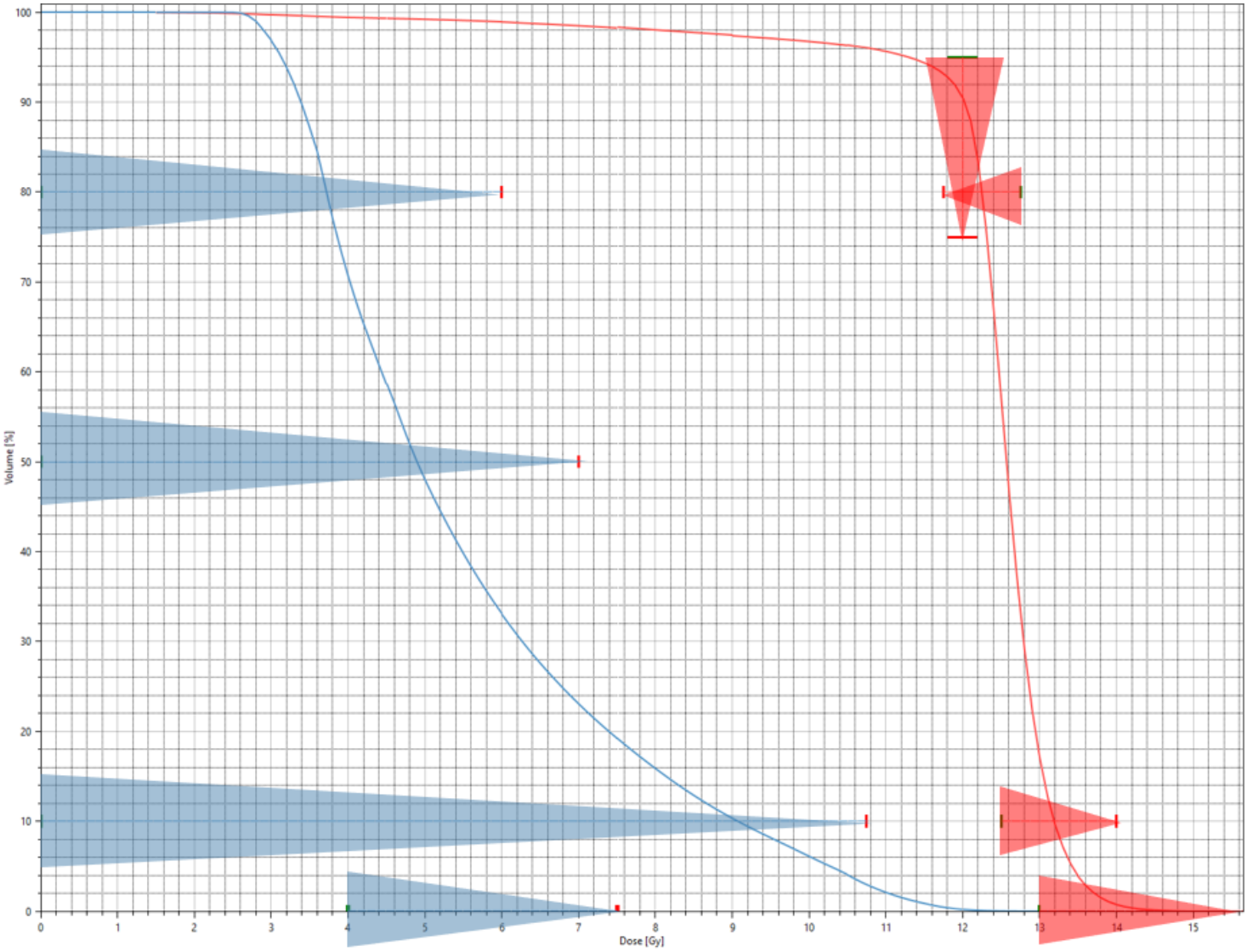
Summary of dosimetric scorecard, based on various clinical goal sets which guided this work.

Dosimetric Scorecard Metric Point Allocations				
Structure	Female		Male	
	Metrics	Points	Metrics	Points
PTVs	49	380	49	380
Brain	5	65	5	65
Liver	5	65	5	65
Rings	5	52.5	5	52.5
Uterus_Ovaries	5	61		
Breasts	5	61		
Bladder	5	65	5	65
Esophagus	5	63	5	63
Larynx	5	63	5	63
Eyes	4	60	4	60
Heart	5	67	5	67
Kidneys	5	65	5	65
Lenses	4	60	4	60
Lungs	7	74	7	74
OpticN_Chiasm	4	60	4	60
OralCavity	5	64	5	64
Parotids	5	64	5	64
Rectum	5	65	5	65
GI_Lower	5	65	5	65
GI_Upper	5	65	5	65
Thyroid	4	60	4	60
Total	147	1644.50	137	1522.50

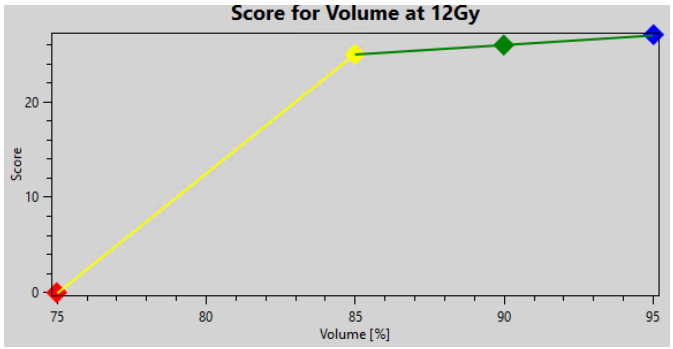
In general, how points are assigned between the various competing metrics on a dosimetric scorecard represents the physician's preference insofar as relative weighting, this weighting is a second order prioritization. Each function spans a DVH value range of two or more values (ranges not pictured, see next page), the starting, failing value (0 points) through the maximum, but often purposely unachievable, point value. The zero value represents a failure and is the first order priority. Optional intermediate point values can be added in between the failing point and the end of the aspirational range, covering the piecewise linear function shape and providing multiple levels of reasonably expected DVH values. Ideally, most maximum values are not achievable so as to continue to quantify additional improvement in already "very good" treatment plans. Care must be taken when attempting such a precise articulation of clinical intent. The full dosimetric scorecard provides a singular objective measure of dosimetric plan quality for a specific intent from which the RapidPlan optimization objective tuning can be manually iterated upon. This laborious model tuning process can prove worthwhile when such a RapidPlan model is deployed in a clinic and works as a single button press auto planning solution of high quality (as defined by its associated dosimetric scorecard).

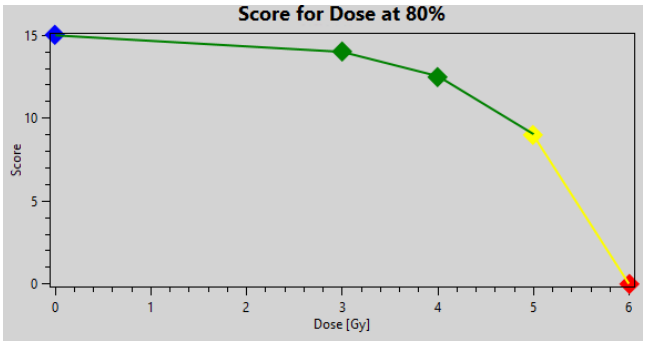
Example metrics for two structures (PTV VExP and Lungs) are shown below. For a full view of this dosimetric score card, see Annex B to download the scorecard json online.

Dosimetric Scorecard selected piecewise linear metrics plotted on DVH:



Volume at Dose (vertical) and Dose at Volume (horizontal) lines with expansions to represent increasing score


Score for Volume at 12Gy
Score
Volume [%]
0
10
20
75
80
85
90
95


Score for Dose at 80%
Score
Dose [Gy]
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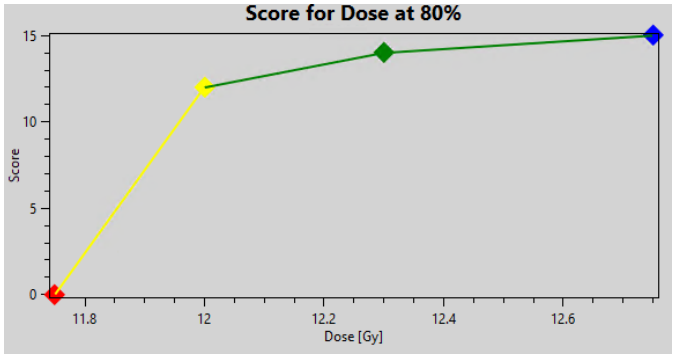
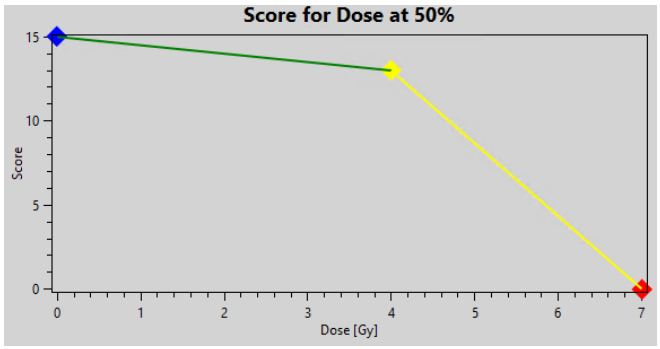
5
10
15
0
1
2
3
4
5
6


Score for Dose at 80%
Score
Dose [Gy]
0
5
10
15
11.8
12
12.2
12.4
12.6


Score for Dose at 50%
Score
Dose [Gy]
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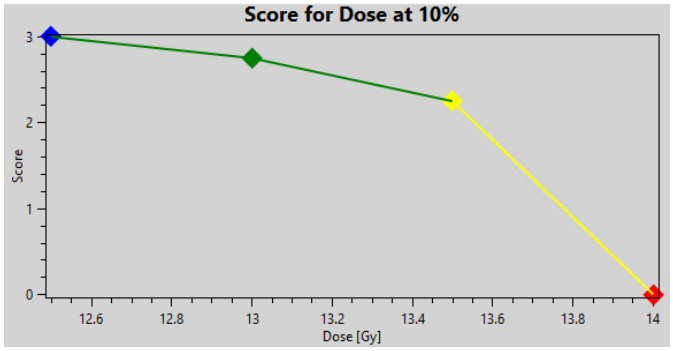
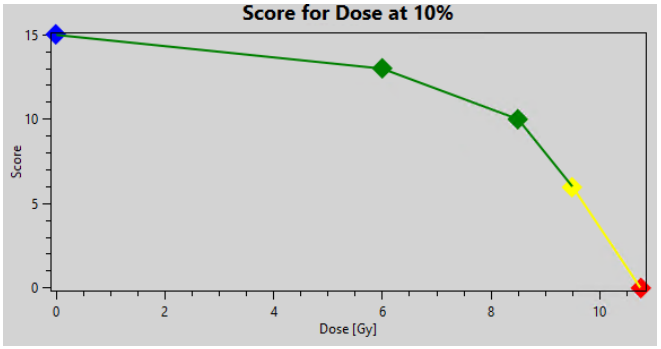
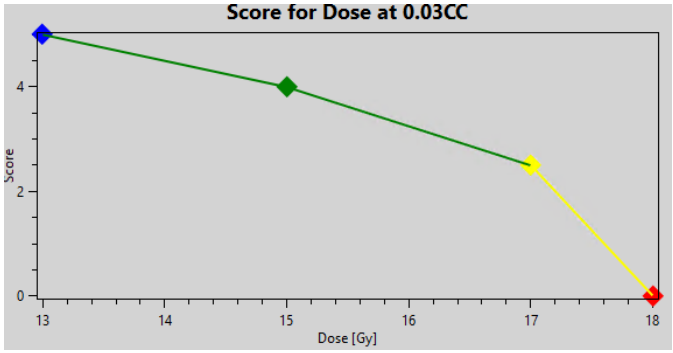
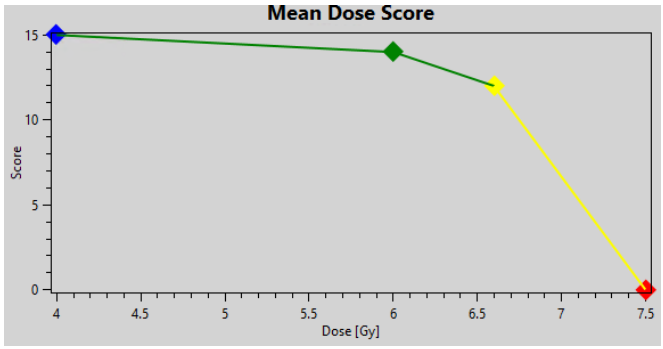
5
10
15
0
1
2
3
4
5
6
7


Score for Dose at 10%
Score
Dose [Gy]
0
1
2
3
12.6
12.8
13
13.2
13.4
13.6
13.8
14


Score for Dose at 10%
Score
Dose [Gy]
0
5
10
15
0
2
4
6
8
10


Score for Dose at 0.03CC
Score
Dose [Gy]
0
2
4
13
14
15
16
17
18


Mean Dose Score
Score
Dose [Gy]
0
5
10
15
4
4.5
5
5.5
6
6.5
7
7.5

Target Doses | Structure matching:

Plan Structure ID (Codes)	Type	Model Structure ID (Codes)	Target Dose
PTV_LN ()	PTV	PTV_LN (PTV_High)	12.00 Gy
PTV_Lower (PTV_High)	PTV	PTV_VExPopti+Low (PTV_H	12.00 Gy
PTV_Ribs ()	PTV	PTV_Ribs (PTV_High)	12.00 Gy
PTV_Skull ()	PTV	PTV_Skull (PTV_High)	12.00 Gy
PTV_SpCord ()	ORGAN	PTV_SpCord (PTV_High)	12.00 Gy
PTV_Spleen ()	ORGAN	PTV_Spleen (PTV_High)	12.00 Gy
PTV_VExParms (PTV_High)	PTV	PTV_VExParms (PTV_High	12.00 Gy
PTV_VExPopti (PTV_High)	PTV	PTV_VExPopti+Low (PTV_H	12.00 Gy
Bladder ()	ORGAN	Bladder (15900)	
Brain ()	ORGAN	Brain (50801)	
Cavity_Oral ()	ORGAN	OralCavity (20292)	
Esophagus ()	ORGAN	Esophagus (7131)	
Eyes (264089)	ORGAN	Eyes (264089)	
GI_Lower ()	ORGAN	GI_Lower (7199)	
GI_Upper ()	ORGAN	GI_Upper (7148)	
Heart ()	ORGAN	Heart (7088)	
Kidneys ()	ORGAN	Kidneys (264815)	
Larynx ()	ORGAN	Larynx (55097)	
Lenses (Control)	CONTROL	Lenses (58242, 58243)	
Liver ()	ORGAN	Liver (7197)	
Lungs (68877)	ORGAN	Lungs (68877)	
OptN_Chiasm (62045)	ORGAN	OpticN_Chiasm (62045)	
Parotids (Parotids)	ORGAN	Parotids (Parotids)	
Rectum ()	ORGAN	Rectum (14544)	
RingBody (Ring)	CONTROL	RingBody (Ring)	
RingOuter (Ring)	CONTROL	RingOuter (Ring)	
RingTotalPTV (Ring)	CONTROL	RingTotalPTV (Ring)	
Thyroid ()	ORGAN	Thyroid (9603)	

Note: If PTV_VExPopti and PTV_Lower are separate structures, match both to PTV_VExPopti+Low.

Optimization objectives:

The following optimization objectives were defined in the model and will be generated when the model is applied to a new case:

PTV_VExPopti+Low	(PTV_High)			
Upper	0.0	13.000	Gy	125
Lower	95.0	12.300	Gy	550
Lower	80.0	12.000	Gy	0

PTV_LN	(PTV_High)			
Upper	0.0	13.000	Gy	125
Lower	95.0	12.300	Gy	500
Lower	70.0	12.000	Gy	0
PTV_Ribs	(PTV_High)			
Upper	0.0	13.000	Gy	125
Lower	95.0	12.300	Gy	450
Lower	45.0	12.000	Gy	0
PTV_Skull	(PTV_High)			
Upper	0.0	13.000	Gy	200
Lower	95.0	12.300	Gy	400
Lower	70.0	12.000	Gy	0

Bladder	(15900)			
Upper (fixed vol., generated dose)	80.0	Generated		125
Upper (fixed vol., generated dose)	50.0	Generated		125
Upper (fixed vol., generated dose)	10.0	Generated		125
Mean		4.000	Gy	175
Line (preferring target)	Generated	Generated		175
Brain	(50801)			
Upper (fixed vol., generated dose)	80.0	Generated		125
Upper (fixed vol., generated dose)	50.0	Generated		125
Upper (fixed vol., generated dose)	10.0	Generated		125
Mean		3.000	Gy	175
Line (preferring target)	Generated	Generated		175

PTV_SpCord	(PTV_High)			
Upper	0.0	13.000	Gy	125
Lower	95.0	12.300	Gy	275
Lower	80.0	12.000	Gy	0
PTV_Spleen	(PTV_High)			
Upper	0.0	13.000	Gy	125
Lower	95.0	12.300	Gy	300
Lower	70.0	12.000	Gy	0
PTV_VExParms	(PTV_High)			
Upper	0.0	13.000	Gy	125
Lower	95.0	12.300	Gy	550
Lower	80.0	12.000	Gy	0

GI_Lower	(7199)			
Upper (fixed vol., generated dose)	80.0	Generated		175
Upper (fixed vol., generated dose)	50.0	Generated		175
Upper (fixed vol., generated dose)	10.0	Generated		175
Mean		6.000	Gy	225
Line (preferring target)	Generated	Generated		225
GI_Upper	(7148)			
Upper (fixed vol., generated dose)	80.0	Generated		150
Upper (fixed vol., generated dose)	50.0	Generated		150
Upper (fixed vol., generated dose)	10.0	Generated		150
Mean		4.000	Gy	200
Line (preferring target)	Generated	Generated		200

Esophagus	(7131)			
Upper (fixed vol., generated dose)	80.0	Generated	125	
Upper (fixed vol., generated dose)	50.0	Generated	125	
Upper (fixed vol., generated dose)	10.0	Generated	125	
Mean	4.000 Gy		175	
Line (preferring target)	Generated	Generated	175	

Eyes	(264089)			
Upper (fixed vol., generated dose)	80.0	Generated	125	
Upper (fixed vol., generated dose)	50.0	Generated	125	
Upper (fixed vol., generated dose)	10.0	Generated	125	
Mean	1.000 Gy		175	
Line (preferring target)	Generated	Generated	125	

Liver	(7197)			
Upper (fixed vol., generated dose)	80.0	Generated	125	
Upper (fixed vol., generated dose)	50.0	Generated	125	
Upper (fixed vol., generated dose)	10.0	Generated	125	
Mean	5.000 Gy		175	
Line (preferring target)	Generated	Generated	175	

Lungs	(68877)			
Upper (fixed vol., generated dose)	80.0	Generated	200	
Upper (fixed vol., generated dose)	50.0	Generated	200	
Upper (fixed vol., generated dose)	10.0	Generated	200	
Mean	6.000 Gy		275	
Line (preferring target)	Generated	Generated	275	

Heart	(7088)			
Upper (fixed vol., generated dose)	80.0	Generated	150	
Upper (fixed vol., generated dose)	50.0	Generated	150	
Upper (fixed vol., generated dose)	10.0	Generated	150	
Mean	4.000 Gy		200	
Line (preferring target)	Generated	Generated	200	

Kidneys	(264815)			
Upper (fixed vol., generated dose)	80.0	Generated	125	
Upper (fixed vol., generated dose)	50.0	Generated	125	
Upper (fixed vol., generated dose)	10.0	Generated	125	
Mean	5.000 Gy		200	
Line (preferring target)	Generated	Generated	200	

OpticN_Chiasm	(62045)			
Upper (fixed vol., generated dose)	80.0	Generated	100	
Upper (fixed vol., generated dose)	50.0	Generated	100	
Upper (fixed vol., generated dose)	10.0	Generated	100	
Mean	1.000 Gy		100	
Line (preferring target)	Generated	Generated	100	

OralCavity	(20292)			
Upper (fixed vol., generated dose)	80.0	Generated	150	
Upper (fixed vol., generated dose)	50.0	Generated	150	
Upper (fixed vol., generated dose)	10.0	Generated	150	
Mean	1.500 Gy		150	
Line (preferring target)	Generated	Generated	150	

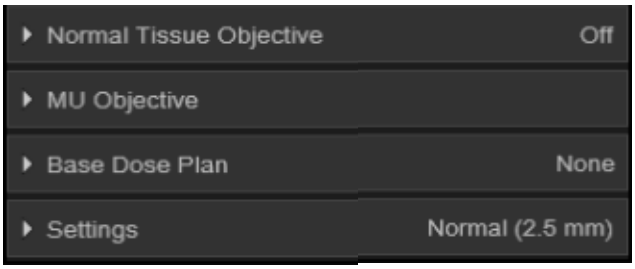
Larynx	(55097)			
Upper (fixed vol., generated dose)	80.0	Generated	100	
Upper (fixed vol., generated dose)	50.0	Generated	100	
Upper (fixed vol., generated dose)	10.0	Generated	100	
Mean	1.500 Gy		150	
Line (preferring target)	Generated	Generated	150	

Lenses	(58242, 58243)			
Upper (fixed vol., generated dose)	80.0	Generated	175	
Upper (fixed vol., generated dose)	50.0	Generated	175	
Upper (fixed vol., generated dose)	10.0	Generated	175	
Mean	1.000 Gy		175	
Line (preferring target)	Generated	Generated	175	

Parotids	(Parotids)			
Upper (fixed vol., generated dose)	80.0	Generated	125	
Upper (fixed vol., generated dose)	50.0	Generated	125	
Upper (fixed vol., generated dose)	10.0	Generated	125	
Mean	2.000 Gy		125	
Line (preferring target)	Generated	Generated	125	

Rectum	(14544)			
Upper (fixed vol., generated dose)	80.0	Generated	125	
Upper (fixed vol., generated dose)	50.0	Generated	125	
Upper (fixed vol., generated dose)	10.0	Generated	125	
Mean	4.000 Gy		175	
Line (preferring target)	Generated	Generated	175	

RingBody	(Ring)				
Upper		0.0	12.000	Gy	250
RingOuter	(Ring)				
Upper		0.0	9.000	Gy	275
RingTotalPTV	(Ring)				
Upper		0.0	12.000	Gy	250
Thyroid	(9603)				
Upper (fixed vol., generated dose)		80.0	Generated		100
Upper (fixed vol., generated dose)		50.0	Generated		100
Upper (fixed vol., generated dose)		10.0	Generated		100
Mean			2.500	Gy	150
Line (preferring target)		Generated	Generated		150



Model training and validation:

This 12Gy TMLI model was trained with a 25-case dataset from City of Hope. A cohort of 25 previously treated cases (10 female and 15 male) were all planned to 12Gy with an Eclipse V18 treatment planning system using 6MV FFF VMAT on a Halcyon.

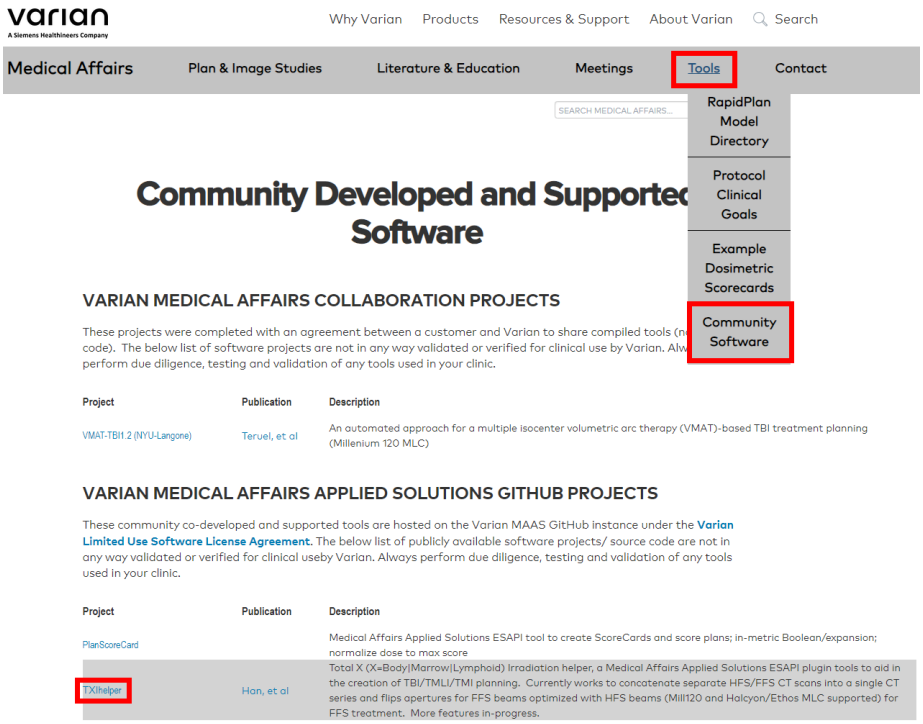
Target coverage and normal organ sparing goals were defined according to institutional historical dosimetric studies as well as published practice guidelines. Using these clinical goals as guidelines, a dosimetric scorecard quantifying target coverage, OAR sparing and conformality was developed to evaluate plan quality during the manual replanning step.

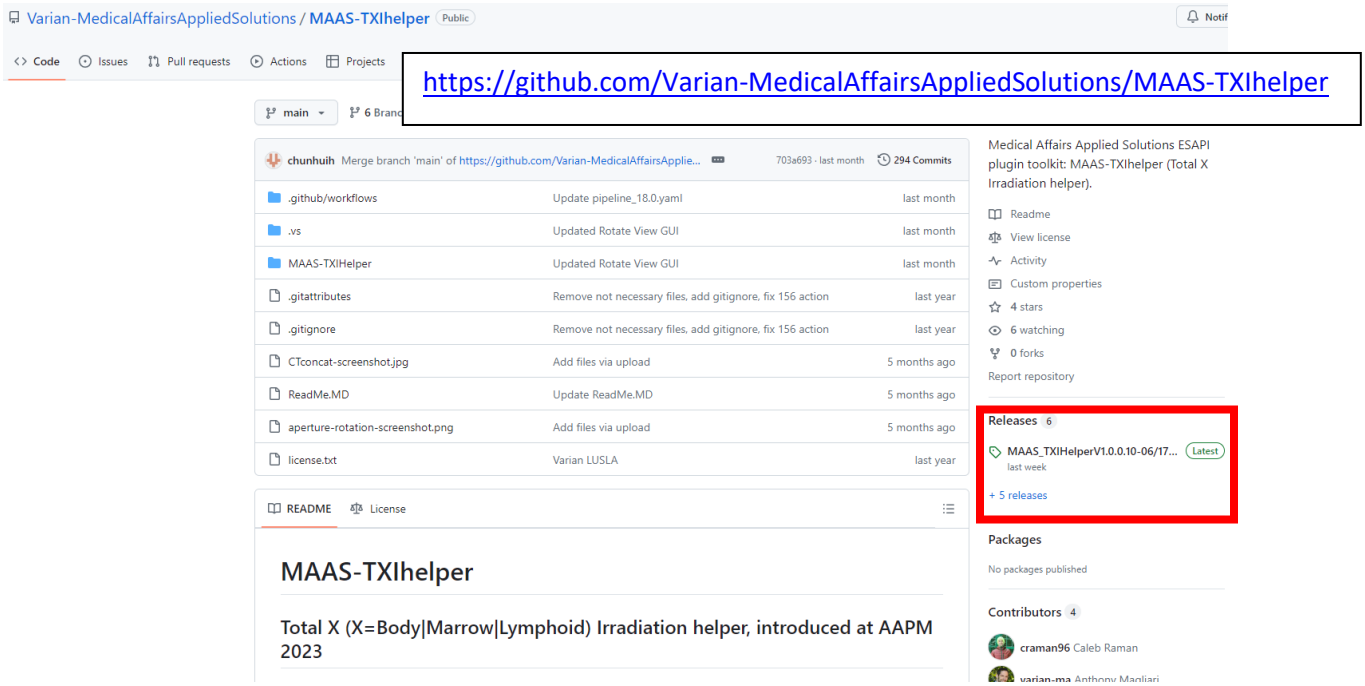
5 additional cases were used for the validation of TMLI 12Gy model. This 12Gy TMLI RapidPlan model validation demonstrates expected performance with both v15 and v17 algorithms, and both AAA and AXB dose calculations. An additional case was used for the validation of TMLI 12Gy model using TrueBeam. (See Annex C).

Annex Directory

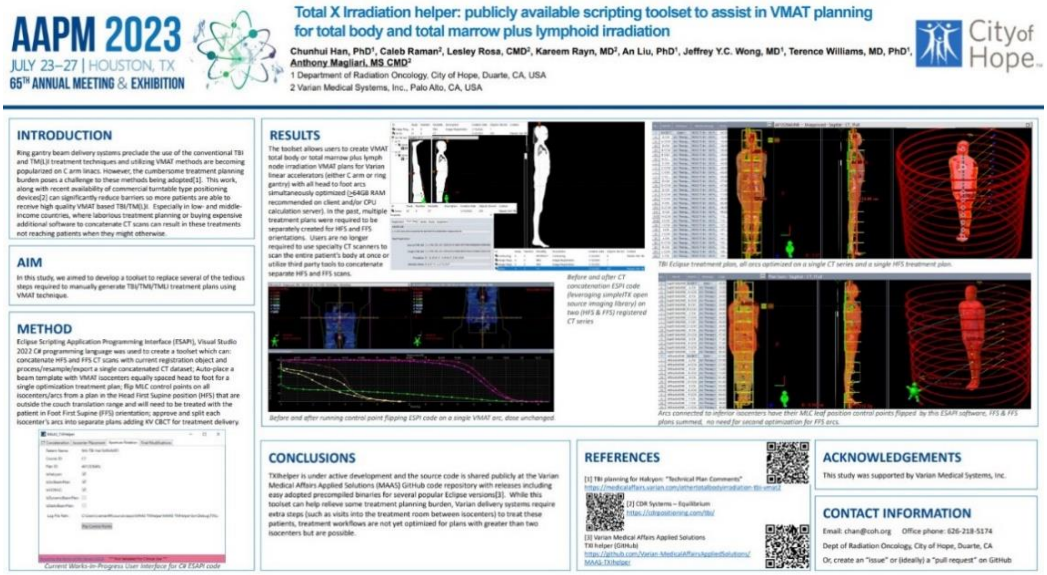
Annex A: TXIhelper

https://medicalaffairs.varian.com/





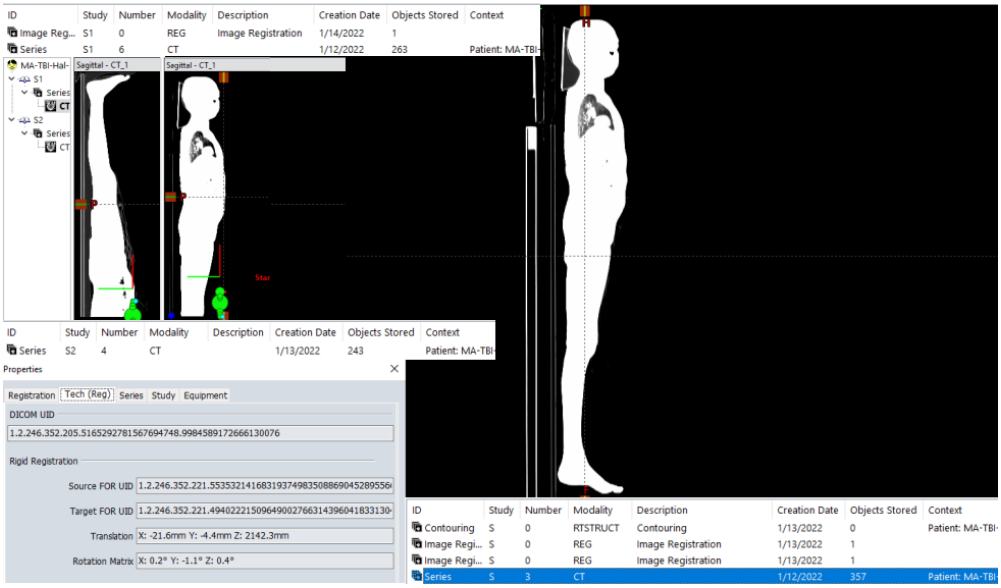
Please download the TXI 2023 AAPM poster PDF to view it: [Download PDF]



MAAS-TXIhelper walkthough:

Due to the limitations of the treatment machine and CT scanner patients are often scanned head first supine (HFS) for upper body and scanned feet first supine (FFS) for the lower body.

This tool concatenates the HFS and FFS CT scans for ease of treatment planning and delivery.

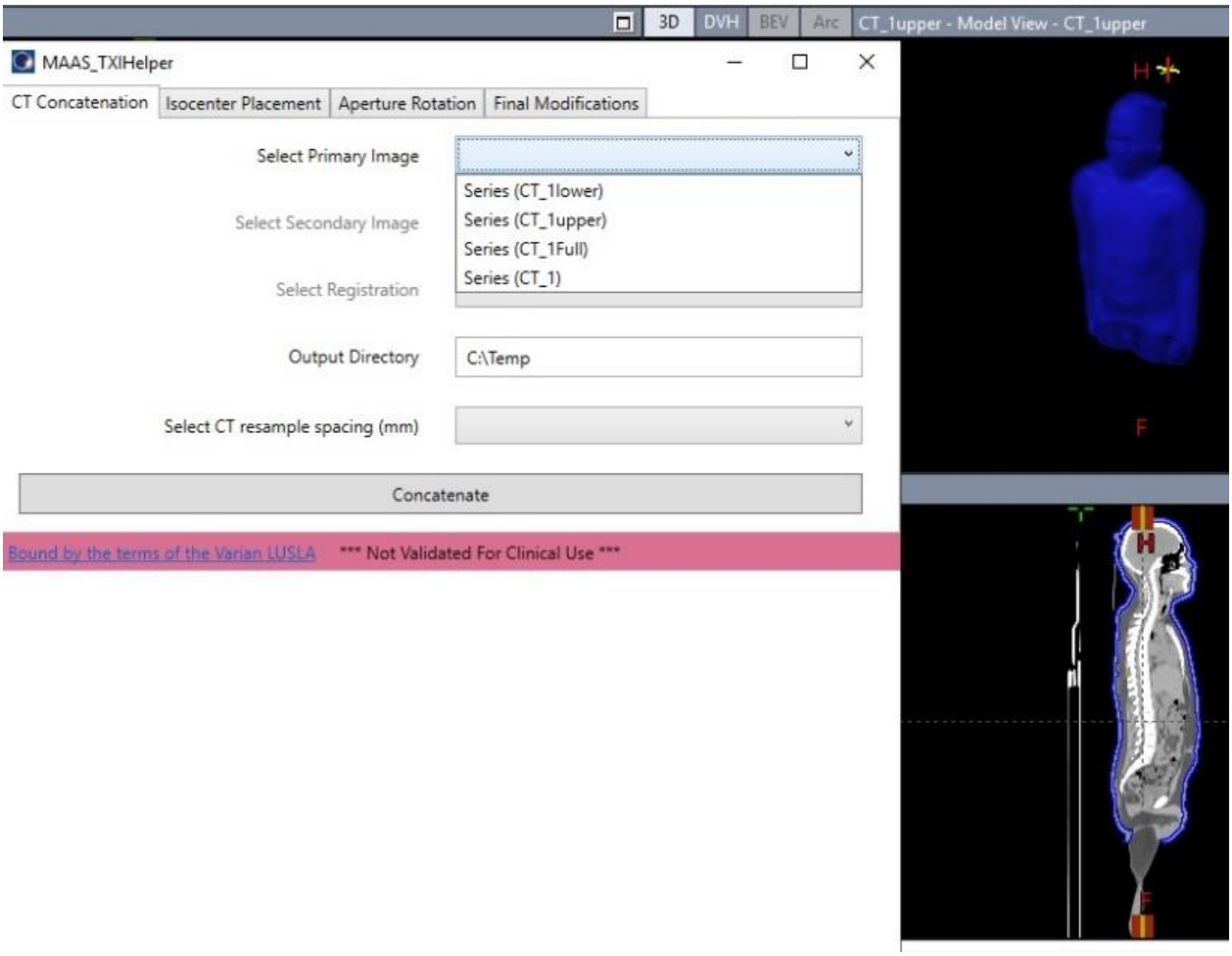


Before and after CT concatenation on two (HFS & FFS) registered CT series.

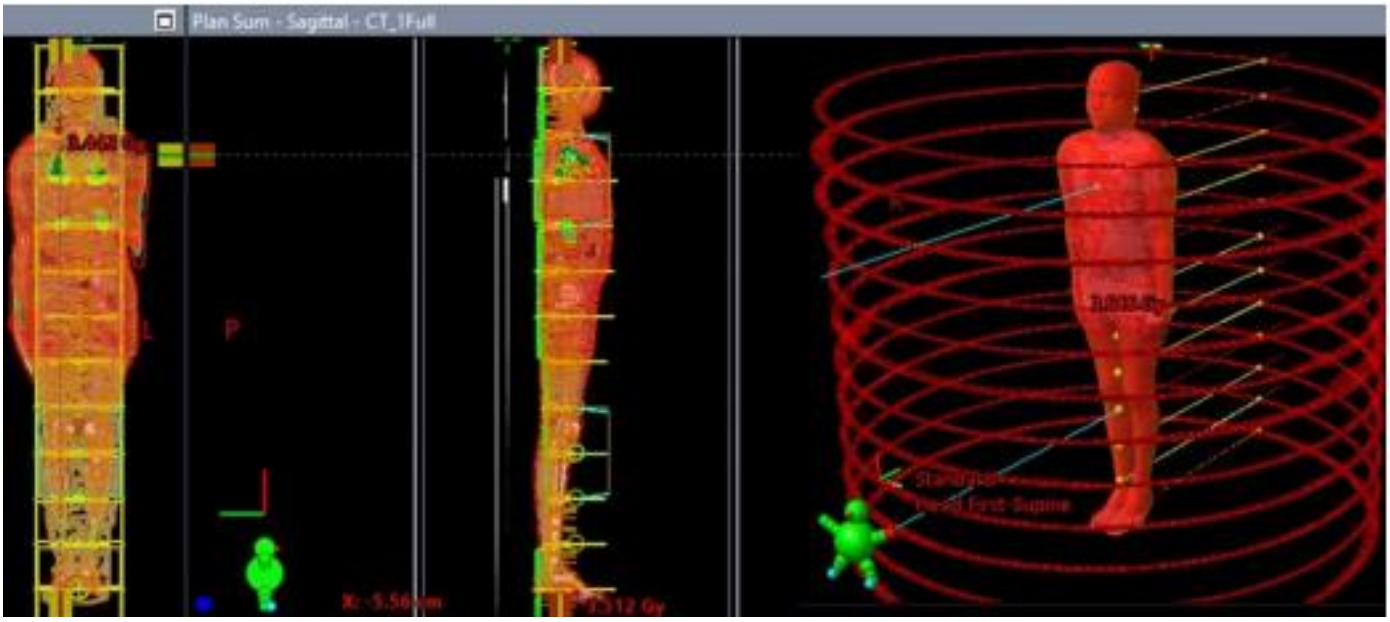
Requires Head First Supine superior series with rigid registration to inferior Feet First Supine Series in External Beam Planning.

- no plan needed
- default CT slice thickness taken from existing scans but can be resampled
- progress bar is accurate, could take as many as 30 minutes (or more) to complete concatenation

Import fully merged CT series from output directory (i.e C:\Temp) when completed.



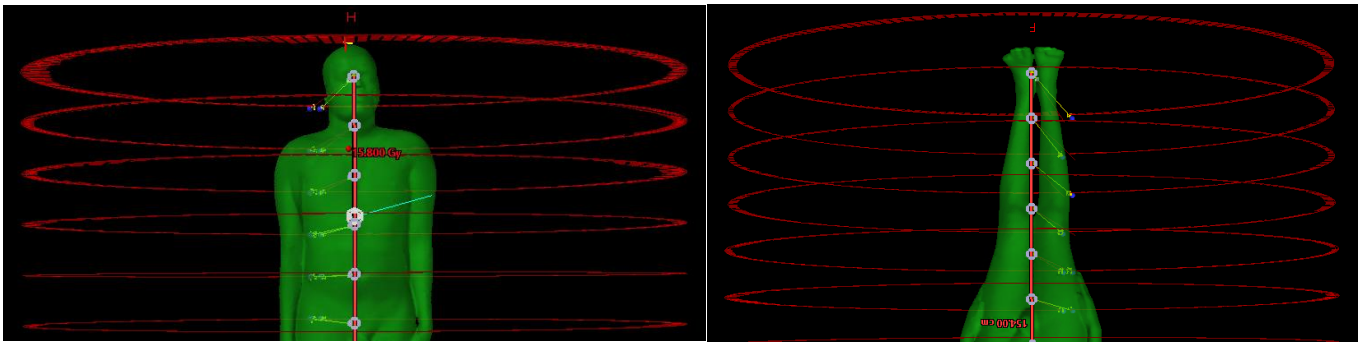
All arcs are optimized on a single CT series and a single HFS treatment plan.



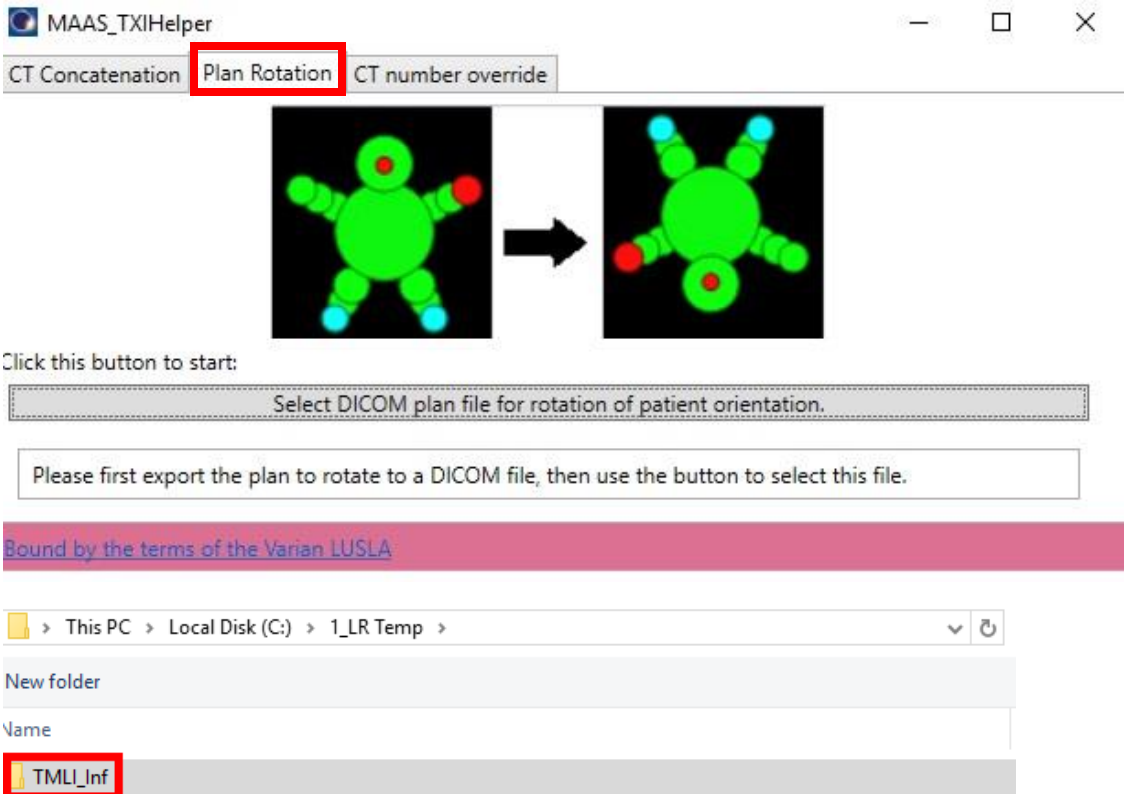
After plan optimization and dose calculation, treatment delivery requires the lower body of the patient in Foot First Supine (FFS). TXIhelper can flip the MLC control points on all isocenters/arcs on a DICOM treatment plan. (supports either: C series / TrueBeam / Halcyon / Ethos).

Couch translation range is limited.

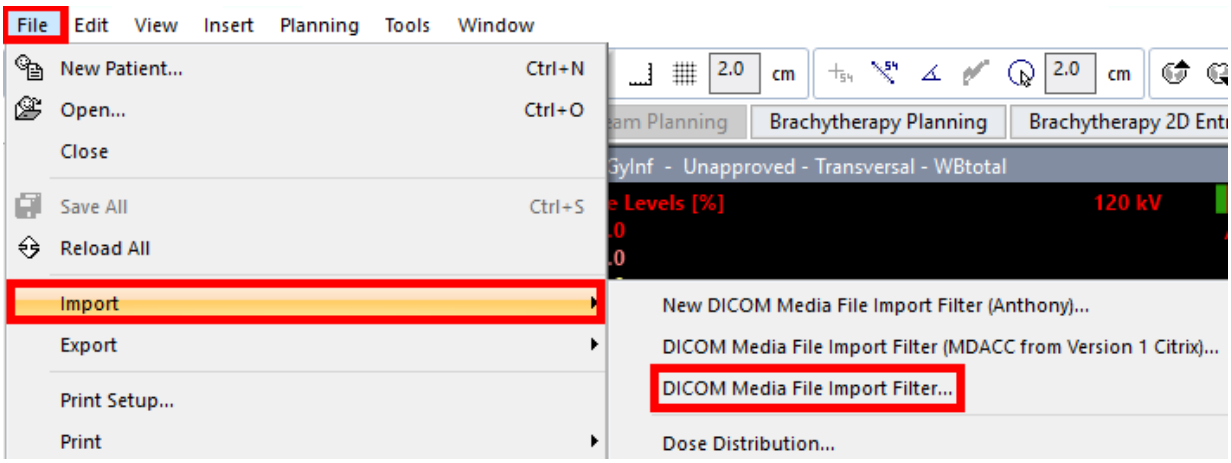
Copy and paste twice the complete plan created in HFS orientation with desired dose distribution head to foot. In one plan delete all beams/isocenters that will be treated HFS and the other plan FFS (image left). DICOM export the plan that has only the inferior isocenters that is currently in the HFS orientation (image right).



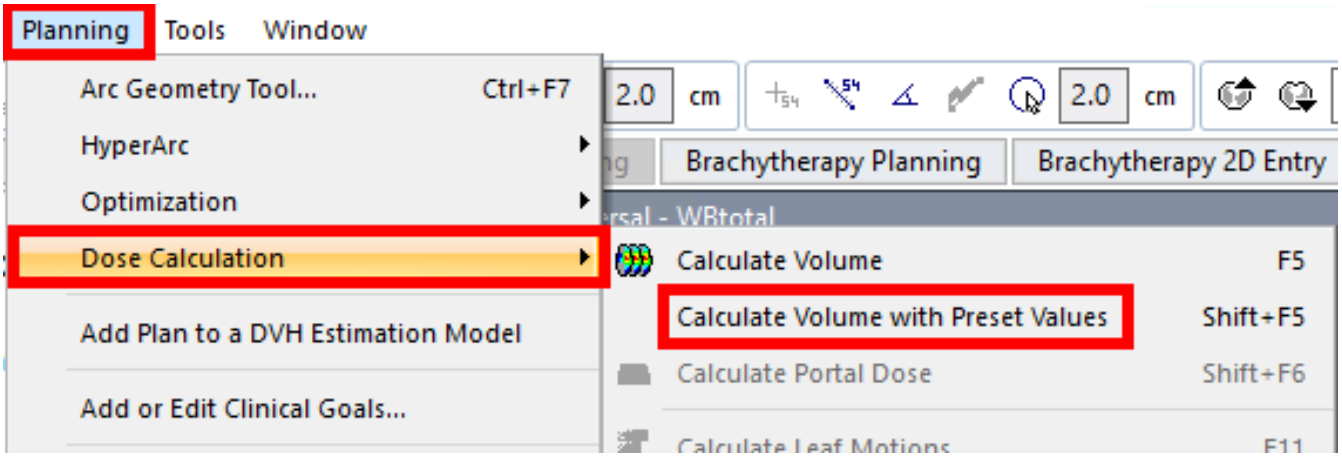
Launch the TXIhelper tool, click the Plan Rotation tab, and selected the exported DICOM plan file for aperture rotation.



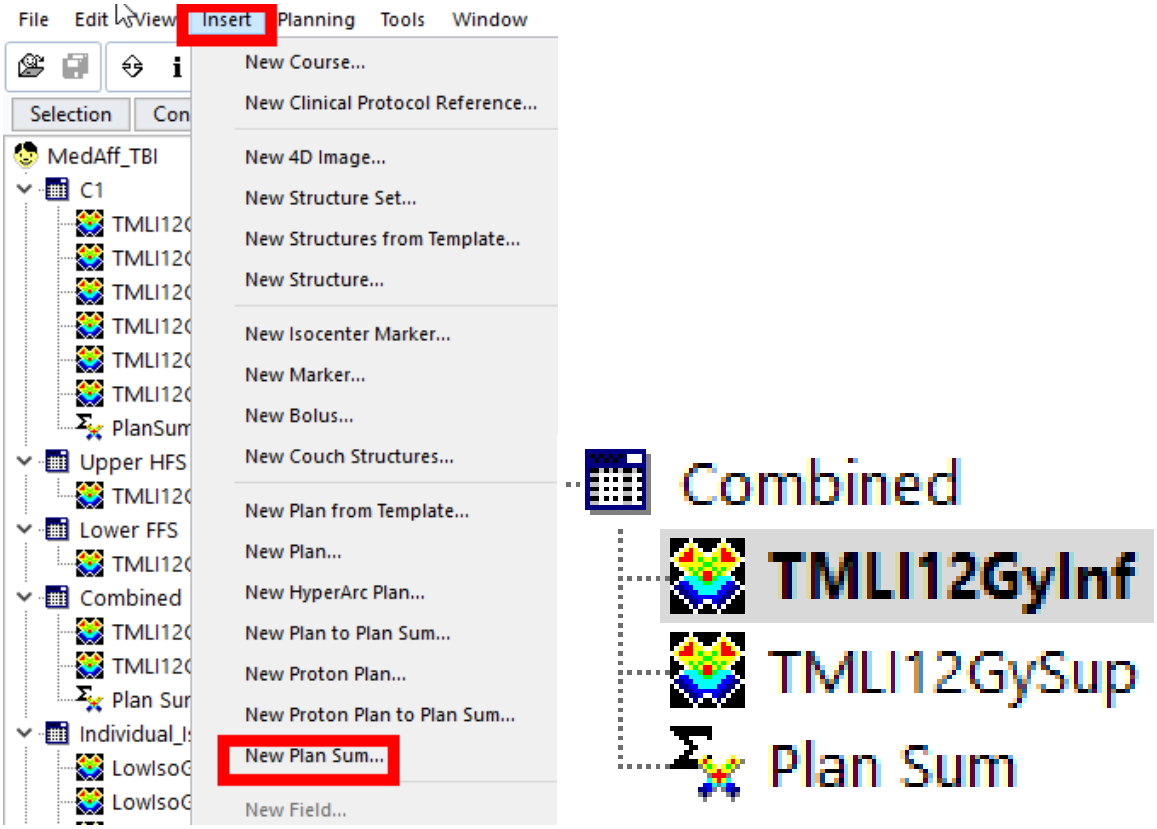
After aperture rotation script completes, import new DICOM-RT plan generated from TXIhelper.



Calculate dose with fixed Mus.

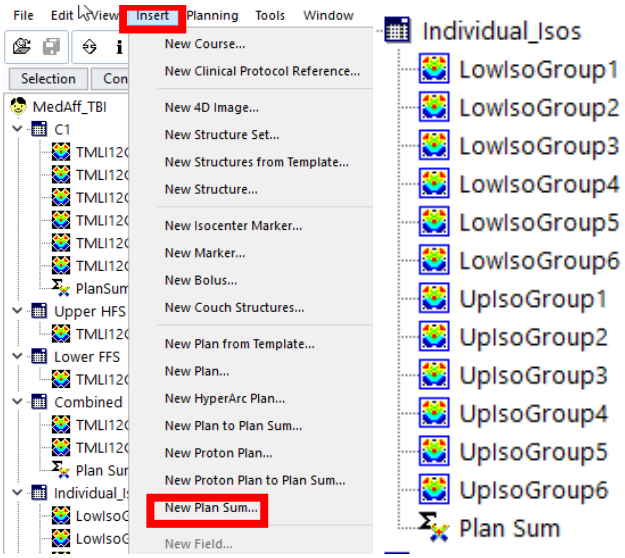


Create a plan sum with superior plan. The plans sum dose should be identical to initial completed plan.



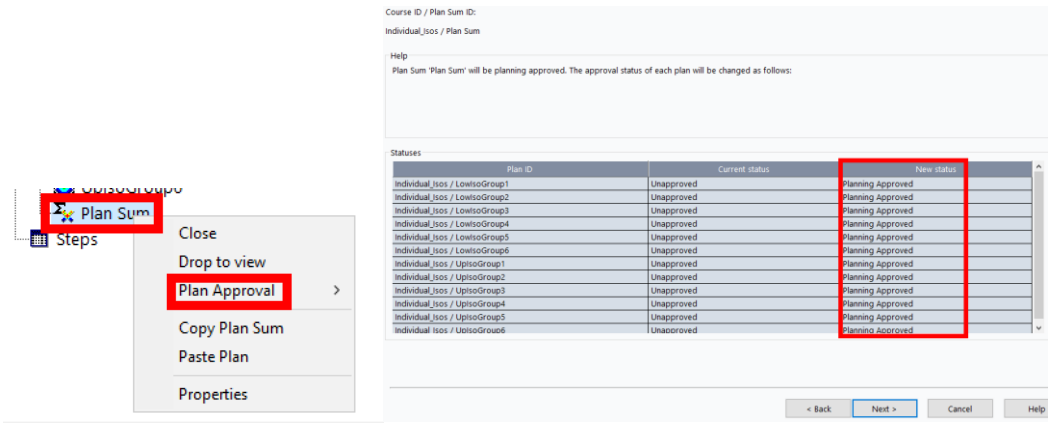
Due to current Halcyon treatment delivery workflow each isocenter is treated separately and requires the user to enter the room to unload and reload the patient between each isocenter. Each isocenter's arcs will need to be moved to be a separate plan with a KV CBCT imaging setup. To complete this step:

- Both plans from the previous 2-plan plan sum will need to be copied and pasted once for each isocenter they contain
- Delete all isocenter beams until only one isocenter exists in each plan
- Add KV CBCT imaging setup to each individual plan
- Insert a plan sum, add all the single isocenter plans



Again. compare this plan sum with the originally optimized single treatment plan.

If it is still identical, treatment approve the plan sum and add needed setup notes.



**Future versions of TXI helper to automate the steps on this page in upcoming "Treatment Preparation" tab*

Annex B: Halcyon/Ethos Validation Results

	Patient	Gender	Sep (cm)	# Lat Iso	Manual Replan	Initial KBP Model	KBP Model Rev2d	KBP Model v17 AXB	KBP Model v15	Clinical Plan
KBP Model Training Set	COH12Gy01	F	57	2	1303.30/1589.50 (81.99%)	1305.08/1589.50 (82.11%)	1308.80/1589.50 (82.34%)			1190.29/1589.50 (74.88%)
	COH12Gy02	M	60	2	1213.95/1467.50 (82.72%)	1188.90/1467.50 (81.02%)	1193.87/1467.50 (81.35%)			1134.53/1467.50 (77.31%)
	COH12Gy03	F	48	1	1270.62/1589.50 (79.94%)	1262.99/1589.50 (79.46%)	1275.73/1589.50 (80.26%)			1150.15/1589.50 (72.36%)
	COH12Gy04	M	47	1	1177.15/1467.50 (80.21%)	1170.53/1467.50 (79.76 %)	1178.35/1467.50 (80.30%)			1047.67/1467.50 (71.39%)
	COH12Gy05	F	58	2	1295.51/1589.50 (81.50%)	1290.50/1589.50 (81.19%)	1312.91/1589.50 (82.60%)			1025.35/1589.50 (64.51%)
	Avg Score				1252.11 (81.27%)	1243.60 (80.71%)	1253.93 (81.37%)			1109.60 (72.09%)
	COH16Gy01	M	55	2	1252.36/1467.50 (85.34%)					
	COH16Gy02	M	47	1	1126.52/1467.50 (76.76%)					
	COH16Gy03	F	48	1	1042.34/1467.50 (71.87%)					
	COH16Gy04	M	48	1	1075.50/1467.50 (73.29%)					
	COH16Gy05	M	55	2	1152.84/1467.50 (78.56%)					
	COH20Gy01	M	55	2	1226.28/1467.50 (83.56%)					
	COH20Gy02	F	38	1	1356.39/1589.50 (85.33%)					
	COH20Gy03	M	53	1	1087.62/1467.50 (74.11%)					
	COH20Gy04	M	58	2	1238.16/1467.50 (84.37%)					
	COH20Gy05	M	49	1	1185.74/1467.50 (80.80%)					
	TMLI, WB	M	52	1	1073.70/1467.50 (73.17%)					
	COH20Gy06	M	54	1	1085.10/1467.50 (73.94%)					
	COH20Gy07	F	47	1	1239.40/1589.50 (77.97%)					
	COH20Gy08	M	55	2	1264.92/1467.50 (86.20%)					
	COH20Gy09	F	48	1	1266.68/1589.50 (79.69%)					
	COH20Gy010	M	47	1	1179.59/1467.50 (80.38%)					
	COH20Gy012	M	56	2	1266.00/1467.50 (86.27%)					
	COH20Gy013	F	42	1	1242.32/1589.50 (78.16%)					
	COH20Gy014	F	59	2	1315.27/1589.50 (82.75%)					
	COH20Gy015	F	47	1	1272.96/1589.50 (80.09%)					
Validation Set	COH20Gy016	M	56	2		1224.48/1467.50 (83.44%)	1222.51/1467.50 (83.31%)	1222.99/1467.50 (83.34%)	1219.81/1467.50 (83.12%_)	
	COH20Gy017	F	50	1		1217.41/1589.50 (76.59%)	1219.34/1589.50 (76.71%)	1234.26/1589.50 (77.65%)	1210.05/1589.50 (76.13%)	
	COH20Gy018	F	44	1		1263.58/1589.50 (79.50%)	1273.08/1589.50 (80.09%)	1269.11/1589.50 (79.84%)	1271.44/1589.50 (79.99%)	
	COH20Gy019	M	55	2		1268.82/1467.50 (86.46%)	1269.71/1467.50 (86.52%)	1273.87/1467.50 (86.81%)	1266.37/1467.50 (86.29%)	
	COH20Gy020	M	50	1		1166.47/1467.50 (79.49%)	1169.02/1467.50 (79.66%)	1159.66/1467.50 (79.02%)	1167.13/1467.50 (79.53%)	
	Avg Score					1228.15 (81.10%)	1230.73 (81.26%)	1231.97 (81.33%)	1226.96 (81.01%)	

This 12Gy TMLI model was trained with a 25-case dataset from City of Hope. A cohort of 25 previously treated cases (10 female and 15 male) were all planned to 12Gy with an Eclipse V18 treatment planning system using 6MV FFF VMAT on a Halcyon. 5 additional cases , not included in the training set, were used for the validation of TMLI 12Gy model.

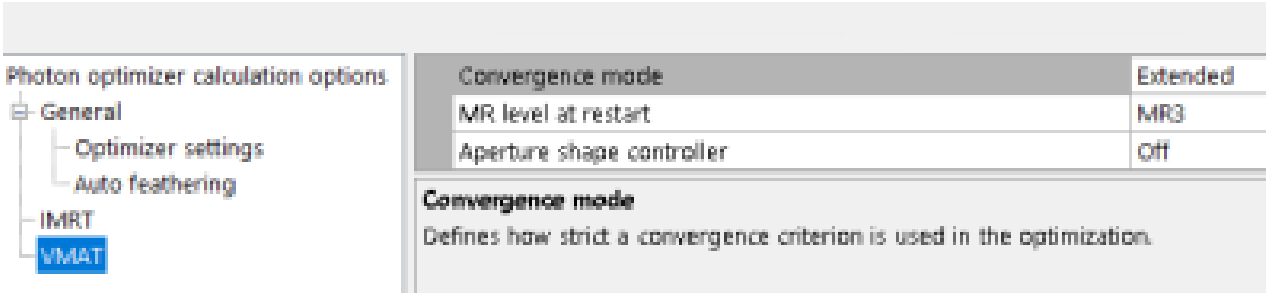
Target coverage and normal organ sparing goals were defined according to institutional historical dosimetric studies as well as published practice guidelines. Using these clinical goals as guidelines, a dosimetric scorecard quantifying target coverage, OAR sparing and conformality was developed to evaluate plan quality during the manual replanning step.

Each plan in the training set was iteratively manually optimized to achieve the highest possible plan score **(Manual Replan)**. Objectives and priorities used from these training set cases optimized to max score were used to create an initial model and that model's performance was tested **(Initial KBP Model)**. Objectives were once again retuned to further increase the average score of the tested cases, resulting in the final model **(KBP Model Rev2d).** Prior validation had dose calculated with AAA. Using the final model, validation cases were reoptimized and calculated with AXB **(KBP Model v17 AXB).** Finally, the released version of the model was rebuilt in Eclipse V15 and a validation was done with the RapidPlan model generated from a v15 system with AAA used for dose calculation **(KBP Model v15)**. These variations had minimal impact to the model's overall dosimetric score performance. Previously treated clinical scored plans are listed for reference **(Clinical Plan)**.

This 12Gy TMLI RapidPlan model validation demonstrates expected performance with both v15 and v17 algorithms, and both AAA and AXB dose calculations.

Annex B1: Convergence Mode Validation Results

For best results, it is recommended to calculate 3D dose with a resolution size of 0.25cm. The "Automatic Intermediate Dose" function of the Photon Optimizer was utilized with MR3 return and convergence mode: Extended. These settings should be changed prior to starting the optimization or plan quality will be compromised dramatically, as showed in an example case below.



Extended selected in the calculation options provides best results.

Convergence Mode Halcyon with MR3 Intermediate dose					
Off		**On**		**Extended**	
Score	**MU**	**Score**	**MU**	**Score**	**MU**
798.12*	4546	985.85*	5096	1269.56	7448

*All plans have failing metrics when Extended Convergence Mode is **NOT** used

Annex C: TrueBeam VMAT arc arrangement comparisons on example case

Annex C1: Isocenter spacing example

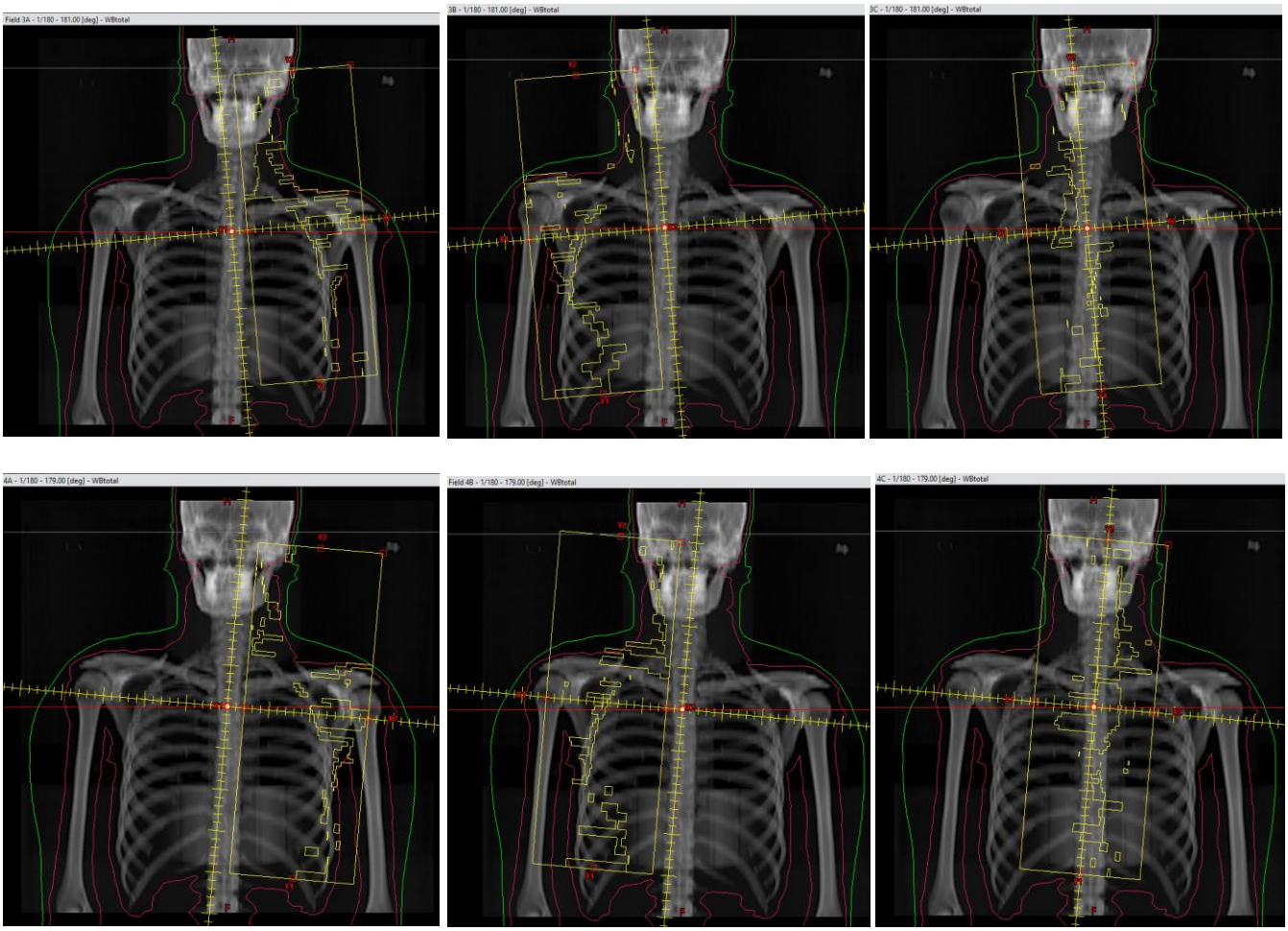
For True Beam (Millenium120MLC), keeping the X jaw total for each arc at or below the leaf span of 15cm, a 'flip flop technique' was manually set to define a portion of the target in one arc and the other portion of the arc in another (with an overlap of 2cm). Opposed collimator rotation between the two (350/10) were used. All arcs are optimized simultaneously. Some portions of the target will be treated in its own arc, while the other portions will also be treated with dose from arcs in adjacent isocenters. As with TMLI cases, very wide targets can require an additional central arc if the two 'flip flop' fields do not cover the target adequately. A third arc field matching the other two arc rotations can be created, in this example, adding the third central arc provided best results.

Field ID	Technique	Machine/Energy	Gantry Rtn [deg]	Coll Rtn [deg]	Couch Rtn [deg]	Wedge	Field X [cm]	X1 [cm]	X2 [cm]	Field Y [cm]	Y1 [cm]	Y2 [cm]	X [cm]	Y [cm]	Z [cm]	Calculated SSD [cm]	MU
Field 1	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	15.0	-2.0	+13.0	23.0	-10.5	+12.5	0.00	-20.00	-14.00	90.4	336
Field 2	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	15.0	-2.0	+13.0	23.0	-10.5	+12.5	0.00	-20.00	-14.00	90.4	322
Field 1A	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	15.0	-13.0	+2.0	23.0	-10.5	+12.5	0.00	-20.00	-14.00	90.4	334
Field 2A	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	15.0	-13.0	+2.0	23.0	-10.5	+12.5	0.00	-20.00	-14.00	90.4	342
Field 3	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	15.0	+2.0	+17.0	40.0	-20.0	+20.0	0.00	-20.00	-35.00	90.5	411
Field 4	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	15.0	+2.0	+17.0	40.0	-20.0	+20.0	0.00	-20.00	-35.00	90.5	432
Field 3A	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	15.0	-17.0	-2.0	40.0	-20.0	+20.0	0.00	-20.00	-35.00	90.5	429
Field 4A	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	15.0	-17.0	-2.0	40.0	-20.0	+20.0	0.00	-20.00	-35.00	90.5	634
Field 3B	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	15.0	-7.5	+7.5	40.0	-20.0	+20.0	0.00	-20.00	-35.00	90.5	274
Field 4B	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	15.0	-7.5	+7.5	40.0	-20.0	+20.0	0.00	-20.00	-35.00	90.5	287
Field 5	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	15.0	+2.0	+17.0	40.0	-20.0	+20.0	0.00	-20.00	-65.00	91.1	631
Field 6	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	15.0	+2.0	+17.0	40.0	-20.0	+20.0	0.00	-20.00	-65.00	91.1	470
Field 5A	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	15.0	-17.0	-2.0	40.0	-20.0	+20.0	0.00	-20.00	-65.00	91.1	485
Field 6A	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	15.0	-17.0	-2.0	40.0	-20.0	+20.0	0.00	-20.00	-65.00	91.1	561
Field 5B	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	15.0	-7.5	+7.5	40.0	-20.0	+20.0	0.00	-20.00	-65.00	91.1	260
Field 6B	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	15.0	-7.5	+7.5	40.0	-20.0	+20.0	0.00	-20.00	-65.00	91.1	266
Field 7	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	15.0	+2.0	+17.0	40.0	-20.0	+20.0	0.00	-20.00	-95.00	93.0	422
Field 8	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	15.0	+2.0	+17.0	40.0	-20.0	+20.0	0.00	-20.00	-95.00	93.3	686
Field 7A	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	15.0	-17.0	-2.0	40.0	-20.0	+20.0	0.00	-20.00	-95.00	93.0	503
Field 8A	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	15.0	-17.0	-2.0	40.0	-20.0	+20.0	0.00	-20.00	-95.00	93.3	325
Field 7B	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	15.0	-7.5	+7.5	40.0	-20.0	+20.0	0.00	-20.00	-95.00	93.0	187
Field 8B	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	15.0	-7.5	+7.5	40.0	-20.0	+20.0	0.00	-20.00	-95.00	93.3	194
Field 9	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	30.0	-15.0	+15.0	40.0	-20.0	+20.0	0.00	-20.00	-125.00		130
Field 10	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	30.0	-15.0	+15.0	40.0	-20.0	+20.0	0.00	-20.00	-125.00		178
Field 11	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	181.0 CW 179.0	5.0	0.0	None	30.0	-15.0	+15.0	40.0	-20.0	+20.0	0.00	-20.00	-155.00		163
Field 12	Arc Therapy-I	SP_TrueBeam_Mill - 6X-FFF	179.0 CCW 181.0	355.0	0.0	None	30.0	-15.0	+15.0	40.0	-20.0	+20.0	0.00	-20.00	-155.00		204

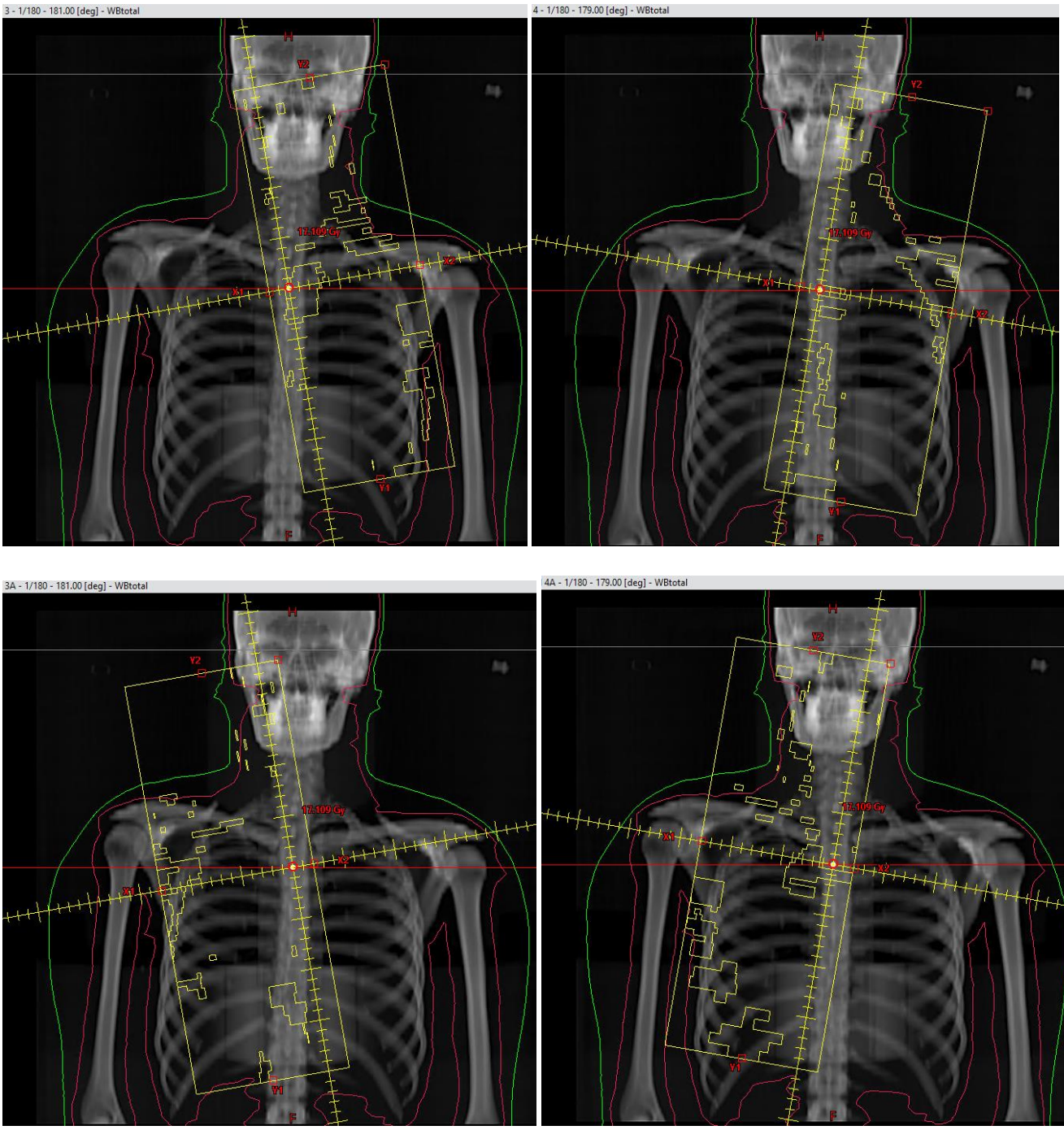
Beam geometry example with TrueBeam 10cm Z direction overlap between isocenters

For both the 4 arc and 6 arc per isocenter plans, an overlap of the arcs of each isocenter is 10cm in the craniocaudal direction. This results in 30cm isocenter spacing. With this field configuration, a slightly decreasing dose gradient (Calculation Option: AutoFeathering) into the consecutive isocenter is obtained resulting in general approximately 6 (or 10 if patient width requires additional later isocenter shifts) isocenters for adult patients. For irradiating lower extremities, VMAT was used with only two arcs per isocenter.

Annex C2: BEV 4 arcs and 6 arcs per isocenter

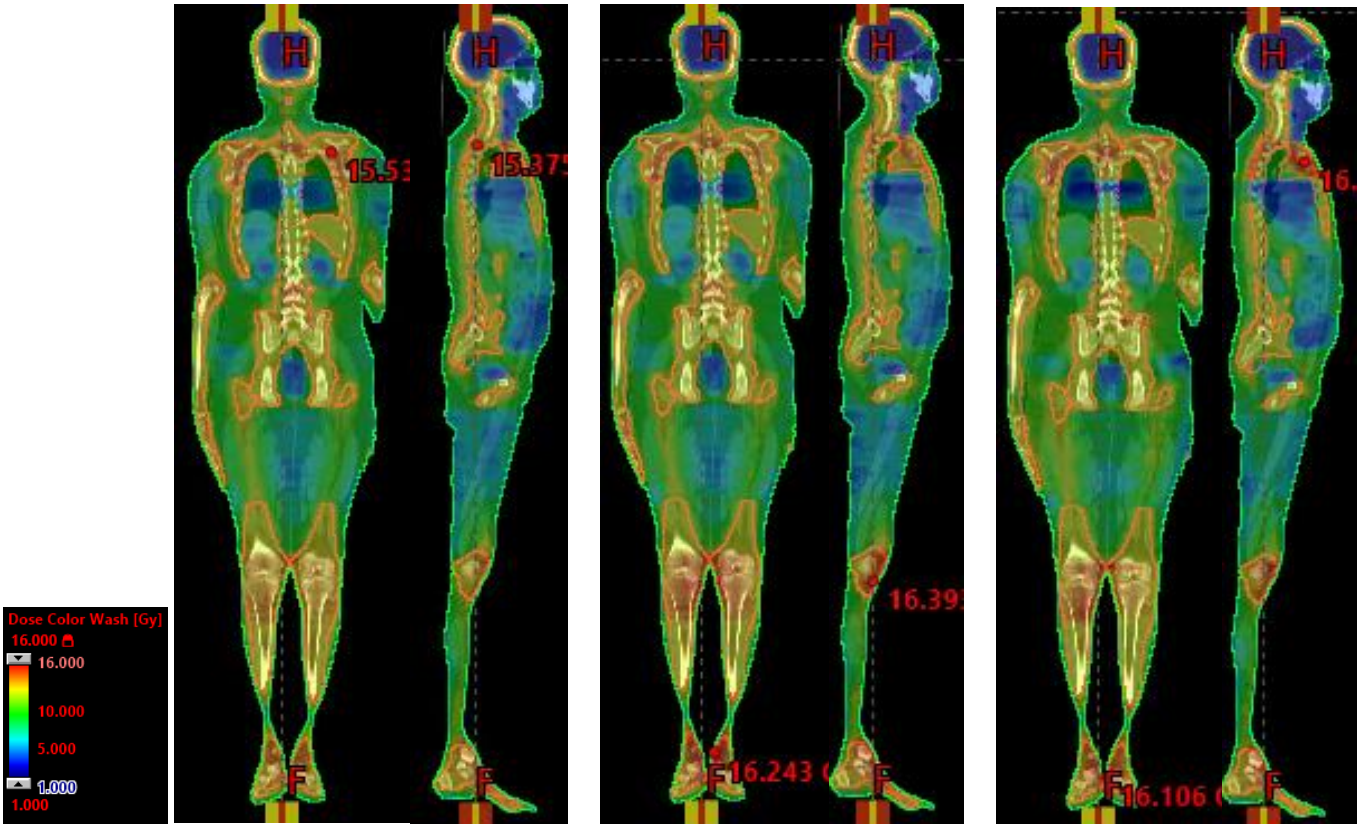


TrueBeam 6 Arcs per isocenter



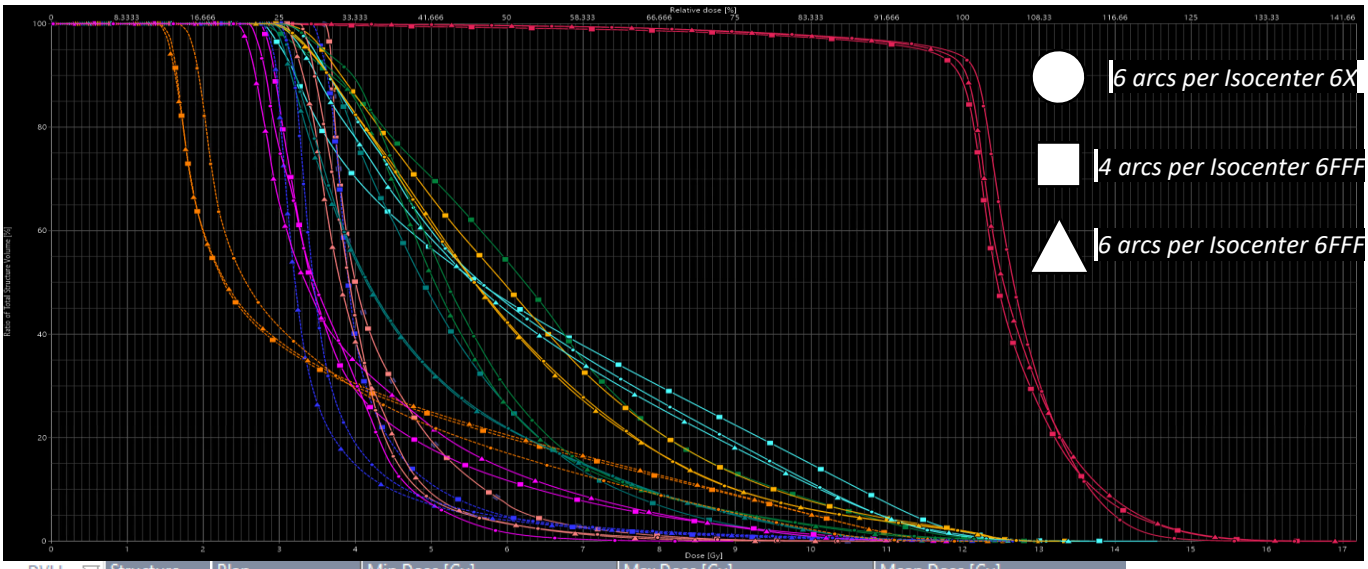
TrueBeam 4 Arcs per isocenter

Annex C3: Isodose distribution



6 arcs per Isocenter 6X | *6 arcs per isocenter 6FFF* | *4 arcs per isocenter 6FFF*

Annex C4: Dose Volume Histogram

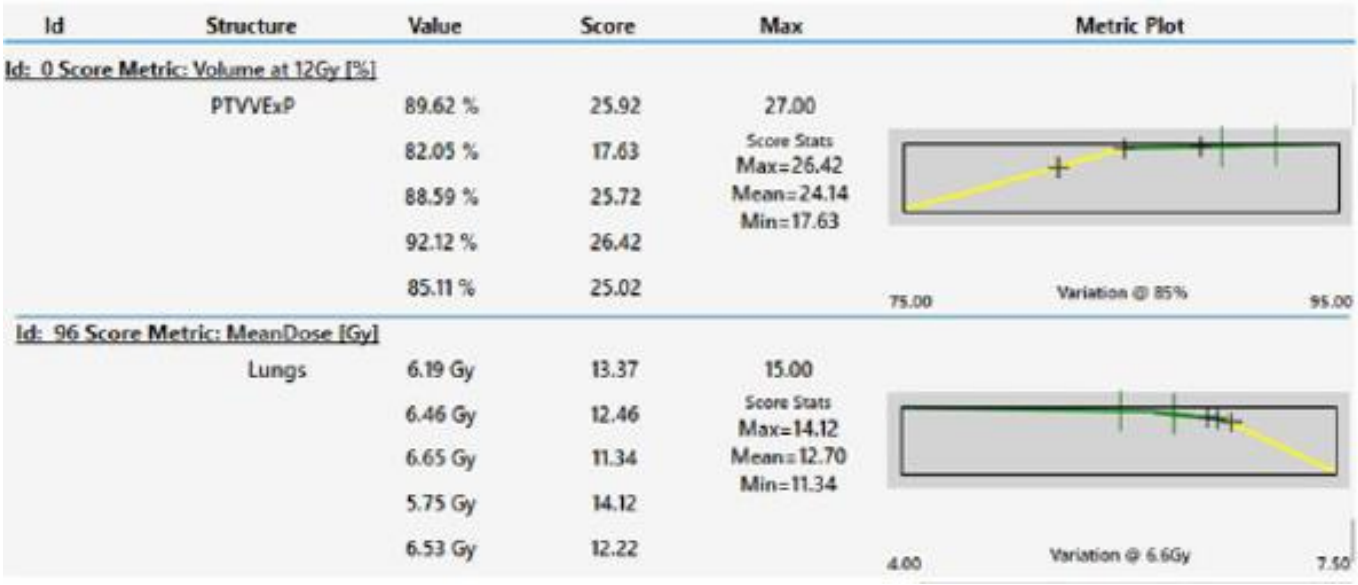


ow DVH	Structure	Plan	Min Dose [Gy]	Max Dose [Gy]	Mean Dose [Gy]
	Rectum	TMLI12GyTB2	3.542	10.706	4.404
	Rectum	TMLI12GyTBFFF	3.043	10.124	4.039
	Rectum	TMLI12GyTB_6X	3.240	11.246	4.108
	PTV_Total	TMLI12GyTB2	2.018	17.109	12.541
	PTV_Total	TMLI12GyTBFFF	2.003	17.176	12.647
	PTV_Total	TMLI12GyTB_6X	2.213	16.391	12.690
	Lungs	TMLI12GyTB2	2.745	14.567	6.325
	Lungs	TMLI12GyTBFFF	2.842	13.401	6.240
	Lungs	TMLI12GyTB_6X	2.996	13.674	6.368
	Liver	TMLI12GyTB2	2.696	12.911	6.398
	Liver	TMLI12GyTBFFF	2.784	12.842	5.448
	Liver	TMLI12GyTB_6X	2.852	13.291	5.589
	Kidneys	TMLI12GyTB2	2.949	11.892	5.256
	Kidneys	TMLI12GyTBFFF	2.755	12.137	4.843
	Kidneys	TMLI12GyTB_6X	2.814	12.434	4.883
	Heart	TMLI12GyTB2	2.696	12.086	4.081
	Heart	TMLI12GyTBFFF	2.377	11.976	4.085
	Heart	TMLI12GyTB_6X	2.524	8.981	3.679
	GI_Lower	TMLI12GyTB2	2.806	13.538	6.329
	GI_Lower	TMLI12GyTBFFF	2.736	13.236	6.017
	GI_Lower	TMLI12GyTB_6X	2.756	13.274	6.022
	Brain	TMLI12GyTB2	1.410	12.735	3.722
	Brain	TMLI12GyTBFFF	1.397	12.722	3.754
	Brain	TMLI12GyTB_6X	1.631	12.359	3.711
	Bladder	TMLI12GyTB2	3.400	12.813	4.218
	Bladder	TMLI12GyTBFFF	2.753	12.666	3.567
	Bladder	TMLI12GyTB_6X	2.969	13.053	3.805

TrueBeam 6arcs AXB 6XFFF	TrueBeam 6arcs AXB 6X	TrueBeam 4arcs AXB 6X FFF
1265.19/1522.50 (83.10%)	1250.87/1522.50 (82.16%)	1212.46/1522.50 (79.64%)

Annex D: Dosimetric scorecard details and PlansScoreCard ESAPI tool

D1: Full Scorecard for TMLI 12Gy (non binary)



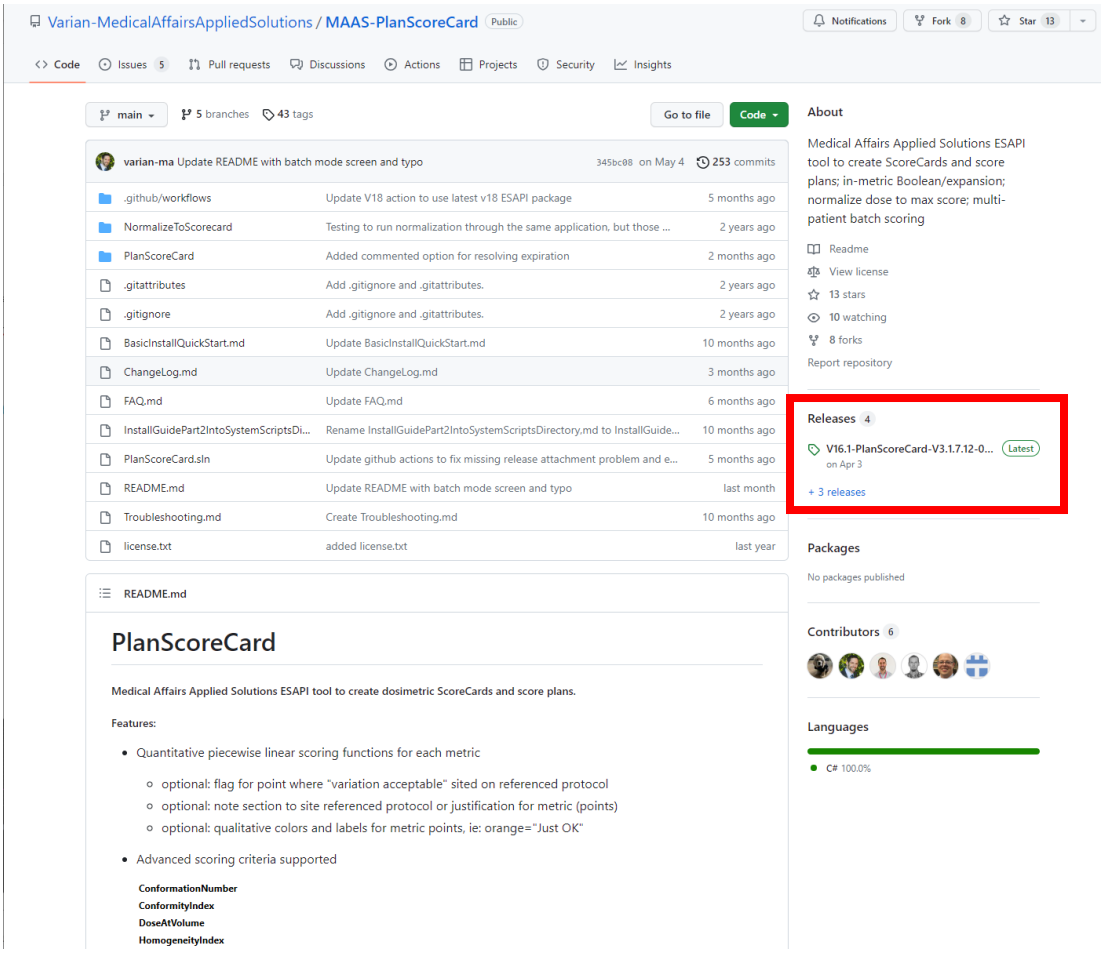
Id	Structure	Value	Score	Max	Metric Plot
Id: 0 Score Metric: Volume at 12Gy [%]					
	PTVVExP	89.62 %	25.92	27.00	
		82.05 %	17.63	Score Stats Max=26.42 Mean=24.14 Min=17.63	
		88.59 %	25.72		
		92.12 %	26.42		
		85.11 %	25.02		75.00 Variation @ 85% 95.00
Id: 96 Score Metric: MeanDose [Gy]					
	Lungs	6.19 Gy	13.37	15.00	
		6.46 Gy	12.46	Score Stats Max=14.12 Mean=12.70 Min=11.34	
		6.65 Gy	11.34		
		5.75 Gy	14.12		
		6.53 Gy	12.22		4.00 Variation @ 6.6Gy 7.50

Download full Scorecard(json), DICOM case example and this RapidPlan model:

Varian Medical Affairs - Total Marrow plus Lymphoid Irradiation - TMLI 12Gy [RapidPlan]

D2: PlanScoreCard ESAPI tool: where to find

Varian-MedicalAffairsAppliedSolutions (https://github.com/Varian-MedicalAffairsAppliedSolutions/MAAS-PlanScoreCard)



Currently, the source code is shared on the Varian Medical Affairs Applied Solutions GitHub where it can be downloaded and complied with Visual Studio 2022 (including with the free community edition), in the releases section users can find precompiled binaries ready to run in all compatible versions of Eclipse (v15.6+). PlanScoreCard is made available under the Varian Limited Use Software License Agreement.

The PlanScoreCard tool has a feature where derived structures (made with Boolean and expansion tools) can be created automatically. These structures can be created temporarily (to be used for scoring the plan but never saved back to the database) or (if the ESAPI tool has been approved for writing) the PlanScoreCard tool's configuration file can be edited so these generated structures are saved.

Annex E: Acknowledgements

Manually optimized plans created by Lesley Rosa, CMD

All data generated and complied by Lesley Rosa, CMD and Anthony Magliari, MS CMD

Dosimetric Scorecard TMLI 12Gy and derived structures designed by Lesley Rosa, CMD, Anthony Magliari, MS CMD and Chunhui Han, PhD

Model generated validation plans created by Lesley Rosa, CMD

Clinical Description document created by Lesley Rosa, CMD, Anthony Magliari, MS CMD and Chunhui Han, PhD

Annex F: Distribution and compatibility

This RapidPlan model is to be distributed exclusively via the links found on Varian Medical Affairs:

Varian Medical Affairs - Total Marrow plus Lymphoid Irradiation - TMLI 12Gy [RapidPlan]

Please do not re-distribute this model as number of downloads will be tracked (strictly to judge the success of this project).

This RapidPlan model was built with Eclipse v18.0 and rebuilt and validated from Eclipse v15.6 RapidPlan for maximal compatibility.