# Hippocampal Limited Sparing Enhanced Coverage Whole Brain (HLS-EC-WB) Model Description

#### Purpose:

This document describes the context in which the Hippocampal Limited Sparing Enhanced Coverage Whole Brain (HLS-EC-WB) 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 five 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 HLS-EC-WB 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.

- This model is designed to be used for RapidArc treatment plans for whole brain utilizing a hippocampal sparing technique. This model was created using 4 arc Halcyon plans calculated with AcurosXB but has also been validated with multiple (coplanar and non-coplanar) beam geometries on TrueBeam. (See Annex C for quantification of performance for each method).
- This HLS-EC-WB model differs from prior v2.0 model in that this model is preconfigured for **20Gy Rx with** greatly reduced sparing to the Hippocampus. Unless you are sure to be treating to 20Gy with reduced hippocampal sparing, it is recommended to use either HMS-EC-WB or HSWBv2.

Intent	20Gy/5fx-only	30Gy Scalable Rx	30Gy Scalable Rx
	Limited Sparing	Moderate Sparing	Aggressive Sparing
	Enhanced Coverage	Enhanced Coverage	HSWBv2
	H <b>LS-EC</b> -WB	(H <b>MS-EC-</b> WB)	
Hippocamus	7.6Gy ( <b>38% Rx</b> )	9Gy (30% Rx)	9Gy (30% Rx)
Dmin	ALARA	ALARA	ALARA
Hippocamus	13Gy ( <b>65% Rx</b> )	16Gy (53.3% Rx)	16Gy (53.3% Rx)
D0.03cc			ALARA
PTV Rx	20Gy @ 98%-99%	30Gy @ 98%-99%	30Gy @ <u>&gt;</u> 95%
dose coverage			

- The model is intended to be used in conjunction with a **MU objective** with a **strength of 80** and **minimum MU 1000 (1600 for 6X-FFF) and maximum MU of 2500**. This MU objective **must be added manually each time**.
- The "Automatic Intermediate Dose" function of the Photon Optimizer was utilized with MR3 return and convergence mode: extended selected in the calculation options. These settings should be changed prior to starting the optimization or plan quality will be compromised. Also, to reach desired homogeneity goals, consider an additional intermediate dose optimization: "2xMR3" (See Annex C)

 The model is intended for whole brain with hippocampal sparing without a simultaneous integrated boost (SIB) to gross disease. If SIB is intended to be utilized for boost volume, clinical validation of model performance is necessary. The model was not generated or fully validated for SIB clinical cases (See Annex D).

#### Target and OAR contouring and planning guidelines:

The HLS-EC-WB model was created using the following guidelines. Every patient must have a planning CT. The CT simulation scan must encompass the entire head to include the most superior aspect of the patient through the entire head. Axial slice thickness should not exceed 2.5mm and smaller axial cuts are recommended. The use of MRI guided contouring is also recommended. The MRI axial slice thickness should match the CT slice thickness as much as possible. It is recommended to obtain gadolinium-enhanced studies to include three-dimensional spoiled gradient (SPGR), magnetization-prepared rapid gradient echo (MP-RAGE), or turbo field echo (TRF) axial MRI scans with axial slice thickness not greater than 1.5mm. Standard axial and coronal gadolinium contrast-enhanced T1-weighted sequence and axial T2/FLAIR sequence scans should be acquired with no greater than 2.5mm slice thickness.

The planning target volumes (PTV) and the organs at risk (OARs) are contoured on the planning CT.

#### Target contouring guidelines:

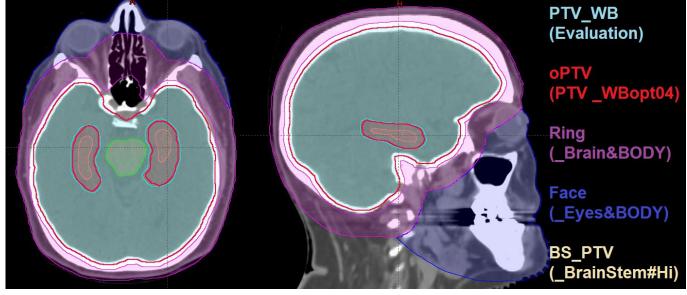
Target name	Guidelines
CTV (or Brain)	Whole brain parenchyma through the foramen magnum
PTV_WB	CTV + 2mm setup margin added in this model, but 0-3mm are valid (institutional preference) excluding the hippocampal avoidance region

#### OAR contouring guidelines:

OAR name	Guidelines
Hippocampus(R+L)	Bilateral hippocampal contours (contoured in one structure); will be generated from the CT simulation image set fused to MRI image sets <u>Average</u> <u>Total Volume of this structure was 4.5cc</u> in training set cases. The largest volumes seen in the training set were ~7cc (>7.5cc were excluded).
Brainstem	Best generated on MRI image set and verified on CT simulation image set. Inferior aspect at the level of foramen magnum (should be at the interface of CTV inferior aspect) and superiorly to include midbrain
Spinal Canal	Superior aspect to begin at the distal edge of the brainstem through inferior aspect of the image set
Lens(R/L)	Use CT image set only for creation; bilateral contoured separately
Optic Nerve (R/L)	Use CT image set only for creation; bilateral contoured separately
Eye(R/L)	Best generated from CT simulation image set; delineate the entire globe of the eye; bilateral contoured separately
Optic Chiasm	Structure best visualized on MRI image set and confirmed on CT image set; located above the pituitary fossa which is located within the sella turcica
Lacrimal Gland(R/L)	Structure sits superior and lateral to the globe of the eye; best generated on CT simulation image set and verified on MRI; bilateral contoured separately

#### **Optimization structure Guidelines\***

Hippocampus+05(R+L)	Avoidance used to create PTV_WB for evaluation only (not trained in this
	model)
PTV_WBopt04	PTV excluding hippocampi <u>+4mm additional margin from hippocampus</u>
	structure. Reduced margin in optimization to achieve Rx @ 99% PTV_WB).
_Brain&BODY (Ring)	+20mm from the brain, SUB +5mm from brain, removed from outside body
_Brainstem#Hi (BS_PTV)	Brainstem SUB Hippocampus + 5mm
_Eyes&BODY (Face)	Eyes +100mm, SUB brain +20mm, removed from outside of the body



\* Optimization structures can be automatically created with ESAPI PlanScoreCard tool (Annex B3)

#### Treatment planning guidelines:

All cases used to train and to validate the model were planned using head-first supine position with head positioned in a neutral position. All patients were immobilized with an aquaplast mask. A four arc VMAT technique was utilized with four full coplanar arcs on Halcyon with MLC in SX2 mode (standard mode on all Halcyon D / Drive and above configurations). Arcs had alternating clock-wise and counter clock-wise gantry rotations with collimator positions set at 315, 0, 45 and 90. The coplanar arcs had 359.8 degrees of arc rotation for each field. Arcs were positioned at a single isocenter located in the center of the target.

Full validation with different number of arcs, geometries and dose calculation methods on TrueBeam (M120 MLC) can be seen in Annex C, including a quantification of the relative dosimetric performance of each method.

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

Target	PTV_WB	20Gy in 5 fractions
	coverage	D100% at 99%; D98% > 20Gy; D2% < 21Gy (normalization to D100% >=99%)
OARs	Chiasm	D0.03cc < 21Gy
<b>O</b> ANS	Brainstem	D0.03cc < 22Gy
	Cord	D0.03cc < 22Gy
	Optic Nerve	D0.03cc < 21Gy
	Eye	Mean dose < 2Gy; Max dose <11Gy
	Lacrimal Gland	Mean dose < 4Gy
	Lens	D0.03cc < 3Gy
	Hippocampus	D0.03cc <13Gy; Mean dose < 9Gy; D100% < 7.6Gy

**References for contouring and planning guidelines:** 

Roberge D, Chan M, Gondi V. CCTG CE. 7: Stereotactic Radiosurgery Compared With Hippocampal-Avoidant Whole Brain Radiotherapy (HA-WBRT) Plus Memantine for 5 or More Brain Metastases https://www.ctg.queensu.ca/public/brain/brain-disease-site (HLS-EC-WB-2023 https://medicalaffairs.varian.com/wholebrain-limited-hippocampalsparing-20gy-vmat2)

Liu H, Clark R, Magliari A, Foster R, Reynoso F, Schmidt M, Gondi V, Abraham C, Curry H, Kupelian P, Khuntia D, Beriwal S. RapidPlan hippocampal sparing whole brain model version 2-how far can we reduce the dose? Med Dosim. 2022 Autumn;47(3):258-263. doi: 10.1016/j.meddos.2022.04.003. https://www.meddos.org/article/S0958-3947(22)00039-5/fulltext (HSWBv2-2022 https://medicalaffairs.varian.com/wholebrain-hippocampalsparing-vmat2)

Magliari V, Magliari A, Foster R. Hippocampal Sparing Whole Brain: Rapid Plan ModelFollowing the NRG-**CC001 Protocol**. AAMD Conf Poster Present.

https://medicalaffairs.varian.com/download/PosterPresentationAAMD2017RapidplanHCSWB.pdf (HSWBv1-2016 http://medicalaffairs.varian.com/wholebrain-hippocampalsparing-vmat1)

Brown P, Gondi V NRG-CC001: A Randomized Phase III Trial of Memantine and Whole-Brain Radiotherapy With or Without Hippocampal Avoidance in Patients with Brain Metastases https://www.nrgoncology.org/Clinical-Trials/NRG-CC001

Prokic V, et al Whole Brain Irradiation with Hippocampal Sparing and Dose Escalation on Multiple Brain Metastases: A Planning Study on Treatment Concepts http://dx.doi.org/10.1016/j.ijrobp.2012.02.036

Physicians with considerable experience in treating patients under the CCTG CE.7 protocol, additional planning goals and contouring consistency were completed to their clinical preference.

#### Structure codes:

To ensure robust structure matching between new cases and the structures defined in the model, it is recommended to use the following structure code assignment:

Structure name example	Structure name in model	Structure code(s) in model
PTV_WBopt04mm	PTV_WBopt	(PTV_High,PTV_Int Target)
Hippocampus_Totl	Hippocampus(R+L)	(275020)
Chiasm	OpticChiasm	(62045)
Brainstem	Brainstem	(79876)
Spinal Cord	SpinalCanal	(9680, 7647)
LOptic	OpticNerve(R/L)	(50878, 50875)
ROptic	OpticNerve(R/L)	(50878, 50875)
LEye	Eye(R/L)	(12515, 125124)
REye	Eye(R/L)	(12515, 125124)
LLacrimal	Lacrimal(L/R)	(59103, 59102)
RLacrimal	Lacrimal(L/R)	(59103, 59102)
LLens	Lens((R/L)	(58243, 58242)
RLens	Lens((R/L)	(58243, 58242)
NS_Ring	_Brain&BODY	(Control Region)
BrainstemPTV	_Brainstem#Hi	(Control Region)
Face	_Eyes&Body	(Control Region)

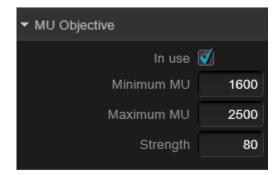
#### **Optimization objectives and settings:**

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

Applying the model will also set the following parameters for the NTO:



# MU objective is also recommended for planning with the following parameters:



Minimum 1600 for 6X-FFF, 1000 for 6X

\*\*\*\*\* MUST be added manually \*\*\*\*\*

Target ID	Vol [%]	Dose	Priority	gEUD a
Yes _BRAINSTEM#HI (Cor	ntrol)			
Lower		100.5 %		
Yes PTV_WBopt4 'TV_High, PTV_Intermed	iate)			
Upper	0.0	105.0 %	400	
Upper	1.5	103.5 %	190	
Upper	12.0	102.4 %	175	
Lower		101.6 %		
Lower		100.5 %		
Lower		95.7 %		
Upper gEUD		101.8 %		
_BRAIN&BODY (Cor	ntrol)			
Upper	0.0	99.0 %	350	
_Eyes&BODY (Cor	ntrol)			
Mean		Generated	85	
Line (preferring OAR)	Generated	Generated	110	
Brainstem (79	876)			
Upper	0.0	101.0 %	175	
Eye(R/L) (12515, 12	514)			
Upper (fixed vol., generated dose)	0.0	Generated	125	
Mean		Generated	95	
Line (preferring target)	Generated	Generated	85	
Hippocampus(R+L) (275	020)			
Upper (fixed vol., generated dose)	99.0	Generated	230	
Upper (fixed vol., generated dose)	0.0	Generated	185	
Mean		Generated	120	
Line (preferring target)	Generated	Generated	135	
Lacrimal(L/R) (59103, 59	102)			
Mean		Generated	65	
Line (preferring target)	Generated	Generated	80	
Lens(R/L) (58243, 58	242)			
Upper (fixed vol., generated dose)	0.0	Generated	110	
Mean		Generated	68	
Line (preferring target)	Generated	Generated	74	
OpticChiasm (62	045)			
Upper	0.0	100.5 %	160	
OpticNerve(R/L) (50878, 50	875)			
Upper	0.0	100.5 %	160	
Line (preferring target)	Generated	Generated	30	
SpinalCanal (9680, 7	647)			
Upper	0.0	100.5 %	160	

#### **Model Training:**

This Hippocampal Limited Sparing Enhanced Coverage Whole Brain (HLS-EC-WB) model was trained with the same final 42 case multi-institution CT dataset from the HSWBv2, structures were modified as needed. Each case was simulated with aquaplast mask immobilization and neutral head position.

All cases were initially re-planned to 20Gy in 4Gy fractions with 6X-FFF energy on a Varian Halcyon with SX2 MLC mode.

All cases utilized VMAT technique. Arcs had alternating clockwise and counterclockwise gantry rotations with collimator positions set at 315, 0, 45 and 90 degrees. The coplanar arcs had 359.8 degrees of arc rotation and were positioned with isocenter located in the center of the target.

The recursive method of model creation was utilized to generate a RapidPlan model with very consistent, highquality plans developed with tight DVH prediction bands allowing for finely balanced hippocampal sparing, target coverage and homogeneity optimization objectives to be used. HLS-EC-WB uses plans created from HSWBv2 (which was, in-turn, created from HSWBv1 model released in 2016) as its starting point leveraging the Rx scaling feature (30Gy->20Gy). These initial plans were created without the HSWBv2 hippocampal DVH prediction line objectives and instead DVH point objectives were generated along the hippocampus line objectives. These objectives were then offset by fixed percentages toward higher dose levels to account for the dose gradient shifting toward the hippocampal structures in order to achieve the desired target coverage goal (Rx dose covering 99% of PTV\_WB). A modified version of the V2.0 scorecard was created which adjusted previous metrics and added additional metrics to capture CE. 7 and it's author's clinical preference (aggressive target coverage and maximal homogeneity). The free PlanScoreCard ESAPI scoring tool was not only utilized to score plans (scores which guide tuning the model's automatically generated optimization objective priorities), but was also used to automatically create optimization structures (see Annex B3).

Those initial plans created from HSWBv2 model scaled to 20Gy and with offset hippocampal sparing objectives became the training set for the initial HLS-EC-WB model. A recursive model creation process was employed to ensure the final HLS-EC-WB training set consisted, exclusively, of plans generated from the initial HLS-EC-WB model. Evaluating plan scores at each step in the process informed multiple iterations of re-tuning the optimization objective set.

#### **Model Validation:**

The HLS-EC-WB model was validated using the 42 cases included in the final model training set. See the table on the next page to better understand the model creation / validation and scores achieved throughout the process.

Five additional validation cases not included in the model training set are explored, in detail, in the Annex. Those cases are scored with various arc geometries (both coplanar and non-coplanar) on both Halcyon and TrueBeam (Millennium120 MLC) with differing numbers of intermediate dose optimizations, with a quantification of the relative dosimetric performance (score) of each method. Further validation including differing beam energies, dose calculation methods and convergence mode options, are available in the clinical description included with the HSWBv2 RapidPlan Model.

	V2.0 Scorecard=142	HLS-EC-WB Scorecard = 158.5 Total points					
	Final Result	created by modV2.0 model	created by initial HLS-EC-WB	<b>Final Result</b>			
		Training Set for initial	Training Set for final	Final HLS-EC-			
Patient	Final V2.0 Model	HLS-EC-WB	HLS-EC-WB	WB Model			
Patient 1	132.35	141.86	145.71	145.44			
Patient 3	132.47	145.2	144.86	143.44			
Patient 4	137.17	147.19	147.07	149.02			
Patient 5	129.81	142.07	147.21	147.2			
Patient 8	132.53	140.78	143.11	142.5			
Patient 9	132.6	140.45	141.33	142.38			
Patient 11	132.32	133.87	138.56	140.29			
Patient 13	131.92	144.49	145.4	145			
Patient 16	136.6	141.81	143.81	146.68			
Patient 19	134.64	139.96	138.36	142.39			
Patient 20	131.66	135.18	140.46	140.36			
Patient 21	131.36	133.19	134.17	139.98			
Patient 23	134.14	145.68	146.29	144.43			
Patient 24	133.82	137.54	143.45	141.3			
Patient 25	134.88	145.97	146.43	146.63			
Patient 27	133.96	146.26	146.81	145.79			
Patient 28	131.32	139.94	141.11	140.14			
Patient 30	133.23	140.83	140	143.21			
Patient 34	131.16	141.55	143.28	143.15			
Patient 35	132.72	144.64	145.4	145.29			
Patient 44	129.91	137.45	135.43	140.17			
Patient 45	129.64	139.56	141.95	143.56			
Patient 47	133.63	145.21	145.85	146.5			
Patient 48	135.3	145.59	146.16	146.85			
Patient 49	134.7	144.78	146.3	145.5			
Patient 50	131.7	144.62	144.8	144.11			
Patient 52	132.01	138.99	142.36	141.31			
Patient 54	134.41	145.38	143.13	145.87			
Patient 55	132.49	135.02	135.9	140			
Patient 57	134.69	140.16	140.75	145.58			
Patient 60	131.74	134.59	131.7	135.36			
Patient 64	134.42	141.49	146.32	145.41			
Patient 65	133.45	143.75	143.68	143.29			
Patient 66	132.58	136.49	138.8	140.33			
Patient 68	132.24	134.1	143.46	144.42			
Patient 69	130.8	131.62	126.21	135.51			
Patient 70	133.5	135.17	139.71	140.47			
Patient 71	132.54	141.31	143.41	143.58			
Patient 72	132.72	140.79	138.28	142.04			
Patient 77	131.67	142.35	144.01	142.5			
Patient 80	134.76	147.27	147.11	146.36			
Patient 85	135.24	144.27	140.82	145.73			
Average	132.9714286	140.9147619	142.1180952	143.3111905			

# **Annex Directory**

Annex A: Visual comparison of HLS-EC-WB/HSWBv2: different tradeoffs (coverage / sparing)

- A1 DVH comparison
- A2 Isodose comparison

### Annex B: Scorecard

- B1 Score comparison of HLS-EC-WB/HSWBv2: expressing intent with precision
- B2 PlanScoreCard ESAPI tool: where to find
- B3 PlanScoreCard ESAPI tool: automatically generate derived structures
- **B4 Scorecard modifications** HLS-EC-WB from HSWBv2

### Annex C: Validation Results

- C1 Beam Arrangements: Halcyon and TrueBeam
- C2 1xMR3, 2xMR3, 3xMR3 (Convergence Mode: Extended)
- C3 Rapidplan v15.6 and v17 model versions
- C4 HLS-EC-WB model evolution progress (scores) on validation set

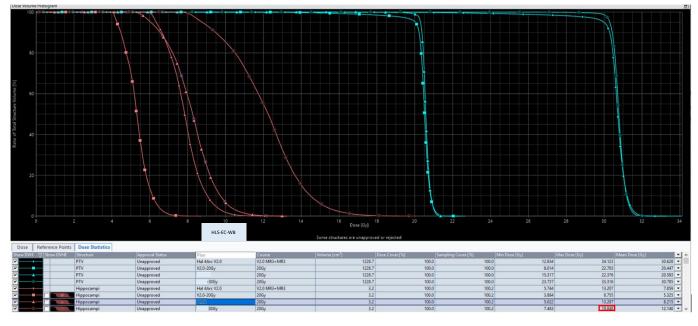
Annex D: Examples applying this model for Simultaneous Integrated Boost

- **D1** Example SIB Plan 27.5Gy in 5Fx
- **D2** SIB DVH Comparison
- **D3** Planning Structures
- D4 Metastasis proximity to hippocampus

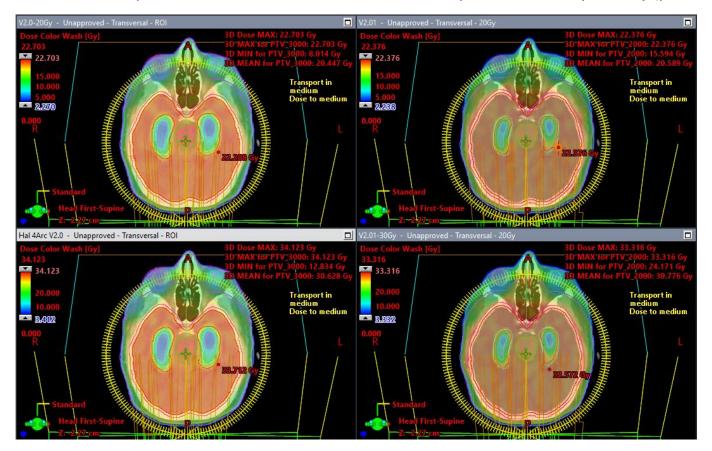
### Annex E: Acknowledgements

### Annex F: Distribution and compatibility

Annex A: Comparison of HLS-EC-WB / HSWBv2: different tradeoffs (coverage vs sparing)
A1 DVH comparison-HSWBv2 & HLS-EC-WB models reoptimized to 20Gy & 30Gy (patient 36)



A2 Isodose comparison-HSWBv2 & HLS-EC-WB models reoptimized to 20Gy & 30Gy (patient 36)



### For reference only:

HLS-EC-WB should not be scaled to 30Gy, D.03cc hippocampus dose will be too high!

	Plan Score Comparison								
		V2.0 Score (142 tota	ecard 30G al points)	У	HLS		orecard 20Gy al points)		
Patient	v2.0	model	-	EC-WB @30Gy	v2.0 model@20Gy		HLS-EC-WB model		
36	132.08	93.01%	110.48	77.80%	123.42	81.07%	141.32	90.81%	
37	133.24	93.83%	112.35	79.12%	128.49	73.64%	143.93	90.42%	
39	132.17	93.08%	117.58	82.80%	116.72	72.34%	143.31	86.62%	
40	133.39	93.94%	116.68	82.17%	114.66	78.08%	137.3	89.30%	
41	131.82	92.83%	112.31	79.09%	123.76	76.60%	141.54	89.26%	
Average	132.54	93.34%	113.88	80.20%	121.41	76.35%	141.48	89.28%	

### B1 Score comparison of HSWBv2/HLS-EC-WB: expressing intent with precision

For reference only:

HLS-EC-WB should not be scaled to 30Gy, D.03cc hippocampus dose will be too high!

nnonNon	Plan Scores	WASHU-HCSW8-03& WASHU-HCSW8-03&	(206y) V2.01: 141.32/158.50 (89.16%) (206y) V2.0-206y: 122.42/158.50 (77.24%)	Δ 🖸				
Nate of the set		Structure	Score Metric					Metric Plot
Note		PTV_2000					Score Stats Max-19.00	98.00 Volume [N] 99.50
NoteN	2	PTV <u>1</u> 000					Score Stats Max-14.00	
	VARIATION(8) 3	PTV3000	Dose at 95% (Gy)				2.00	18.00 Variation & Hdy 20.00
NoteN	£000(0) 4	ptwhi	Dose at 2% (Gy)	V2.01	21.07 Gy	10.93	Mean=1.40 Min=0.80	20.00 Dow (5y) 20.1
	6000[11]			V2.0-20Gy			Score Stats Max=10.93 Mean=10.90 Min=10.87	21.00 Dose (6y) 26.7
mmm <th< td=""><td></td><td>PTV_2000</td><td>Volume at 105% (%)</td><td></td><td></td><td></td><td>5.50 score Stats Max=5.23 Mean=5.23 Min=5.22</td><td>0.00 Volume [h] 50.00</td></th<>		PTV_2000	Volume at 105% (%)				5.50 score Stats Max=5.23 Mean=5.23 Min=5.22	0.00 Volume [h] 50.00
Normal And an analysis of the sector of t		PTV <u>3</u> 000	Dose at 0.03CC [Gy]				8.00 Score State	
NUMN	VARIATION[8]	6000(7] WAR	ManDase [Gy]	V2.01		4.51	5.00	21.00 Weission @ 220y 22.2
	IDEAL[5]		Atomije	1/2.0-20Gy	22.70 Gy	0.00	Score Stats Max=4.51 Mean=2.26 Min=0.00	21.50 Variation © 22.46y 22.4
	8 IDEAL[2]		ні († - 99)/20)				Score Stats Max=1.87	0.00 M (1 - 599/20) 0.1
	9	PTV_2000	Conformation No. at [12.7Gy]				Score Stats Max=0.44	0.33 Conformation (CC) 1/2
		Hippocampi					Score Stats Max=7.50	
NATION INTERPORTNATURENATUR	"	i Alippocampi					Maxe 11.71 Mean-10.43	<u> </u>
	12		Dose at 100% [Gy]				17.00 Score Stats Max=16.54 Mean=15.87	5.00 MaanDoos (5y) 11.6
	IDEAL[17] 13	A					3.50 Score Stats Max=3.50	3.50 Veriation © 7.70y 8.5
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Math By       Lat By	106AL[3]	-	ATTONIA				Mean=1.95 Min=1.70	20.00 Dune (6y) 22.0
MARATINE MARCINE (S)       March (S)       Marc	IDEAL[3,5]	econgi var	x20x153	1/2.0-20Gy	14.84 Gy	3.50	Score State Max=3.50 Mean=3.42 Min=3.35	20.00 Dose (6y) 22.2
NUMARY INTER       NULL 26 2607       N0 6 6r       3.20       Numerical of the second se	16 IDEAL[3.5]	OpticNervel,	Dose at 0.03CC (Gy)				Score Stats Max=3.50 Maan=3.03	2020 Dow (Sy) 210
Market         Market         V2.20 V2.210 V2.2509         L13 00 L13 00 V2.200         L13 00 L13 V2.200 L13 00         L13 00 V2.200 L13 V2.200         L13 00 L13 V2.200 <thl13 th="" v2.200<="">         L13 00 L13 V2.200         <thl13< td=""><td>17 IDEAL(3.5)</td><td>OpticNerve®</td><td>Dese at 0.03CC [Gy]</td><td></td><td></td><td></td><td>Score Stats Max::: 8.50 Mean = 3.01</td><td>2000 Dow (Sy) 210</td></thl13<></thl13>	17 IDEAL(3.5)	OpticNerve®	Dese at 0.03CC [Gy]				Score Stats Max::: 8.50 Mean = 3.01	2000 Dow (Sy) 210
Material         Material         V2.21         3.27 Gy         1.73         ZAN Material         Material           28         Gyd         Machine [Gyl         V2.210         SAR Gy         1.35         ZAN Material         Material	18		MaxDose [Gy]				2.00 Score Stats Max=1.85 Mean=1.85 Min=1.85	6.00 Maußsae (b)) 14.0
$\begin{array}{                                    $	19	Eye <u>i</u>					2.00 Score Stats Max=1.79 Mean=1.79 Min=1.78	
NUME         NUME <th< td=""><td>20</td><td>A</td><td></td><td></td><td></td><td></td><td>2.00</td><td></td></th<>	20	A					2.00	
maximum         maximum <t< td=""><td>10EAL[2] 21</td><td>fyr8</td><td>Amonjej MeanDose (Gy)</td><td></td><td></td><td></td><td>2.00 Score Stats Max=1.79</td><td>6.00 ManDove[6] 34.0</td></t<>	10EAL[2] 21	fyr8	Amonjej MeanDose (Gy)				2.00 Score Stats Max=1.79	6.00 ManDove[6] 34.0
Marketick         Marketick <t< td=""><td>22</td><td>LacrimalGland<u>i</u></td><td>Anoxyg MeanDose [Gy]</td><td></td><td></td><td></td><td>3.50 Score Stats Max=3.43</td><td>130 MaanDoor (5y) 103</td></t<>	22	LacrimalGland <u>i</u>	Anoxyg MeanDose [Gy]				3.50 Score Stats Max=3.43	130 MaanDoor (5y) 103
Market in the intervent of the int	23	A		V2.01	3.32 Gy	3.42	Mean=3.38 Min=3.33 3.50	2.70 MassGeer [Cy] 13.3
International Internatio International International International Internatio	24	A					Mean=3.36 Min=3.30	2.79 MeanDone (Oy) 13.
NUMBER IN         NUMBER IN <t< td=""><td>IDEAL[2.25]</td><td></td><td>ATION(E)</td><td>V2.0-20Gy</td><td>2.17 Gy</td><td>2.08</td><td>Score Stats Max=2.09 Mean=2.08 Min=2.08</td><td>107 Dow (5y) 6.</td></t<>	IDEAL[2.25]		ATION(E)	V2.0-20Gy	2.17 Gy	2.08	Score Stats Max=2.09 Mean=2.08 Min=2.08	107 Dow (5y) 6.
1884.00         Norman         1984.00         20.7 CC         3.80         March 100         1000<	25	Lens®	Dose at 0.03CC (Gy)				Score Stats Max=2.04	100 Dow (Sy) 63
Annual         Standard V         ManDose (N)         V2.21         S64.47 %         4.11         5.09           27         Brainkabov         V2.25 200y         S03.25 %         4.15         Scale 4.15 <t< td=""><td>26 IDEAL[5]</td><td>Erain&amp;BCDY</td><td>Volume at 99.5% [CC]</td><td></td><td></td><td></td><td>Score Stats Max=5.00</td><td>0.00 Volume [CC] 100.0</td></t<>	26 IDEAL[5]	Erain&BCDY	Volume at 99.5% [CC]				Score Stats Max=5.00	0.00 Volume [CC] 100.0
Amount         Does at 19% (Gr)         V2.01         20.11 Gry         2.00         2.00           28         (rand-free-H4)         V2.01         20.11 Gry         2.00         (rand-free-H4)	27	Reals&BCDY	MaxDose [%]				Score Stats Max=4.76	MacOos [b]
Bitsus         Konsus         Bitsus         Dewelloy:         Date         Date <thdat< th="">         Dat         Date</thdat<>		la BrainStem#Hi	Dose at 95% (Gy)				Score Stata Max=2.00 Mean=1.99	
V2.8-20Gy 3.41 Gy 3.79 Know fram Max=3.79	29	Eyes&BODY	MeanDose (Gy)				5.00	15.30 Dem (Dy) 20.0

Plan Scores:	WASHU-HCSWI WASHU-HCSWI	s 036: [206y] V2.01 306y: 110.48/142.00 (77.80%) 9-036: [V2.0 MR3+MR3] Hal 4Arc V2.0: 132.20/142.	.00 (93.10%)				Ĵ
ld	Structure	Score Metric	Plan Id	Value	Score	Max	Metric Plot
1	PTV3000	Volume at 30Gy [%]	V2.01-30Gy Hal 4Arc V2.0	98.76 % 95.07 %	15.00 14.79	15.00 Score Stats Max=15.00	
	PTV_3000		Hal 4Arc V2.0	95.07 %	14.79	Max=15.00 Mean=14.89 Min=14.79	
VASIATION(0)	cooptsi	GOCOLITZE INTATIZE					85.00 Variation © 90% 95.50
2	PTV3000	Dose at 98% [Gy]	V2.01-30Gy Hal 4Arc V2.0	30.12 Gy 28.45 Gy	14.00	14.00 Score Stats Max=14.00	
	PTV_3000	ACCEPTABLE[14]				Mean=13.85 Min=13.69	22.50 Variation @ 256y 30.00
Transition (1)	6000[13]						2250
3	PTV_0000	Dose at 2% [Gy]	V2.01-30Gy Hal 4Avc V2.0	31.50 Gy 31.61 Gy	11.00	11.00 Score Stats Max=11.00	
UEAL[11]		TION(7.5] NAMATION(3.75] SUB-OPTIMAC[8]				Mean=10.96 Min=10.93	31.50 Variation (2 37.50y 40.00
4		Volume at 105% [%]	V2.01-30Gy	2.03 %	5.36		31.50 40.00
4	PTV <u>3000</u> PTV_3000	Volume at 105% [%]	V2.01-30Gy Hal 4Arc V2.0	2.03 % 3.25 %	5.36	5.50 Score State Max-5.36	+
IDEAL(5.5)	60001375	MARIATIONID				Score State Max=5.36 Mean=5.32 Min=5.27	0.00 Variation (2.25% 50.00
5	PTV2000	Dose at 0.03CC [Gy]	V2.01-30Gy	32.41 Gy	4.50	4.50	
	PTV 3000	Dose at WOLL [0]]	Hal 4Arc V2.0	33.00 Gy	4.50	Score Stats Max=4.50 Mean=4.50 Min=4.50	
DEAL[4.5]	0000 [25]	[VARIATION  0]				Mean=4.50 Min=4.50	13.00 Variation @ 360y #3.00
6	PTV <u>2</u> 000	HI [1 - 99]/30]	V2.01-30Gy	0.05	1.68	2.00	
	PTV_3000		Hall 4Are V2.0	0.21	1.54	Score Stats Max=1.88 Mean=1.71 Min=1.54	+
IDEAL[2]	6000 (0)					Mean=1.71 Min=1.54	0.00 HI (7 - 99)/20] 0.90
7	PTV2000	Conformation No. at [28.5Gy]	V2.01-30Gy	0.77 CC	0.66	1.00	
	PTV_3000		Hel 4Arc V2.0	0.88 CC	0.83	Score Stars Max=0.83 Mean=0.75 Min=0.66	
6000 [1]	DEAL[0]					Mean=0.75 Min=0.66	0.30 Centernation (CC) 1.00
	Hippocampi	Dose at 0.03CC [Gy]	V2.01-30Gy	16.78 Gy	0.33	7.50	
	Hippocampi		Hal 4Arc V2.0	10.32 Gy	6.80	Score Stars Max=6.80	
IDEAL[7.5]	6000(6)	VARIATIONEE				Mean=3.57 Min=0.33	a.co Dese (0y) 17.00
9	Hippocampi	MeanDose (Gy)	V2.01-30Gy	12.14 Gy	0.00	12.00	
	Hippocampi		Hal 4Arc V2.0	7.86 Gy	10.14	Score Stats Max=10.14	
IDEAL[17]	6000[16]	VARIATION[7]				Mean=5.07 Min=0.00	6.00 MeanDose (Ry) 12.00
10	Hippocampi	Dose at 100% [Gy]	V2.01-30Gy	7.48 Gy	11.75	17.00	
	Hippocampi		Hall 4Are V2.0	5.74 Gy	15.88	Scon Stats Max=15.88 Max=13.82	
IDEAL[17]	6000(14)	VARADONICI				Mean=13.82 Min=11.75	5.00 Dose (6y) 10.00
11	OpticChiasm	Dose at 0.03CC [Gy]	V2.01-30Gy	30.43 Gy	2.93	3.50	
	OpticChiasm		Hel 4Arc V2.0	28.60 Gy	3.05	Max-3.05	++
IDEAL[3.5]	cocotal	ACCEPTABLE [2] SUB-OPTIMAL[0]				Mean=2.99 Min=2.93	15.00 Variation @ MGy 37.50
12	BrainStem	Dose at 0.03CC [Gy]	V2.01-30Gy	31.56 Gy	2.99	3.00	1
	BrainStem		Hal 4Arc V2.0	31.77 Gy	2.94	Score Stats Max=2.99 Mean=2.96	
IDEAL[3]	6000[3]	VARIATIONE				Mean=2.96 Min=2.94	21.10 Victation (\$ 360y 27.50
13	SpinalCord	Dose at 0.03CC [Gy]	V2.01-30Gy	30.42 Gy	2.51	3.50	
	SpinalCord		Hal 4Arc V2.0	22.23 Gy	3.11	Score Stats Max=3.11 Mean=2.81 Min=2.51	
IDEAL[3.5]	6000[3]	WARIATION[2] SUB OPTIMAL[8]				Min=2.51	12.10 Variation @ 36Gy 37.50
14	OpticNervel	Dose at 0.03CC [Gy]	V2.01-30Gy	30.35 Gy	2.94	3.50	
	OpticNerve_L		Hal 4Arc V2.0	28.33 Gy	3.06	Mean=3.00 Min=2.94	
ideal(3.5)	6000[3]	VARIATION(2) KUB-OPTIMAL(0)				Min=2.94	15.00 Variation (§ 360y 37.50
15	OpticNerve8	Dose at 0.03CC [Gy]	V2.01-30Gy	29.97 Gy	3.00	3.50 Score States	
	OpticNerve_R		Hal 4Arc V2.0	28.33 Gy	3.06	Score Stats Max=3.05 Mean=3.03 Min=3.00	
IDEAL[3.5]	cocotal						15.00 Variation @ 36Gy 37.53
16	EyeL	MeanDose [Gy]	V2.01-30Gy Hal 4Arc V2.0	5.42 Gy 5.12 Gy	3.07	3.50 Score Stats	
	Eye_L		nel 4Mit V2.0	5.12 Gy	2.11	Score Stats Max=3.11 Mean=3.09 Min=3.07	
IDEAL[378]	cocolil	VARIATION(0)					2.00 MeanDose (6y) 15.00
17	tys <u>R</u>	MeanDose [Gy]	V2.01-30Gy Hal 4Arc V2.0	5.53 Gy 5.27 Gy	3.05 3.09	3.50 Score State	
	Eye_R		110 4010 12.0	227 Gy	2.00	Score Stats Max=2.09 Mean=3.08 Min=5.06	
IDEAL[3-5]	6000[3]	VARIATION(8)					2.00 MeanDose [6y] 15.00
18	LacrimalGland <u>L</u>	MeanDose [Gy]	V2.01-30Gy Hal 4Arc V2.0	4.83 Gy 5.95 Gy	3.43 3.34	3.50 Score Stats Max=3.43	
	LacrimalGland_L		ne sele vz.u	2.45 Gy		Max=3.43 Mean=3.38 Min=3.34	
IDEAL[3:5]	6000[3]	VARIATION[0]					4.00 MeanDone (6y) 20.00
19	LacrimalGland	MeanDose [Gy]	V2.01-30Gy Hal 4Arc V2.0	4.91 Gy 5.97 Gy	3.42	3.50 Score State	
	LacrimalGland_R		The write V2.0	sdi Gy	3.54	Score Stats Max-2.42 Mean=3.38 Min=3.34	
IDEAL[3:5]	6000[3]	VARIATION[8]					4.00 MeanDone (6y) 20.00
20	Lem	Dose at 0.03CC [Gy]	V2.01-30Gy Hal 4Arc V2.0	3.43 Gy 3.19 Gy	2.05	2.25 Score Stats Max=2.08	
_	Lens_L					Max=2.08 Mean=2.07 Min=2.05	
IDEAL[2,25]	eocols1	www.miowlej					1.50 Doos (0y) 10.00
21	Lens <u>R</u>	Dose at 0.03CC [Gy]	V2.01-30Gy Hal 4Avc V2.0	3.40 Gy 3.58 Gy	2.06	2.25 Score Stats Max-2.06	-
	Lens_R					Max=2.05 Mean=2.05 Min=2.04	
IDEAL[2,25]	6000[2]	www.coviel					1.50 Dune (Gy) 10.00
22	Brain&BODY	Volume at 99.5% [CC]	V2.01-30Gy Hel 4Arc V2.0	1.57 CC 0.00 CC	4.92 5.00	5.00 Score Stats Max-5.00	+
						Max-5.00 Mean=4.96 Min=4.92	
IDEAL[5]	C000011						0.00 Velume (CC) 500.00
23	Brain&BODY	MaxDose [%]	V2.01-30Gy Hal 4Arc V2.0	105.58 %	3.88 4.83	5.00 Score Stats Maxed 82	+
						Score Stats Max=4.83 Mean=4.36 Min=3.88	Marclass [5] 125 cm
6000[5]	A						100.00 MacCess (%) 125.00

ScoreCard Comparison HLS-EC-WB(left) and HSWBv2(right) both RP models reoptimized to both 20Gy & 30Gy (patient 36) Note: HSWBv2 plan fails HLS-EC-WB Scorecard target coverage and Dmax, while HLS-EC-WB plan fails HSWBv2 scorecard for hippocampal mean dose (red arrow = 0pts/FAIL)

### B2 PlanScoreCard ESAPI tool: where to find

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

varian-ma Update README with batch  .github/workflows  NormalizeToScorecard	n mode screen and typo 345bc08 on M	ay 4 😗 253 commits	Medical Affairs Applied Solutions ESAPI			
		ay 4 O 255 commits	tool to create ScoreCards and score plans; in-metric Boolean/expansion;			
NormalizeToScorecard	Update V18 action to use latest v18 ESAPI package	5 months ago	normalize dose to max score; multi-			
	Testing to run normalization through the same application, but those .	2 years ago	patient batch scoring			
PlanScoreCard	Added commented option for resolving expiration	2 months ago	🛱 Readme			
🗋 .gitattributes	Add .gitignore and .gitattributes.	2 years ago	গ্রীয় View license ☆ 13 stars			
🗋 .gitignore	Add .gitignore and .gitattributes.	2 years ago	<ul> <li>10 watching</li> </ul>			
BasicInstallQuickStart.md	Update BasicInstallQuickStart.md	10 months ago	😵 8 forks			
ChangeLog.md	Update ChangeLog.md	3 months ago	Report repository			
FAQ.md	Update FAQ.md	6 months ago				
InstallGuidePart2IntoSystemScriptsDi	Rename InstallGuidePart2IntoSystemScriptsDirectory,md to InstallGuid	e 10 months ago	Releases 4			
PlanScoreCard.sln	Update github actions to fix missing release attachment problem and	e 5 months ago	V16.1-PlanScoreCard-V3.1.7.12-0 Lates on Apr 3			
README.md	d Update README with batch mode screen and typo last month					
Troubleshooting.md	Create Troubleshooting.md	10 months ago				
license.txt	added license.txt	last year	Packages			
			No packages published			
iΞ README.md						
PlanScoreCard			Contributors 6			
			🎯 🚯 🄋 🔮 🛟			
Medical Affairs Applied Solutions ESAPI	tool to create dosimetric ScoreCards and score plans.					
Features:			Languages			
• Quantitative piecewise linear sc	oring functions for each metric		• C# 100.0%			
<ul> <li>optional: flag for point whe</li> </ul>	ere "variation acceptable" sited on referenced protocol		• C# 100.078			
	te referenced protocol or justification for metric (points)					
<ul> <li>optional: qualitative colors</li> </ul>	and labels for metric points, ie: orange="Just OK"					
<ul> <li>Advanced scoring criteria support</li> </ul>	orted					
Advanced scoring criteria support	orted					

Currently, the source code is shared on the Varian Innovation Center GitHub where it can be downloaded and complied with Visual Studio 2022 (including with the free community edition), now 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.

### B3 PlanScoreCard ESAPI tool: automatically generate derived structures

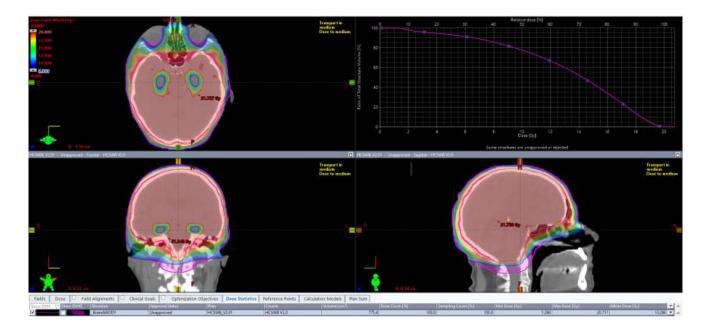
The PlanScoreCard tool has a feature where derived structures (made with Boolean and expansion tools) can be created automatically. These structures can be created temporarily (to be used for scoring the plan but never saved back to the database) or (if the ESAPI tool has been approved for writing) the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

Below are screen captures showing how to build structures

### **Ring Structure Generation**

Operation       Structure       Margin (mm)       Image: Complexity of the structure       Group 1       Image: Complexity of the structure	+	AND OR		or sub			Edit Grou		Groupings	ngs		
Brain         •         20         • <th>Operation</th> <th>Structure</th> <th></th> <th></th> <th>Margin (m</th> <th>um]</th> <th>+</th> <th>Group1</th> <th></th> <th></th> <th>đ</th> <th></th>	Operation	Structure			Margin (m	um]	+	Group1			đ	
AND   BODY  BODY  AND  BODY   O  C  C  C  C  C  C  C  C  C  C  C  C		Brain	٠	-	20	+		- KBrain > (2	0 SUB <brain>(</brain>	AND (BODY)		
Group1 - 0 - • <brain> 5 AND <body> ← ↓ ↑ →</body></brain>	SUB -	Brain	٠	•	5	+	Ĩ					
Group1 <body> <body <b<="" <body="" td=""><td>AND -</td><td>BODY</td><td>•</td><td>-</td><td>0</td><td>+</td><td><b>I</b></td><td></td><td></td><td></td><td></td><td></td></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body></body>	AND -	BODY	•	-	0	+	<b>I</b>					
	<brain> 20 SUB <brain> 5 AND</brain></brain>	D <body></body>								1	>	

# **Ring Structure**



**B3** PlanScoreCard ESAPI tool: automatically generate derived structures

# **Brainstem Target Structure Generation**

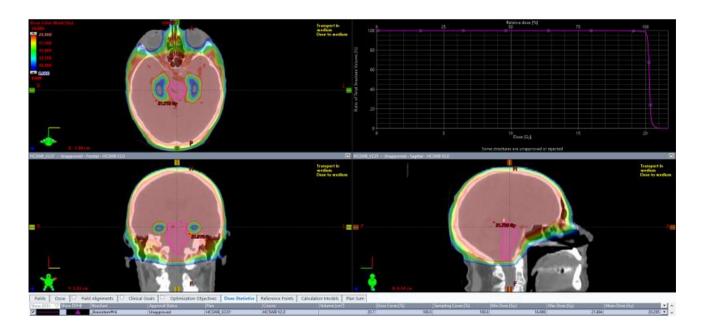
Brainstem SUB Hippocampi + 5mm



FINALIZE STRUCTURE

< <pre>{<brainstem></brainstem></pre>	lder Comment SUB <hippocampus_totl>(5)</hippocampus_totl>	)	
Structure Id:	_Brainstem#HI		

# **Brainstem Target Structure**



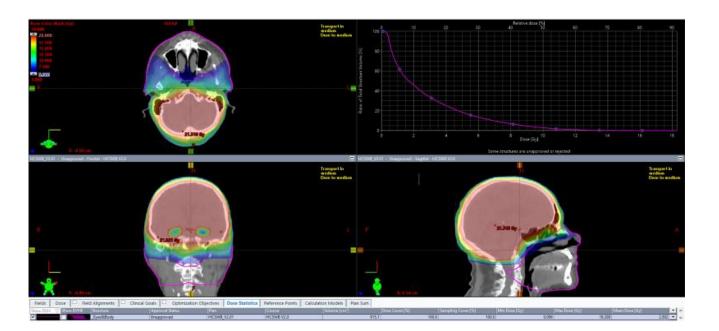
**B3** PlanScoreCard ESAPI tool: automatically generate derived structures

### **Face Structure Generation**

Eyes + 100mm, SUB Brain +20mm, and removed from outside of the body

	AND OR	SU	JB				Edi	t Groupings	
+	9	6	9						
Operation	Structure			Margin (mrr	+	Group	01		ď
	Leye	•	•	100	•	<leye></leye>	(100 OR <reye>)</reye>	100 SUB <brain>)</brain>	20 AND <800
OR .	Reye	•	•	100	•				
SUB	Brain	•	•	20	•				
AND	BODY	*	-	0	•				
Group1							0		•
<leye> 100 OR <reye> 100</reye></leye>	) SUB <brain> 20 AND <bc< th=""><th>DY&gt;</th><th></th><th></th><th></th><th>•</th><th>0</th><th>1</th><th>&gt;</th></bc<></brain>	DY>				•	0	1	>
	) SUB <8rain> 20 AND <80	DY>				•		↑	
<leye> 100 OR <reye> 100</reye></leye>	) SUB <8rain> 20 AND <80	IDY>				•		1	
<leye> 100 OR <reye> 100</reye></leye>	) SUB <brain> 20 AND <bc< td=""><td>)DY&gt;</td><td></td><td></td><td></td><td>÷</td><td></td><td>1</td><td></td></bc<></brain>	)DY>				÷		1	
<leye> 100 OR <reye> 100</reye></leye>	i SUB ≺8rain> 20 AND ≺80	)DY>				•		Ţ	
<leye> 100 OR <reye> 100</reye></leye>	I SUB ≺8rain> 20 AND ≺80	)DY>						•	
<leye> 100 OR <reye> 100</reye></leye>		)DY>				+		Ť	

# **Face Structure**

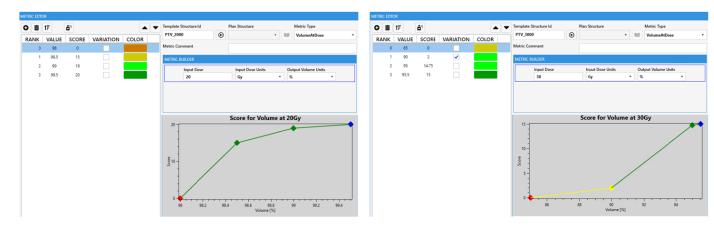


### **B4 Scorecard modifications** HLS-EC-WB from HSWBv2

#### PTV Brain – Volume at 20Gy (customized-not scaled)

**HLS-EC-WB** 

PTV Brain – Volume at 30Gy

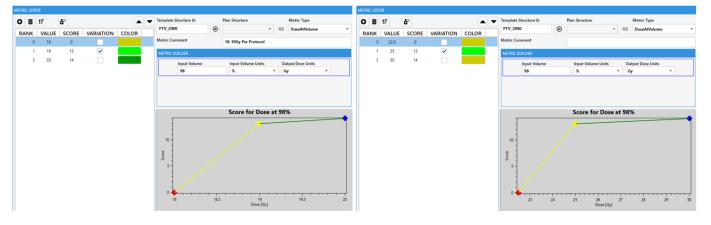


#### PTV Brain - Dose at 98% (scaled)

#### **HLS-EC-WB**

HSWBv2

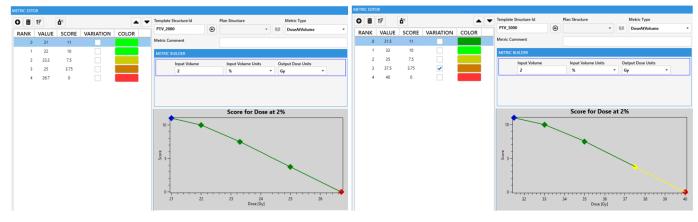
HSWBv2



PTV Brain – Dose at 2% (scaled)

**HLS-EC-WB** 

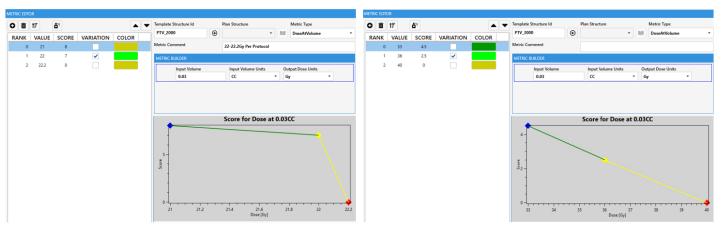




### **B4 Scorecard modifications** HLS-EC-WB from HSWBv2

#### PTV Brain – Dose at 0.03cc (customized-not scaled)



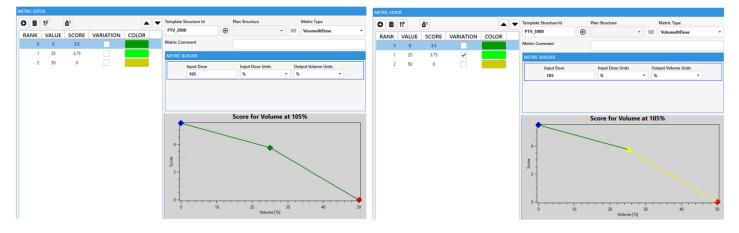


PTV Brain – Volume at 105%

**HLS-EC-WB** 

HSWBv2

HSWBv2

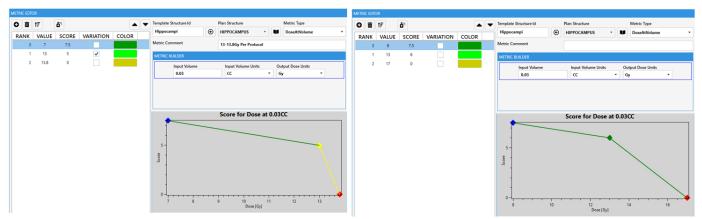


### **B4 Scorecard modifications** HLS-EC-WB from HSWBv2

#### Hippocampus- Dose at 0.03cc (customized-not scaled)



HSWBv2

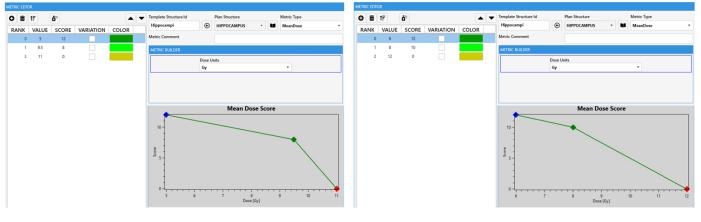


Hippocampus- Mean Dose (customized-not scaled)

#### **HLS-EC-WB**

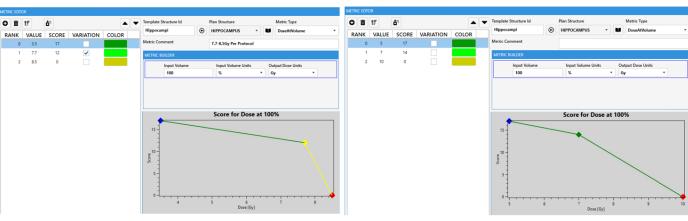
HSWBv2

HSWBv2



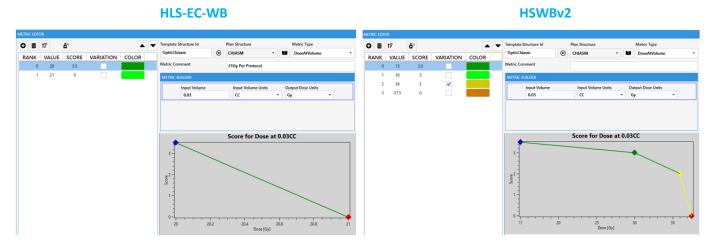
Hippocampus- Dose at 100% (customized-not scaled)

#### **HLS-EC-WB**



### **B4 Scorecard modifications** HLS-EC-WB from HSWBv2

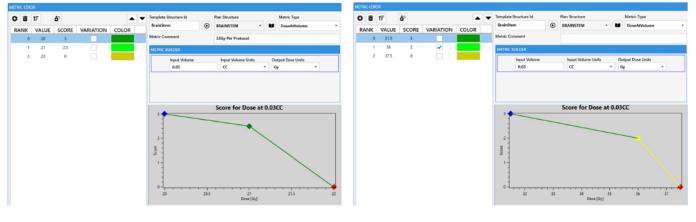
#### Optic Nerves and Chiasm- Dose at 0.03cc (customized-not scaled)



Brainstem- Dose at 0.03cc (customized-not scaled)

#### **HLS-EC-WB**

#### HSWBv2



2

Metric Type

DeseAtion

Output Dose Units
 Gy

21.5

Spinal Cord- Dose at 0.03cc (customized-not scaled)

. . Template Stri

COLOR

SpinalCord

Metric Com

3.5 -

Score 2.5 Input Vo

0 m tr

21 2 22.2 ô"

RANK VALUE SCORE VARIATION

#### **HLS-EC-WB**

Plan Stru ture

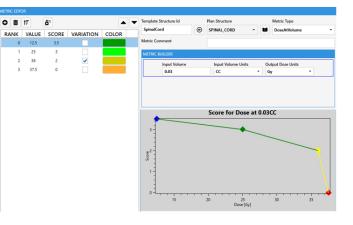
20.5

SPINAL CORD

Input Volume Units CC

Score for Dose at 0.03CC

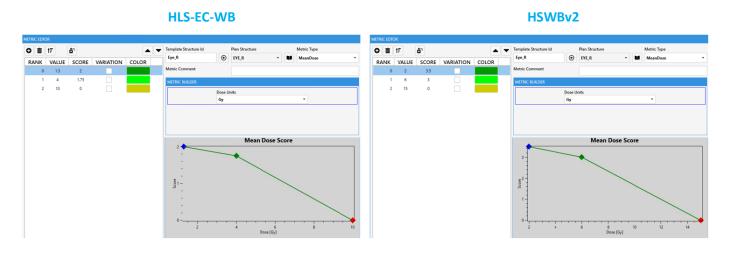
21 Dose [Gy]



#### HSWBv2

### **B4 Scorecard modifications** HLS-EC-WB from HSWBv2

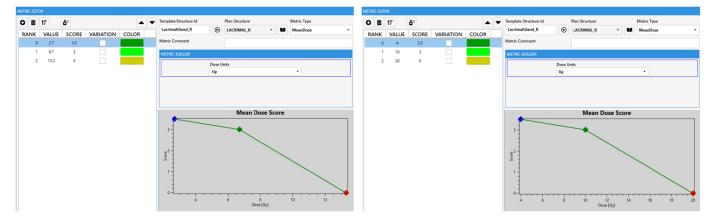
Eyes – Mean Dose (scaled)



#### Lacrimal Glands – Mean Dose (scaled)

#### **HLS-EC-WB**

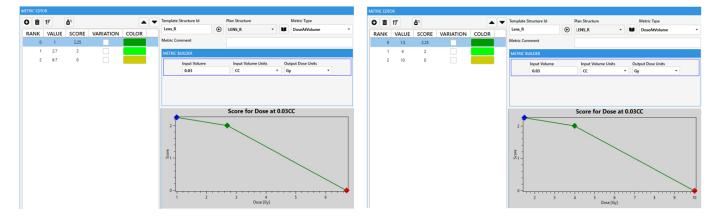
HSWBv2



Lens- Dose at 0.03cc (scaled)

#### HLS-EC-WB



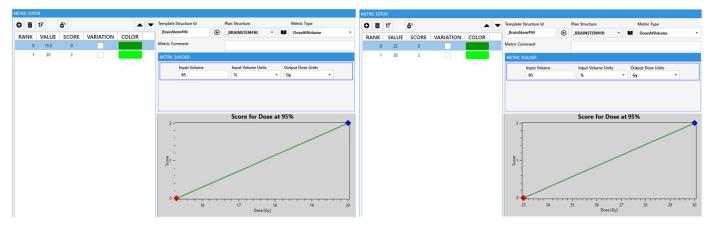


### **B4 Scorecard modifications** HLS-EC-WB from HSWBv2

Brainstem Sub Hippocampi + 5mm – Dose at 95% (scaled)

**HLS-EC-WB** 

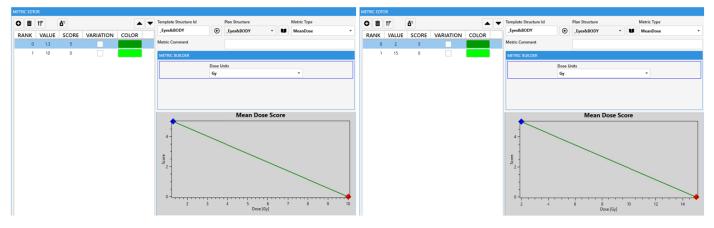
Brainstem Sub Hippocampi + 8mm - Dose at 95%



Face- Mean Dose (scaled)

HLS-EC-WB

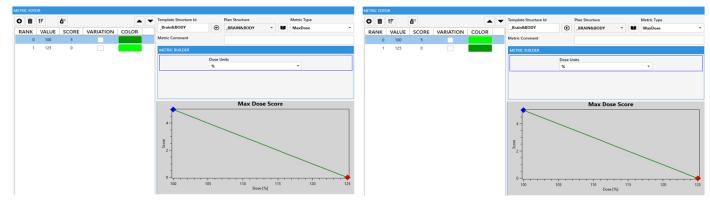
HSWBv2



Ring-Max Dose

#### **HLS-EC-WB**

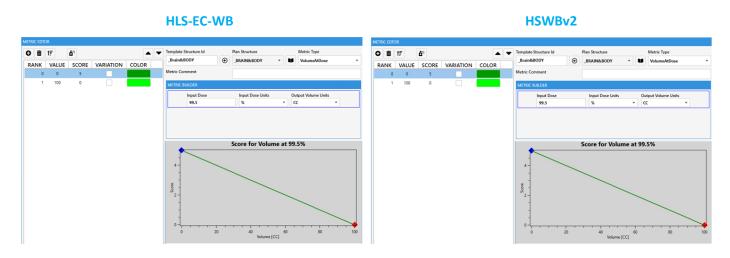




#### HSWBv2

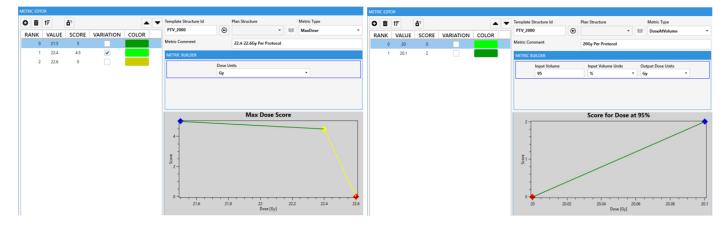
### **B4 Scorecard modifications** HLS-EC-WB from HSWBv2

Ring- Volume at 99.5%

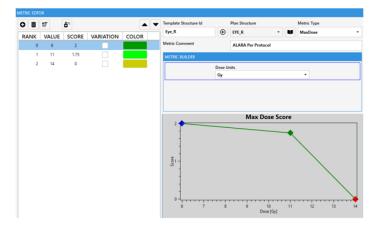


#### PTV Brain – Max Dose (NEW HLS-EC-WB)

PTV Brain – Dose at 95% (NEW HLS-EC-WB)



#### Eyes – Max Dose (NEW HLS-EC-WB)



# Annex C: Validation Results

**C1: Beam Arrangements** (6X-FFF, AcurosXB v17, extended convergence mode, MR3 return, 2x Intermediate dose)

HLS-EC-WB additional 5 case validation on Halcyon and TrueBeam (M120 MLC)

Halcyon SX2MLC: coplanar collimator: 315°, 0°, 45°, 90°.

#### Truebeam M120MLC

HyperArc: full 4 arc arrangement

4 Arcs Non-Coplanar: 2 full arcs 0° couch 315°/45°

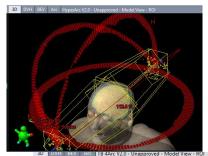
collimators and two vertex 180° (PA) -> 5° (from AP)

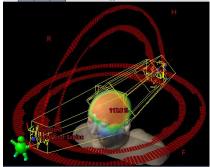
90° couch CW/CCW paired arcs with 315°/45° collimator

3 Arcs Coplanar: collimator: 315°, 45°, 90°

4 Arcs Coplanar: collimator same as 3 Arcs except

90° split X jaw superior/inferior to hippocampus

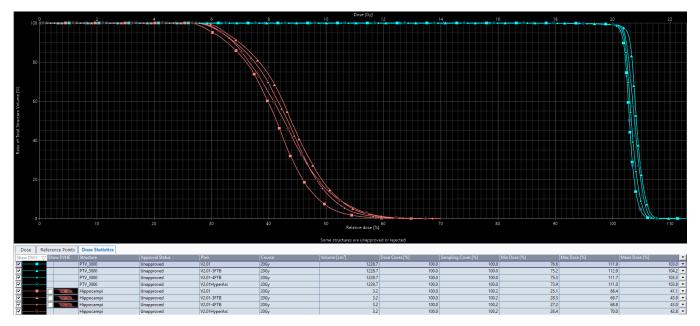




	Halcyon	TrueBeam						
	4 Arcs	4 Arcs (Non-	3 Arcs	4 Arcs	HyperArc (Non-			
Patient	(Coplanar)	Coplanar)	(Coplanar)	(Coplanar)	Coplanar)			
36	141.32	137.2	128.01	137	137.88			
37	143.93	141.02	140	142.28	138.16			
39	143.31	137.32	127.29*	138.12	137.01			
40	137.3	131.18*	117.89**	125.68*	131.36			
41	141.54	131.07	132.13	135.85	133.11			
Average	141.48	136.65	133.38	138.31	135.50			

\* For each metric failing (0 points received)

#### Patient 36 selected DVH:



### Annex C: Validation Results

# C2: 1xMR3, 2xMR3, 3xMR3 (Convergence Mode: Extended)

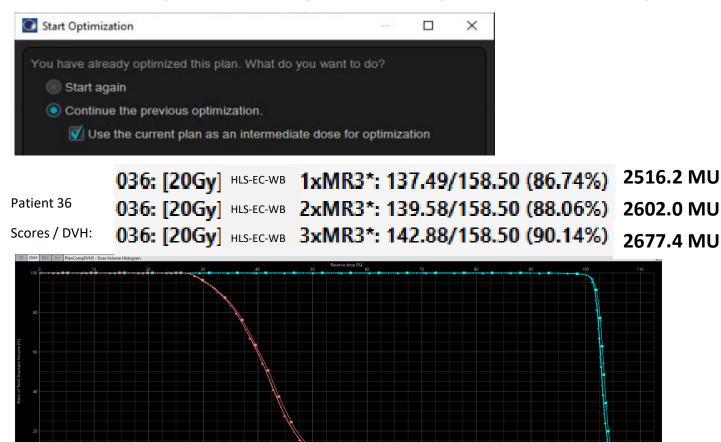
(v17 algorithms, extended convergence mode, MR3 return)

HLS-EC-WB additional 5 case validation on Halcyon

#### Always use extended convergence mode and MR3 return:

Calculation Options			X
Model PO RDS 17.0.1: Photon Optimiz Optimization algorithms for photon be			1XMR3= "Automatic Intermediate dose"
Photon optimizer calculation options	Convergence mode	Extended	Automatic Optimization Mode
🖻 General	MR level at restart	MR3	
Optimizer settings     Auto feathering	Aperture shape controller	Off	Automatic Intermediate Dose
	Convergence mode Defines how strict a convergence criterion is used in the c	pptimization.	Use GPU
			*GPU not required
		OK Cance	al and a second s

2XMR3 and 3XMR3: multiple Intermediate dose optimizations, "current plan as an intermediate dose for optimization"



### Annex C: Validation Results

C3: Rapidplan v15.6 and v17 model versions (Halcyon 4 arc, 6X-FFF, AcurosXB v17)

This model was created on a V17 Eclipse system. For backwards compatibility, all training set cases were exported and imported into a V15.6 system. The V15.6 model was trained and the optimization objectives from the V17 model were replicated. Finally, the V15.6 model was exported from the V15.6 system back into the V17 system and plans were reoptimized with scores compared with the results of the V17 native model.

	Halcyon							
	4 Arcs (Coplanar)							
Patient	V15.6	V17						
36	141.27	141.32						
37	144.45	143.93						
39	144.03	143.31						
40	137.58	137.3						
41	142.45	141.54						
Average	141.956	141.48						

C4: HLS-EC-WB model evolution process (scores) on validation set

	HLS-EC-WB Scorecard (158.5 points)							
Patient	V2.0 Model (Manual Scaling)	HLS-EC-WB Initial Model	HLS-EC-WB Initial Model (New Priorities)	Final HLS-EC-WB Recursive Model				
36	138.9	140	139.81	141.32				
37	143.32	144.66	145.24	143.93				
39	140.32	138.07	139.24	143.31				
40	133.21	127.92	132.74	137.3				
41	140.88	140.12	141.21	141.54				
Average	139.326	138.154	139.648	141.48				

### Annex D: Examples applying this model for Simultaneous Integrated Boost

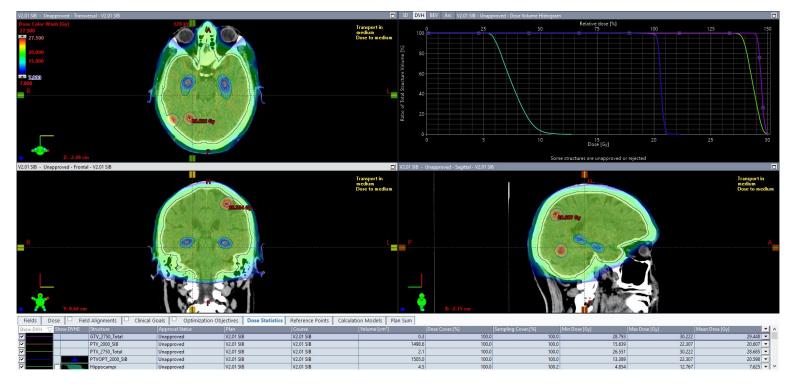
This model was trained for only the PTV whole brain target. However, it could be used to create SIB plans by cropping the PTV\_WBopt, with some additional margin, from the PTVBoost target(s). The PTV whole brain should also be removed from the high risk PTV + 7mm to evaluate heterogeneity within the target. In the below examples, an additional 7mm margin was also used between the WB\_PTVopt (20Gy) and the PTV\_Boost (27.5Gy) target.

After cropping additional margins out of the PTV whole brain and PTV\_WBopt, use HLS-EC-WB to automatically populate the optimizer as intended. Manually add upper and lower dose constraints for the PTVBoost, per prescription. Ensure that the margin removed from the WB\_PTVopt, to accommodate the PTVBoost, is not too conservative or aggressive. Consider increasing the MU objective Maximum MU to >2500 if utilizing this RapidPlan model for SIB treatment plans.

When using this method, the HLS-EC-WB model has no knowledge of the higher dose level target when generating the DVH prediction bands and relative optimization objectives. This situation could cause the model to create objectives that are no longer relevant for your patient and could, as a result, create undesirable plans. The degree to which the objectives are off relates directly to the distance that the higher dose target is from the OARs. This is especially important for the hippocampus DHV bands being predicted and the increased dose the high risk PTV is prescribed relative to the PTV whole brain. In scenarios where the PTVboost is near the hippocampi, it is advised to copy the hippocampi into an evaluation structure and that is cropped with an additional margin away from the PTVboost. This hippocampi evaluation structure is to then be matched to the hippocampi in the HLS-EC-WB model for DVH estimation and optimization. Due to these various clinical scenarios, the usage of SIB cannot be endorsed by the creators of this model. However, what each user does with this model is at the discretion of the user and their associated clinical, physics, and medical staff.

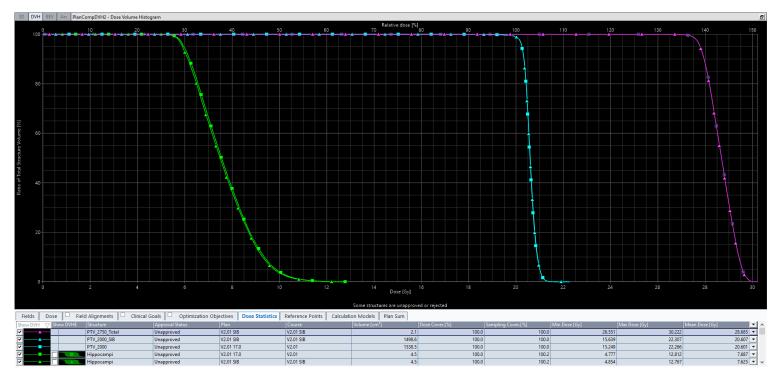
### D1: Example SIB Plan 27.5Gy in 5Fx

PTV\_2750\_Total boost to 27.5Gy and PTV\_2000\_SIB to 20Gy (Halcyon 4 arc, 6X-FFF, AcurosXB v17).



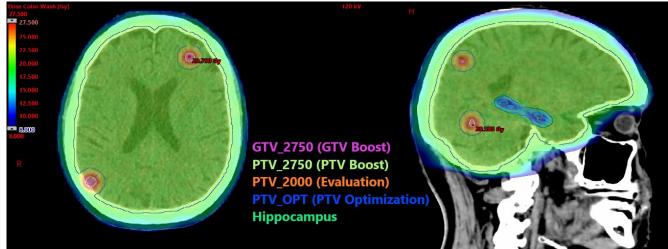
### **D2: SIB DVH Comparison**

DVH comparison: SIB (HCSWB\_SIB) vs Non-SIB (HCSWB HLS-EC-WB) plans



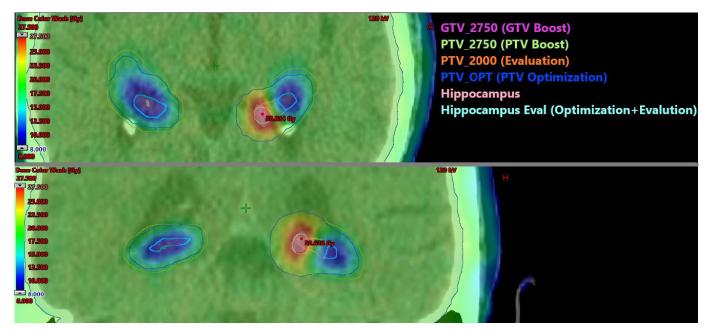
### **D3: SIB planning structures**

PTV\_2000 structure cropped 5mm from hippocampus and 7mm from PTV\_2750 PTV\_OPT optimization structure cropped 4mm from hippocampus and 7mm from PTV\_2750



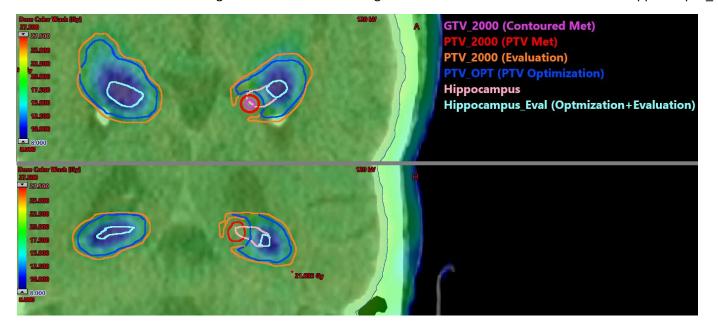
### D4: PTV boost proximity to hippocampi

CCTG CE. 7 allows for hippocampal sparing wherever possible, even with metastasis close to or overlapping. In the below example, to achieve desired hippocampal sparing with this proximity to the boost volume, the Hippocampus is copied and cropped by 5mm from the PTV boost. This hippocampus\_Eval structure is then matched to the hippocampus structure in the HLS-EC-WB model for optimization and evaluation.



### D5: Metastases proximity to hippocampi (sequential boost)

The following workflow can be used in the occurrence for when contoured brain metastases are in proximity of the hippocampus and sequential boosting is implemented. To maintain prescription dose (20Gy) to the contoured GTV and PTV brain metastases, the hippocampus is copied and cropped by 5mm from the "PTV met". This hippocampus\_Eval structure is then later matched to the hippocampus structure in the HLS-EC-WB model for optimization and evaluation. After the PTV\_2000 structure and PTV\_OPT structures are cropped 5mm and 4mm from the hippocampus respectively, the PTV Met with an additional 2mm margin can be added back to the both the PTV\_2000 and PTV\_OPT. This allows the model to account for the desired gradient to achieve coverage of the PTV met and reduce dose to the hippocampus\_Eval.



### Annex E: Acknowledgements

Manually optimized plans created by Ryan Clark, MS CMD

All data generated and complied by Ryan Clark, MS CMD and Anthony Magliari, MS CMD

Dosimetric Scorecard HLS-EC-WB and derived structures designed by Anthony Magliari, MS CMD and Ryan Clark, MS CMD

Model generated plans created by Lesley Rosa, CMD, Ryan Clark, MS CMD and Anthony Magliari, MS CMD

Clinical Description document created by Anthony Magliari, MS CMD, Ryan Clark, MS CMD and Lesley Rosa, CMD

Please reference future publication:

Dosimetric Scorecards express clinical intent with precision: alternate hippocampal sparing whole brain RapidPlan models with enhanced target coverage, homogeneity and less aggressive hippocampal sparing

Kareem Rayn, Anthony Magliari, Ryan Clark, Lesley Rosa, Robert Doucet, Line Comeau, Alan Nichol, Russel Ruo, David Roberge

# Annex F: Distribution and compatibility

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

https://medicalaffairs.varian.com/wholebrain-limited-hippocampalsparing-20gy-vmat2

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 created, tested, and rebuilt with both Eclipse v17.0 and v15.6. For older versions of Eclipse (v13.x), please find the older HSWBv1.