Automation and Standardization of Planning, Plan Evaluation and System Testing Through Advanced Programming in Treatment Planning System

Improve Plan Evaluation with Advanced Scripting

Charles Mayo, Ph.D. University of Michigan

MO-B-KDBRA2-0 Monday 8:30 – 9:30 am Karl Dean Ballroom A2



Disclosures

Grant Support Varian Medical Systems

Patent protections



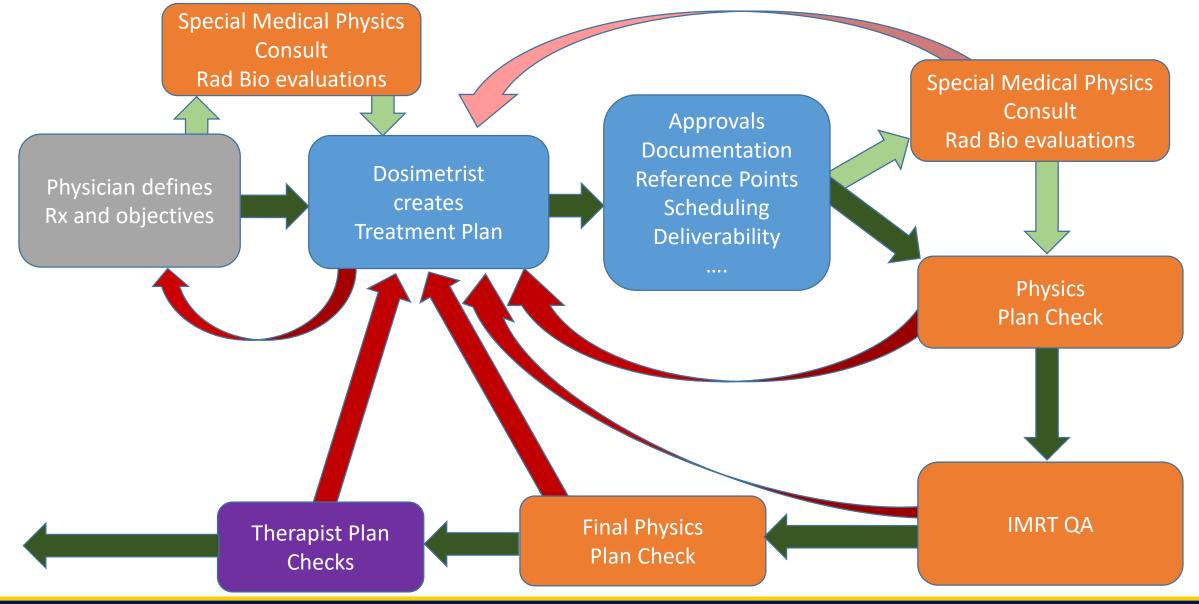
Acknowledgements

- Jean Moran PhD
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Plan Evaluation has Many Component Nodes and Connections



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MICHIGAN MEDICINE
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Standardizations are key to improving plan evaluation through scripting

Reduce variability and inconsistencies

Example TG-263 : Nomenclature for structures, targets, DVH metrics



We often treat to multiple dose levels.

Patient Activities:																																					
					20	017																													20	17	
Timeline Displayed:	Su 26	Mo 27	Tu 28	We 1	Th 2	Fr	Sa	Su 5	Mo 6	Tu 7	We	Th	Fr 10	Sa 11	Su 12	Mo 13	Tu 14	We 15	Th 16	Fr 17	Sa 18	Su 19	Mo 20	Tu 21	We 22	Th 23	Fr 24	Sa 25	Su 26	Мо 27	Tu 28				 _		Tu 4
Prescription R	20	21	20	-	2		-	5	Ū	,		-	10		12	15	14	15	10	1/	10	1	20		22	2.5	24	23	20	21	20	. 25		51			-
▲ Treatment																																					
1.1 PLVS VMAT (25/25)		19	20	21	22	23			24	25																											
1.2 PSV+LN VM (8/8)											1	2	3			4	5	6	7	8																	
1.3 P+SV VMAT (11/11)																							1	2	3	4	5			6	7	8	و	10		11	
Imaging		\checkmark	\checkmark	\checkmark	\checkmark	\checkmark			\checkmark	\checkmark	\checkmark	\checkmark	\checkmark			\checkmark	✓			\checkmark			\checkmark	\checkmark	\checkmark	\checkmark	\checkmark			\checkmark	\checkmark)	\checkmark	\checkmark		\checkmark	
Overrides/Exceptions																																					
Trends																																					
																																					_



	Plan	N Fractions	PTV_High (Prostate + SV)	PTV_Mid00 (Prostate + SV + LN)	PTV_Low (Pelvis)
Here's what we need to	1.1 PLVS VMAT	25	45	45	45
know to script checks	1.2 PSV+LN VM	8	14.4	14.4	0
with matching	1.3 P+SV VMAT	11	19.8	0	0
with matching reference points		Total	79.4	59.4	45

	< ·	1 PELVIS						ACTIVE	
	▼ (☑ View	🖻 Edit	PROST+SV VMA	T 6X : R0				
		Volume	Dose/Frac:	Number Of Fractions:	Total Dose:	Frequency:	Energy:	Technique:	Linked Plans:
		PROST+SV	1.800 Gy	11	19.800 Gy	5 Fx/Week	06X	VMAT	1.3 P+SV VMAT
2	▼ (View	🖻 Edit	PROST+SV + LN	BOOST VMAT	6X : R0			
-		Volume	Dose/Frac:	Number Of Fractions:	Total Dose:	Frequency:	Energy:	Technique:	Linked Plans:
		P+SV+NODES	1.800 Gy	8	14.400 Gy	5 Fx/Week	06X	VMAT	1.2 PSV+LN VM
	▼ (View	🖻 Edit	PELVIS VMAT 6X	(: R0				
		Volume	Dose/Frac:	Number Of Fractions:	Total Dose:	Frequency:	Energy:	Technique:	Linked Plans:
		PELVIS	1.800 Gy	25	45.000 Gy	5 Fx/Week	06X	VMAT	1.1 PLVS VMAT

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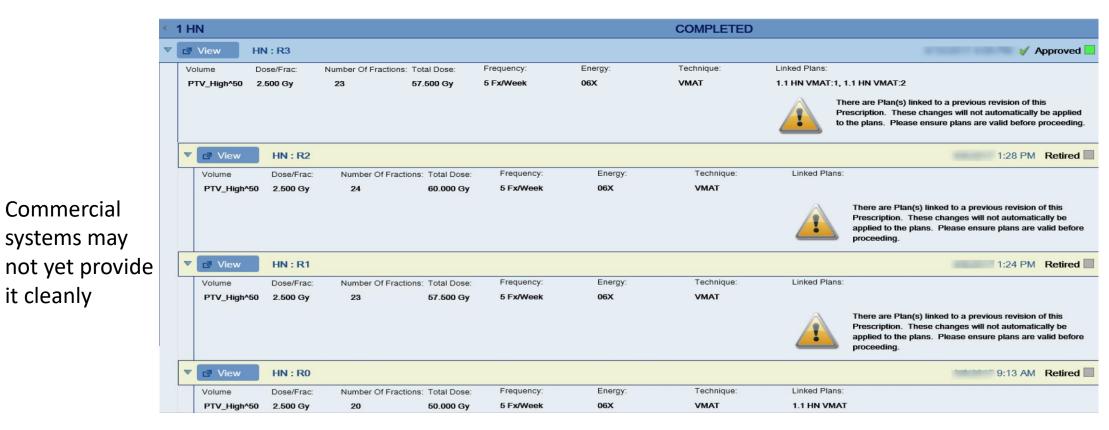
Commercial systems may not yet provide it cleanly

There may be changes to plans during treatment

	Patient Activities:									\square																									
	Timeline Displayed:																							201	.7										
	nineline Displayed:		Su 12		Tu 14	We 15	Th 16	Fr 17	Sa 18	Su 19					Fr 24	Sa 25	Su 26	Mo 27	Tu 28	We 29	Th 30	Fr 31	Sa	Su	Mo	Tu	We 5	TI 6	Fr	Sa 8	Su 9	Mo 10	Tu 11	We 12	
Prescr	ription R	11	12	15	14	15	10	1/	10	19	20	21	22	25	24	25	20	21	20	29	50	51	1	2	2	4	5			0	9)	12	15
 Treatr 	ment T_X																												ᇫ						
4 1.1	1 HN VMAT (23/23)			1	2	3	4	5			6	7	8	و	10			11	12	13	14	15			16	17	18	19	20			21	22	23	
	1.1 HN VMAT			1	2	3	4	5			6	7	8	و	10			11	12	13	14	15			16	17	18	19							
	1.1 HN VMAT:1																												20			21			
	1.1 HN VMAT:2																																22	23	
> Imagi	ng 🛃			\checkmark	\checkmark	\checkmark	\checkmark	\checkmark			\checkmark	\checkmark	\checkmark	\checkmark	\checkmark			\checkmark	\checkmark	\checkmark	\checkmark	\checkmark			\checkmark	\checkmark	\checkmark	\checkmark	\checkmark			\checkmark			
> Overri	ides/Exceptions			!															:	:								1				1		•	
Trend	s 📥																																		



Here's what we need to	Plan	N Fractions	PTV_High	Plan	N Fractions	PTV_High (PTV_High^50)
know to	Pidii		PTV_High^50)	1.1 HN VMAT	19	47.5
script checks	1.1 HN VMAT	25	50	1.1 HN VMAT :1	2	5
with matching		Total	50	1.1 HN VMAT :2	2	5
reference points					Total	57.5





it cleanly

BluePrint : University of Michigan Electronic Prescription and Plan QA System

←	Goals					- 6	×
\$JP_HN1, Sta	Structure	Priority	Goal	Primary	Comments	Data Sets	
\$JP_HN1 Birthdate 7/31/19						Planning CT 20170720HN Image 20170720HN	•
Oncologist ZQA Do	Active Goals Targets					7/20/2017 3:18 PM	
Manage directives	PTV	1 2 3	D95%[Gy] > 50.00	. 45.74 Gy	Comments	Add Data Set	
Contents Directive and Plannir	-		-			Course	
Contours	O PTV	1 2 3	D0.1cc[%] ≤ 130.00	✓ 127.18%	Comments	1 Head/Neck	•
Prescriptions Goals	OARs					Plans	
Plan Parameters Special Instructions	Bowel_Small	1 2 3	D0.5cc[Gy] ≤ 30.00	1.83 Gy	Comments	HN SBRT 2.1 HN SBRT Data Set 4/4/2018 6:52 P	M
IGRT Details IGRT Goals	🔵 Colon	1 2 3	D0.5cc[Gy] ≤ 30.00	12.89 Gy	Comments	Planning CT UnApproved	
	Duodenum	1 2 3	D0.5cc[Gy] ≤ 30.00	👽 9.44 Gy	Comments	Add Plan	
	e Esophagus	1 2 3	D0.5cc[Gy] ≤ 52.50	📀 6.39 Gy	Comments		
	e Esophagus	1 2 3	V27.5Gy[cc] ≤ 5.00	🕑 0.00 cc	Comments		
	Heart	1 2 3	D0.5cc[Gy] ≤ 52.50	🕑 8.78 Gy	Comments		
	Heart	1 2 3	V32Gy[cc] ≤ 15.00	🕑 0.00 cc	Comments		
	O Kidneys	1 2 3	V17.5Gy[cc] ≤ 200.00	🕑 0.00 cc	Comments		
	O Kidneys	1 2 3	V17.5Gy[%] ≤ 35.00	0.00%	Comments		
	Liver-GTV	1 2 3	CV15Gy[cc] > 700.00	🜠 697.61 cc	Acceptable variation Comments	Martha Matu	
	SpinalCord	1 2 3	D0.5cc[Gy] ≤ 25.00	S.83 Gy	Comments	Carlos Anders	son PhD
	O Stomach	1 2 3	D0.5cc[Gy] ≤ 30.00	📀 6.50 Gy	Comments	University of	Michigan
	Chestwall	1 2 3	V35Gy[cc] < 70.00	245.06 cc	Comments		
	Add Goal Show In-	active Goals					



rescription Constraints: Prost	tate - ConvFX		▼ N	Normal Tissue Constraints	: Prostate - ConvFX	
 Single Site Multiple 						
arget Dose Volume Definitions	C Only High C	High and Low	High, Inter	mediate and Low		
Relative Dose	Alias		Contains	\$		
ptv_high	ptv7800		prostate a	nd seminal vesicles		
ptv_intermediate	ptv5940		gross pelv	vic nodes		
ptv_low	ptv4500		remaing p	elvic nodes		
Number of Prescription Fraction	ns in Total Dose 3	•			Dose for fractions must be entered in	*centi-Gray*!
Group	Number of Fraction	ons PTV Hi	gh	PTV Intermediate	PTV Low	
Initial Volume	25	5000 (20	10 cGy per Fx)	4500 (180 cGy per Fx)	4500 (180 cGy per Fx)	
1st Boost	8			1440 (180 cGy per Fx)		
2nd Boost	6	1200 (20	0 cGy per Fx)	0 (0 cGy per Fx)	0 (0 cGy per Fx)	
Total	39	7800 c	Gy	5940 cGy	4500 cGy	
Calcs - only Prescription DVH Constraints	Add	s and then qMon	and Thurforth	ne rest of treatments	entire course; CBCT – preRT daily for the firs	-
Structure		Endpoint	Со	nstraint Value	Planning Priority	
		•	Co	nstraint Value	Planning Priority Report	-
Structure	DVH	Gy]		nstraint Value		<u> </u>
Structure	DVH Max[Gy] %]		nstraint Value	Report	
Structure	DVH Max[Max[Gy] %] Gy]		nstraint Value	Report Report	• •
Structure ✓ ptv7800	DVH Max[Max]	Gy] %] 3y] &]		nstraint Value	Report Report Report	
Structure	DVH Max[Max[Min[Min]	Gy] %] 3y] 6] 1[Gy]		nstraint Value	Report Report Report Report	•
Structure ✓ ptv7800	DVH Max[Max[Min[Min] Mear	Gy] %] &] (] (Gy] %]			Report Report Report Report Report	
Structure ✓ ptv7800	DVH Max[Min[Min] Mear D2%	Gy] %] &] &] 4] 4] (Gy] (%] (%] (%]			Report Report Report Report 3	
Structure ✓ ptv7800	DVH Max[Min[Min] Mear D2% D5%	Gy] %] 3y] 6] 1(Gy] [%] [%]		107 %	Report Report Report Report 3 Report	
Structure ✓ ptv7800	DVH Max[Max] Min[0 Min] Mear D2% D5% D5% D95°	Gy] %] %] %] %] %] %] %] %] %] %] %] %] %]		107 %	Report Report Report Report 3 Report 3	
Structure ✓ ptv7800	DVH Max[Min](Min](Min]2 Mear D2% D5% D953 D953 D953 V110	Gy] %] %] 6] 6] %] %] %] %] %[%] %[%] %[%]		107 % 99 %	Report Report Report Report 3 Report 3 Report 3 Report	•
Structure ✓ ptv7800	DVH Max[Max[Min](Min](Min]2 Mear D2% D5% D953 D983 V110 V983	Gy] %] %] 6] 6] 6] 73] 74] 74] 74] 74] 74] 74] 74] 74] 74] 74		107 % 99 % 0.5 cc	Report Report Report Report 3 Report 3 Report 2 1	
Structure ✓ ptv7800	DVH Max[Max[Min] Min] Mear D2% D5% D95 D98 V110 V987 V997	Gy] %] %] %] %] %[%] %[%] %[%] %[%] %[%]		107 % 99 % 0.5 cc 98 % 98 %	Report Report Report Report 3 Report 3 Report 2 1 2	
Structure ✓ ptv7800	DVH Max[Min](Min](Min] Mear D2% D5% D5% D95 D98 V110 V985 V995 V995	Gy] %] %] %] %[%] %[%] %[%] %[%] %[%] %[%] %[%]		107 % 99 % 0.5 cc 98 % 98 % 95 %	Report Report Report Report 3 Report 3 Report 2 1 2 2	
Structure ✓ ptv7800	DVH Max[Max] Min[3 Min]3 Mear D2% D5% D5% D953 D953 V110 V983 V110 V983 V100 V107	Gy] %] %] %] %] %[%] %[%] %[%] %[%] %[%] %[%] %[%] %[%] %[%] %[%] %[%]		107 % 99 % 0.5 cc 98 % 98 %	Report Report Report Report 3 Report 2 1 2 1 1	
Structure ✓ ptv7800	DVH Max[Max] Min[3 Min]3 Mear D2% D5% D953 D953 V110 V993 V100 V107 V04	Gy] %] %] %] %[%] %[%] %[%] %[%] %[%] %[%] %[%]		107 % 99 % 0.5 cc 98 % 98 % 95 %	Report Report Report Report 3 Report 3 Report 2 1 2 2	

Target DVH Objectives			Priority	Achieved
ptv6480	Max[Gy]		Report	70.14 Gy
	Max[%]		Report	108.2 % (70.13Gy)
	Min[Gy]		Report	58.1 Gy
	Min[%]		Report	89.7 % (58.1Gy)
	Mean[Gy]		Report	67.18 Gy
	D2%[%]	<= 107 % (69.34Gy)	3	106.2 % (68.84Gy)
	D5%[%]		Report	105.8 % (68.56Gy)
	D95%[%]	>= 99 % (64.15Gy)	3	100.9 % (65.41Gy)
	D98%[%]		Report	99.6 % (64.52Gy)
	V110%[cc]	<= 0.5 cc	2	0 cc
	∨98%[%]	>= 98 %	1	99.1 %
	V99%[%]	>= 98 %	2	98.6 %
	V100%[%]	>= 95 %	2	97.4 %
	V107%[%]	<= 2 %	1	0.2 %
	Volume[cc]		Report	249.5 cc
	CV98%[%]	<= 2 %	1	0.9 %
	CV98%[cc]		Report	2.14 cc
ptv5625	Max[Gy]		Report	69.67 Gy
	Max[%]		Report	123.9 % (69.67Gy)
	Min[Gy]		Report	55.55 Gy
	Min[%]		Report	98.8 % (55.55Gy)
	Mean[Gy]		Report	64.19 Gy

Mayo et al, Practical Radiation Oncology 2016; 6(4): e117-e126 PM26825250



Brain Site Example-BN001 Plan Evaluation

Eclipse Scripts Plan Evaluation Results for BN001

(NRG-BN001)

Name (ID)
 Plan or PlanSum ID: EXPORTMHTest

Printed :2016-11-08 10:49:35

Structure ID	Structure Code	Patient Structure	DVH Objective	Evaluator	Variation	Priority	Met	Achieved
PTV_4600		PTV_4600	D95%[Gy]	>=46	43.7	2	Goal	51.541 Gy
PTV_6000		PTV_6000	D95%[Gy]	<=60.75	63	2	Not met	76.307 Gy
PTV_6000		PTV_6000	D95%[Gy]	>=59.75	57	2	Goal	76.307 Gy
PTV_6000		PTV_6000	D10%[Gy]	<=63	65.12	2	Not met	79.647 Gy
PTV_6000		PTV_6000	D0.03cc[Gy]	<=64	66	2	Not met	81.210 Gy
PTV_5000		PTV_5000	D95%[Gy]	>=50	47.5	2	Goal	51.205 Gy
PTV_7500		PTV_7500	D95%[Gy]	<=75.75	78.75	2	Goal	71.603 Gy
PTV_7500		PTV_7500	D95%[Gy]	>=74.25	71.25	2	Variation	71.603 Gy
PTV_7500		PTV_7500	D10%[Gy]	<=78.7	81.4	2	Variation	79.524 Gy
PTV_7500		PTV_7500	D0.03cc[Gy]	<=80	82.5	2	Variation	81.210 Gy
SpinalCord		SpinalCord	D0.03cc[Gy]	<=50	50	1	Goal	8.137 Gy
BrainStemCore		BrainStemCore	D0.03cc[Gy]	<=55	60	2	Variation	59.867 Gy
BrainStemSurf		BrainStemSurf	D0.03cc[Gy]	<=55	64	2	Variation	63.579 Gy
OpticChiasm_PRV		OpticChiasm_PRV	D0.03cc[Gy]	<=55	60	2	Variation	58.335 Gy
OptNrv_L_PRV		OptNrv_L_PRV	D0.03cc[Gy]	<=55	60	2	Goal	41.774 Gy
Retina_L		Retina_L	D0.03cc[Gy]	<=45	50	2	Goal	13.454 Gy
Retina_R		Retina_R	D0.03cc[Gy]	<=45	50	2	Goal	31.863 Gy
Brain		Brain	D5%[Gy]	<=78.7	81.4	1	Goal	64.170 Gy
Lens_L		Lens_L	D0.03cc[Gy]	<=7	10	2	Goal	5.425 Gy
Lens_R		Lens_R	D0.03cc[Gy]	<=7	10	2	Variation	

Ying Xiao, Ph.D. UPENN, NRG

Center for Innovation in Radiation Oncology



Scripting to standardize calculations of physical and biological dose metrics

Note: Note: <th< th=""><th>O DVH Analysis</th><th></th><th></th><th></th><th></th><th></th><th> 🗆 🗡</th><th><</th></th<>	O DVH Analysis						🗆 🗡	<
Choose at Emplate to load: Metric 2.11L_LNG 0.5VC1+C2 Metric Properties Apply Create New 0.003cc(C), colp=2.5][EQD2Gy] [Changed] ¥ 7.06 Gy 9.87 Gy DVH Model Properties Ø BODY 0.003cc(C), colp=2.5][EQD2Gy] [Changed] ¥ 6.10 Gy (L(2) 8.38 Gy (L(2)) DVH Model Properties Ø BODY 0.003cc(C), colp=2.5][EQD2Gy] [Changed] ¥ 2.87.4 Gy (L(2) 0.003cc(C) 0.003cc(C), colp=2.5][EQD2Gy] [Changed] ¥ 2.87.4 Gy (L(2) 0.003cc(C) 0.003cc(C)	DVH ANALYSIS S UNIVERSITY OF MICHIGAN HEALT	CRIPT H SYSTEM	Patient:)
Notice LatL(Not Schule Note Note <td>Templates</td> <td>Metrics Volumes</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	Templates	Metrics Volumes						
Apply Create New Structures © BOOY © Brochus,Main © Ecophague © Graves © SpinalCord © Graves All Math Math Math <		Metric	2.1tL_LNG 0.5	i*C1+C2		Metric Propertie	25	
Φ SpinalCord SpinalCord_PRV Φ D0.03cc(LQ, α/β=2.5)[EQD2Gy] [Changed] 20.78 Gy 31.16 Gy Φ D0.03cc(LQ, α/β=2.5)[EQD2Gy] [Changed] 30.68 Gy (LQ2)	Apply Create New Structures BODY Bronchus_Main Esophagus GreatVes GTV Heart ITV Lung_L Lungs	SpinalCord D.0.3cc[Gy] D.0.3cc[LQ, α/β=2.5)[EQD2Gy] [Changed] Esophagus D.0.3cc[Gy] D.0.3cc[LQ, α/β=2.5)[EQD2Gy] [Changed] Mean[Gy] Mean(LQ, α/β=2.5)[EQD2Gy] [Changed] GreatVes D.0.3cc[Gy] D.0.3cc[Gy] Heart	7.06 Gy 9 6.10 Gy (LQ2) 8.38 19.95 Gy 30 28.74 Gy (LQ2) 43.90 6.34 Gy 9 6.27 Gy (LQ2) 9.14 22.00 Gy 33 33.60 Gy (LQ2) 50.50	2.87 Gy 8 Gy (LQ2) 0.23 Gy 6 Gy (LQ2) 9.24 Gy 4 Gy (LQ2) 3.00 Gy 0 Gy (LQ2)		Metric type: Mean DVH Model Pro DVH model type: L Dose type: O Absolute O Relative α/β:	Dose perties QBioDose Volume type: Absolute Relative 2.5	
	SpinalCord_PRV	OD.03cc(LQ, α/β=2.5)[EQD2Gy] [Changed] Bronchus_Main OD.03cc[Gy]	32.89 Gy (LQ2) 48.90 20.78 Gy 31	0 Gy (LQ2) 1.16 Gy	Ç€			
			View DVHs	Export to Excel	BioEval Report	Metrics	Templates	

Martha Matuszak, Ph.D., Carlos Anderson Ph.D University of Michigan



Scripting to Evaluate Plan in Context of Prior Plans

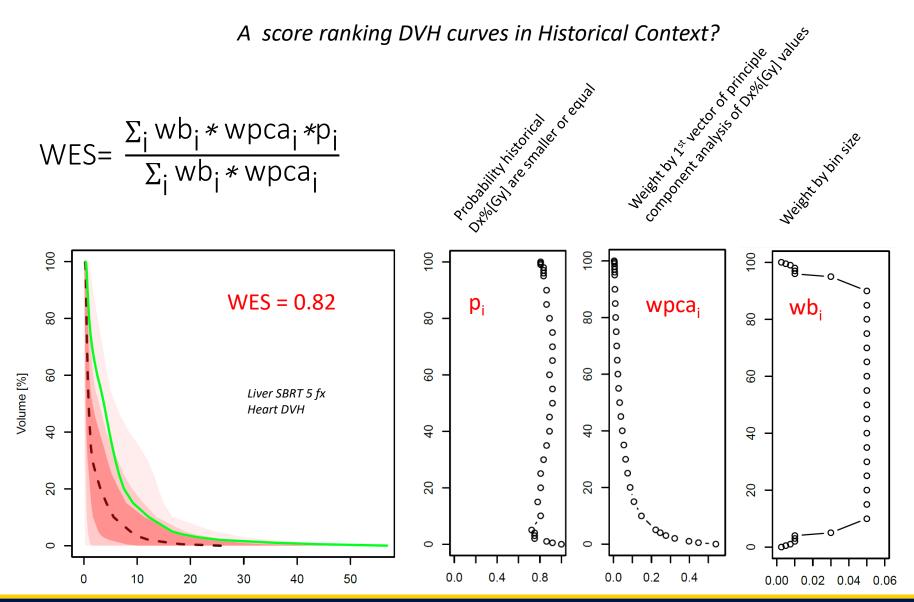
• Statistical DVH

- Visualization method quantifying comparison of plan DVH curve with historical values
- Weighted Experience Score (WES)
 - Ranking score (0-1) quantifying comparison of <u>DVH curves</u> to historical values
- Generalized Evaluation Metric (GEM)
 - Ranking score (0-1) quantifying comparison of <u>DVH metrics</u> to constraints and historical values
- Population Generalized Evaluation Metric (GEM_{POP})
 - Ranking score (0-1) quantifying <u>As Low As Reasonably Achievable (ALARA)</u> using historical values for <u>DVH metrics</u>

Mayo CS, Yao J Eisbruch A, et al. Incorporating big data into treatment plan evaluation: Development of statistical DVH metrics and visualization dashboards. Advances in Radiation Oncology 2017; 2(3):503-514



Weighted Experience Score



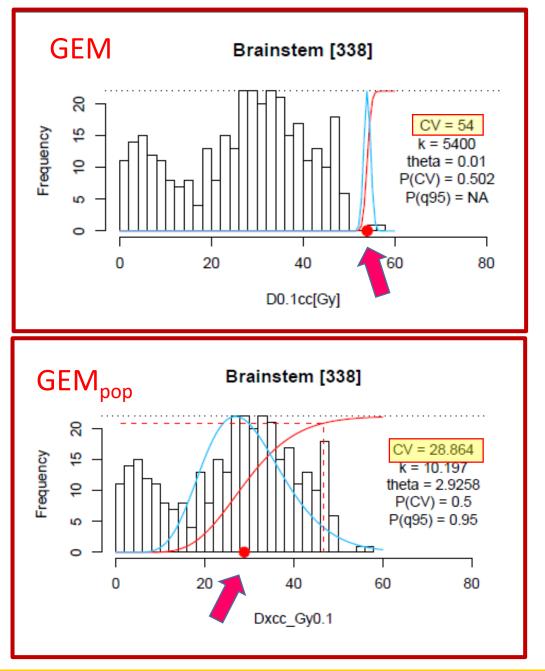


Generalized **E**valuation **M**etric

A score ranking ability to meet dose constraints, in historical context

Structures	Drawn	Priority	Parameter	Planning Limit	— A	Acceptable	e value compa	ared to constrain
	by				<u> </u>	-	-	
Rectum	MD	1 or	Max Dose to 0.1 cc (including PTV			1		COMMICCOMMICCOMMICCO
			overlap) ≤ Rx dose				de la constanción de	Rat Contraction of the second s
		1 or	<15% ≥ 75 Gy			Vee	000	95% values 5
		1 or	<25% ≥ 70 Gy		8	Yes	°	Values -
		1 or	<35% ≥ 65 Gy				i i i i i i i i i i i i i i i i i i i	
		1 or	<50% ≥ 50 Gy				° (
		3 or	<5% ≥ 75 Gy		o l		Maybe 🗸	This plan
		3 or	<15% ≥ 70 Gy		9 0			is plan
		3 or	<17% ≥ 65 Gy ALARA		5	L	0	
		4 or			GEM		<u></u>	
Bladder	MD	3 or	<25% ≥ 75 Gy		0 4	-	o	
		3 or	<35% ≥ 70 Gy				0	
		3 or	<50% ≥ 65 Gy ALARA				°	
Example	Dealer	4 or					0	
Femur R/L	Dosim	3 or 4 or	Max ≤ 45 Gy ALARA		0 -	-		
Penile Bulb	MD	3 or	Mean ≤ 50 Gy				e e e e e e e e e e e e e e e e e e e	l i l l l l l l l l l l l l l l l l l l
	IVID	4 or	ALARA				A CONTRACTOR OF	
Bowel	MD	1 or	Max to 1cc ≤ 54 Gy		- 8 -		8800	No
Dowei	IVID	4 or	ALARA					
Sigmoid	MD	401	Max to 1cc ≤ 60 Gy			0 20	40 thread	80 100
Other	- The						40 thresh	old
							DVH Metric	
C			$\sum_{i} \left[2^{-(Prior)} \right]$	$ity_i - 1)$.	$\gamma\left(k_{i},\frac{P}{P}\right)$	$\frac{lanV}{\theta_i}$	$\left[\frac{alue_i}{2}\right]$	
G	C IVI			$\sum_i 2^{-(Pr)}$	iority;-	1)		

Mine data from prior treated plans to parametrize evaluation metrics for current plans



GEM - What we must do

Historically we meet the physician's constraint

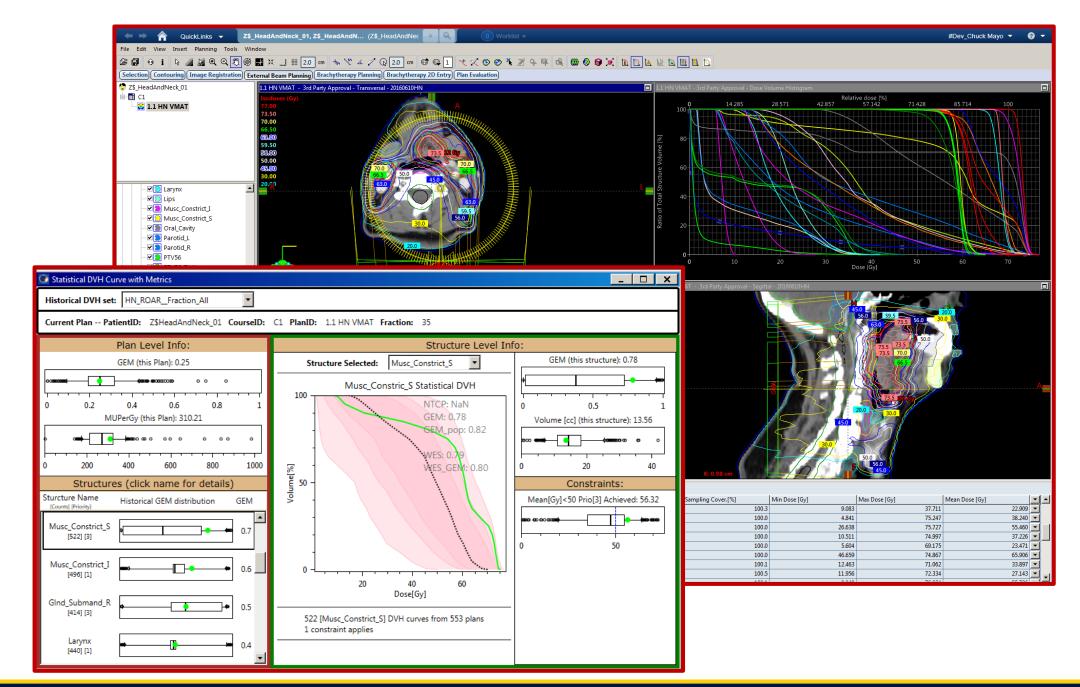
GEM << 1

GEM_{pop} - Could we do better ? - Have we done better ?

- Set threshold to median of historic distribution
- Set priority to 4

Now we can quantify what we mean by ALARA from our history of what has been clinically acceptable





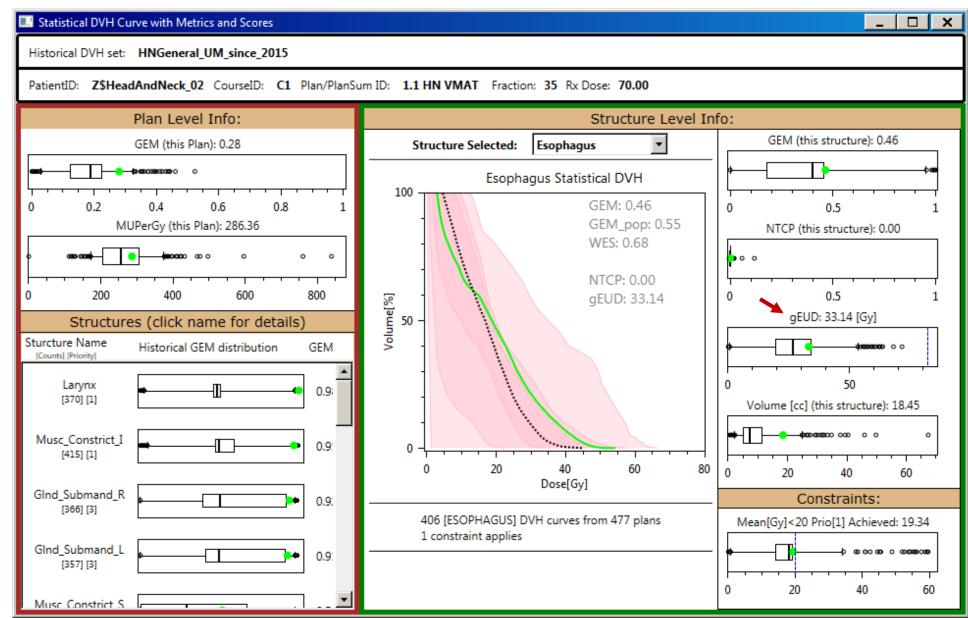


Summary Report Card Dashboard

Plan Summary - Sta Patient: Name: ZS				2 140 76 1				open in new win					_ 0	×		
Plan: Course ID: C1		Plans/PlanSu				Fraction:		e: 70.00	luow							
Historical Experie		text:	-		n GEM	-		•		0.28						
[HN_General_OW_SI	nce_2015			Cou	int [477]	0	0.	5	1							
				Struct	ure-wise	e Evaluatio	n: (click ea	ch row for S	tatistical	DVH det	ails)					
Sturcture	Count	Constraint(s)	Priority	Cal_Prio	DRS		Historical (SEM [0,1]		GEM ▼		Historical Metric	Met	ric		
Larynx	370	Mean[Gy]<20	1	1.3		-			-•	0.98	0 🗕 🗖	0000 000	d 80 Gy 72	.8		
Musc_Constrict_I	415	Mean[Gy]<20	1	1.5		-	Œ		-•	0.95	• ⊢		•• 80 Gy 64	.9		
GInd_Submand_R	366	Mean[Gy]<30	3	1.9		۰	T		⊐••	0.92	0		80 Gy 61	.1		
GInd_Submand_L	357	Mean[Gy]<30	3	1.8		o	—- — —		⊐⊷	0.91	0		80 Gy 59	.1		
Musc_Constrict_S	442	Mean[Gy]<50	3	1.5	\bigcirc	•			-	0.51	0 an annoan		80 Gy 50	.1		
Parotid_L	413	Mean[Gy]<24	3	1.7	\bigcirc	•			-	0.48	0		80 Gy 23	.4		
Esophagus	406	Mean[Gy]<20	1	1.2		•	_ _		-0 @	0.46	0		80 Gy 19	.3		
Oral_Cavity	132	Mean[Gy]<30	3	1.9	\bigcirc	•				0.46	0 10000		80 Gy 2	9		
Parotid_R	414	Mean[Gy]<24	3	1.7	0	•	•			0.46	0 -		80 Gy 22	.9		
Bone_Mandible	462	D0.10-(Gy]<70	3	1.5	\bigcirc	¢L 🖕				0.17	0 =======	 •	80 Gy 67	.5		
Brain	449	Mean[Gy]<0	3	1	0	•				0	0 • 🗖 🚽 🚥 🚥 🚥	•	80 Gy 1.	5		
Brainstem	460	D0.1cc[Gy]<54	1	1	0		0 0		٥	0	0 📼	.	80 Gy 30	.4		
Brainstem_PRV03	453	D0.1cc[Gy]<54	1	1.1	0	+				0	-	·	00 Gy 32	.5		
Cochlea_L	407	D0.1cc[Gy]<40	1		0	۰۰ ۵۰								Struct	ure-wis	se Evaluation: (click each row for Statistical DVH details)
Cochlea_R	405	D0.1cc[Gy]<40	1	1.1	\bigcirc	00				_	Count	Constraint(a)	Dutantha	1	DRS	
Lips	450	V35Gy[%]<5	1	1.1	0		_		turctur	e	Count	Constraint(s)	Priority	Cal_Prio	DKS	Historical GEM [0,1] GEM 🔻
SpinalCord	476	D0.1cc[Gy]<45	1	1	0		o o	Musc	Const	rict_S	442	Mean[Gy]<50	3	1.5	\bigcirc	• 0.51 0 m ·
SpinalCord_PRV05	465	D0.1cc[Gy]<50	1	1.1	0	•										
* Extra Structures (WE		P() Prostal Disc.	(0.78) 6			(0.65) CT	1	P	arotid_	L	413	Mean[Gy]<24	3	1.7	\bigcirc	
BODY (0.91) AUTORE PTV56_EVAL (0.19)	G_IGKT (0.	50) BrachiaiPlex_	L (U.78) C	iv_Hign (0.	(2) PIV30	0 (0.05) CIV_	LOW (0.0)	Es	ophag	us	406	Mean[Gy]<20	1	1.2		• 0.46 0 •
* The following structur	res cannot b	e found in the sele	cted conte	kt [HN_Gener	al_UM_sir	nce_2015] : AU	TOREG_BST,				1		1	1 1	-	
								Or	al_Cav	ity	432	Mean[Gy]<30	3	1.9	\bigcirc	• 0.46 0 mm
								Pa	arotid_	R	414	Mean[Gy]<24	3	1.7	\bigcirc	• • 0.46 0 ·
Display level: @	0 Constrair	t C Struct	ure	C Both								•	•			

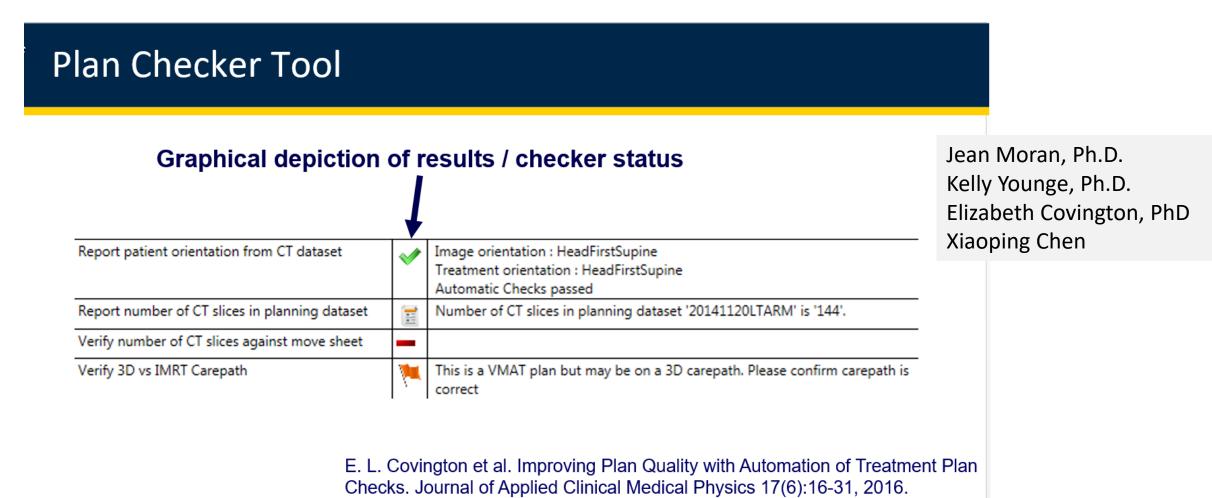


Statistical DVH Dashboard





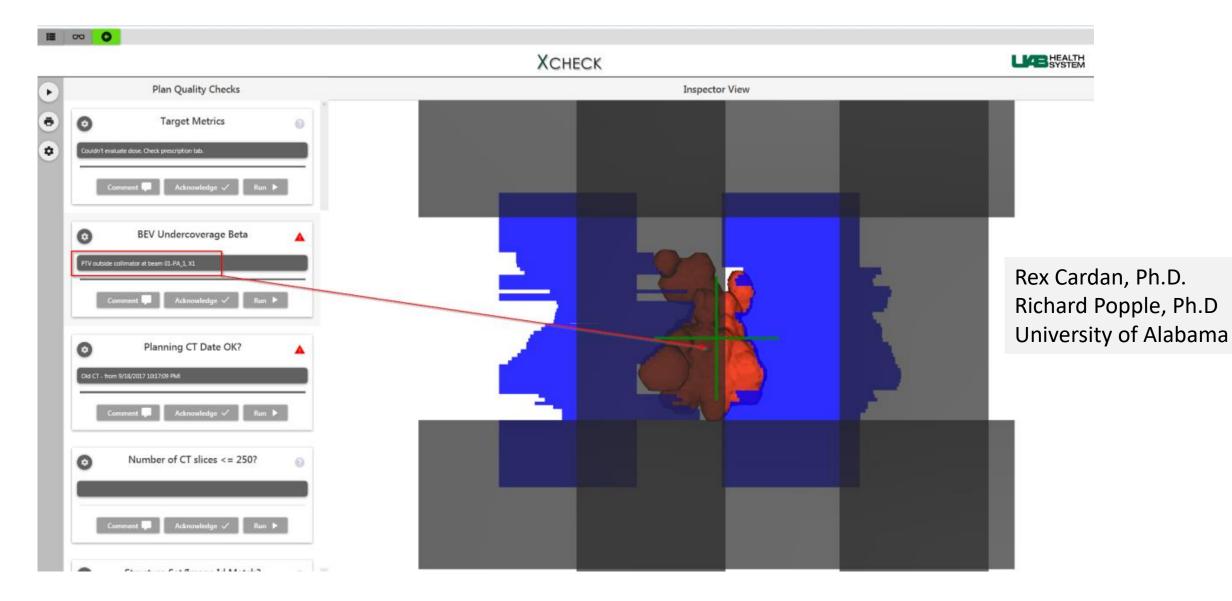
Scripting to Make Plan Checking Faster and More Effective







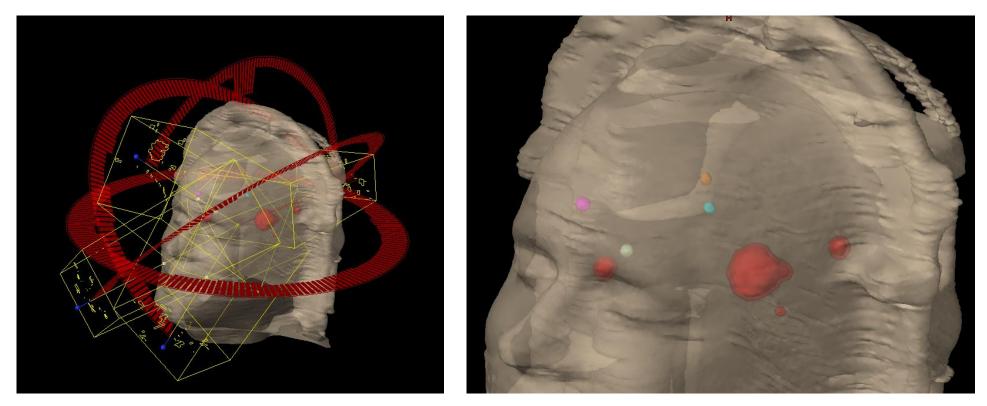
Scripting to Make Plan Checking Faster and More Effective





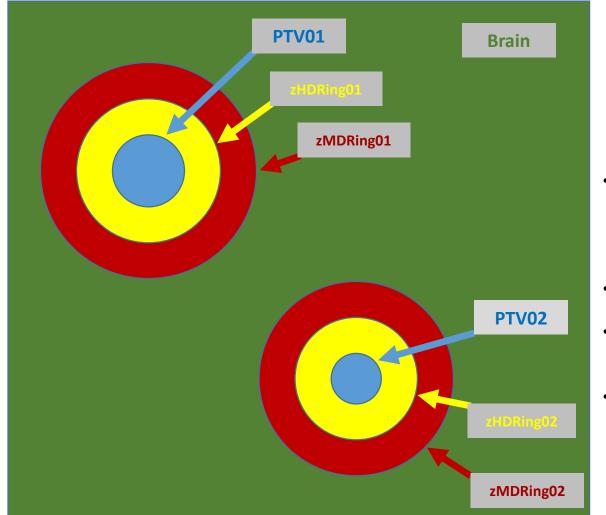
Standardized approach to SRS planning and evaluation

Manual implementation now Scripted automation with availability of writable scripting



Automation scripting developed in Research Mode



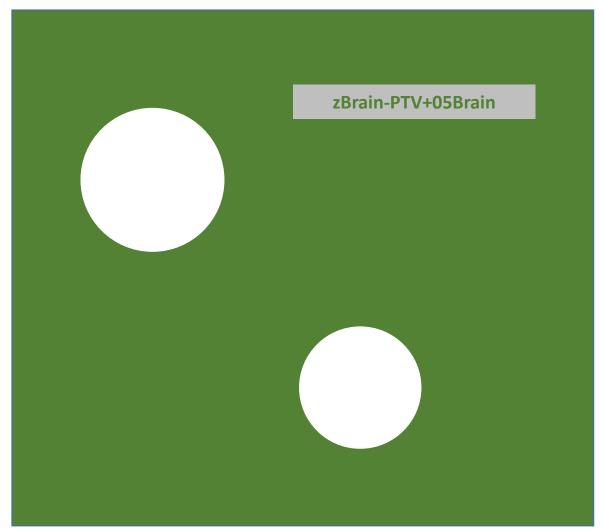


The answer begins with standardized contouring and naming

- Targets and rings are sequentially numbered e.g. PTV01, zHDRing01, zMDRing02.... PTV15, zHDRing15, zMDRing15
- Rings are 5 mm thick
- Use zHDRings to control dose gradients and conformality in optimizer
- Use zMDRings to monitor midrange dose falloff

Research mode script – automates creation of all structures for all targets in < 1 sec.





The answer begins with contouring

- Track dose to parts of brain where dose should be low
- Boolean out PTVs and zHDRingxxs from Brain
- zBrain-PTV+05 = Brain-(PTVs+HDRings)
- Use in optimizer to limit low and mid-range dose levels to brain not proximal to targets

Research mode script – automates creation of all structures for all targets in < 1 sec.





The answer begins with contouring

- What if the PTVs are close?
- Boolean PTVs out of Rings
- Create buffer structures from
 overlap of zHDRingxxs
- Use buffers to "pinch-off" dose in between targets in optimizer

Research mode script – automates creation of all structures for all targets in < 1 sec.

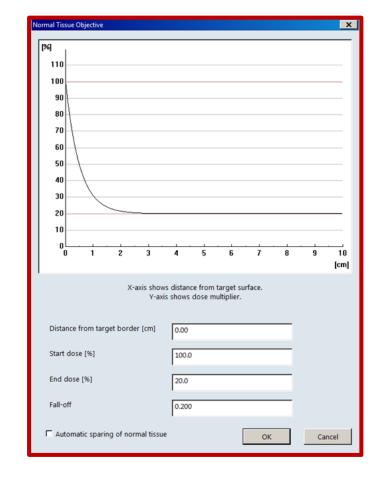


Algorithmic approach for planning that can be moved to script automated planning

Optimize starting with these parameters

Structure	Туре	Volume[%]	Dose	Priority	Comment
PTVxx	Lower	100	Rx[Gy]	120	
	Upper	0	Rx[Gy]+25%	50	-
GTVxx	Lower	50	Rx[Gy]+8%	50	Push dose higher if needed to reduce horns in dose profile
zHDRingxx	Upper	2	Rx[Gy]	80	
	Upper	70	0.5 * Rx[Gy]	100	Push Volume[%] to < 70% as optimization allows
zBrain- PTV+05	Upper	0	0.5*Rx[Gy]	120	-
	Upper	3	0.25*Rx[Gy]	50	Push dose to < 0.25*Rx[Gy] as optimization allows
zBufxxyy	Upper	20	0.9* Rx[Gy]	50	Push volume[%] to < 20% as optimization allows

Research mode script – automates optimization





Use scripting to calculate standard metrics for plan quality assessment

esa A, Kadish S, Fitzgerald h volumetric IMRT (RapidArc) otactic radiosurgery Biol. Phys. 78(5): 1457-1466	PTVxx • Rx[Gy] • Volume[cc] • V100%[cc] • Min[Gy] • Max[Gy] • Cl • Greff	zHDRingxx and zMDRingxx • V100%[cc] • V50%[cc] • V12Gy[cc] • DC5%[cc] • D5%[cc]	zBrain – PTV+05 • Volume[cc] • V12Gy[cc] • V10Gy[cc] • V05Gy[cc]
Biol. Phys. 78(5): 1457-1466 ATPS 2.2.0.0			_ □ X

Mayo CS, Ding L, Addes TJ, Moser R: Initial experience with for intracranial stereot Int. J. Radiat. Oncol. Bi

														_		
	1 BRA	IN SRS	ATPS 2.2	.0.0												
zBrain-PTV-0	5															
/olume[cc]	V12Gv[cc]	V10Gv[cc]	V05Gv[cc]	Ι.												
	0.0		67.9													
																7 3
Targets, HDRi	ings and N	1DRings														
Targets, HDRi Farget Name		-	V100%[cc]	Min[Gy]	Max[Gy]	HDRing:V100%[cc]	HDRing:V50%[cc]	HDRing:V12Gy[cc]	HDRing:DC5%[Gy]	HDRing:D5%[cc]	MDRing:V100%[cc]	MDRing:V50%[cc]	MDRing:DC5%[Gy]	MDRing:D5%[cc]	СІ	Gr
-	Rx[Gy]	-		Min[Gy] 20.8		HDRing:V100%[cc] 0.32	HDRing:V50%[cc] 2.70	HDRing:V12Gy[cc]	HDRing:DC5%[Gy] 7.2		MDRing:V100%[cc] 0.00	MDRing:V50%[cc] 0.20	MDRing:DC5%[Gy] 2.30	MDRing:D5%[cc] 9.1	CI 1.77	
Farget Name	Rx[Gy] 20	Volume[cc]	0.42		24.4	0.32	-			21.0		-		_		13
Farget Name PTV01	Rx[Gy] 20 18	Volume[cc] 0.42	0.42 2.28	20.8	24.4 23.9	0.32 0.39	2.70	2.03	7.2	21.0 18.0	0.00	0.20	2.30	9.1	1.77	13 10
Farget Name PTV01 PTV02	Rx[Gy] 20 18 20	Volume[cc] 0.42 2.28	0.42 2.28 1.93	20.8 17.8	24.4 23.9 26.2	0.32 0.39 0.25	2.70 6.14	2.03 3.60	7.2 7.3	21.0 18.0 19.6	0.00 0.18	0.20 2.01	2.30 3.64	9.1 11.2	1.77 1.17	13 10 11
Farget Name PTV01 PTV02 PTV03	Rx[Gy] 20 18 20 20 20	Volume[cc] 0.42 2.28 1.93	0.42 2.28 1.93 1.31	20.8 17.8 20.0	24.4 23.9 26.2 26.4	0.32 0.39 0.25 0.24	2.70 6.14 5.48	2.03 3.60 3.55	7.2 7.3 8.8	21.0 18.0 19.6 19.7	0.00 0.18 0.00	0.20 2.01 0.34	2.30 3.64 4.65	9.1 11.2 9.4	1.77 1.17 1.13	13 10 11 10



Approaches for actualizing standards to reduce variability and improve evaluation

Book of Policies



Writeable scripting will enable automating creating policy compliant plans



Enforcement

Summary

- Advanced scripting is being used by many groups to address all components of plan evaluation
- Un-necessary variability and inconsistency undermine potential of scripting to automate

Start now with standardizing

- o process
- nomenclatures
- plan policies

