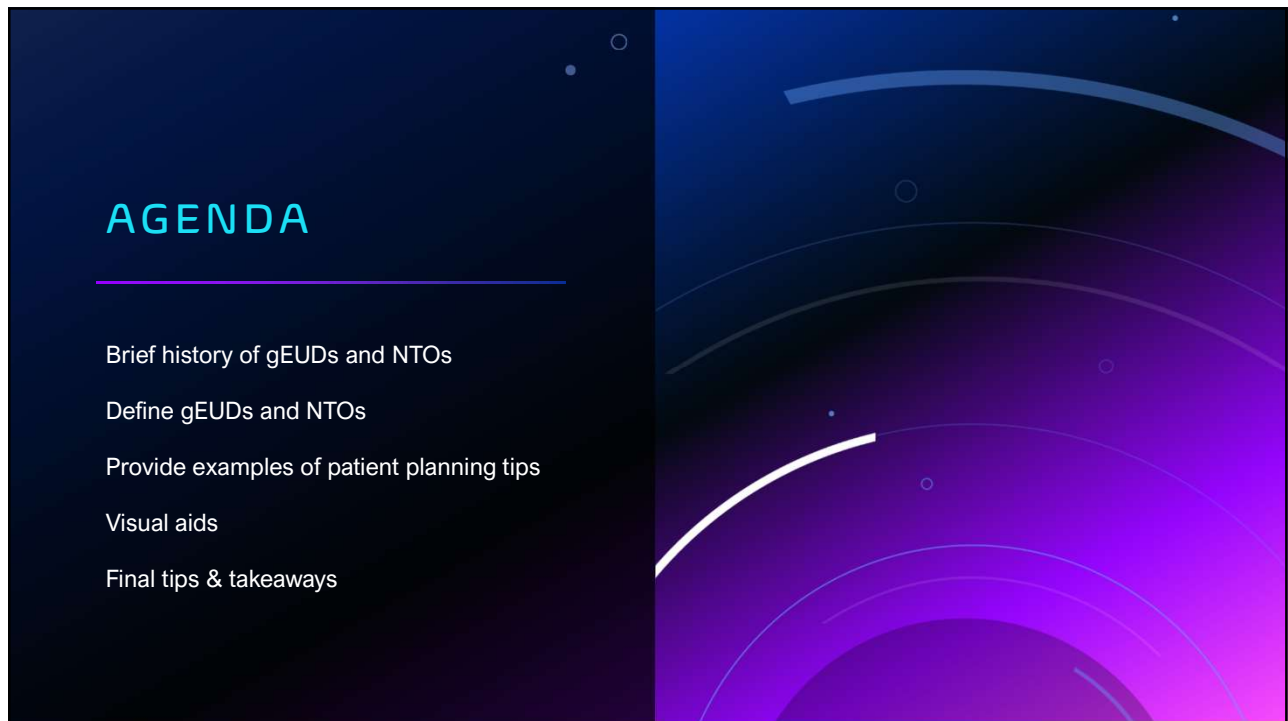




1



2

History of NTOs

- In 1994, IMRT was initiated with the introduction of the NOMOS Peacock System.
- Eclipse treatment planning system was introduced in 2001 with IMRT planning capabilities available in 2002.
- The NTO (Normal Tissue Objective) was implemented in 2006.
- In 2018, the SBRT NTO was introduced, specifically designed for stereotactic treatments.

3

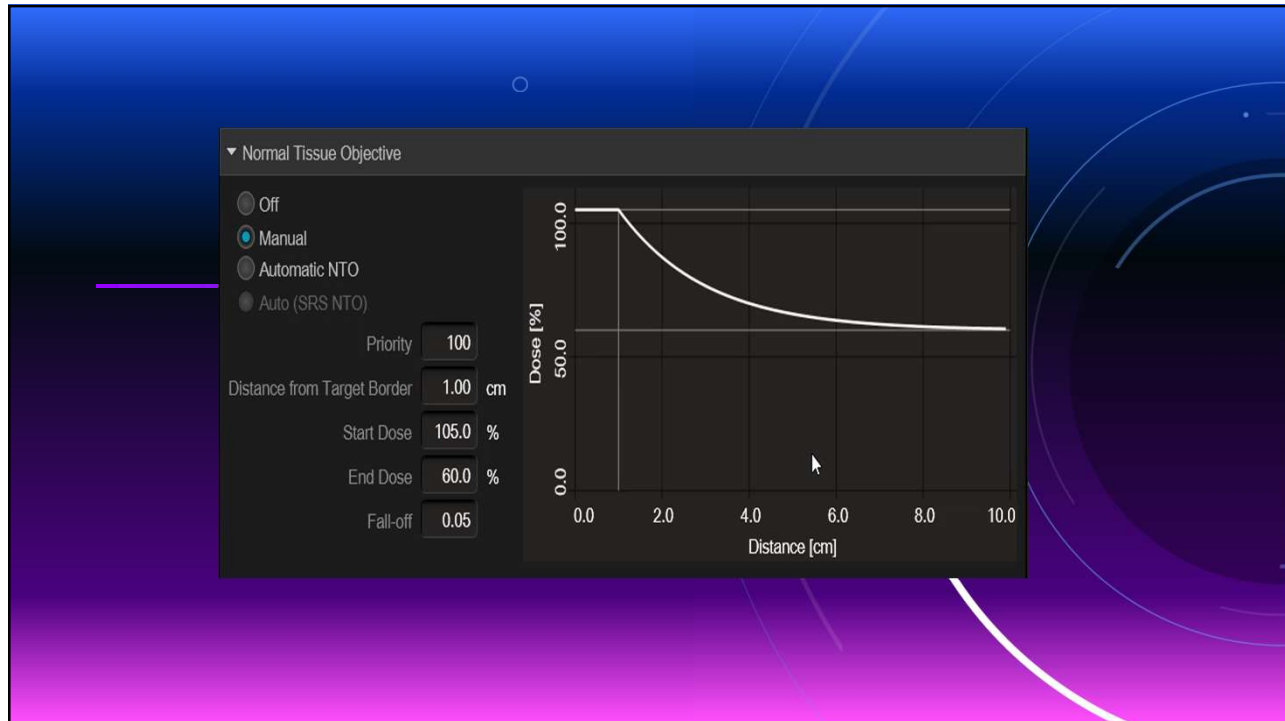
Definition of NTO

NTO (Normal Tissue Objective) is a constraint tool introduced by Varian in which helps limit dose to the surrounding normal tissue by defining priority, distance from target and dose gradient.

▼ Normal Tissue Objective

- Off
- Manual
- Automatic NTO
- Auto (SRS NTO)

4



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TIPS AND TRICKS

Disclaimer: The information I am about to share is based on my own experiences with utilizing NTOs in my treatment plans.

Focus will be on setting manual NTOs.
Plans were calculated with the Acuros algorithm, Eclipse version 15.6

6

Setting Manual NTO

Normal Tissue Objective

Off
 Manual
 Automatic NTO
 Auto (SRS NTO)

Priority:

Distance from Target Border: cm

Start Dose: %

End Dose: %

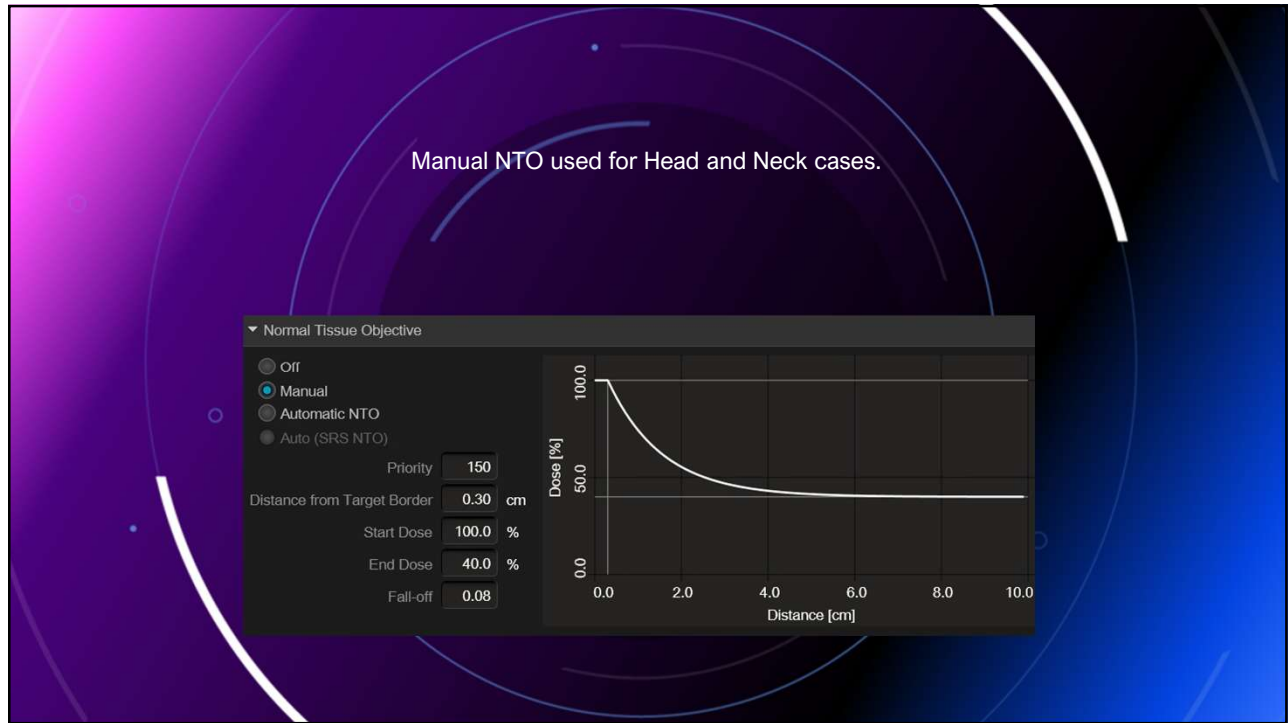
Fall-off:

Used frequently for standard dose fractionation. Examples would include pelvis cases such as prostates and GYNs.

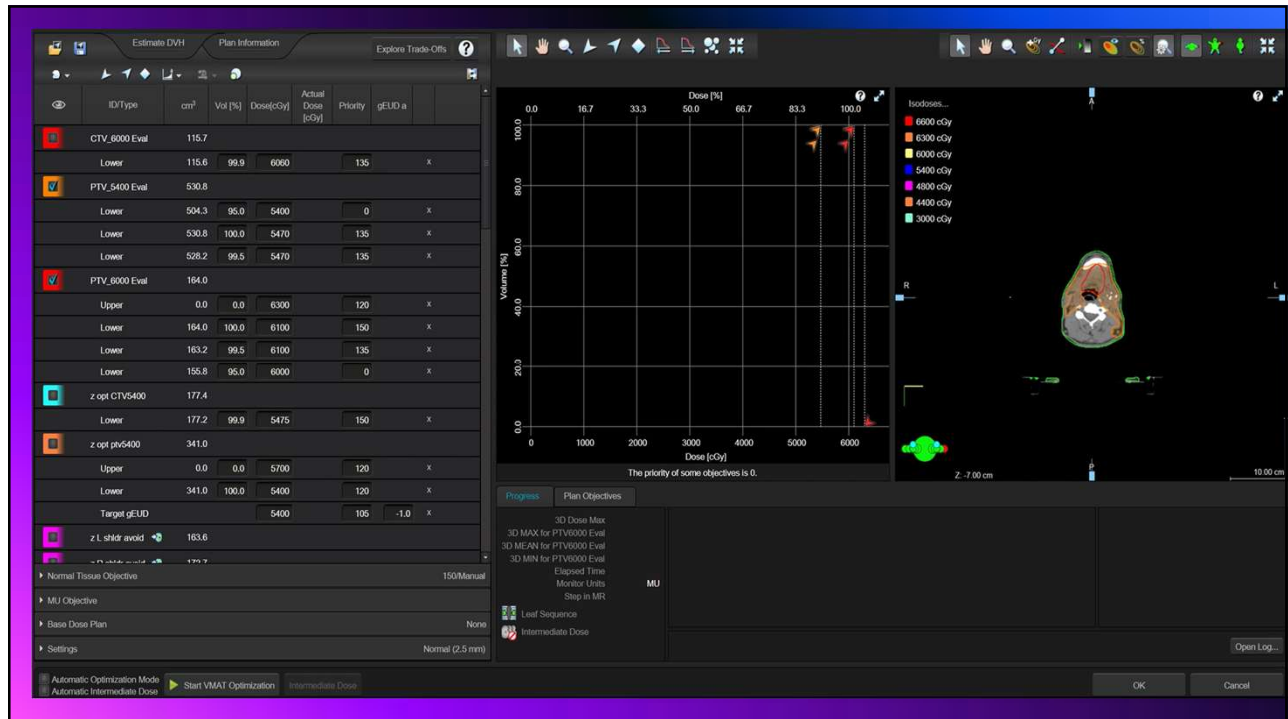
7

View	Manual NTO (Left)	Auto NTO (Right)
Transversal	<p>3D Dose MAX: 5920.3 cGy</p> <p>3D MAX for PTV_n55: 5920.3 cGy</p> <p>3D MIN for PTV_n55: 5510.9 cGy</p> <p>3D MEAN for PTV_n55: 5736.7 cGy</p>	<p>3D Dose MAX: 5884.2 cGy</p> <p>3D MAX for PTV_n55: 5884.2 cGy</p> <p>3D MIN for PTV_n55: 5509.0 cGy</p> <p>3D MEAN for PTV_n55: 5726.5 cGy</p>
Sagittal	<p>3D Dose MAX: 5920.3 cGy</p> <p>3D MAX for PTV_n55: 5920.3 cGy</p> <p>3D MIN for PTV_n55: 5510.9 cGy</p> <p>3D MEAN for PTV_n55: 5736.7 cGy</p>	<p>3D Dose MAX: 5884.2 cGy</p> <p>3D MAX for PTV_n55: 5884.2 cGy</p> <p>3D MIN for PTV_n55: 5509.0 cGy</p> <p>3D MEAN for PTV_n55: 5726.5 cGy</p>
Frontal	<p>3D Dose MAX: 5920.3 cGy</p> <p>3D MAX for PTV_n55: 5920.3 cGy</p> <p>3D MIN for PTV_n55: 5510.9 cGy</p> <p>3D MEAN for PTV_n55: 5736.7 cGy</p>	<p>3D Dose MAX: 5884.2 cGy</p> <p>3D MAX for PTV_n55: 5884.2 cGy</p> <p>3D MIN for PTV_n55: 5509.0 cGy</p> <p>3D MEAN for PTV_n55: 5726.5 cGy</p>

8



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Head & Neck - Unapproved - Transverse - HN_12,04,25

Head & Neck - Unapproved - Axial - HN_12,04,25

Head & Neck - Unapproved - Frontal - HN_12,04,25

Head & Neck - Unapproved - Sagittal - HN_12,04,25

Group	Field ID	Technique	Machine/Beam	M/C	Field Weight	Scale	Setup Rn (deg)	Coll Rn (deg)	Couch Rn (deg)	Wedge	Field X (cm)	X1 (cm)	X2 (cm)	Field Y (cm)	Y1 (cm)	Y2 (cm)	R (cm)	Z (cm)	Calculated Dose (Gy)	MU	Ref ID (Gy)
1	CBCT	STATIC-I	CU.TrueBeam5058 - 6X		0.000	Varian IEC	0.0	0.0	0.0	None	10.0	-13.3	-13.3	10.0	-10.7	-10.7	0.00	2.00	-7.00	92.4	
1	1 G181-179	ARC-I	CU.TrueBeam5058 - 6X	VMAT	1.500	Varian IEC	181.0 CW 179.0	20.0	0.0	None	14.3	+13.3	+1.0	19.7	+10.7	+9.0	0.00	2.00	-7.00	91.8	299.9
1	2 G177-183	ARC-I	CU.TrueBeam5058 - 6X	VMAT	1.607	Varian IEC	177.0 CW 183.0	340.0	0.0	None	14.6	+1.0	+13.6	19.7	+10.7	+9.0	0.00	2.00	-7.00	91.8	321.5
1	3 G182-178	ARC-I	CU.TrueBeam5058 - 6X	VMAT	1.485	Varian IEC	182.0 CW 178.0	30.0	0.0	None	16.8	+9.1	+7.8	25.4	+12.7	+12.7	0.00	2.00	-7.00	91.8	296.9
1	SETUP AP	STATIC-I	CU.TrueBeam5058 - 6X		0.000	Varian IEC	0.0	0.0	0.0	None	10.0	-10.0	-10.0	10.0	-10.0	-10.0	0.00	2.00	-7.00	92.4	
1	SETUP IT	STATIC-I	CU.TrueBeam5058 - 6X		0.000	Varian IEC	90.0	0.0	0.0	None	10.0	+5.0	+5.0	10.0	+5.0	+5.0	0.00	2.00	-7.00	94.7	
Start	SETUP IN	STATIC-I	CU.TrueBeam5058 - 6X		0.000	Varian IEC	0.000	0.0	0.0	None	10.0	-10.0	-10.0	10.0	-10.0	-10.0	0.00	2.00	-7.00	91.8	

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Manual vs Automatic NTO used for SBRT/SRS cases

Normal Tissue Objective

Off
 Manual
 Automatic NTO
 Auto (SRS NTO)

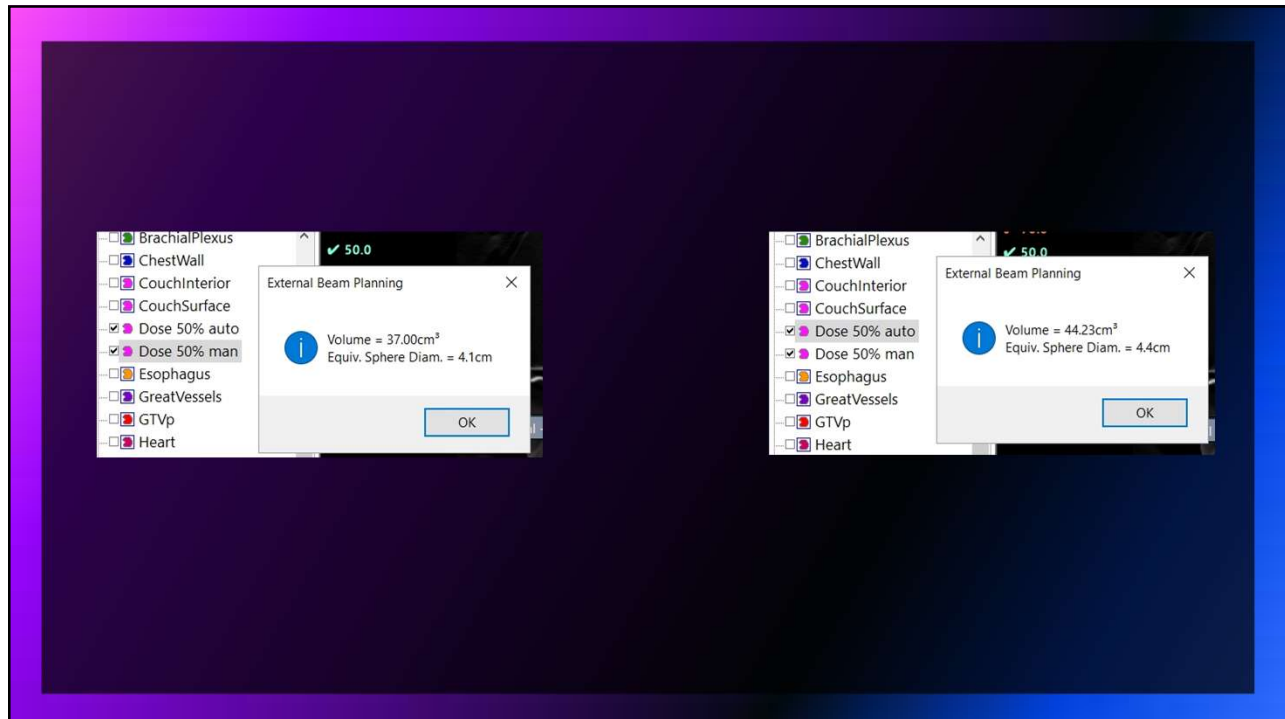
Priority:
 Distance from Target Border: cm
 Start Dose: %
 End Dose: %
 Fall-off:

The graph plots Dose [%] on the y-axis (0.0 to 100.0) against Distance [cm] on the x-axis (0.0 to 10.0). A smooth curve starts at (0, 100) and decays to approximately 40% at 10 cm, illustrating the fall-off characteristic of the NTO.

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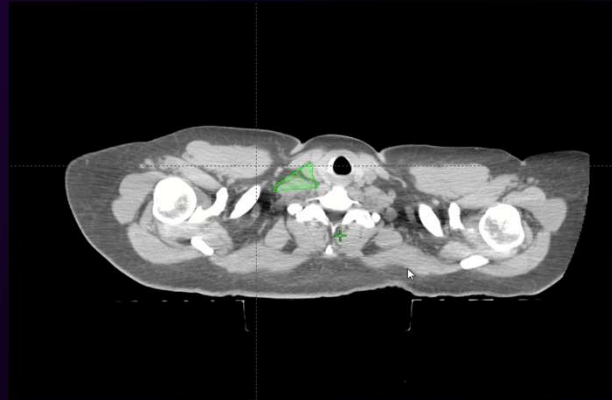
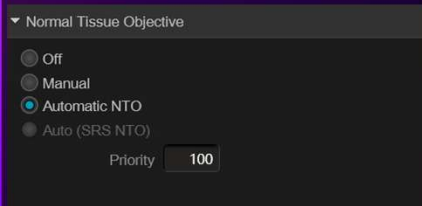


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Use Automatic NTO or turn it off when there are multiple overlapping PTVs with varying dose coverage. Example would be a chest wall patient with nodal involvement.



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NTO FINAL TIPS & TAKEAWAYS

- Use of Manual NTO can eliminate use of rings.
- Fall off variability within a plan may lead to using Automatic NTO or turning off this feature. In these cases, rings most likely will need to be utilized.
- Setting Manual NTOs can lead to a more conformal plan compared to using the Automatic NTO feature.

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History of gEUDS

- Introduction of IMRT presented an increased interest in the impact of heterogeneous dose distributions with treatment outcomes.
- There was a concern that there was a correlation with heterogeneous dose and the reduction of tumor control probability.
- To compare and evaluate; a metric was needed to compare the effects. Hence EUD also known as equivalent uniform dose was created to provide the same radiobiological effect as a given non-uniform dose distribution.
- Originally it was based off a mechanistic model for tumors using the linear quadratic cell survival formula.

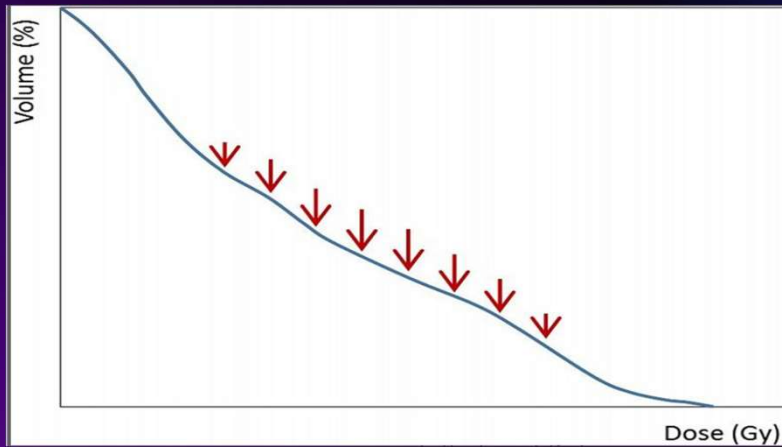
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Definition of gEUD

- gEUD, generalized equivalent uniform dose was presented for both tumors and normal tissues.
- The EUD portion refers to the generalized mean dose where the parameter 'a' accounts for the seriality of a structure and determines the weighting of dose distribution.
- gEUDs can be used for both targets and organs at risk in the objective function.
- The 'a' range for organs at risk can be anywhere from 1 to 40, never being 0. Increasing the alpha parameter value in the gEUD objective will decrease the volume of higher dose given to the OAR in your plan.
- The 'a' range for targets in -1 to -40.
- Biological treatment plan optimization became available in 2012 with Varian's Eclipse 13.6 version

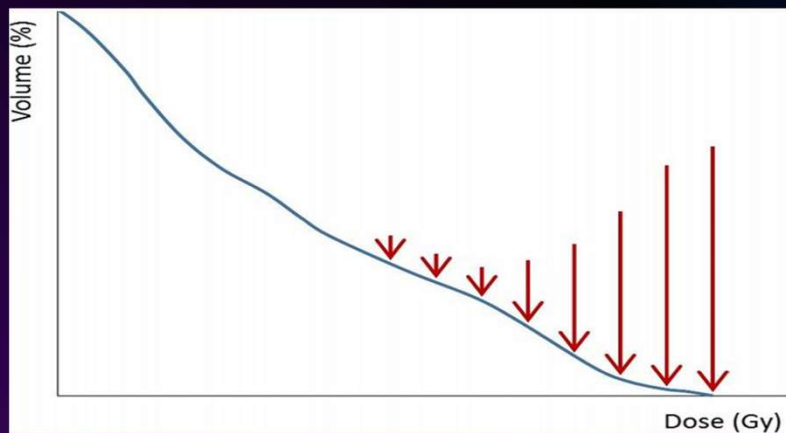
18

The first graph shows an alpha parameter value equal to 1. The optimization force is directed to reduce the volume receiving mid-dose levels



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The second graph shows the result of gEUD optimization utilizing a high alpha parameter. It shows how the optimization force is directed at decreasing the structure volume receiving higher dose levels.



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Generalized Equivalent Uniform Dose		
Example "a" values		
Structure	Source	"a" Value
Normal Tissue (Upper gEUD)		
Bladder	Emami	3.8
Brain	Emami	4.6
Brain Stem	Li	16.0
Colon	Emami	6.3
Esophagus	Emami	18.0
Eye	Li	16.0
Femoral Head	Li	12.0
Heart	Emami	3.1
Inner Ear	Li	16.0
Kidney	Emami	1.3
Liver	Lawrence	0.6
Liver	Emami	2.9
Lung	Emami	1.2
Mandible	Li	10.0
Optic Chiasm	Li	16.0
Optic Nerve	Li	16.0
Parotids	Chao	0.5
Rectum	Li	8.0
Spinal Cord	Powers	13.0
Spinal Cord	Schultheiss	20.0
Targets (Lower gEUD)		
PTV	Li	-10.0
Breast	Brenner	-7.2
Melanoma	Brenner	-10.0
Squamous CC	Brenner	-13.0

Scanned with CamScanner

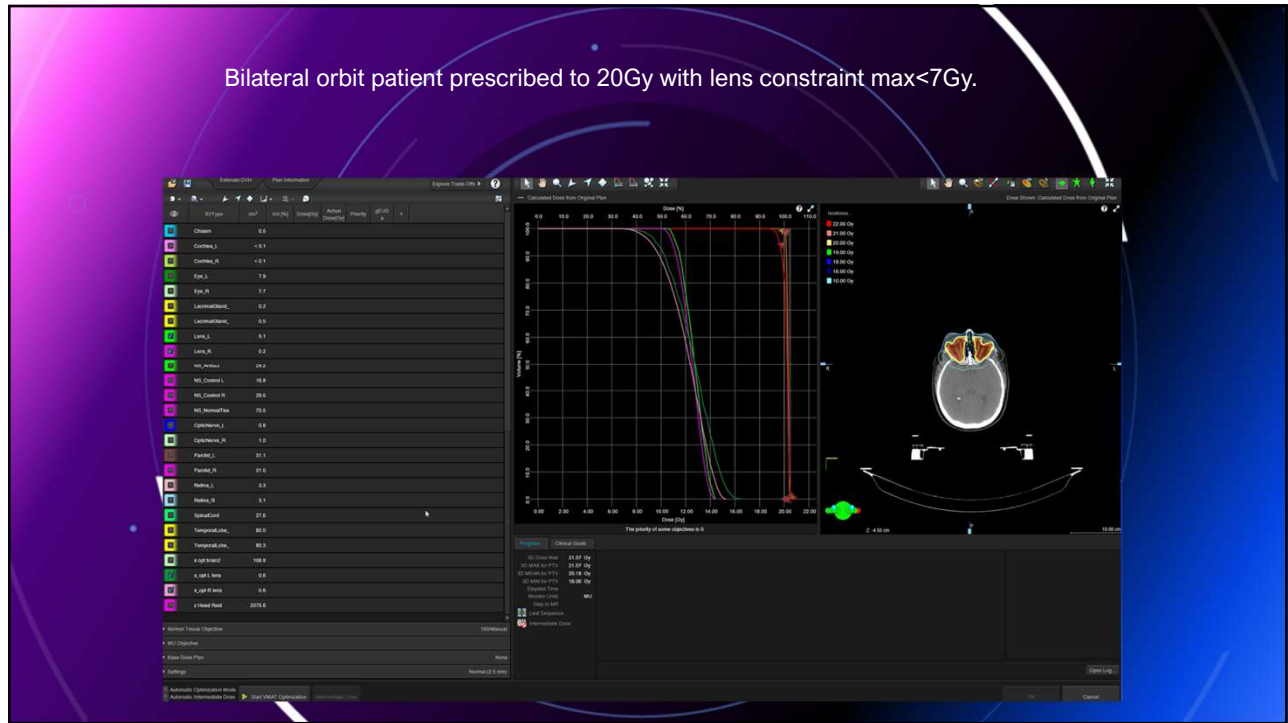
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TIPS AND TRICKS

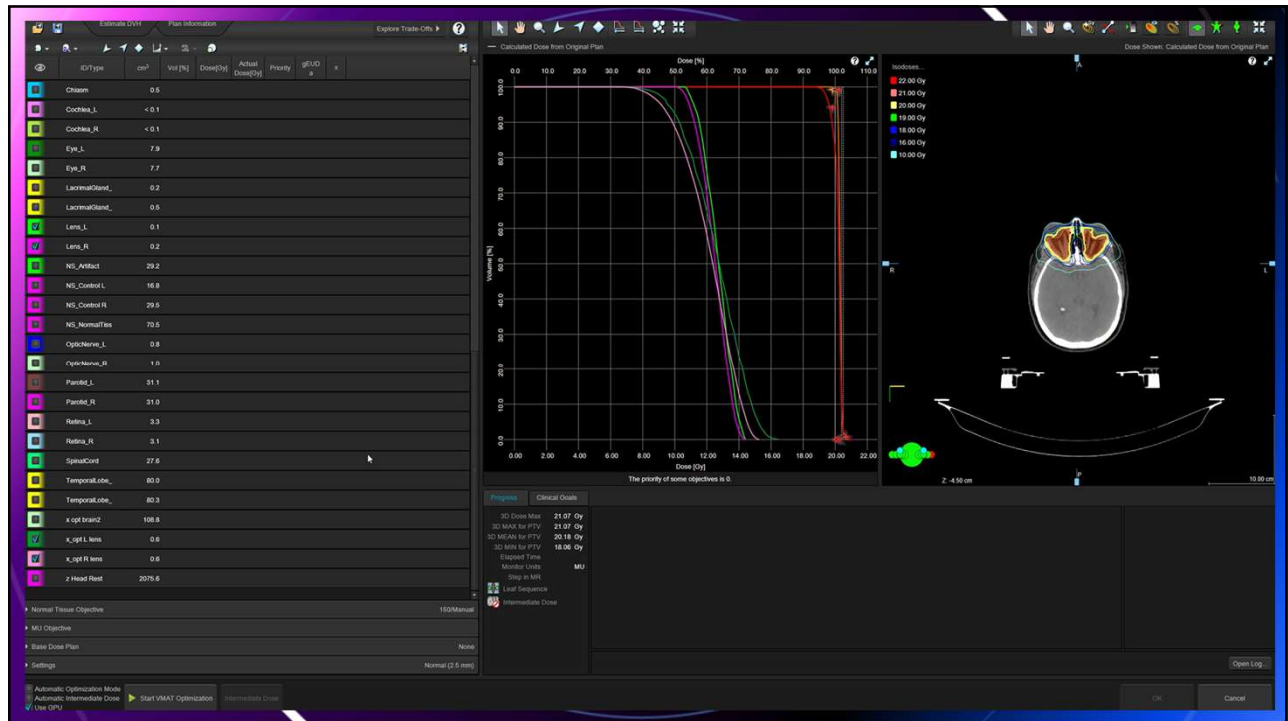
Disclaimer: The information I am about to share is based on my own experiences with utilizing gEUDs in my treatment plans. Plans were calculated with the Acuros algorithm, Eclipse version 15.6.

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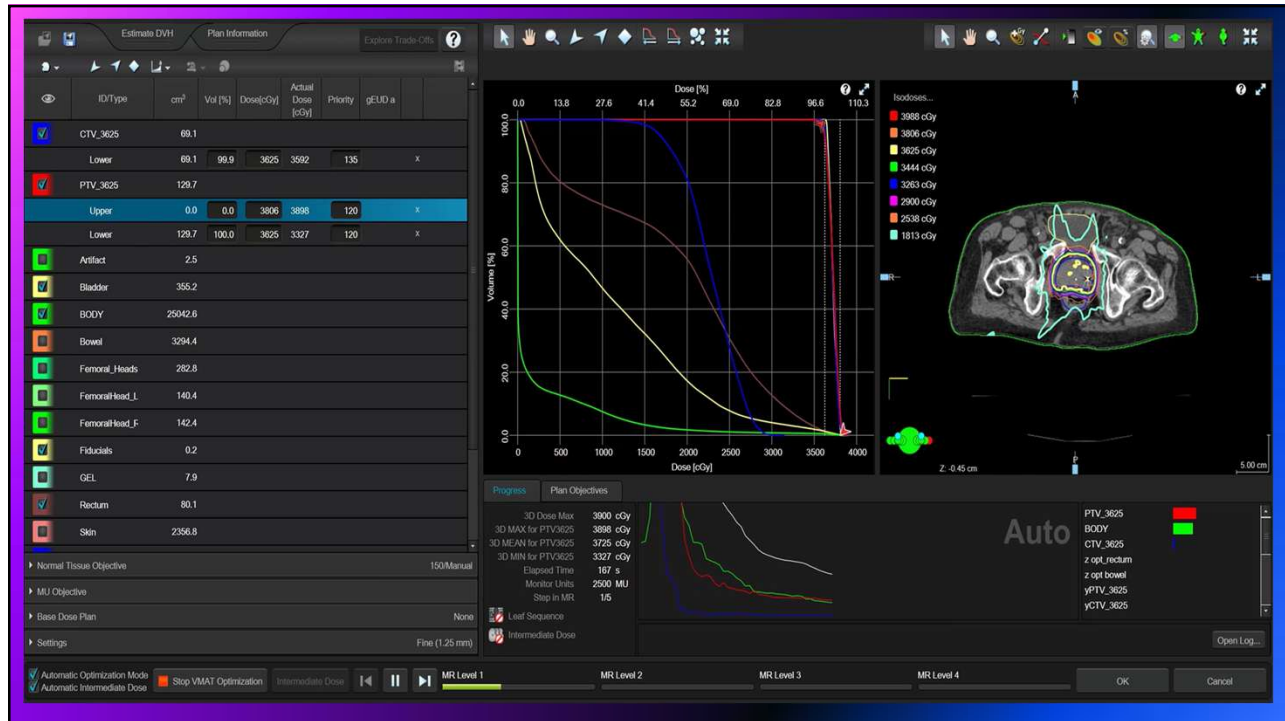
Bilateral orbit patient prescribed to 20Gy with lens constraint max<7Gy.



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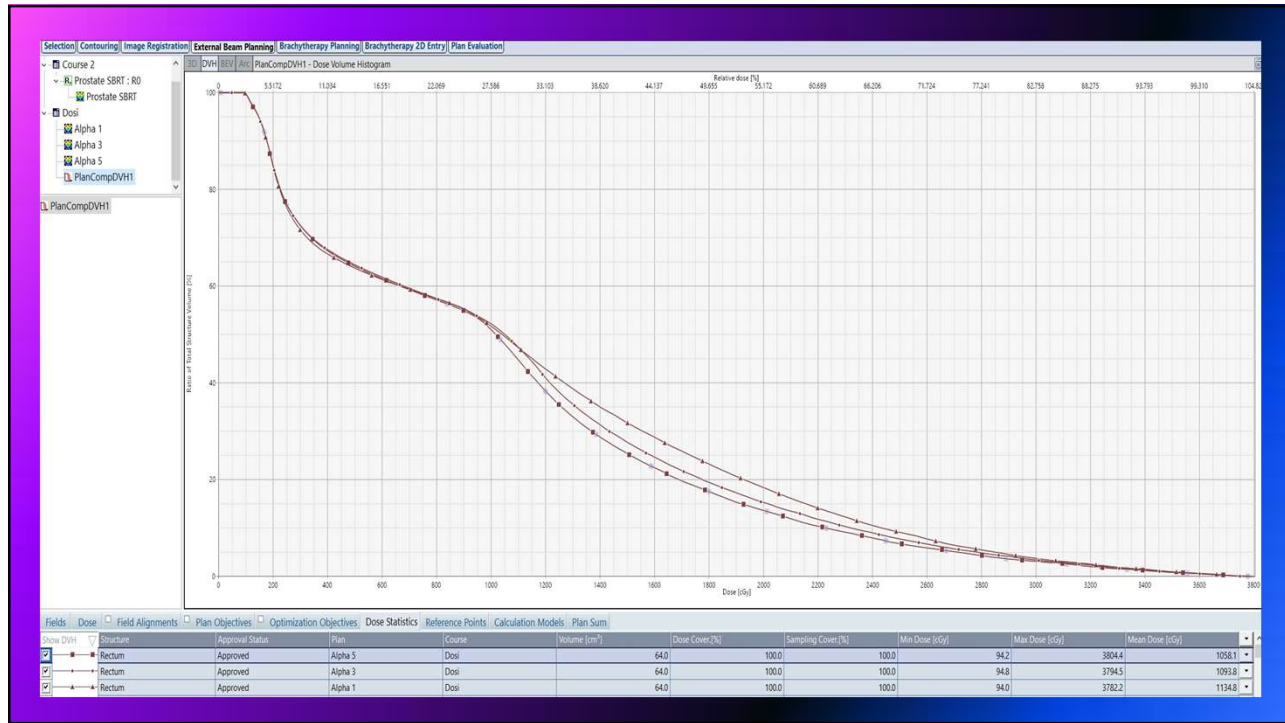
24



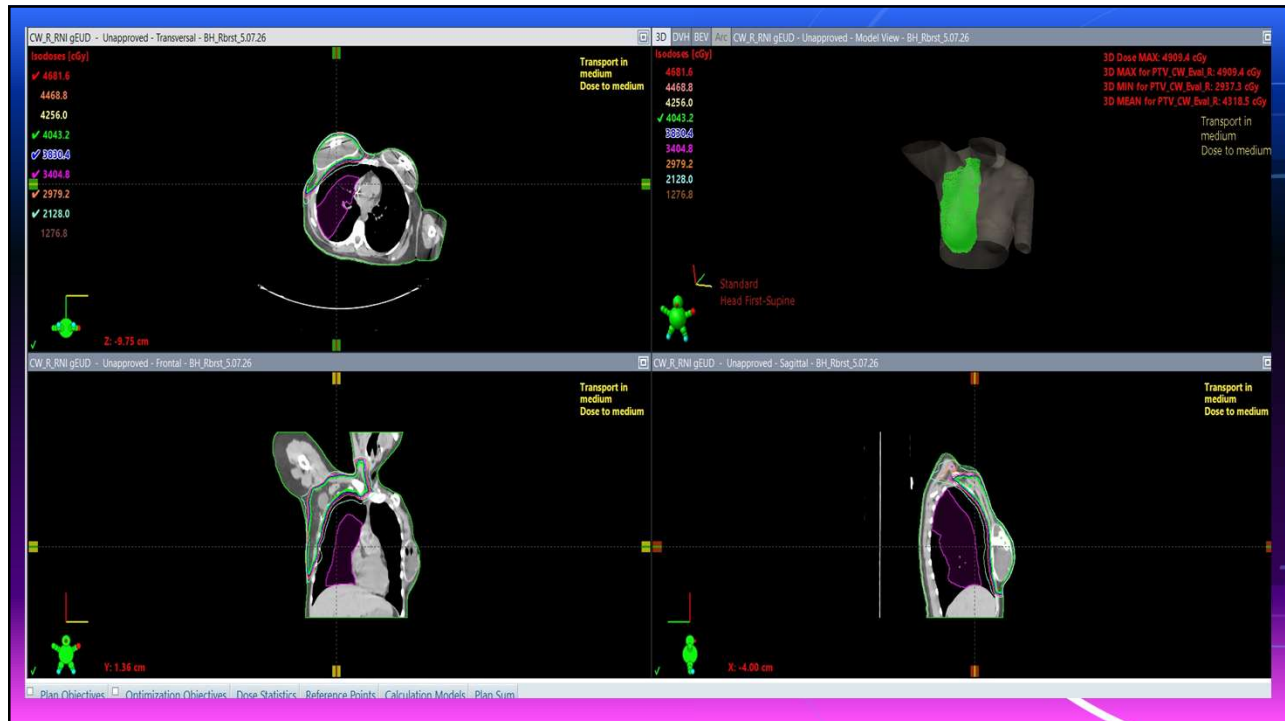
25



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		z 500[cGy]	1073.0		
Upper gEUD		600	731	120	5.0 x
Upper gEUD		800	818	120	8.0 x

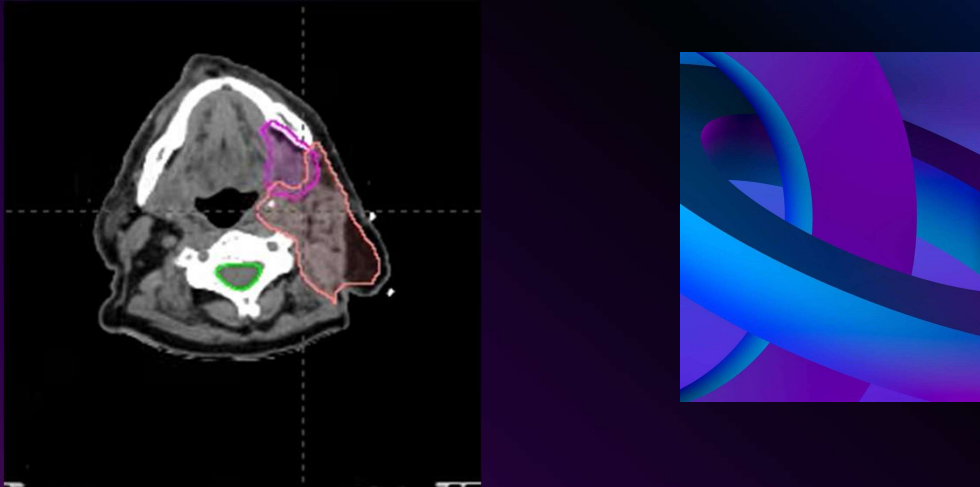
Lung_R	OAR	V500cGy ≤	65%	60.87%	✓
Lung_R	OAR	V1000cGy ≤	45%	31.651%	✓
Lung_R	OAR	V2000cGy ≤	25-35%	12.121%	✓
Lung_L	OAR	V500cGy ≤	10-15%	13.401%	△
Lung_L	OAR	V1000cGy ≤	5%	2.47%	✓
Lungs	OAR	Mean ≤	1000cGy	604.9cGy	✓
Lungs	OAR	V2000cGy ≤	15%	6.343%	✓
Breast_L	OAR	V1000cGy ≤	15%	14.269%	✓
Esophagus	OAR	Max ≤	4000cGy	2568.4cGy	✓
Esophagus	OAR	Mean ≤	1000cGy	625.7cGy	✓
Esophagus	OAR	V3500cGy ≤	5%	0%	✓
Esophagus	OAR	V2500cGy ≤	20%	0.01%	✓
Liver	OAR	Mean ≤	1000cGy	173.1cGy	✓

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15 fraction Hypofractionated Head and Neck Case

PTV5010-red
 PTV4500-pink
 PTV3750-magenta

Cord and Brainstem constraint: Max<2000cGy



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With the introduction of multiple upper gEUDs with different alpha values, I was able to achieve the brainstem and spinal cord doses under 2000cGy max.

<input checked="" type="checkbox"/>	Brainstem	30.0							
	Upper	0.0	0.0	2000	1702	0			x
	Upper gEUD			1465	1466	55	40.0		x
	Upper gEUD			1345	1352	55	20.0		x
	Upper gEUD			1415	1423	55	30.0		x
<input type="checkbox"/>	z opt brainstem	22.6							
	Upper gEUD			2065	1861	65	40.0		x
	Upper gEUD			1850	1662	75	20.0		x
<input checked="" type="checkbox"/>	SpinalCanal	43.3							
	Upper	0.0	0.0	2000	1921	0			x
	Upper gEUD			1620	1618	85	40.0		x
	Upper gEUD			1500	1517	85	20.0		x
<input type="checkbox"/>	z opt cord	80.4							
	Upper gEUD			2200	1928	75	40.0		x

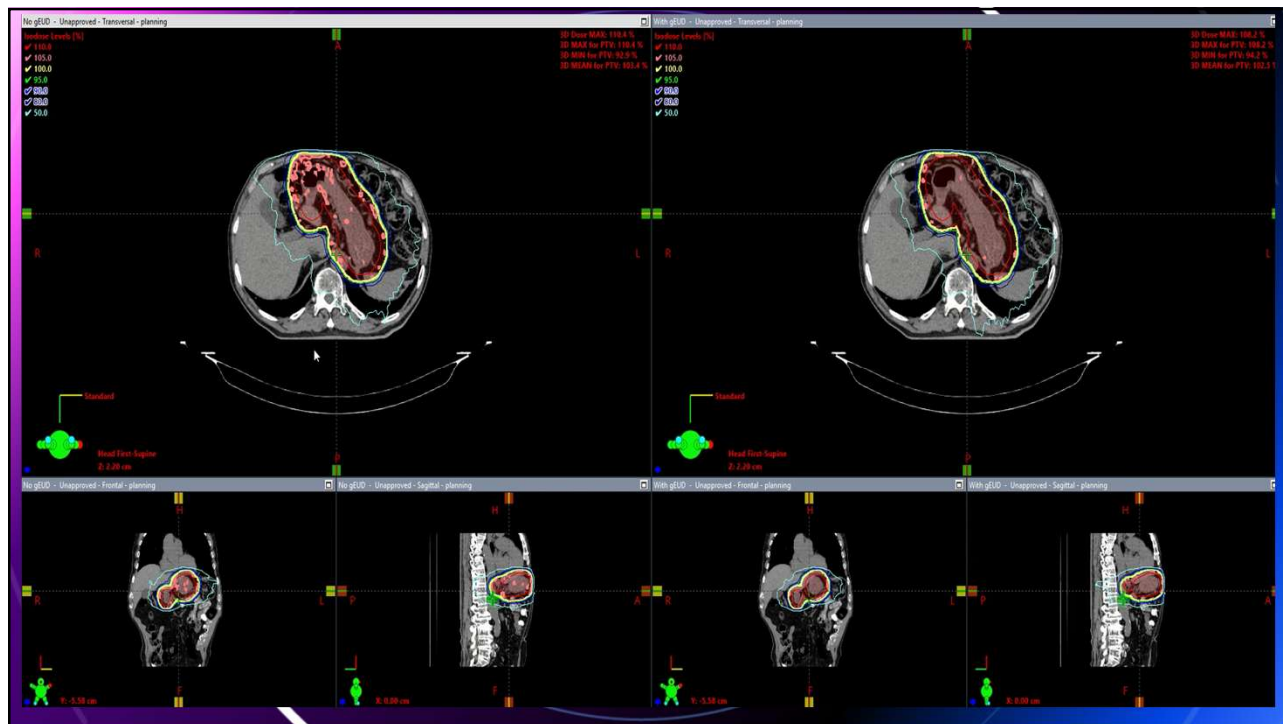
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TaTarget gEUDs

- An alpha of -40 to -1 is utilized for target structures.
- I have experimented using -40 to control the Dmax, but seldomly use it.
- I have found if you place a target gEUD with a value of -1 with a priority of 70% of your lower priority of the inner target it can help reduce the 105% volume.

<input checked="" type="checkbox"/>	CTV_3625	69.1							
	Lower	69.1	99.9	3625	3607	150			x
<input checked="" type="checkbox"/>	PTV_3625	129.7							
	Upper	0.0	0.0	3806	3885	120			x
	Lower	129.7	100.0	3625	3520	120			x
	Target gEUD			3625	3733	105	-1.0		x

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gEUD FINAL TIPS & TAKEAWAYS

- Create opt structures cropped away 5-7mm away from the target if there's overlap, otherwise expand structure 1-5mm if outside the target.
- Try a gEUD alpha of 1 initially for a mean increase to 5 if necessary to pull the center of the DVH.
- Start with a gEUD alpha of 40 to decrease max dose.
- When a single gEUD objective doesn't help you achieve the acceptable max or mean, try adding additional gEUD objectives with a different alpha value.
- Use target mean gEUD to help reduce volume of 105% and overall Dmax.
- Most important takeaway is to not be afraid to experiment with gEUDs and NTOs (manual and/or automatic) if you haven't yet! They are great tools to help you achieve a nice plan!

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