




Static Proton Arc Plan Quality, Delivery Time, Initial Clinical Experience

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AAMD Annual Meeting 2026

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Agenda




1. History
2. Initial planning/delivery time studies
3. Treatment planning considerations
4. Clinical case examples
5. Summary




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History




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Origins (2016)




One of the first major proton arc planning papers introduced the concept.

Spot-Scanning Proton Arc (SPArc) Therapy: The First Robust and Delivery-Efficient Spot-Scanning Proton Arc Therapy
DOI: [10.1016/j.ijrobp.2016.08.049](https://doi.org/10.1016/j.ijrobp.2016.08.049) *Beaumont Health System*



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Development (2019)



First prototype dynamic proton arc delivery on a clinical proton system showed delivery feasibility with IBA Proteus®One at The William Beaumont Proton Therapy Center

The first prototype of spot-scanning proton arc treatment delivery

PMID: 31100606.

DOI: [10.1016/j.radonc.2019.04.032](https://doi.org/10.1016/j.radonc.2019.04.032)



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Introduction to Static Arc (2023)

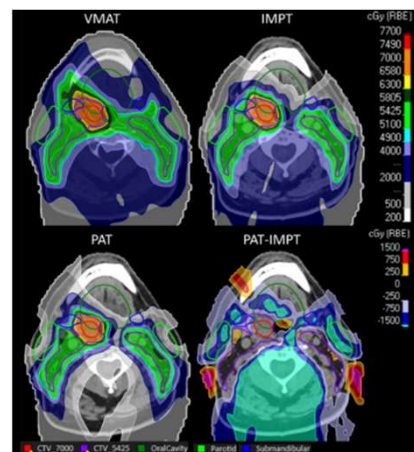


Studies from RaySearch / UMCG showed reduced toxicity / improved plan quality versus IMPT in H&N, with “step-and-shoot” delivery reaching potentially acceptable times.

30 beams and 360 energy layers

Spot scanning proton arc therapy reduces toxicity in oropharyngeal cancer patients

PMID: 36373893, DOI: [10.1002/mp.16098](https://doi.org/10.1002/mp.16098)



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Introduction to Static Arc (2023)



DISCRETE PROTON ARC THERAPY (PAT) FULLY COMMISSIONED AND VALIDATED AT THE TRENTO PROTON THERAPY CENTER


This "Discrete PAT" approximates fully rotational delivery with **20-30 discrete static beams** that are comprehensively optimized and sequentially delivered

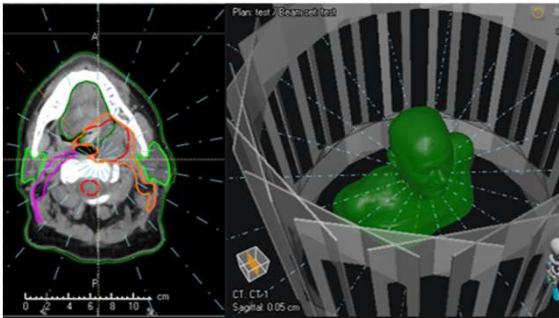
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Static Arc vs Dynamic Arc (Simplified)

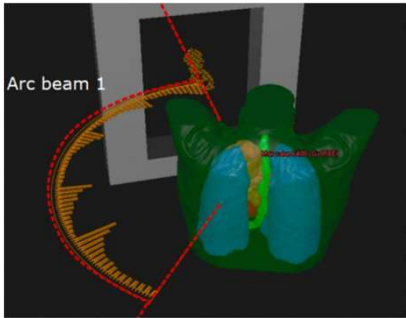




Static Arc


- “Step and Shoot” delivery
- Similar to a static field IMRT approach

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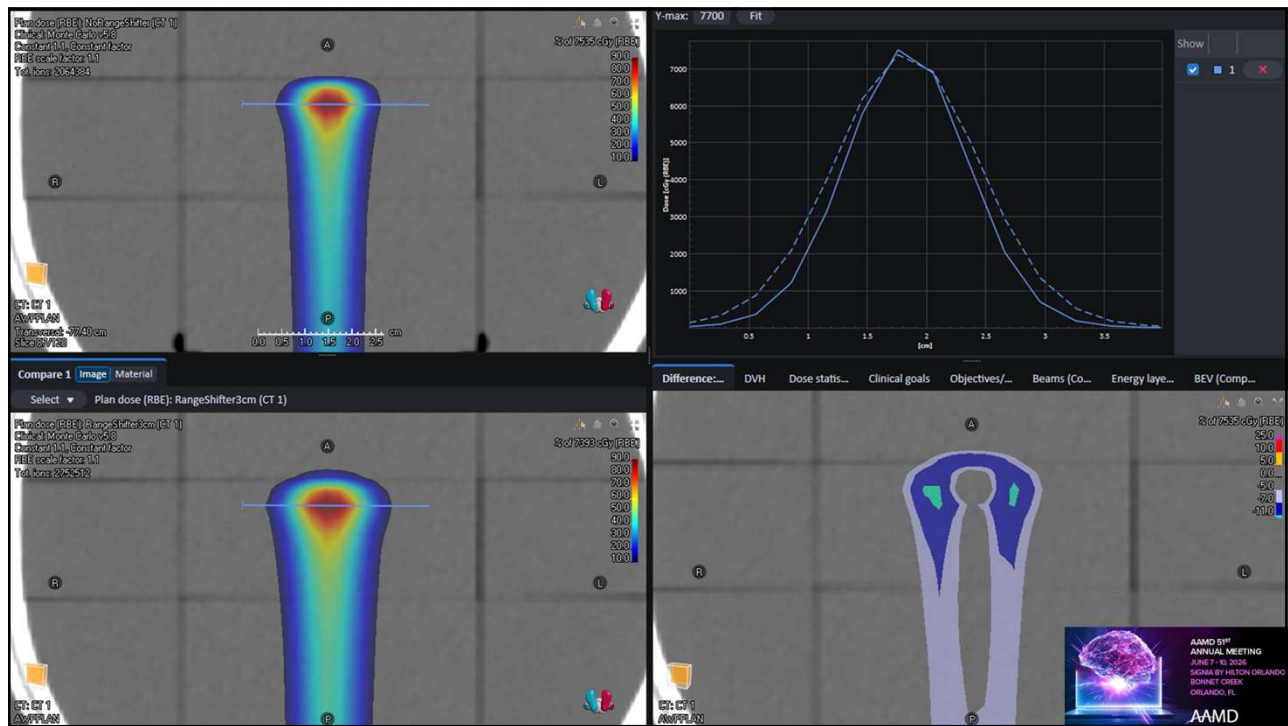


Dynamic Arc

- Beam is delivered during gantry/chair motion
- Similar to VMAT delivery





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Additional Resources (Webinars on YouTube)






RaySearch Webinars: Proton Arc Therapy in RayStation®

- RaySearch Laboratories




DirectARC™: Proton Arc at Full Speed

- Mevion Medical Systems




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Initial Planning and Delivery Time Studies

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Protons Can Still Improve for Head and Neck Cancers


Oropharynx (MDACC phase III), n=440: IMPT still had **34% swallowing difficulty**, **26.8% feeding tube dependence**, and **33% dry mouth**

Oropharynx (TORPEdO), n=205: 12-month QoL/swallowing was essentially the same with IMPT vs IMRT: **UW-QOL physical composite 78.3 vs 77.1** and **MDADI 79.4 vs 79.5**; **severe weight loss was 18.2% with IMPT**

(meta-analysis), n=956: Pooled proton data still showed **grade 3+ mucositis 32%**, **grade 3+ dysphagia 13%**, and **acute feeding tube use 21%**
DOI: 10.7759/cureus.78849


Nasopharynx, n=58: 69% had a clinically significant swallowing decline during IMPT, and **34% had not recovered by 12 months**
DOI: 10.1016/j.jfma.2025.06.035

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Planning Study Centro di Protonterapia | Trento (IBA)



MEDICAL PHYSICS

The International Journal of Medical Physics Research and Practice

RESEARCH ARTICLE | [Full Access](#)

Static proton arc therapy: Comprehensive plan quality evaluation and first clinical treatments in patients with complex head and neck targets


[Francesco Fracchiolla](#) [Erik Engwall](#) [Victor Mikhalev](#) [Marco Cianchetti](#) [Irene Giacomelli](#)
[Benedetta Siniscalchi](#) [Johan Sundstrom](#) [Otte Marthin](#) [Viktor Wase](#) [Mattia Bertolini](#) ... See all authors

First published: 12 February 2025 | <https://doi.org/10.1002/mp.17669> | [VIEW METRICS](#)

Region of interest	Dose index	MFO [GyRBE] median [± standard deviation (STDV)]	PAT [GyRBE] median [± STDV]	Dose difference (PAT–MFO) [GyRBE] median [± STDV]
CL parotid	Mean dose	21.0 [± 5.9]	7.7 [± 5.7]	-11.9 [± 3.9]
IL parotid	Mean	24.7 [± 9.3]	11.3	-10.5 [± 7.5]


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PSI Clinical Implementation



1. Learn from Centro di Protonterapia | Trento (IBA)
 - One of their main focuses was reducing the total number of energy layers
 - We have relatively quick energy layer spacing but longer time to load fields
2. Can we reduce the number of fields from 20?
3. What number of fields and energy layer spacing will have similar delivery time to our standard IMPT approach
4. How to improve plan quality

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PSI Gantry Specifications







Table 1: Gantry 3 Main Performance Specifications

Energy range	70 – 230 MeV
Energy precision	< 0.1 MeV
Beam momentum spread	< 1%
Layer switching time	200 ms
Beam FWHM at IC (in air)	8.5 mm
Lateral beam position precision (IC)	1 mm
Field size	300 × 400 mm ²
Dose delivery	2 Gy/Liter/min


Varian ProBeam® 360°
Opened in 2018
2 gantries (Varian/PSI-built) and 1 eye line

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Planning/Delivery Time Study




- 7 recent sinonasal/nasopharyngeal cases were selected (28 plans per patient)
- Compared with our standard 6 field IMPT plans with a range shifter
- Static Arc plans with **8, 9, 10, 12, 15, and 18** coplanar fields with equal spacing
- Automatic energy layer spacing of **0.7, 1.0, 1.4, and 2.0**

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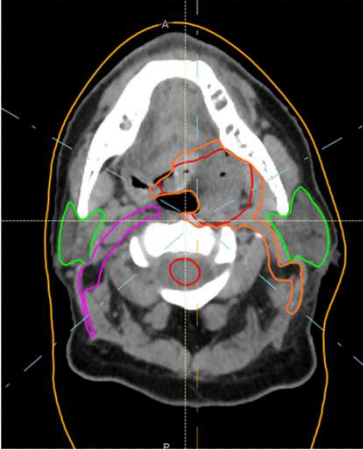
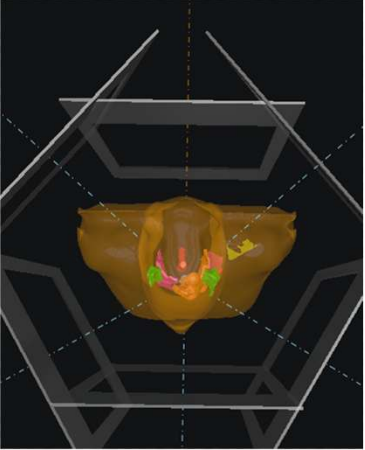
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Head and Neck Standard IMPT Beam Arrangement



6 field IMPT with 3 cm range shifter


Gantry [deg]	Couch [deg] Rotation	Range shifter
180.0	0.0	RS = 3cm
130.0	345.0	RS = 3cm
60.0	0.0	RS = 3cm
0.0	0.0	RS = 3cm
300.0	0.0	RS = 3cm
230.0	15.0	RS = 3cm

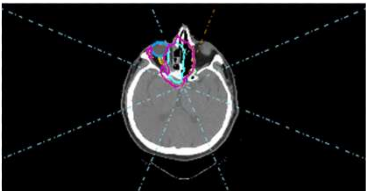



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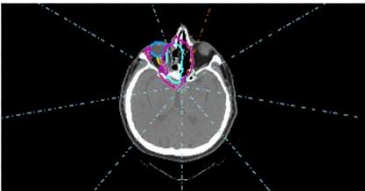
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Static Arc Beam Arrangements

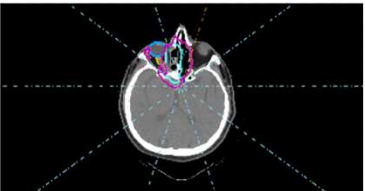




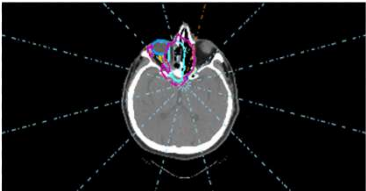
8 Beams



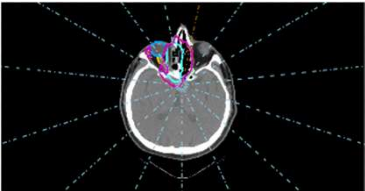
9 Beams



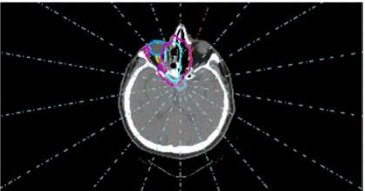
10 Beams




12 Beams



15 Beams



18 Beams

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Example Static Arc Comparison

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Example Static Arc Comparison

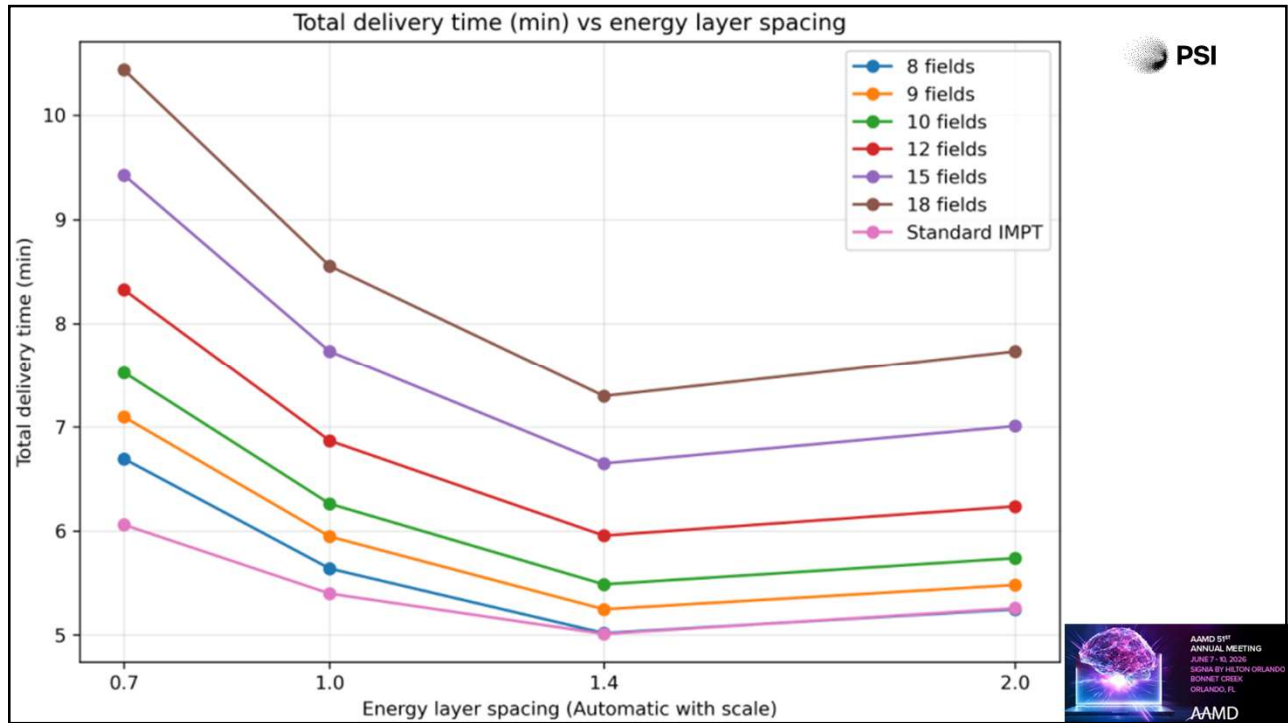
Name	ROI	ROI vol. [cm ³]	Dose [cGy (RBE)]						
			D99	D98	D95	Average	D50	D2	D1
Plan dose (RBE): G3_9f_v1_E1 [L...]	Brainstem	30.96	1049	1123	1226	2334	2000	5103	5384
Plan dose (RBE): G3_12f_v1_E1... [L...]	Brainstem	30.96	1001	1064	1171	2251	1996	4867	5075
Plan dose (RBE): G3_18f_v1_E1... [L...]	Brainstem	30.96	1092	1151	1236	2289	1947	4938	5165
Plan dose (RBE): G3_9f_v1_E1 [L...]	CTV_5412	427.34	5407	5431	5463	6243	6202	7089	7115
Plan dose (RBE): G3_12f_v1_E1... [L...]	CTV_5412	427.34	5407	5431	5459	6239	6191	7082	7107
Plan dose (RBE): G3_18f_v1_E1... [L...]	CTV_5412	427.34	5411	5434	5461	6242	6201	7081	7105
Plan dose (RBE): G3_9f_v1_E1 [L...]	CTV_6996	118.42	6196	6432	6808	6972	6996	7118	7142
Plan dose (RBE): G3_12f_v1_E1... [L...]	CTV_6996	118.42	6194	6431	6806	6972	6996	7108	7130
Plan dose (RBE): G3_18f_v1_E1... [L...]	CTV_6996	118.42	6220	6454	6835	6974	6996	7109	7132
Plan dose (RBE): G3_9f_v1_E1 [L...]	Eye_R	7.44	1063	1106	1322	3636	3777	5958	6094
Plan dose (RBE): G3_12f_v1_E1... [L...]	Eye_R	7.44	1067	1126	1357	3720	3856	5984	6139
Plan dose (RBE): G3_18f_v1_E1... [L...]	Eye_R	7.44	1109	1195	1379	3660	3789	5987	6136
Plan dose (RBE): G3_9f_v1_E1 [L...]	Hippocampus_L	2.05	291	297	315	528	464	1328	1625
Plan dose (RBE): G3_12f_v1_E1... [L...]	Hippocampus_L	2.05	311	321	336	543	478	1289	1523
Plan dose (RBE): G3_18f_v1_E1... [L...]	Hippocampus_L	2.05	265	269	291	542	478	1349	1640
Plan dose (RBE): G3_9f_v1_E1 [L...]	Hippocampus_R	2.06	257	265	273	487	370	1509	1670
Plan dose (RBE): G3_12f_v1_E1... [L...]	Hippocampus_R	2.06	267	279	292	535	451	1605	1787
Plan dose (RBE): G3_18f_v1_E1... [L...]	Hippocampus_R	2.06	292	294	300	524	427	1604	1801

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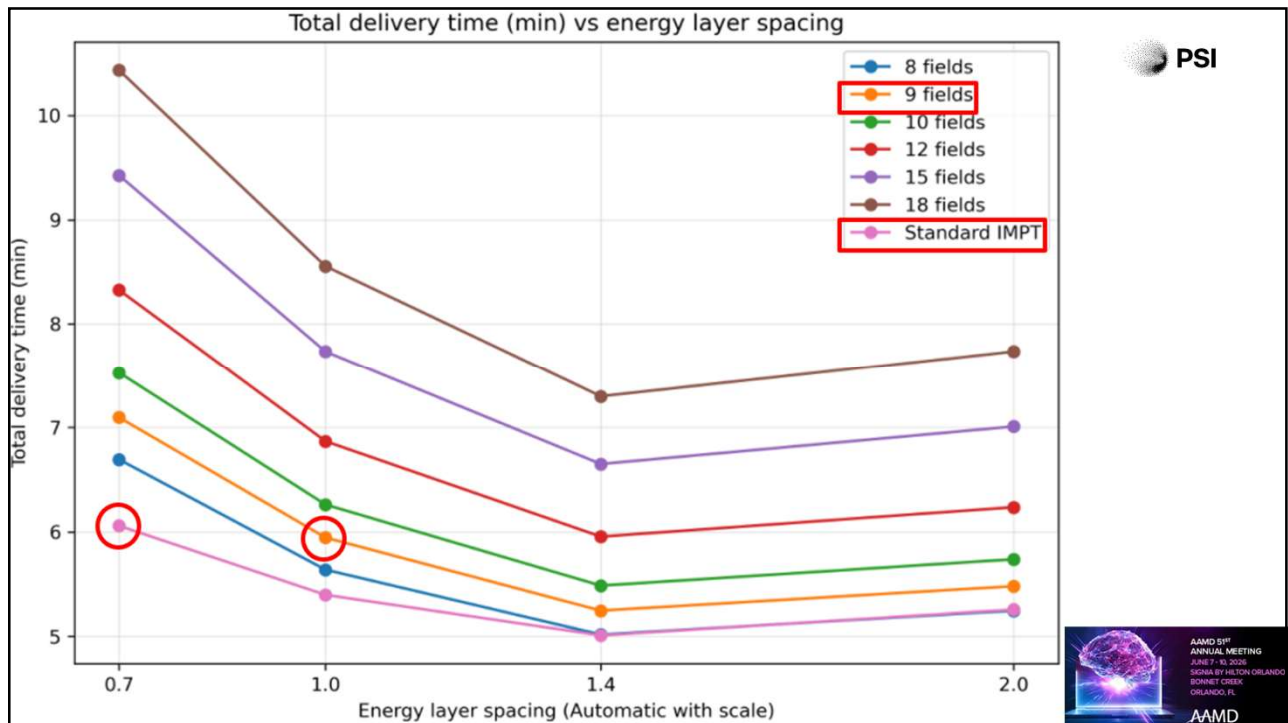
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Comparing Beam on Time




Patient-by-patient comparison:

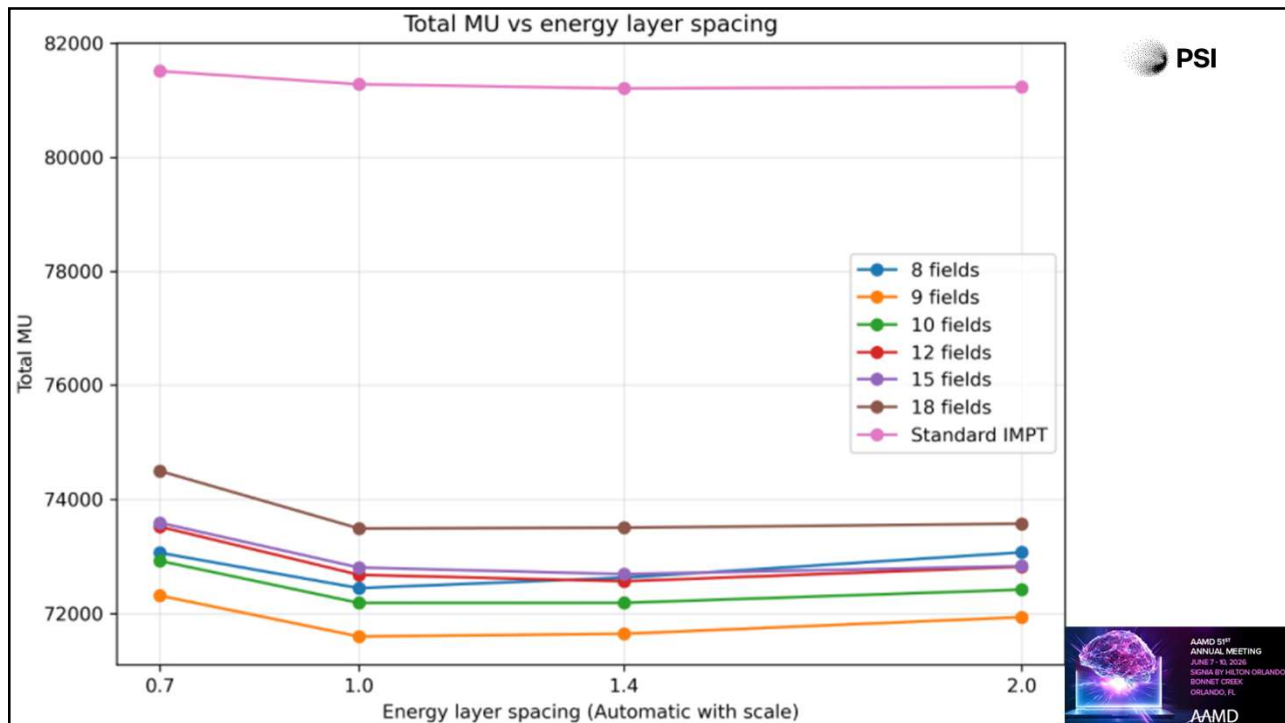
patient_folder	IMPT_E0.7_min	Arc_9fields_E1.0_min	Difference_Arc_minus_IMPT_min
1	4.998	4.606	-0.392
2	5.799	5.706	-0.093
3	5.958	6.147	0.190
4	7.118	7.504	0.386
5	6.265	5.594	-0.671
6	6.374	6.584	0.210
7	5.891	5.473	-0.418

Means:
 Standard IMPT, E=0.7 mean: 6.058 min
 9 fields, E=1.0 mean: 5.945 min
 Mean difference (Arc - IMPT): -0.113 min

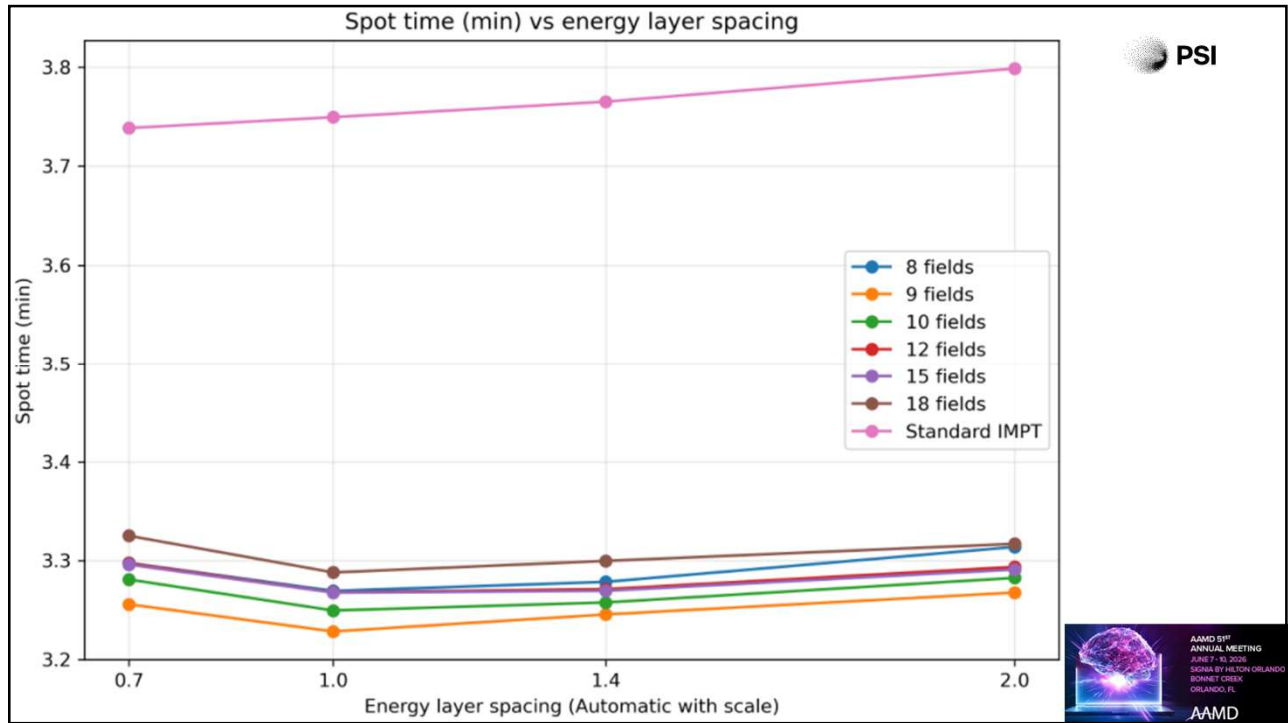
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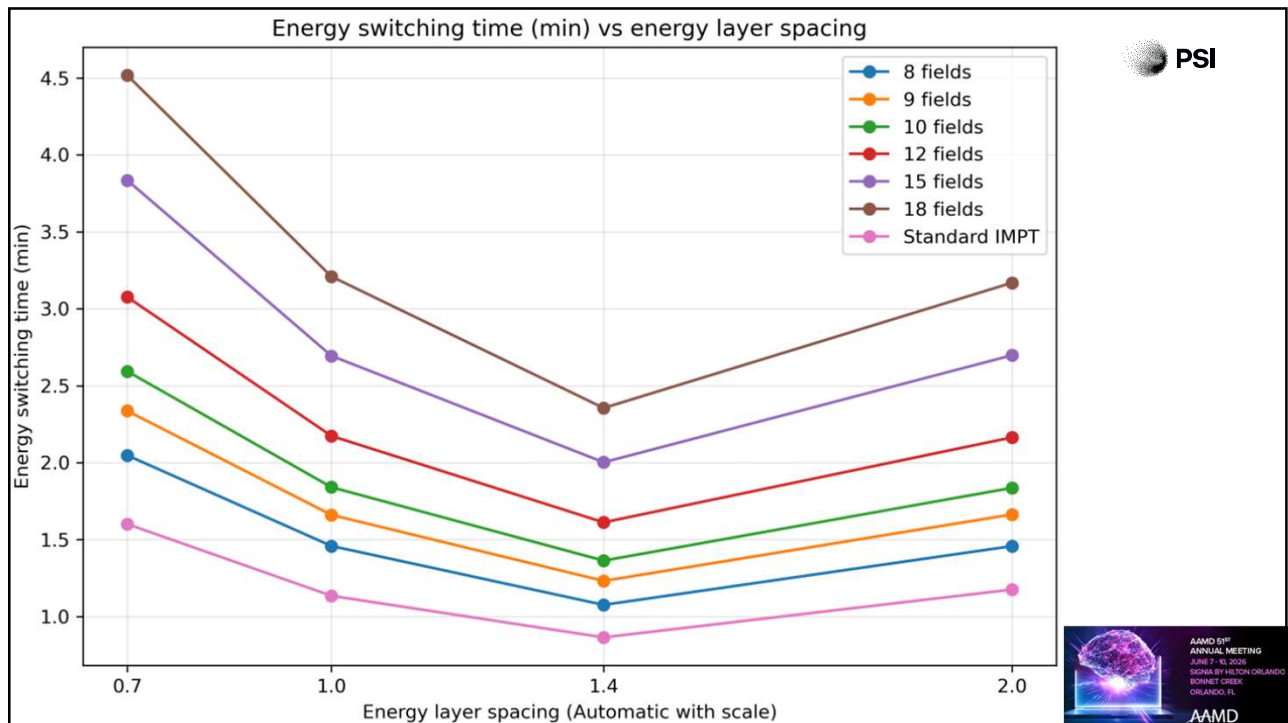
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CTV Coverage Comparison

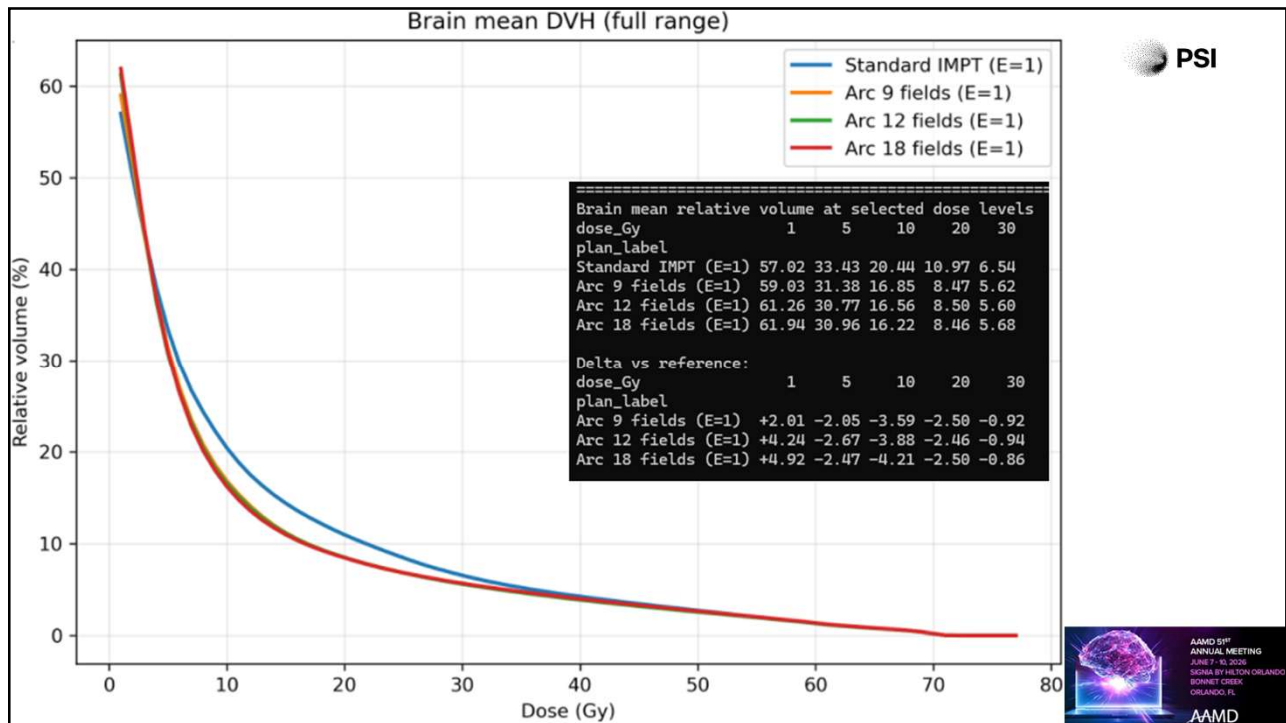


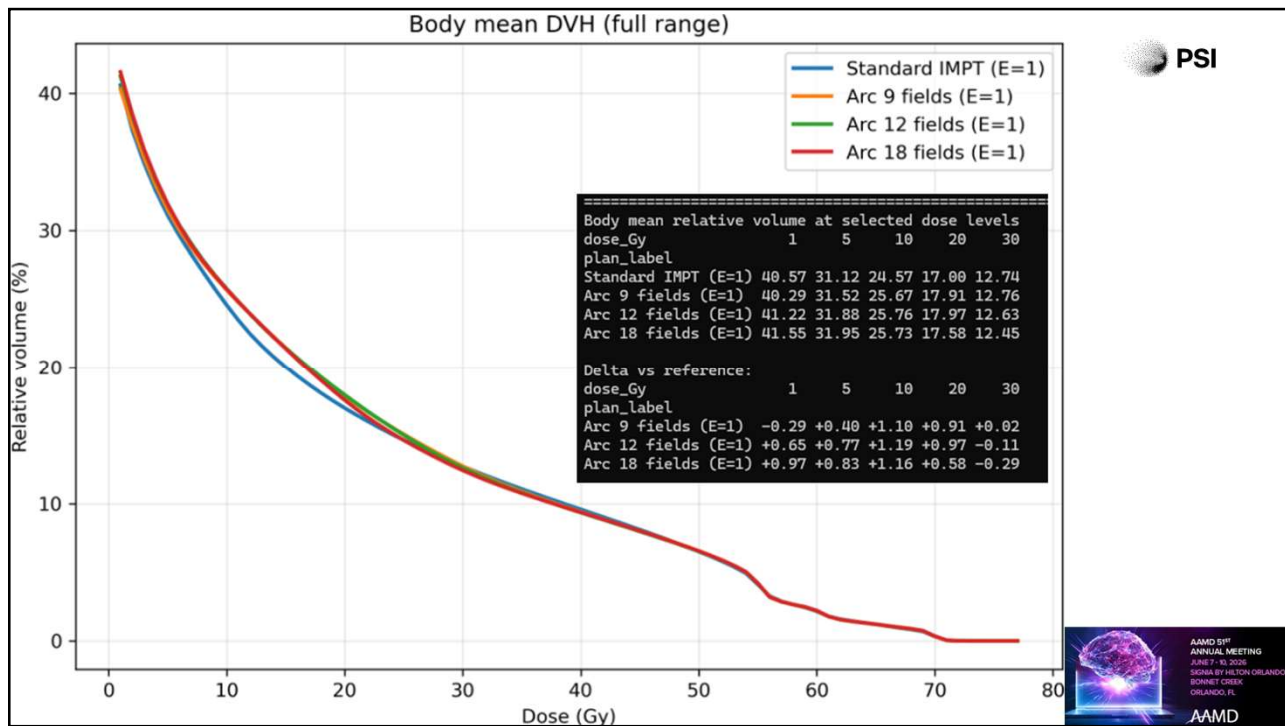
- High dose CTV coverage favored **Static Arc**
- Nominal V98 improved by 1.6–2.7% as fields increased from 8 to 18
- **Robustness improved with more fields:** robust average V98 +1.3 – 4.1% and robust worst case V98 +1.9 – 6.6%
- Intermediate- and low-dose CTV differences were less than 1%
- Adding fields slightly improved high dose CTV robustness at the cost of longer beam on time, with diminishing returns **beyond 12 fields**

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Total Delivery Time (Separate Small Study)


- Additional small study comparing the total time to deliver all fields
- Compared 10 field static arc with 6 field IMPT with a range shifter
- Includes gantry / couch rotation, and nozzle movements
- The 10 field static arc plan delivered in a similar total time (**12.52 min vs 12.38 min**)

Table 4: Measured delivery times at the treatment machine for SAT versus MFO. Times are inclusive of all mechanical overheads, including gantry, couch, and nozzle movements.

Patient (n)	Elective CTV Volume (cc)	SAT Delivery Time (s)	MFO Delivery Time (s)	Difference (s)
1	247	596	591	+5
2	247	567	581	-14
3	269	714	761	-47
4	589	951	873	+78
5	405	905	862	+43
6	302	804	789	+15
Mean	343 cc	756.2 s	742.8 s	+13.4 s


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What We Learned




- 9–10 fields provided a practical balance of plan quality and delivery time
- More fields improved robustness slightly, but with diminishing returns beyond **~12 fields**.
- Local delivery timing matters, so every center should benchmark on its own machine

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Practical Considerations Affecting Static-Arc Implementation





- Shared beamline / room switching
- Dose rate / beam current
- Beam request / beam loading time
- Energy layer switching time
- Number of energy layers
- Spot delivery speed
- Interlocks















Some clinical goals: reduce treatment time, reduce OAR dose, and optimize LET

Delivery time is highly center-specific and should be benchmarked locally.

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Treatment Planning Considerations

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Treatment Planning Considerations

- Beam arrangement
- Optimization approach and objectives
- Spot avoidance areas
- Controlling low dose with optimization objectives (where clinically relevant)




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Current Clinical Beam Arrangement


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- 9 fields
- Initially tested with lateral fields, but we determined their contribution was minimal due to the shoulder avoidance and parotid sparing
- Alternative beams closer to lateral or slightly posterior oblique can be used when treating in the nasal cavity to help reduce dose to the brain.

Gantry [deg]

180.0

160.0

140.0

60.0

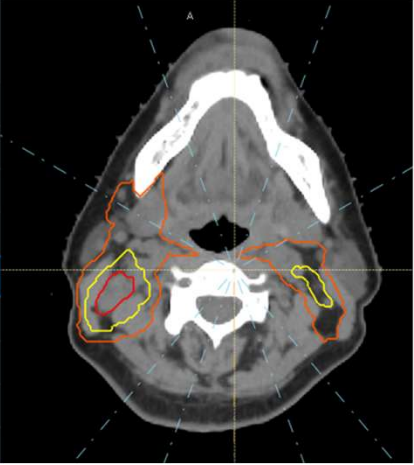
20.0


340.0

300.0

220.0

200.0






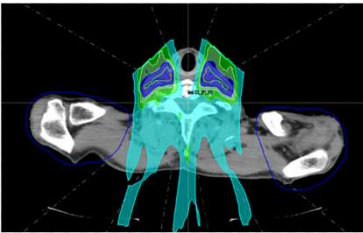
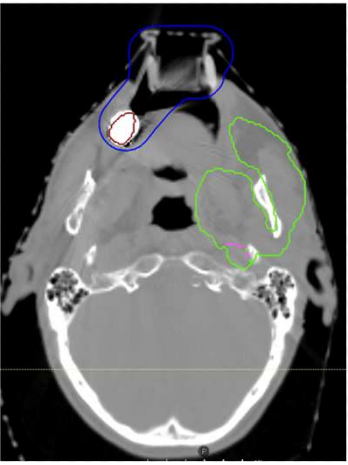
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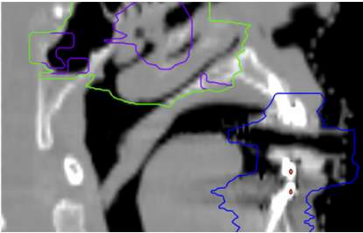
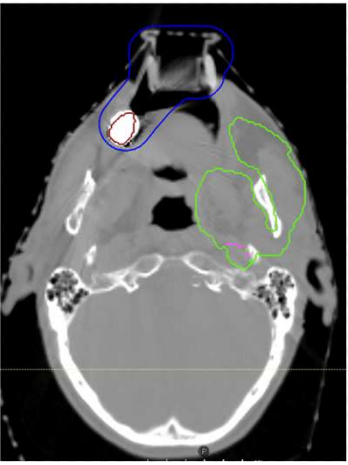
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Spot Avoidance


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- OAR range margin used to avoid spots being placed through the bite block / stent, and shoulders



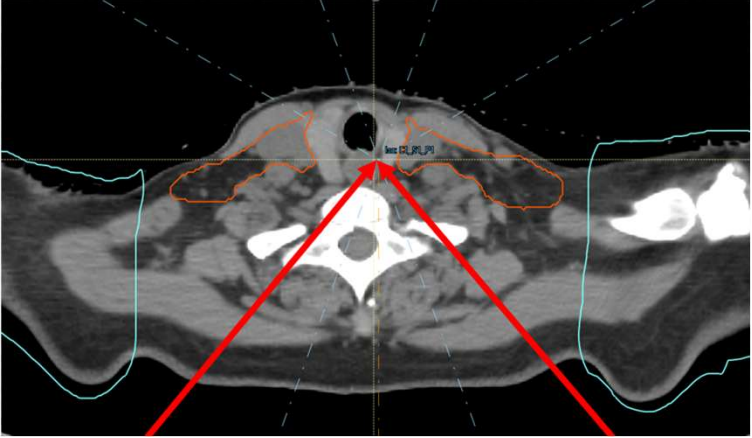
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Shoulder Avoidance

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- Shoulder Avoidance for the two most posterior oblique beams
- Including large/lateral skin folds
- May be adjusted on a patient-specific basis depending on shoulder position and target location



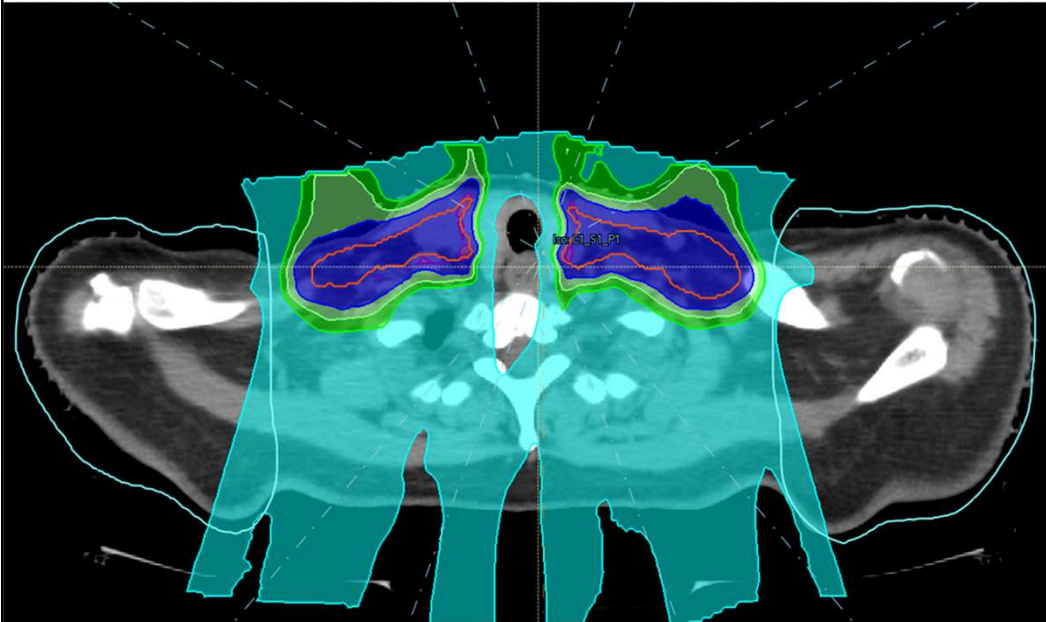
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Shoulder Avoidance

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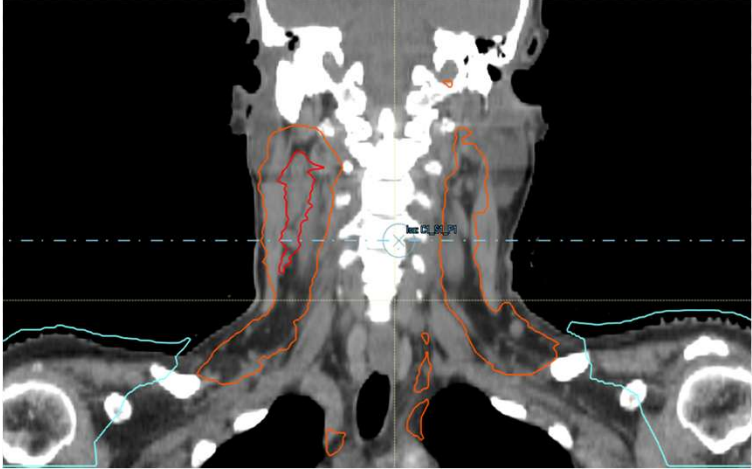


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Shoulder Avoidance Superior Margin


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- Additional superior margin to account for differences in shoulder position




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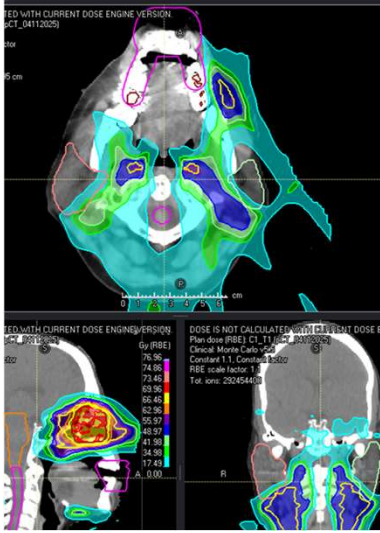


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Dental / Stent Filling Avoidance


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- Includes the stent/bite block and adjacent dental fillings (not avoiding dense teeth)
- Drawn as a single contour to avoid small gaps where spots could be placed



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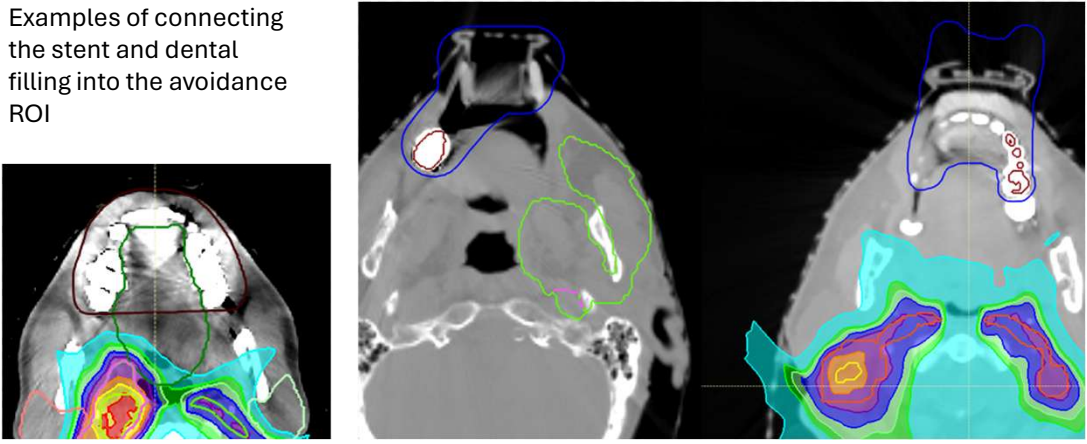


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Dental / Stent Filling Avoidance

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- Examples of connecting the stent and dental filling into the avoidance ROI



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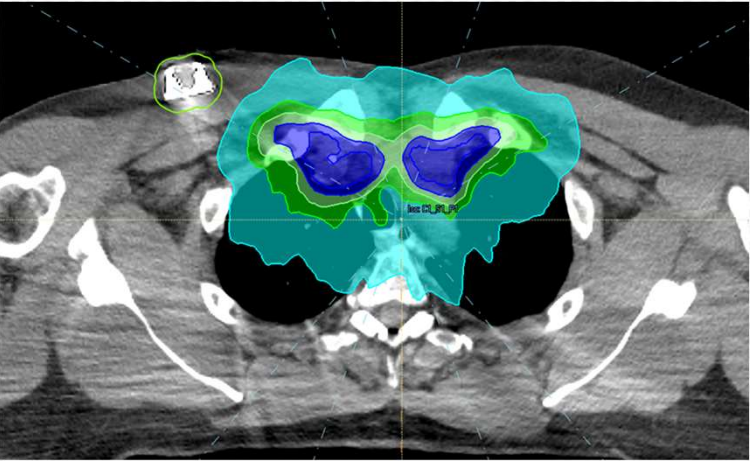
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Port Avoidance

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- Avoiding treating through the port with a small margin



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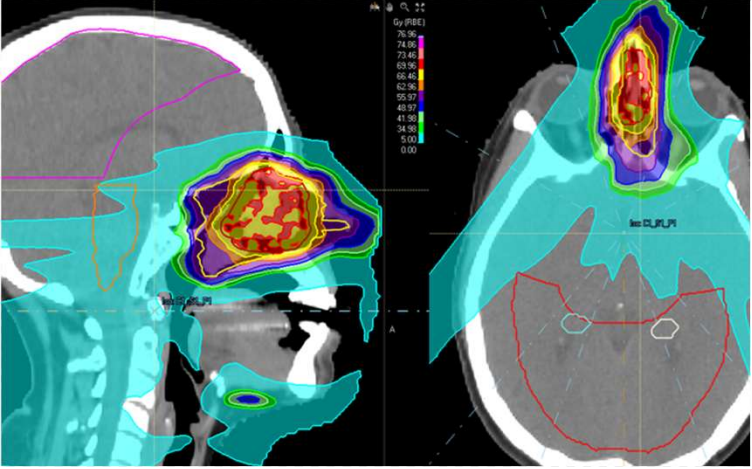
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Low Dose Brain Push OAR (5Gy)

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- Create structures to help reduce the brain dose (not with spot avoidance)
- Cropped to help push the low dose in the brain
- Additional objectives placed on the hippocampi



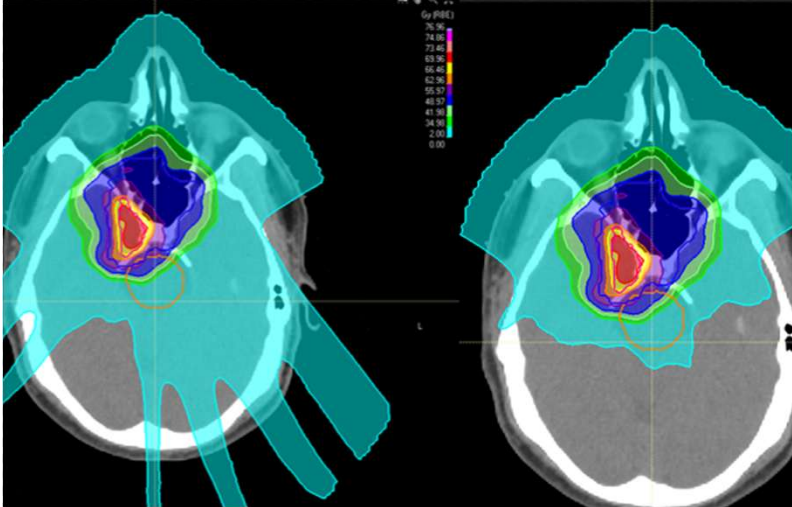
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Controlling the Low Dose (2 Gy / 5 Gy)

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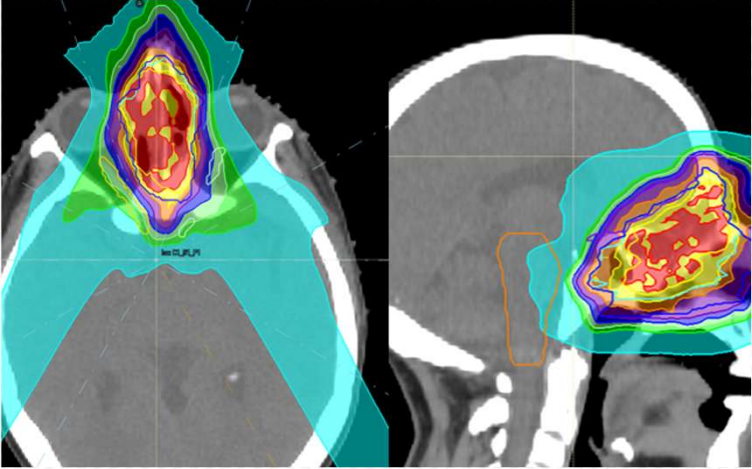


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Controlling the Low Dose

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- Trying to minimize low-intermediate dose to the brain while gaining benefit from posterior beams
- Challenge will be determining how to optimize the low dose without it negatively impacting other aspects of the plan
- Focus on most impactful OARs or areas



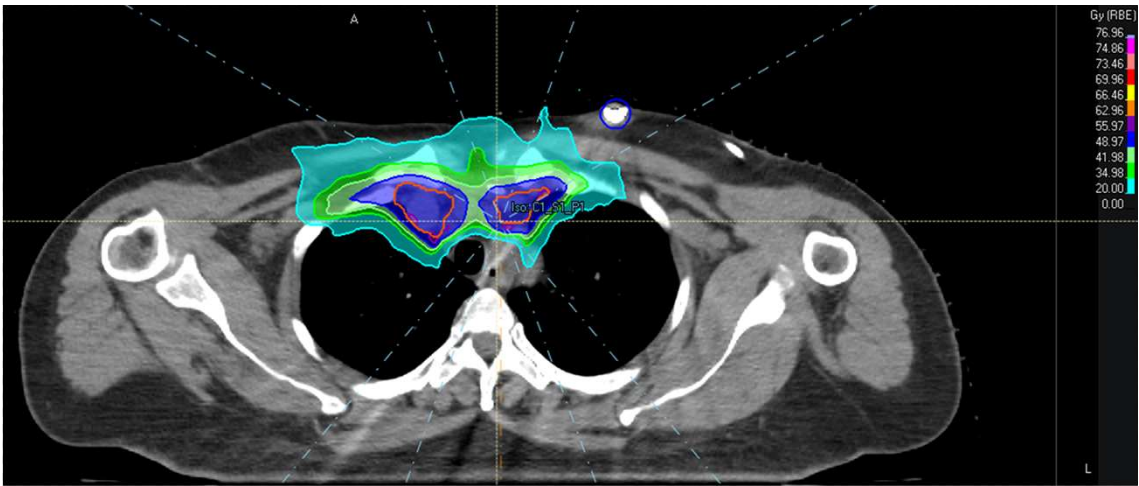
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Lung Dose Push (20 Gy)

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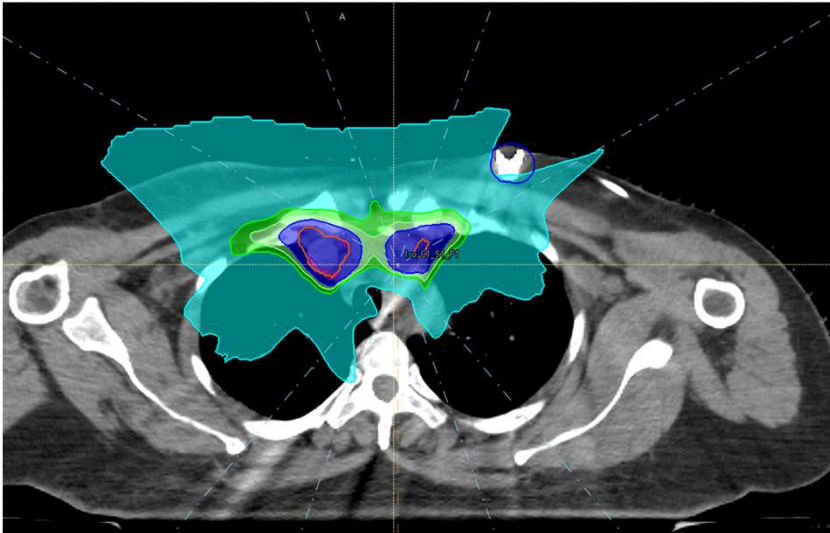

Gy (RBE)
76.96
74.86
73.46
69.96
66.46
62.96
55.97
49.97
41.98
34.98
20.00
0.00

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ORLANDO, FL
AAMD

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Lung Dose Push (5 Gy)




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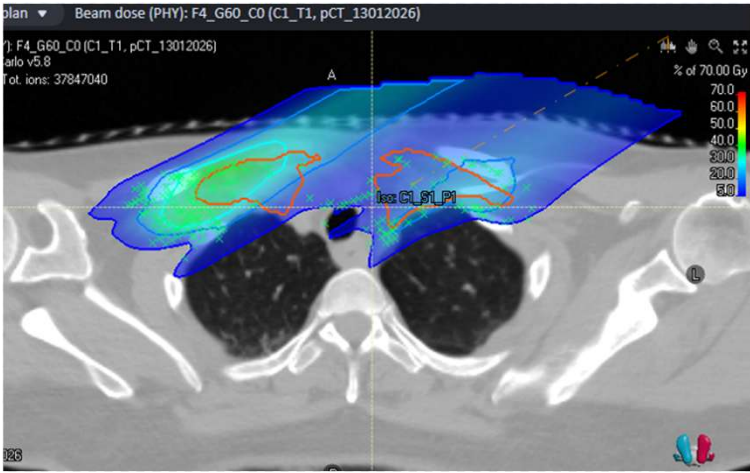
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JUNE 7 - 11, 2026
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Neck Dose




- Even without a range shifter, anterior beams can still contribute meaningful spot placement and dose.



plan Beam dose (PHY): F4_G60_C0 (C1_T1, pCT_13012026)
F4_G60_C0 (C1_T1, pCT_13012026)
v5.8
Total ions: 37847040

% of 70.00 Gy
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0

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Optimization Objectives



- OARs need to be actively pushed to realize the dosimetric benefit.
- A simple approach is to use a low-weight mean-dose objective or falloff-dose objective
- Review the RayStation cost function / actual dose to confirm the OARs are being pushed.


Function	Constraint	Dose	ROI	Description	Robust	Weight	Value
Physical composite objective							
Dose fall-off	Plan (RBE)		BODY	Dose fall-off [H]7100 cGy (RBE) [L]13400 cGy (RBE), Low dose distance 1.30 cm		20.00	0.0092
Max dose	Plan (RBE)		fsOralcavPush	Max dose 3000 cGy (RBE)		3.00	0.0091
Uniform dose	Plan (RBE)		fsUpperS412	Uniform dose 5550 cGy (RBE)		20.00	0.0084
Max EUD	Plan (RBE)		fsParotidSub_L	Max EUD 550 cGy (RBE), Parameter A 1		0.10	0.0077
Max EUD	Plan (RBE)		Parotid_R	Max EUD 450 cGy (RBE), Parameter A 1		0.14	0.0075
Max EUD	Plan (RBE)		fsOralcavPush	Max EUD 500 cGy (RBE), Parameter A 1		0.20	0.0074
Max EUD	Plan (RBE)		fs_PCM_Med_subNew	Max EUD 2100 cGy (RBE), Parameter A 1		0.30	0.0073
Max EUD	Plan (RBE)		Submandibular_R	Max EUD 700 cGy (RBE), Parameter A 1		0.14	0.0072
Max EUD	Plan (RBE)		fs_PCM_Sup_subNew	Max EUD 2400 cGy (RBE), Parameter A 1		0.30	0.0070
Min dose	Plan (RBE)		fsGet69	Min dose 6900 cGy (RBE)		100.00	0.0070
Max dose	Plan (RBE)		fsRing6996	Max dose 6600 cGy (RBE)		90.00	0.0069
Uniform dose	Plan (RBE)		CTV_7000	Uniform dose 6996 cGy (RBE)		100.00	0.0069
Max EUD	Plan (RBE)		Thyroid	Max EUD 2300 cGy (RBE), Parameter A 1		0.10	0.0066
Max dose	Plan (RBE)		fsMandiblePush	Max dose 5000 cGy (RBE)		1.00	0.0054
Max EUD	Plan (RBE)		fsLarynxPush	Max EUD 500 cGy (RBE), Parameter A 1		0.10	0.0054
Max DVH	Plan (RBE)		fsPCM_Sup_sub	Max DVH 3000 cGy (RBE) to 21.00 % volume		1.50	0.0044
Max DVH	Plan (RBE)		fsPCM_Sup_sub	Max DVH 4000 cGy (RBE) to 1.00 % volume		5.00	0.0043
Max EUD	Plan (RBE)		PCM_inf	Max EUD 400 cGy (RBE), Parameter A 1		0.25	0.0039
Max DVH	Plan (RBE)		fsPCM_Med_sub	Max DVH 3000 cGy (RBE) to 14.00 % volume		1.50	0.0037
Max DVH	Plan (RBE)		fsPCM_Med_sub	Max DVH 4000 cGy (RBE) to 1.00 % volume		10.00	0.0030
Uniform dose	Plan (RBE)		fsUpperS940	Uniform dose 6029 cGy (RBE)		50.00	0.0028
Max EUD	Plan (RBE)		fsSupraglottic	Max EUD 500 cGy (RBE), Parameter A 1		0.10	0.0026
Max dose	Plan (RBE)		fsRing940	Max dose 5643 cGy (RBE)		90.00	0.0021
Max dose	Plan (RBE)		fsAirwayPush	Max dose 5300 cGy (RBE)		1.00	0.0017
Max DVH	Plan (RBE)		fsAirwayPush	Max DVH 3000 cGy (RBE) to 10.00 % volume		0.10	0.0015
Max dose	Plan (RBE)		fsRing412	Max dose 5300 cGy (RBE)		90.00	0.0013



Clinical Case Examples



Delivering High Quality Plans (Planning Study)





Plan dose (RBE) PSI_Phase1 (CT 1)
Clinical Monte Carlo v5.8
Constant 1.1, Constant factor
RBE scale factor: 1.1
Tel. no.: 384683952


CT, CT 1
AVPPLAN
Transversal: 2.80 cm
Slice: 134.03

Plan dose (RBE) PSI_Phase1 (CT 1)
Clinical Monte Carlo v5.8
Constant 1.1, Constant factor
RBE scale factor: 1.1
Tel. no.: 384683952

CT, CT 1
AVPPLAN
Sagittal: 0.24 cm
Slice: 134.03

Plan dose (RBE) PSI_Phase1 (CT 1)
Clinical Monte Carlo v5.8
Constant 1.1, Constant factor
RBE scale factor: 1.1
Tel. no.: 384683952

CT, CT 1
AVPPLAN
Coronal: 20.84 cm
Slice: 134.03



Plan dose (RBE) PSI_Phase1 (CT 1)

Dose axis: Absolute cGy (RBE) | Volume axis: Relative max


Organs at Risk	Associated dose Result	Current plan dose (RBE) Result
Esophagus_Cerv	Dmean ≤ 3000 cGy (RBE) 296 cGy (RBE)	296 cGy (RBE)
GlotticArea	Dmean ≤ 4000 cGy (RBE) 553 cGy (RBE)	553 cGy (RBE)
Lips	Dmean ≤ 2000 cGy (RBE) 10 cGy (RBE)	10 cGy (RBE)
Mandible	D0.00 % ≤ 7200 cGy (RBE) 7090 cGy (RBE)	7090 cGy (RBE)
OralCavity_Ext	Dmean ≤ 3000 cGy (RBE) 2980 cGy (RBE)	2980 cGy (RBE)
Parotid_L	Dmean ≤ 2600 cGy (RBE) 1404 cGy (RBE)	1404 cGy (RBE)
Parotid_R	Dmean ≤ 2600 cGy (RBE) 683 cGy (RBE)	683 cGy (RBE)
PCM_Inf	Dmean ≤ 5500 cGy (RBE) 512 cGy (RBE)	512 cGy (RBE)
PCM_Med	Dmean ≤ 5500 cGy (RBE) 4724 cGy (RBE)	4724 cGy (RBE)
PCM_Sup	Dmean ≤ 5500 cGy (RBE) 5294 cGy (RBE)	5294 cGy (RBE)
SpinalCord	D0.00 % ≤ 6000 cGy (RBE) 2996 cGy (RBE)	2996 cGy (RBE)
Supraglottic	Dmean ≤ 4000 cGy (RBE) 681 cGy (RBE)	681 cGy (RBE)

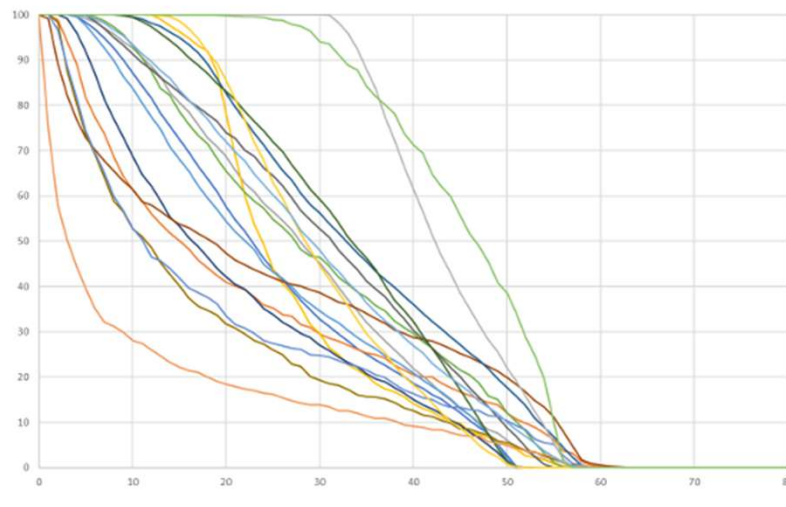
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Contralateral Submandibular Gland (Planning Study)





Case 05, Case 04, Case 05, Case 05, Case 07, Case 08, Case 09, Case 10, Case 11, Case 12, Case 13, Case 14, Case 15, Case 16, Case 17, Case 18, Case 19



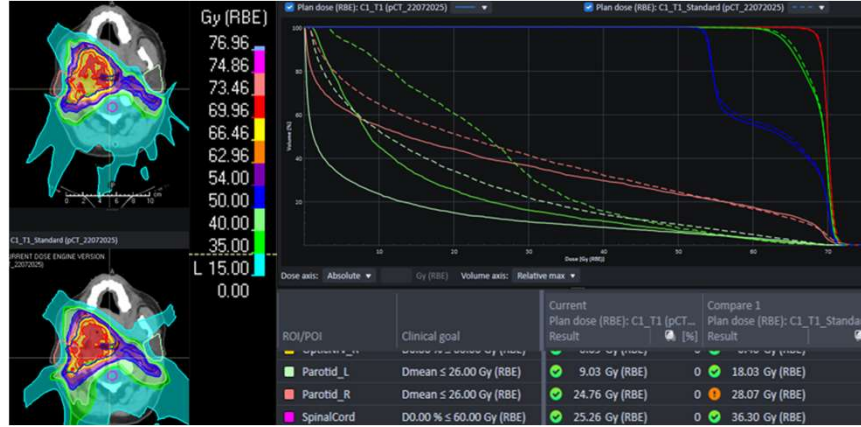
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Initial Clinical Plan Comparison



- For the first few months, all patients had both a standard IMPT plan and a static proton arc plan created.
- The physician then selected the preferred plan

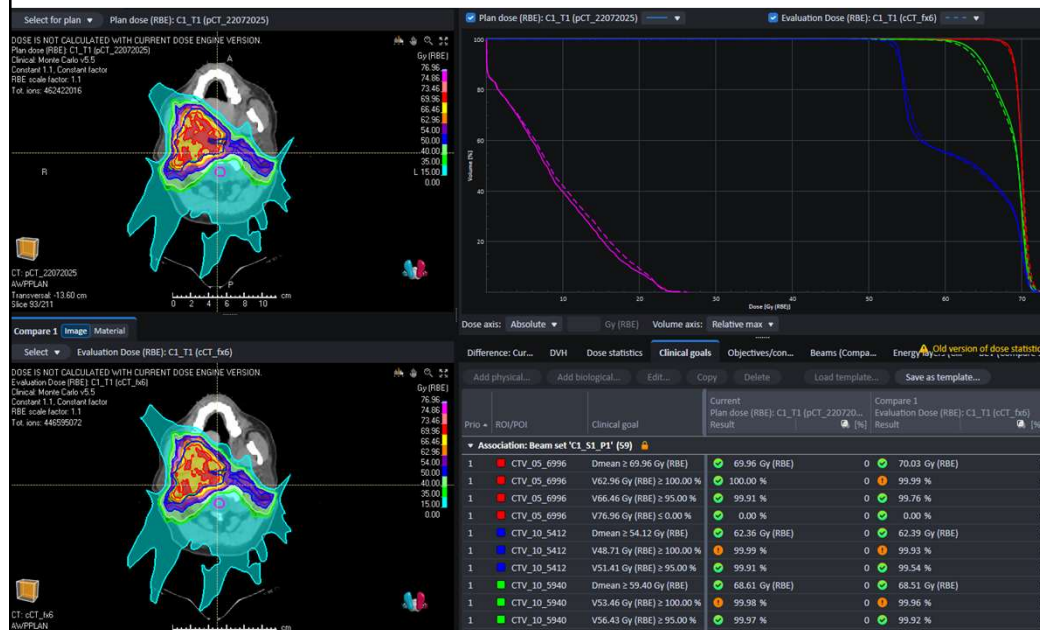


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Recalculation Fx 6

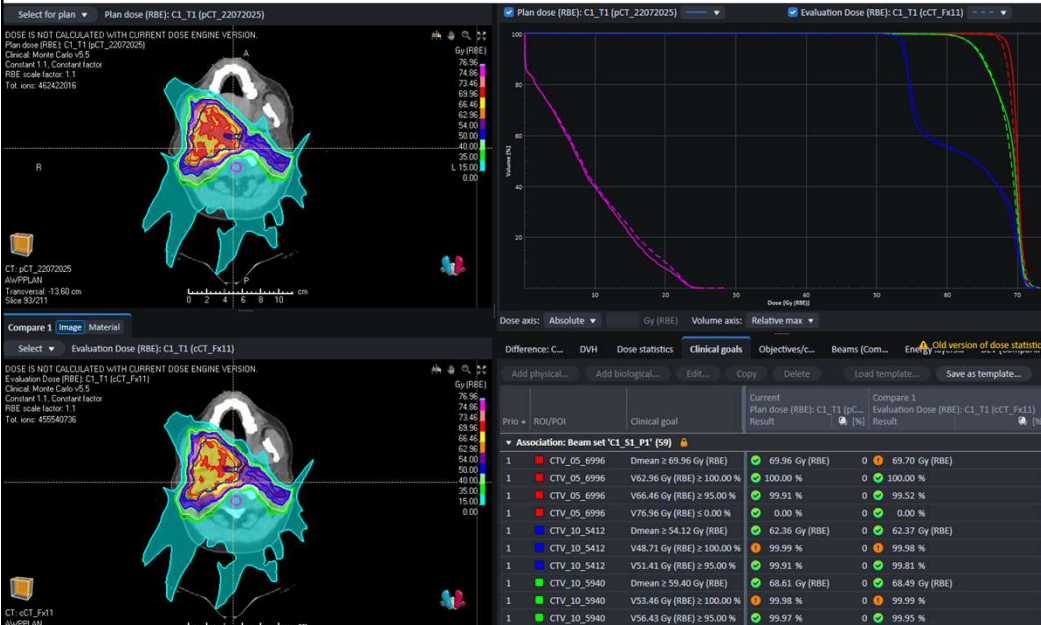


54



Recalculation Fx 11






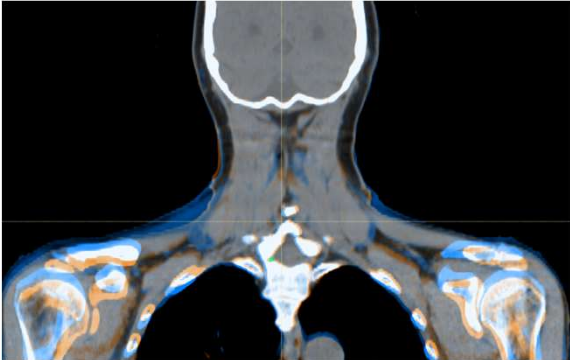
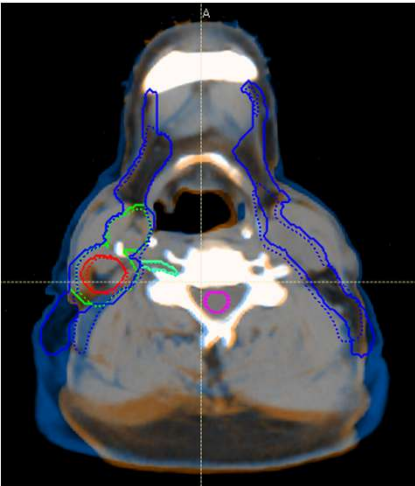
Prio	ROI/POI	Clinical goal	Current Plan Dose (RBE): C1_T1 (pCT_22072025) Result	Compare 1: Evaluation Dose (RBE): C1_T1 (cCT_Fx11) Result
1	CTV_05_6996	Dmean ≥ 69.96 Gy (RBE)	69.96 Gy (RBE)	69.70 Gy (RBE)
1	CTV_05_6996	V62.96 Gy (RBE) ≥ 100.00 %	100.00 %	100.00 %
1	CTV_05_6996	V66.46 Gy (RBE) ≥ 95.00 %	99.91 %	99.52 %
1	CTV_05_6996	V76.96 Gy (RBE) ≤ 0.00 %	0.00 %	0.00 %
1	CTV_10_5412	Dmean ≥ 54.12 Gy (RBE)	62.36 Gy (RBE)	62.37 Gy (RBE)
1	CTV_10_5412	V48.71 Gy (RBE) ≥ 100.00 %	99.99 %	99.98 %
1	CTV_10_5412	V51.41 Gy (RBE) ≥ 95.00 %	99.91 %	99.81 %
1	CTV_10_5940	Dmean ≥ 59.40 Gy (RBE)	68.61 Gy (RBE)	68.49 Gy (RBE)
1	CTV_10_5940	V53.46 Gy (RBE) ≥ 100.00 %	99.98 %	99.99 %
1	CTV_10_5940	V56.43 Gy (RBE) ≥ 95.00 %	99.97 %	99.95 %


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Recalculation Fx 20



- Changes in shoulder position

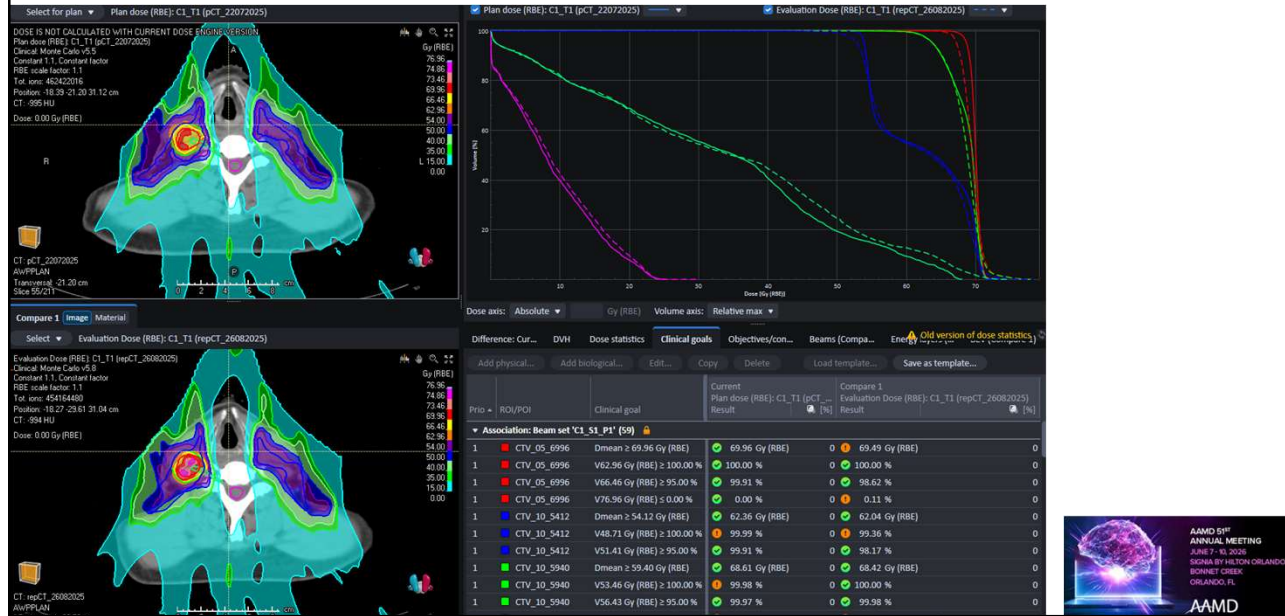


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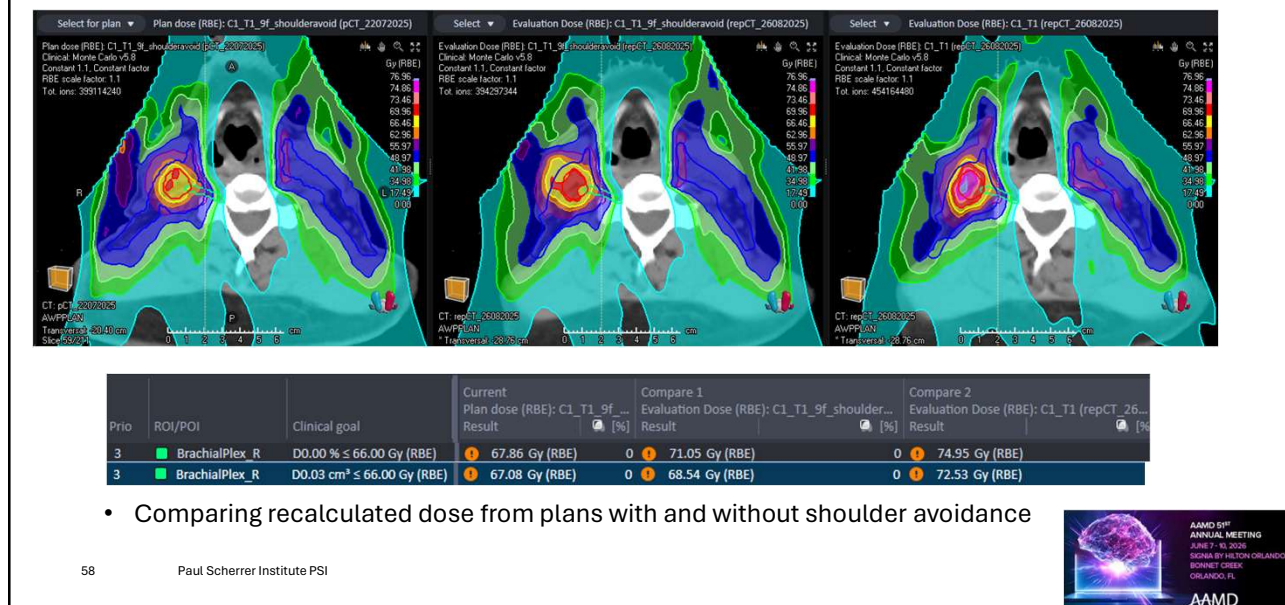
56

Recalculation Fx 20 (No Shoulder Avoidance)



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Recalculation Fx 20 (With Shoulder Avoidance)




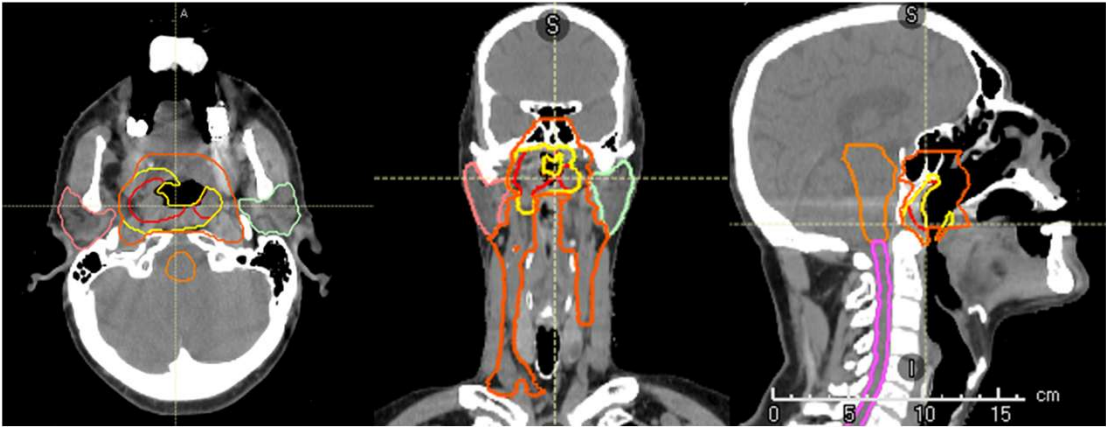
- Comparing recalculated dose from plans with and without shoulder avoidance

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Clinical Plan Comparison






0 5 10 15 cm

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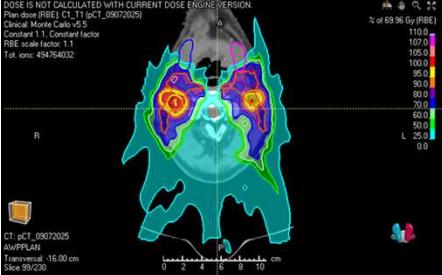
Clinical Plan Comparison



Select for plan: Plan dose (RBE): CI_T1 (pCT_09072025)

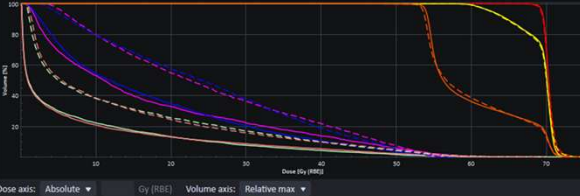
DOSE IS NOT CALCULATED WITH CURRENT DOSE ENGINE VERSION

Plan dose (RBE): CI_T1 (pCT_09072025)
Clinical: Moria Carlo v5.5
Constant: 1.1, Constant factor
RBE scale factor: 1.1
Tot ions: 484764032



CT: pCT_09072025
AWPPLAN
Transversal: 16.00 cm
Slice: 99/220

Select for plan: Plan dose (RBE): CI_T1 (pCT_09072025)



Dose axis: Absolute Gy (RBE) | Volume axis: Relative max %

Difference: Curr... DVH | Dose statistics | Clinical goals | Objectives/con... | Beams (Compa... | Energy (pCT_09072025) | AAMD version of dose statistics

Add physical... Add biological... | Edit... | Copy | Delete | Load template... | Save as template...

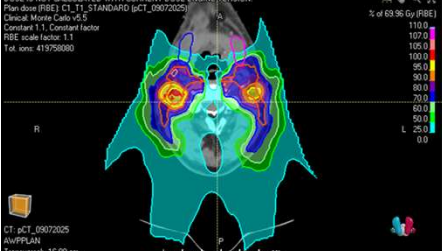
Prio	ROI/POI	Clinical goal	Current Plan dose (RBE): CI_T1 (pCT_09072025) Result	Compare 1 Plan dose (RBE): CI_T1_STANDARD (pCT_09072025) Result
2	Parotid_L	Dmean ≤ 26.00 Gy (RBE)	7.17 Gy (RBE)	13.23 Gy (RBE)
2	Parotid_R	Dmean ≤ 26.00 Gy (RBE)	7.20 Gy (RBE)	13.20 Gy (RBE)
2	SpinalCord	DD.00 % ≤ 60.00 Gy (RBE)	17.99 Gy (RBE)	25.00 Gy (RBE)
2	Temporallobe_L	DD.10 cm³ ≤ 70.00 Gy (RBE)	55.10 Gy (RBE)	55.51 Gy (RBE)
2	Temporallobe_R	DD.10 cm³ ≤ 70.00 Gy (RBE)	56.07 Gy (RBE)	57.38 Gy (RBE)
2	TMJ_L	Dmean ≤ 68.00 Gy (RBE)	35.03 Gy (RBE)	35.13 Gy (RBE)
2	TMJ_R	Dmean ≤ 68.00 Gy (RBE)	43.93 Gy (RBE)	45.05 Gy (RBE)
3	A_Carotid_L	DD.00 % ≤ 40.00 Gy (RBE)	70.68 Gy (RBE)	69.96 Gy (RBE)
3	A_Carotid_R	DD.00 % ≤ 40.00 Gy (RBE)	70.67 Gy (RBE)	69.98 Gy (RBE)
3	Bone_Mandible	DD.00 % ≤ 72.00 Gy (RBE)	51.94 Gy (RBE)	48.51 Gy (RBE)
3	BrachialPlex_L	DD.00 % ≤ 66.00 Gy (RBE)	55.33 Gy (RBE)	55.05 Gy (RBE)
3	BrachialPlex_R	DD.00 % ≤ 66.00 Gy (RBE)	65.90 Gy (RBE)	67.38 Gy (RBE)
3	Buccal_Mucosa_L	Dmean ≤ 30.00 Gy (RBE)	13.91 Gy (RBE)	14.88 Gy (RBE)
3	Buccal_Mucosa_R	Dmean ≤ 30.00 Gy (RBE)	20.07 Gy (RBE)	21.66 Gy (RBE)
3	Cavity_Oral	Dmean ≤ 30.00 Gy (RBE)	10.14 Gy (RBE)	15.05 Gy (RBE)
3	Gland_Submand_L	Dmean ≤ 30.00 Gy (RBE)	17.16 Gy (RBE)	25.11 Gy (RBE)
3	Gland_Submand_R	Dmean ≤ 30.00 Gy (RBE)	17.01 Gy (RBE)	25.03 Gy (RBE)

Compare 1 image Material


Select: Plan dose (RBE): CI_T1_STANDARD (pCT_09072025)

DOSE IS NOT CALCULATED WITH CURRENT DOSE ENGINE VERSION

Plan dose (RBE): CI_T1_STANDARD (pCT_09072025)
Clinical: Moria Carlo v5.5
Constant: 1.1, Constant factor
RBE scale factor: 1.1
Tot ions: 419750080




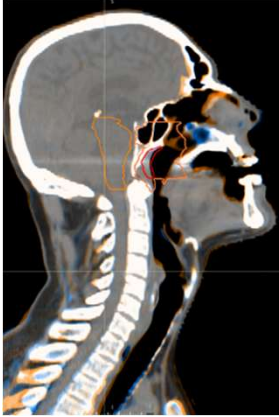
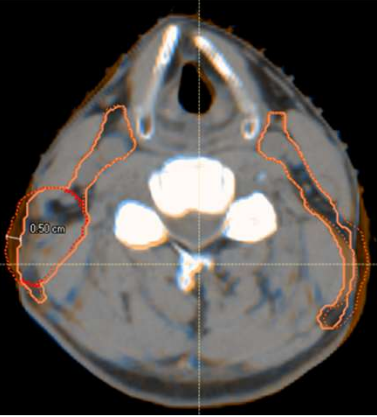
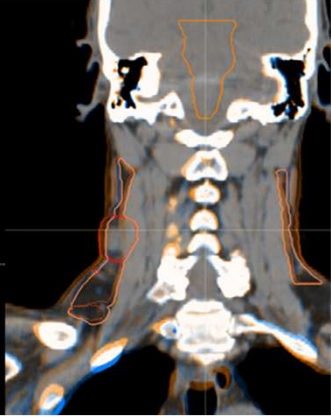
CT: pCT_09072025
AWPPLAN
Transversal: 16.00 cm
Slice: 99/220



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Detecting Anatomical Changes




- Good setup
- Some weight loss noticed in the neck

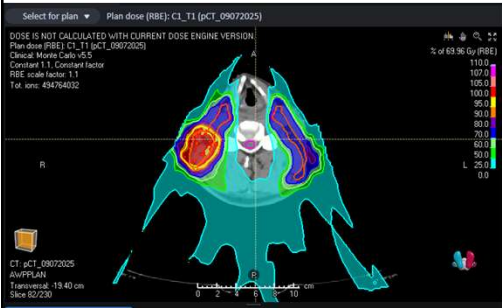
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Recalculation (Fraction 17)

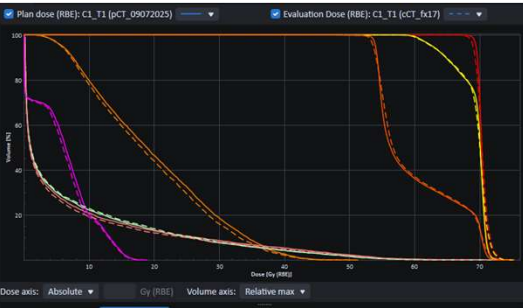




DOSE IS NOT CALCULATED WITH CURRENT DOSE ENGINE VERSION
Plan dose (RBE): C1_T1 (pCT_09072025)
Clinical Monte Carlo v5.5
Constant 1.1, Constraint factor
RBE scale factor 1.1
Tot. ions: 484794032




DOSE IS NOT CALCULATED WITH CURRENT DOSE ENGINE VERSION
Evaluation Dose (RBE): C1_T1 (cCT_fx17)
Clinical Monte Carlo v5.5
Constant 1.1, Constraint factor
RBE scale factor 1.1
Tot. ions: 487882752



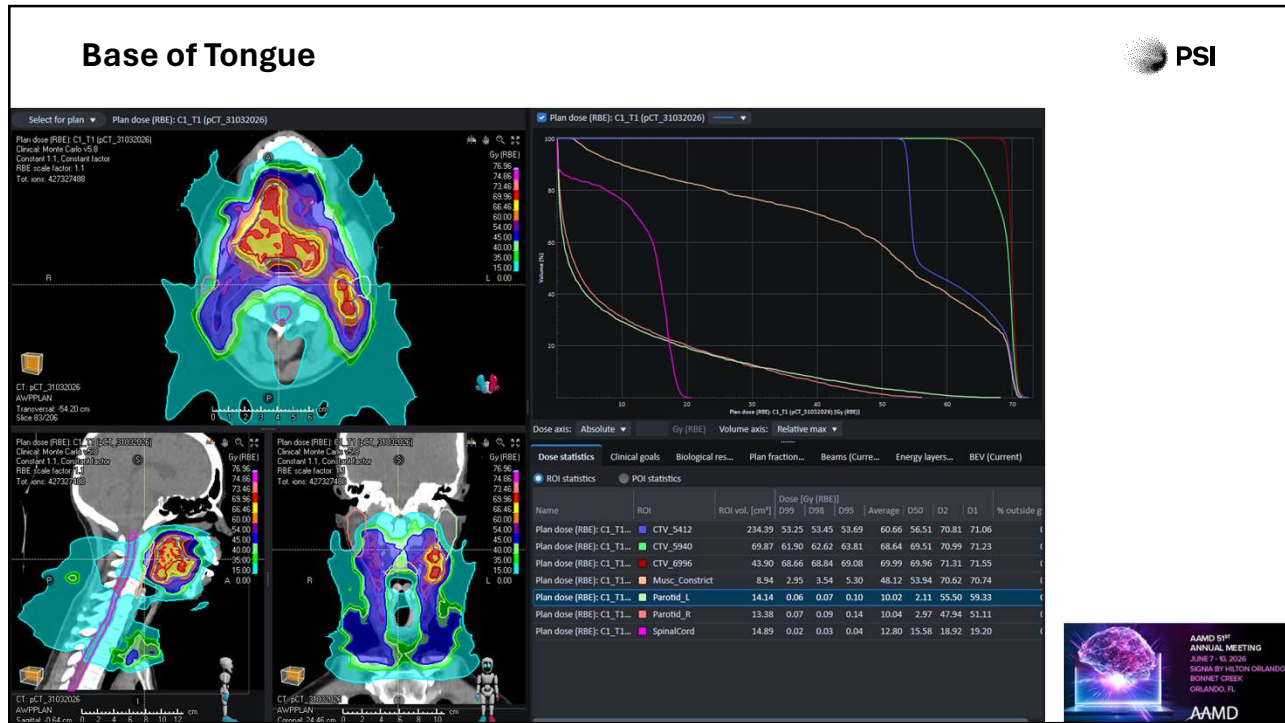
Plan dose (RBE): C1_T1 (pCT_09072025) | Evaluation Dose (RBE): C1_T1 (cCT_fx17)

Dose axis: Absolute Gy (RBE) | Volume axis: Relative max

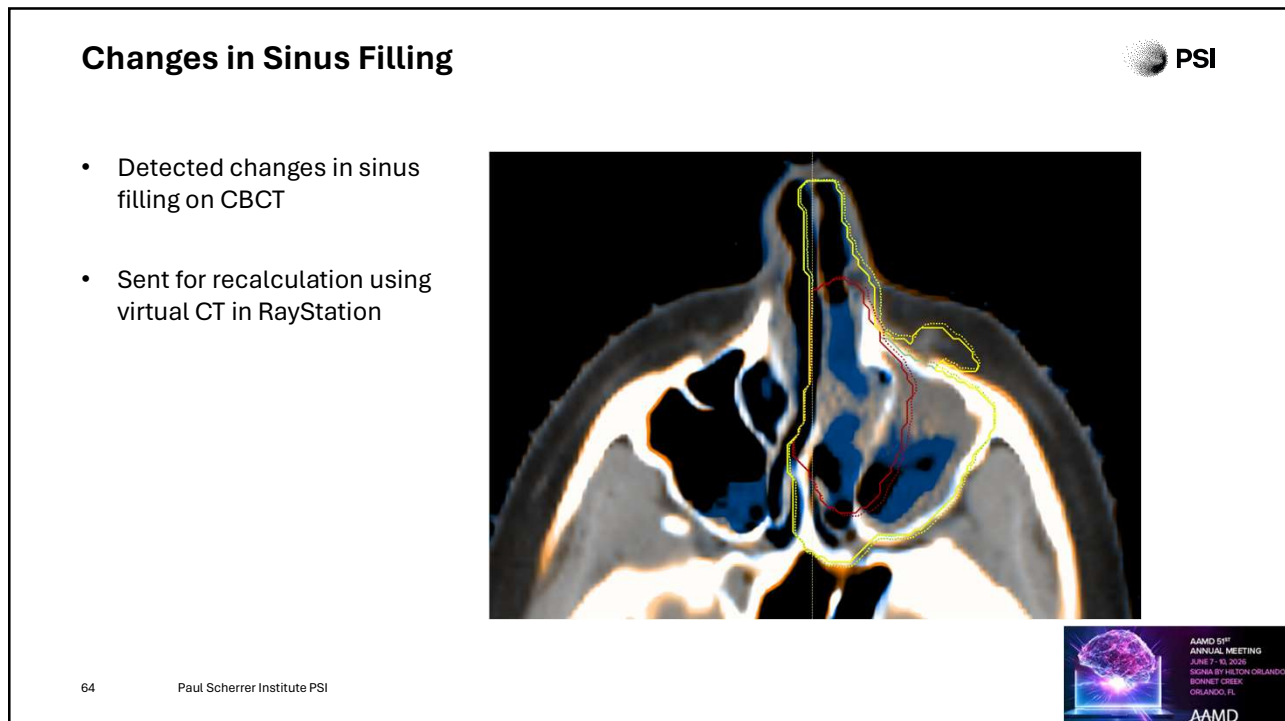
Name	ROI	ROI vol. [cm ³]	Dose [Gy (RBE)]	D99	D95	D90	Average	D50	D2	D1	% outside grid
Plan dose (RBE): C1_T1...	Brainstem	31.36	3.47	4.32	5.88	19.87	18.87	40.67	42.22		0 %
Evaluation Dose (RBE):...	Brainstem	31.39	3.47	4.21	5.73	19.14	18.06	40.19	41.59		0 %
Plan dose (RBE): C1_T1...	CTV_5412	326.76	53.41	53.67	53.98	59.93	56.29	71.12	71.42		0 %
Evaluation Dose (RBE):...	CTV_5412	329.64	52.92	53.21	53.64	60.12	56.67	71.67	72.16		0 %
Plan dose (RBE): C1_T1...	CTV_5940	71.26	60.32	60.98	62.77	69.08	70.07	71.58	71.84		0 %
Evaluation Dose (RBE):...	CTV_5940	72.37	60.05	60.84	62.59	69.16	70.00	72.48	72.93		0 %
Plan dose (RBE): C1_T1...	CTV_6996	51.89	68.91	69.13	69.43	70.33	70.30	71.70	72.00		0 %
Evaluation Dose (RBE):...	CTV_6996	52.77	68.27	68.58	68.96	70.40	70.34	72.71	73.15		0 %
Plan dose (RBE): C1_T1...	Parotid_L	24.45	0.10	0.11	0.13	7.17	0.98	48.82	52.78		0 %
Evaluation Dose (RBE):...	Parotid_L	24.61	0.10	0.11	0.13	7.37	1.02	48.80	52.63		0 %
Plan dose (RBE): C1_T1...	Parotid_R	26.48	0.09	0.10	0.12	7.20	0.90	51.03	54.45		0 %
Evaluation Dose (RBE):...	Parotid_R	26.87	0.08	0.10	0.12	6.79	0.84	49.74	54.10		0 %
Plan dose (RBE): C1_T1...	SpinalCord	18.80	0.00	0.00	0.00	6.12	6.36	15.54	16.18		0 %
Evaluation Dose (RBE):...	SpinalCord	18.24	0.00	0.00	0.00	5.86	5.97	15.41	16.04		0 %



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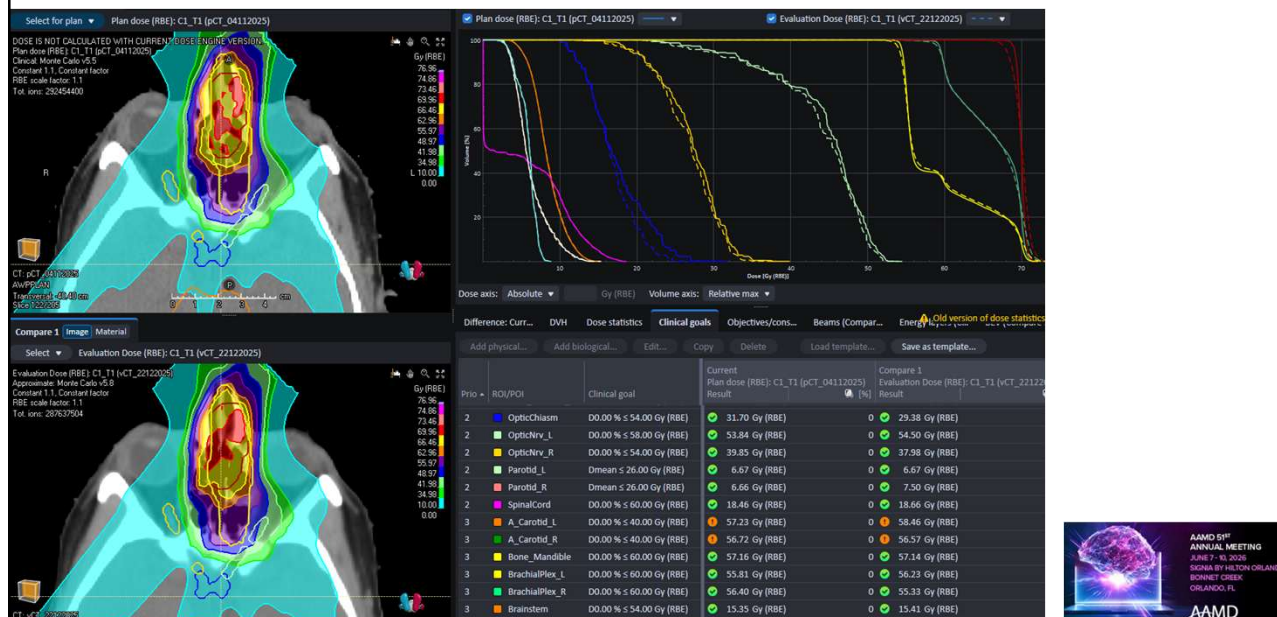
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Recalculation for Sinus Filling Changes




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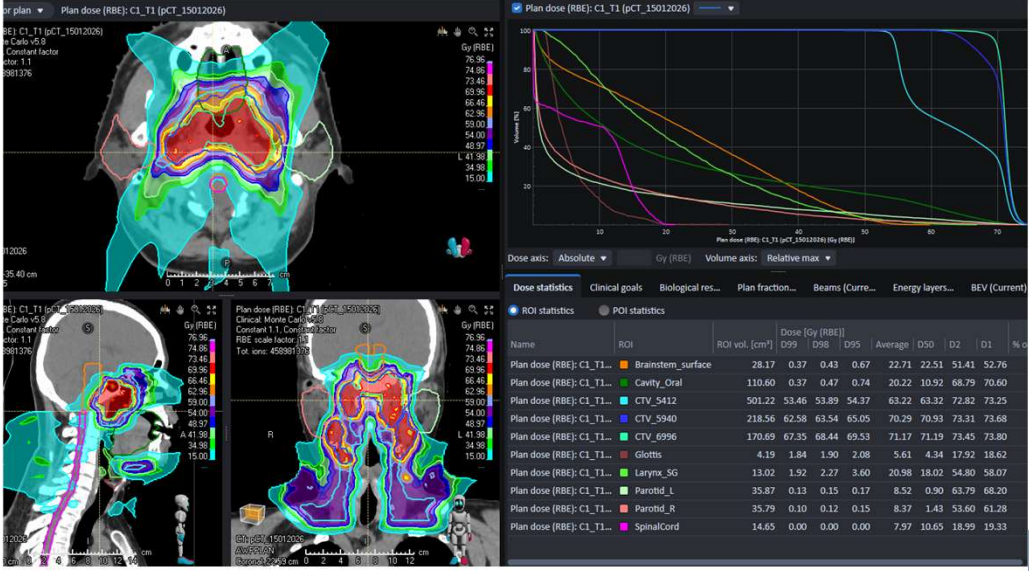
Recalculation for Sinus Filling Changes



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Case Example Nasopharynx






Name	ROI	ROI vol. [cm³]	Dose [Gy (RBE)]	D99	D98	D95	Average	D50	D2	D1	% c
Plan dose (RBE): C1_T1...	Brainstem_surface	28.17	0.37	0.43	0.67	22.71	22.51	51.41	52.76		
Plan dose (RBE): C1_T1...	Cavity_Oral	110.60	0.37	0.47	0.74	20.22	10.92	68.79	70.60		
Plan dose (RBE): C1_T1...	CTV_5412	501.22	53.46	53.89	54.37	63.22	63.32	72.82	73.25		
Plan dose (RBE): C1_T1...	CTV_5940	218.56	62.58	63.54	65.05	70.29	70.93	73.31	73.68		
Plan dose (RBE): C1_T1...	CTV_6996	170.69	67.35	68.44	69.53	71.17	71.19	73.45	73.80		
Plan dose (RBE): C1_T1...	Glottis	4.19	1.84	1.90	2.08	5.61	4.34	17.92	18.62		
Plan dose (RBE): C1_T1...	Larynx_SG	13.02	1.92	2.27	3.60	20.98	18.02	54.80	58.07		
Plan dose (RBE): C1_T1...	Parotid_L	35.87	0.13	0.15	0.17	8.52	0.90	63.79	68.20		
Plan dose (RBE): C1_T1...	Parotid_R	35.79	0.10	0.12	0.15	8.37	1.43	53.60	61.28		
Plan dose (RBE): C1_T1...	SpinalCord	14.65	0.00	0.00	0.00	7.97	10.65	18.99	19.33		

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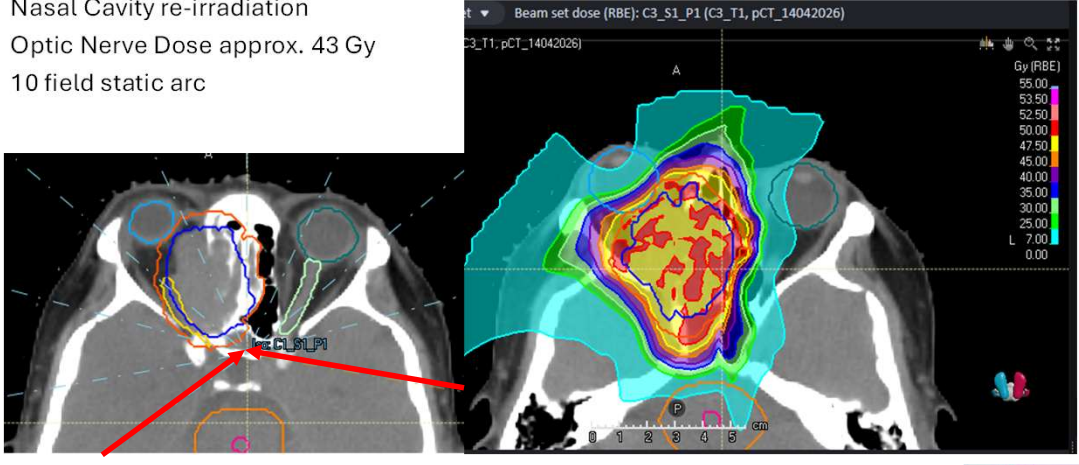


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Re-Irradiation



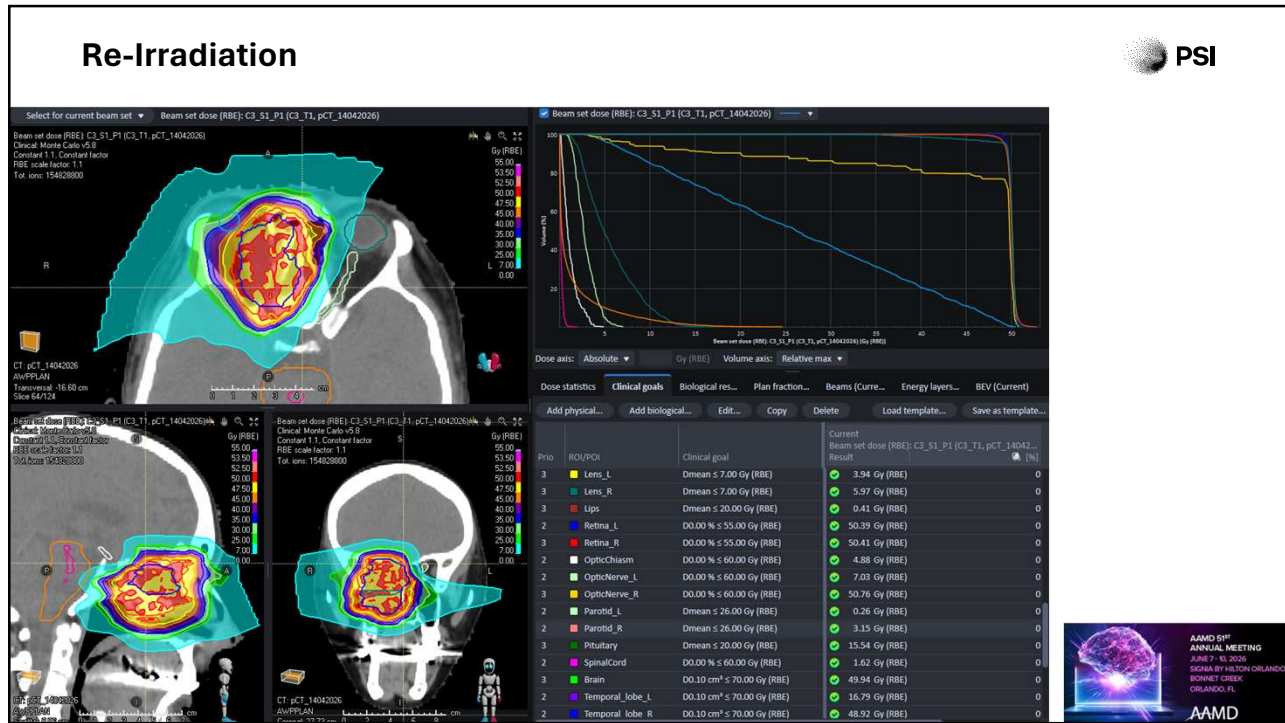
- Nasal Cavity re-irradiation
- Optic Nerve Dose approx. 43 Gy
- 10 field static arc



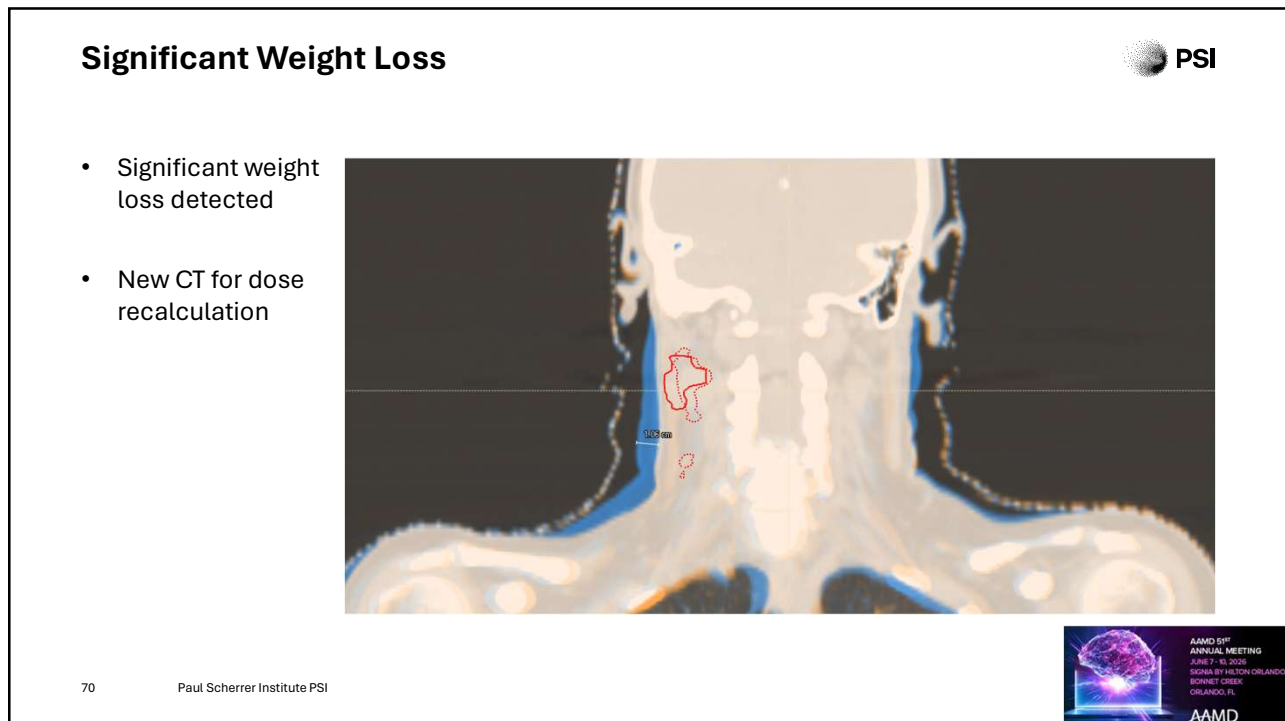
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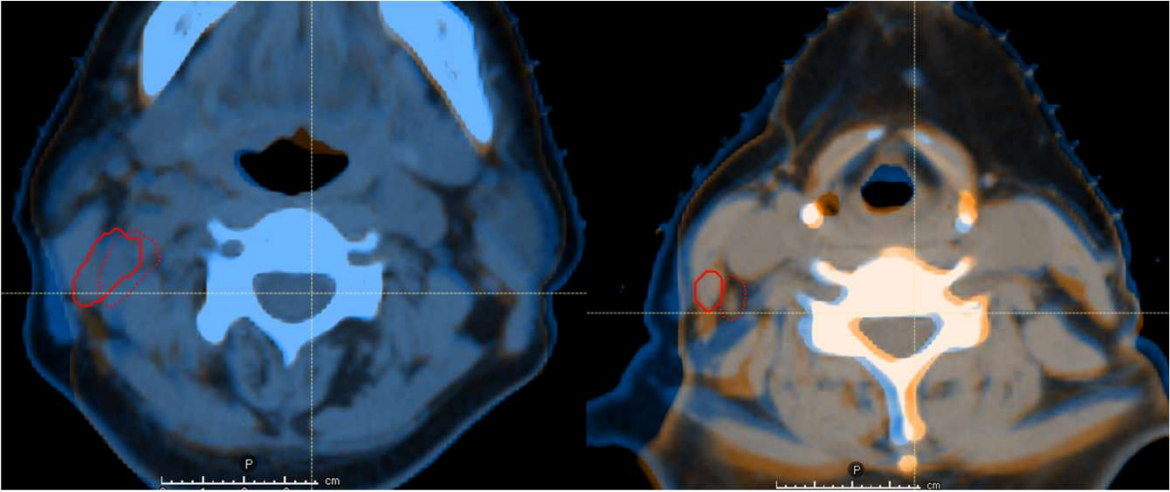
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Changes to High Dose CTV Location in the Neck






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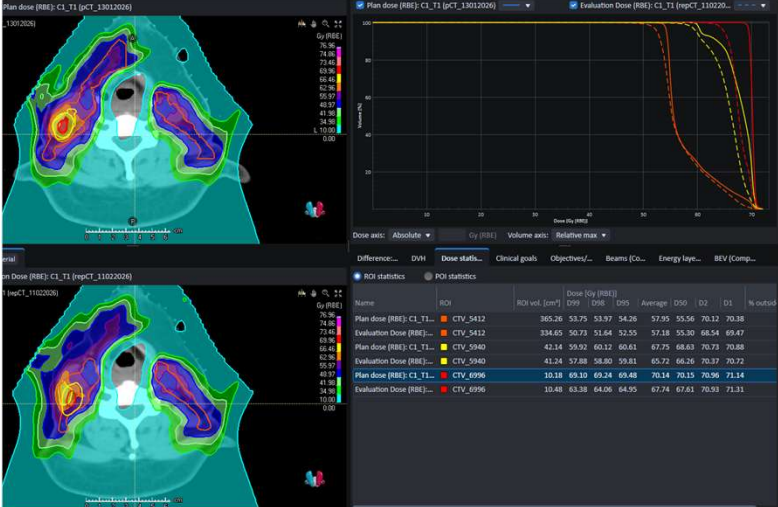


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Recalculation



- Nominal D98%: **69.24 Gy**
Recalculated D98%: **64.06 Gy**
- 98% of CTV_6996 was covered by approximately **1.94 Gy/fx**
- Each fraction delivered represented an approximate reduction of **0.16 Gy**




Name	ROI	ROI vol. [cm³]	D98	D95	Average	D50	D2	D1	% out of
Plan dose (RBE): CI_T1...	CTV_5412	385.26	53.75	53.97	54.26	57.95	55.56	70.12	70.38
Evaluation Dose (RBE):...	CTV_5412	334.65	50.73	51.64	53.55	57.18	55.30	68.54	69.47
Plan dose (RBE): CI_T1...	CTV_5940	42.14	59.92	60.12	60.61	67.75	68.83	70.73	70.88
Evaluation Dose (RBE):...	CTV_5940	41.24	57.88	58.80	59.81	65.72	66.26	70.37	70.72
Plan dose (RBE): CI_T1...	CTV_6996	10.18	69.10	69.24	69.48	70.14	70.15	70.96	71.14
Evaluation Dose (RBE):...	CTV_6996	10.48	63.38	64.06	64.95	67.74	67.61	70.93	71.31



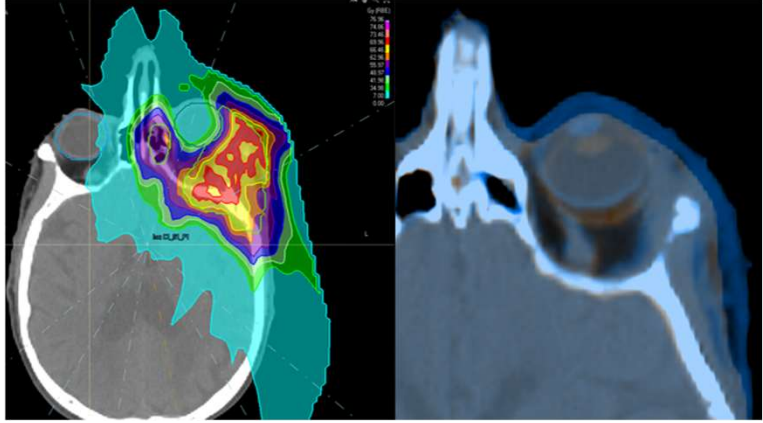
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Complex Anatomy and Anatomical Changes


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- Multiple adaptive replans were required due to tumor shrinkage, anatomical shift, and weight loss.




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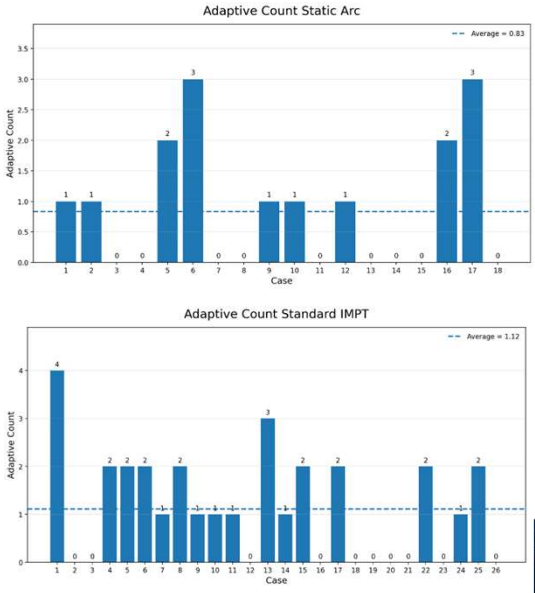
Adaptive Rate of Arc vs Standard IMPT


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- Similar rate of adaptive in static arc vs standard IMPT
- Shoulder avoidance mattered for posterior oblique beams if there is variation
- Anatomical changes (weight loss / tumor shrinkage) still require adaptive workflow

Static Arc = 0.83 per patient

Standard IMPT = 1.12 per patient



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Summary



- Started test plans with static arc in **March 2025**
- First patient treated **July 2025**
- 9–10 fields provided improved plan quality with similar treatment time
- No increase in adaptive rate was observed with static arc versus standard IMPT
- Additional planning structures and optimization strategy needed to help control the dose



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Future Direction (Potential Developments)



- Alternative beam arrangement / patient specific beam arrangement
- LET / RBE optimization and/or its potential impact from different beam arrangement
- Different optimization approaches and objectives
- Dose tracking to better monitor for anatomical / dose trends over time



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Thank You



Thank you for your time!

Please feel free to reach out if you have any questions in the future, or if you want to collaborate

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