PSI

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

Tyler Williamson MCS, CMD
Dosimetrist / Clinical Scripting Coordinator
Paul Scherrer Institute, Villigen, Switzerland

AAMD Annual Meeting 2026

1

Agenda

PSI

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

2 Paul Scherrer Institute PSI

2

History

3

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 Beaumont Health System

4

Development (2019)

PSI

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

5 Paul Scherrer Institute PSI

5

Introduction to Static Arc (2023)

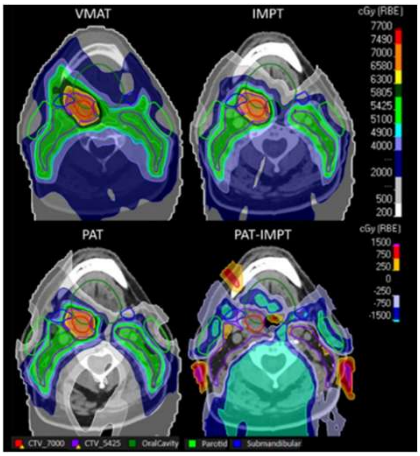
PSI

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



6 Paul Scherrer Institute PSI

6

Introduction to Static Arc (2023)

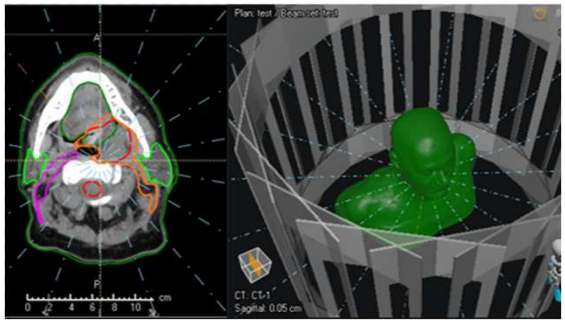
PSI

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

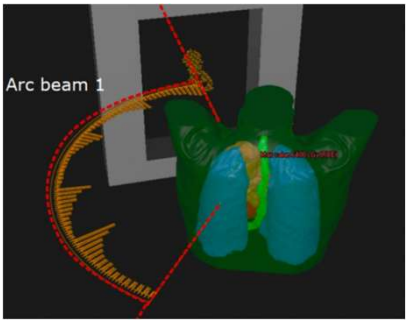
Static Arc vs Dynamic Arc (Simplified)

PSI



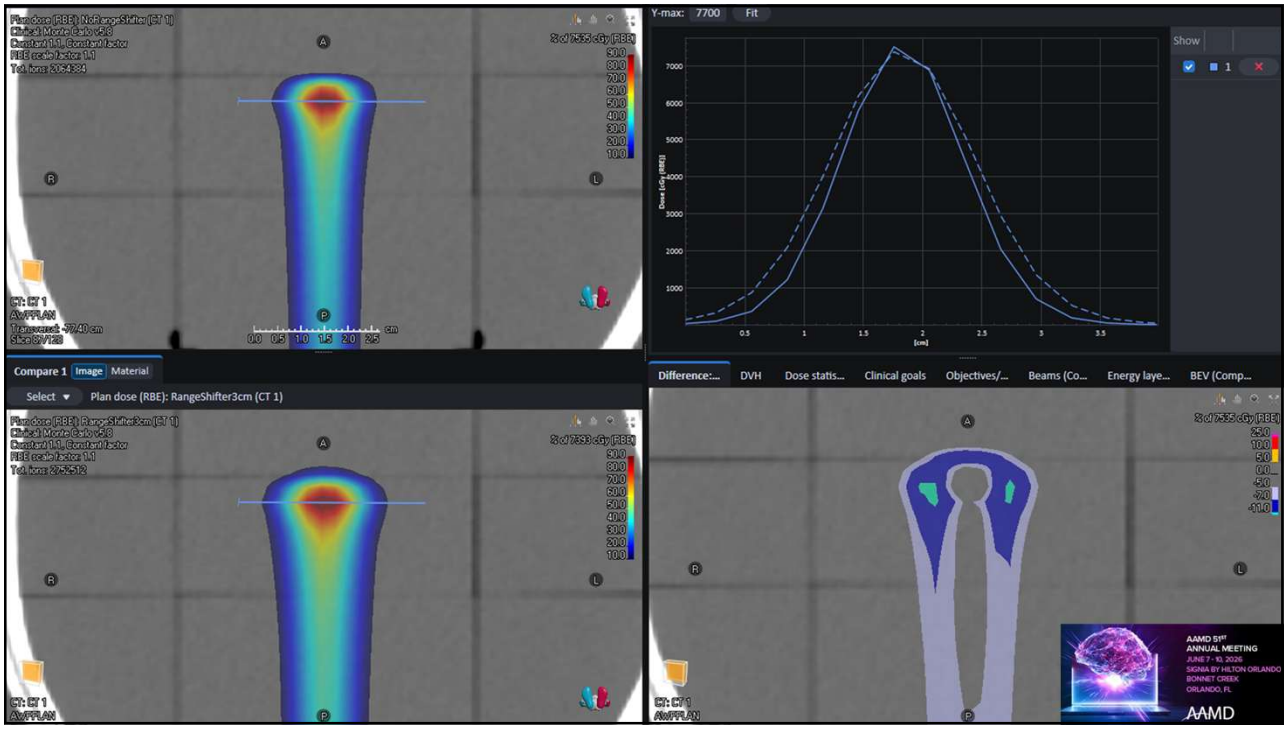
Static Arc

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



Dynamic Arc

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



9

Additional Resources (Webinars on YouTube)

PSI

RaySearch Webinars: Proton Arc Therapy in RayStation®

- RaySearch Laboratories

DirectARC™: Proton Arc at Full Speed

- Mevion Medical Systems

10

Initial Planning and Delivery Time Studies

11

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

12

Planning Study Centro di Protonterapia | Trento (IBA)

PSI

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 Sundström, Otte Marthin, Viktor Wase, Mattia Bertolini ... See all a

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]

13

PSI Clinical Implementation

PSI

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

14

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

15 Paul Scherrer Institute PSI

15

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**

16 Paul Scherrer Institute PSI

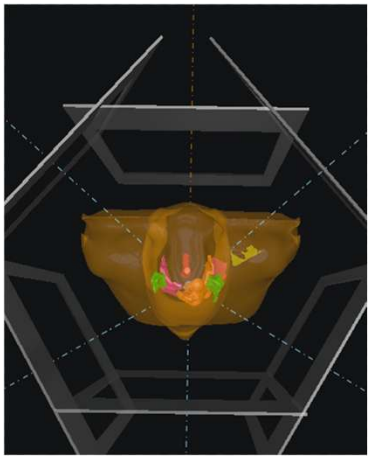
16

Head and Neck Standard IMPT Beam Arrangement

PSI

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

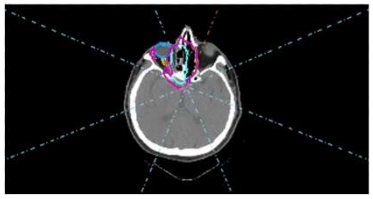


17 Paul Scherrer Institute PSI

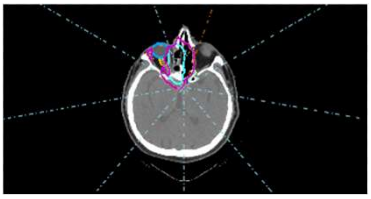
17

Static Arc Beam Arrangements

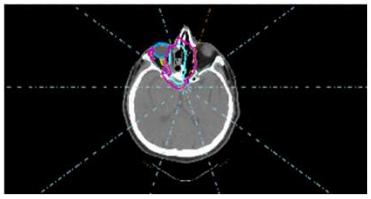
PSI



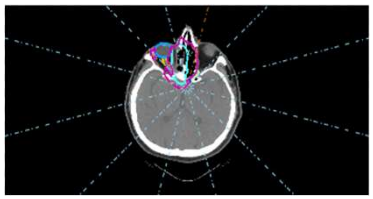
8 Beams



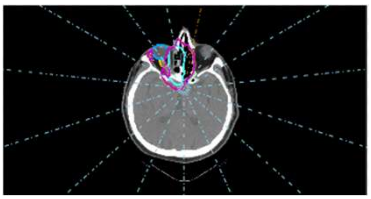
9 Beams



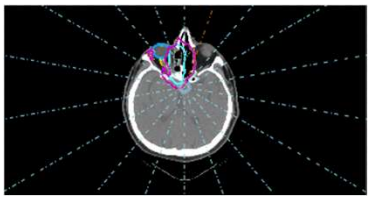
10 Beams



12 Beams



15 Beams



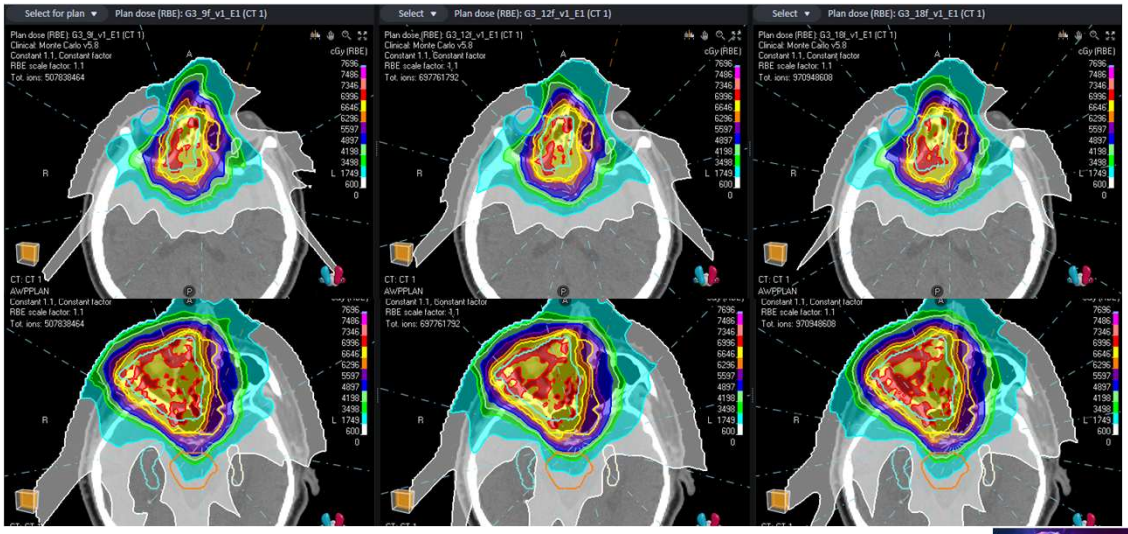
18 Beams

18 Paul Scherrer Institute PSI

18

Example Static Arc Comparison

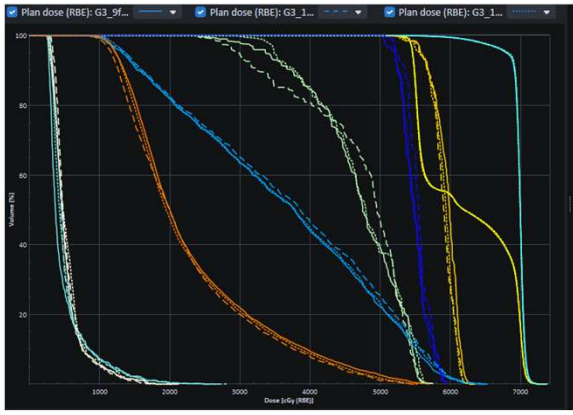
PSI



19

Example Static Arc Comparison

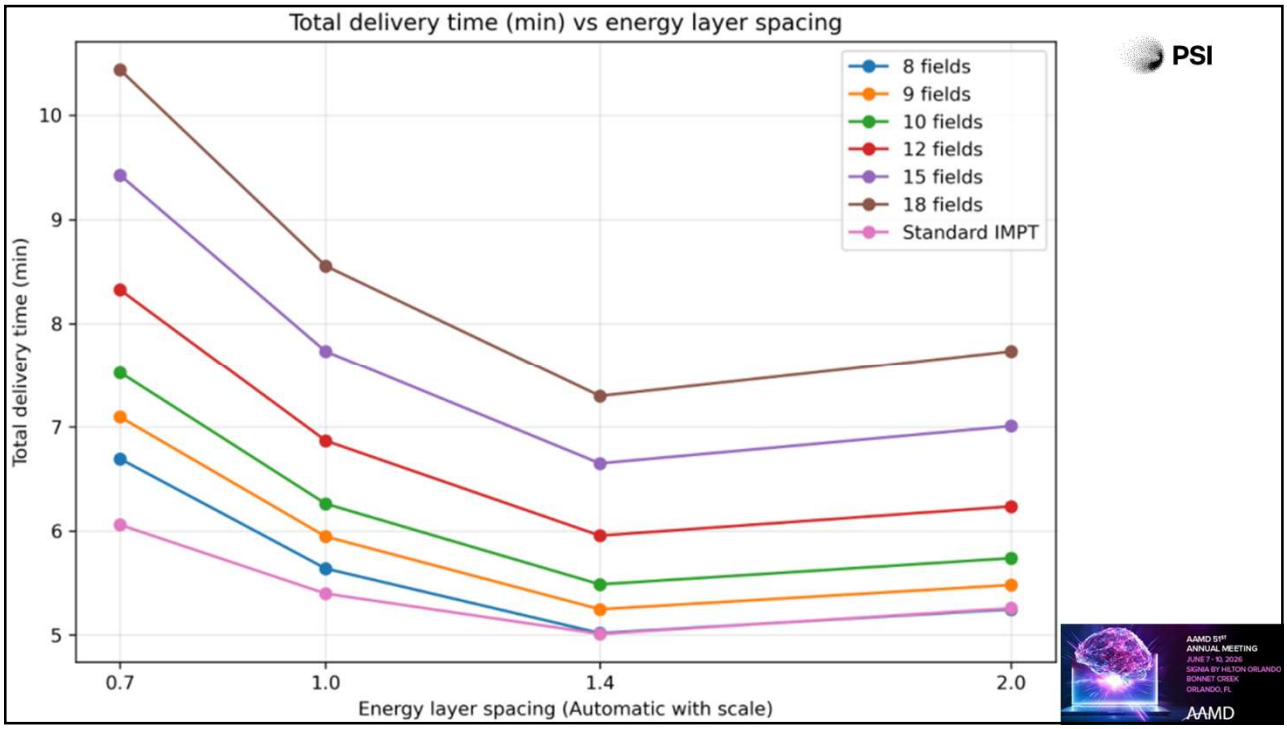
PSI



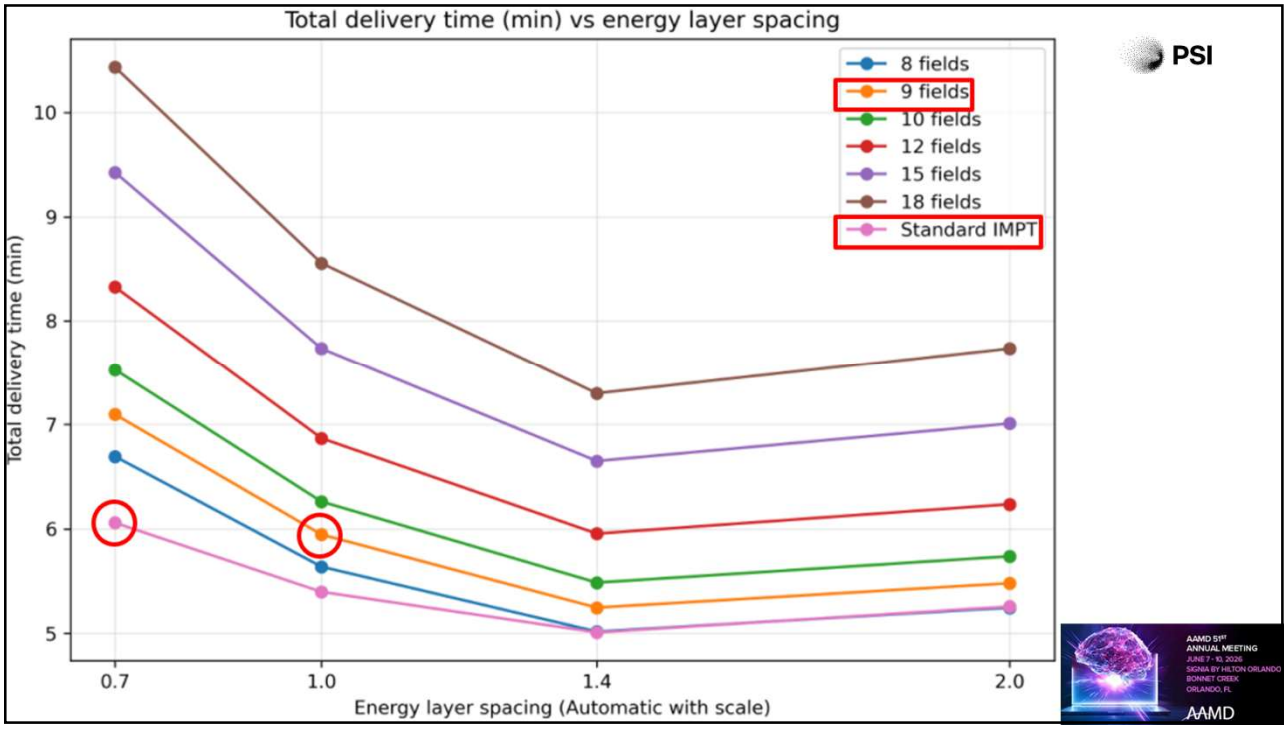
ROI statistics | POI statistics

Name	ROI	ROI vol. [cm³]	Dose [cGy (RBE)] D99	D98	D95	Average	D50	D2	D1
Plan dose (RBE): G3_9f_v1_E1 (...	Brainstem	30.96	1049	1123	1226	2334	2000	5103	5384
Plan dose (RBE): G3_12f_v1_E1...	Brainstem	30.96	1001	1064	1171	2251	1996	4867	5075
Plan dose (RBE): G3_18f_v1_E1...	Brainstem	30.96	1092	1151	1236	2289	1947	4938	5165
Plan dose (RBE): G3_9f_v1_E1 (...	CTV_5412	427.34	5407	5431	5463	6243	6202	7089	7115
Plan dose (RBE): G3_12f_v1_E1...	CTV_5412	427.34	5407	5431	5459	6239	6191	7082	7107
Plan dose (RBE): G3_18f_v1_E1...	CTV_5412	427.34	5411	5434	5461	6242	6201	7081	7105
Plan dose (RBE): G3_9f_v1_E1 (...	CTV_6996	118.42	6196	6432	6808	6972	6996	7118	7142
Plan dose (RBE): G3_12f_v1_E1...	CTV_6996	118.42	6194	6431	6806	6972	6996	7108	7130
Plan dose (RBE): G3_18f_v1_E1...	CTV_6996	118.42	6220	6454	6835	6974	6996	7109	7132
Plan dose (RBE): G3_9f_v1_E1 (...	Eye_R	7.44	1063	1106	1322	3636	3777	5958	6094
Plan dose (RBE): G3_12f_v1_E1...	Eye_R	7.44	1067	1126	1357	3720	3856	5984	6139
Plan dose (RBE): G3_18f_v1_E1...	Eye_R	7.44	1109	1195	1379	3660	3789	5987	6136
Plan dose (RBE): G3_9f_v1_E1 (...	Hippocampus_L	2.05	291	297	315	528	464	1328	1625
Plan dose (RBE): G3_12f_v1_E1...	Hippocampus_L	2.05	311	321	336	543	478	1289	1523
Plan dose (RBE): G3_18f_v1_E1...	Hippocampus_L	2.05	265	269	291	542	478	1349	1640
Plan dose (RBE): G3_9f_v1_E1 (...	Hippocampus_R	2.06	257	265	273	487	370	1509	1670
Plan dose (RBE): G3_12f_v1_E1...	Hippocampus_R	2.06	267	279	292	535	451	1605	1787
Plan dose (RBE): G3_18f_v1_E1...	Hippocampus_R	2.06	292	294	300	524	427	1604	1801

20


Total delivery time (min) vs energy layer spacing
PSI
8 fields
9 fields
10 fields
12 fields
15 fields
18 fields
Standard IMPT
Total delivery time (min)
Energy layer spacing (Automatic with scale)
0.7
1.0
1.4
2.0
5
6
7
8
9
10
AAMD

21


Total delivery time (min) vs energy layer spacing
PSI
8 fields
9 fields
10 fields
12 fields
15 fields
18 fields
Standard IMPT
Total delivery time (min)
Energy layer spacing (Automatic with scale)
0.7
1.0
1.4
2.0
5
6
7
8
9
10
AAMD

22

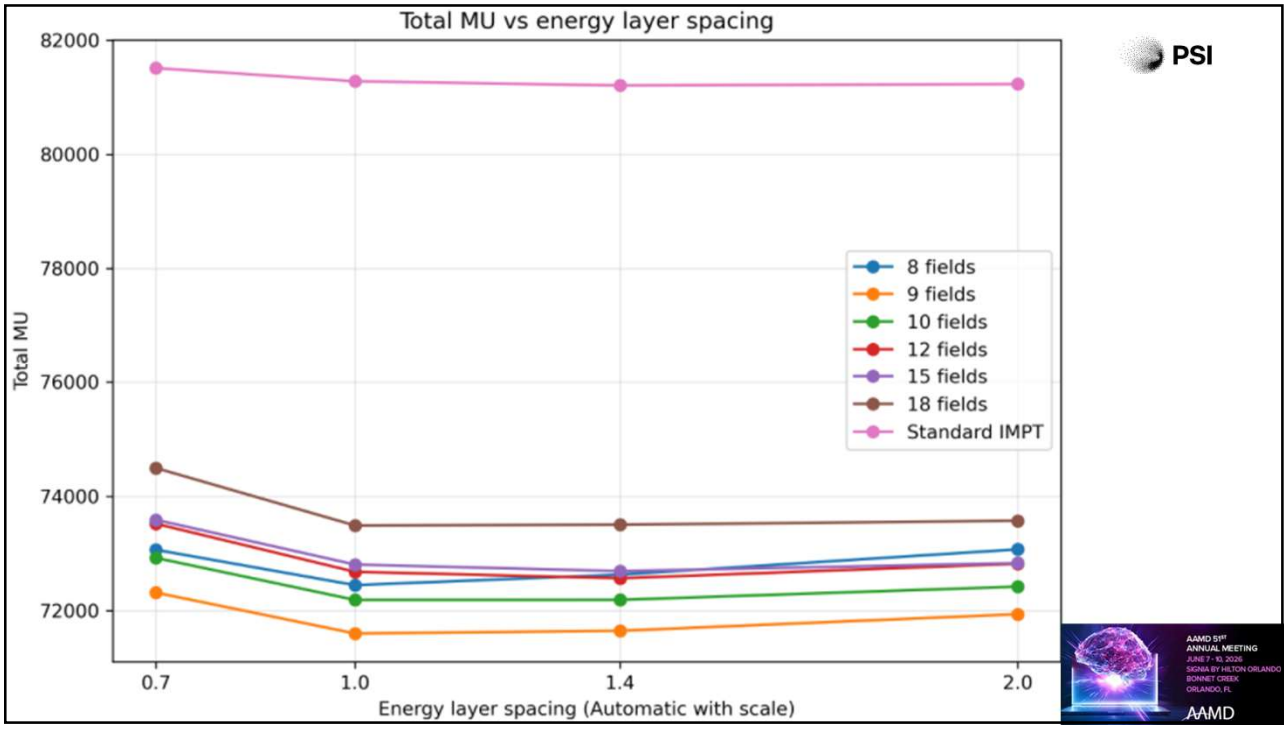
Comparing Beam on Time

PSI

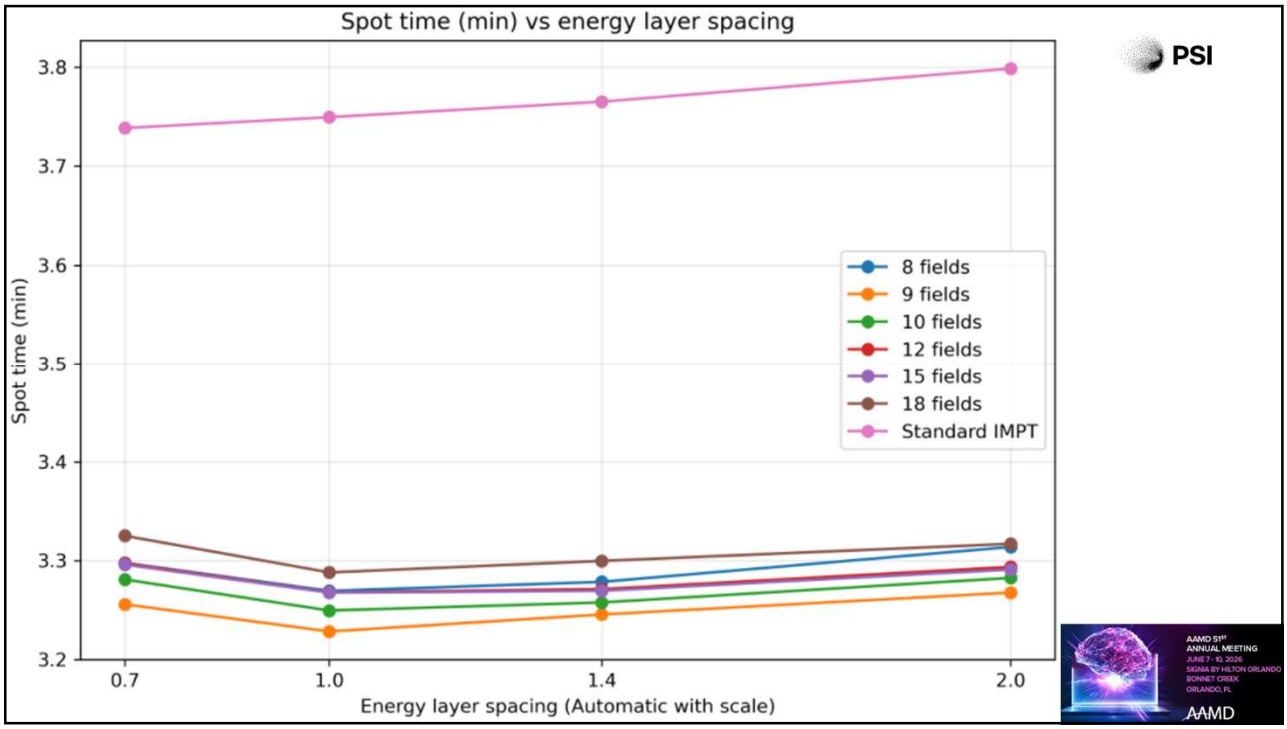
```
Patient-by-patient comparison:
 patient_folder  IMPT_E0.7_min  Arc_9fields_E1.0_min  Difference_Arc_minus_IMPT_min
              1          4.998                 4.606                         -0.392
              2          5.799                 5.706                         -0.093
              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
```

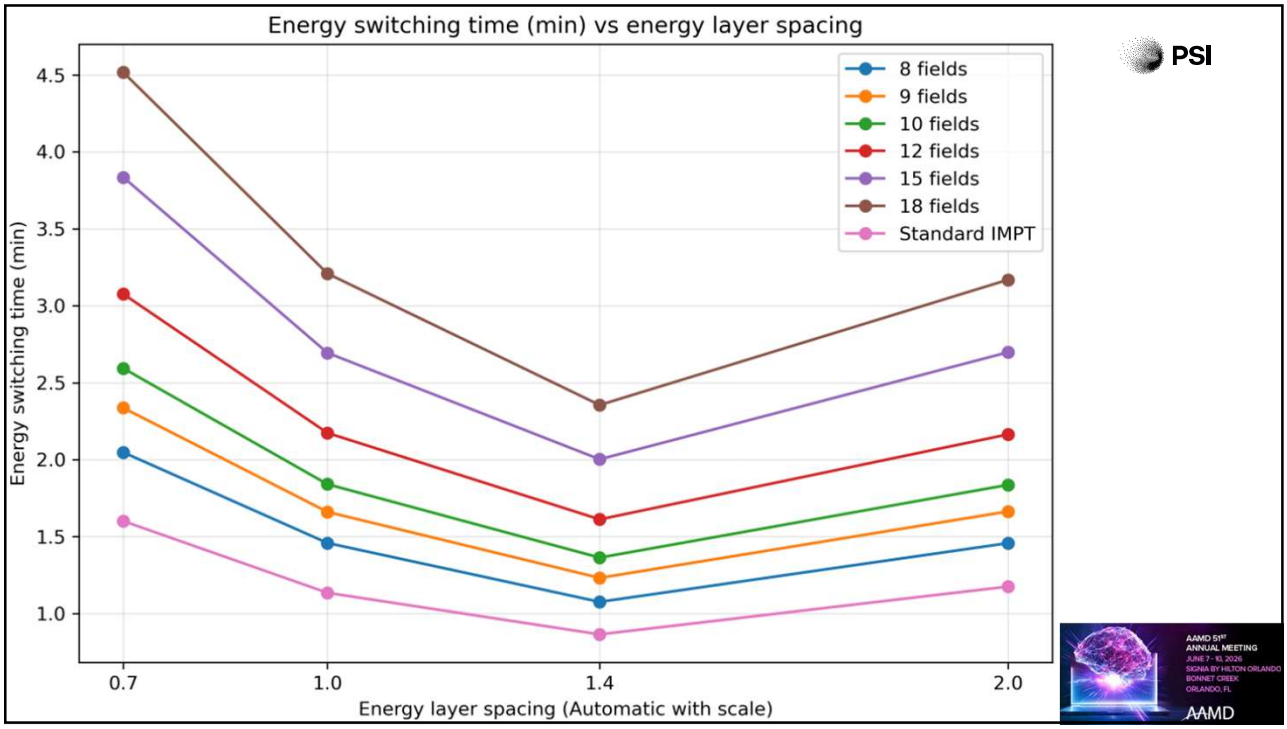
23



24


Spot time (min) vs energy layer spacing
PSI
Spot time (min)
Energy layer spacing (Automatic with scale)
8 fields
9 fields
10 fields
12 fields
15 fields
18 fields
Standard IMPT
3.2
3.3
3.4
3.5
3.6
3.7
3.8
0.7
1.0
1.4
2.0
AAMD

25


Energy switching time (min) vs energy layer spacing
PSI
Energy switching time (min)
Energy layer spacing (Automatic with scale)
8 fields
9 fields
10 fields
12 fields
15 fields
18 fields
Standard IMPT
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
0.7
1.0
1.4
2.0
AAMD

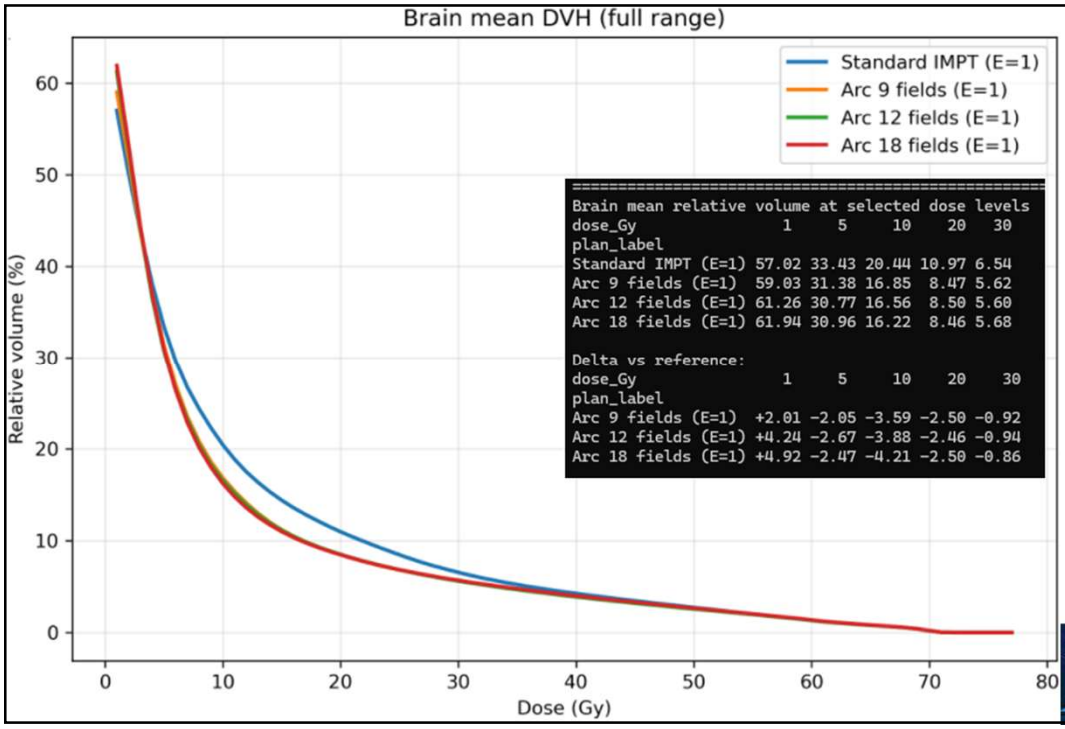
26

CTV Coverage Comparison

PSI

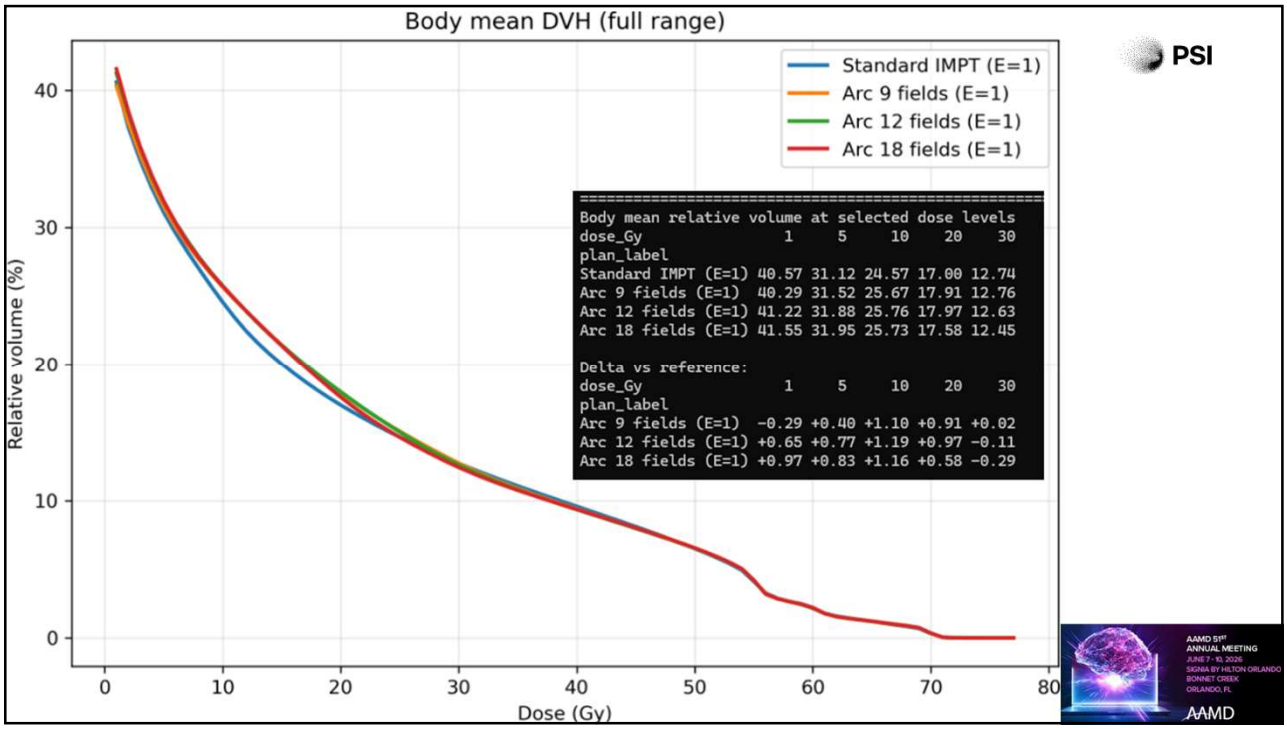
- High dose CTV coverage favored **Static Arc**
- Nominal V98 improved by 1.6–2.7% as fields increased from 8 to 18
- **Robustness improved with more fields:** robust average V98 +1.3 – 4.1% and robust worst case V98 +1.9 – 6.6%
- Intermediate- and low-dose CTV differences were less than 1%
- Adding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

27



PSI

28



29

Total Delivery Time (Separate Small Study)

PSI

- 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**

AAMD 51ST ANNUAL MEETING
JUNE 7 - 10, 2026
SIGNIA BY HILTON ORLANDO BONNET CREEK
ORLANDO, FL
AAMD

30 Paul Scherrer Institute PSI

30

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

31

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.

32

Treatment Planning Considerations

33

Treatment Planning Considerations

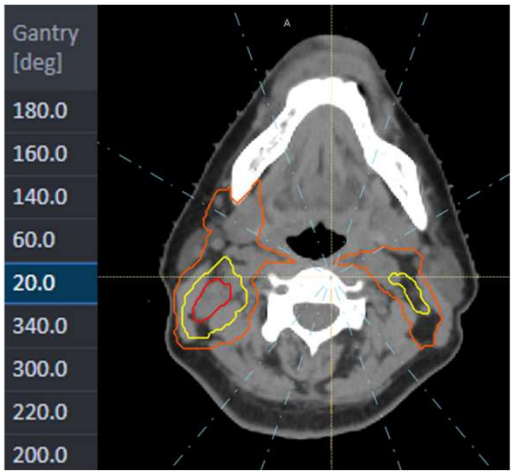
- Beam arrangement
- Optimization approach and objectives
- Spot avoidance areas
- Controlling low dose with optimization objectives (where clinically relevant)

34

Current Clinical Beam Arrangement

PSI

- 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.

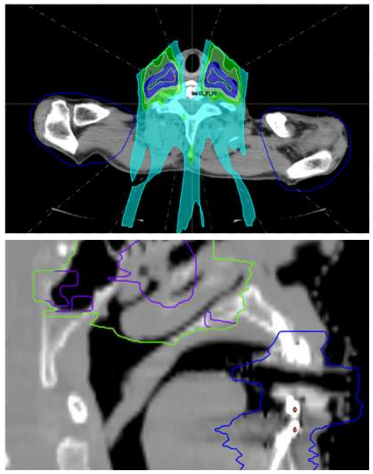


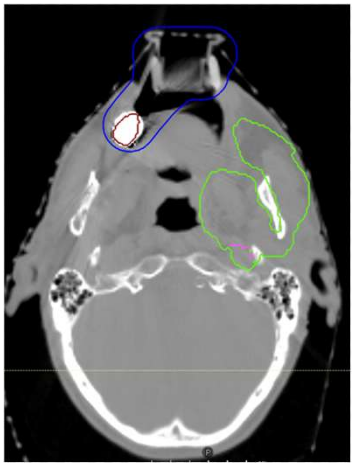
35

Spot Avoidance

PSI

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



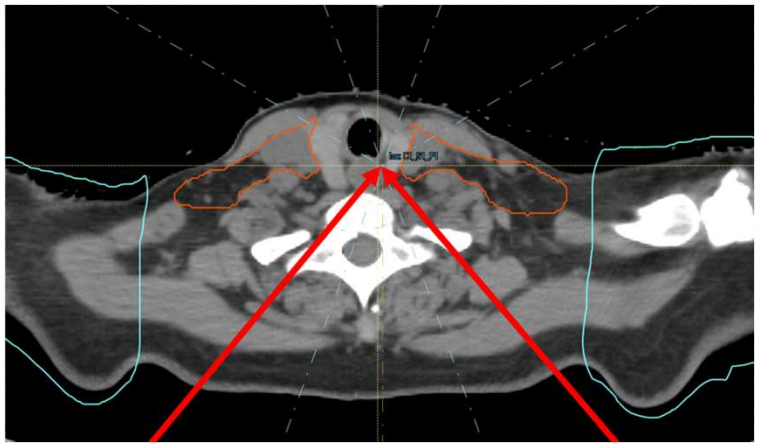


36

Shoulder Avoidance

PSI

- 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



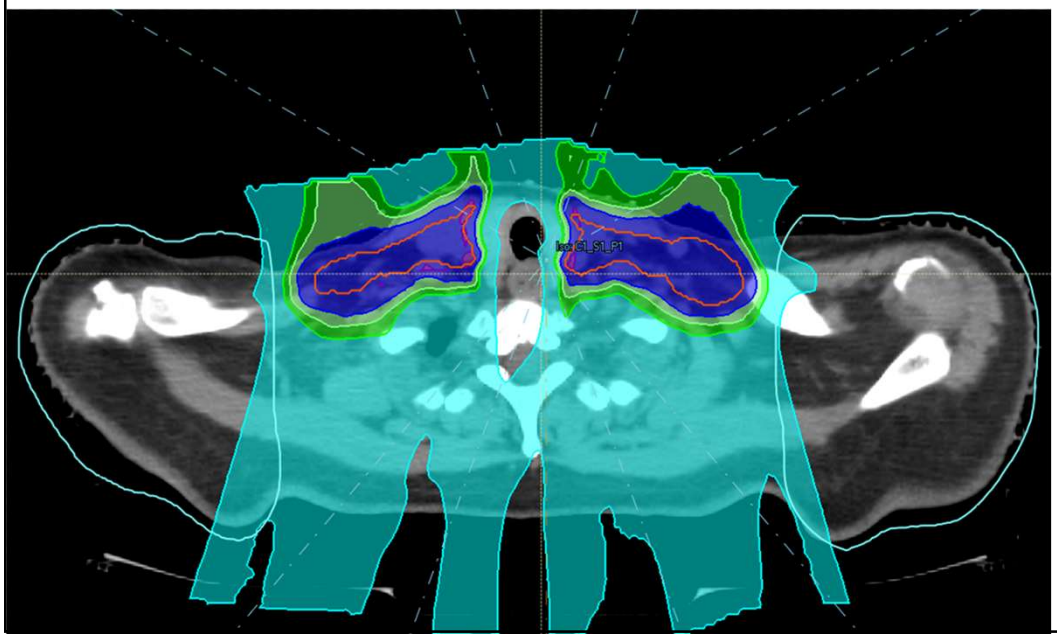
37 Paul Scherrer Institute PSI

AAMD 51ST ANNUAL MEETING JUNE 7 - 10, 2026 SIGNIA BY HILTON ORLANDO BONNET CREEK ORLANDO, FL AAMD

37

Shoulder Avoidance

PSI



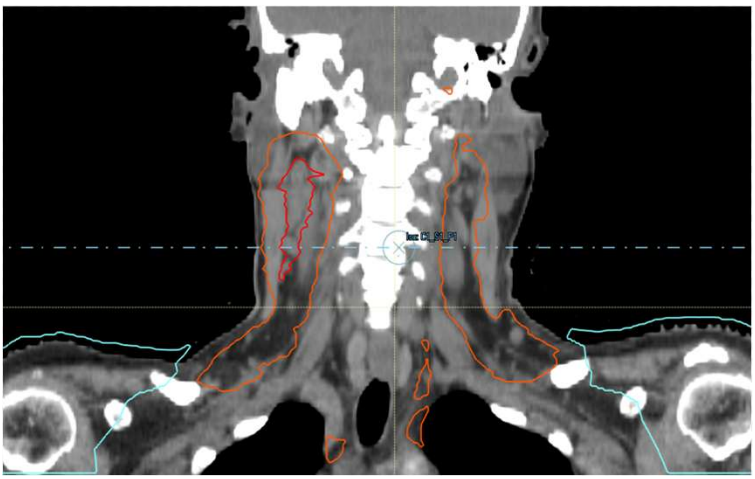
AAMD 51ST ANNUAL MEETING JUNE 7 - 10, 2026 SIGNIA BY HILTON ORLANDO BONNET CREEK ORLANDO, FL AAMD

38

Shoulder Avoidance Superior Margin

PSI

- Additional superior margin to account for differences in shoulder position

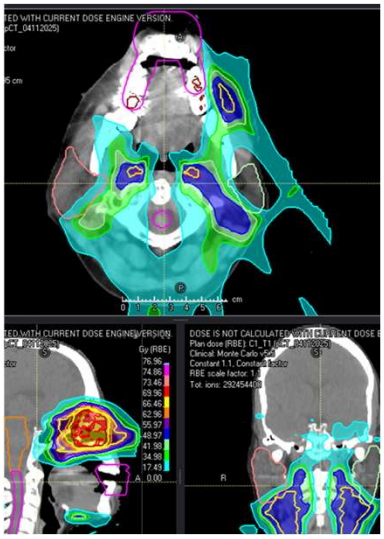


39

Dental / Stent Filling Avoidance

PSI

- 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

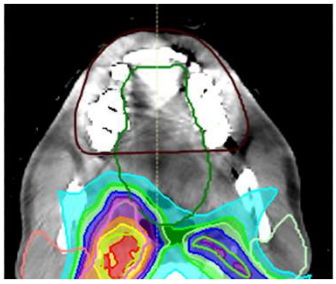


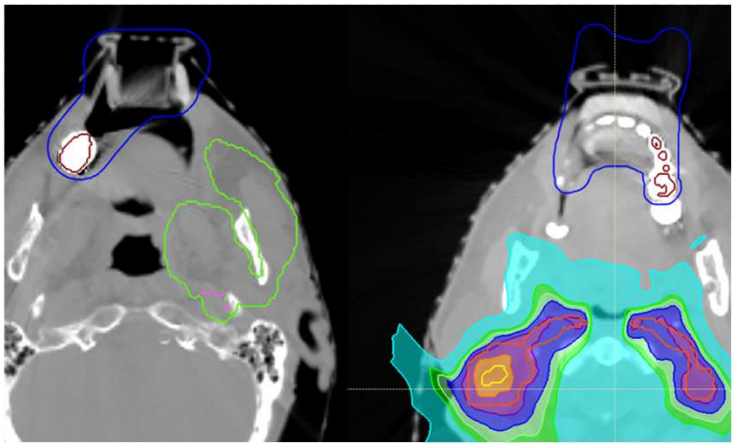
40

Dental / Stent Filling Avoidance

PSI

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





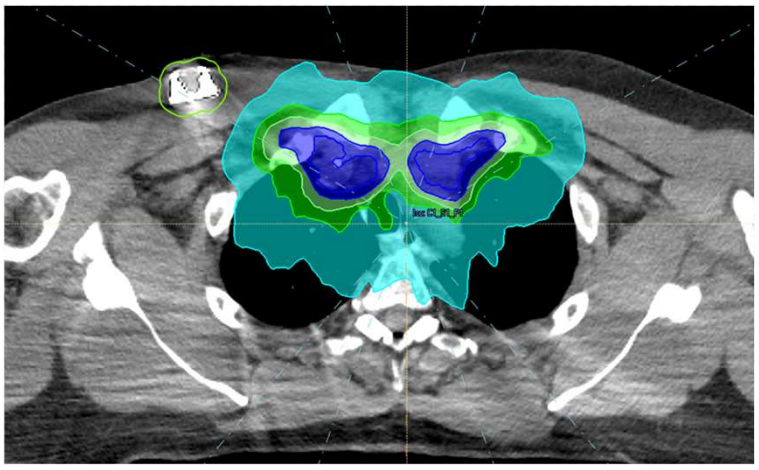
41 Paul Scherrer Institute PSI

41

Port Avoidance

PSI

- Avoiding treating through the port with a small margin



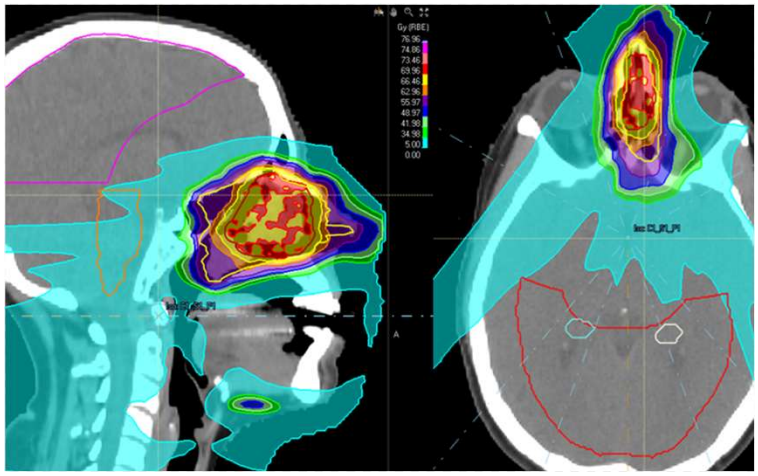
42 Paul Scherrer Institute PSI

42

Low Dose Brain Push OAR (5Gy)

PSI

- 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

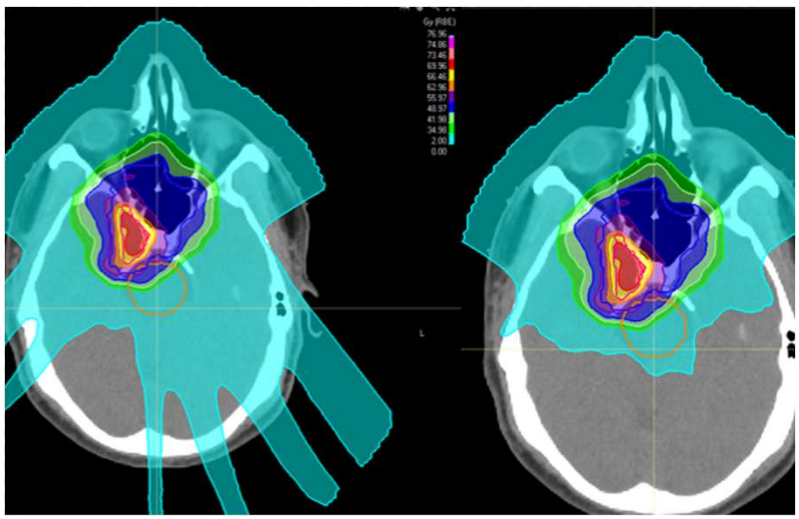


43 Paul Scherrer Institute PSI

43

Controlling the Low Dose (2 Gy / 5 Gy)

PSI



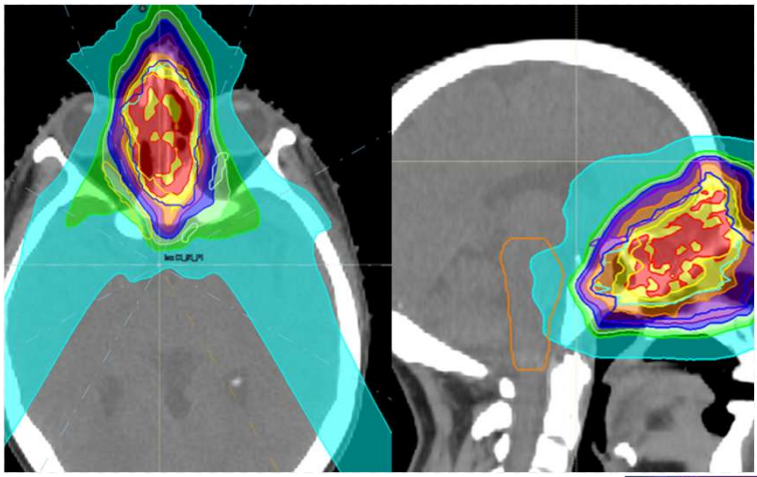
44 Paul Scherrer Institute PSI

44

Controlling the Low Dose

PSI

- 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

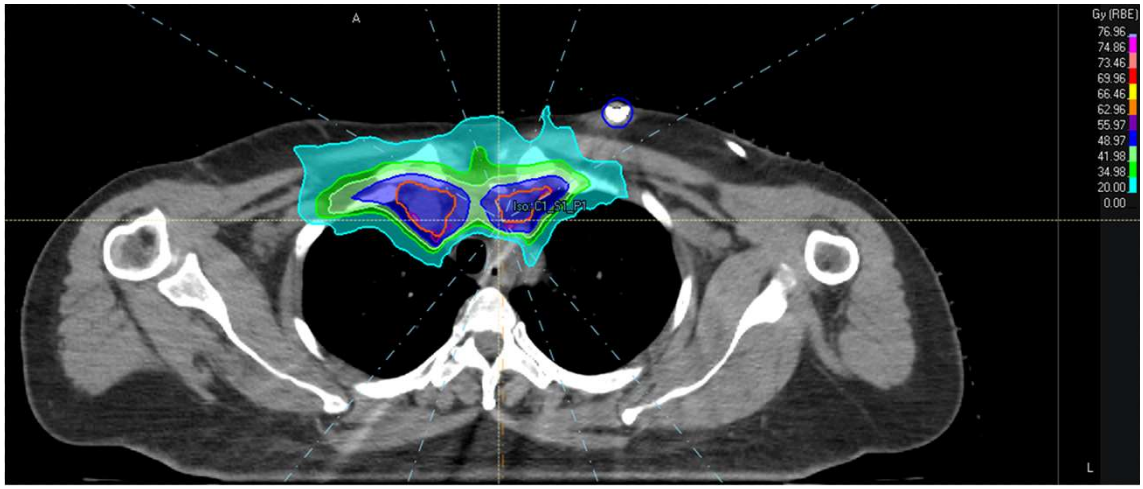


45 Paul Scherrer Institute PSI

45

Lung Dose Push (20 Gy)

PSI

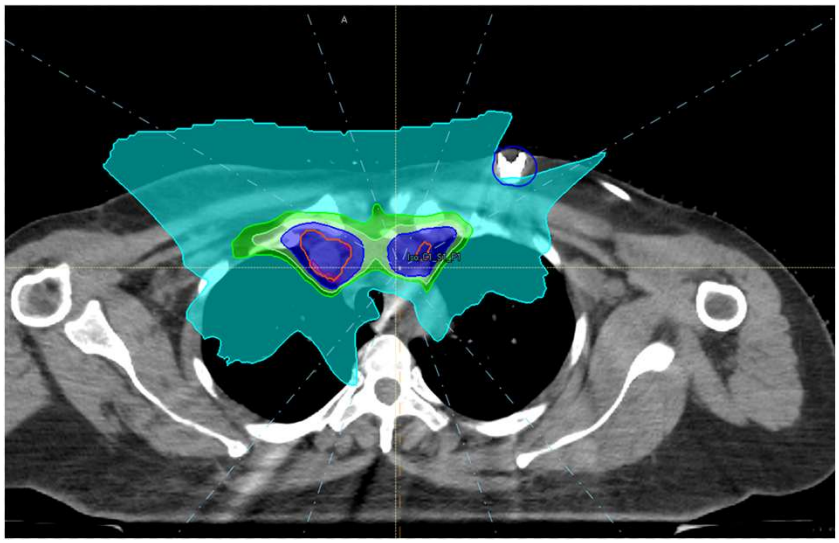


46 Paul Scherrer Institute PSI

46

Lung Dose Push (5 Gy)

PSI

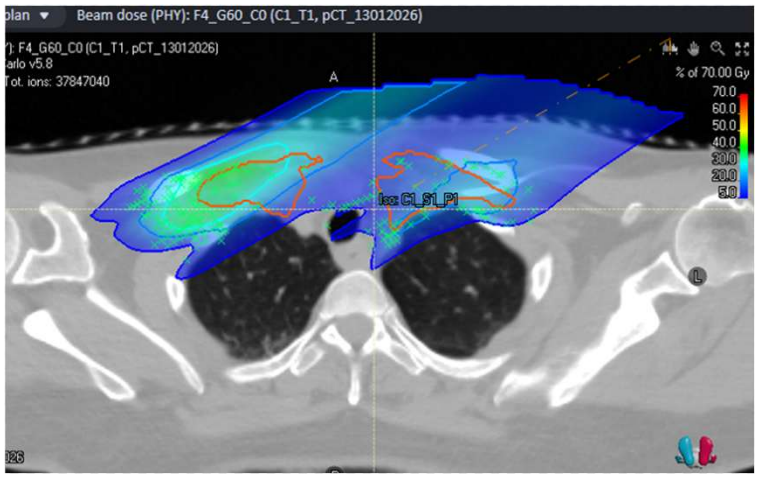


47

Neck Dose

PSI

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



48

Optimization Objectives

PSI

- 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]3400 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)	Supraglottic	Max EUD 500 cGy (RBE), Parameter A 1		0.10	0.0026
Max dose		Plan (RBE)	fsRingS940	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)	fsRingS412	Max dose 5300 cGy (RBE)		90.00	0.0013

49 Paul Scherrer Institute PSI

49

PSI

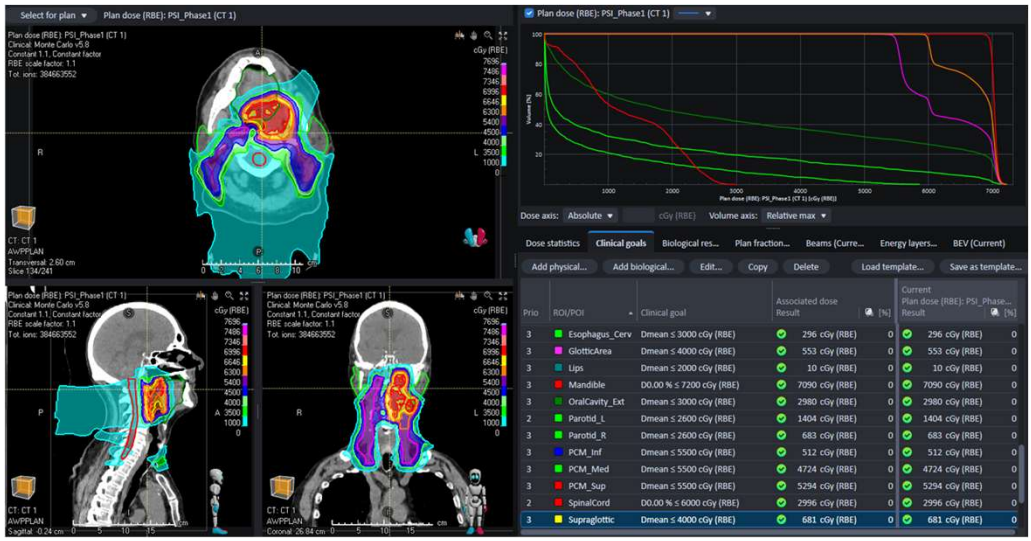
Clinical Case Examples

50 Paul Scherrer Institute PSI

50

Delivering High Quality Plans (Planning Study)

PSI

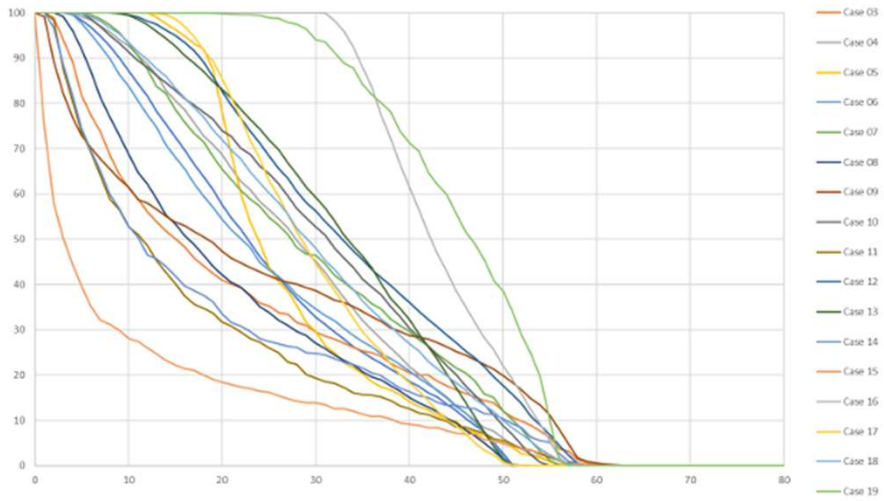


51 Paul Scherrer Institute PSI

51

Contralateral Submandibular Gland (Planning Study)

PSI



52 Paul Scherrer Institute PSI

52

Initial Clinical Plan Comparison

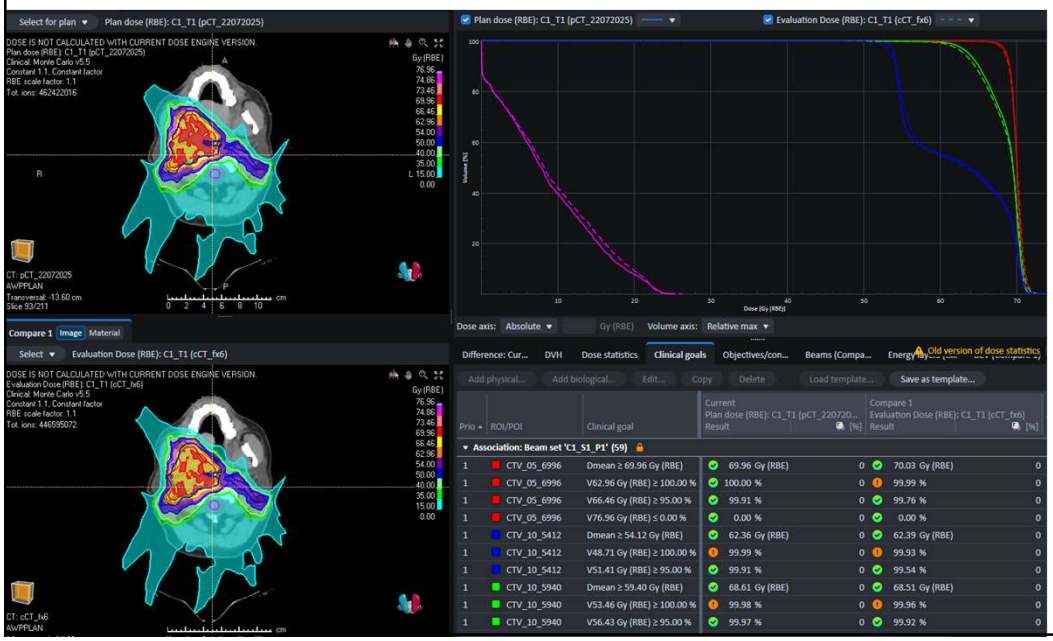
PSI

- 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

53

Recalculation Fx 6

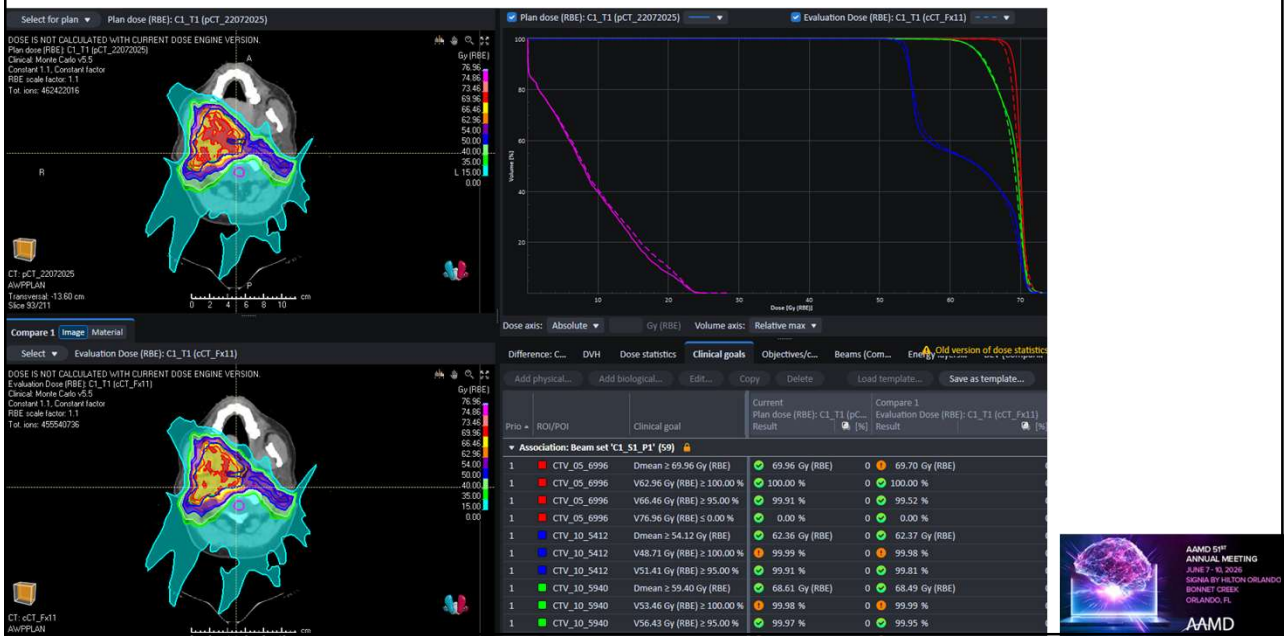
PSI



54

Recalculation Fx 11

PSI

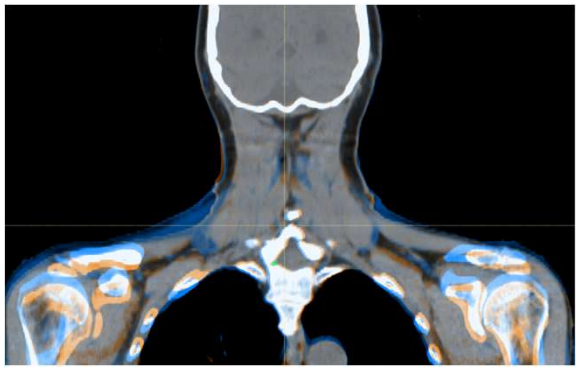


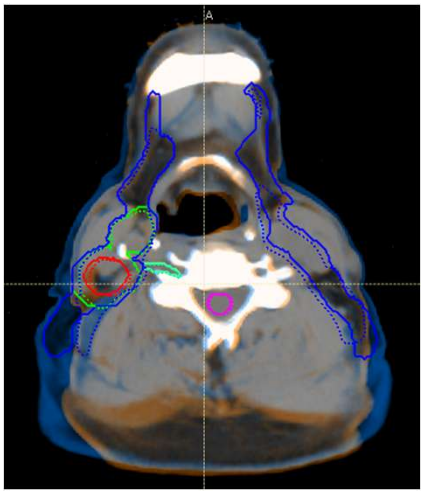
55

Recalculation Fx 20

PSI

- Changes in shoulder position



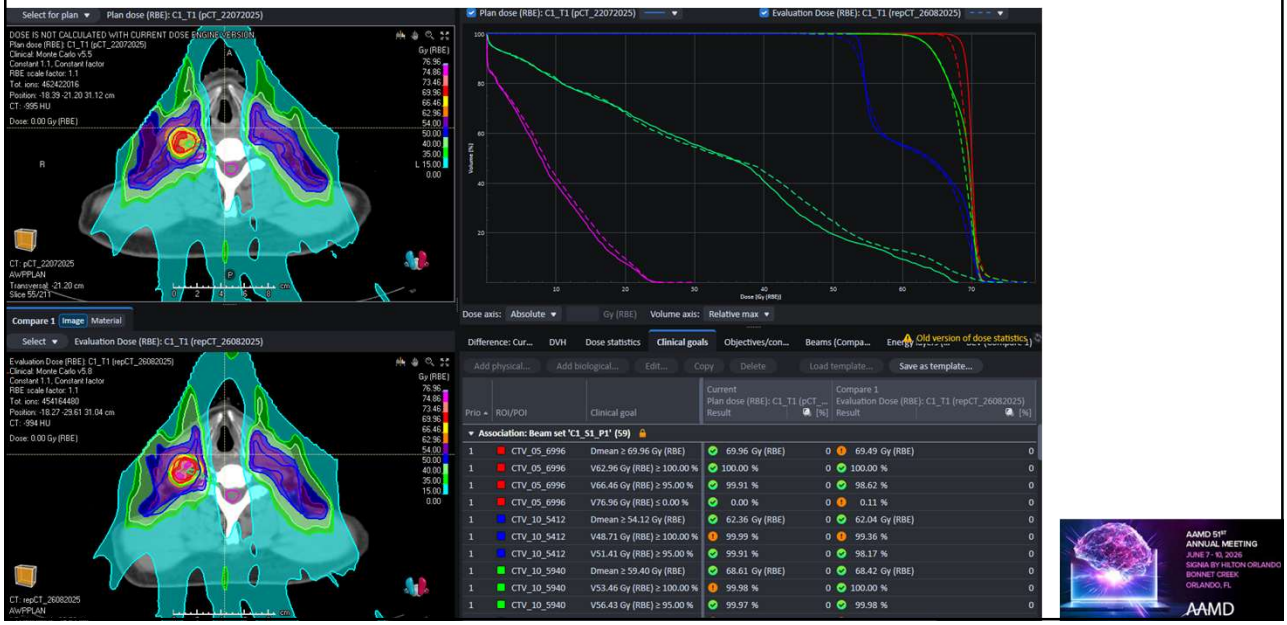


56 Paul Scherrer Institute PSI

56

Recalculation Fx 20 (No Shoulder Avoidance)

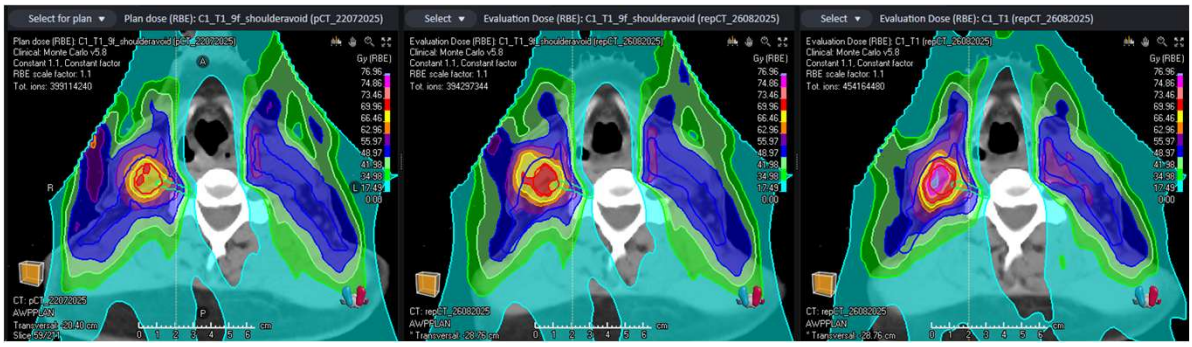
PSI



57

Recalculation Fx 20 (With Shoulder Avoidance)

PSI



Prio	ROI/POI	Clinical goal	Current Plan dose (RBE): C1_T1_9f_... Result	[%]	Compare 1 Evaluation Dose (RBE): C1_T1_9f_shoulder... Result	[%]	Compare 2 Evaluation Dose (RBE): C1_T1 (repCT_26... Result	[%]
3	BrachialPlex_R	D0.00 % ≤ 66.00 Gy (RBE)	67.86 Gy (RBE)	0	71.05 Gy (RBE)	0	74.95 Gy (RBE)	
3	BrachialPlex_R	D0.03 cm³ ≤ 66.00 Gy (RBE)	67.08 Gy (RBE)	0	68.54 Gy (RBE)	0	72.53 Gy (RBE)	

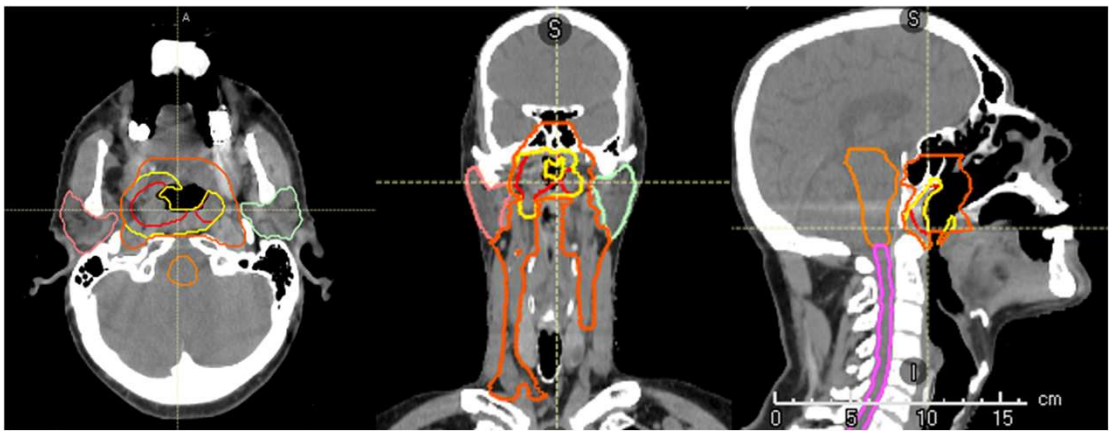
- Comparing recalculated dose from plans with and without shoulder avoidance

AAMD 51ST ANNUAL MEETING
JUNE 7 - 10, 2026
SIGNIA BY HILTON ORLANDO BONNET CREEK
ORLANDO, FL
AAMD

58

Clinical Plan Comparison

PSI

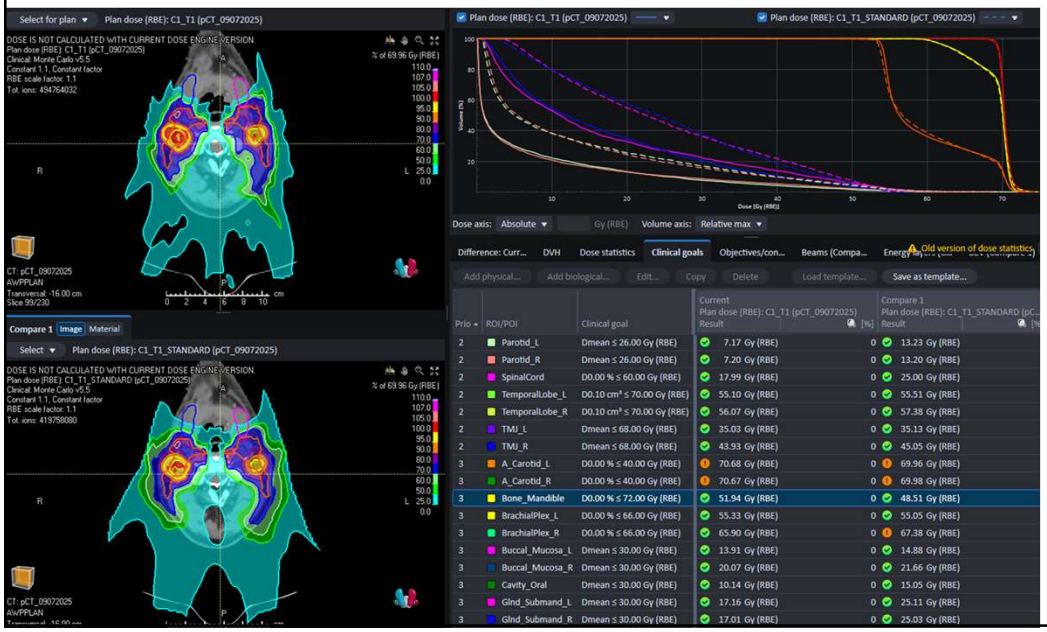


AAMD 51ST ANNUAL MEETING JUNE 7 - 10, 2026 SIGNIA BY HILTON ORLANDO BONNET CREEK ORLANDO, FL AAMD

59

Clinical Plan Comparison

PSI

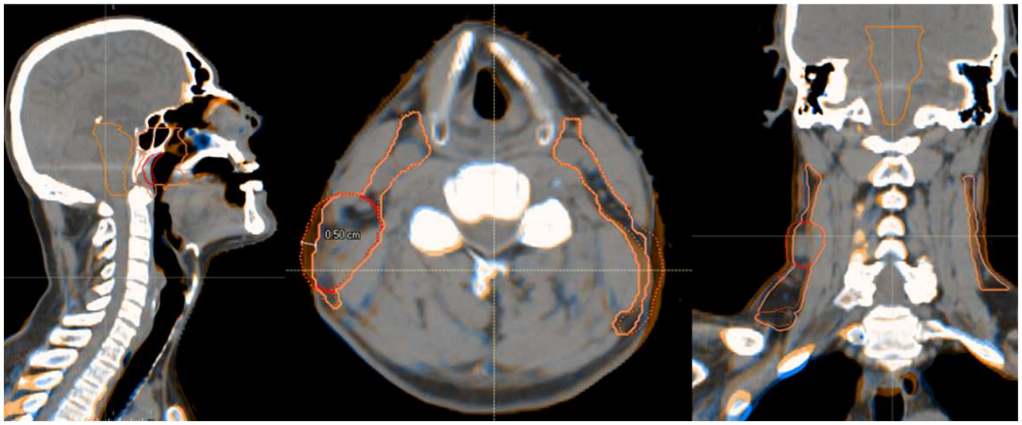


AAMD 51ST ANNUAL MEETING JUNE 7 - 10, 2026 SIGNIA BY HILTON ORLANDO BONNET CREEK ORLANDO, FL AAMD

60

Detecting Anatomical Changes

PSI

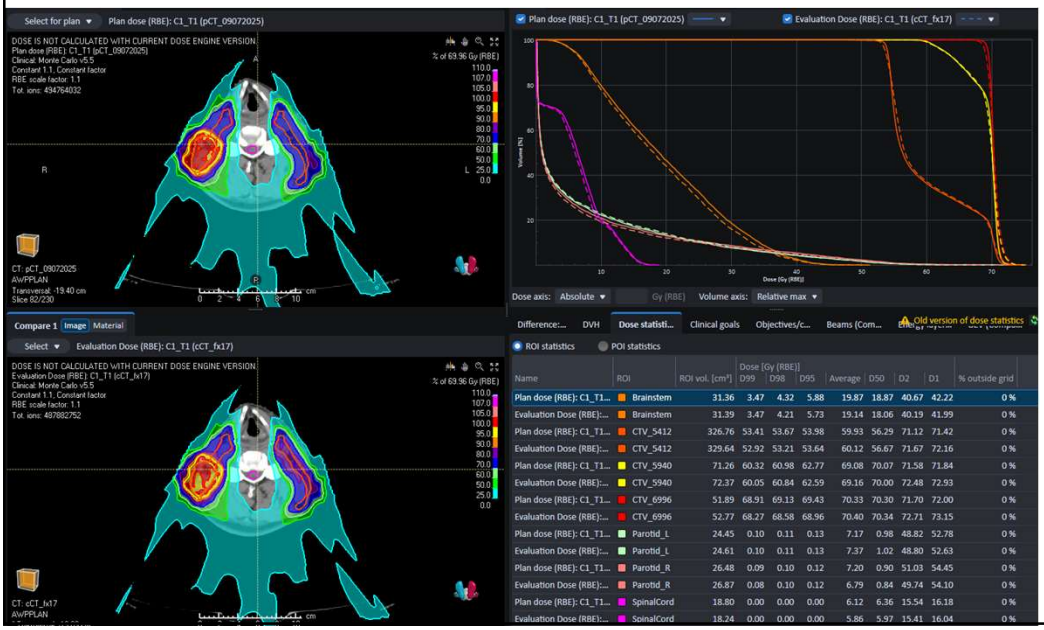


- Good setup
- Some weight loss noticed in the neck

61

Recalculation (Fraction 17)

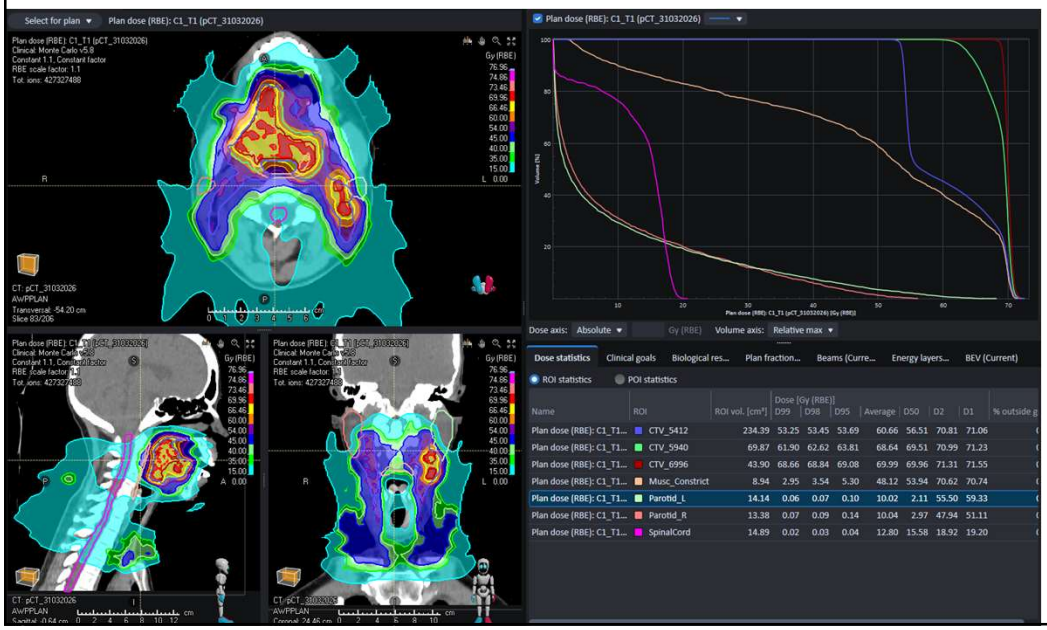
PSI



62

Base of Tongue

PSI

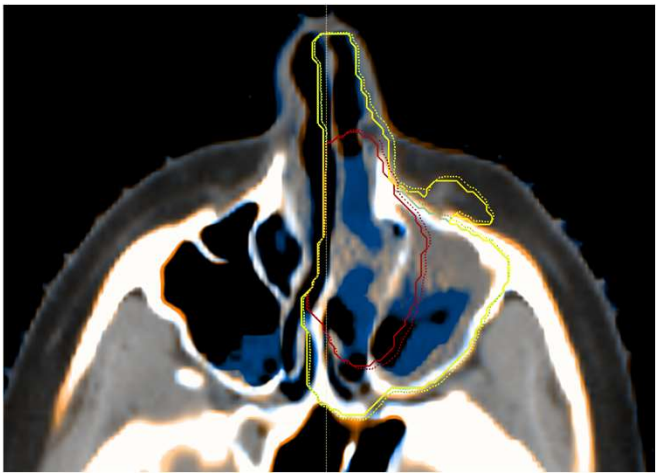


63

Changes in Sinus Filling

PSI

- Detected changes in sinus filling on CBCT
- Sent for recalculation using virtual CT in RayStation



64 Paul Scherrer Institute PSI

64

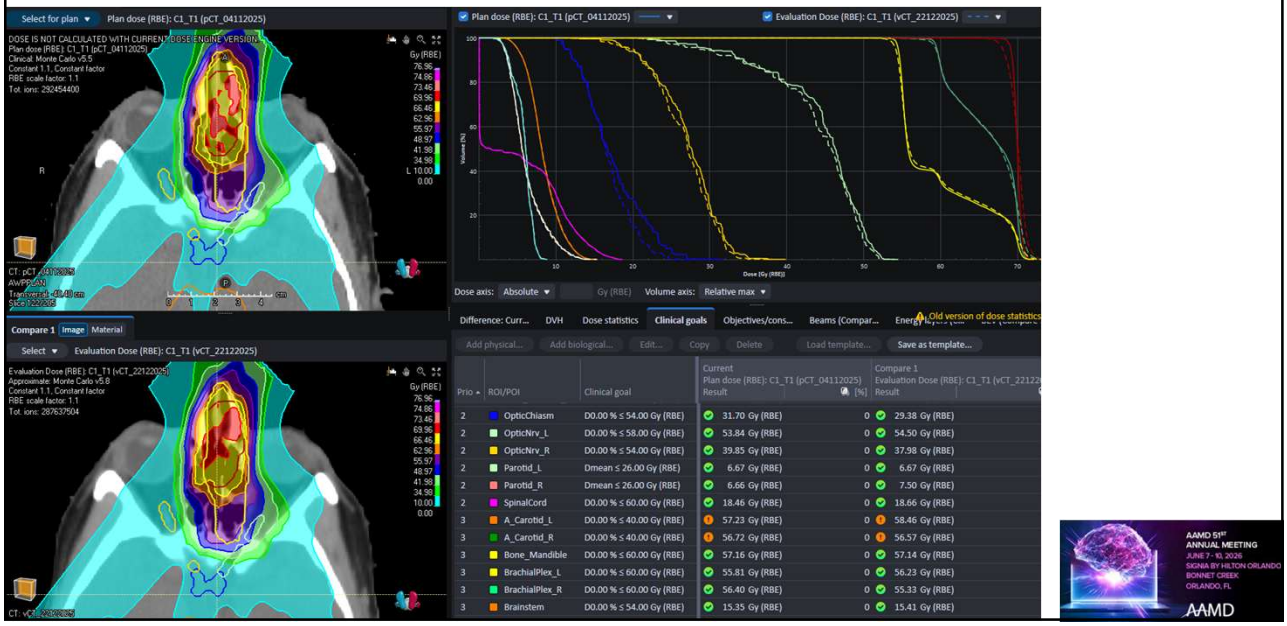
Recalculation for Sinus Filling Changes

PSI

65

Recalculation for Sinus Filling Changes

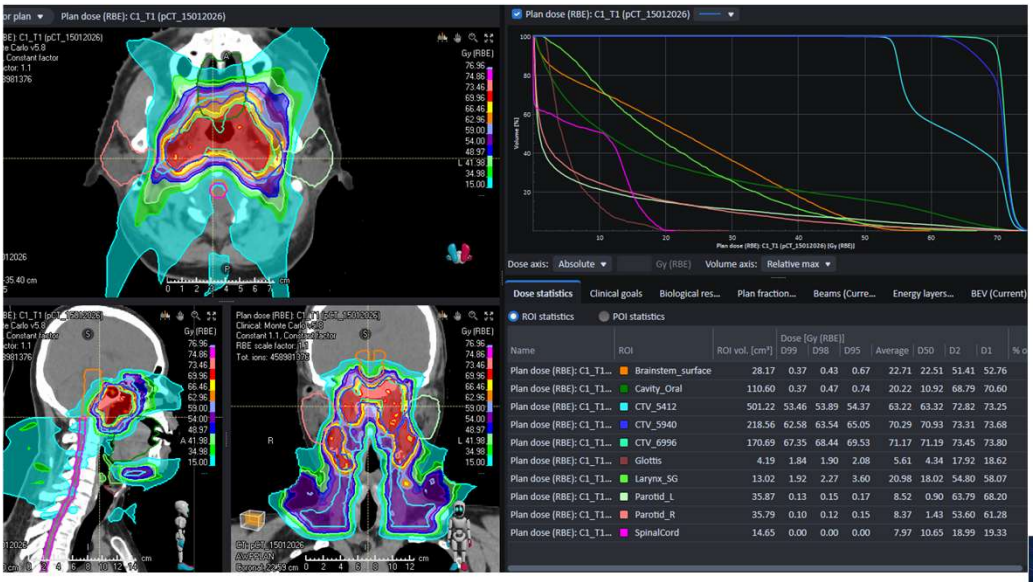
PSI



66

Case Example Nasopharynx

PSI



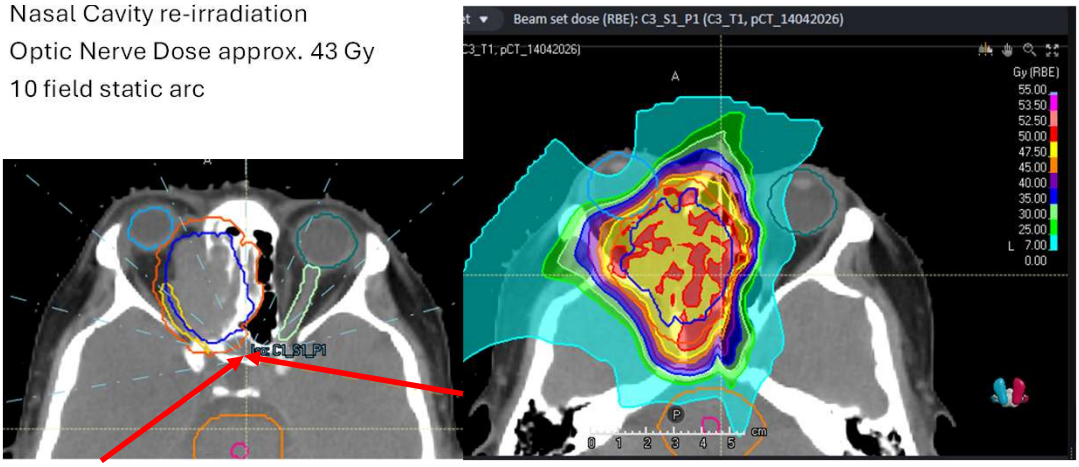
Name	ROI	ROI vol. [cm³]	Dose [Gy (RBE)] D99	D98	D95	Average	D50	D2	D1
Plan dose (RBE): C1_T1...	Brainstem_surface	28.17	0.37	0.43	0.67	22.71	22.51	51.41	52.76
Plan dose (RBE): C1_T1...	Cavity_Oral	110.60	0.37	0.47	0.74	20.22	10.92	68.79	70.60
Plan dose (RBE): C1_T1...	CTV_5412	501.22	53.46	53.89	54.37	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

67

Re-Irradiation

PSI

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



68

Re-Irradiation

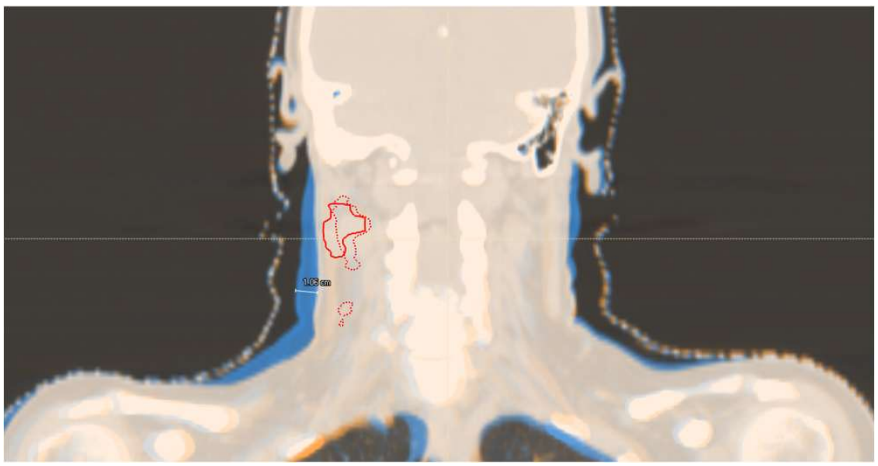
PSI

69

Significant Weight Loss

PSI

- Significant weight loss detected
- New CT for dose recalculation

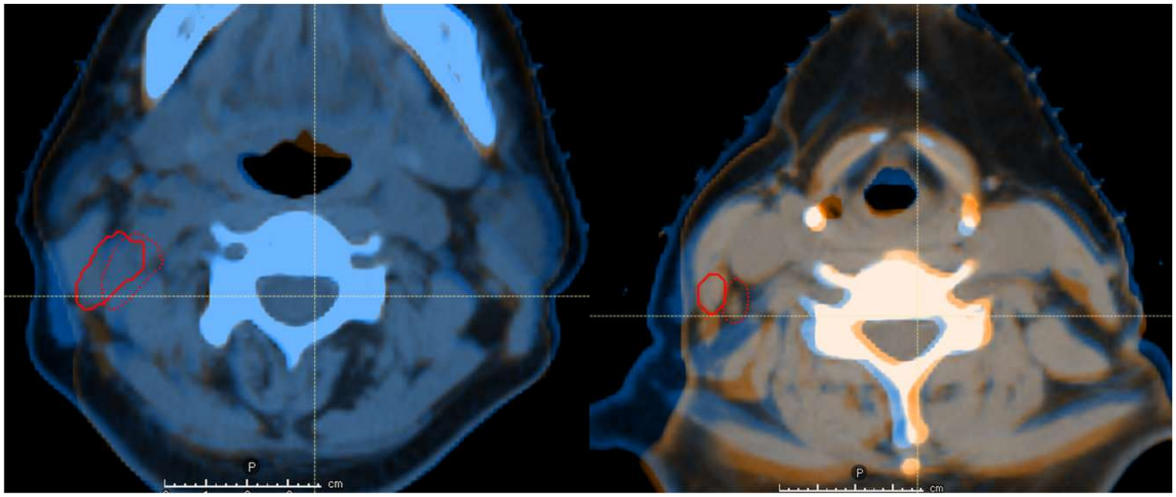


AAMD 51ST ANNUAL MEETING
JUNE 7 - 10, 2026
SIGNIA BY HILTON ORLANDO BONNET CREEK
ORLANDO, FL
AAMD

70

Changes to High Dose CTV Location in the Neck

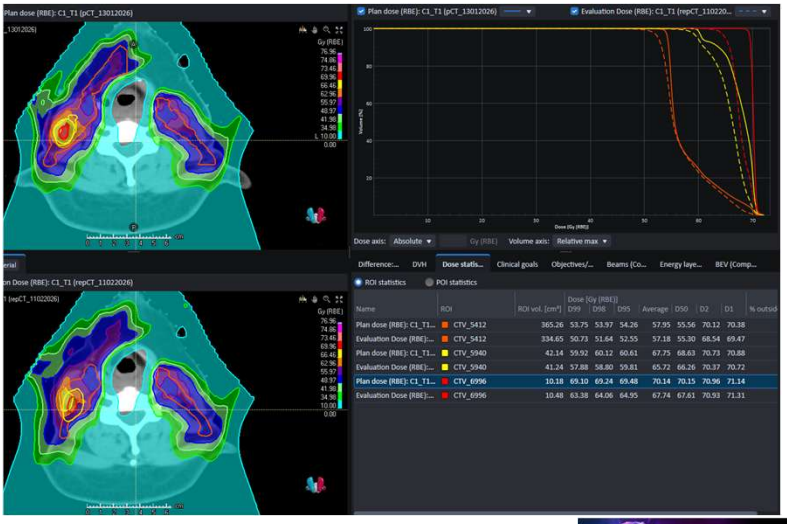
PSI



Recalculation

PSI

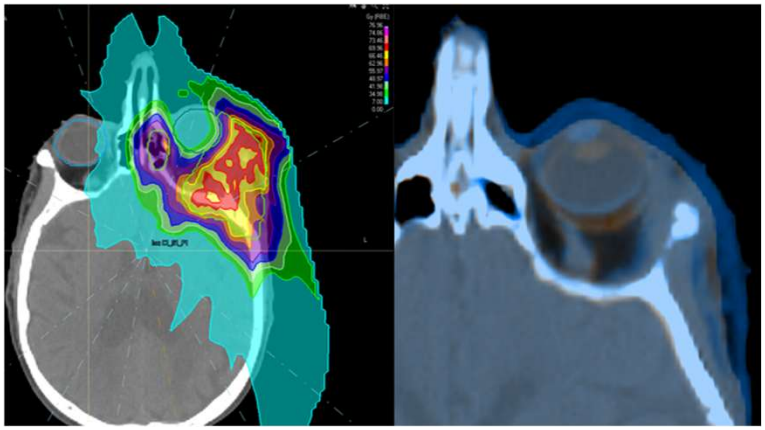
- Nominal D98%: **69.24 Gy**
  Recalculated D98%: **64.06 Gy**
- 98% of CTV_6996 was covered by approximately **1.94 Gy/fx**
- Each fraction delivered represented an approximate reduction of **0.16 Gy**



Complex Anatomy and Anatomical Changes

PSI

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



73

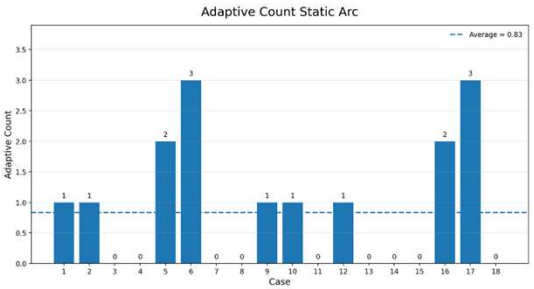
Adaptive Rate of Arc vs Standard IMPT

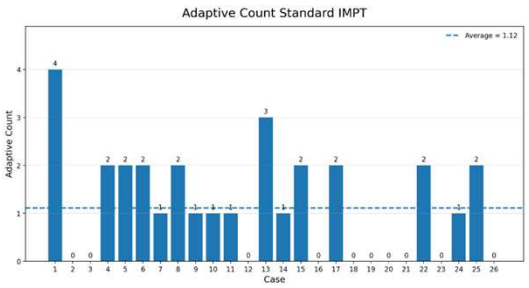
PSI

- 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





74

Summary

PSI

- 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

75

Future Direction (Potential Developments)

PSI

- 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

76

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

Connect on **LinkedIn** or **Email**

Tyler.Williamson@psi.ch