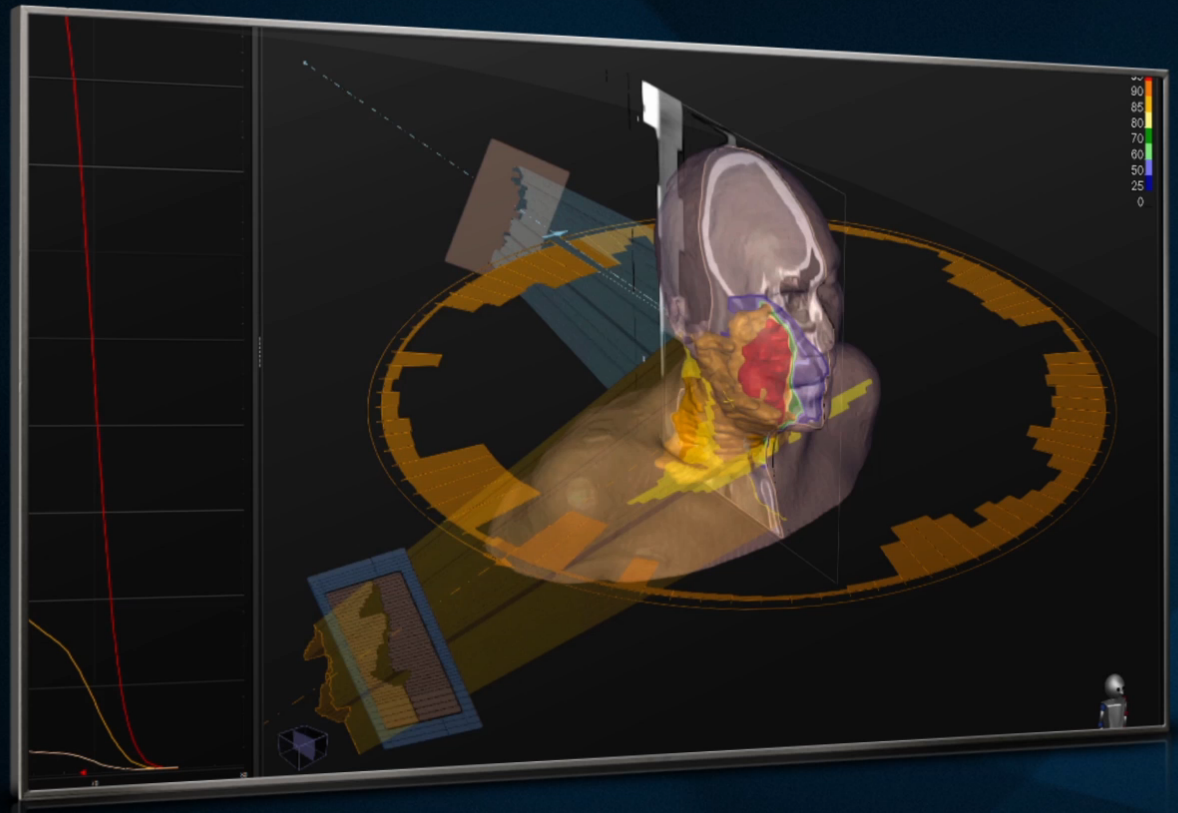
LOWER COST RT THROUGH NEW SOFTWARE TOOLS (OPTIMIZATION AND AUTOMATION)

Johan Löf

CEO & founder, RaySearch Laboratories AB

MY POINTS TODAY



Treatment delivery is never better than the plan

Software can compensate for machine weaknesses

Some machine features may not be necessary

Treatment planning considerations should be part of machine design

Keep machines longer!

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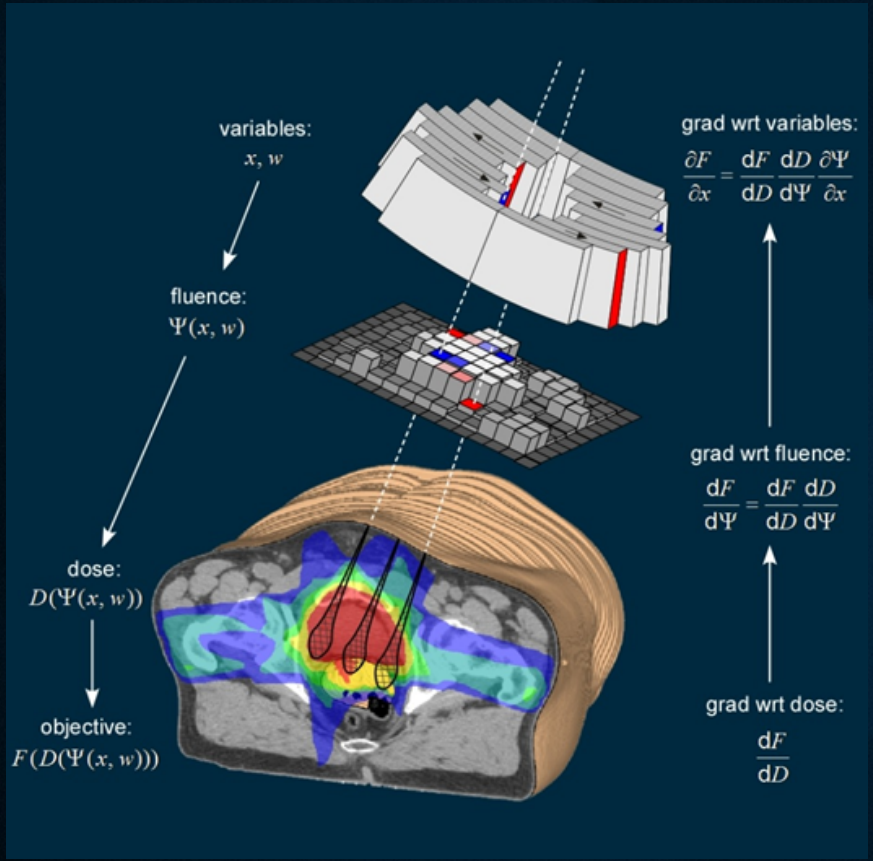
DIRECT MACHINE PARAMETER OPTIMIZATION



Optimizer aware of machine limitations during optimization

Leads to more effective solutions

All degrees of freedom optimized simultaneously

Explicit handling of linear and nonlinear constraints

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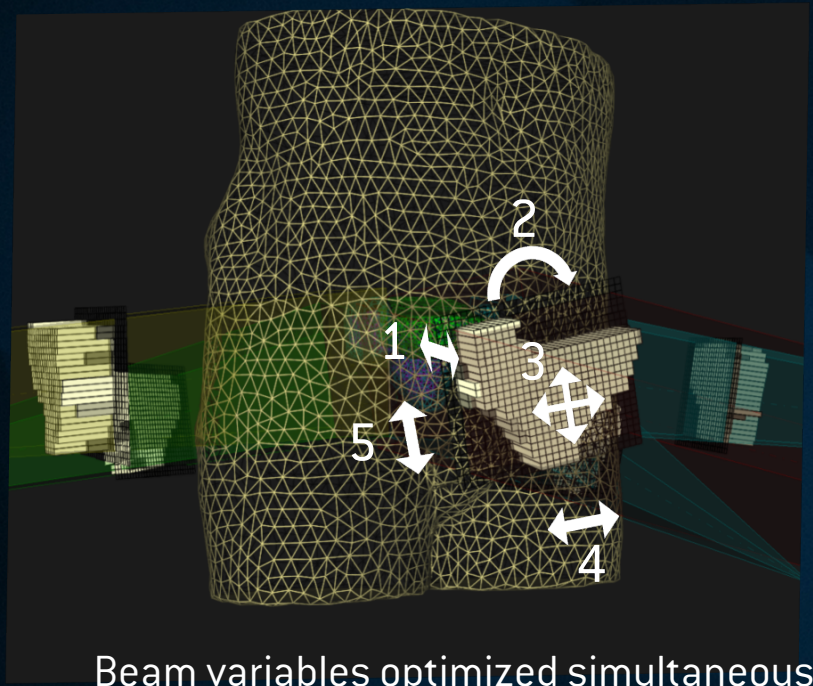
OPTIMIZATION OF 3D-CRT



Beam variables optimized simultaneously:

1. Beam weight
2. Collimator angle
3. Aperture shape
4. Gantry angle
5. Couch angle
6. Wedge angle

Optimize all relevant degrees of freedom

Leads to improved dose distributions

An example of how software can improve machine performance

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OPTIMIZATION OF 3D-CRT

Adaptive demo fr 7, 3DCRT - RayStation v4.4.0.199 - Not For Clinical Use

Automated Planning | Patient Data Management | Patient Modeling | Plan Design | Plan Optimization | Plan Evaluation | QA Preparation | Treatment Adaptation

Plan Optimization | Multi Criteria Optimization

Patient: Adaptive demo fr 7 | Plan: 3DCRT | Beam Set: 3DCRT | Plan Dose

SETTINGS: Optimization & segmentation

OPTIMIZATION CONTROLS: Start optimization | Pause | Cancel | Reduce OAR dose

FINAL DOSE: Final dose | Cancel | Scale dose

PRESCRIPTION: Auto scale to prescription | 79.20 Gy to dose at 95.00% volume in PTV

Compute function values

DVH | Biological Response | Clinical Goals | Dose Statistics | Fractionation Schedule | Biological Progress

Volume [%]

Plan dose: 3DCRT (Planning CT) [Gy]

Dose axis display options: Absolute values | Relative max dose value | Relative reference value [Gy]:

2D | BEV | 3D

[Plan dose: 3DCRT (Planning CT)] [No dose]

% of 0.00 Gy

Planning CT
Generic CT_9
Transversal -1.40 cm
Slice 36/111

Objectives/Constraints | Beams | Control Points | Beam Optimization Settings | Beam Weighting

Add physical... | Add biological... | Edit... | Delete | Load template... | Create template... | Add MCO functions

Function	Constraint	Dose	ROI	Description	Robust	Weight	Value
Physical Composite Objective							
Dose Fall-Off		Plan	External	Dose Fall-Off [H]79.20 Gy [L]35.00 Gy, Low dose distance 5.00 cm		20	
Max Dose		Plan	PTV	Max Dose 82.50 Gy		20	
Max Dose		Plan	FemoralHead (Left)	Max Dose 30.00 Gy		5	
Max Dose		Plan	FemoralHead (Right)	Max Dose 30.00 Gy		5	
Max EUD		Plan	Bladder	Max EUD 55.00 Gy, Parameter A 1.2		20	
Max EUD		Plan	Rectum	Max EUD 30.00 Gy, Parameter A 1.2		20	
Min Dose		Plan	PTV	Min Dose 79.20 Gy		100	

Optimization Progress

Value

Iteration

Iteration number:

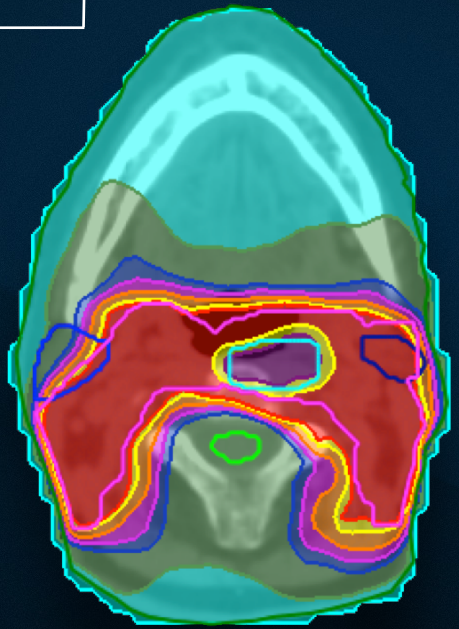
Objective value:

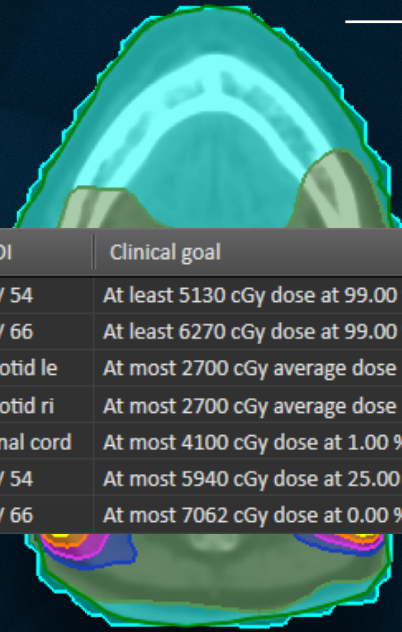
Status:

IS VARIABLE DOSE RATE NECCESSARY FOR VMAT?

Variable dose rate
Dual arc
1 subarc/arc

Constant dose rate
Dual arc
2 subarcs/arc





ROI/POI	Clinical goal	Value	Result
PTV 54	At least 5130 cGy dose at 99.00 % volume	5194 cGy	✓
PTV 66	At least 6270 cGy dose at 99.00 % volume	6348 cGy	✓
Parotid le	At most 2700 cGy average dose	2690 cGy	✓
Parotid ri	At most 2700 cGy average dose	2664 cGy	✓
Spinal cord	At most 4100 cGy dose at 1.00 % volume	4008 cGy	✓
PTV 54	At most 5940 cGy dose at 25.00 % volume	5900 cGy	✓
PTV 66	At most 7062 cGy dose at 0.00 % volume	6946 cGy	✓

Delivery time:

- 2:17

ne:

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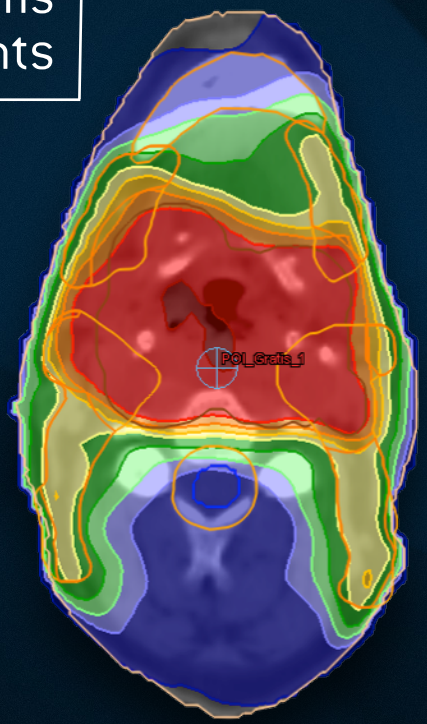
MAXIMIZE EFFICIENCY FOR STEP & SHOOT IMRT DELIVERY

Linac B
7 beams
110 segments



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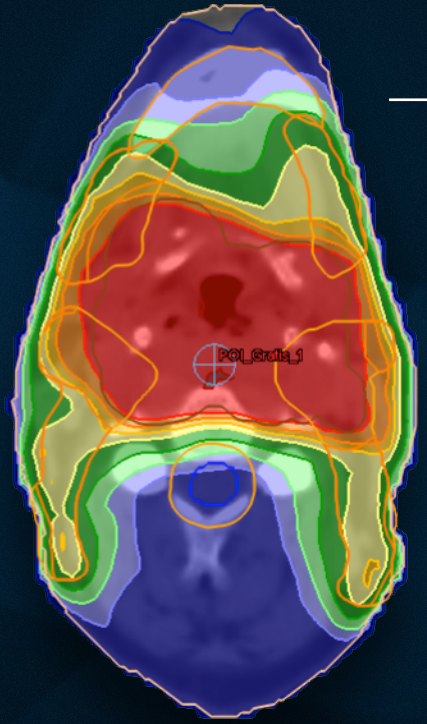

Linac C
7 beams
110 segments

Delivery time:

- 6:44

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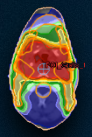
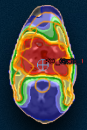
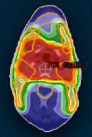
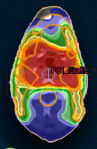
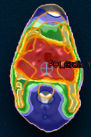
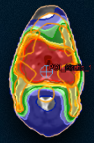
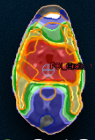
FIND A FASTER PLAN FOR LINAC B

	IMRT 7 beams	IMRT 9 beams	IMRT 11 beams	IMRT 13 beams	IMRT 15 beams	IMRT 17 beams	IMRT 19 beams
High number of segments	 110	 80	 70	 70	 70	 70	 70
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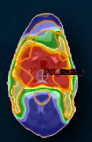
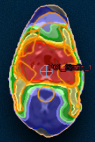
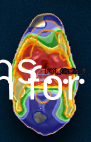
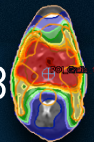
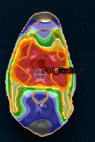
Medium number of segments	 100	 70	 60	 60	 60	 60	 60
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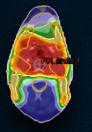
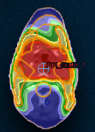
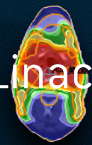
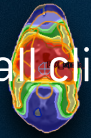
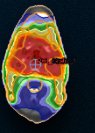
Low number of segments	 90	 60	 50	 50	 50	 50	 50
	11:44	8:40	7:18	7:15	6:58	5:57	6:41

Autogenerating plans

The fastest plan for Linac B

Linac B plans that fulfill all clinical goals

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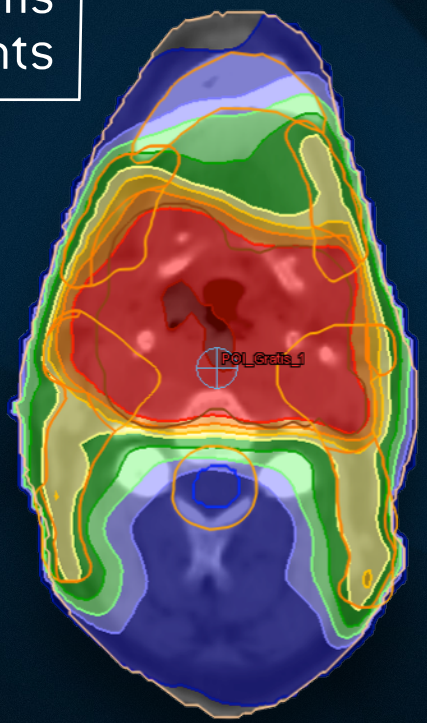
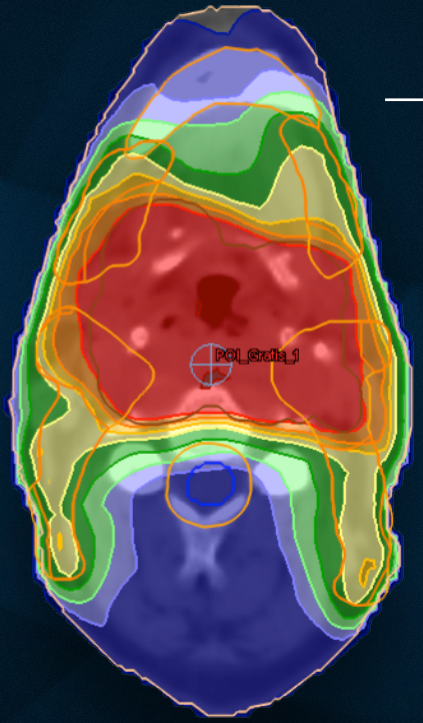
MAXIMIZE EFFICIENCY FOR STEP & SHOOT IMRT DELIVERY

Linac B
7 beams
110 segments



Delivery time:

- 14:38



Linac B
11 beams
60 segments

Delivery time:

- 8:15

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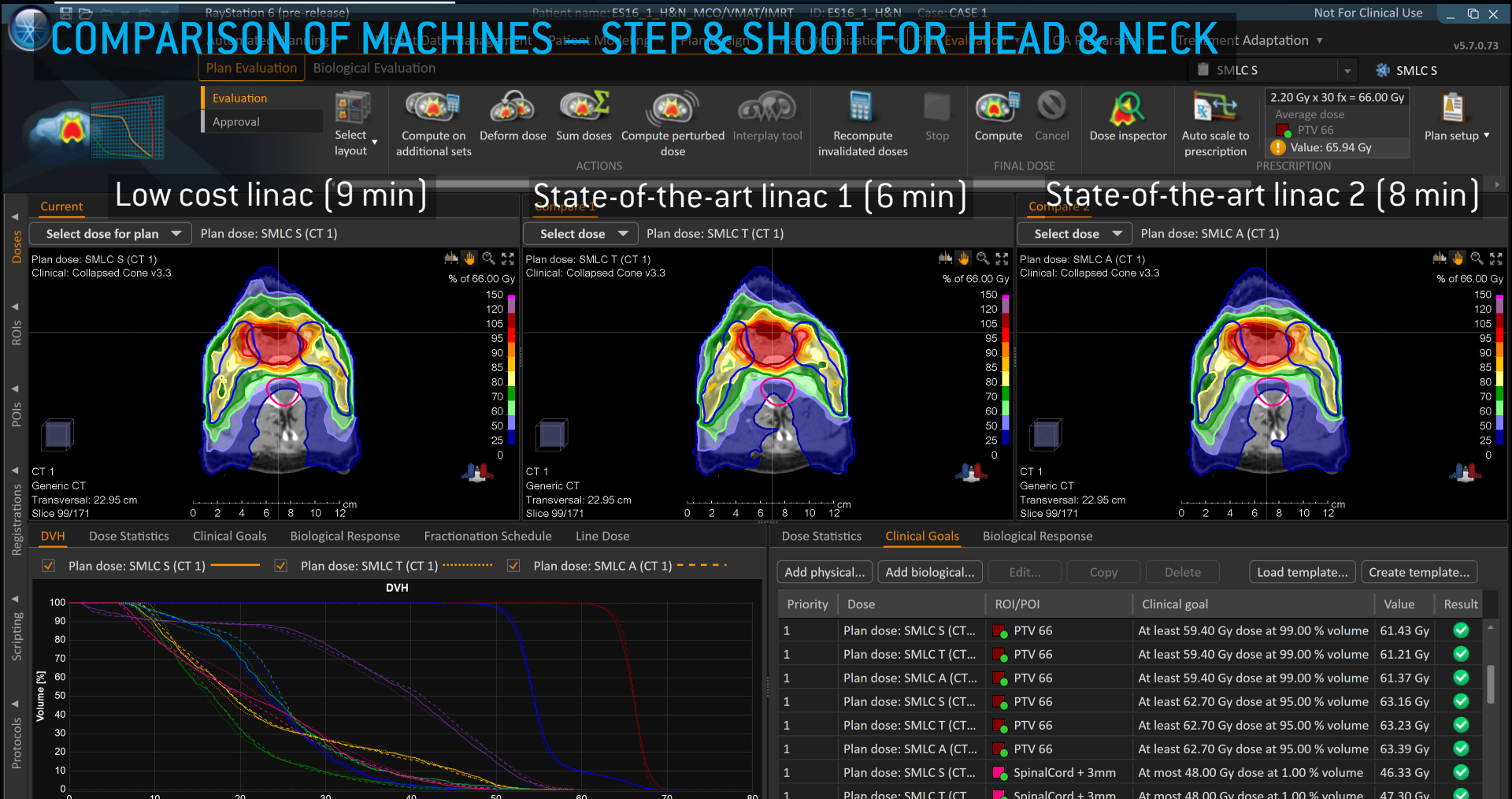
COMPARISON OF MACHINES - STEP & SHOOT FOR HEAD & NECK



PLAN EXPLORATON: FIND THE MOST EFFICIENT PLAN FOR A H&N CASE

Treatment techniques:

- VMAT (1-3 arcs)
- DMLC (5-11 beams)
- SMLC (5-11 beams)

Five machines

105 plans

VMAT dual arc on Linac A FFF

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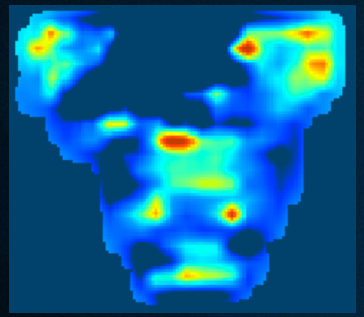
CONCLUSIONS

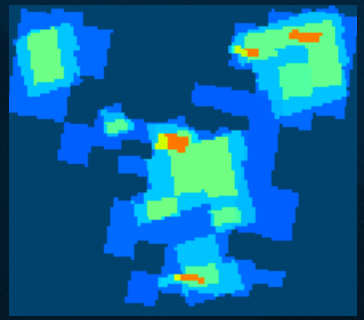
Example: Rotation of collimator can compensate for leaf width



Ideal fluence

Segment 1

Segment 2



8 segments

Software can compensate for lack of fancy and expensive features

Focus on reliability, robustness, accuracy, and cost

Use Plan Exploration during the design of the machine

Complete planning solution should exist long before production begins

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THANK YOU!

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