Clinical Implementation of Auto-Planning

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Disclosures

- Philips: Research Grant
- Siemens: Research Grant

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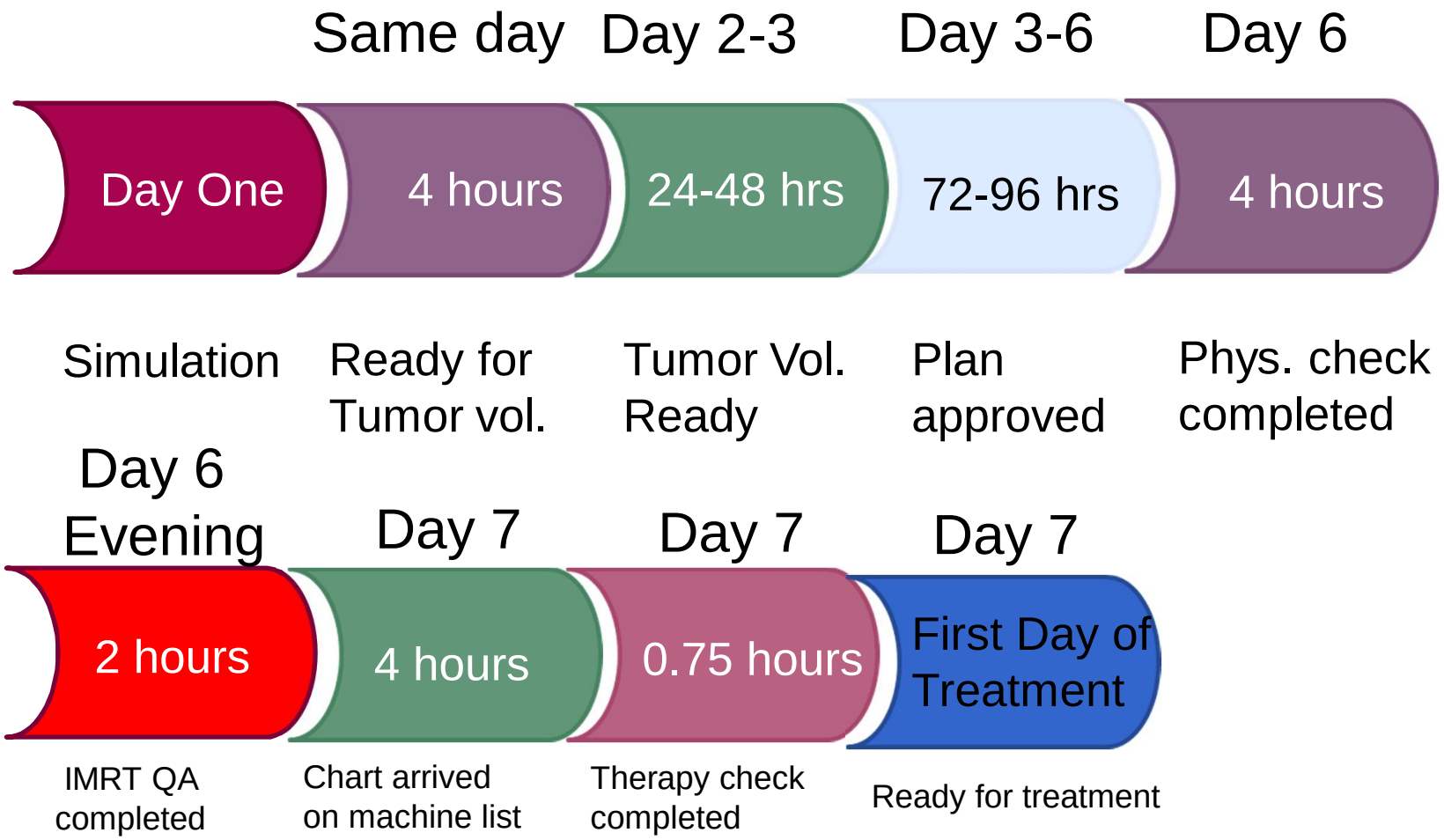
Clinic Demands Efficiency and Quality Cares

- One of 2015's themes at Cleveland Clinic is to improve patient access.
- From Cancer Center, we aim to reduce time from cancer diagnosis to treat.
- From Radiation Oncology, we aim to reduce time from simulation to treat.

Cleveland Clinic Clinical Workflow and Timeline



Why Auto-Planning ?

- IMRT planning requires constant real time tuning of the planning objectives and extra contours Chinese Cooking method
- Highly dependent on how and when these tuning planning objectives and contours are added in optimizer - cooking process.
- It depends anatomical relationship among the OARs and PTVs - cooking ingredients.

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What Is Auto-Planning (AP)

- AP is a new IMRT planning module in Pinnacle system, released in version 9.10.
- Users can create their own cancer specific, machine specific, or IMRT delivery method specific AP technique to speed up IMRT planning
  - recipe method
- Users can also use AP to perform IMRT optimization while setting other planning parameters such as beam angles, delivery method (step and shoot vs. VMAT)
  - spontaneous method

My Early Experience in 2003

ELSEVIER

Int. J. Radiation Oncology Biol. Phys., Vol. 59, No. 3, pp. 886–896, 2004

0360-3016/04/$–see front matter

doi:10.1016/j.ijrobp.2004.02.040

PHYSICS CONTRIBUTION

A STUDY OF PLANNING DOSE CONSTRAINTS FOR TREATMENT OF NASOPHARYNGEAL CARCINOMA USING A COMMERCIAL INVERSE TREATMENT PLANNING SYSTEM

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I was Skeptical

- Auto-Planning could only work for simple cases
- Ideal candidates include sites with small variations in tumor shape and location - prostate cancer, possibly nasopharynx cancer.
- Challenging sites include head and neck cancer with variations in tumor shapes and locations.

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Example 1

- Oral Cavity Case
- Rx dose: 64 Gy, 60 Gy, and 54 Gy.
- Nine beams used in the clinical plan,
- Nine beam used in the auto-plan Step and Shoot (SS) plan
- 2 arcs used in auto-VMAT plan

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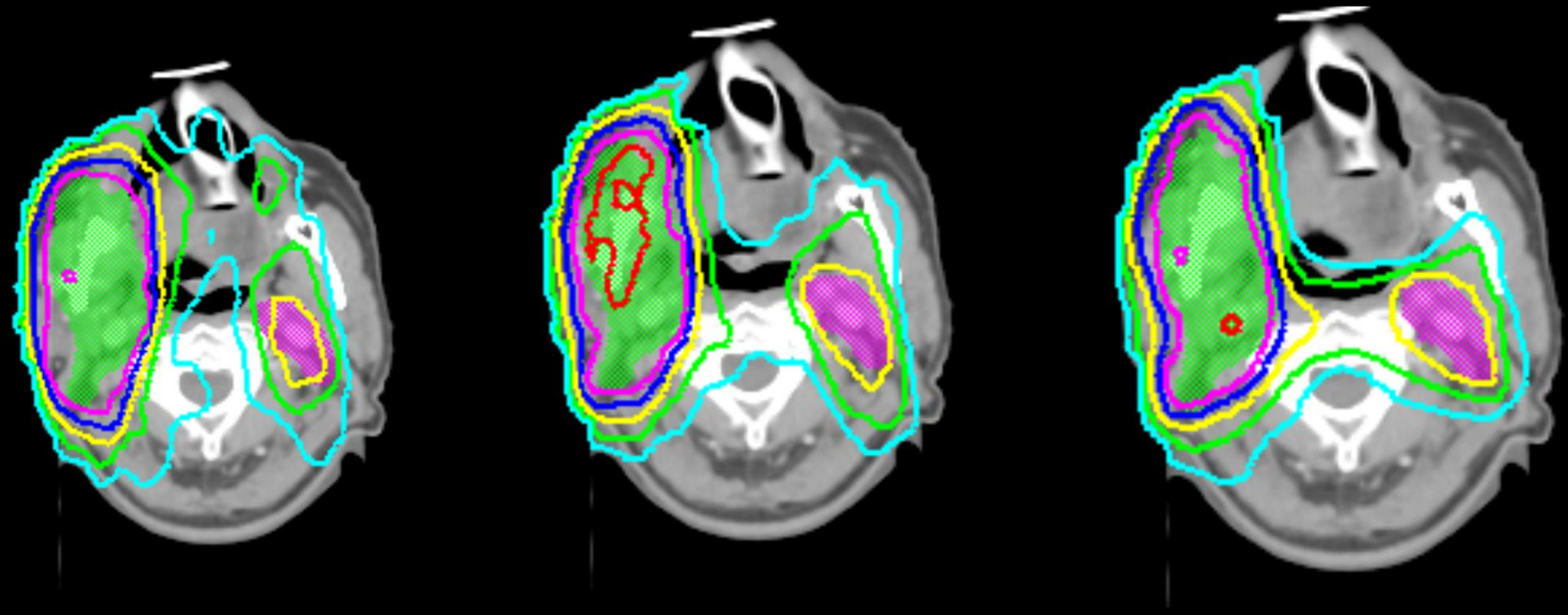
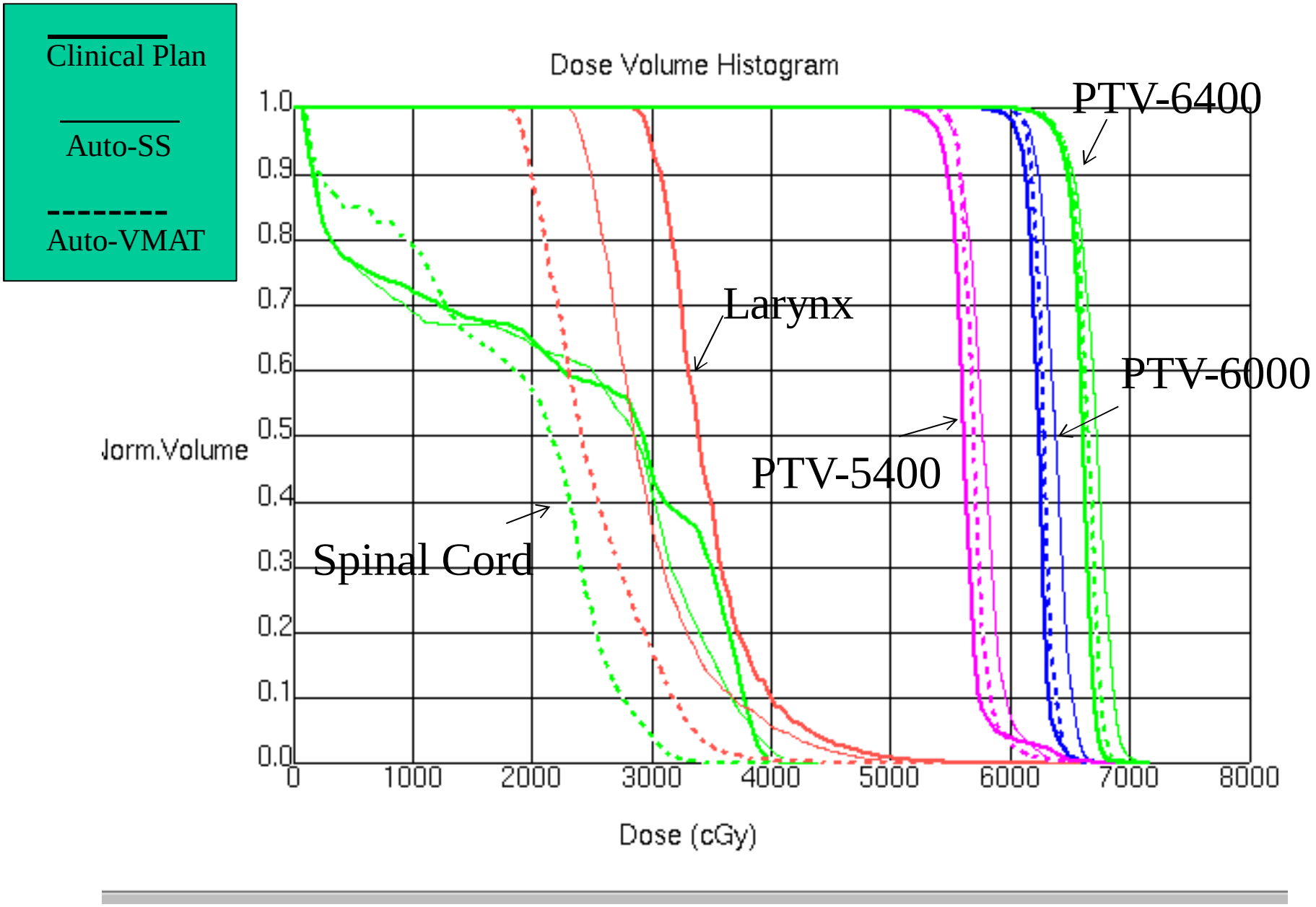
Clinical Plan

Auto-Plan SS

Auto-Plan VMAT



68.0, 64.0, 60.0, 54.0, 45.0, 35.0


Clinical Plan
Auto-SS
Auto-VMAT
Dose Volume Histogram
PTV-6400
Larynx
PTV-6000
PTV-5400
Spinal Cord
Norm.Volume
1.0
0.9
0.8
0.7
0.6
0.5
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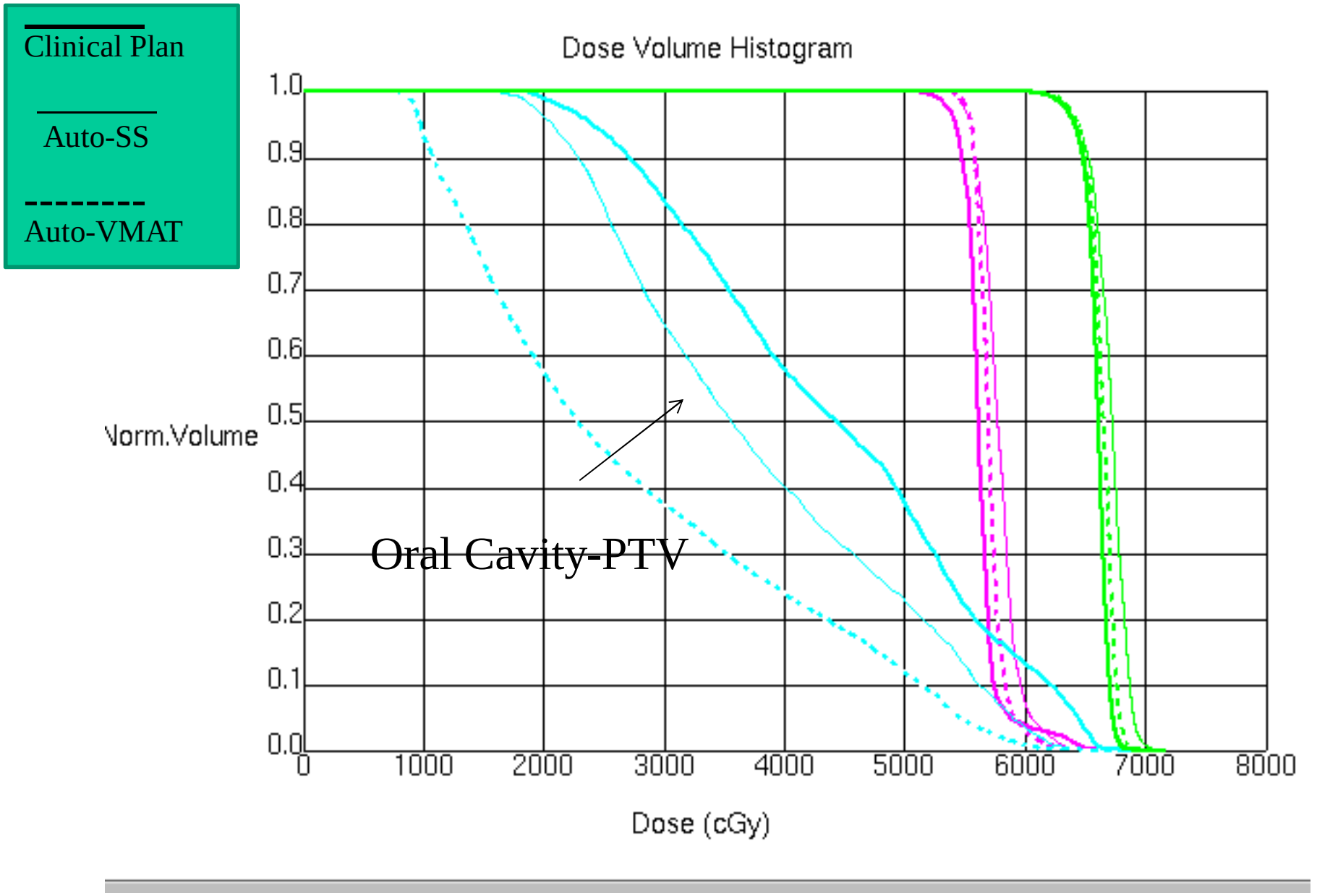
7000
8000
Dose (cGy)


Clinical Plan
Auto-SS
Auto-VMAT
Dose Volume Histogram
Norm.Volume
1.0
0.9
0.8
0.7
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0
1000
2000
3000
4000
5000
6000
7000
8000
Dose (cGy)
Oral Cavity-PTV

Example 2

- Larynx Cancer
- Rx: 70 Gy and 56 Gy
- Clinical Plan: Nine beam angles
- Auto Plan: Nine beam Angles step and shoot (SS)
- Auto Plan: 2 arc VMAT

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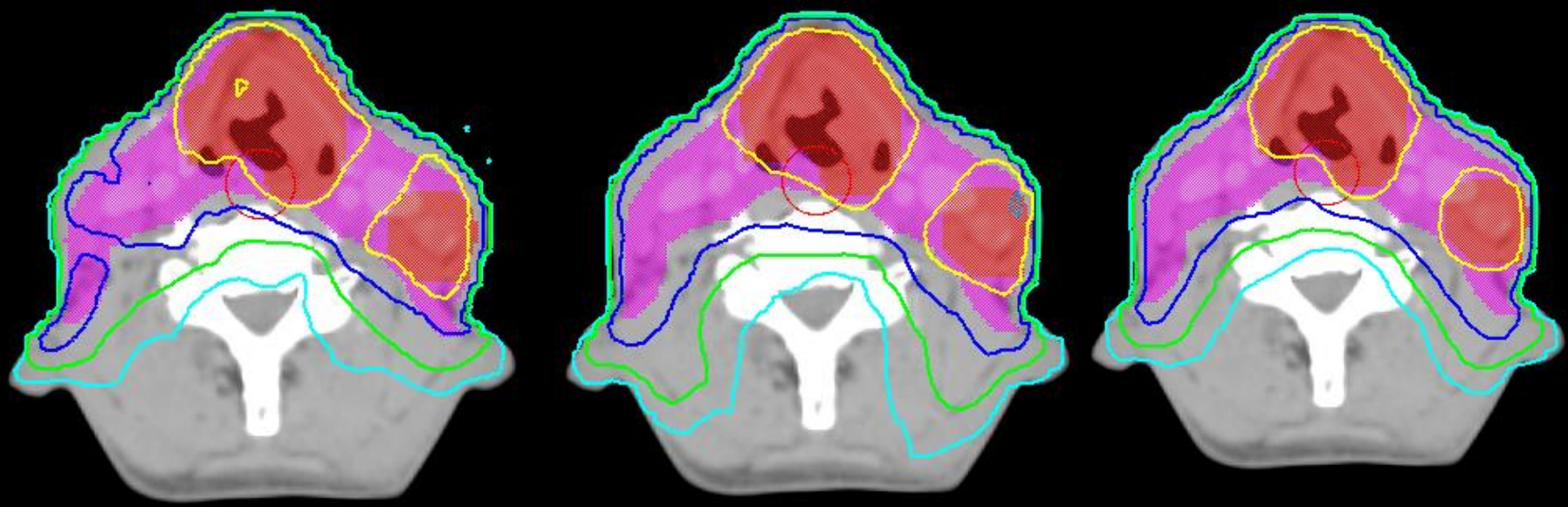
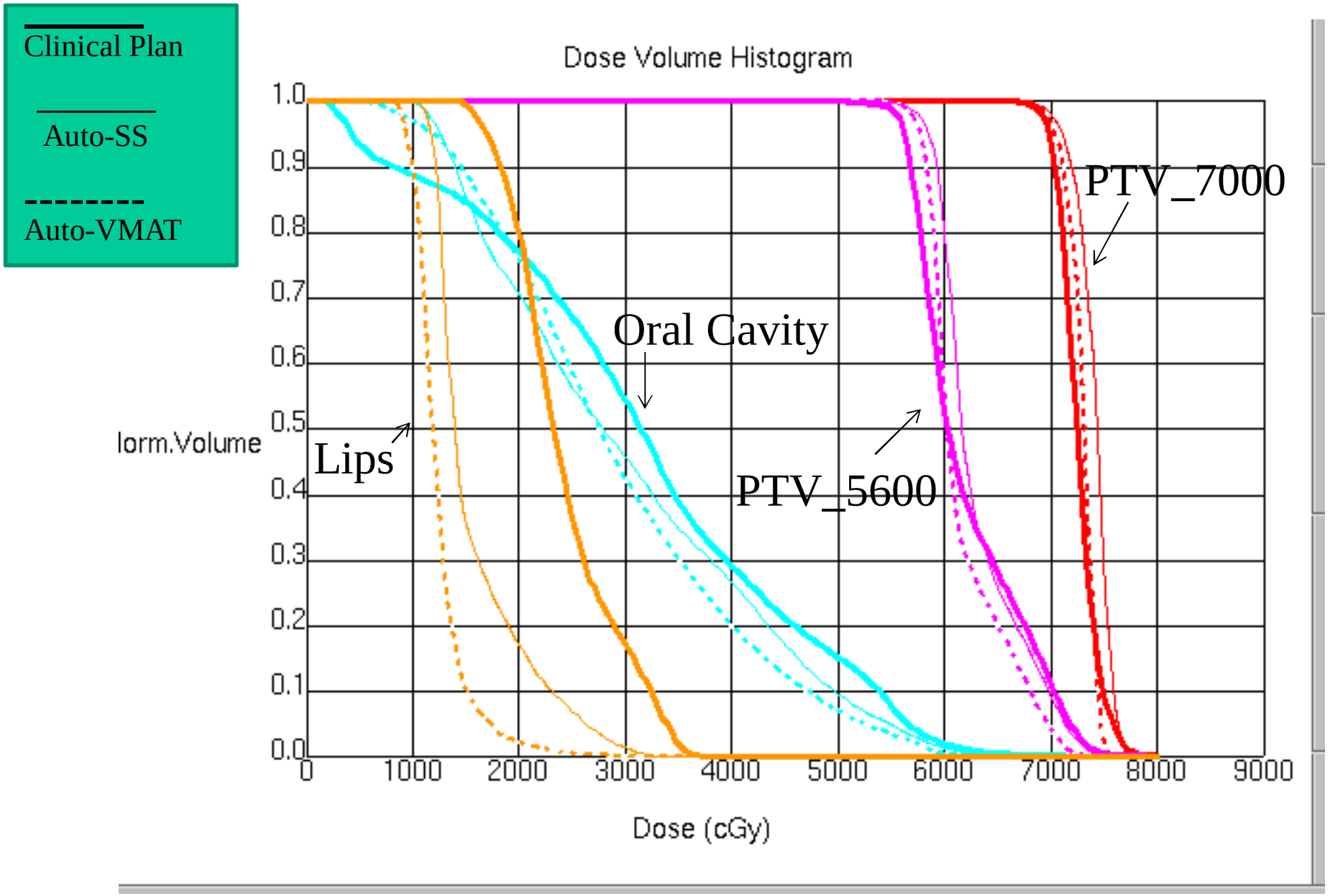
Clinical Plan

Auto-Plan SS

Auto-Plan VMAT



77.0, 70.0, 56.0, 45.0, 35.0 Gy


Clinical Plan
Auto-SS
Auto-VMAT
Dose Volume Histogram
lorm.Volume
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Dose (cGy)
PTV_7000
Oral Cavity
Lips
PTV_5600

Comparison of HN Plans (n=7)

		Clinical	AP_IMRT	AP_VMAT	Clinical vs. AP_IMRT p-value	Clinical vs. AP_VMAT p-value
HD_PTV	V_{70Gy} (%)	95.5	95.5	95.5	0.643	0.884
LD_PTV	V_{56Gy} (%)	96.5	98.5	98.7	<0.001	0.001
Brainstem	D_{max} (Gy)	30.7	24.7	20.4	0.016	0.012
Spinal_cord	D_{max} (Gy)	40.7	40.0	37.9	0.703	0.339
Paratid_L	D_{mean} (Gy)	31.8	28.4	27.2	0.213	0.091
Paratid_R	D_{mean} (Gy)	32.4	28.3	26.6	0.109	0.032
Larynx	D_{mean} (Gy)	41.1	30.07	29.3	0.014	0.008
Trachea	D_{mean} (Gy)	26.6	21.6	22.0	0.030	0.036
Esophagus	D_{mean} (Gy)	25.6	17.3	17.2	0.002	0.001
HI		1.11	1.13	1.10	0.154	0.314
CI		1.14	1.12	1.01	0.746	0.003

Prostate

- High risk Prostate
- Rx: 78 Gy to prostate-PTV, 66 Gy to SV
- Clinical Plan: 7 beam angles
- Auto-Plan: 2 arc VMAT

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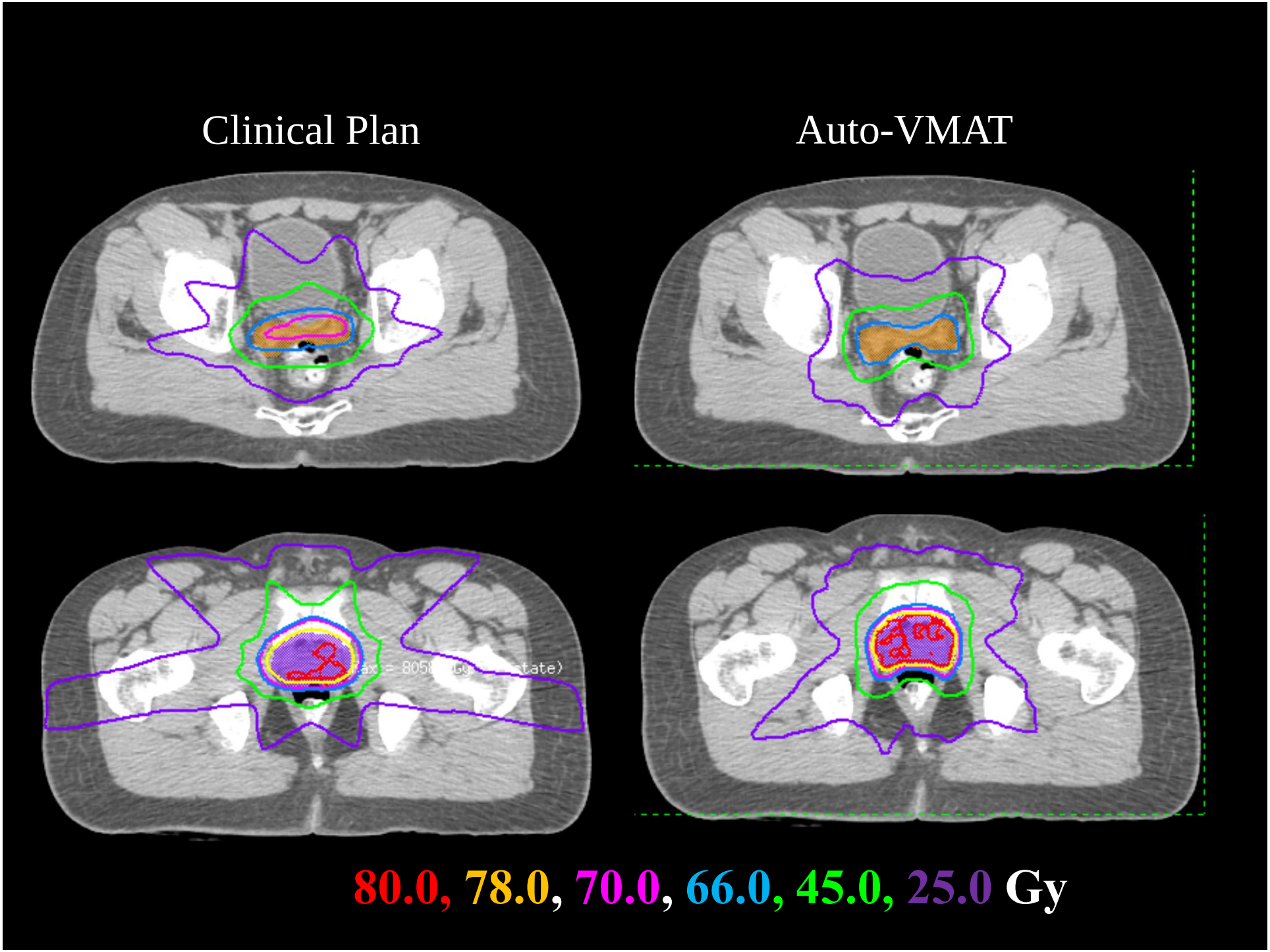
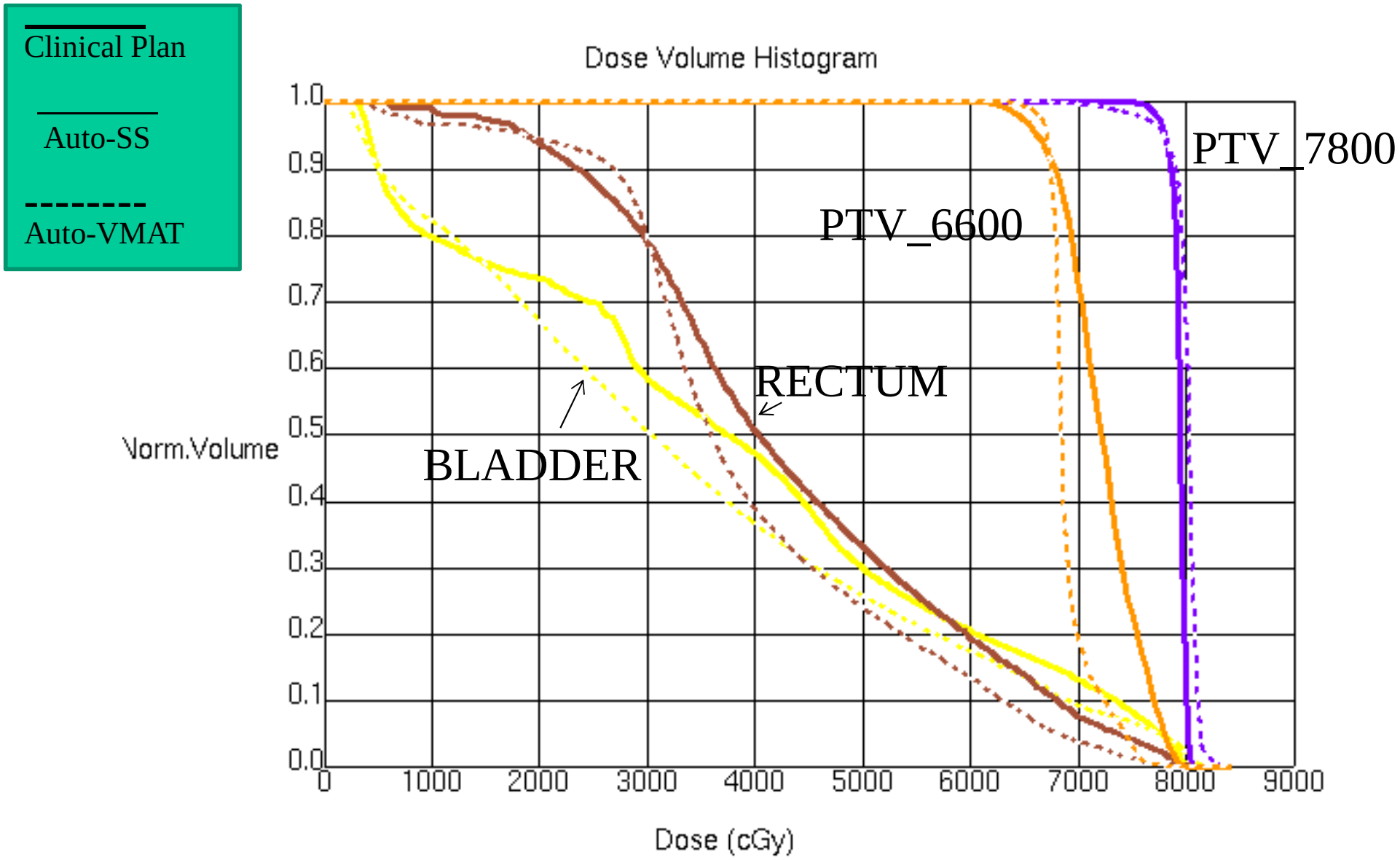
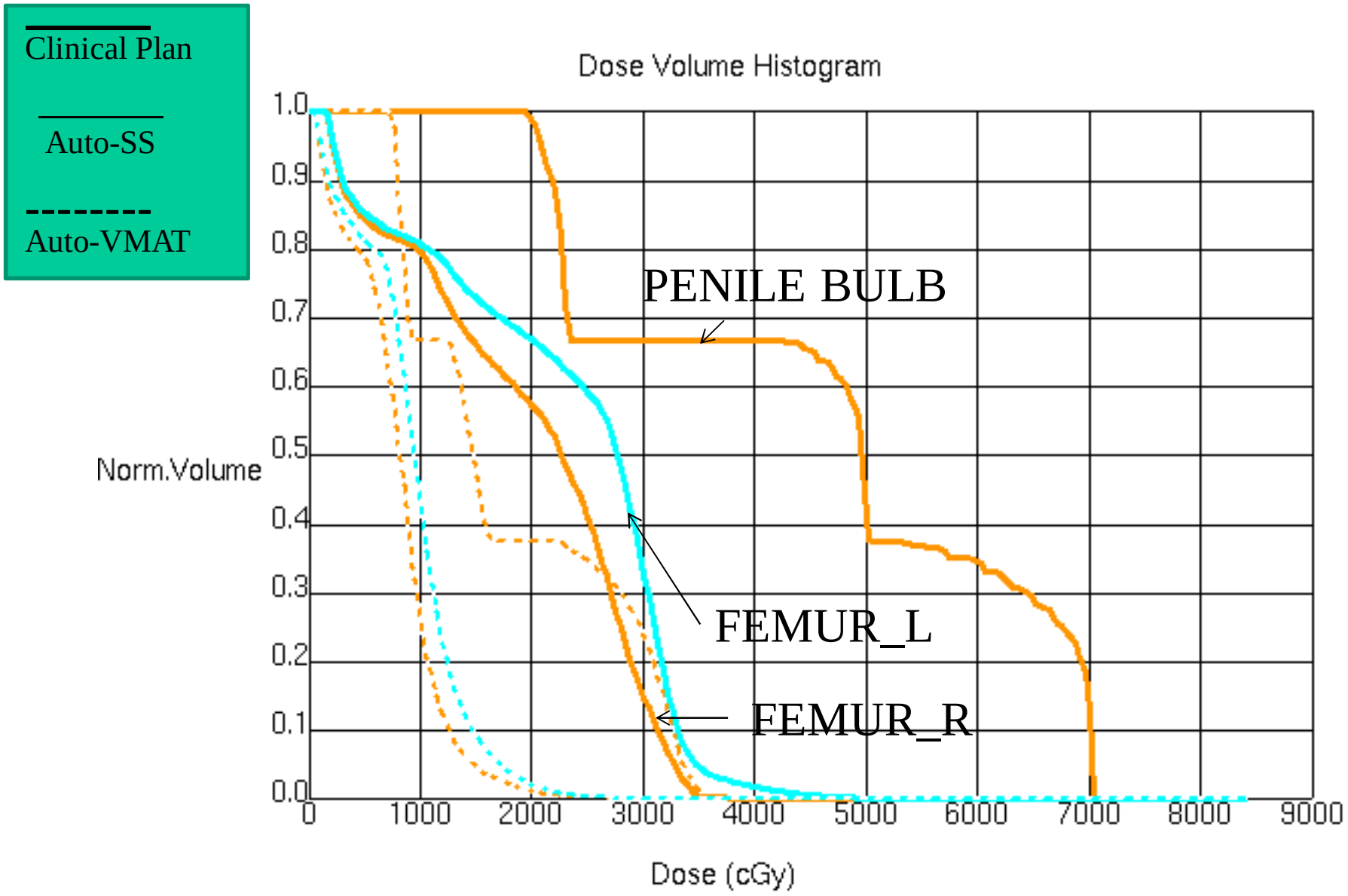

Clinical Plan
Auto-VMAT
80.0, 78.0, 70.0, 66.0, 45.0, 25.0 Gy


Clinical Plan
Auto-SS
Auto-VMAT
Dose Volume Histogram
Norm.Volume
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Dose (cGy)
PTV_7800
PTV_6600
RECTUM
BLADDER


Clinical Plan
Auto-SS
Auto-VMAT
Dose Volume Histogram
Norm.Volume
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Dose (cGy)
PENILE BULB
FEMUR_L
FEMUR_R

Prostate and Pelvic Lymph Nodes (n=8)

		Clinical plan (mean ± SD)	Auto-plan (mean ± SD)	p-value
PTV_prostate	V_{70Gy} (%)	95.3 ± 0.1	95.4 ± 0.1	0.310
PTV_SV	$V_{60/56Gy}$ (%)	96.3 ± 2.8	99.7 ± 0.4	0.012
PTV_LN	$V_{50.4/45Gy}$ (%)	93.3 ± 3.4	96.4 ± 1.7	0.067
Bladder	V_{63Gy} (%)	8.9 ± 4.0	9.2 ± 3.7	0.274
Rectum	V_{63Gy} (%)	11.8 ± 2.7	9.1 ± 1.9	0.016
Rectum	V_{45Gy} (%)	39.2 ± 8.6	25.2 ± 3.3	0.005
Penile bulb	D_{mean} (Gy)	38.2 ± 15.8	25.6 ± 13.6	0.001
HI		1.06 ± 0.01	1.08 ± 0.01	0.006
CI		1.00 ± 0.03	1.00 ± 0.02	0.888

How it works

- Mimics the plannersô thought process
- Utilizes the plannersô tricks, such as creation of surrounding structures, tuning contours automatically
- Automatically runs multiple loops while adjusting planning objectives ï similar to what planners manually do

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No More Negotiation With Optimizer

- IMRT planning was a process of negotiating with the optimizer.
  - Adding tuning structures, cold spots, and hot spots.
- Auto-Planning allows us to simply state the dosimetric planning goals
- Auto-Planning automatically creates planning objectives and tuning structures that are required.

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A Complex HN case

- 40 structures (include two tumor volumes) were contoured.
- 28 dose evaluation goals were input into auto-planning.
- 26 additional tuning structures were automatically created.
- 74 optimization objectives were automatically set for optimization.

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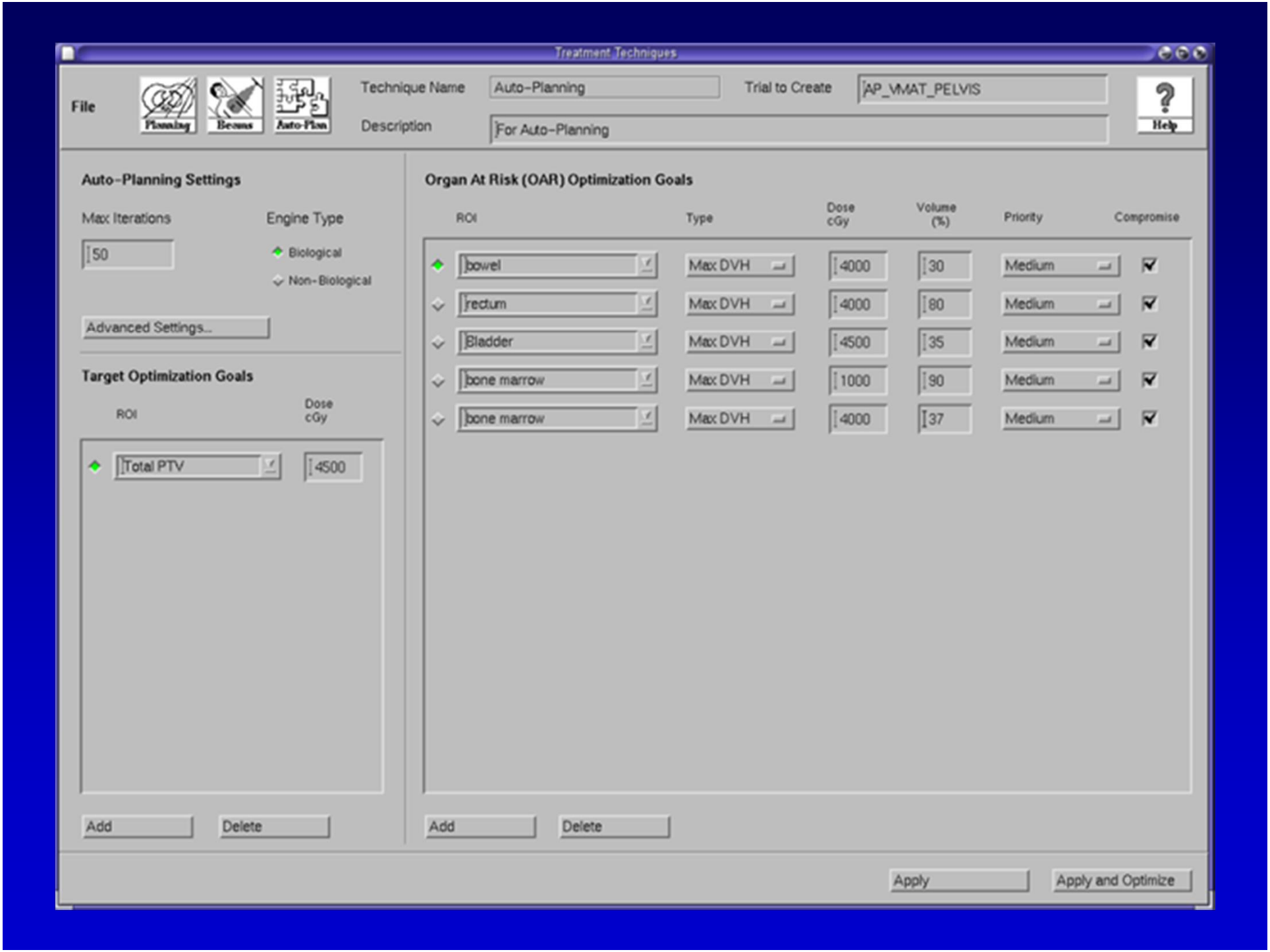
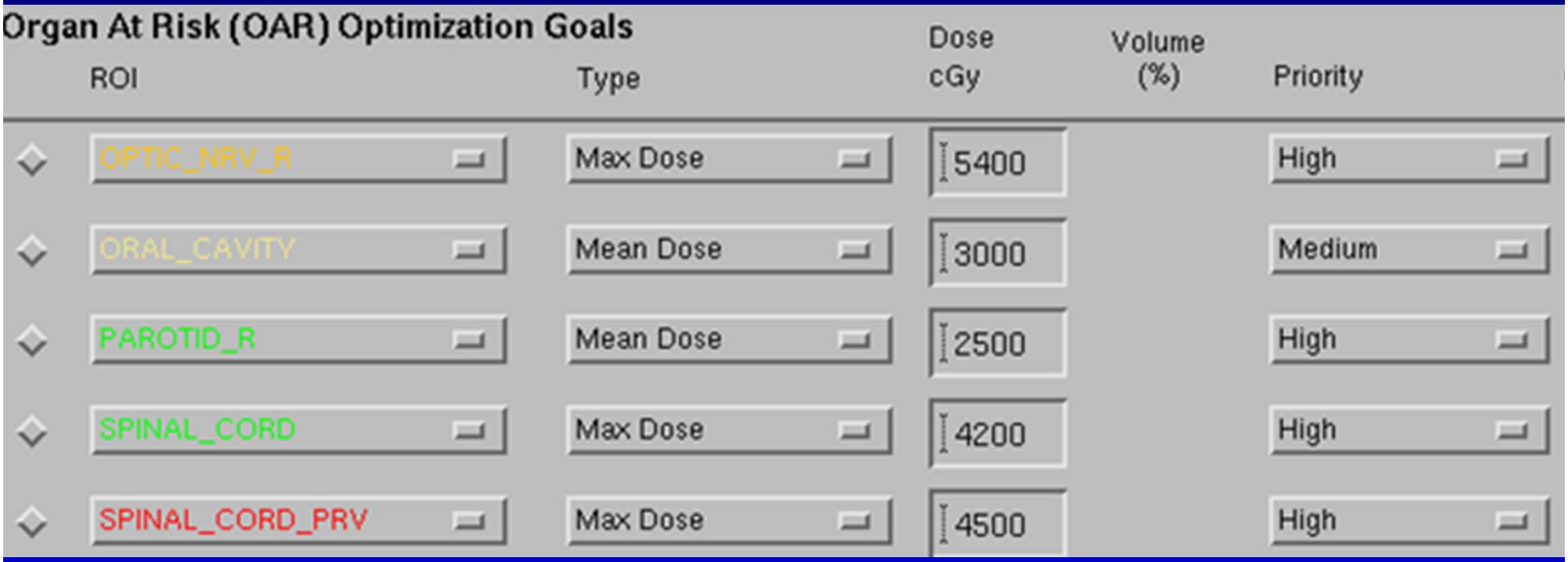

Treatment Techniques
File
Planning
Beams
Auto-Plan
Technique Name
Auto-Planning
Trial to Create
AP_VMAT_PELVIS
Description
For Auto-Planning
Help
Auto-Planning Settings
Max Iterations
50
Engine Type
Biological
Non-Biological
Advanced Settings...
Target Optimization Goals
ROI
Dose cGy
Total PTV
4500
Add
Delete
Organ At Risk (OAR) Optimization Goals
ROI
Type
Dose cGy
Volume (%)
Priority
Compromise
bowel
Max DVH
4000
30
Medium
rectum
Max DVH
4000
80
Medium
Bladder
Max DVH
4500
35
Medium
bone marrow
Max DVH
1000
90
Medium
bone marrow
Max DVH
4000
37
Medium
Add
Delete
Apply
Apply and Optimize

An Example of Planning Goals for OARs



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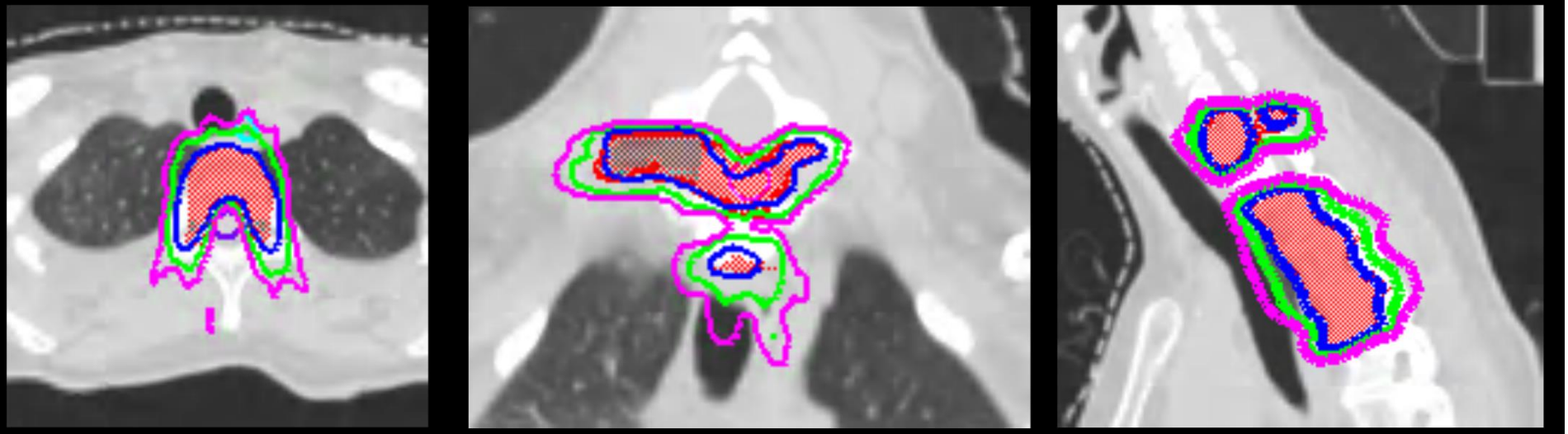
AP Spine SBRT



16 Gy,12 Gy,10 Gy

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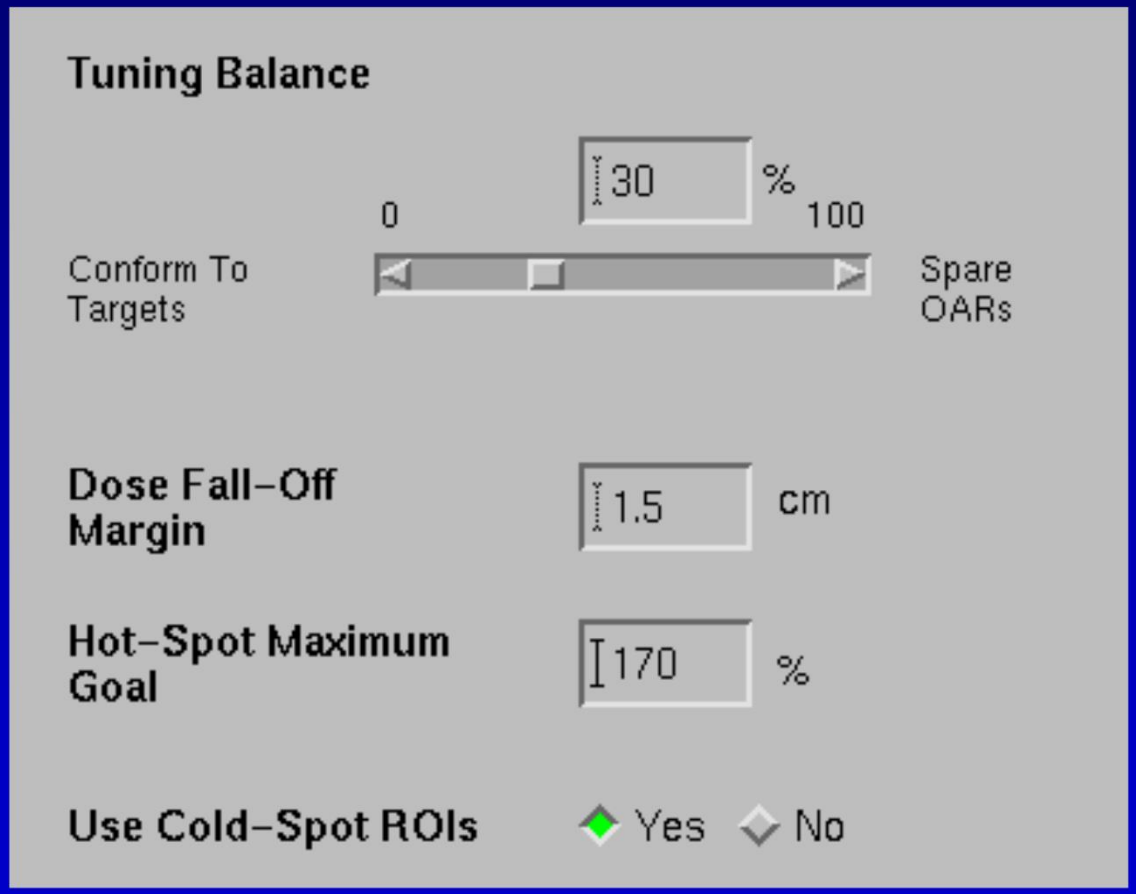
Advance Tool Setting



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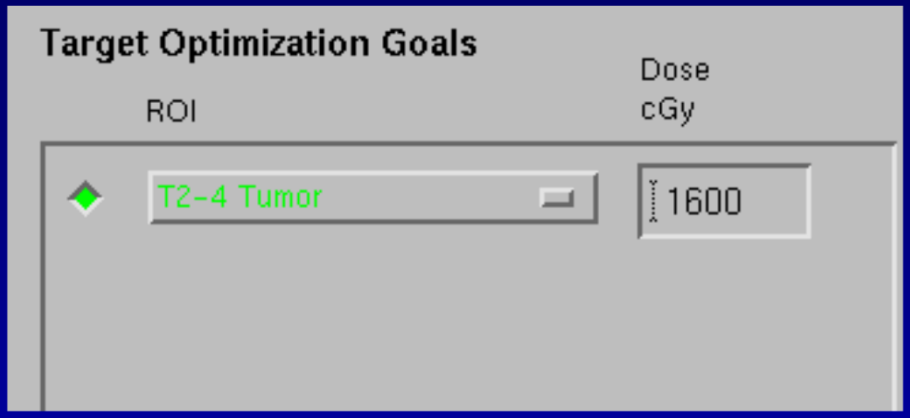
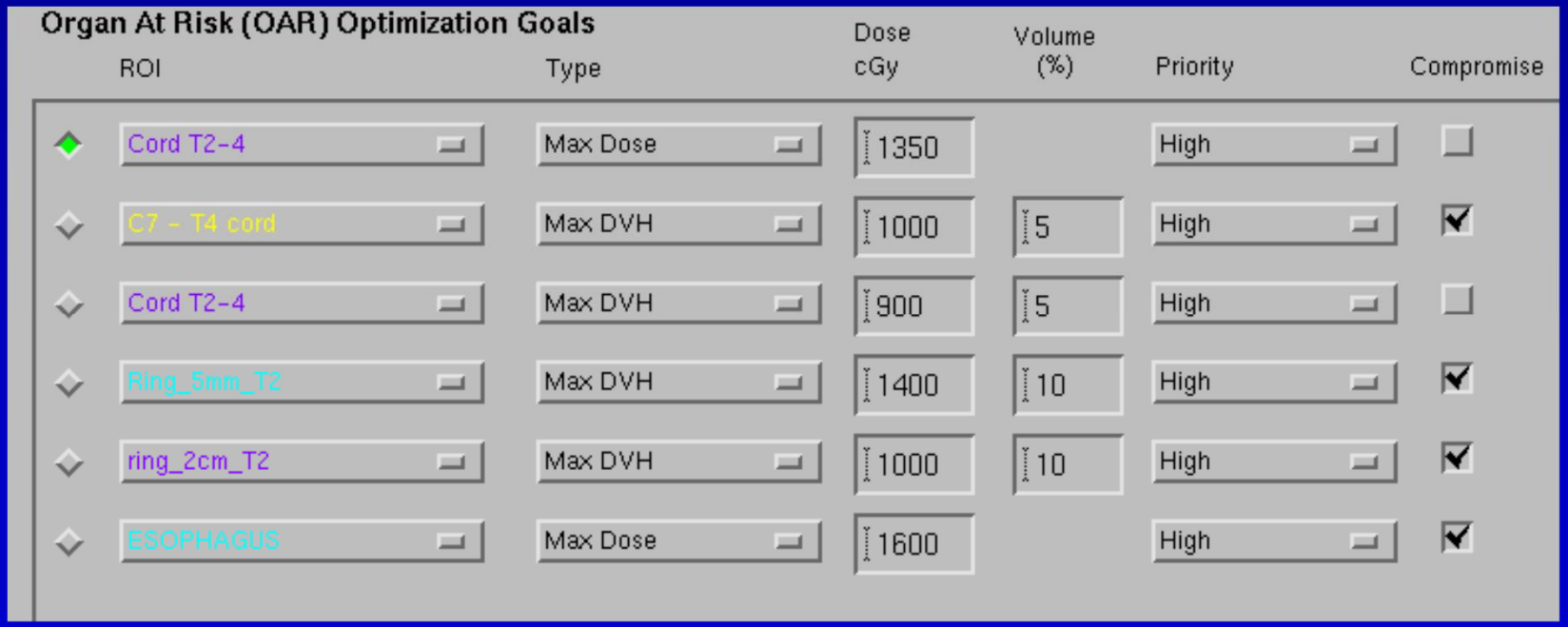
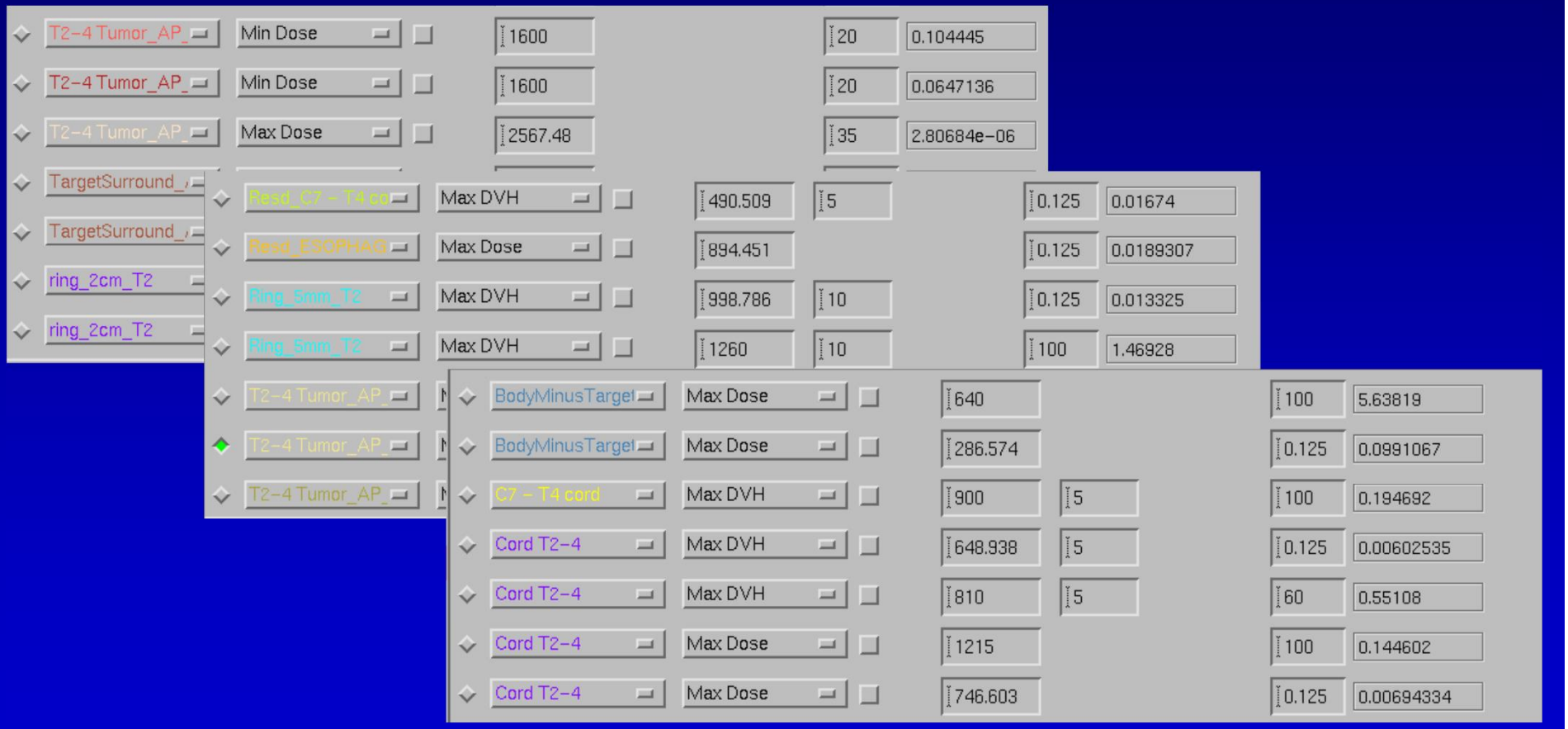
Input Planning Goals





Automatic Created Planning Objectives



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Lung SBRT

- Re-planned 20 SBRT lung cases, 10 for peripheral tumors and 10 for central tumors.
- Ask physicians to rank quality of AP vs. Clinical plans.
- 15% AP plans are better, 80% AP plans are comparable, and 5% AP plans are worse than clinically approved plans.

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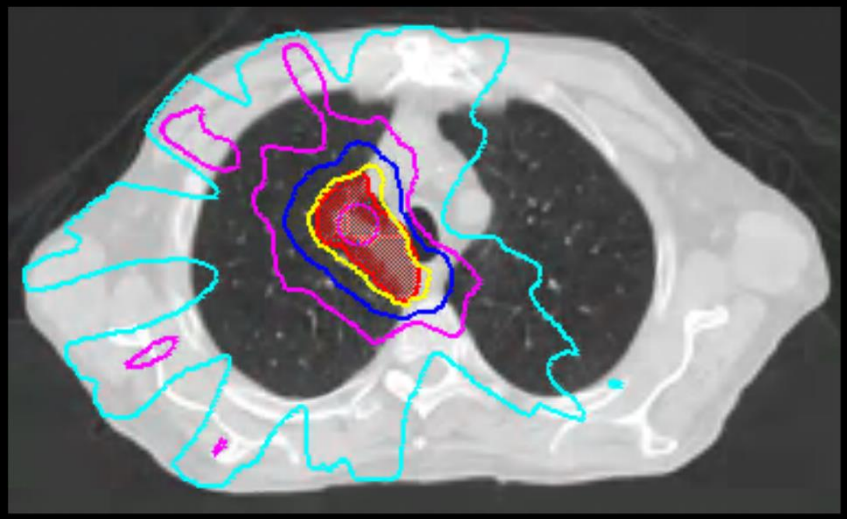
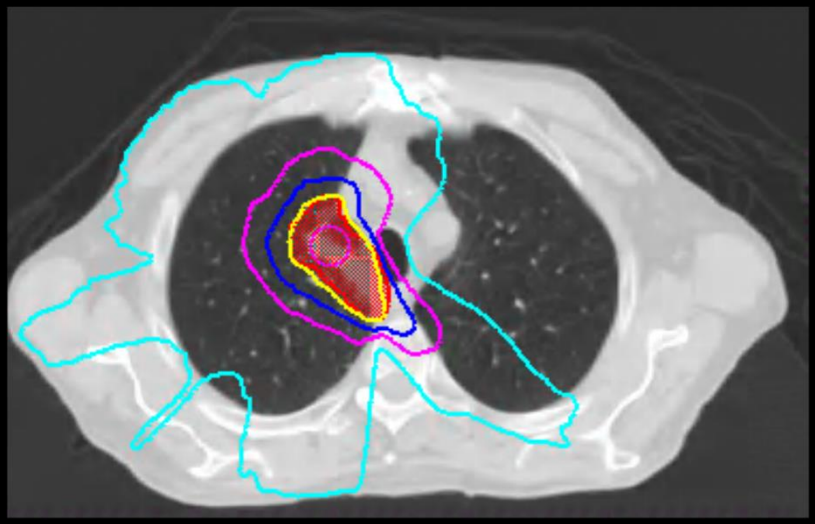
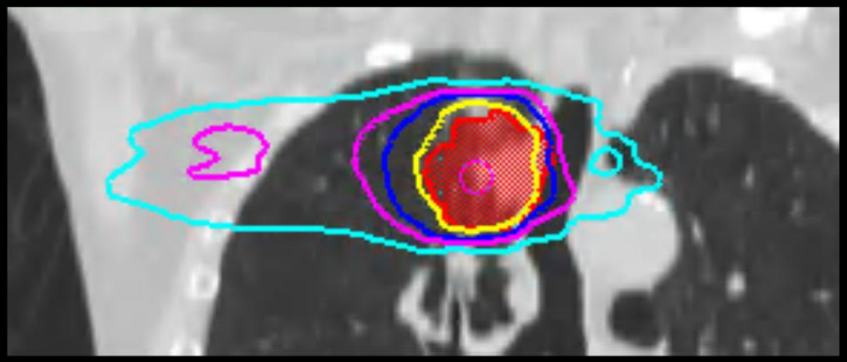
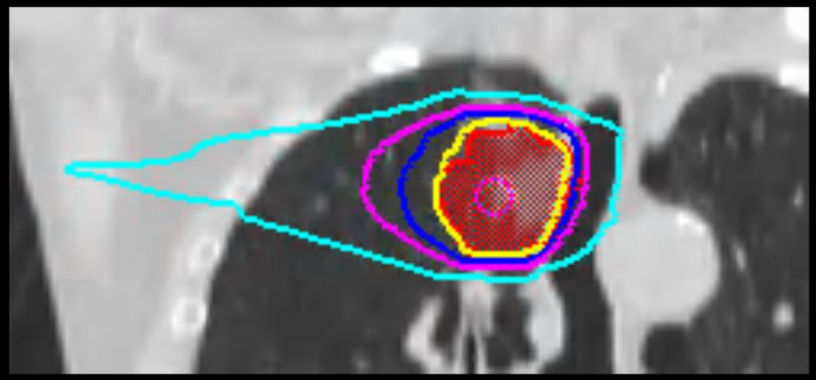
Manual Plan

AP Plan









50 35 25 10 Gy

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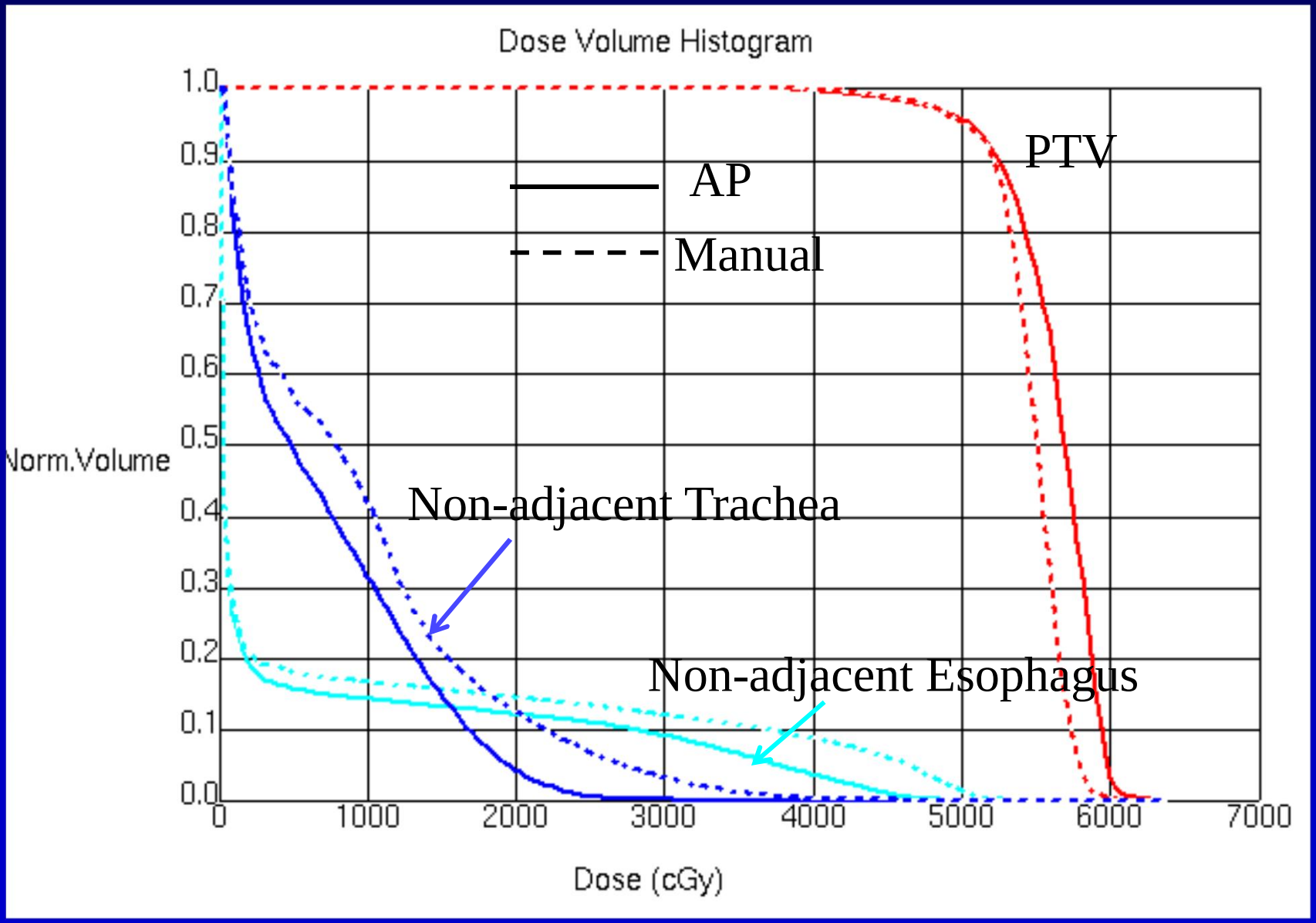
Central Lung SBRT



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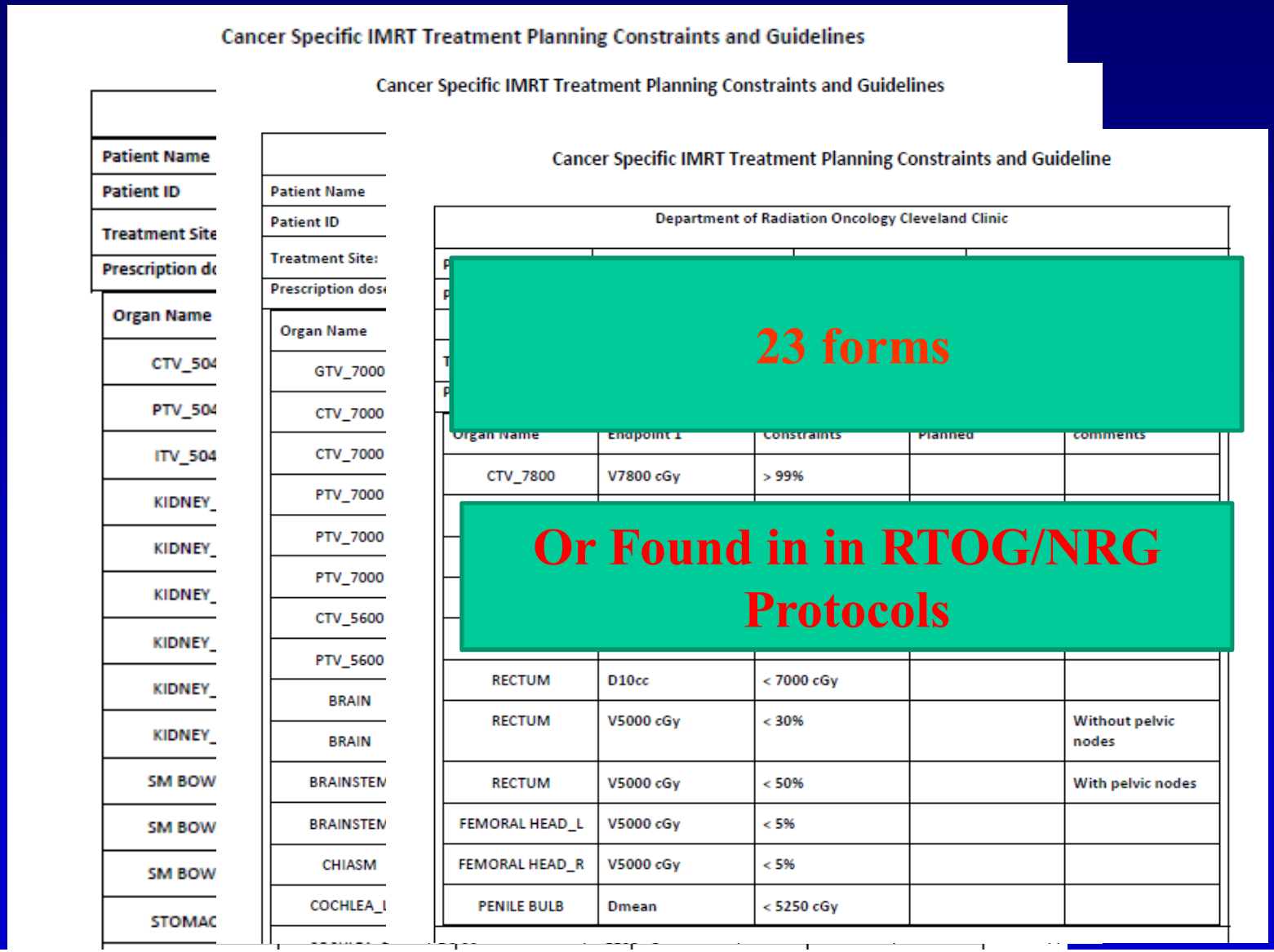
Do We Know What We Want to Achieve in IMRT Planning?

CCF Cancer Specific Treatment Planning Guidelines and Dose Constraints



Cancer Specific IMRT Treatment Planning Constraints and Guidelines

Cancer Specific IMRT Treatment Planning Constraints and Guidelines

Patient Name
Patient ID
Treatment Site
Prescription dc
Organ Name
CTV_504
PTV_504
ITV_504
KIDNEY_
KIDNEY_
KIDNEY_
KIDNEY_
KIDNEY_
KIDNEY_
SM BOW
SM BOW
SM BOW
STOMAC

Patient Name
Patient ID
Treatment Site:
Prescription dos
Organ Name
GTV_7000
CTV_7000
CTV_7000
PTV_7000
PTV_7000
PTV_7000
CTV_5600
PTV_5600
BRAIN
BRAIN
BRAINSTEM
BRAINSTEM
CHIASM
COCHLEA_I

Cancer Specific IMRT Treatment Planning Constraints and Guideline

Department of Radiation Oncology Cleveland Clinic

Organ Name	Endpoint 1	Constraints	Planned	comments
CTV_7800	V7800 cGy	> 99%		
RECTUM	D10cc	< 7000 cGy		
RECTUM	V5000 cGy	< 30%		Without pelvic nodes
RECTUM	V5000 cGy	< 50%		With pelvic nodes
FEMORAL HEAD_L	V5000 cGy	< 5%		
FEMORAL HEAD_R	V5000 cGy	< 5%		
PENILE BULB	Dmean	< 5250 cGy		

23 forms

Or Found in in RTOG/NRG Protocols

Pinnacle plan
DVH information

CCF Pinnacle Plan Evaluation

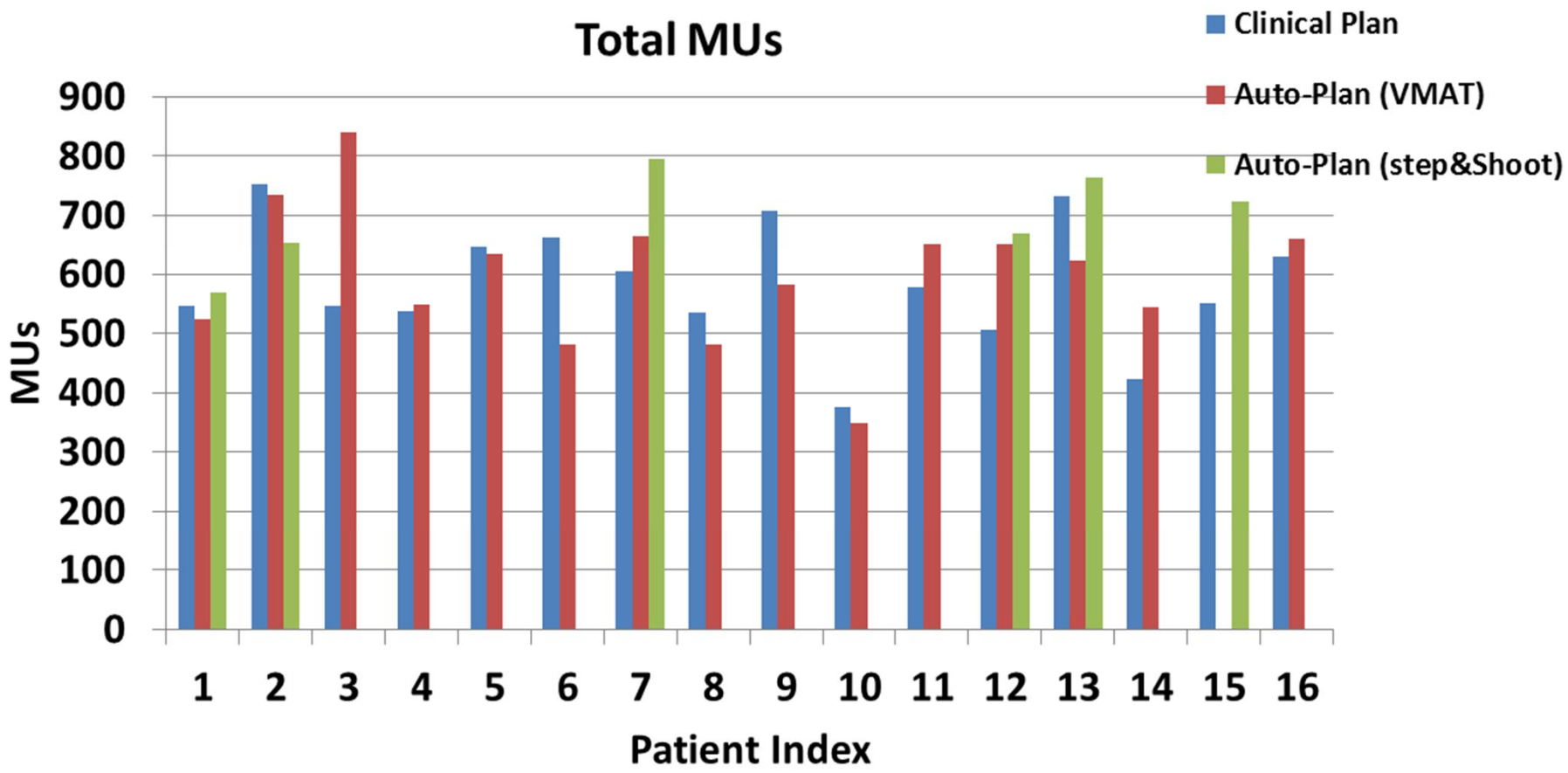
ROI	EndPoint (cGy/Vol)	Constraint (cGy/Vol)	Plan (cGy/Vol)
PTV_6400	V6400	>95%	95.6%
CTV_6400	V6400	>98%	98.0%
PTV_6000	V6000	>95%	98.7%
CTV_6000	V6000	>98%	99.9%
PTV_5400	V5400	>95%	95.6%
CTV_5400	V5400	>98%	99.2%
BRAIN	D0.03CC	<6400	6649.8
BRAIN	V6000	<33%	0.1%
BRAINSTEM	D0.03CC	<5400	2631.5
BRAINSTEM	V3000	<50%	0.0%
COCHLEA_L	D0.03CC	<5500	1292.6
COCHLEA_R	D0.03CC	<5500	4078.8
ESOPHAGUS	DMEAN	<5000	2082.7
GLOBE_L	D0.03CC	<4500	1185.0
GLOBE_R	D0.03CC	<4500	2448.0
LARYNX	DMEAN	<3500	3417.0
LENS_L	D0.03CC	<1000	625.0
LENS_R	D0.03CC	<1000	690.6
LIPS	DMEAN	<3500	5129.9
MANDIBLE	D0.03CC	<7500	6808.0
MANDIBLE	V7000	<1%	0.0%
ORAL_CAVITY_PTV	D0.03CC	<6000	6811.3
ORAL_CAVITY_PTV	DMEAN	<3500	4354.0
PAROTID_L_PTV	V3000	<50%	22.4%
PAROTID_L_PTV	DMEAN	<2600	1936.1
PAROTID_R_PTV	V3000	<50%	33.6%
PAROTID_R_PTV	DMEAN	<2600	2652.1
SPINAL_CORD	D0.03CC	<4500	4148.1

Quantitative Plan Evaluation - Score Cards

ROI	Type	Dose cGy	Volume		Dose cGy	Volume		Dose cGy		Volume at Primary Goal Dose		Result
GTV_7200	Min DVH (%)	7200	99	%	0	0	%	7260.9	Min	99.998	%	Met
CTV_7200	Min DVH (%)	7200	98	%	0	0	%	7234.6	Min	99.998	%	Met
CTV_7200	Min DVH (%)	6700	99	%	0	0	%	7234.6	Min	99.998	%	Met
PTV_7200	Max DVH (cm^3)	8200	0.03	cm^3	0	0	cm^3	7745.0	Max	0.000	cm^3	Met
PTV_7200	Min DVH (%)	7200	95	%	0	0	%	3944.2	Min	95.545	%	Met
PTV_7200	Min DVH (%)	6700	98	%	0	0	%	3944.2	Min	99.895	%	Met
CTV_5800	Min DVH (%)	5800	99	%	0	0	%	5888.7	Min	99.998	%	Met
PTV_5800	Min DVH (%)	5800	95	%	0	0	%	1298.7	Min	98.819	%	Met
BRAIN	Max DVH (cm^3)	7000	0.03	cm^3	0	0	cm^3	2606.0	Max	0.000	cm^3	Met
BRAIN	Max DVH (%)	6000	33	%	0	0	%	2606.0	Max	0.000	%	Met
BRAINSTEM	Max DVH (cm^3)	5400	0.03	cm^3	0	0	cm^3	1680.7	Max	0.000	cm^3	Met
BRAINSTEM	Max DVH (%)	3000	50	%	0	0	%	1680.7	Max	0.000	%	Met
CHIASM	Max DVH (cm^3)	5400	0.03	cm^3	0	0	cm^3	90.9	Max	0.000	cm^3	Met
COCHLEA_L	Max DVH (cm^3)	5500	0.03	cm^3	0	0	cm^3	349.7	Max	0.000	cm^3	Met
COCHLEA_R	Max DVH (cm^3)	5500	0.03	cm^3	0	0	cm^3	391.3	Max	0.000	cm^3	Met
CONSTRICTORS	Mean Dose	5000			0			5507.2	Mean			Not Met
ESOPHAGUS	Mean Dose	5000			0			2395.9	Mean			Met
GLOBE_L	Max DVH (cm^3)	4500	0.03	cm^3	0	0	cm^3	248.3	Max	0.000	cm^3	Met
GLOBE_R	Max DVH (cm^3)	4500	0.03	cm^3	0	0	cm^3	237.8	Max	0.000	cm^3	Met
LARYNX	Mean Dose	3500			0			2836.3	Mean			Met
LENS_L	Max DVH (cm^3)	1000	0.03	cm^3	0	0	cm^3	126.0	Max	0.000	cm^3	Met
LENS_R	Max DVH (cm^3)	1000	0.03	cm^3	0	0	cm^3	125.2	Max	0.000	cm^3	Met
MANDIBLE	Max DVH (cm^3)	7500	0.03	cm^3	0	0	cm^3	7434.2	Max	0.000	cm^3	Met

Result
Not Met
Met
Met
Met
Not Met
Met
Met
Met
Met
Met
Met
Met
Met
Met
Not Met
Met
Met
Met
Not Met
Met
Met
Met

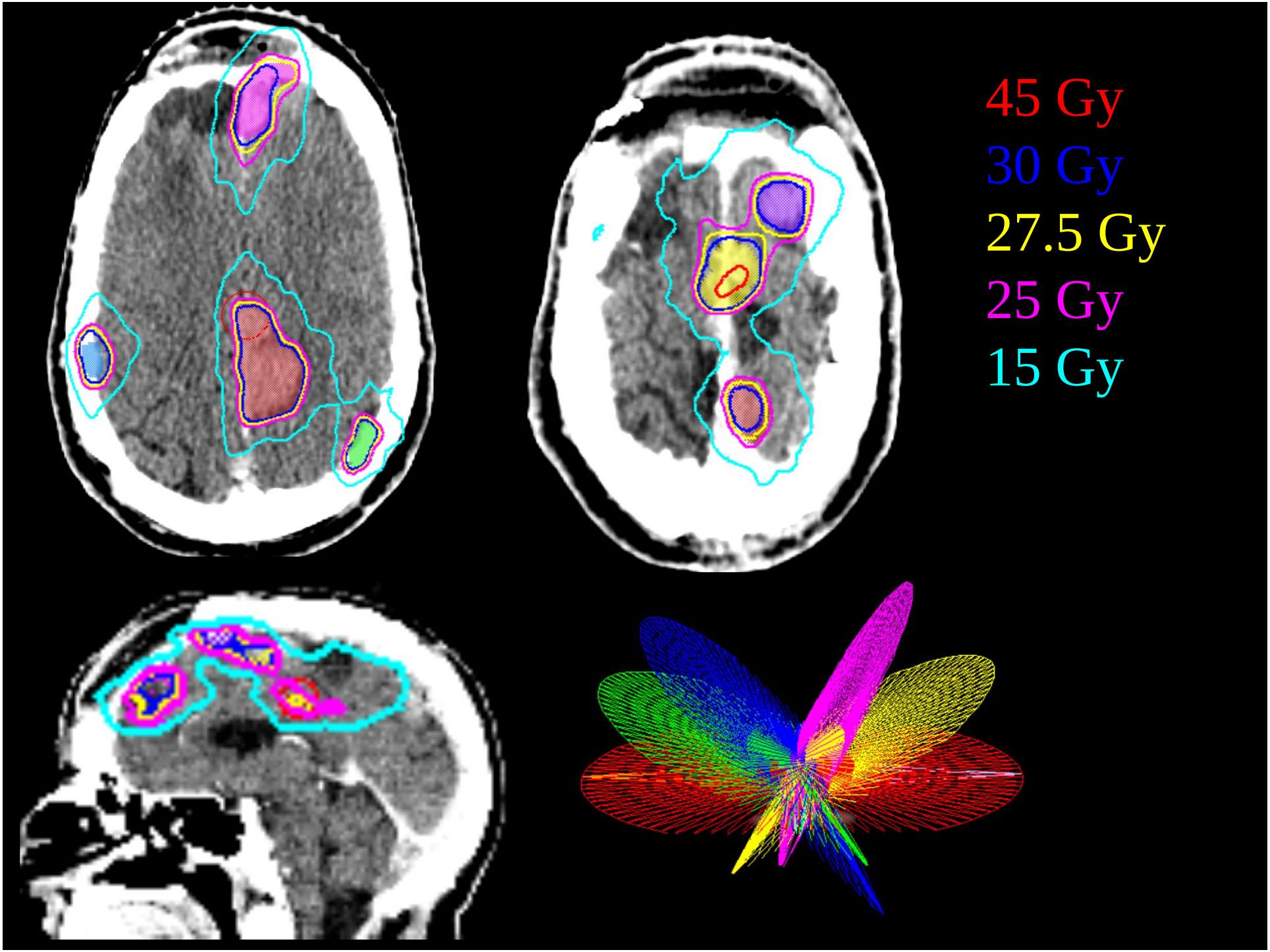
How Are Total MUs Affected



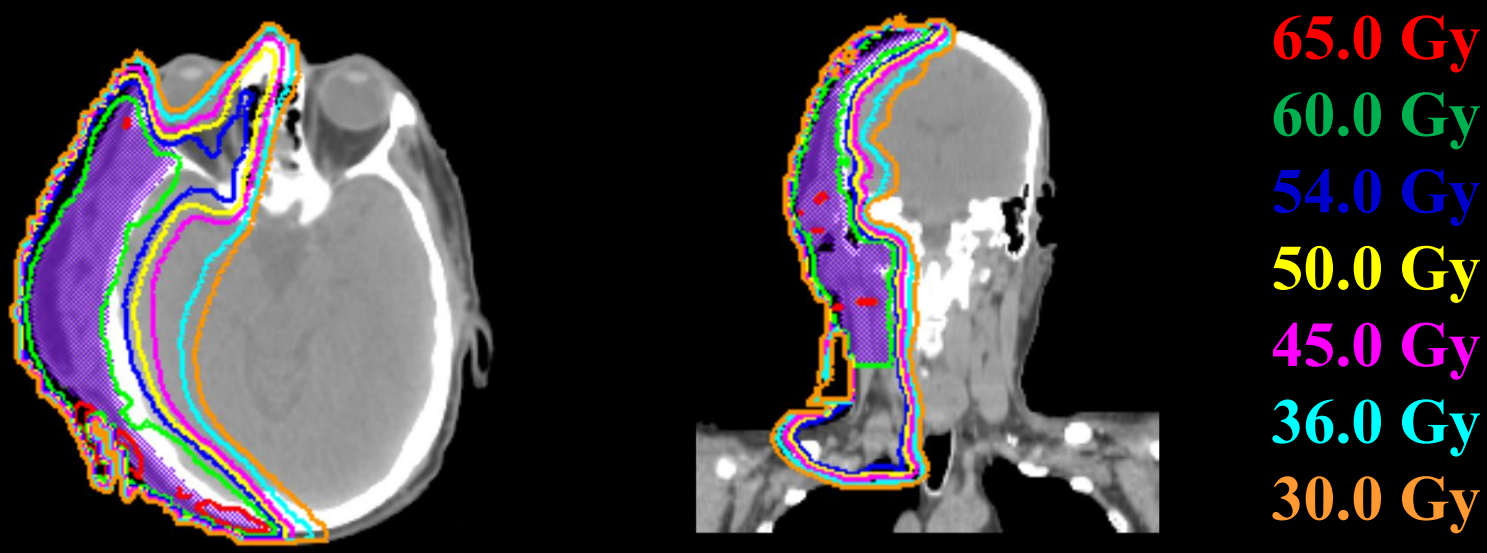
AP for Multiple Brain Mets

- A patient with multiple brain mets (6 mets)
- Using a single iso-center and five non-coplanar arcs.
- Three RXs concurrently: 30 Gy, 27.5 Gy, and 25 Gy in five fraction.

Cleveland Clinic


45 Gy
30 Gy
27.5 Gy
25 Gy
15 Gy

Apply AP to An Unusual Case



- Use two iso-centers and VMAT beams to produce the feathering regions.
- With AP, dosimetrists can produced this complicated plan with two runs of AP optimizations.

Magic Button: Cure without Complications

- Auto-Planning is a promising tool.
- Auto-Planning will improve plan quality and reduce planning time
- Leverages dosimetrists human power, relying on the computer for grunt work
- Auto-Planning will demand more computational power, not human power.

What types of treatment plans can be created using the auto-planning in the Pinnacle?

20%	1. Electron plans only
20%	2. 3D conformal plans only
20%	3. Step and shoot IMRT plans only
20%	4. VMAT IMRT plans only
20%	5. Step-shoot and VMAT IMRT plans

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What is the advantage of auto-planning?

20% a. To improve work efficiency

20% b. To keep consistency in planning process

20% c. To replace dosimtrists entirely

20% d. To improve plan quality, efficiency, and consistency.

20% e. To learn from previous planning techniques

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SAM Question 3

Which answer below includes most features of the auto-planning process

-

(a)To create models based on previous plans.

(b)To create multiple tuning structures automatically .

(c) To create optimization objectives automatically

(d)To run optimization multiple times

(e) (b, (c), and (d)

Which answer below includes most features of the auto-planning process

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SAM Question 4

Which statement below summaries common features of knowledge-based planning and auto-planning?

(a) Only knowledge-based planning propagates knowledge from expertsô planning

(b) There is no common feature between the two methods.

(c) Only knowledge-based planning requires building a new model.

(d)Auto-planning is the same as the conventional IMRT planning.

(e) Both methods can improve plan quality, consistency, and efficiency.

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0% e. Both methods can improve plan quality, consistency, and efficiency.

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Clinical Implementation of Auto-Planning

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