Monaco计划系统在乳腺癌治疗中的应用

鞍山市肿瘤医院

王璐

2018ProKnow AAMD Breast 5 Targets

计划要求

24 Key Metrics Total Points 150

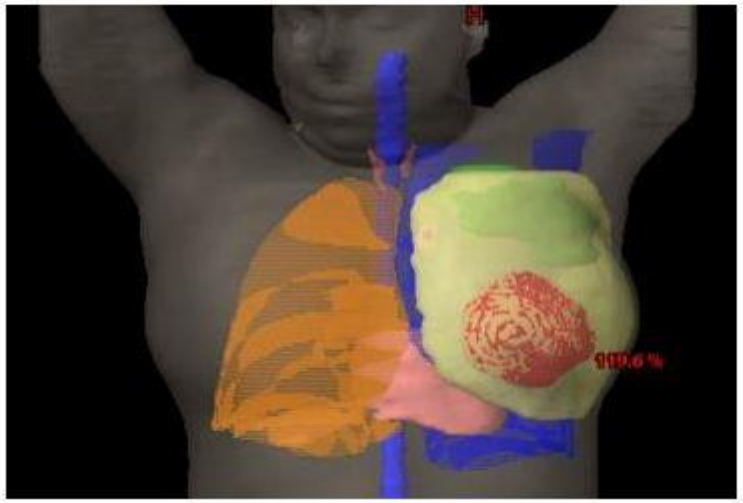
ProKnow

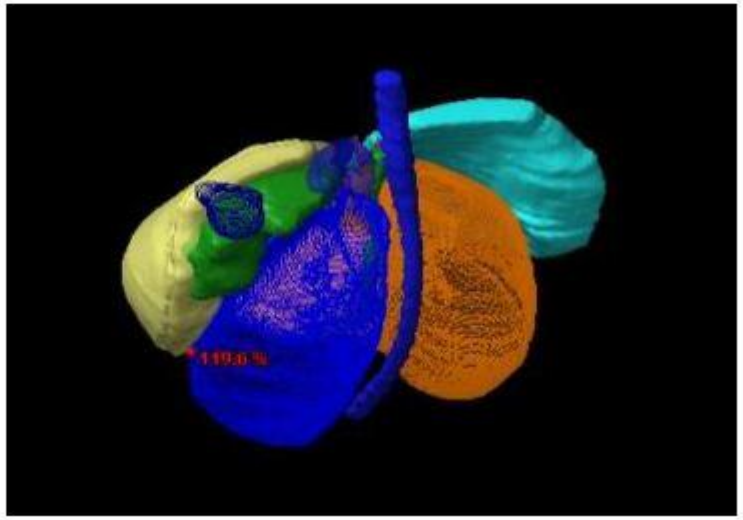
Scoring powered by PlanIQ™
Sun Nuclear Corporation

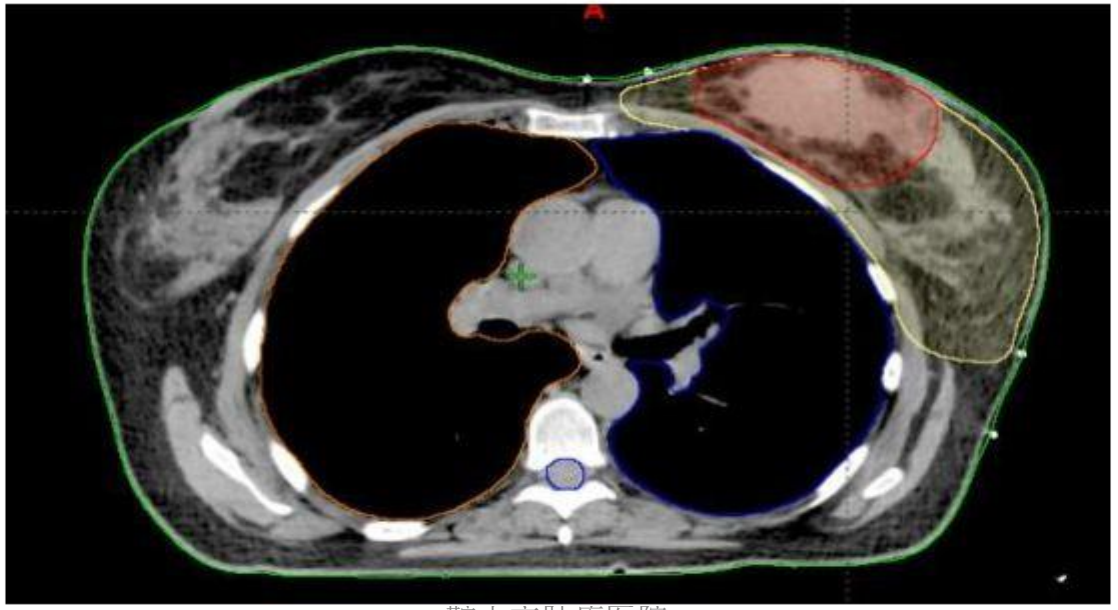
50 Gy (25 x 2 Gy) to the target volumes detailed in the plan metrics.

#	METRIC ID (28 Total Metrics)	MIN REQ	IDEAL	WEIGHT (150)
[01]	Volume (%) of the BREAST_PTV_EVAL covered by 47.5 (Gy)	90	97	20 points
[02]	Dose (Gy) covering 50 (%) of the BREAST_PTV_EVAL	54	52	3 points
[03]	Dose (Gy) covering 0.03 (cc) of the BREAST_PTV_EVAL	57	56	2.5 points
[04]	Volume (%) of the LUMPEC_PTV_EVAL covered by 47.5 (Gy)	95	99	20 points
[05]	Dose (Gy) covering 50 (%) of the LUMPEC_PTV_EVAL	54	52	3 points
[06]	Dose (Gy) covering 0.03 (cc) of the LUMPEC_PTV_EVAL	57	56	2.5 points
[07]	Structure(s) containing the global max dose point	BREAST_PTV_EVAL	LUMPEC_PTV_EVAL	3 points
[08]	Volume (%) of the SUPRACLAV_PTV covered by 47.5 (Gy)	90	97	15 points
[09]	Dose (Gy) covering 0.03 (cc) of the SUPRACLAV_PTV	55	53.5	2.5 points
[10]	Volume (%) of the AXILLARY_PTV covered by 47.5 (Gy)	90	97	15 points
[11]	Dose (Gy) covering 0.03 (cc) of the AXILLARY_PTV	55	53.5	2.5 points
[12]	Volume (%) of the IMN_PTV covered by 47.5 (Gy)	90	97	15 points
[13]	Dose (Gy) covering 0.03 (cc) of the IMN_PTV	55	53.5	2 points
[14]	Dose (Gy) covering 5 (%) of the BREAST_CONTRA	3	2	5 points
[15]	Dose (Gy) covering 0.03 (cc) of the BREAST_CONTRA	7	5	3 points
[16]	Dose (Gy) covering 5 (%) of the HEART	20	5	2 points
[17]	Dose (Gy) covering 30 (%) of the HEART	10	5	5 points
[18]	Mean dose (Gy) to the HEART	3	2	5 points
[19]	Volume (%) of the LUNG_IPSI covered by 20 (Gy)	37	20	5 points
[20]	Volume (%) of the LUNG_IPSI covered by 10 (Gy)	55	30	5 points

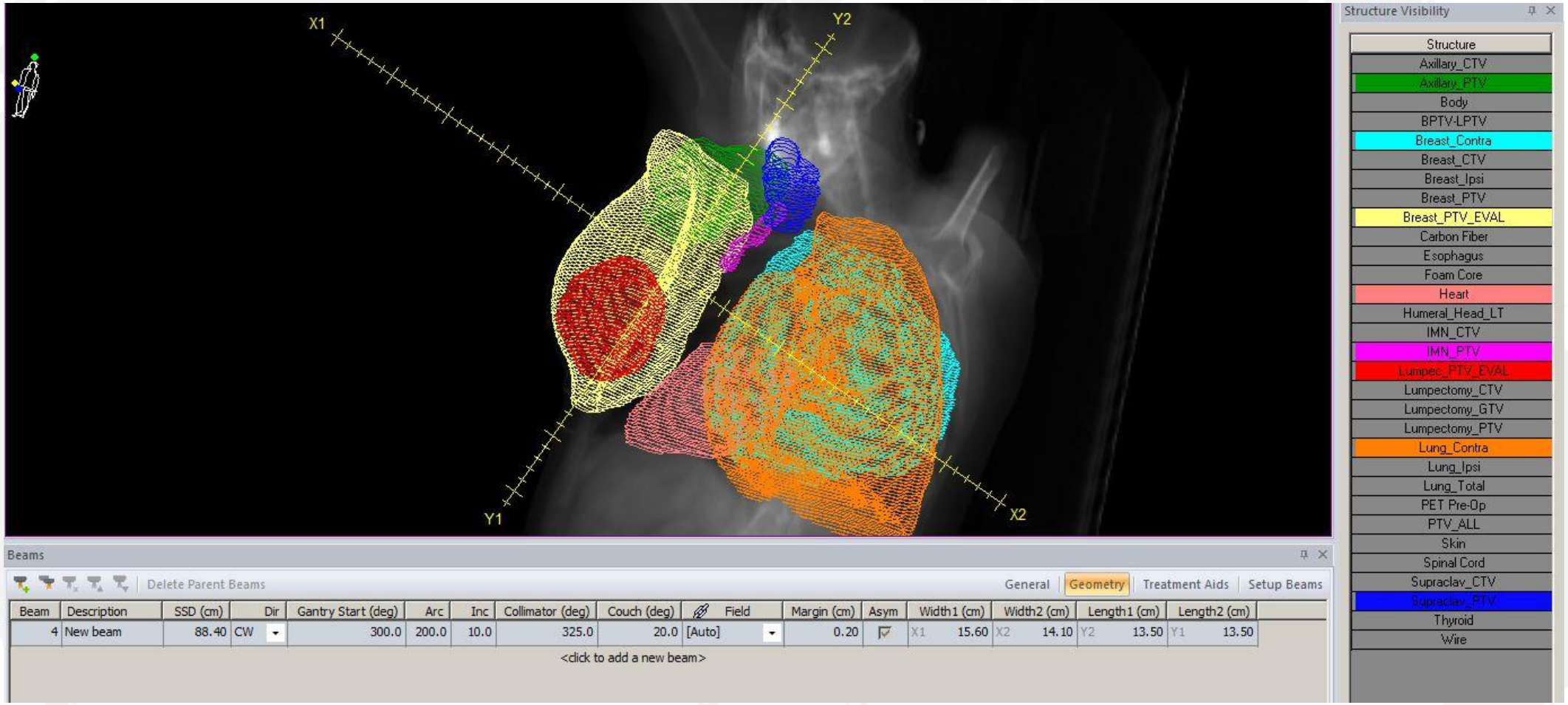
靶区及主要OAR的空间分布



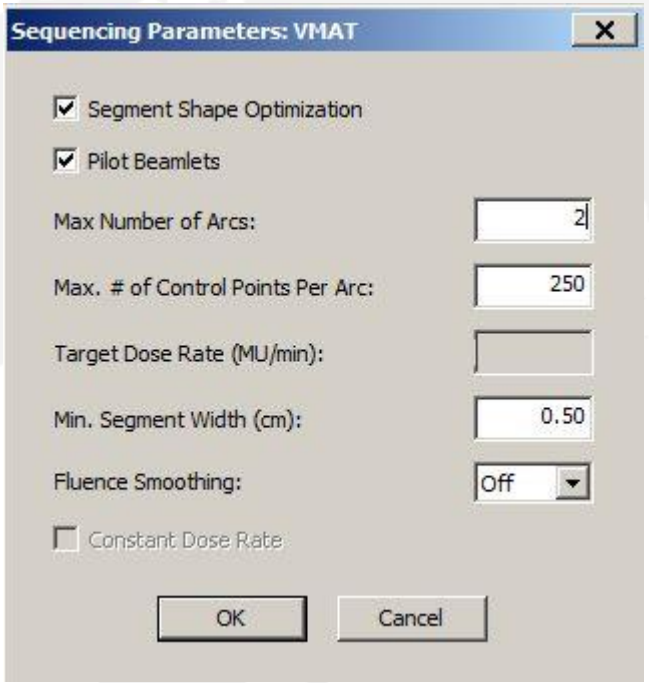


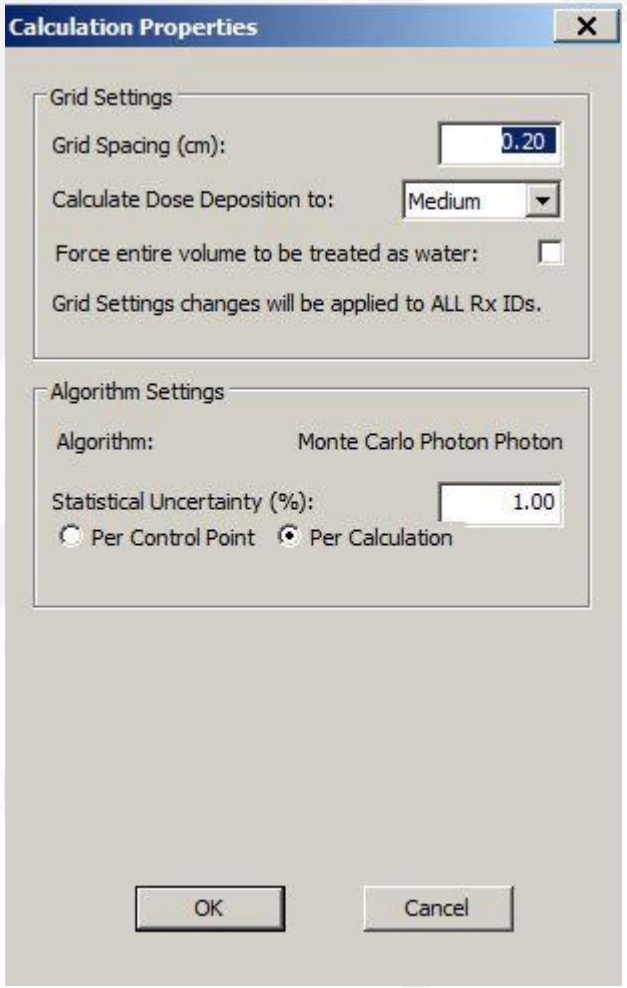


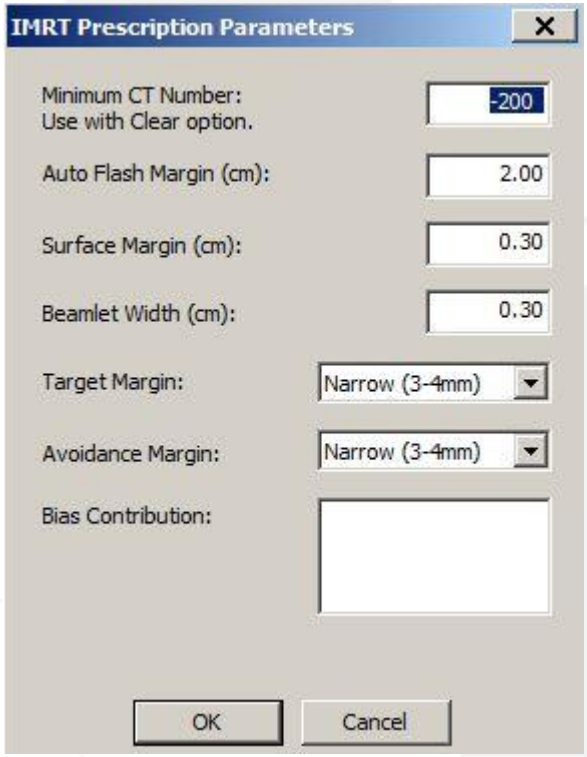
射野角度及床角的选择


X1
Y2
Y1
X2
Structure Visibility
Structure
Axillary_CTV
Axillary_PTV
Body
BPTV-LPTV
Breast_Contra
Breast_CTV
Breast_Ipsi
Breast_PTV
Breast_PTV_EVAL
Carbon Fiber
Esophagus
Foam Core
Heart
Humeral_Head_LT
IMN_CTV
IMN_PTV
Lumpec_PTV_EVAL
Lumpectomy_CTV
Lumpectomy_GTV
Lumpectomy_PTV
Lung_Contra
Lung_Ipsi
Lung_Total
PET Pre-Op
PTV_ALL
Skin
Spinal Cord
Supraclav_CTV
Supraclav_PTV
Thyroid
Wire
Beams
Delete Parent Beams
General
Geometry
Treatment Aids
Setup Beams
Beam
Description
SSD (cm)
Dir
Gantry Start (deg)
Arc
Inc
Collimator (deg)
Couch (deg)
Field
Margin (cm)
Asym
Width1 (cm)
Width2 (cm)
Length1 (cm)
Length2 (cm)
4
New beam
88.40
CW
300.0
200.0
10.0
325.0
20.0
[Auto]
0.20
X1 15.60
X2 14.10
Y2 13.50
Y1 13.50
<click to add a new beam>

计划参数设计


Sequencing Parameters: VMAT
Segment Shape Optimization
Pilot Beamlets
Max Number of Arcs:
2
Max. # of Control Points Per Arc:
250
Target Dose Rate (MU/min):
Min. Segment Width (cm):
0.50
Fluence Smoothing:
Off
Constant Dose Rate
OK
Cancel


Calculation Properties
Grid Settings
Grid Spacing (cm):
0.20
Calculate Dose Deposition to:
Medium
Force entire volume to be treated as water:
Grid Settings changes will be applied to ALL Rx IDs.
Algorithm Settings
Algorithm:
Monte Carlo Photon Photon
Statistical Uncertainty (%):
1.00
Per Control Point
Per Calculation
OK
Cancel


IMRT Prescription Parameters
Minimum CT Number:
Use with Clear option.
-200
Auto Flash Margin (cm):
2.00
Surface Margin (cm):
0.30
Beamlet Width (cm):
0.30
Target Margin:
Narrow (3-4mm)
Avoidance Margin:
Narrow (3-4mm)
Bias Contribution:
OK
Cancel

一个关键词，一个函数，一个答疑

Fluence Smoothing

只作用于通量结果
对于通量结果的理想预期
预期越高对于二阶优化影响越大
高的预期会降低Segment数量

Target EUD

它是一个线性控制函数
表现于对于靶区内冷点的罚分增益
靶区作用效果/靶区作用效果+靶区约束效果

Margin

Beam Target Oar Surface 散射控制
Autoflash 散射补偿
Function 划分控制区域

计划函数设计

IMRT Constraints

Pareto | Constrained | IMRT Parameters | Constraints | Sensitivities

Structure	Cost Function	Enabled	Status	Manual	Weight	Reference Dose (cGy)	Multicriterial	Isoconstraint	Isoeffect	Relative Impact
Supraclav_PTV	Target Penalty	☑	On	☑	60.00			5100.0	4904.4	
	Maximum Dose	☑	On	☐	2319.03			5248.0	5239.8	++++
Axillary_PTV	Target Penalty	☑	On	☑	75.00			5100.0	5014.9	
	Maximum Dose	☑	On	☐	1494.05			5300.0	5304.6	++++
	Underdose DVH	☑	On	☑	75.00	4810.0		98.00	99.65	+++
	Target EUD	☑	On	☐	1.00			5000.0	5111.5	
	Target EUD	☑	On	☐	1.00			5000.0	5111.5	
Lung_Ipsi	Serial	☑	On	☐	0.01		☐	700.0	514.4	
	Overdose DVH	☑	On	☐	797.59	2000.0	☐	18.00	16.31	++++
	Overdose DVH	☑	On	☐	4549.52	1000.0	☐	27.00	26.63	++++
	Overdose DVH	☑	On	☐	445.88	500.0	☐	45.00	39.02	++++
	Serial	☑	On	☐	0.01		☐	370.0	258.1	
	Serial	☑	On	☐	1079.54		☐	1560.0	1520.3	++++
	Maximum Dose	☑	On	☐	0.01			5505.0	5395.2	
Breast_Contra	Serial	☑	On	☐	1.47		☐	285.0	280.1	++
	Overdose DVH	☑	On	☐	86.42	200.0	☐	4.00	3.16	+++
	Maximum Dose	☑	On	☐	5.50			520.0	535.0	++
	Parallel	☑	On	☐	4735.73	200.0	☐	6.50	6.07	++++
	Maximum Dose	☑	On	☐	5.50			520.0	535.0	++
	Parallel	☑	On	☐	4735.73	200.0	☐	6.50	6.07	++++
Lung_Ipsi	Serial	☑	On	☐	0.01		☐	700.0	514.4	
	Overdose DVH	☑	On	☐	797.59	2000.0	☐	18.00	16.31	++++
	Overdose DVH	☑	On	☐	4549.52	1000.0	☐	27.00	26.63	++++
	Overdose DVH	☑	On	☐	445.88	500.0	☐	45.00	39.02	++++
	Serial	☑	On	☐	0.01		☐	370.0	258.1	
	Serial	☑	On	☐	1079.54		☐	1560.0	1520.3	++++
Lung_Contra	Overdose DVH	☑	On	☐	3812.03	500.0	☐	4.40	4.20	++++
	Parallel	☑	On	☐	86.54	500.0	☐	7.50	6.51	+++
Heart	Overdose DVH	☑	On	☐	0.01	500.0	☐	5.00	2.72	
	Serial	☑	On	☐	2295.49		☐	199.0	199.3	++++
	Overdose DVH	☑	On	☐	0.05	200.0	☐	37.00	24.89	+
Humeral_Head_LT	Serial	☑	On	☐	90.59		☐	1000.0	980.9	+++
Thyroid	Serial	☑	On	☐	784.04		☐	2150.0	2098.3	++++
	Serial	☑	On	☐	0.01		☐	3600.0	3489.1	
	Parallel	☑	On	☐	7193.01	2000.0	☐	37.50	36.45	++++
Body	Conformality	☑	On	☐	1.60		☐	0.50	0.40	++
	Maximum Dose	☑	On	☐	4.27			5500.0	5444.4	++

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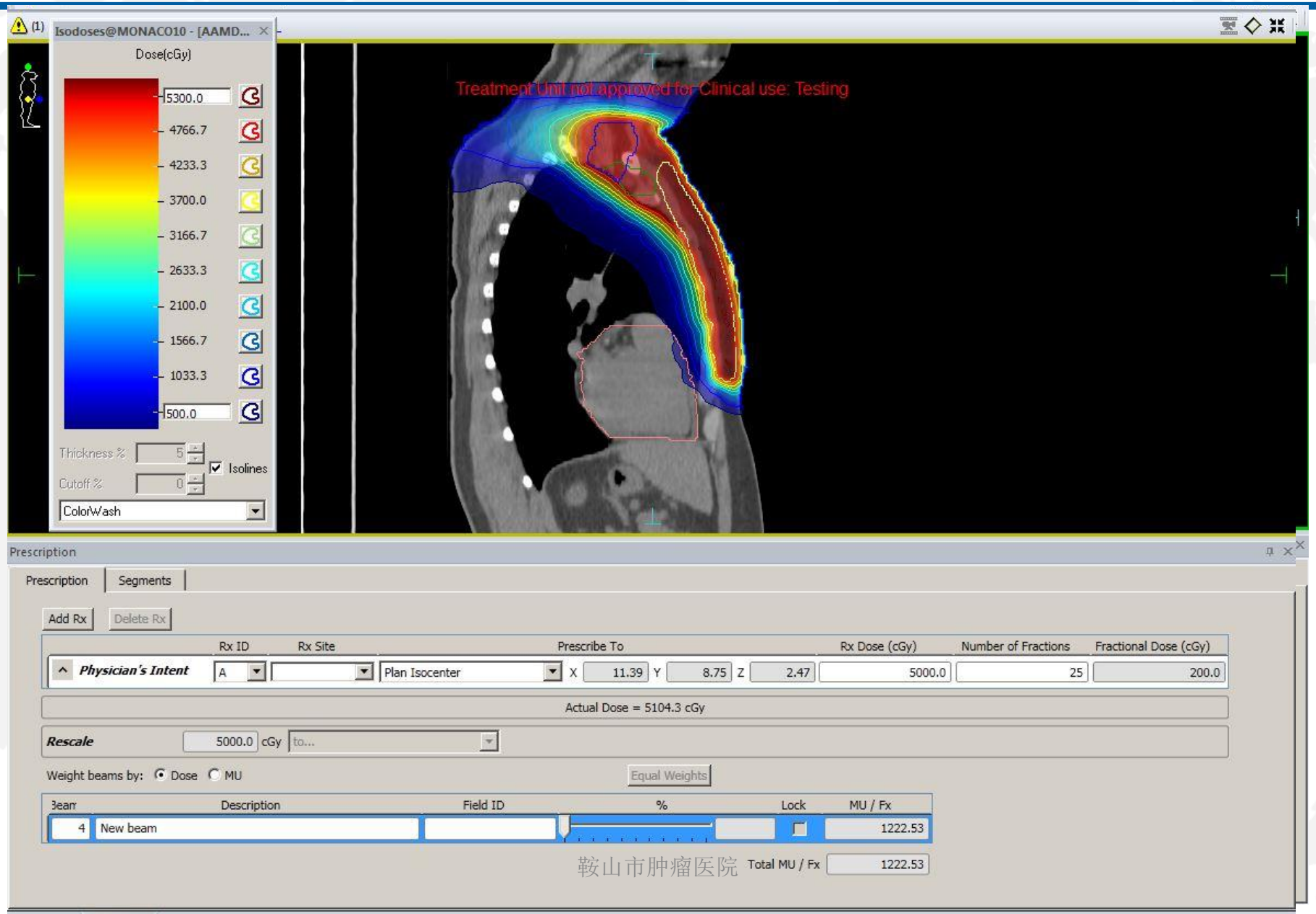
计划剂量分布


Isodoses@MONACO10 - [AAMD...
Dose(cGy)
5300.0
4766.7
4233.3
3700.0
3166.7
2633.3
2100.0
1566.7
1033.3
500.0
Thickness %
Cutoff %
Isolines
ColorWash
Treatment Unit not approved for Clinical use: Testing
Prescription
Prescription
Segments
Add Rx
Delete Rx
Rx ID
Rx Site
Prescribe To
Rx Dose (cGy)
Number of Fractions
Fractional Dose (cGy)
Physician's Intent
A
Plan Isocenter
X 11.39 Y 8.75 Z 2.47
5000.0
25
200.0
Actual Dose = 5104.3 cGy
Rescale
5000.0 cGy
to...
Weight beams by: Dose MU
Equal Weights
Beam
Description
Field ID
%
Lock
MU / Fx
4
New beam
1222.53
鞍山市肿瘤医院
Total MU / Fx
1222.53

竞赛型计划小结

1：先进行摸底性条件设计，找出计划设计难点

2：针对计划设计难点通过改变射野分布，治疗床角度、参数条件以及函数配置来实现目标

3：最好的剂量保护是钨门遮挡或者入射规避

4：纸面结果并不代表好的治疗效果

乳腺术后调强放疗

放射治疗医嘱单

放疗

姓

治疗日期：2018 年 6 月 15 日　　　　医师：

计划系统：(　)Pinnacle　(✓)Monaco

计划类型：(　)静态调强　(✓)动态调强　(　)适形

照射部位：左胸壁+左锁上区

PW　总剂量：(50)Gy　分割剂量：(2)Gy　次数：(25)Fx

总剂量：(　)Gy　分割剂量：(　)Gy　次数：(　)Fx

总剂量：(　)Gy　分割剂量：(　)Gy　次数：(　)Fx

结束日期：　年　月　日

靶区	体积(%)	关系	剂量(Gy)	热点(Gy)	关系	体积(%)
PW	D95	≥	50Gy		≤	
		≥			≤	
		≥			≤	

危急器官	体积(%)	关系	剂量(Gy)	平均剂量(Gy)	最大剂量(Gy)
heart		≤		Dmean<8Gy	
SC		≤			Dmax<40Gy
lung	V20	≤	30%		
	V10	≤	40%.		
Oropharynx	V35	≤	40%		
		≤			
		≤			
		≤			
		≤			
		≤			
		≤			
		≤			

备注：每日人造皮0.3cm

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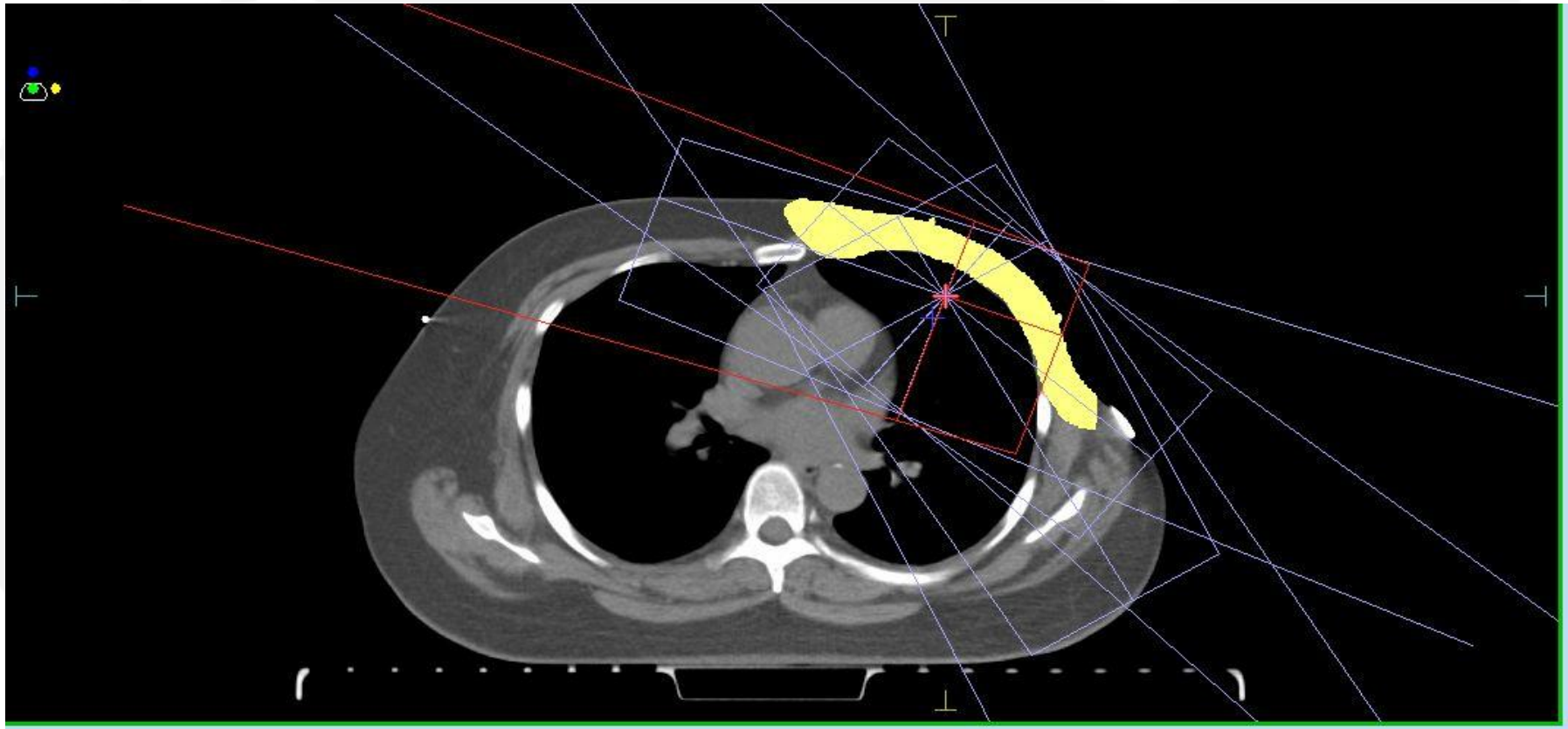
根治性乳腺癌IMRT射野分布



Beams

Delete Parent Beams | General | Geometry | Treatment Aids | Setup Beams

Beam	Description	Field ID	Visible	Delivery	Treatment ...	Modality	Algorithm	Energy	MU / Fx	SSD (cm)	Isocenter Loca...	X (cm)	Y (cm)	Z (cm)
1	A310		☑	dMLC	4090	Photon	Monte Carlo	6.0 MV	144.64	93.47	Interest Point 1	7.88	-115.60	35.51
2	A330		☑	dMLC	4090	Photon	Monte Carlo	6.0 MV	99.09	95.83	Interest Point 1	7.88	-115.60	35.51
3	A290		☑	dMLC	4090	Photon	Monte Carlo	6.0 MV	155.96	86.87	Interest Point 1	7.88	-115.60	35.51
4	A130		☑	dMLC	4090	Photon	Monte Carlo	6.0 MV	109.33	88.42	Interest Point 1	7.88	-115.60	35.51
5	A150		☑	dMLC	4090	Photon	Monte Carlo	6.0 MV	92.48	83.78	Interest Point 1	7.88	-115.60	35.51
6	A110		☑	dMLC	4090	Photon	Monte Carlo	6.0 MV	137.54	94.65	Interest Point 1	7.88	-115.60	35.51

<click to add a new beam>

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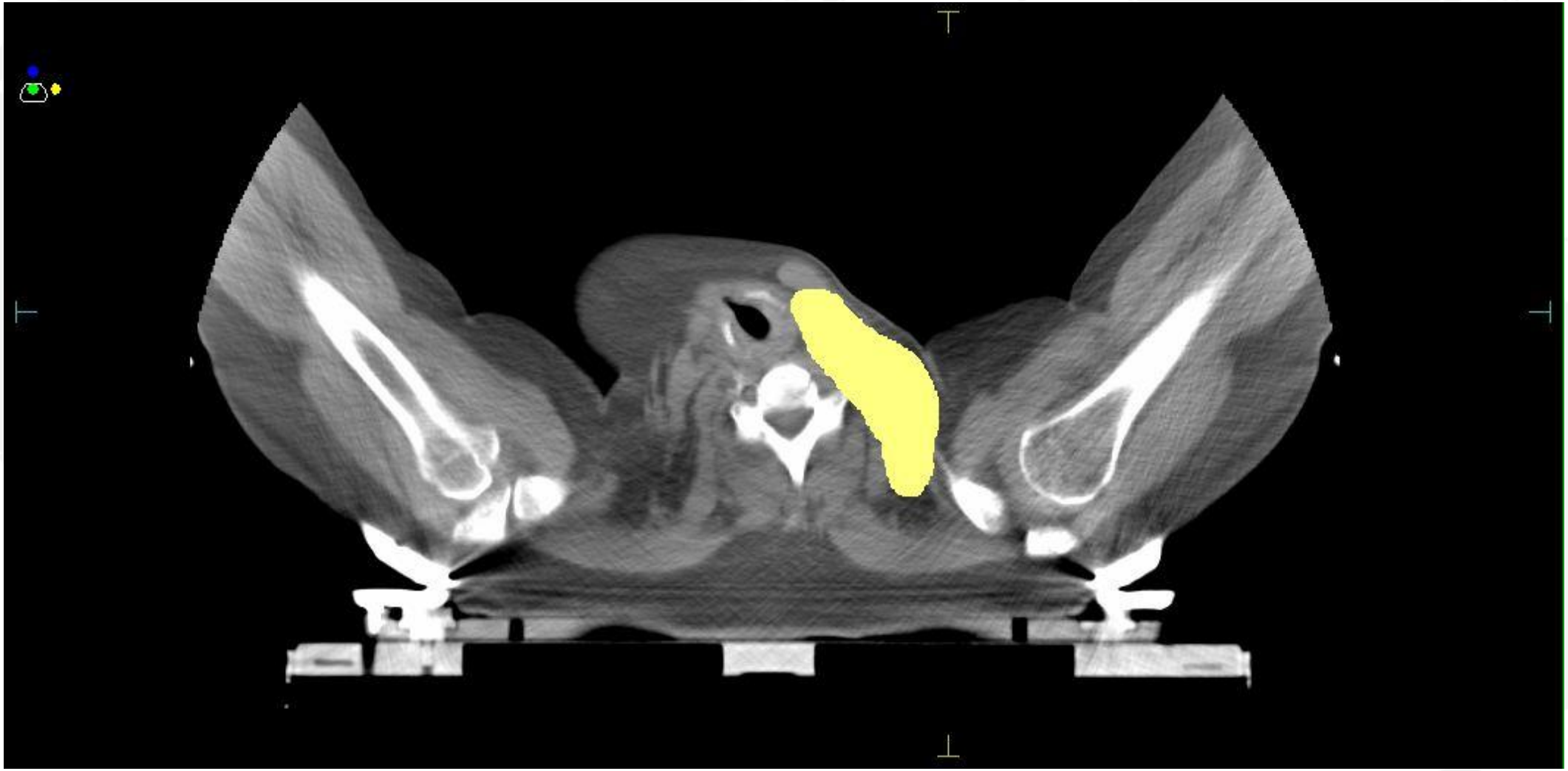
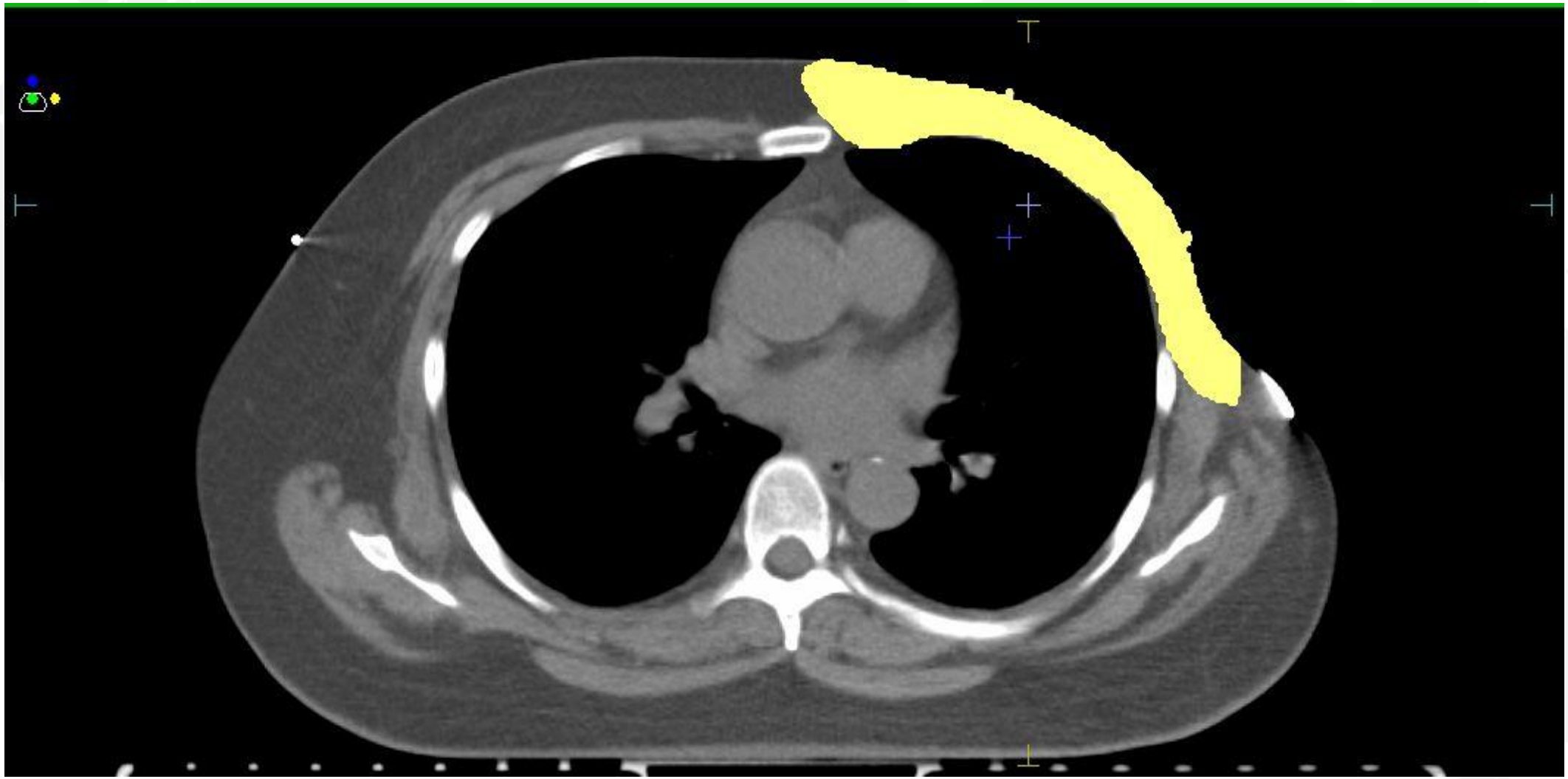
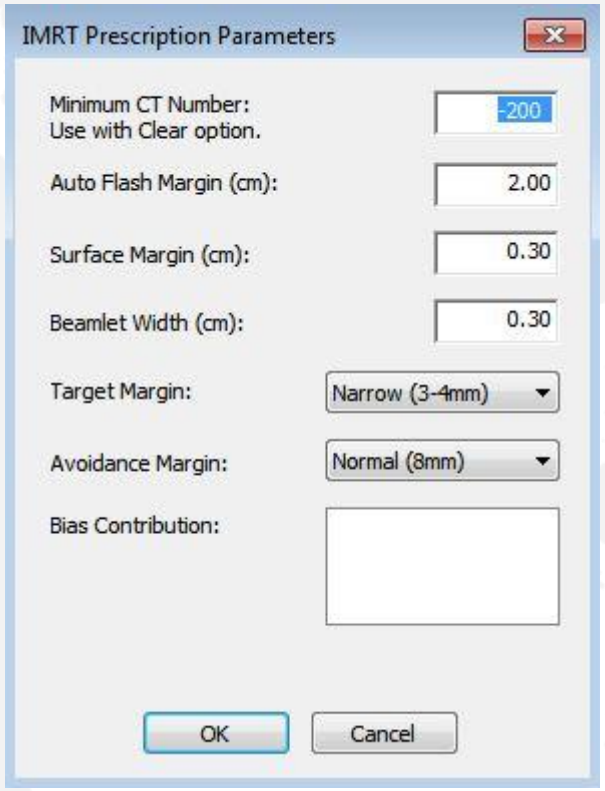
扫描图像决定射野布局

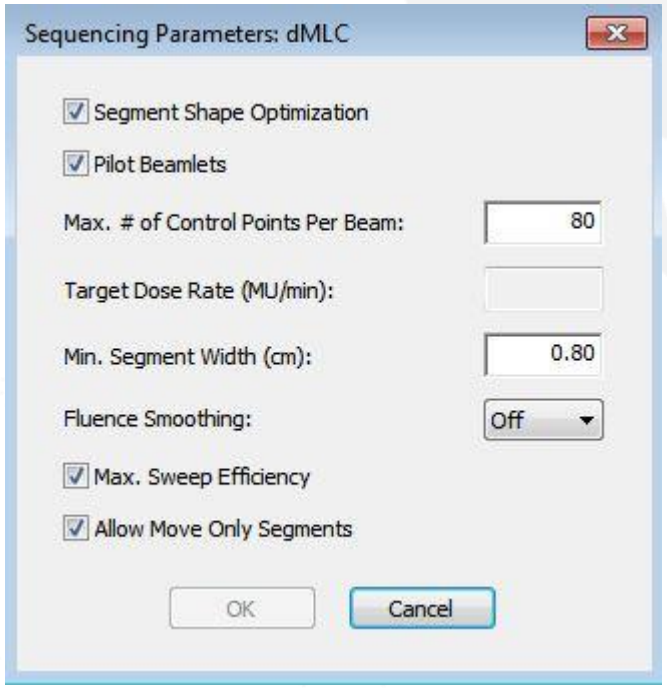


ISO Point 位置的选择



IMRT参数配置


IMRT Prescription Parameters
Minimum CT Number:
Use with Clear option.
-200
Auto Flash Margin (cm):
2.00
Surface Margin (cm):
0.30
Beamlet Width (cm):
0.30
Target Margin:
Narrow (3-4mm)
Avoidance Margin:
Normal (8mm)
Bias Contribution:
OK
Cancel


Sequencing Parameters: dMLC
Segment Shape Optimization
Pilot Beamlets
Max. # of Control Points Per Beam:
80
Target Dose Rate (MU/min):
Min. Segment Width (cm):
0.80
Fluence Smoothing:
Off
Max. Sweep Efficiency
Allow Move Only Segments
OK
Cancel

IMRT函数配置

IMRT Constraints

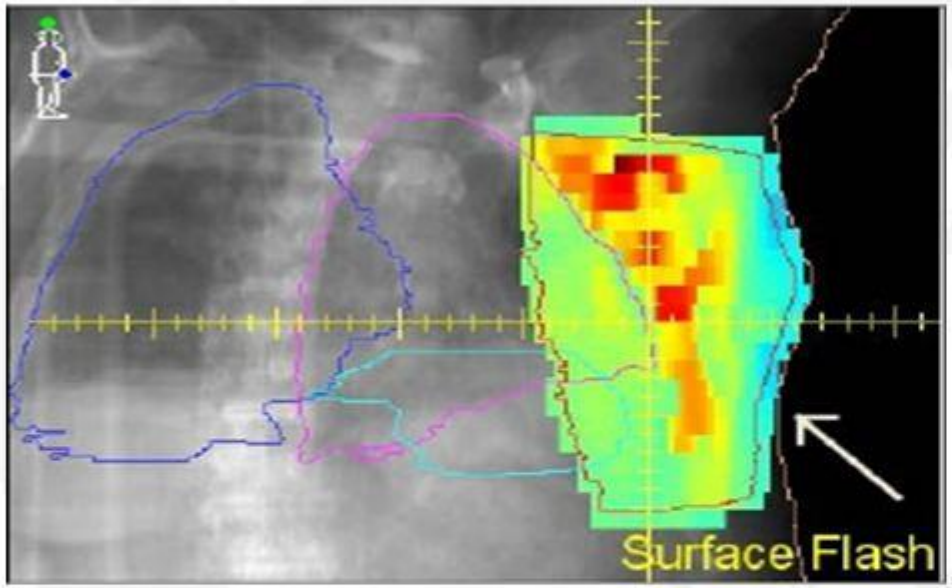
Pareto | Constrained | IMRT Parameters | Constraints | Sensitivities

Structure	Cost Function	Enabled	Status	Manual	Weight	Reference Dose (cGy)	Multicriterial	Isoconstraint	Isoeffect	Relative Impact
PTV50	Quadratic Overdose	☑	On	☐	0.01	5150.0		100.0	14.5	
	Target EUD	☑	On	☑	3.00			5000.0	4887.4	
	Target Penalty	☑	On	☑	3.00			5100.0	4754.8	
l lung	Parallel	☑	On	☐	1459.53	2000.0	☐	28.00	27.93	++++
	Parallel	☑	On	☐	6.35	1000.0	☐	40.00	38.78	+++
	Serial	☑	On	☐	486.71		☐	1400.0	1398.1	++++
Heart	Parallel	☑	On	☐	0.02	800.0	☐	45.00	30.72	
	Serial	☑	On	☐	0.01		☐	2000.0	1234.4	
SC	Maximum Dose	☑	On	☐	0.01			4000.0	2549.6	
Oropharynx	Serial	☑	On	☐	0.01		☐	2500.0	2231.8	
3cm	Serial	☑	On	☐	71.22		☐	4050.0	4042.4	+++
	Quadratic Overdose	☑	On	☐	0.01	4700.0	☐	100.0	76.3	
skin	Maximum Dose	☑	On	☐	665.58			5400.0	5418.5	++++
	Maximum Dose	☑	On	☐	9.19			4700.0	4694.9	+++
	Conformality	☑	On	☐	0.01		☐	0.70	0.27	

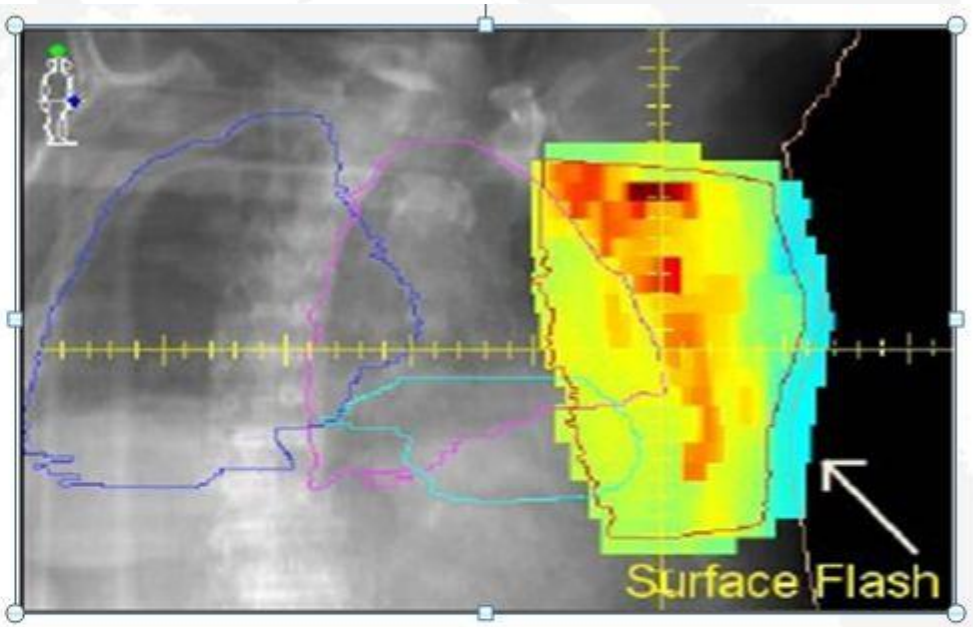
剂量数据及分布

Structure	Volume (cm³)	Min. Dose (cGy)	Max. Dose (cGy)	Mean Dose (cGy)	Cold Ref. (cGy)	Volume < (cm³)	Volume < (%)	Hot Ref. (cGy)	Volume > (cm³)	Volume > (%)
PTV50	805.075	3423.7	5358.0	5092.2	4957.0	**40.254**	5.00	5198.3	**16.102**	**2.00**
l lung	1016.005	2.8	5418.5	1435.3	**1000.0**	621.570	61.18	**2000.0**	289.497	28.49
Heart	617.480	0.0	5142.3	765.8						
SC	60.990	0.0	2474.3	197.1						
Oropharynx	35.725	57.4	5079.0	1739.9				**3500.0**	4.246	11.89
3cm	2587.855	107.4	5418.5	3577.6						
skin(Unsp.Tiss.)	16621.350	0.0	5249.2	337.5						

IMRT乳腺癌术后调强计划设计总结

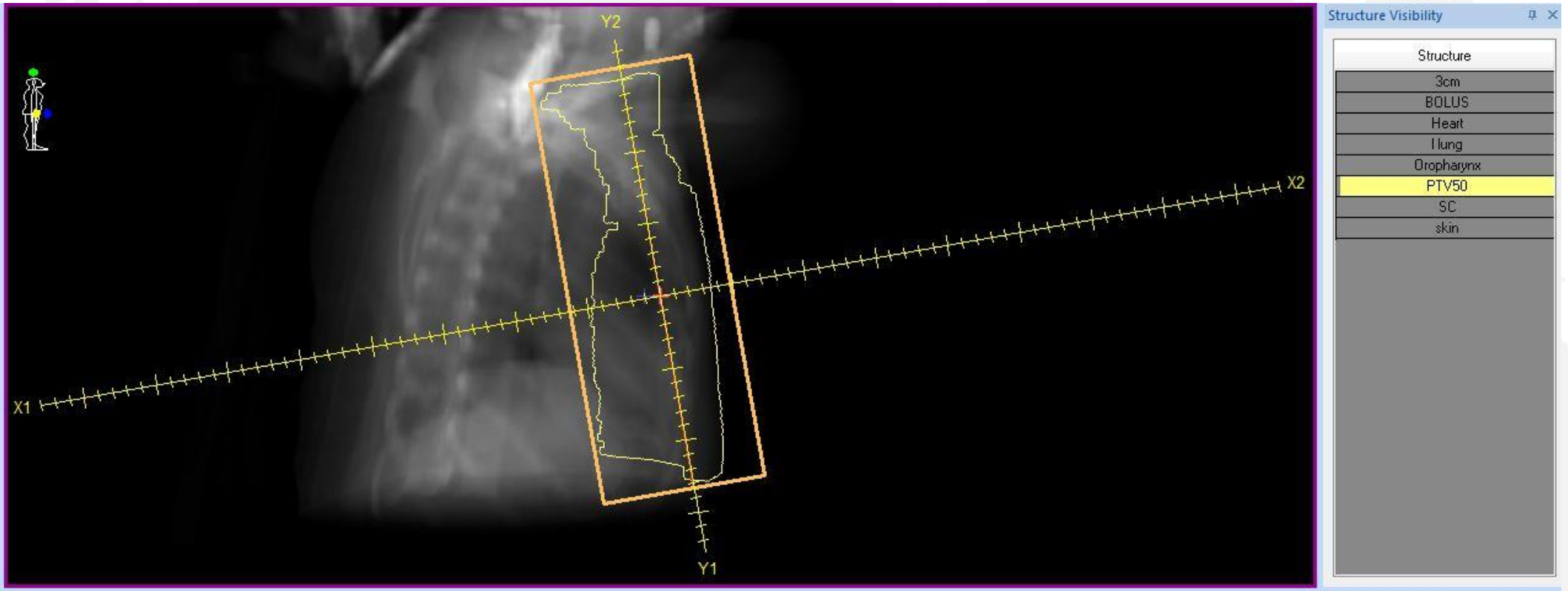


未使用Auto Flash



使用2CM Auto Flash

VMAT段弧设计



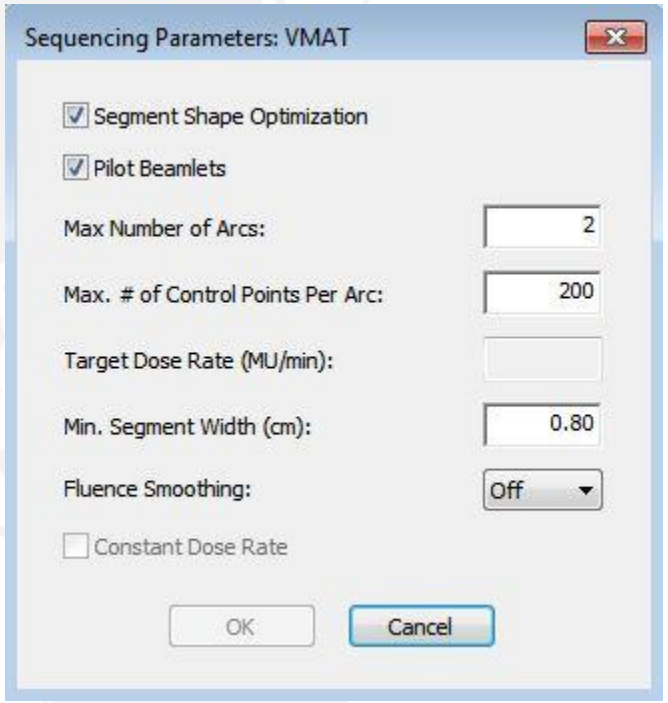
Beams

Delete Parent Beams | General | Geometry | Treatment Aids | Setup Beams

Beam	Description	SSD (cm)	Dir	Gantry Start (deg)	Arc	Inc	Collimator (deg)	Couch (deg)	Field	Margin (cm)	Asym	Width1 (cm)	Width2 (cm)	Length1 (cm)	Length2 (cm)
1	v280	81.95	CW	280.0	40.0	20.0	10.0	0.0	PTV50	0.30	☑	X1 6.27	X2 4.88	Y2 15.89	Y1 13.36
2	v110	88.42	CW	110.0	40.0	20.0	350.0	0.0	[Fixed]	0.30	☑	X1 5.78	X2 5.00	Y2 15.60	Y1 13.55

<click to add a new beam>

VMAT参数配置


Sequencing Parameters: VMAT
Segment Shape Optimization
Pilot Beamlets
Max Number of Arcs:
2
Max. # of Control Points Per Arc:
200
Target Dose Rate (MU/min):
Min. Segment Width (cm):
0.80
Fluence Smoothing:
Off
Constant Dose Rate
OK
Cancel

VMAT函数配置

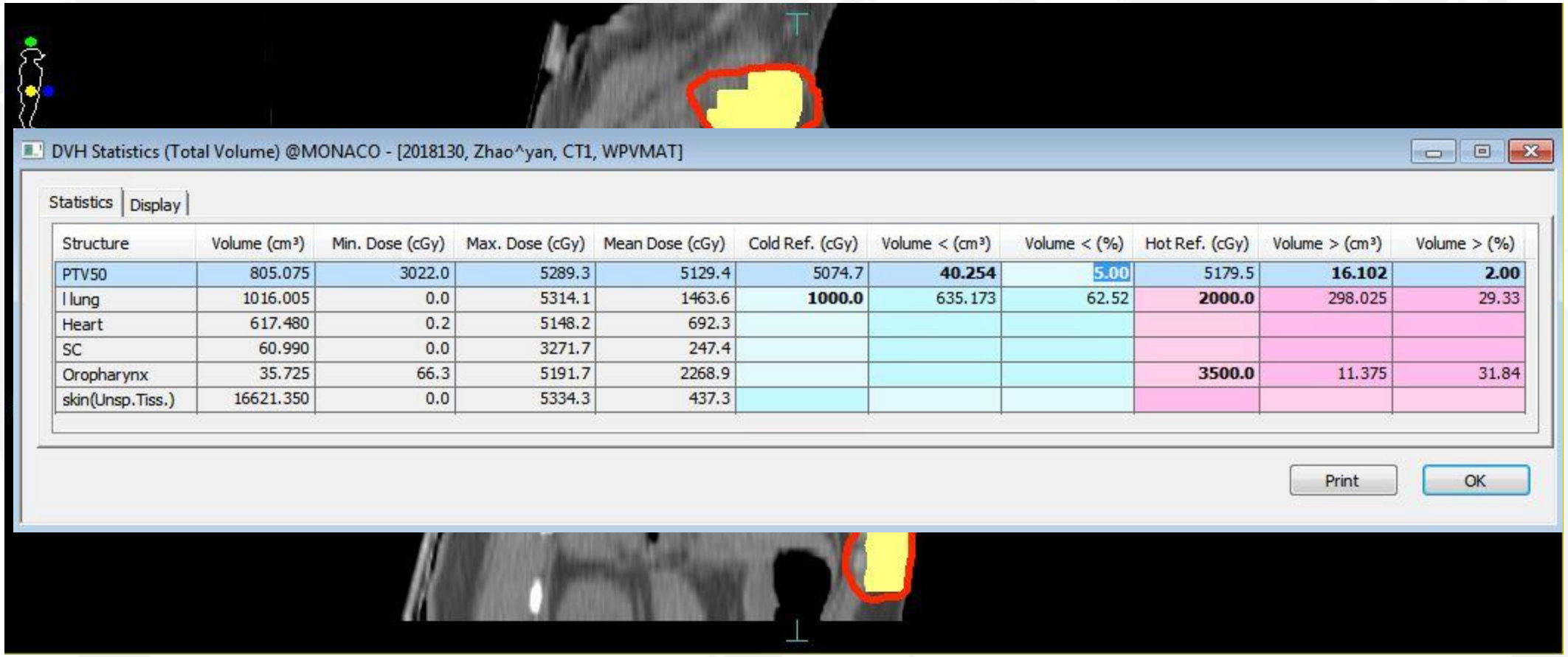
IMRT Constraints

Pareto | Constrained | IMRT Parameters | Constraints | Sensitivities

Structure	Cost Function	Enabled	Status	Manual	Weight	Reference Dose (cGy)	Multicriterial	Isoconstraint	Isoeffect	Relative Impact
PTV50	Quadratic Overdose	☑	On	☐	0.01	5150.0		100.0	11.1	
	Underdose DVH	☑	Infeasible	☐	100.00	5000.0		95.00	97.80	++++
	Target EUD	☑	On	☐	1.00			5000.0	4806.4	
	Maximum Dose	☑	On	☐	1170.69			5350.0	5355.9	++++
	Target Penalty	☑	On	☐	1.00			5100.0	4969.6	
l lung	Maximum Dose	☑	On	☐	0.01			5000.0	5000.4	
	Parallel	☑	On	☐	678.33	2000.0	☐	28.50	28.57	++++
	Parallel	☑	On	☐	0.04	500.0	☐	55.00	48.50	+
	Serial	☑	On	☐	288.60		☐	1400.0	1422.5	++++
Heart	Parallel	☑	On	☐	0.01	800.0	☐	45.00	23.74	
	Serial	☑	On	☐	0.06		☐	800.0	699.2	+
SC	Maximum Dose	☑	On	☐	0.01			4200.0	3310.9	
Oropharynx	Parallel	☑	On	☐	0.02	3500.0	☐	30.00	28.36	+
skin	Maximum Dose	☑	On	☐	111.90			5400.0	5380.4	++++
	Maximum Dose	☑	On	☐	8.00			4600.0	4605.8	+++
	Conformality	☑	On	☐	0.01		☐	0.70	0.21	

<click to add a new structure>

VMAT剂量数据及分布



DVH Statistics (Total Volume) @MONACO - [2018130, Zhao^yan, CT1, WPVMAT]

Statistics | Display

Structure	Volume (cm³)	Min. Dose (cGy)	Max. Dose (cGy)	Mean Dose (cGy)	Cold Ref. (cGy)	Volume < (cm³)	Volume < (%)	Hot Ref. (cGy)	Volume > (cm³)	Volume > (%)
PTV50	805.075	3022.0	5289.3	5129.4	5074.7	**40.254**	5.00	5179.5	**16.102**	**2.00**
l lung	1016.005	0.0	5314.1	1463.6	**1000.0**	635.173	62.52	**2000.0**	298.025	29.33
Heart	617.480	0.2	5148.2	692.3						
SC	60.990	0.0	3271.7	247.4						
Oropharynx	35.725	66.3	5191.7	2268.9				**3500.0**	11.375	31.84
skin(Unsp.Tiss.)	16621.350	0.0	5334.3	437.3						

Print OK

IMRT-VMAT计划跳数分析

Prescription

Prescription | Segments

Add Rx | Delete Rx

	Rx ID	Rx Site	Prescribe To						Rx Dose (cGy)	Number of Fractions	Fractional Dose (cGy)
Physician's Intent	A		Plan Isocenter	X	7.88	Y	-115.60	Z	35.51	5000.0	25	200.0

Actual Dose = 4657.6 cGy

Rescale 5000.0 cGy to...

Weight beams by: Dose MU Equal Weights

Beam	Description	Field ID	%	Lock	MU / Fx
1	v280				362.55
2	v110				306.84

Total MU / Fx 669.39

Prescription

Prescription | Segments

Add Rx | Delete Rx

	Rx ID
Physician's Intent	A

Rescale 5000.0 cGy to...

Weight beams by: Dose MU Equal Weights

Beam	Description	Field ID	%	Lock	MU / Fx
1	A310				119.11
2	A330				93.80
3	A290				156.68
4	A130				104.00
5	A150				90.77
6	A110				126.92

Total MU / Fx 691.28

鞍山市肿瘤医院

THANK YOU!

15541260977

7470298@qq.com

7470298