

1例宫颈癌放疗计划的设计

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2010京津鲁地区放射物理专业委员会第十五次学术会议
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逆向计划

图像的采集
(CT/MRI/PET等)

靶区及危及器官等的勾画

确定射野个数、方向等

定义目标函数
(剂量/剂量-体积约束)

优化射野强度分布、剂量计算

计划评估

否



放疗计划设计流程

- 病历基本情况
- 靶区及危及器官定义
- 目标函数
- 等中心及射野方向数量
- 优化条件
- 计划结果分析

2017年上海市放疗物理专业组第十五次学术会议
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病历基本情况（协和医院）

- 女性，49岁
- 宫颈中-低分化鳞癌I b1期术后
- 调强放疗（SIB）

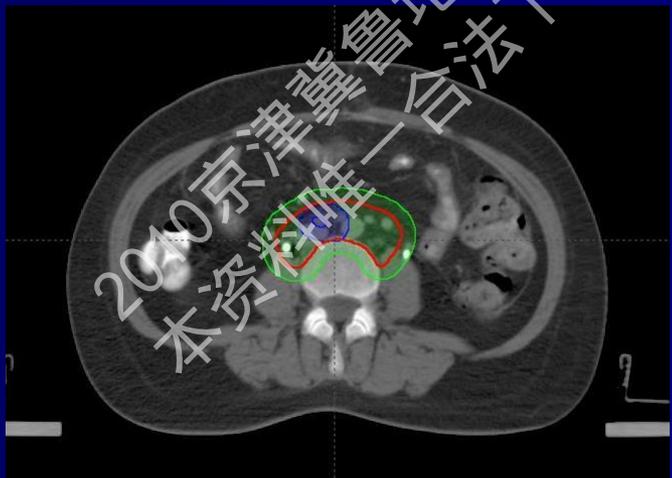
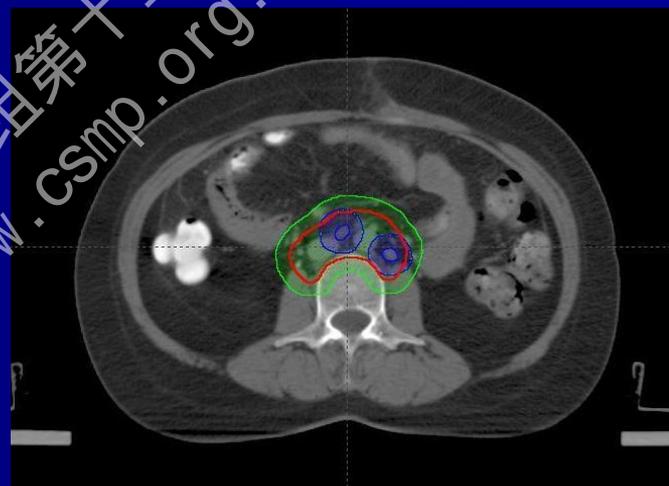
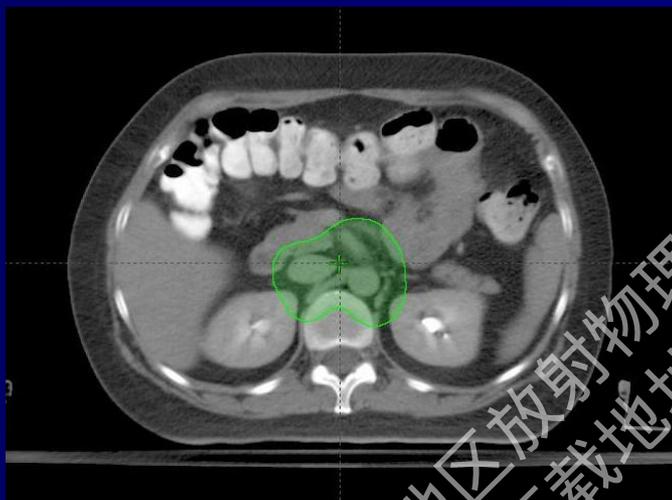
计划系统 (Varian Eclipse)

- 射线能量: 15MV
- MLC: 120
- 计划传输方式: Step and shoot
- 计算模型: AAA

靶区及危及器官定义

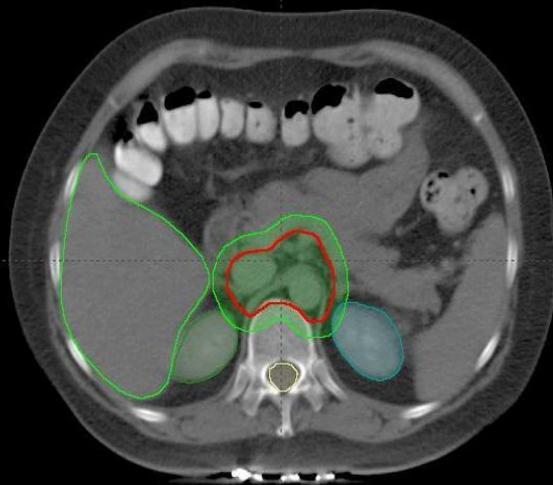
- **GTV:** 腹主动脉旁可见的淋巴结
剂量59.92Gy/28次, 2.14Gy/次
- **CTV:** 包括阴道残端和盆淋巴结引流区(髂总、髂内、髂外、骶前、闭孔)和腹主动脉旁淋巴引流区
剂量50.4Gy/28次, 1.8Gy/次

靶区定义 (GTV/CTV/PGTV/PCTV)



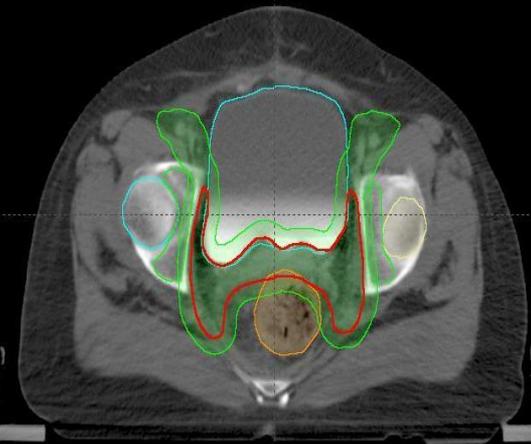
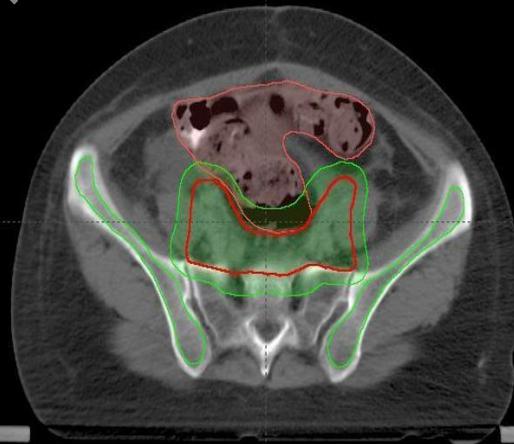
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危及器官定义



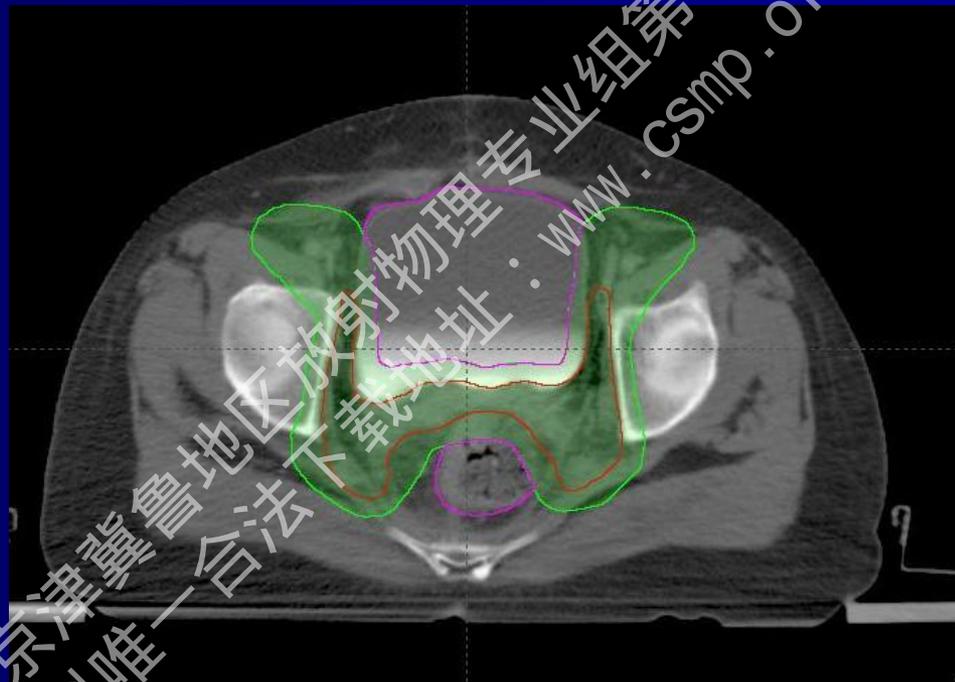
Femoral Head R&L / Ileum
Small Intestine / Rectum
Bladder

↑
spinal cord / stomach
Kidney R&L / Liver



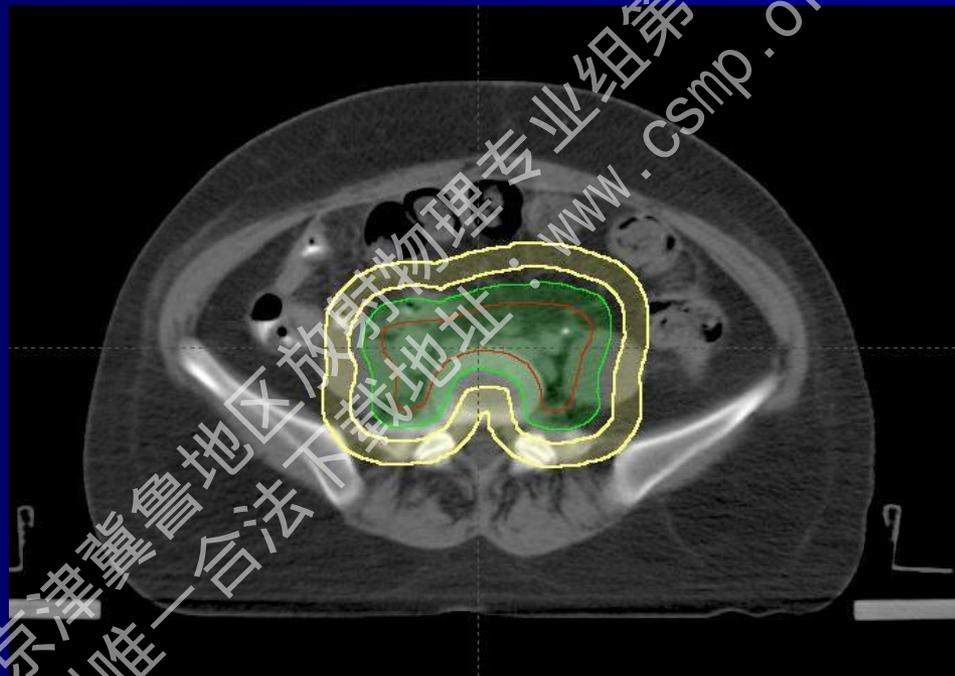
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优化中其它限制器官定义



Bladder-PTV / rectum-PTV

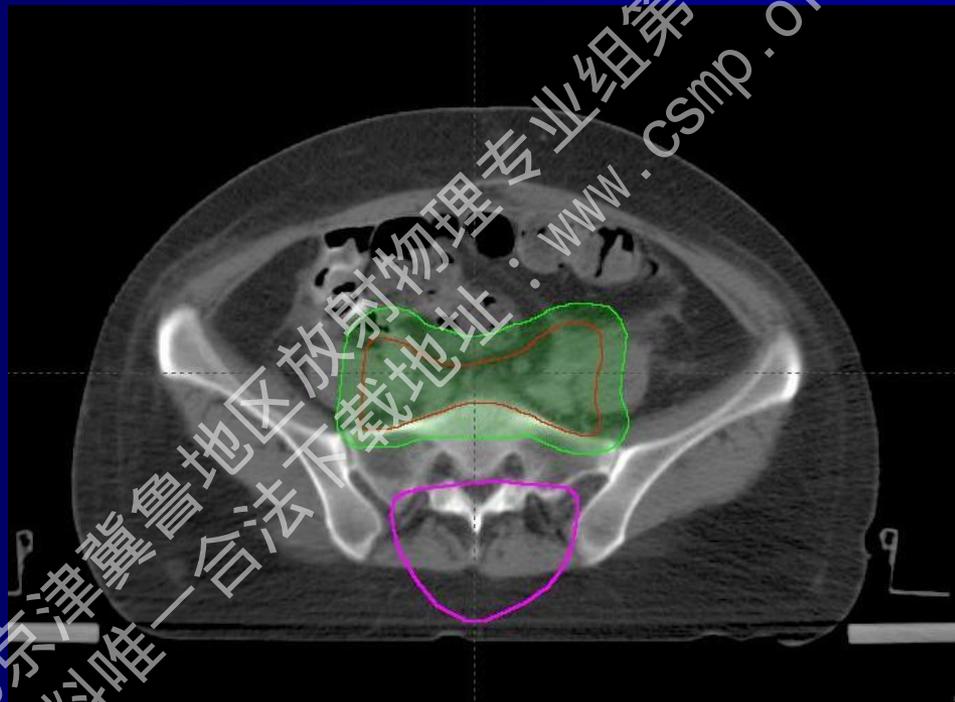
优化中其它限制器官定义



ring

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优化中其它限制器官定义



Hot-5040

目标函数（靶区）

- PGTV>V: (59.92Gy)

59.92Gy 包绕95%以上的PGTV

59.92Gy 包绕100%的GTV

PGTV中 $D_{max} < 59.92Gy * 107\%$ (6411Gy)

$D_{min} > 59.92Gy * 98\%$ (5872Gy)

$D_{mean} < 59.92Gy * 105\%$ (6292Gy)

目标函数 (靶区)

- PCTV&CTV: (50.4Gy)

50.4Gy 包绕95%以上的PCTV

50.4Gy 包绕100%的CTV

PCTV中 $D_{max} < 50.4Gy * 107%$ (6411Gy)

$D_{min} > 50.4Gy * 95%$ (4788Gy)

PCTV中除包括PGTV的层面外,

$D_{max} < 50.4Gy * 110%$ (5544Gy)

PCTV SUB PGTV : $D_{mean} < 50.4Gy * 105%$ (5292Gy)

目标函数（危及器官）

- spinal cord V30Gy<0.1cc
- stomach V15-20<50%
- Kidney R&L V15-18<33%
- Liver V15-20<33%
- Femoral Head R&L V45-50<5%
- Ileum V30-35<50%
- Small Intestine V30<40% V25<50%
- Rectum V40-45<50%
- Rectum sub PCTV V50.4Gy<1cc
- Bladder V40-45<50%
- Bladder sub PCTV V50.4Gy<1cc

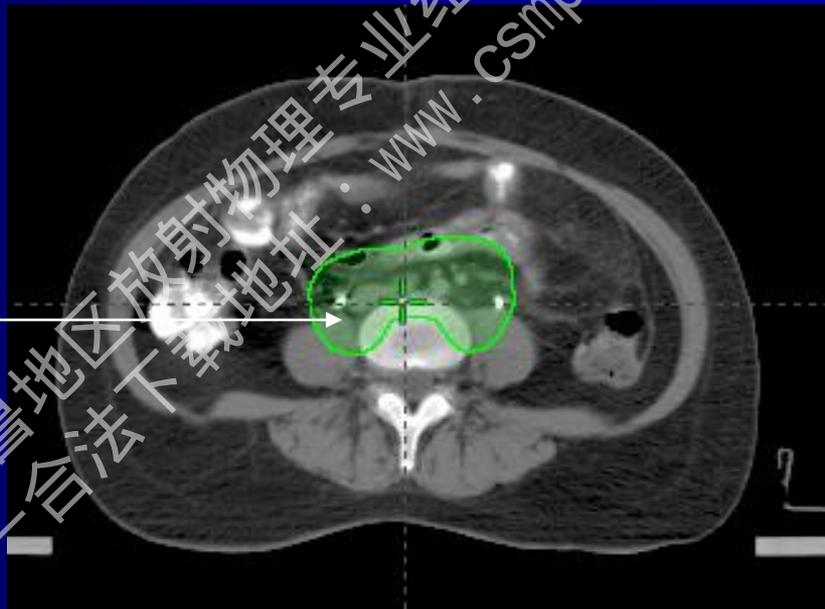
放疗计划设计

- 一个等中心调强计划
- 两个等中心调强计划
- Rapid-ARC计划

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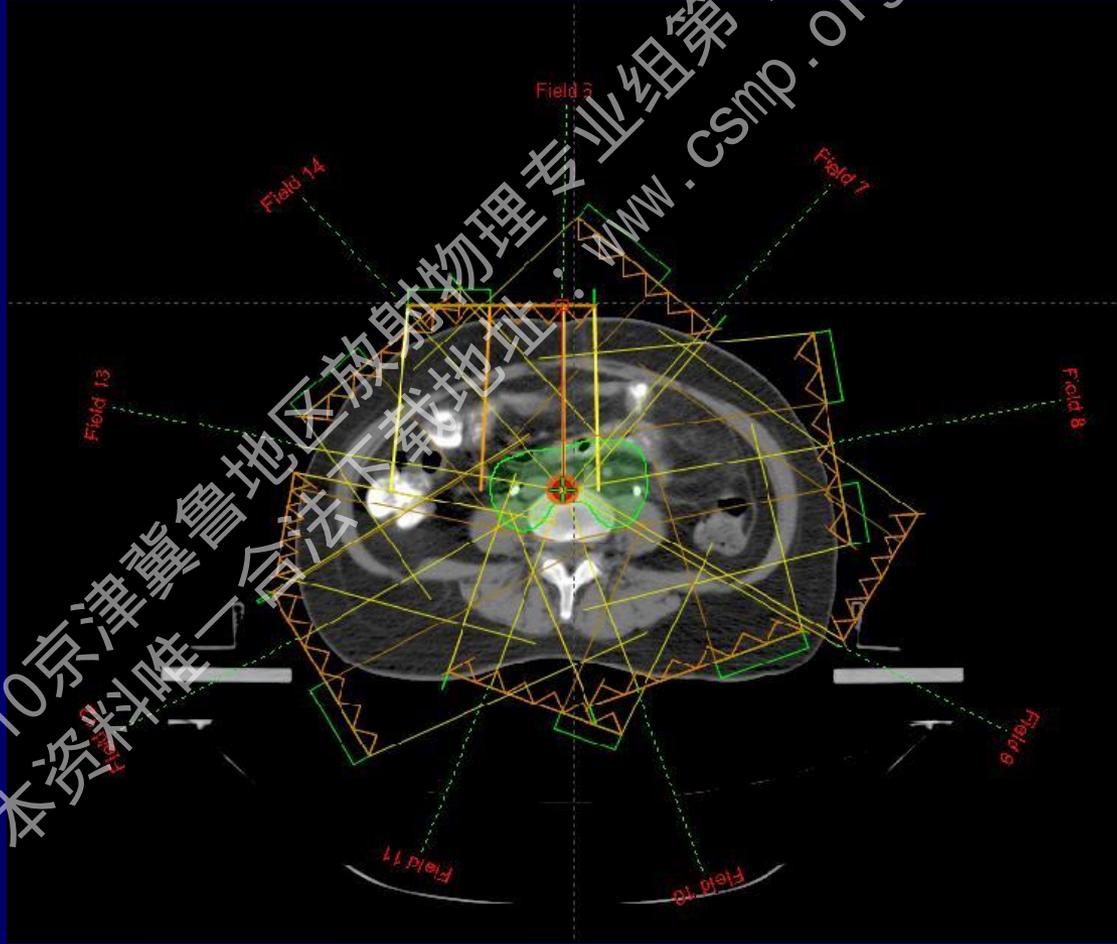
一个等中心调强计划

ISO



一个等中心调强计划

九个野调强计划



优化条件（一个等中心）

Optimization - test-lujie, (1608229), ()

Structures and Objectives

Use Normal Tissue Objective Priority: 150 Define Settings...

Structure/Objective	Volume [cc]	Points	Resolution [mm]
<input checked="" type="checkbox"/> Bladder	480	16006	3.00
Upper Volume [%]:	50.0	Dose [cGy]: 4000.0	Priority: 200
Upper	30.0	4500.0	200
<input checked="" type="checkbox"/> Bladder-PTV	388	12930	3.00
Upper Volume [%]:	0.0	Dose [cGy]: 5000.0	Priority: 400
<input checked="" type="checkbox"/> Body	25974	256536	4.50
<input checked="" type="checkbox"/> CTV1	890	29671	3.00
Lower Volume [%]:	100.0	Dose [cGy]: 5040.0	Priority: 1000
<input checked="" type="checkbox"/> Dose 5544[cGy]	60	2000	3.00
<input checked="" type="checkbox"/> Femoral Head L	41	2000	2.65
Upper Volume [%]:	0.0	Dose [cGy]: 4300.0	Priority: 150
<input checked="" type="checkbox"/> Femoral Head R	38	2000	2.58
Upper Volume [%]:	5.0	Dose [cGy]: 4300.0	Priority: 150
<input checked="" type="checkbox"/> GTV1	3	2000	1.13
Lower Volume [%]:	100.0	Dose [cGy]: 5992.0	Priority: 1000
<input checked="" type="checkbox"/> Int-5040	99	3298	3.00
Upper Volume [%]:	0.0	Dose [cGy]: 4800.0	Priority: 300
<input checked="" type="checkbox"/> Ileum	240	8011	3.00
Upper Volume [%]:	42.0	Dose [cGy]: 2500.0	Priority: 200
Upper	24.0	3200.0	150
<input checked="" type="checkbox"/> Kidney L	158	5265	3.00
Upper Volume [%]:	30.0	Dose [cGy]: 1300.0	Priority: 350

优化条件（一个等中心）

Optimization - test-lujie, (1608229), ()

Structures and Objectives Exclude Structures...

Use Normal Tissue Objective Priority: 150 Define Settings...

	Upper	Volume [%]:	17.0	Dose [cGy]:	2000.0	Priority:	150
<input checked="" type="checkbox"/>	Kidney R	Volume [cc]:	186	Points:	5520	Resolution [mm]:	3.00
	Upper	Volume [%]:	25.0	Dose [cGy]:	1400.0	Priority:	300
	Upper		15.0		2200.0		150
<input checked="" type="checkbox"/>	Liver	Volume [cc]:	716	Points:	23860	Resolution [mm]:	3.00
	Upper	Volume [%]:	30.0	Dose [cGy]:	1400.0	Priority:	100
<input checked="" type="checkbox"/>	PCTV	Volume [cc]:	1869	Points:	62287	Resolution [mm]:	3.00
	Upper	Volume [%]:	0.0	Dose [cGy]:	6000.0	Priority:	700
	Upper		10.0		5300.0		700
	Lower	Volume [%]:	95.0	Dose [cGy]:	5040.0	Priority:	800
	Lower		100.0		4950.0		1000
<input checked="" type="checkbox"/>	PCTV-PGTV	Volume [cc]:	1736	Points:	57870	Resolution [mm]:	3.00
	Upper	Volume [%]:	0.0	Dose [cGy]:	5200.0	Priority:	500
<input checked="" type="checkbox"/>	PGV	Volume [cc]:	28	Points:	2000	Resolution [mm]:	2.33
	Upper	Volume [%]:	0.0	Dose [cGy]:	6300.0	Priority:	800
	Upper		10.0		6200.0		700
	Lower	Volume [%]:	95.0	Dose [cGy]:	5992.0	Priority:	800
	Lower		100.0		5950.0		1000
<input checked="" type="checkbox"/>	Rectum	Volume [cc]:	105	Points:	3509	Resolution [mm]:	3.00
	Upper	Volume [%]:	48.0	Dose [cGy]:	3700.0	Priority:	200
	Upper		26.0		4500.0		200
<input checked="" type="checkbox"/>	Rectum-PTV	Volume [cc]:	77	Points:	2569	Resolution [mm]:	3.00

优化条件（一个等中心）

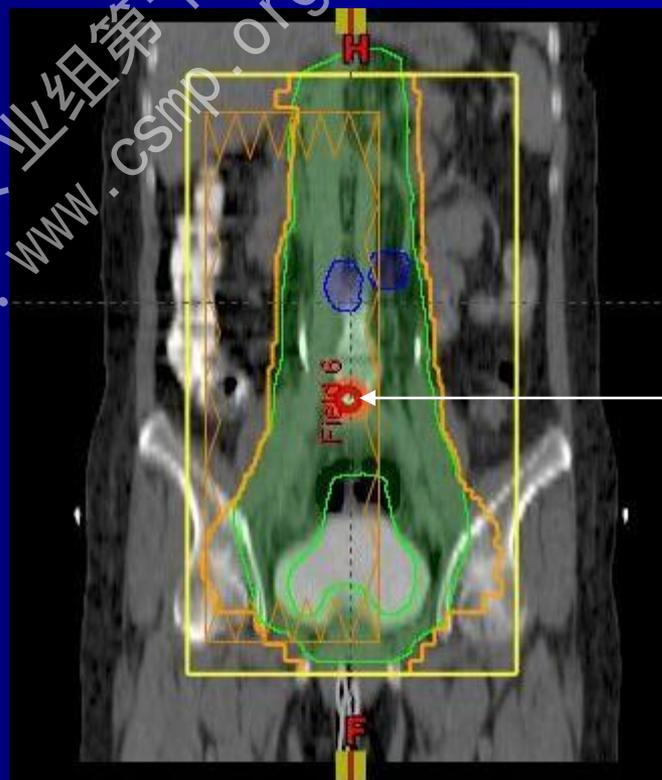
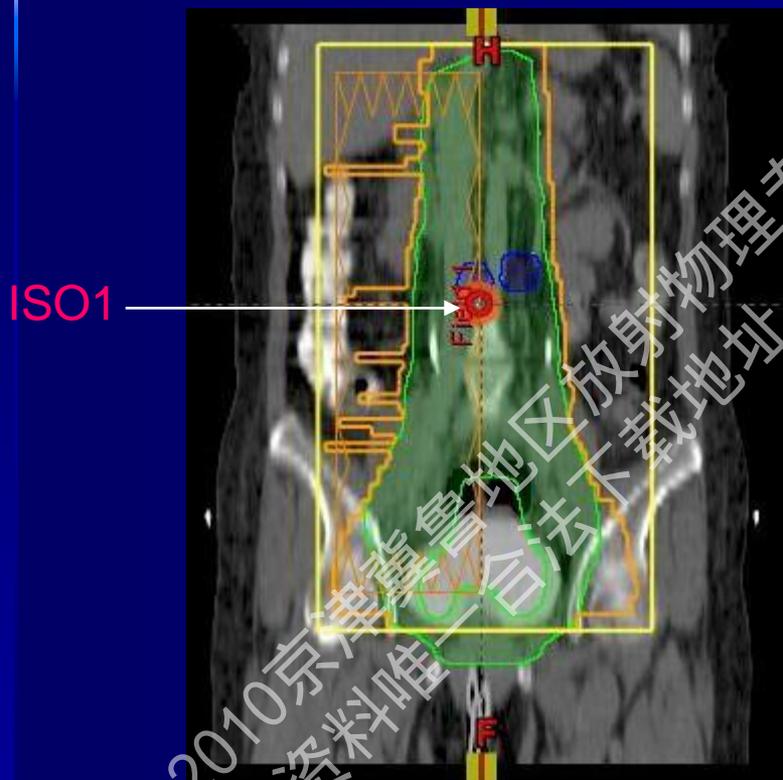
Optimization - test-lujie, (1608229), ()

Structures and Objectives

Use Normal Tissue Objective Priority: 150 Define Settings...

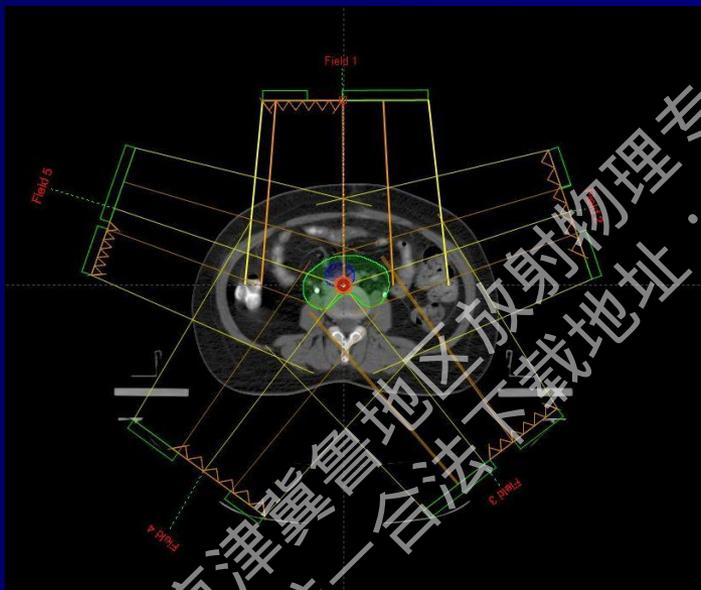
Structure	Region	Volume [cc]	Volume [%]	Dose [cGy]	Points	Resolution [mm]	Priority
PGTV	Upper	0.0	0.0	5200.0			500
	Volume [cc]	28			2000	2.33	
	Upper	0.0	0.0	6300.0			800
	Upper	10.0		6200.0			700
	Lower	95.0		5992.0			800
Rectum	Lower	100.0		5950.0			1000
	Volume [cc]	105			3509	3.00	
	Upper	48.0		3700.0			200
Rectum-PTV	Upper	26.0		4500.0			200
	Volume [cc]	77			2569	3.00	
ring	Upper	0.0	0.0	5000.0			400
	Volume [cc]	1670			55662	3.00	
Small Intestine	Upper	0.0	0.0	4600.0			300
	Volume [cc]	2964			98791	3.00	
Spinal Cord	Upper	48.0		1900.0			200
	Upper	24.0		3200.0			200
	Volume [cc]	37			2000	2.55	
Stomach	Upper	0.0	0.0	2500.0			600
	Volume [cc]	158			5272	3.00	
	Upper	40.0		1300.0			50
	Upper	20.0		2265.0			50

两个等中心调强计划

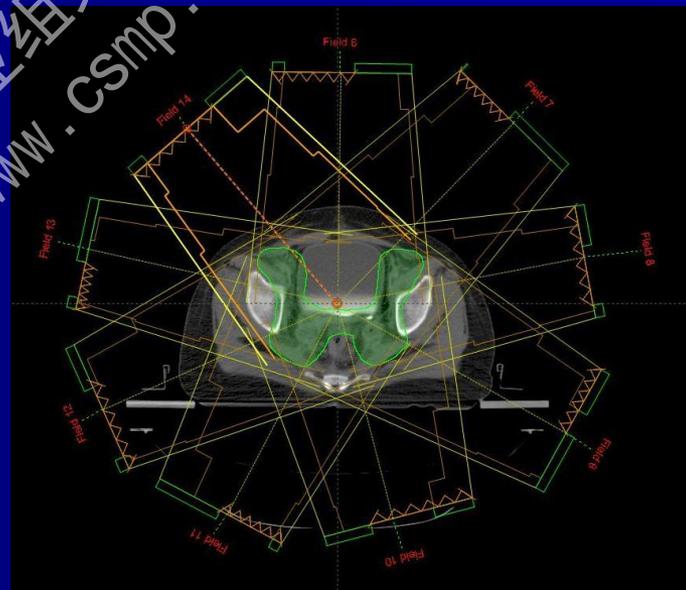


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两个等中心调强计划



ISO1



ISO2

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优化条件（两个等中心）

Structures and Objectives

Use Normal Tissue Objective Priority: 150 Exclude Structures... Define Settings...

Structure	Objective	Volume [cc]	Volume [%]	Points	Dose [cGy]	Resolution [mm]	Priority
Bladder	Volume [cc]	480		16006		3.00	
	Upper Volume [%]		50.0		4000.0		200
	Upper		38.0		4500.0		200
Bladder-PTV	Volume [cc]	388		12930		3.00	
	Upper Volume [%]		0.0		5000.0		400
Body	Volume [cc]	25974		256536		4.50	
CTV1	Volume [cc]	890		29671		3.00	
	Lower Volume [%]		100.0		5040.0		1000
Femoral Head L	Volume [cc]	41		2000		2.65	
	Upper Volume [%]		0.0		4300.0		150
Femoral Head R	Volume [cc]	38		2000		2.58	
	Upper Volume [%]		5.0		4300.0		150
GTV1	Volume [cc]	3		2000		1.13	
	Lower Volume [%]		100.0		5992.0		1000
Int-5040	Volume [cc]	99		3298		3.00	
Ileum	Upper Volume [%]		0.0		4800.0		300
	Upper		48.0		1900.0		150
Kidney L	Upper		24.0		3200.0		150
	Volume [cc]	158		5265		3.00	
Kidney R	Upper Volume [%]		30.0		1300.0		350
	Upper		17.0		2000.0		150

优化条件（两个等中心）

Structures and Objectives

Use Normal Tissue Objective Priority: 150 Exclude Structures... Define Settings...

<input checked="" type="checkbox"/>	Kidney R	Volume [cc]	166	Points:	5520	Resolution [mm]:	3.00
	Upper	Volume [%]	25.0	Dose [cGy]:	1400.0	Priority:	300
	Upper		15.0		2200.0		150
<input checked="" type="checkbox"/>	Liver	Volume [cc]	716	Points:	23860	Resolution [mm]:	3.00
	Upper	Volume [%]	30.0	Dose [cGy]:	1400.0	Priority:	100
<input checked="" type="checkbox"/>	PCTV	Volume [cc]	1869	Points:	62287	Resolution [mm]:	3.00
	Upper	Volume [%]	0.0	Dose [cGy]:	6000.0	Priority:	700
	Upper		10.0		5300.0		700
	Lower	Volume [%]	95.0	Dose [cGy]:	5040.0	Priority:	800
	Lower		100.0		4900.0		1000
<input checked="" type="checkbox"/>	PCTV-PCTV	Volume [cc]	1736	Points:	57870	Resolution [mm]:	3.00
<input checked="" type="checkbox"/>	PCTV	Volume [cc]	28	Points:	2000	Resolution [mm]:	2.33
	Upper	Volume [%]	0.0	Dose [cGy]:	6300.0	Priority:	800
	Upper		10.0		6200.0		700
	Lower	Volume [%]	95.0	Dose [cGy]:	5992.0	Priority:	800
	Lower		100.0		5900.0		1000
<input checked="" type="checkbox"/>	Rectum	Volume [cc]	105	Points:	3509	Resolution [mm]:	3.00
	Upper	Volume [%]	48.0	Dose [cGy]:	3700.0	Priority:	200
	Upper		26.0		4500.0		200
<input checked="" type="checkbox"/>	Rectum-PTV	Volume [cc]	77	Points:	2569	Resolution [mm]:	3.00
	Upper	Volume [%]	0.0	Dose [cGy]:	5000.0	Priority:	400
<input checked="" type="checkbox"/>	ring	Volume [cc]	1670	Points:	55662	Resolution [mm]:	3.00

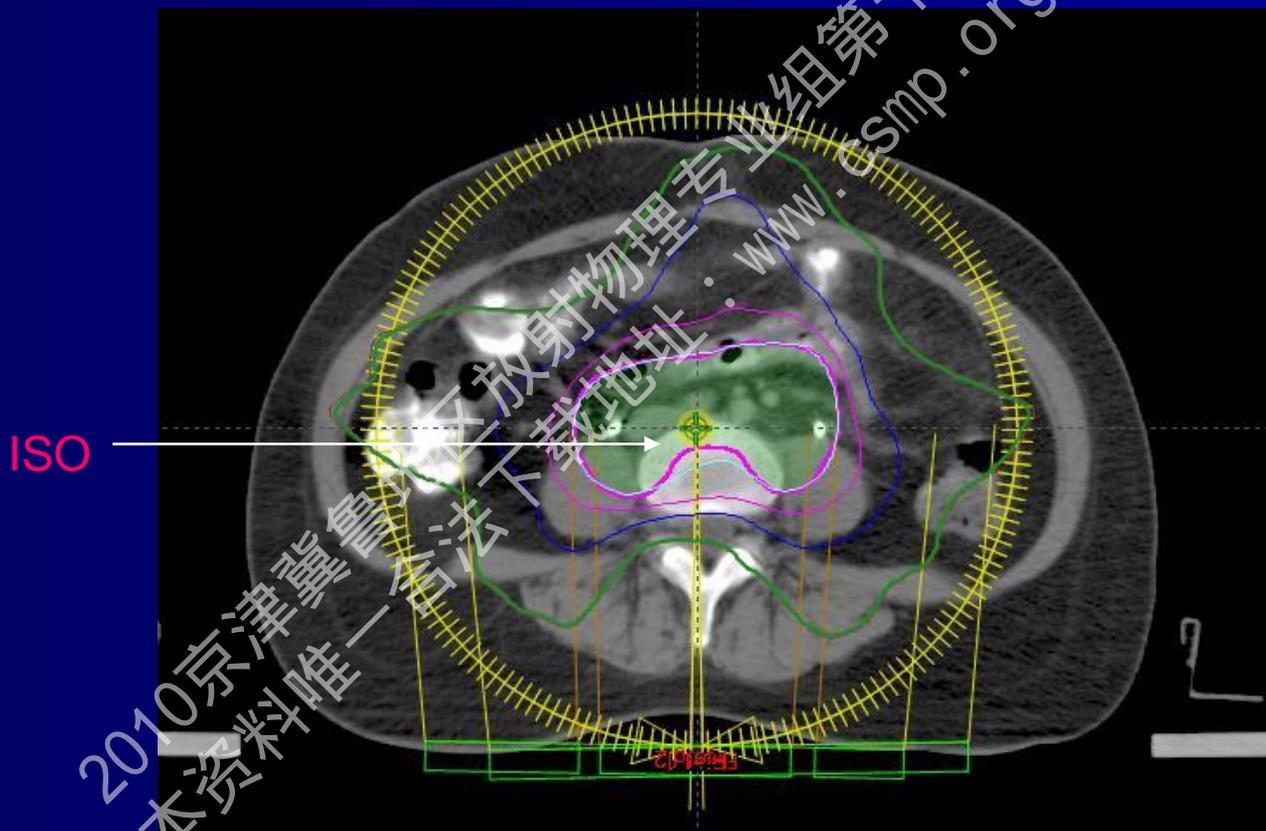
优化条件（两个等中心）

Structures and Objectives

Use Normal Tissue Objective Priority: 150 Exclude Structures... Define Settings...

<input checked="" type="checkbox"/>	PCTV-PGTV	Volume [cc]	1736	Points:	57870	Resolution [mm]:	3.00
<input checked="" type="checkbox"/>	PGTV	Volume [cc]	28	Points:	2000	Resolution [mm]:	2.33
	Upper	Volume [%]	0.0	Dose [cGy]:	6300.0	Priority:	800
	Upper		10.0		6200.0		700
	Lower	Volume [%]	95.0	Dose [cGy]:	5992.0	Priority:	800
	Lower		100.0		5900.0		1000
<input checked="" type="checkbox"/>	Rectum	Volume [cc]	105	Points:	3509	Resolution [mm]:	3.00
	Upper	Volume [%]	48.0	Dose [cGy]:	3700.0	Priority:	200
	Upper		26.0		4500.0		200
<input checked="" type="checkbox"/>	Rectum-PTV	Volume [cc]	77	Points:	2569	Resolution [mm]:	3.00
	Upper	Volume [%]	0.0	Dose [cGy]:	5000.0	Priority:	400
<input checked="" type="checkbox"/>	Uterus	Volume [cc]	1670	Points:	55662	Resolution [mm]:	3.00
	Upper	Volume [%]	0.0	Dose [cGy]:	4600.0	Priority:	300
<input checked="" type="checkbox"/>	Small Intestine	Volume [cc]	2964	Points:	98791	Resolution [mm]:	3.00
	Upper	Volume [%]	48.0	Dose [cGy]:	1900.0	Priority:	200
	Upper		24.0		3200.0		200
<input checked="" type="checkbox"/>	Spinal Cord	Volume [cc]	37	Points:	2000	Resolution [mm]:	2.55
	Upper	Volume [%]	0.0	Dose [cGy]:	2500.0	Priority:	600
<input checked="" type="checkbox"/>	Stomach	Volume [cc]	158	Points:	5272	Resolution [mm]:	3.00
	Upper	Volume [%]	40.0	Dose [cGy]:	1300.0	Priority:	50
	Upper		20.0		2265.0		50

Rapid-ARC计划



1个等中心旋转照射野：15MV X线， 179.9° - 180.1° ，逆时针方向旋转
15MV X线， 180.1° - 179.9° ，顺时针方向旋转

优化条件 (ARC)

Optimization - test-lujie, (1608229), ()

Structures and Objectives

Use Normal Tissue Objective Priority: 150 Define Settings...

Exclude Structures...

Structure	Volume [cc]	Points	Resolution [mm]
<input checked="" type="checkbox"/> Bladder	480	16006	3.00
Upper	Volume [%]: 50.0	Dose [cGy]: 4000.0	Priority: 200
Upper	30.0	4500.0	200
<input checked="" type="checkbox"/> Bladder-PTV	Volume [cc]: 388	Points: 12930	Resolution [mm]: 3.00
Upper	Volume [%]: 0.0	Dose [cGy]: 5000.0	Priority: 400
<input checked="" type="checkbox"/> Body	Volume [cc]: 25974	Points: 256536	Resolution [mm]: 4.50
<input checked="" type="checkbox"/> CTV1	Volume [cc]: 890	Points: 29671	Resolution [mm]: 3.00
Lower	Volume [%]: 100.0	Dose [cGy]: 5040.0	Priority: 1000
<input checked="" type="checkbox"/> Dose 5544[cGy]	Volume [cc]: 60	Points: 2000	Resolution [mm]: 3.00
<input checked="" type="checkbox"/> Femoral Head L	Volume [cc]: 41	Points: 2000	Resolution [mm]: 2.65
Upper	Volume [%]: 0.0	Dose [cGy]: 4300.0	Priority: 150
<input checked="" type="checkbox"/> Femoral Head R	Volume [cc]: 38	Points: 2000	Resolution [mm]: 2.58
Upper	Volume [%]: 5.0	Dose [cGy]: 4300.0	Priority: 150
<input checked="" type="checkbox"/> GTV1	Volume [cc]: 3	Points: 2000	Resolution [mm]: 1.13
Lower	Volume [%]: 100.0	Dose [cGy]: 5992.0	Priority: 1000
<input checked="" type="checkbox"/> Int-5040	Volume [cc]: 99	Points: 3298	Resolution [mm]: 3.00
Upper	Volume [%]: 0.0	Dose [cGy]: 4800.0	Priority: 300
<input checked="" type="checkbox"/> Ileum	Volume [cc]: 240	Points: 8011	Resolution [mm]: 3.00
Upper	Volume [%]: 42.0	Dose [cGy]: 2500.0	Priority: 200
Upper	24.0	3200.0	150
<input checked="" type="checkbox"/> Kidney L	Volume [cc]: 158	Points: 5265	Resolution [mm]: 3.00
Upper	Volume [%]: 30.0	Dose [cGy]: 1300.0	Priority: 350

优化条件 (ARC)

Structures and Objectives

Use Normal Tissue Objective Priority: 150 Define Settings...

Exclude Structures...

Structure	Objective	Value	Dose [cGy]	Points	Resolution [mm]	Priority
Kidney R	Upper	Volume [%]: 17.0	2000.0		3.00	150
		Volume [cc]: 166		5520		
Liver	Upper	Volume [%]: 25.0	1400.0		3.00	300
	Upper	15.0	2200.0			150
		Volume [cc]: 716		23860		
PCTV	Upper	Volume [%]: 30.0	1400.0		3.00	100
		Volume [cc]: 1869		62287		
PCTV-PGTV	Upper	Volume [%]: 0.0	6000.0		3.00	700
	Upper	10.0	5300.0			700
	Lower	Volume [%]: 95.0	5040.0		3.00	800
	Lower	100.0	4950.0			1000
PGTV	Upper	Volume [%]: 0.0	5200.0		3.00	500
		Volume [cc]: 28		2000		
Rectum	Upper	Volume [%]: 0.0	6300.0		3.00	800
	Upper	10.0	6200.0			700
	Lower	Volume [%]: 95.0	5992.0		3.00	800
	Lower	100.0	5950.0			1000
Rectum-PTV		Volume [cc]: 105		3509		
	Upper	Volume [%]: 48.0	3700.0		3.00	200
	Upper	26.0	4500.0			200

优化条件 (ARC)

Structures and Objectives

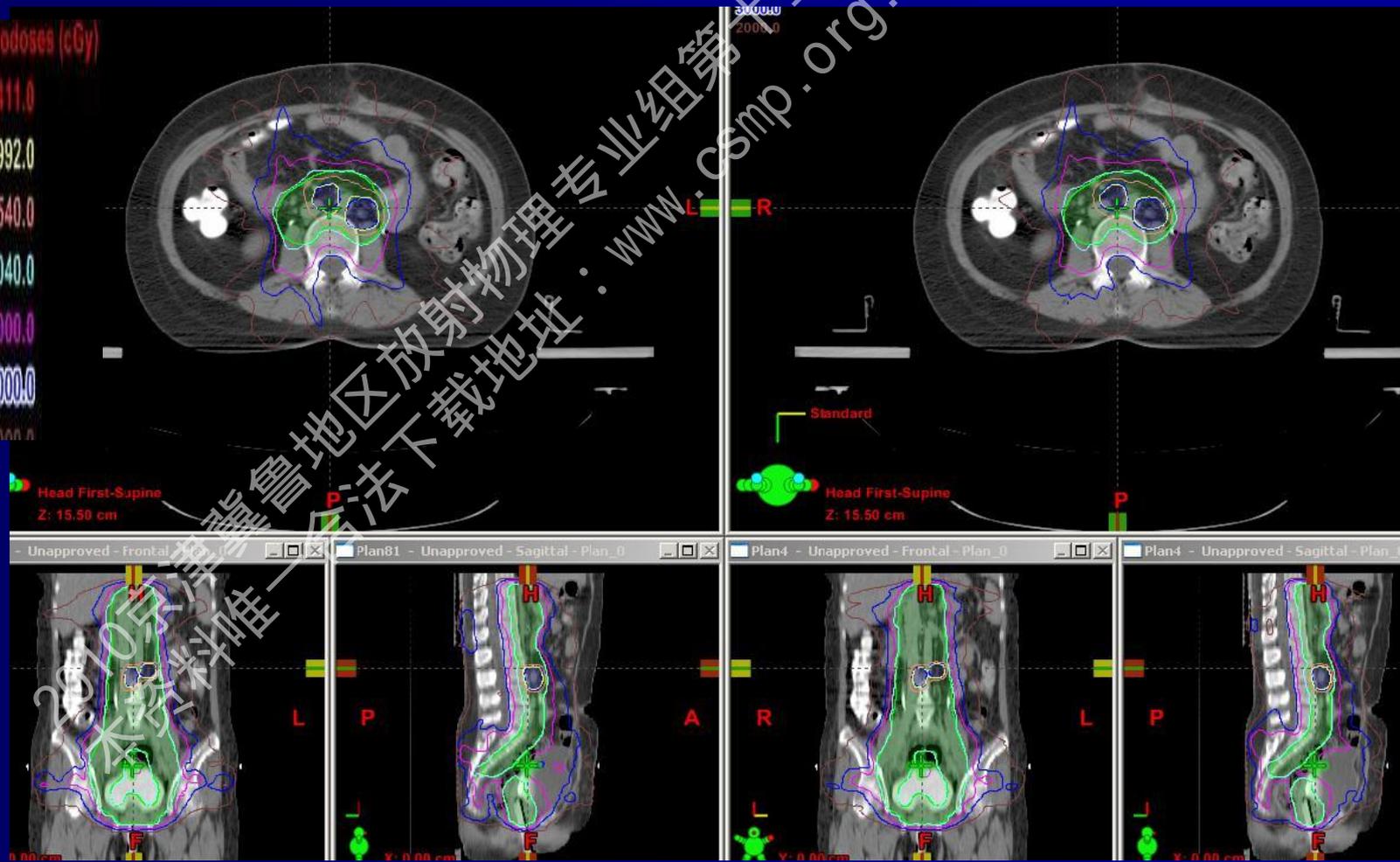
Use Normal Tissue Objective Priority: 150 Define Settings...

Exclude Structures...

	Upper	Volume [%]:	0.0	Dose [cGy]:	5200.0	Priority:	500
<input checked="" type="checkbox"/>	PGTV	Volume [cc]:	28	Points:	2000	Resolution [mm]:	2.33
	Upper	Volume [%]:	0.0	Dose [cGy]:	6300.0	Priority:	800
	Upper	Volume [%]:	10.0	Dose [cGy]:	6200.0	Priority:	700
	Lower	Volume [%]:	95.0	Dose [cGy]:	5992.0	Priority:	800
	Lower	Volume [%]:	100.0	Dose [cGy]:	5950.0	Priority:	1000
<input checked="" type="checkbox"/>	Rectum	Volume [cc]:	105	Points:	3509	Resolution [mm]:	3.00
	Upper	Volume [%]:	48.0	Dose [cGy]:	3700.0	Priority:	200
	Upper	Volume [%]:	26.0	Dose [cGy]:	4500.0	Priority:	200
<input checked="" type="checkbox"/>	Rectum-PTV	Volume [cc]:	77	Points:	2569	Resolution [mm]:	3.00
	Upper	Volume [%]:	0.0	Dose [cGy]:	5000.0	Priority:	400
<input checked="" type="checkbox"/>	ring	Volume [cc]:	1670	Points:	55662	Resolution [mm]:	3.00
	Upper	Volume [%]:	0.0	Dose [cGy]:	4600.0	Priority:	300
<input checked="" type="checkbox"/>	Small Intestine	Volume [cc]:	2964	Points:	98791	Resolution [mm]:	3.00
	Upper	Volume [%]:	48.0	Dose [cGy]:	1900.0	Priority:	200
	Upper	Volume [%]:	24.0	Dose [cGy]:	3200.0	Priority:	200
<input checked="" type="checkbox"/>	Spinal Cord	Volume [cc]:	37	Points:	2000	Resolution [mm]:	2.55
	Upper	Volume [%]:	0.0	Dose [cGy]:	2500.0	Priority:	600
<input checked="" type="checkbox"/>	Stomach	Volume [cc]:	158	Points:	5272	Resolution [mm]:	3.00
	Upper	Volume [%]:	40.0	Dose [cGy]:	1300.0	Priority:	50
	Upper	Volume [%]:	20.0	Dose [cGy]:	2265.0	Priority:	50

计划结果分析 (靶区)

一个等中心和两个等中心计划比较



中国物理学会
放射物理专业委员会第十五次学术会议
www.csmf.org.cn

计划结果分析 (靶区)



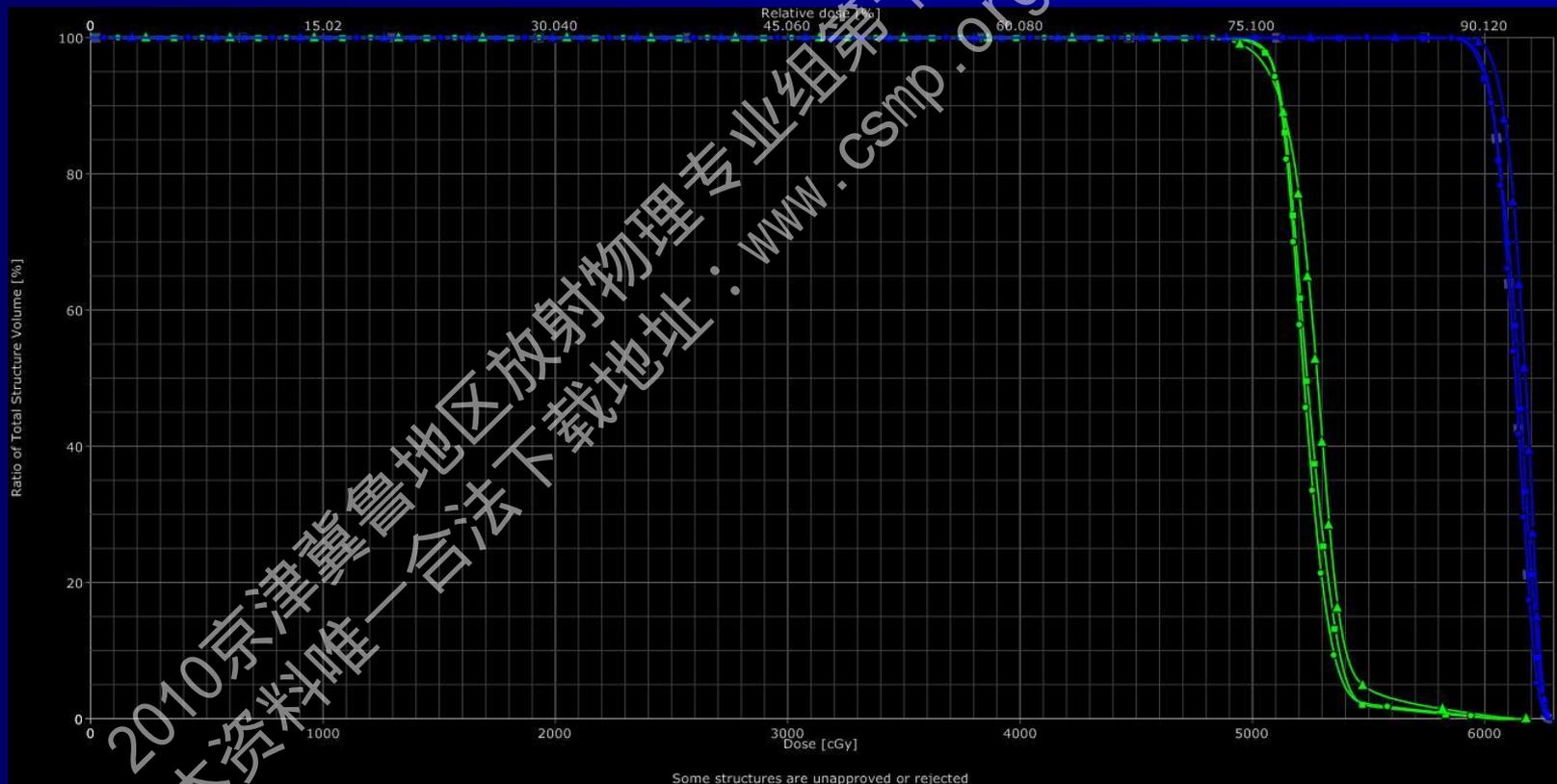
一个等中心计划

两个等中心计划

ARC计划

2010京津鲁豫地区放射物理专业组第十五次学术会议
www.csmp.org.cn
本资料唯一合法下载地址

计划结果分析 (靶区)

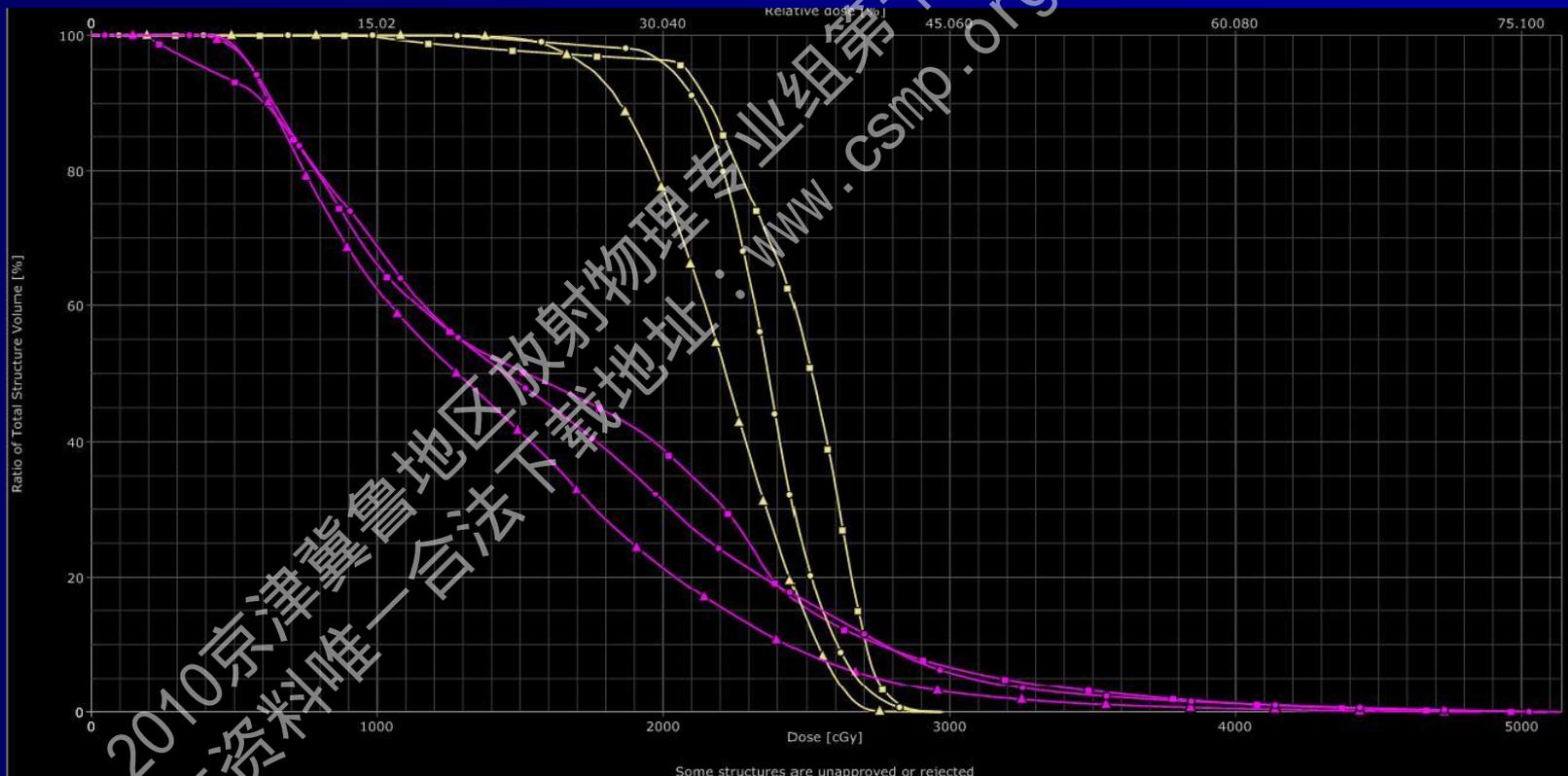


三个计划比较

计划结果分析（靶区）

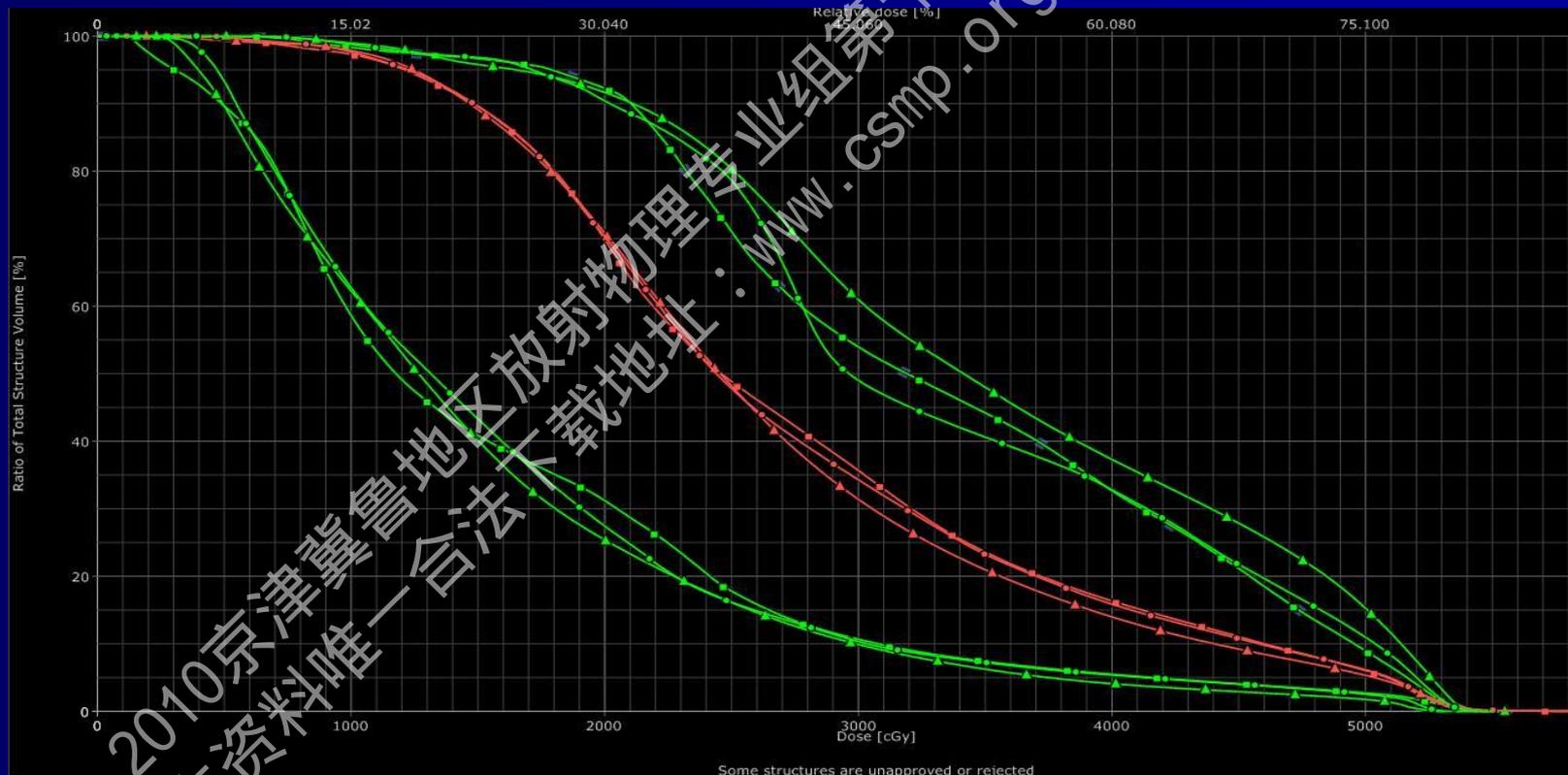
		目标 函数	实际值		
			1个中心	2个中心	ARC
PGTV	Dmax (cGy) <	6411	6294	6291	6296
	Dmin (cGy) >	5872	5819	5811	5852
	Dmean (cGy) <	6292	6125	6135	6165
PCTV	Dmax (cGy)	6411	6135	6123	6202
	Dmin (cGy) >	4788	4627	4715	4557
PCTV- PGTV	Dmean (cGy) <	5292	5222	5240	5263
	Dmax (cGy) <	5544	5746 (0.01)	5832 (0.6)	5818 (0.01)

计划结果分析 (胃、脊髓)



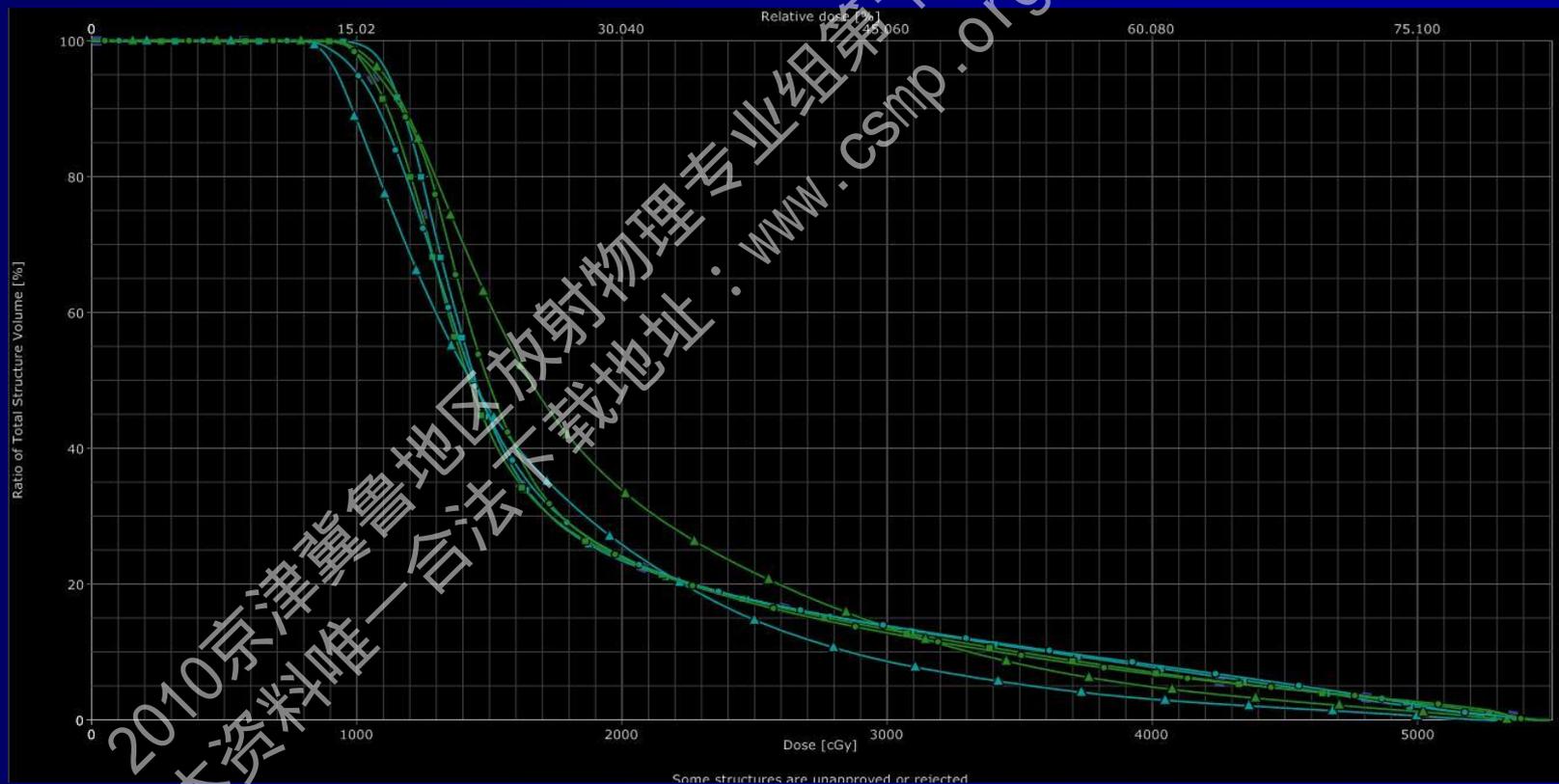
三个计划比较 (三角表示ARC, 圆点表示一个等中心, 方块表示两个等中心计划)

计划结果分析 (肝、小肠、骨髓)



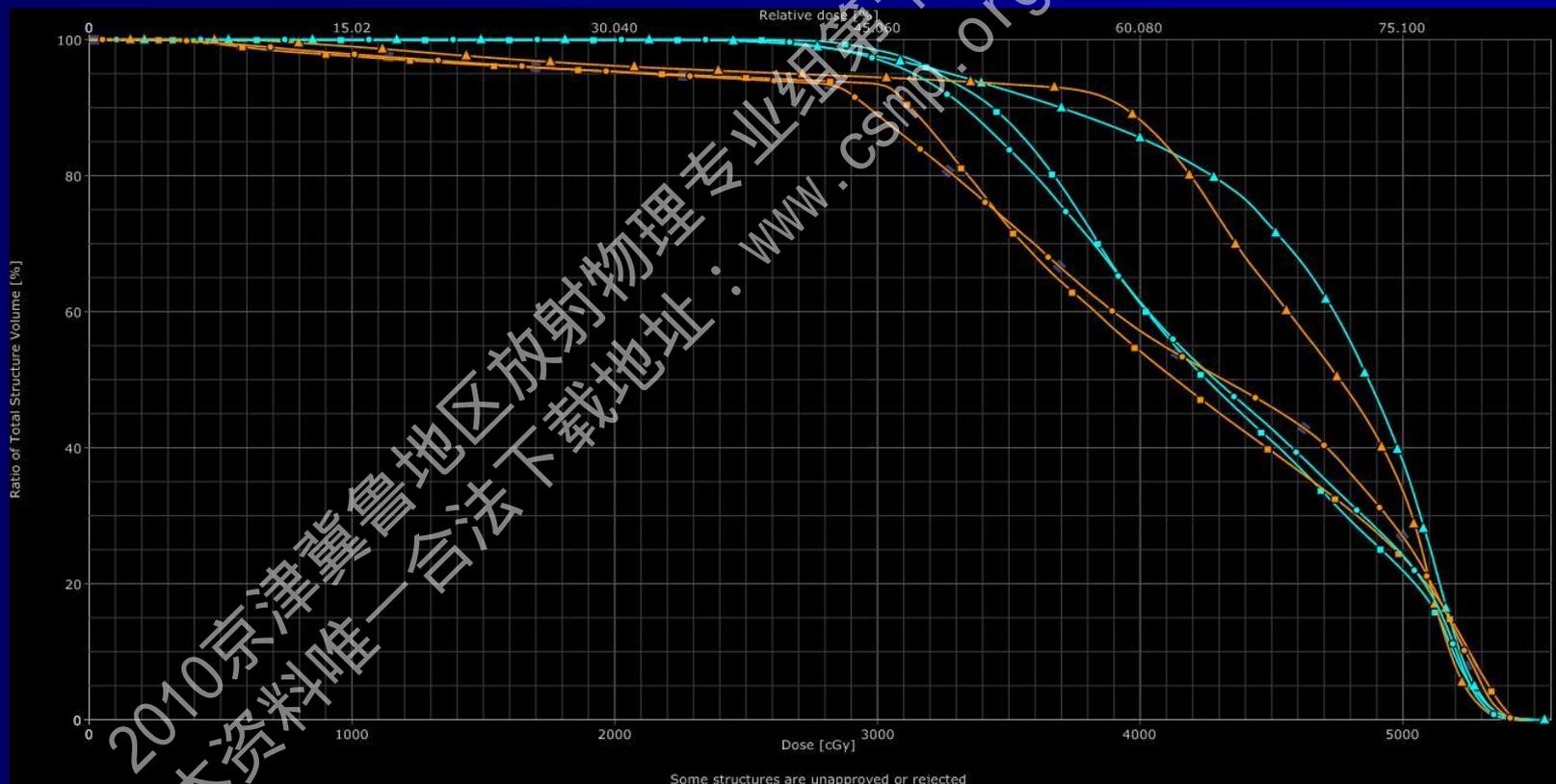
三个计划比较

计划结果分析 (左右肾)



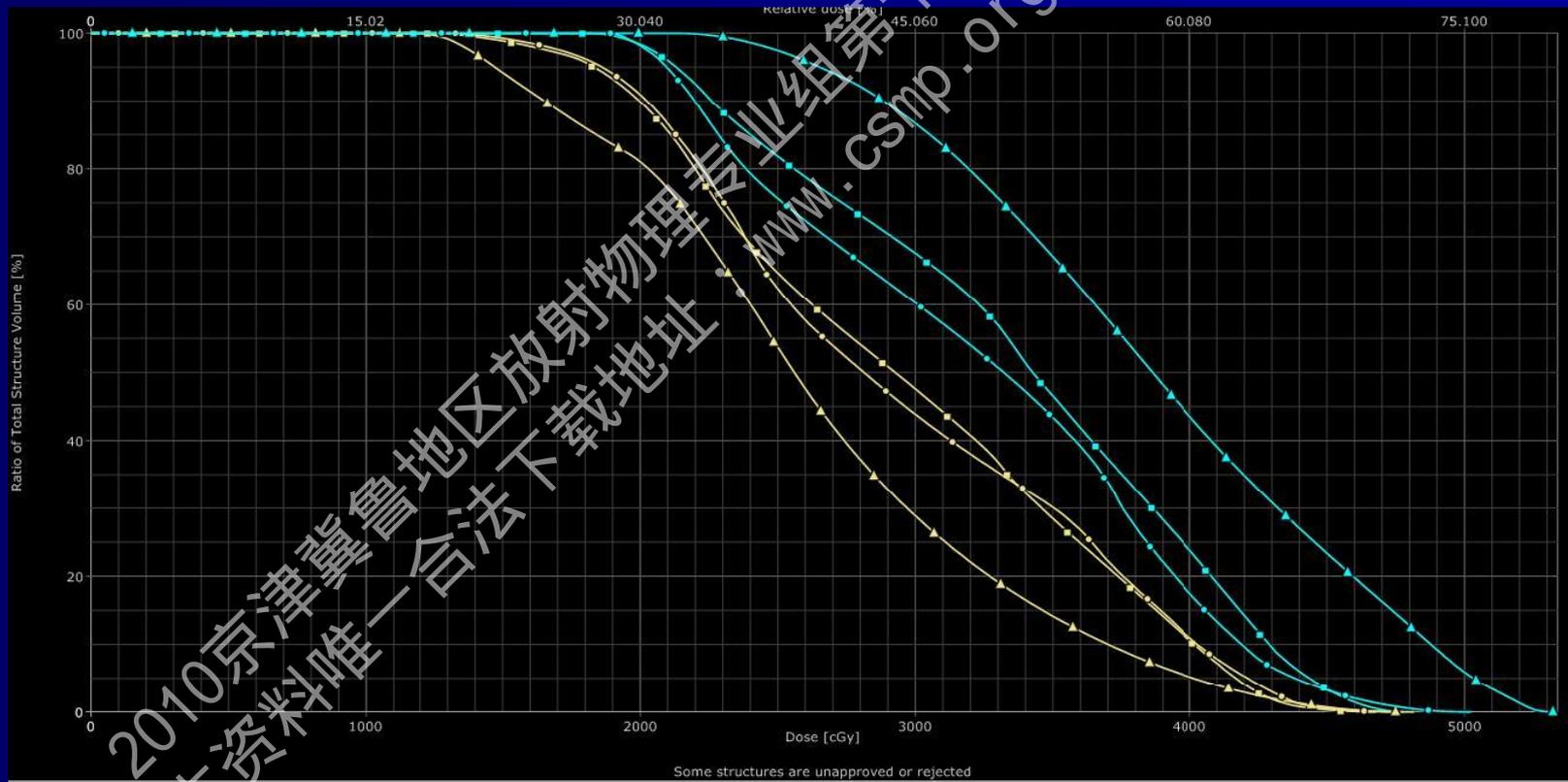
三个计划比较

计划结果分析 (膀胱、直肠)



三个计划比较

计划结果分析（左右股骨头）



三个计划比较

计划结果分析（危及器官）

	目标函数	实际值		
		1个中心(Gy)	2个中心(Gy)	ARC(Gy)
spinal cord	V30Gy<0.1cc	0	0	0
stomach	V15-20<50%	14.5	15.2	12.8
Kidney R&L	V15-18<33%	17.0/16.9	16.5/16.6	17.8/20.2
Liver	V15-20<33%	18.1	19.2	17.0
Femoral Head R&L	V45-50<5%	42.1/43.9	41.7/44.4	40.1/50.3
Illeum	V30-35<50%	29.6	31.9	34.1

计划结果分析（危及器官）

	目标值	实际值		
		1个中心	2个中心	ARC
Small Intestine	V30<40% V25<50%	34% 48%	36% 49%	31% 48%
Rectum	V40-45<50%	43.2Gy	41.3Gy	47.6Gy
Bladder	V40-45<50%	42.9Gy	42.5Gy	48.7Gy
Rectum sub PCTV	V50.4Gy<1cc	1.7cc	0.1cc	9cc
Bladder sub PCTV	V50.4Gy<1cc	4.6cc	2.4cc	18cc

计划结果分析

	1个中心	2个中心	ARC
子野数	748	1134	354
总MU	1490	1453	554
照射时间	15-20分钟	2倍调强	3分钟

小结

- 静态调强计划均满足临床目标函数要求
 - 两个等中心计划：增加了子野数目及摆位复杂性
- ARC计划：在降低正常组织受量方面没有明显优势，但显著减少机器跳数，缩短照射时间

山东省肿瘤医院

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