

北京大学第三医院2012年物理工作汇报

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中国医学物理分会京津冀鲁晋地区
放射物理专业组第二十次学术会议

2013. 1. 19

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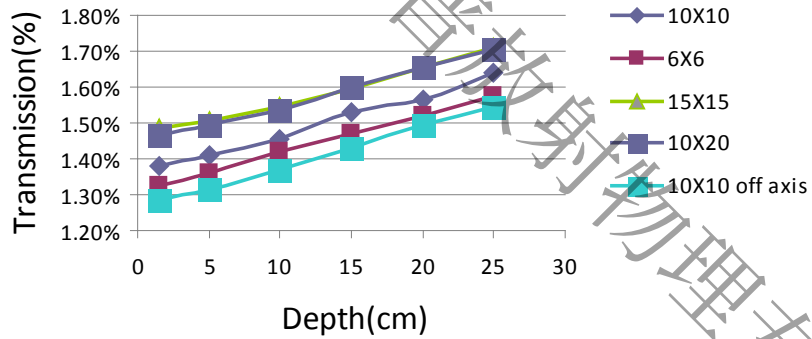
- ❖ 剂量验证：准确性、效率
- ❖ 计划设计：计划质量和实施效率评价
- ❖ 粒子植入

剂量验证

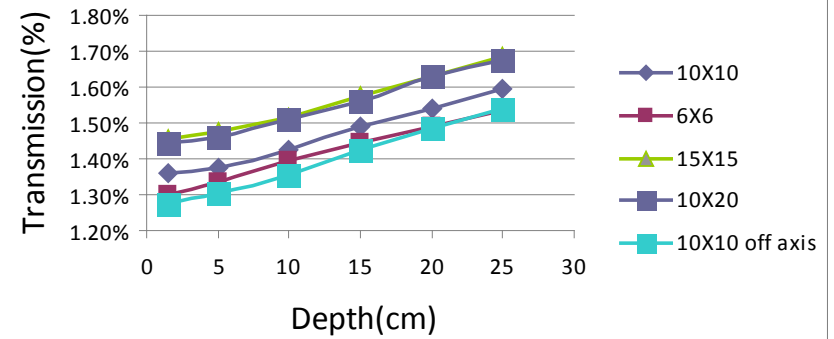
病例	能量 (MV)	Gamma 通过率				等中心点剂量 (cGy)		
		2% / 2 mm		3% / 3 mm		修改前	修改后	测量
		修改前	修改后	修改前	修改后			
鼻咽癌	6	64.2		88.5		125.8		129.3
鼻咽癌	6	32.0		84.3		145.7		150.0
宫颈癌	10	81.5		99.6		184.7		187.9
宫颈癌	10	76.5		97.4		190.1		193.5
乳腺癌	6	83.5		96.3		128.0		130.6
乳腺癌	6	96.8		99.6		137.8		140.8
肺癌	6	75.0		88.7		198.2		197.8
肺癌	6	93.5		99.8		151.5		151.2
脑转移	6	92.4		99.4		150.2		151.4
骨转移	10	95.7		99.1		273.3		274.7

MLC叶片平均透射

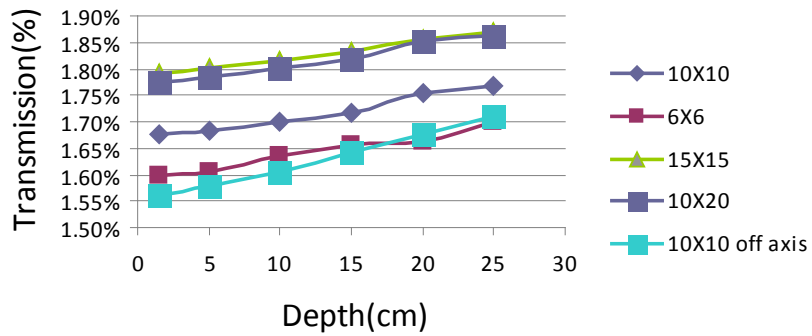
6MV Bank A



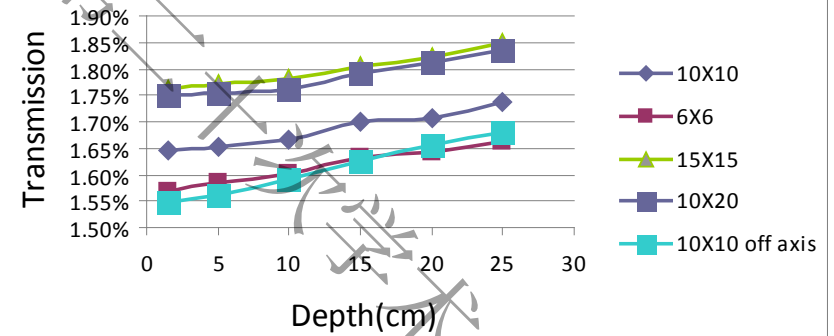
6MV Bank B



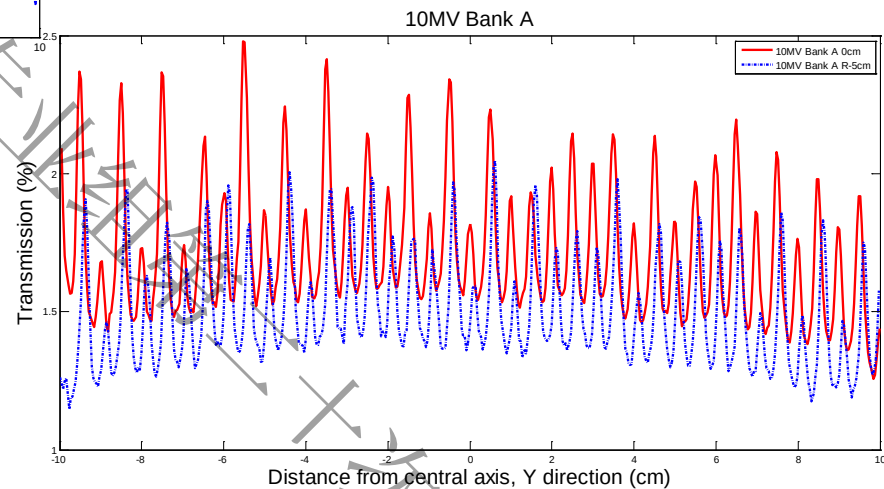
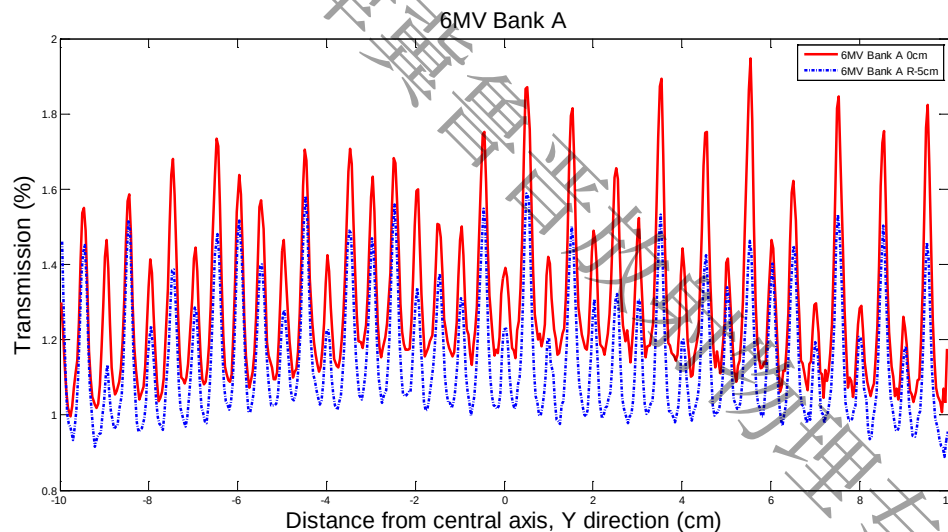
10MV Bank A



10MV Bank B

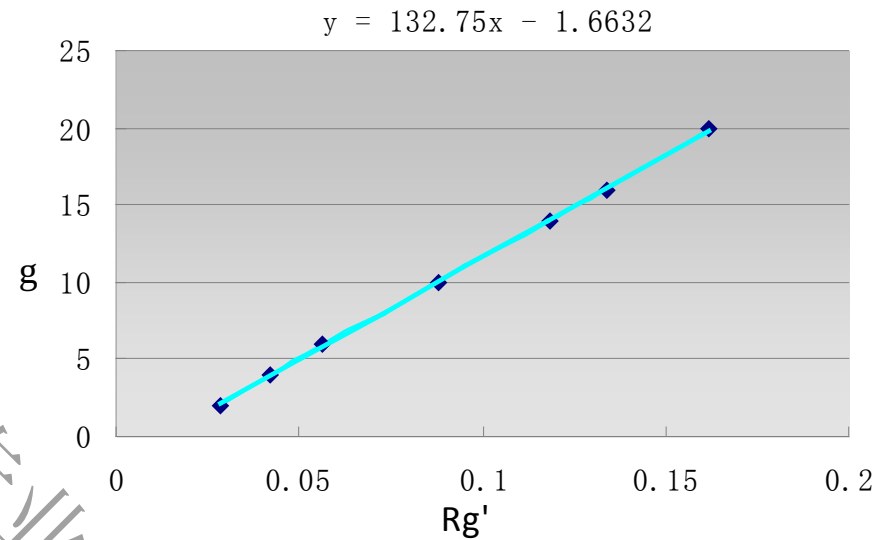
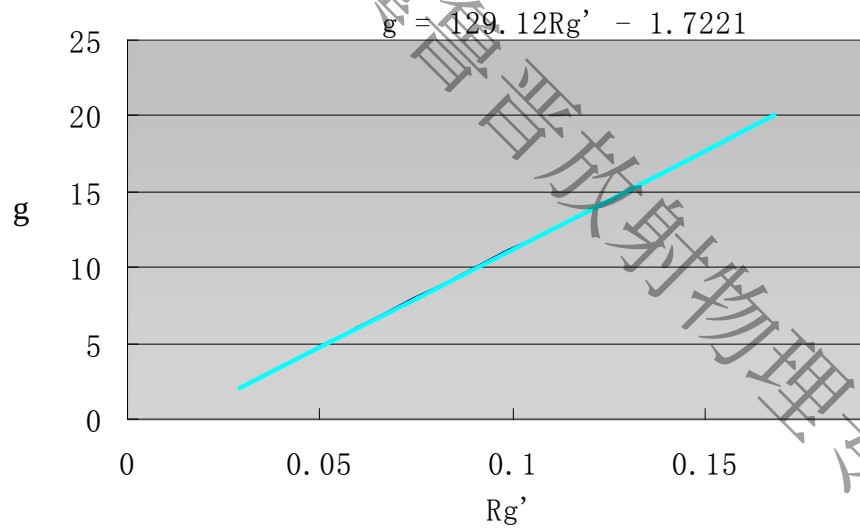


MLC叶片内和叶片间透射



- ❖ **6 MV X射线叶片内透射约为0.8 % -1.2 %，叶片间透射约为1.3 % -1.9 %**
- ❖ **10 MV X射线叶片内透射约为1.1 % -1.6 %，叶片间透射约为1.6 % -2.5 %**

Dosimetric leaf gap



❖ **6 MV和10 MV X射线DLG: 1.66 mm和1.72 mm**

患者调强剂量验证—MLC模拟参数

	叶片平均透射		DLG	
	6 MV	10 MV	6 MV	10 MV
初始	1.30 %	1.50 %	1.50 mm	1.80 mm
测量	1.60 %	1.80 %	1.66 mm	1.72 mm

Explanations for Failures

Explanation	Minimum # of occurrences
Incorrect output factors in TPS	1
Incorrect PDD in TPS	1
IMRT plan that exceeds linac capabilities	3
Software error	1
Inadequacies in beam modeling at leaf ends (Cadman <i>et al</i> , PMB 2002)	14
QA technique	3
Couch indexing errors with Peacock system	3
Equipment performance	2
Setup errors	7

多叶准直器透射及其对调强放疗剂量计算准确性的影响

病例	能量 (MV)	Gamma 通过率				等中心点剂量 (cGy)		
		2% / 2 mm		3% / 3 mm		修改前	修改后	测量
		修改前	修改后	修改前	修改后			
鼻咽癌	6	64.2	64.3	88.5	93.6	125.8	128.1	129.3
鼻咽癌	6	32.0	51.8	84.3	94.5	145.7	146.9	150.0
宫颈癌	10	81.5	90.5	99.6	99.9	184.7	185.9	187.9
宫颈癌	10	76.5	78.5	97.4	97.8	190.1	190.3	193.5
乳腺癌	6	83.5	95.4	96.3	99.1	128.0	129.7	130.6
乳腺癌	6	96.8	97.0	99.6	99.6	137.8	137.9	140.8
肺癌	6	75.0	98.4	88.7	100.0	198.2	199.4	197.8
肺癌	6	93.5	97.2	99.8	99.8	151.5	152.4	151.2
脑转移	6	92.4	96.0	99.4	99.7	150.2	150.8	151.4
骨转移	10	95.7	96.0	99.1	99.1	273.3	273.4	274.7

电子射野影像系统用于调强放疗剂量验证的研究

Portal Dosimetry



Varian aS1000

2D Array

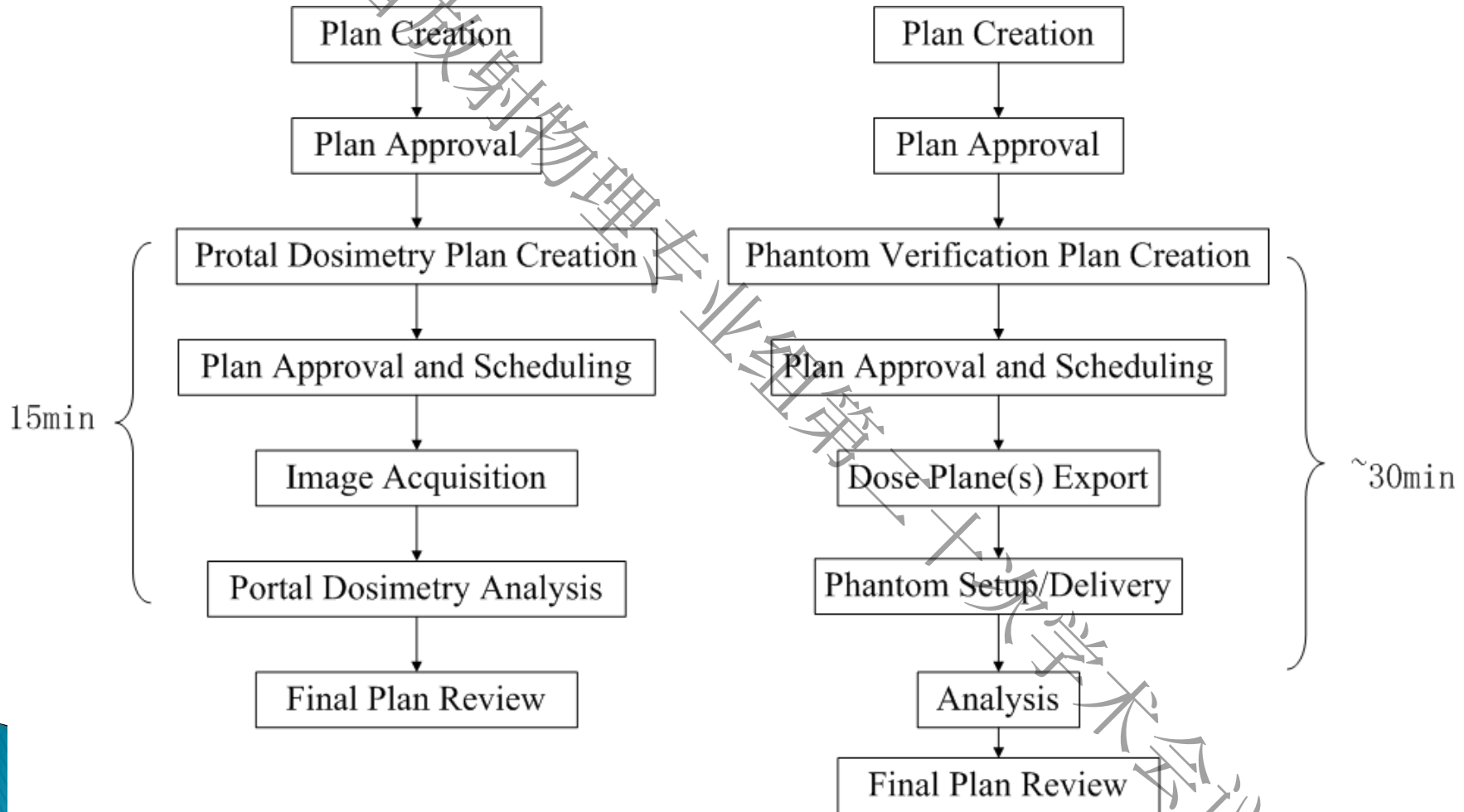


IBA MatriXX/Compass

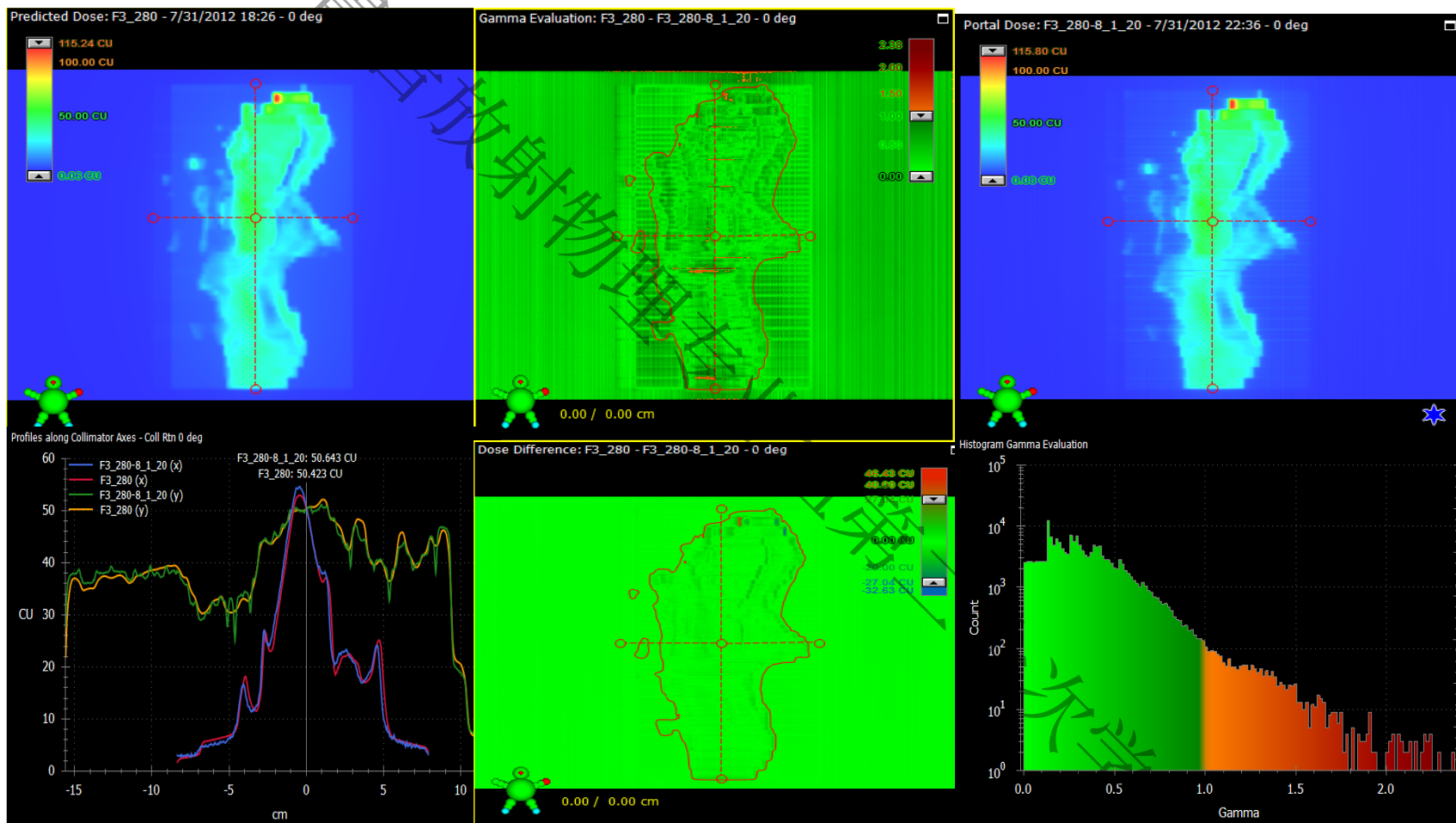
Portal Dosimetry Workflow

Portal Dosimetry

2D Array



电子射野影像系统用于调强放疗剂量验证的研究



鼻咽癌: 9 野 IMRT, Gamma 通过率 97.9%, 3%/3mm, 10%

电子射野影像系统用于调强放疗剂量验证的研究

10例患者使用aS1000和MatriXX调强验证的伽玛通过率(%，±)

方法	2%/2mm	3%/3mm	4%/4mm	平均伽玛值3%/3 mm
aS1000	85.16±8.02	95.82±3.47	98.93±1.28	0.40(0.38-0.42)
MatriXX	92.56±6.06	99.08±1.22	99.88±0.16	0.35(0.32-0.37)

10例患者使用aS1000和MatriXX调强验证时间（min）

方法	计划时间	摆位时间	数据采集时间	结果分析时间	合计
aS1000	1.3	1.0	8.7	1.7	12.7
MatriXX	11.7	21.0	10.5	4.6	47.8

电子射野影像系统用于调强放疗剂量验证的研究

- ❖ **aS1000**用于调强放疗患者剂量验证
 - 不需要采购第三方设备
 - 探测器方向性和体积效应
 - **aS1000**探测范围大、分辨率高
 - 计划、摆位、照射、分析方便快捷
 - 提高物理师工作效率、降低工作负荷

电子射野影像系统用于调强放疗剂量验证的研究

❖ **aS1000**验证治疗是否按计划准确实施

- 治疗计划传输错误
- 治疗实施误差:加速器机械和剂量学稳定性
机器输出变化、**MLC**运动叶片到位精度等

❖ **aS1000**不能验证计划系统剂量计算误差

- **PDIP**不使用临床剂量计算**AAA**
- 不计算患者或模体内剂量分布
- 质量保证需结合**TPS**验收测试

❖ **aS1000 (RIT113)**用于**MLC QA**、**RapidArc commissioning**

治疗计划设计

- ❖ 剂量学优势能否转化为临床获益
- ❖ 计划质量和实施效率评价：低剂量区
- ❖ 复杂技术简化：机器技术要求 and 效率

SmartArc-based volumetric modulated arc therapy for endometrial cancer: a dosimetric comparison with helical tomotherapy and intensity-modulated radiation therapy

Ruijie Yang, Ph.D.,*[§] Junjie Wang, M.D.,* Shouping Xu, Ph.D.

Purpose: To investigate the feasibility of volumetric modulated arc therapy with SmartArc (VMAT-S) for endometrial cancer to achieve equivalent plan quality with higher delivery efficiency, against with intensity-modulated radiotherapy (IMRT) and helical tomotherapy (HT).

Methods and Materials: Nine patients with endometrial cancer were retrospectively studied. Three plans were generated with 2 arcs VMAT-S, nine-field IMRT and HT for each patient. The dose distribution of PTV, organs at risk (OARs) and normal tissue were compared. The monitor units (MUs) and treatment delivery time were also evaluated.

Results: The average homogeneity index was 1.06, 1.10 and 1.07 for VMAT-S, IMRT and HT plans. The V_{40} of rectum, bladder and pelvis bone decreased 9.0%, 3.0%, and 3.0% in VMAT-S compared with IMRT, respectively. The target coverage and OARs sparing were comparable between VMAT-S and HT. The average MU was 823, 1105 and 8403 for VMAT-S, IMRT and HT. The average delivery time was 2.6 minutes, 8.6 minutes, and 9.5 minutes.

Conclusion: VMAT-S provided comparable plan quality with significant shorter delivery time and less MUs compared with IMRT and HT for endometrial cancer. In addition, more homogeneous PTV coverage and superior OARs sparing in the medium to high dose region were observed in VMAT-S over IMRT.

[Key words] Endometrial cancer; Volumetric modulated arc therapy; Intensity-modulated radiation therapy; Helical tomotherapy

SmartArc-based volumetric modulated arc therapy for endometrial cancer: a dosimetric comparison with helical tomotherapy and intensity-modulated radiation therapy

Table 2. Summary of PTV coverage data for VMAT-S, IMRT and HT plans

	PTV ₉₅	PTV ₁₀₀	PTV ₁₀₅	PTV ₁₁₀	D _{mean}	ID	CI	HI
	(%)	(%)	(%)	(%)	(Gy)	(Gy-L)		
Mean (VMAT-S)	99.82	95.10	40.50	0.00	52.01	53.13	0.89	1.06
Mean (IMRT)	99.91	95.60	67.10	5.30	52.51	53.92	0.87	1.10
<i>P</i>	0.53	0.68	0.03	0.01	0.51	0.32	0.07	0.01
Mean (HT)	99.61	95.80	16.70	0.20	51.45	52.87	0.87	1.07
<i>P</i>	0.37	0.83	0.00	0.71	0.08	0.17	0.06	0.25

Table 4. ID to OARs and NT for VMAT-S, IMRT and HT plans

Plans	VMAT-S		IMRT		HT		
Structures	Mean	Mean	Δ	<i>P</i>	Mean	Δ	<i>P</i>
	(Gy-L)	(Gy-L)	(Gy-L)		(Gy-L)	(Gy-L)	
Bowel	23.83	23.22	-0.61	0.35	23.45	-0.38	0.21
Rectum	3.18	3.34	0.16	0.36	3.26	0.08	0.32
Bladder	11.40	11.98	0.58	0.17	11.02	-0.38	0.20
Pelvic bones	36.60	36.10	-0.50	0.21	37.50	0.9	0.35
Normal tissue	262.30	258.50	-3.80	0.11	265.12	2.82	0.09

Feasibility study of volumetric modulated arc therapy with constant dose rate for endometrial cancer

Ruijie Yang*, Junjie Wang*[§], Feng Xu[†], Hua Li[‡], Xile Zhang*

Objective: To investigate the feasibility, efficiency, and delivery accuracy of volumetric modulated arc therapy with constant dose rate (VMAT-CDR) for whole pelvic radiotherapy of endometrial cancer.

Materials and methods: The nine-field intensity-modulated radiotherapy (IMRT), volumetric modulated arc therapy with variable dose rate (VMAT-VDR), and VMAT-CDR plans were created for 9 patients with endometrial cancer undergoing whole pelvic radiotherapy. The dose distribution of planning target volume (PTV), organs at risk (OARs) and normal tissue (NT) were compared. The monitor units (MUs) and treatment delivery time were also evaluated. For each VMAT-CDR plan, a dry run was performed to assess the dosimetric accuracy with MatriXX from IBA.

Results: Compared with IMRT, the VMAT-CDR plans delivered a slightly greater V_{20} of bowel, bladder, pelvis bone and normal tissue, but significantly decreased the dose to the high dose region of rectum and pelvis bone. The monitor units decreased from 1105 with IMRT to 628 with VMAT-CDR. The delivery time also decreased from 9.5 min to 3.2 min. Very similar dose distribution was found in the VMAT-VDR and VMAT-CDR plans. The average gamma pass rate was 95.6% at the 3%/3 mm criteria with MatriXX pre-treatment verification for nine patients.

Conclusions: Volumetric modulated arc therapy with constant dose rate can achieve comparable plan quality with significant shorter delivery time and smaller number of MUs compared with IMRT for endometrial cancer patients undergoing whole pelvic radiotherapy. It can be accurately delivered and be an alternative to IMRT on the linear accelerator without variable dose rate capability.

[Key words]: Volumetric modulated arc therapy; constant dose rate;

Feasibility study of volumetric modulated arc therapy with constant dose rate for endometrial cancer

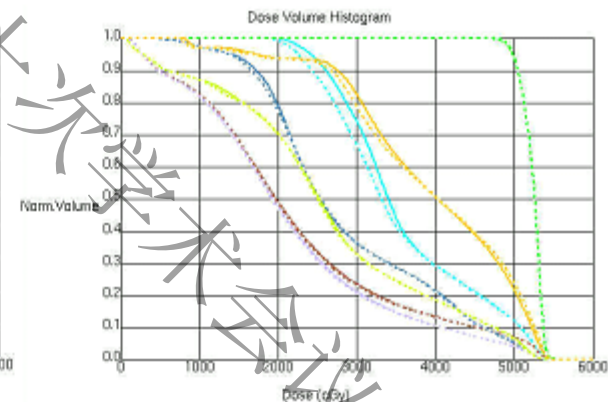
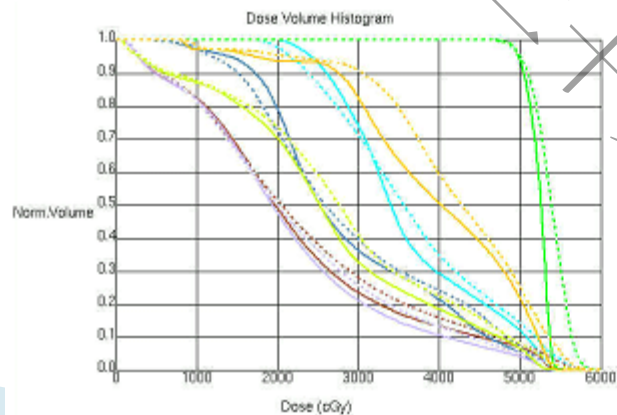
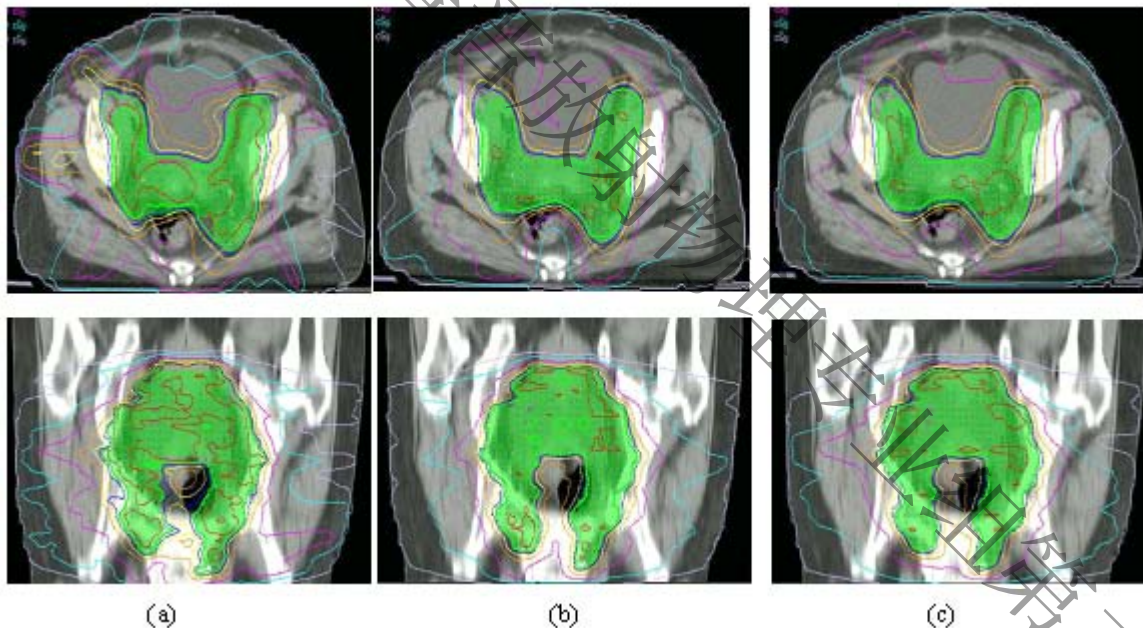
Table 2. Summary of PTV coverage data for IMRT, VMAT-VDR and VMAT-CDR plans

	PTV ₉₅	PTV ₁₀₀	PTV ₁₀₅	PTV ₁₁₀	D _{mean}	ID	CI	HI
	(%)	(%)	(%)	(%)	(Gy)	(Gy-L)		
Mean (VMAT-CDR)	99.31	95.80	52.1	0.20	52.91	55.87	0.87	1.07
Mean (IMRT)	99.91	95.60	67.10	5.30	52.51	53.92	0.87	1.10
<i>p</i>	0.13	0.06	0.03	0.03	0.17	0.10	0.35	0.03
Mean (VMAT-VDR)	99.82	95.10	40.50	0.00	52.01	53.13	0.89	1.06
<i>p</i>	0.25	0.11	0.00	0.21	0.31	0.08	0.09	0.31

Table 4. Mean integral dose to OARs and normal tissue for IMRT, VMAT-VDR and VMAT-CDR plans (Gy-L)

Structures	VMAT-CDR	IMRT	<i>p</i>	VMAT-VDR	<i>p</i>
Bowel	23.76	23.22	0.26	23.83	0.51
Rectum	3.21	3.34	0.31	3.18	0.60
Bladder	11.85	11.98	0.27	11.40	0.35
Pelvic bones	37.37	36.10	0.08	36.87	0.08
Normal tissue	265.81	258.50	0.07	262.30	0.10

Feasibility study of volumetric modulated arc therapy with constant dose rate for endometrial cancer



粒子植入

2012年度粒子植入手术量统计

手术部位	手术例数
头颈部	62
胸部	50
腹盆部	72
胰腺	22
前列腺	48
四肢	1

粒子植入

2012年度粒子植入手术量统计

手术部位	手术例数
头颈部	61
胸部	50
腹盆部	72
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前列腺	48
四肢	1



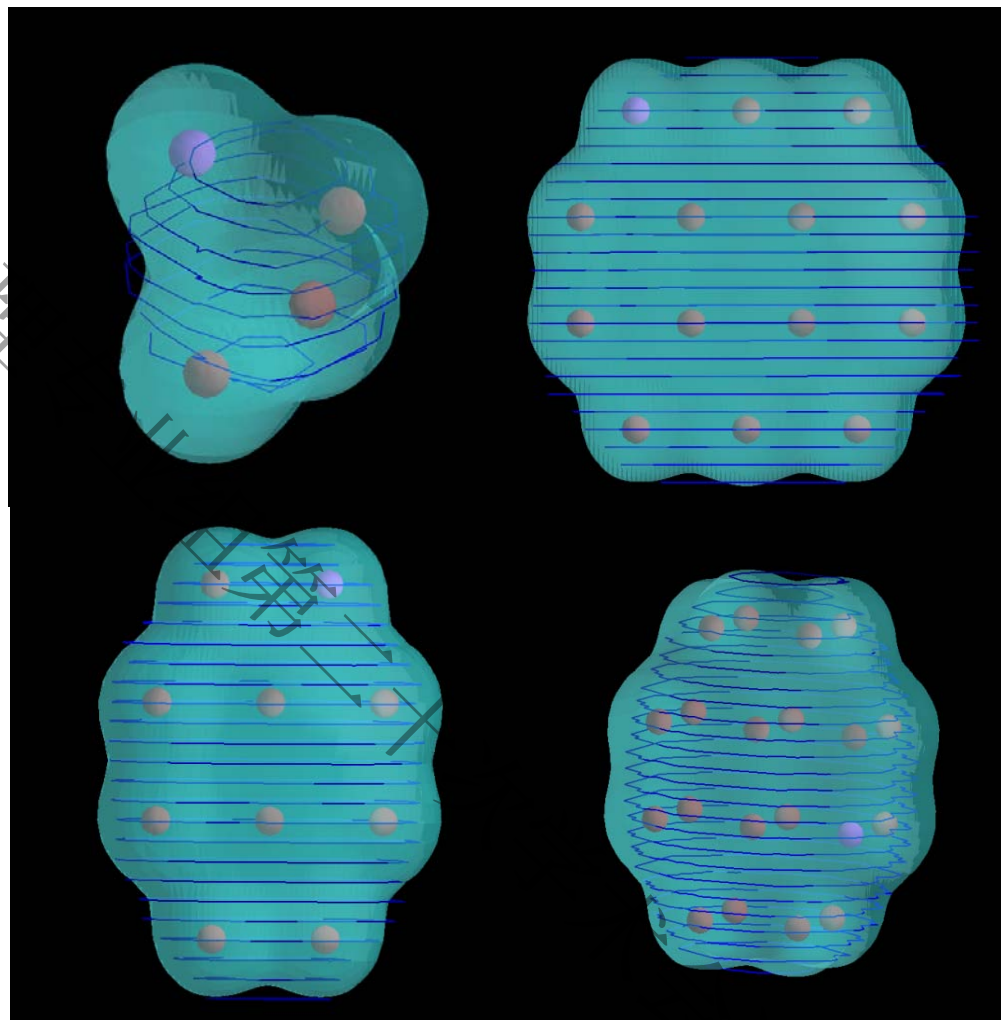
粒子植入

❖ 计划和植入分离

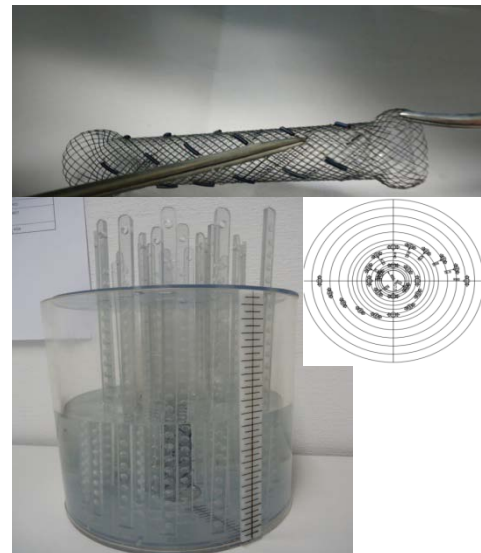
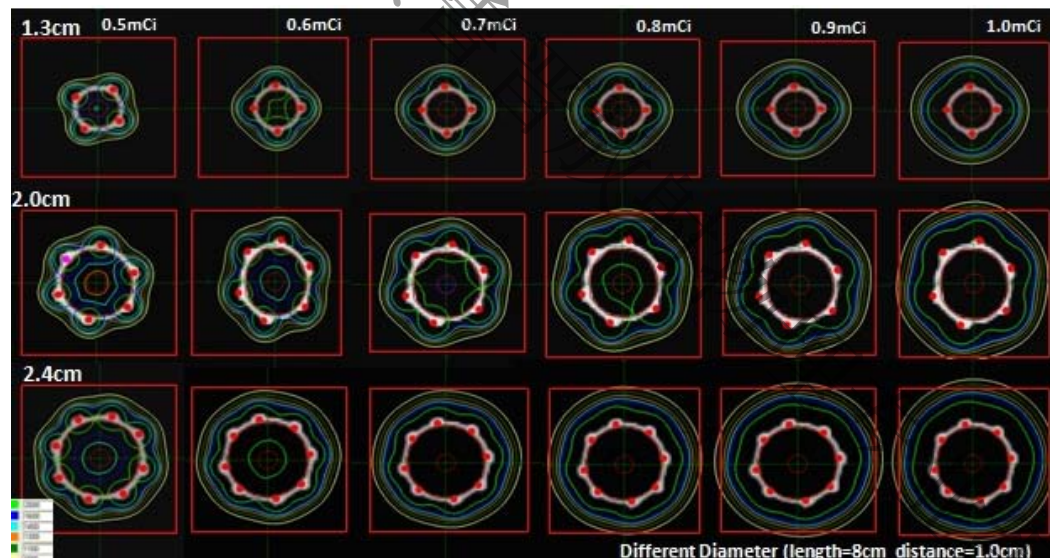
- ❖ ^{125}I 放射性粒子均匀性植入计划定制可行性研究
- ❖ 碘-**125**放射性粒子食管支架的剂量学研究
- ❖ 实时计划的 ^{125}I 放射性粒子植入技术研究
 - ❖ 模板
 - ❖ 时间

^{125}I 放射性粒子均匀性植入计划定制可行性研究

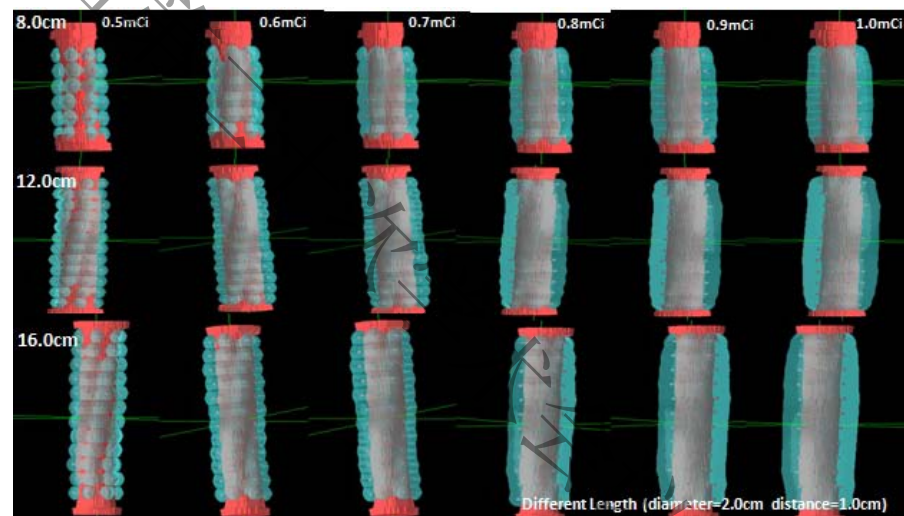
- ❖ 粒子间距0.75cm均匀植入比间距1cm均匀植入粒子活度更小，剂量分布均匀性、适形性更好，靶区外剂量更低



碘-125放射性粒子食管支架的剂量学研究



- ❖ 粒子间距1.0cm
- ❖ 粒子活度0.7mCi



北京大学第三医院2012年物理工作汇报

- ❖ 多叶准直器透射及其对调强放疗剂量计算准确性的影响
- ❖ 电子射野影像系统用于调强放疗剂量验证的研究
- ❖ **SmartArc-based volumetric modulated arc therapy for endometrial cancer: a dosimetric comparison with helical tomotherapy and intensity-modulated radiation therapy**
- ❖ **Feasibility study of volumetric modulated arc therapy with constant dose rate for endometrial cancer**
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- ❖ ^{125}I 放射性粒子均匀性植入计划定制可行性研究
- ❖ 实时计划优化的放射性粒子植入技术研究

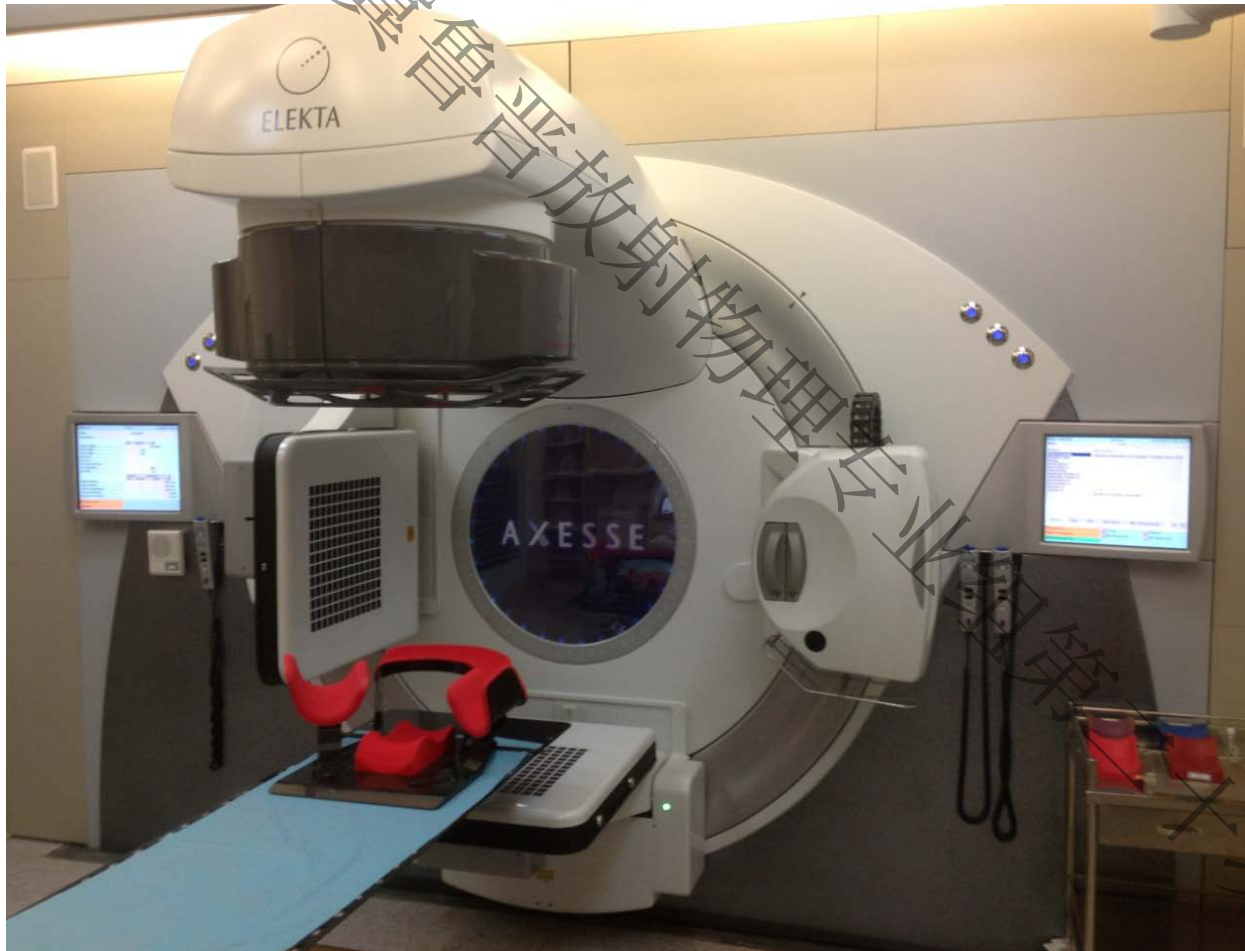
设备安装



Trilogy 安装和使用进程

- ❖ 11.28: 安装
- ❖ 2.1: 验收、数据采集、建模和调试
- ❖ 2.29: 第一例三维适形和电子线患者
- ❖ 3.5: 第一例IGRT患者
- ❖ 3.20: 第一例IMRT患者
- ❖ 5.18: 第一例RapidArc患者
- ❖ 5.29: 第一例Hypo-fractionated SBRT患者
- ❖ 12.31: ~500例患者

2013安装设备



- ❖ Simulix Evolution
- ❖ HDR
- ❖ Oncentra TPS
- ❖ Monaco TPS

致谢和祝福



Thank You !