

A review of RTTQA audit

Karen Venables

CHART 8 hours on the machine

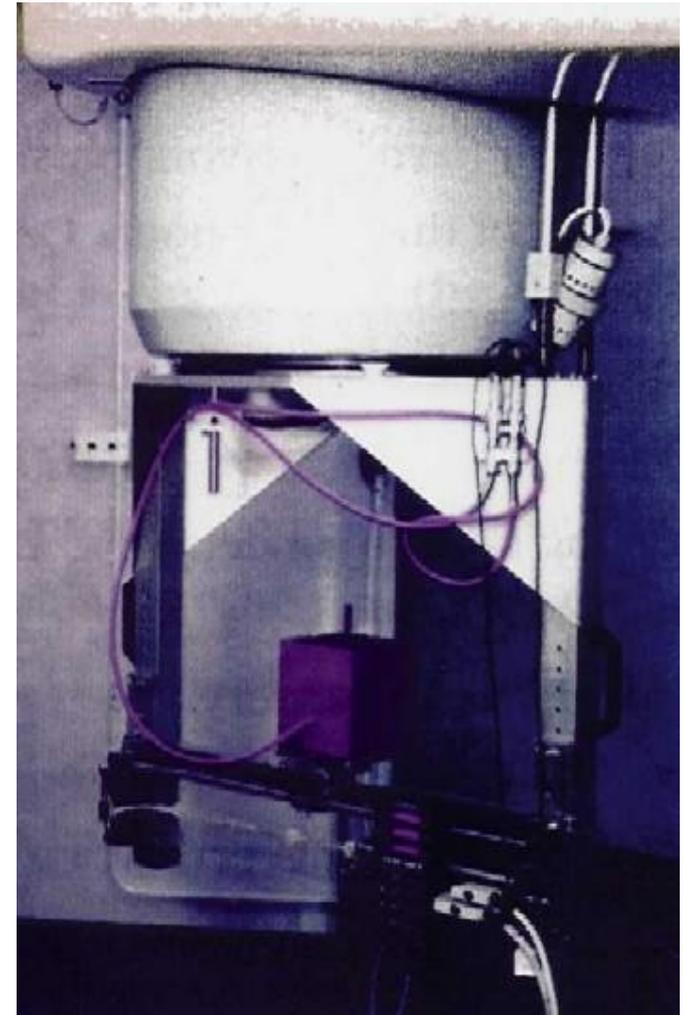


Chart cord

Table 5

Spinal cord dose, calculated vs. measured (mean doses (cGy))

Bronchus		Head and neck	
Measured	Calculated	Measured	Calculated
37.6 ± 11.3	34.3 ± 12.4	40.3 ± 20.7	37.3 ± 20.4
Difference:	3.3 ± 1.3		3.0 ± 1.4
(Paired mean ± SE)	$p < 0.025$		$p < 0.025$

CHART QA: Phantoms(1st use of anatomical phantoms)

- Designed for treatments in Bronchus and Head and Neck (2D only)
- Outlines sent to centre in advance of visit
- Phantom set up by centre staff
- Dose delivered and measured promptly (using semi-flex-0.125cc- ion chamber) by visiting staff

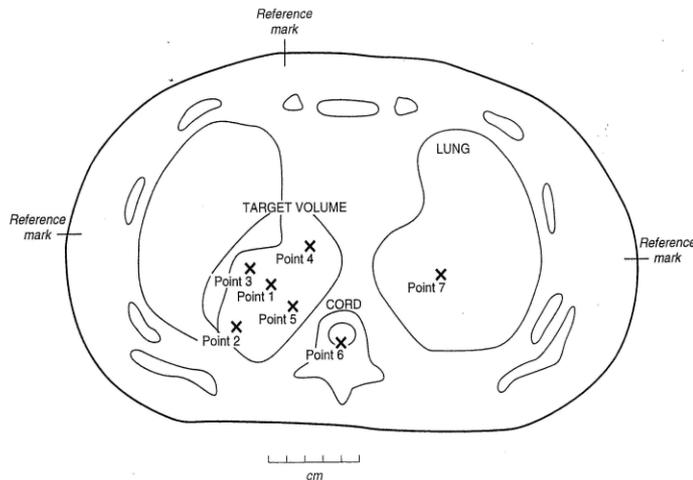
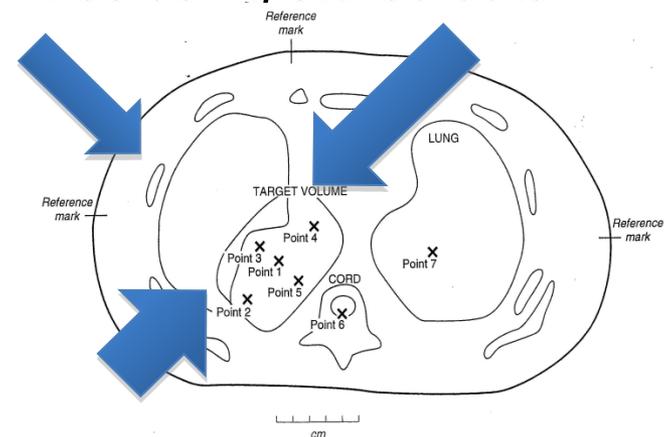


CHART QA; some results of phantom measurements

- Dose delivered to the prescription point within 4% of 1.5Gy
- Variation of dose across volume: 5%
- Variation of dose to critical structures: very dependent on planning method.....
- Dose to spinal cord lower in non-UK centres where only 2 fields (opposed pair) were used instead of 3 fields in UK
- Correction for lung: quite good! (most centres using stored data with bulk correction)



START QA Visit

- Measured dose to prescription point: average = 0.985
- Cobalt60
- Incorrect normalisation point

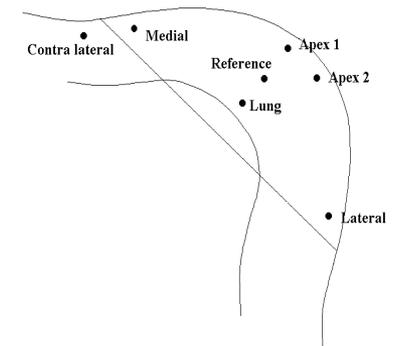
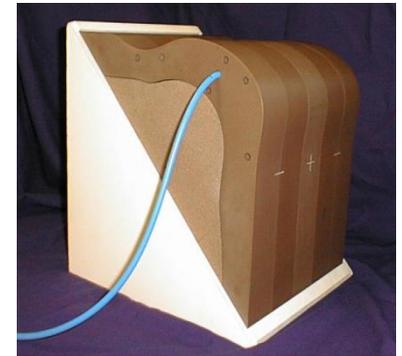
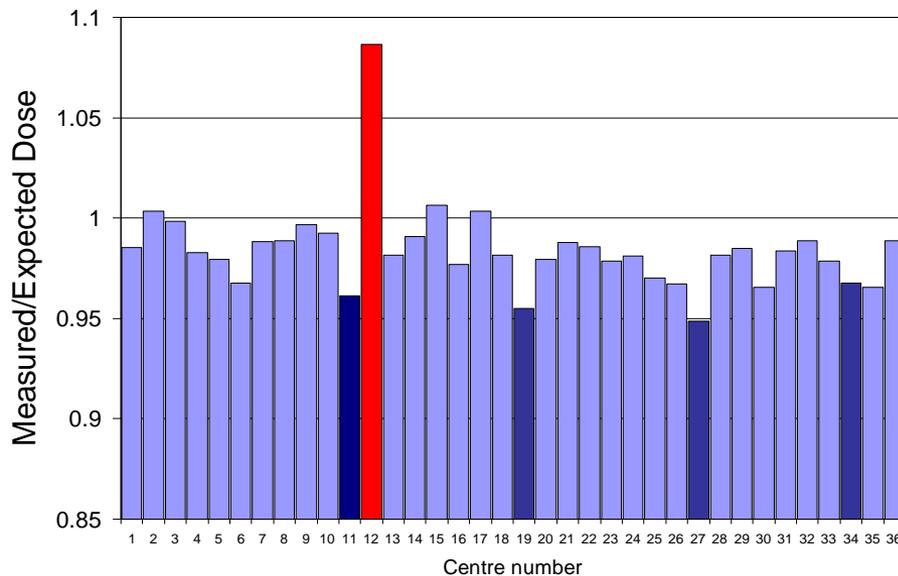


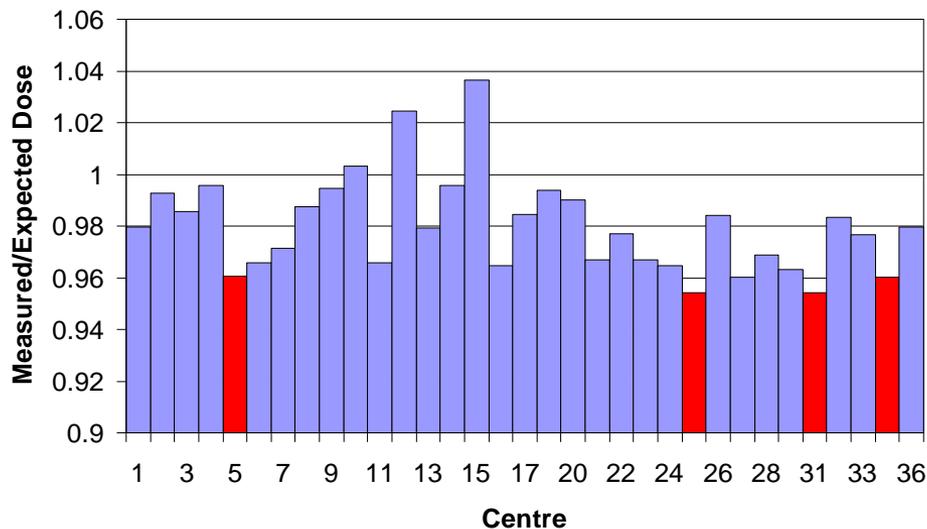
Figure -1 Breast phantom showing measurement points

START Reference Point Chest wall phantom

Mean measured/expected dose 0.98

Tolerance 4%

Some centres implemented a 'lack of scatter correction'



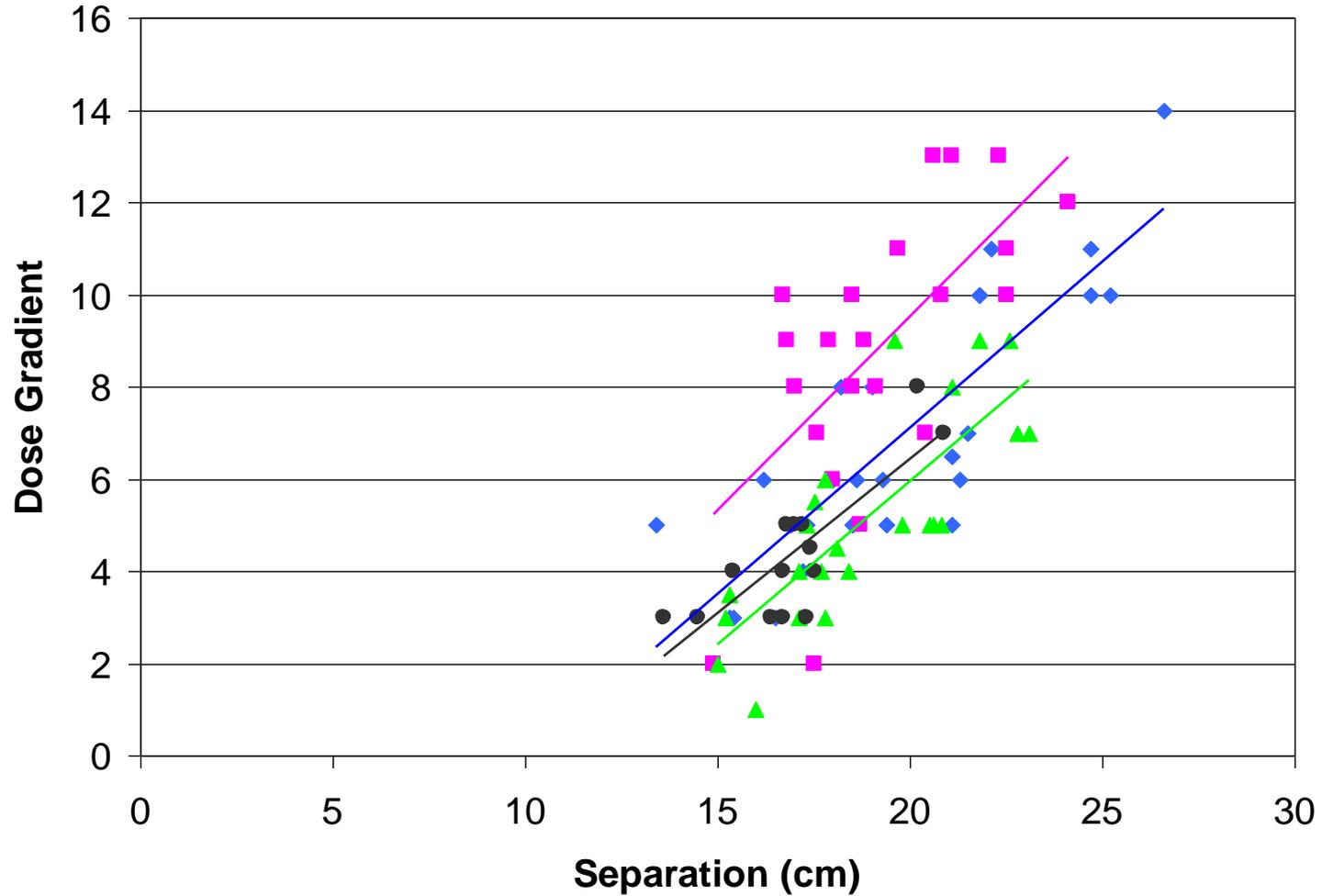
Machine Issues found during audit visits - START



- Wedge
- Monitor ion chamber varying during the day
- Flatness at non zero gantry angles

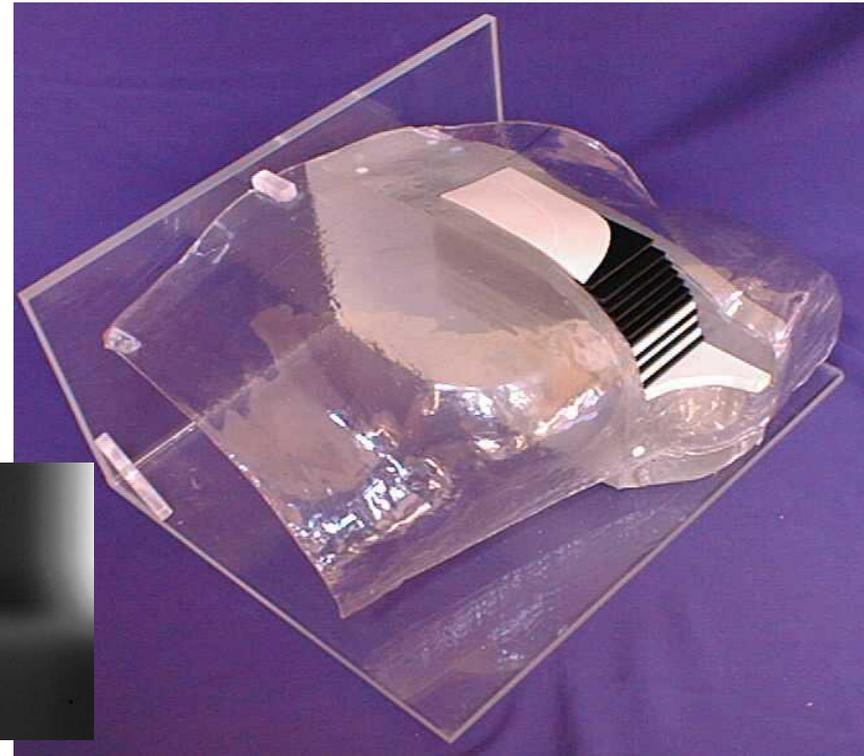


Planning System A



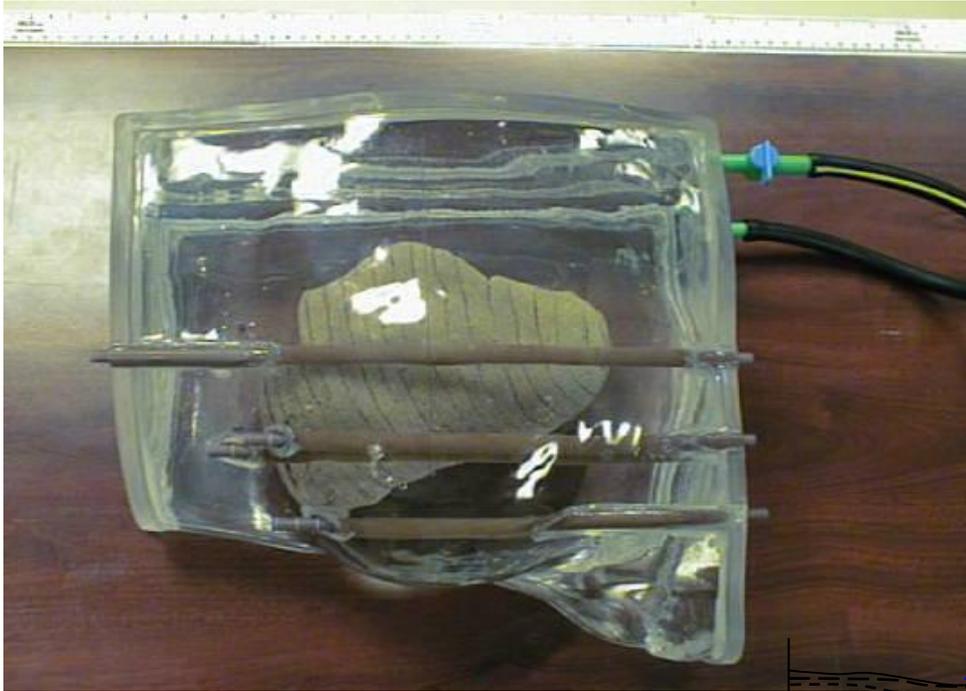
Junction Phantom

- Overdoses of over 20% were found with some techniques in the junction between SCF and tangential fields

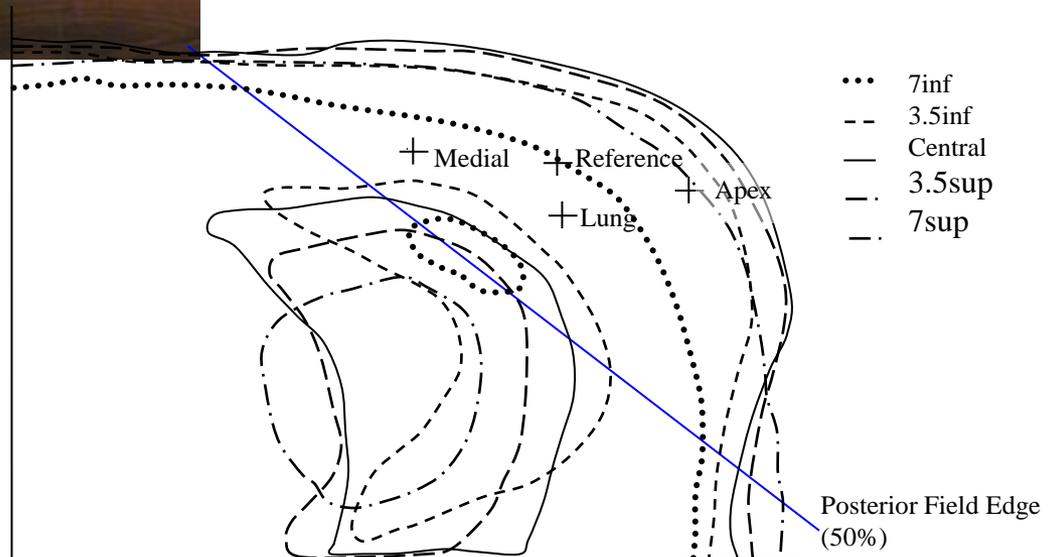


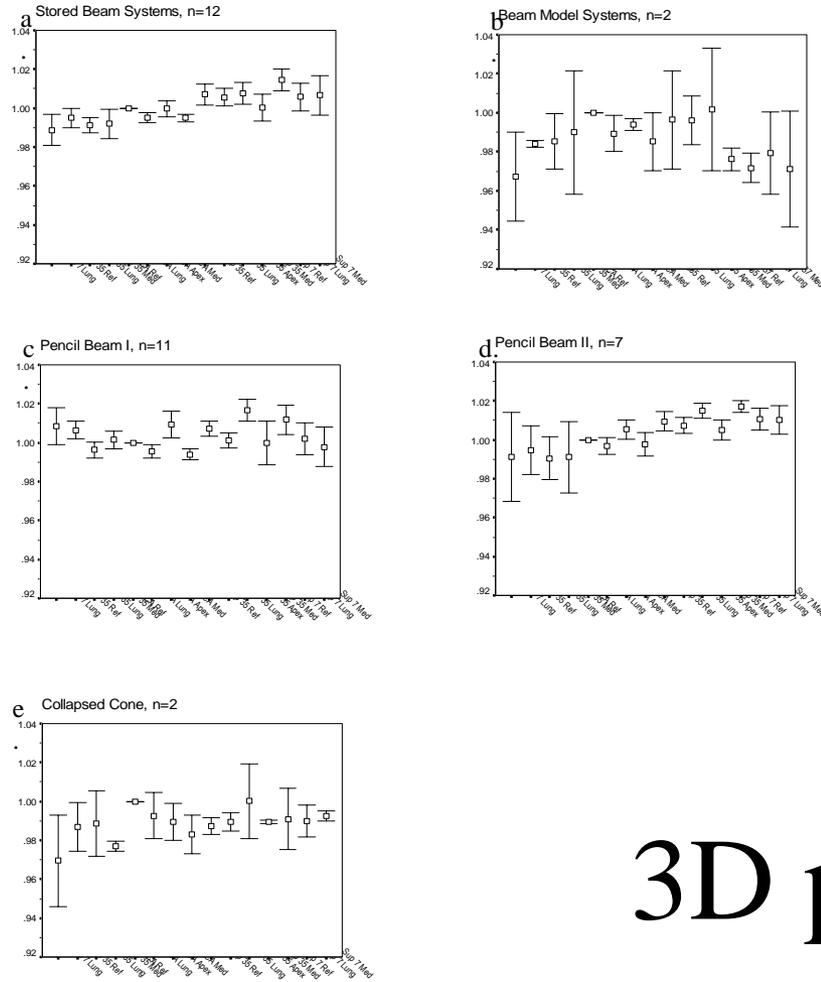
3D phantom (K Venables

Liz Miles)



Results: 14 planning systems
Mean dose 0.987 (SD 0.013)
All relative measurements within 5% of calculated; largest discrepancies at edge of field
Small number of depths still not using lung correction





3D phantom

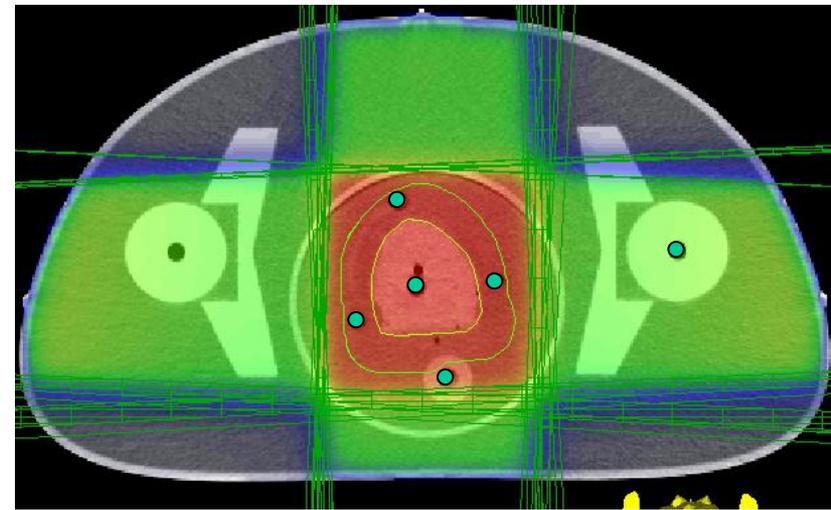
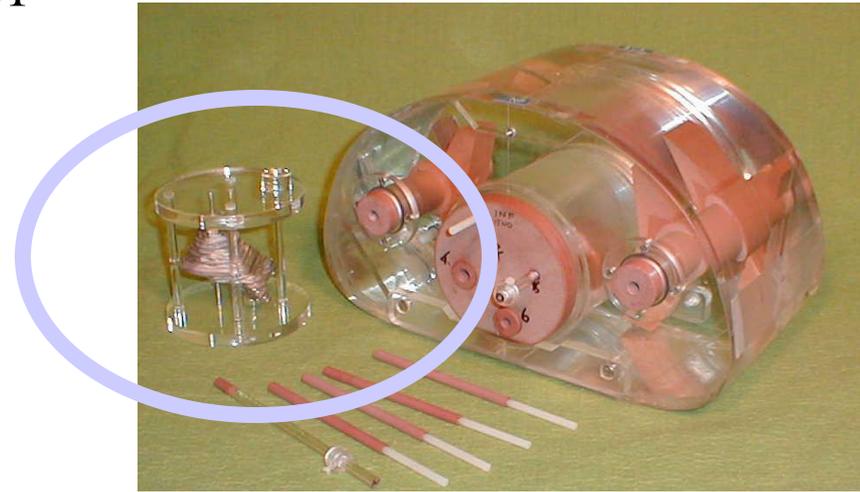
Figure 3-11 Accuracy of algorithms in the 3D breast phantom

PROSTATE PHANTOM for RT01

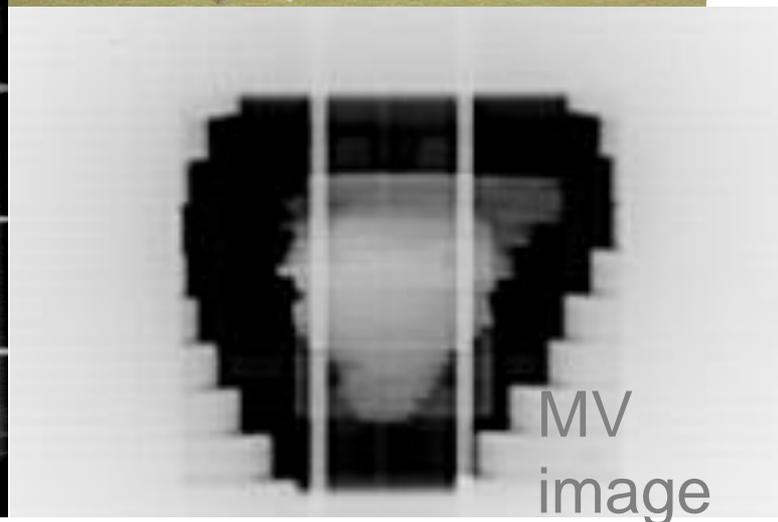
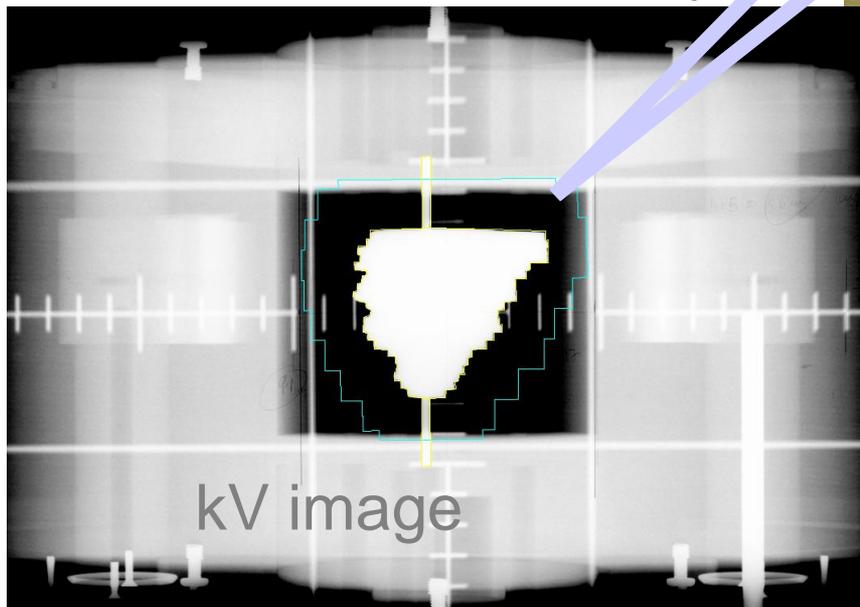
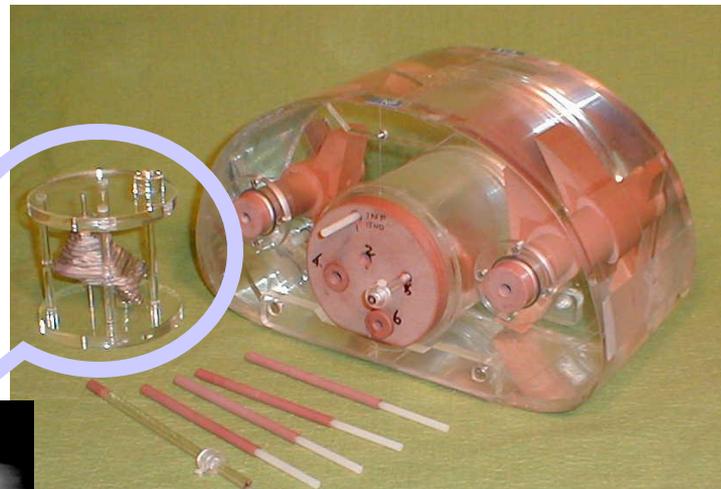
Moore AR, Warrington AP, Aird EG,
Bidmead AM, Dearnaley DP

Constructed from water/WEP
“Silver” prostate used for
localisation
Measuring points located in 3
planes

Small ion chamber for
immediate dose measured
at selected 3D points
Independent Dose check
with Alanine-from NPL



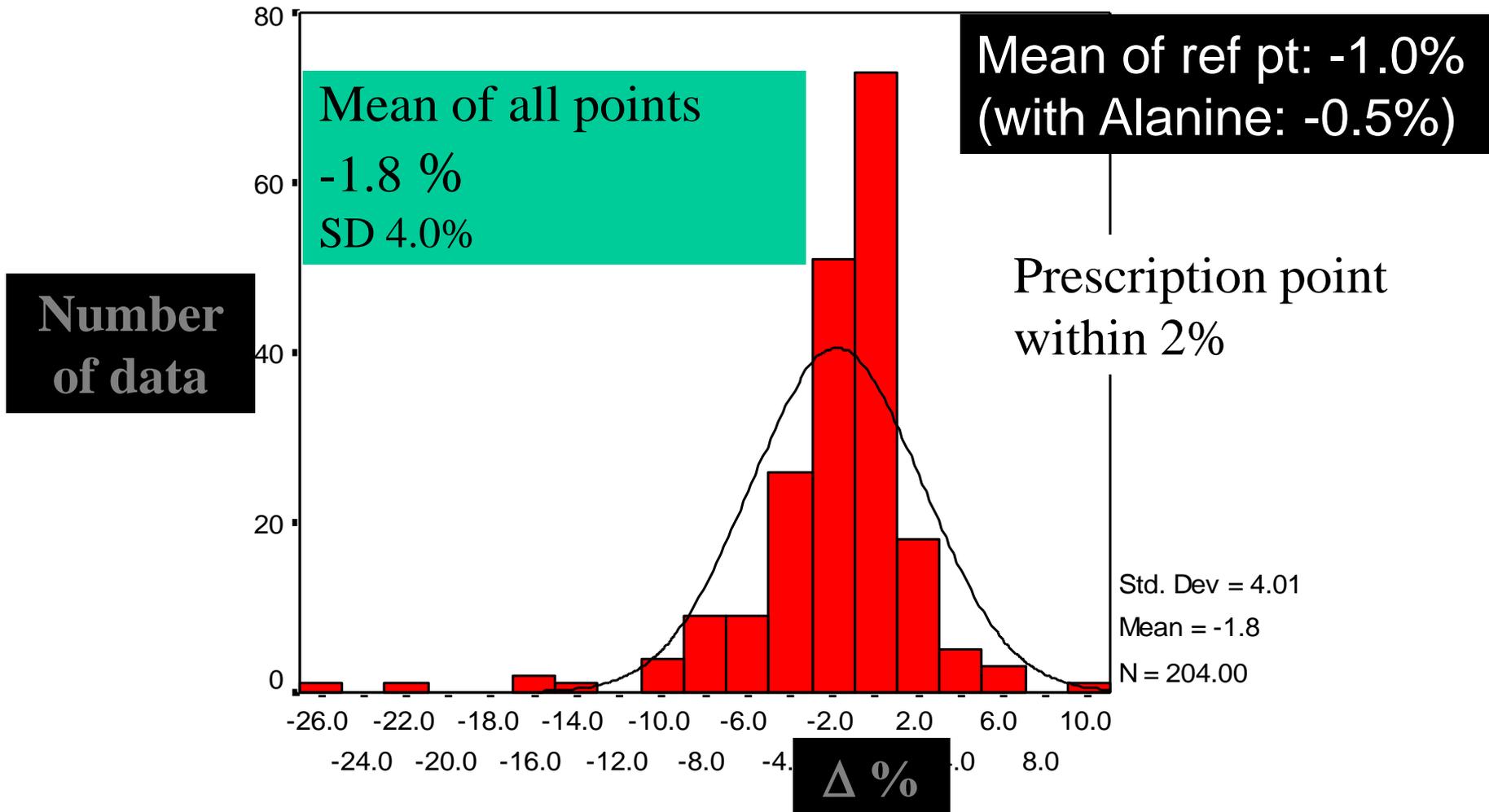
The Silver Prostate



**Slides into phantom - before dosimetry
physical 1 sd ~ 1.6 mm**

**15 visits - no shift on phantom
2-3mm shift on phantom at 2 visits**

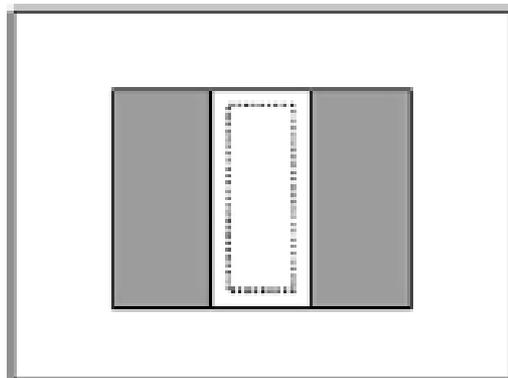
All measured data differences from TPS



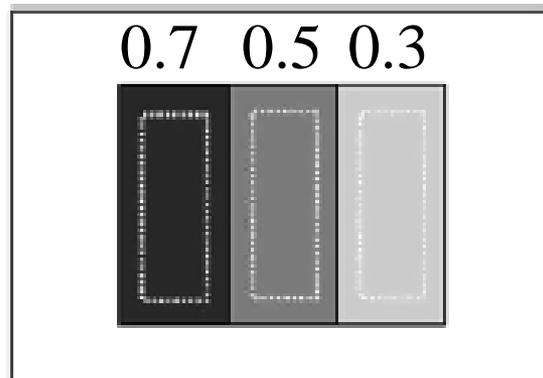
Some more RT01 results

- Rectal dose generally OK
-but plan data used critically to determine new Rectal Volume constraints (ref: **Dose-volume constraints to reduce rectal side effects from prostate radiotherapy: evidence from MRC RT01 Trial ISRCTN 47772397.**[Gulliford SL, Foo K, Morgan RC, Aird EG, Bidmead AM, Critchley H, Evans PM, Gianolini S, Mayles WP, Moore AR, Sánchez-Nieto B, Partridge M, Sydes MR, Webb S, Dearnaley DP.](#)

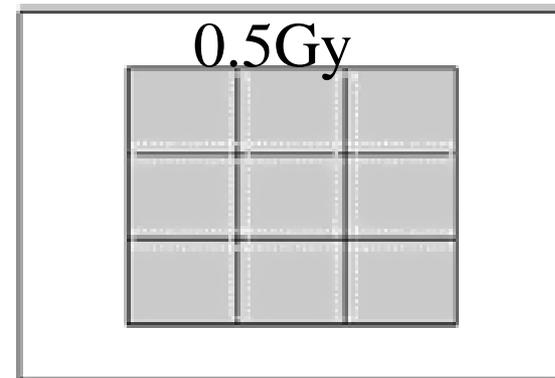
PARSPORT TRIAL TPS tests



(a)



(b)



(c)

3x3 or 4x4
Depending on
MLC

	Dip test	Steps test		Jigsaw test
Tolerance	3%	3%		20%
Result	Mean -1.0%	High dose mean -0.5%	Low dose mean -0.4%	28/40 (70%) [38/40 (95%) for tolerance of 25%]
Range	0.0 to -2.5%	3 to -7.5% ^a	1.9 to -3.0%	-26.2% to 26.6%

^a One centre failed due to film saturation in the high dose region.

Parsport

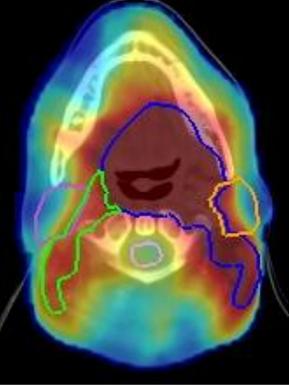
Clark et al R+O 93(2009)102-109

Parsport

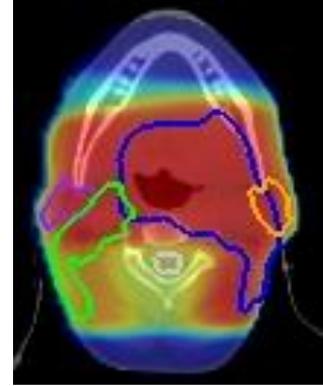
- 5-6 hours of machine measurement
- CIRS head and neck phantom
 - Conventional plan
 - IMRT plan

Combined point dose results for conventional (*italic*) and IMRT (**bold**) plans. Mean and standard deviation (SD) are of the data for the six centres. Negative results for percentage differences mean that the measured point was lower than the TPS calculated point.

CONV IMRT	Average dose (Gy)	Dose range (Gy)	Centre no.						Mean (%)	SD (%)
			1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)		
PTV1	<i>1.95</i>	<i>1.83–2.11</i>	<i>1.1</i>	<i>2.0</i>	<i>1.2</i>	<i>-0.9</i>	<i>0.0</i>	<i>0.9</i>	<i>0.7</i>	<i>1.0</i>
	2.24	2.17–2.32	0.1	-0.4	-2.0	1.8	-2.4	-0.5	-0.6	1.5
PTV2	<i>1.89</i>	<i>1.69–2.06</i>	<i>0.9</i>	<i>1.7</i>	<i>0.3</i>	<i>-0.3</i>	<i>-0.7</i>	<i>-2.6</i>	<i>-0.1</i>	<i>1.5</i>
	1.82	1.68–2.02	0.5	2.2	-1.9	-2.7	-2.4	-0.7	-0.8	1.9
Cord	<i>0.46</i>	<i>0.24–1.06</i>	<i>-1.7</i>	<i>0.0</i>	<i>-1.5</i>	<i>-35.8</i>	<i>-32.7</i>	<i>2.9</i>	<i>-11.5</i>	<i>17.8</i>
	1.12	0.55–1.43	-0.5	2.4	-6.4	4.2	-4.9	-2.6	-1.3	4.1



Plan results (10 centres)



		IMRT		Conventional	
	AIM	<i>median</i>	<i>range</i>	<i>median</i>	<i>range</i>
PTV1 D ₉₅	> 61.8	61.8	61.2 - 63.2	47.5	36.0 - 60.5
PTV2 D ₉₅	> 51.3	50.0	46.0 - 52.7	37.0	22.1 - 44.0
SC _{max}	< 48.0	45.3	39.4 - 48.0	43.7	42.6 - 46.9
CL parotid _{mean}	< 24.0	26.3	22.0 - 29.4	63.9	56.1 - 65.9
IL parotid _{mean}	< 24.0	55.9	34.3 - 63.9	63.4	61.3 - 65.4

All data in Gy

A national dosimetric audit of VMAT and Tomotherapy in the UK

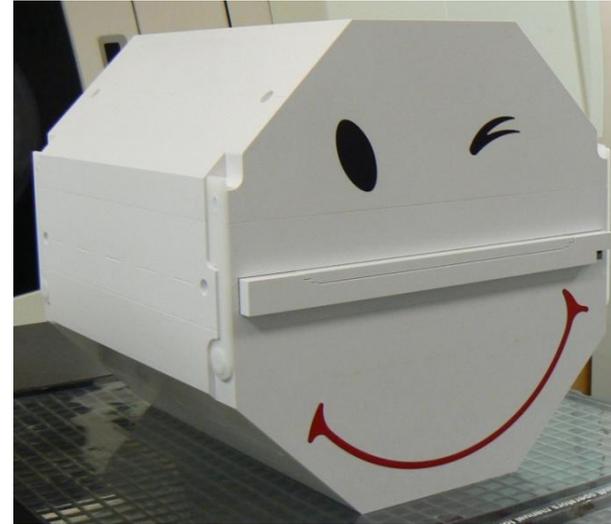
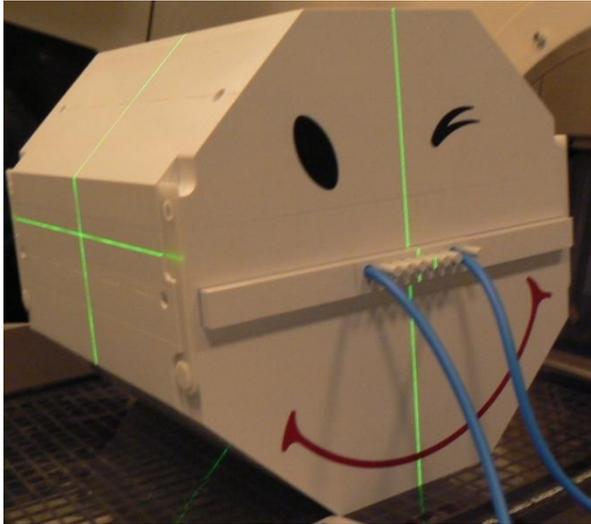
Catharine Clark^{1,2,3,4}, M Hussein^{1,4}, Y Tsang^{3,5}, R Thomas², C
Gouldstone², G Bass²,
D Maughan², J Snaith², S Bolton^{6,7}, D Wilkinson^{3,5}, L Ciurlionis^{3,5},
R Nutbrown², K Venables^{3,5}, A Nisbet^{1,4}

¹Royal Surrey County Hospital, ²National Physical Laboratory, ³Radiotherapy
Trials QA (RTTQA), ⁴University of Surrey, ⁵Mount Vernon Hospital, ⁶Christie
Hospital, ⁷Institute of Physics and Engineering in Medicine

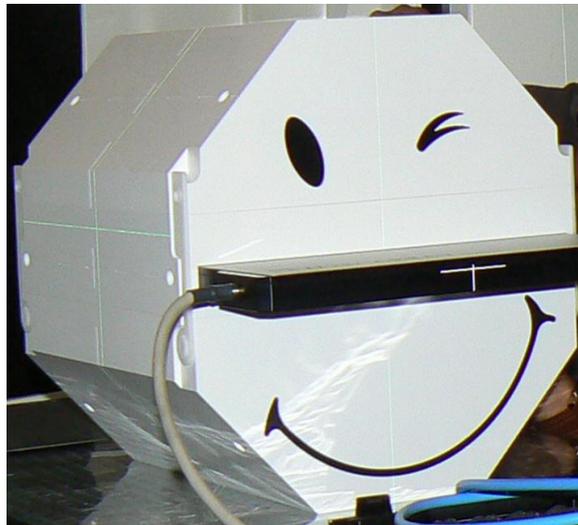
PTW Octavius II phantom with various detectors



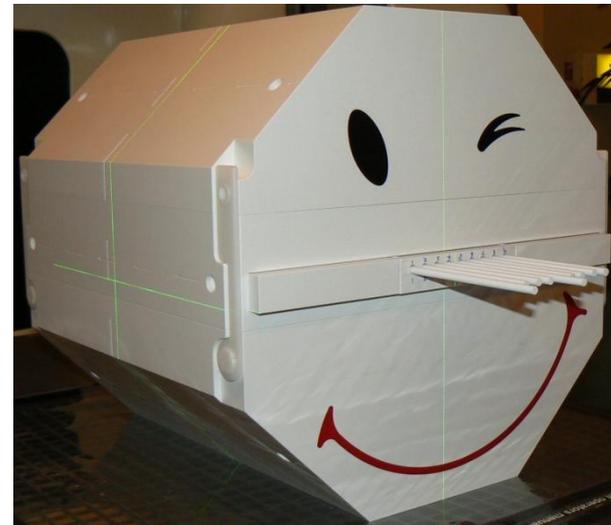
PTW Semiflex
ion chambers



Gafchromic
film

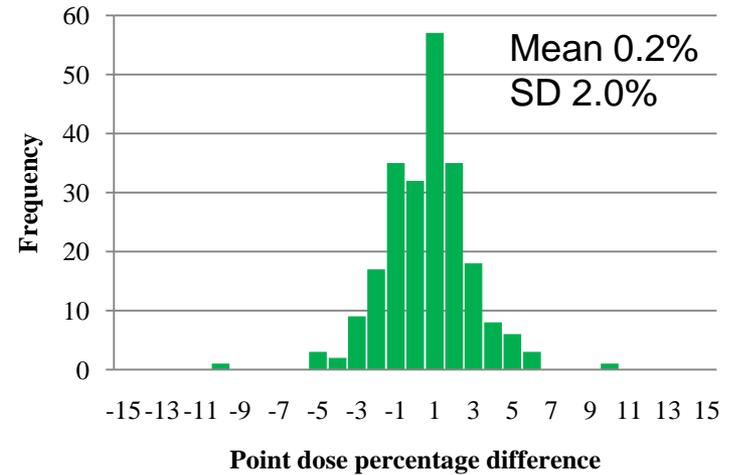
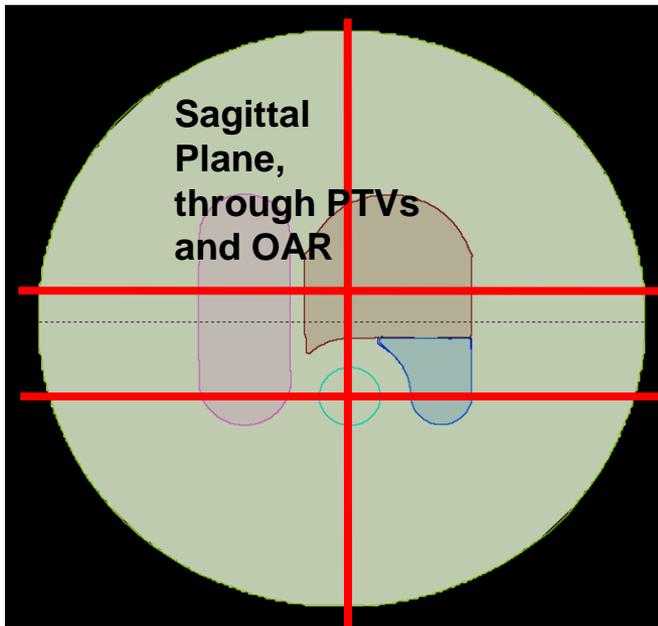
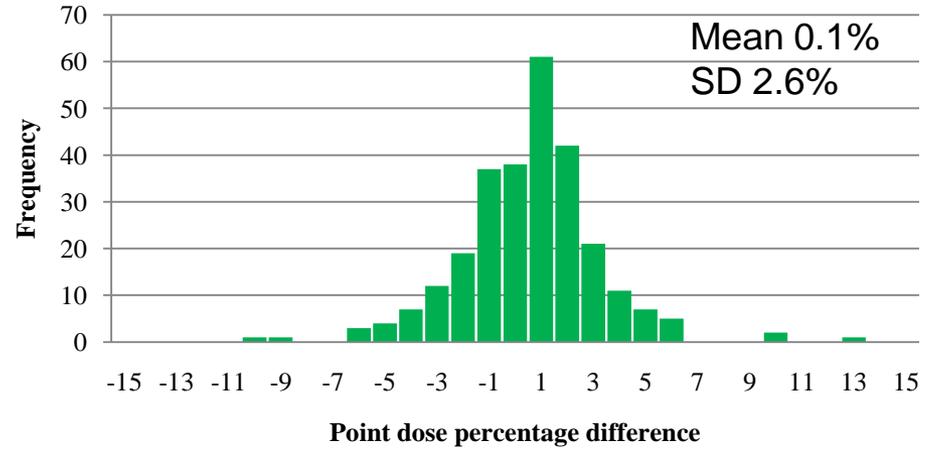
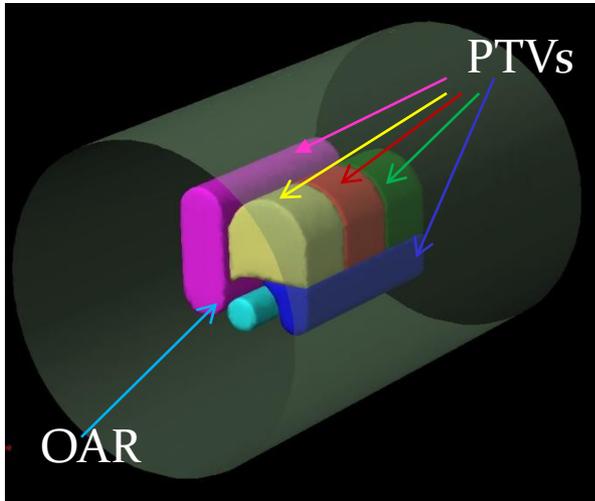


PTW 729
2D array



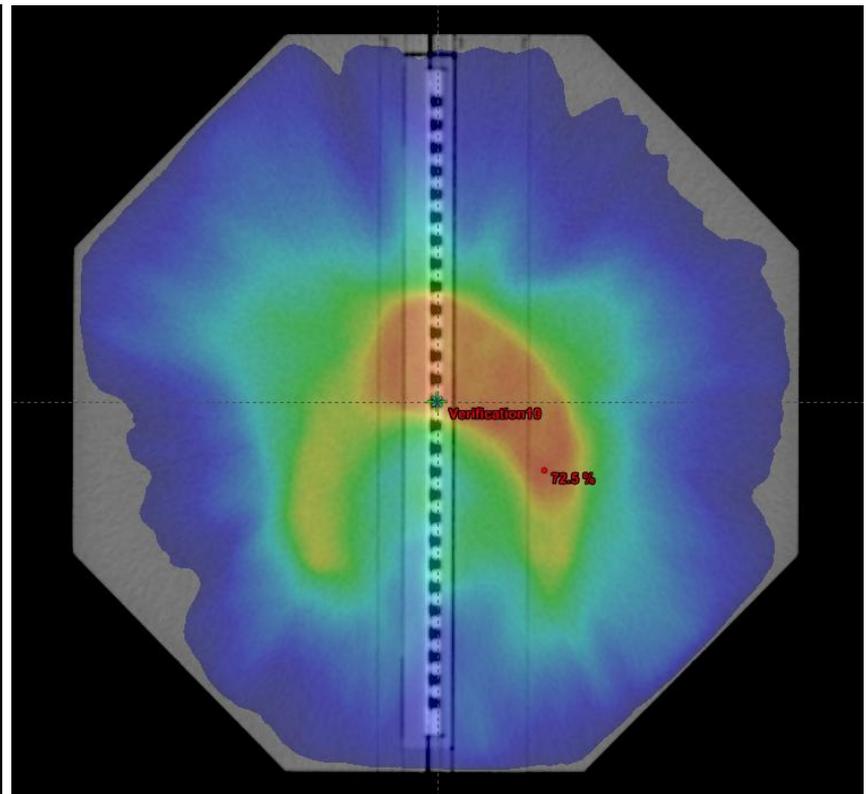
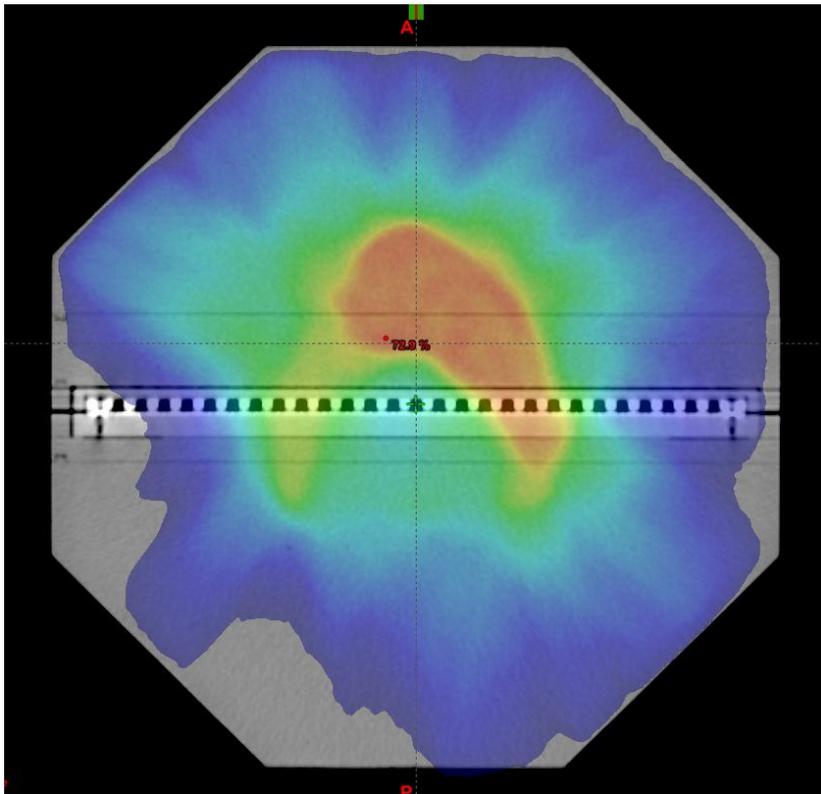
Alanine

3DTPS test plan

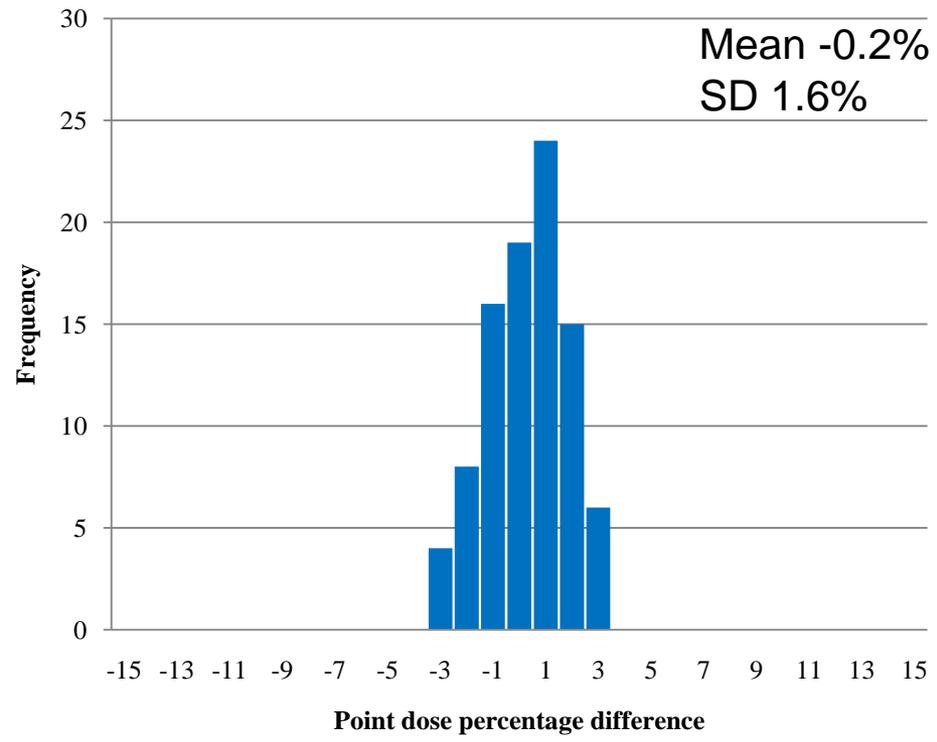
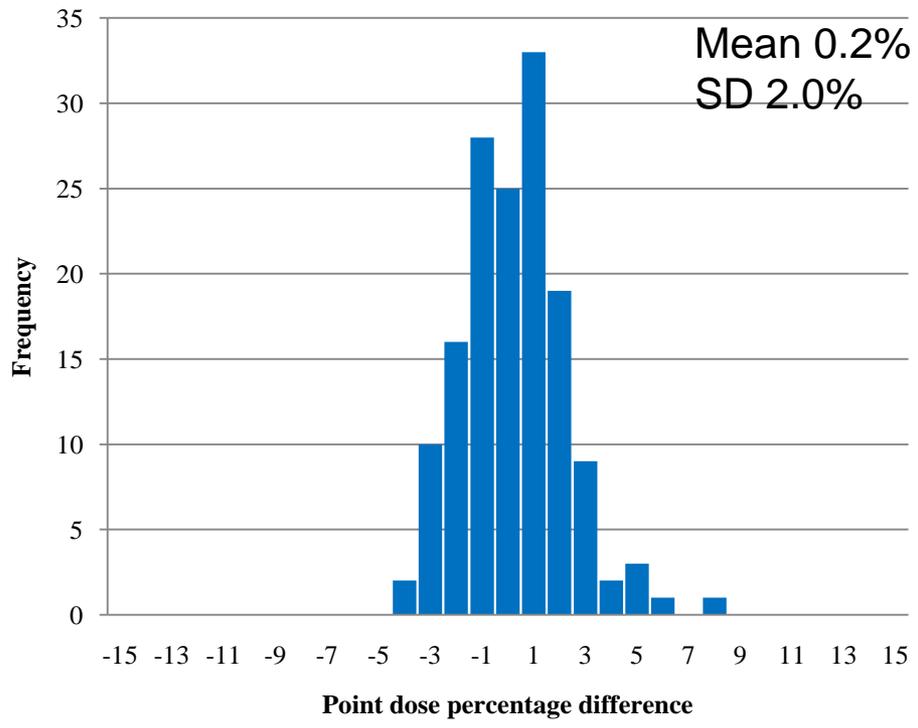


Head and Neck plan measurements

Typical coronal and sagittal planes



Point dose differences in clinical plans



Gamma analysis results

	mean pass rate	
	Clinical	3DTPS
2%/2mm	93.6%	91.5%
3%/2mm	97.9%	96.3%
3%/3mm	99.3%	98.3%
4%/4mm	99.9%	99.7%

Gamma analysis results

	mean pass rate		percentage of planes >95% of $\gamma < 1$	
	Clinical	3DTPS	Clinical	3DTPS
2%/2mm	93.6%	91.5%	60.5%	56.1%
3%/2mm	97.9%	96.3%	86.0%	75.0%
3%/3mm	99.3%	98.3%	98.8%	88.6%
4%/4mm	99.9%	99.7%	100%	100%

Gamma analysis results at 2%/2mm

	mean pass rate	percentage of planes >95% of $\gamma < 1$
Breast	99.8%	100%
Prostate and Nodes	94.9%	73.1%
Head and Neck	93.4%	55.4%
3DTPS	91.5%	56.1%

Rotational Audit Issues identified

- Lack of couch modelling
- Minimum leaf gap too small
- High modulation / high MUs
- Non-continuously variable dose rate
- Lack of information as to what some TPS/Linac combinations are capable of achieving
- Lasers and barometers

Conclusions

- A national dosimetry audit of rotational radiotherapy has been undertaken
- More than 93% of analysed planes achieved more than 95% pass rates for gamma parameters of 3%/3mm
- For many systems 3%/2mm were better criteria
- The majority of centres achieved accurate implementation of TPS modelling and delivery for VMAT and Tomotherapy
- Evaluation of the standards which others starting a VMAT program should be able to achieve

Conclusion

- The implementation of QA in radiotherapy has become vitally important in recent years. Often, as has been demonstrated here, a clinical trial has led the way to the general benefit of all patients receiving radiotherapy. By pursuing QA in the first year of the clinical trial, the standard of treatment was set and any later uncertainties when analysing the results were avoided. Wariness at each centre visited was replaced by active co-operation and satisfaction with the high standards that could be achieved and maintained. In addition, these visits gave an opportunity for mutual exchange of ideas.

Aird et al R+O 36(1995)235-245

Acknowledgements

- All staff who have worked on clinical trials particularly those who have provided slides and information
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