Performance Reproducibility of Intra Operative Radiotherapy Equipment – Photon Radiosurgery System

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IORT in the UK

Two IORT centres -

- Ninewells Hospital and Medical School (Dundee)
  Treat approx. 35 patients per year.
- University College (London)
  Treat approx. 30 patients per year.

Ninewells Hospital (Dundee)

- Large teaching hospital providing care for population of approx. 0.5 million
- Oncology Service to 1400 new cancer patients annually.

3 Linear Accelerators (Varian) • HELAX Treatment Planning

IORT • LDR Brachytherapy • PLATO Brachy Planning System

Pantak DXT300 • Simulator (CT Ext.) • VISIR • Mould Room

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What is IORT?

- **I**ntra**O**perative **R**adio**T**herapy (IORT) is defined as the delivery of a single, large radiation dose to the bed of a resected tumour at the time of surgical intervention.

- In early stage breast cancer, IORT avoids unnecessary irradiation of the whole breast [1].

- We are investigating whether a single high dose imparts the same clinical benefit as external beam radiotherapy (typically 6 weeks).

[1] Vaidya JS, Baum M *et al*. The novel technique of delivering targeted intraoperative radiotherapy (Targit) for early breast cancer. Eur J Surg Oncol. 2002;28:447-54.

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The Potential of IORT

In breast cancer, IORT may potentially replace EBRT in the treatment of stage I patients undergoing wide local excision (WLE).

These patients represent about 33% of the projected 2011-2015 EBRT breast cancer workload (Scotland) and therefore, if IORT is proven to be clinically effective a considerable workload would be directed away from external beam services [2].

"… if IORT replaces EBRT for early breast cancer this would have a *profound effect* on the requirement for machine capacity".

[2] Scottish Executive Health Department (2005) Cancer in Scotland: Radiotherapy Activity Planning for Scotland 2011 - 2015. Edinburgh: The Scottish Executive.

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IORT Equipment at Ninewells

- Four Intrabeam™ X-ray sources (Carl Zeiss Surgical, Germany).
- Currently used to treat breast and neurological tumour sites.

1.5 – 5.0 cm

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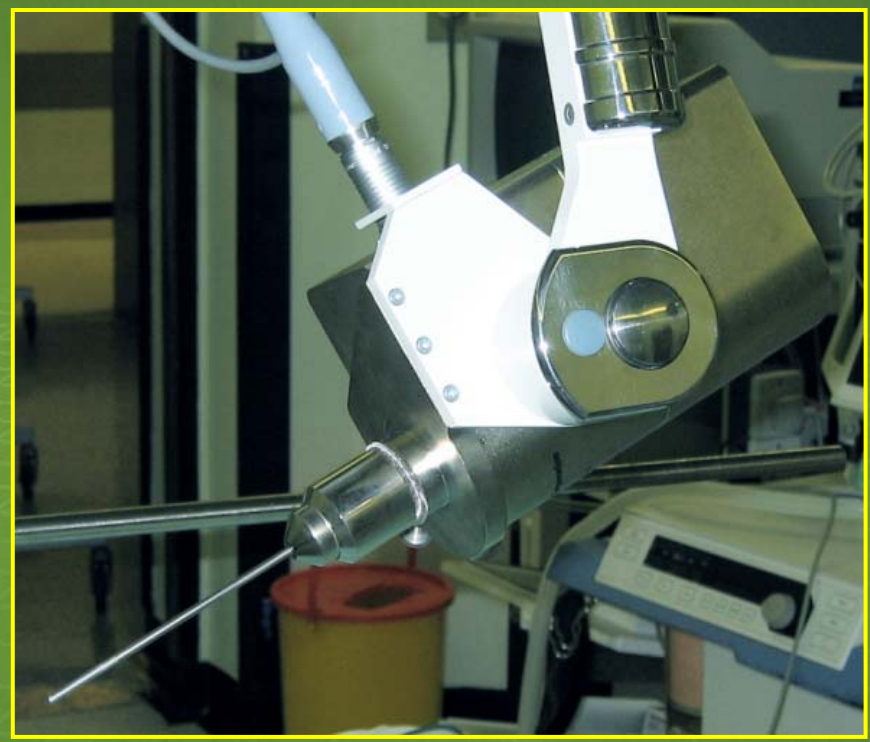
The Miniature X-Ray Source

- Each XRS weighs 1.62 kg, has dimensions 17.5 x 11 x 7 cm with a 3.2 x 100 mm long chromium nitride coated probe.



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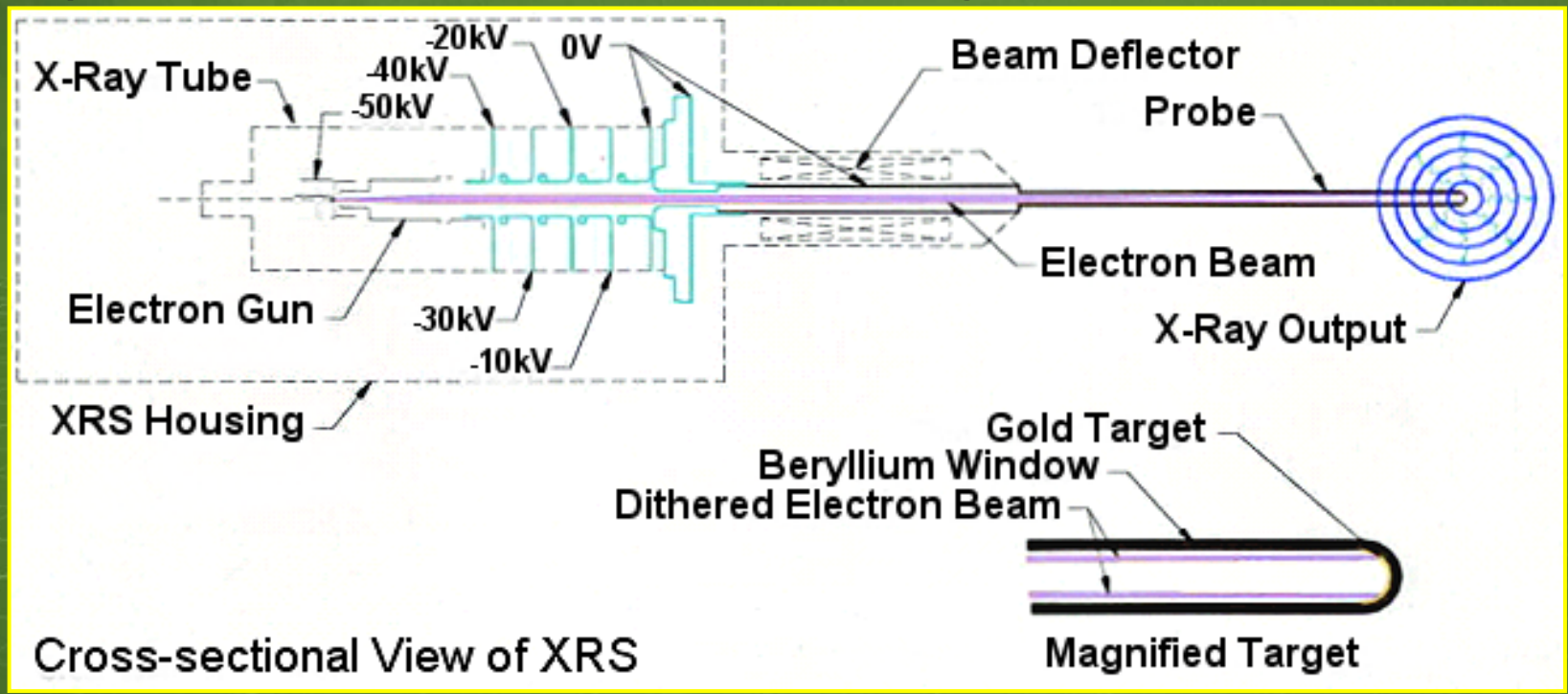
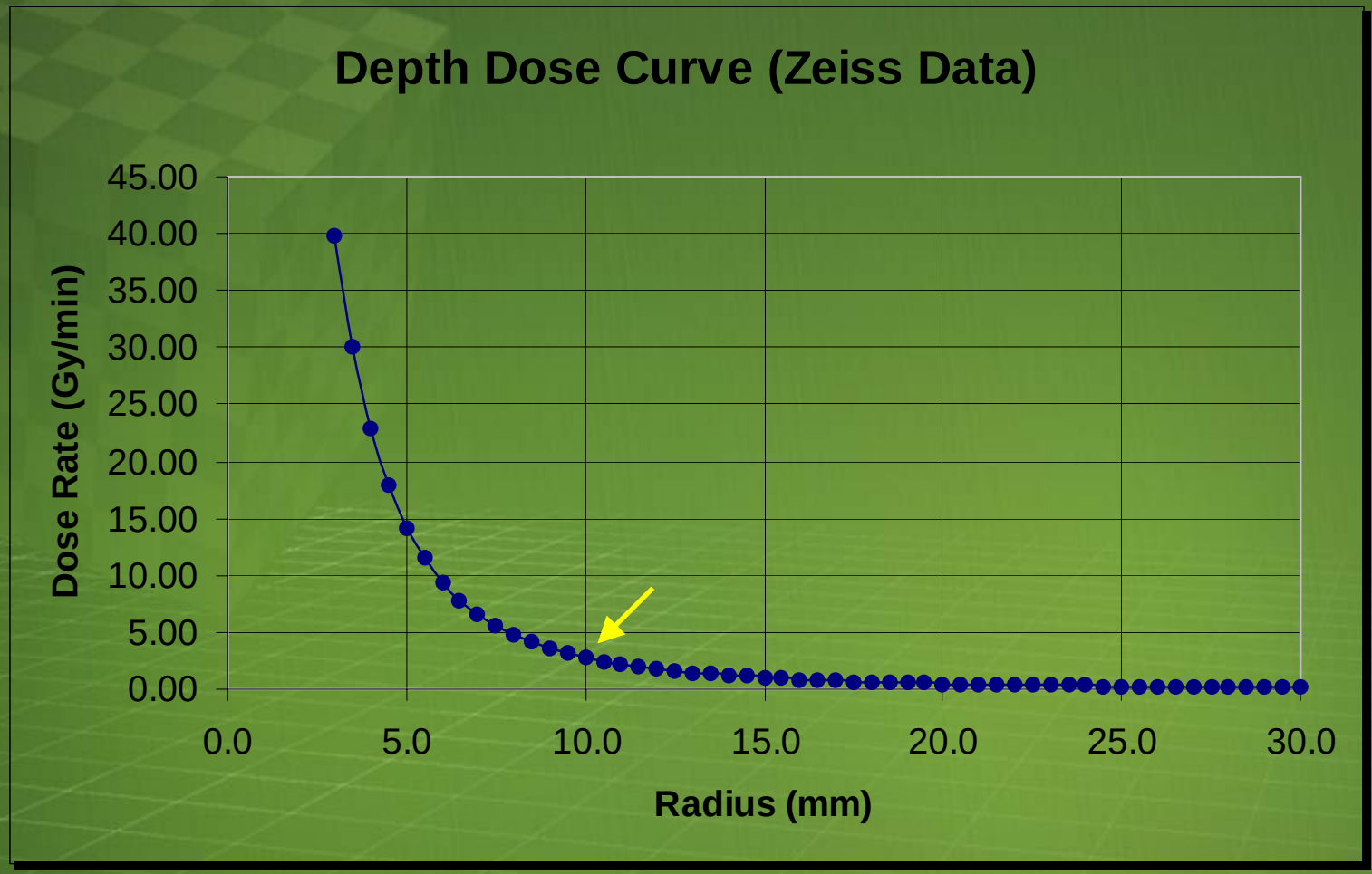
How does it work?

- Beam accelerated through field (up to 50 kV).
- Beam current is selectable (up to 40 µA).
- Gold target (1 µm). Effective energy 5-20 keV.
- Spherical dose distribution ~ 2.5 Gy/min at 10 mm.



Depth Dose Curve



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Device Intercomparison

- Performance of four x-ray sources was compared over a period of seven months.
  - Half Value Layer
  - Depth Doses in water
  - Output Trends
  - Internal Rate Monitor (IRM) reproducibility
  - Accuracy of treatment time.

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Half Value Layer

- The HVLs for all XRS were determined by a broad beam method; probe 20 cm from IC, Al attenuators near the midpoint.
- Attenuator thickness 0.03 to 3.00 mm.
- To quantify beam hardening at prescription depths, 5 and 10 mm of solid water attenuators placed ~ 2 cm from probe.

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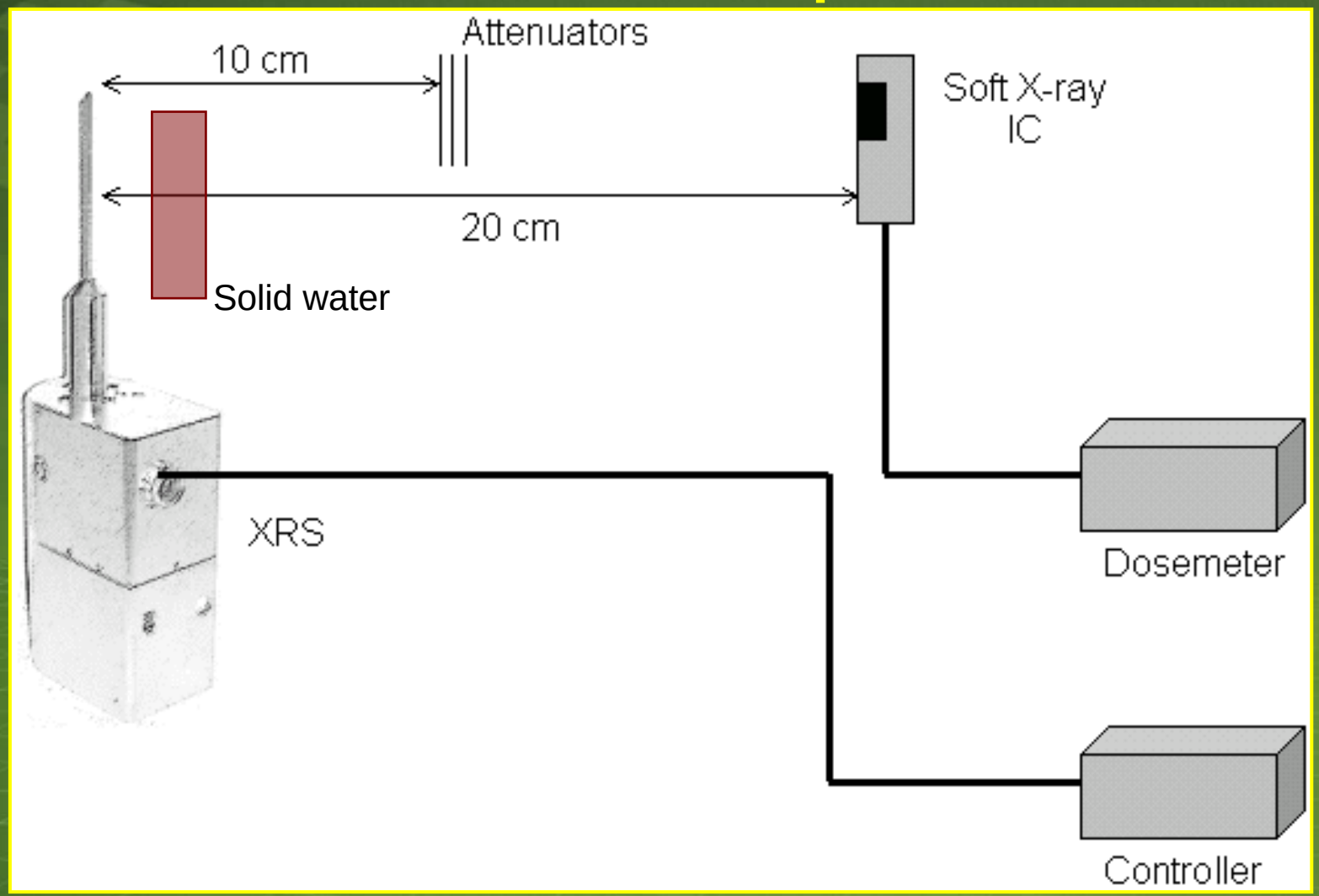
HVL Setup


Attenuators
10 cm
Soft X-ray
IC
20 cm
Solid water
XRS
Dosemeter
Controller

HVL Results

- Unattenuated beam ~ 0.11 mm Aluminium
- 5 mm solid water ~ 0.54 mmAl.
- 10 mm solid water ~ 1.11 mmAl.
- Equivalent energies approx. 12 and 24 keV.

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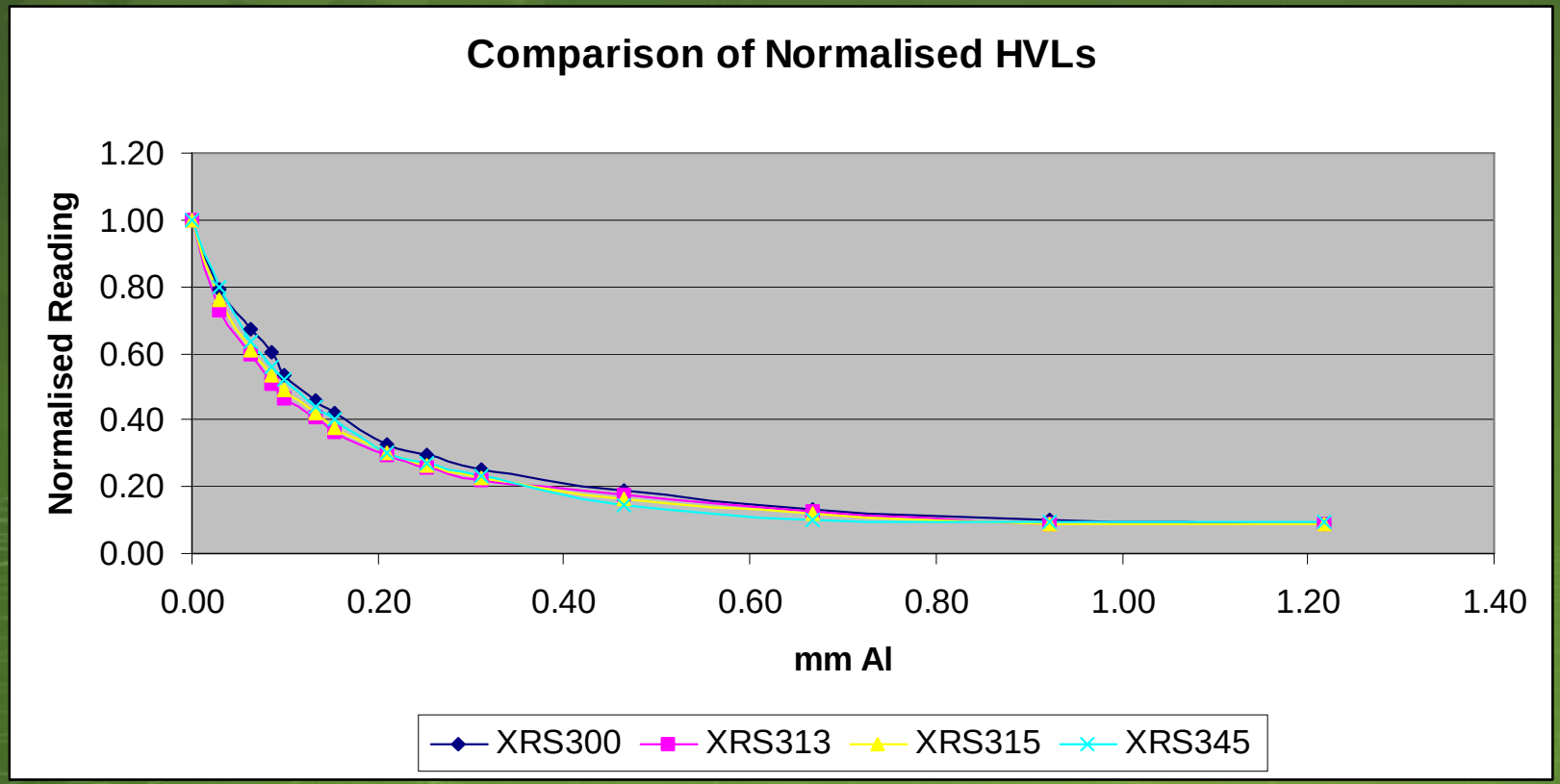
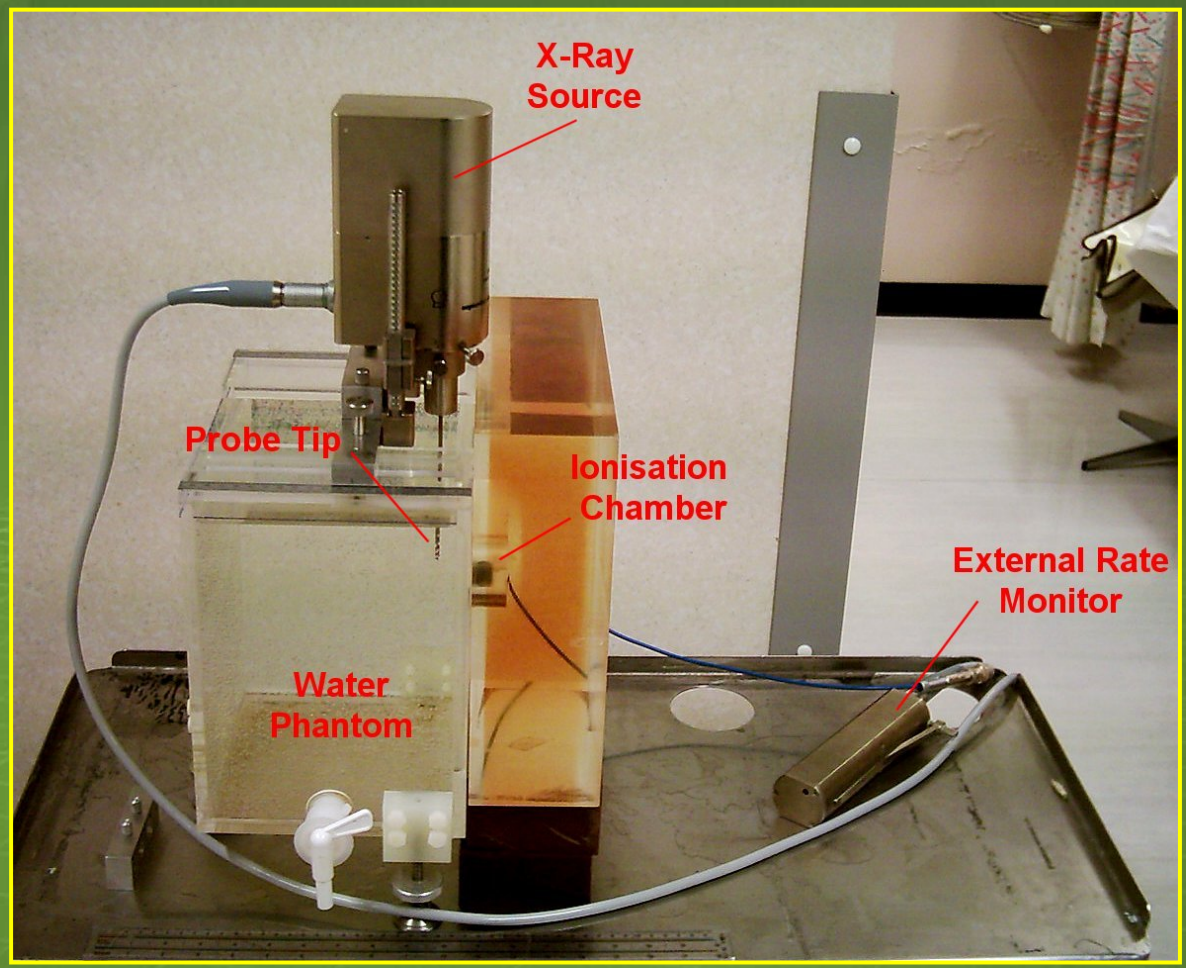
Comparison of HVLs



Depth Dose in Water

- Chamber output measured at 10 to 35 mm from probe tip in water.
- Custom-built water phantom.
- Low kV x-ray parallel plate IC (PTW N23342).



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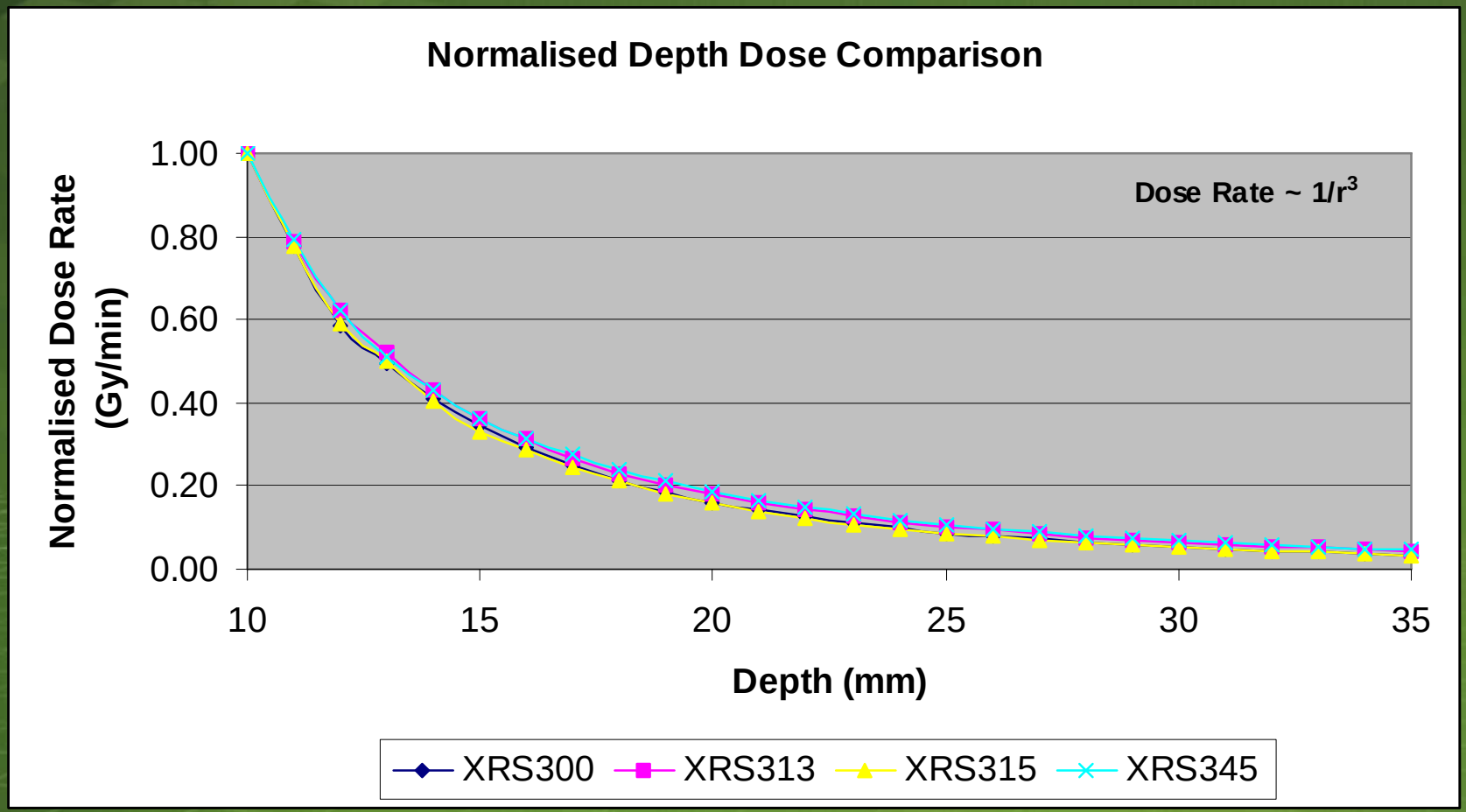
Depth Dose Curves



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Output Trends

- Weekly calibrations on four x-ray sources.
- An internal rate monitor (IRM) test procedure used to check the response of the IRM.
- The IRM count rate obtained during this verification procedure is used in clinical treatment time calculation.

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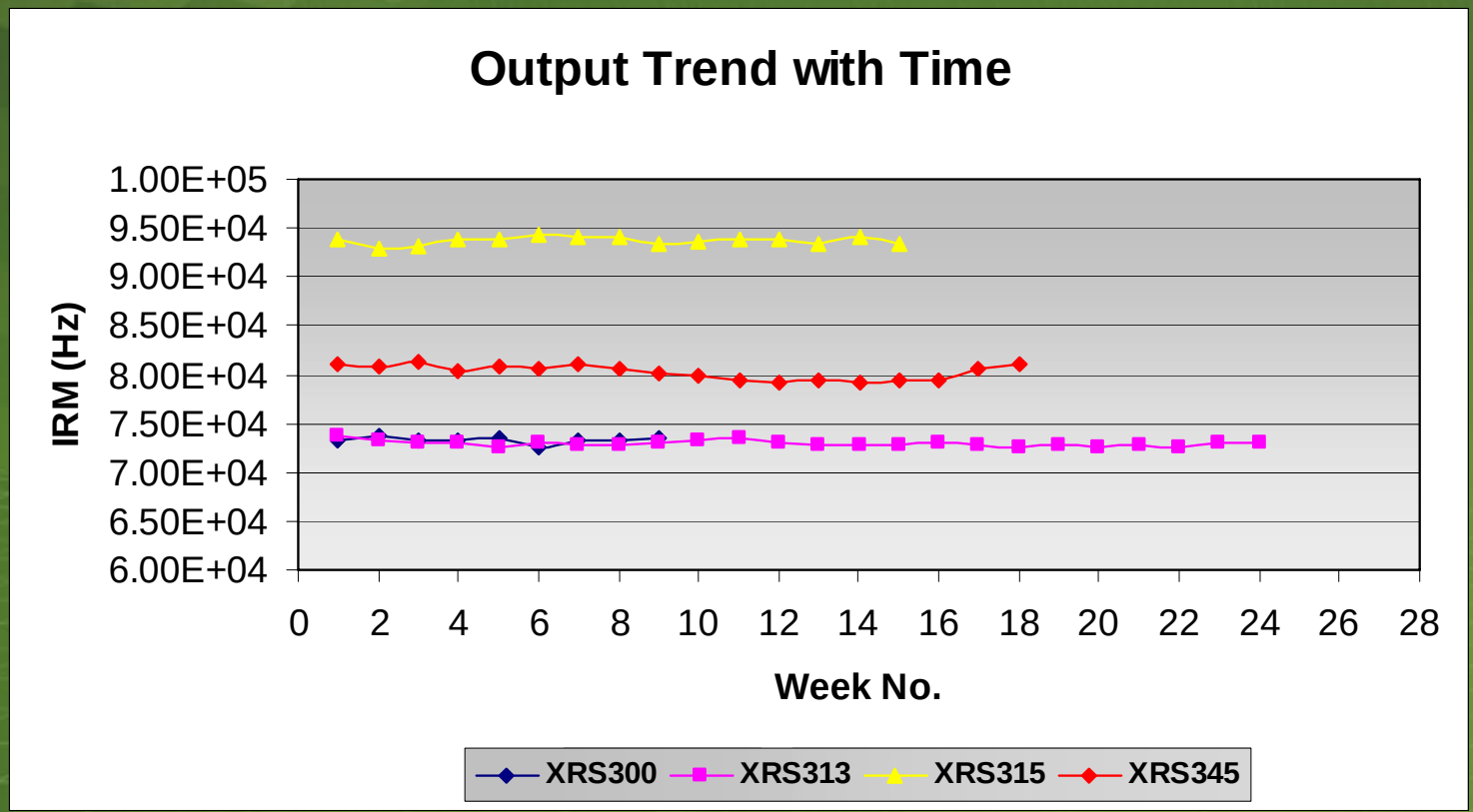
Intercomparison of Output Trend with Time



IRM Reproducibility

- Reproducibility of the IRM dosimetry system was investigated for increasing exposures.

- Exposure controlled using a pre-set number of IRM counts at a count rate of approx. 7×10^4 cps (at 50kV, 40µA).

- Measurements made for exposures equal to counts of 4, 20, 40, 60 x 10^6, equivalent to exposures of 1, 5, 10 and 15 minutes.

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IRM Reproducibility

Difference between the preset IRM limit and IRM count obtained on beam termination was < 0.1%.

A		B		
IRM Limit	Time (min)	IRM Limit	Beam ON	% Diff.
Calculated		Beam Termination	Average	(A:B)
$x10^7$ Cnts		$x10^7$ Cnts	mins	
0.4361	1.00	0.4361	1.001	0.00%
2.1807	5.00	2.1810	4.978	0.01%
4.3614	10.00	4.3610	9.967	0.01%
6.5421	15.00	6.5420	14.916	0.00%
			Mean:	0.01%

XRS 000313
IRM Count Rate = 7.269×10^4 Hz
50kV, 40uA. Controller S/N 000034

Clinical Treatment Times

- Clinical treatment times were recorded for 25 breast and 14 brain cancer patients.

- The mean difference between the calculated and actual treatment times for breast patients was 0.46% and for brain patients 0.37%.

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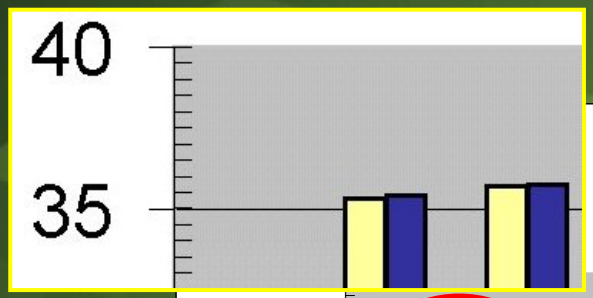
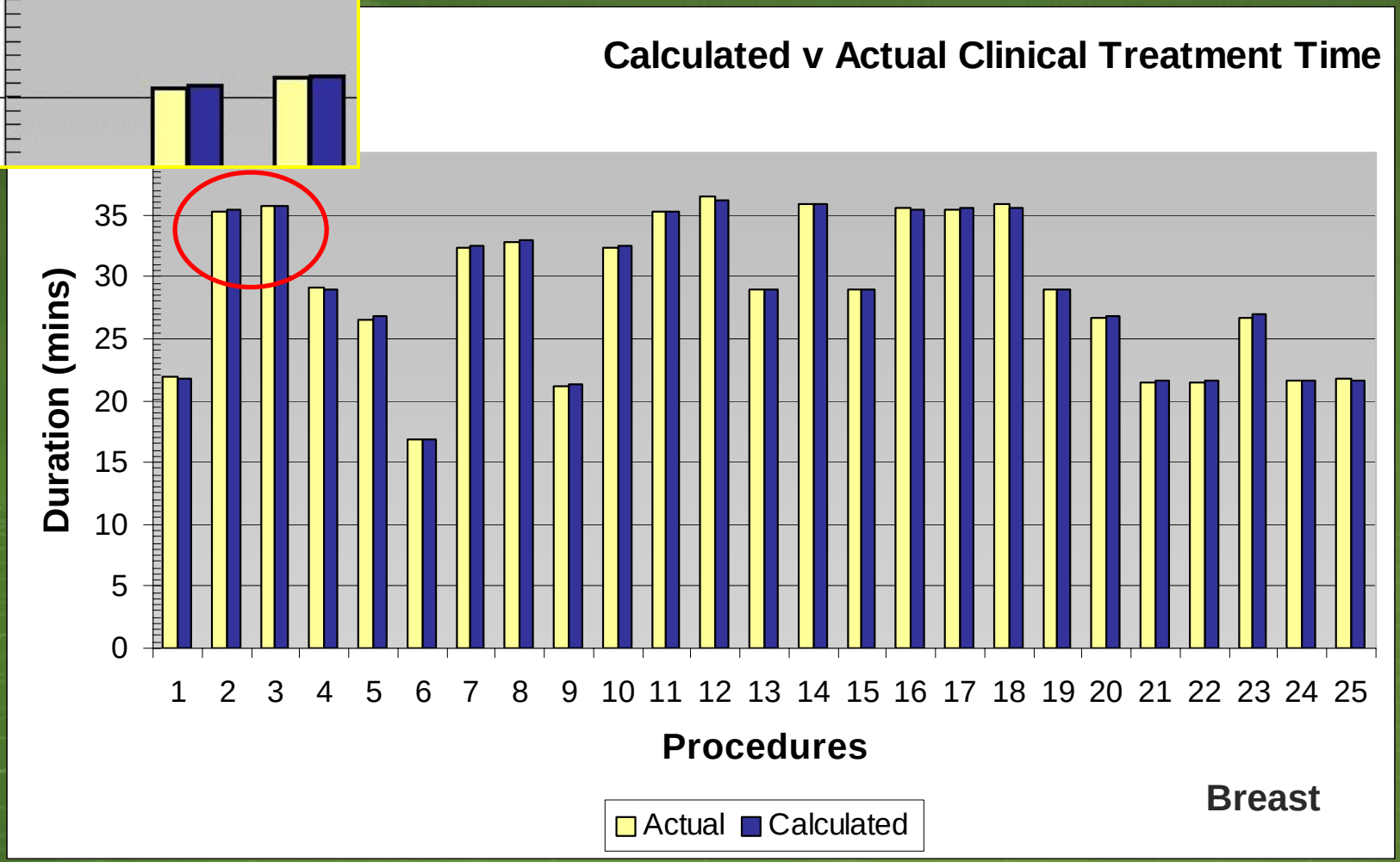
Clinical Treatment Times





22-25

Conclusions

- The four x-ray sources have proven to be stable over time.
- Measurements were found to lie within the manufacturer's tolerances.
- Intercomparison shows that the x-ray sources have similar performance characteristics.

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www.medicalphysicist.co.uk

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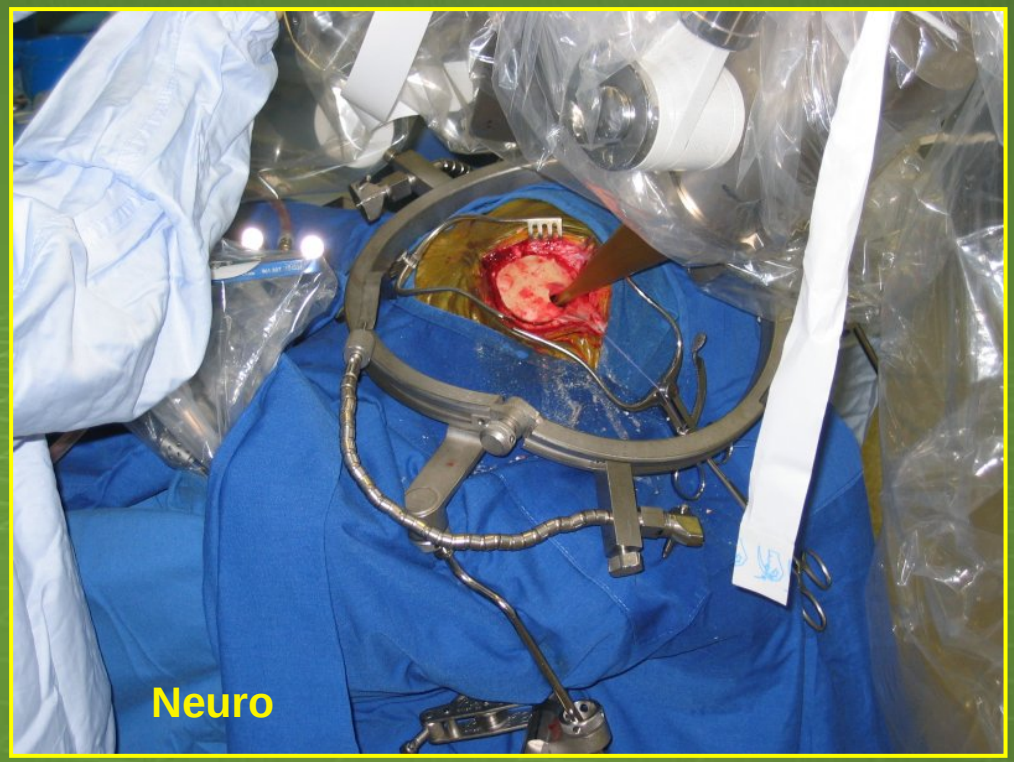
And finally…



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