Review of options for cabin dosimetry & operation

Helen Amatiello & Colin Martin
Health Physics Service
Glasgow

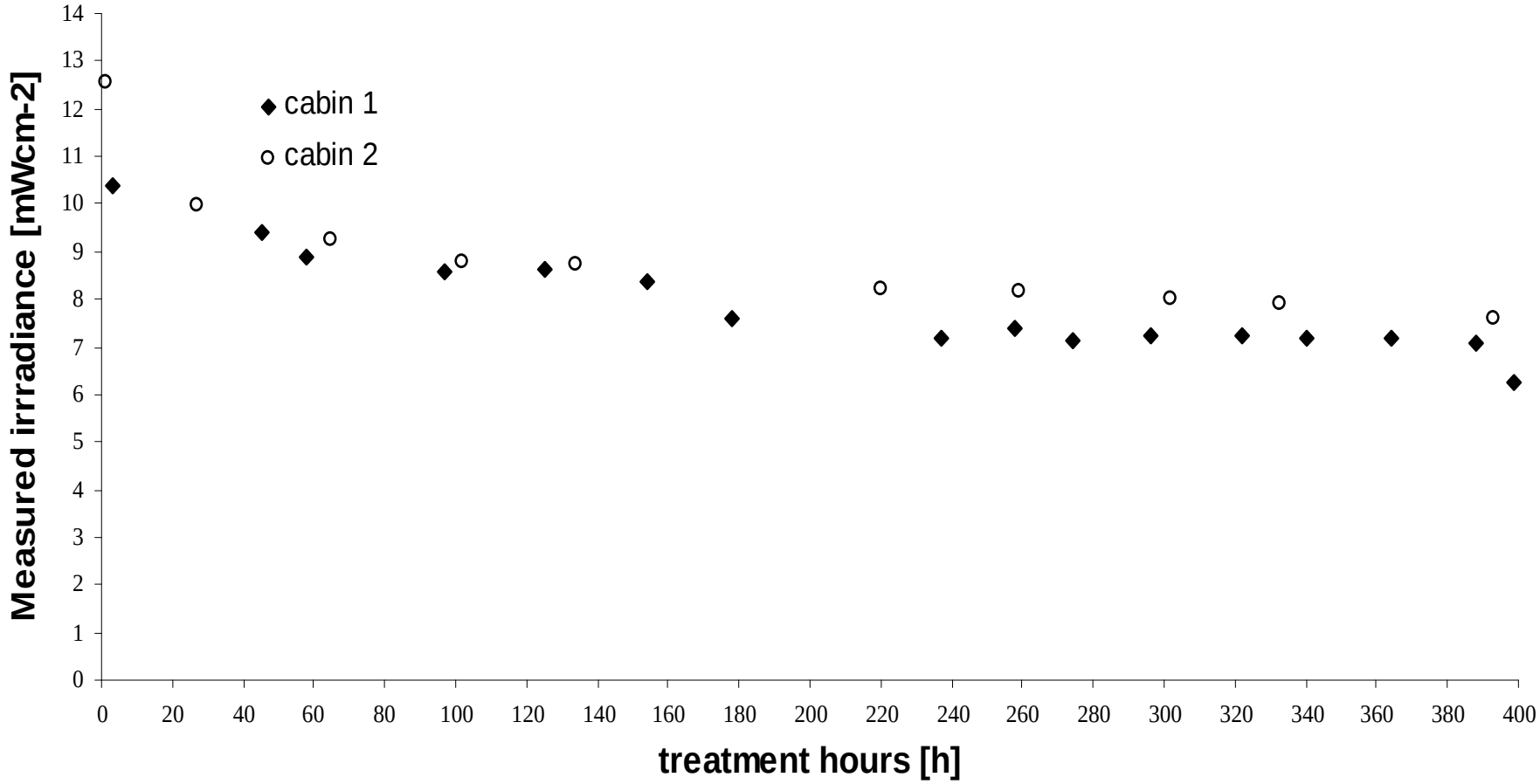
Review of options for cabin dosimetry & operation

- Different centres have differing lamp replacement policies
- More centres using internal detectors to control patient dose for Tl01 phototherapy to account for gradual reduction in tube output with treatment hours

Aims of study

- Assess the influence of cold and hot spots on lamp replacement policy
- Investigate how patient position could affect detector reading and hence patient dose
- Investigate the contribution of lamp banks to the overall irradiance

Decline in Cabin Output with time



30 – 40% reduction in cabin irradiance over 200 h

Mean lamp lifetime ±1sd = 470 ± 170h

Influence of cold/hot spots

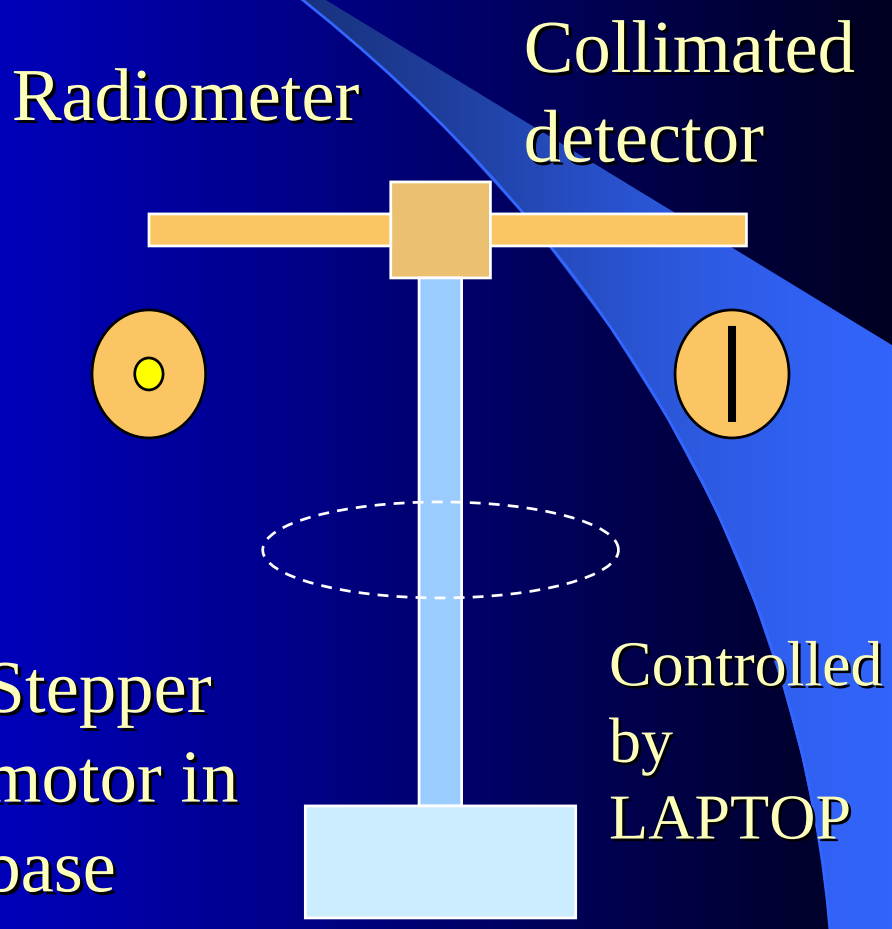
- Lamps failure produces an area of low irradiance – a ‘cold spot’
- Defined as the magnitude of the irradiance in a quadrant where the tube has failed compared to a normal quadrant
- Similarly for a ‘hot spot’
- Historical data from West of Scotland automated UV dosimetry system[1,2] interrogated for various Tl01 cabin types

1 - Currie GD et al. 2001 An automated dosimetry system for testing whole-body ultraviolet phototherapy cabinets *Physics in medicine and biology* **46** 333-45

2 - Evans AL et al. 2002 Instrument for scanning the angular variation of irradiance in ultraviolet phototherapy cabinets *Journal of Medical Engineering & Technology* **26(3)**126-31

Automated UV Dosimetry System

- System to take 800 measurements of irradiance around 360^{o} rotation
- Collimated detector to give indication of output from individual lamps (radiant intensity)

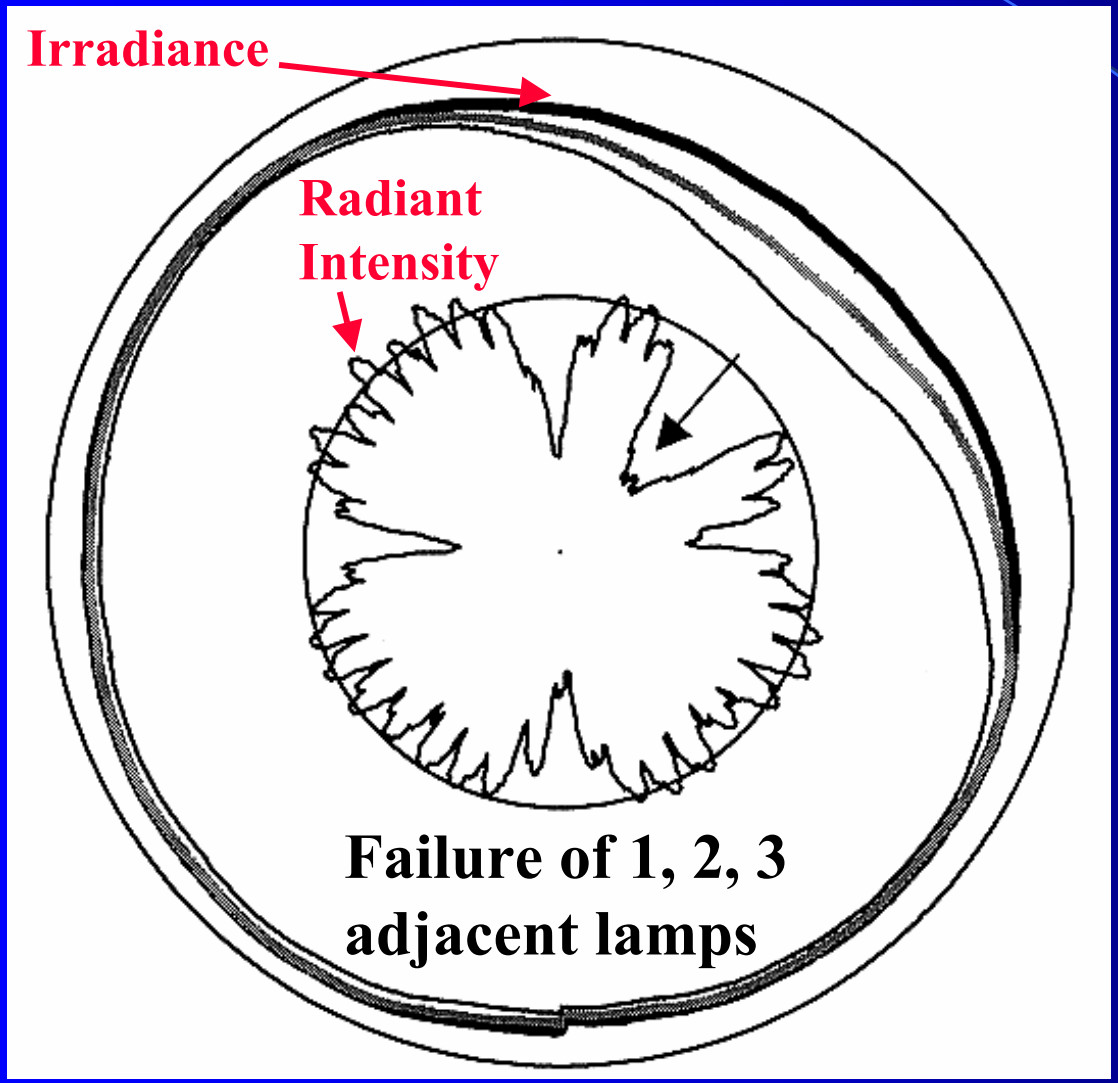


Automated UV calibration system

Dual detector head

Rotation achieved using stepper motor controlled by integrated circuits

Influence of cold/hot spots (a)



UV 7001 – 40 tubes

1 out centre: 10%

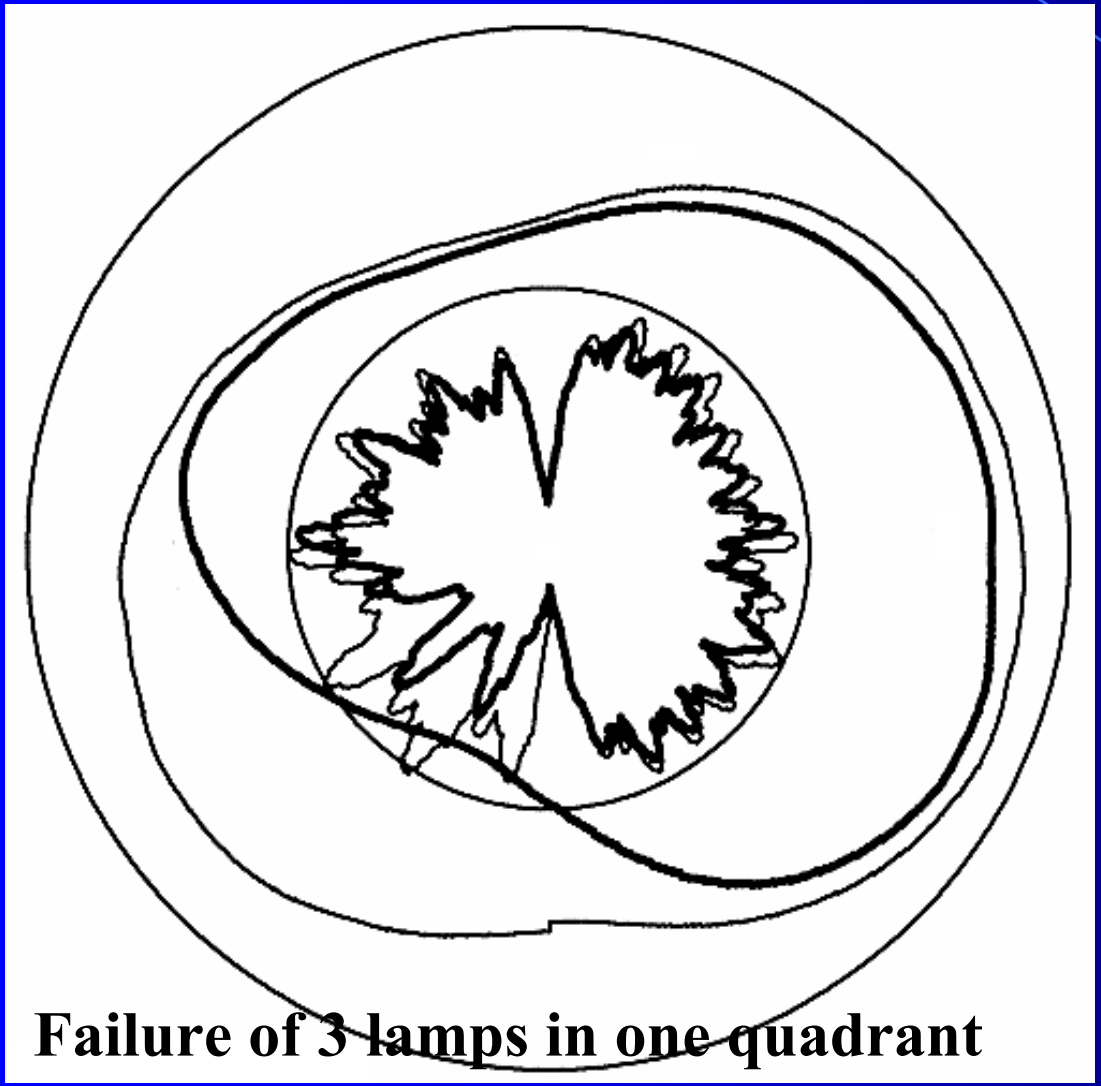
2 adjacent: 18%

1 out corner: 7%

2 adjacent: 13%

Hot spot: 4 - 5% 1 tube replacement

Influence of cold/hot spots (b)



Failure of 3 lamps in one quadrant

UV 1000 – 26 lamps

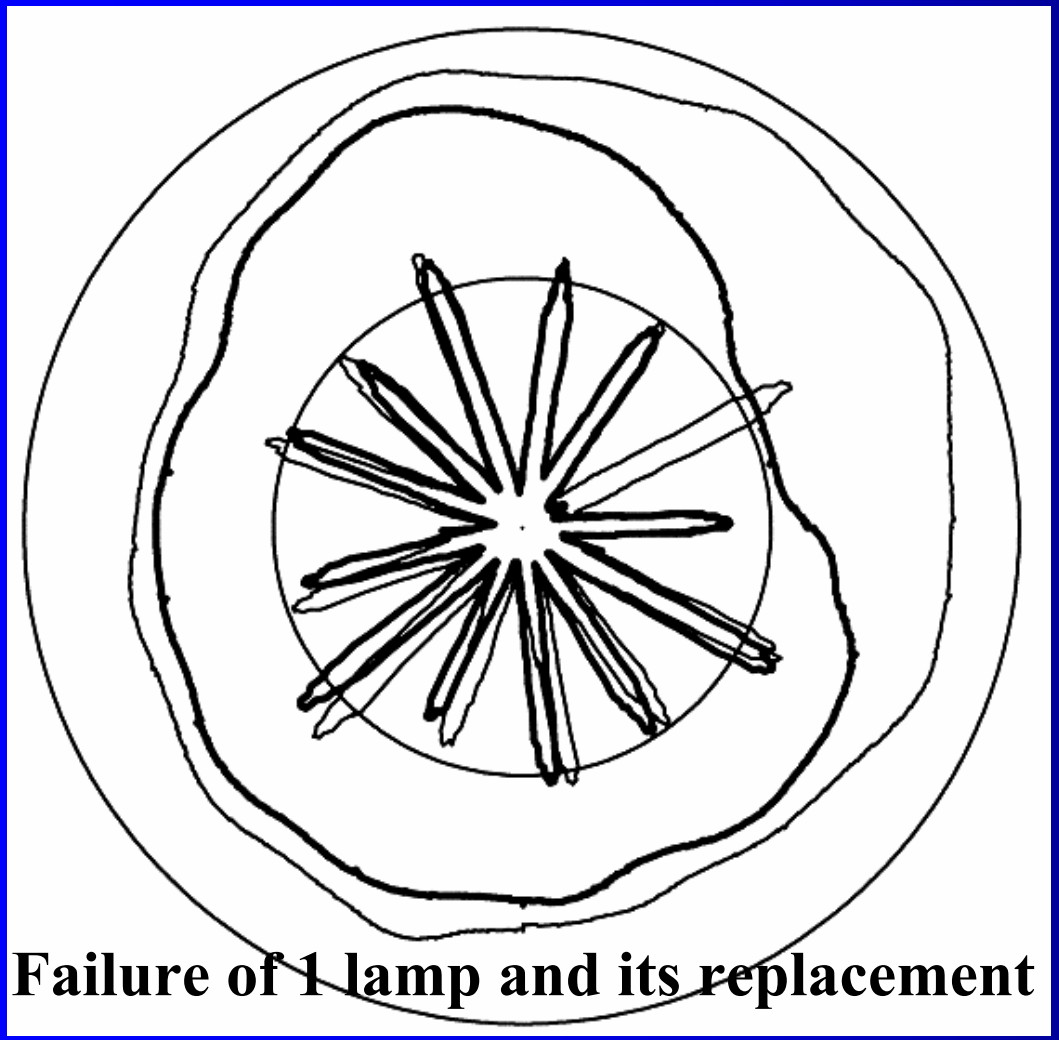
Integral 20-25% reduction towards hinges due to cabin geometry

1 tube out centre: 7-10%

1-2 tubes out hinge:30-40%

3 lamps out: 55%

Influence of cold/hot spots (c)



Failure of 1 lamp and its replacement

UV 7001k – 13 tubes

30% reduction if one tube out

15% increase for replacement tube

Also UV 5000 – 24 tubes

12% reduction if one tube out

6-7% increase for replacement tube

Influence of cold/hot spots

- % irradiance variation of cold spots ~ double that of hot spots
- More significant for cabins with fewer lamps & dependent on cabin geometry
- Modern cabins – localised erythema unlikely due to variation in irradiance (order of 10%)
- Older dual lamp cabins or smaller cabins – lamp failures should be dealt with promptly (order of 30%)

Study of Internal detectors

- Tl01 cabins only
- 3 different types of cabin
- Developed a phantom with reflectance approximately the same as skin

  (Phantom: 5% ± 8%, Skin 4 – 7%)
- Allowed cabin warm-up to stabilise output
- Moved phantom in Anterior Posterior (AP) & Lateral directions, controlled from outside cabin during single run

Cabin Summary

Unit	№ Tubes	Internal Detector Type
Waldmann UV 7001	40	Double detector Facing side banks Knee height
Waldmann UV 5000	24	Single detector Facing Patient right Knee height
Cosmedico GP 42	Dual UVA/TL01 21 Tl01 lamps	Double detector Facing 2 banks to Patient Right Above head height

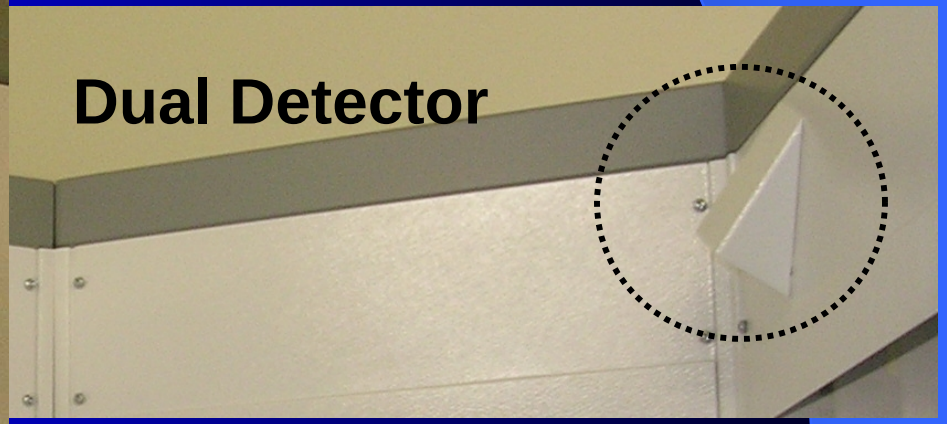
Detector configurations

UV 5000/7001

Dual Detector 7001

Single detector 5000

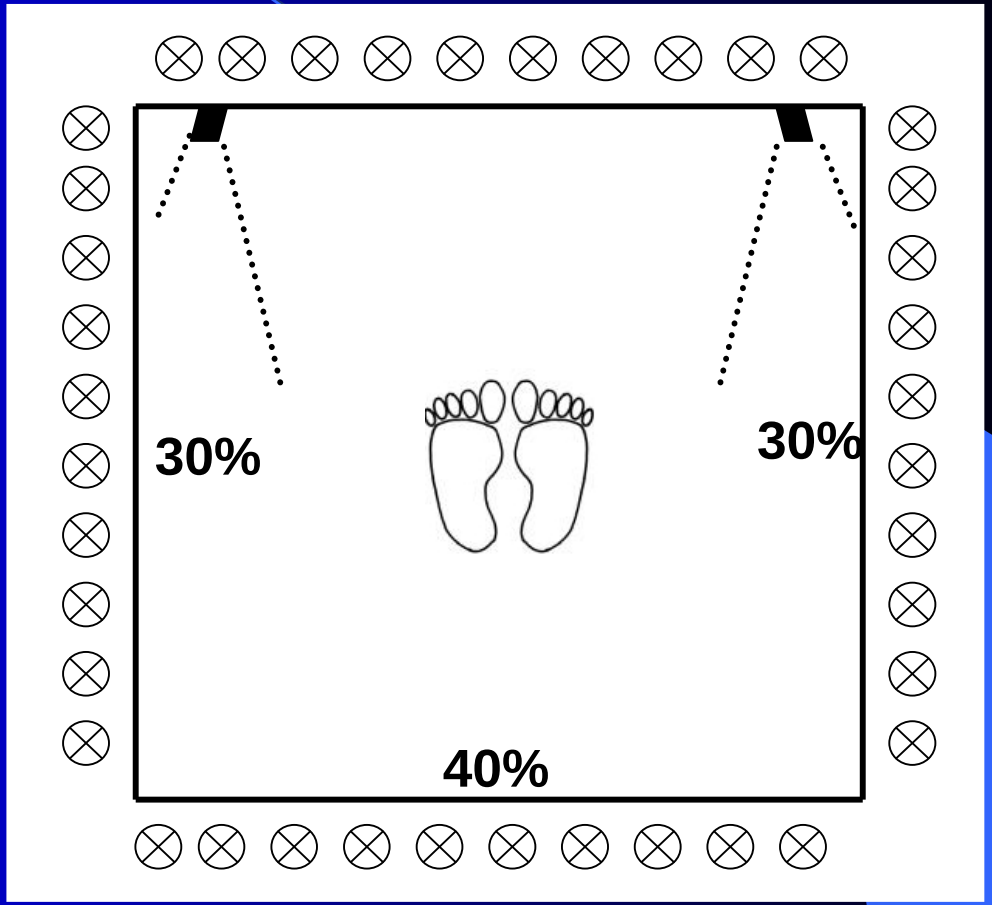
Cosmedico GP42



Dual Detector

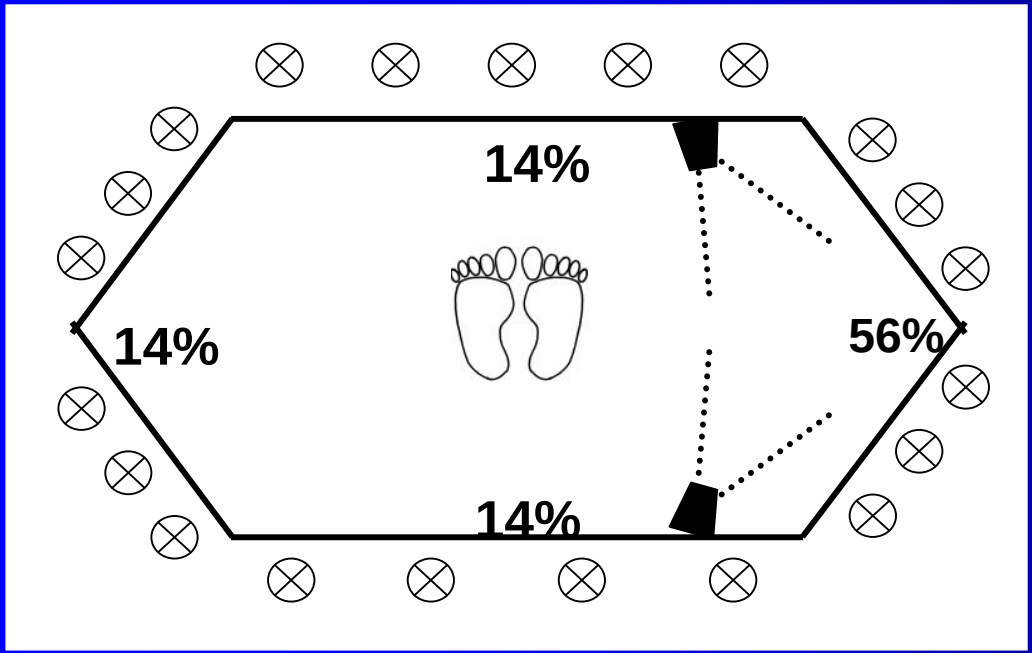
Bank dependency

- Whole lamp banks covered and resulting internal detector reading recorded
- Relative dependency calculated as a percentage
- Measured dependency from door bank negligible



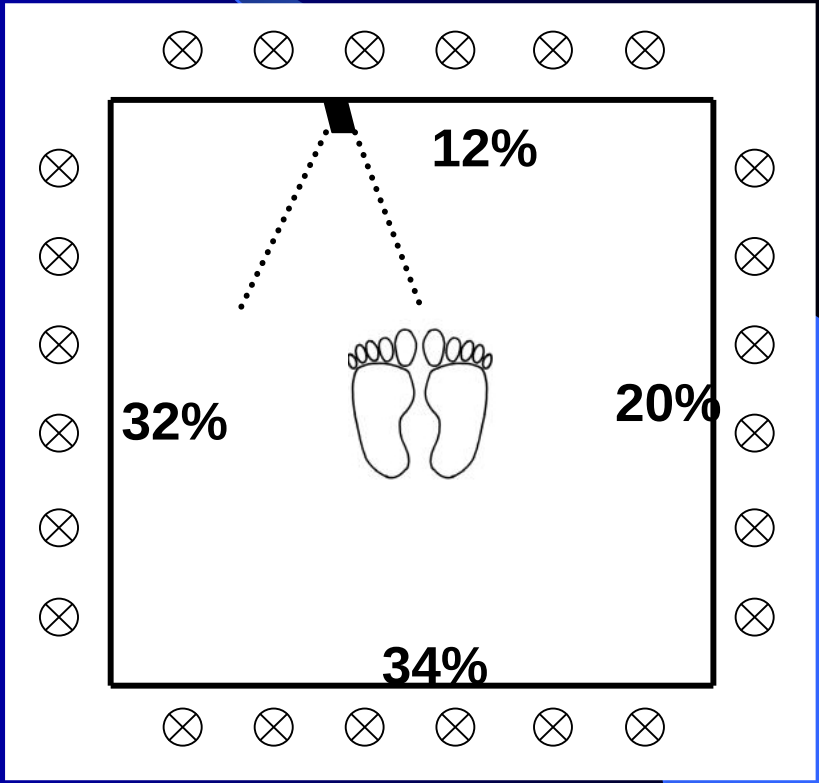
UV 7001 - Dual Detectors

Bank dependency

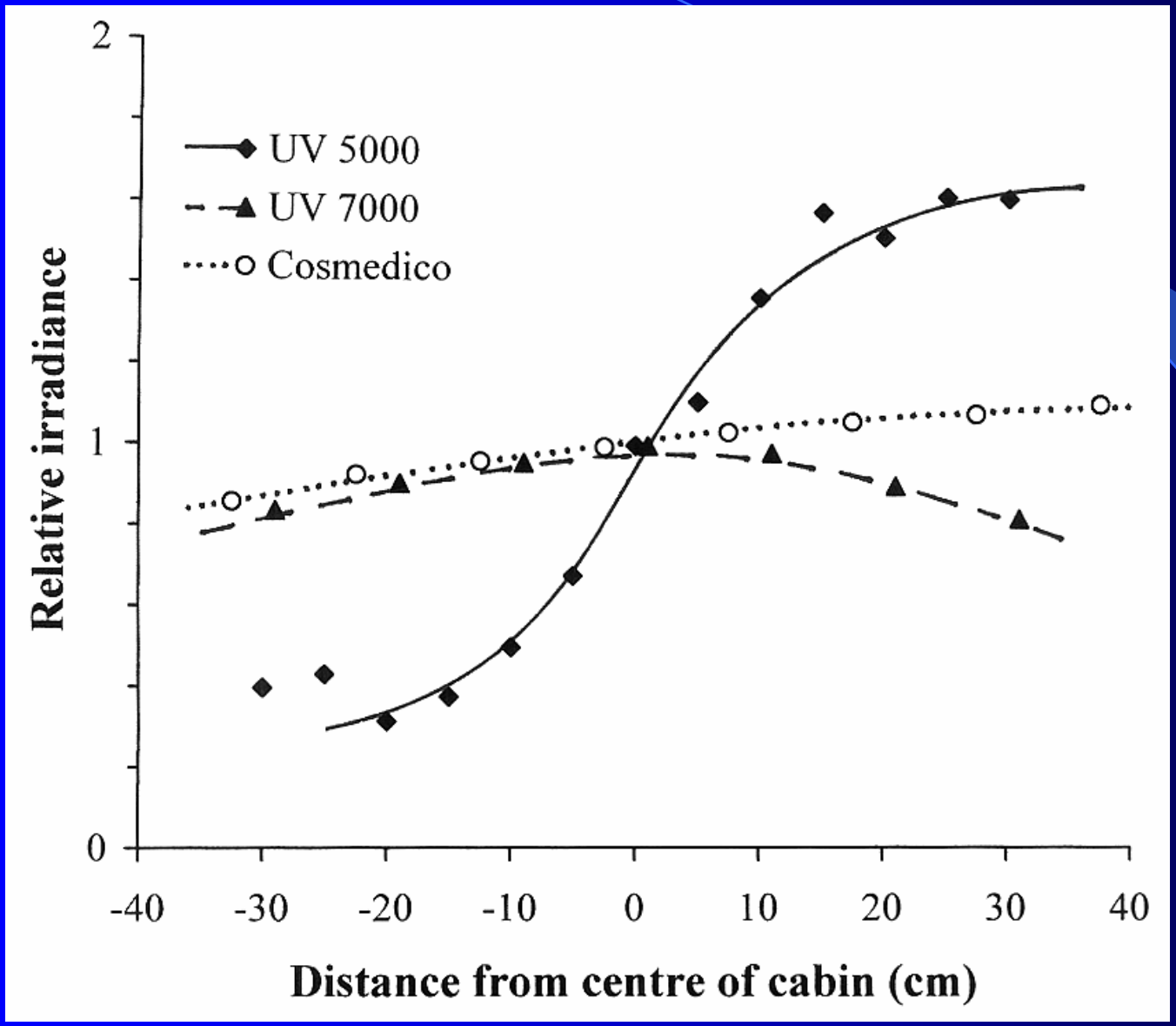


Cosmedico GP42 - Dual Detector

UV 5000 - Single Detector



Variation in irradiance



Patient position Vs. relative irradiance (lateral direction)

Results

Centre Offset [cm]	% Dose Discrepancy					
	UV 7001		Cosmedico GP42		UV 5000	
	AP	LAT	AP	LAT	AP	LAT
-10	-2	-4	<1	-3	0	37
10	5	-3	<1	4	-6	-50

Negative values indicate under-dosing

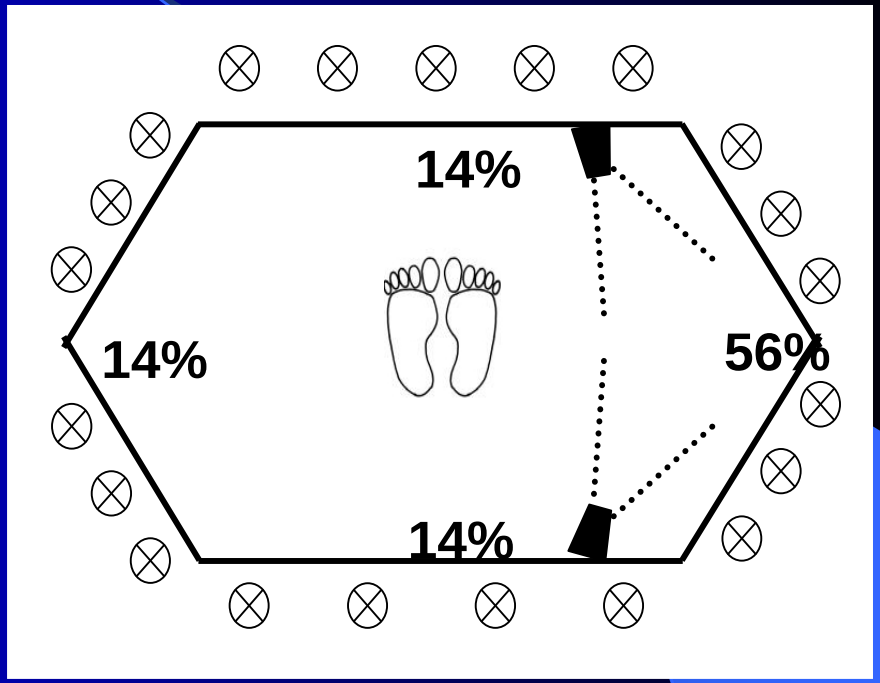
Results

- Few % difference between standard & large patients
- Single detector system outliers ±60% (for ±10-20cm offset)
- However, UV 5000 cannot be used with internal detector control
- Newer Waldmann UV 5001 has single internal detector with calibration performed without patient in cabin
- Results in a 15% patient attenuation coefficient dose discrepancy
- Cosmedico GP42 outliers ±10-15% for taller patients (for ±10-20cm offset)

Results

- Two bank dependency for Cosmedico GP42 (56%)
- If a single tube out on these banks, results in a

  9 – 10 % reduction in detected cabin irradiance, compared to ~ 3% for other banks
- However, actual reduction in overall cabin irradiance will be ~ 5%



Conclusions

- Whole batch & single lamp replacement policies are considered equally acceptable provided there is a robust system to identify & replace failed lamps
- However, batch replacement will also have periods of failed tubes → cold spots
- Waldmann 7001 cabin internal detector readings only varies by ±5% with patient position
- Waldman 5000 cabin readings varies by 50% with patient position, but not used to control treatment
- Cosmedico GP42 cabin readings vary by ±5% with patient position, but one lamp failure can change reading by 10%

Acknowledgements

- Stuart MacCalman & Graeme Phanco

  Health Physics Service

- Cameron Hosie

  Lanarkshire Acute Hospitals NHS Trust