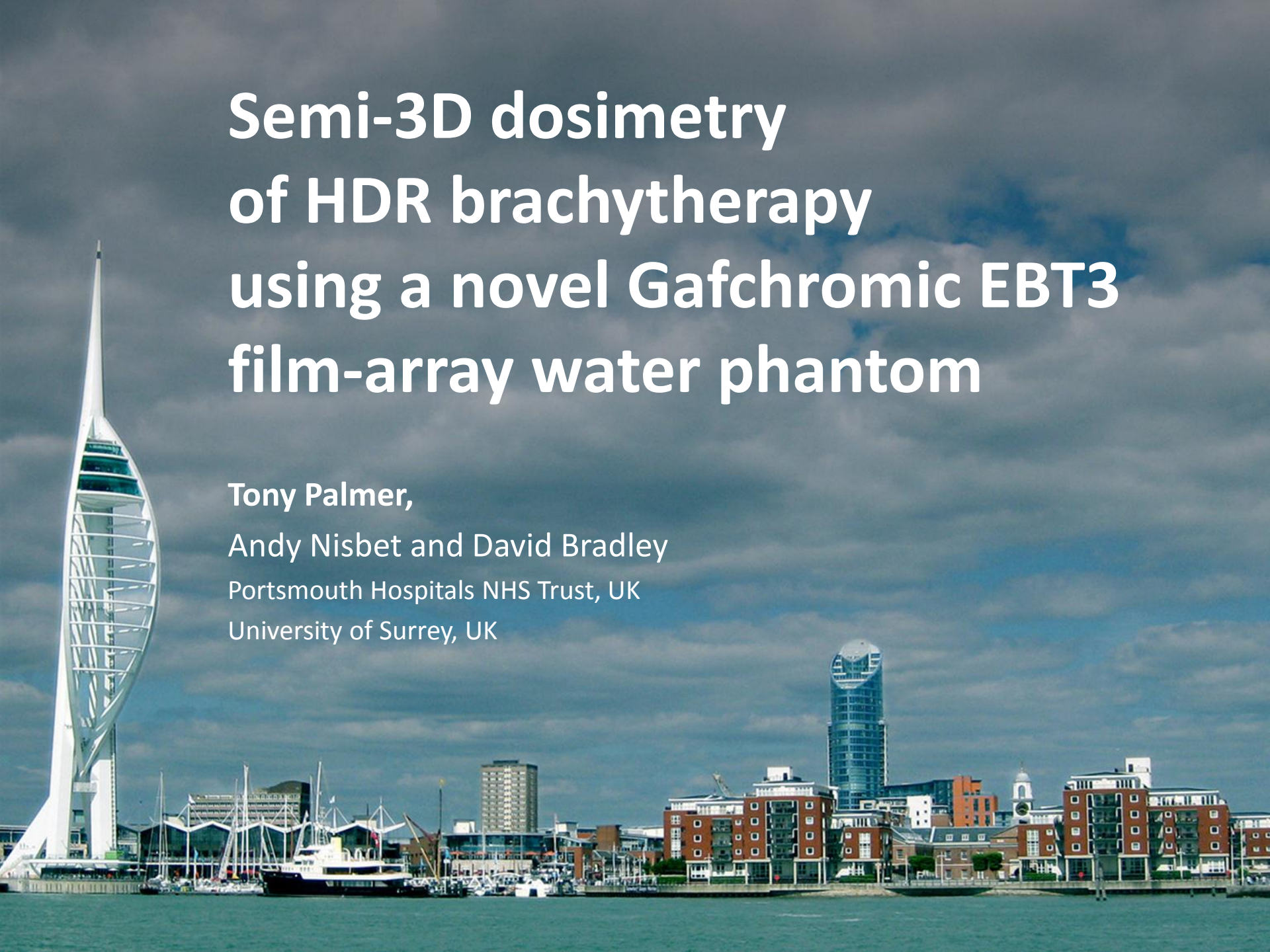

Semi-3D dosimetry of HDR brachytherapy using a novel Gafchromic EBT3 film-array water phantom

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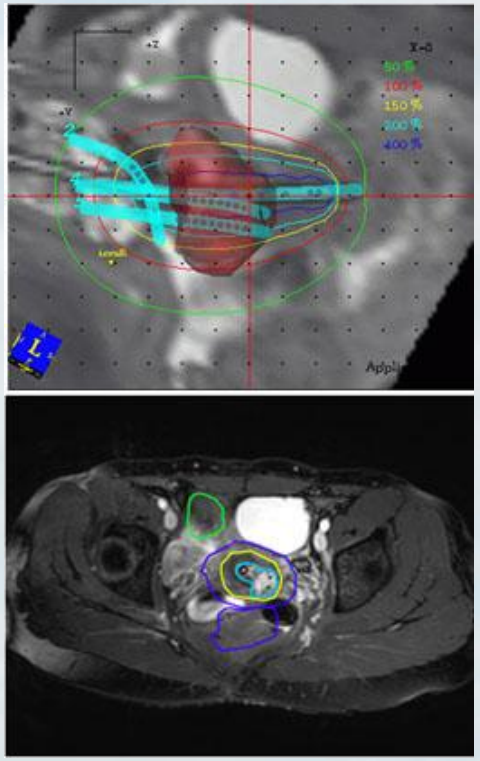
Purpose

Modern HDR brachytherapy is complex:

- 3D image guidance CT, MRI
- Volume prescribing and OAR
- Inverse planned patient-specific optimisation

But, lack of modern QC:

- Basic tests conceptually removed from the clinical situation
- Source strength, point doses, linear dwell position



Dosimetry for Brachytherapy Quality Control

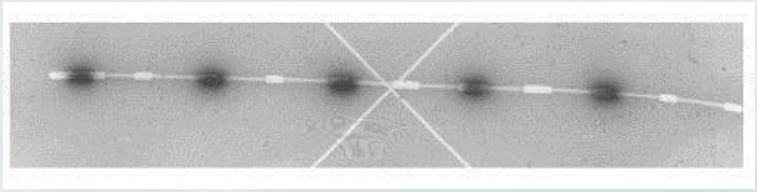
High dose gradients, large dose variations, small scales, complex applicators shapes

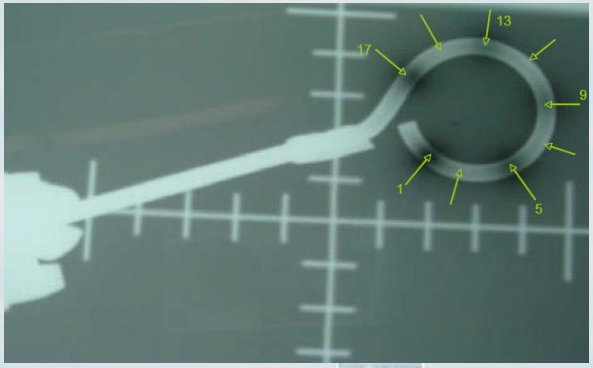
Current methods generally either too simple (point doses) or too complex (3D research)

Aim is a simple, practical QC test comparing planned and delivered doses for modern 3D HDR brachytherapy

Basic HDR brachytherapy QC

Required, but insufficient

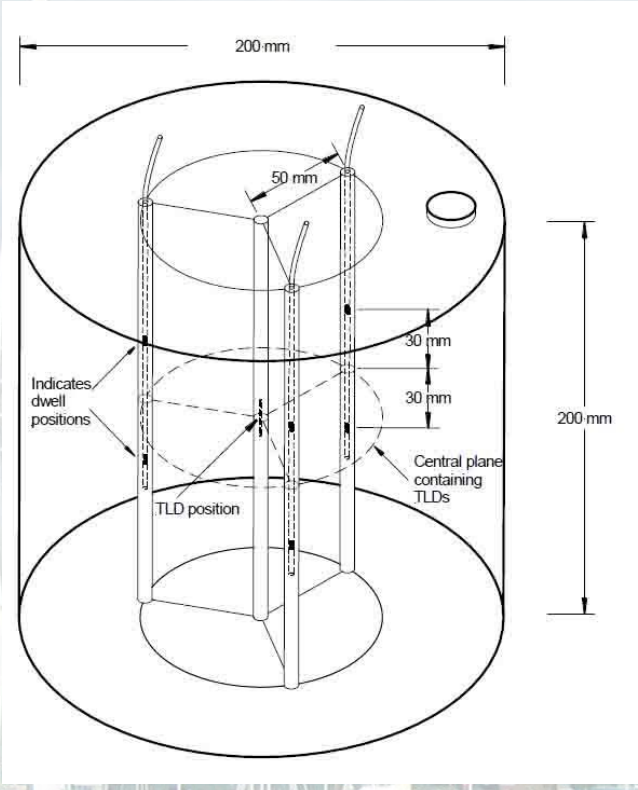




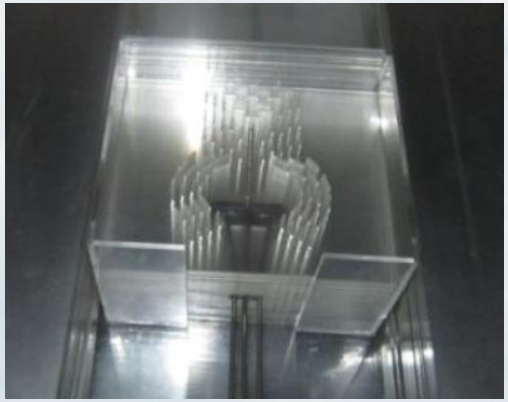
Advanced HDR brachytherapy QC

Inappropriate for routine QC tests

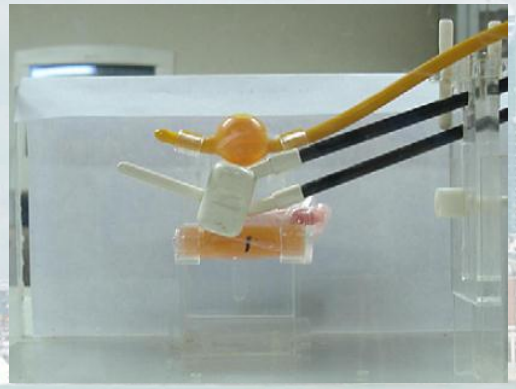
Australian HDR audit,
Haworth (2012)



Perspex TLD phantom,
Mahdavi (2012)



FBX chemical dosimeter,
Bansal (2012)



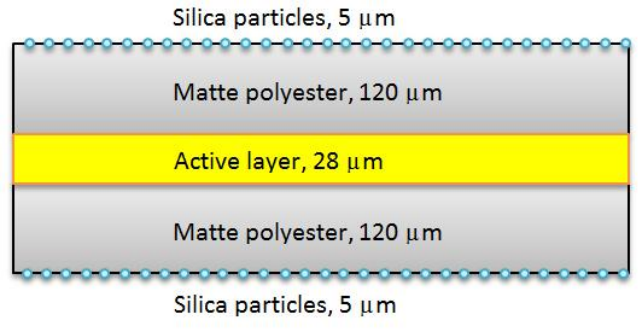
Presage dosimeter,
Palmer (2012)

Renaissance of film?

Single or multiple 2D planes

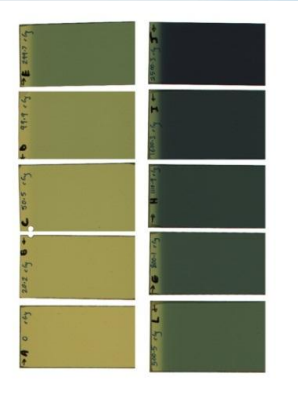
Gafchromic EBT3 film:

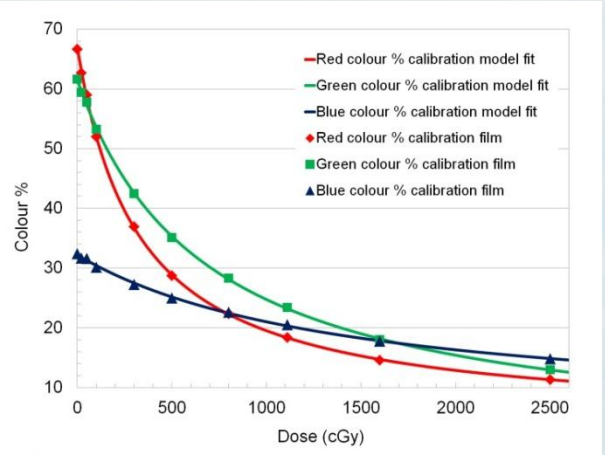
- High spatial resolution,
- Weak energy dependence,
- Near water-equivalence
- Advanced multichannel scanning (FilmQAPro software)



Film calibration

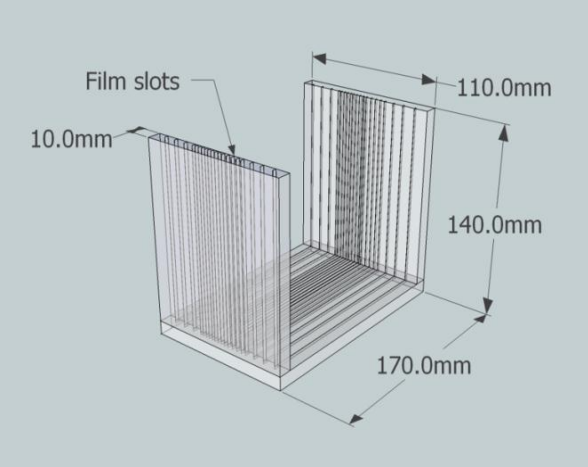
- Calibration function for each colour channel.
- Disturbance function, measured colour signal to allowed colours in the dose-to-rgb calibration.
- Separate the dose-dependent and dose-independent parts:
  Eliminates film non-uniformities, many scanner artefacts.

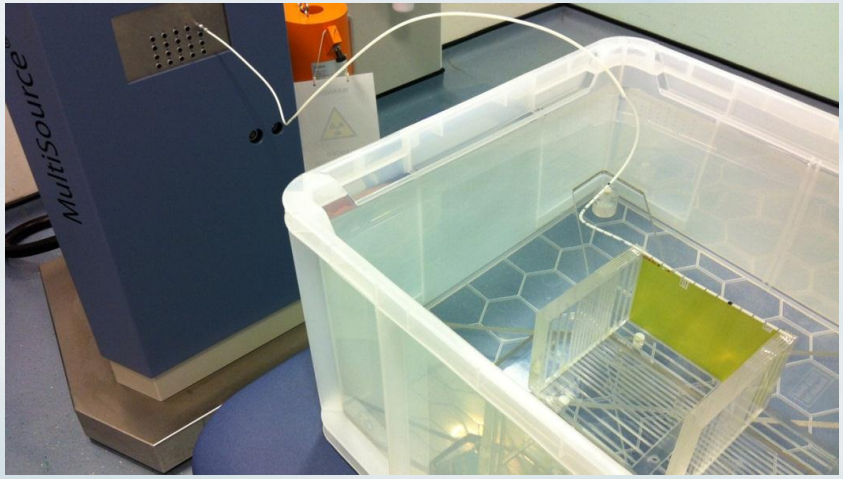




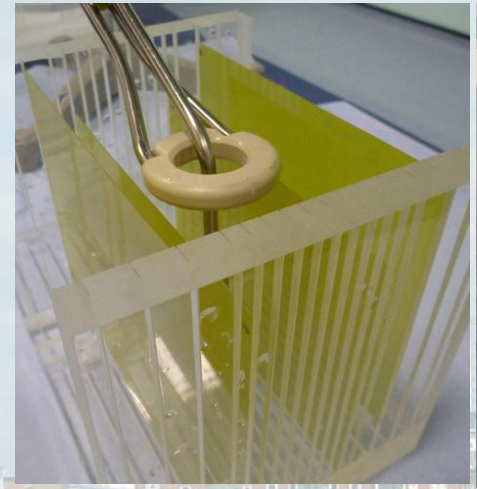
Micke A, Lewis DF, Yu X 2011 Multichannel film dosimetry with nonuniformity correction *Med. Phys*. 38 2523-34

HDR dose measurement

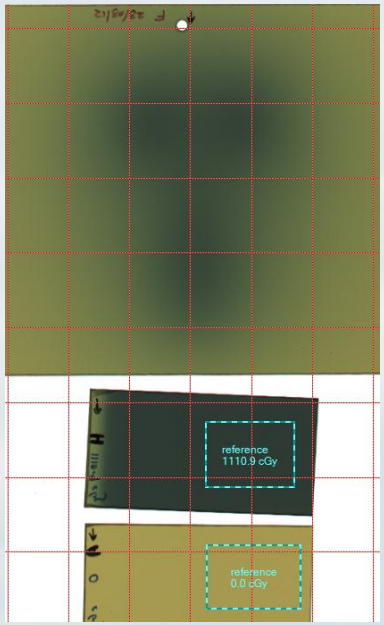




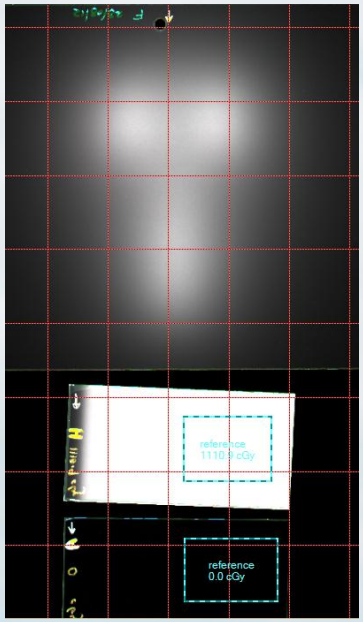
EBT3 film-array
in ‘full scatter’
water tank



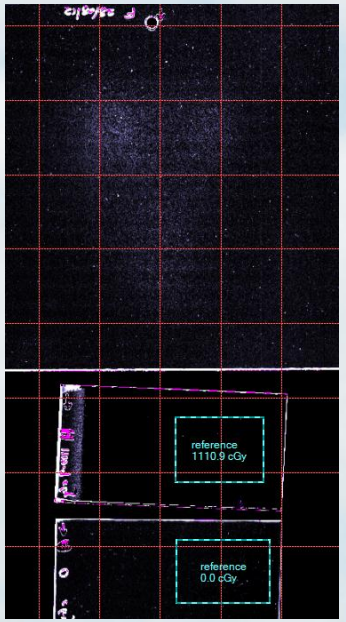
Film analysis



Exposed film with reference patches



Dose map

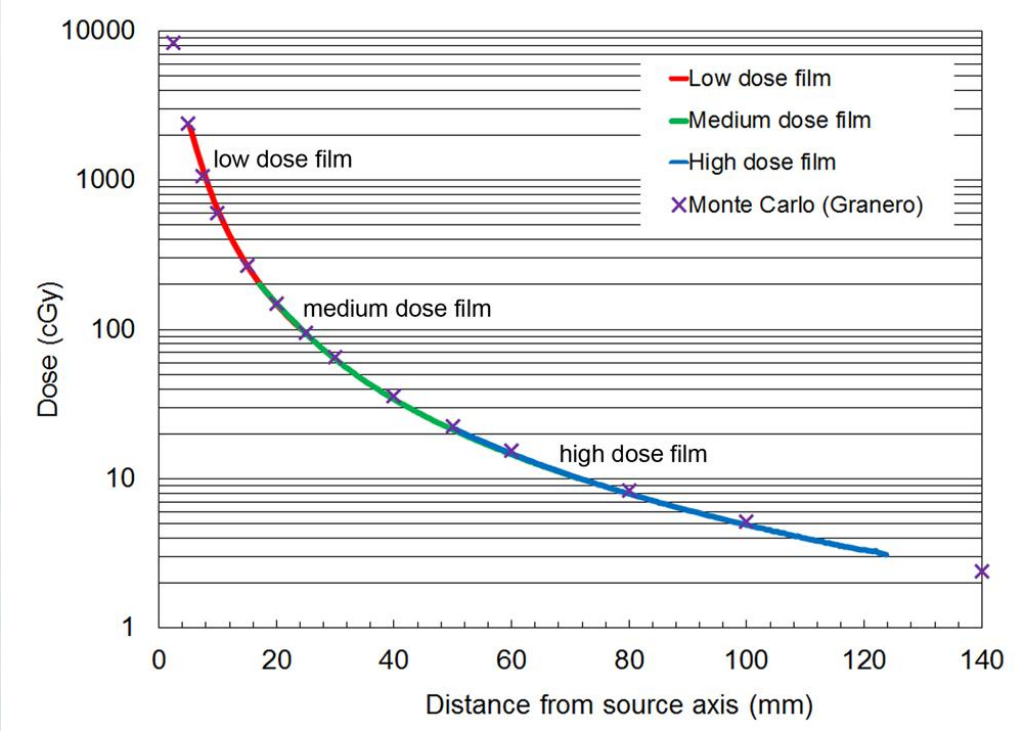


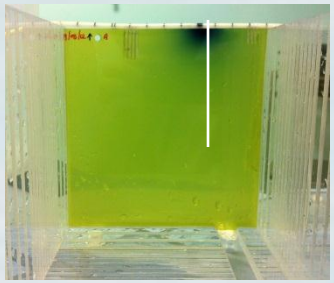
Calibration consistency map

Single dwell point

Validate film technique in HDR brachytherapy dose/energy range.

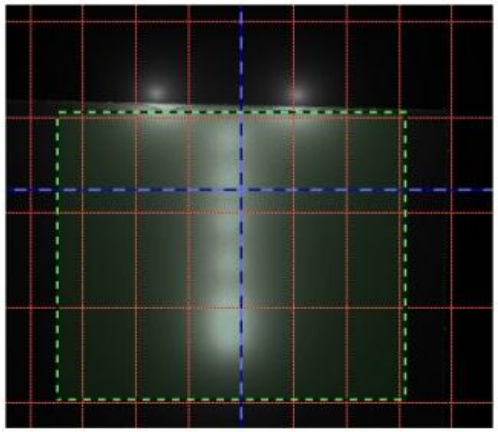
Radial dose measured with film compared to Monte Carlo data





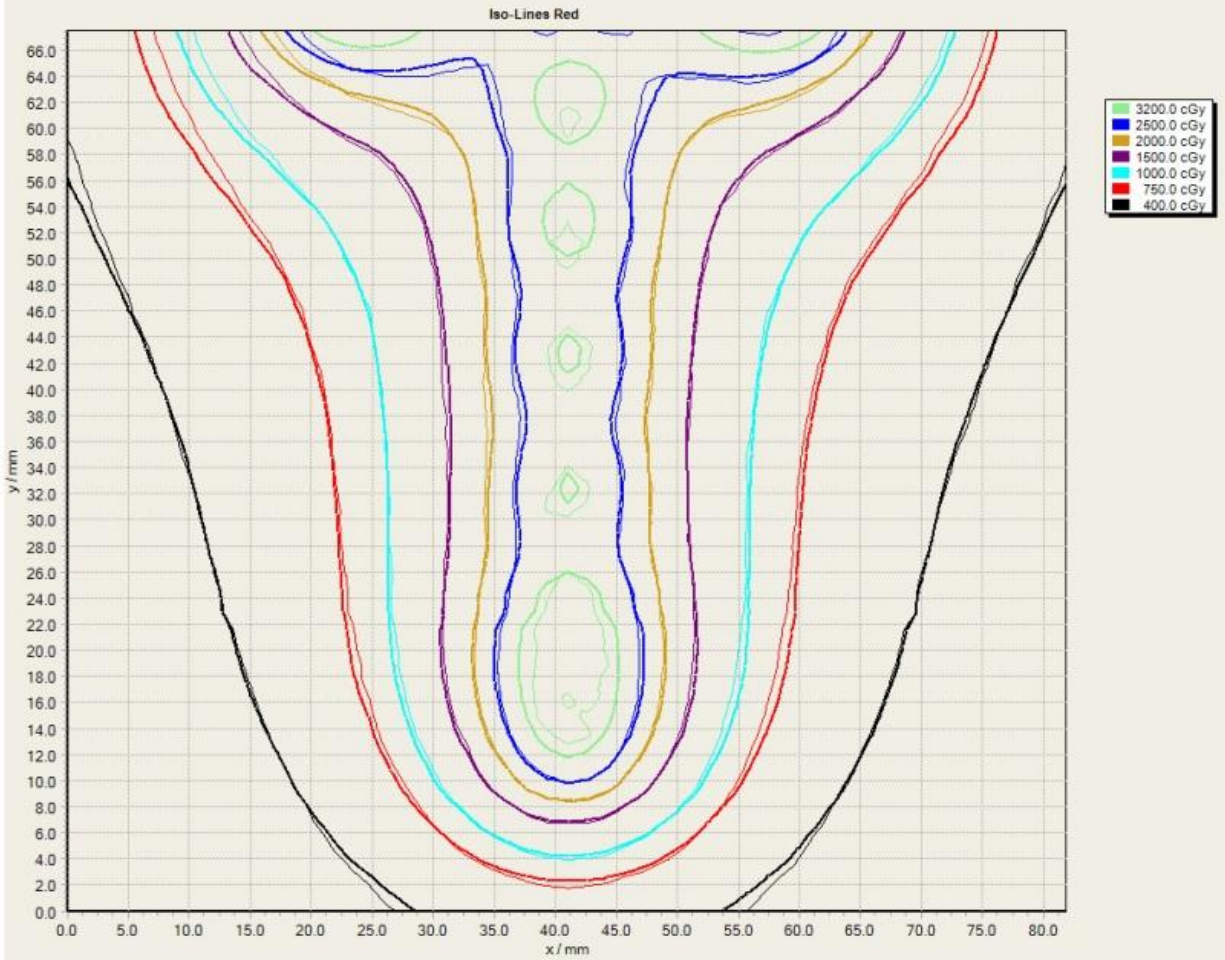
Single dwell position and
Radial dose profile

HDR cervix ring and IU treatment applicator

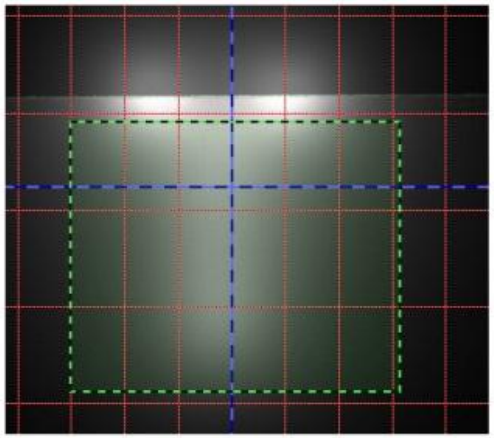


Film dose (thin line) and TPS isodose (thick line),

5 mm from applicator IUT

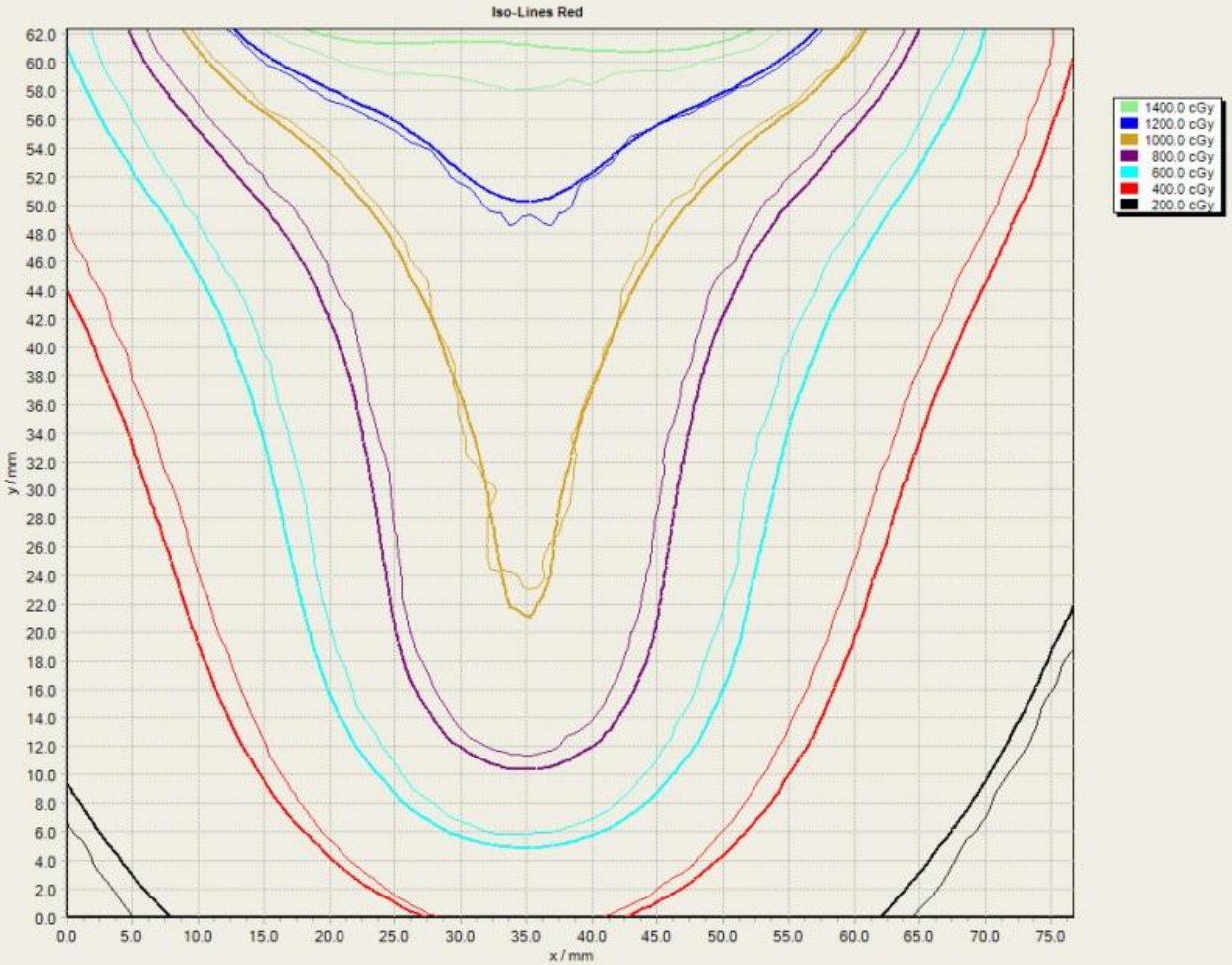


HDR cervix ring and IU treatment applicator



Film dose (thin line) and TPS isodose (thick line),

15 mm from applicator IUT



HDR cervix ring and IU treatment applicator

2D gamma analysis of difference between film dose and TPS dose for HDR applicator measurement

Film position	Gamma criteria	Passing rate: local gamma	Passing rate: global gamma
5 mm from IU axis	2 % / 2 mm	91.3%	98.3 %
	3 % / 3 mm	99.1%	99.4 %
15 mm from IU axis	2 % / 2 mm	86.9%	96.8 %
	3 % / 3 mm	99.6%	99.9 %

Standard uncertainty (k=1) 1.5% to 2.7%

Conclusions

- A practical and suitable QC technique for modern 3D HDR brachytherapy using a closely-spaced film array.
- Semi-3D technique, but since 3D >= 2D gamma passing rates, sufficient to assure dose actually delivered is in agreement with that planned.
- Calibration function for Gafchromic EBT3 film derived over 0 to 90 Gy dose range using three colour channel analysis (FilmQAPro software), validated with comparison to MC data.
- Film measurements around a cervix applicator agree with TPS calculations with 2D local gamma passing rate > 99% at 3% 3mm.

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