# Adapting a 3D scanning water phantom for use in brachytherapy dosimetry

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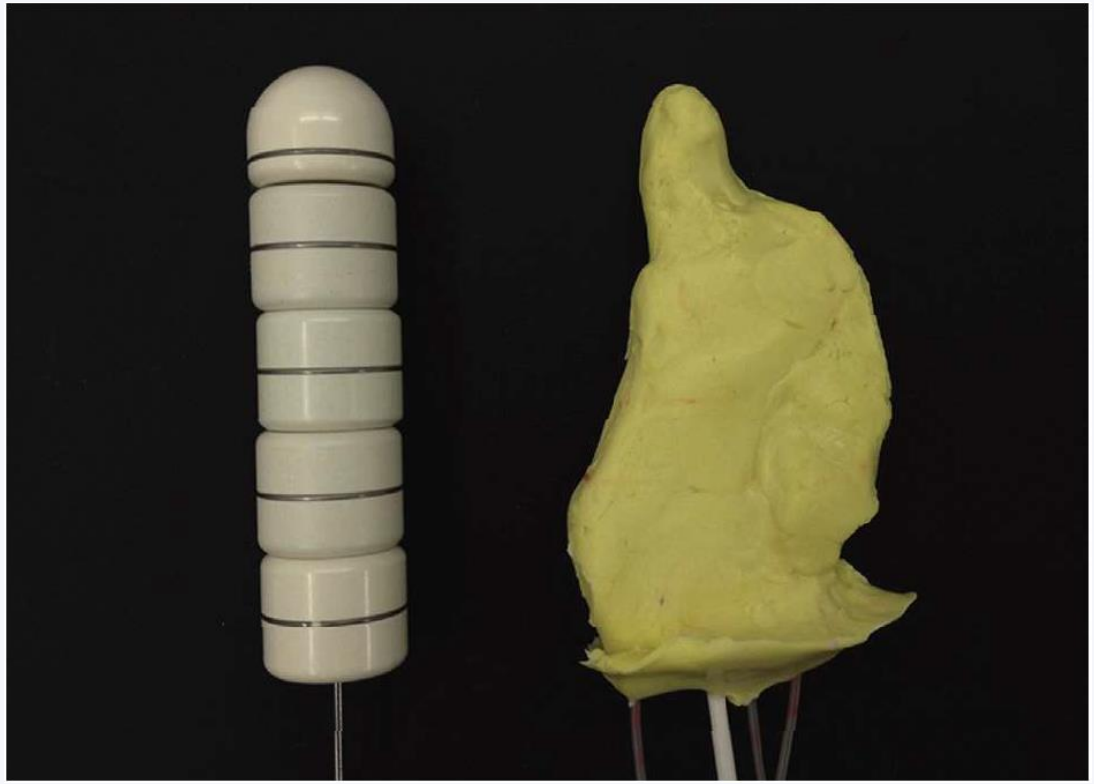
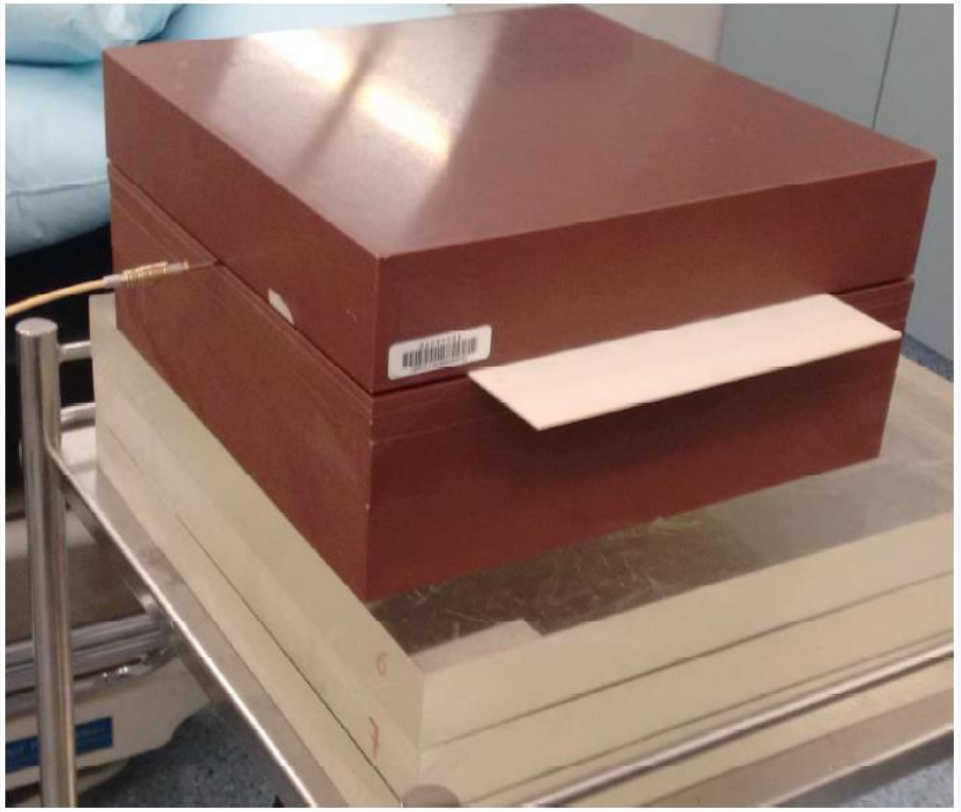
# Brachytherapy

- HDR brachytherapy features hypofractionated deliveries involving sharp dose gradients. Dose validation is important.
- If we adopt model-based dose calculation algorithms and make non-water-equivalent patient matched applicators, we need methods to validate dose distributions.



# Dosimetry challenges

- High dose gradients that make brachytherapy attractive for highly conformal treatments can make relative dosimetry difficult.
- A displacement of 2.5 mm can lead to approximately 25% dose difference 2 cm from source.
- These uncertainties necessitate precise dosimeter placement.

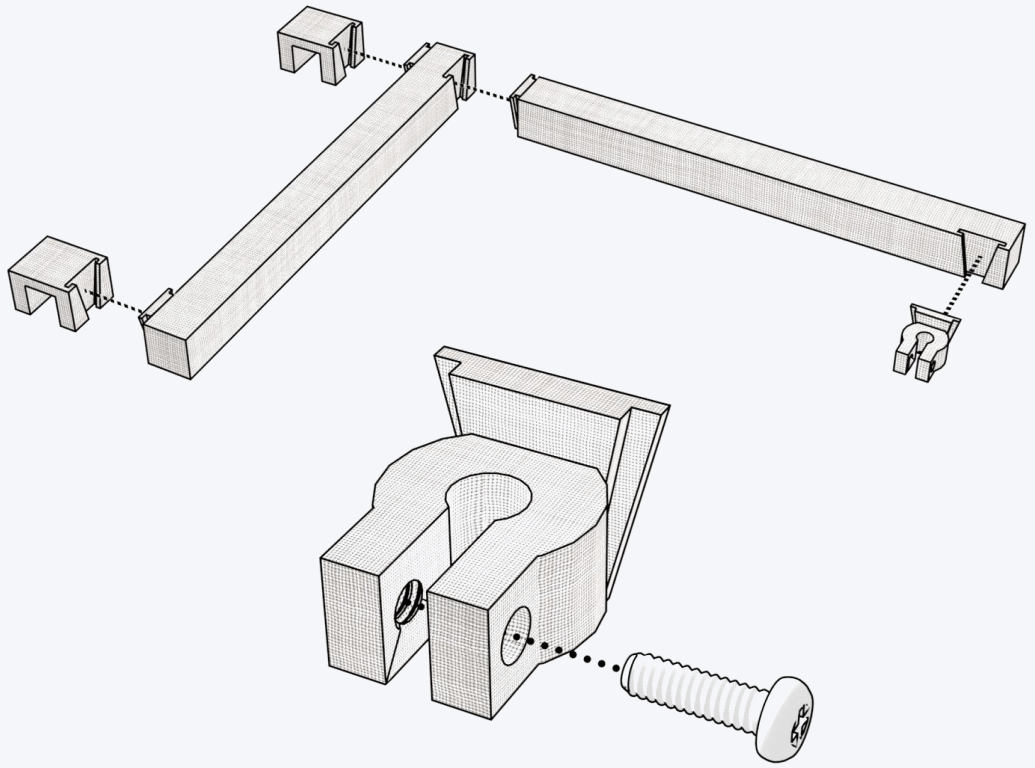


# Dosimetry challenges

- Scanning water phantoms are ubiquitous, and provide high precision relative dose measurements for linacs.
- The aim of this investigation was to manufacture a modular jig to enable precise and reliable dose measurements around a brachytherapy source.

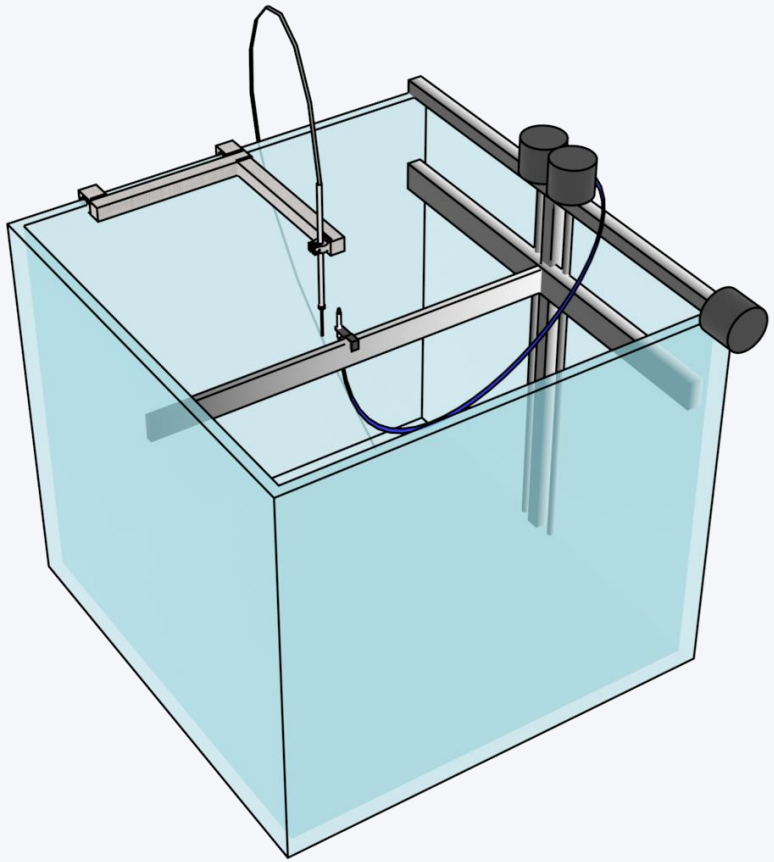
# Design and fabrication

- Jig designed for PTW BeamScan dimensions, to hold titanium intrauterine applicator.
- Three parts: stabilizing arm, arm extension, and applicator clamp, with dove tail joins.
- 30% in-fill PLA for rigid jig, PLAflex for clamp. Printed on a Raise3D Pro2.
- Post-print QA performed.



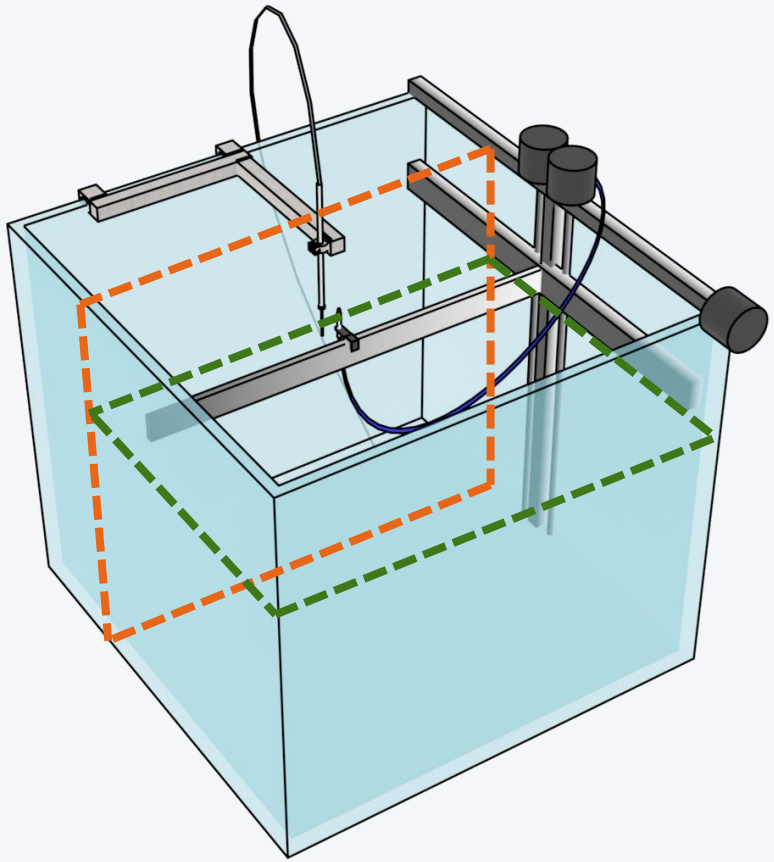
# Dose measurements

- PTW Pinpoint 3D was used to measure distribution of $^{192}$Ir source of a GammaMedplus HDR afterloader.
- The exact position of the source was identified by profile scans:
  - Longitudinally, along applicator length (i.e. vertical drive)
  - Radially in both dimensions, from underneath applicator



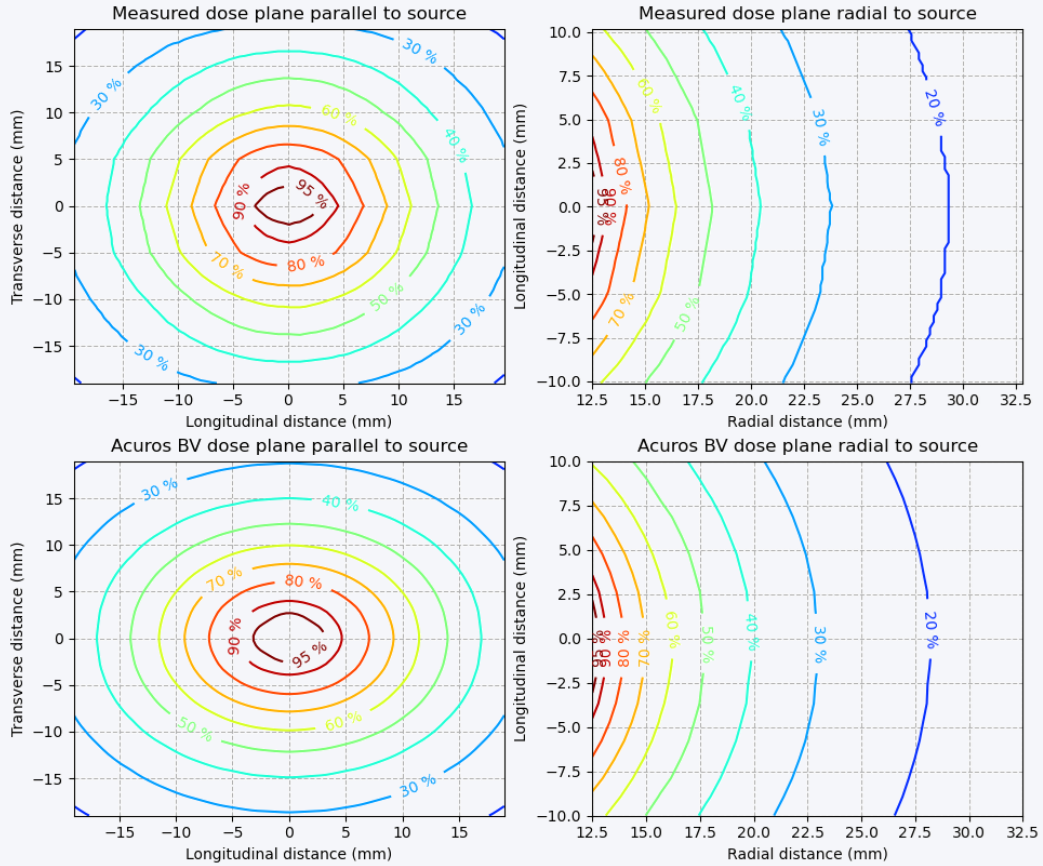
# Dose measurements

- Both radial (green) and parallel (orange) dose planes measured, with an offset from source to any avoid collision.
- Performed with & without water, to facilitate comparison against reference data.
- Continuous 1 mm scan, taking 5 to 7.5 minutes for 4×4 $cm^2$ area.



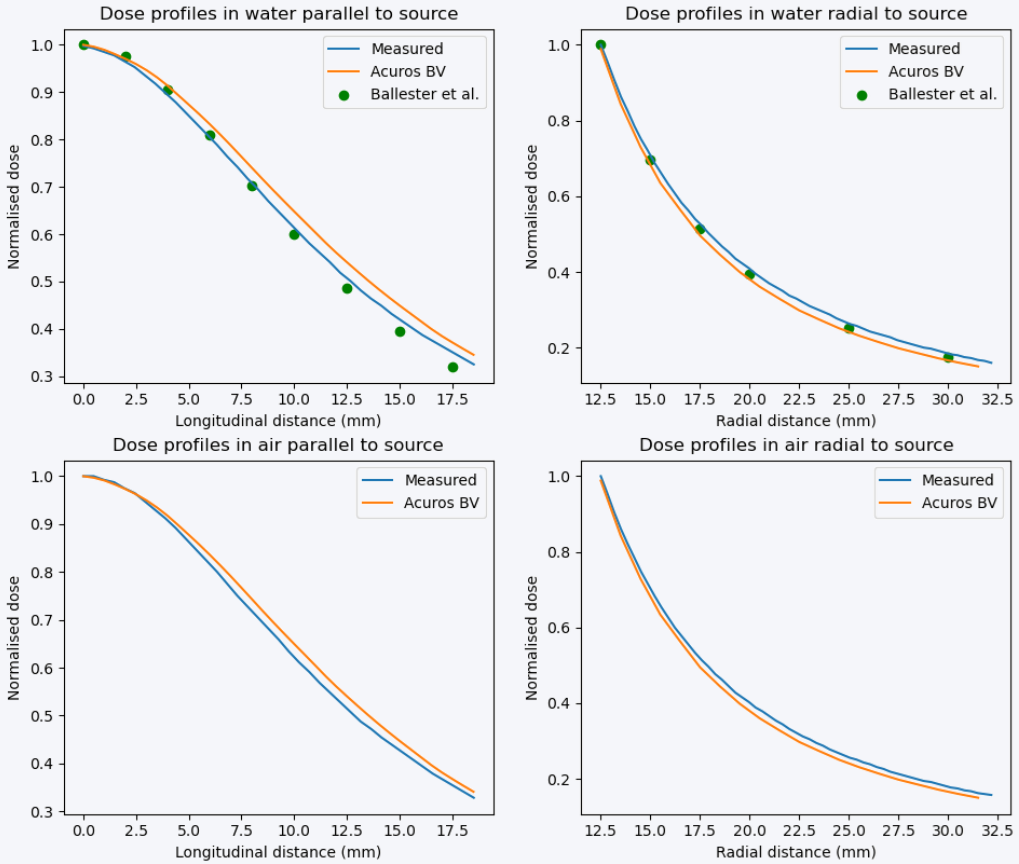
# Dose evaluation

- To evaluate whether results were sensible, measurements were compared against Acuros BV dose calculations in water.
- Isodose measurements (top) and dose calculations in a water phantom (bottom), parallel (left) and radial (right) to the source shown.



# Dose evaluation

- To facilitate comparisons, profiles are shown, in water (top) and air (bottom), parallel (left) and radial (right) to source.
- Measurements (blue line) are compared against reference TG-43 reference data (green dots), and Acuros BV (orange line).



# Potential utility

- The modular design can be adapted to support other applicators and scanning water phantoms, at low cost.
- It could be used to characterise dose for complex applicators, including non-water equivalent materials (e.g. with shielding).
- It could be used for precise point dose measurements for multiple- dwell position and channel treatments.
- It could be used for in-air measurements for reference air kerma rate measurements, using seven-distance method to correct for scatter.

# Conclusion

- A cost-effective 3D-printed modular jig was designed and fabricated to allow brachy dose measurements in a scanning water phantom.
- The mechanical precision proved suitable for these measurements despite high dose gradients.