PROJECT 18NRM02 PRISM-eBT - WP4 STATUS REPORT –14/12/2021

WP 4 – 3D DOSE DISTRIBUTION MEASUREMENTS AND COMPARISON WITH MANUFACTURER-SUPPLIED DOSE MAPS

Task 4.1 – Measurement of the 3D dose distributions close to the considered eBT devices with or without applicators fitted

A3.3.1-3.3.3 (M24) – Characterization and calibration of dosimeters based on alanine pellets

- **A4.1.1 (M21) – Design and manufacture of the phantom for 3D dose measurements using alanine pellets**
- **A4.1.2 (M30) – Measurements of D_W distributions in 3D using alanine dosimeters for INTRABEAM and Papillon50 eBT devices**

A3.2.3-3.2.4 (M12) – Characterization and calibration of dosimeters based on Fricke gels

- **A4.1.3 (M12) – Design and manufacture of the phantom for 3D dose measurements using Fricke gels**
- **A4.1.4 (M15) – Monte Carlo calculations to convert absorbed dose to gel in absorbed dose to water D_W**
- **A4.1.5 (M18) – Development of an automatic program for the analysis of MRI readings**
- **A4.1.6 (M21) Measurements of D_W distributions in 3D using Fricke gel dosimeters for INTRABEAM device**

WP 4 – 3D DOSE DISTRIBUTION MEASUREMENTS AND COMPARISON WITH MANUFACTURER-SUPPLIED DOSE MAPS

Task 4.1 – Measurement of the 3D dose distributions close to the considered eBT devices with or without applicators fitted

A3.1.1 (M9) – Characterization and calibration of dosimeters based on scintillators and ion-chambers

- **A4.1.7 (M18) – Design and development of a method to measure 3D dose distributions using commercially available motorized water phantoms for scintillator detectors and ion-chambers**
- **A4.1.8 (M20) – Characterization of the positional accuracy of the detectors inside the motorized water phantom**
- **A4.1.9 (M24) - Measurements of D_W distributions in 3D using scintillator and ion-chamber based dosimeters for INTRABEAM & Papillon50 eBT devices**

WP 4 – 3D DOSE DISTRIBUTION MEASUREMENTS AND COMPARISON WITH MANUFACTURER-SUPPLIED DOSE MAPS

Task 4.2 – Traceable dosimetry for 3D dose distribution measurements including a comparison of different absorbed dose to water (D_W) maps

A4.1.2 (M30) – Measurements of D_W distributions in 3D using alanine dosimeters for INTRABEAM and Papillon50 eBT devices

A4.1.9 (M24) – Measurements of D_W distributions in 3D using scintillator and ion-chamber based dosimeters for INTRABEAM & Papillon50 eBT devices

A4.2.1 (M32) – comparison of the dose map supplied by the manufacturer for the Papillon50 eBT device with the D_w 3D distributions measured using alanine detectors and a combination of scintillator and ion-chamber detectors

A4.2.2 (M33) – Comparison of the dose map supplied by the manufacturer for the INTRABEAM system with the D_w 3D distributions measured using a combination of scintillator and ion-chamber detectors (A4.1.7) and alanine detectors (A4.1.2)

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A4.1.2 (M30) – Measurements of D_W distributions in 3D using alanine dosimeters for INTRABEAM and Papillon50 eBT devices

A4.1.6 (M21) – Measurements of D_W distributions in 3D using Fricke gel dosimeters for INTRABEAM device

A4.1.9 (M24) – Measurements of D_W distributions in 3D using scintillator and ion-chamber based dosimeters for INTRABEAM & Papillon50 eBT devices

A4.2.3 (M33) – Comparison of the dose map supplied by the manufacturer for the INTRABEAM system with the D_w 3D distributions measured using Fricke gel, alanine detectors and a combination of scintillator and ion-chamber detectors

A4.2.1-4.2.3 (M33) Comparison of the dose maps supplied by the manufacturer with the D_W 3D distributions measured using different dosimeters

A4.2.4 (M34) – Report with the collection of the results

WP4 Progress (NPL)

A4.1.1 (M27; Sep 21) (delayed to M33, March 2022)

- Design ideas for phantoms for alanine pellets discussed with WP4 partners on 24 June 2021
- Three CIRS Plastic Water® LR test pieces made at NPL workshop to gain experience with the machining properties of this phantom material
- Detailed design drawings of all plastic phantoms need to be finalised and discussed with AU and PTB

A4.1.2 (M36; Jun 22):

- The 3D absorbed dose measurements using NPL's alanine dosimeters will be performed at Aarhus University Hospital (setup: Papillon 50 with 25 mm applicator) and at PTB (setup: Intrabeam with and without 40 mm spherical applicator)
- In case of travel restrictions due to Covid-19, it should be possible to pre-load the phantoms with alanine pellets, mail them to AU and PTB, and mail them back to NPL for processing
- Dates of measurements to be confirmed after completion of phantoms for alanine pellets
- Measurements at PTB provisionally booked from 27 June - 1 July 2022

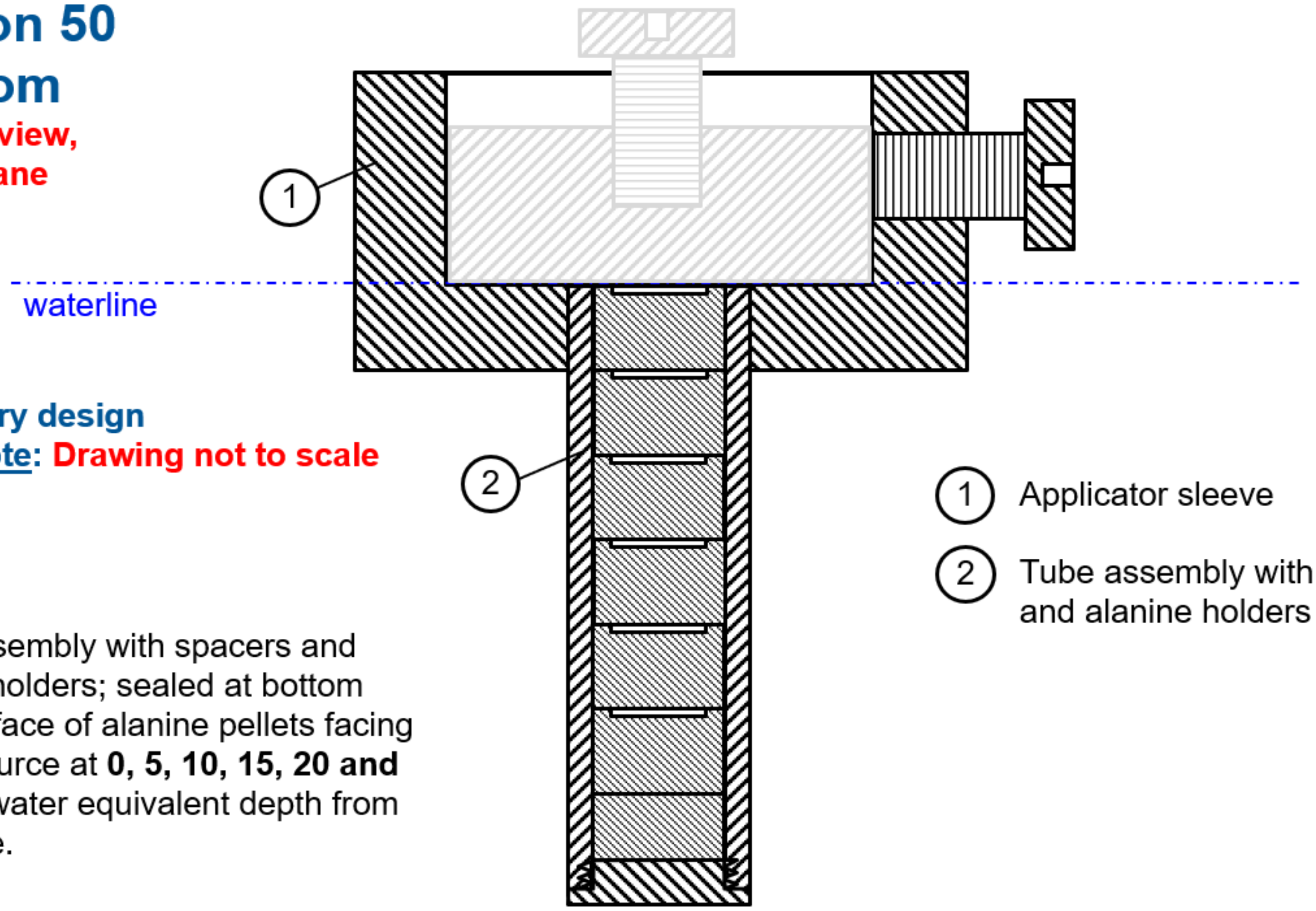
A4.2.1 (M38; Aug 22) and A4.2.2 (M39; Sep 22):

- no progress

WP 4 – ALANINE DOSIMETRY (NPL)

Papillon 50 phantom

sectional view, central plane



Preliminary design

Please note: Drawing not to scale

Tube assembly with spacers and alanine holders; sealed at bottom end; surface of alanine pellets facing X-ray source at **0, 5, 10, 15, 20 and 25 mm** water equivalent depth from waterline.

1 Applicator sleeve

2 Tube assembly with spacers and alanine holders

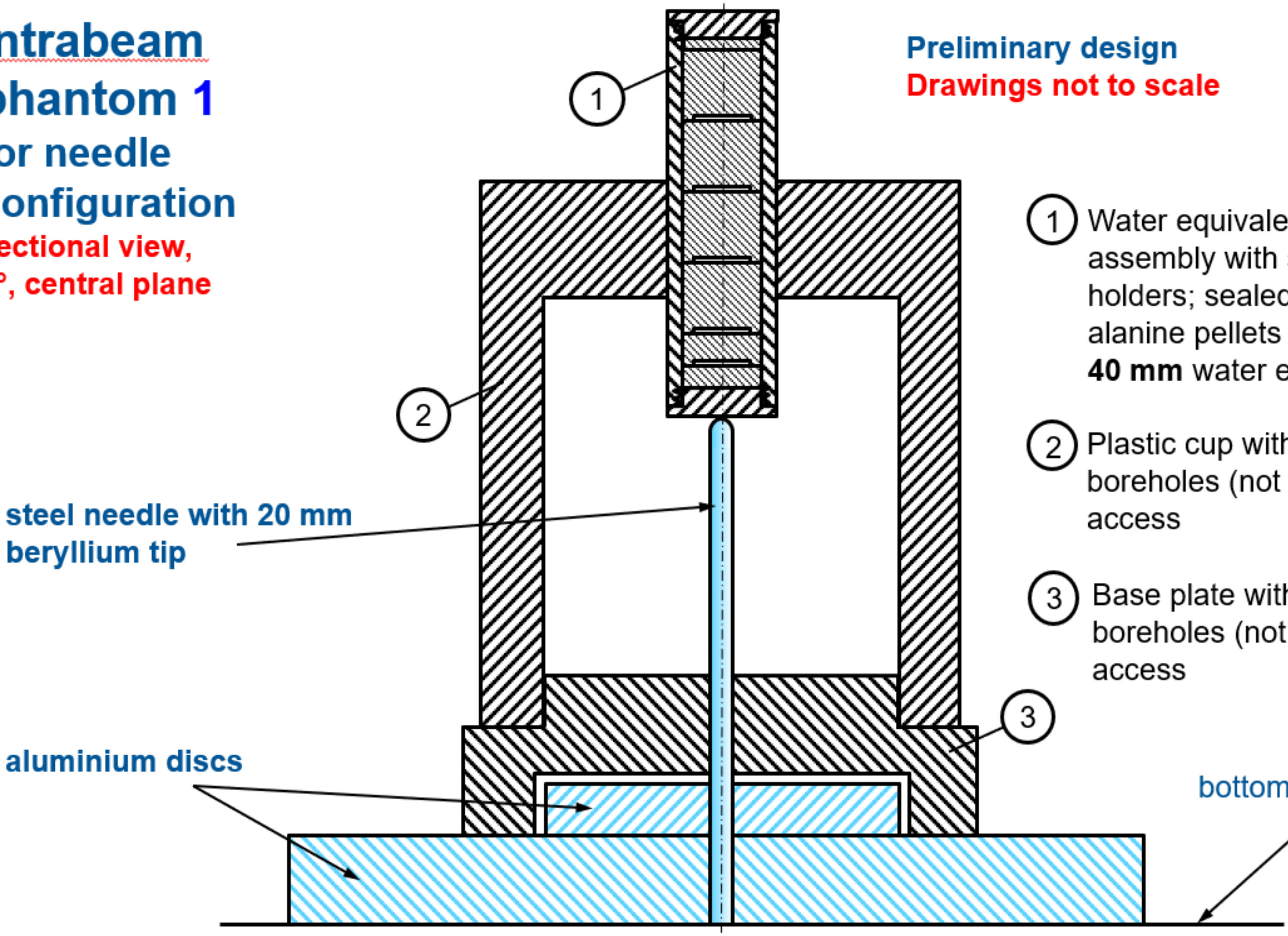
- Vaseline (petroleum jelly) might not be suitable to provide a watertight seal
- Hylomar Universal Blue (non-setting gasket sealer, polyester urethane based) to be used instead

WP 4 – ALANINE DOSIMETRY (NPL)

Intrabeam phantom 1 for needle configuration

sectional view, 0°, central plane

Preliminary design
Drawings not to scale



1. Water equivalent plastic tube assembly with spacers and alanine holders; sealed at both ends; alanine pellets at **5, 10, 20, 30 and 40 mm** water equivalent depth
2. Plastic cup with various boreholes (not shown) for water access
3. Base plate with various boreholes (not shown) for water access

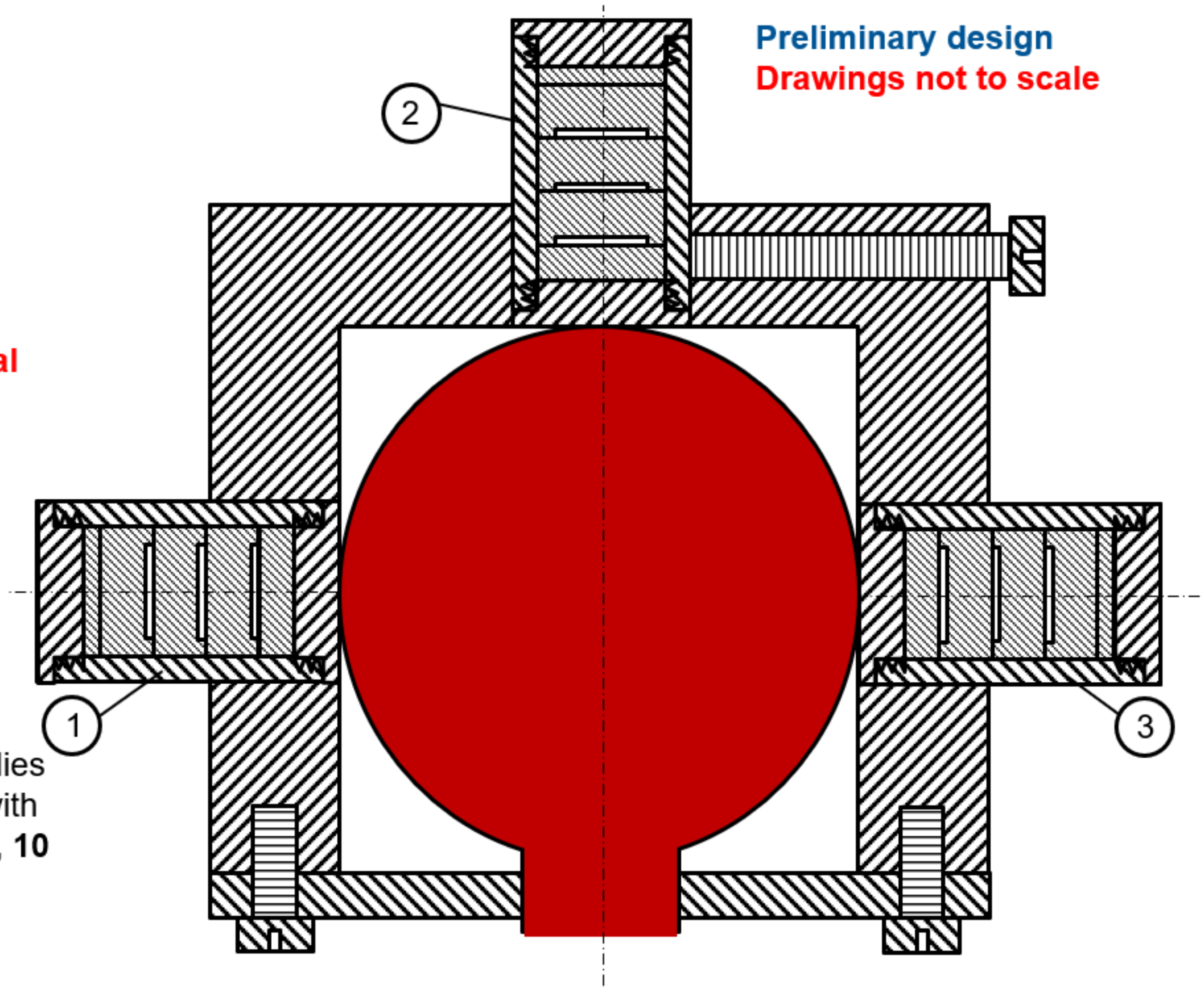
WP 4 – ALANINE DOSIMETRY (NPL)

Intrabeam phantom 2 for 40 mm Ø spherical applicator

sectional view, 0° and 90°, central plane

Preliminary design

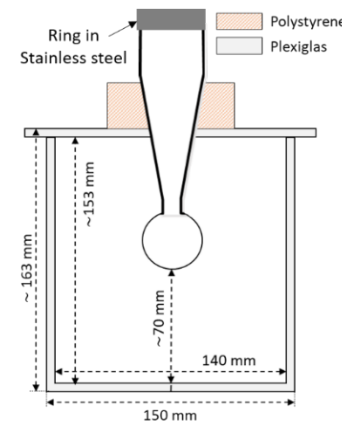
Drawings not to scale

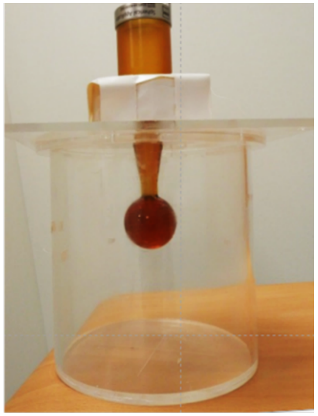


Short tube assemblies (parts 1, 2 and 3) with alanine pellets at **5, 10 and 15 mm** water equivalent depth.

WP4 Progress (CEA)

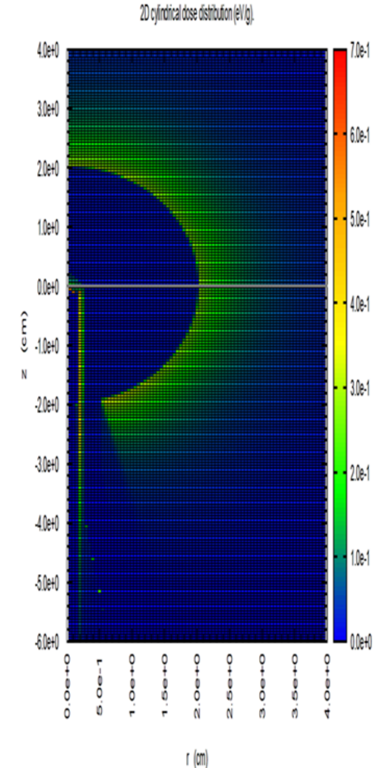
A4.1.3: Phantom for measurement using Fricke gels of 3D distributions of D_W has been manufactured et tested.





A4.1.4: A numerical model (PENELOPE 2018) of the INTRABEAM system with 4 cm spherical applicator has been developed.

Conversion coefficients $D_{gel} \rightarrow D_W$ to be calculated. Need to agree on the effective source focal point as discussed during the WP4 meeting in June.



A4.1.5: Automatic program for the analysis of the MRI readings

- Python based software has been developed to process the data obtained by imaging irradiated Fricke gel dosimeters with an MRI readout. The MRI sequence used was a T_2-weighted one called 2D Fast-Spin-Echo.
- The intensity values of the pixels in the DICOM images (coming from the MRI readout) are converted into $R_2=1/T_2$ values.
- 3D dose distributions are obtained through a preliminary calibration $D = f(R_2)$

WP4 Progress (AU)

Start with A4.1.7: AU will design and develop a method to measure the 3D D_w dose using a commercial motorised stage system water phantom for scintillation detectors and suitable ionisation chambers.

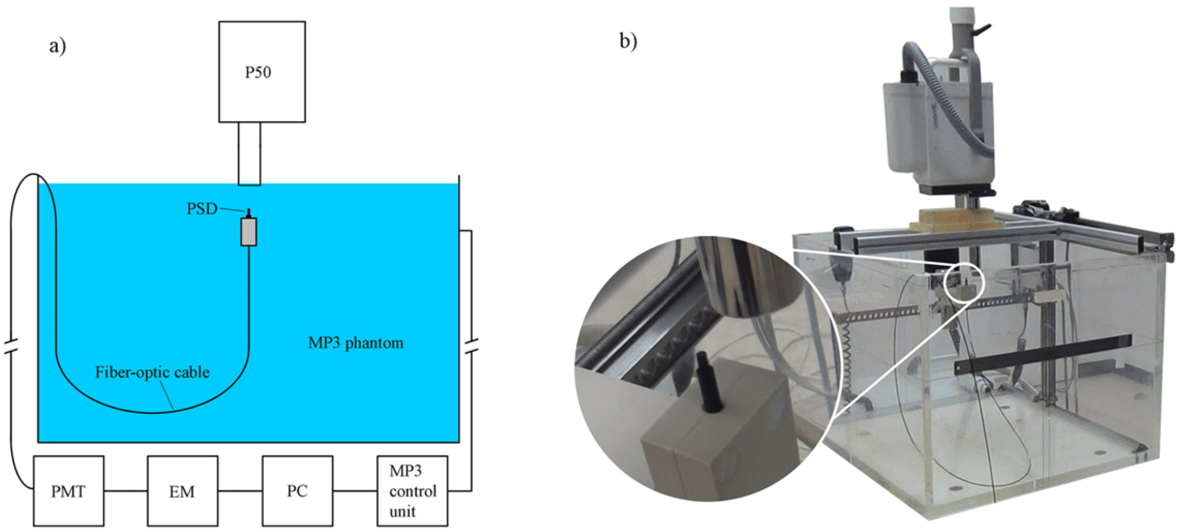


Fig. 1: Sketch and picture of the setup-for 3D dose distribution measurements

- 3D dose measurements:

  Custom build holder for Papillon 50 and PSD probe allows for measurements with large MP3 water phantom (PTW).

  Effectively performing A4.1.7 and A4.1.9 concurrently (result follows on later slides).

WP4 Progress (AU)

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A4.1.8: AU will characterise the positional accuracy of the motorised water phantom used to measure the 3D D_w **dose.**

- Video tracking of motorised stage and dosimeter.
- Compare positions recorded by phantom with those recorded with video.
- SD of ±0.1 mm along each axis.

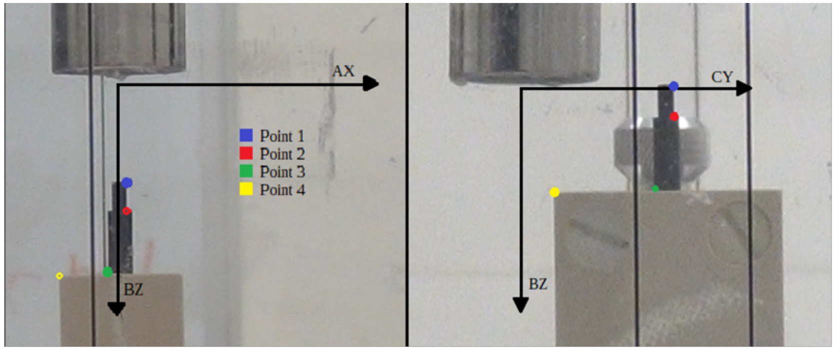


Fig. 2: zoom in on still-frame from video recording of the MP3 stage with mounted PSD

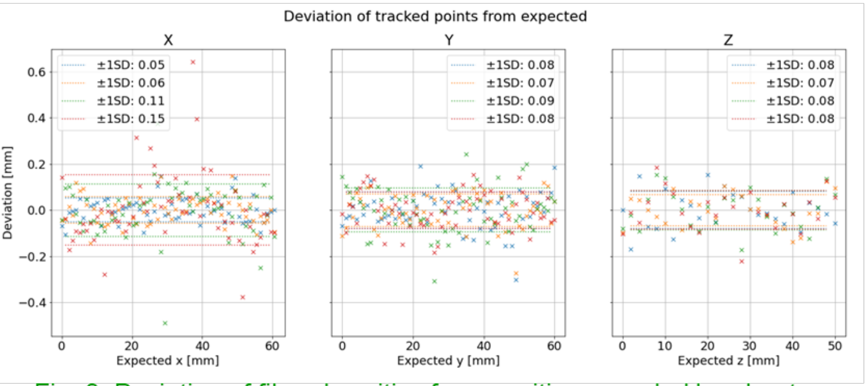


Fig. 3: Deviation of filmed position from position recorded by phantom for the individual tracked points on fig. 2.

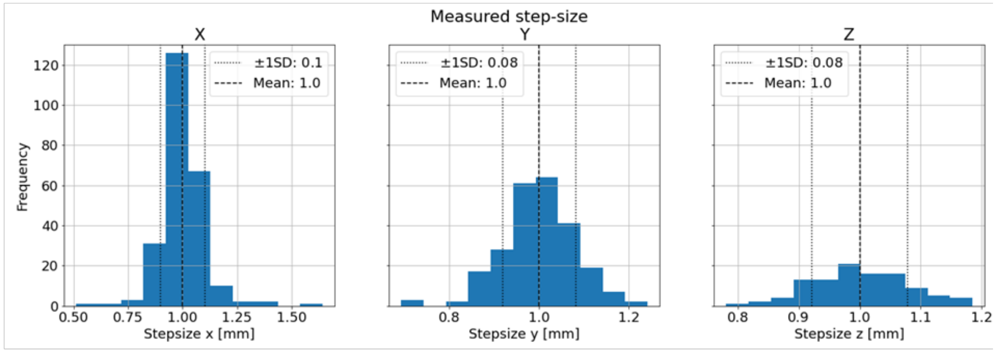


Fig. 4: Combined deviation of filmed position from position recorded by phantom for each axis on fig. 2.

WP4 Progress (AU)

Start with A4.1.9: AU, in collaboration with PTB, will measure the 3D D_W dose distribution for the Papillon and INTRABEAM systems using ~~commercially available and~~ laboratory developed scintillation detector systems.

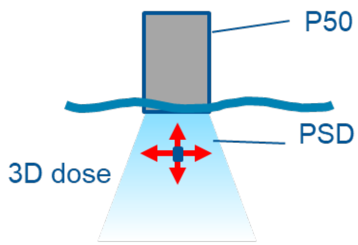


Fig. 5: Sketch of 3D dose measurement setup.

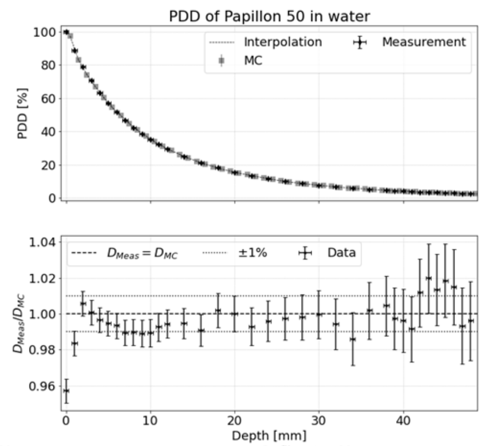
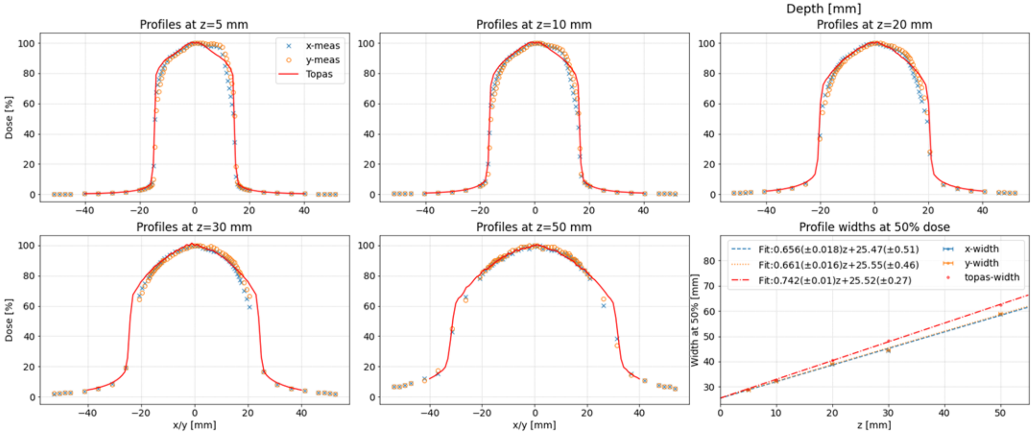


Fig. 5: PDD as measured with PSD and scored with MC.

- Setup as for 4.1.7:

  So far! Relative profiles and depth-dose of Papillon 50 with corresponding uncertainty budget. Added *r* and *T* to terms from WP3.

  Lacks reference-point for absolute dose (WP1+3).



Term	Description	Relative uncertainty contribution [%]
D_{PSD}	Conservative estimate of total uncertainty ($\sqrt{\Sigma\sigma^2}$) of detector system. Dominates far from source and at profile plateaus.	2.5
T	Factor accounting for temporal change in the P50 output.	0.3
r	The relative position between the source and detector. Dominates close to the source and at profile edges.	±0.4 mm

Submitted to Medical Physics

3D Dose verification of an electronic brachytherapy source with a plastic scintillation detector

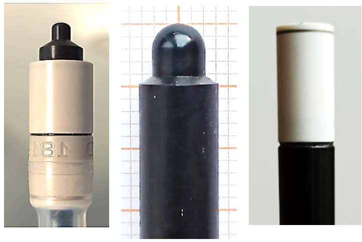
Dosimetry for electronic brachytherapy

Peter Georgi[a*], Gustavo Kertzscher[b], Lars Nyvang[b], Jaroslav Šolc[c], Thorsten Schneider[d], Kari Tanderup[a,b], Jacob Graversen Johansen[a,b]

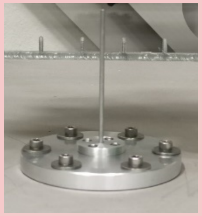
WP4 progress at PTB

A4.1.9, A4.2.1, A4.2.2, Measurement of 3D dose distributions (cont.)

Using the commercial detectors characterized in WP3



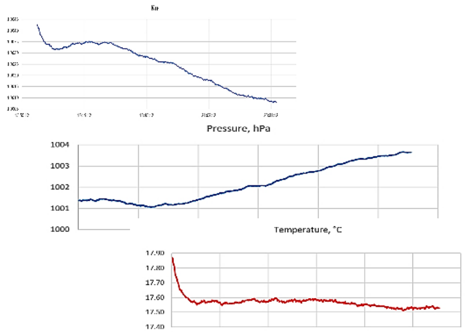
PTB will measure the 3D D_w dose distribution for the INTRABEAM system with:

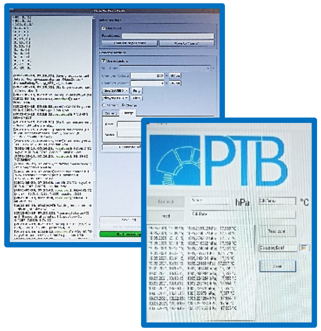
Configuration		Status
Intrabeam bare needle		**Nearly finished**
40 mm spherical applicator		**On-going**

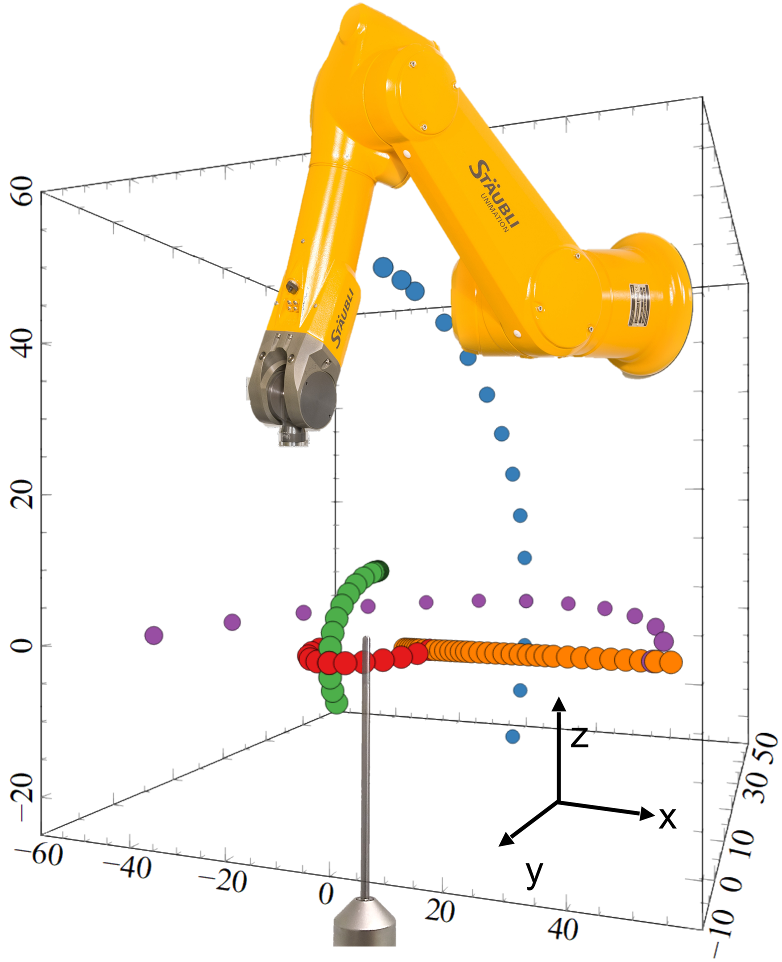
POINTS OF MEASUREMENTS

The measuring points:
For dose with distance
For radial distribution at 10 mm and 50 mm
For polar distribution at 10 mm and 50 mm

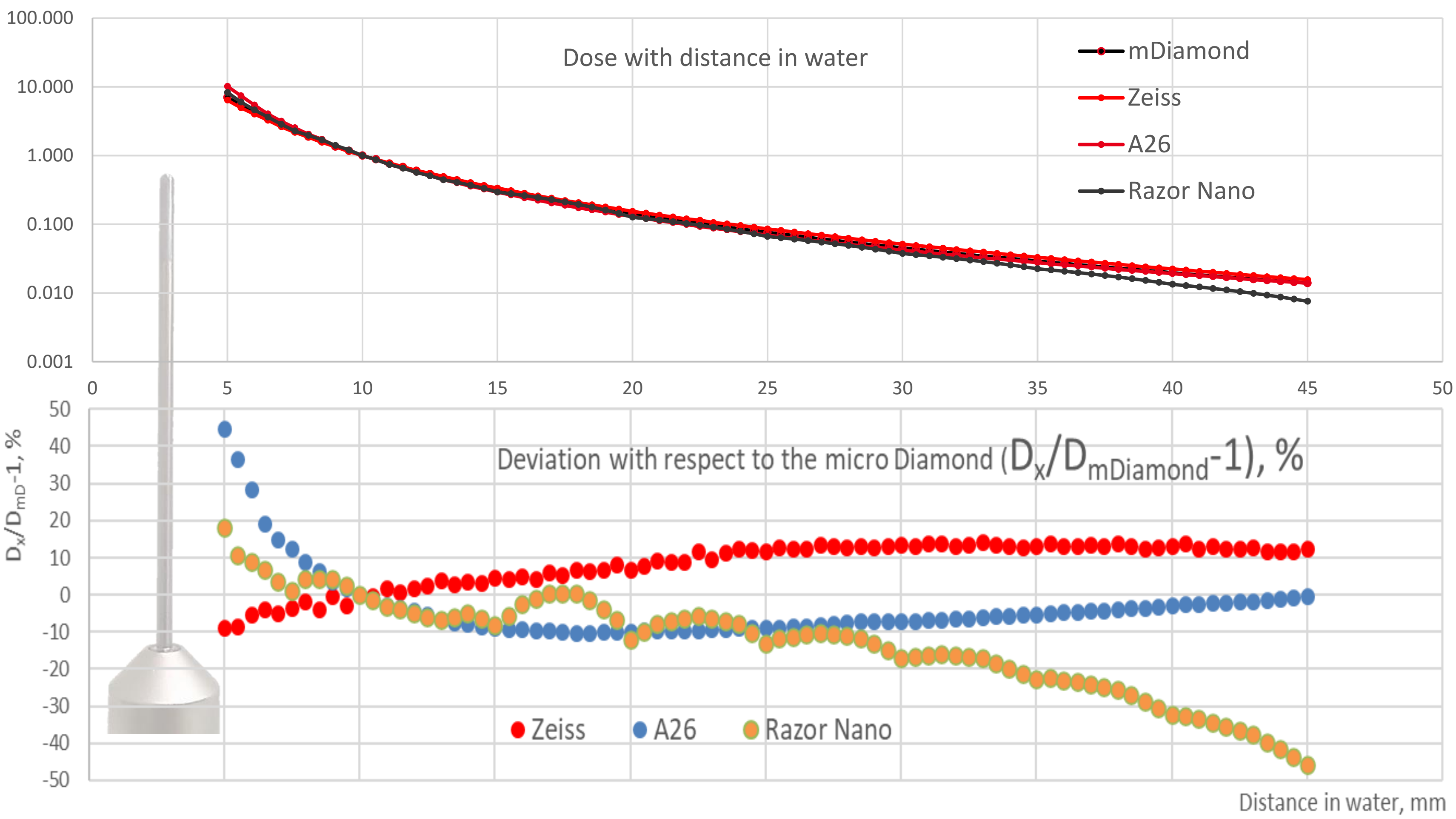
In-house software control the robot, record the collected charge and measure pressure and temperature



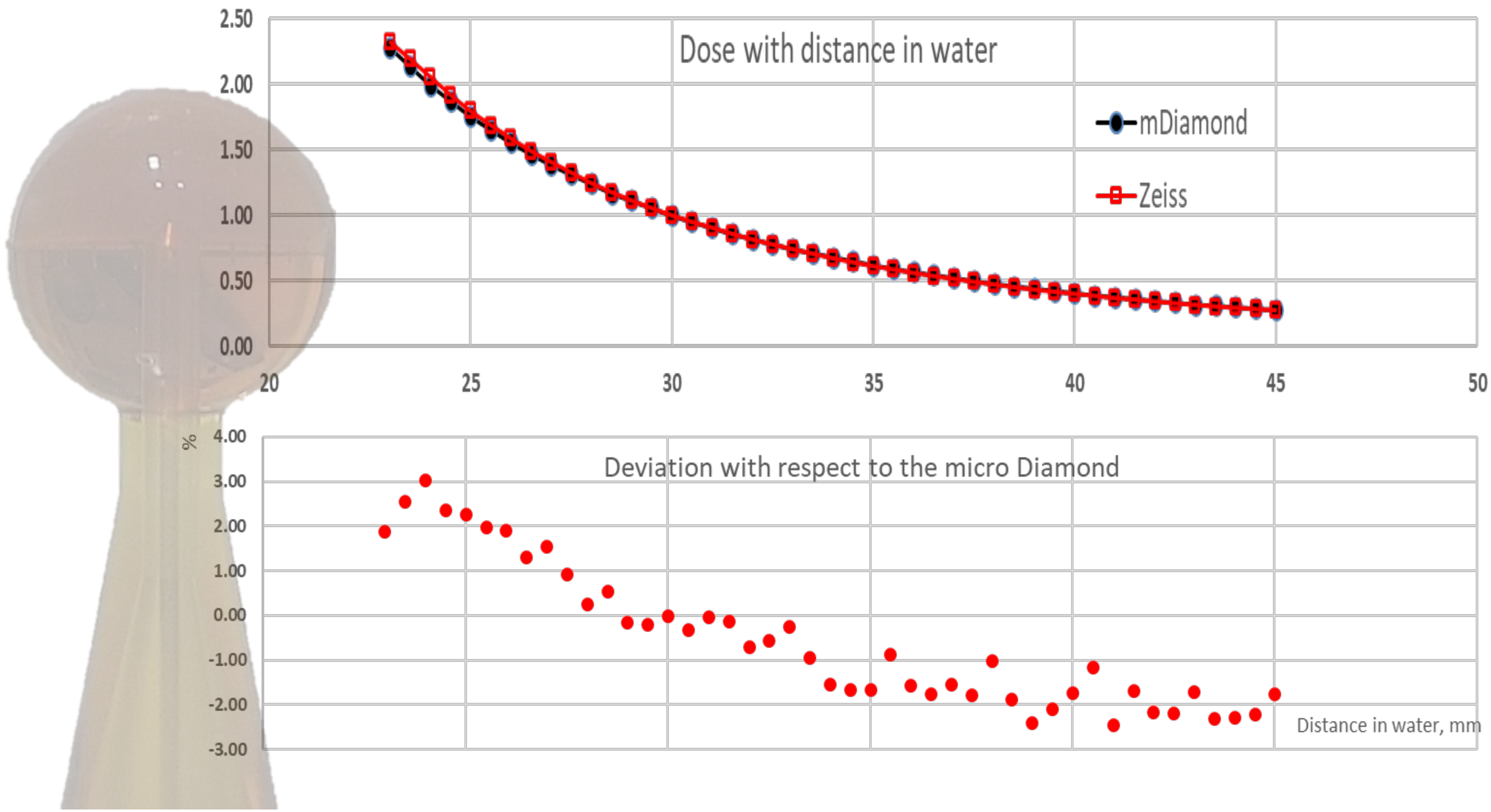




Measurements vs Zeiss provided user data. INTRABEAM bare needle

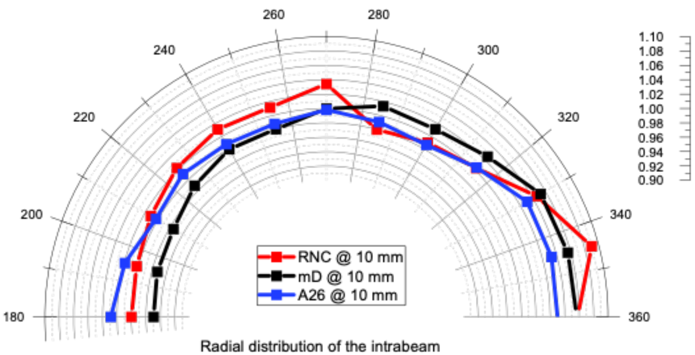


Measurements vs Zeiss provided user data. INTRABEAM 40 mm spherical app.

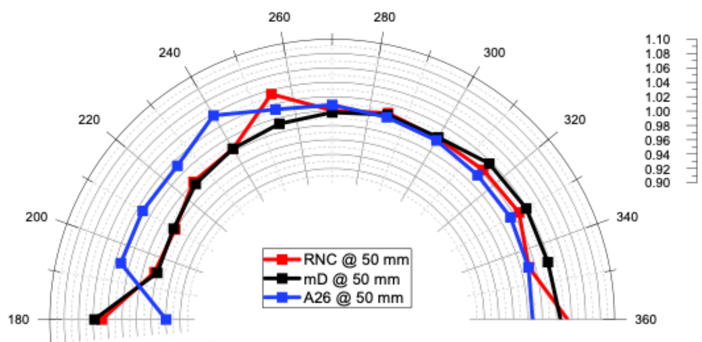


RADIAL AND POLAR DISTRIBUTIONS OF INTRABEAM BARE NEEDLE

Radial distribution

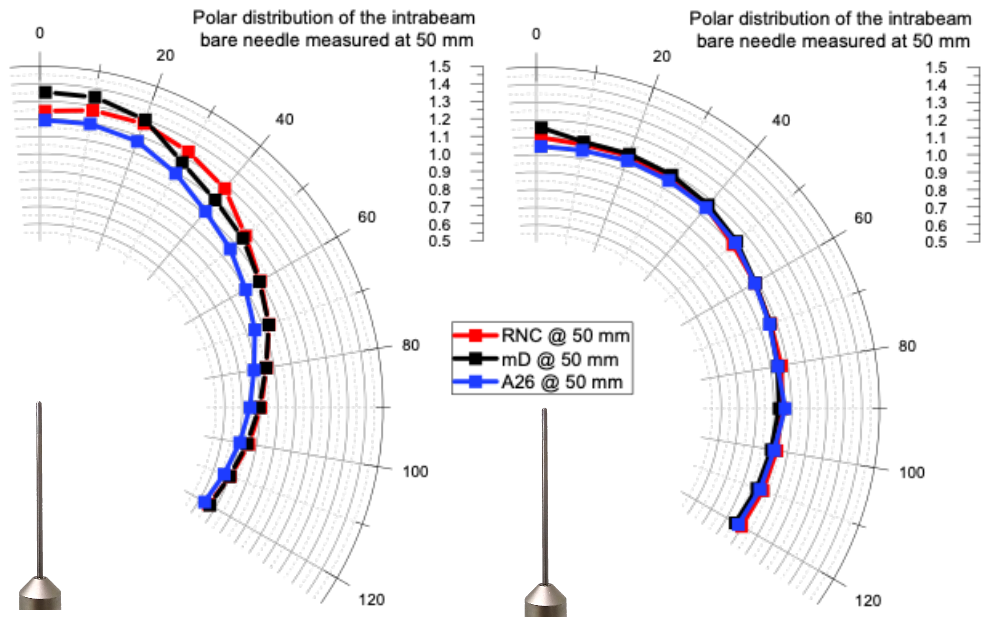


Radial distribution of the intrabeam bare needle measured at 10 mm



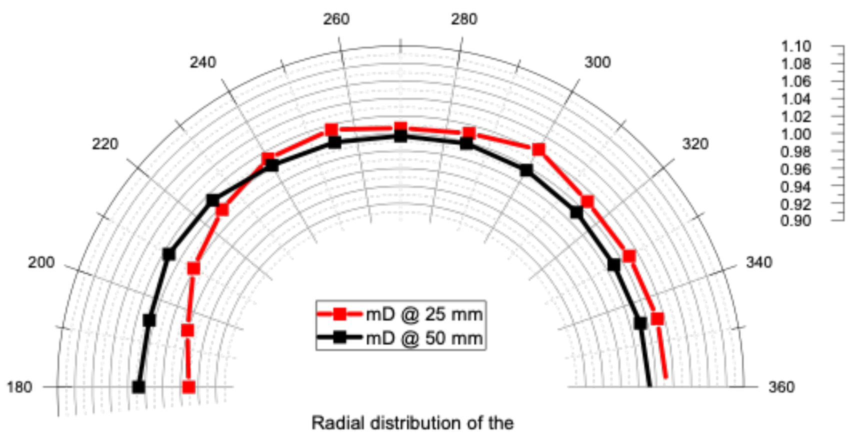
Radial distribution of the intrabeam bare needle measured at 50 mm

Polar distribution



Measurement results with the INTRABEAM 40 mm App

Radial distribution



Radial distribution of the intrabeam 40 mm spherical App

Polar distribution at planes YZ and XZ