Outcomes of the CoBra project for robotic MRI-guided prostate brachytherapy and biopsy

Sarah Wilby *(on behalf of the CoBra partners)*

Content

- Background to CoBra
- Limitations in current practice for Brachytherapy and Biopsy
- CoBra Solutions:
  - Robot overview
  - Trajectory calculation
  - Steerable needle
  - Dose calc on pseudo CT
  - Biopsy module
  - Phantom Development
- Conclusions

University of Lille simulation Lab

Introduction

- The CoBra (Cooperative Brachytherapy) project began January 1st 2018.
- Ended 30th September 2022.
- EU funded project across the 2seas region

- **Project Aim:**

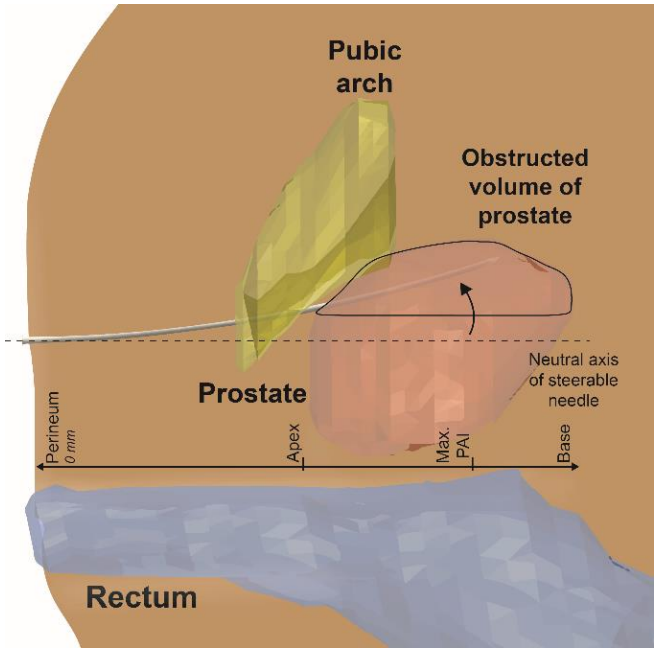
CoBra project aims ***to improve quality of both diagnosis and treatment of localized cancers****, by developing* ***a new medical robot Prototype for use in MRI***

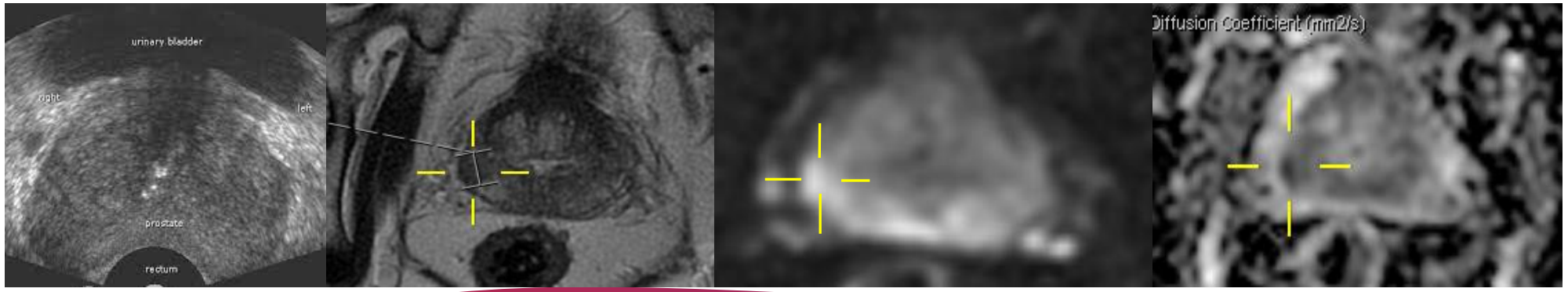
- **Project Focus:**

Prostate Brachytherapy and Biopsy

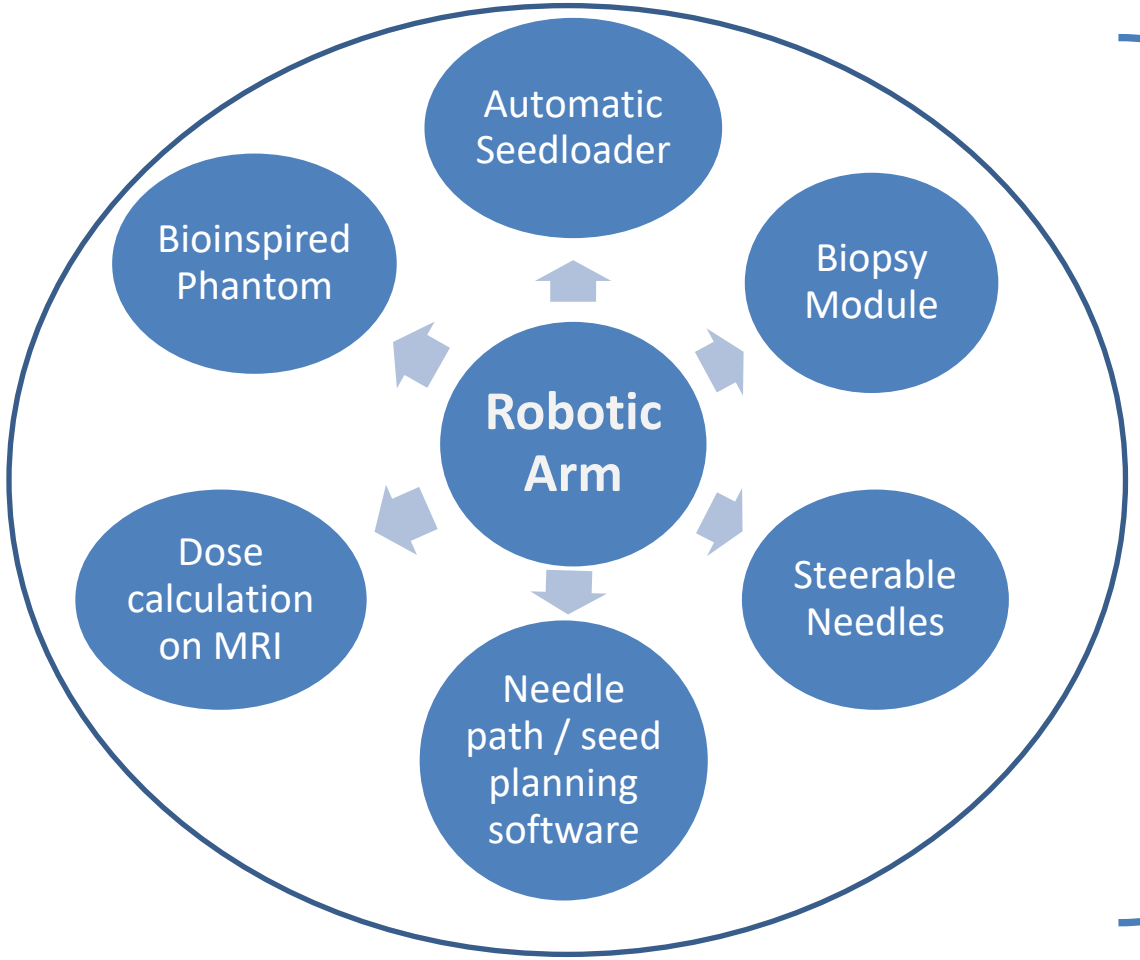
Limitations in current practice (Brachytherapy & Biopsy)

- Lesions not visible on UltraSound
- MRI / US fusion→ uncertainty in image registration
- Small lesions (e.g. 0.5 cc) in large prostates (e.g. 120 cc) are hard to hit.
- Lesions towards base are harder to hit.
- Increase number of cores taken →
  - Pressure on histopathology
  - Increased urinary retention
- Template and straight needles
- Obstructions e.g. pubic arch, urethra, calcifications
- Inter-operator variability





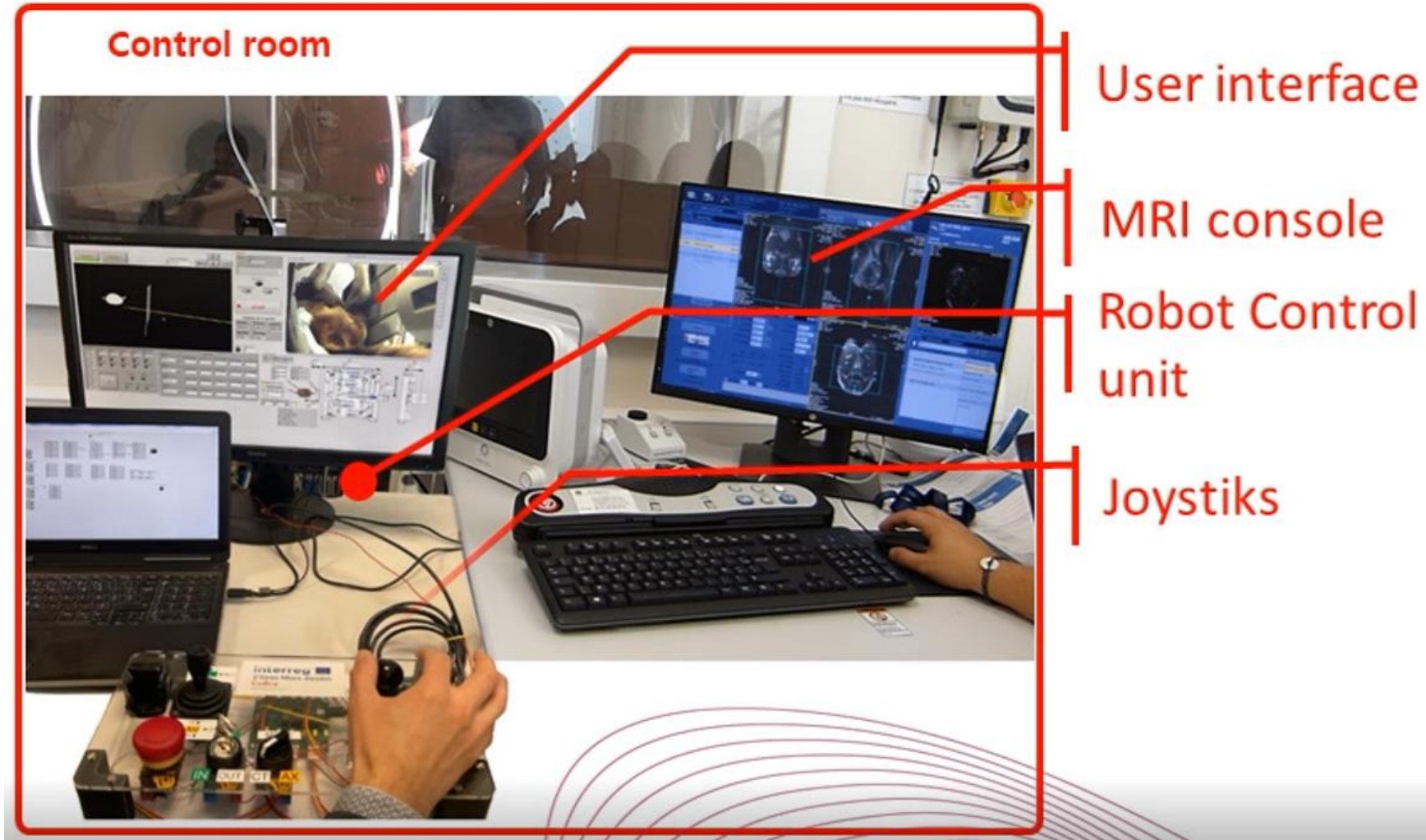
CoBra Solutions



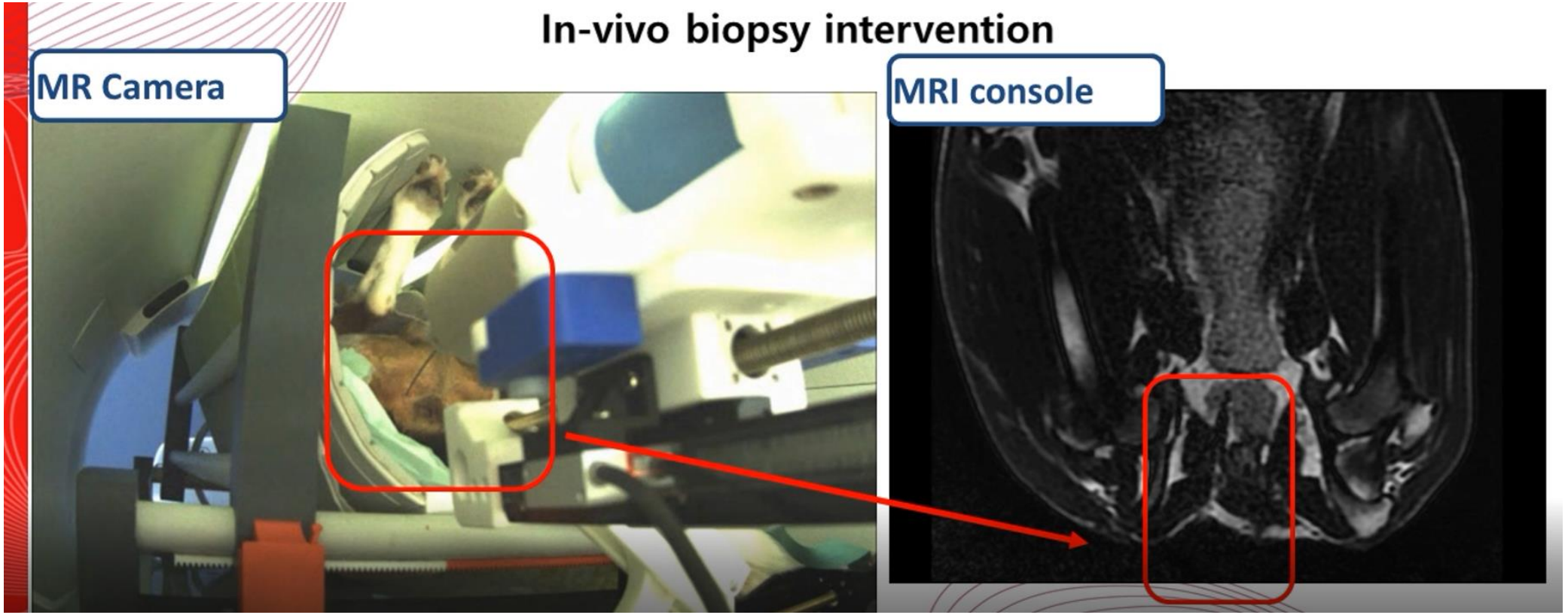
All MRI compatible

MRI Robot

MRI Robot


Control room
User interface
MRI console
Robot Control unit
Joystiks

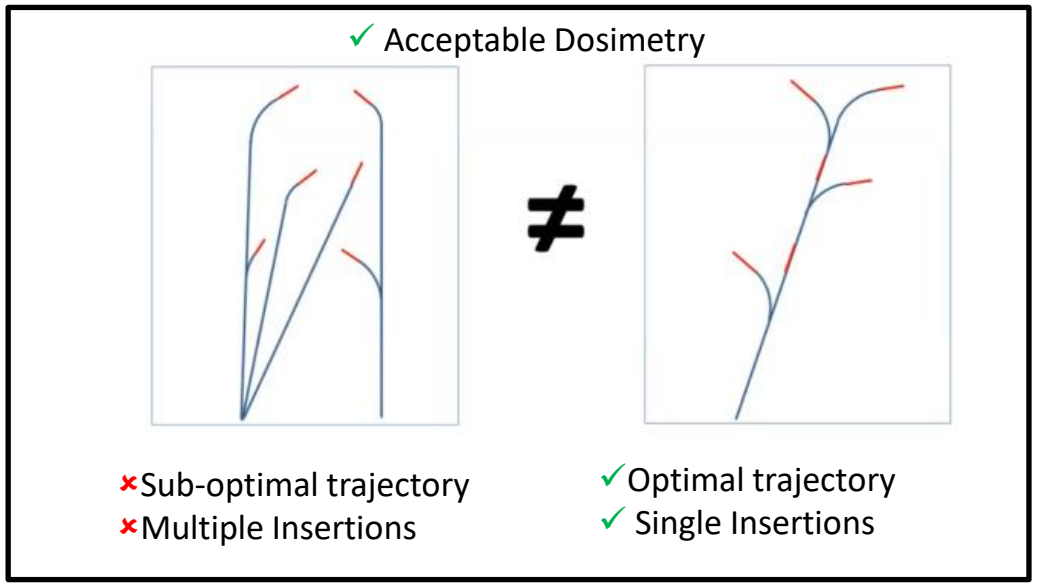
MRI Robot

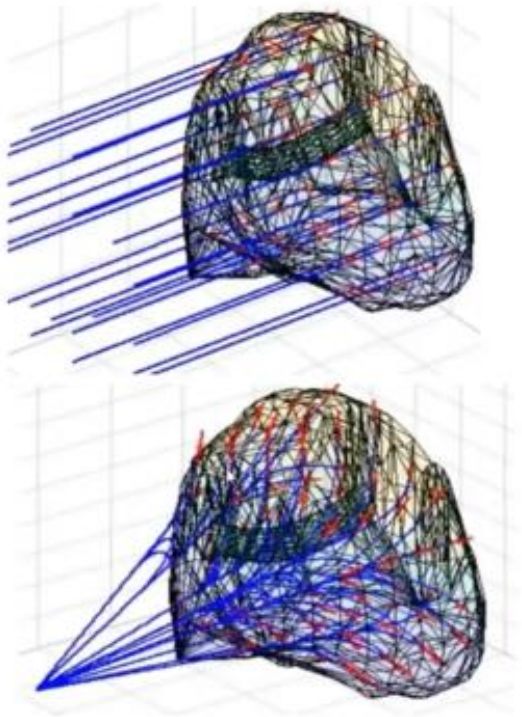


Needle Trajectory Planning

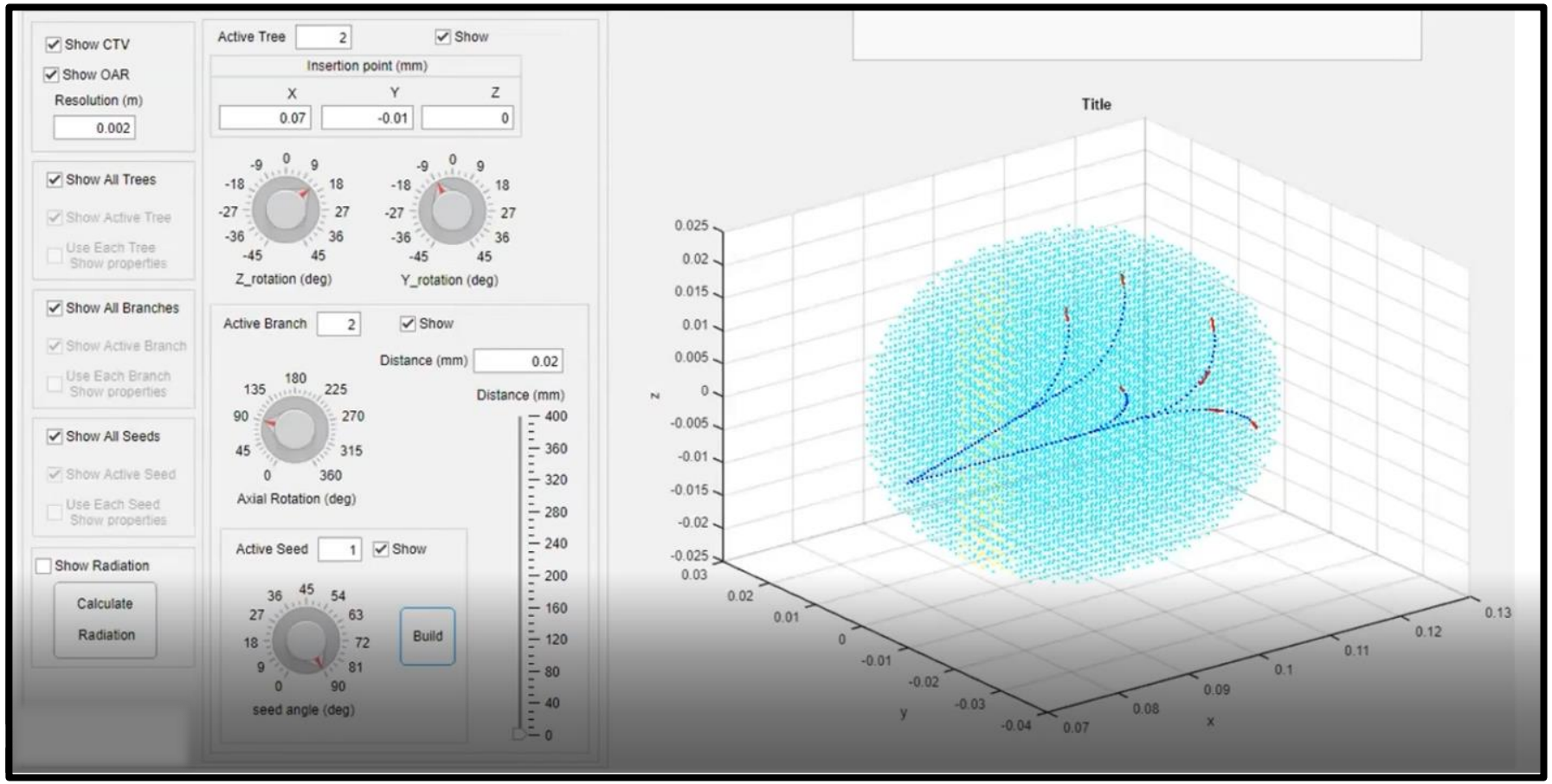
- Criteria:
  - Achieve dose distribution as closely as possible
    (dose distribution received as input)
  - Minimise number of needle insertions
  - Utilise a steerable needle of known geometry (TUDelft)

Multi-criteria decision making algorithm





Needle Trajectory Planning - GUI

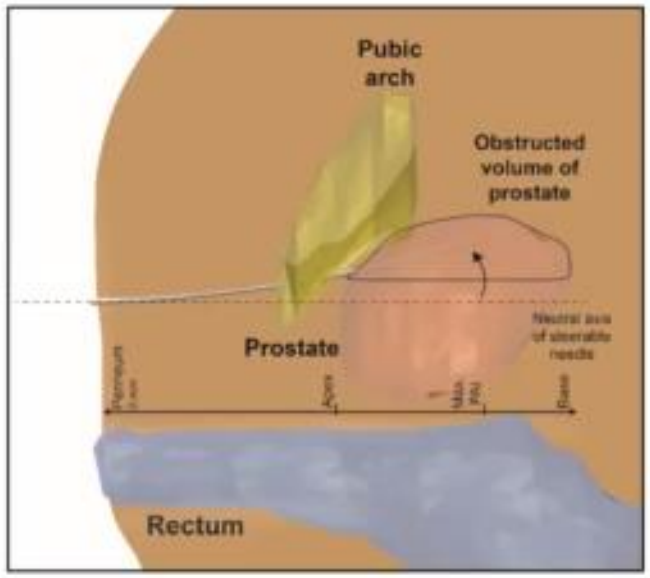


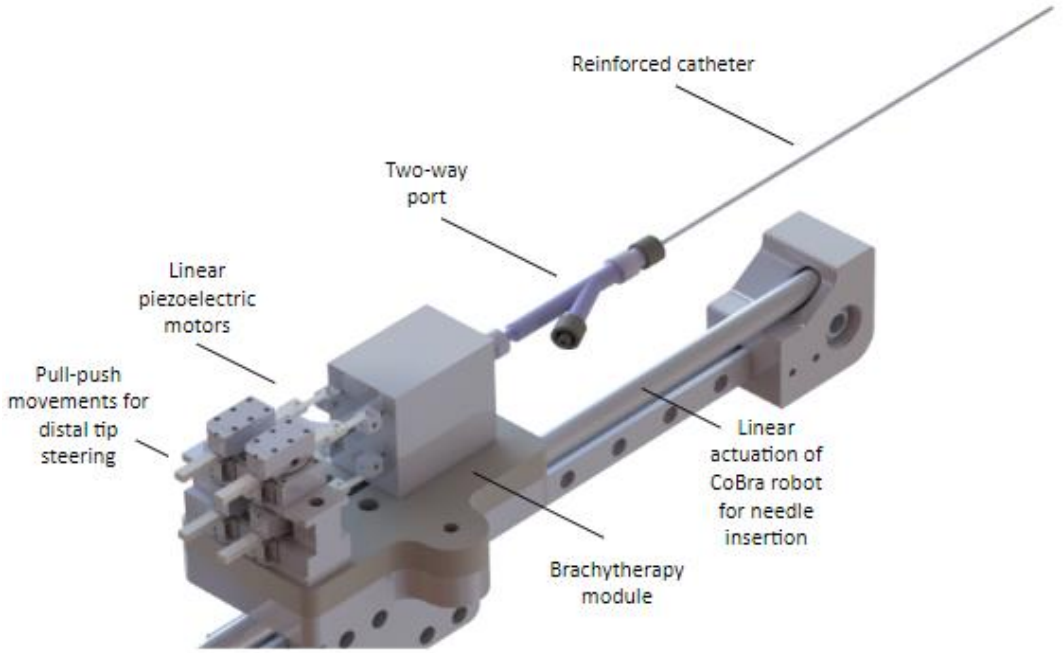
- Advantages:
  - Treat larger prostates
  - Avoid obstructions
  - Minimise tissue damage

Steerable Needle

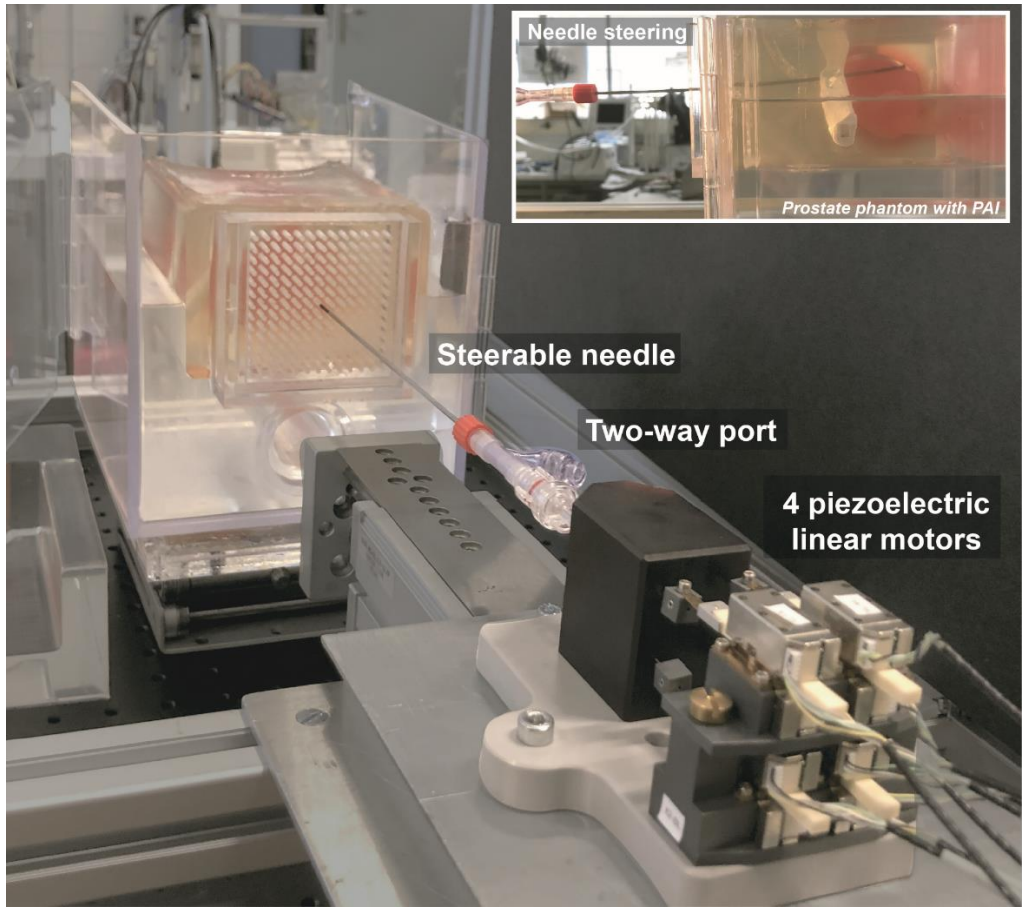
Aim

- Increase controllability during needle implantation
- Increase the reach within prostates with pubic arch interference (PAI)
- Treat patients normally excluded from brachytherapy





Steerable Needle



Title

Overcoming pubic arch interference in prostate brachytherapy

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- 27 patient with Vp > 60 cc included
- 10 of 27 patients > 5 mm PAI with 15° pelvic rotation
- 27 of 27 patients with enlarged prostates and pubic arch interference can be included with the steerable needle approach
- No need for hormonal therapy to downsize the prostate

Synthetic CT Generation

PAPER

MR to CT synthesis with multicenter data in the pelvic area using a conditional generative adversarial network

RECEIVED
30 September 2019
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13 February 2020

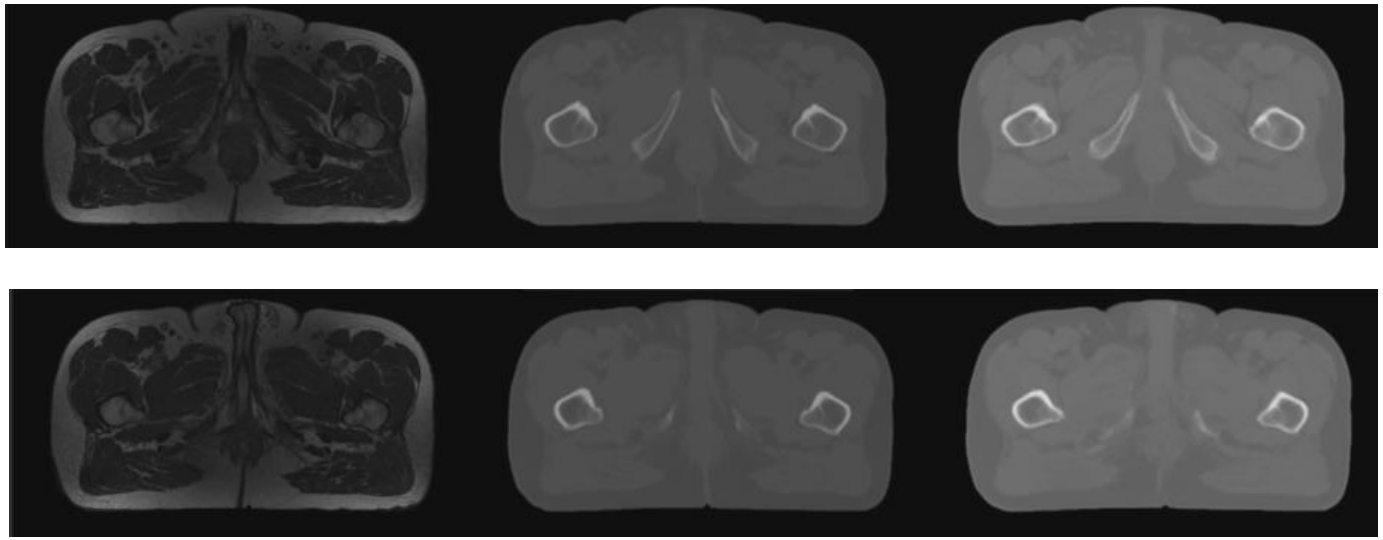
Kévin N D Brou Boni[1,2,5], John Klein[2], Ludovic Vanquin[1], Antoine Wagner[1], Thomas Lacornerie[1], David Pasquier[2,3] and Nick Reynaert[1,4]

Research Article

Improving generalization in MR-to-CT synthesis in radiotherapy by using an augmented cycle generative adversarial network with unpaired data

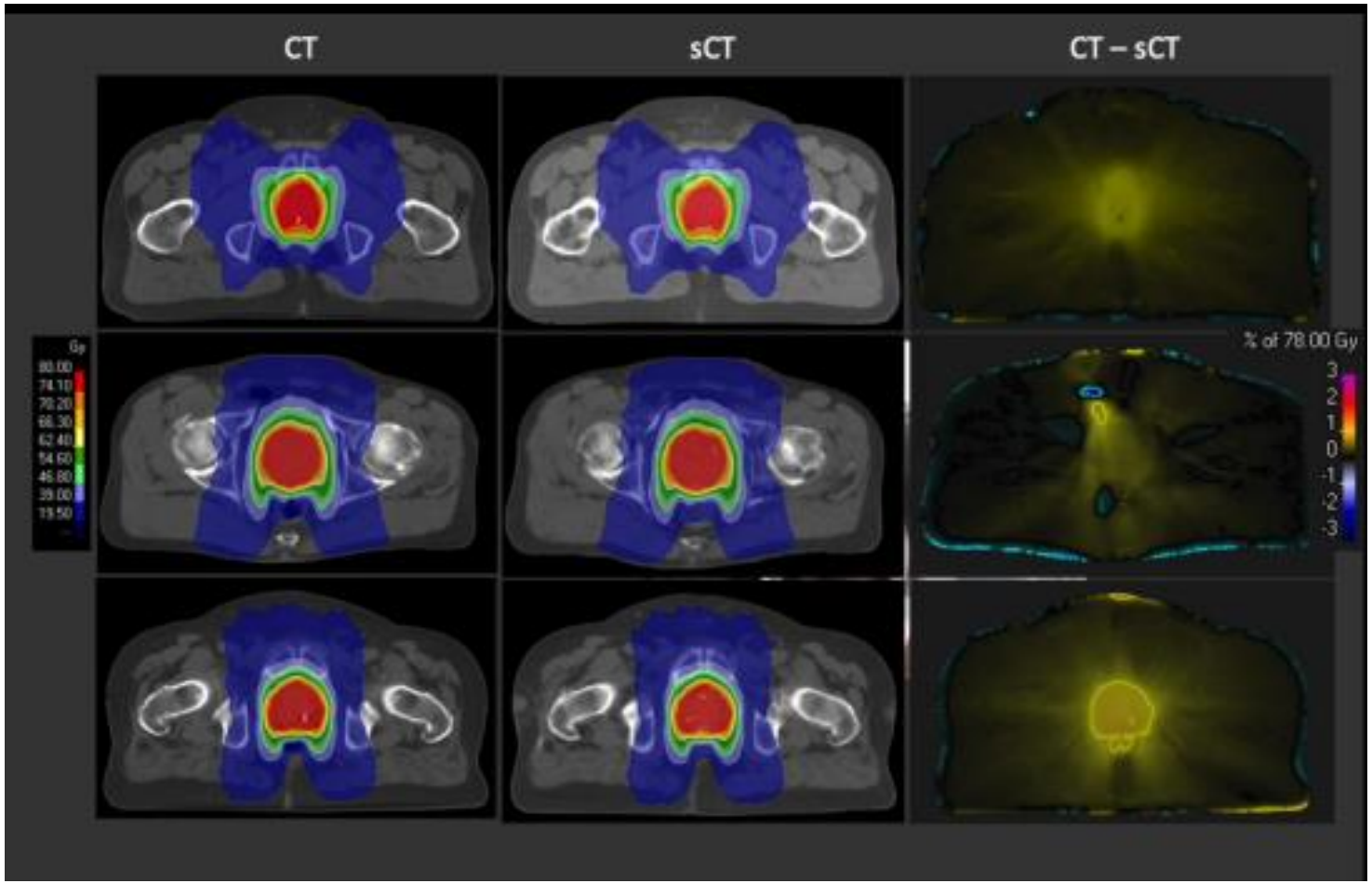
Kévin N. D. Brou Boni, John Klein, Akos Gulyban, Nick Reynaert, David Pasquier,

First published: 27 March 2021 | https://doi.org/10.1002/mp.14866



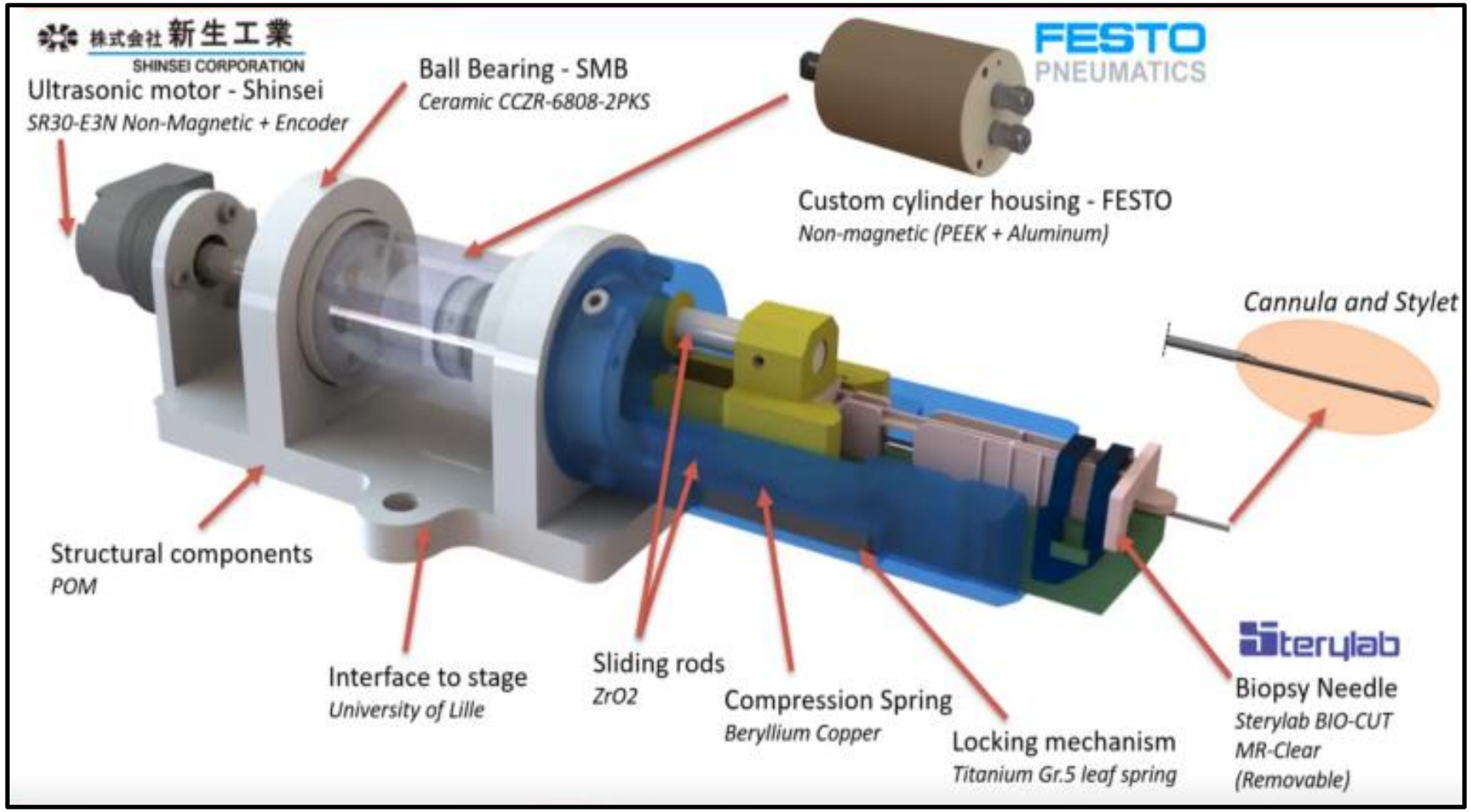
- 7 s → 90 slices, GPU

Synthetic CT Generation

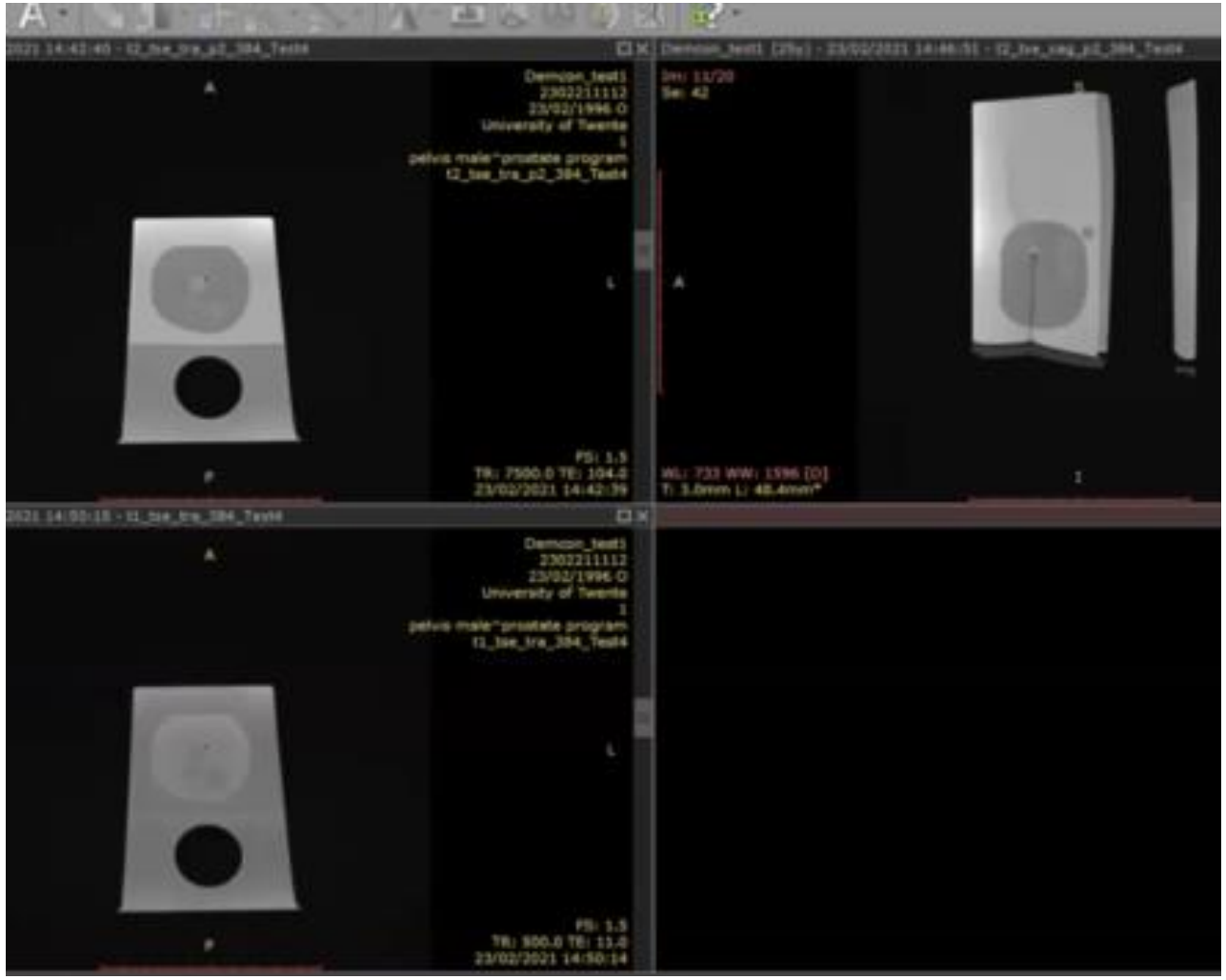


Volume	$\frac{\lvert D_{CT} - D_{sCT} \rvert}{D_p}$
Body	0.00 ± 0.01
	[0.01; 0.03]
Dose >10%	0.12 ± 0.07
	[0.00; 0.22]
Dose >50%	0.49 ± 0.29
	[0.03; 0.92]
Dose >90%	0.68 ± 0.35
	[0.19; 1.23]

Biopsy Module



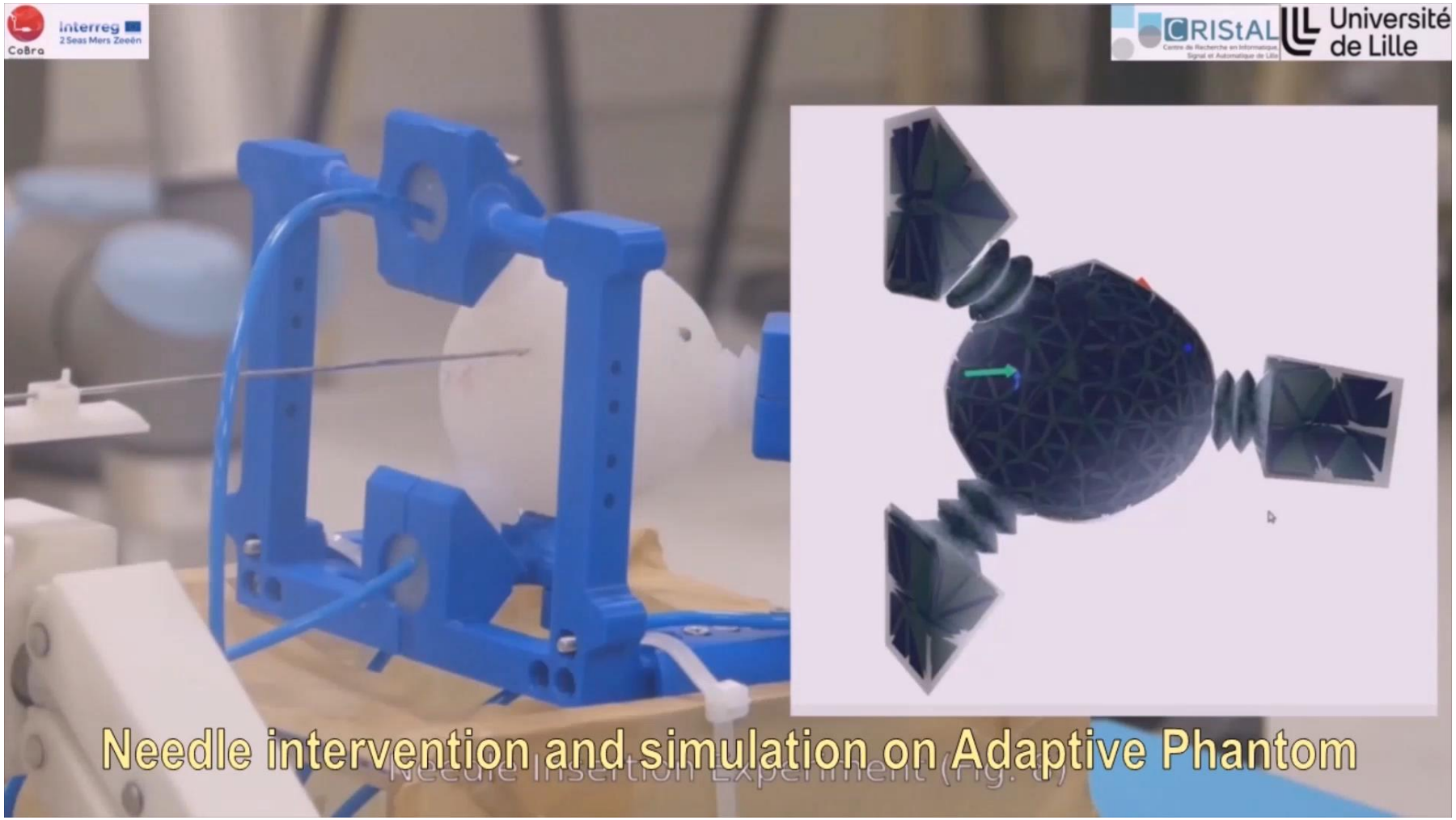
Biopsy Module



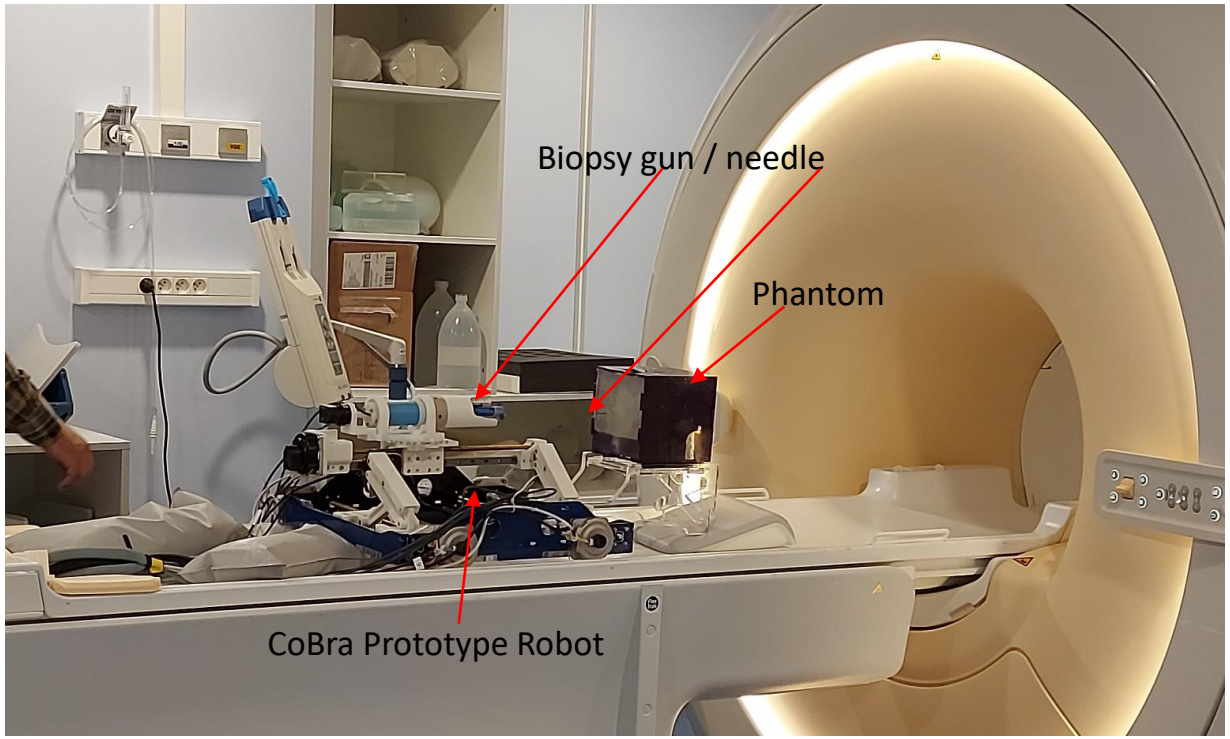
Conclusions:

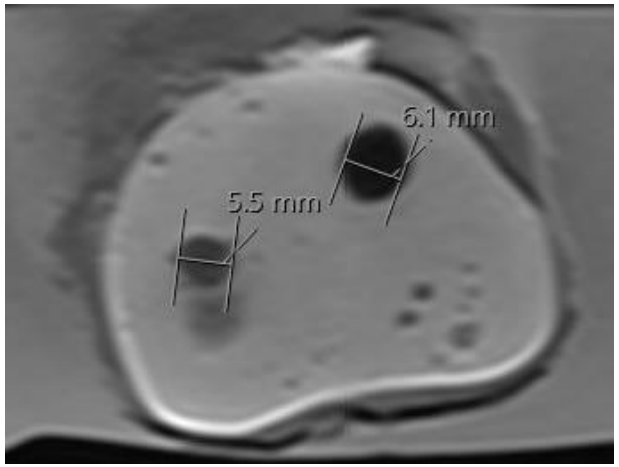
- No artefacts from presence of biopsy module material
- No distortion from motor actuation
- Very limited noise detected when motors running
- Limited artefacts from biopsy needle

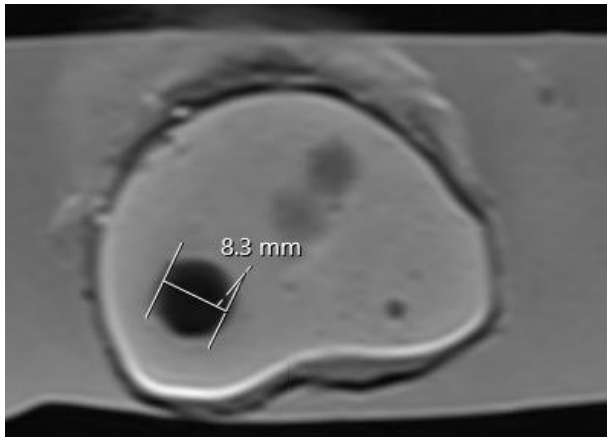
Bio-inspired Phantoms



Reusable Anthropomorphic Phantom



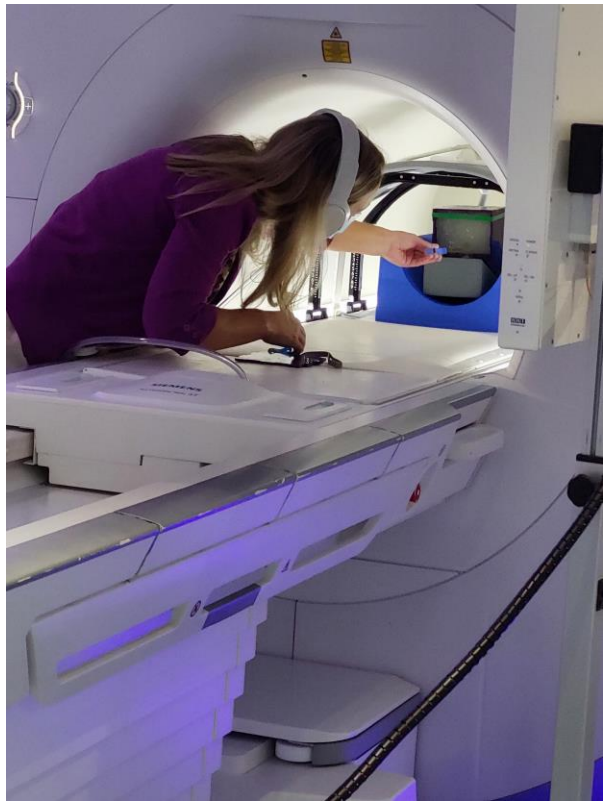


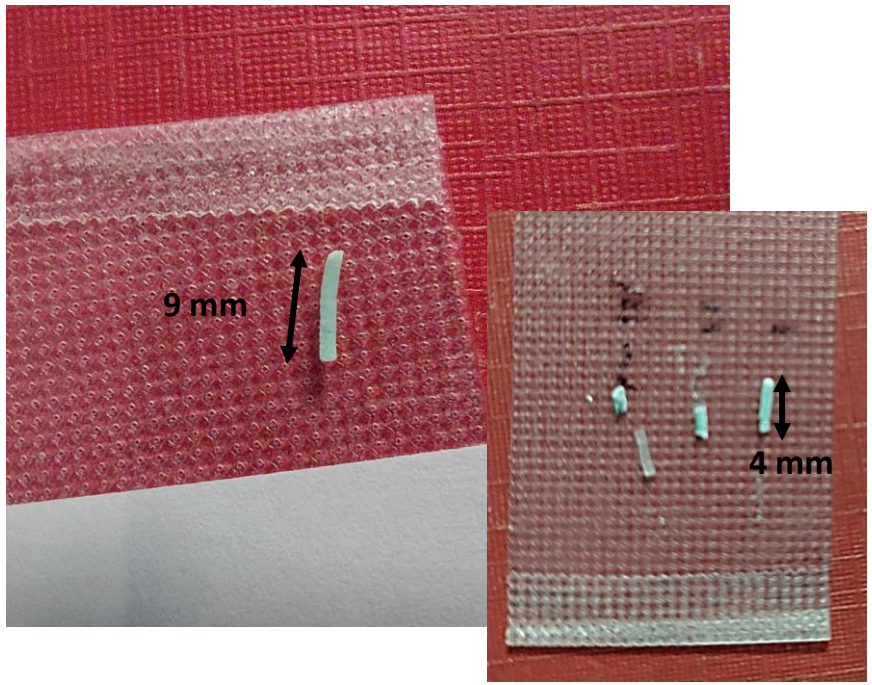


- Large & Small prostate sizes tested
- Mobile & rigid prostates tested

Reusable Anthropomorphic Phantom

- **Aim:** Use phantom to compare accuracy of manual vs robotic biopsy / brachytherapy





Conclusions

- All deliverables required by Iterreg2Seas were met

- The robot itself reached TRL 6
  - Known issues with the prototype
  - Further development and integration required
  - University Of Lille are bidding for additional funding

- New knowledge and technology gained from all supplementary modules
  - Many of these can be utilised with or without the robot e.g.
    - Steerable needled
    - Phantoms
    - MRI to pseudo CT conversion
    - Trajectory planning software

- An excellent experience to work on such a collaborative project from the 2 seas region

Interreg

EUROPEAN UNION

2 Seas Mers Zeeën

CoBra

European Regional Development Fund

CoBra BRACHYTHERAPY

COBRA PARTNERS

Université de Lille

Centre Oscar Lambret

eurasanté Invest for Success

DEMCON

OCR The OneHealth Company

NHS Portsmouth Hospitals University NHS Trust

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MRI Robot: SeedLoader