X-ray phase contrast CT.

Moving closer to clinical implementation: recent experiences and planned activities at the IMBL.

THE UNIVERSITY OF SYDNEY

Two main parts to this talk

– What have we done so far and why?

– What are we planning?

– What have we done so far and why?

The overall aim.

– To transform diagnosis of breast and lung cancers by providing a path to clinical implementation of a novel low-dose, high-quality, three-dimensional (3D) imaging technology: X-ray propagation-based phase-contrast computed tomography (PB-CT).

The aim.

- To **transform diagnosis** of **breast** and **lung** cancers by providing a **path to clinical implementation** of a novel low-dose, high-quality, three-dimensional (3D) imaging technology: **X-ray propagation-based phase-contrast computed tomography (PB-CT).**

Why are we bothering?

Breast:

Breast cancer is the most common cancer in women worldwide with more than 2 million new cases diagnosed per year.

But current techniques have:

- Low sensitivity.
- Low specificity.
- Biologically-relevant radiation doses
- Painful compression.

Why are we bothering?

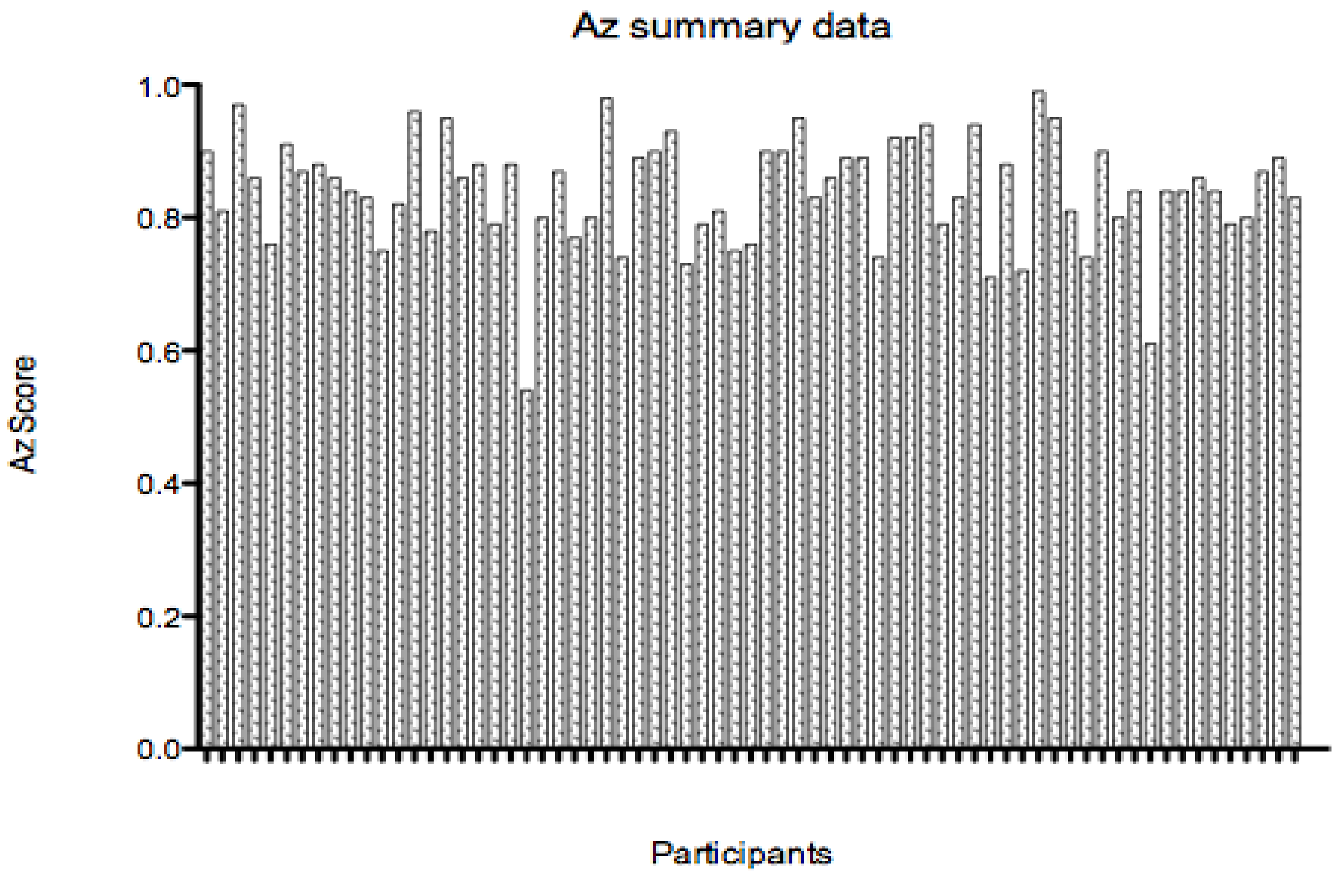
Chest:

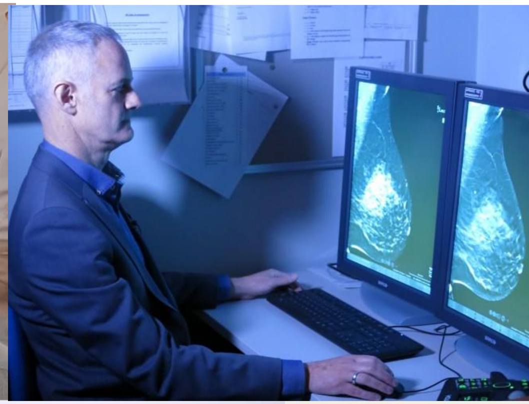
Lung cancer is the most commonly occurring cancer in men worldwide, and the third most common in women, with 2 million new cases diagnosed each year.

But current techniques have:

- Low sensitivity;
- Low specificity;
- Biologically-relevant radiation doses;
- Poor definitive diagnosis.

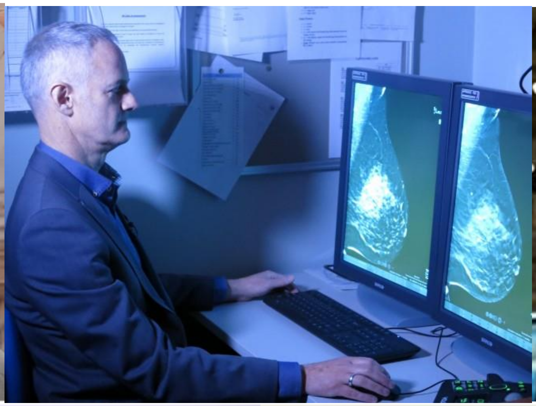
Results ROC












And our Elettra Sincrotrone Trieste Colleagues
led by Prof Tromba and Longo

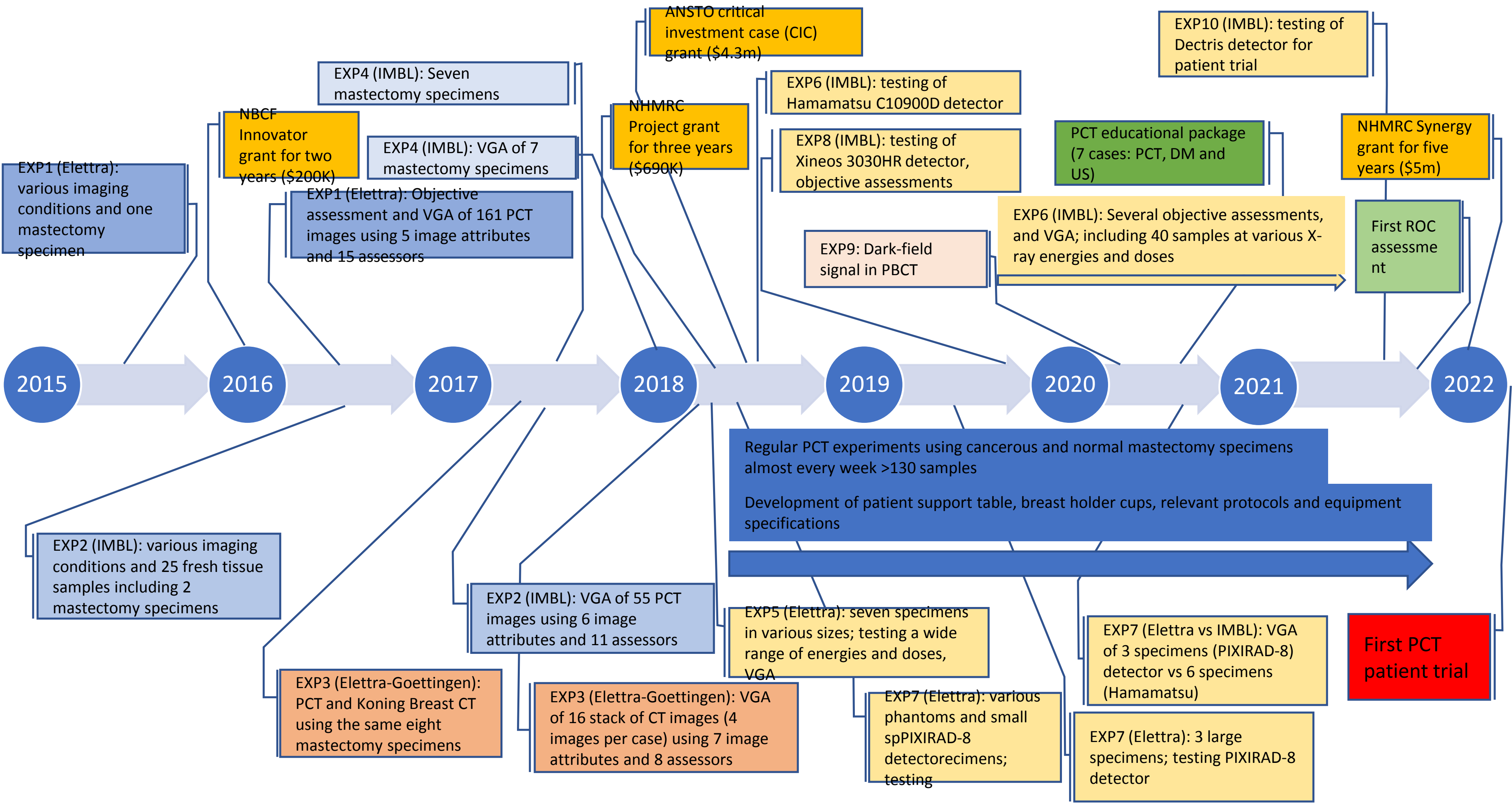
What have we achieved so far?

What have we achieved so far?

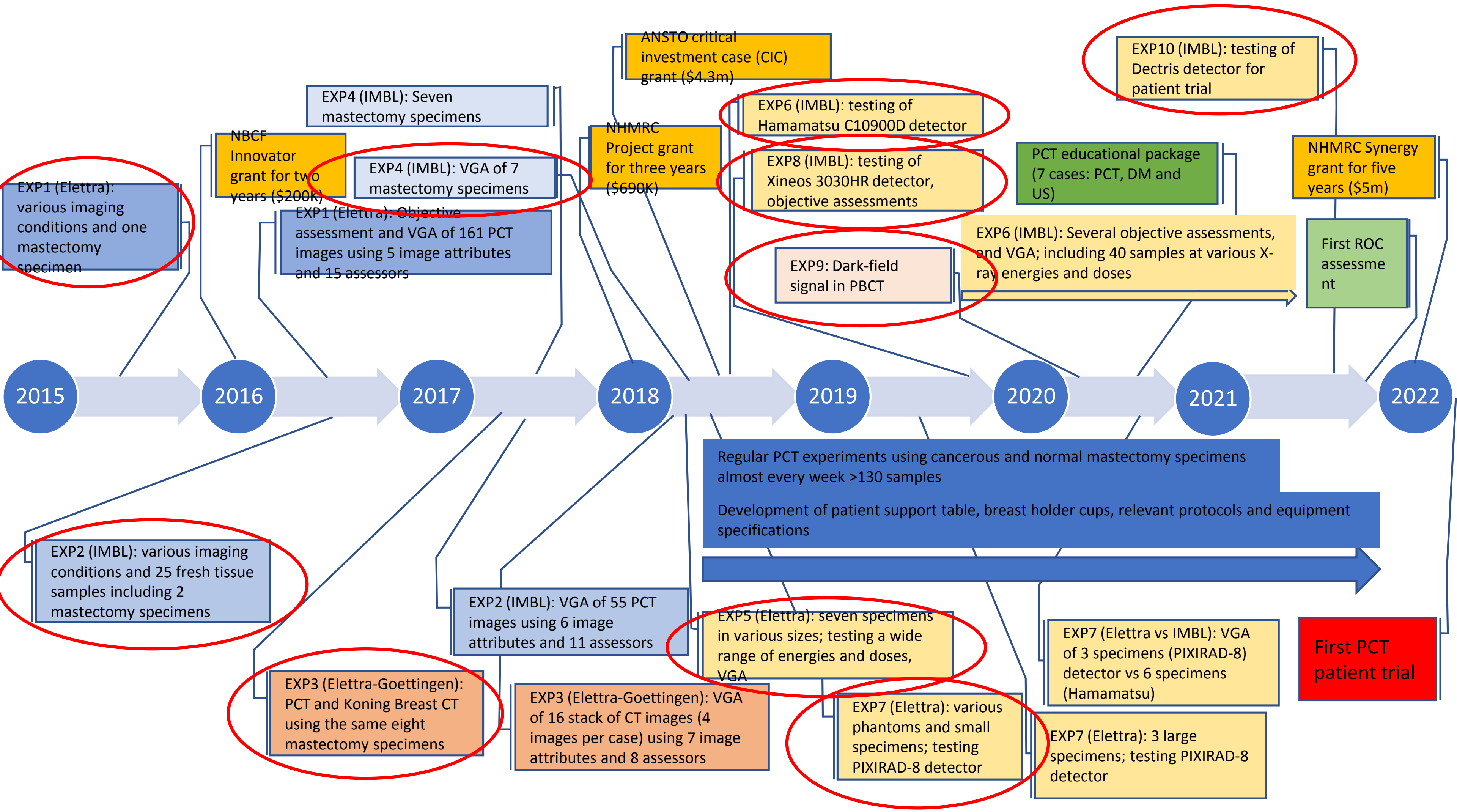
We have transitioned this technology from non-living objects to large human excised tissues and shown that PB-CT provides a superior image quality (by up to 200 times) compared to conventional X-ray imaging *at the same radiation dose*.

What have we achieved so far?

We have **transitioned this technology** from non-living objects to **large human excised tissues** and shown that **PB-CT provides a superior image quality (by up to 200 times)** compared to conventional X-ray imaging *at the same radiation dose*.



2015
2016
2017
2018
2019
2020
2021
2022
EXP1 (Elettra): various imaging conditions and one mastectomy specimen
NBCF Innovator grant for two years ($200K)
EXP4 (IMBL): Seven mastectomy specimens
EXP4 (IMBL): VGA of 7 mastectomy specimens
EXP1 (Elettra): Objective assessment and VGA of 161 PCT images using 5 image attributes and 15 assessors
ANSTO critical investment case (CIC) grant ($4.3m)
NHMRC Project grant for three years ($690K)
EXP6 (IMBL): testing of Hamamatsu C10900D detector
EXP8 (IMBL): testing of Xineos 3030HR detector, objective assessments
EXP9: Dark-field signal in PBCT
PCT educational package (7 cases: PCT, DM and US)
EXP6 (IMBL): Several objective assessments, and VGA; including 40 samples at various X-ray energies and doses
EXP10 (IMBL): testing of Dectris detector for patient trial
NHMRC Synergy grant for five years ($5m)
First ROC assessment
EXP2 (IMBL): various imaging conditions and 25 fresh tissue samples including 2 mastectomy specimens
EXP3 (Elettra-Goettingen): PCT and Koning Breast CT using the same eight mastectomy specimens
EXP2 (IMBL): VGA of 55 PCT images using 6 image attributes and 11 assessors
EXP3 (Elettra-Goettingen): VGA of 16 stack of CT images (4 images per case) using 7 image attributes and 8 assessors
Regular PCT experiments using cancerous and normal mastectomy specimens almost every week >130 samples
Development of patient support table, breast holder cups, relevant protocols and equipment specifications
EXP5 (Elettra): seven specimens in various sizes; testing a wide range of energies and doses, VGA
EXP7 (Elettra): various phantoms and small spPIXIRAD-8 detectorecimens; testing
EXP7 (Elettra vs IMBL): VGA of 3 specimens (PIXIRAD-8) detector vs 6 specimens (Hamamatsu)
EXP7 (Elettra): 3 large specimens; testing PIXIRAD-8 detector
First PCT patient trial


2015
2016
2017
2018
2019
2020
2021
2022
EXP1 (Elettra): various imaging conditions and one mastectomy specimen
NBCF Innovator grant for two years ($200K)
EXP1 (Elettra): Objective assessment and VGA of 161 PCT images using 5 image attributes and 15 assessors
EXP4 (IMBL): Seven mastectomy specimens
EXP4 (IMBL): VGA of 7 mastectomy specimens
ANSTO critical investment case (CIC) grant ($4.3m)
NHMRC Project grant for three years ($690K)
EXP6 (IMBL): testing of Hamamatsu C10900D detector
EXP8 (IMBL): testing of Xineos 3030HR detector, objective assessments
EXP9: Dark-field signal in PBCT
PCT educational package (7 cases: PCT, DM and US)
EXP6 (IMBL): Several objective assessments, and VGA; including 40 samples at various X-ray energies and doses
EXP10 (IMBL): testing of Dectris detector for patient trial
NHMRC Synergy grant for five years ($5m)
First ROC assessment
Regular PCT experiments using cancerous and normal mastectomy specimens almost every week >130 samples
Development of patient support table, breast holder cups, relevant protocols and equipment specifications
EXP2 (IMBL): various imaging conditions and 25 fresh tissue samples including 2 mastectomy specimens
EXP2 (IMBL): VGA of 55 PCT images using 6 image attributes and 11 assessors
EXP3 (Elettra-Goettingen): PCT and Koning Breast CT using the same eight mastectomy specimens
EXP3 (Elettra-Goettingen): VGA of 16 stack of CT images (4 images per case) using 7 image attributes and 8 assessors
EXP5 (Elettra): seven specimens in various sizes; testing a wide range of energies and doses, VGA
EXP7 (Elettra): various phantoms and small specimens; testing PIXIRAD-8 detector
EXP7 (Elettra vs IMBL): VGA of 3 specimens (PIXIRAD-8) detector vs 6 specimens (Hamamatsu)
EXP7 (Elettra): 3 large specimens; testing PIXIRAD-8 detector
First PCT patient trial

Experiment 1 (Elettra optimisation) is done and published

- Tavakoli Taba, S., Baran, P., Lewis, S., Heard, R., Pacile, S., Gureyev, T., Brennan, P., et al (2018). Towards improving breast cancer imaging: radiological assessment of propagation-based phase-contrast CT technology. Academic Radiology, 26(6), e79-e89.
- Baran, P., Pacile, S., Nesterets, Y., Mayo, S., Dullin, C., Dreossi, D., Arfelli, F., Thompson, D., Lockie, D., Tavakoli Taba, S., Brennan, P., et al (2017). Optimization of propagation-based x-ray phase-contrast tomography for breast cancer imaging. Physics in Medicine and Biology, 62(6), 2315-2332.

Experiment 2 (IMBL exposures) is done and published

- Pacile, S., Baran, P., Dullin, C., Dimmock, M., Tavakoli Taba, S., Lewis, S., Brennan, P., Gureyev, T., et al (2018). Advantages in breast cancer visualisation and characterisation with synchrotron radiation phase-contrast tomography technique. Journal of Synchrotron Radiation. 25, 1460-1466.
- Tavakoli Taba, S., Lewis, S., Baran, P., Arhatari, B., Nesterets, Y., Mayo, S., Thompson, D., Fox, J., Kumar, B., Prodanovic, Z., Gureyev, T., Brennan, P., et al (2020). Comparison of propagation-based phase-contrast CT and absorption-based CT for breast imaging using synchrotron radiation. 15th International Workshop on Breast Imaging (IWBI 2020), Bellingham: Society of Photo-Optical Instrumentation Engineers (SPIE).

Experiment 3 (Cone beam CT) is done and published

- Tavakoli Taba, S., Baran, P., Nesterets, Y., Pacile, S., Lewis, S., Gureyev, T., Brennan, P., et al (2020). Comparison of propagation-based CT using synchrotron radiation and conventional cone-beam CT for breast imaging. European Radiology, 30(5), 2740-2750.
- Pacile, S., Dullin, C., Baran, P., Tavakoli Taba, S., Lewis, S., Brennan, P., Gureyev, T., Tromba, G., Wienbeck, S., et al (2019). Free propagation phase-contrast breast CT provides higher image quality than cone-beam breast-CT at low radiation doses: a feasibility study on human mastectomies. Scientific Reports, 9, 13762.

Experiment 4 (IMBL 7 mastectomy exposures), is done and published

- Gureyev, T., Nesterets, Y., Baran, P., Tavakoli Taba, S., Mayo, S., Thompson, D., Arhatari, B., Lewis, S., Tromba, G., Quiney, H., Brennan, P., et al (2019). Propagation-based x-ray phase-contrast tomography of mastectomy samples using synchrotron radiation. Med. Phys., 46, 5478-5487.

Experiment 5 (Elettra energy optimisation) is done

Experiment 6 (IMBL mastectomy exposures), is done and published

- Tavakoli Taba, S., Arhatari, B., Nesterets, Y., Gadomkar, Z., Lewis, S., Gureyev, T., Brennan, P., et al (2021). Propagation-based phase-contrast CT of the breast demonstrates higher quality than conventional absorption-based CT even at lower radiation dose. Academic Radiology, doi: 10.1016/j.acra.2020.01.009.
- Wan, S., Arhatari, B., Nesterets, Y., Mayo, S., Thompson, D., Hausermann, D., Maksimenko, A., Lewis, S., Gureyev, T., Brennan, P., Tavakoli Taba, S., et al (2021). Effect of x-ray energy on the radiological image quality in propagation-based phase-contrast computed tomography of the breast. Journal of Medical Imaging, 8(5), 052108-1-052108-12.

Experiment 7 (Elettra PIXIRAD-8 vs IMBL Hamamatsu): radiological assessment done.

- A conference paper and an article drafted (Giannotti, N., et al)

Experiment 8 (Xineos). Scans done using > 60 mastectomy samples. Published some early results.

- Arhatari, B., Stevenson, A., Abbey, B., Nesterets, Y., Maksimenko, A., Hall, C., Thompson, D., Mayo, S., Fiala, T., Quiney, H., Tavakoli Taba, S., Lewis, S., Brennan, P., Gureyev, T., et al (2021). X-ray phase-contrast computed tomography for soft tissue imaging at the imaging and medical beamline (IMBL) of the australian synchrotron. Applied Sciences, 11(9), 4120.

Experiment 9 (Dark-field signal in PBCT): ongoing, 1 article published (Gureyev, T., et al) and 1 under review (Aminzadeh, A., et al)

- Gureyev, T., Paganin, D., Arhatari, B., Tavakoli Taba, S., Lewis, S., Brennan, P., Quiney, H. (2020). Dark-field signal extraction in propagation-based phase-contrast imaging. Physics in Medicine and Biology, 65(21), 215029.

Patient Support table and breast holder studies: ongoing, 2 articles published and 1 under review (Lewis, S., et al)

- Lewis, S., Tam, N., Arana Pena, L., Juria, I., Tavakoli Taba, S., Hausermann, D., Brennan, P., Hall, C., Arhatari, B., Tromba, G., Gureyev, T., et al (2020). Getting a-breast of immobilisation needs for the implementation of phase contrast tomography. 15th International Workshop on Breast Imaging (IWBI 2020), Bellingham: Society of Photo-Optical Instrumentation Engineers (SPIE).
- Lewis, S., Gureyev, T., Baran, P., Tavakoli Taba, S., Pacile, S., Dullin, C., Tromba, G., Hausermann, D., Peele, A., Lockie, D., Brennan, P. (2018). Towards clinic-friendly solutions for patient trials in breast cancer phase contrast imaging. 14th International Workshop on Breast Imaging (IWBI 2018), Bellingham: Society of Photo-Optical Instrumentation Engineers (SPIE).

Educational Package (done) and ROC study (DM and PBCT images collected and under preparation)

Experiment 10 (Dectris): some early scans done

› Phys Med Biol. 2017 Mar 21;62(6):2315-2332. doi: 10.1088/1361-6560/aa5d3d. Epub 2017 Jan 31.

Optimization of propagation-based x-ray phase-contrast tomography for breast cancer imaging

P Baran [1], S Pacile, Y I Nesterets, S C Mayo, C Dullin, D Dreossi, F Arfelli, D Thompson, D Lockie, M McCormack, S T Taba, F Brun, M Pinamonti, C Nickson, C Hall, M Dimmock, F Zanconati, M Cholewa, H Quiney, P C Brennan, G Tromba, T E Gureyev

Affiliations + expand

PMID: 28140377 DOI: 10.1088/1361-6560/aa5d3d

ELSEVIER

Academic Radiology

Volume 26, Issue 6, June 2019, Pages e79-e89

Original Investigation

Toward Improving Breast Cancer Imaging: Radiological Assessment of Propagation-Based Phase-Contrast CT Technology

Seyedamir Tavakoli Taba [a], Patrycja Baran [b], Sarah Lewis [a], Robert Heard [c], Serena Pacile [d, e], Yakov I. Nesterets [f, g], Sherry C. Mayo [f], Christian Dullin [d, h, i], Diego Dreossi [d], Fulvia Arfelli [j], Darren Thompson [f, g], Mikkaela McCormack [k], Maram Alakhras [a], Francesco Brun [d, e], Maurizio Pinamonti [l], Carolyn Nickson [m], Chris Hall [n], Fabrizio Zanconati [l] … Patrick C Brennan [a]

Reconstruction Method	Level of Phase Retrieval	Distance Between Object and Detector								
		0.16 m			1.85 m			9.31 m		
		38 keV	35 keV	32 keV	38 keV	35 keV	32 keV	38 keV	35 keV	32 keV
iFBP	Without	-1.23	-1.02	-0.46	0.22	-0.51	0.71	-0.38	0.97	0.90
	Half	-0.77	-0.32	-0.03	0.98	0.34	0.09	1.58	1.85	1.80
	Full	-0.72	-0.42	-0.31	1.14	0.78	0.98	1.55	1.71	1.88
SIRT1000	Without	-0.88	-0.26	0.00	0.43	0.00	0.66	0.54	1.31	1.71
	Half	-0.78	-0.09	0.03	0.75	0.75	0.78	1.46	1.69	1.77
	Full	-0.85	-0.06	0.00	0.75	0.65	1.12	1.63	1.71	1.74
SIRT400	Without	-0.57	0.09	0.54	1.02	0.42	0.74	1.09	1.78	1.74
	Half	-0.42	0.37	0.31	1.02	1.02	1.02	1.34	1.72	1.80
	Full	-0.29	0.06	0.48	0.78	0.39	1.37	1.22	1.52	1.55

nature › scientific reports › articles › article

Article | Open Access | Published: 24 September 2019

Free propagation phase-contrast breast CT provides higher image quality than cone-beam breast-CT at low radiation doses: a feasibility study on human mastectomies

S. Pacilè, C. Dullin, P. Baran, M. Tonutti, C. Perske, U. Fischer, J. Albers, F. Arfelli, D. Dreossi, K. Pavlov, A. Maksimenko, S. C. Mayo, Y. I. Nesterets, S. Tavakoli Taba, S. Lewis, P. C. Brennan, T. E. Gureyev, G. Tromba & S. Wienbeck

Scientific Reports **9**, Article number: 13762 (2019) | Cite this article

Breast | Published: 23 January 2020

Comparison of propagation-based CT using synchrotron radiation and conventional cone-beam CT for breast imaging

Seyedamir Tavakoli Taba, Patrycja Baran, Yakov I. Nesterets, Serena Pacile, Susanne Wienbeck, Christian Dullin, Konstantin Pavlov, Anton Maksimenko, Darren Lockie, Sheridan C. Mayo, Harry M. Quiney, Diego Dreossi, Fulvia Arfelli, Giuliana Tromba, Sarah Lewis, Timur E. Gureyev & Patrick C. Brennan

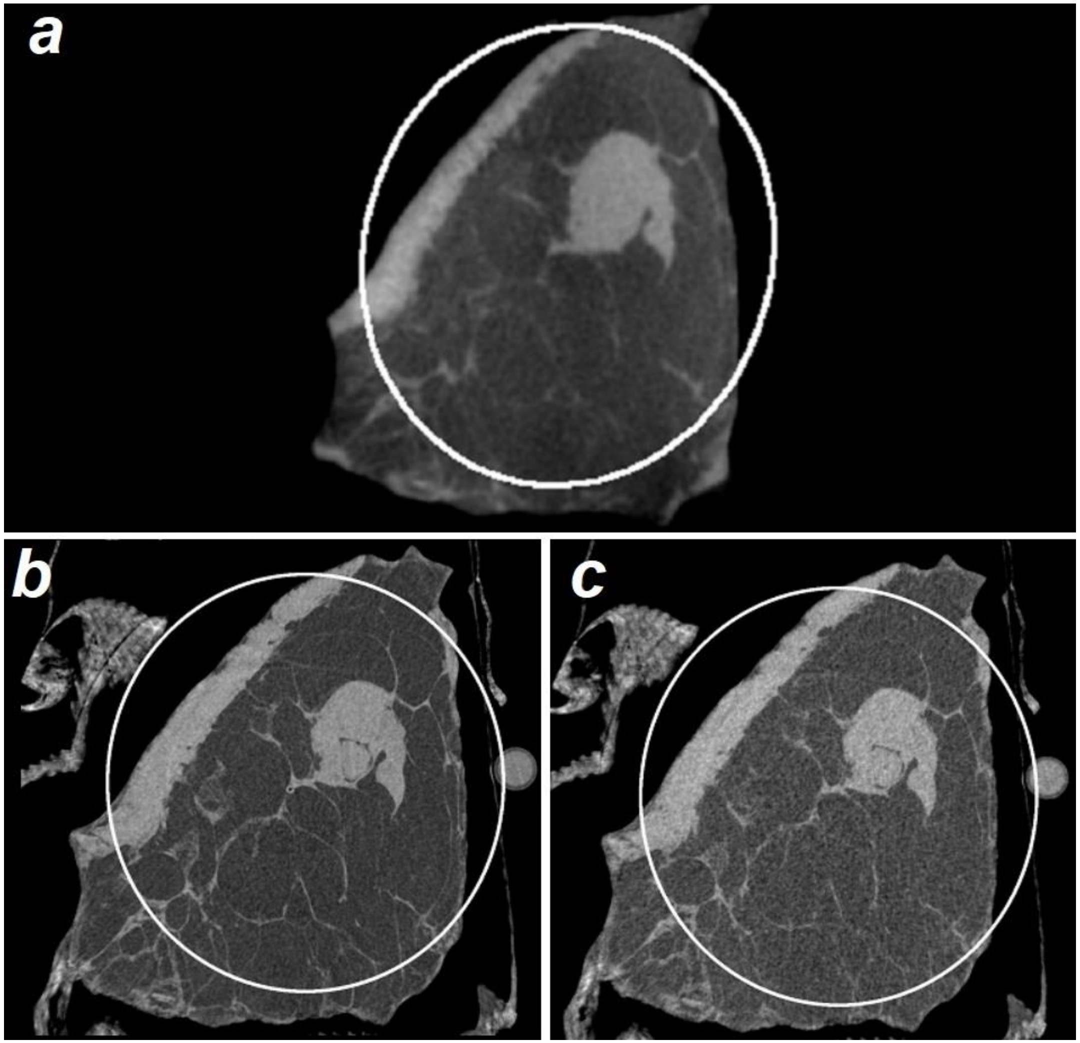
European Radiology **30**, 2740–2750 (2020) | Cite this article

***5.8 mGy** PBCT vs **5.8 mGy** CBCT images*

Image criterion	AUC_{VGC}	95% Confidence Interval		P-value
		Lower Bound	Upper Bound	
Overall quality	0.990*	0.958	1.000	0.002
Perceptible contrast	0.969*	0.875	1.000	0.005
Lesion sharpness	1.000*	1.000	1.000	0.011
Normal tissue interfaces	0.989*	0.938	1.000	0.006
Calcification visibility	0.958*	0.875	1.000	0.008
Image noise	0.809*	0.594	0.969	0.058

***1.5 mGy** PBCT vs **5.8 mGy** CBCT images*

Image criterion	AUC_{VGC}	95% Confidence Interval		P-value
		Lower Bound	Upper Bound	
Overall quality	0.812*	0.594	0.979	0.046
Perceptible contrast	0.834*	0.615	0.990	0.032
Lesion sharpness	0.820*	0.604	0.979	0.038
Normal tissue interfaces	0.785*	0.542	0.958	0.043
Calcification visibility	0.824*	0.583	1.000	0.043
Image noise	0.512	0.281	0.770	0.903



A breast specimen (sample 2) including an intraductal papillary;

a) CBCT image at 5.8 mGy

b) PB-CT image at 5.8 mGy

c) PB-CT image at 1.5 mGy

› Acad Radiol. 2021 Jan;28(1):e20-e26. doi: 10.1016/j.acra.2020.01.009. Epub 2020 Feb 5.

Propagation-Based Phase-Contrast CT of the Breast Demonstrates Higher Quality Than Conventional Absorption-Based CT Even at Lower Radiation Dose

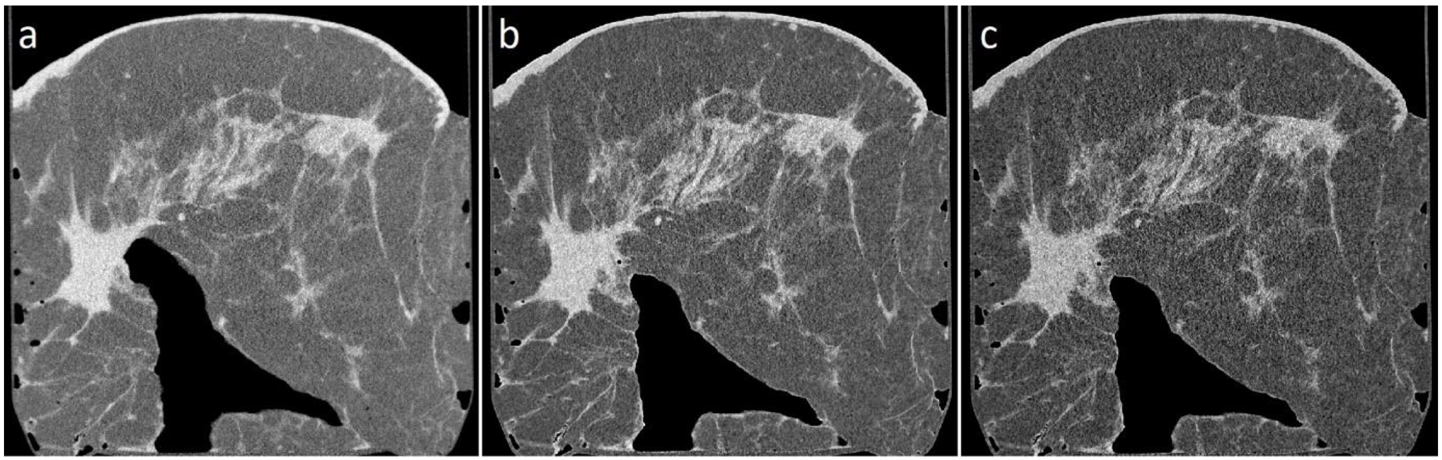
Seyedamir Tavakoli Taba [1], Benedicta D Arhatari [2], Yakov I Nesterets [3], Ziba Gadomkar [4], Sheridan C Mayo [5], Darren Thompson [3], Jane Fox [6], Beena Kumar [6], Zdenka Prodanovic [6], Daniel Hausermann [7], Anton Maksimenko [7], Christopher Hall [7], Matthew Dimmock [6], Konstantin M Pavlov [8], Darren Lockie [9], Masoumeh Gity [10], Andrew Peele [7], Harry M Quiney [11], Sarah Lewis [4], Timur E Gureyev [12], Patrick C Brennan [4]

Affiliations + expand

PMID: 32035759 DOI: 10.1016/j.acra.2020.01.009

Image set	AUC_{VGC}	95% Confidence Interval		P-value
		Lower Bound	Upper Bound	
PB-CT 32KeV-hTIE (4mGy) vs AB-CT (4mGy)	0.901*	0.811	0.970	0.001
PB-CT 32KeV-hTIE (2mGy) vs AB-CT (4mGy)	0.819*	0.651	0.954	0.011

* P≤.05



Absorption-based CT at 4 mGy

PB-CT at 4 mGy

PB-CT at 2 mGy

› J Med Imaging (Bellingham). 2021 Sep;8(5):052108. doi: 10.1117/1.JMI.8.5.052108. Epub 2021 Jul 12.

Effect of x-ray energy on the radiological image quality in propagation-based phase-contrast computed tomography of the breast

Sarina Wan [1], Benedicta D Arhatari [2 3], Yakov I Nesterets [4 5], Sheridan C Mayo [4], Darren Thompson [4 5], Jane Fox [6 7], Beena Kumar [7], Zdenka Prodanovic [7], Daniel Hausermann [2], Anton Maksimenko [2], Christopher Hall [2], Matthew Dimmock [6], Konstantin M Pavlov [5 8 9], Darren Lockie [10], Mary Rickard [1], Ziba Gadomkar [1], Alaleh Aminzadeh [3], Elham Vafa [1], Andrew Peele [2], Harry M Quiney [3], Sarah Lewis [1], Timur E Gureyev [1 3 5 9], Patrick C Brennan [1], Seyedamir Tavakoli Taba [1]

Affiliations + expand

PMID: 34268442 PMCID: PMC8273647 (available on 2022-07-12) DOI: 10.1117/1.JMI.8.5.052108

Table 5 Data analysis of the AUC_{VGC} resulting from the VGC analysis for PB-CT images versus AB-CT images.

	Energy (keV)	No. of samples	AUC_{VGC}	95% confidence interval: Lower bound	95% confidence interval: Upper bound	*p*-value
PB-CT versus AB-CT at 4 mGy	26	9	0.454	0.278	0.627	0.510
	28	25	0.654*	0.571	0.734	0.015
	30	9	0.754*	0.667	0.849	0.009
	32	38	0.731*	0.675	0.788	≤0.001
	34	39	0.723*	0.668	0.771	≤0.001
	60	12	0.162*	0.060	0.298	0.009

*$p \leq 0.05$

PAPER

Dark-field signal extraction in propagation-based phase-contrast imaging

T E Gureyev[1,2,3,4], D M Paganin[3], B Arhatari[1,5,6], S T Taba[2], S Lewis[2], P C Brennan[2] and H M Quiney[1]

Published 5 November 2020 • © 2020 Institute of Physics and Engineering in Medicine

Physics in Medicine & Biology, Volume 65, Number 21

Citation T E Gureyev *et al* 2020 *Phys. Med. Biol.* **65** 215029

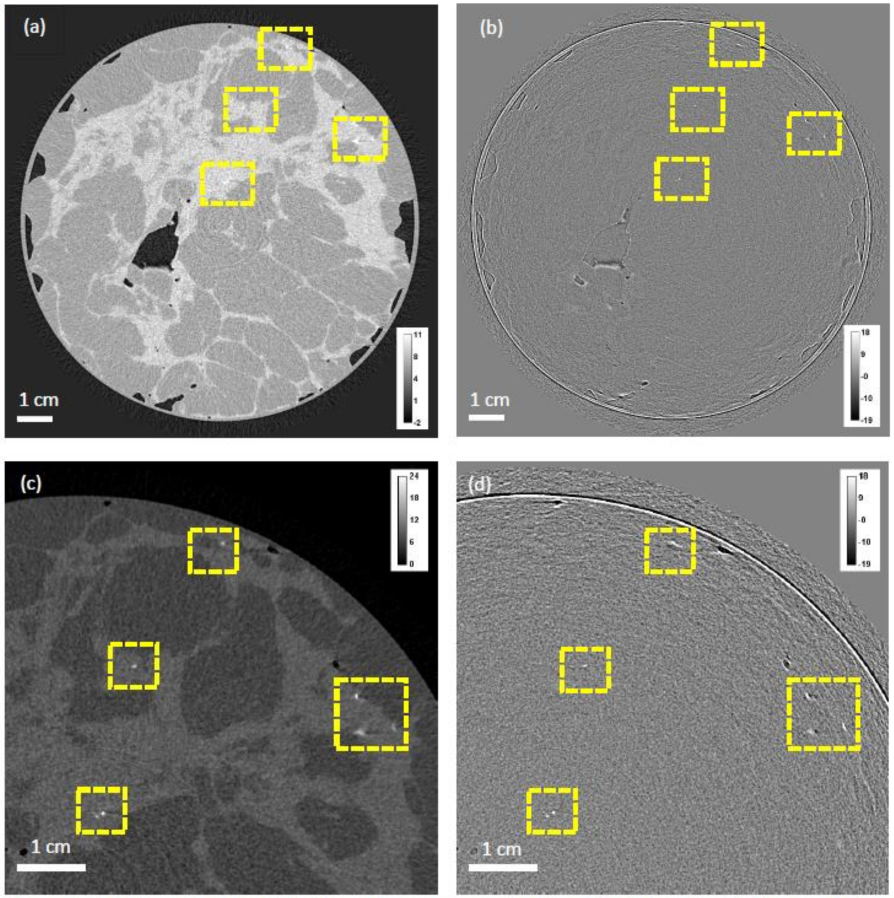


Figure 4. PBI CT reconstructed distribution of the imaginary part of absorption index, $\beta(x,y)\times10^{11}$, in a 100 μm thick coronal slice of mastectomy sample 2145659R, obtained from X-ray projections collected at 34 keV energy, 6 m sample-to-detector distance and 4 mGy dose: (a) a slice from the reconstructed bright-field (TIE) CT image stack; (b) the same slice from the dark-field (Born) reconstructed stack; (c) magnified version of the upper-right part of the slice shown in (a) after adjustment of the image histogram settings to maximize the visibility of the microcalcifications; (d) magnified version of the upper-right part of the slice shown in (b), without any adjustment of the image histogram. The dashed-line boxes outline areas with microcalcifications.

Getting a-breast of immobilisation needs for the implementation of phase contrast tomography

Sarah J. Lewis, Nathan Tam, Lucia Mariel Arana Pena, Isabella Juria, Seyedamir Tavakoli Taba, Daniel Hausermann, Patrick C. Brennan, Chris Hall, Benedicta Arhatari, Giuliana Tromba, Renata Longo, Timur E. Gureyev

Author Affiliations +

Proceedings Volume 11513, 15th International Workshop on Breast Imaging (IWBI2020); 115131P (2020)

https://doi.org/10.1117/12.2563572

Event: Fifteenth International Workshop on Breast Imaging, 2020, Leuven, Belgium

Towards clinic-friendly solutions for patient trials in breast cancer phase contrast imaging

Sarah J. Lewis, Timur E. Gureyev, Patrycja Baran, Seyedamir Tavakoli Taba, Serena Pacile, Christian Dullin, Giuliana Tromba, Daniel Hausermann, Andrew Peele, Darren Lockie, Patrick C. Brennan

Author Affiliations +

Proceedings Volume 10718, 14th International Workshop on Breast Imaging (IWBI 2018); 107181P (2018)

https://doi.org/10.1117/12.2316498

Event: The Fourteenth International Workshop on Breast Imaging, 2018, Atlanta, Georgia, United States

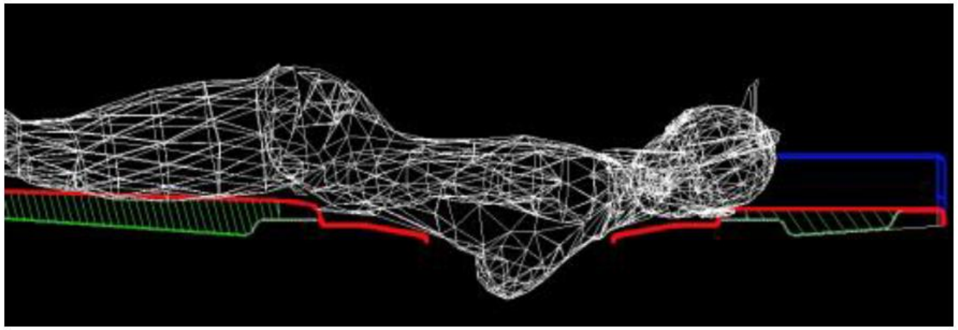
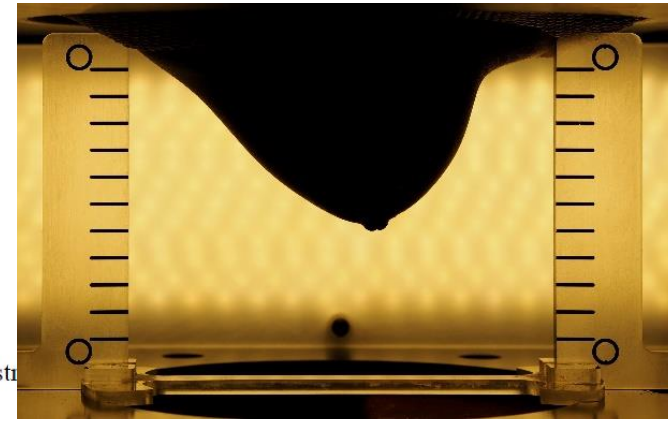
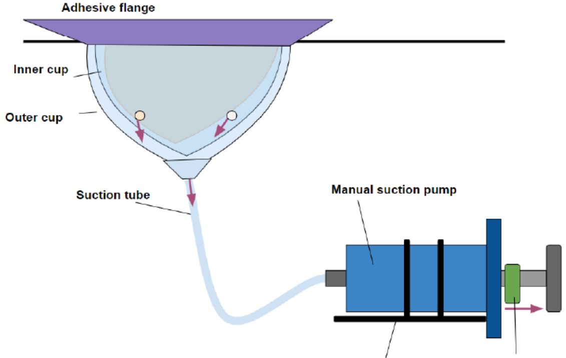
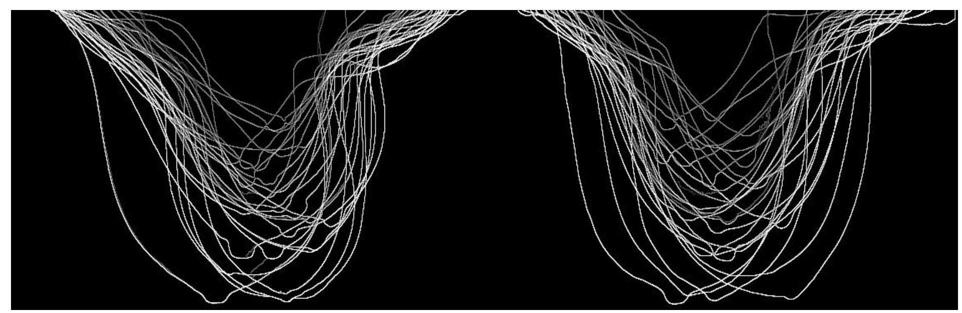


Figure 1. Schematic diagram of participant positioning required for Patient PCT trial at the IMBL Austr
courtesy of the SYRMEP Triste, Italy.





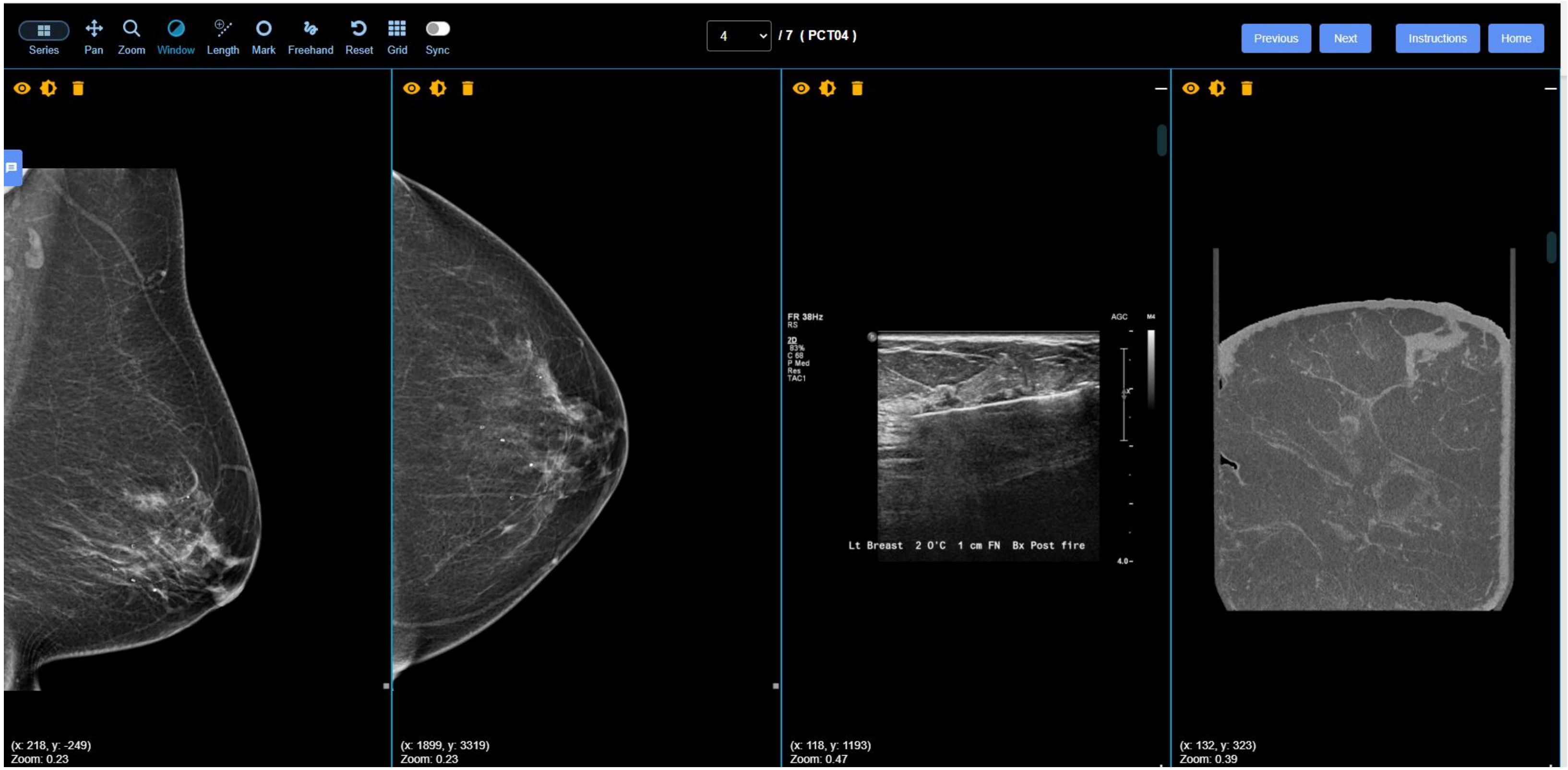


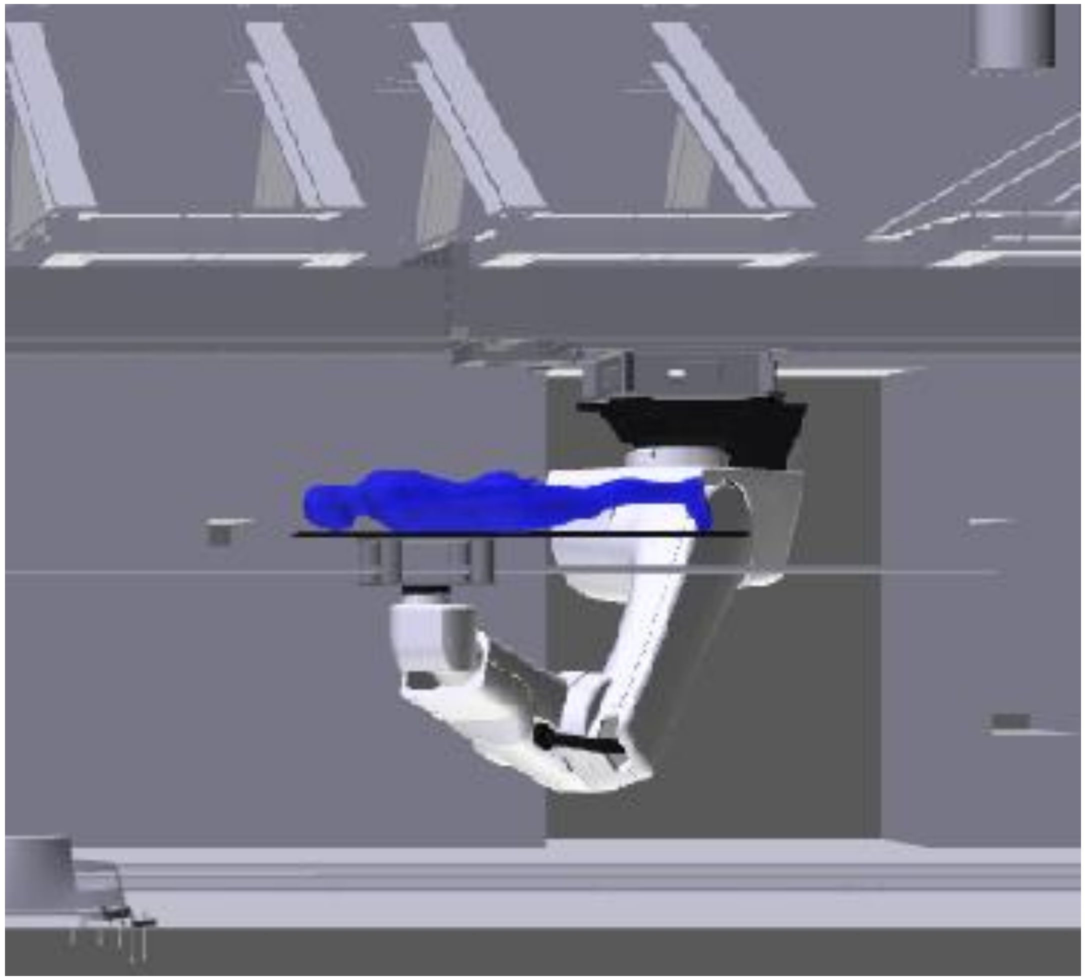
Learning to Read PCT Images

- An Educational Package is designed for radiologists
- Increase familiarity with reading PCT images of breast tissue.
- Learners will learn to mark the lesions in cancer samples through DetectEDx software.

Educational Package Design

Educational Package Design





What are our plans?

Synergy and IMPACT

*Our **vision** is to make PB-CT an advanced personalised breast and lung cancer diagnostic tool.*

Aims

Aim 1. Optimise imaging conditions for clinical settings.

Aim 2. Conduct a large clinical trial to validate preliminary results.

Aim 3. Establish a world-first mammographic PB-CT clinic for staging/treatment options.

Aim 4. Develop a pathway for widespread clinical implementation using compact sources.

Aim 5. Conduct a health economics evaluation.

Aim 6. Establish the feasibility of PB-CT for lung cancer imaging.

Aims

Aim 1. **Optimise imaging** conditions for clinical settings.

Aim 2. Conduct a large **clinical trial** to validate preliminary results.

Aim 3. Establish a world-first mammographic **PB-CT clinic** for staging/treatment options.

Aim 4. Develop a pathway for widespread clinical implementation using **compact sources.**

Aim 5. Conduct a **health economics** evaluation.

Aim 6. Establish the feasibility of PB-CT for **lung cancer** imaging.

Aims: PHASE 1 (2022-2024)

– **Part A (Aim 1). Optimise imaging conditions for clinical settings.** We will conduct a series of studies to determine optimal PB-CT imaging conditions to suit different breast sizes and compositions.

– **Part B (Aim 2). Conduct a large clinical trial to validate preliminary results.** Theoretical and computer simulation data for PB-CT has been accumulated, alongside experimental results utilising excised tissue samples. We will now verify these preliminary results in real-life human imaging.

Aims: PHASE II (2023-2026)

- **Part A (Aim 3). Establish a world-first mammographic PB-CT clinic for staging and treatment options.** We will establish the diagnostic breast clinic at Australian Synchrotron's flagship Imaging and Medical Beamline (IMBL).

- **Part B (Aim 4). Develop a pathway for widespread clinical implementation using compact X-ray sources.** Delivering PB-CT technology via commercially available compact X-ray sources will allow it to be widely integrated into specialist cancer care facilities across Australia and overseas.

- **Part C (Aim 5). Conduct a health economics evaluation.** Clinical outcomes and cost-effectiveness of using PB-CT in breast cancer diagnostic settings and population screening assessments will be determined.

Aims: PHASE III (2024-2026)

– **(Aim 6). Establish the feasibility of PB-CT for lung cancer imaging**. The platforms, models, processes and techniques we develop for breast cancer imaging will then be applied to lung cancer.

Table 4. IMPACT team

CIs	Expertise	Phase involved in
Prof Patrick Brennan	**Diagnostic Imaging** (Diagnostic Imaging Chair, Sydney U)	I-A, I-B, II-B, III
Prof Harry Quiney	**Physics and Chemistry** (Deputy Head, School of Physics, Melbourne U)	I-A, II-B
Prof Sarah Lewis	**Medical Imaging** (Associate Dean Research Performance, Sydney U)	I-B, II-A, II-B, III
Prof Keith Nugent	**Physics, X-ray optics** (FAA; Deputy Vice-Chancellor, ANU)	I-A
Prof Andrew Peele	**Physics, X-ray optics** (Director, Aust. Synchrotron)	I-B, II-A, II-B
Dr Amir Tavakoli Taba	**Medical Imaging Science** (Lecturer, Sydney U)	I-A, I-B, II-B, III
Dr Kaye Morgan	**Physics** (ARC Future Fellow, Monash U)	II-B, III
Dr Jane Fox	**Medicine, Surgery** (Director, Breast Services at Monash Health)	I-B, II-A
Dr Giuliana Tromba	**Physics** (Head, SYRMEP beamline of Elettra Synchrotron)	I-A, I-B, III
Dr Darren Lockie	**Medicine, Radiology** (Director, Maroondah BreastScreen)	I-B, II-A, II-C
AIs		
Dr Timur Gureyev	**Applied Mathematics** (Principal Research Fellow, Melbourne U)	I-A, I-B, II-A, II-B, III
Dr Yakov Nesterets	**Physics, X-ray Science** (Scientist, CSIRO)	I-A, I-B, II-A, II-B, III
Dr Christian Dullin	**Medicine, Radiology** (Lecturer, Goettingen Hospital)	III
Dr Daniel Hausermann	**Physics & Synchrotron Techniques** (Scientist, Aust. Synchrotron)	I-B, II-A, III
Dr Sherry Mayo	**Medical Imaging Science, X-ray physics** (Scientist, CSIRO)	II-B
Dr Matthew Dimmock	**Medical Imaging Physics** (Lecturer, Monash U)	I-A
Dr Yobelli Jimenez	**Medical Imaging Clinician, Patient Educator** (Lecturer, Sydney U)	I-B, II-A
A/Prof Marcus Kitchen	**Physics, X-ray Optics** (Associate Professor, Monash U)	II-B, III
Dr Foruhar Moayeri	**Medicine, Health Economy** (Lecturer, Monash U)	II-C
Dr Nicola Giannotti	**Diagnostic Imaging** (Lecturer, Sydney U)	I-A, I-B, III