International Workshop on Medical Ultrasound Tomography

27.-29. June. 2022, London, United Kingdom

PROGRAM

Welcome

Dear colleagues,

It is a great pleasure for us to welcome you all in London for the third International Workshop on Medical Ultrasound Tomography (MUST 2022).

Ultrasound Tomography is an emerging technology for medical imaging that is quickly approaching its clinical utility. Multiple research groups around the globe are engaged in research spanning from theory to practical clinical applications and commercialisation. The MUST workshop is designed to be interactive and brings together scientists from all over the world to exchange their knowledge and discuss new ideas and results to boost research in Ultrasound Tomography and related fields.

We are very excited to host this workshop and would like to sincerely thank all the colleagues involved in the scientific and local committee for their commitment. We are furthermore grateful for the financial support of UK Acoustics Network, Blatek, Precision Acoustics and the National Measurement System under the Department for Business, Energy & Industrial Strategy, and the organisational support from the National Physical Laboratory, University College London and Imperial College London.

We are looking forward to the exciting upcoming days.

Welcome to London and enjoy the workshop!
D. Sarno, B. Zeqiri, B. Cox & L. Guasch

NPL UCL Imperial College London

Scientific committee

Daniel Sarno
National Physical Laboratory, UK

Bajram Zeqiri
National Physical Laboratory, UK

Ben Cox
University College London, UK

Lluís Guasch
Imperial College London, UK

Local committee

National Physical Laboratory, UK

Daniel Sarno
Paris Aitken-Smith
Roger Hughes

Supporters

PRECISION ACOUSTICS

acoustics.ac.uk
THE UK ACOUSTICS NETWORK

Blatek
ULTRASONIC TRANSDUCERS

Department for Business, Energy & Industrial Strategy

Practical information

Language
English is the official language of the workshop.

Registration fee
The registration fee is £450 and £225 for regular and student attendance, respectively. It includes access to all conference days, tea and coffee breaks, lunch and conference dinner.

Certificate of attendance
If you wish to obtain a certificate of attendance, please send an e-mail to must2022@npl.co.uk.

Oral presentations
Please upload your presentation slides to the presentation notebook in the auditorium during the break before your presentation at latest. Oral presentation time slots are 20 minutes including 5 minutes for discussion.

Posters
Posters will be displayed during the entire workshop on digital totems positioned throughout the reception area. Please upload your posters on to your assigned totem at your earliest convenience.

Coffee breaks and lunch
Conference breaks and lunch will be served in reception.

Internet access at workshop venue
To connect to the guest network:

1. Connect to the NPL-Guest wireless network
2. Open your internet browser
3. Follow the on screen instructions by providing the relevant information

Please report any problems connecting to this network to the IT Helpdesk on 020 8943 6000.

eduroam is also available at NPL

Meeting rooms and work zones
There are areas available for attendees to work between sessions if required. First floor meeting rooms CS6 and CS7 outside the auditorium are available for use. Additionally, there are a number of booths in the ground floor reception area open to attendees.

Workshop proceedings
Workshop proceedings will be open access and have an ISBN key allowing citation. They will be available online and by print-on-demand. Please look out for emails from must2022@npl.co.uk following the workshop for more information.

Venue address
National Physical Laboratory
Hampton Road
Teddington
TW11 0LW
UK

Parking
Parking is available on the NPL site in front of reception (see Venue Map)

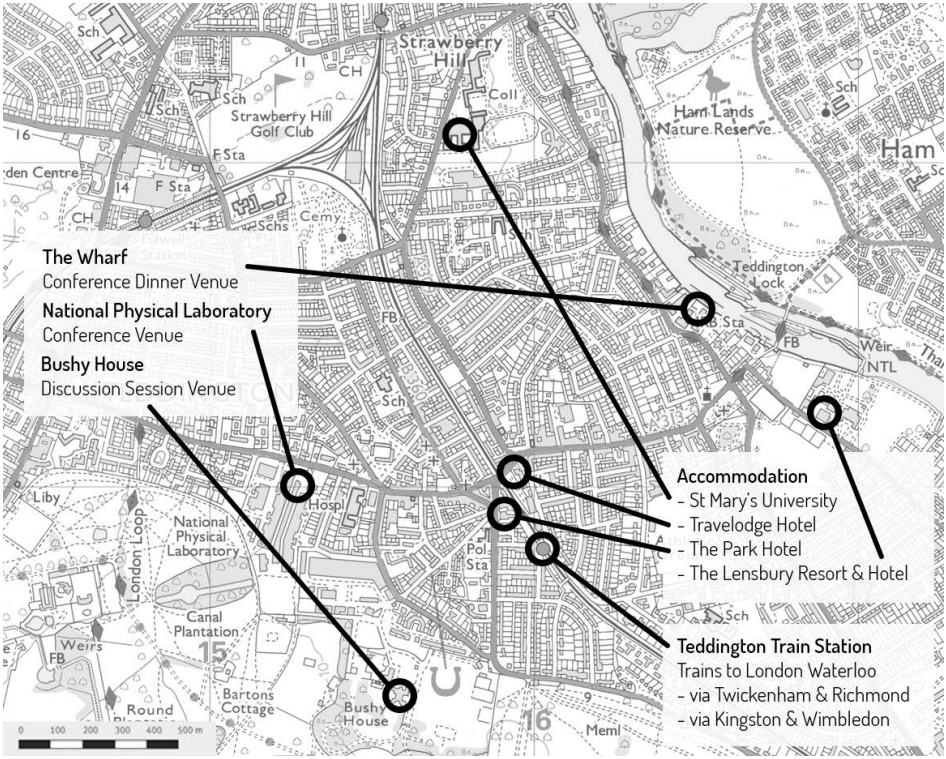
ATM
ATMs are located on Teddington High Street at Halifax Bank and the Post Office.

Public transportation
All places of interest in and around Teddington within walking range, with the high street taking approximately 20 minutes to walk end-to-end.

For public transport, there are many bus routes that cover the town (please note: London buses are cashless so you will require a contactless bank card or oyster card to use them). Stop SN is closest to St Mary's University and route 33 will take you into Teddington. Stop U at Teddington Lock is closest to The Lensbury Hotel and the 285/R68 will take you to Stop K outside NPL.

For trips to London Waterloo, the train station is centrally located in Teddington. Tickets can be purchased from machines at the station or simply tap in with a contactless bank card or oyster card before boarding the train. Teddington train station is in Zone 6 and is served by Southwest Trains. Trains to London Waterloo leave the station approximately every 15 minutes and cost £8.10.

Map of important locations



What to see and do near Teddington

Teddington is a suburb in south-west London. Teddington stretches from the River Thames to Bushy Park, between the towns of Kingston and Richmond. Nearby sights include:

- Bushy Park
- Hampton Court Palace
- Richmond Park
- Ham House
- Kew Gardens

Further afield, central London is just a 35 minute train journey from Teddington Station to London Waterloo Station.

Social events

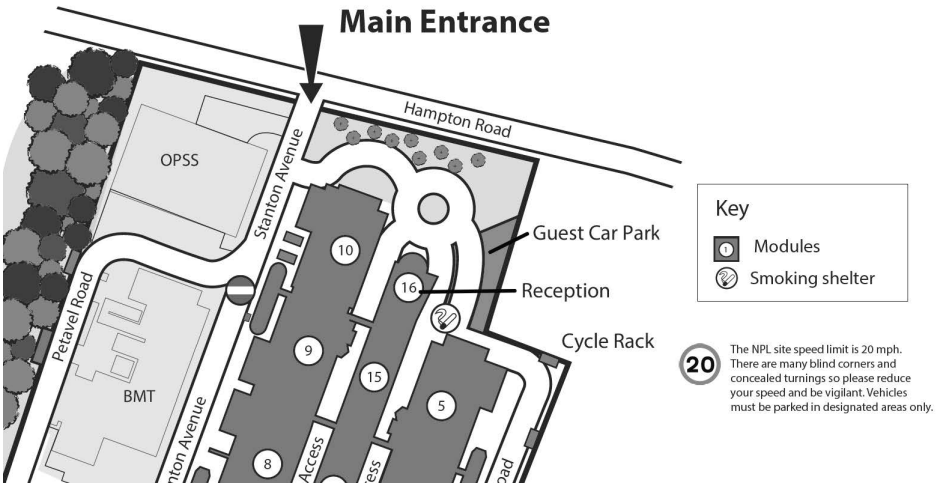
Conference dinner
Monday 27th June 18:45 - 21:00, The Wharf Restaurant

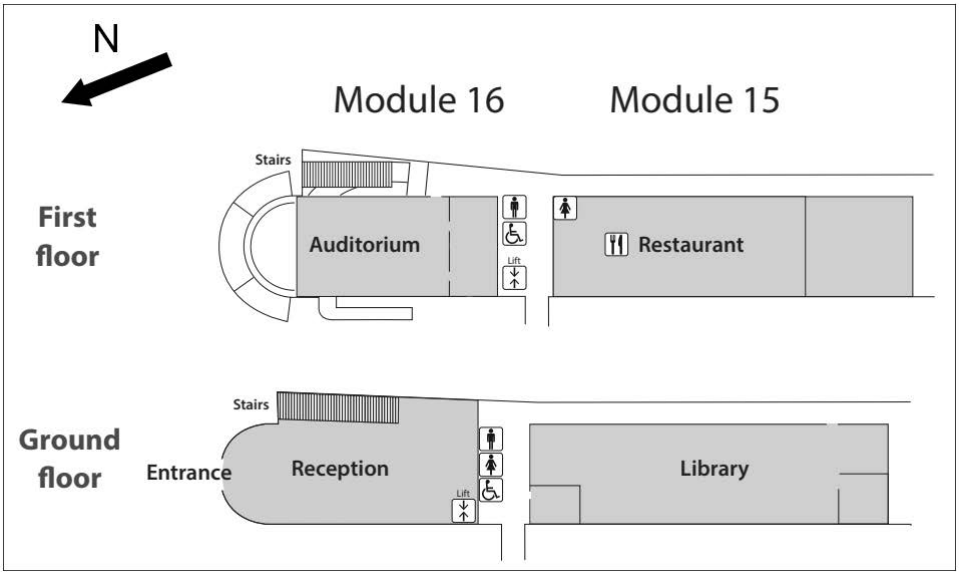
The conference dinner will be held at The Wharf Restaurant overlooking the river Thames. The Wharf offers a unique dining experience combining a mouth-watering menu with an eclectic wine list and warm and friendly staff. The menu offers a fantastic blend of modern European cuisine with a nod towards its riverside location.

The final session of the day finishes at 17:00, after which attendees are free to make their own way to the venue for arrival at 18:45. For those who wish to stay at the National Physical Laboratory after the final session, we will meet at reception at 18:20 for a short walk through Teddington to The Wharf. If you wish to take transport from the National Physical Laboratory to The Wharf, please find a member of the local committee at the 15:40 break who will arrange taxis.

Note: Pre-registration for attendees is mandatory
Dress code: Smart-Casual
Address: The Wharf, Manor Rd, Teddington TW11 8BG


Venue map





Disability Access - There is disabled parking by Reception and every effort has been made to provide assistance for the disabled visitor. Dogs are banned on site, with the exception of guide and assistance dogs.

Invited talks

Clinical use of ultrasound computed tomography

Jeroen Veltman, *University of Twente, Netherlands*
Monday 27th June, 13:00

ABSTRACT ▪ As a radiologist ultrasound is mainly used as a low threshold, first step, confirm or rule out imaging modality. In combination with the correct clinical information it can be applied at bed side to support clinical decisions, also by clinicians. Besides the use as a diagnostic tool ultrasound is also used for image guided interventions.

In daily practice 2d handheld ultrasound is standard of care. Acquisition is user dependant, interpretation real time and documentation is only a selection of the exam.

The use of 3d ultrasound imaging overcomes the aforementioned limitations making it a more robust tool. However it does not improve it's imaging properties. In breast ultrasound however the additional imaging plane that is created does help in the recognition of lesions.

Improving the diagnostic performance of ultrasound can however be achieved using additional methods like ultrasound contrast or photoacoustic tissue characteristics.

For instance in prostate or breast imaging MRI is currently the gold standard of imaging. However MRI is not the modality of choice for both prostate or breast, ultrasound is. In bore MRI guided biopsies can be performed for both organs but they are time consuming and uncomfortable for patients. This is where target biopsies supported by image fusion plays a key-role. Using image fusion the lesions detected on MRI are biopsied on whole organ 3d ultrasound imaging. This can also technically be done with the assistance of a robot arm.

Full Waveform Inversion, from geosciences to medical imaging

Jeroen Tromp, *Princeton University, USA*
Tuesday 28th June, 09:20

ABSTRACT ▪ The concept of imaging based on the full physics of seismic wave propagation was introduced in seismology approximately 35 years ago. Thanks to modern numerical methods and high-performance computers, seismic Full Waveform Inversion (FWI) has finally come to fruition in the past decade. Today, FWI is used across nine orders of frequency and wavelengths, from megahertz frequencies and millimeter wavelengths in ultrasound medical imaging and non-destructive testing to millihertz frequencies and thousand-kilometer wavelengths in seismology. The ultimate goal of FWI is to use every wiggle in a time series to map an object, be it the Earth or the Sun, a rock sample, or a body part. The purpose of this talk is to give an overview of the challenges and opportunities for FWI in medical imaging, in light of the geosciences state of the art.

3D Ultrasound tomography (volography): Theory, History and Clinical applications

James Wiskin, *QT Imaging, USA*
Tuesday 28th June, 13:00

ABSTRACT ▪ We review some history and give a theoretical basis for the 3D low frequency ultrasound tomography (LFUT) algorithm, i.e. volography, including the evolution from CT based algorithms to nonlinear large scale minimization and performance optimization. We explain why 2D algorithms are insufficient for clinical applications, indicate relevant timing results and discuss the congruence to training a

convolutional neural network (CNN) with Lie symmetries and the resulting efficiency that leads to reconstructions in clinically relevant times, making this method ideal as a high resolution imaging technology for low resource environments and underserved populations.

We summarize clinical applications including breast imaging, early detection and monitoring of breast cancer, breast density measurements, functional ultrasound tomography (FUT), knee and orthopedic imaging, pediatric and whole body imaging. We give examples and review the concomitant refraction corrected reflection algorithm, critical to obtaining sub-mm resolution. We show FUT enables doubling time estimation, calcium location in ducts or masses and introduce sequential calcium scoring and its clinical implications for monitoring cancer and disease.

We show the quantitative accuracy of speed of sound estimation for various tissues using literature values for ligaments, cartilage, tendons, muscle, skin and fat, in the presence of bone and verify its ability to monitor Duchenne MD, or sports injuries in humans or animals.

The consistent high resolution and quantitative accuracy is shown and specific breast cancer cases are reviewed. Detailed comparison of knee images with MRI indicate the improved contrast and spatial resolution. Fusion of speed of sound and reflection yield sub-mm resolution quantitative orthopedic images.

The low cost, simple training, lack of ionizing radiation or contrast agents in LFUT volography are discussed. The system is easily converted to a portable platform to serve Low Resource Environments. Over 13000 breast and related scans have been performed and extensive training sets have been culled from these. Clinical trials are reviewed showing improved area under the ROC curve when compared to X-ray mammography breast cancer screening.

Doubling time estimation, calcification and tumor functional imaging are shown and discussed. Ductal and Glandular individual segmentation is shown over time and correlated with hormone levels in volunteers, indicating high spatial and contrast resolution. Quantitative estimates of spatial/contrast resolution are reviewed.

The clinical advantages of 3D LFUT volography as a tested technology is summarized. We conclude this technology is safe and ideally suited for clinical deployment in diverse situations.

Ultrasound Tomography: Technical Challenges and System Design

Nicole V. Ruiter, *Karlsruhe Institute of Technology*

Wednesday 29th June, 14:00

ABSTRACT ▪ A clinically applicable ultrasound tomography system should produce data that both provides optimal imaging results for diagnosis and is at the same time suitable for clinical use. Clinical applicability includes patient safety and comfort, high patient throughput, rapid image reconstruction, and low cost of acquisition and operation.

The technical challenges of building and operating such a device are due to the large size of a complex object being imaged, e.g. the female breast, compared to the wavelength of the ultrasound. A large number of ultrasound transducers is required to image the object, which need to be as identical as possible. In order to approximate spherical waves (3D systems) or cylindrical (2D systems), the individual transducers have to be very small, resulting in low sound level pressures and a low signal-to-noise ratio. The large number of ultrasound transducers that have to be recorded in parallel leads to a large number of parallel channels and a high data rate in order to avoid patient motions with the shortest possible data acquisition times. Due to the complex interaction of ultrasound with tissue, reconstruction algorithms for high image quality are complex and time consuming.

This paper discusses these challenges, presents the different available hardware setups and how they tackle these challenges, and provides an outlook on future developments.

Monday 27th June	
12:00	Welcome Lunch *Reception, Ground Floor, Module 16, National Physical Laboratory*
12:40	**Introduction to NPL and Opening Remarks**
13:00	**Invited Talk:** Clinical use of ultrasound computed tomography *Dr Jeroen Veltman, University of Twente*
14:00	Tea and Coffee Break
14:20	Ultrasound Tomography for Breast Cancer Screening and Diagnosis *Prof. Neb Duric*
14:40	Reconstruction of scatter characteristics using 3D Ultrasound Tomography *Torsten Hopp*
15:00	In vivo measurements of the bulk ultrasonic attenuation coefficient of breast tissue using a novel phase-insensitive receiver *Daniel Sarno*
15:20	A 3D Lung imaging using ultrasound computed tomography *Prof. Manuchehr Soleimani*
15:40	Tea and Coffee Break
16:00	Towards ultrasound full-waveform inversion for in-vivo whole-body slice imaging of a mouse *Ines Ulrich*
16:20	Transcranial Ultrasound Computed Tomography with Minimal Prior Knowledge Using Optimal Transport *Patrick Marty*
16:40	Wave-based Ultrasound Transmission Tomography Using the Paraxial Approximation in 2D and 3D *Prof. Hartmut Gemmeke*
18:45	Conference Dinner

Tuesday 28th June	
09:00	Breakfast *Reception, Ground Floor, Module 16, National Physical Laboratory*
09:20	**Invited Talk:** Full Waveform Inversion, from geosciences to medical imaging *Prof. Jeroen Tromp, Princeton University*
10:20	Tea and Coffee Break
10:40	First imaging results with the new 3D USCT III setup at KIT *Torsten Hopp*
11:00	Crosstalk-free source encoding *Etienne Bachmann*

11:20	High-Performance Full-Waveform Inversion using Stride and Devito: a Practical View *Dr Carlos Cueto*
11:40	Using uncertainty to estimate imaging errors induced by variable density, attenuation, and position *Oscar Bates*

12:00	Lunch

13:00	**Invited Talk:** 3D Ultrasound tomography (volography): Theory, History and Clinical applications *James Wiskin, QT Imaging*

14:00	Tea and Coffee Break

14:20	Quantification of Speed-of-Sound with Preclinical Multimodal Transmission-Reflection Optoacoustic Ultrasound (TROPUS) system *Prof. Joaquin L. Herraiz*
14:40	Deep-Learning-Driven Low Frequency Extrapolation for Full-Waveform Inversion Breast Imaging *Thomas Robins*
15:00	Reconstructions of experimental low-frequency ultrasound tomography data collected on a circular belt of Tonpilz transducers *Andre Vieira Pigatto*
15:20	Multimodality imaging for preclinical oncology applications using a PET registered Ultrasonography (PETRUS) device *Dr. Mailyn Pérez-Liva*

16:15	Walk to Bushy House
16:30 – 18:00	**Discussion Session** *Bushy House*

Wednesday 29th June	
09:00	Breakfast *Reception, Ground Floor, Module 16, National Physical Laboratory*

09:20	MUBI Research Platform: Recent Advances and New Developments *Jorge Fernandez Cruza*
09:40	Towards In-Vivo Multi-Perspective Bistatic Ultrasound Imaging Using Aberration Correction *Vera van Hal*
10:00	Ray-based inversion accounting for scattering for biomedical ultrasound tomography *Dr. Ashkan Javaherian*

10:20	**Poster Session** *Reception, Ground Floor, Module 16, National Physical Laboratory*	Tea and Coffee Break

11:00	Comparison of Phase-Insensitive and Phase-Sensitive Ultrasound Absorption Tomography in the Frequency Domain

	Santeri Kaupinmäki
11:20	Multi-perspective bistatic 2-D and 3-D ultrasound acquisitions and strain imaging of abdominal aortas *Hein de Hoop*
11:40	Characterisation of Bone through Guided Circumferential Lamb-Type Waves *Aaron Chung*

12:00	Lunch

13:00	**Lab Tours** *Ultrasound Laboratory, Ground Floor, Module 10, National Physical Laboratory*

14:00	**Invited Talk:** Ultrasound Tomography: Technical Challenges and System Design *Dr Nicole Valerie Ruiter, Karlsruhe Institute of Technology*

15:00	Tea and Coffee Break

15:20	Acoustic propagation in weakly nonlinear regime using ray tracing approximation with applications in HIFU *Matt Foster*
15:40	Automatic aperture localization in free-hand multi-perspective ultrasound imaging *Hans-Martin Schwab*
16:00	ADMM-based full-waveform inversion (FWI) for photoacoustic tomography (PAT) *Dr Hossein Aghamiry*

16:20	**Closing Remarks**

Posters

(1) A new Generation of Transducer Arrays for 3D USCT
Martin Angerer

(2) Preliminary Result of Strain Elastography by Ultrasound Computed Tomography System
Qi Yang

(3) Real time imaging by FPGA for ultrasound computed tomography
Li Mao; Qiude Zhang; Mingyue Ding; Ming Yuchi

(4) Deep learning-based Compressed Sensing for Ultrasound Computed Tomography
Xin'an Zhu; Zhaohui Liu; Vikentii Pankov; Oleg Granichin; Mingyue Ding; Ming Yuchi

(5) The upgraded design of TAS with self-gain control
Zewei Lu; Michael Zapf; Klaus Schlote-Holubek; Birgit Burger; Volker Reiling; Nicole Ruiter

(6) DAQ software architecture for the KIT 3D USCT III system
Michael Zapf

(7) Improved temperature modeling for 3D USCT III: Phase compensation
Tabea Friedrich; Zewei Lu; Lei Xiaoxu; Fu Junyu; Michael Zapf; Nicole Ruiter

(8) Forward and Adjoint PAT Operators Based on Multiscale Gaussian Beams
Kiko Rul·lan; Elliott Macneil; Ben Cox; Marta Betcke

(9) A MATLAB toolbox for ray-based Biomedical ultrasound tomography
Ashkan Javaherian