1Micron
–IMAGING

A project financed by EIC Pathfinder

A project within the EIC Pathfinder programme that develops ultra-high-resolution x-ray sensors for real-time detection of tumour margins. Revolutionizing pathology with faster and more accurate diagnostics during surgery.

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Prismatic sensors

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From left to right: *Johan Schuber, Julia Herzen, Jakob Wikner, Rikard Brunskog, Mats Persson, Julia Parnell, Leonard Paus, Lucio Panchini, Sara Garbol, Anders Björklid, Manuel Rolo, Irma Fredriksson, Mats Danielsson, Moa Yveborg Tamm, Franz-Leonard Klaus, Johan Hartman.*

"Of course there are challenges, but we have physics on our side."

1MICRON IS A flagship project funded by the EU's EIC Pathfinder Open programme. Its aim is to develop an ultra-high-resolution X-ray sensor – and if the project succeeds, it could completely revolutionise X-ray diagnostics. Swedish experts ***Mats Danielsson***, ***Johan Hartman*** and ***Anders Björklid*** are the principal investigators (PIs), along with their European colleagues ***Julia Herzen, Lucio Pachini*** and ***Manuel Rolo.***

Cooperation between academia, industry and healthcare is key to the success we hope to achieve because, from my experience with interdisciplinary projects, a systems perspective is also necessary. This establishes a framework for the project's organisation, and the insight that we should not lock ourselves into a solution that is not industrially scalable.

I believe this project can revolutionise medical X-ray imaging. One important element is the sensor's design and the ability to demonstrate, in real time, how it can achieve the phase-contrast imaging we are striving for.

We held our kick-off event in Stockholm on 22 May – personally, I am excited to be part of what could be the biggest thing in medical imaging in a very long time. Of course, there are challenges, but we have physics on our side. Our hand-picked team comprises researchers who are at the forefront of their fields, as well as an industrial partner that understands hospitals' technical requirements – a combination that gives us a good chance of success.

Moa Yveborg Tamm,
project coordinator for 1Micron.

Presentation of the project's six PIs

Mats Danielsson – professor at KTH Royal Institute of Technology and a pioneer in photon-counting X-ray imaging, including the MicroDose mammography system and photon-counting computed tomography using silicon as the detector material. In 2019, the start-up company Prismatic Sensors AB was acquired by GE Healthcare. Awarded an ERC Advanced Grant in April 2024.

Julia Herzen – professor at Technische Universität München, Germany, with over ten years' experience in interdisciplinary research in medical physics, biomedical engineering, medicine, and computer science. Expert in instrument and method development for grating-based phase-contrast X-ray imaging. She was awarded an ERC Consolidator Grant in November 2023.

Lucio Pancheri – associate professor of electronics at the University of Trento, Italy, with 20 years of experience in the design and characterisation of integrated circuits for optical radiation detectors. His research focuses on the development of radiation sensors for imaging applications, and he holds several patents.

Manuel Rolo – PhD and expert in microelectronics design, production and testing. Worked for ten years at Italy's National Institute for Nuclear Physics, where he developed and coordinated integrated circuits for use in particle, astroparticle and nuclear physics. Pioneer in monolithic sensor technology.

Anders Björklid – has worked with ASIC design since 1995, as a designer, chip architect, system architect, project manager and head of design teams. Designer for photon-counting computed tomography in collaboration with the KTH Royal Institute of Technology's group for physics and medical imaging; head of Prismatic Sensors AB's electronics design team.

Johan Hartman – head of breast pathology at Södersjukhuset general hospital, professor at Karolinska Institutet, and scientific director of the Swedish Society of Pathology. He is also a co-founder of Stratipath, which develops AI solutions for pathology.

Background – why is 1Micron needed?

At present, there is a significant difference between biomedical X-ray examinations and the microscope images of prepared tissue samples taken by pathologists, where the latter can have a resolution of a couple of micrometres and reveal details such as the cell nucleus. 1Micron, part of the EU's EIC Pathfinder Open programme, aims to combine new types of silicon sensors with advanced phase-contrast imaging, where the interference pattern can be directly measured, thus obtaining a high-resolution image with a very high contrast.

One potential area of application is in cancer care. According to a European review, one in ten cancer surgeries must be followed by reoperations when histology shows that tumour tissue was not removed with a sufficient margin. In Europe, 100,000 operations could be avoided every year if relevant image information was available in the operating theatre.

The sensor could also provide a basis for the next generation of clinical X-ray images. One example is that photon-counting computed tomography is moving to the next level, providing better diagnostics and increasing the chances of early cancer detection.

The project aims to use new technology and achieve higher resolutions by exploiting how X-rays are both particles and waves. The periodicity of waves changes when they are refracted, and measuring this phase shift provides greater contrast than current X-ray imaging.

1Micron technology is based on monolithic sensors, where semiconductor electronics are integrated in the sensor chip. This allows individual photons to be counted at high speeds and with high resolutions.

The ultimate goal is a scientific breakthrough: an imaging technology that provides significantly higher resolution and contrast than today's most advanced technology.

The project PIs first met on 22 May 2025, at KTH Royal Institute of Technology's AlbaNova centre in Stockholm. They presented their different approaches to the project, providing a foundation for concrete guidelines for their work.

Current situation and **future opportunities**

Mats Danielsson first paints a picture of the current situation for the diagnostics and treatment of various diseases – and where the results of the 1Micron project could fit in.

MATS DANIELSSON BEGINS by saying that he and his colleagues like to make a difference.

— But in this project, one revolution is not enough. In fact, two are necessary. I will return to this, but one of them is in computed tomography, which I'd like to briefly review.

— Ten years ago, you could basically only get physiotherapy, and an ambulance wouldn't even use its siren because it wasn't considered urgent.

Nowadays, thrombectomy is used, with physicians on call around the clock so that they can remove clots using a special instrument. However, CT scans are required to identify where the blood supply is blocked, as an MRI scan takes too long. Standard computed tomography (CT) is now used, but the contrast between white and grey matter is low. This is where high-resolution CT could make a difference.

Another application is lung imaging diagnostics, as lung cancer is the fifth most common form of cancer and one of the deadliest.

— However, the radiation dose is a problem when it comes to organising some form of screening for high-risk groups. With our low-radiation photon-counting CT, we can reduce the radiation dose while achieving better image quality.

Danielsson also mentions diagnostics for other lung diseases, such as fibrosis. The delicate structures of the inner ear also require high spatial resolution, and better imaging can help when fitting cochlear implants, for example.

— We also expect to push the boundaries of skeletal imaging, such as bone density measurement.

In cardiology, stents are a standard solution for narrowed coronary arteries. CT can be used to visualise whether the stent has recalcified, as well as to check the function of new heart valves.

Danielsson returns to the plaque that builds up on the inner →

> *We are the dream team, and we can succeed.*
>
> Mats Danielsson

wall of blood vessels, which may detach and then cause a heart attack or stroke.

— To be able to identify this in time and treat it before it happens would be fantastic! There are always some people who ask why higher resolution is needed, but, in medical imaging, I have never heard a doctor who has used a higher resolution say that 'I want to go back to something worse.

He points out that better imaging will potentially be powerful, especially when combined with the developments in phase-contrast and dark-field imaging that Julia Herzen is working on. Adapting 1Micron for clinical use is a long process, but the hope is that the consortium finds typical cases and then proceeds step by step.

—We believe that phase-contrast imaging can have a practical use in healthcare, and at this resolution, we will achieve levels that are currently only available in pathology.

Danielsson emphasises the importance of using silicon, describing how Lucio Pancheri and Manuel Rolo have integrated semiconductor electronics, CMOS, into the chip that is the actual sensor.

— This monolithic silicon is crucial to what we are trying to achieve, such as achieving resolutions down to the micrometre.

Another important aspect is that these technical solutions must be compatible with current standards so that Prismatic Sensors AB can integrate the innovations into standardised CT devices, something that Anders Björklid returns to.

The group can make 20-micrometre pixels, but to get down to a single pixel, a few —physical tricks", as Danielsson puts it, are necessary, such as using a Gaussian distribution method to measure the interaction depth.

— We actually produced a chip and tested how to make something that may look ugly, but which works in the lab. It didn't have CMOS on it, but we were basically able to connect some of those channels — it looks like a spider web, but it worked to demonstrate the principle.

He also shows images from an article in Nature, in which a brain is imaged with phase contrast in a synchrotron, providing extremely rich details. Similar to Google Earth, it is possible to zoom in all the way to the level of the cell.

— But our pictures will never look as good. The radiation dose they used is astronomical, and the measurement is not clinically realistic — they basically carried the organs in bags to the synchrotron and then placed them in the beam. Still, I think this shows that, although it is a large object, a very high resolution can be achieved.

Danielsson regards the 1Micron consortium as a winning team.

— In EU projects, political reasons sometimes dictate how staff are selected, but even if I'd had the money in an account and could have chosen my partners myself, I would have arrived at exactly this list. We are the best experts in our fields – the crème de la crème – and are exactly what is needed to make this happen.

That said, even if everyone is an expert individually, team spirit is essential.

— I am old enough to remember the hockey match between the Soviet Union and the best NHL players, the Stars, who were beaten 11-1, or around that. Not that I want us to be the new Soviet Union, but individual Stars won't take us all the way," he says, and continues. — We all need to want to make this work. And who can do that? We need to look in the mirror, because we are the only ones who can.

Communication is key, and problems need to be addressed immediately.

— And I expect there to be many problems, many unexpected events. And that's where we are now — let's come out of this as winners, together!

Danielsson began by mentioning two revolutions, one of which relates to new imaging technology. The other is an application that could revolutionise breast cancer care. Currently, biopsies are performed to characterise what types of cells are in the tumour that has been removed by the surgeon. However, the margin to normal tissue is also important – ensuring that the tumour has been removed radically enough.

— Between 10 and 30 per cent of operations must be supplemented with more surgery. In the meantime, the cancer grows, and it has been shown that waiting reduces the chances of survival.

If the margin between healthy and diseased tissue is positive for cancer cells, then the tumour is likely to have also spread further — what you want to see is a clear gap.

The same applies if there are tumour cells in the first lymph node, the sentinel node. If that one is positive, the surgeon will need to remove more lymph nodes.

— It changes the treatment, but in Sweden, it can take up to three weeks to get an answer. This varies from country to country. We hope to offer a new imaging method that will eventually be accurate enough to avoid follow-up operations, or at least halve their number, which would save both money and human suffering.

Danielsson envisions the consortium's findings becoming the new standard for computed tomography, and says,

— We like challenges, from both technical and scholarly perspectives."

He concludes,

— I truly believe that we have the best team we could possibly bring together in Europe. No one is missing, as far as I can see. We are the dream team, and we can succeed. Of course it's difficult, but why wouldn't we try? ⬡

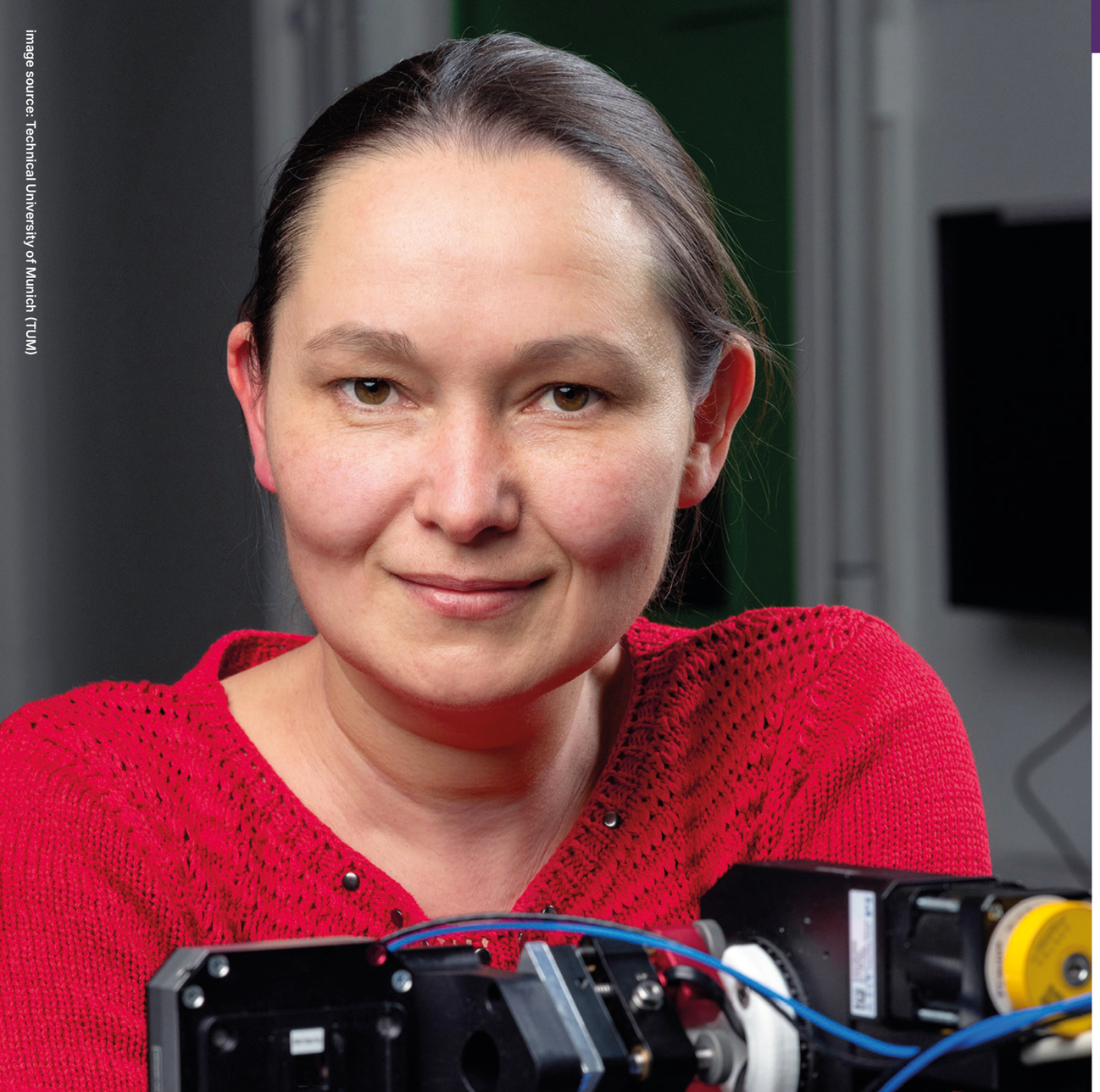


image source: Technical University of Munich (TUM)

Om medical imaging – now and in the future

Julia Herzen describes medical imaging, focusing on phase-contrast imaging and what her group has done so far – and points to what can be done in the future.

JULIA HERZEN BEGINS her presentation by describing how she has worked with medical phase-contrast imaging for over a decade, primarily in the field of breast cancer. Being able to utilise all the information contained in X-rays is crucial to achieving the goals of the 1Micron project, and this is where her expertise is essential.

But first, a short explanation for readers whose physics skills may be a little rusty concerning how X-rays compare with ordinary light, how synchrotrons work, and how they are linked to X-ray-based phase-contrast imaging in the laboratory.

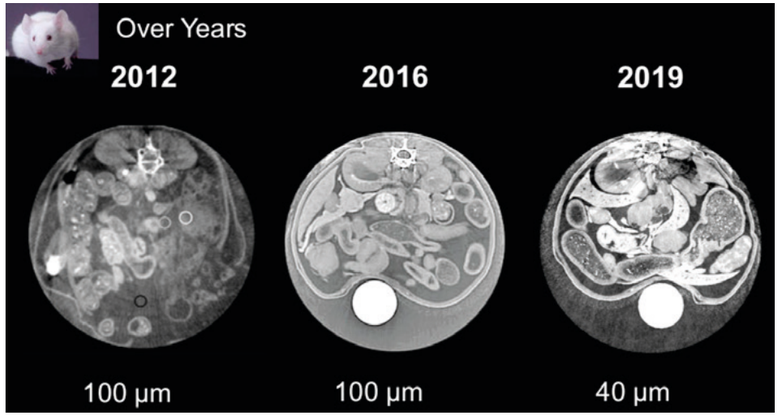
In 1895, German doctor *Wilhelm Conrad Röntgen* discovered the radiation now known as X-rays, which has the astonishing ability to penetrate matter and generate pictures of the inside of objects – a quality that was quickly embraced in both medicine and industry. X-rays behave like rays of ordinary light, but their constituent electrons produce wavelengths of 0.01 to 10 nanometres (compared to 390–700 nanometres for visible light). When the wave-shaped beam passes through an object, the beam's amplitude decreases. This is called attenuation, and this effect is what has been used for imaging, right up to the present day.

However, like visible light, X-rays can also bend when they hit an object. This is called refraction and becomes apparent if you examine a cell on a microscope slide under a standard light microscope – with attenuation alone, very little contrast is visible, but when you use the microscope's optical finesses, a clear contrast effect is achieved. Refraction can be utilised as a mechanism for obtaining contrast when using X-rays.

The problem has been that, in the X-ray range, the refraction angles are so small that they cannot be measured directly; instead, a kind of intensity pattern must be created and then measured. This could previously only be done in large-scale facilities, synchrotron light sources, which can be described as extremely bright X-ray microscopes. They are gigantic, with diameters from 300 metres to one kilometre, and there are only about fifty of them in the world. In one, a researcher can place a sample about 100 metres from the radiation source and measure the refraction at that point. The fact that the beam travels such a long distance causes interference; small deviations in direction — refraction – manifest themselves when the intensity increases at the edges, where it can be detected. →

→ Fantastic resolution can be achieved using imaging from synchrotrons, similar to the brain image that Danielsson presented.

However, high radiation doses and extremely limited availability mean that these instruments cannot be used clinically. During her time as a doctoral student, Herzen was at a synchrotron when she heard that a researcher had been able to transfer the technology to the laboratory. That researcher was *Franz Pfeiffer*, with whom Herzen's research group now works closely.



In a 2019 TED Talk, she describes how her idea arose in 2012 – for an instrument that could be built from standard equipment which could fit on a lab bench and provide images of medical samples in a similarly advanced way to that of a synchrotron. After numerous attempts, her group succeeded and produced images of similar quality to those obtained at a synchrotron.

Herzen's setup is currently two and a half metres long and consists of an X-ray source, the sample, which is often fixed in formalin, and a detector at the far end. There are three gratings between these components. These are round, flat silicon wafers with an etched pattern of holes. In the first and third grating, the holes are partially filled with gold, which blocks the X-ray beam. This setup creates an interference pattern that encodes the refraction information.

The first grating, called the source grating, is between the beam and the sample, and the next two are in a sequence between the sample and the detector. The source grating creates coherence and allows X-rays to pass through in a specific pattern. The second one is a reference grating that creates refraction, and the third one, the analysis grating, translates a fine periodic signal that is passed on to the detector. The trick is to adjust the X-rays and first measure without the sample in the beam, then with the sample. This allows even the smallest deviations to be recorded, and it is possible to produce a very high-resolution image by using a series of physical and mathematical methods.

The researchers use three types of information to create the images: one is normal attenuation, in which the rays are dampened by the material they pass through; the second is refraction, which is about the beam deviating and creating contrasts; thirdly, the presence of any small air bubbles in the sample is also measured. Clinically, lung tissue could look like this or, as in the image, milk foam on a cappuccino. This effect is called scattering and gives rise to dark-field imaging, which will be discussed in more detail later.

Herzen says that there are several methods for collecting these three types of signals, but she uses this optics-based method, with different types of gratings that are highly sensitive to small refraction angles.

— My setup measures two and a half metres from source to detector and is the most sensitive in the world, with better sensitivity than in a synchrotron. But we do have a few ideas about how to shrink it to 80 centimetres while retaining the same sensitivity.

X-ray dark-field signal

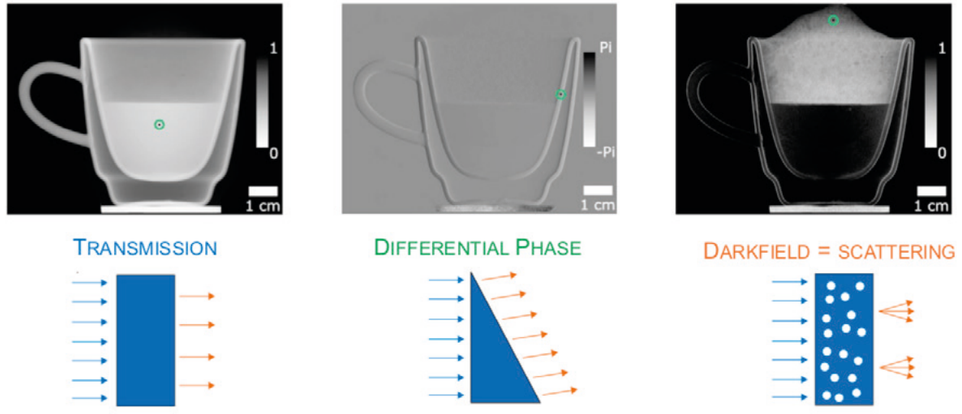


image source: PhD thesis Grating-based X-ray Dark-Field Imaging: Theory and Applications in Material Research av Dr. Friedrich Prade, Technical University of Munich (TUM)

The technology has been refined over the years; the fact that 40 micrometres is currently the highest resolution that can be achieved with this setup is due to limitations in both the radiation source and the photon-counting detector.

— Time is also a limiting factor. Imaging three length centimetres of a mouse fixation in a Falcon tube takes us twelve hours.

Her team is working on different ways to reduce the time without losing image quality.

— But I believe that even if we just halve the time to six hours — pathologists can correct me here — this could be of interest for biopsies or samples containing lymph nodes, so information can be obtained on the same day rather than a week or so later, says Herzen.

In the synchrotron, the two gold gratings can be removed.

— We don't need them because we have a highly coherent source, created by a very small spot size and a high-resolution detector. So we can use just one grid — here, a 2D silicon grid — for sensitivity in both directions, she says.

Its holes act as focusing lenses, with a distance of five to ten micrometres.

— Here too, the beam is measured with and without the sample, and, if refraction occurs, the spots are shifted slightly to the side, she says.

This type of analysis is called unified modulated pattern →

Phase contrast– Stained mouse kidney

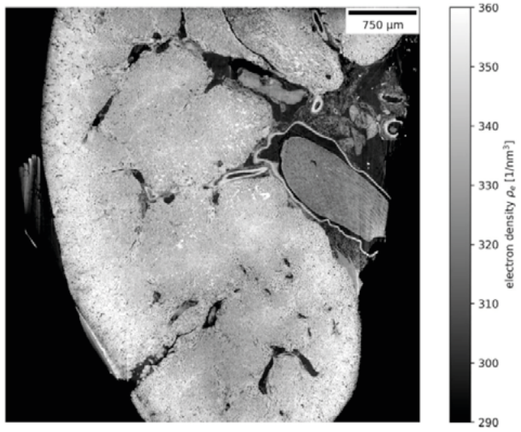


image source: Riedel M, et al, Scientific Reports (2023)

analysis, UMPA, which she is working on with Pierre Thibault in Trieste.

Another colleague, chemist Madleen Busse, modifies staining agents for pathology.

— This enters the cell nuclei, so you can see how they are highlighted. It is very similar to the way pathologists' microscope images appear in visible light, says Herzen, showing human heart tissue and an imaged mouse kidney.

A publication by doctoral student *Mirko Riedel* compares the group's method with conventional phase-contrast imaging. His conclusion was that at a resolution of approximately three micrometres, the group's method is somewhat more sensitive.

An audience member asks whether the image of the kidney is real or is a simulation by the reconstruction algorithm.

— This is an authentic image. The entire mouse kidney is scanned in 45 minutes, after which you can reconstruct it. Mouse cells are smaller than ours, but in human kidneys, you can see the cells because they are about 20 micrometres in size, answers Herzen, adding that a balance must always be made when using a synchrotron.

You get one day and one night to conduct measurements and have to decide how many samples to scan, so it's always a compromise.

The above were examples of phase contrast, whereas dark-field imaging is something else. In the image of the cappuccino cup, dark-field imaging was used to capture the foam.

The method can also be applied to other preparations, such as calcifications in breast tumours. There, the imaging provides clearer pictures of small calcifications than it does of large ones, because many small signals have greater scattering, which allows researchers to sort calcifications in different tumour samples based on size, using a scatter plot. This type of information may be important, as scholarly publications describe how size may be linked to severity, because small calcifications are more malignant than large ones.

Herzen's group has mainly worked with different types of imaging in breast cancer, primarily 2D mammography images and various forms of computed tomography.

One image shows collagen strands from a confirmed tumour in a dissected breast. She describes how they scanned breast tissue from a hospital south of Munich for the study.

— They called us the night before to say they would be operating on a suitable patient the following day. My student went there, took the sample, which was kept in formalin to prevent it from drying out, went to TUM and scanned it for a few hours, and then took the sample back to the university hospital on the same day — something we did 40 or 50 times, she says.

A clinical diagnosis was made by the pathologists as soon as the sample had been returned. Herzen points out that not only was the study time-consuming, but its design was also ethically problematic, because the procedure delays

Improved soft-tissue contrast in phase signal

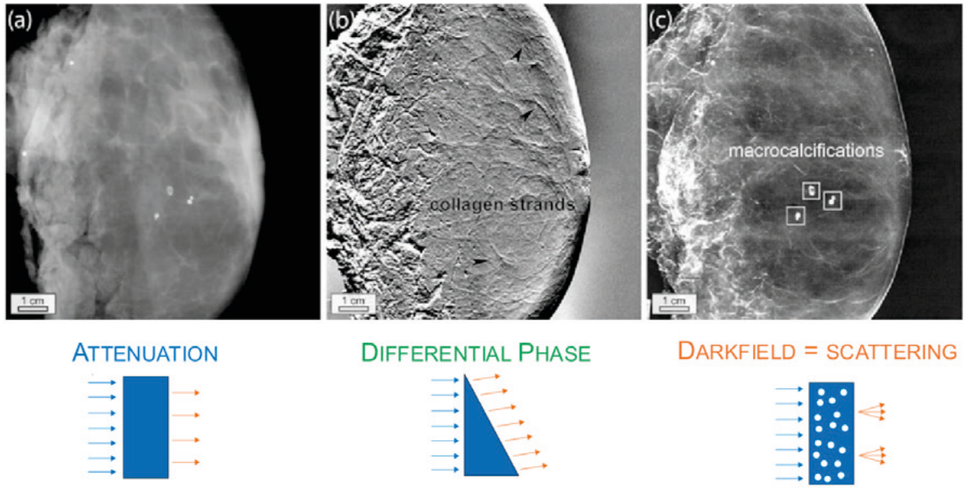


image source: Scherer K, et al, PLOS One, June 25, 2015

diagnosis. There was also a theoretical risk that the sample could get lost, meaning that the patient would never receive a diagnosis.

At this point in the presentation, there is a discussion about how long it actually takes for pathologists to prepare tissue for making a diagnosis, with the conclusion being that it usually takes two to three days. However, the scan would be relevant for the surgeon if it were quick and could be performed immediately prior to the operation. Another area of application was for pathologists, who, when dealing with large specimens, could get an indication regarding which areas of tissue should be prepared.

Herzen also raises the issue of radiation dose. This is not relevant for tissue samples, but it is an important factor for in vivo imaging. She demonstrated that a single mammography projection with a dose of 2.5 milligray, a clinically acceptable level, produced good images.

They also scanned formalin-fixed samples of non-malignant fibroadenomas.

— Refraction provides more contrast for soft tissue than attenuation does – wherever there is more fibrotic tissue, you get more contrast. This is why I also believe that we'll see tumour margins if we use a highly sensitive technique, as tumours have an edge that can appear brighter.

As a final example, she shows samples of ductal carcinoma.

— My vision is built upon my belief that we can take breast tissue imaging to the next level, using micro-CT for all three of these different signals – that would help us to really make a difference, concludes Herzen.

Silicon sensor design builds upon **integrated circuits**

Reading photons quickly and accurately is crucial for achieving the goals of the 1Micron project – and this is where Lucio Pancheri and Manuel Rolo have important roles to play.

IN HIS INTRODUCTORY PRESENTATION, Mats Danielsson highlighted the importance of silicon sensors, a development project that, although partly conducted at KTH Royal Institute of Technology, is primarily conducted by Lucio Pancheri and Manuel Rolo, who work at the University of Trento and at the Istituto Nazionale di Fisica Nucleare (INFN). They initiated the ARCADIA project, an acronym that stands for Advanced Readout CMOS Architectures with Depleted Integrated Sensor Arrays. As part of this collaboration, they developed monolithic CMOS silicon chips with ultra-fast readout. In the future, these could be used in particle detectors at CERN, the European Organisation for Nuclear Research, as well as in various space applications and in medical physics. But first – for anyone who doesn't have this fresh in their memory – a review of why some materials conduct electricity and how semiconductors and integrated circuits work.

A material's ability to conduct electricity depends on its atomic structure, with shells of negatively charged electrons surrounding the positively charged atomic nucleus. Silicon has four electrons on the outermost shell. Because there is actually enough room for eight electrons, silicon atoms can share electrons with four neighbours, which gives each atom eight electrons. This means that the material has no free electrons that can move around, which is why silicon conducts electricity poorly. Although silicon is not a natural conductor, it can be "doped" to make it behave like one. This is done during manufacturing, when another substance that either emits or accepts electrons is added to the silicon.

One such element could be phosphorus, which has five electrons in its outer shell. Together with the silicon atoms, the fifth electron has nothing to bond with, so it moves freely in the silicon crystal, making this N-type doped silicon an effective conductor. The N stands for negative, which is the charge.

If boron is added instead, this is P-type doping. Boron has three outer electrons, so if all the atoms around it

Lucio Pancheri

Manuel Rolo

are to have a full outer shell, one is missing. This creates "holes" in the silicon-boron crystal. The lack of electrons creates a positive charge, which is why it is called P-type doping. These holes can be regarded as electrically charged particles with the same amount of charge as an electron, but with the opposite sign. Under the influence of an electric field, the holes and electrons move in different directions.

A small amount of an added substance therefore changes how silicon behaves, as well as determining the semiconductor's electrical properties. A PN-junction forms when P-type and N-type doped materials are combined — current flows in one direction but not the other. The semiconductor then functions like a switch that can be opened or closed, giving the signal 1 or 0.

CMOS, which was mentioned above, stands for Complementary Metal Oxide Semiconductor and has been the dominant technology for creating microchips for decades.

CMOS technology consumes very little power – except at the moment when switching occurs. This property has enabled today's high-density integration in circuits. Silicon wafers are the foundation material for semiconductors, and, as mentioned above, components are built by implanting impurities, called dopants, into selected areas of the wafer's surface to create the components, known as transistors. They are then connected by thin wires made of conductive material, such as aluminium or copper, that are attached to the surface of the silicon wafer. Millions of electronic components can thus be placed on a wafer the size of a square centimetre. The very first integrated circuit was made in 1958 by *Jack Kilby* at Texas Instruments.

> *Manuel and I have had a hotline between Trento and Turin over the last few years.*
>
> **Lucio Pancheri**

Many integrated circuits have a general function, but some have very specific applications. These are called ASICs, or Application Specific Integrated Circuits, and can vary in size – from a circuit in a wristwatch to a control system in a vehicle.

To detect charged particles or photons, specially adapted ASICs are used; these can amplify and process the information from the extremely weak electrical signal that the particles or photons emit when they interact with →

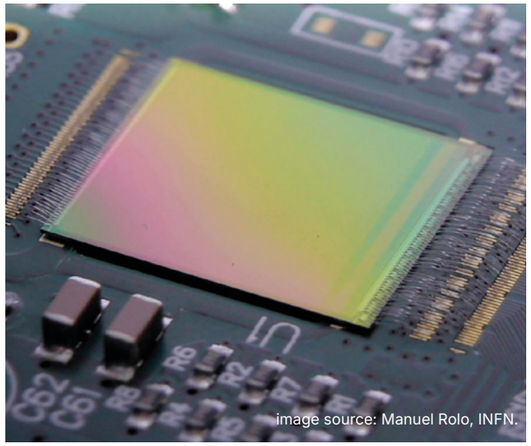


image source: Manuel Rolo, INFN.

the detection material, usually a semiconductor. In more advanced solutions, the sensing device and microelectronic chip are built on the same silicon wafer. This offers advantages in terms of robustness, cost-efficiency and image quality, thanks to good noise performance. This is the function that the 1Micron project must create in order to use phase-contrast imaging in a CT scanner.

In his presentation, Lucio Pancheri describes how the ARCADIA project started with a standardised manufacturing process, which was gradually modified to achieve the desired level of performance.

— Ultimately, our goal was to create a technology platform for building pixel detectors, ones for applications for detecting charged particles, as well as photons, for medical imaging, space applications, energy physics and X-ray detection in various fields.

He concludes by promoting the city of Trento, situated close to both the Dolomites and Lake Garda.

— Manuel and I have had a hotline between Trento and Turin over the last few years.

Manuel Rolo, the ARCADIA project's PI, shows a picture of an ARCADIA-MD3 chip, which has an active area of just under 1.3 × 1.3 centimetres and pixels of 25 × 25 micrometres.

— Its pixels use binary reading – so when a pixel sees the photon, it raises its hand to tell the end of the column what it and its neighbours have seen."

The group at INFN has demonstrated the chip's performance using a test beam with high-energy protons. They have also developed test beds for X-ray radiography, where they have imaged a leaf, for example, as well as a small demonstrator for computed tomography.

— To sum up, we already have several strong starting points for our work, and we are already making progress, concludes Rolo. ⬡

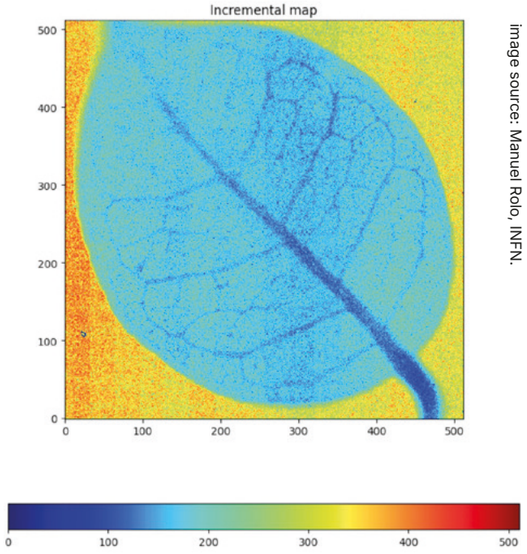


Image source: Manuel Rolo, INFN.

From innovation to a working CT scanner

Anders Björklid emphasises that for this new technology to truly deliver full-scale clinical benefits, the solutions must fulfil the requirements set by the CT scanner.

ANDERS BJÖRKLID ffocuses his presentation on existing limitations on the new technology's capacity to benefit healthcare through a CT solution.

— In principle, I have tried to view the whole thing from the perspective of computer tomography, as the device's standard design entails a number of restrictions.

A computerised tomography scanner comprises a small X-ray source and a detector that is twice the size of the object to be imaged so, if 50 centimetres of a person is to be scanned, the detector must be 100 centimetres wide. It rotates around the patient at speeds of up to five revolutions per second. A certain number of exposures per rotation are required to reduce the level of blurring, and the general rule is one thousand exposures per millimetre of resolution. The detector module is organised in layers, like a sandwich, and all the sensors must point at the radiation source.

One of Björklid's tasks is to review the requirements table that the researchers submitted in their application, comparing specific CT-based requirements with those that must be met for the 1Micron project's goals to be achieved. For example, energy ranges of up to 140 keV are normal in CT scanners.

The group also discusses the difference between getting the system to work as a tabletop prototype and as a clinically applicable CT scanner. Björklid rounds off by saying that his basic point is that any problems must be divided into several parts.

— And a CT machine has specific requirements that we must take into account."

Looking ahead – medical evaluation

Once the researchers have succeeded in creating the technical solutions that the 1Micron project is striving for, it will be time for vital and comprehensive medical validation.

JOHAN HARTMAN is a professor of pathology at Karolinska Institutet and conducts research in the field of breast cancer. As a PI for the 1Micron project, he is responsible for medical validation and works with Munich-based pathologists *Caroline Mogler* and *Franz-Leonard Klaus*.

In the autumn of 2025, their first step will be to develop a baseline, which is a summary of how good current images are. Researchers can then use this standard to compare with the project's solutions. The project application estimates that around 40 clinical samples will primarily be used as evaluation material.

However, this part of the project will necessarily depend on the other parts being put in place. Medical validation is scheduled for four years into the project, in 2028, so a more detailed description will be provided in the next instalment of the documentation.

The researchers' expectations for the **1Micron project**

"I expect that 1Micron will pave the way for the future of high-resolution X-ray imaging at high rates and with high energy resolution."

Mats Danielsson

"Through the 1Micron project, we will lay the foundation for a new generation of computerised tomography scanners that will enable even better diagnostics in the future."

Anders Björklid

"The 1MICRON Consortium is unparalleled in terms of the multidisciplinary competences necessary to bring such a disruptive technology into the medical field. However, what strikes me the most is the unique motivation that drives all the people involved in the project; everybody has the same crystal-clear objective: to build this groundbreaking detector with unprecedented performance and revolutionise medical imaging. So my expectations are definitely very, very high."

Manuel Rolo

"I hope that the project will improve opportunities for quickly finding residual cancer after surgery. One goal is to reduce the number of reoperations."

Johan Hartman

"I expect that the outcome of the 1Micron project will fundamentally change the way we do imaging at high resolutions. At the moment, the only way to generate images with a resolution of a few micrometres, both in the lab and at the synchrotrons, is to use very inefficient detectors which convert X-rays into visible light, and then photograph this visible light using a standard camera with very small pixels. We are wasting more than 90 per cent of the X-ray flux, which results in very long scans. The 1Micron detector will push photon-counting technology into the micro-CT field with all its amazing abilities."

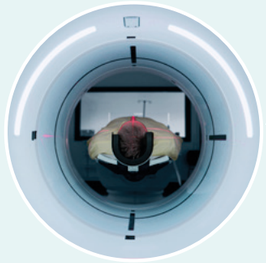
Julia Herzen

"My expectations and hopes for the 1Micron project are that it will leverage a decade of technological development and realise an instrument that is capable of significantly improving life expectancy for many people."

Lucio Pancheri

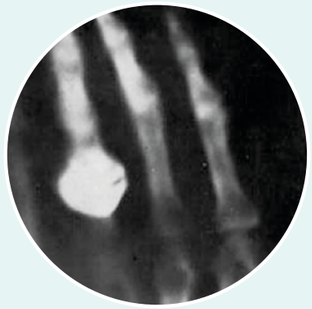
The 1Micron project through the years

This is a chronological overview, based on the Nobel Prizes that have been awarded important discoveries that various parts of the project are building upon.



1901

In 1895, German physicist *Wilhelm Conrad Röntgen* discovered X-rays. In 1901, he received the Nobel Prize in Physics for his discovery



The first X-ray image was taken in November 1895. The image depicts the hand of *Bertha Röntgen*, the scientist's wife.

1956

Researchers at the American Bell Labs were tasked with developing an alternative to electron tubes based on semiconductor technology. *John Bardeen, Walter Brattain* and *William Shockley* succeeded in demonstrating the transistor effect in 1947 and were rewarded with the Nobel Prize in Physics in 1956.

1962

British scientists *James Watson, Francis Crick* and *Maurice Watkins* are awarded the Nobel Prize in Physiology or Medicine for their discovery of DNA's double helix structure, which provided the key to studying biological mechanisms in conditions such as breast cancer.

1979

Allan Cormack and *Godfrey Newbold Hounsfield* receive the Nobel Prize in Physiology or Medicine for developing computed tomography.

2000

The Nobel Prize in Physics was awarded for "basic work on information and communication technology". Half of the prize went to *Zhores Alferov* and *Herbert Kroemer* for the development of semiconductor heterostructures used in high-speed and optoelectronics, and half to *Jack Kilby* for the invention of the integrated circuit.

2017

Stockholm County Council gave its approval to MedTechLabs, initiated by *Mats Danielsson*. Karolinska Institutet, KTH Royal Institute of Technology and Region Stockholm provide support, and it is an arena where physicians and engineers collaborate.

2024

In July, it was announced that the 1Micron project would receive three million euros in funding.

2025

On 22 May, the 1Micron consortium held its kick-off meeting in Stockholm, with presentations and break-out sessions.

Going forward... The project will run until February 2029 with a number of different review dates.

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