

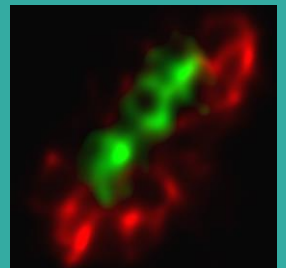
# Annual Report 2023

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NOVEMBER 2023

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**3DNanoscopy**





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# Introduction

Hello world!

This is the first time that 3DNanoscopy team/group is making its annual report. I, as the group leader, am immensely happy and proud to present it on behalf of the group members.

I helm the ship and that is all I do (well, more or less). The rest of it works automatically thanks to a spirited team of young scientists and engineers who are fascinating individuals of great potential and driven to achieve their best while contributing their piece of cobble on the road of science.

Here, you will see what these bubbles of joy and sparks of brilliance were up to in 2023. This report will probably help you probe what is playing on their mind and how they look to the future.

Together, we look forward to 2024 and welcome you to read this report.

Cheers!

Krishna Agarwal

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**Professor,**  
**Department of Physics and Technology,**  
**UiT The Arctic University of Norway**  
**([krishna.agarwal@uit.no](mailto:krishna.agarwal@uit.no))**

# Highlights of 2023

Krishna Agarwal

Here, in simple language I recount the highlights of the overall events and activities in the group. With such a diverse group working on several projects with many collaborators, I am sure that my best attempt will still be inexhaustive. I apologize in advance for the things I may miss because of my human limitation of working on this section at 2.27 am on a Wednesday! I am still a work under construction, and the text here be treated as such. Also, for now I leave objectivity to academic articles and funding proposals, and indulge a bit in emotional reflections here and there.

***“I am still a work under construction”***

## **A year of transitions.**

Sebastian, my first PhD student as the main supervisor, is graduating soon (snapshot of the cover page of his thesis below). He found a position that he likes and feels valued in the industry. Ida, formerly my first formally co-supervised student and subsequently a stellar postdoc, is now transitioning to SINTEF also in a position that she finds herself suited to. In addition, her family expanded with a little bundle of Joy. Daniel, formerly my master student and later an engineer in my group, transitioned to a spin-off. Ankit and Joy are applying for funding; hopefully soon they will be successful and become PIs in their own right. I wonder that it feels like the group just started (in 2019) and is it already mature enough to see successful transitions of its team members. 2021 was similar, two postdocs transitioned out then, and one is already a full professor in China

 **UIT** The Arctic University of Norway

Faculty of Science and Technology  
Department of Physics and Technology

**Multiple Signal Classification Algorithm:  
A computational microscopy tool for fluorescence  
microscopy**

Sebastian Andres Acuña Maldonado  
A dissertation for the degree of Philosophiae Doctor  
December 2023



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and another an associate professor in India. My heart fills with pride and swells with emotion. I hope the group feels forever young and remains forever ready to be the launch pad of great talents at their right time.

### **A year of influx.**

Yingying had an overseas engagement at Singapore. I was so happy to see her enjoying spicy noodles in Singapore and finding peers to talk about inverse problems. The PhD students, Farhad, Abhinanda, Rohit, Iqra, all seem to have found their footing. We had new engineers fueling some of our pilot projects, Shivam and Kamil. More PhD students have been identified for joining us in 2024. More collaborators from diverse disciplines are on board.

ERC

## **Millions for two Norwegian research projects**

Two research projects in Norway have secured funding from the European Research Council.

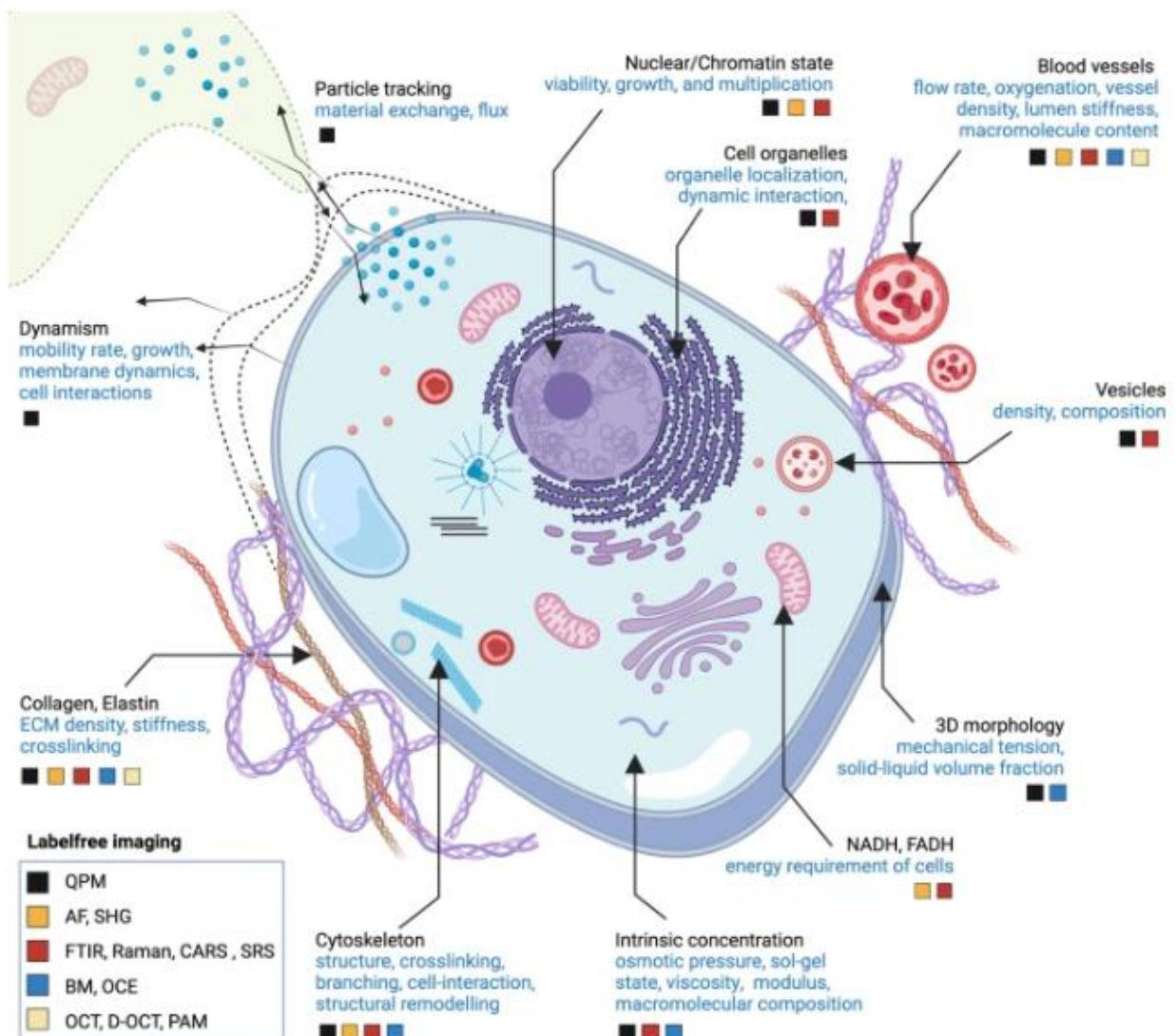


Senior researcher Ankit Butola, one of the researchers working with Krishna Agarwal, in the laboratory at UIT. Photo: Kjetil Rydland

## A year of innovation.

If I were to identify one scientific highlight of this year, it won't be publications, open science or funding. It will be innovations. We have embarked on this train, and how! 1 patent granted, 3 patents filed, 1 invention disclosure submitted, 6 grants for pursuing commercialization of our innovations and very active talks with industry including potential licensees. This has been a happening year for innovation in our group. So much so that Lars and Ingrid, members of our technology transfer agency Norinova AS, feel like our extended team members. They even contribute to this report. Ooh, and Ankit was the poster boy for the ERC PoC project in many news articles (see snapshot from the local [Krono](#) on the previous page).

**Fig. 1: Structure is function: an overview of bio-application potential of labelfree optical microscopes.**





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### **Firm foothold in multidisciplinary research.**

Our publications are now more interdisciplinary (checkout our perspective article on label-free microscopy [here](#), its Figure 1 replicated on the previous page). It is easy to think that we include multidisciplinary in our funding applications to make them look more appealing. But, our evolution shows that we mean it. We have multiple disciplines represented in our team and we have learnt to communicate despite the barriers of jargon. This new form of communication is fuelled by our will to work with other disciplines and extend our comfort of zones beyond our initial training. We do not now collaborate across disciplines because we need to, we now do so because we want to, because it is exciting, and because we can. We have successfully transitioned from ‘we hope’ to ‘we can’, and it took Dominique Lesselier (emeritus director, L2S, CNRS, France) to visit us and tell us this.

### **Sincerity in operations and communications.**

It is easy to take some important things for granted – friendship, work environment, trust, safety, security, diversity, health, and more. Especially when you are busy, fast-paced, goal-driven, and super-focused on the work at hand. Especially, when almost the entire team is composed of such individuals. Especially when these important things need a continuous and sustained effort, sometimes actions that cannot be put on a task list or post-it notes. This is a big risk for our group.

Thankfully, we have not done too bad so far. Each and every member of the team has contributed to this, and I applaud the team to do so sincerely and not begrudgingly, even if not with a beaming enthusiasm. But, Deanna and Jean-Claude deserve special mention. They often are our soul-keepers (and this is often opaque to other team members) and they help me see if something, however minor, needs attention. If a group member needs to be told that they are doing great or if the risk of exposure to bacteria needs to be conveyed more explicitly. I also highly value to the trust that team members have put in each other and in my leadership. I hope that I have been an active listener and an accessible leader, with whom my team members could bring a topic which seems trivial but is nagging you or affecting you adversely. I hope that I have been able to address their challenges, if not resolve them. But, I am happy that they are generous with feedback, both positive and negative, and they help me do my job better than I could do alone.

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**Team:** please continue to do so, please continue to communicate with each other and with me as openly as you can. I cannot promise much, but I promise I will try my best to listen and act.

**A sincere thanks to our work environment and ecosystem.**

Systems are never perfect. No group, no department, no university, no administration is perfect. I consider this as an axiom. But, there are systems that are supportive, and there are systems that are challenging. This also depends on the state, composition, and nature of the one seeking support. For our group, we have received a high quality of support from UMO (our parent group in the department), our department, and our faculty. Things have been a roller coaster, and we have faced many challenges of administrative and systemic nature. But, we have never faced them alone.

[Geir](#), [Tore](#), Deanna, [Olav](#), [Arne](#) (and not named but not forgotten fleet) – they have stepped in and held our hands when needed or guided us when necessary. Please continue to do so. We are a dynamic group in our growth phase. Our needs are unique and evolving all the time. We can sometimes be too painful to deal with, and just plain demanding at other times. But, we do remember you as our enablers in the moments of success and celebration.

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# Growth, challenges and achievements: A Reflective Journey Through 2023

Ankit Butola

2023 brought a mix of emotions, making some progress in my professional journey, achieving milestones, and facing various challenges. It was a year to develop new skills set i.e., successfully formulating and writing research proposals, out of the box ideas and steppingstone towards becoming an independent researcher.

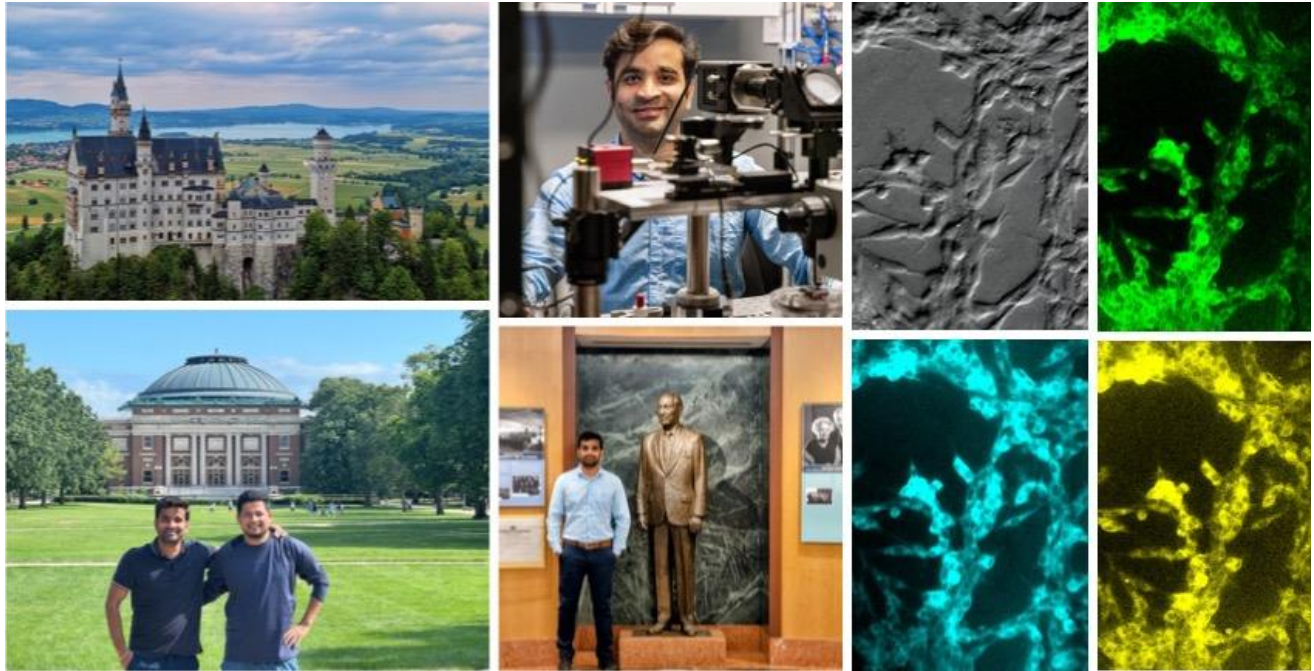
A highlight of the year was my also first research visit to the USA, fulfilling a dream of working with Prof. Gabriel Popescu's legacy at UIUC, now overseen by Prof. Stephen Boppart. This year, I get a chance to work in Beckman Institute, UIUC. My exchange research experience at the University of Illinois, Urbana Champaign, USA, provided a unique experience and expanded my collaborative network across QPI, IR imaging, computational imaging, and non-linear imaging. Also, my first visit to MIT and University of Connecticut provide experience to different optics labs.

***“Naturally, the journey was not without its share of challenges and hurdles in achieving some important milestones.”***

In this year, supervising both Master's and PhD students allowed me to share knowledge and mentor emerging researchers. Both of my master students worked in quantitative phase imaging and machine learning for biological application. Their projects helped me to progress towards my goal of becoming an independent researcher. Additionally, stepping into the role of a Work Package (WP) leader in an ERC-PoC grant helped me to improve my professional abilities and deliver the output timely.

Naturally, the journey was not without its share of challenges and hurdles in achieving some important milestones. The Challenges are refining the art of writing successful

research proposals and navigating collaborations with researchers possessing complementary skills. Looking forward to the next year, my goals include writing a successful research grant, publishing over 20 impact factor papers, and moving towards becoming an independent researcher.



*Figure: My trip to Neuschwanstein castle and a visit to the Beckman Institute at the University of Illinois Urbana Champaign, where we developed multi-channel label-free imaging method for morpho-chemical imaging of cells.*

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## Achievements

### Journal Articles:

- Qin, Yingying, **Ankit Butola**, and Krishna Agarwal. "3D refractive index reconstruction from phaseless coherent optical microscopy data using multiple scattering-based inverse solvers-a study." *Inverse Problems* (2023)
- Qin, Yingying, **Ankit Butola**, and Krishna Agarwal. "3D full-wave multi-scattering forward solver for coherent microscopes." *Optics Express* 31, no. 9 (2023): 15015-15034.
- Mann, Priyanka, Vishesh Dubey, Azeem Ahmad, **Ankit Butola**, and Dalip Singh Mehta. "Synthetic wavelength scanning interferometry for 3D surface profilometry with extended range of height measurement using multi-colour LED light sources." *Journal of Modern Optics* 70, no. 2 (2023): 114-123
- Bhatt, Sunil, **Ankit Butola**, Anand Kumar, Pramila Thapa, Akshay Joshi, Suyog Jadhav, Neetu Singh, Dilip K. Prasad, Krishna Agarwal, and Dalip Singh Mehta. "Single-shot multispectral quantitative phase imaging of biological samples using deep learning." *Applied Optics* 62, no. 15 (2023): 3989-3999.

### Conferences / meetings:

- **Ankit Butola**, Sebastian Acuna, Daniel Henry Hansen, and Krishna Agarwal. "Multiscale resolution in structured illumination microscopy." In *Advances in Microscopic Imaging IV*, vol. 12630, pp. 32-34. SPIE, 2023
- Bhatt, Sunil, **Ankit Butola**, Pramila Thapa, and Dalip Singh Mehta. "White light phase-shifting interferometry using deep learning-based phase-shifter." In *Advances in Microscopic Imaging IV*, vol. 12630, pp. 45-49. SPIE, 2023.
- Mehta, Dalip Singh, Shilpa Tayal, Azeem Ahmad, Sunil Bhatt, Vishesh Kumar Dubey, **Ankit Butola**, and Balpreet Singh Ahluwalia. "Effect of partial spatial coherence of light on quantitative phase microscopy of biological samples: improved spatial phase sensitivity, space-bandwidth product, and high accuracy in phase measurement." In *Quantitative Phase Imaging IX*, vol. 12389, pp. 108-114. SPIE, 2023.
- Ahluwalia, Balpreet Singh, Azeem Ahmad, Vishesh Kumar Dubey, and **Ankit Butola**. "Quantitative phase microscopy for life science and diagnosis (Conference Presentation)." In *Quantitative Phase Imaging IX*, p. PC123890G. SPIE, 2023.
- Mehta, Dalip Singh, Sunil Bhatt, Harpreet Kaur, Pitambar Mukherjee, Dibakar Borah, Azeem Ahmad, Anand Kumar, and **Ankit Butola**. "Longitudinal spatial coherence gated line-field optical coherence tomography of multilayer structures with speckle-free and reduced crosstalk." In *Label-free Biomedical Imaging and Sensing (LBIS) 2023*, vol. 12391, pp. 150-156. SPIE, 2023.
- Bhatt, Sunil, **Ankit Butola**, Sebastian Acuña, Daniel Henry Hansen, Jean-Claude Tinguely, Dalip Singh Mehta, Balpreet Singh Ahluwalia, and Krishna Agarwal. "Quantitative phase imaging for tracing the motion of waveguide trapped bead particle." In *Imaging, Manipulation, and Analysis of Biomolecules, Cells, and Tissues XXI*, vol. 12383, pp. 19-26. SPIE, 2023.

### ArXiv:

- Arora, Gauri, **Ankit Butola**, Ruchi Rajput, Rohit Agarwal, Krishna Agarwal, Alexander Horsch, Dilip K. Prasad, and Paramasivam Senthilkumaran. "Taxonomy of hybridly polarized Stokes vortex beams." *arXiv preprint arXiv:2306.05974* (2023).

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**Book:**

Mehta, Dalip Singh, **Ankit Butola**, and Veena Singh. *Quantitative Phase Microscopy and Tomography: Techniques using partially spatially coherent monochromatic light*. IOP Publishing, 2022

**Invention disclosures/patents:**

- **Ankit Butola**, Dilip K Prasad, Krishna Agarwal, “Spermotile: Sperm cell grading, selection, and analysis system”. Patent pending (2306238.8) to be published Oct 2024.

**Visibility drives**

- <https://climb.beckman.illinois.edu/article/2023/07/12/dr.-ankit-butola-uit-the-arctic-university-of-norway-senior-researcher-visits-climb-at-uiuc-for-imaging-studies>
- <https://khrono.no/millioner-til-to-norske-forskningsprosjekter/779431>
- <https://www.framtidinord.no/nyheter/i/GMqxXV/faar-1-5-millioner-for-aa-forske-paa-saedceller-eu-tar-regningen>
- [https://uit.no/nyheter/artikkel?p\\_document\\_id=811290](https://uit.no/nyheter/artikkel?p_document_id=811290)

**Engagement of research communities:**

- Member: Digital life Norway, SPIE
- CLIMB center, UIUC, USA

**Funding applications applied/granted**

- ERC-PoC Spermotile (Grant ID: 101123485)/ WP leader/ ERC /Ongoing
- PES/PI/UiT Tromsø/granted and finished
- Terje og Valerie Stalder Jacobsens forskningsfond/ PI/UiT Tromsø/granted and finished

**Other contributions to your work environment at UiT**

- Supervision: 2 Master students
- Contribution to administrative work:
- Teaching: Quantitative phase imaging and its application to two of my master students
- Interview committee member: Conducted 8 PhD interview

**Other commissions of trust outside UiT**

- Reviewer: Optica, Nature, IOP, SPIE

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# Time-capsule 2023: my research activities within an eyelet

Biswajoy Ghosh

The year has been an adventure consisting of several ups and downs and looking back it feels good. Since there were several aspects. This year has given me quite a lot of goodies. In no particular order, they include entry into innovation, successful funding applications, international research collaborations, and research outcomes are the notable ones. My research lies in biology, advanced imaging, image analysis, and material science. I make 3D biological models in the lab to understand pathological developments and derive mechanistic insights.

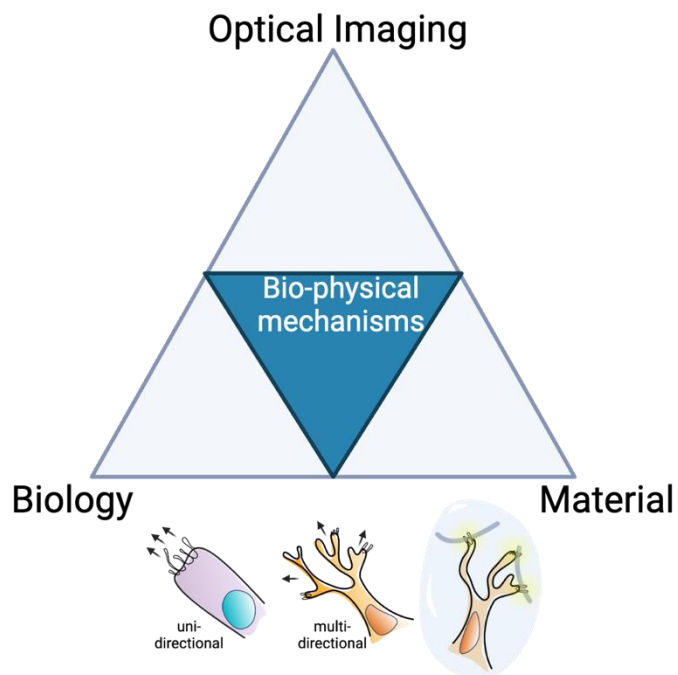
This year I have been successful in establishing a new 3D hydrogel-based organotypic of the kidney mesangium that I developed myself in collaboration with the kidney group at UiT. With this, we can assess kidney function in the lab under various stressful conditions like diabetes, cancer, etc. The manuscript is now close to submission and is an important milestone for me for my future funding applications. The future of this activity is manifold and more dedicated members will be eventually needed. From the model side, I initially developed this kidney matrix with GelMA hydrogel that elastically matches the nephropathy microenvironment and then expanded it by adding carbohydrates like chitosan nanofibers to get a more tissue-mimicking hydrogel composition.

***“This year has given me quite a lot of goodies. In no particular order, they include entry into innovation, successful funding applications, international research collaborations, and research outcomes are the notable ones.”***

New cells and other in vitro models can be further augmented to get a more complete understanding of kidney function and pathology. From the imaging side the model provides new challenges for several label and label-free microscopes and new insights

can be obtained from them. One initiative is already ongoing with Ankit who has traveled to UIUC, USA where this kidney model is studied under several label-free microscopes for correlative morphological and chemical imaging. We will be submitting the first paper on it soon.

I am also working on the maturation of engineered heart tissue in collaboration with UNN (Åsa), UKE, Hamborg (Florian), and USoton, UK (Dipanjan, Sumeet) which made from induced pluripotent stem cells grown on a fibrin matrix. We have identified the biological question in the engineered tissues and working collaboratively to identify using label-free imaging modalities how the cardiac cells modify themselves while maturing. Something that is beyond the purview of the labeled methods. We have started with the manuscript and I am taking this as a new challenge to finish drafting sooner.



*Figure 1: My work lies at the junction of optical imaging, biology, and material science, where I try to understand the physics of biological events that happen when cells interact with their ambient matrix.*

As an activity in the Erasmus mobility grant, I traveled to EMBL with Sebastian and it was a lovely opportunity for me to work together jointly with the collaborators from microscopy and vesicle biology from EMBL. This experience was key for me to note that I am more efficient when I am doing one task. Seb and I had several sessions of brainstorming and working together, and we generated a large dataset and analyzed them. However, after returning, that activity took a back seat when I got involved in other projects. The key takeaway for me here was to simply finish the task while I was there.

I have an innovation project called Cymoplive which is an assay platform for analyzing cell motility and plasticity. This has been a very important milestone for me as I was very averse to innovation. I had this discussion with Krishna several times and I was very confident that I won't go to the dark side. One year later today, I am already knee-



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deep into it. Besides the obvious IP filing and invention disclosure submissions, I learned the differences in how we approach research and innovation are very different. Since then, I have approached various market players and worked closely with our tech transfer office. Now the technology has received interest from several top biotech companies and some of the leaders are already on board to help this move forward. This is a very humbling and gratifying experience for me, something that I would have not known if I had not kept my eyes open. I have also applied for innovation funding in the research council and supplementary funds for scalability. The technology now requires rapid prototyping methods like 3D bioprinting and maskless lithography. Although I personally do not have practical expertise in bioprinting, for my work, I have created a network with the bioprinting industry and academia.

In addition, I have experience writing in academic, popular, and grant application settings. All these have really added to my insights and propelled me to learn at an accelerated pace.

I have a long way to go and several aspects in my work and personal life I would like to work on, but I have thought about them and actively working in them, one step at a time.

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## Achievements

### Journal Articles:

- Ghosh, B., Agarwal, K. Viewing life without labels under optical microscopes. *Commun Biol* **6**, 559 (2023).

### Conferences / meetings:

- Ghosh, B., Agarwal, K. GelMA hydrogel mechanics affect the collective migration of fibroblast cells, TERMIS European Chapter Meeting, Manchester, UK, March 2023.
- Ghosh, B., Fenton, K., Agarwal, K. Gradient Light Interference Microscopy for labelfree detection of early changes in kidney cells embedded in a soft and stiff hydrogel matrix, FOM 2023, Porto, Portugal, April 2023.
- Ghosh, B., Acuña, S., Agarwal, K. MUSI-tAF: autofluorescence-based super-resolution of collagen fibrils in fixed tissues for density estimation, FOM 2023, Porto, Portugal, April 2023.
- Corrio C, Le Gac J, Werning L, Ghosh B, and Agarwal, K, GelMA-Chitosan-Polyethylene Oxide Composite Enhances Proliferation of Fibroblast Cells In-Vitro, E-Materials Research Society Conference, September 2023

### Data and code release:

- Dataset: 2 sets of Correlative GLIM and Confocal images of fixed EHT sections (ca 200 GB) generated and shared with the OrganVision Team through UiT's data repository (internal).

### Books and Book Chapters:

- Ghosh, B. and Chatterjee, J., 2023. Advances in Medical Imaging for Wound Repair and Regenerative Medicine. In *Regenerative Medicine: Emerging Techniques to Translation Approaches* (pp. 57-76). Singapore: Springer Nature Singapore.

### Invention disclosures/patents:

- Ghosh, B., Agarwal, K., *Cymoplive* Patent filed. Patent application no.: 2309453.5, 22.06.23
- Agarwal, Komal, Agarwal, Krishna, Ghosh, B., *FIRsT*, Patent filed. Patent application no.: 2309111.9, 16.06.2023

### Popular science contributions

- A popular article "OrganVision: Little organs MAGNIFIED!" was posted on the OrganVision [website](#).
- A popular article "Are Labels Okay? - a message to biologists from DLN researchers" Published by Digital Life Norway, posted on the [DLN website](#), [LinkedIn](#), [Twitter](#), and [Facebook](#).

### Industry outreach and visibility in industry:

- Ibidi Co-founder on board as advisor to Cymoplive. Reached out to Ibidi-GmbH during the FOM-2023 meeting in Portugal and received feedback on Cymoplive and we are in communication to assess further interest.
- Reached out to different 3D cell culture, organoid, and spheroid manufacturing companies in TERMIS-2023 EU meeting in Manchester, UK like Gelomics, React4life, Readily3D, Advanced Biomatrix, CollPlant, and Cellink to understand the opportunities and challenges they face in imaging 3D *in vitro* systems.

### Visibility drives

- Presented "Optical Microscopy of 3-D *In Vitro* Biological Models for Biomedical Research", at NTU Optical Bio-Imaging Centre's (NOBIC)  $\mu$ -Talks, Singapore, June 2022, posted as a [Youtube Video](#).

### Engagement of research communities

- Participated in DLN's activities on (a) scientific/technical writing workshop, (b) popular science writing workshop, and (c) scientific illustrations workshop.
- 1-month Research visit at EMBL Heidelberg, Germany with Advanced Light Microscopy Facility in February 2023 and worked on vesicle counting method with computational super-resolution methods.
- Mentored 1 PhD candidate at Indian Institute of Technology Kharagpur, India resulting in a [publication](#).
- 1-week Research visit to the University of Southampton, UK in March 2023 and delivered a talk on "Optical Analysis of Scarring: From cells to tissues to 3D *in vitro* models".
- Research collaboration with the University of Illinois Urbana-Champaign's CLIMB Center, USA for label-free imaging of cells in 3D hydrogels.

#### **Funding applications applied/granted**

- Received *Erasmus plus mobility grant* of 10362 NOK for research travel on 24.10.2022.
- Ghosh, B., Punnakkal, A., funded 25 kNOK for a pilot project "Testing AI-based 3D synthetic reconstructions of cell organelles of 2D real microscopy images" as a part of DLN's cross-project funding.
- Received Research Council of Norway Qualification Grant for Cymoplive. Funding of 500 kNOK. Team: UiT- Ghosh, B., Agarwal, K., and Norrinova (TTO)- Skjæveland, I., Smithies, B.
- Received Research Council of Norway Qualification Grant for FiRsT. Funding of 500 kNOK. Team: UiT- Agarwal, Komal, Agarwal, Krishna., Ghosh, Biswajoy, and Norrinova (TTO)- Skjæveland, I., Smithies, B.
- Received funding by Digital Life Norway (DLN) Research School to attend the Bioinnovation Institute (BII) Summer school in Denmark in August 2023 for a 5-day workshop on Bio-innovation.
- Applied Funding: RCN Verification Grant 5M NOK for Innovation project Cymoplive as PI.
- Applied Funding: UiT Supplementary Funding of 100 kNOK for scaling up Cymoplive as PI.

#### **Other contributions to your work environment at UiT**

- Supervised 2 Bachelor's students from Université de RENNES, France May-July 2023, and submitted an abstract.

#### **Other commissions of trust outside UiT**

- Reviewer of journals: Gels, Molecules, Crystals, International journal of molecular sciences, Life, metabolites, Applied sciences.

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# Productive Year of Open Science and Scientific Writing, with a New Job landed

Ida Sundvor Opstad

This year has been a productive one for me. I have accomplished a lot in terms of publishing and writing manuscripts. Specifically, I have published four open datasets and co-authored four published articles/book chapters. Additionally, I have written three first-author manuscripts, one of which has been published on BioRxiv, and two others are close to being published. I have also had the opportunity to visit the European Molecular Biology Laboratory to work on aspects of sharing and visualizing large biological image data.

***“This year has been a productive one for me. I have accomplished a lot in terms of publishing and writing manuscripts”***

Furthermore, I was active in the Data Steward Network and helped organize the next meetings. I have also peer reviewed two articles for Nature journals and discussed with companies that have shown interest in the commercial use of technology developed in our group. In addition to my research accomplishments, I have also applied for jobs and successfully landed one at SINTEF Helgeland. On a more mundane note, I have also emptied the common kitchen dishwasher at least 10 times.

Made with help of chatuit

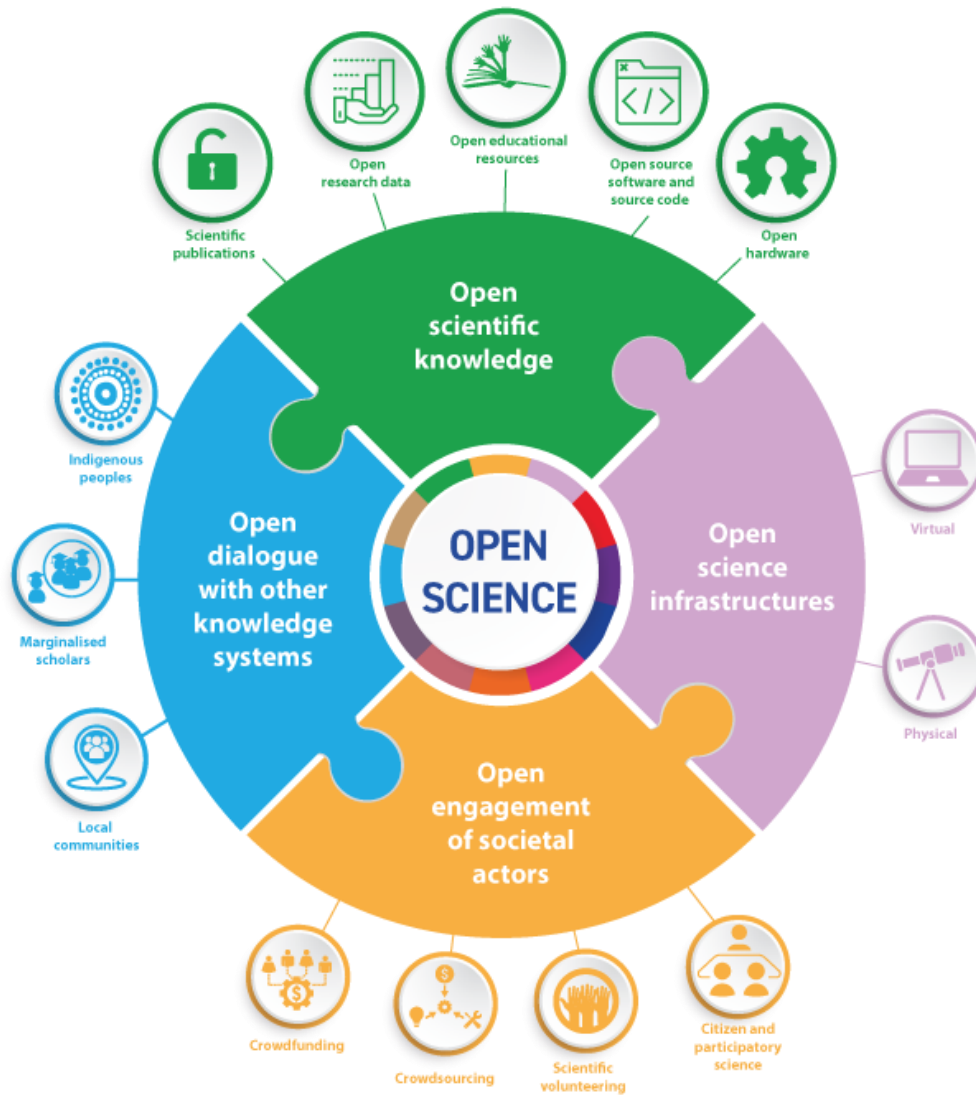


Figure: As my year has been largely about publishing and sharing open research data I have chosen a figure about open science. “Understanding open science” from UNESCO <https://doi.org/10.54677/UTCD9302>.

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## Achievements

### Journal Articles:

- Godtliebsen, G., Larsen, K. B., Bhujabal, Z., Opstad, I. S., Nager, M., Punnakkal, A. R., ... & Birgisdottir, A. B. (2023). High-resolution visualization and assessment of basal and OXPHOS-induced mitophagy in H9c2 cardiomyoblasts. *Autophagy*, 19(10), 2769-2788.
- Ströhl, F., Wolfson, D. L., Opstad, I. S., Hansen, D. H., Mao, H., & Ahluwalia, B. S. (2023). Label-free superior contrast with c-band ultra-violet extinction microscopy. *Light: Science & Applications*, 12(1), 56.

### Conferences / meetings:

- Focus on Microscopy, Porto
- Data Steward Network meeting, Tromsø
- Blått kompass, havkonferanse, Tromsø

### Data and code release:

- Opstad, Ida, 2023, "Fluorescence microscopy videos of mitochondria and endosomes in H9c2 cardiomyoblasts", <https://doi.org/10.18710/HQDBYF>, DataverseNO,
- Opstad, Ida, 2023, "Fluorescence microscopy videos of mitochondria and endosomes in H9c2 cardiomyoblasts", <https://doi.org/10.18710/HQDBYF>,
  - Replication Data for: Multiple signal classification as a blind reconstruction approach for three-dimensional structured illumination microscopy
  - Volumetric light-sheet data of freely moving sea anemone, Ida Sundvor Opstad, Kaushikaram Subramanian, Rajwinder Sing, Aissam Ikmi, Robert Prevedel, Isabel Kemmer

### Invention disclosures/patents:

- “Distributed computing solution of MUSICAL for high throughput imaging”, UK International Patent Application. 2206117.0 / PCT/GB2022/053018. Patent online. <https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2023209318>
- “Fiber Resolution Targets (FiRsT) for both Fluorescence and Label-Free Microscopes and Nanoscopes”, prior art search complete. Patent filed on 16th June 2023. UK international Patent Application 2309111.9
- “Sperm cell grading, selection, and analysis system (Spermotile)”, patent filed on 27th April 2023. UK International Patent Application 2306238.3 .
- “Cyto-Motility and cyto-plasticity in-vitro life cell assay (Cymoplive)”, patent filed on 22nd June 2023. UK International Patent Application 2309453.5

### Book chapters:

Hutmacher, F., Opstad, I. S., Hutmacher, F., & Ströhl, F. (2023). Visualizing the Invisible: Microscopy and How It Affects Our Understanding of Cells and Tissues. In *Microscopy Techniques for Biomedical Education and Healthcare Practice: Principles in Light, Fluorescence, Super-Resolution and Digital Microscopy, and Medical Imaging* (pp. 3-23). Cham: Springer Nature Switzerland.

### Archived documents:

Opstad, I. S., Larsen, K. B., Birgisdottir, Å. B., & Agarwal, K. (2023). LysoTracker Deep Red exhibits photoconversion in multi-color structured illumination microscopy. *bioRxiv*, 2023-10.

### Industry outreach and visibility in industry:

I have supported in commercialization activities with Krishna and Norinova.

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**Visibility drives:**

I was active in the Data Steward Network and helped organize the next meetings.

**Engagement of research communities:**

I have been active in Digital Life Norway, but maybe not so much this year.

**Funding applications applied/granted:**

I have applied for jobs and gotten one in SINTEF Helgeland.

**Other contributions to your work environment at UiT:**

Emptied dishwasher ca 10 times

**Other commissions of trust outside UiT :**

I have peer reviewed two manuscripts for Scientific Reports and Nature Communications

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# A year of traveling and relaxation

Yingying Qin

This year I have travelled to many places, for purpose of overseas research, conference and vacation.

I have stayed in Singapore for 6 months for overseas research at National University of Singapore. I am happy that I can visit the tropical after I have lived in temperate and worked in frigid zones. I have met many researchers in my society and I could discuss with them. I also attended several classes and seminars there. Some courses were quite fundamental and some are relevant and may be helpful in the future. I hope we can also have such lectures in our group someday.

In Singapore, I have also met my seniors and my PhD supervisor and had dinner together. We have not seen each other since my graduation or even earlier. It is good for me to see my old friends and talk to them.

***“Finally there is a railway station in my hometown and we have travelled to some other cities by train.”***

I have also been back to my city and stayed home for one month, after almost four years abroad. My hometown has changed a lot and my family and I have been to several nice restaurants. Finally there is a railway station in my hometown and we have travelled to some other cities by train. I have relaxed a lot at home. After lunch I would have a long siesta while it is usually replaced by a coffee abroad.

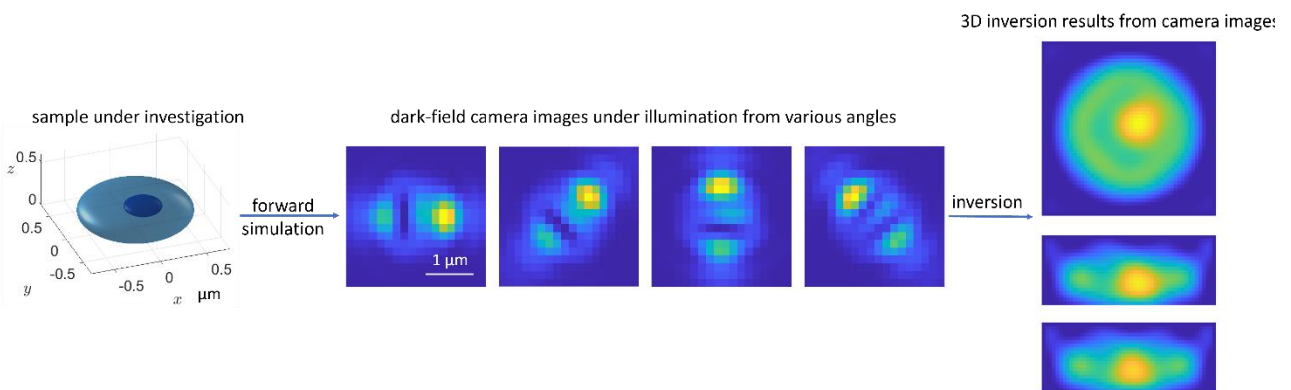
I have travelled to two cities to present our work, with one in Porto and one in Sapporo. The presented work is mainly focused on electromagnetic scattering problem, including forward simulation and preliminary study on the inverse problem where conventional inverse algorithms are adapted to this specific problem and that their results are compared. I have worked on such problems during my PhD but now we need to solve 3D problems. In Porto, we have shown an accurate forward model to simulate the camera images for a conventional microscope in a poster. In Sapporo,



we have given a presentation of the forward model as well as the preliminary inversion results. At spare time, I also walked around the cities and tried local food. Apart from these conferences, two journal papers are published concerning these work in this year.

Apart from the scattering problem, I also work on diffusion problem. It is a more complicated problem for me as it is five dimensional and I have to learn it from the beginning. Yet we have finished the forward simulation and the inversion will be still challenging.

In all I have travelled a lot this year and had a good relaxation. Next year the work needs to be solved will be more challenging.



*Given a sample with known physical parameters and microscope setup, we can simulate camera images based on the physical relations. With these simulated camera images and known microscope, we are able to retrieve the three-dimensional distribution of the sample parameters. Our final aim is to achieve reconstruction with real microscope images.*

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## Achievements

### Journal Articles:

- Y. Qin, A. Butola, and K. Agarwal, 3D full-wave multi-scattering forward solver for coherent microscopes, 2023, doi: 10.1364/OE.480578.
- Y. Qin, A. Butola, and K. Agarwal, 3D refractive index reconstruction from phaseless coherent optical microscopy data using multiple scattering-based inverse solvers - a study, *Inverse Problems*, 2023, doi: 10.1088/1361-6420/ad0c29.

### Conferences / meetings:

- Y. Qin, A. Butola, K. Agarwal, Full-wave multiple-scattering forward modeling for conventional label-free microscope, [Poster] *Focus on Microscopy (FOM 2023)*, Porto, Apr. 2023.
- Y. Qin, A. Butola, K. Agarwal, 3D Full Wave Electromagnetic Modeling of Label-free Optical Microscopes, [Oral] *Photonics & Electromagnetics Research Symposium (PIERS 2023)*, Prague, July 2023.
- Y. Qin, K. Agarwal, 3D Full Wave Electromagnetic Modeling of Label-free Optical Microscopes, [Oral] *General Assembly of URSI (URSI GASS 2023)*, Sapporo, Aug. 2023.

### Funding applications applied/granted

- Grant for overseas research stay, 150 000NOK

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# Journalling 2023

Abhinanda Ranjit Punakkal

The year 2023 started with writing the DLN cross-project activity. This was a great learning experience for me in learning how to present your research for an audience who might not be familiar with the domain but are technically strong to understand the implications of the work. I learnt a lot from my co-applicant Joy, who is excellent at perceiving the need of the hour and designing the document in such a way that it highlights what the readers are looking for. Additionally, the success of this grant application and the activities that followed was a great opportunity to understand the workflow and challenges in a cross-project activity.

My first teaching assignment for the year was for the, AI- applications and methods. It is one of my favorite subjects as well and I enjoyed going through the exercises and project work for the course. It was interesting to see the students come up with lots of fun projects including designing their games. The second teaching assignment was for the course “Cloud and Big Data Technology” for which I was handling the labs related to Docker and web application on Azure Cloud. This was also a personal learning experience of the cloud platform.

***“Outside of work, I tried cross-country skiing this year and alpine.”***

Learning blender was a long-awaited activity personally. The nature of the task was so frustrating for a person without an artistic flare. But in the end, it was one of my learning targets of the year. Another learning objective is Norwegian. Joining the classes at UiT is also a nice platform to socialize with people outside of work.

The research tasks of this year involved more of the good old data processing of large datasets. I appreciate all the people who have worked on creating and publishing large datasets for machine learning. This is a task that often does not get credited appropriately. The fact that this task is still ongoing is a bit frustrating but at least now

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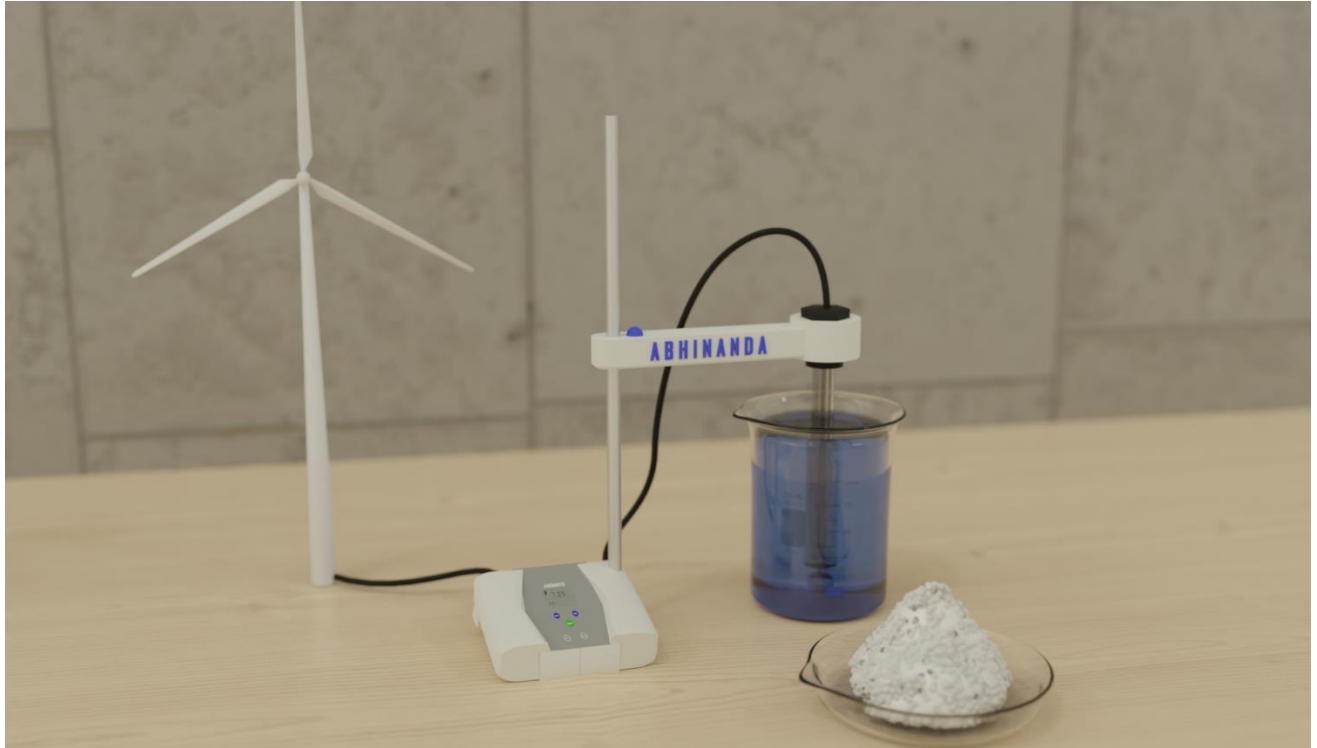
with the support from Oracle for Research, I now have a platform that I can work on. Two journal articles on which I worked got published. One of the articles was a video journal which was something new for me. Planning and coordinating between different groups for the manuscript and then working on how to present it using a video was an interesting activity.

My research project on modeling the shape of organelles using machine learning was rejected by two Computer Vision conferences. Both times the review was right in the middle where the final decision could have tipped on either side. For the second submission, I missed a formatting detail of the conference template which was also mentioned in the final decision. Though it is not the reason for rejection, it was a lesson on the consequences of being careless as a researcher.

The LLM workshop was a surprising event of the year. Though apprehensive in the beginning about how the event would turn out without hands-on experience in the topic it turned out to be a fantastic experience. The time crunch and the teamwork worked magic on the final output. It was also the first time that the BioAI lab organized an event and it was a bonding experience for the team. It made me realize how much more can be accomplished when people come together rather than working individually.

Outside of work, I tried cross-country skiing this year and alpine. Parallel braking in alpine skiing and skate skiing in cross-country skiing are the targets for the coming winter. Floya was my practice hill and I have hiked up Floya at least 10 times. I tried several new routes and even experienced a tiny avalanche. This has left me with a mark on my sunglasses and a greater respect for the strength of nature. I also joined Yoga classes in the second semester of the year and it has been great in helping me center and ground down.

I am grateful to my supervisors for their constant support and encouragement and for believing in me even when I have been doubtful.



*Modelling a workbench in my imaginary lab*

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## Achievements

### Journal Articles:

- Punnakkal, A. R., Godtliebsen, G., Somani, A., Maldonado, S. A. A., Birgisdottir, Á. B., Prasad, D. K., ... & Agarwal, K. (2023). Analyzing Mitochondrial Morphology Through Simulation Supervised Learning. *JoVE (Journal of Visualized Experiments)*, (193), e64880.
- Godtliebsen, G., Larsen, K. B., Bhujabal, Z., Opstad, I. S., Nager, M., Punnakkal, A. R., ... & Birgisdottir, A. B. (2023). High-resolution visualization and assessment of basal and OXPPOS-induced mitophagy in H9c2 cardiomyoblasts. *Autophagy*, 19(10), 2769-2788.

### Archived:

- Punnakkal, A. R., Jadhav, S. S., Horsch, A., Agarwal, K., & Prasad, D. K. (2023). MiShape: 3D Shape Modelling of Mitochondria in Microscopy. *arXiv preprint arXiv:2303.01546*.

### Data and code release:

- Analysis code released as part of journal publication 1. [\(link: error on page\)](#)

### Industry outreach and visibility in industry:

- Oracle Cloud Platform - Help review and perform benchmarking of different GPUs for 'Oracle for Research Project Award' for our project on Generative AI for Microscopy.
- NVIDIA - Engaged with NVIDIA for opportunities of funding and support for the research activities of the lab.

### Visibility drives

- LLM workshop  
A 2-day workshop on a Large Language Models was carried out in 27th-28th Oct. 2023. The workshop explored the far-reaching implications, advancements, and applications of LLMs while navigating through their technical, ethical, and societal aspects.

### Funding applications applied/granted

- **Cross-project activities grant 2023**, Centre for Digital Life Norway (Received).  
This was a cross-project activity based on a joint activity derived from the NFR projects NanoRIP (PI Krishna Agarwal) and NanoAI (PI Dilip Prasad). The activity aims to use AI to enable 3-dimensional visualization of microscopic/nanoscope biological structures like mitochondria using just 2D images even with suboptimal quality. The activity is funded 25000 NOK for the operational costs, with additional support on dissemination activity if needed in the future.
- Erasmus Mobility grant to fund my internship at the **Marr Lab, Helmholtz Center, Munich** under the supervision of **Prof. Carsten Marr**. (Applied)
- NVIDIA Graduate Fellowship grant (Rejected)

### Other contributions to your work environment at UiT

- Supervising Aaron on his work on creating motion of synthetic organelle shapes.
- Teaching assistant for the course INF-2220-1 23H Cloud and Big Data Technology.
- Teaching assistant for the course INF-2600-1 23V Artificial Intelligence, AI - Methods and Applications.
- Supervising two interns remotely.
- Preparing layout/plan for the BioAI imaging lab

### Other commissions of trust outside UiT

Reviewer for ICML Workshop SynS and ML, NeurIPS workshop on Machine Learning and the Physical Sciences

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# Me and the Wonderland!

Farhad Niknam

This year has possibly been one of the most exciting years of my life. In contrast to my belief that I'm stepping onto a remote no-man's land on the Arctic Circle and I am doomed to stay there for four long years, I can courageously say I was so wrong. Even though Tromsø can be the smallest city I've ever lived in (not even close to the mega city Tehran with its gigantic population of 12 million), I have seen more life than I could imagine. With its exotic nature and world-class scenery of snow, mountains, northern lights, and fjords, I could say I've never been this lucky. To my own surprise, even the snow, low temperature, and dark periods haven't changed my mood so far, and I always liked staring into the darkness sometimes; which I find strangely peaceful. And interestingly, that's only half of the luck I have got.

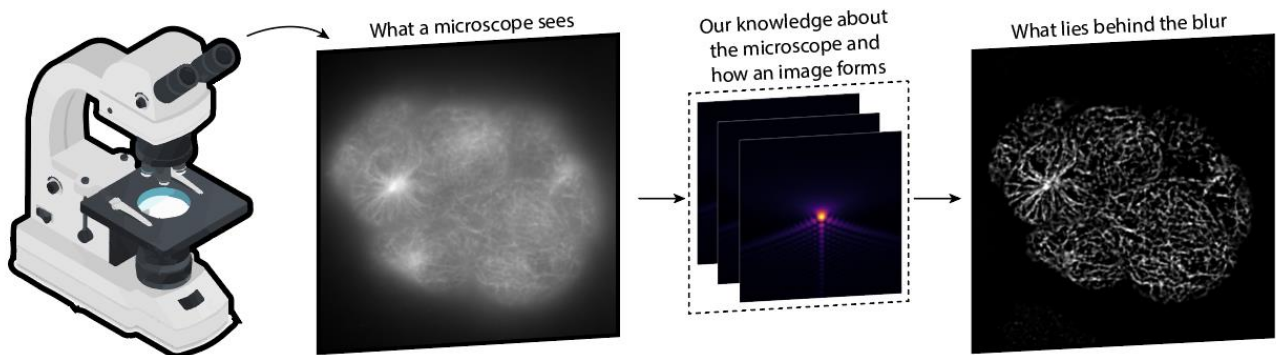
***“I managed to effectively convey my knowledge to a few keen students and place a brick on their under-construction wall of growth.”***

Last year was the year of tough decisions, and eventually, I made a move that I imagined for so long: continuing studies for a Ph.D. Now, I find myself in a great team with great people who are willing to make a change. Nothing can compete with the value of such a purpose of planting the seed of a tree and taking care of it to grow and eventually, one day, make fruit not for us but for humankind. And, of course, nothing can compete with the sheer luck that I have got to take part in this journey. Our efforts may push the boundaries of science by a baby step forward, but it is valuable to its core, and once it is accumulated with all the baby steps of all of those who share purpose with us, it will turn to leap.

Regardless of my being a beginner, 2023 has been quite fruitful. I learned a lot, worked a lot, experienced a lot, and, of course, improved. I can clearly see the difference between my current self and past self, and that's joyful to think of. I also got to know

lots of great people with vast experience and wonderful stories to tell, which cannot be replaced by anything of value.

I can summarize my professional experience into two mildly distinctive sections, which are research and teaching. I should admit that I am so grateful that I was given this opportunity to take part in conducting a course. The Waves and Optics course is still young. However, I managed to effectively convey my knowledge to a few keen students and place a brick on their under-construction wall of growth. This came with the cost of spending a lot of time and effort during the spring and summer, however, especially in producing the material and developing the roadmap of the course. However, I believe it was worth it. One may ask why and what difference it makes. I truly believe one individual is enough to make a significant change in societies and turn the course of history, and we may not even be aware of the importance of our role! Physics has convinced me in a statistically chaotic system, even a small disturbance may lead to significantly vast consequences, and that can be as simple as one simple moving sentence.



*My latest scientific achievement. I developed a model that characterizes the microscope parameters and estimates the point spread function of the system. The resulting knowledge aids us in, for instance, reconstructing a high-resolution image with a greater contrast.*

This wasn't the whole story of my Ph.D., however, and my research job began with a rough idea of volumetric reconstruction of microscopy samples by looking at their scattered light. This is a great topic, I shall say, but it has many aspects and needs a lot to achieve. In the first few months, I tried to understand the phenomenon and its physical implications and obtain an intuition. I tried to identify problems, gaps, and possible solutions and explored electromagnetics and diffraction theories. In the meantime, I sensed that it would be plausible to begin an experiment with real-world



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measurements. That's when I began excavating the roots of the problem and understanding the limits. The conclusion is that the greatest limit is the extent of information at hand about an imaging system and the sample, and honestly, we just know a little.

Here began the challenge of understanding a system just by looking at the measurements. To this end, I had to dive deep into the toughest mathematical concepts of statistics and physical modeling of image formation. To solve this honestly difficult problem, I flew from inverse optimization methods to statistical modeling of system response and eventually managed to find a solution that surprisingly worked so well! At the moment that I'm writing this text, I'm in the process of writing an invention disclosure, which hopefully I can submit on early December.

I am now full of hope, yet not optimistic for the future. I'm trying to build a reasonable understanding of my life and purpose to develop a realistic view of the world. May be at some time I will find a compromise between ambition of living and success and find peace within.

## Achievements

### Data and code release:

- Released a major update on the Fringe.py python package that includes an GPU accelerated Rayleigh -Sommerfield diffraction solver. The package is publicly available at <https://github.com/farhadnkm/Fringe.Py>

### Invention disclosures/patents:

- Invention disclosure: System characterization .... To be submitted in Dec. 2023.

### Engagement of research communities:

- **International visit:** Visited Marti Ducastella's team in the University of Barcelona. From Jan. to Feb. 2023

### Other contributions to your work environment at UiT

- Participated in teaching, material preparation, and mentorship in Waves and Optics course
- Co-supervised a bachelor student Oddvar Leiros, on his bachelor's project with the title of "Ray Optics Simulation".

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# Embracing Challenges and Triumphs: A Year of Growth and Discovery in My PhD Journey

Iqra Qasim

As I reflect on the past year, marking the commencement of my PhD journey, I am filled with a profound sense of accomplishment and gratitude. The year began with a whirlwind of uncertainties and queries, as is typical for anyone embarking on such a significant academic pursuit. Questions about my research team, supervisors, and the overall working environment in a new cultural setting were at the forefront of my mind.

The transition, however, turned out to be remarkably smooth. I quickly found myself deeply impressed by the Norwegian working style, which harmoniously blends efficiency with a commendable emphasis on work-life balance. This aspect of my new environment was not only conducive to my professional growth but also significantly enhanced my personal well-being.

***“The transition, however, turned out to be remarkably smooth.”***

One of the year's highlights has been my involvement in the journal club and Digiphysi meetings. These sessions, aimed at bolstering our skills as researchers, provided me with invaluable opportunities to connect with my team members. Witnessing their active engagement and dedication was both inspiring and motivating. It fostered a sense of camaraderie and intellectual stimulation that is often the hallmark of successful research teams.

Moreover, the project meetings have been a source of enjoyment and learning. These interactions with my supervisors have not only bolstered my confidence in discussing my research but also made me more comfortable in addressing challenges I

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encountered. The open and supportive atmosphere during these meetings allowed for a healthy exchange of ideas and constructive feedback, which has been instrumental in my growth as a researcher.

The year highlight would be incomplete without acknowledging the unique challenges I faced, particularly managing my academic responsibilities alongside my pregnancy. The understanding and support extended by my colleagues and supervisors were remarkable. They played a crucial role in creating an environment where I could balance my health and work effectively. This support was pivotal in enabling me to write a survey on my research topic and successfully complete 20 of the 30 ECTS required, despite the physical and emotional demands of pregnancy.

Among the rigorous academic pursuits, our team also cherished moments of relaxation. A memorable BBQ party, serving as an outdoor retreat, provided a delightful opportunity for everyone to unwind, bond, and enjoy the scenic beauty of our surroundings. A few traditional gatherings we did in this year are also memorable. As I conclude this year, I do so with a sense of contentment and eagerness for the years ahead in my PhD journey. The experiences of this year have not only shaped me as a researcher but have also instilled a deeper appreciation for the academic community I am a part of. I look forward to further embracing the challenges and opportunities that lie ahead, confident that they will continue to enrich my personal and professional growth.



*Celebrating Milestones and Memories: Team's Journey Through the Lens!" 🇲🇾 ✨*  
*#PhDAdventures #TeamSpirit*

## **Achievements**

### **Journal Articles:**

- Dense Video Captioning (DVC): A survey of techniques, datasets and evaluation protocols , submitted to ACM Surveys

### **Visibility drives**

- In the Summer of 2023, I represented UiT at the [EUGLOH](#) Summit, where I was a key contributor to a group project focused on the innovative concept of the 'NapCap'. This futuristic device is designed to enhance learning efficiency simply by being worn. Our team's presentation and execution of this idea were exceptionally well-received, culminating in us securing the first place among seven competing groups.

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# Seeking to broaden my professional horizons

Rohit Agarwal

Upon beginning my PhD, I had resolved to focus solely on one task at a time, as my past experiences during my bachelor's and master's degrees had been characterized by involvement in multiple activities, including academics, sports, and management. I was saturated by doing so many tasks and thus I came to the conclusion of focusing on only one task. After a year and a half in my PhD program, I came to realize that my previous approach of focusing solely on one task at a time was not conducive to my productivity nor the enjoyment of my research. Consequently, I have since modified my work style and daily routine to allow for greater flexibility and involvement in multiple projects, including those related to my PhD topic as well as other areas of AI.

***“I found great enjoyment and gained substantial knowledge from my experience supervising a master student.”***

In addition to my work in AI, I have also undertaken a physics-based problem with limited AI involvement. Outside of work, I have pursued various personal interests, such as learning to swim. I have dedicated significant effort to mastering this skill, seeking guidance from coaches, online resources, and friends. While I have yet to achieve a high level of proficiency, I have made considerable progress. A significant development for me this year has been my active engagement in managerial tasks. I find great satisfaction in interacting with people and tackling new and complex challenges, which has motivated me to organize multiple events for the BioAI team. These events included a social barbecue at the Telegrafbukta beach in Tromsø, as well as a technical event focused on Large Language Models, which was attended by approximately 40 individuals and followed by a social dinner for the BioAI members.



*Me presenting my poster at NorwAI Innovate 2023 held at Stavanger, Norway*

Furthermore, to fulfill my day-to-day managerial responsibilities, I have become a member of the Digital Life Norway Junior Research Group (DLN-JRG) with the aim of expanding DLN's activities in North Norway. My most significant learning experience this year has been through attending various scientific dissemination events. Through these events, I have gained valuable knowledge and skills in networking and presenting myself and my work to a broader audience. This has highlighted for me the importance of public dissemination of research, which I believe will serve as a steppingstone for my future personal and professional endeavors.

Finally, I found great enjoyment and gained substantial knowledge from my experience supervising a master student. This experience allowed me to develop skills in time management, expectations management, and learning new topics. As a result, I am currently supervising five interns in my lab, each specializing in different AI fields. Moving forward, I aspire to maintain the momentum of my current workload while improving my time management skills to prioritize my health and well-being.

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## Achievements

### Journal Articles:

- Aux-Drop: Handling Haphazard Inputs in Online Learning Using Auxiliary Dropouts [Link](#) *First Author* **Transactions on Machine Learning Research**
- SegPC-2021: A challenge & dataset on segmentation of Multiple Myeloma plasma cells from microscopic images [Link](#) *Co-Authored* **Medical Image Analysis**

### Conferences / meetings:

- MABNet: Master Assistant Buddy Network with Hybrid Learning for Image Retrieval [Link](#) *First Author* **International Conference on Acoustics, Speech, and Signal Processing**
- Auxiliary Network: Scalable and Agile Online Learning for Dynamic System with Inconsistently Available Inputs [Link](#) *First Author* **International Conference on Neural Information Processing**

### Arxiv:

- Taxonomy of hybridly polarized Stokes vortex beams [Link](#) *Co-Authored* (In Journal Review)
- Modelling Irregularly Sampled Time Series Without Imputation [Link](#) *First Author* (In Conference Review)

### Code Release (Github Open-Source):

- Aux-Drop: <https://github.com/Rohit102497/Aux-Drop>
- MABNet: <https://github.com/Rohit102497/MABNet>
- Modelling Irregularly Sampled Time Series Without Imputation: <https://github.com/Rohit102497/SLAN>

### Popular science contributions (Videos)

- YouTube video of Auxiliary Network Paper: [Link](#)
- YouTube video of MABNet: [Link](#)

### Visibility drives

- **Symposium, 2023:** Association for the Advancement of Artificial Intelligence (AAAI). <https://aaai.org/conference/summer-symposia/summer-series-2023/>. Place: Singapore.
- **Summer School, 2023:** AI in Neuroscience Summer School from NRSN. <https://www.ntnu.edu/nrsn/summer-school>. Place: Stavanger, Norway

### Engagement of research communities:

- Member
  - Digital Life Norway (DLN)
  - Norwegian Artificial Intelligence Research Consortium Conference (NORA)
  - IEEE
- **Administration Member** at DLN-JRG (Junior Research Group).
- **Conference, 2023: DLN.** <https://www.digitallifenorway.org/conference/>. Place: Bergen, Norway. **Poster Presentation**
- **Conference, 2023: NORA.** Annual Conference. Place: Copenhagen, Denmark. **Poster Presentation**
- **Startup Event, 2023: NORA.** <https://www.nora.ai/events/nora.startup-GAI.html>. Place: Tromso, Norway.
- **LLM Workshop, 2023:** Organised by Bio-AI Lab in collaboration with **NORA** and **DLN**. <https://www.bioailab.org/arcticllmworkshop2023> Place: Tromso, Norway
- **NorwAI Innovate, 2023:** LLM conference by NorwAI. <https://www.norwaiinnovate.no/> . Place: Stavanger, Norway. **Poster Presentation**

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### Funding applications applied/granted

- UiT Travel Grant for 3 months: Research Stay at Singapore from 22<sup>nd</sup> May till 13<sup>th</sup> August at NUS Centre for Research in Privacy Technologies ([N-CRiPT](#)) Lab, NUS.

### Other contributions to your work environment at UiT

- Social Acitivity at Bio-AI Lab:
  - Organised Barbecue at Telgrafbukta, Tromso.
  - Organised the LLM Workshop <https://www.bioailab.org/arcticllmworkshop2023> at Tromso, Norway.
- Supervision:
  - Aaron Vaughn Celeste. Master Student. Department of Computer Science, UiT Tromso. Spring 2023. **Passed with highest grade A**

### Other commissions of trust outside UiT

- Reviewer
  - **2 papers** at IEEE International Conference on Acoustics, Speech, and Signal Processing (**ICASSP 2024**). <https://2024.ieeeicassp.org/>
  - **1 paper** at Nordic Machine Intelligence (**NMI 2023**) <https://journals.uio.no/NMI/about>
  - **2 papers** at International Conference on Data, Electronics and Computing (**ICDEC 2023**) <https://icdec.org/>

### Rejection

- WACV, ICCV – MABNet
- NeurIPS - Modelling Irregularly Sampled Time Series Without Imputation
- Optica, ACS Photonics, Photonix, Nanophotonics, Physical Review A- Taxonomy of hybridly polarized Stokes vortex beams



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# Past, present and future of MUSICAL

Sebastian Andres Acuna Maldonado

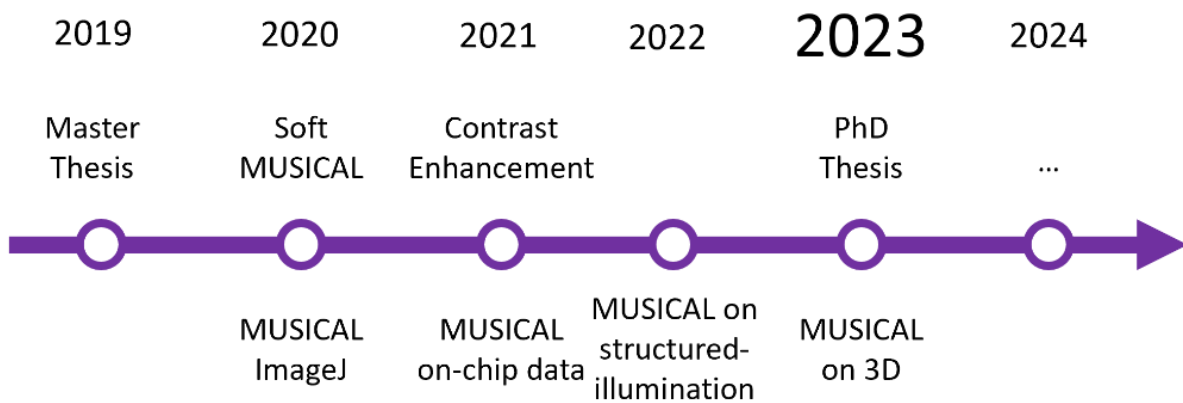
I started my PhD on April 2019, just after presenting my master's thesis in public in March. My topic was MUSICAL, a method that I couldn't understand very well even though I could explain the algorithm step by step. My presentation was based on optimizing the already existing code, which I complemented with some Machine Learning-based approaches to pick some of the parameters. However, my knowledge on microscopy, fluorescence or other super-resolution techniques was inexistent.

Now it is 2023 and I recently submitted my PhD thesis. The title is Multiple Signal Classification Algorithm: A computational microscopy tool for fluorescence microscopy. This should pretty much summarize and suggest what all these 4 years were about. The thesis serves the purpose of collecting the knowledge acquired during this time but I also hope it serves as a starting point for future research in MUSICAL. For me 2023 was the year where I got to appreciate all the work I have done.

***“It is really about the journey and what you learn about yourself while sprinting through it.”***

When I started working on this topic, MUSICAL for me was a MATLAB code. My task was to make it faster. I never really considered the why. For me, this is the past. Currently, with several hours of reading, thinking, coding and writing, I can visualize it better. MUSICAL is a powerful concept that right now is used for improving microscopy images through the decomposition of temporal stacks of fluorescence microscopy images. However, this is the key part: the fluctuations can be created from any source. It can be a chip, it can structure illumination, speckles, etc. I cannot mention more because there is where my knowledge ends. But I firmly believe that the right person can take the algorithm to the next level.

When I talk about the right person, I mean of course, the people that follow me. If something, 2023 has taught me that right now, I don't want to continue with research. I started to feel how my curiosity for the field has started to decline and shift towards other directions. Therefore, it was also the year where I decided that I wanted to shift in a different direction. However, it is also the year where I realized and reflected on everything I've learned up to date and the meaning of a PhD. It is not the knowledge you gain. It is really about the journey and what you learn about yourself while sprinting through it. The 4 years passed flying, but I learned what I like to do, what I dislike, and most importantly, what I cannot do (or maybe that I can but not alone). Right now, after highs and lows (which I felt as periods of low motivation), I can say that I envision a bright future for the algorithm. There is still so much that is unexplored with potential for high impact. Even more considering that new systems with new types of illuminations will still be engineered in the next years. I think this overall is my biggest conclusion of 2023.



*Figure: This is year where I reflected on everything I have done during my PhD journey. This timeline summarizes my main contributions and the progress from Master to PhD.*

To conclude this brief reflection, I want to express my profound gratitude. I am thankful for this University, for this group, and for the small town that welcomed me during these years. I joined in 2017, and since then, my experiences have been more than positive. I cannot recall a single negative aspect, but that may be nostalgia talking too. I appreciate life for the blessings it has bestowed upon me, and I will always hold this place dear in my memories.

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## Achievements

### Journal Articles:

- Abhinanda Ranjit Punnakkal, Gustav Godtlielsen, Ayush Somani, Sebastian Andres Acuna Maldonado, Ása Birna Birgisdottir, Dilip K. Prasad, Alexander Horsch, Krishna Agarwal. **Analyzing Mitochondrial Morphology Through Simulation Supervised Learning.** *J. Vis. Exp.* (193), e64880, doi:10.3791/64880 (2023).

### Conferences / meetings:

- Sebastian Acuña and Krishna Agarwal. **MUSICAL – a versatile super-resolution microscopy solution for gentle imaging of physical characteristics of biological samples.** 4th International Conference On Optics, Photonics, And Lasers (OPL-2023). 4-7 Dec. 2023, Hiroshima, Japan. (Invited)
- Ankit Butola, Sebastian Acuña, Daniel Henry Hansen, and Krishna Agarwal. **Multiscale resolution in structured illumination microscopy.** *Advances in Microscopic Imaging IV*, vol. 12630, pp. 32-34. SPIE, 2023.
- Sunil Bhatt, Ankit Butola, Sebastian Acuña, Daniel Henry Hansen, Jean-Claude Tinguely, Dalip Singh Mehta, Balpreet Singh Ahluwalia, and Krishna Agarwal. **Quantitative phase imaging for tracing the motion of waveguide trapped bead particle.** *Imaging, Manipulation, and Analysis of Biomolecules, Cells, and Tissues XXI*, vol. 12383, pp. 19-26. SPIE, 2023.
- L.E. Villegas-Hernández, V.K. Dubey, S.A. Acuña, H. Mao, J.C. Tinguely, K. Agarwal, B.S. Ahluwalia. **Photonic chip: a high-throughput multimodal nanoscopy platform for Histopathology.** *Focus on Microscopy*, Porto, 2-5 April 2023.
- S.A. Acuña, I. S. Opstad, L.E. Villegas-Hernández, B.S. Ahluwalia, K. Agarwal. **MUSICAL: a family of computational techniques for fluorescence nanoscopy.** *Focus on Microscopy*, Porto, 2-5 April 2023.
- J.C. Tinguely, I.S. Opstad, S. Acuña, L.E. Villegas-Hernández, V.K. Dubey, F. Ströhl, K. Agarwal, B.S. Ahluwalia. **Optical waveguides for multimodal super-resolution microscopy.** *Focus on Microscopy*, Porto, 2-5 April 2023.
- S. Acuña, L.E. Villegas-Hernández, I.S. Opstad, J.C. Tinguely, B.S. Ahluwalia, K. Agarwal. **MUSICAL: results on chip nanoscopy.** *Focus on Microscopy*, Porto, 2-5 April 2023.
- I.S. Opstad, S. Acuña, S. Ströhl, F. Ströhl, B.S. Ahluwalia, K. Agarwal. **Blind reconstruction of challenging raw data outperforms commercial 3DSIM.** *Focus on Microscopy*, Porto, 2-5 April 2023.
- I.S. Opstad, S. Acuña, A. B. Birgisdottir, B. S. Ahluwalia, K. Agarwal. *From super-resolution imaging to cellular dynamics.* *Focus on Microscopy*, Porto, 2-5 April 2023.
- A. Butola, S. Acuna, D.H. Hansen, K. Agarwal. *Multiscale resolution in Structured illumination microscopy.* *Focus on Microscopy*, Porto, 2-5 April 2023.

### Invention disclosures/patents and innovations:

- Sebastian Acuña, Balpreet S. Ahluwalia, Krishna Agarwal. **Window-based parallelized method and system for producing super-resolution microscopy image from an image time-series.** Patent number PCT/GB2022/053018. Available at: <https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2023209318>
- MusiCloud Project closure.

### Industry outreach and visibility in industry:

- Starting conversation with Confocal.nl for the commercialization of MUSICAL

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### Visibility drives

- Organvision Meeting in Tromsø: I created the visual material such as sign and posters for dissemination purposes. I also hosted one of the sessions.

### Engagement of research communities:

- EMBL visit for carrying experiments on MUSICAL with a moving stage.

### Funding applications applied/granted

- (Mobility) Erasmus+ 1000 EUR grant. Used during February 2023 to visit EMBL facilities in Heidelberg, Germany.

### Unpublished work

- Ida Opstad, Sebastian Acuña and Krishna Agarwal. **MUSICAL as a blind reconstruction method for 3D-SIM data** (*in-progress*): MUSICAL can be modified to process 3D temporal stacks of data without knowledge of the PSF and illumination system
- Biswajoy Ghosh, Sebastian Acuna, Aliaksandr Halavatyi, and Krishna Agarwal. **Vesicle counting in biological cells with programmed nano-motion trace and superresolution microscopy** (*in-progress*): We exploit MUSICAL and an acquisition system that acquires images with a moving stage.
- Sebastian Acuña, Ida Opstad, Krishna Agarwal. **MUSICAL: A Versatile Computational Tool for Super-Resolution and Contrast Enhancement for Fluorescence Microscopy Data**. JoVE (in-review)

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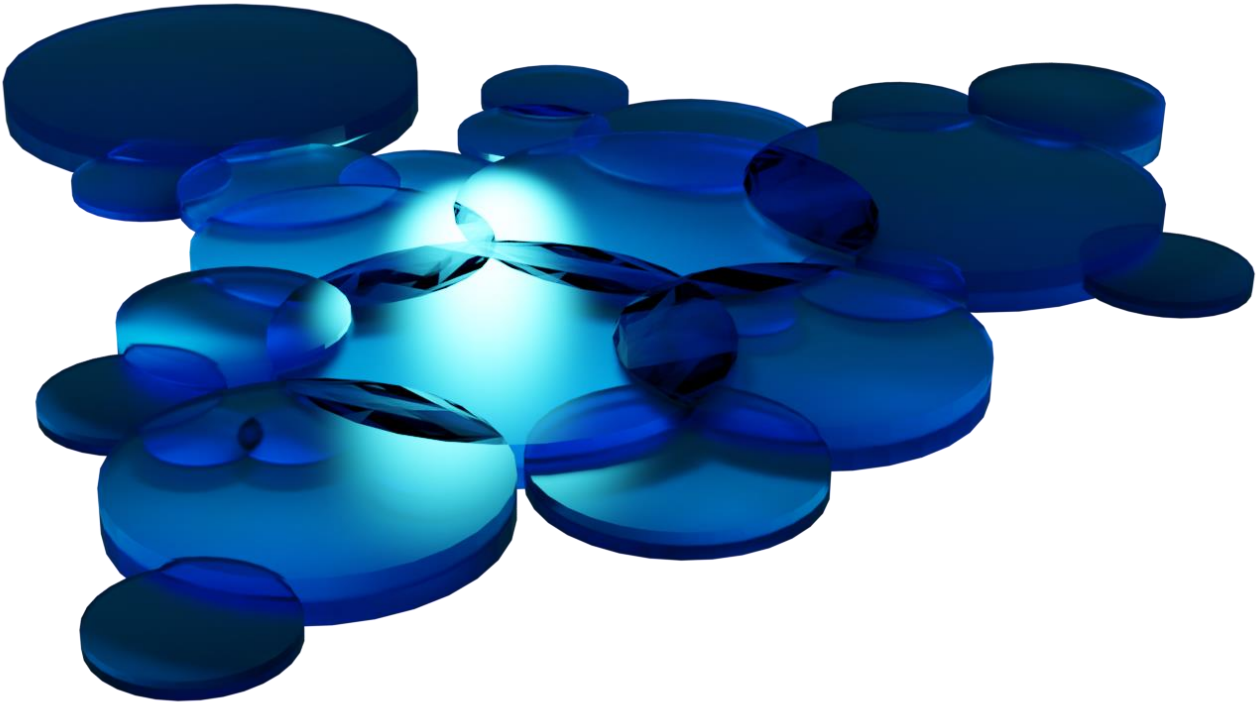
# Adiabatic expansion of a mostly linear (as opposed to turbulent) flow state

Jean Claude Tinguely

2023 did not feel particularly different from the previous years – I'm grateful to be a central point in the group and to be helpful to many people. I feel like this is also recognized. Despite being a relatively large group, the interaction with as good as all members is very good, with mutual respect and a friendly setting (as far as I can tell). This multitude of characters is in exceptional moments difficult to conciliate, but mostly very rewarding. Some leading members put an extra effort beyond what might be seen as strictly necessary professional matters, making it interesting to observe (and participate in) how the entire group environment is developing.

***“This multitude of characters is in exceptional moments difficult to conciliate, but mostly very rewarding.”***

When it comes to research, publications involving me have been less about integrated optics but the collaboration with Sathi Das from IIT around surface-enhanced spectroscopy has been quite productive, with one published paper and another two which are under review. There have been many discussions with new and established group leaders at IIT Delhi as well as a promising idea involving an MIT group in Boston, which I look forward to developing further. Quite a few hours were spent in the cleanroom in Trondheim, providing a better insight into current lithography possibilities without outsourcing. The limitations still need to be understood better, where the current collaboration with Southampton on transparent substrates is very interesting for a comparison when it comes to e.g. scattering hotspots between ours and their deposition instruments. My current work with aluminum oxide will hopefully also be interesting for optical waveguides down to the UV range.



*Abstract rendition of JC's inter-connected tasks – JCT, Nov. 2023*

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## Achievements

### Journal Articles:

- Transmission structured illumination microscopy with tunable frequency illumination using tilt mirror assembly, Krishnendu Samanta, Azeem Ahmad, Jean-Claude Tinguely, Balpreet Singh Ahluwalia and Joby Joseph, Scientific Reports volume 13, Article number: 1453 (2023)
- SERS Nanowire Chip and Machine Learning-Enabled Classification of Wild-Type and Antibiotic-Resistant Bacteria at Species and Strain Levels, Sathi Das, Kanchan Saxena, Jean-Claude Tinguely et. al, Appl. Mater. Interfaces 2023, 15, 20, 24047–24058 (2023)

### Submitted / in preparation:

- Sculptured silicon nanopillars bridging face to face nanogaps with metal- insulator-metal coating for surface enhanced Raman spectroscopy, Sathi Das, a Jean-Claude Tinguely, et.al, under review
- Sculptured silicon nanopillars bridging face to face nanogaps with metal-insulator-metal coating for surface enhanced Raman spectroscopy, Sathi Das, Jean-Claude Tinguely et al., under review
- Motion Trace Analysis of Head of Sperm Cell using Label-Free Quantitative Phase Imaging, Sunil Bhatt et.al, in preparation

### Conferences / meetings:

- Focus on Microscopy, Porto / Portugal, April 2023 – poster contribution
- Norwegian Physics Meeting, Bergen / Norway, August 2023 – presentation, “Integrated optical circuits for multimodal super-resolution microscopy”
- Workshop on Cosmic Dust and Dusty Plasmas in Ionospheres, Stockholm/Sweden, November 2023 - attendance
- Antimicrobial resistance (AMR) Workshop, New Delhi/India – attendance, possibly presentation
- INTPART meeting, New Delhi / India, December 2023 - presentation

### Administrative contributions at UiT

- “Ølbrygging”/beer brewing course (Institute for Engineering and Safety) - Lecture on organic chemistry, lab exercise on yeast cell counting/microscopy
- Co-/main organizer of 2 group seminars
- Committee member for two PhD positions
- Master thesis evaluation (Space Physics group)
- (Substitute) member for Faculty board meeting
- Committee for updated safety training guidelines for NT-faculty
- Safety training for UMO group
- Chemical waste responsible for Technology building
- Gas responsible for UMO group
- Co-financial administration
- Procuring
- Shipping
- Lab management

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# Deep dive In MEMS of biomedical applications

Shivam Jaiswal

Over the course of the past year, my academic and professional endeavors have woven a rich tapestry of experiences, encapsulating the intricate domains of MEMS technology, Digital Twins, and innovative sensor development.

Embarking on my Master's journey, my stint at DRDO was characterized by a deep dive into the nuanced world of MEMS. Specifically, I was engaged in the design intricacies of MEMS-based pressure sensors tailored for high-stakes missile testing applications. This hands-on experience not only honed my technical skills but also instilled in me a profound appreciation for the critical role that precision sensing plays in complex and mission-critical scenarios.

Simultaneously, my professional journey took me to L&T Technology Services, where I delved into the realm of Digital Twins, contributing substantively to a triad of projects. The first, a Digital Twin for Electric Vehicle Cooling System, involved harnessing the power of UNREAL ENGINE and Cloud Sensor integration to create a dynamic digital replica. This, in turn, facilitated real-time monitoring and optimization of electric vehicle cooling systems.

***“I am poised at the nexus of innovation, driven by a passion for pushing the boundaries of what is technologically possible.”***

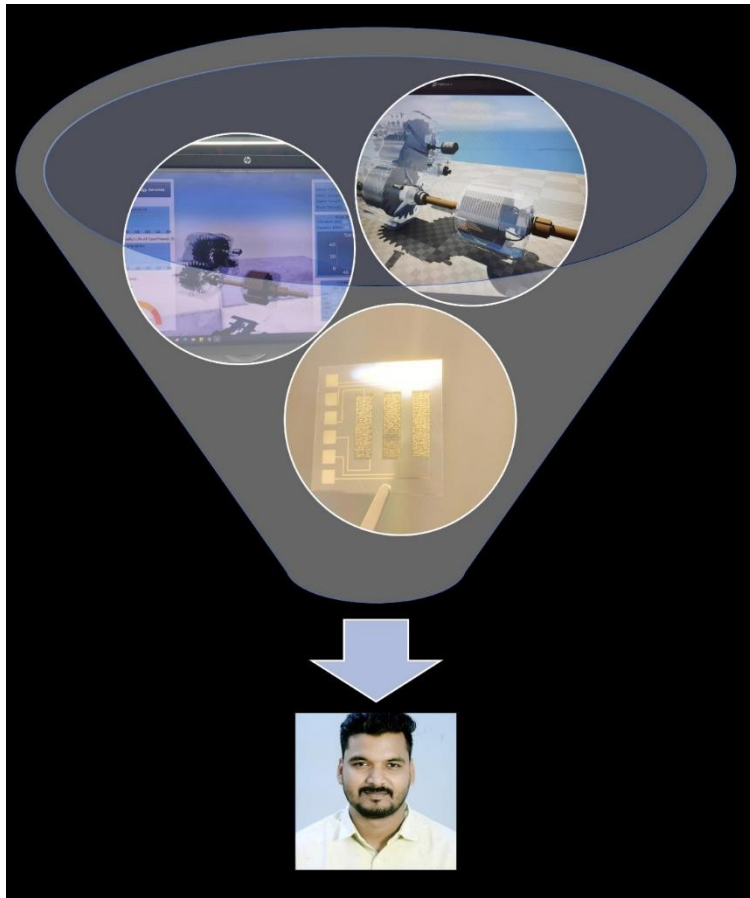
In the realm of Building Management Systems, I took on the challenge of sensor design and data verification. Ensuring the accuracy and reliability of data in these systems is pivotal for their effective functioning, and my contributions aimed at enhancing the robustness of these critical components.

The third project saw me collaborating on the Digital Twin for an Electric Motor-Gearbox System. Here, I applied my skills in UNREAL ENGINE, Cloud Sensor



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integration, and Finite Element Analysis (FEA) to create a comprehensive digital model. The integration of FEA added a layer of sophistication, providing insights into the system's performance under varying conditions.



*"I am the accumulation of all my experiences"*

In tandem with these professional engagements, I embarked on a significant academic pursuit at IIT Delhi, where my focus was on pushing the boundaries of sensor technology. The culmination of this effort was a Master's thesis that showcased the development of a pioneering SU-8 graphene nanocomposite-based localized biomechanical sensor. Tailored for biomedical sensing applications, this novel sensor holds promise for advancing the frontiers of healthcare technology.

Beyond these roles, I undertook a market survey in India for the Innovation project "Spermotile" at UIT Norway, adding a dimension of global exposure to my repertoire. Subsequently, my journey led me to join UIT as an engineer, where my focus shifted towards the development of Microfluidics and automation, broadening my expertise further.

This holistic journey has not only fortified my technical acumen but has also cultivated a mindset that seamlessly integrates academic rigor with real-world applications. As I navigate the intricate landscape of MEMS technology and sensing applications, I am poised at the nexus of innovation, driven by a passion for pushing the boundaries of what is technologically possible.

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## Achievements

### Conferences / meetings:

- IEEE TRANSDUCERS 2023, KYOTO JAPAN “LOCALIZED BIOMECHANICAL STRAIN SENSING WITH GRAPHENE/SU-8 NANOCOMPOSITE BASED HIGHLY FLEXIBLE PIEZORESISTIVE SENSOR”  
Faizan Tariq Beigh, Shivam Jaiswal, Nadeem Tariq Beigh, Dr. Dhimann Mallick.

### Engagement of research communities:

- IEEE TRANSDUCERS 2023

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# A year to remember for a long time

Krishna Agarwal

2023 has been a special year. A year I might remember for a long time. A lot is covered at a group level in the sections before this one. So, I will focus on more personal/individual level here.

At a personal level, this year was a year of evaluation and reflection. I have been thinking about what I expect from myself or my career for the next 10 years. It has been clear to me for the past few year already that I wont remain in nanoscopy forever, I will need to reinvent myself by moving to another domain (still in inverse imaging which is the common thread in my research). But, I had given myself time till 2030 approx. to remain in the nanoscopy domain. This year, after being promoted to full professor in 2022, I had been thinking what do I want from myself while I am in the nanoscopy domain. What is my personal vision for me and for nanoscopy as a scientific domain? Some rough answers have emerged.

***“At a personal level, this year was a year of evaluation and reflection”***

I want the nanoscopy domain to have a good quality master degree program by 2030, hopefully given internationally to develop a workforce that can support research, innovation, application, and ground-level impact creation. And I want me to play a role in the development of such a program. My new course, Waves and Optics, is probably the foundational stone there. I hope I can develop, co-develop a new course every two years which I see as an integral component of such a study program. I hope I can participate or support other course from optics and allied multidisciplinary subjects within the scope. I don't think that I should be the lone soldier here. I will be one of the many soldiers, and probably there will be several better than me. But, I see a need for a unified vision for what such a course should look like, what should it achieve, how should it be implemented. And so on. The details will slowly emerge, I may join forces with researchers worldwide already delivering/planning such courses.

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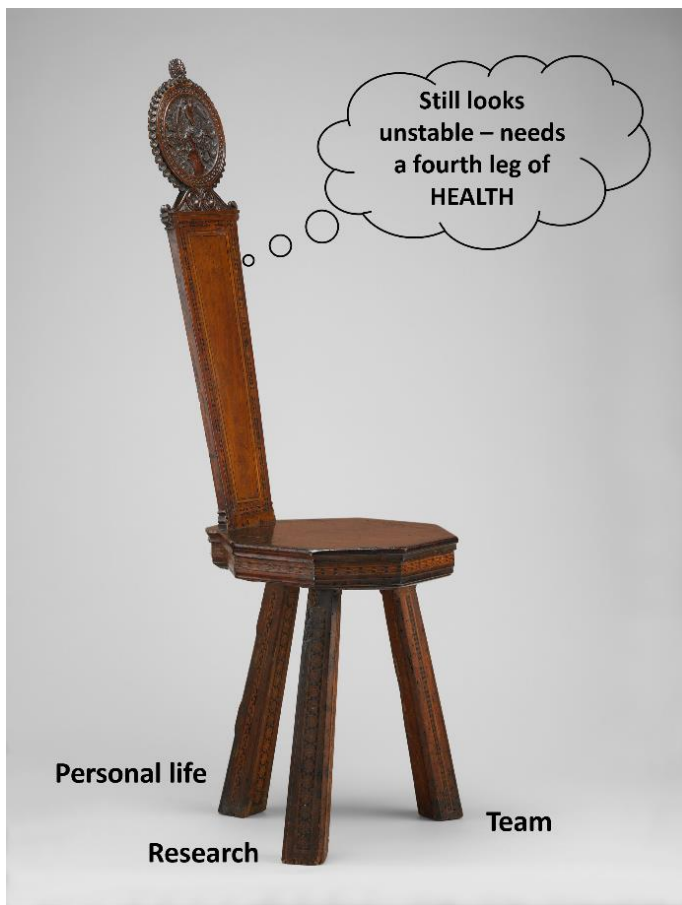
I hope that the nanoscopy domain thinks of nanoscopes beyond resolution, penetration, etc. Beyond such quantitative numbers which may not relate to the actual value nanoscopes should create. Nanoscopes, as I see, will create value in the new insights we can derive for given applications (for example, metabolism in heart cells). My current abstract and intuitive opinion is that the real question about a suitable nanoscope then is not resolution or penetration. It is whether what the nanoscope shows is reliable. We probably need to evaluate nanoscopes for qualitative aspects such as interpretability, reliability, inferability, and so on. In my little head, there is an abstract multidimension performance space in which resolution, etc. are certain dimensions, and qualitative aspects for a given application are the other dimensions. In that multidimensional space, we could place each microscopy/nanoscopy technique as a point. That would say which microscope is best suited for that application. But, I realize that digressed from the big picture to a narrow detail just now. Returning to the big picture, it appears to me that development of microscopes and nanoscopes will soon come to a pointless standstill (a local minimum in the parlance of optimization theory) if we keep on chasing the elusive resolution. Resolution has been an important chase, a big scientific endeavor, and a big accomplishment. But, we need to move on. We, as a research community, need to move towards newer and now more meaningful ambitions. I would like to play a part in it. Anything ranging from a vocal piece to an opinion maker, but I would like to do something about it.

Another important thing that I would like to do is to create a network of inverse imaging scientists worldwide. We are all working on either fundamental mathematical problems or applied problems with context to real systems. Someone in photonics, someone in acoustics, and then someone in astronomy. As we specialize with our own applications, we also start closing doors on ideas from other applications and physical systems which sometimes can be directly used, sometimes can be adapted, and often can simply serve as an allied knowledge. As an inverse imaging scientist, one of my strengths has been that I have hopped from one application domain to another every few years, bringing new ideas to the new domain I chose and imparting longevity to the old ideas which were reaching saturation in their original domain. But, this process is individual and time consuming. If we, the scientists in inverse imaging, form a

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community – we will have enrichment available as an easy option. I want to do something about it.

Now, I reflect a little bit on other things around work which had an effect on me on a personal level. This year has been challenging in terms of two professional relationships, which were strained and/or broken. It gave me a scope of introspection and reflection, and taken a significant emotional toll, but one has to find positive aspects in order to move on. So, after much reflections I conclude that these soured relationships have opened up for more independence of operations, for better reinforcement of the identity of my team, and for newer relationships I guess.



Sabbatical in Singapore gave me a break from the very demanding Tromsø winters. But returning to Tromsø for the autumn semester has been challenging. It seems like my body, my brain, and my mind are not in sync. Probably it is the 40s. I am much clearer with my ambition, feel mentally more efficient, but my body fails to cooperate. It has been health-wise quite challenging, sometimes taking away some good days of work and putting brakes on the pace of work. I do think that it is high time that I give my health some deserved attention, especially if I want to have an academic long haul.

I was having variety of discussions with senior researchers and academicians this year on myriad topics. In one of them, with Prof. Alexander Horsch, we were discussing about 3-4 priorities, like the legs of a chair in which we sit, that help us deal with the chaos around us, stabilize ourselves and focus in times of need. He shared his, and I realized that I had only two up till 2023 – my personal life. A third leg has clearly emerged, and that is mentoring young people in their endeavor to find their best

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selves. I am enjoying research leadership, and working with these young fascinating energetic people, who are our tomorrow. But, I guess I should start thinking of a fourth leg, that of my health. This paragraph is a summary of what I am walking into 2024 with.

Welcome, 2024! I look forward to work with you!

## Achievements

### Journal Articles:

- Yingying Qin, Ankit Butola and Krishna Agarwal, "3D refractive index reconstruction from phaseless coherent optical microscopy data using multiple scattering-based inverse solvers - a study," *Inverse Problems*, accepted.
- Gustav Godtlielsen, Kenneth Bowitz Larsen, Zambarlal Bhujabal, Ida S Opstad, Mireia Nager, Abhinanda R Punnakkal, Trine B Kalstad, Randi Olsen, Trine Lund, Dilip K Prasad, Krishna Agarwal, Truls Myrmed, Asa Birna Birgisdottir. "High-resolution visualization and assessment of basal and OXPPOS-induced mitophagy in H9c2 cardiomyoblasts." *Autophagy* 19, no. 10 (2023): 2769-2788.
- Jadhav, Suyog, Ravali Kuchibhotla, Krishna Agarwal, Anowarul Habib, and Dilip K. Prasad. "Deep learning-based denoising of acoustic images generated with point contact method." *Journal of Nondestructive Evaluation, Diagnostics and Prognostics of Engineering Systems* 6, no. 3 (2023).
- Ghosh, Biswajoy, and Krishna Agarwal. "Viewing life without labels under optical microscopes." *Communications Biology* 6, no. 1 (2023): 559.
- Bhatt, Sunil, Ankit Butola, Anand Kumar, Pramila Thapa, Akshay Joshi, Suyog Jadhav, Neetu Singh, Dilip K. Prasad, Krishna Agarwal, and Dalip Singh Mehta. "Single-shot multispectral quantitative phase imaging of biological samples using deep learning." *Applied Optics* 62, no. 15 (2023): 3989-3999.
- Qin, Yingying, Ankit Butola, and Krishna Agarwal. "3D full-wave multi-scattering forward solver for coherent microscopes." *Optics Express* 31, no. 9 (2023): 15015-15034.
- Banerjee, Pragyan, Sibasish Mishra, Nitin Yadav, Krishna Agarwal, Frank Melandsø, Dilip K. Prasad, and Anowarul Habib. "Image inpainting in acoustic microscopy." *AIP Advances* 13, no. 4 (2023).
- Punnakkal, Abhinanda Ranjit, Gustav Godtlielsen, Ayush Somani, Sebastian Andres Acuna Maldonado, Åsa Birna Birgisdottir, Dilip K. Prasad, Alexander Horsch, and Krishna Agarwal. "Analyzing Mitochondrial Morphology Through Simulation Supervised Learning." *JoVE (Journal of Visualized Experiments)* 193 (2023): e64880.

### Conferences / meetings:

- Somani, Pragyan Banerjee, Manu Rastogi, Krishna Agarwal, Dilip K. Prasad, and Anowarul Habib. "Image Inpainting With Hypergraphs for Resolution Improvement in Scanning Acoustic Microscopy." In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, pp. 3112-3121. 2023.

- Sebastian Acuña and Krishna Agarwal. "MUSICAL – a versatile super-resolution microscopy solution for gentle imaging of physical characteristics of biological samples," 4th International Conference On Optics, Photonics, And Lasers (OPL-2023). 4-7 Dec. 2023, Hiroshima, Japan. (Invited)
- Sebastian Acuña and Krishna Agarwal, "MUSICAL – a versatile computational nanoscopy approach," European Summit On Laser Optics & Photonics Technology (ELOPS 2023), 25-27 Spe. 2023, Barcelona. (Invited).
- Ankit Butola, Sebastian Acuña, Daniel Henry Hansen, and Krishna Agarwal. "Multiscale resolution in structured illumination microscopy." In *Advances in Microscopic Imaging IV*, vol. 12630, pp. 32-34. SPIE, 2023.
- Sunil Bhatt, Ankit Butola, Sebastian Acuña, Daniel Henry Hansen, Jean-Claude Tinguely, Dalip Singh Mehta, Balpreet Singh Ahluwalia, and Krishna Agarwal. "Quantitative phase imaging for tracing the motion of waveguide trapped bead particle." In *Imaging, Manipulation, and Analysis of Biomolecules, Cells, and Tissues XXI*, vol. 12383, pp. 19-26. SPIE, 2023.
- Ghosh, K. Fenton, K. Agarwal, "GelMA hydrogel mechanics affect the collective migration of fibroblast cells", OrganVision Annual Meeting Open Talks, Tromso, 19-21 June 2023.
- Ghosh, K. Agarwal. "Gradient Light Interference Microscopy for label-free detection of early changes in kidney cells embedded in a soft and stiff hydrogel matrix" OrganVision Annual Meeting Open Talks, Tromso, 19-21 June 2023.
- B. Ghosh, S. Acuna, K. Agarwal. "MUSI-tAF: autofluorescence-based super-resolution of collagen fibrils in fixed tissues for density estimation", OrganVision Annual Meeting Open Talks, Tromso, 19-21 June 2023.
- B. Ghosh, K. Fenton, K. Agarwal, GelMA hydrogel mechanics affect the collective migration of fibroblast cells, TERMIS European Chapter Meeting, Manchester, UK, March 2023
- L.E. Villegas-Hernández, V.K. Dubey, S.A. Acuña, H. Mao, J.C. Tinguely, K. Agarwal, B.S. Ahluwalia. "Photonic chip: a high-throughput multimodal nanoscopy platform for histopathology", Focus on Microscopy, Porto, 2-5 April 2023.
- S.A. Acuña, I. S. Opstad, L.E. Villegas-Hernández, B.S. Ahluwalia, K. Agarwal. "MUSICAL: a family of computational techniques for fluorescence nanoscopy", Focus on Microscopy, Porto, 2-5 April 2023.
- B. Ghosh, K. A. Fenton, K. Agarwal, "Gradient Light Interference Microscopy for label-free detection of early changes in kidney cells embedded in a soft and stiff hydrogel matrix", Focus on Microscopy, Porto, 2-5 April 2023.
- Y. Qin, A. Butola, K. Agarwal. "Full-wave multiple-scattering forward modeling for conventional label-free microscope", Focus on Microscopy, Porto, 2-5 April 2023.
- Butola, D.A. Coucheron, P. McCourt, K. Agarwal, B.S. Ahluwalia. "Multimodal nanoscopy and phase microscopy for 3D morphological imaging of liver sinusoidal endothelial cells", Focus on Microscopy, Porto, 2-5 April 2023.
- J.C. Tinguely<sup>1</sup>, I.S. Opstad, S. Acuña, L.E. Villegas-Hernández, V.K. Dubey, F. Ströhl, K. Agarwal, B.S. Ahluwalia, "Optical waveguides for multimodal super-resolution microscopy", Focus on Microscopy, Porto, 2-5 April 2023.
- S. Jadhav, S. Majhi, A.S. Chowdhury, D.K.. Prasad, K. Agarwal, "Reconstructing 3D shape from 3D ThunderSTORM Point Clouds", Focus on Microscopy, Porto, 2-5 April 2023.
- S. Acuña, L.E. Villegas-Hernández, I.S. Opstad, J.C. Tinguely, B.S. Ahluwalia, K. Agarwal, "MUSICAL: results on chip nanoscopy", Focus on Microscopy, Porto, 2-5 April 2023.

- I.S. Opstad, S. Acuña, S. Ströhl, F. Ströhl, B.S. Ahluwalia, K. Agarwal, “Blind reconstruction of challenging raw data outperforms commercial 3DSIM”, Focus on Microscopy, Porto, 2-5 April 2023.
- I.S. Opstad<sup>1</sup>, S. Acuña, AA.B. Birgisdottir, B.S. Ahluwalia, K. Agarwal, “From super-resolution imaging to cellular dynamics”, Focus on Microscopy, Porto, 2-5 April 2023.
- Ghosh, S. Acuña, K. Agarwal. “MUSI-tAF: autofluorescence-based super-resolution of collagen fibrils in fixed tissues for density estimation”, Focus on Microscopy, Porto, 2-5 April 2023
- Butola, S. Acuna, D.H. Hansen, K. Agarwal. “Multiscale resolution in Structured illumination microscopy”, Focus on Microscopy, Porto, 2-5 April 2023.
- Y. Qin and K. Agarwal. “3D full wave electromagnetic modeling of label-free optical microscopes”, 35th URSI General Assembly and Scientific Symposium, Sapporo Japan, 19-26 August 2023. (Invited)
- K. Agarwal, Z. Liu, M. Roy, D. K. Prasad, “Physics-guided Loss Functions Impact Performance of Deep-learning-based Inverse-scattering-problem Solver”, Photonics and Electromagnetics Research Symposium (PIERS), Prague, 3-6 July 2023. (Invited).

#### **Invention disclosures/patents:**

- “Distributed computing solution of MUSICAL for high throughput imaging”, UK International Patent Application. 2206117.0 / PCT/GB2022/053018.  
Patent online. <https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2023209318>
- “Fiber Resolution Targets (FiRST) for both Fluorescence and Label-Free Microscopes and Nanoscopes”, prior art search complete. Patent filed on 16th June 2023. UK international Patent Application 2309111.9
- “Sperm cell grading, selection, and analysis system (Spermotile)”, patent filed on 27th April 2023. UK International Patent Application 2306238.3 .
- “Cyto-Motility and cyto-plasticity in-vitro life cell assay (Cymoplive)”, patent filed on 22nd June 2023. UK International Patent Application 2309453.5

#### **Popular science contributions**

- A popular article “Are Labels Okay? - a message to biologists from DLN researchers” Published by Digital Life Norway, posted on the DLN website, LinkedIn, Twitter, and Facebook.
- A very active blog site hosting WP videos and popular science articles at <https://www.organvision.eu/news/>

#### **Archives**

- Opstad, I. S., Larsen, K. B., Birgisdottir, Å. B., & Agarwal, K. (2023). LysoTracker Deep Red exhibits photoconversion in multi-color structured illumination microscopy. bioRxiv, 2023-10.

#### **Industry outreach and visibility in industry:**

- In communication with confocal.nl, Intelligent Imaging Innovations Inc. (3i) regarding innovations
- Engagement with Nvidia, AMD, Lightspeed photonics, Amazon UK, Google Singapore, Samsung India, Samsung Vietnam, VinAI for scientific cooperation

#### **Visibility drives**

- Organizing focus session on ‘Computational Imaging: Novel System Design and Reconstruction Algorithms’ at PIERS 2024.
- Open Talks, OrganVision Annual Meeting, 19-21 June 2023, 8x open talks by PIs of OrganVision



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- My innovation Spermotile featured in multiple Norwegian newspapers after successful ERC PoC grant (5th May 2023):
    - iTromsø: [https://lnkd.in/g\\_aimp4X](https://lnkd.in/g_aimp4X)
    - Folkebladet . <https://lnkd.in/gDDd5vu7>
    - Khrono. <https://khrono.no/millioner-til-to-norske-forskningsprosjekter/779431>
    - UiT News. [https://uit.no/nyheter/artikkel?p\\_document\\_id=811290](https://uit.no/nyheter/artikkel?p_document_id=811290)

#### **Engagement of research communities:**

- Member, IEEE. Also associate editor of IEEE TGRS
- Senior member, Optica.
- Senior member URSl.
- Award committee member in SPIE MGM Award in Photonics
- Member DLN, including partner project nanoRIP with DLN

#### **Funding applications applied/granted**

- Spermotile, ERC PoC, Principle investigator, 150 K Euros
- Spermotile in REACH Silicon Valley program, Team representative, 15K Euros
- 4x RCN Qualification Grants, for four innovations, WP leader, 50 K Euros each
- NovoNordisk Distinguished Innovator, PI, applied but not granted

#### **Other contributions to your work environment at UiT**

Beyond the normal research leadership and PI duties (~90% of my official time allocation)

- Associate Professor search committee member
- PhD committee leader, Mathias Jensen
- Mentored 2 ERC applicants
- 'EU funding success story', Center of Ice, Cryosphere, Carbon and Climate, 22<sup>nd</sup> November 2023
- During the visit of Indian Ambassador to Norway to UiT in 2023, I was invited to represent a successful Indian in Norway creating research impact at UiT.
- Associate Editor, IEEE Transactions on Geoscience and Remote Sensing

#### **Other commissions of trust outside UiT – typically volunteer**

- Swedish Research Council, invited to be Panel Chair for 2024 funding cycle
- Swedish Research Council, expert international reviewer 2023
- Reviewer, Human Frontier Science Program Research Grants, 2023
- PhD 1<sup>st</sup> opponent, Erik Olsen, Chalmers Technological University, 2023
- PhD 2<sup>nd</sup> opponent, Håvard Ugulen, University of Bergen, 2023

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# 2023: the year of grant writing and puppy training

Ingrid Skjæveland (Norinnova, technology transfer)

Professionally 2023 has been focused on getting external funding for a large project portfolio in addition to getting to know co-workers and personal preferences in depths through personality mapping (JTI). Also the team has been challenged to explore business opportunities outside of our regular focus areas. On a personal level, the year has been focused on raising a new puppy and re-discover the joy of clicker training a dog. Lastly, the perfect warm summer weather in Tromsø stands out and the thrill of ending hiking trips with a swim is a big highlight for the year.

*“the perfect warm summer weather in Tromsø stands out”*



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# Get the ball rolling on commercialization

Lars Sorensen (Norinnova, technology transfer)

In 2023 the process of bringing inventions from UiT to the market has improved drastically. Firstly, being able to understand the technical foundation of various inventions is somewhat set, speeding up the necessary steps for the technology transfer office (TTO) to properly commit funds to prioritize inventions. Secondly, the in-house progression to evaluate, plan, and launch a project based on the invention has been completed several times, improving the speed of which I am able to do this. And lastly, the network of external professionals from industry and academia has been improved. Managing these tasks means the TTO and I are more equipped to faster and better help commercialize new inventions from our researchers.

***“we have expanded our options on actors we can seek advice from”***

During the summer I spent 5 weeks across several states in the US, in a messy mix of vacation and work. At any city I visited, I reached out to their local TTOs, relevant industry players, and attended any relevant conference that could provide value for my project portfolio. The result of this trip has been some invaluable input from small and medium sized industry players in the field of microscopy, strengthening our understanding of the commercial terms we can seek in the event of a licensing or spin-off option for our inventions. Additionally, we have expanded our options on actors we can seek advice from in clarifying the potential and technical interest from our various inventions may have to the customers and end-users alike.

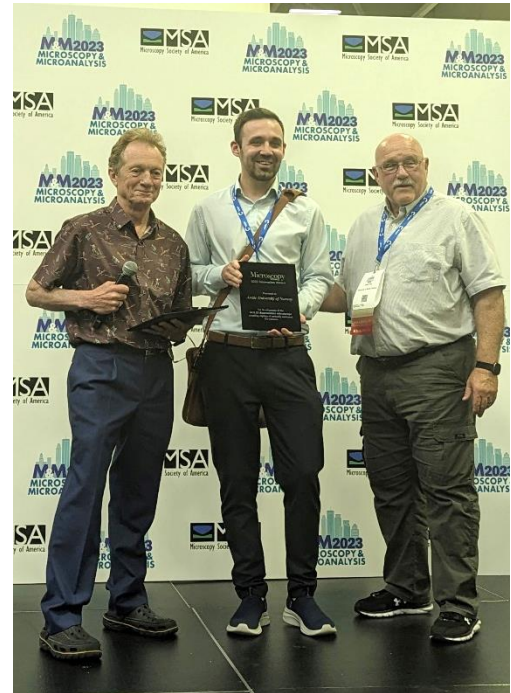
This year has also been a great success in the funding of my projects. Competing with all universities and TTOs in Norway for a national grant, we successfully got grants for the 6 projects applied for. The estimated hit-rate is 75%, meaning it being one of the

most achievable grants, though having all 6 projects go through was still a happy achievement. This means the funds can help the inventors to further develop their inventions, and TTO to meet industry, do market research, and protect the IP of the invention where/if necessary (e.g., patent).

The year is ending with a few new inventions in microscopy, meaning I will be the most likely to be responsible for the TTO process. With these new inventions and my current portfolio, I feel confident we will be able to show that a lot of discoveries from researchers at UiT have the potential to improve science and lives.



*Meeting with industry and potential customers for a few of our future products from UiT*



*Picking up a prize for "best microscopy innovation 2023"*

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# Honorable Mentions

## Krishna Agarwal

There are other heroes in our team, which for different reasons did not see a full-page feature in this report. I, Krishna, on behalf of the team recount them in.

**Aaron Vaughn Celeste:** He completed his master thesis, and I had the honor of being a co-supervisor. He kindly took up the responsibility of handling the dissemination and visibility of our team as a small part-time endeavor. A new handsome website and this report has his sweat (hopefully not blood) behind it. He feeds to me enthusiasm and energy about visibility through vision, ideas, suggestions, and a very warm big smile. Most importantly, he works hard so that it feels easy to us.



**Daniel Henry Hansen:** He was in my team since 2019, 1 week after completing his master defense. He served our team formally as an engineer, but has been a great friend and support for me as I was navigating being a PI for the first time. He has made a big positive difference to many. He is a great scientific mind and master of many trades. He has found a new cause in 2023 – a new place to make a difference – he has joined a UiT spin-off which needs people like him.

**Deanna Wolfson:** She continues to be a great support since a nice August (literally the month) day in 2016. That day a very apprehensive me was considering if Tromsø is a nice next place for me – a place for me to write Marie Curie application and then ERC. That is as far as my thought went then. She was right – this place deserves a chance and it surprises you with what it can offer. I have not just made great collegial friends who continue supporting my crazy self, but built a team I can be proud of. I lean on Deanna and Jean-Claude more than I express, they are backbones of our bioimaging and microscopy activities and form a firm agile matrix which integrates our team members. I am proud



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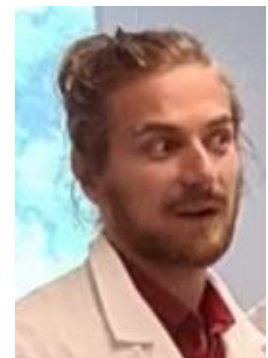
of Deanna to step out of her comfort zone and step into a leadership role. She proved many of us wrong and made many of us very proud (and less burdened with several responsibilities).

**Hallvard Myhre Vittersø and Sigurd Hellberg:** They both did their master thesis with my group. They worked on quantitative phase microscopy and its used with AI to derive more from the microscopy data. Each took a different problem, crackled their knuckles, and got working fearlessly. Challenges ahead did not daunt them and they submitted good master thesis. Sigurd's work, with generous help from Ankit, is now being planned for publication, for which Sigurd spent two months in an engineer position right after his master thesis submission.



**Himanshu Joshi:** A PhD student at IIT Delhi, who I co-supervise, I know him more by his voice in the digiPhysiCoffee meetings, his emails and his work, than by his face. But I know that I am dealing with a person of strength, a student who is ready to put in effort to grow, and someone who is ready to take the chase. I hope to know him more in the near future. Hopefully, he can visit us in Tromsø sometime soon so that we can work more closely and grow as researchers.

**Kamil Piotr Wiejaczka:** So far, Kamil has spent a short few weeks with our team. His eyes shine when he thinks of scientific work, an involuntary smile sneaks and spreads itself wide on his face. And I see the determination written all over him to make his way into science, come what may. This is inspiring. For someone like me, who never needed to imaging a day without science being (in) my life since I was 11 year old, I think I had never known what it was like to seek and chase science. It's a love of its own form – filled with hope, pregnant with expectations, and ready to dispel any shred of doubt – it's a form of love that is strong on its own (like an EM wave propagating without the need of a medium). And Kamil made me experience this through him. Thanks a lot, Kamil!





**Suyog S. Jadhav:** Suyog is that member of my team who has sort of always been around – but never in. An excellent mind who is treat to work with, also equipped with a dry wit and good humor. He is someone who makes me realize how crazy I am with no influence of alcohol. And can he slip into roles – scientist, writer, engineer, programmer, creator, idea popper, listener, challenger! When he says ‘haan, ye ho jayega,’ one knows it will be done with not an ounce of doubt. He is Rahul Dravid, the wall!

**Yu Zhong:** Yu joined our team in 2022 as an adjunct associate professor in order to support our activity on inverse problems as an adviser, co-supervisor, and mentor. He has filled the void created by my need to cater to other administrative responsibilities in my team and projects. He has in fact led this section of the activity better than I could reasonably do even with no other responsibility. He brings a state of being grounded, an advantage of depth of expertise, and an experience of mentoring young people at different stages of their career. He contributes profoundness and perspective to our team which is steeped in breadth of experience in academics, research labs, and now his own spin-off.



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# Outlook for the next year

Krishna Agarwal and Aaron Celeste

We have several journal articles in the pipeline. I look forward to their journey from our tables to their readers. I hope we can work on impact factor (also), longevity and shelf life of our articles. We need to amp up our publication output in the group as a whole. This will indeed call for hard work, but this is not a worry. We have a high quality line up and each of these article is backed by a high-octane young researcher. Not the polar night nor the midnight sun can stop them. There can be windows of slowing down, but there is no stopping them.

Quite some projects are ending in 2025, and we need to start preparing for the next round of funding applications. The team size is close to optimal and funding is important to keep it this way. As a group, it seems like we are at consensus on not becoming more diverse in disciplines for now. We would like to focus on reinforcing our strengths and also training new group members (especially master and PhD students) on the expertise existing in our group. This will reflect in our funding proposals and planning for the near future.

We want to work more on training and education from multidisciplinary aspect. There are suggestions to organize longish lectures on specific topic, where the lecturer (one of our team members) does not bring slides but goes old school with a board and pen, and the students (the remaining us) bring our own notebooks and pens and make notes for ourselves. We want to savor the topics, slow down, ask silly questions, learn or revise some basic scientific language of the topics our group deals with. It will be difficult to organize, and probably an ad hoc approach will suit better than forcing a regularity in the initial tests. The next semester, the group members and not Krishna will lead and organize the digiPhysiCoffee meetings, so that they can identify what soft skills or peripheral-to-science topics they want to work upon.



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As we advance into the upcoming year, one of our objectives is to significantly elevate the visibility and accessibility of the groundbreaking work coming out of 3DNanoscopy. In alignment with this goal, we are committed to playing a pivotal role in executing our social media strategy. Fundamental to our mission is the belief that knowledge should be open and accessible.

***“My focus will be on bridging the gap between our research group and the wider public.” - Aaron***

This will involve regular updates on platforms like Twitter, LinkedIn, and YouTube, showcasing our latest research findings and upcoming events. The effective dissemination of articles and research findings is key. Through these efforts along with our collaboration with the Digital Life Norway (DLN) newsletter, our research will reach a diverse array of readers, extending our impact beyond the icy north.

Text by ChatGPT



Image by ChatGPT

Last but not the least, in our group, scientists are more important than the science. Gravity existed before and continued after Newton. But, we needed Newton to think of the apple that fell down and did not fly away. We will continue to build an environment that is conducive to scientists for their happiness and health, growth as individuals, and realization of their goals in science and life.

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**Conceptualized, edited, and compiled by:**

**Aaron Vaughn Celeste**

**Krishna Agarwal**

**On 21<sup>st</sup> and 22<sup>nd</sup> November 2023**

Content contributed by team members of the 3DNanoscopy group at UiT The Arctic University of Norway. Some help of our collaborators ChatGPT and ChatUiT was used. Some content was taken from online sources as snapshots. No ownership is claimed or intentional misuse has been exercised for these content, and we have judged from our limited knowledge these to be open access in the form we have taken. Where possible, source has been linked or credited.