HIP TECHNOLOGY PROGRAMME OVERVIEW

Filip Tuomisto, Department of Physics and Helsinki Institute of Physics
University of Helsinki

AIM OF THE PROGRAMME

- The HIP Technology Programme promotes research, development, innovation, technology transfer and pre-commercialization activities with links to CERN
- Synergies with other international big science initiatives are actively sought
- The programme consists of 2 larger projects:
  - materials technology challenges in existing and new large accelerators (CERN)
  - radiation and nuclear safety, security, and safeguards (STUK)
- In addition, 3 medium/small projects:
  - robotics for monitoring and intervention purposes in accelerator tunnel conditions (CERN)
  - x-ray spectroscopy for materials in extreme conditions (CEA)
  - AlN-on-Si quantum emitters and sensors

PROGRAMME STRUCTURE IN 2026

Large projects	Medium and small projects	Programme director
• RAD3S → 2028 • MAT → 2026 • HIP budget: 201 k€	• ROBOT → 2028 • IDEAL → 2026 • AQUES → *2027* • HIP budget: 161 k€	• Industry activation • New initiatives • HIP budget: 40 k€

LARGE PROJECTS

- Radiation and nuclear safety, security, and safeguards (RAD3S) 2026 – 2028
  - Project manager @ UH/STUK: Teemu Siiskonen
  - co-manager @ JYU: Paul Greenlees
  - co-manager @ UH/HIP: Peter Dendooven (visiting prof at HIP 2/2019 →)

- **Materials for Accelerator Technologies (MAT) 2024 – 2026**
  - **project manager @ UH/HIP: Flyura Djurabekova**
  - **up for renewal 2027 – 2029**

MEDIUM AND SMALL PROJECTS

- Robotics and AI for monitoring and intervention (ROBOT) 2026 – 2028
  - project manager @ Aalto: Risto Ojala
  - co-manager @ TUNI: Roel Pieters
- Improved detection for elemental analysis at laboratory (IDEAL) 2024 – 2026
  - project manager René Bès, UH/HIP
- AlN-on-Si quantum emitters and sensors (AQUES) 2025 – 2027
  - project manager Nikhilendu Tiwary, Aalto University

- Constantly looking for more and new small projects (sometimes successfully!)

RADIATION AND NUCLEAR SAFETY, SECURITY, AND SAFEGUARDS (RAD3S)

Project leader: Prof. Teemu Siiskonen
2026 – 2028

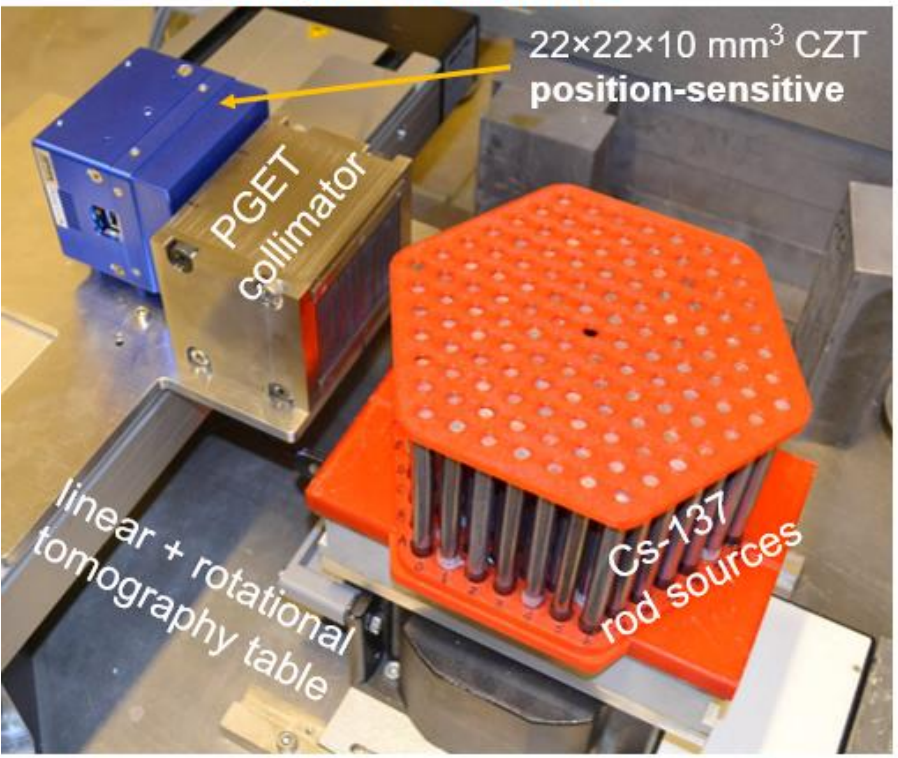
RAD3S – Radiation safety, security and safeguards

- Three subtopics
  - Radiation detection and environmental monitoring
  - Imaging technologies for radiation sources incl. spent nuclear fuel
  - Dosimetry and medical applications
- Funding is actively sought, many EU funded projects are ongoing (either at UH, STUK or JyU) that support RAD3S activities
- Several PhD students engaged in RAD3S activities

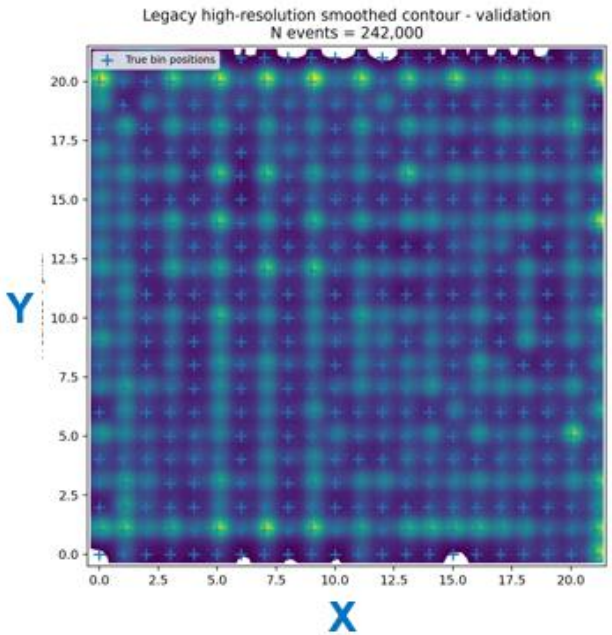
Radiation safety and safeguards – Imaging technologies for spent nuclear fuel and radioactive sources – Peter Dendooven

large position-sensitive CZT detectors

passive gamma emission tomography of spent nuclear fuel



neural network for detector interaction position

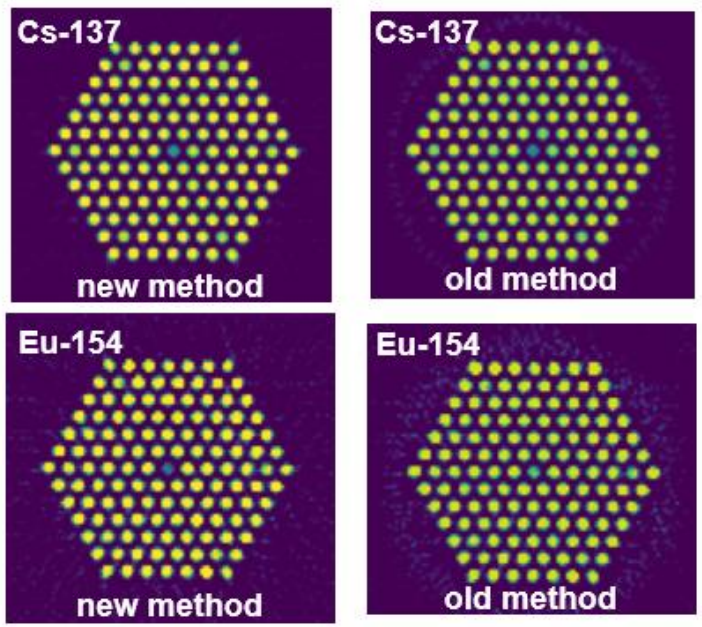


neural network output for collimator grid measurements

advanced PGET image reconstruction

using at the same time:
Cs-137 (662 keV) and Eu-154 (1274 keV)

↓ high emission high attenuation + ↓ low emission low attenuation



Radiation Safety and Security: Radiation detection and environmental monitoring Activities at JYU / JYFL-ACCLAB – Paul Greenlees

- Many projects ongoing and new funding being actively sought (PV, BF, MATINE, …)
- HIP funding limited and majority of work funded through other sources
- Current staff at JYU working on 3S themes:
  - Kari Peräjärvi, Professor in Practice (20% JYU / 80% STUK)
  - Paul Greenlees, Professor, Head of Department
  - Ville Bogdanoff, Project Researcher (PhD thesis Autumn 2026)
  - Philson-Amanda Aden, PhD researcher (PhD thesis 2027)
  - Jaron Virjo, PhD researcher (PhD thesis 2030)
  - Panu Rahkila, University Researcher (DAQ expertise)

- Strong links to STUK, CORES (Steering Group), Finnish Defence Forces, Finnish Customs, …
- New MSc(Tech) ”DI program” in Technology for Safety and Risk Management, first intake 30 students in 2026, strongly based on expertise in Department of Physics
- Publications and PhD theses partially supported by HIP funding forthcoming

Radiation Safety and Security: Radiation detection and environmental monitoring Activities at JYU / JYFL-ACCLAB – Paul Greenlees

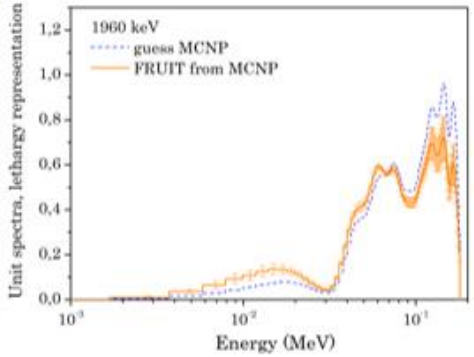
Conceptual drawings of the integrated multipurpose probe.

- Themes 2026-2028:
- Development of radiation detection techniques for environmental samples (mainly air filters)
  - New techniques for identification, processing, imaging and analysis of radioactive “hot particles”
  - Will feed directly into processes used by authorities
- Development and commercialisation of direction and nuclide-sensitive radiation detectors (hand-held)
  - Patenting process ongoing, JYU POC funding for Ville Bogdanoff, BF application in preparation
- Extension of use cases for modern digitising electronics, data acquisition and list-mode data
  - Improvement in capabilities of Radiation Portal Monitors
  - Improved detection of nuclear materials such as HEU

Medical applications – improving safety and efficacy of radiotherapy
Teemu Siiskonen

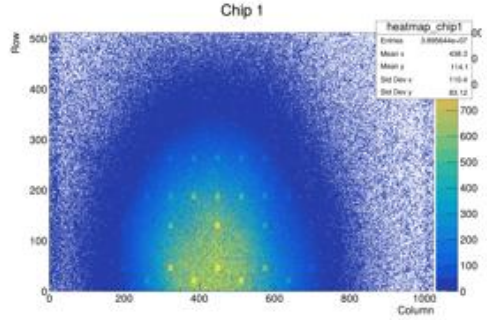
Development and calibration of neutron irradiation facility at accelerator laboratory

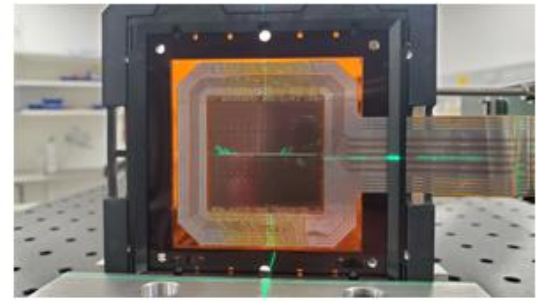
- Proton beam to LiF target
- Production of quasimonoenergetic neutrons below 500 keV, traceable to SI through STUK
- PhD students Mila Myllymäki, Santeri Saariokari, MSc Aappo Perkkiö



Pixel detectors for hadron therapy beam QA

- ALICE Pixel Detectors for real time beam monitoring
- Analysis of beam test data ongoing
- Interviews with proton therapy centers about their needs
- PhD student Hira Sharif, together with JYFL





Optimisation of radiotherapy imaging

- Machine learning for organ segmentation and dosimetry
- Model adaptation ongoing with patient CT data
- Funding from PIANOFORTE SONORA project
- PhD student Saara Alenius, together with HUCH

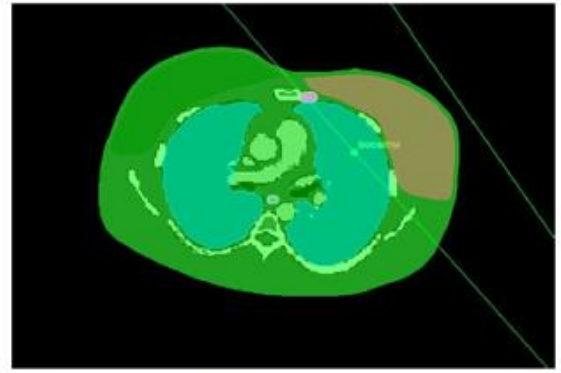


Figure S1. Location of the isocenter, 3D slicer, Saara Alenius

ROBOTICS AND AI FOR MONITORING AND INTERVENTION (ROBOT)

Project leader: Prof. Risto Ojala
2026 – 2028

HIP SAB - ROBOT activities (-2026)

Remote robotic access for inspection, maintenance and interventions: webpage

Personnel

- Roel Pieters (Prof.) link
- **Kulunu Samarawickrama (Doc. student)**
- Osama Tasneem (Doc. student)

Contact, PI: Roel Pieters, roel.pieters@tuni.fi

Publications:

- Human–robot collaborative visual inspection with Large Language Models, RCIM, 2026
- PVRA: A Pointwise Key-point Voting Framework for Robotic Assembly, Under review, 2026.

Related projects:

JARVIS (Horizon Europe, Innovation Action, 2023-2027)

PERFORM (Research Council of Finland, project, 2025-2029)

Intelligent Work Machines Doctoral program (Research Council of Finland, 2024-2027)

Personnel

- Risto Ojala (Assist. Prof) link
- Kari Tammi (Prof.) link
- **Pejman Habibiroudkenar (Doc. student)**

Contact, PI: Risto Ojala, risto.j.ojala@aalto.fi

Recent Publications:

- Non-Repetitive Scan Correction for LiDAR Odometry via Spatial Analysis in CERN Facilities, IEEE Access, 2026.
- Towards autonomous execution of safe and precise robotic radiation surveys in the super proton synchrotron, *Journal of Intelligent & Robotic Systems,* 2025.

Related projects:

ScaleDown (European Regional Development Fund, 2025-2027))

TwinFlow (Business Finland, co-innovation, 2024-2027)

Intelligent Work Machines Doctoral program (Research Council of Finland, 2024-2027)

TAU activities

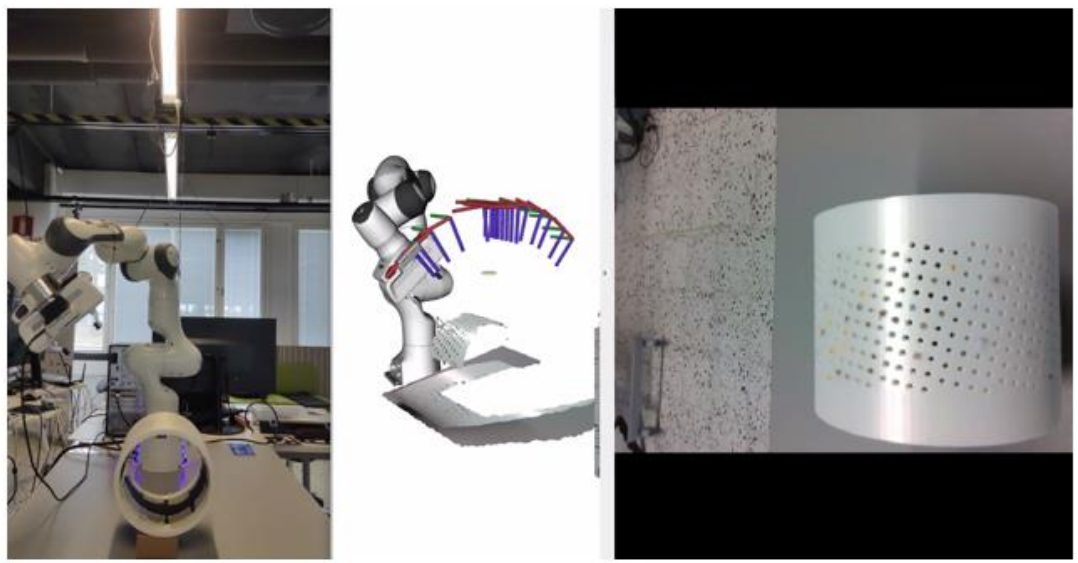
- **Towards Autonomous Robotic Assembly, 2026**

Modern computer vision has enabled partial autonomy in robotic assembly manipulation. However, performing autonomous manipulation of a progressive assembly demands a more specific set of skills, in addition to perceiving the objects. We present a 3D keypoint-based modular learning framework to learn assembly dependencies to infer actionable outputs given a RGB-D input of an assembly scene.

Assembly instance results. Green boxes indicate target-pose estimates and red boxes indicate assembled-target estimates; dashed boxes indicate the corresponding ground-truth poses

- **Human-Robot Collaborative Visual Inspection with LLMs, 2026**

Large Language Models (LLMs) offer new possibilities for intuitive human-robot interaction through natural language. We present a fully offline, closed-loop robotic assistant for visual inspection tasks in HRC settings. The system supports speech-based interaction, where the LLM produces custom responses for robot perception and manipulation actions.

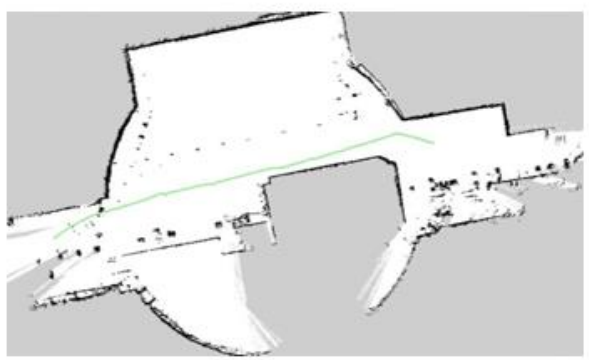


Result of robotic visual inspection performed on a dummy object. Center image depicts the LMM generated target poses. Right image shows the camera's view (on robot arm) during the robotic inspection process.

Aalto activities

- **Towards Autonomous Execution of Safe and Precise Robotic Radiation Surveys in the Super Proton Synchrotron, 2025**

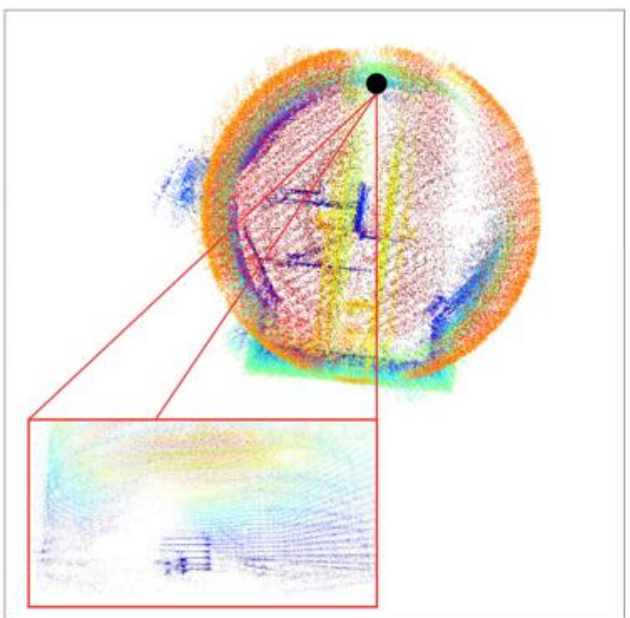
Automating SPS radiation surveys required navigating complex spaces (pillars, doors, open areas) while ensuring measurement accuracy and safety, including autonomous charging for long-term deployment and handling difficult zones like beam dumps. Robots used supervised navigation, autonomous docking, and manipulator arms for sensor deployment, controlled via a telerobotic GUI. LiDAR mapping and SLAM Karto enabled accurate navigation, validated through tests like the MIRA campaign at DESY.



-Left: Mira3 robot used for robotic interventions –Right: Map created using Karto SLAM at Dump area

- **Non-Repetitive Scan Correction for LiDAR Odometry via Spatial Analysis in CERN Facilities, 2026**

A novel LiDAR registration technique was developed, which enables the use of non-repetitive LiDARs for mapping purposes. Non-repetitive LiDARs are actively used in CERN, as they provide laser scans with a wide coverage of the environment with little cost. However, mapping applications suffer from the scan patterns used in the LiDARs. Maps are needed by mobile robots for navigation. Our approach uses feature recognition and kinematics to produce high-quality laser scan maps from non-repetitive LiDARs.



AIN-ON-Si QUANTUM EMITTERS AND SENSORS (AQUES)

Project leader: Dr. Nikhlendu Tiwary
2025 – 2027

AQUES project

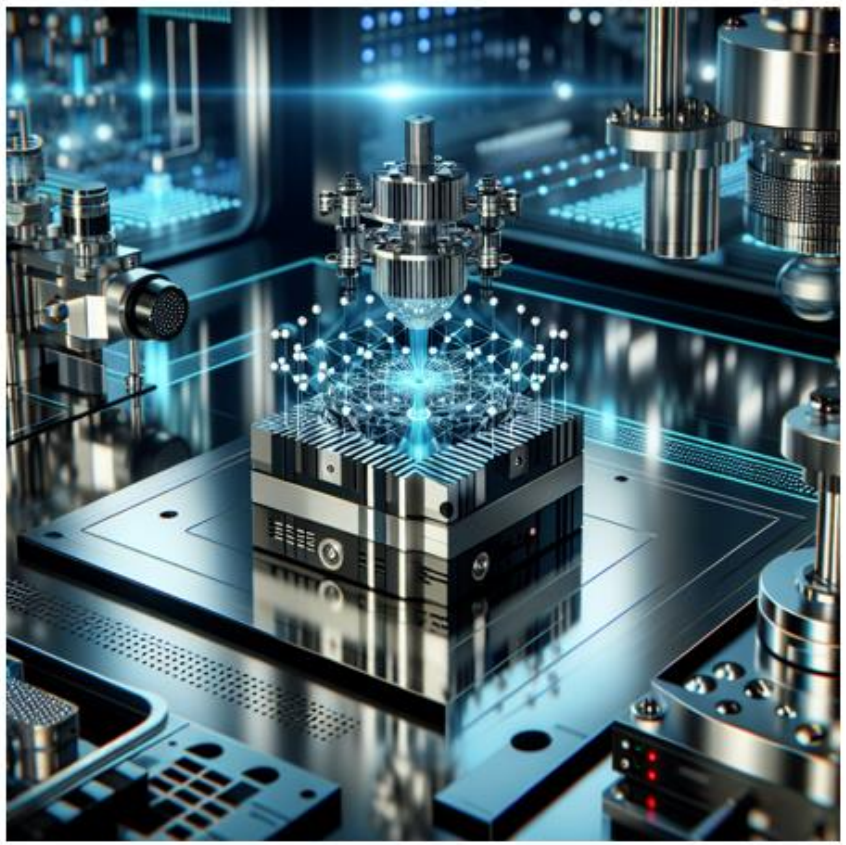
Project duration:	**1.1.2025-31.12.2027 (36 months)**
Project budget:	**180 000 Euros**

Objectives:

- Investigation of intrinsic point defects as single photon emitters (SPEs) in AlN grown on Si
- Engineering specific defect formation by ion implantation
- Characterization of the defects as SPEs

Applications:

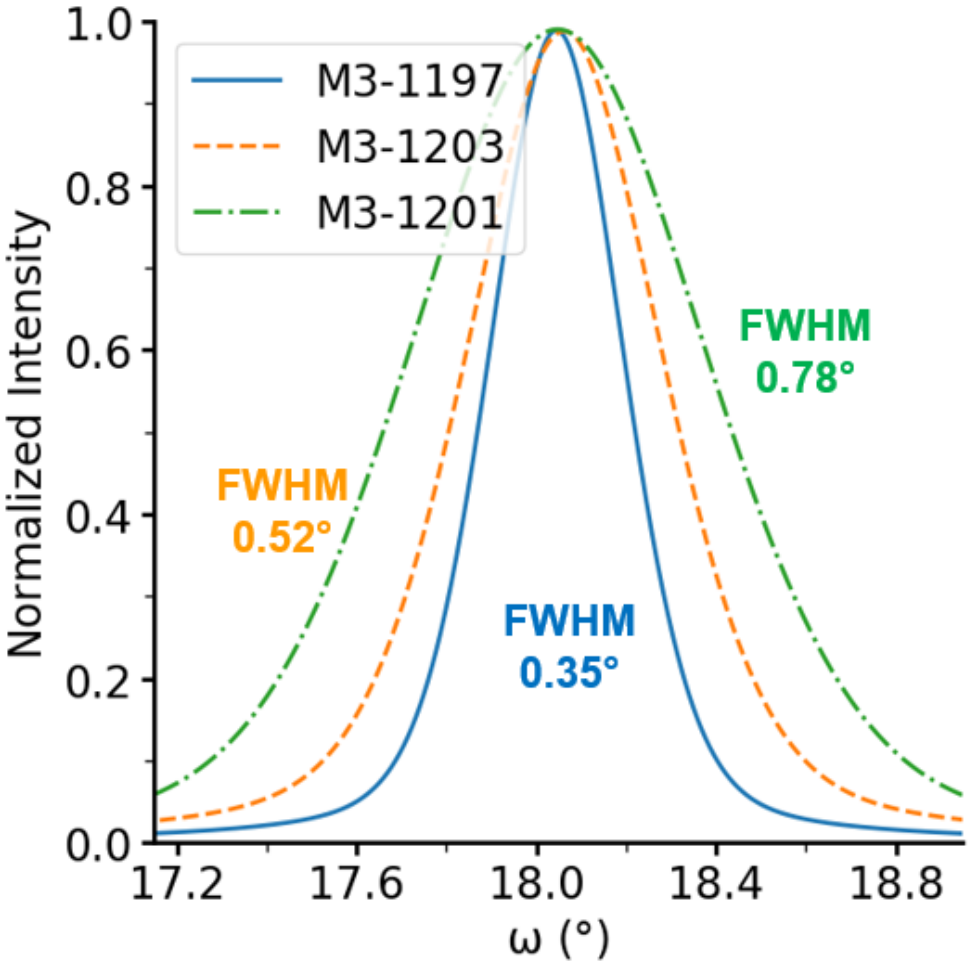
- Quantum communication and computing, magnetometers, biosensors

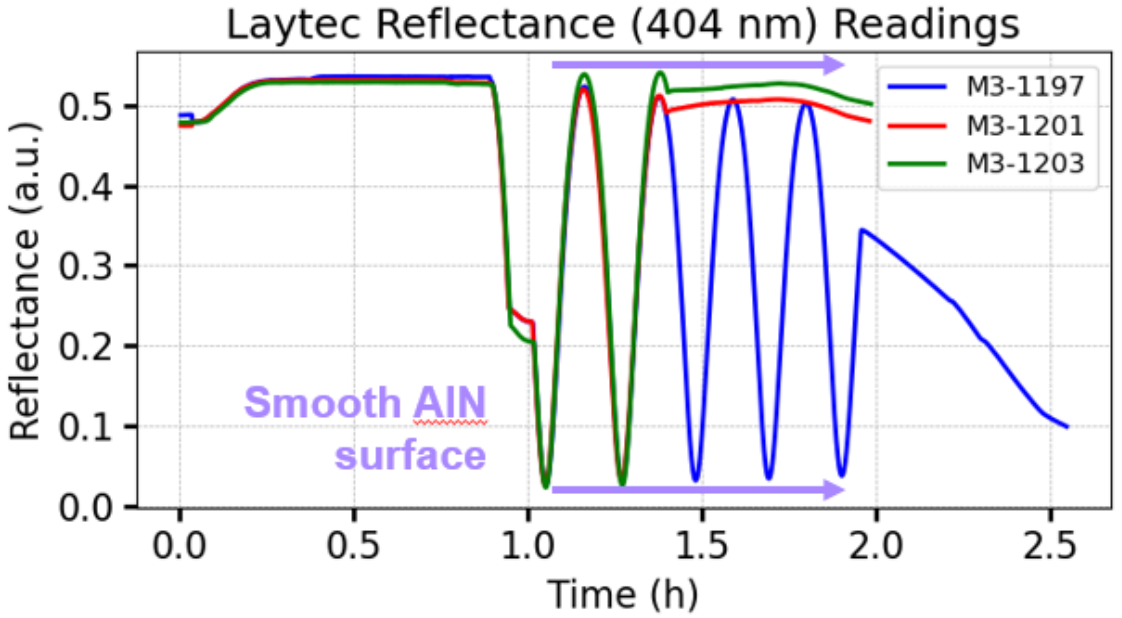


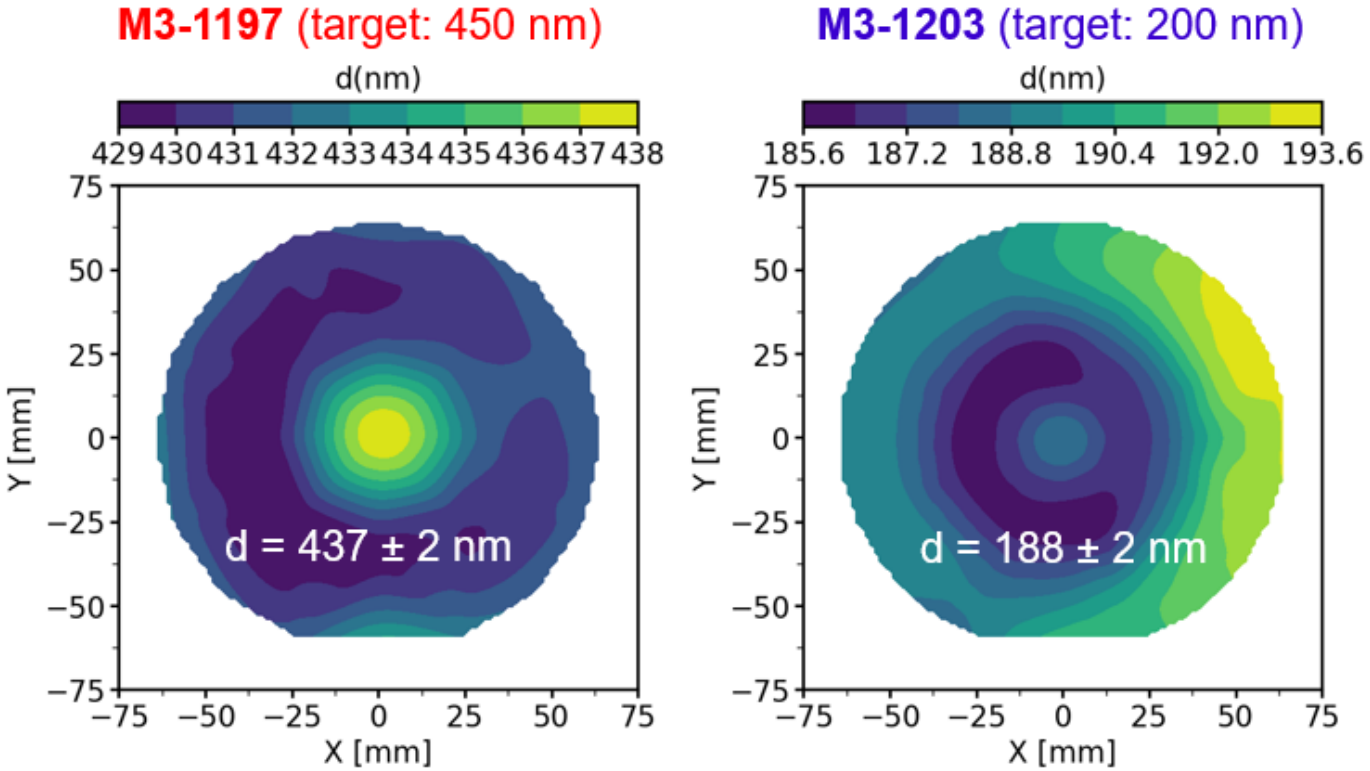
AI image for illustration of applications utilizing SPEs

A!

MOCVD Process Optimization for AQUES







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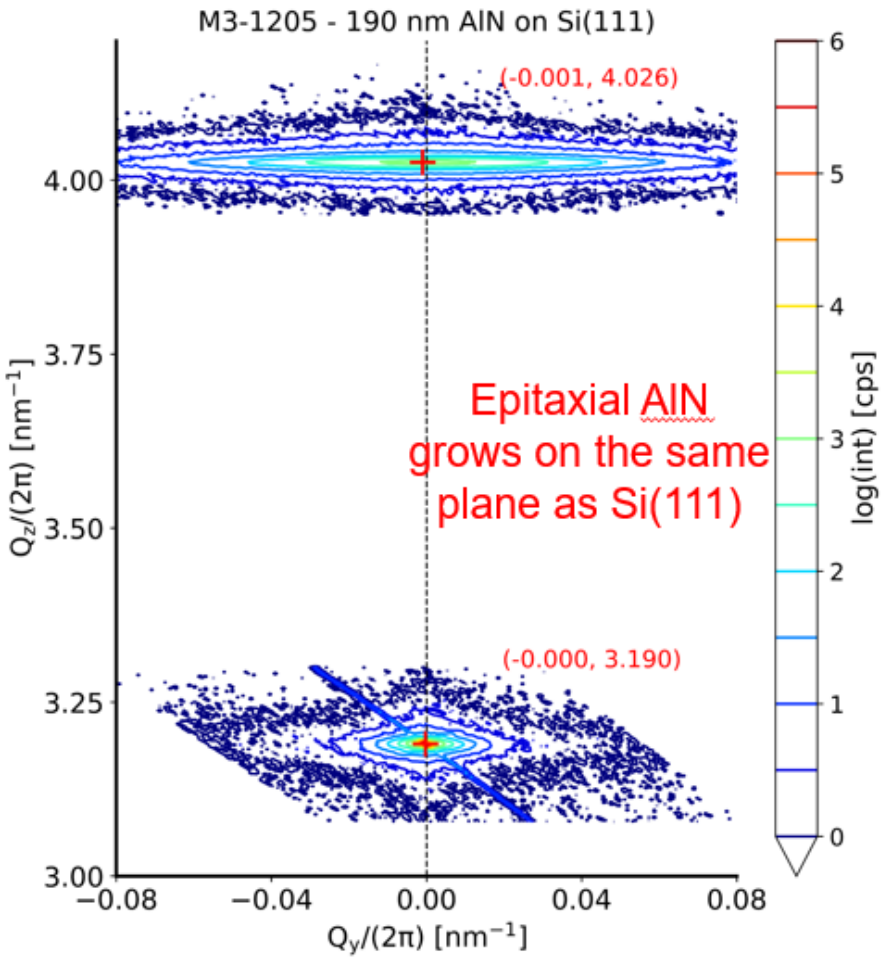
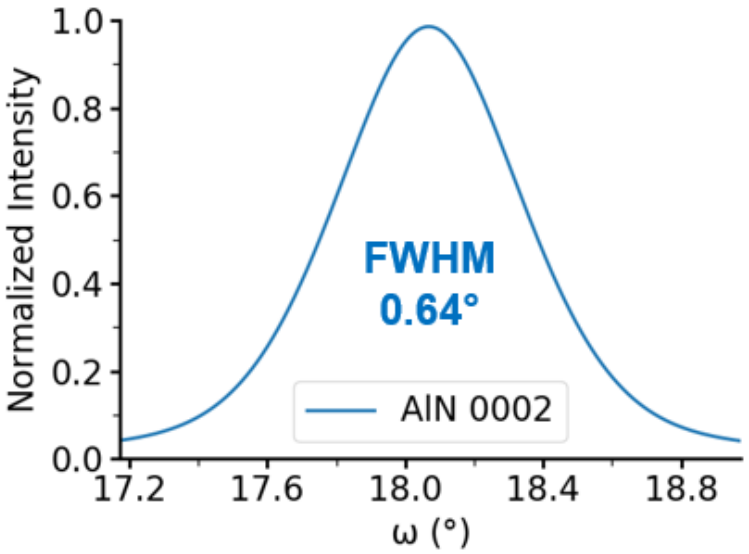
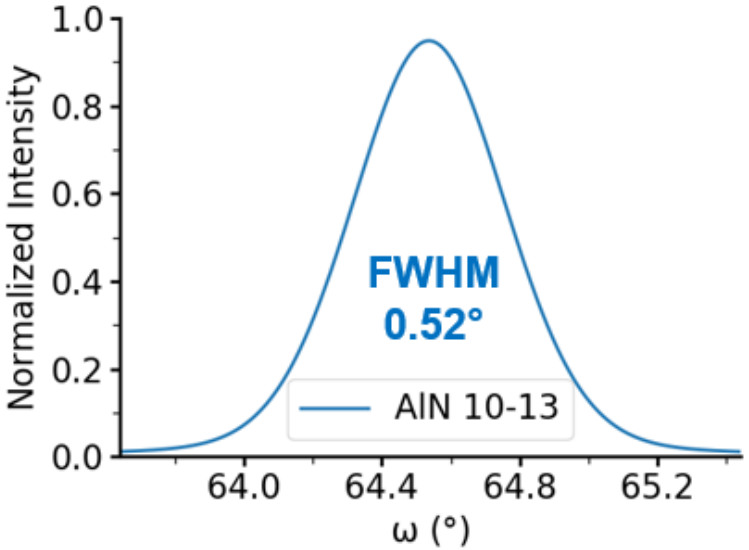
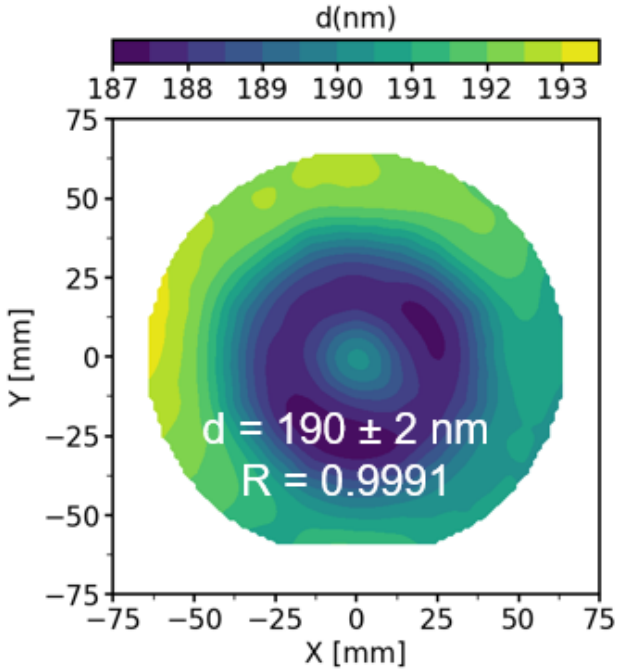
HR-XRD of M3-1205 – 15s TMAl

AlN grown on Si(111) plane; Epitaxial film with (many) dislocations







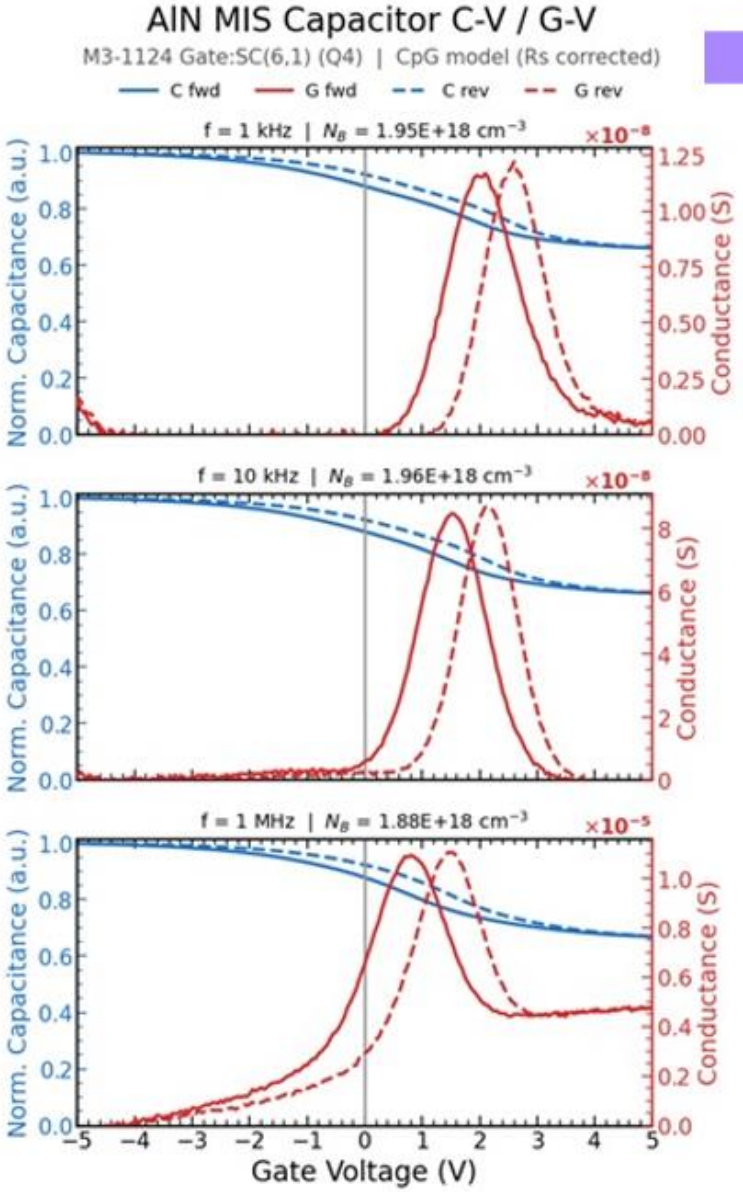


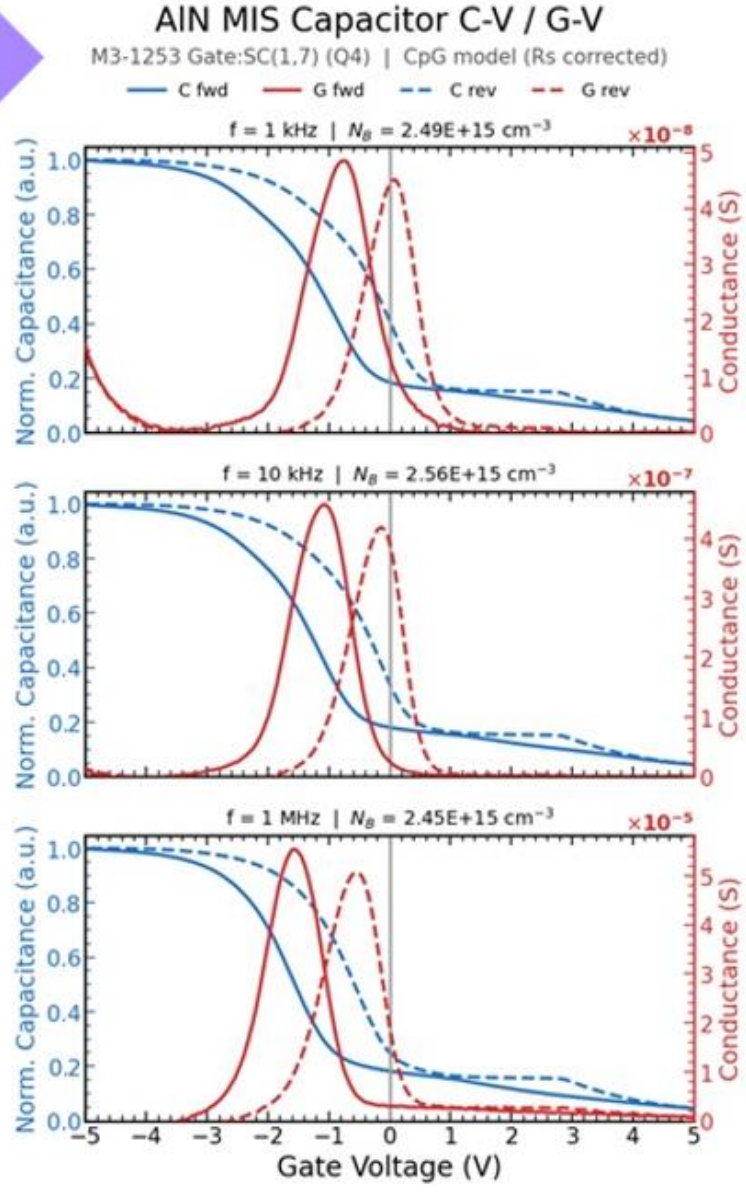
Mixed TDD: 1.2×10^{10} cm^{-2}

Edge TDD: 2.3×10^{10} cm^{-2}

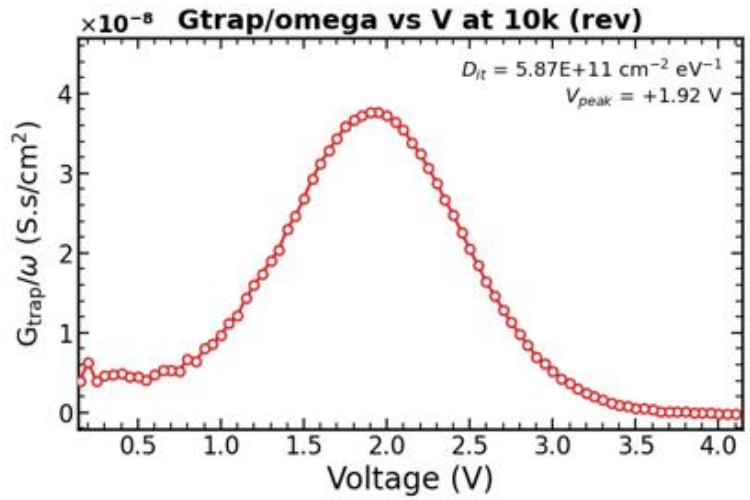
A!

Interface Engineering to Reduce Al doping

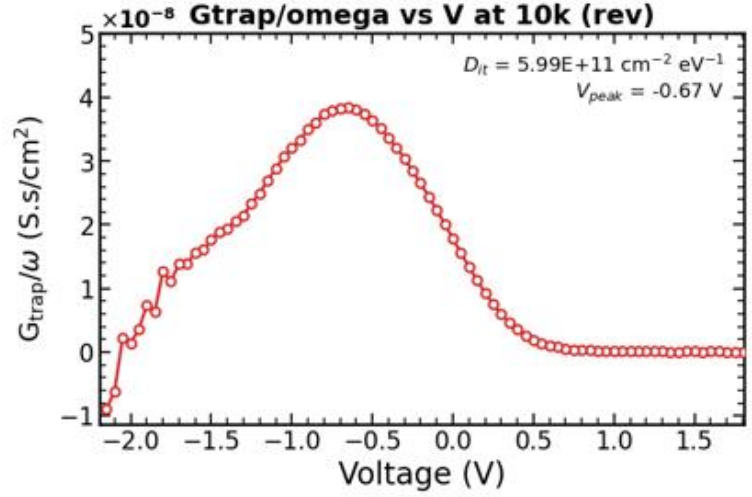




M3-1124 (NH3 15s)



M3-1253 (TMA 10s)



Summary and next steps

- Summary
  - MISCAP fabrication and characterization on NH_3 and TMAl pretreated samples to reduce in-situ Al doping and engineer interfacial traps. TMAl pretreatment is effective to reduce Al doping and engineering interfacial traps/charge
  - Samples with 450 nm and 200 nm thick AlN on Si were sent to UoH for defect and impurity analysis with PAS and ToF-ERDA respectively. The measurements are done and analysis is ongoing
- Next steps
  - Impurity analysis → Ion Implantation → Characterizations

IMPROVED DETECTION FOR ELEMENTAL ANALYSIS AT LABORATORY (IDEAL)

Project leader: Dr. René Bès
2024 – 2026

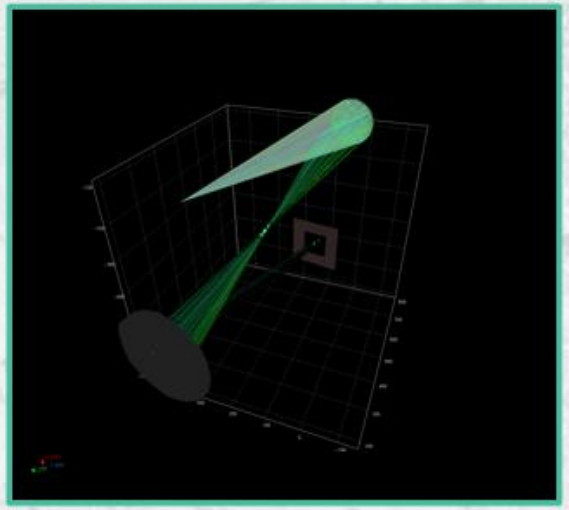
IDEAL PROJECT

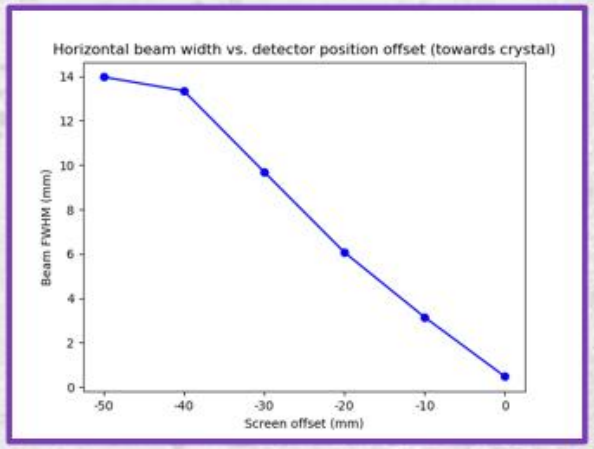
HELSINKI INSTITUTE OF PHYSICS

Center for X-ray spectroscopy

IDEAL = **I**mproved **D**etection for **E**lemental **A**nalysis at **L**aboratory

- Goals: developing new detection system(s)
  1. To bringing synchrotron techniques back to the laboratory → new detectors
  2. To develop new instrumentation for synchrotron experiment → mini-spectrometers
- Status of the project:
  - New detector's goal progressing very slowly:
    - ✓ **Lack of personnel at detector laboratory to pursue prototyping of ultra-thin SDD** for incoming beam intensity measurements
    - ✓ Drawing of masks and processing at Advafab scheduled this autumn
  - Mini-spectrometer's goal progressed:
    - ✓ First tests of spectrometer show difficulties in manual alignment (need to be done once)
      - → acquisition of motorized movement to ease the process (delivered in April)
      - → new monochromator bought from ESRF to use our existing device as proper X-ray source for alignment (delivered in July)
      - → **X-ray tracing simulations on-going to ensure alignment is effective and fast using our newly developed approach + to develop a more compact design with MiniPix**
    - ✓ Proper alignment planned in September/October





IDEAL FORMAL RESULTS

- PhD thesis by Simon Orlat
  - Cooperation with CEA Marcoule, co-tutelle University of Montpellier
  - Submitted 8/2026
  - Defense expected end of 2026

- Articles:
  - S. Orlat, I. Prozheev, I. Arts, G. Leinders, E. Bazarkina, K. Kvashnina, F. Tuomisto, P. Martin, P. Moisy, and R. Bes, **Crystal-field splitting strength of U-6*d* orbitals in $NaUO_3$, KUO_3 and $RbUO_3$**, Journal of Synchrotron Radiation **32**, 1 (2025).
  - S. Orlat, P. Martin, P. Moisy, F. Tuomisto, and R. Bes, **Optimisation of laboratory-scale x-ray absorption spectroscopy (XAS) apparatus for nuclear fuel research**, Review of Scientific Instruments **97**, 075203 (2026).
  - S. Orlat, P. Martin, P. Moisy, F. Tuomisto, and R. Bes, Reflective and geometrical properties of spherically bent crystal analysers in Johann asymmetric configuration, submitted.

INDUSTRY & TECHNOLOGY & INFRA NEWS

AQUES is a ”spin-off” of a larger collaboration between Aalto University, VTT, University of Helsinki, LUT University, and several Finnish companies (incl. Okmetic) focusing on development of WBG and UWBG semiconductor technologies

- WIBASE: ~8 M€ co-innovation project funded by Business Finland 2025-2028
- Power Electronics Association (Industry-Academia) founded in December 2025
- Flagship proposal POLARIS: Power-electronics Leadership for Advanced, Resilient, Integrated semiconductor devices and Systems
  - submitted in March 2026 to Research Council of Finland, RCF budget ~ 10 M€ for 2027-2030 (+ eventual extension for another 4 years)
- CHIPS JU RIA – ALMINE – AIN made in Europe: next generation electronics based on Aluminum nitride, 30 partners (6 from Finland)
  - submitted in May 2026, second round in Sep 2026, EU+national budget ~16 M€

INDUSTRY & TECHNOLOGY & INFRA NEWS CONT'D

- Together with VTT, Helsinki Accelerator Laboratory was granted Business Finland Rise-to-the-Challenge 3-year funding of 6 M€ (+ 2-year extension 4 M€)
  - **Radical AI-Driven Materials Acceleration for Next-gen Technologies (RADIANT)**
  - In essence: first step towards self-driving laboratories, starting with materials development
  - Project starts 1.9.2026

- Follow-up: including ROBOT activities for achieving true SDL
  - Technology Industries of Finland Centennial Foundation Strategic Growth Initiative proposal for 20 M€ funding level submitted in June 2026
  - waiting for news…

INDUSTRY & TECHNOLOGY & INFRA NEWS CONT'D

- Helsinki Accelerator Laboratory (HAL) is developing, together with CEA spin-off, a compact electron linac based positron-electron-gamma-x-ray source to be installed at HAL end of 2027, operation expected end of 2028
  - Based on CLIC technology and the positron source developed in CERN for the GBAR
  - Procurement contract signed in June 2026, UH investment 1.8 M€

- Kumpula Materials Innovation Park (KUMPARK) investments:
  - UH rector's funding 2025 – 2028: 1.4 M€ (PHYS+CHEM)
  - FIRI2025 (2026 – 2028): 1.55 M€
  - FIRI2026 (2027 – 2030): 2.53 M€ (decision pending)

MATERIALS SCIENCE AND INNOVATION AT UNIVERSITY OF HELSINKI

Faculty of Science, **Kumpula Materials Innovation Park** jointly operated by:

- Department of Chemistry
- Department of Physics

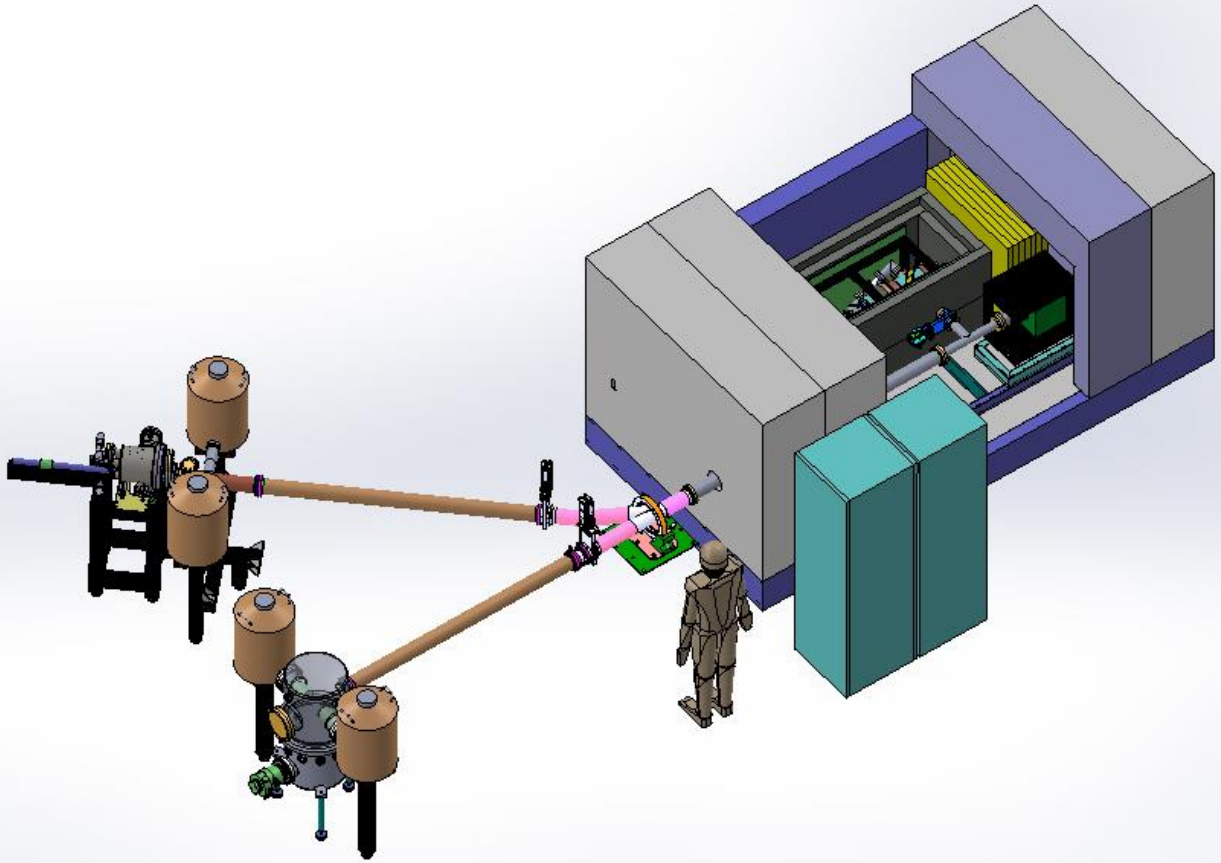
Director: Prof. Filip Tuomisto
Vice-director: Prof. Mikko Ritala

Focus areas:

- Advanced materials for future electronics, quantum technologies, hydrogen economy and catalysis
- Structural materials for extreme environments
- Cellular-level biological processes for health promotion
- Novel, stimuli-responsive functional polymer materials for additive manufacturing, biomedical engineering and nanomedicine

Approaches:

- Thin film and nanostructure synthesis and etching (e.g. ALD, MLD, ALE, ASD, PVD)
- Advanced polymerization and colloid chemistry, 3D/4D printing
- Ion and positron beam based materials modification and analysis
- Advanced structural characterization and crystallography
- Multi-scale materials modeling



Compact, 4.5 MeV e-linac

Slow positron flux 10^8 s^{-1}

Potential for soft X-ray flux 100x present day lab sources

High intensity e- source up to 4.5 MeV

High intensity gamma source up to 4 MeV

(Particle) physics with many positrons? Positronium Bose-Einstein condensation, gamma-ray lasing, antimatter-matter balance, etc

INDUSTRY & TECHNOLOGY & INFRA NEWS CONT'D

- Pietari Kauttu, our long-term collaborator in CERN technology transfer, defended his PhD at Tampere University May 8, 2026
  - *Open Hardware Ecosystems: Strategic, Legal, and Innovation Foundations*

- New ILO at Business Finland: Christina Rinne. Ministry for Foreign Affairs of Finland interested.

PROGRAMME STRUCTURE IN 2027

Large projects	Medium and small projects	Programme director
• RAD3S → 2028 • *MAT → 2029* • HIP budget: ~200 k€	• ROBOT → 2028 • AQUES → 2027 • *RADIANT-Si → 2029* • HIP budget: ~220 k€	• Industry activation • New initiatives • HIP budget: ~40 k€

SUMMARY

- The projects are successful on many frontiers
- Major new things for 2027
  - Continuation of the MAT project for 2027 – 2029
  - RADIANT-Si: new project led by Prof. Andrea Sand from Aalto University!
- New directions are (as always) explored