Biennial Report 2020 - 2021

Metrology Research Institute

Editor: Juho Karhu
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1 INTRODUCTION

During 2020–2021, covid-19 pandemic affected the activities of the Metrology Research Institute. After the first shock in spring 2020, however, the laboratory work continued quite normally. Examples of highlights include promising test results of new PQED photodiodes from the Chipscale project, development of a photoacoustic detector with broad spectral range in collaboration with Tampere and Helsinki Universities, and construction of a 3D gonioreflectometer for Earth observation applications. Furthermore, the effect of gas lens formation due to nitrogen flow was found and eliminated in the Predictable Quantum Efficient Detector (PQED).

Many new doctoral candidates have started their studies at the Institute. The research group personnel achieved four oral presentations in the NEWRAD 2021 conference, which is the main international event in radiometry/photometry research field. Three of those talks were given by the newly recruited staff which is a huge success when taking into account that NEWRAD conference does not include any parallel sessions. The online conference was organized by the National Institute of Standards and Technology (Boulder, USA) and the conference proceedings were produced by the Metrology Research Institute personnel (DOI 10.5281/zenodo.4882794).

The Institute was nominated as the national standards laboratory in optical quantities in 1996. In November 2021, the Quarter of a Century Celebration was arranged as an onsite event at Aalto University. It was very pleasant that despite the pandemic many international guests could attend in person, including the President of the Consultative Committee of Photometry and Radiometry.

The Metrology Research Institute provides teaching within Aalto University and it operates under the Finnish name MIKES-Aalto Mittaustekniikka as the Finnish National Standards Laboratory for optical quantities. One doctoral degree and one M.Sc. degree were achieved in 2020–2021. These numbers are significantly lower than during the previous two-year period and may be affected by the pandemic. The number of calibration certificates issued in 2020–2021 is 83, which is about the same number as for the period 2018–2019.
2 PERSONNEL

Aalto University School of Electrical Engineering
Department of Signal Processing and Acoustics
Metrology Research Institute (MIKES-Aalto Mitaustekniikka)
P.O. Box 15500, FI-00076 Aalto, Finland

Visiting address: Maarintie 8, 02150 Espoo, Finland

Switchboard +358 9 470 01
Webpage http://metrology.aalto.fi

Use country code +358 with all telephone numbers.

In 2020–2021, the total number of employees working at the Metrology Research Institute was 25.

<table>
<thead>
<tr>
<th>Name</th>
<th>Telephone</th>
<th>E-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ikonen, Erkki, D.Sc.</td>
<td>50 550 2283</td>
<td>erkki.ikonen(at)aalto.fi</td>
</tr>
<tr>
<td>Professor, Head of Laboratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aschan, Robin, M.Sc.</td>
<td></td>
<td>robin.aschan(at)aalto.fi</td>
</tr>
<tr>
<td>Research scientist</td>
<td></td>
<td></td>
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<tr>
<td>Askola, Janne, D.Sc.</td>
<td></td>
<td>janne.askola(at)aalto.fi</td>
</tr>
<tr>
<td>Research scientist</td>
<td></td>
<td></td>
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<tr>
<td>Danilenko, Aleksandr, M.Sc.</td>
<td></td>
<td>aleksandr.danilenko(at)aalto.fi</td>
</tr>
<tr>
<td>Research scientist</td>
<td></td>
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<tr>
<td>Das, Sudatta, M.Sc.</td>
<td></td>
<td>sudatta.das(at)aalto.fi</td>
</tr>
<tr>
<td>Research scientist</td>
<td></td>
<td></td>
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<tr>
<td>Haarnoja, Elias</td>
<td></td>
<td>May 2021 – December 2021</td>
</tr>
<tr>
<td>Research assistant</td>
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<td></td>
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<tr>
<td>Hakkarainen, Riina</td>
<td></td>
<td>June 2020 – December 2020</td>
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<tr>
<td>Research assistant</td>
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<td></td>
</tr>
<tr>
<td>Harju, Iiro</td>
<td></td>
<td>Since June 2020</td>
</tr>
<tr>
<td>Research assistant</td>
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</tr>
</tbody>
</table>
Huttu, Iikka
Research assistant
June 2020 – August 2020, May 2021 – December 2021

Karhu, Juho, D.Sc.
Research scientist
juho.j.karhu(at)aalto.fi
Since August 2020

Korpusenko, Mikhail, M.Sc.
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Kärhä, Petri, D.Sc.
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Lahti, Leo
Research assistant
May 2021 – November 2021

Lampinen, Tuomas
Research assistant
June 2020 – December 2020

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Until June 2020

Maham, Kinza, M.Sc.
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Mantela, Ville, M.Sc.
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ville.mantela(at)aalto.fi
Since August 2020

Nordlund, Roope
Research assistant
Since May 2021

Porrasmaa, Santeri
Research assistant
Till May 2020

Rastgou, Masoud, M.Sc.
Research scientist
masoud.rastgou(at)aalto.fi
Since September 2021

Sharma, Sucheta, M.Sc.
Research scientist
sucheta.sharma(at)aalto.fi
Simonen, Tarmo, M.Sc.  50 413 0179  tarmo.simonen(at)aalto.fi
Network and PC Administrator

Talvitie Sami  
Research assistant  
May 2021 – August 2021

Docents and lecturers:

Ludvigsen, Hanne  Aalto University
Laurila, Toni  Sensmet Ltd.
3 TEACHING

3.1 Degrees

3.1.1 Doctor of Science (Technology), D.Sc. (Tech.)


3.1.2 Master of Science (Technology), M.Sc. (Tech.)


3.2 Bachelor of Science (B.Sc.) Theses


Iikka Huttu (2021), *Aurinkokennojen tehontuotto LED-valaistuissa toimistoissa asioiden internetin kuvakulmasta*, guided by Petri Kärhä

Niklas Rehnberg (2021), *Ultraviolettisäteilyyn perustuva liekinilmaisin*, guided by Petri Kärhä

### 3.3 Courses

The following courses were offered by the Metrology Research Institute in 2020–2021. Those marked by * are given biennially.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tr>
<td>ELEC-E5730</td>
<td>Optics, 5 cr</td>
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<tr>
<td></td>
<td>(Toni Laurila, Mikhail Korpusenko)</td>
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<tr>
<td>ELEC-E5710</td>
<td>Sensors and Measurement Methods, 5 cr</td>
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<tr>
<td></td>
<td>(Petri Kärhä)</td>
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<tr>
<td>ELEC-E5720</td>
<td>Virtual Instrumentation, 5 cr</td>
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<td></td>
<td>(Petri Kärhä, Janne Askola, Ville Mantela)</td>
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<tr>
<td>ELEC-E5750</td>
<td>Project Work in Measurement Science and Technology, 2–10 cr</td>
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<tr>
<td></td>
<td>(Petri Kärhä)</td>
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<tr>
<td>ELEC-E5760</td>
<td>Project Work in Optical Technology, 2–10 p</td>
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<td>(Erkki Ikonen)</td>
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<tr>
<td>ELEC-E5780</td>
<td>Postgraduate Course in Measurement Science and Technology, 10 cr*</td>
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<td></td>
<td>(Petri Kärhä)</td>
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<tr>
<td>ELEC-E5740</td>
<td>Research Seminar on Measurement Science and Technology, 2 cr*</td>
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<td></td>
<td>(Petri Kärhä)</td>
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<tr>
<td>ELEC- C5070</td>
<td>Electronics Workshop, 5 cr</td>
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<tr>
<td></td>
<td>(Petri Kärhä)</td>
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<tr>
<td>ELEC-C5270</td>
<td>Insinööri työelämässä, 5 cr</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Petri Kärhä</td>
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</table>
4 NATIONAL STANDARDS LABORATORY

Metrology Research Institute is the Finnish national standards laboratory for the measurements of optical quantities, as appointed by the Centre for Metrology and Accreditation (MIKES) in April 1996.

The institute gives official calibration certificates on various optical quantities in the fields of Photometry, Radiometry, Spectrophotometry and Fiber Optics. During 2020, 41 calibration certificates were issued. In 2021, the number of calibration certificates was 42. The calibration services are mainly used by the Finnish industry and various research organizations. There are two accredited calibration laboratories in the field of optical quantities.

The Institute offers also other measurement services and consultation in the field of measurement technology. Various memberships in international organizations ensure that the laboratory can also influence e.g. international standardization so that it takes into account the national needs.

The Metrology Research Institute performs its calibration measurements under a quality system approved by MIKES. The quality system is based on ISO/IEC 17025.

Further information on the offered calibration services can be obtained from the web-pages of the laboratory (http://metrology.aalto.fi/). Especially the following sub-pages might be useful:


Quality system: http://metrology.aalto.fi/quality/

Additional information may also be asked from Farshid Manoocheri (Head of Calibration Services) or Petri Kärhä (Quality Manager):

Farshid.Manoocheri (at) aalto.fi, Tel. +358 50 590 2483

Petri.Karha (at) aalto.fi, Tel. +358 50 596 8469
5 RESEARCH PROJECTS

Light is everywhere around us in the form of sunlight, artificial lighting and signaling. Most electrical equipment use either visible or infrared radiation for signaling, displays, sensing, data read-out, or digital communication. Color is one of the most significant properties in consumer products.

Metrology research of Optical Radiation Measurements is divided into three branches: Radiometry dealing with characteristics of light sources and detectors, Photometry measuring light as people see it, and Spectrophotometry investigating optical components as well as optical properties of materials. Some of the facilities developed in the laboratory are at the world-leading level when comparing accuracy, compactness, and operating costs. The research activities of the group involve electronics, modern optics and optical radiation measurements.

Metrology Research Institute is a joint laboratory of Aalto University and VTT MIKES, and it is involved in many international projects. Most of the research in the laboratory is currently carried out within the EURAMET EMPIR programme. Metrology Research Institute is the national standards laboratory for optical quantities in Finland maintaining national standards of optical quantities and carrying out calibrations at the highest level.

Recent research activities of the group can be browsed through the links below.

5.1 Photometry

- EMPIR MetTLM - Metrology for Temporal Light Modulation (2021-2024)
- EMPIR RevStdLED - Revision and extension of standards for test methods for LED lamps, luminaires and modules (2020-2023)
- Lifetime projection of lamps and luminaires based on high power LEDs (2009-)

5.2 Radiometry

- EMPIR QADeT - Quantum sensors for metrology based on single-
atom-like device technology (2021-2024)

- **EMPIR SEQUENCE** - Developing the metrology and instrumentation for single-photon sources, required for future advances in quantum technologies (2021-2024)

- **EMPIR MetISQ** - Metrology for Testing the Implementation Security of Quantum Key Distribution Hardware (2020-2024)

- **EMPIR Metro-PV** - Metrology for Emerging PV applications (2020-2023)

- **EMPIR MAPP** - Metrology for aerosol optical properties (2020-2023)

- **EMPIR chipSCALE** - Self-calibrating photodiodes for the radiometric linkage to fundamental constants (2019-2022)

- Universal electromagnetic radiation detector (UNIDET) (2018–2021)

- **EMPIR SIQUEST project** - Single-photon sources as new quantum standards (2018-2021)

- **EMPIR PV-Enerate** - Advanced PV Energy Rating (2017-2020)

5.3 Spectrophotometry

- **EMPIR ATMOC** - Traceable metrology of soft-X-ray to IR optical constants and nanofilms for advanced manufacturing (2021-2024)

- **EMPIR Smart PhoRa** - Supporting smart specialization and stakeholder linkage in Photometry and Radiometry (2021-2023)

- **EMPIR MetEOC4** - Metrology to establish an SI-traceable climate observing system (2020-2023)

- **EMPIR BxDiff** - New quantities for the measurement of appearance (2019-2022)

- **EMPIR BiRD** - Bidirectional reflectance definitions (2017-2020)
• EMPIR EMIRIM - Improvement of Emissivity Measurements on Reflective Insulation Materials (2017-2020)

• EMPIR SURFACE - Pavement Surface Characterisation for Smart and Efficient Road Lighting (2017-2020)

• EMPIR MetEOC3 - Metrology for Earth Observation and Climate (2017-2020)
6 INTERNATIONAL CO-OPERATION

6.1 International Comparison Measurements

Since 2005, the Metrology Research Institute of Aalto University has participated in key comparisons under the name MIKES or MIKES-Aalto.

Key comparison EURAMET.PR-K6, spectral transmittance 380–1000 nm, pilot CNAM

Measurements by MIKES-Aalto and CNAM have been carried out.

Key comparison CCPR-K5, diffuse reflectance 380 – 800 nm, pilot MIKES-Aalto

MIKES-Aalto has completed first round measurements.

Key comparison EURAMET.PR-K3, Luminous intensity, pilot METAS

First measurements by MIKES-Aalto have been carried out. Repeat Measurements are to be done fall of 2022.

6.2 Conferences and Meetings

Meeting on European Partnership on Metrology at Commission, January 16, 2020, Brussels, Belgium; Erkki Ikonen

EMPIR BxDiff project meeting, January 21–22, 2020, Bern, Switzerland; Robin Aschan

EURAMET TC-PR Workshop, January 28, 2020, Chisinău, Moldova; Petri Kärhät

EURAMET TC-PR Annual meeting, January 29–30, 2020, Chisinău, Moldova; Petri Kärhät, Farshid Manoocheri, Erkki Ikonen
EURAMET Quality Forum, January 30–31, 2020, Chișinău, Moldova; Petri Kärhät

EMPIR Chipscale Project meeting, February 12–13, 2020, Turin, Italy; Mikhail Korpusenko, Santeri Porrasmaa, Erkki Ikonen

EURAMET BoD meeting, February 19, 2020, Paris, France; Erkki Ikonen

EURAMET BoD/TCC/EMNC workshops, February 20–21, 2020, Paris, France; Erkki Ikonen

EMPIR project midterm review, February 27–28, 2020, Berlin, Germany; Erkki Ikonen

EMPIR SC-CB meeting, March 30, 2020, online; Erkki Ikonen (Chair)

EMPIR SC-R meeting, March 31–April 2, April 7, April 30, 2020, online; Erkki Ikonen (Chair)

EMPIR Committee meeting, May 27–28, 2020, online; Erkki Ikonen (Chair)

EMPIR MAPP Kick-off meeting, June 9–10, 2020, online; Petri Kärhät, Kinza Maham, Iiro Harju

EMPIR PV-Enerate Final project meeting, September 22–23, 2020, online; Petri Kärhät

EMPIR Metro-PV Kick-off meeting, September 23–24, 2020, online; Petri Kärhät

Meeting on cryogenic radiometer vs. PQED responsivity comparison, October 16, 2020, NIMT Bangkok, Thailand; Erkki Ikonen

EMPIR SC-R meeting, October 21–22, 2020, online; Erkki Ikonen (Chair)

EMPIR Committee meeting, November 17–18, 2020, online; Erkki Ikonen (Chair)

CCPR WG-KC TG-4 meeting, LED-based key comparison lamps, January 22, 2021, online; Erkki Ikonen (Chair), Robin Aschan (Recorder)
EMPIR MAPP Project meeting, February 10–11, 2021, online; Petri Kärhä, Kinza Maham, Iiro Harju

BIPM Workshop on “SI for FAIR digital data”, February 22–26, 2021, online; Erkki Ikonen

EURAMET BoD WG on Partnership meeting, March 3, 2021, online; Erkki Ikonen (Convener)

EMPIR SC-R meeting, April 7–12, 2021, online; Erkki Ikonen (Chair)

EMPIR SC-CB meeting, April 13, 2021, online; Erkki Ikonen (Chair)

Annual meeting of the Nordic Ozone and UV group, NOG2021, April 20–21, 2021, online; Petri Kärhä

EMPIR Metro-PV Project meeting, May 6, 2021, online; Petri Kärhä, Kinza Maham

EMPIR MetTLM Kick-off meeting, May 17 and 21, 2021, online; Ville Mantela, Roope Nordlund

EURAMET BoD WG on Partnership meeting, May 31, 2021, online; Erkki Ikonen (Convener)

EMPIR Committee meeting, June 10, 2021, online; Erkki Ikonen (Chair)

EURAMET BoD WG on Partnership meeting, June 10, 2021, online; Erkki Ikonen (Convener)

NEWRAD 2021 Conference, June 21–24, 2021, online; Mikhail Korpusenko (talk), Petri Kärhä (talk), Kinza Maham (talk), Sucheta Sharma (talk), Janne Askola, Robin Aschan, Dmitri Lanevski, Erkki Ikonen (session chair)

Online Workshop on Europe-China Metrology Development and Cooperation, June 22, 2021; Erkki Ikonen (invited talk)

EMPIR RevStdLED Project meeting, July 13–14, 2021, online; Janne Askola, Ville Mantela
Meeting on PQED measurements and transportation of a PQED to CMI, August 17–18, 2021, Prague, Czech Republic; Erkki Ikonen

International Congress on Metrology CIM2021, September 7–9, 2021, Lyon, France; Petri Kärhä (talk), Iiro Harju (talk), Sucheta Sharma (talk)

CIE 2021 Midterm Conference, September 27–29, 2021, online; Erkki Ikonen, Kinza Maham (talk), Ville Mantela (talk)

Meeting on research collaboration with PTB, October 25–27, 2021, PTB Braunschweig, Germany; Erkki Ikonen

Quarter of a Century Celebration of MIKES-Aalto as Designated Institute, November 3, 2021, onsite at Aalto University; all staff

EMPIR MAPP Project meeting, November 22–23, 2021, PTB Braunschweig, Germany; Petri Kärhä, Iiro Harju

EMPIR/Partnership Committee meeting, November 30 – December 1, 2021, PTB Berlin, Germany; Erkki Ikonen (Chair)

Optics and Photonics Days, December 1–3, 2021, Turku, Finland; Sucheta Sharma, Erkki Ikonen

6.3 Visits by the Laboratory Personnel

Petri Kärhä, Tallinn Technical University, Estonia, December 15, 2021

6.4 Research Work Abroad

Sucheta Sharma, Physikalisch-Technische Bundesanstalt, Berlin, Germany, August 16–20, 2021.

Mikhail Korpusenko, Physikalisch-Technische Bundesanstalt, Braunschweig, Germany, August 3–15, October 12–17, October 24 – November 2, 2021.
6.5 Visits to the Laboratory

Aleksandr Dunaev, VNIIOFI, Russia, March 11–12, 2020

Meelis Sildoja, Metroser, Estonia, September 15, November 3, 2021

Toomas Kübarsepp, Metroser, Estonia, September 21–23, 2021

Joaquin Campos, IO-CSIC, Spain, October 21–22, 2021

Jarle Gran, JV, Norway, November 3–4, 2021

Maria Luisa Rastello, INRIM, Italy, November 3–4, 2021

Marek Smid, CMI, Czech Republic, November 3–4, 2021
7 PUBLICATIONS

7.1 Articles in International Journals


M. Roiz, J.-Y. Lai, J. Karhu, and M. Vainio, “Mid-infrared frequency comb with


### 7.2 International Conference Presentations


S. Sharma, T. Laurila, J. Rossi, J. Uotila, M. Vainio, F. Manoocheri and E. Ikonen, “Cantilever-based photoacoustic detection of electromagnetic radiation
from ultraviolet to near infrared spectral region,” 20th International Metrology Congress CIM2021, Lyon, France, September 7–9, 2021, p. 83 (Talk).

https://doi.org/10.25039/x48.2021

https://doi.org/10.25039/x48.2021

7.3 National Conference Presentations


7.4 Other Publications

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Metrology Research Institute

Editor: Juho Karhu