Department of Electrical Engineering and Automation

Biennial Report 2022 - 2023

Metrology Research Institute

Editor: Juho Karhu

Aalto University

SCIENCE + TECHNOLOGY

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School of Electrical Engineering
Department of Electrical Engineering and Automation
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1 INTRODUCTION

During 2022–2023, the activities of the Metrology Research Institute largely recovered from the negative effects of the pandemic. The number of publications and international collaboration have developed favorably as compared with the previous two-year period. Highlights include new digital implementations for determination of temporal light artefacts of LED luminaires, specific reflectometry methods for test chip structures containing small air gaps, and surprising results from spectral analysis of deviations from key comparison reference values. Janne Askola received the award for the best paper of 2022 published in journal *Lighting Research and Technology*. The paper considered effects of adaptive control on the LED street luminaire lifetime and on the lifecycle costs of a lighting installation.

The European Metrology Partnership project *Establishing European traceability for medical measuring devices through liquid absorbance filters*, coordinated by Farshid Manoocheri, was selected for funding in November 2023. It is the first funded project within any of the three European Metrology programmes coordinated by Aalto's Metrology Research Institute.

The research group personnel participated in many scientific conferences of which especially NEWRAD 2023 conference held in Teddington, UK, is worth mentioning with our six oral presentations. This is two talks more than the research group reached in previous NEWRAD conferences in 2017 and 2021, indicating an excellent achievement when taking into account that NEWRAD conferences do not include any parallel sessions. NEWRAD is the main international conference series in the research field covering traceability and primary standards of radiometric and photometric measurements in various applications.

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. Four doctoral degrees and one M.Sc. degree were achieved in 2022–2023. The number of doctoral degrees is similar as what it was before the pandemic, but the number of M.Sc. degrees is significantly lower. The number of calibration certificates issued in 2022–2023 is 79, which is about the same number as for the period 2020–2021.

2 PERSONNEL

Aalto University School of Electrical Engineering
Department of Electrical Engineering and Automation
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Webpage http://metrology.aalto.fi

Use country code +358 with all telephone numbers.

In 2022–2023, the total number of employees working at the Metrology Research Institute was 22.

Name	**Telephone**	**E-mail**
Ikonen, Erkki, D.Sc. Professor, Head of Laboratory	50 550 2283	erkki.ikonen(at)aalto.fi
August, Leevi Research assistant		Since May 2023
Aschan, Robin, M.Sc. Research Scientist		robin.aschan(at)aalto.fi
Danilenko, Aleksandr, M.Sc. Research Scientist		aleksandr.danilenko(at)aalto.fi
Das, Sudatta, M.Sc. Research Scientist		sudatta.das(at)aalto.fi
Eghbali, Afsaneh, M.Sc. Research Scientist		afsaneh.eghbali(at)aalto.fi Since September 2022
Harju, Iiro Research assistant		Till December 2023

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Karhu, Juho, D.Sc. Research Scientist		juho.j.karhu(at)aalto.fi
Korpusenko, Mikhail, D.Sc. Research Scientist		mikhail.korpusenko(at)aalto.fi
Lanevski, Dmitri, M.Sc. Research Scientist		dmitri.lanevski(at)aalto.fi Till November 2022
Maham, Kinza, M.Sc. Research Scientist		kinza.maham(at)aalto.fi Till May 2023
Manoocheri, Farshid, D.Sc. Senior Research Scientist Head of calibration services	50 590 2483	farshid.manoocheri(at)aalto.fi
Mantela, Ville, M.Sc. Research Scientist		ville.mantela(at)aalto.fi
Nordlund, Roope, M.Sc. Research Scientist		Till March 2022
Peltoniemi, Juha, D.Sc. Senior Research Scientist Quality manager (since 2023)		juha.t.peltoniemi(at)aalto.fi Since Dec 2022
Rastgou, Masoud, M.Sc. Research Scientist		masoud.rastgou(at)aalto.fi
Rezazadeh, Yasaman, M.Sc. Research Scientist		yasaman.rezazadeh(at)aalto.fi Since September 2022
Sharma, Sucheta, D.Sc. Research Scientist		sucheta.sharma(at)aalto.fi

Simonen, Tarmo, M.Sc. Network and PC Administrator	50 413 0179	tarmo.simonen(at)aalto.fi
Talvitie, Sami Research assistant		May 2022 – August 2022 and May 2023 – August 2023
Vesa, Aaron Research assistant		May 2023 – August 2023

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.)

Dmitri Lanevski (2022), *Measurement, Reporting and Applications of Bidirectional Reflectance Distribution Function*, Opponent: Dr Heather Patrick, National Institute of Standards and Technology, USA.

Sucheta Sharma (2023), *Applications of Interferometric Measurements and Photoacoustic Detection in Optical Metrology*, Opponents: Dr. Howard W. Yoon, National Institute of Standards and Technology, USA, and Dr. Tom Kuusela, University of Turku, Finland.

Mikhail Korpusenko (2023), *Characterization of Predictable Quantum Efficient Detector*, Opponent: Dr. Howard W. Yoon, National Institute of Standards and Technology, USA.

Jussi Havunen (2023), *Application of Signal Processing Methods for Precision Impulse Voltage and Partial Discharge Measurements*, Opponent: Dr. Joni Klüss, RISE Research Institutes of Sweden, Sweden.

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

Roope Nordlund (2022), *Validation for Measurement of Temporal Light Artefacts on LED Light Sources,* guided by Ville Mantela and Janne Askola.

3.1.3 Bachelor of Science (Technology), B.Sc. (Tech.)

Silmu Valaskivi (2022), *Luminesenssiin perustuva ratiometrinen hapen kuvantaminen*, guided by Petri Kärhä.

Shahram Barai (2022), *Terveysvalvonta-anturit: suodatus ja tietojen analysointi*, guided by Ville Mantela

3.2 Courses

The following courses were offered by the Metrology Research Institute in 2022–2023. Those marked by * are given biennially.

ELEC-E8751	Optics, 5 cr (Juho Karhu)
ELEC-E8748	Sensors and Measurement Methods, 5 cr (Petri Kärhä)
ELEC-E8750	Virtual Instrumentation, 5 cr (Petri Kärhä, Ville Mantela)
ELEC-E8747	Optical Design: numerical modelling, 5 cr (Masoud Rastgou, Erkki Ikonen)
ELEC-E8753	Project Work in Measurement Science and Technology, 2–10 cr (Petri Kärhä)
ELEC-E8754	Project Work in Optical Technology, 2–10 p (Erkki Ikonen)
ELEC-L8745	Doctoral Course in Measurement Science and Technology, 10 cr* (Juha Peltoniemi)
ELEC-E8752	Research Seminar on Measurement Science and Technology, 2 cr* (Petri Kärhä)
ELEC-C8701	Electronics Workshop, 5 cr (Petri Kärhä)
ELEC-C8730	Insinööri työelämässä, 5 cr (Juha Peltoniemi)

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 2022, 42 calibration certificates were issued. In 2023, the number of calibration certificates was 37. 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 VTT 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:

Maintained quantities including price list: http://metrology.aalto.fi/calibration/

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

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

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

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

Juha Peltoniemi (at) aalto.fi, Tel. +358 50 435 0142

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 national and international projects. Most of the research in the laboratory is currently carried out within EURAMET EMPIR and EPM programmes. 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

- **EPM HiDyn – Support for the standardization of luminance distribution measurements for assessing glare and obtrusive light using high-dynamic-range imaging systems. (2022-2025)**
- **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

- **EPM ScaleUp - Self-calibrating photodiodes for UV and exploitation of induced junction technology (2023-2026)**
- **EPM MeLiDos - Metrology for Wearable Light Loggers and Dosimeters (2023-2026)**
- **EPM Newstand - New calibration standards and methods for radiometry and photometry after phaseout of incandescent lamps (2023-2026)**
- **EMPIR QADeT - Quantum sensors for metrology based on single-atom-like device technology (2021-2024)**
- **EMPIR SEQUME - 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)**

5.3 Spectrophotometry

- **EPM Parametric -Metrological framework for passive radiative cooling technologies (2022-2025)**
- **EMPIR ATMOC - Traceable metrology of soft-X-ray to IR optical constants and nanofilms for advanced manufacturing (2021-2024)**

- **PREIN Mensa - Multi-sensory environmental sensing for enhanced sensitivity and selectivity (2023-2024)**
- **Trace metal analysis (2023-2024)**
- **EMPIR Smart PhoRa - Supporting smart specialization and stake-holder 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)**

6 INTERNATIONAL CO-OPERATION

6.1 International Comparison Measurements

Since 2005, the Metrology Research Institute has participated in many key comparisons under the abbreviation MIKES or MIKES-Aalto.

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

Measurements have been completed. Preparation of Pre-draft A is ongoing.

Key comparison CCPR-K5, diffuse reflectance 360 – 830 nm, pilot Aalto

Pilot second round measurements ongoing.

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

Measurements have been complemented. Preparation of Pre-draft A is ongoing.

6.2 Conferences and Meetings

EURAMET TC-PR Contact Persons Meeting, January 25–27, 2022, online; *Erkki Ikonen, Farshid Manoocheri, Petri Kärhä*

EMPIR Metro-PV Project meeting, April 4–5, 2022, SUPSI, Mendrisio, Switzerland; *Petri Kärhä, Kinza Maham*

CCPR WG-KC TG-4 meeting, April 22, 2022, online; *Ville Mantela, Erkki Ikonen (Chair)*

Annual meeting of the Nordic Ozone and UV group (NOG2022), April 26–27, 2022, NILU, Oslo, Norway; *Kinza Maham, Iiro Harju*

EMPIR BxDiff project meeting, April 25–28, 2022, CSIC, Madrid, Spain; *Robin Aschan, Erkki Ikonen*

EMPIR Chipscale project meeting, May 3–5, 2022, CNAM, Paris, France; *Mikhail Korpusenko, Erkki Ikonen*

CCPR meeting, May 10–11, 2022, online; *Erkki Ikonen*

EURAMET GA, EURAMET Partnership Committee meeting, May 31 – June 2, 2022, BEV, Vienna, Austria; *Erkki Ikonen*

9th International Symposium on Sensor Science, June 19–22, 2022, Warsaw, Poland; *Mikhail Korpusenko*

EMN Climate and Ocean Observation Annual General Meeting, June 21–22, 2022, Brussels, Belgium; *Erkki Ikonen*

OPTICA Optical Sensors and Sensing Congress, July 11–15, 2022, online*; Juho Karhu*

Optics and Photonics Days 2022, September 6–8, 2022, Tampere, Finland; *Mikhail Korpusenko, Juho Karhu, Erkki Ikonen*

EMPIR MAPP Project meeting, September 8–9, 2022, Izaña Observatory, Tenerife, Canary Islands, Spain; *Petri Kärhä, Iiro Harju*

EPM HiDyn Project meeting, September 11–14, 2022, PTB, Braunschweig, Germany; *Ville Mantela*

CIE Division 2 Annual Meeting Part 1, September 14, 2022, online; *Erkki Ikonen*

BIPM-WMO Workshop on Metrology for Climate Action, September 26–30, 2022, online; *Erkki Ikonen*

EMPIR BxDiff project meeting, September 28–30, 2022, DFM, Copenhagen, Denmark; *Erkki Ikonen*

CIE Workshop and Symposium on the Measurement of Temporal Light Modulation, October 10–11, 2022, Athens, Greece; *Erkki Ikonen, Ville Mantela*

CIE Division 2 Annual Meeting Part 2 and CIE TC meetings, October 12–13, 2022, Athens, Greece; *Erkki Ikonen*

CIE Board of Administration Meeting, October 17–19, 2022, Vienna, Austria; *Erkki Ikonen*

EMPIR QADet project meeting, October 26–27, 2022, INRIM, Turin, Italy; *Farshid Manoocheri*

EPM Parametric project meeting, October 27–28, 2022, INRIM, Turin, Italy; *Farshid Manoocheri*

EMPIR Chipscale project meeting, November 1–3, 2022, CMI, Prague, Czech Rebublic; *Mikhail Korpusenko, Erkki Ikonen*

Metrology for XR & Freeform Optics event, November 8, 2022, University of Eastern Finland, Joensuu, Finland; *Erkki Ikonen (Invited talk)*

EMPIR MetTLM Project meeting, November 9–10, 2022, VSL, Delft, The Netherlands; *Ville Mantela.*

Metrology Partnership project proposal Review Conference, November 14–17, 2022, Monaco; *Farshid Manoocheri*

Workshop on Quantum Metrology: the present and the future, November 21, 2022, Lisbon, Portugal; *Erkki Ikonen*

EURAMET Partnership Committee meeting, November 22–23, 2022, IPQ, Lisbon, Portugal; *Erkki Ikonen*

EMPIR SEQUME project meeting, November 23–24, 2022, PTB, Braunschweig, Germany; *Mikhail Korpusenko*

EMN Quantum Annual General Meeting, November 30 and December 2, 2022, online; *Erkki Ikonen*

EMPIR ATMOC project meeting, December 5–7, 2022, PTB, Berlin, Germany; *Aleksandr Danilenko, Erkki Ikonen*

EMPIR Metro-PV project meeting, December 13–14, 2022, Aalto University, Espoo, Finland; *Petri Kärhä, Afsaneh Eghbali, Juha Peltoniemi, Erkki Ikonen*

Meeting on evaluation of grant proposals submitted to the Research Council of Lithuania, January 3, 2023, online; *Erkki Ikonen (Chair)*

EMPIR RevStdLED project meeting, January 10–11, 2023, LNE, Paris, France; *Yasaman Rezazadeh, Erkki Ikonen*

EURAMET TC-PR Annual meeting, January 24–26, 2023, Tallinn, Estonia; *Farshid Manoocheri, Erkki Ikonen*

SPIE Photonics West Conference, January 29 – February 2, 2023, San Francisco, United States; *Erkki Ikonen*

EURAMET Partnership Committee meeting, March 24, 2023, online; *Erkki Ikonen*

CCU-CCQM Workshop on The Metrology of Quantities Which Can Be Counted, March 28–30, 2023, online; *Erkki Ikonen*

Physics Days, March 29–31, 2023, Tampere, Finland; *Juha Peltoniemi, Erkki Ikonen*

EURAMET Partnership Sub-Committee Research meeting, April 2–5, 2023, PTB, Berlin, Germany; *Erkki Ikonen*

EURAMET Partnership Sub-Committee Capacity Building meeting, April 6, 2023, online; *Erkki Ikonen*

Comparative Expert Assessment (CEA) of the research performance of Lithuanian universities and research institutes in Vilnius, Kaunas and Klaipeda, Lithuania, April 16–21, 2023; *Erkki Ikonen (Chair of expert panel)*

EMPIR MAPP project meeting, May 10–12, 2023, PMOD, Davos, Switzerland; *Erkki Ikonen*

The Walsh Weston award ceremony for the best paper in SLL Lighting Research & Technology of more fundamental lighting matters, May 24, 2023, London, UK; *Janne Askola (Speech on the awarded paper)*

Optics and Photonics Days 2023, May 30 – June 1, 2023, Joensuu, Finland; *Masoud Rastgou, Juho Karhu, Erkki Ikonen*

EURAMET GA, EURAMET Partnership Committee meeting, June 1–2, 2023, Tallinn, Estonia; *Erkki Ikonen*

EPM ScaleUp project meeting, June 6–7, 2023, Aalto University, Espoo, Finland; *Mikhail Korpusenko, Farshid Manoocheri, Ville Mantela, Yasaman Rezazadeh, Erkki Ikonen*

EPM HiDyn project meeting, June 7–8, 2023, CMI, Prague, Czech Republic; *Ville Mantela, Yasaman Rezazadeh*

EMPIR MetTLM project meeting, June 13–14, 2023, CSTB, Grenoble, France; *Ville Mantela*

EMN Climate and Ocean Observation Annual General Meeting, June 14–15, 2023, METAS, Bern, Switzerland; *Erkki Ikonen*

EPM Parametric project meeting, June 15–16, 2023, PTB, Berlin, Germany; *Farshid Manoocheri (online)*

EPM Melidos project meeting, June 19, 2023, LNE, Paris, France; *Juha Peltoniemi*

EPM NewStand project meeting, June 20–21, 2023, PTB, Braunschweig, Germany; *Juha Peltoniemi, Erkki Ikonen*

EMPIR METEOC4 project meeting, July 4–5, 2023, NPL, Teddington, UK; *Robin Aschan, Erkki Ikonen*

The Fourteenth Finland-Japan Joint Symposium on Optics in Engineering, August 28–31, 2023, Hamamatsu, Japan; *Erkki Ikonen (Session chair)*

EMPIR QADet project meeting, August 31 – September 1, 2023, PTB, Braunschweig, Germany; *Farshid Manoocheri*

EMPIR SEQUME project meeting, September 4, 2023, Aalto University, Espoo, Finland; *Mikhail Korpusenko, Farshid Manoocheri, Erkki Ikonen (online)*

EMPIR SEQUME project meeting, September 5, 2023, Metrosert, Tallinn, Estonia; *Mikhail Korpusenko (online), Farshid Manoocheri (online), Erkki Ikonen*

CCPR WG-CMC, WG-KC and WG-SP meetings, September 7–8, 2023, NPL, Teddington, UK; *Erkki Ikonen*

NEWRAD 2023 - 15th International Conference on New Developments and Applications in Optical Radiometry, September 11–15, 2023, National Physical Laboratory (NPL), Teddington, UK; *Petri Kärhä, Farshid Manoocheri, Yasaman Rezazadeh, Sucheta Sharma, Mikhail Korpusenko, Robin Aschan, Aleksandr Danilenko, Erkki Ikonen (Session chair)*

EMPIR ATMOC project meeting, September 12–13, 2023, Istanbul, Turkey; *Masoud Rastgou (online)*

CIE BA meeting and CIE General Assembly, September 16–17, 2023, Ljubljana, Slovenia; *Erkki Ikonen*

CIE Quadrennial Session, September 18–20, 2023, Ljubljana, Slovenia; *Masoud Rastgou, Robin Aschan, Ville Mantela, Erkki Ikonen*

CIE TC meetings and CIE D2 Annual meeting, September 21–22, 2023, Ljubljana, Slovenia; *Erkki Ikonen*

The 13th International Conference on Instrumental Methods of Analysis, September 17–20, 2023, Chania, Greece; *Sudatta Das*

EMN Quantum Annual General Meeting, September 25–26, 2023, INRIM, Turin, Italy; *Erkki Ikonen (online)*

EURAMET BoD WG CB meeting, October 5–6, 2023, Skopje, North Macedonia; *Erkki Ikonen*

EURAMET Extraordinary GA, October 13, 2023, online; *Erkki Ikonen*

WELMEC's & EURAMET's consultation event on 'Metrology for Regulation', October 23, 2023, online; *Erkki Ikonen*

EURAMET Extraordinary Partnership Committee meeting, October 25, 2023, online; *Erkki Ikonen*

EPM SC-R meeting, October 26, 2023, online; *Erkki Ikonen*

Copernicus Ocean Colour System Vicarious Calibration (OC-SVC) Information Day, November 8, 2023, EUMETSAT, Darmstadt, Germany; *Petri Kärhä*

Metrology Partnership project proposal Review Conference, November 14–15, 2023, Amsterdam, The Netherlands; *Farshid Manoocheri*

Middle East and North Africa Solar Conference, November 14–17, 2023, Dubai, United Arab Emirates; *Erkki Ikonen*

EMPIR Metro-PV Project meeting, November 14–16, 2023, EU JRC, Ispra, Italy; *Petri Kärhä, Afsaneh Eghbali*

EURAMET Partnership Committee meeting, November 21–22, 2023, INRIM, Turin, Italy; *Erkki Ikonen*

EU Commission Workshop on Future of Metrology, November 23, 2023, Brussels, Belgium; *Erkki Ikonen*

The 15th Congress of the International Colour Association, November 28 – December 2, 2023, Chiang Rai, Thailand; *Erkki Ikonen (Session chair)*

6.3 Visits by the Laboratory Personnel

Petri Kärhä, Tallinn Technical University, Estonia, January 13, 2022

Ville Mantela, *Erkki Ikonen*, METAS, Bern, Switzerland, March 24–25, 2022

Erkki Ikonen, University of Latvia, and companies Light Space Technologies and Groglass, Riga, Latvia, May 18–19, 2022

Petri Kärhä, VSL, Delft, The Netherlands, May 18–19, 2022

Masoud Rastgou, CSIC, Madrid, Spain, June 11–15, 2022

Erkki Ikonen, National Institute of Metrology, Bangkok, Thailand, July 11, 2022

Ville Mantela, Technical University of Eindhoven, The Netherlands, November 11, 2022

Masoud Rastgou, CNAM, Paris, France, November 28 – December 1, 2022

Afsaneh Eghbali, PTB, Braunschweig, Germany, January 9–13, 2023

Erkki Ikonen, METAS, Bern, Switzerland, March 1, 2023

Erkki Ikonen, EUMETSAT, Darmstadt, Germany, April 26–27, 2023

Erkki Ikonen, National Institute of Metrology and Chulalongkorn University, Bangkok, Thailand, December 4–15, 2023

6.4 Visits to the Laboratory

Meelis Sildoja, Metrosert, Estonia, April 6–7, 2022, June 16, 2022, November 8, 2023

Mart Noorma, NATO Cyber Defence Centre, June 16, 2022

Heather Patrick, NIST, USA, November 7–11, 2022

Participants of the EMPIR Metro-PV project meeting: *Michael Rauer*, FISE; *Kasimir Reichmuth*, FISE; *Karsten Bothe*, ISFH; *David Hinken*, ISFH; *Carsten Schinke*, ISFH; *Tony Sample*, JRC; *Jimmy Dubard*, LNE; *Stefan Riechelmann*, PTB; *Stefan Winter*, PTB; *Gabriele Friesen*, SUPSI; *Flavio Valoti*, SUPSI; *Özcan BAZKIR* , TUBITAK; *Seval Meric*, TUBITAK; *Giorgio Bardizza*, TUV; *Werner Herrmann*, TUV; December 13–14, 2022.

Seval Meriç TUBITAK, Turkiye, January 31 – February 3, 2023

Nikolay Alexandrov, BIM, Bulgaria, January 31 – February 3, 2023

Anzhela Kunova, BIM, Bulgaria, January 31 – February 3, 2023

Gergana Blaskova, BIM, Bulgaria, January 31 – February 3, 2023

Participants of PREIN MENSA project kick-off meeting: *Juha Toivonen*, TAU; *Vishal Dwiveldi*, TAU; *Francisco Senna Vieira*, VTT; *Timo Dönsberg*, VTT; February 16, 2023.

Participants of the EPM ScaleUp project meeting: *Eivind Bardalen*, USN; *Jarle Garn*, JV; *Trinh Tran*, JV; *Johanne Solheim*, JV; *Julian Gröbner*, PMOD/WRC; *Ørnulf Nordseth*, IFE; *Michael Getz*, SINTEF; *Marco Povoli*, SINTEF; *Ozhan*

Koybasi, SINTEF; *Joaquin Campos Acosta*, CSIC; *Pedro Corredera*, CSIC; *Stefan Källberg*, RISE; *Lutz Werner*, PTB; *Ulrike Linke*, PTB; *Tobias Pohl*, PTB; *Meelis-Mait Sildoja*, Metrosert; *Toomas Kubarsepp*, Metrosert; *Mauro Rajteri*, INRIM; *Giorgio Brida*, INRIM; *Geiland Porrovecchio*, CMI; *Fredrik Edhborg*, RISE; June 6–7, 2023.

Participants of the EMPIR SEQUME project meeting: *Stefan Kück*, PTB; *Marco Lopez*, PTB; *Hristina Georgieva*, PTB; *Sebastian Raupach*, PTB; *Justus Christinck*, PTB; *Franziska Hirt*, PTB; *Geiland Porrovecchio* , CMI; *Mikael Lassen*, DFM; *Jarle Gran*, JV; *Toomas Küb*arsepp, Metrosert; *Meelis-Mait Sildoja*, Metrosert; *Haji Ahmedov*, TÜBITAK; *Pietro Lombardi*, CNR-INO ; *Benito Alén*, CSIC; *Stephan Reizenstein*, TUB; *Christoph Becher*, UDS; *Fuchs Philipp*, UDS; *Paolo Olivero*, UNITO; *Michael Jetter*, USTUTT; *Sven Burger*, ZIB; *Mauro Rajteri*, INRIM; *Daiji Fukuda*, AIST-NMIJ; September 4, 2023.

Howard Yoon, NIST, USA, October 19–20, 2023

Tom Kuusela, University of Turku, October 19–20, 2023

Petri Syrjälä, Finnish Defense Forces Logistic Command, December 5, 2023

7 PUBLICATIONS

7.1 Articles in International Journals

M.R. Vogt, S. Riechelmann, A.M. Gracia-Amillo, A. Driesse, A. Kokka, K. Maham, P. Kärhä, R. Kenny, C. Schinke, K. Bothe, J.C. Blakesley, E. Music, F. Plag, G. Friesen, G. Corbellini, N. Riedel-Lyngskær, R. Valckenborg, M. Schweiger, and W. Herrmann. "PV Module Energy Rating Standard IEC 61853-3 Intercomparison and Best Practice Guidelines for Implementation and Validation," *IEEE J. Photovolt.* **12**, 844–852 (2022). https://doi.org/10.1109/JPHOTOV.2021.3135258

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K. Maham, P. Kärhä, F. Manoocheri, and E. Ikonen, "Optical power scale realization using the Predictable Quantum Efficient Detector," *J. Phys. Conf. Ser.* **2149**, 012006, 5 p (2022). https://doi.org/10.1088/1742-6596/2149/1/012006

D. Lanevski, F. Manoocheri, and E. Ikonen, "Gonioreflectometer for measuring 3D spectral BRDF of horizontally aligned samples with traceability to SI," *Metrologia* **59**, 025006, 13 p (2022). https://doi.org/10.1088/1681-7575/ac55a7

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J. Fu, T. Quast, E. Velke, M. Esslinger, M. Pastuschek, A. Schirmacher, R. Aschan, F. Manoocheri and E. Ikonen, "Development of primary reference facilities and measurement comparison of standard artifacts for the bidirectional transmittance distribution function," *Rev. Sci. Instrum.* **94**, 083102, 8 p (2023). https://doi.org/10.1063/5.0151803

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M. Campanelli, V. Estelles, G. Kumar, T. Nakajima, M. Momoi, J. Gröbner, S. Kazadzis, N. Kouremeti, A. Karanikolas, A. Barreto, S. Nevas, K. Schwind, P. Schneider, I. Harju, P. Kärhä, H. Diémoz, R. Kudo, A. Uchiyama, A. Yamazaki, A.M. Iannarelli, G. Mevi, A. Di Bernardino, and S. Casadio, "Evaluation of 'on site' calibration procedures for sun-sky photometers," *Atmos. Meas. Tech.*, Pre-print amt-2023-165 (2023). https://doi.org/10.5194/amt-2023-165

7.2 International Conference Presentations

I. Harju, P. Kärhä, E. Ikonen, J. Gröbner, N. Kouremeti, and G. Hülsen, "Angular responsivities of PMOD lunar radiometer," Annual meeting of the Nordic Ozone and UV group (NOG2022), NILU, Oslo, Norway, April 26–27, 2022. (Talk)

K. Maham, P. Kärhä, and J. Gröbner, "Uncertainty estimation in aerosol optical depth," Annual meeting of the Nordic Ozone and UV group (NOG2022), NILU, Oslo, Norway, April 26–27, 2022. (Talk)

M. Korpusenko, O. Koybasi, F. Manoocheri, J. Gran, and E. Ikonen, "Optical Studies of a high-performance Predictable Quantum Efficient Detector based on induced-junction photodiodes passivated with SiO_2/SiN_x," The 9th International Symposium on Sensor Science, Warsaw, Poland, June 20–22, 2022, Eng. Proc. **21**, 39 (Talk). https://doi.org/10.3390/engproc2022021039

J. Karhu, J. Kuula, A. Virkkula, H. Timonen, M. Vainio, and T. Hieta, "Cantilever-enhanced Photoacoustic Detector for Light-absorbing Aerosols," Optical Sensors and Sensing Congress 2022, online, July 11–15, 2022, LW4D.5. (Talk). https://doi.org/10.1364/LACSEA.2022.LW4D.5

E. Ikonen, R. Nordlund, V. Mantela, J. Askola, and P. Kärhä, “Improvement in the Temporal Light Artefact metrics of commercial LED lamps,” Abstracts of the CIE Symposium on the Measurement of Temporal Light Modulation, Athens, Greece, October 11, 2022, pp. 14–15 (Talk).

Ville Mantela, Roope Nordlund, Janne Askola, Petri Kärhä, and Erkki Ikonen, “Novel implementations of digital meters for flicker and stroboscopic effect,” Abstracts of the CIE Symposium on the Measurement of Temporal Light Modulation, Athens, Greece, October 11, 2022, pp. 16–17 (Talk).

E. Ikonen, S. Sharma, M. Ahmadi, J. Rossi, M. Vainio, Z. Sun, and A. Steiger, “Cantilever-Based Photoacoustic Sensor for Terahertz Range,” SPIE Photonics West, San Francisco, United States, January 28 – February 2, 2023, Proc. SPIE **12420**, 124200A, 5 p (Talk). https://doi.org/10.1117/12.2647551

A. Danilenko, E. Ikonen, F. Manoocheri, M. Rastgou, “Characterization of PillarHall test chip structures using reflectometry technique,” 21st International Metrology Congress CIM 2023, Lyon, France, March 07–10, 2023 (Talk).

S. Das, K. Blomberg von der Geest, A. Mäkinen, A. Roost, E. Ikonen, and T. Laurila, “Sensitive real-time detection of metal concentrations in aqueous solution using micro-plasma emission spectroscopy,” 21st International Metrology Congress CIM 2023, Lyon, France, March 7–10, 2023 (Poster).

J. Karhu, J. Kuula, T. Mikkonen, M. Ward, A. Virkkula, E. Ikonen, T. Hieta, H. Timonen, M. Vainio, “Cantilever-Enhanced Photoacoustic Detector for Black and Brown Carbon,” 2023 Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference (CLEO/Europe-EQEC), Munich, Germany, June 26–30, 2023 (Poster).
https://doi.org/10.1109/CLEO/Europe-EQEC57999.2023.10231909

E. Ikonen, M. Korpusenko, A. Vaskuri, and F. Manoocheri, “Impact Ionization in Silicon at Ultraviolet and Short Visible Wavelengths,” The Fourteenth Finland-Japan Joint Symposium on Optics in Engineering, Hamamatsu, Japan, August 28 – September 1, 2023, 2 p (Invited talk).

J. Karhu, J. Kuula, T. Mikkonen, M. Ward, A. Virkkula, E. Ikonen, T. Hieta, H. Timonen, M. Vainio, “Cantilever-enhanced photoacoustic instrument for measurement of aerosol light absorption at three wavelengths,” European Aerosol Conference EAC2023, Malaga, Spain, September 3–8, 2023 (Poster).

M. Korpusenko, F. Manoocheri, and E. Ikonen, “Measurements of Low Optical Power with Cryostat-Based Predictable Quantum Efficient Detector at Liquid Nitrogen Temperature,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 6–7 (Talk).

A. Vaigu, T. Kubarsepp, and E. Ikonen, “Hybrid Trap Detector Sensitive at Visible and Telecom Wavelengths,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 8–9 (Poster).

E. Ikonen, V. Kosonen, K. Maham, and P. Kärhä, “Spectral analysis of deviations from key comparison reference values,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 38–39 (Talk).

Y. Rezazadeh, A. Sperling, T. Gerloff, U. Krüger, A. Ferrero, J. Campos, O. Pellegrino, J. Dubard, and E. Ikonen, “Uncertainty of evaluation of spectral mismatch correction factor,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 42–43 (Talk).

V. Leroy, S. Schunke, Y. Govaerts, P. Woolliams, R. Aschan, F. Manoocheri, and D. Lanevski, “SI-traceable reflectance simulation using the Eradiate radiative transfer model,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 108–110 (Poster).

L. Werner, E. Bardalen, G. Brida, E. Ikonen, M. Korpusenko, O. Koybasi, T. Kubarsepp, U. Linke, F. Manoocheri, P. Meindl, Ø. Nordseth, C. Pepe, G. Porrovecchio, M. Povoli, M. Rajteri, M.-M. Sildoja, M. Smid, T. Tran, and J. Gran, “Validating the predicted PQED spectral responsivity,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 123–124 (Talk).

M. Korpusenko, A. Vaskuri, F. Manoocheri, and E. Ikonen, “Quantum yield of Predictable Quantum Efficient Detector at ultraviolet and short visible wavelengths,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 125–126 (Talk).

F. Manoocheri, D. Lanevski, R. Aschan, and E. Ikonen, “Gonioreflectometer for Measuring 3D Spectral BRDF of Non-Rigid Samples,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 166–167 (Talk).

A. Eghbali, P. Kärhä, J. Peltoniemi, and E. Ikonen, “Comparison of indoor solar cells characteristics,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 172–174 (Poster).

A. Danilenko, M. Rastgou, F. Manoocheri, J. Kinnunen, V. Korpelainen, A. Lassila, and E. Ikonen, “Use of Reflectometry to Determine PillarHall Test Chip Structure,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 175–176 (Poster).

R. Aschan, F. Manoocheri, and E. Ikonen, “Measurement of Bidirectional Transmittance Distribution Function in the Visible to Near-Infrared Spectral Range,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 192–194 (Poster).

P. Kärhä, I. Harju, N. Kouremeti, G. Hülsen, J. Föller, M. Campanelli, V. Estellés, J. Gröbner, and E. Ikonen, “Angular responsivity measurements of solar and lunar radiometers,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 211–212 (Poster).

S. Sharma, M. Ahmadi, J. Rossi, M. Vainio, Z. Sun, A. Steiger, and E. Ikonen, “Photoacoustic detector for terahertz power measurements,” Proceedings of NEWRAD 2023 Conference, Teddington, UK, September 11–15, 2023, pp. 225–226 (Talk).

U. Krüger, A. Ferrero, A. Thorseth, O. Pellegrino, J. Dubard, E. Ikonen, and A. Sperling, “Sensitivity Evaluation of Measurement Uncertainty Contributions of Spectral Data for Calculated Integral Quantities,” Abstracts of CIE 30th Session Conference 2023, Ljubljana, Slovenia, September 18–20, 2023, pp. 32–33 (Talk).

R. Aschan, F. Manoocheri, D. Lanevski, and E. Ikonen, “Universal Bidirectional Reflectance Distribution Function Data Format for Machine-Driven Science,” Abstracts of CIE 30th Session Conference 2023, Ljubljana, Slovenia, September 18–20, 2023, pp. 117–118 (Talk).

A. Ferrero, L. Gevaux, M. Rastgou, M. Jaanimets, I. Jurgo, F. Manoocheri, T. Kübarsepp, A. Nilsson, G. Szajna, and G. Obein, “Preliminary Study for Traceability on Specular Gloss,” Abstracts of CIE 30th Session Conference 2023, Ljubljana, Slovenia, September 18–20, 2023, pp. 250–251 (Presented poster).

V. Mantela, R. Nordlund, J. Askola, P. Kärhä and E. Ikonen, "Temporal light artefact metrics of commercial LED lamps," Abstracts of CIE 30th Session Conference 2023, Ljubljana, Slovenia, September 18–20, 2023, pp. 256–257 (Presented poster).

M. Rastgou, E. Ikonen, F. Manoocheri, and A. Danilenko, "Validation of a micro-reflectometer for accurate characterization of thin film coatings," Abstracts of CIE 30th Session Conference 2023, Ljubljana, Slovenia, September 18–20, 2023, pp. 256–257 (Presented poster).

S. Das, K. Blomberg von der Geest, A. Mäkinen, A. Roost, E. Ikonen, and T. Laurila, "Towards Real-Time, On-Site Monitoring of Trace Metals in the Environment Using Micro-Plasma Emission Spectroscopy," Abstracts of the 13th International Conference on Instrumental Methods of Analysis, Chania, Greece, September 17–20, 2023, p. 107 (Talk).

A. Eghbali, E. Ikonen, and P. Kärhä, "Differential Spectral Responsivity of Solar Cells Measured with an LED Based Experimental Setup," 2023 Middle East and North Africa Solar Conference (MENA-SC), Dubai, United Arab Emirates, November 15–18, 2023, pp. 1–6 (Talk).
https://doi.org/10.1109/MENA-SC54044.2023.10374492

E. Ikonen, Y. Rezazadeh, and K. Maham, "Reliable Uncertainty Evaluation of Measurements of Color Quantities," Proceedings of the 15th Congress of the International Colour Association, Chiang Rai, Thailand, November 27 – December 2, 2023, pp. 611–616 (Talk).

7.3 National Conference Presentations

J. Karhu, J. Kuula, A. Virkkula, E. Ikonen, H. Timonen, M. Vainio, and T. Hieta, "Cantilever-enhanced photoacoustic spectroscopy for measuring aerosol light absorption", *Optics and Photonics Days 2022*, Tampere, September 6–8, 2022 (Poster).

M. Korpusenko, O. Koybasi, F. Manoocheri, J. Gran, and E. Ikonen, "Optical Studies of High-Performance Predictable Quantum Efficient Detector Based on Induced-Junction Photodiodes Passivated with SiO_2/SiN_x", *Optics and Photonics Days 2022*, Tampere, September 6–8, 2022 (Poster).

J. Karhu, J. Kuula, T. Mikkonen, M. Ward, A. Virkkula, E. Ikonen, T. Hieta, H. Timonen, and M. Vainio "Cantilever-enhanced photoacoustic measurement of wavelength dependence of aerosol light absorption", *Optics and Photonics Days 2023*, Joensuu, May 30 – June 1, 2023 (Poster).

M. Rastgou, A. Danilenko, F. Manoocheri, E. Nolot, and E. Ikonen "High-resolution micro-reflectometric characterization of thin film coatings", *Optics and Photonics Days 2023*, Joensuu, May 30 – June 1, 2023 (Poster).

7.4 Awards

Petri Kärhä: *Measurement Science and Technology*: 2021 Outstanding Reviewer Award, https://publishingsupport.iopscience.iop.org/questions/measurement-science-technology-2021-reviewer-awards/

Janne Askola: Award for best paper of 2022 published in journal *Lighting Research & Technology*: J. Askola, P. Kärhä, H. Baumgartner, S. Porrasmaa, and E. Ikonen, "Effect of Adaptive Control on the LED Street Luminaire Lifetime and on the Lifecycle Costs of a Lighting Installation," *Lighting Research & Technology* **54**, 75–89 (2022). https://doi.org/10.1177/14771535211008179

Erkki Ikonen: Recognition of significant long-term contribution to lighting technology by CIE National Committee of Finland (Suomen Valoteknillinen Seura, 2023).

Afsaneh Eghbali: Best paper award at the MENA-Solar Conference: A. Eghbali, E. Ikonen, and P. Kärhä, "Differential Spectral Responsivity of Solar Cells Measured with an LED Based Experimental Setup," in 2023 Middle East and North Africa Solar Conference (MENA-SC), November 15–18, 2023, Dubai, United Arab Emirates, https://doi.org/10.1109/MENA-SC54044.2023.10374492

Erkki Ikonen: *Measurement Science and Technology* Centenary Award for the article "Recent advances and perspectives in photometry in the era of LED lighting" (*Meas. Sci. Technol.* **35**, 021001, 2024) which updates a century of progress since "The measurement of photographic density" by A. J. Bull and H. Mills Cartwright (*J. Sci. Instrum*. **1**, 74–81, 1923). https://doi.org/10.1088/1361-6501/ad0de6

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