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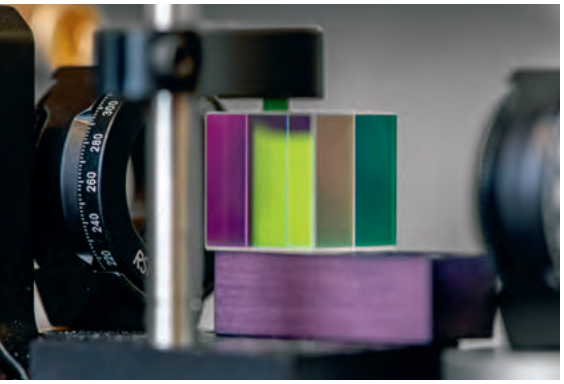
Swiss Confederation

Federal Institute of Metrology METAS

METAS in 2020



Cover picture: Measurement of fibre optic components (see p. 18).

Publisher's details

This report aims to provide an easily understandable overview of the activities of METAS in the reporting year. Further information can be gained from the Annual Report of METAS, the annual report on the implementation of the Metrology Act (both published on www.metas.ch), the Executive Pay Reporting (published on www.epa.admin.ch) and the short extracts of the Federal Council regarding the fulfilment of the strategic objectives of the independent units of the Confederation (published on www.efv.admin.ch).

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Changes at all levels

The Institute Council normally holds its meetings at METAS. This allows us to visit a laboratory, inspect a measuring place or gain direct insight into the progress of a research project, for example, as part of our meeting. However, this was not possible in 2020. Two of our meetings were held as virtual sessions only. One meeting did take place at METAS but under very unusual conditions: The meeting was held in a room that was actually far too large for the number of attending persons, in order to satisfy the social distancing requirements.

These are only minor adjustments compared to other effects of the Covid-19 pandemic. At the same time, however, it demonstrates how the pandemic has impacted our everyday work routines at many different levels – not to mention our private lives. Many procedures and practices we previously took for granted were suddenly no longer possible. A number of adjustments and changes were also required at METAS (see page 8). The fact that we managed to keep METAS running – despite all of the changes and special measures – can be attributed solely to the enormous level of commitment shown by the METAS employees. Adapting quickly and flexibly, they were able to continue working under the altered conditions. On behalf of the Institute Council, I would like to thank everyone for their flexibility and commitment.

Dr. Matthias Kaiserswerth
President of the Institute Council

> The pandemic has impacted our everyday work routines at many different levels.

Masks and focus on future requirements

If anyone had stated at the beginning of 2020 that we would soon all be walking around at METAS wearing protective masks or that masks would become mandatory in public transport, they would not have been taken seriously. However, masks are now well ingrained in our everyday lives. No one can say with certainty how the pandemic situation will develop in future. Of course, this situation has also clearly shown just how critical it is – insofar as possible – to make provisions for future developments.

Over the past year, alongside our ordinary business, the Executive Board has also intensively dealt with the various changes faced by METAS. A number of challenges await METAS in the coming years: For example, digitalisation will transform metrological services. In addition to our traditional work areas in physics, chemical and biological references are becoming more important. It is also important to focus on modern forms of customer contact as well as new organisational structures and work types. In the aim of meeting these requirements, the Executive Board has developed its "Vision METAS 2025". This is intended to provide the framework for a transformation programme while defining the direction of future development at METAS. Over the coming years, we will be working to implement our Vision METAS 2025.

Dr. Philippe Richard
Director

« New challenges await METAS in the coming years. »

Guiding METAS: the Institute Council and Executive Board

At the head of METAS is the Institute Council. It is responsible for guiding the organisation. The operative management is handled by the Executive Board.

The statutory requirements call for the Institute Council to be made up of five to seven expert members. In the reporting year, it comprised seven members: Dr. Matthias Kaiserswerth (President), Dr. Ursula Widmer (Vice President), Prof. Dr. Thierry Courvoisier, Dr. Tony Kaiser, Prof. Dr. Sonia Isabelle Seneviratne, Dr. Alessandra Curioni Fontecedro, Dr. René Lenggenhager.

The duties of the Institute Council are defined in the Institute Act. It applies to the Federal Council for the monies for services to be provided by the Federal Government and authorises the research and development programme. It exercises a supervisory role vis-à-vis the Executive Board and issues the personnel regulations. The members of the Institute Council have extensive leadership experience, in both academic and entrepreneurial terms, and many years of diverse experience in research and development in both sciences and technology.

Vision METAS 2025

Among the Institute Council's most important tasks is the definition of the strategic orientation of METAS, which it carries out in conjunction with the Executive Board. In so doing, it follows the Federal Council's guidelines set out in the strategic goals for METAS. In the reporting year, the Institute Council was especially involved with Vision METAS 2025, developed by the Executive Board, which it approved in November 2020.

Vision METAS 2025 is the framework for a transformation programme. It represents the response by METAS to challenges associated with developments that are expected in a variety of key areas, including the field of metrology, expectations among our stakeholders, digitalisation and other aspects of society. Vision METAS 2025 lays out the direction in which METAS is to be heading over the coming years.

Members of the Institute Council in 2020 (left to right): Dr. Matthias Kaiserswerth (President), Prof. Dr. Thierry J.-L. Courvoisier, Dr. Tony Kaiser; Dr. Ursula Widmer, Prof. Dr. Sonia I. Seneviratne, Dr. Alessandra Curioni-Fontecedro, Dr. René Lenggenhager.

Operative management

The Executive Board is responsible for the operative management of METAS. It represents METAS to the outside world. It has four members: the Director, Dr. Philippe Richard, the Deputy Director, Dr. Gregor Dudle, the Vice-Director, Dr. Bobjoseph Mathew, and the Head of the Chemistry Division, Dr. Hanspeter Andres, who was appointed Vice-Director by the Institute Council with effect from 1 January 2021.

Development of Vision METAS 2025 was an important focus in the work of the Executive Board. Definition and implementation of measures related to the coronavirus pandemic also shaped the day-to-day activities over the past year.

The METAS Executive Board (from top left to bottom right): Dr. Philippe Richard (Director), Dr. Gregor Dudle, Dr. Bobjoseph Mathew, Dr. Hanspeter Andres.

Measurement under different conditions: effects of the pandemic

The Covid-19 pandemic also impacted METAS. Numerous changes and adjustments were necessary. Nevertheless, we were able to keep our operations and customer service running at all times.

The pandemic greatly influenced our lives in the year 2020. Obviously, this included our everyday routines at METAS. We needed to introduce measures to protect the health of our employees and third parties while still keeping METAS up and running.

Working under changed conditions

Unlike most office jobs, laboratory work is feasible from the home office only to a limited extent. Measurements must be performed using specialised measuring stations. This is why the protective measures taken were so critical. They allowed our work to be performed under different conditions. Many procedures we previously took for granted were suddenly no longer possible. It was always critical to ensure that as few people as possible were together at the same location. Certain teams were divided up so the same persons could always work together at METAS. In some cases, these measures led to delays. For the most part, however, we were able to carry out the requested laboratory services. The situation especially had an impact on courses and events. In August, we were able to hold two information events with a limited number of participants on the topic of measuring non-ionising radiation. Unfortunately, we were forced to postpone most of the courses and training programmes at METAS.

Providing expertise

To assist in clarifying technical questions, METAS also made its expertise available in some cases. For example, we provided consulting related to production of disinfectants. In connection with exceptional approval for disinfectants, analyses were also performed to ensure that the products are both effective and non-hazardous. Furthermore, due to increased demand for ethanol for production of disinfectants, we analysed a greater number of ethanol samples.

Besides the usual disinfectants, ultraviolet radiation can also be used to disinfect surfaces and rooms. Special UV-C disinfection devices are used for this purpose. However, these devices can be hazardous due to potential damage to the eyes and skin. The Optics laboratory at METAS investigated some of these UV-C disinfection devices in terms of their risk potential.

The ongoing discussion on the reliability and traceability of tests used to detect Covid-19 virus infections is highlighting the importance of traceable measurements of nucleic acids in clinical laboratory testing. In 2019, METAS began building up its capabilities to perform traceable measurements of nucleic acids in order to function as a point of contact and service provider for questions related to metrological traceability of nucleic acids.

Implementation of protective measures.

Measurement for industry and society: the role of METAS

Wabern, the place with the most accurate measurements in Switzerland. Here the Federal Institute of Metrology METAS is at home – the metrological reference centre of Switzerland.

METAS is the Swiss national metrology institute. It serves as the Federal Government's centre of competence for all issues related to measurement and for measuring equipment and measuring procedures. Through its activities in research and development and its range of services, METAS is instrumental in ensuring that measurements can be performed in Switzerland at the level of accuracy demanded by industry, research, administration and society.

Authoritative reference standards

METAS realises the Swiss reference standards, ensures their international recognition and disseminates them with the requisite degree of accuracy. In this way, it provides industry and society with a basic metrological infrastructure that is important wherever measurements are made.

METAS oversees the market launch process, use and control of measuring equipment in the retail trade, traffic, public safety, health and environmental protection. It makes sure that the measurements required for the protection of people and the environment can be carried out correctly and in the prescribed manner.

Metrology

Metrology is the science and technology of making measurements (from the Greek word *metron,* meaning "measure"). *Metrology* is frequently confused with *meteorology.* However, these two fields are clearly distinct. *Meteorology* is the study of weather phenomena (from the Greek word *meteoros,* meaning "raised from the ground").

Progress demands precision

Reliable manufacture and monitoring is only possible with the aid of accurate measuring systems. Science and technology are therefore dependent on continuously evolving metrological principles and processes. Important branches of the Swiss economy such as micro and medical technology use measuring and control procedures that call for measuring methods with an accuracy that lies in the order of millionths of a millimetre.

METAS keeps up with scientific and technological developments in order to maintain its place at the cutting edge. It is engaged in research and development with a view to improving measuring stations and metrological services. It regularly reviews its range of services and adapts it to market needs.

The place with the most accurate measurements in Switzerland: at METAS in Wabern.

Measurement projects: research and development at METAS

METAS conducts much research and development work within the framework of the European Metrology Programme for Innovation and Research (EMPIR).

International cooperation also traditionally plays a key role in metrological research and development. Such cooperation takes place mostly as part of the European Metrology Programme for Innovation and Research (EMPIR). EMPIR was developed by the European Association of National Metrology Institutes (EURAMET) and the EU Commission. The goal of the programme is to coordinate the research conducted by the national metrology institutes more effectively and to strengthen metrological collaboration. In the reporting year, METAS participated in 28 EMPIR projects.

From subjective assessments...

Although it might come as a surprise, metrology can also deal with the visual appearance of products. This characteristic is critical in the marketing process. We associate perceptions such as quality, desirability or the expression of a personal lifestyle with visual appearance, which naturally has an influence on the market price. Accordingly, it is absolutely necessary for manufacturers to optimally manage the various aspects related to visual appearance. Nowadays, a product's appearance is typically judged by a human test group on the basis of the group's innate subjectivity. However, such intersubjective assessment is of course non-conclusive and is also dependent on cultural background.

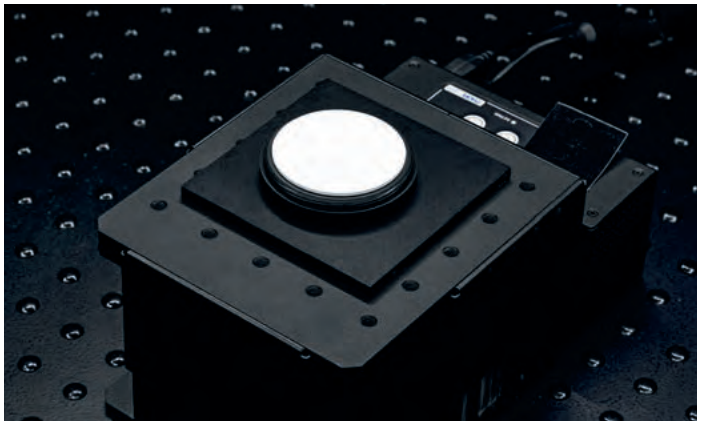
... to ascertainable objectivity

The EMPIR project known as "BxDiff" is working on measurable quantitative assessment of the visual appearance of a product. This quantity must be characterised as accurately as possible with low measurement uncertainty.

The goal is to produce a traceable scale representing what is known as the bidirectional reflectance distribution function. In simple terms, this is a measure of how light is reflected on surfaces. The influence of the light's polarisation and the texturing of the surface are also taken into account. The measurements are intended to be applicable to tiny samples with dimensions of only a few micrometres as well as objects in the centimetre range. It should also be possible to use the results in the fields of virtual prototyping as well as in rendering algorithms for virtual 3D visualisations.

The long-term goal is to support the wide spectrum of areas in industrial manufacturing where the visual appearance of a product is relevant. This includes manufacturers of optical measuring devices, material and pigment manufacturers, the watchmaking, automotive, paper, high-tech and cosmetics industries, as well as players in the fields of virtual reality and standardisation. As a result, this EMPIR project is generating industrial interest on a large scale.

Through this research project, METAS hopes to provide help in boosting visual appeal – even if it only involves an objective assessment of a physical quantity. Of course, there will never be a way to fully replace the subjective aesthetic perception of humans with a measurement.



Quantifying the visual appearance of products.

Measurement in the service of product development: cooperation projects with industry

METAS is recognised as a research partner by Innosuisse. Companies can thus make use of METAS's research and development expertise for their own innovations and carry out application-oriented development projects in conjunction with METAS.

METAS possesses broad technical and scientific expertise. Its profound metrological know-how is available to industry in the form of calibration and measurement services as well as through consulting services for product development or process optimisation.

Measuring air quality

As the Covid-19 pandemic has raged, other health risks have been pushed into the background. Of course, the nitrogen oxide in the environment, ozone and particulate matter are still as hazardous as ever. According to the World Health Organization (WHO), 4.2 million deaths worldwide per year can be attributed to air pollution. Over 91 % of the global population lives in regions where the air quality does not meet WHO standards.

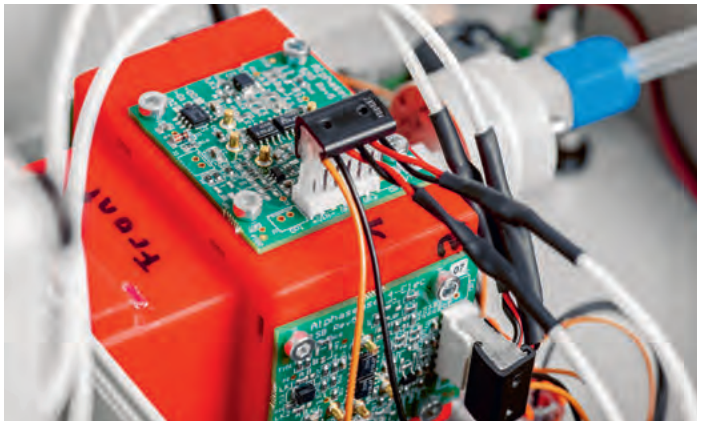
This is why there is a great deal of interest in improving air quality. The relevant physical quantities in the air must be measured in order to evaluate the efficiency of any steps that are undertaken. Measuring stations for assessment of hazardous gas molecules and particulate matter in the air have been available for some time now. However, the existing stations are large and expensive – and thus not widely used. Since pollution can vary widely at a local level, a denser air pollution monitoring network would be desirable, especially for monitoring individual exposure to toxins.

Monitoring networks with sensors

Accordingly, various measuring devices have been developed in recent years that use inexpensive gas and particulate matter sensors. Thanks to their lower cost and smaller size, a large number of these sensors could be interconnected via the Internet of Things into a dense monitoring network that is capable of supplying high-resolution air quality data, in space and time.

Compared to traditional measuring stations, however, the sensors have some weaknesses. For example, there are questions regarding the sensitivity, potential interference with other quantities, time constancy of the measured values (signal drift), and measurement uncertainty. Some of these error sources could be controlled by means of periodic calibration. However, calibration is expensive in relation to the sensor price and would generate significant operating costs due to the large number of devices.

In this context, the Gas Analysis laboratory at METAS has joined forces with an industrial partner, LNI Swissgas, and the Office for Air, Noise and Non-ionising Radiation (SABRA) of the Canton of Geneva in a project funded by Innosuisse. The goal is to combine these inexpensive pollutant sensors in a single device. Artificial intelligence will be used to filter out any outliers and interference during measurement of various gases. Another goal is to facilitate efficient metrological characterisation of this new device and develop a simple calibration procedure for the sensor network using techniques from experimental design.



Connect and combine pollutant sensors.

Metrology for industry: independent sensor testing for lighting technology

METAS provides services to numerous companies from diverse industry sectors that need to make precise and reliable measurements. This allows them to satisfy the quality requirements placed upon their products. A good example involves characterisation and testing of motion and presence sensors in the field of lighting technology.

METAS provides a large number of calibration, measurement and testing services for industry and the public administration. For example, about 4600 calibration certificates were issued in 2020. The most important customer segments are the engineering, electrical, metalworking and watchmaking industries in addition to medical science and communications technology.

Smart lighting systems

Motion and presence sensors are increasingly important in today's lighting technology. They can be used to control lighting conditions in indoor and outdoor spaces depending on the current situation and requirements. At the same time, they can also help to save energy. In recent years, high-performance sensors have been developed for precise and dependable lighting control.

As for their working principle, motion and presence sensors either actively detect radiation (e.g. ultraviolet, infrared or microwave) that is produced and reflected by the surroundings, or they passively exploit heat that is radiated by the surrounding objects. Passive detectors sense movement in the surroundings by detecting changes in the radiated heat. Nowadays, passive infrared (PIR) sensors are the most commonly used commercial technology.

Independent sensor test lab at METAS

The quality and performance of sensors are based on parameters such as their sensitivity, range and dependability. To support uniform qualification procedures, a set of test standards was recently defined under the auspices of sensNORM, the association of European sensor manufacturers. Until now, however, the actual tests were only performed by a few of the manufacturers themselves.

Against this backdrop, METAS created a dedicated test lab in 2020 that is the first independent institution capable of performing these tests for the manufacturers. The test procedure involves determination of whether the sensor correctly detects movement of a heated test dummy that approaches and moves away from the sensor in different directions under defined conditions. The defined test procedures for different sensor types are almost fully automated by the test system. Beginning in 2021, METAS can provide these test services for motion and presence sensors.

Testing facility for motion and presence sensors for lighting technology.

Measurement for fibre-optic telecommunication: photonics/fibre optics

Fibre optics is now widely used for data transmission. In order to properly deploy this technology, however, the characteristics of optical fibres and fibre components must be determined with increasing levels of precision. METAS is constantly working to develop new measurement capabilities in this area and can provide appropriate reference standards.

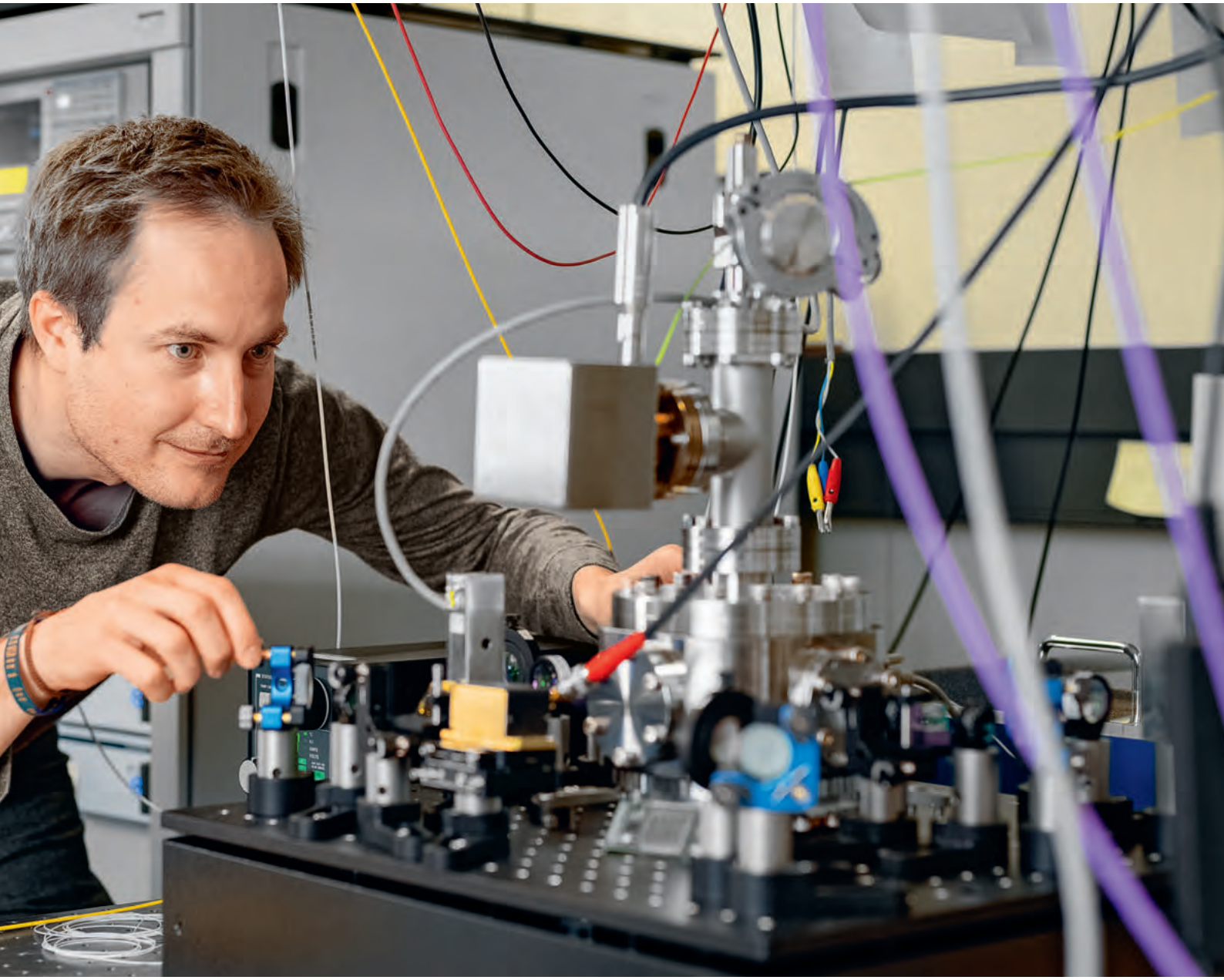
The demand for high-speed data transmission is growing. Communications networks and transmission lines need to keep pace with advances in information technology and telecommunication. Fibre optics plays an important role in data transmission. This technology is used to connect companies and households to networks operated by telecommunications providers. It is also used for onboard communication in vehicles and aircraft. Furthermore, optical fibres and fibre components are key elements in many test systems and optical sensors, for example in medical technology and for measurement of diverse physical quantities.

Making precise measurements

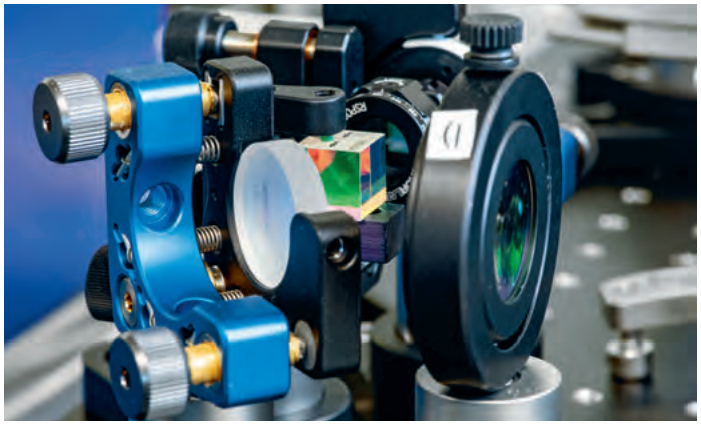
In order to ensure proper transmission of data via optical fibres, the characteristics of the optical fibres and fibre components must be measured with great precision. This is the only way to ensure their proper usage and facilitate rapid determination of the source of any disruptions, for example, that might occur. The Photonics, Time and Frequency laboratory is developing a whole series of references that are available for use in transferring key physical quantities in this field with extremely high precision. Relevant quantities include the dispersion, length, attenuation and reflection characteristics of optical fibres, as well as transmitted optical frequencies that must be determined with very high accuracy. With its references, the laboratory is able to offer comprehensive calibration services for test equipment that is used to determine these and other measurands related to optical fibres.

Quantum-based encryption

New communications techniques are being developed that allow quantum physical encryption of data transferred via optical fibres. This is one of the new and promising fields for which the lab has recently developed innovative measurement methods.



Using quantum physical properties, confidential data can in principle be encrypted in a secure manner. However, systems that use quantum keys are secure only if they are operated under optimum conditions. This can be achieved if all of the constituent components meet very strict requirements for the controlled specifications. The new measurement methods developed by the lab now allow optimal characterisation of all of the components that are used. This ensures that the systems can be correctly launched and then operated in a secure manner.



Measuring station for characterising fibre optical components.

Regulating measurement: legislation concerning metrology

In addition to the duties assigned to METAS under the Federal Act on the Federal Institute of Metrology, the Institute carries out further duties assigned to it by the Federal Council. In 2020, this category was extended with two additional duties.

Participating in the preparation of enactments in the field of metrology is one of METAS's statutory duties. In 2020, two amendments were adopted concerning ordinances specific to measuring instruments along with one amendment to the Ordinance on the Federal Institute of Metrology.

Level measuring instruments and fuel dispensing systems

The Ordinance of the FDJP on Dimensional Measuring Instruments was among the ordinances specific to measuring instruments that were amended in the reporting year. The amendment extends level measuring instruments for tank trucks and certain verification intervals. The Ordinance of the FDJP on Measuring Systems and Measuring Instruments for Liquids other than Water was also amended. The verification intervals for all fuel dispensing systems are being standardised. A tiered procedure for verification is being introduced: The first verification is performed after one year, then there is a verification every two years.

The verification intervals were revised in accordance with Parliamentary Motion 16.3670.

Remunerated duties

The Federal Council can assign remunerated duties to METAS that are not already assigned to METAS by law but which fall within the scope of the objectives of the Institute. The Federal Council had previously assigned four remunerated duties to METAS in the Ordinance on the Federal Institute of Metrology. METAS thus maintains Switzerland's hydrological monitoring network for the Federal Office for the Environment. Furthermore, it provides scientific and technical services to the Federal Customs Administration, the Federal Food Safety and Veterinary Office and the Federal Office of Public Health. As of 1 January 2021, the Federal Council extended the Ordinance on the Federal Institute of Metrology to include two further duties. First, METAS is making technical experts available to the Swiss Accreditation Service (SAS) under the State Secretariat for Economic Affairs. Second, it is providing scientific and technical services to the Federal Roads Office (FEDRO). METAS has already worked with both of these agencies in the past. The new regulation now

allows such cooperation to be specified within contracts under public law, in the interest of legal certainty and flexibility. This makes it easier for these federal agencies to take advantage of scientific and technical expertise available from METAS. At the same time, METAS will be able to more easily schedule its own resources in the affected work areas.

Maintaining the hydrological monitoring networks is one of the remunerated duties assigned to METAS.

Measurement across borders: international metrology organisations

METAS – and thus Switzerland – has a disproportionately high presence in international metrology organisations. The commitment of METAS staff at the international level is considerable.

International collaboration is indispensable in the field of metrology. It has been vital in replacing the multitude of co-existing measurement units and regionally applicable systems of units with the globally applicable International System of Units (SI). Internationally harmonised requirements for measuring instruments simplify commercialisation of the measuring instruments as well as their usage.

Cooperation in Europe...

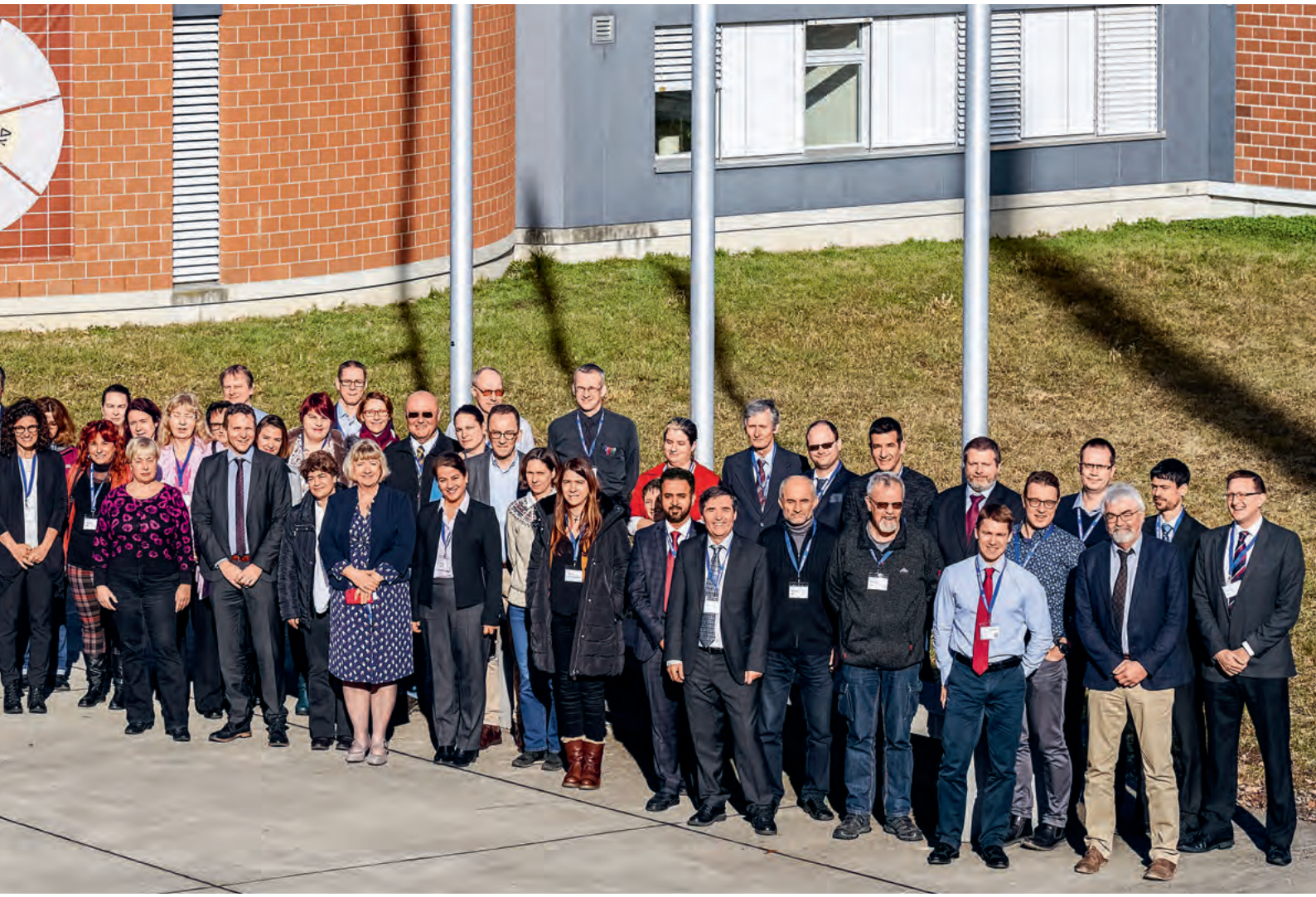
Cooperation between the different national metrology institutes in Europe takes place primarily within the context of the European Association of National Metrology Institutes (EURAMET). EURAMET is focused on scientific and industrial metrology. It played a key role in developing the EMPIR research programme (see page 12). METAS plays an active and formative role in EURAMET. METAS currently provides the chair of the *Electricity and Magnetism* Technical Committee.

There is also the European Cooperation in Legal Metrology (WELMEC). The Deputy Director of METAS served as the chair of WELMEC until October 2020. One focal point of his work involved reorganising the structures there. He was able to introduce a clear legal structure along with a permanent administrative office within WELMEC.

... and worldwide

METAS is also prominently represented within global organisations. The Vice-Director of METAS serves as a vice president of the *International Committee of Legal Metrology* (CIML), the steering body of the *International Organisation of Legal Metrology* (OIML).

The Director of METAS is a member of the *International Committee for Weights and Measures* (CIPM), the supervisory body of the organisation of the international Metre Convention.



One meeting of a Technical Committee could be held at METAS before the outbreak of the pandemic. Otherwise, meetings or sessions took place as video conferences.

Since June 2019, the Head of the Optics laboratory has served as President of the *International Commission on Illumination* (CIE), the international body for standards in the field of lighting technology and illumination.

Not least, these positions and other forms of involvement in international expert organisations demonstrate the high international regard for METAS and its personnel as competent and dependable partners.

Other aspects of measurement: METAS as a training place

Six different professions can be learned at METAS. Internships allow university graduates to gain insight into the world of metrological research and development. METAS also invests into advanced training for its personnel.

With a variety of scientific and technical departments engaged in highly complex activities that demand top precision, METAS is also a popular place for training. This includes professional training, internships for university students and exchange visits by guest researchers.

Apprenticeships for young people

METAS is very committed to vocational training. This is reflected in the relatively high share of trainees in the overall number of staff (7.5 %). Six different training programmes (mostly technical) are available at METAS. They cover chemical and physics laboratory technicians, computer scientists, electronics technicians and mediamaticians, as well as interns from business schools working towards the EFZ certificate of proficiency in business administration.

Internships and exchange visits

Especially in the context of research and development projects, METAS also offers a number of internships extending over several months for graduates of universities and institutes of technology. This allows the interns to gain insight into the world of metrological research and development in certain subject areas. At the same time, METAS benefits from their knowledge and skills. Clearly, this is a situation where both parties can benefit.

A special programme is available to physicists, chemists and engineers who are interested in metrology: During a year-long internship, they become more closely acquainted with the field of metrology. They can also collaborate on one or two longer projects that deal with topics they find particularly interesting.

For a number of years, METAS has promoted cooperation and exchange of knowledge between visiting researchers from other countries and experts at METAS. In the reporting year, for example, a young Slovenian biochemist spent several months as a visiting researcher at METAS working in a field that is currently under development. The mutual exchange of knowledge and cooperation enabled both parties to benefit from the experience and gain new insights.

Further training

It is also worth mentioning that METAS invests a great deal into further training for its workforce. This can support employees in their work and make it easier, or it can help to expand their range of activities. For example, one focal point in 2020 was on training in the area of project management. Many employees began a further training course in this area during the year. Through leadership training, technical courses and professional conferences, METAS is highly committed to serving as a place of training and further training, aiming to be an employer that keeps its staff competitive.

Accuracy and reliability: apprenticeship at METAS.

Finances

METAS ended the 2020 financial year with a profit of 2.5 million Swiss francs. Expenditures amounted to 50.2 million Swiss francs and revenues (including remuneration for extra duties) to 52.7 million Swiss francs.

METAS prepares its accounts in accordance with the International Public Sector Accounting Standards (IPSAS).

Balance sheet

(in thousand CHF)	31.12.2020	31.12.2019
Assets		
Cash	26 941	22 373
Trade receivables	2 466	4 196
Receivables for research projects	2 889	2 702
Other receivables	172	268
Prepaid expenses and accrued income	1 056	1 115
Working capital	**33 524**	**30 654**
Tangible fixed assets	19 778	19 964
Intangible fixed assets	2 131	2 002
Fixed assets	**21 909**	**21 966**
Total assets	**55 433**	**52 620**
Liabilities and equity		
Current liabilities on trade accounts payable	524	911
Liabilities in respect of research projects	3 825	4 009
Other liabilities	1 123	1 381
Accrued expenses and deferred income	296	304
Short-term provisions	1 227	1 230
Short-term borrowed capital	**6 995**	**7 835**
Provisions for pension fund liabilities	42 839	57 002
Provisions for service awards	1 603	1 637
Long-term borrowed capital	**44 442**	**58 659**
Net loss	–11 313	–12 934
Cumulative actuarial profits/losses	9 408	–5 974
Reserves for fixed assets	3 413	3 413
Profit	2 488	1 621
Equity capital	**3 996**	**–13 874**
Total liabilities and equity	**55 433**	**52 620**

Profit and loss account

(in thousand CHF)	2020 1.1.2020–31.12.2020	2019 1.1.2019–31.12.2019
Net revenue	**52 608**	52 722
Profit from sale of fixed assets	**0**	14
Expenditure on materials and third-party services	**–331**	–587
Personnel expenses	–34 853	–34 694
Operating expenses	–11 194	–11 632
Depreciation	–3 641	–3 958
Operating expenses	**–49 688**	–50 284
Financial revenue	57	6
Financial expenses	–12	–76
Financial result	**–45**	–70
Tax expenses	–146	–174
Profit	**2 488**	1 621

In the reporting year, METAS was able to finance 56.7 % of its activities (preceding year: 55.7 %) out of its own resources. The following means contributed to this self-financing level: fees, remuneration for taking over additional duties and external funds.

The auditors have confirmed without reservation that the accounts were properly prepared.

The detailed, IPSAS-compliant annual accounts can be downloaded on the METAS website or requested from METAS.

Telling the measurement story: METAS publications and papers

The research and development work is also reflected in publications and papers authored or presented by METAS researchers.

In the reporting year, METAS personnel again presented the results of their research and development work at symposiums, conferences and in scientific publications. They collaborated in specialist organisations and committees at national and international levels, contributing their know-how and experience. They made metrology accessible to a wide audience, beyond the immediate specialist circles, and were actively involved in courses for students at universities. Most of the presentations, lectures and meetings this year had to take place online.

A summary of the publications authored and papers presented by METAS personnel can be found at the end of this section. A series of lectures were also given in the course of events at METAS itself.

Awards

The scientific journal "IEEE Transactions on Instrumentation and Measurement" took advantage of its 70th anniversary to present awards to notable authors. Such awards were given to two METAS scientists working in metrology in the field of electricity. One is a very deserving author of many years, while the other is a younger and very promising author in this field.

"METinfo" journal

In 2020, METAS published two issues of "METinfo", its technical journal for metrology. The articles are, as a general rule, written by METAS personnel. Several "METinfo" articles were taken up by trade journals from different areas.

A taste of the laboratories

Unlike in recent years, the planned participation by METAS in the "Mädchen – Technik – Los!" programme during National Future Day, which was scheduled for early November 2020, was not possible because National Future Day was cancelled due to the pandemic. The programme normally offers a group of girls a taste of the work and activities carried out in the laboratories at METAS.

Most guided tours for groups also had to be cancelled during the reporting year. Guided tours enable METAS to show visitors its activities and give them a better understanding of its tasks. METAS will naturally begin to schedule these types of events again as soon as possible in view of the pandemic situation.

Publications and papers

The list below provides an overview of the most important publications authored by METAS personnel and the papers presented by them. When giving the authors' names, those of the METAS employees are shown in bold.

Publications

Brown, R. J.C., **Andres, H.:** *How should metrology bodies treat method-defined measurands?* Accreditation and Quality Assurance 25 (2020), 161-166.

Sauvageat, E. (...) **Auderset, K.** (...), **Vasilatou, K.:** *Real-time pollen monitoring using digital holography.* Atmospheric Measurement Techniques 13 (2020), 1539-1550.

Ferrero, A., **Basic, N.** et al: *An insight into the present capabilities of national metrology institutes for measuring sparkle.* Metrologia 57 (2020), 065029 18pp.

Muzeta, V., **Bernasconi, J.** (...), **Blattner, P., Reber, J.** et al.: *Review of road surface photometry methods and devices – Proposal for new measurement geometries.* Lighting Research and Technology (2020), 0: 1-17.

Bircher, B., Meli, F., Küng, A., Thalmann, R.: *X-ray source tracking to compensate focal spot drifts for dimensional CT measurements.* Proceedings. 10th Conference on Industrial Computed Tomography (iCT 2020) Wels, Austria, 6pp.

Bissig, H., Tschannen, M., de Huu, M.: *Traceability of pulsed flow rates consisting of constant delivered volumes at given time interval.* Flow Measurement and Instrumentation 73 (2020), 101729.

Bissig, H., Tschannen, M., de Huu, M.: *Water collection techniques at very low flow rates including strong capillary effects.* Flow Measurement and Instrumentation 73 (2020), 101744.

Reyes, D. R. (...), **Bissig, H.,** Becker, H.: *Accelerating innovation and commercialization trough standardization of microfluidic-based medical devices.* Royal Society of Chemistry (2020), 13pp.

de Huu, M., Tschannen, M., Bissig, H. et al: *Design of gravimetric standards for field-testing of hydrogen refuelling stations.* Flow Measurement and Instrumentation 73 (2020), 101747.

Maury, R. (...), **de Huu, M.** et al.: *Hydrogen refuelling station calibration with a traceable gravimetric standard.* Flow Measurement and Instrumentation 74 (2020), 101743.

Büker, O. Stolt, K., **de Huu, M.** et al.: *Investigations on pressure dependence of Coriolis Mass Flow Meters used at Hydrogen Refueling Stations.* Flow Measurement and Instrumentation 76 (2020), 101815.

Kottler, Ch. et al.: *Comparisons of air kerma and absorbed dose to water standards in Co-60 radiation beams for radiotherapy.* Metrologia 57 (2020), 06013.

Küng, A., Bircher, B., Meli, F.: *Low-Cost 2D Index and Straightness Measurement System Based on a CMOS Image Sensor.* Sensors 19 (2020), 5461.

Lüthi, M., Bircher, B., Meli, F., Küng, A., Thalmann, R: *X-ray flat-panel detector geometry correction to improve dimensional computed tomography measurements.* Measurement Science and Technology 31 (2020), 8 pp.

Fernández-Martínez, M. (...), **Iturrate-Garcia, M.** et al.: *The role of climate, foliar stoichiometry and plant diversity on ecosystem carbon balance.* Global Change Biology 26 (2020), 7067-7078.

Marti, K., Wuethrich, Ch., Aeschbacher, M., Russi, S., Brand, U., Li, Z.: *Micro-Force Measurements: A New Instrument at METAS.* Measurement Science and Technology 31, No. 7 (April 2020), 075007.

Seferi, Y., Blair, S.M., **Mester, Ch.,** Stewart, B.G.: *Power Quality Measurement and Active Harmonic Power in 25 kV 50 Hz AC Railway Systems.* Energies 13 (2020), 5698.

Götz, M (...) **Mortara, A:** *Calibration of ultrastable low-noise current amplifiers without direct use of a cryogenic current comparator.* Metrologia 57 (2020), 055008 9pp.

Heinrich, M., **Overney, F.** et al.: *Application of electrochemical impedance spectroscopy to commercial Li-ion cells.* Journal of Power Sources 480 (2020), 228742.

Overney, F., (...) Jeanneret, B.: *Load compensation bridge for Josephson arbitrary waveform synthesizers.* Measurement Science and Technology 31 (2020), 055004.

Overney, F., Flowers-Jacobs, N.E., **Jeanneret, B.** et al.: *Dual Josephson impedance bridge: towards a universal bridge for impedance metrology.* Metrologia 57 (2020), 065014.

Satar, E., Nyfeler, P., **Pascale, C., Niederhauser, B.,** Leuenberger, M.: *Towards an understanding of surface effects: Testing of various materials in a small volume measurement chamber and its relevance for atmospheric trace gas analysis.* Atmospheric Measurement Techniques 13 (2020), 16 pp.

Satar, E. (...), **Pascale, C., Niederhauser, B.,** Leuenberger, M.: *Investigation of adsorption and desorption behavior of small-volume cylinders and its relevance for atmospheric trace gas analysis.* Atmospheric Measurement Techniques 13 (2020), 101-117.

Högström, R. (...), **Niederhauser, B.** et. al: *Comparison for gas flow range 5 ml/min to 30 l/min.* Metrologia 57 (2020), 07029.

Peier, P., Trachsel, M., Kottler, Ch. et al.: *The European Joint Research Project UHDpulse -Metrology for advanced radiotherapy using particle beams with ultra-high pulse dose rates.* Physica Medica 80, (2020), 134-150.

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Pythoud, F.: *Technical Report: Measurement Method for 5G NR Base Stations up to 6 GHz.* METAS-report 154.1-2020-5218-1016 (2020), 25pp.

Dedyulin, S. (...), **Senn, R.,** de Groot, M.: *On the long-term stability of the triple-point-of-water cells.* Metrologia 57 (2020), 065032 11pp.

Stölting, K., Stettler, K.: *Die Naturwissenschaften machen es vor – Rückführbar messen – auch in der Medizin.* Chemieextra (2020), 11: 14-16.

Tancev, G., Pascale, C.: *The Relocation Problem of Field Calibrated Low-Cost Sensor Systems in Air Quality Monitoring: A Sampling Bias.* Sensors 20 (2020), 6198.

Tas, E., Pythoud, F.: *Design, Implementation, and Evaluation of Proficiency Testing in EMC Surge Immunity.* IEEE Transactions on Electromagnetic Compatibility 62, (2020), 2368-2375.

Trachsel, M., Kottler, Ch. et al.: *Chemical radiation dosimetry in magnetic fields: Characterization of a Fricke-type chemical detector in 6 MV photon beams and magnetic fields up to 1.42 T.* Physics in Medicine and Biology 65 (2020), 10pp.

Vasilatou, K. , (...), **Horender, S., Auderset, K.:** *Calibration of optical particle counters: first comprehensive inter-comparison for particle sizes up to 5 µm and number concentrations up to 2cm^{-3},* Metrologia 57 (2020), 2, 025005.

Wuethrich, Ch., Marti, K.: *Simultaneous Determination of Mass and Volume of a Set of Weights in Group Weighing.* ACTA IMEKO 9, No. 5 (2020), 17–22.

Conference contributions and papers

Agustoni, M.: *Impedance Metrology: Bridging the LF-RF Gap.* CPEM 2020 (online), 24.8.2020.

Andres, H.: *Metrology for Atmospheric Observations from in situ and on site sensors and networks (non-satellite).* Stakeholder webinar for EMN ClimOcNet, 12.2.2020.

Basic, N.: *Brief Description of the Physics of Graininess Sparkle and Graininess.* CIE Tutorial: Measurements of sparkle and graininess, 29.7.2020.

Bernasconi, J.: *Overview on quantities, geometries, instruments and measurement methods.* SURFACE stakeholder webinar, 19.6.2020.

Bircher, B.: *X-ray source tracking to compensate focal spot drifts for dimensional CT measurements.* 10th Conference on Industrial Computed Tomography 2020, Wels, 5.2.2020.

Bircher, B.: *METAS-CT: Metrological X-ray computed tomography at sub-micrometre precision.* euspen's international conference 2020 (online), 10.6.2020.

Bircher, B.: *Dimensional X-ray computed tomography at METAS.* Seminar Series in XCT, University Manchester, (online), 21.7.2020.

Bircher, B.: *State-of-the-art X-ray computed tomography for dimensional metrology.* NPL DXCT Workshop: Advanced X-ray computed tomography for dimensional metrology, (online), 2.12.2020.

Blattner, P.: *Blaulichtgefährdung – Positionspapier der CIE.* SLG Vorabendseminar, Murten, 21.1.2020.
Blattner, P.: METROLOGY - Fundamentals of measurement, terms, units and traceability. CIE/ICNIRP Tutorial on the Measurement of Optical Radiation and its Effects on Photobiological Systems (Online), 14.8.2020.
Blattner, P.: *Physique des rayonnements UV et leurs effets biologiques.* Tagung ARRAD, rayonnement non ionisant, 27.11.2020.
Blattner, P./Stuker, F.: *sensLAB – Bewegungs- und Präsenzsensoren auf dem Prüfstand.* SLG Vorabendseminar, Olten, 24.11.2020.
de Huu, M.: *New measurement capabilities of the METAS piston provers.* Euramet TC Flow, Teams meeting, 4.11.2020
Hof, C.: *Reziprozitätsmethode.* Kalibrier-Seminar SPEKTRA, Dresden, 29.9.2020.
Hof, C.: *Metrologie im Bereich der Vibration am METAS.* Kalibrier-Seminar SPEKTRA, Dresden, 30.9.2020.
Hoffmann, J.: *Calculable RF Standard for Frequencies Between 5 Hz and Several GHz.* CPEM 2020 (online), 30.8.2020.
Esche, M., **Grasso Toro, F.:** *Developing Defense Strategies from Attack Probability Trees in Software Risk Assessment.* FedCSIS (2020), 527.
Iturrate-Garcia, M.: *Metrology for climate relevant volatile organic compounds – MetClimVOC.* 18th Swiss Geoscience Meeting (online), 7.11.2020.
Jeanneret, B.: *The Load Compensation Bridge: Preliminary Results.* CPEM 2020 (online), 24.8.2020.
Kazemipour, A.: *Material Measurements and Parameter Extraction, Error Analysis and Uncertainties.* UMEMA 2020, Workshop on Uncertainty Modelling for Electromagnetic Applications, Paris, 30.1.2020.
Kazemipour, A.: *Material Measurements and THz Metrology.* Seminar Universität Bern, 13.3.2020.
Kazemipour, A.: *THz Corrugated Horn Antennas as TEM Mede-Converter for Power Measurements and Material Characterization in Free-Space.* AES 2020, International Conference on Antennas and Electromagnetic Systems, Marrakesch, 1.6.2020.
Kazemipour, A.: *VNA-Based Material Characterization in THz Domain without Classic Calibration and Time-Gating.* CPEM 2020 (online), 30.8.2020.
Lüthi, M.: *Current Status.* PHOR Physics Meeting (online), 31.3.2020.
Lüthi, M.: *Cross-Section Measurements & Beamline Upgrade.* PHOR Physics Meeting (online), 6.11.2020.
Mallia, S.: *Präsentationen über «Metas-Aktivitäten» und über das «Lebensmittelsicherheitsprojekt».* PTB, Braunschweig, 1.10.2020.
Mallia, S.: *Metas: PAHs CRM Project.* Workshop "NRL-PAK", BVL, Berlin (online), 14.12.2020.
Meli, F.: *Towards primary dimensional X-ray computed tomography.* euspen's international conference 2020 (online), 8.6.2020.
Mester, Ch.: *Sampling primary power standard from DC up to 9 kHz using COTS components.* 3rd International Colloquium on Intelligent Grid Metrology (online). 20.10.2020.
Morel, J.: *Precise time and frequency transfer using the SWITCH network.* ICT-Focus Meeting 2020 (online), 10.11.2020
Niederhauser, B.: *Calibration services for ozone standards and instruments in Switzerland.* Ozone Workshop, 6.10.2020.
Niederhauser, B.: *Metrologie, METAS, Terminologie, Messunsicherheit, Konformität und Atemalkoholmessung.* ZHAW Kurs, 7.12.2020.
Overney, F.: *Characterization of a Dual Josephson Impedance Bridge.* CPEM 2020 (online), 24.8.2020.
Pascale, C.: *EMN for climate and ocean Observation: Atmospheric Section.* TC-MC Workshop PRT Brainstorming, 9.12.2020.
Peier, P.: *Radonmessplatz am METAS.* Mai-Sitzung der Subkommission für Umweltüberwachung der KSR (online), 7.5.2020.
Peier, P.: *Radonvergleichsmessung 2020 und Revision der Strahlenmessmittelverordnung.* Radoninformationstag, BAG (online), 13.10.2020.
Stölting, K.: *Scientific study of measurements, SI units, and the tasks of a National Metrology Institute.* Topical Day – Measurement Uncertainty. EMPA, St. Gallen, 18.8.2020.
Stuker, F.: *Messen und Beurteilen der Blaulichtgefährdung.* SLG Vorabendseminar, Murten, 21.1.2020.
Tas, E.: *An Improved Reference Device for Radiated Immunity Interlaboratory Comparison.* EMC Europe 2020, Rom (online), 24.9.2020.
Vasilatou, K.: *Generation and physicochemical characterisation of ambient-like model aerosols in the laboratory: application in the intercomparison of automated PM monitors with the reference gravimetric method.* SCS Fall meeting (online), 28.8.2020.
Vasilatou, K.: *Calibration of optical and aerodynamic particle size spectrometers.* European Aerosol Conference 2020 (online), 3.9.2020.
Vasilatou, K.: *New calibration procedures for bioaerosol monitors.* AutoPollen meeting (online), 3.9.2020.

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