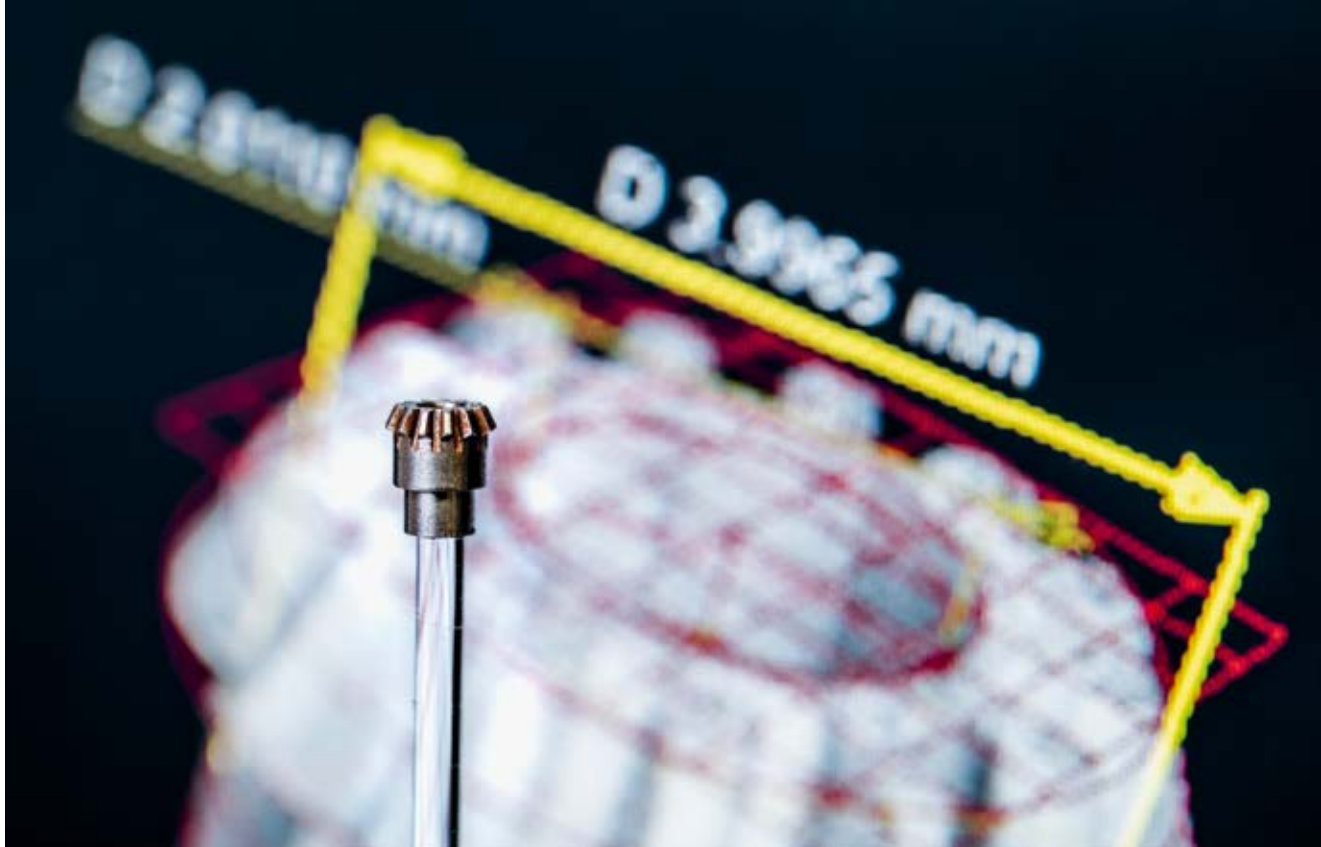




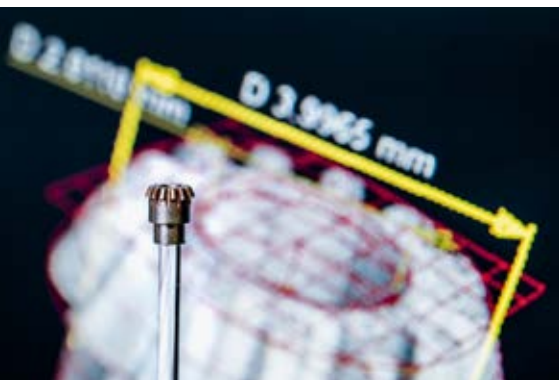
Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

Federal Institute of Metrology METAS

Swiss Confederation



METAS in 2019



Cover picture: High-accuracy measurement of precision parts (see p. 16).

#### **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](http://www.metas.ch)), the Executive Pay Reporting (published on [www.epa.admin.ch](http://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](http://www.efv.admin.ch)).

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# Changes within the Institute Council



The Federal Council elects the METAS Institute Council for four years at a time. The previous term of office ran to the end of 2019. In November 2019, the Federal Council appointed the Institute Council for the new term of office from 2020 to 2023: Four of the five previous members of the Institute Council were chosen along with three new members (see p. 6). Professor Dr. Ulrich W. Suter did not stand for re-election. He served as a member of the Institute Council of the Federal Institute of Metrology METAS since 2012, i.e. from the time METAS became a Federal Institute on 1 January 2013. He served as the Institute Council's Vice President. Together with the other members, he was actively involved in preparations for the founding of the institute and the commencement of operations and contributed to the strategic orientation and the research and development programme of METAS. I wish to express my sincere thanks for his tremendous commitment to METAS.

The duties of the Institute Council will remain the same during the new term of office and in the new composition. They are first and foremost at the strategic level. The Institute Council focuses especially on the orientation of research and development at METAS since these activities are strategically important for a national metrology institute.

There were also some changes on the Executive Board. It has consisted of four members since 1 July 2019. With effect from that date, the Institute Council appointed the head of the newly created *Chemistry* division as a member of the Executive Board of METAS (see p. 8).

Together with my colleagues on the Institute Council and the Executive Board, I look forward to continuing to apply myself over the next four years to the strategic orientation and entrepreneurial leadership of METAS.

Dr. Matthias Kaiserswerth  
President of the Institute Council

« The duties of the Institute Council lie primarily at the strategic level. »

## Showcasing our work

People bustling through the corridors next to the laboratories, crowds of visitors in the entrance hall, children everywhere – none of these descriptions are typical for METAS. National metrology institutes are not normally in the business of hosting large groups of visitors or allowing them to wander from laboratory to laboratory. Instead, the focus is on the actual work inside the laboratories, in particular the provision of metrological services. This is why METAS – like any other national metrology institute – is structured and organised to allow the work that goes on inside its laboratories to proceed as smoothly as possible, without interruption.

However, crowds of visitors dominated the scene on 25 May 2019. On this Saturday, METAS opened its doors to the general public. Local residents, family members, friends and acquaintances of employees, and basically anyone interested from near and far had a chance to look inside the buildings with the distinctive tower in Wabern. It was an opportunity to experience at first hand what METAS actually does. Visitors learnt about the International System of Units (SI), had a look inside the laboratories and at the measurement equipment, and listened to what METAS employees – all recognisable by their

white T-shirts with the SI logo – had to say about different devices and test procedures. Thanks to the beautiful weather, it was also possible to enjoy an occasional break in the area in front of the entrance.

The visitors were clearly fascinated by the variety of technical fields at METAS as well as the wealth of knowledge. They were particularly impressed by the employees' dedication to their work and their pride in their technical knowledge and abilities. In fact, this strong commitment on the part of the employees is what forms the basis for the success of METAS. This commitment can be felt time and time again in everyday life, too. Together with my colleagues on the Executive Board, including our new member since July 2019 (see p. 8), I am working to further promote and maintain this culture of professional commitment during all of our changes and adjustments.

Dr. Philippe Richard  
Director



This strong commitment on the part of the employees is what forms the basis for the success of METAS.



# Setting the direction: the Institute Council

*At the head of METAS is the Institute Council.  
It is responsible for guiding the organisation.*

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.

## **Defining the strategic orientation**

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. The Federal Council expects METAS to provide industry, the scientific community and the public administration with an effective metrological infrastructure as well as the necessary measurement principles and metrological services.

## **New term of office**

The statutory requirements call for the Institute Council to be made up of five to seven expert members. In the reporting year (the final year of the 2016 to 2019 term of office), it comprised five members. At the end of November 2019, the Federal Council elected the members of the Institute Council for the new term of office from 2020 to 2023: four previous and three new members. The fifth previous member, Prof. Dr. Ulrich W. Suter, did not stand for re-election.

Since the start of 2020, the Institute Council of METAS is made up as follows:

**Dr. Matthias Kaiserswerth (President)**, Computer Scientist, Managing Director of the Hasler Foundation since 2015, Director of the IBM Research Laboratory in Zurich-Rüschlikon from 2006 to 2015.

**Prof. Dr. Thierry Courvoisier**, Emeritus Professor of Astrophysics at the University of Geneva, President of the European Academies Science Advisory Council (EASAC) until 2019.

**Dr. Tony Kaiser**, Senior Consultant at Consenec AG in Baden-Dättwil until 2015, previously responsible at ALSTOM Power for long-term technology programmes in the power plant sector.

**Dr. Ursula Widmer**, attorney at law specialising in IT, Internet and telecommunications law, lecturer for information security law at ETH Zurich.

**Prof. Dr. Sonia Isabelle Seneviratne (new)**, Head of the Land-climate dynamics group at the Institute for Atmospheric and Climate Science in the Department of Environmental Systems Science at ETH Zurich.

**Dr. Alessandra Curioni Fontecedro (new)**, Head of the Lung and Thoracic Tumours group in the Clinic for Medical Oncology and Haematology of the University Hospital of Zurich.

**Dr. René Lenggenhager (new)**, physicist, Dr. sc. nat. ETH/EMBA HSG, was CEO of the COMET GROUP in Flamatt from 2017 to 2019.



The members of the Institute Council of METAS from the beginning of 2020 (from top left to bottom right): Dr. Matthias Kaiserswerth (president), Prof. Dr. Thierry J.-L. Courvoisier, Dr. Tony Kaiser, Dr. Ursula Widmer, Prof. Dr. Sonia I. Seneviratne, PD Dr. Alessandra Curioni-Fontecedro, Dr. René Lenggenhager.



# Guiding METAS: the Executive Board

*The operative management of METAS is handled by the Executive Board.*

The Executive Board is responsible for the operative management of METAS. It represents METAS to the outside world. In mid-year, it was expanded from three to four members. With effect from 1 July 2019, the Institute Council appointed Dr. Hanspeter Andres, the head of the newly created *Chemistry* division, as a member of the Executive Board. The other members of the Executive Board are the Director, Dr. Philippe Richard, the Deputy Director, Dr. Gregor Dudle, and the Vice-Director, Dr. Bobjoseph Mathew.

## **New Chemistry division**

Until 1 July 2019, analytical chemistry was a technical field within the *Physics and Chemistry* division. On that date, a separate *Chemistry* division was formed alongside the *Physics* division. This organisational development was related to the size of the technical field and especially the increasing importance of chemistry in metrology. For example, METAS began expanding its activities two years ago into two new areas of chemistry and biology.

The head of the new division, Dr. Hanspeter Andres, holds a doctoral degree in chemistry. Following a postdoc project at Carnegie Mellon University in Pittsburgh (USA) and the University of Bern, he was employed by Nitrochemie Wimmis AG. There, his work included development of a new propellant for automobile safety systems as well as a process for de-acidification and stabilisation of paper. In 2007, he joined METAS as head of the analytical chemistry sector. He has also completed an EMBA programme. From 2015 to 2019, he was Chair of the Technical Committee of Metrology in Chemistry for the European Association of National Metrology Institutes (EURAMET).



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



# 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.

## Great commitment at the international level

Cooperation between the different national metrology institutes in Europe takes place primarily within the context of the European Association of National Metrology Institutes (EURAMET). METAS plays an active and formative role in EURAMET. The Chief Science Officer of METAS is a member of the Supervisory Board of EURAMET. METAS provides the chair of the *Electricity and Magnetism* Technical Committee, and the *Metrology in Chemistry* Technical Committee was also chaired by a METAS employee until May 2019.

The Deputy Director of METAS serves as the chair of WELMEC, the European Cooperation in Legal Metrology. Since October 2019, the Vice-Director of METAS has served as a vice president of the *International Committee of Legal Metrology* (CIML). The Director of METAS is a member of the *International Committee for Weights and Measures* (CIPM), the supervisory body for the organisation of the international Metre Convention.



Meeting of a Technical Committee at METAS.

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.

# 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 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 each case. 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. New scientific and technological developments are therefore dependent on constantly evolving metrological principles and processes. Important branches of the Swiss economy such as micro and medical technology or applications such as measuring and control procedures call for measuring methods with an accuracy that may lie 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 its research and development work to a large extent within the framework of the European Metrology Programme for Innovation and Research (EMPIR).*

EMPIR was developed by EURAMET, the European Association of National Metrology Institutes, 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 33 EMPIR projects. In parallel, 2019 saw the sixth project tender for the EMPIR programme. METAS submitted project proposals relating to the key topics “Environment”, “Energy” and “Pre-normative”, and achieved an above-average success rate.

## **Monitoring natural radioactivity**

Radon is a radioactive noble gas that is colourless, odourless and tasteless. It is formed as a decay product of heavy metals that were originally radioactive and which occur naturally in the ground. Through geological processes, radon gas can get from the ground into buildings. Despite a half-life of only 3.8 days, it can accumulate there – especially in closed or poorly ventilated rooms. It is estimated that radon causes between 3 and 14 % of all cases of lung cancer, depending on the average radon concentration in a given country. This means that about 15,000 to 20,000 persons in Europe die from lung cancer every year due to radon exposure.

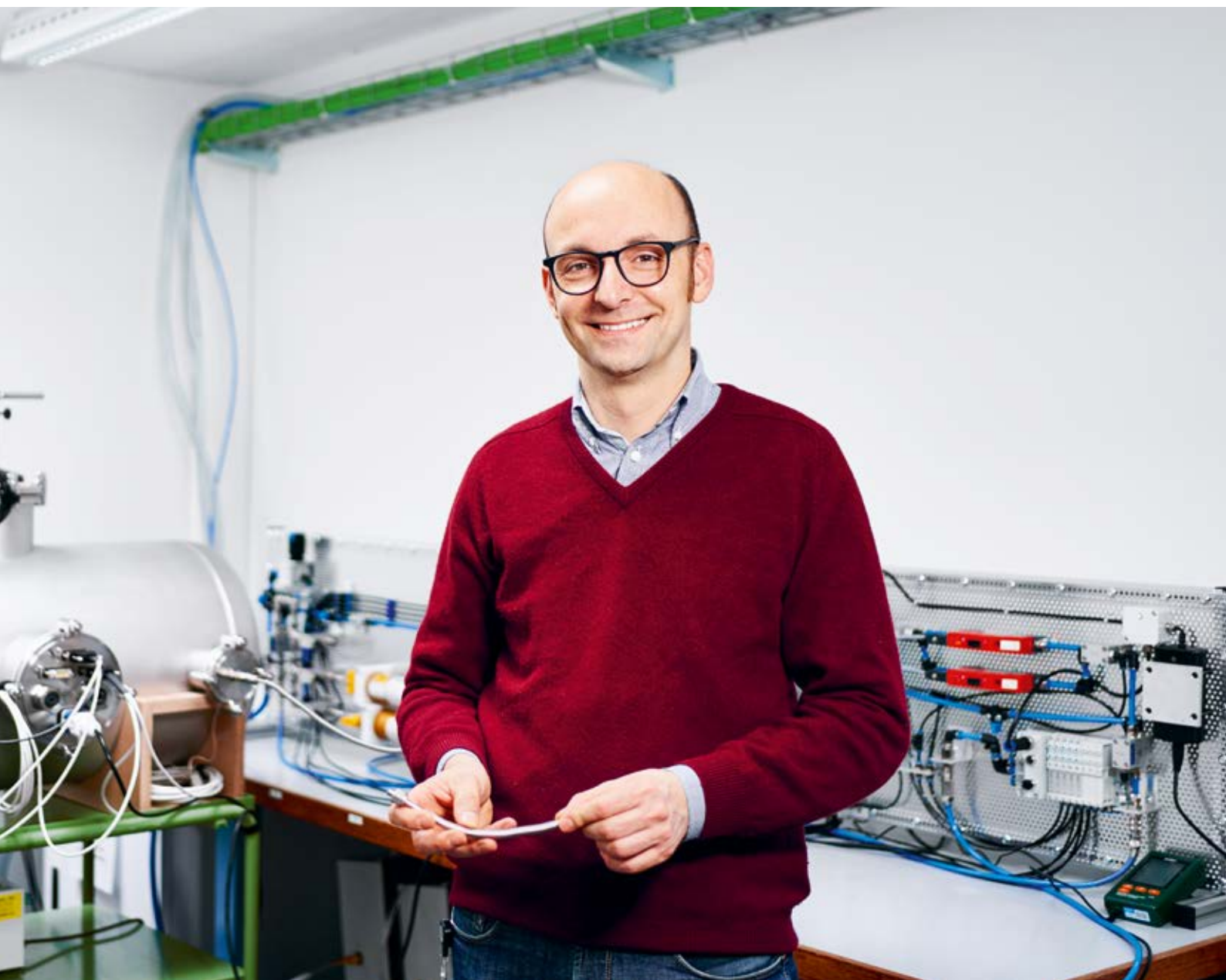
In Switzerland, the limit for radon exposure of 1000 Becquerel per cubic metre (Bq/m<sup>3</sup>) was replaced at the start of 2018 with a reference value of 300 Bq/m<sup>3</sup> for the yearly average of the radon activity concentration in rooms where persons are regularly present for several hours per day. The measuring instruments used in Switzerland for official radon measurements in residential spaces and common rooms are legally regulated and are subject to periodic recalibration or comparison measurement.

## **New calibration method for radon measuring instruments**

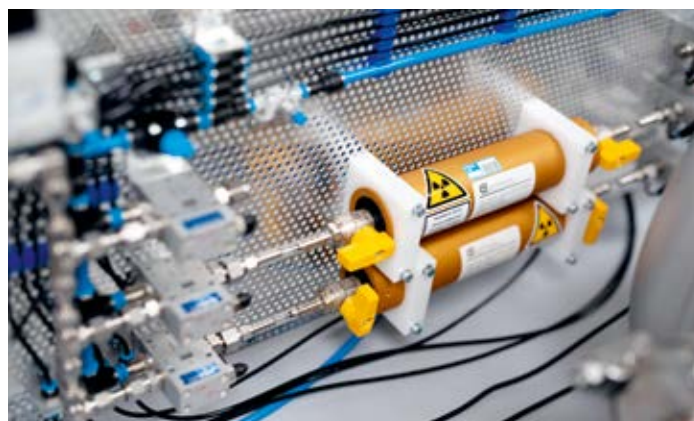
In order to also allow reliable assessment of the radon exposure for the new, reduced reference value, METAS developed an improved calibration method for radon measuring instruments as part of the EMPIR project known as MetroRADON. As radon sources, it uses references that allow air containing radon to escape (“emanation standards”). This method enables a metrologically traceable concentration of radon activity to be produced in the carrying air by varying the quantity of air that flows through the source per time interval and is







fed into the measurement volume. Radon measuring devices located within the measurement volume can thus be calibrated for different values of radon activity concentration. The new radon measuring station is already being used for verification and calibration of radon measuring instruments as well as for comparison measurement of passive radon dosimeters.



Calibration of radon measuring instruments.

# 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 developments and carry out projects in application-oriented research and development in conjunction with METAS.*

The scientific and technical knowledge accumulated by METAS may be used by industry not only in the form of calibration and measurement services but also directly for product and process development. This makes METAS an attractive partner in the most diverse areas. Since 2013, fourteen cooperation projects have been approved by Innosuisse (formerly CTI).

## **Reference signals for weather radar systems**

Weather radar is used worldwide to forecast storms and warn the public about potentially dangerous weather events. However, these warnings are only reliable if the underlying radar measurements are sufficiently precise. Unfortunately, it is difficult to calibrate radar systems and there is still no well-established method for calibration. In addition, weather services are often dependent on equipment manufacturers for verification and configuration of their systems. There are practically no quality standards for weather radar systems – despite significant efforts by the World Meteorological Organization (WMO) to encourage the development of such standards. In order to allow improved calibration of weather radar systems, a radar target simulator (RTS) was developed. On the basis of the incoming radar signal, this instrument generates an artificial, well-defined target that can be used as a reference standard for calibration purposes.

With a view to further developing this RTS technology for commercial sale, and in order to provide professional calibration services for weather radar equipment, the company Palindrome Remote Sensing GmbH was founded in 2017 in Landquart. A project supported by Innosuisse in cooperation with the University of Applied Sciences Buchs (NTB) and METAS was to help this young company to realise its business idea. The project was aiming

to build a precision radar target generator and acquire all of the relevant hardware and software knowledge in order to offer radar calibration services from a single source in future.

## **Ensuring the traceability of measurement results**

It was the job of METAS to develop a calibration method for this new radar target simulator and ensure that the measurement results could be traced back to SI units. Comprehensive measurements were performed on the overall system as well as on individual components. One of the main challenges was due to the brief duration of the signal pulses (on the order of a few microseconds). There







is thus very little time to reliably determine the signal amplitude and especially the phase. The problem was solved by implementing a measuring set-up that allows simultaneous measurement of the incoming and reflected pulses. Another important characteristic of the system is its sensitivity to environmental influences. Accordingly, the temperature and humidity dependency of the relevant measurands was assessed in a climate-controlled chamber.



Measurements in the electromagnetic compatibility laboratory.



# Metrology for industry: measurement of hidden structures using X-ray computer tomography

*METAS provides services to 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. This concerns, for example, measurement of small precision parts.*

METAS provides a large number of calibration, measurement and testing services for industry and the public administration. For example, some 4500 calibration certificates were issued in 2019. The most important customer segments are the engineering, electrical, metalworking and watchmaking industries in addition to medical science and communications technology.

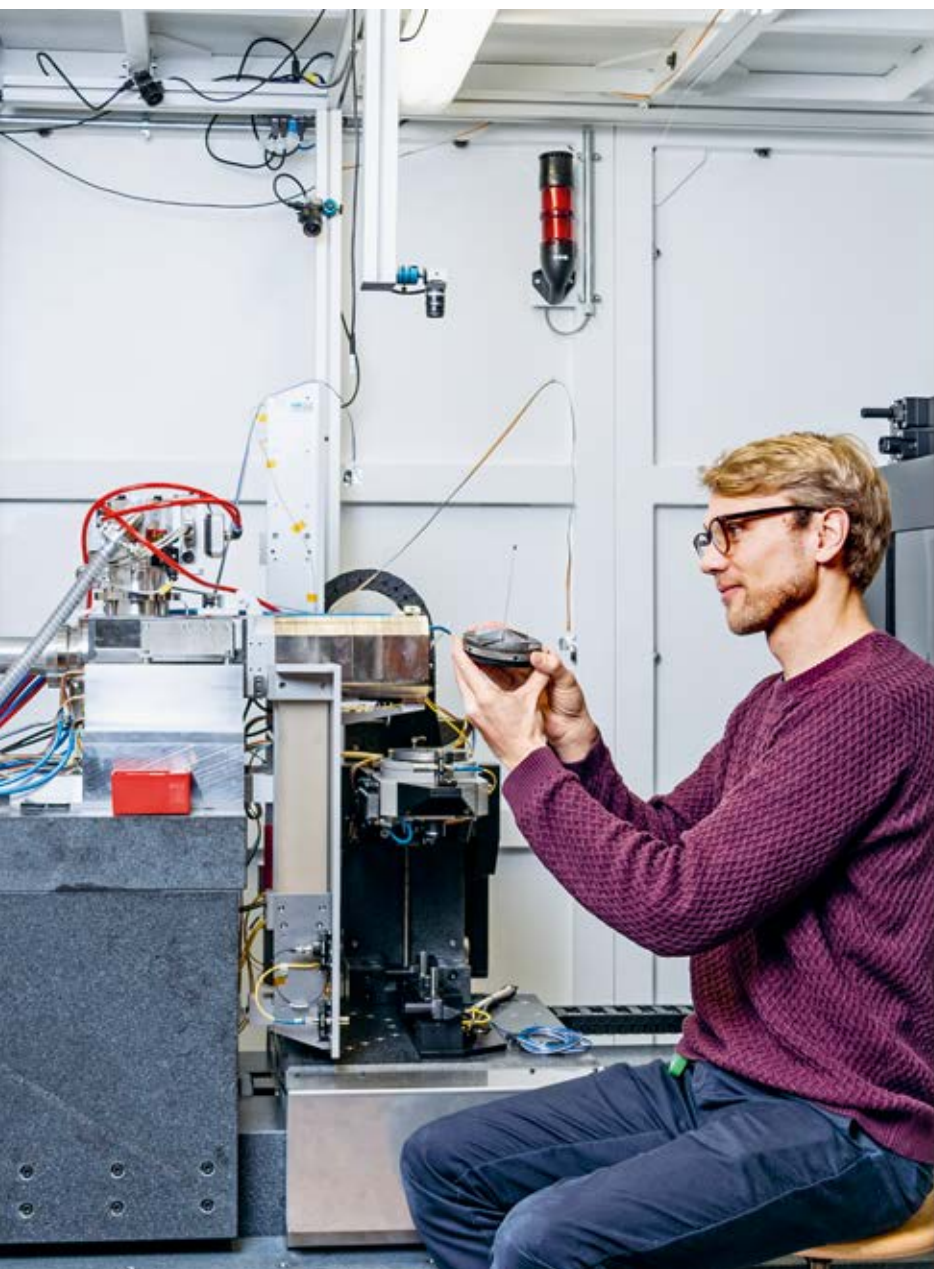
## **Computer tomography**

X-ray computer tomography is a non-destructive technique for complete imaging of the three-dimensional structure of samples. Initially, this technique was used mostly for material testing, but in recent years it has been applied increasingly in measurement tasks. For example, it can be used to measure small precision parts with features that are either too tiny or inaccessible for tactile measurements. This typically involves watch components, precision stamped parts, connector systems or reference objects for validation of computer tomography equipment.

Five years ago, METAS began building up its expertise in the field of dimensional computer tomography. In particular, it developed a high-precision computer tomography system known as METAS-CT and put it into operation. In order to improve this system and to develop appropriate procedures for estimating the measurement uncertainty, METAS is also conducting research in the field of dimensional computer tomography. This research is taking place within the framework of European cooperation.

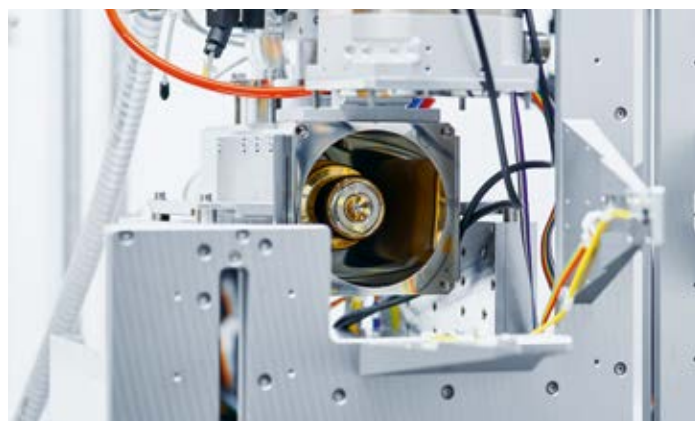
One objective is to obtain a more precise assessment of the opportunities and limits of dimensional computer tomography while advancing standardisation and boosting confidence in this powerful technology. Another area of research is focused on establishing measurement capabilities for metal parts that are created through additive manufacturing (also known as 3D printing).





#### Delicate parts in the watchmaking industry

As an application example for this measurement technique, new manufacturing processes for small precision parts made of glass introduced in the watchmaking industry may be mentioned. The *Association Suisse pour la Recherche Horlogère* (ASRH) consulted with METAS and provided test specimens for use in evaluating the measurement capabilities for such fine structures. With METAS-CT, it was possible to fully measure all of the features of these delicate glass parts. The measurement uncertainties were close to one thousandth of a millimetre, which would have been inconceivable with conventional techniques.



High-accuracy measurement of tiny parts.

# Showcasing the world of measurement: Open Day at METAS

*On the last Saturday in May, METAS opened its doors to the general public. Visitors had a chance to learn about diverse activities at METAS, including some of the measuring instruments and techniques. An important topic was the revision of the International System of Units (SI). The Open Day was well attended and highly successful.*

Some 1600 visitors took advantage of the opportunity on Saturday, 25 May 2019, to visit METAS and learn about its activities and technical facilities. On the previous Friday, customers had a chance to visit METAS as part of a special Customer Day event.

## **Insight into labs, experiments, presentations...**

The Open Day was held to mark the revision of the International System of Units (SI). This involves new definitions of certain units like the kilogramme and the ampere. The revised SI entered into force on 20 May 2019. Accordingly, the Open Day included a variety of presentations and information about SI and the units of measure. Above all, visitors had a chance to learn about what goes on at METAS and view special facilities such as the anechoic chamber and the imposing power machine.

A tour of the METAS buildings stopped by many laboratories and items of equipment. At numerous stations, visitors could find out more about a lab's activities, get familiar with a specific measuring system, or learn about a particular measurement procedure or technology. Some stations even allowed children and the young-at-heart to try out a few things. For example, they were required to travel a certain distance on a scooter at as uniform a speed as possible. The actual speed was measured to assess how well the task had been performed.

Of course, it is impossible to give free access to every laboratory and every measuring system at METAS. Some of the labs could at least be visited in small groups with a guide. These tours were quickly booked up, and additional viewings were offered where possible. Information material was available in German and French, and guided tours and presentations were also held in both languages.



## **Palpable commitment to the cause**

The Open Day was well attended from the start. Visitors could personally choose among a wide variety of information materials and viewing opportunities. No matter how much time they spent at METAS, people were clearly satisfied with the experience, and many were quite enthusiastic. It was not only the fascinating topics, activities, labs and equipment that impressed them, but also the universal commitment they sensed among the METAS employees. Of course, the scientific and technical





knowledge that exists at METAS is very impressive indeed. One visitor spontaneously noted as she was leaving: "It is truly incredible how much expertise you have here."



Visiting METAS.

# Measurement for future mobility: calibration of hydrogen filling stations

*In order to use hydrogen as a vehicle fuel, suitable filling stations are needed in addition to the actual vehicles. METAS has developed a system that can be used to test and calibrate hydrogen filling stations.*

Hydrogen could play a major role in the operation of emission-free electrical vehicles. Apart from water vapour, a fuel cell produces no direct emissions. Hydrogen-powered vehicles have a large operating range and refuelling is very quick. Hydrogen has another great advantage. A hydrogen plant can also store surplus electrical energy. Using electrical energy, water can be broken down into its elements of hydrogen and oxygen (electrolysis). Since an electrolysis plant can be integrated into a hydrogen filling station, the fuel gas can be directly produced on-site.

## **Numerous influencing factors**

For more widespread usage of hydrogen as a vehicle fuel, suitable filling stations are needed. It is also necessary to ensure that these filling stations make dependable measurements. In order to allow testing and traceable calibration of hydrogen filling stations, METAS has developed a mobile reference measuring system. It works on the basis of weighing.

The system has two carbon-fibre pressure tanks that can be filled up. The weight of the hydrogen is determined before and after fuelling using a precision balance, and then compared with the meter display on the filling station. It sounds like a simple principle. However, construction of a system of this kind is anything but simple. This is because a wide range of influencing factors have to be either excluded or taken into account and determined. For example, ice forms on the lines during the fuelling process. Hydrogen must be pre-cooled to  $-40^{\circ}$  Celsius to facilitate fast fuelling. During the fuelling process, the pressure and temperature in the containers are subject to fluctuations, leading to changes in the volume and thus in the buoyancy. Other factors such as wind or air currents can also have an impact due to fluctuating surface temperatures on parts of the system.



## **Explosion protection**

In certain mixing ratios, hydrogen and oxygen can easily explode. Explosions must be prevented under all circumstances. Accordingly, in-depth risk assessment and explosion zone planning were carried out in cooperation with SUVA, and the safety of the measuring system was fully certified by a recognised body (ATEX certification).

Testing performed on a hydrogen filling station operated by EMPA demonstrated that the system works flawlessly. However, making on-site measure-





ments with this system is time-consuming and it is cumbersome to transport. One possible way to simplify the procedure would involve development of a “measuring kit” containing a transfer reference standard (flow meter). The “measuring kit” would be calibrated with the measuring system at METAS. It could then be connected between the fuel pump and the vehicle at a filling station during the fuelling process.



Measuring system for calibrating hydrogen filling stations.

# Regulating measurement: legislation concerning metrology

*Statutory regulations within the area of responsibility of METAS concern not only measuring instruments but also quantity indications in the sale of loose goods and on prepacks (prepackaged goods). In 2019, the Federal Council and the FDJP agreed to revisions of the corresponding ordinances that had been prepared by METAS.*

Participating in the preparation of enactments in the field of metrology is one of METAS's statutory duties. In 2019, amendments were adopted relating to measurement of exhaust gases for wood-fired systems as well as to the Quantity Indication Ordinances of the Federal Council and the Federal Department of Justice and Police (FDJP).

## **Exhaust gases from wood-fired systems**

One of the ordinances that was amended in the reporting year is the Ordinance of the FDJP on exhaust measuring instruments for combustion installations. It was supplemented with new provisions on the measurement of exhaust gases from smaller wood-fired systems. This includes systems such as boilers, fireplaces and stoves. The revision was in response to an amendment of the Ordinance on Air Pollution Control that specifically aims to reduce particulate emissions from smaller wood-fired systems.

## **Quantity indications**

Under the Metrology Act, the content and form of quantity indications for measurable goods offered for sale to consumers are regulated by the Federal Council. It is METAS that prepares such regulations. They are contained in the Quantity Indication Ordinances of the Federal Council and the FDJP. Both ordinances entered into force in 2013. They have proven themselves since that time, and no fundamental amendments are required. After several years, however, some minor improvements and updates to these ordinances were called for. The most important amendment concerns regulation of a new procedure for verification of the filling quantity of prepacks. The revision of the two ordinances also includes clarifications and updates relating to other detailed issues.

## **New statistical test procedure**

A large share of goods sold in retail trade are prepackaged ("prepacks"). The Quantity Indication Ordinance of the Federal Council regulates just how much the actual filling quantity of a prepack may diverge from the nominal quantity specified on the package (permissible negative deviation). Due to the huge volume of prepacks in commerce, these regulations are very important in practice. Compliance is checked by the cantonal verification offices on the basis of random inspections. A test procedure is required for this purpose that specifies in detail how the check must be performed. In the







past, a procedure was used that was taken from older Swiss regulations found in the Quantity Indication Ordinance. The provisions have now been revised. For the most important category of pre-packs, the European Union's widely used procedure has been adopted. The new provisions entered into force on 1 January 2020.

As part of the implementation of the new provisions, METAS adapted its directives relating to the Quantity Indication Ordinances. METAS also provided training sessions for the cantonal verification offices.



Measurement of exhaust gases from wood-fired systems.

# Making measurement possible: our employees are what counts

*METAS is an attractive place to work. This is evidenced by our low staff fluctuation as well as the results of our employee survey. Besides the employees, METAS also surveyed its customers. Overall, they are very satisfied with the services provided by METAS.*

In order for METAS to provide services to the satisfaction of its customers, it is dependent on the technical competence and initiative of its employees. METAS thus places great emphasis on being a desirable employer and training location. Dedicated, satisfied and motivated employees are the key to the success of any organisation – as was also shown by the recent METAS customer survey.

## **Valued employees**

In the summer, METAS conducted a survey among its Swiss customers. For the sake of comparability, this survey of the degree of customer satisfaction with services from METAS was based on earlier surveys from 2012 and 2015. However, the content of the questions was revised and streamlined to shorten the survey. The survey was carried out and evaluated by an independent external company. The response rate was 15 %, meaning the survey has statistical significance. The overall satisfaction of customers with services from METAS is at a very high level. Compared with the 2015 survey, the degree of satisfaction is even slightly higher. Included for the first time, the question of whether customers would recommend METAS to others attained a respectable value that fits with the overall satisfaction. Our employees are rated very highly by the customers: As in previous years, the employees were rated the top quality aspect of METAS.

## **High job satisfaction**

The employee survey was also managed by an external independent company. It was carried out in May 2019 and was very similar to the survey used by the Swiss federal administration. The survey had a pleasingly high response rate of 84 %. The results show that the METAS staff is very satisfied. Some values exhibit a slight decrease compared to the

2015 survey, but they are still above the corresponding federal administration values (or an external benchmark). Positive changes were noted in the areas of staff information and the exchange of knowledge and experience, i.e. areas where action had been taken following the 2015 survey.

Freedom of action and the development measures were mentioned as the greatest strengths at METAS. Other highly rated areas included cooper-







Cooperation in teams is highly rated.

ation in teams and reconciliation of work and private life. Based on the results, no urgent steps are required. However, a number of subject areas were considered in relation to potential improvements. The main challenge now is to maintain such good results in future, too.

#### **METAS as a training centre**

METAS is also committed to providing good vocational training for future professionals. It offers various apprenticeships in technical and scientific areas (physics laboratory technician, chemical laboratory technician, polymechanic, electronics technician, computer scientist), a commercial BMS internship as well as a range of university internships.

# Finances

*METAS ended the 2019 financial year with a profit of 1.6 million Swiss francs. Expenditures amounted to 51.1 million Swiss francs and revenues (including payments received) 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)	31.12.2019	31.12.2018
<b>Assets</b>		
Cash	22 373	20 202
Trade receivables	4 196	3 000
Receivables for research projects	2 702	2 778
Other receivables	268	110
Prepaid expenses and accrued income	1 115	811
<b>Working capital</b>	<b>30 654</b>	<b>26 901</b>
Tangible fixed assets	19 964	20 923
Intangible fixed assets	2 002	2 336
<b>Fixed assets</b>	<b>21 966</b>	<b>23 259</b>
<b>Total assets</b>	<b>52 620</b>	<b>50 160</b>
<b>Liabilities and equity</b>		
Current liabilities on trade accounts payable	911	1 322
Liabilities in respect of research projects	4 009	3 930
Other liabilities	1 381	1 466
Accrued expenses and deferred income	304	155
Short-term provisions	1 230	1 098
<b>Short-term borrowed capital</b>	<b>7 835</b>	<b>7 971</b>
Provisions for pension fund liabilities	57 002	49 580
Provisions for service awards	1 637	1 467
<b>Long-term borrowed capital</b>	<b>58 639</b>	<b>51 047</b>
Net loss	-12 934	-17 235
Cumulative actuarial profits/losses	-5 974	663
Reserves for fixed assets	3 413	3 413
Profit	1 621	4 301
<b>Equity capital</b>	<b>-13 874</b>	<b>-8 858</b>
<b>Total liabilities and equity</b>	<b>52 620</b>	<b>50 160</b>

**Profit and loss account**

(in thousand CHF)	2019 1.1.2019–31.12.2019	2018 1.1.2018–31.12.2018
<b>Net revenue</b>	<b>52 722</b>	<b>51 295</b>
<b>Profit from sale of fixed assets</b>	<b>14</b>	<b>13</b>
<b>Expenditure on materials and third-party services</b>	<b>–587</b>	<b>–685</b>
Personnel expenses	–34 694	–31 699
Other operating expenses	–11 632	–10 993
Depreciation	–3 958	–3 575
<b>Operating expenses</b>	<b>–50 284</b>	<b>–46 267</b>
Financial revenue	6	61
Financial expenses	–76	–106
<b>Financial result</b>	<b>–70</b>	<b>–45</b>
Tax expenses	–174	–10
<b>Profit</b>	<b>1 621</b>	<b>4 301</b>

In the reporting year, METAS was able to finance 55.7 % of its activities (preceding year: 58.1 %) out of its own resources. The following means contributed to this self-financing level: fees, payments for taking over additional tasks 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 to a live audience 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.

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.

In addition, a number of specialised courses were offered and held at METAS, ranging from an introduction to the fundamentals of measurement uncertainty to a course on dimensional metrology.

## Brochure on the International System of Units (SI)

In 2019, 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.

To mark the entry into force of the revised International System of Units (SI), METAS published a special brochure that is available in French, German and Italian. The brochure is targeted at a general, i.e. non-specialist audience. It provides insight into the International System of Units and the significance of metrology.

## A taste of the laboratories

As in previous years, METAS took part in the “Mädchen – Technik – Los!” programme during National Future Day on 9 November 2019. It offered a group of girls a taste of the work and activities carried out in the laboratories at METAS.

Due to the Open Day, fewer guided tours were available for groups during the reporting year compared to other years. 20 groups totalling over 500 participants took the opportunity to glean a direct insight into the laboratories and the development of measuring equipment. Guided tours enable METAS to show visitors its activities and give them a better understanding of its tasks.

## 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

- A. Schavkan, (...), **G. Baur, K. Vasilatou** et al.: *Number Concentration of Gold Nanoparticles in Suspension: SAXS and spICPMS as Traceable Methods Compared to Laboratory Methods*. *Nanomaterials* 2019, 9, 502, 20 pp.
- B. Bircher, F. Meli, A. Küng, R. Thalmann**: *CT geometry determination using individual radiographs of calibrated multi-sphere standards*. 9th Conference on Industrial Computed Tomography, Padova, Italy (iCT 2019) 7 pp.
- B. Bircher, F. Meli, A. Küng, R. Thalmann**: *CT machine geometry changes under thermal load*. 9th Conference on Industrial Computed Tomography, Padova, Italy (iCT 2019) 5 pp.
- A. Bossen, M. Trösch, A. Küng, F. Meli**: *Long range wire based yaw and straightness measuring system for a 50 m bench*. euspen's 19th International Conference & Exhibition, Bilbao, ES, June 2019. p. 300.
- D. Amaripadath, (...), **J.-P. Braun** et al.: *Design of versatile waveform platform for supraharmic testing and calibration*. 25th International Conference on Electricity Distribution, Paper n° 647.

- D. Amaripadath, (...), **J.-P. Braun** et al.: 2019 54th Int. Universities Power Engineering Conference, UPEC 2019 – Proceedings 8893632.
- S.M. Blair, (...), **J.-P. Braun**: *IEEE Access* 7,8665864, pp. 48689-48698.
- G. Frigo, (...), **J.-P. Braun** et al.: *Characterization of uncertainty contributions in a high-accuracy PMU validation system*. *Measurement Journal of International Measurement Confederation* 146, pp. 72-86.
- D. Corninboeuf**: *Calibration of the absolute linearity of lock-in amplifiers*. *IEEE Transactions on Instrumentation and Measurement* 68, 2060-2065.
- J. Hoffmann, P. Huerlimann, M. Wollensack, J. Ruefenacht, M. Zeier**: *S-Parameter Definition for Adapters with a Dielectrically Loaded Connector*. 93<sup>rd</sup> ARFTG Microwave Measurement Symposium, Conference Digest, 2019.
- S. Horender, K. Auderset, K. Vasilatou**: *Facility for calibration of optical and condensation particle counters based on a turbulent aerosol mixing tube and a reference optical particle counter*. *Review of Scientific Instruments*. 90/ 075111 (2019) 11 pp.
- A. Jallageas** (...) **J. Morel** and U. Keller: *Calibration of high-accuracy spectrometers using stabilized 11-GHz femtosecond semiconductor laser*. *Optics Express* 27 (2019) 37552, 7 pp.
- B. Jeckelmann, F. Piquemal**: *The Elementary Charge for the Definition and Realization of the Ampere*. *Annalen der Physik* 531/5 (2019) 10 pp.
- C. Kessler, D.T. Burns, P. Roger, **C. Kottler, S. Vörös, P. Peier**: *Comparison of the standards for absorbed dose to water of the METAS, Switzerland and the BIPM in accelerator photon beams*. *Metrologia* 56/1A, 15 pp.
- A. Kazemipour, M. Wollensack, J. Hoffmann, J. Ruefenacht, M. Zeier**: *THz Detector Calibration Based on Microwave Power Standards*, UCMMT 2019, Conference Digest.
- A. Kazemipour, M. Wollensack, J. Hoffmann, J. Ruefenacht, G. Gaeumann, M. Zeier, S-K. Yee, M. Hudlicka**: *Material Parameter Extraction in THz Domain, Simplifications and Sensitivity Analysis*. 2019 Asia-Pacific Microwave Conference, Conference Digest, 2019.
- T. Le Quang, D. Vasyukov, J. Hoffmann, A. Buchter, M. Zeier**: *Fabrication and Measurements of Inductive Devices for Scanning Microwave Microscopes*. *IEEE-Nano, Conference Digest*, 2019.



O. Aseev, (...), **B. Niederhauser**, L. Emmenegger: *High-precision ethanol measurement by mid-IR laser absorption spectroscopy for metrological applications*. Optics Express 27/4 (2019), 12pp.

P. Gournay, (...), **F. Overney** et al.: *Comparison CCEM-K4.2017 of 10 pF and 100 pF capacitance standards*. Metrologia 56, 01001-01001.

M. Delaval, D. Egli, **P. Schüpfer** et. al.: *Novel instrument to generate representative e-cigarette vapors for physicochemical particle characterization and in-vitro toxicity*. Journal of Aerosol Science 129 (2019), pp. 40-52.

**E. Tas**, **F. Pythoud**, D. Zhao: *The Consequences of Missing Specification for Coupling-Decoupling Networks*. Proc. of the 2019 International Symposium on Electromagnetic Compatibility – EMC EUROPE 2019, Barcelona Spain, September 2-6 2019.

**K. Vasilatou** et al.: Chapter 3.1.3 *Electrospray-differential mobility analysis (ES-DMA)*. In: Characterization of Nanoparticles: Measurement Processes for Nanoparticles. Amsterdam, p. 97–116.

#### Conference contributions and papers

**M. Agostoni**: *The METAS IEC 61850-9-2 Test Bench*. (Poster) AMPS Applied Measurements for Power Systems, Aachen, 27.9.2019.

**M.-O. André**: *Electrical standards based on quantum effects*. Summer School of Metrology, BIPM-SIF, Varenna, 4.7.2019.

**M.-O. André**: *Applying electrical standards in real-life applications*. Summer School of Metrology, BIPM-SIF, Varenna, 5.7.2019.

**H. Andres**: *Support for EURAMET DIs – Practical aspects*. 2019 Workshop for incoming TC-chairs. Braunschweig, 29.8.2019.

**H. Andres**: *Messunsicherheit & Konformitätsbewertung Atemalkoholmessmittel*. ZHAW, Wädenswil, 26.11.2019.

**F. Assi/U. Schneider**: *Die Rolle des METAS in der Audiometrieverordnung*. SG-ORL, Herbstversammlung 2019, Interlaken, 15.11.2019.

**B. Bircher**: *CT geometry determination using radiographs of multi-sphere standards*. iCT Conference 2019, Padova, 13.2.2019.

**B. Bircher**: *X-ray computed tomography for dimensional metrology. New frontiers for metrology: from biology and chemistry to quantum and data science*, Varenna, 5.7.2019.

**B. Bircher**: *Industrial high-resolution computed. Micro and Nanotomography Symposium: 3D Imaging for Industry*, PSI, Villigen, 7.11.2019.

**H. Bissig**: *Liquid properties effects on Coriolis and thermal mass flow meters at very low flow rates*. Flomeko 2019, Lissabon, 26.6.2019.

**H. Bissig**: *Traceability of pulsed flow rates consisting of constant delivered volumes at given time interval*. Flomeko 2019, Lissabon, 28.6.2019.

**H. Bissig**: *Traceable response time characterization of flow devices with process-oriented liquids*. Microfluidics & Flow Chemistry 2019, San Diego, USA, 9.10.2019.



**H. Bissig**: *Traceable response time characterization of flow devices with process-oriented liquids*. Workshop on dynamic measurements methods for water metering, Villeurbanne, France, 14.11.2019.

**C. Blaser**: *Die Revision des Internationalen Einheiten-systems*. Informationstagung 2019 Eichstellen Elektrizität, METAS, 25.6.2019.

**P. Blattner**: *Measurement Methods, Set-ups and Devices*. CIE Tutorial on S 026 – Use and Application of the New Metrology for ipRGC-Influenced Responses to Light, Eindhoven, 14.3.2019.

**P. Blattner**: *Aktuelle Aktivitäten der Internationalen Beleuchtungskommission CIE*. LTG – Kongress 2019, Spielberg, Österreich, 21.5.2019.

**P. Blattner**: *Measurement uncertainty in the context of CIE TC2-67*. (Photometry of Lighting and Light-Signalling Devices for Road Vehicles). CIE TC2-67 Meeting, Webex 5.8.2019.

**P. Blattner**: *Metrics and quantities for horticulture lighting*. International Scientific and Technical Greenhouses Lighting Conference, Moscow, 9.9.2019.

**P. Blattner**: *Current activities of the International Commission on Illumination (CIE)*. XVII. Lux et Color, Veszprimiensis, Veszprém, Ungarn, 10.10.2019.

**P. Blattner**: *Danger of la lumière bleue des LEDs – prise de position de la CIE*. SLG Vorabendseminar, Lausanne, 27.11.2019.

**T. Bühlmann**: *SI-traceable F-Gas Standards*. AGAGE Meeting 59, Weggis, 1.5.2019.

**T. Bühlmann**: *SI-traceable Reference Gas Mixtures*. GAW-CH Landesausschuss, Dübendorf, 6.11.2019.

**D. Corminboeuf**: *Calibration of lock-in amplifiers in  $\mu$ V ranges*. DMS, Dresden, 15.5.2019.

**D. Corminboeuf**: *Calibration and applications using inductive voltage dividers*. Messunsicherheit 2019, VDI-Fachtagung, Erfurt, 13.11.2019.

**G. Couvreur**, **D. Lussi**: *Datensicherheitsprüfungen*. VSE Fachtagung, Olten, 13.3.2019.

**M. N. Ess** (...) and **K. Vasilatou**: *Optical and morphological properties of soot aerosols generated with the novel „miniCAST 5201 BC“ burner*. EAC 2019, Göteborg, 25.8.2019.

**M. de Huu**: *Design of gravimetric primary standards for field testing of hydrogen refuelling stations*. Flomeko 2019, Lissabon, 26.6.2019.

**M. de Huu**: *Introduction to hydrogen flow metering, laboratory calibrations using liquids*. Workshop on hydrogen quality and flow metering for hydrogen fuel cell vehicles, VSL, The Netherlands, 11.9.2019.

**C. Hof**: *Characterization of new LS2P-microphones*. Dresden metrologists summit, 14.5.2019.

**C. Hof**: *Metrologie im Bereich Vibration am METAS*. SPEKTRA-Kalibrierseminar, Dresden, 9.10.2019.

**C. Hof**: *Implementierung der Druckkalibrierung von Laborstandard-Mikrofonen durch die Reziprozitätsmethode am METAS*. SPEKTRA-Kalibrierseminar, Dresden, 10.10.2019.

**C. Hof**: *METAS and its national standards in AUV*. CCAUV, Paris, 26.9.2019.

**J. Hoffmann**: *S-Parameter Measurements in Coaxial Systems*. CCEM RF&MW Workshop, BIPM, Paris, 27.3.2019.

**J. Hoffmann**: *S-Parameter Definition for Adapters with Dielectrically Loaded Connectors*. 93rd ARFTG Microwave Measurement Symposium, Boston, MA, USA, 7.6.2019.

**J. Hoffmann**: *Tips and Calibration of Tips and Calibration of Nearfield Scanning Microscope*. European Microwave Week, MMAMA Workshop, 30.9.2019.

**J. Hoffmann**: *Measurement Uncertainty Training at METAS*. MathMet International Workshop 2019, LNEC, Lisbon, Portugal, 21.11.2019.

**J. Hoffmann**: *Standards and Coaxial Tips for Scanning Microwave Microscopy*. High Frequency Scanning Probe Microscopy Workshop, NIST, Colorado, 13.12.2019.

**S. Horender**, **M. N. Ess** and **K. Vasilatou**: *EMPIR-AEROMET: Towards the generation of synthetic ambient aerosols*. EAC 2019, Göteborg, 25.8.2019.

**S. Horender**, **M. N. Ess** and **K. Vasilatou**: *Towards the generation of synthetic ambient aerosols for calibration of PM monitors and low cost sensors*. Air Quality: Responding to new challenges, London, 11.12.2019.



- M. Iturrate-Garcaia:** *Characterisation of impurities in NO<sub>2</sub> reference gas mixtures using FTIR spectroscopy.* European Geosciences Union (EGU), Wien, 10.4.2019.
- M. Iturrate-Garcaia:** *Improving dynamically prepared nitrogen dioxide (NO<sub>2</sub>) reference gas mixtures.* GAS Analysis 2019, Den Haag, 18.6.2019.
- M. Iturrate-Garcaia:** *“EMN Climate and Ocean Observation”: a coordinated metrology network supporting ECVs and EOVs measurements.* Swiss Geoscience Meeting 2019, Freiburg, 27.11.2019.
- B. Jeanneret:** *Josephson Voltage Standards: the early days and the DC standard.* Metrological Summer School 2019, Kloster Drübeck, Deutschland, 5.8.2019.
- B. Jeanneret:** *Josephson Voltage Standards: state of the art quantum AC sources.* Metrological Summer School 2019, Kloster Drübeck, Deutschland, 6.8.2019.
- B. Jeckelmann:** *A milestone in the evolution of the International System of Units.* PSI Colloquium, Villigen, 14.3.2019.
- B. Jeckelmann:** *Une étape cruciale dans le développement du système international d'unités (SI).* Conférence publique de la Société Valaisanne de Physique, Sion, 12.4.2019.
- B. Jeckelmann:** *Zeitdefinition und moderne Zeitmessung.* 3. Internationales Jost-Bürgi-Symposium, Lichtensteig, 4.5.2019.
- B. Jeckelmann:** *Das revidierte SI: Hintergründe und wichtigste Änderungen.* Weiterbildungsveranstaltung der Deutschschweizerischen Physikkommission, METAS, Wabern, 3.9.2019.
- A. Kazemipour:** *Feasibility of Accurate Power Measurement in Submillimeter / mm-Wave Domain Based on Free-Space Techniques.* 12th UK/Europe-China Workshop on Millimetre-Waves and Terahertz Technologies (UCMMT), 10.9.2019.
- A. Kazemipour:** *Quasi Free-Space (TEM) Material Measurements.* European Microwave Week, MMAMA Workshop, 30.9.2019.
- A. Kazemipour:** *Material Parameter Extraction in THz Domain, Simplifications and Sensitivity Analysis.* (Poster) 2019 Asia-Pacific Microwave Conference (APMC), Singapore, 12.12.2019.
- A. Küng:** *Long range wire based yaw and straightness measuring system for a 50 m bench.* euspen's 19th International Conference & Exhibition, Bilbao, 4.6.2019.
- T. Le Quang:** *Impedance Standards for Scanning Microwave Microscope.* CMI/EPFL Annual Meeting, CMI, Lausanne, 7.5.2019.
- T. Le Quang:** *Impedance Standards for Scanning Micro-wave Microscopy.* Nanometrology 2019, Paris, 26.6.2019.
- T. Le Quang:** *Impedance Standards for Scanning Microwave Microscopy.* European Microwave Week, ADVENT Workshop, 29.9.2019.
- K. Marti:** *Dissemination of the kilogram after redefinition: a focus on sorption effects, contamination and cleaning of mass standards.*, RADWAG, Radom, 6.3.2019.
- K. Marti:** *Redefinition of the kilogram,* Berner Fachhochschule, Burgdorf, 8.11.2019
- B. Mathew:** *Datensicherheitsprüfung – erste Erfahrungen.* Swissmig Fachtagung, 8.11.2019.
- F. Meli:** *CT machine geometry changes under thermal load.* iCT Conference 2019, Padova, 14.2.2019.
- F. Meli:** *Polystyrene nanoparticle deformation – range extended.* Nanoscale Conference 2019, Braunschweig, 15.10.2019.
- C. Mester:** *Technologiegerechtes Kalibrierprogramm für moderne Messgeräte.* Messunsicherheit 2019, VDI-Fachtagung, Erfurt, 13.11.2019.
- B. Niederhauser:** *Aktiv bei reaktiven Analyten.* ERFA 2019 des Cercl'air, Freiburg, 10.9.2019.
- F. Overney:** *Progress report: Dual Josephson Impedance Bridge (DJIB).* EURAMET TC-EM DCQM meeting, 20.5.2019.
- C. Pascale:** *Dynamic generation of VOCs reference gas mixtures with a mobile generator and comparison to static preparations.* CCQM-Workshop, Paris, 9.4.2019.
- C. Pascale:** *The European Metrology Network for Climate and Ocean Observation.* Actris Technical meeting for trace gases, Dübendorf, 9.5.2019.
- C. Pascale:** *The European Metrology Network for Climate and Ocean Observation: Stakeholders and plans.* CIM 2019, Paris, 10.9.2019.
- P. Peier:** *Photonics an Beschleunigern.* University of Applied Sciences HTW, Chur, 22.3.2019.
- P. Peier:** *Calibration and verification of dosimeters for high energy electron and photon radiation at METAS 22 MeV accelerator.* SGSMP Annual Meeting, PSI, Villigen, 22.11.2019.
- F. Pythoud:** *Introduction to EMC.* SwissT.net, Fachtagung EMV und Funk, Zürich, 16.1.2019.
- D. Stalder:** *Traceable Noise Temperature Calibration Based on RF-Power.* European Microwave Week, ADVENT Workshop, 29.9.2019.
- E. Tas, F. Pythoud, D. Zhao:** *The Consequences of Missing Specification for Coupling-Decoupling Networks.* Proc. of the 2019 International Symposium on Electromagnetic Compatibility – EMC EUROPE 2019, Barcelona, 4.9.2019.
- E. Tas:** *Proficiency Testing in EMC.* EUROLAB-CH Seminar, Sicherung der Qualität von Laborergebnissen, Olten, 3.12.2019.
- R. Thalmann:** *Traceability of nano-scale measurements to the international system of units SI.* Swiss Nano Convention, EPFL, Lausanne, 7.6.2019.
- R. Thalmann:** *Überprüfung und Kalibrierung von optischen Mikro-Koordinatenmessgeräten.* Fachtagung Produktionsmesstechnik, NTB, Buchs, 5.9.2019.
- R. Thalmann:** *Auswertung und Bewertung von Vergleichsmessungen.* EUROLAB-CH Seminar, Sicherung der Qualität von Laborergebnissen, Olten, 3.12.2019.
- M. Trachsel:** *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.* SGSMP Annual Meeting, PSI, Villigen, 22.11.2019.
- K. Vasilatou:** *Generation and characterisation of model soot aerosols for instrument calibration and health studies.* Métrologie des suies, Paris, 4.7.2019.
- M. Geiser, Z. Leni, K. Vasilatou, M. Ess, A. Keller:** *A novel facility to generate stable and reproducible aerosol mixtures that simulate the physicochemical properties of ambient air.* EGU 2019, 8.4.2019.
- D. Vasyukov:** *Introduction to Scanning Microwave Microscopy.* SPM Workshop, Lednice, CZ, 27.3.2019.
- D. Vasyukov:** *Impedance Standards for Scanning Microwave Microscopy.* IEEE-Nano, Macau, 22.7.2019.
- C. Wüthrich:** *New definition of the unit system: from man defined system to nature constants, consequences on daily life and vacuum measurement.*, Inficon, Balzers, 20.05.2020
- M. Zeier:** *Introductory talk to workshop.* CCEM RF&MW Workshop, BIPM, Paris, 27.3.2019.
- M. Zeier:** *Scanning Microwave Microscopy: Impedance measurements at nanoscale.* EURAMET TC-EM SC RF&MW meeting, INTA, Madrid, 9.4.2019.
- M. Zeier:** *S-parameter measurement comparison in Type-N.* EURAMET TC-EM SC RF&MW meeting, INTA, Madrid, 10.4.2019.



