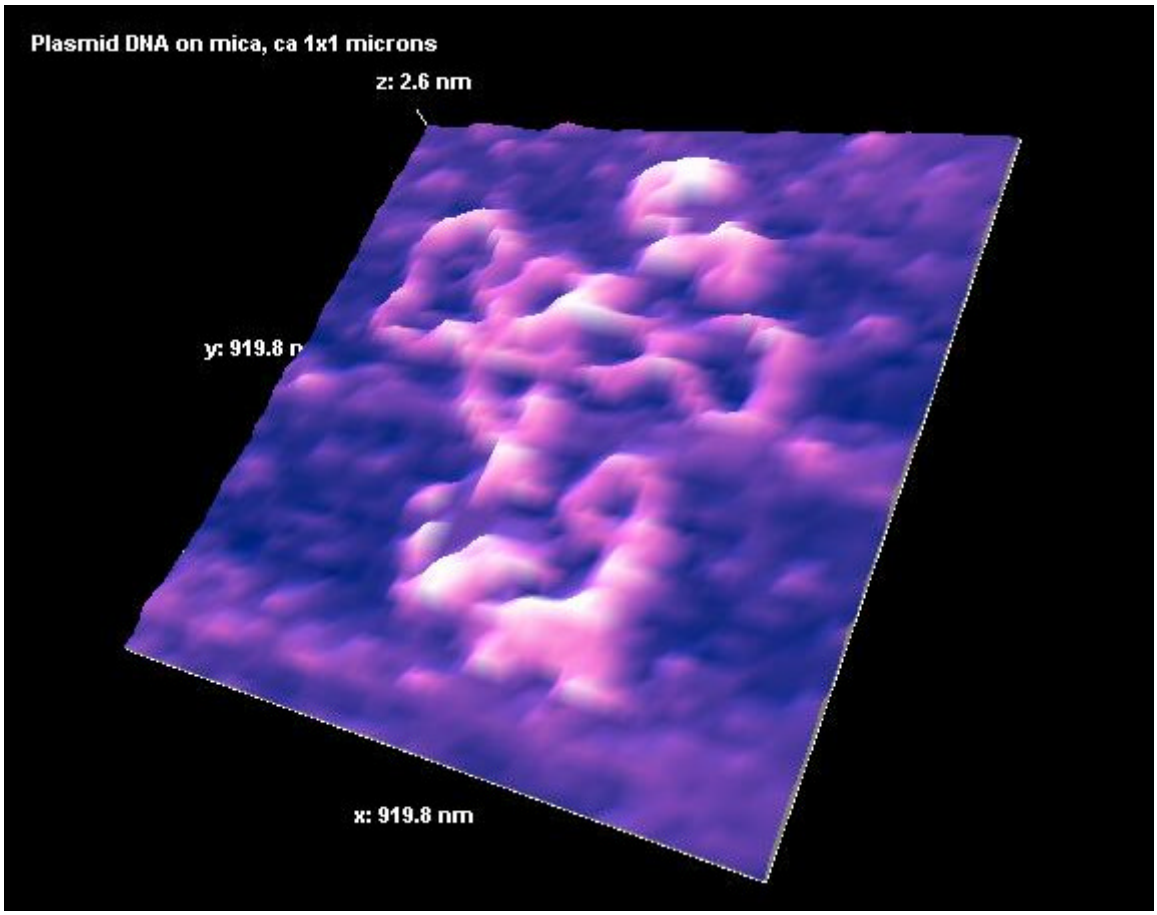
Danish Institute of Fundamental Metrology

Annual Report and Statement of Income for 2001

Edited by

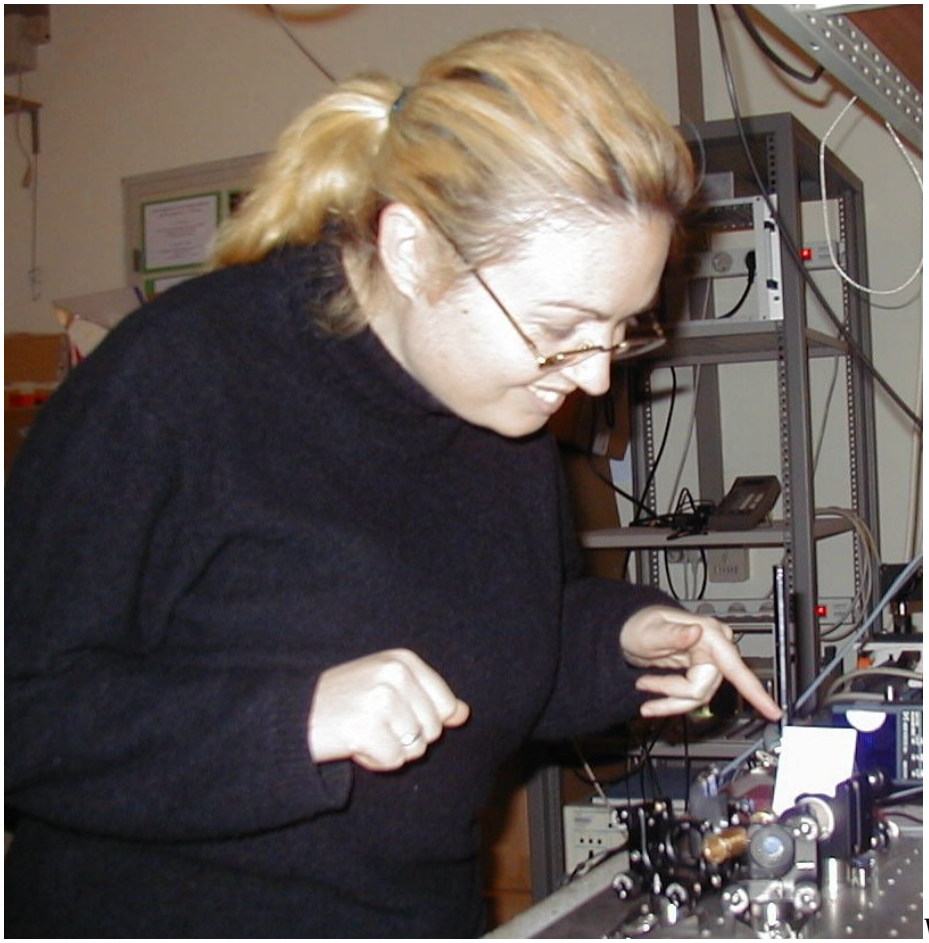
Bendt Gerhardt, Jes Henningsen and Kim Carneiro



DFM - Danish Institute of Fundamental Metrology
Matematiktorvet Building 307,
2800 Kongens Lyngby, Denmark

DFM-2002-R1
0209 BG
2002-03-12

Telephone +45 4593 1144
Telefax +45 4593 1137
E-mail: info@dfm.dtu.dk



Valentina Russeva from Bulgaria is associated with the CAUAC network as PhD student. Her task is to develop ultra-stable blue laser sources for spectroscopy of laser cooled magnesium atoms. These atoms will eventually keep time in atomic clocks.

Table of Content

Front cover picture:
Plasmid DNA molecules are deposited on a mica surface and characterized with an atomic force microscope in the tapping mode – a step on the road towards building DNA-based biosensors.

Back cover picture:
Second generation primary standard for electrolytic conductivity, cut in a heavy cylinder of BK7 glass, and characterized geometrically to high precision.

Steen Konradsen

Chairman of the Board

Kim Carneiro

Director

1. Sharing knowledge in metrology

In 2001 DFM continued previous years´ trend of making more services available to clients and winning more research contracts. As a result, DFM has increased its competitive income from 18% to 45% of the total income during the past five years. In other words, the contract with Government is now being converted much more efficiently into services that are appreciated by the market.

This transition has been carried out without compromising the mission that DFM bases its activities on a scientific approach. In 2001 approximately 1,3 articles per person-year allocated to scientific research were published in refereed journals. Our philosophy is that DFM constantly acquires new knowledge by performing research in collaboration with selected partners with complementary competences, in order to be able to build and maintain measurement standards of the highest quality and to disseminate traceable measurements and knowledge to clients on a competitive basis. All in all we are sharing our knowledge in metrology with partners throughout the world. Together with the knowledge of our staff our partner network forms the basis for our activities. During 2001 we were able to extend our network, particularly amongst Danish research institutes. The recent change in government organisation will make these connections even easier, for the benefit of transferring scientific knowledge into prosperity.

As the core institute of the Danish metrology organisation, DFM took several initiatives during 2001. Nationally, the Law on Business Development, passed by the Folketing in May, now for the first time directly mentions the Danish system of primary and national reference laboratories. Our organisation DANIAmet developed satisfactorily during the year with two members seeking upgrading from reference status to primary status, and a number of new members are knocking on the door. However, chemical metrology showed little progress during the year. Internationally, the focal point was the Mutual Recognition Arrangement (MRA) within the Metre Convention, set up to put further transparency to the global equivalence between the standards and measurement capabilities of National Metrology Institutes. DANIAmet takes pride in being the first organisation in the world to demonstrate full compliance with the requirements of the MRA, when the quality system of DANIAmet was presented and accepted by the EUROMET QS-FORUM in March.

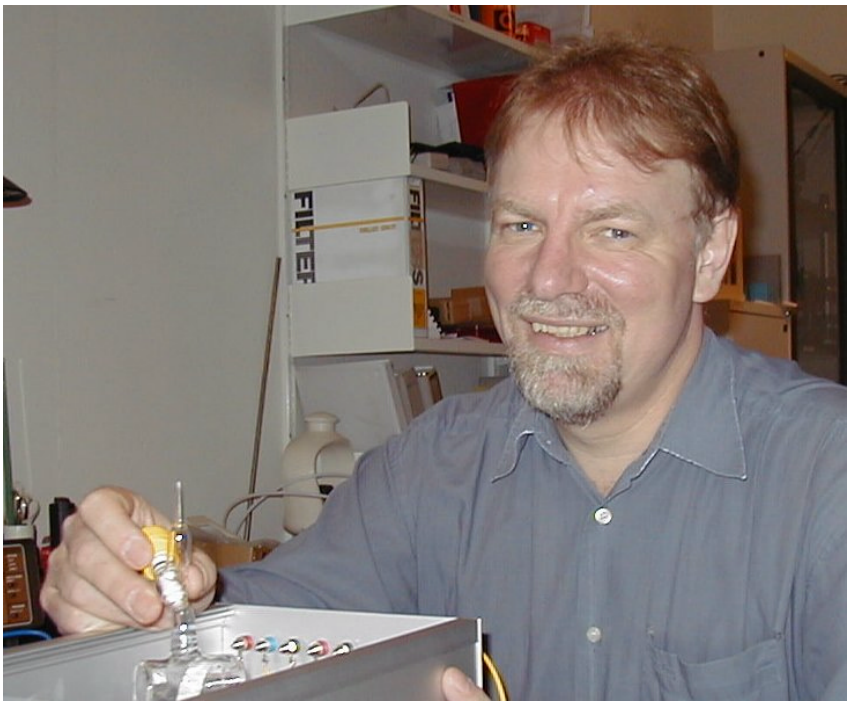
Economically the year was satisfactory with a positive net result. The long lasting effort to improve the laboratory facilities found its solution in a comprehensive plan for refurbishing of our current premises, a work that we expect to be finish early 2002.

Our plans for the coming year will reflect our contractual situation with the Ministry for Science, Research and Innovation, where we will focus on reaching the set milestones of our current contracts and formulate new ones within the scope of a new strategy. In the years to come we expect metrology to develop into new areas of society, such as clinical chemistry and nanotechnology, where sizeable gains can be obtained from an increased focus on correct measurements.

Steen Konradsen	*Kim Carneiro*
Chairman of the Board	Director

2. Research, calibration, and consulting

2.1 Research



Jan C. Petersen, head of the research section, devotes part of his research efforts to the development of wavelength standards for optical telecommunication

The research section is responsible for the development and maintenance of standards that are necessary to keep Denmark at an international level in metrology as well as for providing metrological knowledge requested by Danish industry. The section participates in a number of national and international projects addressing problems in metrology in areas where DFM can contribute with its competences.

The section has in 2001 published 17 papers in international refereed journals and contributed 26 presentations at international conferences. In addition to the permanent staff 1 visiting scientist, 4 Ph.D. and 1 M.Sc. students have been associated with projects in, surface metrology (3), and optical metrology (3). The section has been involved in 4 EU financed projects, DFM being the co-ordinator of one of them, two projects financed by the Nordic Industry Foundation (1) and Nordtest (1), DFM being the coordinator of one of them, and in two Danish centres focusing on surface metrology and functionality and on AC electricity, DFM being the coordinator of the latter .

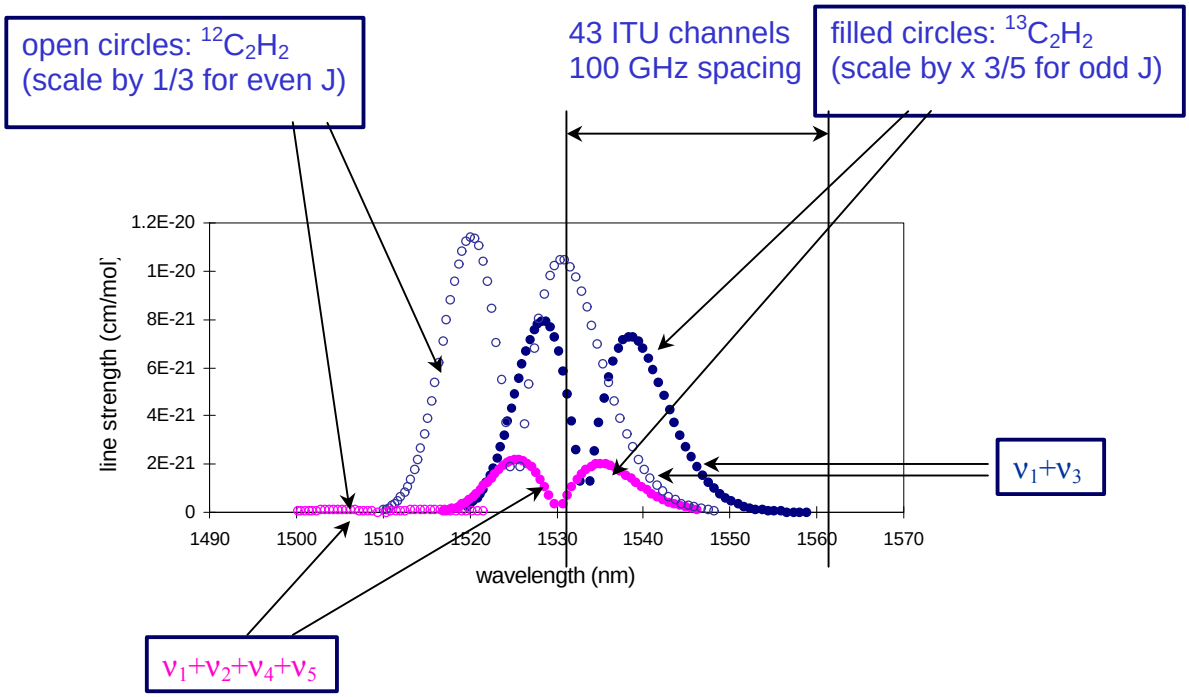
Electrical Metrology

A new primary cell for electrolytic conductivity with a greatly improved mechanical stability and reproducibility is under development and is expected to lead to an improvement in accuracy by a factor 5-10. Work on a measurement facility for the calibration of ultra pure water has been initiated with the aim of allowing for calibration in the range of 0,1 mS/m. For this setup a closed circulating system is necessary in order to avoid the dissolution of CO_2 in water that will lead to a change in conductivity.

DFM has improved its resistance calibration facility by finalising an automated setup for resistance calibration.

The activity of establishing a current standard based on single electron tunnelling has been continued. A cryostat capable of achieving a temperature of 0,3 K is being used at DFM and samples and sample holders have been developed. This will allow DFM to perform the first experiments on single electron tunnelling in samples driven by surface acoustic waves.

The Centre responsible for establishing a primary laboratory for AC electricity has been evaluated and primary status obtained. During the year on-site calibration of the standards for AC/DC transfer has been performed using the DC primary Josephson standard.



Molecular absorption lines for two isotopomers of the acetylene molecule are favorably located relative to an important wavelength band of optical telecommunication. This makes these lines ideal for providing universally fixed reference wavelengths.

Optical Metrology

DFM participates in a project aiming at developing certified reference materials for optical telecommunication wavelengths. These materials are needed in order to increase the capacity of optical fibres without risk of cross-talk. Molecular absorption lines turn out to be ideal for providing universally fixed reference wavelengths, and DFM is concerned with identifying suitable candidates. The project is funded by the EU and the Nordic Industrial Fund. Closely associated with this work are efforts towards constructing compact calibrators based on fibre Bragg gratings and hollow wave guides.

In radiometry, UV detectors have been characterised with respect to their use as transfer standards to the primary standard, the cryogenic radiometer. A new UV-B (280-320 nm) source based on frequency doubling of a diode laser is being built. An automated setup for measuring the homogeneity of optical photodetectors has been constructed.

DFM is coordinating an EU project CAUAC (*Cold Atoms and Ultra precise Atomic Clocks)* with 8 European Universities and Metrology Institutes. Together with the University of Copenhagen, DFM is building an atomic clock based on laser cooled Mg atoms. A 457 nm laser has been developed and the clock transition in cold Mg atoms has been observed at this wavelength. In addition, a 30 mW laser operating at 383 nm has been built by frequency

doubling of a diode laser. This light source will be used in a new laser-cooling scheme that is expected to result in temperatures considerably below the 2mK so far obtained.

The CAUAC network meeting at Sandbjerg 40 members from the 8 participating European institutions met with invited researchers from the United States. The network is concerned with developing atomic clocks based on laser cooled atoms.

Mass and Surface Metrology

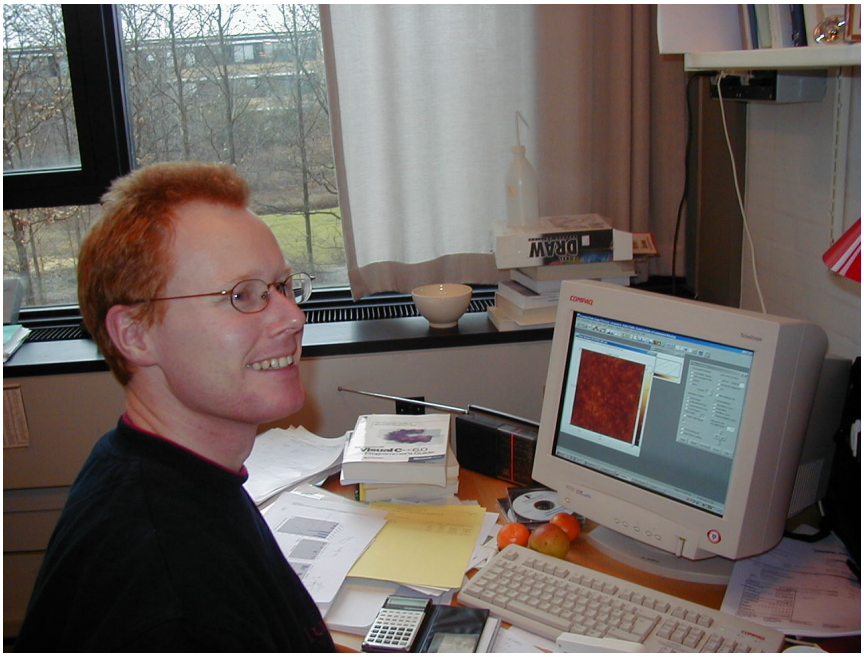
In surface metrology work has been concentrated within the Centre for Surface Metrology and Functionality, where DFM together with other Danish research institutes and companies develops methods for characterisation of surfaces. Work has focussed on the development of pore analysis in membranes and on accurate step height and roughness measurements. Two Ph.D. students have worked on nanometer scale metrology and on the characterisation of biosensor surfaces in collaboration with the Microelectronic Centre at the Danish Technical University.

DFM has successfully participated in the first comparison of line spacing measurements (300 nm and 700 nm) between national metrology institutes. The comparison is approved by the BIPM (Bureau International des Poids et Mesures) as one of the key comparisons within the field of length.

A test for validation of the combination of Monte Carlo simulation and Least Squares fit methods is being developed. The aim is to make sure that all the physical constraints between input and output quantities are fulfilled. DFM participates in ”BIPM Director’s Ad

Hoc Advisory Group on Uncertainty". The group has produced recommendations for working out reference values in connection with key comparisons.

2.2 Calibration



Anders Kühle, head of the calibration section, spends his research time within the field of nanometrology

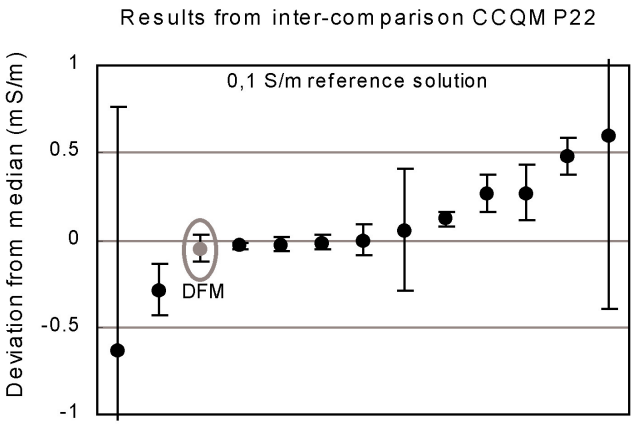
The Calibration Section provides traceability to the Danish national standards for mass and volume, DC voltage, resistance, electrolytic conductivity, length, and optical radiometry through accredited calibrations. This is accomplished by continuously upgrading the standards and by participation in international comparisons in order to ensure international equivalence. DFM also performs non-accredited calibration and testing, in particular within the field of nanometre scale surface metrology.

Maintenance of standards

In order to improve efficiency a large program for upgrading the software and computers in nearly all calibration setups has been initiated and is to be completed in the year 2002.

Electrical metrology

DFM has expanded its DC voltage calibration service by providing calibration directly against the Josephson primary standard. DFM has organised and provided the reference solutions for a pilot comparison, CCQM-P22, of electrolytic conductivity for the Consultative Committee for Amount of Substance of the Metre Convention. All together 13 countries have participated in the comparison, which is the first of its kind.



Results of the CCQM-P22 comparison on electrolytic conductivity, in which DFM took part together with 12 other national metrology institutes

Mass metrology

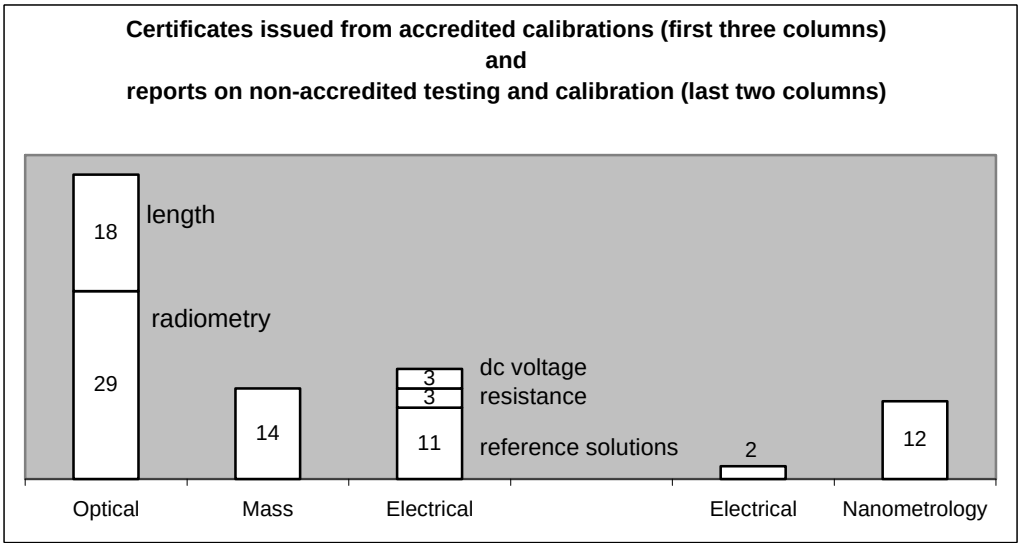
In 2001 DFM has significantly improved its measurement capability for weights, and in the range of 1 mg to 1 kg it is now about an order of magnitude below the tolerance of OIML class-E1 weights. The Danish 1 kg prototype (no. 48) has been calibrated at the BIPM. Since the 3rd international verification of the prototypes in 1988-1992 it has gained 15 µg, which is a little less than expected.

Optical metrology

DFM is upgrading its gauge block interferometer in collaboration with the Swiss national metrology institute *METAS.*

Calibration and testing activities

Calibration for customers has resulted in the issuing of 78 certificates distributed within the different fields as shown in the graph. Nanometrology services (non-accredited) using atomic force microscopy is a growing fraction of the total activities with 12 customer assignments in 2001.



2.3 Consulting

Preben Howarth, head of the consulting section, is coordinating several projects aimed at transferring metrological know-how to developing metrology organizations

The responsibility of the consulting section is to make the knowledge generated through DFMs activities in research and the development of standards available to a broader community, encompassing Danish industry, laboratories, and public authorities.

The activities of the section are divided into three categories: National and international cooperation, teaching, and client consultancy.

Cooperation

Denmark's status within the international metrological community has been upheld through Danish membership of

- *CGPM (Conférence Générale des Poids et Mesures)*

and the CIPM consultative committees and working groups:

- *Consultative Committee for Electricity and Magnetism (CCEM)*
- *Consultative Committee for Amount of Substance (CCQM)*

In 2001 DFM also supplied a representative to join:

- *BIPM Director's ad hoc Advisory Group on Uncertainty*
- *Joint Committee on Guides in Metrology – Working Group 1 (GUM)*

An important part of DFM´s international collaboration is carried out in EUROMET, the umbrella organisation of European National Metrology Institutes. EUROMET has subdivided metrology into 11 fields, and DFM contributes Danish contact persons to 6 of these. During 2001 DFM has participated in the yearly technical committee meetings for mass (DFM chairman), electricity, length, time and frequency, photometry and radiometry, and interdisciplinary metrology. The task of the contact persons is to transfer metrological knowledge from EUROMET to the relevant part of the Danish metrological community.

DFM had the Euspen (*European Society for Precision Engineering and Nanotechnology*) Presidency in 2001. DFM has also participated in the national metrological collaboration, in

part through the Centre for Danish Fundamental Metrology (CDFM), and in part through DANIAmet.

DFM has organised meetings in the users group for calibration of mass and in the reference group for single electron phenomena. The purpose of these groups is to inform DFM's clients about the competences of DFM, and to provide DFM with input concerning future needs for services and research.

Teaching

DFM has collaborated with DANAK and EUROLAB Denmark in giving a series of courses intended for accredited laboratories:

- Estimation of measurement uncertainty in microbiology
- Use of software within accredited calibration and testing
- Estimation of uncertainty in chemical measurements
- Traceability of chemical measurements (new course)

To further uniform assessment of accredited laboratories, DFM has organised in collaboration with DANAK a 1-day brush-up seminar on the use of software in accredited calibration and testing, aimed at DANAK's technical assessors. Finally, workshops have been organized as an aid to clients who have chosen to use DFMs uncertainty software package DFM-GUM.

Client Consultancy

On behalf of DANAK, DFM has participated in the international experts groups:

- EA Expert Group DC-LF (chairman)
- EA Expert Group Mass

and DFM has assessed the technical competence of laboratories for the following accreditation and certification bodies:

- DANAK (Denmark)
- Dansk Standard (Denmark)
- SWEDAC (Sweden)
- UKAS (Great Britain)
- Norsk Akkreditering (Norway)

DFM has participated in the working group DANAK RL10 dealing with the procedure "Validation of software used in accredited calibration and testing". Nordtest has granted DFM partial funding to develop this into a Nordic procedure.

In Latvia and Lithuania DFM has assisted the national metrology institutes to upgrade their national reference standards and strengthen their metrological infrastructure. The Danish Ministry of Foreign Affairs financed the projects under the Danish "Preparation for EU" programme. Together with PTB (Germany) DFM performed an assessment of the metrological infrastructure in Chile.

The DFM-GUM software for uncertainty calculations was sold to 13 companies.

2.4 Administration

Grethe Bjørndal Jensen, head of the administration section, takes firm hand of the bookkeeping, and ensures timely reporting

Administration, Accounting, Internal Services

Electronic archiving was implemented at DFM in 2001. Careful planning has resulted in a smooth transfer and a considerable decrease in paper flow .

The staff situation in the administration has been stable while 2 scientific staff members have left DFM. One of these has been replaced, and the second position will be filled as of 1 January 2002. Two researchers have been temporarily employed during the last 3 months of the year.

One Bulgarian Ph.D. student has started in the summer for a 3-year period and an Australian and a Swiss IAESTE student have been working at DFM during part of the year.

The computer network at DFM has been upgraded to Windows 2000. New investments in both hardware and software have been necessary to keep the system updated.. Considerable attention has been devoted to keep the network free of viruses.

The considerations that have been going on for some time with respect to DFM´s laboratory facilities resulted in a decision of expanding and renovating the present laboratory facilities instead of building new laboratories. Renovating the facilities was started at the end of 2001 and is expected to be finalized in April 2002.

Information, Marketing

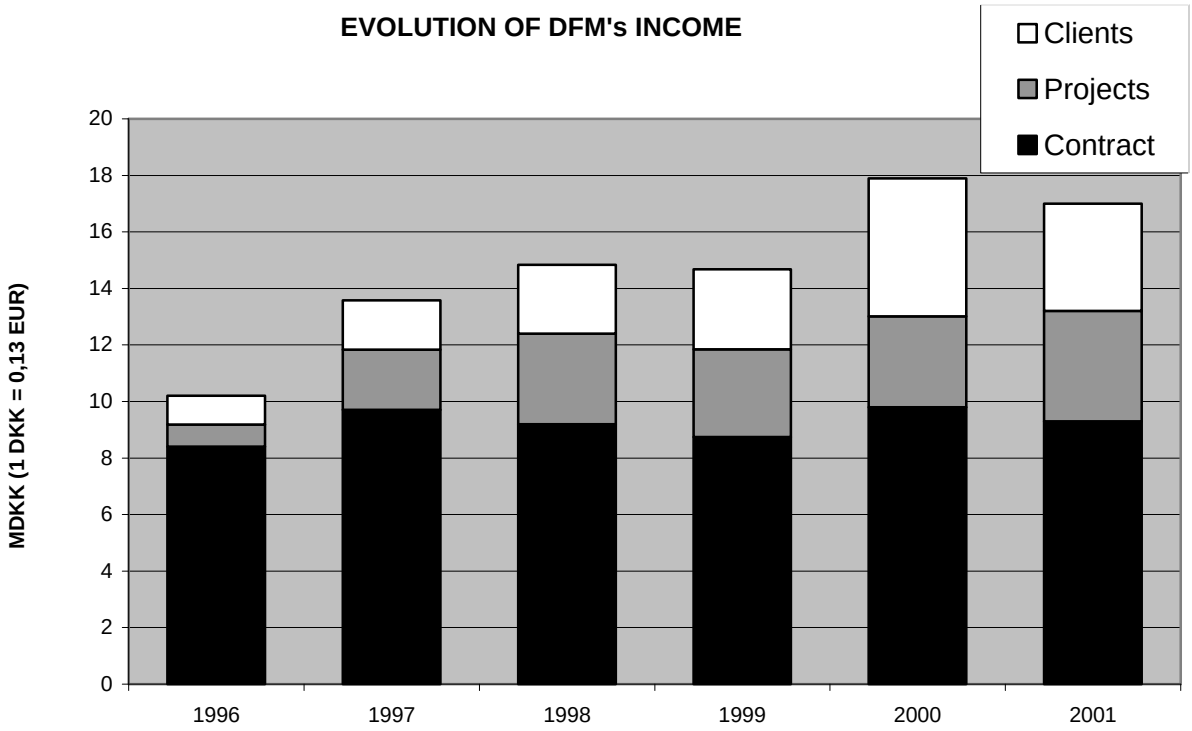
The purpose of the Marketing efforts is to make DFM better known within the target groups and to support the sale. The target groups include Danish and foreign companies and institutes. DFM also provides more general information to organizations, networks, scientists, students and other parties interested in DFM, both in Denmark and abroad.

Advertising and promotion is primarily used to expand the knowledge of DFM and to support the sale of products to large target groups, while direct mail is used with respect to

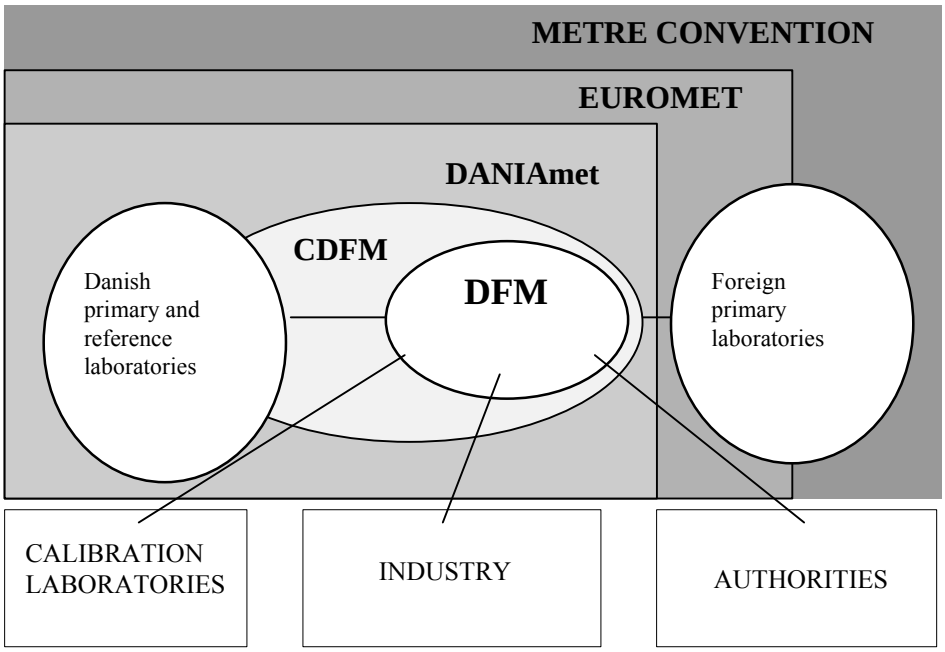
segmented target groups. A continuous upgrading of DFM´s homepage is an essential part of marketing.

The effects of the marketing efforts can be difficult to measure directly, but factors like the level of knowledge within the target groups, increase of turnover and number of visitors on the homepage can show a tendency. Over the last five years the marketing expenses have been tripled, and the following effects have been noticed:

- According to market surveys by Vilstrup Research (1995) and Oxford Research (2001), commissioned by the Agency for Development of Trade and Industry, the knowledge of DFM among a random sample of Danish Companies has increased significantly.
- Turnover from projects and customers has increased from 18 to 45 % of the total turnover.
- Number of visitors on the homepage has increased to 15.000 per year



3. Organisation of Metrology



Structure of Danish metrology connected with the international network

3.1 The Danish metrological organisation

Denmark has a decentralised metrology organisation, with DFM as the core institute. Closely associated with DFM are three research and technology organisations *(GTS Institutes)* with primary and reference laboratories among their activities. Together with DFM they constitute the *Centre for Danish Fundamental Metrology (CDFM).* The umbrella organisation *DANIAmet* covers all of the Danish primary and reference laboratories, some of which are within industrial companies.

Collaboration with primary laboratories outside of Denmark is carried out through the European umbrella organisation for national metrology institutes *EUROMET*, as well as on a bilateral basis, and the Metre Convention, which was signed by Denmark when it was established in 1875, provides the global background.

At the technical level, metrology is divided into 10 subject fields, which have in Denmark been further subdivided into 36 subfields. For each subfield, the Danish Business and Housing Agency may nominate a primary laboratory or a national reference laboratory according to the following definitions:

Primary laboratory:

A nominated laboratory, which is internationally recognised for the realisation of a base unit of the SI system at the primary level, or a derived unit at the highest achievable international level, and which carries out internationally recognised research within the sub-field.

National reference laboratory:

A nominated laboratory, which is capable of calibrating a given measurement quantity at the highest level of accuracy in Denmark, traceable to a foreign primary laboratory

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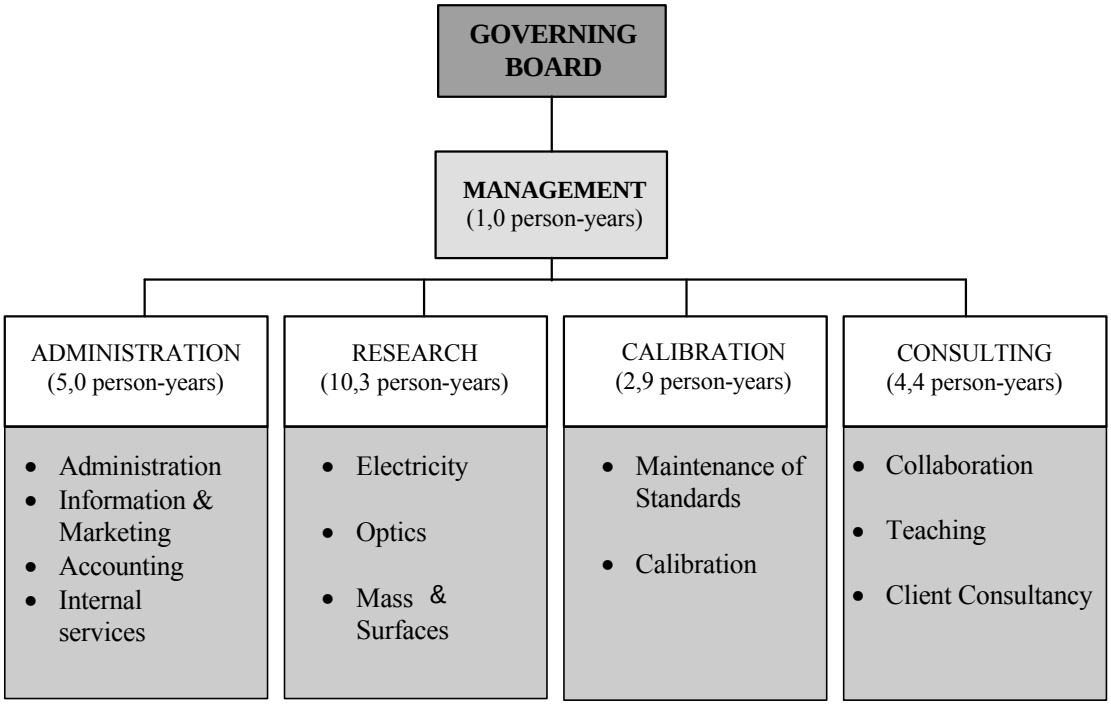

3.2 Danish Institute of Fundamental Metrology - DFM

The organogram of DFM is shown in the figure above. The Board of Governors is appointed by Danish Industry (2), the Technical University of Denmark (1), the GTS Institutes (2), DANIAmet (1), and the staff of DFM (2). The board in turn appoints a director as responsible for the daily management. According to DFM´s statutes of 20 August, 1997, in addition to governing DFM, the board is responsible for coordinating fundamental metrology in Denmark.

Board of Governors
Knut Conradsen, Vice President, Technical University of Denmark (Vice Chairman)
Hans Dalsgaard Jensen, Staff Scientist, Ph.D., DFM
Ole Bjørn Jensen, Managing Director, SCANPHARM A/S
Steen Konradsen, AREPA Test & Kalibrering A/S (Chairman)
Lars Ole Kornum, President, Danish Technological Institute
Lars Nielsen, Staff Scientist, Ph.D, DFM (until 20. August)
Hans Jørgen Pedersen, Vice President, DANFOSS A/S
Anders Kühle, Staff Scientist, Ph.D, DFM (from 20. August)

Management
Kim Carneiro, M.Sc. (EE), Ph.D.

Accountant
Juul & Partnere, Certified Accountant

Permanent Staff
Kim Carneiro, M.Sc. (EE), Ph.D.
Grethe Bjørndal Jensen, Secretary
Lars Nielsen, M.Sc. (EE), Ph.D.
Steen Rahbek, Technician
Hans Dalsgaard Jensen, M.Sc. (EE), Ph.D.

Jan Conrad Petersen, M.Sc., Ph.D.
Jes Henningsen, M.Sc., Dr.scient.
Jørgen Garnæs, M.Sc., Ph.D.
Bendt Gerhardt, M.Sc. (Commerce)
Preben Howarth, M.Sc., (ME), B.Sc. (Economy)
Peter Høgh Hyllested, Technician
Carl Erik Torp, M.Sc.
Rafael J. Taboryski, M.Sc, Ph.D. (until 1 May)
Anders Kühle, M.Sc., Ph.D.
Henrik Blichfeldt, M.Sc.
Jan Hald, M.Sc., Ph.D
Charlotte Verdier, B.Sc.(eng) (until 1 August)
Isabella Stendal, Secretary
Bo Bengtsen, Technician
Niels-Ebbe Dam, M.Sc., Ph.D (from 13. August)

Non-permanent Staff including research students
José A. P. Condeço, M.Sc, Danish Technological Institute
Niels Kofod, Ph.D.student, Technical University of Denmark
Connie Nielsen, M.Sc. (until 31 March)
Jonathan Kutchinsky M.Sc., Ph.D. (1 April until 30 April)
Mitsuhiro Kusaba, Post.doc, Osaka Sangyu University, Japan (until 10 April)
Susanne Søgaard, Ph.D. student, Technical University of Denmark
Maria Holmberg, Ph.D. student, Technical University of Denmark
Benriah Goeldi, IAESTE student, Australia
Lene S.. Kristensen, FORCE Institute
Jean-Philippe Besson IAESTE student, Switzerland
Valentina Ruseva, Ph.D. student (from 1 June)
Plamen G. Petrov, Ph.D. (1 October until 31 December)
Pia Refstrup, M.Sc. (1 October until 31 December)

3.3 Centre of Danish Fundamental Metrology - CDFM

Centre of Danish Fundamental Metrology (CDFM) was founded in August 1997, and includes those GTS institutes, who are active in fundamental metrology. At present CDFM includes Danish Institute of Fundamental Metrology, Danish Technological Institute, FORCE Institute, and DELTA Danish Electronics, Light & Acoustics.

3.4 DANIAmet

DANIAmet is an umbrella organisation for laboratories which are nominated by the Danish Business and Housing Agency as Primary Laboratories or National Reference Laboratories. The task of this organisation is to further the common interests of the members within the field of fundamental metrology, to seek or suggest representation in relevant councils and bodies, to work for strengthening fundamental metrology in Denmark, to represent Danish fundamental metrology abroad, and to disseminate information about metrology. The members ordinarily meet twice each year. The President of DANIAmet is Sven Nytoft Rasmussen, Danish Technological Institute, and DFM acts as permanent secretariat. DANIAmet at present includes:

DFM

Subfield: Mass measurement (Primary Laboratory).
Contact person: Lars Nielsen, DFM, B 307, Matematiktorvet, DK-2800 Kgs. Lyngby.
Telephone: +45 4525 5866. Telefax: +45 4593 1137

DFM

Subfield: Length measurement (Primary Laboratory).
Contact person: Jes Henningsen, DFM, B 307, Matematiktorvet, DK-2800 Kgs. Lyngby.
Telephone: +45 4525 5865. Telefax: +45 4593 1137

DFM

Subfield: DC electricity (Primary Laboratory).
Contact person: Hans Dalsgaard Jensen, DFM, B 307, Matematiktorvet, DK-2800 Kgs. Lyngby.
Telephone: +45 4525 5874. Telefax: +45 4593 1137

DFM

Subfield: Optical radiometry (Primary Laboratory).
Contact person: Jan C. Petersen, DFM, B 307, Matematiktorvet, DK-2800 Kgs. Lyngby.
Telephone: +45 4525 5864. Telefax: +45 4593 1137

Danish Primary Laboratory for Acoustics

Subfields: Acoustical measurements in gases and solids (Primary Laboratory)
Contact persons: Erling Frederiksen (Microphones) and Torben R. Licht (Accelerometry), Brüel and Kjær A/S, Skodsborgve j 307, DK 2850 Nærum
Telephone: +45 7741 2376, +45 7741 2313, Telefax: +45 7741 2013.
Knud Rasmussen, Institute of Acoustical Technology, Building 352, Technical University of Denmark, DK 2800 Lyngby.
Telephone: +45 4525 3937. Telefax: +45 4588 0577.

Radiometer Medical A/S

Subfield: pH measurement (Primary Laboratory).
Contact person: Hans Bjarne Kristensen, Åkandevej 21, DK 2700 Brønshøj.
Telephone: +45 3827 3827. Telefax: +45 3827 2727

AREPA Test & Calibration A/S

Subfield: AC electricity (Reference Laboratory)
Contact person: Torsten Lippert, Mads Clausens Vej 12, DK 8600 Silkeborg.
Telephone: +45 8720 6969. Telefax: +45 8681 2654.

Danish Technological Institute

Subfield: Temperature measurement by contact (Reference Laboratory).
Contact person: Jan-Ulrik Holtoug, Teknologiparken, DK 8000 Aarhus C.
Telephone: +45 7220 1228. Telefax: +45 7220 1212

FORCE Institue

Subfield: Force and Pressure (Reference Laboratory)
Contact person: Lene Schou, Park Allé 345, DK 2605 Brøndby.
Telephone: +45 4326 7160. Telefax: +45 4326 7011.

FORCE Institue

Subfield: Gas volume flow (Reference Laboratory)
Contact person: Jesper Busk, Navervej 1, DK 6600 Vejen.
Telephone: +45 7696 1600. Telefax: +45 7536 4155.

FORCE Institue

Subfield: Flow of liquids other than water (Reference Laboratory)
Contact person: Lene S. Kristensen, Park Allé 345, DK 2605 Brøndby.
Telephone: +45 4326 7106. Telefax: +45 4326 7011.

National Laboratory for Geometrical Metrology (NGM)

Subfield: Dimensional metrology (Primary Laboratory)
Contact person: Leonardo De Chiffre, NGM-CGM, Building 425, Technical University of Denmark, DK 2800 Lyngby.
Telephone: +45 4525 4760, Telefax: +45 4593 0190
Sven Nytoft Rasmussen, Danish Technological Institute, DK 2630 Taastrup .
Telephone: +45 7220 3032. Telefax: +45 7220 2999

Danish Technological Institute

Subfield: Flow of water (Primary Laboratory)
Contact person: John Frederiksen, Teknologiparken, DK 8000 Aarhus C.
Telephone: +45 72201235. Telefax: +45 7220 1212.

AREPA Test & Calibration A/S

Subfield: HF electricity (Reference Laboratory)
Contact person: Orla Kristensen, Torsten Lippert, Mads Clausens Vej 12, DK 8600 Silkeborg.
Telephone: +45 8720 6969. Telefax: +45 8681 2654.

FORCE Institute

Subfield: Volumen and density (Reference Laboratory)
Contact person: Lene S. Kristensen, Park Alle 345, DK 2605 Brøndby.
Telephone: +45 4326 7106. Telefax: +45 4326 7011.

DELTA Danish Electronics, Light & Acoustics

Subfield: Humidity (Reference Laboratory)
Contact person: Anders B. Kentved, Venlighedsvej 4, DK 2970 Hørsholm.
Telephone: +45 4586 7722. Telefax: +45 4586 5898.

3.5 Reference Laboratories outside of DANIAmet

Danish Ministeries and Agencies other than the Business and Housing Agency have nominated Reference Laboratories for specialised subfields. Subfields are given in accordance with Section 3.6. Some laboratories within the subject field of chemistry have responsibilities which do not strictly follow this grouping.

The National Institute of Occupational Health

Subfield: Environmental Chemistry
Contact person: Jesper Kristiansen, Lersø Parkallé 105, 2100 København Ø
Telephone: +45 3916 5200. Telefax: +45 3916 5201.
Ministry: Ministry of Occupation

Danish Institute for Fisheries Research

Subfield: Food Chemistry
Contact person: Maike Timm Heinrich, DTU, Søltofts Plads, Building 221, DK -2800 Kgs. Lyngby
Telephone: +45 4588 3322. Telefax: +45 4588 4774
Ministry: Ministry of Food, Agriculture and Fisheries

Danish Institute of Agricutural Sciences

Subfield: Environmental Chemistry (soil and water)
Contact person: Erik Agustinussen, Forsøgsvej 1, Flakkebjerg, DK -4200 Slagelse
Telephone: +45 5811 3300. Telefax: +45 5811 3301.

Ministry: Ministry of Food, Agriculture and Fisheries

Danish Institute of Agricutural Sciences

Subfield: Environmental Chemistry (soil and water)
Contact person: Arne Jensen, Forskningscenter Foulum, DK-8830 Tjele
Telephone: +45 8999 1680. Telefax: +45 8999 1699
Ministry: Ministry of Food, Agriculture and Fisheries

Danish Institute for External Quality Assurance in laboratories in the Health Sector

Subfield: Clinical Chemistry
Contact person: Adam Uldall, 54M1, Herlev Sygehus, DK-2730 Herlev
Telephone: +45 4488 3310 Telefax: +45 4453 5369
Ministry: Ministry of Interior Affairs and Health

DHI Water & Environment

Subfield: Environmental Chemistry (water, soil, sludge and waste)
Contact person: Kirsten Andersen, Agern Alle 11, DK-2970 Hørsholm
Telephone: +45 4516 9200 Telefax +45 4516 9292
Ministry: Ministry of Environment

dk-TEKNIK ENERGY & ENVIRONMENT

Subfield: Environmental Chemistry (measurement of emission in air)
Contact person: Lars Gram, Gladsaxe Møllevej 15, DK -2860 Søborg
Telephone: +45 3955 5999 Telefax: +45 3969 6002.
Ministry: Ministry of Environment

National Enmvironmental Research Institute, Depoartment of Atmospheric Environment

Subfield: Environmental Chmeistry (ambient air pollution measurements)
Contact person: Lone Grundahl, Frederiksborgvej 399, DK-4000 Roskilde
Telephone: +45 4630 1134. Telefax: +45 4630 1214
Ministry: Ministry of Environment

National Environmental Research Institute, Department of Environmental Chemistry

Subfield: Environmental Chemistry
Contact person: Pia Lassen, Frederiksborgvej 399, DK-4000 Roskilde
Telephone: +45 4630 1200 Telefax: +45 4630 1114
Ministry: Ministry of Environment

Frederiksberg Hospital

Subfield: Clinical Chemistry
Contact person: Rene Dybkjær, Nordre Fasanvej 57, DK -2000 Frederiksberg
Telephone: +45 3816 3870 Telefax: +45 3816 3879
Ministry: Ministry of Interior Affairs and Health

Danish Veterinary and Food Administration, Institute of Food Safety and Nutrition

Subfield: Food chemistry/food microbiology
Contact person: Inge Meyland, Mørkhøj Bygade 19, DK -2860 Søborg
Telephone: +45 3395 6100. Telefax: +45 3395 6028
Ministry: Ministry of Food, Agriculture and Fisheries

Lægemiddelstyrelsen

Subfield: Microbiology
Contact person: Finn H. Clemmensen, Frederikssundsvej 378, DK-2700 Brønshøj
Telephone: +45 4488 9111. Telefax: +45 4488 9195
Ministry: Ministry of Interior Affairs and Health

Eurofins Denmark A/S / Alfred Jørgensens Laboratorium

Subfield: Environmental Chemistry
Contact person: Vibeke From Jeppesen, Frydendalsvej 30, DK-1809 Frederiksberg C
Telephone: +45 7022 4233. Telefax: +45 7022 4255
Ministry: Ministry of Environment

Danish Plant Directorate

Subfield: Food Chemistry/ Environmental Chemistry
Contact person: Mogens Nagel Larsen, Skovbrynet 20, DK-2800 Kgs. Lyngby
Telephone: +45 4596 6603 Telefax: +45 4596 6610
Ministry: Ministry of Food, Agriculture and Fisheries

Departments of Forensic Chemistry Institute of Forensic Medicine

Subfield: Forensic Chemistry
Contact person: Bent Kæmpe/Charlotte Windberg/Henning Willads Petersen, Københavns Universitet, Frederik V's vej 11, 2100 København Ø
Telephone: +45 3532 7900
Ministry: Ministry of Law

National Institute of Radiation Hygiene

Subfield: Ionising radiation and radioactivity
Contact person: Klaus Ennow, Knapholm 7, DK-2730 Herlev
Telephone: +45 4454 3454. Telefax: +45 4454 3450.
Ministry: Ministry of Interior Affairs and Health

Statens Seruminstitut

Subfield: Microbiology
Contact person: Helle Bruhn-Rasmussen, Artillerivej 5, DK-2300 København S
Telephone: +45 3268 8103. Telefax: +45 3268 8124.
Ministry: Ministry of Interior Affairs and Health

Danish Veterinary Institute

Subfield: Microbiology
Contact person: Conny Wolstrup, Bülowsvej 27, DK-1790 København V
Telephone: +45 3530 0100
Ministry: Ministry of Food, Agriculture and Fisheries

3.6 The 10 subject fields of metrology

Fundamental metrology is divided in accordance with the ten EUROMET fields, mass, electricity, length, time and frequency, thermometry, ionising radiation & radioactivity, photometry and radiometry, flow, acoustics and amount of substance. Plans of action for each field are published and serve as guide lines in the nomination of primary and reference laboratories. The years in which plans of action has been published are shown in parenthesis.

SUBJECT FIELD	SUBFIELD	LABORATORY
MASS (1989, 1997)	Mass measurement	Danish Institute of Fundamental Metrology. *Primary Laboratory*
	Force and Pressure	FORCE Institute. *Reference Laboratory*
	Volume and Density	FORCE Institute. *Reference Laboratory*
ELECTRICITY (1989, 1994)	DC electricity	Danish Institute of Fundamental Metrology. *Primary Laboratory*
	AC electricity	AREPA Test & Calibration A/S. *Reference Laboratory*
	HF electricity	AREPA Test & Calibration A/S. *Reference Laboratory*
	High current and high voltage	
LENGTH (1989, 1998)	Length measurements	Danish Institute of Fundamental Metrology. *Primary Laboratory*
	Dimensional metrology	National Reference Laboratory for Geometrical Metrology (NGM). *Primary Laboratory*
TIME AND FREQUENCY (1992, 2000)	Time measurement	
	Frequency	
THERMOMETRY (1992, 1999)	Temperature measurement by contact	Danish Technological Institute. *Reference Laboratory.*
	Non-contact temperature measurement	
	Humidity	DELTA Danish Electronics, Light & Acoustics. *Reference Laboratory*

SUBJECT FIELD	SUBFIELD	LABORATORY
IONISING RADIATIONS AND RADIOACTIVITY (1992, 2000)	Absorbed radiation dose Industrial products.	
	Absorbed radiation dose Medical products	
	Radiation protection	
	Radioactivity	
PHOTOMETRY AND RADIOMETRY (1990, 1996)	Optical Radiometry	Danish Institute of Fundamental Metrology. *Primary Laboratory*
	Photometry	
	Colorimetry	
	Optical fibres	
FLOW (1990, 1999)	Gas flow (volume)	FORCE Institute. *Reference Laboratory*
	Flow of water (volume, mass and energy)	Danish Technological Institute. *Primary Laboratory*
	Flow of liquids other than water	FORCE Institute. *Reference Laboratory*
	Anemometry	
ACOUSTICS (1992, 2000)	Acoustical measurements in gases	Danish Primary Laboratory for Acoustics, Brüel & Kjæ A/S. *Primary Laboratory*
	Acoustical measurements in solids	
	Acoustical measurements in liquids	
AMOUNT OF SUBSTANCE (1992, 1995)	Environmental chemistry	
	Clinical chemistry	
	Materials chemistry	
	Food chemistry	
	Biochemistry	
	Microbiology	
	pH measurement	Radiometer Medical A/S. *Primary Laboratory*.

4. *Accounts of Particular Activities*

Refereed publications in international journals and monographs

J. F. Jørgensen and K. Carneiro, "Calibrating scanning probe microscopes", Metrology and Properties of Engineering Surfaces, Edited by E. Mainsah, J.A. Greenwood, D.G. Chetwynd, pp. 203-242 (2001), ISBN 0-412-80640-1, DFM-2001-P1

J. Hald and E.S. Polzik, "Mapping a quantum state of light onto atoms" Jounal of Optics B: Quantum and Semiclassical Optics 3, S83-S92 (2001), DFM-2001-P2

H.R. Simonsen and F. Rose, "Absolute measurement of the hyperfine splittings of six molecular $^{127}I_2$ lines around the He-Ne/I_2 wavelength at ë ~ 633 nm", Metrologia 37, 651-658 (2000), DFM-2001-P3

H.R. Simonsen, J. Hu and K. Nyholm, "International comparison of He-Ne lasers stabilized with $^{127}I_2$ at ë ~ 543 nm (December 1999)", Metrologia 37, 709-714 (2000), DFM-2001-P4.

J. Hald, "Second harmonic generation in an external ring cavity with a Brewster-cut nonlinear crystal: theoretical considerations", Optics Communications 197, 169-173 (2001), DFM-2001-P5.

A. Kühle, J. Garnæs, C. Nielsen, L. Blunt, "A Comparative Study Of Roughnes s Measurements Using Interference Microscopy And Atomic Force Microscopy", Proceedings of the NMC2001 conference, 4 pages (2001), DFM-01-P6

Mitsuhiro Kusaba and Jes Henningsen, "The $í_1$+ $í_3$ and the $í_1$+ $í_3$+ $í_4^1$+ $í_5^{-1}$ Combination Bands of $^{13}C_2H_2$. Linestrengths, Broadening Parameters, and Pressure Shifts", Journal of Molecular Spectroscopy 209, 216-227 (2001), DFM-2001-P7

Kim Carneiro, "International Comparison: Gauge blocks of nominal length 1 mm, 10 mm, 100 mm and 10,3 mm", Metrologia 38, 273-275 (2001), DFM-2001-P8

Kim Carneiro, "International Comparison: A set of mass standards from 1 g to 5 kg", Metrologia 38, 277-279 (2001), DFM-2001-P9

Jan Hald, Valentina Ruseva, Jes Henningsen, J. W. Thomsen, D. N. Madsen, F. Y. Loo, A. Brusch and N. O. Andersen, "Constrution of a Magnesium based Optical Clock", Proceedings of the 10th International Metrology Congress (2001), ISBN nr. 2-914324-00-6, DFM-01-P10

Susanne Søgaard , Jes Henningsen, Jens Engholm Pedersen: "Wavelength modulation of fibre lasers – a direct comparison with semiconductor DFB lasers and extended cavity lasers", OFS2000 Venezia, SPIE vol. 4185, 436-439 (2001), DFM-01-P11

Harald Simonsen, Jes Henningsen and Susanne Søgaard: "DFB lasers as optical wavelength standards in the 1.5 µm region", IEEE Trans. Instr. Meas. 50, 482-485 (2001), DFM-01-P12

Jes Henningsen and Jan C. Petersen, "Reference wavelength standards for optical communication: extended C-band coverage with $^{13}C_2H_2$", Conference Digest, 6th Optical Fibre Measurement Conference, pp. 183-187 (2001), ISBN 0 946754 40 3, DFM-01-P13

Susanne Søgaard and Jes Henningsen, "Fibre laser modulation by integrated thin film resistive heating", Conference Digest, 6th Optical Fibre Measurement Conference, pp. 251-254 (2001), ISBN 0 946754 40 3, DFM-01-P14

J. Garnæs, N. Kofod, A. Kühle, C. Nielsen, K. Dirscherl, L. Blunt, "Traceable step height and roughness measurements with atomic force microscopes" Proceedings of the 2nd euspen

International conference European society for precision engineering and nanotechnology, pp. 514-517 (2001), DFM-01-P15

Susanne Søgaard, Martin Kristensen and Jacob Rathje, "Characterization of a long-period grating (LPG) bend sensor in a core concentricity error fiber", Bragg Gratings, Photosensitivity, and Poling in Glass Waveguides, BThC4, 1-3 (2001), ISBN 1-55752-680-X, DFM-01-P16

R. Breil, T. Fries, J. Garnæs, J. Haycocks, D. Hüser, J. Jørgensen, W. Kautek, L. Koenders, N. Kofod, K. R. Koops, R. Kornter, B. Linder, W. Mirandé, A. Neubauer, J. Peltonen, G.B. Picotto, M. Pisani, H. Rothe, M. Sahre, M. Stedmand, G. Wilkening, "Intercomparison of Scanning Probe Microscopes" Edited by: A. Balsamo, C. J. Evans, A. Frank, W. Knapp et al., Proceedings of the 2nd euspen International conference European society for precision engineering and nanotechnology, pp. 510-513 (2001), DFM-01-P17

Dissertations

Jonatan Kutchinsky, "Coherence and Nonequilibrium in Mesoscopic Superconductor-Normal Conductor-Superconductor Structures of Aluminum and Gallium-Arsenide", PhD Thesis - DFM-01-PhD1

Michael Wrang Mortensen, "Biological sensor surfaces investigated by Atomic Force Microscopy", DFM and Microelectronic Centre DTU, Ph.D. Thesis - DFM-01-PhD2

Other publications and reports

(An asterisk indicates that the report is also listed as a publication)

Rafael Taboryski, Jes Henningsen, Bendt Gerhardt og Kim Carneiro "DFM Årsrapport 2000", DFM-01-R1

Lars Nielsen, "Præstationsprøvning NIF P1/DANAK W2: Kalibrering af analysevægt". DFM-01-R2

Kim Carneiro, Jes Henningen and Henrik Blichfeldt: "Documentation for EUROMET QS-FORUM on the quality system of the Danish Metrology Organization DANIAmet". DFM-01-R3

Carl Erik Torp and Lars Nielsen: "DFM Calibration DataSheet 2000", DFM-01-R4

*J.Hald: "Second harmonic generation in an external ring cavity with a Brewster-cut nonlinear crystal: theoretical considerations", DFM-01-R5

Anders Kühle og Connie Nielsen: "COMF: DSS rapport nr. 3", DFM-01-R6. Confidential.

Jørgen Garnæs, Anders Kühle og Connie Nielsen: "Kortlægning af overfladeruhed pånanoniveau", DFM-01-R7

Anders Kühle: "COMF - Novo Nordisk rapport nr. 7", DFM-01-R8

Anders Kühle: "COMF - Validering af porestørrelsesmålinger vha. Nuclepore membraner", DFM-01-R9

Jes Henningsen: " Primary Laboratory for Length. Annual Report 2000", DFM-01-R10

Lars Nielsen: " Primary Laboratory for Mass. Annual Report 2000", DFM-01-R11

Hans Dalsgaard Jensen: " Primary Laboratory for DC Electricity. Annual Report 2000", DFM-01-R12

Jan C. Petersen: “Primary Laboratory for Optical Radiometry. Annual Report 2000”, DFM-01-R13

Rubina H. Shreiner, Judit Fuko, Hans D. Jensen, Marie Wandel, and Jeanett Sørensen, "International Intercomparison of Electrolytic Conductivity Between DFM (Denmark), NIST (USA), and OMH (Hungary)", DFM-01-R14

Jørgen Garnæs, “COMF: Image Metrology Repport nr. 3”, DFM -01-R15. Confidential

Hans D. Jensen, "Sporbar ledningsevnemåling af vand", Teknisk Nyt Special, Nr. 26, Juni 2001, DFM-01-R16

L. Erard, M. Chambon, K. Carnerio, J. Hald, P. Key, J. Basen and A. Henson, “A Panorama over the European Union Metrology Infrastructure”, DFM-01-R17

Kim Carnerio, “The need for metrology in nanotechnology”, DFM-01-R18

Jes Henningsen, “QMET statusrapport, ultimo juli 2001”, DFM-01-R19. Confidential.

*Mitsuhiro Kusaba and Jes Henningsen, “The $í_1 + í_3$ and the $í_1 + í_2 + í_4^1 + í_5^{-1}$ combination Bands of 13C2H2. Line Strengths, Broadening Parameters and Pressure Shifts”, DFM-01-R20.

*Susanne Søgaard and Jes Henningsen, “Fibre laser modulation by integrated thin film resistive heating” DFM-01-R21

*Jes Henningsen and Jan C. Petersen, “Reference wavelength standards for optical communication: extended C-band coverage with 13C2H2, DFM-01-R22.

Jes Henningsen, “LIT - Pre-packing and Quality in Metrology - Visit to Lithuania 2001-06-19 to 20”, DFM-01-R23

Kaj Bryder, “Quality assessment visit in Latvia” DFM-01-R24

Lars Nielsen, “Evaluation of the calibration history of a measurement standard”, DFM-01-R25

Hans D. Jensen og Peter Hyllested, “Præstationsprøvning DANAK EL 3, Digital Multimeter”, DFM-01-R26

Anders Kühle: “COMF: DSS rapport nr. 4”, DFM-01-R27. Confidential.

Anders Kühle, J. Garnaes, C. Nielsen, L. Blunt "A Comparative Study Of Roughness Measurement Using Interference Microscopy And Atomic Force Microscopy", DFM-01-R28

Kim Carneiro: “The actual and expected situation of Chilean metrology, with particular attention to the Red Nacional de Metrologia (RNM)”, DFM-01-R29

Hans Dalsgaard Jensen and Charlotte Verdier: ”DFM report on CCQM P22 measurement”, DFM-01-R30

Hans Dalsgaard Jensen and Niels-Ebbe Dam: ”Report on CCQM P22”, DFM-01-R31

Hans D. Jensen and Charlotte Verdier, "Towards An Improved Primary Standard for Electrolytic Conductivity", 2001 NCSL International Workshop & Symposium, Session 4A, DFM-01-R32.

Anders Kühle: ”AFM-målerapport”, DFM -01-R33

Anders Kühle: ”Atomic Force Microscope measurement report”, DFM-01-R34

Preben Howarth, “Quality system assessment of Lithuanian metrology labs”, DFM-01-R35

Plamen Petrov and Jes Henningsen, ”INCO Progress Report”, DFM-01-R36

Anders Kühle, ”CIMF: Novo Nordisk rapport nr. 8”, DFM-01-R37. Confidential.

Jørgen Garnæs , “Calibration of an AFM Microscope”, DFM -01-R38.

Jan C. Petersen and David A. Humphreys, “Certified Reference Materials for Optical Telecommunication wavelengths: Atomic and molecular absorption lines”, DFM-01-R39

*Jørgen Garnæs, Niels Kofod, Anders Kühle, Connie Nielsen, Kaj Dirscherl, L. Blunt, “Tre a-cable step height and roughness measurements with atomic force microscopes” Proceedings of the euspen 2nd International conference European society for precision engineering and nanotechnology, DFM-01-R40.

Jørgen Garnæs, Niels Kofod, Anders Kühle, Connie Nielsen, Kaj Dirscherl, L. Blunt, “Cal i-bration of step heights and roughness measurements with atomic force microscopes”, DFM-01-R41.

M.W. Mortensen, R. Marie, A. Kühle, J. Garnæs, I. Chorkendorff, C.B.V. Christensen and A. Boisen, “Adsorption mechanisms for differently treated thiol-modified ssDNA on gold“, DFM-01-R42.

Niels Kofoed, ”Projektprocessen – en central del af teknologiskabelsen”, DFM-01-R43.

A. Kühle, J. Garnæs, EU project "SURFSTAND" - DFMs contribution to the final report, DFM-01-R44

Kim Carneiro, “Metrology and Quality”, DFM-01-R45.

Kim Carneiro, “MetroTrade – Metrological Support to International Trade”, DFM-01-R46.

Kim Carneiro, Jes Henningsen, Henrik Blichfeldt, “La metrologia in Danimarca”, DFM-01-R47.

Hans D. Jensen, Jes Henningsen, Lars Nielsen, “LET 0101 – Pre-packing and Quality in Metrology – Laboratory assessment in Latvia 30-31 August 2001“, DFM-01-R48.

Jørgen Garnæs, “Roughness measurements on silicon dioxide”, DFM -01-R49. Confidential.

Jørgen Garnæs og Niels Kofod, “Measurements results for key comparison Nano4 – 1D gratings”, DFM-01-50

Jan-Ulrik Holtoug, “Assessement thermometry laboratory, Lithuania”, DFM-01-51

Jan-Ulrik Holtoug, “Assessement thermometry laboratory, Latvia”, DFM-01-52

Contributions at conferences

Kim Carneiro, ”nanometrology”, Netværksmøde om nanoteknologi, Dahlerups Pakhus, Copenhagen, 2001-03-02.

Kim Carneiro, Jes Henningsen and Henrik Blichfeldt, “Presentation for EUROMET QS-FORUM on the quality system of the Danish Metrology Organization DANIAmet”, QS-FORUM meeting, SMU, Bratislava, 2001-03-23.

J. Garnaes, N. Kofod, A. Kühle, C. Nielsen, K. Dirscherl, L. Blunt, “Traceable step height and roughness measurements with atomic force microscope”. The euspen 2nd International Conference european society for precision engineering and nanotechnology, Turin, Italy (poster), 2001-05-27-31.

Jan Hald, Jes Henningsen, N.O. Andersen, J.W. Thomsen, D.N. Madsen and F.Y. Loo: ”An optical clock based on cold Magnesium atoms (Poster), Danish Physical Society annual meeting, 2001-05-31-06-01

S. Søgaard, M. Kristensen and J. Rathje, "Characterization of a long-period grating bend sensor in a core concentricity error fiber" BGPP 2001, paper BThC4, Stresa, Italy, 2001-07.

Lars Nielsen,” Evaluation of measurements by the method of least squares”, The Fourth International Symposium on Algorithms for Approximation (A4A4), Huddersfield 2001-07-15-20.

Anders Kühle, Jørgen Garnæs, Connie Nielsen, N.b. Larsen and H. Everland, ”Surface and Subserface AFM Imaging of Compliant, Sticky Materials” (Poster), 11th International conference on Scanning Tunneling Microscopy/Spectroscopy and Related Proximal Probe Microscopy – STM01, Vancouver, 2001-07-15-20.

Hans D. Jensen and Charlotte Verdier, "Towards An Improved Primary Standard for Electrolytic Conductivity", 2001 NCSL International Workshop & Symposium, Washington DC, USA, Session 4A, 2001-07-31.

Kim Carneiro and Preben Howarth “MetroTrade - Metrological Support to International Trade”, NCSL International 2001 Workshop and Symposium, Washington D.C., 2001-07-29-08-02

J.C. Petersen, T. Bjørnholm, I.-Y. Wu, and J.T. Lin, “Large third-order nonlinear response from an Organoruthenium complex with an effective multidirectional charge-transfer transition”, Poster. SPIE’s 46th Annual meeting, The International Symposium on Optical Science and technology, San Diego, 2001-07-29-08-03.

D.R. Greve, R.A. Janssen, and J.C. Petersen, “Novel highly conjugated polythiophene for third order NLO”, SPIE’s 46th Annual meeting, The International Symposium on Optical Science and technology, San Diego, 2001-07-29-08-03

Maria Holmberg, M.W. Mortensen, Anders Kühle, Jørgen Garnæs, A. Boisen, ”Biosensor Surfaces Studied with Atomic Force Microscopy (Poster)”, Trends In Nanotechnology, Segovia, Spain, 2001-09-03-07

Jes Henningsen and Mitsuhiro Kusaba: “Combinatino bands of $^{13}C_2H_2$ in the 1500 nm region. Line strengths, broadening parameters and pressure shifts”, 17th Colloquium on High Resolution Molecular Spectroscopy, F-15, Nijmegen, 2001-09-09-13

Jes Henningsen and Georg Ole Sørensen, “On modeling the overtone and combination bands of acetylene in the 1500 nm region”, 17th Colloquium on High Resolution Molecular Spectroscopy, L-17, Nijmegen, 2001-09-09-13

Kim Carneiro, “Industrial Innovation and metrology – seven case stories” in “International Metrology Conference” Bucharest, 2001-09-18-20.

Jan Hald, Jes Henningsen, Valentina Ruseva: ”Overview of activities at DFM (Poster)”, CAUAC Network meeting, Sandbjerg, 2001-09-23-25

Valentina Ruseva: “Construction of a Magnesium based Optical Clock”, CAUAC Network meeting, Sandbjerg, 2001-09-23-25

J. Henningsen and J. C. Petersen, “Reference wavelength standars for optical communication: extended C-band coverage with $^{13}C_2H_2$”, 6th Optical Fibre Measurement Conference, OFMC ’01, Girton College, Cambridge, 2001-09-26–28

E. G. Grosche, U. Sterr, J. Meissner, D. Humphreys, J. C. Petersen, F. Wonnacott, F. Bertinetto, C. Svelto, R. Lano, and L. Tallone, “Certified Reference Materials for Optical Telecommunication Wavelengths”, 6th Optical Fibre Measurement Conference, OFMC ’01, Girton College, Cambridge, 2001-09-26–28

Susanne Søgaard and Jes Henningsen, “Fibre laser modulation by integrated thin film resistive heating”, 6th Optical Fibre Measurement Conference OFMC’01, Cambridge, 2001-09-26-28

Jan Hald, Valentina Ruseva, Jes Henningsen, J.W. Thomsen, D. N. Madsen, F. Y Loo, A. Brusch and N. O. Andersen, “Construction of a Magnesium based Optical Clock”, (Poster), 10th Internatioal Metrology Congress, Saint-Louis, 2001-10-22-25

Kim Carneiro, “Metrology for the service of nanotechnology”, nanoSTAG meeting, Leuven, Belgien, 2001-10-29.

Anders Kühle, Jørgen Garnæs, Connie Nielsen, L. Blunt, ”A Comparative Study of Roughness Measurements Using Interference Microscopy and Atomic Force Microscopy”, NMC2001 Conference, Harrogate, UK, 2001-11-06-08.

J. Garnaes, N. Kofod, A. Kühle, K. Dirscherl, L. Blunt, “Calibration of the z-coordinate and roughness measurements with atomic force microscopes”, NanoScale 2001 5th Seminar on Quantitative Microscopy and 1st Seminar on Nanoscale Calibration Standards and Methods, Bergisch Gladbach, Germany, 2001-11-15-16.

Susanne Søgaard and Jes Henningsen, "Thermal Modulation of a DFB Fibre Laser" DOPS annual meeting, Aarhus, 2001-11-22-23.

Kim Carneiro, “Quality and Metrology”, Initiation Workshop, Bucharest, 2001-12-13-14.

Other talks

Jes Henningsen: “Fundamental Standards”, Center for Tele-information, DTU 2001-02-15

Rafael Taboryski: “Electronic Transport Phenomena in Mesoscopic Al/GaAs/Al, Superconductor/Semiconductor/Superconductor Junctions”, Wroclaw University of Technology, Wroclaw, 2001-02-23-27.

Kim Carneiro: “Standards in the Global Economy: Past, Present and Future”, Meeting of directors of NMIs, NIST, Gaithersburg 2001-03-06-11

Jørgen Garnæs, Four lectures in course 44420, “Scanning Probe Microscopy”, The Technical University of Denmark, 2001-03-27-31

Jan Hald: “An optical clock based on cold Magnesium atoms”, Atomic Physics Seminar, Aarhus University, 2001-03-30

Kim Carneiro: “IVD Directive Expectations and Implications”, Workshop on Legal Metrology, Vilnius 2001-04-01-03

Jørgen Garnæs og Kim Carneiro: “Scanning Probe Microscopy”, Tutorial arranged by European Society for precision engineering and nanotechnology (euspen), Turin, Italy, 2001-05-27

Kim Carneiro, “Challenges for European Metrology in the XXI Century”, IEN, Torino, 2001-06-07

N E Dam: Presentation of the Danish results of CCQM-P22, Euromet Project nr. 632: "Expert workshop on electrolytic conductivity measurement", Delft, Holland 2001-10-18

N E Dam: Results of CCQM-P22, Euromet Project nr. 632: "Expert workshop on electrolytic conductivity measurement", Delft, Holland 2001-10-18

Kim Carneiro “CIPM-MRA Mutual recognition arrangement”, INN, Santiago de Chile, 2001-11-13.

Preben Howarth, Henrik Blichfeldt: “Establishing a quality system based on ISO 17025 and 9000:2000”, Seminar at State Metrology Service, Vilnius 2001-11-19-20

Preben Howarth, Kaj Bryder: “Quality manuals complying with both ISO 17025 and 9000:2000 requirements”, Workshop at Latvian National Metrology Center, Riga 2001-12-04-06

Visitors

Joseph Bartolo, Malta Standards Authority, Malta: “Introduction to Metrology in Denmark”, 2001-02-14 to 2001-03-03

6 Visitors from NIM, Beijing, China, March 2001

SAW cooperation partners from University of Copenhagen , Poul Erik Lindelof, Pawel Utko, NPL, Tony Hartland, Nick Fletcher, JanTheodor Janssen, PTB Franz Josef Ahlers, Jens Ebbecke and Scuola Normale Superiore, Vincenzo Piazza, May 2001.

Kontorchef Søren Hellener, Erhvervsfremme Styrelsen, 2001 -06-28

Rüdiger Kessel,: “Software-Tool for Evaluation of Uncertainty of Measurement”, Metrodata GmbH, 2001-07-30

Robert F. Werner, Coates & Jarratt, Inc. Washington D.C. “ Possible Collaboration in forecasting nanotechnology”, 2001-09-04

Tomizo Kurosawa, National Metrology Institute of Japan NMIJ, “Current Activities of Dimensional Standards Section”, 2001-09-14

Horst Kunzmann, Physikalish-Technische Bundesanstalt, Germany, 2001-11-05

Anne Andersson-Fäldt, SP, “Optical communication wavelength references”, 2001-11-14-15

Harul Nizam Abdul Rashid, SIRIM Malaysia, 2001-11-28

Mads Peter Schreiber, Nordtest, “Possible Nordic Metrology Cooperation”, 2001-12-07

Jesper Lasthein Hansen og Kurt Stochholm, Kamstrup A/S, 2001-12-18

5. Statement of Income 2001 (in Danish)

(16. regnskabsår)

5.1 Anvendt regnskabspraksis

Indtægter:

Indtægterne medtages i resultatopgørelsen i takt med arbejdets udførelse efter produktionskriteriet, hvilket medfører, at avancen påsolgte ydelser medtages i resultatopgørelsen i takt med udførelsen af arbejdet, jævnfør nedenfor under igangværende arbejder.

Bevillinger forbrugt til udstyr, som regnskabsmæssigt afskrives, er indtægtsført i resultatopgørelsen.

Regnskabet er baseret påinstituttets bogføring, men tallene er angivet i hele kroner (tusinde kroner for foregående år); Der kan derfor forekomme tilsyneladende afrundingsfejl ved sammentællingerne.

Materielle anlægsaktiver:

Småanskaffelser med en anskaffelsessum påunder 20.000 kr. udgiftsføres i resultatopgørelsen.

Udstyr med begrænsede anvendelsesmuligheder, fremstillet af underleverandører, udgiftsføres.

Mindre kontorinventar udgiftsføres (tidligere blev dette afskrevet over 4 år; ændringen påvirker ikke årets resultat).

EDB-udstyr afskrives lineært over 3 år.

Videnskabeligt udstyr afskrives lineært over 4 år.

Igangværende arbejder:

Igangværende arbejder er optaget til salgsværdi omfattende medgået tid til salgspris med tillæg af afholdte udlæg.

Henlagt til byggeri

Af de henlagte midler på8 millioner kr. er anvendt 650.000 kr. til igangværende indretning af laboratorier. I 2002 forventes anvendt yderligere ca. 3,9 millioner kr. der ligeledes vil blive fratrukket henlæggelser.

5.2 Resultatopgørelse

Noter		2001	2000 (1000 kr)
	Kundeomsætning	3.777.548	4.871
	Projektomsætning	3.855.287	3.217
	Resultatkontrakt	9.300.000	9.800
	BRUTTOINDTÆGTER I ALT	**16.932.834**	**17.888**
	Underleverandører	1.688.108	2.026
	Rejseomkostninger	756.589	806
	Andre udlæg	583.165	898
	UDLÆG I ALT	**3.027.861**	**3.730**
1	**NETTOINDTÆGTER**	**13.904.973**	**14.158**
2	Personaleomkostninger	9.475.009	9.234
	Andre omkostninger	3.426.685	3.548
	OMKOSTNINGER I ALT	**12.901.694**	**12.782**
	RESULTAT AF ORDINÆR DRIFT	**1.003.279**	**1.377**
	Afskrivninger	1.254.882	1.775
	RESULTAT FØR RENTER	**-251.603**	**399**
3	Nettorenter	592.150	424
	ÅRETS RESULTAT	**340.547**	**26**

Årets resultat overføres til næste år.

5.3 Balance pr. 2001-12-31

Noter	AKTIVER	2001	2000 (1000 kr)
4	**FINANSIELLE ANLÆGSAKTIVER**	**142.544**	**126**
5	**MATERIELLE ANLÆG SAKTIVER IALT**	**2.095.303**	**2.021**
	Igangværende arbejder	726.091	1.345
	Tilgodehavender	1.941.972	2.224
	Debitorer	2.194.967	375
	Periodeafgrænsninger	128.728	210
	Tilgodehavender i alt	**4.991.758**	**4.154**
6	**Likvide midler i alt**	**7.915.692**	**10.501**
	OMSÆTNINGSAKTIVER I ALT	**12.907.450**	**14.656**
	AKTIVER I ALT	**15.145.297**	**16.802**

5.4 Direktionens underskrift

Lyngby, 2002-02-21

Kim Carneiro
Direktør

Noter	PASSIVER	2001	2000 (1000 kr)
7	Henlagt til byggeri	7.350.000	8.000
	Overført resultat	1.762.065	1.422
	EGENKAPITAL I ALT	**9.112.065**	**9.422**
	Andre hensættelser	30.907	24
	Forudbetalinger	3.067.301	4.692
	Kreditorer og skyldige omkostninger	1.835.025	1.569
	Feriepengeforpligtelse	1.100.000	1.096
	KORTFRISTET GÆD I ALT	**6.002.326**	**7.357**
	PASSIVER I ALT	**15.145.297**	**16.802**

5.5 Bestyrelsens underskrifter

Lyngby, 2002-02-21

Knut Conradsen

Steen Konradsen
Formand

Hans Jørgen Pedersen

Lars Ole Kornum

Anders Kühle
Medarbejderrepræsentant

Hans Dalsgaard Jensen
Medarbejderrepræsentant

Ernst Tiedemann

Ole Bjørn Jensen

5.6 Revisionspåtegning

Vi har revideret det af ledelsen aflagte årsregnskab for 2001 for Dansk Institut for Fundamental Metrologi.

Den udførte revision

Revisionen er udført i overensstemmelse med Erhvervsfremme Styrelsens revisionsinstruks pr. 1. Januar 1998 for GTS-institutter under iagttagelse af god offentlig revisionsskik.

Vi har i overensstemmelse med almindeligt anerkendte revisionsprincipper tilrettelagt og udført revisionen med henblik på at opnå en begrundet overbevisning om, at årsregnskabet er uden væsentlige fejl eller mangler. Under revisionen har vi ud fra en vurdering af væsentlighed og risiko efterprøvet grundlaget og dokumentationen for de i årsregnskabet anførte beløb og øvrige oplysninger. Vi har herefter taget stilling til den anvendte regnskabspraksis og de udøvede regnskabsmæssige skøn samt vurderet, om årsregnskabets informationer som helhed er fyldestgørende.

Revisionen har ikke givet anledning til forbehold.

Konklusion

Det er vor opfattelse, at årsregnskabet er aflagt i overensstemmelse med lovgivningens krav til regnskabsaflæggelse herunder de for Dansk Institut for Fundamental Metrologi gældende regnskabsbestemmelser, og at det giver udtryk for årets indtægter og udgifter samt Instituttets aktiver og passiver pr. 31. december 2001

Forvaltningen af de bevilgede midler er varetaget tilfredsstillende af Dansk Institut for Fundamental Metrologi.

København, 2002-02-21

Juul & Partnere

Niels Bjerregaard
statsautoriseret revisor

5.7 Noter

1 Egenfinansierede forsknings- og udviklingsomkostninger, opgjort efter den af Erhvervsfremme Styr godkendte timesats, udgjorde i året kr. 969.914

2 DFM har i 2001 i gennemsnit beskæftiget 24 medarbejdere fordelt på 20 faste medarbejdere og 4 konsulenter (blandt andet Ph.D. studerende)

3 Nettorenter indeholder renteindtægter fra forudbetalinger til projektpartnere på kr. 24.320

4 Anparter i Image Metrologi ApS (Lyngby-Tårbæk) og Qmet ApS (Søllerød) er værdiansat til anskaffelsu Virksomhederne har ikke aflagt årsregnskab for år 2001

5

Anskaffelsessum	**EDB**	**Videnskab.**	**Kalibrering**	**Ialt**
Saldo 2001 01 01	3 474 582	17 175 660	5 342 419	25 992 661
Tilgang 2001	79 880	1 016 767	232 294	1 328 941
Afgang 2001	14 883	-	-	14 883
Saldo 2001 12 31	3 569 345	18 192 427	5 574 713	27 336 485
Afskrivninger				
Saldo 2001 01 01	3 350 422	15 692 298	4 929 212	23 971 933
Afskrivning 2001	**133 973**	**922 380**	**200 928**	**1 257 281**
Afskrevet årets afgang	14 883	-	-	14 883
Saldo 2001 12 31	3 499 279	16 614 678	5 130 140	25 244 097
Bogført værdi	70 067	1 577 749	444 573	2 092 388

6

Likvide midler	**2001**	**2000 (1000 kr)**
Obligationer	5 879 303	7 391
Indestående i bank	838 935	936
Giro	51 155	44
Forudbet. projektpartnere	1 146 299	0
LIKVIDE MIDLER IALT	**7 915 692**	**8 371**

7

Henlagt til byggeri	
Primo	8 000 000
Anvendt til indretning af laboratorier	(650 000)
Ultimo	7 350 000

6. Key Figures

Economy (million Danish kroner)	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Turnover gross	10.2	13.6	14.8	14.7	17.9	16.9
Turnover net	7.5	10.7	11.4	12.5	14.2	13.9
Result for the year	-2.8	-0.4	-0.4	-1.3	0.0	0.3
Equity	11.4	11.0	10.7	9.4	9.4	9.1
Export turnover from projects and customers	0.6	1.7	2.3	3.5	5.0	3.0
R & D						
R & D number of projects	4	13	11	17	17	15
- of this centre contracts	0	0	1	1	2	2
- of this international projects	4	10	8	13	9	7
R & D total turnover	8.1	11.9	12.4	11.9	13.0	13.2
- of this internally financed	2.0	1.3	2.4	3.6	0.8	1.0
R & D person-year	8.5	10.5	7.7	9.4	13.9	10.3
Number of customers						
Danish private companies	-	-	37	36	42	38
- of this small companies (under 50 employed)	-	-	16	16	18	22
- of this medium sized companies (50-200)	-	-	10	8	13	7
- of this large companies (over 200 employed)	-	-	11	12	11	9
Public Danish institutions	-	-	8	8	5	8
Foreign companies	-	-	16	32	22	29
Total mass of customers	-	-	61	76	69	75
Staff						
Scientific	9	10	10	10	10	9
Other academic incl. temporary employed	5	7	4	6	9	9
Other technical	3	3	3	3	3	3
Administrative	2	2	2	2	3	3
Average staff	19	21	19	22	25	24
Number of publications						
Dissertations	-	-	3	1	4	2
Calibrations certificates, accredited	31	32	31	49	80	78
Refereed publications in international journals	11	15	14	21	15	17
Conference contributions	27	29	22	29	17	26
Other publications and reports	40	27	29	59	43	52
Refereering	-	-	44	27	82	54
Press clips	22	16	14	55	29	25
Teaching						
Days	-	-	15	17	32	25
Participants	-	-	201	200	337	232
Censoring / teaching at universities	-	-	3	3	7	6
Members of commities, councils	-	-	9	6	6	3
- of this international	-	-	7	5	5	3
Efficiency						
Turnover per employee (1.000 DKK)	537	648	779	668	716	704
Profit per employee (1.000 DKK)	-147	-19	-21	-59	1	13
Client turnover per Government Contract DKK	0.1	0.2	0.3	0.3	0.5	0.4
R & D turnover per Government Contract DKK	1.0	1.2	1.3	1.4	1.3	1.4

Niels-Ebbe Dam combines skills in chemistry and electricity. He uses these skills in his work with DFM´s standards for electrolytical conductivity.

Mission

As Centre of Excellence in metrology the Danish Institute of Fundamental Metrology ensures
that measurement knowledge in Denmark is continually developed and maintained at an international scientific level
and
that the Danish effort in fundamental metrology is coordinated