PTB news
Metrology
Technology
Services
Cooperation
02.1

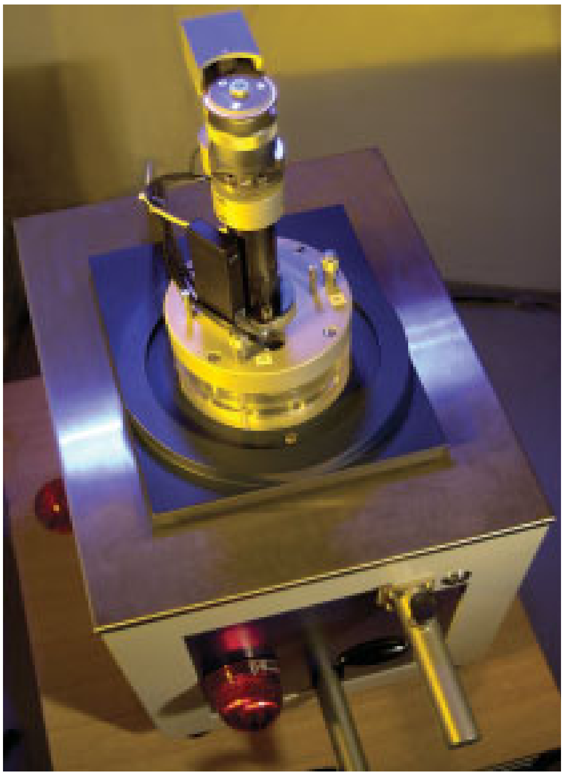
β-radiation standard for brachytherapy

The chances of lastingly opening constricted coronary vessels increase significantly when the vascular area affected is additionally irradiated with a radioactive source after having been mechanically dilated. For traceable dose measurements for this cardiovascular brachytherapy with β-radiation sources, the PTB has developed a secondary standard which is commercially manufactured under a licence and calibrated at the PTB.

In Germany, every year much more than 100000 persons contract a constriction of their coronary vessels. The therapy most frequently used is angioplasty by which the vascular obliteration is opened again using an inflatable balloon to be introduced into the artery through a cardiac catheter (balloon dilatation). However, more than half of the patients having undergone this therapy will contract another obliteration (restenosis) in the same location in the months to follow.

To avoid these restenoses, cardiovascular brachytherpy has been used for some years so that the restenosis rate could be reduced by up to 70 %. Directly after the angioplasty, the area of the coronary vessel injured by the dilatation is irradiated with a radioactive source inserted in the artery, in most cases a ^{90}Sr/^{90}Y beta emitter. Within the scope of various medical studies it is at present attempted to find an optimum dose for this radiation therapy. Particular difficulties are posed by the great changes in the dose rate within small spacings (typically by the factor 10 within 3 mm of tissue).

To enable clinics practising irradiation of the coronary vessels to ensure traceability of their dose measurements, the PTB has developed a secondary standard for cardiovascular brachytherapy using β-radiation sources. This standard consists of a ^{90}Sr/^{90}Y extended beam source about 15 mm in diameter with an activity of about 7,5 GBq, which is enclosed in a suitable protective casing. Owing to a precise mechanical system almost free from play, the source can be brought into four different beam positions (at distances between 1,7 mm and 40 mm from a reference area). Directly on the reference area and behind tissue-equivalent layers whose thicknesses are 0,1 mm to 8 mm, the water/absorbed dose rate is determined using a primary standard measuring device, an extrapolation chamber. In addition, the radial dose rate distribution is measured for each of the different layer thicknesses with the aid of a special ionization chamber of high spatial resolution. The clinical user thus has a β-radiation field in a tissue-equivalent medium, which is specified in three dimensions as regards the dose rate and shows similar properties as fields of clinical radiation sources. By calibration of his dosemeters in this radiation field, the user can ensure that his dose measurements are traceable to the national standards of the PTB.



The β-radiation standard of the PTB for brachytherapy with primary standard measuring device placed on top

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Remote control via Internet

At the research reactor of the GKSS Forschungszentrum Geesthacht (about 200 km from Braunschweig), the PTB operates the polarization diffractometer POLDI for neutrons. For this complex instrument a remote control system has now been realized which allows more than 20 devices to be controlled. The control software available has been alter by adding extensions developed at the PTB and open source products available on the market so that the instrument can now be controlled from all over the world through the Internet.

For the control of the data acquisition, a TCP/IP (Internet protocol) based protocol has been developed and implemented in various programming and script languages, so familiar and well-tried program segments can

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Remote control via Internet

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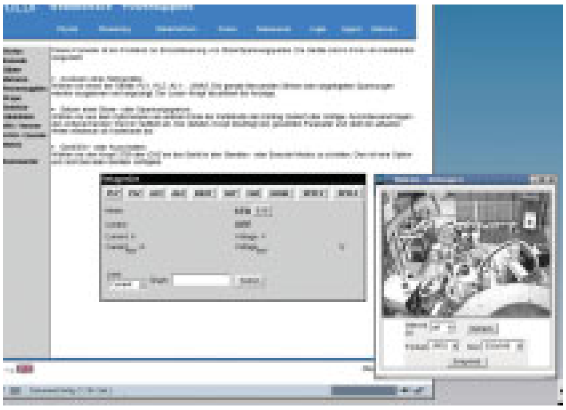
be further used. Also, simultaneous access to different programs from different operating systems is possible.

The presentation of the instrument in the Internet is based on the open source projects LINUX, APACHE and PHP which are (the server-end) part of a web interface. By a browser (the client-end part of the interface) such as Netscape or Internet Explorer, an authorized user gets access to individual devices such as stepping motors, temperature controllers, meters, current sources. He is able to program measurement sequences, monitor and change device parameters or watch from Braunschweig the experimenter in Geesthacht.

Such experiments – which are also carried out with guests of the Geesthacht Neutron Facility – relate to magnetic model systems and technical materials. The diffractometer has also been used to develop equipment for investigating internal stresses in deformed materials and for determining material properties (spin-dependent n-cross section of ^{3}He).



Web interface: monitoring of power supply units with the browser, view of the sample environment with a webcam

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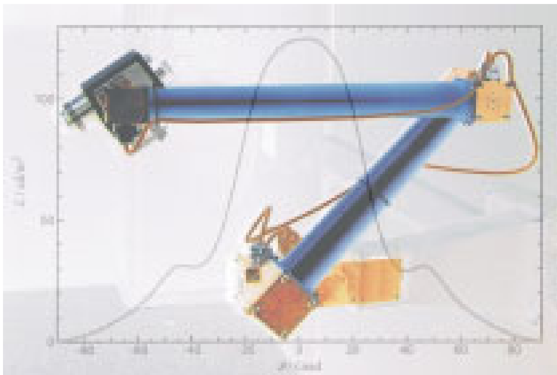
Light and colour of displays

Displays are key components for visual information switching. With the advance of the display technique – from organic light emitting diodes to semiconductor lasers to micro mirror arrays –, the metrological requirements for the determination of the most important characteristics and simultaneous reduction of the uncertainty of measurement are increasing. So the new measuring facility of the PTB is used to develop measuring procedures and to optimize transfer standards adapted to the specific properties of modern display structures.

At the PTB a display measuring assembly has been developed using the arm of a circular robot to align photometric and colorimetric measuring instruments to the display and to displace them in the hemisphere in front of it. The arm has four rotation axes and allows measurements with radii up to 0,8 m for which any position or path can be selected. With a luminance measuring device or a compact CCD spectroradiometer, the mean values of the luminance and of the relative spectral distribution are measured for the partial areas as a function of angle. From these, colour dot coordinates, colour saturation and most similar colour temperature as well as luminance and colour contrasts are calculated. When determining the values for the optical quantities and the location and direction as well as the operating and ambient conditions, the measurement instants are also stored as “time stamps” and used for “synchronization” in the common evaluation.

The new measuring assembly also allows multidimensional influence parameters such as polarization, temporal modulation, angular and position dependence, including the retroaction of thermal and magnetic ambient conditions to be taken into consideration. Thus the measurement of photometric and colorimetric characteristics of displays can be traced back to the national standards which under international arrangements have been recognized as “equivalent”. Thus for medical, traffic and safety-relevant applications in particular, global marketing is ensured complying with strict regulations. The development aims to create new transfer standards which are made available to the users for improved production and quality control, for example, in the form of modified displays provided with stabilizing additional measures such as optical feedback and detailed measuring procedures.



Circular robot for the displacement of a photometer or spectroradiometer in the hemisphere in front of a display for the determination of the values of photometric and colorimetric characteristics and their angular dependence. Plotted is also the luminance as a function of the viewing angle, measured in a horizontal plane in front of a “white-controlled” display (TFT display of a laptop), with strongly decreasing “brightness” at the edge of the viewing area.

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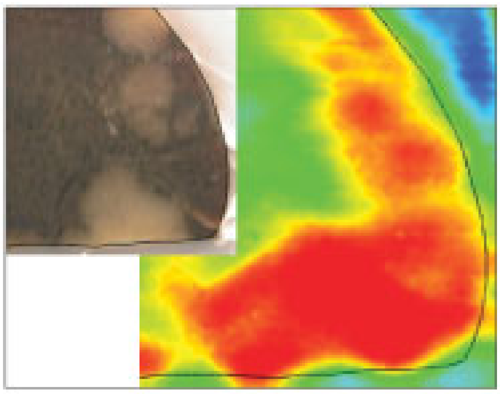
Imaging spectroscopy with continuous THz-radiation

The technical exploitation of the spectral region between hundred GHz and a few THz has always represented a special challenge. Five years after images were first produce using pulsed THz radiation the world's first functioning THz spectrometer has been built that operates with continuous radiation.

One promising application of THz radiation is imaging various different samples, e. g. in the fields of biomedicine or materials sciences. Transmission images of probed samples deliver information not accessible using other techniques or only by accepting other disadvantages in the measurements, such as, for instance, accepting the radiation load on living organisms for x-ray imaging. Lately, research in the field of THz-spectroscopy is also focussing on image formation with continuous rather than pulsed radiation. Imaging with continuous THz-radiation can be applied at discrete frequencies and achieves better signal-to-noise ratios than the method utilizing pulsed radiation which itself requires integrating over a small region of the pulse spectrum.

The first operative THz-spectrometer with continuous radiation has been constructed by the work group "terahertz-system technology" at the Institute for High Frequency Technology of the Technical University Braunschweig in cooperation with PTB's Special Laboratory "Semiconductor Structures". To produce the radiation requires manufacturing photoconductive dipole antennae. The base material is semiconductor GaAs specially processed to create extremely short charge carrier life times. The material and the photoconductive antennae were produced at PTB and optimised for the application.

To demonstrate the potential of the method in a first application related to medical research a THz-transmission image was made of a specimen of human liver infiltrated by cancer. Now that the prototype has been completed further investigations of power and performance and of the new method can be tackled.



THz-Transmission images of a specimen of human liver infiltrated with cancer in comparison with conventional photography on the sample. Metastasen appear as light spots on the conventional photograph.

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New method for early malaria recognition

In cooperation with the Charité Clinic for Infectiology (Berlin), a method based on laser flow cytometry has been developed to support malaria diagnostics. Owing to the detection of rare white blood cells (monocytes) modified by the infection, it has for the first time been possible to recognize malaria in non-immune patients with high specificity and sensitivity. The method is suitable for screening to detect malaria.

With about 2,5 millioncasese of death per year, malaria is one of the most dangerous infectious diseases worldwide. In the industrialized countries, too, there are fatalities which might be prevented if the infection was recognized as early as possible. The standard method of malaria diagnostics is microscopy which allows the four different kinds of parasites to be distinguished and the concentration of the parasitized red blood cells to be determined. Such examinations are, however, carried out only if an infection is clinically suspected, i. e. establishing of a diagnosis for persons returning from a journey to endemic regions might be delayed.

To check the suitability of flow cytometry as a screening tool for malaria recognition, the concentration of monocytes containing malaria pigment (PCM) was measured. After incorporation of the birefringent malaria pigment haemozoin, a degradation productof the parasites, these cells are distinguished by their high intensity of depolarized orthogonal light.

The flow cytometric method investigated by the PTB together with their medical partner allows malaria to be recognized with a specificity of 100 % a sensitivity of 86 % (100 %) for non-immune (semi-immune) patients was achieved.

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New method for early malaria recognition

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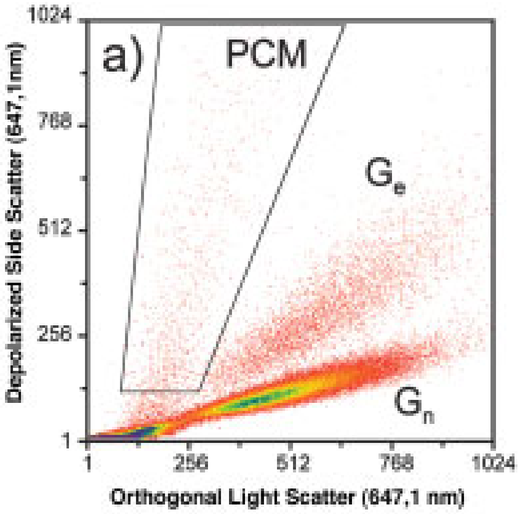
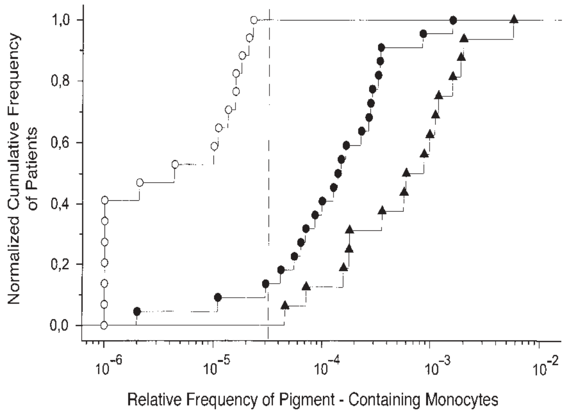


(Fig. 1): Scatter plot (about 250000 white blood cells) of a blood sample of a malaria patient. Each dot represents at least one white blood cell (G_n = neutrophilic, G_e = eosinophilic granulocytes). In this scatter plot the pigment carrying monocytes occur in the region denoted as PCM. Their identification was realized by sorting and subsequent microscopic analysis.



(Fig. 2): For three cohorts (patients, volunteers) the normalized cumulative frequency is plotted as a function of the relative concentration of the cells in the PCM region. The open symbols stand for malaria negative persons and closed circles (triangles) for non-immune (semi-immune) malaria patients. The threshold of $3{,}3 \times 10^{-5}$ which corresponding to the vertical line represents the biological background, i. e. events in the PCM region are recorded even for malaria negative persons. Generally, non-immune patients are persons having returned from a journey, while semi-immune patients live in epidemic regions and have become partially immune because they are in permanent contact with the parasites. In this group of patients, the characteristic symptoms of a malaria infection can be observed at a higher concentration of the PCM.

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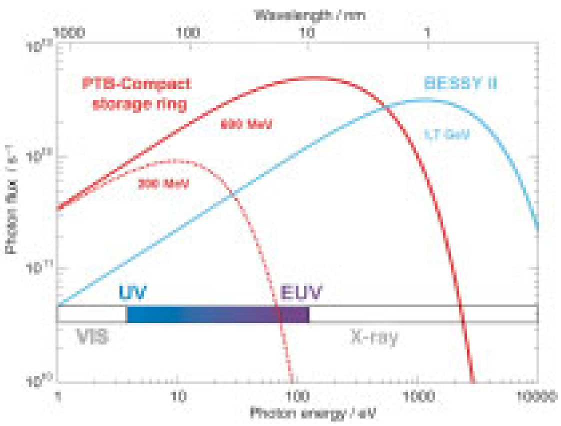
Low-energy compact storage ring constructed in Berlin-Adlershof



Photon flux of the compact storage ring, compared with BESSY II

In Berlin-Adlershof the PTB is constructing a low-energy compact storage ring optimized for metrological applications in the spectral region from the ultraviolet (UV) to the extreme UV (EUV).

For 18 years, until its decommissioning in late 1999, the PTB had used the electron storage ring BESSY I in Berlin-Wilmersdorf for realizing and disseminating radiometric units in the UV and EUV regions. As a successor to this source, a compact storage ring with a tunable electron energy from 200 MeV to 600 MeV is at present being constructed by the PTB. It is built in close cooperation with the Berliner Elektronenspeicherring-Gesellschaft mbH (BESSY) at the scientific and economic site of Berlin-Adlershof and will form, together with the high-energy storage ring BESSY II, which has been used since 1999 by the PTB for X-ray radiometry, the European competence centre for metrology with synchrotron radiation.

After four years of construction, the facility will take up operation in 2007. It will be Europe's sole primary standard radiator for the UV and EUV regions and used not only by the PTB for its own purposes but also by other national metrology institutes. Furthermore, it serves to further speed up EUV lithography which according to the current "International Technology Roadmap for Semiconductors" will produce semiconductor structure widths of 65 nm beginning in 2007. According to the prognosis, the further development steps will yield structural widths of 22 nm in 2016. To achieve this, it is absolutely necessary to carry out at-wavelength measurements with 13 nm radiation. The compact storage ring thus is also of importance to optical industry which has a great interest in metrological support for the UV and EUV regions.

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