ARIES-ADA Topical Workshop

Materials and Engineering Technologies for

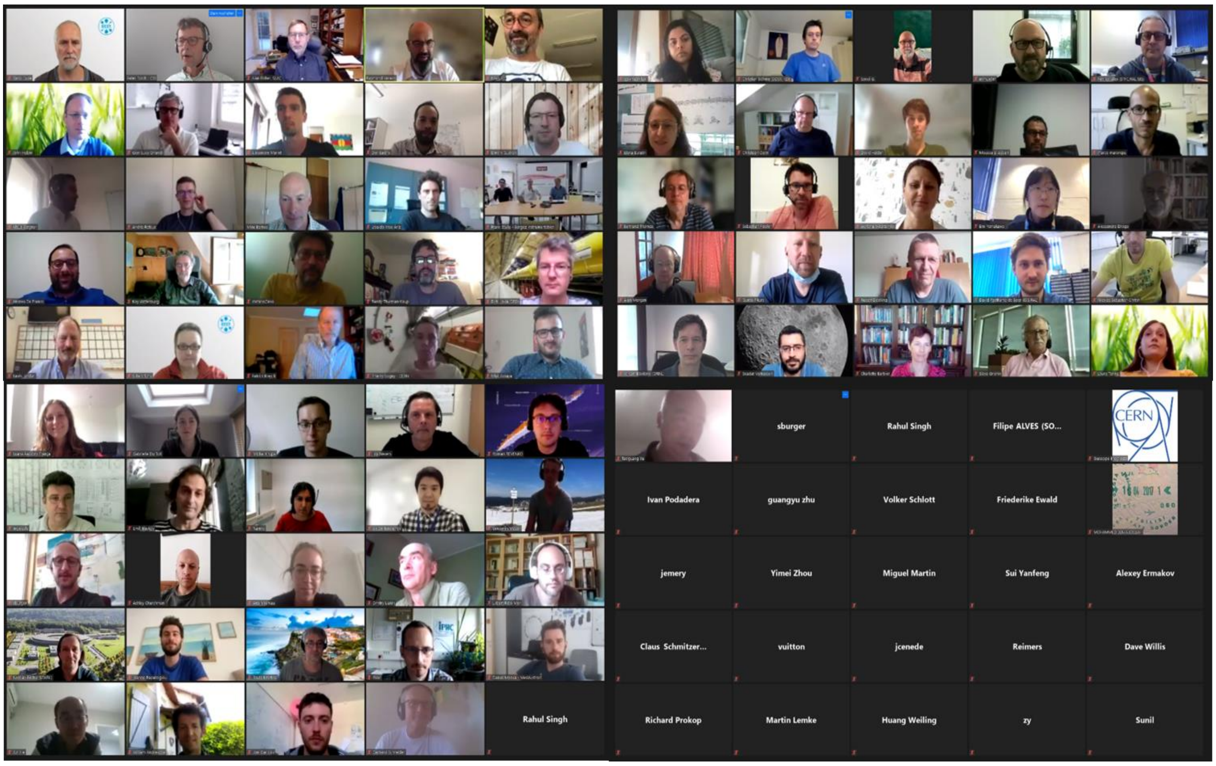
Particle Accelerator Beam Diagnostic Instruments

Online Workshop, June 21st to 23rd, 2021

INDICO-site: https://indico.cern.ch/event/1031708/

Workshop Summary

Editors: Daniel Eakins - Oxford Uni., Peter Forck - GSI, Ubaldo Iriso - CELLS, Rhodri Jones - CERN, Gero Kube - DESY, Volker Schlott - PSI, Kay Wittenburg – DESY, Ray Veness - CERN



Organised by: CERN, Department of Engineering Science, University of Oxford, GSI

Sponsored by: ARIES

This project has received funding from the European Union's Horizon 2020 programme under Grant Agreement No 730871

Workshop introduction and goals (Raymond Veness – CERN, Peter Forck – GSI)

Within the frame of ARIES-ADA, topical workshops are executed to discuss actual subjects of high relevance not covered in detail at typical conferences but which are relevant for ongoing developments [1, 2, 3]. The aims of the workshop entitled 'Materials and Engineering Technologies for Particle Accelerator Beam Diagnostic Instruments' (https://indico.cern.ch/event/1031708/ [4]) was targeted at design and technology of physical instruments – an area which receives relatively little coverage in the literature. The discussed topics are related to: https://indico.cern.ch/event/1031708/

- Novel materials and production, e.g. ultra-thin wires for wire scanners and SEM-Grid
- Novel materials for vacuum installations with improved properties
- Precise vacuum installations and drives, e.g. magnetically coupled
- Improved methods for mechanical development & production, e.g. 3-d printing
- Review the state-of-the-art materials & production technologies
- Intensify collaborations institutes and industry

Initially, the workshop was planned as a face-to-face meeting hosted at the Wadham College Oxford, UK end of March 2020. About 50 registrants planned to participate, and 32 oral contributions were initially scheduled. However, due to the Corona pandemic, it was cancelled and then restructured and executed as a remote workshop from June 21st to 23rd 2021 from 13:30 to about 17:30 o'clock Central European Summer Time; the agenda is available on https://indico.cern.ch/event/1031708/.

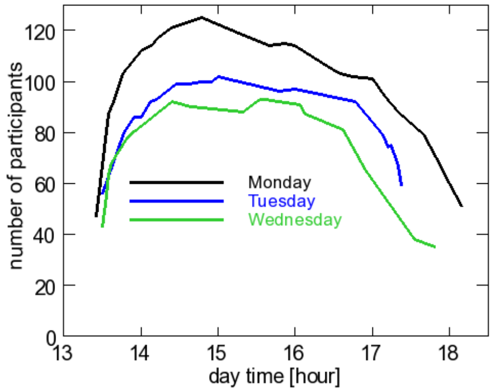
The remote workshop comprises 20 oral presentations in life-format of typically 20 min plus 5 minutes for discussion. The workshop agenda included four technical talks from European industry, demonstrating close links to science in the field.

There were 205 participants registered from around the globe, inducing 15 registrations from America and 20 registrations from Asia. No conference fee was required. The number of people connected is depicted in the figure below: About 80 to 120 people were following the presentation online during the entire workshop duration. (This must not always be the same people; it is assumed that the number of people attending was considerably larger than the connected number). The workshop program comprises a great variety of presentations, which resulted in a 'critical mass' of technical expertise and lively online discussions.

As a novelty for these workshops, the speakers of the individual sessions were asked to enter separate breakout rooms to enable a discussion with interested workshop participants. As the workshop's topics are not very frequently presented at conferences, the individual private discussions were intensively used to clarify details and enable personal contacts. This procedure was very well accepted, and intense discussions on dedicated topics were executed. This procedure is recommended for further workshops with a comparable amount of participants to enhance the efficiency of such workshops.

The workshop was jointly organised by CERN and GSI with Raymond Vaness as the workshop chairman and Peter Forck as the co-chair. The program committee consists of (in alphabetic order): Daniel Eakins -Department of Engineering Science at Oxford University, Peter Forck - GSI, Ubaldo Iriso - CELLS-ALBA, Rhodri Jones - CERN, Gero Kube - DESY, Volker Schlott - PSI, Tom Shea - ESS, Kay Wittenburg - DESY, Raymond Veness - CERN. Technical support was applied from Madeleine Catin and Dmitry Gudkov – CERN.

At the International Beam Instrumentation Conference IBIC 2021, a summary of the workshop was presented in the frame of a contributed talk, including a scientific paper (see https://www.indico.kr/event/23/timetable/#20210913.detailed; proceedings are presently not published). This proves the relevance of such topical workshops.



Number of connected participants during the workshop (hor. axis refers to CEST time zone).

SESSION 1a - Beam Instruments Design, Production and Operation; chairperson Volker Schlott

Beam Instrumentation highlights from CERN

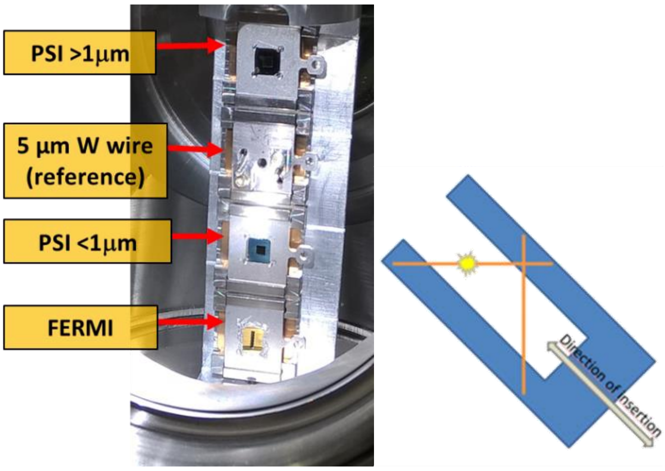
Thibaut Lefevre, CERN, Geneva, Switzerland

Thibaut Lefevre opened the scientific part of the workshop by introducing the current beam instrumentation highlights from CERN. He showed how the trends in particle physics accelerators, both on the energy/brightness frontier and in areas such as antimatter and rare isotope physics, are creating new challenges for beam instrumentation. CERN has just completed a major upgrade to the LHC injector complex. This required new instrument designs for highly radioactive environments, such as the BTV in the SPS synchrotron [5] as well as new simulation-driven designs for the mitigation of impedance heating. Designs for beam-intercepting devices such as screens and wire scanners have been upgraded with modern thermally resistant materials and faster movements. However, most innovation for current and future machines is related to non-invasive beam profile devices. New devices based on laser stripping of the LINAC4 H^- beams [6] and beam-gas ionisation in the Proton Synchrotron [7] are now operational at CERN whilst upgraded devices using synchrotron light and diffraction radiation are developed for the future High Luminosity LHC.

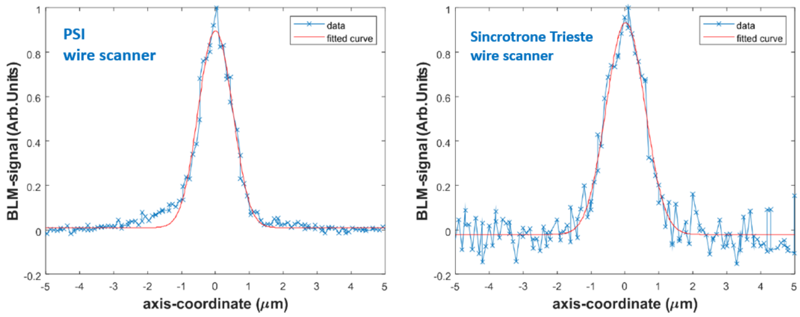
New precision wire scanners at PSI

Gian Luca ORLANDI, PSI, Villingen, Switzerland

Gian Luca Orlandi (PSI) presented a collaboration between the Paul Scherrer Institut and Sincrotrone Trieste on electron beam lithography fabricated, freestanding wire scanners [8]. The project aims for minimally invasive electron beam profile measurements with sub-micron resolution. Applications are for FEL user operation and ultra-high precision, transverse beam diagnostics at novel laser and plasma driven accelerators. PSI produced 800 nm and 500 nm wide Au wires of 2 µm thickness and 2 mm beam clearance. FERMI manufactured a set of wires consisting of 3 µm thick sandwiches made of Au (1 µm) and Si_3N_4 (2 µm) and a Ti (20 nm) middle layer with a width of 0.7 µm, 0.8 µm, 1 µm and 2 µm, respectively [9, 10]. The hardware fort the test is depicted below. Beam tests were successfully conducted at SwissFEL, where a 300 MeV, low charge (1 pC), and low emittance (ε_y ~ 55 nm) beam can be focused to transverse beam sizes of < 500 nm, see Figure and [11].



The wire scanner hardware for the comparison tests at SwissFEL (left) and a general scheme for wire scanners (right).

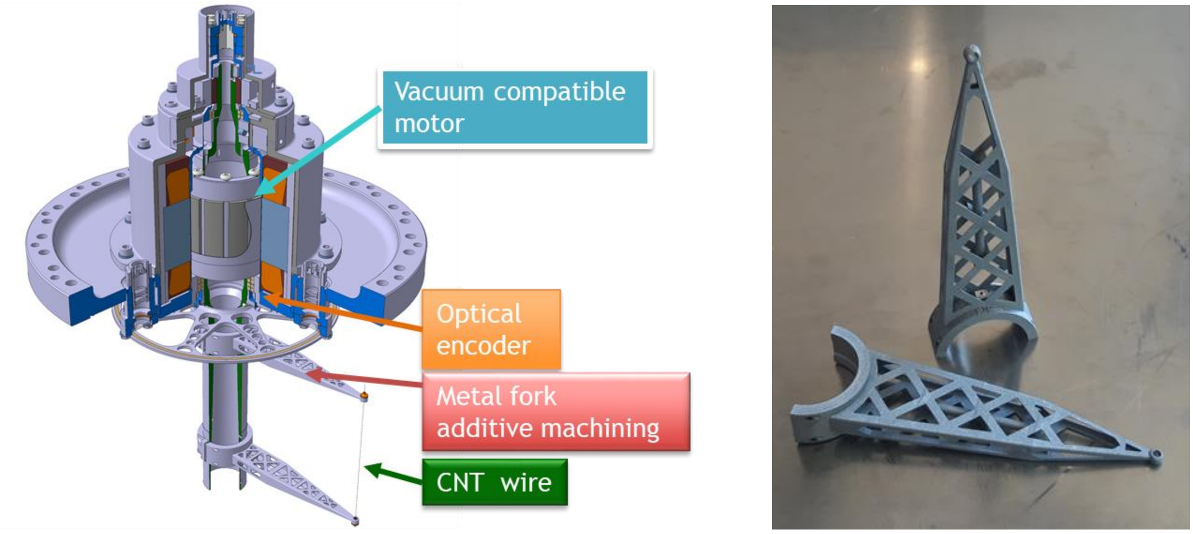


Vertical beam profiles at SwissFEL taken with single shot data acquisitions. The measured beam sizes are 434 ± 7 nm (PSI wire scanner) and 443 ± 33 nm (Sincrotrone Trieste wire scanner).

New wire scanner technology at CERN

William Andreazza, CERN, Geneva, Switzerland

William Andreazza (CERN) presented a new generation of fast wire scanners built for the LHC Injector Upgrade project at CERN and the European Spallation Source in Lund, Sweden [12]. The high power beams require a wide range of measurement speeds (5 m/s to 20 m/s) and a position accuracy in the order of 1 µm. The wire must withstand an angular acceleration of 15.000 rad/s^2. Key components are an in-vacuum drive system without kinematic links, a vacuum-compatible frameless electrical motor, a high precision optical encoder (mark width of 6 µm at a pitch of 40 µm) and a metal wire fork fabricated by 3D additive machining technology. Prototypes were extensively tested in all CERN injector rings, and the full series of wire scanners has been delivered to CERN accelerators and ESS. The wire material is discussed below in the frame of the talk by A. Mariet.



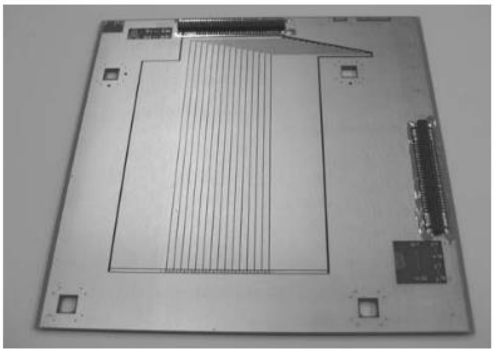
The mechanical layout of the CERN flying wire scanner arrangement (left) and the fork produced by additive manufacturing.

SESSION 1b - Beam Instrument Design, Production and Operation; chairperson Peter Forck

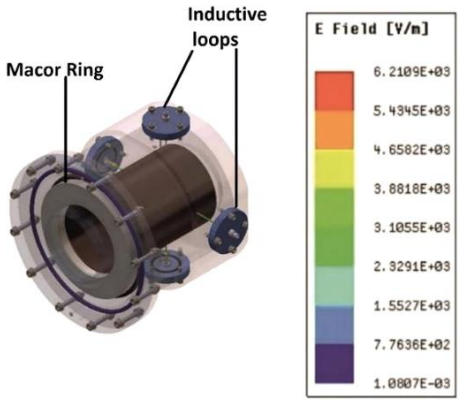
Monitoring the beam delivered to a proton therapy patient at PSI

Serena Psoroulas, PSI, Villingen, Switzerland

The talk focused on three main topics: an introduction about the conditions for patient's irradiations, the definition of requirements on beam monitoring for clinical applications, and the types of detectors used clinically. Irradiating a patient provides different challenges than an experimental beamline since the object to monitor (the beam inside the patient) is not directly accessible. In practical realisations, monitoring takes place at different locations along the beamline, monitors different aspects of the delivered beam indirectly, and provides redundancy, particularly important to ensure that an unexpected failure of one monitoring system does not result in the uncontrolled delivery of dose to the patient. Requirements for patient monitoring are based on two international guidelines, the ICRU report (2007) and IEC standard (60601-2-64, 2014), requiring that proton range, dose uniformity, and absolute delivered dose are known with high precision at all times. These quantities are monitored indirectly through monitoring of beam energy (for proton range), number of protons delivered (for absolute dose) and beam position (for dose uniformity). Different examples from the field have been presented: the monitoring chain of PSI Gantry 1, based on mainly ionisation chambers for dose and position and Hall probes detectors for position and energy monitoring, is a standard for the field but other approaches have been discussed as well. For energy monitoring, Faraday cups as well as online PET and prompt-gamma imaging have been investigated, though they are not routinely used for online energy monitoring. To avoid drawbacks caused by ionisation chambers [13] in particularly at high beam currents (see left figure below), a new resonant position and current monitor prototype [14] is being investigated at PSI (see right figure below). With the current interest in the proton therapy community to reach even higher beam currents, the input from the accelerator and detector community will be even more important, helping to introduce new technology in clinical practice.



Ionisation chambers used for online monitoring or, partly in a destructive manner for commissioning [13].

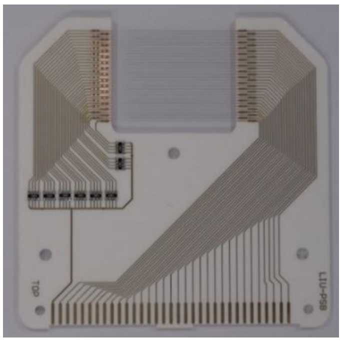


Resonant position monitor for non-destructive current measurement [14].

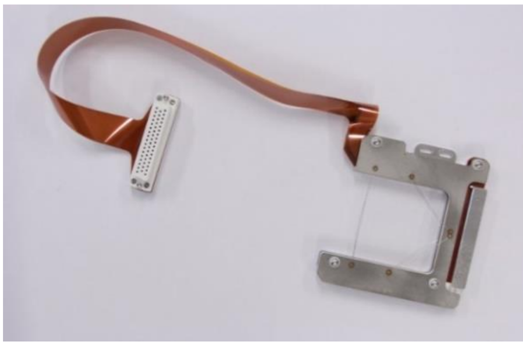
Modern SEM materials and methods at CERN

Christophe Vuitton and Benjamin Moser, CERN, Geneva, Switzerland

Benjamin Moser (CERN) showed the recently developed production procedure for SEM-Grids at CERN as depicted in the Figure below. The Printed Circuit Board (PCB) substrate for the wire support consists of alumina (Al_2O_3) with a purity of 96-97 %. It is equipped with 1 MΩ SMD resistors to verify the condition of the wires without beam. For the electrical connection between the feedthrough and the wire support, PI-CAL NP polyimide film is used as a base for flex-PCBs. The properties of an improved winding machine constructed at CERN were discussed. This machine allows for efficient preparation of the wires. CERN brought forward "sticking wires" as a topic for discussion. A potential solution has already been designed but has not yet been tested in the machine. The discussion at the end mainly revolved around different ways to maintain tension in wires lost due to thermal expansion from by beam heating. CERN also brought forward the method of a „sticking wires" as a topic to for the discussion. A potential solution has already been designed but was not yet been tested with beam.



Alumina PCB with wires and resistors mounted

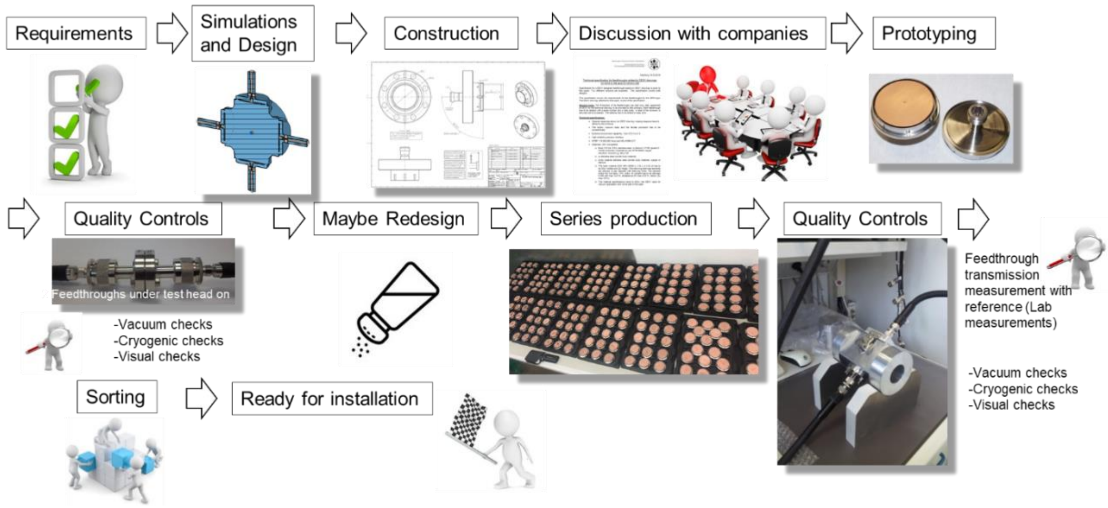


Ceramic feedthrough assembled with Flex-PCB and fully assembled SEMGRID

Translation from 3D simulations to realisation

Dirk Lipka and S. Vilcins, *DESY, Hamburg, Germany*

The contribution by Dirk Lipka (DESY) described a formalised approach for the realisation of a diagnostics system from design up to implementation of a large-scale accelerator, using the example of a button BPM [15, 16]. All requirements and conditions have to be collected, and subsequently, these conditions have to be divided into required sub-systems, e.g. mechanics and electronics. Here simulation tools speed up the design time as the tools can predict the behaviour with high precision. Attention has to be taken to the correct use of simulation tools, e.g. meshing and convergence. The design phase is completed with tolerance studies to prepare the construction. Produce prototypes with extensive tests to check the performance and optimise the design for the series. The design phase is finalized with tolerance studies to prepare the construction. For a large number of items, initial pre-series are required to train companies for the final production. During the series production, the pieces should be checked to optimise the results and production process. In parallel, electronics should be developed and produced. Finally, the system has to be installed, calibrated and commissioned.

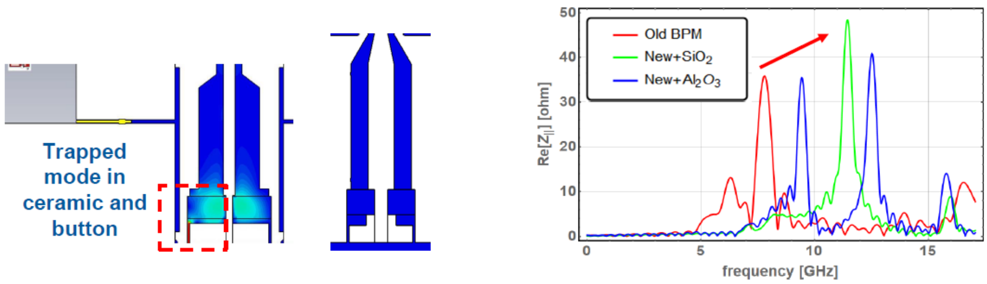


Example for the various steps for the development of a button BPM feedthrough; the individual steps were discussed in detail in the talk.

Review of beam position button design and manufacture

Alun Morgan, Diamond Light Source, Didcot, UK

Alun Morgen (DSL) reported on a dedicated workshop on button BPM production held in May 2019 [17] and reported recently [18]. The topic is of great relevance due to the large quantity installed at any light source. One major topic is related to the minimization of 'trapped modes' within the BPM housing caused by the field penetration between the button and the housing, which results a signal deformation and, more important for many applications, in the heating of the insulator holding the button; simulations from several facilities were presented. Glass sealing technology is attracting increased interest, with several facilities receiving of prototype buttons to gain experience with this technology. Communication with the supplier at all stages of the process was identified as key to success. Particular care needed to be taken when the design is handed from one sub group to another e.g. subcontractors, or moving from design engineers to machinists. An increase in the in-house testing capability of facilities will be needed to establish and maintain the level of quality and tolerancing required for the successful operation of our diagnostics devices. In order to enable that and allow the tracking of individual components through the testing and validation processes, laser marking is being investigated. There have been design improvements in many distinct aspects of the button geometry, and further improvements may be possible by using these design changes in combination.

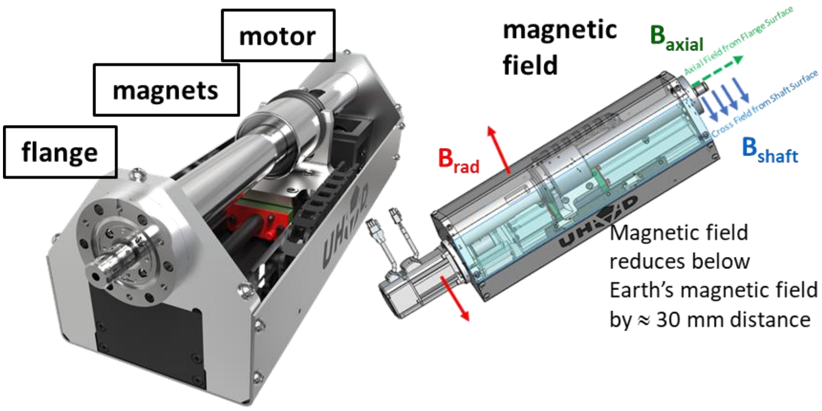


Example for a caclulation of the influence of the trapped mods for the BPMs at BESSY, courtesy of A. Schälicke and J.-G. Hwang.

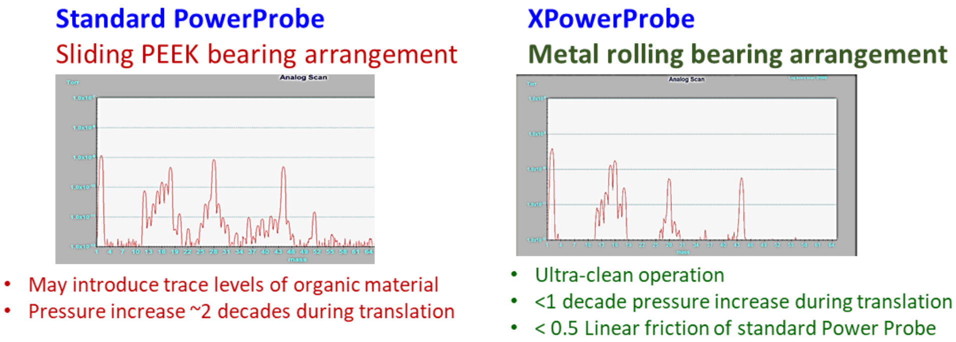
Magnetically coupled push-pulls for UHV

Nick Clark, UHV Design Ltd., Laughton UK

Magnetically coupled drives are recently developed and commercially available for ultra-high vacuum applications, as Nick Clark (from the UHV-Design company) reported. There are several features: Non-polymer and without dry lubricant, all-metal and ceramic push-pulls for the lowest outgassing and lowest friction; high speed and high precision pneumatic and ball screw driven actuators designed explicitly for beam diagnostics. Different designs for the magnet assemblies exist, providing high coupling forces or torque and minimal external stray magnetic fields. Case studies are executed in collaboration between industry (here UHV-Design) and major institutes like BNL, CERN, Diamond and PSI, such as fast wire scanners allowing for a scan speed up to 10 m/s. At CERN a fast-acting magnetic coupled device is under evaluation and design as a potential wire scanner and bellows version is under evaluation at BNL.



FExample for an magntically coupled drive (left) and themagentic field arrangement for a push-pull drive (right).



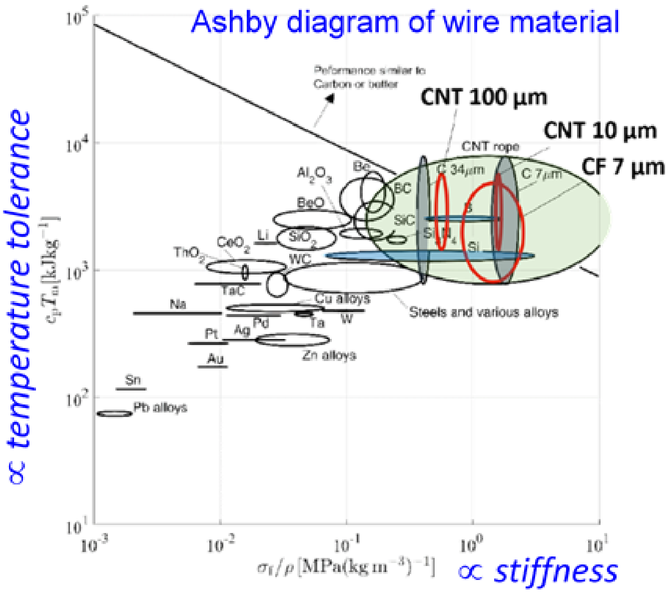
Residual gas spectra for magentically coupled drives comparing the standard bearing realization (left) with the novel designed arrangement (right).

Session 2a: Novel materials and applications; chairperson Daniel Eakins

Materials selection for wire scanner wires

John Huber, University of Oxford, Department Engineering Science, UK

John Huber's team at University of Oxford, together with the CERN beam instrumentation group, explored different candidates for wire materials which could be viable for fast wire scanners, as current materials are expected to be unsuitable due to the associated temperatures and mechanical loads. Using the concepts behind Ashby diagrams [19, 20], a merit index was developed for selecting the wire material as depicted in Fig. 3 [21]. It suggested the best materials would be carbon-based, such as carbon nanotubes (CNT) and CNT ropes. Nearby competitor materials including beryllium and boron carbide were also identified. The force displacement response was measured for candidate materials including CNT ropes of different thicknesses. Combining this with thermal properties and density data, it was possible to identify CNT ropes on the Ashby diagram and confirm their superior performance. The group had also examined failure mechanisms in some of the wires, identifying the CNT ropes as preferable to ordinary carbon fibres due to having less statistical variation in breaking strength.

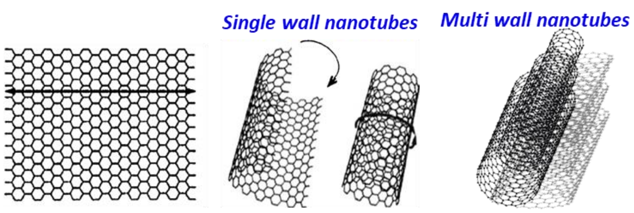


Ashby map showing the thermal and mechanical perfor-mance for potential wire scanner materials [21].

Novel beam-intercepting materials

Alexandre Mariet, CERN, Geneva, Switzerland

Alexandre Mariet (CERN) extended the discussion of carbon-based wire materials. For intense beam interactions local overheating can lead to sublimation, and hence premature failure during subsequent usage. He provided the properties of different CNT allotropes. These included both individual CNTs as well as wound strand CNT. A novel process for manufacturing the CNT wires was presented. Subsequent examination confirmed the presence of only carbon, indicating a material of high quality. In particular, Alexandre contrasted the mechanical behaviour and performance of 30 µm diameter CNTs and CNT wires, showing clear differences in their mode of failure. Further examples and material properties are summarized in the talk as supported by related images from Scanning Electron Microscope investigations. Beam based radiation tests are ongoing. The prototype test for the fast scanner at SPS are reported, showing the applicability of the CNTs. A device foreseen for regular operation will be installed at CERN SPS in September 2021.



Mechanical properties of carbon materials

Material	ρ [g.cm^{-3}] Density	σ_{max} [GPa] Tensile strength	E [GPa] Young modulus
CNT (SWNT)[1]	0,02 - 4	up to 150	up to 1e3
Carbon fiber[2]	1,7 - 2,5	0.6 - 4.5	60 - 500
CNT wire[3]	1.1 - 2.1	0.2 - 3.3	20 - 100

Scheme of carbon nano-material, single wall (SWNT) and multi wall naontubes (MWNT) (left) and some material properties (right).

Boron-based nanotubes as scintillators and further applications

Kevin Jordan, Jefferson Lab, Newport News, USA

Kevin Jordan (JLAB) talked about the use of boron nitride nanotubes (BNNT) as scintillators. In recent years, several studies were carried out at BNL, GSI and JLAB using BN as a scintillator, showing outstanding performance with electrons between 1.6 MeV and 7.4 GeV, and Au ions at 4.8 MeV/u. In particular, no blooming effect is expected as the florescence is emitted from single tubes of 2 to 6 nm diameter. The presentation showed BN nanotubes of 2-6 nm diameter, providing mechanical properties (like tensile strength, Young modulus), as well as scintillator properties: decay time in the order of ns, photon yield only four times lower than Chromox, and peak emission wavelength below 500 nm. The material can withstand high beam powers, and studies for its lifetime and resolution were presented.

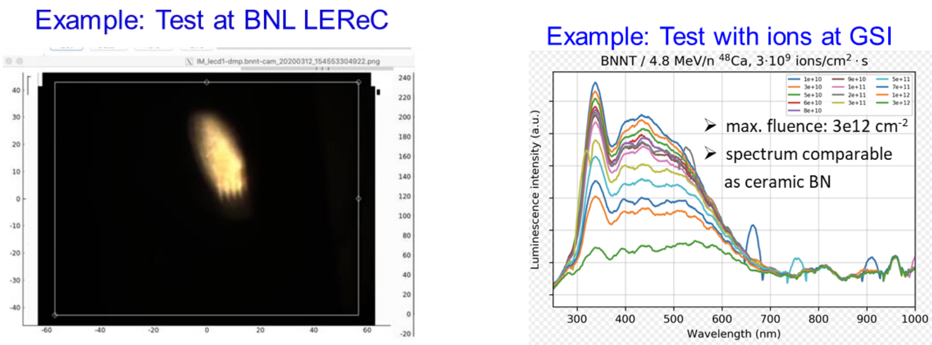


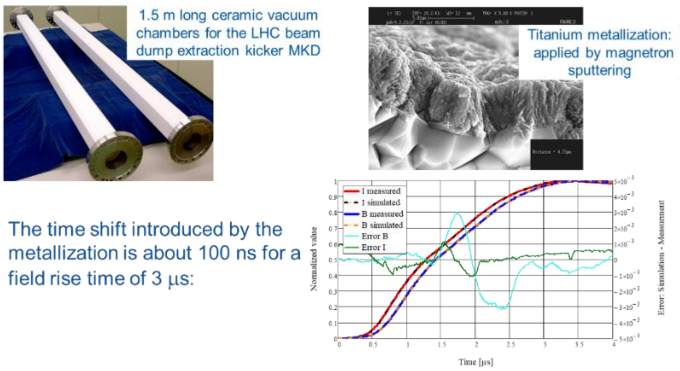
Image from the BNNT screen for electron beams and detailed sprectra investigations with Ca-ions for various fluences.

Session 2b: Novel materials and applications; chairperson Ubaldo Iriso

Ferrite materials for in-vacuum instruments

Mike Barns, CERN, Geneva, Switzerland

Mike Barnes (CERN) discussed the design and optimisation of ferrite-based materials used for kickers, and the challenges posed by the high temperatures that can be developed due to beam-induced current. For the specific work described, hot-isostatic pressing (HIP) was employed to manufacture a bulk ferrite material from constituent powder, resulting in a near net dense compact. HIP exhibited a noticeable improvement in thermal properties, while the frequency-dependent magnetic permeability limits the rise-time to a few hundred ns. Adding a thin protective buffer to the magnet (e.g., 3 µm Ti), resulted in shifting its activation time by ~100 ns. These measurements were shown to be in good agreement with a thermal model which includes radiation transport.



Example of a cermic chamber frm LHC, an image of the titanium matallization and related current and magntic field measurement.

Specification Changes of 316 LN ESR after higher temperature procedure - Vacuum firing and vacuum brazing

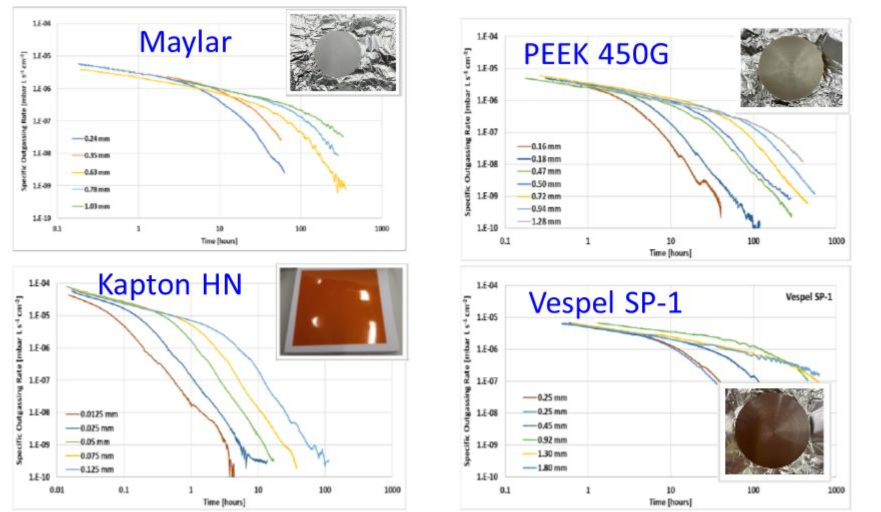
Silke Vilcins, DESY, Hamburg, Germany

Silke Vilcins (DESY) talked about changes to 316LN ESR material properties after high-temperature treatment. She provided practical advice and pragmatic solutions based on experience over the last 30 years. Processes like welding, brazing and stress relief heat treatments require special attention because they affect material properties like hardness, permittivity, grain structure or nitride concentration. At temperatures below 300ºC, there is almost no outgassing because the thermal energy is too low. Between 500ºC and 900ºC, there is the formation of M23C6 and possibly s-phase inter-granular corrosion and grain disintegration. A vacuum annealing treatment, which leads to a low outgassing rate with constant hardness, appears challenging. Finally, a new material called 'Alloy 50' was presented as an alternative due to its superior hardness limits, low permittivity, good weldability.

Outgassing of Polymers

Ivo Wevers, CERN, Geneva, Switzerland

Ivo Wevers (CERN) described the outgassing rate of four common polymers used in accelerators: PEEK©, Kapton©, Mylar©, and Vespel©. The description was based on theoretical models and experimental results, and the measurements are well fitted with a 3-step model (related to moisture evaporation and bulk diffusion). At room temperature, the outgassing is initially very high but decays rapidly after a certain amount of time $\tau/2$, depending mainly on the probe thickness. Higher moisture content causes higher outgassing rates during all stages of the pump-down, while a greater diffusion coefficient (although increasing the initial outgassing rates) results in overall lower outgassing rates, particularly for pumping times beyond $\tau/2$. Finally, it was shown that storing polymeric parts with dried silica gel granules can effectively reduce their outgassing rates, but exposure to air during installation must be minimized. A detailed report discusses the physical basis and depicts the measurements by this group is available on the workshop web-site https://indico.cern.ch/event/1031708/timetable/#20210622.



Outgasing rate in [(mbar·l)/(s·cm²)] *as a function of time for commonly uused polymers; note the logarithmic scales.*

Defined Cleanliness on surfaces leads to success in Research and Industry - Cleanliness classes and measurability

Klaus Bergner, VACOM, Jena, Germany

Coming from a private company, Klaus Bergner (company VACOM) shared his experience of adequately defining the quality requirements. The focus was set on surface cleanliness in the manufacturing of vacuum components. In this regard, the specifications should be given for the total outgassing rate in the assembly and quantitatively so that the user can test and validate them. Thus, continuous communication between user and supplier is essential.

Session 3a: New Technology and Components; chairperson Gero Kube

Recent experience with viewports and mirrors

Gerhard Schneider, CERN, Geneva, Switzerland

Gerhard Schneider (CERN) reported on his experience with viewports and mirrors. About 250 window flanges are installed on the CERN accelerator complex, either made of borosilicate glass (Kodial©) or fused silica (quartz) glass. CERN has experienced failures of brand-new window flanges, mainly with fused silica material. The beam instrumentation group is the biggest user of window flanges at CERN, on instruments like the beam on Alumina screen set-up instrument, in CERN terms called BTV. There are about 200 BTVs installed at CERN with one window flange each; in total, there are about 250 window flanges installed across the accelerator complex. The experience with window flanges is limited to borosilicate glass (Kodial©) and fused silica (quartz) glass.

Investigating the cause, they found out that window flange manufacturers used elastomer seals during leak tests, different from the use-case with non-annealed copper gaskets. The failure analyses led to a new technical specification requiring 100% of the window flanges to be tested with CERN supplied gaskets and baked to the nominal temperature. Metal flange parts and windows are usually procured by the window flange manufacturer from a sub-contractor. The real expertise of the manufacturer is solely the connection from the glass window to the weld ring and the welding of the ring to the base flange material. If the weld ring is too rigid, all deformation resulting from flange deformation during the assembly and differential thermal expansions during bake-out will be transferred to the non-ductile glass which then will break. Weld rings must carefully be chosen, considering radiation and magnetic parameters and possible oxidation and low differential thermal expansion coefficient versus the optical window. E.g. for the often used Kovar weld ring, a high Nickel-Cobalt stainless steel, but also possible oxidation and low differential thermal expansion coefficient versus the optical window must be considered.

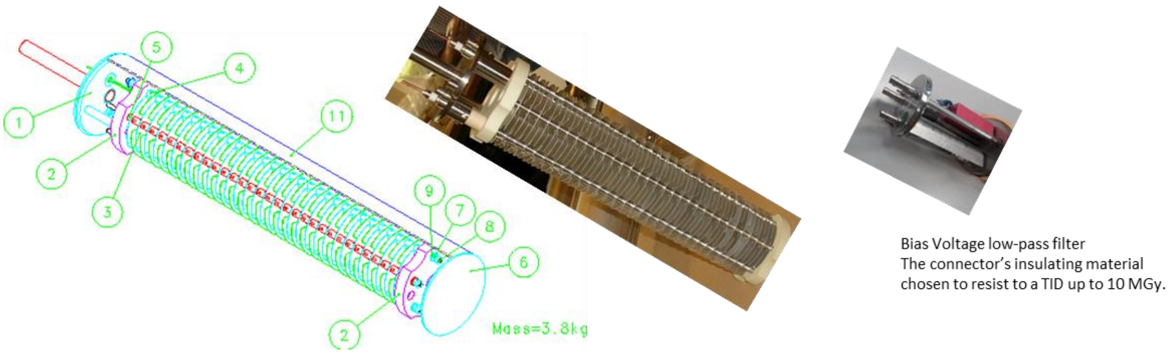
During the discussion Silke Vilcins (DESY) reported on negative experiences with lead weld rings since they oxidised. Silke also suggested not to use washers, which reduces the risk of window failures.

Example for a brocken fused silica window after mounting.

Materials for BLMs (Ceramics, electrodes)

Viatcheslav (Slava) Grishin, on behalf of CERN and IHEP, Geneva, Switzerland and Protvino, Russia

Slava Grishin (ESS ERIC) shared his experience on 16 years of collaborative work between CERN and IHEP (Protvino), where more than 5000 beam loss monitor (BLM) detectors of various types have been produced. The manufacturing process was under the responsibility of IHEP, using industry-produced components [22, 23]. For the success of such a collaborative project, crucial points are generally design optimisation and organisation of the collaboration between both partners particularly for specification and selection of industrial suppliers and components. The production of prototypes (with a pre-series for a large number of items), continuous material verification, continuous monitoring of the production schedule, several tests before, during and after production, final installation, and final control of detector performance are all key to success. Driven by the system complexity, no compromise should be allowed in some details, however, a high focus should be placed on quality assurance.

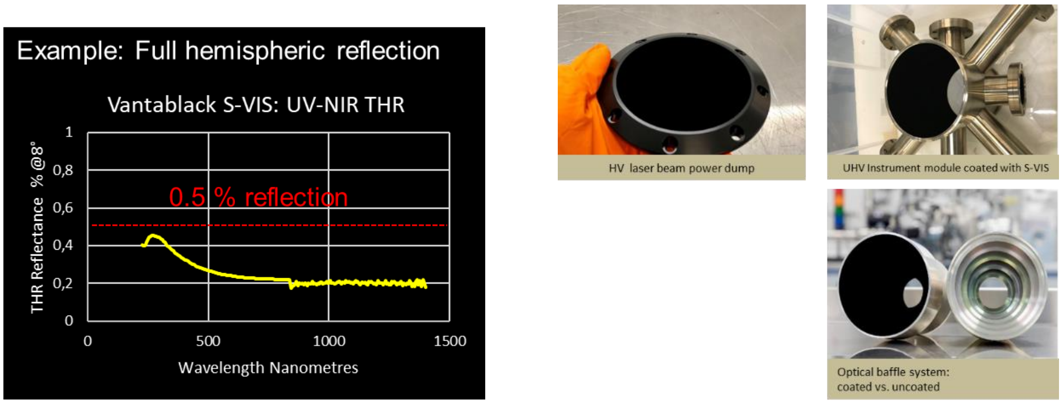


Technical drawing aand photos of the CERN type BLMs.

New technology for optical Blackening of vacuum chambers

Ben Jensen, Vantablack, Newhaven, UK

Ben Jensen (company Surrey NanoSystems) presented coatings for UHV instrument stray light suppression. Such coatings should have high absorbance at specific instrumentation wavelengths, both good Total Integrated Scattering (TIS) values and spectral Bidirectional Reflectance Distribution Function (BRDF) and low outgassing at chamber operational temperatures. They should be compatible with UHV bake-out and experience no degradation from long term UV exposure, be tolerant to radiation exposure, thermally stable and electrically conductive. Based on company experience in space technology applications, super-black coatings were developed (brand name Vantablack). Two such coatings were discussed, which were already tested at CERN: S-VIS and CX2 (a beta phase development coating). While both materials are spray applied, S-VIS requires vacuum post-processing (activation) to create the required absorbing cavities. This coating shows good UV-THz performance and seems to be well suited for applications in an accelerator environment.



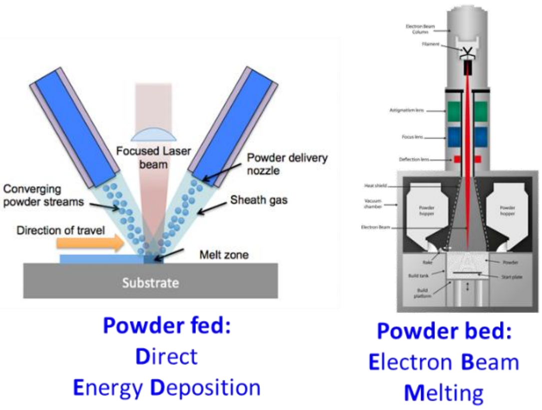
The wavelength dependent reflection as a function of wavelength (left9 and some examples of coated metal pieces.

Session 3b: New Technology and Components; chairperson Kay Wittenburg

3D additive machining for vacuum applications

Ana Miarnau Marin, CERN, Geneva, Switzerland

Additive Manufacturing (AM) in Beam Instrumentation was presented by Ana Miarnau (CERN): A brief description of the techniques of AM was given. The "Selective Laser Melting" technique is used at CERN for the production of vacuum parts. Some mechanical constraints such as roughness, tolerances and vacuum constraints like impurities and porosity were reported. However, outgassing tests at CERN showed a typically clean and unbaked metal pump-down curve without significant contamination. Some examples from CERN were discussed [24]. The serial production of the forks for the fast wire scanners was finished recently, see the talk by William Andreazza above. Here the alloyTi-6Al-4V was used showing full functionality and comparable vacuum outgassing as for the traditionally production method.

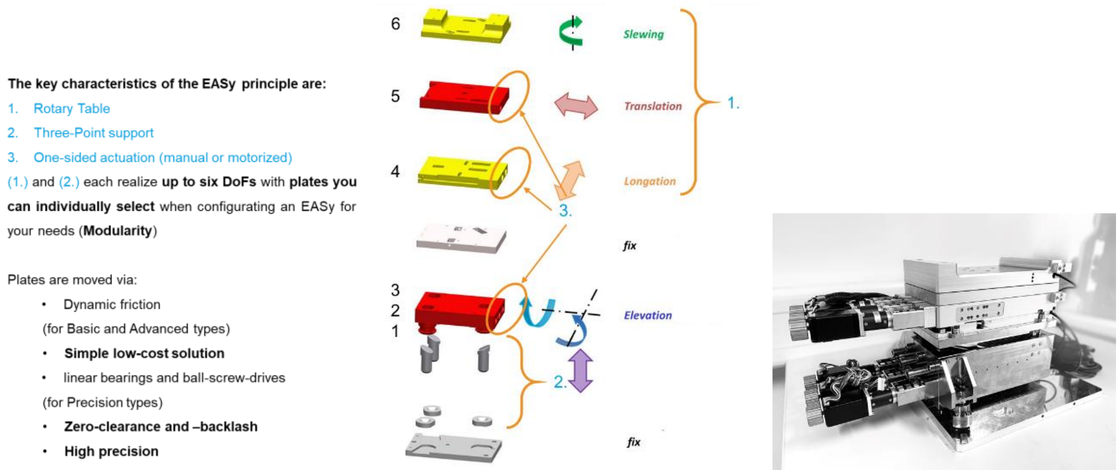


The two most frequently used method for metal additive manufacturing.

EASy (Easy Alignment System) is a new high precision in-house movement system

Ufuk Akkaya, DESY, Hamburg, Germany

The Easy Alignment System (EASy) was described by Ufuk Akkaya (DESY). New High-Precision 6-Axes-Positioning devices, the EASy-family, was developed at DESY to meet the needs of accelerators/experiments for high precision and stiffness. It has the advantage of combining compactness and a carrying capacity between 10 kg to > 5000 kg with a precision of weight-dependent positioning 1 to 20 µm. A standardised motor control unit will ensure integration in control systems whilst manual operation is also possible.

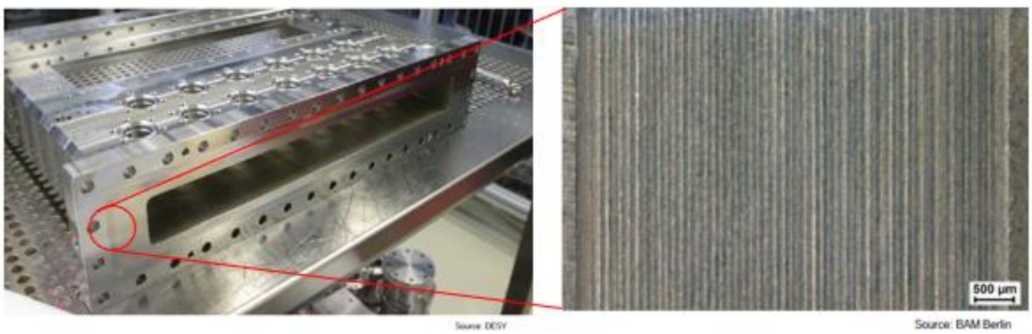


System overview of EASy.

Using of new sealing technology for high precision wide open vacuum flanges and waveguide connections

Martin Lemke, DESY, Hamburg, Germany

A sealing technology for high precision wide open vacuum flanges and waveguide connections was presented by Martin Lemke (DESY). The traditional metal sealing technology for large vacuum flanges requires a mirror-like surface. The new concept introduces small grooves on the sealing surface with about 50 µm depth and distance from each other of about 25 µm; an example is depicted in Fig. 4. This concept also reduces the requirements of the flange surface by some factors. No vacuum leaks (in terms of virtual leakage caused by gas insertions between the grooves) were discovered during tests and installations at DESY and BESSY. The manufacturing can be performed with a marker for metallized surfaces; DESY has good experiences using the commercially available ‘AMF-Write’.



Top: A large flange vacuum chamber with grooves. The zoom shows a high magnification photo of one of the first test pieces. Bottom: The production of the grooves ona a CNC machine using the

Conclusion (Raymond Veness – CERN, Peter Forck – GSI)

The workshop took place with a lively atmosphere even despite the absence of a face-to-face contact. Each session was followed by a breakout room session, with one virtual room per speaker. This gave a more informal environment where detailed questions and discussions could be held and proved very successful, with some discussions, in particular those not discussed in regular conferences, lasting for an hour after the end of the programme.

Raymond Veness (CERN) chaired the final wrap-up session. He summarised some subjects of general interest to be followed-up by the community. These included:

- The use of nanotubes (carbon, boron nitride) for beam intercepting and other instrumentation uses
- Particle-free and low particle count devices and environments
- Development of a new generation of precision linear wire scanners
- The usage of magnetically coupled drives for UHV applications
- Novel methods of black coatings for optical light absorption.

Beam instrumentation experts from laboratories around the world were keen to share knowledge and best-practice in these areas, and it was agreed to make e-mail groups for the interested parties.

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