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Book of Abstracts

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Detailed 3D modeling of the DEMO TF coil design according to the SPC high current react & wind concept

Author: Rafał Ortwein[1]

Co-authors: Federica Damatte [2]; Xabier Sarasola [2]

[1] *Institute of Nuclear Physics, Polish Academy of Sciences (IFJPAN)*

[2] *EPFL Swiss Plasma Center, CH-5232 Villigen-PSI, Switzerland*

Corresponding Authors: federica.dematte@psi.ch, xabier.sarasola@psi.ch, rafal.ortwein@ifj.edu.pl

The SPC team has proposed a design for the Toroidal Field (TF) coil of the DEMO tokamak based on the react & wind (R&W) concept and the use of the Nb3Sn superconductor [1]. Thanks to the grading of both the superconductor and the steel in the jackets the size of the TF coil was considerably reduced and hence the overall cost [2].
The mechanical analysis in the recent works was focused on using 2D models and consideration of the equatorial plane only. In this work a full 3D model was built accounting for the casing, detailed geometry of the winding pack (WP) as well as the forces from the PF (poloidal field) coils. Thanks to the symmetry, only one TF coil was analyzed assuming periodic boundary conditions. The Lorentz forces were computed based on a global electromagnetic (EM) model of the DEMO tokamak and mapped on the mechanical mesh. Three load conditions were considered in the study: PREMAG (pre-magnetization), SOF (start-of-flat top) and EOF (end-of-flat top). Particular attention was given to the EOF scenario leading to the largest deformations and stresses. Due to the uncertainty of the friction coefficient between the winding pack and the inner surface of the steel casing a parametric study was performed. Starting from the frictionless contact, through frictional contact with varying friction coefficient from 0.01-0.5 up to a fully bonded interface. This analysis will reveal the re-distribution of the electromagnetic load between the winding pack and the casing.
All the modeling was performed with the Ansys Mechanical APDL 2023R2 software. The computational cost was analyzed using a 16 CPU workstation with 1.5 TB of RAM memory. Further perspectives of running nonlinear mechanical models with ~30e6 elements and larger on the state-of-the art workstations were discussed.

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Control, coil voltage monitoring system design and quench monitoring results of the SSRF superconducting wiggler

Author: Tianya Meng[1]

[1] *Shanghai Advanced Research Institute, Chinese Academy of Sciences*

Corresponding Author: mengty@sari.ac.cn

The SSRF (Shanghai Synchrotron Radiation Facility) superconducting wiggler consists of three parts: a superconducting multipole magnet, a cryostat system and magnet power & control system. Superconducting multipole magnet generates a strong magnetic field with a peak of 4.2 T, which alternates positively and negatively along the direction of electron motion in the storage ring. The superconducting wiggler is installed in the BL12 unit of the SSRF Storage Ring. The control and monitoring system of the wiggler controls and monitors both the equipment parameters like temperature, helium pressure & level, and the voltage of superconducting coil, and interlocks with system of other part of the storage ring. The voltage monitoring part of the system can monitor the voltage of each part of the coil of the superconducting multipole magnet through the voltage sensing leads, thereby recording the voltage of each part of the coil when a quench occurs. The system collects the voltage data of each coil through a Siemens S7-1512 PLC analog input modules which is an innovative method. And the system realizes the quench detection by recording the voltage cycle by cycle with a delay threshold judgement. Based on the PLC system both the equipment temperature and other

parameters monitoring & control as well as the voltage monitoring function are achieved. The operation and quench voltage of each coil is captured and analyzed.

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Growth pressure effects and physical properties of high Tc iron-based superconductors

Author: Shiv Singh[1]

[1] *Institute of High-Pressure Physics (IHPP), PAS, Warsaw, Poland*

Corresponding Author: sjs@unipress.waw.pl

Iron-based superconductors (FBS) present an ideal material platform for studying fundamental and applied research [1]. More than 100 compounds have been reported for this high-Tc superconductor that can be categorized into 5–6 families [2–4]. The 1111 (REFeAsO, RE = rare earth) and 1144 (AEAFe4As4, AE = Ca, Eu; A = K, Rb) families are the two most important families of FBS, which offer high Tc of 58 and 36 K with and without doping, respectively. Furthermore, sample growth of these families is not an easy process, and a lot of research efforts have been reported in this direction. However, the preparation of high-quality and suitable-sized samples is still challenging. In this presentation, we review the superconducting properties of 1111 and 1144 families as well as their growth processes, such as polycrystals and single crystals. A brief comparison is made between the reported papers to better understand the developmental issues [4], implying that high-pressure techniques may be a viable option for resolving the sample issues of these families. In this regard, we are currently using Hot-Isostatic Pressing (HIP) technique to optimize the growth parameters and the applied gas pressure to grow high-quality single crystals and polycrystals of 1111 and 1144 families. Our HIP technique can generate an inert gas pressure of up to 1.5 GPa in a cylinder chamber fitted with a three-zone furnace capable of reaching 1700℃ [5-6]. All prepared samples are characterized by various measurements to reach the final conclusions. In this presentation, we provide a concise summary of our current research work, which is being sponsored by the Polish government [5-6].

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Technology of lead-free K0.5Bi0.5TiO3 ceramics

Author: Piotr Czaja[1]

Co-authors: Dariusz Bochenek [2]; Grzegorz Jagło [1]; Jarosław Jędryka [3]; Kamila Kluczewska-Chmielarz [4]; Katarzyna Osińska [2]

[1] *Institute of Technology, University of the National Education Commission, Podchorążych 2, 30-084 Kraków, Poland*

[2] *Faculty of Science and Technology, Institute of Materials Engineering, University of Silesia in Katowice*

[3] *Faculty of Electrical Engineering, Czestochowa University of Technology*

[4] *Institute of Technology, University of the National Education Commission*

Corresponding Authors: piotr.czaja@up.krakow.pl, jaroslaw.jedryka@pcz.pl, dariusz.bochenek@us.edu.pl, katarzyna.osinska@us.edu.pl, kamila.kluczewska-chmielarz@up.krakow.pl, grzegorz.jaglo@up.krakow.pl

The search for lead-free ceramic materials is one of the priorities in both scientific and technological areas. This results from the ecological policy pursued by the European Union, in which, materials containing, among others, toxic lead is to be replaced with materials that are safe and friendly to humans and the environment. The expression of these activities are European Union Directives. The most important of them are RoHS (The Restriction of Hazardous Substances in Electrical and Electronic Equipment) and WEEE (Waste of Electrical and Electronic Equipment) [1-3].
One of the most promising compounds in recent years, which is experiencing a scientific renaissance, is bismuth-potassium titanate K0.5Bi0.5TiO3 (KBT). However, due to the low density of the materials obtained, the challenge facing scientists and, above all, technologists is to develop an appropriate, repeatable technology that will allow obtaining KBT materials with an appropriately high density [4].
The work will explain the individual stages of the KBT technological process along with the specialized equipment used in each of them. The most important technological issues will be described and the most important problems occurring at each stage of the technological process will be indicated.

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Prof

Author: Daniel Gajda[1]

Co-authors: Michał Babij [1]; Andrzej Zaleski [1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences (PAS), Okólna 2, 50-422 Wroclaw, Poland*

Corresponding Authors: d.gajda@intibs.pl, m.babij@intibs.pl, a.zaleski@intibs.pl

Daniel Gajda

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Superconducting magnet system of W7-X fusion experiment –Design and Operation experiences

Author: Konrad Risse[1]

Co-author: W7-X Team

[1] *D*

Corresponding Author: konrad.risse@ipp.mpg.de

The Wendelstein 7-X stellarator (W7-X), one of the largest stellarator fusion experiments, is in operation since 2015 at the Max Planck Institute for Plasma Physics in Greifswald. The final completion of the in-vessel components in 2022 allows longer pulses with higher plasma energies.
The superconducting magnet system consist of 50 non-planar and 20 planar coils grouped in five equal modules and electrically connected in seven circuits with 10 coils each. Seven power supplies provide individual coil currents in the seven circuits in a wide spread of configurations. At the moment the magnet system is operated with a 2.5 T field on the plasma axis, which requires a non-planar coil current between 11.4 kA and 15.3 kA. The design criteria is 3 T with a maximum non-planar coil current of 18.4 kA. The quench detection system checks permanently the superconducting system regarding the onset of a quench. In case of a quench or a severe failure, the magnet protection system will be activated and leads the current into dump resistors. The magnet protection system consists of a set of switches and breakers and a dump resistor, made of pure nickel. The system was original designed for currents up to 20 kA and voltages up to 8 kV with a total energy of about 1 GJ. The coils with their support structure are located in a cryostat and protected against thermal radiation by vacuum and a thermal shield. Cooling of the coils and of the shield is provided with a helium refrigerator keeping the magnet system at 4 K and the shield at 70 K. High voltage tests are performed before and after the single operational phases to confirm the integrity of the electrical insulation of the magnet system.
The paper will describe the components of the magnet system, the typical 2.5 T operation conditions and the impact of fast plasma breakdowns on the quench detection system. The long term observation results from the high voltage tests will be presented as well.

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Modeling of Cryogenic Pulsating Heat Pipe Using CFD Techniques

Authors: Marcin Opalski[1]; Przemysław Błasiak[1]; Sławomir Pietrowicz[1]; Tisha Dixit[2]; Bertrand Baudouy[2]

[1] *Wrocław University of Science and Technology*

[2] *Université Paris-Saclay, CEA, France*

Corresponding Authors: bertrand.baudouy@cea.fr, marcin.opalski@pwr.edu.pl, tisha.dixit@cea.fr, przemyslaw.blasiak@pwr.edu.pl, slawomir.pietrowicz@pwr.edu.pl

Cryogenic technologies require efficient, cost-effective thermal management. In the field of cryocooling, i.e., low-temperature cooling using a mechanical cryocooler, the pulsating heat pipe (PHP) is a promising solution because it is passive, thermally efficient, simple to build, lightweight, and reliable over time. Thanks to these unique features, PHPs are used in the space industry for cooling satellites and telescopes and are the subject of intensive academic studies for cryogenic schemes. As an attractive alternative to traditional cooling methods with liquid cryogens, PHPs are used in various applications, including cooling liquid storage tanks and superconducting magnets. Predicting the thermal performance of PHPs based on their design and operating conditions is a significant challenge as the heat and mass transfer phenomena within are far from being fully understood [1-4]. Numerical modeling using OpenFOAM for calculations tries to address this issue by providing insight into PHP behavior. This manuscript presents the comparison of numerical results with experimental data from a single-loop PHP at nitrogen temperature, showcasing the capabilities of CFD code using the Volume of Fluid method, which involves phase change along with conjugate heat transfer. The study examines the influence of thermal load on the temperature, thermal resistance, and effective thermal conductivity of operating PHPs, highlighting the main challenges of modeling

PHPs in cryogenic environments.

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Simplified Model of Thermo-Fluid Processes in Forced Flow He II

Authors: Bertrand Baudouy[1]; Marcin Opalski[2]; Przemysław Błasiak[2]; Sławomir Pietrowicz[2]

[1] *Université Paris-Saclay, CEA, France*

[2] *Wrocław University of Science and Technology*

Corresponding Authors: przemyslaw.blasiak@pwr.edu.pl, marcin.opalski@pwr.edu.pl, bertrand.baudouy@cea.fr, slawomir.pietrowicz@pwr.edu.pl

The main objective of this study is to analyze the thermo-fluid processes in He II forced flows using a simplified two-fluid model. The model is obtained directly from the simplification of the so-called two-fluid model assuming, that the dominant terms in the superfluid momentum equation are the thermo-mechanical, the Gorter-Mellink mutual friction and the pressure gradient terms. After this simplification, a new system of equations describing the heat and mass transfer in He II is obtained with a conventional continuity equation, a modified momentum equation for the total fluid, and an energy equation revealing the unique counterflow heat transport mechanism and considering the pressure gradient effect in He II. The model was validated and compared to other models available in the literature, such as the original two two-fluid model [1], Kitamura's one [2], and the 1-D Fuzier models [3], as well as experimental data. The model was implemented with the OpenFOAM software. The proposed model, despite the simplifications introduced, provides shorter computation time compared to, for example, the two-fluid model and shows good agreement with the experimental results.

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11

Fabrication and various characterizations of SCSC cables

Authors: Naoyuki Amemiya[1]; Masato Fujino[1]; Akira Takahashi[1]; Hiiragi Uegaki[1]; Yusuke Sogabe[1]

[1] *Kyoto University*

Corresponding Author: amemiya.naoyuki.6a@kyoto-u.ac.jp

*Naoyuki Amemiya, Masato Fujino, Akira Takahashi, Hiiragi Uegaki, and Yusuke Sogabe, Kyoto University, Kyoto, Japan

We have been developing the Spiral Copper-plated Striated Coated-conductor cable, abbreviated to the SCSC cable or the double "SC"cable. Its geometry is similar to that of CORC® cable, but its

use of copper-plated multifilament coated conductors can help to reduce magnetization of coated conductors, which affecting field qualities of accelerator magnets. The cables are also compatible with ac and fast-ramp applications due to reduced magnetization losses. Note that the spiral geometry of the coated conductors plays similar role to the twisted geometry of filament bundle in a low Tc superconducting wire to decouple filaments. We have been fabricating SCSC cables with various types of cores. We will report the current transport characteristics of straight cables, those of bended cables, and those of miniature saddle-shape coils. We will also report the ac loss measurements of a small coil wound with cable similar to CORC® cable consisting of monofilament coated conductors. The experiments are preliminary ones before the experiments using coil wound with SCSC cables.

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Cryogenic developments for very high field magnets

Author: Bertrand Baudouy[1]

[1] *CEA Paris-Saclay*

Corresponding Author: bertrand.baudouy@cea.fr

Very high permanent magnetic fields, i.e., over 20 T, are produced by superconducting magnets made partially, or fully, with high-temperature superconducting (HTS) conductors. These specific magnets generally operate at liquid helium temperatures to take full advantage of the HTS properties. Very high-field magnets, usually immersed in a saturated liquid helium bath, experience an excessive temperature increase in working conditions above 20 T. Beyond this threshold, it has been demonstrated that the magnetic force is strong enough to interact with helium molecules due to their diamagnetism. The magnetic field distribution can cause this body force to compensate for gravity, creating zones of levitation around the magnet. It either degrades the boiling heat transfer, preventing bubbles from developing freely and leaving the magnet surface, or traps helium vapor structures on the magnet surface, thus creating a film at the liquid and the magnet interface. To avoid jeopardizing the long-term operation of superconducting high-field magnets cooled by liquid helium at 4.2 K beyond 20 T, heat transfer in liquid helium under these conditions must be fully understood and quantified. An alternative solution is to use a non-gravity-assisted cooling system, such as a capillary heat pipe. This talk presents the recent experimental studies carried out at CEA Paris-Saclay on the helium pool boiling heat transfer under reduced gravity and the development of gravity-independent heat pipes for cooling a 10T class HTS magnet.

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Proceedings in Development of Cryogenic Research Infrastructure at IFJ PAN

Author: Waldemar Maciocha[1]

Co-authors: Dariusz Bocian [1]; Jacek Świerblewski [1]; Jakub Jaros [1]; Jaromir Ludwin [1]; Marcin Curyło [1]; Marcin Wartak [1]; Michał Sienkiewicz [1]; Paweł Halczyński [1]; Tomek Cieslik [1]; Wawrzyniec Gaj [1]; Wojciech Marek [1]

[1] *IFJ PAN*

Corresponding Authors: marcin.wartak@ifj.edu.pl, wojciech.marek@ifj.edu.pl, curylo.marcin@gmail.com, jacek.swierblewski@ifj.e
waldemar.maciocha@ifj.edu.pl, dariusz.bocian@ifj.edu.pl, michal.sienkiewicz@ifj.edu.pl, wawrzyniec.gaj@ifj.edu.pl, pawel.halczynski@ifj.edu.pl, tomasz.cieslik@ifj.edu.pl, jakub.jaros@ifj.edu.pl, jaromir.ludwin@ifj.edu.pl

In 2014 the Directory and Scientific council of IFJ PAN accepted a proposal of cryogenic infrastructure development to support research in the field of superconducting devices and materials at IFJ PAN site. Since then a number of cryogenics installations with auxiliary installations have been prepared and finally assembled. Few cases required dedicated solution and custom design. One of such things is custom built heat exchanger with dedicated air flow which can be regulate adequate to needs. His second feature is a heater mounted in the air flow channel. That solution gives possibility to change the air temperatures flow around heat exchanger ribs. The heat exchanger as well as another parts of the cryogenics installation and installation itself have been designed and performed by engineers and technicians form one of the IFJ PAN department namely: Division of Scientific Equipment and Infrastructures Construction (DAI). This division has several engineers and technicians as well as has a workshop and CNC machines which connected to the gained skills and competences of the team gives possibilities to work on complex and custom solution for science. All prepared solution are currently during study and commissioning phase. This paper will present the overall view of the existing experimental hall with key components installed.

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Status of the Cryomodule tests as a part of Polish In-Kind contribution to the European Spallation Source (ESS) realized by IFJ PAN

Author: Jacek Świerblewski[1]

Co-authors: Dariusz Bocian [1]; Filip Skalka [1]; Jakub Jaros [1]; Marcin Wartak [1]; Michał Sienkiewicz [1]; Paweł Halczyński [1]; Piotr Strączek [1]; Tomek Cieslik [1]; Waldemar Maciocha [1]; Wawrzyniec Gaj [1]

[1] *IFJ PAN*

Corresponding Authors: waldemar.maciocha@ifj.edu.pl, filip.skalka@ifj.edu.pl, jacek.swierblewski@ifj.edu.pl, pawel.halczynski@ifj.edu.pl, wawrzyniec.gaj@ifj.edu.pl, michal.sienkiewicz@ifj.edu.pl, piotr.straczek@ifj.edu.pl, dariusz.bocian@ifj.edu.pl, tomasz.cieslik@ifj.edu.pl, jakub.jaros@ifj.edu.pl, marcin.wartak@ifj.edu.pl

The European Spallation Source (ESS), as one of the complex accelerator require installation and commissioning of many systems and components. One of them is the accelerator line which is composed with the cryomodules uses to accelerate of the particles. Taking into account that ESS is one of the most technological advanced accelerator in Europe we can expect also that accelerator line is very complex and advanced part of the machine. Among others things three types of the cryomodules spokes, medium and high beta are used to assembly accelerator line. In 2017 first group of engineers from the Henryk Niewodniczanski Institute of Nuclear Physics Polish Academy of Science (IFJ PAN) arrived to Lund in order to start execution of IFJ PAN contribution to this project. One of them is perform the test of the medium and high beta cryomodules. In total 31 cryomodules have to be tested and prepared for assembly in the tunnel as a part of the accelerator line. In this paper the current status of the tests as well as early stage of the optimalization process regarding test program for cryomodules tests is showed . The main focus is done on the procedures and quality aspects, required skills and challenges occurring during the tests work; inter alia: incoming inspection, tests before installation in the bunker, preparation of the cryomodules for the test, test in the bunker, outgoing inspection. A very expensive RF cryomodules and systems required the special skills and the right approach to quality which is provided by engineers and technicians from IFJ PAN.

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R&D on React&Wind Nb3Sn Superconductors for Fusion Magnets

Author: Kamil Sedlák[1]

Co-authors: Pierluigi Bruzzone [1]; Federica Dematte [1]; Xabier Sarasola [1]

[1] *EPFL - Swiss Plasma Center*

Corresponding Authors: pierluigi.bruzzone@psi.ch, xabier.sarasola@psi.ch, kamil.sedlak@psi.ch, federica.dematte@psi.ch

The magnets for ITER tokamak are made of cable-in-conduit conductors (CICC), either NbTi or Nb3Sn. The conductors were manufactured by pull-through technique, where the superconducting cable is inserted into an empty steel jacket, several hundred meters long. Afterwards, the jacket is compacted, and the coil winding pack is wound, the Nb3Sn coil is heat-treated, and the brittle superconducting structure is created (wind&react technology). Due to different thermal-expansion coefficient of Nb3Sn, copper and steel, the Nb3Sn filaments are in compression state after the cool down. The typical strain of 0.6-0.8% leads to 40-60% decrease of critical current of a Nb3Sn cable. For fusion magnets with big bending radius, one can also design a flat Nb3Sn cable that can withstand the bending after heat treatment. The cable in this react&wind (RW) approach is heat-treated spooled, straightened for jacketing, and afterwards wound to the final coil shape. The jacketing is done by laser welding of two separate stainless-steel half-profiles positioned around the Nb3Sn cable. The strain accumulated during the cooldown from room temperature is significantly smaller (˜0.3%), and the shape of the steel jacket can be freely adjusted according to the stress distribution in the coil winding pack. We will present the recent development in the RW conductors at Swiss Plasma Center of EPFL designed for the TF and CS coils of EUROfusion DEMO tokamak. We will discuss the results from the tests of several RW prototype samples tested in the SULTAN test facility, with the successes and various setbacks along the way.

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Challenges of the Future Circular Collider Project

Author: Marek Gasior[1]

[1] *CERN*

Corresponding Author: marek.gasior@cern.ch

An overview of the Future Circular Collider (FCC) will be presented, with the focus on challenges of the project. The current state of the collider design and ongoing studies will be outlined, with a special mention to a development being carried in Krakow.

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COMMISSIONING OF THE FIRST HELIAC CRYOMODULE CM1

Author: Maksym Miski-Oglu[1]

Co-authors: Christoph Burandt [2]; Florian Dziuba [2]; Hartmut Vormann [3]; Julian List [2]; Simon Lauber [2]; Stepan Yaramyshev [2]; Thorsten Kuerzeder [2]; Uwe Scheeler [3]; Viktor Gettmann [2]; Winfried Barth [4]

[1] *Deutsch*

[2] *GSI Darmstadt, HI Mainz*

[3] *GSI Darmstadt*

[4] *GSI Darmstadt, HI Mainz / JGU Mainz*

Corresponding Authors: h.vormann@gsi.de, t.kuerzeder@gsi.de, f.dziuba@gsi.de, c.burandt@gsi.de, j.list@gsi.de, m.miskioglu@gsi.de, w.barth@gsi.de, s.yaramyshev@gsi.de, u.scheeler@gsi.de, v.gettmann@gsi.de, s.lauber@gsi.de

The superconducting heavy ion HELmholtz LInear ACcelerator (HELIAC) is designed to meet the needs of the Super Heavy Element (SHE) research and material science user programs at GSI in Darmstadt. The beam energy can be varied smoothly between 3.5 and 7.3 MeV/u, with an average

current of up to 1 emA and a duty cycle of 100 %.
Recently, the first cryomodule CM1, was fully commissioned and tested. CM1 comprises three Crossbar H-mode (CH)-type accelerator cavities, a CH-rebuncher, and two superconducting solenoid lenses. Following the commissioning of the cryogenic supply- and RF-systems, a successful beam test was conducted at the end of 2023. A helium ion beam was successfully accelerated to the design energy of 2.7 MeV/u, moreover the beam energy could be varied continuously between 1.3 and 3.1 MeV/u without significant particle losses.
The focus of the contribution is on details of cryogenic operation and experience gained during assembling, commissioning of the cryogenic module. The main requirements for the construction of the cryomodule are (i) fidelity of transverse alignment of the accelerator components during evacuation and cooling, (ii) accessibility of the RF power coupler assembly, (iii) visibility of the alignment marks of the superconducting accelerator components during installation in the tunnel. A rather unconventional cryostat design with four side doors met these requirements.

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Progress in technological solutions for EU-DEMO magnets advanced conductors

Author: Valentina Corato[1]

[1] *ENEA*

Corresponding Author: valentina.corato@enea.it

Within the Europen DEMO (EU-DEMO) project, innovative magnet designs are explored as possible alternative to ITER approach, which is considered as a baseline variant as well. In the last decade the R&D mainly focused on React&Wind (R&W) Nb3Sn conductors and, more recently, on HTS conductors, mostly based on REBCO tapes. These innovative solutions are studied in combination with layer-wound designs, for the sake of optimize the amount of superconducting material and stainless steel in each layer, reducing the space occupancy of Toroidal Field (TF) coils and increasing the magnetic flux generated by the Central Solenoid (CS).
Short lengths of TF R&W conductors have been successfully developed and tested in SULTAN, even after the application of sequential increasing applied bending strain, up to 0.53%. The results have shown that R&W Nb3Sn conductors have no degradation with electromagnetic cycles and that in the design phase the acceptable bending strain can be increased from 0.3% to 0.5%. Also, the test of the resistance of the diffusion-bonded joint developed between two TF R&W conductors is of 0.6 nOhm at 8T, 63 kA, which is well below the target value of 1 nOhm. Since the jacket to surround the R&W Nb3Sn conductor requires a longitudinal welding along the whole length, the manufacture of 1Km longitudinal leak-tight weld on stainless steel profiles has been launched for demonstrating the feasibility of the conductor technology at industrial scale. Five hundred meters of empty jacket were laser welded on both sides with a synchronous movement and monitored through X-Ray, dye penetrant, ultra-sonic test and final He leak test. However, the typology and frequency of defects during the welding was not satisfying to proceed immediately to the demonstration manufacturing of 100 m long R&W Nb3Sn conductor and further studies to improve the laser welding procedure are ongoing.
Concerning HTS conductors a set of requirements has been fixed to compare the different solutions: operating current of 60 kA, peak field of 18 T, inlet temperature of 4.5 K, and minimum bending radius of 1.5 m. Europe and China are collaborating on HTS conductor development, with Europe proposing the ASTRA Roebel cable and SECAS braided stack cable, while China suggests CORC-like conductors. These designs will be tested and compared at the SULTAN facility. The aim is to evaluate their performance and select the best design for the Central Solenoid.
On behalf of the WPMAG team I will present the progress in technological solutions for EU-DEMO magnets innovative conductors and the gaps that still need to be filled to validate the advanced solutions.

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Cryogenics technology applied to superconducting magnets, accelerating cavities and physics detectors

Author: roser vallcorba[1]

[1] *cea Saclay*

Corresponding Author: roser.vallcorba-carbonell@cea.fr

Over the past, CEA Saclay have demonstrated a large experience in large superconducting magnets and accelerating cavities testing, as well as subcomponents qualification or physics detectors at low temperatures.
The new vertical STAARQ test station operating at 4.5 K or in superfluid helium at 1.9 K is now available. This station can host 5 m long magnets, with a maximum diameter of 640 mm, and power them up to 13 kA thanks to HTS current leads.
What is more the recent developments of high-temperature superconductors (HTS), based on REBCO tapes, will now make it possible to achieve magnetic fields over 20 T at much higher temperatures. This allows it possible large societal applications as design compact magnetic fusion machines. To this aim, the CEA former JT-60SA large-scale test facility is being updated to make a test stand versatile enough to test these new magnet technologies. The main goal is to prepare the challenges concerning the new detector like dipole magnet for dark matter - Madmax- as well as the magnetic fusion needs. For that, it aims to test in nominal conditions a large-scale demonstrator achieving about 20 T and 100 MJ of stored energy to prove the technology maturity.
This paper will present an overview of the latest improvements in our test stands and platforms, to meet the new challenges associated with the development of HTS superconducting technology.

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Innovations and Operations of the SOLARIS Synchrotron

Author: Adriana Wawrzyniak[1]

[1] *SOLARIS NSRC, Jagiellonian University*

Corresponding Author: adriana.wawrzyniak@uj.edu.pl

The SOLARIS synchrotron, a third-generation light source, has been operational since 2015 at Jagiellonian University (JU) in Kraków, following a collaborative project initiated in 2010 with MAX-Lab in Lund, Sweden. This advanced facility comprises a 600 MeV linear accelerator (linac) with a thermionic RF gun, a vertical transfer line, and a 96 m circumference storage ring with a nominal energy of 1.5 GeV. Utilizing S-band technology, the linac features six 5 m long copper structures with an accelerating gradient of 20 MV/m, organized into three units powered by RF modulators with klystrons. The storage ring, built with twelve double-bend achromats (DBA) integrated into solid magnetic blocks, achieves precise magnet alignment (approximately 25 µm) and delivers excellent electron beam parameters (emittance of 6 nmrad). It also includes 3.5 m straight sections for insertion devices (undulators and wigglers) that serve as additional sources of synchrotron radiation and 100 MHz RF system with two main cavities for electrons energy boosting. Additionally, 3rd harmonic passive cavities serves as a bunch length stretcher, which improves the Touschek lifetime. During the start-up phases, very good efficiency of the storage ring [1-3] was achieved and the beam optics were set close to the designed one.
Since October 2018, SOLARIS has been supplying synchrotron radiation to users, operating 24/7 with an electron current of around 400 mA and a total lifetime of 15 hours in decay mode, ensuring over 95% beam availability [4]. The SOLARIS Centre is continually evolving [5], currently hosting seven active research lines (URANOS, PIRX, PHELIX, DEMETER, ASTRA, POLYX, CIRI), with two more (SOLCRYS and SMAUG) set to commence in 2026/2027, and additional lines in the conceptual stage. The SOLARIS synchrotron, thanks to its advanced technology and high beam availability, is a valuable tool for various scientific and technological research, contributing to the development of science both in Poland and internationally. During the presentation, the comprehensive overview,

and key parameters of the SOLARIS accelerators together with available research techniques will be presented.

Acknowledgements
The author would like to thank all members of the SOLARIS Team for their incredible contribution to the construction, commissioning and continuous maintenance and development of the SOLARIS Center infrastructure.
The project is executed under the provision of the Polish Ministry and Higher Education project "Support for research and development with the use of research infrastructure of the National Synchrotron Radiation Centre SOLARIS"under contract nr 1/SOL/2021/2.

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Linear accelerator and accompanying equipment as a system for Hyper-Kamiokande detector calibration.

Author: Michał Matusiak[1]

[1] *Narodowe Centrum Badań Jądrowych*

Corresponding Author: m.matusiak@ncbj.gov.pl

One of the most well-known water Cherenkov detectors is the Super-Kamiokande detector in Japan. Its successor, the larger Hyper-Kamiokande detector, is currently being developed. A key aspect for both detectors is the calibration method for the measurement systems. In the new detector, similar to its predecessor, the calibration of detection systems will use, among other systems, e- beam of precisely defined energy produced by a linear electron accelerator. Scientists from the National Centre for Nuclear Research are responsible for delivery of the electron linac, the beam path and the accompanying equipment.
The linear electron accelerator is designed to accelerate an electron beam emitted from a triode electron gun to one of the selected energies in the range of 3.5 to 24 MeV. The electron beam, with a relatively wide spectrum, will pass through a system of triple magnetic chicanes for precise energy selection and particle count reduction. The calibration process for the detection system requires that only one electron is delivered to the detection area in each radiation pulse. The transport of the electron beam will be conducted through a transmission line consisting of two sections: a horizontal section over 40 meters long and a vertical section over 60 meters long. The vertical section will allow the electron emission at one of several selected depths.
During the speech, the technical and technological solutions applied in the constructed device will be discussed. The challenges that need to be addressed to ensure the proper functioning of the entire calibration system will also be covered.

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Overview of the PIP-II RF Systems: Design and Delivery

Author: Jeremiah Holzbauer[1]

Co-authors: Edward Cullerton [1]; James Steimel [1]; Joseph Dey [1]; Nathan Eddy [1]; Niral Patel [1]; Philip Varghese [1]; Victor Grzelak [1]

[1] *Fermi National Accelerator Laboratory*

Corresponding Authors: vgrzelak@fnal.gov, dey@fnal.gov, ecullert@fnal.gov, npatel@fnal.gov, eddy@fnal.gov, varghese@fnal.gov, steimel@fnal.gov, jeremiah@fnal.gov

The PIP-II Project is a generational upgrade to the Fermilab accelerator complex, centered around an 800 MeV superconducting proton Linac. PIP-II is also the first major accelerator project in the US with significant in-kind contributions from international partners. Successful integration of FNAL and Partners during the design, fabrication, and delivery of this machine will be essential for the Project's success. This paper will review and status the major RF systems for PIP-II including SRF system (including five flavors of SRF cavities), warm RF systems (e.g., RFQ, upgrades to existing synchrotron RF systems), and ancillary RF systems (reference lines, RF protection interlock systems), including our partner contributions and integration.

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Investigation of 2G HTS tapes irradiation towards applications in the space industry

Author: Paweł Pęczkowski[1]

[1] *Cardinal Stefan Wyszyński University*

Corresponding Author: p.peczkowski@wp.pl

The most popular second-generation high-temperature superconducting tapes (2G HTS) include superconducting tapes made of *RE* $Ba_2Cu_3O_7$ (*RE* BCO), where *RE* is a rare earth atom such as yttrium or gadolinium (YBCO or GdBCO, respectively). *RE* BCO superconducting tapes have a thickness of several dozen µm, of which the superconductor itself is characterized by a thickness of about 1 µm 1. Due to their advantages such as very high critical current density, flat shape, the possibility of creating artificial pinning centers that allow for reducing anisotropy, *RE* BCO-based materials are among the most promising high-temperature superconductors.

HTS, especially in the form of superconducting tapes, are considered for future applications such as particle accelerators [2]. Another application may be superconducting lossless power networks containing wires made of HTS tapes. One of the commercially operating networks is the AmpaCity project in Essen (Germany) [3]. One of the important contemporary applications of HTS in modern projects are current limiters [4] and superconducting transformers [5]. Recently, HTS tapes have also found application in the space industry, as protection of astronauts and spacecraft modules against cosmic radiation. Also in the space industry, materials such as superconducting foams [6] are used, where it is necessary to use strong and at the same time light sources of magnetic fields.

In space, tapes are exposed to various types of radiation, including: cosmic radiation, solar wind and various ions, including noble gas ions such as $^{10}Ne^{+}$ [7], and $^{40}Ar^{8+}$, $^{86}Kr^{17+}$, $^{132}Xe^{27+}$ [8]. Under the influence of radiation, various types of defects appear in the tape structure, including: Frenkel and Schottky defects, which act as centers for fixing Abrikosov vortices. The resulting defects affect the superconducting and structural parameters of the irradiated tapes. During my talk I will discuss the influence of irradiation of 2G HTS SF tapes (without stabilizer) 12050 from SuperPower Inc. [9] with noble gas ions of different fluences and energies on superconducting parameters.

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Friction factor of the cooling channels of the DEMO PF CICCs

Authors: Aleksandra Dembkowska[1]; Monika Lewandowska[2]; Paweł Herbin[1]; Rafał Ortwein[3]

[1] *West Pomeranian University of Technology in Szczecin*

[2] *The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*

[3] *Institute of Nuclear Physics, Polish Academy of Sciences (IFJPAN)*

Corresponding Authors: rafal.ortwein@ifj.edu.pl, pawel.herbin@zut.edu.pl, monika.lewandowska@ifj.edu.pl, aleksandra.dembkowska@zut.edu.pl

The European DEMOnstration Fusion Power Plant (EU-DEMO), based on the tokamak concept, is being designed by the EUROfusion consortium to demonstrate the possibility of electricity production (at the level of several hundred MW) from nuclear fusion. The fully superconducting magnet system of DEMO includes the Toroidal Field Coils, Central Solenoid, and Poloidal Field (PF) coils, which will be cooled by forced flow of supercritical helium.
Thermal-hydraulic analyses of the DEMO winding packs, aimed at assessing their minimum temperature margin, hot spot temperature, or coolant pumping cost, require reliable friction factor correlations for each flow channel in the DEMO conductors. Two different concepts for the six DEMO PF coils are proposed by EPFL-SPC (Switzerland) and CEA IRFM (France). According to the CEA concept, each PF coil will be wound using a square NbTi CICC with a central cooling channel separated from the outer bundle region by a flat spiral. The layout of conductors designed for different PF coils varies. The outer diameter of the central spirals in the PF3, PF4, and PF6 conductors ranges from 13.6 to 15.8 mm. Spirals with such large diameters have never been tested for pressure drop. Therefore, the available correlations used to compute the friction factor may not be accurate for them.
In this work, we performed pressure drop tests on spiral ducts with geometry identical to the cooling channels of the PF4 and PF6 conductors. We used demineralized water at three different temperatures ranging from room temperature to about 60°C. The samples were produced by 3D printing. The experimental results were complemented by CFD simulations of flow in spiral ducts using the ANSYS Fluent software. Our work aimed to obtain friction factor correlations for the considered ducts in the Reynolds number range typical for normal operation of the DEMO PF coils.

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A New Linac Design for Top-Up Mode Operation of Solaris Synchrotron

Author: Roman Panaś[1]

Co-authors: Adriana Wawrzyniak [1]; Alessandro Curcio [2]; Krzysztof Guła [1]; Jarosław Wiechecki [1]

[1] *SOLARIS NSRC, Jagiellonian University*

[2] *INFN - Istituto Nazionale di Fisica Nucleare, Frascati, Latium, Italy*

Corresponding Authors: roman.panas@uj.edu.pl, krzysztof.gula@uj.edu.pl, jaroslaw.wiechecki@uj.edu.pl, adriana.wawrzyniak@uj.edu.pl, curcioalexander@gmail.com

SOLARIS is a third generation light source operating since 2015 in Kraków, Poland. It is based on 600 MeV linear accelerator (linac) and 1.5 GeV storage ring. Currently, electron accumulation in the ring begins at 0.5 GeV, followed by a ramping process to reach the operational energy of 1.5 GeV. A new linac design, based on novel high-gradient S-band accelerating structures, will facilitate top-up operation, enabling 1.5 GeV acceleration within the existing linac tunnel. Additionally, a new photocathode electron source is planned to upgrade the current thermionic cathode. The presentation will detail the layout of the components responsible for acceleration, transfer, control and monitoring electron beam along the linac system.

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RF Devices in the Solaris Synchrotron: Applications in the Linear Accelerator and Storage Ring

Author: Krzysztof Guła[1]

Co-authors: Adriana Wawrzyniak [2]; Grzegorz Cioś [1]; Lucjan Niewiedział [1]; Mateusz Szczepaniak [1]

[1] *Solaris NSRC, Jagiellonian University*

[2] *SOLARIS NSRC, Jagiellonian University*

Corresponding Authors: krzysztof.gula@uj.edu.pl, grzegorz.cios@uj.edu.pl, lucjan.niewiedzial@uj.edu.pl, mateusz.szczepaniak@uj.edu.pl, adriana.wawrzyniak@uj.edu.pl

The Solaris Synchrotron, located in Kraków, stands as one of Poland's premier research facilities, dedicated to delivering synchrotron radiation for diverse scientific investigations. Central to its infrastructure are the radio frequency (RF) devices, which are essential for the functioning of both the linear accelerator (linac) and the storage ring 1. Utilizing cutting-edge RF systems, the Solaris Synchrotron ensures the provision of stable and high-quality synchrotron radiation, thereby facilitating a wide array of world-class scientific research [2-3].
The linac RF system features 3GHz accelerating structures and SLED cavities, powered by high-power klystrons with modulators. In contrast, the storage ring is outfitted with 100MHz main cavities powered by 60 kW solid-state transmitters, alongside 300 MHz passive cavities. The RF signals (frequency and amplitude) are meticulously managed by a digital Low Level RF (LLRF) system based on ALBA's development, which enables precise control over electron beam acceleration.
This presentation will delve into the RF devices at Solaris Synchrotron, detailing their technical specifications, functions, and their influence on the facility's performance and stability. Additionally, it will address the challenges of integrating RF devices within the linac and storage ring, along with the strategies employed to surmount these obstacles. Test and measurement results that underscore the effectiveness and reliability of these technological solutions will also be showcased.

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Analysis on the results of the Quench Experiment taking into account variable contact strands-jacket heat transfer coefficient

Author: Monika Lewandowska[1]

Co-authors: Aleksandra Dembkowska [2]; Kamil Sedlák [3]

[1] *The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*

[2] *Instytut Fizyki Jądrowej PAN*

[3] *EPFL - Swiss Plasma Center*

Corresponding Authors: kamil.sedlak@psi.ch, monika.lewandowska@ifj.edu.pl, aleksandra.dembkowska@ifj.edu.pl

Abstract
Next-generation fusion magnets could benefit greatly from High-Temperature Superconductors (HTS). The EUROfusion consortium is already exploring HTS conductors for specific parts of the EU-DEMO tokamak's superconducting magnet system, in particular the innermost layer of the Central Solenoid. However, geometry and thermo-physical properties of HTS conductors are different from those of currently used conductors Low-Temperature Superconductors (LTS). Importantly, quench propagation in HTS conductors is much slower than in LTS. These differences suggest that numerical simulations of HTS conductor behavior might require new approaches, especially for analyzing fast events like quenching. To address this, a collaborative effort between EUROfusion and China produced and tested at the SULTAN test facility a series of dedicated HTS subsize samples with different geometries. This Quench Experiment aimed to gather huge amount of data for understanding quench behavior in HTS conductors and to validate different numerical models and tune their uncertain parameters. Our analysis contributes to the ongoing effort to interpret the results of this experiment.
One of the important parameters significantly affecting the thermal-hydraulic behavior of conductors during quench is the contact strands-jacket heat transfer coefficient. In numerical simulations, it is typically assumed to be constant, but its value is very uncertain. Moreover, recent experimental investigations revealed that it may strongly depend on temperature and surface pressure. In the present work, we simulated selected experimental runs of the Quench Experiment using the THEA model with the variable contact strands-jacket heat transfer coefficient to check if this assumption allows for more accurate reproduction of the experimental results.

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Results of the Cold Test of the first HL-LHC Cold Powering System

Author: Christian Barth[None]

Results of the Cold Test of the first HL-LHC Cold Powering System
Amalia Ballarino1, Wendell Bailey2, Christian Barth1,, *P. Cruikshank1, Vanessa Gahier1, Y. Leclercq1, F. Pasdeloup1, Gerard Willering 1, Yifeng Yang2*
1CERN, European Organization for Nuclear Research, Geneva, 1211, Switzerland
*2SOTON, University of Southampton, Southampton, SO17 1BJ, United Kingdom*c.barth@cern.ch

ABSTRACT

The powering of the High Luminosity LHC (HL-LHC) magnets will rely on Cold Powering Systems incorporating superconducting lines (Superconducting Links) based on MgB2 cables. A Cold Powering System interconnects the HL-LHC magnets, in the LHC tunnel, to the power converters, in the newly excavated galleries that are about 10 m higher than the LHC tunnel and 100 m far away from the magnets. It feeds magnet circuits rated at currents ranging from 2 kA to 18 kA and is designed to transfer a total DC current of up to 120 kA with the MgB2 cables, in the Superconducting Link, at up to 25 K. Cryogenic cooling is via forced flow of helium gas, which is generated at 4.5 K and recovered at room temperature after efficient cooling of the system. A Superconducting Link is about 100 m long and consists of nineteen MgB2 sub-cables housed in a compact and flexible vacuum-insulated cryostat. REBCO cables, operated between about 25 K and 60 K, provide the electrical bridge between the MgB2 and the resistive part of current leads, where the current is transferred to room temperature.
After about ten years of development, the first HL-LHC Cold Powering System was successfully assembled and tested at CERN. The Superconducting Link was measured in a geometrical configuration that included a vertical path simulating the final routing, in the LHC underground, from the new HL-LHC galleries to the LHC tunnel. We report on the qualification campaign that validated the mechanical, cryogenic and electrical performance of the system both in steady state conditions and under various transient scenarios.

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Concept for Data Acquisition Link for Beam Diagnostics at ESS

Author: Maciej Grzegrzółka[1]

Co-authors: Kaj Rosengren [2]; Krzysztof Czuba [3]; Paweł Jatczak [1]

[1] *Institute of Electronic Systems, Warsaw University of Technology*

[2] *European Spallation Source*

[3] *Warsaw University of Technology*

Corresponding Authors: maciej.grzegrzolka@pw.edu.pl, kaj.rosengren@ess.eu, kczuba@elka.pw.edu.pl, pawel.jatczak@pw.edu.pl

The beam instrumentation at European Spallation Source (ESS) consists of many of systems, generating over 100 gigabytes of data per second. The project aims to develop a system to gather data from all beam instrumentation systems and transfer it to a central, high-performance FPGA, where it will be processed. The detailed analysis of this data can bring valuable information about machine operation, help optimize the beam parameters, and detect potential problems early. This is possible by utilizing the high computing power of modern FPGAs and machine learning algorithms.
This contribution presents the concept of a beam diagnostic data acquisition link. The information about the project's planned firmware and hardware structure and its current status is presented.

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Performance of the Thermal-Hydraulic Model for the ITER TF Magnets; Numerical Instability and its Solution

Author: Dong Keun Oh[1]

Co-authors: Alexandre Louzguiti [2]; Christine Hoa [2]; Jacek Kosek [2]; Junjun Li [2]; Luca Bottura [3]

[1] *Korea Institute of Fusion Energy and ITER Organization*

[2] *ITER Origanization*

[3] *CERN*

Corresponding Authors: luca.bottura@cern.ch, alexandre.louzguiti@iter.org, jacek.kosek@iter.org, dongkeun.oh@iter.org, junjun.li@iter.org, christine.hoa@iter.org

In the idea of integrated modeling, the SuperMagnet suite has proven itself as a primary refer-ence of magnet operation in the ITER project, as it enables an interoperating platform just to couple the well-established independent codes of thermal-hydraulic subdomains by part. Along with the practical modeling in large scale, extra effort had to be made to extend the limitation of the Super-Magnet model, in particular, toward the maximum capability of each independent code, since the basic design has been established just relying on the dependable functionality of each code to be integrated around the core parts of CICC (Cable-In-Conduit Conductor) model. Recently, there has been noticeable improvements to enhance the overall performance of the SuperMagnet model by focusing on the interfacial problems. However, those developed ideas have not been applied yet to a full-fledged case of practical modeling. Thus, it is required to demonstrate the efficacy up to the large scale devices. In this study, the SuperMagnet model of the ITER TF magnet system is discussed. On the technical issue of numerical stability, the interfacial heat flux is intensively investigated at the boundaries be-tween the TF structure and the CICCs. As a result, the practical solution for the numerical is-sue is introduced, as well as an alternative solution scheme for further improvement, based on the approach to the coupled boundary problems using the interface Jacobian.

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Summary of Installation and Commissioning of the European Spallation Source Phase Reference Line Project

Author: Krzysztof Czuba[1]

Co-authors: Anirban Krishna bhattacharyya [2]; Dominik Sikora [1]; Morten Jensen [2]; Paweł Jatczak [1]; Radosław Papis [1]

[1] *Warsaw University of Technology*

[2] *ESS*

Corresponding Authors: rad.papis@gmail.com, pawel.jatczak@pw.edu.pl, anirban.krishna.bhattacharyya@ess.eu, morten.jensen@ess.eu, dominik.sikora@pw.edu.pl, kczuba@elka.pw.edu.pl

The Phase Reference Line (PRL) was installed recently in the European Spallation Source (ESS) facility in Lund, Sweden. It is a passive system based on a 1 5/8”coaxial rigid line designed to distribute 352 MHz and 704 MHz harmonic phase reference signals to over 300 devices installed in a 600 m long linear proton accelerator (LINAC). Required phase synchronization accuracy reaches 0.1° at both operating frequencies. Design requirements are fulfilled with the use of system temperature stabilization within +/- 0.5 oC range and keeping a slightly overpressurized dry Nitrogen inside of the coaxial line, to minimize temperature and air humidity influence on distributed signal stability. This contribution describes the main design assumptions and system architecture, the current design and installation summary, methods used for operation and signal quality commissioning, and current performance measurement results.

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Analysis of electrodynamic losses in LTS and HTS conductors for fusion magnets

Authors: Antonio Macchiagodena[1]; Lorenzo Cavallucci[1]; Marco Breschi[2]; Pierrre Bauer[3]

[1] *University of Bologna*

[2] *University of Bologna, Italy*

[3] *ITER Organization*

Corresponding Authors: lorenzo.cavallucci3@unibo.it, marco.breschi@unibo.it, antoni.macchiagoden2@unibo.it

The central solenoid (CS) is the backbone of any tokamak magnet system; it works under time-varying magnetic flux density and operating currents, up to several T/s and kA/s respectively. This rapid time-varying field induces a plasma current in the order of 10 MA.
These time-varying working conditions generate AC losses in the CS during operation. The CS of the ITER tokamak is manufactured with Nb3Sn strands assembled in the Cable in Conduit Conductors (CICC) configuration. The CS of the DEMO tokamak, currently in the design phase in the frame of the EUROfusion programme, is conceived with a grading including a High Temperature Superconducting (HTS) insert, wound with twisted-stacked REBCO conductor, and a Low Temperature Superconducting (LTS) outsert, based on Nb3Sn and NbTi CICCs.
In this work, the analytical model presently taken as a reference for the ITER project is used for the loss computation in the modules of the ITER CS and compared to the experimental results obtained in the tests of the CS modules at General Atomics (Poway, USA). The paper describes the techniques to derive relevant information for the loss computation in the CS magnet from measurements on straight conductors, performed in the SULTAN facility (Villigen, Switzerland), and on a single layer solenoid (the so-called CS Insert), performed at the QST center (Naka, Japan).
To explore the impact of the cable configuration on the losses during electrodynamic transients, the paper presents a comparison between two typical fusion conductor configurations, based on LTS and HTS materials. The CS ITER conductor is taken as a reference for LTS, while one possible design of the DEMO twisted-stacked conductor is considered for the HTS case. The losses in the twisted-stacked HTS conductor configuration are computed by means of recently developed analytical formulae. The comparison of losses is performed by subjecting the two conductors to the same cycle of applied magnetic field and transport current.

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The superconducting magnets of the Muon Collider –a study case for a future HEP machine

Author: Bernardo Bordini[1]

[1] *CERN*

Corresponding Author: bernardo.bordini@cern.ch

The muon collider is under consideration as a next-generation facility for high-energy physics (HEP) discoveries. It holds a prominent position in the European Strategy for Particle Physics (ESPP) and is recommended by the US Particle Physics Project Prioritization Panel (P5). Magnets are vital across various sectors of the collider complex, presenting significant challenges and being recognized as a critical technology. Initiatives started by the US-DOE Muon Accelerator Program have evolved into a collaborative effort under the International Muon Collider Collaboration. In this collaboration, we have reevaluated the requirements and challenges associated with magnets, considering advancements in superconducting magnet technology over the past decade, particularly in High-Temperature Superconducting (HTS) coated conductors, and the growing emphasis on sustainable technologies due to our planet's limited resources.
Ongoing studies highlight the critical need for a deep understanding of the mechanical properties, potential failure modes, and limitations of HTS to fully utilize their exceptional superconducting capabilities. This knowledge is crucial for developing compact and cost-effective magnets. We assert that this requirement is not confined to the muon collider but extends to any advanced collider proposed to succeed the Large Hadron Collider (LHC).

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Predicting Lifetime of Irradiated Metastable Materials at Extremely Low Temperatures

Author: Blazej Skoczen[None]

Corresponding Author: blazej.skoczen@pk.edu.pl

Metastable materials, like stainless steels, are massively used for construction of scientific instruments, operating at extremely low temperatures (superconducting particle accelerators). The components operating in the proximity of a source of primary or secondary particles are subjected to irradiation that induces an enhanced level of porosity, accompanied by the presence of inclusions of secondary phase resulting from the strain induced phase transformation.
Exposure to irradiation (flux of particles) leads to creation of clusters of defects in the material 1. The so-called atomic displacement damage process correlates with the evolution of porosity. Energy brought by the incident particles is dissipated mainly by the elastic collisions with the lattice atoms. These nuclear interactions lead to creation of atoms moving inside the lattice, and to the production of defects (interstitials and vacancies). The vacancies form clusters and grow into the so-called cavities, often filled with helium at high pressure. It is shown that the actual pressure is function of the overall strain, that leads to the evolution of size of the clusters according to the Rice-Tracey kinetics.
Formulation of the constitutive model of elastic-plastic continuum subjected to the strain induced phase transformation in the presence of radiation induced porosity is based on the multiscale approach. In particular, it takes into account the micromechanical phenomena such as the interactions of dislocations with the inclusions and the pressurized cavities (micro-level), or the influence of hard inclusions and "soft"cavities on the resultant tangent stiffness of two-phase continuum (meso-level). Evolution of the material micro-structure induces strain hardening related to the increase of the equivalent tangent stiffness as a result of evolving proportions between both phases, each characterized by different stiffness. The final constitutive model comprises the model of mixed, isotropic and kinematic hardening. The analysis is cross-checked with the results of experiments carried out in liquid helium (4.2 K). The experiments including detection of porosity and identification of the volume fraction of secondary phase are presented.
The constitutive model allows to predict the lifetime of components, including the superconductors, subjected to complex loads at cryogenic temperatures.

1 Skoczeń, B., Ustrzycka, A. Kinetics of evolution of radiation induced micro-damage in ductile materials subjected to time-dependent stresses. International Journal of Plasticity, 2016, 80, pp. 86-110.

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The LLRF systems for elliptical cavities - from specification till successful installation

Author: Wojciech Cichalewski[1]

[1] *DMCS*

Corresponding Author: wcichal@dmcs.pl

Authors:

W. CICHALEWSKI,
G. Jablonski, K. Klys, D. Makowski, A. Mielczarek, A.
Napieralski, P. Perek, P. Plewinski, A. Abramowicz, K. Czuba, M.
Grzegrzolka, K. Oliwa, I. Rutkowski, W. Wierba, P. Bartoszek, K.
Chmielewski, Z. Golebiewski, K. Kostrzewa, T. Kowalski, D. Rybka, M.
Sitek, J. Szewinski, Z. Wojciechowski, M. Jensen, A. Svensson, A. Johansson

Abstract:

The proton beam acceleration depends on the performance of various systems. The low-level RF (LLRF) is a key component of the ESS linac infrastructure. Its fundamental role is to adjust the amplitude and phase of the RF signal to achieve the best energy transfer to the accelerated beam.
The Polish Electronic Group (PEG) was established in 2016 to support the ESS in the LLRF system design and implementation. The National Center for Nuclear Research, the Warsaw University of Technology, and the Lodz University of Technology jointly continue their efforts toward successful Medium- and High-Beta cavities LLRF systems commissioning.
The PEG involvement includes the system requirements preparation, specification, design, prototyping, production, verification, and the installation phase.
As the last installation and verification activities take place in the ESS linac gallery this work summarizes all the mentioned phases and particular responsibilities of each PEG member in successful LLRF systems delivery.

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European Spallation Source and new opportunities for Polish scientists

Corresponding Author: dyrektor@ifj.edu.pl

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Corresponding Author: ciprian.plostinar@ess.eu

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Summary of Installation and Commissioning of the European Spallation Source Phase Reference Line Project

Corresponding Author: kczuba@elka.pw.edu.pl

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The LLRF related software and firmware tools to support the ESS elliptical cavities characterization and operation

Author: Wojciech Cichalewski[1]

Co-authors: G Jablonski [1]; K Klys [1]; R Kielbik [1]; W. Jalmuzna [1]; W. Tylman [1]

[1] *Department of Microelectronics And Computer Science, Lodz University of Technology*

Corresponding Author: wcichal@dmcs.pl

The European Spallation Source is currently in its advanced production and installation phase. At this stage, the facility transitions from delivery and integration to focus on verification and commissioning activities. For instance, elliptical superconducting cavity cryomodules undergo extensive testing and final qualification campaigns before being placed in the dedicated accelerator section.
This phase has led to the need for additional software and firmware tools development and implementation. These applications and algorithms allow us to determine specific crucial parameters for the cavities and full cryomodules. Additionally, experiences collected during cryomodule studies need to be formalized in the operation routines for future regular linac work. Yet another set of firmware and software tools emerges from such activities.
In the scope of the LLRF related software, this endeavor is a part of the project realized by TUL in the scope of the Polish in-kind for ESS.
This work summarizes the overall content of this project and the status of its work units realization.

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Design and Implementation of a Simultaneous Readout High-Accuracy Calibration System for Cryogenic Temperature Sensors

Authors: Dawid Siuta[1]; Dominik Nowak[1]; Kamil Kozlowski[2]; Kamil Nowatkowski[1]; Ryszard Duda[1]

[1] *Frako-Term*

[2] *GSI Helmholtz Centre for Heavy Ion Research*

Corresponding Authors: dominik.nowak@frakoterm.pl, k.kozlowski@gsi.de, dawid.siota@frakoterm.pl, ryszard.duda@frakoterm.pl

The design of a universal calibration system for various types of resistance temperature detectors (RTDs) is presented. This includes TVO and Cernox sensors, which are among the most commonly used for cryogenic applications.
Optimized for high-accuracy calibration at cryogenic temperatures, the measurement system is based on 24-bit ADC units that allow simultaneous readout of each channel, eliminating the need for an analog multiplexer. The measurement environment is maintained at cryogenic temperatures through the implementation of a cryocooler system.
This versatile system is designed to meet the rigorous demands of precise temperature monitoring in cryogenic environments.

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FAIR's SIS100 Accelerator: An Update on the Superconducting Magnets Status

Author: Kamil Kozlowski[1]

Co-authors: Aleksandra Stuglik [1]; Alexander Bleile [1]; Alexander Warth [1]; Andreas Waldt [1]; Anna Szwangruber [1]; Christian Roux [1]; Florian Kaether [1]; Hans Mueller [1]; Ivan Pongrac [1]; Jan Patrick Meier [1]; Jochen Ketter [1]; Karol Witkowski [1]; Kei Sugita [1]; Lars Bozyk [1]; Matthias Janke [1]; Niels Pyka [1]; Patricia Aguar Bartolome [1]; Peter Spiller [1]; Piotr Szwangruber [1]; Stefan Wilfert [1]; Tiemo Winkler [1]; Walter Freisleben [1]

[1] *GSI Helmholtz Centre for Heavy Ion Research*

Corresponding Author: k.kozlowski@gsi.de

This work provides an update on the SIS100 accelerator, a crucial part of the FAIR project in Darmstadt, Germany, with a focus on the production and testing of superconducting magnets. The SIS100 accelerator is designed to accelerate heavy ions and protons, featuring six sectors, each composed out of arc and straight sections. Every sector contains optical cells with dipole magnets (DP) and quadrupole doublets (QDM). All magnets are based on the Nb-Ti nuclotron cable.
Emphasis is placed on the preparation and evaluation processes of superconducting magnets, which

are necessary to assure their high-performance operation. The magnets, capable of ramping up to 4 T/s (for DP magnets), are produced and tested across multiple sites to ensure they meet high quality and performance standards. Key aspects of the supply chains involved in the production and delivery of these magnets are also discussed, highlighting their role in maintaining project timelines and quality assurance.

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Installation, Testing and Commissioning Status of the European Spallation Source

Author: Ciprian Plostinar[1]

[1] *European Spallation Source*

Corresponding Author: ciprian.plostinar@ess.eu

The European Spallation Source (ESS) is a multi-disciplinary neutron research facility currently under construction in Lund, Sweden. The driver for ESS is a multi-megawatt proton linear accelerator that is pushing the technology and physics boundaries for high-power, high-intensity low-loss operation. When completed, the linac will accelerate a 62.5 mA, 2.86 ms, 14 Hz beam up to 2 GeV through a series of normal and superconducting cavities delivering an unprecedented 5 MW beam power to a rotating target. With construction and installation making significant progress, the Accelerator, Target and the first set of Neutron Instruments are now entering an intense period of testing and commissioning. Commissioning with beam will be done in several stages as more hardware becomes available. In this paper, a summary of recent progress and achievements will be presented with particular emphasis on the latest developments in Accelerator. The roadmap to sending the first beam to the Target will also be discussed as well as the challenges and the lessons learned so far.

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Deposition of Niobium on Copper Substrates with Trench Structures for Superconducting RF Cavities: Insights from Molecular Dynamics Simulations

Author: Milad Ghaemikermani[1]

Co-authors: Alvaro Lopez Cazalilla [1]; Flyura Djurabekova [1]

[1] *University of Helsinki*

Corresponding Authors: milad.ghaemikermani@helsinki.fi, flyura.djurabekova@helsinki.fi, alvaro.lopezcazalilla@helsinki.fi

The performance and reliability of superconducting radio frequency (SRF) cavities are critical for advancing particle accelerator technologies. This study investigates the mechanical properties, surface roughness, porosities, and heat conductivity of niobium (Nb) films deposited on copper (Cu) substrates, aiming to improve the efficiency of SRF cavities.

We utilize molecular dynamics (MD) simulations to model the deposition of Nb films using the high-power impulse magnetron sputtering (HiPIMS) technique. The mechanical properties are analyzed through the stress distribution at the Nb/Cu interface, employing the von Mises stress criterion. Surface roughness and porosity distribution are examined to understand their impact on the film quality and superconducting performance. Additionally, we investigate the heat conductivity in the lateral directions to assess the thermal management capabilities of the Nb films.

Our results highlight the significant influence of deposition parameters on the mechanical stability, surface characteristics, and thermal properties of Nb-coated Cu substrates. These insights provide a pathway to optimizing the fabrication process of SRF cavities, enhancing their application in particle accelerators and related fields.

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Corresponding Author: wcichal@dmcs.pl

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Corresponding Author: maciej.grzegrzolka@pw.edu.pl

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Linear accelerator and accompanying equipment as a system for Hyper-Kamiokande detector calibration

Corresponding Author: m.matusiak@ncbj.gov.pl

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Corresponding Author: k.kozlowski@gsi.de

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Corresponding Author: marek.gasior@cern.ch

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Corresponding Author: adriana.wawrzyniak@uj.edu.pl

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Rapid and Precise Hadron Beam Energy Distribution Measurement via the Time-of-Flight Method

Corresponding Author: wiktor.parol@ifj.edu.pl

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Control, coil voltage monitoring system design and quench monitoring results of the SSRF superconducting wiggler

Corresponding Author: mengty@sari.ac.cn

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Corresponding Author: valentina.corato@enea.it

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Corresponding Author: kamil.sedlak@psi.ch

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Corresponding Author: konrad.risse@ipp.mpg.de

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Corresponding Author: monika.lewandowska@ifj.edu.pl

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Corresponding Author: marco.breschi@unibo.it

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Corresponding Author: dongkeun.oh@iter.org

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Corresponding Author: rafal.ortwein@ifj.edu.pl

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Corresponding Author: m.miskioglu@gsi.de

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Corresponding Author: jeremiah@fnal.gov

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Corresponding Author: bertrand.baudouy@cea.fr

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Corresponding Author: roser.vallcorba-carbonell@cea.fr

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Corresponding Author: mengty@sari.ac.cn

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Corresponding Author: amemiya.naoyuki.6a@kyoto-u.ac.jp

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Corresponding Author: d.gajda@intibs.pl

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Corresponding Author: sjs@unipress.waw.pl

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Corresponding Author: p.peczkowski@wp.pl

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Corresponding Author: blazej.skoczen@pk.edu.pl

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Corresponding Author: k.kozlowski@gsi.de

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Corresponding Author: maciej.chorowski@pwr.edu.pl

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Corresponding Author: slawomir.pietrowicz@pwr.edu.pl

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Corresponding Author: marcin.opalski@pwr.edu.pl

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Corresponding Author: piotr.czaja@up.krakow.pl

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Corresponding Author: jtabin@ippt.pan.pl

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Corresponding Author: milad.ghaemikermani@helsinki.fi

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Corresponding Author: wcichal@dmcs.pl

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Progress in Development of Cryogenic Research Infrastructure at IFJ PAN

Corresponding Author: tomasz.cieslik@ifj.edu.pl

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Corresponding Author: krzysztof.gula@uj.edu.pl

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Status of the Cryomodule tests as a part of Polish In-Kind contribution to the European Spallation Source (ESS) realized by IFJ PAN

Corresponding Author: marcin.wartak@ifj.edu.pl

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An Analytical Framework for Computing AC Losses in the HTS Insert of the EU-DEMO Central Solenoid

Corresponding Author: gianluca.demarzi@enea.it

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Friction factor of the cooling channels of the DEMO PF CICCs

Corresponding Author: aleksandra.dembkowska@zut.edu.pl

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Rapid and Precise Hadron Beam Energy Distribution Measurement via the Time-of-Flight Method

Author: Wiktor Parol[1]

Co-authors: Adam Kozela [2]; Paweł Kulessa [1]; Bogusław Włoch [1]

[1] *IFJ PAN*

[2] *Instytut Fizyki Jądrowej PAN*

Corresponding Authors: adam.kozela@ifj.edu.pl, boguslaw.wloch@ifj.edu.pl, pawel.kulessa@ifj.edu.pl, wiktor.parol@ifj.edu.pl

W. Parol[1], ∗, A. Kozela[1], P. Kulessa[1] and B. Włoch[1]

[1] *Institute of Nuclear Physics Polish Academy of Sciences, PL-31342 Kraków*

High-precision experiments, such as investigations of nuclear interactions in few-body systems 1, require a precise knowledge of the reaction kinematics. This is primarily defined by key parameters of the hadronic beam, including the average kinetic energy of particles and the distribution of their individual kinetic energies. Accelerators deliver beams with specified energies within nominal parameters, but independent beam monitoring within experimental setups is crucial for accurately determining of beam parameters and minimizing systematical uncertainties. Discrepancies between requested and received beam energies, or their variations for individual hadrons, not only contribute to error calculations but also impact the reliability of procedures such as detectors calibration, particle identification, and, in the case of few-body experiments, the determination of normalization factors for cross-sections. Furthermore, some accelerators used in scientific research, originally designed for medical applications, require calibration based on parameters like particle range in water or received dose, rather than directly on beam energy. The proposed method enables instant and precise measurement of beam energy distribution without perturbing ongoing experiments. This approach can significantly improve duty factor of medical facilities and decrease time required for reliable measurement possible to perform during patient transitions. The need for new detectors and methods becomes apparent in the ongoing research for beam monitoring [2, 3].

Introduced Waveform Pattern Alignment method, based on time-of-flight technique is capable of prompt determining the energy of hadron beams used in nuclear physics experiments or clinical applications. The innovative feature in proposed method relies on the determination of a kinetic energy of a representative sample of individual hadrons in the beam, offering insights into the energy distribution of hadrons in the beam.
Tests of the method and a prototype device were performed on the beamlines of accelerators COSY in FZ Juliech, Proteus-235 and AIC-144 in IFJ PAN. The method itself, along with the test results confirming its effectiveness, achieved accuracies, and measurement repeatability, will be presented during the presentation.

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[2] A. Vignati and al., Phys. Med. Biol.P 65, 215030 (2020).
[3] M. Kisieliński and J. Wojtkowska, NUKLEONIKA 52(1), 3–5 (2007).

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European Spallation Source and new opportunities for Polish scientists

Author: Marek Jezabek[1]

[1] *The Henryk Niewodniczanski Institute Of Nuclear Physics PAN*

Corresponding Author: dyrektor@ifj.edu.pl

Abstract: Poland supplies a significant contribution to the construction and operation of scientific centres in European Research Area. A new world class infrastructure will start its operation in Lund in 2028. A brief history of European Spallation Source (ESS), its construction, scientific potential and plans for Steady State Operations (SSO) will be presented. A coordinated effort of Polish research groups from universities and research institutes is necessary to fully profit from nearly two decades of our involvement in this project.

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Modelling and first optimisation attempts of the JT-60SA cryoplant regime during pulsed heat load events

Author: Mercedes PARODY-GUZMAN[1]

Co-authors: Francois BONNE [2]; Louis ZANI [1]

[1] *Fusion for Energy*

[2] *CEA-IRIG*

Corresponding Authors: mercedes.parody@ext.f4e.europa.eu, louis.zani@ext.f4e.europa.eu, francois.bonne@cea.fr

The upgrade to JT-60SA tokamak (R=3m, a=1.2m) was conducted within a Europe-Japan collaboration agreement featuring the implementation of superconducting magnets. In 2021 and 2023 the magnet system commissioning was conducted, undergoing cool-down and energization of the 18 Nb-Ti Toroidal Field (TF) coils (400 tons) up to full nominal current (25.7 kA). When Poloidal Field (PF) coils were pulsed, the TF quench detection signal unexpectedly triggered punctual TF fast safety discharges (FSD) due to interferences between PF and TF systems.
When a TF FSD occurs at high currents, the actual protocol imposes a disconnection of the TF coil hydraulic circuits from the cryoplant and a release of the heated and pressurized helium in the warm quench tank to avoid overpressures in the magnet system and/or the refrigerator.
To shorten the time to recover from FSD, one would avoid disconnection provided absence of tripping risk for the Warm Compression Station (WCS) since it is even more time-consuming. In this regard, Simcryogenics was used to model the cryodistribution and simulate TF FSD to explore the possibility to avoid disconnecting the cryoplant after any TF FSD at high current. One of the driving factors in the decision is the pressure rise observed in the thermal buffer bath of the refrigerator during a FSD, preventing the WCS from being overloaded, that would otherwise induce a severe tripping.
In this paper we present a model that reproduces the experimental signals of the thermal buffer bath-during and after the FSDs. Additionally, it is used in prediction mode to investigate the behaviour of the bath when FSD occurs at 25.7 kA.
We conducted several parametric studies to explore the impact of some drivers of the bath pressure rise: the increasing rate of the pressure and a mass flowrate control over contributions to the total WCS mass flowrate. We show here some analysis and interpretations of the resulting trends obtained in the study and further conclude with a strategy proposal to manage the cryo-magnet system during a nominal TF FSD avoiding disconnection.

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An Analytical Framework for Computing AC Losses in the HTS Insert of the EU-DEMO Central Solenoid

Authors: Gianluca De Marzi[1]; Valentina Corato[1]; Monika Lewandowska[2]

[1] *ENEA*

[2] *The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences*

Corresponding Authors: monika.lewandowska@ifj.edu.pl, valentina.corato@enea.it, gianluca.demarzi@enea.it

High-temperature superconductors (HTS) are being explored for integration into coil systems for magnetic confinement fusion, due to their ability to extend operational margins in terms of temperature, current, and magnetic field. Recently, a conductor design based on the SECAS concept was proposed for the innermost layer of the central solenoid (CS) module in the EU-DEMO tokamak. The dynamic nature of plasma scenarios, characterized by rapid variations in current and magnetic fields, induces significant AC losses in the superconducting magnets. These losses can be particularly pronounced during phases like plasma start-up and control, where field variations are significant. In this study, we evaluate the instantaneous power losses —both hysteretic and coupling losses —during a baseline plasma scenario using an analytical model that accurately accounts for the temporal evolution of the magnetic field profile within the innermost layers of the CS1 HTS insert.

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The PolFEL status

Author: Robert Nietubyć[1]

[1] *National Centre for Nuclear Research*

Corresponding Author: robert.nietubyc@ncbj.gov.pl

After the transformation of the PolFEL project from an ensemble of FELs covering THz –VUV range of electromagnetic radiation, to a hybrid of accelerator-, plasma harmonics- and solid state lasers-based sources maintaining that range and supplemented with an EUV plasma jet HH generator, the ultimate arrangement of constituting elements has been frozen. The superconducting linac based on two Rossendorf-like accelerating cryomodules and including all superconducting electron gun, has been designed in order to deliver 20 pC –250 pC electron bunches to superradiant THz undulator. IR-VUV range will be covered by a set of Nd:YLF and Ti sapphire generators and OPAs enabling the flexible choice of wavelength, pulse duration and repetition rate as well as pulse shaping. The light source facility combined in this way will be complemented with a continuous wave, MeV ranged UED beamline dedicated for solid and gasous samples. Currently the major components procurement is being completed, the installation will begin in the half of 2025 aiming at the commissioning and first light in 2026. The efforts to provide a wide range tuneable and coherent electromagnetic radiation source dedicated for fundamental and applied sciences are, on the other hand, intended as an introductory step in FEL science and engineering development in Poland.

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Simulation of electron bunch compression for Ultra-fast Electron Diffraction facility at Center for Nuclear Research

Author: Jacek Sekutowicz[1]

Co-authors: Jacek Krzywiński [1]; Marcin Staszczak [1]; Paweł Czuma [1]; Paweł Krawczyk ; Robert Nietubyć [1]

[1] *National Centre for Nuclear Research*

Corresponding Authors: jacek.sekutowicz@ncbj.gov.pl, robert.nietubyc@ncbj.gov.pl, pawel.czuma@ncbj.gov.pl, marcin.staszczak@ncbj.gov.pl, pawel.krawczyk@ncbj.gov.pl

We are presenting simulation of acceleration and compression of electron bunches for ultra-fast electron diffraction (UED) experiments planned at the Centre for Nuclear Research in Poland (NCBJ). That compact UED facility, being currently under construction, will consist of electron photo-injector, accelerating superconducting HZDR/RI type cryomodule, housing two TESLA cavities and experimental chambers. The simulations showed that it is possible to produce short electron bunches with duration of few femtoseconds for the electron beam energy range of 2-9 MeV.

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Corresponding Author: robert.nietubyc@ncbj.gov.pl

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Corresponding Author: louis.zani@ext.f4e.europa.eu

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A New Linac Design for Top-Up Mode Operation of Solaris Synchrotron

Corresponding Author: roman.panas@uj.edu.pl

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The superconducting magnets of the Muon Collider –a study case for a future HEP machine - Remote

Corresponding Author: bernardo.bordini@cern.ch

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RF Devices in the Solaris Synchrotron: Applications in the Linear Accelerator and Storage Ring

Corresponding Author: krzysztof.gula@uj.edu.pl

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Simulation of electron bunch compression for Ultra-fast Electron Diffraction facility at Center for Nuclear Research

Corresponding Author: robert.nietubyc@ncbj.gov.pl

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Testing and characterization of Solid-State Amplifiers for PolFEL Accelerator

Authors: Jarosław Szewiński[1]; Konrad Chmielewski[1]; Michał Matusiak[1]; Piotr Bartoszek[1]; Tomasz Kowalski[1]

[1] *National Centre for Nuclear Research*

Corresponding Authors: konrad.chmielewski@ncbj.gov.pl, m.matusiak@ncbj.gov.pl, tomasz.kowalski@ncbj.gov.pl, piotr.bartoszek@ncbj.gov.pl, jaroslaw.szewinski@ncbj.gov.pl

PolFEL stands for Polish Free Electron Laser, the first FEL research infrastructure in Poland. It will be based on a superconducting linear accelerator using Tesla-type resonant cavities with fundamental RF frequency of 1.3 GHz. Each superconducting cavity will operate in closed loop driven by individual Solid-State Amplifier (SSA) in single cavity regulation mode. The amplifiers have been specially designed for PolFEL by Kubara Lamina S.A. company. They are designed for providing 7kW peak power in pulsed regime and 5kW of continuous wave power at 1.3 GHz. This contribution presents the test stand for the SSA, the results of long-term stability tests and characterization of the power amplifier static and dynamic behaviour.

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Testing and chracterization of Solid-State Amplifiers for PolFEL Accelerator.

Corresponding Author: piotr.bartoszek@ncbj.gov.pl

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Plastic Flow Instability in Austenitic Stainless Steels at a Wide Range of Temperatures: From Macroscopic Tests to Microstructural Analysis

Authors: Jakub Tabin[1]; Adam Brodecki[1]; Zbigniew Kowalewski[1]; Jakub Kawałko[2]; Piotr Bała[2]; Kinga Nalepka[3]

[1] *Institute of Fundamental Technological Research PAS*

[2] *AGH University of Krakow, Academic Centre for Materials and Nanotechnology, 30-059 Krakow, Poland*

[3] *AGH University of Krakow, Faculty of Mechanical Engineering and Robotics 30-059 Krakow, Poland*

Corresponding Authors: knalepka@agh.edu.pl, zkowalew@ippt.gov.pl, kubaka@agh.edu.pl, abrodecki@ippt.pan.pl, jtabin@ippt.pan.pl, piotr.bala@agh.edu.pl

Deformation-induced phase transformation stabilizes the macroscopic shear band propagation in the metastable austenitic stainless steels (304, 316L). At room temperature, this strain localization arises only in the metastable 304 ASS at the final stage of the tensile test. The front, where the strain drop reaches almost 10%, propagates continuously through the specimen. Temperature decrease to 4K diametrically changes the nature of the shear band. Its propagation is sequential and discontinuous and starts at the beginning of a tensile test. The formation of an individual shear band induces a rapid drop of stresses followed by their gradual growth in the elastic and plastic range, which proceeds in an adjacent area belonging to the next band. The phase transformation is concentrated at the boundary of the shear band, where two different deformation fields are in contact.

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Analysis on the results of the Quench Experiment taking into account variable contact strands-jacket heat transfer coefficient

Corresponding Author: monika.lewandowska@ifj.edu.pl

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Simplefied Model of Thermo-Fluid Processes in Forced Flow

Corresponding Author: slawomir.pietrowicz@pwr.edu.pl