6th Workshop

Energy for Sustainable Science

at Research Infrastructures

29/30 September 2022

ESRF Grenoble, France

Organized by CERN / ESS / DESY / PSI / ERF,
hosted by ESRF

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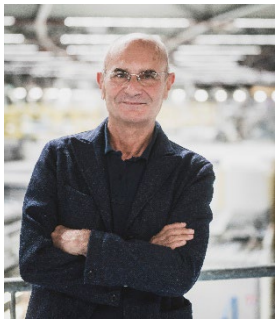
PREFACE BY F SETTE



It is my great pleasure to welcome you to the workshop “Energy for Sustainable Science at Research Infrastructures (ESSRI) 2022”, which is jointly organised by CERN, DESY, ERF member laboratories, ESRF, ESS, PSI, and in cooperation with the IFAST programme. ESRF is very happy to host this important workshop, also in consideration of the fact that we just celebrated (25 August 2022) two years of successful operation of the new ESRF - Extremely Brilliant Source, a new generation of high-energy synchrotron light source with many new important features including a major reduction of energy consumption.

The energy and climate change crisis has exposed the crucial importance of advancing more sustainable and innovative technologies to continue to develop affordable energy, jobs, economic growth and a cleaner environment for future generations.

Science has, without a doubt, a major role to play, and in particular at big science facilities, where we are constantly pushing the frontiers of knowledge and technology to the highest levels of excellence and inventiveness.

Sharing the same values for scientific excellence for the benefit of humankind and our planet, we must act together to address the complex and pressing climate and energy crisis that we are facing worldwide but also to reduce the carbon footprint of our own research activities.

Today, more than ever, the ESSRI workshop is highly relevant. With this in mind, I wish you stimulating discussions and the achievement of results that will highlight the key role of our research infrastructures in developing a better world.

I would like to express my sincere gratitude to the organisers, speakers and chairs for all their efforts to prepare an exciting programme, and I wish you a very successful and productive workshop.

Francesco Sette

Director General ESRF

WELCOME

Given the current situation regarding climate change and the energy crisis, this sixth workshop on Energy for Sustainable Science in Research Infrastructures (ESSRI) comes at an important time. Over the past decade, the rapid evolution in climate change has made us acutely aware of the swiftly deteriorating situation and scarcity of resources. Now the facts are in and we are almost all convinced of the influence of human activities on climate change. Our organizations need to act responsibly on energy consumption (reduction in consumption, energy efficiency and recovery,….) and on the transfer of technology towards society in the broad field of sustainability. In this context, it is important to show the relevance of our research and at the same time show that the technologies developed are useful to society: physics is beautiful and useful!

For more than 10 years, we have demonstrated the importance of sharing our practices in the field of energy as well as in water management and more broadly in the field of the environment. It is also essential to combine our efforts to carry out joint research programmes and thus avoid a duplication of effort. In this context, the construction, rationalization and operation of joint facilities is also crucial.

Most research infrastructures are already engaged in programmes to reduce their carbon footprint. However, the recent energy crisis, with its soaring operating costs, has highlighted the vital need to accelerate this approach and save even more energy. Many of the facilities represented here are looking to the long-term future, and it is vital that this is done with energy efficiency programmes in mind. Today, the urgency of the situation also requires short and medium term actions. This series of workshops, initiated in 2011, comes at the right time to bring together experts and stakeholders concerned by all these issues.

The number of topics to be addressed is large and we cannot expect to cover them all in less than two days. The International Organizing Committee has put together this programme in the continuity of past events, with an emphasis on recent achievements. We have avoided repeating topics that have already been discussed in previous workshops, but we wanted to follow up on the progress of the most important actions discussed previously.

We have also selected reports from facilities or institutes that have initiated significant actions. Technical issues and challenges are also discussed in relation and complementarity to the thematic workshops or conferences. Our research infrastructures mainly consume electrical energy. Most of the discussions will therefore focus on reducing and optimizing electrical energy consumption. The sharp increase in costs is now seriously affecting the projects and daily operations of the institutes. We are also convinced that the optimisation of cooling is becoming an important topic.

Although there is a large contribution from European countries, this workshop is international, and we are happy to have participants and speakers from all over the world, especially from the USA and Japan.

2022 is the International Year of Basic Sciences for Sustainable Development. YBSSD2022 aims to help highlight the crucial role of basic sciences for sustainable development and their contributions to the implementation of the 2030 Agenda and the achievement of the Sustainable Development Goals (SDGs). We are proud that this sixth ESSRI22 workshop is part of the YBSSD2022 calendar.

With the health crisis due to COVID, we preferred to postpone the sixth workshop by one year to allow it to be held in person in order to promote exchanges between participants.

The next event is planned for autumn 2024 and the venue will be announced at the end of this workshop.

We have had great pleasure in preparing this programme and welcome you to our sixth workshop. We have an important task ahead of us both in terms of the sustainable operation of our research infrastructures and their contribution to the environmental problem. We are convinced that this 6th ESSRI workshop has much to contribute to this task.

INTERNATIONAL SCIENTIFIC COMMITTEE

Carlo Bocchetta – ESS
Frederick Bordry – CERN
Serge Claudet – CERN
Andrew Harrison – ERF
Jean-Luc Revol – ESRF
Mike Seidel – PSI
Denise Voelker - DESY

LOCAL ORGANISING COMMITTEE

Sandra Cardot – ESRF
Philippa Lean – ESRF
Anne-Françoise Maydew – ESRF
Jean-Luc Revol – ESRF

PROGRAMME
6TH WORKSHOP ON ENERGY FOR SUSTAINABLE SCIENCE AT RESEARCH INFRASTRUCTURES

Organized by CERN/ESS/DESY/PSI/ERF. Hosted by ESRF.

THURSDAY, 29 SEPTEMBER 2022

	Plenary Session		
	Room: ESRF Auditorium		
	Convener: F. Bordry, CERN		
09:00	Welcome – F. Sette, ESRF Director General		
09:10	Introduction – F. Bordry, CERN		
09:20	Practical information – JL. Revol, ESRF		
09:30	Climate change is accelerating. We need to move much faster – M. Jarraud, World Meteorological Organization		
10:00	Energy Transition: towards a complex cyber-physical system of systems – L. Saludjian, RTE		
10.30	Coffee break & Photo – ESRF Central Building Entrance Hall		
11:15	Electrical Flexibility Market – B. Remenyi & C. Gaunand, Energy Pool		
11:45	Energy management at Stanford University – L. Bleveans, Stanford University		
12:15	ERLs and Sustainability – A. Hutton, Jefferson Lab		
12:45	Lunch - onsite restaurant		
	Parallel Session Energy efficient technologies		Parallel Session Energy management at research infrastructures
	Room: MD-1-21		Room: ESRF Auditorium
	Convener: D. Voelker, DESY		***Convener: JL. Revol, ESRF***
14:00	Challenges of a megawatt CW class solid state power amplifier for the SPS at CERN – E. Montesinos, CERN		An overview of the status of energy sustainability at the European Spallation Source (ESS) – M. Eshraqi, ESS
14:25	Progress with permanent magnets and return on experience – J. Chavanne, ESRF		Energy optimisations implemented at accelerators and infrastructures at PSI – D. Reinhard, PSI
14.50	Free Air cooling solution for the Data Centers – L. Roy, CERN		Energy management at High Magnetic Field Facilities – F. Debray, CNRS Grenoble
15:15	Energy management University Darmstadt – C. Ripp		ESRF EBS energy management – C. Nevo, ESRF

THURSDAY, 29 SEPTEMBER 2022

15.40	Coffee break – ESRF01		
	Parallel Session How will projects deal with energy and sustainability		Parallel Session Energy management at research infrastructures and materials
	Room: MD-1-21		Room: ESRF Auditorium
	Convener: M. Eshraqi, ESS		***Convener: S. Claudet, CERN***
16:00	Sustainability at Fermilab and the PIP-II Project – T. Price, Fermi National Accelerator Laboratory		A big science facility as a living-lab for energy transition: the LNCMI use case – F. Wurtz, G2ELAB-CNRS-UGA
16:25	Sustainability studies for Linear Colliders – S. Stapnes, CERN		ISO 50001 Energy management – N. Bellegarde / S. Claudet, CERN
16.50	Investigating energy futures: The KITTEN test facility for sustainable research infrastructures – G. De Carne, KIT		Water, reduction in consumption and treatment of effluents from cooling towers – S. Deleval, CERN
17:15	Sustainable accelerator R&D in the UK – B. Shepherd		Rare earth and Life cycle management – D. Voelker, DESY
17.40	Closeout		Superconducting alternative magnets – L. Rossi, INFN
18.05	Closeout		Closeout
19:00	Workshop Cocktail & Dinner, ‘Bouillon A’ restaurant, Grenoble		

FRIDAY, 30 SEPTEMBER 2022

	Plenary Session
	Room: ESRF Auditorium – ESRF Central Building
	Convener: F. Bordry, CERN
08:30	Summary: Energy efficient technologies – D. Voelker, DESY
08:45	Summary: How will projects deal with energy and sustainability? – M. Eshraqi, ESS
09:00	Summary: Energy management at research infrastructures – JL. Revol, ESRF
09:15	Summary: Energy management at research infrastructures and materials – S. Claudet, CERN
09:30	Summary: Energy management for the Future Circular Collider (FCC) – JP. Burnet, European Organisation for Nuclear Research
10:00	Efforts to save Energy consumption in KEK accelerator facilities – T. Koseki, KEK
10.30	Coffee break – ESRF Central Building Entrance Hall
10:50	Advanced energy concepts and energy efficiency – HJ. Eckoldt, DESY
11:20	Transmutation of Nuclear Waste with Accelerator-driven Systems – M. Bourquin, Genova University
11:50	EBS: A New Light for Science - first scientific highlights – M. Krisch, ESRF
12:20	Closing remarks and next workshop – JL. Revol, ESRF & JM. Perez, CIEMAT
12:35	Take-away lunch
13:30	Facility tours (optional): ESRF, LNCMI
16:00	End of workshop

ABSTRACTS
THURSDAY, 29 SEPTEMBER 2022

PLENARY SESSION

Climate change is accelerating. We need to move much faster

Michel Jarraud, World Meteorological Organisation

I will first share with the audience the latest scientific information with respect to Climate Change: information from the recent IPCC 6th assessment report, WMO State of the climate 2021 ... I will then present the challenges we are facing to translate this knowledge into action, as well as the fast growing urgency of such action. I will analyse progress (or insufficient progress) since the Paris agreement, 7 years ago and I will elaborate on what we should expect from the next COP meetings. I will also develop the link with some other major global issues, such as Sustainable Development. I will finish by sharing some personal reflections on what should be key priorities over the next few years.

Energy Transition: towards a complex cyber-physical system of systems

Lucas Saludjian, RTE

Achieving carbon neutrality will require transforming the economy and lifestyles, and restructuring the power system in such a way as to allow electricity to replace fossil fuels as the country's leading energy source.

This presentation gives an overview of the changes that affect the physics of electrical systems in the future and that force to rethink the control of the system in its new complexity. Beyond this (r)evolution of power system, the need for very different types of flexibilities will be mandatory to ensure security of supply in the different scenarios provided by RTE for the 2050 horizon. There is an economic case for increasing demand-side management, expanding interconnections and hydropower storage, and installing batteries to support solar power. Additionally, new thermal power plants fuelled by decarbonised gas (including hydrogen) will be necessary if the nuclear revival is minimal.

Electrical Flexibility Market

Bernadette Remenyi & Corentin Gaunand, Energy Pool

Energy Management at Stanford University

Lincoln Bleveans, Stanford University

Climate change is changing everything at Stanford University, with comprehensive decarbonization at the forefront. In 2015, we commissioned a first-of-its-kind, $500 million district thermal energy system. That system, in turn, is now powered by 100% renewable energy. In the meantime, we are

pushing the envelope of building energy efficiency and instrumentation and control across a diverse and demanding built environment. And we've only just begun – from transportation electrification to resource recovery to deep digitalization – for Stanford's 24/7 operational benefit; to meet our aggressive sustainability, resilience, and justice goals; and as a living lab and global exemplar. My presentation brings the audience along for a deep dive into Stanford's one-of-a-kind sustainability, operational decarbonization, and district energy journey. It's a challenging and wonderful ride and, again, we have only just begun.

ERLs and Sustainability

Andrew Hutton[1] and Max Klein
[1]Jefferson Lab, USA, [2]University of Liverpool, UK

In any new accelerator proposal, sustainability issues will be heavily scrutinized, be that in electricity and water use, the overall efficiency of the facility, including reusing the heat for other purposes (space heating, biogas production, etc.) or energy recycling. These aspects are important for all new facilities, but ERLs bring a new dimension. Directly returning the energy of an unused beam into RF that can be used for acceleration with practically no losses is a unique feature of ERLs. While not all of the energy can be recovered, the overall efficiency of the process is extremely high. This advantage starts with a reduction in the RF power needed for acceleration, which translates into smaller RF sources and their associated power transformers (reducing the resources needed for their production), and less electric power and water cooling required (reduced operating costs as well as a reduced carbon footprint). Given the inherent advantages of ERLs, it is to be expected that their sustainability profile will eclipse other colliders with similar physics potential.

PARALLEL SESSION

ENERGY EFFICIENT TECHNOLOGIES

Challenges of a megawatt CW class solid state power amplifier for the SPS at CERN

Eric Montesinos, CERN

Within the frame of our LHC Injector Upgrade program, CERN decided to build two new amplifiers of 2 MW cw operating at 200 MHz. These amplifiers are based on Solid State technology, and use Cavity Combiner systems to reach the required power levels. After a quick review of the challenges we had to face during the design phase of this new amplifiers, the commissioning and the performances obtained during the first years will be presented. Availability being the key word with respect to global efficiency, hints to improve the wall-plug efficiency with a large RF amplifier will also be proposed.

Progress with permanent magnets and return on experience

Joel Chavanne, ESRF

Since January 2020, the ESRF is operating the Extremely Brilliant Source (EBS) with a horizontal emittance of 130 p.m.rad for the stored electron beam. Due to an obvious need to reduce the electrical power

consumption, the magnet lattice of the storage ring includes 128 permanent magnet dipoles (4 per cell) with longitudinal gradient (DLs) corresponding to a total length of 230 m. After more than two years of operation the stability versus time of the DLs magnets has received preliminary studies with positive outcomes. This experience suggests further use of permanent magnet for other type of magnetic structures such as combined function magnets (dipole/quadrupole) or high gradient quadrupoles: a central subject in several projects of ultra-low emittance storage ring based sources.

Free Air cooling solution for the Data Centers

Laurent Roy, CERN

Two CERN LHC Experiments (Alice and LHCb) did a major upgrade of their detectors and electronics associated in 2019-2021. An increase of computing power had been needed to treat the much larger data flow that will be produced by the Experiments starting in 2022.

The last server generations (their CPUs) can run in hotter air than in the past. Using outside air to cool down the servers and be complying with their specifications is now possible. It reduces drastically the energy footprint of the cooling part.

The modular free air-cooling Data Centers 2MW recently put into operation will be presented, with in particular their energy efficiency. Also, a new Data Center project of several MW for CERN IT computing will be evoked. The construction of a standard building is started, it will be based on free air-cooling technology, a heating recovery system is also foreseen.

Energy management University Darmstadt

Christopher Ripp, TU Darmstadt

Effective measures against the climate change steadily increase the complexity of the management of our energy systems. The factors are manifold: how do we integrate renewable volatile generation, how is the overall system optimally to be operated, when and how do our actions cause less CO2 emissions and what are our energy consumption related CO2 emissions in the first place. Moreover, the managerial scope no longer concludes only one form of energy, e.g., electricity, but considers multiple forms in parallel. This multi-energy perspective or so called sector-coupling enables the identification of inter-sectoral efficiency potentials. Digitization can support us, humans, with our limited comprehension capabilities to deal with this increasing complexity by processing the sheer amount of data or information and hence, empowers us to effectively manage these systems.

At the Technical University of Darmstadt as a part of the research project "EnEff Campus Lichtwiese", we created a multi-energy web platform of the energy system of the Campus Lichtwiese, which was conceptualized on the basic idea of the "digital twin". This platform offers an intuitive access to the data of the realized, comprehensive multi-energy monitoring in near real time. Moreover, the platform connects other public data sources such as the ENTSO-E Transparency platform. A prominent result is the transparency of time-dependent, consumption-related CO2 emissions of all of the campus' buildings over all energy forms. This developed platform demonstrates how future multi-energy management can be supported by appropriate digitalization and how the concept of the "digital twin" can also be applied to complex

energy systems to support experts and decision makers in their managerial processes.

PARALLEL SESSION

ENERGY MANAGEMENT AT RESEARCH INFRASTRUCTURES

An overview of the status of energy sustainability at the European Spallation Source (ESS)

Mamad Eshraqi, ESS

The ESS has been designed and built with energy sustainability in its project vision: use of sustainable energy, heat recovery and energy efficiency. The ESS started as a green field project and the ecological value and wellbeing of the site and surroundings were taken into consideration from the very start. Heat recovery from the cooling systems has been implemented to provide heating for regional municipalities and the newly built office buildings are state of the art in sustainability. These buildings were accredited with an outstanding BREEAM award and are one of the top 20 office buildings in the world for 2021. Energy efficiency has been taken into account when designing and building technological plants, such as the cryogenic systems and the major energy consuming components of the linear accelerator. The talk will cover all these aspects of the ESS project.

Energy optimisations implemented at accelerators and infrastructures at PSI

David Reinhard, Section Leader Building Technical Infrastructures; PSI

Following the Energy Mission of PSI as well as legal Obligations PSI has systematically identified and executed various energy optimization measures. In total over 70 projects where executed since the beginning of the systematic recording in the year 2013. The presentation will provide an overview of the overall investments, savings and its economical benefits. Typical examples are presented, for example in the categories operational measures, cryogenics, heat recovery, cooling, HVAC or lightning. Furthermore, an outlook of remaining potentials will be made, especially on the energy optimisations planned with the upgrade of the Swiss Light Source.

Energy management at High Magnetic Field Facilities

François Debray, CNRS

Few Research Infrastructures worldwide are providing high magnetic fields to users beyond the State of the Art of Superconductivity.

For this purpose copper-based electromagnets are set into operation. Most of the users are sweeping the magnetic field during their experiments.

A high field facility is then characterised by a rather "low" annual consumption (~10 GWH) if one considers the high power installed (20 to 30 MW) to reach the maximal magnetic field. In Europe the two DC magnetic field facilities located in Grenoble and in Nijmegen act together in the EMFL consortium. We will describe progresses made by these facilities to optimize the usage of energy.

An emphasis will be given on heat recovery and services to the electric grid.

ESRF EBS energy management

Christian Nevo, ESRF

The ESRF, located in Grenoble France, is a facility supported and shared by 22 partner nations. This light source, in operation since 1994, has been delivering 5500 hours of beam time per year on up to 42 beam-lines. The chain of accelerators consists of a 200 MeV linac, a 4 Hz full-energy booster synchrotron and a 6 GeV storage ring (SR) 844 m in circumference. A large variety of insertion devices are installed along the 28 available straight sections. Bending-magnet radiation, now produced by short bends and wigglers, is used by 12 beamlines. Since 2009, the ESRF has embarked on an upgrade programme of its infrastructure, beamlines and accelerators. The second phase (ESRF-EBS, 2015-2022), saw the design and the installation of a new storage ring based on a hybrid multi-bend achromat (HMBA) replacing the double-bend lattice. Reducing the horizontal emittance from 4 nm rad down to 133 pm rad allows a dramatic increase in brilliance and coherence.

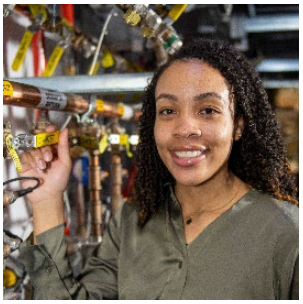
The energy consumption is a critical issue for our institute, not only by its impact on our carbon foot print but also in terms of the budgetary burden it represent. The ESRF-EBS has a significant positive impact on the ESRF electricity bill, however, the general context of soaring electricity price and, more recently, the government's call for greater sobriety impose to take further actions for reducing our electricity and heating consumption. For both the accelerator and the facility we must identify and implement all possible actions to improve the efficiencies of our processes and operate with energy saving constraints in mind. This talk reports on the current situation and evolution since the creation of the institute, highlighting the ongoing and planned evolution.

PARALLEL SESSION

HOW WILL PROJECTS DEAL WITH ENERGY AND SUSTAINABILITY?

Sustainability at Fermilab and the PIP-II Project

Tiffany Price, Fermi National Accelerator Laboratory



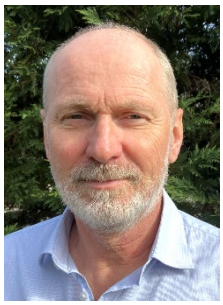
The Proton Improvement Plan-II, or PIP-II, is an essential enhancement to Fermilab's particle accelerator complex that will power the world's most intense high-energy beam of neutrinos for the Deep Underground Neutrino Experiment (DUNE). PIP-II will use the latest advancements in superconducting radio frequency (SRF) technology to construct an 800 MeV H- SRF linear accelerator and provide upgrades to the existing booster, main injector, and recycler rings in the accelerator complex.

This large-scale and high energy linac will consume a significant amount of electrical power. With rising energy costs, increasing environmental concerns resulting from climate change, and federal mandates regarding sustainability, it is critical that Fermilab and the PIP-II project implement sustainability and energy efficiency strategies into the design and operation of this groundbreaking facility.

In this talk an overview of Fermilab and PIP-II will be provided, followed by a discussion of sustainability and energy efficiency measures that PIP-II is exploring and how those fit into the lab-wide sustainability plan.

Sustainability Studies for Linear Colliders

S. Stapnes, CERN, Switzerland
B. List, DESY, Hamburg, Germany
S. Michizono, KEK, Tsukuba, Japan



Two large electron-positron linear colliders are currently being studied as potential future Higgs-factories, the International Linear Collider (ILC) in Japan, and the Compact Linear Collider (CLIC) at CERN, Switzerland. The former is based on Super-Conducting 1.3 GHz RF technology and will start operation at 250 GeV (with length ~20.5km) centre-of-mass energy and the latter is based on room temperature 12 GHz copper RF structures starting at 380 GeV (~11.5km). The initial luminosities are in both cases estimated to be around 1.5-2.5 x 1034 cm-2s-1, but either facility would be upgradable in energy and luminosity as part of a longer term electron-positron collider programme.

Sustainability considerations, in addition to the more traditional cost concern and need for developing core technologies, are today the primary R&D drivers for the projects.

Concerning energy consumption, both colliders have a power consumption in the ~110 MW range, in their initial configurations. Turning these power numbers into yearly energy consumption gives estimates ~600-700 GWh. As a reference CERN uses around 1.2 TWh of electricity yearly.

To achieve these numbers and address sustainability more generally, several dedicated studies have been conducted. Among these are:

- The designs of ILC and CLIC, including key performance parameters as accelerating gradients, pulse lengths, bunch-charges and luminosities, have been optimised for cost but also increasingly focusing on reducing power consumption.
- Technical developments targeting reduced power consumptions at system level, primary examples are developments of high Q and high gradient SC cavities, high efficiency klystrons, and super conducting and permanents magnets for damping rings and linacs.
- Local impact studies of establishing ILC as a new laboratory in the Tohoku region in Japan. These studies focus on use and production of local materials for construction, utilizing waste heat, reducing the ecological footprint, use and development of local infrastructure benefitting the entire community, availability of “green” energy and other key resources for establishing a new large laboratory, etc.
- The possibility of making use of the fact that the linear colliders are single pass, i.e. the beams and hence power are needed “shot by shot”, possibly allowing to operate in daily or weekly time-windows when power is available in abundance from suppliers and costs are reduced. Seasonal operation is already being used for energy cost reasons.
- Estimating the renewable power that can be made available for running the colliders by investing for example 10% of the overall construction costs in solar and wind energy capabilities, again profiting from the fact that single pass colliders can quickly adapt to changes in energy output from such sources.

In many cases the studies mentioned are still on-going and the programme for further work will also be presented. For example, a full analysis of the start to end environmental impact including carbon footprints will still need to be done for ILC and CLIC.

Investigating energy futures: The KITTEN test facility for sustainable research infrastructures

Giovanni De Carne, Karlsruhe Institute of Technology

To efficiently and reliably enable the operation of future large-scale research facilities, it is indispensable to conduct multi-area and multi-disciplinary research, taking into account in the facility design not only scientific aspects, but also energy-related challenges. At the Karlsruhe Institute of Technology (KIT), the innovative research laboratory KITTEN has recently been developed, connecting two of the largest research infrastructures at KIT: the particle accelerator KARA, and the energy research facility Energy Lab 2.0. The goal of KITTEN is to study in a comprehensive and multi-disciplinary way novel solutions for improving the energy use in particle accelerators, and, in general, in any energy-intensive research infrastructure. The questions to be addressed in the joint research encompasses the impact of new grid architectures, the integration of various storage technologies, novel efficient hardware, control strategies, and the seamless integration of renewable energy sources. This presentation will introduce the KITTEN research infrastructure and will describe the current research activities at KIT that have been developed in the direction of energy efficient and sustainable research infrastructure.

Sustainable Accelerator R&D in the UK

Ben Shepherd, STFC Daresbury Laboratory

Accelerators are inherently energy-hungry facilities and consume a large amount of material resources in their construction. This talk describes the work of STFC's Sustainable Accelerators Task Force, which has the aim of reducing the climate impact of accelerator facilities. Several of ASTeC's R&D activities in this area are presented here. We are undertaking a complete lifecycle analysis of accelerators, encompassing design, construction, operation, maintenance, and final decommissioning. We analyse each individual subsystem, assessing the facility's overall carbon footprint and identifying areas where significant savings can be made. We use a mid-scale facility, RUEDI, as a case study, but with wider applicability for accelerators in general.

PARALLEL SESSION

ENERGY MANAGEMENT AT RESEARCH INFRASTRUCTURES AND MATERIALS

A big science facility as a living-lab for energy transition: the LNCMI use case

Frédéric Wurtz, G2ELAB/CNRS/UGA

Faced with the climate problem, and the mandatory energy transition associated to it, humanity is facing the greatest challenge in its history. If big science facilities contribute firstly to fundamental science, we will illustrate how they can also be “living-labs” for observation, development and test at real scale of key questions of energy transition, and this as social and technical nodes of intense energy consumers included in energy networks. This will be illustrated by the case of LNCMI as an electro-intensive and flexible electricity consumer and a possible producer

of wasted heat that can be locally valorized. We will especially focus on observations and production of scientific and technical data, methods and tools associated to those challenges in an Observatory of Transition for Energy.

ISO 50001 Energy Management
Nicolas Bellegarde, CERN
(To be presented by Serge Claudet)

With the growing environmental awareness of the recent decades, CERN strives to be an example for environmentally-friendly research. Energy is one of the factors in reducing the Organization's ecological footprint. In continuation with efforts to improve energy efficiency since 2015 through the Energy Management Panel (EMP), the Organization has initiated the process of obtaining the ISO 50001 certification for energy management. This process requires to define the Laboratory's energy baseline and energy performance indicators covering the Organization's main energy uses. It then sets objectives and energy targets and a plan to achieve them. Getting the certification also entails reviewing and completing CERN's energy policy, designing new tools to measure performance, and organising formal audits carried out by an accredited certification body. This talk will cover the current status towards the certification, detailing the completed, ongoing and future steps.

Water, reduction in consumption and treatment of effluents from cooling towers
Serge Deleval, CERN

CERN accelerators and Experiments require a cumulative cooling power of more than 400 MW. This primary cooling is carried out by means of open wet cooling towers, consuming a substantial quantity of water. For the past 20 years, CERN has been working on the rationalisation of its water consumption, which has been reduced by 20% in the last two decades, while the overall cooling need has increased by 100% in the last 10 years, mainly due to the LHC operation. In addition to the work performed on used and rejected water quantities, CERN has implemented solutions to improve the quality of rejection and to reduce the impact of the water treatment on the environment. The deployment of these solutions was planned over several years and is ongoing. Long Shutdown provided opportunities to achieve part of the work on CERN's Meyrin site. 2021 was a full run year of operation for LHC injectors, accelerators, and experimental areas, allowing data collection and performance confirmation of these solutions. The author will present the main technical aspects of the above-mentioned solutions, the results achieved so far and the implementation planning for the coming years.

Rare earth and Life cycle management
Denise Völker, DESY

The high-tech components of research infrastructures such as accelerators consist of valuable materials such as rare earth metals for permanent magnets or niobium for cavities. Many of these materials are being mined, produced and processed under poor and critical environmental

and social conditions. Their mining operations are often in conflict with other forms of land use or are connected to ancient forest destruction. At the same time the usage of such materials enables high level research to tackle the grand challenges of the future, make research infrastructures much more efficient and can save a lot of valuable energy. Scientific institutions therefore must consider the entire life cycle of accelerators, laboratories etc., including questions of origin of components as well as recyclability at the end of the infrastructure's life span.

Superconducting alternative magnets

Lucio Rossi, INFN

This work concerns the initial development of the idea to use low-field, low-cost MgB2 superconductor for low field magnets in use in particle accelerator based facility: 1) to replace normal conducting beamline magnets which have very high dissipation. 2) to propose a type of high order beamline magnets for new facilities. The common feature of these superconducting magnets is the operation at temperature higher than liquid helium, about 10-20 K, by using cryocooler and indirectly cooled coils, which may give a considerable power reduction, and non-negligible energy saving, with respect to use of classical superconducting like Nb-Ti operating at liquid helium or normal conducting magnets with classical water cooling.

ABSTRACTS
FRIDAY, 30 SEPTEMBER 2022

PLENARY SESSION

Energy management for the Future Circular Collider (FCC)

Jean-Paul Burnet, European Organisation for Nuclear Research

The FCC-ee will be the largest accelerator ever built with kilometers of different accelerator devices. The identification of the main loads is crucial for designing the electricity infrastructure and for evaluating its energy consumption. An update of the FCC power demand is ongoing with the evaluation of its annual energy consumption depending on the machine configurations. The next step is to identify how energy consumption can be reduced, by design and optimization of equipment and systems, and by optimization of the operation mode of the accelerators and their infrastructures. The goal is to identify where the effort needs to be focused to reduce the environmental impact of the project. Potential energy recovery will be addressed.

Efforts to save Energy consumption in KEK accelerator facilities

Tadashi Koseki, KEK

In KEK, there are three large accelerator facilities which are in operation for international users; (1) the SuperKEKB collider, (2) light sources named PF (Photon Factory) and PF-AR (PF-Advanced Ring), and (3) J-PARC (Japan Proton Accelerator Research Complex). After the large earthquake in March of 2011, we have drastic increase of the electric cost in Japan. In this talk, some efforts to save energy consumption in the KEK accelerator facilities are presented.

Advanced accelerator concepts and energy efficiency
(Sustainability as a core „Leitmotif“ at DESY)

Hans-Joerg Eckoldt, Group Leader Machine Power Converter, DESY, Hamburg

Sustainability is being rediscovered by modern society as an essential element to ensure continued livability and even survival on our planet. DESY has embraced this necessity to act and sees it as part of our societal duty to contribute to solutions through science, technology, way of doing business and cultural changes. We will discuss our goals, and both short and mid-term strategy and practical steps that are being taken to achieve them. Specifically, we will discuss R&D towards more compact plasma-based advanced accelerators, the potential energy efficiency they offer, and what the steps are to advance this technology.

Transmutation of Nuclear Waste with Accelerator-Driven Systems

Maurice Bourquin, Genova University

The main issues associated with a more sustainable nuclear energy production could be solved, in a large part, if substantial investments could be invested in the technology of nuclear transmutation. A particularly important aspect is the reduction of long lived nuclear waste. The main scientific research in this domain has been performed at the CERN laboratory and at the Paul Scherrer Institute in Switzerland. The practical implementation now requires the development of high power accelerators, subcritical assemblies cooled by heavy liquid metals, thorium fuel treatment facilities and powerful simulation codes. I will present the status of the technology in the world and the perspectives.

EBS: A New Light for Science - first scientific highlights

Michael Krisch, ESRF

The ESRF is the first high-energy, fourth-generation synchrotron, which constitutes a landmark for fundamental and innovation-driven research. With the support of the ESRF’s international partner countries, a brand-new generation of high-energy synchrotron, the ESRF’s Extremely Brilliant Source (EBS) was launched in 2020 with superior X-ray performances (up to a factor 100) in terms of brilliance, coherence and emittance. In the quest to push the boundaries of knowledge and technology for the benefit of society, EBS produces the most brilliant X-rays to unveil the structure of matter. Thus, EBS provides scientists from all over the world with new opportunities to pioneer new fields of investigation for fundamental research, also permitting unprecedented analysis and understanding of materials down to atomic resolution. Based on scientific excellence, research carried out with the EBS contributes to addressing the complex global challenges that our society faces, such as health, energy and the environment. Pushing the frontiers of science, ESB makes the invisible visible, unveiling the secrets of matter to advance fundamental knowledge and new applications, covering biomedical science, novel materials for energy, extreme conditions (planetary research and geoscience, cutting-edge materials), nanomaterials, etc. It also contributes to the development of new and clean technologies for industry and to preserving humanity’s cultural heritage, lighting the way to a brighter, sustainable

and peaceful future.

This talk will present the EBS benefits, its exploitation and the new experimental capabilities available to academic and industrial users in Physical and Life Sciences. The first scientific highlights from the main flagship and refurbished beamlines will be briefly described. Like a super-microscope, the presentation will illustrate how the enhanced performance of the X-rays, combined with new stations and state-of-the-art instruments, will revolutionize biomedical phase-contrast imaging, and will make the study the structure of condensed matter possible at the nanometre scale under operando or extreme thermodynamical conditions with higher resolution, greater image quality and faster framerate. Finally, this presentation will give a summary of the status of the beamlines under construction, their design choices and strategic research, a snapshot of its present status and some considerations of their future perspectives.

ORGANISING INSTITUTIONS

ESRF

The ESRF, the European Synchrotron, an international research facility supported by 21 countries, based in Grenoble, France, is the most intense source of synchrotron-generated light, producing X-rays 100 billion times brighter than the X-rays used in hospitals. These X-rays, endowed with exceptional properties, are produced at the ESRF by the high energy electrons that race around the storage ring, a circular tunnel measuring 844 metres in circumference. After nearly 30 years of operation, on August 2020, the ESRF opened its completely rebuilt x-ray source, ESRF-EBS (Extremely Brilliant Source), the world's first fourth-generation high-energy synchrotron. ESRF-EBS opens new vistas for X-ray science in imaging condensed and living matter from metre to nanometre scales, enabling scientists to address the global challenges facing our society such as health, climate change and environment, but also energy and innovative industry.

Each year, the demand to use these X-ray beams increases and near to 9000 scientists from around the world come to Grenoble, to "beamlines", each equipped with state-of-the-art instrumentation, operating 24 hours a day, seven days a week.

CERN

ERN (www.cern.ch), the European Organization for Nuclear Research (Organisation Européenne pour la Recherche Nucléaire), is a European research organization that operates the largest particle physics laboratory in the world. Established in 1954, the organization is based in Geneva on the Franco–Swiss border, and has 23 member states and 10 associate member states.

CERN's mission is to provide a unique range of particle accelerator facilities that enable research at the forefront of human knowledge, to perform world-class research in fundamental physics, to unite people from all over the world to push the frontiers of science and technology, for the benefit of all.

The landmark discovery of the Higgs boson at the Large Hadron Collider (LHC) ten years ago, and the progress made since then to determine its properties, have allowed physicists to make tremendous steps forward in our understanding of the universe

ERF-AISBL

ERF-AISBL (www.erf-aisbl.eu) has the not-for-profit purpose to promote the cooperation and the projects between European level research infrastructures which are open, at international level, to external researchers. These Infrastructures include national infrastructures as well as European networks and consortia of research infrastructures. Since 2013 ERF has been recognized as an AISBL (Association Inter nationale Sans But Lucratif) according to the Belgian law, taking the place of the former ERF de facto association. In order to promote the cooperation and the projects between European-level research infrastructures the Association acts as a single voice, representing the Members with decision-makers, in particular at EU and international level; encourages the coordination, the development, the setting- up and the operation of high quality infrastructures, open at world level, contributing to the strength of the European Research Area, also through high level workshops and meetings; helps in the creation of mechanisms and best practices for an appropriate allocation of funding and resources by the European

States and the EU, to ensure the best response to international users requirements and to societal challenges; facilitates the availability of resources (human, financial, instrumental) for high quality research infrastructures by encouraging the cooperation of the members, also through the initiation of specific joint initiatives, training courses or consortia; facilitates and support the collection and the access to data relevant for users, policy makers and other stakeholders; develops and implements specific projects of common interest, supported by the EU and/or international funding; supports the development of strategic planning and forward looking at national and international level.

ESS

The European Spallation Source (ESS) (www.europeanspallationsource.se) is one of the largest science infrastructure projects being built in Europe today. The ESS has the objective to be the world's leading research facility using neutrons, providing the tools for analysis that will enable the next important discoveries in nanotechnology, life science, pharmaceuticals, materials engineering, and experimental physics. It will also be the first large scale research facility that will be environmentally sustainable.

Organized as a European Research Infrastructure Consortium, or ERIC, this next-generation research facility is being built through the collective global effort of hundreds of scientists and engineers from institutes and laboratories in the Member Countries throughout Europe. Located in Lund (Sweden), next to the world-leading synchrotron light source MAX IV, it will be an economic driver for all of Europe, serving up to three thousand guest researchers from universities, institutes and industry each year. ESS construction formally began with the Groundbreaking Ceremony on September 2, 2014. All civil works and utility services are completed and the ESS and partners are in an intense phase of installing and commissioning the state-of-the-art technological contributions in order to deliver first neutrons in 2024.

DESY

DESY is a national German research center and member of the Helmholtz Association. Researchers use the large- scale facilities at DESY to explore the microcosm in all its variety – from the interactions of tiny elementary particles and the behaviour of new types of nanomaterials to biomolecular processes that are essential to life. The accelerators and detectors that DESY develops and builds are unique research tools generating the world's most intense X-ray light, accelerate particles to record energies and open completely new windows onto the universe. That makes DESY not only a magnet for more than 3000 guest researchers from over 40 countries every year, but also a coveted partner for national and international cooperation.

PSI

The Paul Scherrer Institute PSI is the largest research institute for natural and engineering sciences in Switzerland, conducting cutting-edge research in three main fields: matter and materials, energy and the environment and human health. PSI develops, builds and operates complex large research facilities. Every year, more than 2400 scientists from Switzerland and around the world come to PSI to use the unique facilities to carry out experiments. PSI is committed to the training of future generations. About one quarter of PSI's staff are apprentices, post-graduates or post-docs.

I-FAST

I.FAST aims to enhance innovation in the particle accelerator community, mapping out and facilitating the development of breakthrough technologies common to multiple accelerator platforms. The project involves 49 partners, including 17 companies as co-innovation partners, to explore new alternative accelerator concepts and advanced prototyping of key technologies. These include, among others, new accelerator designs and concepts, advanced superconducting technologies for magnets and cavities, techniques to increase brightness of synchrotron light sources, strategies and technology to improve energy efficiency, and new societal applications of accelerators.

PRACTICAL INFORMATION

Registration

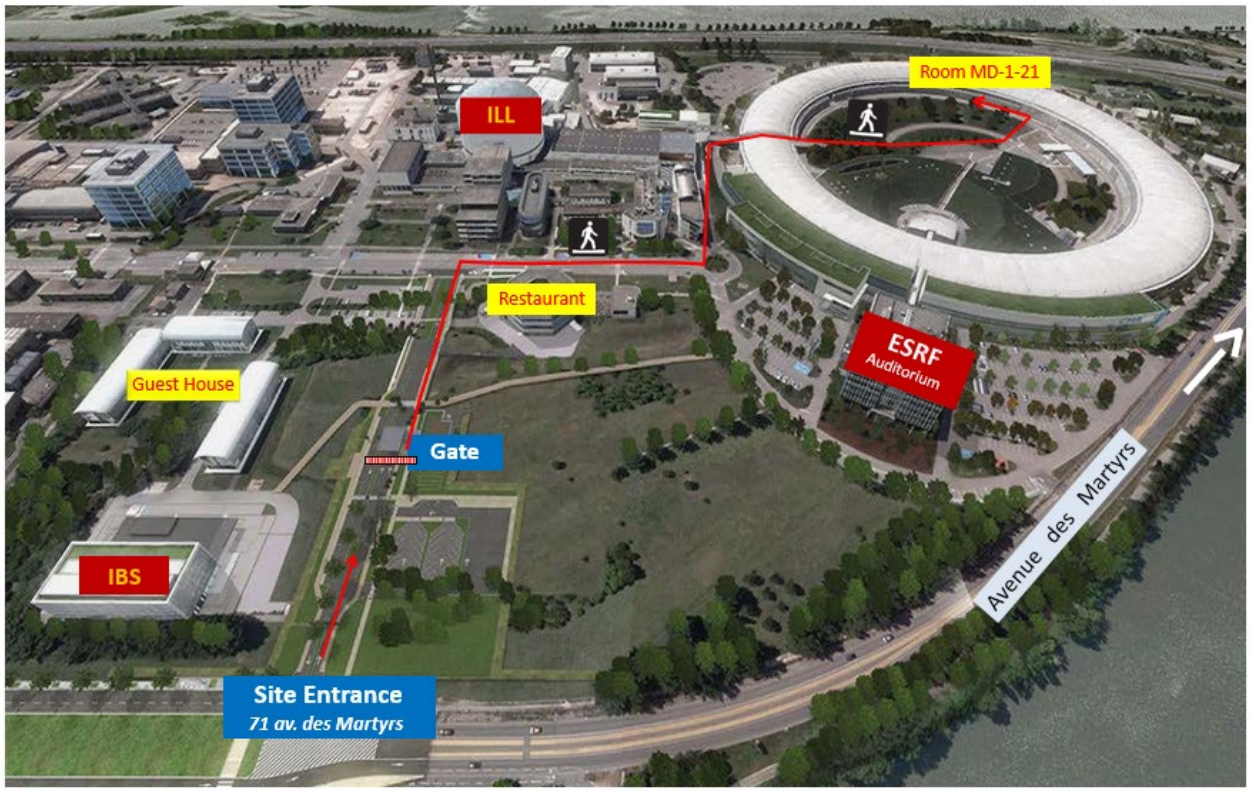
Thursday, 29 September | 8.00 – 9.00 Entrance hall of ESRF Central Building

WiFi connection on EPN Campus

To connect to the ESRF WiFi (EPN visitors):

* your login is: your **e-mail address** (as registered in your ESRF user account)
* your password is: the one used to access your User Account in **lower case**

EPN site map



<u>Meeting venues</u>

Plenary sessions: ESRF Central Building, Auditorium

Parallel sessions: ESRF Central Building, Auditorium / Room MD-1-21

Masks will be provided and must be worn in all meeting rooms.

<u>Catering</u>

Lunch in EPN Campus restaurant - please show your workshop badge at the cash till

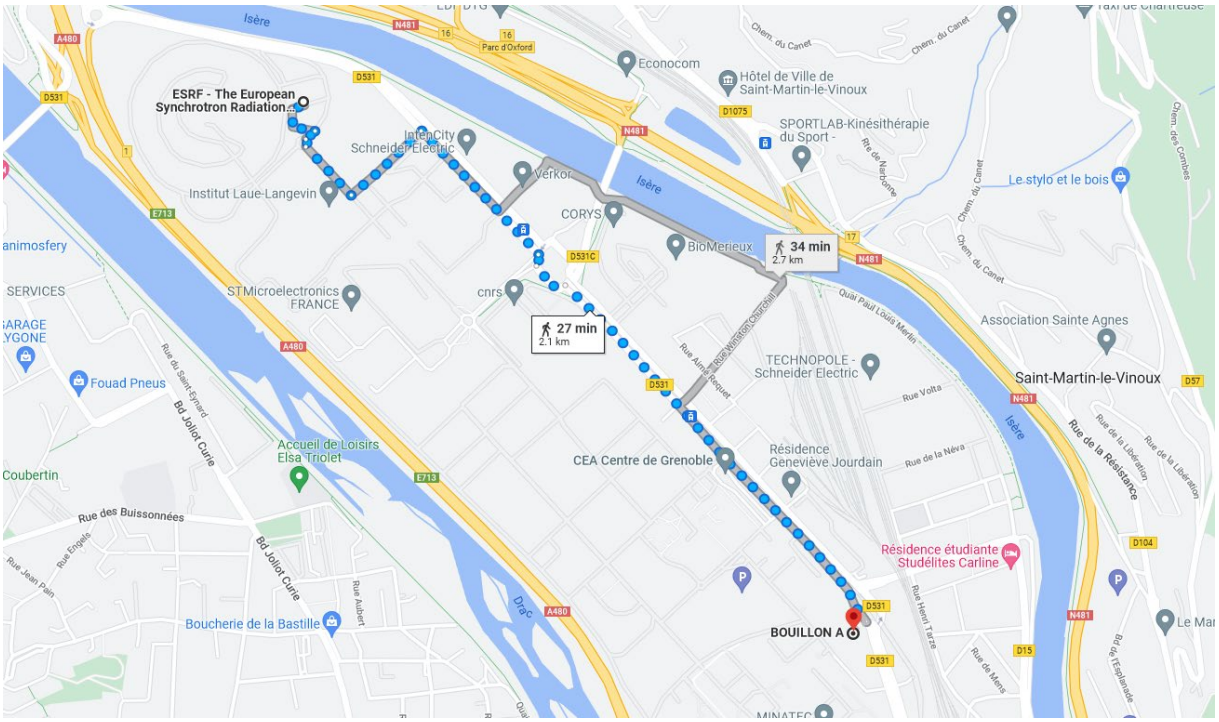
A takeaway lunch bag will be provided on the Friday (if requested via registration)

Workshop aperitif & dinner

‘Bouillon A’ restaurant, 5 Place Nelson Mandela, 38000 Grenoble

The restaurant is a 30 minute walk from the ESRF

Tram tickets will be provided - tram line B, get off at ‘Marie-Louis Paris CEA’



Facility Tours

The tours of the ESRF and LNCMI will be organized in five groups leaving from the entrance hall of the ESRF Central Builiding.

Participants will be able to register for the group of their choice during the coffee breaks.

An ID or passport must be shown to enter the LNCMI.