LCWS2023 Industry & Sustainability Forum

Session Conveners:

Nuria Catalán Lasheras (CERN)
Valery Dolgashev (SLAC, USA)
Juan Fuster (IFIC-Valencia, Spain)
Jie Gao (IHEP Beijing, China)
Benno List (DESY, Germany)
Sam Posen (FNAL, USA)
Takayuki Saeki (KEK, Japan)
Emma Snively (SLAC, USA)
Steinar Stapnes (CERN)
Tohru Takahashi (Univ. Hiroshima, Japan)
Maxim Titov (Irfu, CEA Saclay, France)
Marc Winter (IJCLab, France)
Masakazu Yoshioka (Iwate University, Japan)

International Workshop on Future Linear Colliders (LCWS2023), SLAC, USA, May 15 - 19, 2023

Industrial Forums at the Linear Collider Workshops

ECFA LC2016 (Santander, Spain): June 2016

https://agenda.linearcollider.org/event/7014/sessions/3895/#20160601

LCWS2016 (Morioka, Japan): Dec. 2016

https://agenda.linearcollider.org/event/7371/sessions/4305/#20161206

LCWS2017 (Strasbourg, France): Oct. 2017

https://agenda.linearcollider.org/event/7645/sessions/4537/#20171025

Japanese-European Industrial Forum on Accelerator Technologies and Advanced Instrumentation for the Future Large-Scale Facilities (ILC/CLIC)

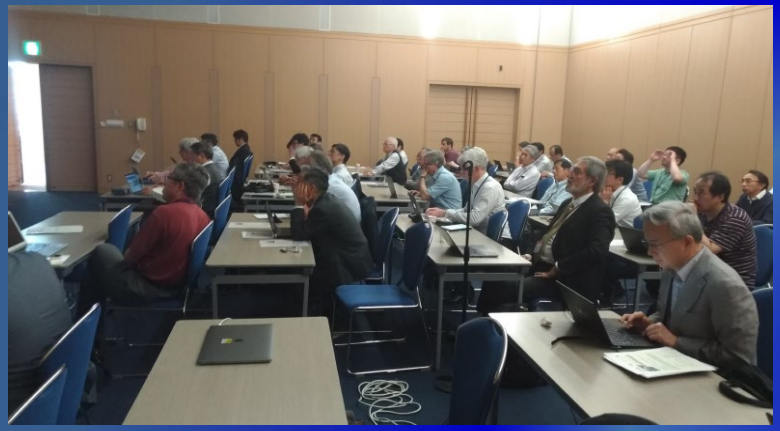
Among participants:

ZANON, RI, THALES, ALSYOM, INEUSTAR, AAA, Piges, AMICI, … CLIC-related industries

Industrial Forums at the Linear Collider Workshops

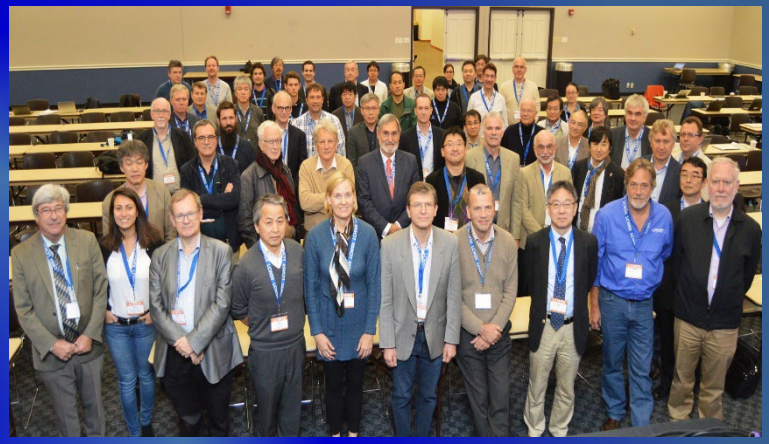
ALCW2018 (Kyushu, Japan): May 2018

https://agenda.linearcollider.org/event/7826/sessions/4652/#20180529



LCWS2018 (Arlington, USA): Oct. 2018

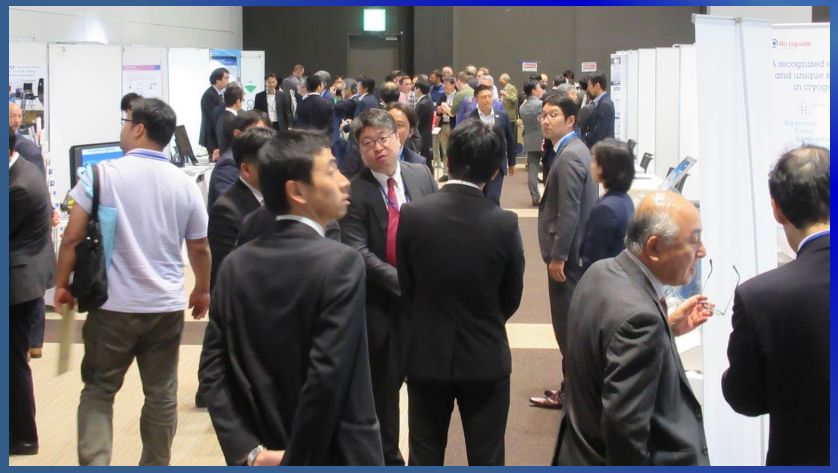
https://agenda.linearcollider.org/event/7889



LCWS2019 (Sendai, Japan): Oct. 2019

https://agenda.linearcollider.org/event/8217

Session + Exhibition (~ 60 companies)



LCWS2021 (Europe, Online): Mar. 2021

https://indico.cern.ch/event/995633/sessions/387855/#20210316

Future Colliders: Approaches to Increase Sustainability

✓ **Resource optimization traditionally done for accelerators:**

- *Length/complexity -> construction cost*
- *Power/energy consumption -> operating costs*

Traditionally we optimize for energy reach and luminosity wrt to cost and power

✓ **Sustainability in a wider sense adds new construction and operation optimization criteria:**

- *Energy use not only costs but also embedded CO_2 in construction materials and components, rare earth usage → responsible sourcing in general for all parts, landscaping, integration in local communities, life cycle assessments including decommission and many more issues*

- ***Overall system design***
  - ***Compact accelerator → high gradient; high field magnets***
  - ***Energy efficient → low losses (wall-plug to beam)***
  - ***Effective → nm-beam sizes to maximize luminosity***
  - ***Energy recovery concepts***
  - ***Civil engineering including landscaping and « community » integration***
- ***Subsystem and component design, e.g.***
  - ***High-efficiency cavities and klystrons***
  - ***Permanent magnets, HTS magnets***
  - ***Heat-recovery. e.g. in tunnel linings***
  - ***Responsible sourcing and material choices***
- ***Sustainable operation concepts***
  - ***Renewables***
  - ***Adapt to regenerative power availability***
  - ***Exploit energy buffering potential***
  - ***Recover energy (heat recovery)***

Good progress on the green points (was also part of the our radiational approach), initial progress/focus on the yellow / black ones

Sustainable Construction: Proactivity

- ***Operation costs dominated by energy (and personnel)***
  - Reducing power use, and costs of power, will be crucial → huge uncertainty in how the energy market, prices and price variations will be in ~2040 (ILC), ~2050 (CERN projects)
  - Carbon footprint related to energy source, relatively low already for CERN (helped by nuclear power), expected to become significantly lower towards 2050 when future accelerators are foreseen to become operational (in Europe, US and Japan).
  - Align to future energy markets, green and more renewables, make sure we can be flexible customer and deal with grid stability/quality
  - Other consumables (gas, liquids, travels, computing …) during operation need to be justified (and estimated)

- ***For carbon the construction impact might be (more) significant (also rare earths etc) than operational footprint***
  - *Construction: CE, materials, processing and assembly – not easy to calculate, very likely a/the dominating carbon source*
  - *Markets will push for reduced carbon, "responsible purchasing" crucial – construction costs likely to increase*
  - *Many other factors than a carbon life cycle assessment, rare earths, toxicity, acidity ..*
  - *Environmental studies, integration in local environment/power grids, very important (CERN generally, Green ILC)*

- ***Decommissioning – how do we estimate impacts ?***

Europe – America – Japan (EAJADE) Program (2023-2027)

European Union's Horizon Europe Marie Sklodowska-Curie Staff Exchanges programme under grant agreement no. 101086276

2014 → 2023

http://www.eajade.eu/

E-JADE
Europe -Japan Accelerator Development Exchange Programme

EAJADE
Europe-America-Japan Accelerator Development Exchange Programme

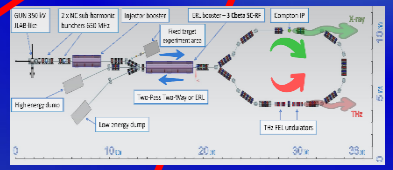
Work package no.	Work package title	Activity type	Number of person-months involved per secondment	Lead beneficiary	Start month	End month
1	R&D&I at currently operating state-of-the-art facilities	Research, training	143	CNRS	1	48
2	State-of-the-art high-gradient, high-efficiency, reduced-cost radio-frequency structures and power sources	Research, training	68	INFN	1	48
3	Special technologies, devices and systems performance	Research, training	74	CERN	1	48
4	Sustainable technologies for scientific facilities	Research, Training	12	CEA	1	48
5	Investigation of potential early applications of novel and advanced technologies for colliders	Research, training	52	DESY	1	48
6	Management, dissemination, training, knowledge transfer, and communication	Management, training, dissemination, communication	4	DESY	1	48

WP4: Sustainable Technologies for Scientific Facilities

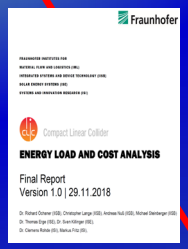
WP4

Task 4.1: High Efficiency & Sustainable SC cavities

Task 4.2: High efficiency RF power amplifiers



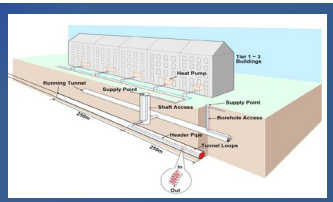
Task 4.3: Energy Recovery Linacs



Task 4.4: Power Modulation

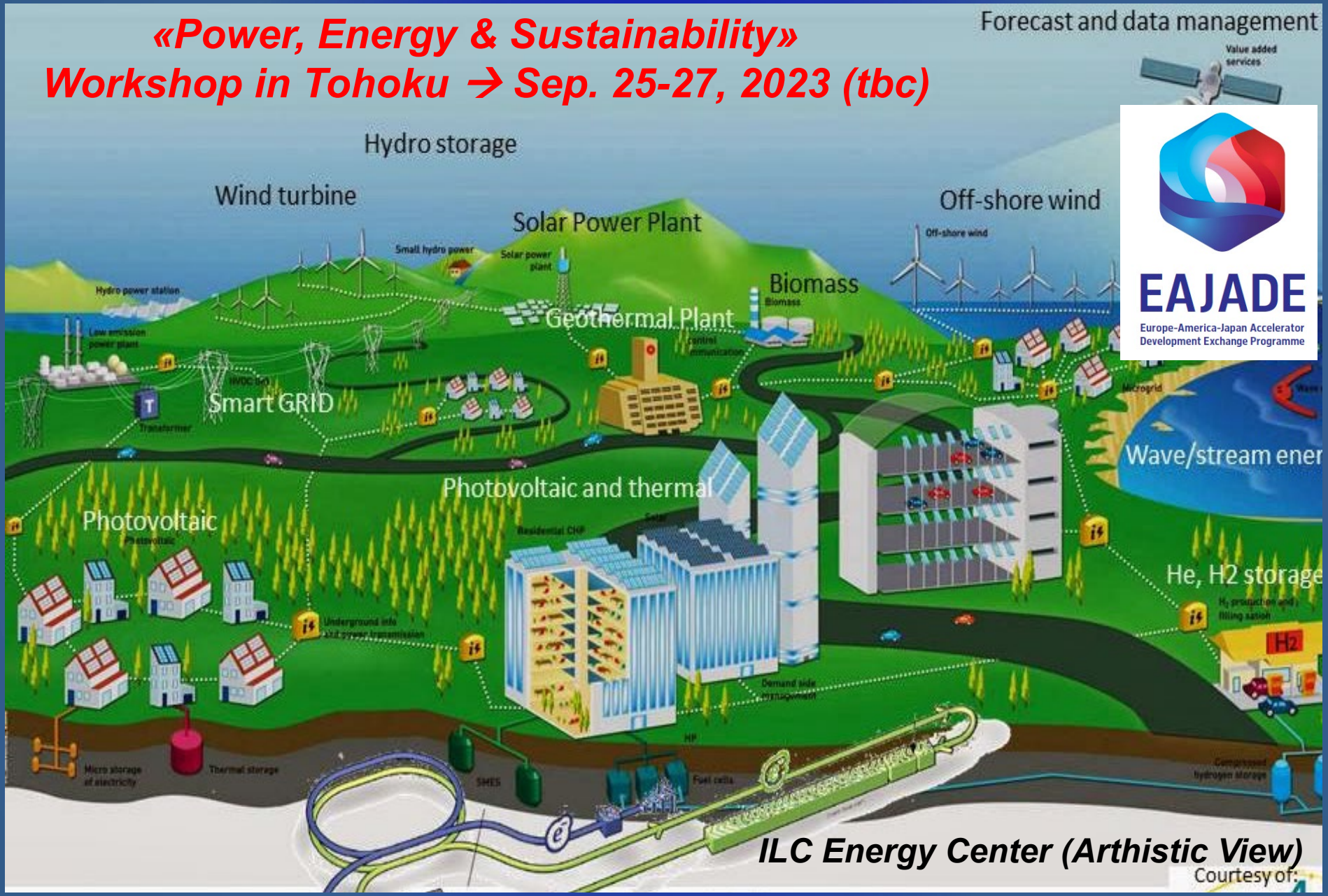
Task 4.6: "Green ILC"

Task 4.5: Smart Tunneling



From Power and Energy Towards Addressing Sustainability

«Power, Energy & Sustainability»
Workshop in Tohoku → Sep. 25-27, 2023 (tbc)



EAJADE
Europe-America-Japan Accelerator Development Exchange Programme

ILC Energy Center (Arthistic View)

Courtesy of:

LCWS2023 @SLAC: International Workshop on Future Linear Colliders (May 15-19, 2023)

The 2023 International Workshop on Future Linear Colliders (LCWS2023) will take place on May 15-19, 2023, SLAC, USA. The program will feature ILC progress in Japan, and the establishment of the International Technology Network (ITN) as the prominent topic, to review the progress in accelerator design, detector developments and physics studies. The progress of the CLIC studies within the same areas will also be covered and most sessions and topics will be common. The ILC project in Japan and CLIC project at CERN are also the central elements of the recently approved EU / EAJADE (Europe-America-Japan Accelerator Development and Exchange) program. Emerging new linear collider concept, C^3, will be also presented. More details about the workshop program may be found at the conference website: https://indico.slac.stanford.edu/event/7467. As a part of the LCWS2023 Symposium, we are pleased to announce the following special events:

Industrial Forum on Accelerator Technologies and Advanced Instrumentation for Future Linear Colliders

Date: 16 May 2023, 13:00 – 15:00 (PDT, US)

Indico link: https://indico.slac.stanford.edu/event/7467/sessions/441/#20230516

The goal of the event is to strengthen international cooperation between academia and industrial partners involved in the development of advanced accelerator technologies and instrumentation techniques. The forum will be devoted to the industrial aspects of future Linear Colliders, which offers an opportunity to valorise and highlight the expertise and innovation capabilities of national laboratories and their related industrial partners.

13:00-13:15 Introduction to Industry and Sustainability Forum – Session Conveners

13:15-13:35 Japan - AAA activity - Takahashi Tohru (Hiroshima Univ./AAA, Japan)

13:35-13:55 US Office of Accelerator R&D and Production (ARDAP) – Ginsburg Camille (Deputy Director of ARDAP, USA)

13:55-14:15 Advances in Spanish Science Industry – Fernandez Erik (INEUSTAR, Spain)

14:15-14:35 Development of C-band RF infrastructure and initial experiments at RadiaBeam - Murokh Alex (Radiabeam, USA)

14:35-14:45 Experience in participating in the development of an electron-driven positron source as a company in the Tohoku region – Kondo Masahiko (Kondo Equipment Corporation, Japan)

14:45-14:55 Development of Nb3Sn SRF cavity using electroplating method – Takahashi Ryo (Akita Chemical Industry Co., Ltd, Japan)

15:00-15:30 Coffee Break

Sustainability Forum for Future Linear Colliders

The environmental credentials of future colliders are increasingly in the spotlight, because of their size and complexity, and will be under scrutiny for their impact on the climate. Therefore, sustainability has become a prioritized goal in the design, planning and implementation of future accelerators; approaches to improved sustainability range from overall system design, optimization of subsystems and key components, to operational concepts. A direct quantification of the ecological footprint, be it greenhouse gas emissions during construction and operation, or consumption of problematic materials, is currently performed only sporadically, mostly through translation of electricity consumption into equivalent CO2 emissions.

This forum will highlight studies to reduce power consumption of accelerator systems, to quantify the impact of future facilities in terms of CO_2 footprint, to address smart integration of future accelerator infrastructure with the surrounding site and society (e.g. Green ILC concept), and to discuss medical and environmental applications of accelerator technologies.

Date: 16 May 2023, 15:30 – 18:00 (PDT, US)

Indico link: https://indico.slac.stanford.edu/event/7467/sessions/443/#20230516

15:30-15:50 Sustainability Studies for ILC and CLIC – Benno List (DESY, Germany)

15:50-16:10 High Efficiency Klystrons project at CERN: Status and updates – Syratchev Igor (CERN)

16:10-16:30 Linear Collider Carbon Assessments: A Life Cycle Assessment of the CLIC and ILC Linear Collider Feasibility Studies - Evans Suzanne (ARUP Group)

16:30-16:50 Green ILC Concept – Yoshioka Masakazu (Iwate University/KEK, Japan)

16:50-17:10 Permanent magnet technology for sustainable accelerators – Shepherd Ben (STFC, UK)

17:10-17:25 IHEP high efficiency, high power klystron development - Zhou Zusheng (IHEP, China)

17:25-17:35 Basic research using synchrotron radiation and commercialization of waste heat recovery technology from ILC - Mitoya Goh (Higashi Nihon Kidenkaihatsu Co., Ltd., Japan)

17:35-17:45 Town planning in the vicinity of ILC candidate site as a regional company - Kondo Masahiko (Kondo Equipment Corporation, Japan)

Accelerator: Sustainability and Applications Session

Date: 18 May 2023, 10:30 – 12:00 & 13:30 - 14:30 (PDT, US)

Indico link: https://indico.slac.stanford.edu/event/7467/sessions/450/#20230518

10:30-10:50 Sustainability Studies for the Cool Copper Collider- Bullard Brendon (SLAC)

10:50-11:10 Sustainability Considerations for Accelerator and Collider Facilities – Nappi Emilio (SLAC)

11:10-11:30 Strong-field QED Experiments for & at Linear Colliders – List Jenny (DESY)

11:30-11:50 High Temperature Superconducting RF cavity – Le Sage Gregory (SLAC)

13:30-13:50 Progress of High-Efficiency L-Band IOT Design for Accelerator Applications at SLAC - Othman Mohamed (SLAC)

13:50-14:10 High Efficiency, 1 MW, 1 MeV Accelerator for Environmental Applications – Shumail Muhammad (SLAC)

14:10-14:30 Applications of High Gradient Accelerator Research for Novel Medical Accelerator Technology - Snively Emma (SLAC)

BACK – UP SLIDES

LCWS2023 @SLAC: International Workshop Future Linear Colliders (May 15-19, 2023)

INDUSTRY PLENARY SESSION (May 16, 13:00 – 15:00):

- *13:00 – 13:15 Intro to Industry/Sustainability Session – Titov Maxim (on behalf of Session Conveners)*
- *13:15 – 13:35 Japan - AAA activity - Takahashi Tohru (Hiroshima Univ./AAA, Japan)*

Abstract: The Advanced Accelerator Association Promoting Science & Technology (AAA) is a general incorporated association aimed at promoting accelerator science by fostering collaboration among academia, government, and industry. The primary focus of the AAA is the International Linear Collider, and the organization is actively involved in project promotion, technical liaison, and public relations to achieve its objective. This presentation will provide an overview of the latest developments in the Project Promotion, Technology, and Public Outreach working groups.

- *13:35 – 13:55 US Office of accelerator R&D and Production (ARDAP) – Ginsburg Camille (Deputy Director of ARDAP, USA)*

Abstract: Particle accelerators are the fundamental tools enabling discovery science at many of the Department of Energy (DOE) Office of Science (SC) facilities, supporting roughly 20,000 users per year in the areas of Basic Energy Sciences, Fusion Energy Sciences, High Energy Physics, and Nuclear Physics. Accelerators are also used by the DOE Isotope Program to develop and produce radioactive and stable isotopes that are used worldwide for medical diagnosis and treatment, and are used in medicine, national security, and industrial processes, among other applications. These accelerator-based SC programs contribute to the economic, technical, and scientific strength of the United States. The Accelerator R&D and Production (ARDAP) program helps ensure that new and emerging accelerator technology will be available for future discovery science, medicine, industry, and national security needs by helping leverage and coordinate accelerator science and technology investments made through the other SC programs. ARDAP also makes its own investments in fundamental accelerator technology R&D and in the commercialization of these technologies. This presentation will describe the mission and activities of the ARDAP office.

LCWS2023 @SLAC: International Workshop Future Linear Colliders (May 15-19, 2023)

INDUSTRY PLENARY SESSION (May 16, 13:00 – 15:00):

- *13.55 – 14:15 Advances in Spanish Science Industry – Fernandez Erik (INEUSTAR, Spain)*

Abstract: Spanish Science Industry is developing technology, components systems and subsystems for particle accelerators world wide. The relationship of the industry with the scientific and technological institutes in Spain makes possible the advance of critical technologies that will be applied in the future accelerators as the International Linear Collider. During the presentation, key characteristics of Spanish Science Industry Sector and some developments related to advanced accelerators and specifically to ILC project will be presented.

- *14:15 – 14:35 Development of C-band RF infrastructure and initial experiments at RadiaBeam - Murokh Alex (Radiabeam, USA)*

Abstract: RadiaBeam is a small business providing systems, components, instrumentation, as well as testing, consulting and engineering services to the industrial and scientific accelerator communities. In this paper we'll discuss the projects most relevant to the high energy physics community with the emphasis on a recent development of the in-house C-band infrastructure for accelerator R&D. We'll also present more general case studies, which illustrate successes as well as challenges of serving the discovery science accelerator laboratories market, and discuss the current business outlook*

LCWS2023 @SLAC: International Workshop Future Linear Colliders (May 15-19, 2023)

INDUSTRY PLENARY SESSION (May 16, 13:00 – 15:00):

- *14:35 – 14:45 Experience in participating in the development of an electron-driven positron source as a company in the Tohoku region – Kondo Masahiko (Kondo Equipment Corporation, Japan)*

Abstract: In cooperation with Iwate University, Iwate Prefectural University, and several private companies, we are constructing a 20-hectare facility within a 40-minute drive time and 30-40 km from the ILC candidate site to provide residential facilities and outdoor activities to promote health and familiarity with nature. This facility can serve as a model for town planning where ILC-related people can live. The basic policy of this project is to be in line with the Japanese government's policy of "achieving carbon neutrality by 2050". We will report the concept, status, and future vision of the facility under construction.

- *14:45 – 14.55 Development of Nb3Sn SRF cavity using electroplating method – Takahashi Ryo (Akita Chemical Industry Co., Ltd, Japan)*

Abstract: Nb3Sn is a material with about twice the superheating field and superconducting transition temperature of Nb. By forming an Nb3Sn film on the inner surface of an Nb cavity, the cavity length can be shortened and the system can be operated with a small refrigerator, thus realizing a compact superconducting accelerator system with low operating cost and low price. At KEK, the electroplating method is being investigated as an alternative to the conventional method for forming Nb3Sn films. Based on this research, we have been studying the formation of Nb3Sn films in 3GHz single-cell cavities as our ultimate goal. In this presentation, we will report on the Nb3Sn film formation process and the evaluation results of the fabricated samples.

LCWS2023 @SLAC: International Workshop Future Linear Colliders (May 15-19, 2023)

SUSTAINABILITY PLENARY SESSION (May 16, 15:30 – 17:45):

- *15:30 – 15:50 Sustainability Studies for ILC and CLIC – Benno List (DESY, Germany)*

Abstract: Sustainability has become a prioritized goal in planning and implementation of future large accelerators, where ILC and CLIC have been collaborating to study novel design and technology solutions to address power efficiency and reduce the environmental impact of the facilities. Recent activities include studies on high efficiency components and life cycle assessments of civil engineering and accelerator construction and operation.

- *15:50 – 16:10 High Efficiency Klystrons project at CERN: Status and updates – Syratchev Igor (CERN)*

Abstract: Klystron is a key element of almost all particle accelerators. The High Efficiency Klystron Project at CERN is targeted to develop, fabricate and commission the new devices with improved efficiency for various particle accelerators and other applications. This activity is conducted in a close collaboration with industrial partners and scientific Labs. We will review the status and ongoing activities within HE project at CERN with emphasis given to their application in the Linear Colliders.

LCWS2023 @SLAC: International Workshop Future Linear Colliders (May 15-19, 2023)

SUSTAINABILITY PLENARY SESSION (May 16, 15:30 – 17:45):

- *16:10 – 16:30 Linear Collider Carbon Assessments: A Life Cycle Assessment of the CLIC and ILC Linear Collider Feasibility Studies - Evans Suzanne (ARUP Group)*

Abstract: Linear colliders are a promising technology for exploring the frontiers of particle physics. However, the construction and operation of these large-scale scientific instruments have significant environmental impacts, particularly in terms of carbon emissions. In this talk, we present a comprehensive life cycle assessment (LCA) of both the Compact Linear Collider (CLIC) and International Linear Collider (ILC) feasibility studies, focusing on the assessment of LCA construction phases A1 to A5. The LCA considers the materials and construction methods proposed for both the CLIC and ILC and assesses the carbon footprint of each phase of the construction process, from the extraction of raw materials to the disposal of waste. In addition, our study identifies opportunities for reducing the embodied carbon of linear colliders, including the use of low-carbon materials. We conclude that a careful consideration of the environmental impact of linear colliders is crucial for the future of particle physics research, and that reducing the embodied carbon of these large-scale scientific instruments should be a priority for the scientific community.

- *16:30 – 16:50 Green ILC Concept – Yoshioka Masakazu (Iwate University/KEK, Japan)*

Abstract: The Kitakami Highlands of Iwate Prefecture, where the ILC candidate site is located, is served by Tohoku Electric Power Co. The company's CO2 emission coefficient for FY2021 is 0.483 kg-CO2/kWh. This is about twice the figure for Europe. The Japanese government has set a goal of achieving carbon neutrality by 2050. This report presents a scenario in line with that policy.

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SUSTAINABILITY PLENARY SESSION (May 16, 15:30 – 17:45):

- *16:50 – 17:10 Permanent magnet technology for sustainable accelerators – Shepherd Ben (STFC, UK)*

Abstract: Permanent magnet technology is a path to reducing energy usage and carbon emissions for accelerator facilities. This talk presents some examples of where PM technology has been adopted in place of electromagnets, and highlights the advantages and disadvantages of this technology.

- *17:10 - 17:25 IHEP high efficiency, high power klystron development - Zhou Zusheng (IHEP, China)*

Abstract: After the discovery of the Higgs boson at LHC, Chinese scientists have planned to build a “Great Collider,” which is a next-generation multinational particle accelerator research facility proposed as a circular electron-positron collider (CEPC) and a super proton–proton collider (SPPC). The CEPC synchrotron radiation power is supposed to be more than 60MW. Institute of High Energy Physics (IHEP) is developing a higher efficiency klystron of frequency 650 MHz/800 kW with an efficiency goal of around 80%. Several klystron prototypes have been manufactured in the last five years to achieve this goal. The prototype was developed in March 2020 with 62% efficiency at 800 kW pulsed output power. The first stage of the high-power test for the second prototype was also completed in July 2022 with 70.5% efficiency at 630 kW CW power. The third prototype (Multi-beam klystron) is being manufactured, and it will be tested by the middle of 2023. In addition, the beam dynamics of 2860MHz (80MW) klystron are completed and will be manufactured in 2023. The design of 5720 MHz (80 MW&50 MW) klystron for CEPC Linac is also in progress.

LCWS2023 @SLAC: International Workshop Future Linear Colliders (May 15-19, 2023)

SUSTAINABILITY PLENARY SESSION (May 16, 15:30 – 17:45):

- *17:25 - 17:35 Basic research using synchrotron radiation and commercialization of waste heat recovery technology from ILC - Mitoya Goh (Higashi Nihon Kidenkaihatsu Co., Ltd., Japan)*

Abstract: We are conducting research to recover and utilize the energy discharged from the ILC facility under the concept of Green ILC. As the candidate site for construction, Iwate Prefecture, which has the Kitakami site, is 80% mountainous, and an effective model for heat energy circulation and utilization that suits the regional characteristics is required. Therefore, we aim to commercialize an off-line waste heat circulation model using an innovative adsorption-type heat storage material called "HASClay," which can be regenerated at low temperatures. Here, we introduce fundamental research aimed at understanding the structural changes caused by the adsorption and desorption of water molecules into the fine pore structure of HASClay using a synchrotron radiation facility, as well as conducting demonstration tests to achieve commercialization.

- *17:35 – 17:45 Town planning in the vicinity of ILC candidate site as a regional company - Kondo Masahiko (Kondo Equipment Corporation, Japan)*

Abstract: In cooperation with Iwate University, Iwate Prefectural University, and several private companies, we are constructing a 20-hectare facility within a 40-minute drive time and 30-40 km from the ILC candidate site to provide residential facilities and outdoor activities to promote health and familiarity with nature. This facility can serve as a model for town planning where ILC-related people can live. The basic policy of this project is to be in line with the Japanese government's policy of "achieving carbon neutrality by 2050”. We will report the concept, status, and future vision of the facility under construction.

LCWS2023 @SLAC: International Workshop Future Linear Colliders (May 15-19, 2023)

SUSTAINABILITY PARALLEL SESSION (May 18, 10:30 – 12:00):

- *10:30 - 10:50 Sustainability studies for the Cool Copper Collider- Brendon Bullard (SLAC)*

Abstract: The successful continuation of high energy physics probing regimes of ever-higher energies using conventional experimental methods is unsustainable both fiscally and environmentally. The already visible effects of climate change put additional pressure on the HEP community to develop techniques to mitigate the carbon footprint of large-scale collider experiments through direct and indirect greenhouse gas emissions. We propose a set of benchmark physics measurements that summarize the required physics output of an e+e- Higgs factory. We argue that C^3 fulfills the main goals of a Higgs factory with the lowest environmental impact based on these benchmarks. We will also discuss specific strategies for mitigating C3 's carbon footprint, including powering strategies for the liquid nitrogen plant required for operating the high-gradient accelerating cavities.

- *10:50 – 11:10 Sustainability Considerations for Accelerator and Collider Facilities – Emilio Nanni (SLAC)*

Abstract: As the next generation of large accelerator-based facilities are being considered at the Snowmass 2021 study high priority has to be given to environmental sustainability including energy consumption, natural resource use and the environmental impact of effluents. Typically, increased performance - higher beam energies and intensities - of proposed new facilities have come with increased electric power consumption. In the following we discuss the most important areas of development for the sustainability of accelerator-based research infrastructures in three categories - technologies, concepts and general aspects. To achieve the goal of increased performance with reduced energy consumption a focused R&D effort is required with the same or even higher priority as the traditional performance-related R&D. Such a recommendation was included in the recent European Strategy for Particle Physics Accelerator R&D Roadmap.

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SUSTAINABILITY PARALLEL SESSION (May 18, 10:30 – 12:00):

- *11:10 - 11:30 Strong-field QED Experiments for & at Linear Colliders - Jenny List (DESY)*

Abstract: Appropriately designed, the ILC facility could offer unique applications beyond the main collider program. This contribution will review the possibilities to extract electron and/or positron bunches from the main beam, and focus in particular on their use for a LUXE-type experiment, which would allow strong-field QED to be probed in regimes relevant multi-TeV colliders and for astrophysical plasmas eg in magnetars, and at the same time would offer discovery opportunities for light dark sector particles. The design of the LUXE experiment at the Eu.XFEL will be presented as a basis to discuss the requirements for implementing such an experiment at the ILC.

- *11:30 – 11:50 High Temperature Superconducting RF cavity – Gregory Le Sage(SLAC)*

Abstract: High Q cavities are an essential component for rf pulse compression. In order to reduce cavity losses and increase compatibility with applications requiring long fill times, we are interested in developing compact superconducting cavities that operate at high temperature (~80 K). We are designing and planning to measure an RF cavity at 11.424 GHz that will include High Temperature Superconductor (HTS) tapes attached to inner cavity surfaces. The cavity uses a TM011 mode and has been designed with eight separate facets. This allows each facet to have a flat surface where the HTS tapes can be applied. A TE10 to TM01 mode converter will feed the cavity through a coupling aperture designed to give the correct value of loaded Q. The cavity Q is designed to allow a fill time (1 exponential step) of 1 microsecond, corresponding at 11.424 GHz to QL = 71,779. The design assumes the HTS surface conductivity is 11.02e9 S/m, which is 190 times that of copper. The TM01 waveguide has been shown in simulation to function correctly even with a small physical gap at the input. The facets can also have small gaps since the wall current for the TM01 mode is axial. That is also important since wall current does not cross gaps between HTS tapes. Cavity tuning is planned by separating the facets with wedges. Addition of the HTS tapes will increase the cavity resonant frequency, so pushing apart the facets will lower the frequency. We only need to stay within the bandwidth of a klystron, which is about 10 MHz. The cavity and mode converter will be cooled with a He compressor in vacuum. Performance of the cavity will be characterize between 4K and the transition temperature of the superconductor at ~90K.

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SUSTAINABILITY PARALLEL SESSION (May 18, 13:30 – 14:30):

- *13:30 - 13:50 Progress of High-Efficiency L-Band IOT Design for Accelerator Applications at SLAC - Mohamed Othman (SLAC)*

Abstract: Recent efforts at SLAC aim at developing high-power accelerators powered by compact, high-efficiency rf sources such as klystrons and Inductive output tubes (IOT). In particular, a high-efficiency IOT is an electron-beam-driven RF source employed in the UHF band that offers high efficiency at variable output power levels. Due to the improved linearity, high efficiency, and reduced size, it is the RF amplifier of choice in the TV broadcast market. Stellant Systems (formerly L3Harris Electron Devices) has long pioneered the IOT design and recently leveraged its power toward various accelerator applications. In this talk, we show the progress of developing a 1.3 GHz HEIOT in terms of design and performance. We also show results of 3D space-charge beam dynamics simulation of an L-Band inductive output tube (IOT) RF electron gun using the accelerator code ACE3P as a transformative approach to HEIOT design. We also show an optimization scheme of the rf output cavities that results in >100 kW of average power with an upward of 80% power efficiency.

- *13:50 – 14:10 High Efficiency, 1 MW, 1 MeV Accelerator for Environmental Applications – Muhammad Shumail (SLAC)*

Abstract: We present design of a normal conducting, high efficiency linac that would provide a CW beam of 1 MW electrons at 1 MeV energy for various environmental applications. For example, when a flowing sheet of wastewater is exposed to such a beam, various radiation-induced reactants are generated that lead to water purification by decomposing the chemical and biological pollutants therein. The implemented linac could treat 24 million gallons of wastewater per day with an ample dose of 1 kGy. Our design is based on three accelerating rf cavities operating at 476 MHz. The shunt impedance of each cavity is optimized according to its position in the linac. A compact rf distribution manifold is designed to split the power from a 1 MW klystron in the appropriate ratio and phase for each accelerating cavity. The beam capture efficiency is 80% and the rf to beam efficiency is 94%. The total length of our accelerator - including the 30 keV gun, the buncher cavity, and the accelerating cavities - is 2 m. In this paper, we present the corresponding beam dynamics, the implementation of rf couplers and feeding manifold, the thermo-mechanical simulations, and the fabrication and test plan.

LCWS2023 @SLAC: International Workshop Future Linear Colliders (May 15-19, 2023)

SUSTAINABILITY PARALLEL SESSION (May 18, 13:30 – 15:00):

- *14:10 - 14:30 Applications of High Gradient Accelerator Research for Novel Medical Accelerator Technology - Emma Snively (SLAC)*

Abstract: Accelerator technology developed for future collider designs can form the basis for components in a broad range of medical accelerator applications, enabling new treatments like Very High Energy Electron (VHEE) therapy and new high-speed beam scanning systems for proton therapy. For example, the large aperture of the proposed C3 linac design is optimized to transport long and high charge bunches and, if adapted for a beam energy modulation system for protons or acceleration for VHEE, could increase transmission of the beam for therapeutic purposes. An RF-based approach to changing the proton beam energy would be significantly faster than current methods which typically rely on the beam passing through a range shifter controlled with mechanical motion. Techniques like cryogenic cooling, implemented for the C3 concept to improve RF efficiency, can be applied to novel medical accelerator designs to reduce the size and power consumption in a clinical facility. We discuss the synergistic design efforts for medical accelerator projects currently underway at SLAC funded by the DOE's Accelerator Stewardship program.