CERN-ACC-SLIDE-2013-084

HiLumi LHC

FP7 High Luminosity Large Hadron Collider Design Study

Presentation

Accelerating News Issue 7

Szeberenyi, Agnes (CERN) *et al*

02 October 2013

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

This work is part of HiLumi LHC Work Package **1: Project Management & Technical Coordination**.

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Issue 7: Autumn 2013

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EVENTS

6-11 October 2013
ICALEPCS 2013 - 14th International Conference on Accelerator and Large Experimental Physics Control Systems
San Francisco, US

16-18 October 2013
6th TLEP Workshop
Geneva, Switzerland

11-15 November 2013
3rd Joint HiLumi LHC-LARP Annual Meeting
Daresbury, UK

19-20 Nov 2013
WAMAS - Workshop for

Acc

From the editors

by Mathilde Chaudron (CERN), Agnes Szeberenyi (CERN), Celine Tanguy (CEA)

In this autumn issue, we are happy to announce the launch of the accelerators-for-society.org website. We look at possible strategies for future proton and electron facilities in Europe and promising techniques for affordable and compact accelerators. We also inform you about the US LHC Accelerator Program (LARP), unconventional RF structures, and the design of a compact irradiation device for target testing. Successful achievements for the MICE and T2K experiments are also highlighted.

Help us improve! Please take 2 minutes to fill the short questionnaire on Accelerating News available here.

We invite you to attend the 3rd Joint HiLumi/LARP meeting combined with the HL-LHC kick-off meeting between 11-15 November and the final general meeting of TIARA-PP between 25-27 November.

It is still possible to order EuCARD booklets: 18 topics on Accelerator Science and Technology have been addressed in total. Click here to see all the topics and request a copy (free of charge).

We hope you enjoy this issue. Please contact us with any news or events that you would like added to future issues.

Read more >>

Keywords: editors; introduction

The 3rd Joint HiLumi/LARP meeting combined with the HL-LHC kick-off meeting will take place on November 11-15. Image credit: Hilumi LHC.

The International Conference on Translational Research in Radio-Oncology and Physics for Health in Europe will take place on February 10-14, 2014 in Geneva. Registration is open >>.
Image credit: Geneva Tourism & Conventions.

TIA
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Accelerators for Society is live now

by Daniel Potter (STFC) and Celine Tanguy (CEA)

Visit the recently launched www.accelerators-for-society.org website to learn more on applications of particle accelerators.

First developed almost a century ago for fundamental physics research, particle accelerators now have a very large number of applications, from the well-known applications such as cancer treatment and the production of semiconductors for the electronics industry, to the lesser-known applications such as improving the taste of chocolate and the treatment of water supplies.

WAMAS - Workshop for Science and Business on Advanced Materials and Surfaces
Geneva, Switzerland

25-27 November 2013
TIARA final general meeting
Daresbury, UK

4-15 December 2013 LCS 2013 - 8th International Accelerator School for Linear Colliders
Antalya, Turkey

16-20 December 2013
HEP 2013 - 5th International Workshop on High Energy Physics in the LCH Era
Valparaíso, Chile

6 January - 14 March 2014
JUAS school - Joint Universitites Accelerator School
Archamps, France

20-31 January 2014
USPAS - US Particle Accelerator School
Knoxville, US

10-14 February 2014
ICTR-PHE 2014
Geneva, Switzerland

12-14 February 2014
TLEP Kickoff meeting
Geneva, Switzerland

25-30 May 2014
CAARI 2014 - 23rd International Conference on the Application of Accelerators in Research and Industry
San Antonio, US

02-06 June 2014
TIPP 2014 — Technology and Instrumentation in Particle Physics 2014
Amsterdam, Netherlands

15-20 June 2014
IPAC'14 - International Particle Accelerator Conference
Dresden, Germany

IN THE HEADLINES

taste of chocolate and the treatment of water supplies.

The website www.accelerators-for-society.org has been developed as part of the TIARA preparatory phase and outlines many applications of particle accelerators in areas such as Research and Development, Health, Medicine, Industry, Energy, Environment and beyond, showing just how much society benefits from particle accelerators.

Click here to visit www.accelerators-for-society.org. Image credit: TIARA.

Read more >>

Keywords: TIARA, society, accelerator applications

Exploring the accelerator frontiers

by Frank Zimmermann (CERN) with Mathilde Chaudron (CERN)

Discussing technologies and limits for future particle accelerators is key to defining a coherent long term strategy. In 43 workshops (co-)organized by EuCARD WP4 AccNet between 2008 and 2013, experts from all around the world drafted an R&D roadmap for the next 50-100 years.

Going beyond the state-of-the-art requires novel materials supporting higher magnetic or electric fields for acceleration or bending, e.g. stronger superconductors, dielectrics, plasmas or crystals. Energy efficiency and cost effectiveness are also becoming ever more important.

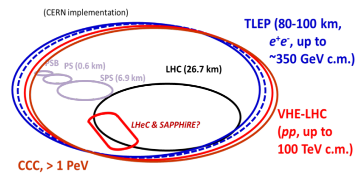

Fig 1: Schematic of a sequence of circular high-energy colliders after the LHC consisting of LHeC-SAPPHiRE, TLEP, VHE-LHC and CCC.
Image credit: CERN.

Taking into account emerging technologies, EuCARD WP4 delivered a coherent long-term vision for highest-energy circular colliders (Fig. 1). Encompassing a high-luminosity e+e- Higgs factory (TLEP or LEP3) and a 100-TeV proton collider (VHE-LHC), this approach could culminate in a circular crystal collider (CCC), boosting the c.m. energy to 1 PeV or beyond. An alternative "linear" approach (Fig. 2) would start with an ILC utilizing SC cavities, continue with CLIC, be followed by dielectric and plasma lepton colliders, and terminate with a linear x-ray crystal muon collider (XRCMC).

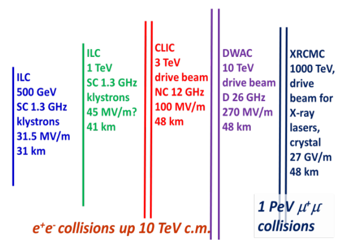

Fig 2: Possible long-term strategy based on sequence of linear colliders.
Image credit: CERN.

Remarkably, both linear and circular approaches require crystals to reach 1 PeV – for either acceleration or bending. Since crystals have been used only for bending so far, the circular route might be easier to follow. An ultimate limit is imposed by the Sauter-Schwinger critical field, constraining the minimum size of a Planck-scale collider to ~1010 m in either approach.

Read more >>

Keywords: EuCARD, future particle accelerators, strategy

Successful test of HQ02: Nb_3Sn is getting closer to proton beams

by Ezio Todesco (CERN)

US LHC Accelerator Research Program (LARP) scientists in collaboration with CERN under the framework of HiLumi LHC are working on the development of the Nb_3Sn technology to produce accelerator magnets that are able to operate at 12 T peak field in the coil. After the first successful test of HQ02 further tests are on-going to test other critical aspects of the magnet.

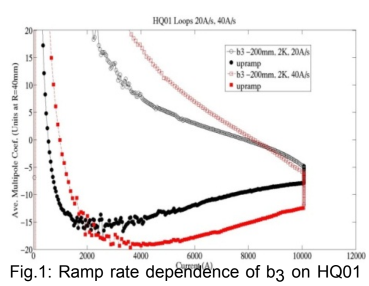

Fig.1: Ramp rate dependence of b_3 on HQ01 without cored cable.
Image credit: LARP collaboration.

HQ02 is the first magnet that makes use of a "cored" cable, i.e. a 25-mm-thick strip between the superconducting strands to increase the resistance between strands. In case of Nb-Ti LHC magnets, the interstrand resistance was controlled through an

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magnets, the interstrand resistance was controlled through an oxidation of the strands. This method cannot be used for the Nb_3Sn which becomes superconductive after a heat treatment at 650 ºC lasting more than one day. First results show that the field quality versus current is extremely smooth compared to the behaviour of a magnet without cored cable. The core also allows reducing the heating induced by a fast ramping, so that the magnet is superconductive even at ramp rate higher than nominal.

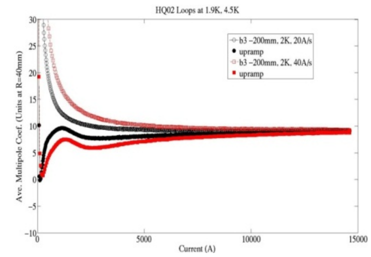


Fig.2: Ramp rate dependence of b_3 in HQ02 with cored cable.
Image credit: LARP collaboration.

In its first test, HQ02 reached the power supply limit of 15 kA, corresponding to operational current at 1.9 K, with a few quenches. The second powering is being done at 2.2 K, after a warm up and cool down, showing a perfect memory (i.e. the magnet was able to reach the same current as before warm up without any quench), and capability of operating at 16 kA, i.e. a margin of 1 kA. The powering is still in progress and a special program is now on-going to test other critical aspects as quench protection. The new inner triplet to be installed at the beginning of next decade will be based on this design, taking all the features that have been successfully proved by LARP.

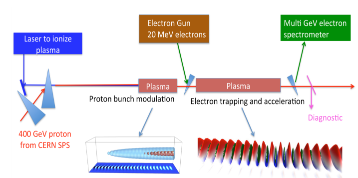
Read more >>

Keywords: Hilumi LHC, LARP, magnets

A novel technique for compact accelerators

by Edda Gschwendtner (CERN) and Victor Malka (CNRS)

Circular electron colliders are not feasible at TeV energies; hence future TeV accelerator designs are based on linear colliders. However, as the beam energy increases, the scale and cost of conventional machines become very large. New acceleration technology is mandatory for the future of particle physics, to build more affordable and compact accelerators for various applications (e.g. medical). A rapidly developing, promising candidate is the Plasma Wakefield acceleration.



Conceptual Design of the AWAKE experiment at CERN. The major elements of the experiment are shown and the expected effects are described.
Image credit: CERN.

Plasma acceleration is a novel technique for accelerating charged particles using an electric field associated with electron plasma wave or other high-gradient plasma structures. A Proton Driven Plasma Wakefield Acceleration Experiment has been proposed as an approach to use high-energy protons to drive a plasma wakefield in a single plasma section for an electron beam acceleration to the TeV energy range.

To verify this novel technique, AWAKE has been launched at CERN as the first proton-driven wakefield acceleration experiment worldwide, using 400 GeV proton bunches from the CERN SPS. First beam to the plasma cell is expected for end 2016. The result of AWAKE will have a strong impact on future larger-scale R&D projects on proton-driven plasma wakefield acceleration and could open a pathway towards a revolutionary plasma-based TeV lepton collider.

AWAKE experts are working closely together with experts from the Novel Acceleration Techniques (ANAC2) Work Package of EuCARD-2. The goal of task 13.4 of this WP is to develop concepts for the instrumentation of the plasma cell that can have a length of 10s of meters.

Read more >>

Keywords: AWAKE, EuCARD-2, novel technique, compact

Keywords: AWAKE, EuCARD-2, novel technique, compact accelerators, plasma wakefield acceleration

Demonstration of RF drive system for MICE achieved

By Kevin Ronald (University of Strathclyde), Andrew Moss (Daresbury Lab), Ken Long (Imperial College) for the MICE Collaboration

Ionisation cooling is required to reduce the emittance of a muon beam rapidly for application in future accelerators for neutrino factories and muon colliders. Under Work Package 7 of the TIARA-PP project, Daresbury Lab in collaboration with Rutherford Appleton Lab, Strathclyde University and Imperial College has developed the RF drive system and distribution network for the International Muon Ionization Cooling Experiment (MICE).

Each of the 8 MICE cavities demand 1 MW of power at 201.25 MHz in 1ms pulses for a gradient of 8 MV/m. Strong magnetic fields mean the space for the RF drive system is constrained requiring a complex routing to the cavities. Four compact amplifier chains are used to meet these requirements. A signal generator drives a Solid State Power Amplifier (4 kW) feeding a Photonis 4616 tetrode valve amplifier (250 kW) and a Thales 116 triode valve amplifier (2 MW). A complex power supply has been developed to supply and protect the valve amplifiers. Due to the complex and delicate nature of the system, it has been progressively brought to full bias voltage (36 kV on the triode). At these settings the prototype system recently demonstrated the required output parameters. Outstanding support from e2v technologies thyratron section is gratefully acknowledged.

Read more >>

Keywords: TIARA, future accelerators, ionisation cooling, MICE

Fig 1: The triode amplifier under test. The connections are a) the HT feedline, (b) output 9 inch coaxial line, (c) input 3 inch line. Image credit: TIARA/MICE.

Fig 2: Power meter display showing peak pulsed power. Image credit: TIARA/MICE.

Accelerator neutrinos are recovering their lead

by Mathilde Chaudron (CERN) with Vittorio Palladino (INFN)

On July 19th 2013, the international T2K collaboration proudly announced definitive observation of muon neutrino to electron neutrino transformation. "This T2K observation is the first of its kind", stated the collaboration in a press release, underlying that the probability for random statistical fluctuations to produce this result was less than on in a trillion.

In order to get to this result, the T2K experiment used data collected from the world's largest underground neutrino detector, Super-Kamiokande, located in Japan. A muon neutrino beam was produced in the Japan Proton Accelerator Research Complex (J-PARC) and sent 295 km away to Super-Kamiokande, where its composition was studied and compared with the initial one.

Observation of this new type of neutrino oscillation opens the way to new studies - only possible with accelerator neutrinos - of charge-parity (CP) violation, which provides a distinction in physical processes involving matter and antimatter. CP violation in neutrinos in the very early universe might explain one of the most profound mysteries in science: the domination of matter over antimatter in our universe.

The T2K experiment is operated by an international collaboration, gathering over 400 physicists from 59 institutions in 11 countries.

Overview of the T2K experiment in Japan. Image credit: T2K collaboration.

Read more >> [1] [2]

Keywords: T2K, J-PARC, Super-Kamiokande, neutrino oscillation

New developments in unconventional RF structures

by Graeme Burt (ULANC) with Mathilde Chaudron (CERN)

A lot of attention is paid to getting very high accelerating gradient RF structures, either for superconducting or normal conducting machines. Most of these structures use the TM010 accelerating mode in elliptical or pillbox type cavities, similar to those used in the LHC, however there are several other types of structures under development and not all of them are for acceleration.

Fig 1: 4-rod crab cavity for HL-LHC. Image credit: ULANC.

Crab cavities are required to rotate bunches prior to collision and are being developed for LHC, ILC, CLIC and SPX. Quarter-wave cavities and capacitive loading of cavities have been tested by Lancaster University/CERN and ODU/Jlab. Another type of dipole RF structure is the RF undulator which uses RF fields to deliver short period undulators that can vary polarisation very quickly.

There are also developments in SRF monopole cavities. Niowave and ODU are developing spoke resonators for compact light sources, while BNL has developed a low frequency SRF gun based on a quarter-wave structure. Also for acceleration and for deflecting, several photonic bandgap (PBG) cavities are being developed, high gradient tested by SLAC and MIT, while LANL has been developing an SRF photonic cavity to extract HOMs. Additionally, a novel idea from Yale and Manchester University is to have a cavity that operates at two harmonics.

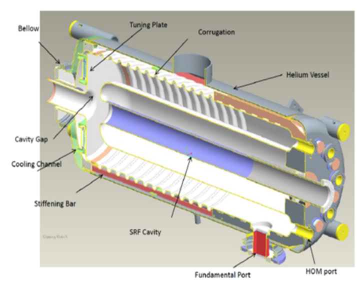


Fig 2: 56 MHz quarter wave cavity. Image credit: BNL.

Read more >> [1] [2]

Keywords: unconventional RF structures, crab cavities

Irradiation facility for target testing

by Karel Samec (CERN), Yoann Fusco (CERN), Yacine Kadi (CERN)

In TIARA Work Package 9, the team led by scientists and engineers from CERN are developing a compact irradiation device. This installation is a key infrastructure for the accomplishment of the R&D programme that is required to enable the construction of EURISOL, the next generation facility for the production of very intense radioactive ion beams (RIB), and also for other projects such as the European Spallation Source (ESS) or the development of Accelerator Driven Systems with the MYRRHA project.

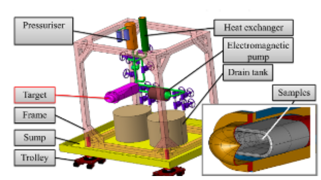


Fig 1: Compact irradiation device developed at CERN within TIARA WP9. Image credits: TIARA/CERN.

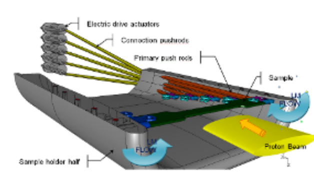


Fig 2: Sample holder (one half) with sample

The compact irradiation device is shown in Fig. 1. The target shown in the detail can absorb a 100 kW proton beam and, through spallation of a dense liquid metal flowing inside, releases a high-density hard neutron flux in a volume which can accommodate various experimental devices. One such device is shown in Fig. 2 and illustrates how tensile specimens may be remotely stress-tested using a robust mechanical system, whilst being bombarded by the proton beam and the neutrons released by the spallation of dense liquid metal flowing around the samples.

loading mechanism.
Image credits: TIARA/CERN.

Evidently the setup can be used to test medical applications, nuclear instrumentation or any other type of device for which a high density neutron field is required. The entire apparatus is housed within a cube 1.5m on a side, for easy transport. Disassembly and treatment of the waste is facilitated by the development of a compact heat exchanger which mechanically separates the primary from the secondary loop.

Read more >>

Keywords: TIARA, irradiation facility, target testing

LINKS

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