1st oPAC Topical Workshop: Grand Challenges in Accelerator Optimisation

Report of Contributions

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Contribution ID: **0** Type: **not specified**

Welcome / Training the next generation of accelerator experts

Wednesday, June 26, 2013 8:30 AM (30 minutes)

Many of today's most advanced research infrastructures rely on the use of particle accelerators. This includes for example synchrotron-based light sources and FELs, high energy accelerators for particle physics experiments, high intensity hadron accelerators for the generation of exotic beams and spallation sources, as well as much smaller accelerator facilities where cooled beams of specific (exotic) particles are provided for precision experiments and fundamental studies.
Moreover, particle accelerators are very important for many commercial applications, such as for example medical applications, where they are used for the provision of radioactive isotopes, x-ray or particle beam therapy. Furthermore, they are widely used for material studies and treatment, lithography, or security applications, such as scanners at airports or cargo stations.
The full potential of any particle accelerator can only be exploited if the performance of all its parts are continuously optimized, if numerical tools are made available that allow for developing and improving advanced machine designs and for benchmarking modelling codes against experimental results, if beam diagnostics methods are developed in partnership between the academic and industry sectors to monitor beams with ever higher intensities and brightness, shorter pulse lengths or smaller dimensions, and if the state-of-the-art in control and data acquisition systems is pushed further by the international research community to link all the above.
These are the aims of the oPAC project. Funded by the European Union with a budget of 6 M€, oPAC is one of the largest-ever research and training networks within the 7th Framework Program. In this talk, I will present an overview of the project, our research activities and planned international training events.

Presenter: Prof. WELSCH, Carsten (Cockcroft Institute / University of Liverpool)

Contribution ID: **1** Type: **not specified**

LHC and its High-Luminosity Upgrade

Wednesday, June 26, 2013 9:00 AM (45 minutes)

The Large Hadron Collider (LHC) at CERN has been operated for three years for physics leading to the discovery of a Higgs boson. The operational experience will be reviewed together with the main challenges encountered and the solutions applied. The performance outlook after the long shut-down and the future upgrade plans will be discussed with particular emphasis on the beam dynamics aspects.

Presenter: ARDUINI, Gianluigi (CERN)

Contribution ID: **2** Type: **not specified**

Circular Higgs Factories & Possible Long-Term Strategy

Wednesday, June 26, 2013 9:45 AM (45 minutes)

In 2012 two LHC experiments have discovered a new particle with a mass around 125 GeV, which appears to be the scalar Higgs boson of the Standard Model. To further examine this remarkable particle it could be produced in large numbers for precision studies by an e+e− collider operating near the ZH threshold at beam energies of 120 GeV, or, in the s-channel by a gamma-gamma collider with primary electron beam energies of 80 GeV, or by a high-energy electron-proton collider. In this talk I will discuss tentative design parameters, novel concepts and accelerator-physics challenges (1) for a high-luminosity lepton-hadron collider, bringing into collision a 60-GeV electron beam from an energy-recovery electron linac with one of the LHC hadron beams –LHeC –, (2) for a gamma-gamma Higgs-factory collider based on the reconfigured recirculating SC electron linac –SAPPHiRE –and (3) for a circular e+e− Higgs-factory collider in a new tunnel with a circumference of 80-100 km –TLEP. I will also discuss future paths to pp and eA collisions at even higher energies (VHE-LHC, TLHeC and VHE-TLHeC), and sketch a possible long-term strategy for accelerator-based high-energy physics.

For the LHeC a conceptual design was completed in 2012. Recently parameters are being modified to further increase the LHeC luminosity, which implies higher lepton-beam current and smaller proton-beam spot size. It is planned to validate key components of the LHeC in a CERN ERL test facility, which is presently being designed.

An important challenge for SAPPHiRE is the layout of the interaction region and the generation of high-power photon pulses needed for Compton back scattering. These photon pulses, which collide with the electron beams about 1 mm from the interaction point proper, could be produced either by a conventional laser together with an optical stacking cavity or by a Free Electron Laser.

TLEP has the potential to deliver some 500 times the LEP luminosity simultaneously to each of four experiments at 240 GeV c.m. More specifically, the proposed TLEP machine covers the full energy range from the Z pole up to above the top quark pair threshold, with luminosities ranging from close to 1036 cm-2s-1 per IP at the Z ("Tera-Z factory") to 1034 cm-2s-1 at the top threshold. Beam polarization at energies up to the W pair threshold should be possible, allowing exquisite energy calibration by resonant depolarization. Many of TLEP's novel design ingredients –such as an insertion with beta* equal to or less than 1 mm, and operation with beam lifetimes of a few minutes –will soon be demonstrated at SuperKEKB in Japan.

Importantly, TLEP provides a path towards a later Very High Energy LHC ("VHE-LHC"), with a centre-of-mass energy approaching 100 TeV in pp collisions: VHE-LHC and TLEP would be housed in the same tunnel and could share a large part of the infrastructure including experimental caverns, magnets, and major detector components. Such a complex could also deliver highest-energy highest-luminosity ep and eA collisions.

Only preliminary rough concepts exist for going to energies beyond VHE-LHC. E.g. 1000-TeV pp collisions could be realized with the help of crystals in the TLEP/VHE-LHC tunnel.

Presenter: Dr ZIMMERMANN, Frank (CERN)

Contribution ID: **3** Type: **not specified**

Challenges related to the design, commissioning and operation of 3rd generation light sources

Wednesday, June 26, 2013 11:00 AM (45 minutes)

Third generation synchrotron light sources under operation have reached very low emittances (1-5 nm.rad) at energies of a few GeV. Linear and nonlinear beam dynamics optimizations of their storage ring lattices are complex but well mastered. An overview of the procedures used for the optimization will be shown in this talk together with the performance of the latest generation of operating storage ring based light sources. Trends and innovations to meet the increasing user' s demands for high brilliance, excellent stability, Top-up injection, and different time structures will also be presented. In addition, efforts are increasing toward the design of ultra-low horizontal emittance lattices either by the construction of new projects (MAXIV in Sweden and Sirius in Brazil) or by proposing possible upgrade of the existing sources based on a rebuild of the arcs with MBA cells (ESRF, SPring8, APS, ⋯).

Presenter: Dr NADJI, Amor (Synchrotron SOLEIL)

Contribution ID: **4** Type: **not specified**

Optics Code MAD-X and Tracking code SixTrack at CERN - An Overview

Wednesday, June 26, 2013 11:45 AM (30 minutes)

The MAD in its F77 incarnation of version 8 has been very successful in the 90's and is used around the world even today. The LHC design tool was supposed to be MAD9 written from scratch in C++. Since this failed, despite a major 5 years effort, the MAD-X project was started. In early 2000 Hans Grote and a team of module keepers had to construct a C & F77 hybrid code within 6 months to provide the desperately needed optics code for the LHC design phase. MAD-X allowed all design work for the LHC and has also become central to the commissioning and control phase of the LHC. The code was complemented by the PTC code written by E. Forest from KEK to allow for a more modern description of accelerator elements and to make use of long established NormalForm techniques.
Presently, there is an attempt to rewrite MAD from scratch to overcome the inherent limitations of MAD-X.
In parallel there has been a decade long strive to speed optimize the single particle tracking code SixTrack. It gets its input from MAD and was used to evaluate the long-term stability limited due to magnet imperfections and the beam-beam interactions. SixTrack is meant for massive tracking studies and has been adapted over the years to the latest computing facilities like the CRAY supercomputers, farms of PCs, world-wide distributed computing on home computers and more recently the option of GPU computing is envisaged.

Presenter: SCHMIDT, Frank (CERN)

Contribution ID: **5** Type: **not specified**

High intensity accelerators

Wednesday, June 26, 2013 2:00 PM (45 minutes)

The high intensity frontier in accelerator science drives development in fields as varying as neutrino physics, material science and life sciences with neutrons, rare decays searches and transmutation. The accelerators used can broadly be divided into high average intensity hadron machines, high instantaneous intensity hadron machines and high intensity electron/positron machines. I will give an overview of the main facilities in the word and the discuss in some detail the design of the high average intensity proton accelerator for the European Spallation Source which soon will be under construction in Lund in Sweden.

Presenter: Dr LINDROOS, Mats (CERN)

Contribution ID: **6** Type: **not specified**

Beam Instrumentation challenges

Wednesday, June 26, 2013 2:45 PM (45 minutes)

Beam instrumentation encompasses all instruments that observe beam behaviour, providing "eyes" for machine operators. Good beam instrumentation is a must for safe and efficient accelerator optimisation. Today's main challenges lie in the request for unprecedented precision with positioning down to well below the micron level; dealing with high beam powers requiring non-invasive measurement techniques; and dealing with the ultra-fast implying measurements on femto-second timescales. All of this typically on a bunch by bunch basis requiring the efficient treatment of increasingly more data. This presentation will give an overview of these challenges and how they are currently being addressed.

Presenter: Dr JONES, Rhodri (CERN)

Contribution ID: **7** Type: **not specified**

Low energy/low intensity beams

Wednesday, June 26, 2013 4:00 PM (45 minutes)

In this talk a wide overview of the current state of the art of facilities that produce low energy/low intensity beams will be presented. Performances and R&D activities will be described, also putting in evidence the future plans for the improvements. The main facilities producing radioactive ion beams will be also presented, with an accurate description of the related beam diagnostics.

Presenter: Dr COSENTINO, Luigi (LNS - INFN)

Contribution ID: **8** Type: **not specified**

Monte Carlo Studies into energy deposition and beam collimation

Wednesday, June 26, 2013 4:45 PM (30 minutes)

At the Large Hadron Collider (LHC), proton beam losses must be controlled to unprecedented levels of accuracy as there are about 9 orders of magnitudes between the beam stored energy ad the quench limits of superconducting magnets. This poses critical challenges for the simulations of collimation performance that must provide accurate estimates with appropriate statistics of beam losses at the level of 1e-5 of the primary beam halo. A review of the available tools for collimation simulations, based on state-of-the-art particle tracking and energy deposition simulations, is presented. The comparison with the experimental data accumulated during the LHC run1 at 3.5 TeV and 4 TeV is also discussed and future challenges of novel collimation concepts are outlined.

Presenter: Dr REDAELLI, Stefano (CERN)

Contribution ID: **9** Type: **not specified**

Trends in Particle Detectors

Thursday, June 27, 2013 8:30 AM (45 minutes)

The main principles of particle detectors will be reviewed together with some key parameters that determine their design and specifications, namely vertex measurement, particle momentum and energy measurement as well as particle identification. Present LHC detectors are used for illustration of these topics. The challenges for future particle detectors are then discussed by using the plans for HL-LHC and ILC detectors as examples.

Presenter: RIEGLER, Werner (CERN)

Contribution ID: **10** Type: **not specified**

Research on ultra-short timescales - LCLS and the X-ray Free Electron Laser

Thursday, June 27, 2013 9:15 AM (45 minutes)

With peak brightness ten orders of magnitude higher than any other X-ray source and pulses as short as a few femtoseconds, Free Electron Lasers
(FELs) have opened new regimes in photon science. This talk will begin by describing the basic principles behind X-ray FELs and the accelerator performance requirements that make them possible, using SLAC's Linac Coherent Light Source (LCLS) as an example. The rest of the talk will focus on new ideas for upgrading future FELs, including coherent control of the radiation, miniaturization, and the push towards the TW power level.

Presenter: Dr RATNER, Daniel (SLAC)

Contribution ID: **11** Type: **not specified**

Electromagnetic field simulations for accelerator optimization

Thursday, June 27, 2013 10:00 AM (30 minutes)

A review of tools for electromagnetic field simulations used at CERN will be given. A number of examples of its usage will be presented covering several areas of accelerator component design and optimization both RF and non-RF equipment: accelerating cavities, collimation devices, etc. Furthermore, brief review of CLIC main linac RF frequency and accelerating gradient optimization will be given as an example of incorporating electromagnetic field simulation into a global optimization process including both constraints coming from the beam dynamics simulations and the empirical RF constraints related to the high gradient linac operation.

Presenter: GRUDIEV, Alexej (CERN)

Contribution ID: **12** Type: **not specified**

Green and Compact Magnet Technology for Optimization of Particle Accelerators

Thursday, June 27, 2013 11:00 AM (45 minutes)

Traditionally magnets for particle accelerators have been based on electromagnetic generation of the magnetic field. A new Green Magnet® technology based on permanent magnets requires close to zero electrical power, no cooling water, and it saves cost, space and natural resources. The technology has been developed as a collaborative R&D project between industry and academia. The performance of the first demonstrator dipole magnet will be presented.
Furthermore, a new highly compact multiple function magnet system for synchrotron light sources is being produced for the MAX IV 3 GeV storage ring. The integration of up to 12 individual dipole and multipole magnets into single monolithic magnet structures enables a compact, low emittance storage ring. Challenges in manufacturing and magnetic testing will be described.

Presenter: NIELSEN, Bjarne Roger (Danfysik A/S)

Contribution ID: **13** Type: **not specified**

Laser Acceleration - Enabling unparalled accelerating gradients

Thursday, June 27, 2013 11:45 AM (45 minutes)

A focused electromagnetic field represents an extreme electromagnetic field. Maybe the highest electric field we can get under controlled conditions? One electric charge inside that field is subject to a tremendous force and it is thus accelerated to relativistic speeds on a few femtoseconds (lab frame time). The relativistic motion of a charged field inside an extreme laser is going to be reviewed with the emphasis not only in the maximum speed it get but also on the violent acceleration (and also slow down) it suffers on femtosecond scale.
When such an extreme field hits a target, solid or gas, atoms are instantaneously ionized and so –as charged particles- accelerated by the field. Depending on the initial intensity, plasma effects can be dominant.
With appropriate conditions, plasma effects can boost the acceleration process. Different approaches are going to be presented in the talk, depending on the plasma density and the laser parameters. Comparison with standard RF (radio frequency) accelerators is to be discussed also.
The presentation will include a review of the state of the art ultra-intense NIR (near infrared) laser facilities around the world, and its usefulness for acceleration. Also comparison with FIR (far infrared) lasers will be mentioned, since FIR lasers lie somehow in between a RF field and an optical laser.
The fast acceleration scheme provided by lasers maybe will allow in the future other hybrid techniques. Among them, post acceleration of short-lived particles, such as charged pions or muons.

Presenter: Prof. ROSO, Luis (CLPU)

Contribution ID: **14** Type: **not specified**

Special Seminar: Unravelling the secrets of the Universe

Thursday, June 27, 2013 4:30 PM (1 hour)

During the 2010-2012 LHC run I, the accelerator delivered a wealth of data to the four large and several smaller experiments at the four collision points, allowing significant advances in our knowledge of high-energy physics and culminating in the discovery of a Higgs boson in 2012. This talk will give an overview of the LHC experiments and physics program, with a particular emphasis on results from the large 2012 dataset.

Presenter: HAWKINGS, Richard (CERN)