THE CRISP PROJECT – BUILDING SYNERGIES BETWEEN RESEARCH INFRASTRUCTURES

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Abstract

Recently, the European Commission granted 12 M€ for a project aiming at the implementation of common solutions in infrastructures on the ESFRI* roadmap in the fields of physics, astronomy and analytical sciences. The objective of this initiative is to generate synergies in the development of components of interest for several infrastructures and thus promote efficiency and optimisation in the use of resources. The project, called "CRISP (Cluster of Research Infrastructures for Synergies in Physics) and started October 2011, gathers many major European large-scale infrastructures (CERN, XFEL, ESRF, ESS, FAIR, ILL, SKA, SLHC, SPIRAL-2, ELI, EuroFEL, ILC-Higrade etc). The generated synergies will be crucial to stimulate scientific and technological progress and to respond to the rapidly evolving user community.

A brief overview of the different activities that are part of the project will be given, presenting the innovative approach of crossing boundaries between scientific disciplines and thus generating synergies.

CONTEXT

Since its first conceptualisation in 2000, the objective of the development of a common European Research Area (ERA) has represented the guiding reference in the pursuit of the research goals of the Lisbon Strategy for growth and jobs in Europe. The development of leading research and research infrastructures represented a core component of this strategy, which is even reinforced in the "Innovation Union" flagship initiative and confirmed worldwide: big research infrastructures, attract a critical mass of expertise, human and financial resources, and act as catalysts in the processes of knowledge creation and dissemination. By requiring cutting-edge technologies, they play a clear societal and economic role through the promotion of innovation as well as technology transfer and allow the materialisation of the so-called <triangle of knowledge> the virtuous connection between the research community, the academia and the industrial actors of innovation.

In this context, the European Commission is undertaking a variety of actions with the aim of promoting and stimulating the optimal use and the resources in science and technology. Recently, the EC funded a project in which eleven of the biggest research infrastructures belonging to the ESFRI Roadmap in the fields of physics and analytical sciences (representing an investment for construction of >8 Billion Euro and potential of 10000 scientists) setup synergies in various fields of research. The project, started in October 2011 and called CRISP (CLUSTER OF RESEARCH INFRASTRUCTURES FOR SYNERGIES IN PHYSICS), is premised on the fundamental idea that setting up synergies between projects is a key element for guiding the development of science and technology worldwide and enhancing its efficiency. Several working-groups are already tackling the technological and scientific challenges that they have indentified and that are part of the Project. Some of those, in particular accelerator topics and accelerator detectors, are presented here. For the others we refer to [1].

ACCELERATOR TOPICS

The development of novel accelerator components and their characterisation is a pre-requisite to reach beyond state-of-the-art performance of accelerator complexes which are in turn one of the key elements for the majority of the participating RI projects. Their development constitutes the basis to deliver beams with superior intensity, operate accelerators with high reliability, and achieve beam characteristics which will allow opening new perspectives and opportunities for the next generation of nuclear and high energy physics projects and experiments in photon, neutron and ion beam science.

Superconducting technology, either applied to radio-frequency cavities or to beam transport magnets, are used for most of the upcoming large scale accelerator projects; the use of solid state amplifiers adapted to a variety of accelerating structures strongly supports this. All participating projects are involved in ambitious particle sources design, either for high intensity ion beams or to drive free-electron lasers with their high brilliance electron beams. These initiatives push accelerator facilities to performances beyond state-of-the-art.

Existing synergies within the accelerator based research infrastructures are exploited further under CRISP by the following actions.

1. The development of an ion source and related beam diagnostics is of central importance for FAIR and SPIRAL2. The FAIR and SPIRAL2 facilities both need a high performance electron cyclotron resonance ion source (ECRIS) to create the high intensity beams required for the envisaged nuclear studies. The two former ion sources financed in the framework of the FP6-EURONS – ISIBHI (MS-ECRIS, A-PHOENIX) are both facing R&D challenges, while the foreseen start of beam delivery is approaching very fast (2012 for SPIRAL2 and 2014 for FAIR). A new design of ECRIS is required by both facilities. SPIRAL2 and FAIR shall engage themselves in the joint development and construction of a new prototype 28 GHz ECR ion source. Joining efforts and expertise is particularly important for the construction of a cost-effective ECRIS and to minimise the project risk of the superconducting magnet design. A second task is related to the common development of a diagnostic

device for the non-intercepting bunch shape measurement for the linear accelerator section of the FAIR and SPIRAL2 projects. No standard device for the determination of this important beam parameter exists. Due to the comparable beam parameters for the FAIR and SPIRAL2 machines, development and construction costs can be reduced. Contact.

2. Superconducting radio-frequency (SRF) technology is used for almost all future large scale accelerator projects. New accelerator structures with improved characteristics were or are to be developed for the participating projects ESS, ILC-HiGrade, SLHC, and XFEL. Highest accelerator performance requires optimised production, surface treatment, and diagnostics of the accelerating structures. The knowledge and mastering of these technologies becomes even more important since large scale production involves large scale series production in industry. The accumulated know-how of EuroFEL, ILC-HiGrade, SLHC (at CERN) and XFEL (at DESY) shall be exploited to further improve the quality of the SRF accelerator cavities by pushing further the detailed diagnostics tools and the surface treatment of the cavities. At DESY an optimised procedure for a second surface treatment required to improve the performance of returns will be investigated and established as a critical element to reach the performance goals of XFEL. At CERN the upgrade of the SM18 test facility is a central ingredient for the common activities. A comprehensive transfer of knowledge to new projects e.g. ESS and SLHC is an essential part of the work, thus guaranteeing an optimum sharing of the acquired know-how and ensuring the best performance of the accelerators at these and other future facilities.

3. The development of fast ramped superconducting magnets is of central importance for the planned synchrotron SIS300 at the FAIR facility. For SLHC it is important to assess whether the technology is suitable and adapted to the construction of the future injector chain of the LHC. The proposed common development is furthermore of key importance as well for accelerator-based medical applications (e.g. hadron therapy). ELI, FAIR and SLHC (at INFN, GSI and CERN, respectively) engage themselves in a joint effort to further optimise the design of the magnet. Future accelerator facilities will rely on the use of these magnets in order to meet their ambitious goals.

4. The joint design of a compact high brightness electron beam and of laser-induced secondary particle sources is of direct benefit to ELI and EuroFEL. It shall create synergies between the “classical” and the laser-based accelerator community. Its interest is to overcome limits that both communities are facing. The high intensity laser community is proposing a laser induced secondary particle source as the next generation of particle accelerators able to produce within the same scheme high quality electron beams as well as protons or other ions with an accelerating gradient of the order of TV/m which cannot be achieved with conventional accelerators. Similarly, other novel acceleration schemes rely on high brightness electrons, presently used in conventional free-electron lasers (FEL), to be fed by plasma accelerators. Moreover, there is a growing interest in developing compact (e.g. X band structures) high brightness electron sources directly for FEL applications as well as more innovative ones. The proposed development of laser induced particle sources and compact electron sources aims at joining the competences of ELI and EuroFEL demonstrating and implementing groundbreaking solutions for the particle accelerators of the next generation.

5. The ESFRI projects ESRFUP, ESS, FAIR and SLHC all require Megawatts of radio-frequency (RF) power to accelerate particles. Conventionally, this power is generated by klystrons, but in recent years LDMOS-FET transistors have become an attractive alternative. The CRISP project aims to take forward the preparatory phase by elaborating a new efficient way to combine the power of many RF transistor modules by means of a single cavity combiner. This concept will result in a more compact, flexible and cost effective design with improved operation reliability. Within the frame of the proposed work, a prototype will be built for ESRFUP and design studies for ESS, FAIR and SLHC shall be performed; these will have a significant impact on the way these projects will envisage the implementation of the high power RF generators that are needed to power their accelerating RF cavities.

DETECTORS & DATA ACQUISITION TOPICS

The need for efficient and high performance detectors and their associated instrumentation is common to essentially all Research Infrastructure projects. Some of the new RIs in preparation heavily rely on the construction of new detector systems that go beyond current, well established technologies. Other RIs need to develop completely new approaches. Research and development efforts, undertaken by individual facilities, are, however, cost intensive; and common developments and sharing of expertise and know-how are often key ingredients for significant progress. Furthermore, with the expected increased performance of the upgraded and new RIs, novel and more performing data acquisition and signal processing standards need to be developed.

Existing synergies between research infrastructures in the area of Detectors and Data Acquisition are exploited further under CRISP by the following actions.

1. High-throughput detector data streaming is of direct relevance to ELI, ESRFUP, EuroFEL, European XFEL and SKA. The tremendous improvements promised by the

new or upgraded light sources (storage rings, FELs, lasers) will be compromised if the detectors do not cope with the timing and/or information rates that are likely to be produced by the very intense photon beams produced at those facilities. In a similar way, the performance of radio telescope arrays is also directly related to the capability of processing in real time the very large data records produced by the thousands of sensing elements and antennas that constitute this kind of instrument. The work will address the selection, definition and development of various techniques and methods to reduce, transmit and process high throughput data streams produced by the last generation detector systems. In addition to technical and scientific performance, the aim is to establish a certain level of standardisation of methods and interfaces. The implementation of common interfaces for the data streams will have a substantial impact on interoperability of the detector systems, both within and across the facilities, and therefore should imply a substantial reduction of deployment and operation costs.

2. The development of CO_2 cooling systems is indispensable for the next generation of particle detectors. SLHC is the driving project in this development, and EuroFEL and FAIR will strongly benefit for their own applications of this technology, in particular for high-performance silicon tracking detector systems and highly integrated electronic assemblies where efficient low-mass cooling is a key prerequisite for novel system concepts. In comparison to fluorcarbon based cooling fluids, CO_2 two-phase cooling possesses superior thermodynamic properties, is less expensive, and is much more environment-friendly. This cooling scheme, whilst serving the CRISP participants, will find wide-spread applications well beyond the CRISP project. The common work plan shall join forces and expertises in the design and construction of these devices.

3. The common development of advanced electronics and software for neutrons and x-ray detectors is of direct benefit to ELI, FAIR, and SPIRAL2 for their upcoming accelerator facilities. Nuclear structure and radioactive ion beam experiments at these facilities require modern data acquisition electronics and algorithms adapted to the advanced γ-ray tracking and neutron detection systems that will become operational on a time scale of a few years. Common solutions for the realisation of the experimental set-ups are planned by expanding the developments and standards performed during the SPIRAL2 preparatory phase and making them applicable also for ELI and FAIR. The work shall focus on the preparation of front-end electronics cards with improved data throughput, calibration and post-processing performance to be deployed across the facilities.

4. Neutron detectors require the use of neutron absorbing elements. Until recently, ^{3}He was widely exploited because of its easy use and the high neutron capture efficiency. However, ^{3}He has become a very scarce and highly expensive material for several reasons: decrease in the production rate (most of the nuclear reactors producing tritium from which ^{3}He is generated have been stopped) and the increase in the demand for neutron science (large area detectors) and homeland security in the United States. All neutron facilities worldwide are impacted by this situation. Finding a substitute to ^{3}He is a formidable task which is to be tackled in the long term by the whole neutron scattering community. However, both ILL20/20 and ESS projects rely on rapid progress on a new detector technology. Several technological options exist (solid 10B, 10B in highly toxic gaseous BF_3, scintillators). ILL20/20 and ESS are proposing to establish collaborative plans for the design and feasibility studies of a neutron detector based on solid 10B films technology as a substitute to 3He gas. Once the feasibility of this technology is demonstrated in terms of efficiency, and manufacturing & maintenance costs, a global evaluation of the different methods will be done at the European and worldwide levels.

ACKNOWLEDGMENT

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REFERENCE

[1] http://www.crisp-fp7.eu