Topic proposal for integrating and opening existing national research infrastructures

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1. Title

Advanced infrastructure for detector development for future High Energy physics project at accelerators

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3. Description of the research infrastructures covered and the trans-national access and /or services provided

The detector developments for High Energy Physics (HEP) experiments are going through well-defined stages that typically span over 10-20 years. Two kinds of infrastructures are needed to test prototypes in realistic conditions to qualify the technologies chosen and assess the performance: beam lines with low and high energy particles of various types and irradiations facilities providing high flux of particles as expected at the LHC future upgrade. Grouping all these infrastructures in a common Integrated Research Infrastructure guarantees a coherent use of these facilities, improving their synergy.

For test-beams, there are two main infrastructures available in Europe:

-CERN beam lines are unique in the world covering both the low and high energy spectra with different particle types. Some beam lines are providing magnet and precise position

measurement devices (developed in FP6-EUDET and FP7-AIDA). The number of users requested beam time exceeds every year by a large amount the available time.
-DESY operates a test-beam facility using the DESY II accelerator providing four beam areas with electrons of up to 6 GeV. The beam areas are equipped with a range of infrastructure, such as a high-precision pixel telescope, which is a copy of the telescope developed in EUDET and which is predominantly used to provide accurate tracking of test-beam particles and thereby facilitates the study of important parameters of newly developed detectors. A large-bore superconducting magnet, refurbished by AIDA, with a field of up to 1 Tesla is provided for the user groups. The DESY facility is intensely used by many international projects, such as Linear Collider detector studies and also LHC related studies.
-The Frascati facility, delivering electrons and photons in the range 25-750 MeV, as well as neutron with wide spectra centered at 0.7 MeV, might also be considered for detector calibration purposes or low energy high flux electromagnetic study
All these infrastructures, intensively used by the HEP community, are also used for astroparticle/astrophysics projects.

There are a number of irradiation facilities across Europe:
-CERN is providing proton and mixed-field irradiation facilities and also the GIF++ facility for photon irradiation of large size detectors, where irradiation of large detectors to lower fluences is sought.
-The Jozef Stefan Institute TRIGA reactor delivers large neutron fluence in a time-span of hours. It is well designed to accept components of modest size like pixel or prototype strip tracking sensors and associated electronics.
-The compact cyclotron at KIT (Karlsruhe Institute of Technology) delivers high proton flux. Detectors larger than the beam spot can be covered by scanning.
-The UCL (Louvain) facility delivers proton, neutron and photon fluxes and is designed to accept large size components for somewhat lower target fluences.

In the next decade, the LHC experiments will have to upgrade their detectors and a new Lepton Collider project is expected to emerge with also strong needs for Silicon detectors and large gas area detectors. Providing common infrastructures with Transnational Access (TA) to assemble and/or perform the quality assurance tests of such detectors would allow a better use of the resources and bring together and develop the European expertise. High-level technical manpower should be also available in these infrastructures to guarantee an efficient use by the incoming teams.
A key tool to organise the effective and broad use of these facilities is the TA scheme, where beam time is made available to eligible users free of charge. The EC funding is expected to cover part of the access costs, part of the technical staff and equipment, as well as the travel and subsistence allowances of the users.

A final selection which facilities can be included in such a scheme can only be done following an updated careful and detailed survey of the needs of the community during the next 5-10 years. Needs by other communities should also be taken into account.

4. Scientific domains served by the research infrastructures

4.a. Select the scientific domain(s) served by the research infrastructures:
- Engineering, Material Sciences, and Analytical facilities
- Physical Sciences

4.b. Indicate here the main scientific domain served:
- Physical Sciences

5. Key potential partners

Below is a table of key potential partners from the AIDA consortium (including beneficiaries and third parties). The upcoming proposal might include other, European, non-AIDA partner institutes as well. In the framework of the network on relation with industry, a few key industrial partners might also be associated to the new project.

Organization name	***Country***	***Contact person***
OEAW	Austria	Manfred Krammer
UCL	Belgium	Eduardo Cortina Gil
ULB		Gilles De Lentdecker
UniSofia	Bulgaria	Roumen Tsenov
INRNE		Plamen Iaydjiev
RBI	Croatia	Tomme Anticic
CUNI	Czech Republic	Zdenek Dolezal
IPASCR		Vaclav Vrba
CNRS	France	Vincent Boudry
CEA		Paul Colas
UH	Finland	Antti Heikkila
DESY	Germany	Ties Behnke
MPG-MPP		Hans-Günther Moser
UBONN		Hans Krüger
Wuppertal		Christian Zeitnitz
JOGU		Stefan Tapprogge
UHEI		Hans-Christian Schultz-Coulon
KIT		Wim De Boer
AUTH	Greece	Chariclia Petridou
DEMOKRITOS		Dimitrios Loukas
NCUA		Paris Sphicas
UoI		Costas Fountas
NTUA		Evangelos. Gazis
Wigner RCP	Hungary	Ferenc Sikler
TAU	Israel	Halina Abramowicz
Technion		Shlomit Tarem
Weizmann		Giora Mikenberg
INFN	Italy	Chiara Meroni
VU	Lithuania	Juozas Vaitkus
FOM	Netherlands	Els Koffeman
UiB	Norway	Gerald Eigen
AGH-UST	Poland	Marek Idzik
IFJPAN		Leszek Zawiejski
JSI	Slovenia	Marko Mikuz
CSIC	Spain	Ivan Vila Alvarez
CIEMAT		Maria de la Cruz Fouz
IFAE		Sebastian Grinstein
USC		Martin Cacheiro
UB		Angel Dieguez
UU	Sweden	Richard Brenner
ULund		Vincent Hedberg
CERN	Switzerland	Patrick Fassnacht
ETHZ		Guenther Dissertori
UNIGE		Martin Pohl
RHUL		Veronique Boisvert
STFC		Claire Shepherd-Themistocleous
UCAM		Mark Andrew Thomson

UNIGLA	UK	Paul Soler
UNILIV		Gianluigi Casse
UNIBRIS		Joel Goldstein
UOXF.DL		Andrei Nomerotski
USFD		Richard French
UNIMAN		Christopher Parkes
QMUL		Adrian Bevan

6. Scope and activities

6.a. *Overall objectives of the activity*

HEP experiments involve a large world-wide community of more than 10,000 scientists, in which Europe has a leading role.

The main objectives of a new Integrating Activity (IA) project will be to further federate the European institutes working on detector R&D on different experiments and to enhance the cross-fertilization between these teams for future HEP projects. It will also focus on identifying and developing common aspects on offering infrastructures with high level equipment and on developing new techniques common to all relevant experiments. The IA project will also forge new creative solutions for applying recent and future technological developments.

The high quality of the instrumentation and detector construction expertise has been a key element of the success of the HEP physics in Europe over the last three decades. To maintain this position it is crucial that instrumentation science continues to increase its visibility at European universities (e.g. becoming an essential part of their curricula) and that it offers attractive opportunities for young scientists.

Future projects beyond LHC (multi TeV LC, CLIC, or High Energy LHC) or new neutrinos large scale experiments are and will increasingly become R&D drivers for detector developments within the next decade. The outcomes of the new IA will not only contribute to European detector R&D activities, but also -on a more global scale- to relevant activities in the US and Asia. The present R&D should therefore be pursued and a possible industrialisation of the detectors in Europe needs to be studied. All options require sophisticated and improved detector-systems and sustained efforts to exploit and encourage industrial development of sensors, electronics and system engineering. Involving the industry partners in the project is a key element to ensure high quality detectors. Such a partnership could also bring mutual benefit on new technology development or applications to other fields than particle physics. The project should therefore be used to create academia-industry partnerships on some well identified technologies needed by the HEP community. The new IA will also foster new projects on the neutrino hierarchy (sterile neutrino or not) and on CP violation in order to progress on our understanding of matter-antimatter asymmetry in the universe.

6.b. *Networking Activities and Joint Research Activities*

Under Horizon 2020, extending and going beyond the present effort in AIDA, a list of proposed NAs to be implemented in a new call is as follows:

- Software development:

Fast response is required for quickly evolving technologies. In most of the HEP future projects, the increased event complexity results in ever-increasing demands on both CPU and memory footprint. The development of common solutions and their adoption by many experiments will be a vital ingredient for meeting requirements using the resources available and within the required timescales. High levels of investment in software development are needed now to obtain order of magnitude improvements in software performance on new computer hardware that are expected to be deployed in the coming years. The paradigm shift towards software parallelization will require significant new levels of expertise that need to be acquired by the community.

- Microelectronics and integration:
The roadmap of semiconductor industry highlights two major paths in future developments: scaling of microelectronic technologies and 3D integration for future pixel sensors. Therefore, a network of microelectronic groups has to be preserved and enlarged so that the design of nanoscale CMOS chips is technically and financially viable. Also the support to a network on 3D integration will remain essential to allow the community to continue exploring different aspects of 3D integration technology. Further technology improvements are also foreseen, e.g. a layer optimized for high rate optical transmission of data or integrated cooling channels for low mass detector systems. The developments in 3D integration have already demonstrated to benefit other communities close the HEP as light source facilities or medical application.

- Relations with industry:
Collaborations between Particle Physics and industry are characterised by long development cycles with long time gaps in between. They offer an essential means for knowledge and technology exchange, which are keys for ensuring the construction of the best possible research equipment in a cost effective manner. There is nevertheless considerable room for improving the effectiveness of academia-industry collaborations, in particularly in these aspects: quality of partners, efficiency, industry capabilities and capacities. Within this network, it is proposed to explore other collaboration routes than pre-commercial procurement contracts and assess their effectiveness on practical cases when moving from the R&D phase into the pre-construction phase.

- Data Acquisition:
Quite often, each user group develops its own data acquisition system when coming to test a prototype in the test beam. Going from test bench to realistic condition (environment, rate) is eventually found to be difficult. Moreover it appears sometimes time consuming to incorporate the various devices offered by the infrastructures. Already started in the LC community, converging and developing a common core data acquisition system might be useful. Such a network could use in the definition of this common part, while the customisation be part of the user project.

- Training:
For the successful long-term realization of the HEP projects it is crucial to ensure the continuity of knowledge and experience over generations of physicists, to strengthen human potential. Therefore, under a new IA it is foreseen to have a dedicated NA for training of young experimentalists and engineers on instrumentation, as well as computer engineers. Key elements of this activity will be dedicated summer schools, special tutorial sessions and workshops with renowned experts in the field, as well as short-term staff exchange visits for scientists, students, engineers and technicians, in particular from countries with less advanced infrastructures.

A proposed list of JRAs, supported by the community is as follows

-Novel Irradiation and beam lines:
In view of new long baseline neutrino experiments, a low energy dedicated beam line would be desirable to satisfy long-term user needs. Beam and radiation monitoring equipment and dose and fluence measurement techniques for irradiation facilities have to be improved for higher precision and time resolved measurements. A unique web entry point for the facilities would foster communication between users and the exchange of test results. Finally, providing adequate user infrastructure would ease the access, reduce the setup time, optimize the throughput and minimize the amount of equipment to be imported by users.

-Enhanced beam equipment:
The infrastructure initiated under EUDET and further extended under the AIDA project has a strong user base. It is therefore mandatory to reserve funds of a future FP8 project to continue to provide the support necessary for an efficient use of these infrastructures beyond the duration of the AIDA project. Also they should cope with any new challenging request and are expecting to evolve along with the new R&D projects. The aim is also to further improve the existing infrastructure (particle identification devices, 3D movement mechanical tables, cooling). A detail survey of the user requirements would be needed before selecting any technology.

-New facilities for quality assurance:
With the increasing scale and stakes in the HEP detector projects the need for an exigent and complete quality planning and assurance program is crucial and is finally gaining – based on the experience on the most recent projects – very rightfully in importance. However, the number of quality assurance and reliability testing centres within the HEP community and their equipment is still very limited. Equipping these centres with state of the art accelerated lifetime and stress screening tools and developing in parallel the according testing procedures adapted to the conditions of the individual HEP experiments is essential.

7. Need for European integration

HEP experiments have traditionally been international for many years, now global collaborations involving hundreds of institutes and thousands of physicists from different countries. For example, two of the LHC experiments – ATLAS and CMS – each has more than 180 institutes and universities from some 40 countries world-wide. All of these institutes, as well as the large national HEP laboratories in Europe are participating in detector R&D oriented towards new projects. In order to cope successfully with the increasing technological challenges and the cost of the HEP experiments and/or their upgrades, European countries need to pool resources and work together. The Integrating Activities under FP6 and FP7 have proven to be an efficient framework for fostering collaborations at European level. The level of funding from the EU is typically about 30% of the full costs of the IA projects; the rest comes from national funding agencies and own institute sources. The interest and the need for participation in the EUDET and AIDA projects have been overwhelming and many participants have been involved as associate partners without receiving any EC contribution. Without the EC framework, some of the collaborating institutes would have never emerged at European level and would have continued developing their activities in parallel. Setting-up federated collaborations with several leading centres of excellence, whereby sharing knowledge and expertise, optimise both financial and human resources., This is in particular relevant for universities and small research institutes in some of the countries involved.
In view of the successful operation of the LHC and the recent discovery of the Higgs-like boson, the interest in particle physics is increasing and a number of global projects are being discussed or prepared. In order for Europe to maintain its leadership and strong position both at the Energy and the Intensity frontier, a new European collaboration under a new Integrating Activity project for detector R&D is called for.

The current AIDA project relies on more than 80 institutes from 23 countries and a large effort was made to include new countries in order to facilitate their participation in the HEP projects. However with an EC contribution at the level of 1/3 of the needs and limited to 8M EUR, it was challenging to build such a coherent project especially to include the smaller institutes. A number of countries and institutes still have an associated partnership. With the aim of coordinating the European activity on detector R&D in HEP around its main infrastructures, the EC funds allocated to a new IA should be at the level of 20M EUR to ensure a real success and inclusiveness of the project.

8. Expected impact

Within AIDA, a large number of new collaborations were formed to develop detector solutions for the new generation of accelerator facilities in Europe by allowing researchers from a diverse number of communities and experiments to work together to find common solutions, andcreate long-term synergies between different detector development projects to enhance their efficiency. Following the discussions held at the Particle Physics community meeting in Cracow in September 2012, the European Strategy for Particle Physics will be adopted in spring 2013 by CERN Council at ministerial level. It is expected that the updated Strategy will underline the importance of coordinated detector R&D activities throughout Europe that could be carried out for example in the framework of EU projects.

The main impact of a new IA will be to consolidate the coordination and develop the implementation of European infrastructures for Particle Physics detector R&D at some of the main laboratories in Europe (such as CERN, DESY, Laboratori Nazionali di Frascati). Detector R&D activities will be covered for all future accelerator facilities recommended by the European Strategy for Particle Physics (Super-LHC, Linear Colliders, Neutrino Facilities and Flavour Physics Facilities). This IA will benefit many institutions from various parts of Europe.

The new IA will continue to foster and expand collaborative projects needed to deliver the advanced detector system. The challenging environment of these new accelerator facilities in terms of luminosity, data throughput, occupancy, radiation tolerance, electronics and materials will be designed and tested under the umbrella of this project. Building, upgrading and developing new infrastructures such as test beams and irradiation facilities, coordinating new software tools, creating networks of researchers (including training of the young experimentalist) and developing new detector concepts will benefit a community of around five thousand collaborators from all around the world that work on the upgrade and development of new particle physics experiments.

The main stakeholders that will continue to benefit from the new IA will be universities, research institutes, national and international laboratories and the variety of national and international funding agencies that contribute to the construction of the next generation particle physics experiments at future and upgraded accelerator facilities. On well-defined technologies, industrial partners might be included as partners in the new IA, at least at the level of associate partner.

Apart from particle physics, other scientific fields such as nuclear physics, astrophysics, space science and condensed matter will also benefit from this IA. In addition, novel detectors and technologies and increased industrial collaborations will have an impact on medical applications, radiation monitoring devices and generally benefit any sensor-based systems used in our society.

9. Projects previously funded under FP7 and FP6

The EUDET program received funding in the context of FP6 from 2005-2010. EUDET comprised 24 European partners from 12 different countries and 29 associated institutes, with the total budget of 21.5 million EUR, with EC contribution of 7M EUR. It was focused on the development of infrastructure for detector R&D and tests particularly for a future Linear Collider. As a result of the activity a number of important and well used infrastructures were developed:

- A testbeam telescope based on small pixel Silicon detectors
- A test-infrastructure installed at an electron beam at DESY optimised for the development and test of time projection chambers.
- A versatile calorimeter test installation, including a flexible and adjustable stack to be used in the development and test of novel calorimeter concepts
- A common and versatile DAQ system used by all partners of the EUDET program.

In the context of the subsequent AIDA program these facilities were expanded and further developed, with the goal to make them available to a broader community and at a larger number of sites. A number of test beam telescopes based on the original EUDET one have been built and are now operated at DESY, CERN and Bonn. The TPC infrastructure at DESY has been significantly improved, in particular by the modernisation of the cooling plant needed for the high field magnet which is part of the setup, and is used intensely by groups from AIDA. The calorimeter infrastructure is now focussed on work done at CERN. It has been expanded to include Tungsten as an absorber. The EUDET DAQ system is developed within AIDA to provide a generic test beam DAQ to a broad range of users.

Currently, there is an ongoing Integrating Activity project AIDA (Advanced European Infrastructures for Detectors at Accelerators) under the FP7-Capacities programme. The overall project budget is 26M EUR€ with EC contribution of 8M EUR. AIDA relies on more than 80 institutes including 39 beneficiaries and a number of associate partners from 23 European countries. The main objectives of the project is to provide a collaborative European framework for the upgrade, improvement and integration of key European research infrastructures and development of advanced detector technologies for future particle accelerators in line with the European Strategy for Particle Physics.

AIDA is running from 1 February 2011 until 31 January 2015, and has the following components:

- The networking activities are studying promising new technologies such as 3D detectors and micro-electronics to build these detectors as well as specifying what the technological needs of the future are. Interactions with appropriate industrial partners are taking place as well. Advanced software development is also the topic of a networking activity.
- The joint research activities involve many institutes working together to improve beam lines to test particle detectors. The equipment needed to produce these detectors is being upgraded and some new technologies developed or tested.
- The transnational access activities offer access to beam lines at CERN and DESY and some irradiation facilities across Europe for testing particle detectors opened up to new users. Researchers from different European countries working in this area can contribute to the field with their findings by using these test facilities.

After the end of AIDA under FP7, it is necessary to ensure that the existing important and well used facilities and equipment remain available to a broad user community. The transnational access scheme of a new integrating activity project under H2020 will allow them to remain central pieces of a common European infrastructure for detector development. In addition, these facilities will require continuous upgrades and further developments in order to match the growing needs and the demanding requirements of the HEP community.