DRAFT SUMMARY OF THE SLHC-CNI PROPOSAL – 27.03.07

Capacities - Research Infrastructures

FP7-INFRASTRUCTURES-2007-1

Proposal full title: **Upgrade of the Large Hadron Collider**

Proposal acronym: SLHC

Type of funding scheme: Combination of Collaborative Projects and Coordination and Support Actions

Work programme topics addressed: *INFRA-2007-2.2.1.33*

Name of the coordinating person: Lyn Evans (CERN)

LHC upgrade – Introduction

The upgrade of the Large Hadron Collider (LHC) is the project with highest priority in the document for the European Strategy in Particle Physics, unanimously approved by the CERN Council in July 2006. This project, whose budget is expected to exceed 1 B€, includes a major upgrade of the cascade of accelerators needed to inject a beam into the LHC and will result in an increase of the luminosity of the LHC by one order of magnitude. This will allow the LHC to remain the most powerful particle accelerator in the world in the next two, possibly three decades, and to fully exploit the potential of the LHC towards new discoveries. Thus Europe will maintain its leading position in the field in the foreseeable future.

The SLHC will enable precise measurements for phenomena within the LHC discovery reach (such as Higgs couplings, properties of SUSY particles, couplings to new forces); it will push the limits of sensitivity for detecting new phenomena to higher mass scales (e.g. new forces or quark substructures); and it will allow to see low-rate phenomena inaccessible to the LHC (such as rare Higgs decay modes).

The Preparatory Phase of the LHC-upgrade will have an important catalytic effect for organising the new collaborations for the implementation of the accelerator and the detector upgrades of the LHC. These will be global endeavours, involving not only the 20 CERN Member States, but also many other countries from Europe and all over the world, among which Russia, USA, Japan, India, and China. European industries will also be involved to contribute to the technology development and prototyping work.

Coordinating the accelerator and experiments activities with the aim of attracting partners, organizing exchange of information and creating collaboration frameworks in vital domains, such as SC quadrupoles for collision area and power distribution for future detectors, are issues to be addressed. The main objectives are clearly defined, in agreement with the European roadmap: the upgrade of the luminosity of the LHC, including the improvement of the LHC injectors, and of the detectors. In the last three years and in particular within the running CARE project partly funded through FP6, options for achieving the first objective have been analysed, while limited R&D work took place concerning the second. Clear priorities have emerged which now have to be elaborated by further studies and prototype work. These specialized activities will continue with the same partners and many new ones, in view of the implementation phase.

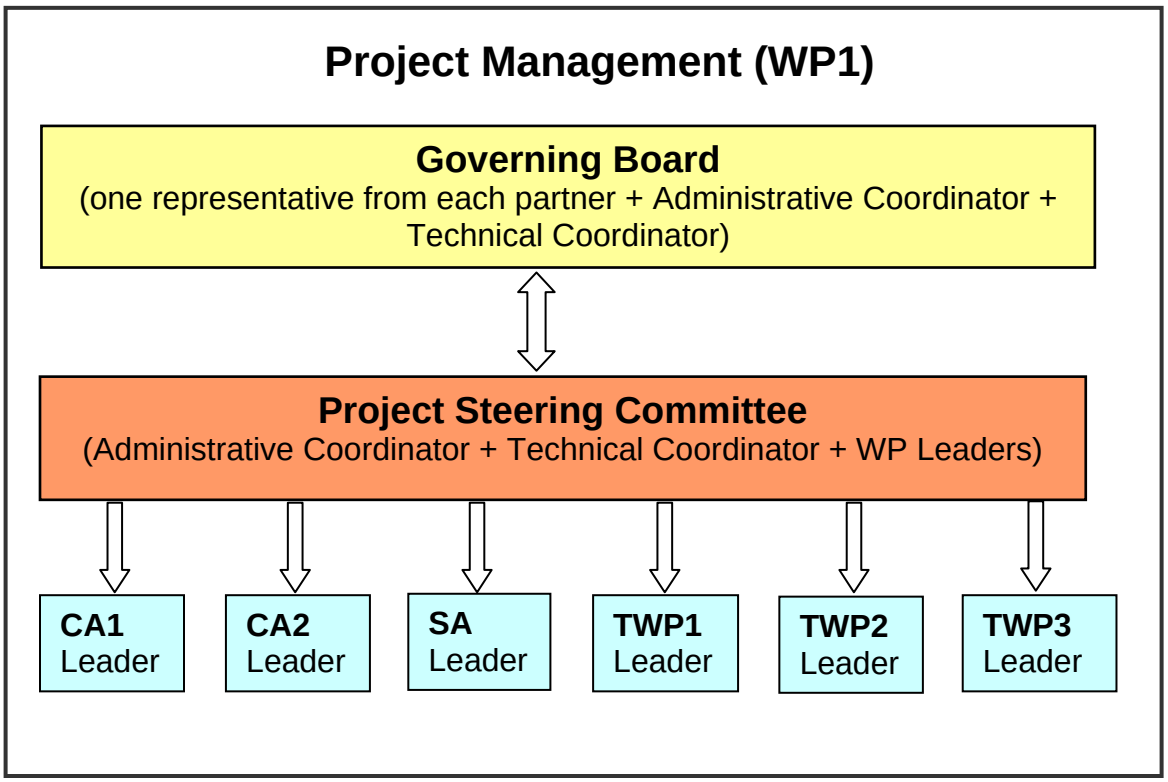
Table 2a - List of Preparatory Phase Work Packages foreseen under this proposal

Work Package No	**Descriptive Title**	**Short description and specific objectives of the task**	**Potential Participants**	**Total budget (kEUR)**	**Requested EC contribution (kEUR)**	Over-heads (kEUR)
WP1	**Management of the contract**	Management and coordination of all Work Packages, progress and budget follow-up and reporting	**CERN**	**600**	**600**	360
WP2	Coordination activities: **SLHC Implementation Coordination: Accelerator**	1. Coordination of the SLHC accelerator upgrade Upgrade planning, establishing common data bases, cost estimates. Formalising the collaborations for the Implementation Phase and MoU preparation. 2. Networking activities, dissemination of information and knowledge, workshops.	**CERN** CEA (FR) INFN (IT) RAL (UK)	**400** **100**	**400** **100**	35
WP3	Coordination activities: **SLHC Implementation Coordination: Experiments**	1. Coordination of SLHC experiments Setting-up formal SLHC Experiments structures, financial rules, review procedures. Preparation of Cost Books and Collaboration Agreements. Networking, dissemination, workshops. 2. Project Office Information and documentation on the infrastructure of the upgraded experiments, web-interfaces, installation scenarios and schedules.	**CERN** Nikhef (NL) RAL (UK) UniGe (CH)	**250** **900**	**250** **450**	50

WP4	Support activities: **Radiation and safety**	1. Radiation impact studies 2. Safety management & documentation	**CERN** CEA (FR) PSI (CH) DESY (DE) ANDRA (FR) NAGRA (CH)	**1,500**	**700**	50
WP5	Technical Work Package 1: **Nb-Ti quadruple magnet prototype**	Development of high field Nb-Ti quadruple magnet prototypes with very large aperture 1. Construction and prototype testing 2. Technical design for serial production	**CERN** CEA (FR) INFN (IT) RAL (UK) CIEMAT (ES)	**2,400**	**800**	480
WP6	Technical Work Package 2: **Components for the injectors' upgrade**	1. R & D for an H- ion source meeting beam characteristics and life-time requirements for future injectors. 2. Development of the low-level RF for future pulsed proton linacs using normal or superconducting accelerating structures	**CERN,** CEA (FR) DESY (DE) IN2P3 (FR)	**2,400**	**800**	480
WP7	Technical Work Package 3: **Tracking detector power distribution**	Development of radiation-hard and magnetic-field tolerant microelectronics components for novel tracking detector power distribution systems	**CERN,** RAL (UK) AGH (PL) PSI (CH) EPFL (CH) UniBonn (DE)	**2,000**	**600**	360
Totals				**10,550**	**4,700**	1,815

LHC upgrade preparatory phase:

1) project organization



Legend:
CA = Coordination Activities
SA = Support Activities
TWP = Technical Work Package

2) project duration and time table

3 years total, starting approximately, if approved, at the beginning of 2008.
This time scale fits very well the plans to make the first upgrading step in 2011 and to complete the upgrading in 2016.

Description of Work-packages

WP1 SLHC CNI pp management

Management and coordination of all the work-packages described below.
Review the progress of the activities, follow-up of the budget, reporting to EC.
Work-package and task leader activities.

600 k€ (incl. 5-6 p.y)

WP2 SLHC collider upgrade Coordination

Task 1.

Organizing meetings gathering the potential participants into the implementation phase to agree upon and define the upgrading plans.
Common data bases, sites for the upgrade of the machine.

Preparation of participation of Institutes and of future MoU in view of organizing and distributing the tasks. Setting-up SLHC collaborations for the implementation phase.

400 k€ (incl. 3 p.y)

Task 2.

Networking activities, organization of workshops and topical meetings.
Dissemination of information and knowledge

100 k€

WP3 SLHC experiment upgrade Coordination

Task 1.

Setting-up of experiment managerial structures, financial rules.
Setting-up the framework for the detector upgrade construction.
Networking activities aiming at attracting partners. Dissemination of knowledge.

Preparation of cost books and of future experiment collaboration agreements.

250 k€ (incl. 2 p.y)

Task 2.

Setting-up a project Office in order to:
- Ensure a consistent information structure for the existing detectors and their upgrade projects,
- cover web interfaces, databases, drawings, CAD and technical documentation, … aiming at good control of the changes to be done.
- define Installation Scenario and scheduling
- launch realistic plans for the final detector construction.

900 k€ (incl. 5 p.y)

WP4 Radiation and Safety support

It covers all items of Support of the accelerator and experiment activities. In particular it covers the legal and regulatory aspects and the safety documentation.

The SLHC is due to operate at a much higher intensity than the present LHC, and the expected radiation levels are major safety constraints to its design and operation. The radiation aspects span the entire lifecycle of the SLHC and it is essential that they are assessed as early as possible.

The assessment of various design options at a very early stage will have an impact on the minimization of material activation and production of radioactive waste and effluents; it will also have an impact on the operability and maintainability of the installations which is directly linked to dose reduction for personnel.

Radiation aspects also cover the radioactive waste characterization and the definition of safe disposal paths for waste produced during operation as well as at time of dismantling.

The activities are distributed in two tasks:

1. Radiation impact studies
2. Safety management & documentation

1500 k€

WP5 Development of Nb-Ti prototype quadrupole

The inner triplets in the high luminosity regions consist of a set of 16 high-gradient quadrupoles which focus the beams at the experimental collision points. As the luminosity increases, ***these quadrupoles will become the main bottleneck to machine performance.*** It is expected that about 5 years will be needed to achieve this. Further increase in luminosity will require the replacement of these quadrupoles by a more advanced design of larger aperture.

In order to be able to start the production of these new quadrupoles, a prototype must be designed, built and tested. The purpose of this work package is:

- The design of an advanced superconducting quadrupole of large aperture and its ancillary corrector packages

- The construction and testing of a prototype

- The preparation for the manufacture of a series of 16 quadrupoles ready for installation in the LHC in 2012.

~2,400 k€

WP6 Components for the injectors' upgrade

1. R&D for an H^- ion source

Study the possibility ***to extend the performance of the H^- source foreseen for the new 160 MeV H^- linac and meet the requirements of the SPL.***
Specifications: 80 mA of H^-, at 50 Hz, pulse length of 0.4 ms. 95 keV extraction, $\varepsilon = 0.25\ 10^{-6}$ radm
Tasks envisaged:

- Optimization and tests of the source.
- Design, construction and commissioning of a single stage 95 KeV extraction
- Pre-chopper design, construction and test.
- Instrumentation design for measurements of source parameters and beam-energy spread.
- Design and test of an active beam compensation
- Upgrade of the low-energy beam transport (solenoids)
- Beam transport measurement with gas injection

~1,500 k€ (incl. ~7-8 p.y)

2. Development of the low-level RF for future pulsed proton linacs

Design and prototyping of the low level RF for Linac4 and the Superconducting Proton Linac (SPL) ***for an optimum control of the field in the accelerating structures, to minimize inefficiencies and beam loss due to fluctuations of the beam characteristics.***

Specifications: field stabilisation with an accuracy of 0.5% in amplitude and 0.5^{o} in phase.
Tasks envisaged:

- model RF system and beam dynamics to determine the effects of field variations on beam characteristics,
- define parameters and algorithm for the low level RF systems (from beam pulse to RF wave form)
- study hardware solutions (digital solution, circuit design)
- production and testing of prototype electronic cards, then of pre-series models

~900 k€ (incl. ~9 p.y)

WP7 Detector Powering Systems

Improve power distribution in the SLHC detectors. The powering methods applied for the LHC cannot be used for SLHC. ***Powering constraints are critical and several high-tech developments will be vital for the future tracking detectors.***

On-detector powering elements have to be developed fulfilling requirements of high-density, low-mass, radiation-hardness and magnetic filed tolerance. This involves work on advanced micro-electronics technologies.

To reduce the overall power losses, options in DC-DC conversion and serial powering will be pursued. In the initial phase individual microelectronics components will be developed, which will subsequently be implemented in tracking detector front-end

2,000 k€

Impact

- Critical questions:

i) Bring the project to level of legal, organizational and financial maturity required to implement it.
Involve the stakeholders necessary to drive the project, take decisions and make financial commitment before construction can start. Set-up participation and financial rules.
ii) Address the technical topics critical for the luminosity upgrade.
iii) Address the safety issue and the compliance to host-countries regulations.

-Attractiveness of the European Research Area

Large impact on the HEP research opening the possibility of new discoveries or of better statistics.
Reinforce the EU capacity of producing high-energy and high-intensity proton beams and in addition intense neutrino and muon beams (for particle physics and nuclear physics).
Technical work proposed aims at mastering technologies with impact on other infrastructures.

- Catalytic Effect

Efficient use of the LHC infrastructure at a moderate additional cost, large parts being reused.
EC support will contribute to define a consistent work-plan and to reinforce interaction with or attract partners for the LHC upgrade.
EC involvement in the preparatory phase is vital to progress on this path in order to be ready within the time scale planned for the upgrading.
The proposal lays the foundation of the future upgraded LHC and EU involvement will boost multilateral efforts and the effectiveness of the collaboration extending beyond CERN.