Discussion of HL-LHC Project

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Object of discussion

- As we summarize the HL-LHC project, we should discuss three things
  - How LARP activities align with the HL-LHC structure
  - How LARP activities could be modified to better align with the structure
  - What opportunities (if any) does this present for bringing US resources to bear which are outside of LARP?

New Project Structure at CERN

LARP

- High Luminosity LHC Projects: L. Rossi
  - ➔ prepare for operation at 5 10^{34} cm^{-2} sec^{-1}
  - ➔ prepare for integrated luminosity of 3000 fb^{-1}
  - ➔ Implementation by 2018 - 2020
- LHC Injector Upgrade Project: R. Garoby
  - ➔ remove bottlenecks in the PS and SPS
  - ➔ investigate options for PSB upgrade (energy)
- LHC Consolidation Project: S. Baird
  - ➔ have to consolidate existing injector complex for at least 15+ yea
- Linear Collider Project: Steinar Stapnes

HL-LHC Planning

- Upgrade planning will utilize EuCARD*,
  - Centrally managed from CERN (Lucio Rossi)
  - Non-CERN funds provided by EU
  - Non-EU partners (KEK, LARP, etc) will be coordinated by EuCARD, but receive no money.
- Work Packages:
  - WP1: Management
  - WP2: Beam Physics and Layout
  - WP3: Magnet Design
  - WP4: Crab Cavity Design
  - WP5: Collimation and Beam Losses
  - WP6: Machine Protection
  - WP7: Machine/Experiment Interface
  - WP8: Environment & Safety

Significant LARP and other US Involvement (WP2–WP5)

*European Coordination for Accelerator R&D

HL-LHC Work Package 2:

Tentative Task List:

1) Communication & management:

2) Optics & Layout:

- NbTi solutions with and without local CC; L^*; round and flat beams; 2-in-1
- Nb_3Sn solutions with and without local CC; L^*; round and flat beams; 2-in-1
- Novel solutions for correction of chromatic aberrations (a la SF & PR)
- IR4 layout and solution with global CC
  - ➔ magnet parameters (aperture and length)

3) Single particle studies and tools:

- DA studies and FQ specifications
- Correction strategy and corrector specifications
  - ➔ magnet parameters (FQ and corrector elements)

HL-LHC Work Package 2 Brainstorming

Tentative Task List:

4) Collective Effects:

- Impedance estimates for new layout (collimator and aperture dependent)
- IBS estimates for different beam configurations
  - ➔ beam separation; optimum configuration (flat beams vs round beams)

5) Beam-Beam Effects:

- BB long range compensation schemes
- BB limit for round and flat beams and coupling tolerances for flat beams
- Head-on BB compensation schemes and options

6) Beam Parameters and Luminosity optimization:

- L reduction and leveling (CC and poor man leveling via x-ing angle)
- Evaluation of operation experience of first 2 year LHC operation
- Options for beam parameter variation for L optimization during run (e.g. Q)

LHC Injector Upgrade Project:

LARP

Areas for USLARP involvement:

1) Turn by turn profile monitor for PSB
2) Space charge studies for the PSB and PS
3) Wide bandwidth feedback system for the SPS
4) Impedance calculations and measurements
5) Instability studies and estimates
6) e-cloud mitigation

WP3 (magnets) TASK LIST

1. Communication and management
2. Nb_3Sn quadrupoles — LARP
3. Separation dipoles — APUL?
4. Cooling
5. Miscellaneous

TASK 2 - Nb_3Sn quadrupoles

LARP

- Task Objectives
  - Analyze the performance of existing Nb_3Sn models, in particular LARP HQ quadrupoles
  - Conceptual design studies of a very large aperture option (150 mm)
  - Finalize the requirements for the HL-LHC inner triplet Nb_3Sn quadrupole
- Task description

This task is intended to give a final assessment of the possibility of using Nb_3Sn quadrupoles for the LHC inner triplet and the performance parameters that can be achieved. A tentative layout with a 120 mm aperture quadrupole is given from WP2, and the necessary full list of requirements (field quality, radiation resistance, integration in the machine) should be worked out. A comparison with the present performance of the 120 mm aperture short model (HQ) magnets of LARP should be done, and iterations on the design if needed should be carried out. In particular we plan to analyze the following issues: (i) radiation resistance of all components (ii) magnet field quality and the possibility to apply corrections using magnetic shims (iii) option of splitting the magnet into two coils, with a related estimate of the loss in performance, possibly complemented by a hardware test, (iv) design of a helium containment vessel compatible with a magnet structure based on aluminum shrinking cylinder (v) magnet protection).

This task will be mainly driven by LARP collaboration (BNL, FNAL and LBL). LASA will lead the quench protection study.

TASK 2 - Nb_3Sn quadrupoles

LARP

- **Deliverables**

  M48 Report on design study of the Nb_3Sn inner triplet

- **Milestones**

  M12 Requirements for Nb_3Sn inner triplet and comparison with present status of the art

  M24 Study of magnetic shimming in HQ

  M36 Study of minimal distance between two coils in a cold mass

- **Relation to other WP**
  - Inputs from WP2. Moreover, this task feeds directly back to WP2 (e.g. required space for eventual absorber inserts at regions with higher losses etc which have an impact on the detailed IR layout).

- **Task leader: G. Luca Sabbi**

TASK 3 – SEPARATION DIPOLES

- Task Objectives
  - Conceptual design of separation dipoles according to the specifications given by WP2 using either Nb_3Al or Nb-Ti. If a model is built, specify and follow-up the tests needed for assessing the design.
  - Explore the possibility of using separation dipoles to create doglegs to increase the beam separation, thus allowing the installation of non-compact crab cavities.

TASK 3 – SEPARATION DIPOLES

LARP

- Deliverables

  M48 Report on design study of the separation dipoles

- Milestones

  M12 Requirements for separation dipoles

  M24 Conceptual design of Nb_3Al and Nb-Ti separation dipoles

  M36 Conceptual design of a crab cavity dogleg

- Relation to other WP
  - Inputs from WP2 and WP4. The task results feed also back to WP: the final length for the dipole magnets will impact the space available for local Crab Cavity installations and potential installations for the compensation of long-range beam-beam interactions.

- Task leader: T. Nakamoto

WP4 (crabs): Prelim. Tasks List (2nd draft)

Task 4.1: Coordination and Communication • Coordination and scheduling of the WP tasks • Monitoring the work, informing the project management and participants within the JRA • WP budget follow-up	CERN, LARP, ULANC
Task 4.2: Support studies • Tunnel preparation SPS and LHC • Local IR layout and spatial integration • Effect of phase noise , LLRF system conceptual design • RF power system specification • Operational aspects (how to commission/make invisible) • Interlocks and fast Feedback	CERN, KEK, LARP
Task 4.3: Compact Crab Cavity design • Complete cavity and cryomodule specifications • Design optimisation for novel schemes • Conceptual design of SOM, HOM and LOM couplers • Conceptual design of helium tank and cryostat • Multipacting simulations on cavity & couplers • FEM simulations: mechanical & thermal aspects • Initial down-selection of the CC options • Completion of a full technical design on the initial down-selected options, with mechanical drawings and specification. • Design of tooling, dies and cavity fabrication equipment	ULANC, LARP, CERN, JLAB

WP4: Prelim Tasks List (2nd draft)

Task 4.4: Elliptical Crab Cavity Technical design • Coupler development and testing • Tuner design and mock up on copper models • Study of mechanical effects: resonances, microphonics. • Cavity performance with couplers and horizontal cryostat • Performance difference between 2 K & 4 K • Cryostat and He Tank Design • Complete the full technical design	CERN, CEA, CNRS, KEK
Task 4.5: Compact Crab Cavity Prototyping and Test • Procurement /fabrication of tooling, dies and equipment. • Construction of models to refine manufacturing techniques and tooling. • Fabrication of prototype niobium cavity • Cleaning and electro-polishing on the bare niobium cavity. (i.e. no couplers, antennas or other accessories), including cavity surface inspection. • Development and procurement of all test equipment and instrumentation. • Low power tests and measurements on the bare cavity in a test cryostat to test for compliance with design gradient and cavity performance specs. • Make the final CC design down-selection	CERN, CEA, CNRS, ULANC, STFC, LARP

WP5 (Collimation) Structure I

- WP 5.1: Coordination and Communication
- WP 5.2: IR Simulations of Halo Loss
  - Collimation Sixtrack: CERN ABP, Valencia
  - Collimation Merlin: Uni Manchester
  - Collimation Geant: Royal Holloway
- WP 5.3: IR Simulations of Energy Deposition
  - Mars: FNAL
  - FLUKA: CERN STI, Uni Manchester
  - Geant: Royal Holloway

WP5 Structure II

- WP 5.4: Design of IR Collimation
  - CERN ABP
  - Uni Valencia
  - SLAC