Summary

H. Mainaud Durand

Review of HL-LHC Alignment and Internal Metrology (WP15.4)
Outline

- Schedule
- Procurement strategy
- Resource strategy
- Potential issues raised during the review
## Schedule

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<tbody>
<tr>
<td>15.4.1</td>
<td>Internal metrology (fiducialisation)</td>
<td>LS2 components + prototypes</td>
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<td>LS3 components: pre-series and series</td>
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<td>15.4.2</td>
<td>Internal monitoring (Inner Triplet &amp; Crab cavities)</td>
<td>R&amp;D and solution alternatives</td>
<td>Implementation on prototypes</td>
<td>Validation on String</td>
<td>Implementation on prototypes</td>
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<td>Operation</td>
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<td>15.4.3</td>
<td>Geodetic studies</td>
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<td>15.4.3</td>
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<td>Support to WP17</td>
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<td>15.4.4</td>
<td>Standard alignment</td>
<td>Preparation meetings</td>
<td>Standard alignment during LS2</td>
<td>Standard alignment of String</td>
<td>Preparation</td>
<td>Standard alignment</td>
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<td>Operation</td>
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<td>15.4.4</td>
<td>Monitoring &amp; positioning</td>
<td>Validation of alternatives</td>
<td>Integration; String Test preparation,</td>
<td>Procurement, calibration,</td>
<td>Installation &amp; validation</td>
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Schedule

Currently scheduled

Associated milestones

- Sensors decision
- Supports design
- Wire protection design

- Sensors procurement launch for String Test
- Design of control benches

2019 - Installation capteurs sur String test

2020 - Installation capteurs dans LHC

2021 - Sensors reception/calibration
- Supports, wire protection, HLS network preparation

2022 - LHC Sensors Reception/calibration
- Supports, wire protection, hydraulic network preparation for LHC

2023 - Procurement launch of sensors and associated supports for LHC

2024

2025

2026
Towards installation (sensors)

Repeatability
Accuracy
Long-term stability
Impact of humidity
Impact of temperature
Irradiation tests
Impact of vibrations

• HLS
• Inclinometer
• WPS
• Longitudinal sensor
• Wire to wire meas. System
• Acquisition system
• Capacitive remote electronics

Qualification tests
Upgrade
Pre-series procurement
Validation
Series procurement
Reception
Calibration
Documentation

Installation
## Summary of tests setups

<table>
<thead>
<tr>
<th>Test setup</th>
<th>Description</th>
<th>Scheduled</th>
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<tbody>
<tr>
<td>TT1</td>
<td>Long term validation of in-house WPS, iHLS, iInclino Validation of new wire</td>
<td>July-Dec. 19</td>
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<td></td>
<td>Validation of new stretching device + automatized wire stretching</td>
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<td>FSI lab</td>
<td>Cross-comparison tests (iHLS, cHLS, iInclino)</td>
<td>July-Oct. 19</td>
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<td>Climatic</td>
<td>Climatic chamber to control the impact of $T^\circ$ and humidity</td>
<td>Jan-June 20</td>
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<td>Dipole test</td>
<td>FSI configuration for IT and CC</td>
<td>Sept-Oct. 19</td>
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<tr>
<td>Irradiation tests</td>
<td>Qualification at Franhoffer institute // other irradiation facilities</td>
<td>June-Aug. 19</td>
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<td>Jan-March 20</td>
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## Sensors qualification plan

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<tr>
<th></th>
<th>kWPS</th>
<th>iHLS</th>
<th>HLS-Lines</th>
<th>Inclin.</th>
<th>Acq. syst.</th>
<th>Remote elec.</th>
<th>Long range FSI</th>
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<tr>
<td>Repeatability</td>
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<td>Long-term stability</td>
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Cross-comparison tests

- Between Inclinometer / cHLS and iHLS
- FSI long distance / laser tracker / interferometer
- kWPS and cWPS
Towards installation (all other systems)

Integration of all alignment systems

Technical specification for all systems design

Study of concept, upgrade of existing solutions

Design of a prototype

Installation

Preparation of installation drawings and procedures

• Sensors support
• Hydraulic network & supports
• Wire protection & supports
• Remote diagnostic devices
• Stretching devices
• Wire to wire meas. system

Manufacture & assembly of a prototype

Validation of a prototype

Order of series

Insertion of series in 3D models

Design of series

Storage of all data in MTF & EDMS

Assembly and test of series

Assembly and test of series
Towards installation (motors assembly for jacks)

- Upgrade of jacks design
- Mech. Interface design
- Development of control/command (Sambuca project)

- Procurement
- Validation on a test setup
- Procurement of pre-series for String test
- Validation on the string test
- Procurement of series
- Reception
- Documentation
- Installation

- Jacks (WP3, WP4, WP8)
- Motors
- Associated sensors (resolver, load cell)
- Gearbox
- Control/command system
Towards installation (motors assembly for UAP platform)

Validation of UAP concept
- Adaptation to the equipment
- Procurement of pre-series for test

Development of control/command (Sambuca project)
- Manufacture of joints & jigs
- Validation on the string test
- Development of Motorized version
- Series procurement
- Validation
- Documentation
- Installation

- UAP platform (WP5, WP13)
- Motors
- Associated sensors (resolver, load cell)
- Gearbox
- Control/command system
## Procurement strategy

### Validation of concepts and prototypes
### Development of pre-series
  Towards industrialization

### External manufacturing/assembly
- Motors
- Sensors: WPS, HLS, resolvers, load cells
- Associated supports

### In-house assembly
- Diagnostics tools
- FSI acquisition
- Motors assembly
- Inclinometers
- Acquisition electronics
- Wire stretchers

### In-kind contribution
- Feedthrough
Resources

- WP15.4.1 and WP15.4.3:
  - Staff;
  - During LS2 or YETS contract services (for series components or scan activities for example)

- WP15.4.2:
  - Staff + MPA (fellows, PJAS)

- WP15.4.4:
  - Staff + MPA (fellows, PJAS) + FSU
Very difficult to find persons knowing already our techniques:
- We absolutely need overlaps between persons
- We plan to extend one PJAS as fellow to keep the knowledge
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- We absolutely need overlaps between persons
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Resources

- **MPA: Collaborations: past, current & future**
  - CNAM (France) [past]
  - AGH (Poland) [current]
  - ? [future]

- **Other resources (FSU, contract services, design office): what is foreseen.**

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<thead>
<tr>
<th></th>
<th>2019</th>
<th>2020</th>
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Resources

- Use of the multi-disciplinarity of the group
Resources

- No staff at 100% on the project
- High work load during LS2 where the same persons involved in FSI and FRAS are also in charge of the LHC low beta consolidation and maintenance of the alignment systems, but also a lot of experience gained!
- Same situation concerning the persons in charge of fiducialisation, geodesy and standard alignment
- One key person still on a Limited Duration contract.

### FTE per WP

<table>
<thead>
<tr>
<th>FTE per WP</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
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FROM EHL-LHC needs – EN manpower meeting. Sept 18.
Material budget status
Material budget status per sub-sub WP
Summary

- FSI system for the internal monitoring of IT quadrupoles and CC:
  - Very satisfactory results obtained on the crab cavities prototype in SPS
  - Two FSI systems evaluated through tests on a dipole.
  - Cryo-condensation problem met on targets inside the dipole, a solution was found (with the help of TE/MSC)
  - CERN MT-FSI chosen, with coated glass spheres, insulated support for targets and simplified feedthrough
  - A final validation plan is defined and scheduled
  - Procedures / workflow on the installation and measurements of FSI targets under finalisation
Summary

- **Internal monitoring:**
  - All magnets will be fiducialised after cold test at CERN
  - Procedures are derived from existing LHC cryomagnet procedure
  - Assembly workflow for all the components under definition in the frame of the WGA
  - Measurement workflow defined for the crab cavities metrology assembly

- **FRAS:**
  - Allows to save radiations to the personal, a reduction of correctors strength, a gain in aperture for several components
  - Opens the possibility to optimize the MS section and to important budget savings.
  - All strategy/requirements/solutions/interfaces defined in the functional specification, to be endorsed by the TCC next month.
  - Still a few cases under discussion (vacuum valves in front of D2, BPM after D1, BBMR not considered as not in the baseline)
Summary

- **Solutions for adjustment**
  - Preliminary results from the 181 string test show that operational issues on present LHC jacks are understood; they could be used for HL-LHC, considering small improvements to be compatible with space requirements.
  - Their re-engineering is targeted this Autumn; procurement strategy: in-kind contribution from Serbia.
  - Small UAP platform fully validated; design of big UAP under way.
  - Standardization of the motors control/command system via SAMbuCA project.

- **Solutions for position determination:**
  - Volume integrated for all alignment systems and their diagnostic tools in the 3D models.
  - Alignment sensors under validation, final choice next year.
Thank you very much