HiLumi
HL-LHC PROJECT

Summary

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CERN

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

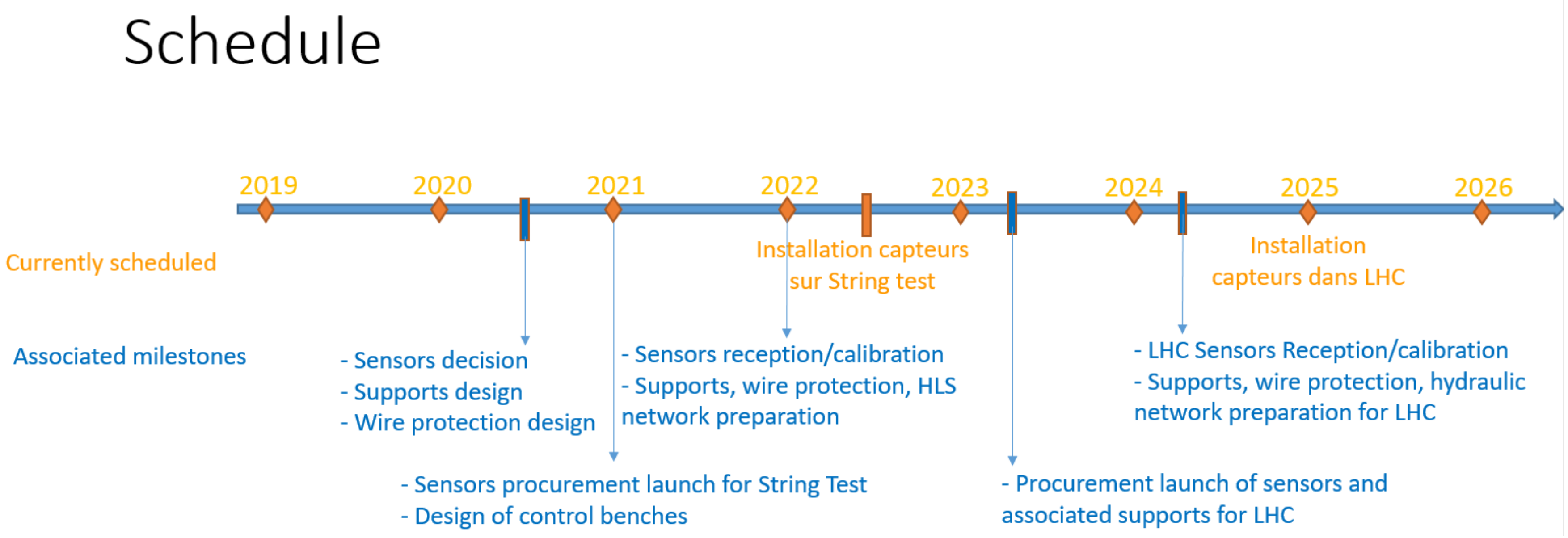
Outline

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

Schedule

WP	Activity	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
15.4.1	Internal metrology (fiducialisation)	LS2 components + prototypes			LS3 components: pre-series and series						
15.4.2	Internal monitoring (Inner Triplet & Crab cavities)	R&D and solution alternatives		Implementation on prototypes		Validation on String	Implementation on prototypes				Operation
15.4.3	Geodetic studies	Geodetic studies									
	Support to WP17			Support to WP17							
	Standard alignment	Preparation meetings		Standard alignment during LS2		Standard alignment of String		Preparation	Standard alignment		
15.4.4	Monitoring & positioning	Validation of alternatives		Integration; String Test preparation,			Procurement, calibration,		Installation & validation		Operation

Schedule



Schedule
2019
2020
2021
2022
2023
2024
2025
2026
Currently scheduled
Installation capteurs sur String test
Installation capteurs dans LHC
Associated milestones
- Sensors decision
- Supports design
- Wire protection design
- Sensors reception/calibration
- Supports, wire protection, HLS network preparation
- LHC Sensors Reception/calibration
- Supports, wire protection, hydraulic network preparation for LHC
- Sensors procurement launch for String Test
- Design of control benches
- Procurement launch of sensors and associated supports for LHC

Towards installation (sensors)

Qualification tests

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

Upgrade

Decision

Pre-series procurement

Validation

Series procurement

Reception

Calibration

Documentation

Installation

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

Summary of tests setups

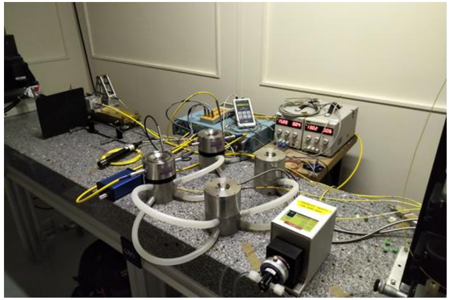
Test setup	Description	Scheduled
TT1	Long term validation of in-house WPS, iHLS, iInclino Validation of new wire Validation of new stretching device + automatized wire stretching	July-Dec. 19
FSI lab	Cross-comparison tests (iHLS, cHLS, iInclino)	July-Oct. 19
Climatic	Climatic chamber to control the impact of T° and humidity	Jan-June 20
Dipole test	FSI configuration for IT and CC	Sept-Oct. 19
Irradiation tests	Qualification at Franhoffer institute // other irradiation facilities	June-Aug. 19 Jan-March 20

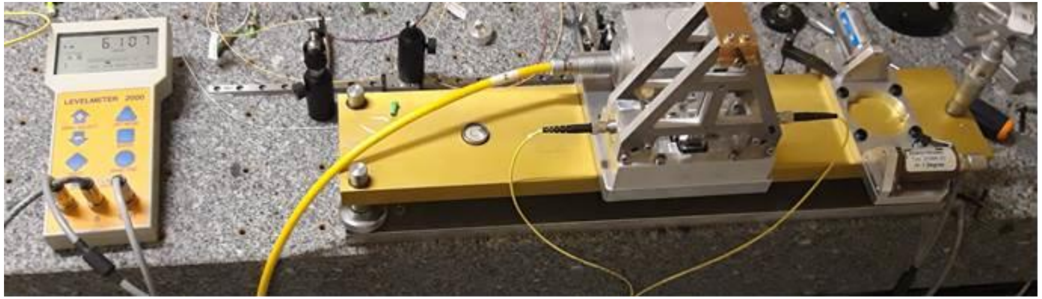
Sensors qualification plan

	kWPS	iHLS	HLS-Lines	Inclin.	Acq. syst.	Remote elec.	Long range FSI
Repeatability				FSI lab			
Accuracy				FSI lab			
Long-term stability	TT1	TT1	TT1	TT1	TT1	TT1	TT1
T° impact	Climatic	Climatic		Climatic	Climatic	Climatic	
Humidity impact	Climatic	Climatic			Climatic	Climatic	
Irradiations tests							

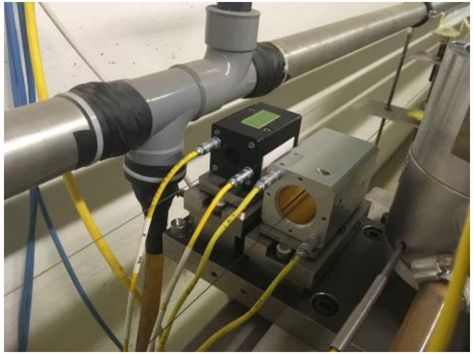
Cross-comparison tests

- 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

Manufacture & assembly of a prototype

Validation of a prototype

Design of series

Insertion of series in 3D models

Order of series

Assembly and test of series

Storage of all data in MTF & EDMS

Preparation of installation drawings and procedures

Installation

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

Towards installation (motors assembly for jacks)

Upgrade of jacks design

Mech. Interface design → Procurement → Validation on a test setup → Procurement of pre-series for String test

↓

Validation on the string test

↓

Procurement of series

↓

Reception

↓

Documentation

↓

Installation

Development of control/command (Sambuca project)

- 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

Manufacture of joints & jigs

Adaptation to the equipment

Validation on the string test

Procurement of pre-series for test

Development of Motorized version

Series procurement

Development of control/command (Sambuca project)

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	In-house assembly	In-kind contribution
• Motors • Sensors: WPS, HLS, resolvers, load cells • Associated supports	• Diagnostics tools • FSI acquisition • Motors assembly • Inclinometers • Acquisition electronics • Wire stretchers	• Feedthrough

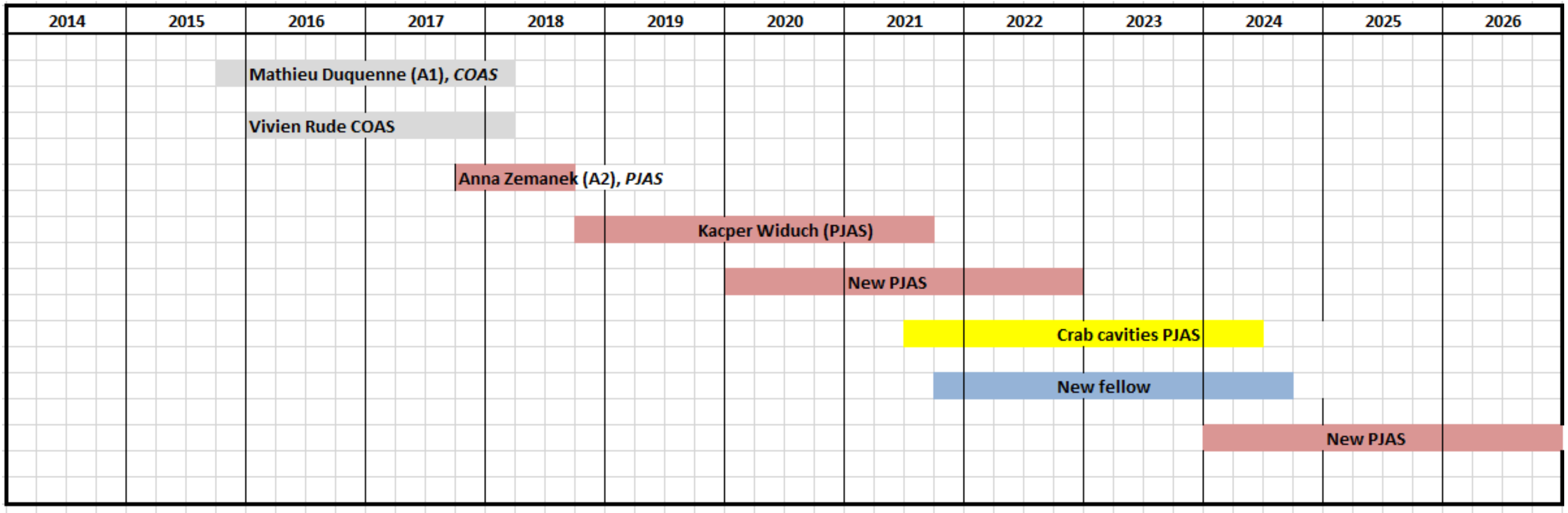
Resources

- 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

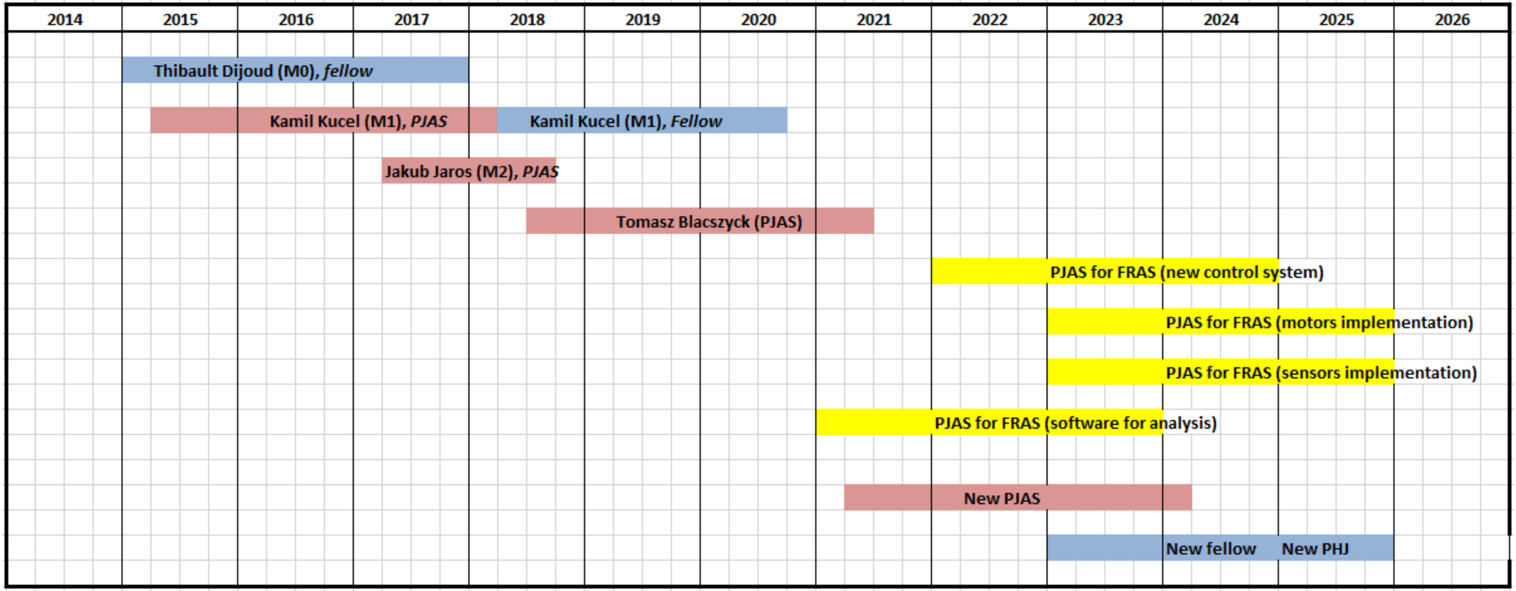
Resources (MPA)



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

Resources (MPA)



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Resources

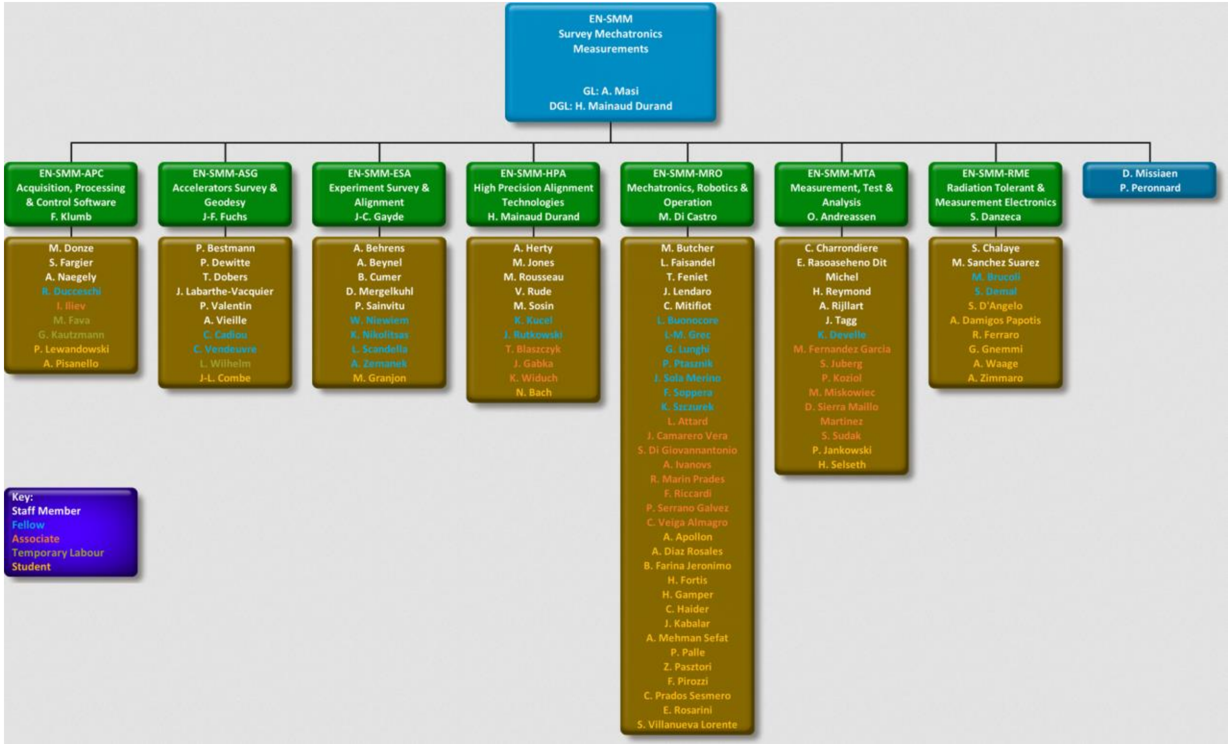
- MPA: Collaborations: past, current & future
  - CNAM (France) [past]
  - AGH (Poland) [current]
  - ? [future]

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

	2019	2020	2021	2022	2023	2024	2025
FSU (kCHF)	110	110	110	110	110	110	110
Design office (kCHF)	30	100	100	100	50	10	10
Contract services (kCHF)	0	60	60	60	60	60	60

Resources

- Use of the multi-disciplinarity of the group



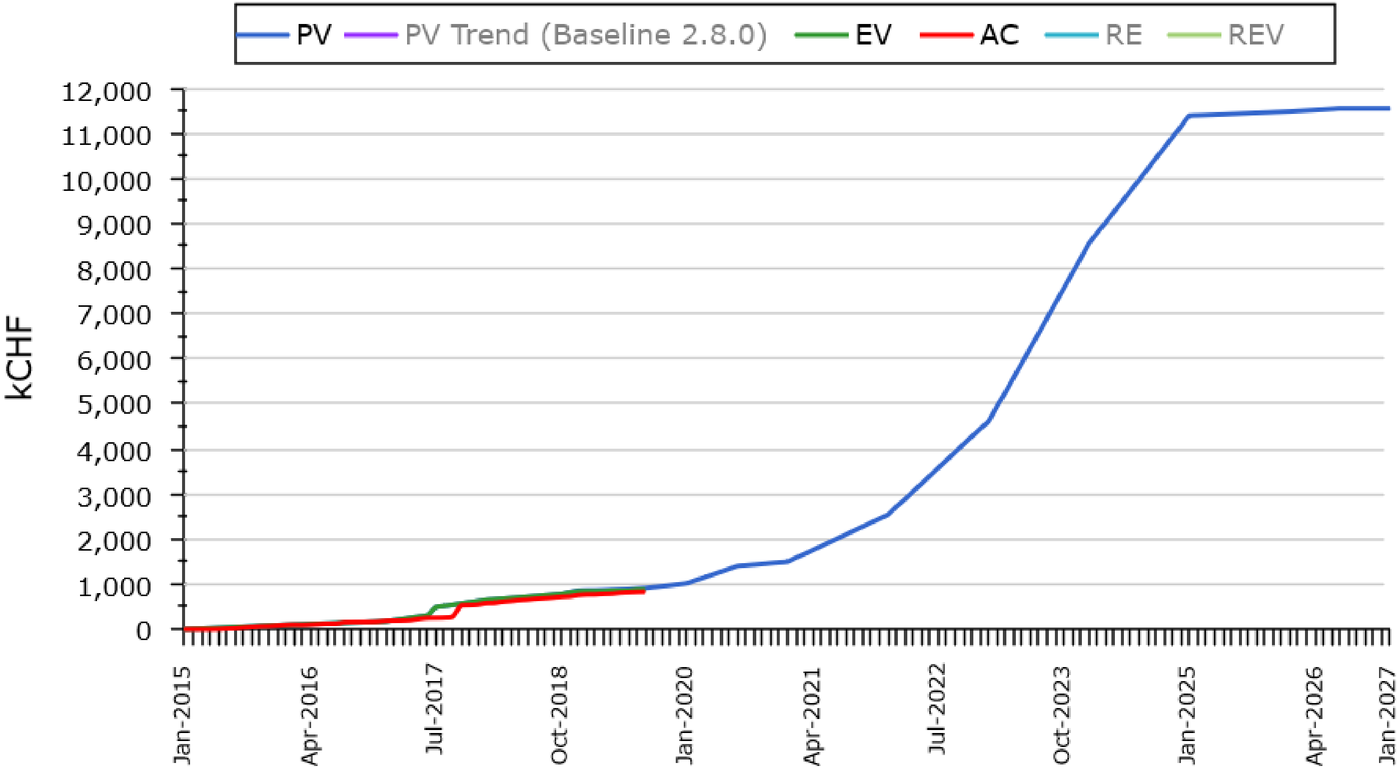
Resources

- 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.

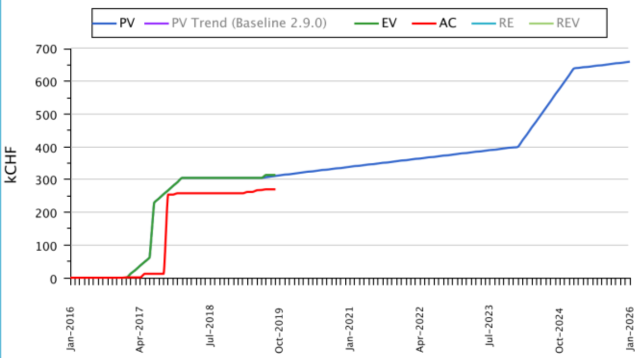
FROM EHL-LHC needs – EN manpower meeting. Sept 18.

FTE per WP	2019	2020	2021	2022	2023	2024	2025	2026
15.4.1	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.2
15.4.2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
15.4.3	0.8	0.9	0.8	0.8	0.8	0.8	0.8	0.8
15.4.4	2.0	1.6	2.1	2	2.7	2.7	3	2.3
15.4	**4.1**	**3.9**	**4.3**	**4.2**	**4.9**	**4.9**	**5.2**	**4.2**

Material budget status



Material budget status per sub-sub WP



Project: LRD-PRJ
Workpackage: HLLHC 15.4.1
Baseline: Baseline 2.9.0

WP15.4.1

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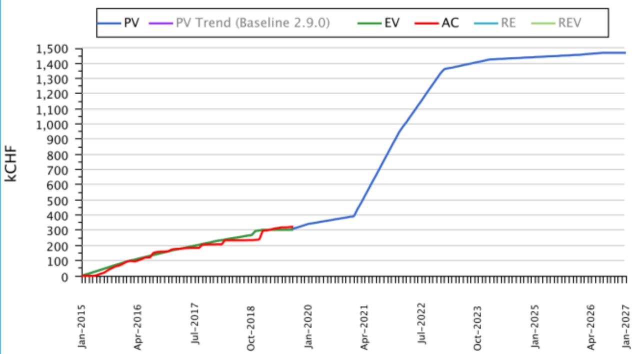

Project: LRD-PRJ
Workpackage: HLLHC 15.4.2
Baseline: Baseline 2.9.0

WP15.4.2

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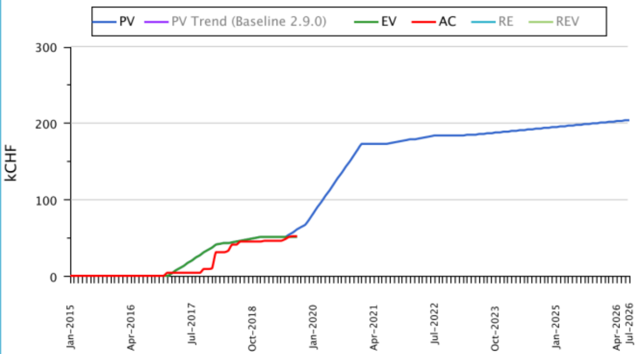

Project: LRD-PRJ
Workpackage: HLLHC 15.4.3
Baseline: Baseline 2.9.0

WP15.4.3

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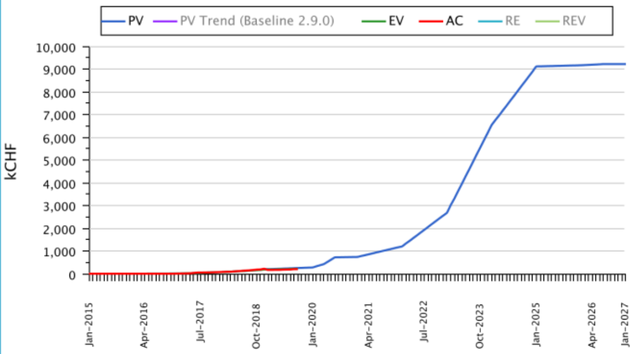

Project: LRD-PRJ
Workpackage: HLLHC 15.4.4
Baseline: Baseline 2.9.0

WP15.4.4

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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