# The Long Shutdown 2 (LS2)

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CERN | **LS2 Project**

**Maintenance & Consolidations**
**LHC Injectors' Upgrade**
**High Luminosity LHC**
**LHC Detectors' Upgrade**

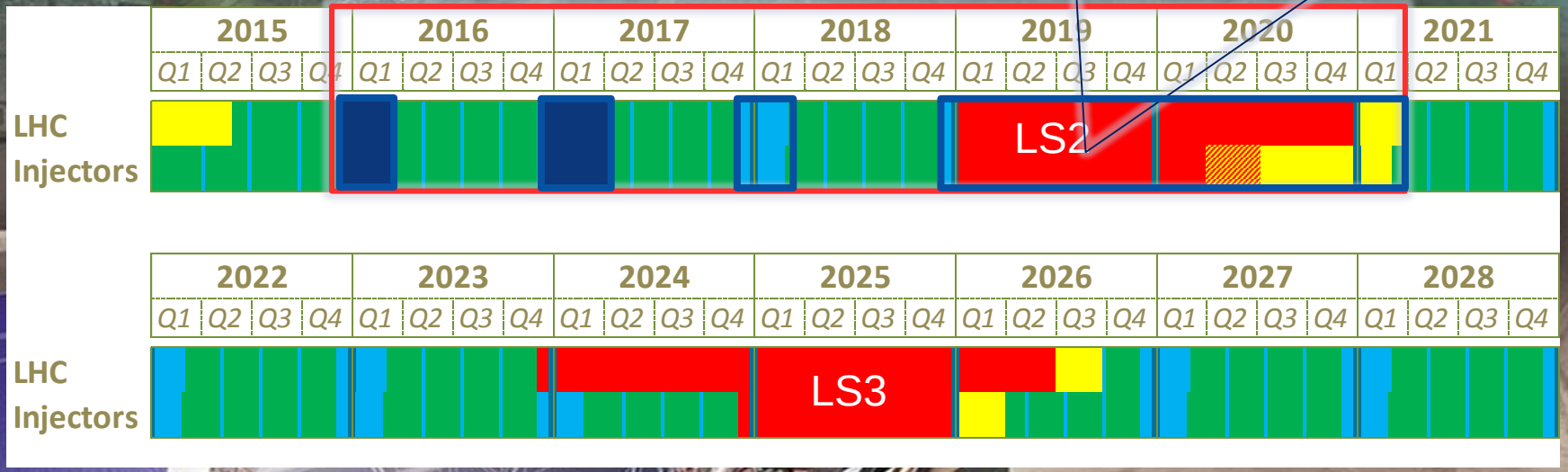
# LS2 Team

| | |
|---|---|
| José Miguel JIMENEZ | Project Leader |
| Jean-Philippe TOCK | Project Office Manager |
| Katy FORAZ | Project Planning Manager |
| Thomas OTTO | Project Safety Officer |
| Ana Paula BERNARDES | Project Safety Officer |
| Mirko POJER | PLAN Quality Officer |
| Samy CHEMLI | LSC Secretary |
| Stefanie SAPOUNTZI | Administrative Support Officer |
| Julie COUPARD | Injectors & LIU Coordination |
| Marzia BERNARDINI | LHC & HL-LHC Coordination |
| Beniamino Di Girolamo | HL-LHC Link Person |

# Long Shutdown 2 (LS2) Project

*Project Schedule*

- Perform major Maintenance and Consolidations
- Increase intensity/brightness in the injectors to match HL-LHC requirements (LIU Project)
- Increase injector reliability and lifetime to cover HL-LHC run (until ~2035) closely related to consolidation programs (in synergy with LIU Project)
- Anticipate HL-LHC work



# Long Shutdown 2 (LS2) Project

*Project Scope & Mandate of LS2 coordinator (1/2)*

Scope covers all activities carried out and resources needed in the context of LS2 over the whole CERN accelerator facilities.

The mandate of the LS2 Project Coordinator includes:

- Prior to the start of the LS2, the definition of main works to be achieved over the LS2 and of potential options based on priorities given to activities. This study shall highlight in particular LS2 duration and resources needed for each option and be presented to the Directorate by mid-2017 for final decision;

- The definition of a CERN-wide “resource-loaded planning”, ensuring the compatibility of resources and planning across the LHC Machine and LHC Experiments;

# Long Shutdown 2 (LS2) Project

*Project Scope & Mandate of LS2 coordinator (2/2)*

The mandate of the LS2 Project Coordinator includes: (cont.)

- The preparation, coordination and follow-up till completion of all LS2 activities in the frame of the Maintenance and Consolidations, LIU, HL-LHC Projects and other CERN approved projects. Work packages will define:
  - The work absolutely essential to achieve the LS2 objectives, which execution will be closely followed up by the LS2 Coordinator;
  - The work which can be postponed to the LS3, which impact on LS3 will be assessed by the LS2 Coordinator.

The flexibility to use the end-of-year technical stops before and after the LS2 to decrease the load of the LS2 is left at the discretion of the LS2 Coordinator and is also part of the scope of the project.

# The main projects during LS2

LIU
(incl. L4 connection)

AWAKE

HL-LHC

DISMAC

ELENA

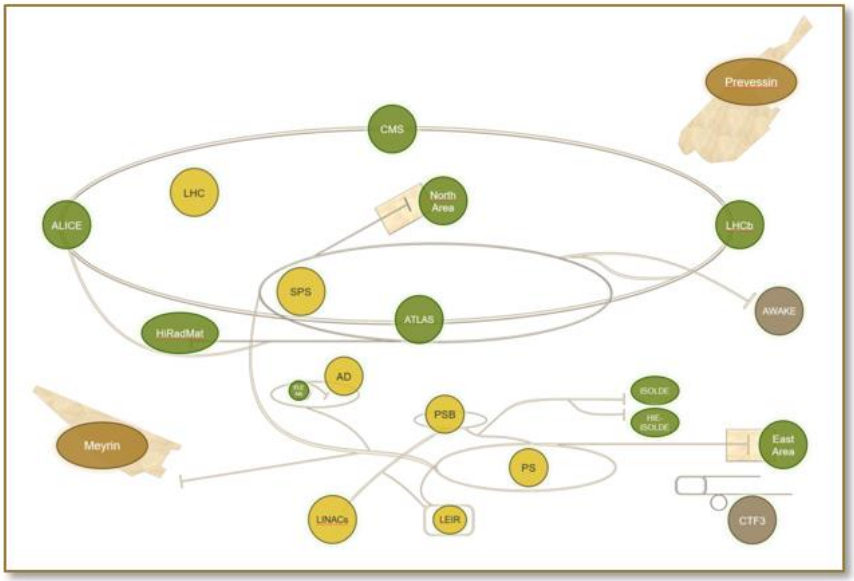
East Area
consolidation

SPS Fire Safety

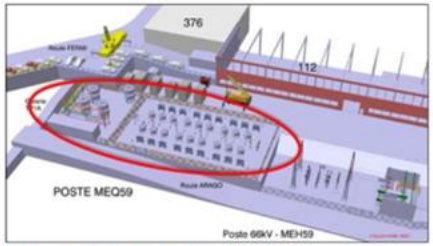
SPS Access

LHC experiments
upgrade

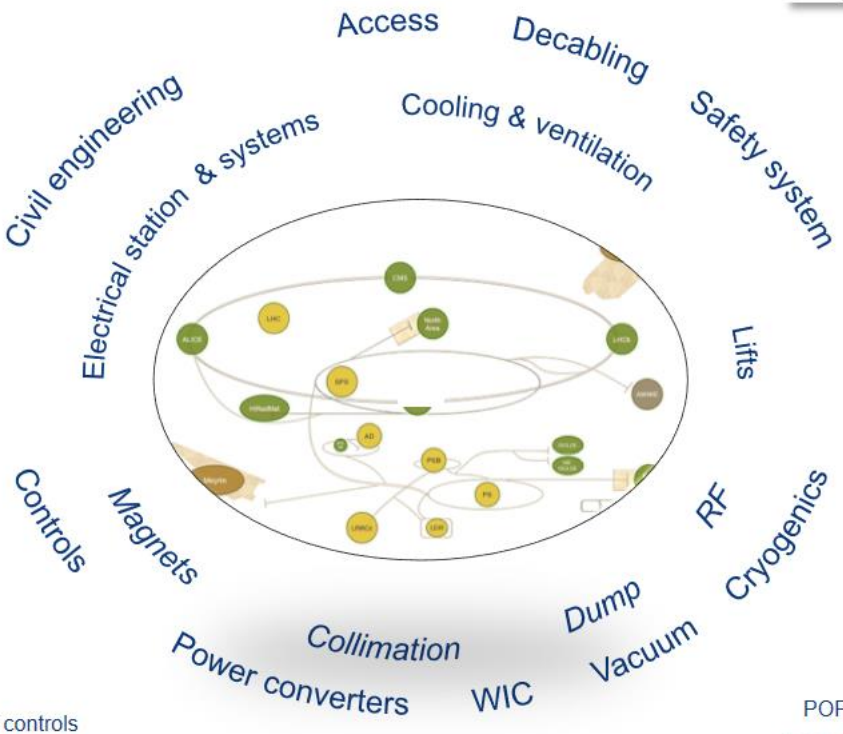
Consolidation



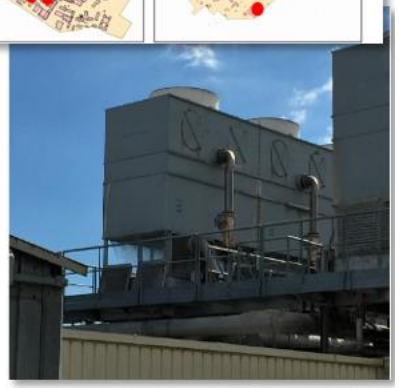
# Consolidation & upgrades



New MEQ59 Static Var Compensator

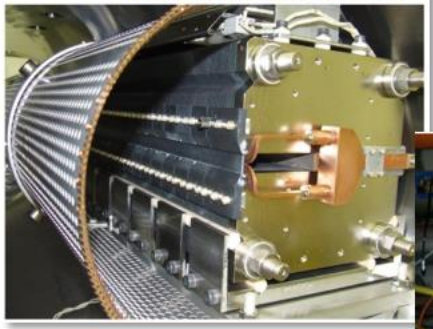



ASBESTOS removal



MKD generators in UA67

New MST SPS extraction septum



LHC EE controls

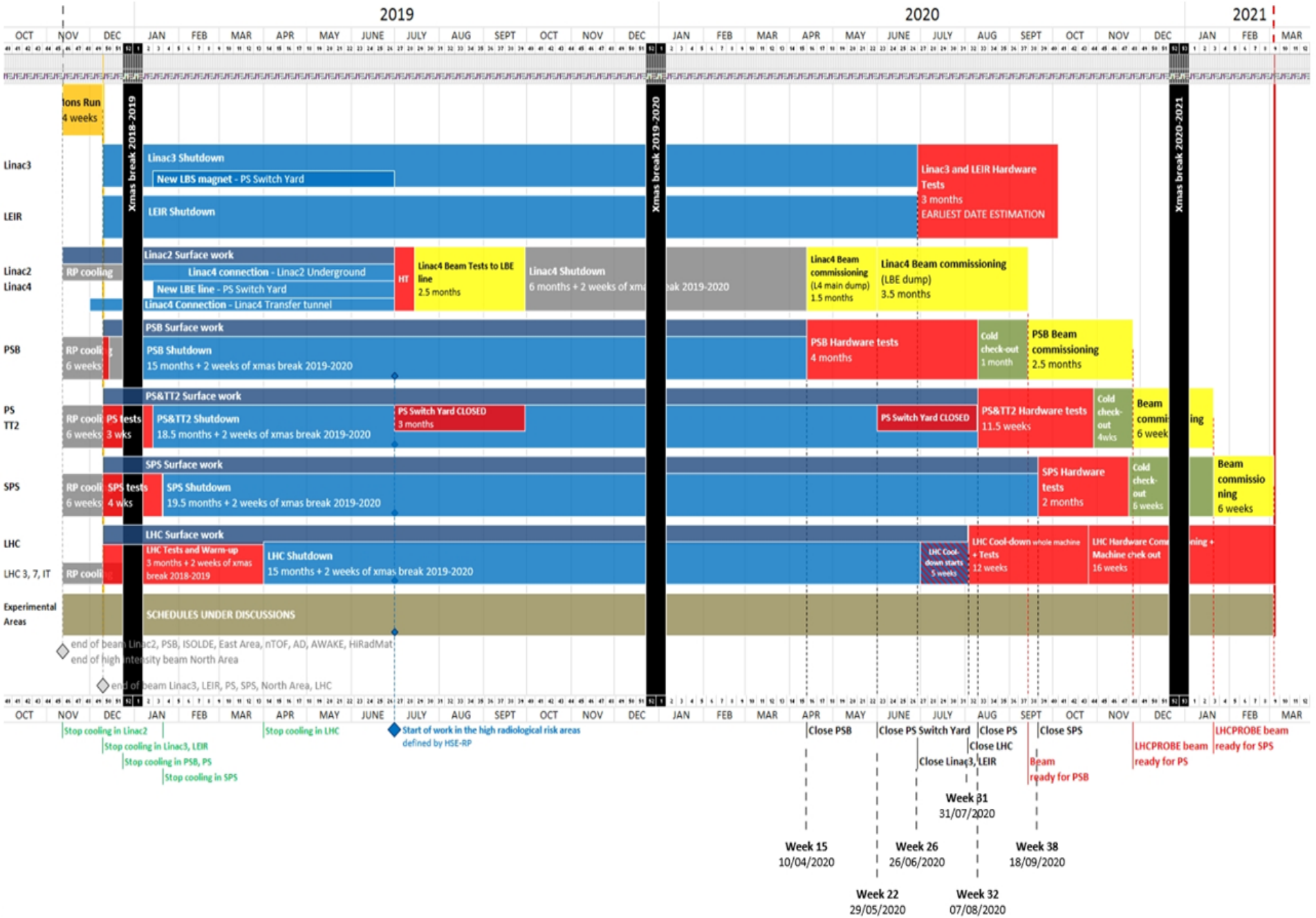
LHC EE controls

POPs capacitor

# Master Schedule of the Long Shutdown 2 (2019-2020)

Week 46
12/11/2018

LHCPROBE beam available for LHC
Week 9
04/03/2021



# LS2 activities

## PS Booster - underground

**Extraction line BTP:** *(see PS&TT2 coordination)*
- Modification of the beam instrumentations
- New beam position monitor
- New beam loss monitors
- Change the quadrupoles

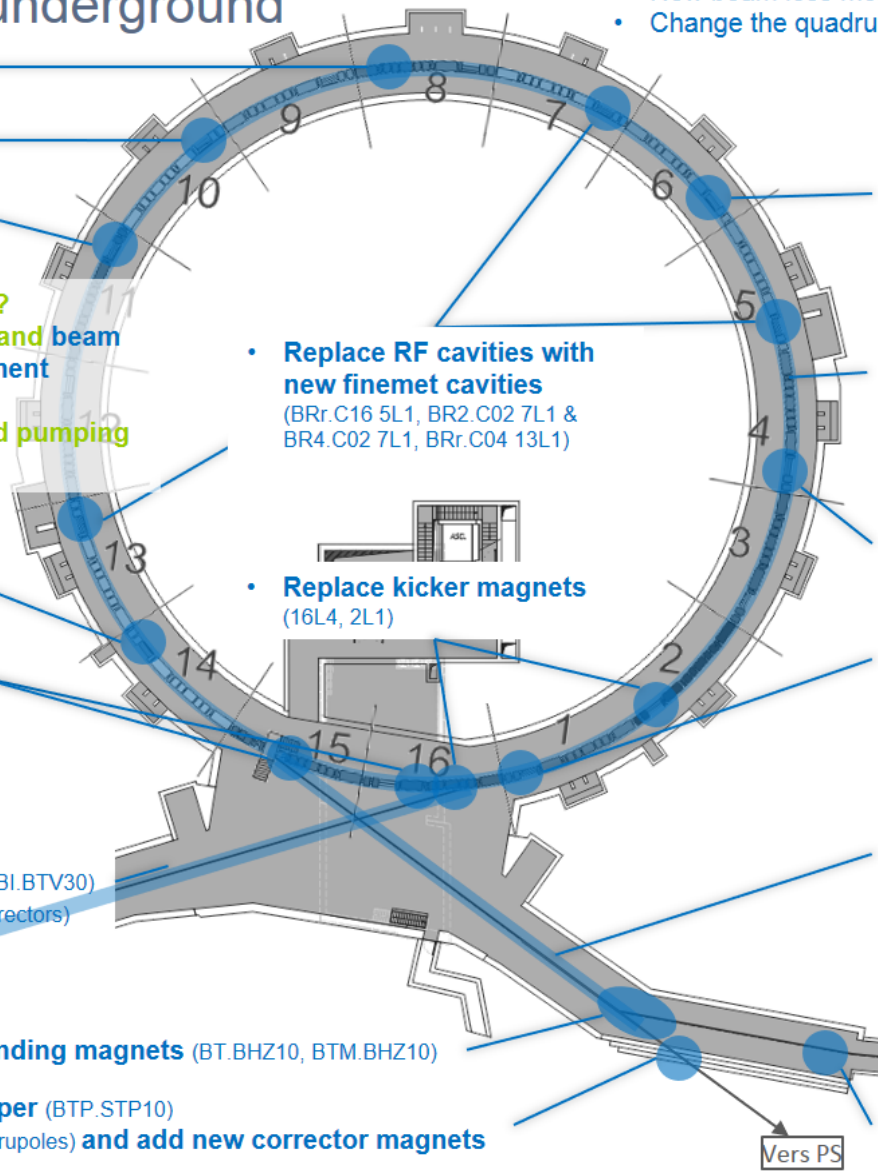
**LIU** Project
**HL-LHC** Project
**Fire Safety** Project
**New PPS** Project
**Consolidations**
**Maintenance**
**Upgrade**

- **New Absorber/Scraper** (8L4)
- **Remove RF cavities** (BR1.C02 10L1 & BR3.C02 10L1)
- **New Wire Scanner x4** (11L1)

- **Refurbishment of the painting?**
- **Warm interlock control** (WIC) **and beam interlock system** (BIS) **deployment**
- **Consolidation of the B-train**
- **Replacement of ion pumps and pumping groups**

- **Replace extraction kicker** (BEr.KFA14L1)
- **Replace bending magnets** (INJ BHZ162, EXT BHZ151)

**Injection line BI:**
- New Injection bending (BHZ INJ)
- New Distributor (BI.DIS10)
- New Septa (BI.SMV10)
- Relocate beam instrumentation (BI.BTV30)
- Change of the magnets (BVTs, correctors)
- New BPMs
- New beam loss monitors
- New RF bypasses




- **Remove prototype finemet cavities** (BR4.ACWF 6L1)

**All around the machine:**
- Laminated side plate on bending (BHZ MAIN)
- Parallel shunt resistors on quadrupoles (QDE, QFO) and bending (BHZ MAIN) magnets *(to be confirmed)*
- Removal of the heating systems

- **Replace RF cavities with new finemet cavities** (BRr.C16 5L1, BR2.C02 7L1 & BR4.C02 7L1, BRr.C04 13L1)
- **Replace kicker magnets** (16L4, 2L1)
- **New Wire Scanner x3** (4L1)

**New PSB Injection Region**
- Remove the current sector (1L1)
- New H- charge exchange injection systems

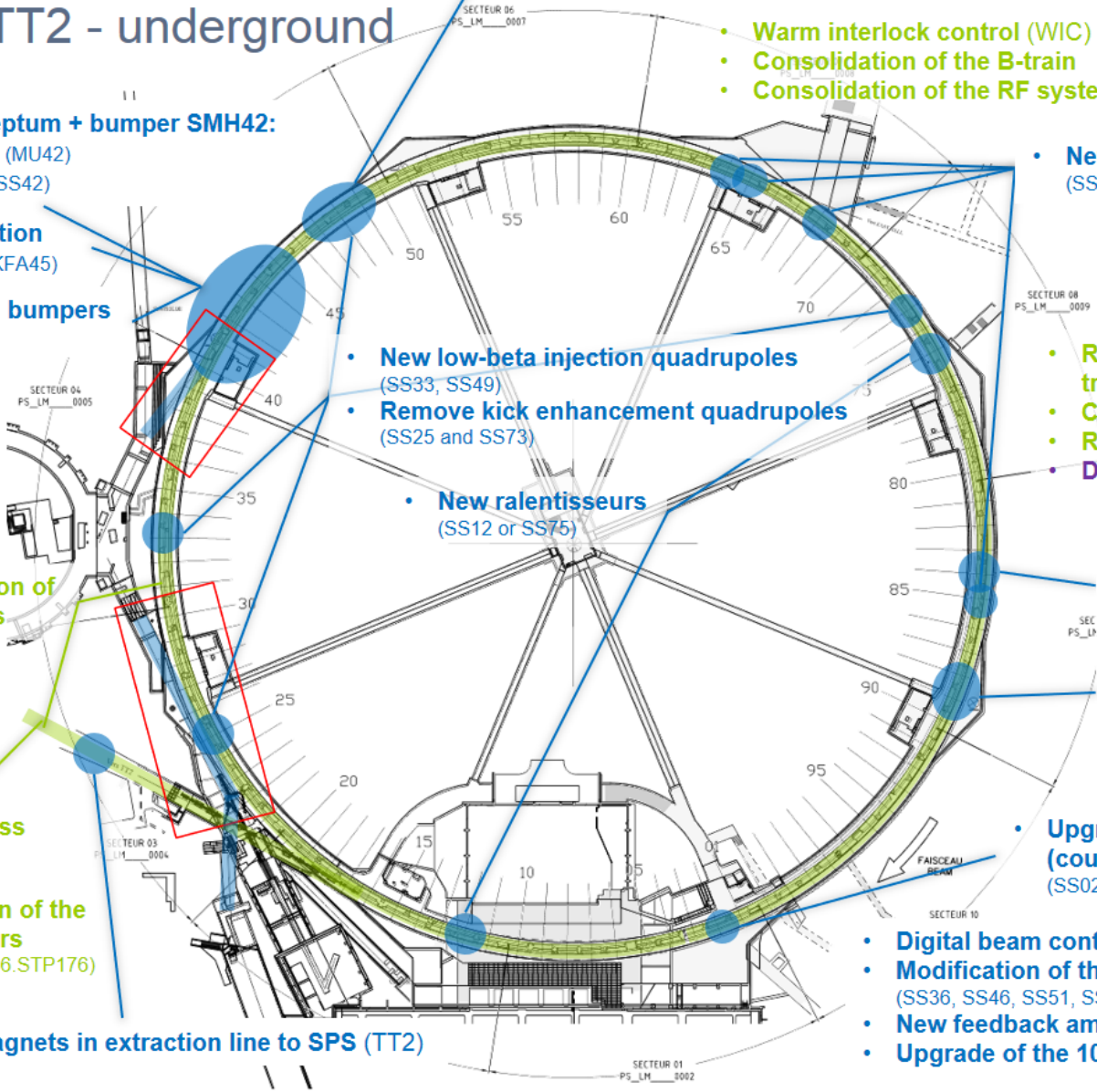
**Extraction line BT:**
- New extraction bending (BHZ EXT)
- New septum (BT.SMV10 and BT.SMV20)
- Relocate beam instrumentations (BT.BTV10)
- New kicker (BT.KFA10, BT.KFA20)
- Change the magnets (BT.BVT10, BT.BVT20, BT.DVT10, quadrupoles)
- New beam loss monitors

- **Change the bending magnets** (BT.BHZ10, BTM.BHZ10)
- **Change the beam stopper** (BTP.STP10)
- **Upgrade magnets** (quadrupoles) **and add new corrector magnets**
- **New vacuum window on BTM line before the PSB Dump**

# LS2 activities

## PS&TT2 - underground

LIU Project
HL-LHC Project
Fire Safety Project
New PPS Project
Consolidations
Maintenance
Upgrade




- **New internal beam dumps** (SS47 and SS48)
- **Warm interlock control** (WIC) **deployment**
- **Consolidation of the B-train**
- **Consolidation of the RF systems**

**New injection septum + bumper SMH42:**
- New SEMGrid (MU42)
- New bumper (SS42)

- **Replace injection extra kicker** (KFA45)
- **New injection bumpers** (40, 41, 43, 44)

- **New beam wire scanners** (SS64, SS65, SS68, SS85)

- **New low-beta injection quadrupoles** (SS33, SS49)
- **Remove kick enhancement quadrupoles** (SS25 and SS73)

- **New ralentisseurs** (SS12 or SS75)

- **Remove the obsolete beam current transformers BCT**
- **Consolidation of the false floor slabs**
- **Removal of the asbestos**
- **De-cabling and cabling**

- **Consolidation of the magnets**

- **New vertical beam gas ionization profile monitor** (SS84)

- **New 80 MHz fast tuner** (SS88 and SS89)

- **New beam loss monitors** (TT2, FTA, FTN)
- **Consolidation of the beam stoppers** (F16.STP512, F16.STP176)

- **Upgrade of Finemet RF system (coupled-bunch feedback)** (SS02)

- **Digital beam control**
- **Modification of the 10 MHz water cooling circuit** (SS36, SS46, SS51, SS56, SS66, SS76, SS81, SS86, SS91, SS96)
- **New feedback amplifiers for the 40/80 MHz**
- **Upgrade of the 10 MHz feedback amplifiers**

- **Replace 2 magnets in extraction line to SPS** (TT2)

# LS2 activities

## SPS

LIU Project
HL-LHC Project
Fire Safety Project
New PPS Project
Consolidations
Maintenance
Upgrade

**LHC injection lines TI2 and TI8** *(see LHC coordination)*
- New collimators TCDIs
- New beam loss monitors
- New vacuum valves

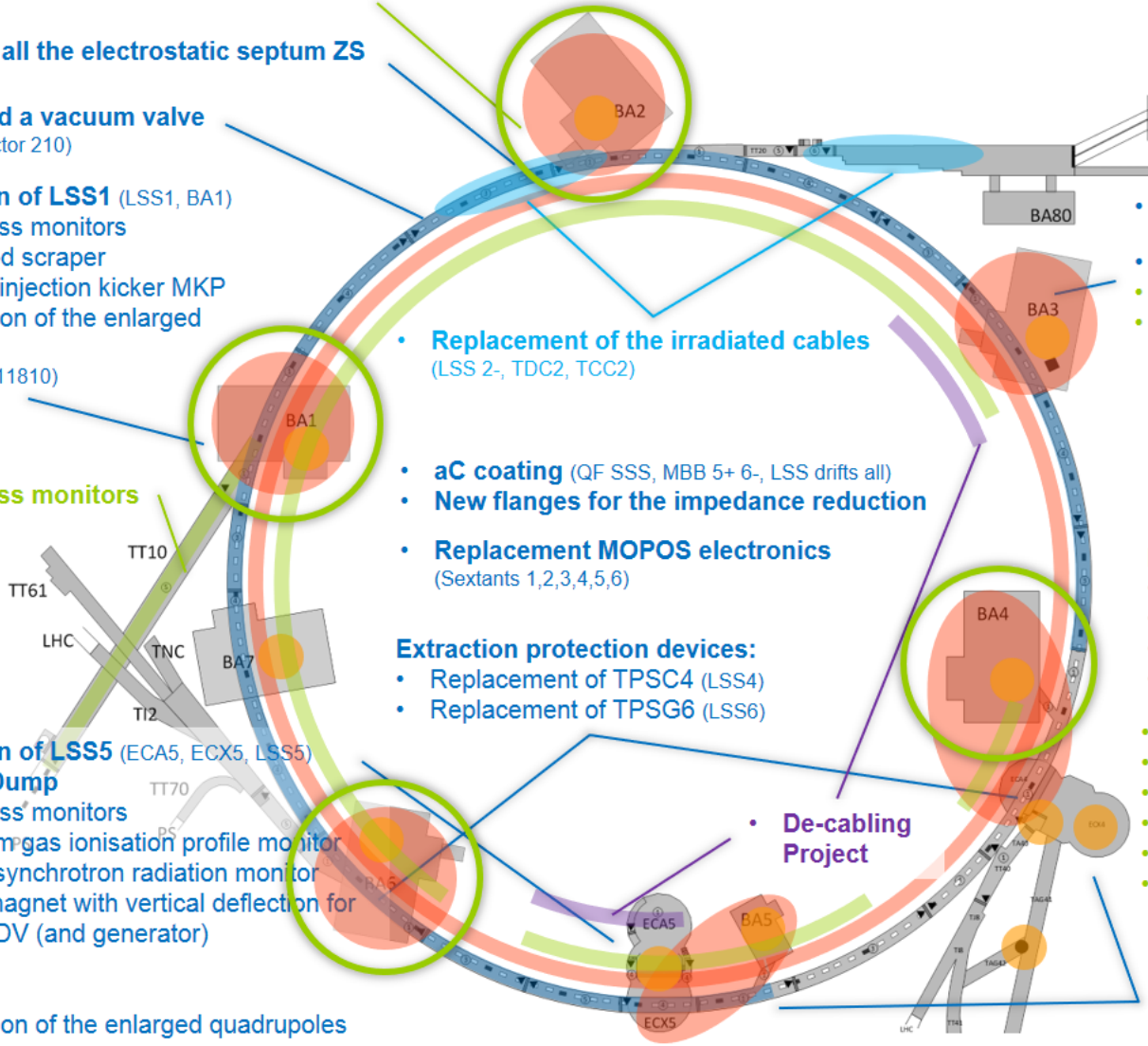
- New UA9 cristal and goniometer pair

- **Change all the electrostatic septum ZS** (LSS2)
  - **Add a vacuum valve** (sector 210)

**Reconfiguration of LSS1** (LSS1, BA1)
- New beam loss monitors
- New upgraded scraper
- Replace one injection kicker MKP
- Reconfiguration of the enlarged quadrupoles (11610, 11710, 11810)

- New beam loss monitors

**Reconfiguration of LSS5** (ECA5, ECX5, LSS5)
- **New Beam Dump**
- New beam loss monitors
- Replace beam gas ionisation profile monitor
- Replace the synchrotron radiation monitor
- New kicker magnet with vertical deflection for dumping MKDV (and generator)
- New BGI
- Move BSRT
- Reconfiguration of the enlarged quadrupoles (51610, 51810)




- **Replacement of the irradiated cables** (LSS 2-, TDC2, TCC2)

- **aC coating** (QF SSS, MBB 5+ 6-, LSS drifts all)
- **New flanges for the impedance reduction**

- **Replacement MOPOS electronics** (Sextants 1,2,3,4,5,6)

**Extraction protection devices:**
- Replacement of TPSC4 (LSS4)
- Replacement of TPSG6 (LSS6)

- **De-cabling Project**

- **200 MHz RF power upgrade** (LSS3, BA3, BAF3)
- **200 MHz low level RF upgrade**
- **Consolidation of BB3 cooling plant**
- **New modern static var compensator** (BEQ1)

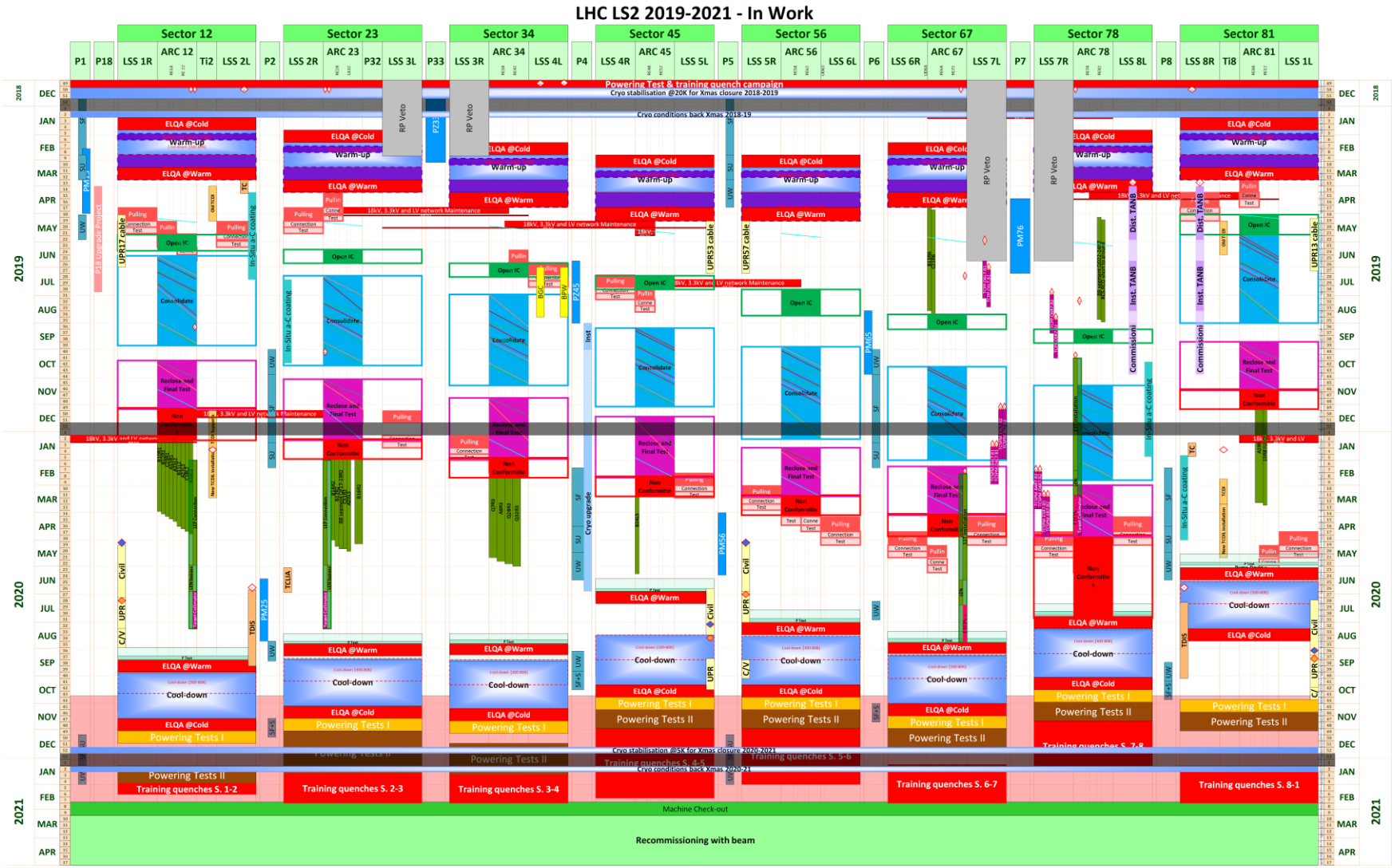
**New access systems**
- New personnal access devices PAD
- New material access Devices MAD
- New emergency exite doors

**Fire Safety**
- Fire compartments
- Fires safety systems
- Manual fire fithing systems
- Automatic fixed fire fihting systems

- **New emergency lighting systems**
- **New safety cable tray**
- **Consolidation of the B-train**
- **WIC and BIS deployment**
- **Refurbishment of the lift** (BA3, BA6)
- **Electrical sub-station consolidation** (BA1,2,4,6)

- **New rotational Wire Scanners BWSRE** (LSS4, LSS5)

# LHC-LS2 schedule in progress – Chamonix 2018



# LHC-LS2: TE - Maintenance

TE-ABT: Kickers & LBDS general maintenance

TE-CRG: major revisions of all compressors (12 months needed)

TE-VSC

- Maintenance on all the vacuum pumps, valves and instrumentation
- Beam gas injection system in LSS4
- Remote reconditioning of NEG cartridge across the ring
- Exchange of ion pumps at MKBs
- Corrective maintenance on defective PIMs
- Leak tests after warm-up and before cool-down (after pressure tests): not maintenance but operational activity

TE-EPC: corrective and preventive maintenance on all power converters

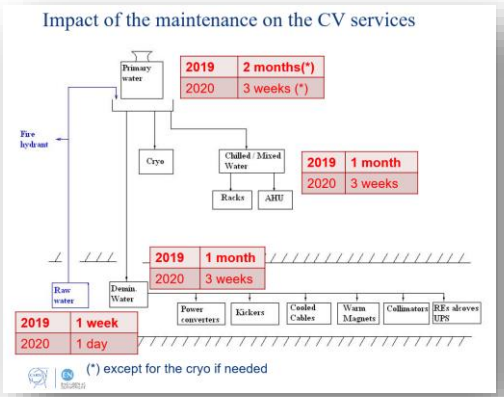
TE-MPE: Maintenance of all systems – EE systems 13kA & 600A, QPS, MPE software, current lead heating system

TE-MSC (including in DISMAC)

- Maintenance of all current leads and thermal switches of 600A, 6kA and 13kA
- Revision of heating systems of current leads
- Replacement of all fans 60-120A & cleaning of warm connectors 60-120A

# LHC-LS2: EN - Maintenance

**2 major maintenance periods: during the LS2 and before the restart (as YETS)**



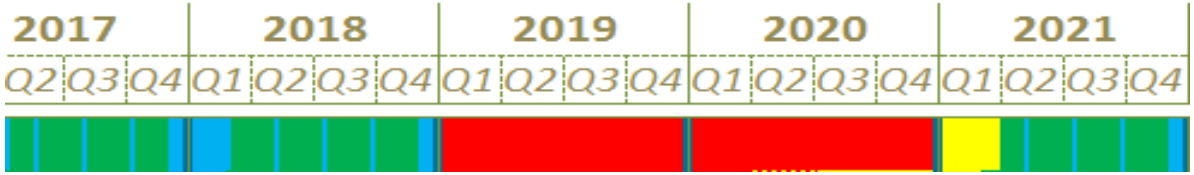

EN-CV

- Mechanical and/or chemical cleaning of heat exchangers
- Safety requirements (vessels,..)
- Mechanical revision of valves, replacement of piping component (flexible sleeves)
- Maintenance of all rotating machine: engines of pumps, ventilators…
- Instrumentation calibrations
- Bug fixing and functional tests

EN-EL

- Power transformers 400 kV and 66 kV maintenance works
- Maintenance of the 400 kV and 66 kV circuit breakers
- Tests on RTE interface protections and various signals (AUG, auto-transfer, …)

Request to HSE to perform maintenance and safety tests on 2 periods (vs 3) for EN-EL and BE-ICS
Mid 2019 & end 2020



# LHC-LS2: BE - Maintenance

BE-ICS

- Annual safety tests (fire detection, ODH, …)
- Maintenance of systems generating alarms level 3: gas, ODH, fire detection, red phones, sniffers
- Access control preventive maintenance

BE-BI

- General Maintenance of all systems, in particular BSRT
- Installation of consolidated interlock BPM electronics in P6
- Installation of consolidated wire scanner control & acquisition electronics in P4
- BGI reinstallation → under discussion
- Installation of full vertical slice of new BLM acquisition electronics for validation in parallel to existing system

BE-RF

ACS system

- Replacement of obsolete components (processors, PS, cards, etc.)
- Restructure of communication
- Radiation monitoring system update
- Klystron area reorganization
- Tuner system maintenance
- Maintenance of all FPC systems

ADT system

- Maintenance of all amplifiers and kickers

# LHC-LS2: Infrastructures consolidation

EN-HE

- Lifts replacement→ 10 wks interruption per lift
  Experiments lifts will be used
- Monorail duct and guiding line consolidation for the MAFI handling machine

EN-CV

- Cooling: consolidation of chilled water production at SU4 and SU6
- Ventilation: installation of a new HVAC system for SR1
  (including power supply)

EN-EL

- Replacement of the water cooled cable hoses in P1, P2 and P5
- Consolidation of the fibre infrastructure in LHC
- 48 V LHC, consolidation, refurbishment or replacement of the DC distribution systems ( rectifier, batteries, inverter, crates)

BE-ICS

- Modification of LHC PPS (Personnel Protection System) - LASS functionalities
  (unavailability of the access point during 2wks)
- Enlargement of MAD of PZ33, PZ45, PZ56, PZ76
  to be compliant with the new lifts dimensions

SMB

- Major support for MADs enlargement
- Cleaning and consolidation of LHC central drain in S. 3-4
- Renovation of underground sanitary systems

| Location | Replacement timeslot |
|---|---|
| PM15 | Dec. 2018 – Feb. 2019, 1st of LS2 |
| PM25 | Feb. 2019 – Apr. 2019, 2nd of LS2 |
| PM76 | Apr. 2019 – Jun. 2019, 3rd of LS2 |
| PZ33 | Jun. 2019 – Aug. 2019, 4th of LS2 |
| PZ45 | Aug. 2019 – Oct. 2019, 5th of LS2 |
| PM56 | Oct. 2019 – Dec. 2019, 6th of LS2 |
| PM65 | Aug. 2020 – Oct. 2020 |
| PX15 (ATLAS) | Dec. 2020 – Jan. 2021, Last of LS2 |

# LHC-LS2: systems consolidation

TE-CRG: Consolidation of LHC cryogenics electrical and control system

TE-EPC (R2E): Radiation to Electronics

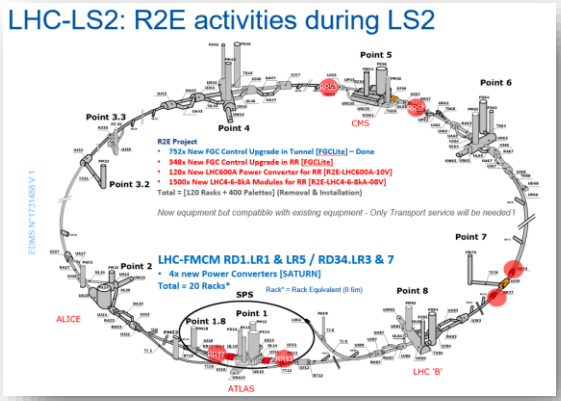
- Supply new LHC4-6-8 kA Power Modules for radiation areas
- Supply new LHC600 A-10 V power converters for radiation areas
- Supply new FGClite Control for LHC converters in RR areas

TE-MPE

- MPE - Upgrade of the DYPQ racks "Quadrupole Yellow Racks"
  All the DYPQ racks will be removed at the beginning of the LS2 and reinstalled in the tunnel at the end
- Upgrade of Quench protection components
  (DQLIM & DQLPR & DQLPU) hosted in the DYPQ racks
- EE - Consolidation of 13 kA & 600 A EE systems
- QPS - Upgrade for IPQ, IPD & IT protection, 600A
- QPS - Monitoring and protection of conical joints for 13kA warm leads
- MPE Software : AccTesting upgrades, to include the equipment changes

TE-MSC

- Exchange of 22 cryo-magnets, due to quench heater circuit failure, high internal splice resistance and layout recovery




## Summary

The baseline is to replace the 22 cryo-magnets + 4 HL-LHC full assemblies (34 units to reconnect)

| Sector | HL-LHC | QH failure | Resistance Issue | Others |
|---|---|---|---|---|
| 1-2 | Connection Cryostat (11L2) | | B10R1, B12R1, C29R1, B31L2, A33R1, A33L2, A23L2, C18L2, A18L2 | |
| 2-3 | Connection Cryostat (11R2) | B16R2 | B14R2, B17R2, C31R2, A20L3 | |
| 3-4 | | | Q7R3, A8R3 | LHC layout : Q28R3, Q32R3 |
| 4-5 | | B24L5 | | |
| 5-6 | | | | |
| 6-7 | 11T (B8L7) | | B13R6, C21R6 | |
| 7-8 | 11T (B8R7) | | | |
| 8-1 | | A26R8 | | C15R8 (ULO) |

| | Dipoles | SSS | Con. cryostat | 11T | By-Pass | Total |
|---|---|---|---|---|---|---|
| To remove | 21 (+1) | 3 | 2 | | | 26 (+1) |
| To install | 19 (+1) | 3 | 4 | 4 | 4 | 34 (+1) |

# LHC-LS2: systems consolidation

TE-VSC

- Consolidation of all turbo pumps of the arcs and 30% of the LSS (LHC-Insulation vacuum)
  96 insulation vacuum turbo pumps in the LHC Arcs
  → *Long cable pulling needed*
- New sectorization of LSS1 and LSS5 around the D1 to be able to vent the D1 without venting the TAN
- Consolidation of warm modules and RF bridges
- Consolidation sector valves compressed air system
- MKB Vacuum Pumping Scheme Consolidation BTD62.DR
- Vacuum Pilot Sector (VPS) for the LHC LS2
- Installation of new turbo pumping groups on triplet cryostats of points 1, 2 & 8 (LHC-IV)

BE-BI

- Consolidation of BLM and CryoBLM, BSRT, wire scanners, BPM, …

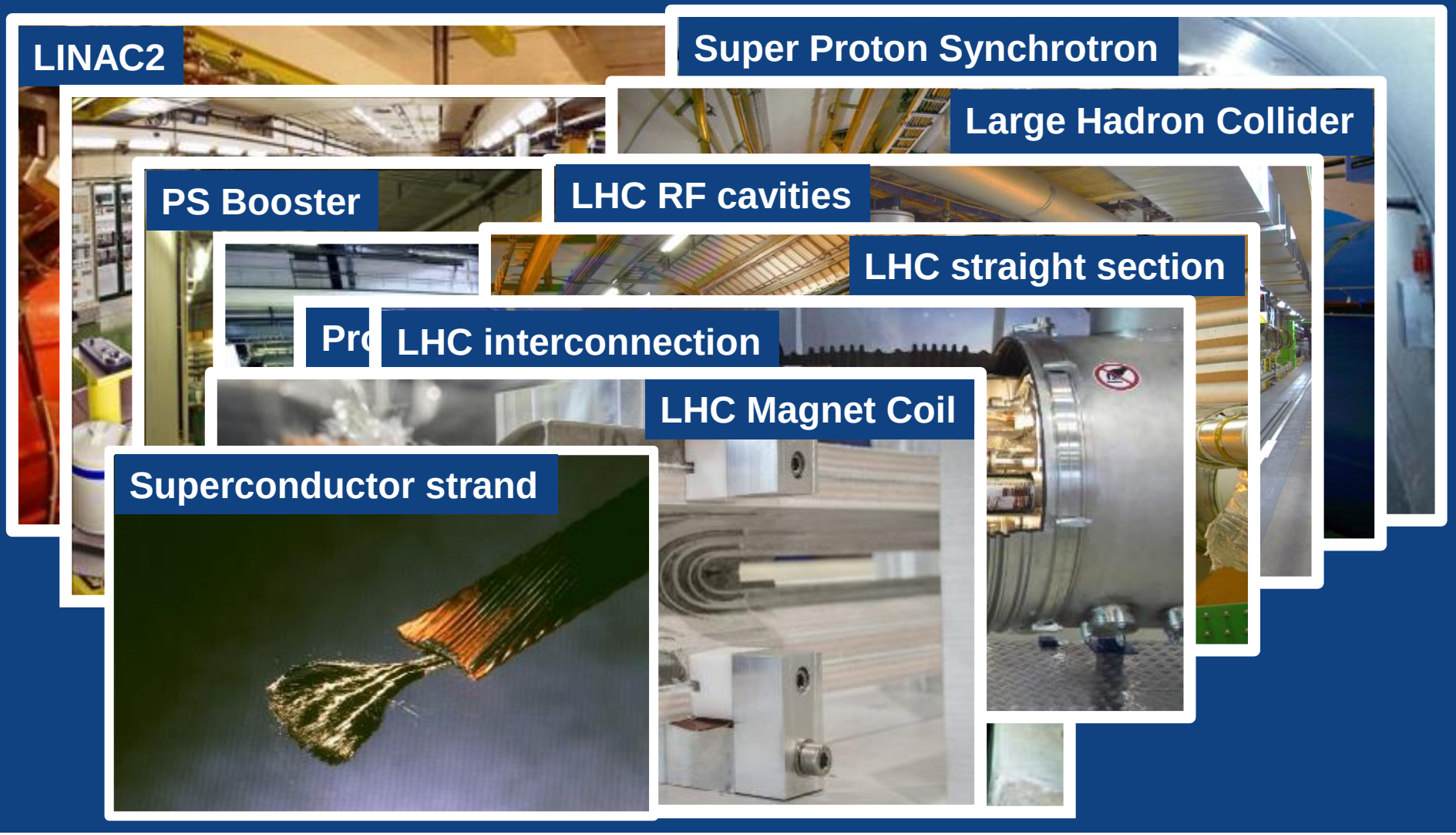
EN-STI

- Installation of 4 new TCPPM in P7
- The action plan to consolidate the LHC main dumps will depend on the conclusion of the present YETS activities
- The control systems will be upgraded, maintained and consolidated


Thank you !


CERN
LS2
Project

# A unique Accelerator chain Worldwide…



# And amazing Detectors…