VSC consolidation, maintenance and operation activities for the LS2

G.Bregliozzi on behalf of TE-VSC Group

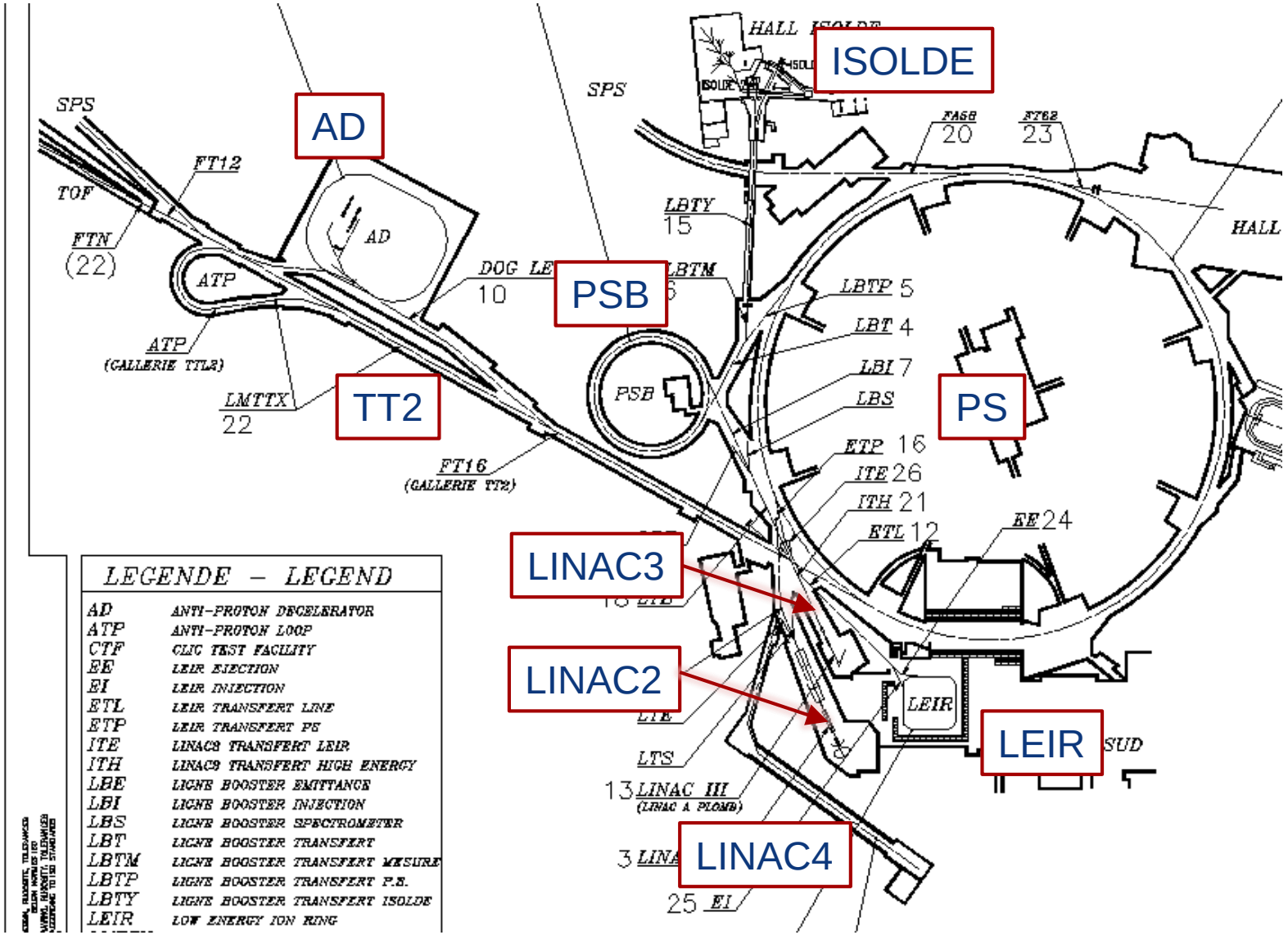
LS2 DAYS
29-30 SEPTEMBER 2015

http://indico.cern.ch/event/436424/

Overview

- PS Complex
- SPS Complex
- LHC
  - Experiments
  - Room temperature and Cryogenic areas
- LHC Insulation Vacuum
- VSC-ICM: Controls activities
- Summary

PS Complex


ISOLDE
AD
PSB
TT2
PS
LINAC3
LINAC2
LEIR
LINAC4
SPS
FT12
TOF
FTN
(22)
ATP
(GALLERIE TT2A)
LMTTX
22
FT16
(GALLERIE TT2)
DOG LE
10
LBTY
15
LBTM
LBTP 5
LBT 4
LBI 7
LBS
ETP 16
ITE 26
ITH 21
ETL 12
EE 24
FA66
20
FT62
23
HALL
LEIR
SUD
LTS
13 LINAC III
(LINAC A PLOMB)
25 EI
LEGENDE – LEGEND
AD ANTI-PROTON DECELERATOR
ATP ANTI-PROTON LOOP
CTF CLIC TEST FACILITY
EE LEIR EJECTION
EI LEIR INJECTION
ETL LEIR TRANSFERT LINE
ETP LEIR TRANSFERT PS
ITE LINAC3 TRANSFERT LEIR
ITH LINAC3 TRANSFERT HIGH ENERGY
LBE LIGNE BOOSTER EMITTANCE
LBI LIGNE BOOSTER INJECTION
LBS LIGNE BOOSTER SPECTROMETER
LBT LIGNE BOOSTER TRANSFERT
LBTM LIGNE BOOSTER TRANSFERT MESURE
LBTP LIGNE BOOSTER TRANSFERT P.S.
LBTY LIGNE BOOSTER TRANSFERT ISOLDE
LEIR LOW ENERGY ION RING

LINACS

EYETS2016-2017

TE-VSC

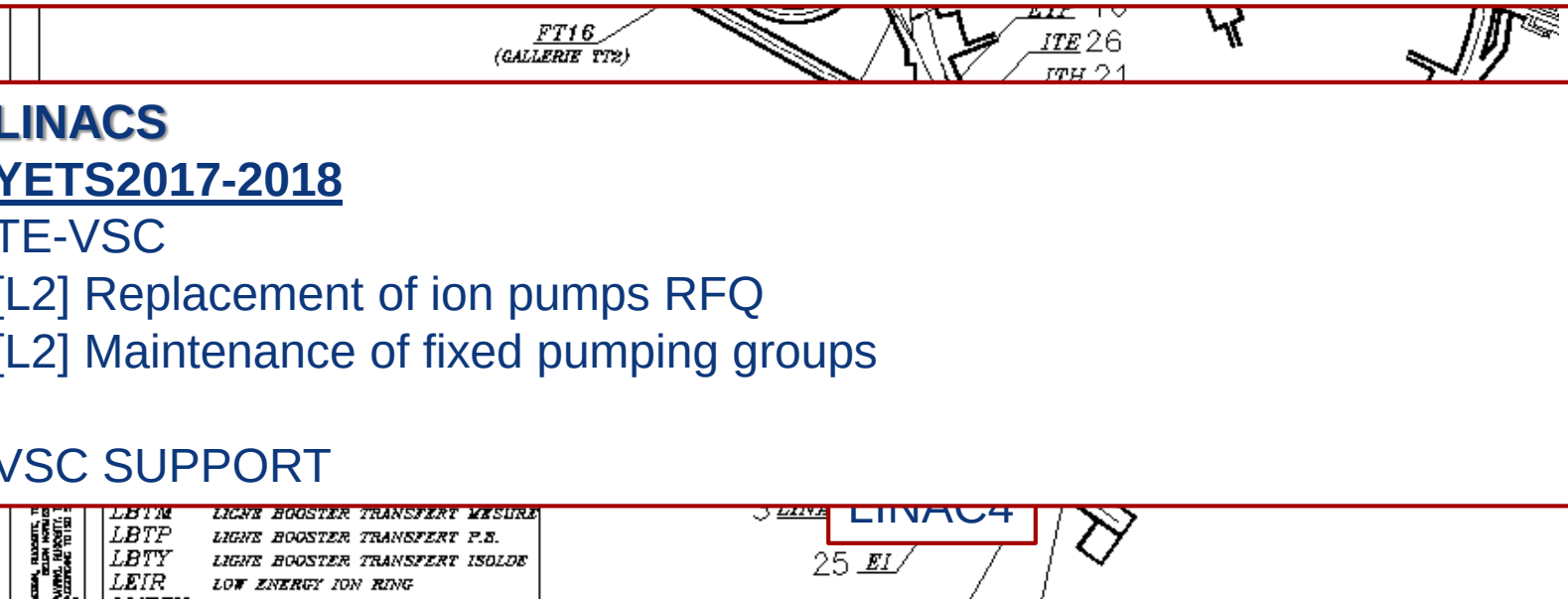
[L2] Maintenance of fixed pumping groups

VSC SUPPORT

[L2][BE-BI] Replacement of 7 BCTs in lines LT, LTB and BI

[L3-LIU][BE-BI] Replace 2 Faraday cups (vacuum sectors ITL and ITM)

[LEIR-LIU] Installation of new dump for LEIR (switchyard of PS)



LINACS

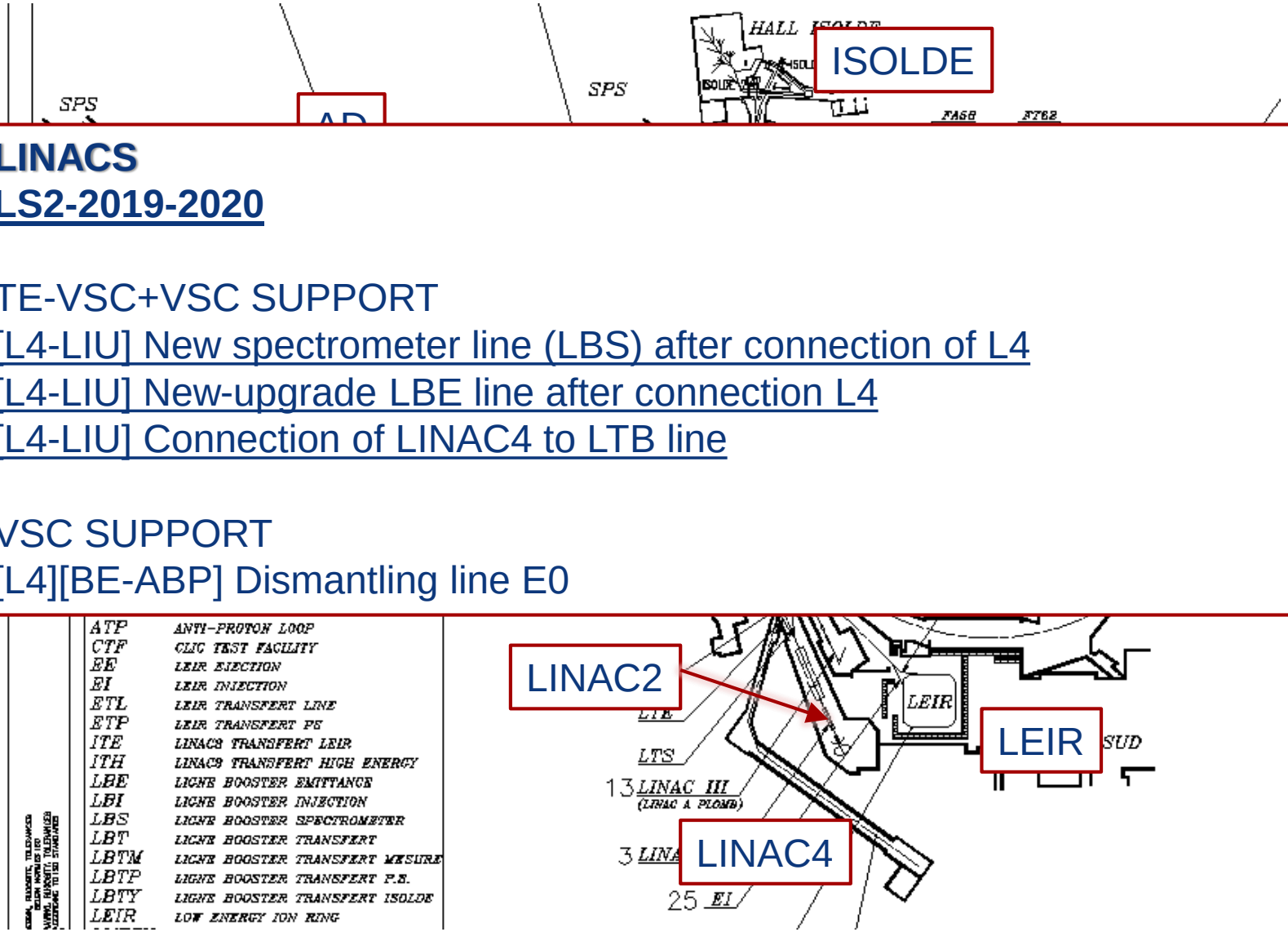
YETS2017-2018

TE-VSC

[L2] Replacement of ion pumps RFQ

[L2] Maintenance of fixed pumping groups

VSC SUPPORT



LINACS

LS2-2019-2020

TE-VSC+VSC SUPPORT

[L4-LIU] New spectrometer line (LBS) after connection of L4

[L4-LIU] New-upgrade LBE line after connection L4

[L4-LIU] Connection of LINAC4 to LTB line

VSC SUPPORT

[L4][BE-ABP] Dismantling line E0

PSB

EYETS2016-2017

TE-VSC

General maintenance.

[Cons] Replacement of old ion pumps (10%)

[Cons] Refurbishment of old fixed pumping groups in BI, BT lines

VSC SUPPORT

[TE-ABT] Pressurization of septa water cooling circuits

[LIU][BE-BI] New pick up line BTP

[LIU][BE-BI] New SEM-grid in 4L1 ring 3

PSB

YETS2017-2018

TE-VSC

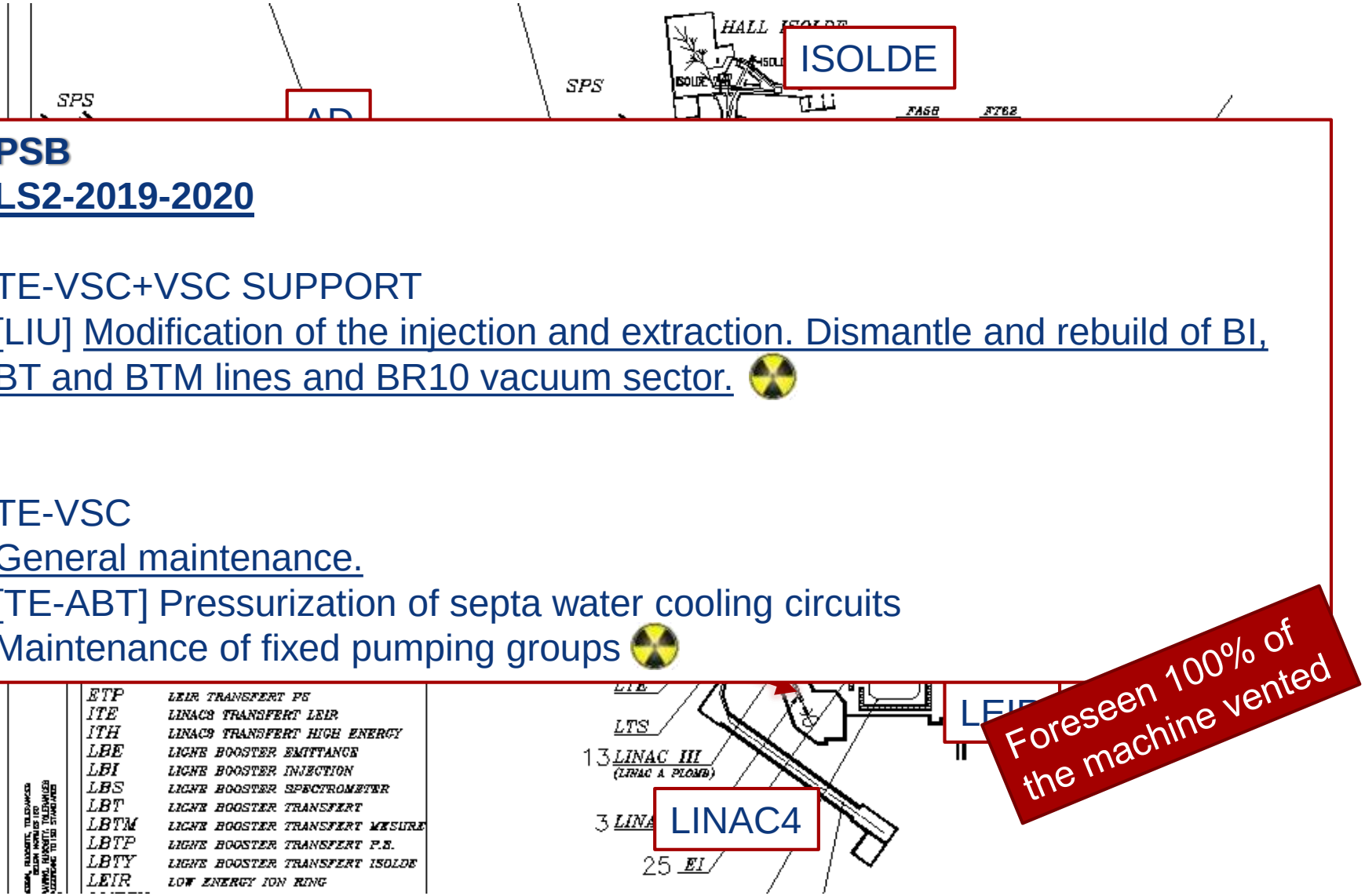
General maintenance.

[Cons] Replacement of old ion pumps (10%)

[Cons] Refurbishment of old fixed pumping groups in PSB ring

VSC SUPPORT

[TE-ABT] Pressurization of septa water cooling circuits



PSB

LS2-2019-2020

TE-VSC+VSC SUPPORT

[LIU] Modification of the injection and extraction. Dismantle and rebuild of BI, BT and BTM lines and BR10 vacuum sector.

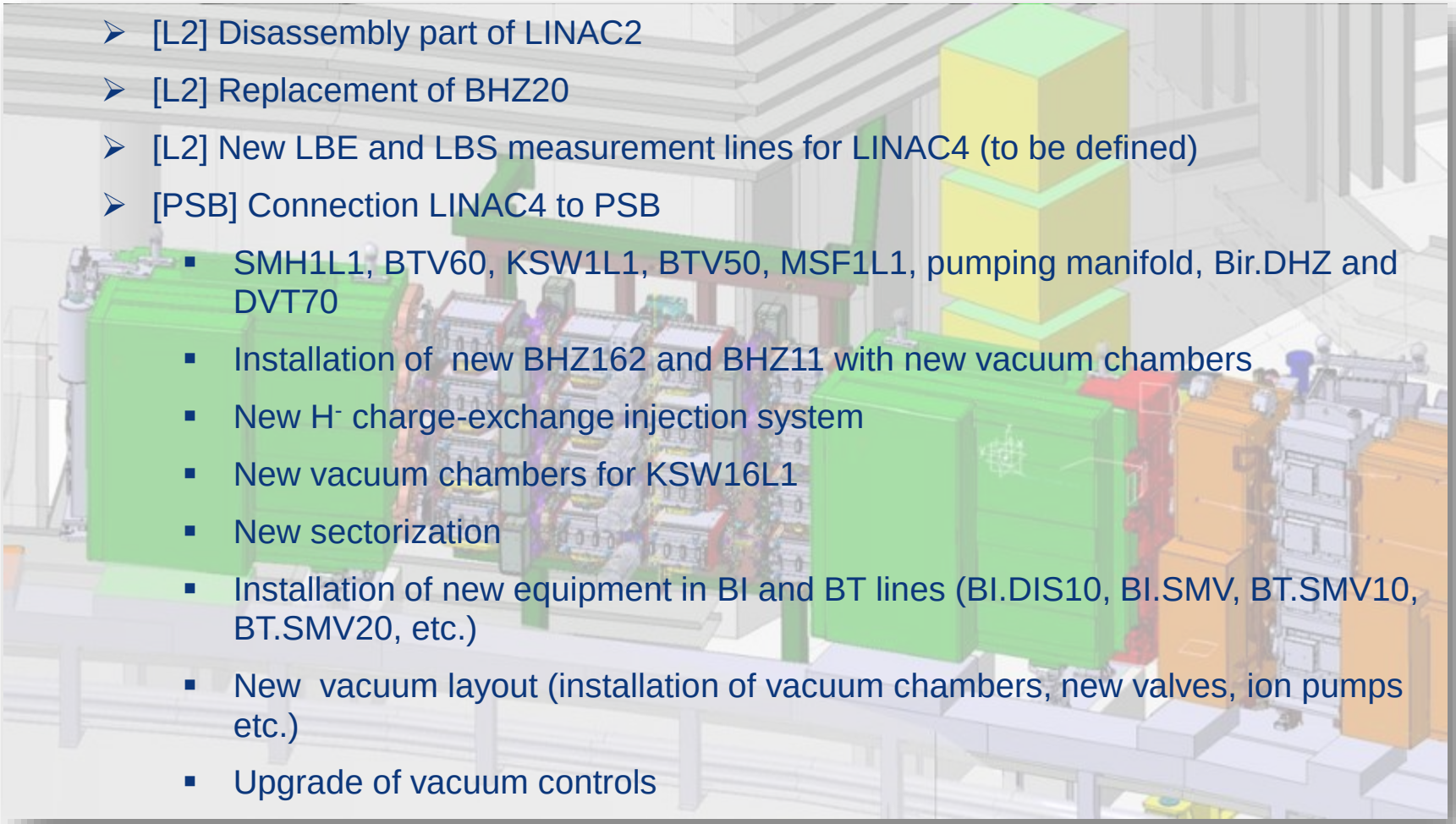
TE-VSC

General maintenance.

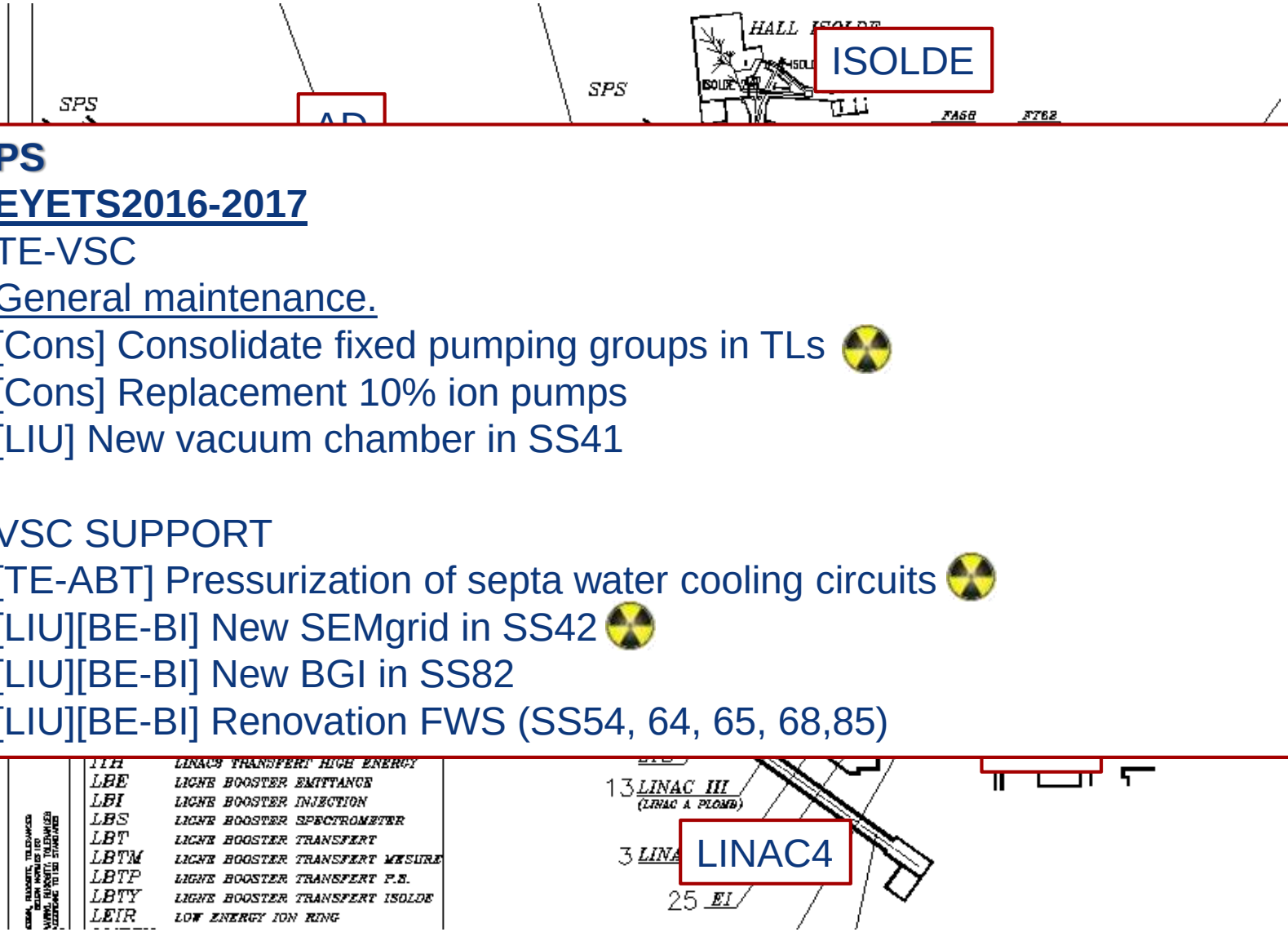
[TE-ABT] Pressurization of septa water cooling circuits

Maintenance of fixed pumping groups

Connection LINAC4 to PSB



- [L2] Disassembly part of LINAC2
- [L2] Replacement of BHZ20
- [L2] New LBE and LBS measurement lines for LINAC4 (to be defined)
- [PSB] Connection LINAC4 to PSB
  - SMH1L1, BTV60, KSW1L1, BTV50, MSF1L1, pumping manifold, Bir.DHZ and DVT70
  - Installation of new BHZ162 and BHZ11 with new vacuum chambers
  - New H^- charge-exchange injection system
  - New vacuum chambers for KSW16L1
  - New sectorization
  - Installation of new equipment in BI and BT lines (BI.DIS10, BI.SMV, BT.SMV10, BT.SMV20, etc.)
  - New vacuum layout (installation of vacuum chambers, new valves, ion pumps etc.)
  - Upgrade of vacuum controls



PS

EYETS2016-2017

TE-VSC

General maintenance.

[Cons] Consolidate fixed pumping groups in TLs

[Cons] Replacement 10% ion pumps

[LIU] New vacuum chamber in SS41

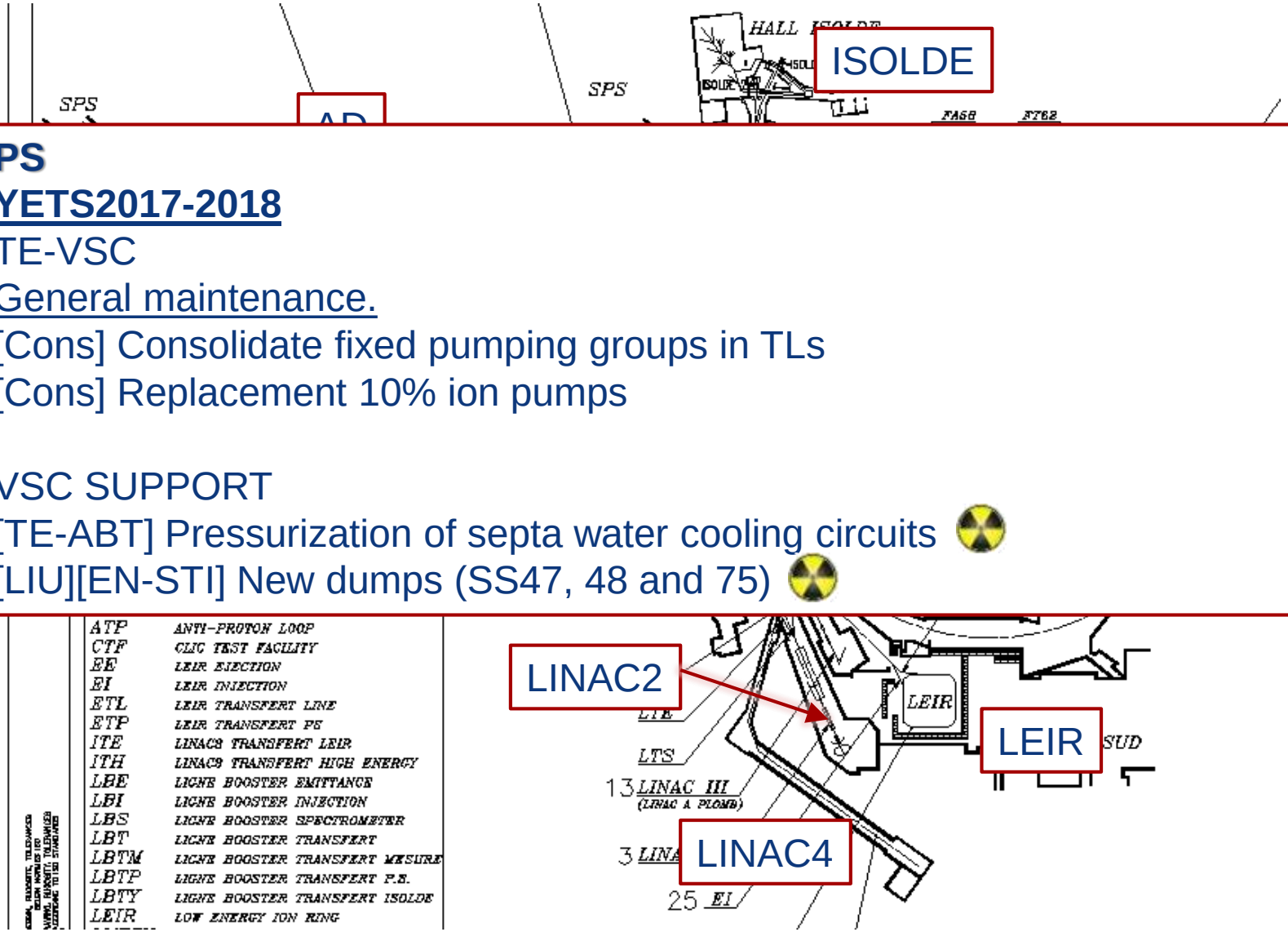
VSC SUPPORT

[TE-ABT] Pressurization of septa water cooling circuits

[LIU][BE-BI] New SEMgrid in SS42

[LIU][BE-BI] New BGI in SS82

[LIU][BE-BI] Renovation FWS (SS54, 64, 65, 68,85)



PS

YETS2017-2018

TE-VSC

General maintenance.

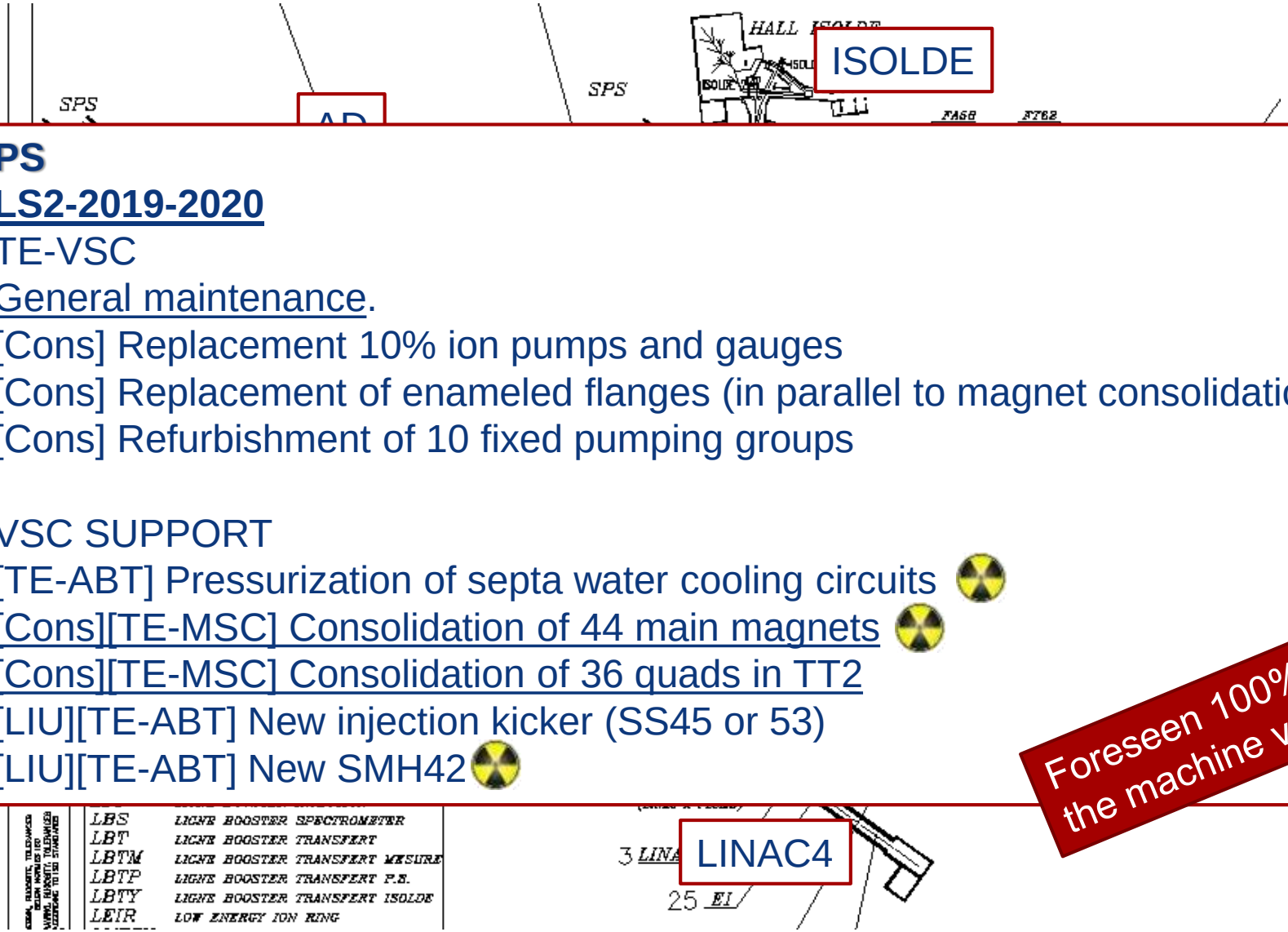
[Cons] Consolidate fixed pumping groups in TLs

[Cons] Replacement 10% ion pumps

VSC SUPPORT

[TE-ABT] Pressurization of septa water cooling circuits

[LIU][EN-STI] New dumps (SS47, 48 and 75)



PS

LS2-2019-2020

TE-VSC

General maintenance.

[Cons] Replacement 10% ion pumps and gauges

[Cons] Replacement of enameled flanges (in parallel to magnet consolidation)

[Cons] Refurbishment of 10 fixed pumping groups

VSC SUPPORT

[TE-ABT] Pressurization of septa water cooling circuits

[Cons][TE-MSC] Consolidation of 44 main magnets

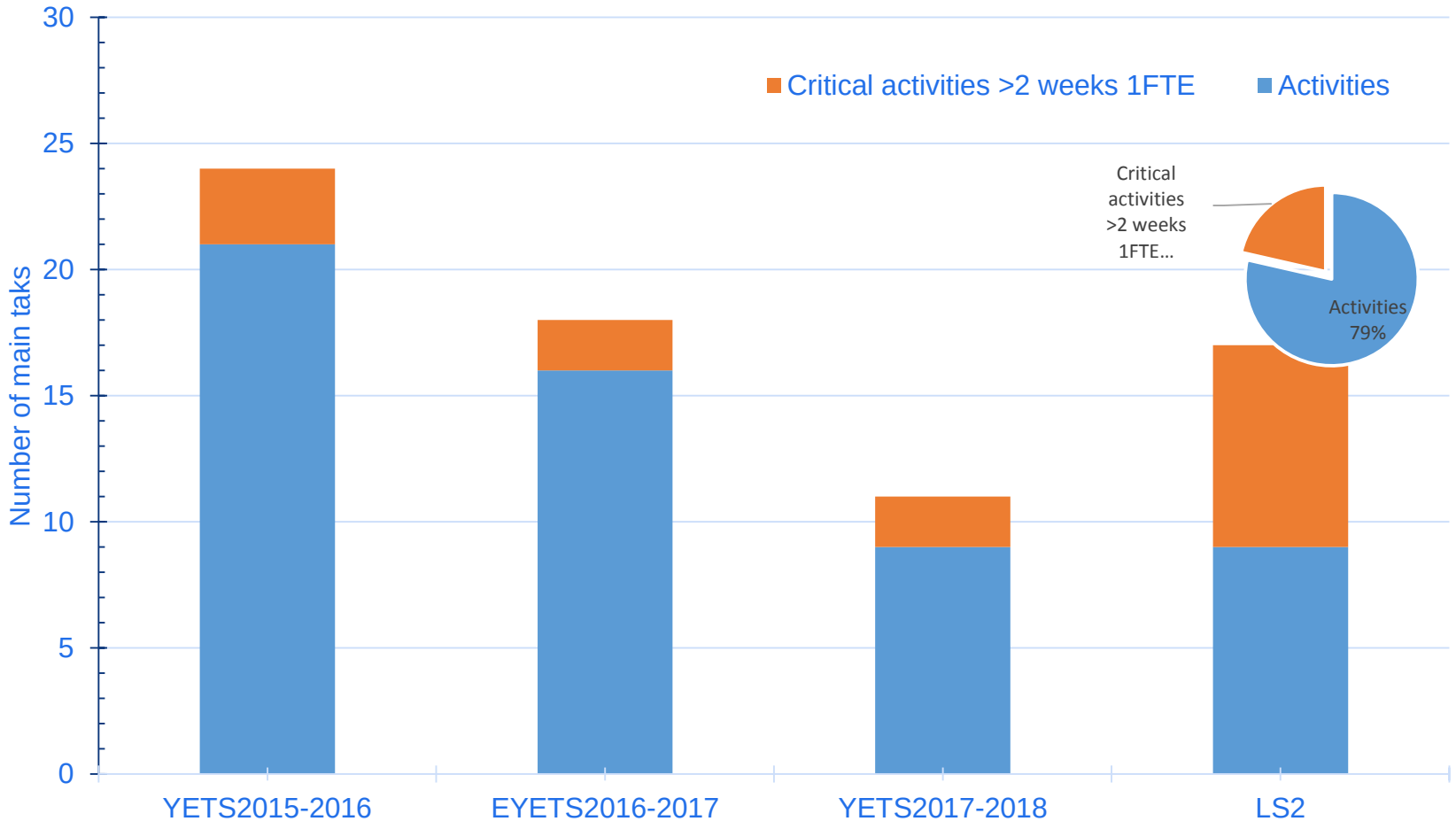
[Cons][TE-MSC] Consolidation of 36 quads in TT2

[LIU][TE-ABT] New injection kicker (SS45 or 53)

[LIU][TE-ABT] New SMH42

Foreseen 100% of the machine vented

cPS – Summary: Known Jobs



Some critical activities have very long durations

Radiological considerations

MSWG, 24/10/2014

Example: after 4 months of cool down (RP survey 18/04/2013) Dose rates at 40 cm

- PSB:
  - Average: 34 μSv/h (88h to 3mSv)
  - Median: 11 μSv/h (34x8h/days to 3mSv)
- PS:
  - Average: 89 μSv/h (34h to 3mSv)
  - Median: 23 μSv/h (16x8h/days to 3mSv)

TE-VSC technicians need to spend long periods in the machine

SPS Complex

SPS-EYETS2016-2017

- General maintenance (replacement of ion pumps, gauges and valves)
- [LIU] Finish arc re-sectorzation
- [Cons] Ion pump grounding consolidation
- [LIU] a-C coating of QF+SSS and impedance reduction pilot run (1 sext.)*
- [LIU] MBB aC coating on limited cells*
- [TE-MSC] Periodical replacement of magnets
- [LIU][BE-RF] Install new crab cavities in LSS6

* a-C coating waiting for final decision

SPS-YETS2017-2018

- General maintenance (replacement of ion pumps, gauges and valves)
- [Cons] Ion pump grounding consolidation
- [TE-MSC] Periodical replacement of magnets
- [LIU][BE-BI] Replacement of wire scanners
- [BE-RF] Crab cavity exchange?

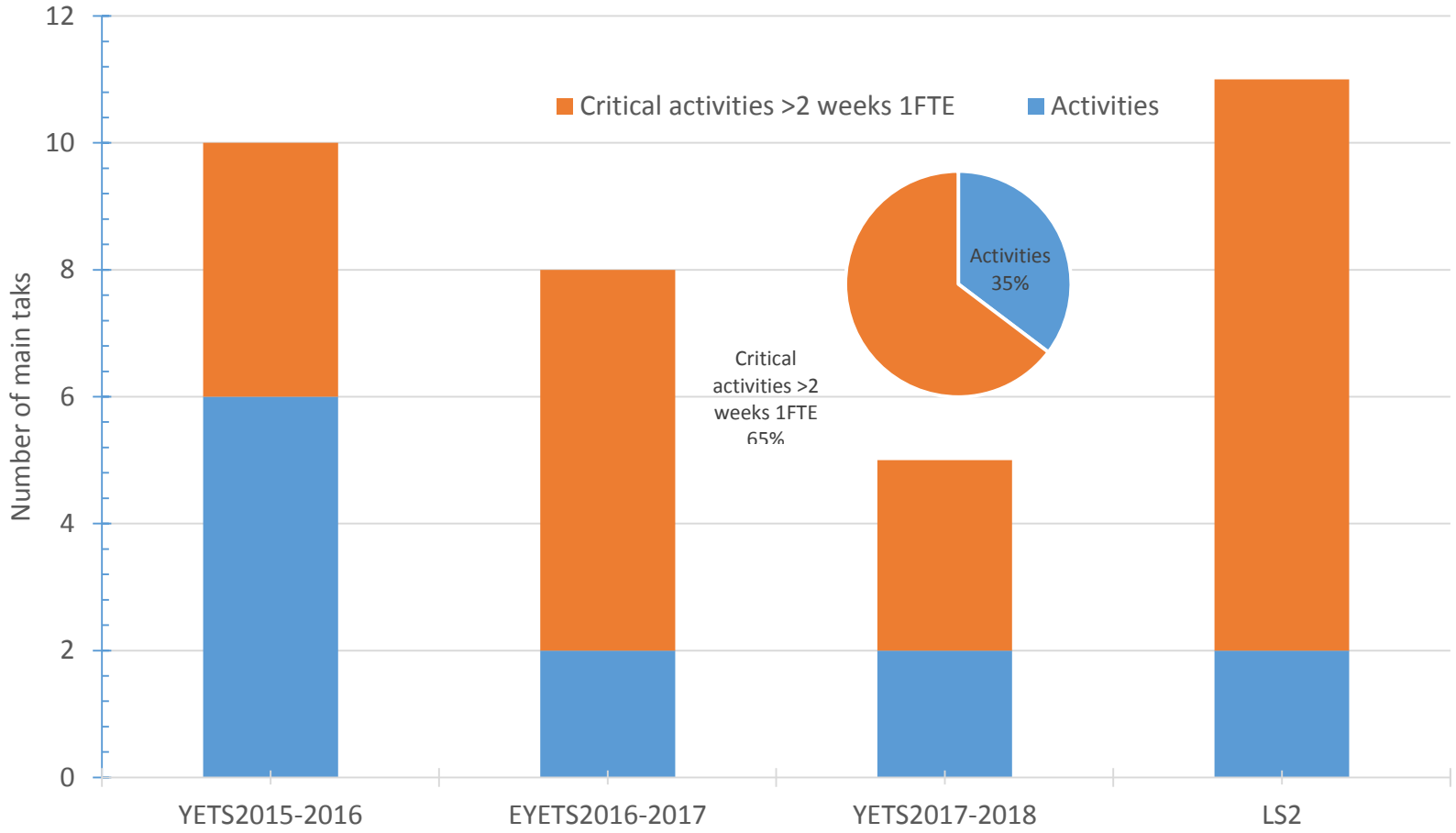
SPS-LS2-2019-2020

- General maintenance (replacement of ion pumps, gauges and valves)
- [Cons] Ion pump grounding consolidation
- [LIU] Full deployment of a-C coating of QF+SSS and impedance reduction (5 sextants) *
- [LIU] Full deployment of Drift chambers a-C coating *
- [LIU] Pilot run of MBB coating (1 arc) *
- [LIU] Pilot run of QD+SSS coating and impedance reduction (1arc) *
- [LIU] Installation of new internal dump in LSS5
- Relocation of all TE-VSC E-clouds monitors: Under study
- [LIU] New layout in LSS1 after dump removal. Installation of new MSI-V and internal dump for ions
- [LIU] New layout in LSS3 (4 to 6 cavities)
- [LIU] New layout TDCI TI2 and TI8
- [LIU] Upgrade of ZS in LSS2
- Preparation TDC2 for SHIP (Not approved?)

Foreseen ~100% of the machine vented

* a-C coating waiting for final decision

SPS – Summary: Known Jobs

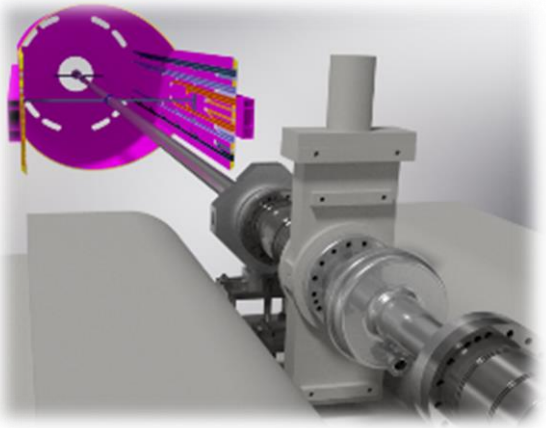


LHC Experiments

LS2: ALICE beam vacuum

A prime goal of the ALICE Phase II upgrade is a significant improvement of the track impact parameter resolution: significantly reduce the beam pipe diameter and reduced wall thickness

1. Design, procure and test beam vacuum equipment for new IP2 layout (including tooling, bake-out equipment etc.).
2. Completely dismount IP2.X, A1L2.X (RB24) sector.
3. Vent and partially dismount A1R2.X sector.
4. Install new aluminium/beryllium central beam pipe.
5. Install new vacuum layout in sector RB 24 and A1R2.X.
6. NEG activation and re-commissioning of the sector.



WP: EDMS 1065775

LS2: LHCb beam vacuum

A prime goal during the LS2 is to support LHCb during the VELO upgrade. This includes safe removal, re-installation and re-commissioning of UX85/1 – 4 vacuum chambers. Also according to the ALARA principle BVO will replace upstream copper chamber with a new aluminium design.

1. Provide consultancy and support for VELO upgrade.
2. Temporary removal of UX85/1 – 4 chambers.
3. Replace upstream copper chamber with aluminium chamber.
4. Install an additional bake-out system on UX85/3 RICH2 section.
5. Re-install UX85/1 – 4 chambers.
6. NEG activation and re-commissioning.

WP: EDMS 1529730

LS2: CMS beam vacuum

Main goal of the CMS Phase II is to design, procure and install new ‘low-mass’ end-cap, forward and CT2 beam pipes. Replacement of these chambers by aluminium thin-wall design will meet aperture requirements for post-TOTEM period and in order with ALARA principle reduce radiation dose to personnel.

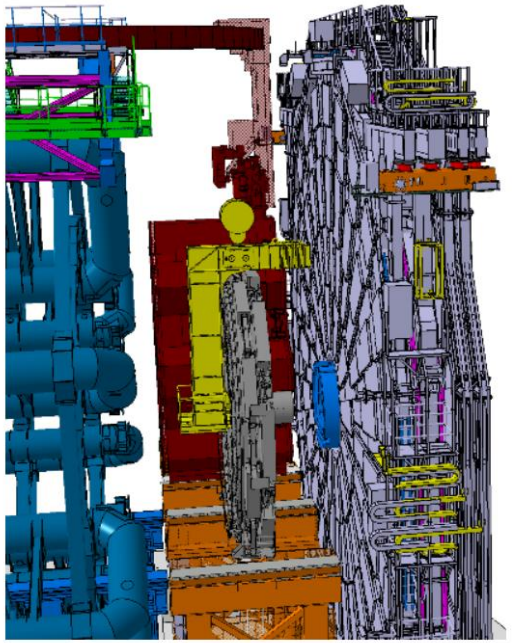
1. Design, procure and test beam vacuum equipment for new IP5 layout (including tooling, bake-out equipment etc.).
2. Participate on all opening/closing actions.
3. Dismount existing endcap and forward chambers.
4. Install new layout with aluminium chambers.
5. NEG activation and re-commissioning of the sector.

WP: EDMS 1065775

LS2: ATLAS beam vacuum

During the LS2 ATALS will replace the present measuring station of the forward muon spectrometer with the New Small Wheel to improve the LVL1 muon trigger capability and cope with rate limitation of the present detector

1. TE-VSC will need to temporary dismount the IP in the ATLAS cavern with all fixed bake-out system
2. After the installation of the New Small Wheels:
   a) Re-installation by stage, like during the LS1, of all the vacuum chambers
   b) Dedicated leak detection on each sections
   c) Dedicated tests of the bake-out system
1. Final reassembly and commissioning with complete bake-out and NEG activation

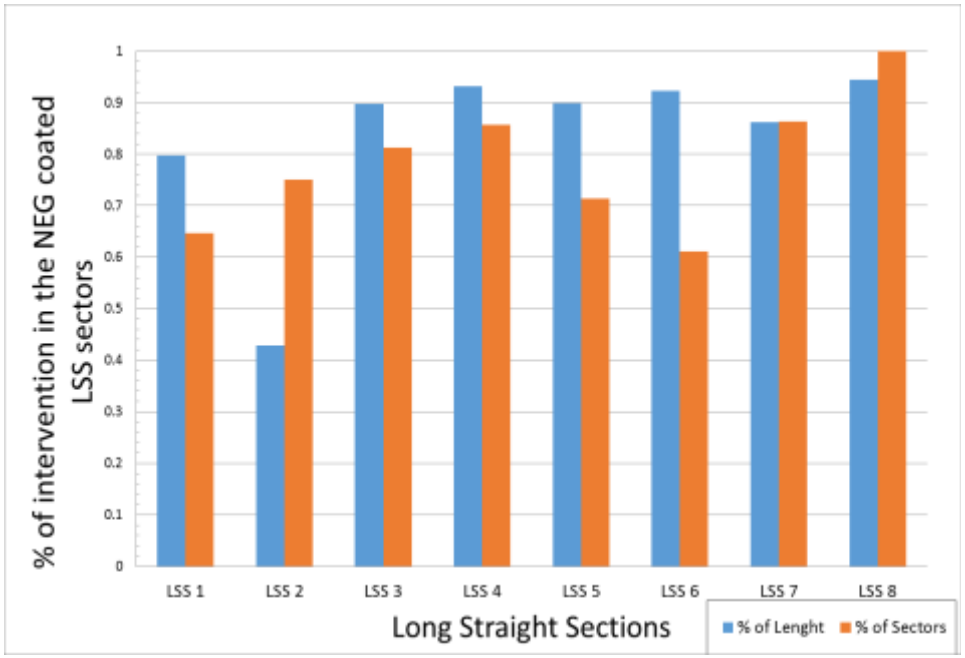


Form L.Pontecorvo LS2 days

LHC Room Temperature Beam Vacuum

LSS Activities during LS1

LS1 was the long shut-down for the splices repair



However:

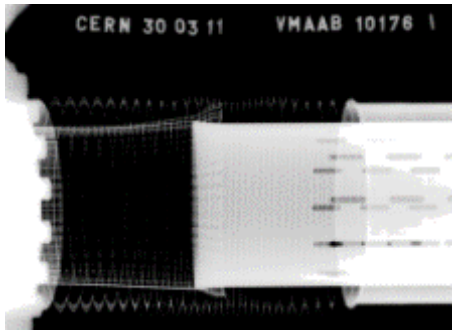
About 80% (148 vacuum sectors) of the LSS were opened to air during the LS1 with consequent bake-out and NEG activation

Different unforeseen or not planned activities and last minute ECR implied the opening of additional vacuum sectors

- 12 IS Support during the LS1 for the LSS & Experiments

Consolidation: Warm modules and RF bridges

During the LS1: 96 NCs identified during Run1, Spread over 52 RT vacuum sector (LHC total is 185) and 29 RT vacuum sectors were opened for this purpose



Problematic:

- Possible sparking with beam intensity increase
- Possible failure with consequent venting of vacuum sector

Consolidation Campaign:

- X-Rays campaign will start already during the EYETS 2016 for the RF Bridges
- Visual inspection of all warm modules will start during EYETS and TS of 2017 to identify NC s and define priorities

- Final upgrade during LS2 mainly in the shadows of vacuum sector opening for other activities
- Final time and needed personnel will be defined after the EYETS

NC announced by V.Baglin in Chamonix 2014

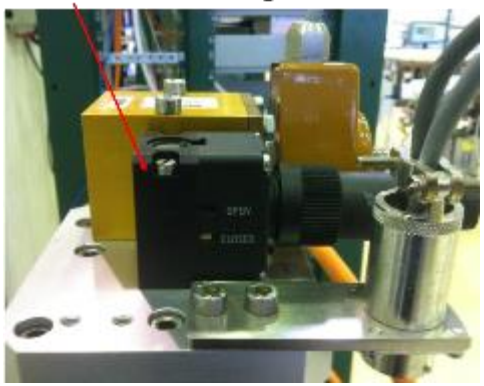
Consolidation: Sector valves

A preventive consolidation campaign will start during the EYETS and will finish during the LS2 for all the 308 sector valves installed in the LHC

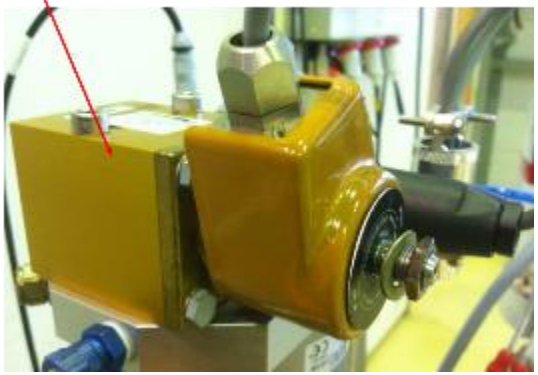
Consolidation Campaign:

- Position indicator
- Pneumatic distributor
- Actuator seals

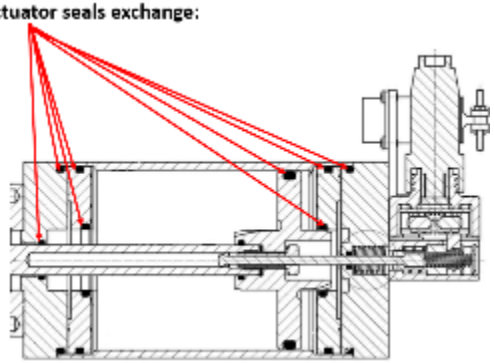
Position indicator exchange:



Pneumatic distributor exchange:



Actuator seals exchange:



- First upgrade EYETS 2016: 30% of sector valves (Mainly LSS3 and LSS7)
- Final upgrade during LS2: 70 % of sector valve

Consolidation: Pumping scheme

- **Reduce background** to the experiments:
  - Continue with NEG coating of RF bridges inserts on all the LSS1, LSS2, LSS5 and LSS8.

- **Minimize impact of radiation** onto the personnel:
  - installation of remotely powered NEG cartridge as complementary lumped pumping system in collimators areas
  - Number of vacuum sector: to be finalized during EYETS 2016

- **Vacuum Pilot Sector in A5L8:**

- Four stations :
  - Study impact of SR and electron cloud on different technical materials

  - During EYETS & LS2 new materials and coating will be installed

Upgrade: MKB Vacuum system

A prime goal of the upgrade is to decrease the pressure at which the ion pumps are working: Longer lifetime and decrease the number of interventions

Damaged Ti cathode due to high pressure

Internal coloration due to sputtering: ion pumps body

Problematic:

- Huge outgassing rate (plastic !)
- Pumping system already partially upgraded
- But 400 l/s ion pumps get destroy under large gas load

Solution:

- Integration of 2 x Turbo Molecular Pump each of 700 l/s
- Decrease the pressure limit at which the ion pumps are working by factor 20
- Linearly the lifetime of the ion pumps is increase of factor 20

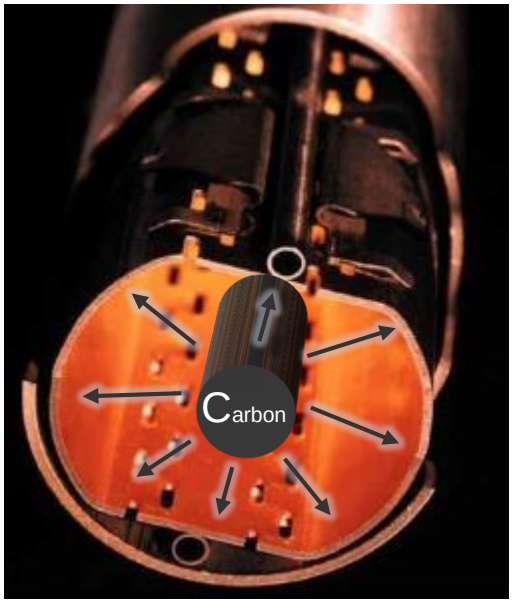
- First upgrade EYETS 2016: TD68 fully upgraded – 2 wk activities
- Final upgrade during LS2: TD62 fully upgraded – 2 wk activities

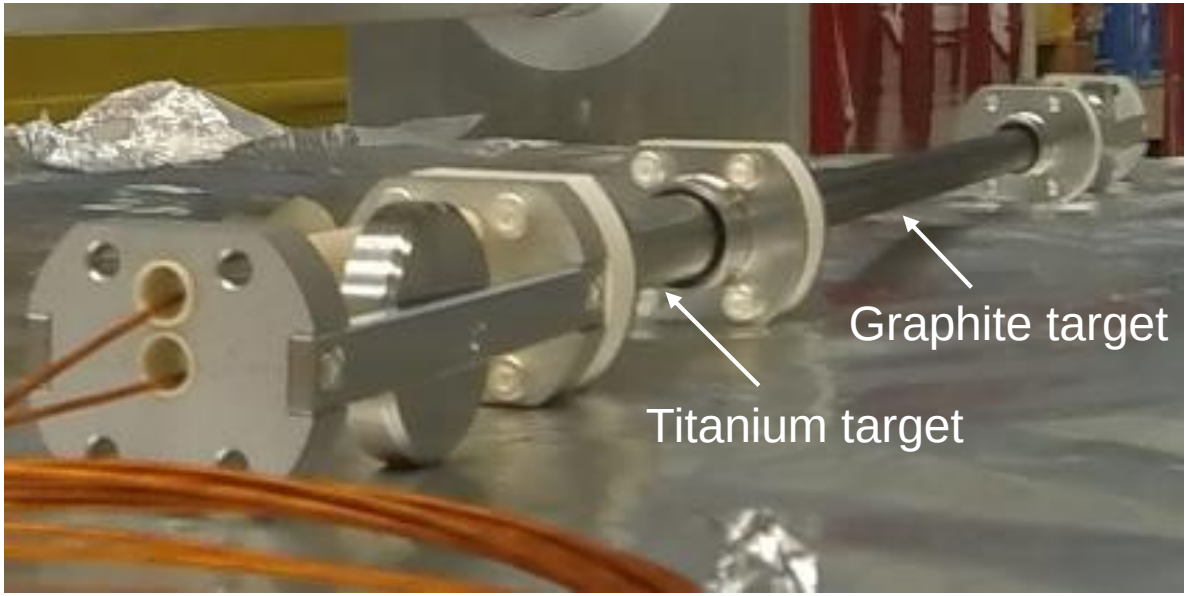
NC announced by V.Baglin in Chamonix 2014

Upgrade Study: Coating of IT2 & IT8

Coat each triplet individually (to avoid damaging the RF fingers).

Develop a “modular sputtering source” that can be inserted in a 150 mm slot and pulled by cables all along a triplet.





Important intervention modification: need a large infrastructure for the realization.

Support to different WPs of HL-LHC

WP3 Insertion Magnets: **Strong layout modification**

- Achromatic Telescopic Squeezing (ATS): Upgrade of the Q5 in P6.

WP5 Collimation System: **Strong layout modification**

- New secondary and tertiary collimators prototype based on advanced robust and low-impedance materials: TCSPM and TCTPM.
- Hollow e-lens & Crystal collimator under evaluation for controlling the beam halo.

WP11 11T Dipole for the DS Collimators: **Strong layout modification**

- For LS2, the present plan is to not install any 11 T (only in LS3 for P2 & P7). An empty cryostat with the by-pass collimator will be installed instead.

WP13 Beam Instrumentation**: Strong layout modification**

- During LS2 there will be an intensive campaign in which certain prototypes will be tested such for the Fast Wire Scanners, the Interlock abort monitor and a second BGV on the right side of IP4.

Support to different WPs of HL-LHC

Other activities under study with strong impact on the vacuum layout

1. TAXN design and layout @ IR8 with interaction of a wider TCL (14th HL-LHC PLC).

2. Replacement of the TDI with new TDIS consisting of several tanks and new absorber materials to cope with intense LIU beam (17th HL-LHC TC).

3. Replacement of TCDD to provide sufficient protection of superconducting elements in the case of injection failures (17th HL-LHC TC).

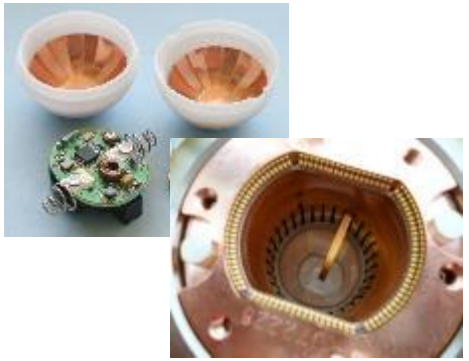
4. MKI Proto-type: Modification concerning beam induced heating/cooling and coating to reduce e-cloud effects (17th HL-LHC TC).

5. 4 “wire in jaw“ collimators: Design finished in 2014. Delivery expected in spring 2016, followed by qualification tests. Installation now scheduled for EYETS 2016/2017 (16th HL-LHC PLC).

Cryogenic beam vacuum

All ARCS: He Leak detection & RF ball & Pump down

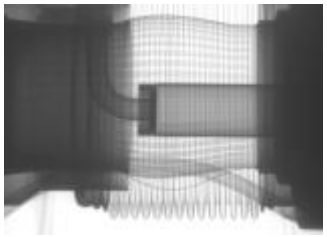
1. Beginning of LS2: During warm up need to pump down the released gases for beam vacuum He leak detection
2. First RF ball after warm-up on all ARCS
3. ARC Consolidation:
   - Possible endoscopies on dedicated area
   - Investigation ULO at 15R8
   - PIMS Exchange
4. Final RF ball test before cool down on all ARCS
5. End of LS2: All the ARCs & SMAs and IT pump down 6 weeks before the final cool down: Installation & dismounting + pinch-off of about 64 pumping group



QQBI.14L1.B2

SAMs

All checked by tomography



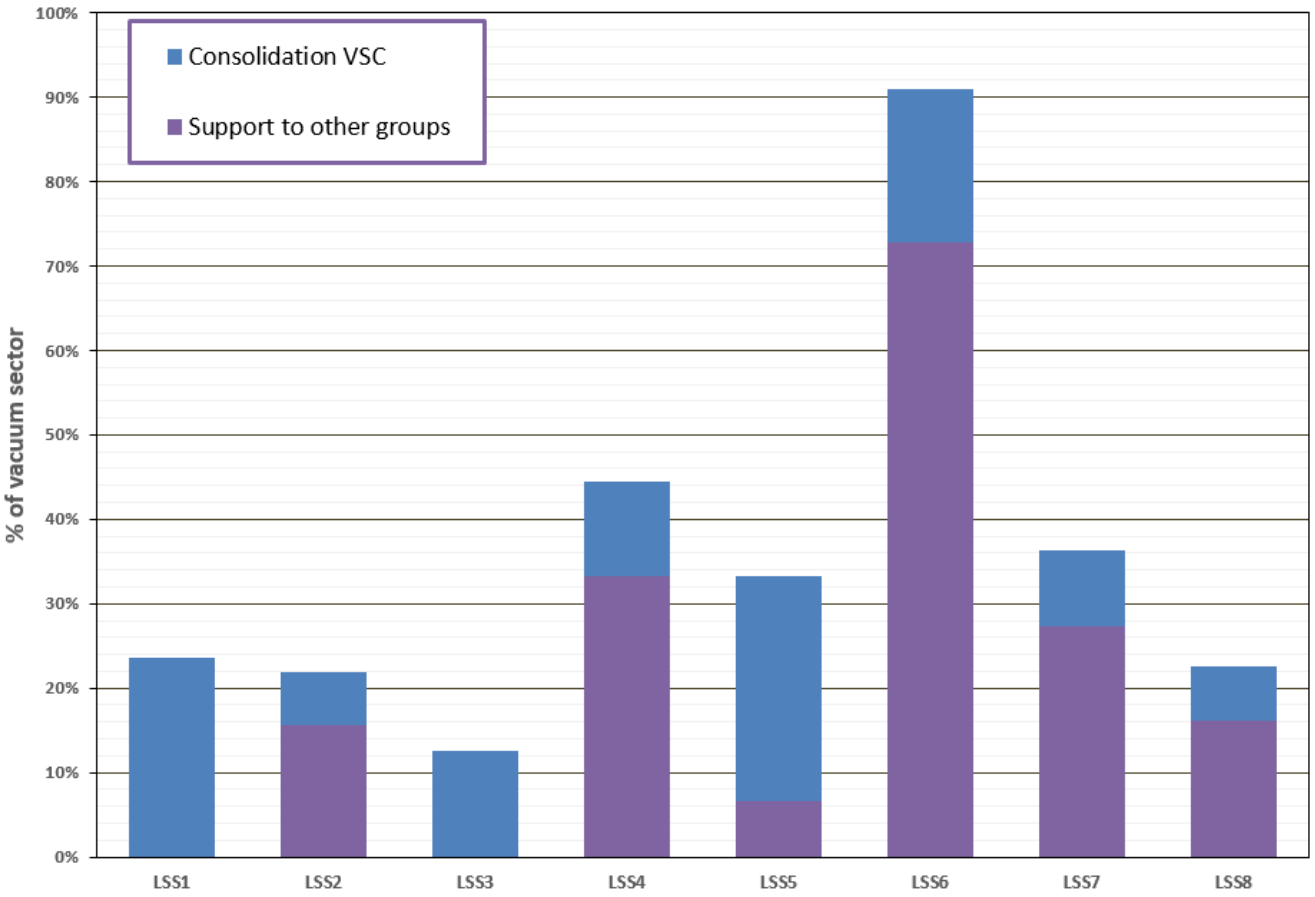
Deformed finger in QBUI.5L4

QQQI.2R5: Endoscopy

Inner Triplets

Checked by endoscopy

Activities up to now: LHC Beam vacuum



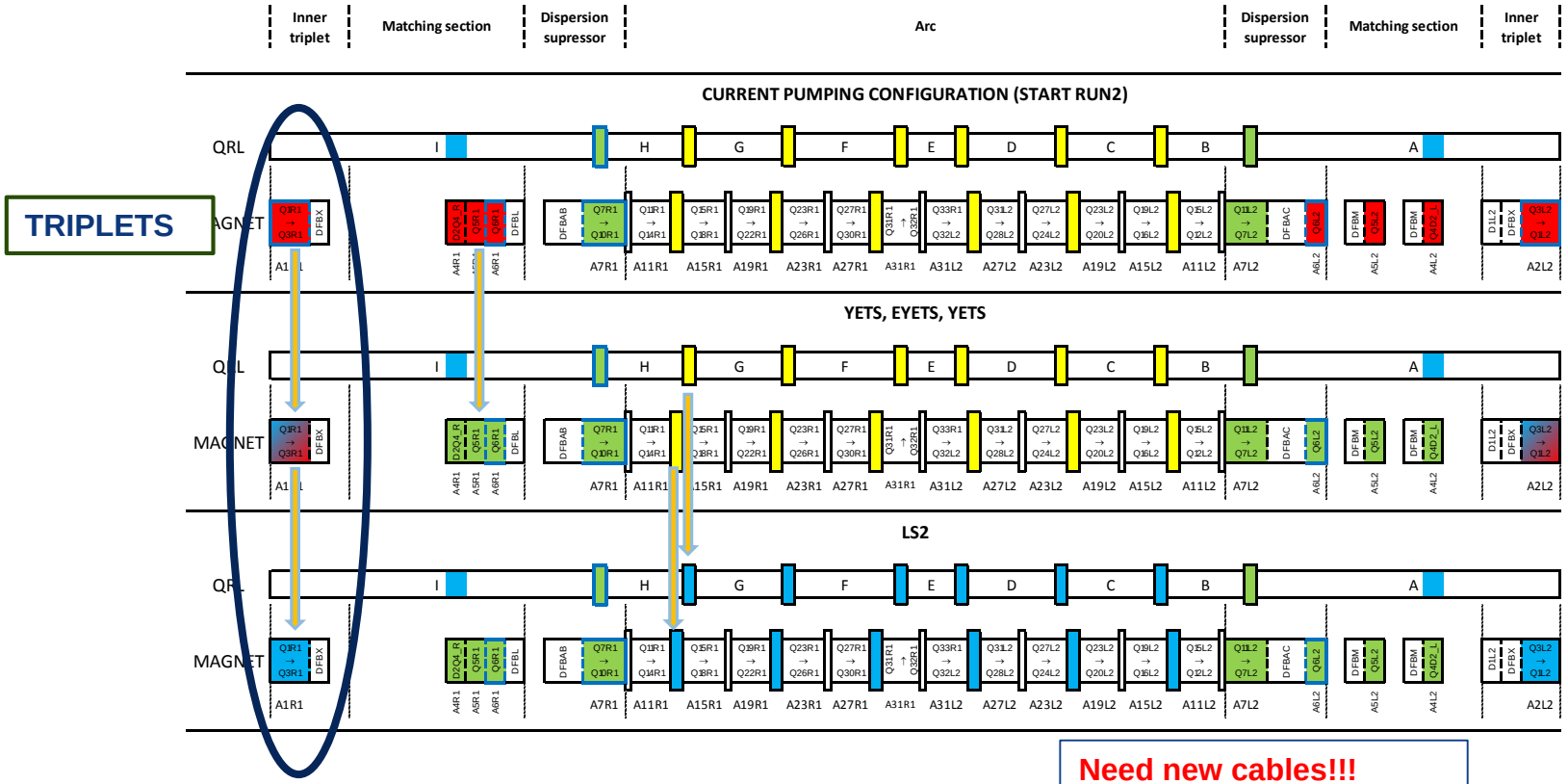
VSC Warm Module Consolidation: Considered 2 sectors for LSS

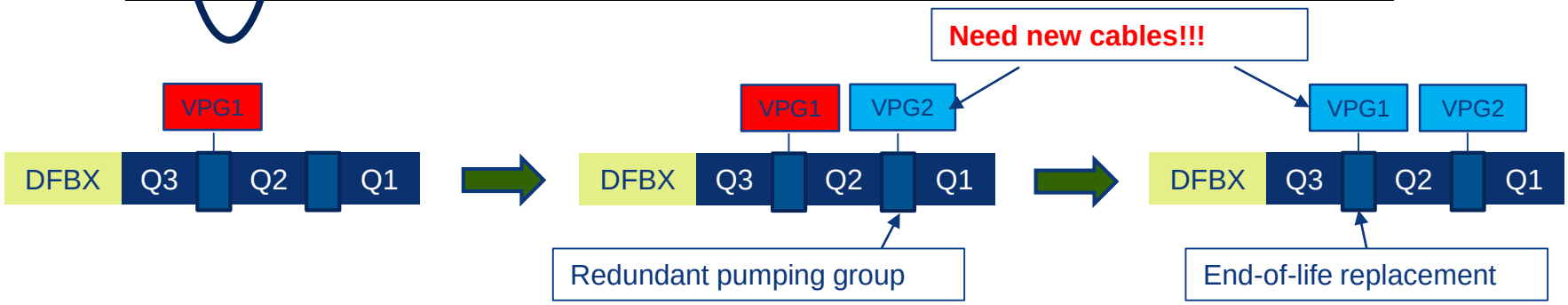
LHC Insulation vacuum

Insulation Vacuum: Consolidation

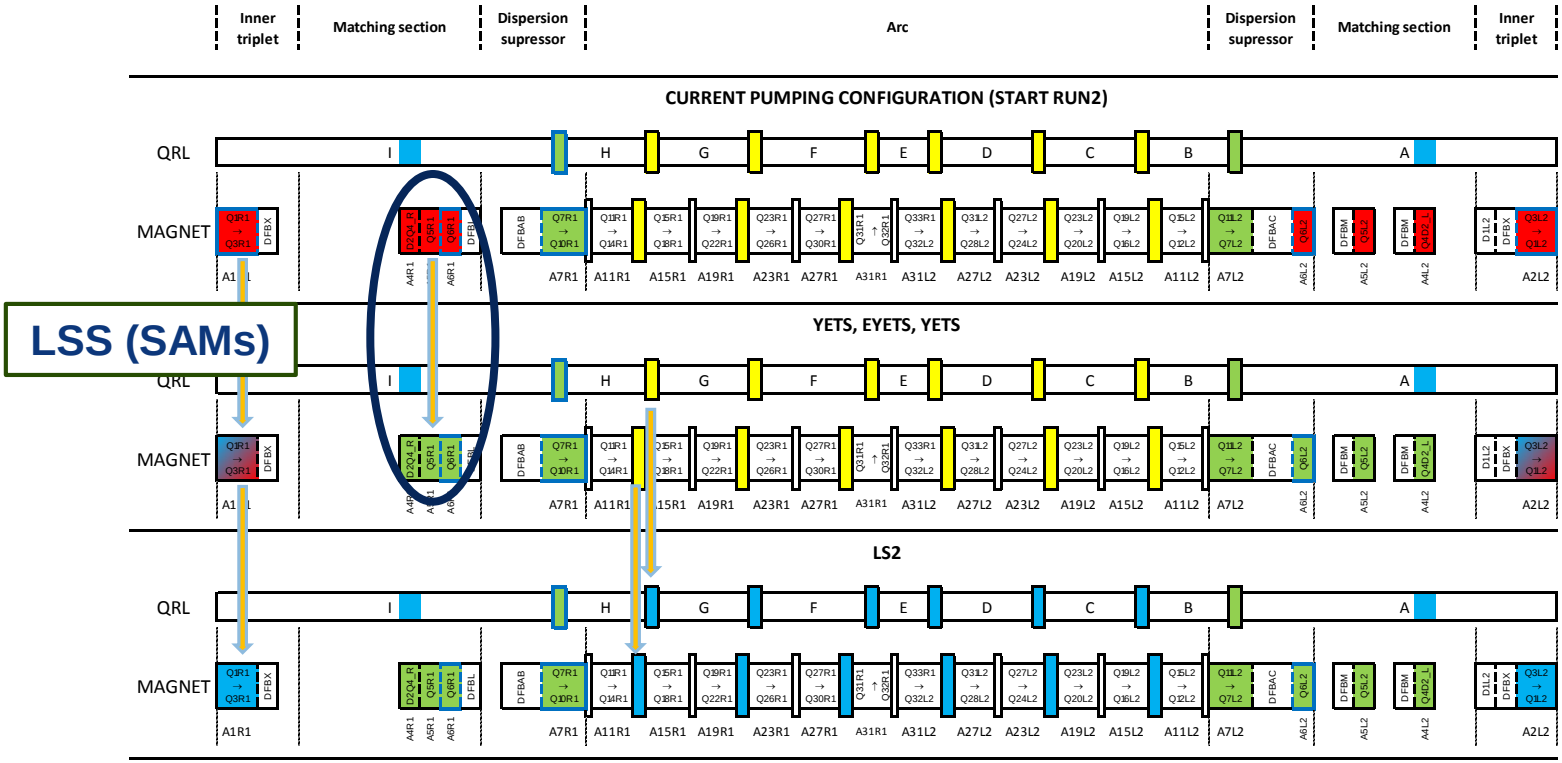
- Pumping groups
  - Fixed: Add pumping redundancy on triplets of points 1, 2 and 8 (6 units)
  - Mobile: migration towards dry pumping solution (no oil mist risk) in large capacity primary pumps (25 units) [**PRIOR TO LS2,** VSC workshop]
- Turbo pumps (fixed pumping groups)
  - End-of-life replacement of 96 units of the arcs (⇒ big cable pulling campaign)
  - End-of-life replacement of 50 units of the standalone magnets (SAM)
- Primary pumps:
  - End-of-life replacement of ~100 units of the SAMs and DS
- Known leaks:
  - Assessment and/or repair of 7 He leaks (2x ARC, 2x triplets, 2x DFBA, 1x QRL) with need of continuous turbo pumping + rest of minor He leaks [**LS2**]
  - Repair of air leaks [**LS2**]
- Others:
  - Add permanent scaffolding for 2 pump. groups at height (L2 and R8) [**LS2**]

Pumping Group Consolidation





Pumping Group Consolidation



Same cable configuration
NO need for cable pulling!!!

End-of-life replacement

Turbo controller <250m

VPG1

End-of-life replacement

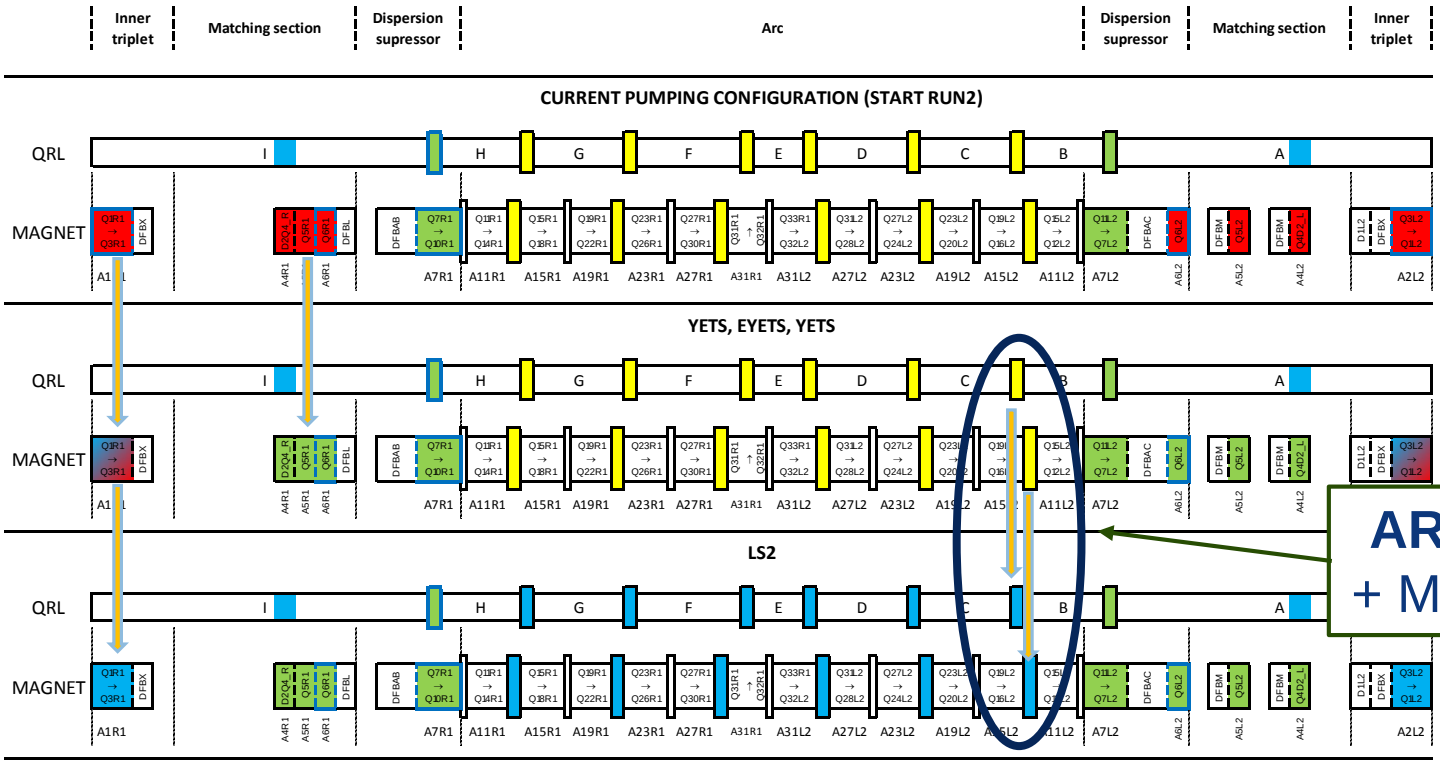
STANDALONE

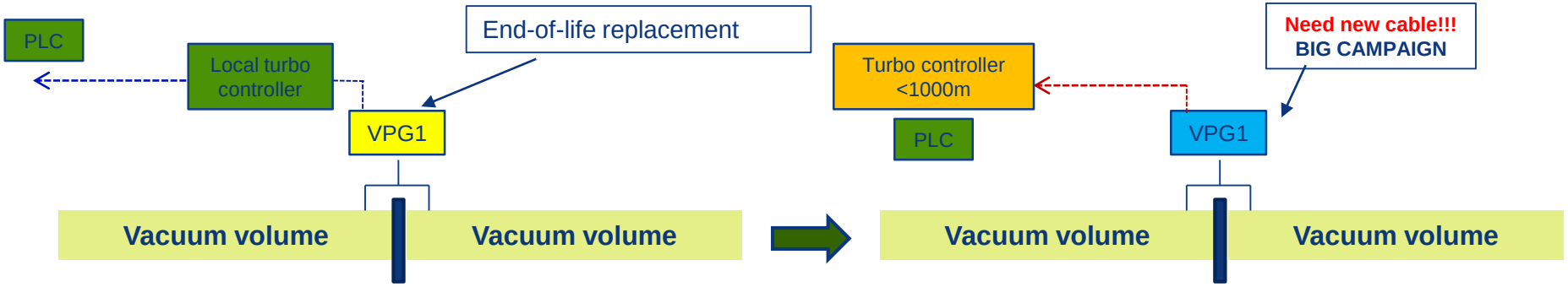
Turbo controller <250m

VPG1

STANDALONE

Pumping Group Consolidation





Insulation Vacuum: Maintenance

- Fixed pumping groups:
  - Maintenance campaign for turbo pumps:
    - YETS-EYETS: ~100 units (shared with TSs)
    - LS2: ~60 units
  - Complete maintenance for primary pumps (single stage pumps):
    - EYETS: ~80 units (VSC workshop) + ~120 units (in-situ)
    - LS2: ~140 units (in-situ)
- Mobile pumping groups:
  - Maintenance of turbomolecular pumping groups: 40 units
    - PRIOR TO LS2, 2015-2018: 10 units fully maintained (VSC workshop)
- Leak detectors (VSC workshop) [**PRIOR TO LS2 (2018)**]
- O-ring inspection campaign (e.g. triplets 2 & 8, isolation valves) [**LS2**]

Insulation Vacuum: Support & Operation

- Support
  - Leak test for special interventions (magnet replacement, DFBs, etc.):
    - Foreseen LS2:
      - Consolidation: ~15 magnets to be replaced + QRL bellows (?) + heat exchanger replacement on triplets pt. 1 & 5 (?)
      - HL-LHC: 11T dipoles @pt. 2 + 2x Q5 @pt. 6 + hollow lens + support for new cryo. RF pt. 4 (?)
      - Pre-assembly on surface (ex-situ) [**PRIOR TO LS2 (2015-2018)**]
      - Interconnection/new weld LT (clamshell) [**LS2**]
      - W LT (open interconnections) [**LS2**]
- Operation (warm-up/cool-down cycles)
  - Envelope/He circuit tightness before LS2 activities start (leak pre-loc. if necessary)
  - Venting
  - Envelope/He circuit tightness after LS2 activities finish: LT 1bar He + pressure test
  - Re-pumping

VSC-ICM: Controls Activities

Controls: Overall support and new equipment

- **Everywhere [(E)YETS, LS2]**
  - Support to all VSC activities for : disconnection / maintenance / reconnection / testing
  - Calibrations, alarm level settings, interlocks check
  - Investigate problems with noisy gauges and bad connections
  - Commissioning of acquisition and control chains, after interventions; Machine checkout

- **Linacs + PSB + PS + TLines**
  - New cables and controls HW & SW needed for
    - Consolidation of Pumping Groups and Ion Pumps
    - New layouts for connection of L4

- **SPS**
  - New cables and controls HW & SW needed for
    - Heavy modifications in layouts in LSS1, LSS3, LSS5, TI2, TI8
    - New crab cavities in LSS6
  - New ARC sectorization
    - Install & commission new controllers (cables already pulled)
  - Consolidation of ion pumps grounding

Controls: Overall support and new equipment

LHC EXPERIMENTS

- LHCb VELO: new vacuum controls
- CMS : new ion pumps

LHC BV

- New cables and controls HW & SW needed for
  - Several new instruments and heavy layout modifications
  - New dipole for DS in P2
  - New turbo pumps for MKB in P6

LHC IV

- Big cabling campaign and rack rearrangement
  - New pumping groups in ITs, SAM, ARCs

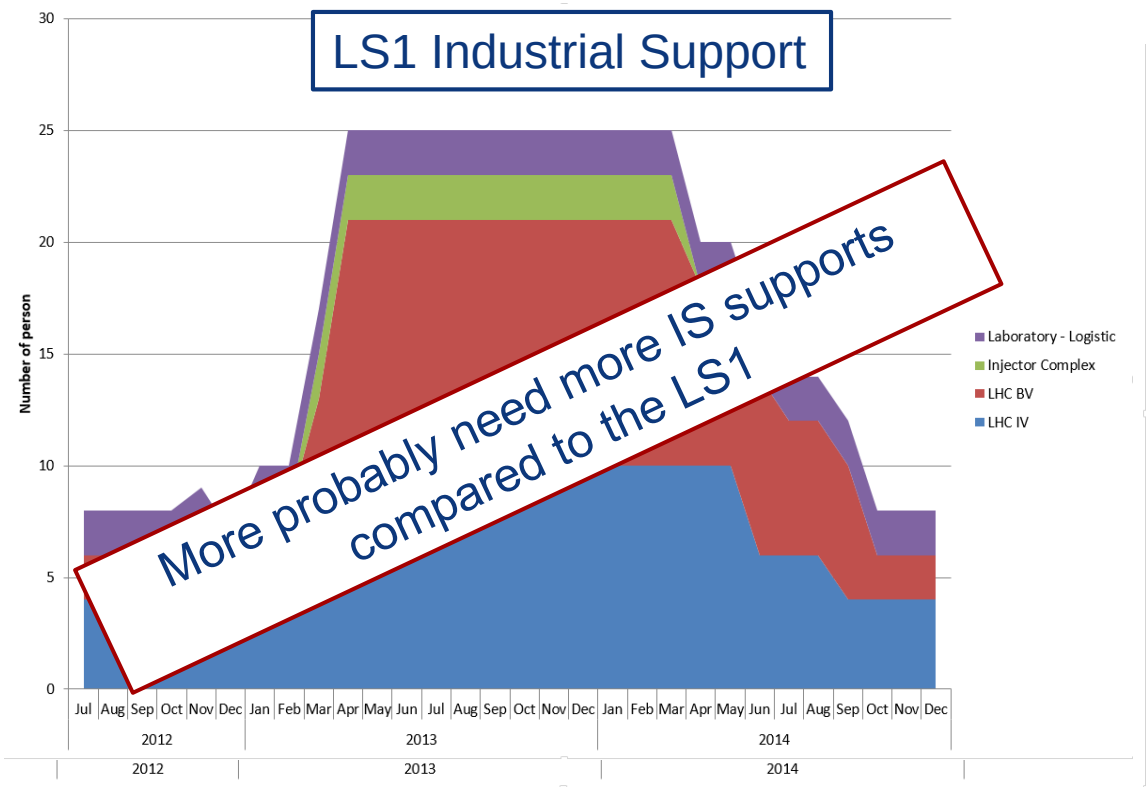
Controls: Consolidation

- **Controls SW framework: migration to UNICOS**
- Field bus for mobile equipment (Profinet / Ethernet / Wireless)
- Ion pump controllers (industrial design with fieldbus)
- Readout electronics for ARC gauges (rad-tol, 4-20mA)
- Master & Slave PLC (obsolescence)
- Pumping group controllers (for replacements and for new machines)
- North Area & East Hall controls ?
- Cables in high-radiation areas (IT, Collimators)
- Sector valves controllers (new CPS BIS; test mode of user-permit; implement fieldbus)

VSC Summary: Expected IS for LS2

LS2

More support for LIU

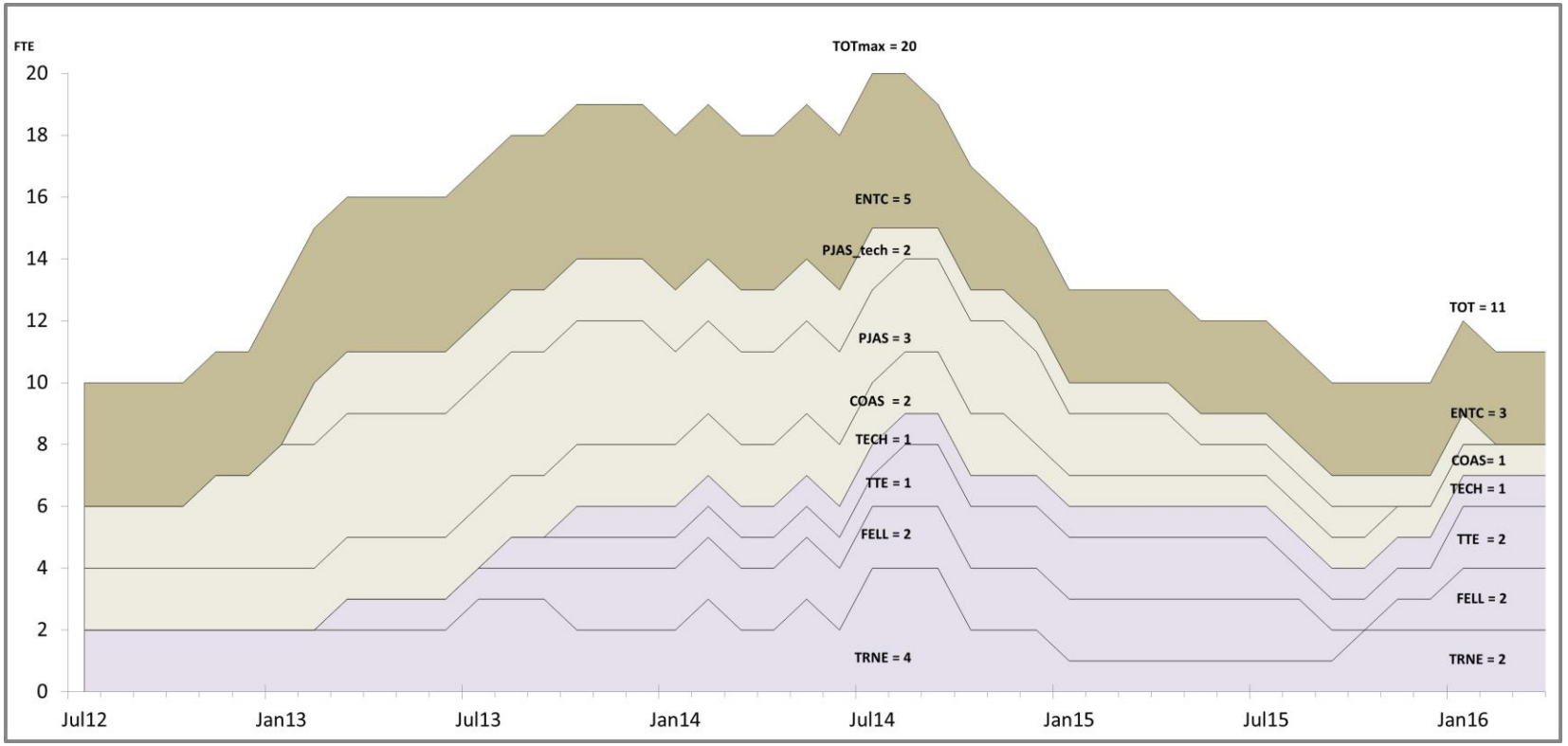


Same/More support for LHC

LS2

Controls summary: Expected IS for LS2

- **LS1** : 20 FTE (5 IS + 15 PJAS & FELL)
  - Most probably need quite more for LS2
  - Also some temporary reinforcement during (E)YETS



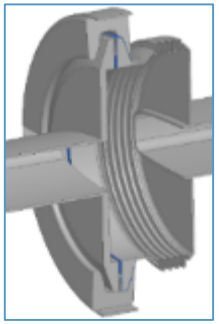
TE-VSC Summary

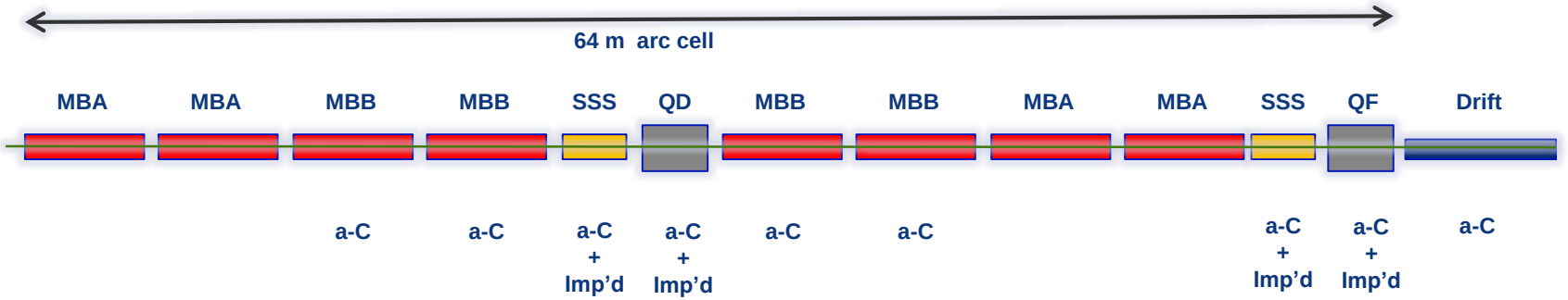
Important work load even bigger than the LS1

- **PS & SPS Complex**
  - Expected an important radiation dose: DIMR need to be well defined and must be respected.
  - Important to group all the activities at the same time on the same vacuum sector.
  - VSC-ICM Important activities connected with all new vacuum layout
- **LHC Beam vacuum**
  - Important activities with strong layout modification are cumulating.
  - Need a precise and well defined planning between all actors.
  - Need ECRs to be released asap to start procurements and productions and plan upgrade of the control system (ICM)
- **LHC Insulation Vacuum**
  - Important TMP consolidation and big cabling campaign and rack rearrangement (ICM).
  - Miscellaneous activities such as repairing ‘appearing’ He & air leaks.
  - Support for other groups

Thanks for your attention

Overview: a-C coating & impedance reduction in SPS





EYETS		Few cells		Up to 1 arc	10%
LS2		1 arc		5 arcs	90%
LS3		5 arcs			

Recommendation of LIU-SPS Scrubbing Review 8-9 September 2015