Insulation Vacuum Instrumentation Scheme, System Tests and Commissioning

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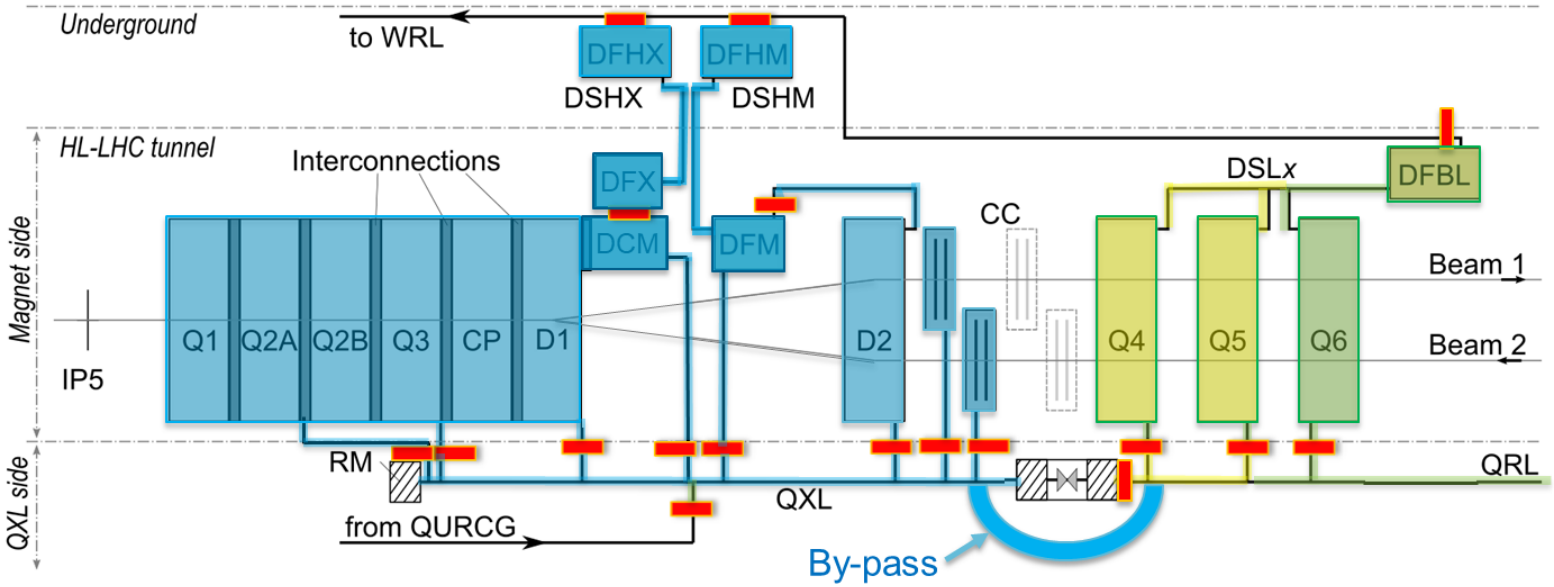
HL-LHC Magnet Circuit Instrumentation Day 2023 20/06/2023

Outline

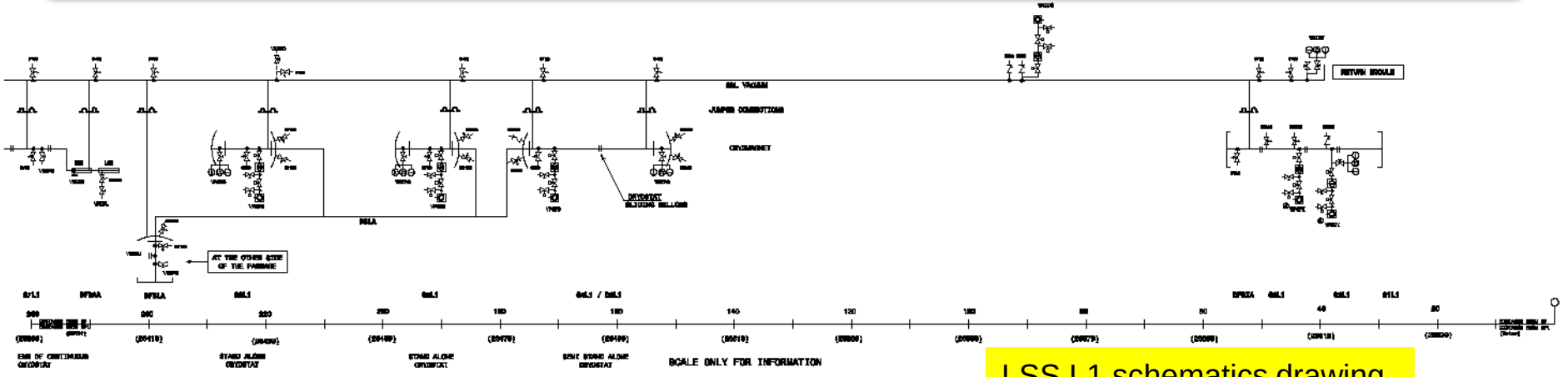
- HL-LHC insulation vacuum scope;
- Overview of the insulation vacuum and its instrumentation layout;
- Variations of the HL-LHC IT String with respect to the tunnel baseline;
- Installation, testing and commissioning;
- Interlocking methods and communication with other systems.

HL-LHC insulation vacuum



LHC insulation vacuum instrumentation (LSS L1 schematics example)

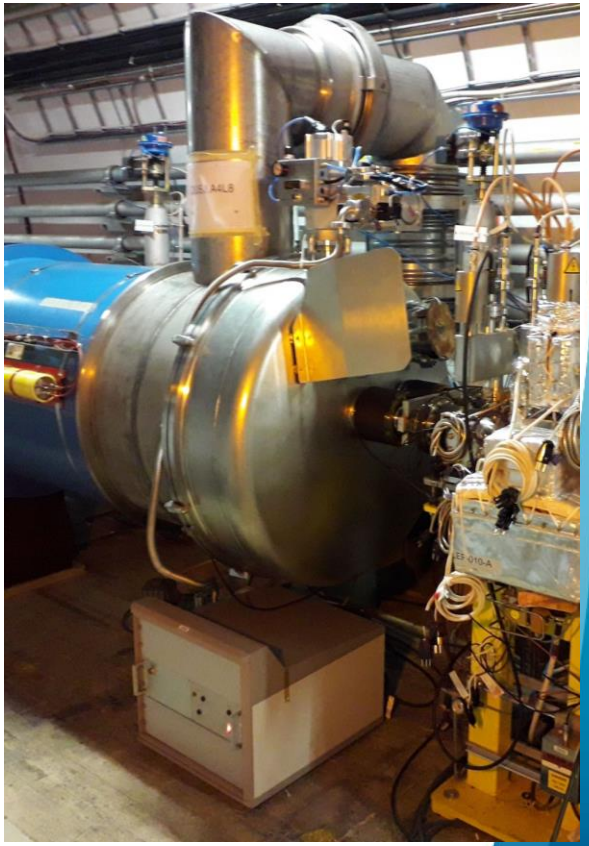
- He relief devices → no controls and no services required
- Pump-out ports → no fix controls, but general compressed air, power supply and Profibus connection are required
  - Controls integrated in the mobile pumping groups
- Pumping groups and gauges → controls and services (compressed air and power supply non-operational functionalities) are required in the machine

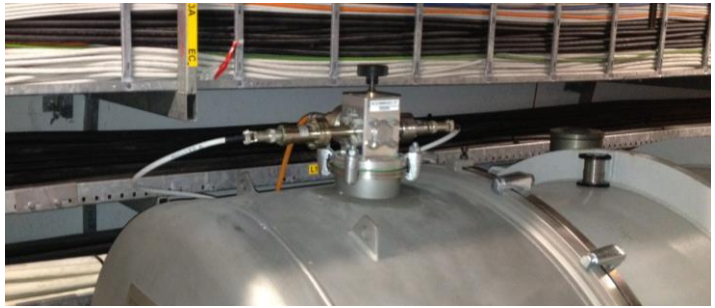


LSS L1 schematics drawing

Pumping groups and gauge groupings

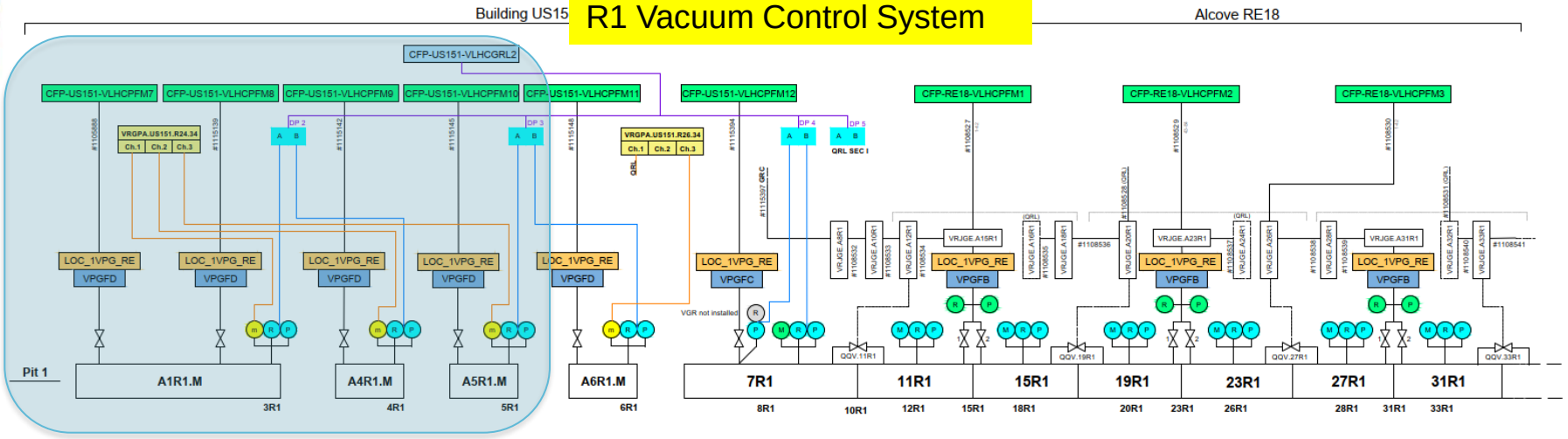
- Pumping groups: valves + primary pump + turbo pump + fittings and vacuum connections
  - No active electronics present in the vicinity of the pumping groups;
  - Turbo controller deported to non-irradiated areas ⇒ long cable pulling required;
  - Crate available for local operation (close to pumping group);
- Gauge groupings: isolation valve + Penning gauge (E-07 - E-02 mbar) + Pirani gauge (E-02 - 1 mbar) + piezo-resistive gauge (1 - 2000 mbar)
  - No active electronics present in the vicinity of the gauges;
  - Gauge controllers installed in non-irradiated areas.





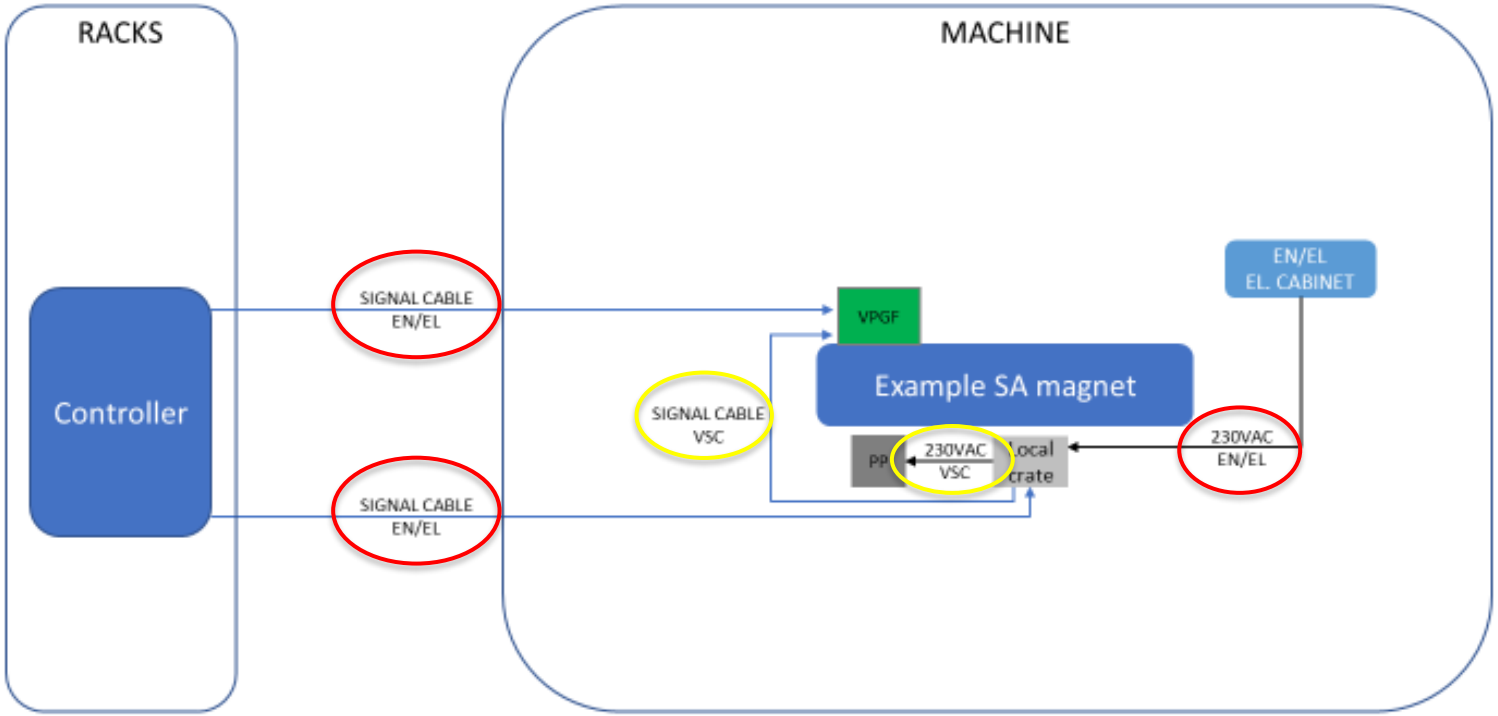
Vacuum Control System schematics

Schematics of LHC Magnets
R1 Vacuum Control System

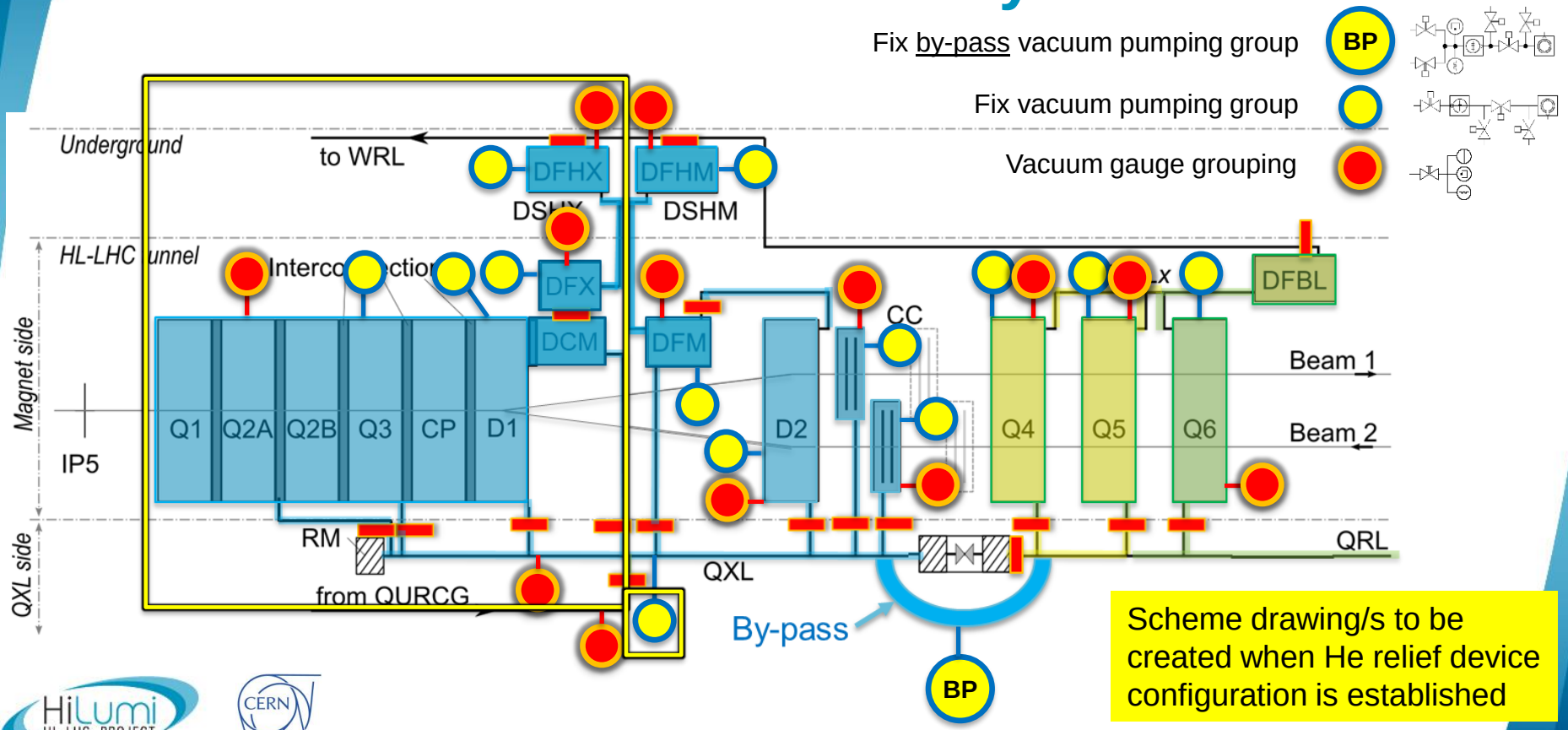


To be updated for HL-LHC, following same approach as in LHC

IV pumping group control architecture



Overview of the insulation vacuum and its instrumentation layout



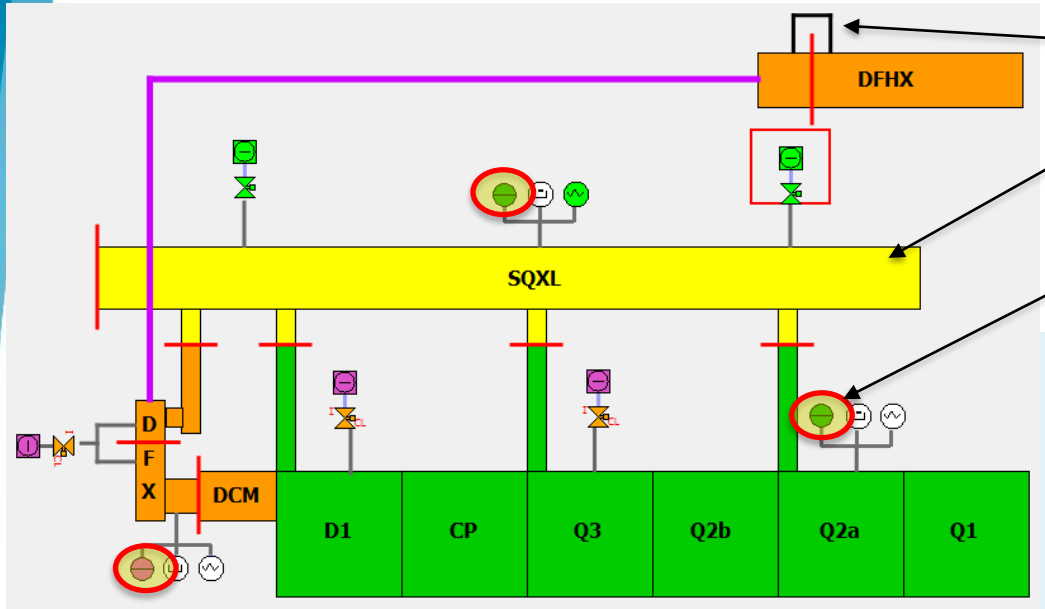
Scheme drawing/s to be created when He relief device configuration is established

LHC vs HL-LHC

LHC		VACUUM BARRIER (*)	PUMPING GROUP (**)	GAUGE GROUPING	SAFETY VALVES
Q1	A1xx.M				FP200
Q2			1	1	SV200
Q3			1		SV200
DFX		1			SV65
D2	A4xx.M	1			2xSV160
Q4		1	1	1	SV160+FP160+SV90
Q5	A5xx.M	1	1	1	2xSV160+SV90
Q6	A6xx.M	1	1	1	2xSV160+SV90
DFBL		1	1		SV200+SV100
	Ixx.Q	1	2	1	9xSV90
			2		2xFP100
		7	7 + 3	5	24xSV + 4xFP

HL-LHC		VACUUM BARRIER (*)	PUMPING GROUP (**)	GAUGE GROUPING	SAFETY VALVES
Q1	A1xx.M		1		FP200
Q2A			1	1	SV200
Q2B		1	1		SV200
Q3			1		SV200
CP		1	1		SV200
D1		1	1		SV200
DCM		1	1		SV200
DFX	Ayy.D	1 + 1 + 1	1 + 1	1	FP200
DSLx+DFHX	Byy.D	1	1 + 1	1	4xSV90
DSLx+DFHM	Cyy.D	1	1 + 1	1	4xSV90
DFM	Dyy.D	1 + 1 + 1	1 + 1	1	FP200
D2	A4xx.M	1	1	1	SV200
CC#1	A.??xx.A	1	1 + 1	1	FP160
CC#2	B.??xx.A	1	1 + 1	1	FP160
Q4	B4xx.M	1	1	1	SV160+FP160+SV90
Q5	A5xx.M	1	1	1	2xSV160+SV90
Q6	A6xx.M	1	1	1	2xSV160+SV90
DFBL+DSLx		1	1		SV200+SV100
QRL	Ixx.Q	1	2*	1	6xSV90
			1		2xFP100
QXL	Jxx.Q	1	1*	1	8xSV90
			2		2xFP100
	Kxx.Q			1 (TBC)	
		2 + 5 + 13	15 + 15	14	~ 39xSV + 8xFP

HL-LHC IT String vs tunnel baseline

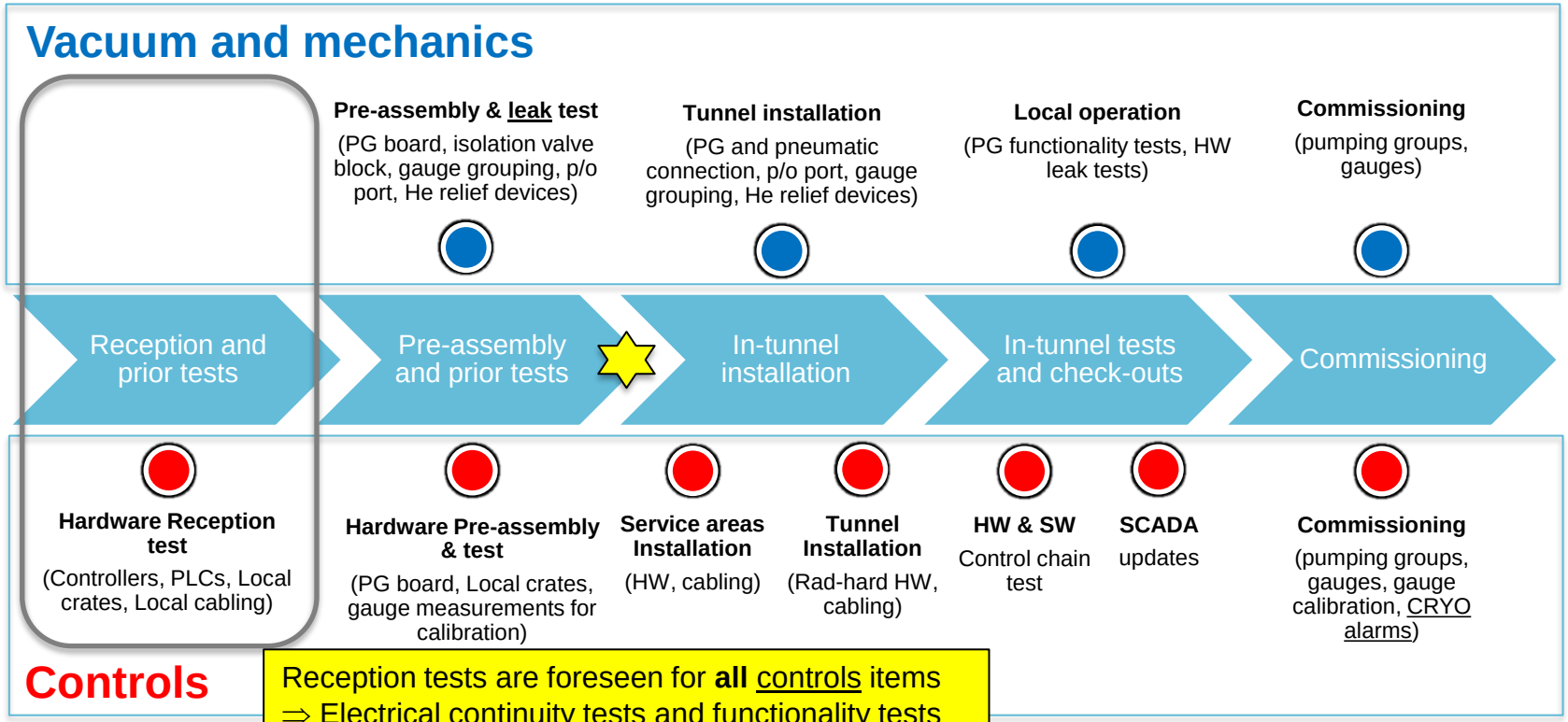


3x DIFFERENCES:

- integration of a turbo mobile pumping group instead of a fix turbo pumping group at DFHX;
- adaptation to dedicated SQXL (2x SA PGs instead of 1x SA + 1x by-pass);
- combination of existing LHC type passive piezo gauge with new type passive piezo gauge (under test and qualification);

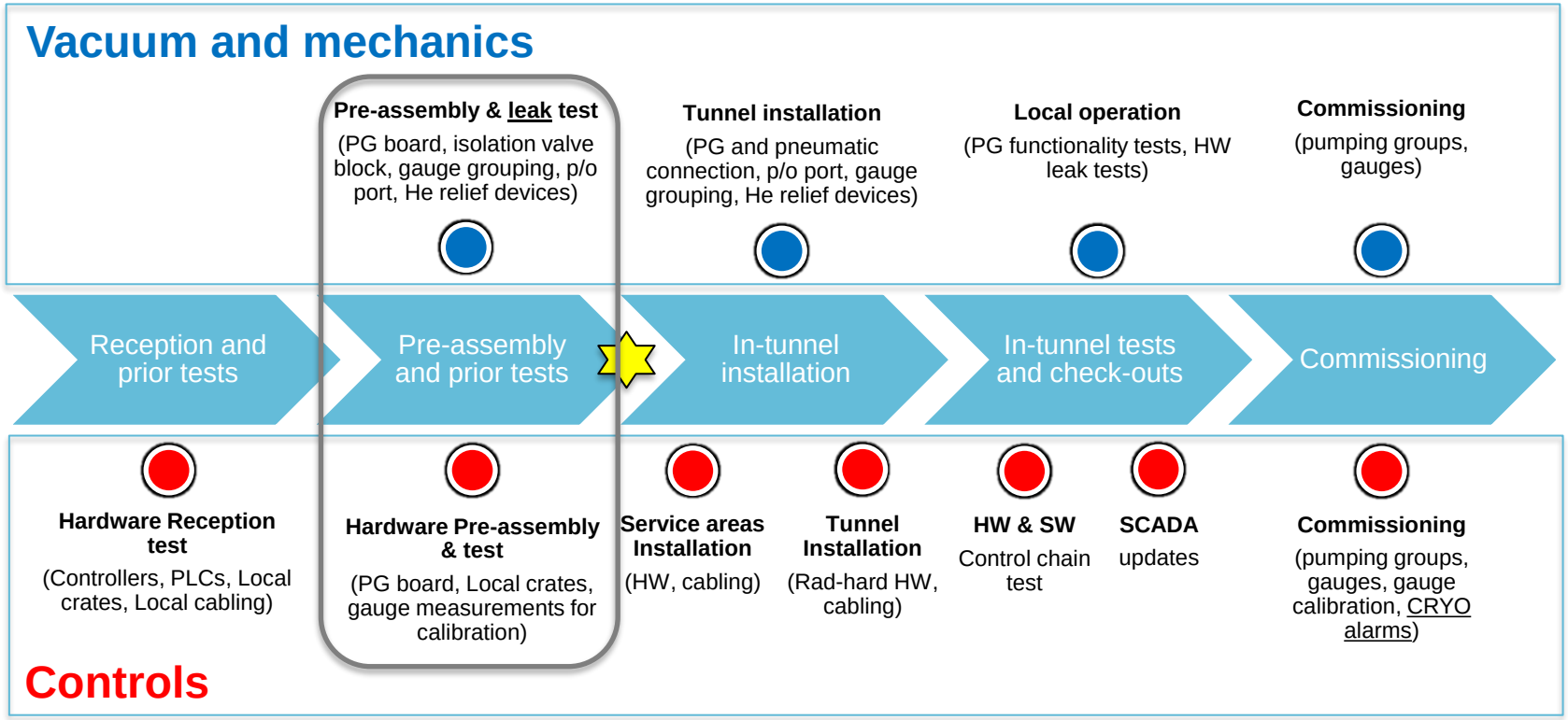
- Dedicated SCADA synoptic for IT string insulation vacuum monitoring and operation
- Turbo mobile pumping group to be visible and operational through SCADA, via Profibus connection
- Integration of new type passive piezo gauge will be possible when solution is qualified; solution is compatible with current controller and cabling infrastructure

Installations, testing and commissioning roadmap

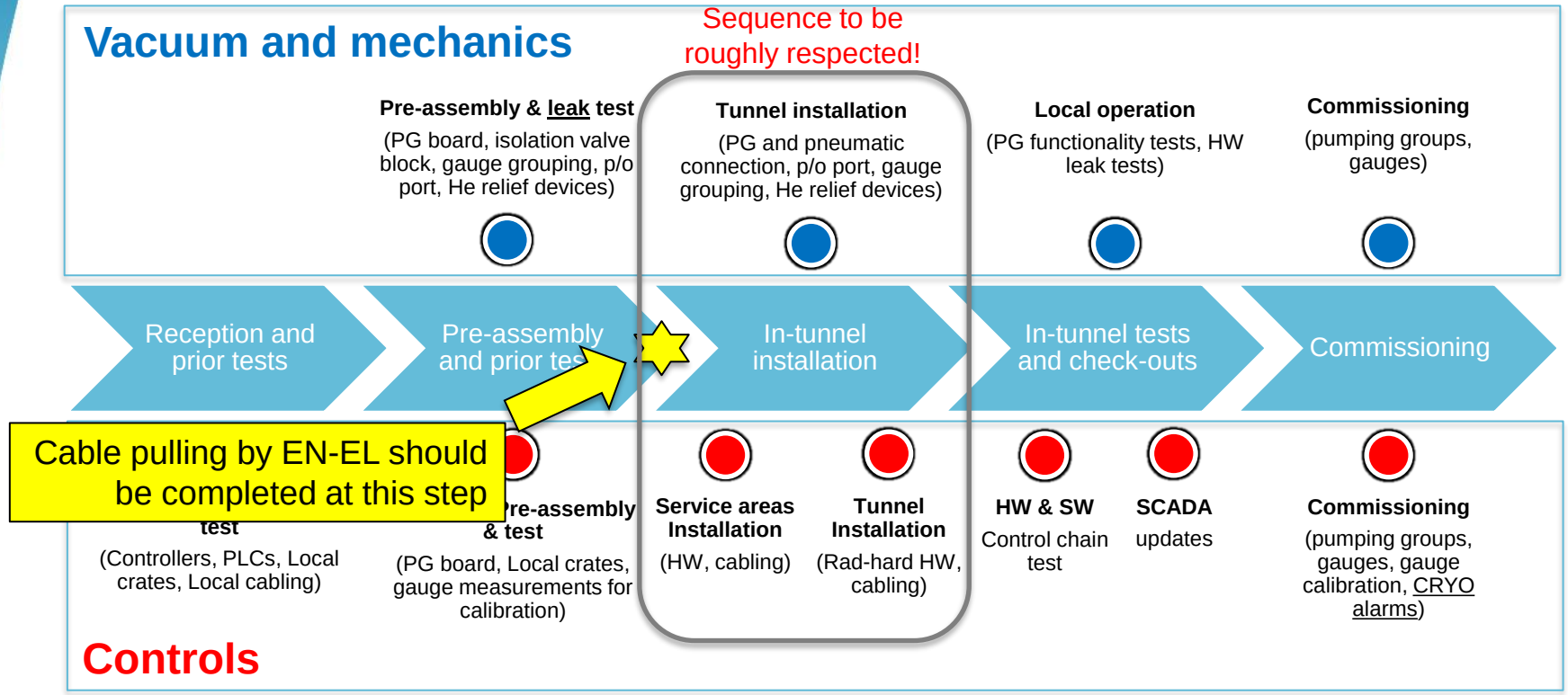


Reception tests are foreseen for **all** controls items
⇒ Electrical continuity tests and functionality tests according to pre-defined procedures

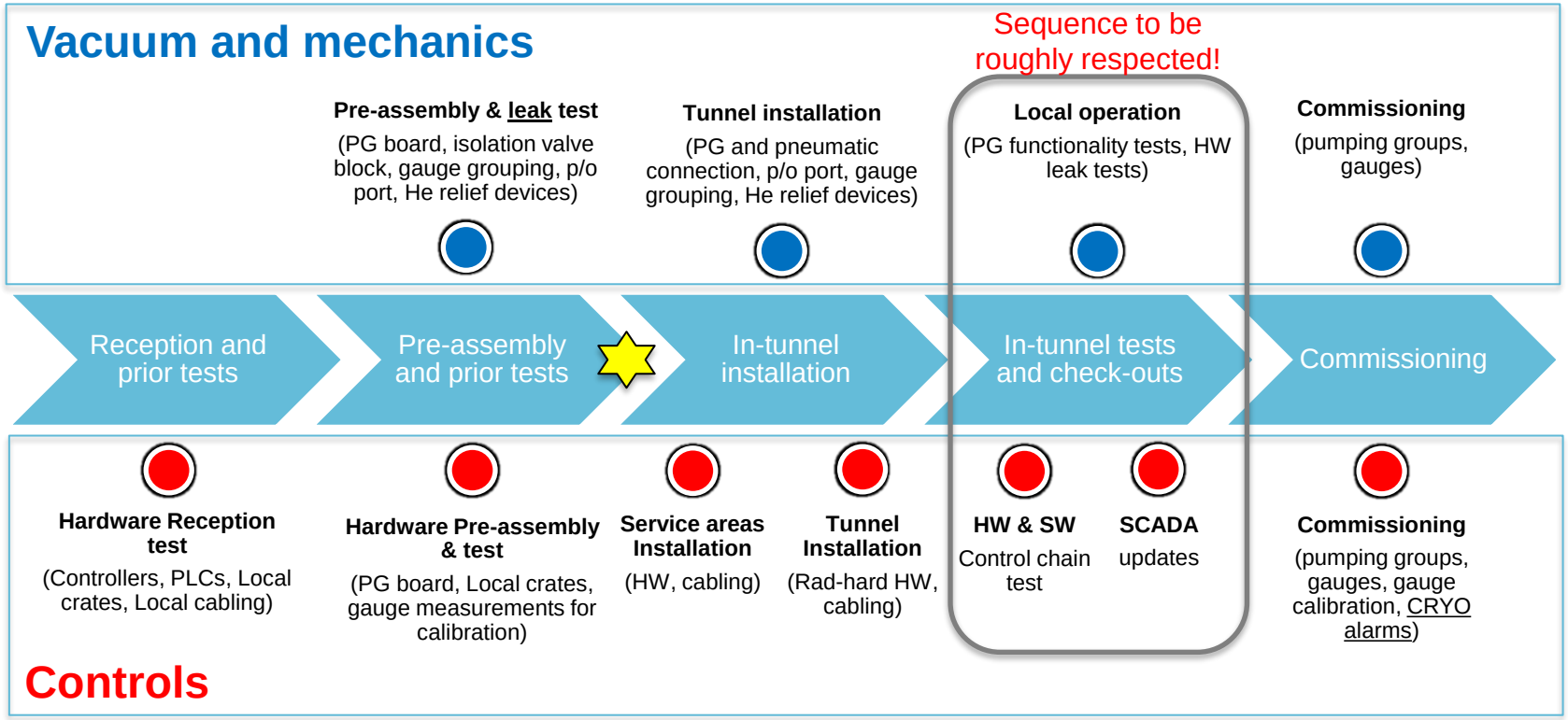
Installations, testing and commissioning roadmap



Installations, testing and commissioning roadmap



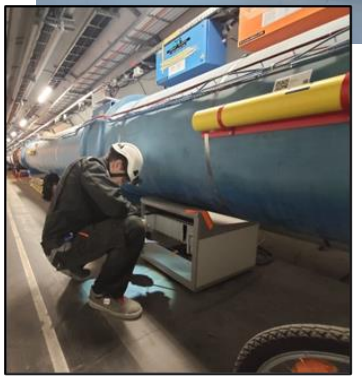
Installations, testing and commissioning roadmap

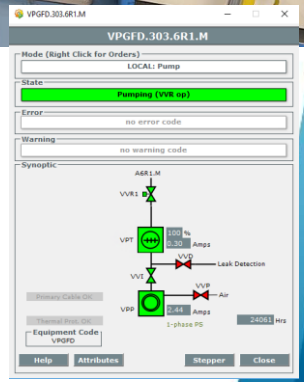


System tests – local operation

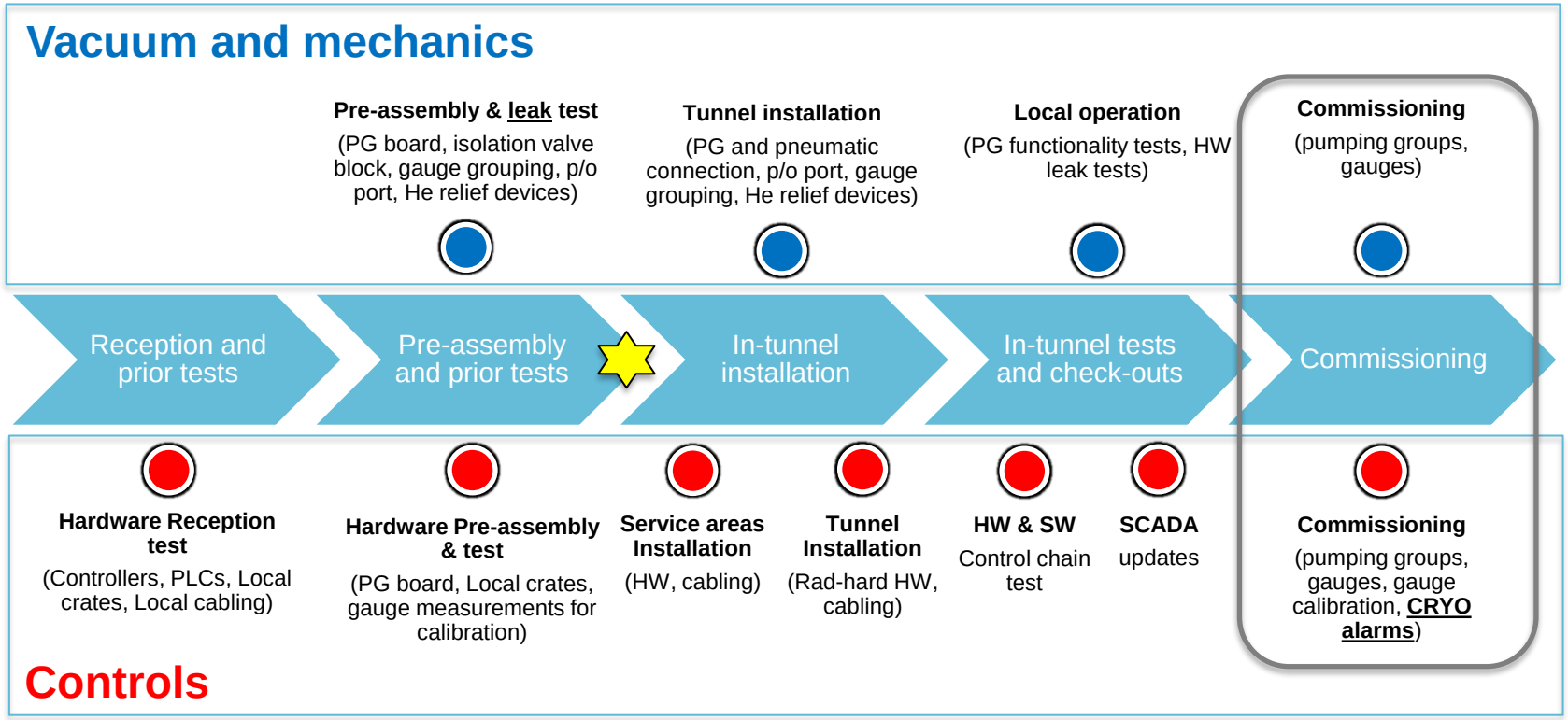
- Vacuum and mechanics
  - Functionality cross-checked through pump-out and leak detection activities → Pumping group commissioning at local
- Controls
  - Control chain test, including cabling pulled by EN-EL
  - Updating of VacDB and SCADA → extraction and synchronization from the official Layout DB (that should be ready at this step);
    - Check-out widgets and visibility
  - *Calibration of Pirani and piezo-resistive gauges at local → <u>to be made under vacuum!</u>*

Functionality cross-check through leak detection at IT String SQXL





Installations, testing and commissioning roadmap



Interlocking methods and communication with other systems

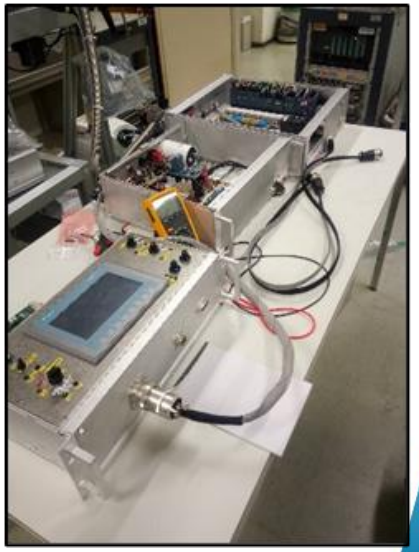
- IV gauges do not interlock IV pumping groups or any other vacuum instrumentation
  - Pumping group control system optimized to react against IV degradation
- Alarm signals are sent to CRG control system to protect cryomodules against IV degradation or loss
  - 2x types of vacuum gauges are used for the alarms: Pirani and piezo resistive gauges;
  - 2x types of alarms are provided depending on the pressure measurement and logics (VAC_OK and VAC_NLOST);
  - gauge signals are acquired by vacuum PLCs located in service areas;
  - vacuum PLCs provide normally open (NO) contacts to the cryogenics PLCs, which can be actuated according to the pressure thresholds given by:
    - Pirani and piezo resistive gauges installed on the magnets and QRL lines;
    - Pirani gauges installed on the RF cavities (pt. 4);
  - the contacts are connected through local cables to cryogenics PLCs
- **Cryo alarms validation (EDMS #2378513) is a mandatory step to give the related cool-down permit (Operational Safety Procedure as per EDMS #1378499)**
  - Same approach is retained for HL-LHC machine (TBC)
    - BE-RF has requested to supply piezo resistive gauges ⇒ Crab cavities to use same approach as magnets and QRL/QXL lines (TBC)
- **Same logics has been agreed with CRG for the IT String**

Thanks for your attention.

Spare slides

Reception and prior tests

- No reception tests are foreseen for vacuum and mechanics → necessary check-outs are made during pre-assembly and/or in-tunnel testing steps
  - All pre-assembly and/or in-tunnel testing procedures are well established and reliable;
  - All key suppliers are known and considered to be highly reliable;
  - In case of failure or malfunctioning, the systems are conceived to make easy and quick replacements.
- Reception tests are foreseen for all controls items
  - Electrical continuity tests and functionality tests according to pre-defined procedures.



Pre-assembly and prior tests

- Vacuum and mechanics
  - Leak tests of pre-assemblies (turbo pump blocks) and p/o ports are foreseen;
  - Functionality tests of isolation valves are foreseen to prevent venting during first in-tunnel tests;
  - Magnetic and functionality tests of p/o ports are foreseen;
  - Assembly and test of pumping group connection board
- Controls
  - Measurement of offset and gain to be done for each individual new type passive piezo-resistive gauge;
  - Assembly and test of pumping group connection board.