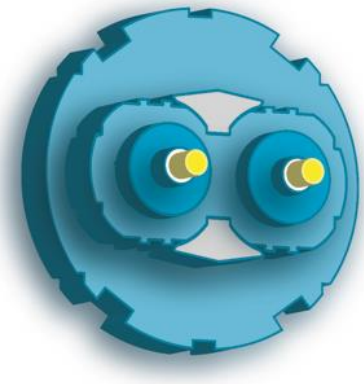


High Luminosity LHC

TEST PLANS and HL LHC IT STRING

M Bajko

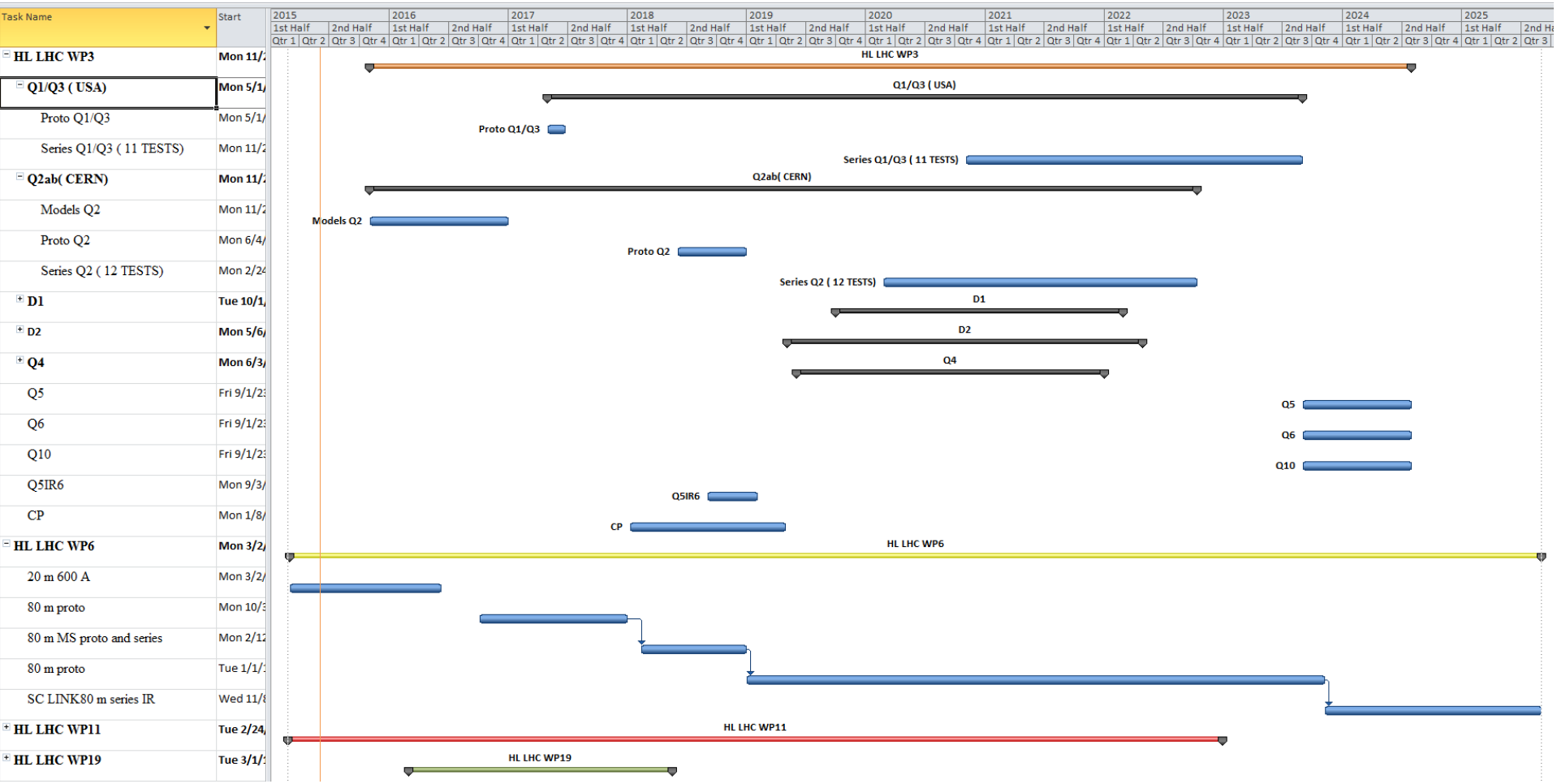
for the TC of HL LHC the 4th of June 2015

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

SUMMARY

- HL LHC Magnets TEST PLAN
  - TIMELINE
  - PERFORMANCE
  - TEST PLAN. Distribution over the next years
- IT STRING for HL LHC
  - SCOPE
  - MANDATE
- Short term actions
- CONCLUSIONS

TIMELINE for the different test for HL LHC magnets



From these it was defined the test stand readiness requirements (see the presentation of Volker)

How this TIMELINE is made?

Every single magnet test is part of the **GLOBAL HL LHC** planning set up for the C&S Review and most of the cases is linked to the fabrication of the magnets.

ID	% Comp	Task Name	Duration	Start	Finish	Predecessors	WP
1	0%	**HL LHC**	**3500 days?**	**Mon 1/2/12**	**Fri 10/31/25**		
43	0%	**WP3: Magnets for insertion regions**	**3293 days**	**Mon 1/2/12**	**Wed 1/15/25**		**WP3**
498	0%	**Cold testing**	**2332 days**	**Mon 8/18/14**	**Wed 12/11/24**		**WP3**
504	0%	**Cryoassemby LQXFA Q1 (4 unit**	**2114 days**	**Mon 8/18/14**	**Fri 2/9/24**		**WP3**
505	0%	**Proto Q1/Q3**	**30 days**	**Mon 8/18/14**	**Fri 9/26/14**		**WP3**
506	0%	Installation	1 wk	Thu 6/1/17	Wed 6/7/17		WP3
507	0%	Cooling	1 wk	Thu 6/8/17	Wed 6/14/17	506	WP3
508	0%	Testing	2 wks	Thu 6/15/17	Wed 6/28/17	507	WP3
511	0%	Warming	1 wk	Thu 6/29/17	Wed 7/5/17	508	WP3
512	0%	Disconnecting	1 wk	Thu 7/6/17	Wed 7/12/17	511	WP3
513	0%	**Unit 1**	**35 days**	**Mon 6/28/21**	**Fri 8/13/21**		**WP3**
514	0%	Installation	1 wk	Mon 6/28/21	Fri 7/2/21	418FS+15 da	WP3
515	0%	Cooling	1 wk	Mon 7/5/21	Fri 7/9/21	514	WP3
516	0%	Testing	1 wk	Mon 7/12/21	Fri 7/16/21	515	WP3
517	0%	TC	1 wk	Mon 7/19/21	Fri 7/23/21	516	WP3
518	0%	Testing	1 wk	Mon 7/26/21	Fri 7/30/21	517	WP3
519	0%	Warming	1 wk	Mon 8/2/21	Fri 8/6/21	518	WP3
520	0%	Disconnecting	1 wk	Mon 8/9/21	Fri 8/13/21	519	WP3
521	0%	**Unit 2**	**35 days**	**Mon 12/6/21**	**Mon 3/14/22**		**WP3**
522	0%	Installation	1 wk	Mon 12/6/21	Fri 12/10/21	419FS+15 da	WP3

It is designated to a test bench and we take as resources:

1. Cryogenic cooling
2. Electrical powering

Those are **services** which are **shared** between benches and users

Typical test is over **7 weeks** and systematically includes a **thermal cycle** (TC) unless is produced in the USA and tested before sent to CERN. In that case no TC is considered so a total of 5 weeks for series and 6weeks for prototypes.

PERFORMANCE TEST CAPACITY estimated to :

20 quench /magnet

+ Corrector test, Splice resistance, Magnetic measurement, High Voltage test

From these It was defined the nr of test stands and integrated service (demineralised water, cryogenic, electricity ect) capacity and availability for a given period. See presentation of Volker

PERFORMANCE test

+ magnet dimension

During the **TRAINING** I_{accept} SHOULD be attained and kept for **3h CONTINOUSE** powering without quench

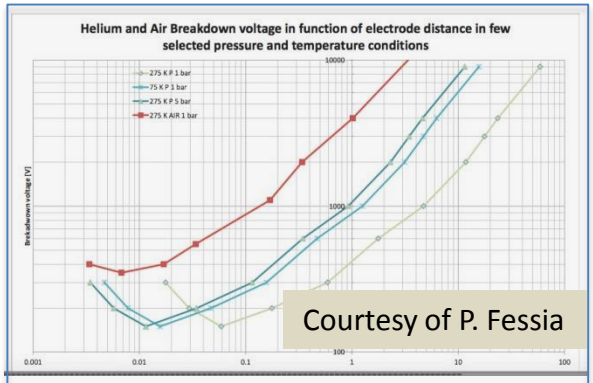
After Thermal Cycle to RT **MEMORY** should be proven by 2nd quench > I nominal

No CRITERIA is defined for the :

a. level of the **FIRST QUENCH**

b. **NUMBER of QUENCHES** to I_{accept}

It is too EARLY for this… but we will be able to do **20 quenches/test**

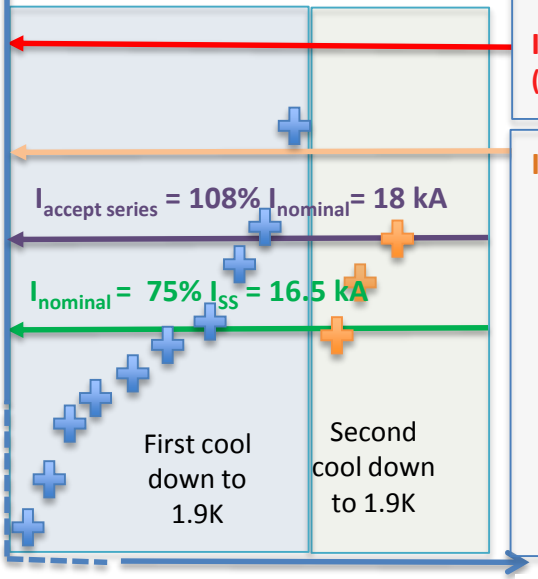


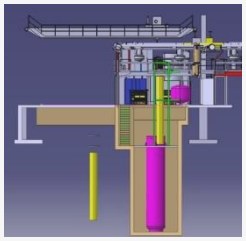
Courtesy of P. Fessia

ELECTRICAL INTEGRITY

$U_{acceptance} = 2 \times U_{max} + 500$

and this is in aprox. **3 kV in He**



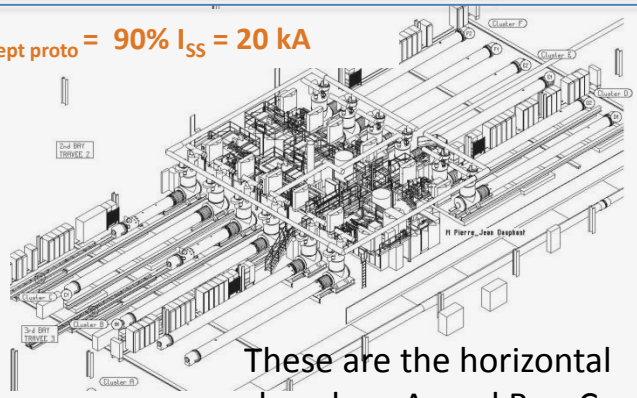


This is the Cluster D vertical test stand for model magnet test

I_{SS} = 22 kA
(we wish this for the model)

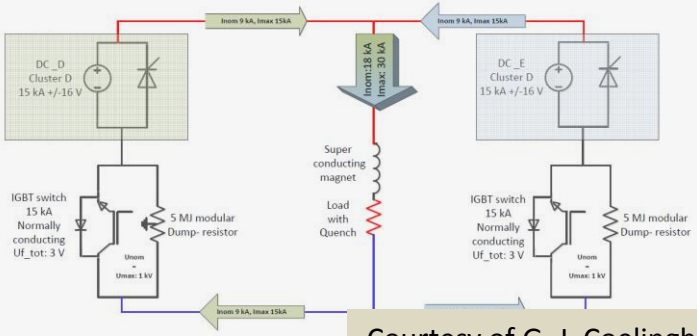
Courtesy of P. Perret

$I_{accept\ proto}$ = 90% I_{SS} = 20 kA



These are the horizontal benches: A, and B or C

PROTECTION is with **EE**, time reaction in the 2-3 ms range, with **dump resistor** of 50-300 mOHM



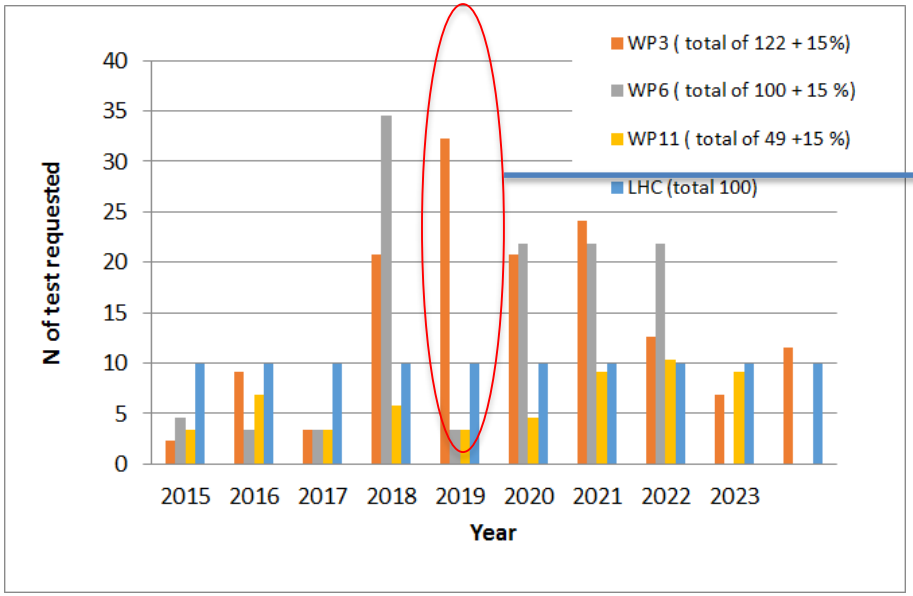
Courtesy of G. J. Coelingh

From these it was defined the test stand specification. See the presentation of Volker.

High Luminosity LHC

TEST distribution over the years. Alternative solutions.

We build a test station for all type of magnets, but some of them will be tested elsewhere….

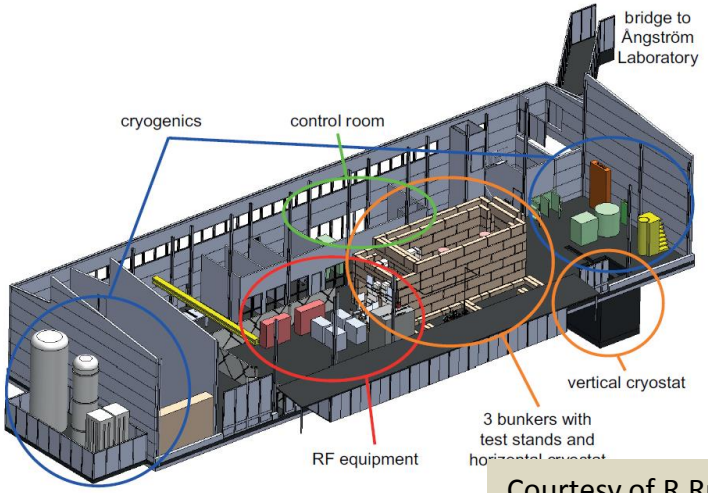


15 % of re-test has been included into the cost and schedule

This peak is due to the high number of orbit correctors

Ex. Alternative option under study for test

50% @ CERN and 50% in Uppsala



Courtesy of R.Ruben

Figure 1: Layout of the FREIA Laboratory.

IT STRING SCOPE

Mandate of the coordinator to the HL-LHC Inner Triplet String test

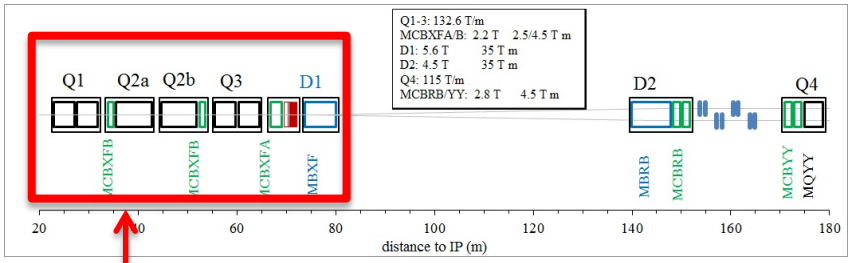
(Mr/Ms IT string)

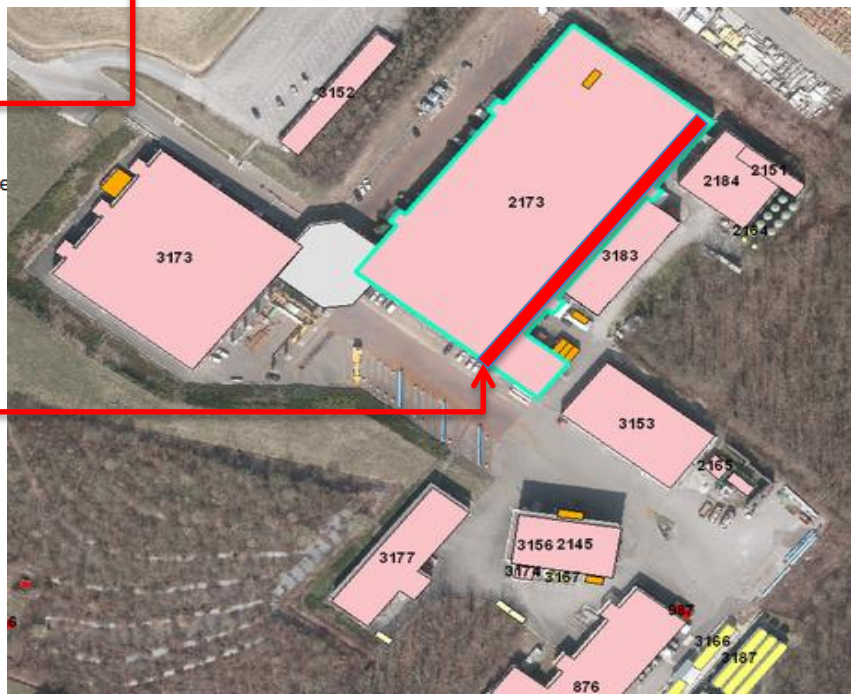
In the HL-LHC configuration, the Inner Triplet (IT) region of IR1 and IR5 will be heavily modified. In particular the Q1-Q2-Q3-D1 magnets will be completely different from the present LHC magnets, all based on new technology:

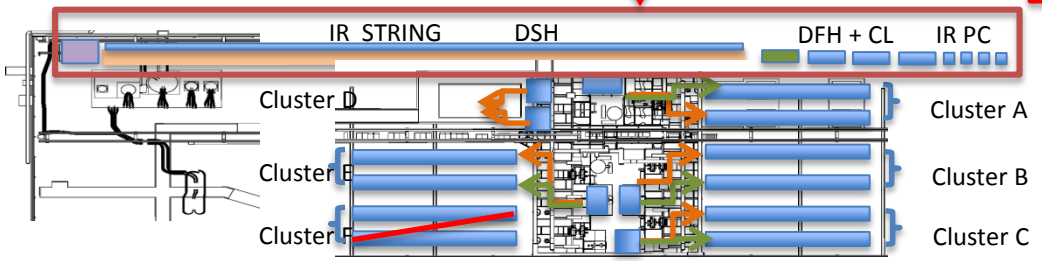
- Superconductor for D1 (present D1 is normal conducting)
- Nb_3Sn technology for the IT quadrupoles (present triplet is based in Nb-Ti)
- New powering and protection scheme

In addition, the aperture will be much larger, the cold mass configuration will be completely different and the corrector package will be substantially modified as configuration and technology, too.

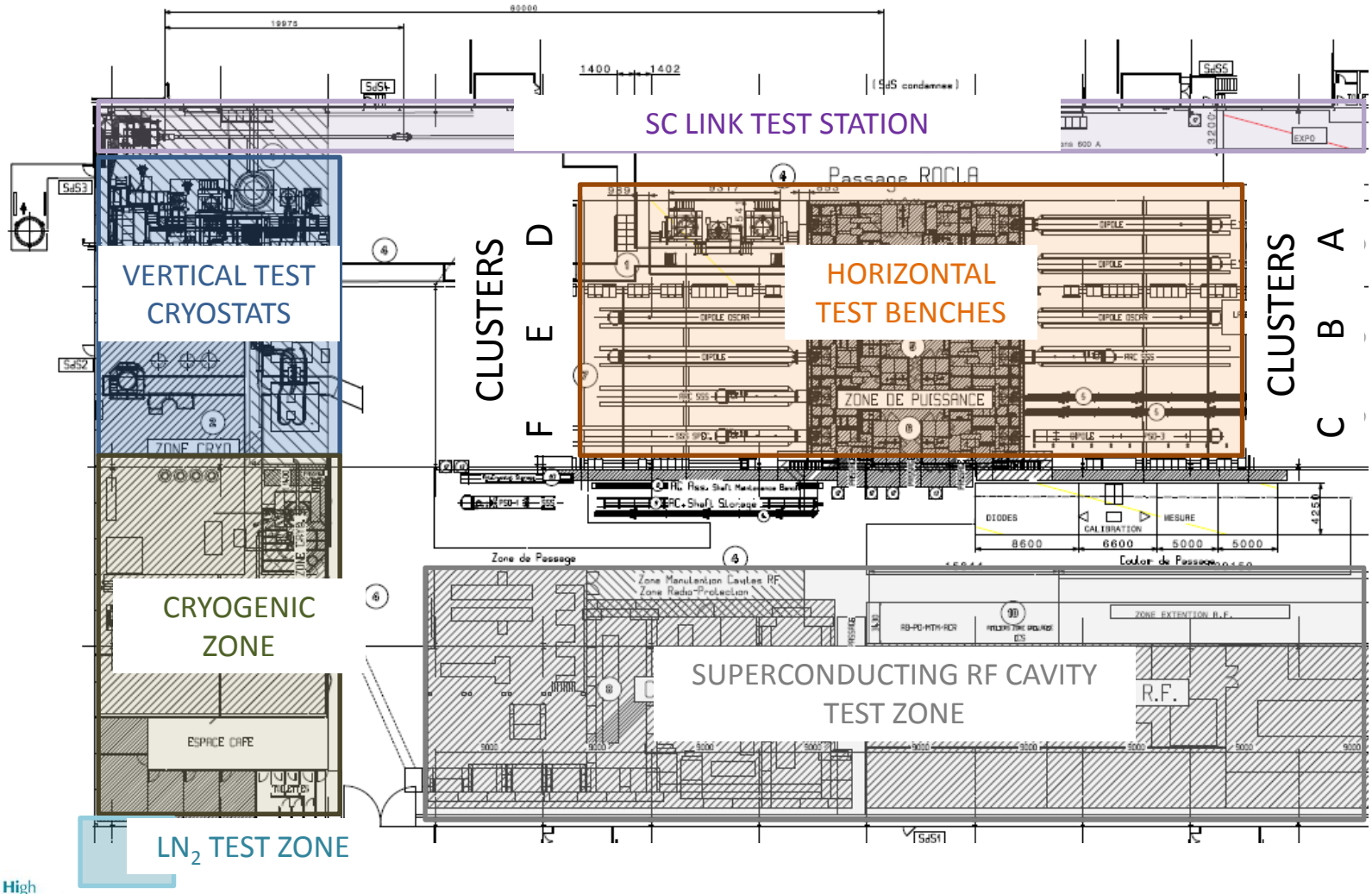
For the above-mentioned reasons, a full integral test of the HL-LHC equipment from Q1 till D1 including the DFX (called IT string) is foreseen in the project, in condition as similar as possible to the operational ones. This IT string will be assembled in SM18 test facility, using prototypes or first-of-series equipment and is intended to be both a technical and an integration test. Not only the magnets, but also the entire electric circuit, the cryogenic equipment, the vacuum elements and alignment system must be under test in a configuration as near as possible to the final one.







THE ZONES in the Building 2173



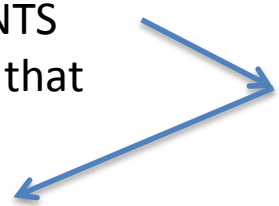
IT STRING short term ACTIVITIES

Extract from the Mandate

.... The HL-LHC IT String Coordinator (Mr/Ms IT String) is in charge to coordinate the activity related to the IT string: procurement of the main equipment, their installation, the readiness of the facility and of the necessary auxiliary systems and services. He/she is mandated of preparing a test plan and to coordinate its execution, too. He/she will decide the most suitable way to carry out the work, favouring the largest collaboration among WPs, Groups and services: weather a Task Force or a permanent Working Group or any other appropriate body. Of course, the major WPs shall be represented in the body and consulted before any important decisions.

Based on scope , the preliminary studies and cost estimates

1. Set up a TEAM and the modus operandi with GL and WPLs
2. ESTABLISH a COMPLET list of INGREDIENTS
3. Set up a possible TIMELINE and agree on that
4. WORK out a TEST plan
5. Work out a BUDGET and RESOURCES



Check specifically those equipment which are only be used in Sm18

1. SET UP A TEAM AND A MODUS OPERANDI

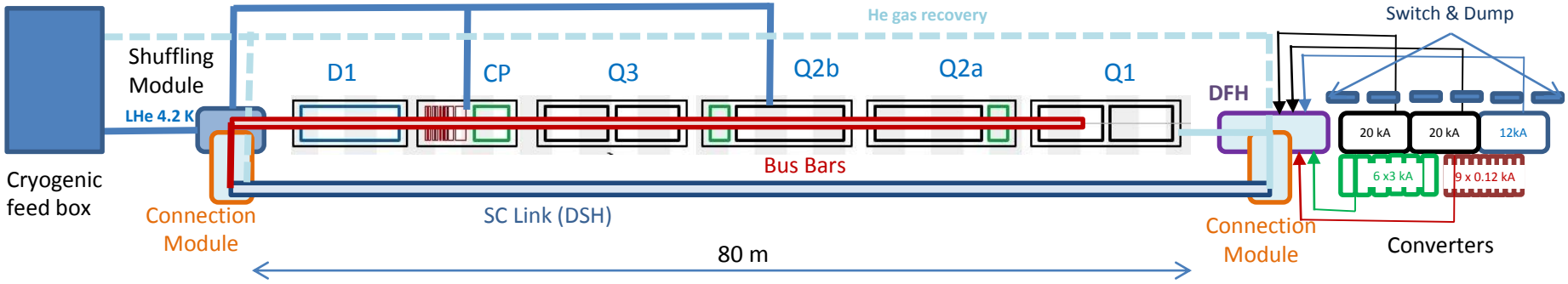
2. IT STRING INGREDIENTS

Test the COLLECTIVE BEHAVIOUR of ingredients tested individually

HL LHC STRING Ingredients… mainly from the WPs and possibly series equipment

Magnets: Q1, Q2a, Q2b, Q3,CP, D1
Power converters: 3 x 20 kA, 6 x 3 kA, 9 x 120 A
Power distribution: DFH and Current leads + SC link (DSH)
Protection and EE system: 3 x switches x 20 kA, 3 x Dump
Cryogenic equipment (cooling and cryo distribution)
Vacuum equippment

DAQ, Interlock, Software for Analysis ect is to be test in the STRING



SERVICE **UPGRADE** needed for :

Cryogenic cooling: additional 6 kW power plant

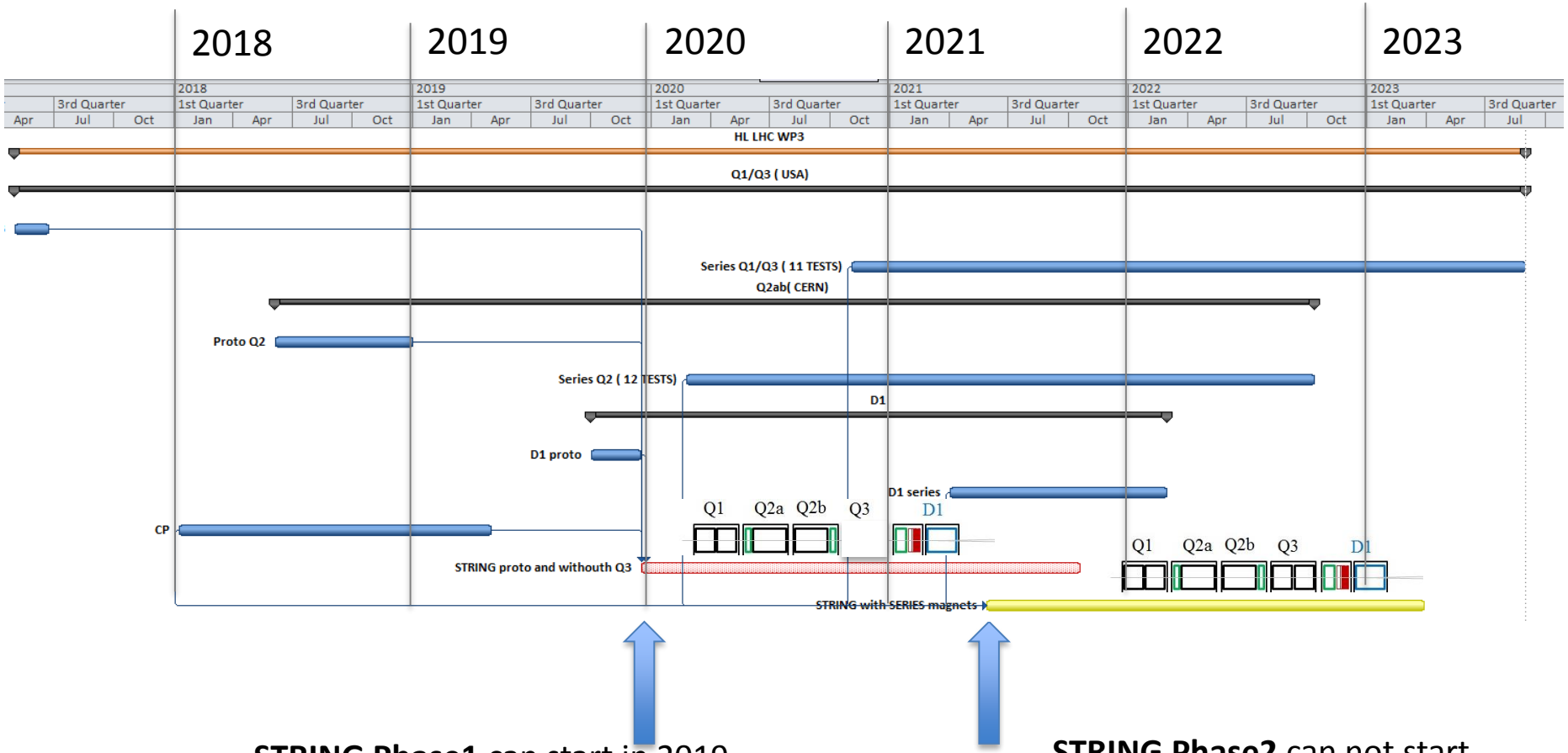
Demineralised water cooling: additional 55 m^3/h (aprox.0.5 MW) ✓

Primary water cooling: additional 2.5 MW for cryogenics

Electricity : tbc

These was defined and is part of the SM18 Test Facility UPG Project. See the presentation of Volker.

3. HL LHC STRING TIMELINE



STRING Phase1 can start in 2019 end with prototypes but Q3 will missing

STRING Phase2 can not start before mid 2021 due to late arrival of the 1st series of D1

4. HL LHC STRING preliminary TEST PLAN

Validation of a layout- integration
Validation of installation sequence and procedures
Validation of a system (of components)
Validation of their collective behaviour

Quench: provoked, natural, holding current, propagation, detection, protection, clic, dump, switch
Cryogenics: cooling- warming speed (Nb_3Sn), heat load, recovery after quench, pressure, temperature, shielding
Integration: layout, interconnections, systems around (racks, cables trays, control cables et), total weight
Powering: bus bar, connections, current leads, power distribution at warm and at cold, converters, water cooled cables
Electrical integrity: splice resistance, electrical insulation
Interlock
Vacuum: leak detection, beam screen
Instrumentation , DAQ systems, DB , QA, QC: specific or not to string
Alignment

GOALS in parallel:

Develop methods, techniques
Develop tooling
Develop procedures

X
definition of

Installations
Test
Operation

2
support

HWC
OP

5. SET UP THE IT STRING BUDGET

				kCHF
	SM18 MAGNETS TEST FACILITY SC LINK and STRING			3840
1		PROJECT MANAGEMENT		
2		CRYOGENIC SYSTEM		2500
	2.1		Feed Box	600
	2.2		CRYO DISTRIBUTION	250
	2.2		CONTROLS AND INSTRUMENTATION	50
	2.3		SOFTWARE MODIFICATION	20
3		MAGNETS TEST STAND		270
	3.1		Shuffeling Module	200
	3.2		SUPPORT	20
	3.3		MEASURING SYSTEMS	50
4		POWERING SYSTEM		0
	3.1		POWER CONVERTERS	0
	3.2		CONTROL AND SOFTWARE	0
5		ENERGY EXTRACTION SYSTEM		200
	5.1		SWITCH	100
	5.2		DUMP RESISTOR	100
6		QUENCH PROTECTION SYSTEM		150
	6.1		PROTECTION HEATER SUPPLYS	0
	6.2		CLIC SYSTEM	0
	6.3		DETECTION CARDS	50
	6.4		SOFTWARE MODIFICATION	100
7		UTILITIES		720
	7.1		CIVIL ENGINEERING	0
	7.2		CONTROLS AND NETWORK	50
	7.3		COOLING WATER AND VENTILATION	20
	7.4		ELECTRICAL POWERING AND DISTRIBUTION	200
	7.5		SURVEY SYSTEM	100
	7.6		TRANSPORT AND HANDLING	150
	7.7		CONTROL ROOM	0
	7.8		DESIGN AND INTEGRATION	200

This is a very preliminary budget probably a lot under estimated but gives an idea what can be….but it contains only non HL LHC items.

The main ingredients will be paid and produced within the WPs and used for the time of the STRING before transforming them to spares.

CONCLUSIONS

- *For all type of The HL LHC magnets we plan to have a test station @ CERN although some of the will be tested elsewhere.*
- *The test plan is done including all magnets but the high order correctors*
- *The test plan is part of the general HL LHC planning and the corresponding test stand is identified for each of them (vertical or horizontal A,B,C cluster ect,)*
- *The definition of the performance test is well advanced*
- *These work led to a specification of the test stands , the ancillary (ex. water cooling) or main (cryogenic) services and a requirements for their readiness . It is giving also the indication of what and when should be done in simultaneous way (STRING, SC link and magnet test)*
- *IT STRING activity has been started but is all preliminary. Actions are listed for the next coming mounts. Proposed timeline is given for 2 years of operation and in two phases starting at 2019 and in 2021. All services but electrical powering has been defined.*