SM18 readiness for tests of HL-LHC magnets

HL-LHC PL
4.6.2015

V. Mertens

with material from M. Bajko, A. J. Broche, Ch. Giloux, M. Nonis, Ph. Perret, L. Serio, M. Strychalski, E. Vergara and others.

SM18 upgrade

SM18: continuously in use + past, present and future transformations.

Upgrade for HL-LHC era being prepared since years, with many items in various stages.
Major parameters defined (I_{max}, ...); test programme known (yet evolving in time and scope).
Many very dedicated persons involved – good share of ground work already done.

Yet many details to be worked out resp. finalised.
Plannings to be made and followed.
Response from involved teams partially impacted by concurring activities („LS1 effect“).

Creation of SM18-UPG project in 2014; focusing on:

Short-team goals (complete ongoing developments on V model test stands:
HFM, new cluster D + associated utilities (demineralised water, crane, ...)).
Evaluate needs for (tentatively costly) cryogenics upgrade (magnets, String/SC link, RF).
Find technical (and not too costly) solutions for series tests at higher currents (H benches).

Budget:
13 MCHF in MTP for infrastructure consolidation + prospect for 10 MCHF from HL-LHC + ... ??

With above uncertainties (evolution of needs, technical challenges (with strong cost impact), scope, budget, ...) not yet in a position to carry out a meaningful C&S review (or launch EVM ...).
Must first find ways to deal with demand for series tests, then put everything together.
Good convergence process ongoing.

B180-SM18 project

SM18-UPG

construction 2014 to ca. 2019
(IT String operation in 2021/22)

ready mid-2016

Project management

PL
V. Mertens

Assistance to PL, overall coordination
F. Formenti

Planning
E. Page

Technical coordinators

Magnet/SC link test stations
M. Bajko

Cavity test stations
K. Schirm

Cryogenic infrastructure
L. Serio

Work packages

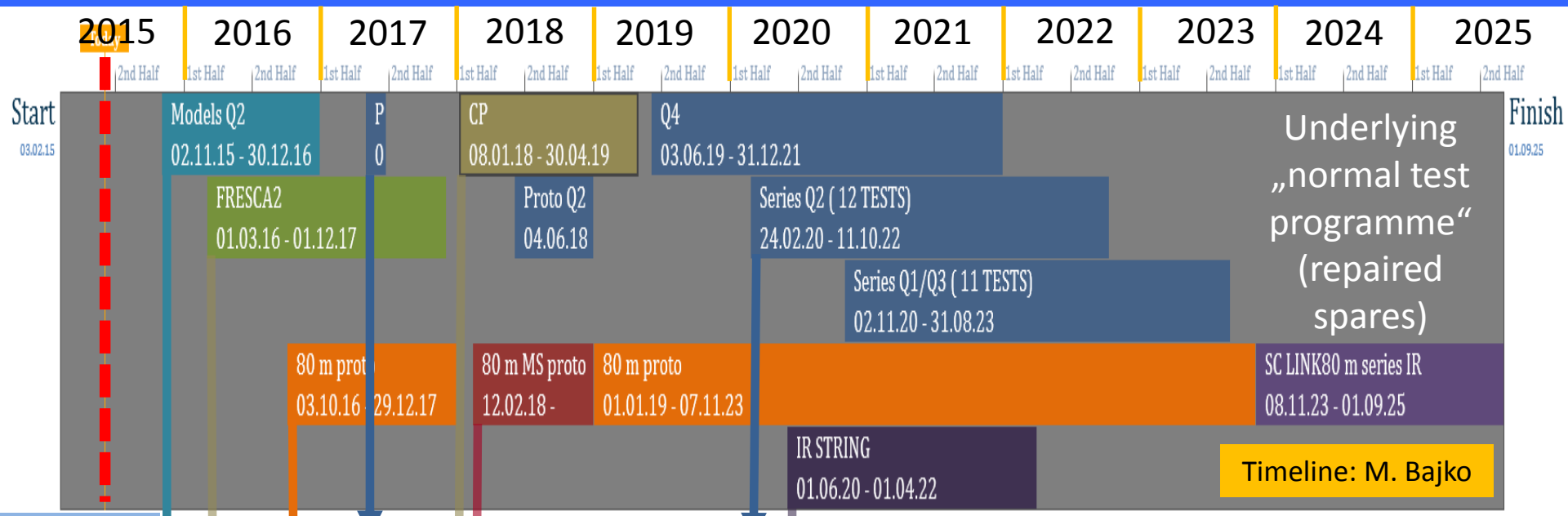
EN-CV

...

...

...

Test planning – which upgrade/modification will be needed when ?



Demineralised water station upgrade

Horizontal test bench allowing higher current (up to 20 kA + 2 x 2 kA)

2nd horizontal test bench for higher current (up to 20 kA + 2 x 2 kA)

Powering from Clusters D + A

New vertical cryostat for larger diameter and higher current („Cluster D“)

Modification of horizontal bench for multiple powering circuits

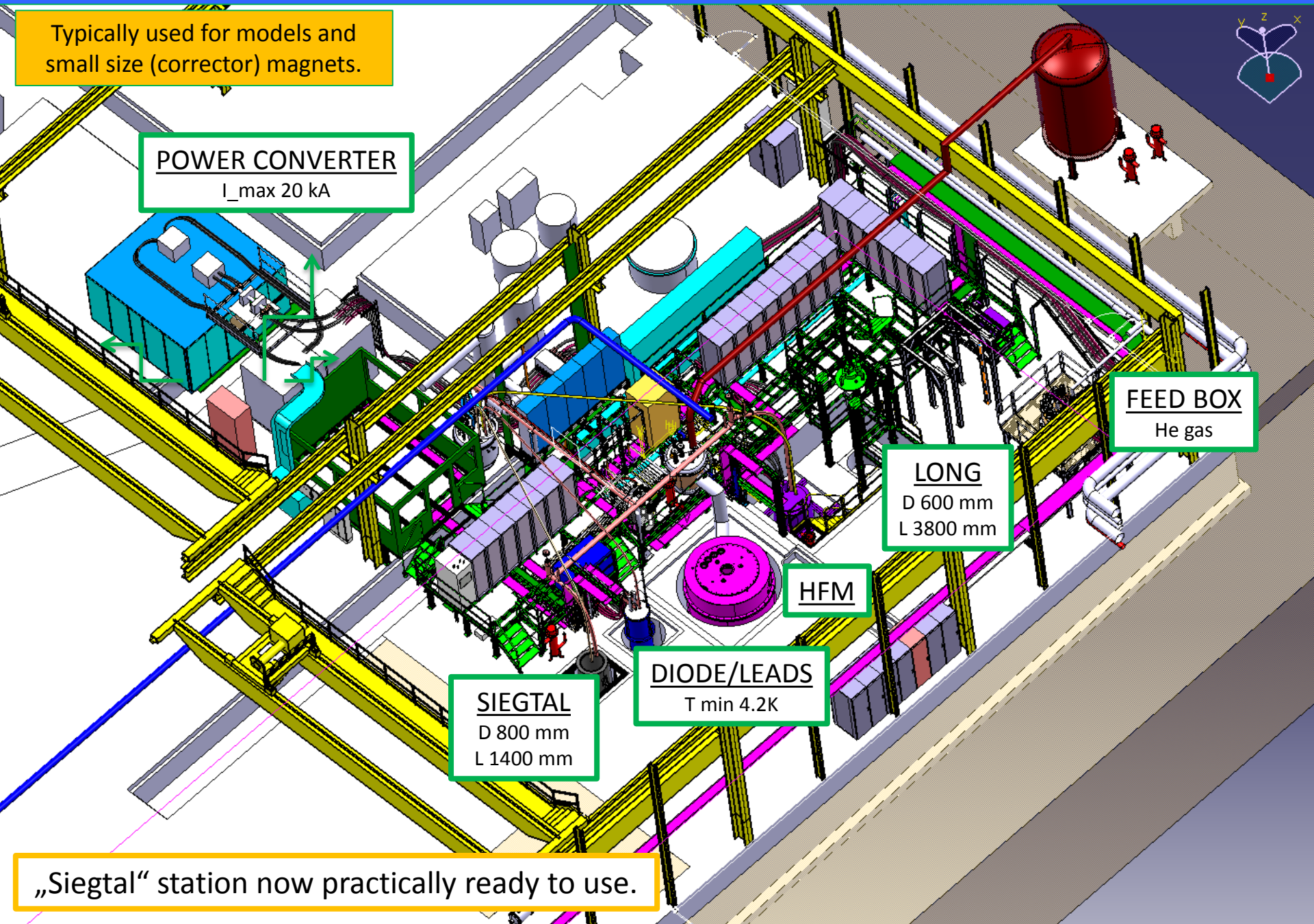
Cryogenics plant upgrade (incl. primary water + possibly electricity upgrade)

25 t crane upgrade

Powering from own range of converters

New vertical cryostat for larger diameter (“HFM”)

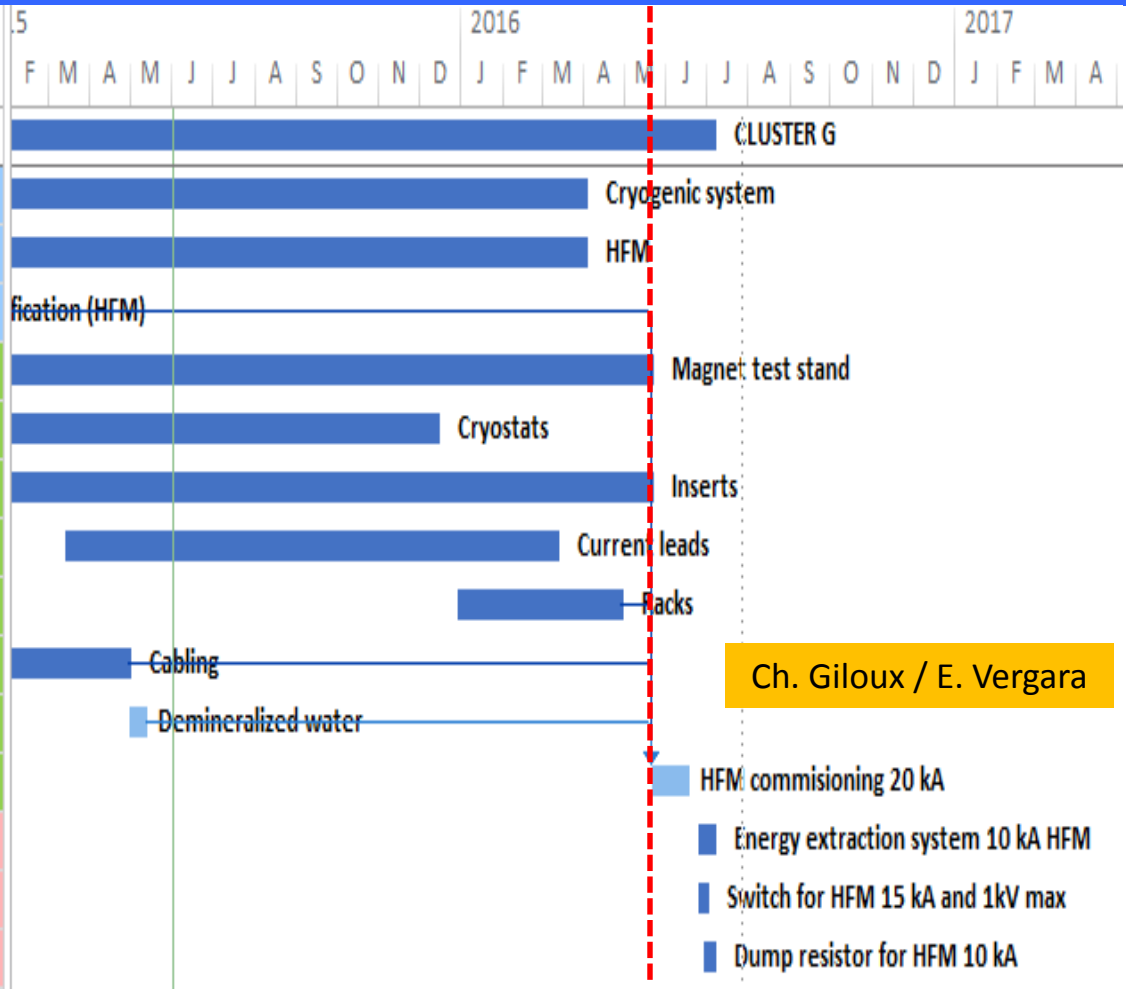
“Cluster G” (vertical test benches incl. former ”Block 4”)



Budget coming directly from (HL-LHC WP 14).

"HFM" planning

Task Name	Start	Finish
CLUSTER G	Tue 12.03.13	Wed 06.07.16
Cryogenic system	Tue 12.03.13	Fri 01.04.16
HFM	Tue 12.03.13	Fri 01.04.16
Software modification (HFM)	Mon 05.05.14	Wed 01.10.14
Magnet test stand	Tue 12.03.13	Fri 20.05.16
Cryostats	Tue 12.03.13	Mon 14.12.15
Inserts	Mon 29.09.14	Fri 20.05.16
Current leads	Mon 16.03.15	Fri 11.03.16
Racks	Fri 01.01.16	Thu 28.04.16
Cabling	Tue 12.03.13	Tue 28.04.15
Demineralized water	Wed 29.04.15	Tue 12.05.15
HFM commisioning 20 kA	Fri 20.05.16	Fri 17.06.16
Energy extraction system 10 kA HFM	Mon 27.06.16	Wed 06.07.16
Switch for HFM 15 kA and 1kV max	Mon 27.06.16	Thu 30.06.16
Dump resistor for HFM 10 kA	Fri 01.07.16	Wed 06.07.16



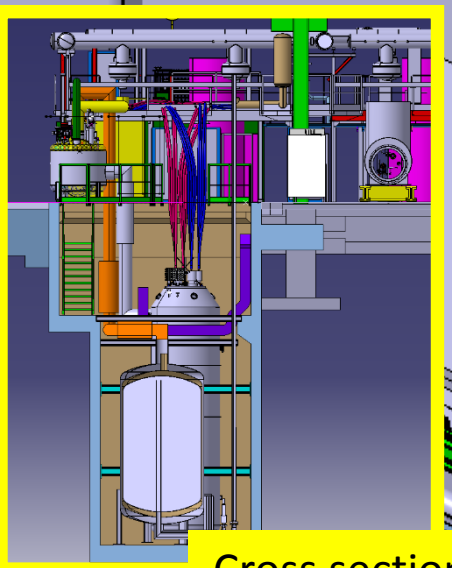
Ch. Giloux / E. Vergara

- TE-CRG confirmed HFM cryogenics will be ready by 05/2016. To be re-verified now.
- Design of current leads has started – should be ready in time.
- Cryostat weld problem – being investigated.

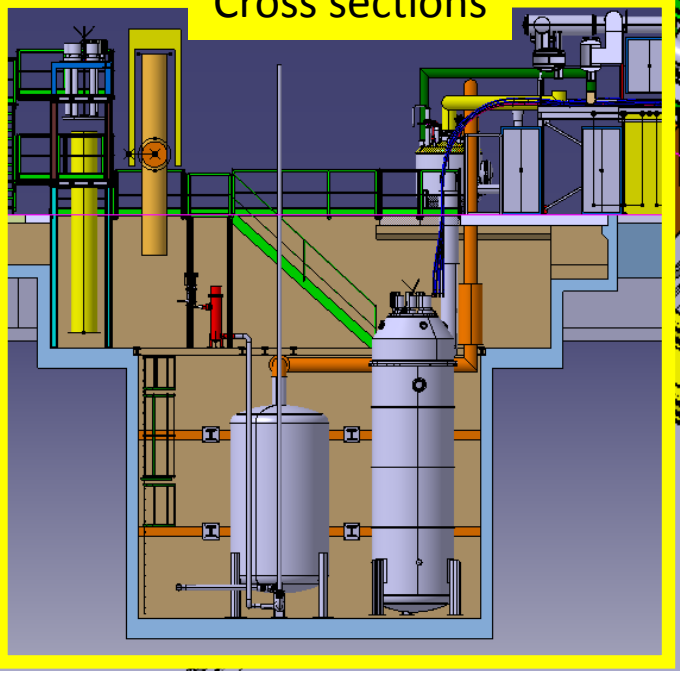
„On time" for FReSCa2 (sliding from 03 to 07/2016 (?)); 7 m late for Q2 models (11/15)
(HFM was meant to be backup for those, while waiting for cluster D).

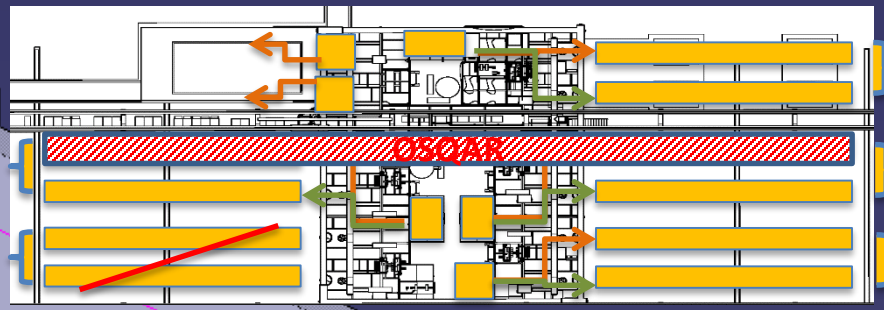
“Cluster D” (new vertical test bench)

Overall cost ca 5.6 MCHF.



Cross sections





To test non-cryostated magnets
with max 5 m / 800 mm,
and powering/EE of I_max = 30 kA
(not for full Q2; 7 m long).
Moving PC from cluster F to D;
cluster F henceforth “in-op”.

Ch. Giloux / Ph. Perret

“Cluster D” civil engineering

Cost ca. 1 MCHF.

- „Groundbreaking“ (geological test drilling) started in 02/2015.
- Work done in several steps, with different companies.
- Dust protection tent has proven its worth – so far
  no real trouble with dust, vibration, noise, exhaust fumes, ...
- Main excavation/concreting to start in 06/2015.
- To be completed by 09/2015.

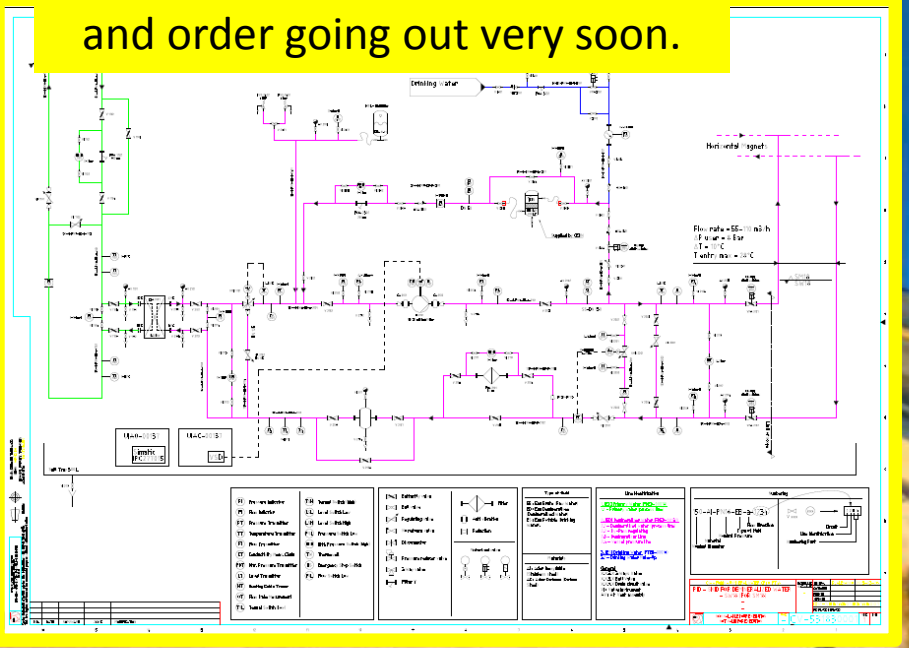
Upgrade of demineralised water station

Capable of 1.3 MW, 55 – 110 m3/h. To be delivered SD 2015/2016. Cost ca 0.54 MCHF.

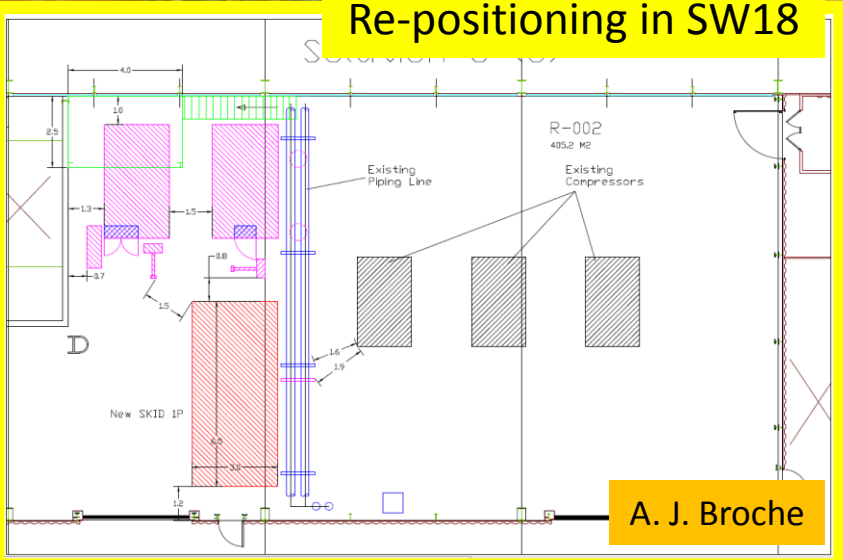
RF

magnets

Fully designed, offers received and order going out very soon.



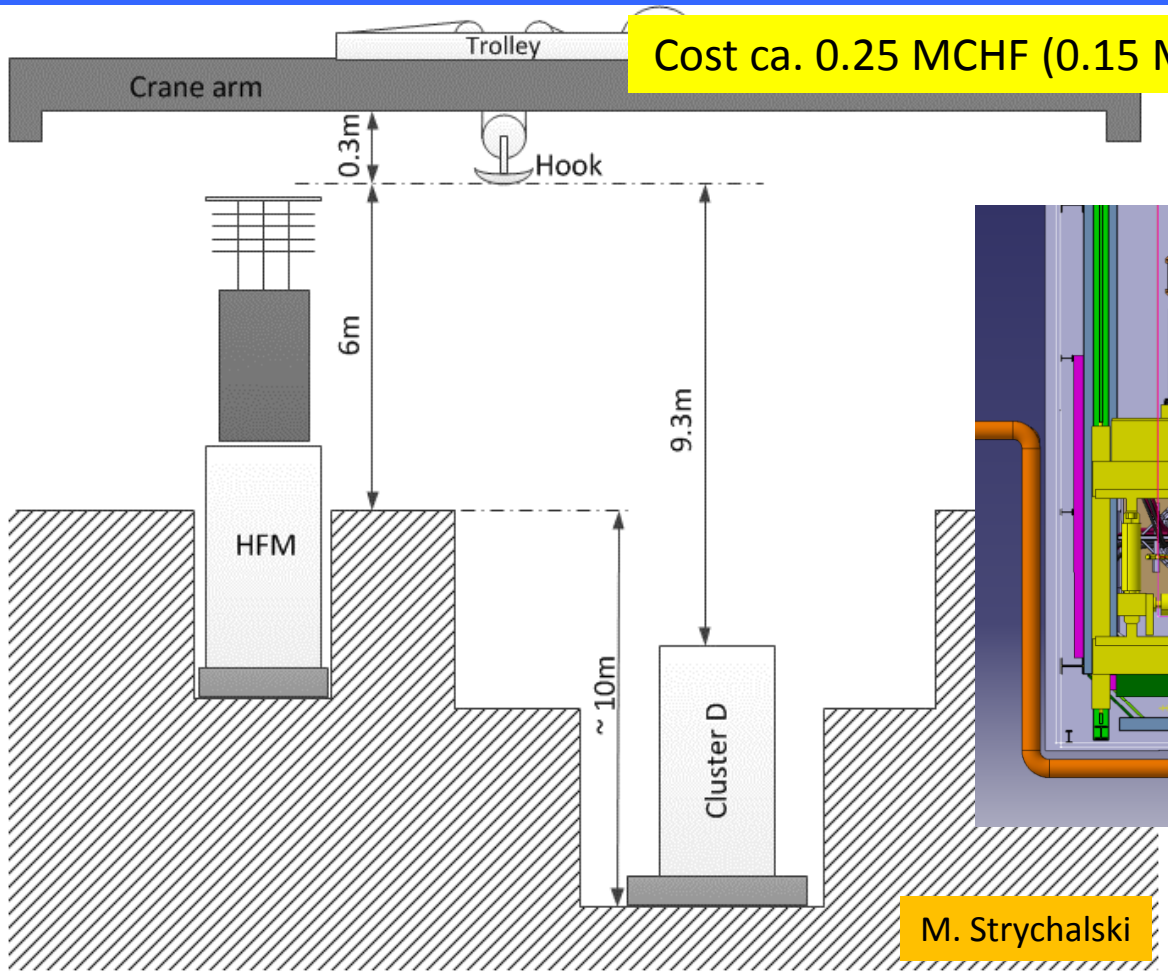
Re-positioning in SW18



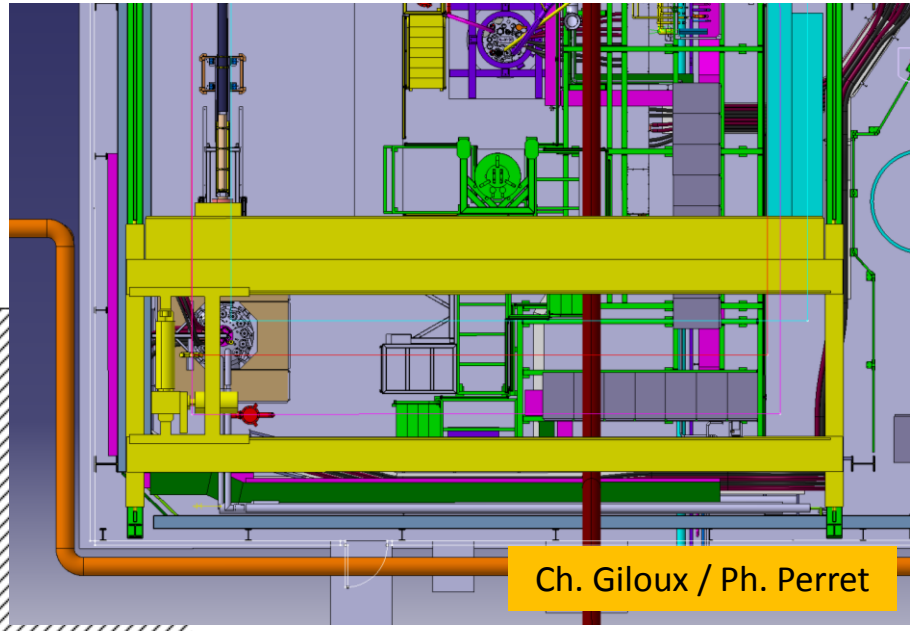
A. J. Broche

Crane upgrade

Cost ca. 0.25 MCHF (0.15 MCHF of it on EN-HE consolidation).



M. Strychalski

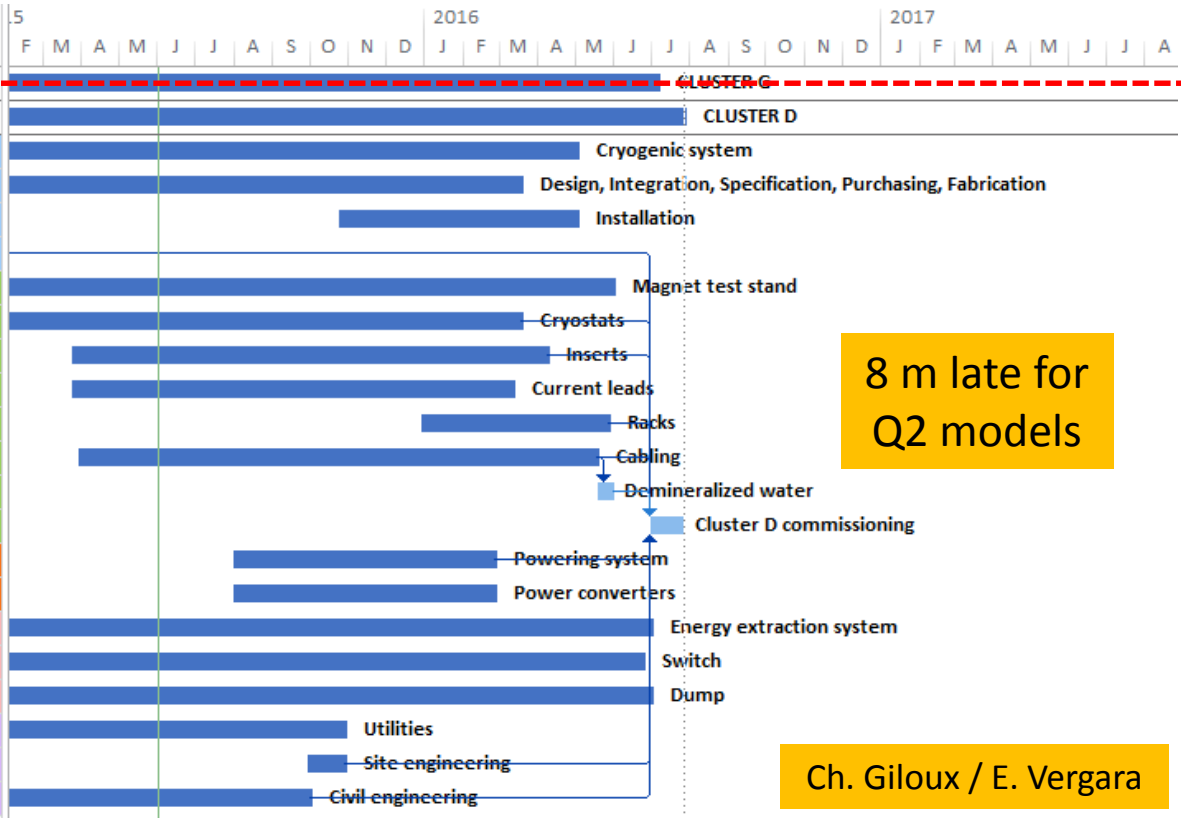


Ch. Giloux / Ph. Perret

- Opting for 25 t upgrade (from 16).
- Proposal of more lean bridge elaborated by EN-HE.
- Not exactly fulfilling the desired clearances, but should be ok.
- Few optimisations to be made (trolley orientation, reach).
- Few remaining points to study (use in tandem with 2nd 25 t crane for IT String installation).
- Will be installed in SD 2015/16.

“Cluster D” planning

Task Name	Start	Finish
CLUSTER C	Tue 12.03.13	Wed 06.07.16
CLUSTER D	Tue 12.03.13	Wed 27.07.16
Cryogenic system	Tue 12.03.13	Mon 02.05.16
Design, Integration, Specification,	Mon 05.01.15	Fri 18.03.16
Installation	Tue 27.10.15	Mon 02.05.16
Software	Tue 12.03.13	Tue 12.03.13
Magnet test stand	Mon 13.10.14	Tue 31.05.16
Cryostats	Mon 13.10.14	Fri 18.03.16
Inserts	Thu 26.03.15	Fri 08.04.16
Current leads	Thu 26.03.15	Fri 11.03.16
Racks	Fri 01.01.16	Fri 27.05.16
Cabling	Wed 01.04.15	Tue 17.05.16
Demineralized water	Wed 18.05.16	Tue 31.05.16
Cluster D commissioning	Thu 30.06.16	Wed 27.07.16
Powering system	Mon 03.08.15	Fri 26.02.16
Power converters	Mon 03.08.15	Fri 26.02.16
Energy extraction system	Mon 29.09.14	Thu 30.06.16
Switch	Mon 29.09.14	Fri 24.06.16
Dump	Mon 03.11.14	Thu 30.06.16
Utilities	Mon 19.01.15	Wed 28.10.15
Site engineering	Thu 01.10.15	Wed 28.10.15
Civil engineering	Mon 19.01.15	Thu 01.10.15



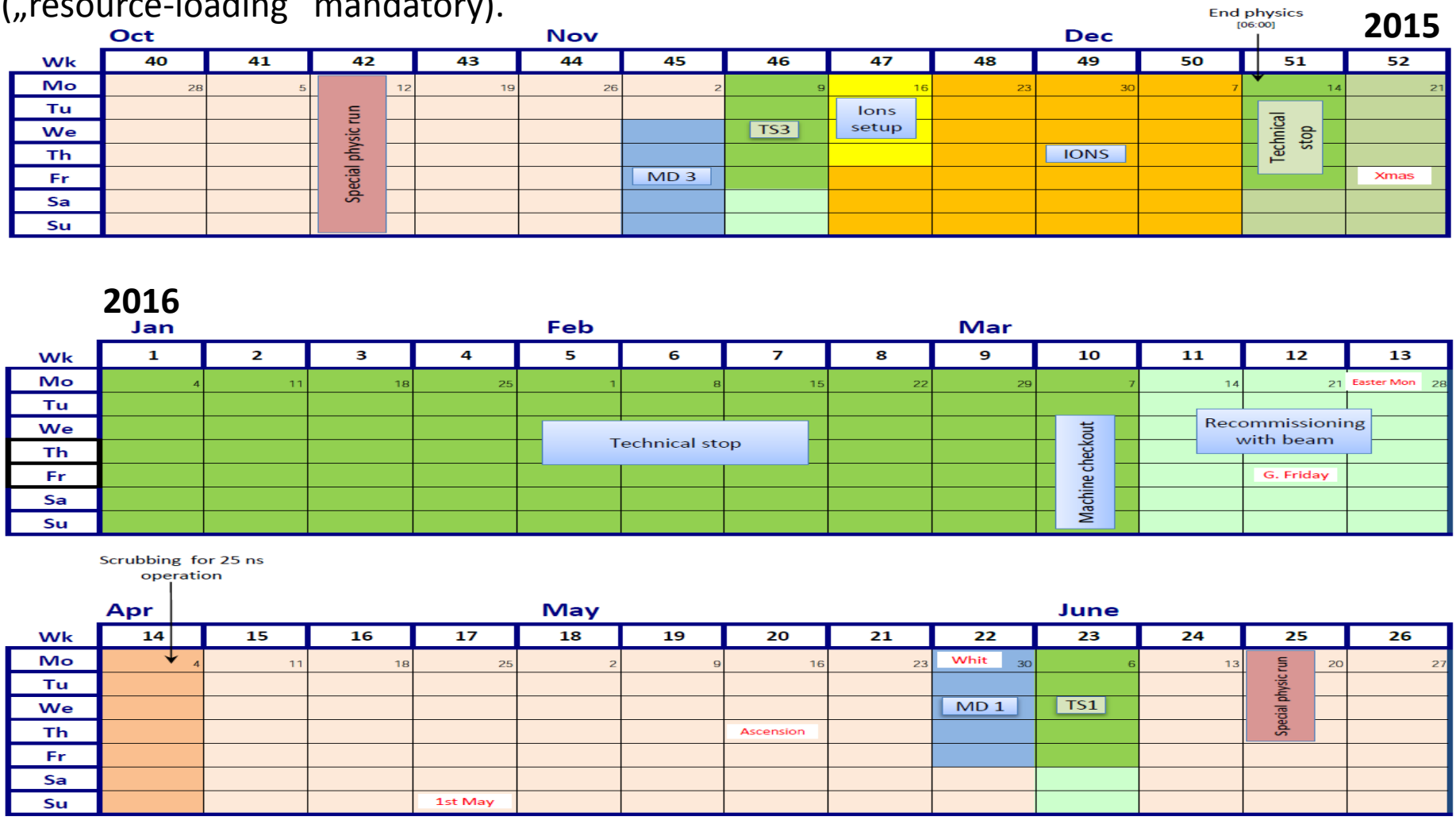
8 m late for Q2 models

Ch. Giloux / E. Vergara

- Possibility to re-use IT from HFM (w small adaptations) led to massive speed-up (and cost reduction) of TE-CRG supplies. The cryogenics shall now be ready by 06/2016.
- Specification Committee for cryostat took place on 19.5.2015.
- Energy extraction on critical path („LS1 effect“). Challenging - R&D to complete. No „Plan B“.
- Linked with water-cooled cable order (lead time) and routing – solution being worked out.
- Interlocks being specified – combined powering circuits and transition to „new generation“ of hardware.
- TE-EPC normally all fine – „in shadow“ (provided racks and cables are there).
- Metallic structures – re-re-launching.

SM18 shutdown planning

Very critical period. Various significant interventions. Co-activties.
Trying to minimise interruption to ongoing test programme.
Time to choose well between concurrent YETS work and material being awaited (risk of delays).
Work to plan this has started (E. Page) – shall have draft in 06/2015 – re-look in 09-10/2015.
(„resource-loading“ mandatory).



SC link

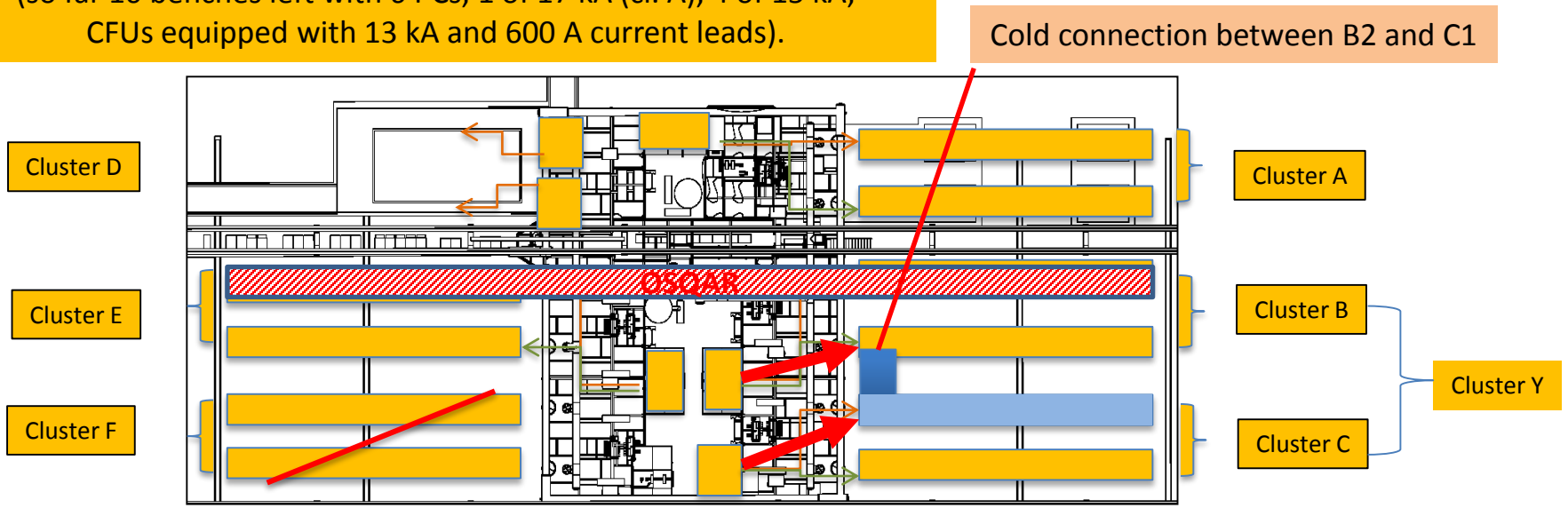
To test prototype SC link w 3 independent circuits of 2 x 15 kA + 17 kA.
Reallocating PCs from cluster A and D; those benches will be blocked.

- To be ready towards end 2016.
- Uses existing cryogenics feedbox.
- Needs appropriate current leads for SC link + 3 sets of water-cooled cables (from cluster D ?).
- This (accepted) solution is 2.8 MCHF cheaper than the desired solution (with dedicated PCs).

- The system test (2020) will use the existing feedbox or a new one, and PCs from/for IRs.

H benches: “upgrade” cluster A+C or new “cluster Y” ??

To test cryostated magnets (Q2 prototype in 2017 and series of Q1/Q3, Q2, Q4, D1, D2 in 2018) with up to 30 kA + 2 x 2 kA for correctors (so far 10 benches left with 6 PCs, 1 of 17 kA (cl. A), 4 of 15 kA; CFUs equipped with 13 kA and 600 A current leads).

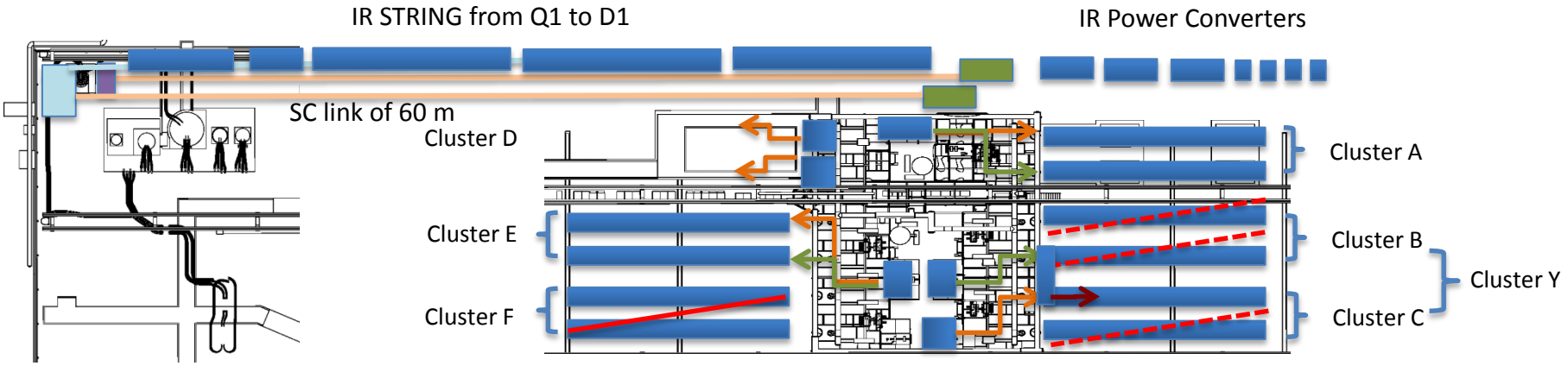


- A solution to test with higher current should be ready first time in 05/2017. ✓
- Hope to be able to use cluster A (16/17 kA PC) at up to 20 kA – first test successful (06/2015).
- Studying current limit of leads and CFU – was supposed to be finished by 05/2015).
- **If** successful can equip one cluster like this 2 x 1 MCHF ???
  (and a 2nd later, for 2019/2020, to test the bulk of the series magnets).
- Still causing significant cost (PC upgrades (14 kA), cables, installation, interlocks, EE (??)).
- **If not** need to launch work on much more involved solution – 3.3 (2) MCHF + ???
  combining 2 H benches at warm or at cold (implying much higher cost, effort, time).
- Should be able to test up to 15 magnets/yr (tbc) – combination space consuming.
- Presently high cost uncertainty and strong push to find technical solution.

New WP – funding presumably coming directly from HL-LHC.

SM18-UPG to provide cryogenics, water, electricity and space (see below).

To test full new magnet system from Q1 to D1, with QRL and SC link.
Not possible to test IR String and SC link at the same time.



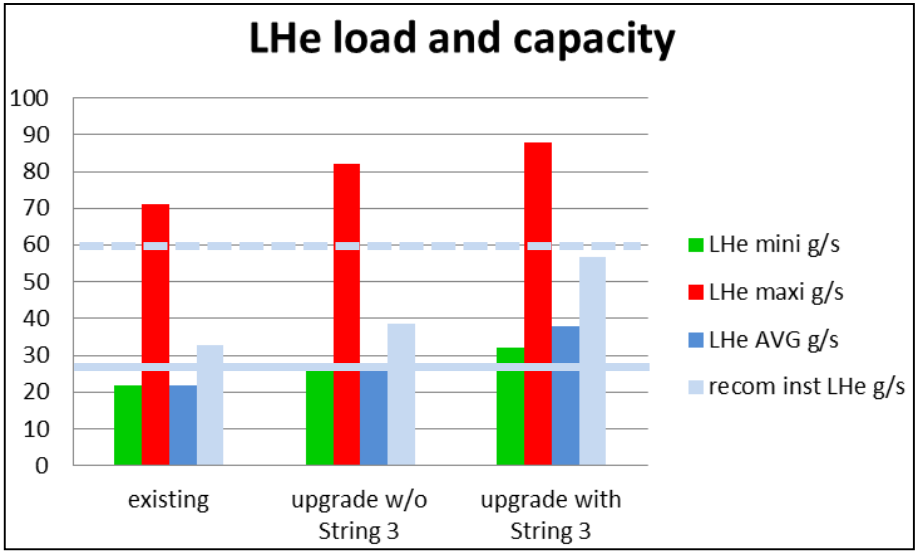
- Today´s most likely dates for IT String are „setting up in 2019“, „operation in 2020-2022“.
- Requires upgrade of the cryogenics infrastructure.
- Will use new dedicated feedbox and the IR power converters (EPC !), integrated w the SC link.
- Budget estimate to be re-looked (material to re-use in HL-LHC ?).
- Space and handling may be issues (practicability and Safety).

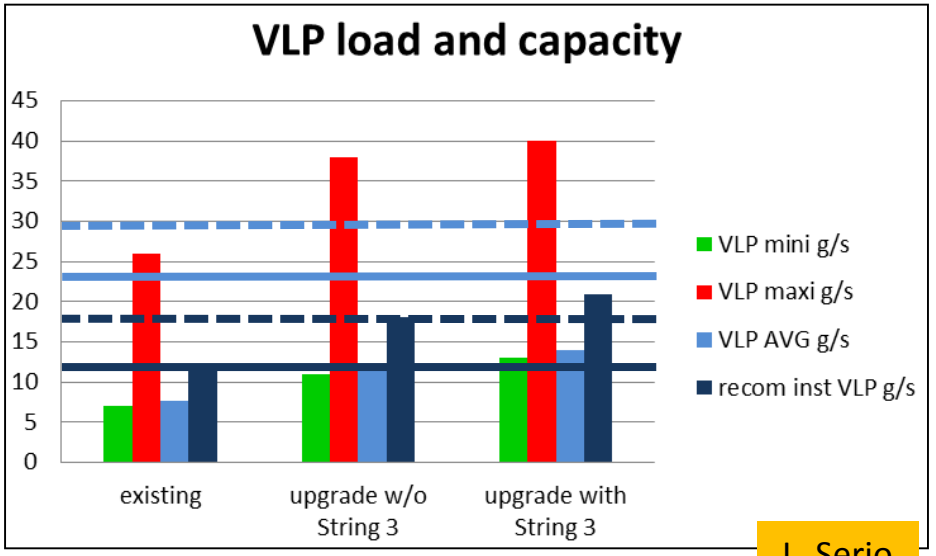
Preliminary assumptions (Q1/2014)

Baseline test capability derived from planned tests and theoretical loads.

Magnets: 2 vertical and 2 horizontal magnets cold / month (2 powering) – L. Bottura
Cavities: 1 cavity test / 2 weeks; 1 module every 6 months – K. Schirm
SC link **or** IT String: integrated systems testing, commissioning and operation
(demanding individual system tests (dynamic loads !) done on dedicated test stands)

50 % contingency for unknown and unplanned tests





L. Serio

LHe 4.2 K existing future
VLP 2.0 K RF existing future
VLP 1.8 K existing future

Mini: lower consumption tests
Maxi: no HW limitation – all tests
AVG: HW/staff limitation and 1 month avg
Recommended installed: AVG + 50 % margin

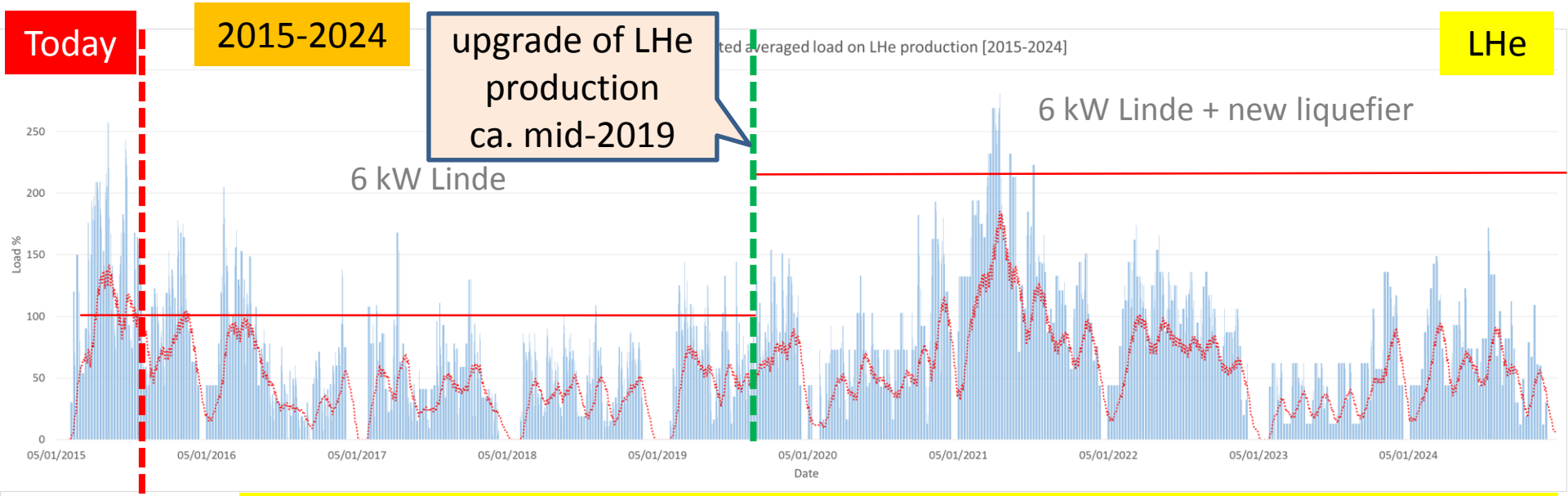
Refined estimate of cryogenics requirements and draft upgrade

Today

2015-2024

upgrade of LHe production ca. mid-2019

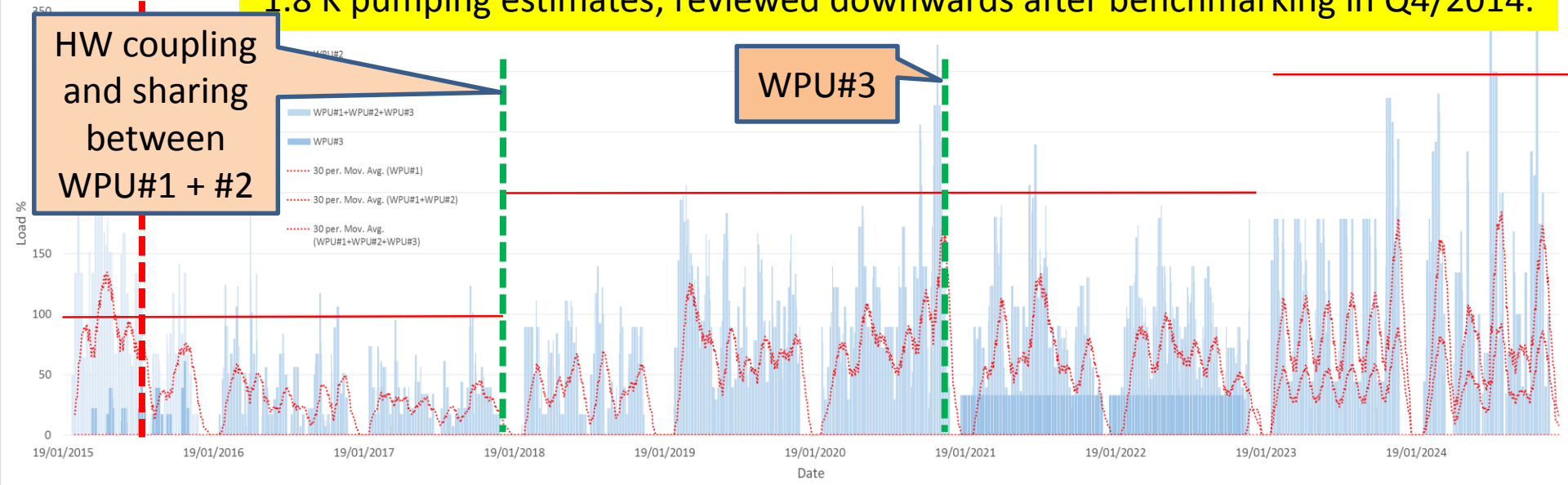
LHe



1.8 K pumping estimates; reviewed downwards after benchmarking in Q4/2014.

HW coupling and sharing between WPU#1 + #2

WPU#3



L. Serio / E. Vergara

Baseline workplan for upgrade of cryogenics infrastructure (tbc)

✓ Baseline test programme 2015 – 2024 re-reviewed (Q2/2015) with all users (magnet test benches, RF cavities and modules, SC links and String 3) and expected average cooling power consumption estimated (Q3/2014) and benchmarked (Q4/2015).

Significant extension in the expected RF test plan.

- Technical proposal with costs/resources/schedule to be presented and reviewed.

  Present conceptual proposal: Cost ca. 15.4 MCHF incl. building, utilities

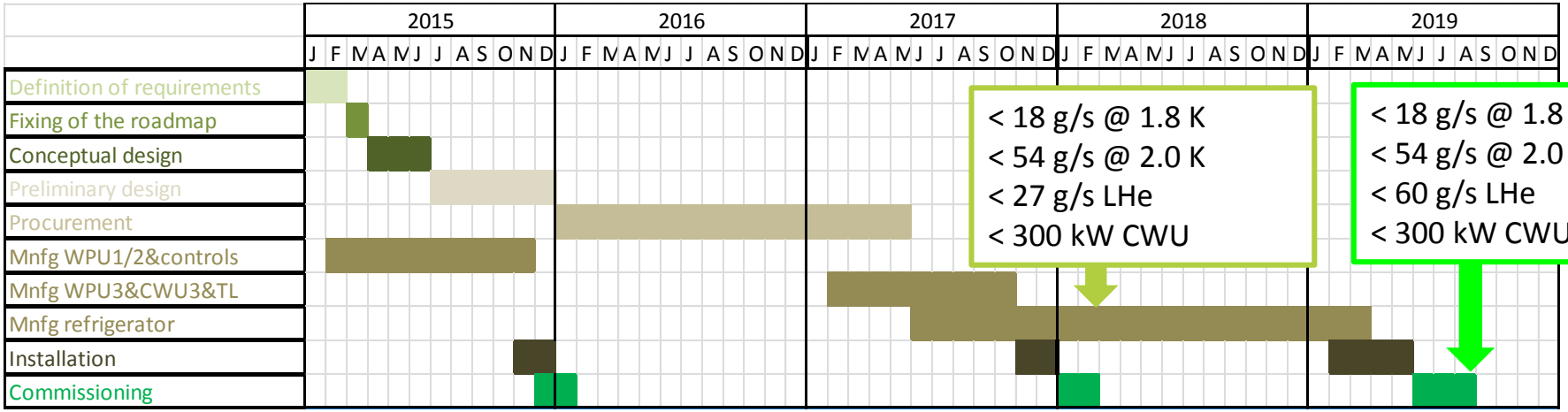
  - Additional 30-40 g/s LHe liquefier for the SM18 clients main supply
  - 6 kW dedicated to the IT String (2021–2022) and boosting of SM18 LHe supply
  - Additional WPU for IT String (and boosting of SM18 capacity) – 6 g/s at 1.8 K
  - Additional CWU for IT String (and future use in SM18) – 100 kW (300–80 K)

✓ Ability to couple WPU 1 + 2 to obtain 12 g/s pumping capacity at 1.8 K (instead of separately 2 x 6 g/s) implemented by software solution (heater control) (tested in 03/2015).

- Addition of flowmeter (hardware or virtual) to allow continuous sharing of the total pumping capacity between RF and magnet test stands (planned by summer 2015).

- Addition of WPU interconnection unit to implement redundancy/sharing of WPUs and provide connections for IT String (aimed at SD 2015/16 but probably delayed by 1 yr).

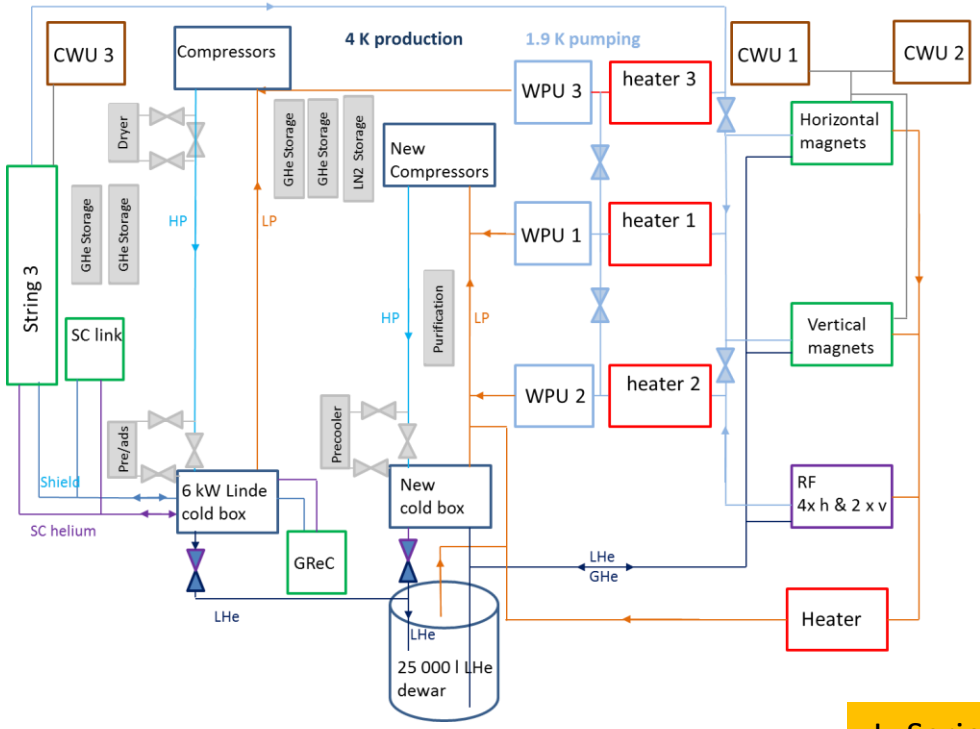
Planning (earliest dates) for upgrade of cryogenics infrastructure



production capacity:

< 6 g/s @ 1.8 K
< 18 g/s @ 2.0 K
< 27 g/s LHe
< 200 kW CWU

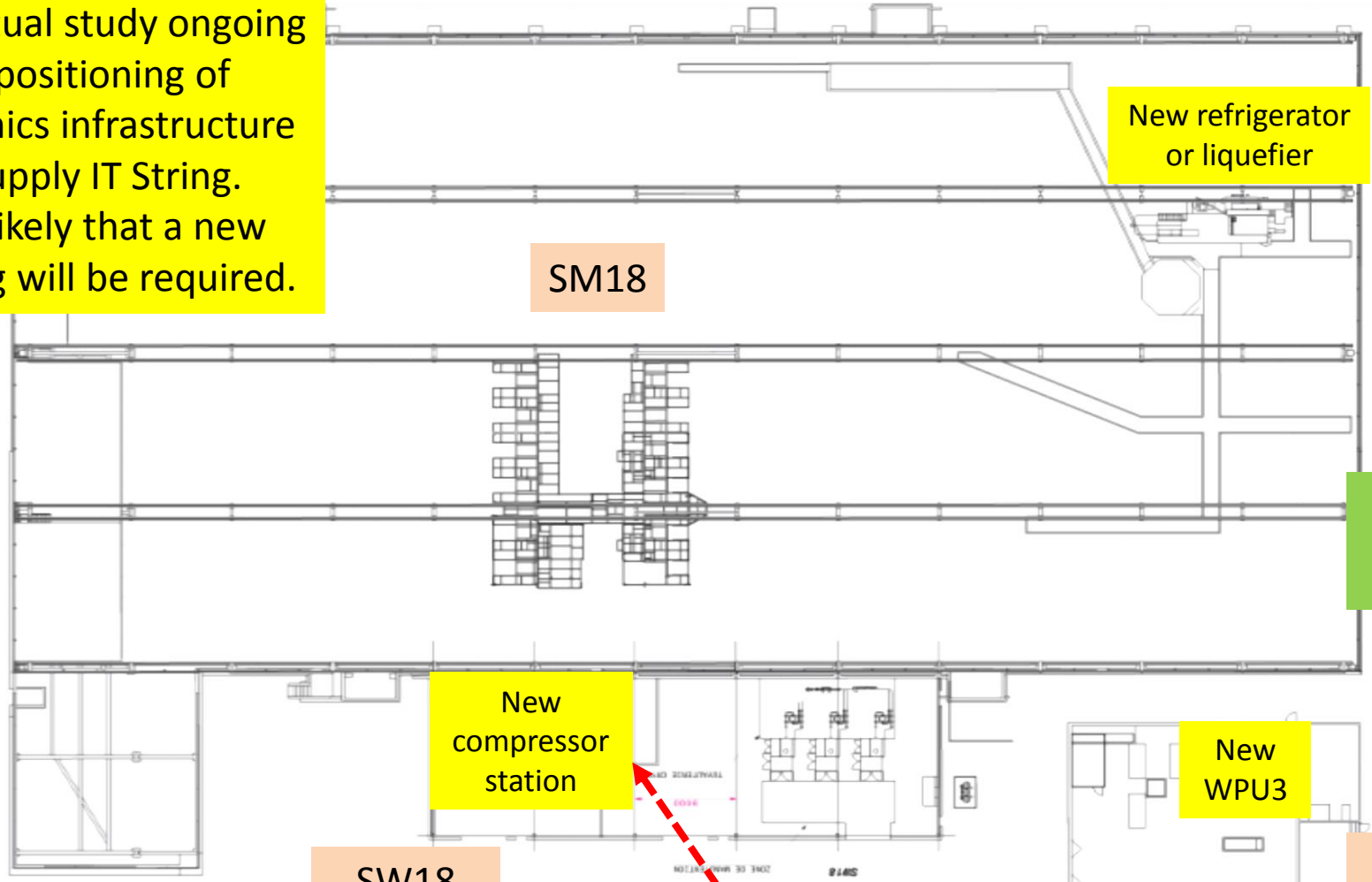
< 12 g/s @ 1.8 K
< 36 g/s @ 2.0 K
< 200 kW CWU



L. Serio

Baseline concept for positioning of new cryogenics infrastructure

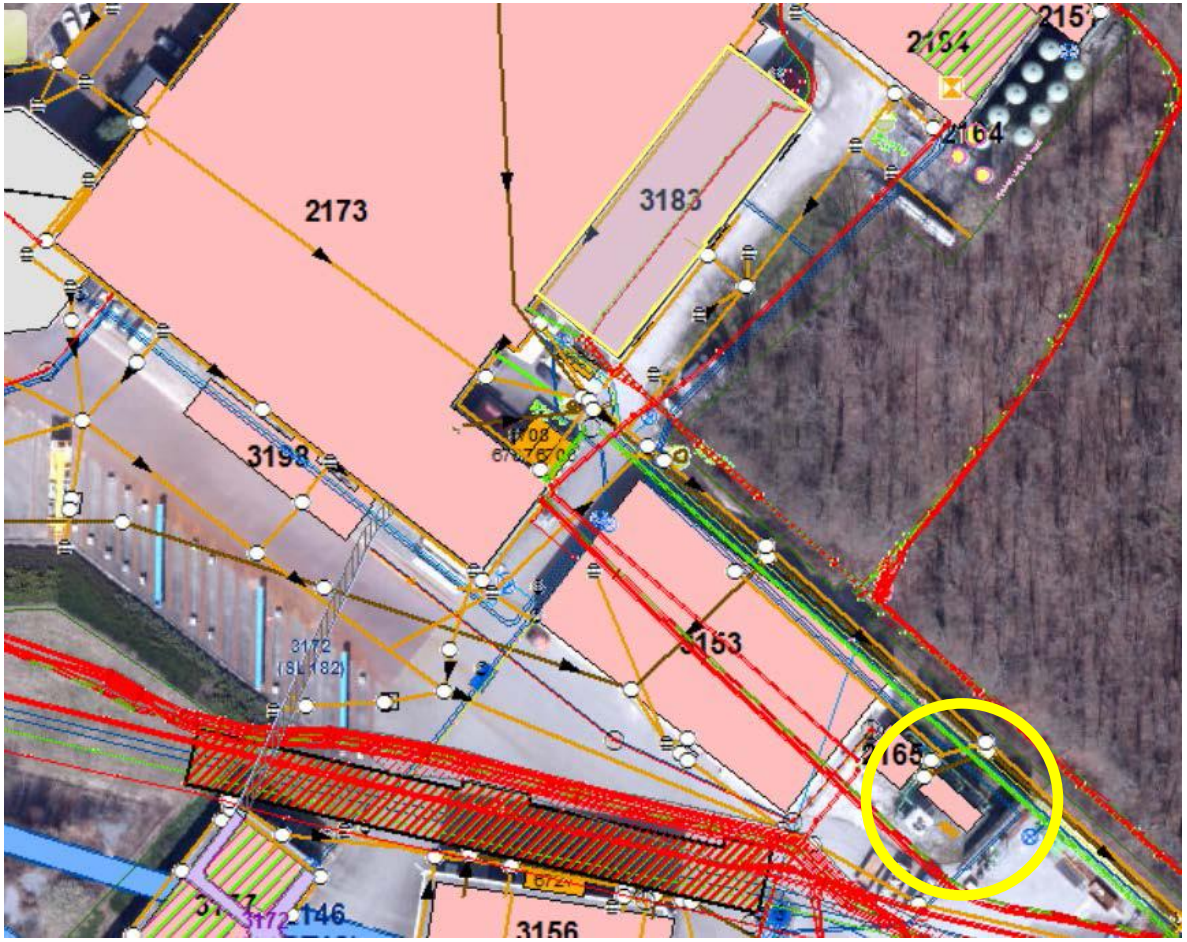
Conceptual study ongoing for positioning of cryogenics infrastructure to supply IT String. Very likely that a new building will be required.



Concept for modernisation/upgrade of primary water system, I

Discussed with M. Nonis / EN-CV. Main requirements defined (from upgrade of the demineralised water system and the cryogenics infrastructure).

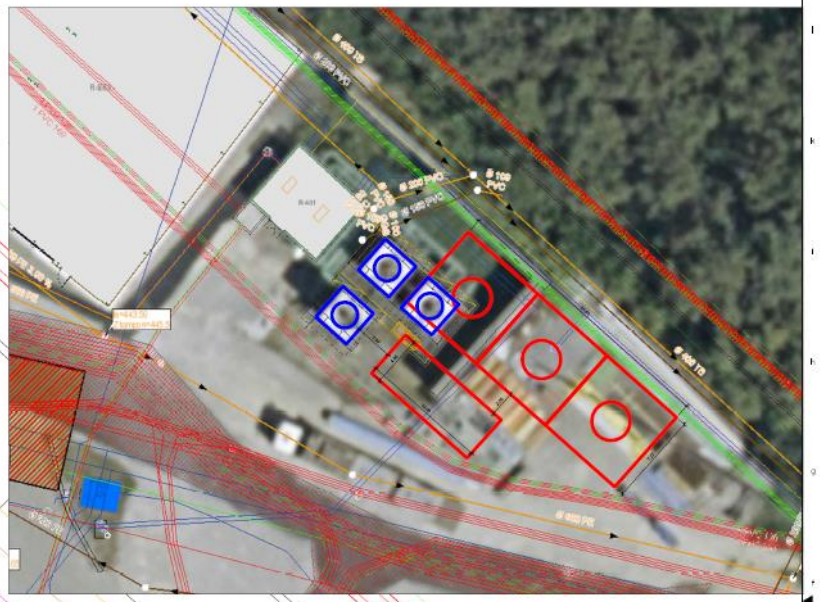
Embedded into larger modernisation/reorganisation of primary water system affecting the whole of P1.8 which is in turn linked with the RF power increase in SPS BA3 (LIU)
(Pt1.8 capacity freed on the SPS loop, avoiding massive and costly modifications elsewhere).



M. Nonis

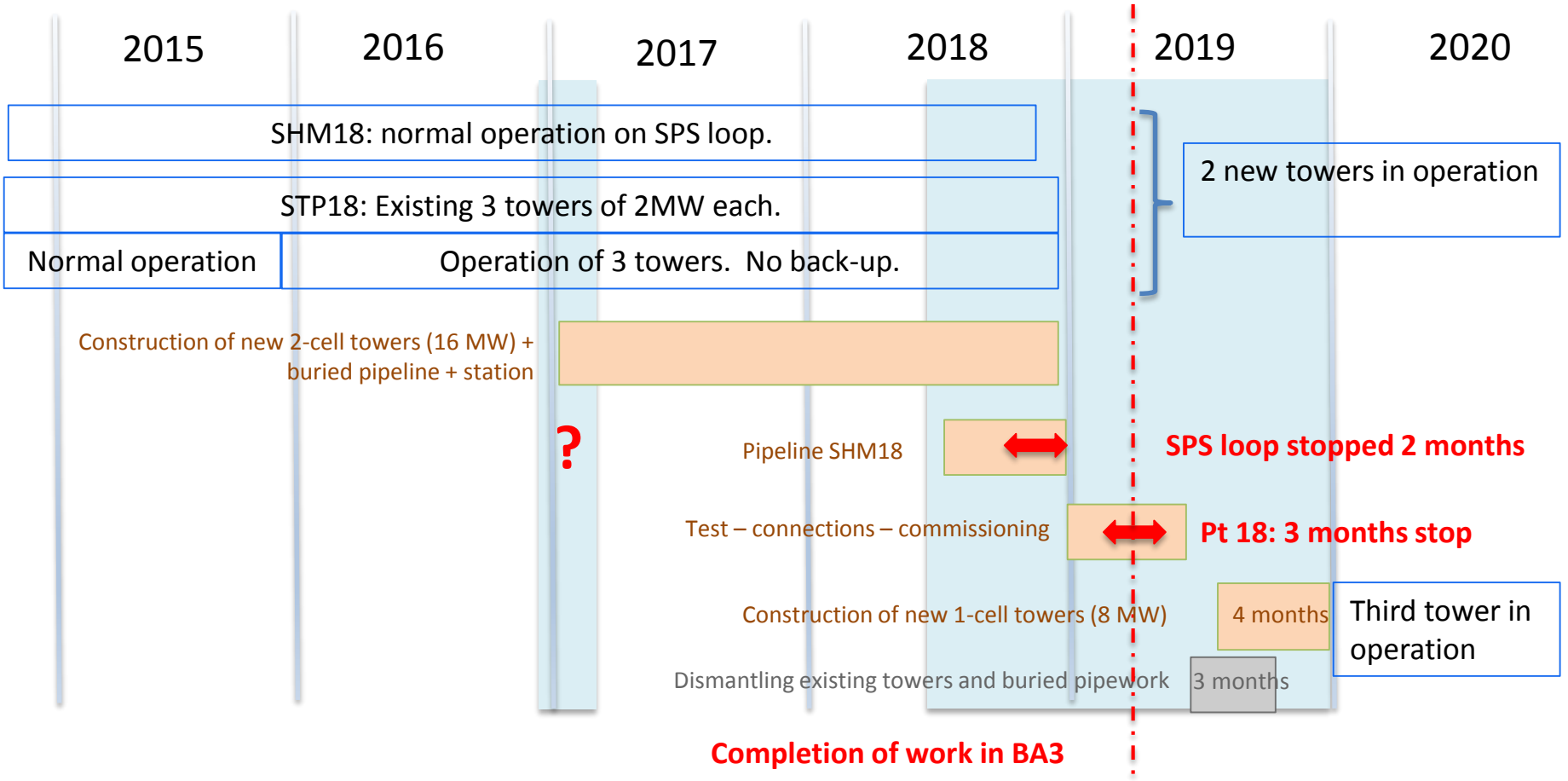
Concept for modernisation/upgrade of primary water system, II

Have optional extension path, with 2 x 8 MW towers (sufficient for the SM18 „baseline“ upgrade), with possibility to add later a 3rd 8 MW tower when needed.



Concept for modernisation/upgrade of primary water system, III

Presented in IEFC 13.2.2015.
To be delivered at the beginning of LS2.
Cost ca. 4.5 MCHF (from EN-CV consolidation).



M. Nonis

Conclusion

- Acknowledgement to the many groups and persons involved in this ambitious extensions.
- Pushing forward on many fronts to get the programme done and milestones reached.
- Short-term milestones planned and well followed up; can´t go faster, schedule still at risk.
- Plea to groups (in particular with critical WPs)
  to put the required resources and respect the schedules.
- Concepts worked out and approved for some of the longer term items (primary water, ...).
- Degree of cryogenics upgrade to be reviewed and formally adopted (lion´s share of cost).
- Feasibility for some medium term goals still to be proven; technical choices to be made.
- Some items in work not mentioned here (safety, control room(s), ...).
- Some other items still to be looked at (electricity, ...) – starting.
- Budget frame to be better defined (income, expenses).
- Manpower to perform all the planned tests also to be foreseen (a different discussion ...).