HL-LHC Cryogenics, Update on alternatives for P4

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On behalf of WP9 team

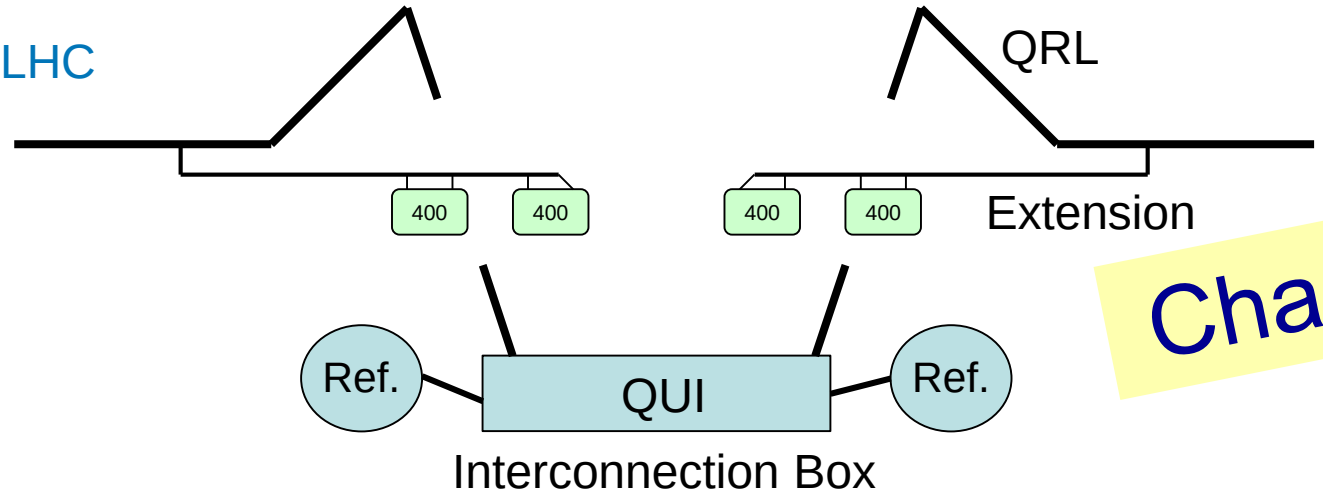
TCC#28, Short update 13 Apr 2017

Content

- Introduction
- Cooling requirements and possible upgrades (update)
- News: Capacity tests & status of 2nd feasibility study
- Summary

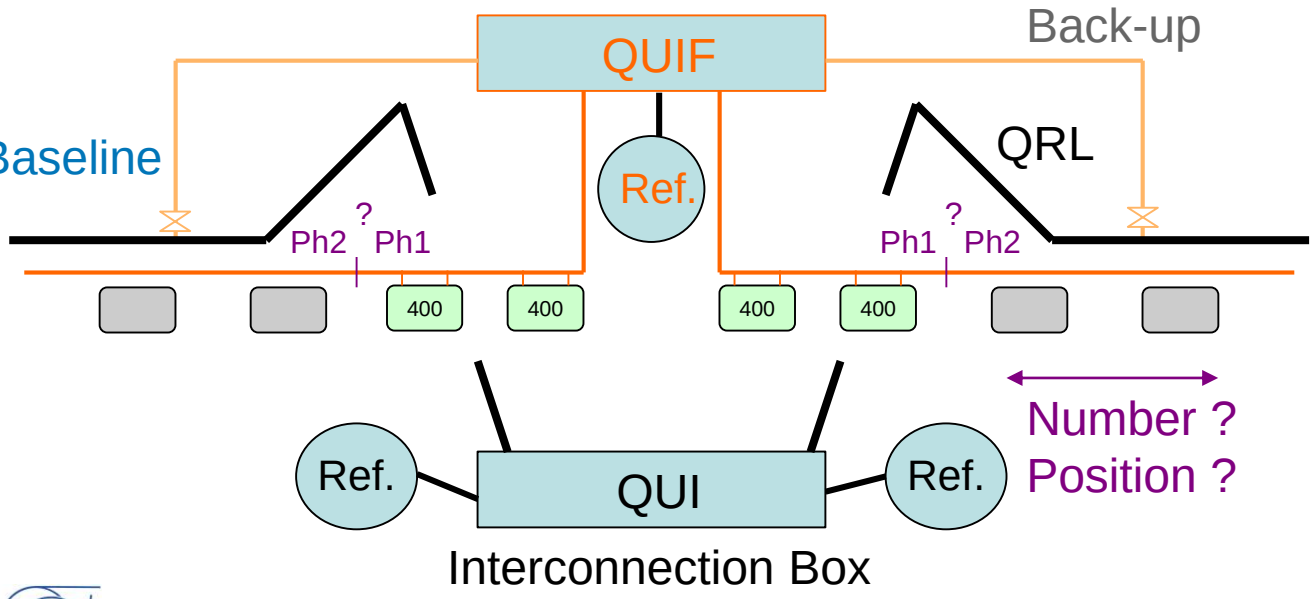
Cryodistribution basic schematics

Present LHC

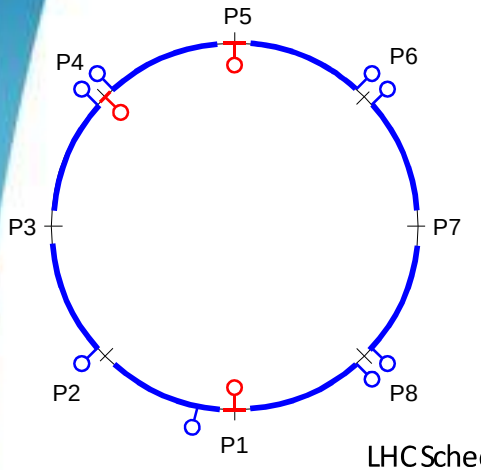


Cham'17

HiLumi Baseline



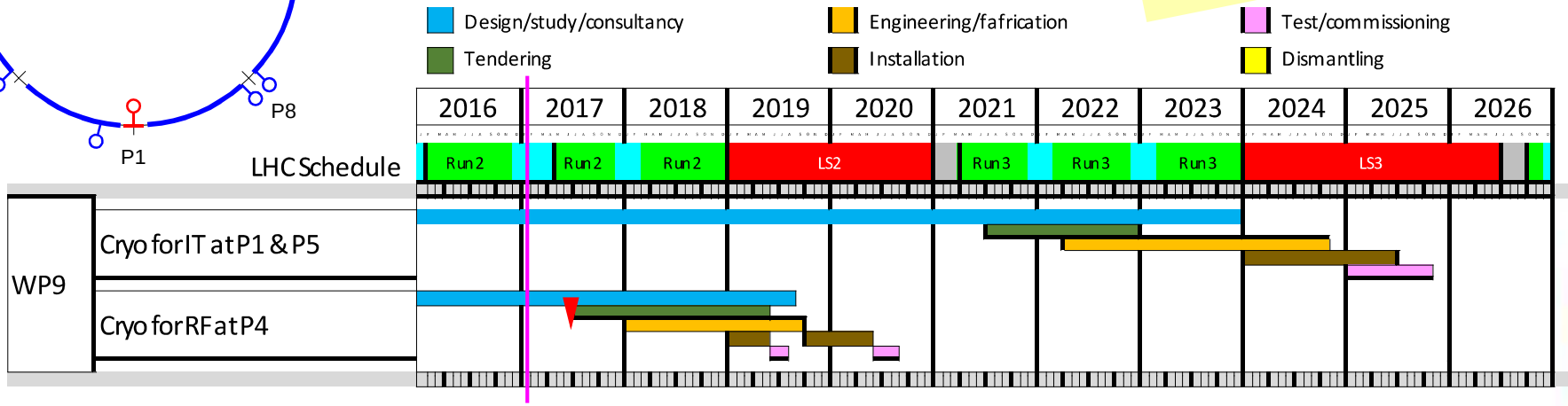
HL-LHC cryogenics master schedule



Major HL-LHC Cryo activities

(SPS-BA6 on tracks, in parallel wit

Cham'17



P4-RF:

=> Tests to be made in March'17 (away from critical path) to confirm capacity

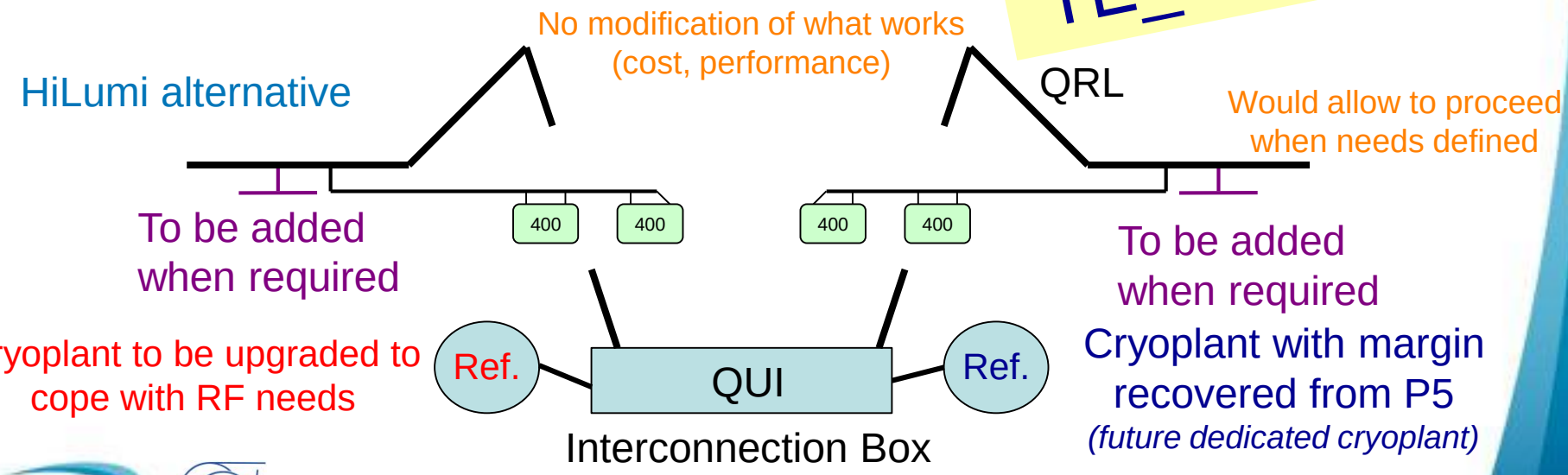
=> Decision baseline/alternative by end of 2016 (2017-Q2) for work @LS2

=> Then specification work 2017-Q3, contracts by end' 2017 (early 2018)

LHC-P4-RF main focus

- Continued efforts to define the global cooling capacity needs to match the existing and future RF needs at P4 *(incl possible e-lens)*
- Our aim: provide cooling capacity and distribution to match the needs with efficient solutions, not making it the weakest sector, avoiding unnecessary modifications (Cryo and others)
- Feasibility study to be launched in Jan'17, tests of existing equipment foreseen in March'17

TE_TM Jan'17



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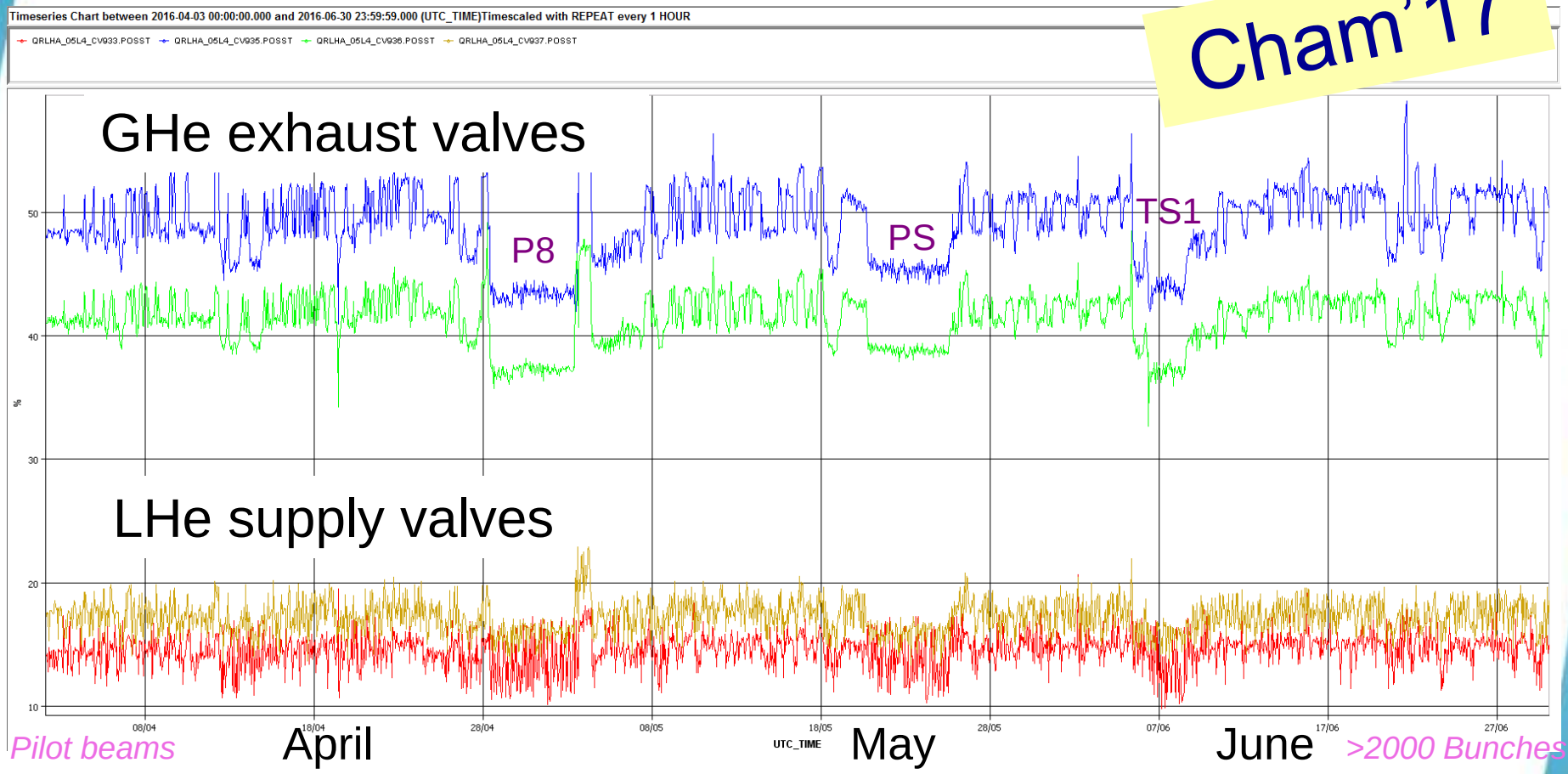
LHC RF cooling capacity

LHC intensity ramp-up 2016 (April-May-June)

Cham'17



=> We can conclude that cooling capacity is independent from beam intensity

"Cham." 2005

Cooling capacity (1/3)

"LHC Design report", recently completed by AB/RF

Complements since Cham'17, with input from RF-ABP

		Injection		Nominal	Maximum operation	Absolute Maximum
	MV/m	1 MV 2.75	1.3 MV 3.575	2 MV 5.5	3 MV 8.25	4 MV 11.0
Static	W			150		
Margin	W			25		
Dynamic	W	25	42 W	100	225	
Total	W	200		275	400	950

LHC so far

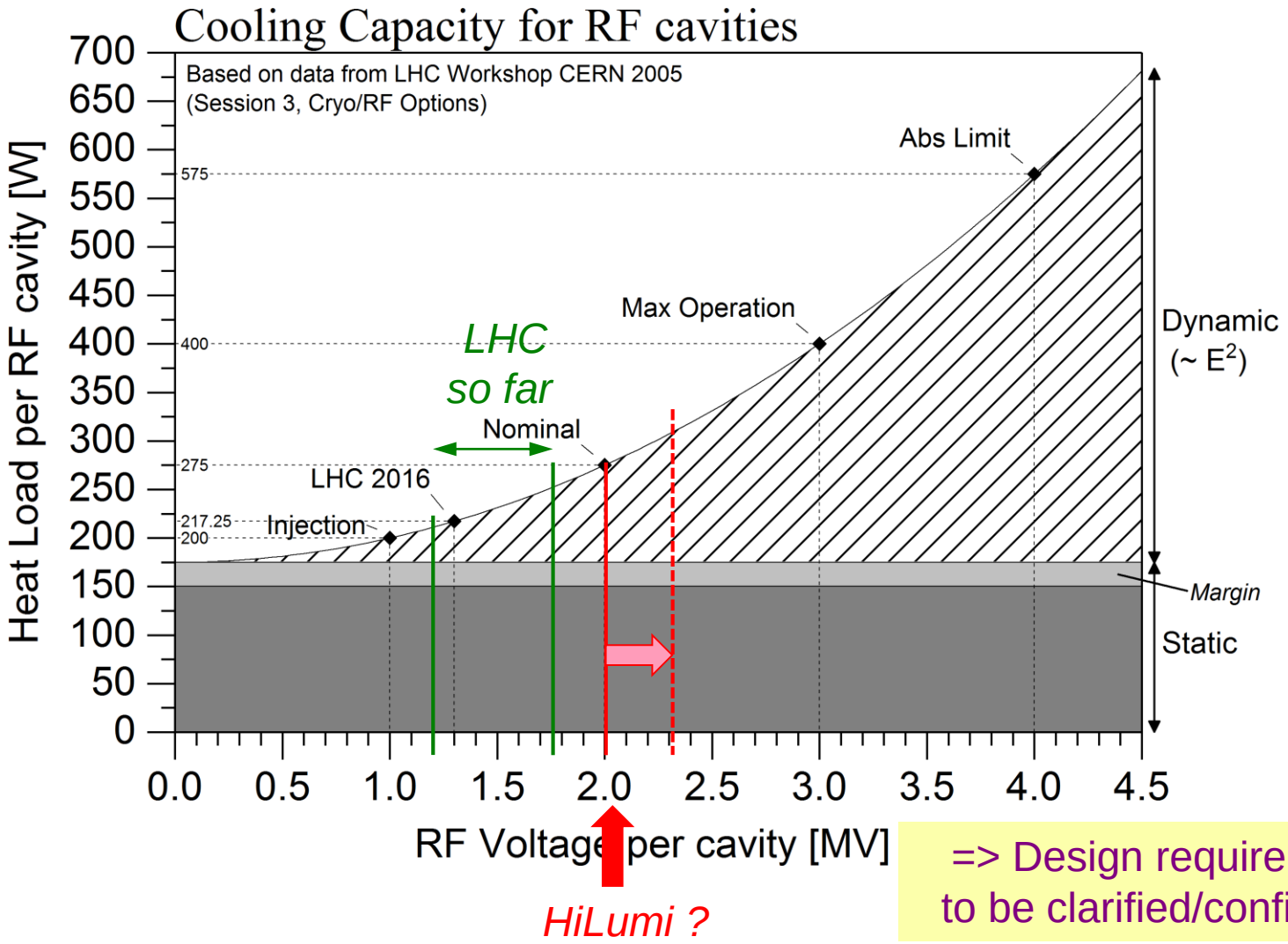
HiLumi ?

Conditioning

LHC Workshop CERN, January 2005

Session 3
Cryo/RF Options

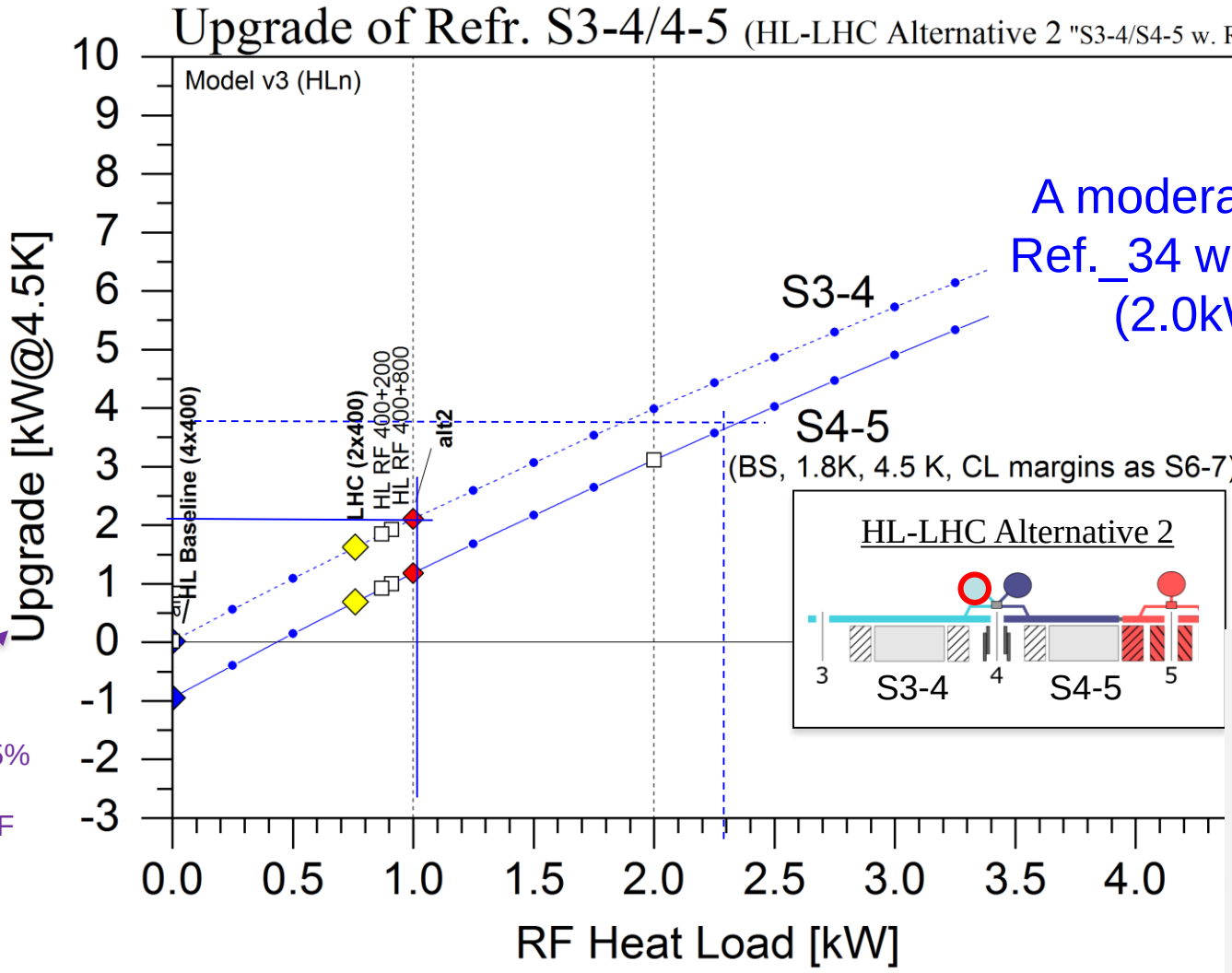
Cooling capacity for LHC-RF



=> Design requirements to be clarified/confirmed

Parametric Study
RF heat load vs Upgrade

New
Model v3
Since Cham'17



A moderate upgrade of Ref._34 would do the job (2.0kW@4.5K)

Includes +15% operational margin on RF heat loads.

With our present heat-load model:
- 56 – 45
- 81 – 12 (45*)
- 67 – 34 (34*)
- 23 – 78

**: alternative 2*

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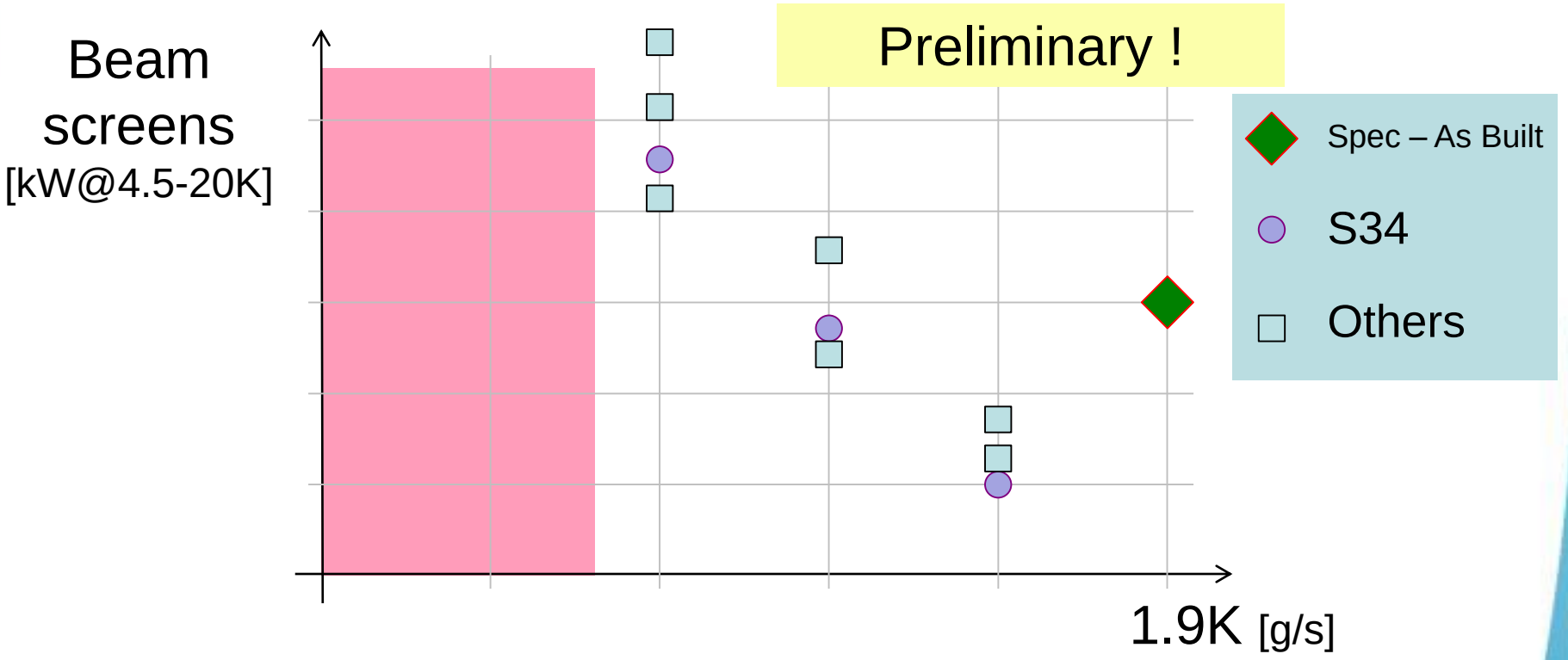
Performance tests done March'17

Combined tests with LHC operation margin limits for beam screens, not as ideal as for initial acceptance tests with a dedicated test box



- Results of these tests being analysed, and will be presented (TE_TM, LMC)
- Obviously some settings to be understood

Feasibility study

- Technical requirements and deliverables specified (EDMS_1753614)
  - Request: +2kW@4.5K , *and ONLY if not possible*
  - Variant 1: with decreased loads for thermal shields
  - Variant 2: maxi possible (<2kW)
  - Variant 3: with new 50m cryoline return at 4.5K (would be easy for Refrigerator, not standard for LHC and not yet studied-integrated)

Dedicated study purchased from manufacturer
- Definition of needs and boundary conditions
- Process study, with identification of major changes required
- Budget estimate

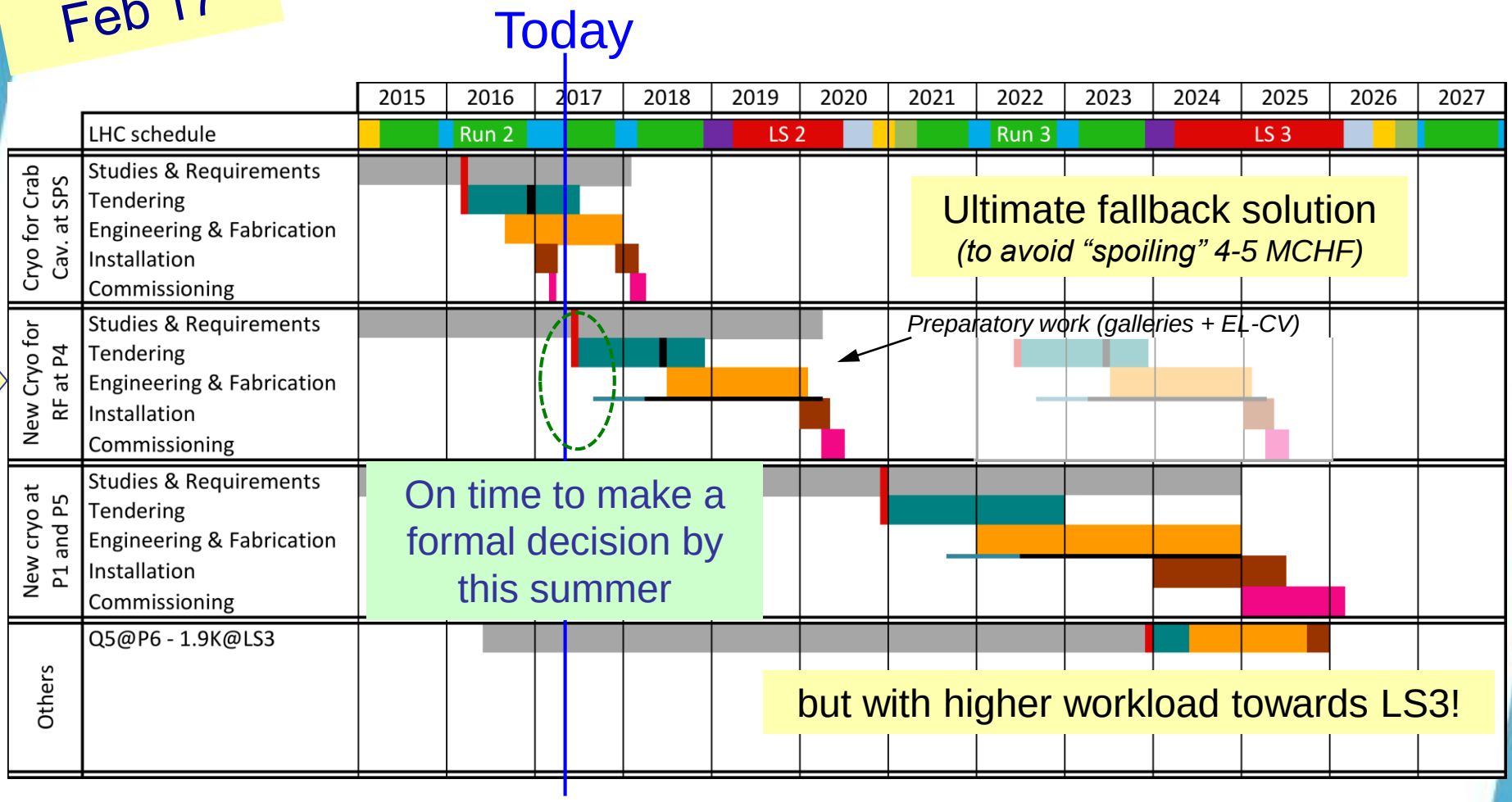
- Preliminary evaluation by industrial contractor (Linde) prior to commercial proposal

  Done with senior expert familiar with this particular 12/18kW@4.5K plant history

- Order being launched this week
- Preliminary report by end of June'17
- Final report in July'17

HL_PSM Feb'17

HiLumi Cryogenic masterplan



Just-in-time for SPS-BA6, last studies for LHC-P4 before decision,
Some more time for us for LHC P1/P5, but interfaces required by others

Summary

- As presented at Chamonix 2017:
- *For the upgrade of existing refrigerators at P4, a 1st feasibility study demonstrated the possibility. A 2nd study is being launched. Modification of the Cryogenic distribution line (QRL) will only be done on purpose when decision taken where to put new RF cavities (feasible as copy/paste of existing service modules)*
- *Decision by this summer for work to be done at LS2*

- We are now more confident that the 2nd feasibility upgrade will provide a positive outcome before this summer *(RF needs to be confirmed)*
- A bit of time left before the Go – NoGo limit for work to be done at LS2
- LHC Run 3 does not need extra capacity at LHC-P4, and if really necessary we could install new cryoplant and cryolines at LS3, with resources to be re-profiled

Complements

Dear Philippe
For HLLHC we are assuming 16 MV as nominal voltage.
Any possibility to operate at larger voltage (up to nominal: 16 MV) and larger longitudinal emittance (same bunch length) might be interesting even during Run 2.
I think Elias mentioned that last year and discussed with Elena and you at one of the LBOC meetings
Cheers
Gianluigi

Subject: RE: Chamonix, operation RF LHC

Hello Serge

In 2016 the RF was operated at 1.25 MV/cavity for protons and 1.75 MV/cav for Pb (in physics). In previous years we have operated with 1.5 MV/cavity in p-p. The "nominal" voltage in physics was 2 MV/cavity in the LHC design report (16 MV/beam**). We may operate at 2 MV/cavity in HiLumi.** So the cryo upgrade must cover operation at 2 MV/cavity "comfortably".

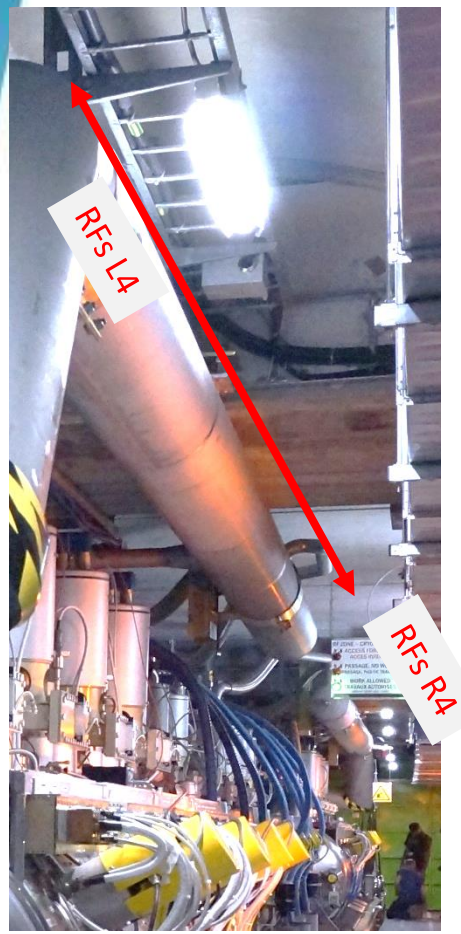
During conditioning in SM18, the RF gradient was pushed to 10 MV/m, resulting in ~3.5 MV (dixit Roberto Losito. I was not present...). So far, in the machine we have conditioned at 2+ MV only as the cavities were operated below that level in physics. If we go for 2 MV/cavity in physics, the conditioning should be pushed somewhat above 2 MV. So the cryo plan must have a margin for RF conditioning above 2 MV.

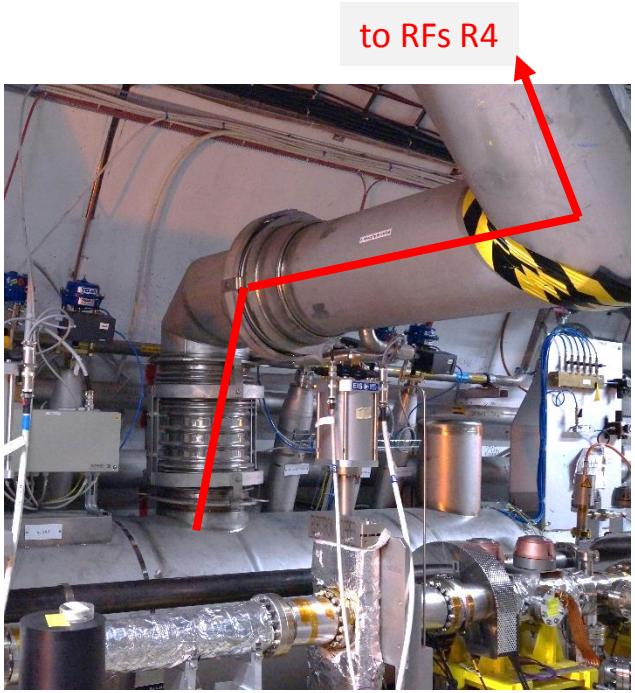
With the new "Full Detuning" scheme, the limit is not the RF power anymore. So we could use more voltage if needed. The hard limit is what gradient the cavity can live at reliably in physics. Although the HiLumi parameters do not plan to operate above 2 MV/cavity, it would be ideal to dimension the cryo for the maximum voltage possible for the cavities. Karl Shirm (in cc) is on charge of the cavities. I leave it to him to specify the "safe" operational (physics) voltage limit, and how much above 2 MV we expect to condition at.

I also cc Elena and Gianluigi. They may wish to comment on the possible operational voltages in HiLumi physics.

Cheers, Philippe

Present LHC P4-RF distribution line

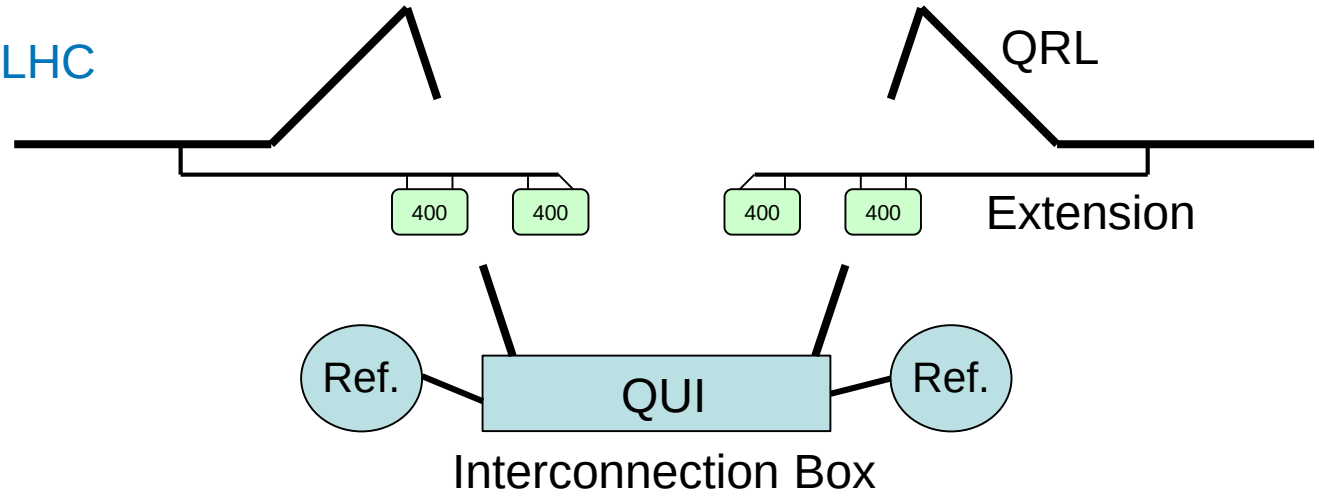




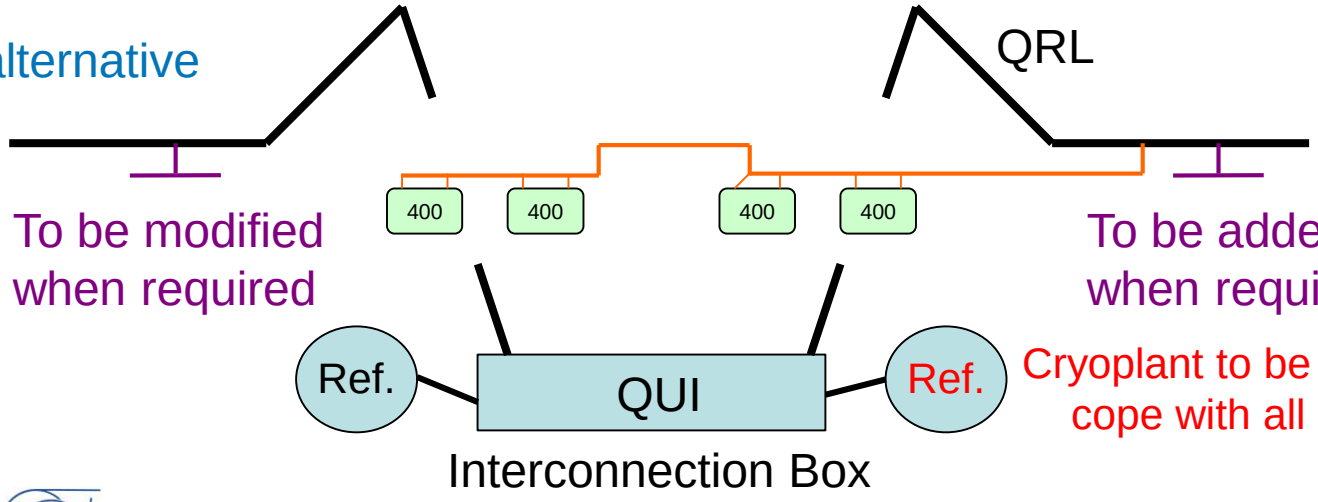
Connection to QRL and distribution along the existing and “future” RF zone (+e-lens!) to be looked at for present baseline and alternative scenario

Cryodistribution basic schematics (2/3)

Present LHC



HiLumi alternative



Cryodistribution basic schematics (3/3)

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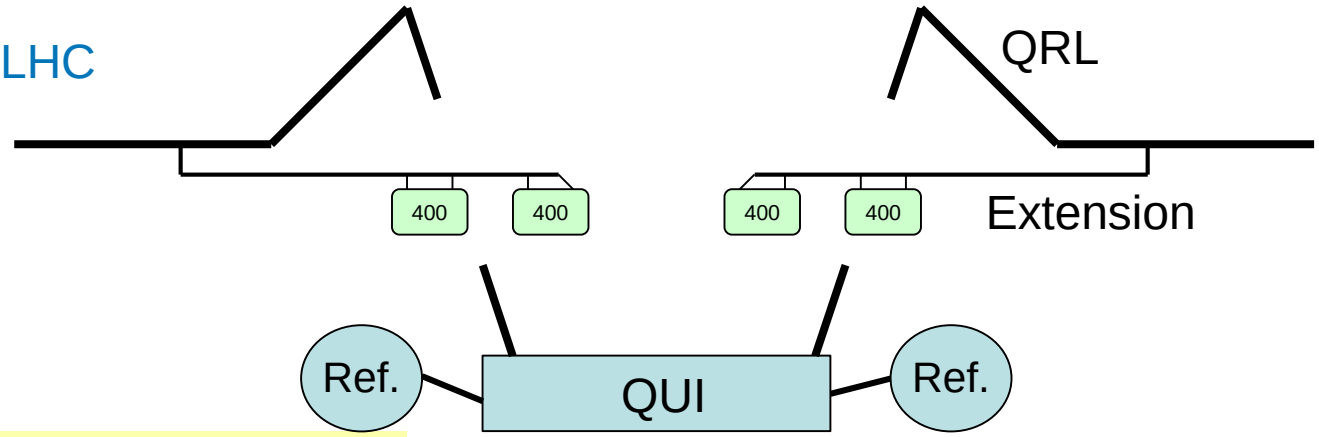
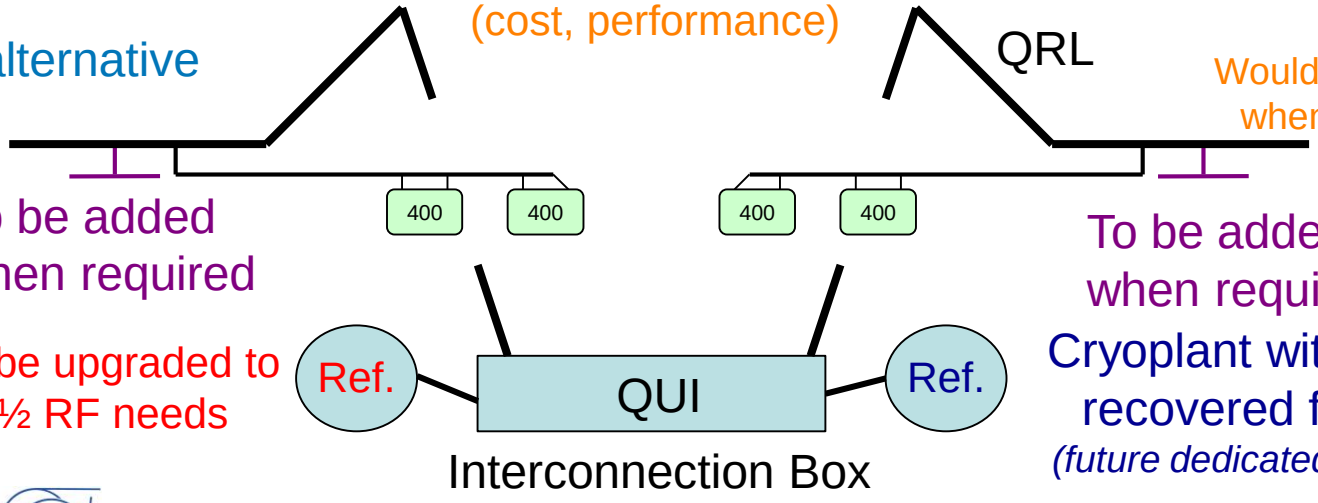


Feasibility to be checked for smaller upgrade of 34

No modification of what works (cost, performance)

HiLumi alternative



Would allow to proceed when needs defined

To be added when required

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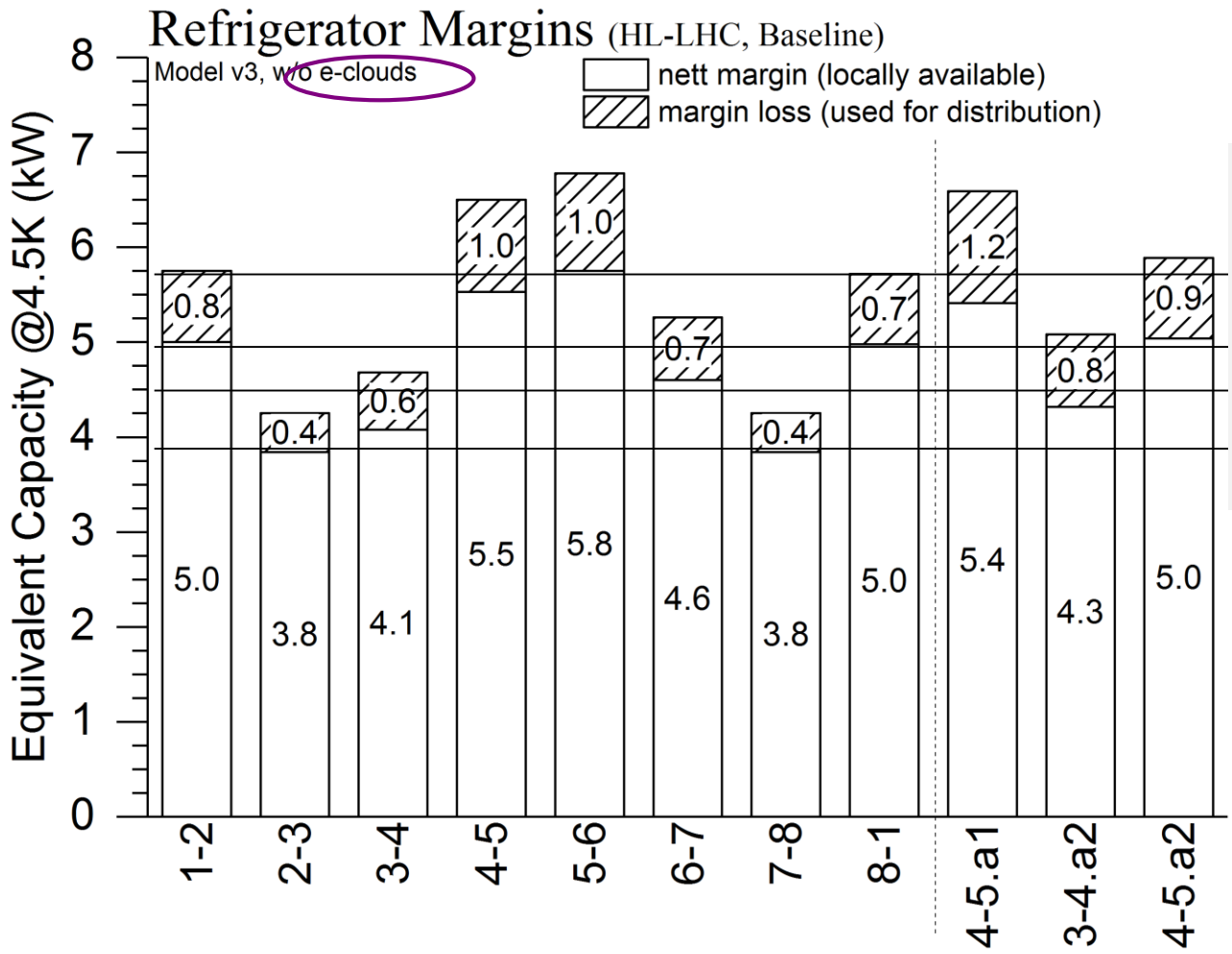
Cryoplant to be upgraded to cope with ½ RF needs

Cryoplant with margin recovered from P5 *(future dedicated cryoplant)*



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