SM 18 infrastructure focused on SPL cavity tests

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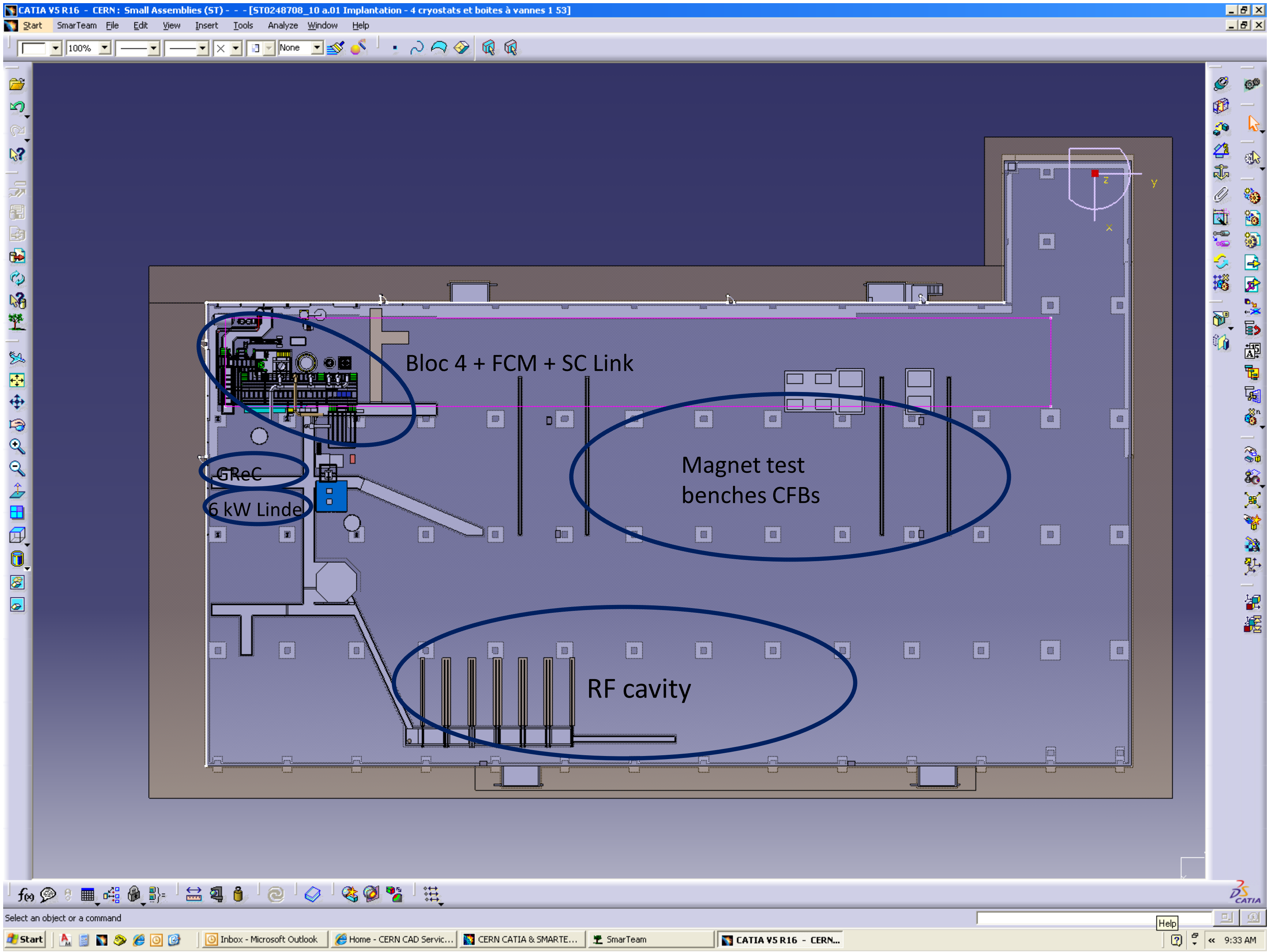
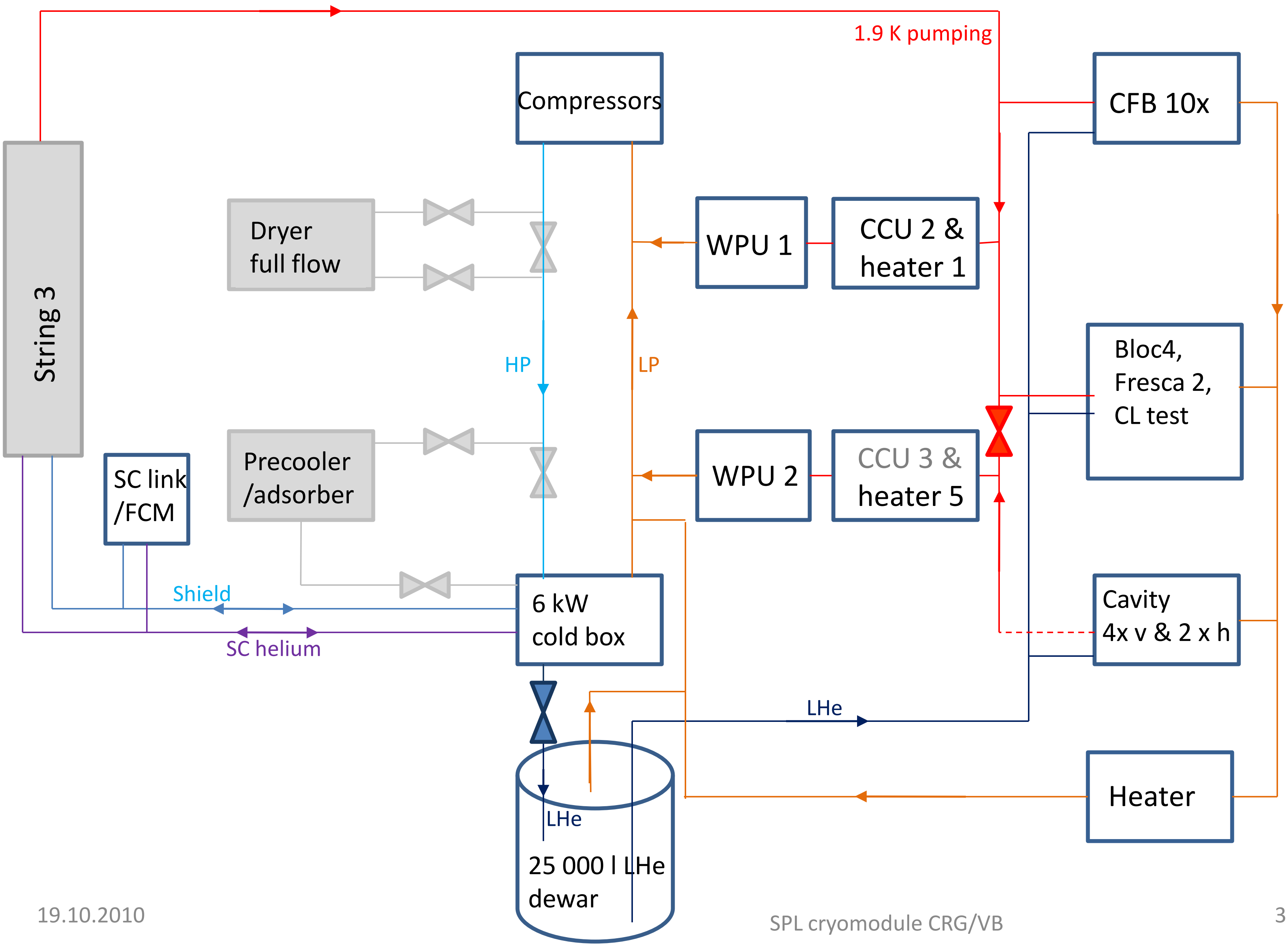
SM 18 layout, current status



SM 18 cryogenic simplified flow scheme

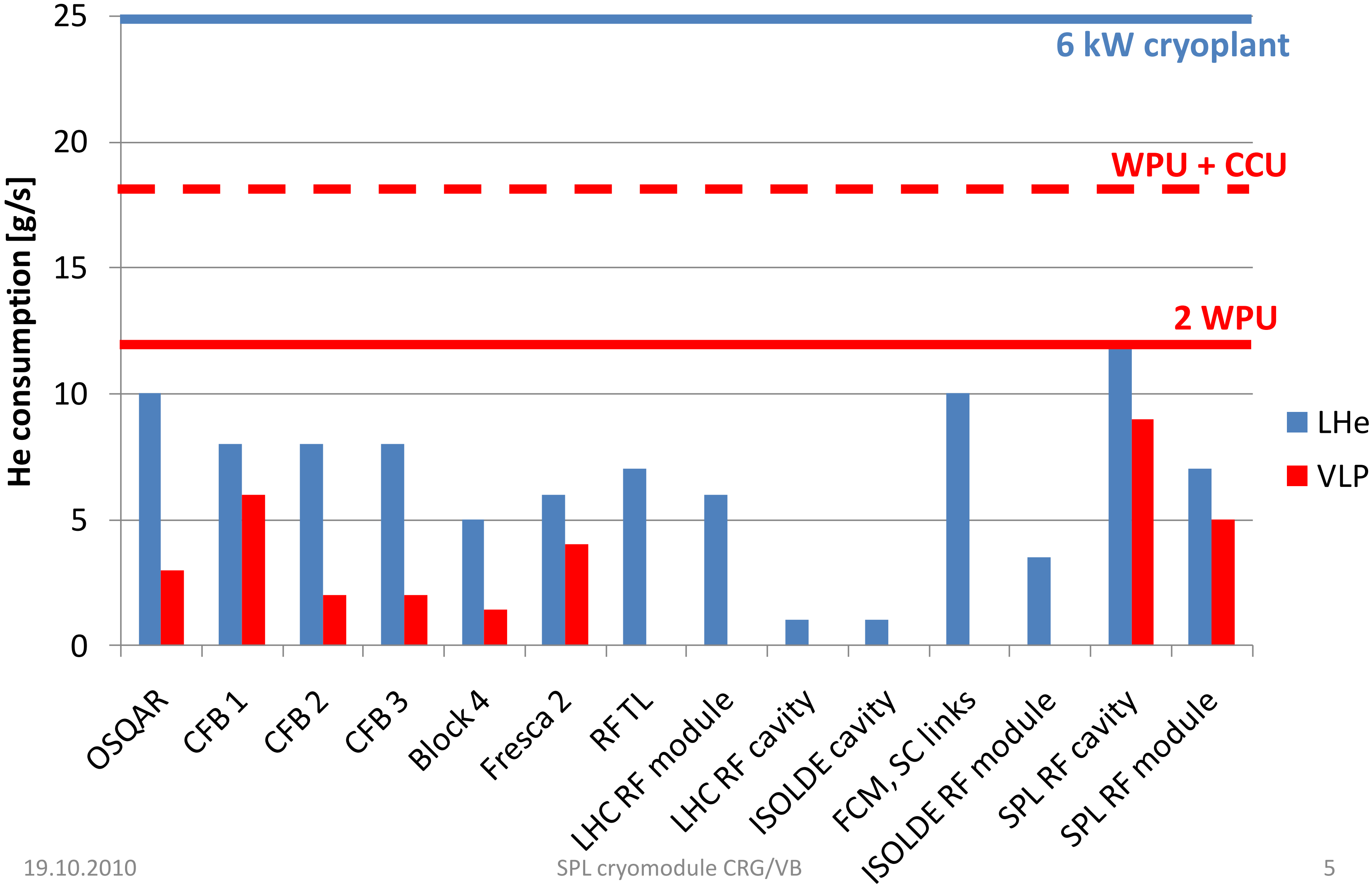


Main inputs of SM 18 cryogenic infrastructure

- The 6 kW Linde cold box
  - Capacity: 25 g/s (700 l/h) of LHe
- The 1.8 K pumping capacity
  - 2 warm pumping units (WPU), each one of a following pumping speed:
    - 6 g/s @ 10 mbar
    - 12 g/s @ 20 mbar
    - 18 g/s @ 30 mbar
  - To each pumping unit is dedicated one very low pressure heater of 32 kW (20g/s)
  - The cold compressor (CCU) & one WPU in series: 18 g/s @10 mbar
  - One WPU is dedicated to CFBs and Bloc 4 including CCU if necessary
  - Second WPU will be dedicated to cavity tests
  - Both WPUs can work in parallel
- New clients
  - Bloc 4, FCM, SC Link: LHe & pumping capacity
  - Cavity: Pumping capacity will required one WPU

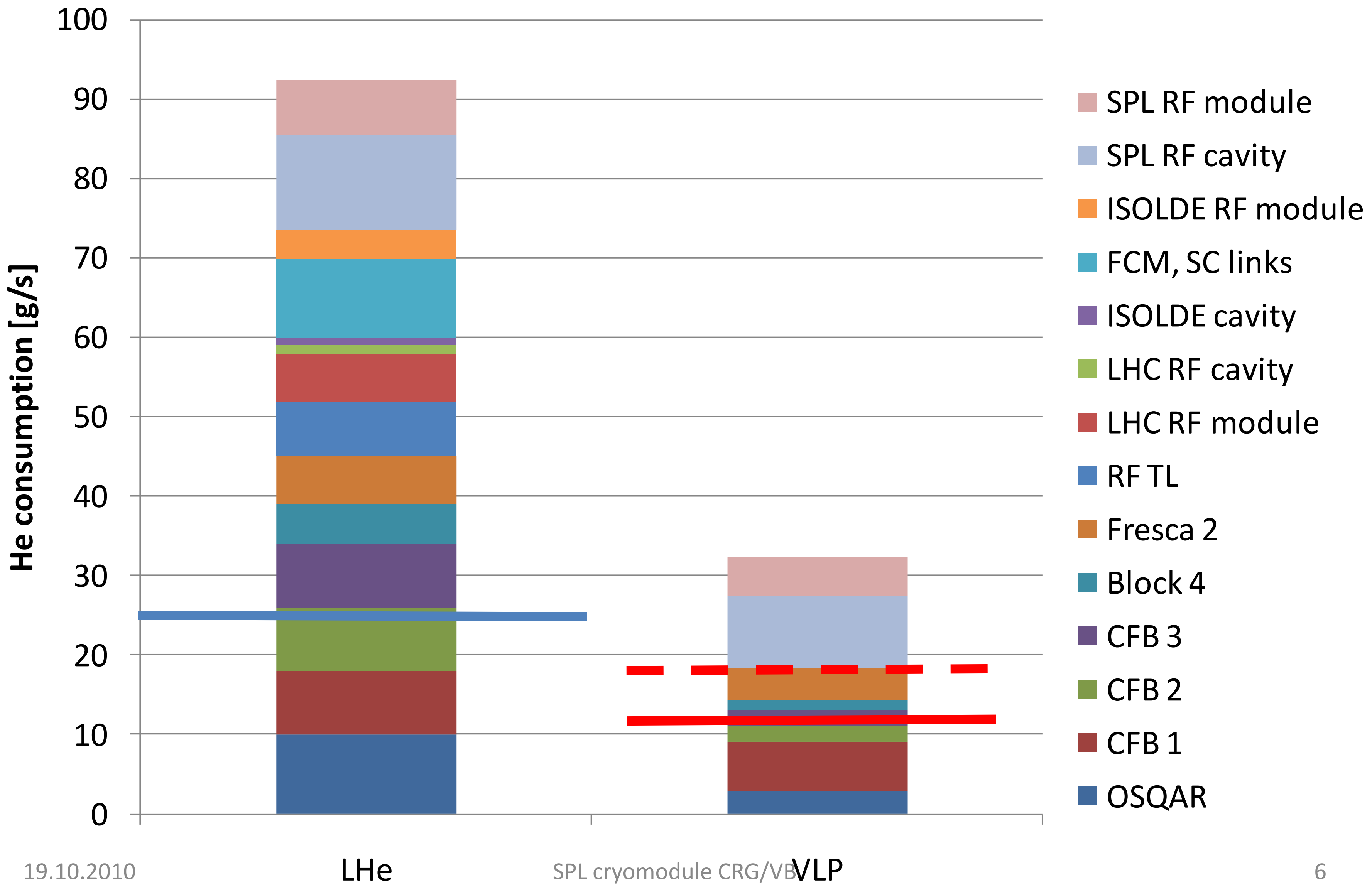
Individual tests compatible with SM18 test capacity…

L. Tavian

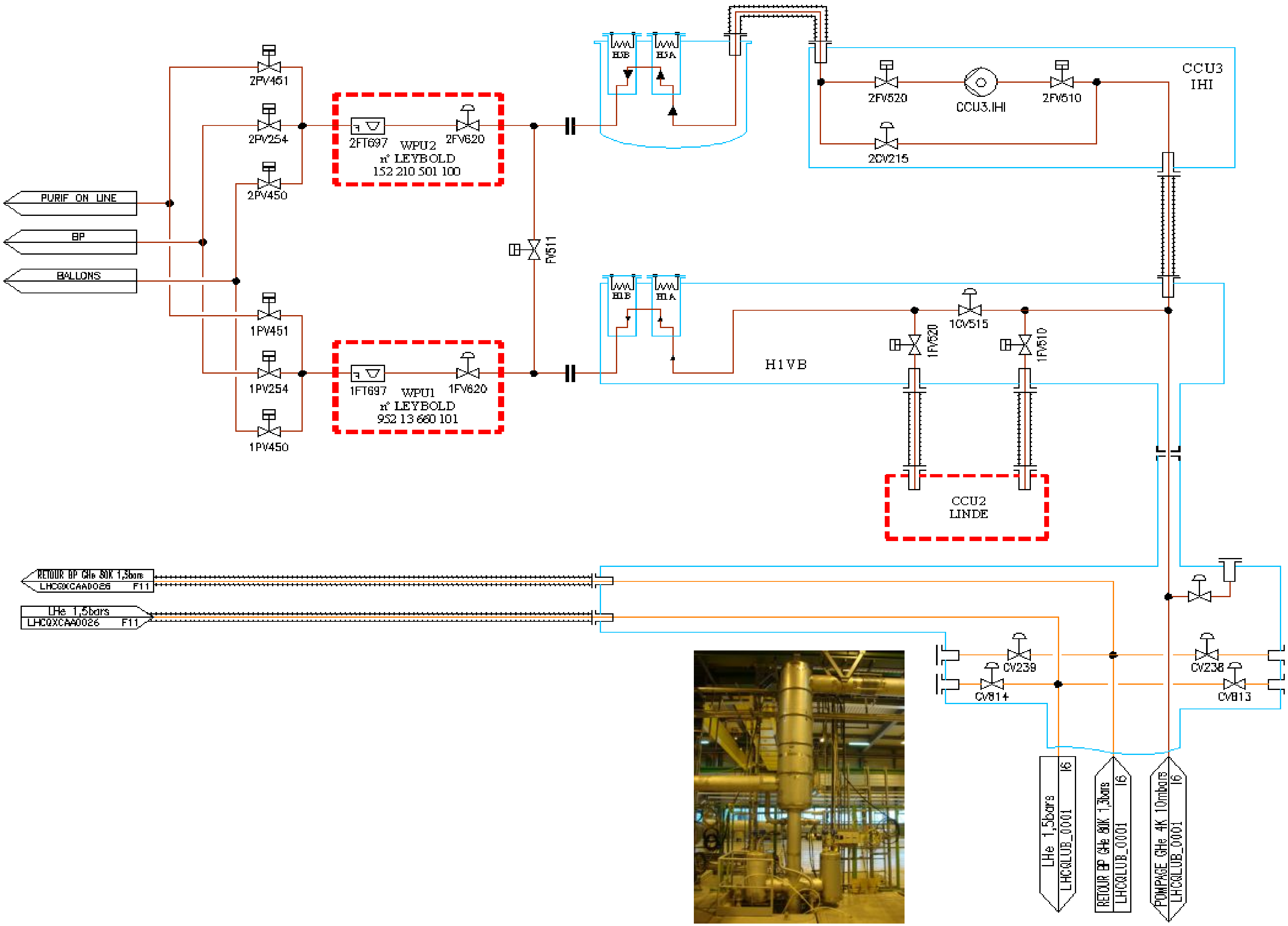


… but not all together ! → Coordination and …

L. Tavian

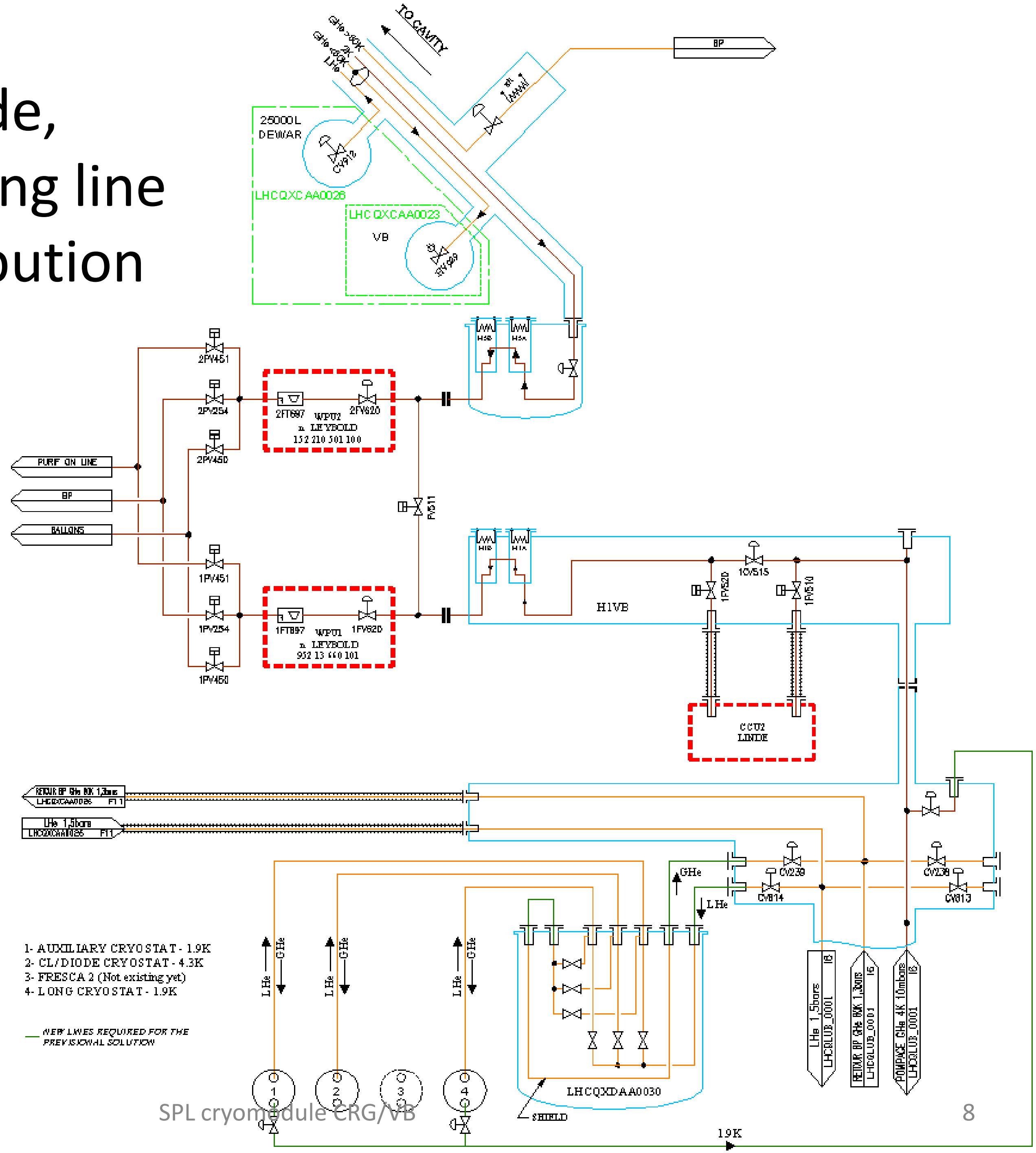


LHe distribution & 1.9 K pumping, current status

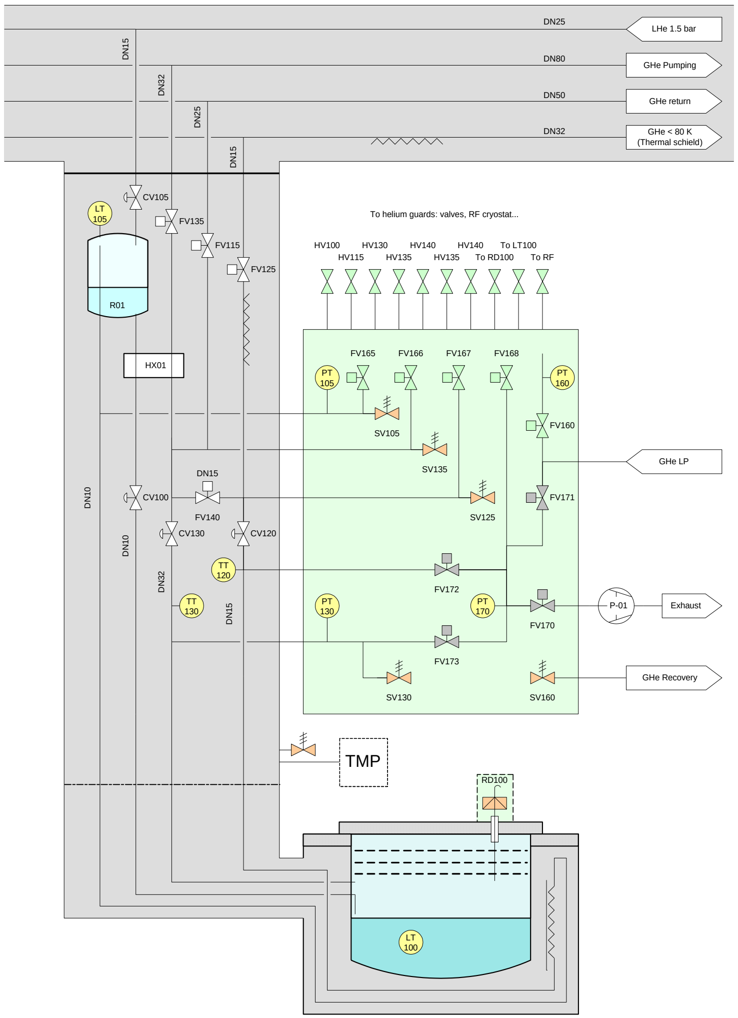


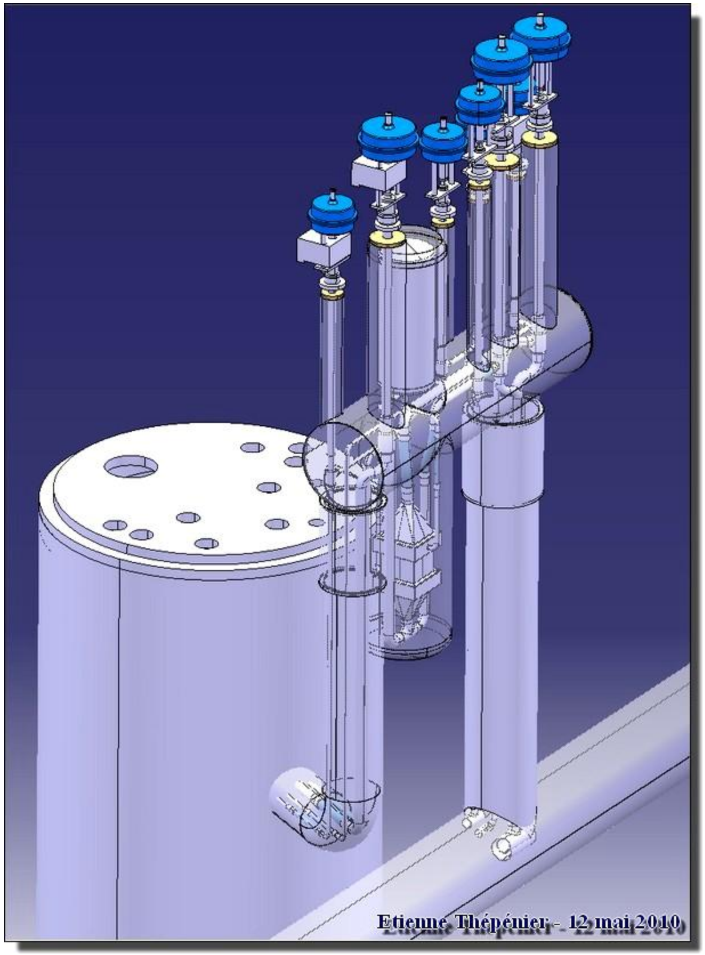
SM 18 upgrade, new cavity pumping line and Bloc 4 distribution

simplified scheme

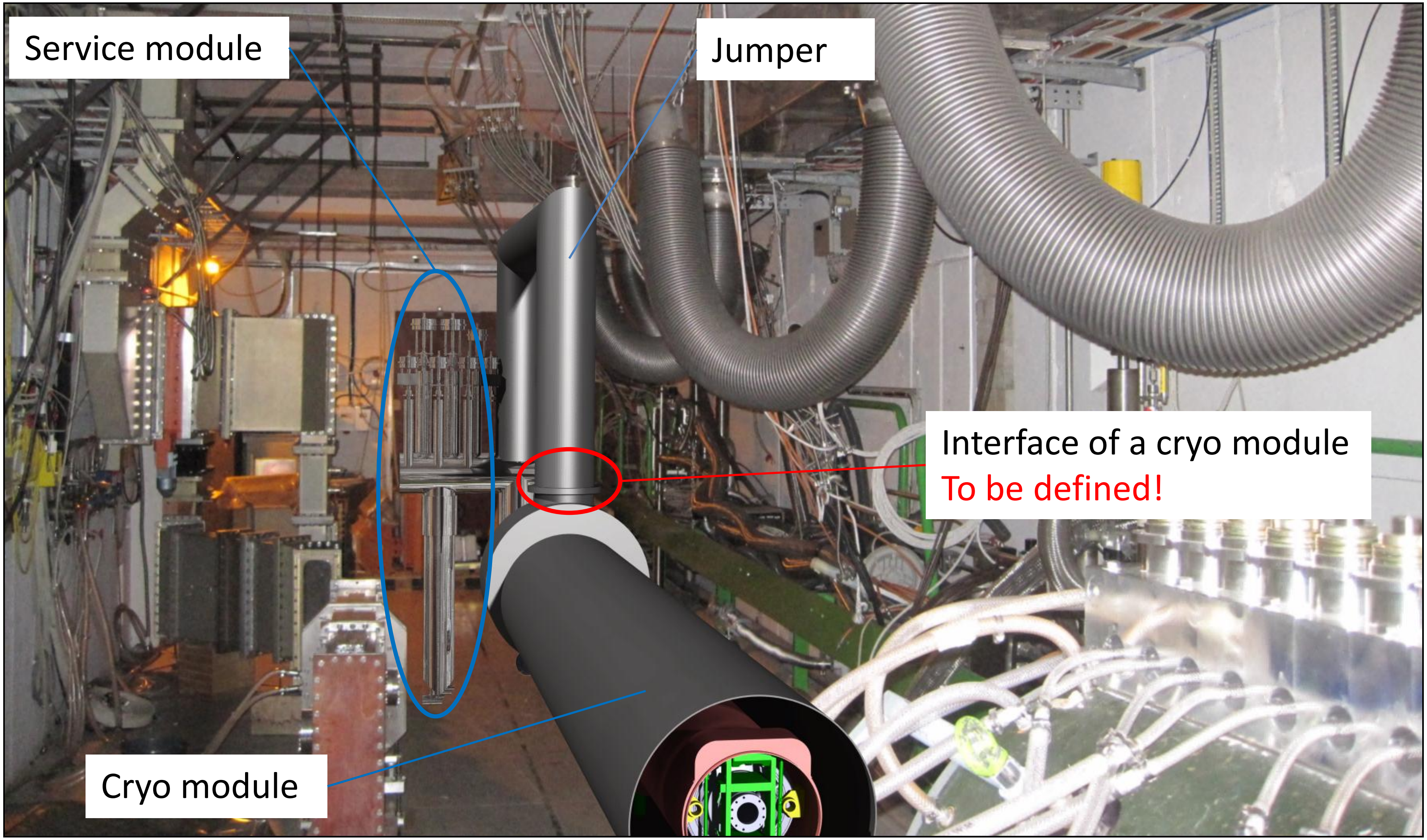


2 K RF service module





Cryo module in the bunker – simulation



Clarification of the required cryogenic power @ 2 K

Operating condition	Value (nominal/"ultimate")
cryo duty cycle	4.11%/8.22%
quality factor	10/5 x 10^9
accelerating field	25 MV/m

Source of Heat Load	Heat Load @ 2K (nominal/"ultimate")
dynamic heat load per cavity	**5.1/20.4 W**
static losses	**<1 W (tbc)**
power coupler loss at 2 K	**<0.2/<0.2 W**
HOM loss in cavity at 2 K	**<1/<3 W**
HOM coupler loss at 2 K (per coupl.)	**<0.2/<0.2 W**
beam loss	**1 W**
Total @ 2 K	**8.5/25.8 W**

Ultimate heat load @ 2 K for 8 cavities is:
8 x 25.8 = 208 W

W. Weingarten 25 May 2010
Functional specification of SM18 SRF vertical test-place, rev. 3

Table 7: Basic numbers needed for the estimation of the lHe consumption

some variables	Quadru-pole reso-nator	SPL cavity	HIE-ISOLDE cavity	LHC cavity	SPL cryomodule	HIE Isolde cryomodule	LHC cryomodule
Required cryostat/bunker	V4	V3	V5	V6	B 1	B2	B2
Helium volume [l], estimation	1400	1400	2300	2300	300	100	100
Duration of individual test [weeks]	4	2	2	2	4	4	4
Weight to cool down (estimation) [kg]	50	63	60	38	500	300	153
lHe evaporation to cooldown from 300 K -> low temperature [kg]	10.5	13.1	5.6	3.6	105.0	28.0	14.3
lHe evaporation to cooldown from 4.5 K to nominal temperature [kg]	2.2	2.2	0.0	0.0	0.5	0.0	0.0
Nominal temperature [K]	2.0	2.0	4.5	4.5	2.0	4.5	4.5
Duty cycle [%] for test, min	50	50	50	50	5	50	50
Duty cycle [%] for test, max	100	100	100	100	5	100	100
Number of cavities per cryomodule	n/a	n/a	n/a	n/a	8	5	4
Standby heat load [W], measured/estimated	3.5	3.5	10	3.5	35	20	50
Dissipated power [W] under usual test conditions, min	1	88	5	10	70[5]	25	40
Dissipated power [W] under usual test conditions, max	1	175	10	20	70	50	80
Helium mass flow [g/s] eq. 4.5 K, min	0.3	6.2	0.7	0.6	7.1	2.1	4.3
Helium mass flow [g/s] eq. 4.5 K, max	0.3	12.1	1.0	1.1	7.1	3.3	6.2
Helium consumption [kg] eq. 4.5 K per test, normal test conditions	624	6434	746	670	16151	4842	9642
Helium consumption [kg] eq. 4.5 K per test, under intense RF processing	700	12605	993	1164	16151	7516	13921

[5] since the scope of the SPL study is now focused on high power instead of low power, i.e. 5 % and no longer 0.2 % duty cycle, the dynamic cryogenic load in bunker for the SPL cryomodule, as indicated in the version of 6 January, must be multiplied by a factor of 5/0.2 = 25, corresponding now to 75 Watt instead of 2.8 W for one cryomodule (with 8 cavities).

What is the maximum required cryogenic power @ 2 K for a module of 8 cavities: 208 W or 75W?

SPL cavity and SPL module cannot be tested simultaneously.

Some questions

1)Cryo module interface to be defined (welded sleeve, 4 x flexibles), as well as allocated volume in the bunker for Cryo equipment.
2)Required cryogenic power @ 2 K to be clarified.
3)Is there any limit of dT during cool down/warm up?
4)Required speed of warm up; procedure?
5) What is a heat inleak to the thermal shield.
6) Point A in the table ??
7) Point B: Safety valve adjustment?
8) Point C: Available temperature of GHe is 5 K.
9) Point D: Available pressure is 0.13 MPa.

Line	Description	Pipe Size (ID,mm)	Normal operating pressure [MPa]	Normal operating temperature [T]	Cool-down/warm-up pressure [MPa]	Cool-down/warm-up temperature [K]	T range [K]	Maximum operating pressure [MPa]	Design pressure [MPa]	Test pressure [MPa]	Comment
L	Cavity helium enclosure	400	0.0031	2	0.13 @ 293K 0.2 @ 2K (A)	293-2	2-293	0.15 @ 293K 0.2 @ 2K (B)	TBD	TBD	
X	Bi-phase pipe	100	0.0031	2	0.13 @ 293K 0.2 @ 2K	293-2	2-293	0.15 @ 293K 0.2 @ 2K	TBD	TBD	
Y	Cavity top connection	80	0.0031	2	0.13 @ 293K 0.2 @ 2K	293-2	2-293	0.15 @ 293K 0.2 @ 2K	TBD	TBD	
XB	Pumping line	100	0.0031	2	0.13 @ 293K 0.2 @ 2K	293-2	2-293	0.15 @ 293K 0.2 @ 2K	TBD	TBD	
E	Thermal shield supply	40 (TBD)	2.0	50-75 (20-40 on test stand?)	2.0	293-50	50-293	2.0	2.0		Heat intercept
E'	Thermal shield return	15 (TBD)	2.0 (D)	50-75 (20-40 on test stand?) (C)	2.0	293-50	50-293				Return only
W	Cryostat vacuum vessel	1000 (TBD)	vacuum	293	vacuum	293	237-293	O.P. 0.1	I.P. 0.15	N.A.	
C1	Cavity filling	4	0.1	4.5	0.1	293-4.5	4.5-293				Liquid supply
C2	Coupler cooling	15 (TBD)	0.1	4.5-293	0.1	293-4.5	4.5-293				Gaseous supply
C3	Cavity top supply	6	0.1	2	0.1	293-4.5	2-293				Liquid supply