



Cryogenic Upgrade of the Helium Central Liquefier and Superconducting Cable & Wire Test Facilities at CERN

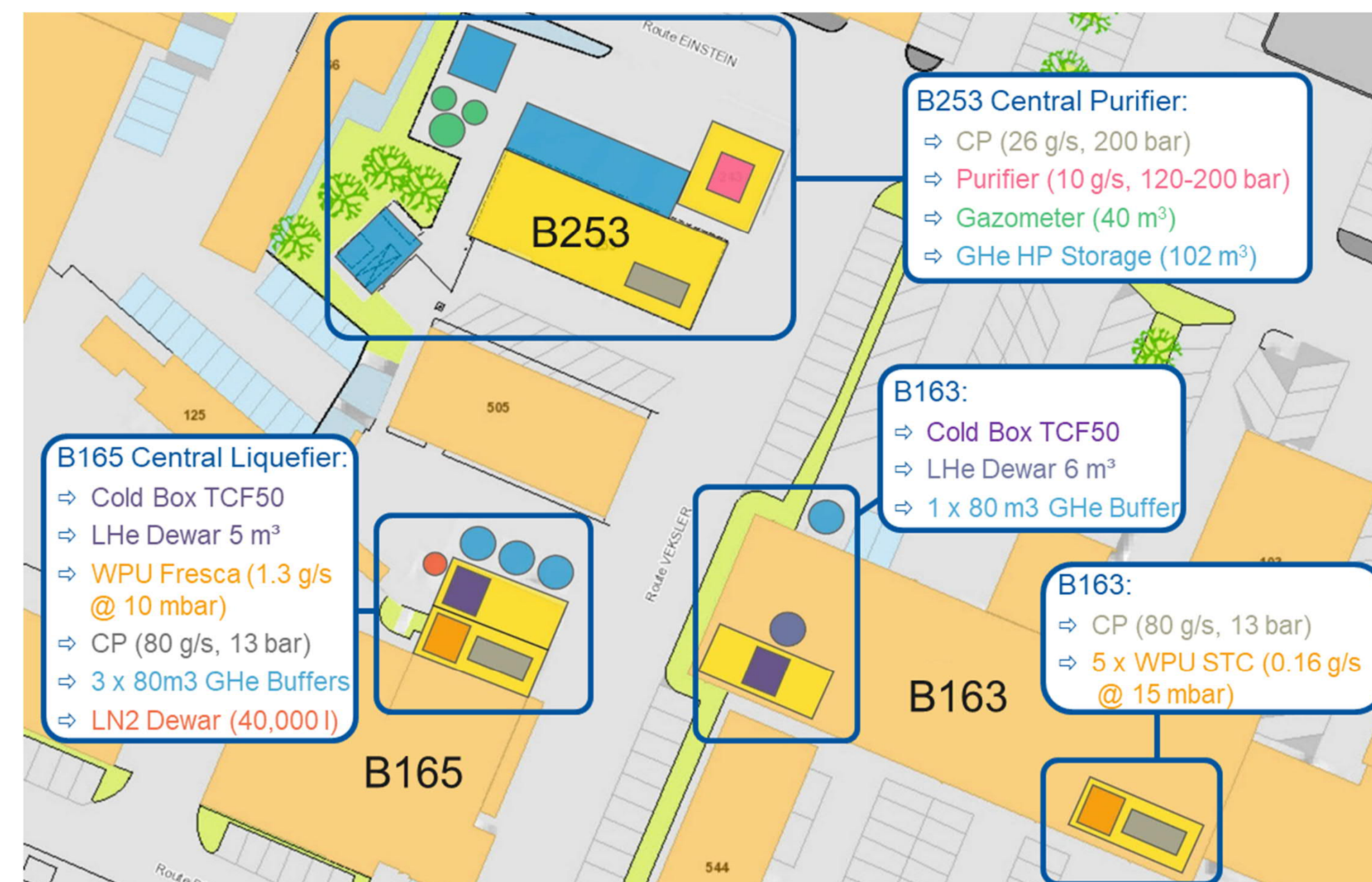
C2Po2A-06 [20]



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Introduction

Central cryogenic infrastructure of the CERN Meyrin site



B165 – Central Liquefier

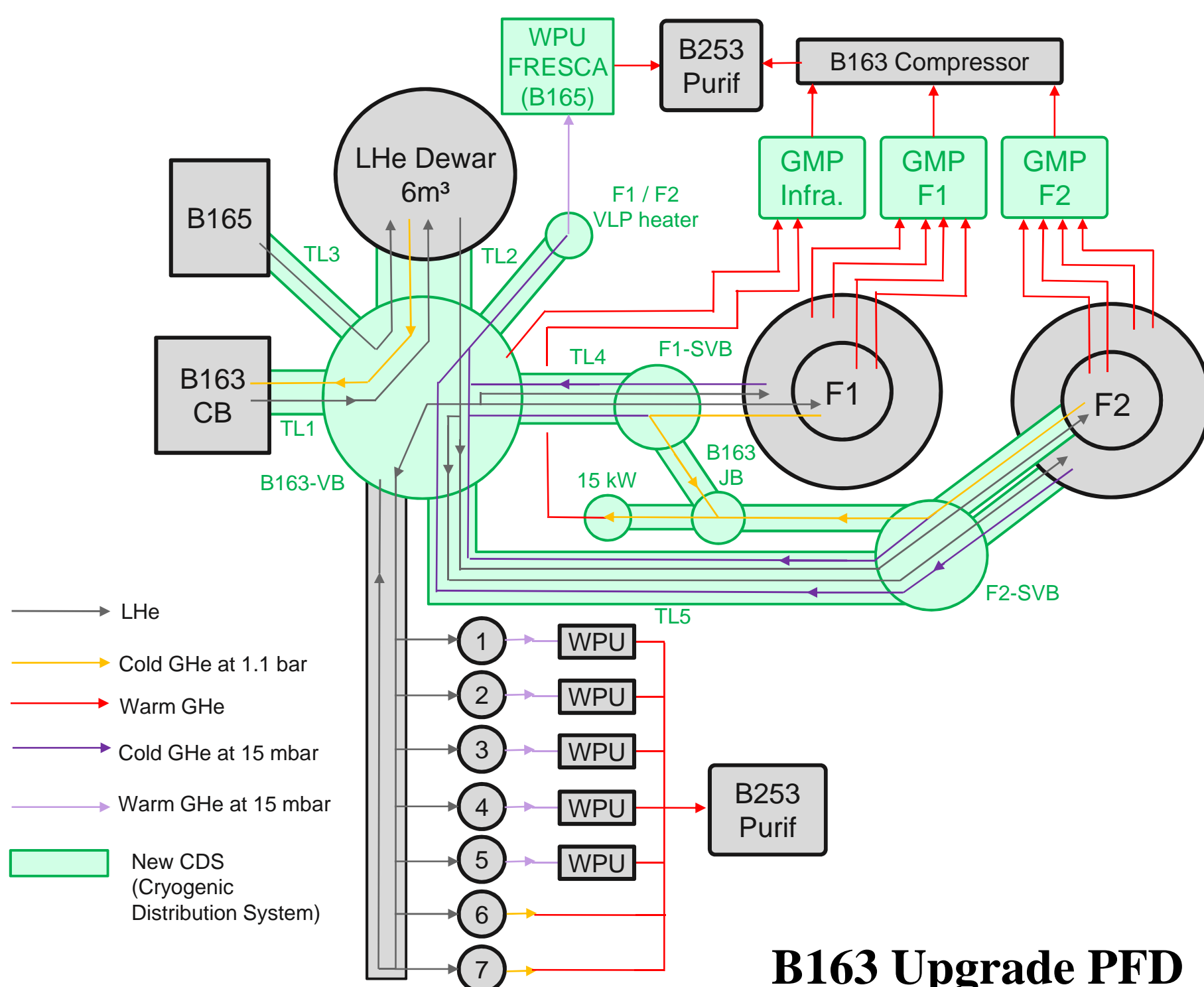
- Supply of 100 l to 500 l LHe mobile dewars to 30 clients CERN wide without dedicated cryogenic infrastructure
- 1998-2006 : average annual LHe volume of 250,000 l
- After 2007, increase due to LHe requirement of experiments in Antiproton Decelerator (AD). Peak of 400,000 l in 2010
- Increase of TCF50 production capacity to 160 l/h (boosted with LN₂), but limitation from LHe storage of 5,000 l

B253 – Central Purifier

- 3 kPa GHe recuperation network
- Two Linde purifiers 120 m³/h @ 120-200 bar
- Impure and pure GHe HP storage @ 160 bar (1,000 l jumbo cylinders and 50 l batteries)

B163 – SC Wire and Cables Test Facilities

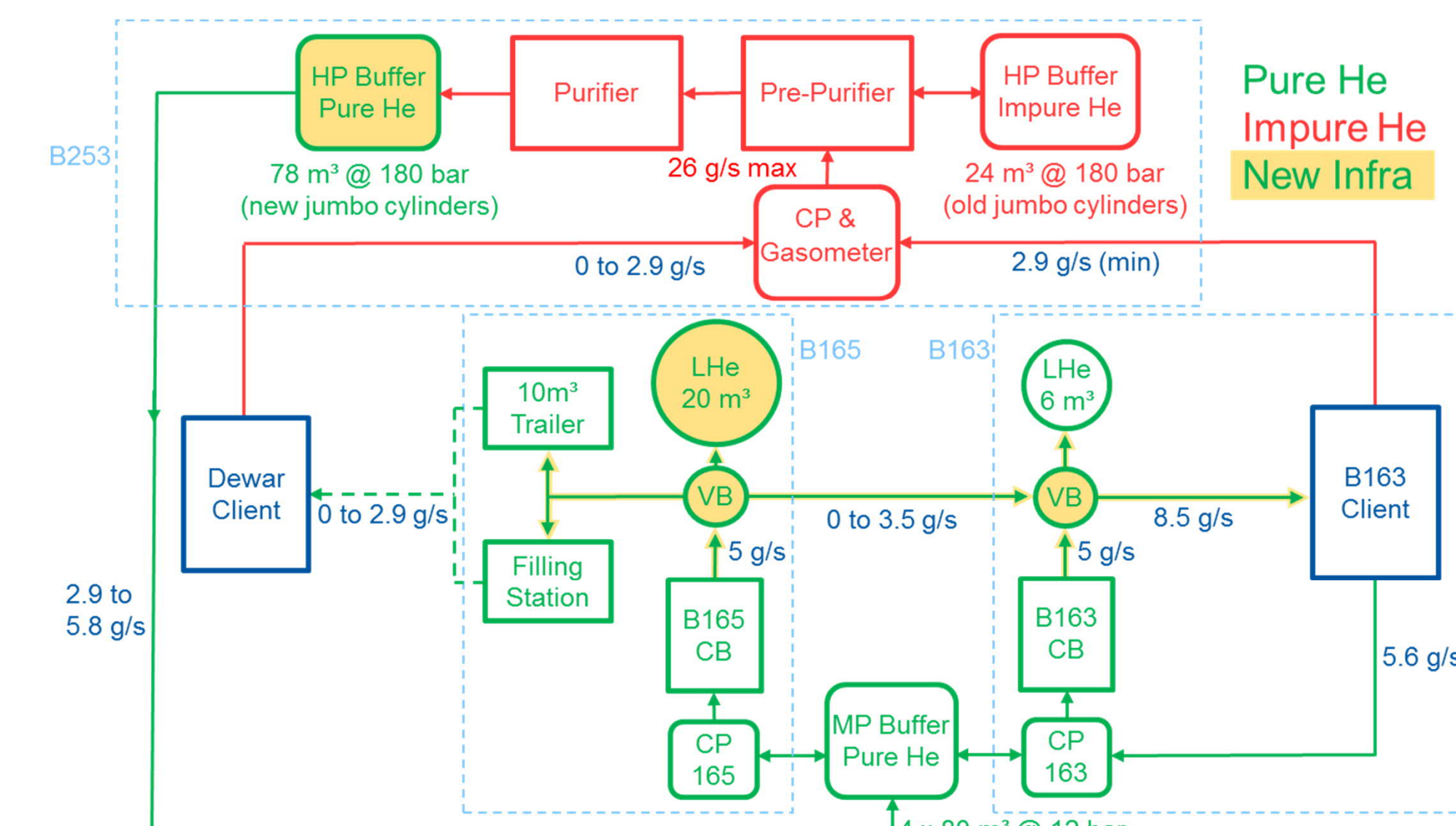
- Sulzer TCF50 boosted with LN₂ : 160 l/h (5.2 g/s)
- Seven small test cryostats (STC) to test SC wires @ 1.9 K
- 6000 l LHe dewar supplying FRESKA double test cryostat (F1) to test SC cables (NbTi) @ 1.9 K in a field of max 10 T
- In project: FRESKA2 (F2) to test new generation of SC cables (Nb₃Sn) and HTS cables under field of 13 T



Definition of upgrade

Harness the full production capacity of the two existing TCF50 to meet the future LHe requirements in B165 and B163 :

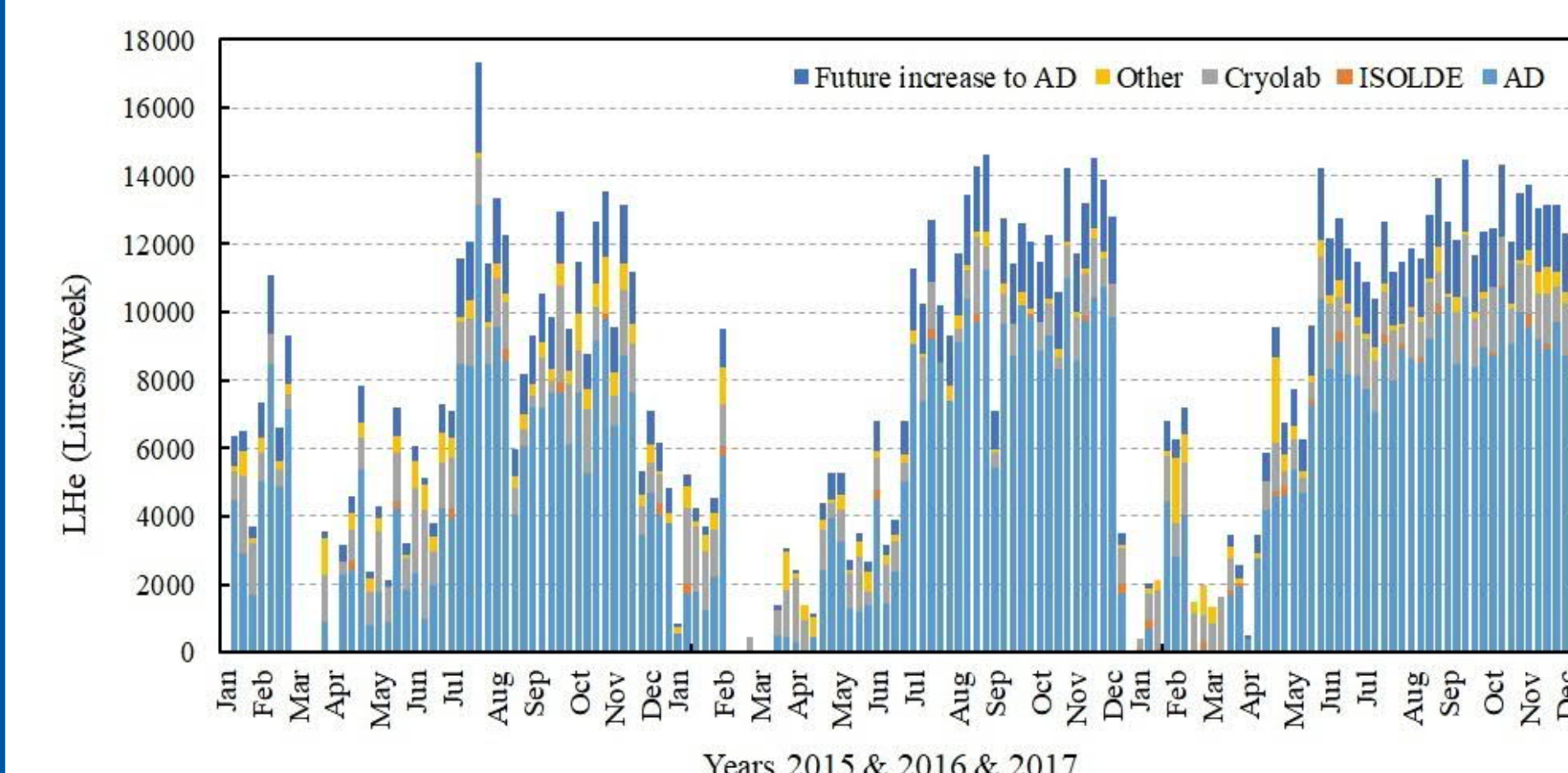
- B165 : 20,000 l LHe dewar to maximize LHe production and allow gravity filling of 10,000 l trailer dewar transportable by road to AD clients
- B163 : connect FRESKA 2, increase LHe supply by enabling the transfer of surplus LHe from B165, connect 6,000 l dewar directly to liquefier and upgrade WPU FRESKA
- B253 : replace 50 l batteries by 24 x 3 m³ jumbo cylinders



Global Process Flow Diagram. Calculated flow rates averaged over 7 days for assume B163 max continual operation of STC + F1 + F2.

LHe demand from B165 clients

Study of historic deliveries (dependence on operational cycle of each client) with future increase of 20% by AD clients



Year	Delivered		Used by client		Max. weekly delivery	
	kg	l	kg	l	kg	l
2015	39,920	318,288	33,672	268,469	1,842	14,687
2016	39,285	313,220	33,971	270,851	1,561	12,446
2017	49,408	393,932	43,235	344,718	1,552	12,370

During the last three years, the total average weekly demand was 6,836 l with a peak weekly demand of 14,687 l (2.9 g/s).

Conclusion

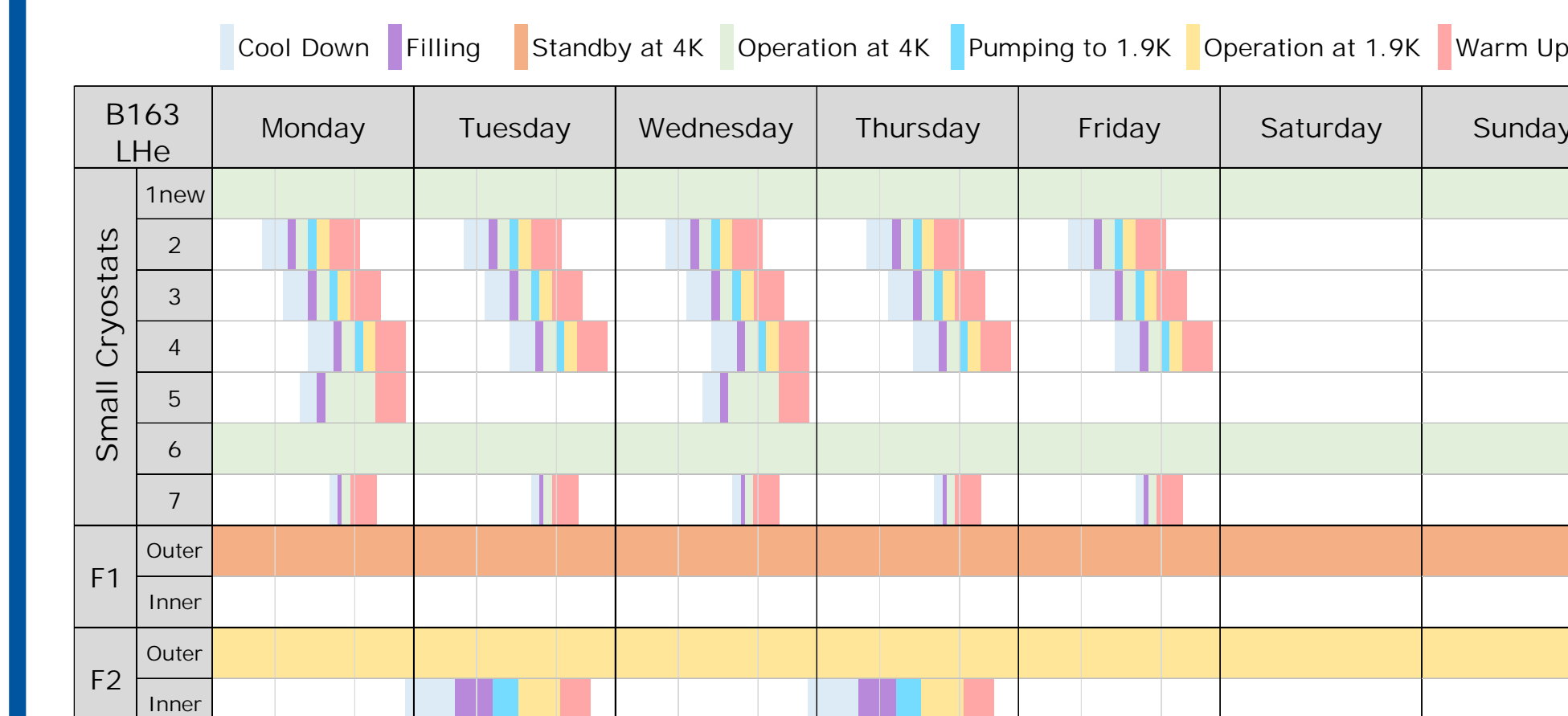
Rather than purchase a new cryogenic plant to supply the increased LHe requirement in B165 and B163, a new CDS has been designed and procured to maximize and share the production of the liquefiers in the two adjacent buildings.

The CDS of B165 was successfully installed and commissioned during 2019, increasing LHe storage capacity to 20,000 l and enabling the gravity filling of 10,000 l trailer dewar. The installation of CDS for B163 is scheduled to finish early in 2020.

LHe Demand from B163 clients

- The historic LHe requirements of the STC and F1 are known. LHe requirement of F2 is scaled from F1
- F1 and F2 will share the WPU, so it is not possible to simultaneously test at 1.9 K in both cryostats. However it is envisaged that the external cryostat of one cryostat could be at 4.5 K while testing is undertaken in the other.

B163 – Worst-case weekly test schedule



Worst case weekly LHe requirement in B163*

Configuration	Load Case	Total average requirement (l/week)	Weekly flow rate (g/s)	
			Average	Peak
1	F1+F2+STC	42,700	8.5	17.4
2	F2+STC	33,700	6.7	15.6
3	STC	12,800	2.60	8.2

* Cool down of either F1 or F2 external cryostat excluded

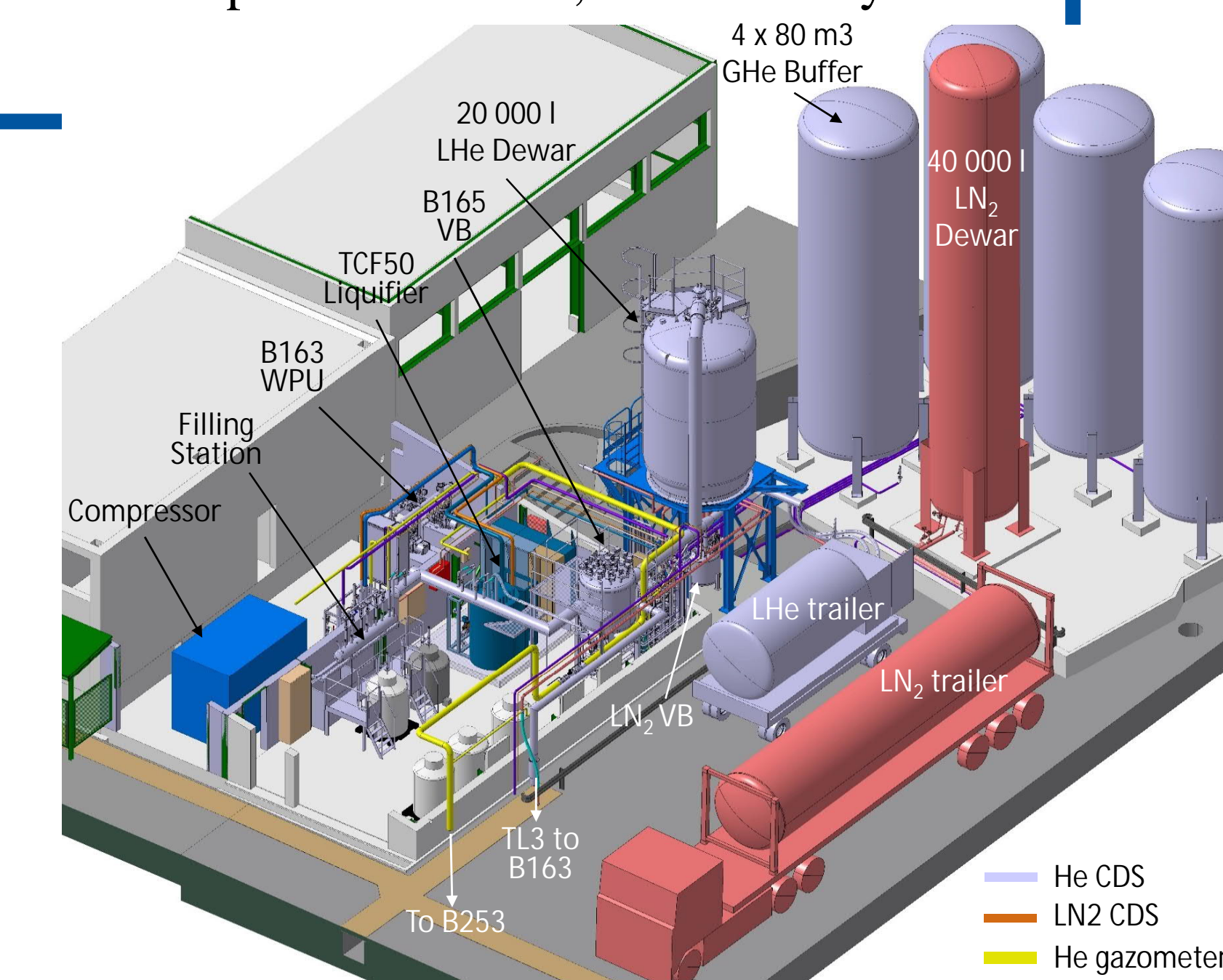
Combined LHe demand from B165 and B163

Analysis undertaken to combine competing requirements:

- B163 average weekly requirement combined with B165 future delivery schedule
- Maximum combined LHe production of B165 and B163 is conservatively 10 g/s (49,950 l / wk)

Total LHe production = 10 g/s (49,950 L/wk)	Configuration 1: F1+F2+STC	Configuration 2: F2+STC	Configuration 3: STC only
	B163 Requirement: 8.5 g/s (42,700 L/wk) Availability = 1.5 g/s (7,250 L/wk) Max LHe shortage ≈ 10,000 L /wk	6.7 g/s (33,700 L/wk) Availability = 3.3 g/s (16,250 L/wk) No LHe Shortage	2.6 g/s (12,800 L/wk) Availability = 7.4 g/s (36,500 L/wk) No LHe Shortage

Shortage would occur if configuration 1 (F1+F2+STC) is combined with peak delivery periods in B165 from May to December. Therefore, Load case 1 in B163 should only be operate during low demand periods in B165, from January to April.



Upgrade of B165 and B163

Main Functional modes of the B165 and B163 CDS

No.	From	To	Frequency
1	B165 Liquefier	B165 LHe Dewar	Continuous
2	B165 LHe Dewar	Trailer Dewar	2 per week
3	B165 LHe Dewar	B165-Filling Station	30 per week
4	B165 LHe Dewar	B163 LHe Dewar	1-3 per week
5	Trailer Dewar	B165 LHe Dewar	Monthly
6	Trailer Dewar	B165 Filling Station	Possible
7	B163 Liquefier	B163 LHe Dewar	Continuous
8	B163 LHe Dewar	B163 client	Continuous
9	B163 LHe Dewar	B165 LHe Dewar	Rare

