Working Group 3

Cryo-modules design and integration

Introduction

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Organization

- 3 Session:
  - **Session 1**: today: 14:00-15:45
    - Talk 1: Contribution from CNRS (P.Duthil) 20'
    - Discussion:
      - limits of scope of CNRS (and CEA?)
      - integration needs: components type, interfaces…
      - List uncovered items and discuss interest from other institutes *(to be discussed throughout 2 days)*
  - **Session 2**: today: 16:00-17:30
    - Talk 2: Possible quadruple solutions (D.Tommasini, CERN) 20'
    - Discussion (cont.d):
      - Type of coupler, integration needs, mechanical interface
      - Type of tuner, integration needs,
      - Interface to cavity helium vessel
      - Magnetic shielding design & integration (internal? external?)
      - Alignment requirements and assembly principles
      - Cryogenics distribution architecture: possible schemes, slope, H/W related issues (ex. Technical Service Modules)
      - Table of Work Packages
  - Interaction between WGs: tomorrow 9:50-11:00 (organization pending!)
  - **Session 3**: tomorrow, 11:00-12:30 in common with WG1 and WG2
    - We should seek answers to questions raised during Sessions 1,2

Goals

- Understand **limits of scope** of CEA and CNRS contributions
- Identification of **integration needs**: components type, interfaces, functional needs
- Identify **uncovered items** and possible **distribution to institutes** interested
- Define list of topics towards a **functional/technical specification**: alignment requirements, thermal budgets (static/dynamic), mechanical requirements
- Define **input for mechanical layouts**, and for **cryogenics specs** (pressures & temperatures)
- Define the key **ingredients for** defining a **layout** for tunnel interfaces: longitudinal layout, interconnect space, coupler layout (vertical, lateral?)
- Elaborate a **work organization** structure

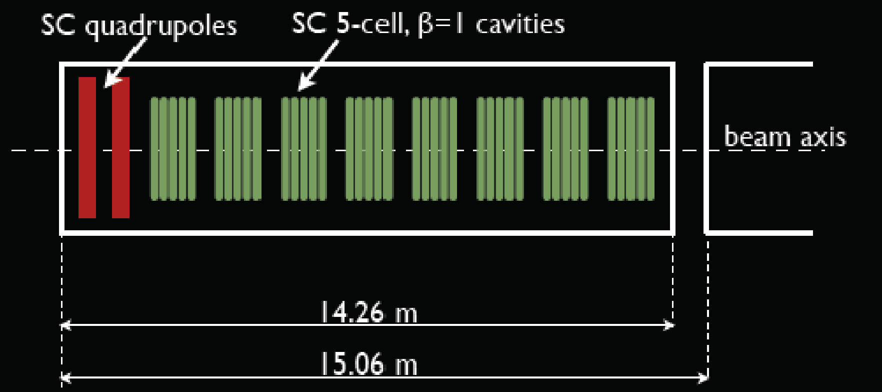
Baseline: HP-SPL (5 GeV)

Base-line cryo-modules

25 High-β cryomodules

high-beta section:

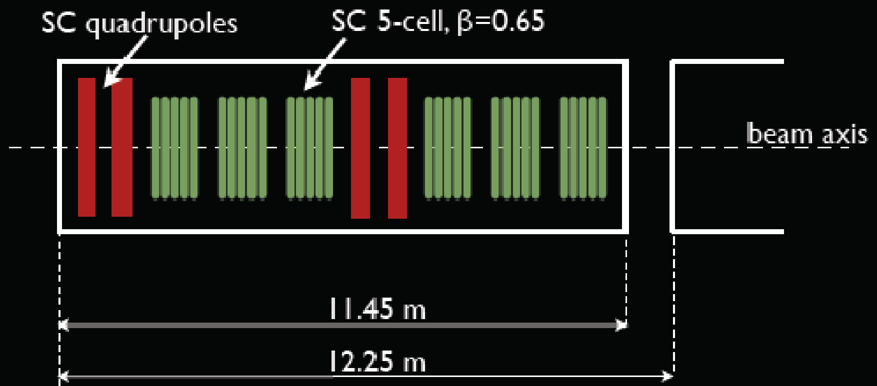
- 704.4 MHz, 25 MV/m,
- 668 - 5094 MeV,
- 25 periods, 200 cavities,
- 377 m



7 Low-β cryomodules

low-beta section:

- 704.4 MHz, 19 MV/m,
- 180 - 668 MeV,
- 14 periods, 42 cavities,
- 86 m



in total: 463 m, 242 cavities, 2 families, 704 MHz

"RF frequency options for the SPL", 9 November 2007, F. Gerigk

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Courtesy of F.Gerigk

Main parameters High-β cryo-module

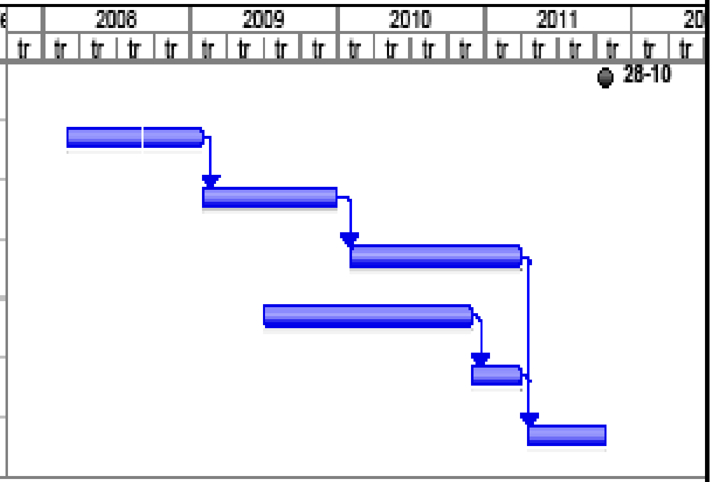
Table of Main parameters for the SPL cryo-module (β=0.92)

	Value	Comment
Active elements		
Number of cavities	8	
Approx. length of a cavity in its helium vessel	1.2-1.4 mm	between flanges, depends on design
Approx. outer diameter of cavity helium vessel envelope	400 mm	following design under Task 3
Number of quadrupoles	2 (1 doublet)	
Length of quadrupole doublet	1.5 m (TBC)	Doublet design by CERN
Cryostat elements		
Approx. outer diameter of doublet helium vessel envelope	TBD	Doublet design by CERN
Approx. length of vacuum vessel	13.6 m (TBC)	Depends on cryostat design
Approx. outer diameter of vacuum vessel	1014 mm (36")	Depends on cryostat design
Approx. value of vacuum vessel thickness	12 mm	Depends on cryostat design
Approx. inner diameter of He Gas Return Pipe	300 mm (TBC)	Defined by mass flow/pressure drop
Approx. thickness of He Gas Return Pipe	6 mm (TBC)	Depends on cryostat design (CNRS) and GRP design (CERN)
Number of cold supports posts	3 (TBC)	Depends on cryostat design. LHC solution/technology can be applied.
Number of Thermal shields	1	Aluminium, active cooling 50-75 K
Thermal shield MLI protection	30 layers	According to LHC technology

Master schedule prototype cryo-module

SPL cryomodules Master Schedule

ID	Task Name	Duration	Start	Finish	Prede
1	Prototype cryomodule ready for testing	0 days	Fri 28-10-11	Fri 28-10-11	
2	Conceptual Design	12 mons	Mon 03-03-08	Fri 30-01-09	
3	Detailed Design of prototype cryostat	11.95 mons	Mon 02-02-09	Thu 31-12-09	2
4	Prototype cryostat fabrication	15.2 mons	Mon 01-02-10	Thu 31-03-11	3
5	Design & construction of assembly tooling	18.5 mons	Wed 01-07-09	Tue 30-11-10	
6	Install cryostat assembly tools at CERN	87 days	Wed 01-12-10	Thu 31-03-11	5
7	Prototype cryomodule assembly	7 mons	Mon 18-04-11	Fri 28-10-11	4,6



Contributions from CNRS and CEA

List of tasks and responsibilities

#	Task	Institute in charge
1	Cryostat design and integration and procurement of cryostat components for 1 prototype cryo-module	CNRS
2	Design and procurement of the supporting/guiding system for the string of cavities in the cryostat	CNRS
3	Design and procurement of 2 helium vessels for cavities β=0.92.	CEA
4	Design and procurement of cryostat assembly tooling	CEA

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Other Work Packages?

See table

Supporting material

Possible cryogenics layout for SPL

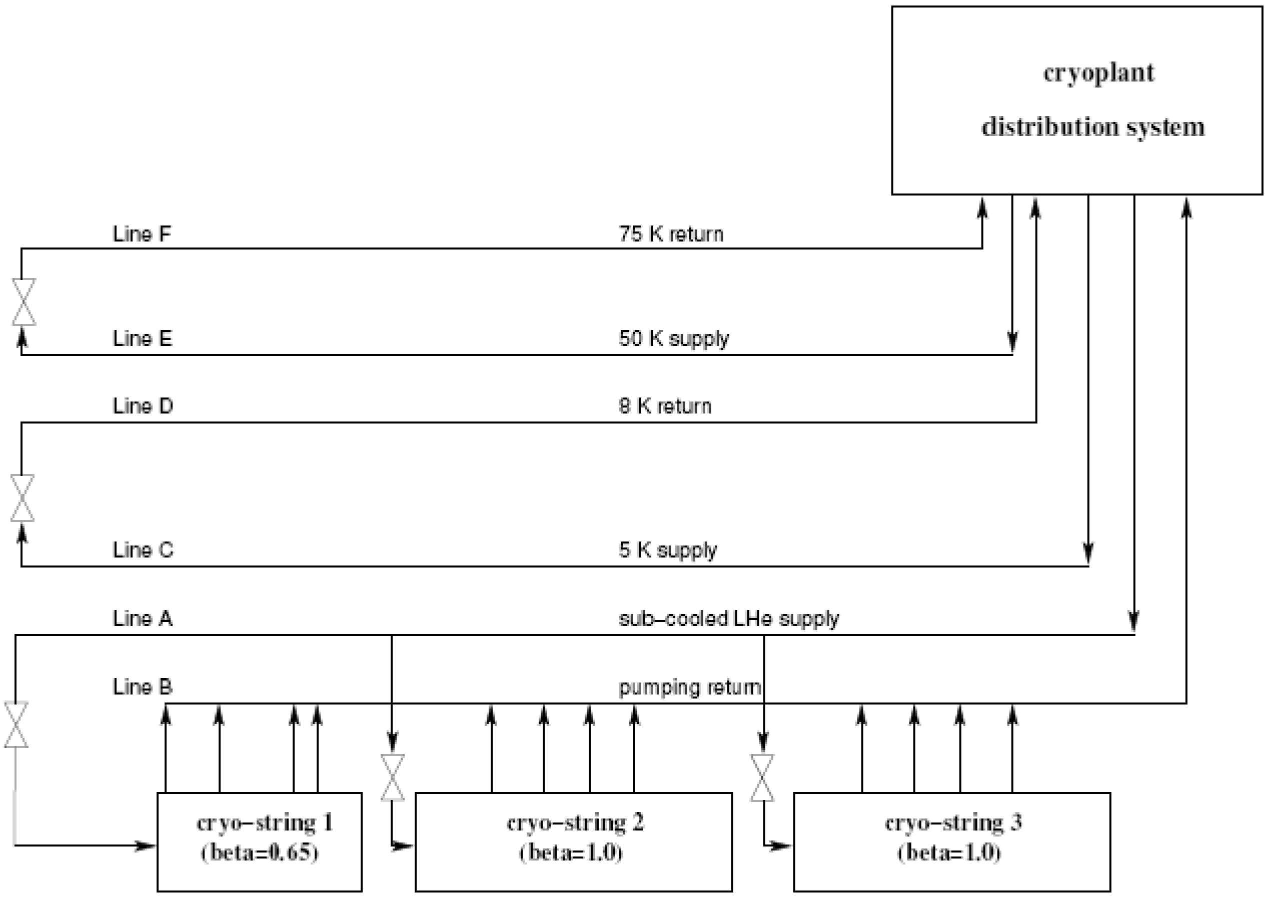


Fig. 4.39: Cooling scheme of the cryogenic system

~10 m (?) shafts

~8 m machine slope

~460 m

1.7% slope

Possible string cryo-scheme

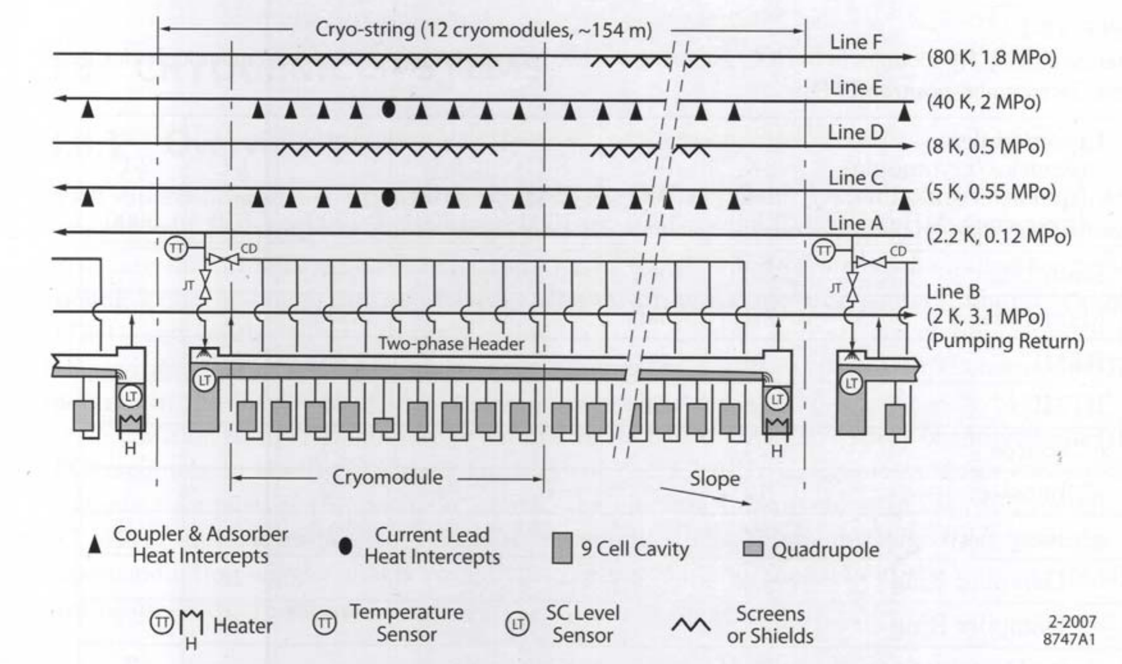
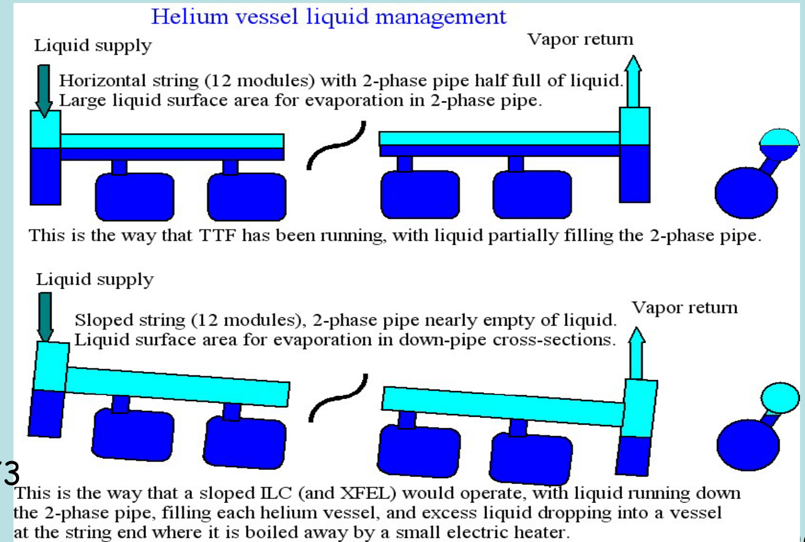


FIGURE 3.8-2. Cooling scheme of a cryo-string.

- similar to Laser-straight ILC: (slope: 0-0.6%)

Ref. ILC RDR, page III-172



Ref. ILC RDR, page III-173

- Similar scheme could be Adopted for SPL

Cryogenic capacity

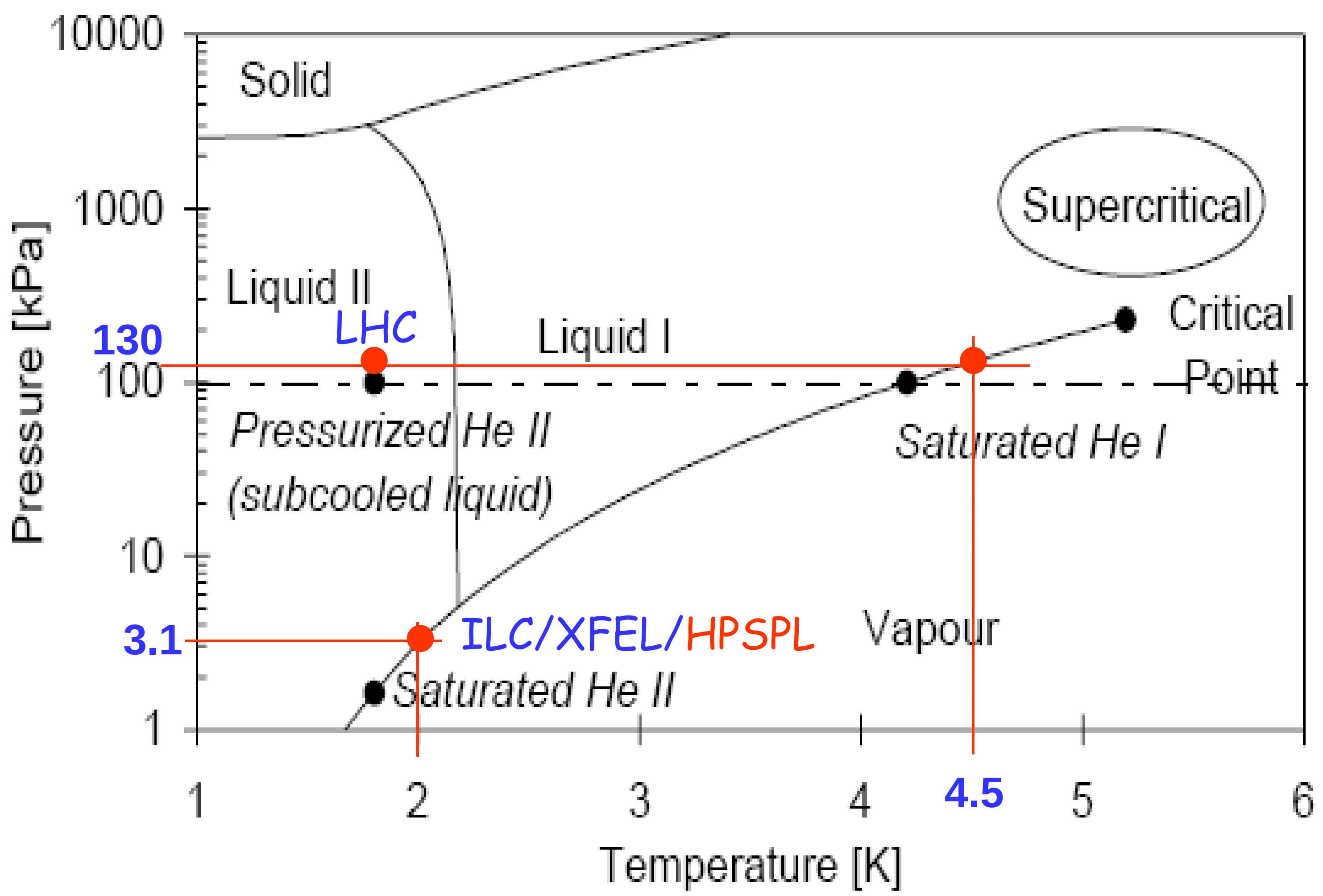
TABLE XVI: Cryogenic plants for 704.4 MHz, considering a 4 GeV LP-SPL and a 5 GeV HP-SPL.

machine	temperature [K]	$Q_{\text{equivalent, 4.5 K}}$ [kW]	P_{el} [MW]
LP-SPL	2	6.3	1.6
LP-SPL	4.5	10.5	2.6
HP-SPL "neutrino operation"	2	20.8	5.2
HP-SPL "neutrino operation"	4.5	95.4	23.9

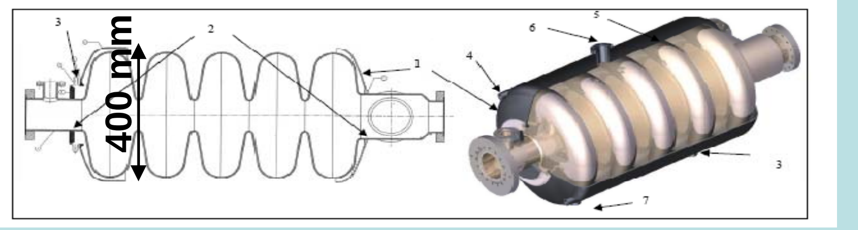
(ref.CERN-AB-2008-067 BI/RF)

- 2 K is mandatory for HPSPL
- Still, very high dynamic heat loads: ~ 14 W/m @ 2K

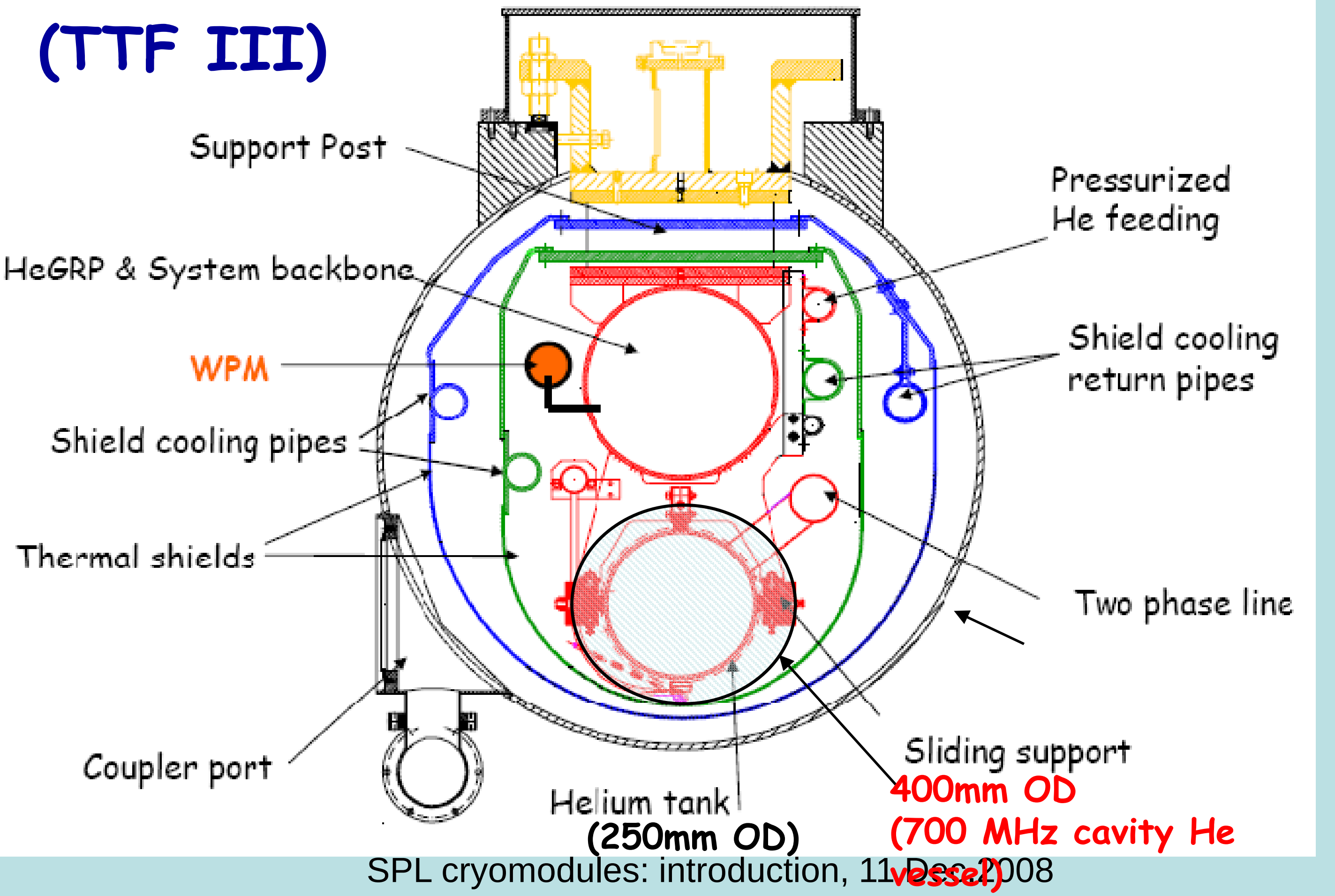
Phase diagram of helium



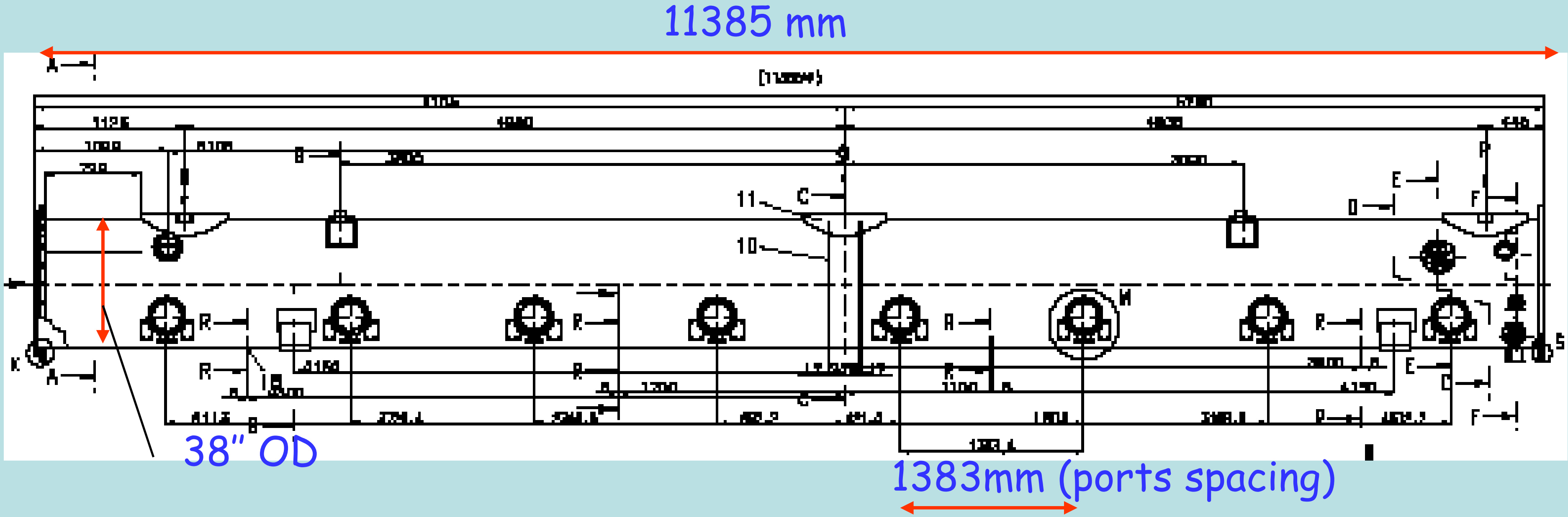
A 704 MHz cavity in an TTF/XFEL vessel?



Ref. H. Saugnac et al., "Preliminary Design of a Stainless Steel Helium Tank …", SRF2001, PT022.



XFEL vacuum vessel



X section of TTF/XFEL/ILC cryomodule

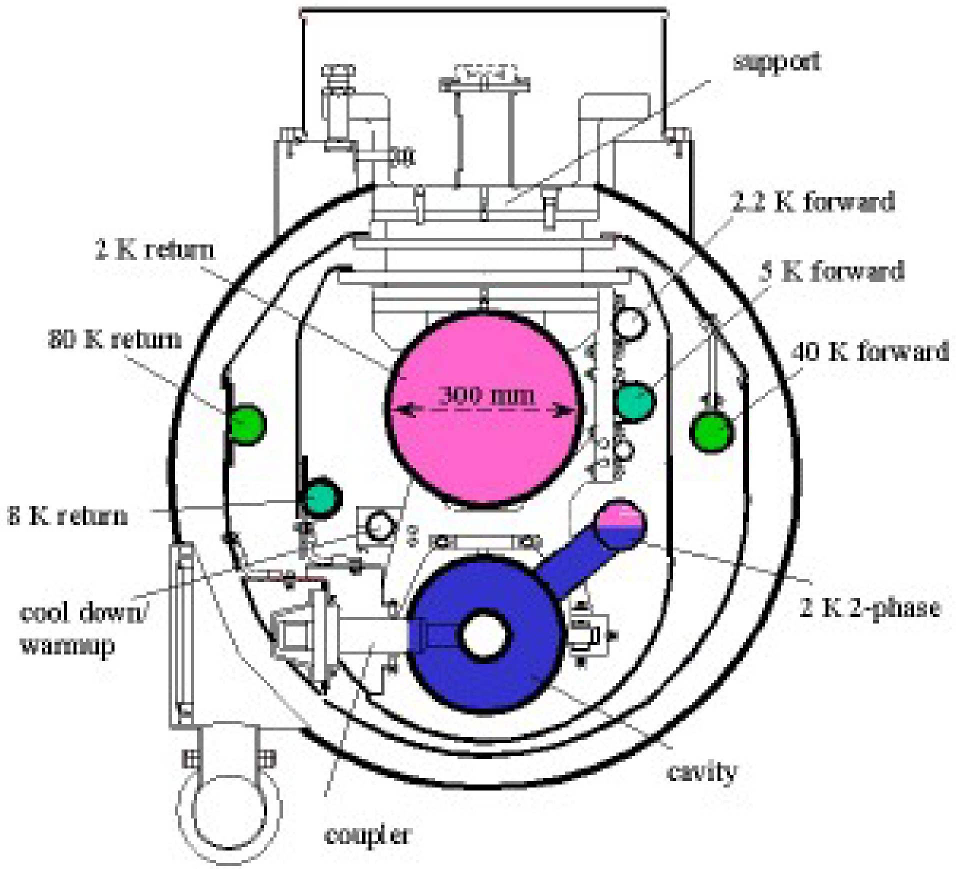


Figure 3.2.11: *Cross section of cryomodule.*