SPL cryomodule specification:

Goals of the meeting

V.Parma, TE-MSC

Goal of today's meeting

- Identify and address still outstanding cryomodule design specification issues

- Address the specific requirements related to the test program of the short cryomodule at CERN (for ex. : windows for in-situ intervention, need for diagnostics instrumentation, etc.).

- Converge towards a technical specification to allow the continuation of the engineering of the short cryomodule, or identify road-maps to settle outstanding issues.

Chairperson: Vittorio Parma (CERN, TE/MSC)
Scientific secretary: Arnaud Vande Craen (CERN, TE-MSC)

Agenda

Tuesday 19 October 2010

09:00 - 09:10	Welcome *10'* Speaker: Roland Garoby (CERN)
09:10 - 09:30	Goals of the meeting *20'* Speaker: Vittorio Parma (CERN)
09:30 - 10:00	Open questions from IN2P3/CNRS *30'* Speaker: Patxi DUTHIL (IPNO - IN2P3 - CNRS)
10:00 - 10:15	Coffee break (Cafeteria Bldg 30 7th floor)
10:15 - 10:45	Cavities and related equipment (tuner, HOM, magnetic shields) *30'* Speaker: Wolfgang Weingarten (CERN)
10:45 - 11:15	RF system (powering, distribution, coupling, control) *30'* Speaker: Olivier Brunner (CERN)
11:15 - 11:45	Cryogenic requirements and test plansCryogenic requirements and test plans *30'* Speaker: Udo Wagner
11:45 - 12:00	Cryogenic test infrastructure in SM18 Cryogenic test infrastructure in SM18 *15'* Speaker: TBD
12:00 - 14:00	Lunch break (---)
14:00 - 14:30	Cryomodule development for Project X *30'* Speaker: Jim Kerby (Fermi National Accelerator Laboratory (FNAL))
14:30 - 16:00	Wrapping-up session *1h30'*
16:00 - 16:15	Coffee break (Cafeteria bldg 30 7th floor)
16:15 - 16:45	Conclusions *30'* Speaker: Vittorio Parma (CERN)

Background information

Short cryo-module: Goal & Motivation

Goal:

- Design and construct a ½-lenght cryo-module for 4 $\beta=1$ cavities (as close as possible to a machine-type cryomodule)

Motivation:

- Test-bench for RF testing on a multi-cavity assembly driven by a single or multiple RF source(s)
- Enable RF testing of cavities in horizontal position, housed in machine-type configuration (helium tanks with tuners, and powered by machine-type RF couplers)
- Validate by testing critical components like RF couplers, tuners, HOM couplers in their real operating environment

Cryostat-related goals:

- Learning of the critical assembly phases:
  - From clean room assembly of cavities to a cryomodule
  - Alignment/assembly in the cryostat;

- Proof of concept of "2-in-1" RF coupler/cavity supporting:
  - Fully integrated RF coupler: assembly constraints
  - Active cooling effect on cavity alignment

- Operation issues:
  - Cool-down/warm-up transients
  - Thermo-mechanics and alignment, vibrations
  - Heat loads

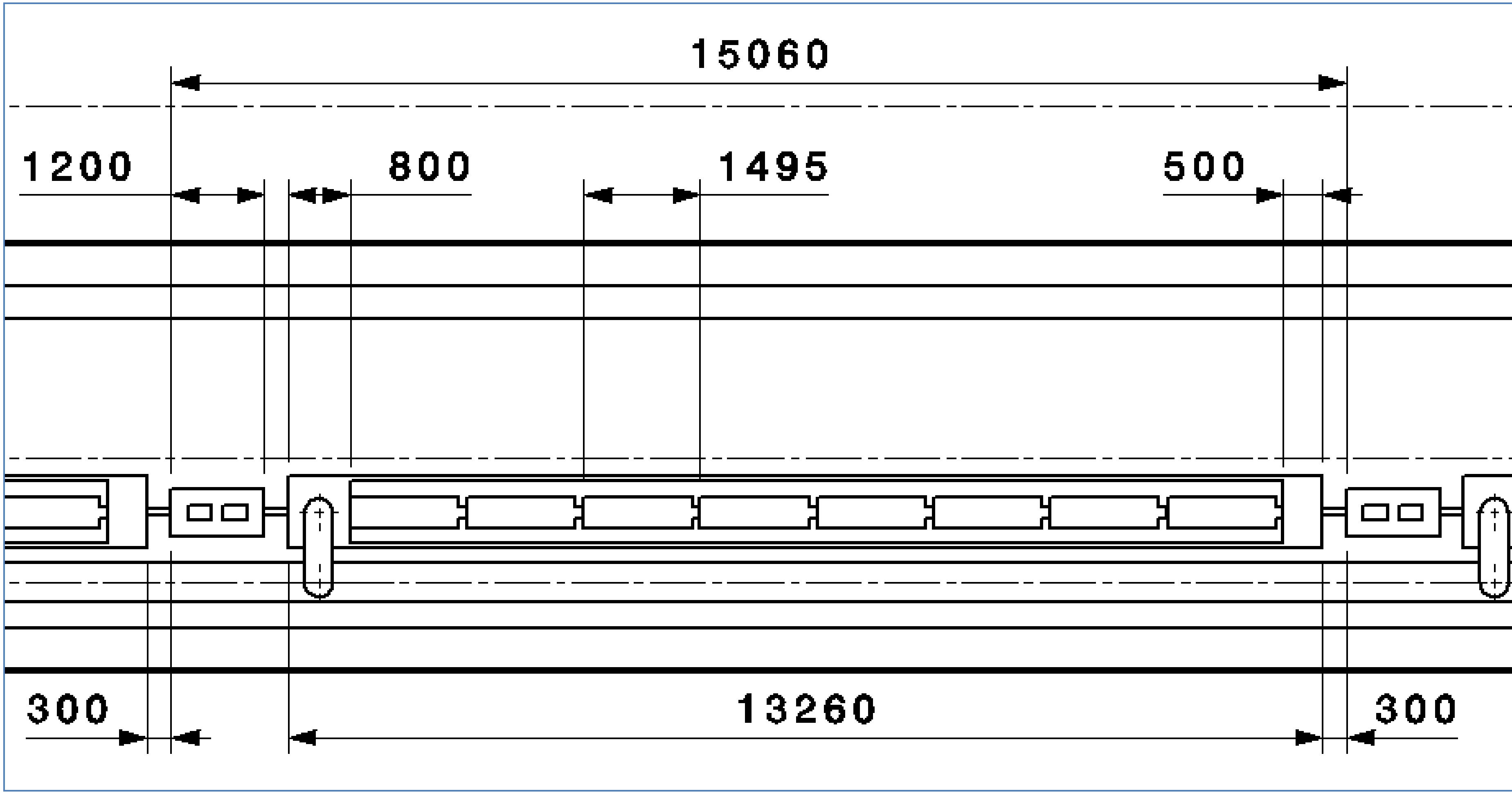
Instrumentation: cryostat-specific needs

- Alignment: Wire Position Monitor (WPM) type system
  - On-line monitoring movements and vibrations of the Cold Mass (CM) during cool down and steady state operation
  - Requires WPM supports of helium vessel
  - Routing of coax cables through cryostat (4 per measurement point)

- Calorimetric precision measurements (LHeII T drift) for static (and dynamic) Heat Loads
  - T gauges in helium bath (1 per cavity)
  - 25 W electrical heaters in helium bath (1 per cavity)

- Temperature mapping: T gauges (in insulation vacuum)
  - RF coupler double-walled tube
  - Tuner mechanical parts (normally badly thermalised, slow transients)
  - Thermal shielding temperature mapping
  - …

β=1 cryo-module in SPL layout

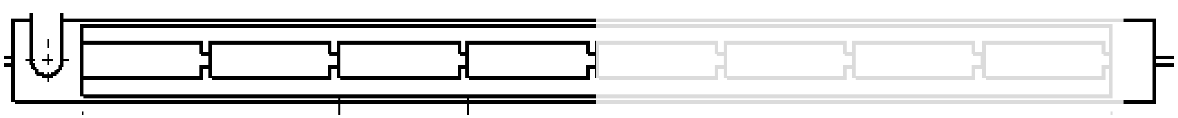


Moving from 8 to a 4-cavity design

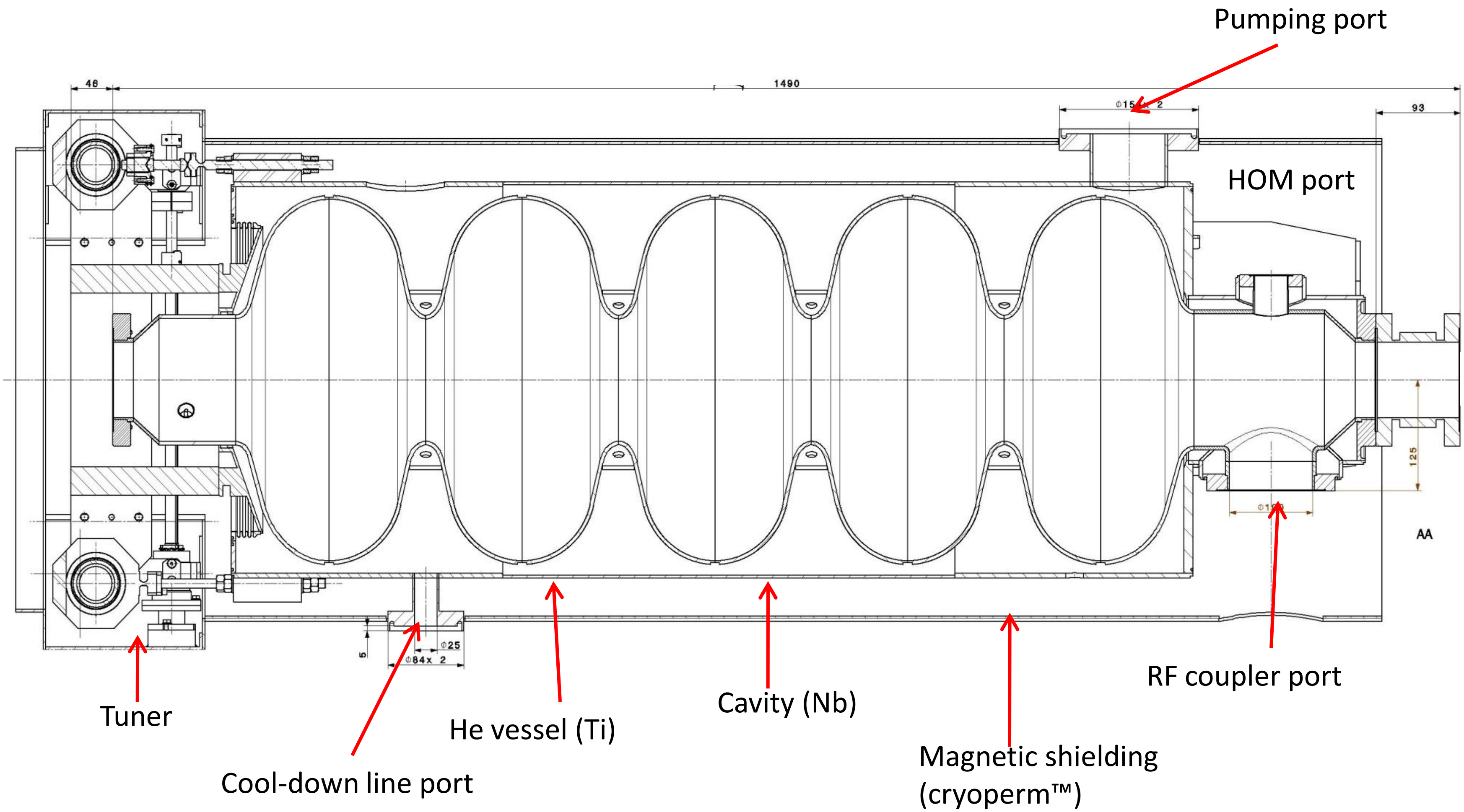
Cryo-module Design Strategy:

- Cryo design for an 8-cavity machine cryomodule:
  - Cryogenics (p,T, heat loads, mass flows…)
  - Inner cryo lines for a fully segmented machine layout:
    - Individual cryo feeding, He vapours pumping, cryo control
      - Pipe IDs, pressure drops, T margins,
      - Control equipment (valves and instrumentation)
  - Design for 1.7% tunnel slope (test 0%-2%)

- *Design for Manufacture* for a small-to-medium number of cryomodule (typically ~50 units)
  - Mechanical design, construction and assembly
  - Alignment goals for machine-type cryomodules



“Dressed” Cavity (CERN mods to CEA’s design)



Includes specific features for cryo-module integration (inter-cavity supports, cryogenic feeds, magnetic shielding …)

Th.Renaglia, EN-MME

Cavity Supporting System: alignment

Transversal position specification

BUDGET OF TOLERANCE			
Step	**Sub-step**	**Tolerances (3σ)**	**Total envelopes**
Cryo-module assembly	Cavity and He vessel assembly	*± 0.1 mm*	Positioning of the cavity w.r.t. beam axis **± 0.5 mm**
	Supporting system assembly	*± 0.2 mm*	
	Vacuum vessel construction	*± 0.2 mm*	
Transport and handling (± 0.5 g any direction)	N.A.	*± 0.1 mm*	Stability of the cavity w.r.t. beam axis **± 0.3 mm**
Testing/operation	Vacuum pumping	*± 0.2 mm*	
	Cool-down		
	RF tests		
	Warm-up		
	Thermal cycles		

Construction precision

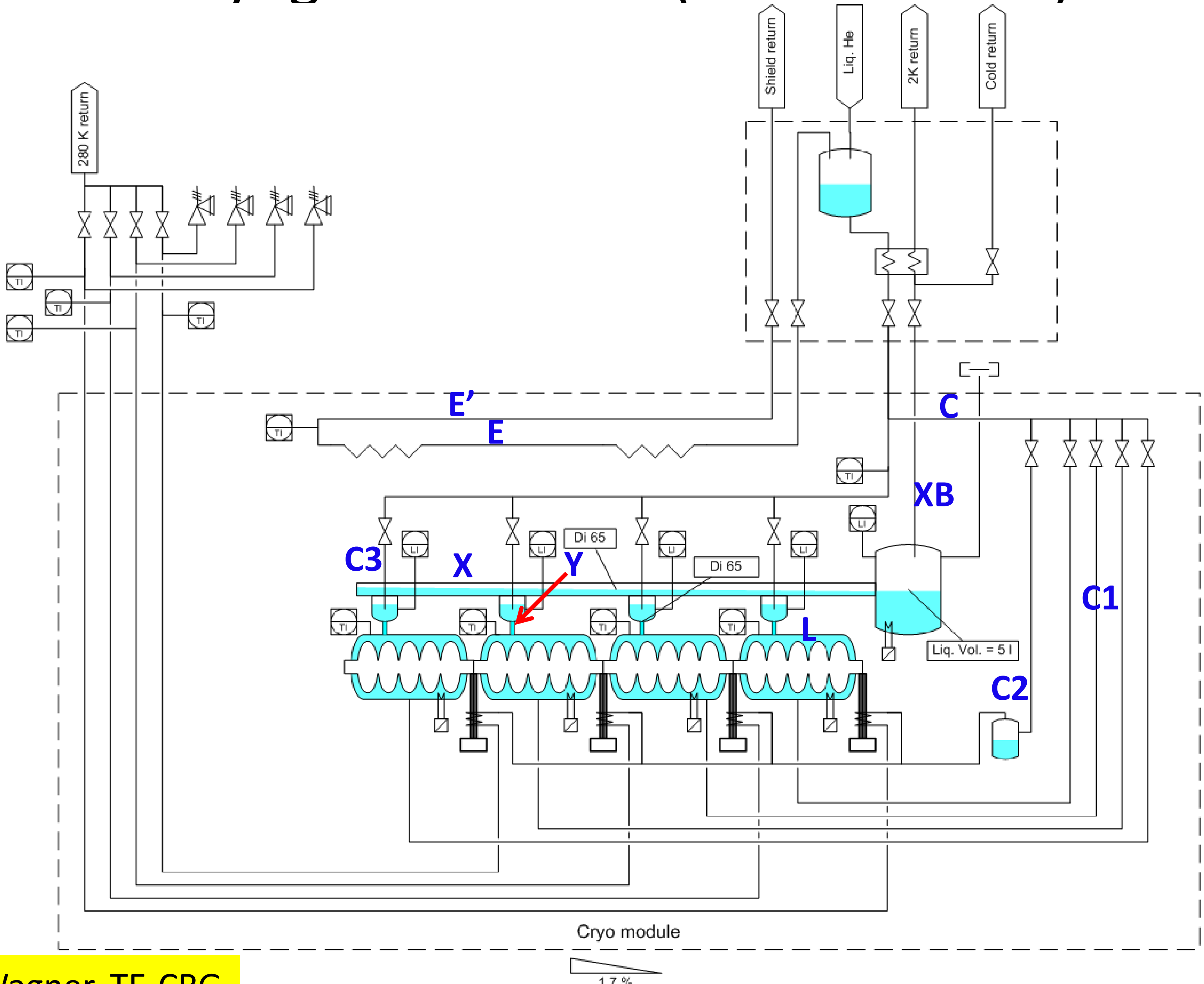
Long-term stability

Heat Loads (per β=1 cavity)

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**

Cryogenic scheme (latest version)

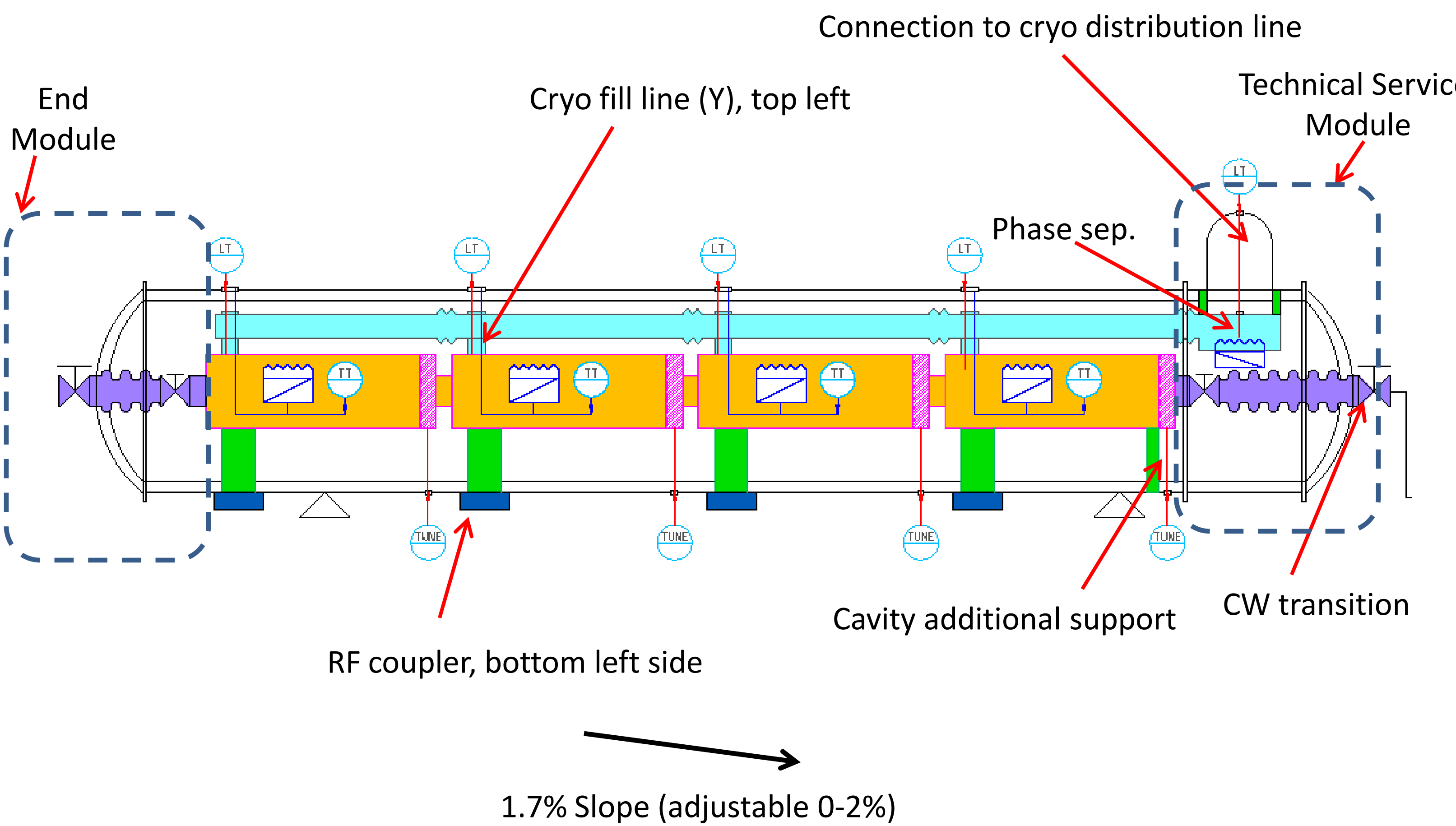


U.Wagner, TE-CRG

Pipe sizes and T, p operating conditions

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	293-2	2-293	0.15 @ 293K 0.2 @ 2K	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	50-75 (20-40 on test stand?)	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

Short cryomodule: layout sketch



A.Vande Craen (MSC-CI)