

CEA Heat Load

N. Bazin on behalf of the Cryomodule Testing Group

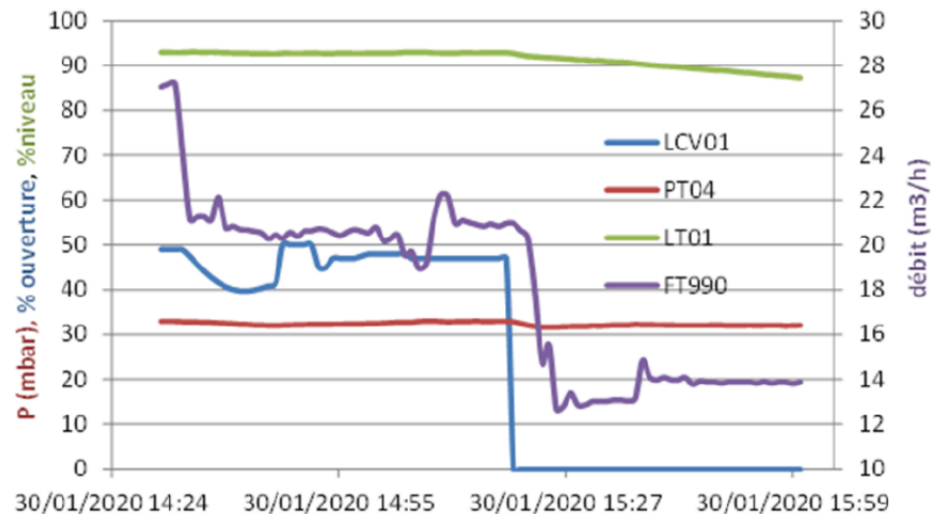
TTC Meeting – December 6th 2023, Fermilab

Cryogenic System at CEA

- The current cryogenic cold box does not deliver supercritical helium and cold pressurized helium gas for the thermal shield (use of liquid nitrogen)
 - The test conditions of the cryomodules are not identical to the nominal operating conditions
- A new cold box will be delivered next year and the cryogenic distribution systems will be improved in order to test the PIP-II LB650 cryomodules according to the PIP-II requirements
 - Characteristics of the new cold box:
 - Supercritical He
 - Higher LHe production capacity: 200 l/h
 - Two input/output stages :
 - Cold Box output for thermal shield : 14.5 bara; 40 K +/- 5 K; 500 W available load (CDS + Cryomodule)
 - Cold Box output for cavity circuit : 3 bara; 5.5 K +/- 0.1 K; 60 W available load (CDS + Cryomodule)
 - Available load @ 2K = 4.45 g/s

Static Heat Loads Measurements of the ESS Cryomodules

- Operating temperature = 2 K
- With the liquid helium input valve closed (LCV01), the stable given by the flowmeter that measured the the helium flow from the pumping group (FT990) is taken to assess the static heat loads



$$P = \dot{m} L_v$$

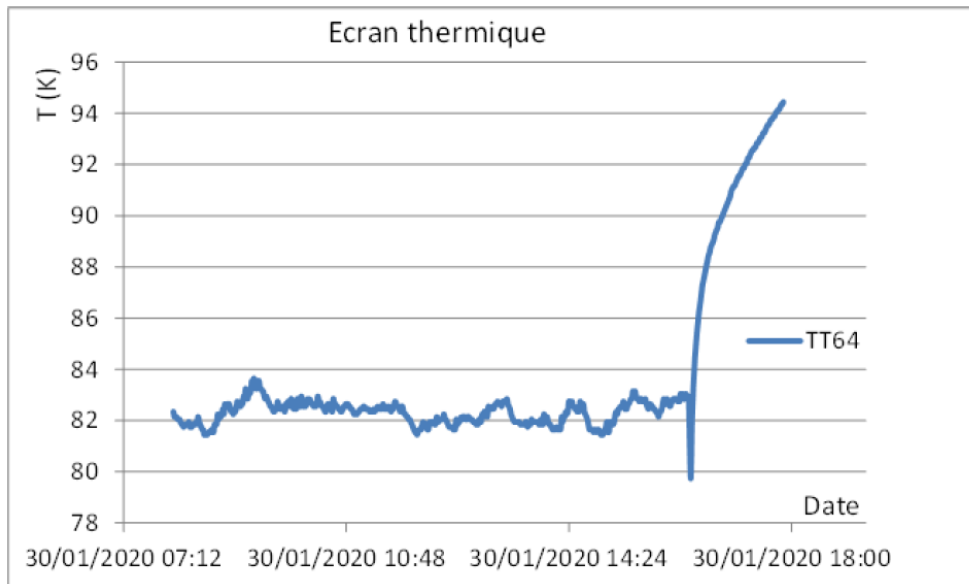
where

- \dot{m} is the measured GHe flow
- L_v is the latent heat of vaporization of helium at 2 K

- Calculated heat loads with a thermal shield at 80 K = 19.2 W
- Measured heat loads at CEA ~ 18 W

Static Heat Loads Measurements of the ESS Cryomodules

- Thermal shield cooled with liquid nitrogen
- Estimation of the heat loads measuring the temperature increase after stopping the LN2 cooling



$$P = m \frac{\int_{T_i}^{T_f} C_p(T) \cdot dT}{\Delta T}$$

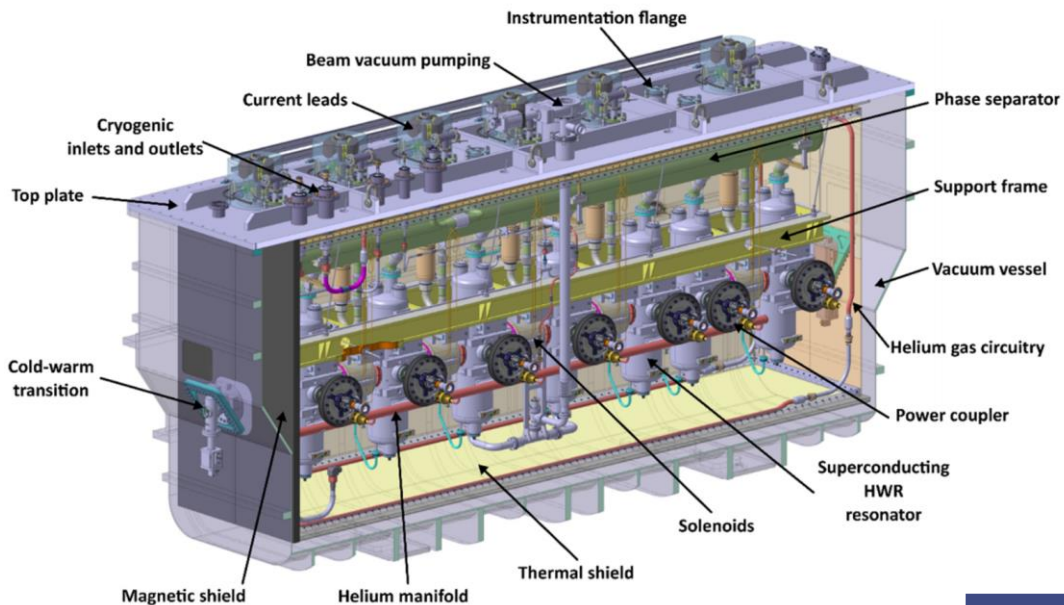
where

- m is the mass of the shield made of aluminum
- C_p is the heat capacity of aluminum

- Calculated heat loads = 50 W
- Measured heat loads at CEA ~ 70 W
- Estimation is based on 1.5 W/m² for the heat flux from room temperature surfaces to the thermal shield covered with MLI → too optimistic?

Static Heat Loads Measurements of the SARAF Cryomodule

- The conservative value of 3 W/m² is considered for the heat flux from room temperature surfaces to the thermal shield to take into account the large number of openings in the MLI blankets (power couplers, clusters of current leads, relief line, tie rods, beam vacuum pumping line ...) with the risk of surfaces not covered by MLI



- Reminder: in case of direct line of sight of room temperature surface on the thermal shield no covered by MLI
 - Black body radiation (emissivity = 1): heat flux = 470 W/m²
 - Raw material (emissivity = 0.2): heat flux = 51 W/m²
- Principle of heat loads measurements similar to the ESS cryomodules

	Calculated	Measured
Static heat loads at 4 K	28 W	29 W
Static heat loads at 80 K	229 W	243 W



Thanks for your attention

Nicolas Bazin
CEA SACLAY
91191 Gif-sur-Yvette Cedex
France
nicolas.bazin@cea.fr

