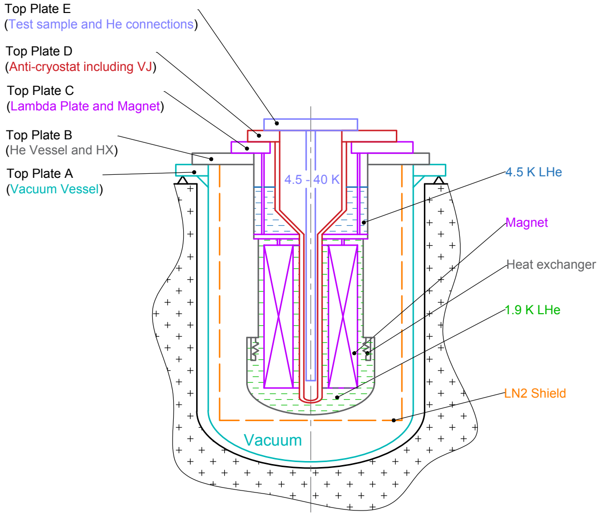
Design of the cryostat for High Field Vertical Magnet Testing Facility at Fermilab

S. Koshelev (FNAL), T. Tope (FNAL), J. Theilacker (FNAL), V. Nikolic (FNAL), G. Velev (FNAL), A. Marone (BNL), P. Kovach (BNL)

Introduction

High Field VMTF is a joint project between the Office of High Energy Physics and the Office of Fusion Energy Sciences. A new double bath 4.5 K/1.9 K superfluid helium cryostat is designed for 15 T test facility dipole magnet (TFD) provided by Lawrence Berkeley National Laboratory.

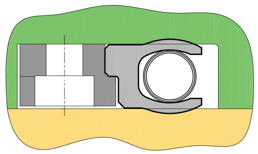


HFVMTF principal schematic

Challenges and design

The TFD magnet presents several challenges due to its dimensions (1.3 m diameter, 3.1 m length), weight (20 ton), and large aperture (100 mm x 150 mm).

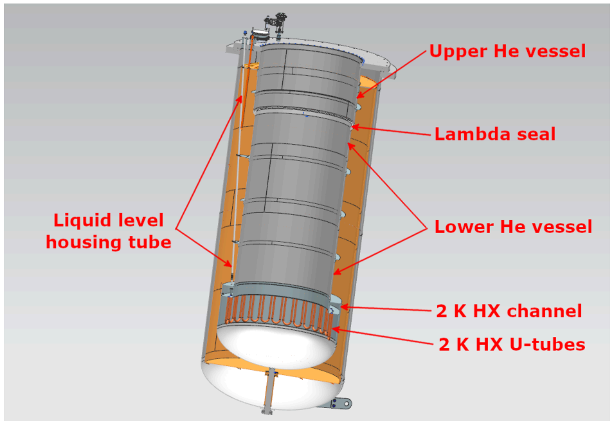
Large magnet diameter affects the 2 K heat load due to longer lambda seal between the two baths.



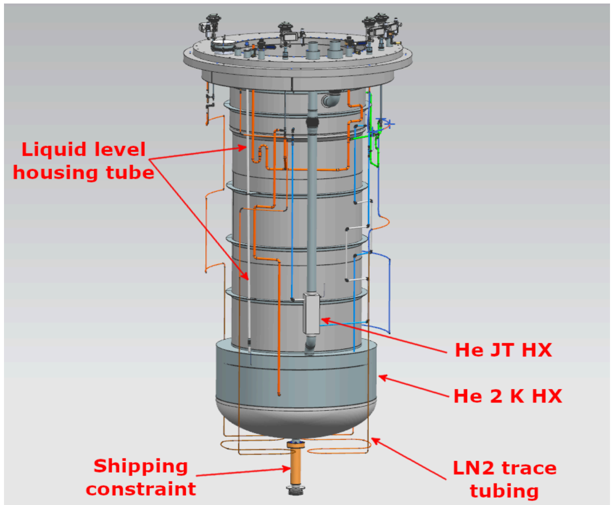
Spring energized PTFE lambda seal

Out of several lambda seal designs analyzed, a spring energized PTFE has been chosen for higher leak-tightness, reliability, and lower cost.

Eccentricity of the magnet's axis creates a magnetic force of 240 N/mm of offset with positive feedback. The cryostat utilizes concentric design of the 2 K heat exchanger (HX) developed at CERN to reduce the offset. The HFVMTF design allows for the cryostat to be moved after installation and initial commissioning to minimize the force.



Cross section of the HFVMTF cryostat

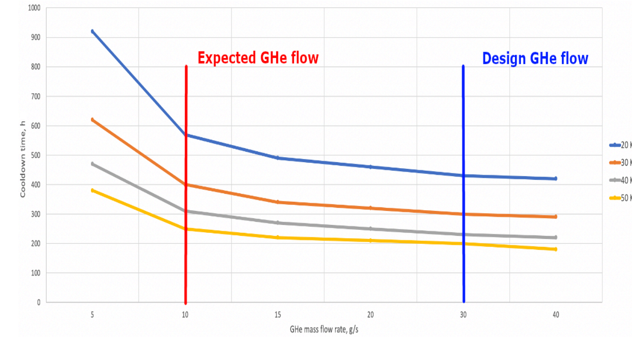


Internal piping and apparati of the HFVMTF cryostat

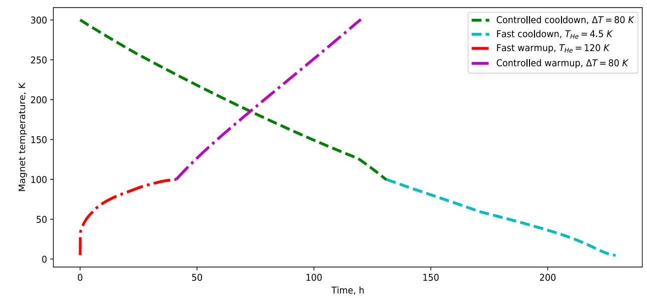
Estimated thermal performance

Cooldown and warmup processes are optimized to balance magnet temperature constraints, cryoplant liquefaction capacity and operations schedule. Transient process time is shown to depend largely on temperature difference between the magnet and the He flow.

The cryostat requires 216 L/h of LHe allowing for minimum of 23 hours of continuous steady-state powered operation.



TFD magnet controlled cooldown time analysis



Optimized cooldown and warmup curves for TFD magnet

Source	4 K heat load, W
Conventional leads, powered	63.5
Conduction down vessel walls	24.0
Helium gas conduction	13.5
Instrument wires	6.7
Thermal radiation from top	4.2
Conduction down magnet supports	2.5
Valves	0.7
Thermal radiation from sides	0.2
Total heat load	115.2

Source	2 K heat load, W
Lambda plate leaks	20.5
Conduction through lambda plate	5.1
Current leads	5.0
Thermal radiation from sides	1.5
Anticryostat CF	1.1
Conduction through lambda seal ring	1.0
Warmup/fill line	0.9
Instrument wires	0.6
Valves	0.1
Conduction down magnet supports	0.0
Conduction down vessel walls	0.0
Total heat load	35.9