Cryogenic system for the HTS conductor tests at E4R

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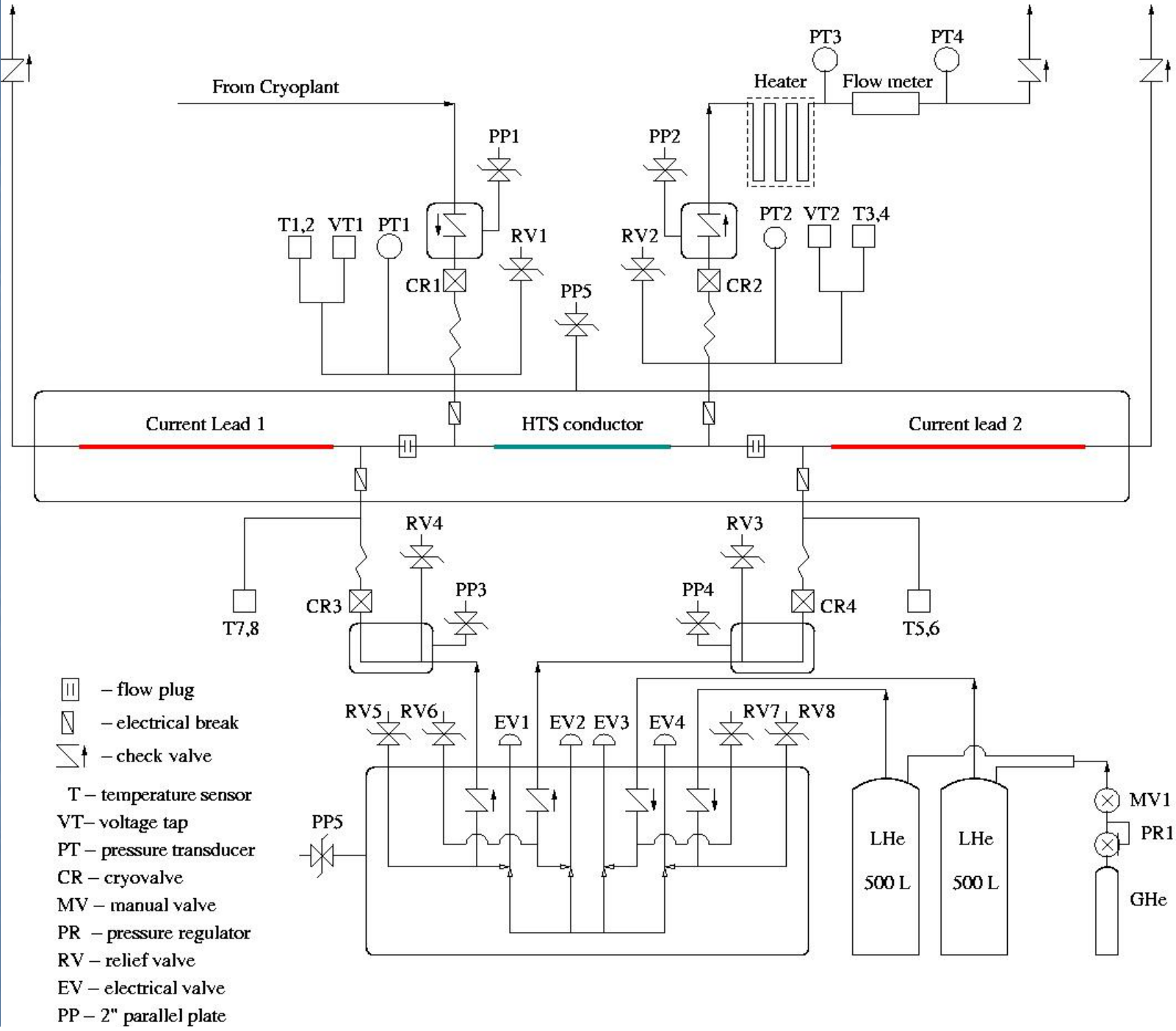
Cooling Requirements

- HTS Conductor – 1.35 m long, 28 tapes inserted in an elliptic shaped tubing, insulated individually by Kapton tapes to generate gaps.
- Current leads – Made up of 7X¼” copper rods, scaled from the original 100 kA DC current leads (202X1/4” copper rods) => 3,500 A DC capability.

Cryogenics at E4R

- Conductor cooling – E4R on site Cryoplant which can provide supercritical helium at 3 bar, 5 K with a maximum mass flow rate of 3 g/s (Liquefaction Mode). Only sensible heat is used for the cooling.
- Current leads – Cooled separately by the liquid helium supplied from two 500 L helium Dewar

E4R CRYOGENIC SYSTEM SCHEMATIC

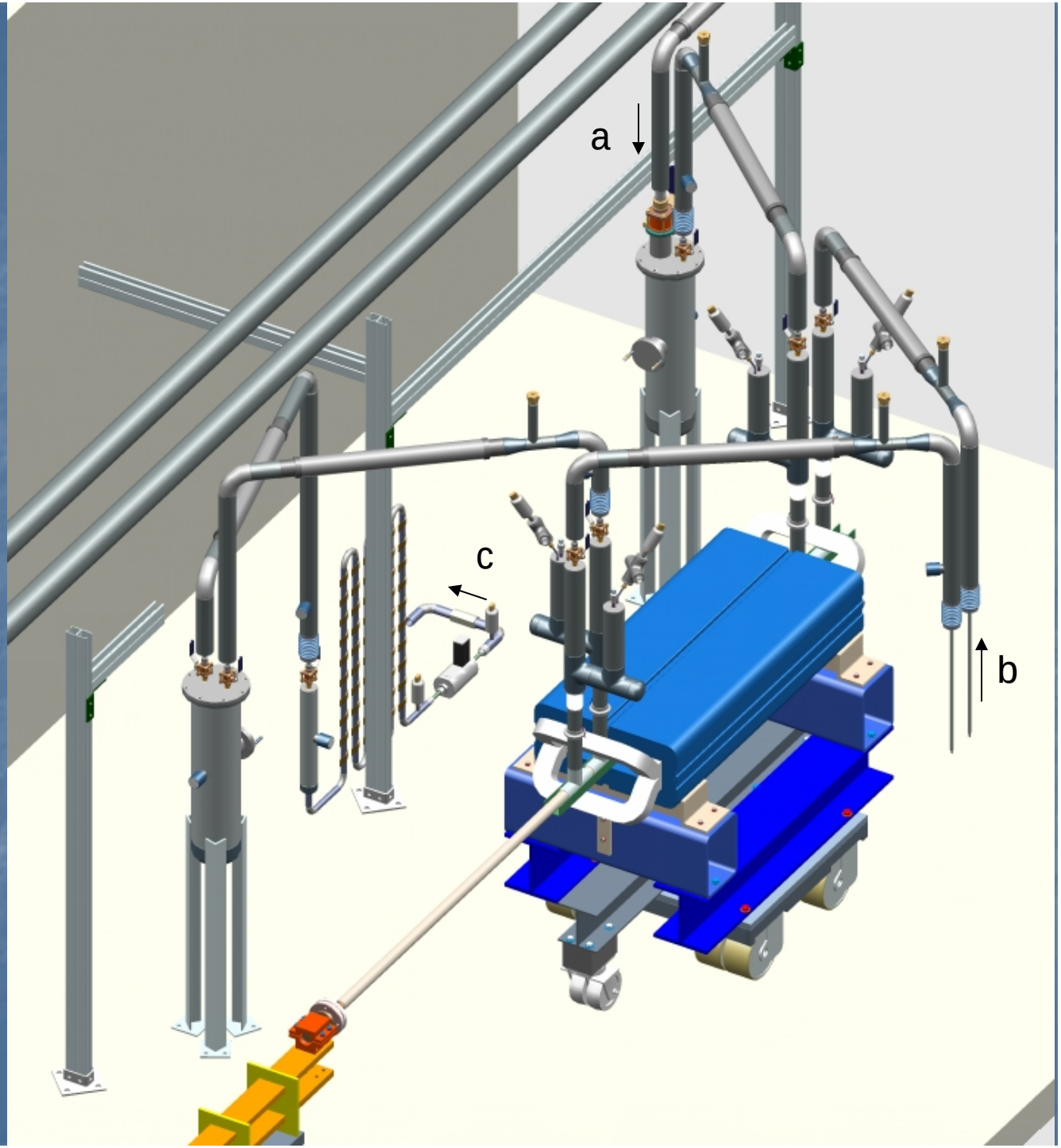


E4R TEST AREA

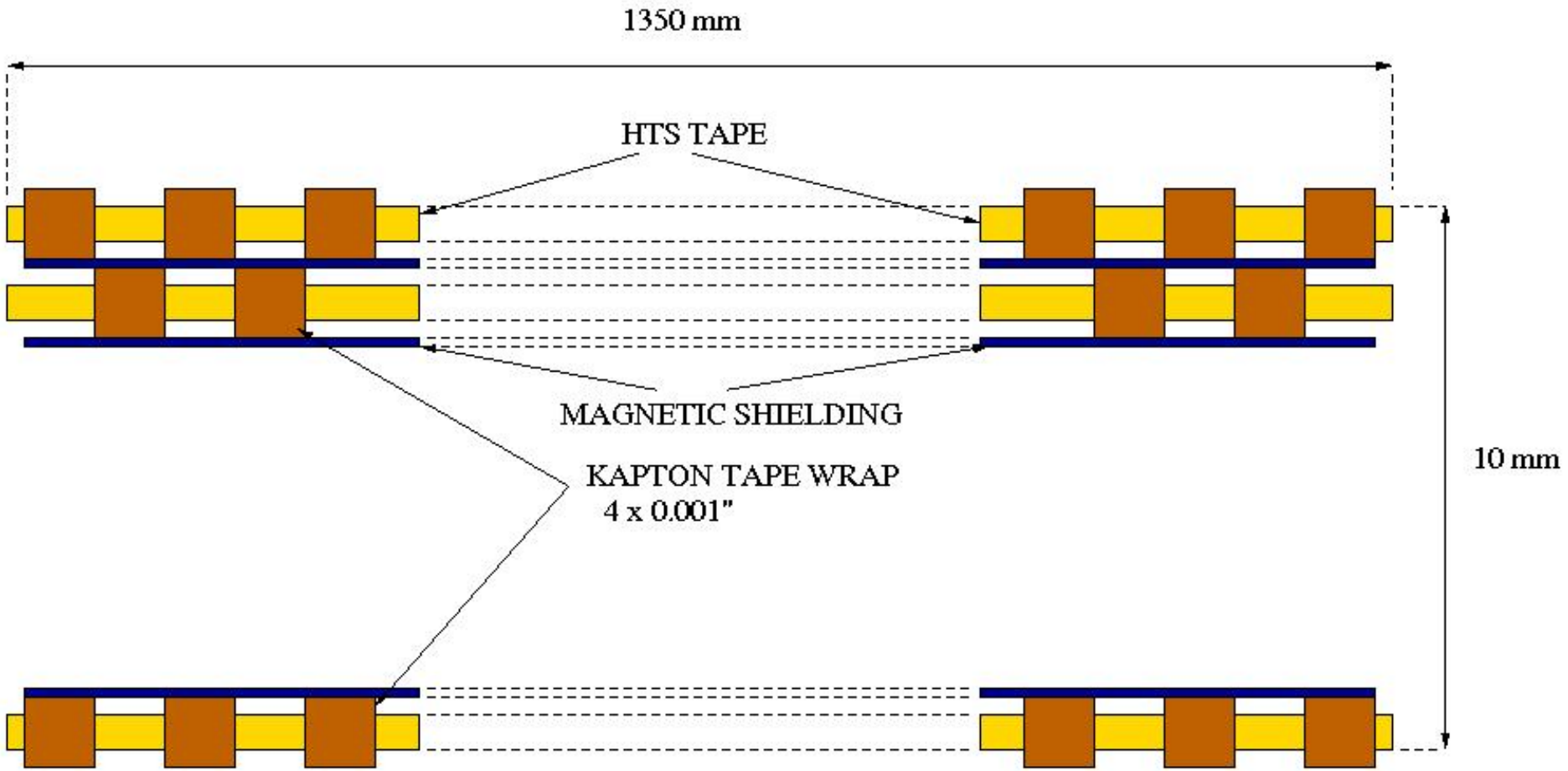
a) Helium Supply from Cryoplant

b) Helium Supply from Dewar (not shown)

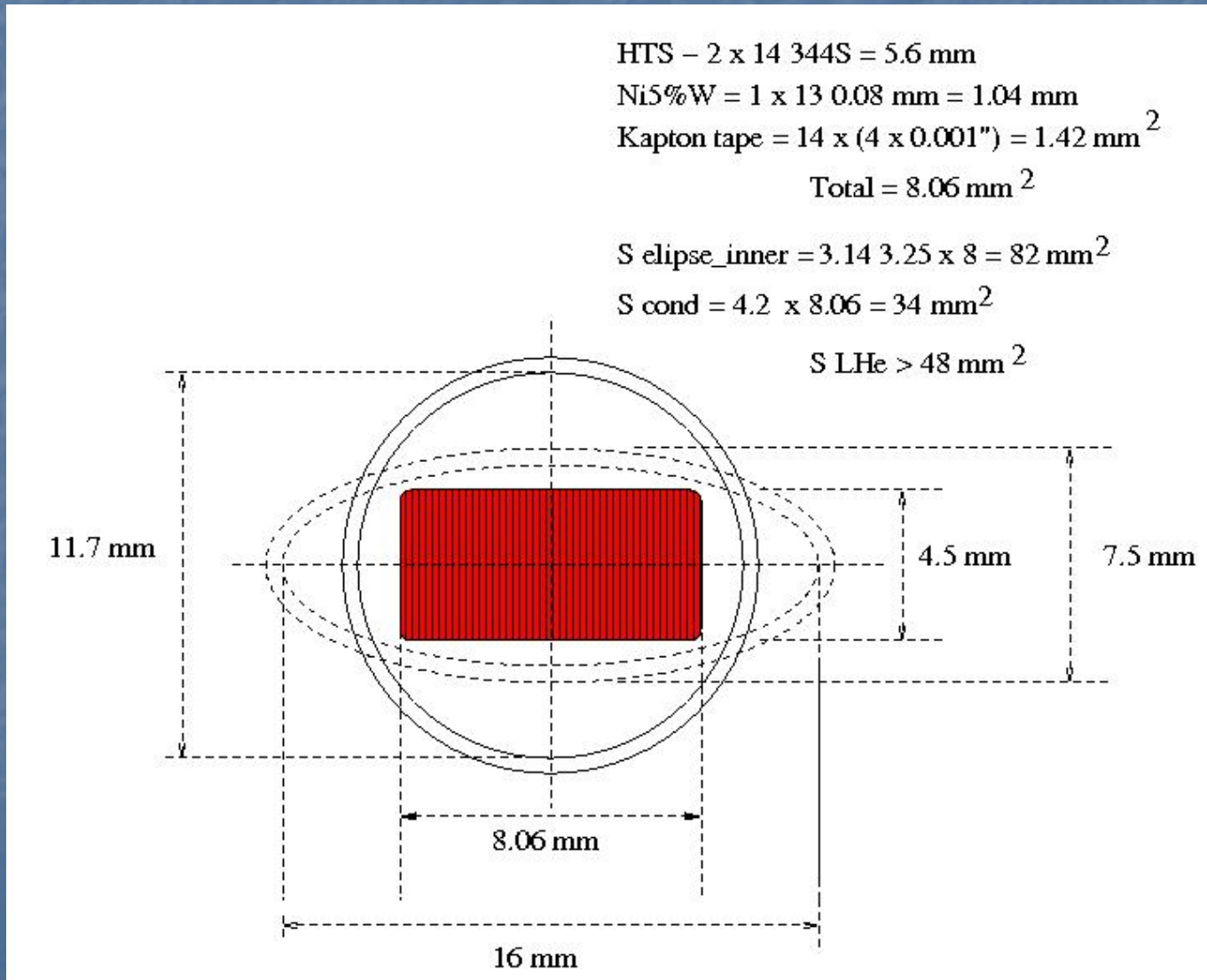
c) Vent to Atmosphere



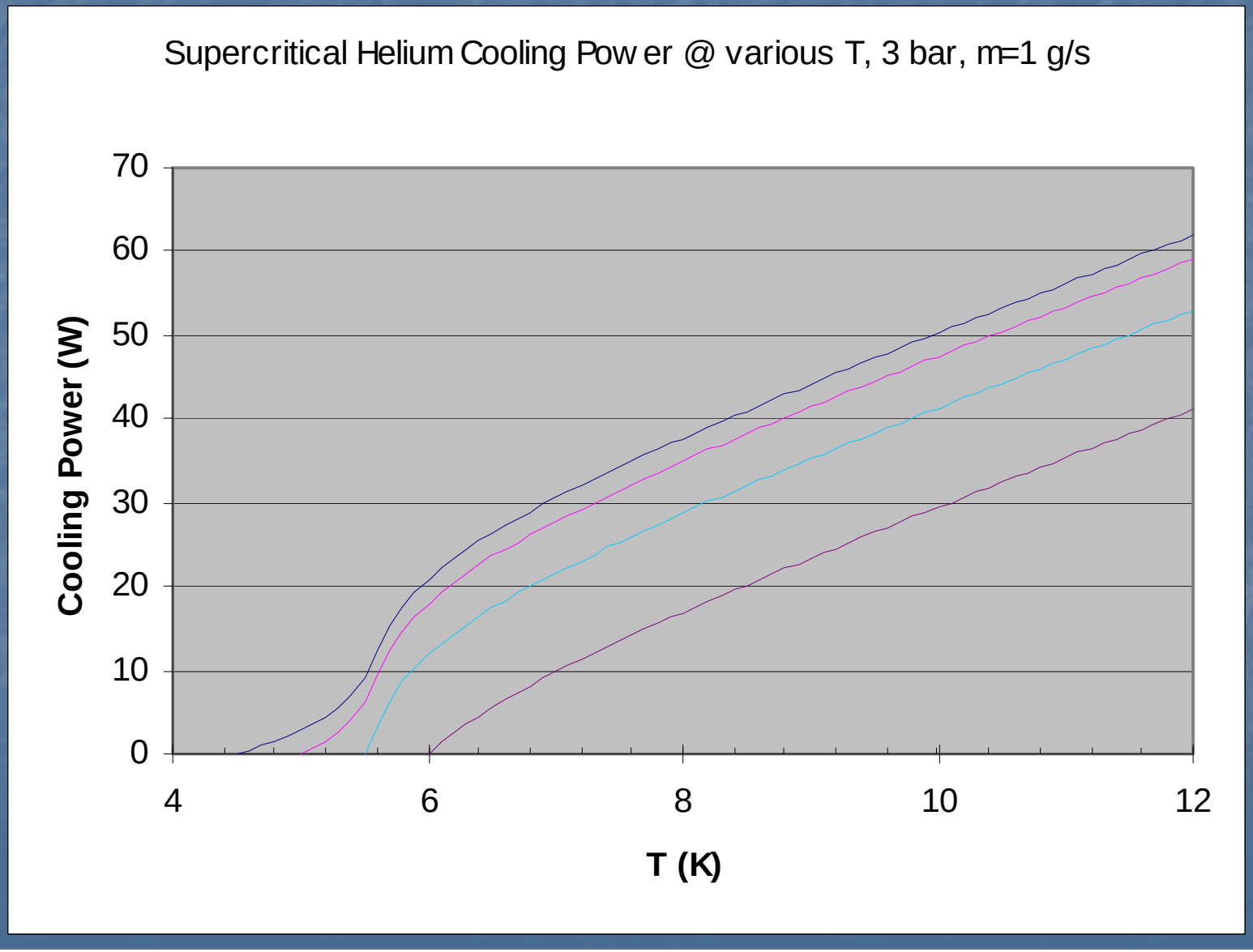
HTS Tape Conductor

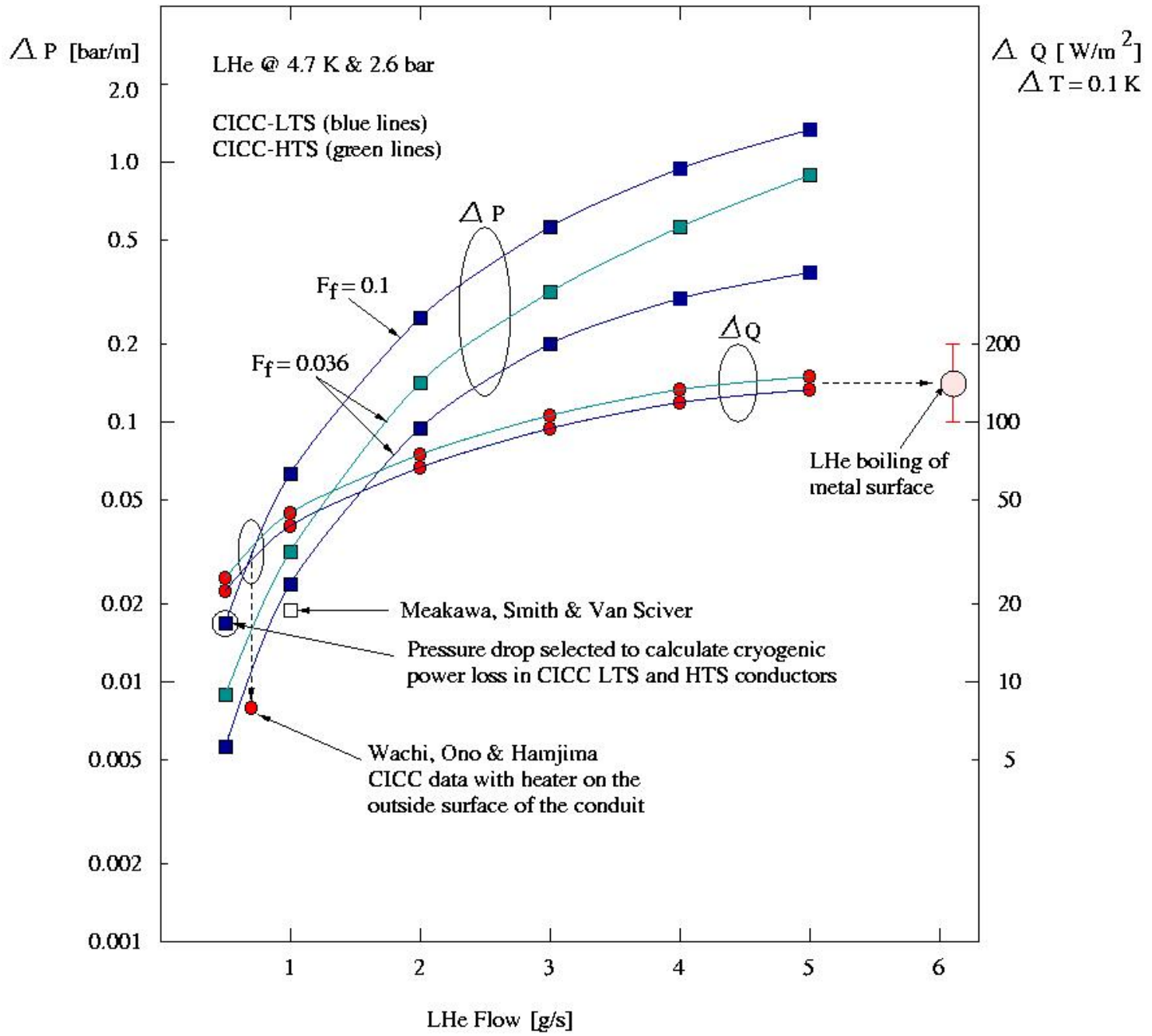


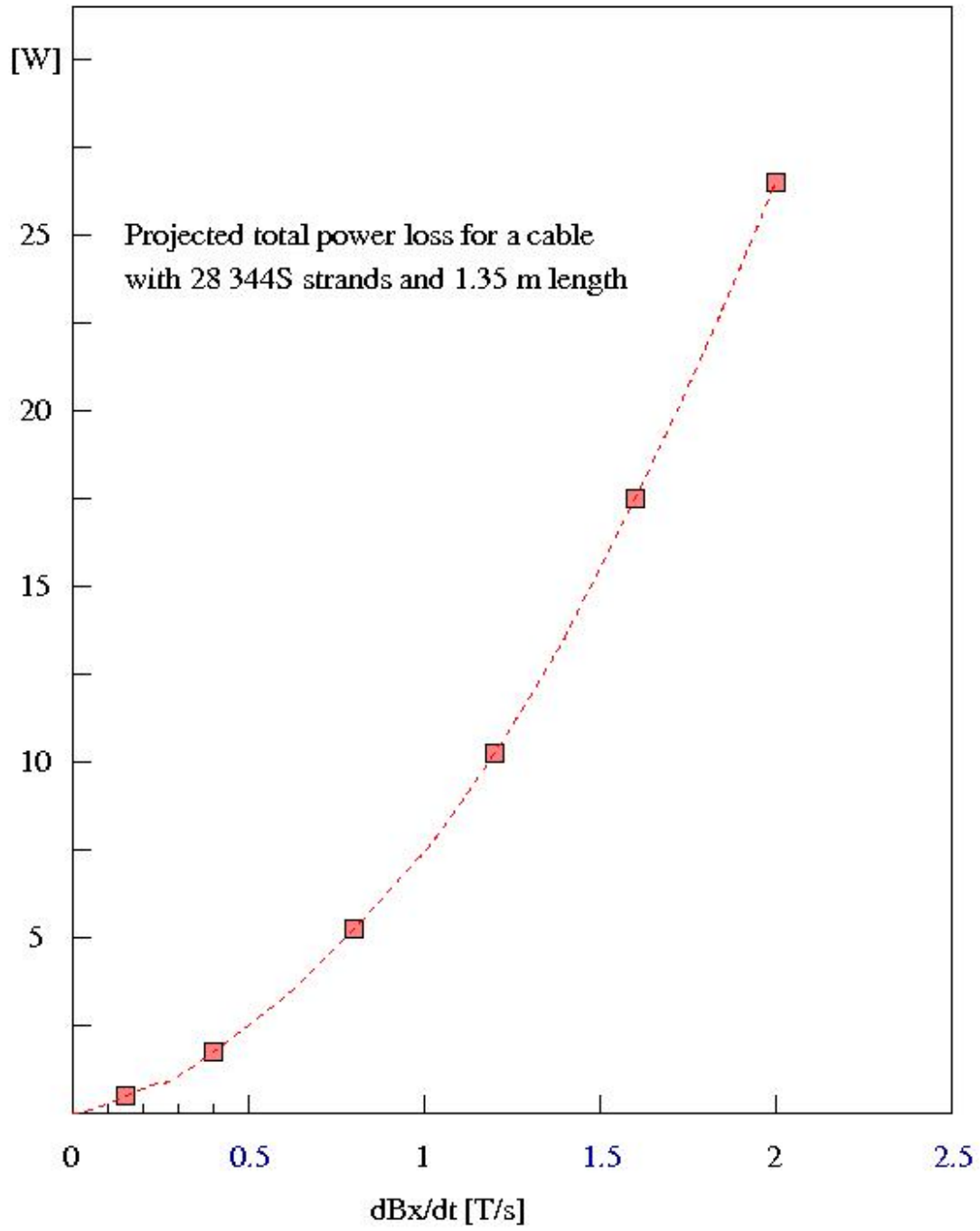
HTS Conductor and Tubing



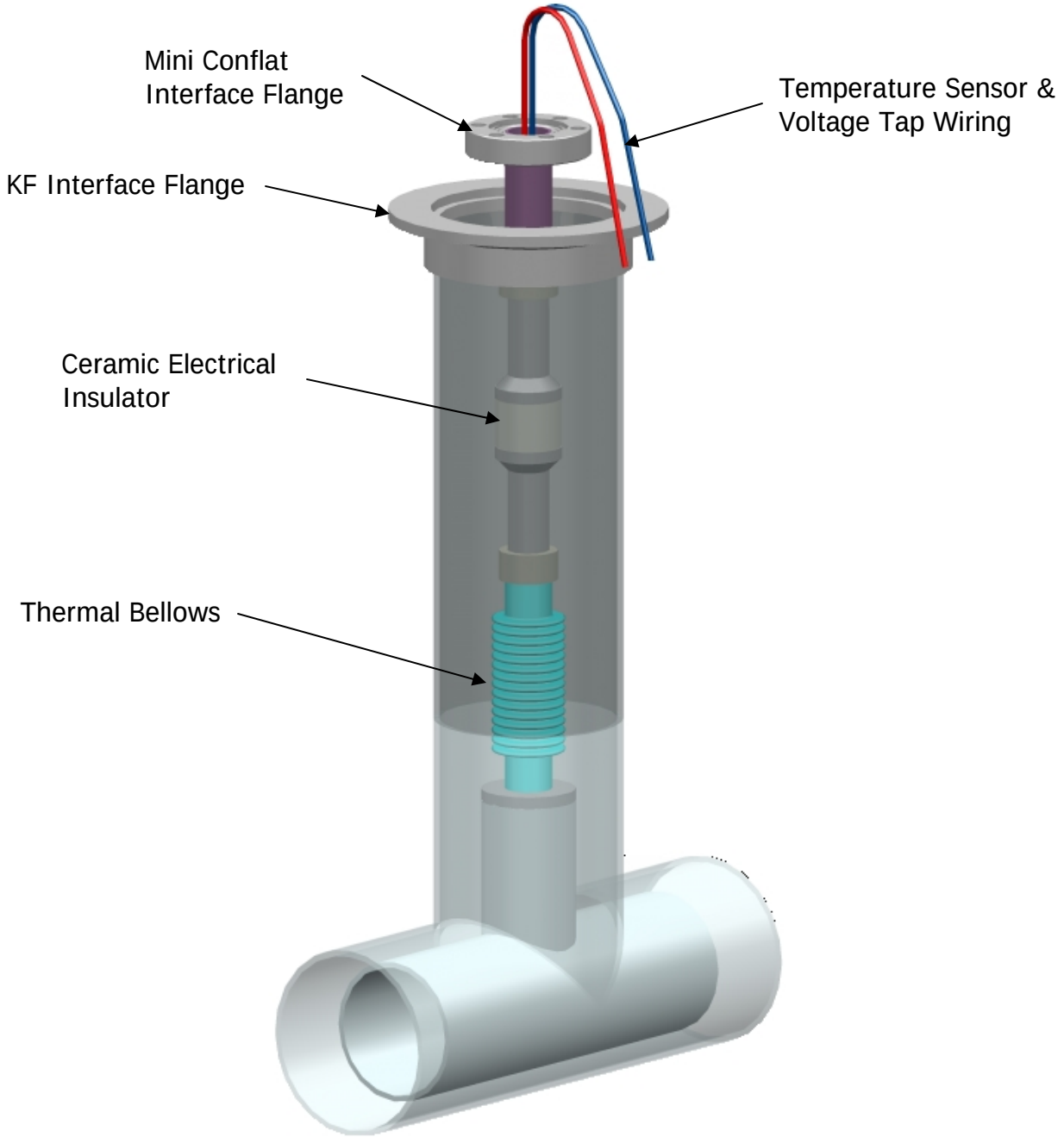
Supercritical Helium Cooling



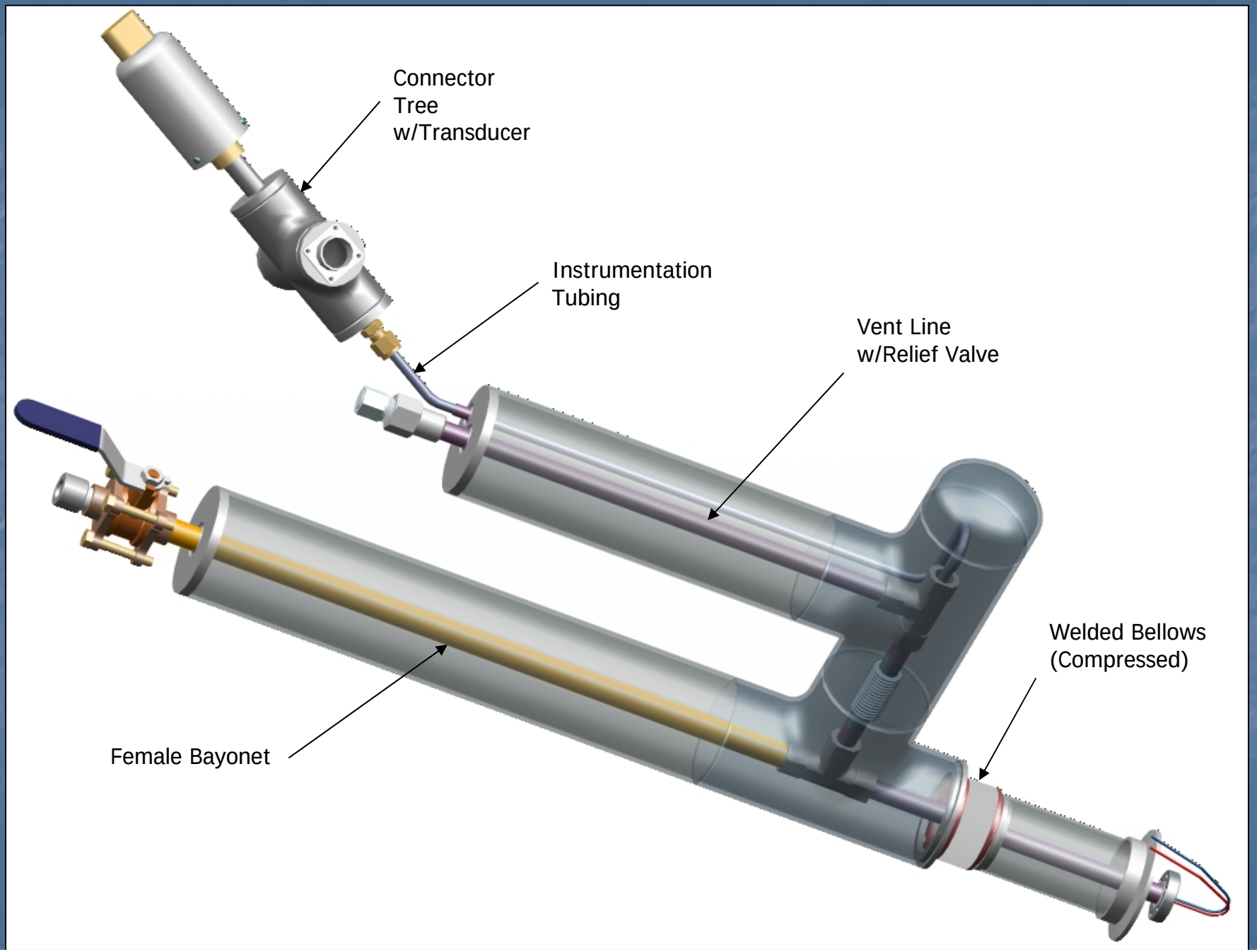

Δ P [bar/m]
Δ Q [W/m 2]
Δ T = 0.1 K
LHe @ 4.7 K & 2.6 bar
CICC-LTS (blue lines)
CICC-HTS (green lines)
Δ P
Ff = 0.1
Ff = 0.036
Δ Q
LHe boiling of metal surface
Meakawa, Smith & Van Sciver
Pressure drop selected to calculate cryogenic power loss in CICC LTS and HTS conductors
Wachi, Ono & Hamjima CICC data with heater on the outside surface of the conduit
2.0
1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
200
100
50
20
10
5
1
2
3
4
5
6
LHe Flow [g/s]


[W]
25
20
15
10
5
Projected total power loss for a cable
with 28 344S strands and 1.35 m length
0
0.5
1
1.5
2
2.5
dBx/dt [T/s]

Lower Female Bayonet Assembly

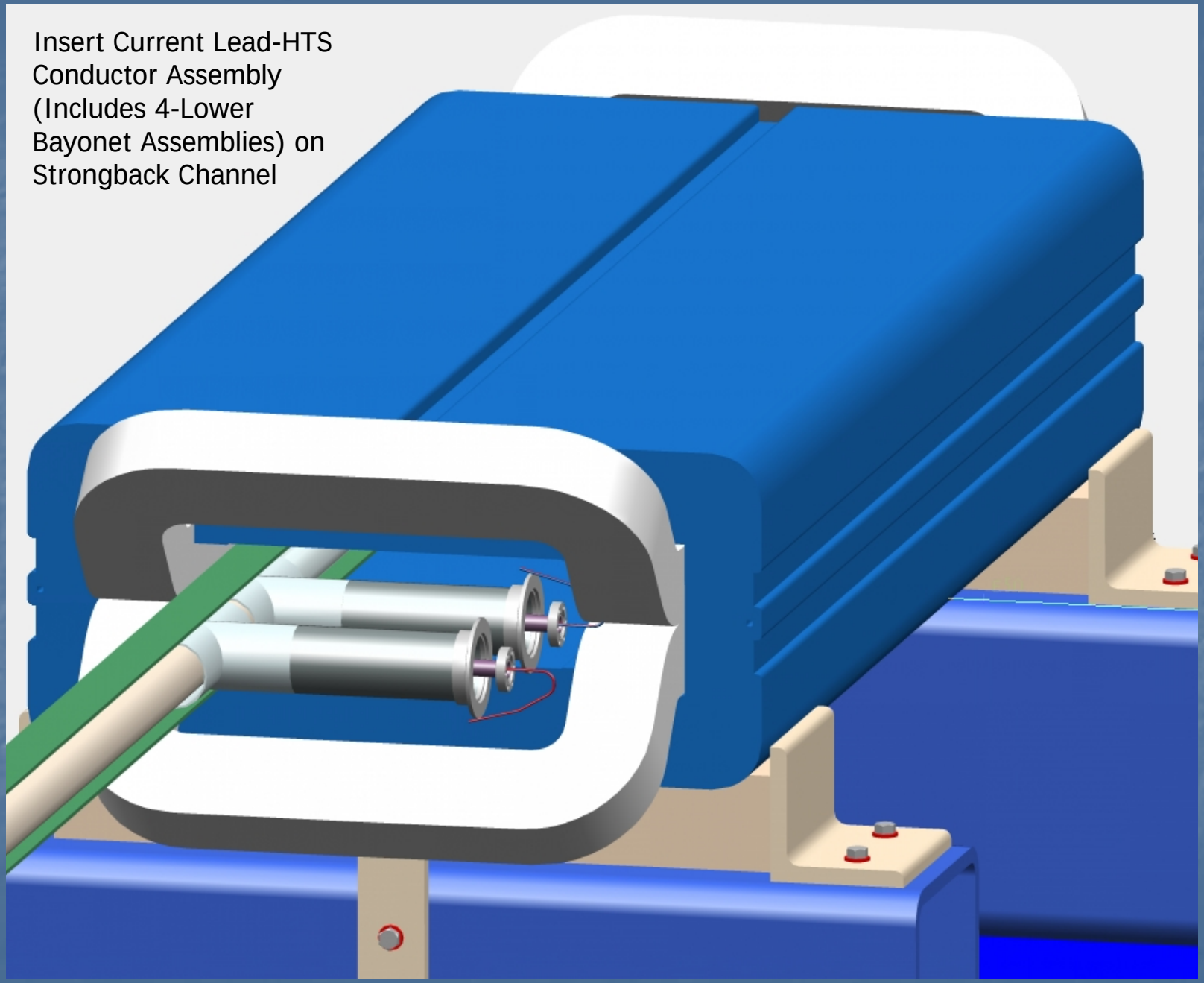


Upper Female Bayonet Assembly



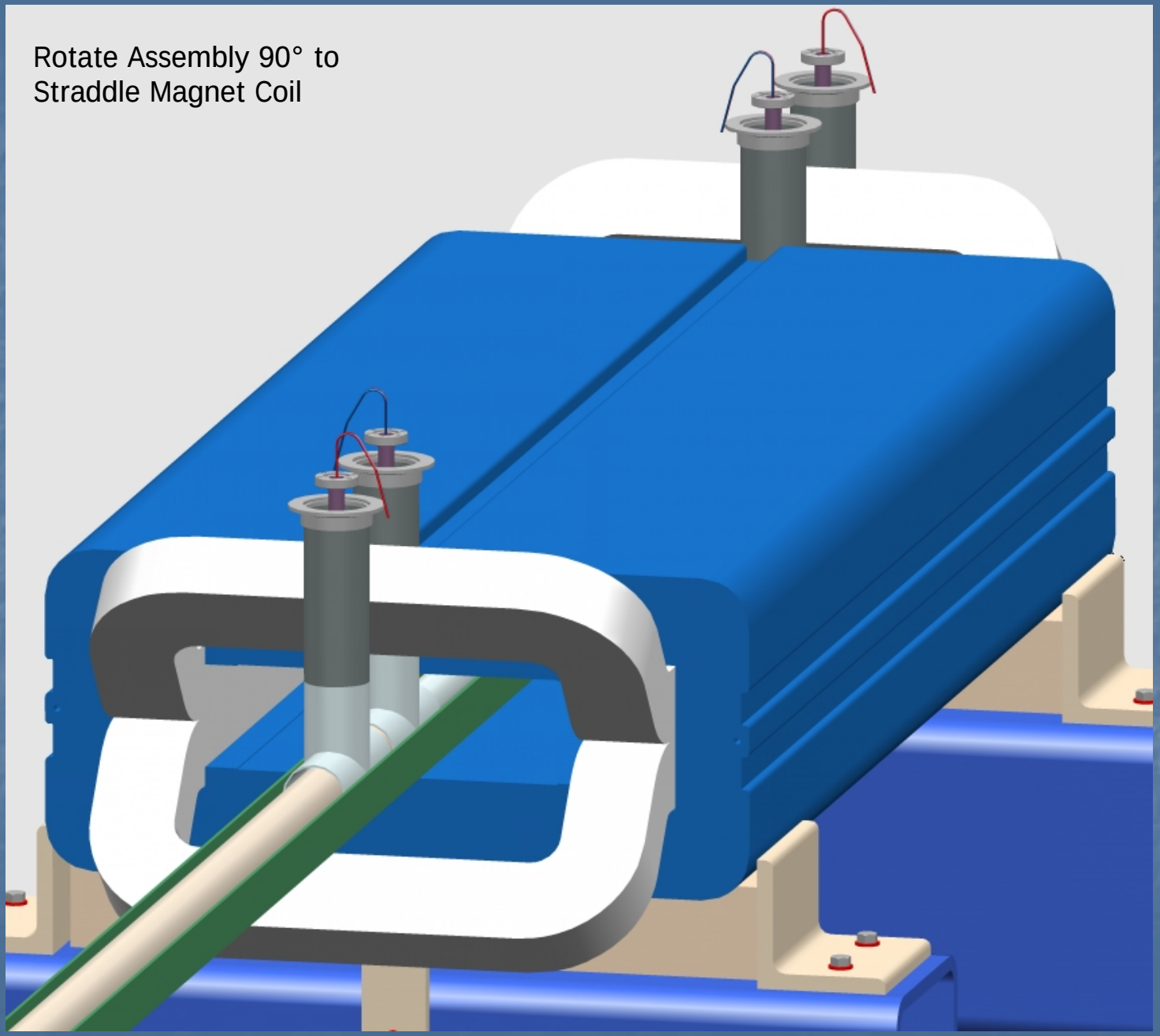
Installation- Step 1

Insert Current Lead-HTS Conductor Assembly (Includes 4-Lower Bayonet Assemblies) on Strongback Channel



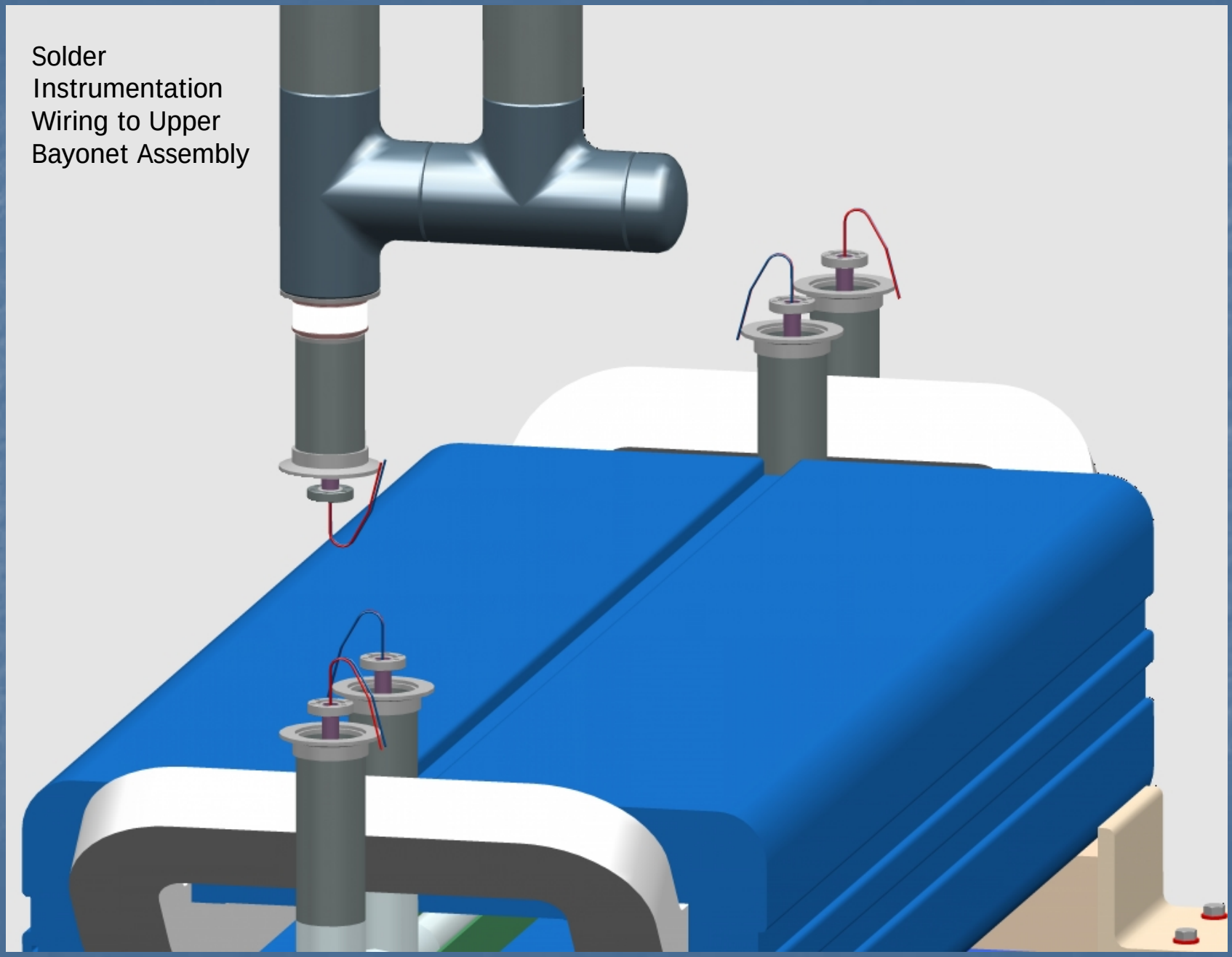
Installation- Step 2

Rotate Assembly 90° to
Straddle Magnet Coil



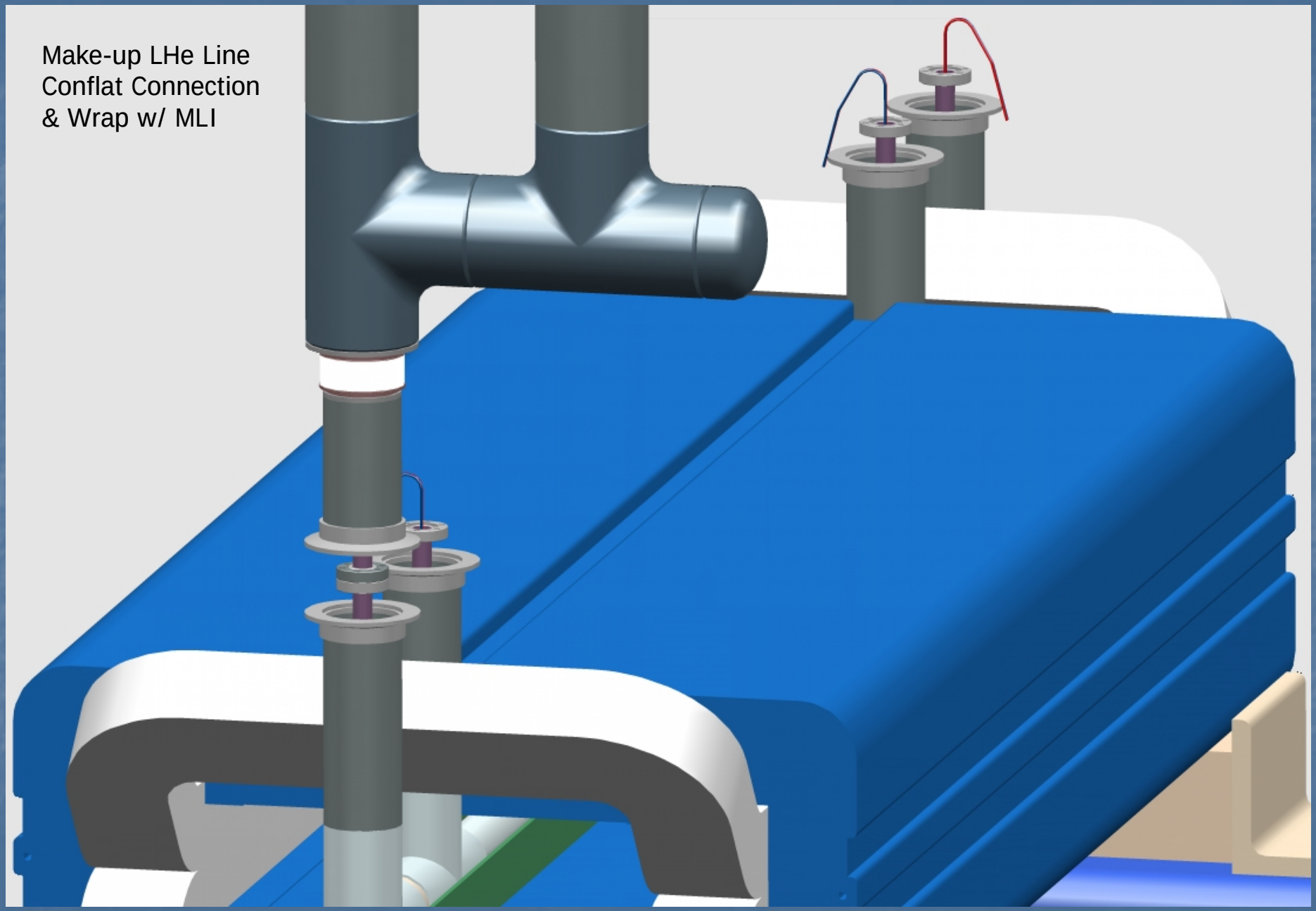
Installation- Step 3

Solder Instrumentation Wiring to Upper Bayonet Assembly



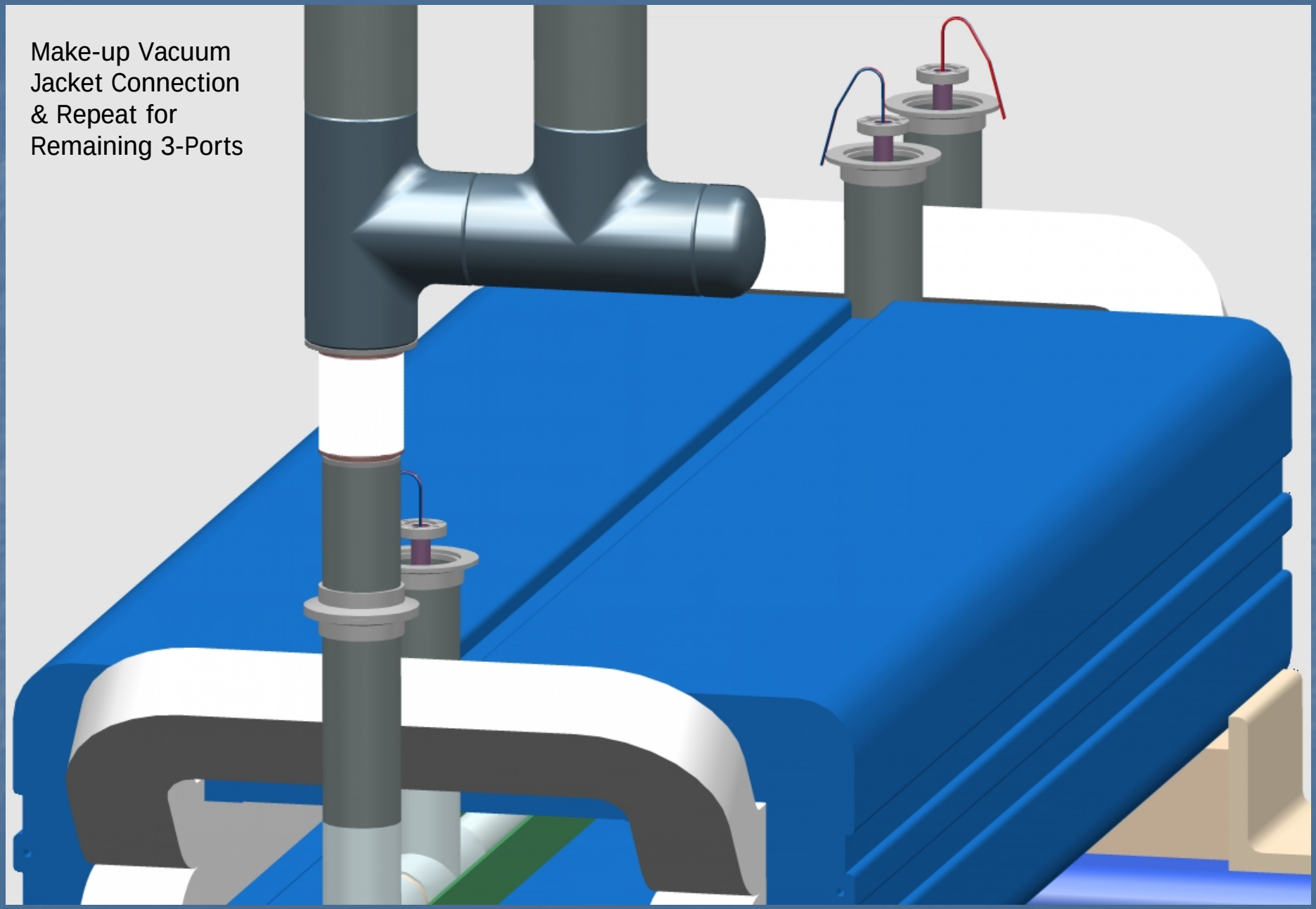
Installation- Step 4

Make-up LHe Line
Conflat Connection
& Wrap w/ MLI



Installation- Step 5

Make-up Vacuum Jacket Connection & Repeat for Remaining 3-Ports



The Measurements

- Inlet and outlet temperatures
- Inlet and outlet pressures
- Mass flow rate
- Voltage drops
- Current leads mass flow measurements
- Helium leak through flow block
- Current leads temperature at both cold and warm ends

Cryogenic System Safety

- Current leads helium flow is vented directly and there is no valve to block the flow
- HTS section is only 1.35 m long and is also vented at the warm end
- If loss of insulation vacuum occurs, heat load is limited since helium is in supercritical state