



A Retrospective on how Cryostats have changed with Cryostat Use and Cooling Methods used to keep Superconducting Magnets Cold

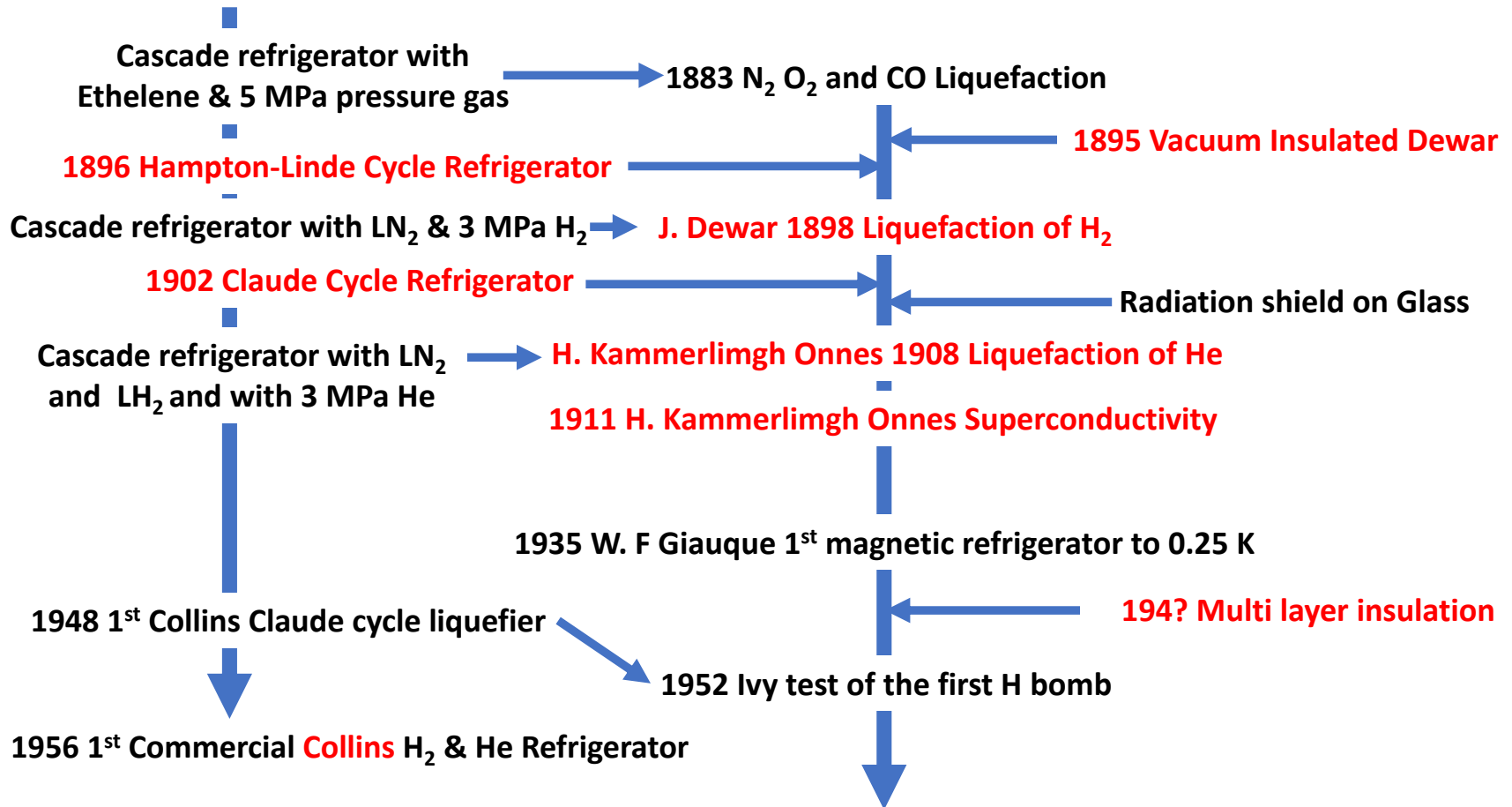
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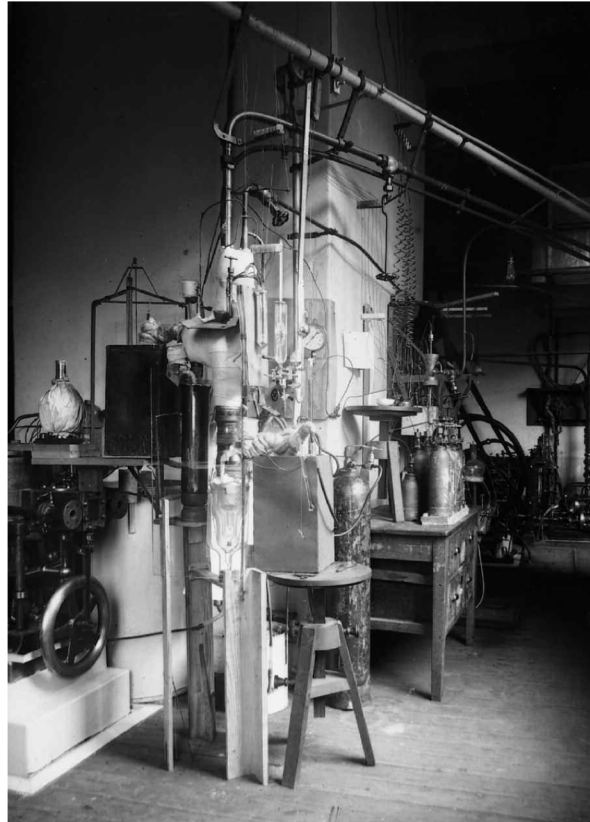
The Beginning 1883 to 1960



Cryostat and Liquefier Photos from before 1960



James' Dewar Vacuum Dewar

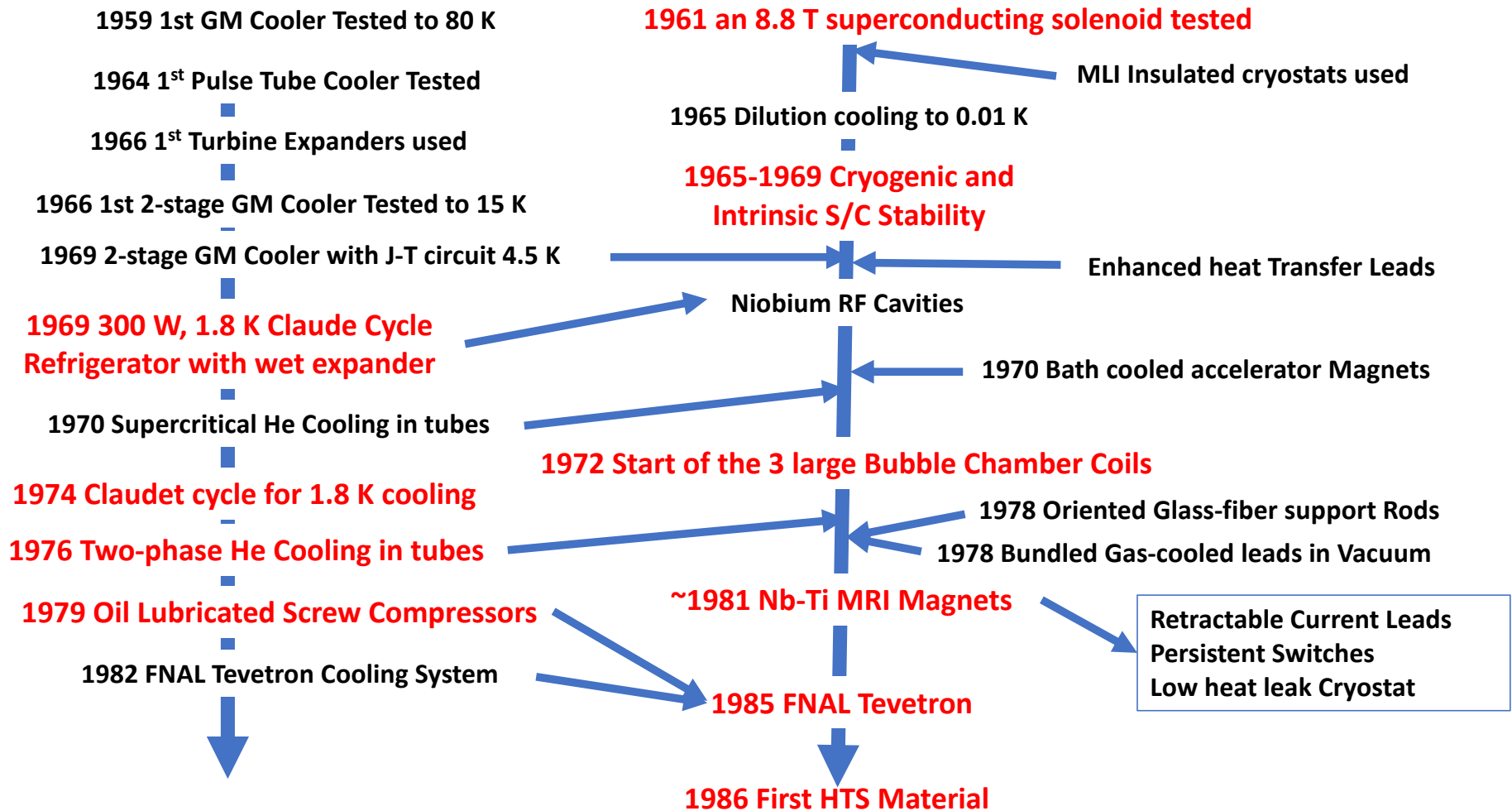


Leiden Helium Liquefier 1911



Sam Collins with an early Liquefier

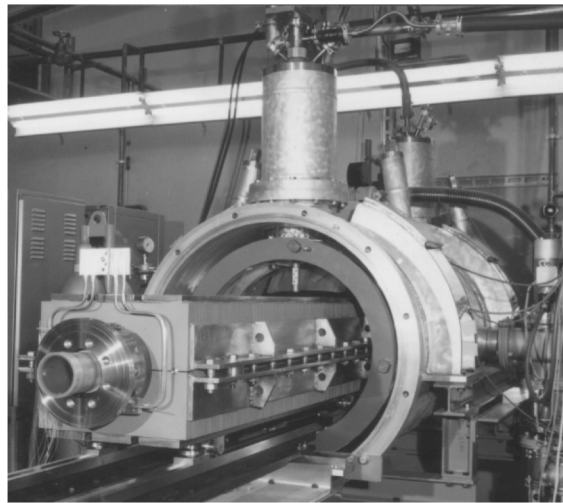
Cryostat Advancement from 1961 to 1986



Images from 1961 through about 1985



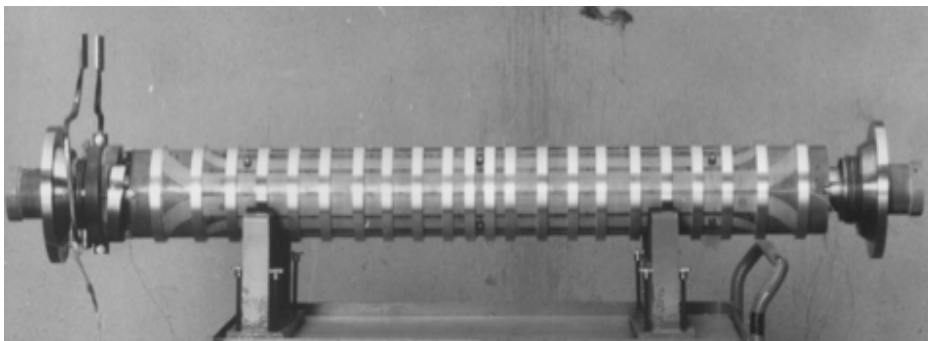
CERN 3 T Bubble Chamber Coil



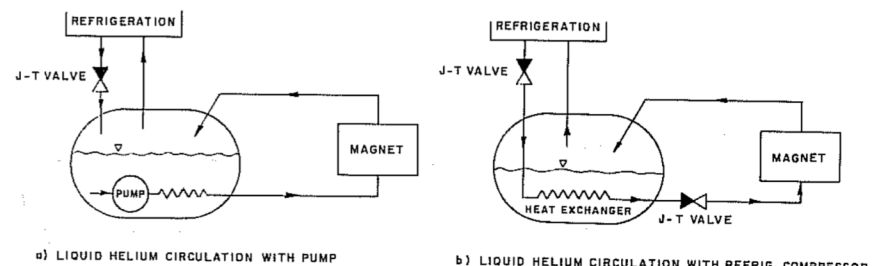
1973 Kfk Dipole and Dipole Cryostat



1980 LBL Thin 1.5 T Solenoid 2 m ID



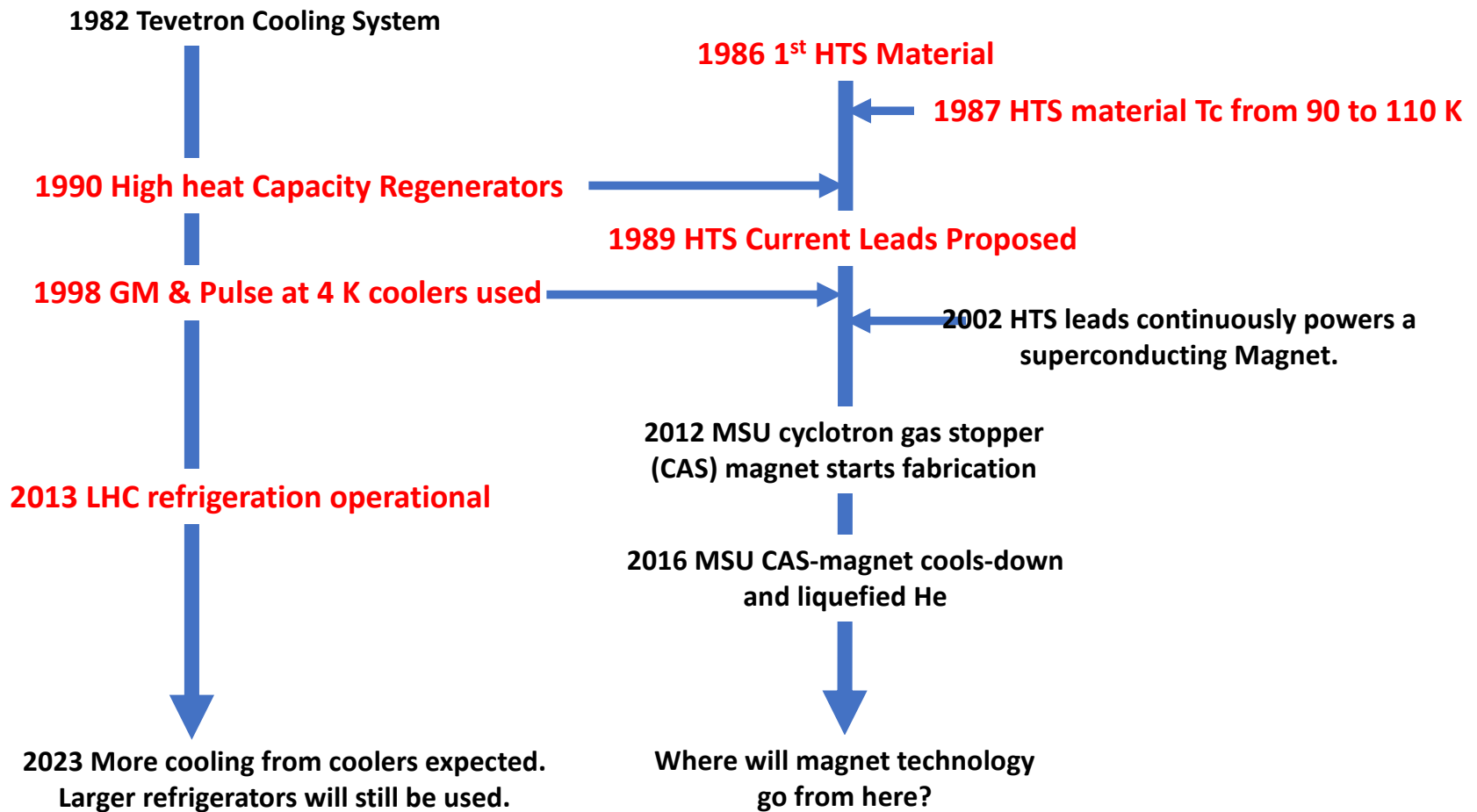
1973 Kfk 4.5 T Dipole of almost Accelerator Quality



Two ways of achieving Forced two-phase He Cooling

XBL 773-7850

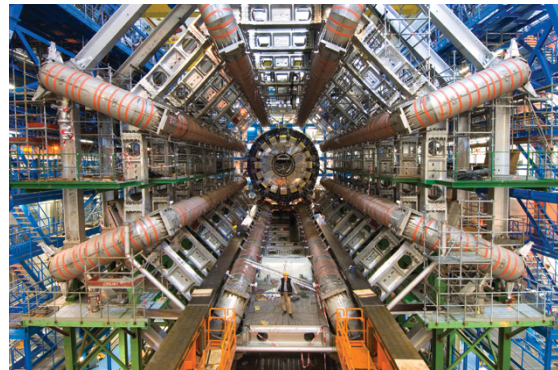
Cryostat Advancement from 1987 to 2022



Images from 1986 through 2020 Large Magnets



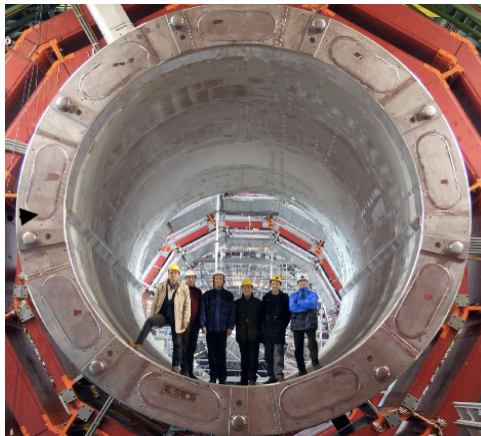
Delphi Magnet Construction



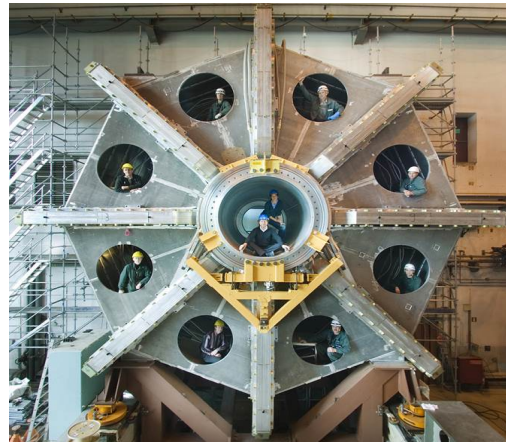
Atlas 22 m long outer Toroid Coils



18 kW 4.5 K Refrigerator for LHC



CMS 4 T Magnet with 6-m Bore

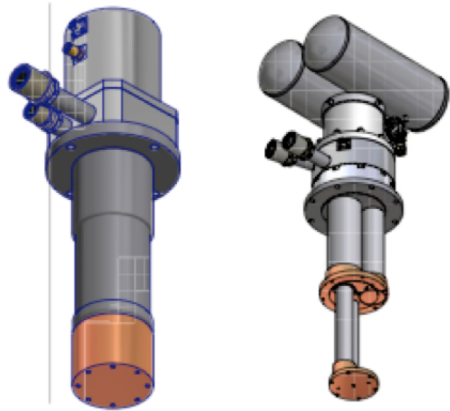


Atlas End-cap Toroidal Coils

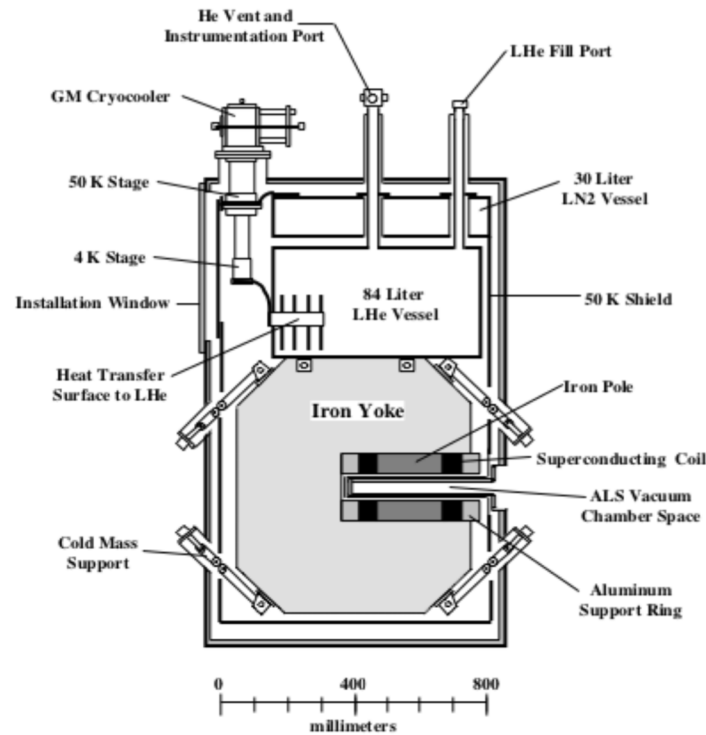


2.4 kW 1.8 K Refrigerator for LHC

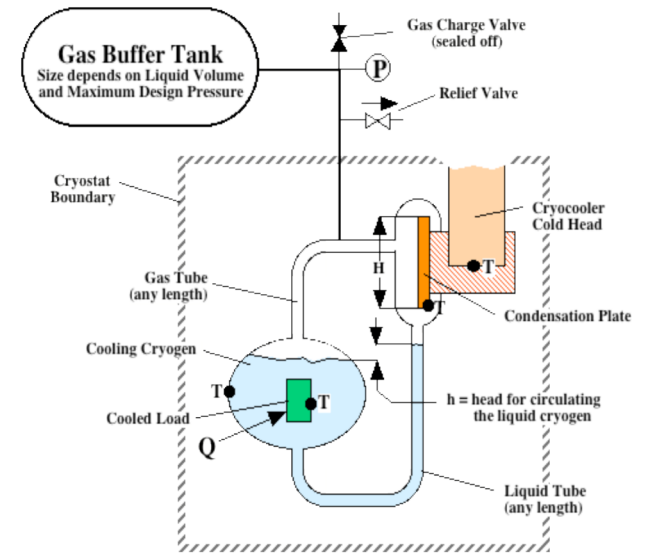
Images from 1986 to 2020 Cooler Cooled Magnets



Cryomech Coolers
 Left A-325 GM Cooler
 Right PT-415, Pulse Tube Cooler



Superbend 5 T Dipole at LBL

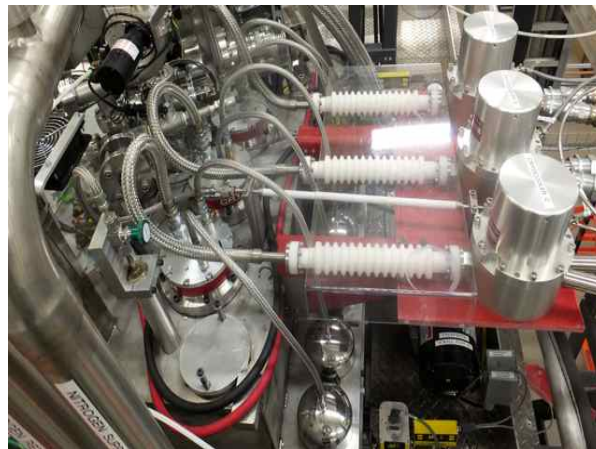


Free convection cooling loop to transfer heat from He bath to the cooler head

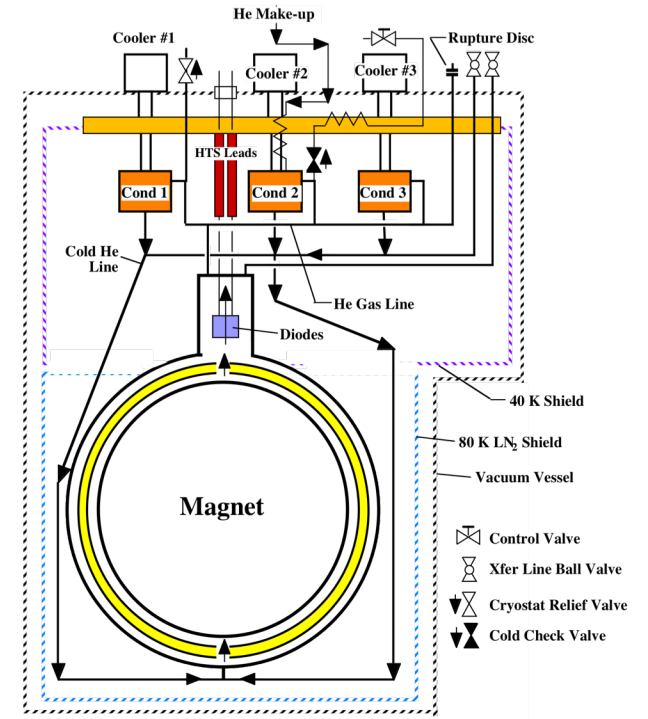
Images from 1986 to 2020 Cooler Cooled Magnets



The MSU cyclotron gas-stopper magnet
With 167 tons of iron for two poles.
Each pole has a cryostat with 3 coolers.
Total cold mass is 2.3 tons.



Three PT415-RM coolers per cryostat.
The remote motors are separated
from the cooler cold heads by a 50 kV
insulator to allow for beam extraction.



Cooling loop to cool-down and liquefy
He gas and keep cold at 4.5 K

Where do we go from here in 2023

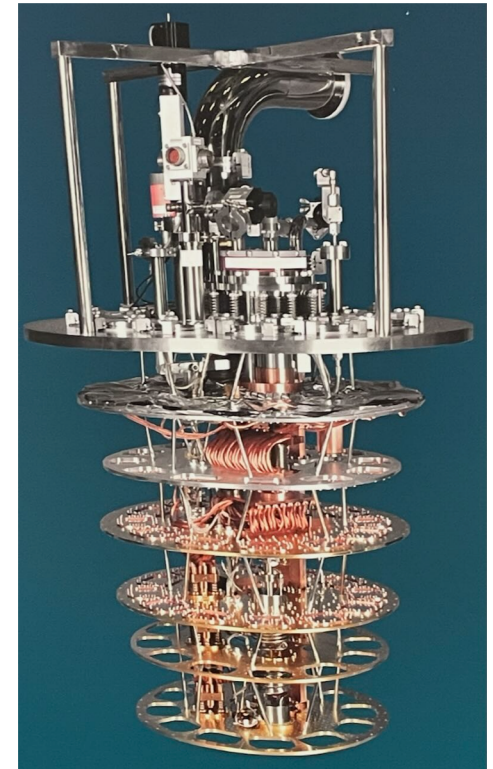
Larger Coolers and Dilution Refrigerators for quantum computers

**Hydrogen cooling for HTS
Magnets and other Uses
Such as;**

**Aircraft generators,
aircraft propulsion,
maybe power applications,
And levitated trains**



New Cryomech PT-450 Cooler



Dilution Refrigerator