Dynacool

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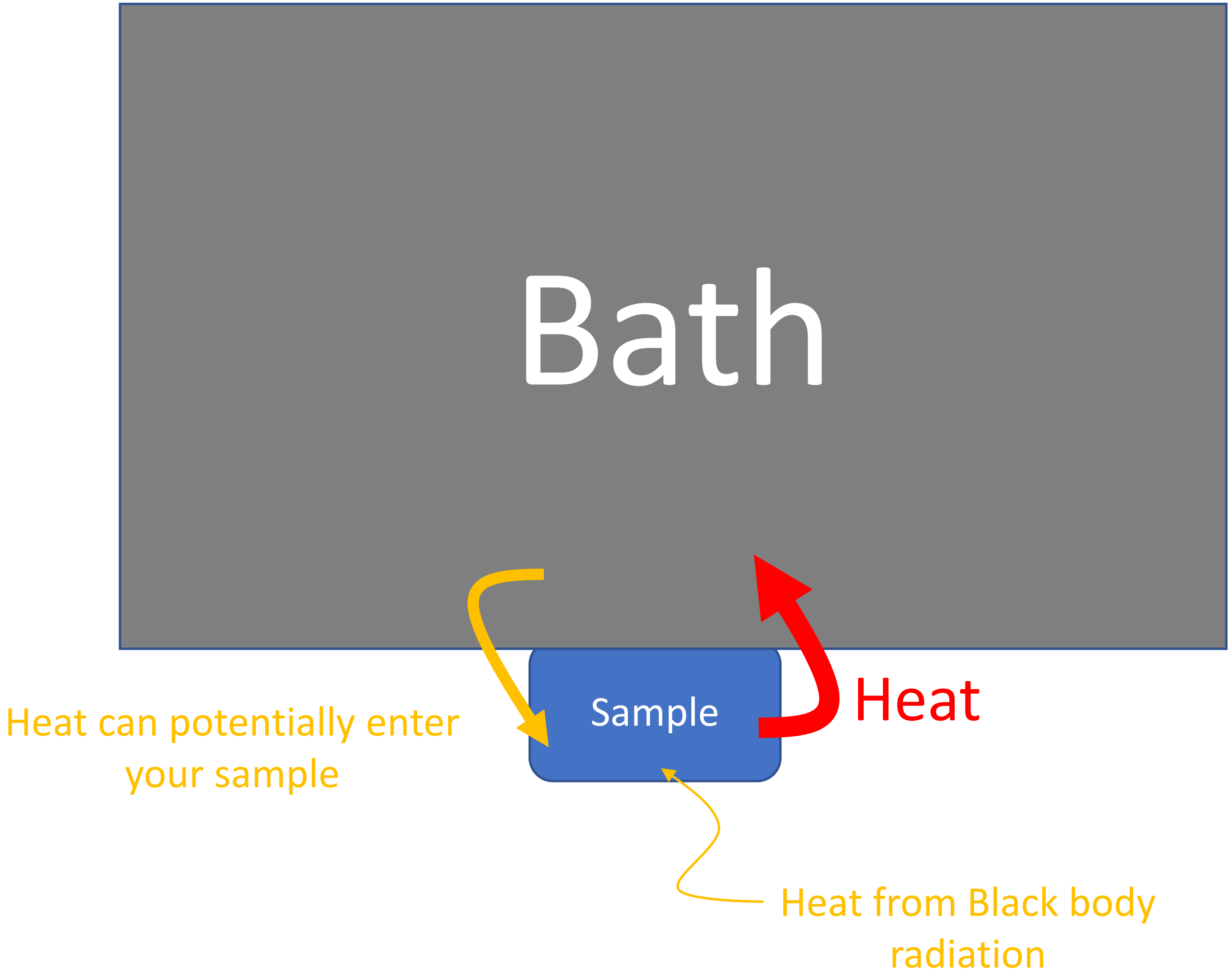
Why cool down samples?

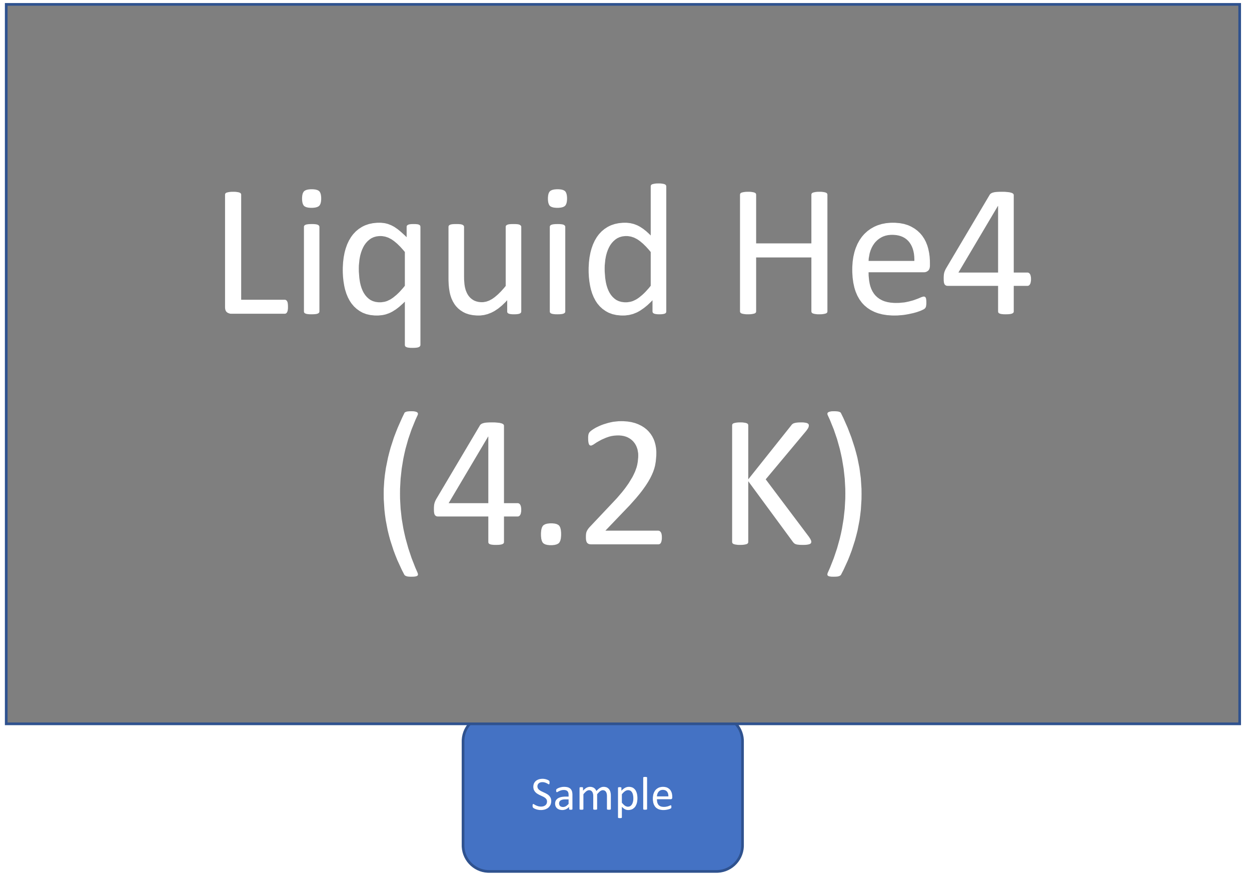
- **Measure the temperature dependence:** Upon cooling, R increases for an insulator, R decreases for a metal, R suddenly drops to zero when it becomes a superconductor.
- **Less thermal processes disturbing the physics we want to study.** Freeze out phonons for example.
- **Phase transitions:** new physics to be discovered as a function of temperature.
- ...

Cooling = Taking away heat from your sample



- Bath temperature needs to be lower than your sample temperature.
- Cooling Power (-dQ/dt) has to be significant enough. Usually this becomes smaller at lower temperatures.

Liquid Helium-4 can give you 4.2 K



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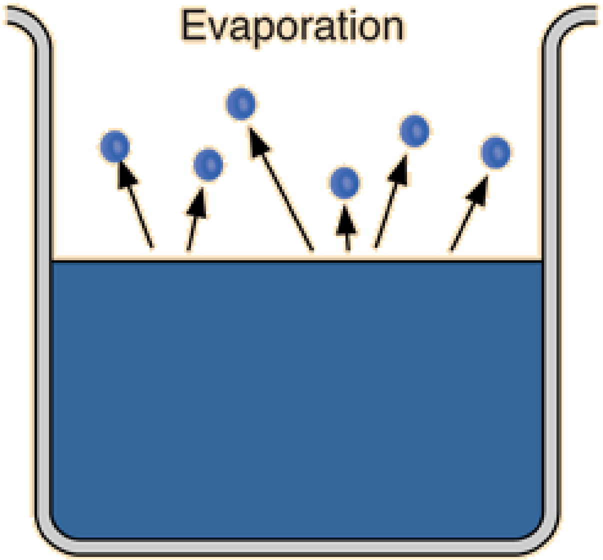
- Cooling Power (-dQ/dt) has to be significant enough. Usually this becomes smaller at lower temperatures.

Q. Can we go lower?

Cooling Method 1: Pumping on Vapor



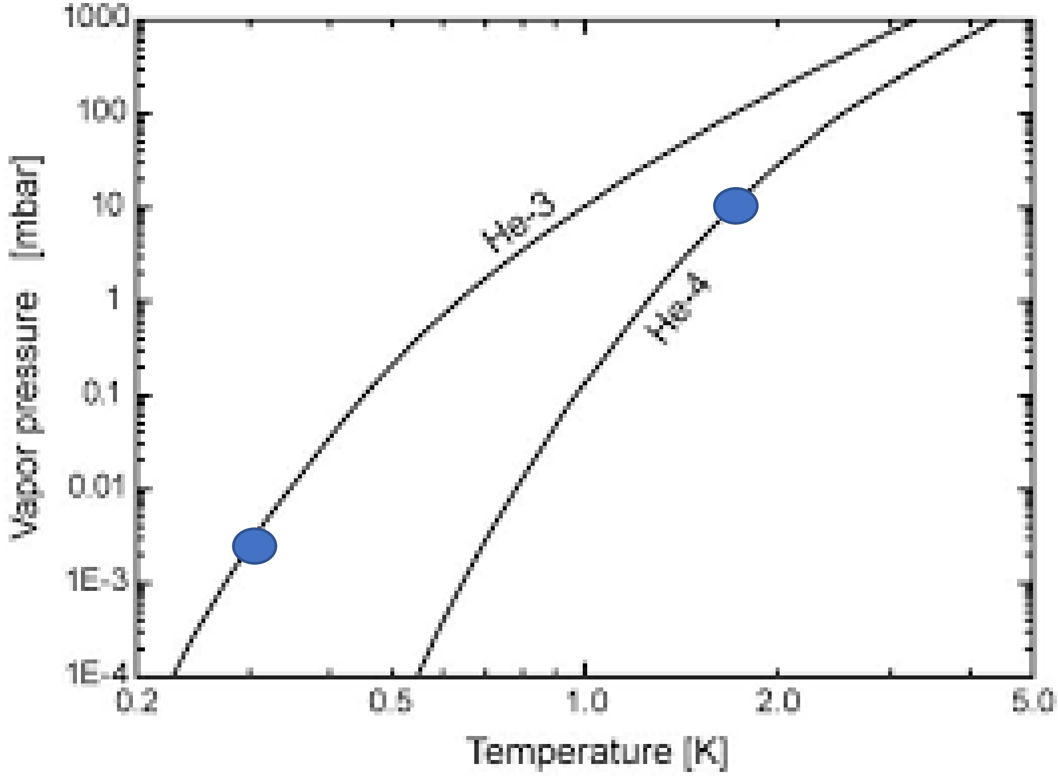
$$-\dot{Q} = L\dot{n}$$

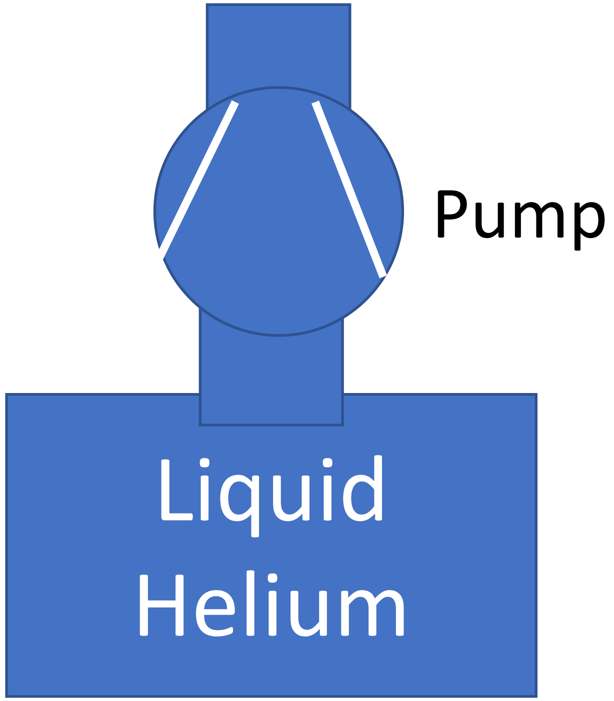
$-\dot{Q}$: Cooling Power

L : Latent heat associated with liquid -> gas

$\dot{n}$: Rate of particles changing from liquid to gas

Cooling Method : Pumping on Helium





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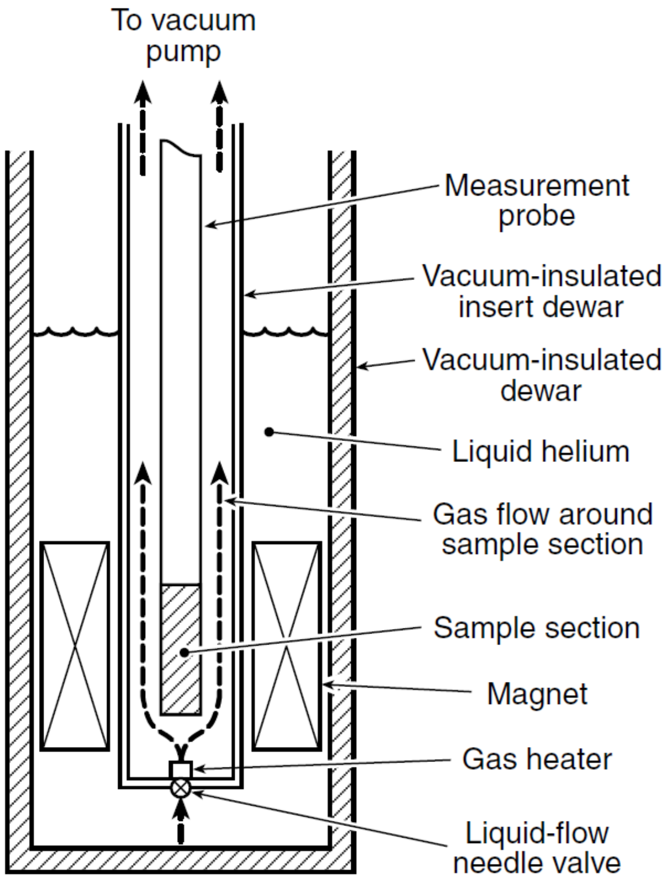
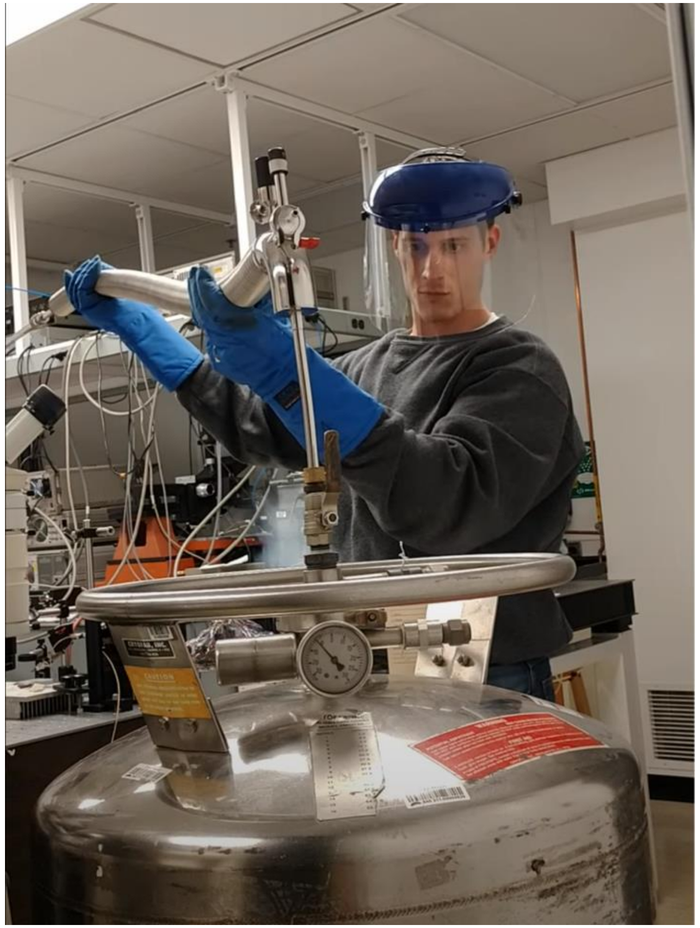
Helium is Valuable

Helium Shortage 4.0: What caused it and when will it end?

Helium is the second-most-abundant element in the universe, but on Earth it's relatively rare. It results from the decay of uranium, can't be artificially created, and is produced as a byproduct of natural gas refinement. Only a limited number of countries produce it, with the U.S. and Russia among top suppliers. Because that's the case, it only takes a handful of supply disruptions to trigger a crisis — the gas industry refers to the current one as "Helium shortage 4.0," it being the fourth since 2006.

Wet Systems (In contrast to Dry Systems)





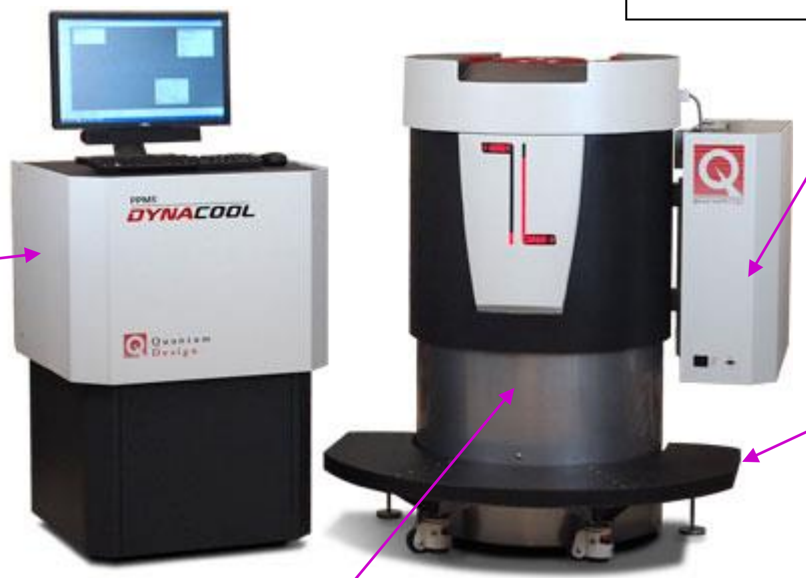
Need to transfer Liquid helium every once in a while

Closed system (Cryocooler is inside)

DynaCool Components Overview

CAN Module Bay
Temperature control module
Measurement modules

Pump Cabinet
2 pumps
Gas manifold
Cryostat control electronics
Computer
Magnet Controller

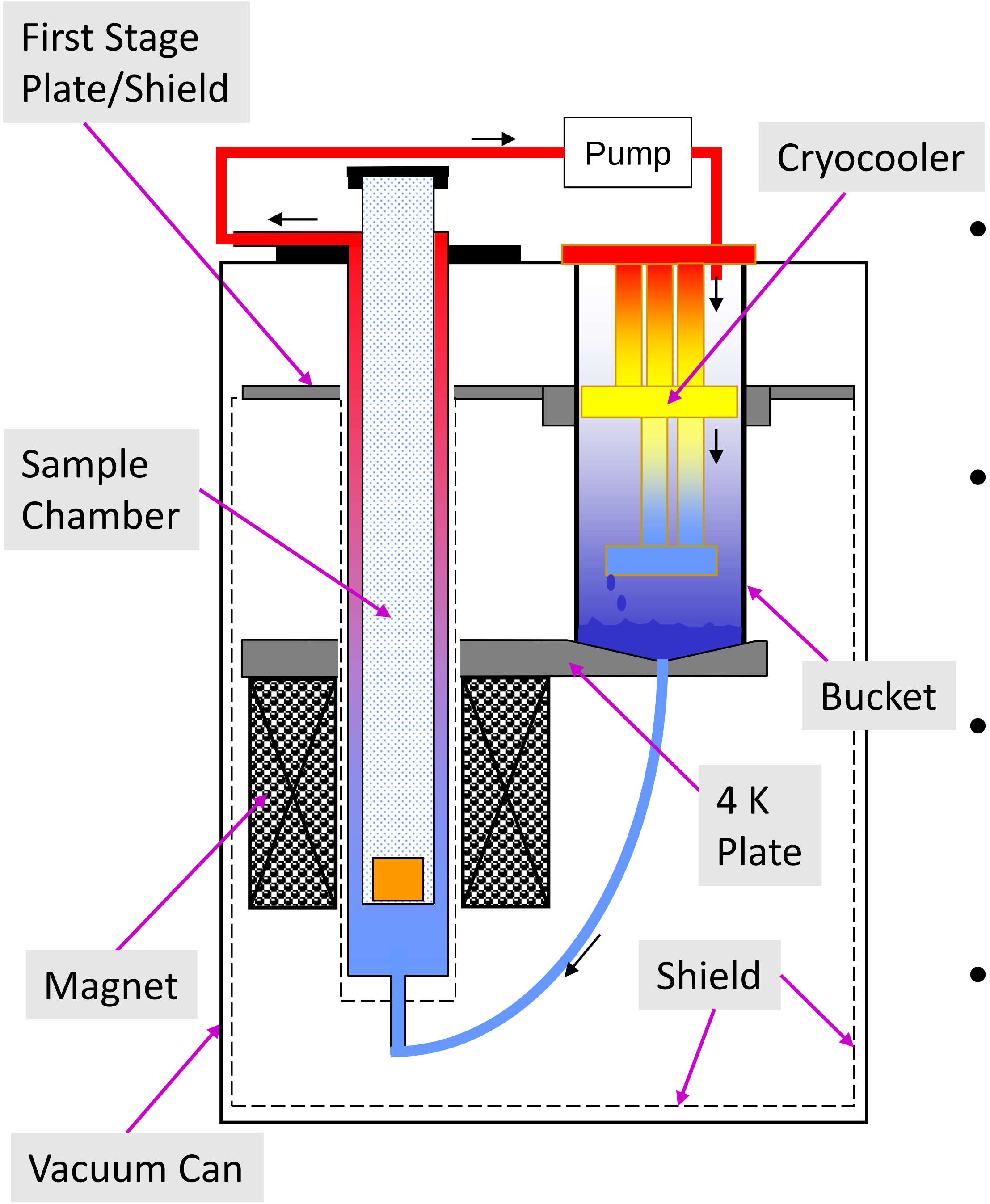


Deck or step

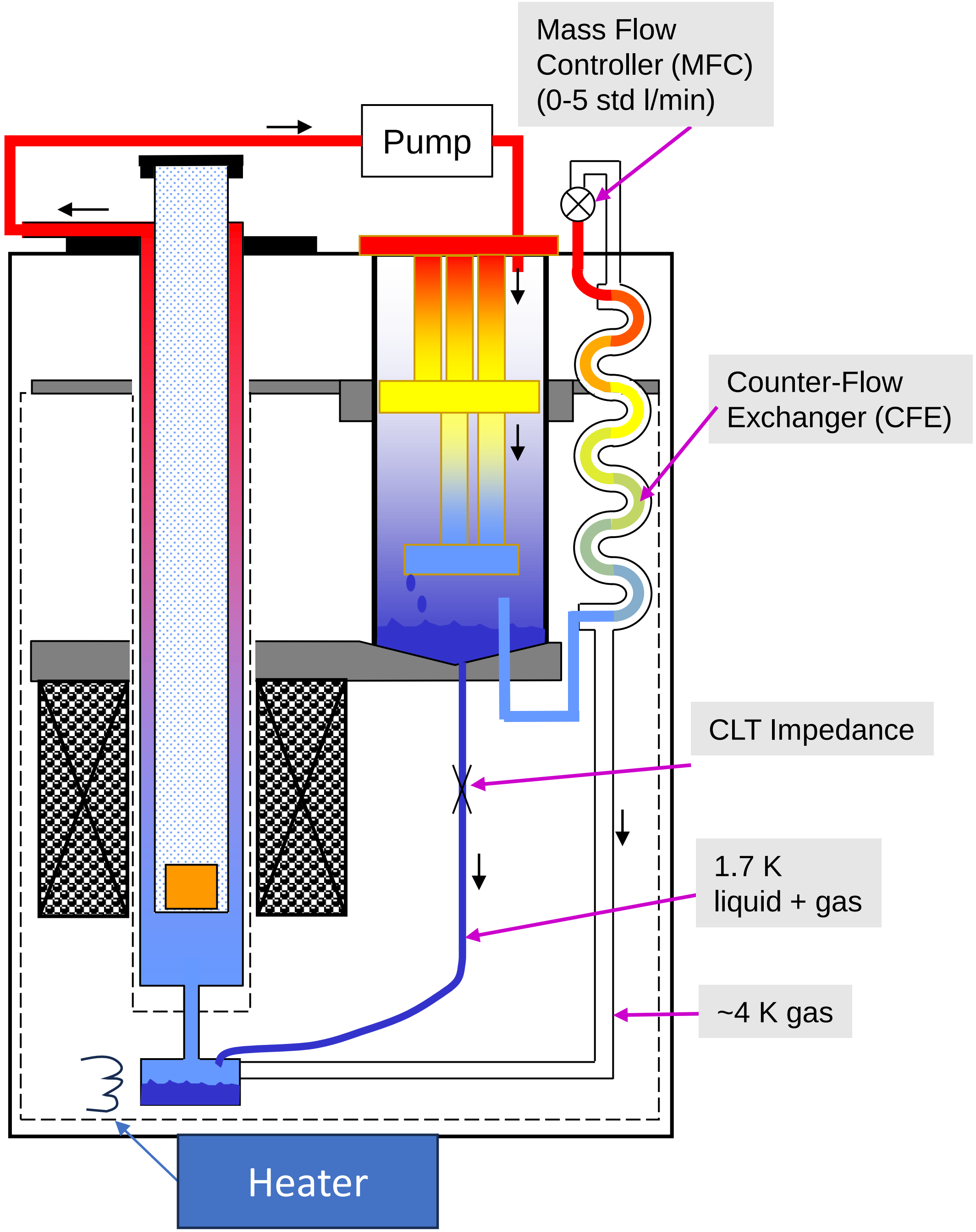
Cryostat Enclosure
Cryostat
Cryocooler
Dump tanks
Magnet shield
Temperature/field display

Helium Compressor
(not shown)

Cryostat Overview



- Cryocooler is in a bucket of He gas
- All other components are in vacuum
- Chamber cooling is achieved by flowing cold gas
- The magnet is cooled via solid conduction through the 4 K plate



- High temperature mode:
    - 400 K to 10 K
    - Counter flow exchanger flow used for cooling (varied using Mass Flow Controller)
    - “Snorkel” takes *gas* from bucket
    - Continuous low temperature (CLT) impedance flow reduced
- Low temperature mode
    - 10 K to <1.9 K
    - CLT flow used for cooling
    - CFE flow impedance set to zero using Mass Flow Controller

Unique Cryostat Design

- Vacuum Space
- Cooling Annulus
- Sample Insertion Tool
- Sample “Puck”
- Sealed Sample Chamber
- 12-pin Connector