Hands-on training 6

IHEP Accelerator Lab
Cryogenic group
Dec. 10-15, 2018

OUTLINE

- Cryogenics
- Insulation support
- Solid Material & Insulation
- Question

Cryogenics

- Cryogenics is a branch of physics that studies what happens to things at low temperatures.

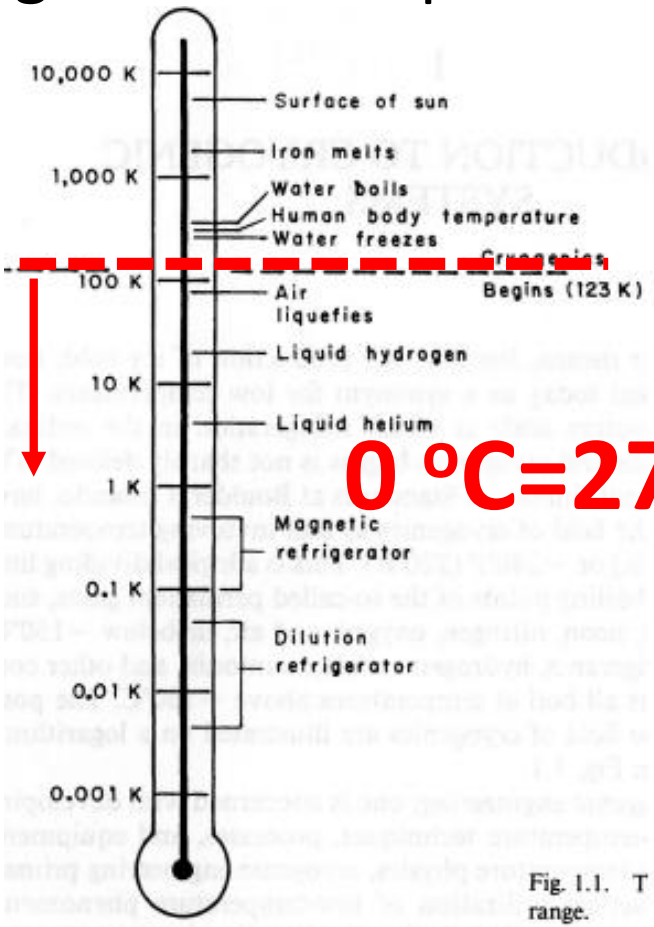


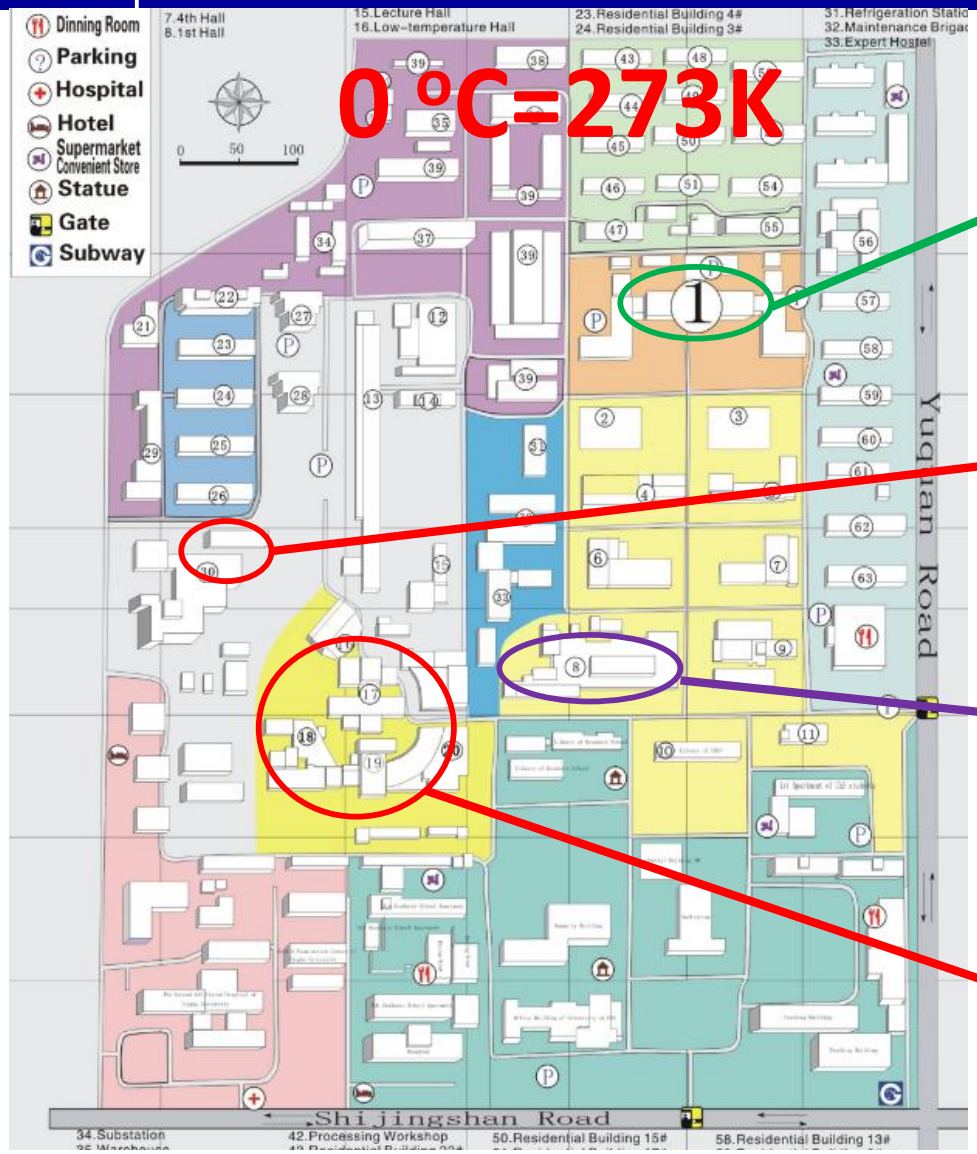
Fig. 1.1. T range.

0 °C=273K

Temperature range is bellow 123 K= -150 °C

Room temperature

Cryogenics in IHEP



Main building 300K

Room temperature

Recycling hall 77K

Liquid Nitrogen

1# hall 2K

Superfluid Helium

13# hall 4.5K

Liquid Helium

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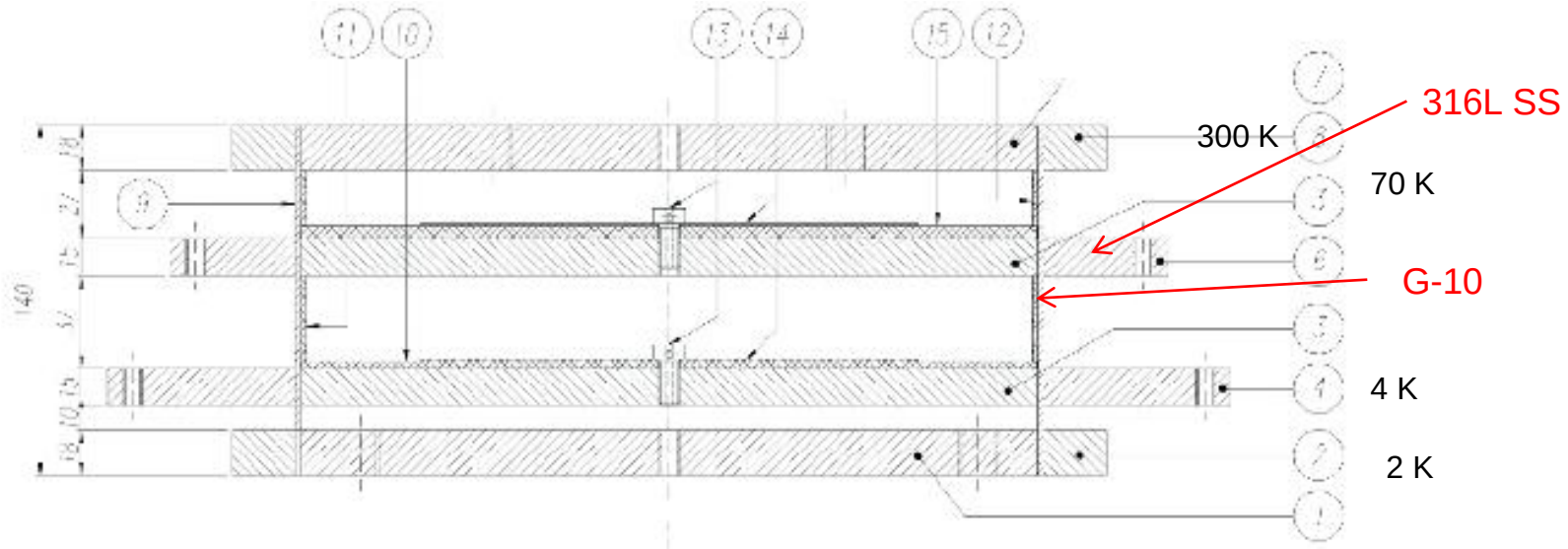
Insulation support

1 Solution is highly dependent on cryostat requirements

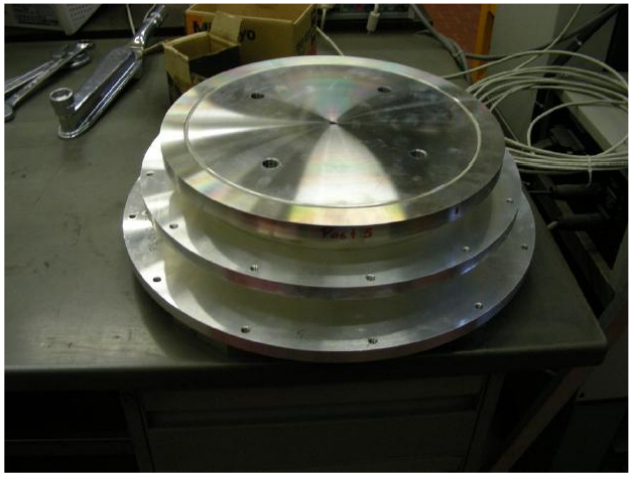
2 Choose materials carefully

- Acceptable for cryogenic temperatures
- Low heat leak

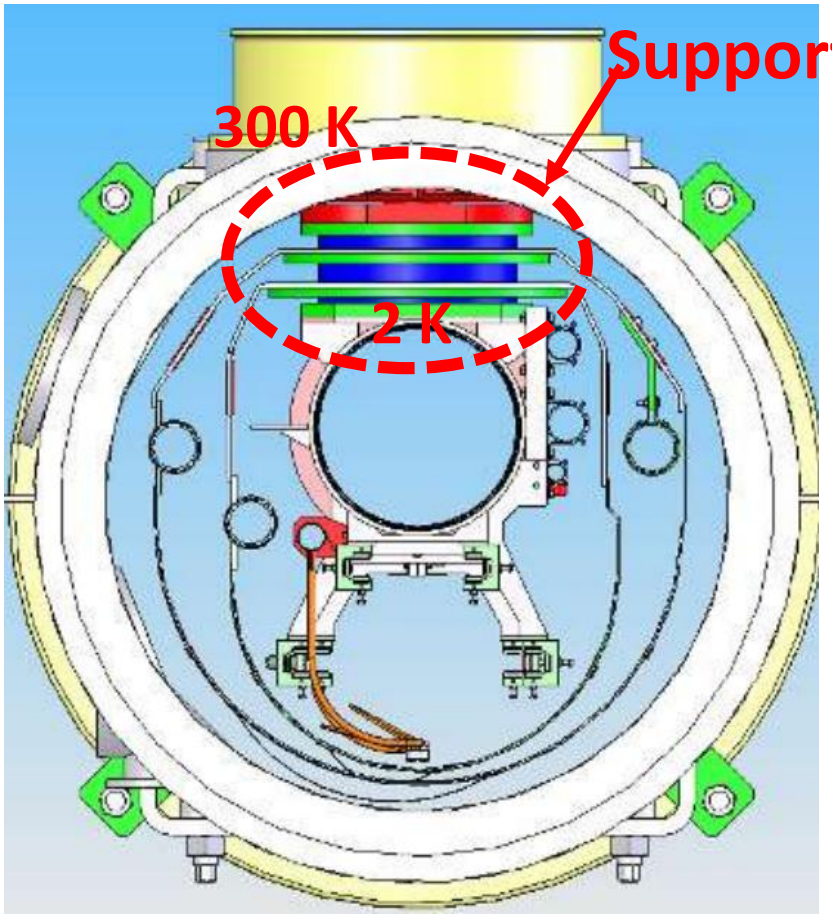
Structural Support of cryostat 1



- 1 Can support up to 50 kN
- **2 Total Heat Leak** (conduction & radiation)
  - 70 K - 10.5 W
  - 5 K - 0.9 W
  - 2 K - 0.03 W



Structural Support of cryostat 1

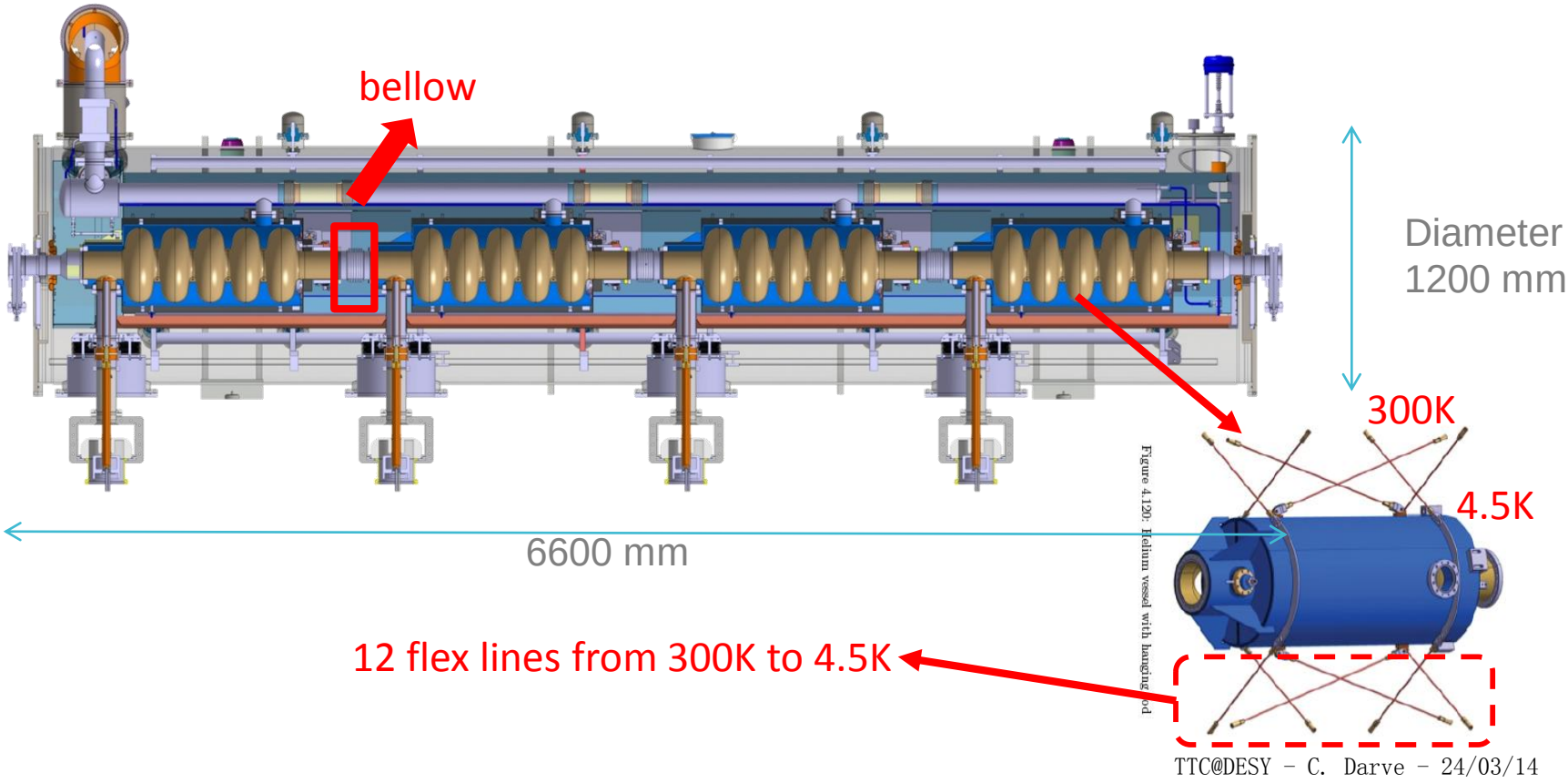


- Support from 300 K to 2K
- Cavity assemblies tied to 300 mm pipe backbone
- All other connections to 300 K have flex line.

XFEL Cryostat is designed by Dr. Rui Ge

Structural Support of cryostat 2

ESS Elliptical Cavity Cryomodule : All components are tied to space frame which rolls into the vacuum vessel.
Connections to 300 K done via flex lines and bellow.



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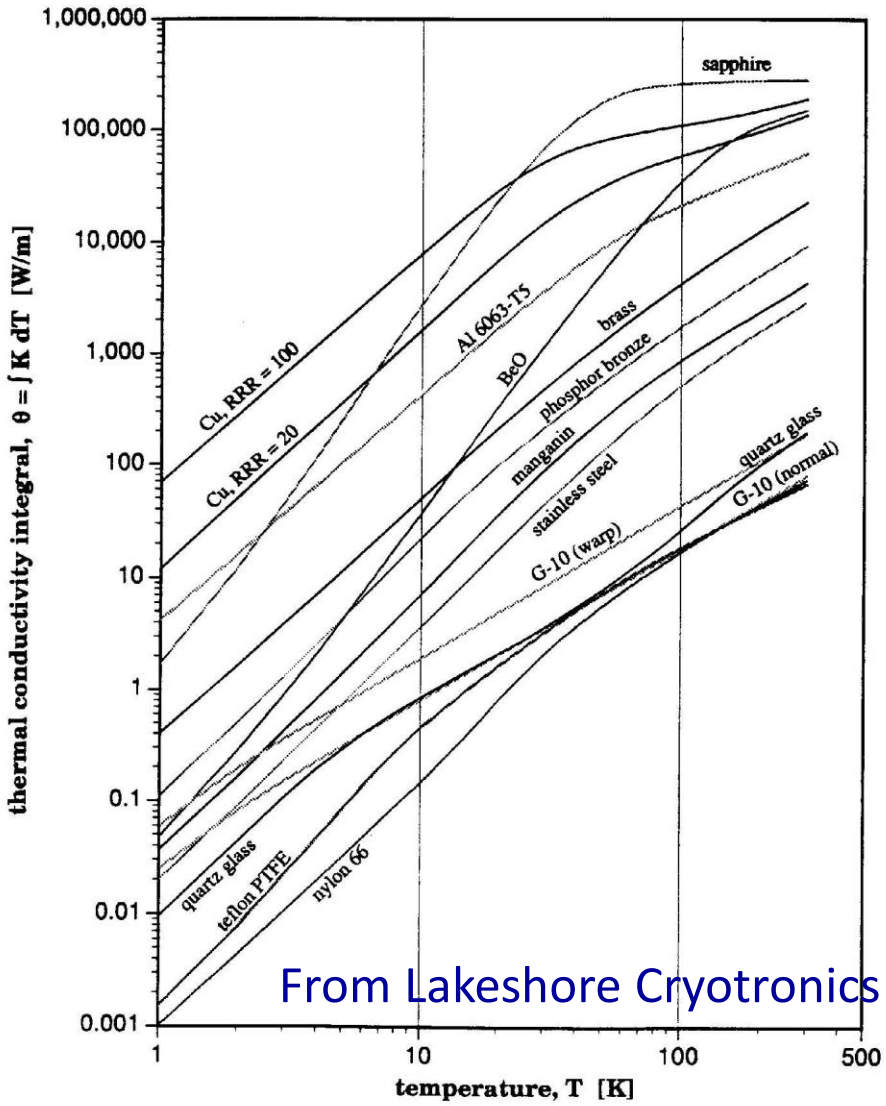
Three Ways to Transfer Heat

- Conduction
  - Heat transfer through solid material
- Convection
  - Heat transfer via a moving fluid
    - Natural or free convection – motion caused by gravity (i.e. density changes)
    - Forced – motion caused by external force such as a pump
- Radiation
  - Heat transferred by electromagnetic radiation/photons
- There is no such thing as a perfect insulator – though we can design systems with very small heat leaks
- All matter above 0 K radiate heat
  - Remember we can't get to 0 K – 3rd Law of Thermodynamics though we can get vanishingly close

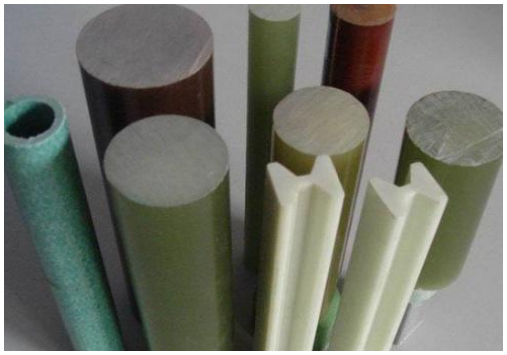
Solid Material



From Lakeshore Cryotronics

Copper

Stainless steel

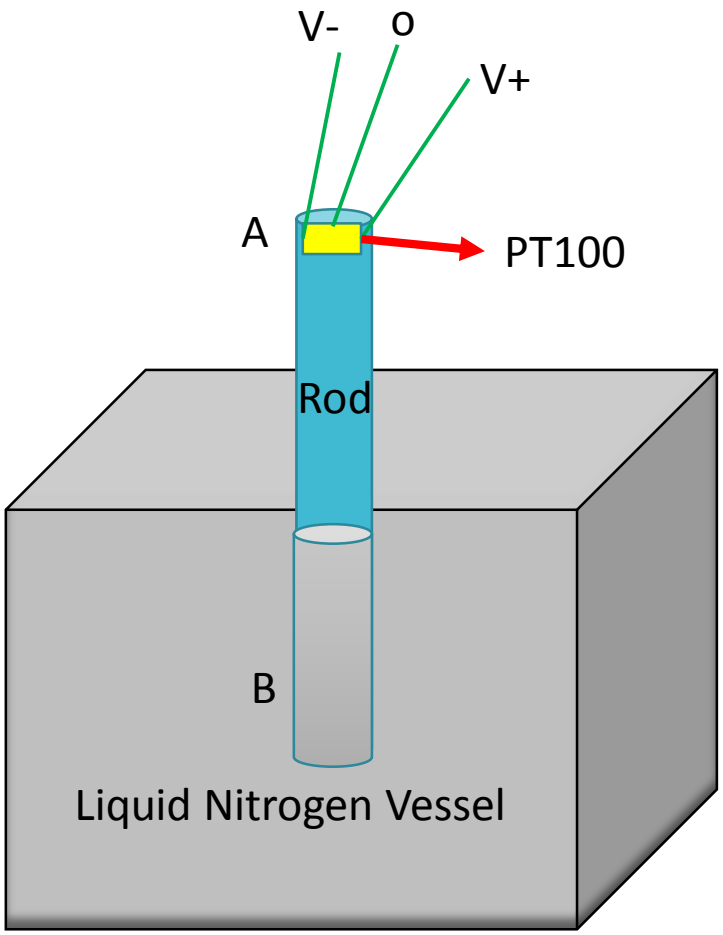


G-10/PTFE

Compound glass fibre

Training 1

Heat transfer through solid material



1 Three rods: Cu/ 304/G-10 Ø6
2 Put in half of rod in the liquid nitrogen vessel.
3 Test temperature at A by a PT100
4 Compare time about 273K from Cu to G-10.

Solid Material

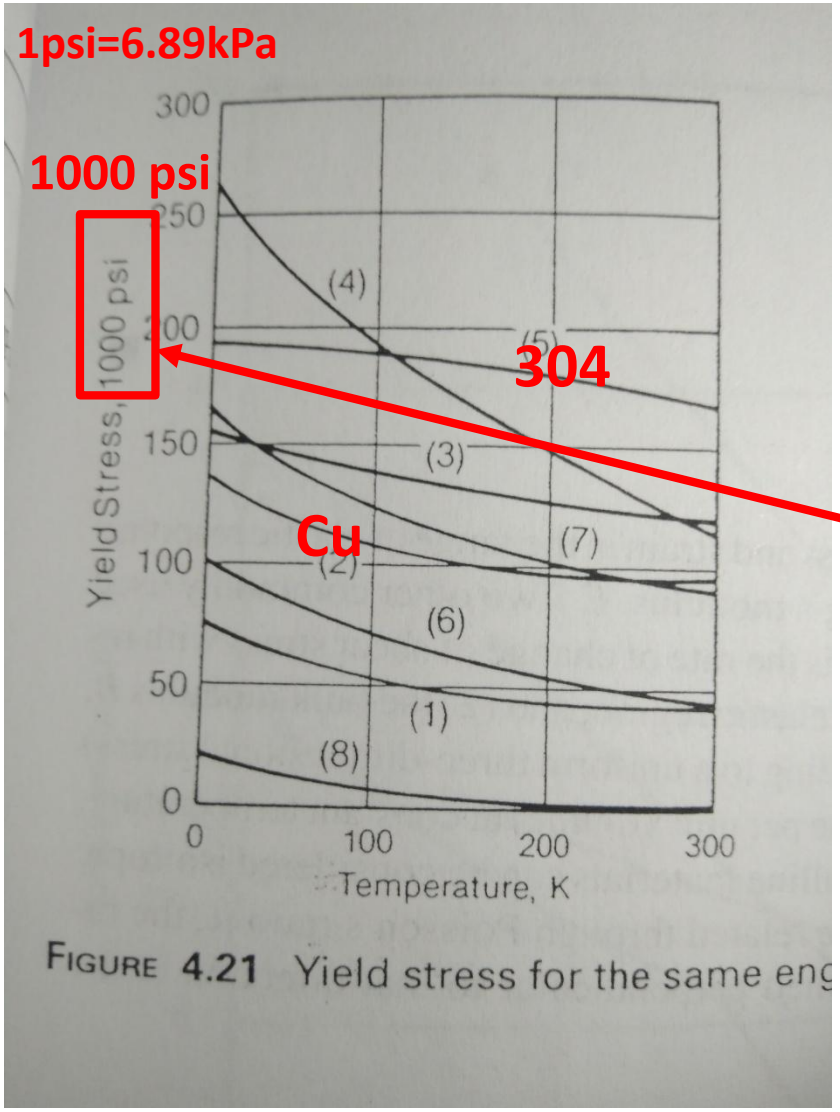


FIGURE 4.21 Yield stress for the same eng

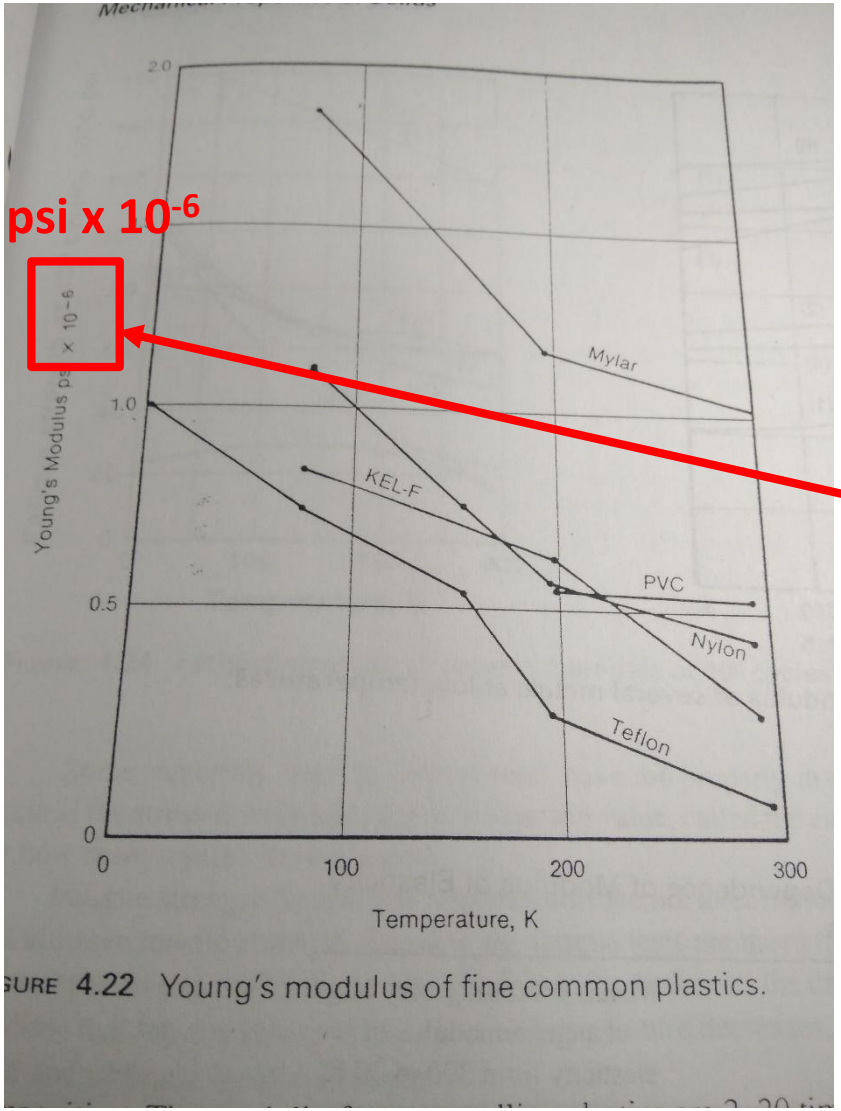
Yield stress of metal

At low temperature, the yield stress of metal usually increases.

Metal

Good toughness at low temperature.

Solid Material



GURE 4.22 Young's modulus of fine common plastics.

Yield stress of material

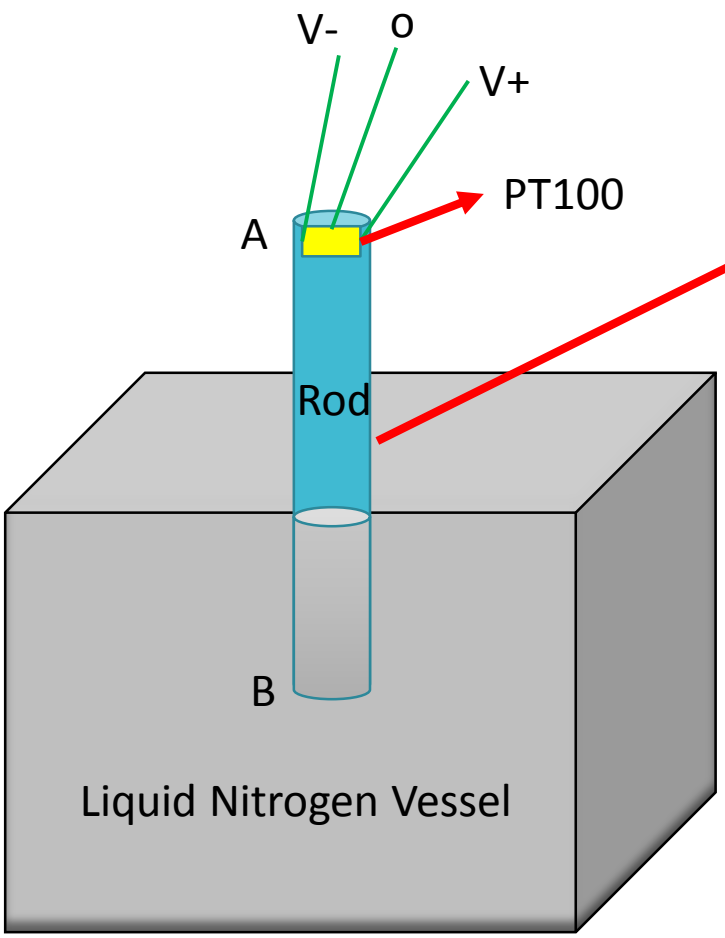
At low temperature, hence the yield stress of nonmetal usually increases.

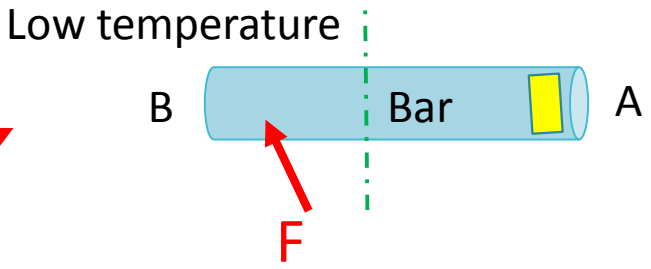
Plastics

Friable at low temperature.

Training 2

Stress of solid material





1 Three rods: Cu/ 304/PVC

2 Put in half of rod in the liquid nitrogen vessel.

3 Test temperature at A by a PT100

4 Compare stress of metals at the same low temperature

Training 2

- Goal： Tests of mechanical properties of supports in liquid nitrogen.

  Unit: Power part, High precision sensor: tension sensor and displacement sensor, Cryostat, support.

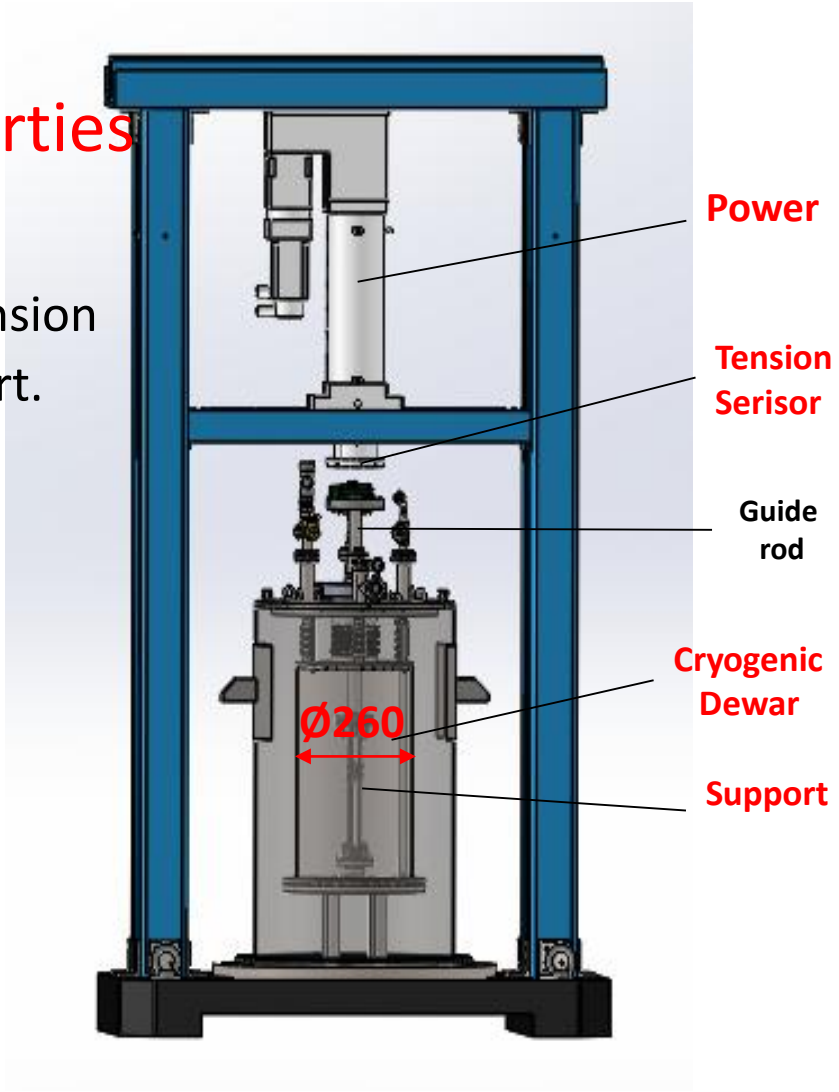
  Function: Maximum force 100kN~0.5%FS.

- Power: Hydraulic cylinder

  High force in a small package size

  Linear displacement and power load

- Cryostat : Temperature —80K~300K



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Question

1 What will you must consider for cryostat support?

2 What is different between 304 and PVC in Young's modulus at low temperature?

3 What will you need to test performance of cryomodule structural support?