Cryogenic System for the ILC IR Magnets QD0 and QF1

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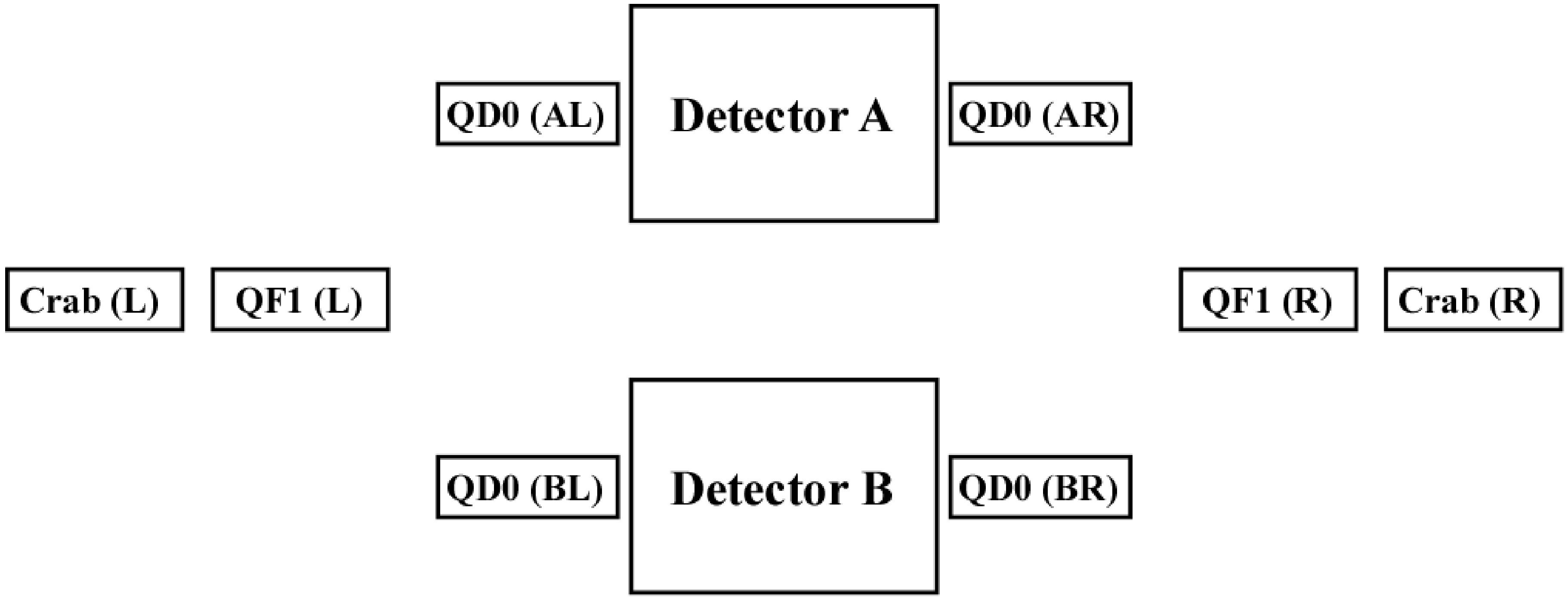
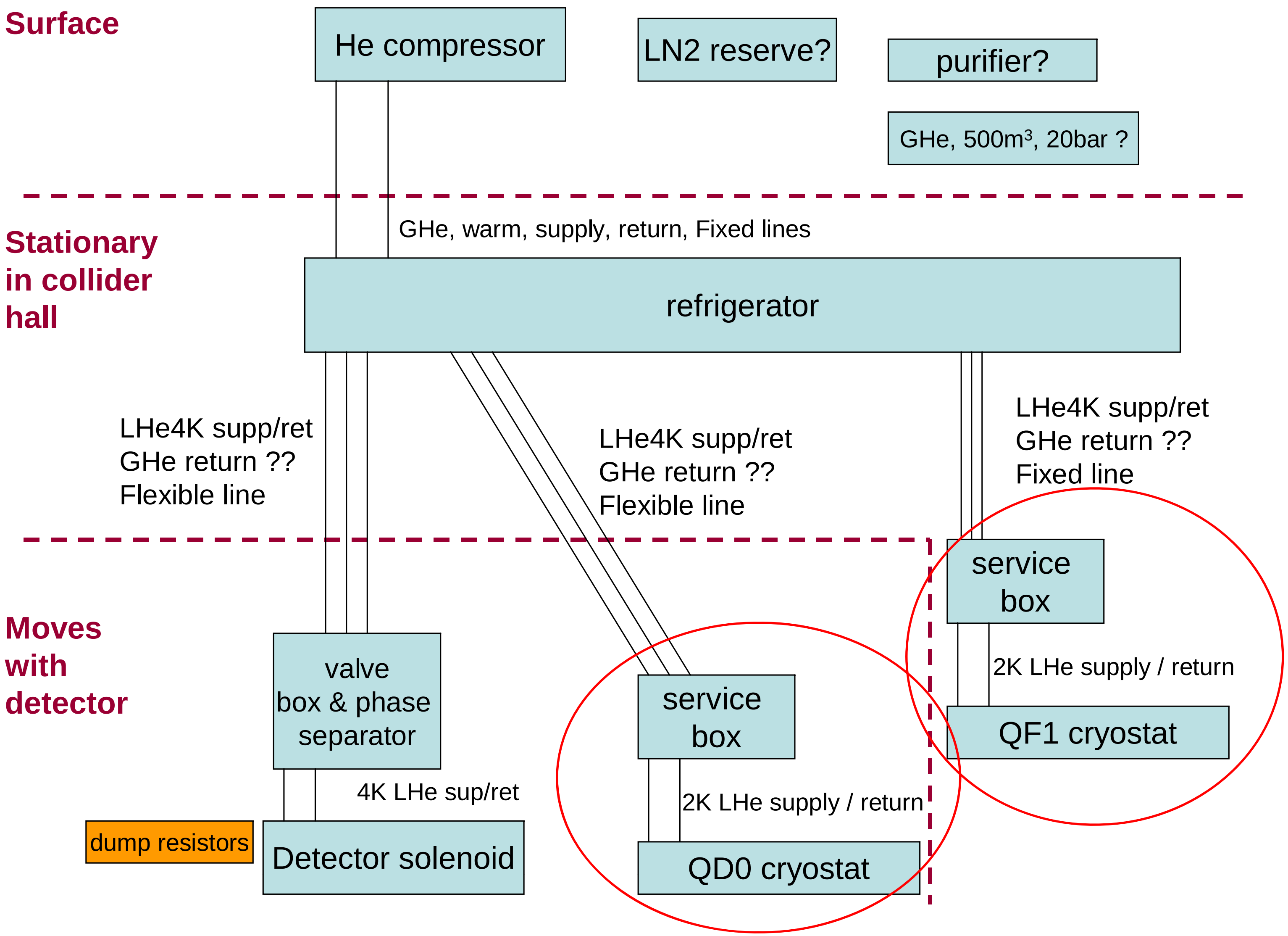
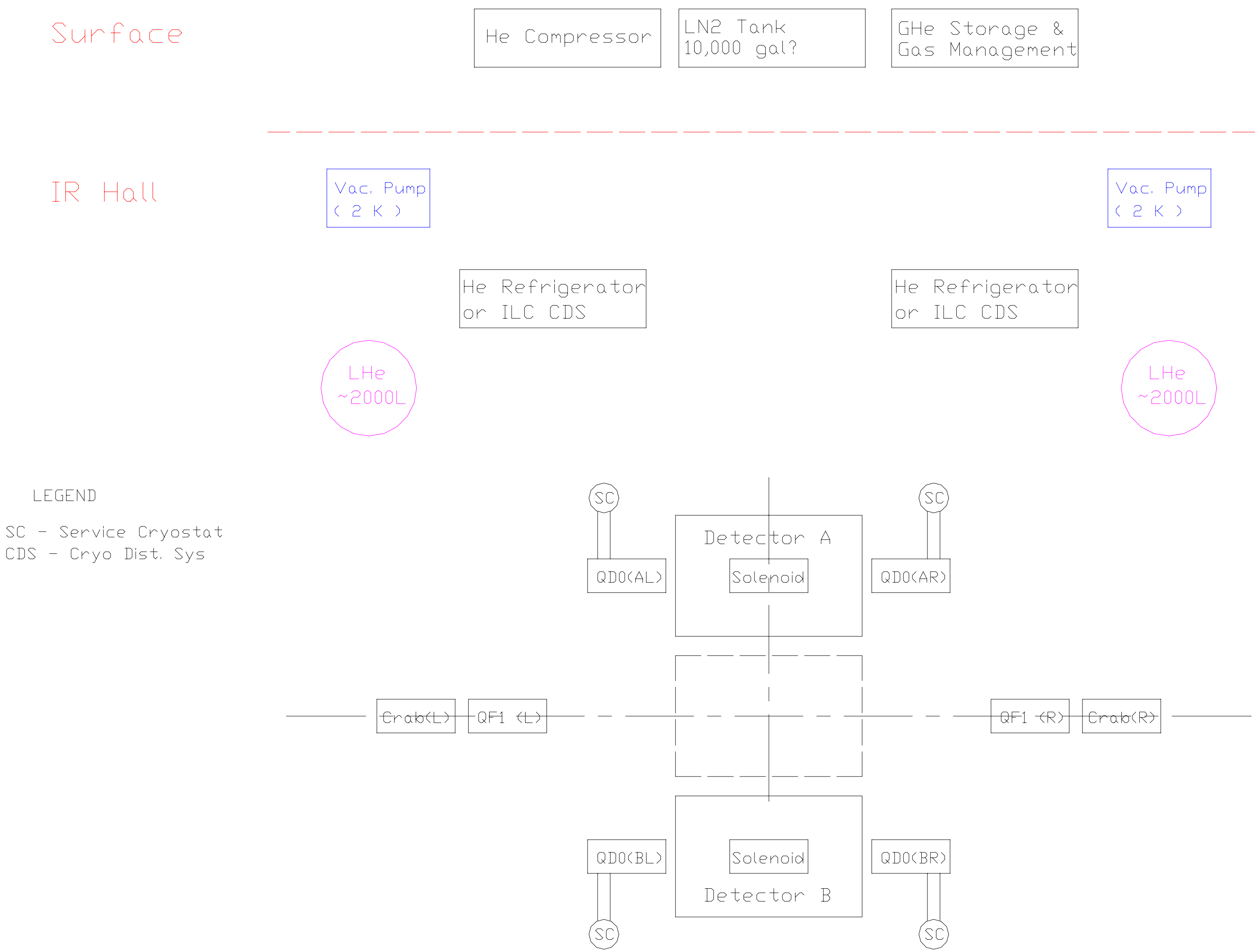
Major Components in ILC IR Hall
Interchangeable Detectors



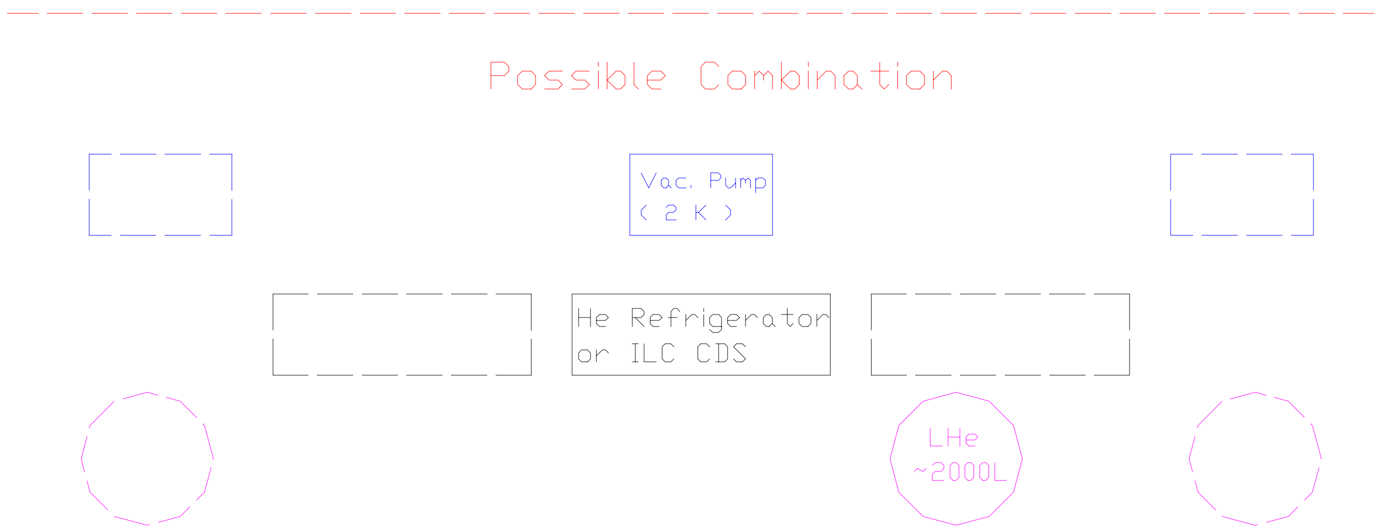
Cryogenic Block Diagram in ILC IR Hall



Cryogenic Block Diagram with Detectors

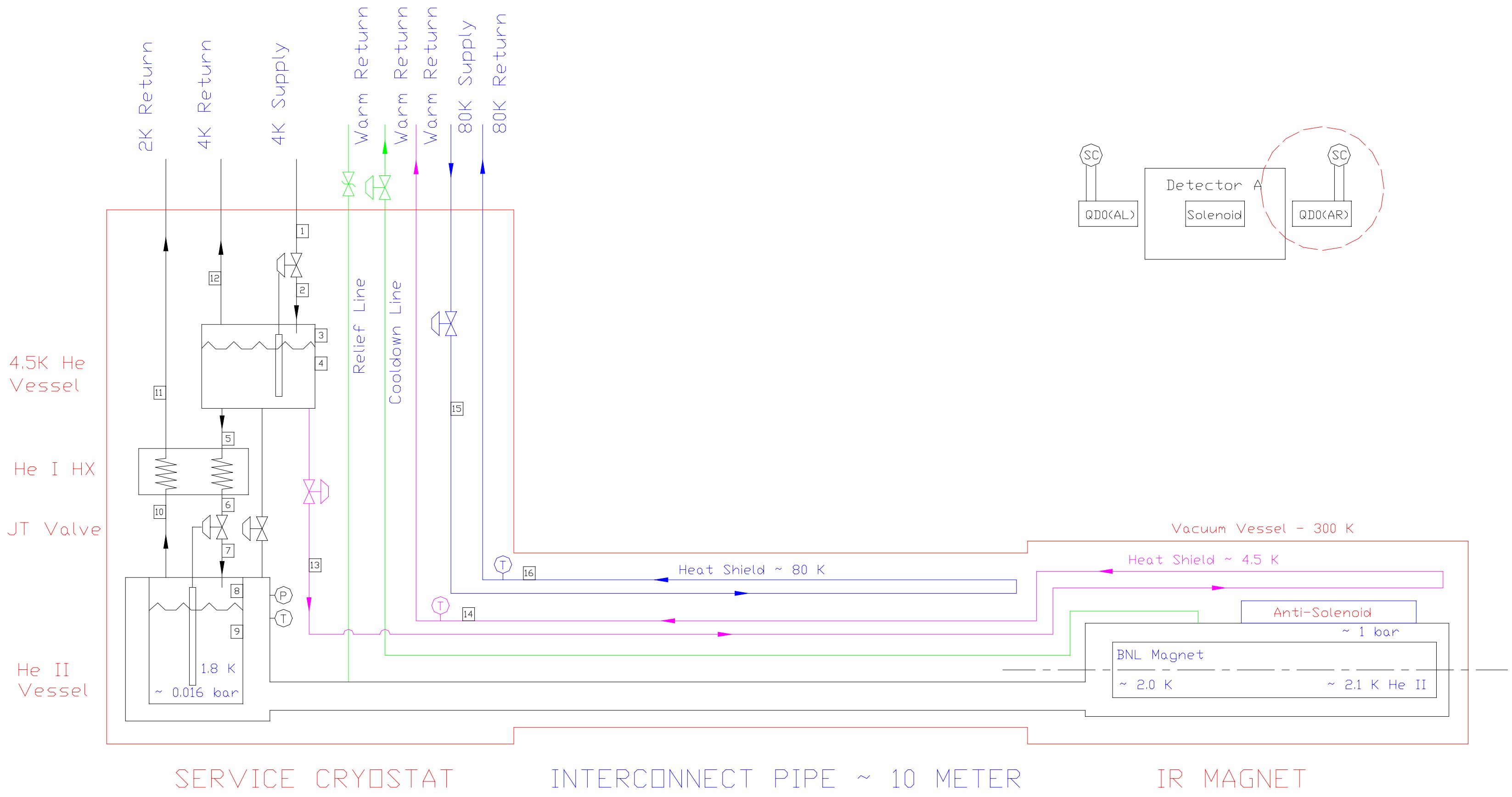


Possible Combination of Cryogenic Hardware



Issues associated with type and number of refrigeration hardware will be studied when system parameters and requirements become available.

2 K Cooling Scheme for Magnets QD0, QF1



Magnet is cooled in He II at ~ 2 K, 1 bar
Design capacity is 15 W

Basic Cooling Requirements for IR Magnets

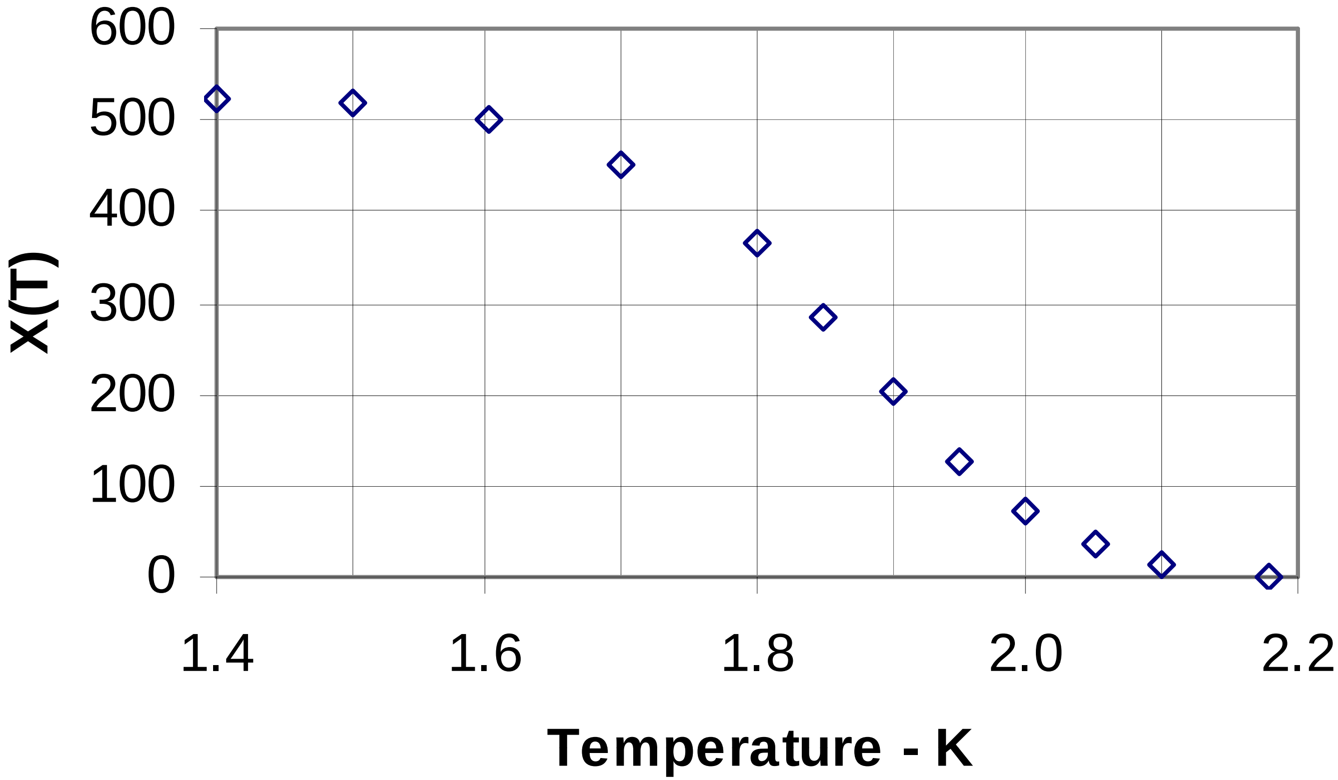
- Keep magnet below 2.1 K at 1 bar
- Design for removing 15 W heat load
- Service Cryostat is installed at approximately 10 meter from the magnet
- Magnet and Service Cryostat are connected by a vacuum envelop which contains 6 lines.
- The largest line is 3 inch in diameter for 1 bar Helium II and is used to provide 2 K cooling and electrical connection
- "No" vibration should be introduced

Description of Service Cryostat

- Service Cryostat is used for interfacing Magnet with Cryogenic Distribution System, CDS or Liquefier
- 4 K Cooling is converted to Superfluid helium
- Service Cryostat consists of a 4.5 K liquid helium reservoir, a (4 – 2 K) JT heat exchanger, an 1.8 K Evaporator, and ~ 5 cryogenic valves
- Lead pot and ~ 10 current leads are not shown on the flow diagram

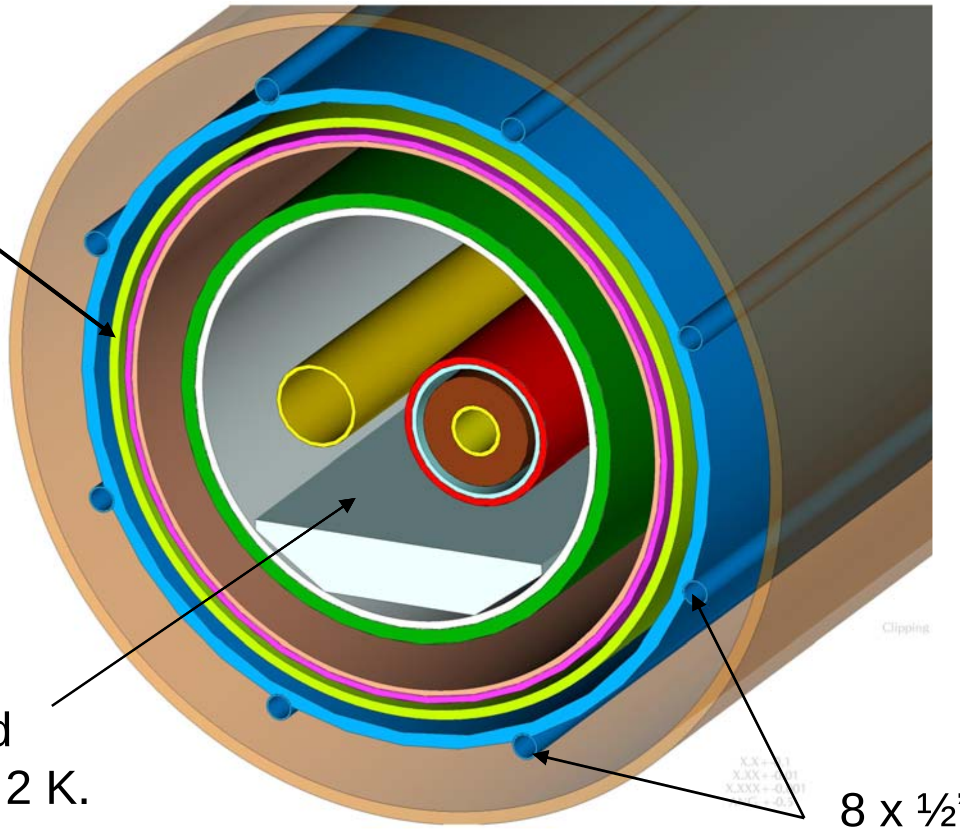
Temp. profile along a channel filled with He II at 1 atm, G. B Marion etc.

$$X(T_c) - X(T_w) = q^{3.4} \times L$$



Cross Section of Magnet

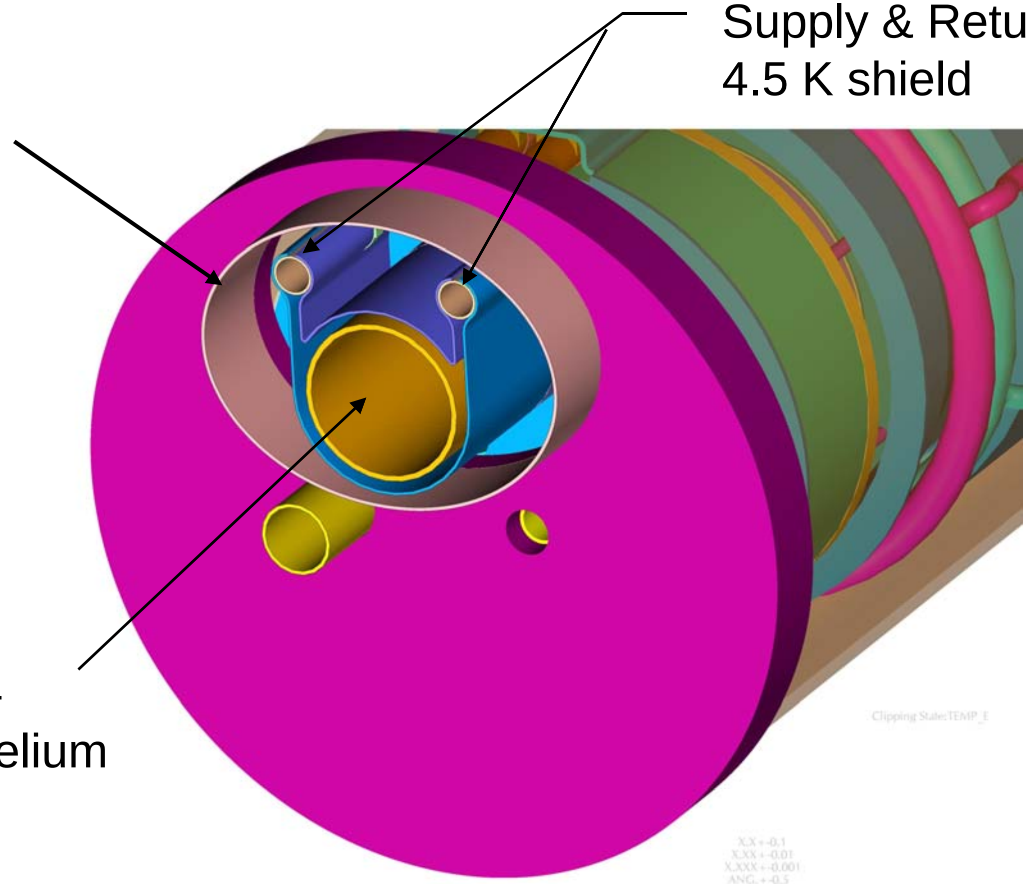
Helium Vessel around Magnets



Superfluid Liquid Helium, 1 bar, ~ 2 K.

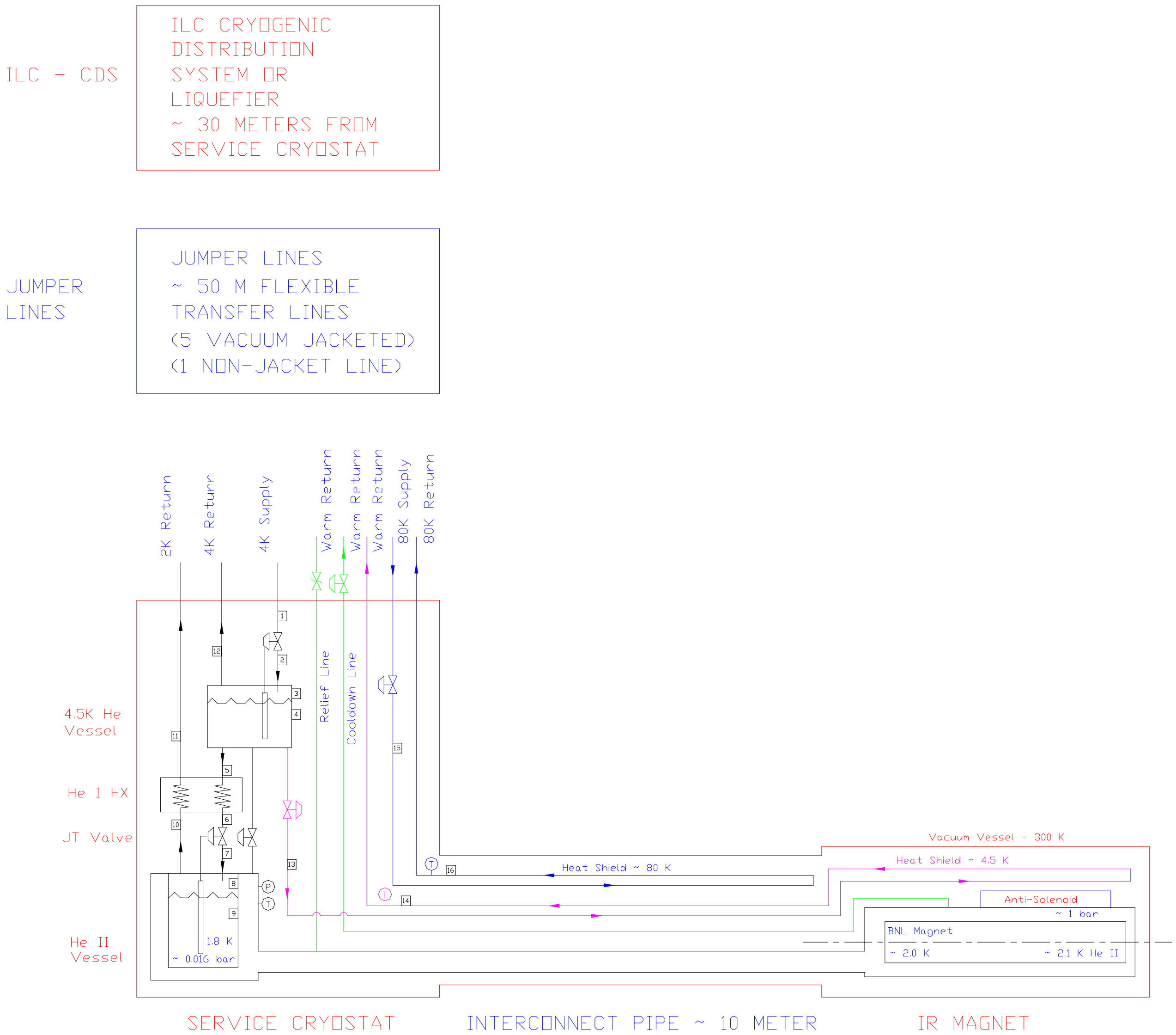
8 x ½" tube for 4.5 K shield, 4 for supply, 4 for return

Cross Section of Connecting Pipe between Magnet and Service Cryostat Near Magnet

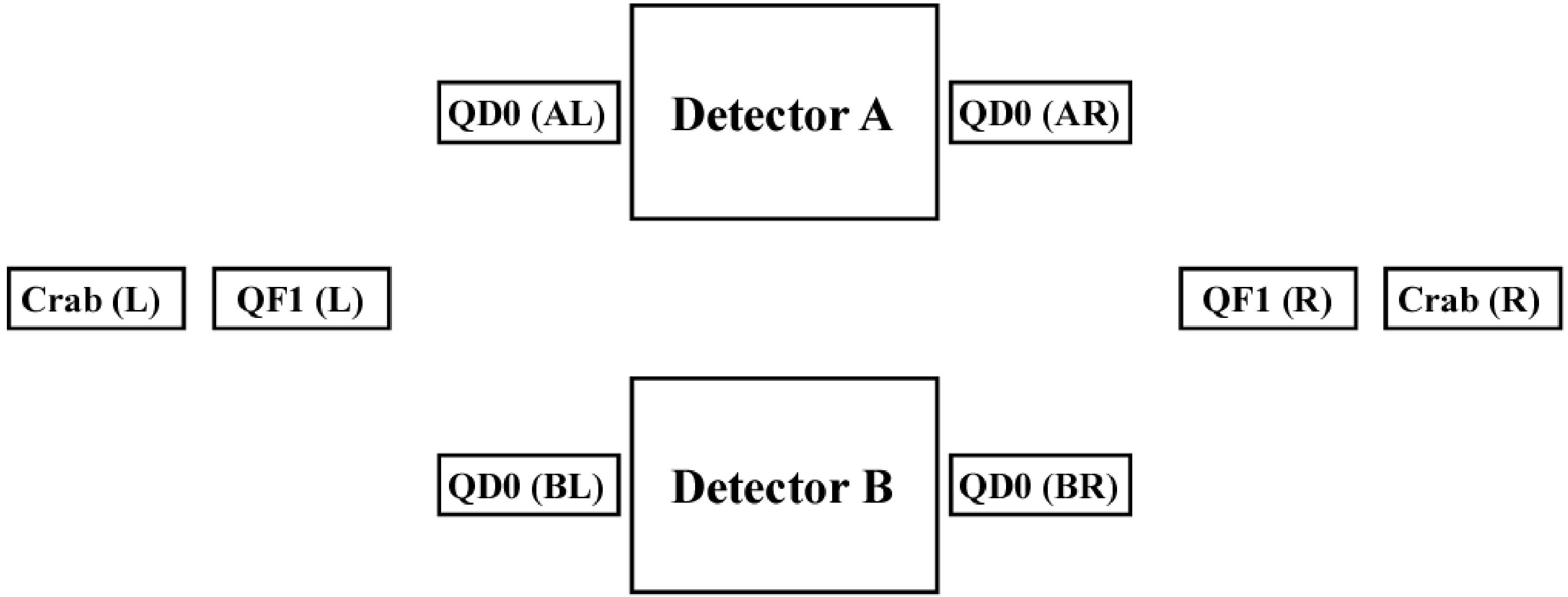


80 K shield is not provided at this cross section
A small vent tube for cooldown, not shown, will be added.

Piping Connection to Cryogenic Distribution System or Liquefier



Moving Requirement of Detector and QD0s



Detector and QD0 need to be moved by ~ 20 meters

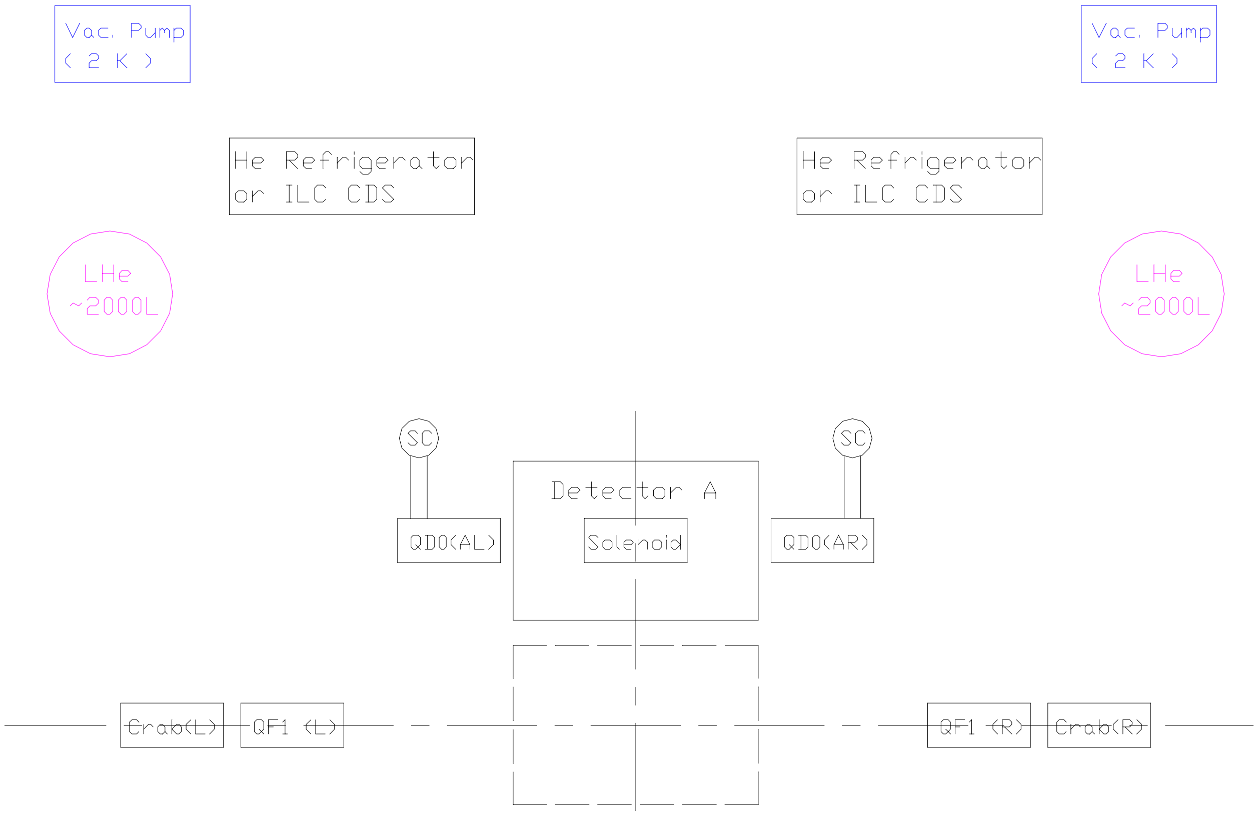
Require ~ 50 m of Flexible Transfer lines between QD0 service cryostat and liquefier (or CDS)

QF1 and Crab Cavity do not move (Rigid Transfer Lines between service cryostat and liquefier (or CDS))

Other Cooling Requirements – Mode of Operation

Independent warmup or cooldown for each magnet?

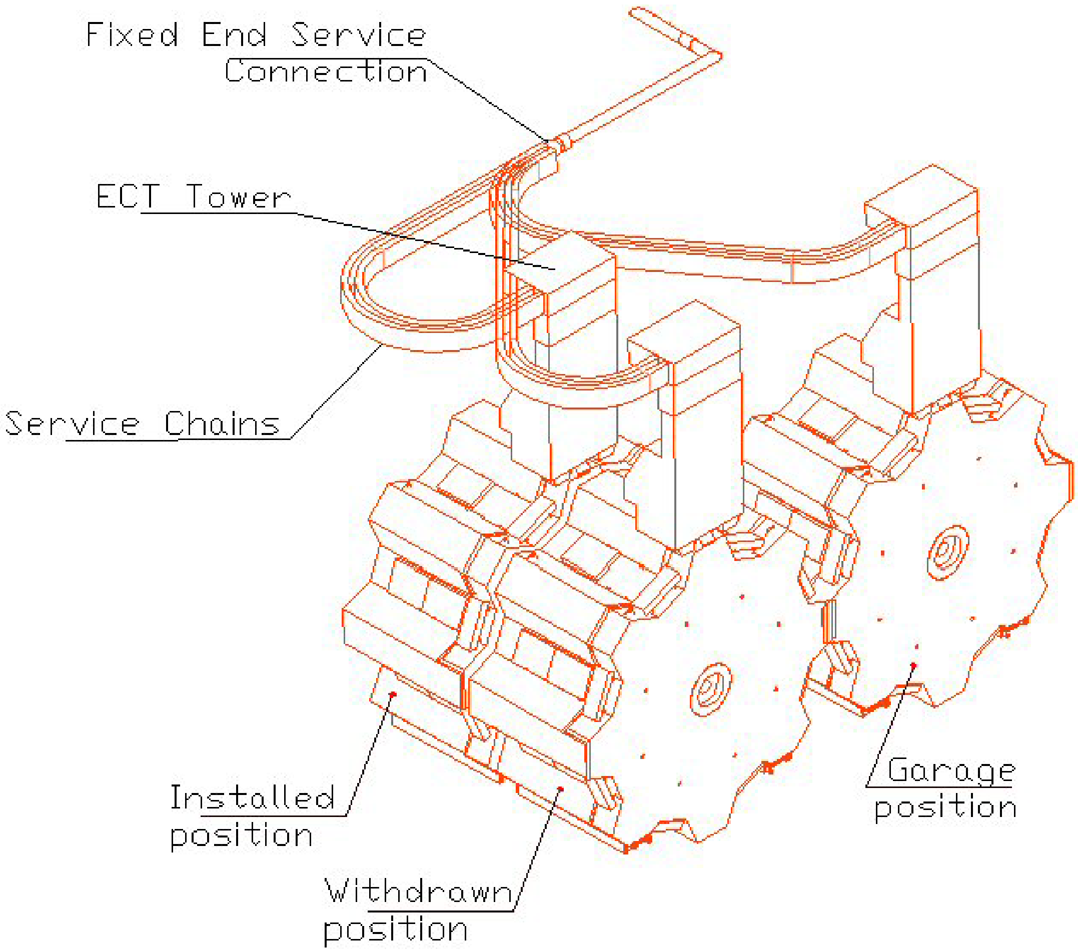
Parker has scenario for common operation "must be vs may be independent"

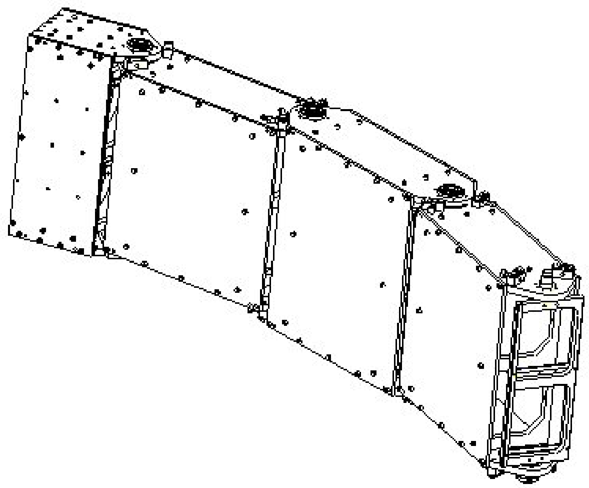


Baseline Heat Loads

- Heat loads at 1.8 K, 4.5 K and 80 K for QD0 are
  - 15 W at 1.8 K
  - 30 W at 4.5 K
  - 500 W at 80 K
- Heat loads for QF1 are assumed to be the same as QD0 for the time being
- Total heat load for two sets of QD0 and QF1
  - 60 W at 1.8 K
  - 120 W at 4.5 K
  - 2000 W at 80 K

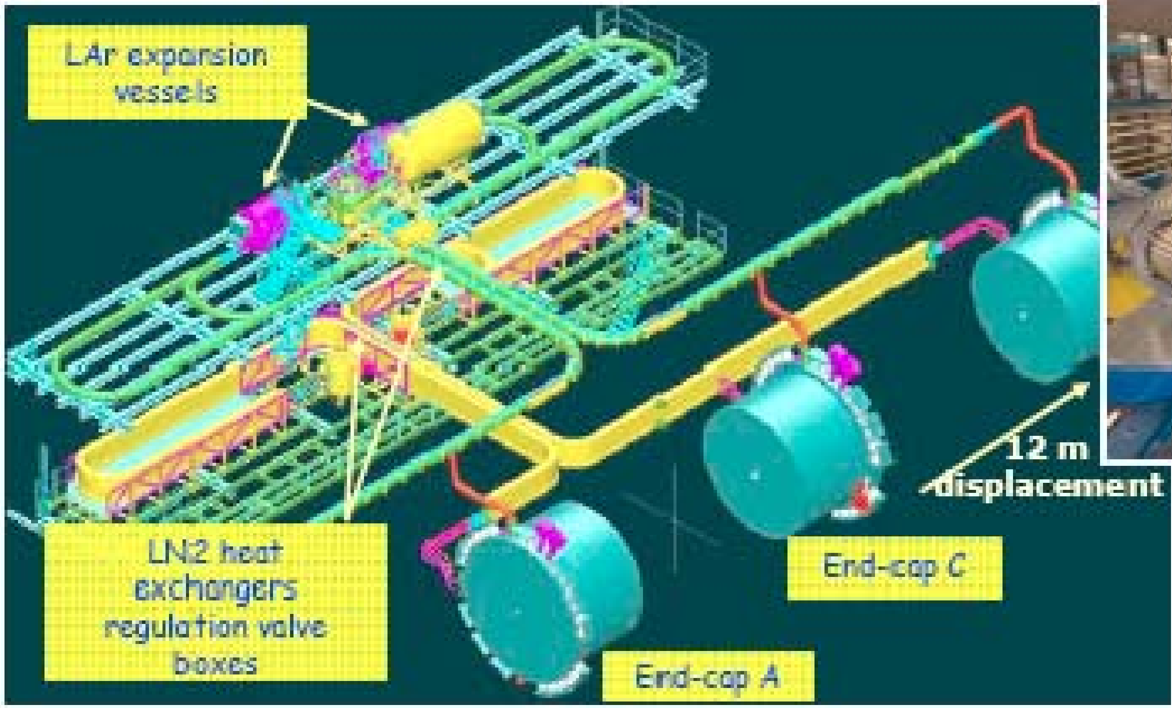
Survey of Flexible Lines
End Cap (ATLAS) in 3 Different Positions



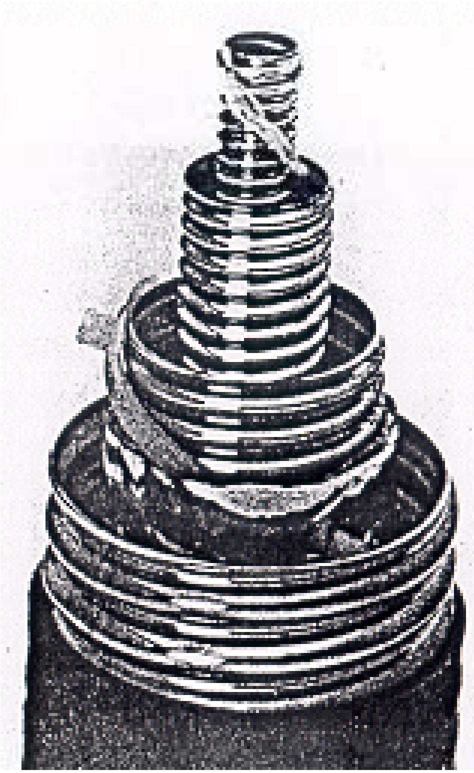


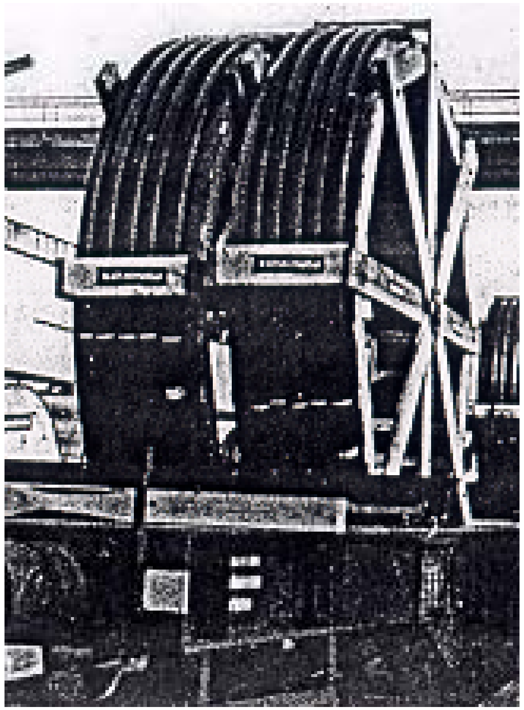
Link Box for flexible cryogenic lines with link sections ~ 622 mm

Flexible Lines used on ATLAS (CERN)



Shielded Flexible Line in ISR (CERN) For Easy Installation or Moving?





Inner channel: 14 mm ID
Annular channel: 34 mm ID, 51 mm OD
30 layers superinsulation,
Bending radii: ~ 1 meter

~ 2.5 W, 4 K load for 50 meter length (with 4 - 120 K shield , not all at 120 K)

Shield load: ~ 170 W

For larger line (~ 46 mm ID) with 80 K shield, calculated heat loads are ~ 0.15 W/m for 4.5 K and 2.5 W/m for 80 K

Number of Cryogenic Lines

- Between Service Cryostat and Magnet - 6 lines (The largest is ~ 3 inch in diameter)
- Between Cryogenic Distribution System and Service Cryostat - 6 or 7 lines
  - 5 Vacuum Jacketed (Should be able to combine into 3 lines)
  - 1 to 2 non-jacketed
  - The length is on the order of 50 meters

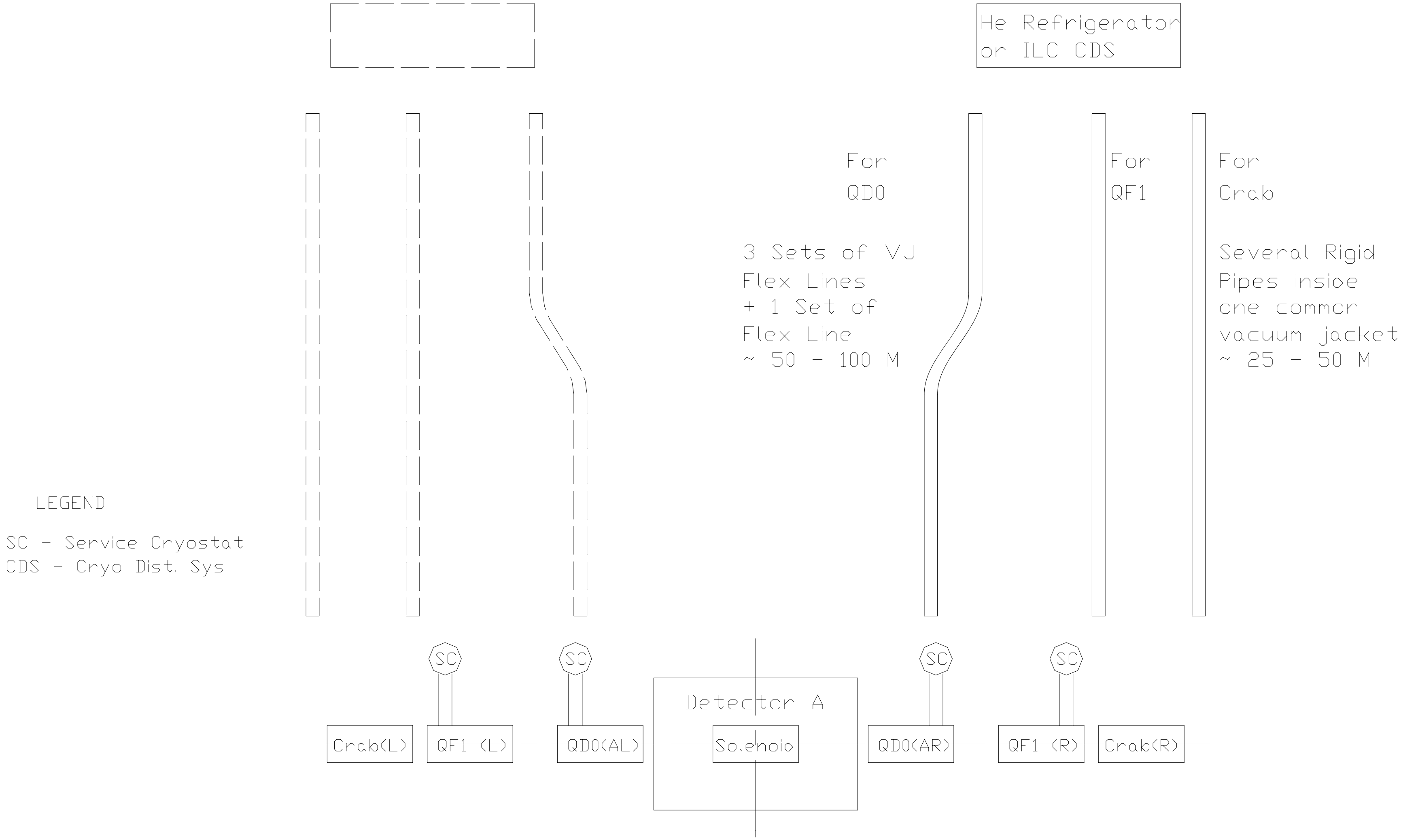
Lines Between Service Cryostat and Magnet

- Main Line for transferring 2 K Heat Load at1 bar over 10 meters, containing bus and instrumentation wires inside
- 4.5 K Shield Supply
- 4.5 K Shield Return
- ~ 80 K (or 40 K) Shield Supply
- ~ 80 K Shield Return
- Cooldown Return
- Quench Vent located near Service Cryostat

Lines Between Service Cryostat and Cryogenic Distribution System (Liquefier)

- 4 K Supply
- 4 K Return
- Low Pressure Return ~ 2 K (0.016 bar) (~ 1 inch inner diameter)
- 4.5 K (or Warm) Return
- ~ 80 K (or 40 K) Shield Supply
- ~ 80 K Shield Return
- Warm Return for Cooldown
- Warm Return for Quench Vent
- Note: Warm lines maybe combined

Some Thought for Transfer Lines in IR Hall



Present Understanding

- Cryogenic lines (including jumper) will be welded in construction. No bayonets are planned – T. Peterson
- SiD detector is used as an example for current study
- For operating purpose, it is desired to be able to move Magnet, Service Cryostat and associated Hardware for ~ 20 meters from beam center when magnet is cold – B. Parker
- The design should allow detector door to move without interfering with cryogenic hardware
- After the 1st detector is moved to the side, it is desirable to quickly move in a 2nd detector which contains cold magnets.

Summary

- The cryogenic system (1st iteration, below 4.5 K) for the ILC IR magnets QD0 and QF1 has been designed and presented.
- Piping interface with the IR cryogenic system has been investigated and identified.
- Detailed layout for cryogenic system in the ILC IR region could be cumbersome, but it is within the state of art technology.
- Will continue to provide input and work with the ILC IR cryogenic working group