ILC Experimental Hall Cryogenics
An Overview

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Introduction

- The hall will contain a number of different systems requiring cryogenic temperatures
- Successful operation of the hall will require that these systems be integrated & coordinated in a logical manner with each other and with other subsystems (e.g. conventional facilities)
- This talk will give a top level overview of these systems and raise questions that need to be answered

Basic Assumptions

- 2 detectors, both with cryogenic components, in a push/pull configuration
- We want to be able to move the detectors while cold
- We want the offline detector to have the option of being cold and powered
- QD0 magnets move with the detectors while the QF1 magnets are fixed in the hall
- Should the temperatures of the two detectors as well as their states (cold, warm, cool down or warm up) should be independent regardless of their position in the hall?

What needs to be Cooled?

Component	Operating Temperatures	Comments
Detector A Superconducting Solenoid	4.2 K Possible 40-80 K Shield	Detector Moves
Detector B Superconducting Solenoid	4.2 K Possible 40-80 K Shield	Detector Moves

What needs to be Cooled?

Component	Operating Temperatures	Comments
IR Final Focus superconducting magnets (QD0, QF1)	2 K 4.5 K shield 40-80 K shield	QD0 moves, QF1 Fixed
Crab Cavities (SCRF)	2 K 4.5 K shield 40-80 K Shield	Fixed

Helium Refrigeration Systems

- Helium is the working fluid
- Cooling is accomplished by making the He do work or by heat exchanging it with a colder flow stream
- Systems are almost completely closed cycle (for the most part the He gas is conserved)
- Thermodynamically, it is better to intercept heat at higher temperatures (thus intermediate temperature thermal shields & sinks)
- It's best to minimize the amount of subatmospheric piping (thus the use of cold compressors)
- It's best to avoid two-phase flow
- It's best to minimize the He II heat transfer length

Components of a He Refrigeration System

- Helium Compressors
  - Provides high pressure (~20 Bar) He gas to cycle
  - Oil flooded screw compressors requiring oil removal equipment
  - Require significant amount of electrical power and water cooling
  - Would be placed on the surface

Components of a He Refrigeration System

- Cold Box
  - Contains heat exchangers, expansion turbines, valves, instrumentation, heaters and vessels
  - Is vacuum insulated
  - Could be placed in the experimental hall

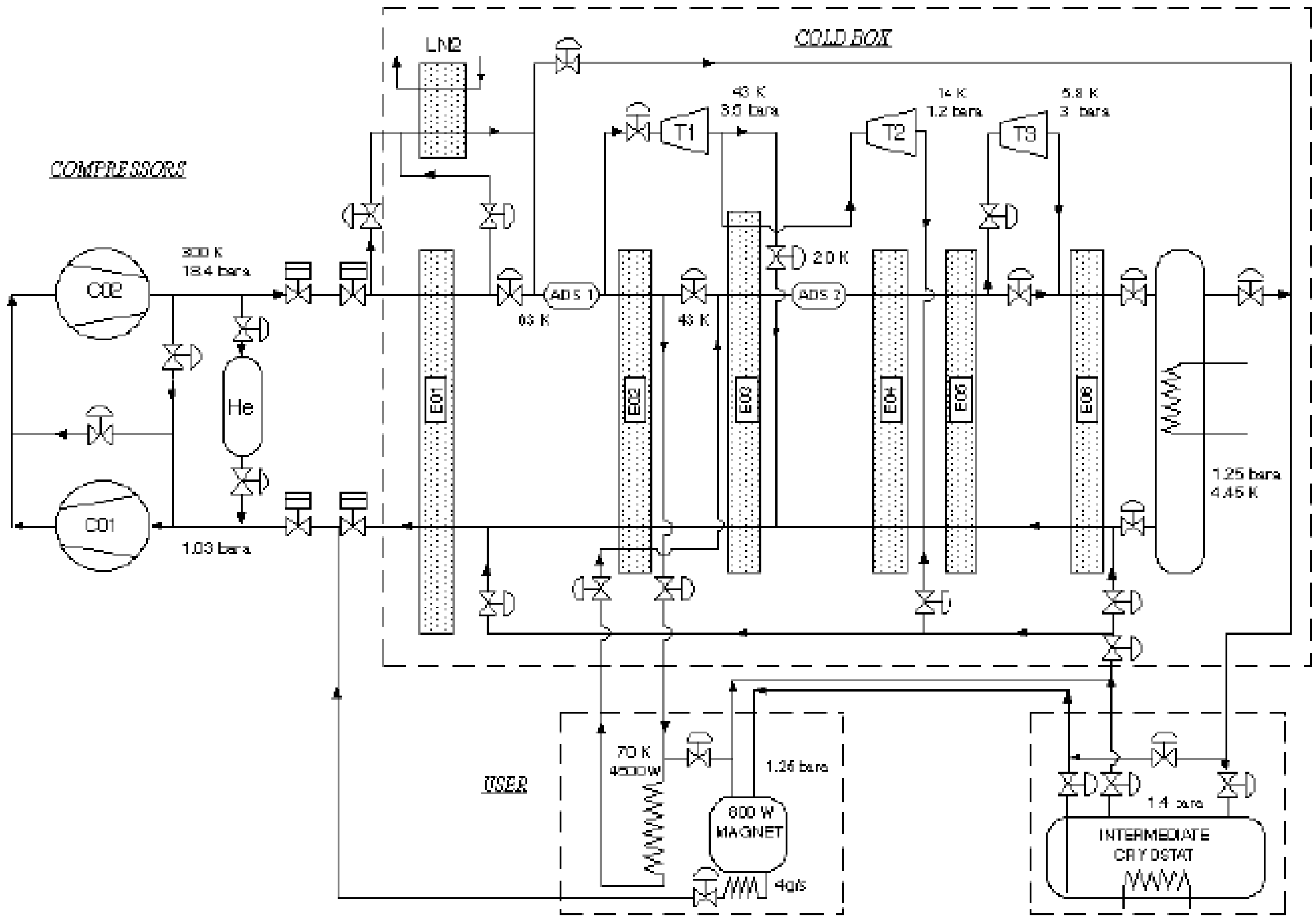


FIGURE 1. Simplified process flow diagram of the CMS refrigeration system.

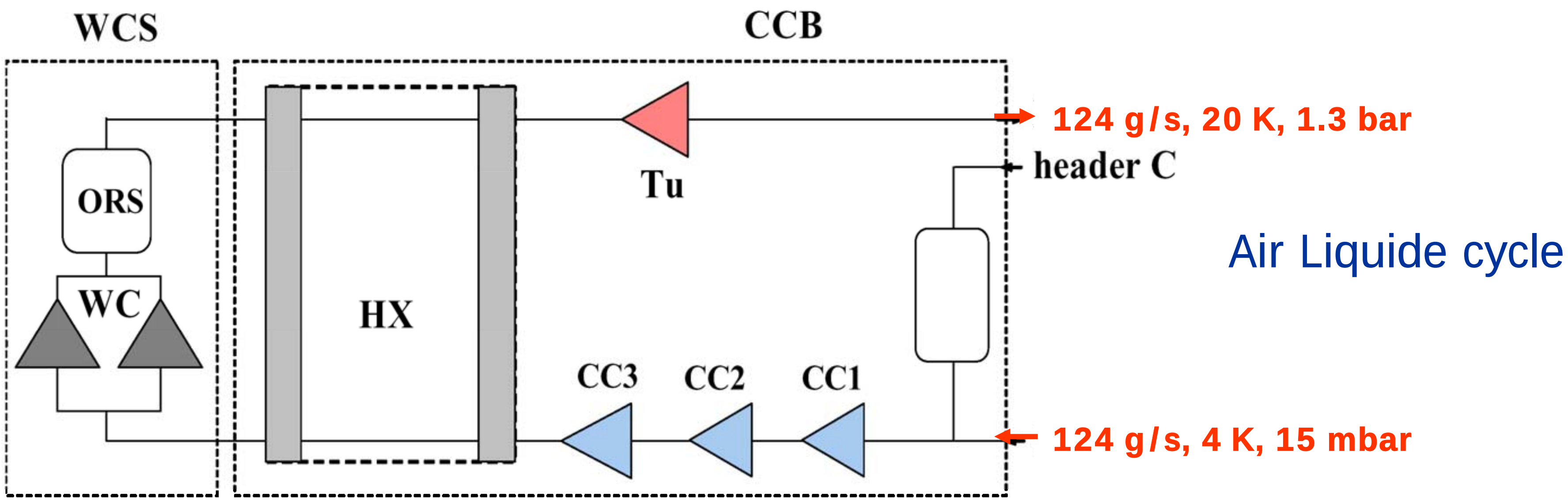
Components of a He Refrigeration System

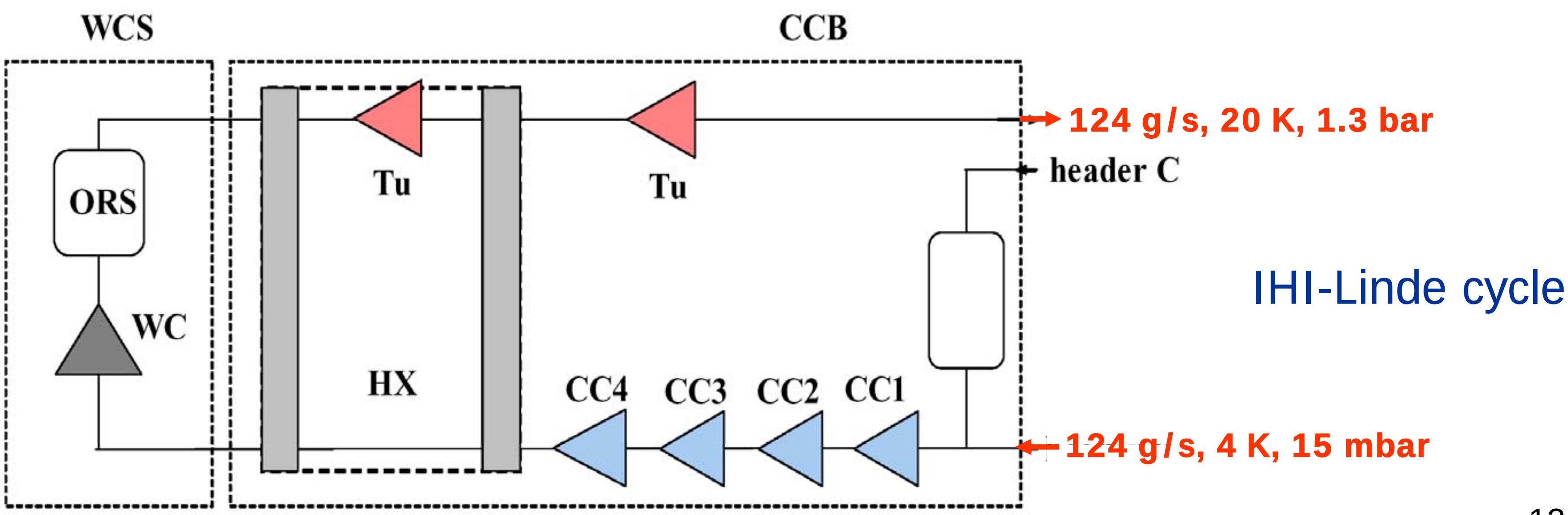
- Distribution or feed boxes
  - Interconnects output of cold box with items to be cooled
  - Typically contains valves, instrumentation and piping
  - Multiple connections are needed for different temperature levels as well as for cooldown/warmup and quench
  - Could be placed on the detector assemblies and move with them

Components of a He Refrigeration System

- Helium II Cold Boxes
  - Converts 4.2 K LHe to He II (T< 2.2 K)
  - Uses heat exchangers and a JT valve
  - Could be part of the distribution box and move with detector
  - Uses cold compressors & probably will also require warm compressors at the surface
- Transfer Lines
  - Vacuum insulated piping that interconnects the various cryogenic components
  - Can be made with some flexibility to allow motion though space has to be carefully thought about

2.4 kW @ 1.8 K refrigeration cycles for the LHC
(Large capacity & need for “turn down” drives cycle other options may be possible for ILC experimental hall systems)





LHC Cold boxes of
2.4 kW @ 1.8 K refrigeration unit

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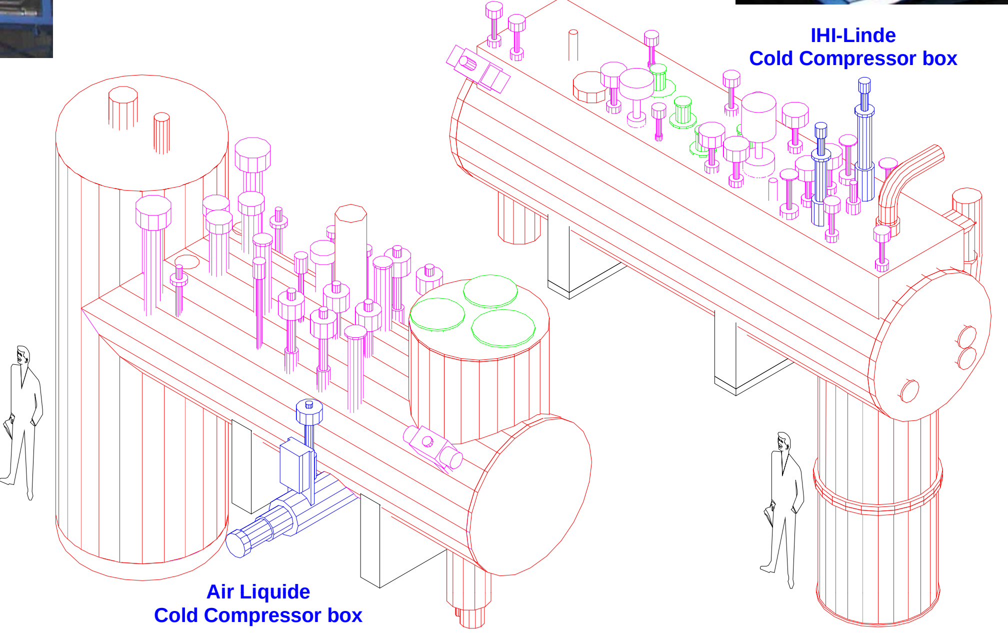

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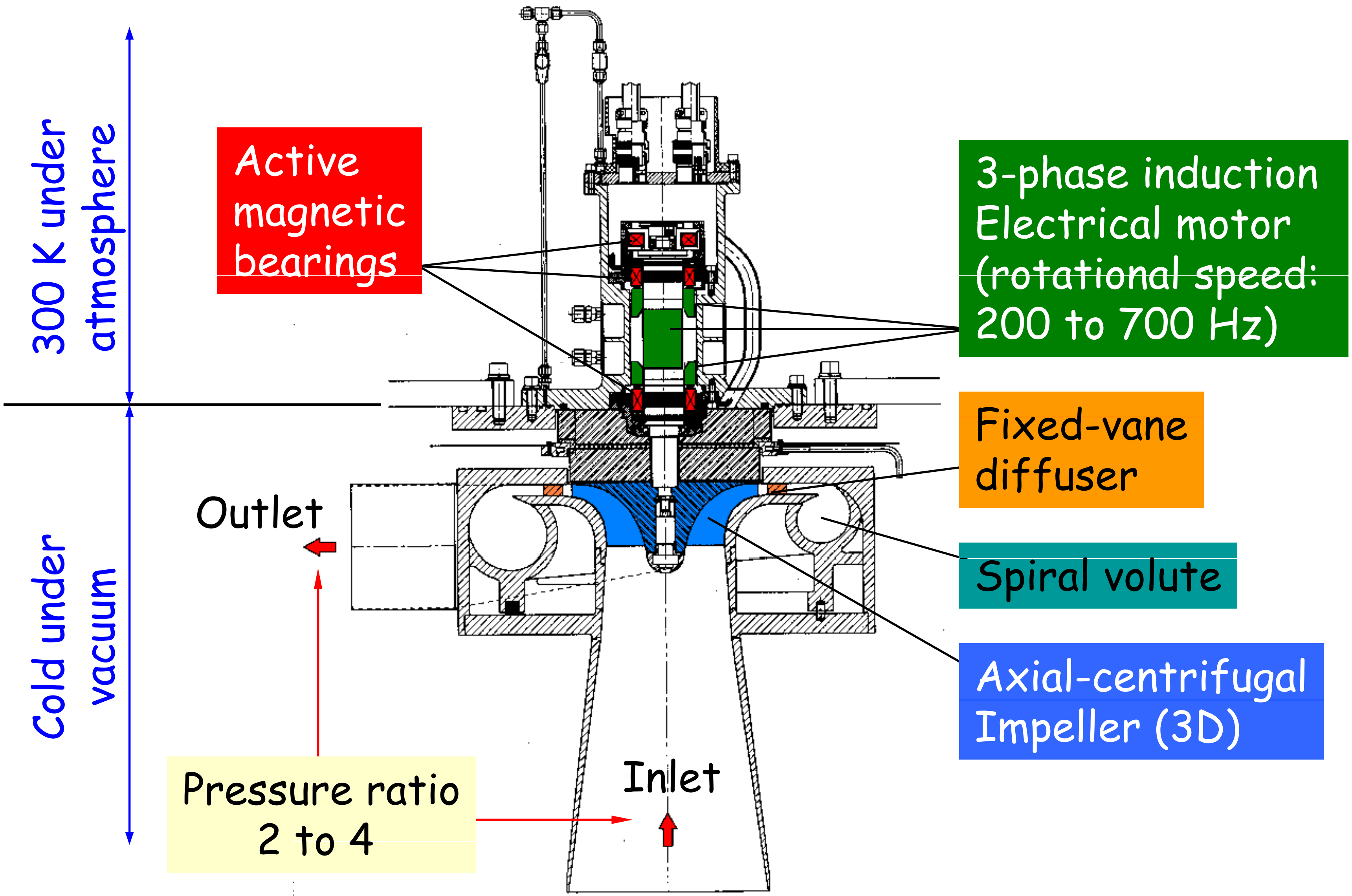
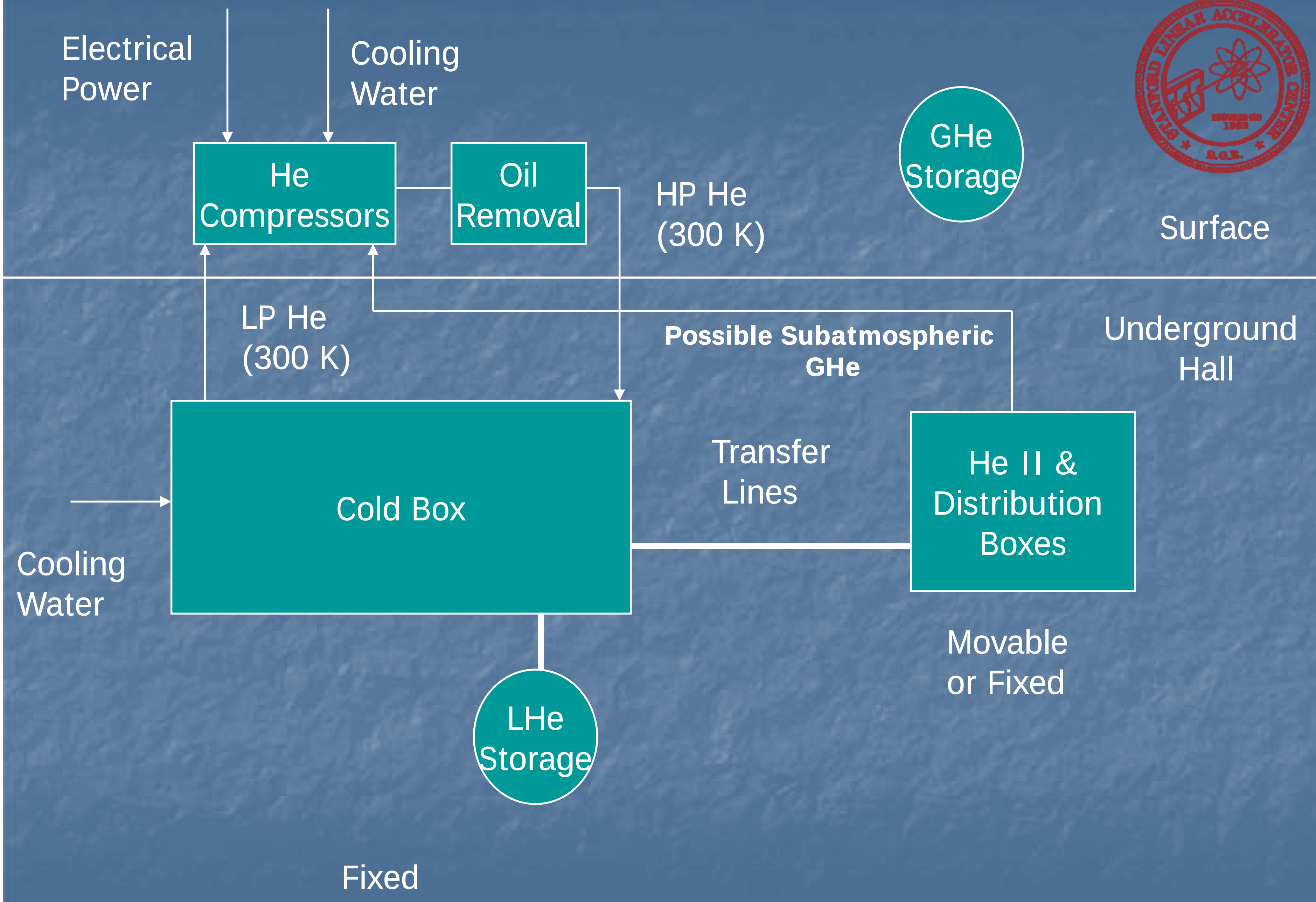
Main features of LHC cold compressors




Electrical Power
Cooling Water
He Compressors
Oil Removal
HP He (300 K)
GHe Storage
Surface
LP He (300 K)
Possible Subatmospheric GHe
Underground Hall
Transfer Lines
He II & Distribution Boxes
Cold Box
Cooling Water
LHe Storage
Movable or Fixed
Fixed

Utilities Required at Both Surface & Hall

- Electrical power
- Instrument air
- Cooling water (mostly surface but some in hall as well)
- Emergency power
- Oxygen Deficiency Monitoring systems

Cryogenic Controls

- Complicated but well within state of the art
- Industrially based (PLC)
- Once everything has been commissioned, automated operation should be possible
- Different cryogenic systems should have the same control systems or at least the same HMI

Questions to be Answered

- How many refrigerators? What do they cool?
- Where are components to be located ?
- Will LN_2 be used?
- Degree of flexibility, redundancy and interconnection for cooling systems ?
- Heat loads at various temperatures & resulting size of refrigeration plants?
- Type & amount of utilities required?
- Space required ?

Summary

- The ILC Experimental Hall will contain a wide variety of cryogenic components requiring cooling.
- The good news is that the cryogenic refrigeration & distribution systems are well within the state of the art. Thanks to LHC, CEBAF, SNS & Tore Supra even large scale He II systems been built & commissioned.
- Some movement of equipment at cryogenic temperatures is certainly possible.
- A key to success with be an integrated approach to hall cryogenics that meets the requirements of all the cryogenic components & coordinates well with other disciplines (conventional facilities, safety etc)
- There are lots of questions to be answered and decisions to be made.
- Basic decisions and the development of a basic layout should be made here. Tasks should be distributed to working groups that continue after the workshop.

Acknowledgements

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"Any opinion, finding, and conclusions or recommendations expressed in this material; are those of the author and do not necessarily reflect the views of the National Science Foundation."