

Cryogenic Test Facility (CTF)

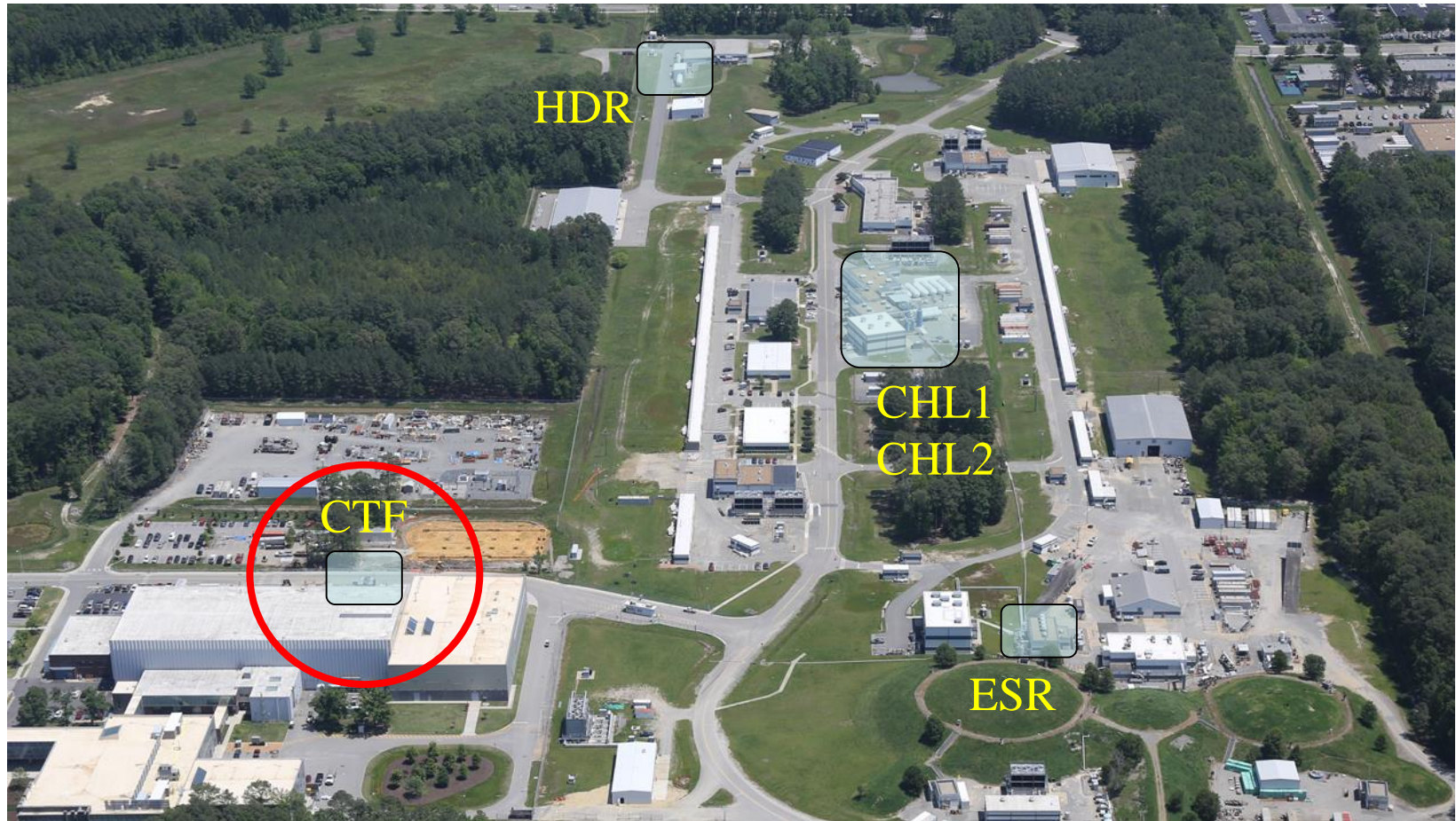
**Historical Perspective
Completed Improvements
and the Future**

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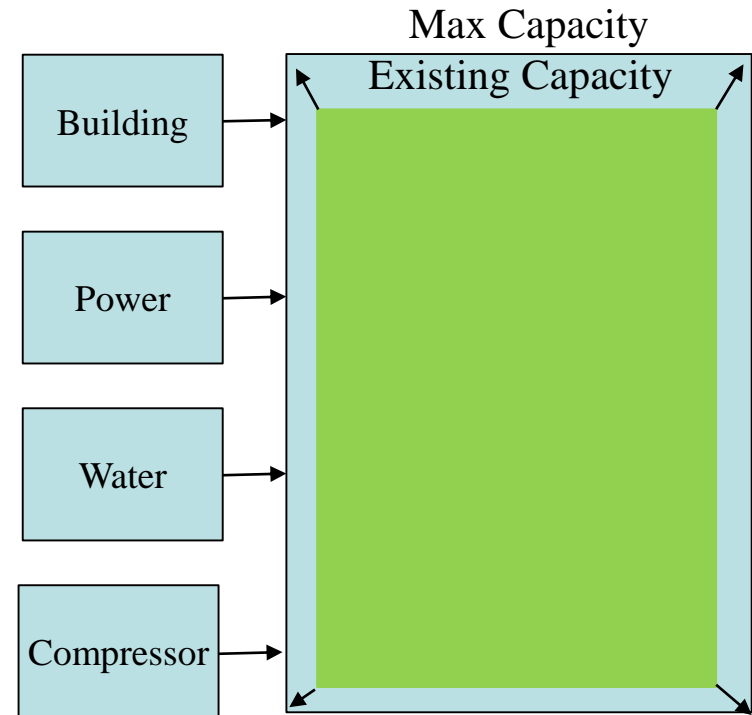
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Cryogenic Test Facility Building 57

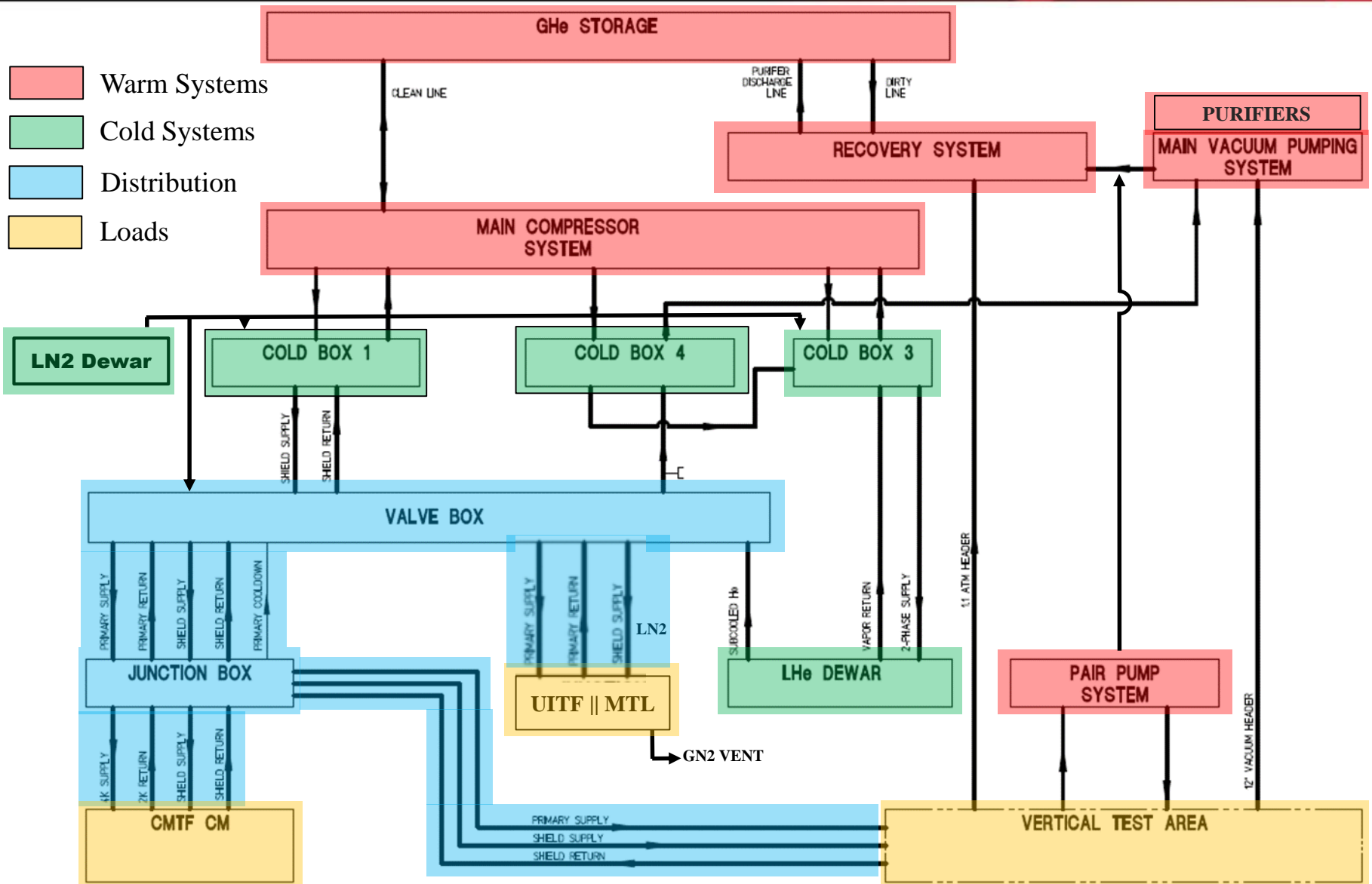


Capacity Definition

- Four main parameters define plant capacity envelope
 - Available building area
 - Available electric power
 - Available cooling water
 - Available compressor capacity
- Changing these factors is typically expensive
- Therefore, for now, CTF capacity envelope is capped
- We will increase capacity where possible within this envelope



CTF Cryogenic Systems Overview



CTF Pre-2015 History

- Built 1989-1990 for CEBAF construction
- Designed to support VTA and CMTF
- Small building for this size plant
- CAMAC controls located inside TestLab instead of inside plant building
- System
 - Three 400HP two-stage compressors
 - Each 55 g/s at 1.08 atm suction pressure
 - One Shield Cold Box (CB1)
 - 800 W at 35 K
 - One 4.5K Cold Box (CB2)
 - 4 g/s Liquefaction or 750W Refrigeration
 - One Sub-Atmospheric Cold Box (CB4)
 - 10 g/s at 2.1 K inlet and 35 K outlet
 - One Kinney Pump (2nd added during SNS)
 - Each 10 g/s flow at 0.02 atm suction
 - Two Recovery Compressors
 - Each 12 g/s at 1.08 atm suction pressure
 - Two Purifiers
 - Each 15 g/s at 13 atm discharge pressure



Planning

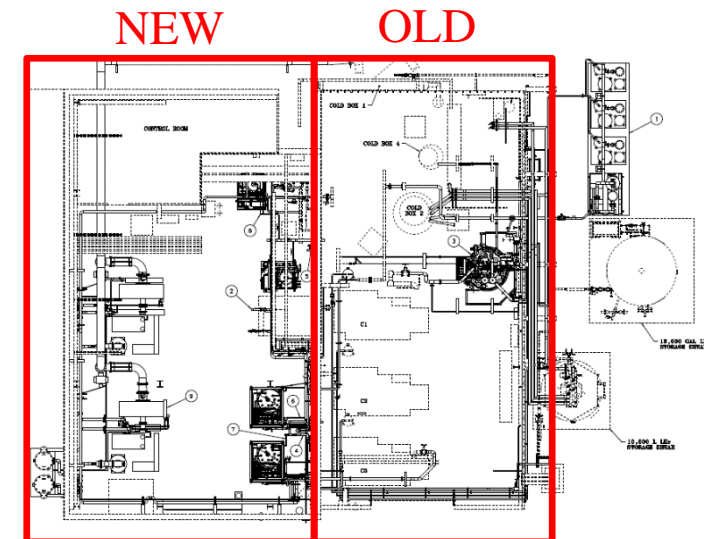
- **Recognized CTF roll was not diminishing**
 - Meetings over 10+ years discussing future of CTF (Cryo, SRF, FM)
 - No specific guidance from lab about future requirements
 - No operations money would typically be available
- **FM found potential source of money for maintaining DOE facilities**
- **Refurbishment money not guaranteed**
 - Significant competition every year with other labs
 - Would not be enough to pay for a new complete plant
 - Required a complete new building
 - Required upgrades to power
 - Required upgrades cooling water,
 - Required upgrades to compressor systems
- **Decision was made by team to concentrate efforts to improve CTF within the existing utilities and compressor footprint**

Planning Continued

- A general improvement plan was formed that would allow incremental improvements as FM received pockets of funding
- As each installment arrived pieces of the plan were executed
 - **Improve safety and space**
 - Build a new addition to existing building
 - **Improve controls**
 - Upgrade CAMAC to PLC and move into plant control room
 - **Improve liquid storage**
 - LHe Dewar and neck can, LN2 Dewar, vaporizers, headers
 - **Improve cold box systems**
 - 4.5K Cold box and 35K cold box
 - **Improve 2.1K and distribution systems**
 - Purifiers and recovery compressors
 - Cold box 4, valve box, and junction box
 - **Improve cooldown liquid helium usage efficiency**
 - LN2 cooled GHe heat exchanger precooler
- Some work would use a mixture of funding sources

Building & Safety Improvements

- **Original CTF designed for ~5 year life**
 - **Small building**
 - **Poor access and serviceability**
 - **Safety problems abound**
 - **Controls remotely located in Test Lab**
- **Building expansion**
 - **Added 1,800 square feet**
 - **Created a control room**
 - **New control system moved from Test Lab high bay into new control room**
 - Final phase waiting for a CMTF down long enough to move remaining channels
 - **Allows equipment expansion**
 - **Allows equipment spread out for safety and serviceability**



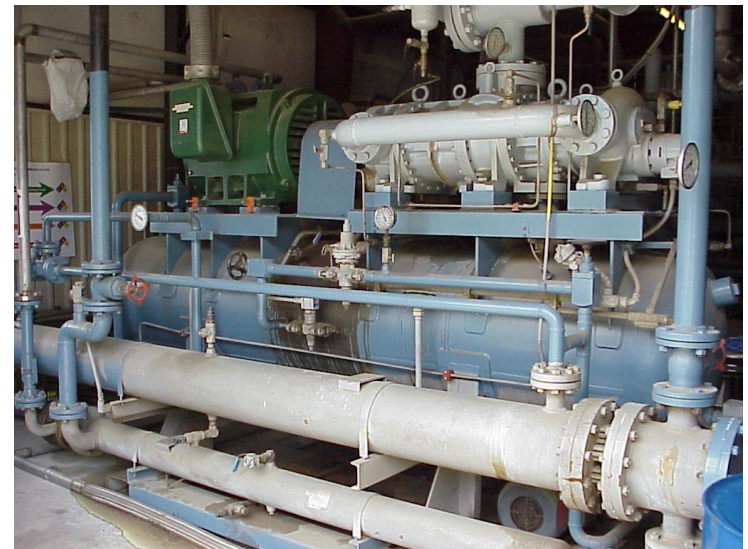
Control System Improvements

- **Old CAMAC system**
 - Located far away from plant in Test Lab high bay
 - Parts difficult to find
 - High failure rates
- **New Allen Bradley Controllogix PLC system**
 - Cryo standard
 - High reliability
 - Flexible
 - Redundant power supplies
 - More troubleshooting information available



Main Compressor Improvements

- Purchased new spare MYCOM warm compressor bodies
 - Two stage/single shaft
 - 400 HP
 - 55 g/s each
 - Old body's
 - High operational hours
 - Seals and bearings worn
 - Reduced flow capacity
 - New body's
 - Ops money
 - Restores full flow capacity
 - Restores reliability



Compressor Improvements

- **Oil flooded screw compressors**
 - Helium and oil separation is critical
- **Installed purifier system adsorber**
 - Ops money
 - Activated carbon
 - Increased purifier protection
 - Reduces risk of compressor oil from reaching purifiers
- **Main compressor oil removal**
 - Refurbished and moved three compressor oil removal skids
 - Added main compressor adsorber
 - Increased cold box protection
 - Reduces risk of compressor oil from reaching cold boxes



4.5K Liquid Storage Improvements

- **Old Helium Dewar**
 - 3,785 Liters
 - High heat leak
 - Too few connections
 - No subcooler
- **New Helium Dewar & Neck Can**
 - 10,000 Liters
 - Lower heat leak
 - Neck can with additional connections to support upgrades
 - Larger “flywheel” to smooth out VTA and CMTF peak draws
 - Added subcooler



Liquid Nitrogen Storage Improvements

- **Old LN2 Dewar 9,000 gallon**
 - Bottom rusting out
 - High heat leak
- **New LN2 Dewar 13,000 gallon**
 - Transferred from Fermi
 - Virtually new
 - Added 44% more capacity
 - Lower static heat leak
 - Designed and installed a better and safer truck fill station



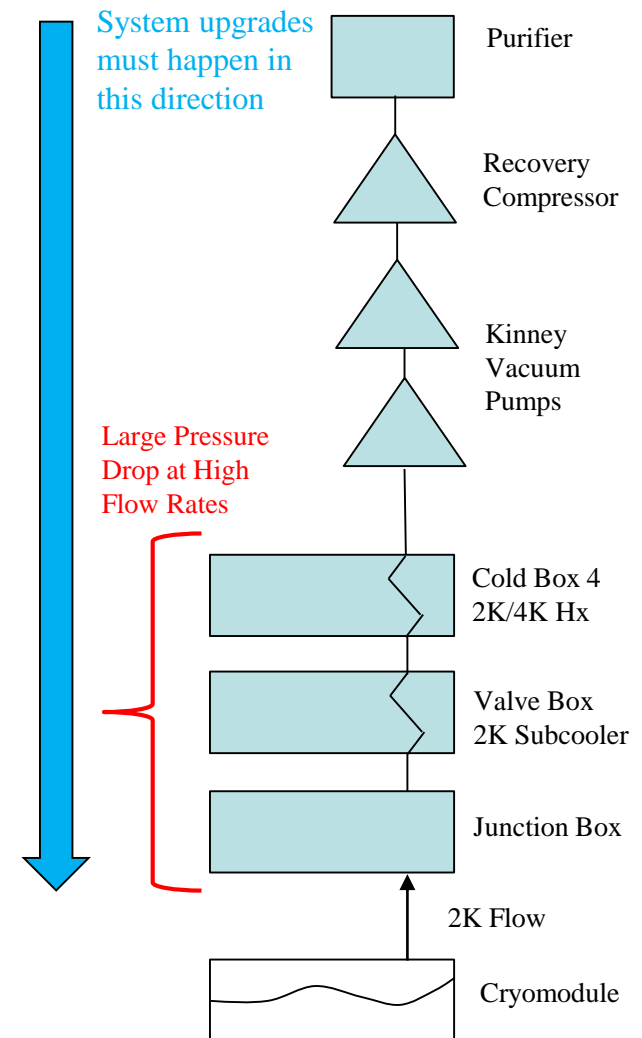
4.5K Cold Box Improvements

- **Purchased a Linde L280**
 - 4.5K cold box (CB3)
 - Replaced CB2
- **Highlights**
 - 2.25 times liquefaction capacity of CB2
 - Up to 9 g/s liquefaction
 - 700 W refrigeration
 - Uses turbines not reciprocating expanders
 - Higher reliability
 - Reduced maintenance
 - PLC controls



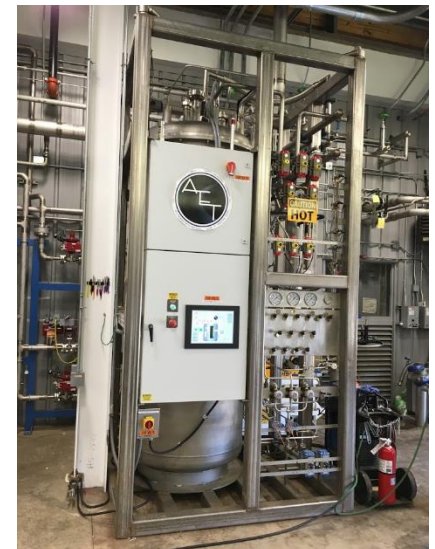
2.1K Improvement Overview

- **Multiple layers in 2K system**
 - Various pieces of hardware
 - Flow limited by HXs & piping not by Kinney capacity
 - Each piece adds differential pressure (back pressure)
 - Requires systematic upgrade approach from CTF toward cave
 - Purifiers
 - Recovery compressors
 - Kinney pumps
 - Cold Box 4
 - Valve box,
 - Junction box



Helium Purifier Improvements

- **Old dual purifiers**
 - **15 g/s max flow**
 - Single compressor operation
 - **Small storage capacity**
 - **All manual operation**
 - Manpower intensive regeneration
 - **One purifier failing**
 - Asymmetric holding and regen capabilities
- **New dual purifiers**
 - **Increased capacity**
 - 60 g/s max flow
 - Larger storage capacity
 - Allows dual recovery compressors operation
 - **PLC based controls**
 - Reduced manpower regeneration



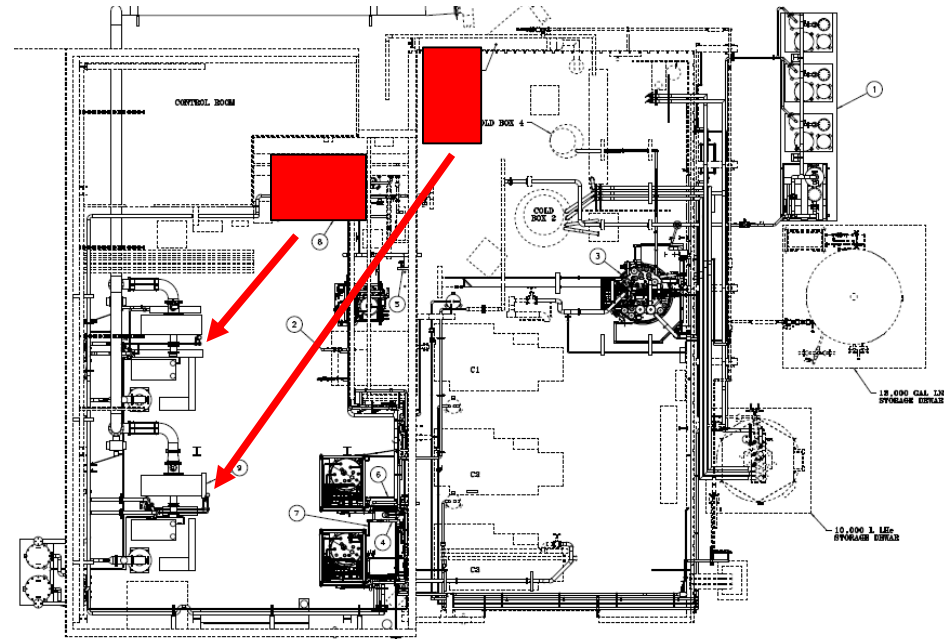
Recovery Compressor Improvements

- **Old recovery compressors**
 - 12 g/s
 - Very old with reduced capacity
 - High failure rates
 - No remote operation/monitoring capability
- **Fabricated two new units**
 - Jlab system design
 - Increased flow capacity
 - 18 g/s each
 - PLC based controls
 - Remote operation and monitoring
 - Suite of operational information
 - Improved
 - Oil and gas cooling
 - Oil removal



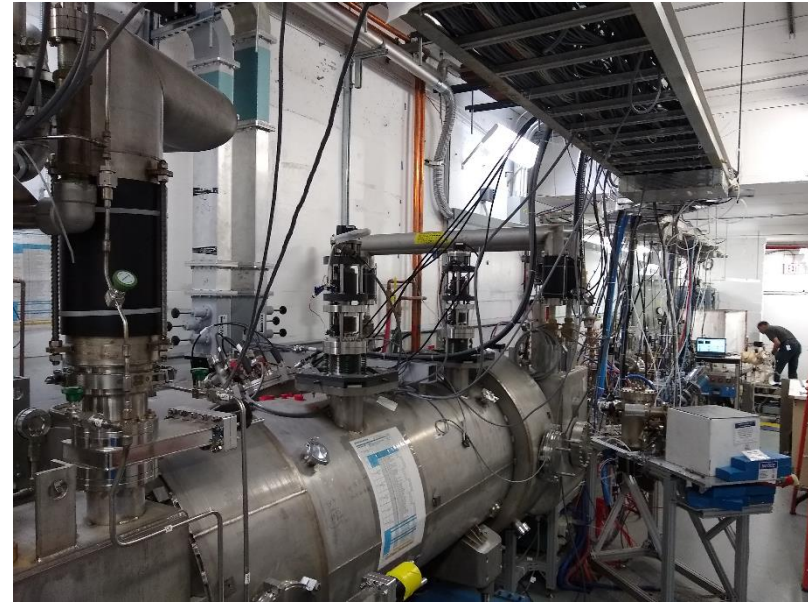
Kinney Pump Improvements

- **Moved Kinney pumps**
 - Into new addition
 - Better serviceability
 - Upsized and rerouted piping
 - New protection valves
- **Rebuilt pumps**
 - Restored full capacity
 - Improved reliability
- **Rebuilt motors**
 - Improved reliability



New Test Facility

- Upgraded Injector Test Facility (UITF)
- Designed, fabricated and installed transferline system to new injector test cave
- Shield circuit can use 35K helium or 77K nitrogen
- 77K LN2 shield circuit uses thermosiphon to reduce LN2 usage
- Allows additional customers to utilize cryogenic facility



Ongoing Effort

- **Refurbish Cold box 1 Shield Refrigerator (35K)**
 - Refrigeration of 800 W at 35 K
 - Cold box contains heat exchangers and valves
 - Satellite expander pod produces refrigeration
 - Dual purpose
 - Provides shield temperature to CMTF test cryomodules
 - Increases VTA helium quality
 - Increases 4.5K helium transfer efficiency between plant and VTA



Ongoing Effort Continued

- **New Cold box-4 2K/4K refrigeration recovery**
 - Recovers refrigeration from CMTF, UITF, or VTA 2.1K vapor and sends it to 4.5K cold box at the 30K level
 - Warms 2.1K flow to 300K before it reaches Kinney vacuum systems
 - Improvements
 - Reduce piping restrictions
 - Reduce Kinney vacuum pump work load
 - Increase 2.1K flow capacity
 - Improve efficiency
 - Potentially lower temperature capability at the module

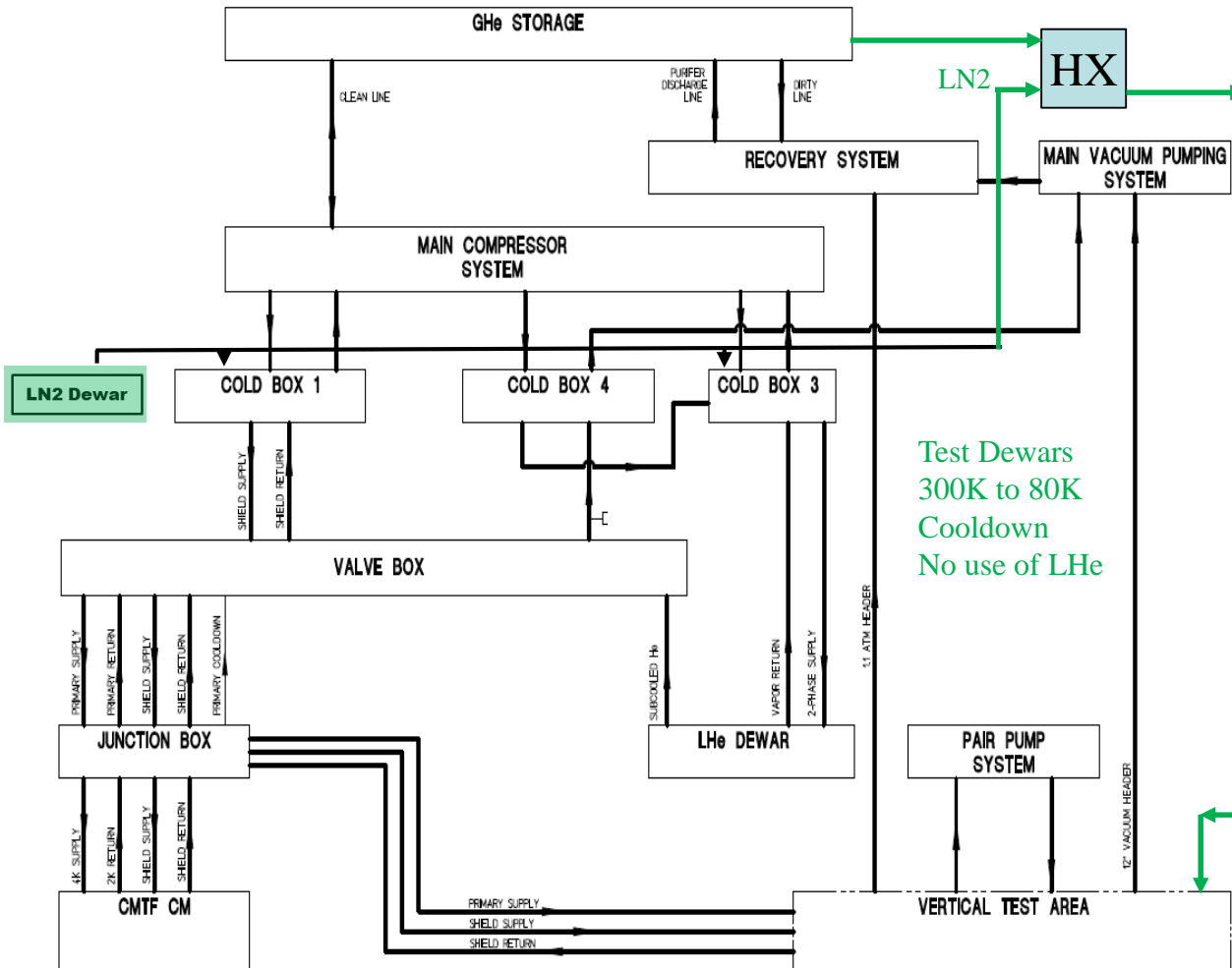


Ongoing Effort Continued

- **New distribution system**
 - **New valve box**
 - **Transfer line**
 - **Junction box**
 - **4.5K Improvements**
 - Lower heat leak
 - Improved connections
 - **2.1K Improvements**
 - Lower back pressure
 - Increased 2.1K flow capacity
 - Higher efficiency
 - Lower heat leak



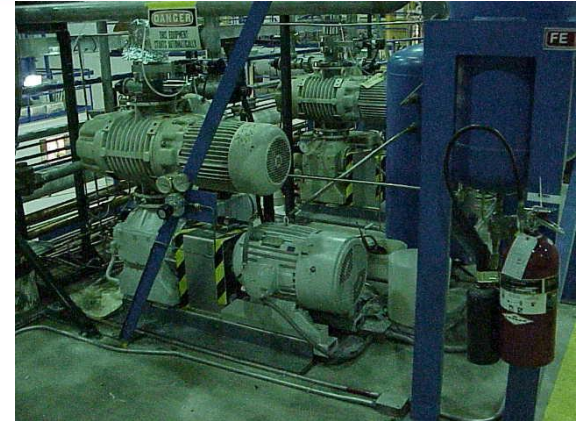
VTA LN2/GHe Precooler System



- **Proposed**
- **LN2 cooled helium heat exchanger**
- **Uses LN2 to cool warm helium**
- **Allows VTA dewar cooldowns from 300-80K using no liquid helium from dewar**
- **Substantially reduces usage rate of liquid helium**
- **Requires design/engineering and fabrication installation**
- **Requires some VTA modifications**

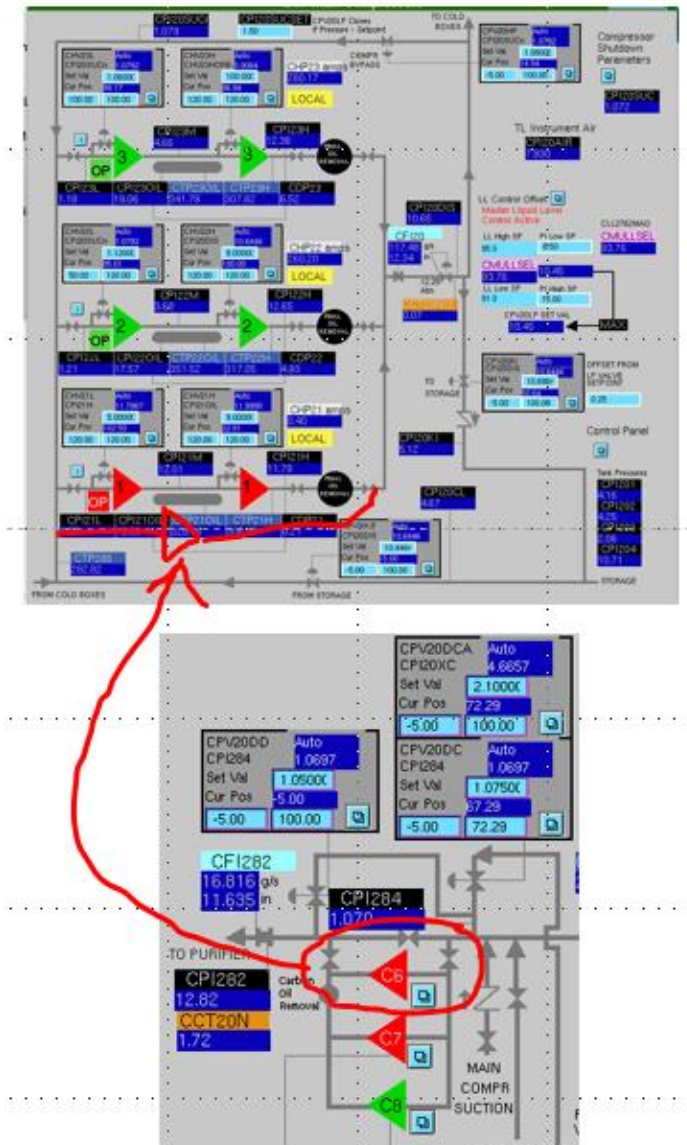
SRF Pair Pump Upgrade

- **New Pair Pumps**
 - SRF and Cryo working together to design a set of replacement pair pumps
 - Increased capacity
 - SRF Ops money
- **Benefit's**
 - Increased 2.1K flow capacity
 - Reliability
 - Shift load from Kinney to pair pumps to allow CMTF and UTF to get more flow capacity

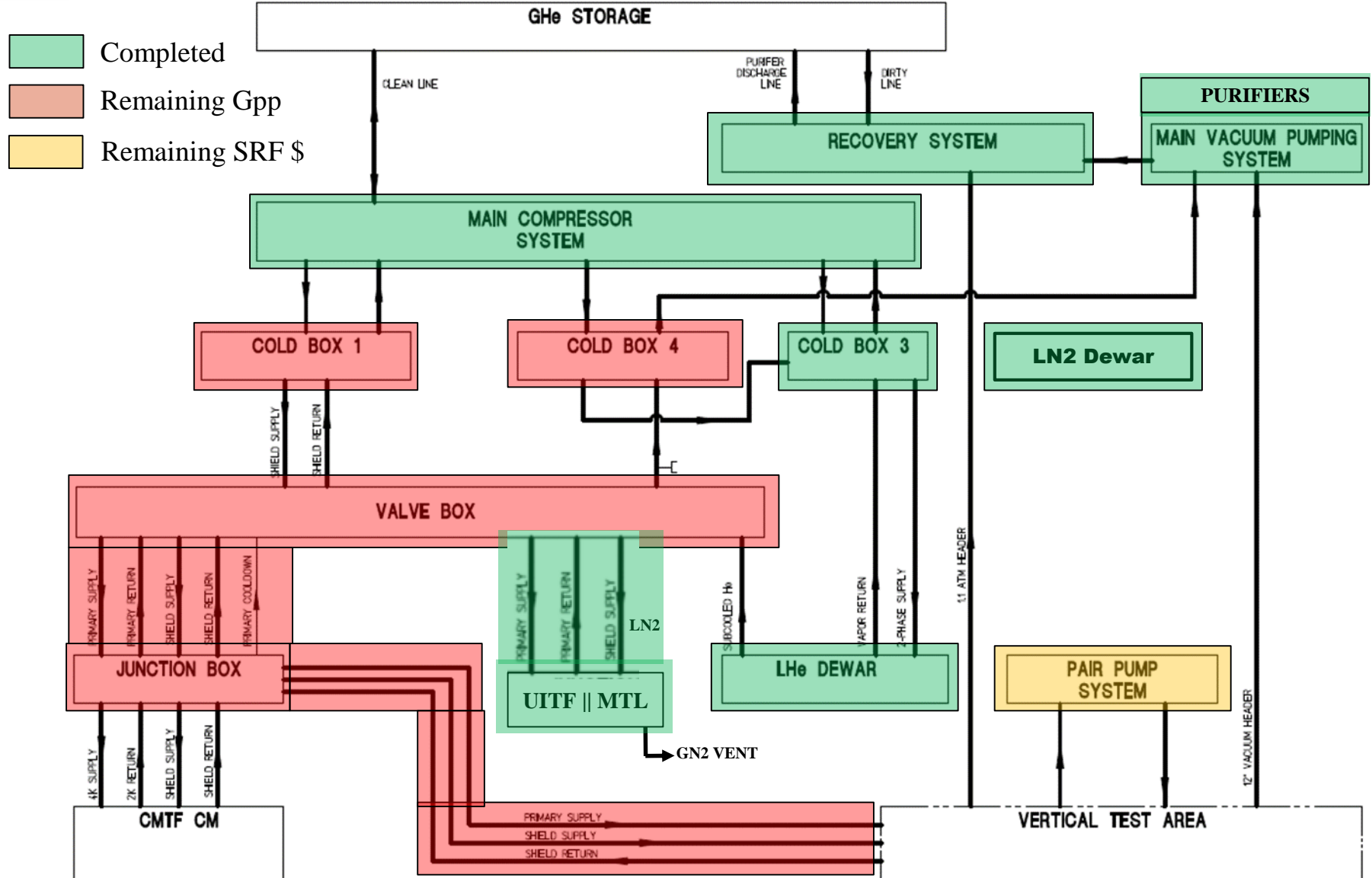


Recovery to Main Compressor

- New cold box 3 requires slightly more compressor flow than two main compressors can provide (third is spare)
- We supplement main compressor flow using cross connect to purifier recovery compressors
- Robs purifier compressor and Kinney 2K capacity and places the system at higher risk for contamination issues
- We have one unused recovery compressor (150HP 16g/s) after the purifier upgrades
- We will re-pipe this machine into the main gas system so it can provide the extra 5-7g/s of required flow to the main gas system.
- Reestablishes main gas system and purifier system separation
- Restores full flow capacity to recovery and Kinney systems



Summary of Improvements



Summary

- Cryogenics and Facilities have worked to continue improving the CTF
- Plan incrementally upgraded through a prioritized logical path addressing
 - Space & Safety
 - Single point failures and aged equipment
 - Restore or slight increased capacities
- Funding to date
 - A mixture of Gpp and Operations
- Reminders
 - All pieces of the system are highly integrated
 - No single piece can be upsized too much without causing problems somewhere else in the system
 - New money received is to continue with predefined updates

Questions?