Cryogenic Test Facility

Past and Future

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Talk Outline

The purpose of this talk is to provide historical context for the CTF cryogenic facility, discuss the current upgrades, and close with a discussion of the current future planned upgrades

- Background
- CTF Overview
- Primary areas concern
- Previous upgrades
- What is UIM?
- Next Phase
- Future upgrades

Background

The Cryogenic Test Facility (CTF) refrigeration plant was commissioned in 1988 to support testing the original CEBAF cryomodules. It was expected to have a life span of not more than 5 years. It has continued supporting the TestLab for more than 28 years.

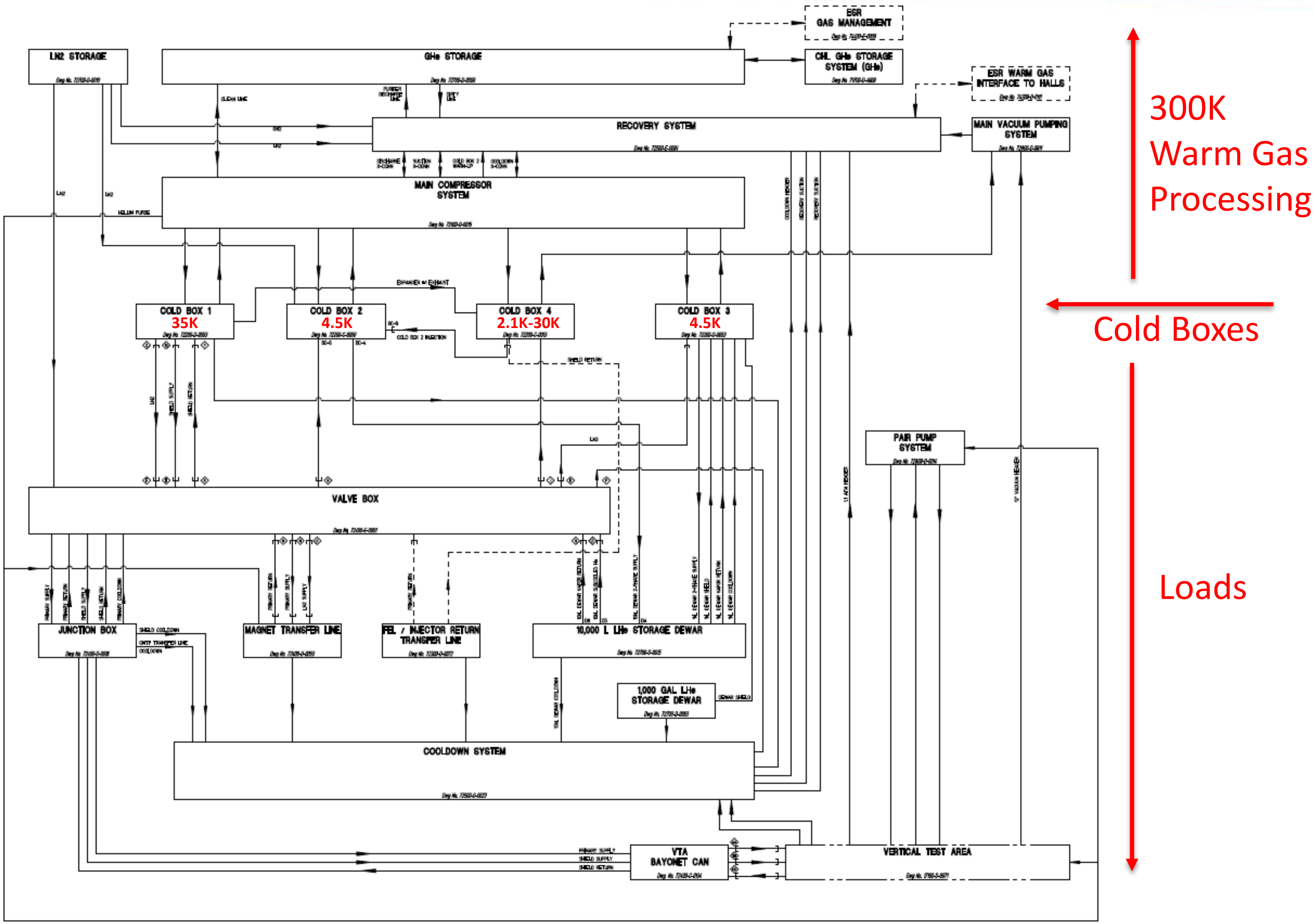
The plant has a capacity of

- Cold box #1: 800W at 35K
- Cold box #2: 750W at 4.5K OR up to 4.5g/s liquefaction
- Cold box #4 and Kinney vacuum pump: 10g/s at 2.1K
- Liquid helium storage: 10k Liters at 4.5K
- Liquid nitrogen storage: 13k gallons

The distribution system delivers cryogens to the Cryomodule Test Cave, the Vertical Test Area, and a new extension that can provide cryogens to the Injector Test Cave. The available capacity is a shared resource and the total load of all test areas cannot exceed the capacity of the plant so project planning is important.

Over the years discussions with SRF to define future capacity needs have not yielded any firm numbers so resources instead look for upgrades to make the system more robust, maintainable, and to replace older equipment.

CTF Overview



Primary Areas of Downtime

- CAMAC controls failures
  - Failure rates are increasing
  - New parts are unavailable
- Rotating equipment repair and maintenance
  - Lots of moving parts, bearings, seals, etc.
  - Some require daily or weekly tuning to maintain efficiency
- Reduced capacity from contamination
  - Primarily from VTA because of how they operate
  - Plugs heat exchangers and valves and reduces mass flows
- Insulating vacuum problems
  - Leak rates increasing with age of equipment
  - Soft seals become brittle and leak, etc.
  - Increases heat loads
- Primary power issues
  - Hard shutdowns allow contamination to move through the plant

Primary Areas of Capacity Issues

- Testlab planning and scheduling of experiments
  - Capacity of the plant is <u>fixed</u>
  - Projects must be scheduled and executed carefully
  - Will become more complicated with new ITC
  - Nights, weekends, etc.

- Distribution system heat loads
  - Poor long term design choices were made originally
    - It's a waste using 4.5K helium to cool from 300K to 4.5K
    - Existing VTA transferline has very high heat leak
  - 3:1 transfer ratio to fill a VTA Dewar from 300K to 4.5K

Previous Upgrades

- Added Kinney #2 as a backup to Kinney #1
  - Provides a backup 2.1K vacuum pump in case of failure or to support maintenance activities in parallel with operations to increase availability
- Added cold box #1 to cold box #2 re-injection booster
  - Provides a small boost to 4.5K capacity by re-injecting any available unused capacity of cold box #1 35K stream into low side return of cold box #2
- Introduced VTA Dewar to VTA Dewar transfers
  - Re-uses liquid already sent to VTA before its warmed up and returned to the cryogenics plant
- Replaced expander DC brake motors and DC speed controls with AC motors and variable frequency drives
  - Reduced maintenance and repairs (brushes, commutators, varidrive)
  - Reduced electrical power sources from 3 to 1 to improve safety
- Replaced weak cold box #2 expansion engine
  - Re-established cold box performance
- Replaced 1,000 gallon helium Dewar with 10,000 Liter
  - Increased liquid helium storage buffer to allow larger draws and support short periods where the load is higher than the plant capacity
- Replaced 9000 gallon nitrogen Dewar with 13000 gallon
  - Old Dewar rusted through the bottom

What is UIM?

UIM money was offered to improve infrastructure, safety, and maintenance of DOE facilities. Cryo had previously provided Facilities Management with a list potential areas that needed attention. After a number of years money awarded to JLAB and Facilities decided to use it on Cryo. This money happened to be awarded when Cryo engineering and design teams were fully engaged in 12GeV and MSU FRIB so choices were limited to items that did not require a large engineering and fabrication effort.

A building extension was chosen to allow the equipment in CTF to be spread out more to improve personal safety when repairing and maintaining equipment and to make room for future upgrades. Also provides a control room inside CTF to allow control system to exist closer to the plant.

A replacement for Cold Box #2 was chosen to improve personnel safety by reducing the need for maintaining reciprocating expanders.

A replacement for CAMAC control system was chosen to improve availability, reduce controls failures, and provide access to off the shelf spare parts

Current UIM History

CTF current UIM project has been ongoing for almost 3 years

Phase 1: Worked with Facilities Management to design and install a building addition that included additional machine space for expansion and a separate control room.

Phase 2: Wrote specification and purchased new 4.5K cold box. Linde L280 was purchased as compromise between cost, available UIM funds, and market availability. It is comparable in capacity to cold box #2. The original plan was to use it to ultimately replace CB2 because or its age and high maintenance reciprocating expanders

Phase 3: Specified and purchased PLC hardware, 19" racks, cabling, and cable tray and conduit to replace the CAMAC control system and reusing as much of the original boxes and cable as possible to save money

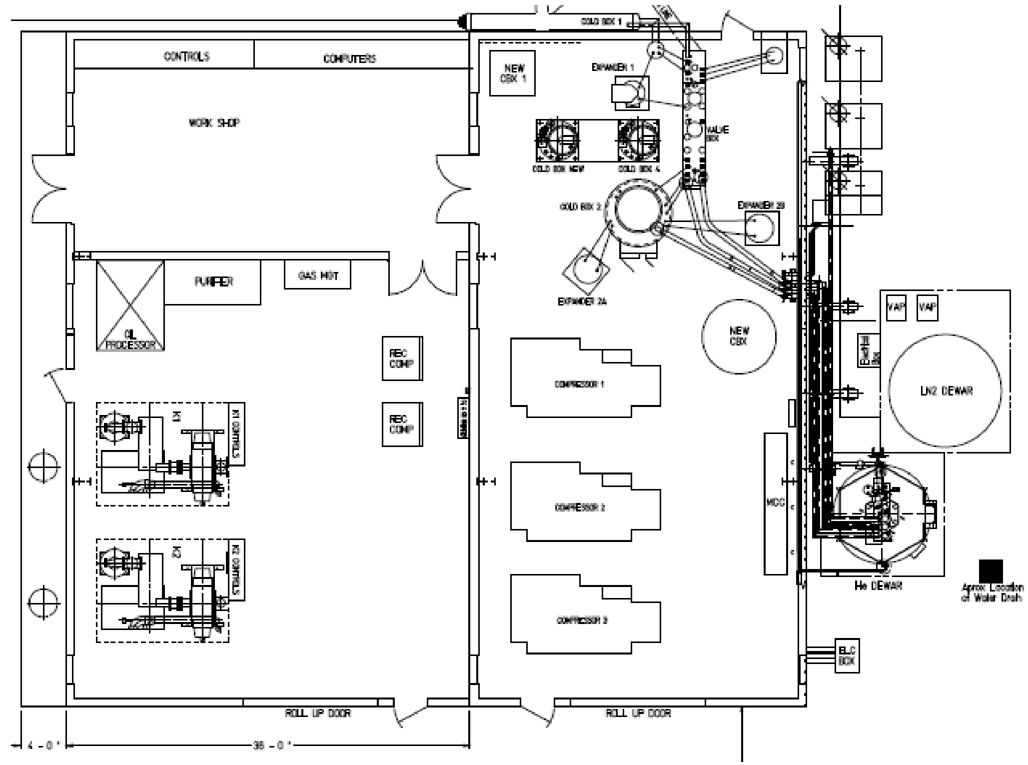
Phase 4: Installation was planned in two steps. The first included pre-fabrication and installation of piping up to final tie ins and pre-building the 19" control racks. The second step included a long shutdown to allow final piping tie ins, complete overhaul of the control system, and commissioning and testing of the new cold box and placing it online with CB2 in reserve

Phase 5: When it became obvious LCLS2 would be negatively impact this project we revised the plan to begin moving ahead with installation of all possible non-invasive pieces of the new control system in parallel with the operating plant. This lead to additional expenditures for boxes, cable, and conduit and tray and a redesign of the planned electrical interconnections because we had to install the new system in parallel with the operating CAMAC system instead of removing it first.

Phase 6: LCLS2 project became more sensitive to any down placing this project in jeopardy of missing critical milestones and losing contingency money that could be used for other projects. It was renegotiated to perform a best effort to complete the installation of the new cold box, complete the new control system installation, and push off cold box and commissioning and testing into the future until the project could tolerate the interruptions. It also pushed off removal of the old CAMAC hardware, cable, and boxes until after the project is over.

Building Addition

- Allows equipment movement
  - Relieves congestion around equipment
    - improve safety and maintainability
  - Provides space for future upgrades



Cold Box #3

- Linde L280 twin turbine 4.5K machine
  - Envisioned as a replacement for Cold Box #2
    - Max refrigeration mode >= 650 W
    - Max liquefaction mode >= 6 g/s
      - Less refrigerator than cold box #2
      - More liquefier than cold box #2
  - This model was purchased as a compromise
    - Existing support systems
    - Available compressor capacity
    - Quantity of money available from UIM
    - Availability of standard product

Control System

- Replace CAMAC with programmable logic controller
  - Allen Bradley ControlLogix
  - Industrial control system
  - Hardware and code used in many previous cryo projects
    - JLAB
      - Hall’s B, C, and D
      - CHL1 and CHL2
    - NASA Houston Vacuum Chamber A
    - MSU FRIB
    - Oakridge SNS

UIM Shutdown Overview

- CTF Shutdown 17 Feb through 9 Apr (Dewar full)
- Actual work duration is shorter because shutdown includes plant warmup, cleanup, and cooldown/fill

- Goals
  - Complete new cold box #3 physical installation
  - Complete CAMAC to PLC controls upgrade in Bldg. 57
  - Install strategic flanges for future upgrade work
  - Install connection for HDIce warm gas return

- Not included in this shutdown work
  - CB3 commissioning and testing
  - Controls upgrade for junction box, Test Cave, or VTA
  - Removal of old wiring, conduits, CAMAC, racks, etc.

Next Phase

- Cold Box #3
  - Commissioning (non-interference in parallel with SRF testing)
  - Testing (approximately 2 weeks of interruption to SRF to be scheduled)
- Kinney vacuum systems
  - Relocation of 2.1K Kinney vacuum systems
  - Improve safety for repair and maintenance
  - New piping will open up restrictive 2.1K return piping
- Warm gas management valve skids
  - Fabricate and install new warm control valve skids
    - Reestablish and improve performance
    - Replaces EV's with PV's
    - Moves control valves down to floor level
      - Improve safety for repair and maintenance

Future Plans

- Learn to operate cold box #3 effectively
- Learn to possibly operate 4.5K cold boxes #2 and #3 together
  - Possible method to deal with short duration peak loads
  - Limited by the capabilities of the surrounding support systems
  - Depends on multiple compressor availability
- Purchase and install two new purifiers
  - Old units are failing
  - New units increase capability and improve contamination management
  - Will allow march to higher 2K flow capabilities with other improvements
- Fabricate and install two new recovery compressors
  - Old units are failing
  - New units increase capability and improve contamination management
  - Will allow march to higher 2K flow capabilities with other improvements

Future Plans (continued)

- Fabricate and install new distribution system
  - Reduce heat leaks and improve delivery
  - Open restrictions in 2.1K returns
- Fabricate and install VTA pre-cooling heat exchanger and piping system
  - 4.5K helium should not be used to cool VTA Dewars or cryomodules from 300K to 100K
    - A heat exchanger with warm helium and LN2 should be used for cooling loads from 300K to 100K without using any cold helium
    - Use cold helium for 100K to 4.5K cooling and filling only
    - Same method used in Halls for cooling magnets
  - Removes the 300K to 100K cooling burden from the 4.5K machine
- Replace the 35K shield refrigerator (cold box #1)
  - Old unit is failing
  - Replace with an off the shelf unit

Question or Comments