Cryogenics

Overview of the Jefferson Lab 12GeV Upgrade

**D. Arenius, V. Ganni,
J. Creel, K. Dixon,
P. Knudsen, J. Wilson Jr.**

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Current 12 GeV Program Status

- **On February 22, 2006, the United States Secretary of Energy, Samuel W. Bodman, announced that President Bush's fiscal year 2007 budget request includes funding for the Jefferson Laboratory's Continuous Electron Beam Accelerator Facility 12GeV upgrade. The funding request is tied to the recent Secretary Bodman's approval of the Critical Decision One (CD-1) Engineering and Design project phase (PED). Advanced Concept Design (ACD) is currently underway with PED starting later this summer.**

  http://www.energy.gov/news/3240.htm

- **Additional 12 GeV Program information available at http://www.jlab.org**
- **More information about Jlab cryogenics operations**

  http://www.jlab.org/accel/eng/cryo

Current JLab Plant Overview

- **Four Current Major Cryogenic Plants**

—CHL(Central Helium Liquifier) *

- **1991, 4600 W @ 2.1 K, 12 KW @ 35K +10 g/s**
- **Supports CEBAF, FEL, Experimental Halls**

—ESR (End Station Refrigerator)

- **1993, 1500 W @ 4 K (former 1977 LBL ESCAR Refrigerator)**
- **Supports Experimental Halls A/B/C**

—CTF (Cryogenics Test Facility)

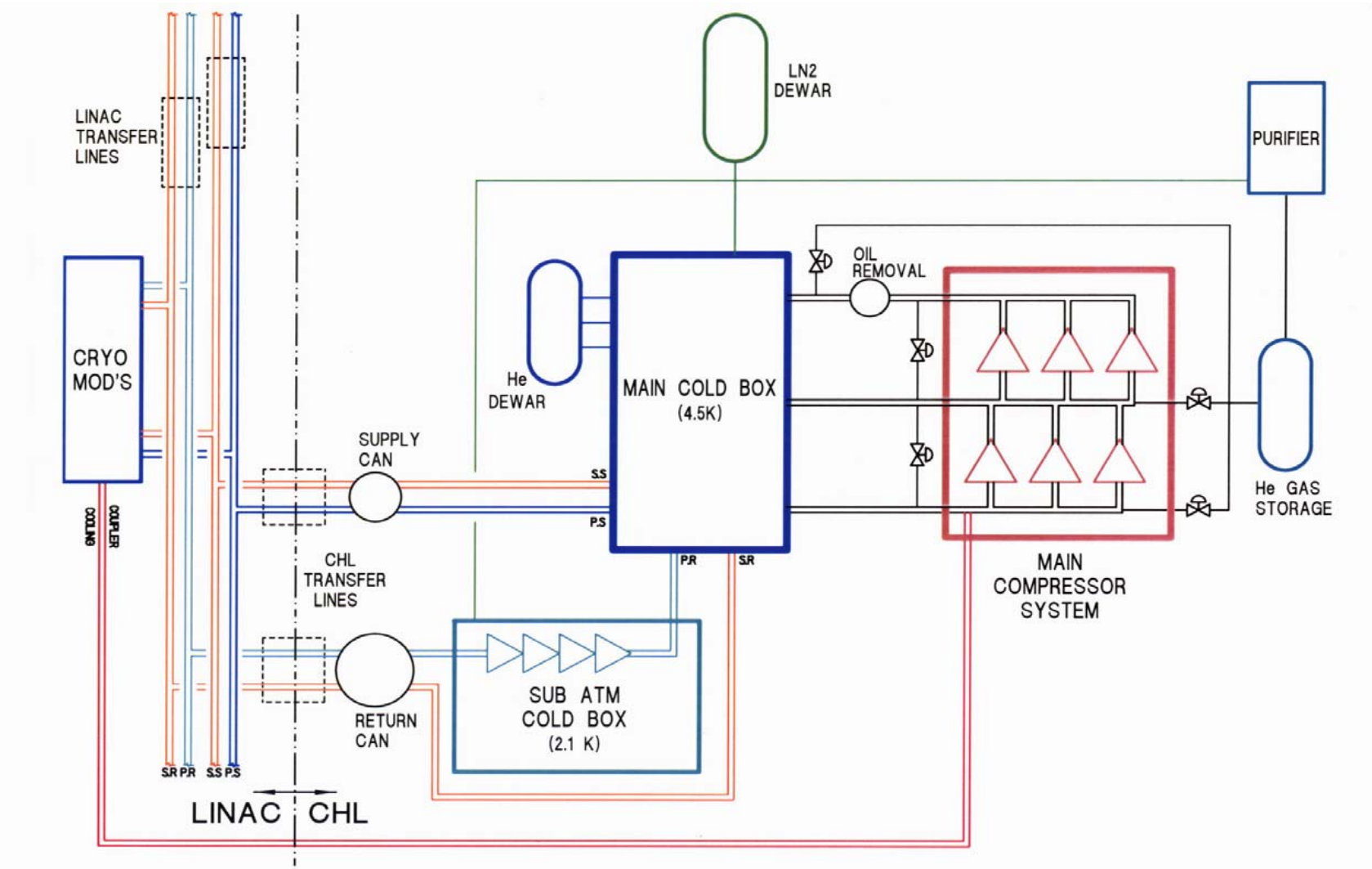
- **1989, 750 W @ 4 K with warm 2.1 K vacuum pumping**
- **1989 800 W @ 35 K Shield Refrigerator**
- **Standby 65 L/hr CTI M2800 Liquefier**

—SBR (Stand-by Refrigerator)

- **1998, 1650 W @ 4K, 13 KW @ 35K**
- **4K Backup for CHL during maintenance/repair**

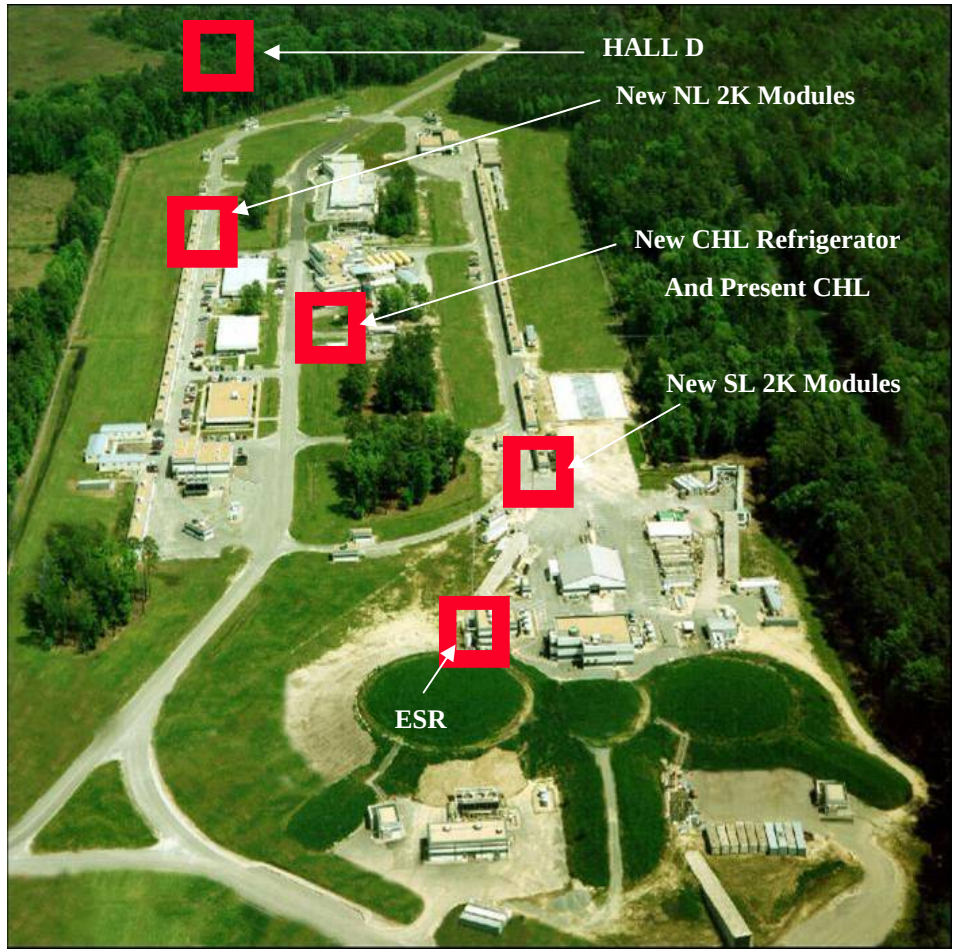
*** Plant to be Upgraded for 12 GeV CEBAF Beam**

Current CHL System Schematic



Accelerator 12GeV Work Scope

- Current 2 linacs maintain 20 cryomodules each, 1600 L @ 2.1K each
- 12 GeV requires additional 5 new “high power” Cryomodules per linac
- The current CHL (CHL#1) remains unmodified for the 12 GeV program
- Additional equipment (CHL#2) must be added to meet the additional linac loads
- A new remote Hall D is to be added as part of 12 GeV, requires modest cryogenic refrigeration
- End Station Refrigerator Loads remain within present capacity
- Existing transfer lines found to be adequate for 12 GeV flow rate with exception of Cv of return bayonet valves for new cryomodules (TBD)



Current vs. New CHL Capacities

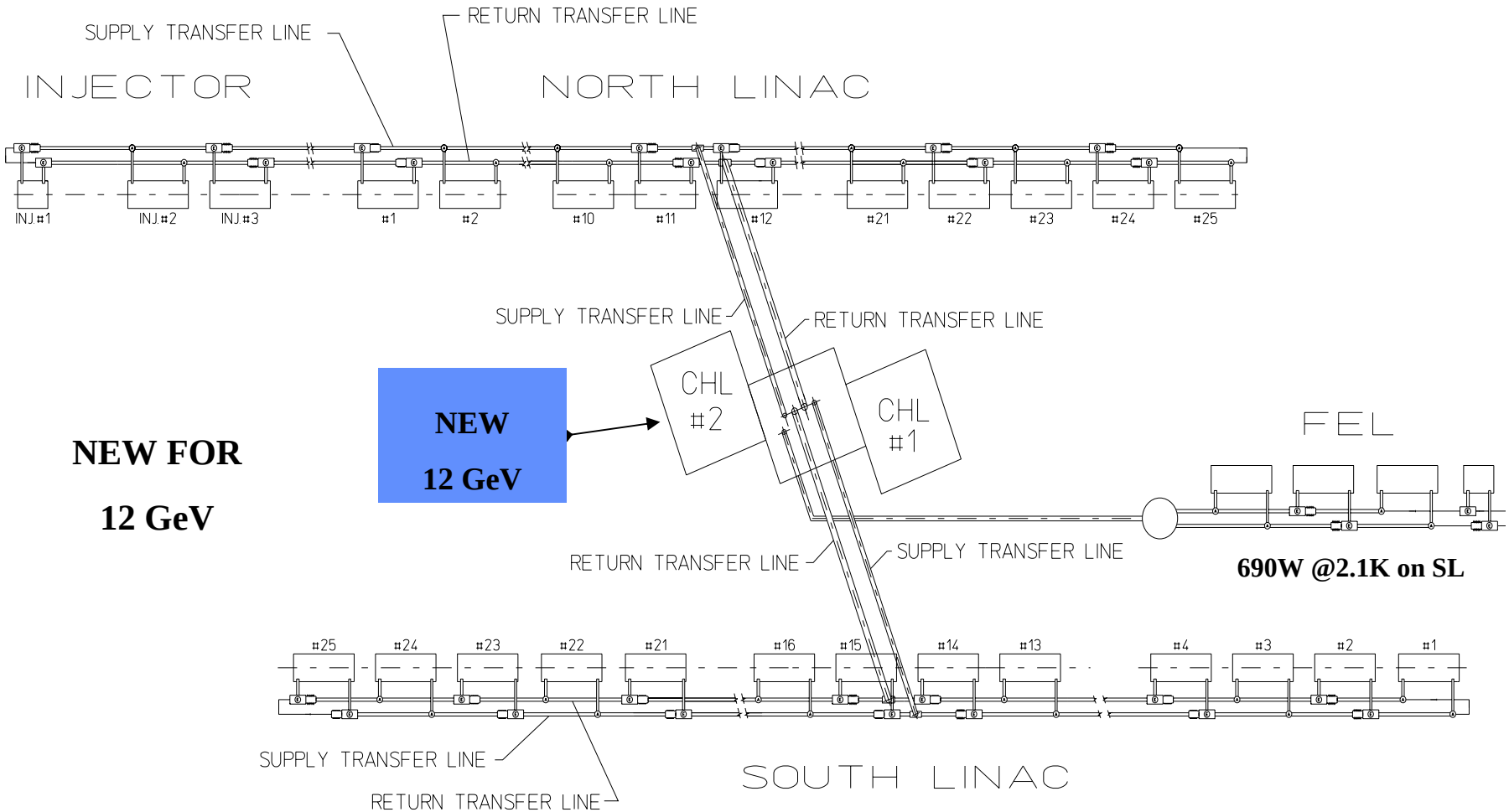
- **Current 6 GeV (CHL #1)**
  - **Load: 4248W @ 2.1K, 11.65 KW @ 35K**
  - **Capacity: 4.6 KW @2.1K, 12 KW @ 35K**
- **New 12 GeV (CHL #1 + new CHL#2)**
  - **Load: 7.4 KW @ 2.1K, 14.65 KW @ 35K**
  - **Capacity: 9.2 KW @ 2.1K, 24 KW @ 35K**

Note: 12 KW shield capacity in both CHL #1 and #2 allows 6 GeV experimental program should one refrigerator be non-operational

Loads/Capacities: 6GeV/12GeV Breakdown

Unit Loads			6 GeV			12 GeV					
						North Linac			South Linac		
	2 K	50 K	#	2 K	50 K	#	2 K	50 K	#	2 K	50 K
Loads (#,W)											
Static											
Transfer Line	530	6360	1	530	7000	0.57	228	3990	0.43	302	3010
Original CM's	16	110	42.25	676	4648	21.25	340	2448	20	320	2200
12 GeV CM's	50	250				6	300	1250	5	250	1250
Dynamic											
Original CM's	72		42.25	3042		21.25	1530		20	1440	
12 GeV CM	250	50				6	1500	300	5	1250	250
Totals			42.25	4248	11648	25.25	3898	7988	29.25	3562	6710
Capacities (W)											
CHL#1 (W)				4600	12000		4600	12000			
% of Full Load				92%	97%		85%	67%			
CHL#2(W)										4600	12000
% of Full Load										77%	56%

Requirement: LINAC TRANSFER LINES



NEW LINAC TL CONFIGURATION

- **CURRENT 6GeV:**

  CHL-1 Supplies All Linacs, FEL and ESR

- **NEW 12 GeV:**

  CHL-1: North Linac and ESR (10 g/s)

  CHL-2: South LInac and FEL

NOTE: IN CASE OF A CHL#1 OR CHL#2 FAILURE, THE LINAC CAN BE RECONNECTED TOGETHER INTO SINGLE REMAINING MACHINE FOR 6 GeV BEAM OPERATION

CHL#1 Current and Future Operational Status

Remains as reliable system for 6 and 12 GeV

- Continues to provide highly reliable operations (>99.25%) combined with the ESR
- CHL#1 operating costs not part of the 12 GeV upgrade until beam commissioning
- Will operate most of the upgrade period supporting 6 GeV
- Main compressors/Final Oil Removal have completed major 75K hour interval overhaul (4Q, FY04)
- Rotation equipment spares remain on hand
  (motors, compressors, oil pumps, spare turbines)
- Control system components replacement underway

ESR Current & Future Operational Status

- **Not affected by 12 GeV**
  - **Hall cryogenic loads for 12 GeV are within the present capacity of the existing End Station Refrigerator (ESR)**
- **ESR will continue to provide reliable experimental support operation**

12 GeV CHL #1 Equipment Already in Place

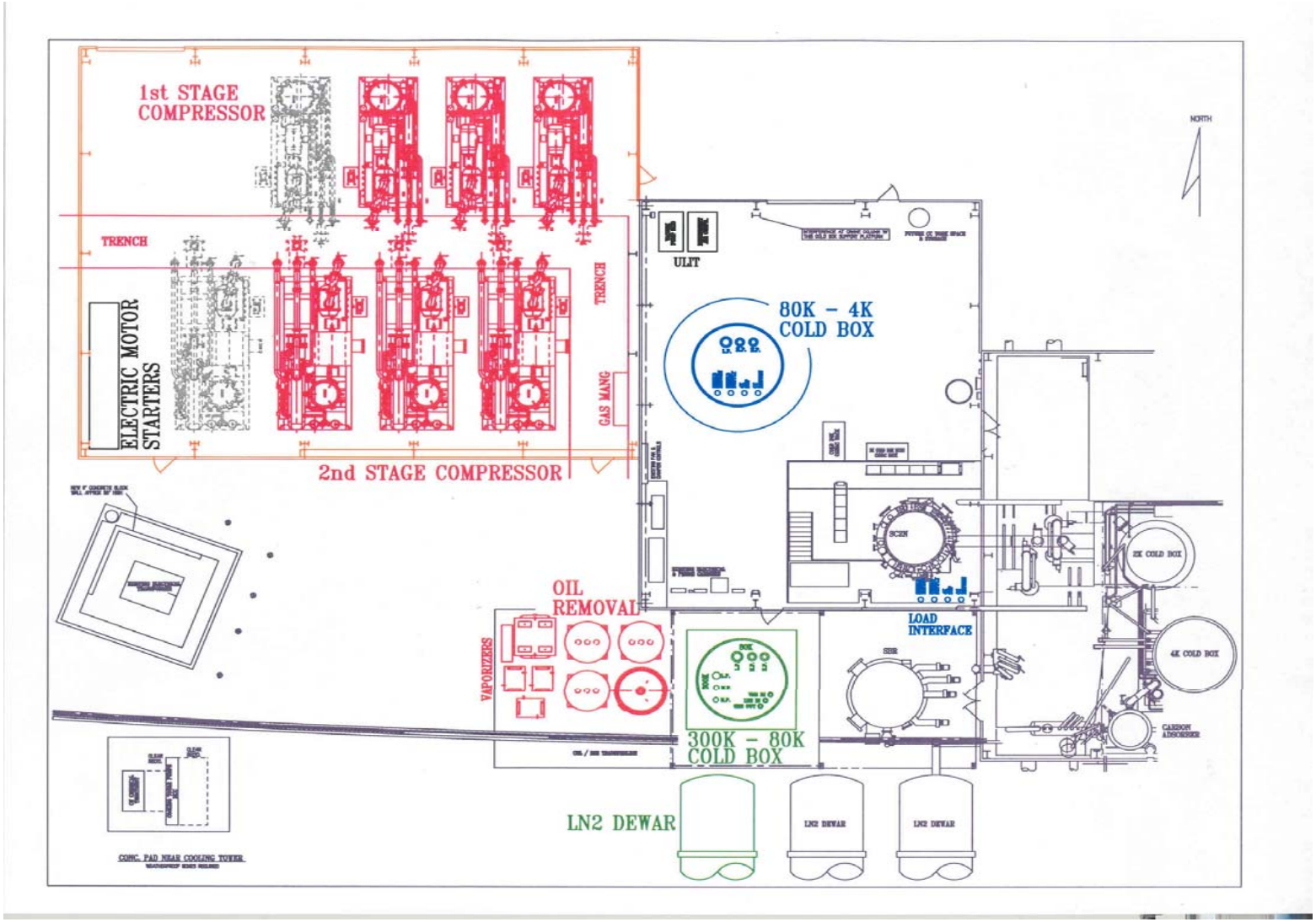
- Six helium screw-compressors: 3x2250 hp, 3x600 hp
- Helium Compressor Oil Removal System
- Two 20,000 gal LN2 storage dewars
- Guard Vacuum System (contamination control)
- Gas Purification and Gas Recovery Compressor System
- Six 4000 cf warm Helium Gas Storage Vessels
- 4K Refrigerator
- Two 2.1K Cold Boxes *(Redundant unit used for 12 GeV upgrade)*
- Integrated Computer Process Control System
- Instrument Air System, 120 scfm
- Motor Control Centers, 4160V/480V
- TL from 4K Cold Box to Existing 2K Cold Box
- *Building and Cold Box Pit for New CHL-2 4.5K refrigerator*
- *480V Power Utility for New CHL#2 Compressor Building*
- *Linac Cryogenic Transfer Line, is adequately sized for 12 GeV*

New CHL #2 Equipment Requirements

- Up to Six helium screw-compressors: 3x2250 hp, 3x600 hp
- Helium Compressor Oil Removal System
- One LN2 storage dewar: 20,000 gal.
- Two 4000 cf Helium Gas Storage Vessels
- 4K Refrigerator
- Integrated Refrigerator Computer Process Control System
- Instrument Air System, 60 scfm
- Motor Control Centers, 4160V/480V
- Possible Return TL Bayonet Valve Modifications for new modules
- TL from 4K Cold Box to Existing 2K Cold Box
- 76'x61' building for helium compressors (civil)
- 10MW 4160V substation (civil)
- 3000 gal/min cooling water towers (civil)

* Note: All Equipment listed is the same as SNS or JLab equipment except TL Bayonet Valve Cv Modification

New CHL #2 Building Equipment Layout



Building Layout Features

- **Uses existing JLab 2K Cold box for CHL#2**
- **Compressor Building layout similar to JLab/SNS**
- **Existing building and cold box used for lower temperature (<80K) CHL-2 cold box section, Refrigerator pit already in place**
- **300K to 80K cold box section is outside, N2 vent is outside, LN2 is close to 300-80K cold box.**
- **Existing 480V power is sufficient for CHL-2 facility**
- **Facilities coordinated with Civil Construction for cooling water, 4160V power, ventilation, etc.**

Compressor Building Helium and Water Piping

Typical: SNS Compressors

Gas Management Valve Rack

Gas Management Valve Rack Installed

Connected to Floor Trench Helium Piping

SNS Shown

Compressor Trench Piping

SNS Installation Shown

Hall D 12 GeV Requirements

- **Current:**

  No current JLab Installed Capability, new facility requirement, remote Hall D location

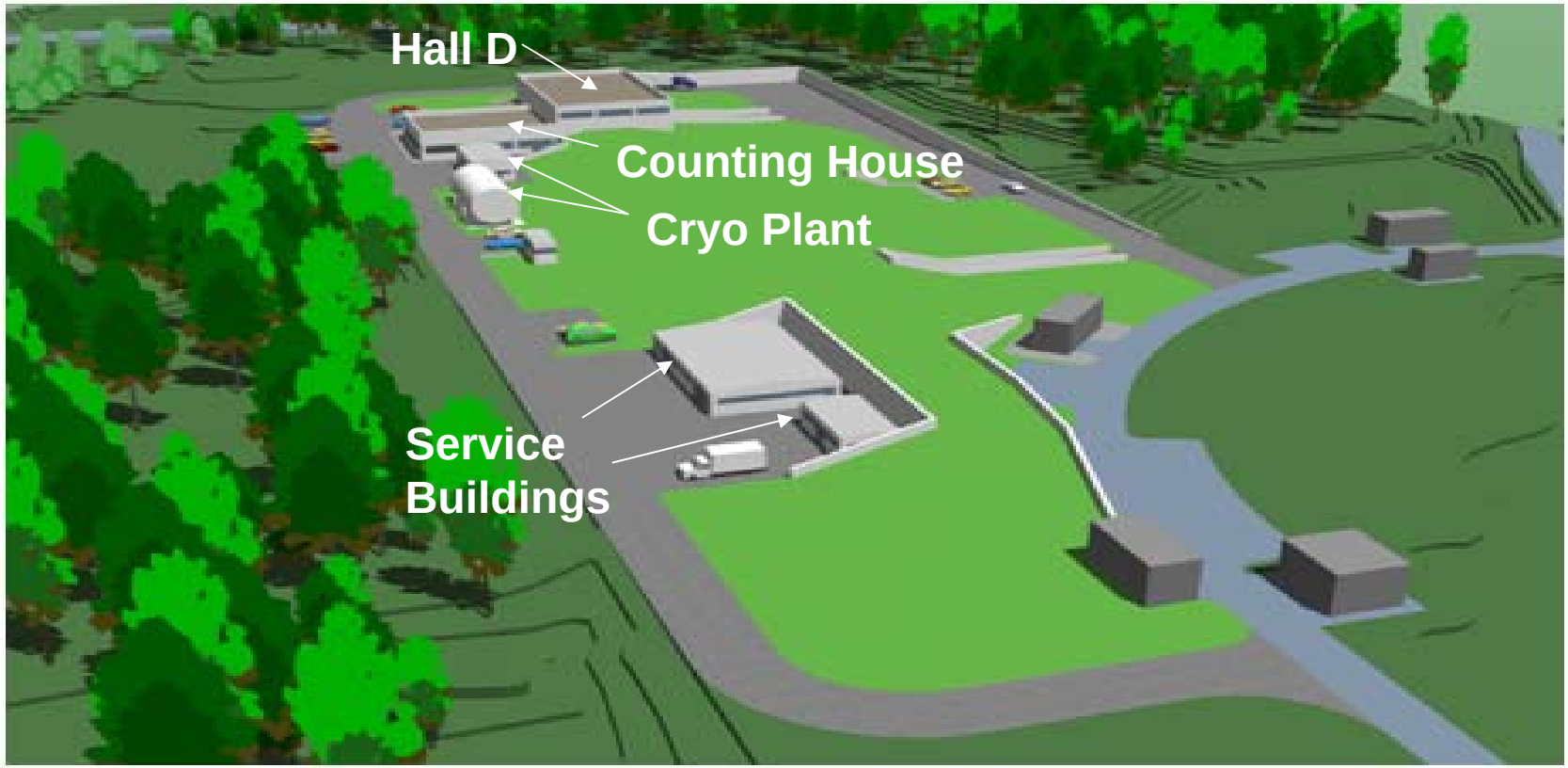
- **New:**

  Install on-hand stored industrial CTI Model 2800 Refrigerator and RS compressors, add new support systems of gas storage, controls, LN2 storage, Hall cryogen distribution system provided by Hall D.

  Load: 100W @4K, 0.7 g/s liquefaction (TL and Solenoid)

  Capacity: 200W @4K or 2 g/s liquefaction

Hall D Cryogenic Site Location



Install existing JLab M2800 Cryogenic Refrigerator and new support equipment

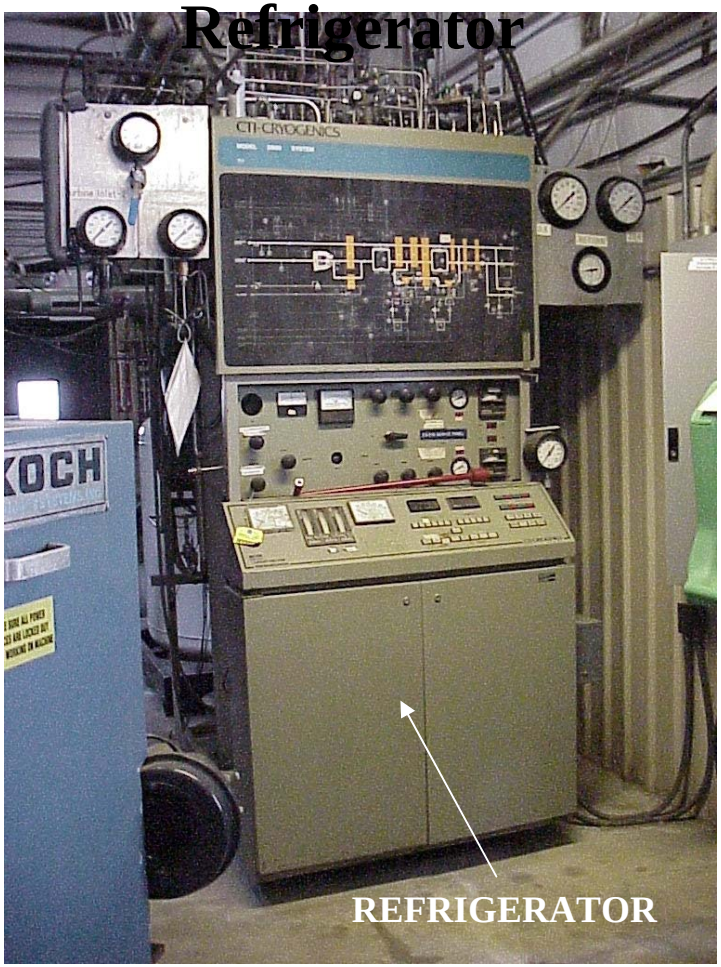
Hall D Cryogenic Equipment Requirements

(Equipment Identical to Current JLab CTF Refrigerator System)

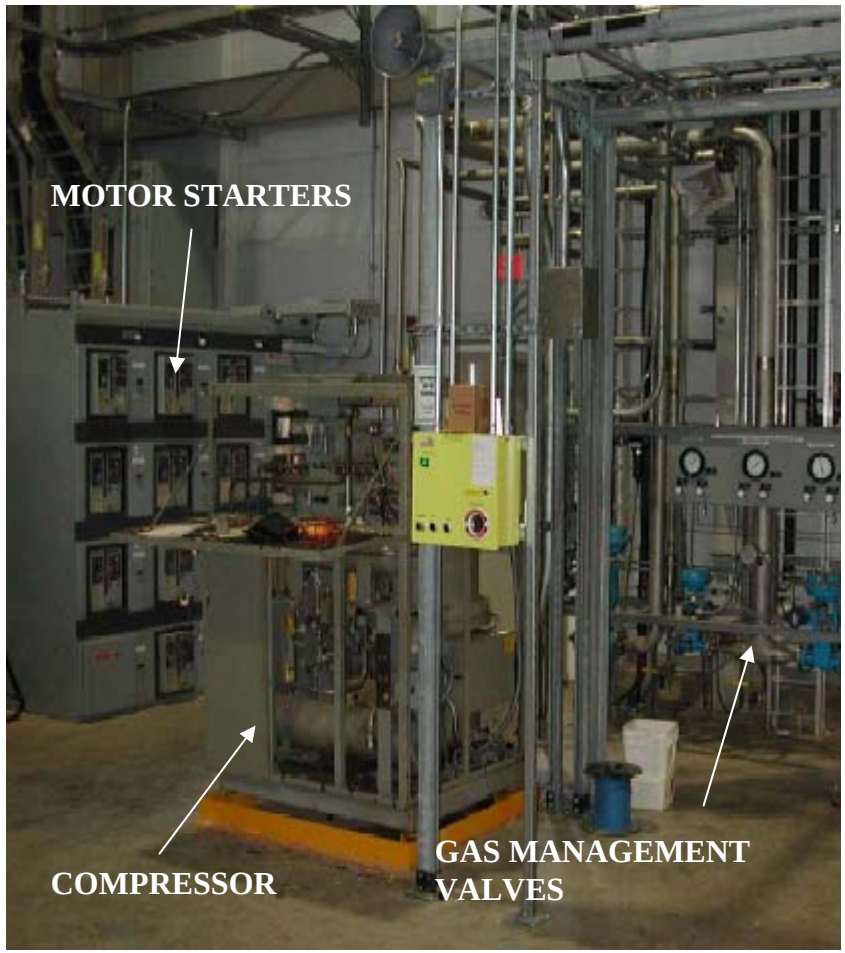
- **Two CTI Cryogenics Helium Compressors**
- **CTI M2800 200W 4K Helium Refrigerator**
- **Gas Management Valve Control Rack**
- **LN2 storage, 10,000 liter dewar**
- **One 4000 cf Helium Gas Storage Vessel**
- **Integrated Refrigerator Computer Controls**
- **Instrument Air System, 15 scfm**
- **Motor Control Centers, 480V**
- **Purification Loop Piping to the CHL via CEBAF North Linac**

Hall D Refrigeration Equipment

JLab CTF Model 2800 Refrigerator



He Compressor



Accelerator Engineering and Design Work Scope PED

—Integrated System Process Cycle Design

- Process State and Flow Diagrams, Failure Mode Analysis, Safety Integration
- System Process and Instrumentation Diagrams

—Major Equipment Technical Documentation for Purchasing*

- Performance parameter requirements
- Required Equipment Design features
- Design Standards to be used (Examples: NEMA, ASME, JLab, NFPA, etc.)
- Support Documentation to be provided…Examples: QC/QA plan, Welding Qualifications and test data, Failure Mode Analysis, Operating Procedures, Maintenance and Repair, Installation Requirements, Spare Parts Listing, Electrical and Mechanical Drawings, Past Work Experience and Personnel Qualifications, Infrastructure, etc.
- Installed Equipment Performance Test Plan
- Technical Performance Review Requirements, Fabrication Site Inspections
- Administrative Requirements, example: Technical Status Reports, Schedule Status vs. Plan, Documentation Submittals

*** Note: 4.5K Refrigerator and Compressors identified as "long lead"**

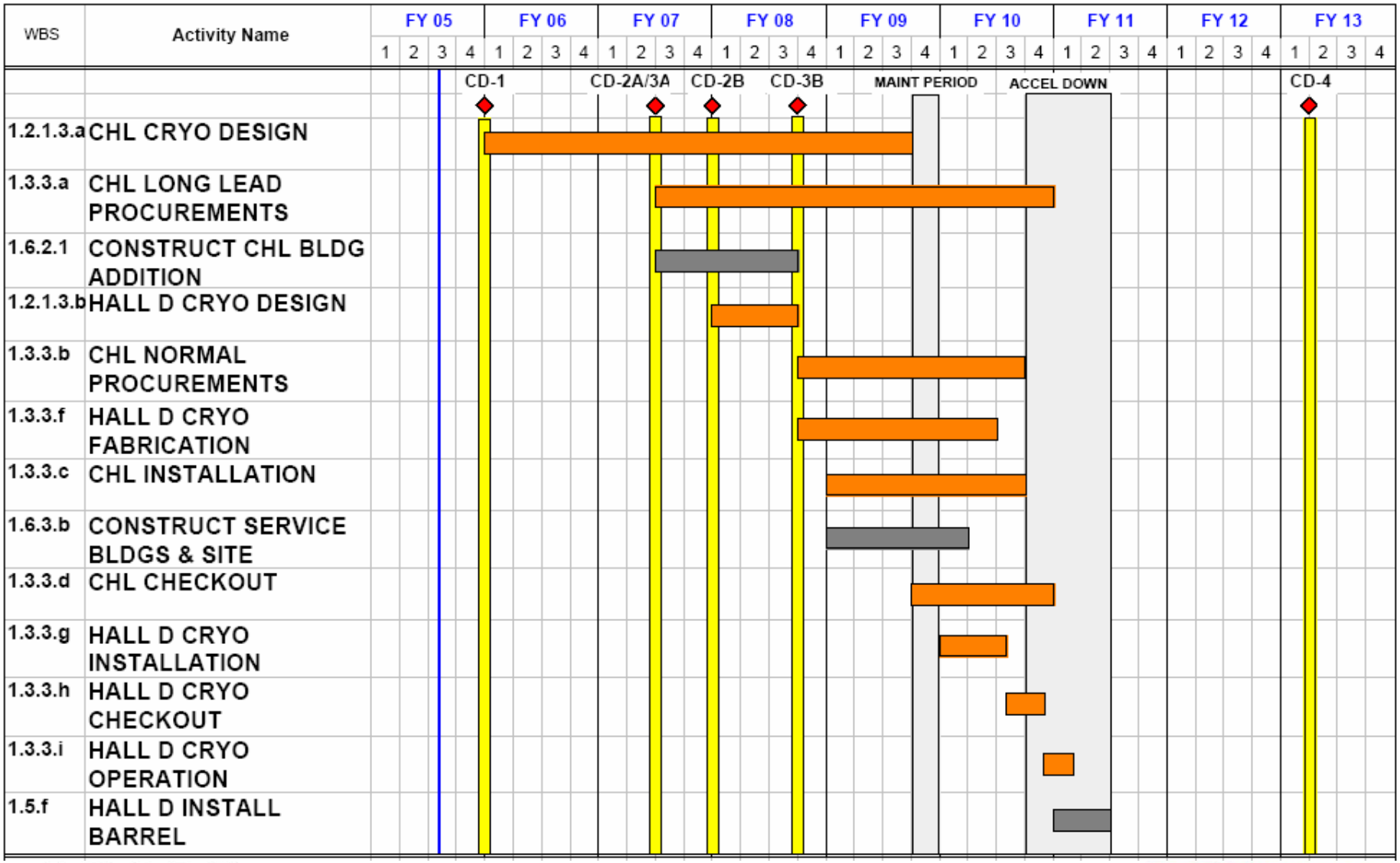
Accelerator Engineering and Design Work Scope PED

- **Vendor Technical Reviews**
- **Facilities Requirements (coordinated with JLab Civil construction)**
  - Building Requirements, Examples: Cranes, ventilation, lighting, equipment floor loading, electric power utility, cooling water utility, equipment layout,etc.
- **Integrated System Documentation**
  - Integrated System Block Diagrams, Process and Instrumentation Diagrams, Control Wiring Diagrams and Control Equipment Assemblies, Mechancial Fabrication and Assembly Drawings (Oil Removal, Gas Management Valve Rack, LN2/He Transfer Lines), Plant test Apparatus design
- **Field Installation and Construction Documentation Package**
  - Electrical Power, Controls, Mechanical Piping, material lists, rigging, QC/QA and installation/checkout/testing requirements
- **Integrated System Test Plans** (in order of commissioning)
  - Warm Helium Compressor System
  - 4.5K Refrigerator
  - Full System with 2K Cold Box and Transfer line
- **Administrative PED budget and schedule control, program review support**

Labor Overview

- **Engineering and Design During FY08/FY09**
  - **—Major Vendor Equipment Purchases**
  - **—Design of Installation and subsystems for compressors**
- **Concentration of Construction Labor During FY09/FY10**
  - **—Support System for compressors (tanks, oil removal, instrument air, etc.) installed FY09**
  - **—4.5K Cold Box and Compressors arrive early FY10 for installation completion**
- **Refrigerator System Commissioning (Late FY10) and Beam Commissioning Support (FY11)**

Cryogenics Schedule
(as of July 2005)



Cryogenic Schedule Profile

- **Major Items**
  - **—CHL 4.5K Cold Box:**
    - **40 month overall schedule, includes float**
      - 6 month bid/procurement
      - 27 month vendor design/fab (24 is standard)
      - 5 month installation (standard)
      - 2 month startup/testing (1 is standard)
  - **—CHL Compressor Skids:**
    - **31 month overall schedule, includes float**
      - 5 month bid/procurement
      - 19 month vendor design/fab (18 is standard)
      - 5 month installation (standard)
      - 2 month startup/testing (1 is standard)

Construction Schedule Profile

Other Major Efforts:

- **Compressor Piping, Oil Removal, etc. July 08 Start**
- **Compressor Building BOD: June 08**
- **Compressor 4160V and Cooling Water Utilities: Dec 09**

Summary

An overview of the planned cryogenic system upgrade work scope has been presented for both the Jlab Accelerator CHL and Hall D. The Jlab cryogenic staff is looking forward to contributing to the advancement of physics research with this exciting upgrade of the CEBAF research facility.

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