# Jlab's 12GeV Cryogenic System Design Experience to Date

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FNAL Project X Review
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# Outline

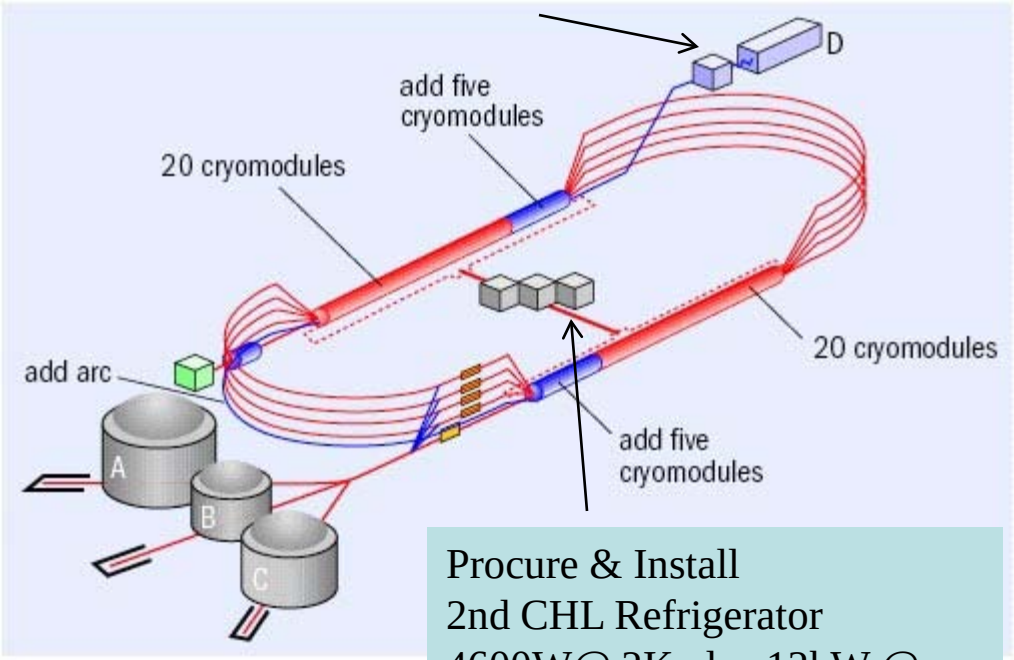
- 12GeV Cryogenics Upgrade Overview
- Project Documentation
- Fundamental Decisions
- Cost Estimate
- Schedule
- Status

* Summary

# Cryogenic System Overview

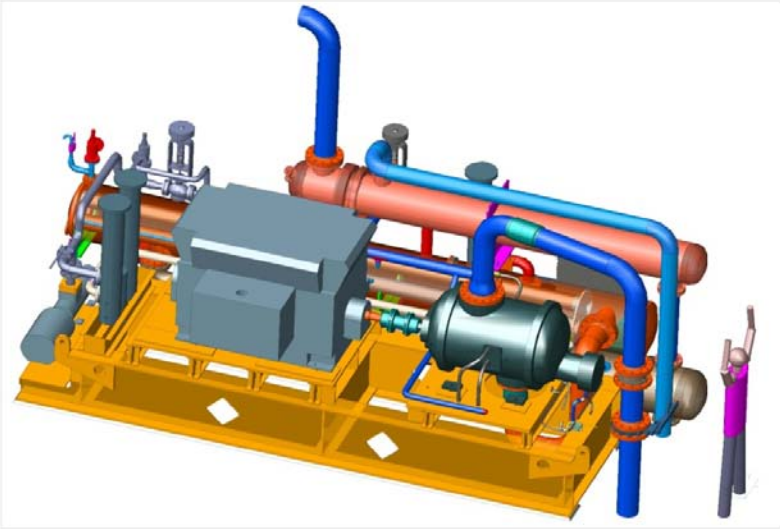
# Cryogenics System Overview

Install Hall D Refrigerator,
200W @ 4.5K

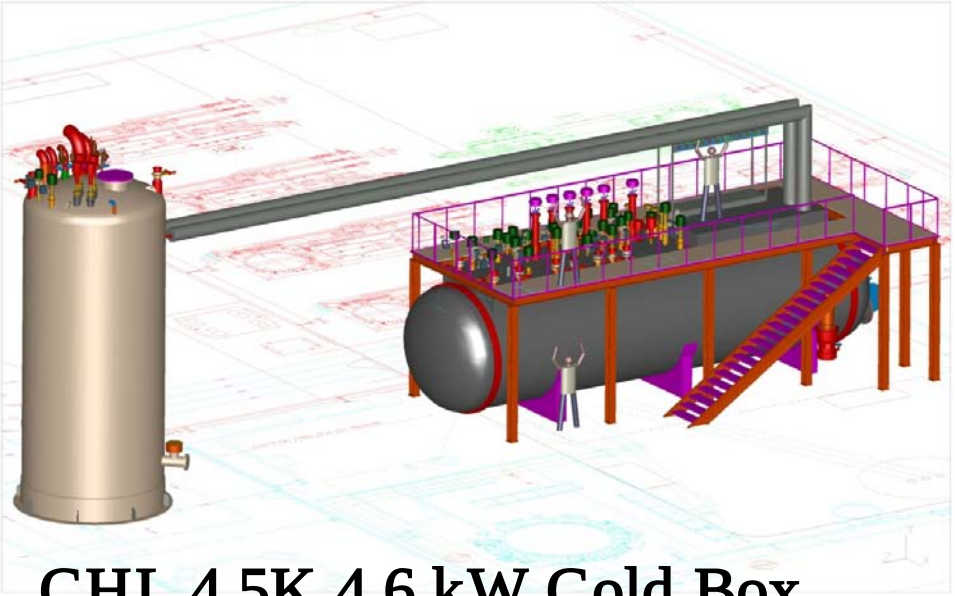



Procure & Install
2nd CHL Refrigerator
4600W@ 2K plus 12kW @
35K plus 25 g/s liquefaction

# Cryogenic Overview-CHL#2 Major Equipment



**NASA/JLab Collaboration**
**Helium Compressors**
Build to Print
3x effective oil removal, smaller vessels
Electric down from 5.5 to 4 MW lower capital cost, smaller #



**CHL 4.5K 4.6 kW Cold Box**
**Indoor and Outdoor Sections**
40% less LN2 use
No Pit, No Roof Hatch
Fits into existing building

# Cryogenic Introduction-Other CHL Components

Gas Management Rack

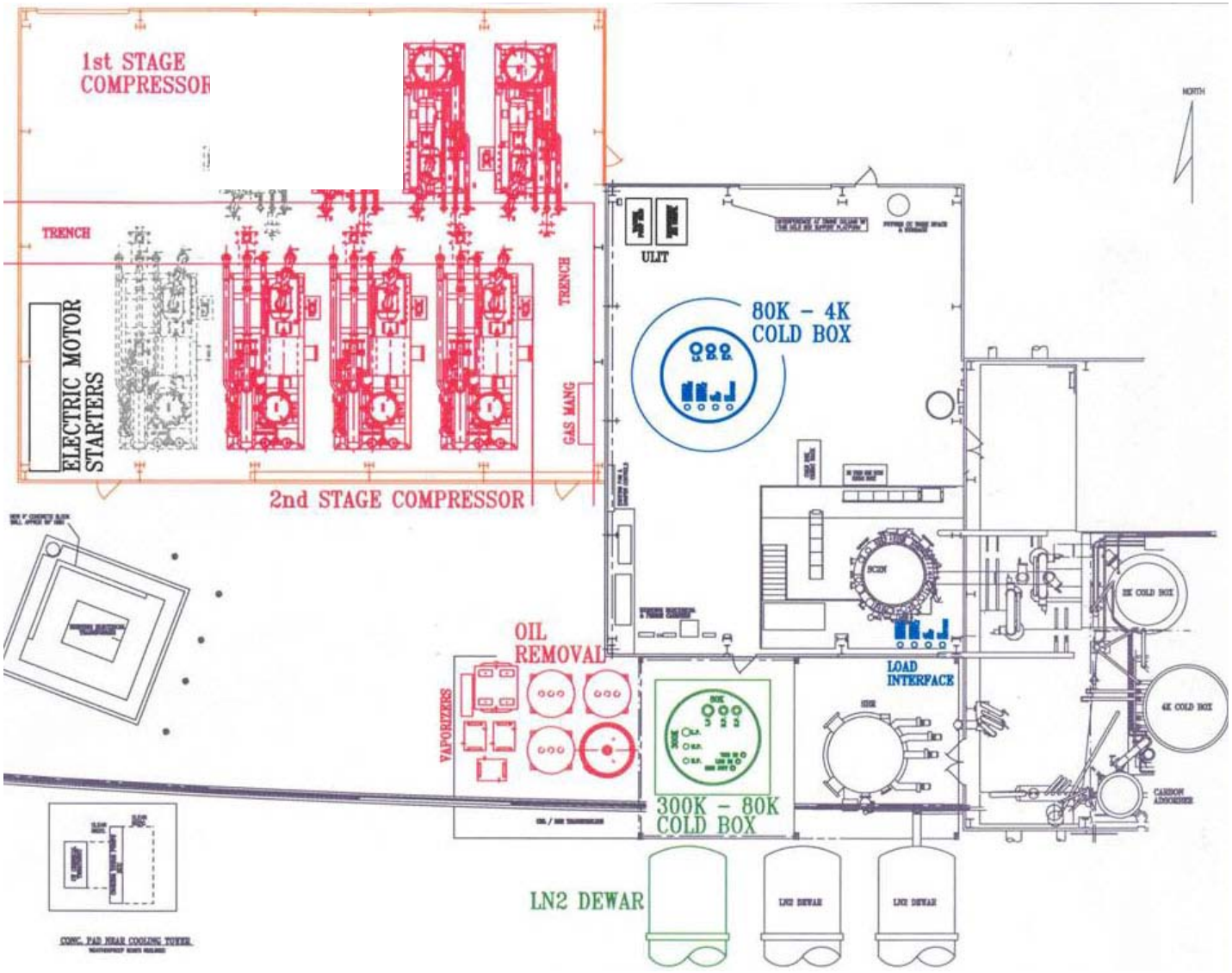
LHe Storage Dewar

4160V Motor Controllers

Oil Removal Vessels

Gas Storage Vessels (1)

# CHL Equipment Layout

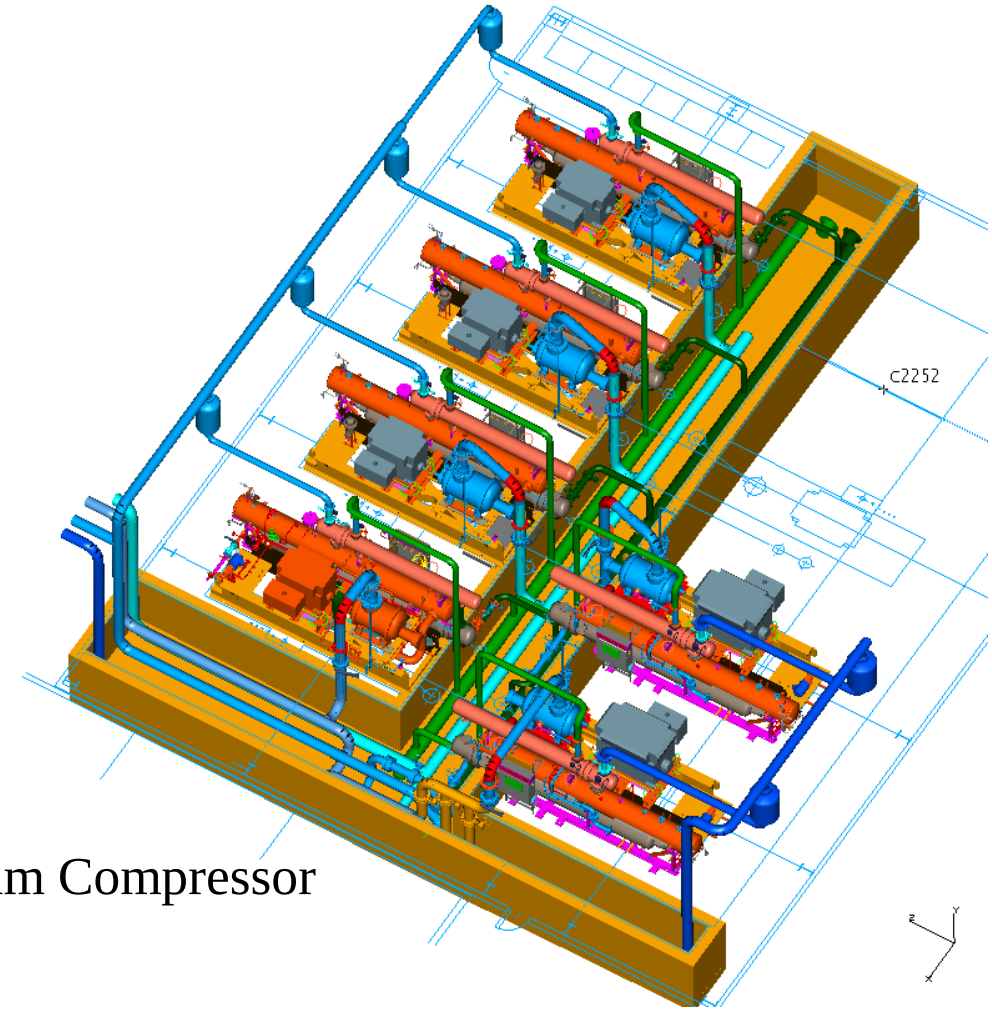


# CHL Compressor Building

Building Steel Being Erected
Aug 2009

Compressor Electrical
Conduits in Floor Slab
July 2009

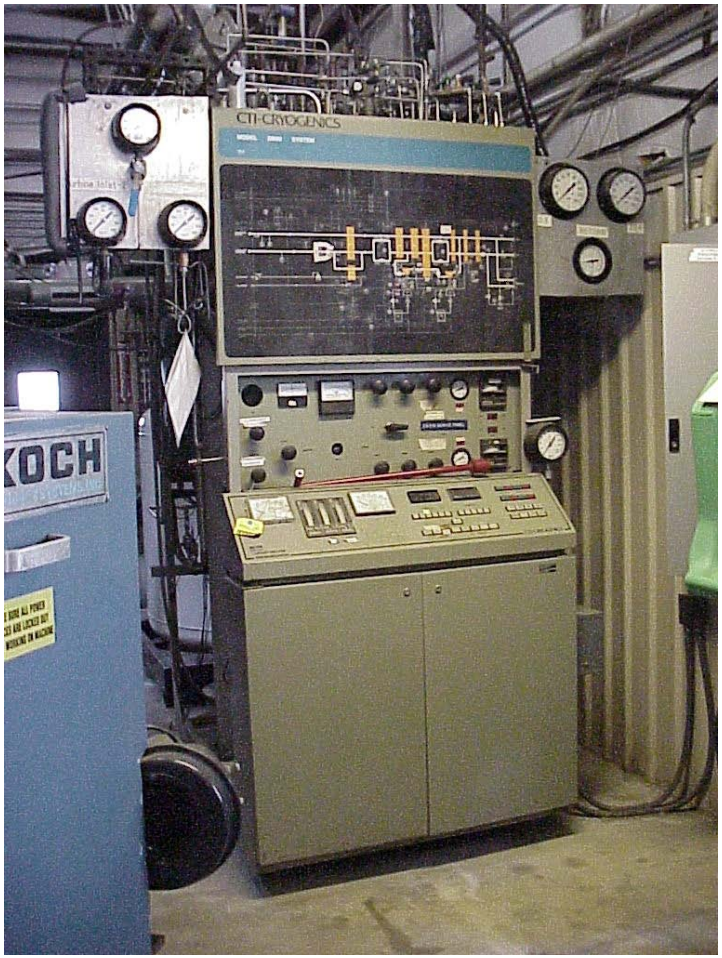
# CHL Installation Piping Design




Warm Helium Compressor Piping

# Hall D Major Refrigeration Equipment

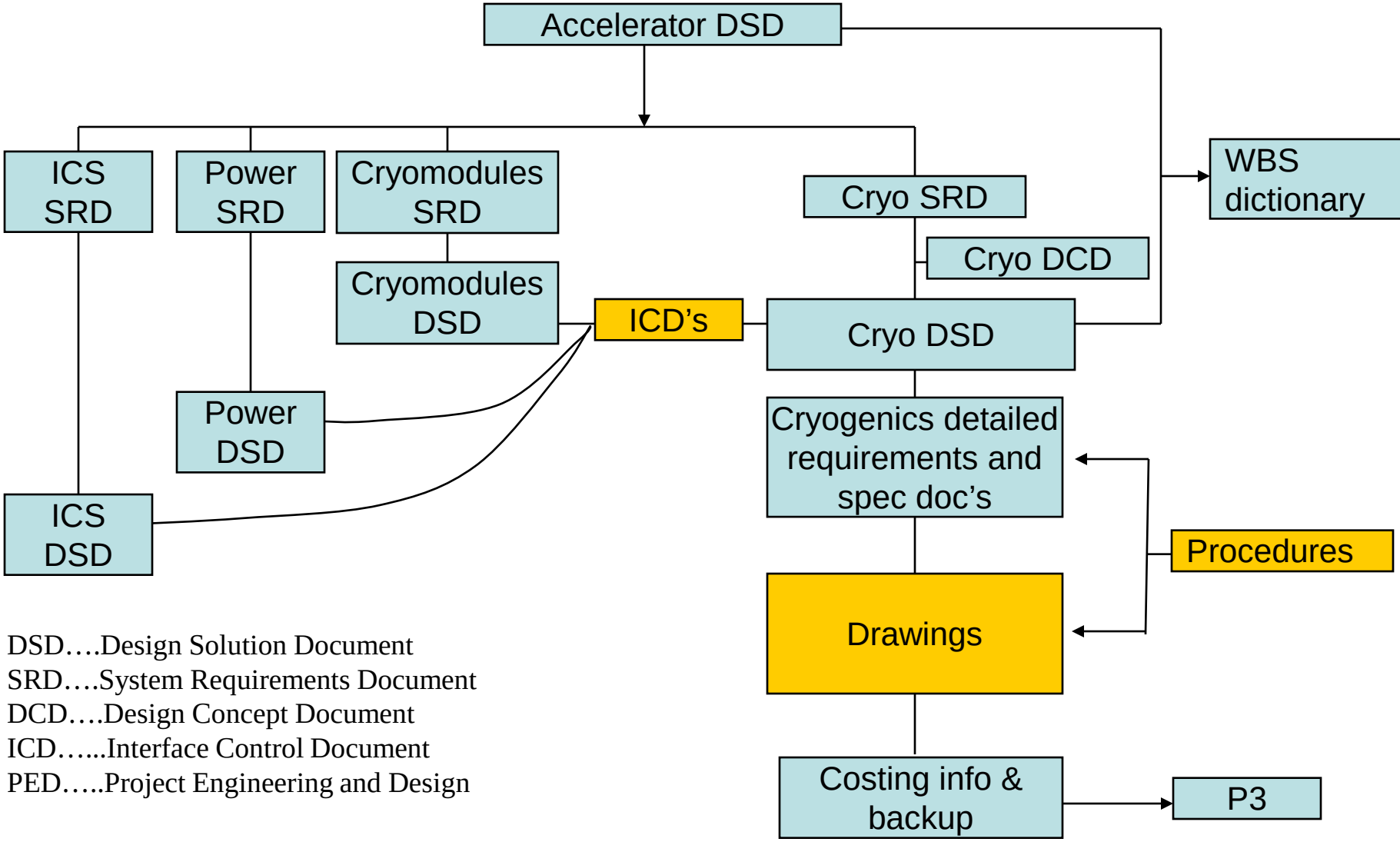
JLab Model 2800 Refrigerator




JLab Helium Compressor

# Documentation

# Project Documentation




DSD….Design Solution Document
SRD….System Requirements Document
DCD….Design Concept Document
ICD…...Interface Control Document
PED…..Project Engineering and Design

# Documentation Sequence

Process Cycle Study (CD-0)
Engineering/Safety Standards
System Block Diagram
Rough Budgetary Estimate
Civil Requirements
Subsystem P&IDs (CD-1)
Equipment Lists
Integrated System Safety Review
Preliminary PED Review
Detailed PED Documentation
Refined Estimates/EIR Review (CD-1/2)
Final PED/Safety Review, CD-2
Construction Phase, CD-3

# FUNDAMENTAL DECISIONS

# Fundamental Decisions

- **WHAT PROCESS CYCLE ? COUPLE OF CHOICES…..**
  1. **STANDARD CYCLE DESIGN**… Based on single or multiple fixed operating process conditions…..usually fixed T-S diagram for operational control parameters for loads anticipated or estimated
     - VERY UNLIKELY TO BE THE ACTUAL BEST PROCESS CYCLE
       - Normal component performance tolerance variations shift the process conditions at which the refrigerator should be operated
       - Actual refrigerated loads end up not as estimated
       - Loads have the tendency of changing with time
       - Old saying…no two machines are alike

Have to establish new operating parameters/controls after refrigerator components were designed and built for different conditions, May have limited flexibility

# Fundamental Decisions

- **WHAT PROCESS CYCLE? COUPLE OF CHOICES…(cont)**
  2. Process cycle which provides constant high efficiency and stability over a full domain of continuous possible operating points where the operating conditions are automatically determined by the system as the load varies.
     - Demonstrated at the Johnson Space Center (JSC) via Jlab/NASA collaboration
     - JSC has new 20K refrigeration system on order to this cycle concept, which industry has confirmed these characteristics
     - Operating modes were outlined within specifications which defined the boundary of the operating domain region.

**JLab adopted choice #2 for 12GeV**

# Fundamental Decisions

- **WHO DOES THE INTEGRATED SYSTEM DESIGN?**
  - **Choices increase in-house or vendor "turn key"**
    - JLab has large number of existing infrastructure to which the new system was to be integrated
      - Transfer line, helium storage, gas purification, controls, building space, etc.
      - The existing infrastructure is to continue to support experimental operations for most of the project

**JLab decided to perform the integration design in lieu of vendor "turn key"**

# Cost Estimate

# Early Input to Other Departments

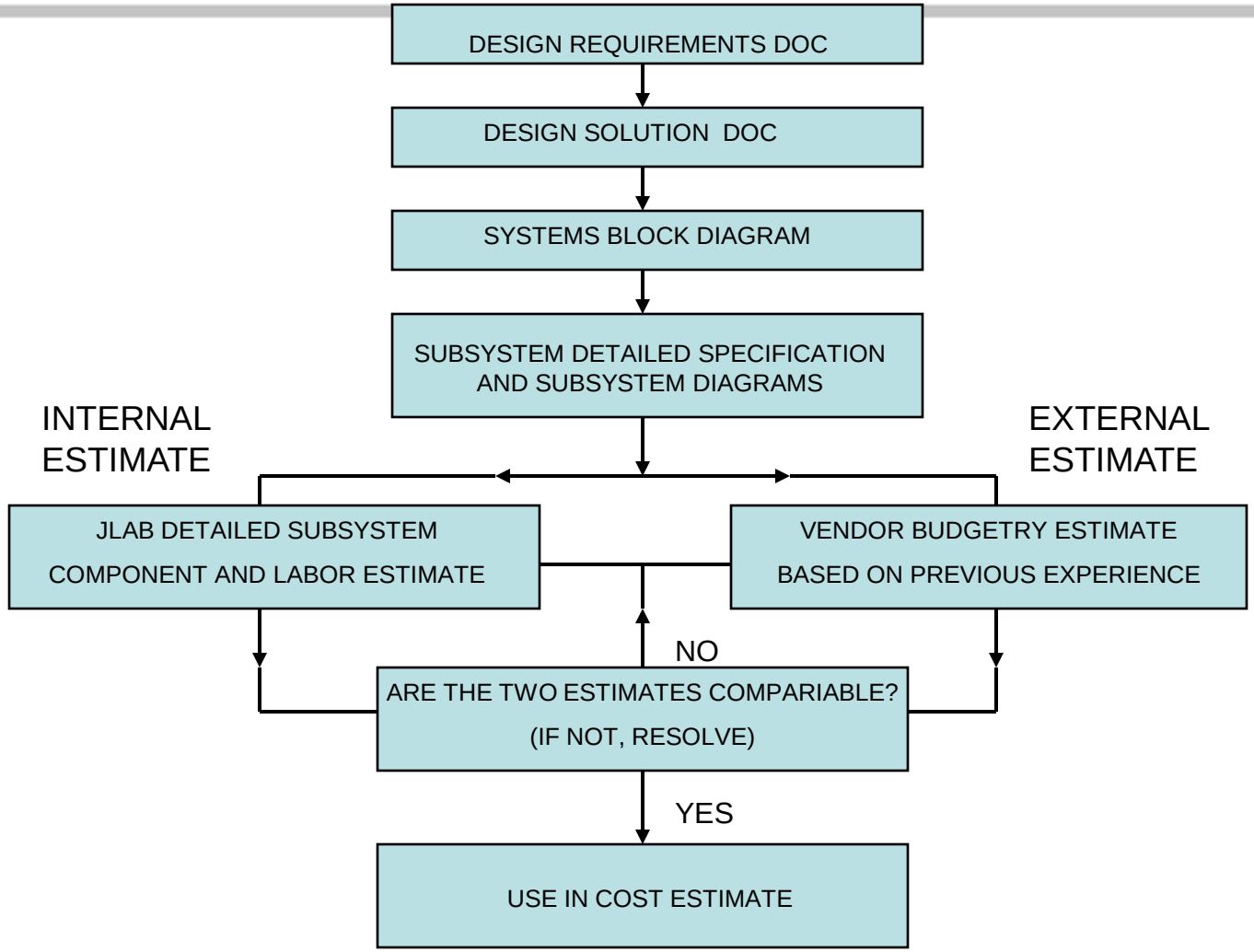
- **Example…Civil (ICD)**
  - Space requirements
  - Equipment Layout
  - Electric and Cooling Water
  - Floor Loading
  - Equipment Installation Plan
  - Ventilation and Heating
  - Crane Requirements
  - Lighting
  - Pipe Trench/Slab Conduits

# Cryogenics Cost Methodology

Basis of Estimate (BOE):

| | |
|---|---|
| • Costed | 0% |
| • Obligated | 0% |
| • Quotes from vendors | 0% |
| • Catalog price | 0% |
| • Estimates from vendors/ consultants | 74% |
| • Previous JLab experience | 26% |
| • Information from other labs, Universities, etc. | 0% |
| • Engineering judgment | 0% |

# Cost Estimate Flow Diagram




CD-0 through CD-2

# Cost Estimate Experience

- **Cost instabilities**
  - Metals Market…..Stainless and Carbon Steel (2x)
  - Foreign Exchange Rates (1.4x)
  - Oil Prices (1.1x)
    - Share same fabrication facility as gas and oil industry
    - Cryogenic fabrication must compete with shop profit margins of gas and oil equipment when fuel prices rise and the demand for refining equipment rises
  - ARRA impact…unknown as yet

# Scheduling Experience

- SEQUENCE…
  - Process Cycle Determination
  - Process cycle sets the requirements of the cold box design.. Cold box delivery is ~24 months, cold box heat exchangers and turbines must be ordered with a few months of cold box award, heat exchanger designs must be checked carefully before they are ordered, first 12 months is generally engineering duration followed by fabrication. Preliminary and final engineering design reviews necessary before fabrication is authorized

# Scheduling (cont)

- **Cold Box design sets requirements of warm helium compressor design**….compressor delivery is 18 months, ordered no later than 4-6 months after cold box…generally like 2-3 months of test time slot before testing cold box which allows fault correction time
- **Civil construction runs in parallel (or before) compressor order**. Utilities (electric/water) and building construction BOD must be ready for compressor testing. One may not have the full equipment vendor engineering details complete at the time needed for the civil design activity
- **Gas management, controls, oil removal, etc. run in parallel with compressor ordering time**.

# STATUS

# Status Overview

- 95% Oveall Engineering/Design Complete
- 65% Complete Installation Design Package
  - Final Vendor Input Needed
- 73% of equipment and materials released for procurement

# Experience Summary

Topics Discussed

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