

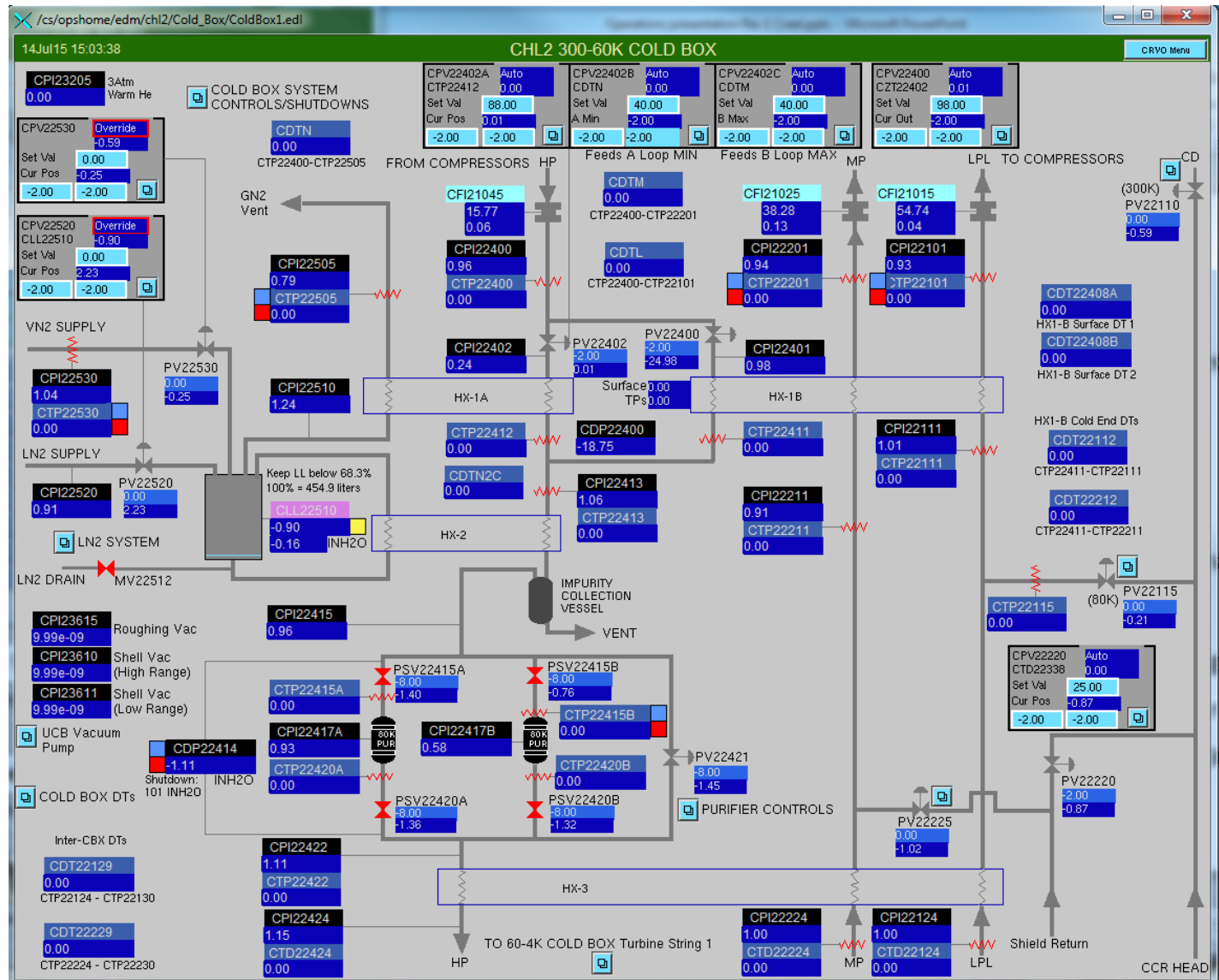
2015 Operations Stay Treat

- CHL2 4K Cold Box Modifications
- SC1 2K Cold Box CC4 Failure
- Helium and LN2 Losses
- Contamination

CHL2 4K Cold Box Modifications

- New 4K cold box designed and built for 12GeV
 - Designed for reduced utility consumption compared to CHL1
 - 3-4.5MW for CHL2 verses 5-6.5MW for CHL1
 - 60 gal/hour CHL2 verses 200 gal/hr for CHL1
 - Testing indicated power usage was on estimates
 - Testing indicated 200 gal/hour or 70% more LN2 than design
 - Linde proposed repair
 - Disconnect and abandon large internal heat exchanger
 - Add new external cold box with new heat exchanger
 - Hope to recover to original design goal 60 gal/hr (\$300K/yr)

CHL2 4K Cold Box Modifications

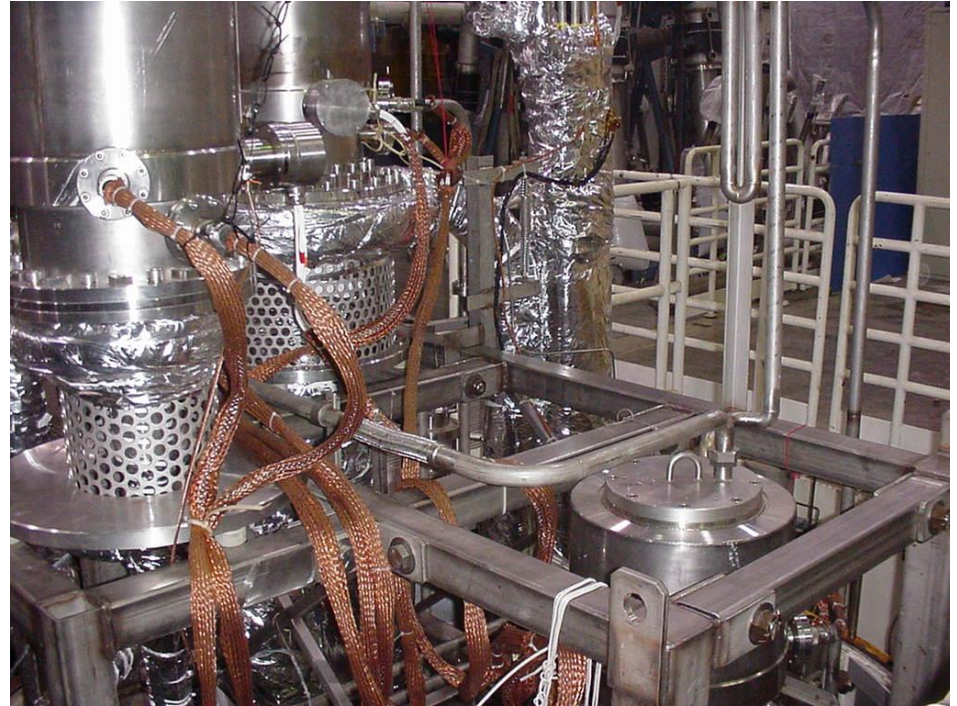


CHL2 Nitrogen Heat Exchanger

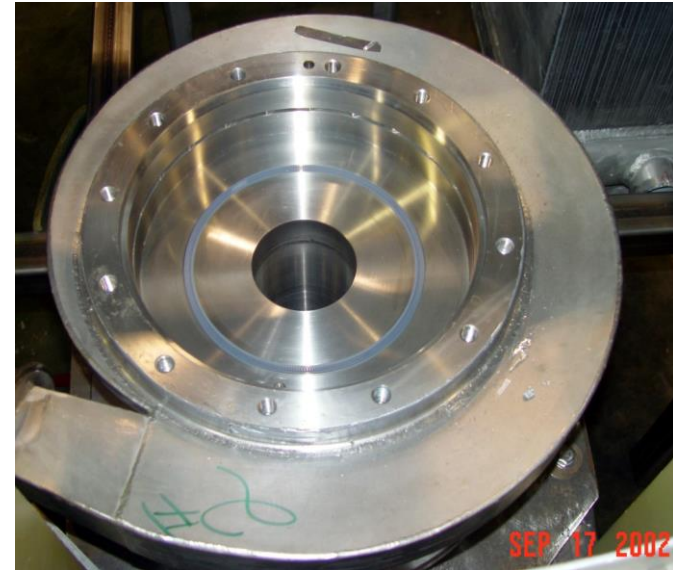


- Plan forward
 - Pressure tests
 - Leak checks
 - I&C
 - Clean up
 - Cooldown
 - Testing

SC1 2 Kelvin Cold Box Repair



Typical Cold Compressor



Cold Compressor Bearing Controls

- Cold compressors
 - Multi-axis magnetic bearing
 - Each cold compressor has a magnetic bearing control cabinet
 - Each cabinet has UPS for protection during power outages
 - Electronics monitors speed to determine when required
 - UPS holds bearings until speed ramps down then turns off
 - UPS has a test button which is used when system is prepared for operation at the end of an extended down



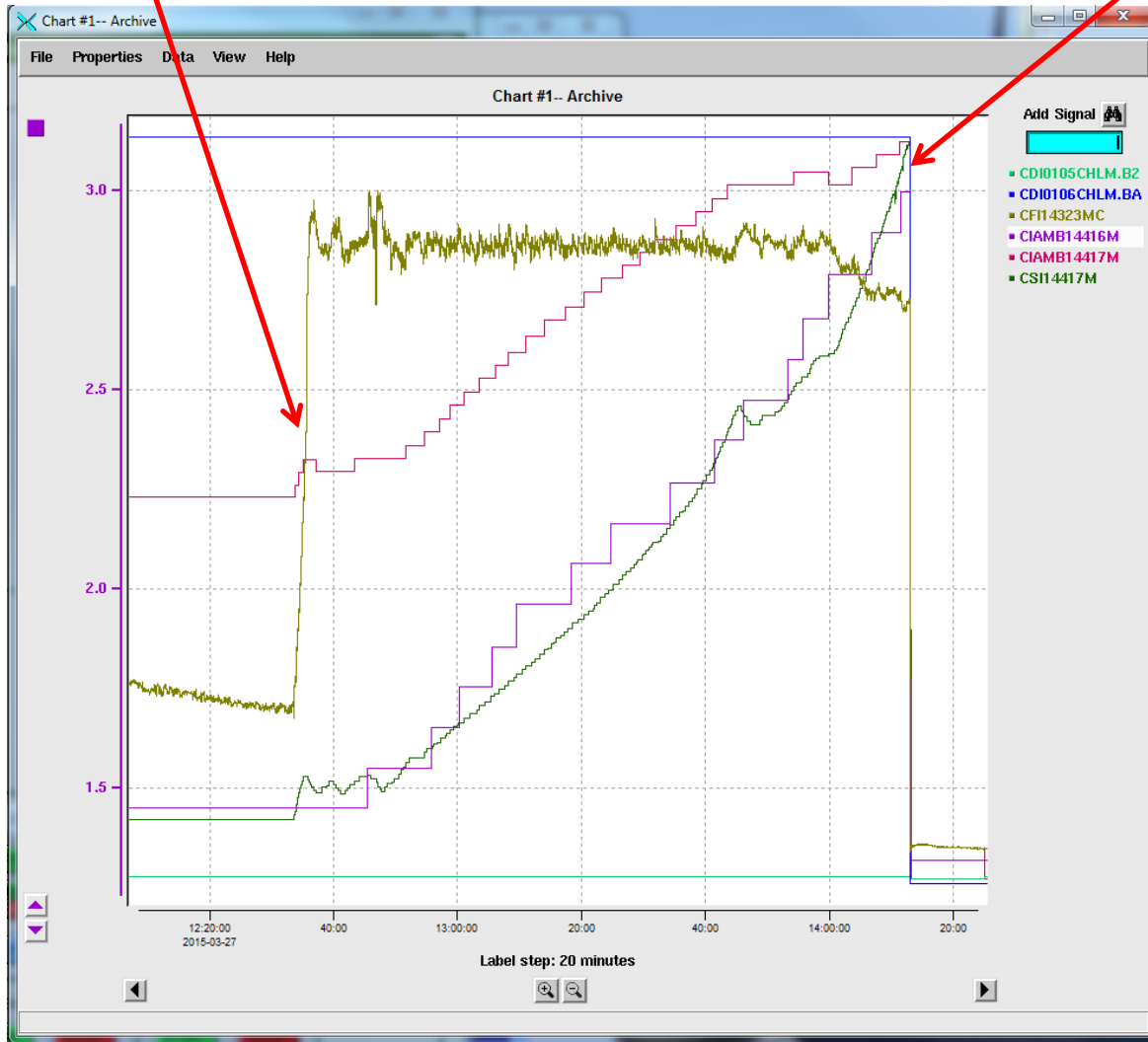
Power Outage

- Site wide power outage
 - CHL1, CHL2, ESR, and Hall D plants shutdown
 - Systems were secured and prepared for restart
 - SC2 brought online first
 - SC1 pumpdown started two days later
 - Magnetic bearing cabinet reported normal conditions
 - Two hours into pumpdown the compressor failed

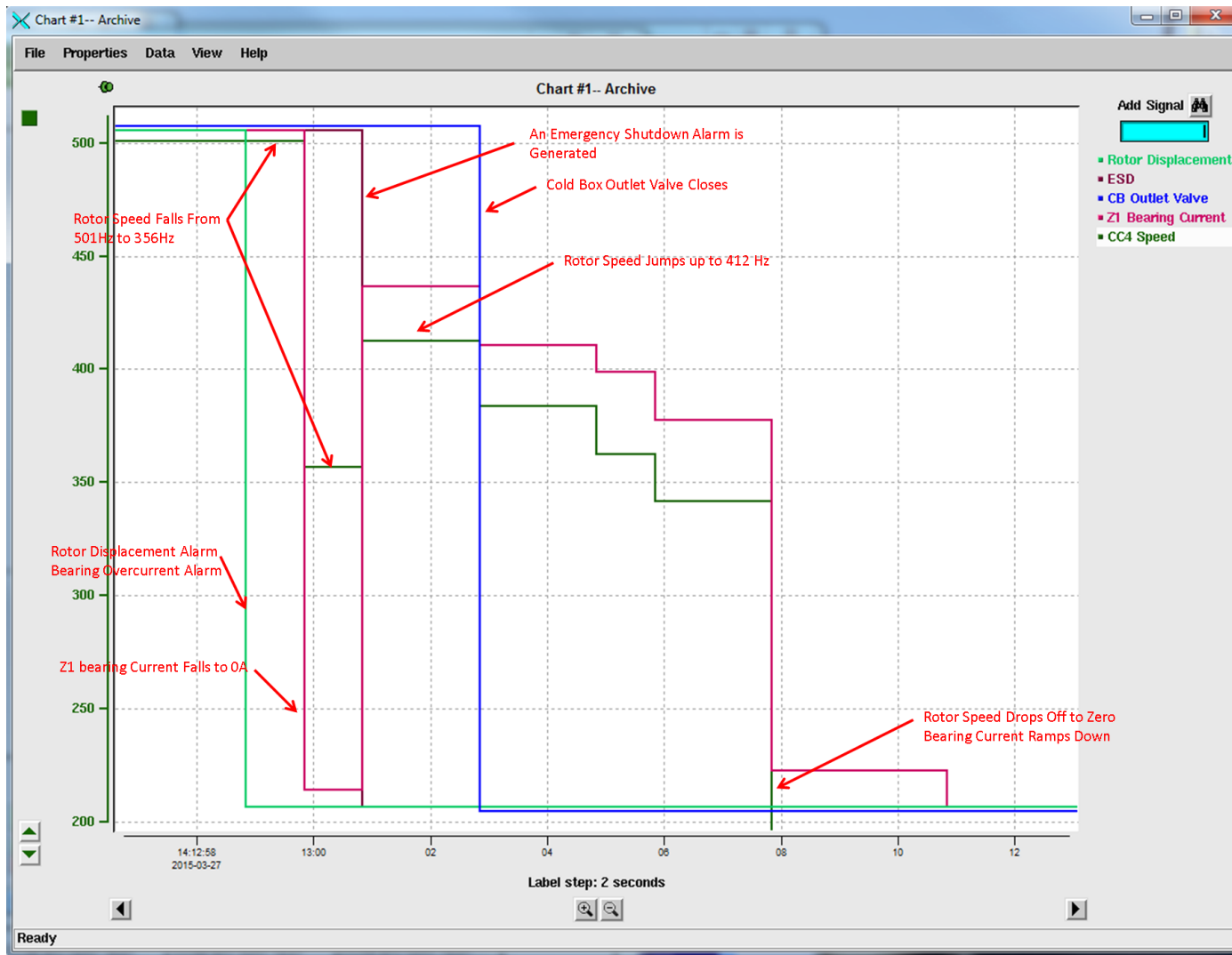
SC1 CC4 Failure

Start of pumpdown

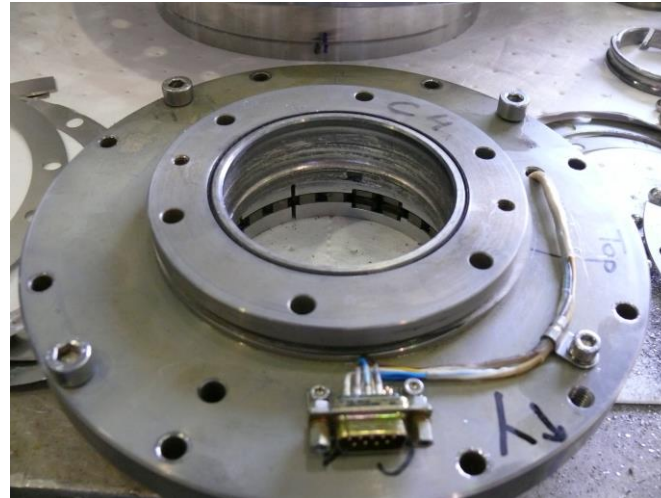
Mag Bearing Trip



SC1 CC4 Failure



SC1 CC4 Findings



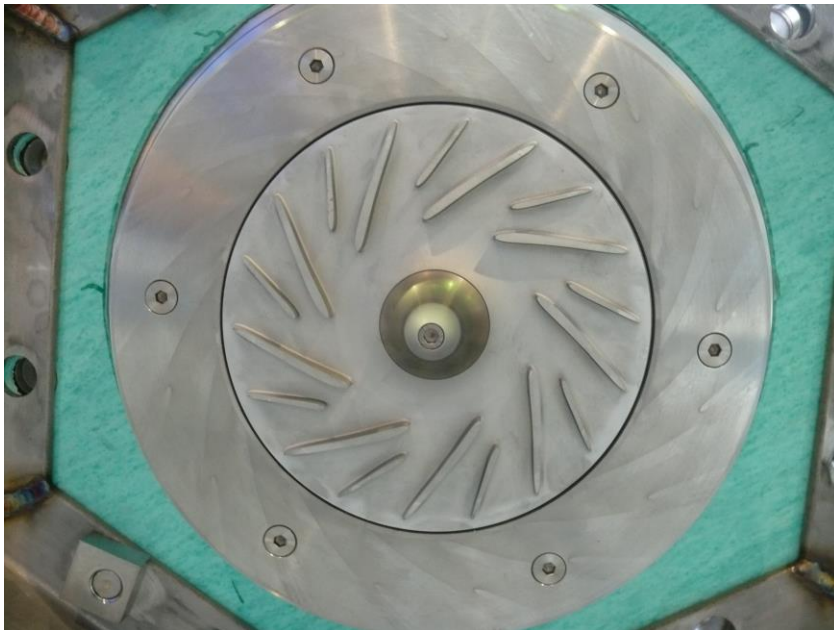
- Backup ball bearing failure
 - When rotor fell bearing 0 to 35,000 RPM instantly
 - Inner and outer races shattered
 - Balls damaged
 - Shaft scored
 - Position sensors damaged
 - Air Liquid and S2M working on estimates
 - CC4 repair
 - Balancing spare wheels
 - List of recommended future spare parts

Post UPS Failure Investigation

- Investigation
 - UPS test function
 - Applies a high wattage resistor across batteries and measures voltage drop over time
 - Does not test actual detection and switching functionality
 - New UPS test designed by JLAB
 - With compressor at zero speed
 - Simulate speed input with function generator
 - Turn off circuit breaker
 - Time 5 minutes
 - Turn down speed until UPS turns off
 - Perform at start of operation and after any power outages

SC1 Repair Using SNS Compressor

- Moved our wheel and backplate to the SNS compressor
- JLAB modified SNS compressor
 - LN2 supply and LN2 return connections
 - Magnetic bearing power and controls feedthroughs (x4)



SC1 CC4 Plan Forward

- Estimate about 1 months of work remaining
 - Pull a vacuum on process piping
 - Check bearing controls
 - Test run compressor (balance and bearing control)
 - Visit from AL/S2M to certify bearings ready
 - Install vacuum shell and establish vacuum
 - Clean up system
 - Utubes and cooldown
 - Test by pumping down

Helium Losses

- Three major losses found and repaired
 - CHL1 C6 (~110 liquid liters per day)
 - ESR utility piping (outside) (~110 liquid liters per day)
 - CHL1 bearing gas (basement of CHL1) (~110 liquid liters per day)

Contamination

- Following the power outage we had two episodes of contamination problems
 - SC1 CC2 froze in place
 - SC2 primary heat exchanger plugged
- Likely causes
 - Large number of utube operations performed during down
 - Subatmospheric relief valves leaking

