

# MicroBooNE Experience: Operations of the cryogenic system for the Fermilab MicroBooNE Liquid Argon Neutrino detector

M. Zuckerbrot, M. Geynisman, J. Kilmer, B. Norris, R. Sanders, M. Sarychev, F. Schwartz, J. Tillman

Workshop on Cryogenic Operations  
Fermilab, 25-27 October 2016

# Presentation Outline

- Cryogenic Requirements
- System Overview
- Stages of Commissioning
  - Piston Purge
  - Gas Recirculation
  - Cooldown
  - Filling
  - Initial Liquid Purification
- Operations
  - Overview and Notes
- Summary

# Cryogenic Requirements

Parameter	Value	Motivation
Argon purity	<100 ppt O <sub>2</sub>	MIP identification at longest drift
Argon purity	<2 ppm N <sub>2</sub>	Scintillation light output
LAr Temperature gradient	<0.1 K	Drift-velocity uniformity
LAr recirculation rate	1 volume change/day	Maintain purity
Cryostat heat load	<15 W/m <sup>2</sup>	Minimize convection currents and bubbles
Cryogenic capacity	10 kW	Capacity to deal with expected heat load
Cryostat maximum pressure	2.1 bar	Determines relief sizing

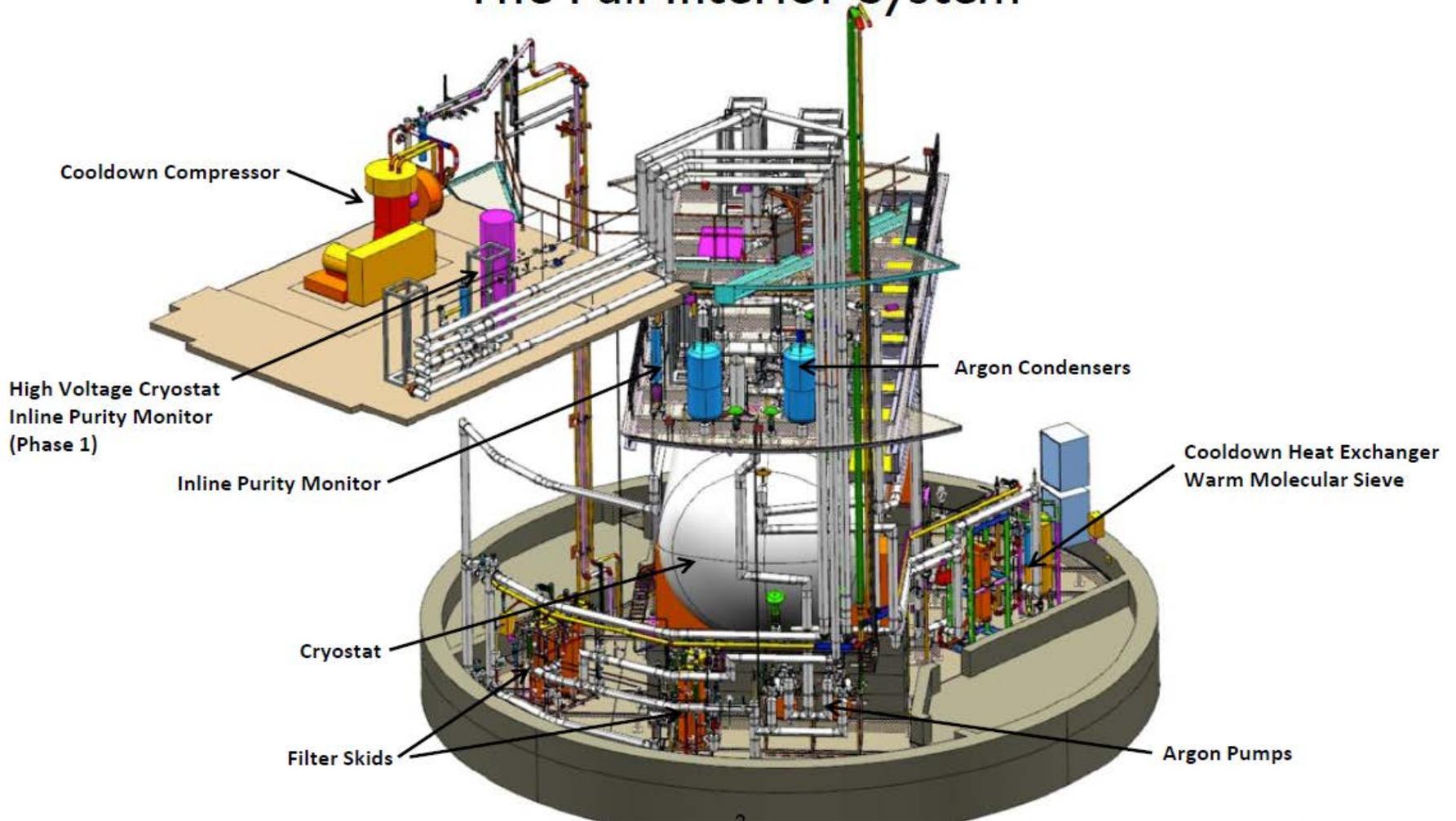
- Additional Requirements:
  - Reach purity requirements without cryostat evacuation
  - < 20 K dT on the TPC during cooldown
  - Level and pressure stability
  - Sampling for contaminants
  - Electrical isolation of cryogenic components from cryostat

# System Overview

- Recirculation/Cooldown System
  - Fluitron gas compressor, 3 pass heat exchanger, Mole. Sieve
- Purification System
  - Cryostat: ASME cylindrical pressure vessel (30 psig)
  - LAr pumps: Barber Nichols
  - Condensers: 10 kW capacity
  - Filtration Skids: Copper (O<sub>2</sub>) and molecular sieve (H<sub>2</sub>O)
    - Can be activated and regenerated in place using hot Ar and Ar/H<sub>2</sub> mix
  - 11,000 gallon liquid Nitrogen dewar: Coolant
  - 500 Gallon LAr Dewar: Supplies makeup gas, actuators, purges, etc...
  - Gas analyzers: O<sub>2</sub>, N<sub>2</sub>, and H<sub>2</sub>O
    - Multiple sample points: LAr pump discharge, post-filters, cryostat ullage/chimneys, 500 gallon dewar, etc...

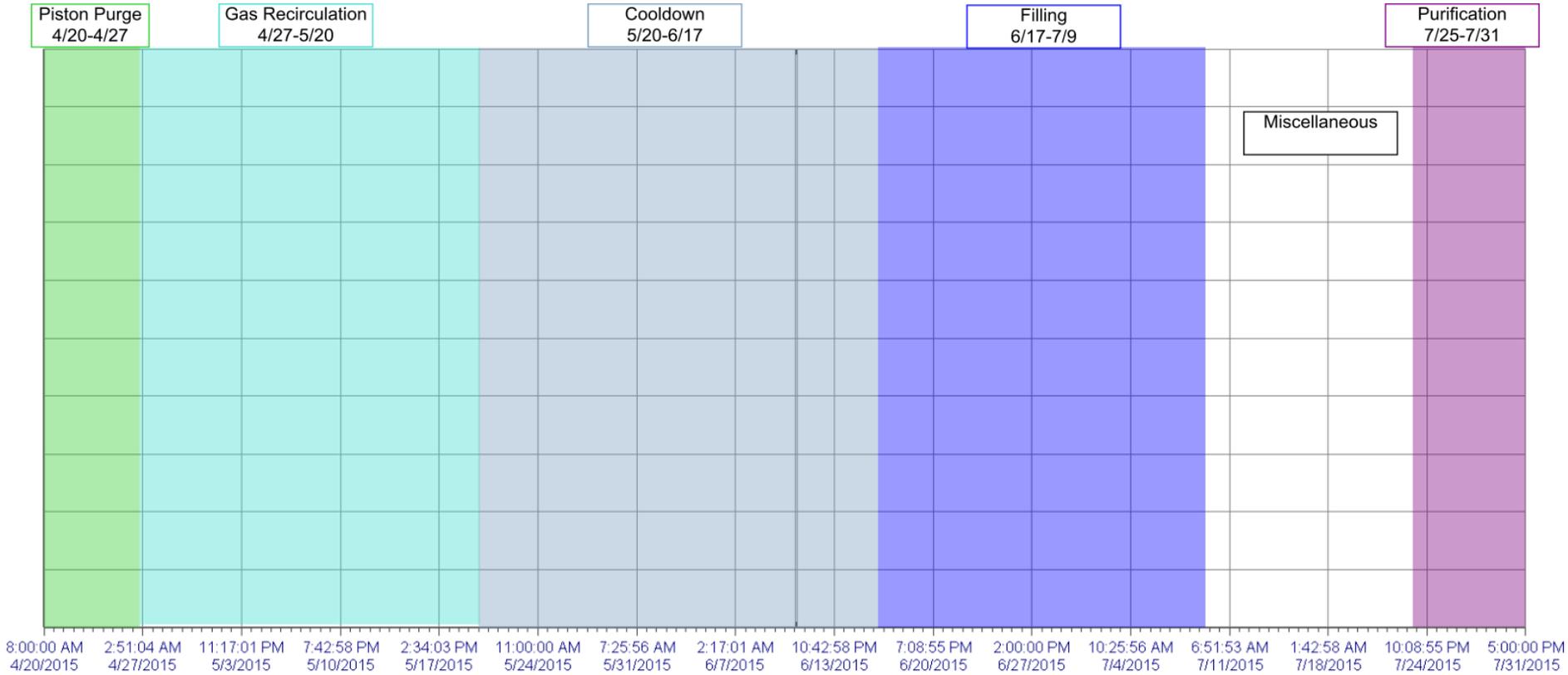
# System Overview

## The Full Interior System



# Stages of Commissioning

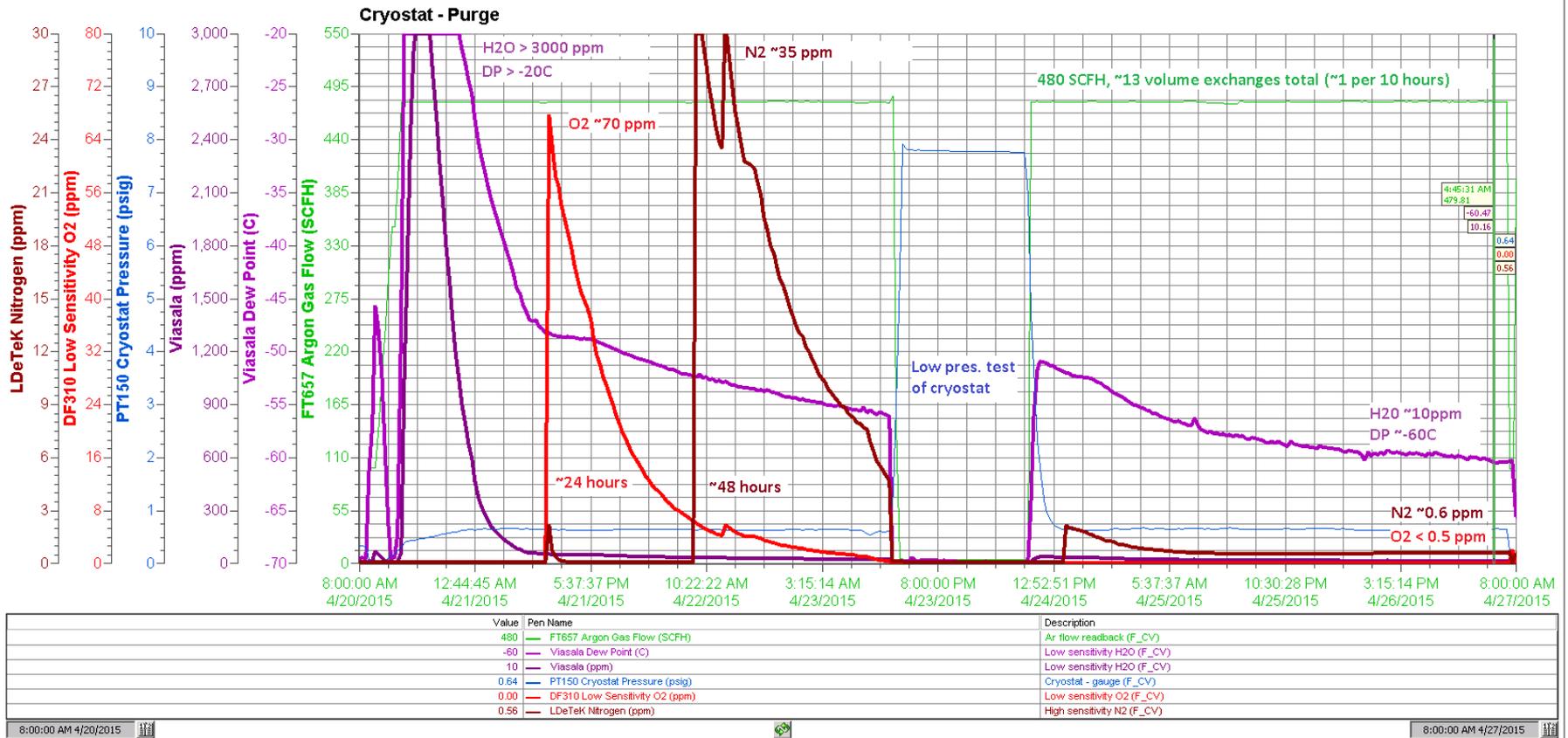
- Commissioning Timeline



# Stages of Commissioning

- Piston Purge

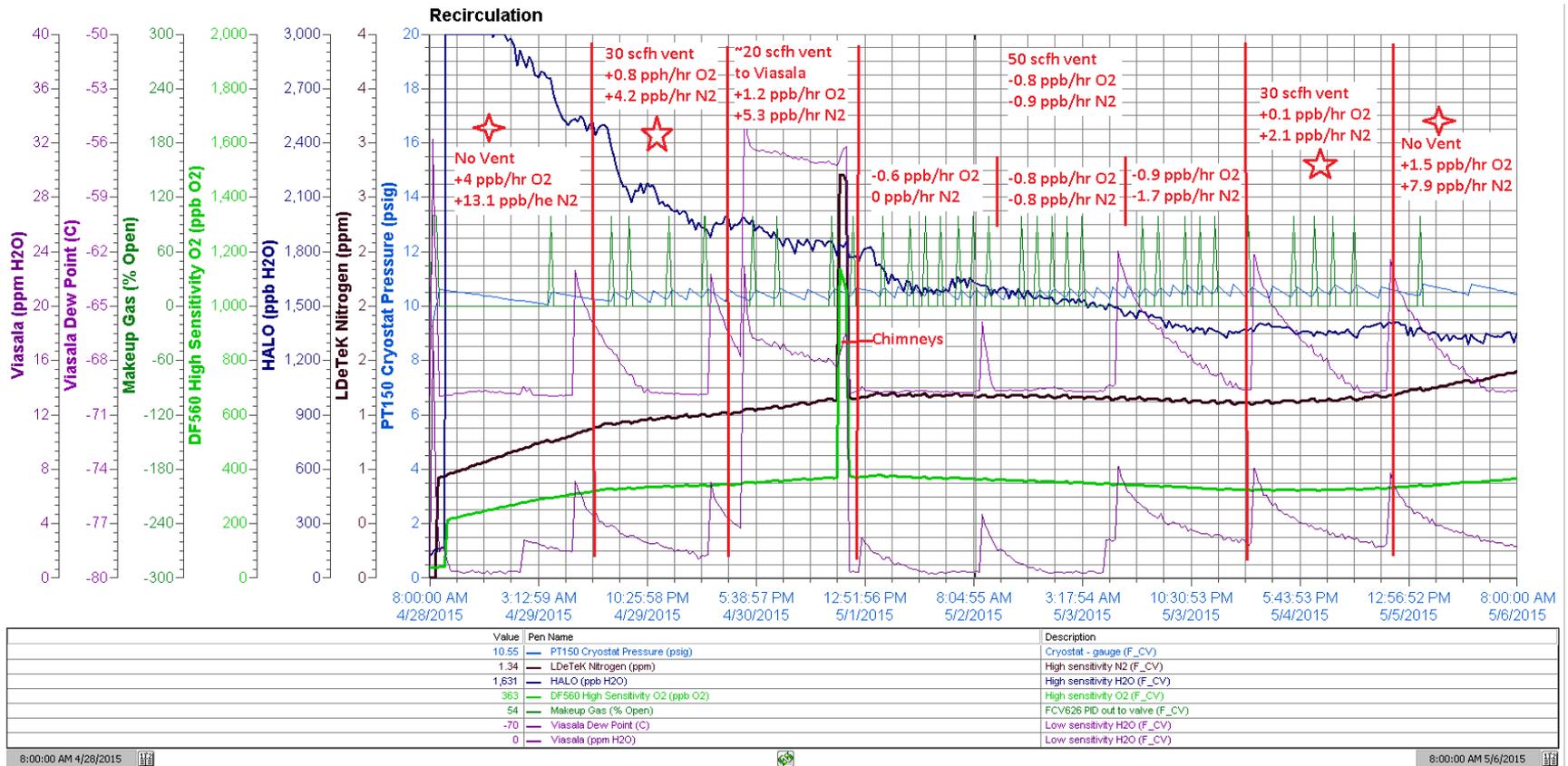
- ~13 volume exchanges, < 10 ppm H2O, < 1 ppm N2, < 1 ppm O2



# Stages of Commissioning

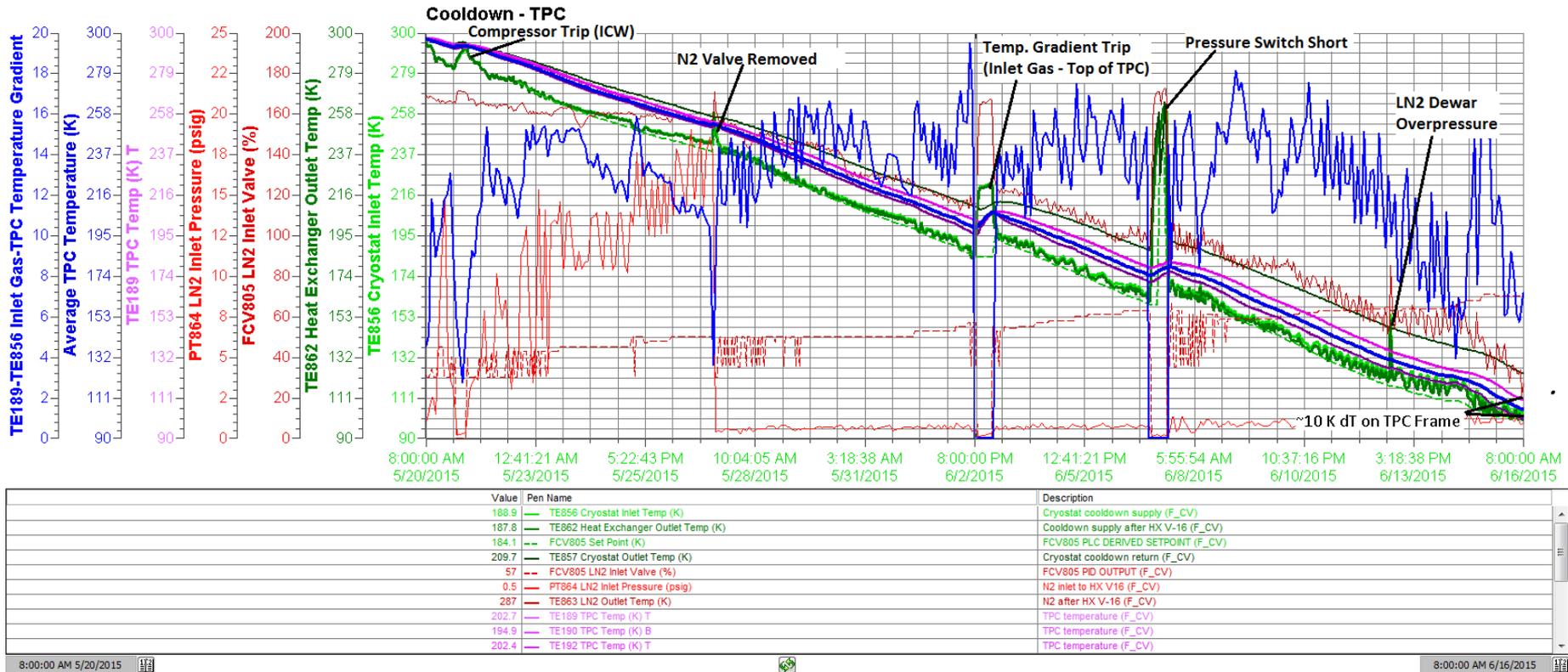
- Gas Recirculation

- With no O2/N2 filtration, contaminants increase due to outgassing, controlled by venting through chimneys



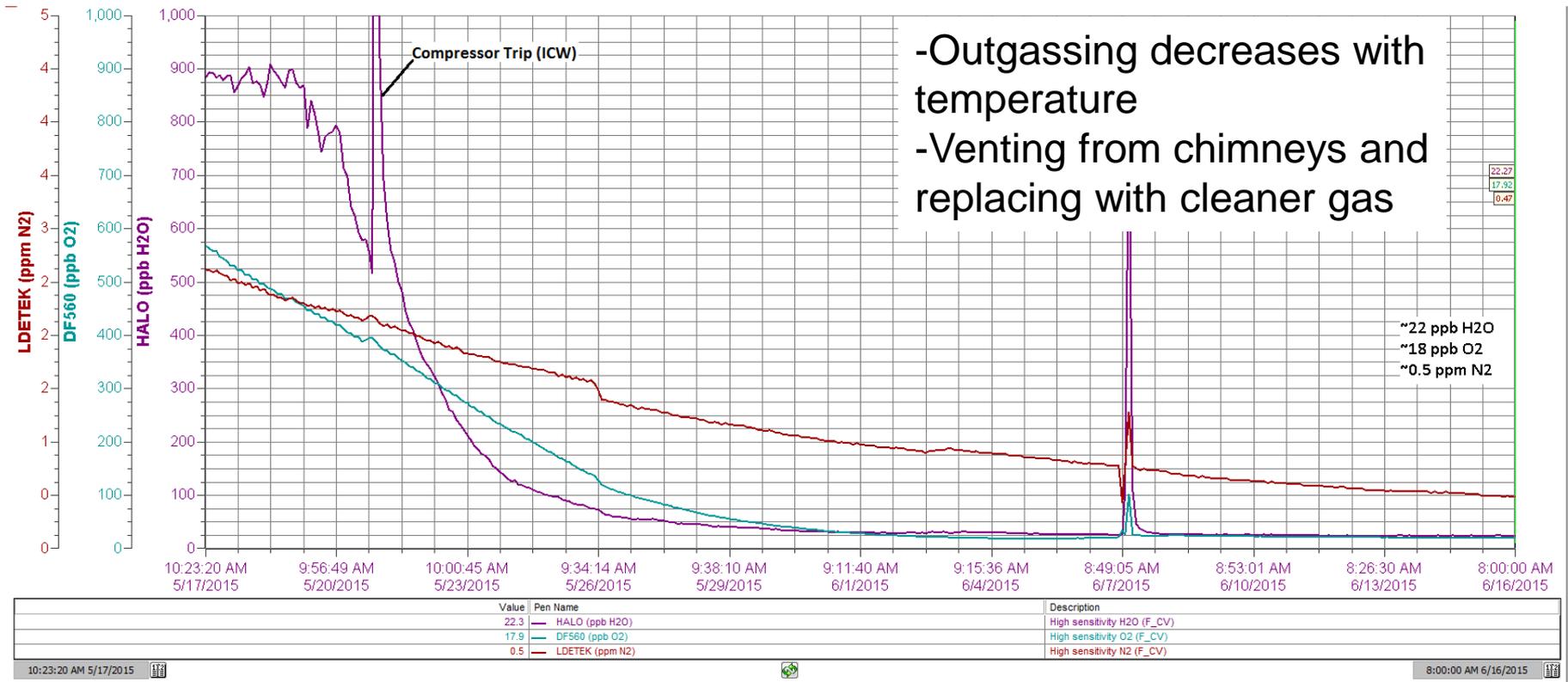
# Stages of Commissioning

- Cooldown
  - Temps. and system trips shown, maintained  $< 20$  K dT



# Stages of Commissioning

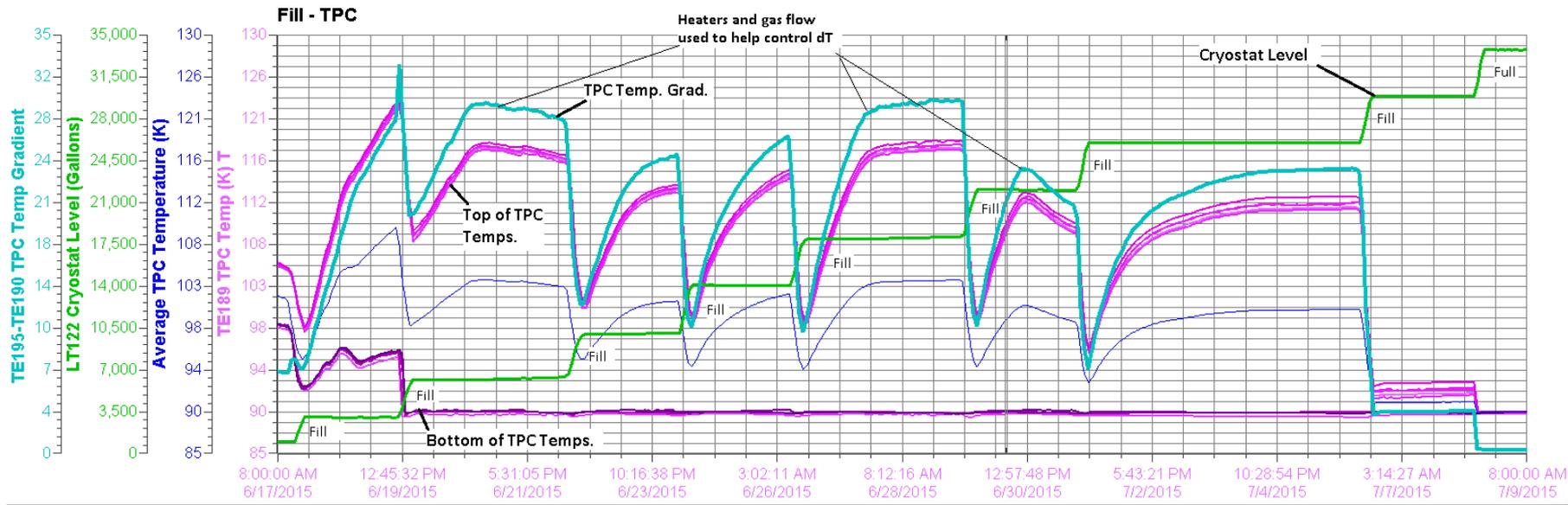
- Cooldown
  - Contamination during cooldown process shown



# Stages of Commissioning

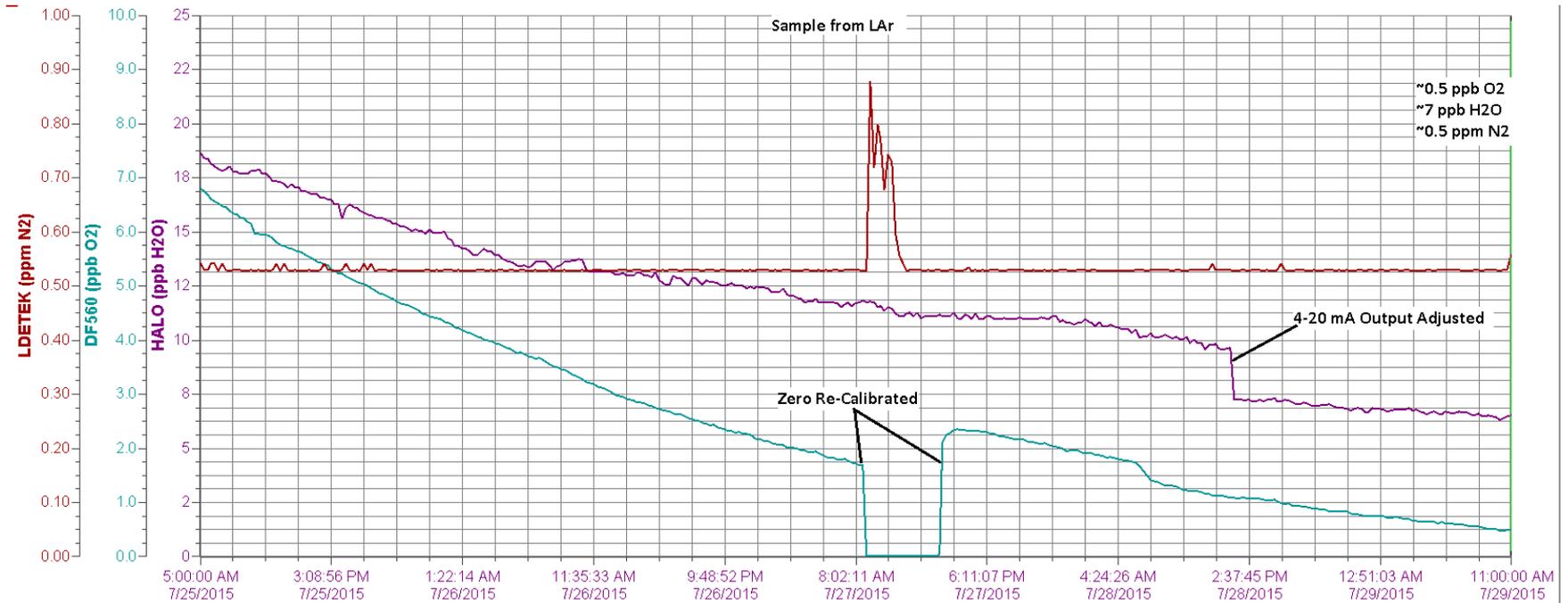
- Filling

- Contractual issues: Vendors hesitant to sign contract due to tight N2 requirements and aggressive schedule
- Temperature gradients: Form when the liquid level is low
  - Controlled with shell heaters and bottom-up gas flow to increase convection in the ullage



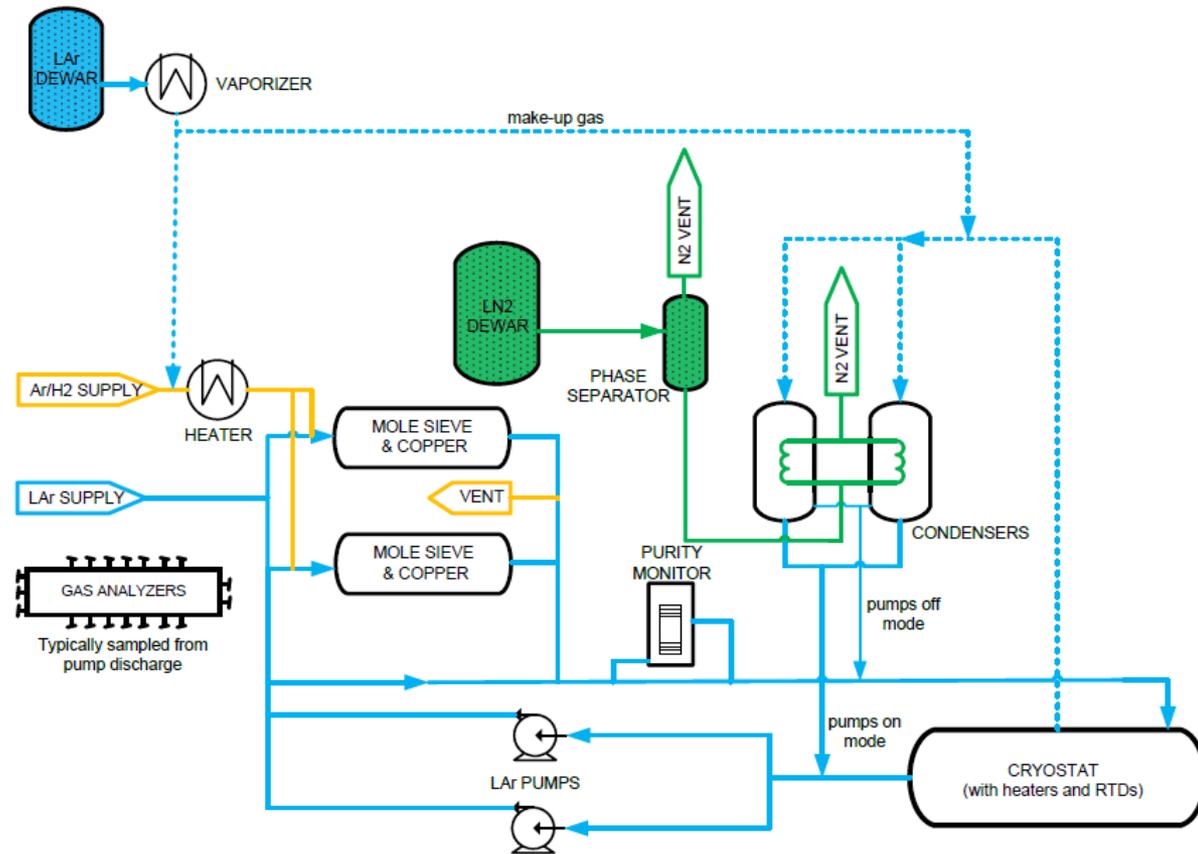
# Stages of Commissioning

- Purification
  - Did not fill through filters, started with commercial argon
  - LAr purified to acceptable levels within a week



# Operations

- Overview of Normal Operating System
  - Spare LAr pump, condenser, and filter skid
  - Makeup argon from utility dewar ~3 weeks
  - Inline PM inactive
  - No active purge on chimney ports
  - Pressure control via LN2 control valve on condenser coil inlet
  - O<sub>2</sub>, N<sub>2</sub> sampled at LAr pump discharge; H<sub>2</sub>O from ullage



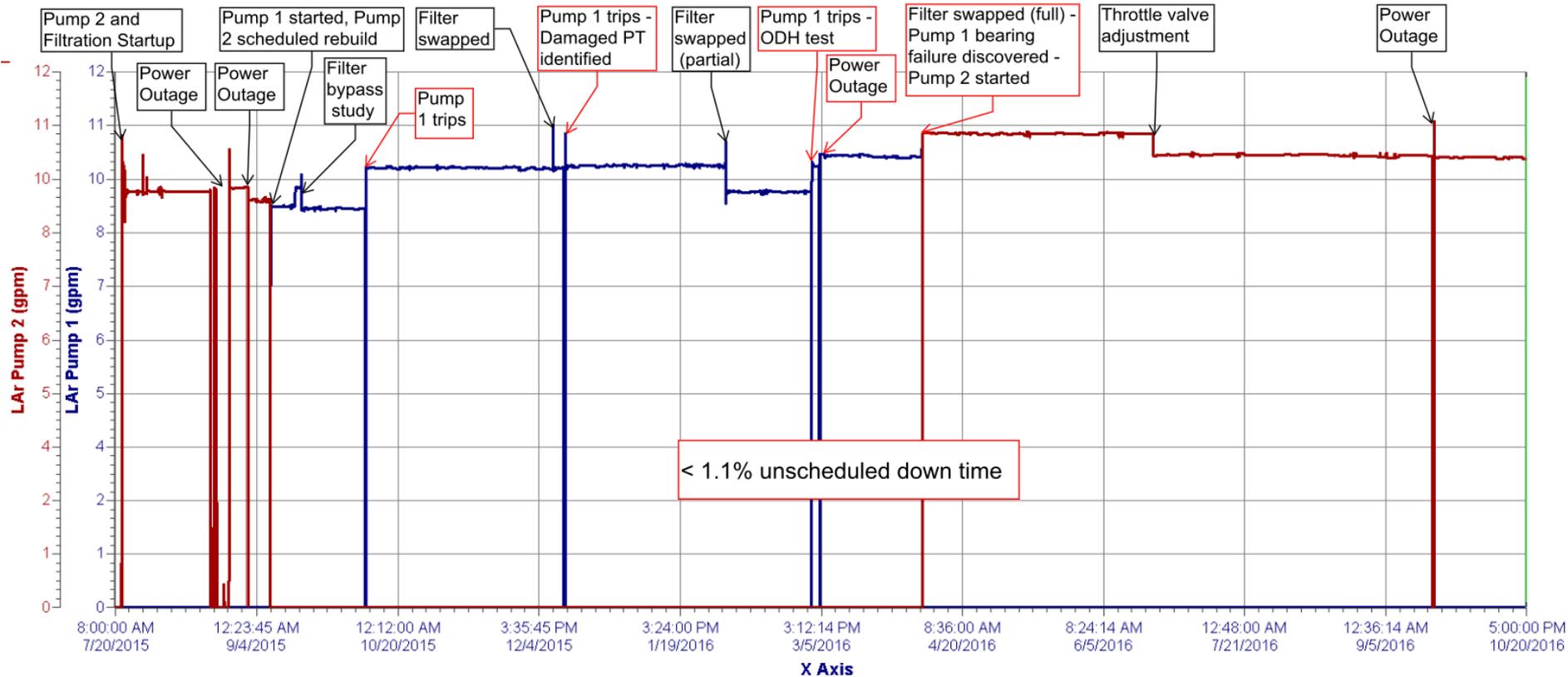
# Operations

- Barber Nichols LAr Pumps
  - Startup: Difficult to start without first bypassing the filters then slowly cooling them, likely amplified by downstream throttle valve
- LAr Pump Bearing Failure
  - Detected audibly
  - Lower cold bearing (cage)
  - ~6000 hours of operation
  - Possible cause: Prior failure of discharge pressure transmitter caused pump to ramp up/down for several hours
  - Likely caused cavitation and shortened bearing life



# Summary

- Electron Lifetime: Analysis is ongoing - 9 ms or greater
- System Reliability: > 98.9% up time



Value	Pen Name	Description
0.0	LAr Pump 1 (gpm)	Pump 1 Flow in Gal/Min (F_CV)
10.1	LAr Pump 2 (gpm)	Pump 2 Flow in Gal/Min (F_CV)

# Questions?