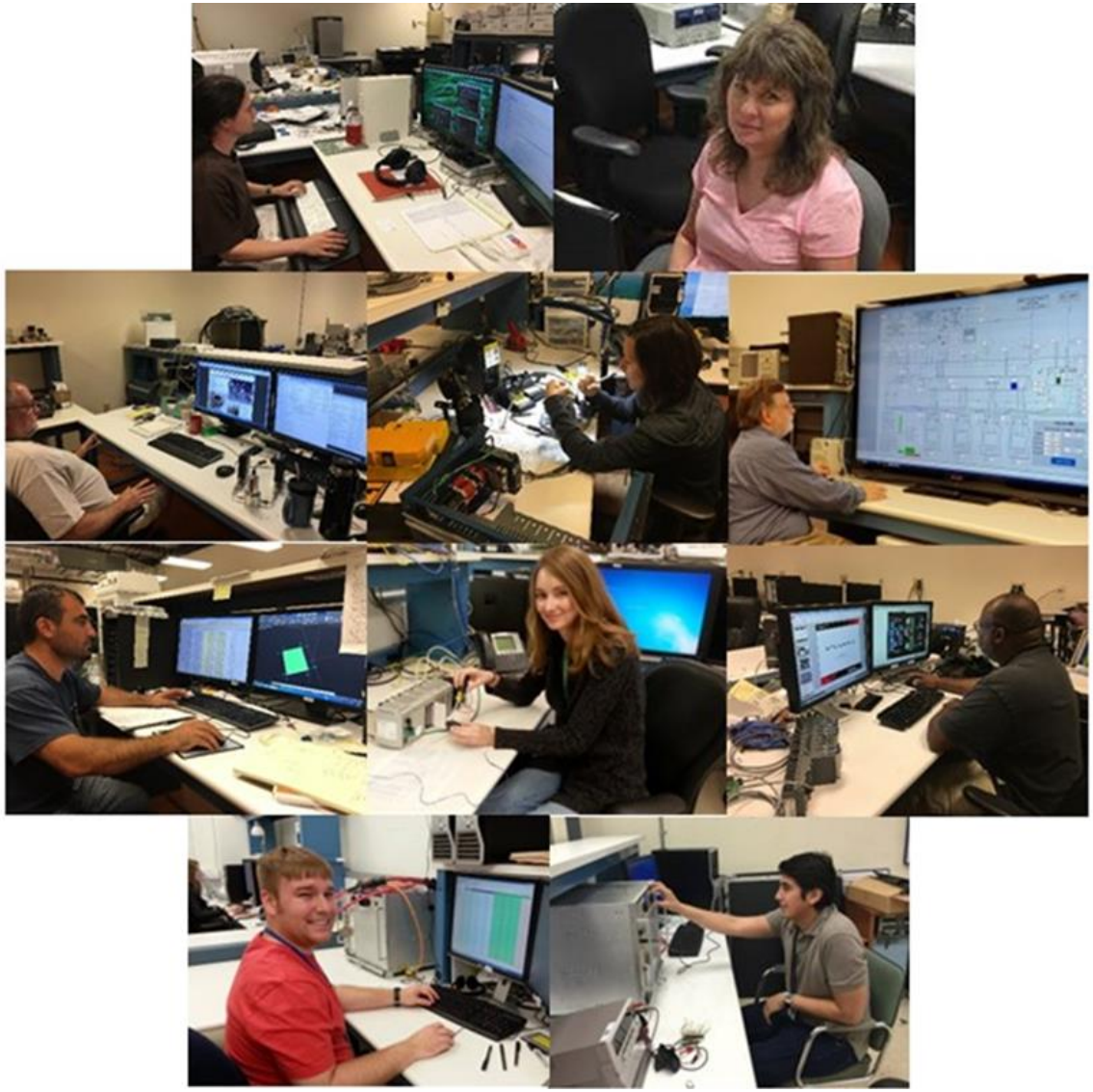
Review of the Hall B Gas System Hardware

George Jacobs

DSG Staff



Hall B Gas Utilities for detectors

- Drift Chamber (DC)
- Low Threshold Cherenkov Counter (LTCC)
- Micromegas Vertex Tracker (MVT)
- Forward Tagger (FT)
- Ring Imaging Cherenkov (RICH)
- High Threshold Cherenkov Counter (HTCC)
- Silicon Vertex Tracker (SVT)

DCGAS Sub-systems

- DCGAS Mixing and Storage
  - Mix 10% CO_2 in argon
- DCGAS Supply
  - Individual gas supply for regions 1, 2, and 3
- DCGAS PID Pressure Control
  - PID control loop for R3 and R1-2 exhaust manifolds
- DCGAS Pressure Protection Interlocks
  - Solenoid valves isolate chambers from gas system
- Passive Detector Over and Under Pressure Protection
  - Oil-filled bubblers vent gas to prevent detector damage when differential pressure exceeds 0.150 “ water column

Hall B Gas Shed – 96B
Liquid Argon, CO_2, and Nitrogen Dewar Locations

10% CO_2 in Argon Gas Mixing

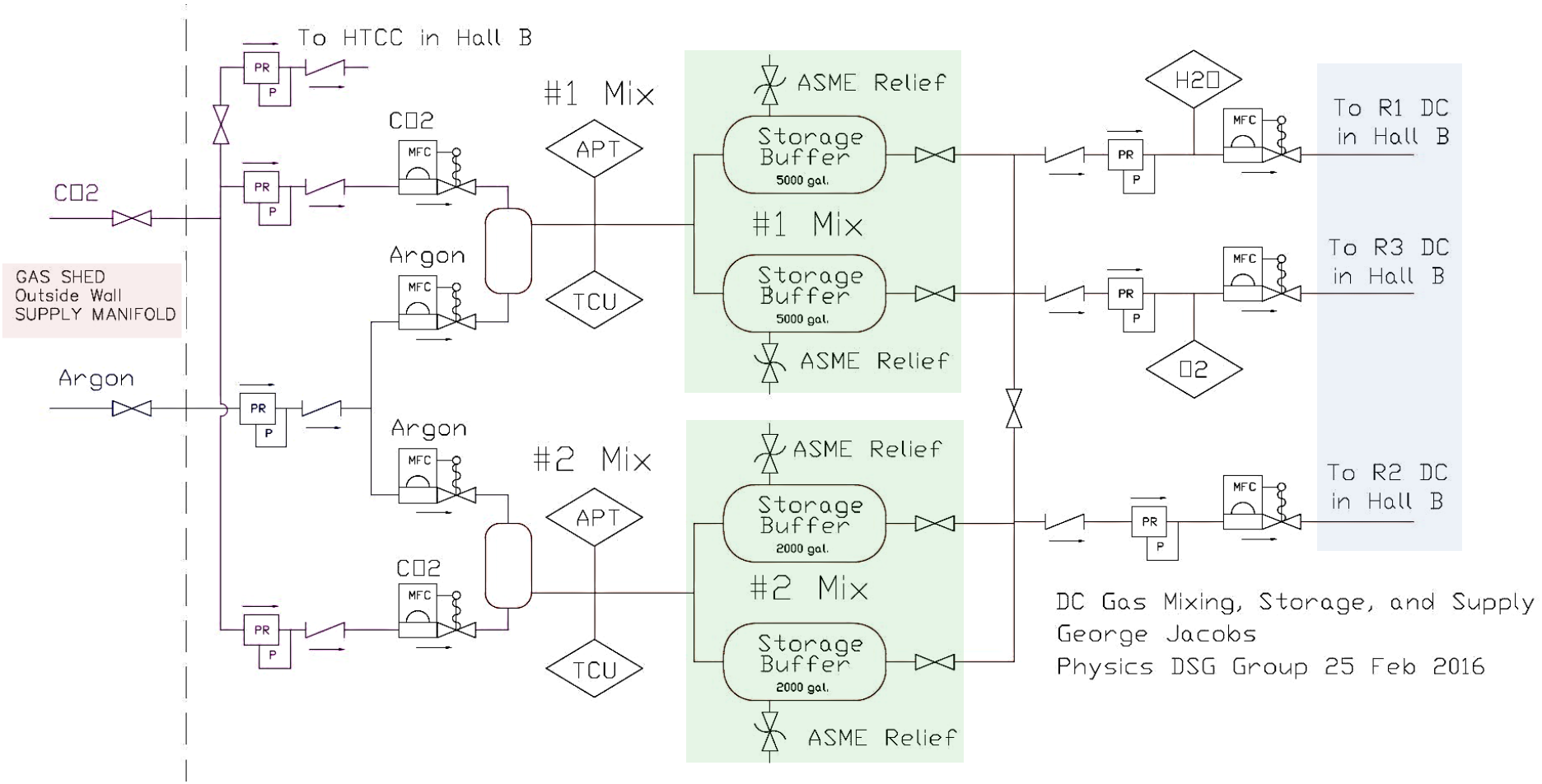
- MKS mass flow controllers mix gas at correct ratio
- Storage tank pressure automatically maintained
  - Pressure 80—100 psi by controlling mixed gas flow rate
- Two identical mixing systems maintain pressure in four storage tanks located at 96B gas shed

10% CO_2 in Argon Mixed Gas Storage (14,000 gal/53,000 liters)

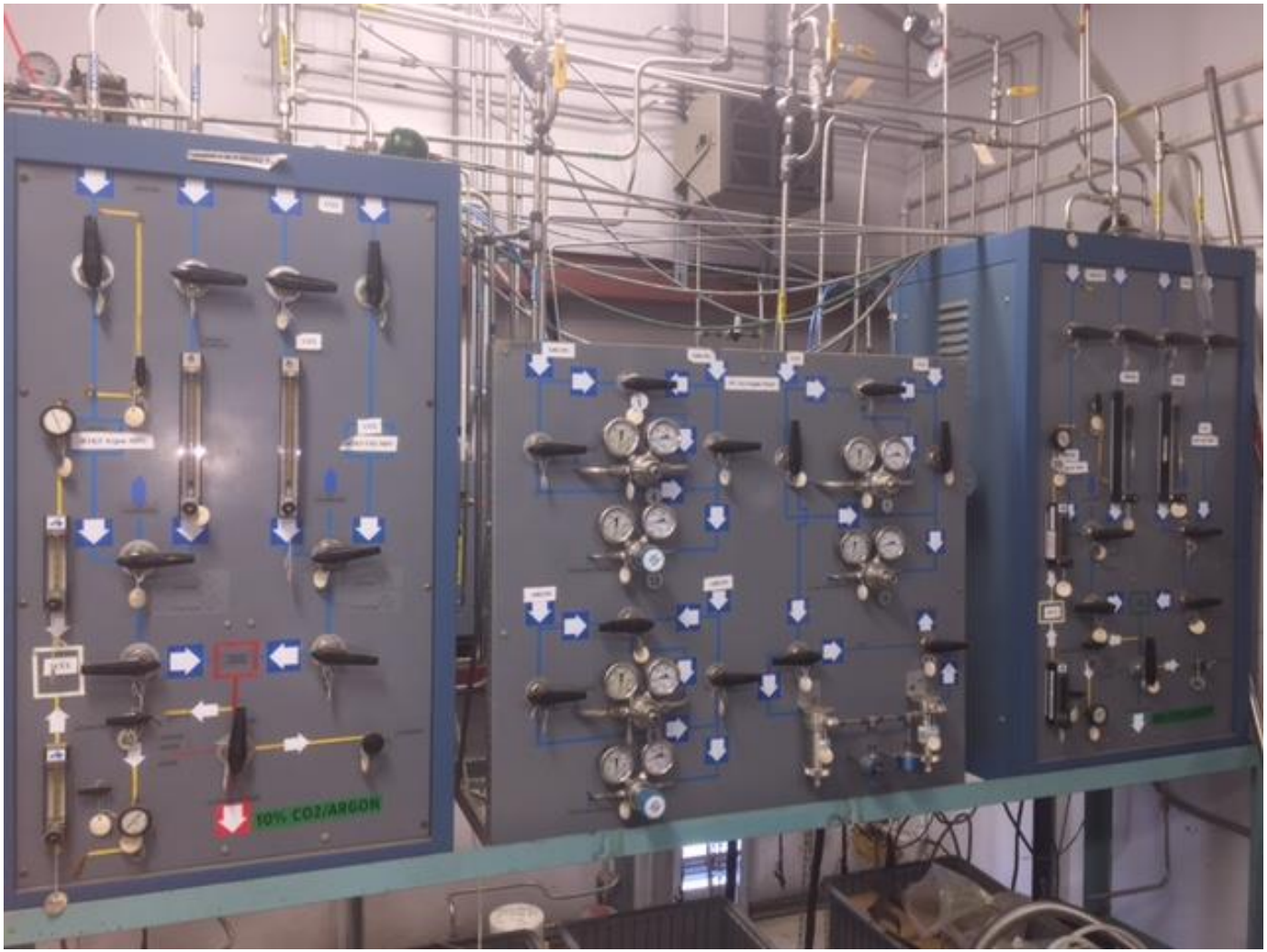
DCGAS Supply

- MKS mass flow controllers meter gas flow
  - To each of the 3 regions
- O_2 concentration monitored
  - Sensor accurate to 1 ppm
- H_2O concentration monitored
  - Sensor accurate to 1 ppm
- MKS mass flow transducers monitor return gas flow

DCGAS Mixing and Supply Piping Diagram



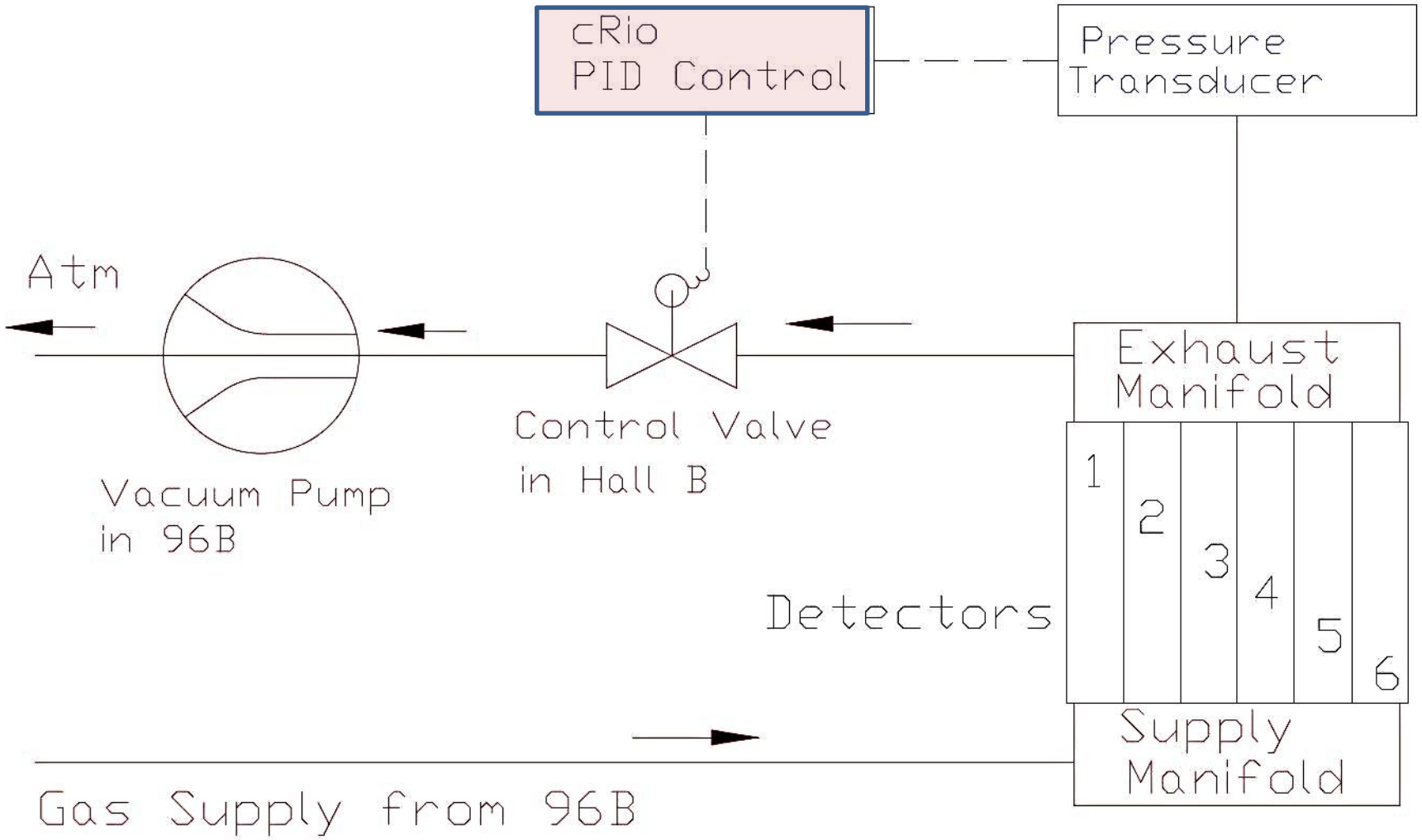
DCGAS Supply and Mixing Panels



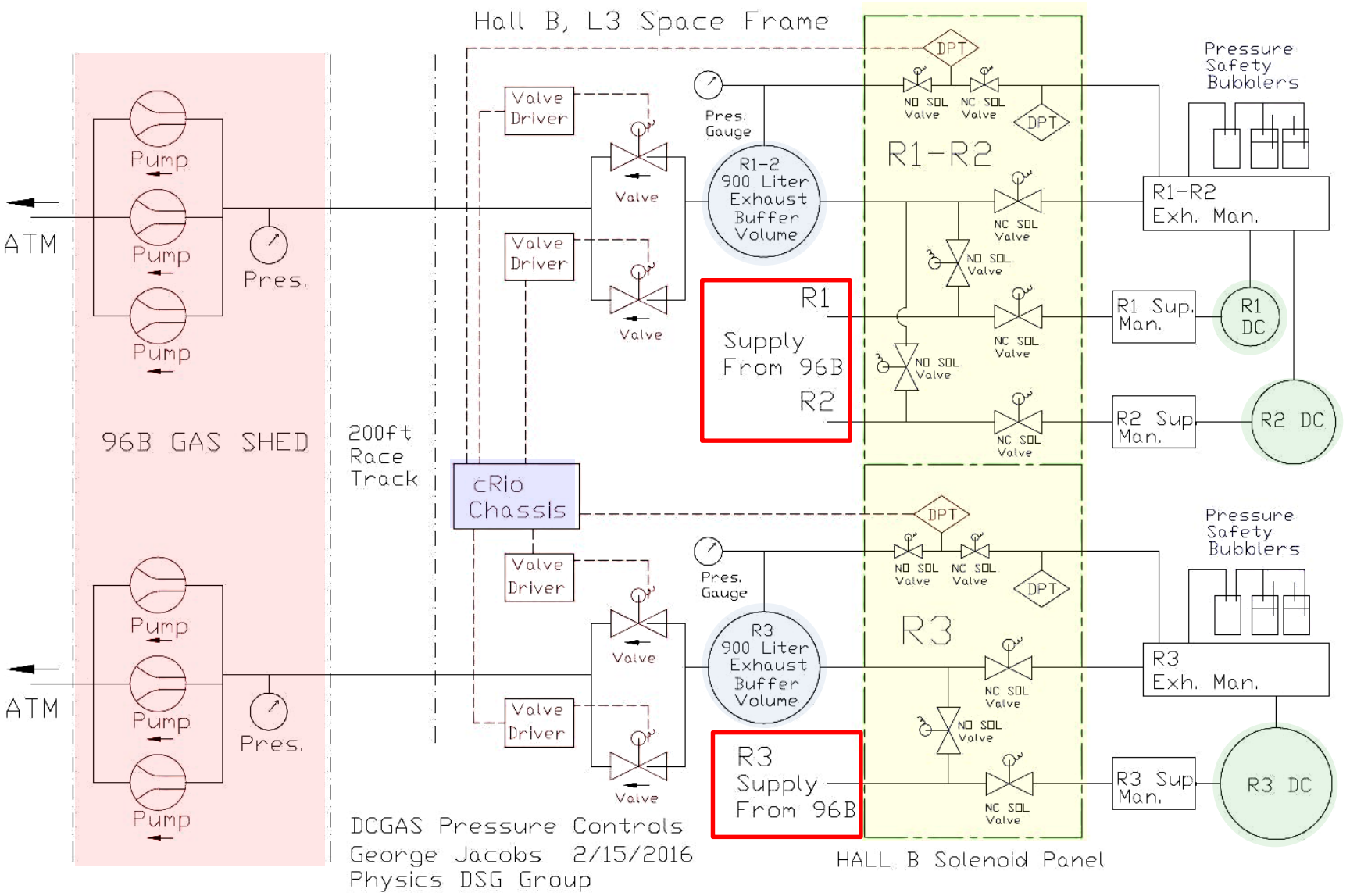
DCGAS Pressure Controls

- PID pressure control program runs on cRIO
  - MKS pressure transducer supplies pressure signal to cRIO
  - cRIO sends valve control signal to MKS valve driver module
  - MKS control valve operates to remove gas at control signal value
- Solenoid valves isolate chambers
  - In case of power outage or system failure

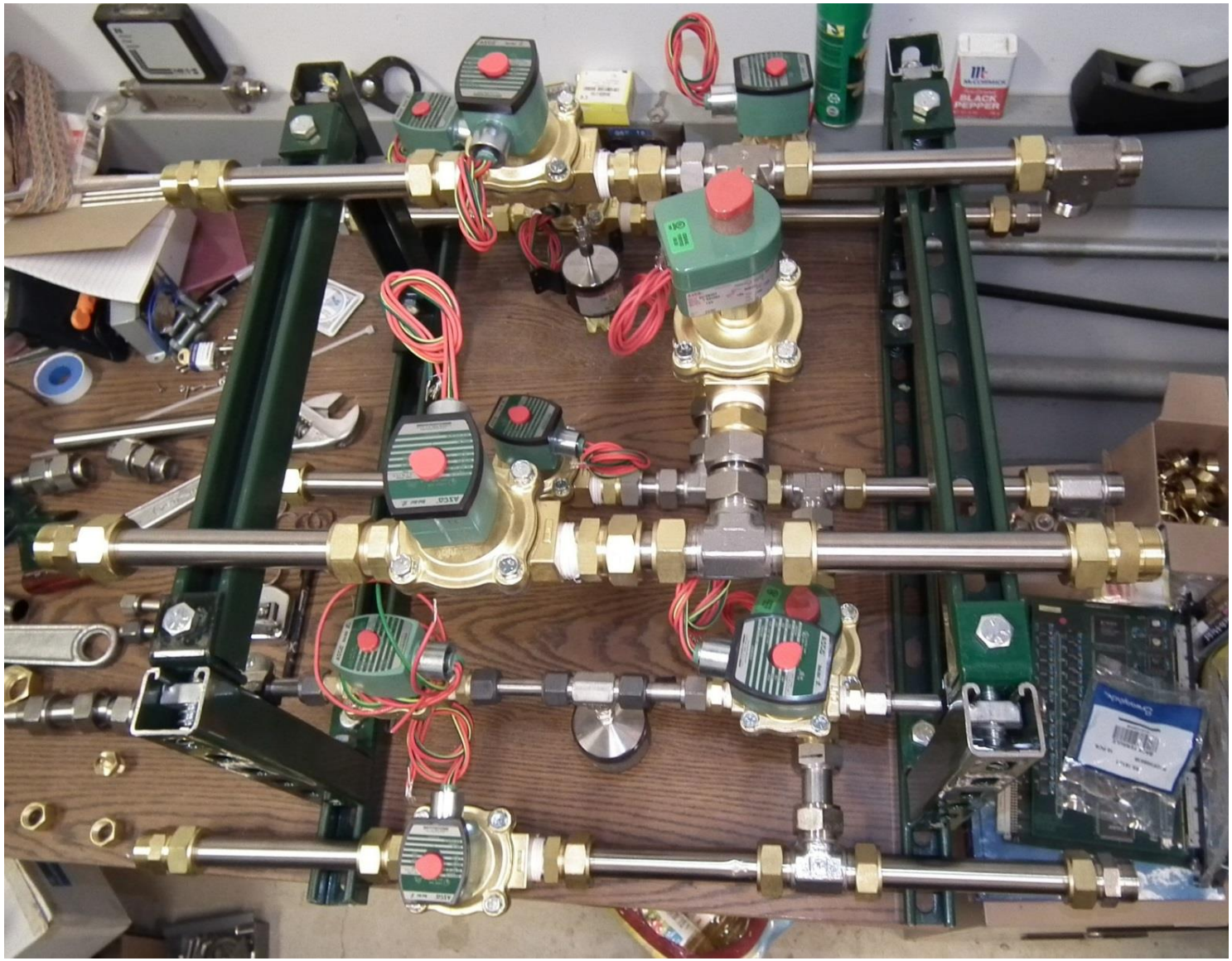
DCGAS PID Loop Pressure Control



DCGAS Pressure Controls Diagram



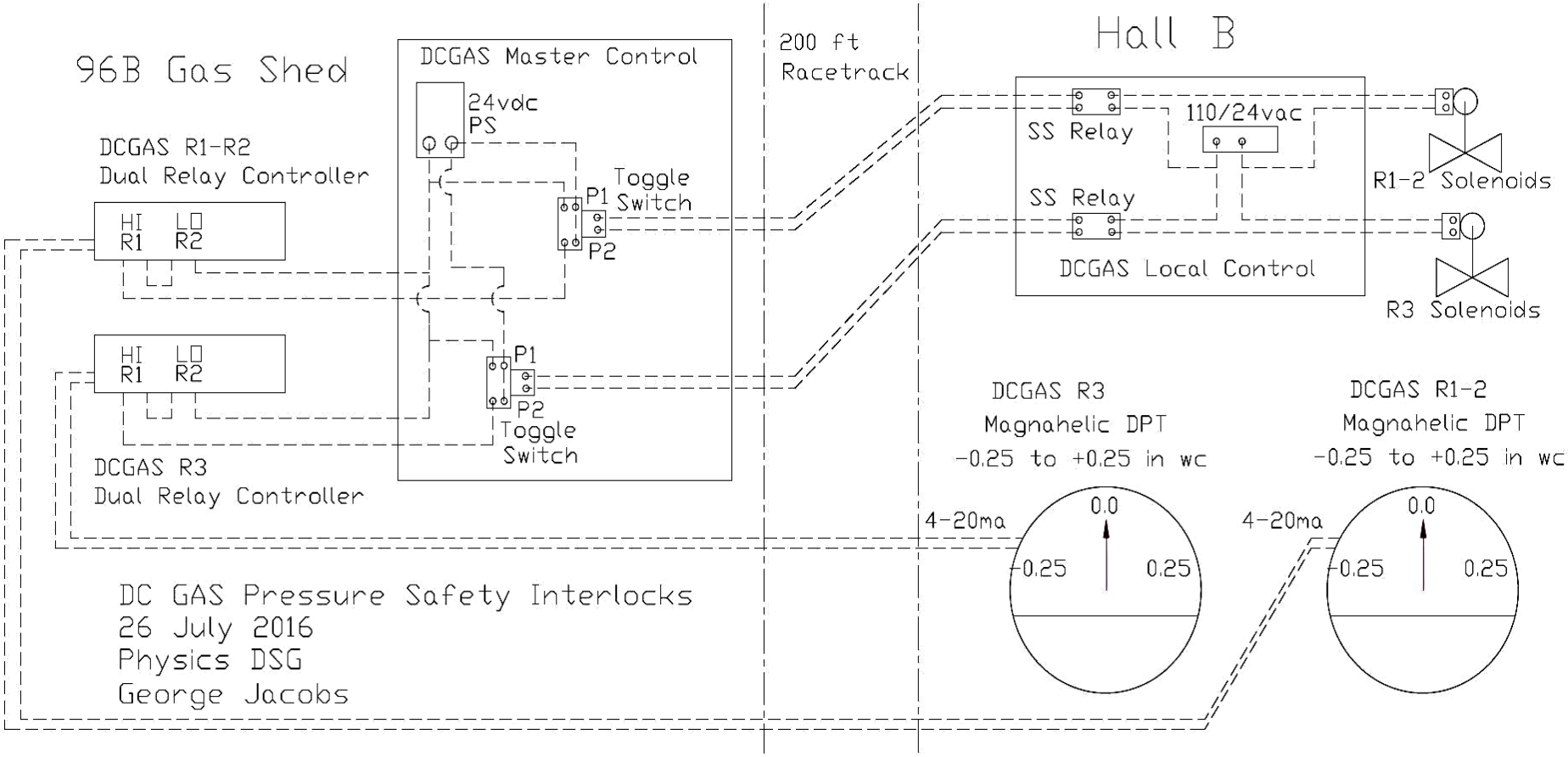
Solenoid Valve Panel



DCGAS Pressure Protection Interlocks

- Pressure monitored by differential pressure transducer
- In case of high or low pressure
  - Omega process controller opens the interlock relays
  - Open relays de-energize solenoid valves, isolating chambers from gas system
- Fail safe in case of complete or partial power failure

DCGAS Pressure Safety Interlock Diagram



DCGAS Operations Critical Path

- Procurement
  - ASME relief valves for storage tanks
  - Argon and CO_2
  - Pressure control pumps
- Installation
  - ASME relief valves
  - Return pumps
  - DCGAS manifold on TORUS
- Connecting
  - DCGAS valve panel to TORUS manifolds
  - Connecting 18 chambers to manifolds
- Commissioning of mixing system

LTCC Gas System

- C_4F_{10} gas supply
  - 500 Kg storage containers
- Detector PID pressure control
- Passive bubbler reliefs
- Detector pressure safety interlocks
  - Prevents detector pressure from exceeding limits
- C_4F_{10} distillation and recovery
  - Batch distillation to recover liquid C_4F_{10}

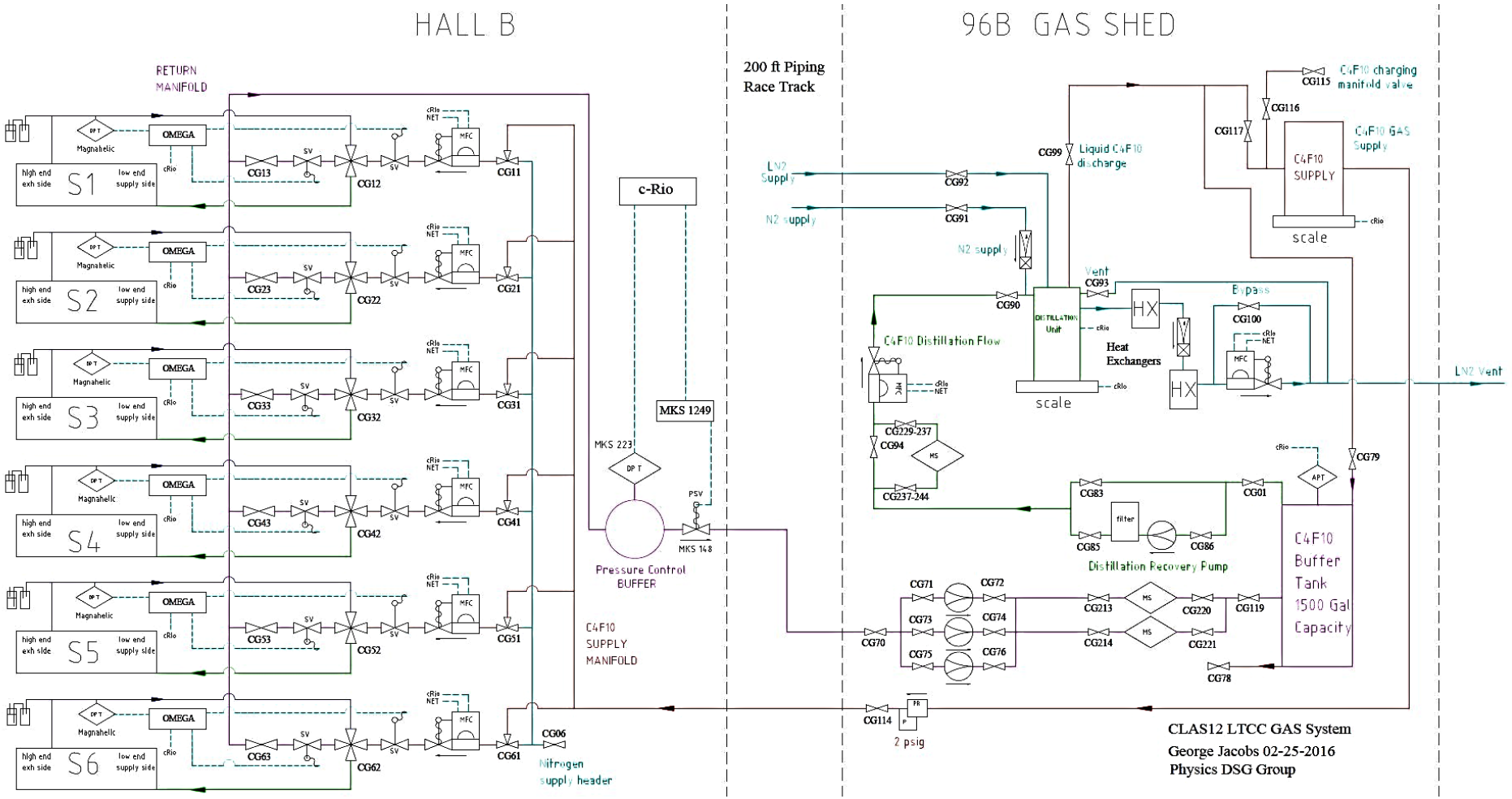
Passive Pressure Protection Oil-Filled Bubblers

Over pressure

Under pressure

Oil trap

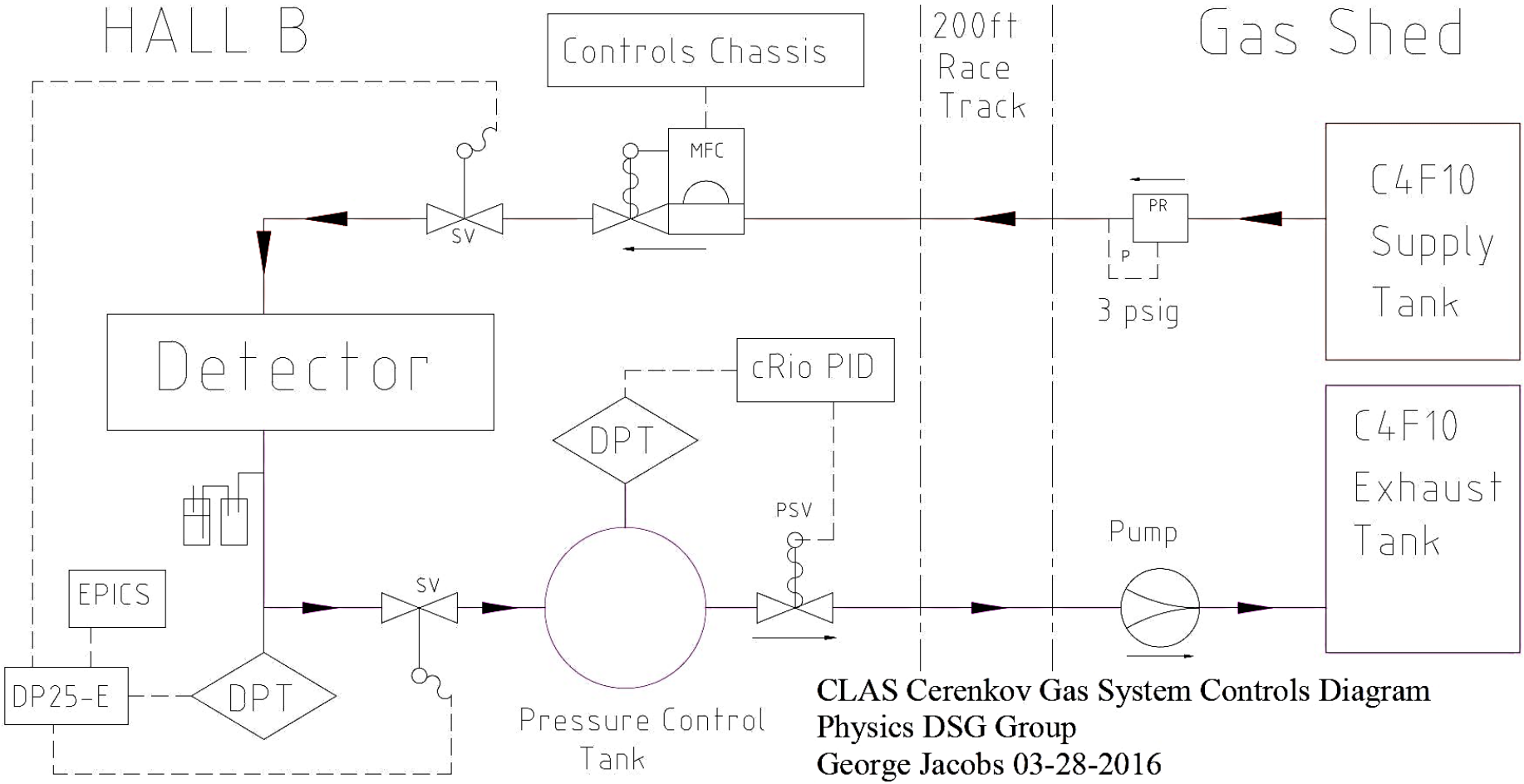
LTCC Gas System Diagram



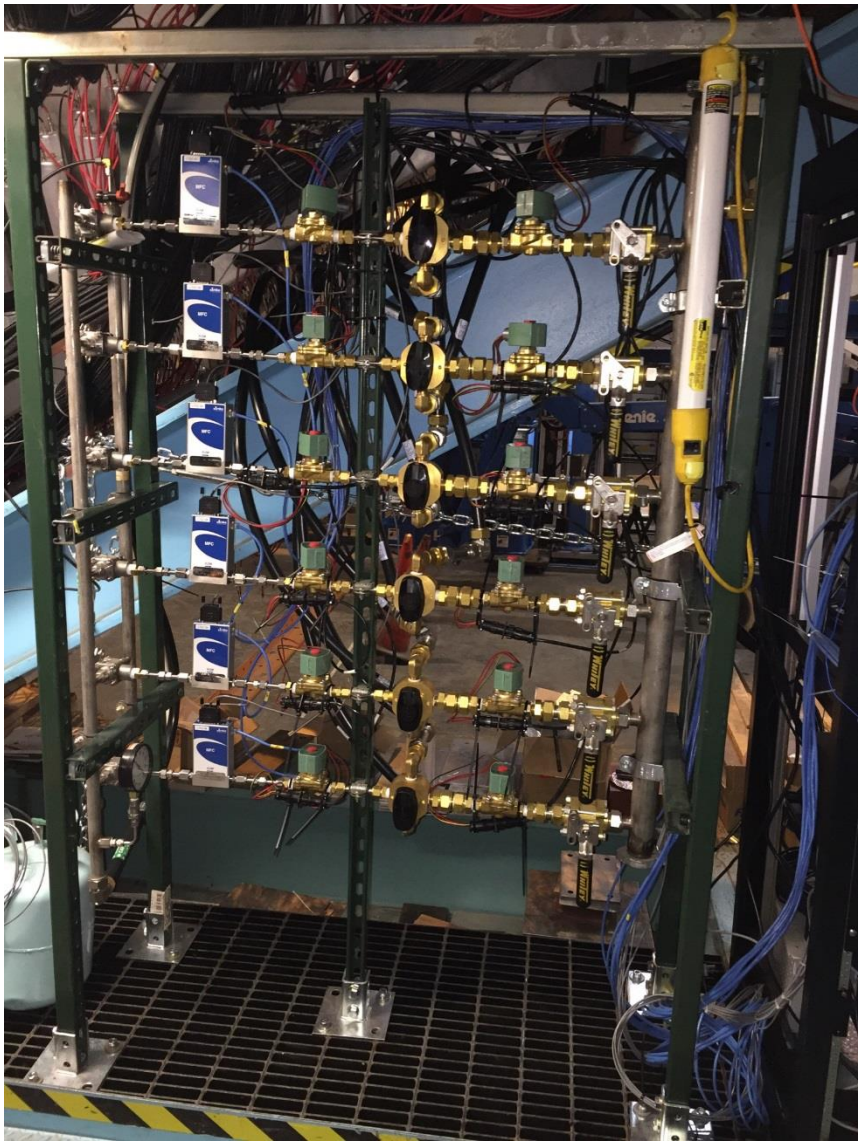
LTCC Gas System Flow and Pressure Controls

- MKS mass flow controllers
  - Meter gas flow to each sector
- Detector safety interlocks
  - Prevent gas venting and air contamination due to pressure controls fault
- Passive pressure safety bubblers
  - Prevent detector damage due to extreme over or under pressure
- PID pressure control
  - Maintains constant pressure in detector exhaust buffer tank

LTCC GAS System Controls



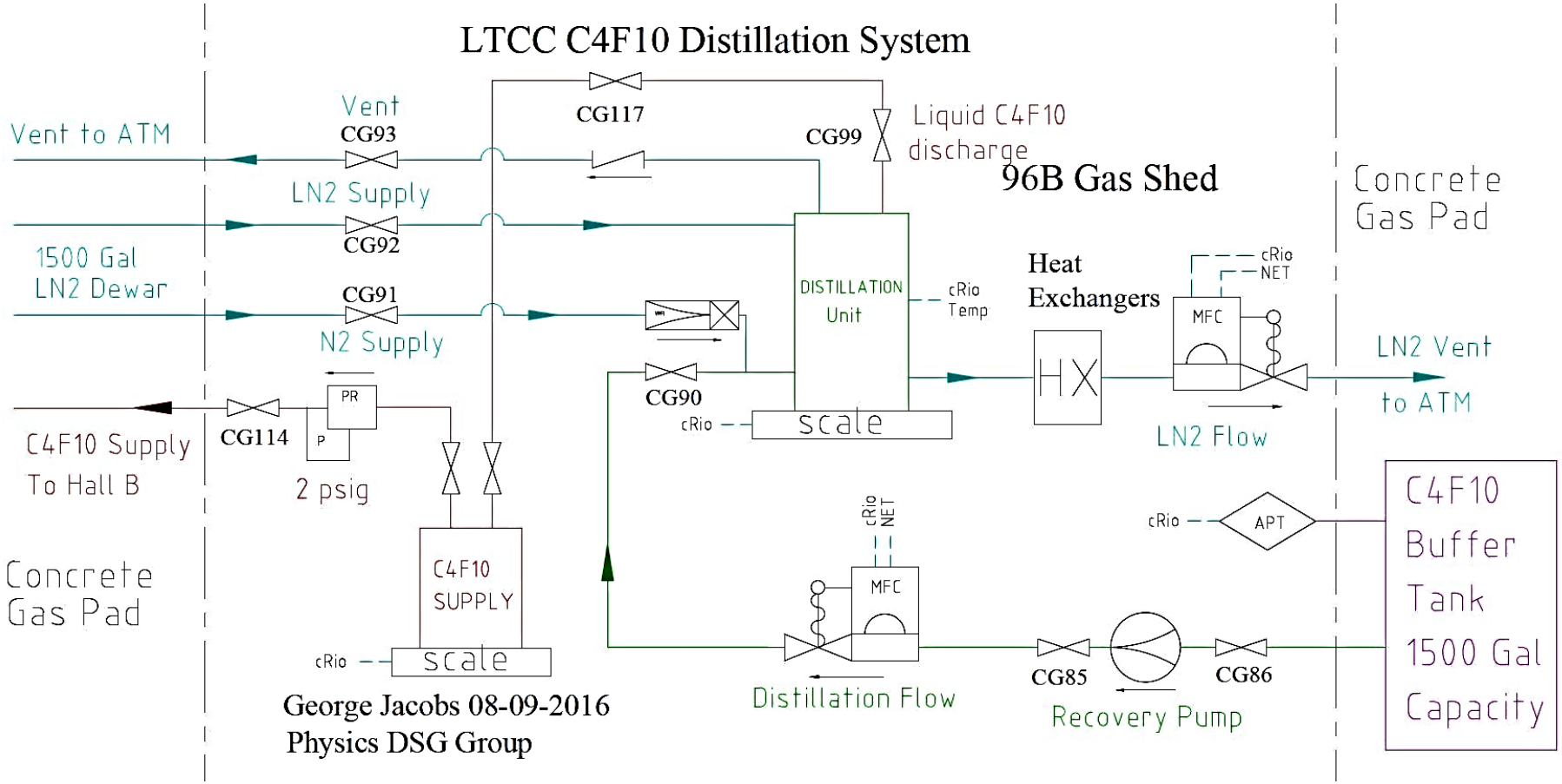
LTCC Gas Panel – Hall B Level 1 Forward Carriage



C_4F_{10} Recovery

- Due to high cost of C_4F_{10}, gas recovered and re-used
- Distillation unit condenses C_4F_{10} for re-use
- Liquid N_2 cools the gas
- Recovery process complex
  - Requires trained operators
- Distillation unit's temperature control is automatic

C_4F_{10} Recovery System



C_4F_{10} Distillation Unit in Hall B 96B Gas Shed

Critical Path for LTCC Gas System Operations

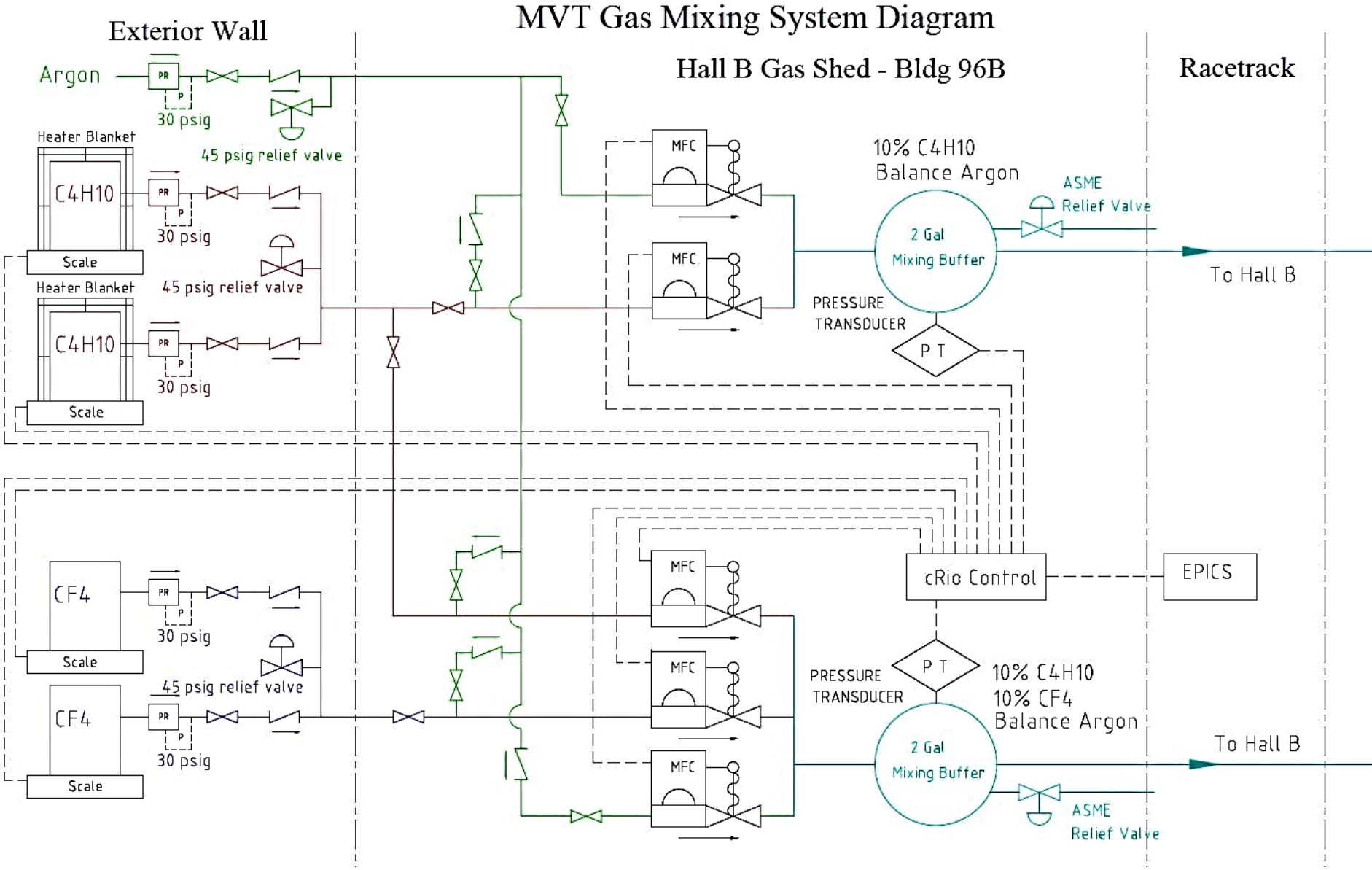
- Install pressure control tank
- Connect pressure control tank to valve panel and gas shed return line
- Zero and span scales for distillation unit and supply tank
- Purge system with N_2
- Procurement of C_4F_{10} gas
  - Long lead time for bulk purchase
- Attach C_4F_{10} gas supply to system

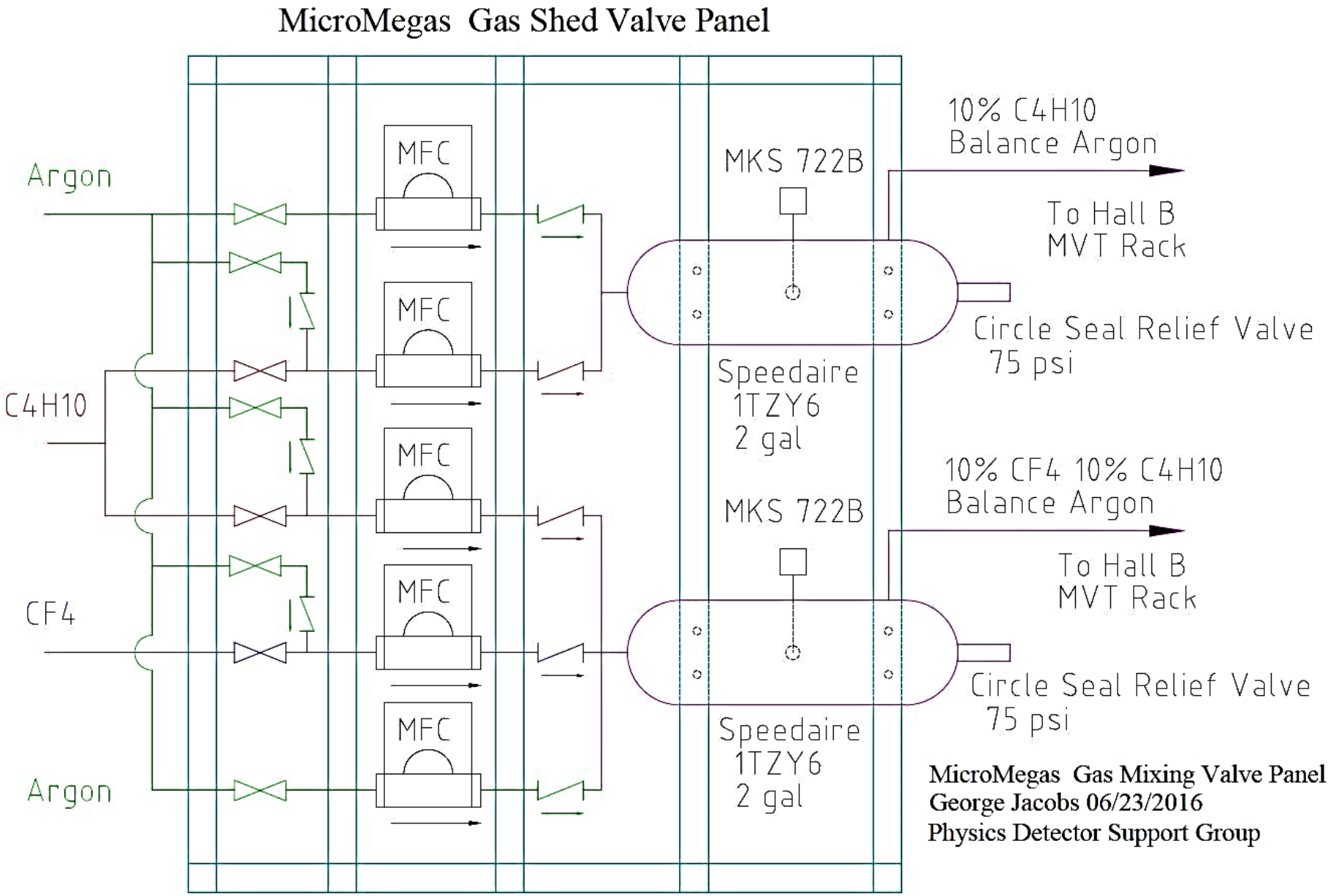
Hall B MVT Gas Mixing System

- Mixing system location: Bldg. 96B gas shed
- System produces two different gas mixtures
  - Mixture 1 - 10% C_4H_{10} in argon
  - Mixture 2 – 10% C_4H_{10} 10% CF_4 in argon
- MKS mass flow controllers mix gases
- Mass flow controllers are controlled by cRIO controller
- Mixed gas pressures monitored by MKS absolute pressure transducer
- Mixed gas pressure automatically controlled by adjusting mass flow controllers' flows
- Mixed gas flows into Hall in temperature-controlled piping

MVT Mixing System Details

- Isobutane, C_4H_{10}, is a flammable gas with explosive limits of 1.4% to 8.3%
- Pressure system requirements apply
- cRIO-based controls
- EPICS monitoring and the alarm handler
- Trained operators required to replace the C_4H_{10} and CF_4 gas supply cylinders (liquid)
- Uses two pre-existing 300 ft long temperature controlled ½" stainless steel tubing running between gas shed and Hall B Level 1 space frame


MVT Gas Mixing System Diagram
Exterior Wall
Hall B Gas Shed - Bldg 96B
Racetrack
Argon
PR
P
30 psig
45 psig relief valve
Heater Blanket
C4H10
Scale
Heater Blanket
C4H10
Scale
CF4
Scale
CF4
Scale
MFC
MFC
MFC
MFC
MFC
10% C4H10
Balance Argon
2 Gal
Mixing Buffer
ASME
Relief Valve
To Hall B
PRESSURE
TRANSDUCER
P T
cRio Control
EPICS
PRESSURE
TRANSDUCER
P T
10% C4H10
10% CF4
Balance Argon
2 Gal
Mixing Buffer
To Hall B
ASME
Relief Valve


MicroMegas Gas Shed Valve Panel
Argon
C4H10
CF4
Argon
MFC
MFC
MFC
MFC
MFC
MKS 722B
MKS 722B
Speedaire
1TZY6
2 gal
Speedaire
1TZY6
2 gal
10% C4H10
Balance Argon
To Hall B
MVT Rack
Circle Seal Relief Valve
75 psi
10% CF4 10% C4H10
Balance Argon
To Hall B
MVT Rack
Circle Seal Relief Valve
75 psi
MicroMegas Gas Mixing Valve Panel
George Jacobs 06/23/2016
Physics Detector Support Group

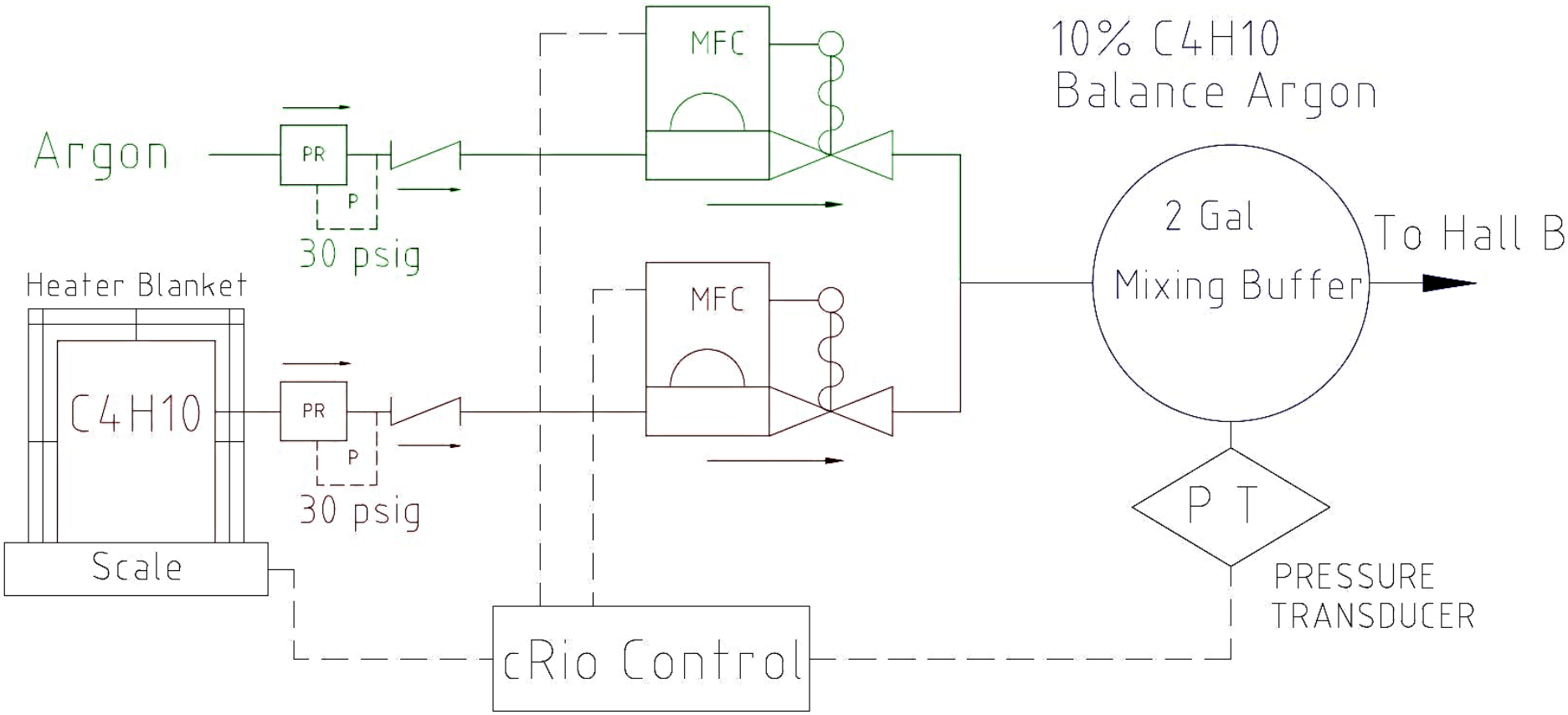
MVT Mix 1 Pressure Control

- Mix 1 – 10% C_4H_{10} in argon
- Pressure is monitored by an MKS absolute Baratron transducer
- Maintain line pressure 12-16 psi

MVT Mix 1 Pressure Control

- Normal detector flow is 750 sccm
  - Vary flow rate between 400-900 sccm
  - @ 16 psi flow is reduced to 400 sccm
  - @ 12 psi flow is increased to 900 sccm
  - @ 17.2 psi flow is turned off
- Purge flow of 1000 sccm
  - Vary flow rate between 500-1500 sccm
  - @ 16 psi flow is reduced to 500 sccm
  - @ 12 psi flow is increased to 1500 sccm
  - @ 17.2 psi flow is turned off

MVT Mix #1 – 10% C4H10 in Argon

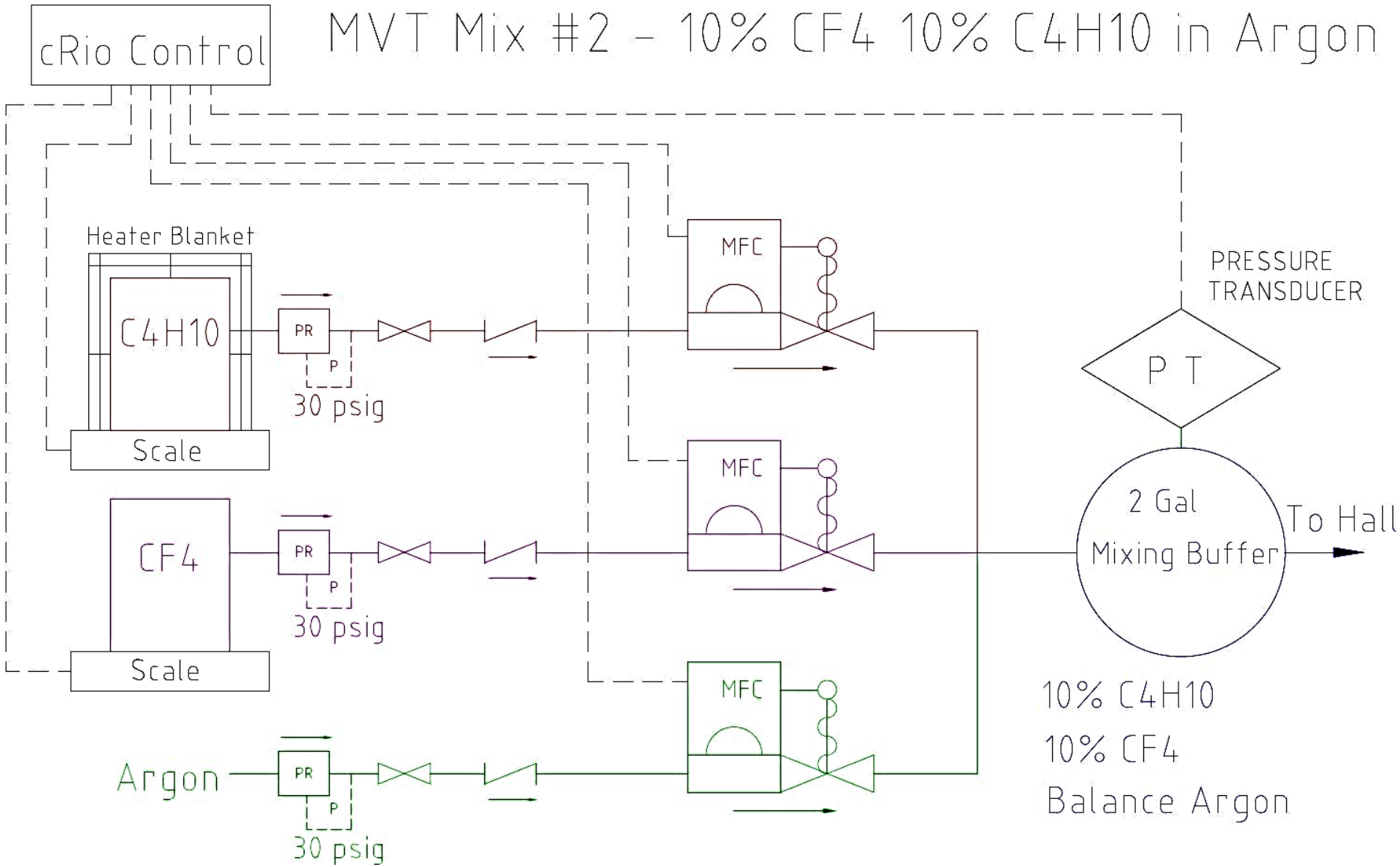


MVT Mix 2 Pressure Control

- Mix 2: 10% CF_4 , 10% C_4H_{10} in argon
- Pressure is monitored by an MKS transducer
- Maintain line pressure at 12-16 psi

MVT Mix 2 Pressure Control

- Normal detector flow is 250 sccm
  - Vary flow rate between 200-300 sccm
  - @ 16 psi flow is reduced to 200 sccm
  - @ 12 psi flow is increased to 300 sccm
  - @ 17.2 psi flow is turned off
- Purge flow of 325 sccm
  - Vary flowrate between 200-400 sccm
  - @ 16 psi flow is reduced to 200 sccm
  - @ 12 psi flow is increased to 400 sccm
  - @ 17.2 psi flow is turned off


cRio Control
MVT Mix #2 - 10% CF4 10% C4H10 in Argon
Heater Blanket
C4H10
Scale
CF4
Scale
Argon
PR
P
30 psig
MFC
PRESSURE
TRANSDUCER
P T
2 Gal
Mixing Buffer
To Hall
10% C4H10
10% CF4
Balance Argon

96B Gas Shed


AIR PRODUCTS
LIQUID ARGON
WARNING
LIQUID NITROGEN
WARNING
150M-200-537
96B

Critical Path for MVT Gas Mixing

- Purchase system components
- Fabricate and install
  - Gas shed valve panel
  - Controls chassis and cables
- Install utilities, scales, and pressure regulators for the C_4H_{10} and CF_4 cylinders
- Run stainless steel tubing in gas shed to connect supply cylinders to valve panel and to Hall B lines

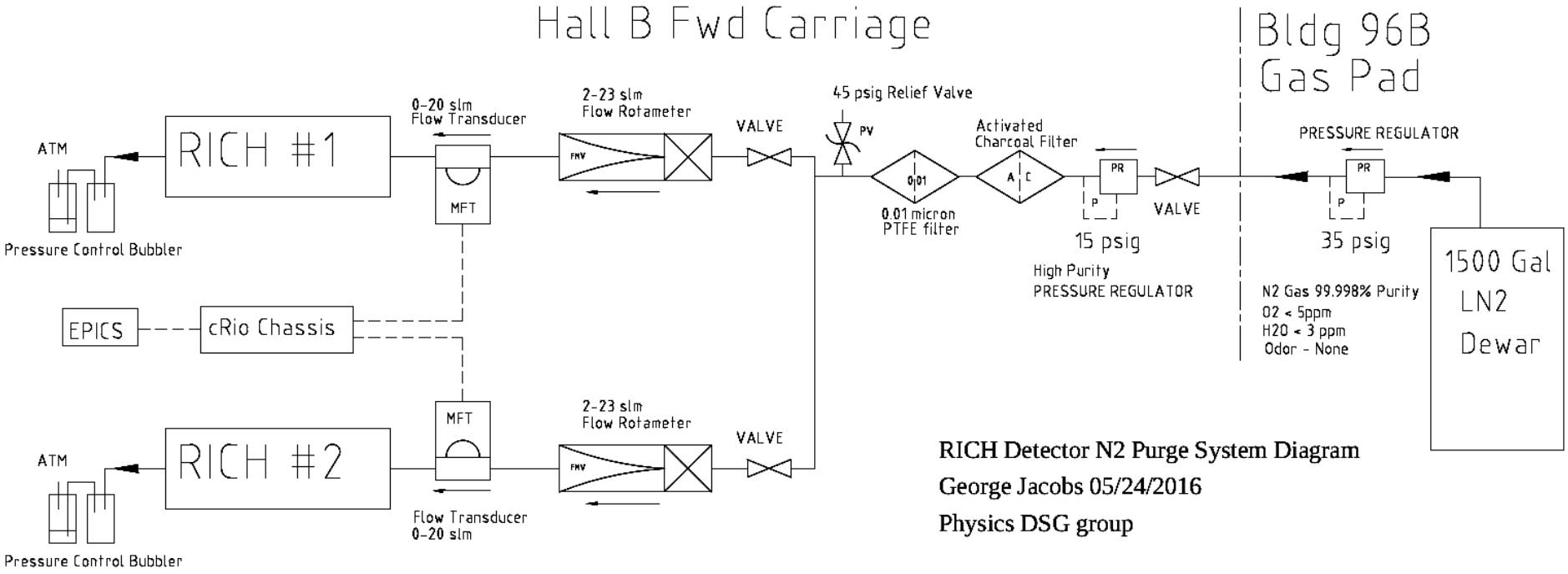
Critical Path for MVT Gas Mixing

- Run stainless steel tubing in Hall B to connect temperature-controlled lines to MVT and Forward Tagger gas panels
- Approval of flammable gas use in 96B gas shed
- Develop and test cRIO controls
- Test MVT and FT gas distribution systems with gas mixing controls

RICH Gas Supply Utilities

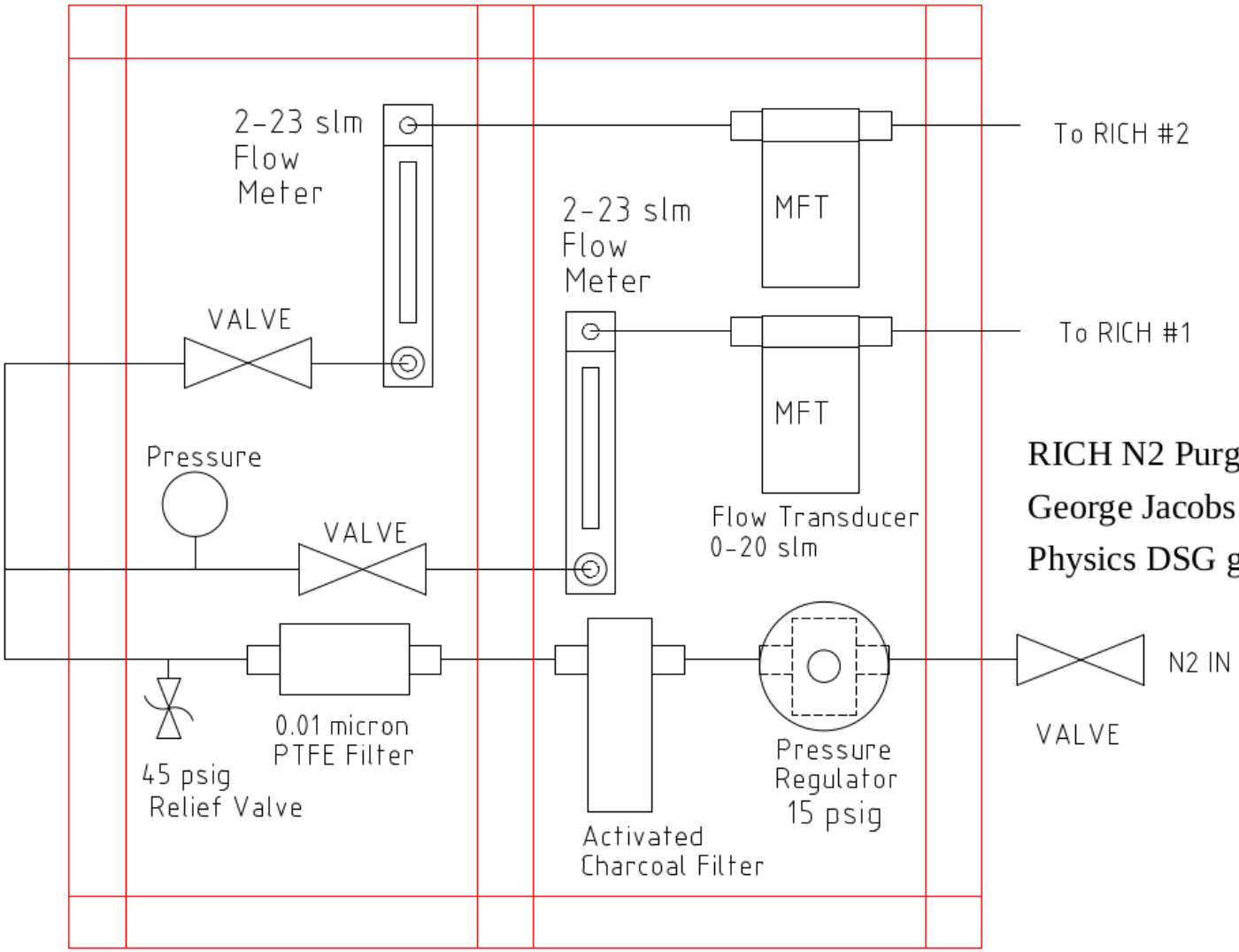
- Dry N_2 gas purge for the Aerogel volume
  - Hall B service N_2 is >99.998 % pure with < 3 ppm H_2O concentration
  - N_2 is supplied via a 5500 liter (1500 gal) LN_2 dewar
- Dry air cooling supply for enclosed electronics
  - Clean dry air is supplied via high capacity Class 0 air compressors
  - Interlocks prevent equipment damage due to electronics operation without sufficient air cooling flow

RICH Detector N2 Purge Gas System Diagram



RICH Detector N2 Purge System Diagram
George Jacobs 05/24/2016
Physics DSG group

RICH N2 Purge Circuit Valve Panel



RICH N2 Purge Circuit Valve Panel

George Jacobs 06/01/2016

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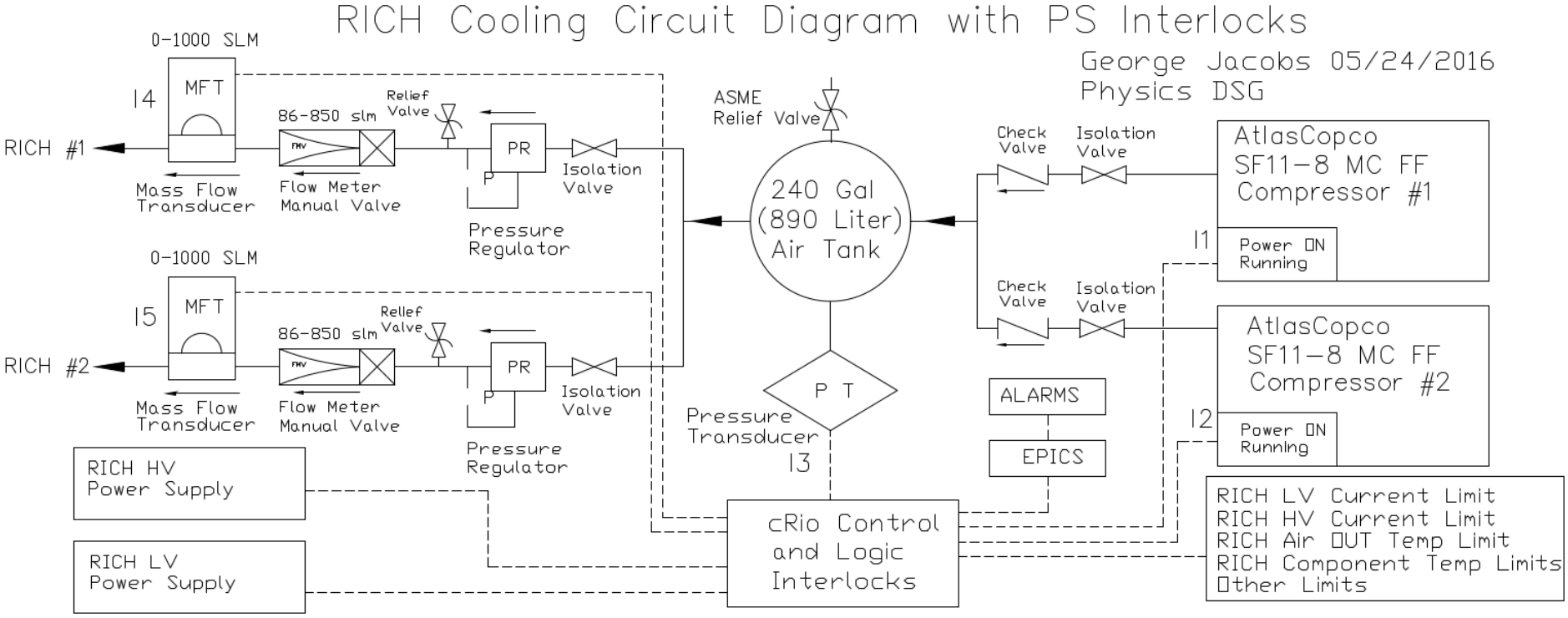
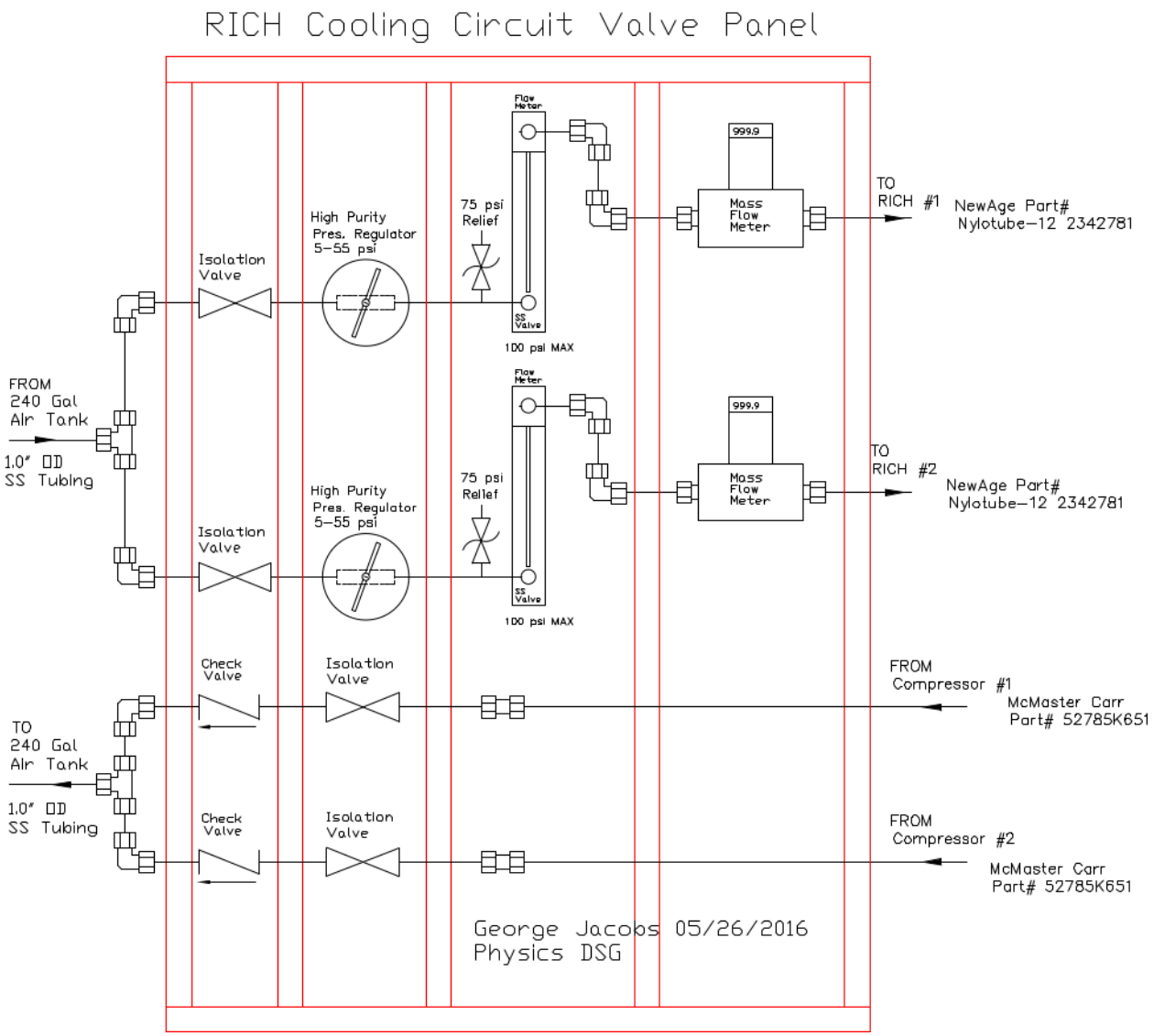


Cooling Circuit Interlocks for RICH HV and LV Power to be Enabled
Air Compressor Power ON Interlock – I1 and/or I2 or PS Power is Disabled
Air Pressure Interlock – I3 > 100 psi (TBD) or Power Disabled
Air Flow Interlock RICH #1 Power – I4 > 250 slm (TBD) or Power to RICH #1 Disabled
Air Flow Interlock RICH #2 Power – I5 > 250 slm (TBD) or Power to RICH #2 Disabled


RICH Cooling Circuit Valve Panel
Flow Meter
999.9
Mass Flow Meter
TO RICH #1
NewAge Part#
Nylotube-12 2342781
High Purity Pres. Regulator 5-55 psi
75 psi Relief
Isolation Valve
SS Valve
100 psi MAX
FROM 240 Gal Air Tank
1.0" OD SS Tubing
TO RICH #2
Check Valve
TO 240 Gal Air Tank
FROM Compressor #1
McMaster Carr Part# 52785K651
FROM Compressor #2
George Jacobs 05/26/2016
Physics DSG

RICH Cooling Circuit Power Supply Interlocks

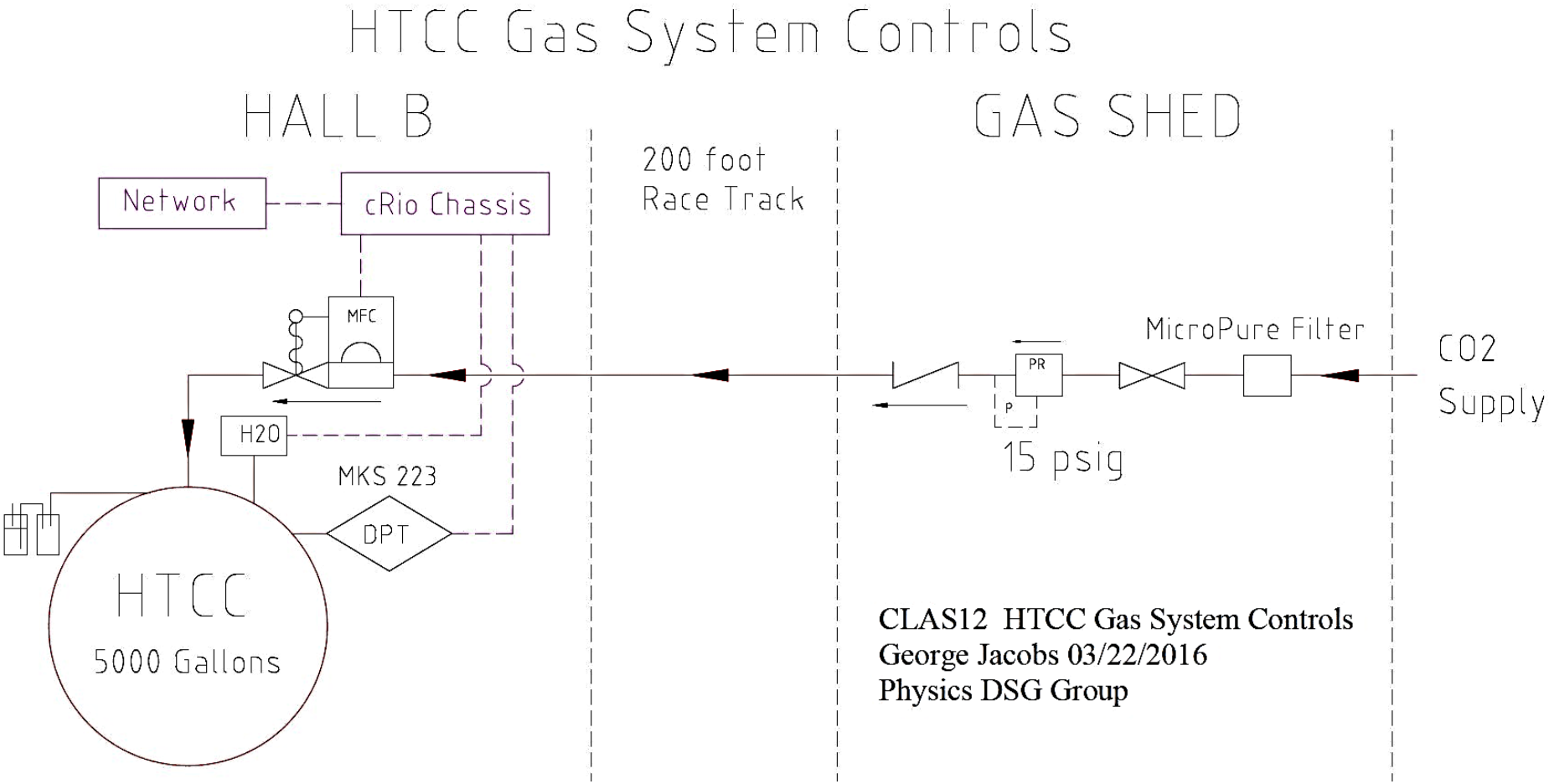
- Interlocks perform 2 main functions
  - Turn off all power to the electronics package
  - Prevent energizing the electronics package
- 3 cooling circuit interlocks
  - Air compressor operation: minimum one of two compressor
  - Minimum air pressure in tank >75 psi
  - Minimum cooling air flow >250 slm

Critical Path for RICH Operation

- Fabricate
  - N_2 purge and air cooling valve panels
  - Controls chassis
- Assemble equipment for clean room testing
- Install
  - Electrical utilities on forward carriage for the compressors
  - Compressors and components in Hall B
  - Lines from N_2 and air valve panels to detector
- Connect N_2 valve panel to Hall B service N_2 supply

HTCC CO_2 Gas Supply

- CO_2 supplied via 182 Kg liquid CO_2 dewars located at 96B gas shed
  - CO_2 is 99.99% pure
- HTCC shares the CO_2 supply with DC gas system
- CO_2 gas flow controlled by MKS mass flow controller
- Detector pressure limited by passive oil-filled pressure relief bubbler


HTCC Gas System Controls
HALL B
GAS SHED
200 foot
Race Track
Network
cRio Chassis
MFC
H2O
MKS 223
DPT
HTCC
5000 Gallons
PR
P
15 psig
MicroPure Filter
CO2
Supply
CLAS12 HTCC Gas System Controls
George Jacobs 03/22/2016
Physics DSG Group

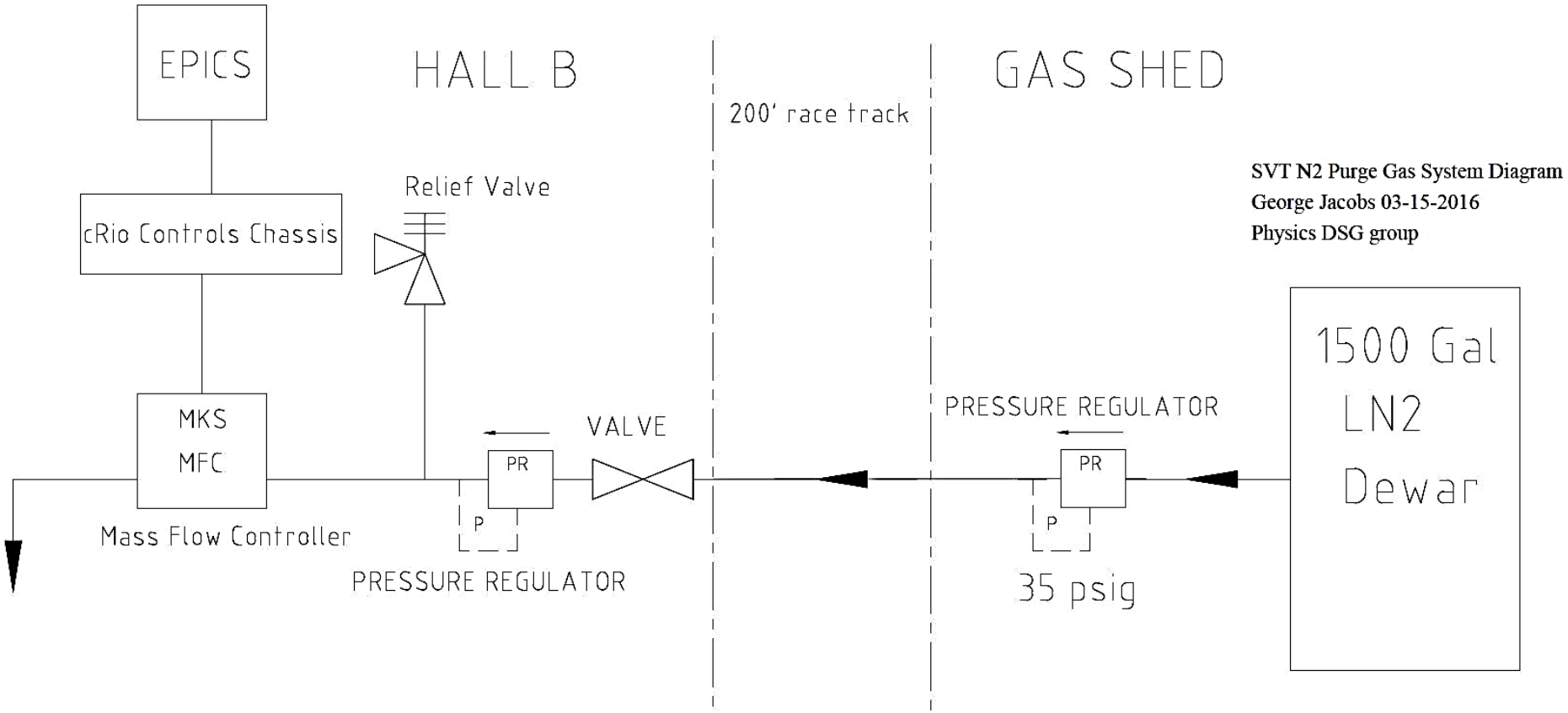
HTCC Critical Path for Operations

- Run
  - Gas line from mass flow controller to HTCC
  - Cables from the controls chassis to system components
    - Mass flow controller
    - Pressure transducer
    - H_2O sensor
  - Network cable to mass flow controller

SVT N_2 Gas Purge Supply

- Dry N_2 gas supplied via Hall B N_2 service supply
- N_2 gas purity >99.998% with <3 ppm H_2O
- N_2 purge flow controlled by MKS mass flow controller

SVT N2 Purge Gas System Diagram



Critical Path for SVT N_2 Purge Operation

- Install mass flow controller in Hall B
- Run
  - Cable from controls chassis to mass flow controller
  - Network cable to mass flow controller
  - Gas line from mass flow controller to SVT cart

Review
Hall B Gas System

Conclusion

- All DSG staff have contributed to the project.
  - Procurement, hardware, software, testing, debugging, installation, and servicing
- Remaining hardware for DC to be purchased FY2017
- Gas for all detectors to be procured FY2017
- Installation in progress for DC, LTCC, HTCC, and SVT
- Procurement in progress for RICH
- Procurement for MVT and FT to occur FY2017

Thank You