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% CO₂ 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

- Atm
- Vacuum Pump in 96B
- Control Valve in Hall B
- cRio PID Control
- Pressure Transducer
- Exhaust Manifold
- Supply Manifold
- Detectors

Gas Supply from 96B
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 CO₂
  – 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 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

HALL B

Controls Chassis

200ft Race Track

Gas Shed

C4F10 Supply Tank

C4F10 Exhaust Tank

Detector

EPICS

DPT

DP25-E

SV

MFC

PR

PSV

cRio PID

DPT

Pressure Control Tank

CLAS Cerenkov Gas System Controls Diagram
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LTCC Gas Panel – Hall B Level 1 Forward Carriage
C₄F₁₀ Recovery

• Due to high cost of C₄F₁₀, gas recovered and re-used
• Distillation unit condenses C₄F₁₀ for re-use
• Liquid N₂ cools the gas
• Recovery process complex
  – Requires trained operators
• Distillation unit’s temperature control is automatic
$C_4F_{10}$ Recovery System

LTCC C4F10 Distillation System

Vent to ATM

1500 Gal LN2 Dewar

C4F10 Supply To Hall B

Concrete Gas Pad

Vent CG93

LN2 Supply CG92

N2 Supply CG91

CG90

C4F10 SUPPLY

CG114

2 psig

CG93

PR

CG117

CG99

Liquid C4F10 discharge

96B Gas Shed

Heat Exchangers

Distillation Unit

Scale

Distillation Flow

Recovery Pump

CG85

CG86

C4F10 Buffer Tank

1500 Gal Capacity

Concrete Gas Pad

LN2 Vent to ATM

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C\textsubscript{4}F\textsubscript{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 N₂
- Procurement of C₄F₁₀ gas
  - Long lead time for bulk purchase
- Attach C₄F₁₀ 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% $\text{C}_4\text{H}_{10}$ in argon
  – Mixture 2 – 10% $\text{C}_4\text{H}_{10}$ 10% $\text{CF}_4$ 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 \( \frac{1}{2} \)” stainless steel tubing running between gas shed and Hall B Level 1 space frame
MicroMegas Gas Shed Valve Panel

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

Argon → PR → 30 psig → C4H10 → Scale

Heater Blanket

10% C4H10 Balance Argon

MFC → Mixing Buffer → To Hall B

2 Gal

PT

PRESSURE TRANSUDER

cRio Control
MVT Mix 2 Pressure Control

- Mix 2: 10% CF$_4$, 10% C$_4$H$_{10}$ 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 flow rate 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
MVT Mix #2 - 10% CF4 10% C4H10 in Argon

Heater Blanket

C4H10
Scale

CF4
Scale

Argon

PR

30 psig

MFC

MFC

MFC

Pressure Transducer

2 Gal Mixing Buffer

10% C4H10
10% CF4
Balance Argon

To Hall
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$_2$O 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 N2 Purge Circuit Valve Panel

2-23 slm Flow Meter

 VALVE

Pressure

45 psig Relief Valve

0.01 micron PTFE Filter

Actuated Charcoal Filter

Flow Transducer 0-20 slm

MFT

To RICH #2

To RICH #1

N2 IN

VALVE

RICH N2 Purge Circuit Valve Panel
George Jacobs 06/01/2016
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Review
Hall B Gas System
Cooling Circuit Interlocks for RICH HV and LV Power to be Enabled
Air Compressor Power ON Interlock – 11 and/or 12 or PS Power is Disabled
Air Pressure Interlock – 13 $> 100$ psi (TBD) or Power Disabled
Air Flow Interlock RICH #1 Power – 14 $> 250$ slm (TBD) or Power to RICH #1 Disabled
Air Flow Interlock RICH #2 Power – 15 $> 250$ slm (TBD) or Power to RICH #2 Disabled
RICH Cooling Circuit Valve Panel

FROM 240 Gal Air Tank
10" OD SS Tubing

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FROM 240 Gal Air Tank
10" OD SS Tubing

75 psi Relief Valve

FROM Compressor #1
McMaster Carr Part# 52785K651

FROM Compressor #2
McMaster Carr Part# 52785K651

Mass Flow Meter

George Jacobs 05/26/2016
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Hall B Gas System
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 CO₂ Gas Supply

• CO₂ supplied via 182 Kg liquid CO₂ dewars located at 96B gas shed
  – CO₂ is 99.99% pure
• HTCC shares the CO₂ supply with DC gas system
• CO₂ gas flow controlled by MKS mass flow controller
• Detector pressure limited by passive oil-filled pressure relief bubbler
HTCC Gas System Controls

HALL B

Network → cRio Chassis

H2O → MKS 223 → DPT

GAS SHED

200 foot Race Track

MicroPure Filter

15 psig

CO2 Supply

CLAS12 HTCC Gas System Controls
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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$_2$O sensor
  – Network cable to mass flow controller
SVT N₂ Gas Purge Supply

- Dry N₂ gas supplied via Hall B N₂ service supply
- N₂ gas purity >99.998% with <3 ppm H₂O
- N₂ purge flow controlled by MKS mass flow controller
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
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