DSG Projects

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10/16/2018

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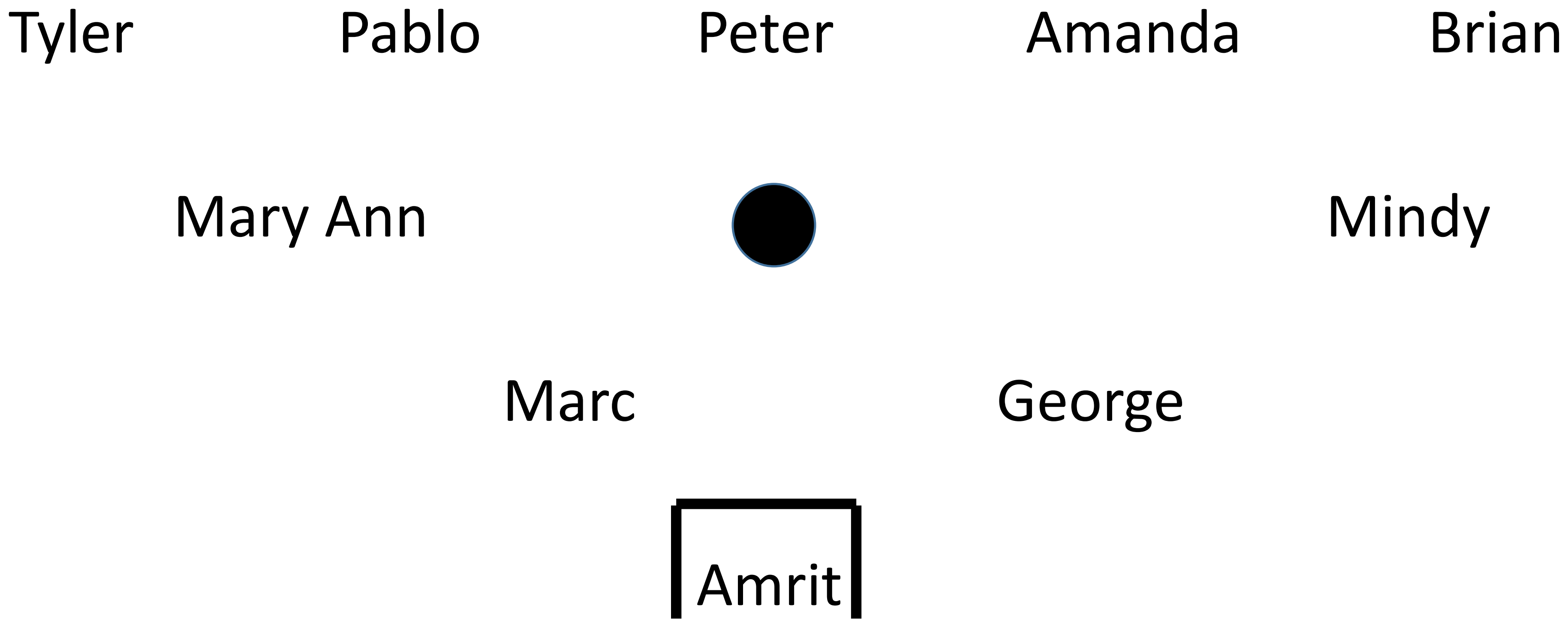
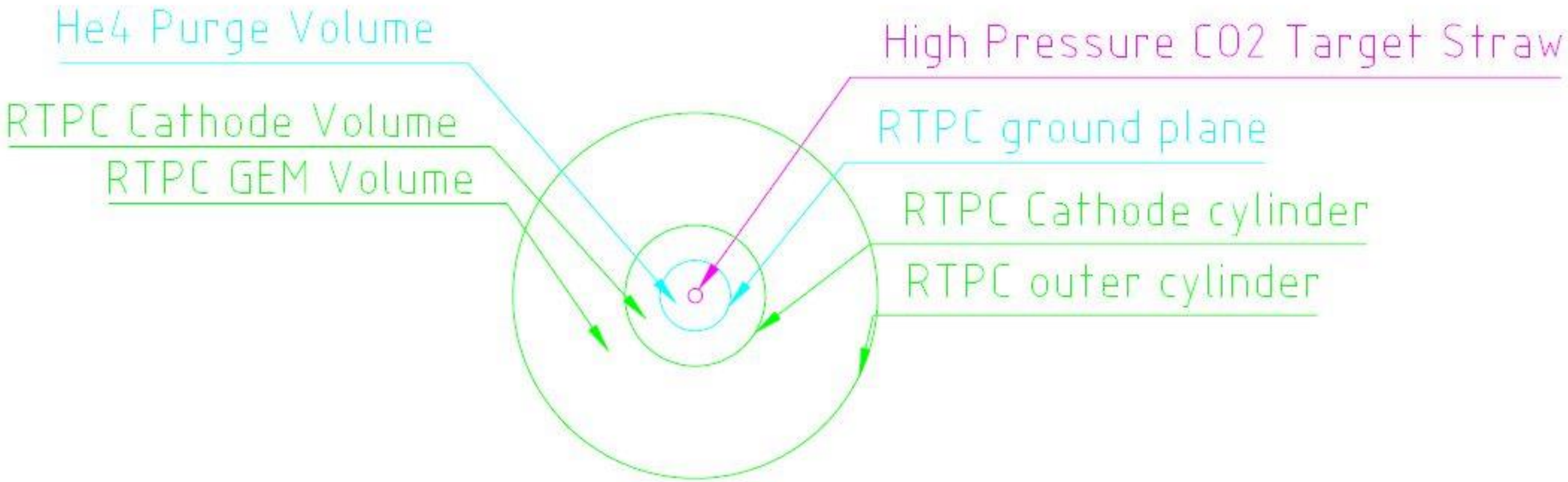
DSG Staff

(Owner/Manager Patrizia)



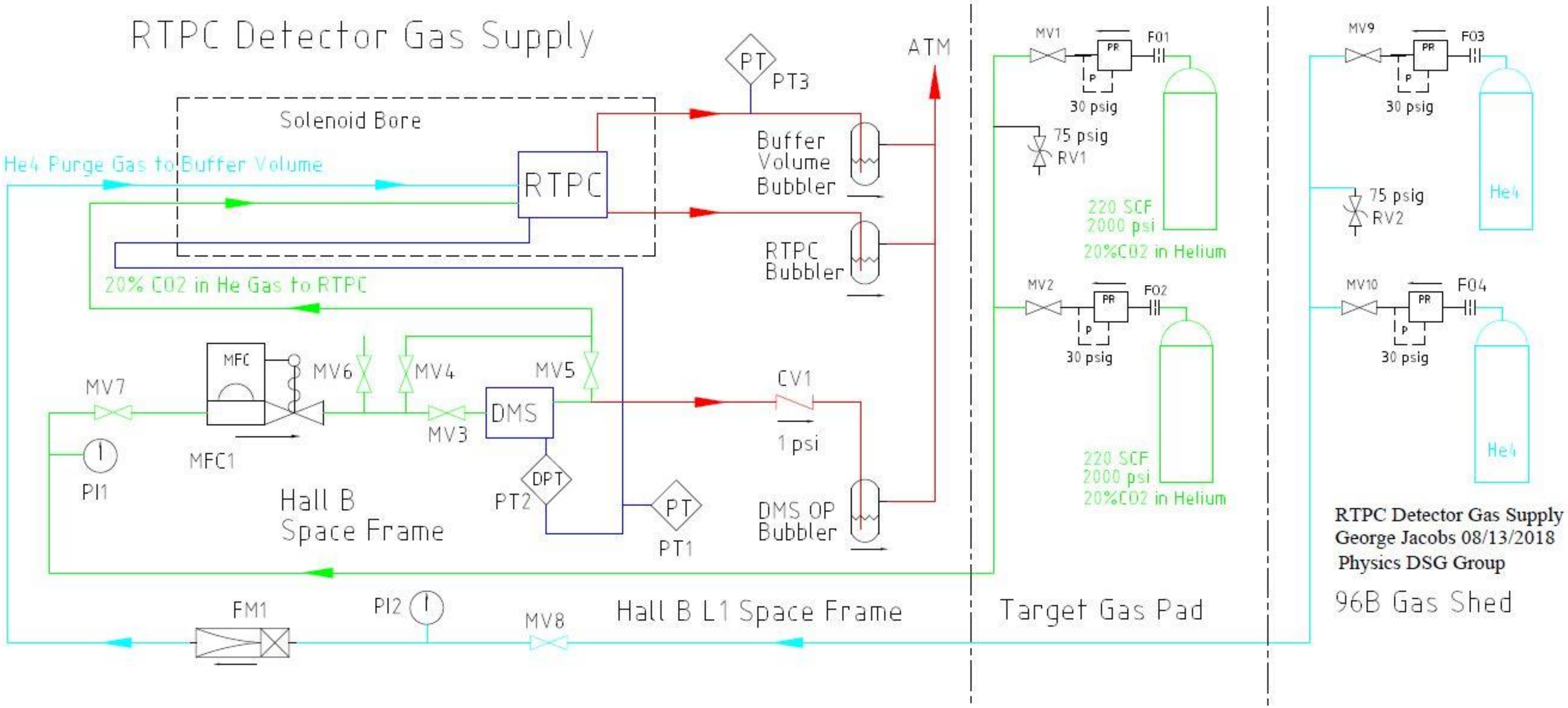
Gas Systems

Hall B: Radial Time Projection Chamber's (RTPC) Gas System



- RTPC and Drift Monitor System (DMS) use 20% CO_2 in He pre-mix gas
- Buffer volume purged with He (by Legacy Hall B He Gas System)

Hall B: RTPC Gas System's P&I Diagram



20% CO2 in He pre-mix gas is located on the Target gas pad.
He purge gas is located at the 96B gas shed
Gas panel is located in Hall B on Level 1 Space Frame

Hall B: RTPC Controls and Monitoring System

- GUI, on NI cRio, controls the MFC and monitors signals.
- Signals available on EPICS
  - RTPC Gas Flow: 120 sccm
  - RTPC Absolute Pressure: 760.2 Torr
  - DMS-RTPC Differential Pressure: 0—0.1 Torr
  - Buffer Absolute Pressure: 760.2 Torr
  - Buffer He flow: 10—20 sccm
- Design is complete.

“Sorry to say, I’ve plain run out of things to nag about - it’s perfect!” Sebastian K

- A pressure systems design authority has been assigned.
- Construction is in progress at William and Mary

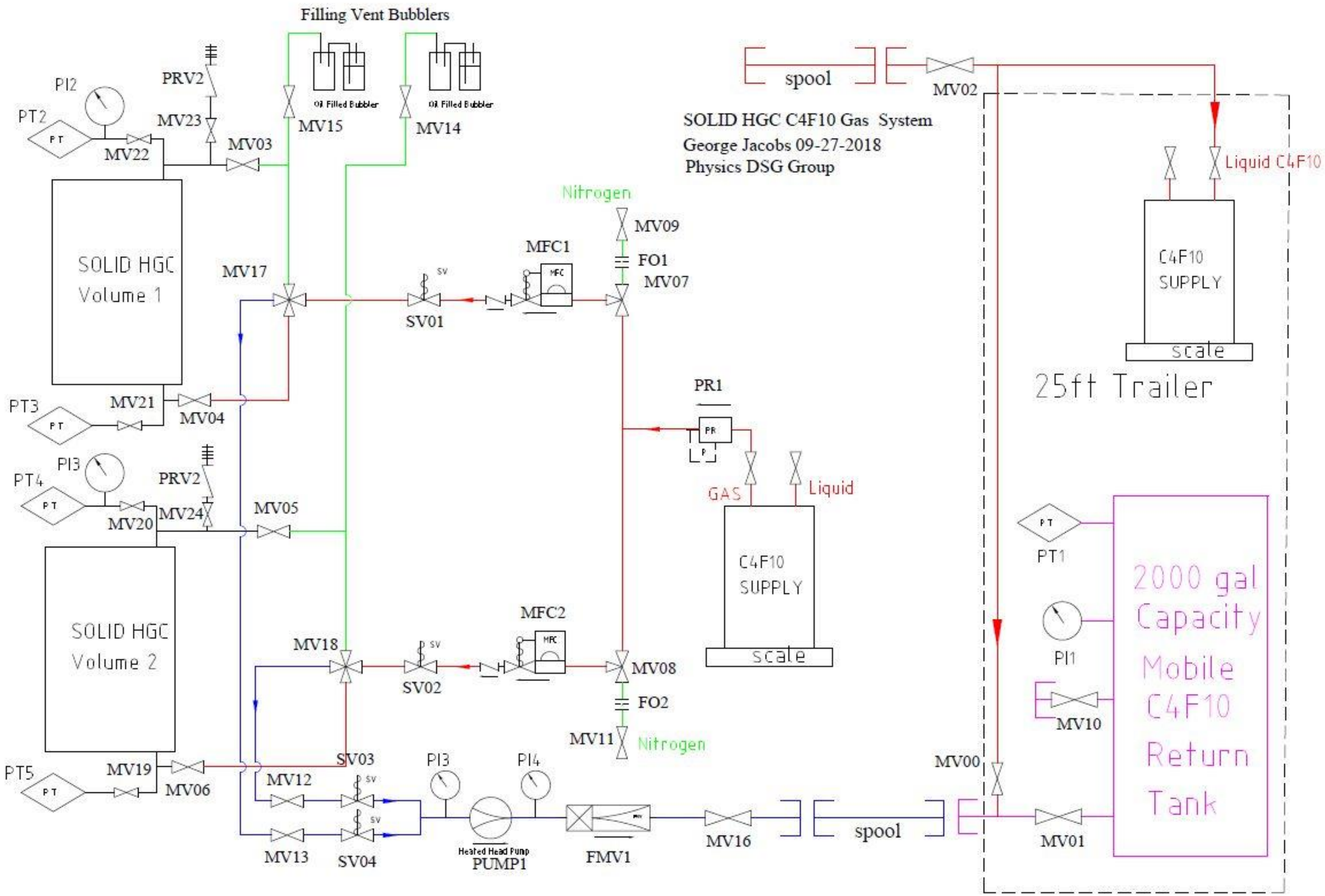
Hall A: Gas System for Solid Heavy Gas Cerenkov (HGC)

- Two “Fill & Seal” detectors operating at 1.5 atm (~7 psig) .
  - Atmospheric pressure changes will not affect detector pressure.
    - During hurricane Michael ΔP~5%
- Detector volume ~10,000 l (~150 Kg of C_4F_{10})
  - “Leak tight” detector critical
    - C_4F_{10} cost, $260/Kg. (Petrol costs ~$0.80/Kg)
- Potential sources of gas loss
    - Detector volume leakage
    - Loss during recovery operations

Hall A: Solid HGC Control and Monitoring System

- Functions
  - Fill gas volume
  - Remove and store gas from gas volume
  - Maintain pressure @ 1.5 atm
- MFCs determine detector volume's leak rate.
- C_4F_{10} recovery for reuse, will use the Hall B distillation system
  - Only minor changes required for the connections
- Mobile gas return tank collects gas from detector volumes
  - Mobile gas return tank eliminates need of fixed tank and heated gas line

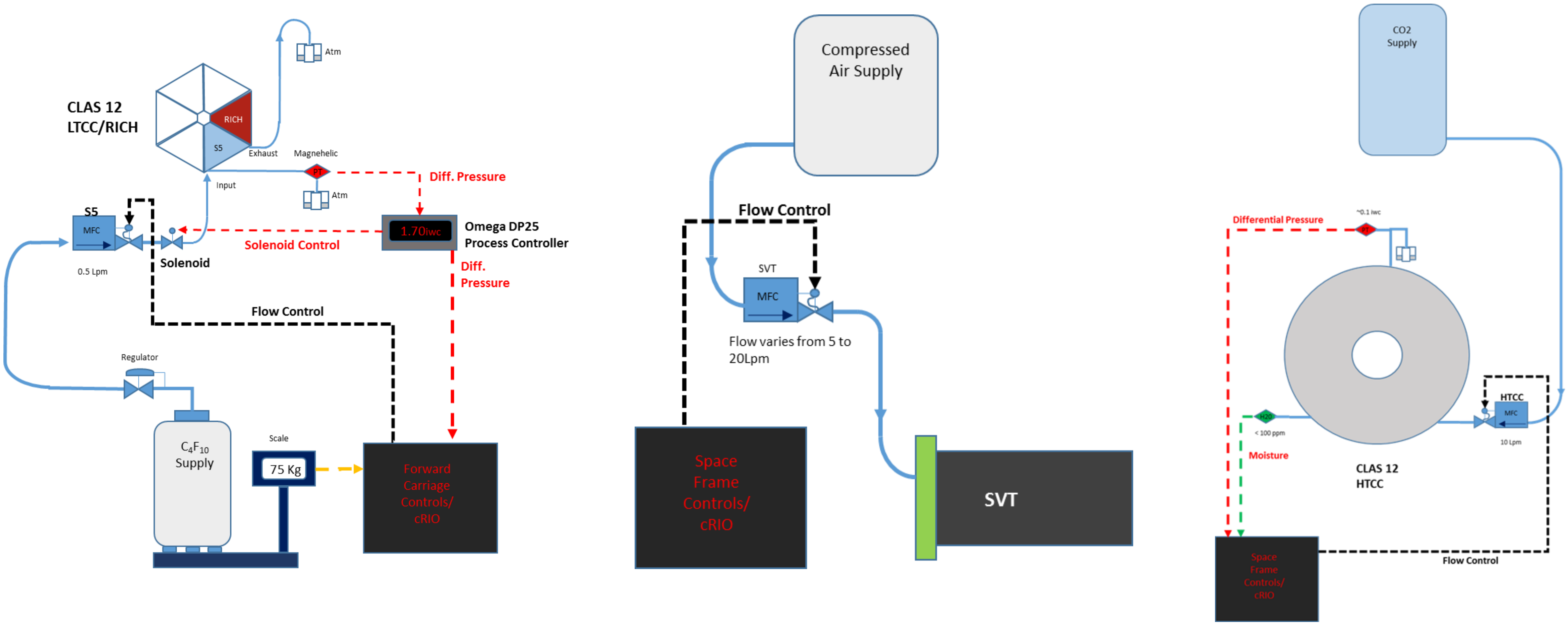
P&I Diagram


Filling Vent Bubblers
Oil Filled Bubbler
Oil Filled Bubbler
PI2
PT2
PRV2
MV23
MV22
MV03
MV15
MV14
SOLID HGC Volume 1
MV17
Nitrogen
MV09
MFC1
FO1
MV07
SV01
MV21
MV04
PT3
PI3
PT4
PRV2
MV24
MV20
MV05
SOLID HGC Volume 2
MFC2
MV18
SV02
MV08
FO2
MV11
Nitrogen
PT5
MV19
MV06
SV03
MV12
MV13
SV04
PI3
PI4
Heated Head Pump
PUMP1
FMV1
MV16
spool
PR1
GAS
Liquid
C4F10 SUPPLY
scale
spool
MV02
SOLID HGC C4F10 Gas System
George Jacobs 09-27-2018
Physics DSG Group
Liquid C4F10
C4F10 SUPPLY
scale
25ft Trailer
PT1
PI1
MV10
MV00
MV01
2000 gal Capacity Mobile C4F10 Return Tank

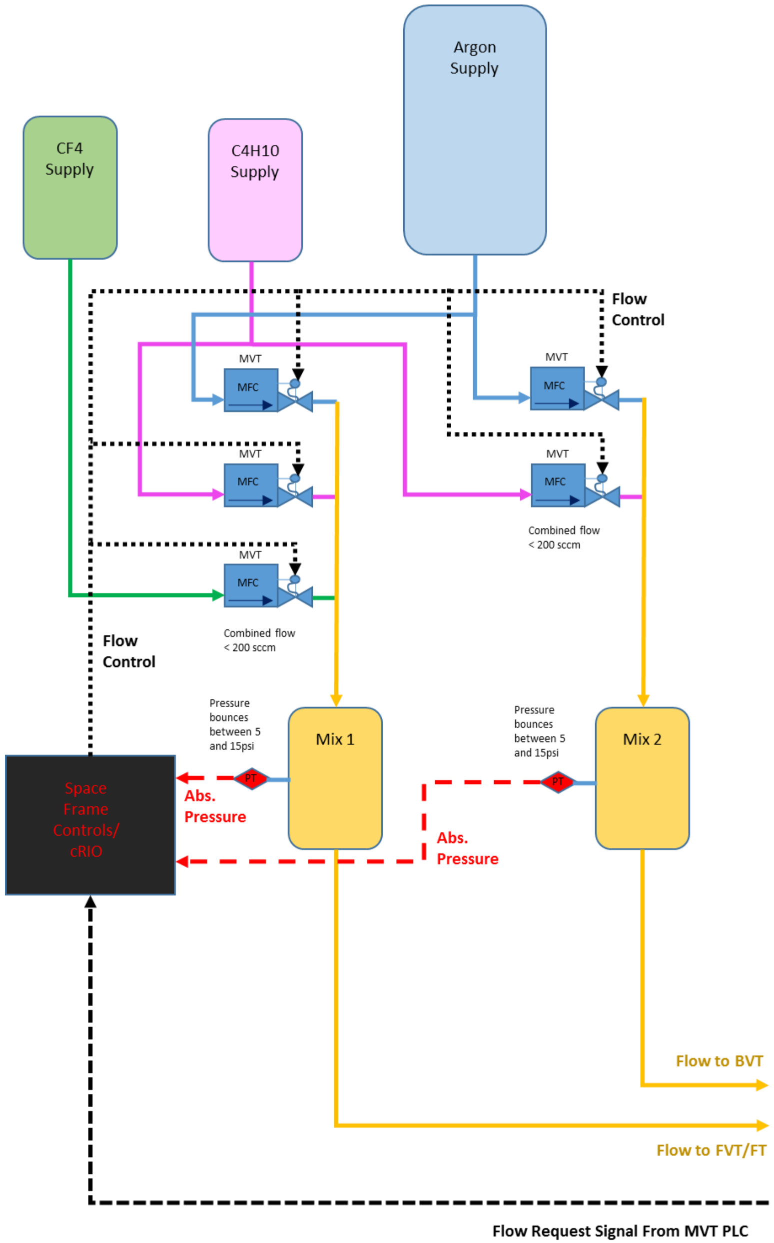
Hall B Gas System's Controls and Monitoring System

- Five Controls and Monitoring systems supply six detectors.
  - DC (Mixing and Supply)
  - HTCC (Supply)
  - LTCC (Supply)
  - SVT (Supply)
  - MVT/FT (Mixing)
- Installation completed in Q4 2017.
- System provides automated controls for DC and MVT/FT mixing systems.
- Intuitive monitoring and control screens for technical staff.
- Provides data for the Hall B EPICS alarms system

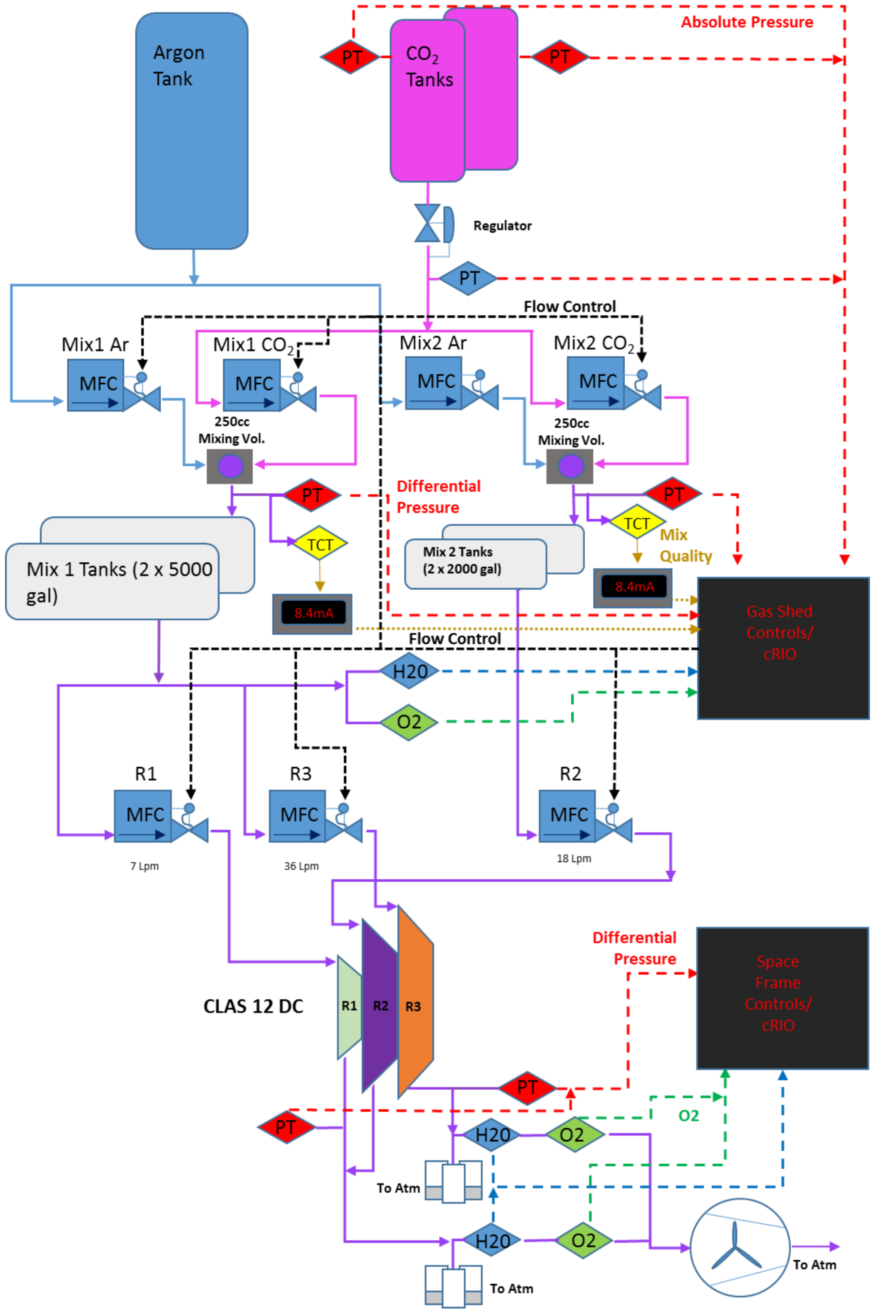
LTCC/SVT/HTCC Controls and Monitoring System



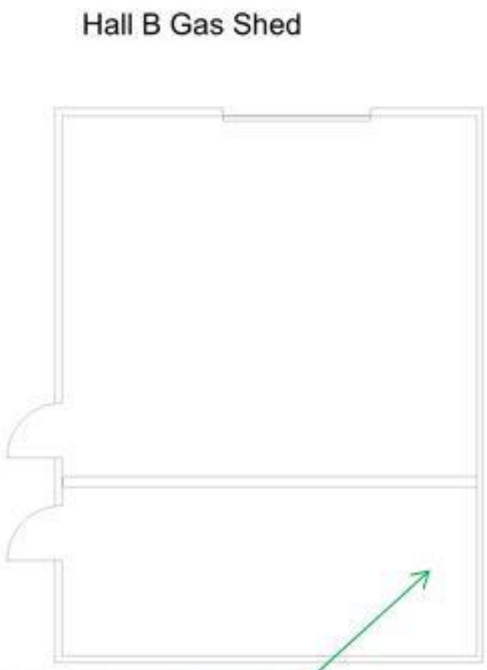
MVT/FT Controls



DC controls

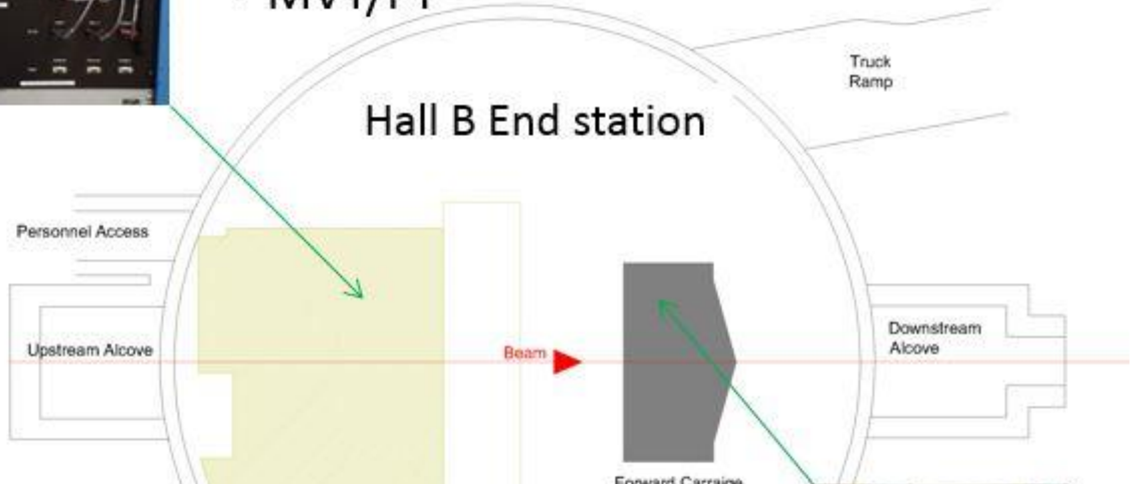

Argon Tank
CO_2 Tanks
PT
Absolute Pressure
Regulator
Flow Control
Mix1 Ar
Mix1 CO_2
Mix2 Ar
Mix2 CO_2
MFC
250cc Mixing Vol.
Differential Pressure
TCT
Mix Quality
Mix 1 Tanks (2 x 5000 gal)
Mix 2 Tanks (2 x 2000 gal)
8.4mA
Gas Shed Controls/ cRIO
H20
O2
R1
R3
R2
7 Lpm
36 Lpm
18 Lpm
CLAS 12 DC
Space Frame Controls/ cRIO
To Atm

Hall B Gas Controls: System Locations



Space Frame L3

- DC
- SVT
- HTCC
- MVT/FT



Hall B Gas Shed

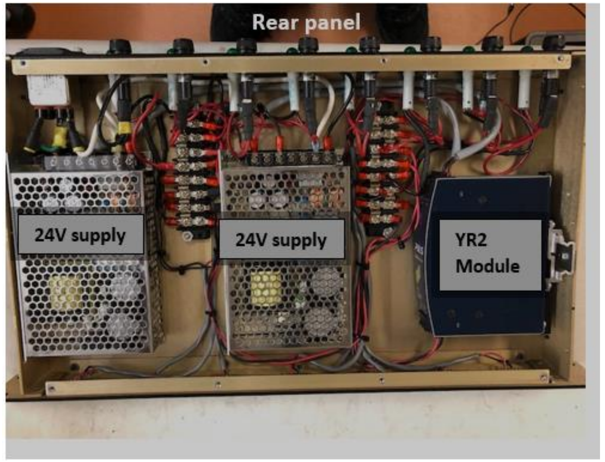
- DC Gas Mixing and Regional Supply
- LTCC Pump Control

Forward Carriage

- LTCC

Gas Controls : MFC Power Chassis

- Individual power chassis
  - Allows system maintenance without interruption of gas flow.
    - MFC will receive power, while work is being done on the interface chassis
  - Contains redundant power supplies.
- Designed, prototyped, and tested.
- Unit installed in gas shed
  - Supports DC Mixing and Supply MFCs.



Magnet Controls

Hall C: PLC Programming

- Developed PLC code for SHMS and HMS
  - Dipole Field Regulation
  - Monitoring UPS backup power supply
  - HMS spectrometer vacuum alarms
  - Quadrupoles Current Regulation

- To be implemented during next shut down

View of the SHMS magnets in Hall C

View of the HMS magnets in Hall C

Hall C: NMR Unit PT 2026

- Configured PT2026 in the Hall C subnet
  - Unit has ethernet interface
  - While testing and configuring found issues with the firmware.
    - NMR unit freezes upon opening connection between unit and computer/PLC
    - Implemented remote power cycle for the unit from the HMS PLC.
- Wrote Python code for Single Board Computer card for PLC controller to communicate with PT2026 NMR unit via Ethernet.
  - SBC resides in a 3-D printed box.

- Installed PT 2026 and its probe in HMS dipole
  - Testing functionality of unit in dipole
  - Issues with locking when dipole field > 1.4 T
    - Different RF Pulse setting in PT2026 required, when dipole field > 1.4 T
- Testing in progress

ROC-RK3328-CC SBC card implemented in Hall C control systems

Metro-Lab PT2026 NMR unit

Hall C: PLC communication modules

Stand Alone PLC setup

- Tested performance and compatibility of PLC system running two different PLC communication modules
  - Controlnet and Ethernet modules
- Test set up with three PLC chassis.
  - Local PLC chassis (X1) : Set up with PLC controller and ControlNet and Ethernet modules
  - Remote PLC chassis (x2): set up with ControlNet and Ethernet and IO modules.
  - Used same PLC controller 1756 - L62 and similar 1756 -IO modules as used for SHMS except for redundancy modules (not available for this test)
- PLC control system runs with both ControlNET and Ethernet modules
  - PLC controller performance and data transmission between local and remote PLC chassis, not affected

Hall C: SHMS PLC upgrades

Converted PLC control systems from version 16 to version 20
Note: Highest version supported by the SHMS PLC controller (1756-L62) is the version 20.58

Upgraded:

- Redundancy modules, communication modules

- Rockwell's PLC software on Windows 7 computers
    - Skylla7 and Controls7 (computer/laptop)
  - RSLOGIX5000 v20.
  - RSNetworks v26. for Ethernet and Controlnet
  - ControlFlash v15

- Firmware for Primary and Secondary SHMS PLC chassis:
  - 1756-L62 PLC controllers from version 16 to Version 20
  - 1756-RM redundancy modules
  - 1756-EN2T Ethernet modules
  - 1756- CN2B ControlNet modules

Hall C: SHMS PLC upgrades

- Re-synchronized redundancy configuration between primary and secondary PLC chassis.

- Swapped Controlnet modules with Ethernet modules for SHMS Quadrupole 1 and Heater Exchanger PLC chassis
    - Reason: On several occasions Controlnet modules lost communication with Local PLC, affecting cryogenics in halls
  - Configured new 1756-EN2T and ENBT Ethernet modules
  - Assigned and tested modules in the *Hall C* subnet
  - Generated new SHMS project file with the module modifications.
    - System configured with two remote chassis communicating with the Local PLC chassis via Ethernet and the remain six PLC remote chassis via ControlNet network.

- Both type of module work in parallel

Hall C: Windows 7 End of Life

- Support for Windows 7 by computer center ends January 2020
- Researched Windows 10 compatibility requirements for HMS and SHMS control systems
- Tested Windows 10 compatibility with SHMS
  - Rebuilt “dsg-hallc-6” windows 7 computer with windows 10
  - Configured computer on Hall C Dev subnet.
  - Installed required Rockwell software to run PLC control systems
  - Went on line with SHMS PLC
- Selected PLC software and firmware upgrades for SHMS control systems run in Windows 10 environment

Hall D Solenoid

- Maintenance/Improvements of existing FastDAQ system
  - National Instruments PXIe
  - 8x 16-bit 8 channel ADC modules
    - Samples @ 250 kHz, data exported @ 10 kHz
- Upgraded controller
  - Increased data rate from 5 to 10 kHz (previous controllers obsolete)
- Installation of additional ADC modules
  - Monitor additional voltage splices, accelerometers
- Perform annual calibration of ADC modules
  - Automate procedure to reduce time required

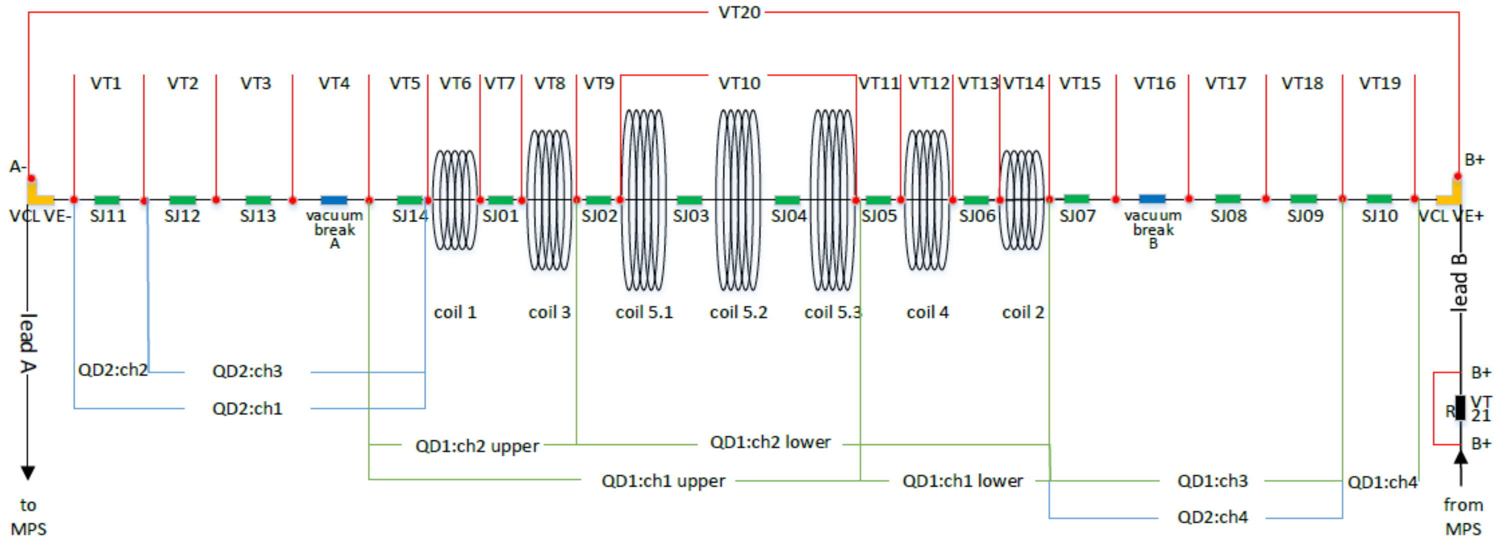
Hall B Solenoid & Torus

Current Activities

- *Pre-power-up interlock* procedure performed prior to full current magnet operation to verify I&C interlocks are operational
  - B00000400-P005
- *Pre-power-up instrumentation checkout* performed prior to full current magnet operation to verify I&C interlocks are operational
  - B00000400-P003
- Provide off hour on call support for magnet controls support (Amanda, Brian, Tyler, Pablo)

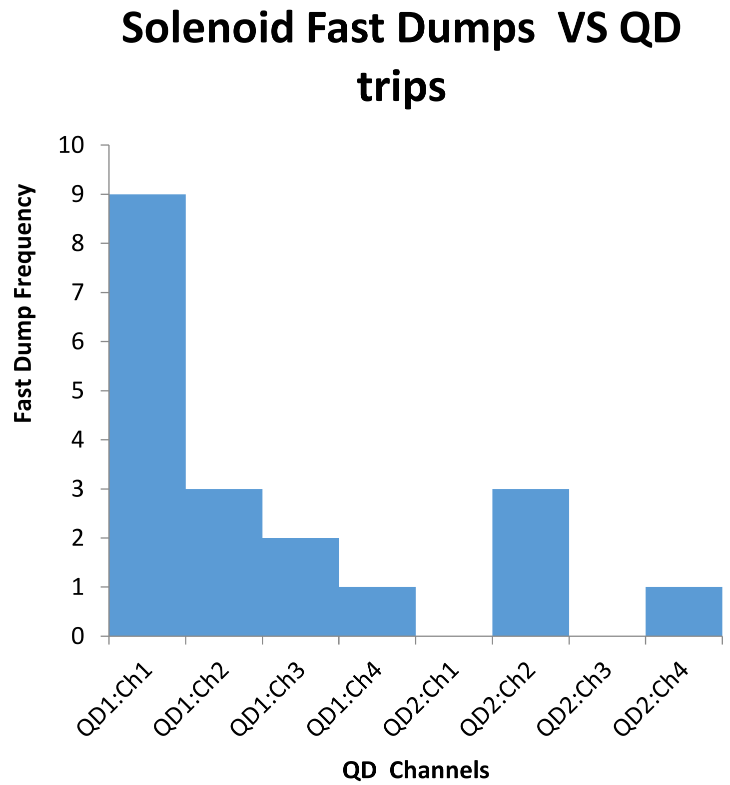
Hall B: Solenoid Quench Issues

- There have been 19 Fastdumps.

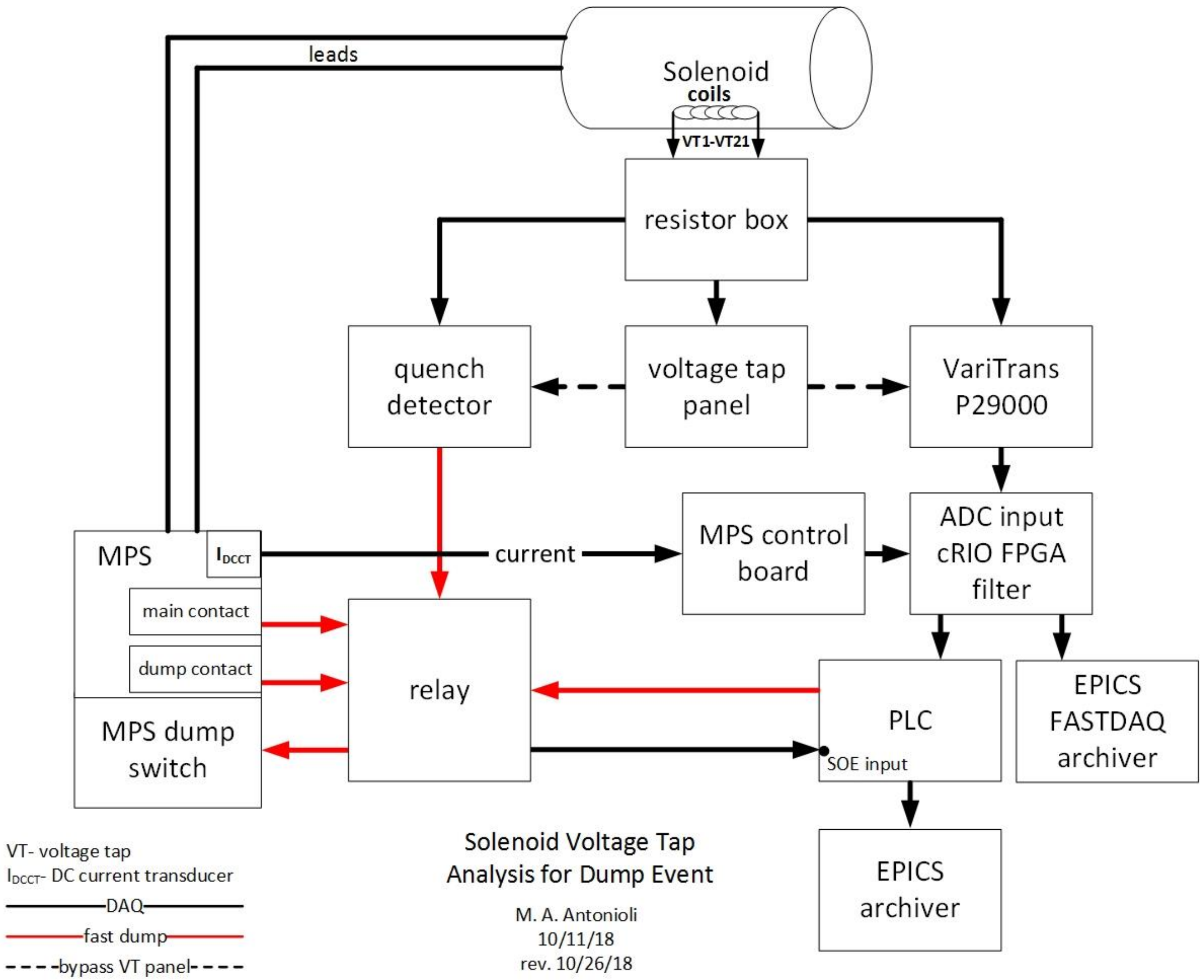


SJ= splice junction
VT = voltage tap
VCL = vapor-cooled lead
QD=quench detector
ch=channel

Solenoid Voltage Taps
M.A. Antonioli
12/20/16
rev. 3/1/18
rev. 10/24/18



Hall B: Solenoid Timing Issues



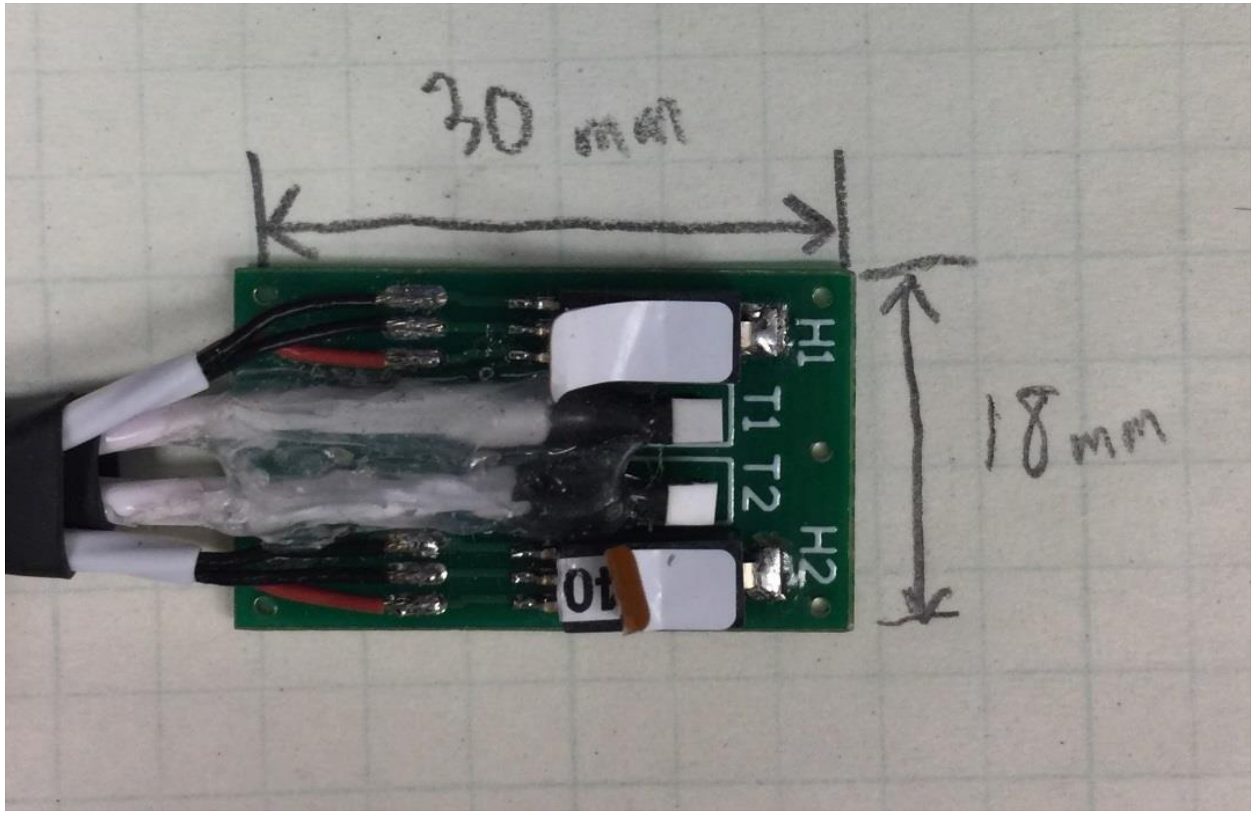
HallB: Solenoid Solenoid Issues

- Analysis of timing issues between SOE, FastDAQ, and power supply contactor
- Analysis of voltage tap values
  - Quench detectors appear to trip on shorter than set value of time over threshold
  - Checking of quench detector potentiometers
- Investigation of stresses on solenoid and torus

Hall B Interlock Systems

Interlock Systems

- Designed hardware interlock systems for **SVT, FT**, and **RICH**.
  - National Instruments cRIO-based system.
  - All systems use NI cRIO-9030 series controllers.
- cRIOs run DSG-developed LabVIEW programs.
  - Programs monitor detector conditions and take appropriate actions if sensors go out of limits.
- Updated LabVIEW programs of existing systems to provide new features.
  - Averaging, time-over-threshold trip, and delay controls for individual sensors.
  - Improved configuration file logging.
- All systems have EPICS user interface and an "expert" LabVIEW user interface.

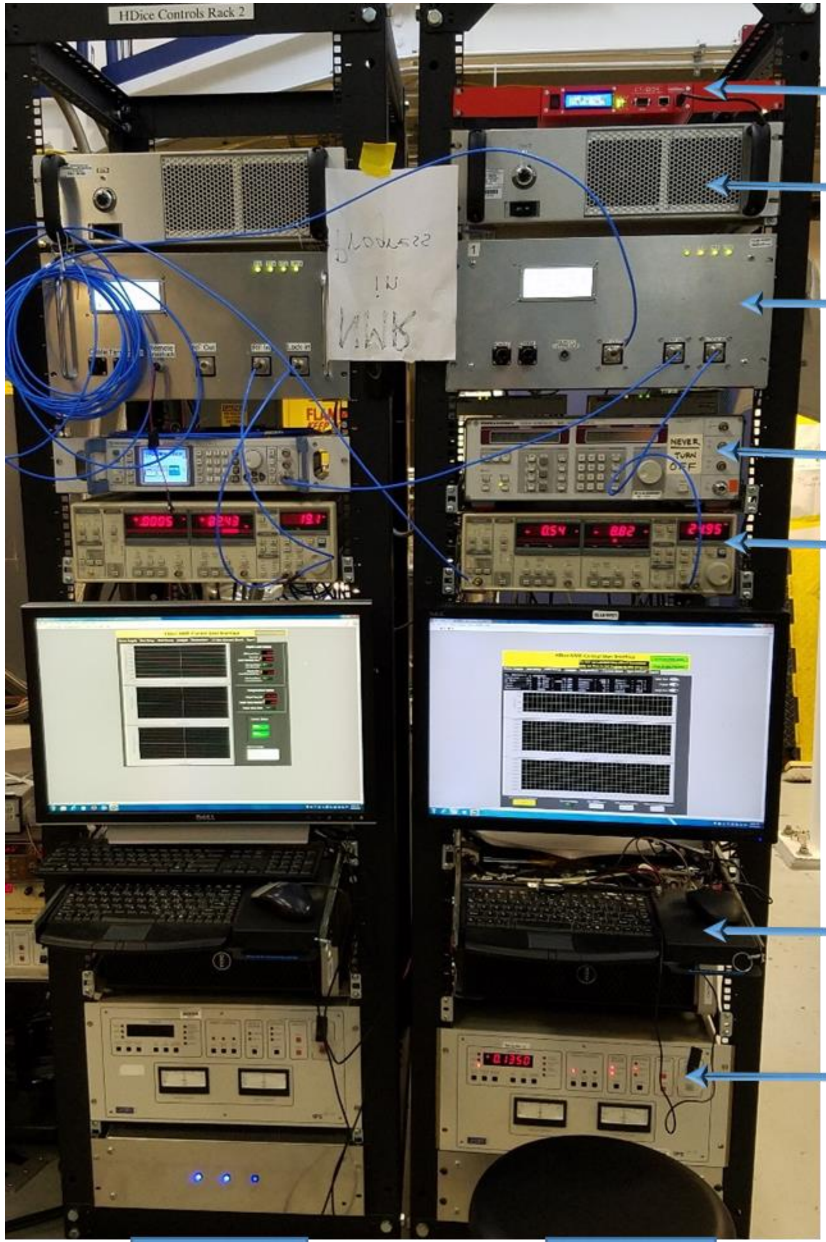


DSG-designed and assembled Humidity-Temperature Sensor Board (HTSB). HTSBs are used in all of DSG's hardware interlock systems.

HDIce

HDIce Program Development

- Researched, designed and assembled two racks (α, ω)
- Rack α has synchronization capabilities, Rack ω does not.
- Both racks completed and moved to HDIce Lab.



CT-box

RF amplifier

RF box

RF signal generator

Lock-in amplifier

CPU

Power supply

Rack ω

Rack α

NMR Synchronization

- Provides independent and accurate magnet current measurements
- Synchronizes current measurements with the lock-in amplifier measurements.
- Maximizes number of acquisition points for variable NMR sweep lengths (20 s—600 s.)
- Stores measurements in NMR data files.

Feature	Previous NMR	Synchronized NMR
Triggering	Asynchronous lock-in trigger.	Synchronized by external lock-in trigger.
Current Measurement Instrumentation	Oxford Power Supply.	CT-Box current shunt.
Data Stream	Asynchronous lock-in amplifier and current measurements.	Synchronized lock-in amplifier and current measurements
Data Acquisition Rates	Different DAq rates for lock-in buffer data & current measurements.	Same DAq rate for instrumentation. Variable rate to maximize data points.
Data Files	Current measurements not stored in NMR data files.	Current and lock-in amplifier measurements are stored in NMR data files.

CAENels CT-Box

- Synchronization with CAENels CT-Box (brand new product)
- Product issues with
  - Firmware errors required updates.
  - Hardware issues.
  - Lack of documentation on software protocols.
  - Not shipped with software we could use.
  - Required extensive development of a library of LabVIEW device drivers.
  - Developed LabVIEW Daq code using DSG device driver library
    - Tested CT-Box.
- All issues resolved

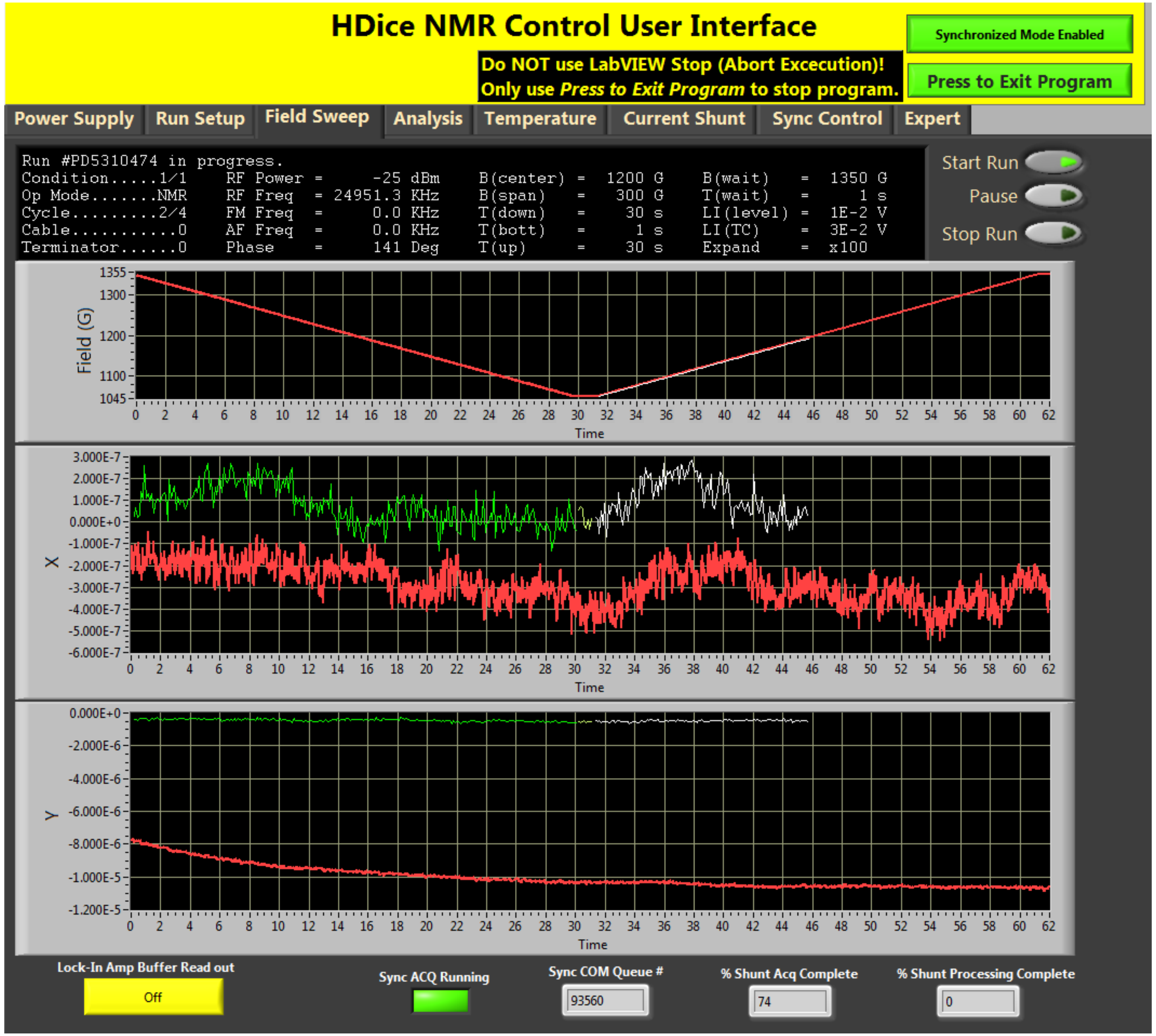
Synchronization Programs

- Developed data acquisition program CT-Box .
  - Tested CT-Box data acquisition and triggering.

- Developed test program for lock-in amplifier
  - Used with CT-Box data acquisition program to test:
    - Lock-in amplifier data acquisition.
    - Data buffer storage and read-out.
    - Lock-in amplifier dual data stream.
    - Lock-in amplifier external triggering capabilities and limitations.

NMR Program Cycle

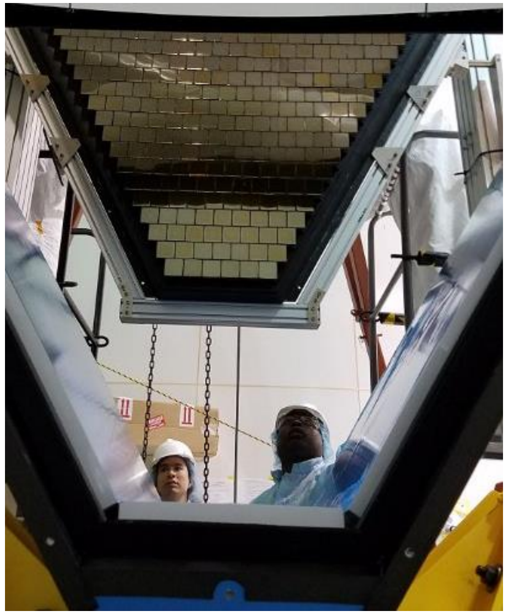
- Field graph shows scanning magnetic field, in Gauss, read from the CT-Box.
- X and Y graphs show data from lock-in amplifier.
- Red lines are averages of each scan.
  - After ~40 scans, two “hills” will be shown in the averaged data indicating NMR.
  - ~1200 scans are conducted to improve NMR reading and reduce noise.
- Run file:
  - Synchronization mode enabled.
  - Temperature and liquid helium level sensors enabled.
  - B(center): 1200 G
  - B(span): 300 G
  - Cycles: 4



Hall B Detectors

RICH Detector Assembly

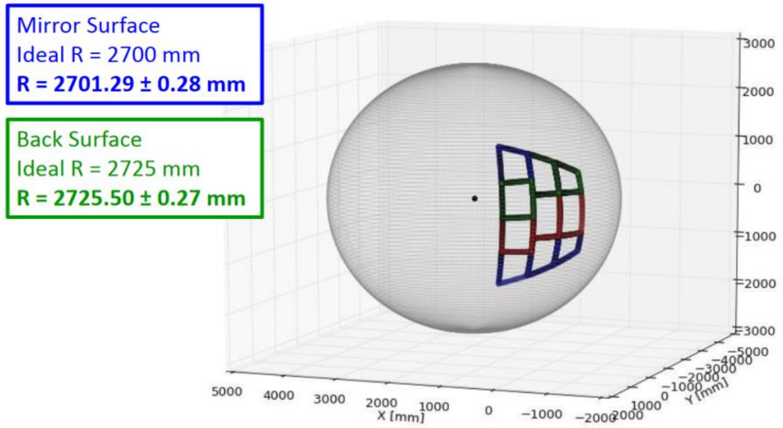
- Assembled in EEL 124 cleanroom.
- Load tested installation lifting structure.
- Installed all components
  - Exit window
  - Spherical mirrors
  - Environmental sensors
  - Electronic panel

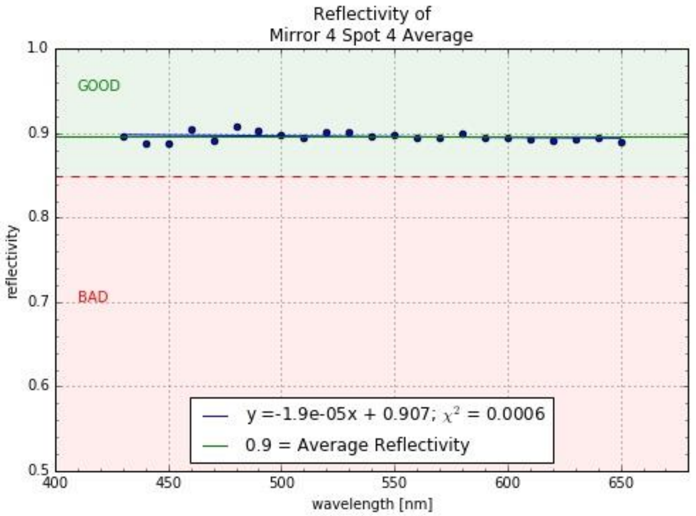


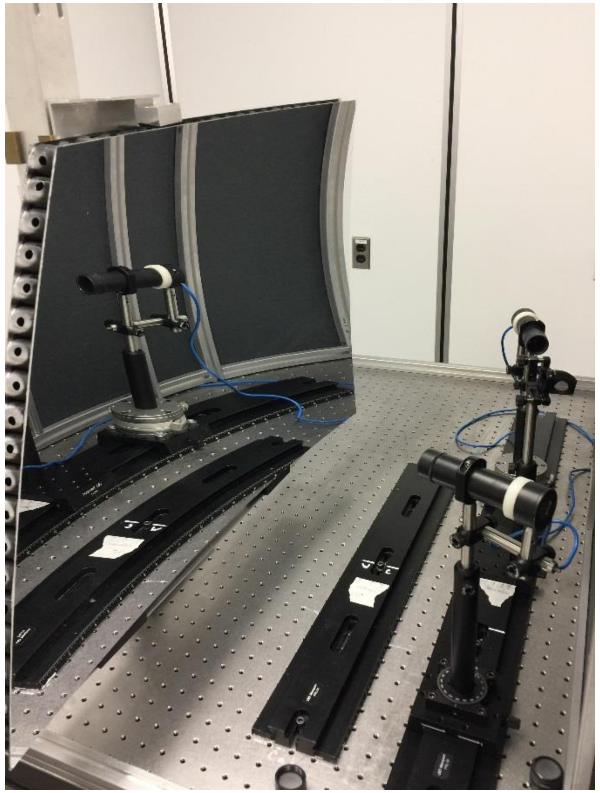
Top Left: DSG installing RICH's electronic panel.
Top Right: DSG performing load test of lifting structure (yellow structure).
Bottom Left: DSG and INFN collaborators in front of assembled RICH.

RICH Acceptance Tests

- Mirrors
  - Developed software to measure radius of curvature of mirrors.
  - Developed test station and LabVIEW software to measure mirror's reflectivity.
    - Bottom-left plot is results from one spot in Mirror 4.
    - Right photo is mirror on test stand and photodiodes for reflectivity measurement
  - Analyzed survey points of spherical mirror surfaces to confirm design specs.
    - Top-left plot shows all survey points fit on to a sphere to give the mirror assembly's radius of curvature.
- Aerogel
  - Inspected tiles on arrival.
    - Bottom-right photo is one 10 cm x 10 cm x 3 cm aerogel tile upon arrival at JLab.
  - Tested UV transparency of aerogel bracket for cosmic tests.



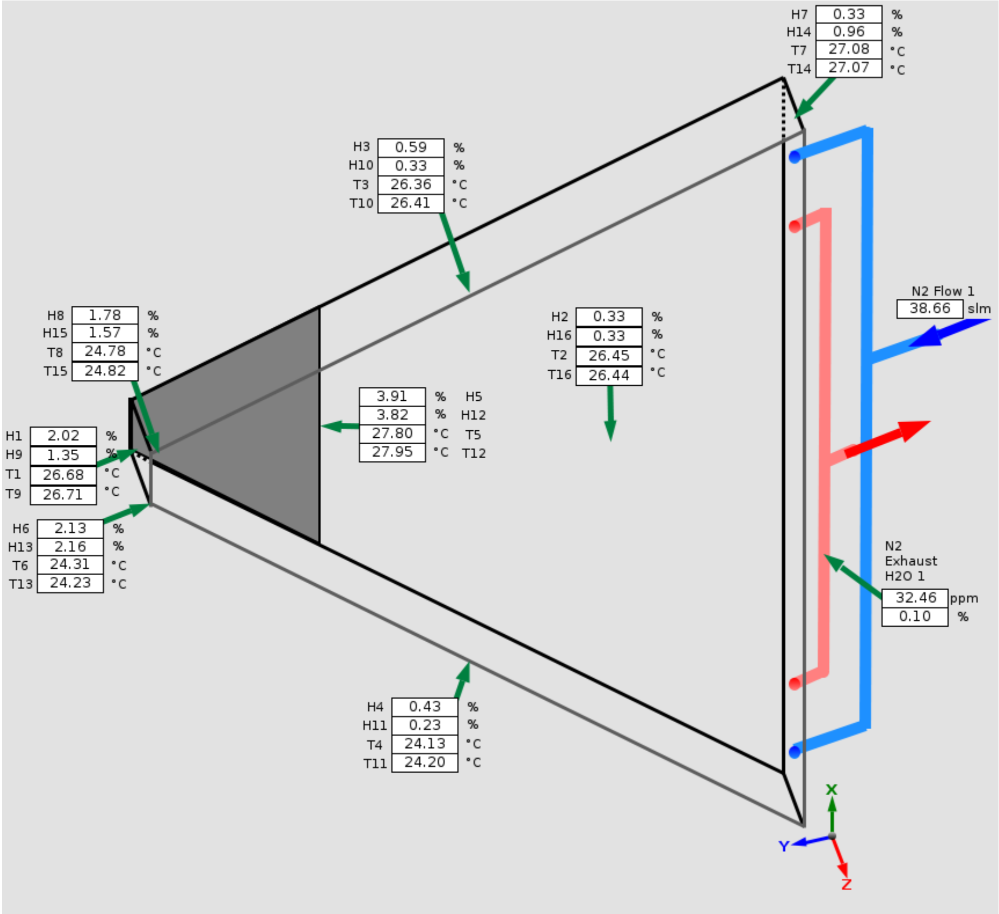




RICH Air-cooling and Nitrogen Purge System

- Air-cooling system (top)
  - Atlas-Copco compressors provide 900 slm airflow to RICH Electronics.
- Nitrogen purge system (bottom)
  - Hall B’s boil-off nitrogen dewar supplies 40 slm of nitrogen flow to keep N2 Vol free of moisture.
  - Critical for keeping RICH’s aerogel in a low humidity environment.
- Designing an automatic N2 Back-Up
  - New system will use a pneumatic valve that opens automatically if the main N2 supply pressure decreases to temporarily suppling RICH with N2 from gas bottles.
  - All components ordered.
  - Will install back-up supply during next downtime.

RICH N2 Volume Sensors

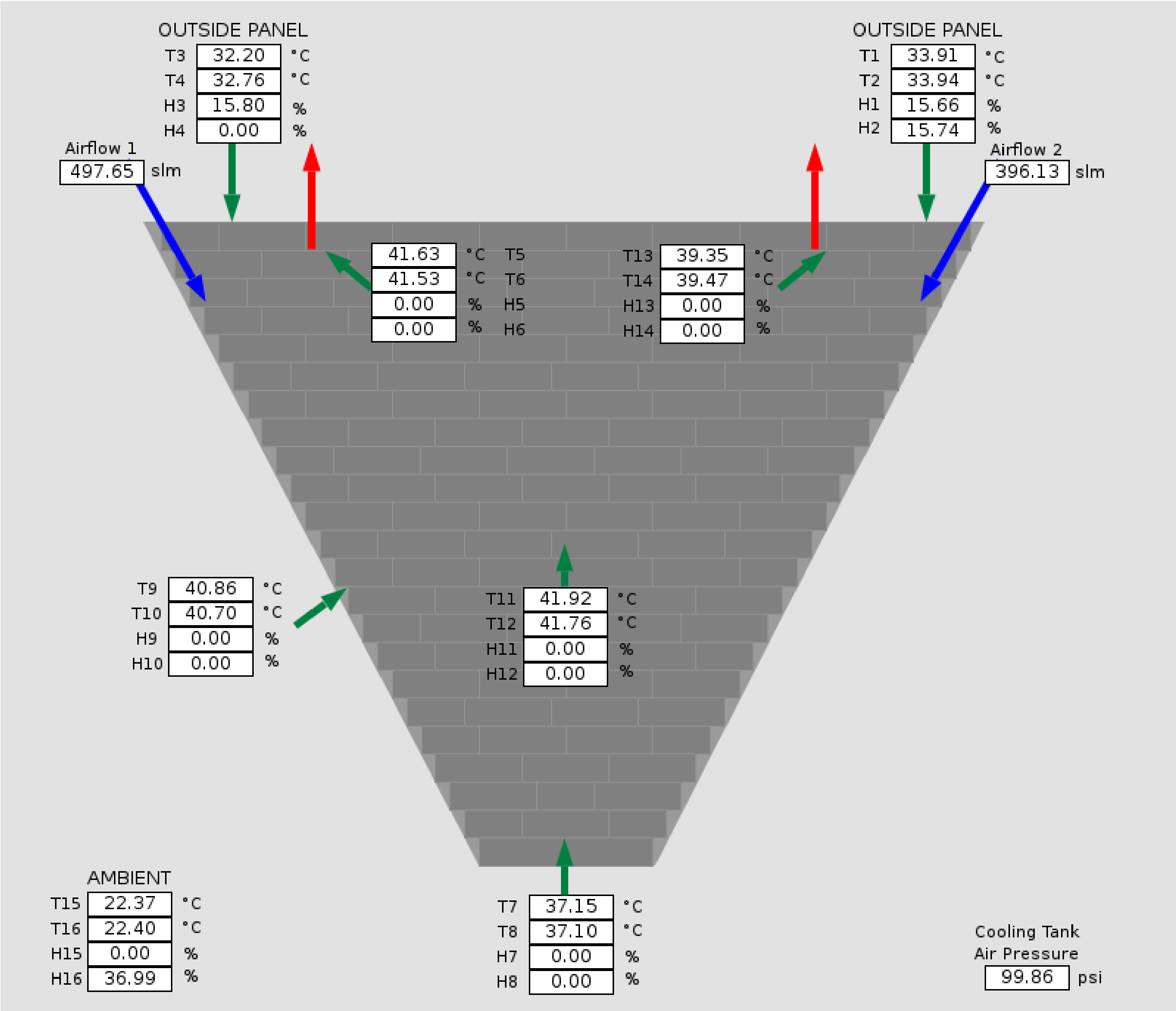


Sensor #	Location in Diagram	Temperature [°C]	Relative Humidity [%]
1	Back, near nose at electronic panel	26.68	2.02
9		26.71	1.35
2	Middle of front panel above aerogel	26.45	0.33
16		26.44	0.33
3	Top at edge of front panel	26.36	0.59
10		26.41	0.33
4	Bottom at edge of front panel	24.13	0.43
11		24.20	0.23
5	Middle near exit window, behind mirror mount	27.80	3.91
12		27.95	3.82
6	Front, bottom, near nose at aerogel	24.31	2.13
13		24.23	2.16
7	Top near N2 Exhaust	27.08	0.33
14		27.07	0.96
8	Front, top, near nose at aerogel	24.78	1.78
15		24.82	1.57
Average		**25.96**	**1.39**
Standard Deviation		**1.33**	**1.20**

Note: Humidity 5 and 12 have always been higher. Higher reading thought to be caused by placement behind mirrors.

Sensor	Value
N2 flow	38.66 slm
N2 Exhaust Water Concentration	32.46 ppm or 0.10 % RH

RICH Electronic Panel Sensors



Sensor #	Location in Diagram	Temperature [°C]	Relative Humidity [%]	
1	Outside of EP on right, back of RICH	33.91	15.66	
2		33.94	15.74	
3	Outside of EP on left, back of RICH	32.20	15.80	
4		15.80	0.00	Known bad sensor
5	In EP at left air exhaust	41.63	0.00	
6		41.53	0.00	At 0 % RH due to high temperatures in EP caused by electronics being powered.
7	Bottom of EP	37.15	0.00	
8		37.10	0.00	
9	Left side of EP	40.86	0.00	
10		40.70	0.00	
11	Middle of EP	41.92	0.00	
12		41.76	0.00	
13	In EP at right air exhaust	39.35	0.00	
14		39.47	0.00	
15	Ambient, in rack with cRIO	22.37	0.00	Known bad sensor
16		22.40	36.99	

Sensor	Value
Airflow 1 (higher due to proximity to hotter portion of EP)	497.65 slm
Airflow 2	396.13 slm

RICH Support Operations

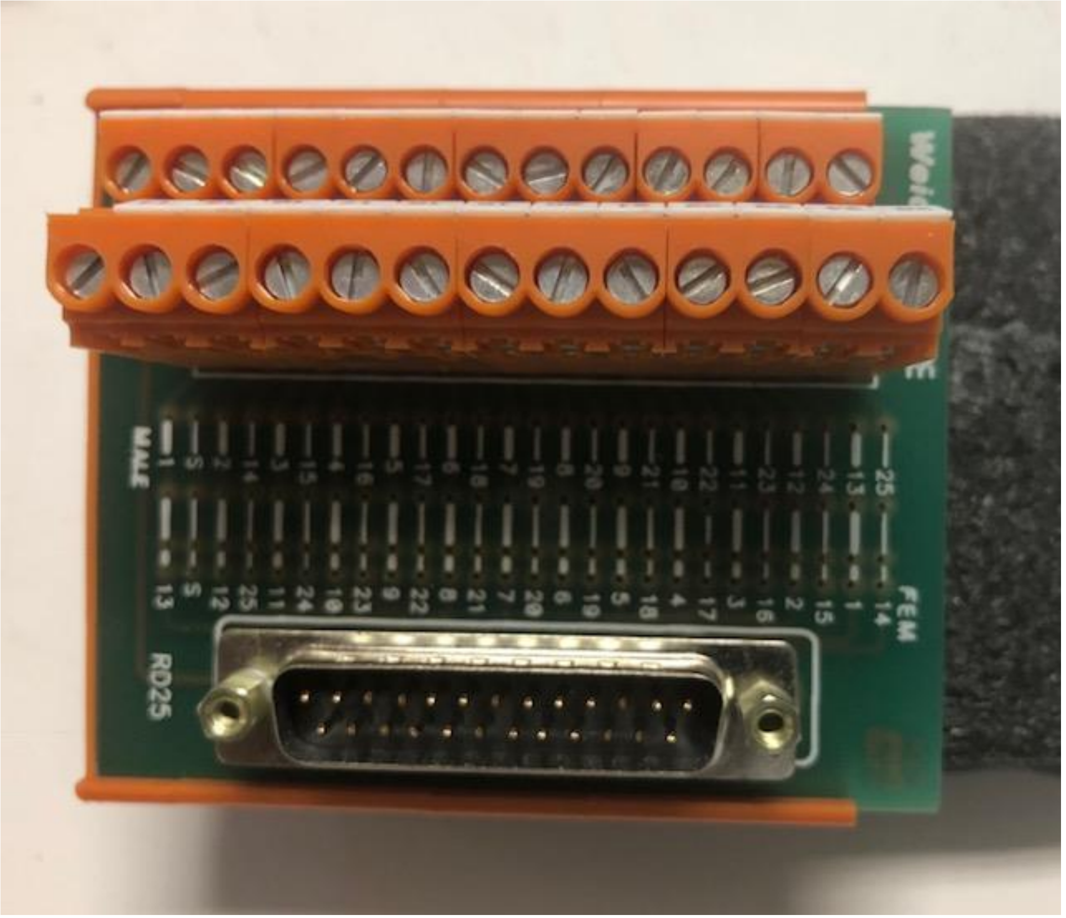
- Improvements on gas systems in preparation for second RICH sector.
- Analysis of temperature and humidity data for development of improved interlock system for future RICH sectors.
- Investigation into cause of RICH DAQ fiber disconnects
  - Occasionally, a few of RICH's 138 electronics boards lose communication with DAQ readout.
    - 19 occurrences since January 1, 2018
    - Distribution and timing of disconnects appears to be random.
  - Currently trying to find trends in which tiles disconnect and conditions (power supply, environmental, or other) are common at times of fiber disconnects.

SVT

- Current Activities
  - Testing spare modules
    - Preparations for module replacement
  - Maintenance of slow controls
    - Hardware interlocks, cabling, etc.

- Designed, developed, installed new patch panel boards

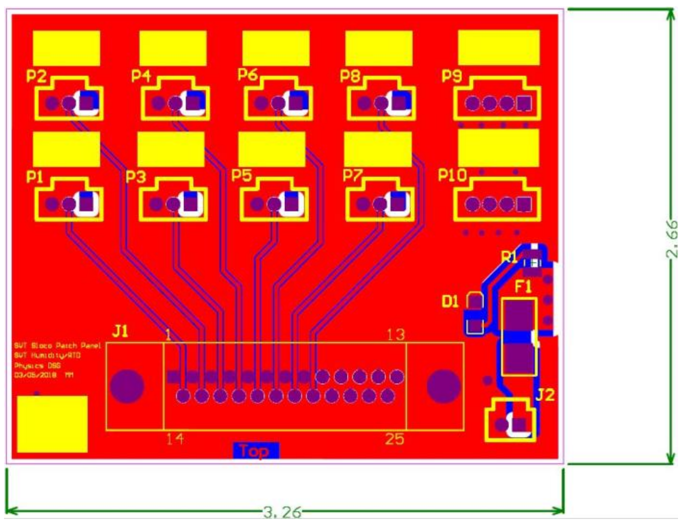
SVT Patch Panel Board Comparison

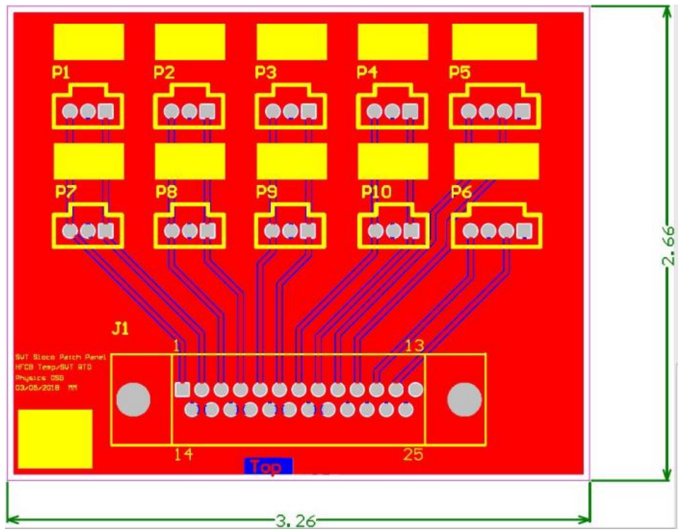


The old board uses screw terminals which are difficult to handle,

The new design uses locking connectors which can be manipulated with one hand.

Patch Panel Board Design: 2 Circuits

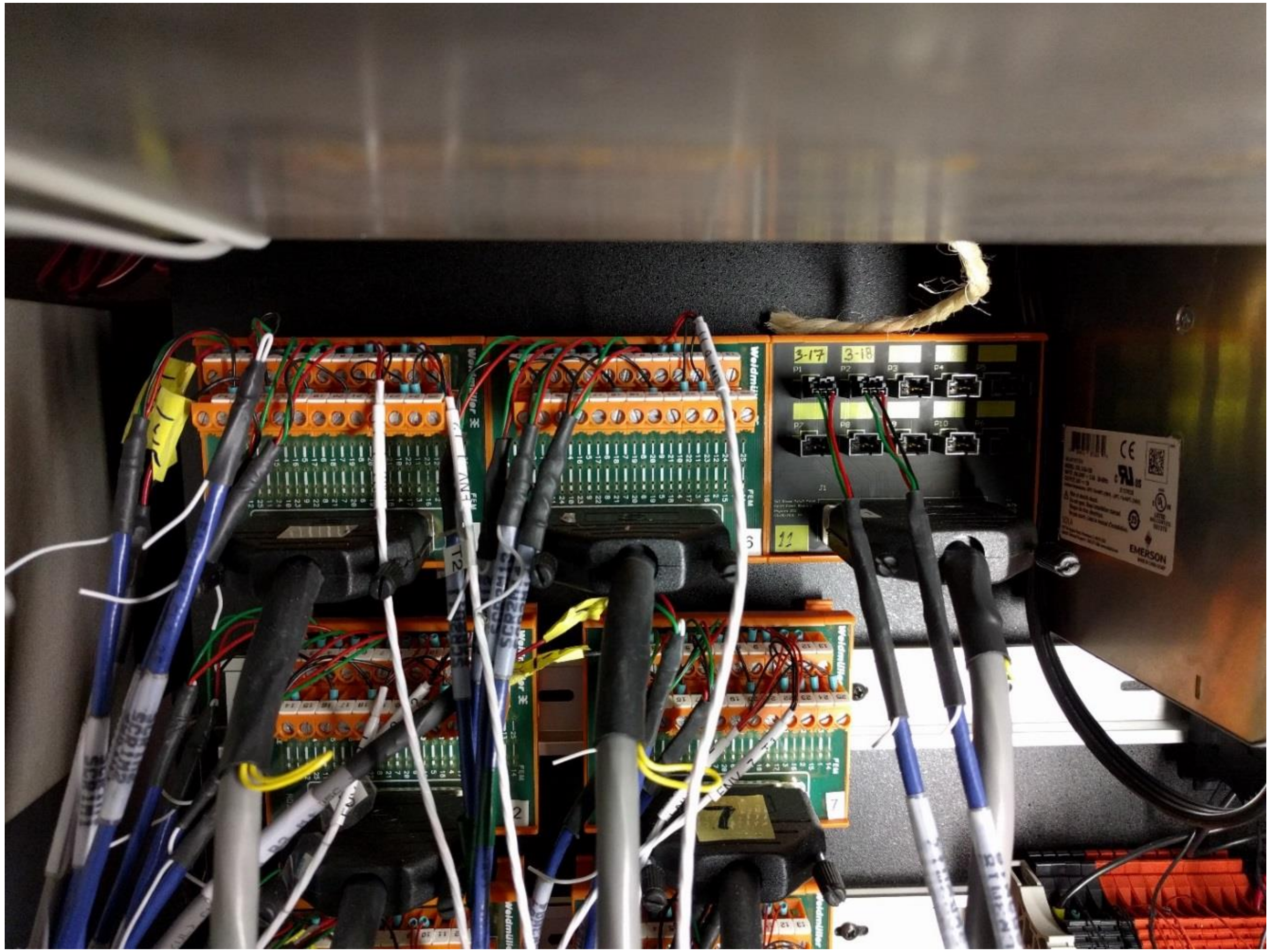




SVT Humidity/ RTD: Provides connectivity and power for 8 Honeywell Humidity Sensors and 2 SVT Environmental RTDS.
Layers: 2
Size: 3.26 x 2.66
Min Trace: 20 mils
Min Space: 10 mils
Max current: 4 mA
Pads (70 D 43), (67 D 43), (50 D 28)
Mounting Holes: 187.4 D 128.3
Operating voltage: 3.3 typ
Power to all clearance 30mils minimum.

HFCB Temperature/SVT RTD: Provides connectivity for 4 HFCB RTDs and 2 SVT Environmental RTDs.
Layers: 2
Size: 3.26 x 2.66
Min Trace: 20 mils
Min Space: 10 mils
Pads (70 D 43) and (67 D 43)
Mounting Holes: 187.4 D 128.3

SVT Patch Panel Upgrade: PCB Installation



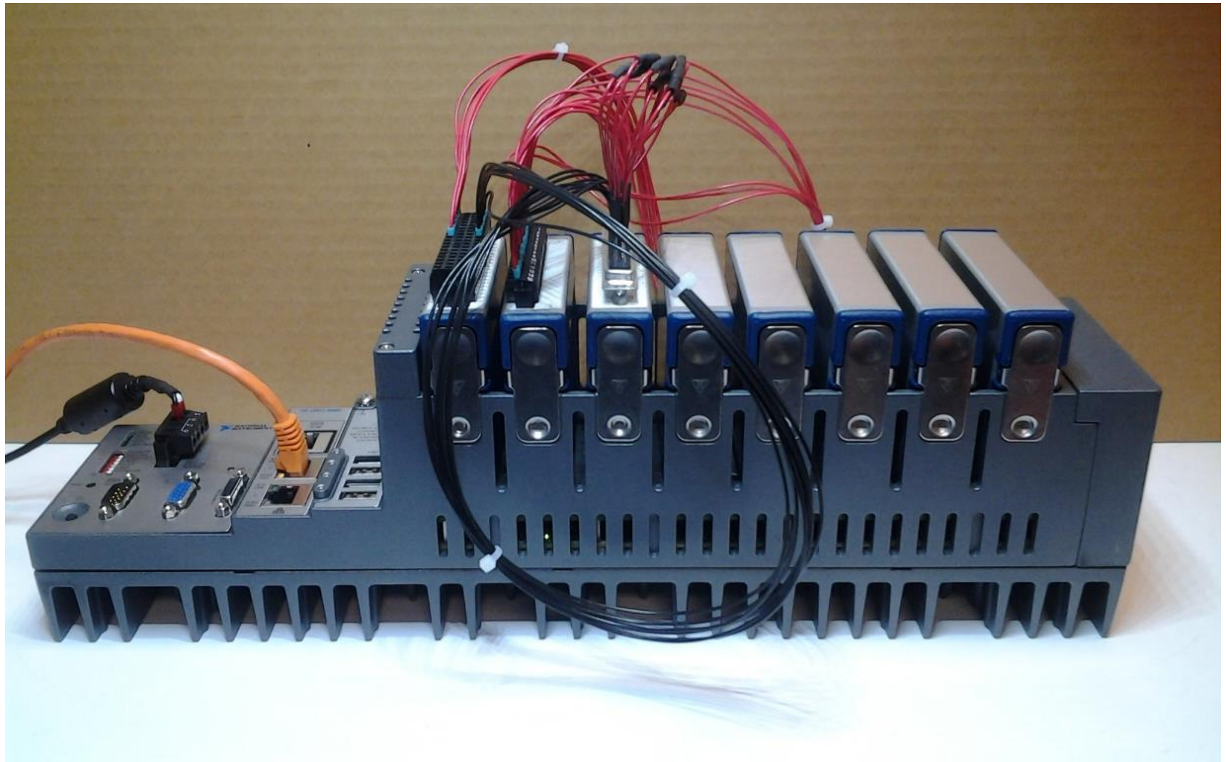
First board replacement.

- After PCB manufacturing, the boards were assembled, tested and installed.
- The slow controls cables were re-terminated and connected.
- The upgrade was completed during the shutdown in May of 2018.

Test Stations

cRIO Test Stand

- cRIO system – controller with built-in processor, up to eight modules, chassis
- Eight Hall B systems use c-RIO-based slow controls
    - FT hardware interlock
    - SVT hardware interlock
    - RICH hardware interlock
    - Torus LV
    - Torus DAQ
    - Solenoid LV
    - Solenoid DAQ
    - Gas system
- 18 module types



cRIO Test Stand, cont.

- Code currently being written for analog input modules
  - NI 9207 module completed; currently working on NI 9205 module
  - Manual mode – choose one of eight tests to be run on one module channel only
  - Automatic mode – all eight tests are run on all module channels
  - Results can be saved in Excel

Conclusion

- **DSG** is dynamic, pro-active, and works as a team
- **S**taff exceptionally skilled with software and hardware
- **G**roup has made solid contributions to projects across the physics division

My heartfelt thanks to Dr. Rossi for her delicatesse, support, and guidance

The End