Hall B Solenoid and Torus Health Report (Sep 2017 to April 2018)

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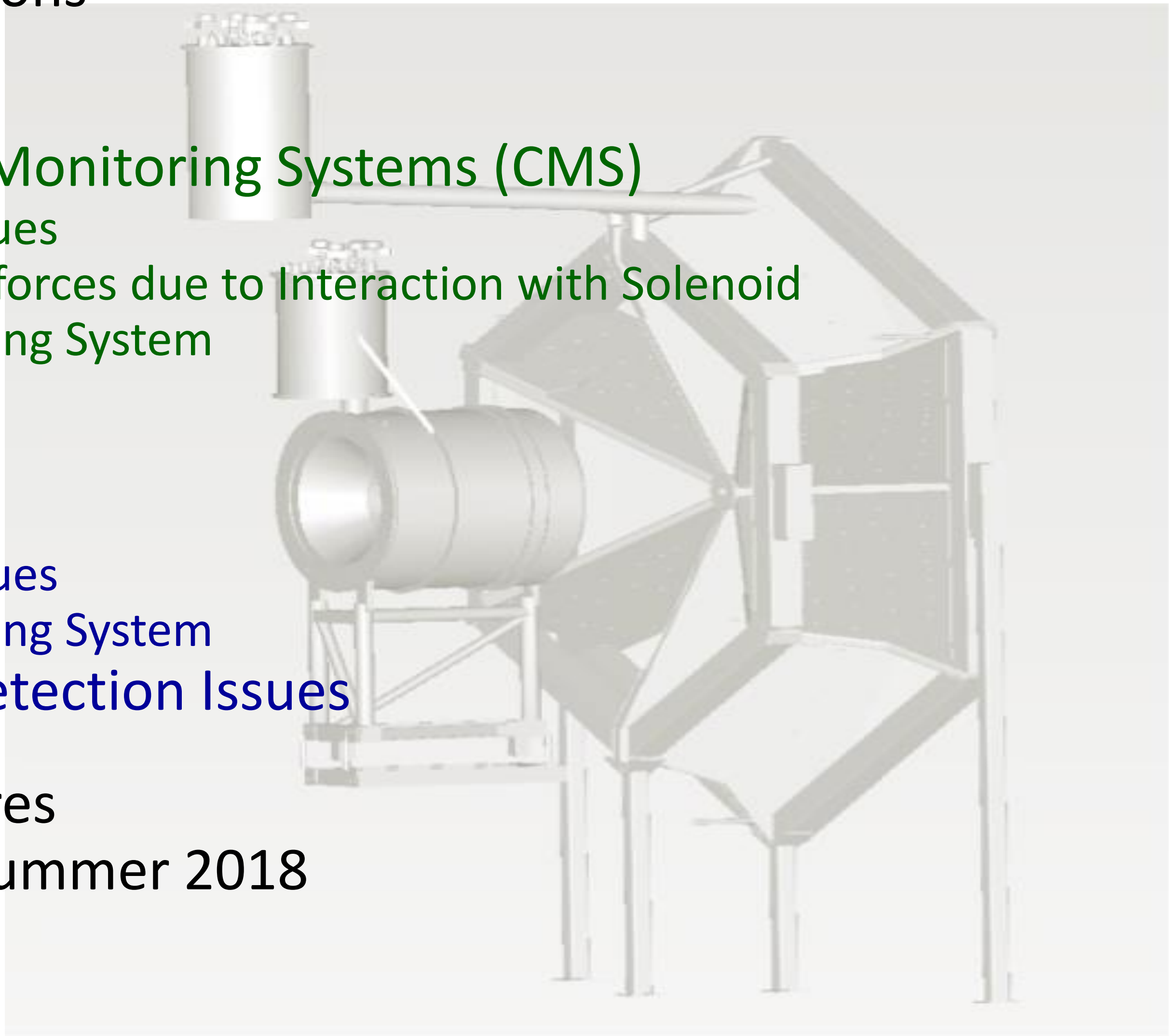
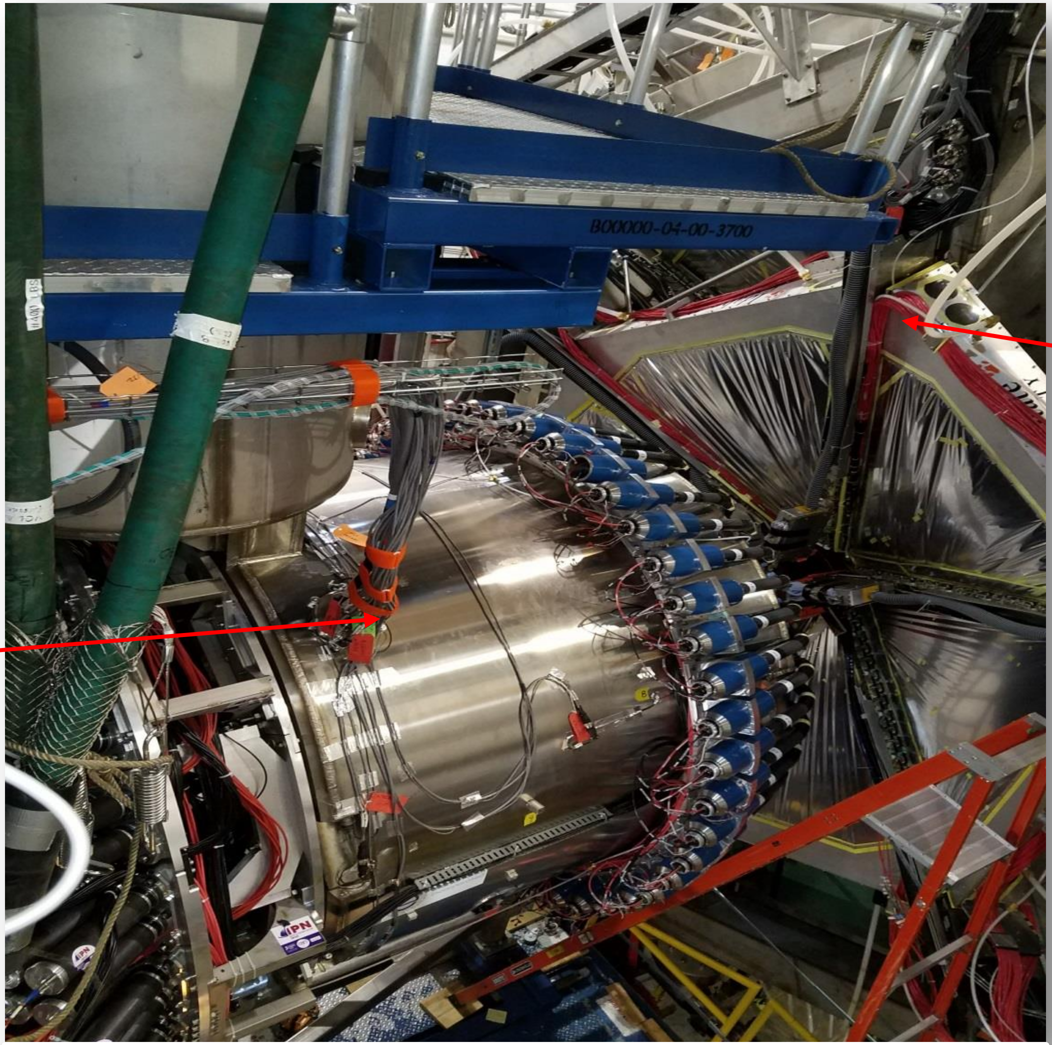
Detector Support Group
04/11/2018

Contents



I. Overview



Solenoid and Torus, upstream view in Hall B

II. Technical Specifications of Torus and Solenoid

Feature	Torus	Solenoid
Number of Coils	6	5
Coil structure	Double pancake potted in aluminum case	Layer wound
Warm bore ∅ (mm)	124	780
Total weight (Kg)	25,500	18,880
Number of turns per pancake	117	N/A
Number of turns per coil	2 x 117 = 234	1392
Number of turns in main coils	N/A	3704 (2 x 840 + 2 x 1012)
Conductor	SSC outer dipole cable soldered in 20 mm x 2.5 mm Cu channel	SSC outer dipole w 17mm x2.5mm Cu channel
Turn-to-turn insulation	0.003" E-Glass Tape ½ Lap	0.004" Glass Tape ½ Lap
Nominal current (A)	3770	2416
Ampere turns (-)	882,000	N/A
Peak field (T)	3.58	6.56
Central field (T)	N/A	5.0
Peak field location	Inner turn near warm bore, adjacent to cooling tube	Inner turn near warm
B-symmetry	Yes	Yes
∫Bdl @ nominal current (Tm)	2.78 @ 5°, 0.54 @ 40°	7.0
Inductance (H)	2	5.89
Stored energy (MJ)	14.2	<20
Quench protection/dump resistor	Hard wired quench detector/0.124 Ω dump resistor	Hard wired quench detector/0.124 Ω dump resistor
Coil cooling	Conduction cooled by supercritical Helium	Conduction cooled
Supply temperature (K)	4.6	4.2
Heat shield cooling	LN_2 thermo-siphon	N/A

III. Torus Trips

- Two fast dump events :
    1. Danfysik Magnet Power Supply (MPS) unable to ramp up over 1080 A
        - Incorrect installation of silicon controlled rectifier (SCR) found on 12/05/17)
    2. PLC lost communications on 04/01/2018

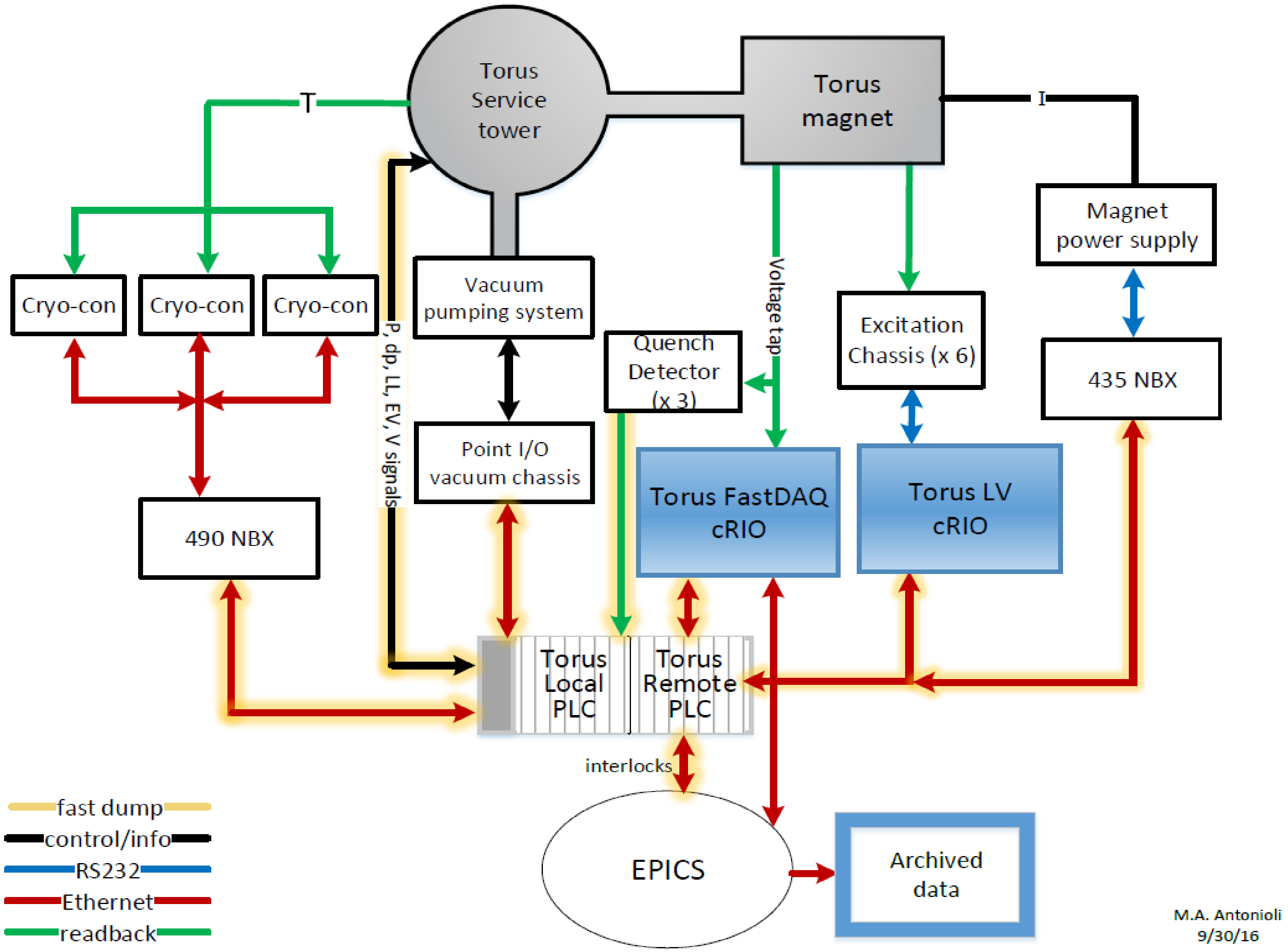
- Ten controlled ramp down events :
    1. Unstable cryogenics / ESR faults
    2. Loss of communication with Fast-DAQ cRIO
    3. Load cells over thresholds

III. Torus Trips

- Two fast dumps

Period	Fast Dump	Date	Time	Trip Current [A]	Cause	Description	Notes
Solenoid Commissioning	**1**	11/22/2017	11:53	1080	MPS	Thermal breaker fault showed as internal interlock in MPS (Status2. B1 bit tripped)	Improper (polarity) installation of SCR in MPS caused trip. Water cooling system's hoses were missing.
Engineering Run	**0**						
Physics Run	**1**	4/1/2018	7:08	3766	PLC	PLC Ethernet module fault/error. Lost communication due to unknown fault.	
Fast Dumps	**2**						

IV. Torus CMS


Torus Service tower
Torus magnet
T
I
Cryo-con
Cryo-con
Cryo-con
Vacuum pumping system
P, dp, LL, EV, V signals
Quench Detector (x 3)
Voltage tap
Excitation Chassis (x 6)
Magnet power supply
435 NBX
Point I/O vacuum chassis
Torus FastDAQ cRIO
Torus LV cRIO
490 NBX
Torus Local PLC
Torus Remote PLC
interlocks
EPICS
Archived data
fast dump
control/info
RS232
Ethernet
readback
M.A. Antonioli
9/30/16

IV.i Torus Instrumentation Issues

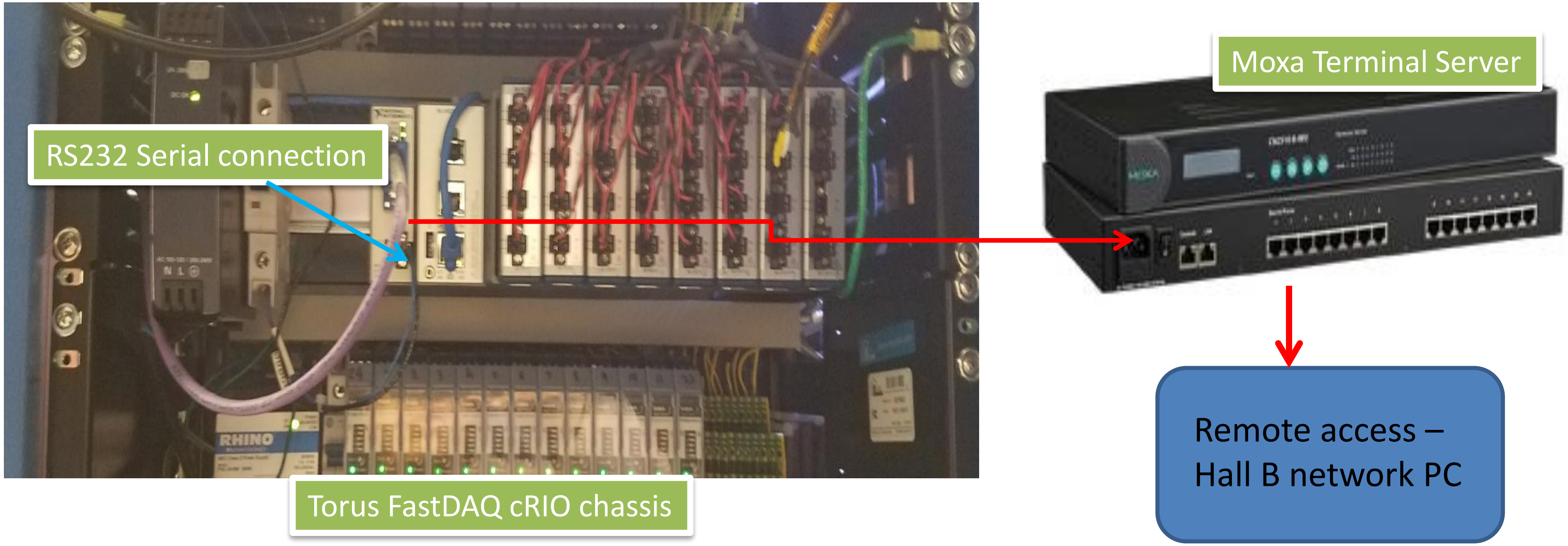
- Fast-DAQ NI cRIO-9067/8 failures caused controlled ramp downs.
  - cRIO failures due to:
    - Inability to communicate with Hall B network
      - Communications possible in “safe mode”; however, LabVIEW program not available in safe mode
    - LabVIEW code missing after cRIO’s failure
      - No error log available, so failure reason unknown

- cRIO recovers by itself after power disconnection.
    - Takes >12 hours (Unexpected behavior)

Suggested purchase of two NI cRIO-9030s to be used as spares for either Solenoid or Torus.

IV.i Torus Instrumentation Issues

- Installed a Terminal Server to enable remote RS232 serial communication with Torus cRIOs
  - Routed cables between cRIOs on SFL2 and Moxa terminal server on SFL1
  - Console output enables easy access to debugging
  - Provides error log and special features



IV.i Torus Instrumentation Issues

- AB 1756 EN2T Ethernet/IP PLC module lost communication with Hall B network and generated Torus fast dump on 04/01/2018.
  - Local PLC controller complained about I/O Fault in Local:9 (Ethernet/IP module)
  - All remote modules had bad status
  - Ethernet/IP module showed error
    - " Cycle Power to Unit: Assert in File wrhvBspEventHandlers.cpp Line 83"

  - Locally power-cycled PLCs' power supplies (local and remote chassis) to solve problem.

1756- EN2T Ethernet/IP PLC Module

IV.i Torus Instrumentation Issues

- Cernox temperature sensor was not reading on LV chassis #4
  - Swapped Q0131 PCB board with developmental LV chassis board
  - Failed Q0131 board had +12 V fuse shorted
    - Fuse replaced and board available as spare
- Load cell readouts over set thresholds caused controlled ramp down
  - Increased interlock delay thresholds
  - Increased alarm levels for load cells and strain gauges (axial and vertical supports)
- 60 mV spike signal at VT21 generated controlled ramp down when Torus was at 0 A
  - PLC logic changed to avoid ramp down when power supply is at 0 A
  - VT21 noise investigated
    - Verified wiring connections; no problems found

IV.i Torus Instrumentation Issues

- On 09/28/2017, SCR circuit overheated in Torus MPS
  - Thyristor (SCR) was not water-cooled as expected from factory setup
  - MPS cleaned and found residuals of machining (drilling, milling, cutting)
  - Danfisyk solution:
    - Provide new SCR
    - Install missed hoses to provide proper water cooling to SCR circuit
    - Install missed thermal switches/ temperature sensors with adaptors
- On 11/22/2017, Torus fast dump at 1080 A
  - Previous SCR replacement was installed backwards (anode, cathode incorrect positions), which led to ramping issues and internal trips on MPS

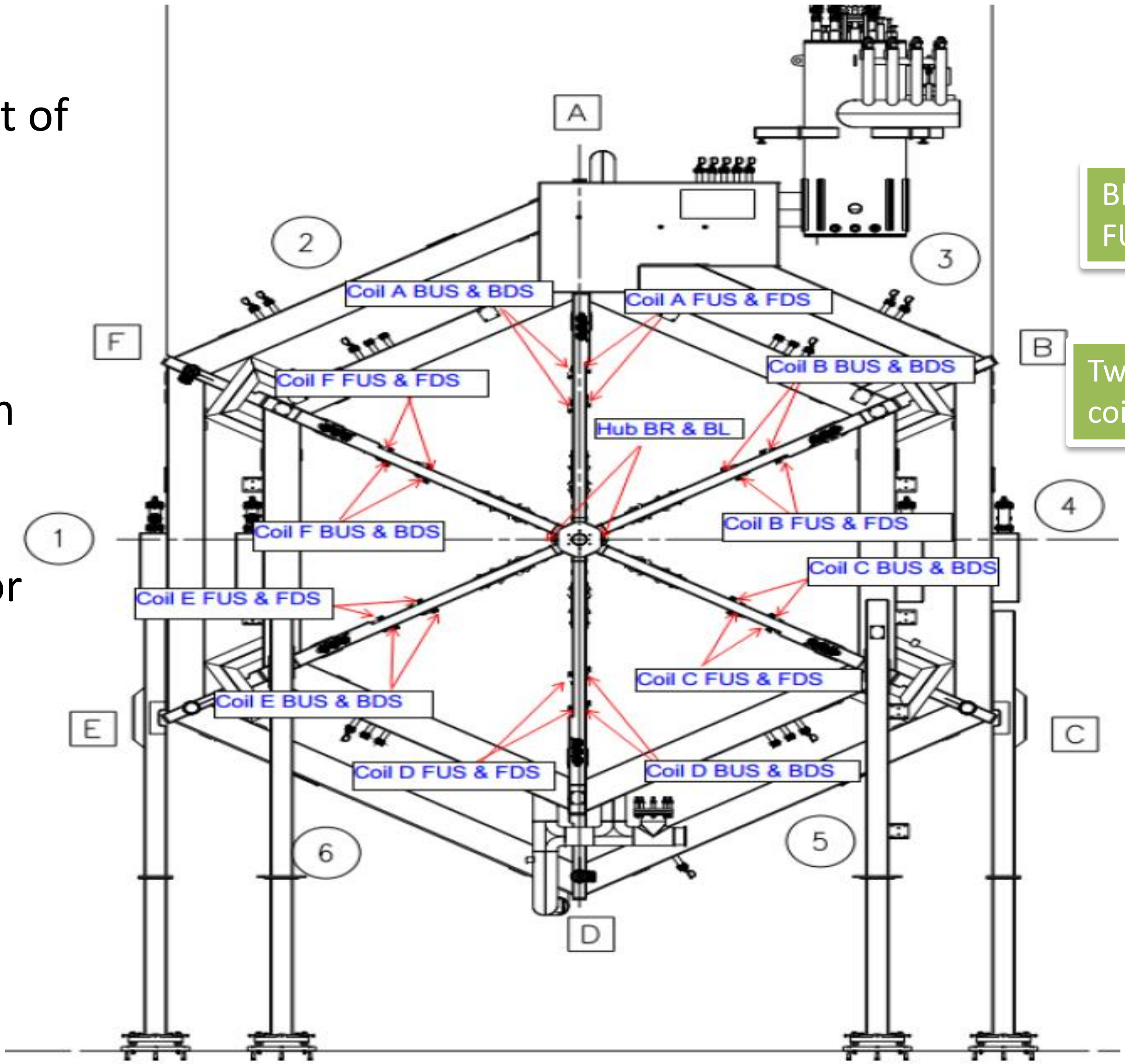
SCR circuit overheated in Torus MPS
Insulation burned

Disconnected hoses on SCR at Torus MPS

Microscopic view of residual materials found in Torus MPS

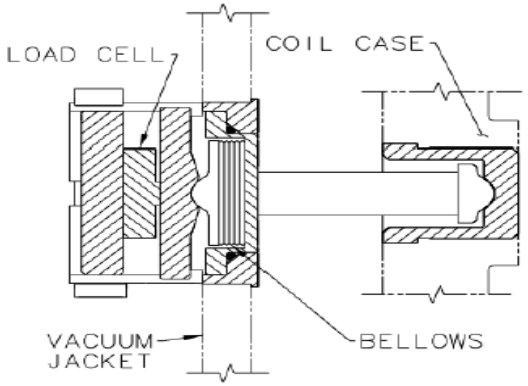
IV.ii Torus – Out Of Plane Forces

- Load cell sensors are part of out of plane support mounted in Torus
- Four load cells are symmetrically installed in each of six coils in Torus
- Torus has 24 load cells for monitoring out of plane forces



BDS = Back Downstream
FUS = Front Upstream

Two load cells installed at each face of coils (back and front)

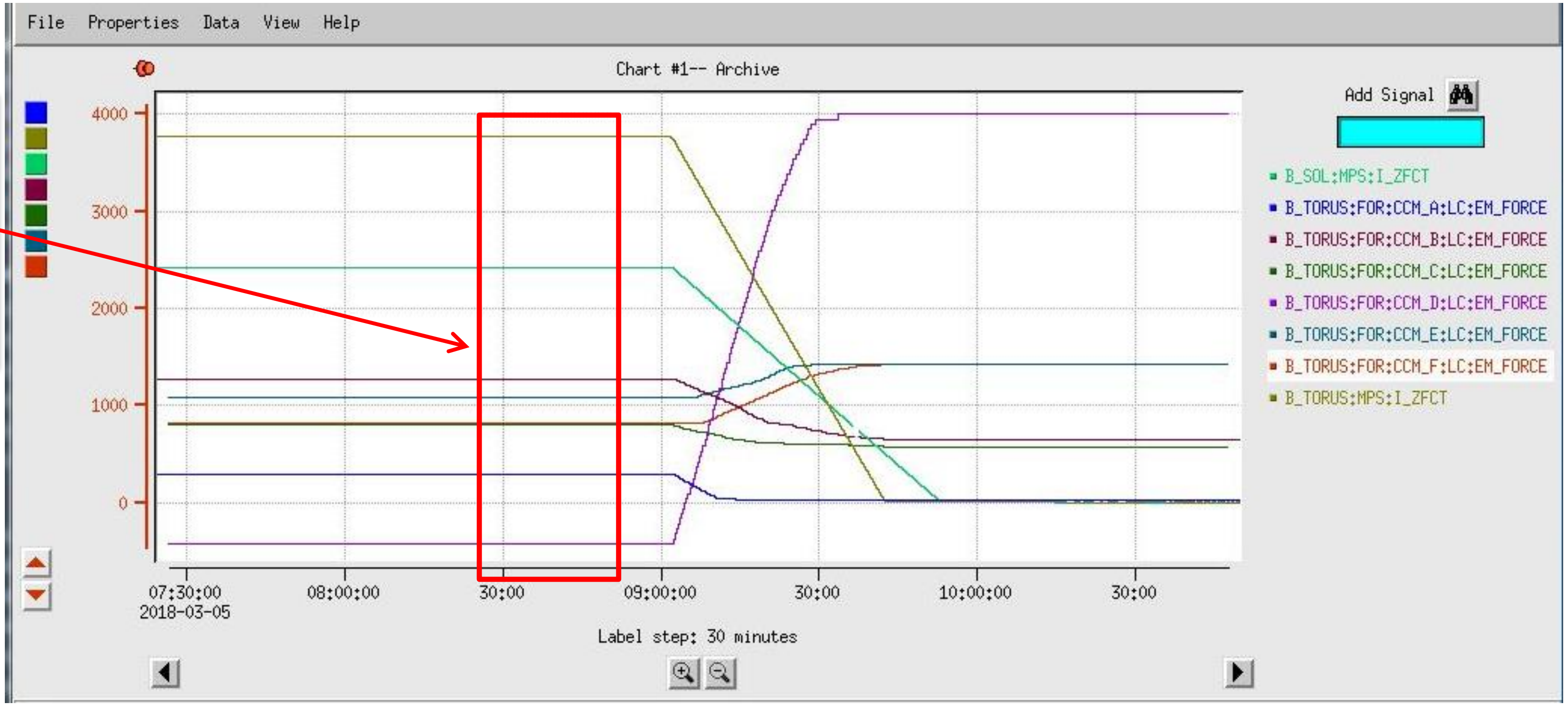


Coil out of plane support detail

IV.ii Torus – OOP Forces due to Interaction with Solenoid

		Current [A]	Polarity	Magnetic Field [T]	Date
Solenoid		2416	positive	4.5	3/5/2018
Torus		3770	positive	2	
Load Cell	**Total EM Force Description**	**Total EM Force Value [lbf]**	**Cooldown Baseline [lbf]**	**EM Differential [lbf]**	**EM Force Diff Limit**
CCM_A	[CCMA_FUS + CCMA_FDS]-[CCMA_BUS + CCMA_BDS]	288	18	270	1000
CCM_B	[CCMB_FUS + CCMB_FDS]-[CCMB_BUS + CCMB_BDS]	1271	573	698	1000
CCM_C	[CCMC_FUS + CCMC_FDS]-[CCMC_BUS + CCMC_BDS]	800	516	284	1000
CCM_D	[CCMD_FUS + CCMD_FDS]-[CCMD_BUS + CCMD_BDS]	-788	61	-849	1000
CCM_E	[CCMD_FUS + CCMD_FDS]-[CCMD_BUS + CCMD_BDS]	1088	1490	-402	2000
CCM_F	[CCMF_FUS + CCMF_FDS]-[CCMF_BUS + CCMF_BDS]	810	1349	-539	2000

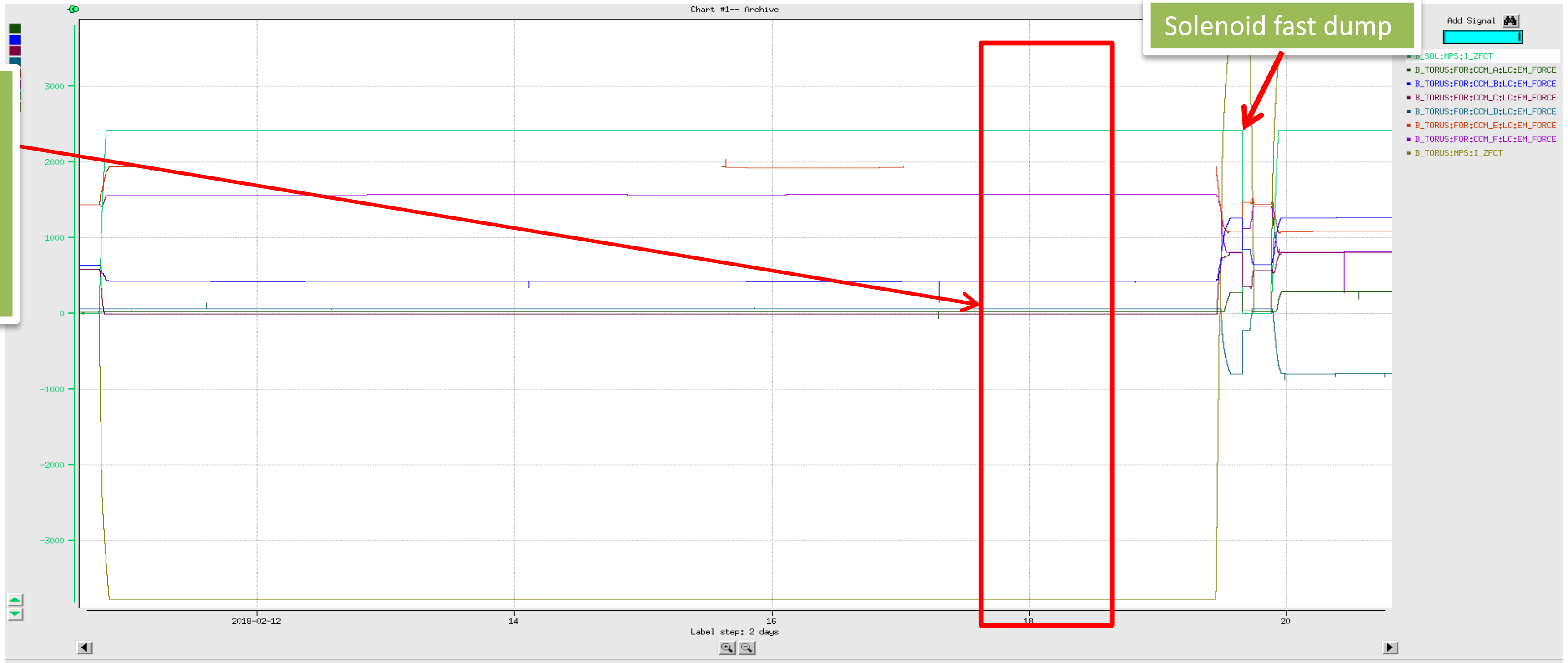
Data entries in table are averages for OOP force values during time shown in red box



IV.ii Torus – OOP Forces due to Interaction with Solenoid

		Current [A]	Polarity	Magnetic Field [T]	Date
Solenoid		2416	positive	4.47	2/18/2018
Torus		-3780	negative	-1.99	
Load Cell	**Total EM Force Description**	**Total EM Force Value [lbf]**	**Cooldown Baseline [lbf]**	**EM Differential [lbf]**	**EM Force Diff Limit**
CCM_A	[CCMA_FUS + CCMA_FDS]-[CCMA_BUS + CCMA_BDS]	28	18	10	1000
CCM_B	[CCMB_FUS + CCMB_FDS]-[CCMB_BUS + CCMB_BDS]	426	573	-147	1000
CCM_C	[CCMC_FUS + CCMC_FDS]-[CCMC_BUS + CCMC_BDS]	-12	516	-528	1000
CCM_D	[CCMD_FUS + CCMD_FDS]-[CCMD_BUS + CCMD_BDS]	61	61	0	1000
CCM_E	[CCMD_FUS + CCMD_FDS]-[CCMD_BUS + CCMD_BDS]	1942	1490	452	2000
CCM_F	[CCMF_FUS + CCMF_FDS]-[CCMF_BUS + CCMF_BDS]	1569	1349	220	2000

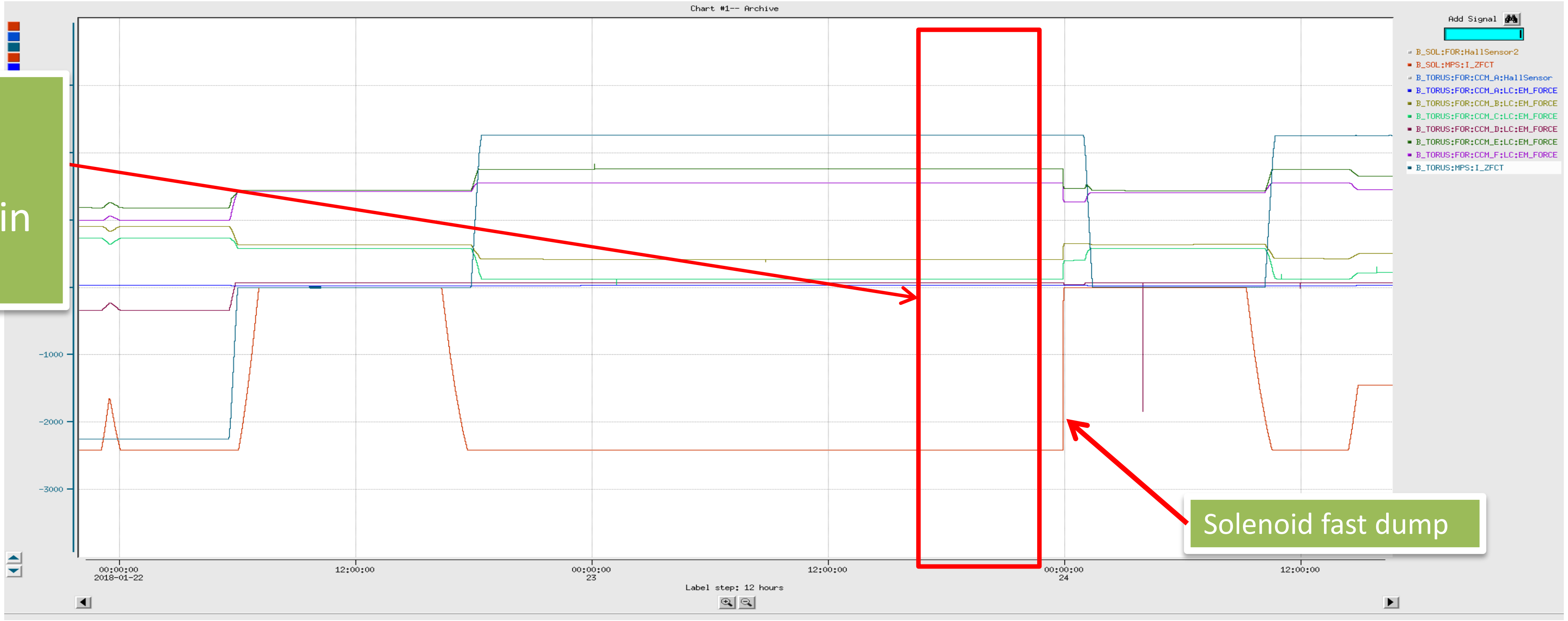
Data entries in table are averages for OOP force values during time shown in red box



IV.ii Torus – OOP Forces due to Interaction with Solenoid

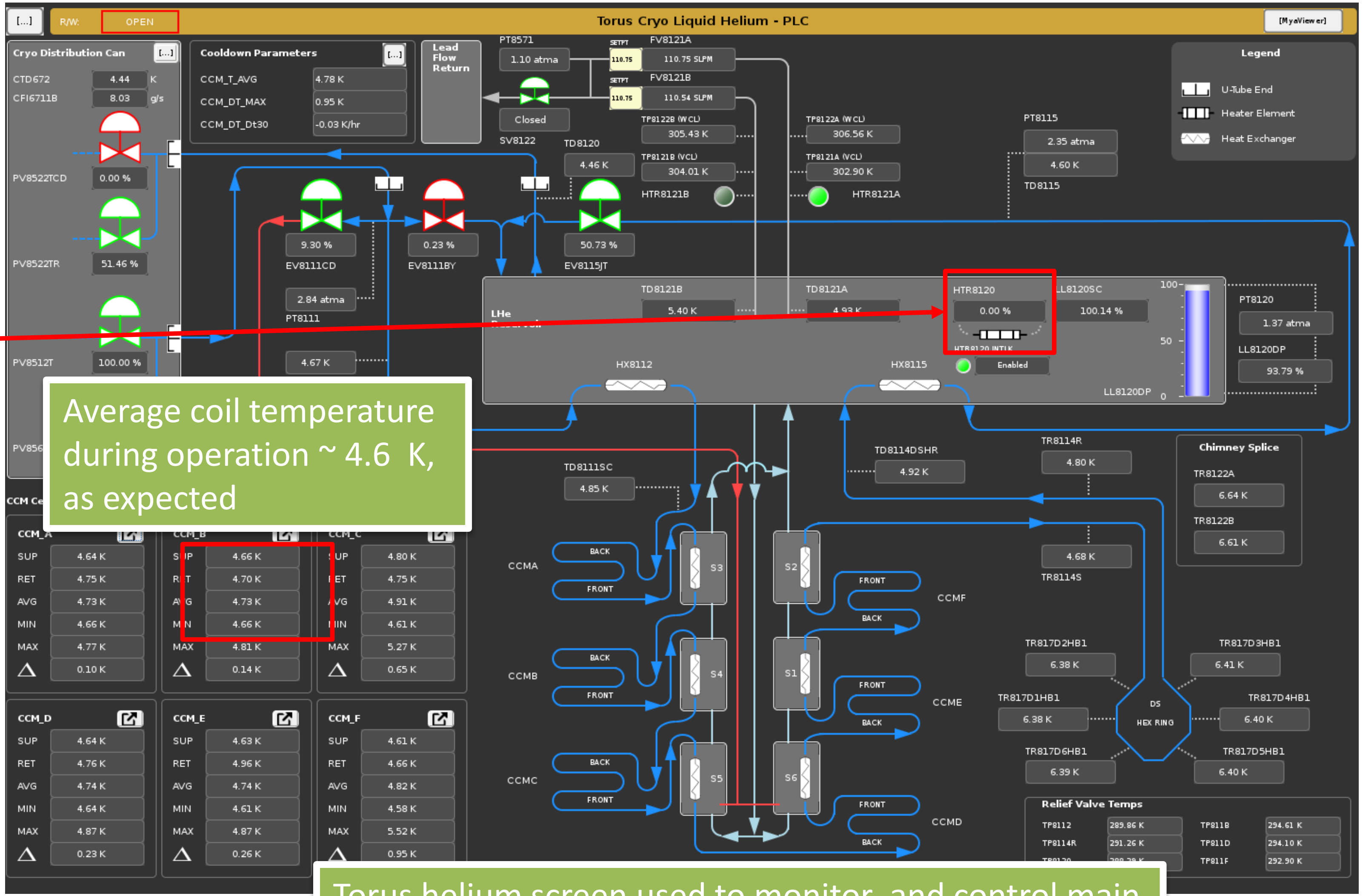
		Current [A]	Polarity	Magnetic Field [T]	Date
Solenoid		-2416	Negative	-4.48	1/23/2018
Torus		2259	Positive	1.2	
Load Cell	**Total EM Force Description**	**Total EM Force Value [lbf]**	**Cooldown Baseline [lbf]**	**EM Differential [lbf]**	**EM Force Diff Limit**
CCM_A	[CCMA_FUS + CCMA_FDS]-[CCMA_BUS + CCMA_BDS]	30	18	12	1000
CCM_B	[CCMB_FUS + CCMB_FDS]-[CCMB_BUS + CCMB_BDS]	411	573	-162	1000
CCM_C	[CCMC_FUS + CCMC_FDS]-[CCMC_BUS + CCMC_BDS]	121	516	-395	1000
CCM_D	[CCMD_FUS + CCMD_FDS]-[CCMD_BUS + CCMD_BDS]	65	61	4	1000
CCM_E	[CCMD_FUS + CCMD_FDS]-[CCMD_BUS + CCMD_BDS]	1759	1490	269	2000
CCM_F	[CCMF_FUS + CCMF_FDS]-[CCMF_BUS + CCMF_BDS]	1556	1349	207	2000

Data entries in table are averages for OOP force values during time shown in red box



IV.iii Torus Cryogenics Monitoring

- Six of ten controlled ramp downs were generated by ESR trips and cryogenic variables (P, T, LL) over threshold conditions
- PID parameters that control valves and heater modified to stabilize cryo system
  - Tuning required to find most stable cryogenic conditions based on Solenoid heat loads
- Overall, cooldown recovers with no major problems after trips



Average coil temperature during operation ~ 4.6 K, as expected

Torus helium screen used to monitor and control main cooldown variables during operations

V. Solenoid Trips

Hall B - Solenoid Fast Dumps (Sep, 2017 to April,2018)										
Period	**Fast Dump #**	**Date**	**Time**	**Trip Current [A]**	**Cause**	**VT combination**	**Description**	**Threshold**	**Time Delay**	**Notes**
Commissioning	**1**	9/12/2017	14:47	932	**QD1 :Ch3**	VT15+VT16+VT17+VT18+VT19	**VT18** had voltage spike ~600 mV that generates VT8 (coil 3 quenching) went to ~ 2.3[V]	60 mV		
	2	9/12/2017	17:27	1014	**QD1:Ch3**	VT15+VT16+VT17+VT18+VT19	**VT18** splice voltage spike ~125 [mV] which generated VT12 (coil 4 quenching) went to ~ 5.5 [V]	60 mV		On 09-15-2017, PLC became primary protection system for VT splices. Thresholds changed for QDs 1 and 2 (non coils VTs) and PLC comparators. QD VT splices thresholds raised from 60 mV to 750 mV and trigger window from 0 to 999 ms
	3	9/13/2017	16:15	1035	**QD1:Ch1**	[VT11+VT12+VT13+VT14] - [VT5+VT6+VT7+VT8+VT9+VT10]	Differential of addition of **all VT** combinations in QD1:CH1 generated Fast dump	60 mV		
	4	9/15/2017	9:07	1060	**QD1:Ch2**	[VT9+VT10+VT11+VT12+VT13+ VT14]-[VT5+VT6+VT7+VT8]	Suspected **VT8** (coil 3)	60 mV		
	5	9/15/2017	11:39	1066	**QD1:Ch2**	[VT9+VT10+VT11+VT12+VT13+ VT14]-[VT5+VT6+VT7+VT8]	Suspected **VT8** (coil 3)	60 mV		Voltage noise of ~41 mV on QD1 (Ch1 and Ch2 associated with VT coils 1-5). Threshold raised from 60 mv to 100 mV.
	6	9/15/2017	19:52	2148	**Cryogenics**	N/A	Over temperature on VCLB. Temperatrue increased to > 14 K	13.5 K		To check coil VTs during fast dump, refer to: https://logbooks.jlab.org/entry/3484612

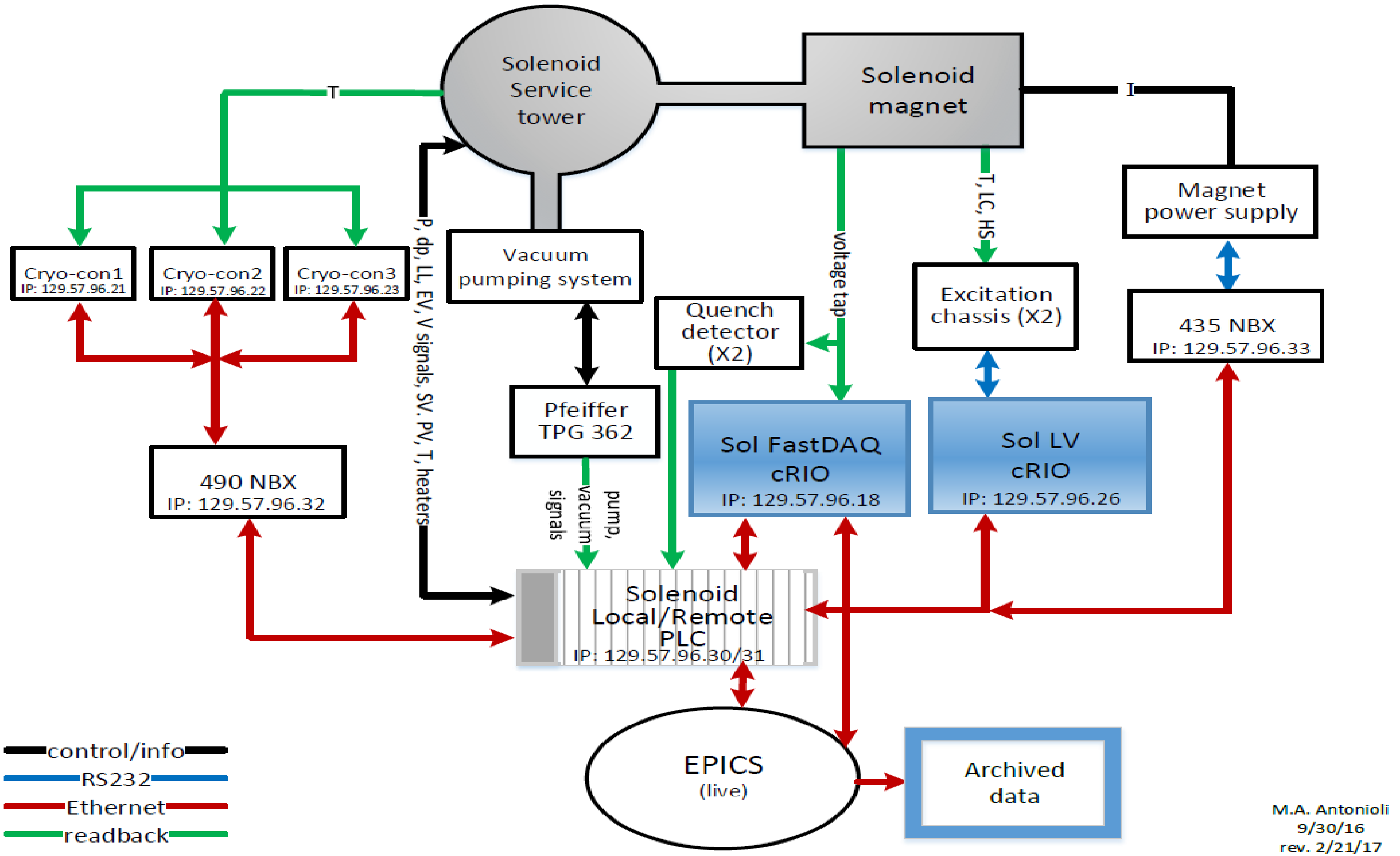
V. Solenoid Trips

Hall B - Solenoid Fast Dumps (Sep, 2017 to April,2018)										
Period	**Fast Dump #**	**Date**	**Time**	**Trip Current [A]**	**Cause**	**VT combination**	**Description**	**Threshold**	**Time Delay**	**Notes**
Engineering Run	**7**	12/12/2017	22:02	1208	**QD1: Ch3**	VT15+VT16+VT17+VT18+VT19	**VT18** had voltage spike ~175 mV	750 mV	999 ms	QD1:Ch4 VT combinations modified to cover only VT19 rather than VT17, VT18, VT19
	8	12/13/2017	9:49	1208	**QD1:Ch3**					Bad jumpered contact on VT panel switches; refer to: https://logbooks.jlab.org/entry/3503731
	9	12/14/2017	14:13	1208	**QD1: Ch3**	VT15+VT16+VT17+VT18+VT19	**VT18** had voltage spike of 170 mV	750 mV	999 ms	Voltage spike tripped QD1 interlock even when read value was lower than set threshold
	10	12/16/2017	10:35	2416	**QD1:Ch1**	[VT11+VT12+VT13+VT14]-[VT5+VT6+VT7+VT8+VT9+VT10]	QD1:Ch1 lower which measure voltages in Coils 4 and 2	100 mV	20 ms	Increased trip delay time thresholds for QD1: Ch1 and Ch2 to 100 ms
	11	12/18/2017	9:01	1493	**QD2:Ch4**	VT15+VT16+VT17+VT18	**VT18** had voltage spike ~ 400 mV	750 mV		Noise along cable used for VT18 (150 mV). Cable consists of three separate, shielded, multi-conductors, none of them grounded.
	12	1/23/2018	23:54	-2416	**QD1:Ch1**	[VT11+VT12+VT13+VT14]-[VT5+VT6+VT7+VT8+VT9+VT10]	Suspected voltage increment across coils generated fast dump. Considered shift of coils as a cause.	100 mV	100 ms	Time delay thresholds for QD1: Ch1 and Ch2 were increased to 200 ms and all other QD Chs to 999 ms

V. Solenoid Trips

Hall B - Solenoid Fast Dumps (Sep, 2017 to April,2018)										
Period	**Fast Dump #**	**Date**	**Time**	**Trip Current [A]**	**Cause**	**VT combination**	**Description**	**Threshold**	**Time Delay**	**Notes**
Phisycs Run	**13**	2/19/2018	15:47	2416	**QD1:Ch3 / QD2:Ch4**	VT15+VT16+VT17+VT18+VT19/ VT15+VT16+VT17+VT18	**VT18** spiked to ~ 60 mV. Adding all VT values in: QD1:Ch3 ~ 155 mV and QD2:Ch4 ~80 mV	1500 mV 1550 mV	999 ms	Third time that voltage spike tripped QD1 interlock, even when read value was lower than set thresholds
	14	4/1/2018	7:08	2416	**QD1:Ch1**	[VT11+VT12+VT13+VT14]- **[VT5+VT6+VT7+VT8+VT9+VT10]**	**VT10** at coil 5 caused by Torus dump. VT10 voltage increased to~260 mV due to electromagnetic inductive coupling	200 mV	200 ms	Torus fast dump due to PLC ethernet module communication failure
	15	4/9/2018	1:26	2416	**QD1:Ch1**	**[VT11+VT12+VT13+VT14]** - [VT5+VT6+VT7+VT8+VT9+VT10]	QD1:Ch1 lower tripped (LED indicator showed red light). SOE PLC module indicated QD Sum1 tripped first. Not sure which VT due to loss of Fast DAQ data.	-186 mV	200 ms	No FastDAQ data recorded. Reason: soft IOCs were not reset after cRIO FastDAQ was swapped on 04/01/2018
Total# of fast dumps	**15**									

VI. Solenoid Control Systems



IV.i Solenoid Instrumentation Issues

- Installed Terminal Server to enable remote RS232 serial communication with Low Voltage cRIO and FastDAQ cRIO.

- FastDAQ NI cRIO-9067 presented the same faulty conditions as 9068 series used in Torus.
  - Three failures
  - No solution suggestions from NI support service
  - Swapped FastDAQ NI cRIO-9067 with cRIO-9035

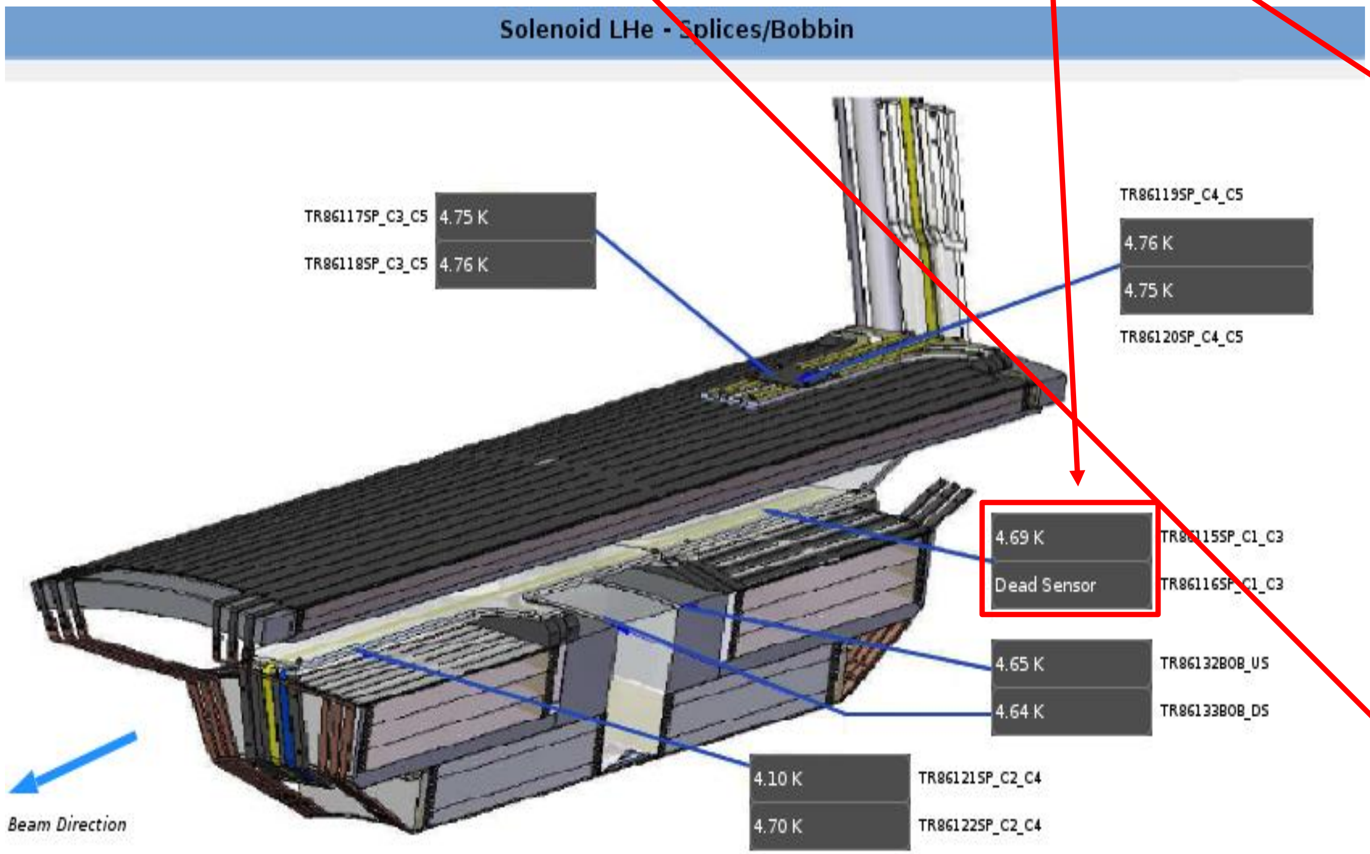
- LV cRIO controller model: NI cRIO-9074 stopped sending data to PLC.
  - Happened twice during physics run (March 19 and April 17, 2018)

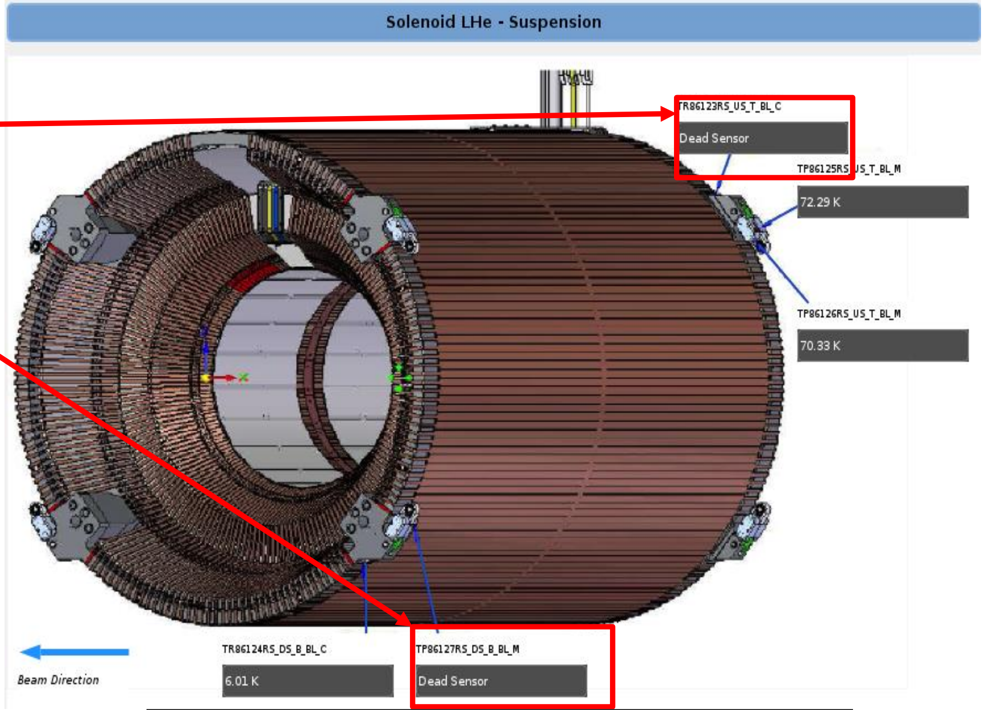
VI.i Solenoid Instrumentation Issues

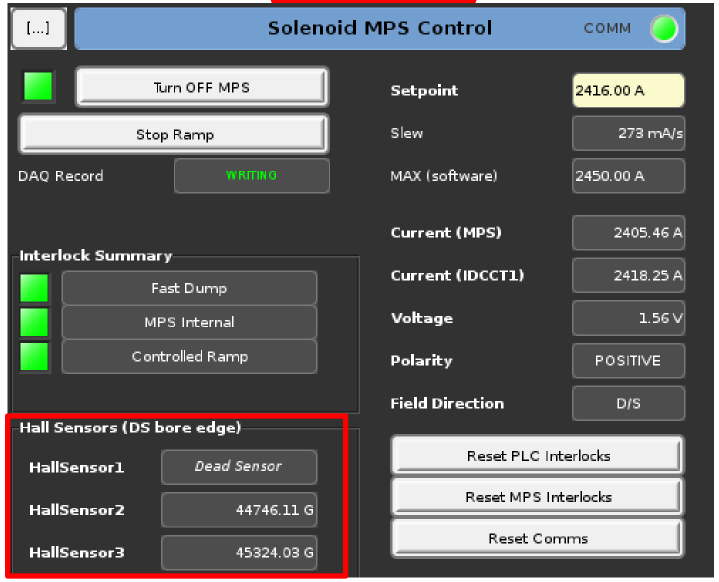
- AB1756-SOE module unable to clear time stamp registers
  - PLC control logic could be improved by adding delay timers that allow at least 200 ms delay to reset fault
- Generated web page to convert RS-Logix timestamp format data to UNIX time
  - Web page saves time, allows prompt answers to determine first fault when Solenoid has fast dump
- PLC quench detection program modified to be primary protection system for quench events in Solenoid.
  - Due to several QD faults during commissioning, QD hardware made to be secondary protection system

IV.i Solenoid Instrumentation Issues

- Found dead sensors during commissioning:
  - Three Cernox temperature sensors
  - One Hall sensor



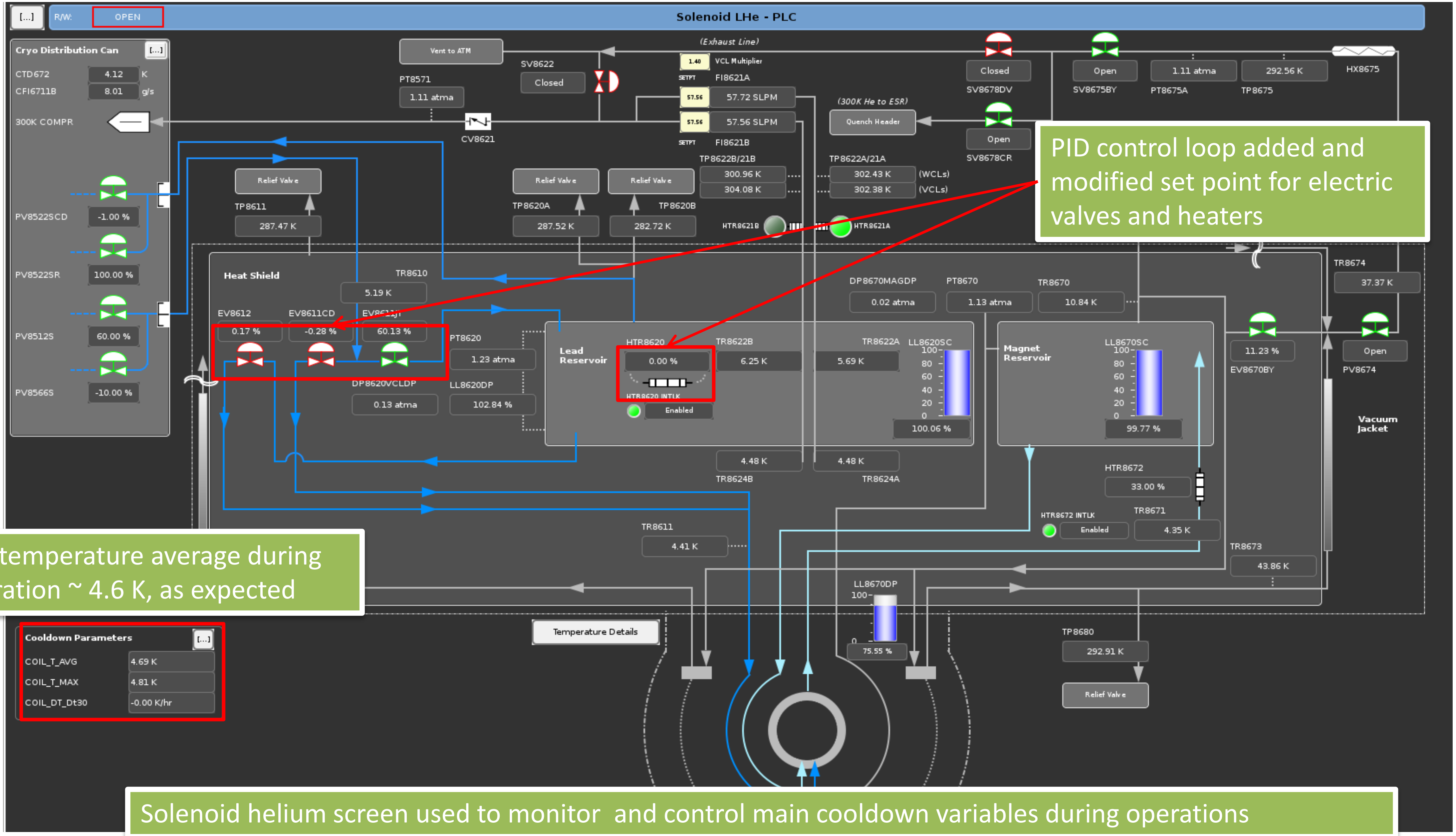




IV.i Solenoid Instrumentation Issues

- ➢ Added 21 s delay to remove spurious trips from load cells interlock
- ➢ Removed load cell interlock that was generating fast dumps
  - Load cell interlock only available for controlled ramp down.
- ➢ Added missed components of water cooling system in MPS
  - After preventive inspection and issues presented in Torus MPS, hoses found to be missing in water cooling system
  - Installed missed thermal switches/temperature sensors with adaptors and hoses
- ➢ Found bad contacts in switches at VTs' panel
  - Bad switches jumpered out.

VI.ii Solenoid Cryogenics Monitoring System

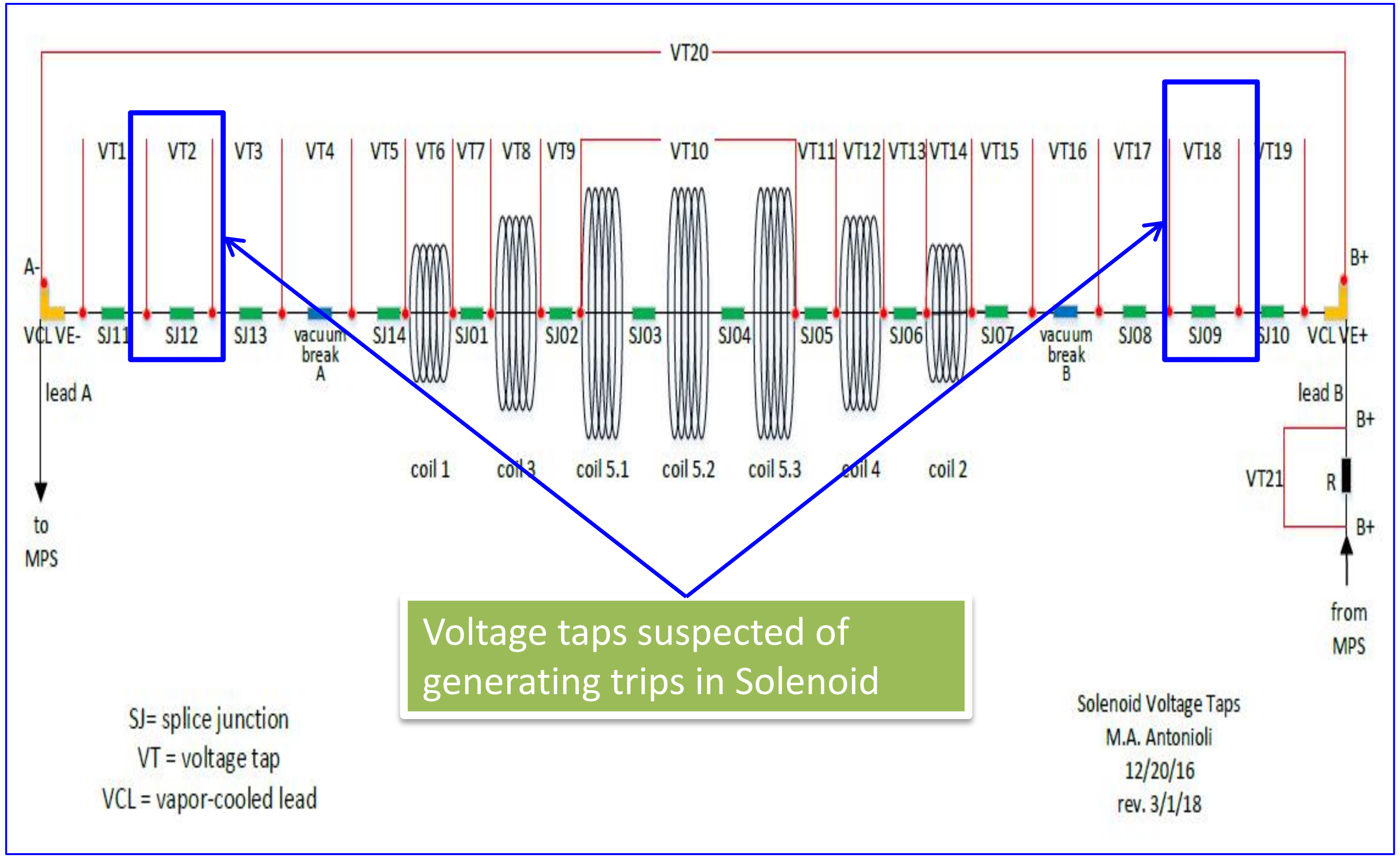


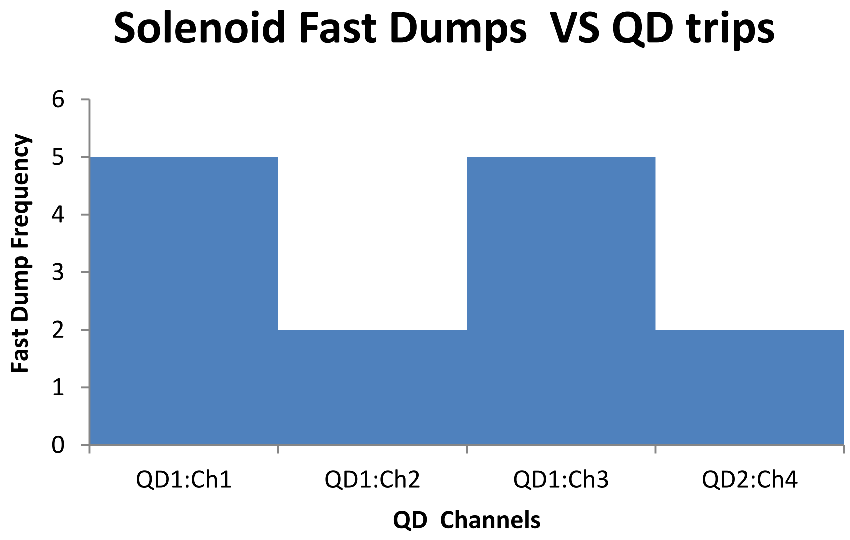
PID control loop added and modified set point for electric valves and heaters

Coil temperature average during operation ~ 4.6 K, as expected

Solenoid helium screen used to monitor and control main cooldown variables during operations

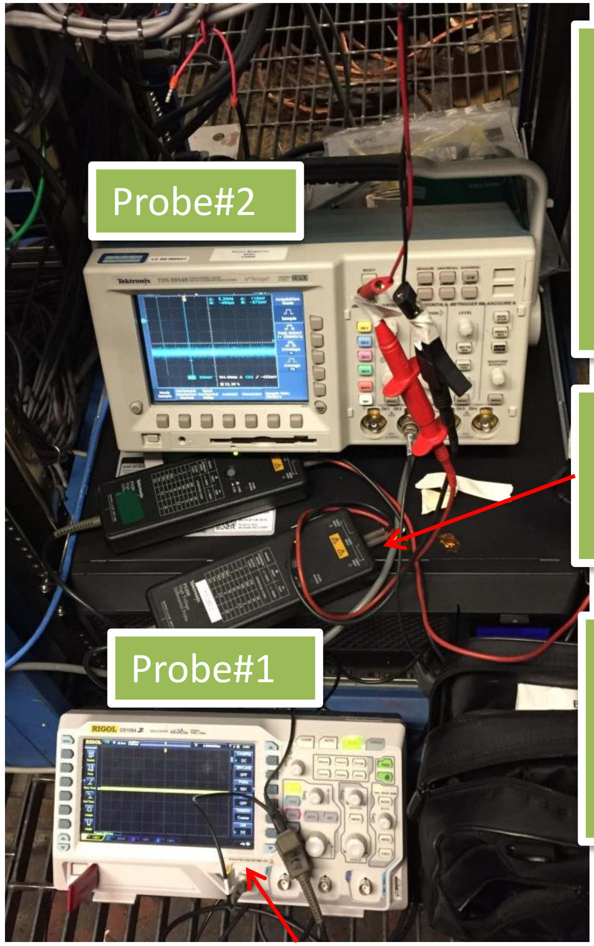
VII. Solenoid Quench Detection Issues





VII. Solenoid Quench Detection Issues

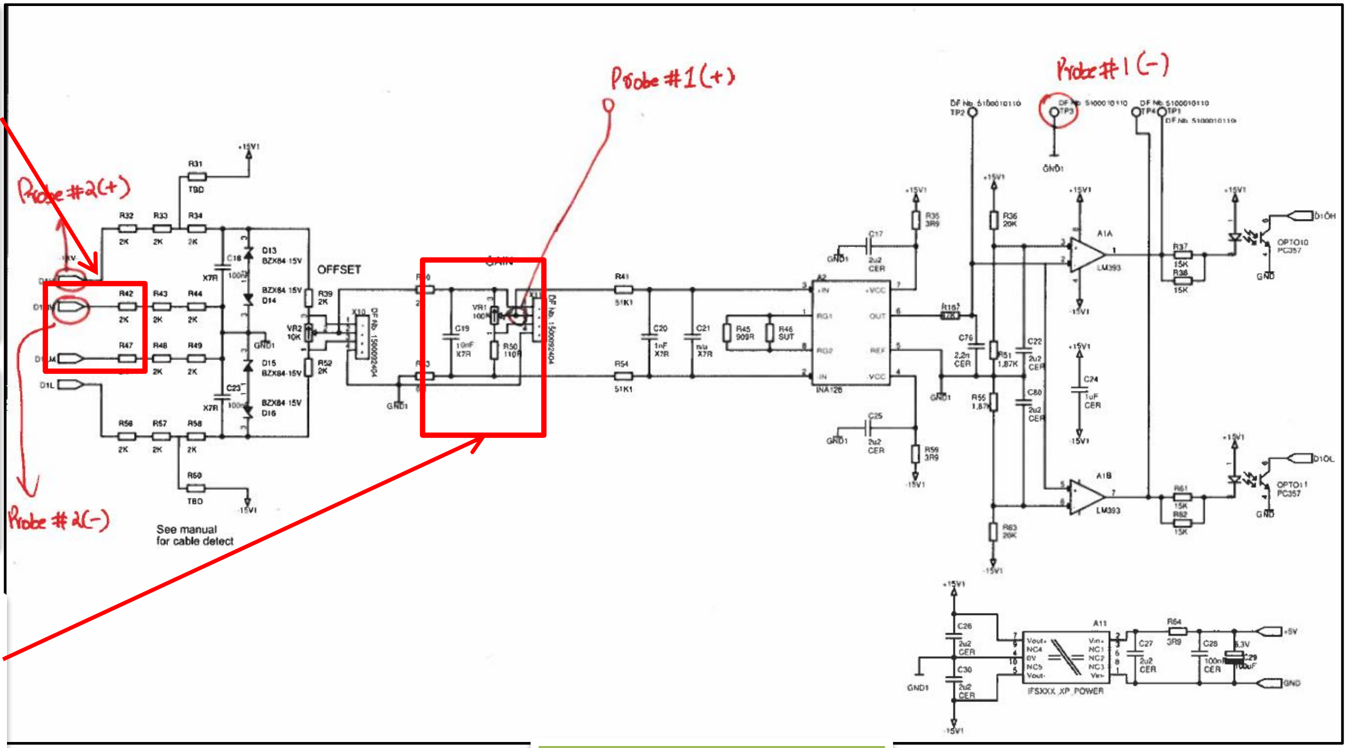
➢ Two scopes to connected to monitor QD2:ch4 as



Probe #2 connected to monitor voltage spikes from Solenoid (to compare with FASTDAQ data)

Differential probes for diagnostic testing

Probe #1 connected to monitor voltage spikes generated internally in QD



Electrical diagram

VII. Solenoid Quench Detection Issues: VT Values at initiation of Fast Dumps

Voltage Tap [mV]	Fast Dump #													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Commissioning					Engineering Run						Physics Run		
	9/12/2017	9/12/2017	9/13/2017	9/15/2017	9/15/2017	12/12/2017	12/13/2017	12/14/2017	12/16/2017	12/18/2017	1/23/2018	2/19/2018	4/1/2018	4/9/2018
	14:47	17:27	16:15	9:07	11:39	22:02	9:49	14:13	10:35	9:01	23:54	15:47	7:08	1:26
VT 1	14.912	13.294	13.660	16.891	14:26	12.695	12.207	11.230	NO Fast DAQ data Available	18.555	-42.480	36.621	34.668	NO Fast DAQ data Available
VT 2	-1.278	1.390	-1.520	0.856	2.441	0.000	-0.488	0.000		1.465	-1.465	-0.488	0.000	
VT 3	0.641	1.209	-1.417	1.215	2.441	-0.488	1.953	1.953		1.953	0.000	-1.465	1.953	
VT 4	-0.742	-0.786	-1.253	0.204	1.953	-2.441	-3.906	-0.977		-2.930	-1.953	-3.418	-3.906	
VT 5	6.926	8.583	6.195	5.556	4.395	6.348	8.301	9.277		3.906	7.324	10.742	15.137	
VT 6	-42458.267	-43389.816	-46558.030	380.821	673.828	9.766	-53154.297	-52285.156		-830.078	-19.531	-101230.469	-99550.781	
VT 7	1.717	5.411	-1.905	2.634	5.859	0.488	3.418	0.488		0.488	-1.953	4.395	1.465	
VT 8	-55346.260	-56415.939	-60386.467	464.439	1630.859	29.297	-70478.516	-69423.828		-1064.453	0.000	-151738.281	-152695.312	
VT 9	2.926	2.306	5.928	6.395	-20.508	4.883	4.395	2.930		2.930	4.883	3.418	3.418	
VT 10	1200.628	-12943.316	-2310.753	-98.467	1818.848	12.207	1354.980	1354.980		36.621	12.207	4187.012	4199.219	
VT 11	4.290	4.728	4.040	0.755	-0.977	0.488	4.395	2.441		0.488	1.465	7.812	4.883	
VT 12	-55308.800	-56240.845	-60315.140	522.919	-1367.188	0.000	-70419.922	-69365.234		-1093.750	19.531	-150117.188	-152792.969	
VT 13	1.036	0.410	-0.853	1.036	9.277	-0.977	-0.977	0.977		2.441	-3.418	0.000	-1.953	
VT 14	-42413.254	-43245.964	-46468.124	373.878	-1015.625	0.000	-53466.797	-52226.562		-839.844	0.000	-101699.219	-97968.750	
VT 15	1.093	-2.508	-3.763	1.575	-0.488	-0.488	-1.465	-6.836		0.000	-0.977	-0.977	-2.441	
VT 16	1.936	0.240	2.125	1.724	0.977	-0.488	3.906	-0.488		-0.977	0.000	3.418	0.488	
VT 17	-0.956	1.799	3.487	-0.601	-0.977	2.441	1.465	0.000		1.953	0.000	1.465	2.441	
VT 18	-1.122	-2.817	-0.012	-2.552	-2.930	-3.418	-1.465	-0.488		-2.441	-2.930	-0.977	-1.465	
VT 19	13.872	18.810	18.686	18.583	20.508	10.742	16.113	12.207		21.484	-70.312	68.359	63.477	
VT 20	-200542.908	2468.872	2293.549	1595.001	1562.500	-78.125	-252578.125	-246875.000		-3906.250	-234.375	-513984.375	-512890.625	
VT 21	312.288	335.794	339.346	341.055	342.773	379.395	371.582	365.723		447.754	-469.727	644.043	641.113	

- VT values in this table taken ***at the trip time*** (based on PLC and SOE timestamps)
- Voltage values of suspected VT18 and VT2 do not seem to be high because their spikes occur ~ 200 ms before trip. New table in progress

VIII Solenoid/ Torus CMS- Spares

- Made spares list for critical components of cRIO and PLC
  - Currently there is not PLC controller spares available.
  - Only five Control Logix PLC modules available.
    - 1756-OW16I Relay module (x3)
    - 1756-OF8 V/I AO module (x1)
    - 1734-IB4 Point IO DC module (x1) (Only to be use as Torus spare)
  - Currently there is not a reliable spare cRIO controller
    - Ordered a NI cRIO-9045 controller to be used as spare ether for solenoid or torus Fast DAQ.
  - Five cRIO spare modules available
    - NI-9239 ADC input module (x4)
      - At this time modules installed and running at the Solenoid and Torus FastDaq cRIO chassis.
    - NI-9870 RS232 Serial interface module (x1)

IX. Summer tasks

1. Update four cRIO controllers to LabVIEW 2017 (Includes Hall B PCs)
2. Update firmware of CryoCon units for the Torus
3. Verify and test variables that could be contributing to QDtrips (VT2 and VT18)
4. Hardware/software filters for Fast DAQ data
5. Grounding/wiring of power source connected to all related controls
6. Change VT panel switches

IX. Summer task

7. Add relay to E-Stops on PSU and remote control crate to generate fast dump
8. Implement Sequence of Event (SOE) timestamps EPICS screen
9. Evaluate recovery procedure of cryogen due to loss of flow from ESR
10. Reduce electronic noise
11. Connect Hall B backup power for vacuum pumps
12. Check leaks on electric valves
13. Complete checking of all drawings and upload to document repository

X. Conclusions

- Torus is in good health
- Solenoid is in fair health
  - Must solve voltage tap issues, which has been cause of most trips