Jefferson Lab
MAGNET GROUP

12th Feb 2019

v1

Ruben Fair

Outline

Project involvement and Contribution to Physics Division

- Operations support for the halls and Cryo
- Publications
- Support for DOE reviews
- On the 'immediate' horizon
  - MOLLER (Hall A)
- 'The Mysterious Case of the Misbehaving Solenoid'

Dave Kashy

- **Cryo - 2K Cold Box** - Chaired the SC1R 2K Cold Box Installation Review wrote up interim report. Awaiting response from the Cryogenics group.
- **Cryo - ESR2 / Targets** –
  - Original goal from previous ESR2 analyses (2010-2017) was to maximize capacity and minimize power bill. Looked in detail about possible distribution to the Halls for target gas at low pressure.
  - Along with C. Keith deemed this impractical. Encouraged Cryo to analyze capacity and electrical cost for providing target gas at "high pressure" (~16atm) and at a variety of pressures. With this information, a detail analysis was carried out of cryogenic target coolant gas distribution from ESR2 to Halls A and C for both High Power (5kW) and standard (1kW) H2 targets. Relayed this information to the Target and Cryo groups.

Possible options: (note all described below use the normal ESMTL between the ESR and either Hall A or C)

1. Tie all circuits into the valve box on south (normal end)
   - Supply/Return the targets through the full ESR VB to the Expansion Cans at ESR
   - Provides the least DP for the target
   - Depending on supply temperature it will work!
   - Lowest cost and probably the cleanest
2. Bypass the ESR VB for both the 15K and 20 K circuits
   - Provides the Most DP for targets
   - Could allow two different target supply temperatures
   - Probably will work with any target supply temperature so lowest operating cost

My Recommendations

- Hybrid System combining Option 1 and part of Option 2 that would allow:
  - Running ALL Halls through the ESR VB at 14.4K or 11.7K
  - Running either Hall A or C, but not both at the same time, with the same temperature gas as in above case, but bypassing the ESR VB for the Supply and Return (may be possible to build one set of U-tubes that fit both Halls for this)
  - Running Hall A and C at different supply temperatures in any combination 14.4K, 11.7K or 8.3K by using the ESR VB for one and an additional line in the TL for the other

Dave Kashy

- **CEBAF Arc Magnet Stand Misalignment** - Developed a hypothesis (cyclic loading of bolts, due to temperature cycles, is more than recommended amount causing bolts to lose pre-load) and analyzed it as to the cause and suggested a solution – limit torque on upper capture bolts, weld washers to plate to limit slippage

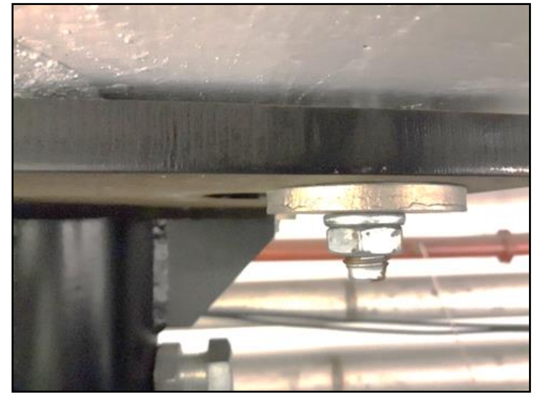
Anchor Cycling Loading Analysis

- Data from the temperature data in EPICS, Data started 1/2/2016
- Comparing the cycling loading to the Allowable and Pullout loads

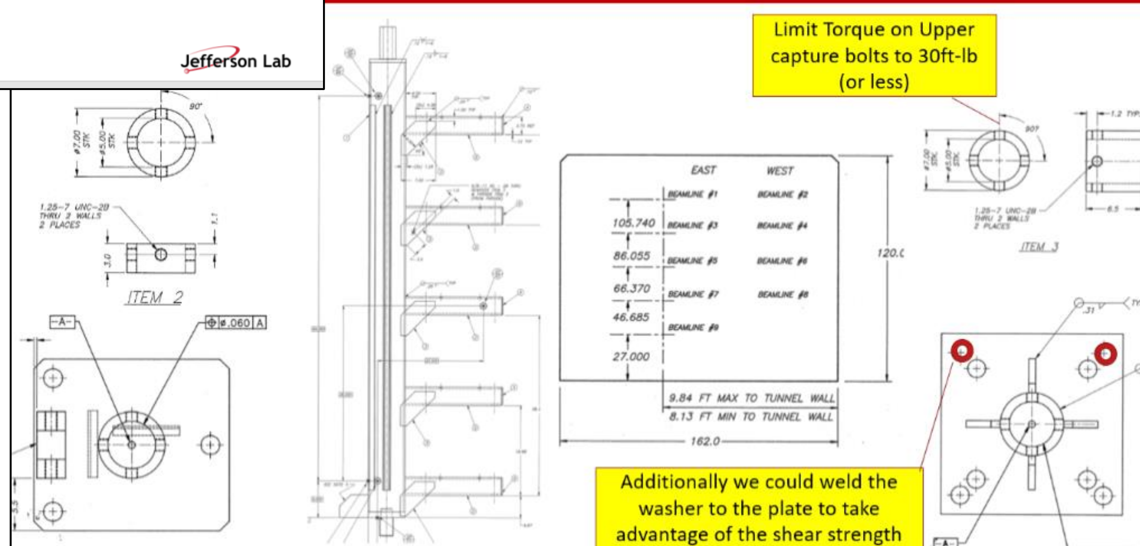
ΔT (C)	Live Load F (lbs)	Effective Live Load (LLx1.6)	Average Frequency West ARC (N/yr)	Average Frequency East ARC (N/yr)	Percentage of 4 bolt Allowable Load	Percentage of 4 bolt Pull Out Load
3.0	7614	12182	20.8	10.4	66%	29%
5.0	12690	20304	4.8	2.2	109%	48%
7.0	17766	28426	1.9	1.0	153%	67%
10.0	25380	40608	0.4	0.3	219%	96%

Single Anchor Allowable load 4638lbs
Single Anchor Pull out load 10,561lbs

- Data is filtered for noise and drop outs, but all data filtered the same way
- This data is Air temperature from signals with epics names
  - ac:ARC_E_TunnTempA (only signals B, C, D used because signal had noise that filters could not remove)
  - ac:ARC_W_TunnTempA (all signals A, B,C, D all used)



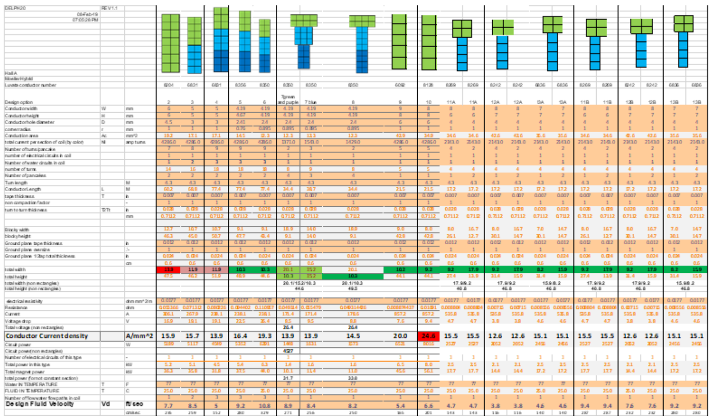
Proposed Solution



Dave Kashy

▪ Hall A (MOLLER)

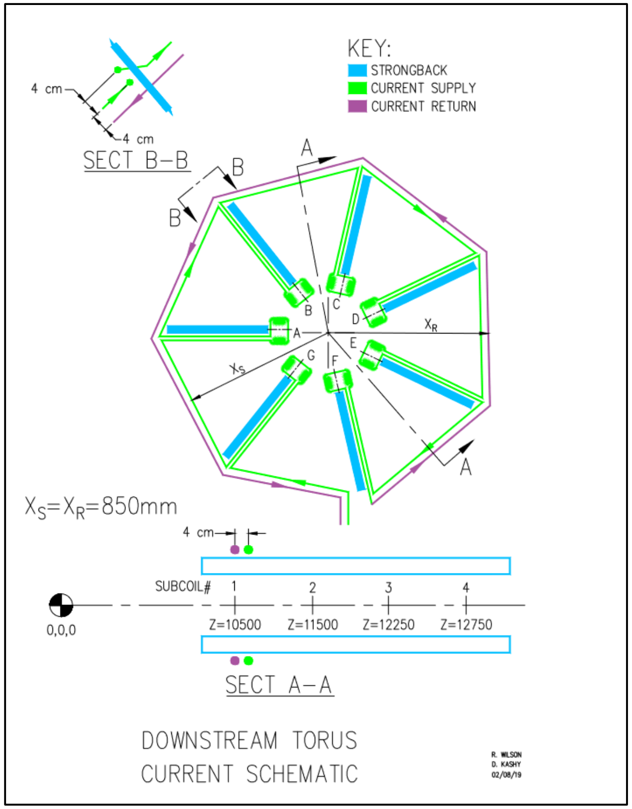
- Reviewed the test data from the MIT test of the prototype coil and put that data on plots along with Jlab calculations. This showed that the data as provided did not match well with any calculation method. This was followed up with a review of the data provided and MIT realized that they had not included in the report the system return pressure. Once subtracted the data fell within reasonable range of expected values (with **Sandesh**)



- Worked on conceptual layouts of conductor winding for two options for the Moeller Hybrid Coil and gave sketches to the designers to lay them out. Started analyses of the coil heating/cooling, coil forces and concepts and hand calculations for coil supports. (with **Sandesh** and **Randy**)

- Preliminary design for upstream torus coils. Goal was to reduce winding complexity (lower cost), use standard conductor, minimize pressure drop and temperature rise and limit current density. All to within our design parameters (with **Sandesh**)

- Preliminary design for power bus bars for hybrid (downstream) torus. Sent to collaboration for inclusion in their study of particle envelop trajectory so that real effects of actual hardware will not be missed when detail design begins. (with **Randy**)



Dave Kashy

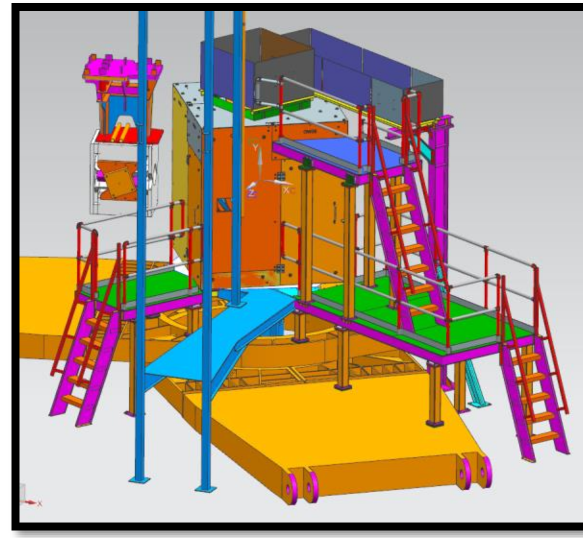
- **Hall B (CLAS12)** - Wrote detailed procedure for 80K warm up and cooldown of the CLAS12 cryogenic system and cross trained D. Insley on this process before and after the SAD December 2018
- **ASC2018** - Attended the Applied Superconductivity Conference in Seattle Wa, and gave an oral presentation about the CLAS12 Torus and Solenoid Commissioning
- **NIM2019** - Wrote sections and helped with editing of the CLAS12 NIM article on the CLAS12 superconducting magnets

Probir Ghoshal

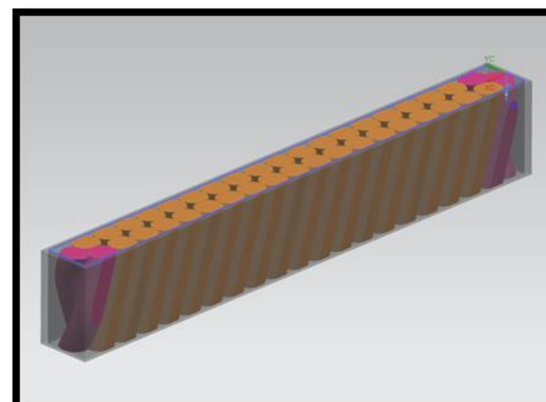
- **Hall A** - MOLLER – Torus magnet coil designs (OPERA FEA, fault scenarios, coil forces)
- **Hall B** – Solenoid fast discharge (dump) investigation
- **Hall C** – Supporting calculations for Quench-back due to fast decaying currents which induce losses in SHMS Magnets (with **Eric Sun**)
- **Hall A** - Model Quads with actual dimensions and conductor layout in order to produce stray field maps – Complete 2018
- **Hall B** – Modelling actual Torus coil conductor layout to improve match with measured magnetic field data - Complete 2018 (with **Dave**)
- **JLEIC** - Conceptual magnet design study employing CICC, evaluation of ac loss, quench behavior, magnet protection, and cooling power requirement for 1T/s ramp rate-3T booster dipole magnet for JLEIC – Complete 2018

Dan Young

- **Hall A** - SBS GEn Experiment. Target and Laser Box Access Platforms
- **Hall B** – Heater plate assembly for relief valve on solenoid – Complete 2018
- **Hall C** - Supporting the design and detailing of components for the He3 Experiment
- **Hall C** - Created solid models of conductor cross sections and modified as required to reflect different iterations needed for engineering analysis (with **Eric Sun**)
- **Hall C** - Continued support of the Hall C Beam Line component configuration change to achieve the required experiment minimum angles.

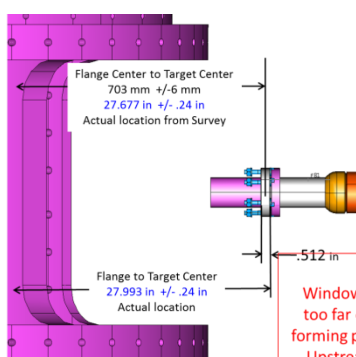


SBS-Gen Experiment – Hall A
Target Chamber/Magnetic Field Shield Assy Installed
Laser Box Assemblies are shown on second level
Personnel Access Platforms shown installed



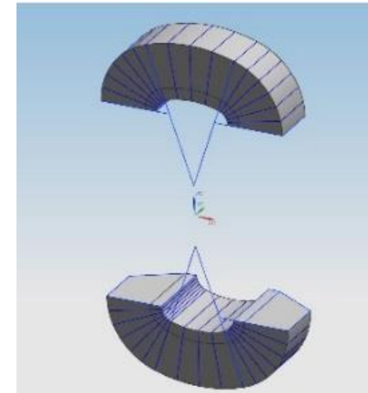
Model used in analysis of superconducting coil at the cable level. Analysis was done to obtain the average material properties of superconducting cables without insulation

Summary
Gate Valve is installed 1.664 inches too far upstream. This is one reason Upstream Beam Pipes are too long



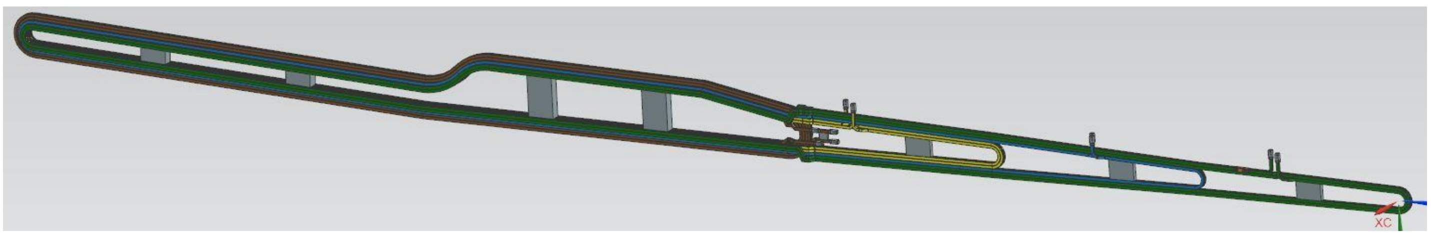
Summary
Window Flange is approx .50 inches too far downstream due to window forming process. This is the one reason Upstream Beam Pipes are too long

Randy Wilson



- **Hall A** - Created a Q4 Coil model for plot point extraction (with **Probir Ghoshal**) – Complete 2018

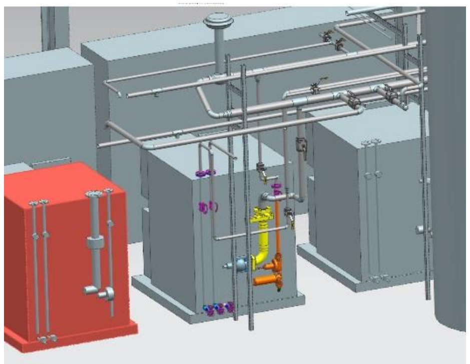
- **Hall A** - Modeled the Moller downstream hybrid coil assembly



- **Cryo** - Designed CHL2 compressor relief valve pipe spools

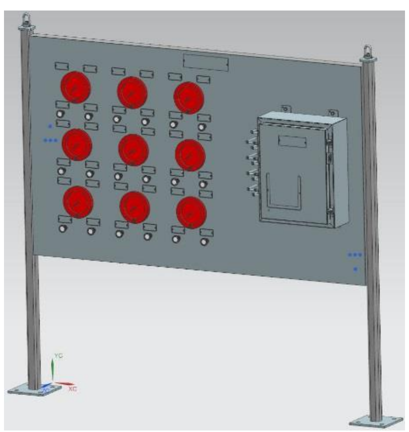
Randy Wilson

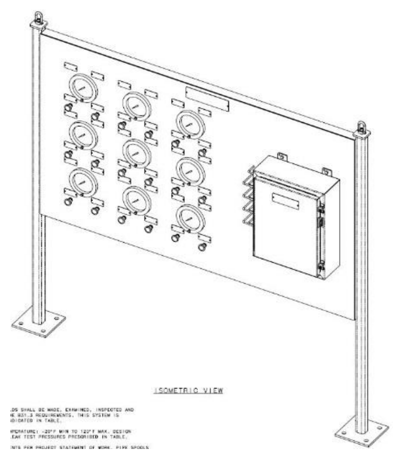
- **Cryo** - Designed CHL1 recovery compressor supply/return pipe spools

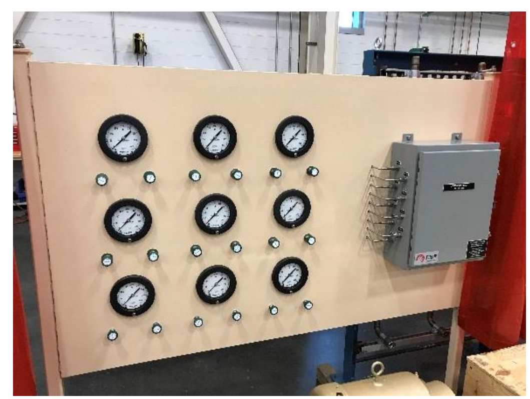


- **Cryo** - Worked at least one weekend per month for LN2 delivery, cryo-plant monitoring and walk-through for CHL

- **LCLSII** - Designed all the cryo-plant gauge panels for LCLS II

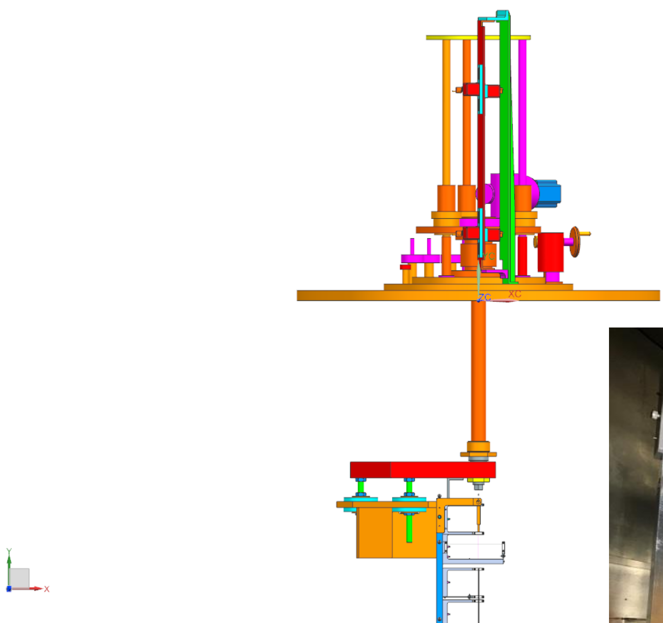






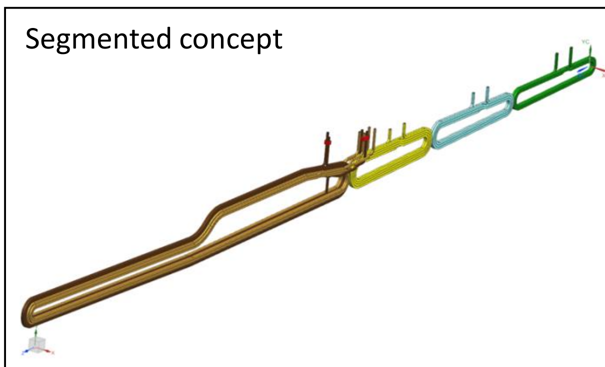
Sandesh Gopinath

- **Hall A** - Support design, procurement, assembly, testing & survey of APEX target system.
  - Modify/replace components due to unseen mechanical interferences. For e.g. Issue with linear bearings housing being larger than bellows ID, NO DRAWINGS/DOCUMENTS available for the vertical motion system.
  - Interface with vendor and hall techs for last minute fabrication needs.
  - Additions to make life easier for Survey group and help them in tight situations.

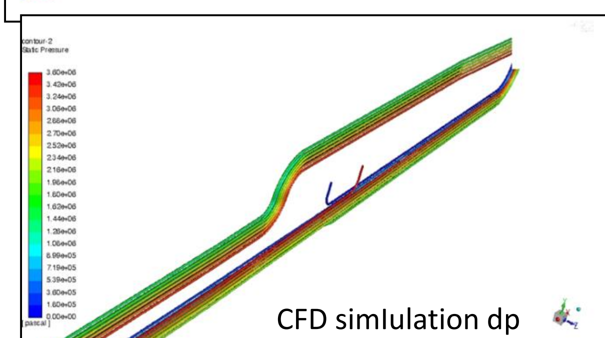


Sandesh Gopinath

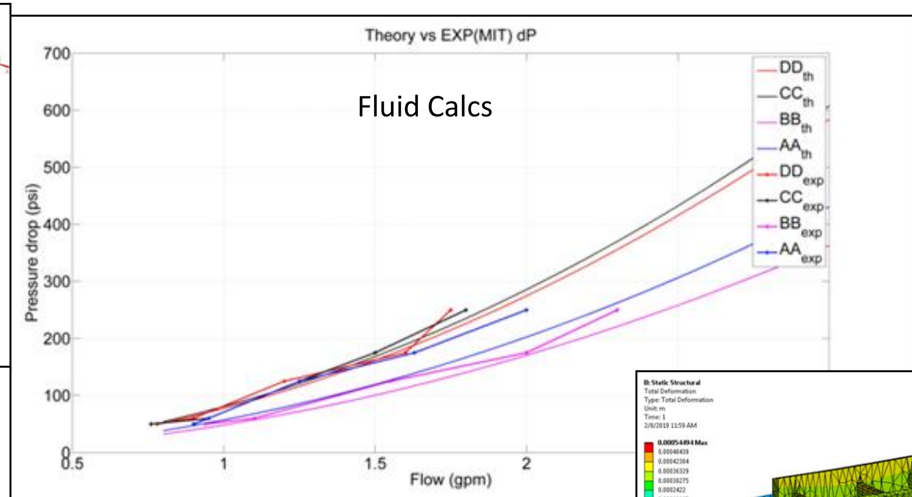
- **Hall A** – MOLLER Perform preliminary thermal, fluid and structural analysis on the Moller hybrid torus and beamline components.
  - Calculations comparing pressure drops in water circuits with MIT results from testing the prototype
  - CFD simulations using ANSYS FLUENT to study/compare/validate theoretical pressure drops and temperature rises in individual coil windings.
  - Thermal simulations to study inter-winding heat transfer through epoxy (since windings with different currents & water flows will be potted together).
  - Structural calculations for thin windows, beam-pipes and coil strong-back support .



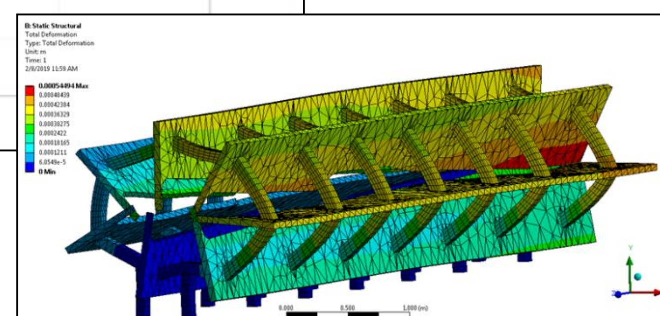
Segmented concept



CFD simlulation dp



Coil support

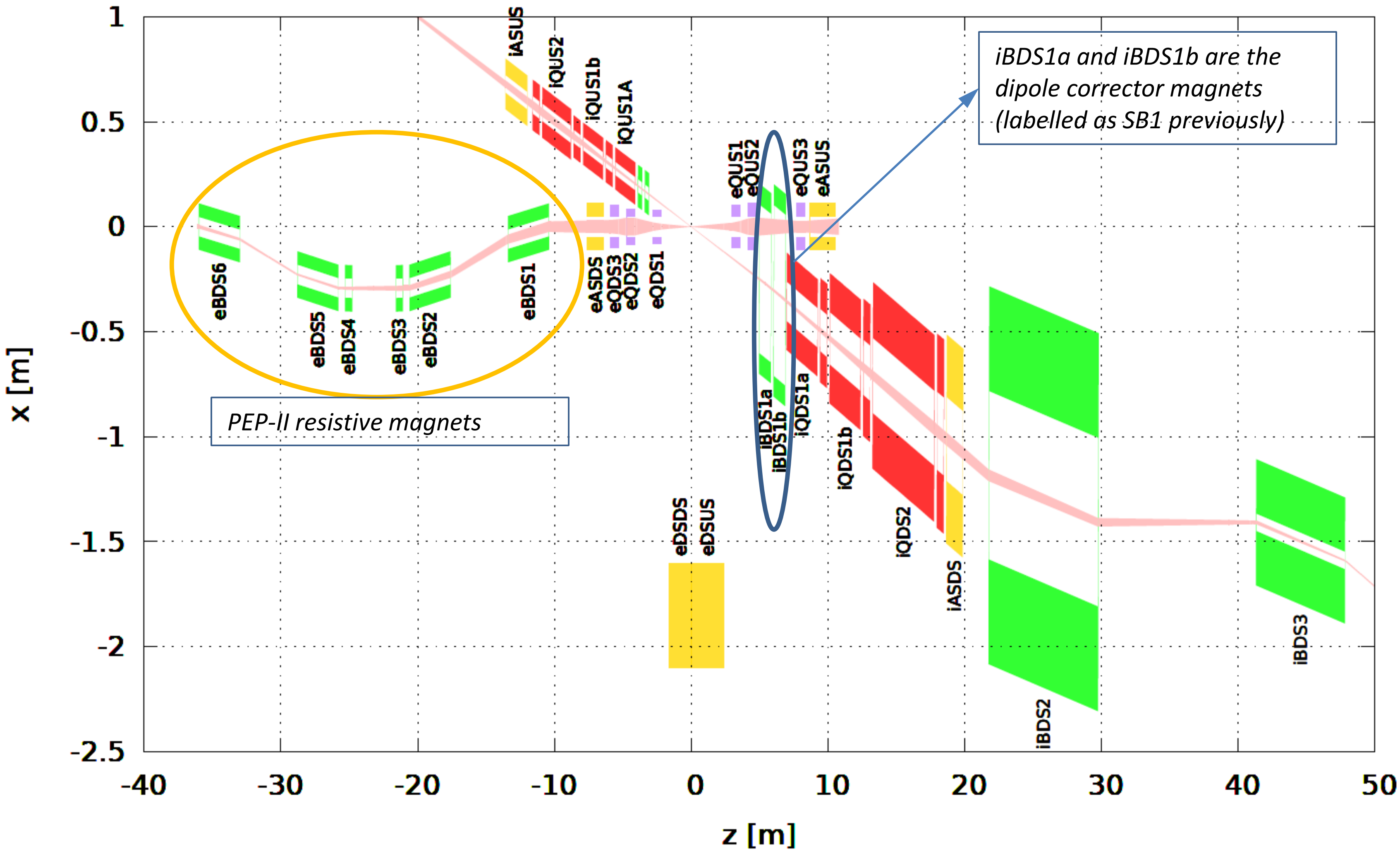


Renuka Rajput-Ghoshal

- **JLEIC** – 2017-2019
  - Preliminary design of all SC quadrupoles, skew quadrupoles, solenoids, corrector magnets for Ion and Electron beam lines in the interaction region has been completed.
  - Wrote the Interaction Region magnet design part of the pre-CDR report in September 2018.
  - All SC magnets for the higher center-of-mass energy will need to be redesigned. Helping to prepare the updated pre-CDR report.
  - The new design has a doublet structure instead of the more conventional triplet structure. The Accelerator Advisory Committee has also recommended to reduce the field (or field gradient) to allow use of NbTi superconductor.
  - Latest IR layout is shown on the next slide - main focus is on iBDS1a and iBDS1a - dipole corrector magnets. The main field (B_y) is 2.5 T and B_x is approximately 1.3 T, these are large bore magnets. In order to get the required integrated field, magnets needs to much longer than the space available.
- **Hall B** – Solenoid – Improving the match between modelled and measured magnetic field data
- **Hall B** – Solenoid and Torus interaction studies – examination of measured load cell data and comparison with models

Renuka Rajput-Ghoshal

IR Layout (February 6th 2019)

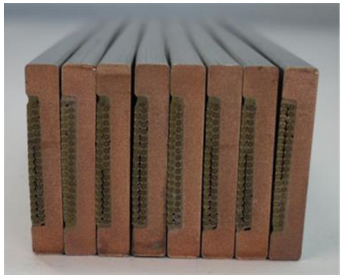


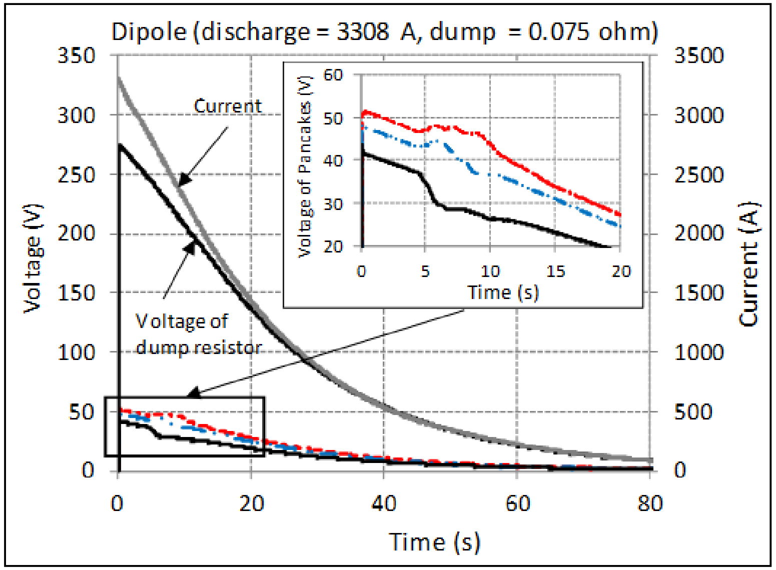
Element name	Type	Length [m]	Good field half-aperture [cm]	Inner Half-A [cm]	Outer Radius [cm]	Dipole field [T]		X center [m]	Y center [m]	Z center [m]
iBDS1a	RBEND	0.85	4	35.2	45.2	1.30	2.47	-0.271	0	5.418
iBDS1b	RBEND	0.85	4	40.5	50.5	-1.09	2.24	-0.327	0	6.467

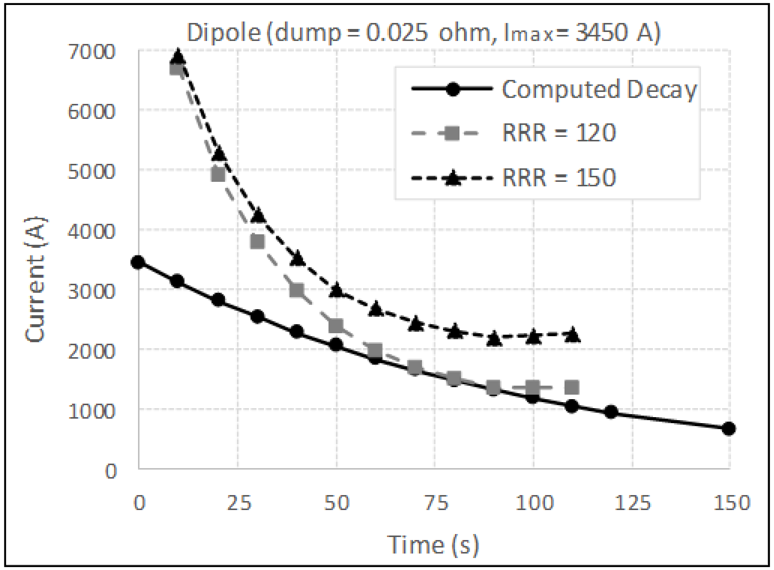
Eric Sun

Hall C - Quench-back Management of SHMS Magnets

- Operation shows that fast dumps of the SHMS Q2/Q3 and Dipole trigger quenches, causing some level of operational difficulty – e.g. loss of all helium
- Tests and detailed analyses indicate that a fast discharge produces fast current decay, resulting in substantial ac loss in the conductor and subsequently triggers a ‘quench-back’ effect.
- Recommendation: Modified (new) dump resistors could manage quench-backs.
- In the process of writing a journal paper.
- New modelling Mathcad tool has been developed.



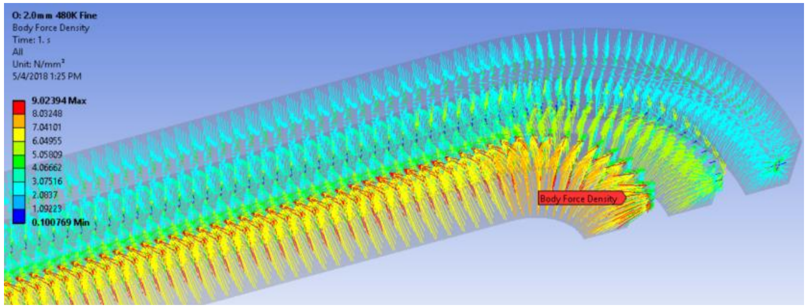


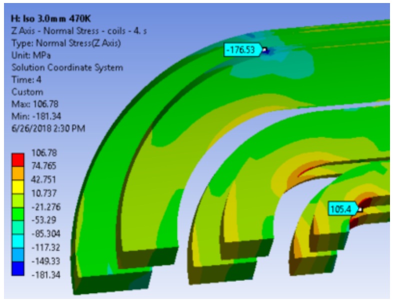


Eric Sun

Stress analysis of JLEIC magnet coil set

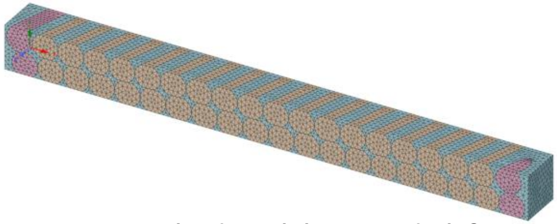
- Investigation of high field, highly stressed Nb_3Sn magnet (JLEIC QFFB2)
- Comparison with published data from FNAL (Hi-Lumi LHC project)
- Provides a means of extending JLab's modelling capability to other 'highly stressed' JLEIC magnets



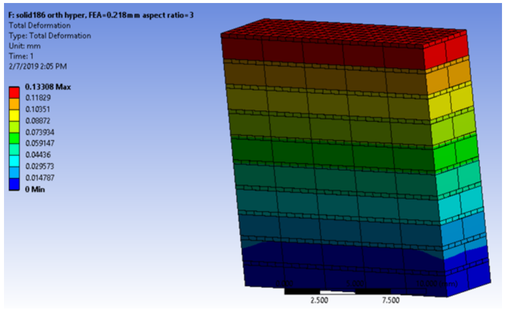


Nonlinear Stress Analysis of Superconducting Magnets

- One of the never-ending challenges of mechanical design of SC coil composite structures
- Ongoing work to develop a realistic tool that can be used for future SC magnets at JLab and elsewhere.
- Trade-off between mesh size, computing time and accuracy



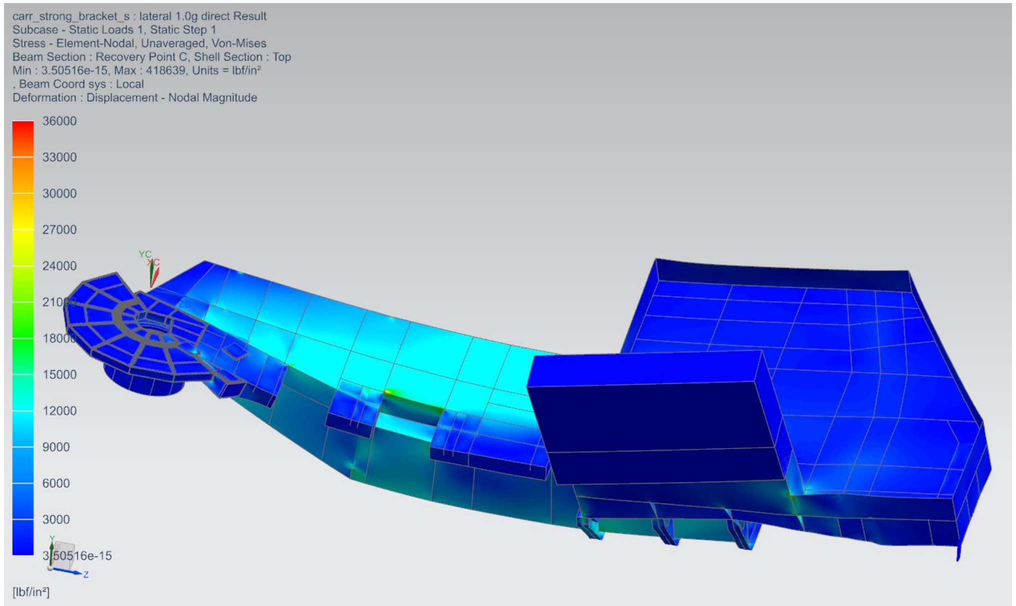
ANSYS Detailed Cable Model for Orthotropic Material Properties



Simple Insulation and Cable Model to Correlate hand calcs with the FEA – *a work in progress*

Eric Sun

- **Hall C** - New Magnet (to replace HB magnet) on SHMS Carriage Platform – check on loading of platform



- **Hall C** - NMR Probe (to allow control of current for the SHMS dipole from close to zero to full field)
- **Hall C** - Lead shielding support structure analysis
- **Hall C** - SHMS Cerenkov window (bolt torques), He3 Be Window (stress-induced beam heating)

Recent Team Publications

Manuscripts Published and under review

1. Ghoshal, P. K., et al., “Commissioning Validation of CLAS-12 Torus Magnet Protection and Cryogenic Safety System”, *IEEE Transactions on Applied Superconductivity*, V28 (6), 2018, DOI:10.1109/TASC.2018. 2841928. *Published*
2. Probir K Ghoshal, et al., “Instrumentation and Control Selection for the 12 GeV Hall-B Magnets at Jefferson Lab”, *Supercon. Sci. and Tech.,* V31 (9), 095007, 2018, DOI: 10.1088/1361-6668/aad277. *Published*
3. Ghoshal, P. K., et al., “Magnetic Field Mapping of the CLAS12 Torus—A Comparative Study Between the Engineering Model and Measurements at JLab”, *IEEE Transactions on Applied Superconductivity,* V29 (4), 4000310, 2019, DOI - 0.1109/TASC.2018.2884968**.** *Published*
4. R. Rajput-Ghoshal, et al., “Preliminary Design of the Interaction Region Magnets for Future Electron-Ion Collider at Jefferson Lab”, *IEEE Transactions on Applied Superconductivity (Submitted and under Review)*

Preparation in Progress for Submission

1. P. K. Ghoshal*,* et al., “Design Study of a Fast-Ramping Super-Ferric Magnet for Future Electron-Ion Collider at Jefferson Lab”, In progress for *IEEE Transactions on Applied Superconductivity*
2. Eric Sun, et al., “Quench-back Management Due to Fast Decaying Current in SHMS Superconducting Magnet and AC Losses in the Conductor at Jefferson Lab”, In progress for *IEEE Transactions on Applied Superconductivity*
3. R. Fair, et al, “Superconducting Magnets for CLAS12”, In Progress (JLAB Internal review) for *NIM* (Elsevier Publications)

❑ External DOE Reviews

- ❑ **FRIB – Facility for Rare Isotope Beams (MSU) – SC magnet design –** *R. Fair, P. Ghoshal*
- ❑ **NSTX-U – National Spherical Torus Experiment – Upgrade (PPPL) – Resistive coil design –** *R. Fair*
- ❑ **Mu2e – Muon to Electron Conversion Experiment (FNAL) – SC magnet design –** *R. Fair*
- ❑ **MPEX – Material Plasma Exposure Experiment (ORNL)** – **SC magnet design** - *R. Fair*
- ❑ **Hi-Lumi LHC – High Luminosity Large Hadron Collider (FNAL)** – **SC magnet design -** *R. Fair, P. Ghoshal*
- ❑ **LSST - Large Synoptic Survey Telescope – Cryogenics –** *D. Kashy*

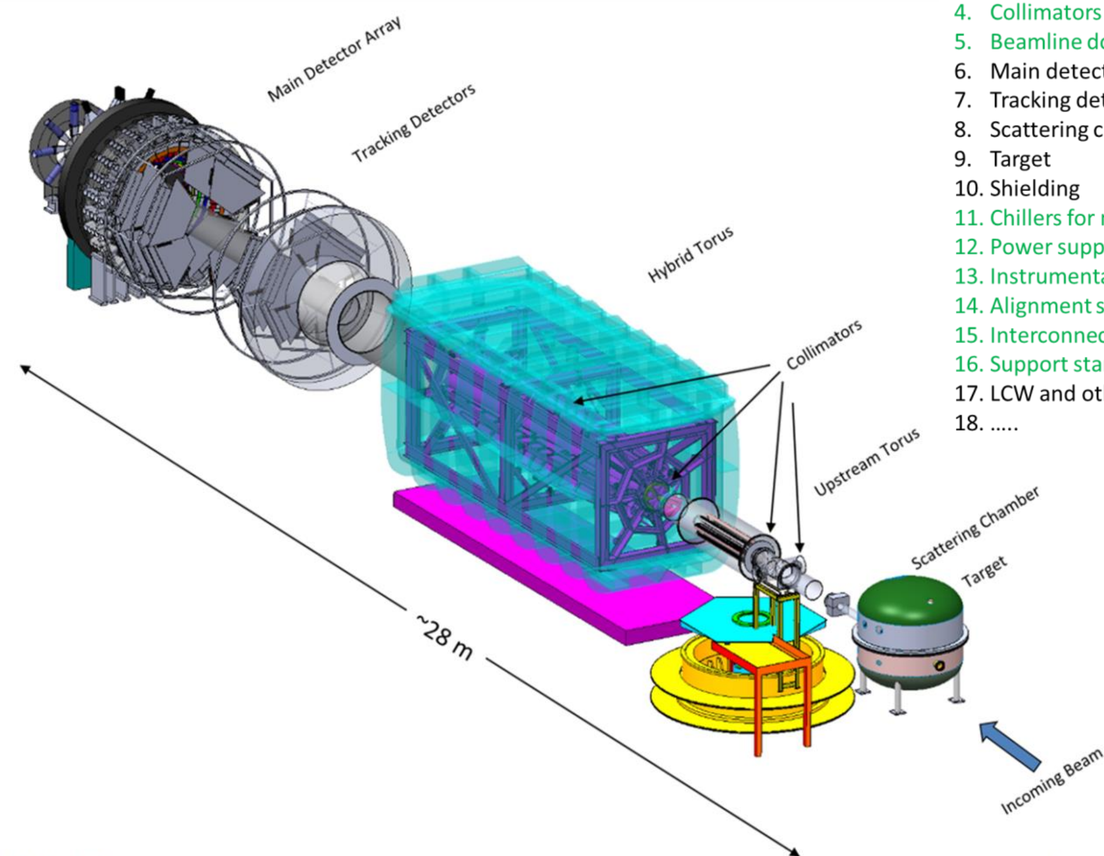
❑ Other ongoing work

- ❑ **Creation of database (design info) for all superconducting magnets at JLab**
- ❑ **Creation of Design Tools for use by 'experts'**
- ❑ **Creation of other informational databases** *(e.g. material properties at cryogenic temperatures)*
- ❑ **Internal training on Cryogenics and Magnet Design for JLab staff**

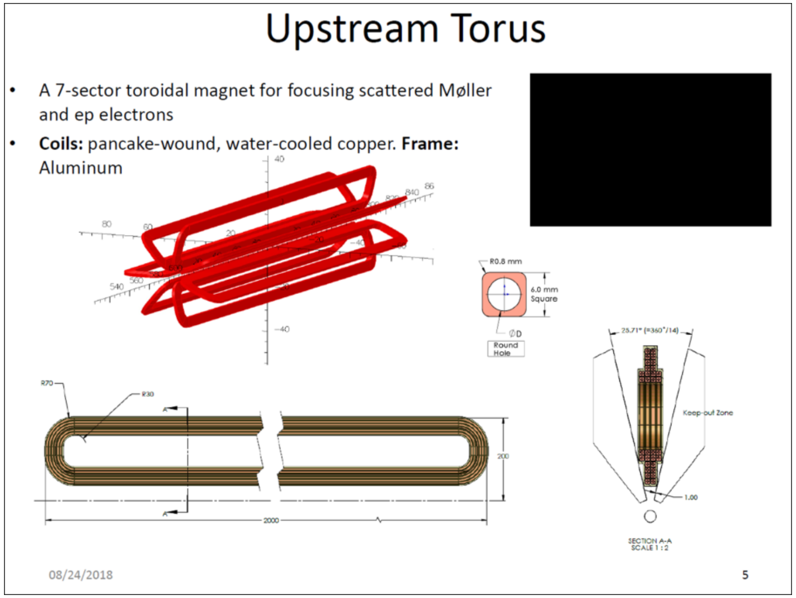
MOLLER (Hall A)

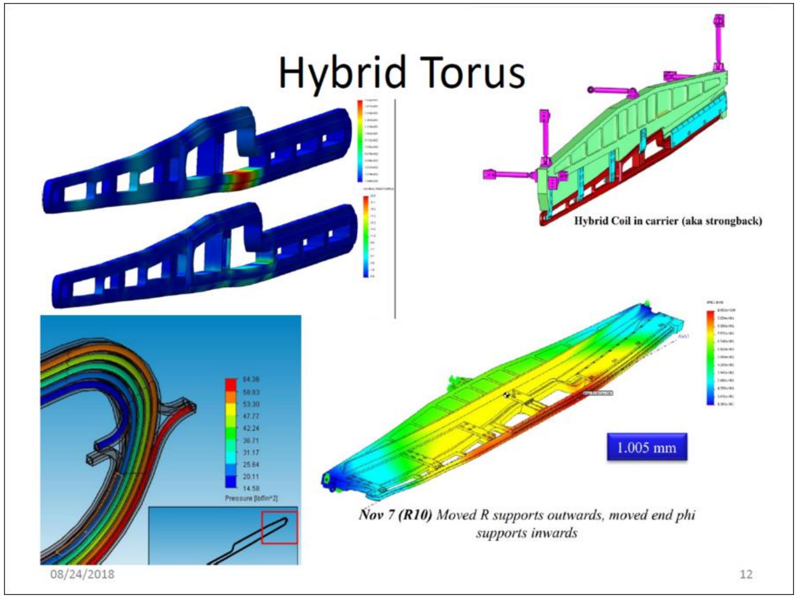
Items in green fall within the scope of the Spectrometer WBS

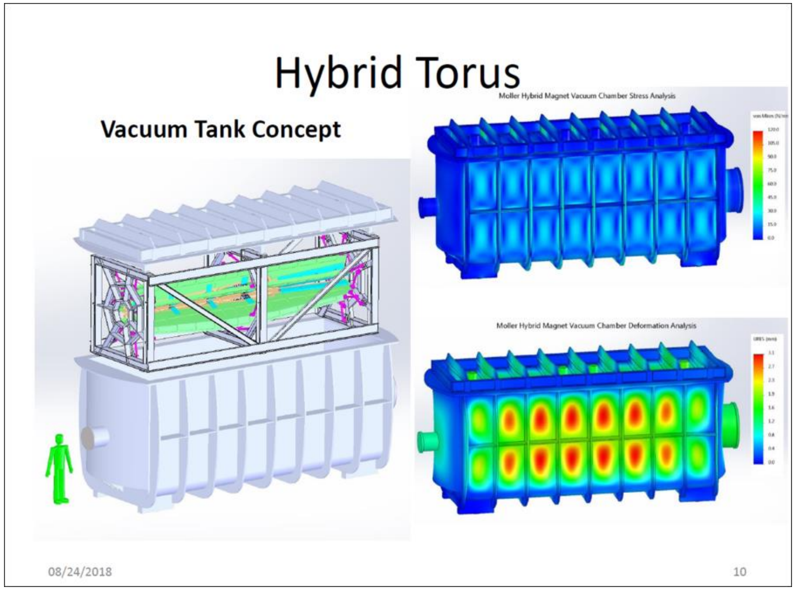
1. Upstream torus
2. Downstream torus
3. Enclosures + ancillary equipment
4. Collimators
5. Beamline downstream of scattering chamber to just upstream of tracking detectors
6. Main detectors
7. Tracking detectors
8. Scattering chamber
9. Target
10. Shielding
11. Chillers for magnets
12. Power supplies
13. Instrumentation and Controls
14. Alignment systems
15. Interconnections
16. Support stands
17. LCW and other hall infrastructure upgrades
18. .....

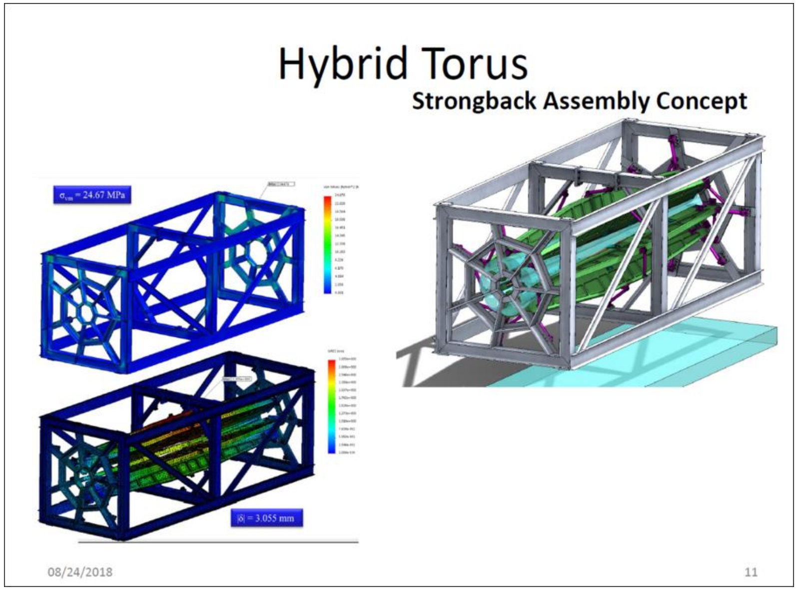


MOLLER (Hall A)









MOLLER (Hall A)

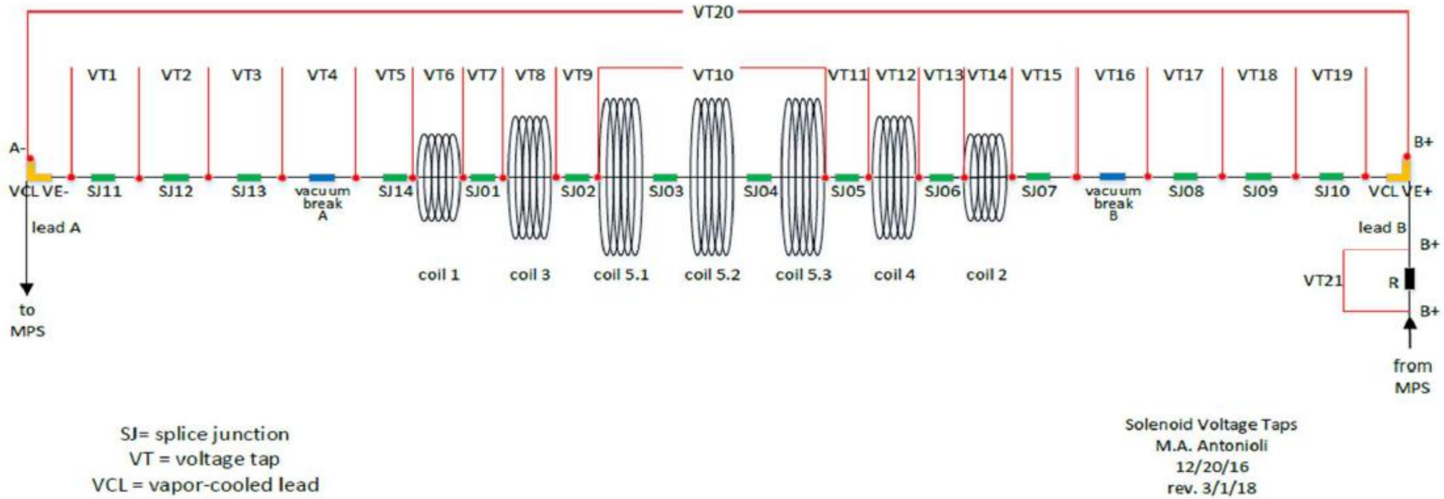
- Transferred magnet designs and information from MIT Bates
- Developed 'Design Targets' document to provide guidelines for coil and magnet design
- Designed two alternative coil designs (Hybrid v5 and Segmented v1) for downstream torus
- Preliminary design of power bus bars for downstream torus
- Preliminary design of upstream torus coil
- Carried out 'bottoms-up' costing exercise with MIT and Jlab engineers
- Produced preliminary project plan
- Using Pugh matrices to down-select designs
- Carrying out a Failure Modes and Effects Analysis (FMEA)
- Preparing for Director's Review in April 2019

Version No.	2.00
Date	02.07.2019
Engineer	R. Fair

TASK	Who (Lead,...)	11-Feb	18-Feb	25-Feb	4-Mar	11-Mar	18-Mar	25-Mar	1-Apr	8-Apr	15-Apr	Director's Review this week 22-Apr
Update/refine coil design tool	DK, SG		■									
Qualify coil design tool	SG, DK	■	■									
Preliminary electrical/hydraulic design of upstream torus coils	DK		■									
Update Design Targets doc	RF, PG, DK, RW, SG, KK, JM, AG, RW			■	■	■	■					
Create OPERA coil model	PG, SG	■	■	■								
Evaluate forces for selected fault scenarios	PG			■	■							
Prelimary coil support design/FEA	DK, SG	■	■	■	■	■	■					
Perform FMEA	RF,PG,DK,RW,SG, R Wines			■								
Identify key risks	RF, KK, JM, R Wines				■							
Produce plans to mitigate risks	RF					■						
Complete SC magnet Pugh Matrix	RF, KK, JM			■								
Produce preliminary P & ID	RF, DK, RW		■	■								
Produce preliminary water buswork schematic	DK, RW				■	■						
Produce preliminary electrical busork schematic	DK, RW						■	■				
Produce draft slides for review (placeholders only)	RF	■										
First draft of slides	RF,PG,DK,RW,SG, R Wines					■						
Second draft of slides	RF,PG,DK,RW,SG, R Wines						■					
Nearly final draft of slides	RF,PG,DK,RW,SG, R Wines								■			
Dry runs for review	RF,PG,DK,RW,SG, R Wines									■		
Freeze slides and post	RF										■	

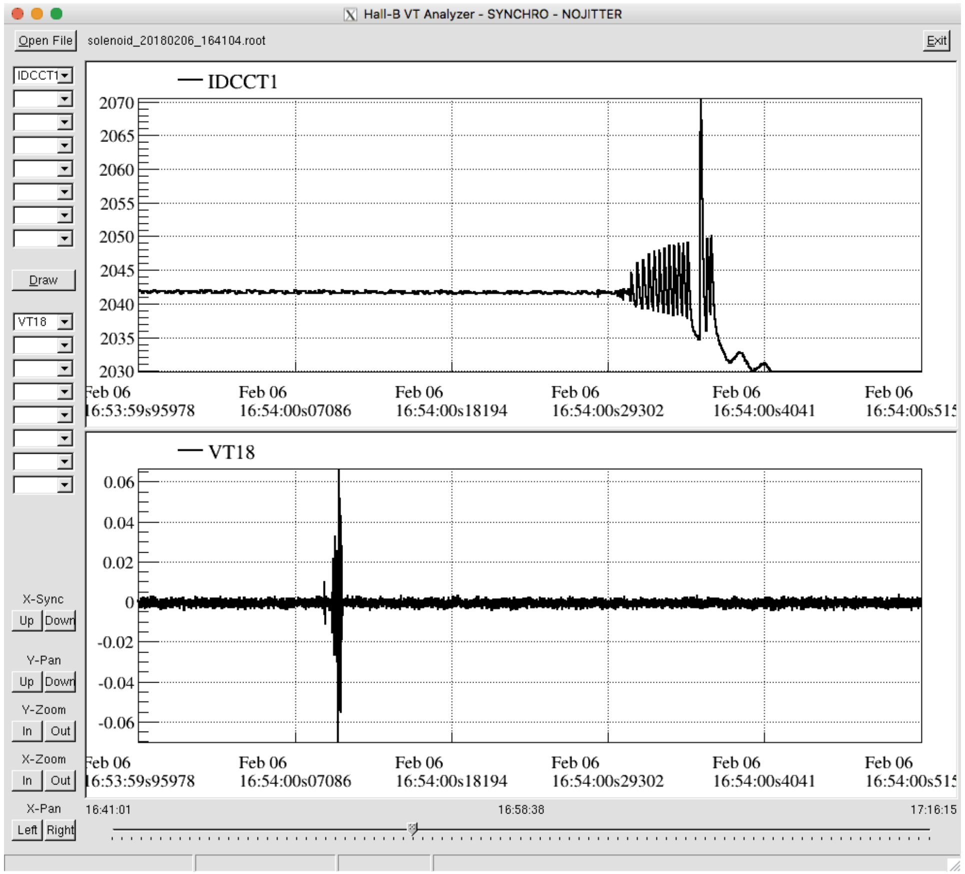
Hall B Solenoid

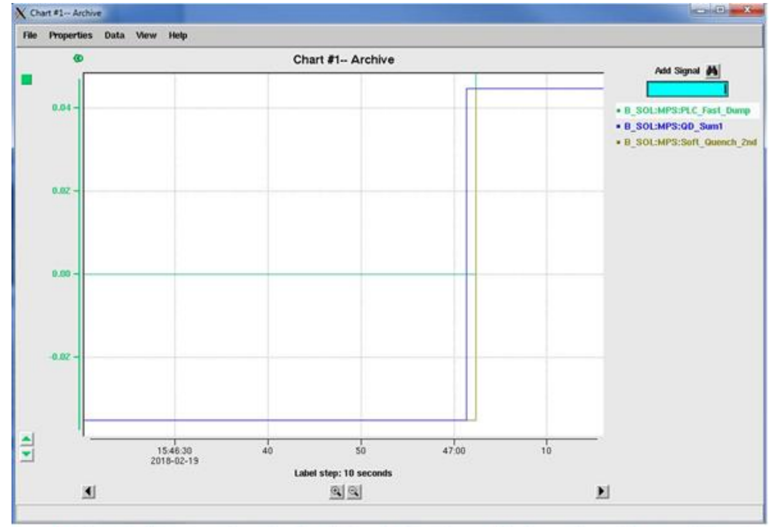
The Mysterious Case of the Misbehaving Solenoid



- **6 fast dumps at low current (less than full field of 2416 A) - commissioning was completed in Sept 2017**
  - **3 fast dumps due to PLC/software threshold voltage limits being too sensitive to noise**
  - **2 fast dumps due to hard wired QD thresholds being too sensitive to noise**
  - **1 fast dump due to an ESR cryogenic event**
- **After commissioning was completed, the magnet regularly achieved 2416 A (5.0 T)**
  - **A total of 15 fast dumps**
    - **1 fast dump attributed to a malfunctioning voltage panel switch →** ***switch now replaced***
    - **1 fast dump attributed to an incorrect QD voltage threshold setting →** ***setting now corrected***
    - **13 fast dumps →** ***VT18 or VT2 voltage taps were the key suspects***

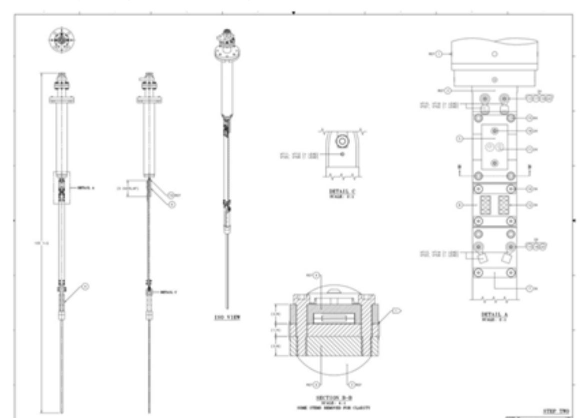
Hall B Solenoid

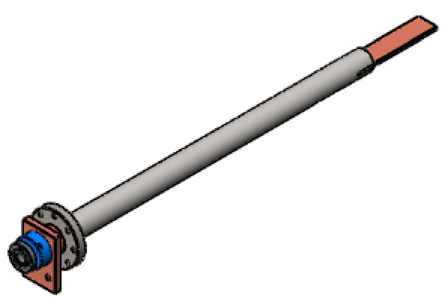




→ Clear indication that the hardwired QD tripped before the software QD trip

VT18 monitors the voltage across the splice at the Indium/bolted joint which links the bottom of AMI Vapor-Cooled Lead B (VCL B) and the copper extension bar *[Figures 5 and 6]*. VT2 monitors the voltage in the same location on VCL A. This splice is therefore located towards the top of the Helium lead reservoir, most likely bathed in cold helium gas rather than liquid. Nevertheless, there is a very high probability that the splice is always superconducting as evidenced by the very low voltage (and therefore very low resistance) during all modes of operation thus far. During the operation of the solenoid at full field, just prior to the fast dump, this Helium lead reservoir was 100% (or very close to 100%) full.





Hall B Solenoid

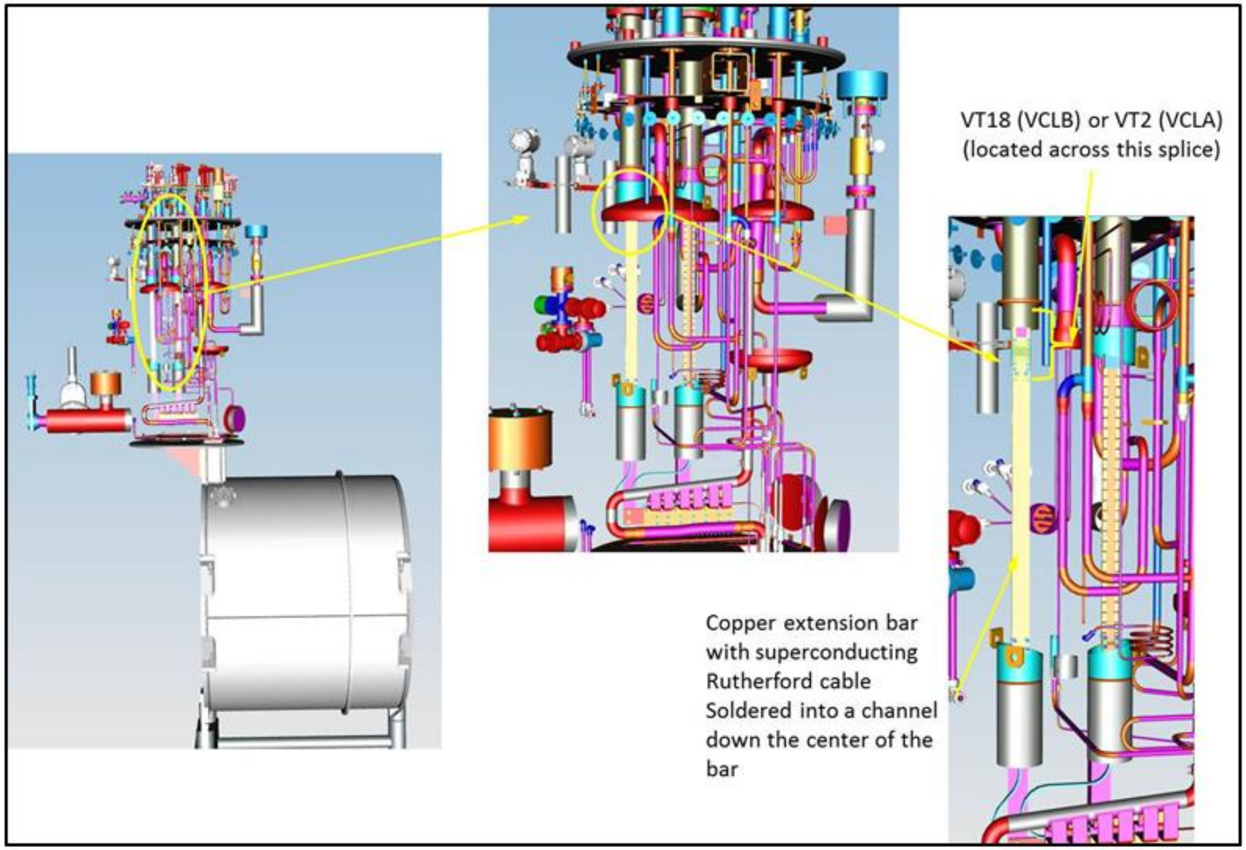


Figure 6 – Location of splice and VT18

Therefore it is very unlikely that we are seeing a voltage spike across this splice as a result of a developing resistance – either due to the splice becoming 'normal' or deteriorating with time.

Hall B Solenoid

Observations / Planned Work:

1. It may be possible that we are not capturing the true VT18 voltage magnitude via our fast DAQ electronics (and perhaps this may apply to some of the other channels also). We have a series of noise filters and iso-amplifiers in line with these signals, so could this be masking the true voltage magnitudes? → *This is a somewhat low probability as we have not observed any such 'masking' during steady and AC voltage injection tests during commissioning [Ref. 3]. But we shall re-investigate the whole electronics string nonetheless. We will also carry out some tests with the present QDSUM1 unit in place (and BEFORE we make any further improvements to the system), to monitor the actual voltage input to this unit to compare it with the fast DAQ voltage data. This means we will need to keep the solenoid at full field for at least one to two weeks after the present Physics run has been concluded.*

2. Could the lead be experiencing random vibrations (due to Helium bubbles or otherwise) → *This is a low probability based on the tests carried out and what we have observed thus far with regards to voltage thresholds and voltage spike magnitudes (assuming we have captured the correct spike amplitudes of course – hence point 1 above).*

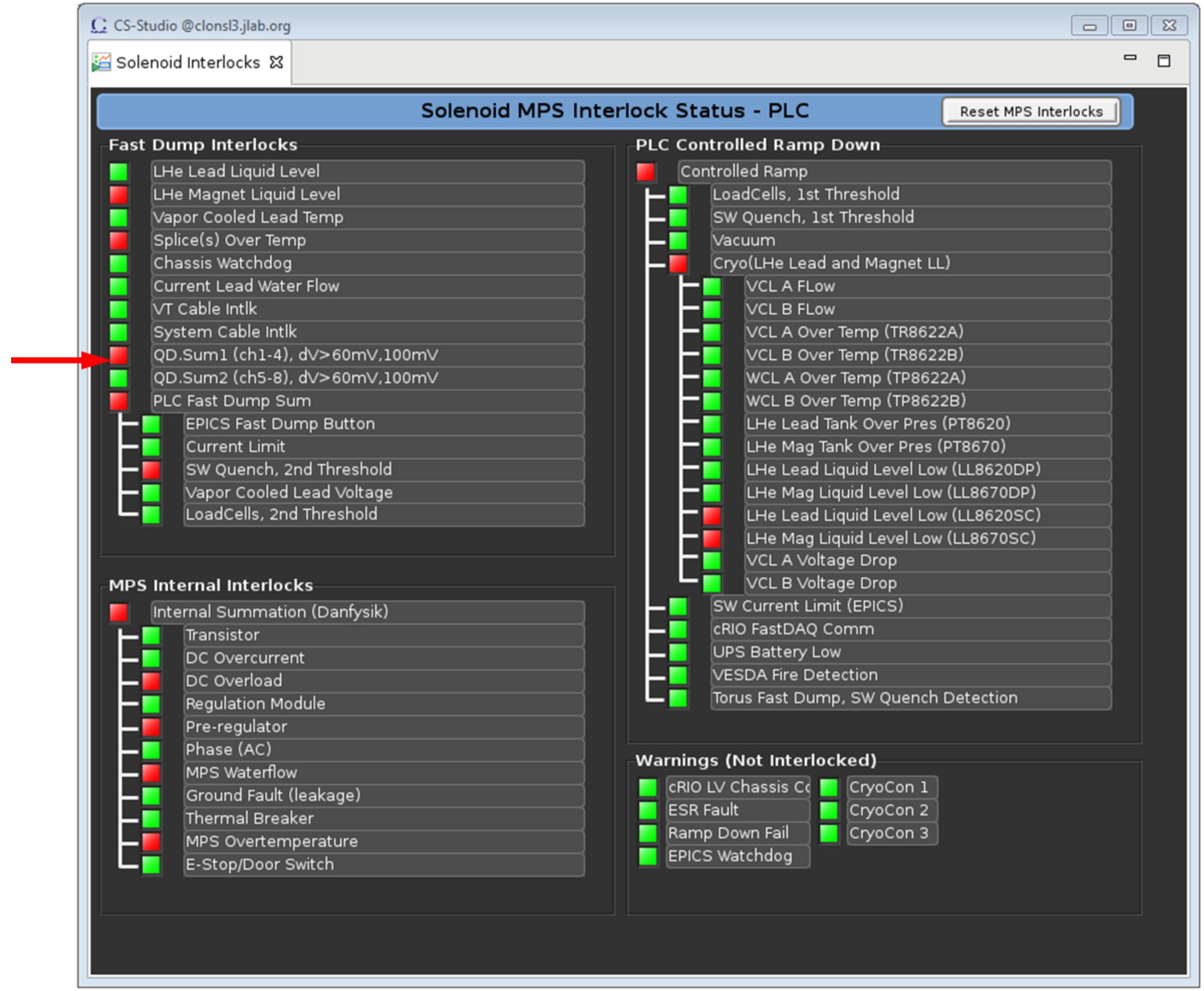
3. Could the hardwired quench detector (QDSUM1) be playing up? → *This possibility is more likely. This postulation is supported by the fact that QDSUM2 did not trip and the spike amplitudes were much lower than the voltage thresholds in use. We have a spare QD unit on hand. We will replace this unit as soon as the Physics runs are complete. This means we will need to keep the solenoid at full field for at least one to two weeks after the present Physics run has been concluded.*

4. There are some Grounding issues with some of the cables which we will also address.
    a. Cable shielding and grounding for the VT panel, Resistor chassis, hardwired QD units and 100 ft instrumentation cables will all be reviewed again.
    b. Tests to isolate and identify the source of the VT18/VT2 noise will be performed again.

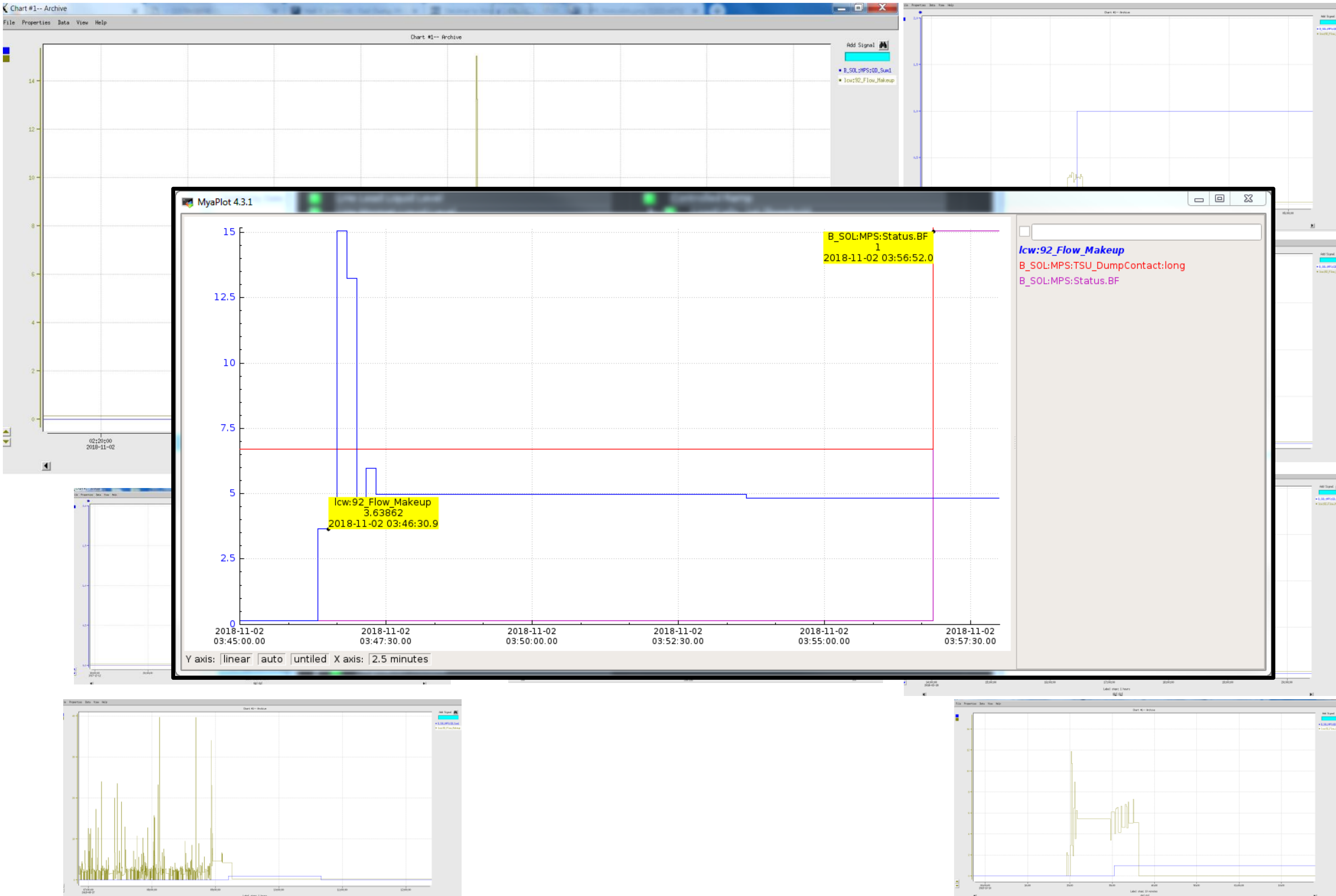
5. Additional software-related improvements:
    a. More PLC tags that should be archived, namely the individual upper/lower hardware QD status (along with the SOE timestamps)
    b. Minor changes to the Magnet Power Supply EPICS control screen to improve clarity

Hall B Solenoid

Interlocks prior to being reset



Hall B Solenoid



Hall B Solenoid

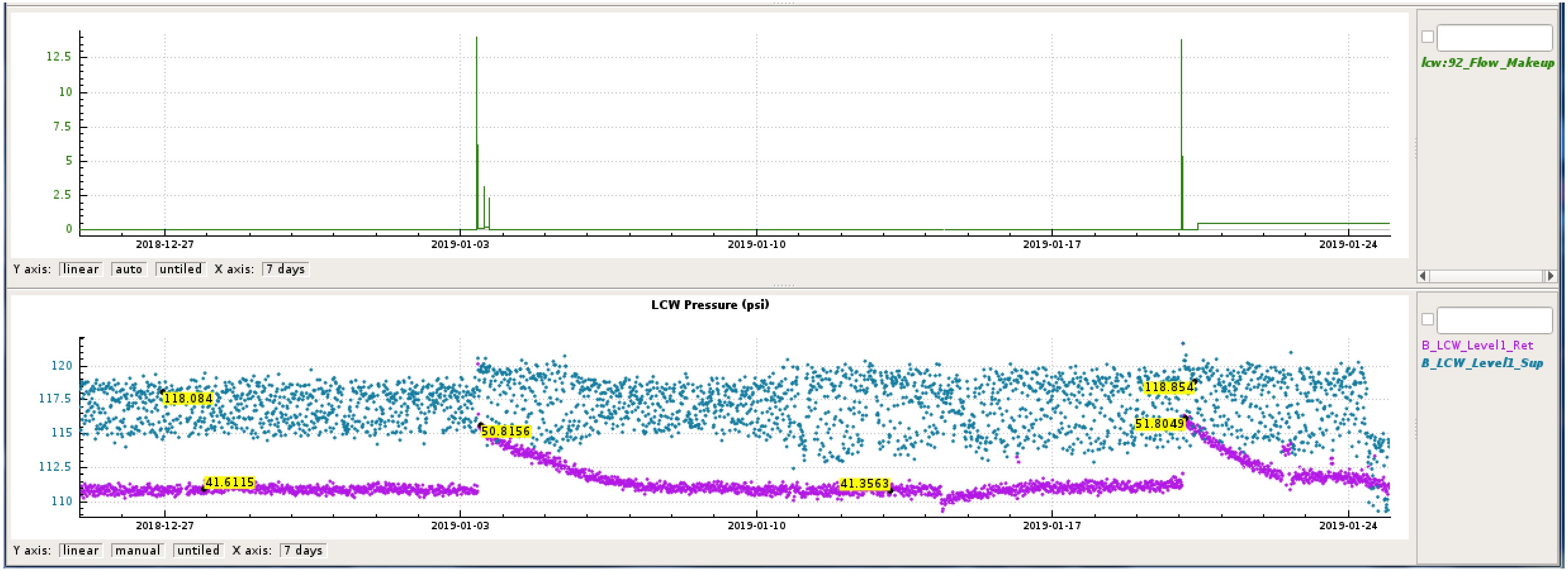
I have reviewed the attached information and reviewed available Hall LCW System historic data. I assume the Hall B Solenoid Fast Dump is connected to the Hall B LCW system which is part of the Hall LCW System. The makeup LCW flow occurs whenever either the Hall LCW System expansion tank level drops to the add water level or when the Hall A and C High Power Beam Dump Cooling Water Makeup System needs water. I believe the event you are concerned with occurred around 4 AM 11/2/18 which appears to have been the Hall LCW System making up. I concluded the Hall LCW made up because the Hall LCW System differential pressure increased slightly (175.6 versus 180.0 PSIG or 4.4 PSIG). Hall B LCW supply pressure is reduced when it enters the Hall by a pressure control system down to 125 PSIG. Pressure control modulation within Hall B should isolate Hall B from Hall LCW System pressure fluctuations, but the Hall B pressure regulation system is currently not operating in a range where the control valve is modulating. I promised Krister Bruhwel during the week that I would evaluate the pressure regulation system when the hall opens up this week.

Currently, the Hall LCW differential pressure control is also not modulating because the current total system flow is more than the design total flow. Hall A flow is 185 GPM versus 250 GPM design flow, Hall B flow is 398 GPM versus 215 GPM design flow, and Hall C flow is 656 GPM versus 505 GPM design flow. Current system flow is 1239 GPM versus 970 GPM design flow. If the main system pressure control was operating at setpoint and with a range where the pump variable speed drive was modulating, the expansion tank pressure fluctuation would also be dampened.

Hall B Solenoid

<u>Instrumentation additions to system:</u>

- Fitted SOE relay for power supply main contactor
- Fitted LCW supply and return pressure transducers – Level 1 spaceframe (Hall B)

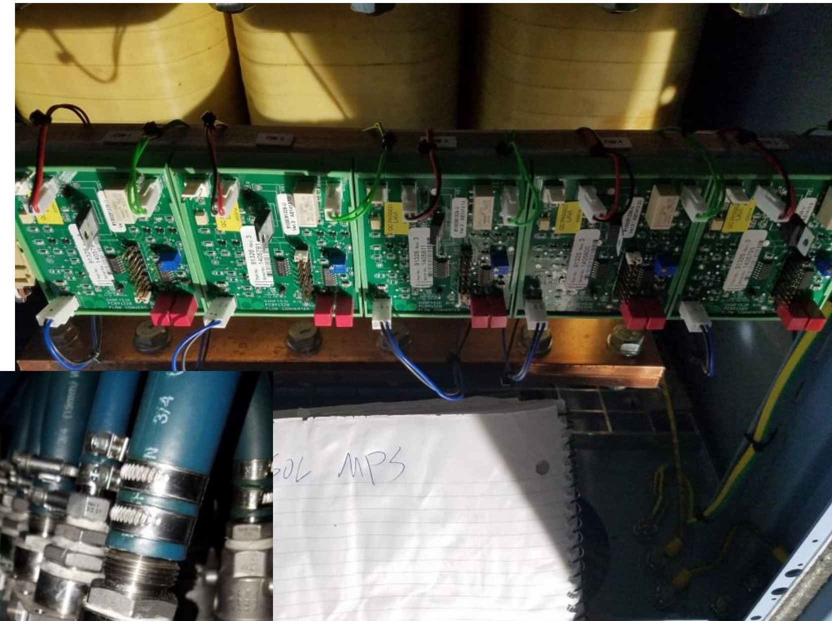


<u>By fitting this additional SOE relay and reviewing data from subsequent fast dumps:</u>

- We discovered that our Fast DAQ data had offsets in the timestamps, primarily due to the way data is being ‘packaged’ and saved to disk. Hence, the false VT18/VT2 indications. We made improvements to the software and will be reviewing performance during the Spring Run.

Hall B Solenoid

3.1	Short circuit protection	No				
3.2	Internal interlock Turns MPS OFF	Phase	±10% & Rot		5.14	
		H.O.Cur.	120%		2.3	
		Water Flow	Approx.. 80% of nominal flow.		4.5 0 Rem 4	
		Over temp	>60°C		4.7-4.10	
		Doors	Open		4.12	
		One trans. Fault	1 Trans. failure		**Error! Reference source not found.**	
		Trans. faults	>5%, >1 Driver		5.12	
		DC overload	- Over current > 110% or - "Trans. Faults"		Rem 2 5.12	
		DCCT Error	Not Connected		Rem 3	
		Module Faults	Not Connected		Rem 3	
		Ground leak	> 100mA		4.14	
		Safety OC.	110%		5.15	
3.3	External Interlocks	Magnet Temp.	Open		0	



4.4 Measure the water flow at 3 Bar delta pressure to be: ☐

FNOMINAL = 100 l/min. ±15 l/min.

FMEASURED = ________ l/min.

4.5 For each individual cooling string, adjust the flow switch as follows, and check that it works: ☐

Main transistor bank #1:	35 l/min.
Rectifiers	7 l/min.
Main transistor bank #2:	35 l/min.
Transformer #1:	1 l/min.
Transformer #2:	1 l/min.

<u>Improvements to system:</u>

- Increased thresholds (slightly) for flow circuits
- Increased diameter of LCW pipework to power supply

Hall B Solenoid

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    - **1 fast dump attributed to an incorrect QD voltage threshold setting → *setting now corrected***
    - **13 fast dumps correlated to LCW make-up water flow rate increase causing a temporary loss of cooling water flow to the solenoid magnet power supply**

      → (a) Additional margin set for flow switches in PSU

      (b) Larger pipe diameters used from manifold to PSU

      (c) Improved regulation of Hall B LCW

      (d) Improved Fast DAQ data transfer

      → So……..is the problem solved…..?

…..perhaps….

MyaPlot 5.2
Solenoid Current (A)
2417.76
B_SOL:MPS:I_ZFCT
B_SOL:MPS:I_MPS
Status Bits (1 = fault)
B_SOL:MPS:PLC_Fast_
B_SOL:MPS:Status.B
29.2552
19.2796
15.116
lcw:92_Flow_Makeup
LCW Pressure (psi)
64.4186
42.6989
117.715
114.653
43.1877
115.383
44.0337
63.8709
117.448
B_LCW_Level1_Ret
B_LCW_Level1_Sup
2019-02-08 12:00:00.00
2019-02-09
2019-02-09 12:00:00.00
2019-02-10
2019-02-10 12:00:00.00
2019-02-11
Y axis: linear auto untiled X axis: 12 hours
Y axis: linear auto tiled X axis: 12 hours

Backup

Backup

Target Circuit Flow Analyses Results

Case (All use Std ESMTL and New TL/ U-tubes in Hall)	Piping System Analyzed	Hall	Supply Temperature (K)	Supply Pressure (atm)	6kW for Target Total Mass Flow (g/s)	Moeller (HP target) Mass flow (g/s)	Pressure at Target Inlet (atm)	***Allowable Target DP (atm)***	Operating cost over baseline k$/yr
Full ESR VB with EV6741	1	A	14.4	16	146	122	12.6	***4.6***	0
	1	C	14.4	16	146	122	12.0	***2.8***	0
	1	A	11.7	16	100	84	14.9	***9.0***	180
	1	C	11.7	16	100	84	14.7	***8.0***	180
	1	A	8.3	16	72	60	15.6	***11.0***	> 650
	1	C	8.3	16	72	60	15.6	***10.3***	> 650
15/20K bypass ESR VB (both valves in the U-tubes	2	A	14.4	16	146	122	14.6	***8.8***	0
	2	C	14.4	16	146	122	14.0	***6.6***	0
	2	A	11.7	16	100	84	15.5	***10.9***	180
	2	C	11.7	16	100	84	15.3	***9.7***	180
	2	A	8.3	16	72	60	15.8	***11.9***	> 650
	2	C	8.3	16	72	60	15.8	***11.2***	> 650
20K bypass ESR VB (return valve in the U-tube)	3	A	14.4	16	146	122	12.6	***6.8***	0
	3	C	14.4	16	146	122	11.9	***4.6***	0
	3	A	11.7	16	100	84	14.9	***10.3***	180
	3	C	11.7	16	100	84	14.6	***9.1***	180
	3	A	8.3	16	72	60	15.6	***11.7***	> 650
	3	C	8.3	16	72	60	15.6	***11.0***	> 650
Full ESR VB (EV6741 valve seat removed thus valve in the U-tube)	4	A	14.4	16	146	122	12.6	***6.2***	0
	4	C	14.4	16	146	122	12.0	***4.1***	0
	4	A	11.7	16	100	84	14.9	***9.9***	180
	4	C	11.7	16	100	84	14.7	***8.8***	180
	4	A	8.3	16	72	60	15.6	***11.5***	> 650
	4	C	8.3	16	72	60	15.6	***10.8***	> 650

Table by D. Kashy, Return at ESR 2 is 20K and 3.0 atm

- 14.4K supply likely would require the 15/20K bypass option

These solutions should not be considered (because more than ½ the total DP is in the distribution)

This should be considered (lowest operating cost that may be possible)

- All others should be workable with MAX allowed DP >8.0

Backup

1. Why weren't the SOE timestamps being cleared automatically before each magnet run?
2. Was this purely down to the PLC itself? i.e. something inherent within the PLC? Not solvable via re-coding?
3. I know that we are now forcing the PLC to clear the timestamps before we run the magnet - are buffers simply being cleared when we hit the 'clear' button or is something else happening?
4. How did we come to the conclusion that tordaqGUI was misbehaving with regards to voltage tap timestamps?

#1-3
The reason we have to clear the timestamps now is because the main contact was added into our SOE chain (MPS :ON/OFF from GUI) and Danfysik did not povide NO and NC contacts, this required a flip/flop relay. The act of turning ON the MPS will switch the state on this contact and create a stamp. We could automate this in the PLC but the concern at that time was missing data as the archived resolution of the time stamps were unusable.

We also considered the fact that that these contacts are now introducing the external 24VDC which would have to be administratively accounted for(or rewired to use the MPS 24VDC). At that time we had proposed leaving things as they were until we determined if the diagnostic would be permanent or not.

Hitting the clear button 'reset interlocks' does multiple things, but regarding this discussion it tells the SOE module to empty all it's registers and prepare itself for the next round, the module is configured as a 'one-shot' so if this was not done any channel with a timestamp in it would be retained.

#4
We were able to confirm that the voltage tap time stamps were still acting up in tordaq gui by performing dump tests with the new diagnostic time stamps and comparing the voltage traces to the actual dump contact opening as reported by the PLC(no more having to guess when it opened). As the PLC is a hardwire device and received the same PTP clock we made assumptions that it was believable, no fudging here.

Ultimately I think tordagui's problem is still an artifact of the the cRIO which will be improved when Brian makes the switch from 5Hz data delivery to 1Hz. It should significantly reduce the amount of binning decisions the algorithm has to make when

attempting to fudge.

Backup

As you may know, we have been suffering for quite sometime with the Hall B Solenoid magnet inadvertently fast dumping.

Investigations thus far point strongly to a correlation between the LCW Make Up Flow 'spiking' and somehow reducing flow to the solenoid magnet power supply within Hall B. The PV that we have been looking at is 'lcw:92_Flow_Makeup'.

We believe this PV monitors the LCW makeup flow to all three halls (A, B and C).

Could I kindly ask you to review the date and timestamps below and let me know if there was anything going on in your halls at those times which could explain why the makeup flow suddenly increases. Times are approximate and indicate when the PV shows a sudden increase.

11.02.18 03:48
10.10.18 00:20
09.29.18 08:05
08.30.18 13:30
08.27.18 08:50
04.08.18 01:15
02.19.18 15:30
01.23.18 23:45
12.12.17 21:45

Carroll,

Can you please confirm that this PV does indeed refer to all 3 halls?

Also, what tells the pump to boost the makeup flow? Is there another electronic signal or PV elsewhere that triggers the pump?

Do you have a LCW pipework diagram that we can take a look at?