



Introduction to event and recovery plans

Russell Feder

11/28/23



Incident and initial entry by emergency team

Title: Failure of the RHIC Building 1004B Valve Box

SCBNL E-01648

Date: 01 August

Description: At 12:31PM, August 1, a RHIC magnet quench link interlock occurred in RHIC. As a response to the quench link interlock, 12 DX magnet heaters automatically turned on and the RHIC beam was aborted. The CAD main control room contacted the cryo control room to inform them of the quench link interlock. At 12:39, the cryo control room reported to Main Control that the blue ring valve box in building 1004B was venting helium to the exterior of the building. Cryo control room started to remove helium from the RHIC blue ring. Fire/Rescue and CAD personnel responded to building 1004B. No personnel were in the building at the time of the event. Fire/Rescue swept the building and found no personnel inside the building. Building 1004B entrances were cordoned off and a perimeter established near the vent. At 3:15PM, Fire/Rescue swept the building again, found no oxygen deficiency and turned the building over to C-AD. Helium recovery efforts will continue.



Potential Cause(s):

- To be determined.

Immediate/Containment Actions:

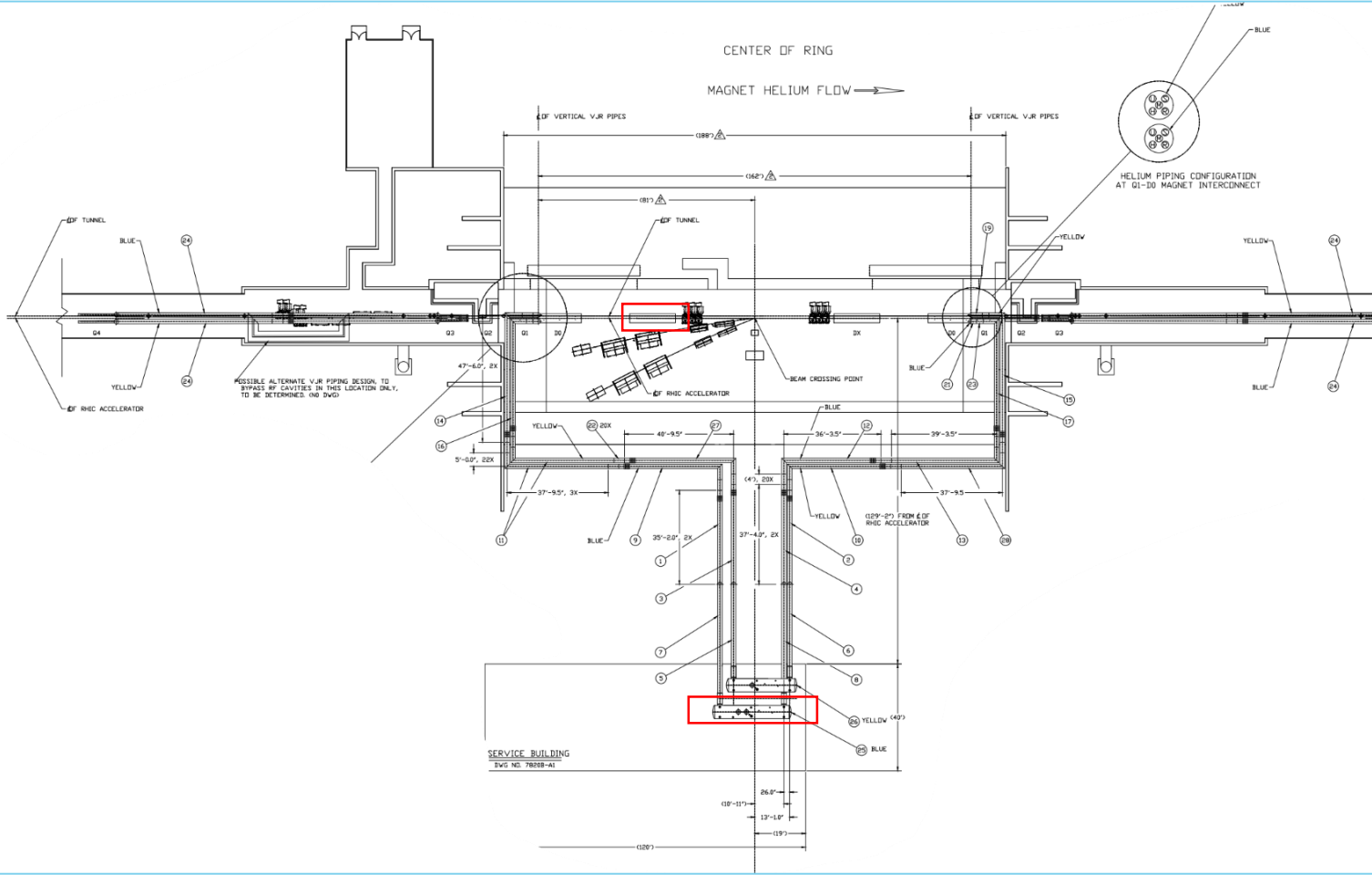
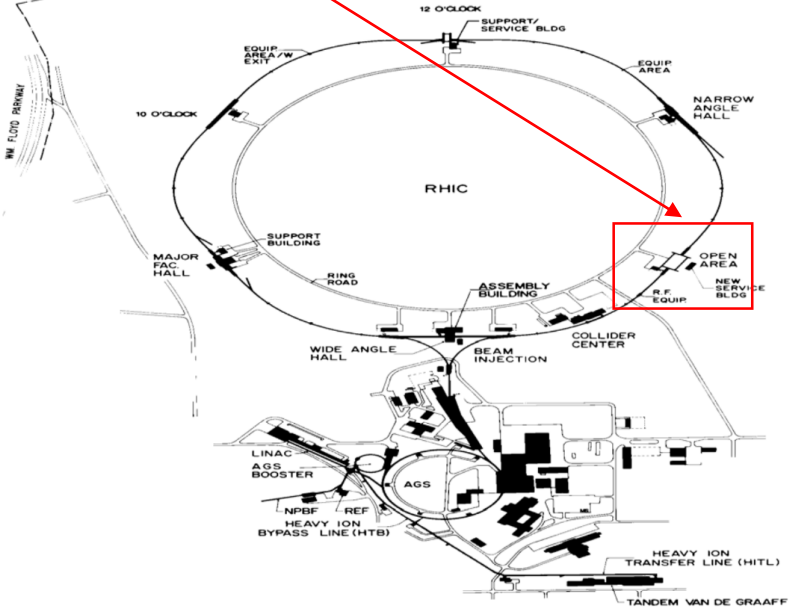
- Fire/Rescue swept building for personnel. No personnel found.
- Building entrances secured.
- Perimeter established around vent.
- Helium Recovery commences in blue ring

POC: Raymond Filler, Frank Craner, Wolfram Fischer

Show initial entry video

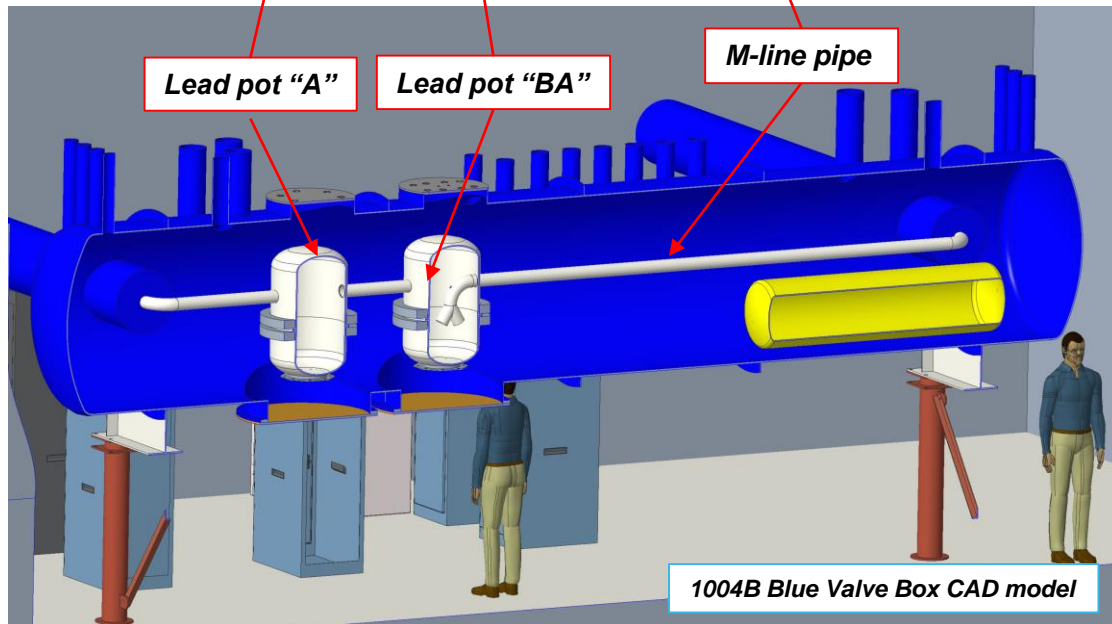
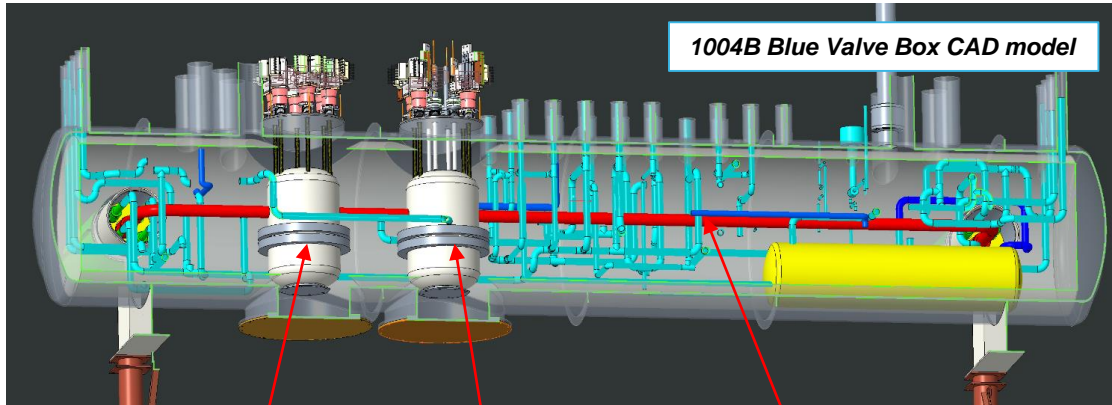


1004B, The 4:00 Service Building

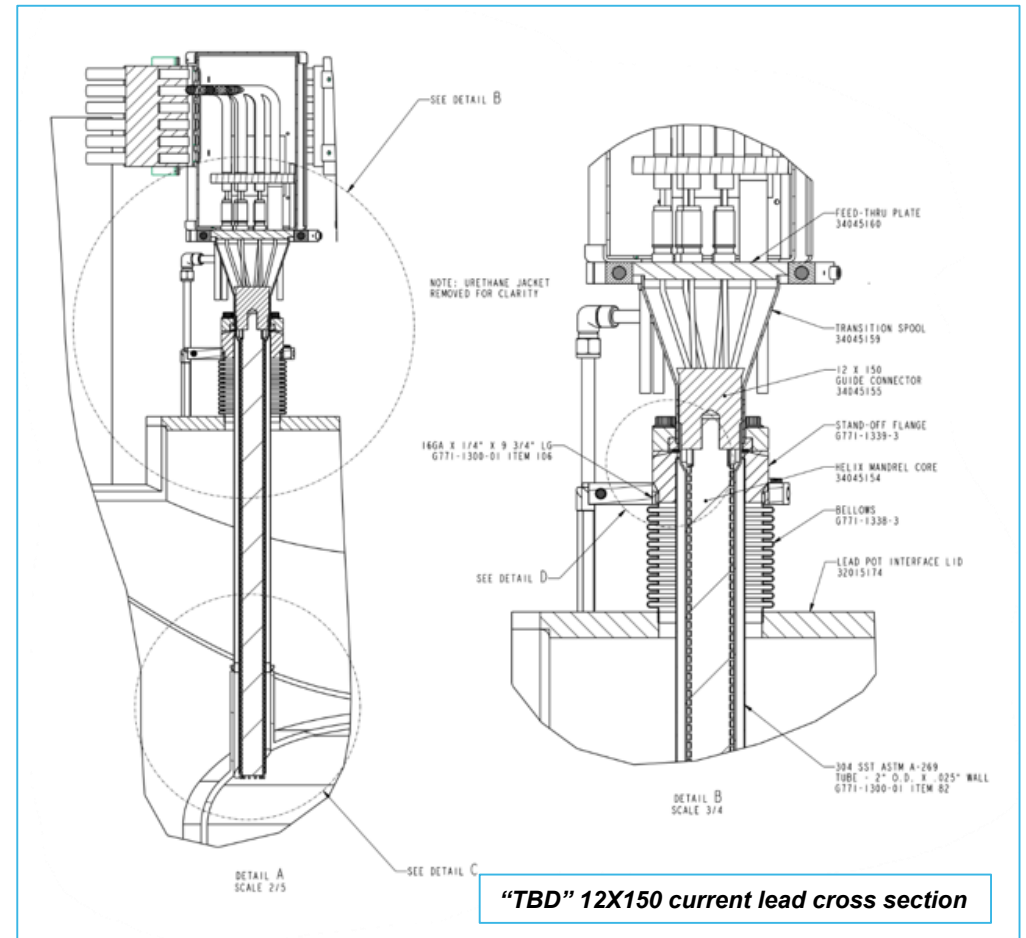
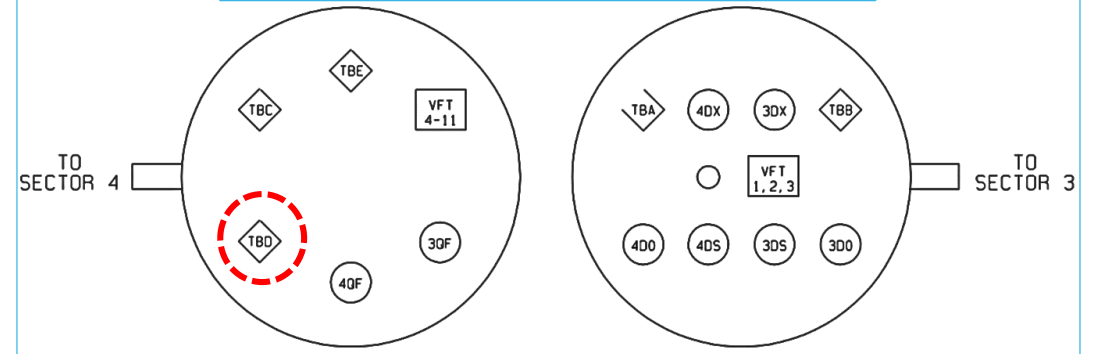


1004B Blue Valve Box

3D CAD models created to troubleshoot repair



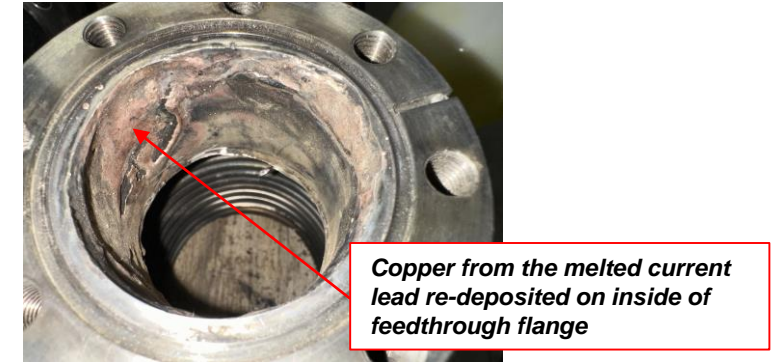
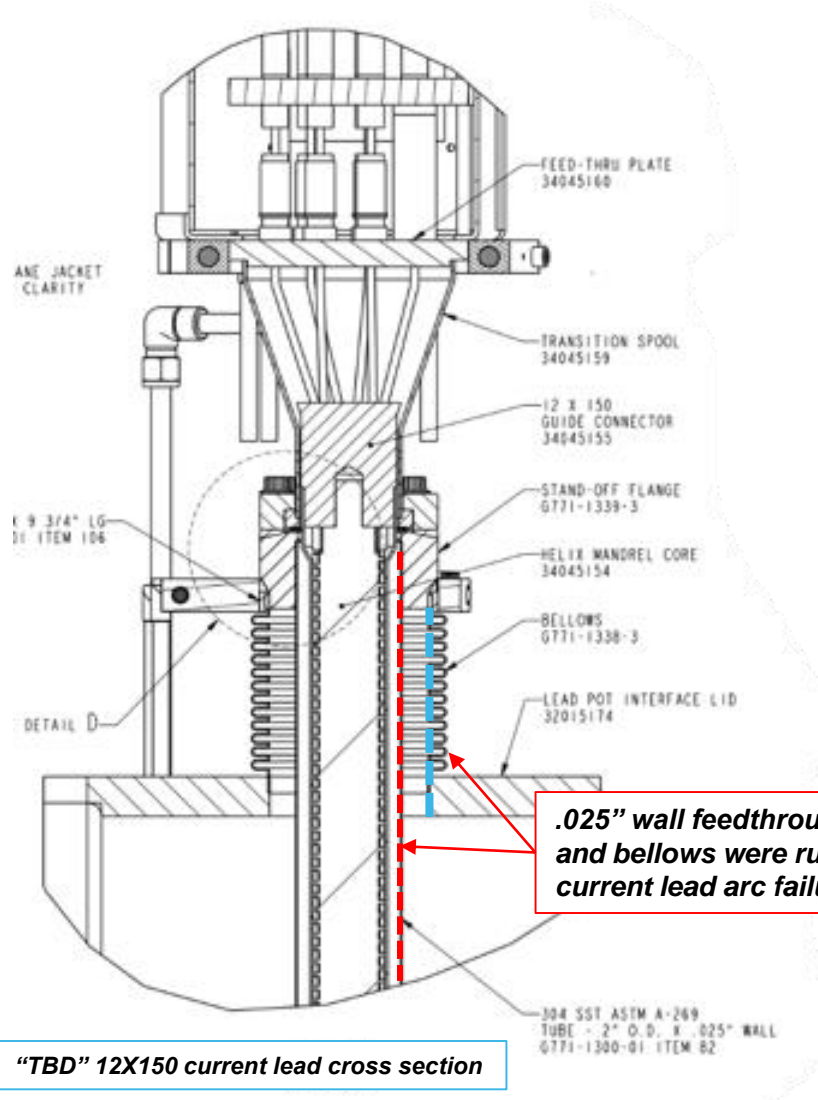
1004B Blue Valve Box Feedthrough Map (from above)



"TBD" 12X150 current lead cross section

Lead pot "A" "TBD" feedthrough piping damage

This feedthrough is part of the M-line pressure boundary and the valve box pressure boundary



For more information on the causal analysis and electrical events that lead to this damage
→ Talks coming up next by Jon Sandberg, Chaofeng Mi, and John Escalier

Lead pot "A" "TBD" 12X150 current lead damage

Photos of the damaged 12X150 current lead

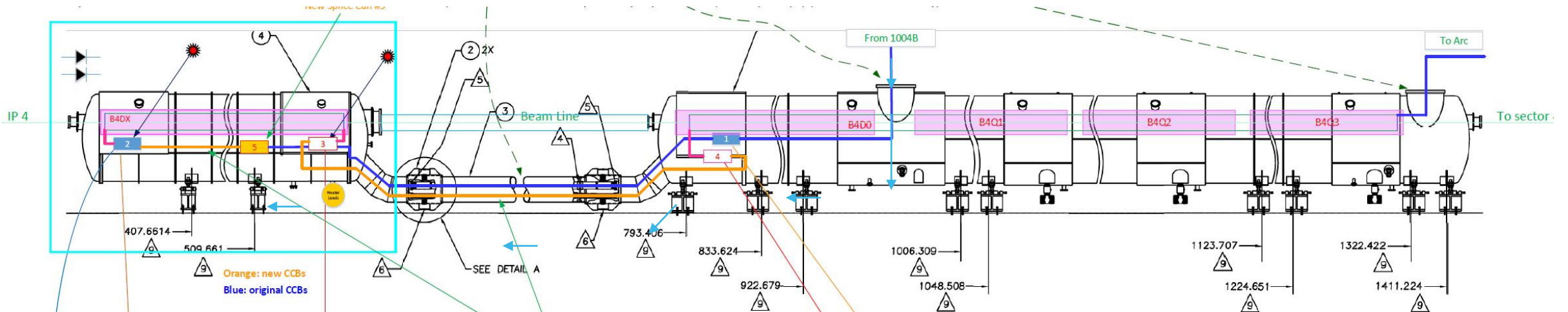


For more information on the causal analysis and electrical events that lead to this damage

→ Talks coming up next by Jon Sandberg, Chaofeng Mi, and John Escalier

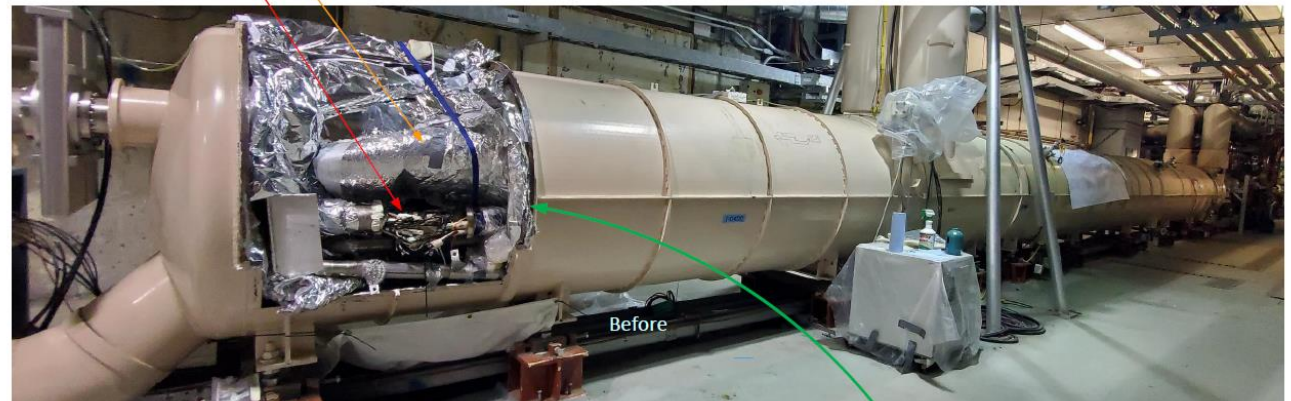
4:00 DX and D0 cryostats and magnets

- After the damaged 12X150 current lead was removed, the team was still measuring shorts-to-ground in the dipole and quad bus back towards the 4:00 D0-DX magnets
- Found damage in the #2 and #3 splice cans at the B4DX magnet



Splice can #3 is removed after found the arcing at splice.

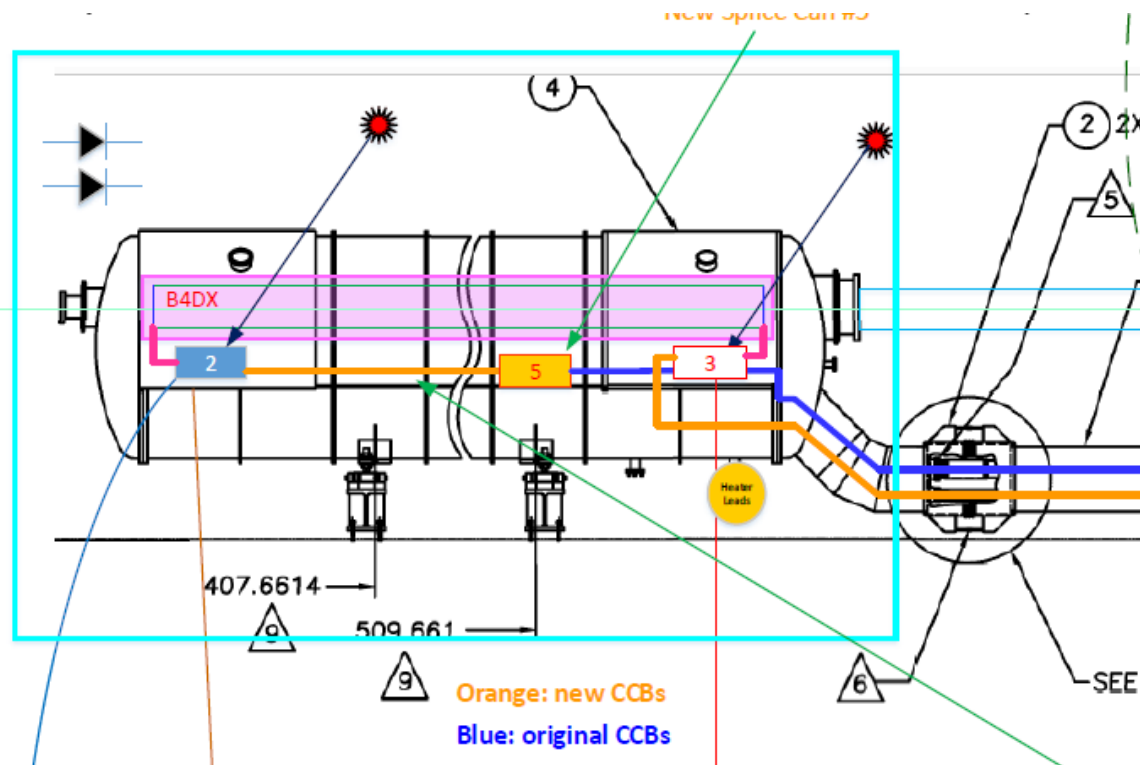
Replacement CCBs



For more information on the causal analysis and electrical events that lead to this damage
→ Talks coming up next by Jon Sandberg, Chaofeng Mi, and John Escalier

Incinerated splice joints found in DX splice cans #2 and #3

Source of shorts-to-ground in dipole and quad bus



For more information on the causal analysis and electrical events that lead to this damage

→ Talks coming up next by Jon Sandberg, Chaofeng Mi, and John Escalier

B4DX DX magnet removed to start 4:00 repairs



Removing the old DX magnet from 4:00



Wiring the spare DX magnet



The bldg. 912 staging area

For more information on the DX magnet recovery work
→ Talk coming up by Joe Tuozzolo and Scott Seberg

RHIC Recovery Schedule

- 4K wave start no-earlier than 3/1/24
- 45k wave start requires ASE approval

Activity	Start	End	% compl.	Aug 23	Sept 23	Oct 23	Nov 23	Dec 23	Jan 24	Feb 24	Mar 24
1004B and 4:00 failure investigation, design, fabricate	8/1/23	10/31/23	100	█							
1004B Valve Box: Feedthrough Pipe Repair	11/1/23	11/19/23	100				█				
1004B Valve Box: Install Spare 12x150 Current Lead	11/20/23	12/17/23	10				█				
1004B Valve Box: Close lead-pots	12/18/23	12/24/23	--					█			
1004B Valve Box: Close and pump down	1/18/23	2/2/24	--						█		
DX magnet: Prep spare at bldg. 912	10/1/23	11/28/23	100			█					
DX magnet: Magnet testing at bldg. 902 (SMD)	11/29/23	12/3/23	50					█			
DX magnet: transport to 4:00 and survey	12/4/23	12/10/23	--					█			
4:00: Prep cryostats and pipe repairs	10/1/23	11/4/23	100			█					
4:00: Splice can #4 and #5 (DX install precursor)	11/5/23	12/8/23	50				█				
4:00: Splice can #2 and #3 , close, ready for M-line test <i>holiday closures and slowdown</i>	12/11/23	1/14/24	---					█			
1004B and 4:00: 4/5 Blue M-line pressure test	1/15/24	1/17/24	--							█	
4:00 Close DX-DO cryostats, install and <u>bake beam tube</u>	1/18/24	2/15/24	--						█		
RHIC ASE and USI draft, through ALD ESH approval	10/24/23	12/8/23	75				█				
RHIC ASE and USI review and approval	12/9/23	1/31/24	--					█			
Cryo: Start Yellow-ring scrub	1/2/24	1/17/24	--						█		
Cryo: Start Blue-ring system scrub	1/18/24	1/31/24	--						█		
Cryo: Start 45K wave (<i>w/ ASE approval</i>)	2/1/24	2/29/24	--							█	
Cryo: 4.5K wave	3/1/24	3/7/24	--								█
RHIC 2024 Start + DX and 12X150 lead cold tests	3/8/24										★

Completing M-line test allows for closure of 1004B valve box, closure of 4:00 cryostats, and start of Cryo blue-ring scrub.

On the road to RHIC recovery

1. We understand what happened

- A. The following presentations will show how, why, and when the 1004B blue valve box “TBD” 12X150 current lead and the 4:00 DX magnet splice joints failed

2. Broad BNL effort to repair RHIC and return to operations

- A. 1004B valve box mechanical repairs
- B. Spare 12X150 current lead preparation and valve box electrical work
- C. 4:00 DX magnet and magnet bus repairs, mechanical and electrical work
- D. 912 and 902 DX magnet preparation and testing
- E. ASE and USI documents and supporting ODH calculations
- F. RHIC 4K cooldown by 3/1/24

3. Milestone tests to verify repair

1. M-line pressure test by 1/15/24
2. DX magnet and super-conducting bus cold testing starting in early March, 2024

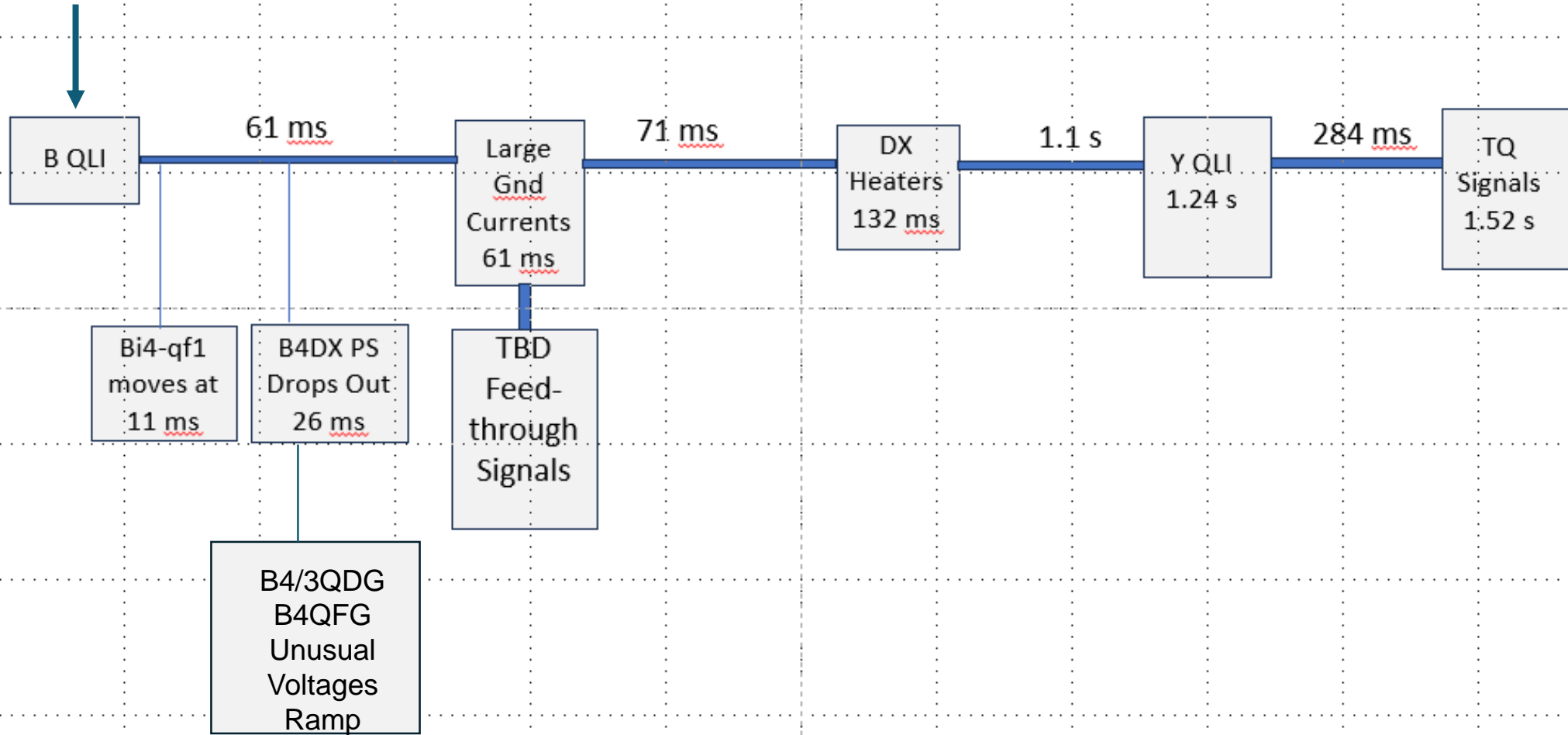
4. Continuing to assess how to prevent recurrences and mitigate for EIC operations

1. 12X150 current lead
 1. Fabricating additional units based on current design
 2. Developing improved design for EIC operations
2. Evaluating improved current lead cooling-flow control

Backup Material

Timeline of Electrical Signals

T0: Aug 1, 2023
12:31:57



1004B valve box failure → Cryo controls alarms

The event timeline as seen from the cryo control system, filtered for the first event that indicated a problem - *Ring Recooler Level*. The second alarm, *Valve Box Insulating Vacuum Failure*, is when the slide valve closed which isolated the 4VB vessel from the vacuum pumps because helium was leaking into the vacuum space. The chain continues until the cryo interlock opens about a minute later.

The timestamps have a high degree of precision, however, this should not be considered as absolute reference time. The actual events preceded these times by as much as 5 seconds.

08/01/2023	12:32:06.339	ALM_ALM92	RING RECOOLER LHe LEVEL HI/LO ALARM	-----	D237
08/01/2023	12:32:09.457	ALM_ALM63	VALVE BOX INSULATING VACUUM FAILURE	-----	D245
08/01/2023	12:32:09.457	ALM_ALM92	RING RECOOLER LHe LEVEL HI/LO ALARM	-----	D237
08/01/2023	12:32:09.457	ALM_ALM63	VALVE BOX INSULATING VACUUM FAILURE	-----	D245
08/01/2023	12:32:21.900	ALM_ALM61	REFRG SUPPLY TO RING FLOW FE210H OUT OF LIMITS	-----	D37
08/01/2023	12:32:43.590	ALM_ALM92	RING RECOOLER LHe LEVEL HI/LO ALARM	-----	D237
08/01/2023	12:32:56.119	ALM_ALM132	BLU RING 'S' HEADER PRESS CNTRL (H4501A) DP DEVIATION ALARM	---	D101
08/01/2023	12:33:01.289	ALM_ALM92	RING RECOOLER LHe LEVEL HI/LO ALARM	-----	D237
08/01/2023	12:33:01.289	ALM_ALM95	RING CORRECTOR LEAD FLOW - HIGH FLOW ALARM	-----	D223
08/01/2023	12:33:01.289	ALM_ALM92	RING RECOOLER LHe LEVEL HI/LO ALARM	-----	D237
08/01/2023	12:33:08.535	ALM_ALM91	CRYO PERMISSIVE INTERLOCK OPEN, CRYO STATUS - NOT READY!	-----	D19

RHIC Valve Box Power Leads Map

TBX = 12 x 150 amp
 12D0 = XXXXXX
 XXXX
XXXXX = XXXXXX

	2:00	4:00	6:00	8:00	10:00	12:00
B	<p style="text-align: center;">A</p>	<p style="text-align: center;">A</p> <p style="text-align: center;">B</p>	<p style="text-align: center;">A</p>	<p style="text-align: center;">A</p>	<p style="text-align: center;">A</p> <p style="text-align: center;">B</p>	
Y						