

# Status of 1004B Valve Box / Ring Repair

3 Oct 2023

M. Minty

## Key personnel involved:

Joe Tuozzolo (C-AD chief mechanical engineer / EIC)

Jon Sandberg (C-AD chief electrical engineer)

with support from John Escallier and George Ganetis (at NSLS-II, formerly SMD)

### Primary groups:

Russ Feder, group leader (GL) / cryo group – valve box repairs

Chaofeng Mi, deputy GL, Don Bruno (GL / EIC), Greg Heppner / electrical group – electrical measurements (valve box, RHIC tunnel)

### supported by:

David Chan, division head of C-AD Experimental Support and Facilities Division and ES&F groups  
Experimental Accelerator Operations Support Group (AOSG)

DX Magnet Spare Preparation: Jesse Schmalze and Mike Anerella (Magnet Division), Scott Seberg (C-AD)

Engineering  
and Technical

Paul Sampson (ASOG GL) – work planning oversight

Ray Fliller (ESSHQ division head), Mike Dany (work planning and control GL) , Francis Craner (ES&H GL)

and others (ESSHQ) + lab SMEs

Eric Johannsen – Electrical Safety and LOTO

Srikantha Chilakala – Confined Space

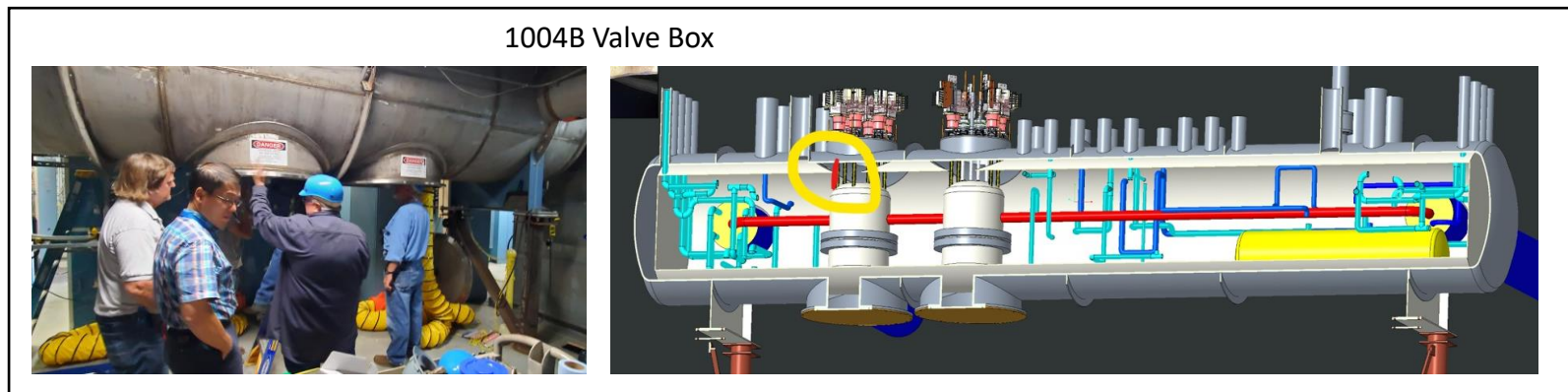
Mike Gaffney – ODH

in coordination with fire department (for hot permits), coordinated by John Benante (AOSG, deputy GL)

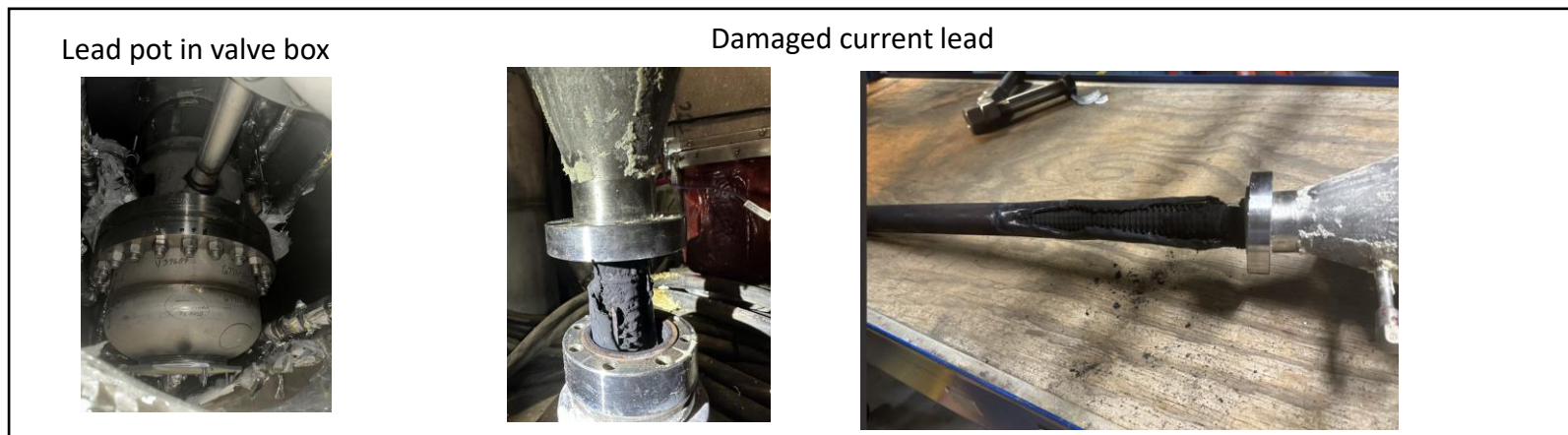
Safety

# 1004B "Valve Box" Failure Timeline

- At 12:31 on 1 Aug 2023 a spurious trip of the Quench Interlock System commanded the RHIC power supplies to turn off and for the energy extraction system to begin dissipating the stored energy in the Blue Ring. At 12:39 the Cryo control room informed the MCR that the Blue Valve Box in 1004 B was venting Helium to the exterior of the building.
- Decision to end RHIC Run-23 made on 4 Aug 2023. RHIC Valve Box/Short status (30 Aug 2023) at RHIC Retreat.
- Following numerous safety reviews (hazards: electrical, confined-space, oxygen deficiency) and work planning, the valve box was opened on 1 Sep 2023; Helium breach found on warm cable interface at top (of the inside) of the valve box



- Valve box lead pots (LP) accessed on 7 Sep 2023 (VB #1) and 8 Sep 2023 (VB#2). Damage to 12-conductor cold-to-warm, gas-cooled current lead found in LP #1, no trouble found in LP #2.



Helium venting at Bldg. 1004B



1004B Valve Box



Helium leak



- Throughout this time, extensive electrical tests of the superconducting cable distribution system were made to localize the short(s) of the Blue Ring dipole and quadrupole magnet strings ultimately isolating the presence of a short and unusual voltage tap readings in the tunnel at the IR4 D0 and DX magnet interface in the RHIC tunnel.

- “splice cans”, which provide electrical continuity of super-conducting cables (locations of suspected shorts) were accessed starting 18 Sep 22023

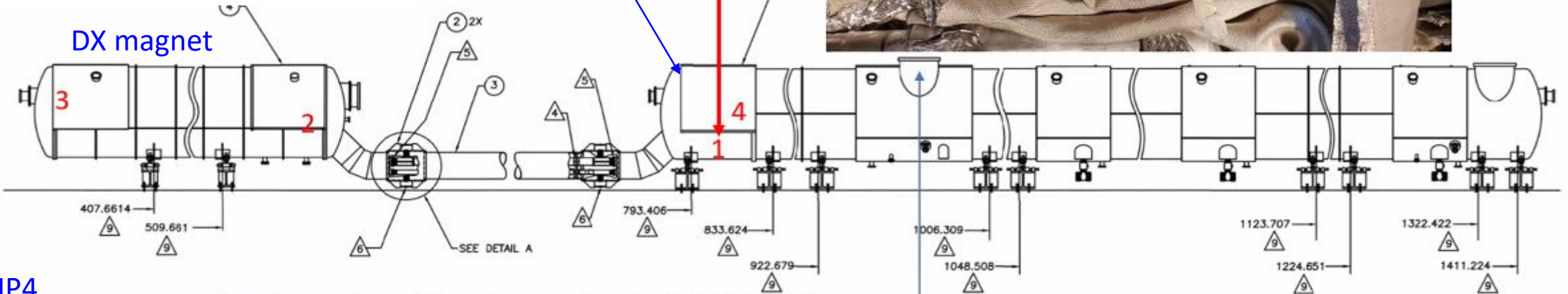
Splice can (#1) before opening



Splice can #1 after opening (no trouble found)



D0 magnet



to IP4



Location of electrical connections to 1004B valve box

DX magnet



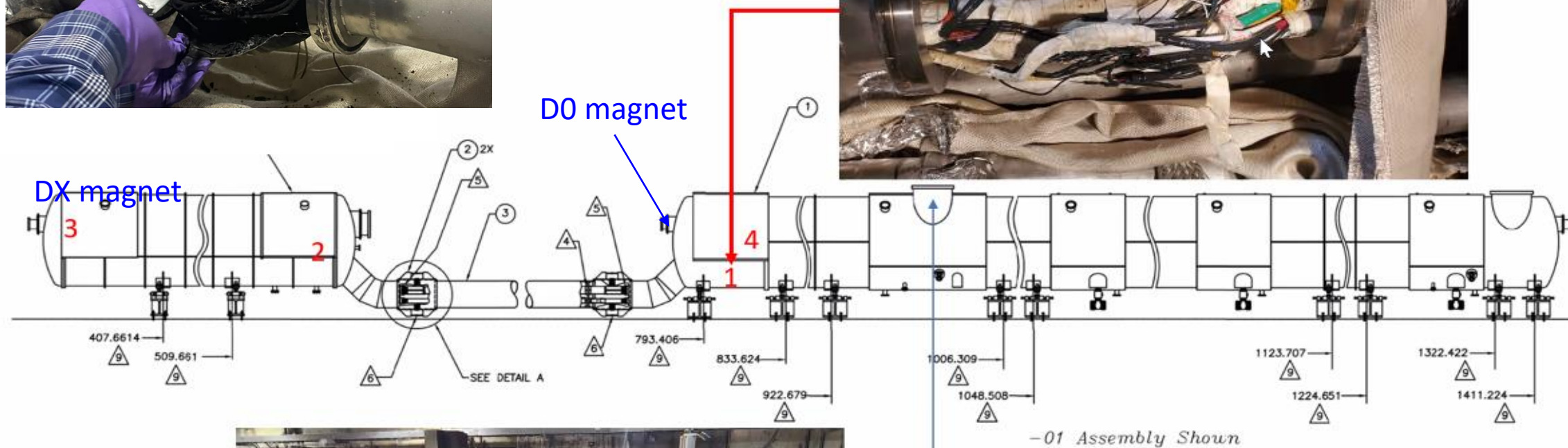
Inside the RHC tunnel

- “splice can #2” at IR4 DX magnet found severely damaged 27 Sep 2023

damage inside splice can



splice can #1 after opening (no trouble found)



to IP4



DX magnet



Inside the RHIC tunnel

- “splice can #3” on other side of DX magnet found damaged as well 29 Sep 2023
- DX magnet removed 2 Oct 2023

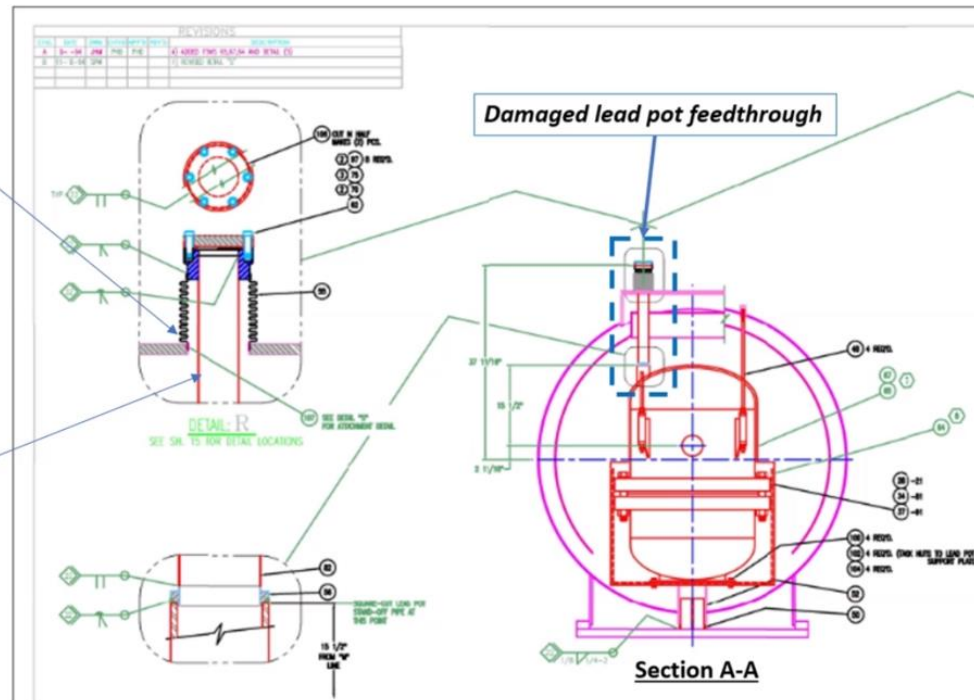
# Repair Status, Helium Breach in 1004B valve box

- Repairs are underway
  - the replacement upper flange has been ordered through BNL Central Shops,
  - the interconnect tube is on hand,
  - a bottom adapter ring drawing to be fabricated in Central shops is in process, and
  - quotes have been received for the replacement bellows.
- All parts for this repair are expected before the end of October.

Bellows rupture



Feedthrough tube rupture



# Repair Status, 12-conductor cold-to-warm, gas-cooled current lead in 1004B valve box / lead pot

- Spare lead assembly under test
  - passed vacuum leak checks
  - electrical and pressure tests underway

Spare 150 A current lead



Vacuum test setup (using another, partially-built current lead)



- Plan B (if pressure test fails)
  - build new lead
  - mine existing lead assembly for parts
  - have identified technician support for this as well as for building new spares

# Repair Status, DX Magnet and Splice Cans

- The DX magnet from the tunnel and two other magnets from storage (spare and prototype) being moved to Bldg 912.
- Spare DX magnet to be built-up for installation, tested warm, and re-installed. Scott Seberg is lead engineer.
- Samples of the Cold Crossing Superconducting bus (CCB) will be used to train and test staff on doing the SC cable splices.
- Causal analysis not complete, contingent on inspection of DX magnet.
- Schedule yet TBD, contingent on inspection of DX magnet.

DX Cold Mass/Yoke assembly - without end volumes (from special process spares inventory)



## Unreviewed Safety Issue (USI) development

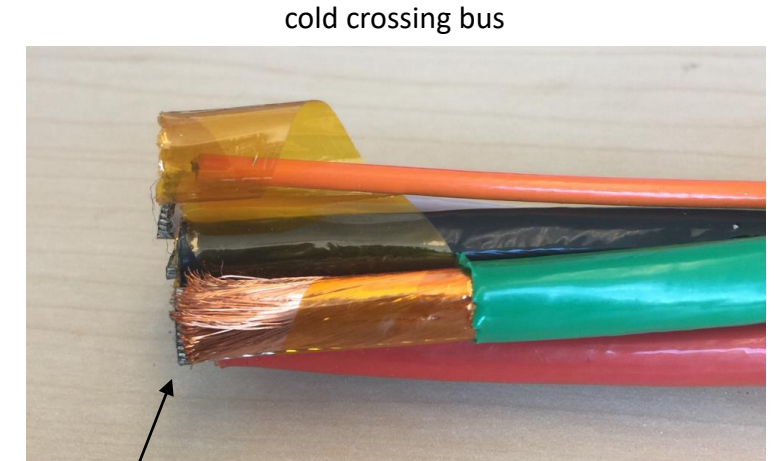
- new issue: Helium release into building - He breach filled 1004B valve box, pressure relief to outside worked as expected but some He released into building unexpectedly (likely that large access port O-rings froze and cracked).
- ODH evaluation underway to determine maximum concentration levels
  - C-AD ES&F engineering evaluating fresh-air makeup rates as input
  - C-AD cryo evaluating leakage rates for components that can fail
- Results will inform if existing ODH monitors (which did not trip, nor did the personal oxygen monitor worn by fire rescue first accessing site) must be made credited controls.
- If that were the case, then the RHIC ASE would need to be modified and approved by BHSO. Scope of that effort, if needed, similar to effort required at sPHENIX last summer.
- Presents potential schedule risk.
- USI development by C-AD ESSHQ (Ray Filler)





## Supplementary slide – details on Electrical Testing of superconducting cable distribution system (25 Sep 2023)

- Background (reference RHIC Retreat - “4B Valve Box Failure”, J. Sandberg)
  - The energy extraction system worked as intended (post mortem data).
  - But after about 50 ms a ground fault was detected in both the Blue Main Dipole Bus and the Blue Main Quadrupole Bus.
- Subsequent measurements showed that all the Trim Quadrupole (TQ) magnets were also shorted to ground. The place where the TQ, Quadrupole, and Dipole magnets are in close proximity is in the cold crossing bus (CCB) that runs from the valve box to the magnets in the ring.
- Results from electrical measurements (applying a floating current source to various portions of the Blue Main dipole bus and measuring the voltage drop to ground at various voltage taps and power supply input leads):
  - Measurements showed high resistance somewhere either in the cold crossing bus
    - between the 4 o’clock side of the valve box to the D0 magnet, or
    - the cold crossing bus to the 4 o’clock DX magnet.
  - Further measurements indicate there is a ground somewhere between the 4DX and 4D0 Magnet.
- The splice box at the D0 magnet has been opened and the return bus has been isolated. Measurements suggested a ground either in a short section of cold crossing bus or the DX magnet, or in the cold crossing bus between the DX magnet and the valve box.
- Measurements on the rest of the return bus going to the other DX magnets indicated 40 ohms to ground which is not understood.



cold crossing bus

flat superconducting  
cable (hard to see)

Added 10/3/23: Once the damaged splice joints were opened, repeat measurement showed > MOhm resistance which makes sense, retrospectively: per Jon Sandberg, Chief Electrical Engineer, the unexplained low (40 Ohm) resistance measured earlier was an artifact of the cables being shorted together in the splice can together with the residual soot.

# Status of 1004B Valve Box / Ring Repair

24 Oct 2023

M. Minty

10/10/23, NPP weekly news

- Update on RHIC/1004B valve box: The DX magnet was removed from the cryostat and, last Friday, transported to a repair area set up in Bldg. 912 where also the spare DX magnet and a DX magnet prototype were brought from storage. Inspection of the DX magnet is foreseen this week following removal of the DX magnet's very large end-volume cylinders. Both spares were tested during RHIC construction however end connections and splices to the Cold Crossing Bus (which contains the superconducting cables) leads will need to be made. A couple of staff from the Magnet Division, who worked on the DX magnets 25 years ago, will also support preparation of the DX magnet for operation. Electrical testing performed last week of the rest of the superconducting cable distribution system indicated no other damage beyond this DX magnet. A schedule for completion is contingent on inspection of the DX magnet.

DX magnet in tunnel prior to removal (IR 4 region)



10/16/23, NPP weekly news

- Update on RHIC/1004B valve box: The DX magnet was opened on one end and revealed upon visual inspection no damage. In the upcoming weeks efforts will concentrate on developing the spare DX magnet into an operational spare for installation.

DX magnet in building 912



Pipe cutter (WACHS) used to grind off DX magnet end caps



DX magnet after removal of end cap



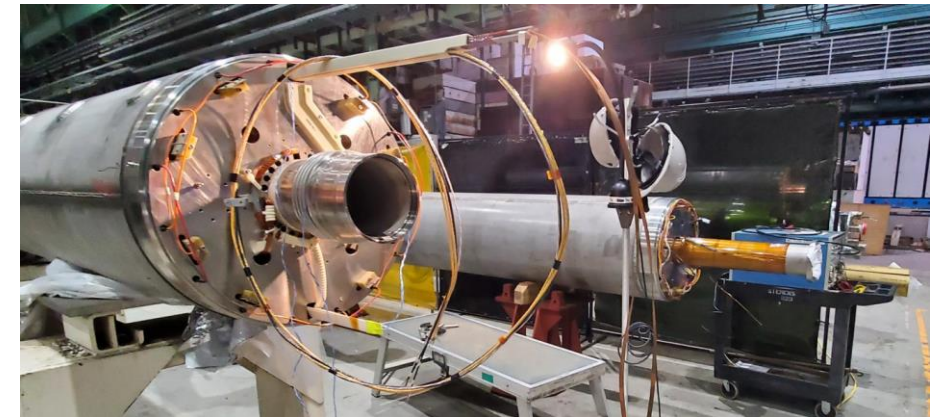
- Update on RHIC/1004B valve box: Work is well underway to prepare the spare DX magnet for installation into RHIC. Resistance measurements were taken showing consistency between the relocated DX magnet and its spare. Welding, leak checks, and other mechanical preparation work on the spare DX magnet are underway and should be completed by the middle of this week. Wiring and installation work, supported by the Magnet Division, will then commence.

10/24/23

DX magnet from ring tunnel



DX magnet spare and DX magnet prototype



Select DX-magnet Cold Crossing Bus cables replaced in tunnel



- ✓ In parallel, continuity checks of the superconducting cable distribution system between the 1004B valve box and magnets in the RHIC tunnel are also underway. Completed (10/23/23) and tested good.
- ✓ The spare lead assembly for the damaged 12-conductor cold-to-warm and gas-cooled current lead in the lead pot inside the 1004B valve box was successfully high-pressure tested and high-potted and is ready for installation.

## Repair Schedule

- Siberian Snake / diode installation – finish mid-December
- Valve Box – current lead/ feedthrough ready for installation, bellows on order, expected mid-November
- DX magnet – critical path is DX electrical work, first estimate is 2 person / 2 weeks with OT on Weekends (haven't confirmed weekend work with MD staff yet)
- Cryo plant maintenance progressing well, will not be critical path
- Schedule as of yesterday, preliminary, shows mid January 4K cooldown, may change depending on schedule for DX magnet work

As of this morning, determination has been made to proceed with a change to the RHIC ASE. This will be the critical path.

# Status of Siberian Snake Installation

24 Oct 2023

M. Minty



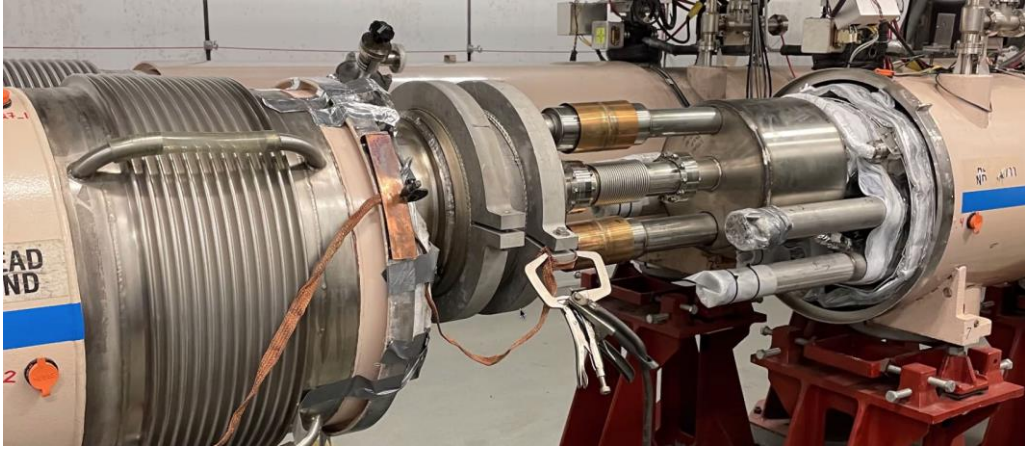
10/10/23, NPP weekly news

- Update on RHIC Blue Ring Siberian Snake magnet reinstatement: The repaired Blue Ring Siberian Snake magnet was installed and surveyed in the RHIC tunnel last week. Welding of the end volumes started last Friday and will continue this week together with soldering of the splice joints. Following that, the snake will be hi-potted, then pressure-tested. Mass spectroscopy measurements in the Helium lines will be made next, then the magnet shield will be installed and the insulating vacuum will be welded closed. Pumpdown of the insulating vacuum is foreseen early November with completion by mid-November. Leveraging off of the opening of the RHIC vacuum for the snake installation, the long-awaited removal of a RHIC quench diode to inform EIC planning was completed and a spare diode (Type I diode with inverting fixture) was installed and hi-potted. Welding of the diode's end volumes and remaining diode-related work is on track for completion this week

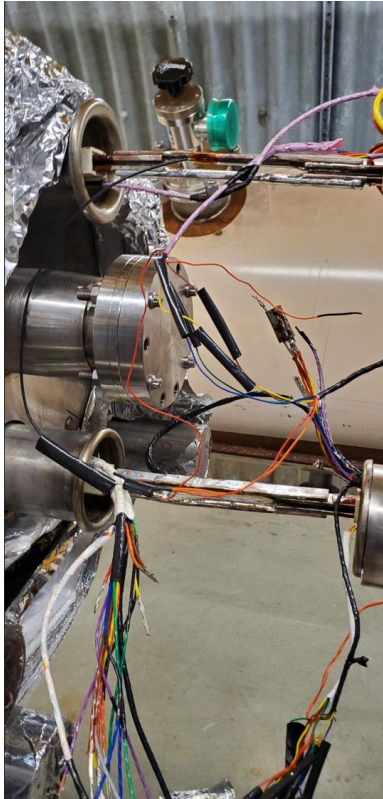
Dummy magnet and snake in RHIC tunnel prior to removal/installation/survey (IR8 region)



## Snake magnet installed and surveyed in RHIC



splicing of SC cables in snake



## Snake install, next steps:

- soldering of the splice joints
- hi-pot test verification
- pressure-tests
- mass spectroscopy measurements in the Helium lines
- magnet shield installation
- installation and weld of insulating vacuum enclosures
- pumpdown of the insulating vacuum early-to-mid November with completion late November.

## RHIC diode installed



- ✓ Leveraging off of the opening of the RHIC vacuum for the snake installation, the long-awaited removal of a RHIC quench diode to inform EIC planning was completed and a spare diode (Type I diode with inverting fixture) was installed and hi-potted.