Spectrometer Solenoid Fabrication Update

NFMCC at LBNL

January 25, 2009

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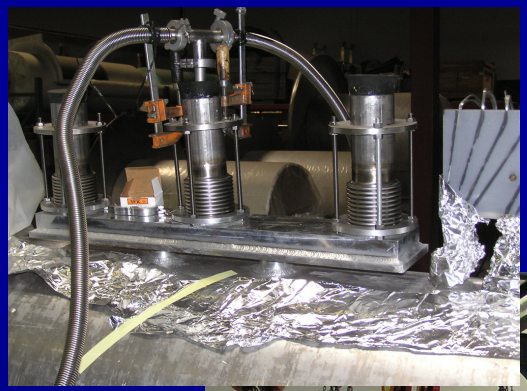
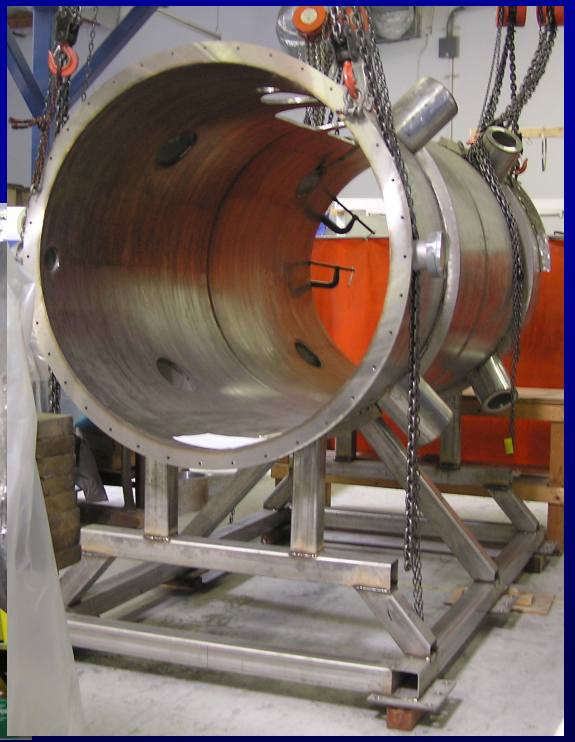
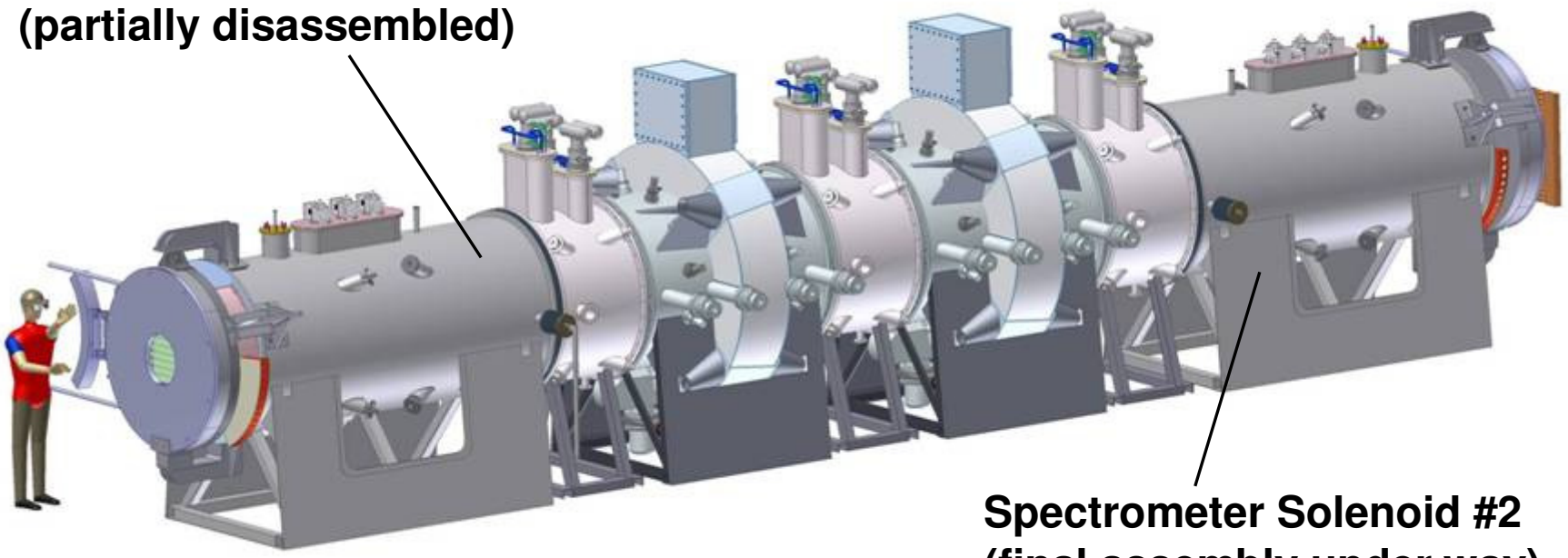




MICE Cooling Channel Layout



Summary

- First magnet completed after several delays caused by both design and assembly errors; testing revealed several issues
- Operational issues: helium lines blocked by N_2, poor thermal connection to radiation shield, insufficient cold mass venting
- Mechanical issues: cold mass alignment, support stand height, iron shield support pads, support stand offset
- Issues resolved on 2nd magnet: new cooling circuit, added relief vent line, LN reservoir added, thermal shield connection improved, support stand modified, portable CMM measurements during assembly will ensure proper alignment
- Second magnet in process of final assembly (w/modifications)
- First magnet has been partially disassembled to add fixes

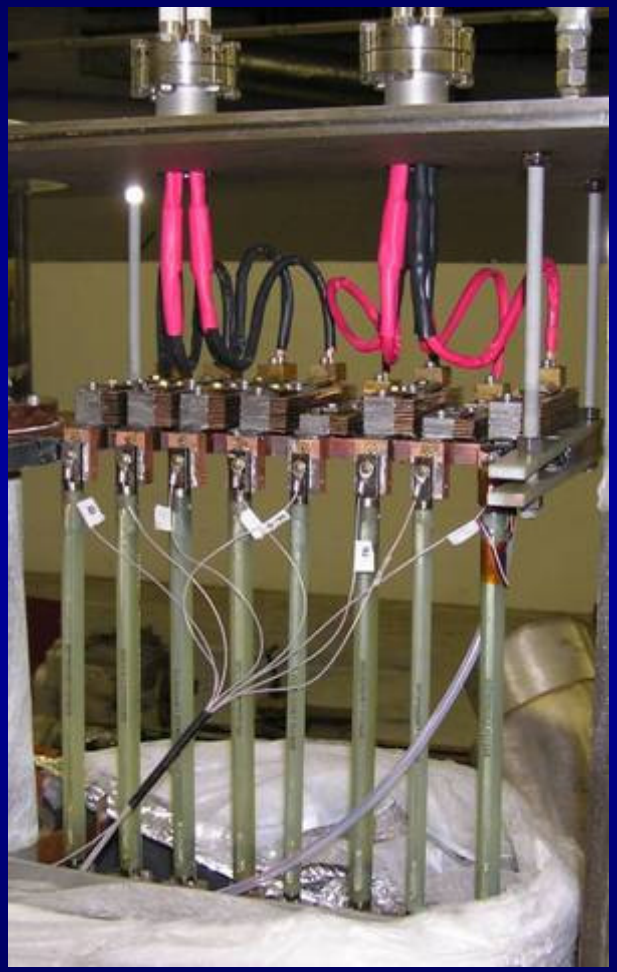
Vacuum Vessel and Thermal Shield

Shield assembled w/5 mm Al sheet

Vacuum vessel ready for cold mass installation

Completion of Cold Mass Installation

HTS Leads and Cryocooler Sleeves



Service Tower Components Wrapped in MLI

Completed Service Tower

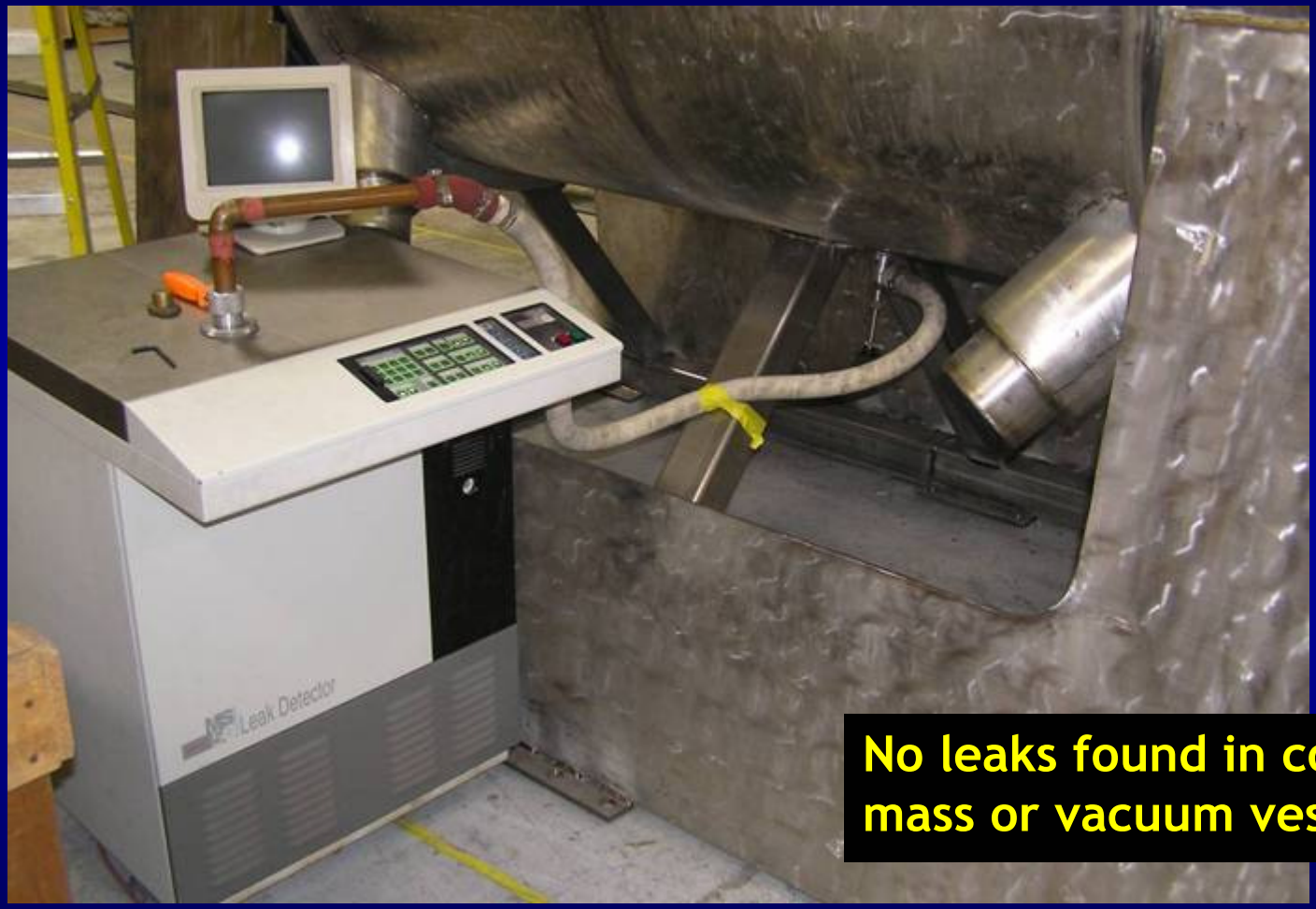
Installed Cryocoolers

Instrumentation Feedthroughs

All instrumentation wired and ready for testing

Completed First Magnet

Vacuum Leak Check



No leaks found in cold mass or vacuum vessel

Magnet Cool Down

Ice on magnet leads during cool down

Vent line

Fill line

Magnet Cool Down and Training

- Magnet cool down accomplished using LN_2 & LHe
- Cool down is done slowly to control cold mass thermal stress (i.e. limited ΔT)
- Cold mass of first magnet reached LHe temperature with no observed problems
- Cold mass temperature could not be maintained with the cryocoolers (no re-condensing)
- Apparent blockage in LHe cooling line occurred due to freezing of LN_2 or air
- All five coils reached a maximum current of 196 amps during training

Cryocooler Testing

All 4 coolers met the mfg. specifications

Magnet Discharge Circuit

- Rapid discharge circuit designed and fabricated by Wang NMR
- Each magnet will have a dedicated circuit
- The water cooled, aluminum body assemblies are rack mounted
- Water cooling is only needed during and after a discharge

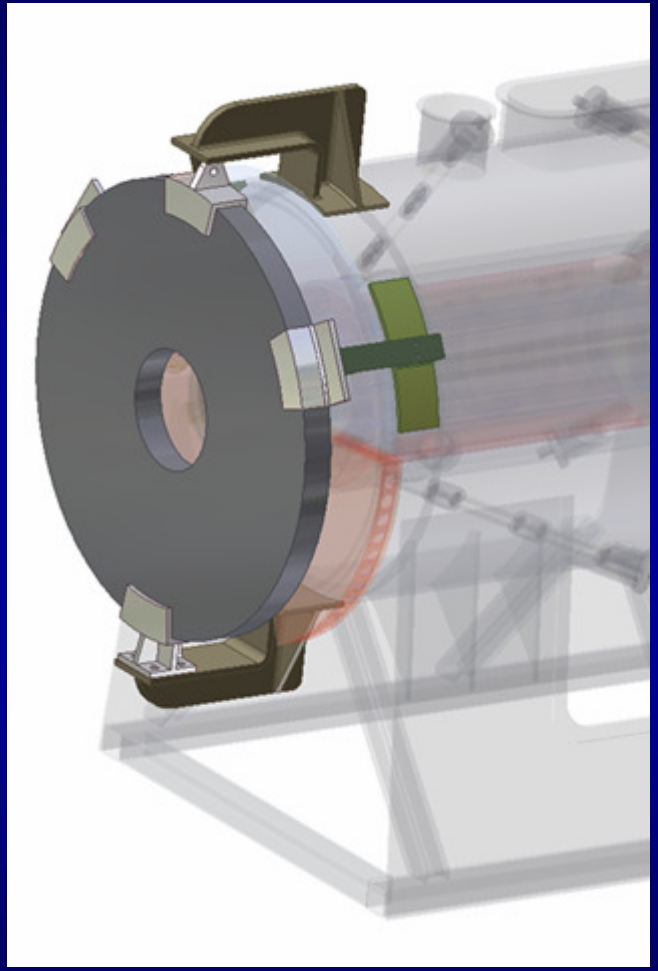
Cryocooler Compressors

Magnet Power Supply Racks

Racks include 300 A power supplies, 60 A power supplies and magnet discharge circuits

Spectrometer Solenoid Iron Shields

- Design integrated with TOF shield; force analysis and fab drawings done at Oxford
- Two sets of shields needed at FNAL and one initial set at RAL
- Fabrication at JK Mfg near FNAL for two shield sets (420 and 600 mm holes) almost complete
- One set of shields to be sent to RAL with the first magnet



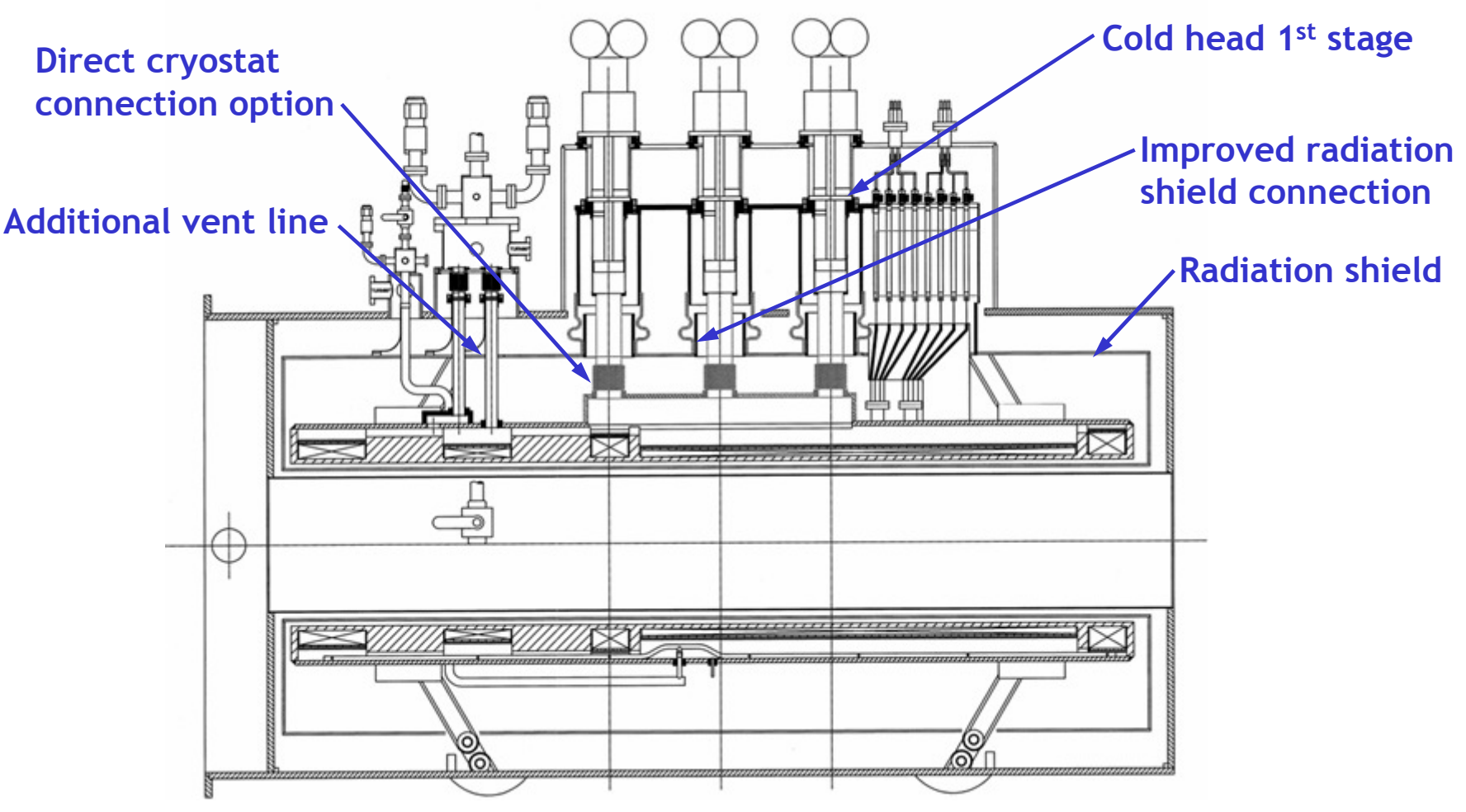
Issues with Magnet #1

- Frozen N_2 in cold mass helium lines prevented proper operation (mainly procedural, partially design issue)
- Inadequate thermal connection between 1st stage of cold heads and cold mass radiation shield
- Venting of cold mass during quench is not sufficient due to crowding of vent line with instrumentation wires
- No provision for direct cooldown of cold mass radiation shield (i.e. long cooldown time)
- Mechanical issues: magnet alignment in vacuum vessel, support stand height, iron shield support pads, support stand offset

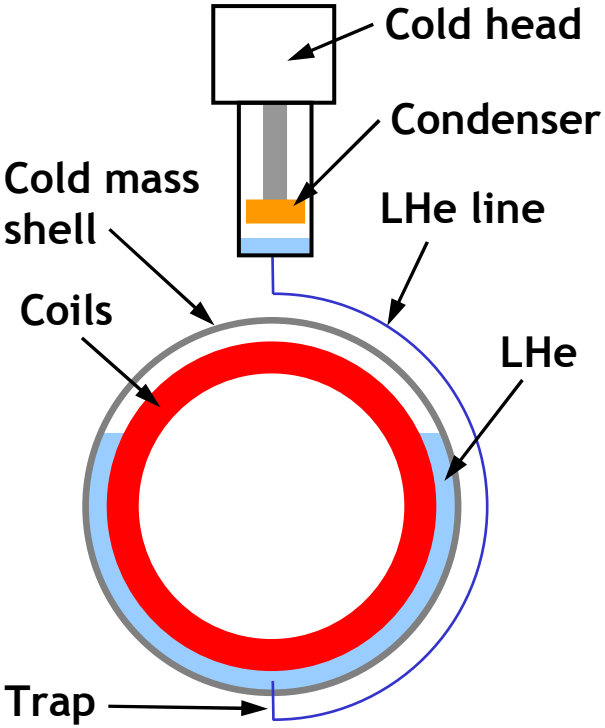
Design Solutions

- Opening of Magnet #1 will be required to perform fixes
- Helium line blockage: connect cryocooler condenser directly to cryostat, improve cooldown procedure
- Radiation shield connection: increase thermal conduction with thick 1100 Al flexible straps (instead of thin Cu)
- Cold mass vent: add additional vent line to the cold mass
- Radiation shield cooldown: incorporate LN reservoir to allow direct cooldown of shield
- Mechanical issues: realign Magnet #1 during reassembly (also corrects support stand height), modify end supports to clear iron shield mount pad (Magnets #1 and #2)

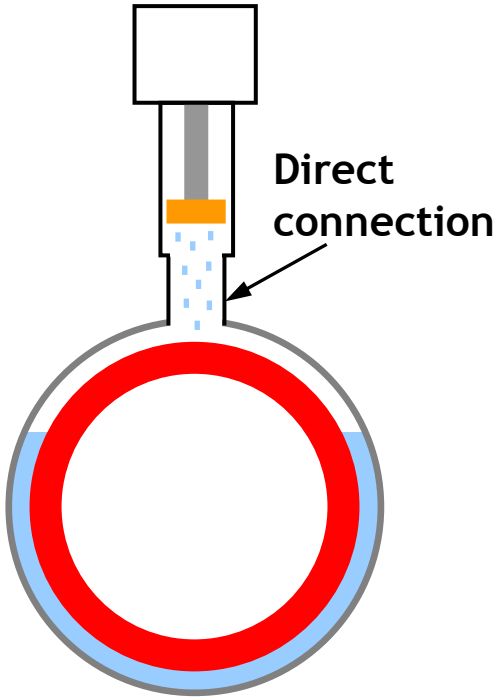
Cryostat and Cooling System Mods



Magnet Cooling Modifications



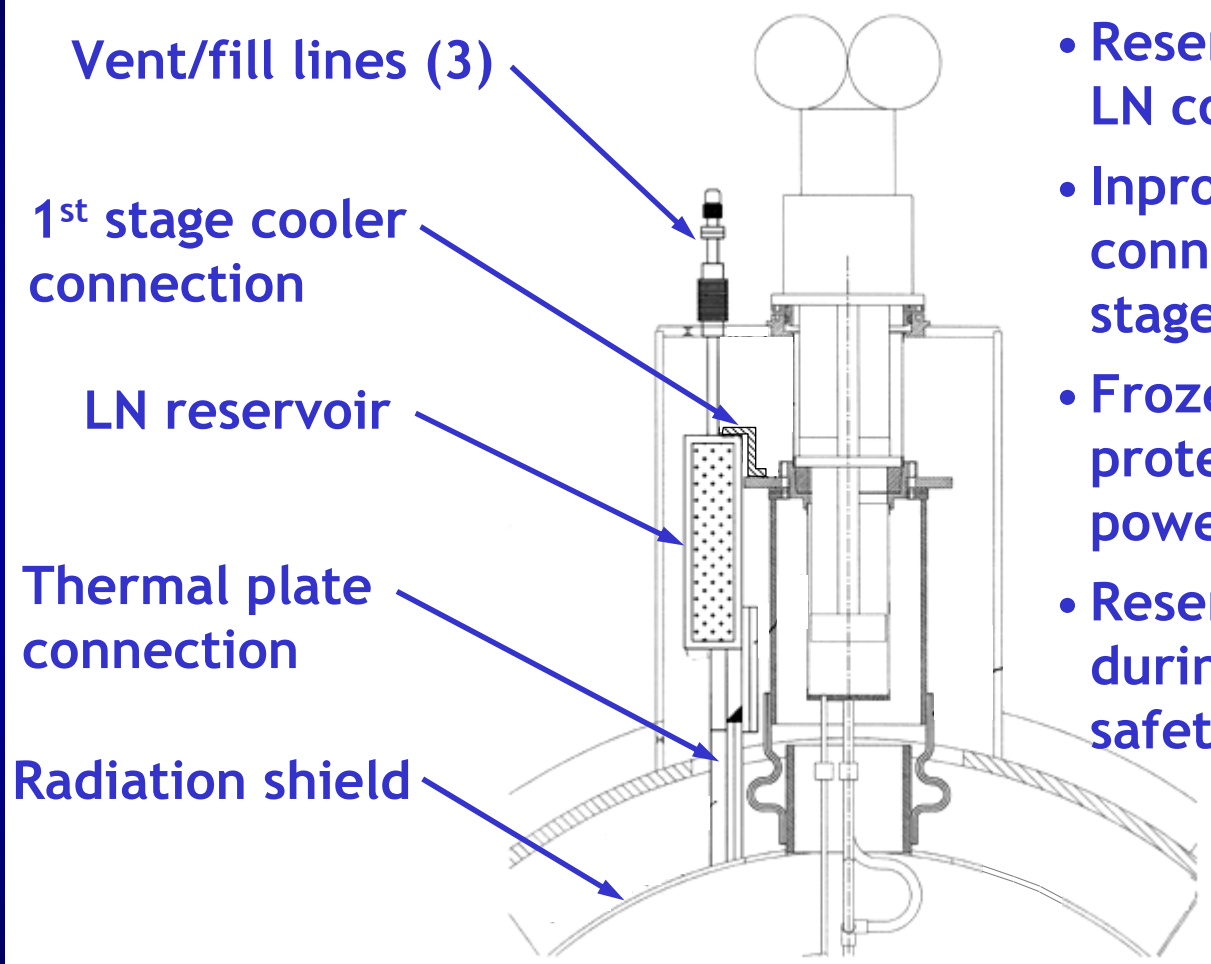
Original Design



Modified Design

A written cooldown procedure will be generated to ensure that all N_2 is purged from the system prior to introducing liquid helium

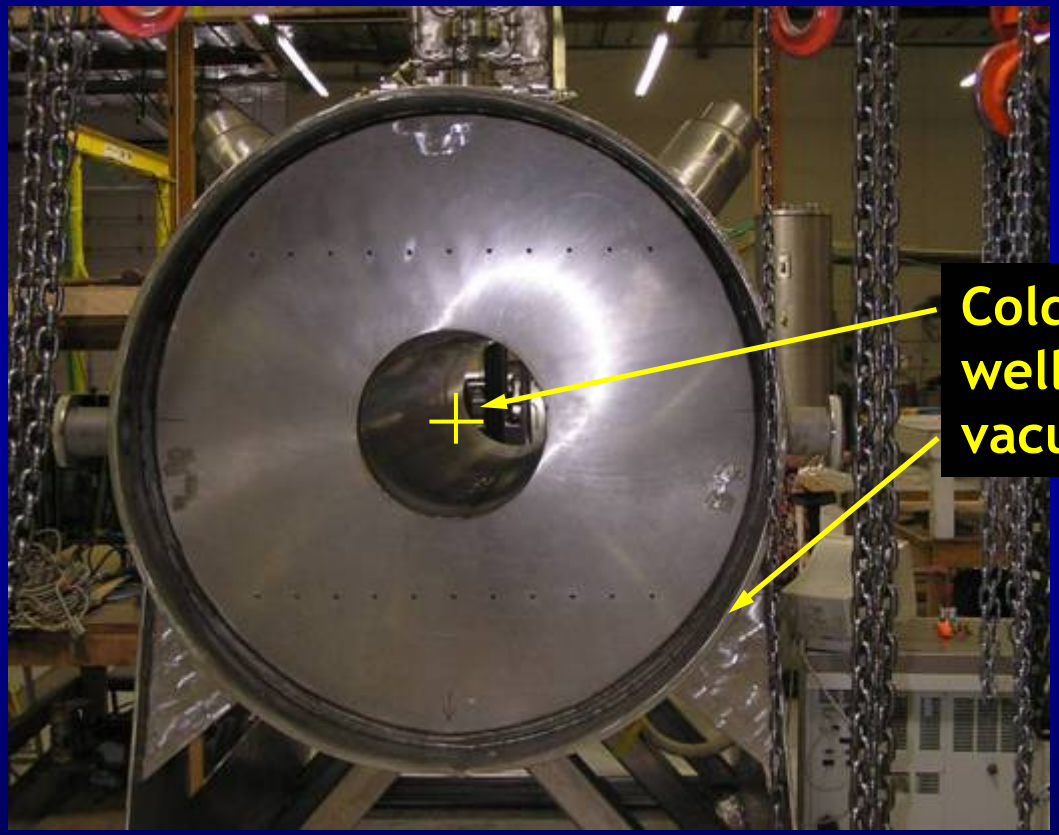
Liquid Nitrogen Reservoir



- Reservoir provides direct LN cooldown of shield
- Inproves thermal connection between 1st stage of cryos and shield
- Frozen mass of nitrogen protects leads in event of power failure
- Reservoir may be empty during operation due to safety concerns

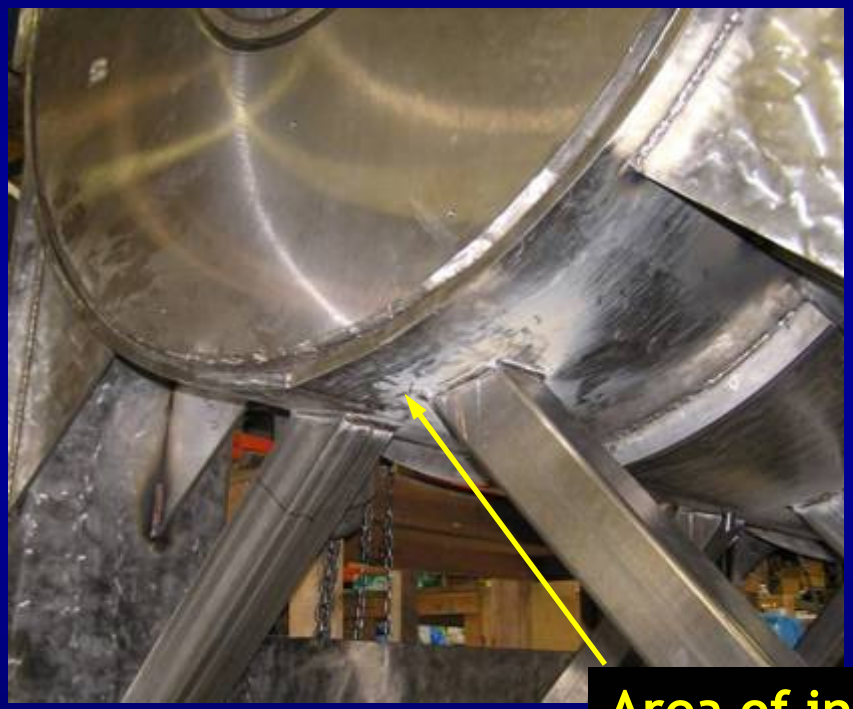
Mechanical Issues

- Vacuum vessel end flange center is not well aligned to coil centers (up to 10mm offset w/current install procedure)



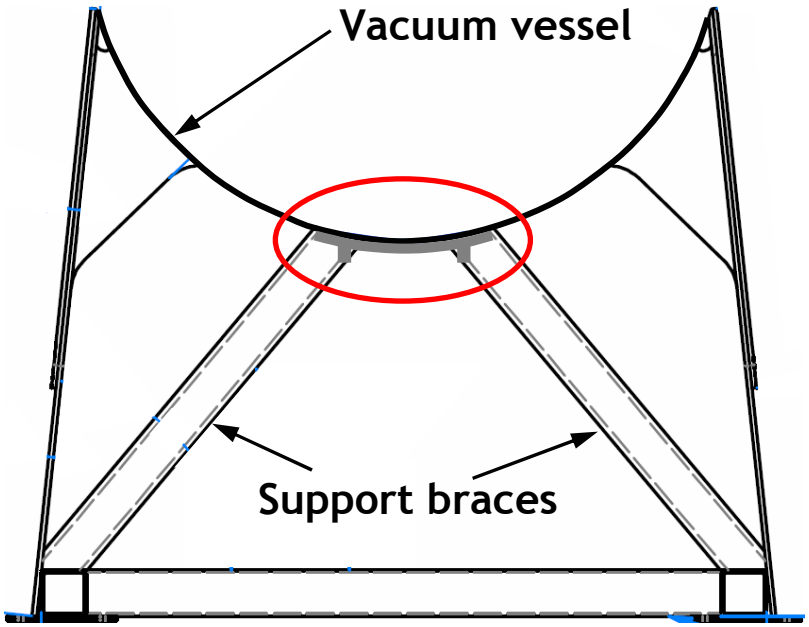
Mechanical Issues

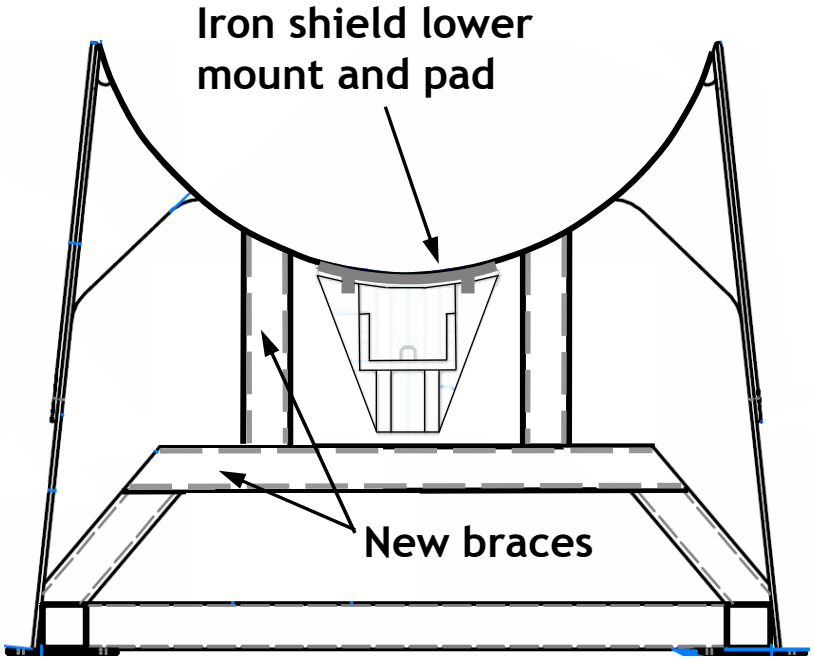
- Support stand cross beams interfere with the planned location of the lower iron shield saddle plate



Area of interference

Support Stand Modification



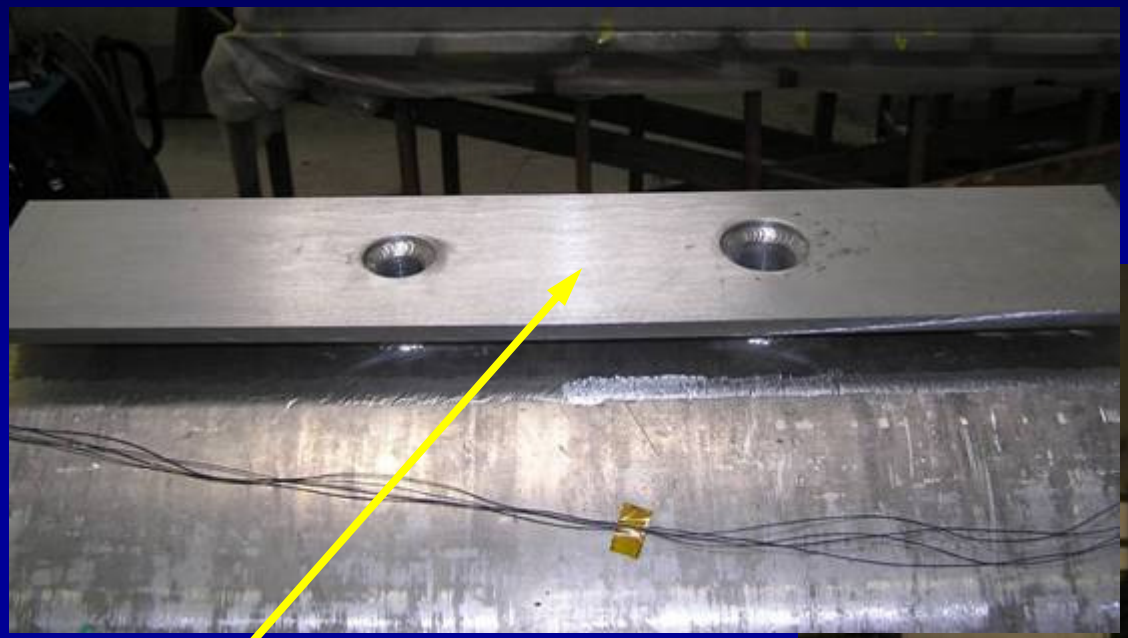


Original Design

Modified Design

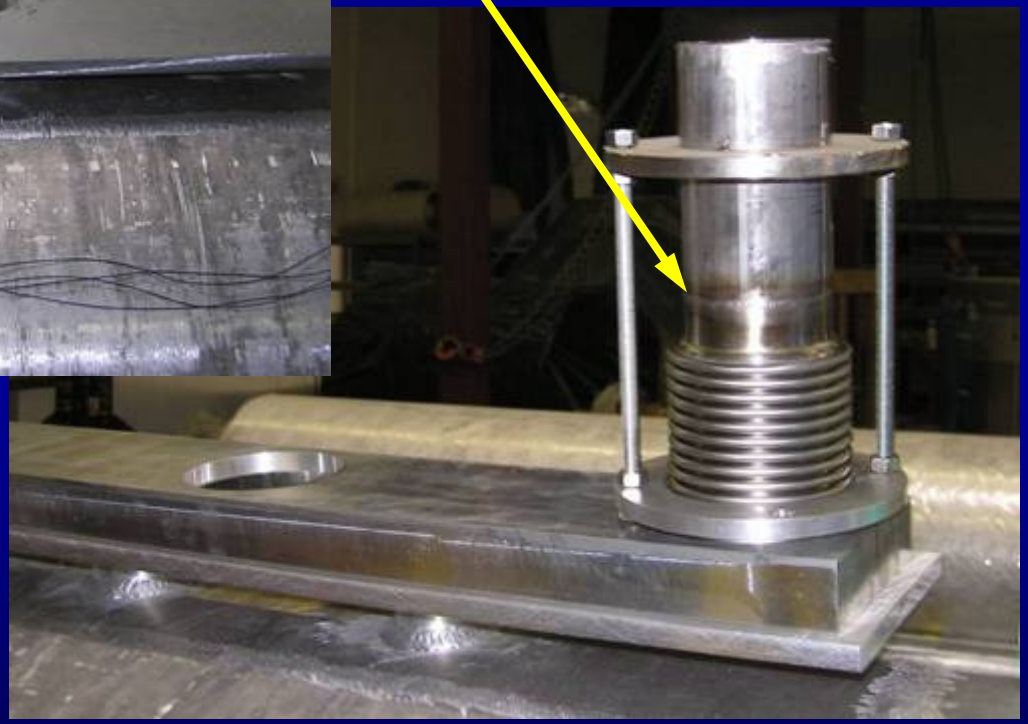
Vendor will modify both ends of both magnets

Modified Cooling System

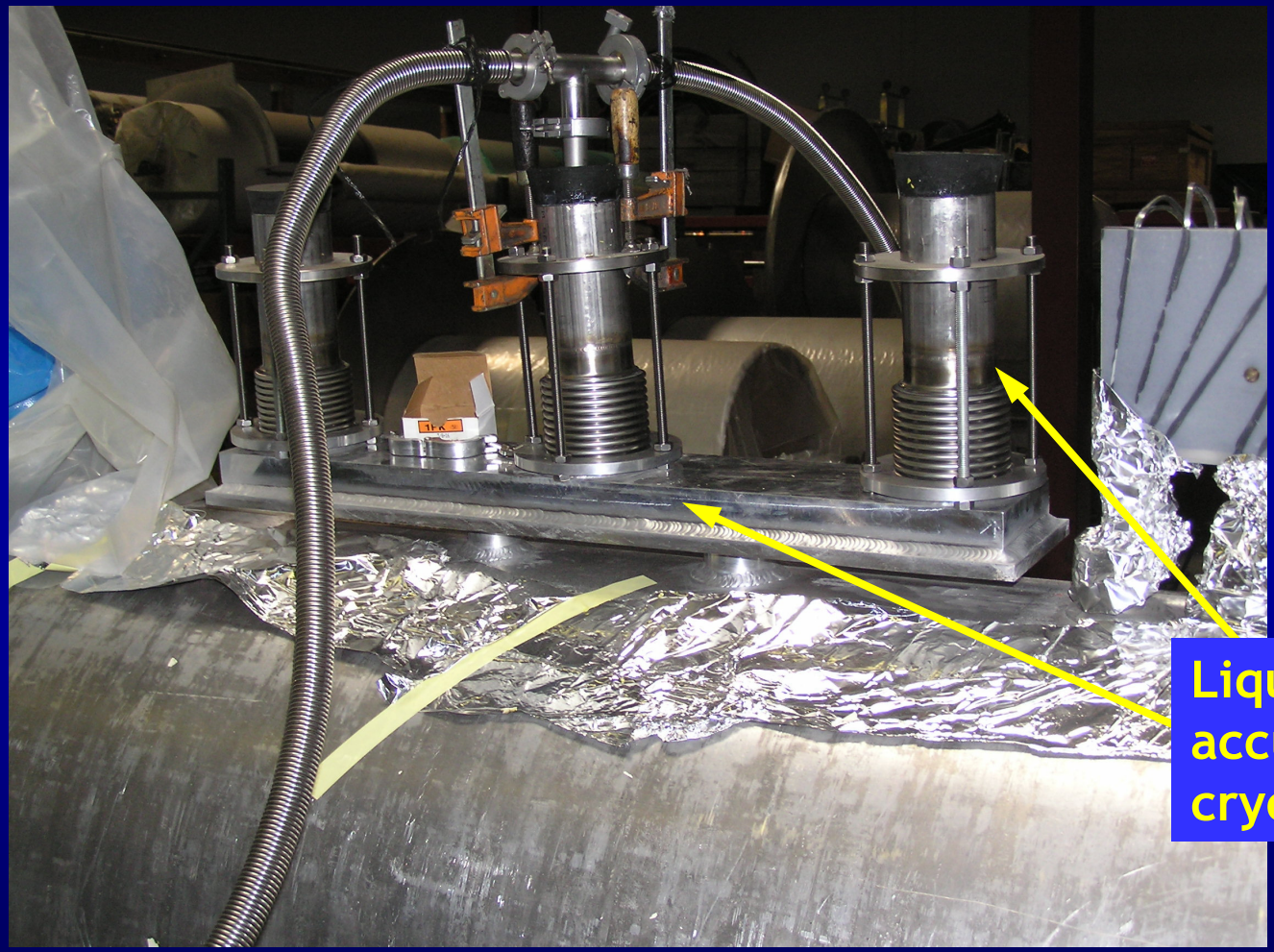


Liquid/vapor helium accumulator base and cold mass connections

Direct cryocooler sleeve connection with bellows



Leak Test of Cooling System



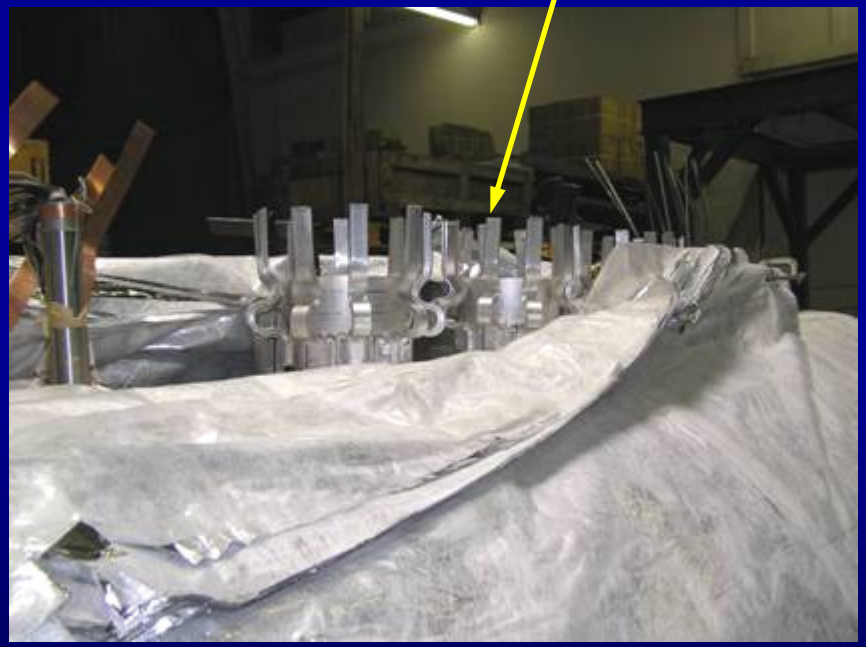
Liquid Nitrogen Reservoir

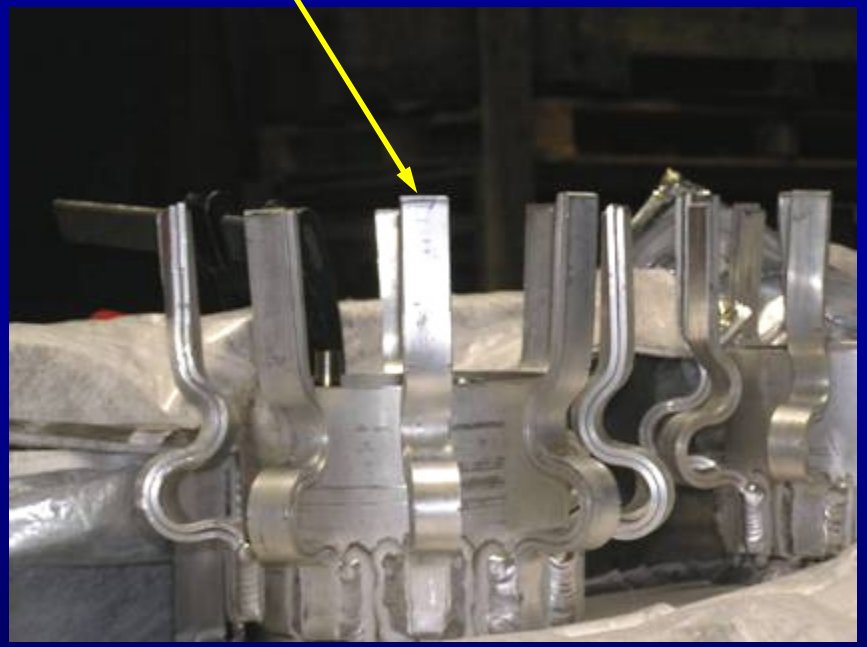
LN_2 reservoir to be thermally connected to radiation shield

Plates welded to radiation shield for reservoir connection

Radiation Shield Thermal Connection

Thicker 1100 series aluminum connection to thermal shield (previously thin copper)



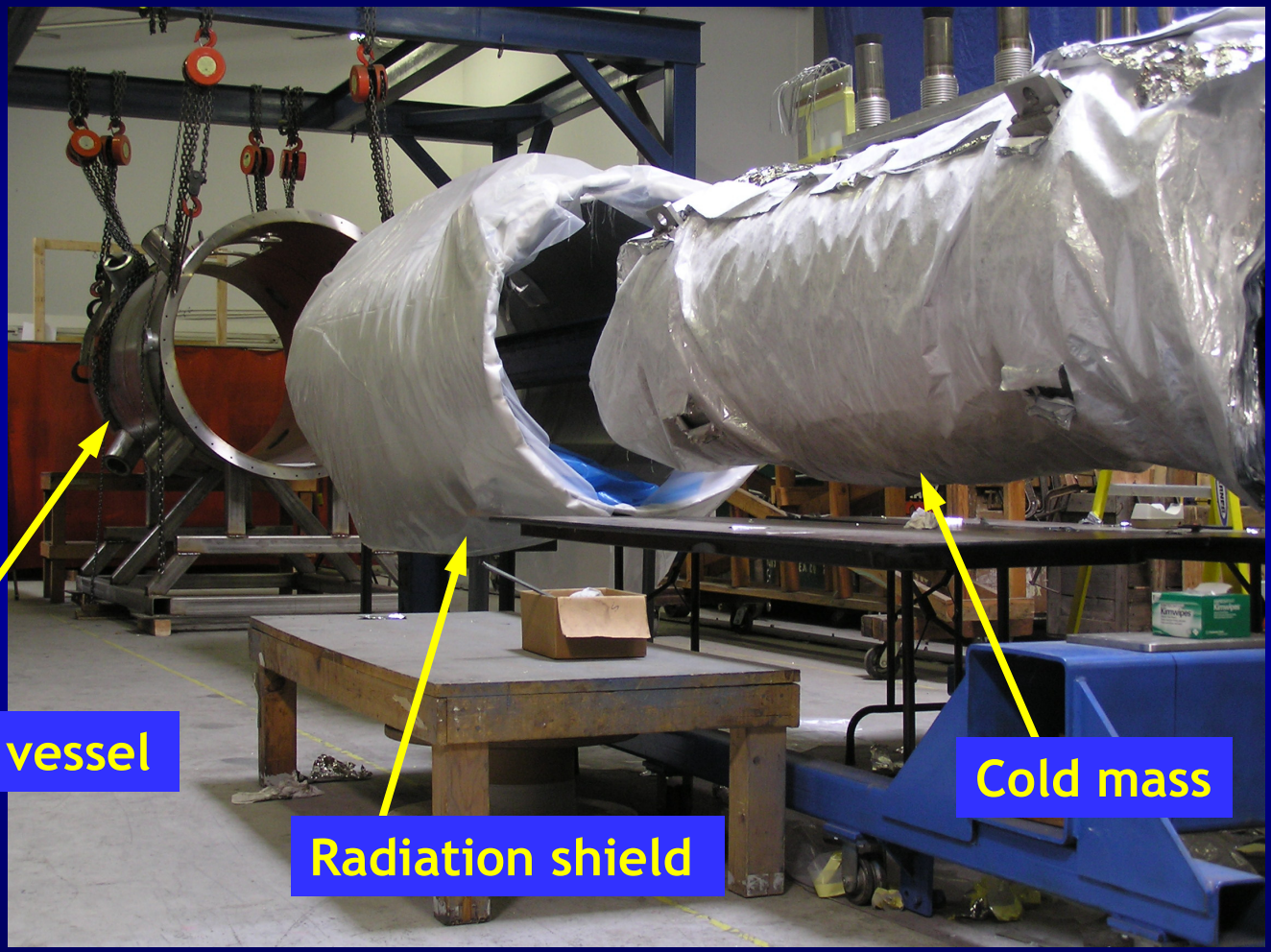


Fully Assembled Cold Mass and Shield

2nd Magnet Cold Mass Ready to Install

- Helium cooling circuit modification is complete
- Improved thermal shield connection added
- Second cryostat vent tube added
- LN reservoir installed on thermal shield

2nd Magnet Components before Assembly



Vacuum Vessel and Support Stand

End flange

Modified support stand legs

Second Magnet Assembly

- Second magnet in process of final assembly
- All system improvements have been incorporated

Second Magnet Assembly

Magnet CMM Measurement

- Portable CMM will be used to align cold mass to end flange and set height
- Tooling balls will also be added to vessel and fiducialized to cold mass

First Magnet Partially Disassembled

Schedule

- The plan to move forward involves completing and testing Magnet #2 first (with all modifications)
- Several technical issues as well as negotiation with the vendor on change costs has delayed completion
- Completion of the first unit (Magnet #2) and start of cooldown & testing is expected to occur in late February
- Upon shipping of Magnet #2 (now first unit), Magnet #1 will be modified (reconfigure cooling, add vent line, LN reservoir, etc.)
- The reassembly and completion of Magnet #1 should follow by two to three months