

Status of MICE Coupling Coil Magnets

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February 16, 2011

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Introduction

- CC fabrication has been under way in China for several years
 - got off to slow start but **has been progressing** during the past year
 - first coil wound and banded
 - mandrels and cover plates for coils 2 and 3 fabricated
 - cryostat design almost completed
 - test system made operational with dummy load
 - preparations under way for welding of cover plate



CC Magnet Fabrication Plan

- **Organization and responsibilities**
 - **LBL** has overall responsibility for the MICE CC magnets
 - **HIT** responsible for design and fabrication (in collaboration with **LBL**)
 - **LBL** took over responsibility for cryostat design in August 2010, in collaboration with SINAP (under US-China HEP Collaboration Agreement)
 - updated addendum reflecting this was signed between LBNL and HIT in August 2010
 - magnet fabrication (contract) at **Qi Huan Corp.** (Beijing, China)
 - 1st MuCool coil winding started early July; finished Dec. 2010

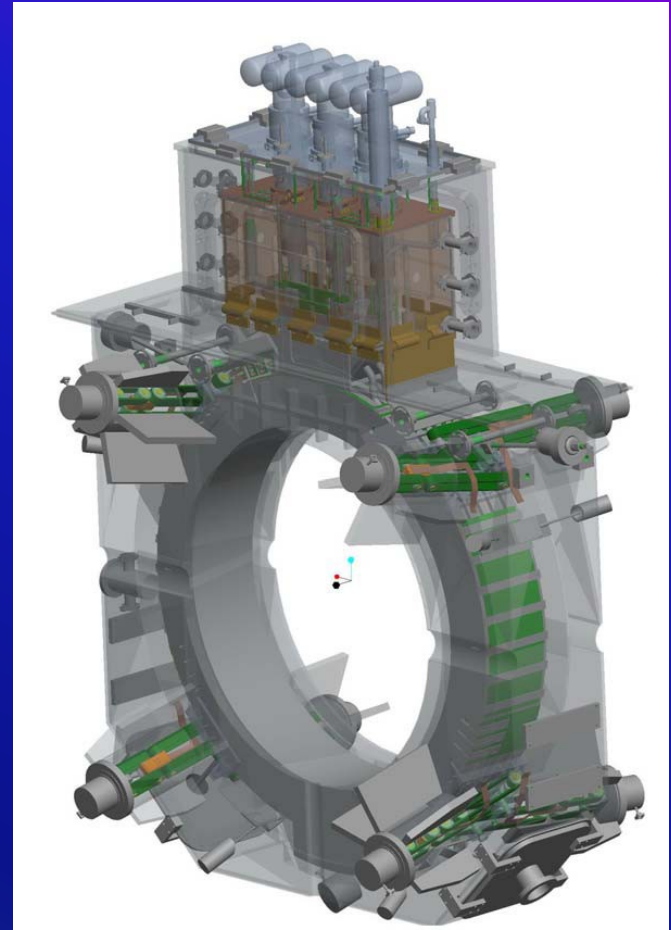


Current Status of the CC Magnets

1st coil winding complete in Dec. 2010



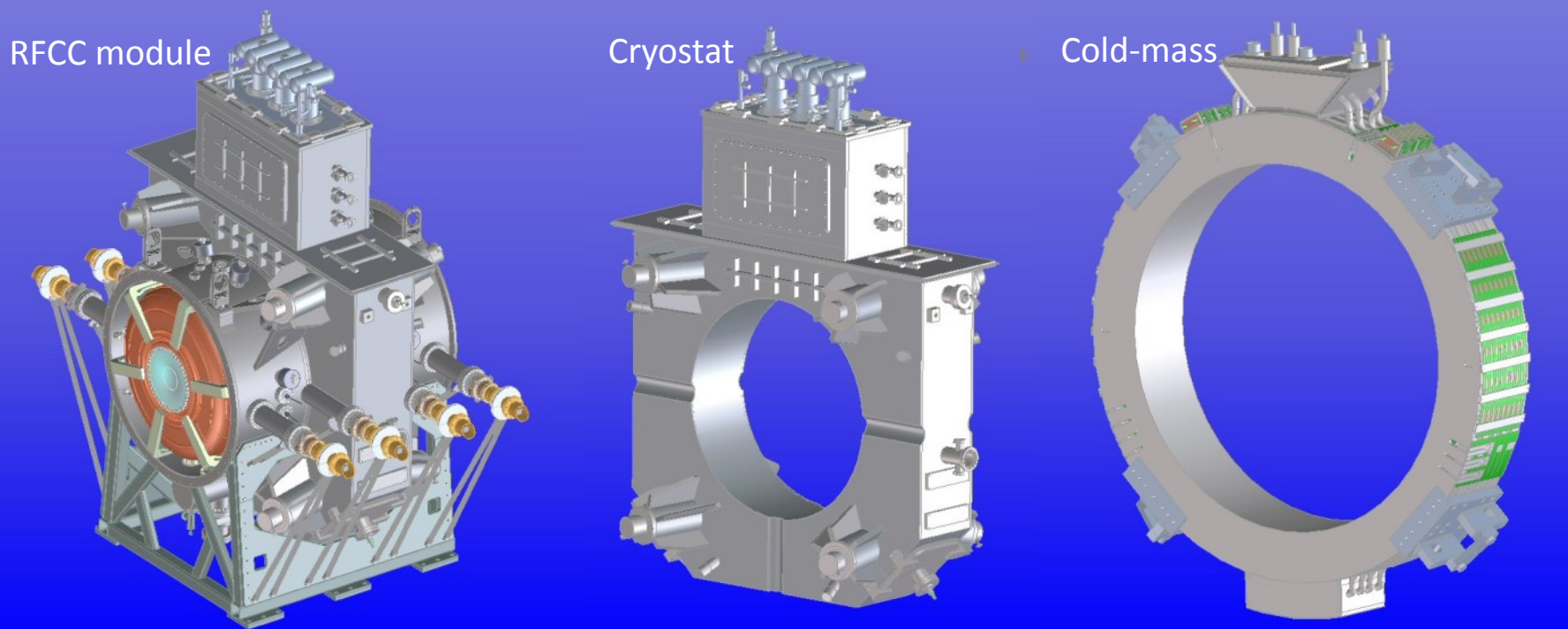
Coil winding at Qi Huan: last layer of SC wire (left) and finished Al banding (right)



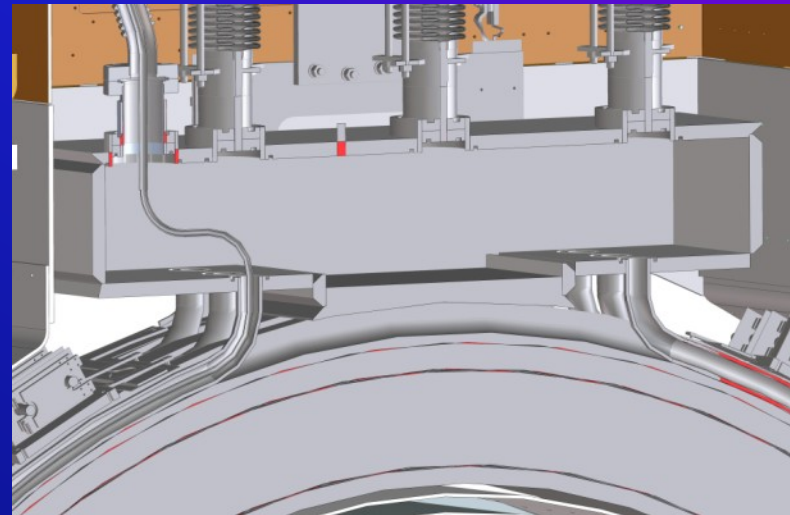
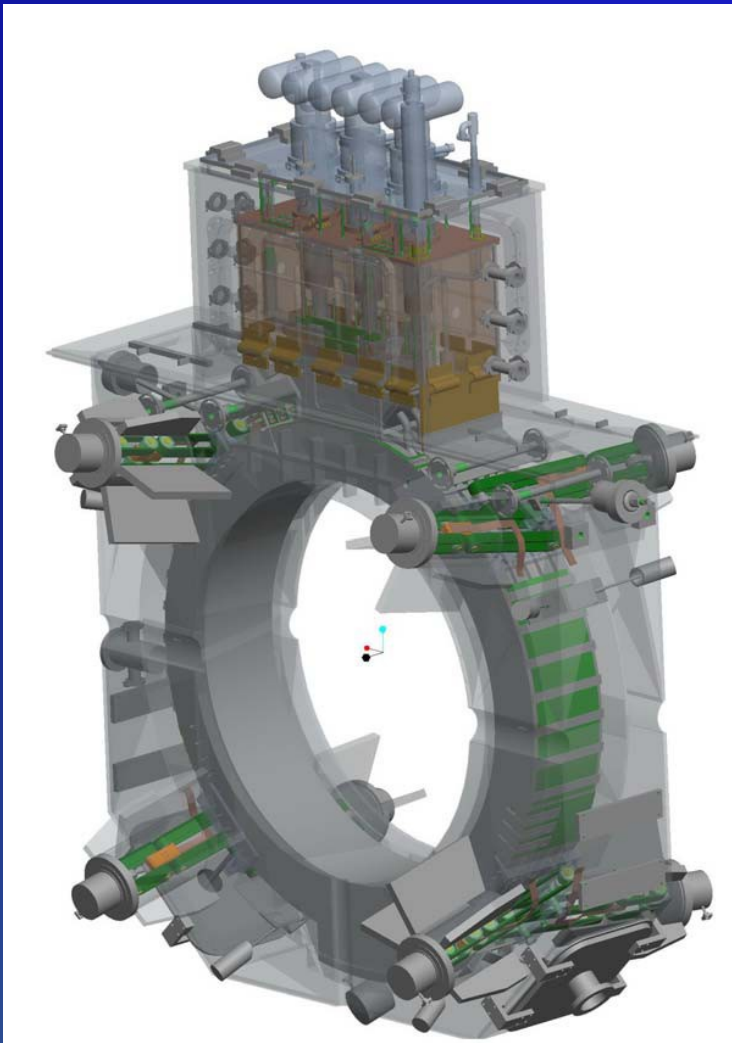
Latest cryostat design with 3 cryocoolers

Improved Cryostat Design

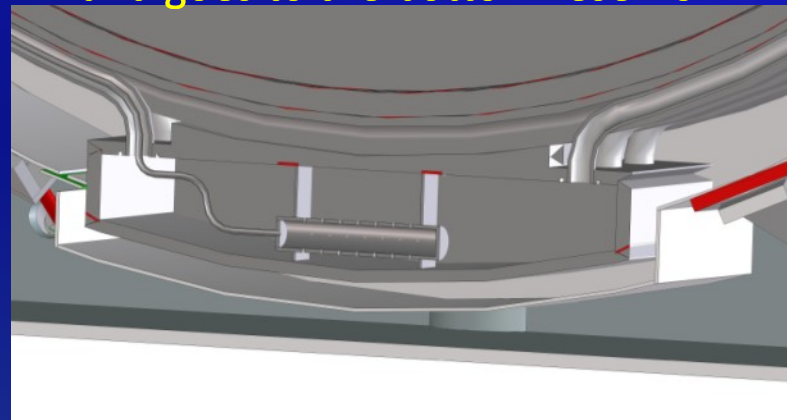
- Three cryocoolers
- Improved cooling circuit design
- Increased spacing for MLI insulation and assembly by 40 mm



Improved Cooling Circuit Design

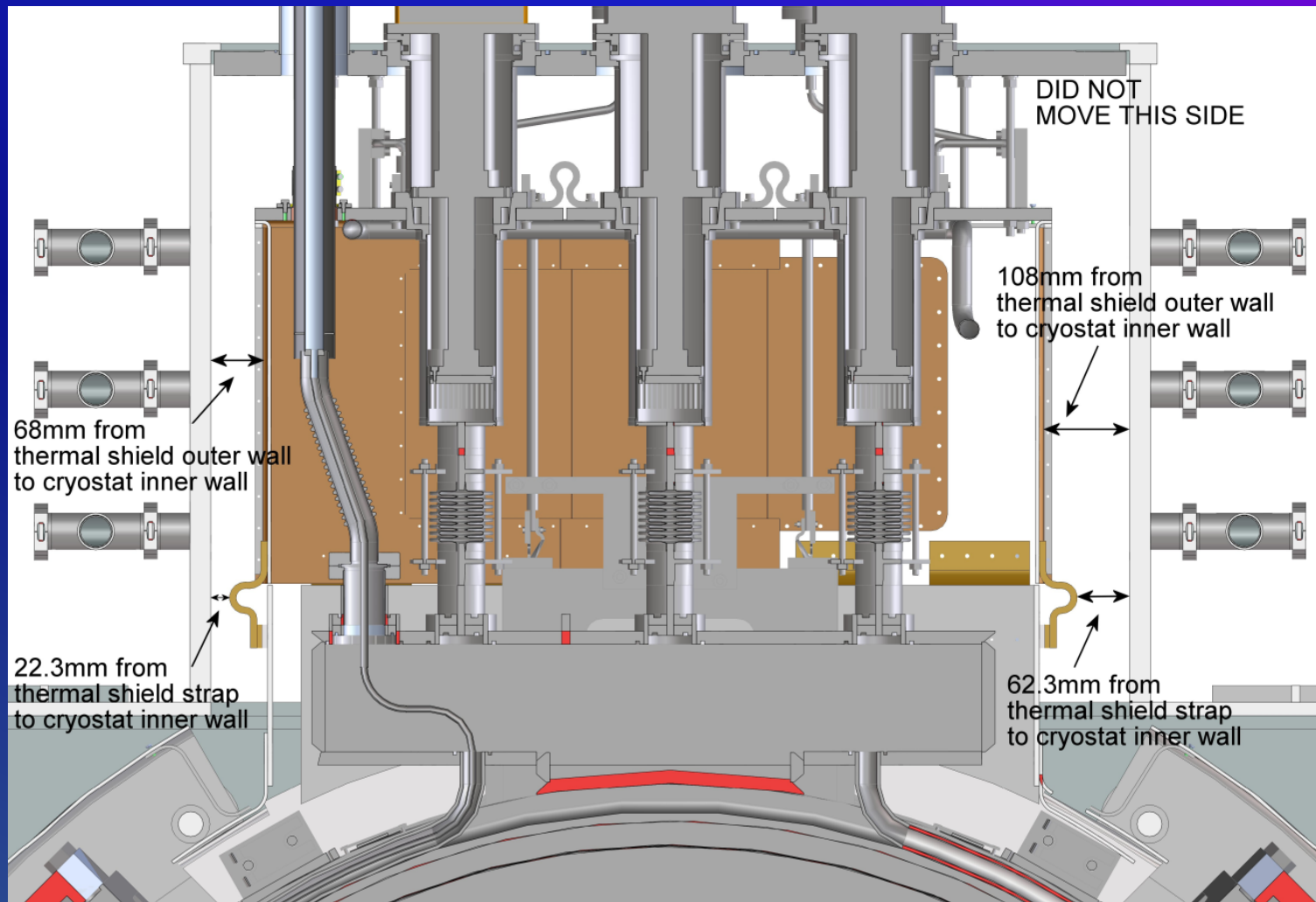


LH fill line inside cooling pipe
and goes to the bottom reservoir



Bottom reservoir with phase separator

Improved Circuit Design at Top Tower

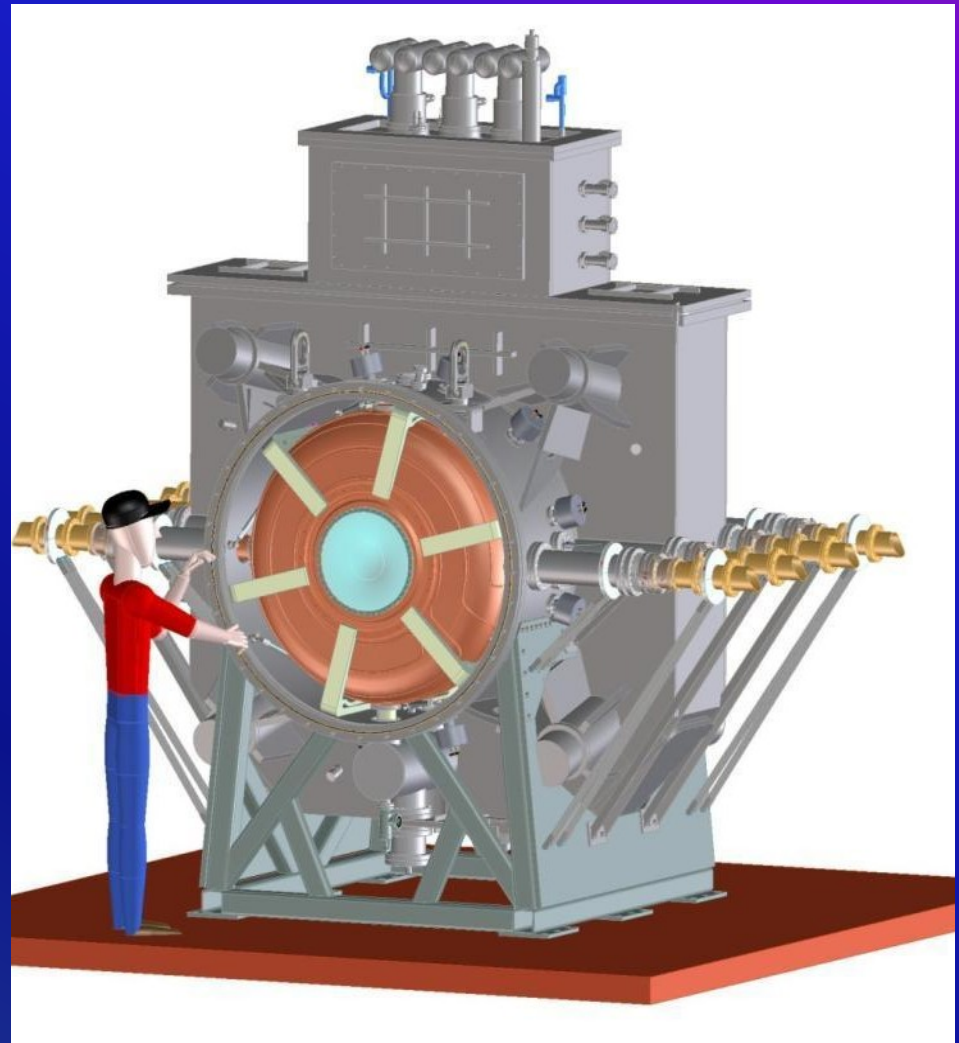


Work in progress and will be finalized soon

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Summary of the Cryostat Design

- Updated design significantly improves performance
 - Three cryocoolers
 - More robust structure
 - More spacing for MLI shielding and assembly
 - Improved cooling circuit
 - Easier assembly
 - Easier access for repair and adjustment (if needed)
 - Direct method to reference cold mass position to outside survey fiducial

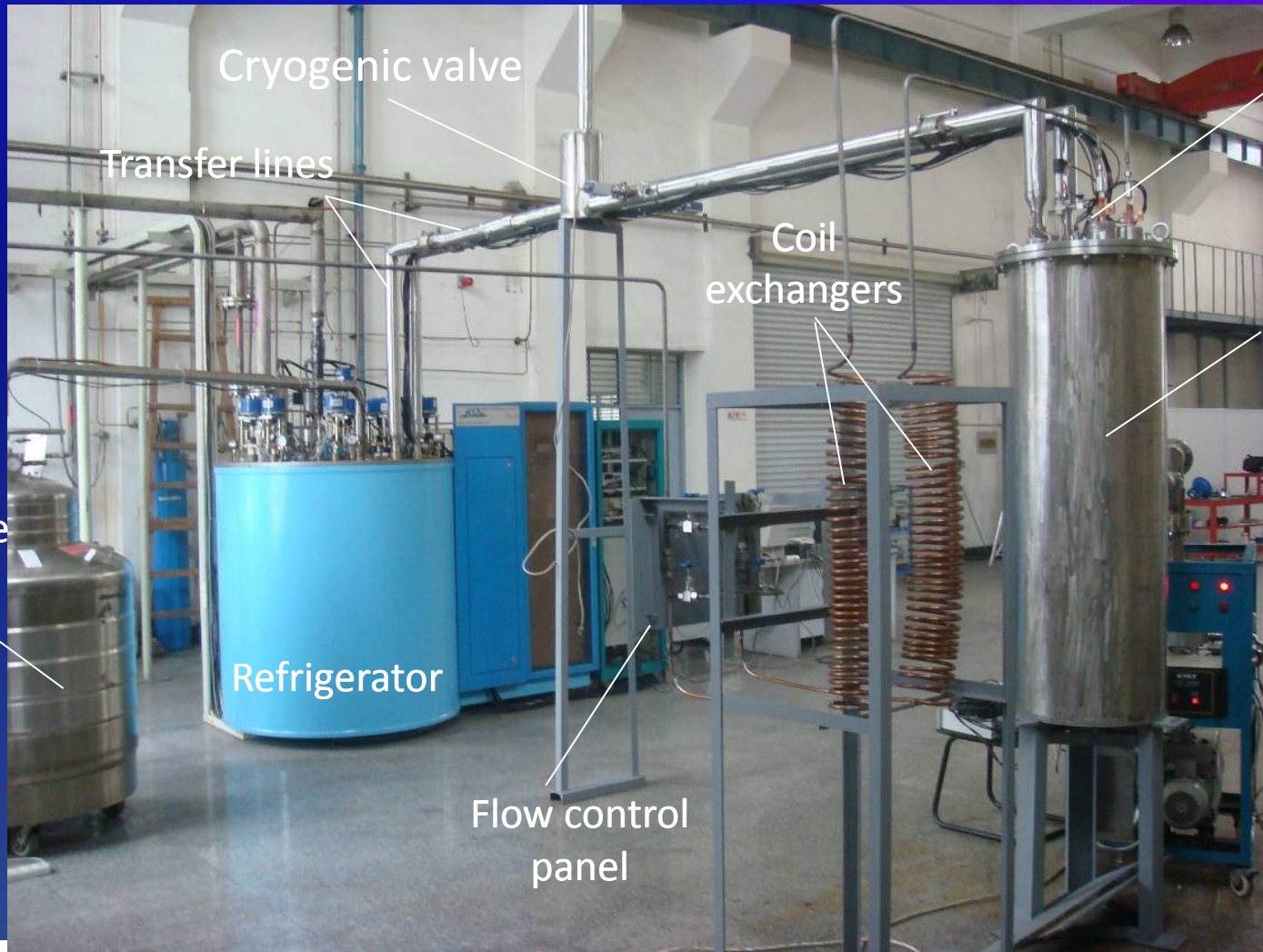


Tests of the HIT System

- Successful tests of HIT cryogenic system carried out using dummy load in January 2011
- Two main achievements:
 - **Modification of existing cryogenic system at ICST**
 - Shorter and better transfer lines
 - **Test of the components that will be needed for MICE CC magnets at cryogenic temperature using the dummy load**
 - Current leads
 - Insulators
 - Temperature sensors
 - LHe level sensors



HIT Cryogenic Test System



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Dummy Load



Pressure transducer

Relief valve

Top flange

Current leads

Copper tanks

Liquid-vapor separator



Insulator

SC wires

**Inside the dummy load:
cryogenic
components needed
for CC magnets**

Feed-through for
center tube

Level
sensor

Temperature
sensor (DT-470)

Heater



Summary of the HIT Tests

- Cryogenic system modified and rebuilt successfully
 - new transfer lines and good vacuum
- Upgraded system able to cool dummy load to 4.2 K
 - produced LHe accumulation (25% of the volume)
- Both current leads tested from 0 to 500 A
 - very stable during 1 hour test period
- All cryogenic components tested successfully
 - transfer lines, bayonets, cryogenic valve, insulators, feed-through and current leads
 - all can be used for testing the large test coil and CC magnets



Remaining Technical Tasks (1/2)

- **SINAP:**
 - Cryostat and cooling circuit design and production of drawings (end of March 2011)
- **HIT:**
 - Preparation for cold-mass cover plate welding
 - Al pipe welding tests to determine the cold-mass welding procedures
 - Fabrication of welding fixtures
 - design complete
 - fabrication starts after Chinese New Year
 - Resume testing of the $\frac{1}{4}$ -scale test coil



Remaining Technical Tasks (2/2)

- **Qi-Huan:**
 - **Vacuum potting of coil 1**
 - and assembly into cryostat after testing
 - **Fabrication of cryostat**
 - awaiting final design drawings from SINAP
 - **2nd and 3rd coil winding**
 - should we wait for test results of the first coil?
 - for finalization of quench protection system design?
- **LBNL:**
 - **Quench protection (ongoing)**
 - **Stabilization of current leads**



Current Situation

- Design and fabrication of the CC magnets now considered to be difficult, and beyond the state-of-art (expert's comments)
- Current design fabrication situation in China
 - Cryostat and cooling circuit design will be complete by SINAP at end of March 2011
 - Recent dummy load test at HIT was successful, but HIT team is resource and (qualified) manpower limited
 - testing of the CC magnets at HIT seems unrealistic without significant involvement and participation of experts from the US or from MICE
 - Large effort needed to design and fabricate a test cryostat
 - concern that this task may be beyond current capability of HIT staff
 - current test cryostat *would need substantial redesign/rework* to be usable
 - Al welding at HIT is possible, but needs U.S. and UK certification
 - Continuation of coil winding and assembly at Qi Huan possible



Future Plan

- Options we have:
 - stay the course and hope for the best
 - least expensive, and likely the fastest, but riskiest
 - move testing from HIT to U.S.
 - with new test cryostat?
 - using final cryostat?
 - move welding and testing from HIT to U.S.
 - cold mass only or cryostat also?
 - cryostat welding is part of Qi Huan contract
 - cryostat welding in U.S. implies assembly and cold-mass integration also done there
 - start entire job over in the U.S.
 - go out for bid on all components (cold mass and cryostat)?
 - fabricate at a Lab?
 - most expensive, and likely the slowest, but (maybe) less risk



Interesting Questions

- How many magnet coils and cryostats should we build?
 - risk mitigation suggests we should plan for more than 3 magnets to get 3 that work
 - how many more?
 - do we augment the Qi Huan contract or build elsewhere?
 - “elsewhere” probably implies Fermilab (or industry)
 - more magnets mean more of many things
 - superconductor, mandrels, cover plates, and \$
- What do we need to do “certified” welding in China?
 - train some Chinese welders?
 - send a U.S. welder to China to do the critical welds?
 - having to bring parts to the U.S. for welding markedly ups the ante
 - since cryostat assembly and integration *must* then be done in U.S.



Issues

- Quench protection needs to be assessed ASAP
 - the need to add heaters should be identified before beginning to wind coil 2
 - this work could by itself make coil 1 a “throw-away”
- Decision on where we test coil 1 needs to be made
 - in a test cryostat or the “real thing”?
 - waiting for the real cryostat would delay test by ~1 year
 - building a suitable new test cryostat will be expensive and time consuming, and may not be much faster
 - in China or U.S.?
 - can existing HIT test cryostat be made to work adequately?
 - *maybe* faster, but would require substantial help from MICE collaborators



What is Being Done

- **Discussions have begun between LBNL and Fermilab technical personnel aimed at arriving at a robust plan to recommend to MICE**
 - hope to converge on this plan in the next several months
 - must identify resources (people and funds)
 - if there are shortfalls, this will be communicated to MICE
 - must provide realistic schedule
- **Steve Gourlay (LBNL AFRD Head) has been designated as technical contact for MICE magnets**
 - **CCs and Spectrometer Solenoids**



Summary

- **MICE CC magnet fabrication plan under way**
 - Organization and responsibilities defined
- **Coil winding status indicated**
 - 1st MuCool coil winding complete at Qi Huan Corp. in Beijing, China
- **MICE CC Cryostat design reviews completed at SINAP (Shanghai Institute of Applied Physics)**
 - Two design reviews held in Sept. and Dec. 2010, respectively
 - Three cryocoolers, improved cryostat and cooling circuit design
 - 3D and 2D drawings to be completed at end of March 2011
- **Status of HIT (Harbin Institute of Technology) activities presented**
 - Update of the ICST test system has been completed and initial tests done
 - Preparations for welding of cold-mass cover plate in progress
- **Updated plans to provide CCs being developed as part of MAP**

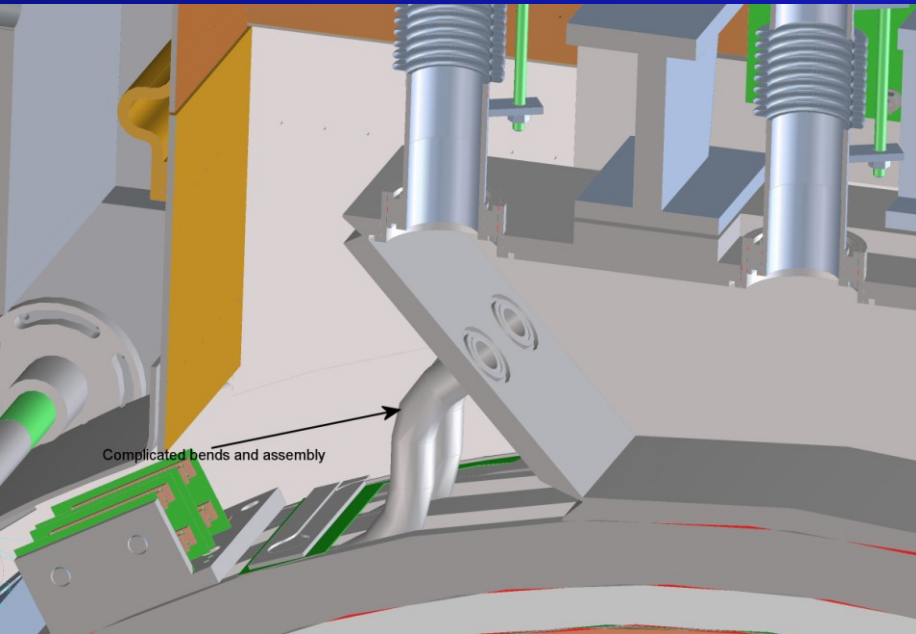


Backups

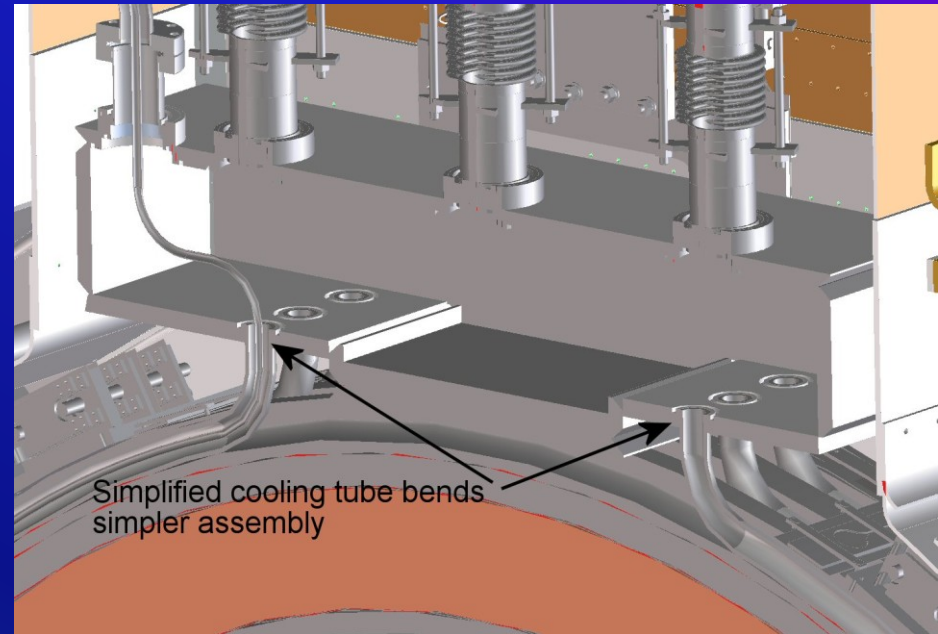


Cooling Tube Improvements

- Simplified cooling tube geometry



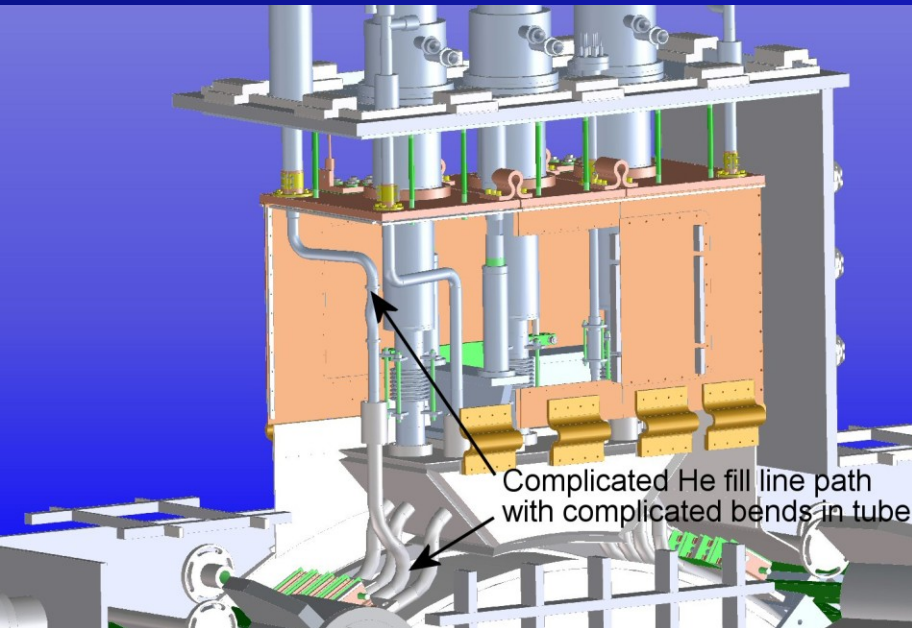
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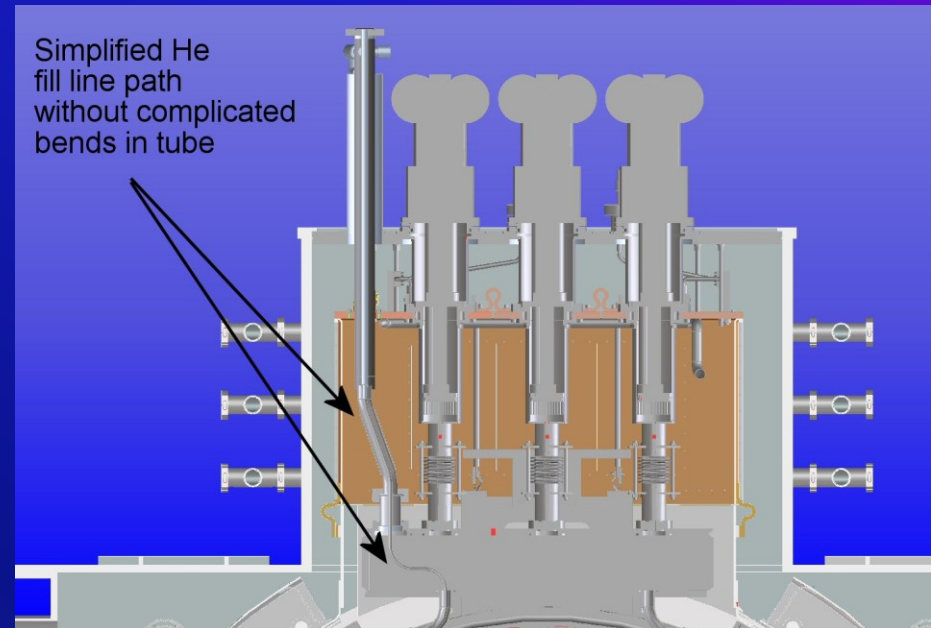
Improved

Fill Line Improvements

- Simplified fill tube geometry



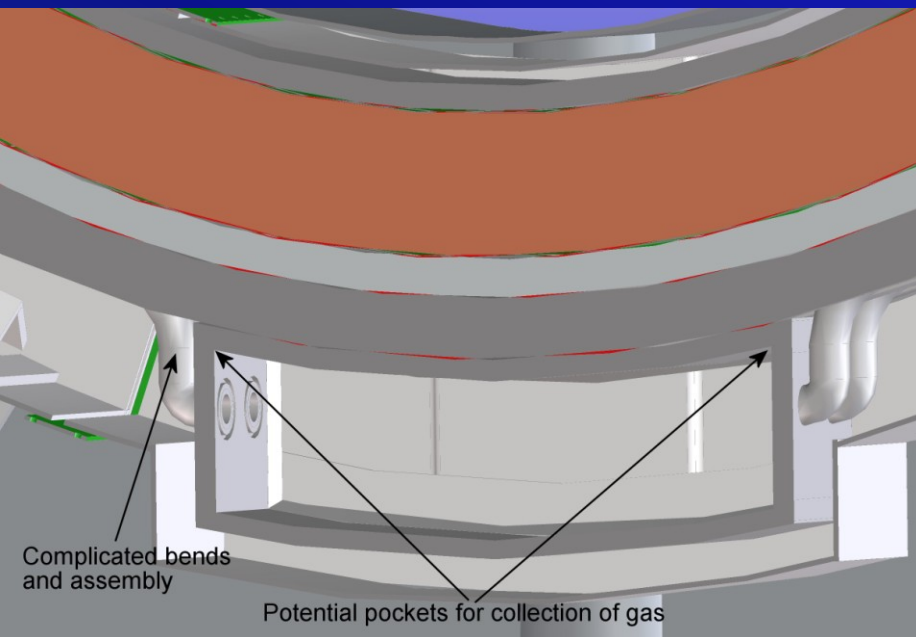
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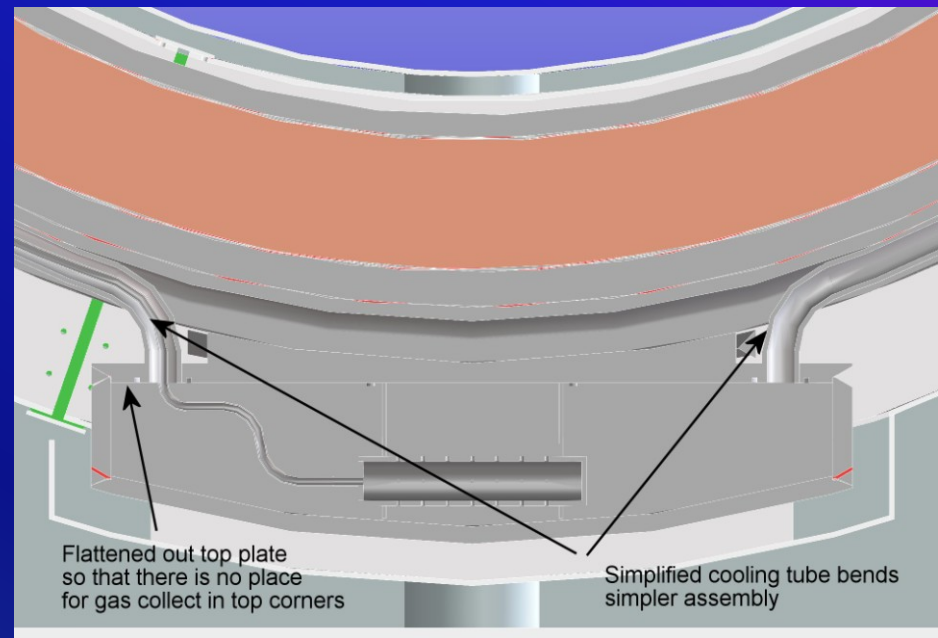
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Bottom Reservoir Improvements

- Simplified cooling tube assembly and eliminated potential area for trapped gas



Original



Improved