

Curved HTS Coils Cooled by Cryo-coolers

Construction and Test Results

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Background

- **Muons, Inc. and BNL team was awarded a Phase II SBIR for developing curved HTS dipole technology for FRIB**
- **FRIB dropped the plans of using HTS magnets**
- **Muons, Inc. and BNL team adjusted the program**
 - **Muons, Inc. continued the design on the curved dipole**
 - **BNL built and tested curved coils with cryo-coolers**
- **Curved HTS coil technology with cryo-coolers has a broader application**
 - **Accelerators and beam lines**
 - **Medical and industry**

>>> Issue: Curved coil requires dealing with negative curvature

>>> Strategy: Wind with positive curvature and then push back on one side (common in LTS)

>>> Concern: Possible damage to HTS which is brittle

Practice Winding with SS Tape (1)



Practice Winding with SS Tape (2)



Practice Winding with SS Tape (3)

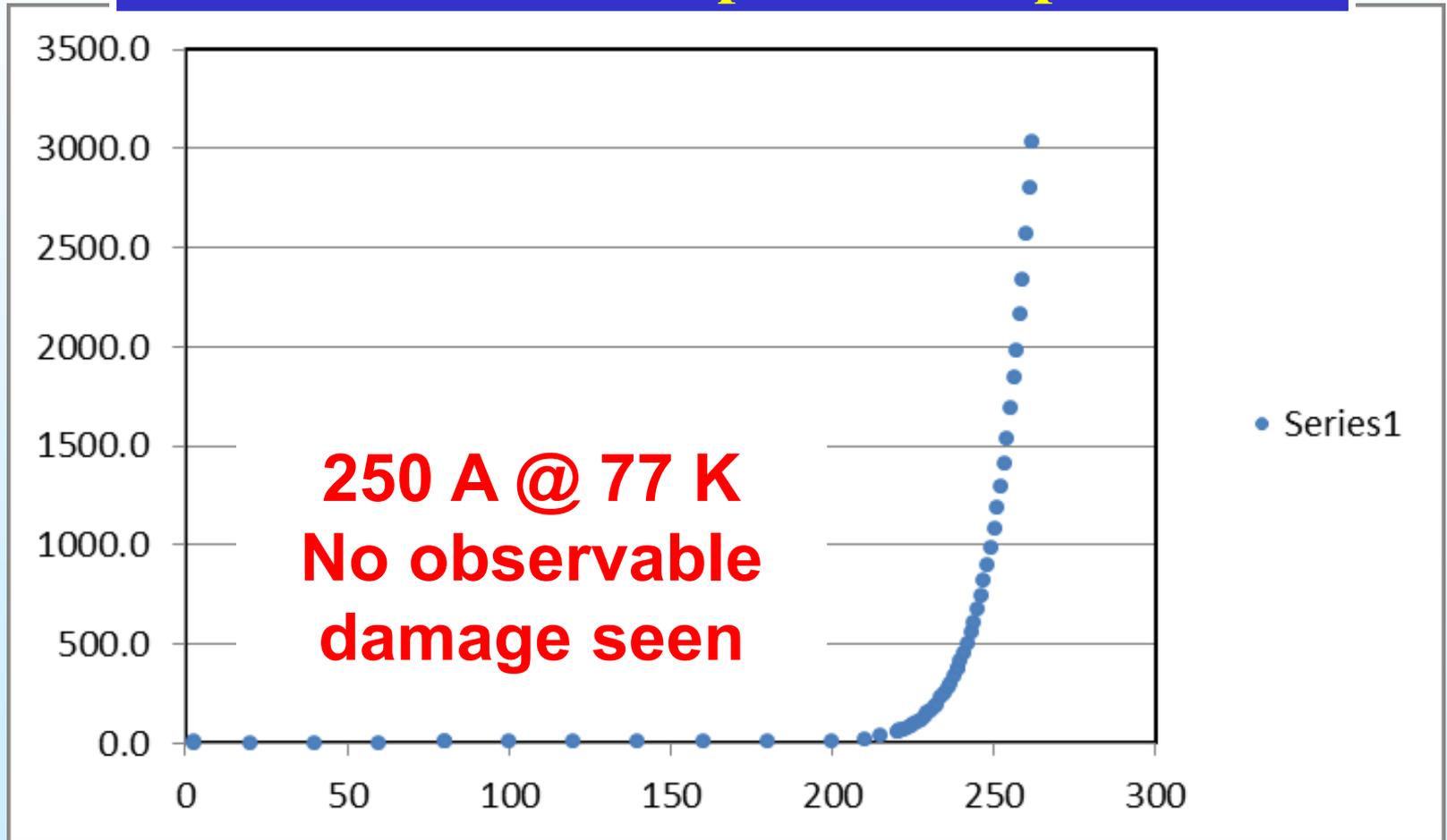


Practice Winding with SS Tape (4)



Test Winding of 5-turn HTS Coil with Negative Curvature

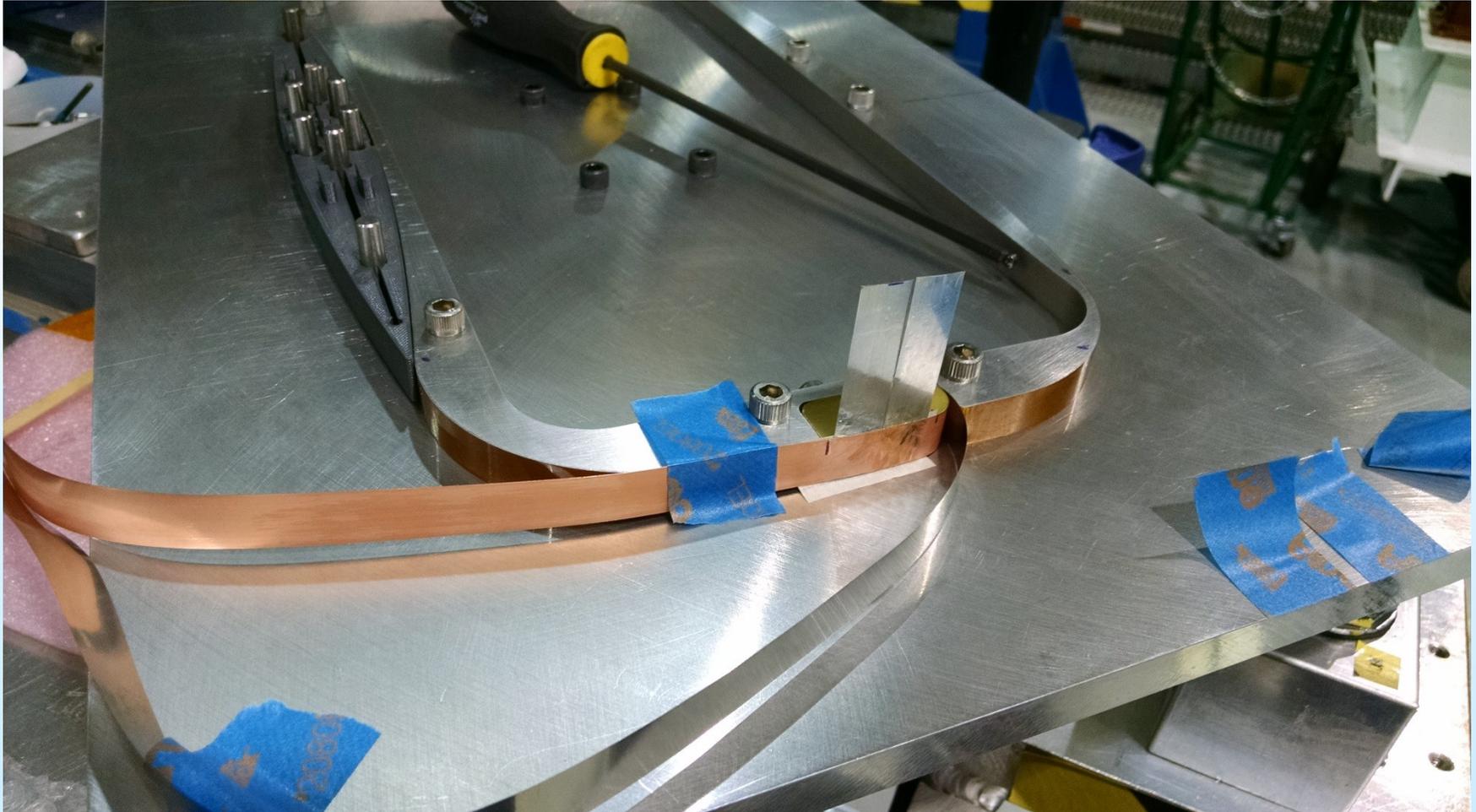
12 mm wide HTS Tape from SuperPower



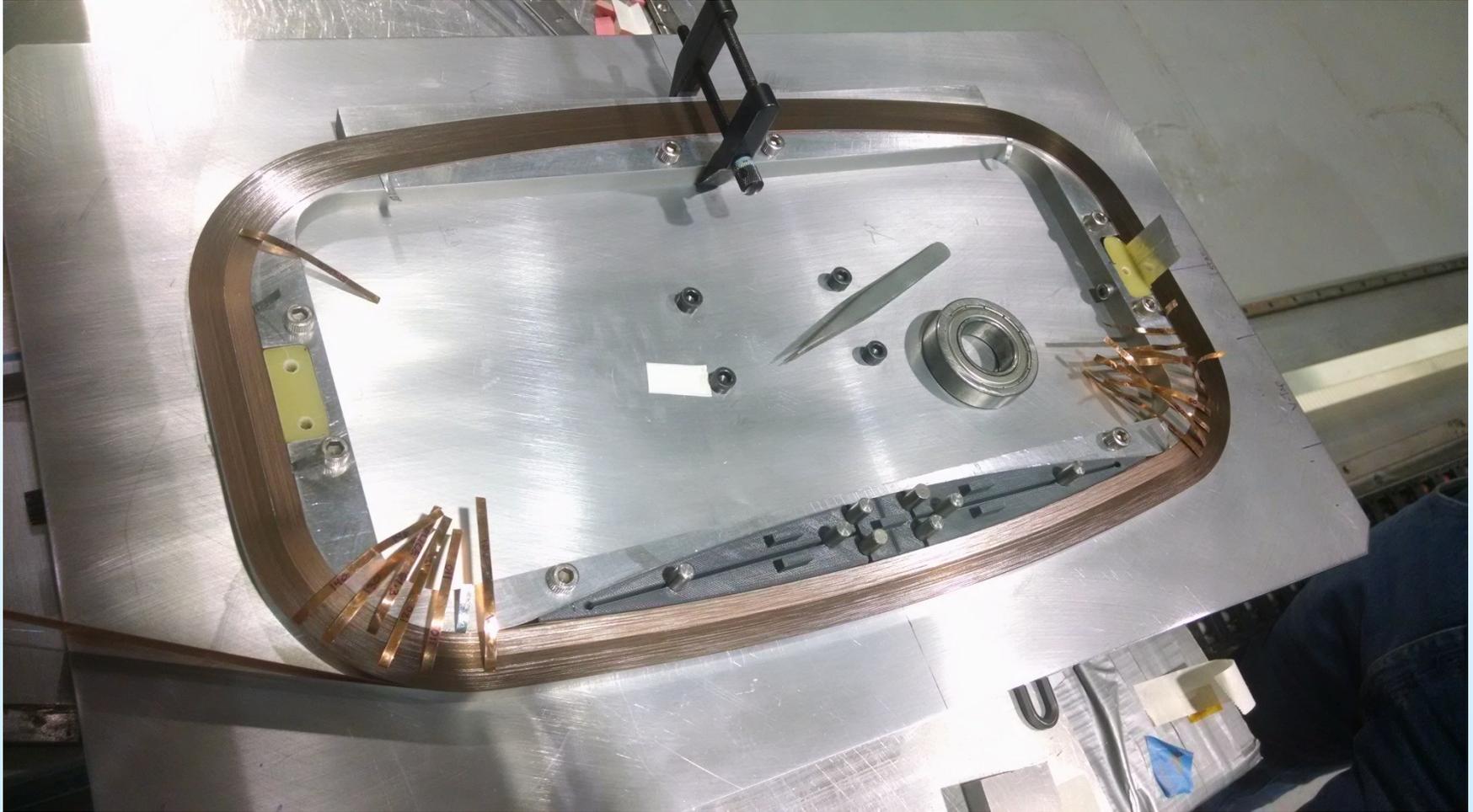
A Walk-through of Making of a HTS Coil with Negative Curvature with Computer Controlled Machine



Start of HTS Coil Winding



Filler Piece for Winding with Positive Curvature



3-d printed parts

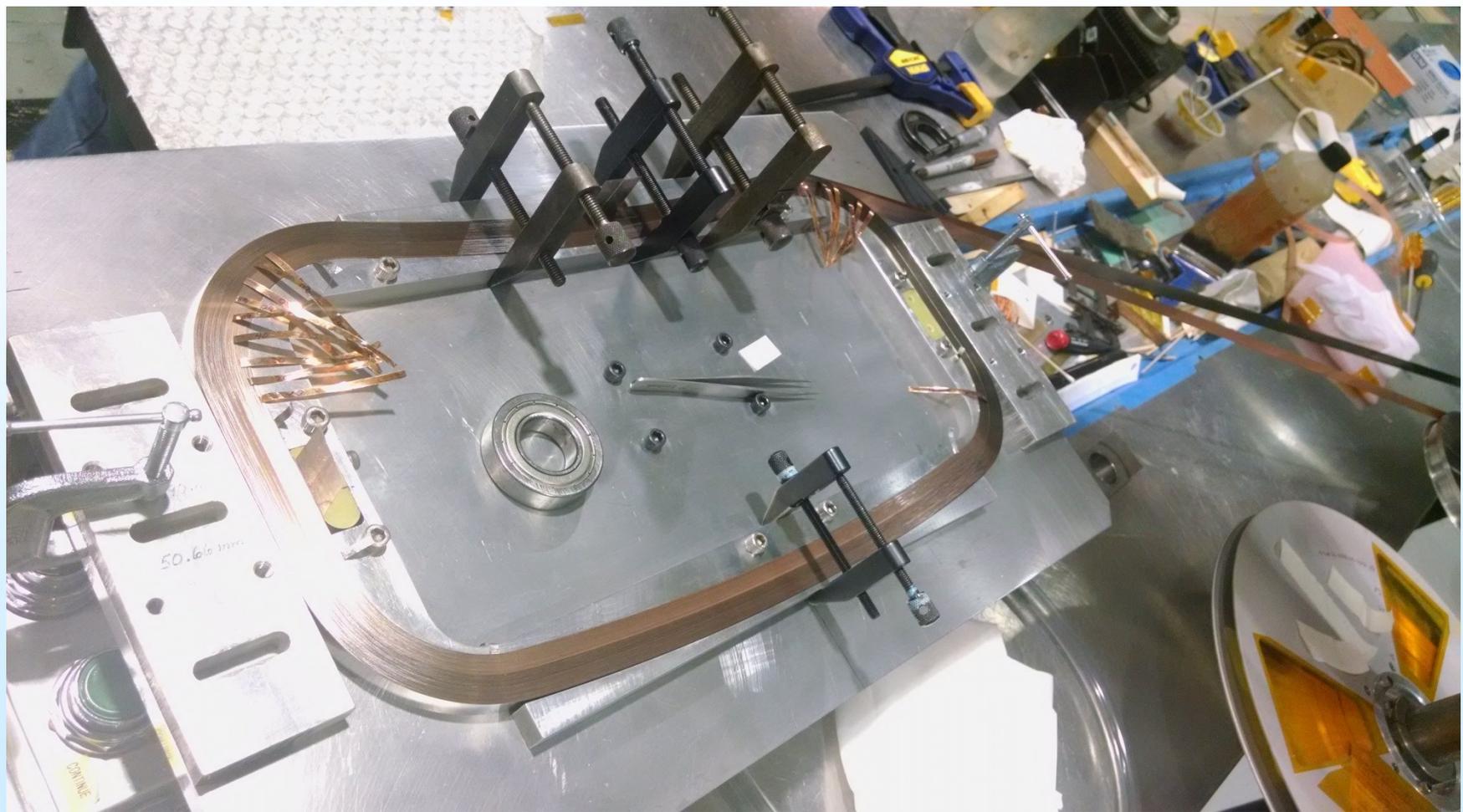
Filler Piece Removed



One Side of the Coil Pushed for Negative Curvature



Negative Curvature Clamped



Epoxy on the Surface to Hold Shape



Second Coil Wound

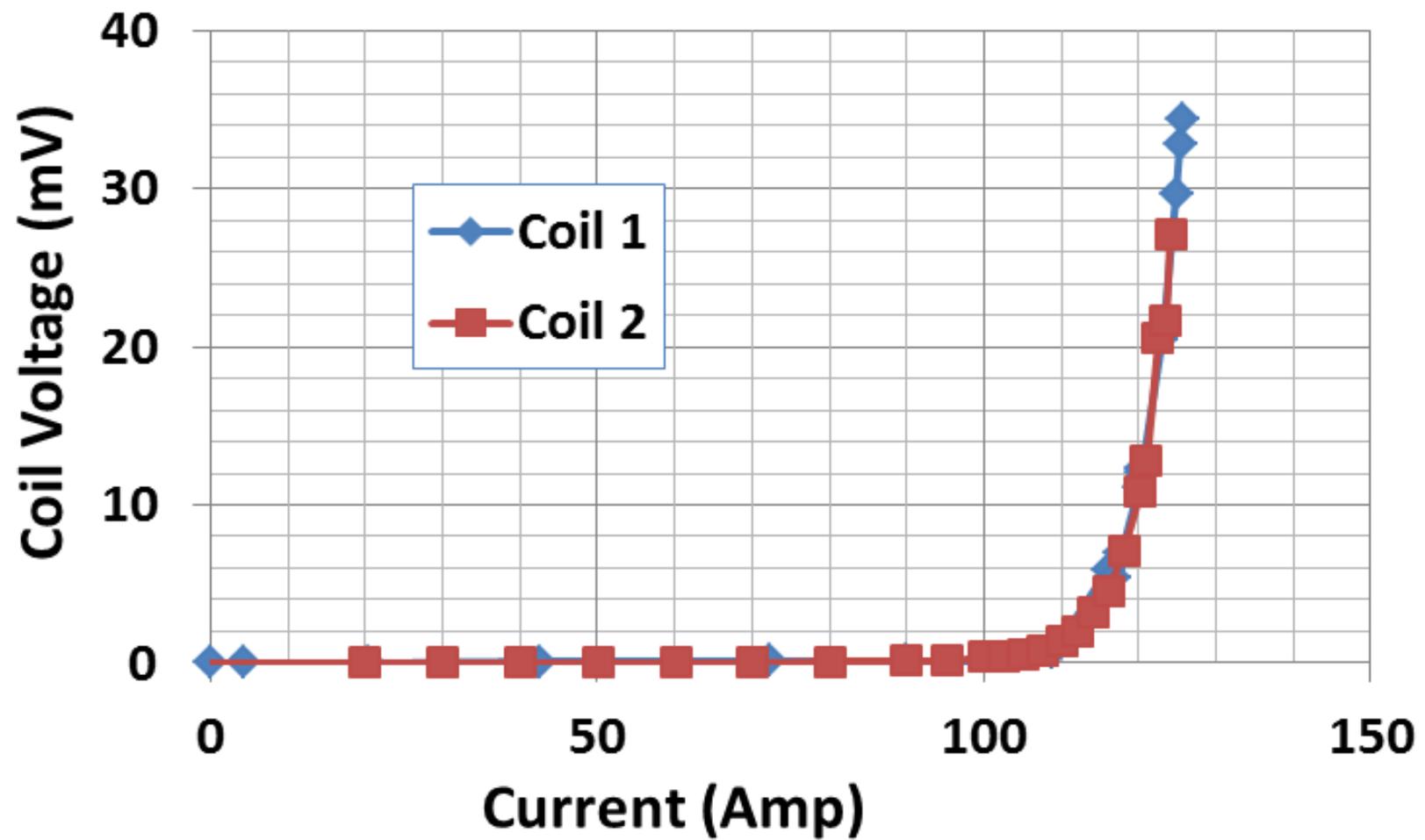


**~145 turns with
SuperPower 12 mm**

Two Single Pancakes



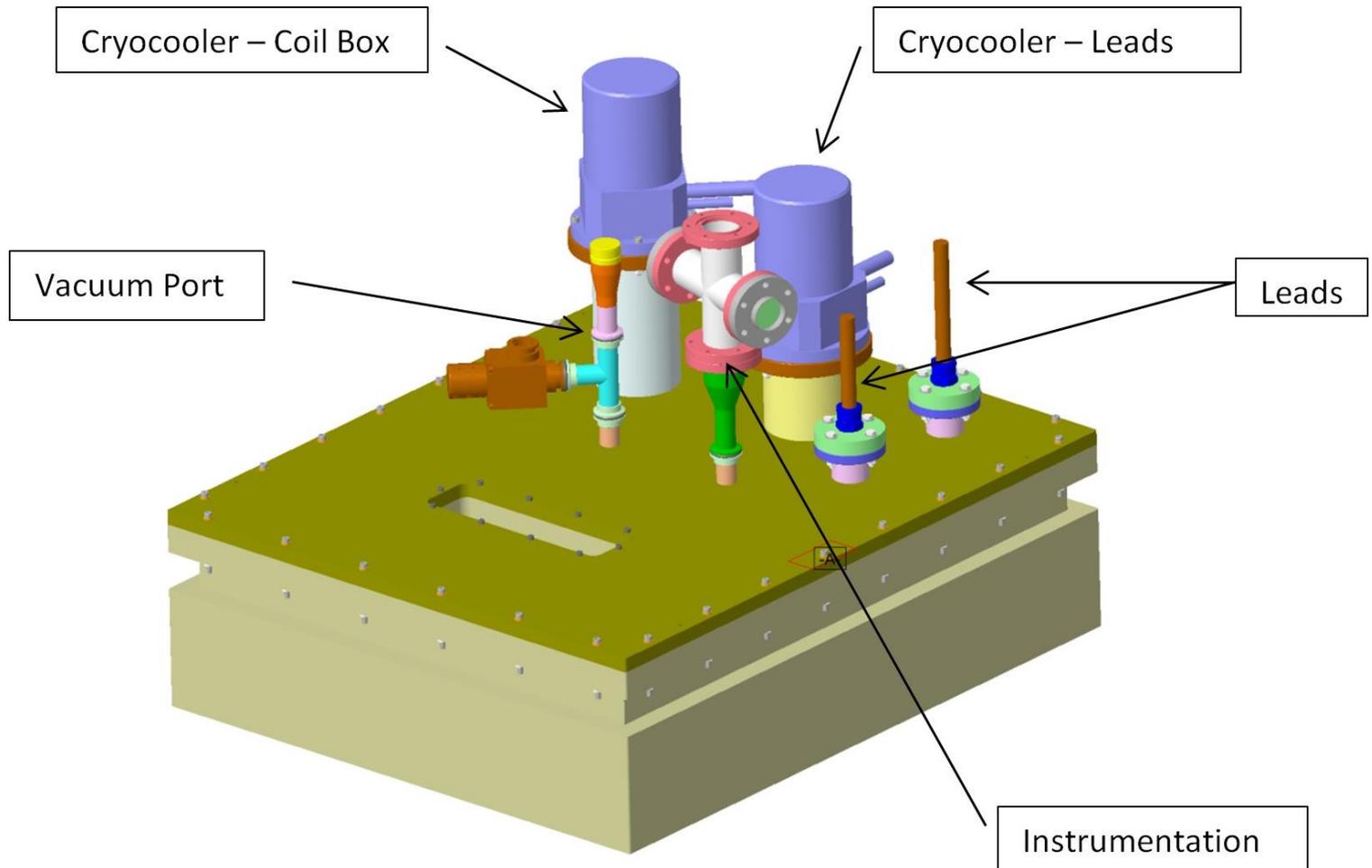
77 K Test Results Coil #1 and Coil #2



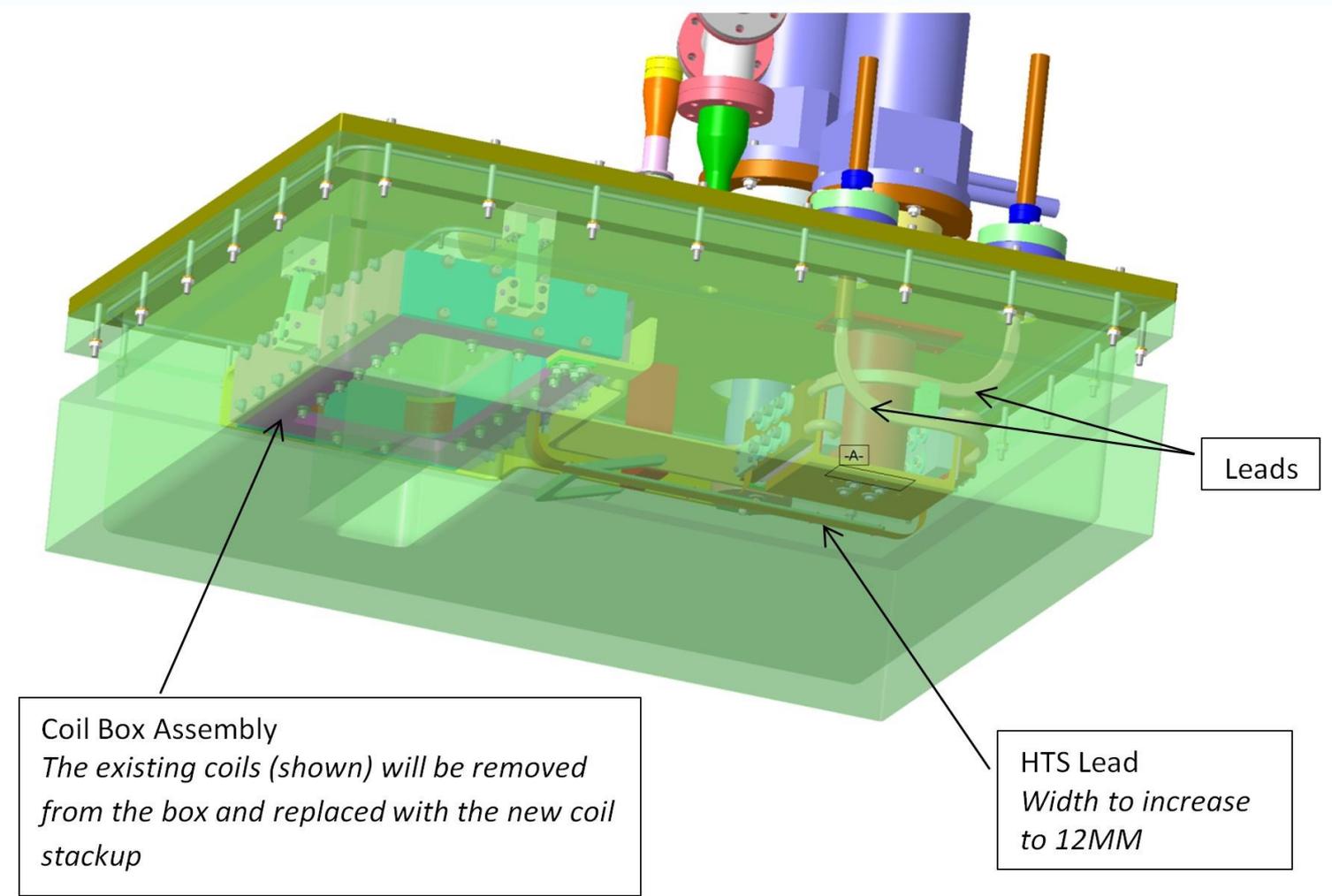
Coil doesn't seem to degrade

Cryo-cooled HTS Magnet Cooling and Cryostat Design

Layout of the cryo-cooled system design (from outside)



Layout of the cryo-cooled system design (from inside)

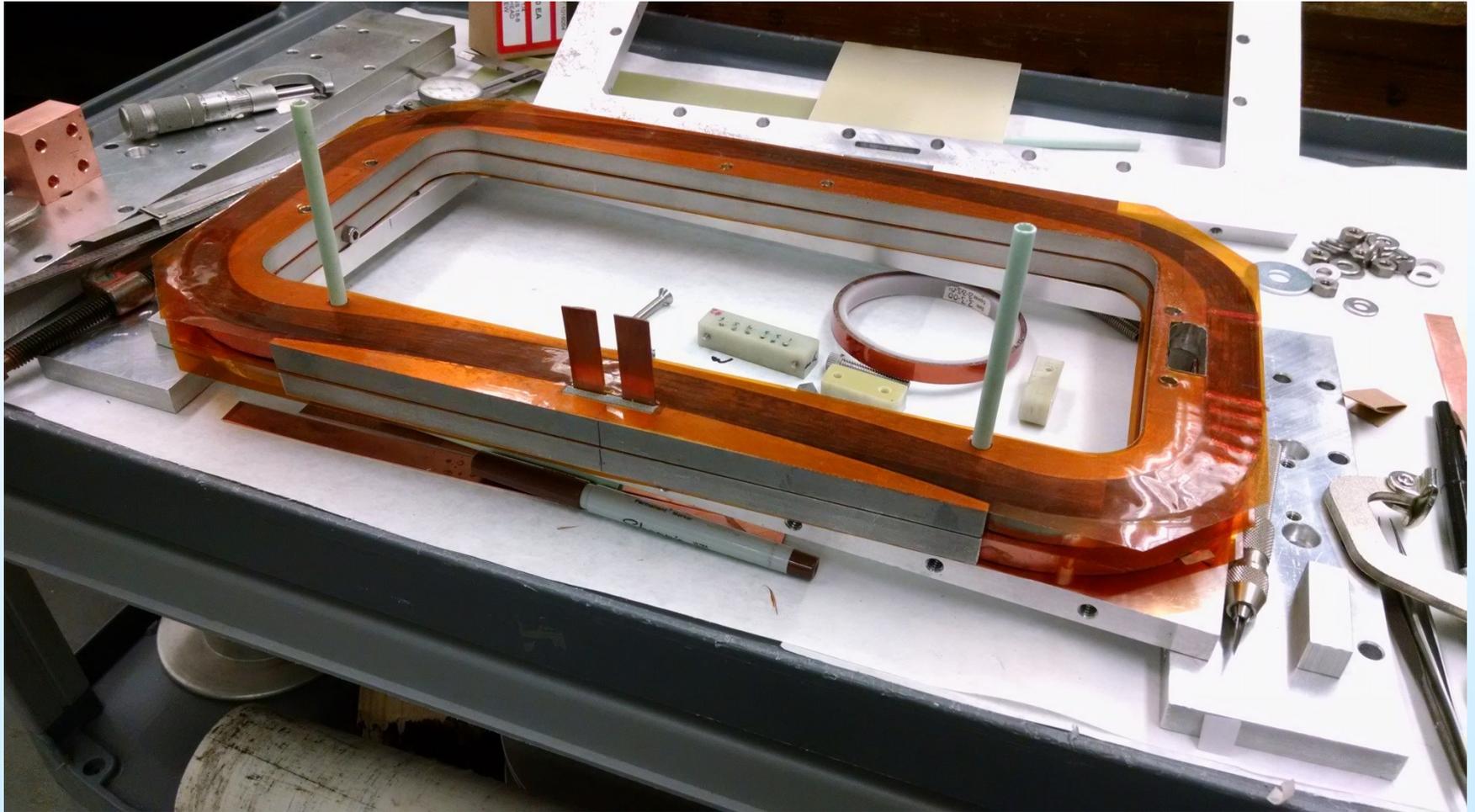


Coil Box Assembly
The existing coils (shown) will be removed from the box and replaced with the new coil stackup

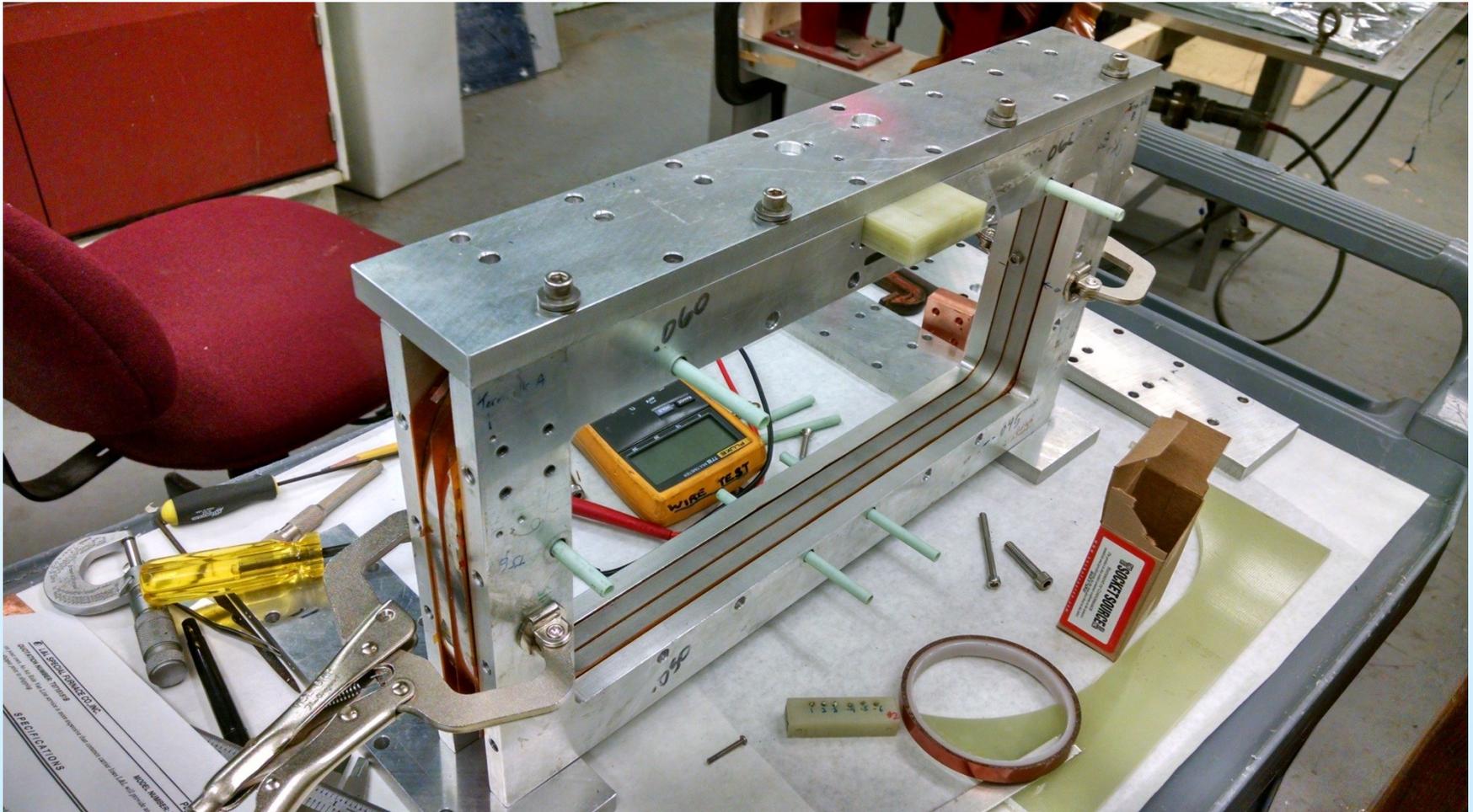
HTS Lead
Width to increase to 12MM

Assembly of HTS Coils inside the Cryostat with Cryo-coolers

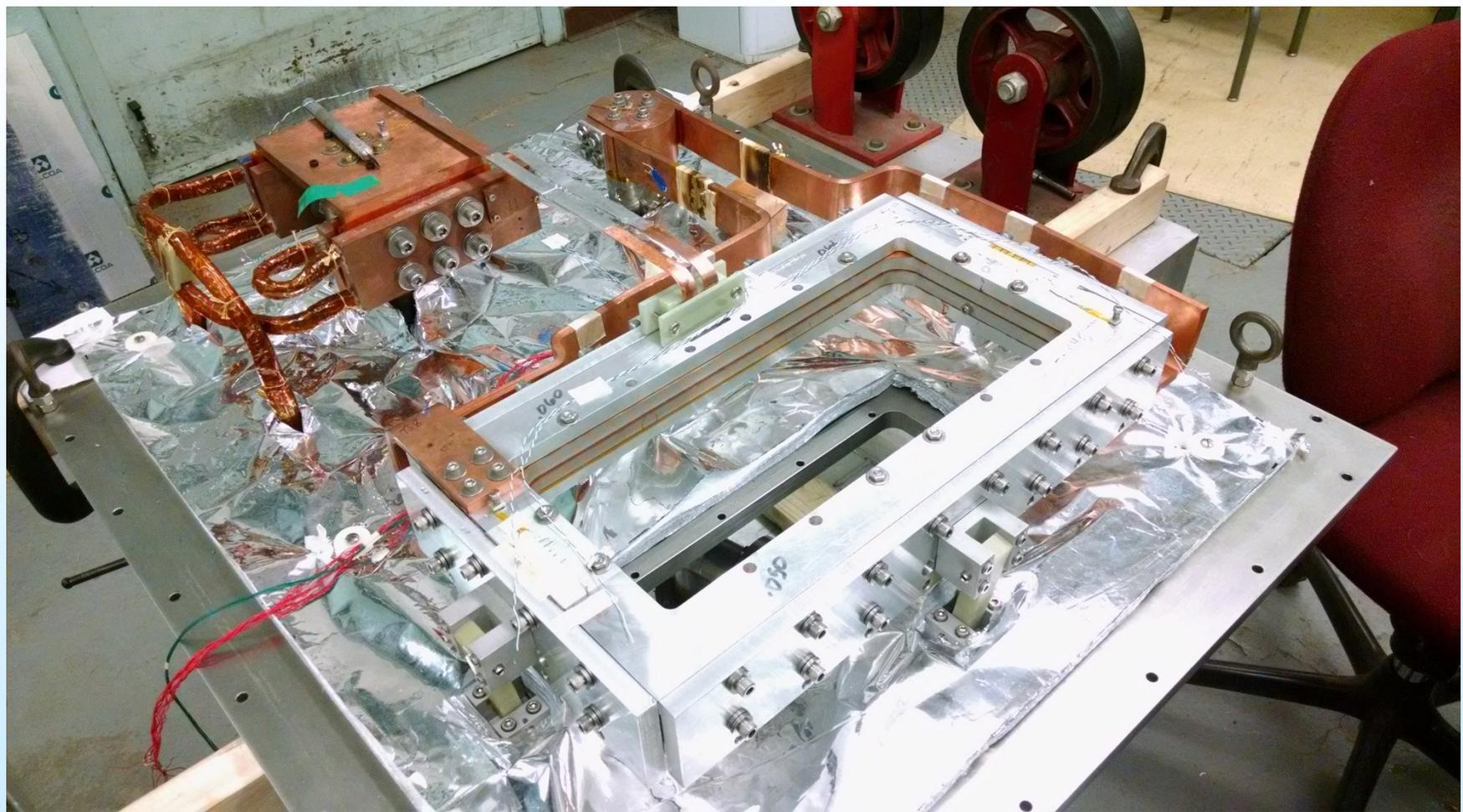
Coils with Insulation being Assembled in Support Structure



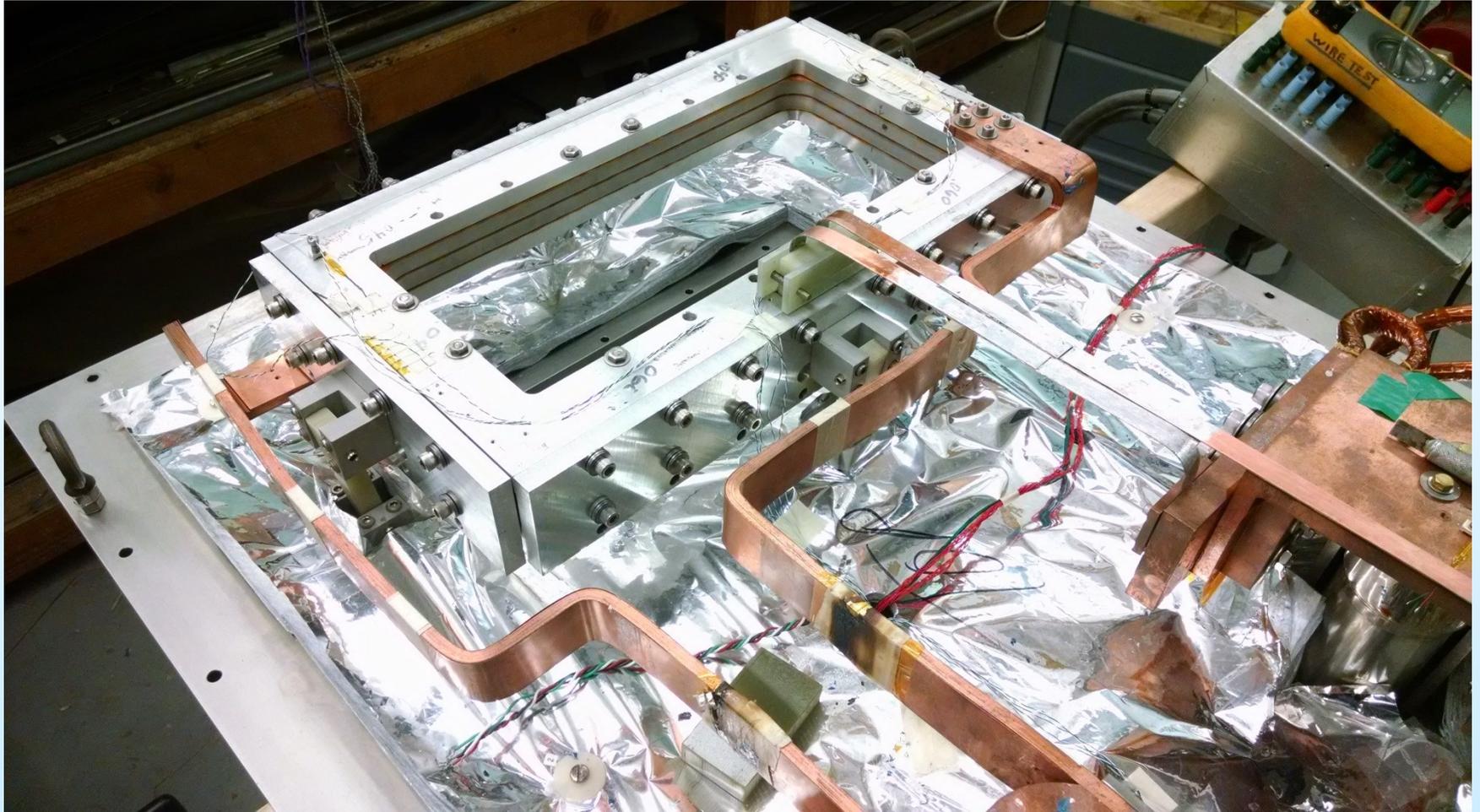
HTS Coils Getting Installed in Support Structure



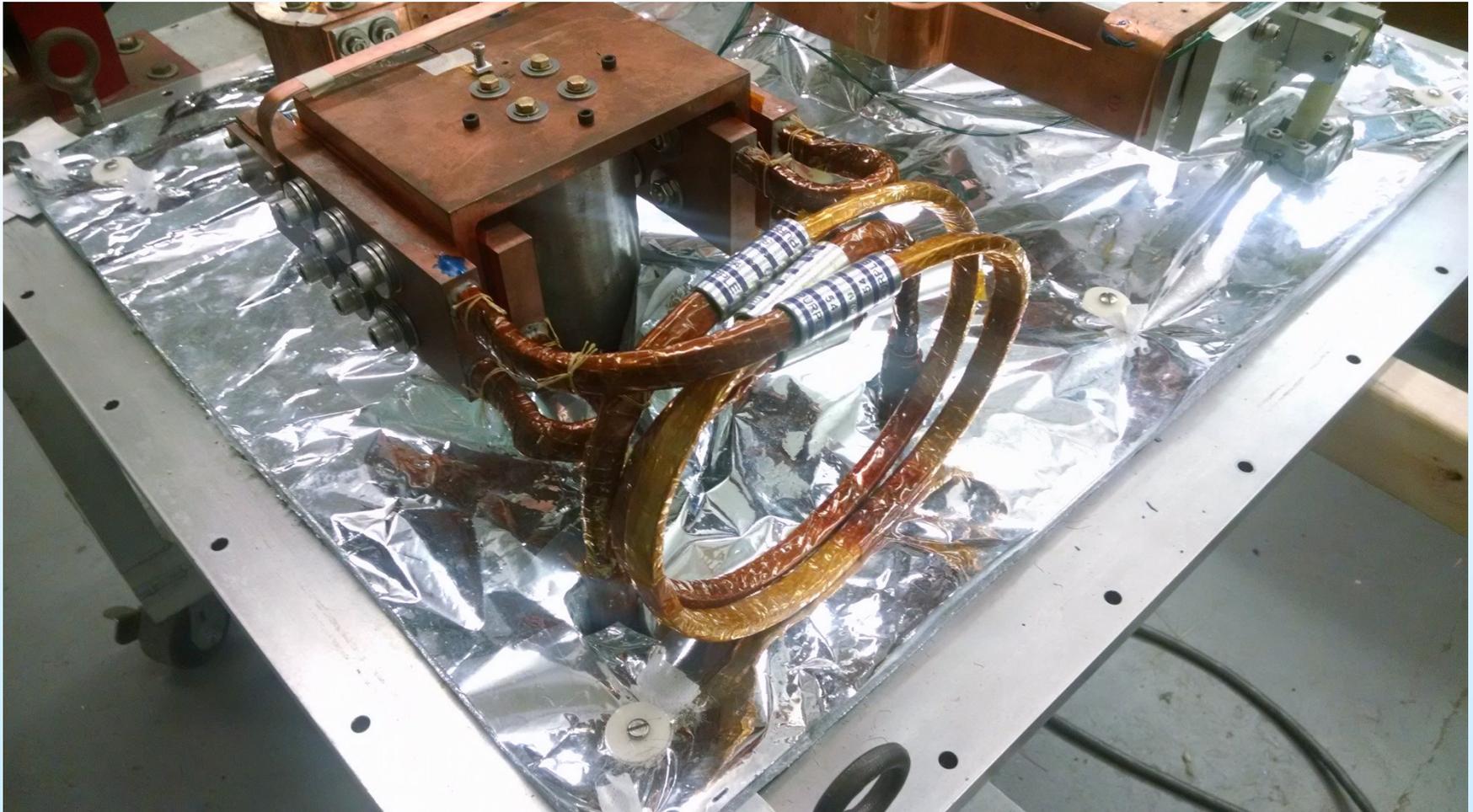
HTS Coils Getting Installed in Cryostat



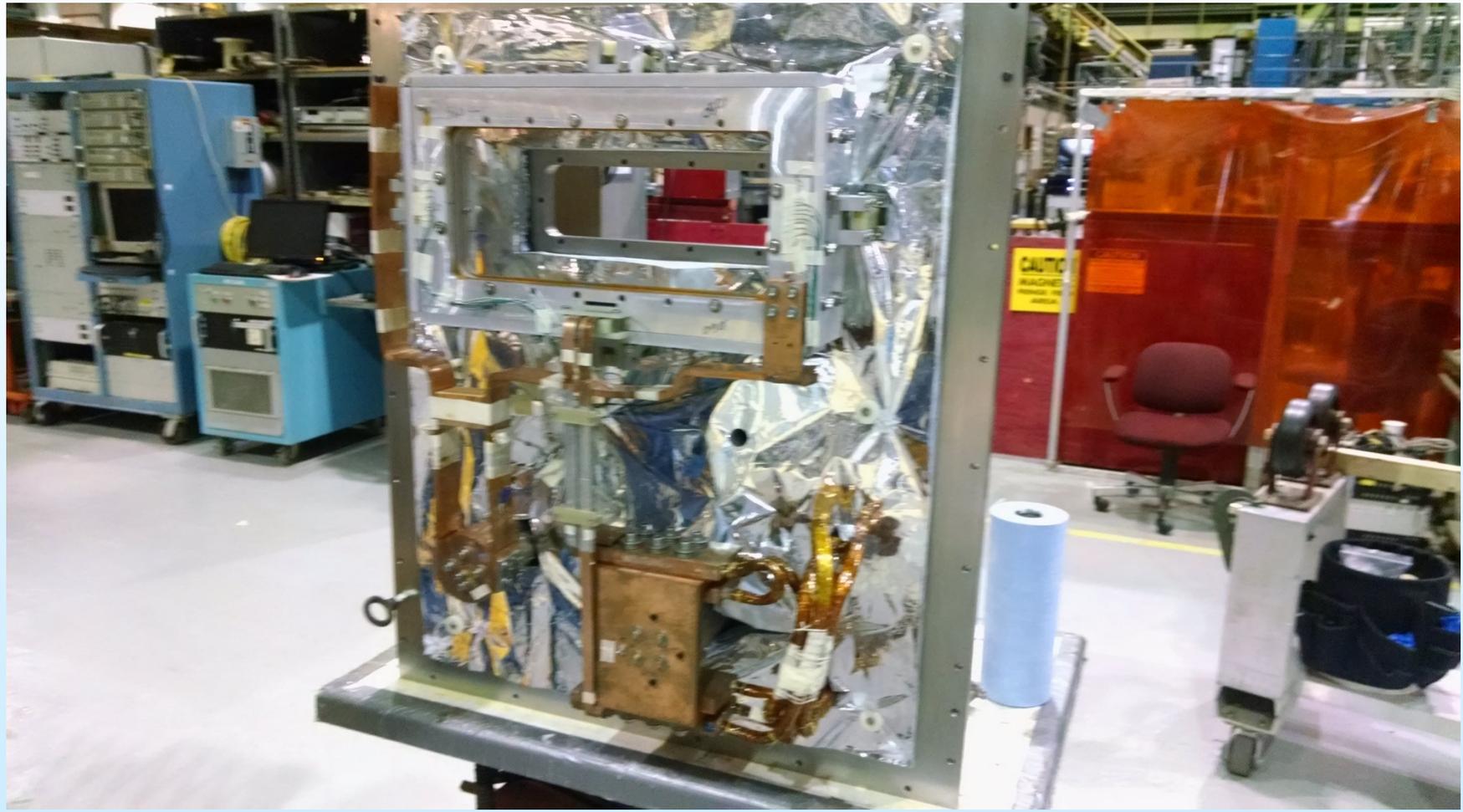
HTS Leads Getting Installed (Cooling fins can also be seen)



Copper Lead Length Adjusted



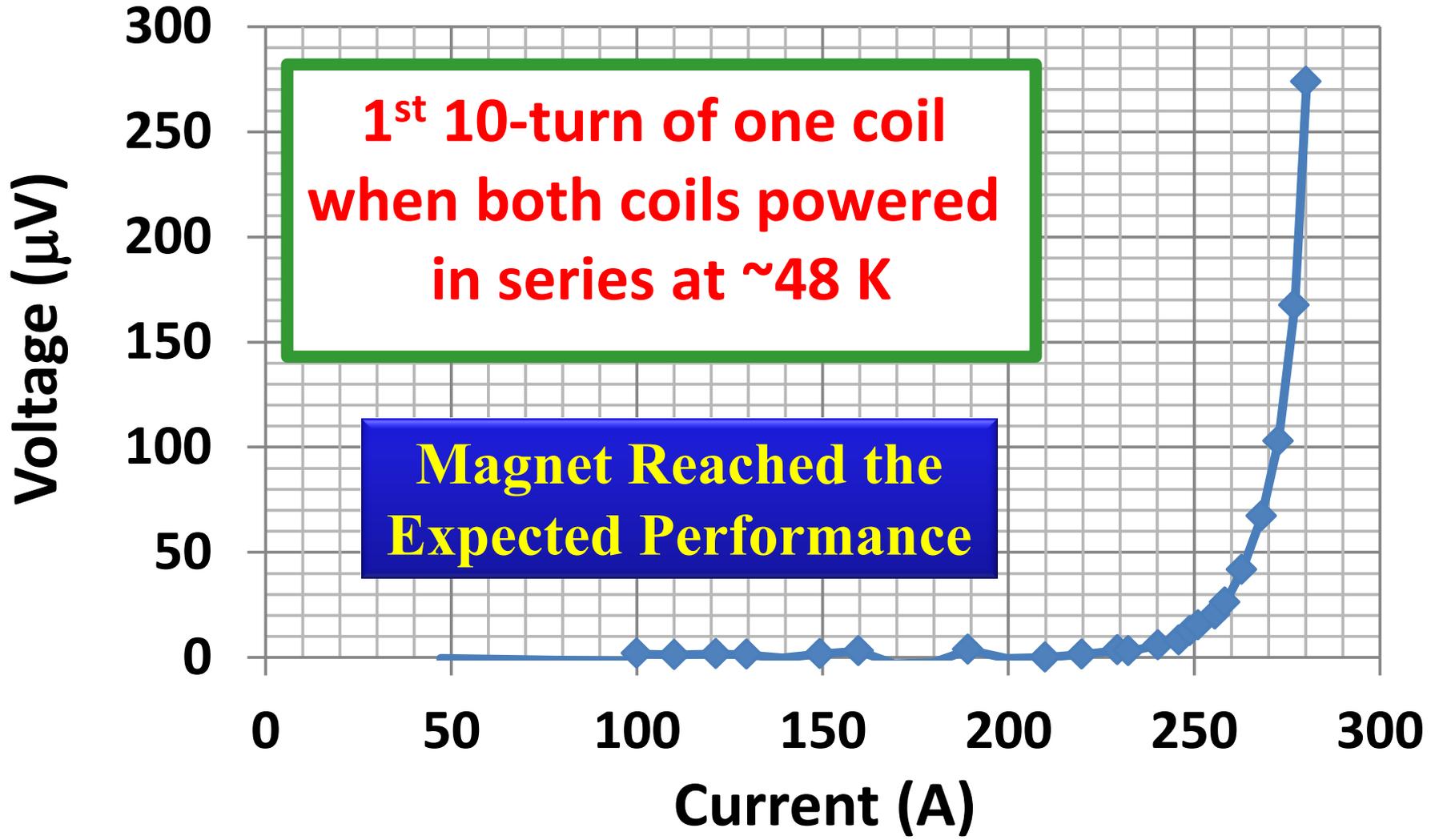
All Structure Assembled
(prior to closing of cryostat)



Cryo-cooled Magnet Being Tested



Test Results



Conclusions

- **Construction techniques used did not cause observable degradation in shifting HTS conductor in coils with positive curvature to coils with negative curvature.**
- **Curved HTS magnet cooled with cryo-coolers has been built and tested.**
- **The technology developed here can be useful in other accelerator, medical, industrial and research facilities.**