Cryogenic Equipment – Part II

(content courtesy: Tom Peterson/SLAC)

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USPAS – Cryogenic Engineering

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Outline

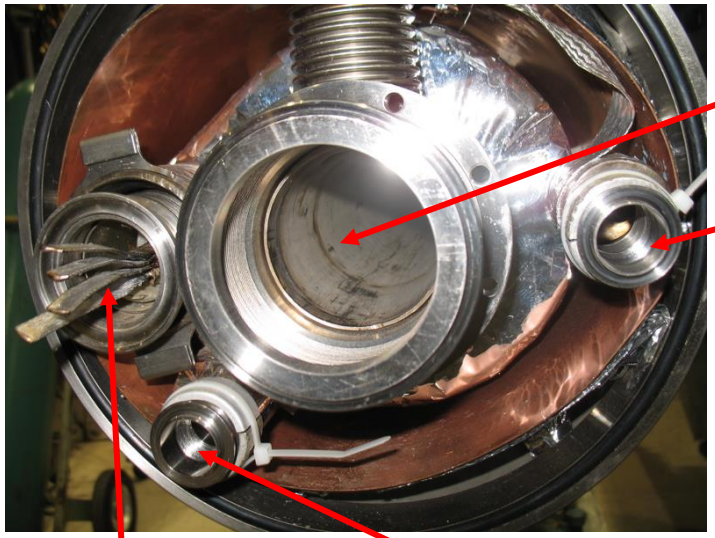
- Cryogenic equipment
  - Mechanical cold seals
  - Pressure relief valves
- Photo stories
  - Feed box fabrication sequence
  - LCLS II SRF cryomodule assembly

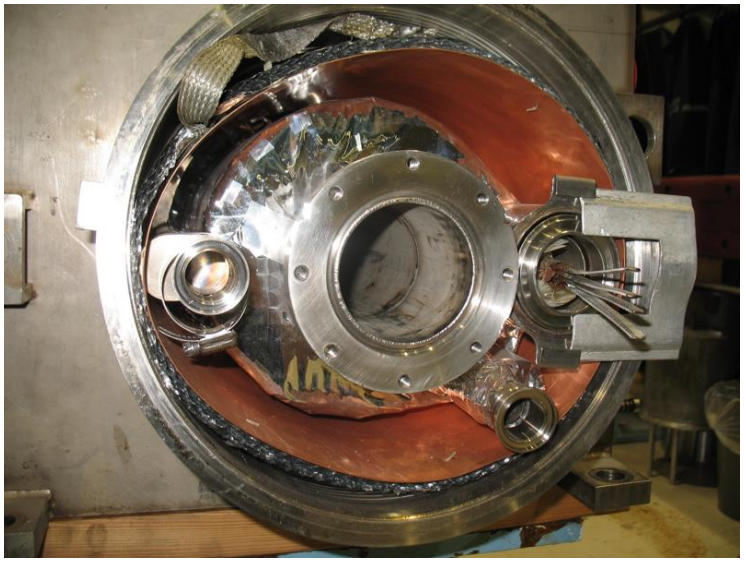
Metallic cold seals

- The Fermilab Tevatron includes about 1200 interconnects (magnet-to-magnet and magnet-to-endbox), each of which includes
  - An insulating vacuum to beam vacuum seal
  - A 4.0 K, 2 bar helium to vacuum seal (“single-phase seal”)
  - A 4.0 K, 1.2 bar helium to vacuum seal (“two-phase seal”)
  - An 80 K, 3 bar nitrogen to vacuum seal

Metallic cold seals

Tevatron magnet interconnect (one side)

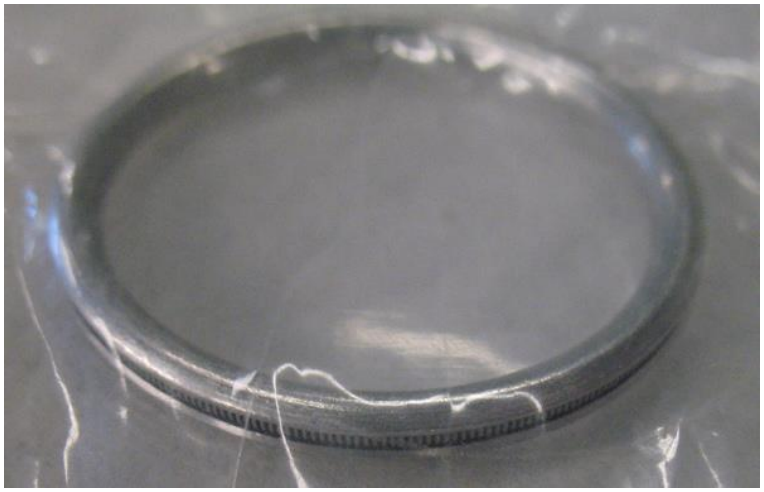




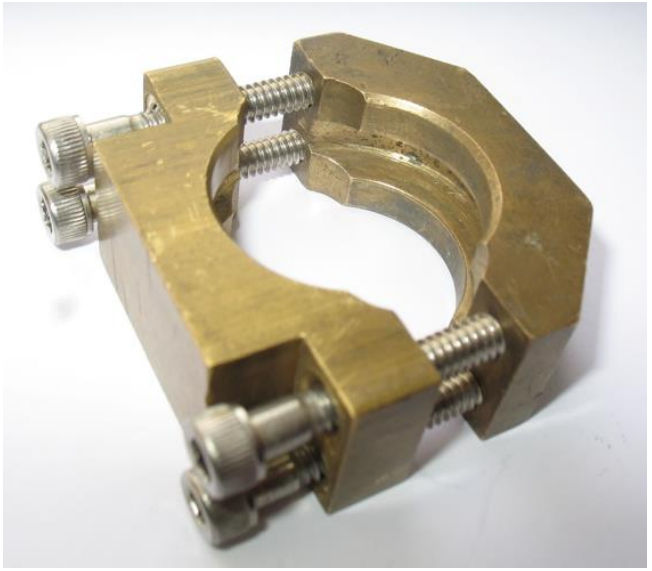
Other side of interconnect

Metallic cold seals

Seals for nitrogen and 2-phase helium lines



Aluminum Helicoflex c-seal with internal inconel spring. Surface finish of flange is about 80 micro-inch (2 microns). Seal is designed specifically for this finish.



Fermilab-designed brass wedge clamp -- we like these brass wedge clamps at Fermilab

Metallic cold seals

Seals for single-phase helium

Stainless steel, elliptical "Conoseal" from Aeroquip Corp.
Silver coated 0.0005" (13 micron) thick plating. Coated locally.
Indium, copper, and gold plating each failed. (Indium creeps, gold had poor adhesion to the SS.)
Good success with silver, although if the silver corrodes, then it leaks.
Similar 4-bolt Fermilab-designed brass clamp on tapered flanges.

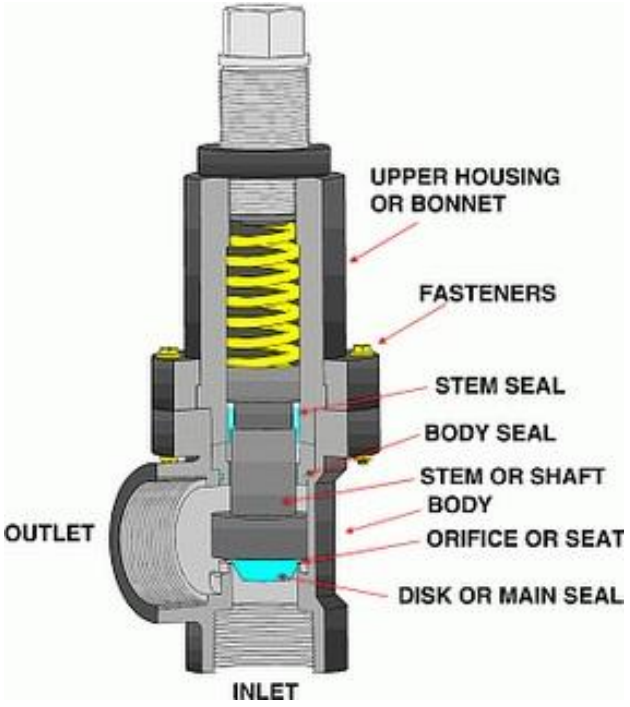
Metallic cold seals

Some concluding remarks

- Indium is popular but not universally endorsed for helium to vacuum metal joints
  - Indium seals used successfully for SF to vacuum seals at Fermilab's Magnet Test Facility
  - Tevatron experience suggested creep and long-term failure
  - Indium seals used extensively at Jlab for long-term seals (See paper by Benesch and Reece, Advances in Cryo Engineering, Vol. 39A, pg 597)
- A very sensitive and successful leak test generally results in a leak tight SF seal. Such a leak check requires a local test fixture around the seal or double-seal.
- "Cold leaks" (4.5 K) may be found which are likely just due to greater He density and leak rate cold.

Spring loaded relief valves

Spring loaded valves are routinely used to relief excessive pressure in helium piping or on a helium bath



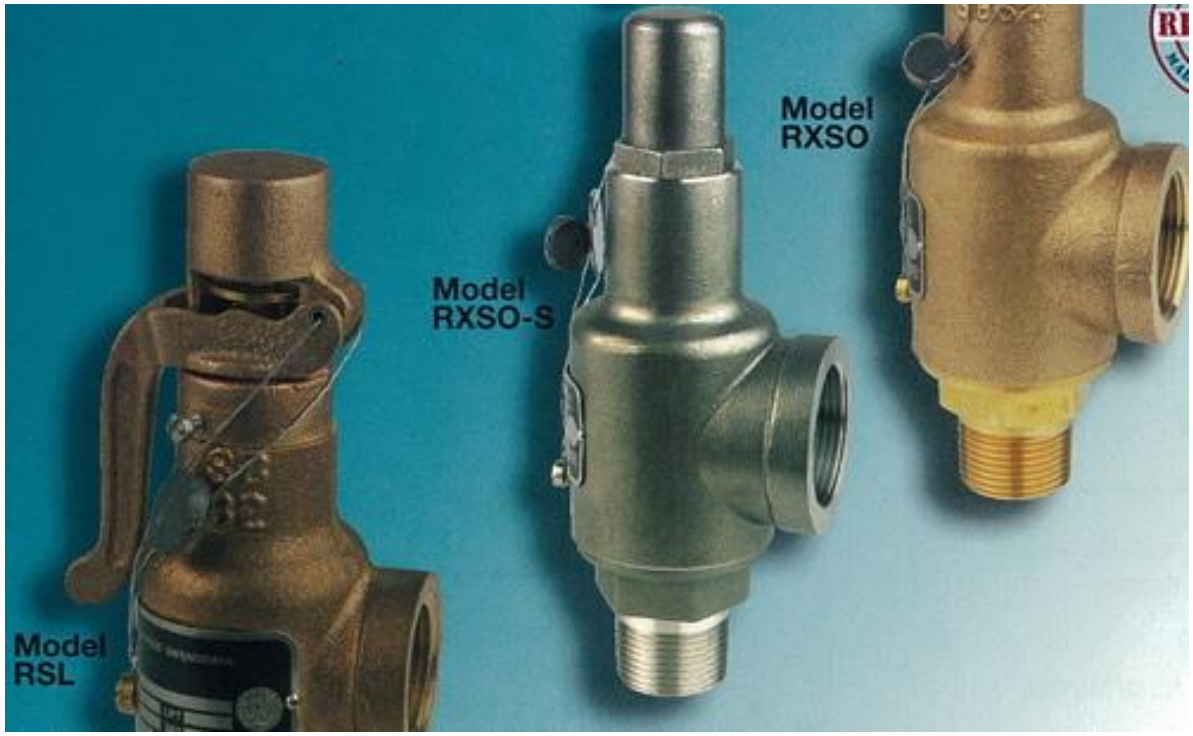
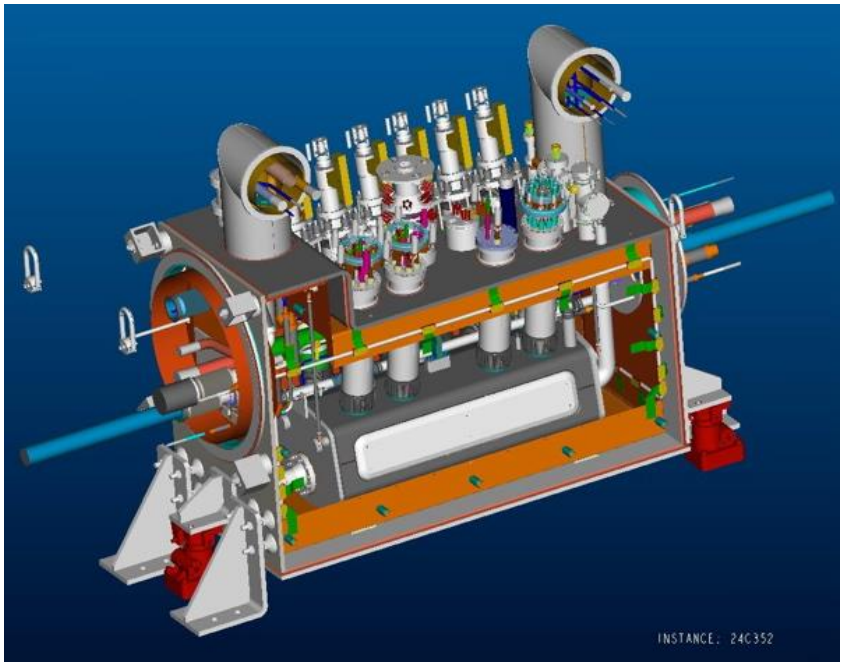


Photo story 1 - Fabrication of a magnet current “feed box”

- The following photos illustrate the sequence of major steps in fabrication of a large cryogenic box in industry
- A “distribution feed box” or DFBX for the inner triplet magnets in LHC
- Eight boxes fabricated at Meyer Tool near Chicago and shipped to CERN



Build from top plate, down

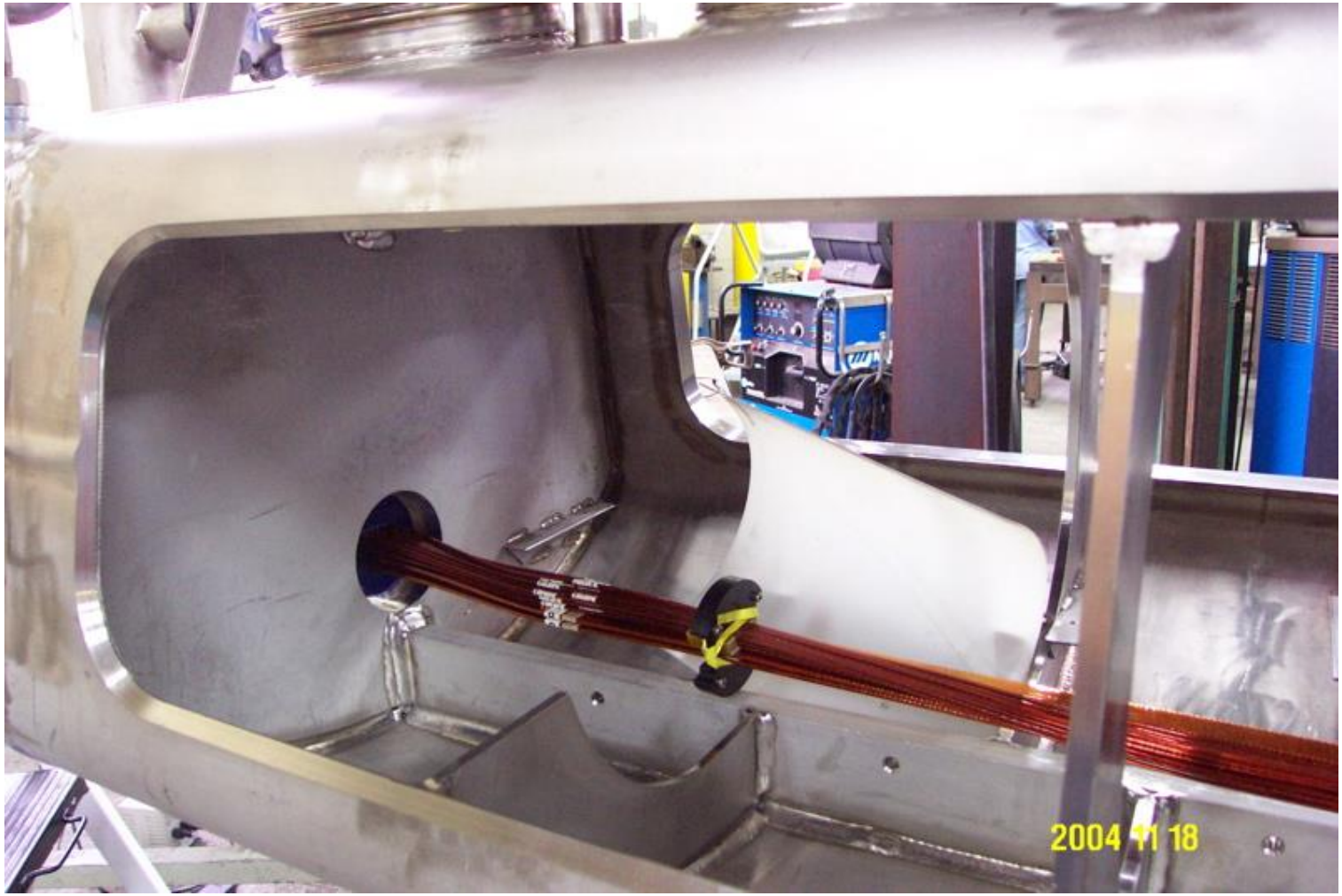
Hang helium vessel

Connect helium vessel

Prefabricated piping

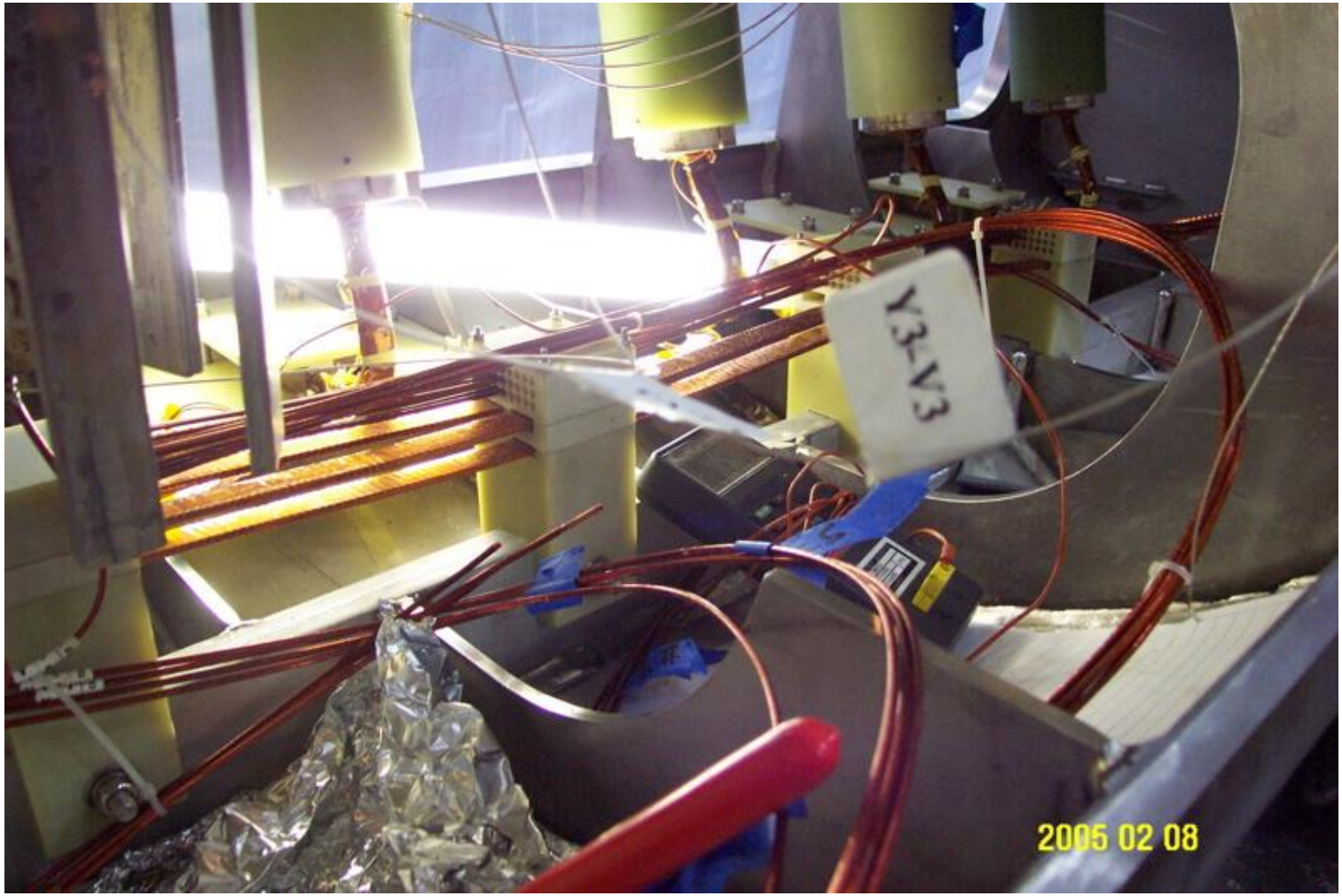
Install prefabricated piping

Splice and package internal cables



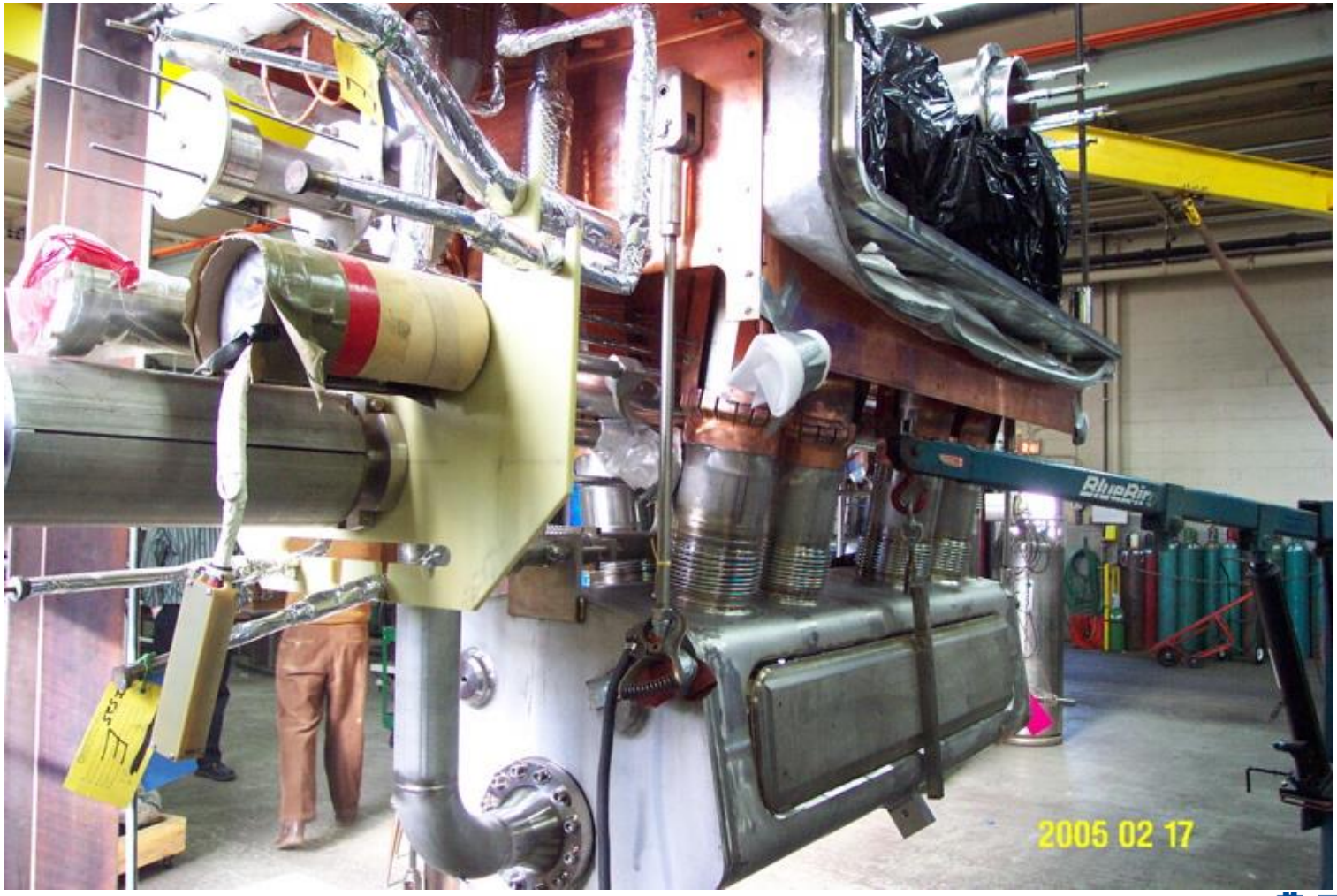
Splice and package internal cables

Splice and package internal cables

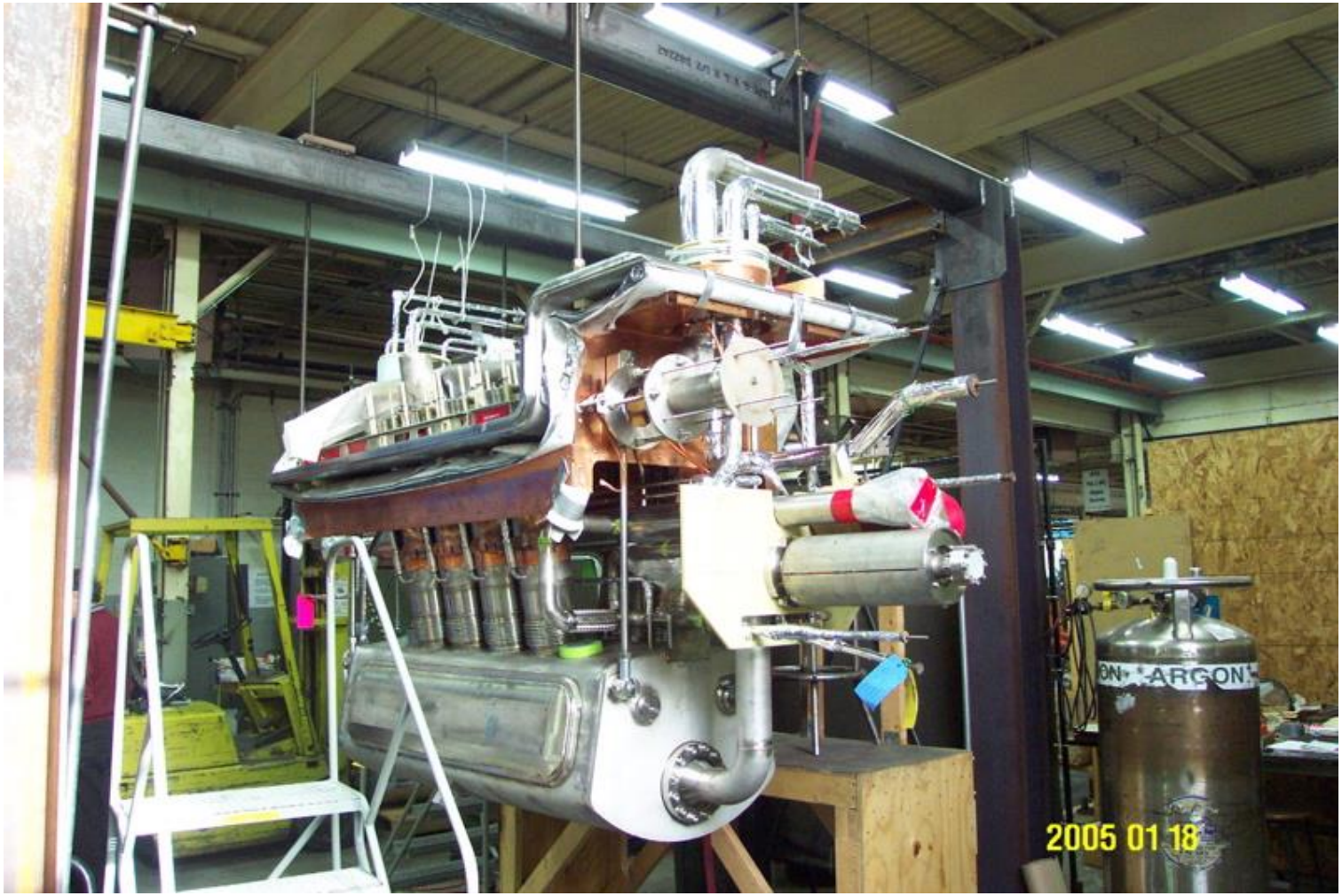


Install remaining internal piping

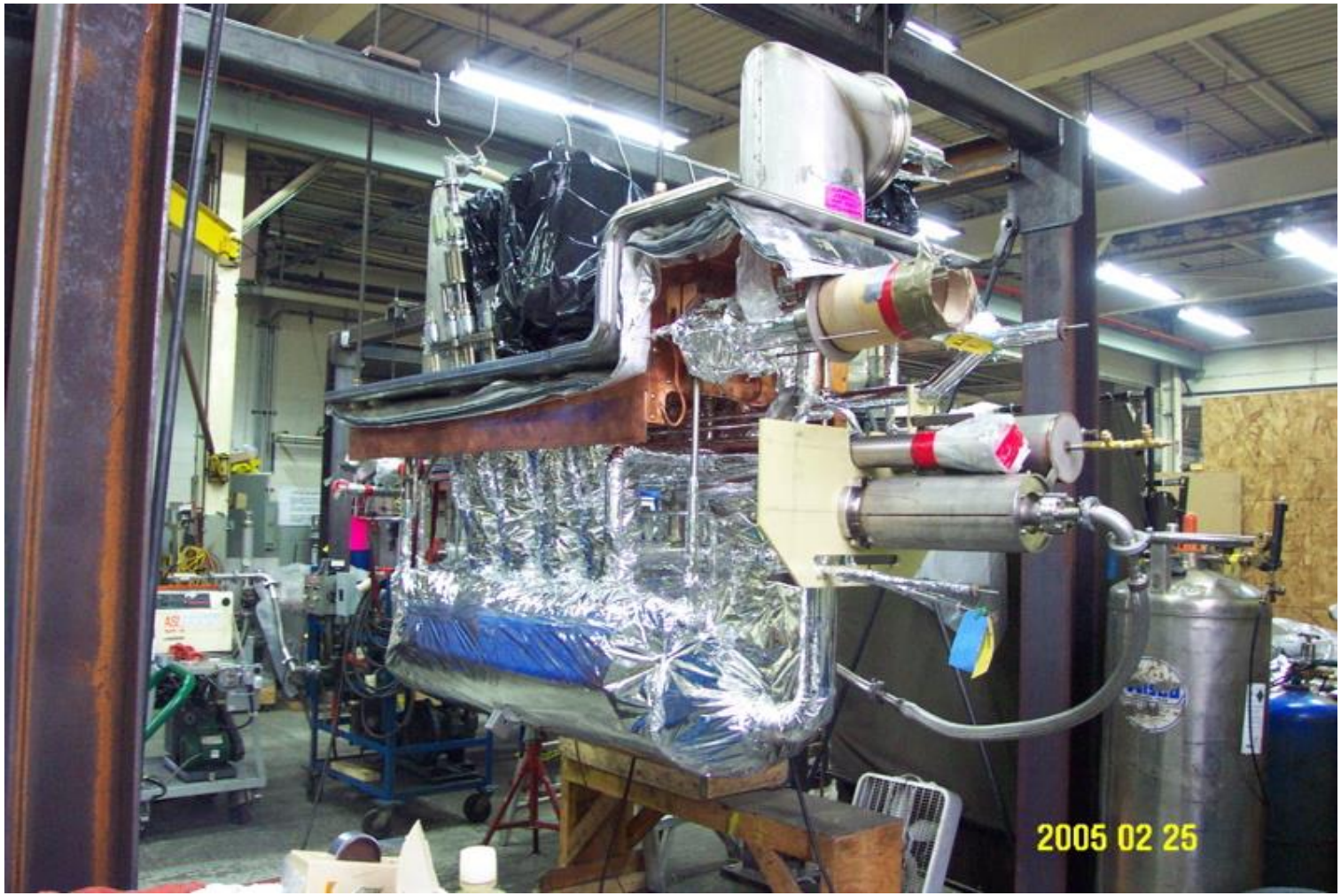
Weld close helium vessel



Leak check helium vessel

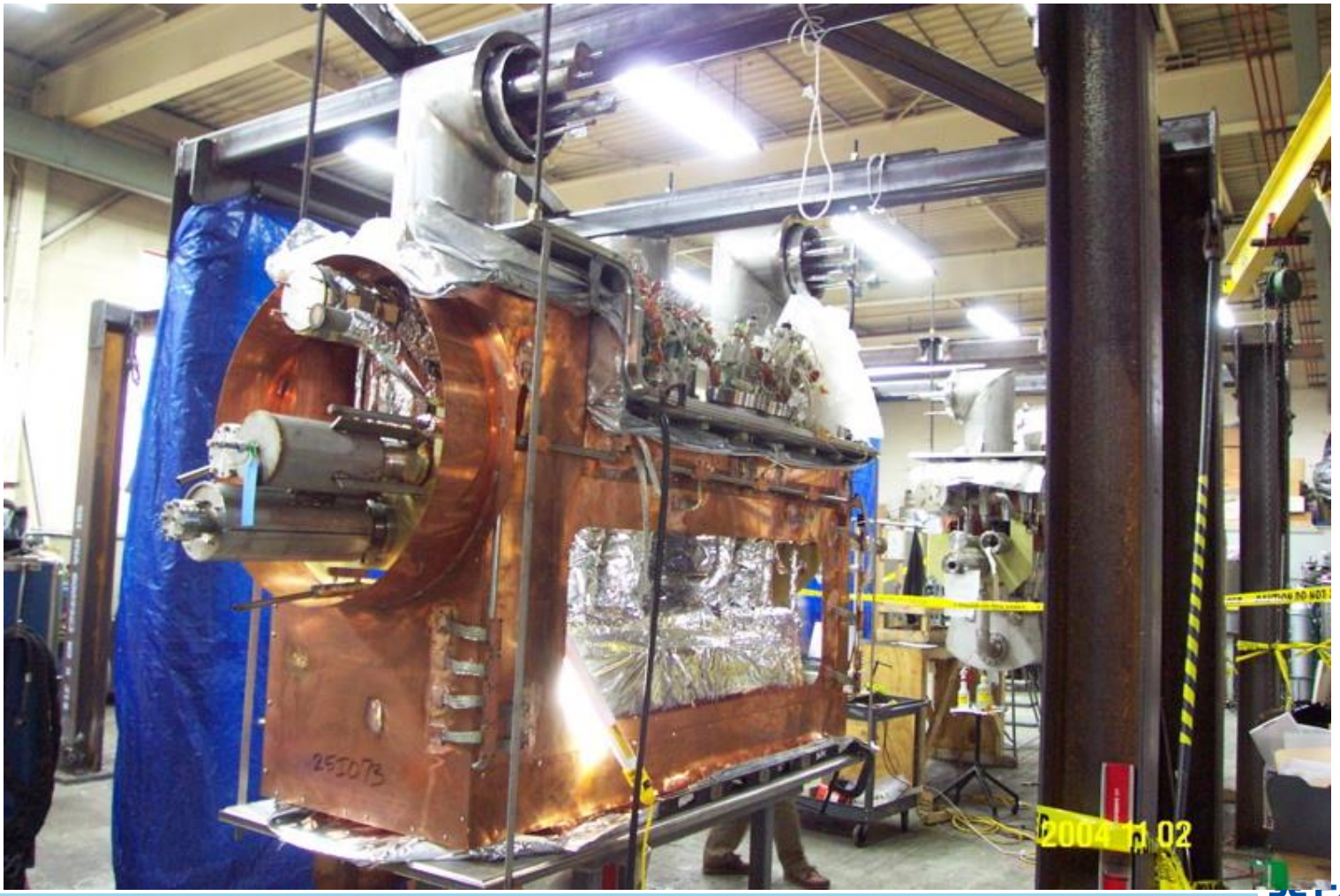


Wrap with multilayer insulation (MLI)



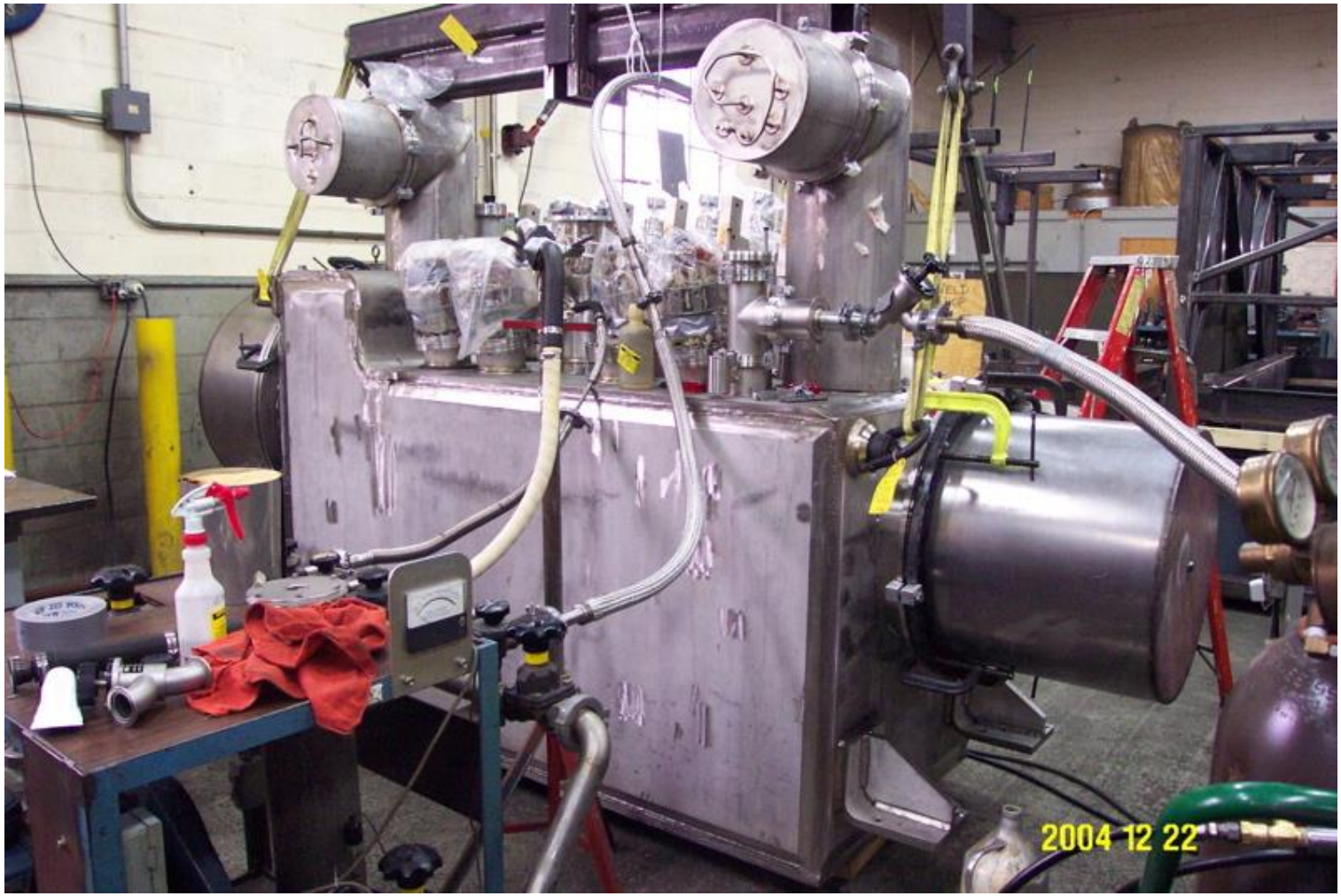
Prefabricated thermal shields

Install thermal shields



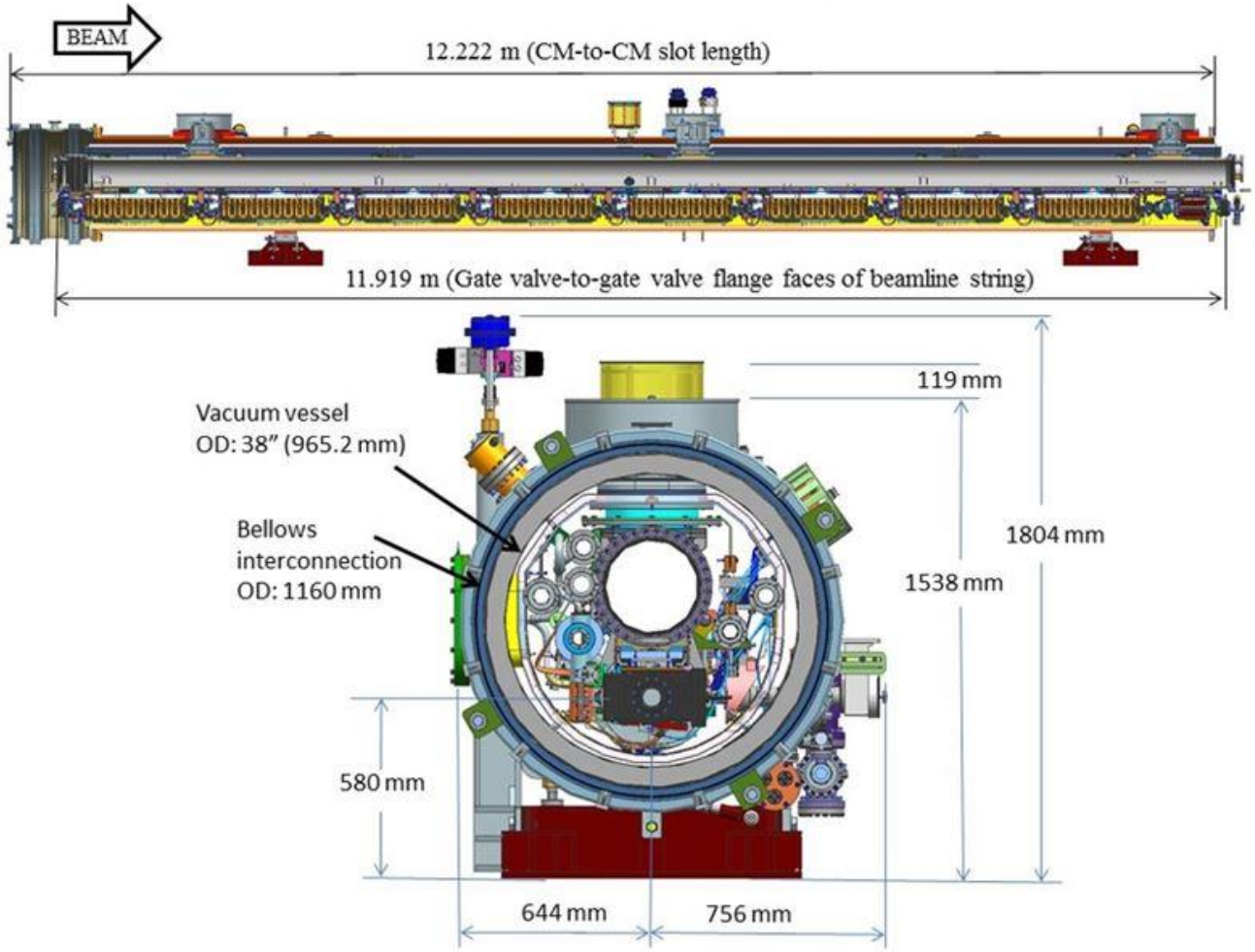
Weld vacuum shell

Final leak check and inspection



Shock-absorbing shipping frame

Photo story 2 – Assembly of LCLS II SRF cryomodule (pictures from FNAL and Jlab)



Cavity string – Jlab cleanroom

Cavity string out of cleanroom (Fermilab)

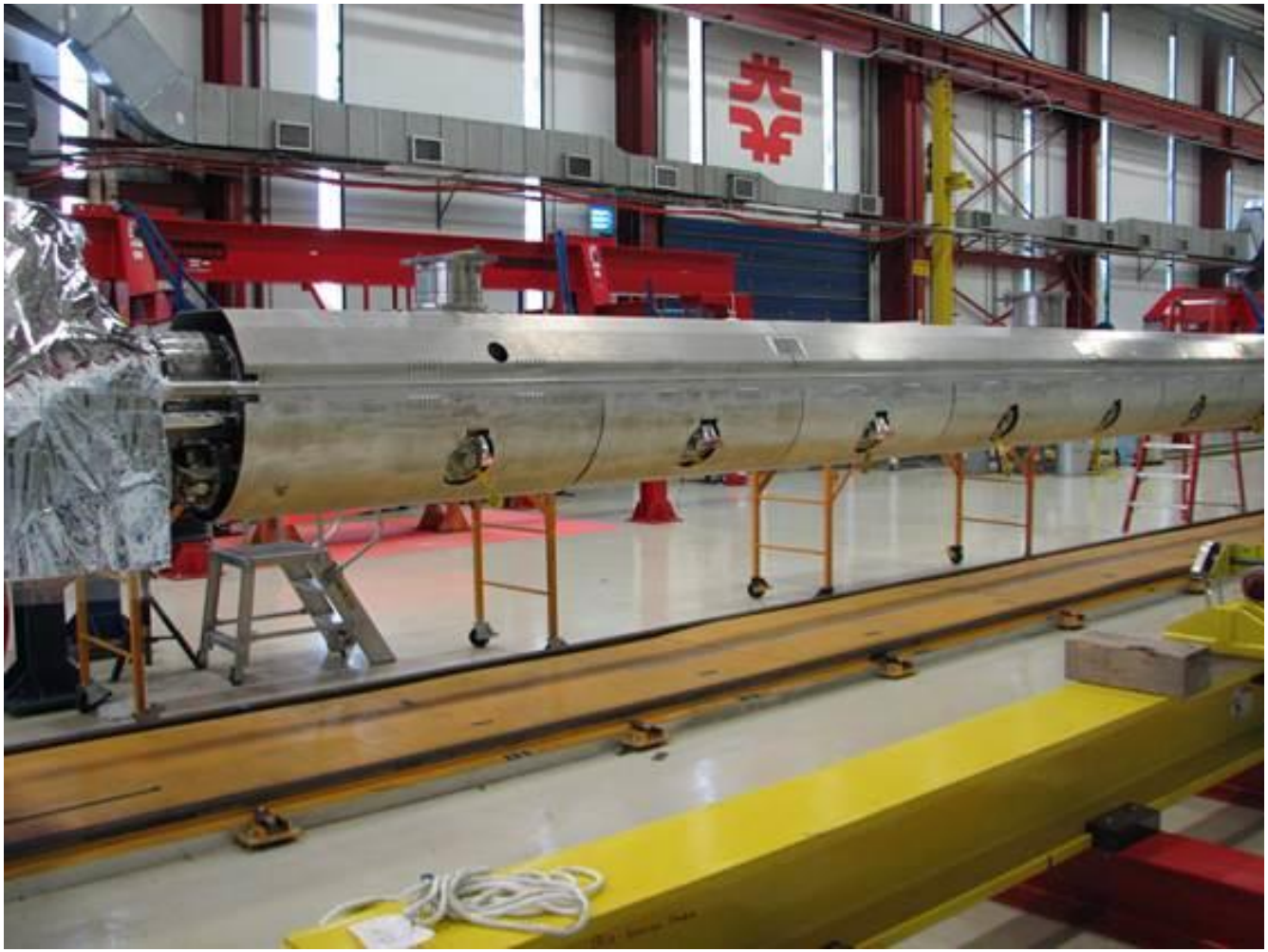
Welding and leak checking cryogenic pipes

Attaching cavity string to cryogenic structure

Integration of cavity string with cryogenic pipes and supports

Assembly at alignment and instrumentation station

Thermal shield installed



Multilayer insulation wrapped

Assembly into vacuum vessel

Instrumentation wiring

Final cryomodule assembly