FERMILAB-SLIDES-21-071-TD

LCLS-II-HE Cryomodule Production Status at Fermilab

Joshua Kaluzny

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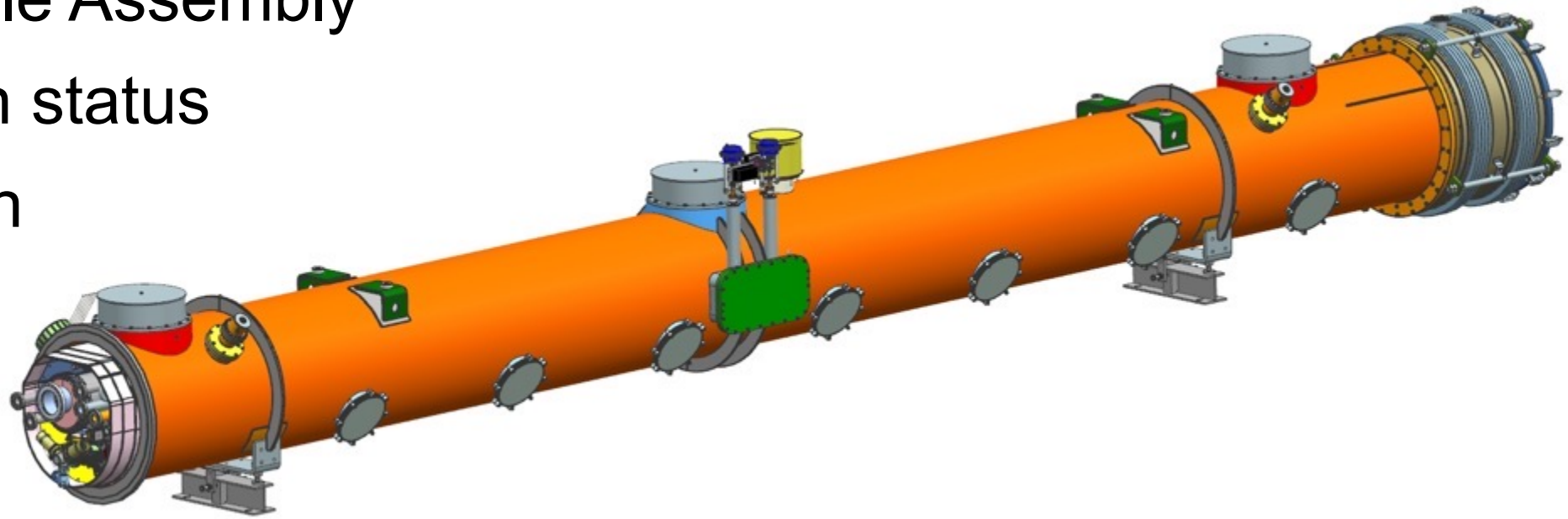
Outline

- LCLS-II and LCLS-II-HE
- Cryomodule Design
- Cryomodule Assembly
- Production status
- Conclusion



LCLS-II and LCLS-II-HE Overview

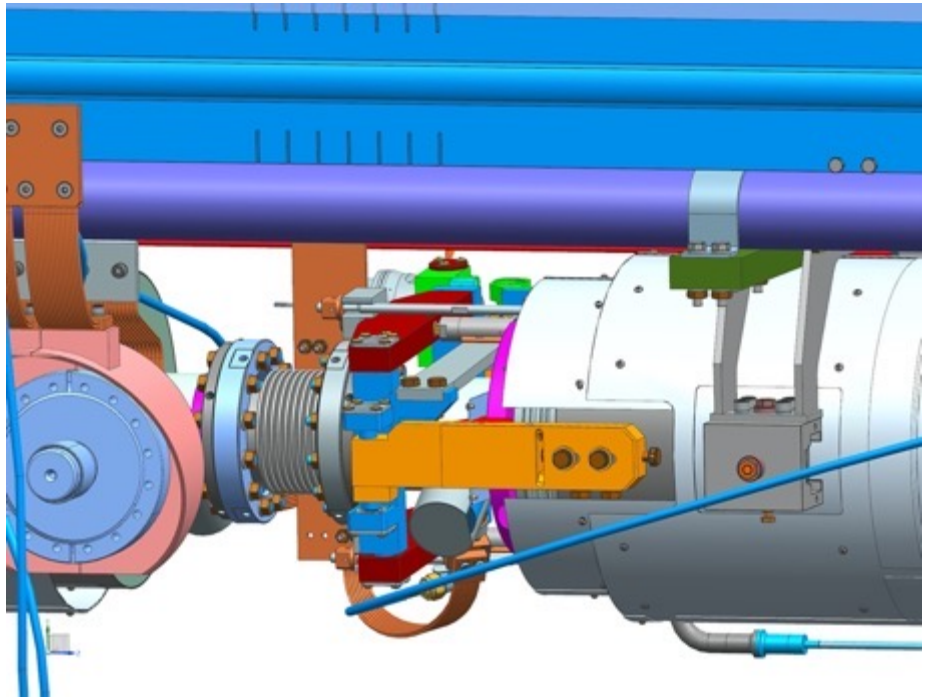
- SLAC National Accelerator Laboratory (SLAC) is currently finishing the LCLS-II project
- First section of the machine accelerates an electron beam to 4 GeV that will be used to create x-rays
- The electron beam is accelerated using superconducting radio frequency (SRF) cavities contained in cryomodules
- Fermilab delivered 17 1.3GHz cryomodules for the LCLS-II project
- LCLS-II-HE is an upgrade to LCLS-II that will enable the production of x-rays at higher energies - https://lcls.slac.stanford.edu/lcls-ii-he
- LCLS-II-HE will increase the electron beam energy from 4 GeV to 8 GeV
- For LCLS-II-HE 24 cryomodules (assembled at Fermilab and Jefferson Lab) will be installed

Fermilab's role in LCLS-II-HE Cryomodules

- Cavity R&D to allow increased cavity performance
- Cryomodule Engineer of Record – cryomodule design
- Cryomodule component procurements – split between partner labs (Fermilab, Jefferson Lab and SLAC)
- Assemble, test and ship 14 cryomodules including the verification cryomodule (vCM)

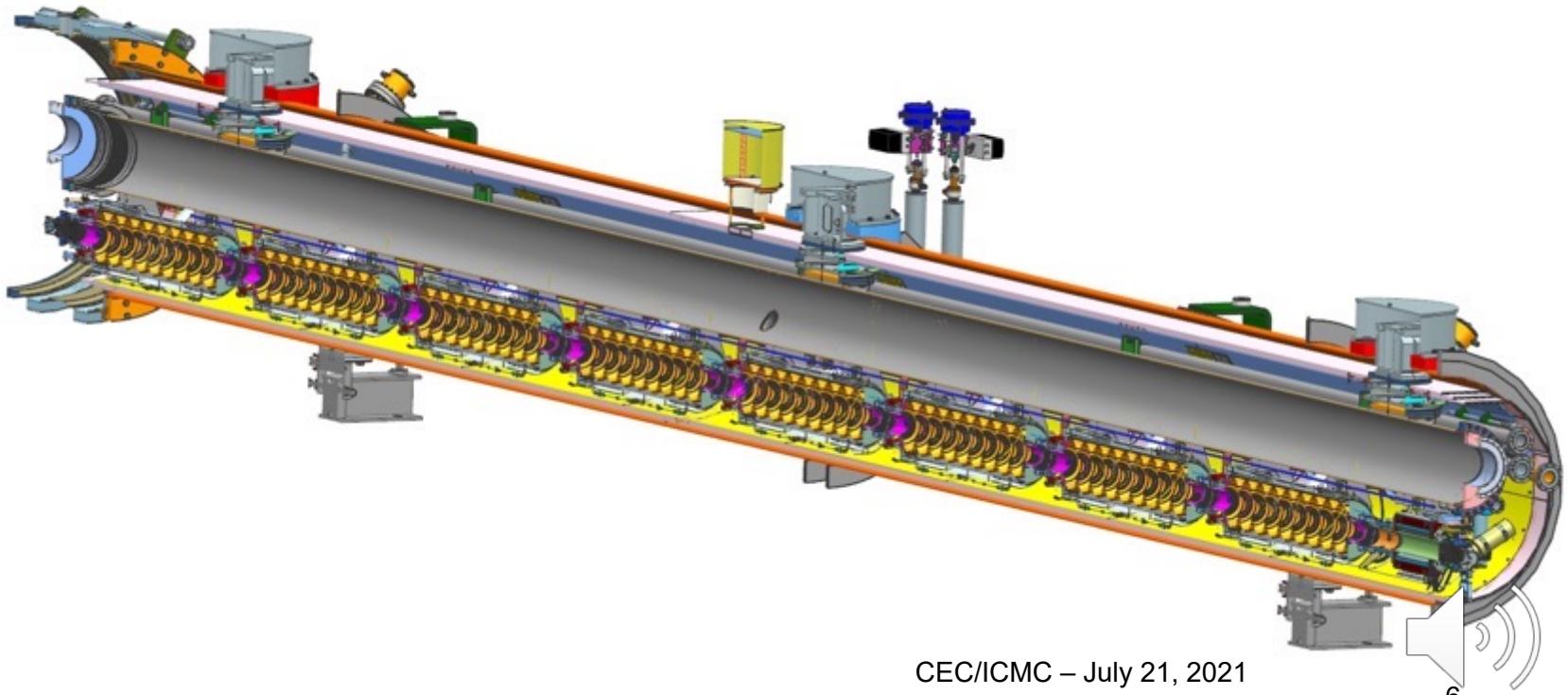
Cryomodule Design Changes

- Design nearly identical to LCLS-II
- Cavity gradient specification increase
  - 16 MV/m to 21 MV/m
  - R&D lead to new recipe
- Extended range tuner
  - Off frequency operation
  - Tuner tested at 2K for 400 cycles
- Formal change request process
- Design reviews – small changes



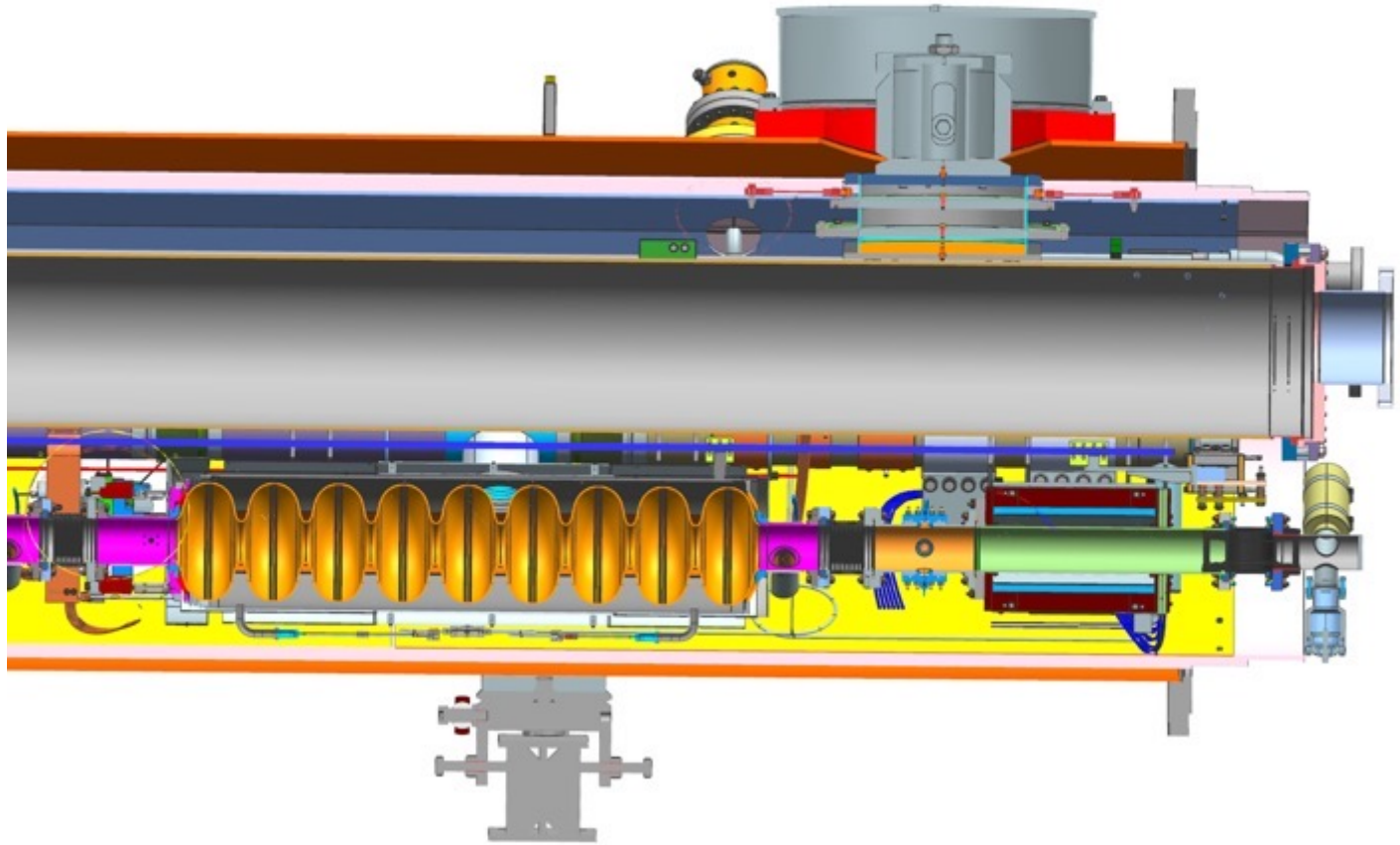
Cryomodule Design

- SRF cavities
- 300mm 2K return
- Vacuum vessel relief
- Cryogenic valves
- Support posts
- Beam Position Monitor (BPM)
- Magnet



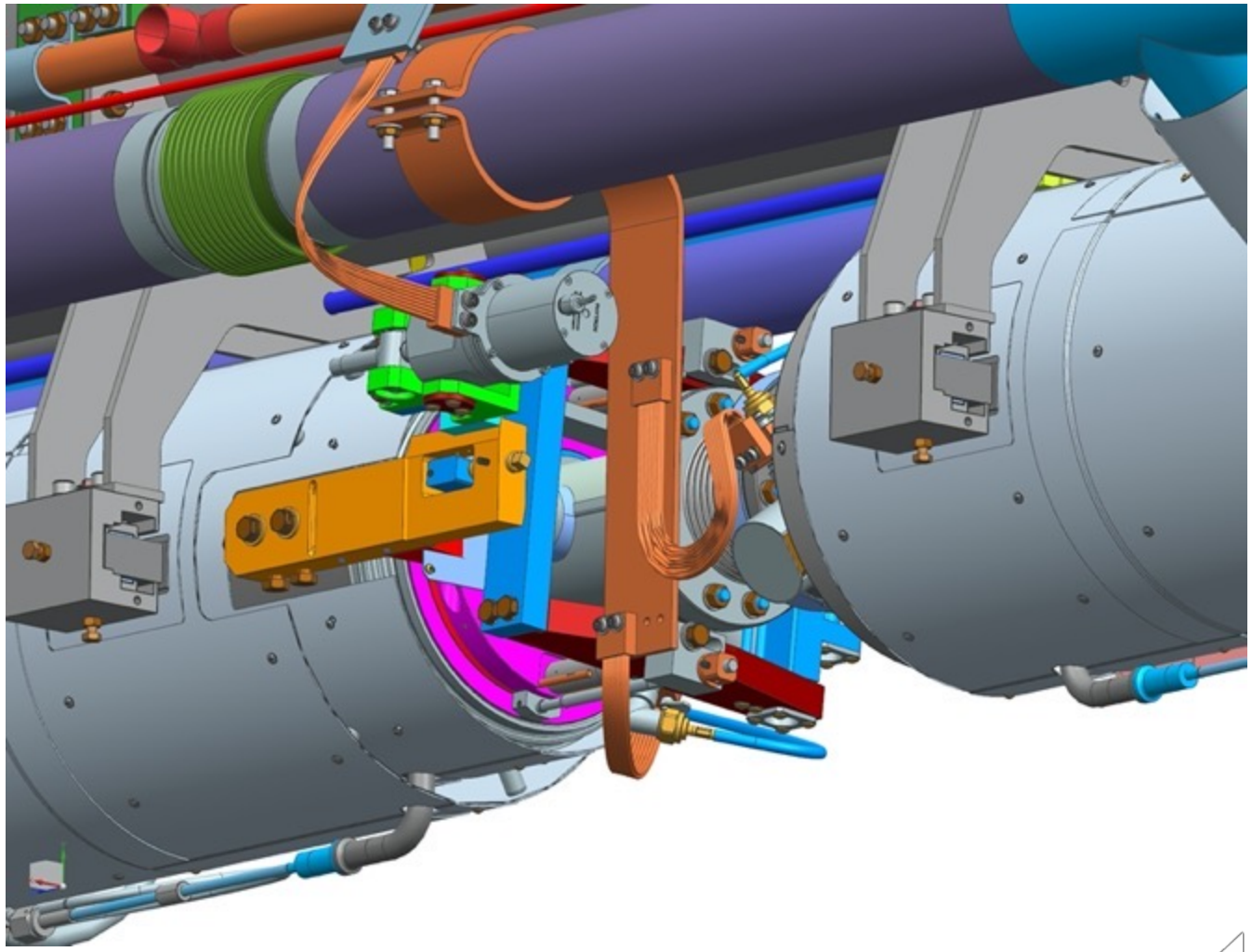
Cryomodule Design

- SRF cavity
- 300mm 2K return
- Support post
- BPM
- Magnet
- Shipping manifold



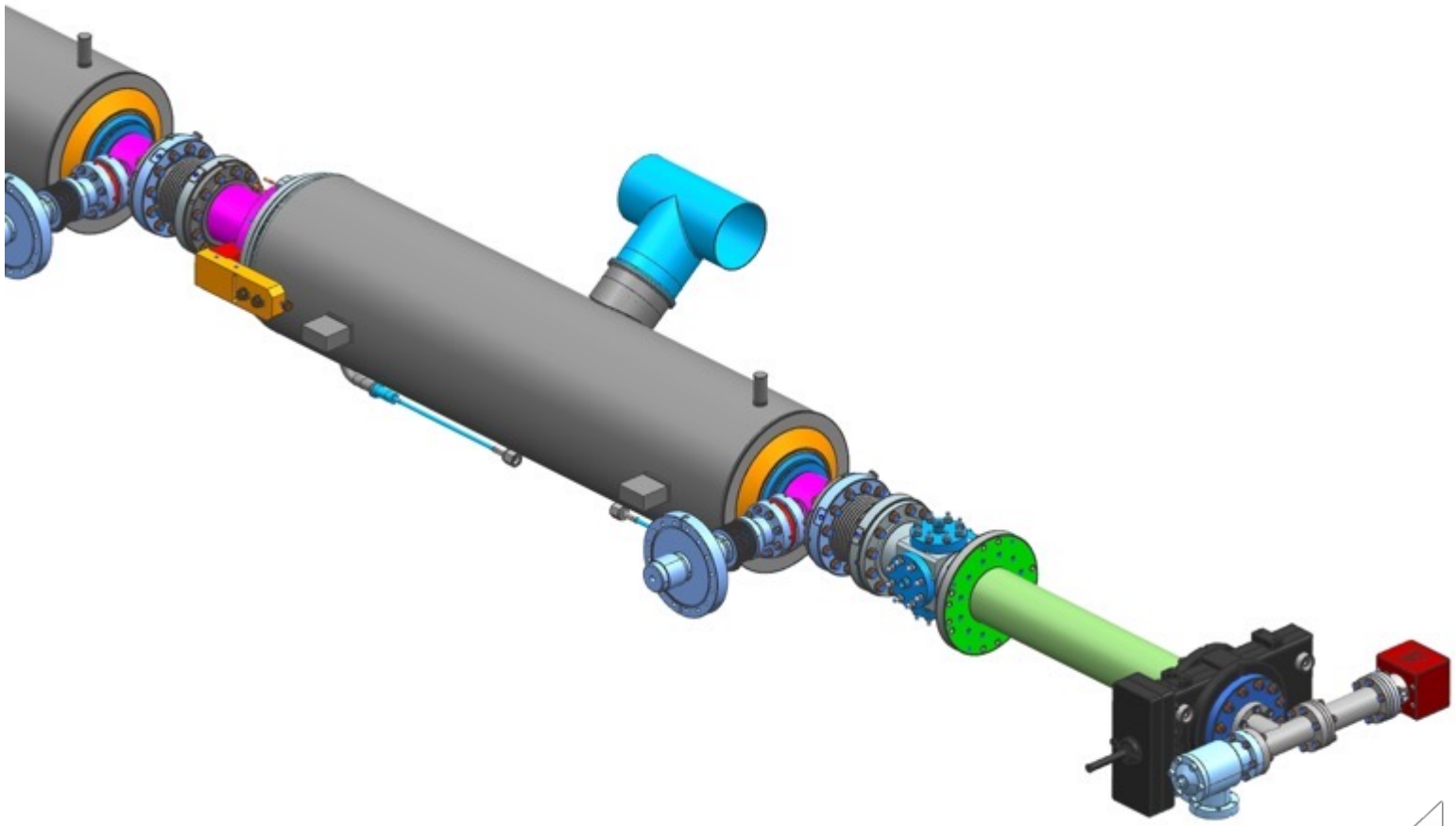
Cryomodule Design

- Extended range tuner
- 2-phase pipe
- Cavity supports
- Thermal intercepts
- Magnetic shields
- Helium cooldown lines



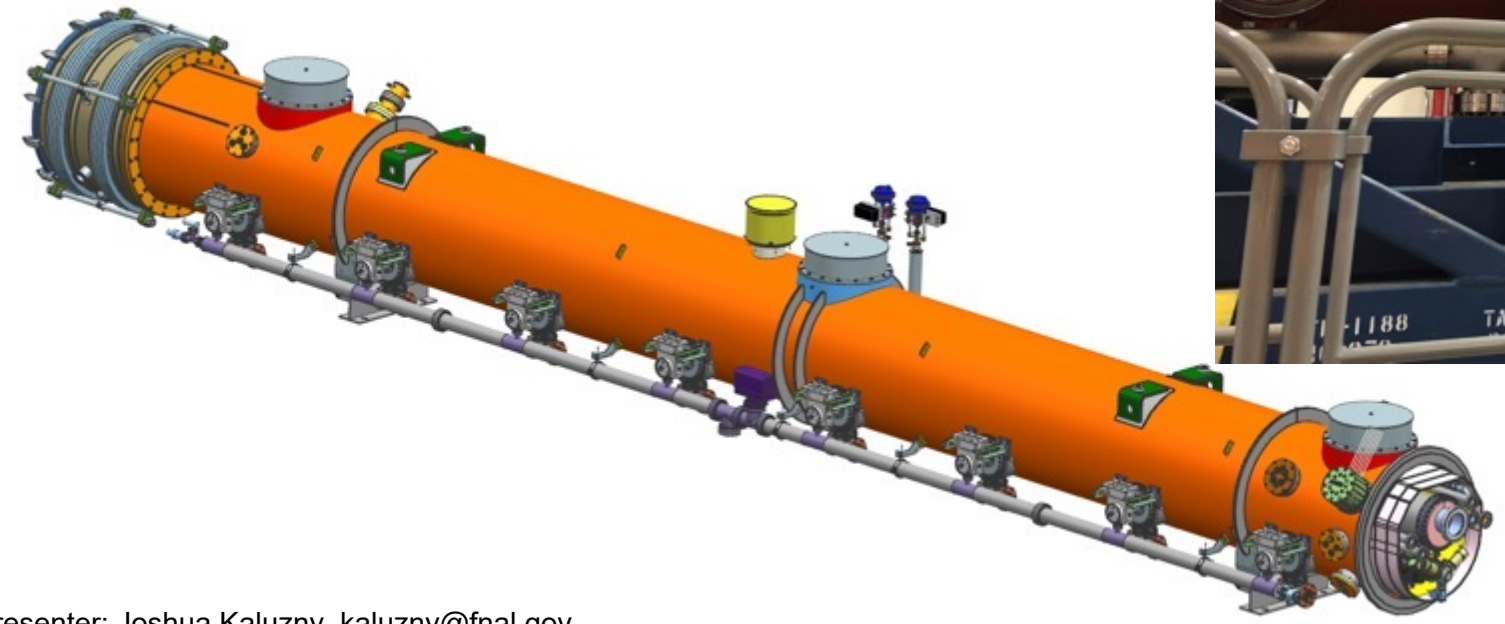
Cryomodule Design

- SRF cavity and helium vessel
- RF coupler
- Beamline bellows
- BPM
- Gate valve
- Beamline pump



Cryomodule Production Status

- Drawing package is released
- All major components on order
- vCM assembly is complete
- Many parts have arrived

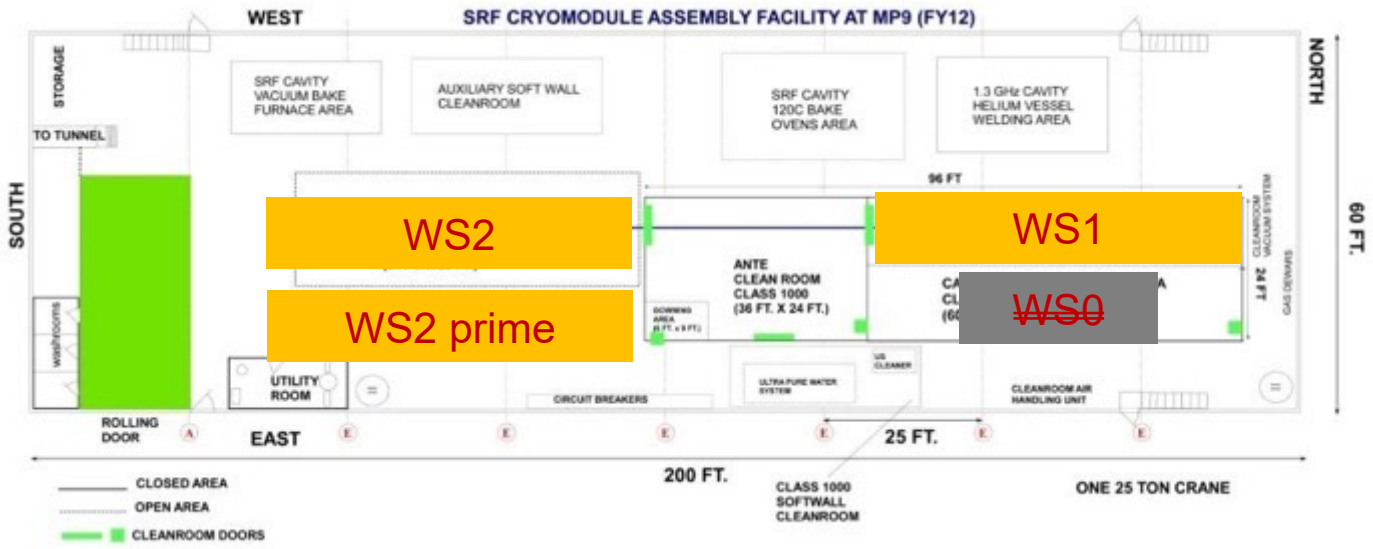


Cryomodule Process Changes

- Document and plan off-normal work
- Many lessons learned throughout LCLS-II production resulted in procedure and traveler revision during LCLS-II
- Significant process changes from LCLS-II to improve cleanliness of beamline
  - Beamline under vacuum assembly
  - Install coupler on cavity on support post
  - Upgrade beamline venting, pump and purge system

Cryomodule Assembly Overview

- Infrastructure developed with Tesla Technology Collaboration similar to what was used for European XFEL
- Assembly is broken into workstations (WS)
- Assembly is performed in two buildings



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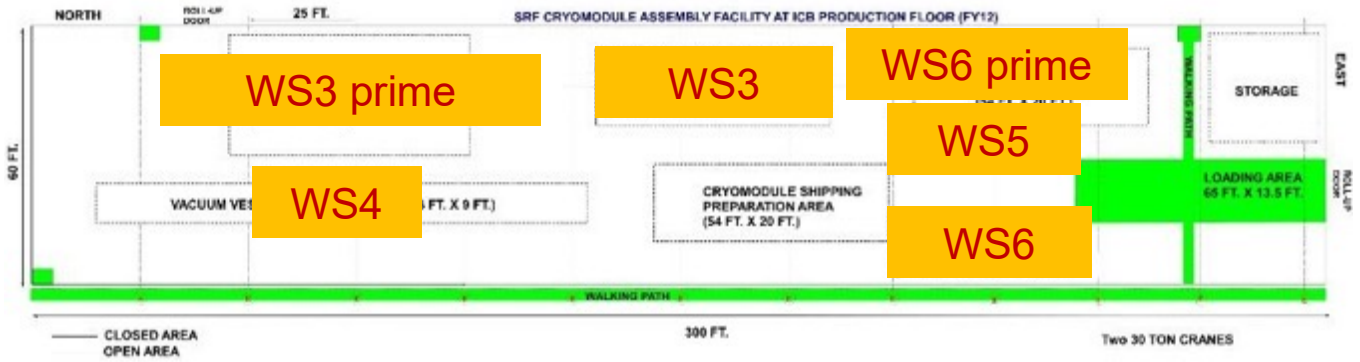
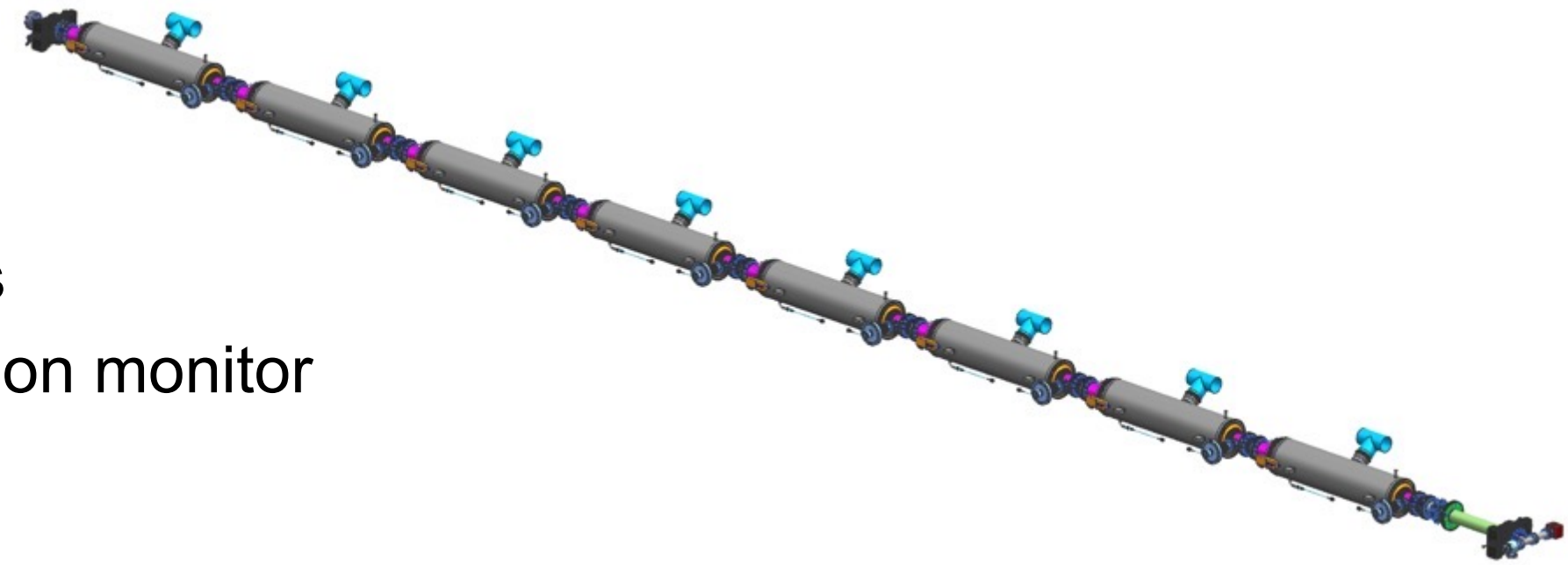


Cryomodule Assembly – WS1

- Assemble couplers to cavities
- Assemble cavity string
  - Cavities
  - Bellows
  - Spools
  - Gate valves
  - Beam position monitor
  - Pump

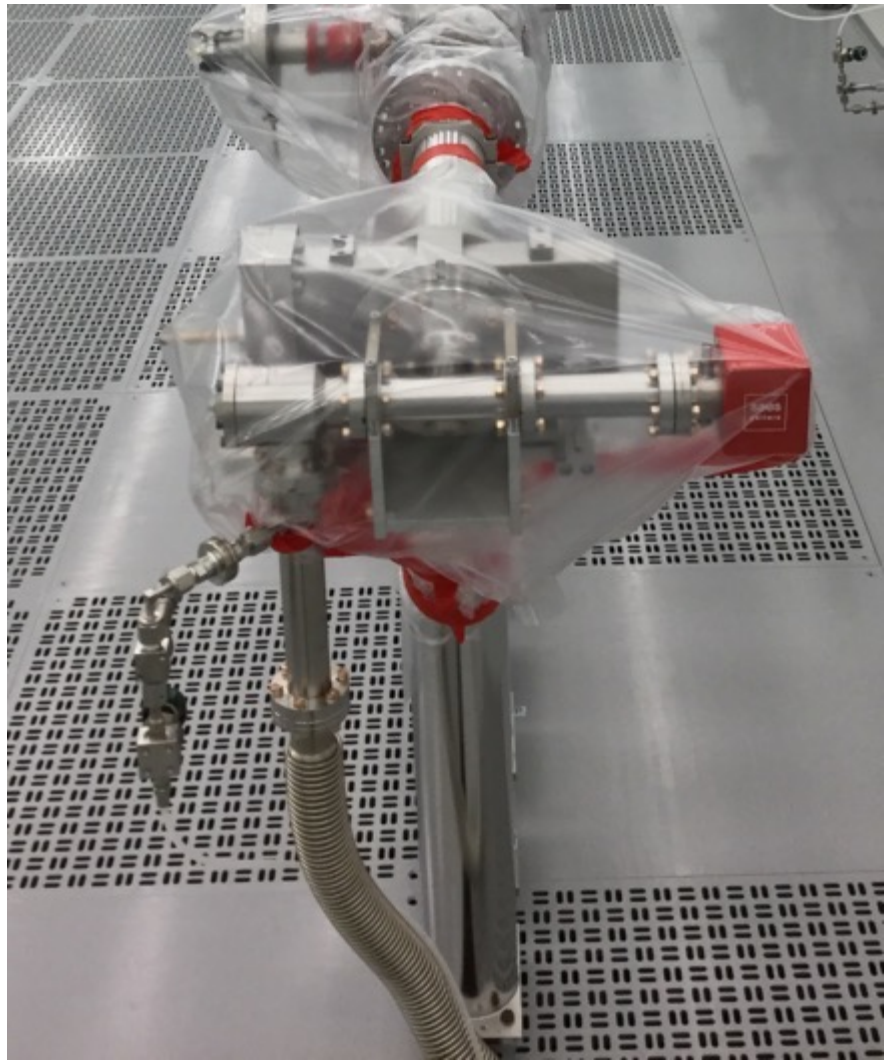


Cryomodule Assembly – WS1

- Assembled in cleanroom
- Cavities mounted on support posts
- Support posts roll on rail
- Leak check
- Pump and purge manifold

Cryomodule Assembly – WS1

- Assemble cryomodule while keeping beam line under vacuum
- Continual passive pumping with NEG
- Cleanroom purge manifold upgrade

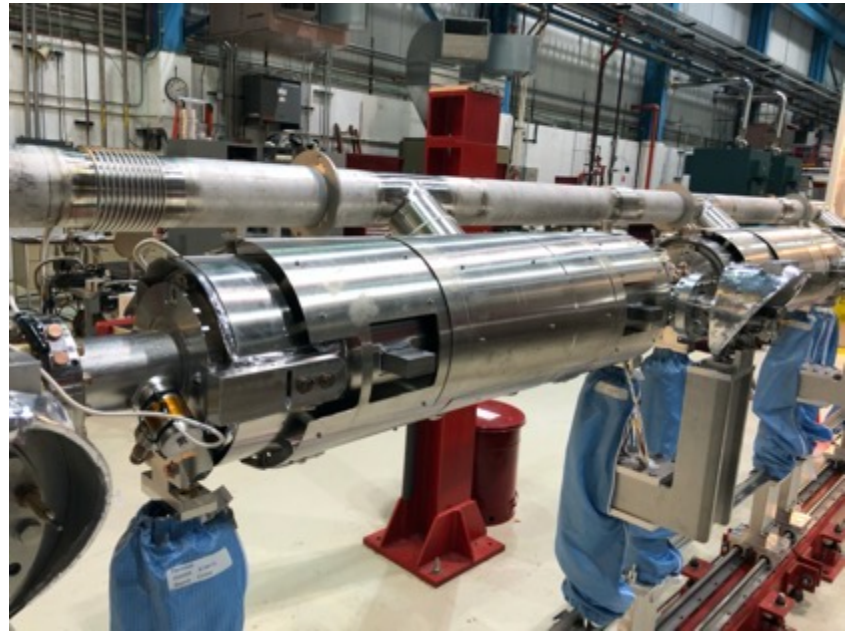


Cryomodule Assembly – WS2

- Coupler support for beamline under vacuum assembly
- Attach upper cold mass to cavity string
- Magnetic shield
- Temperature sensor and heater installation on cavity helium vessels

Cryomodule Assembly – WS2

- Magnetic shield
- 2-phase circuit
- Cavity helium vessel insulation (MLI) installation
- Leak checks
- Electrical checks
- RF checks

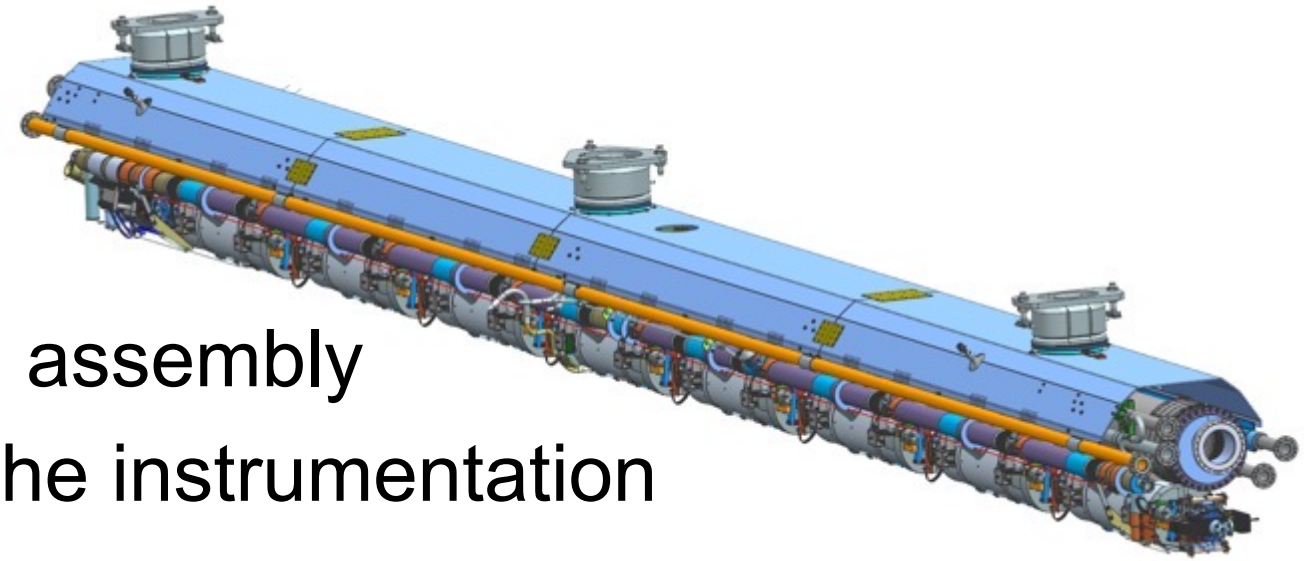


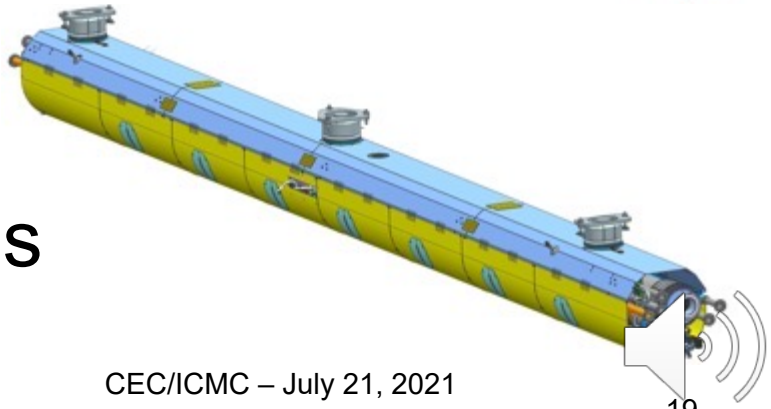
Cryomodule Assembly – WS2

- Cavity string rolled out of cleanroom
- Rail extends into cleanroom
- Coldmass support fixture
- Alignment
- Transportation to WS3

Cryomodule Assembly – WS3

- Current lead thermal intercepts
- Extended range tuner
- Complete thermal intercepts
- RF cables
- Complete magnetic shielding assembly
- Complete the harnessing of the instrumentation wires and RF cables
- Electrical and RF Checks
- Install and weld lower 50K aluminum shields





Cryomodule Assembly – WS3

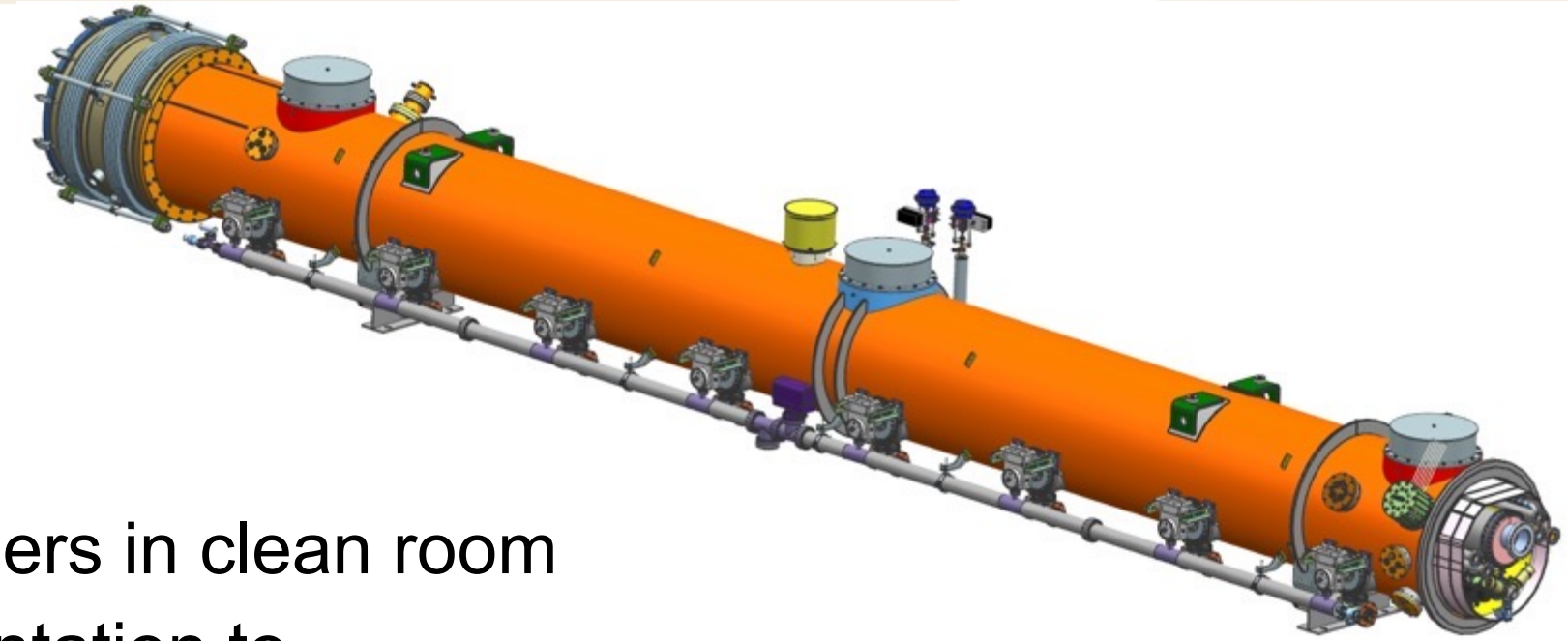
- Cold mass support fixture
- Instrumentation installation
- Magnet/current lead thermal intercepts
- Thermal intercepts

Cryomodule Assembly – WS4

- 30 layers of MLI installed as pre-made blankets
- Electrical & RF checks
- Slide vacuum vessel onto cold mass
- Assemble cold mass supports
- Align cold mass to vacuum vessel

Cryomodule Assembly – WS5

- Weld cryogenic valves
- Leak check
- Pressure tests
- Install warm part of the RF power couplers in clean room
- Terminate instrumentation to feedthrough flanges
- Install coupler pumping lines
- Leak check insulating vacuum



Cryomodule Assembly – Shipping Preparation

- Module is transported to test stand on shipping frame at low speed
- For transport to SLAC, the module has endcaps and other shipping supports installed

Production Assembly Status

- vCM is assembled and on test stand
- Travelers/assembly procedures are being updated based on vCM experience
- Production Readiness Review was held in July 2021
- Awaiting final parts arrival
- Production assembly to start later this year

Conclusion

- LCLS-II-HE will enable the production of higher energy photons
- Building on LCLS-II, LCLS-II-HE will add additional cryomodules to the SRF linac
- At Fermilab and Jefferson Lab, the experience of LCLS-II cryomodule production will be leveraged
- Fermilab will assemble, test and deliver 14 cryomodules for LCLS-II-HE

- Special thanks to Tug Arkan, Brian Hartsell and Chuck Grimm for providing material for these slides