D2 cryostat
Design and interface with cold mass

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CERN

International review on D1 and D2 superconducting magnets for HL-LHC

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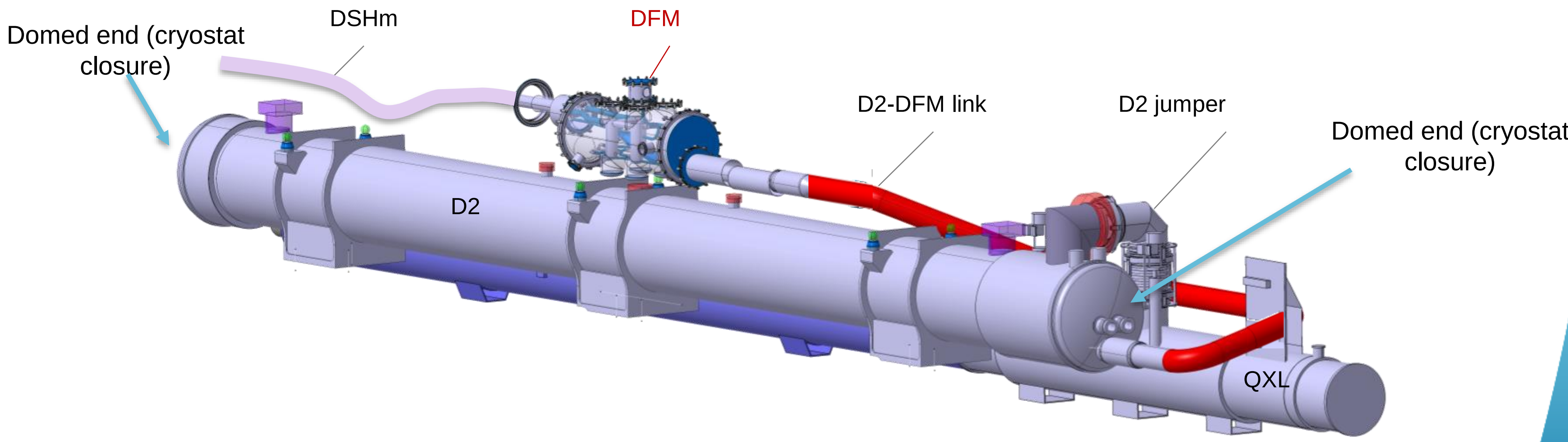
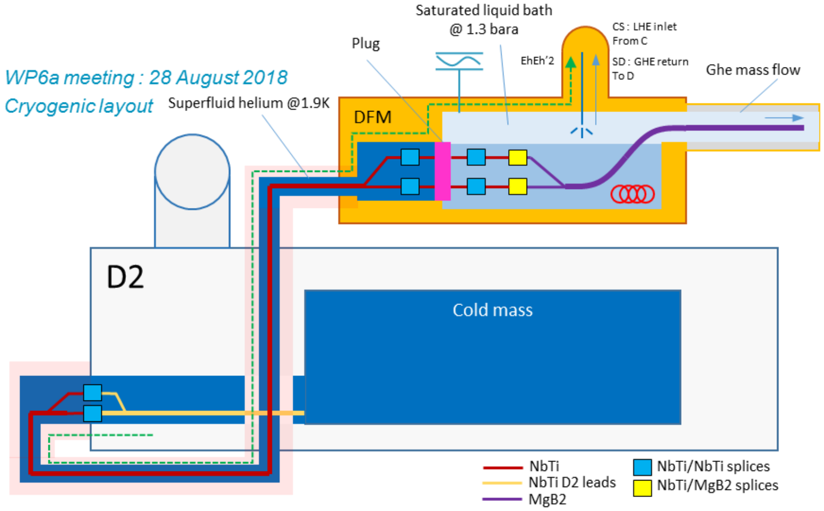
D2 specificity

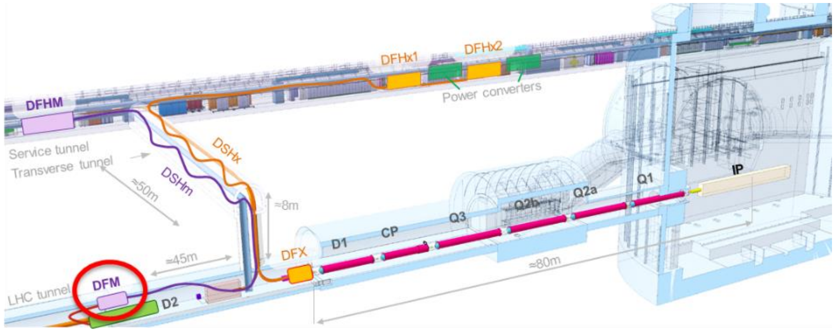
- Standalone magnet
  - Cryostat closed on both ends
  - Cold/warm transition (beam line) on both ends
- Powering through DFM
- Jumper for cryogenic services

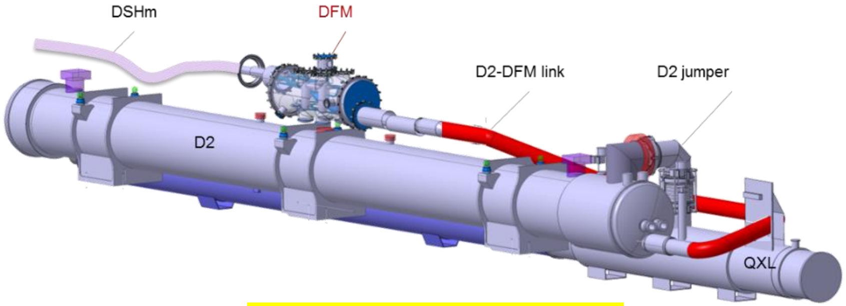


DFM (WP06a)

- Functions
  - Electrical interface between SC (MgB2) and D2 (NbTi)
  - Supply cryogenics to the DSHm SCLink (Ghe mass flow)
- Integration
  - Installed on top of magnet
  - Fixed to tunnel wall
  - Vacuum insulated link to D2 routed behind cryogenic jumper
- Link to D2
  - NbTi round cable (MBRD – 13 kA + 4 correctors MCBRD)
  - Superfluid helium cooled by D2
  - Actively cooled thermal shield (Ghe)

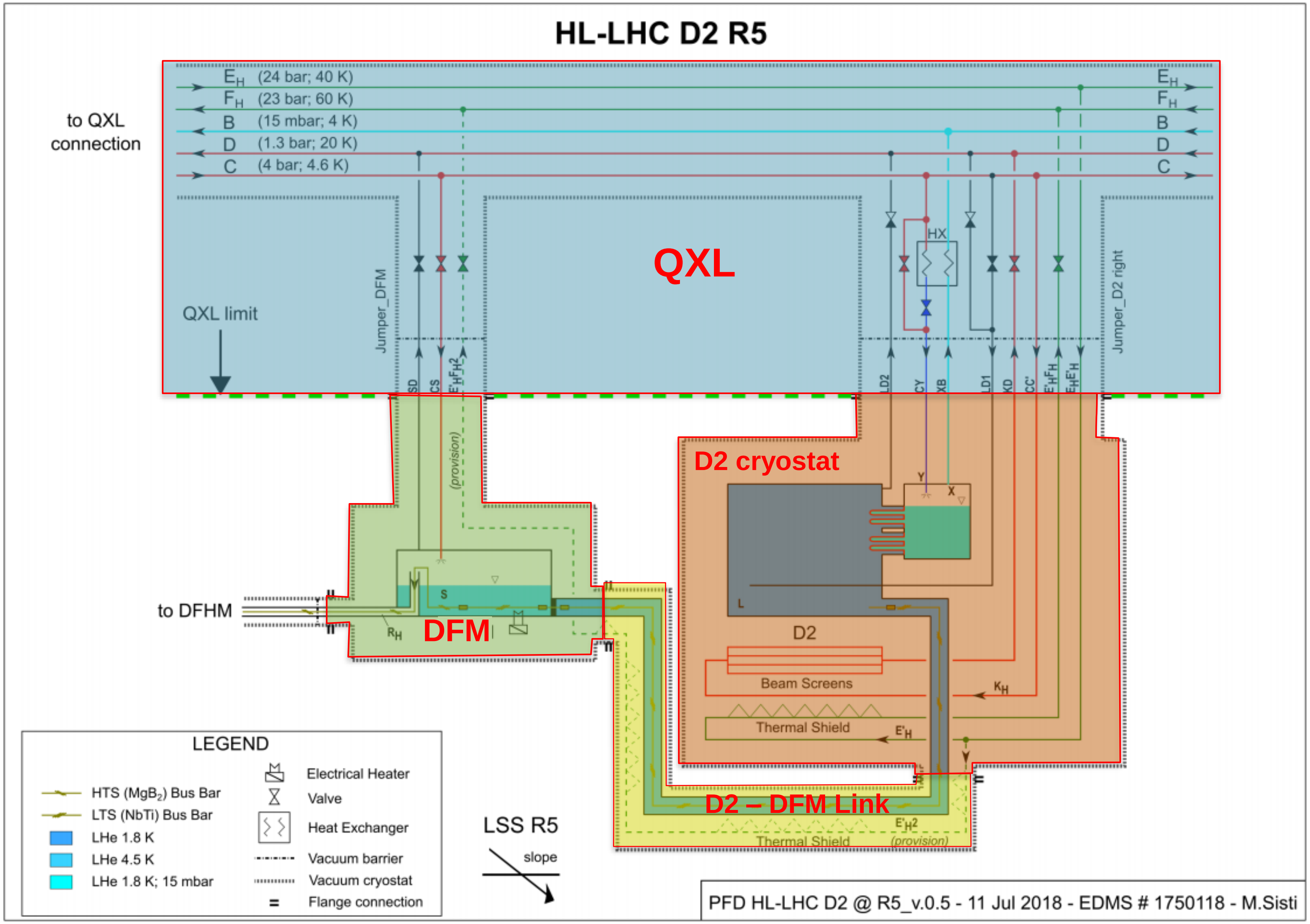






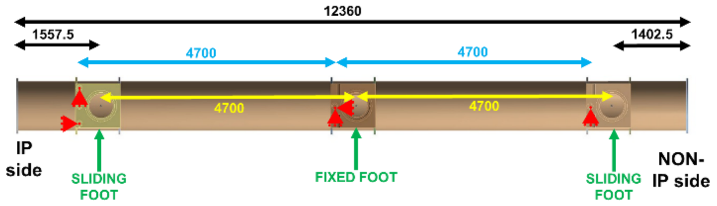
Courtesy Y Leclercq

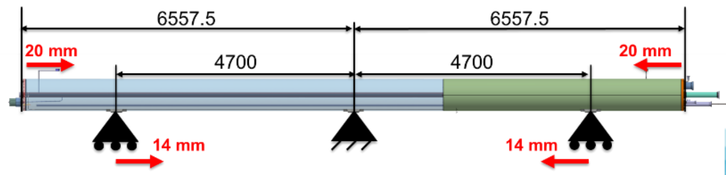
Cryogenic scheme

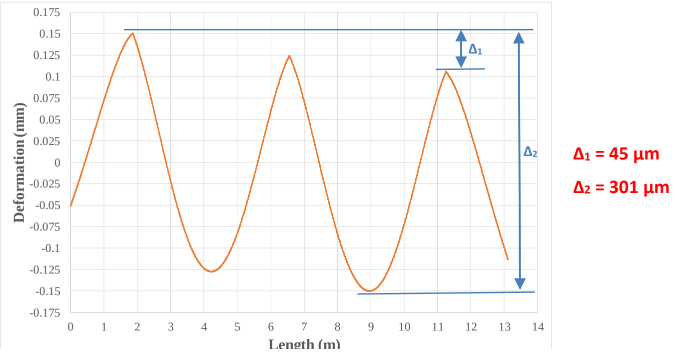


Supporting scheme

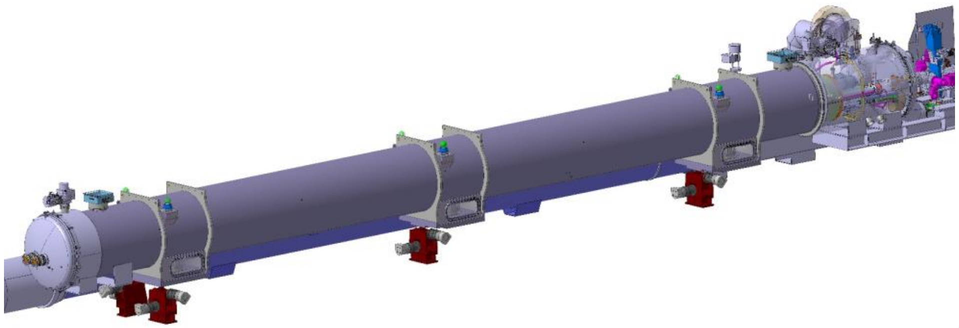
- Cold mass and vacuum vessel supported on 3 points
  - Central support
    - Centre of cold mass (not centre of cryo-assembly)
    - Fixed support, for symmetry of beam line cold/warm transition
  - Side supports
    - 4700 mm from centre (from optimization of cold mass deformation)
    - Sliding supports (movement due to thermal contraction = 14 mm)
- Cold mass vertical deflection = 0.3 mm
- Thermal contraction of cold mass extremity = 20 mm (symmetric)
- Vacuum vessel supported on 4 jacks with remote alignment (from CCC)







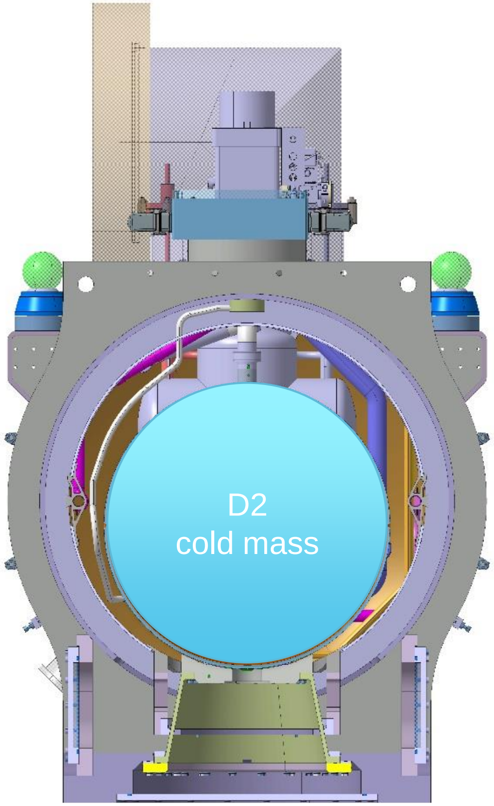
Vertical deflection of cold mass



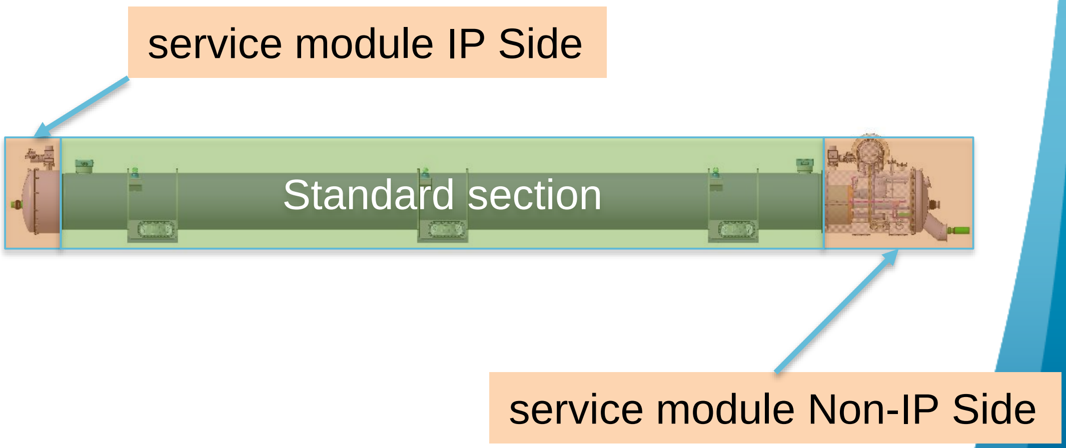
Vacuum vessel on its jacks

Cryostat breakdown

- "Standard section" (Construction principle common to all triplets)
  - Conical GFRE columns
  - Cryostat designed for larger cold mass with LHC vacuum vessel diameter
  - New assembly tooling
- Service module IP-side
  - Closes cryostat (vacuum vessel, thermal shield)
  - Beam lines cold/warm transitions
- Service module Non-IP side:
  - Closes cryostat
  - Beam lines components
  - Cryogenic circuit to QXL
  - Cryogenic equipment
  - Magnet powering (link to DFM)

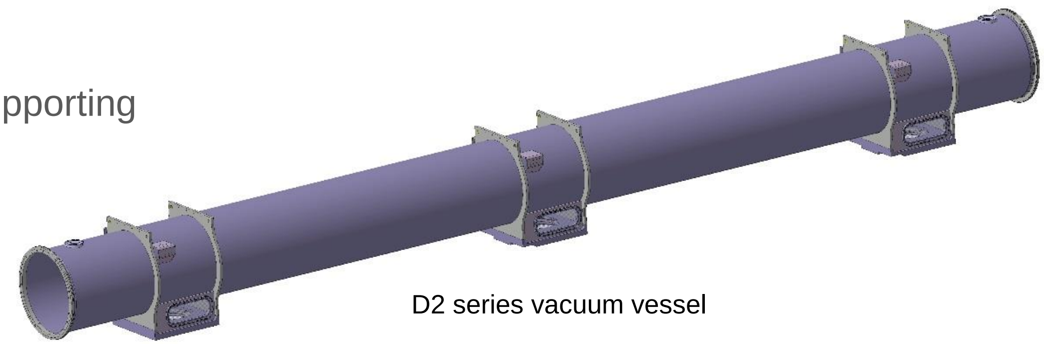


Cross section as seen from IP



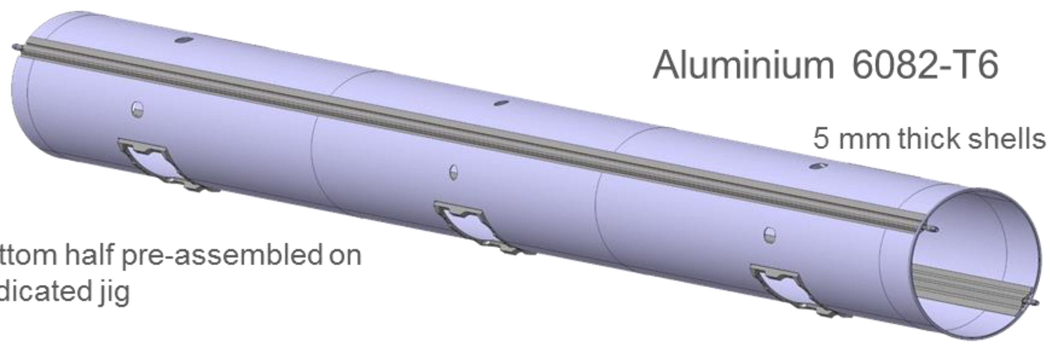
Standard section

- Vacuum vessel (in procurement)
  - Share WP11 features (see D Ramos presentation)
    - Support posts interface
    - Extremity flanges
    - Cradles for vacuum vessel supporting
  - Two types
    - Proto (3 IFS)
    - Series (2 IFS)



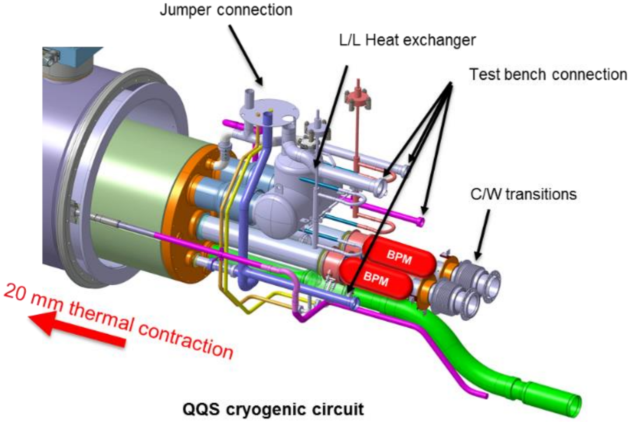
D2 series vacuum vessel

- Thermal shield (detailed design on-going)
  - Common principal features for WP11 (see D Ramos presentation)

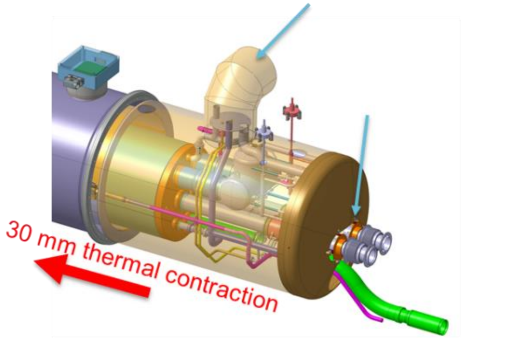


Service module

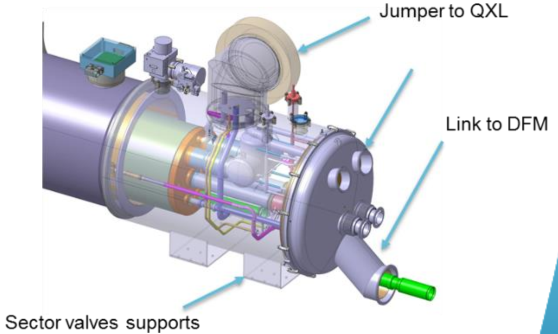
- Jumper layout complete
  - Thermal shield fixed inside jumper, independent of service module TS
  - 10 mm offset of cryogenic pipes for 20 mm thermal contractions
- Integration of all large elements is complete (HX, BPM, C/W transition)
- Conceptual cryogenic piping routing is complete according to PFD (detailed design on-going)
  - Pipes flexibility requirement defined
  - Routing to be completed for test bench connection in parallel to jumper
- Thermal shield (detailed design on-going)
  - Fixed to standard section
  - Independent domed end
  - IFS routing on-going, passage through thermal shield agreed
- Vacuum vessel (detailed design on-going)
  - Ports position defined
  - Support for sector valves under study
- Assembly sequence being defined



QQS cryogenic circuit



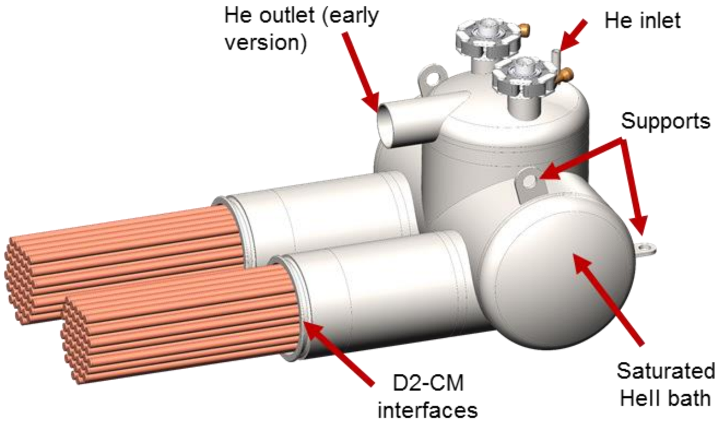
QQS thermal shield

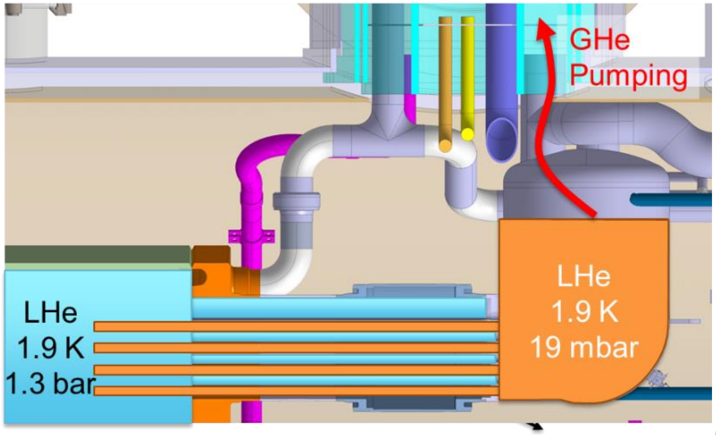


QQS vacuum vessel

Service module - 1.9 K L/L heat exchanger

- Collaboration agreement with CEA INAC-SBT (Grenoble) for design, fabrication and testing
- Operation in pressurized superfluid helium
  - Pumping on saturated helium bath
  - Heat exchange through copper heat exchanger
- Configuration chosen (2x 52) cylindrical HX channels protruding into the D2 cold mass
- Sleeve connection to cold mass
  - Installation after pressure test due to space constraint in the test facility
  - Add flexibility during welding to relax manufacturing tolerances
- Integrated instrumentation
  - Level sensors (2x)
  - Temperature sensor (Cernox)

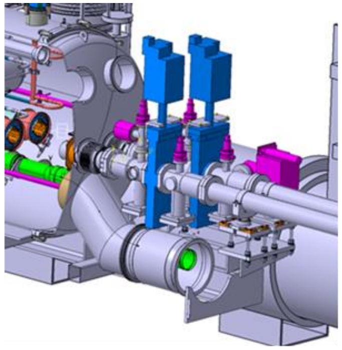




Responsibility of CERN TE-CRG

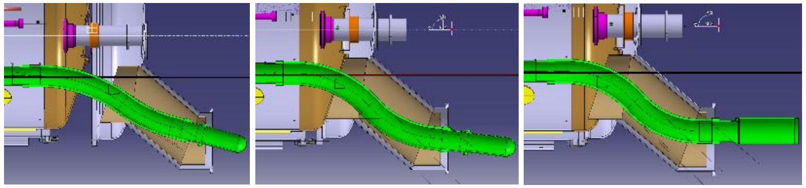
Service module - Connection to DFM

- Due to sector valves, link to DFM must be lower than cryostat (offset of 320 mm)
  - Rigid vacuum vessel and thermal shield outside of cryostat
  - Flexible cryogenic hose and busbar (pre-formed) for assembly, to be checked on mock-up



Non-IP side integration view (with sector valves)

- Flexible S-bend is used for compensation of thermal contraction (20 mm)

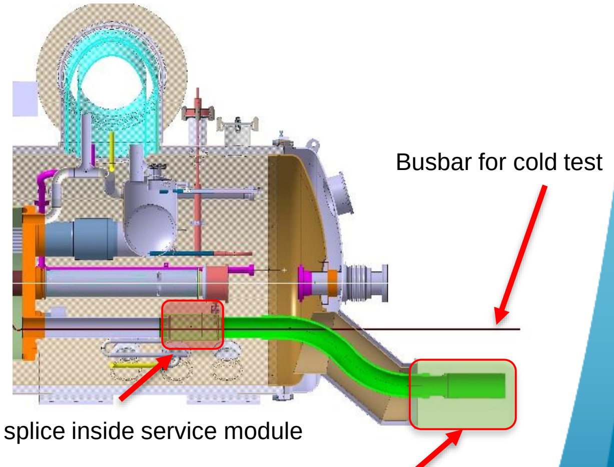


Domed-end assembly sequence

- Flexible cannot be used for cold test
  - Risk to damage the busbar insulation if too large movement
  - Flexible too long for connection to test bench

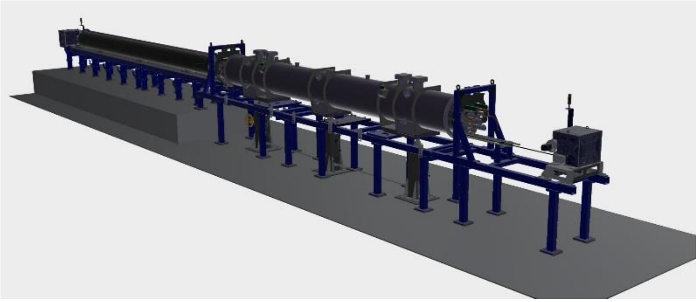
  ➔ Splice to be done inside the service module after cold test

- Interconnection box to DFM link at D2 extremity of S-bend (design on-going)

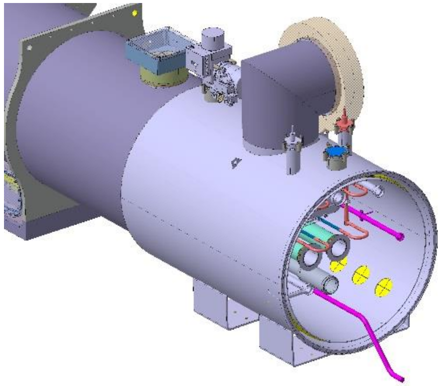


Cryostat assembly and cold test sequence

- Cryostating - Phase 1 + 2
  - Cold mass insertion inside standard section (with supports posts, thermal shield and MLI)
  - Cold mass instrumentation (IFS)
  - Service module welding
    - Heat exchanger
    - Piping (open to extremity for connection to test bench)
    - Vacuum vessel, thermal shield and MLI
    - Jumper (closed for cold test)
- Cold test
  - Connection to test bench with temporary interfaces and cryostat end cover
- Cryostating - Phase 3
  - Beam screen, BPM and CWT welding
  - Link to DFM (splice, flexible)
  - Close temporary interface for cold test
  - Open jumper interface
  - End covers



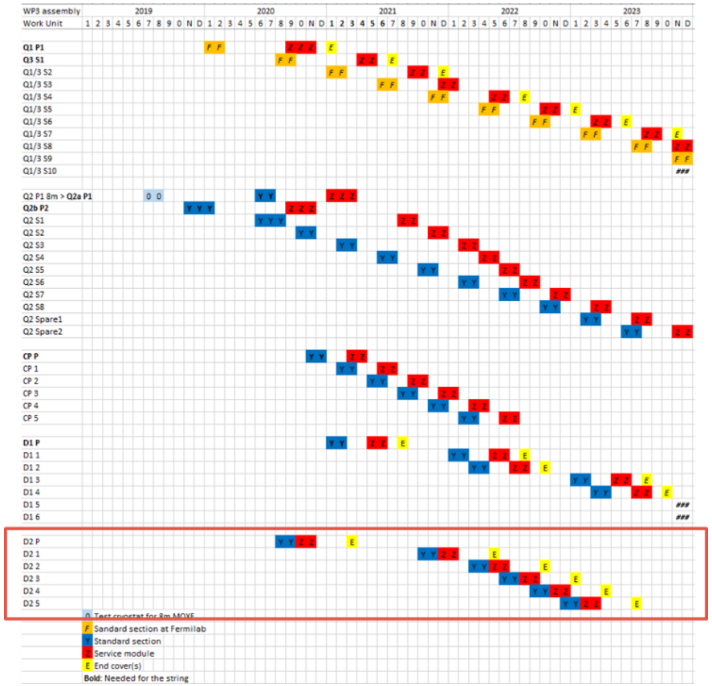
D2 on cryostating tooling



D2 service module extremity ready for cold test

Schedule

- Vacuum vessel (see D Ramos presentation)
  - Invitation for tender is on-going
  - Purchase order to be issued in July 2019
- Heat exchanger
  - Prototype assembly on-going
  - Delivery at CERN in August 2019
- Cryostating tooling (see D Ramos presentation)
  - Contract running
  - Contractual installation schedule: July 2019 at CERN
- All components for prototype order to be issued before end 2019
- Prototype assembly to start in August 2020
- Series assembly to start in October 2021



Summary

- Cryostat conceptual design is complete
  - Based on WP3 standard section
  - Cryogenic component integration completed
  - Assembly sequence defined

- Detailed design is on-going work

- Long lead items (vacuum vessels and cryostating tooling) are under procurement

- Prototype components drawings to be issued for procurement before end 2019

Thank you !