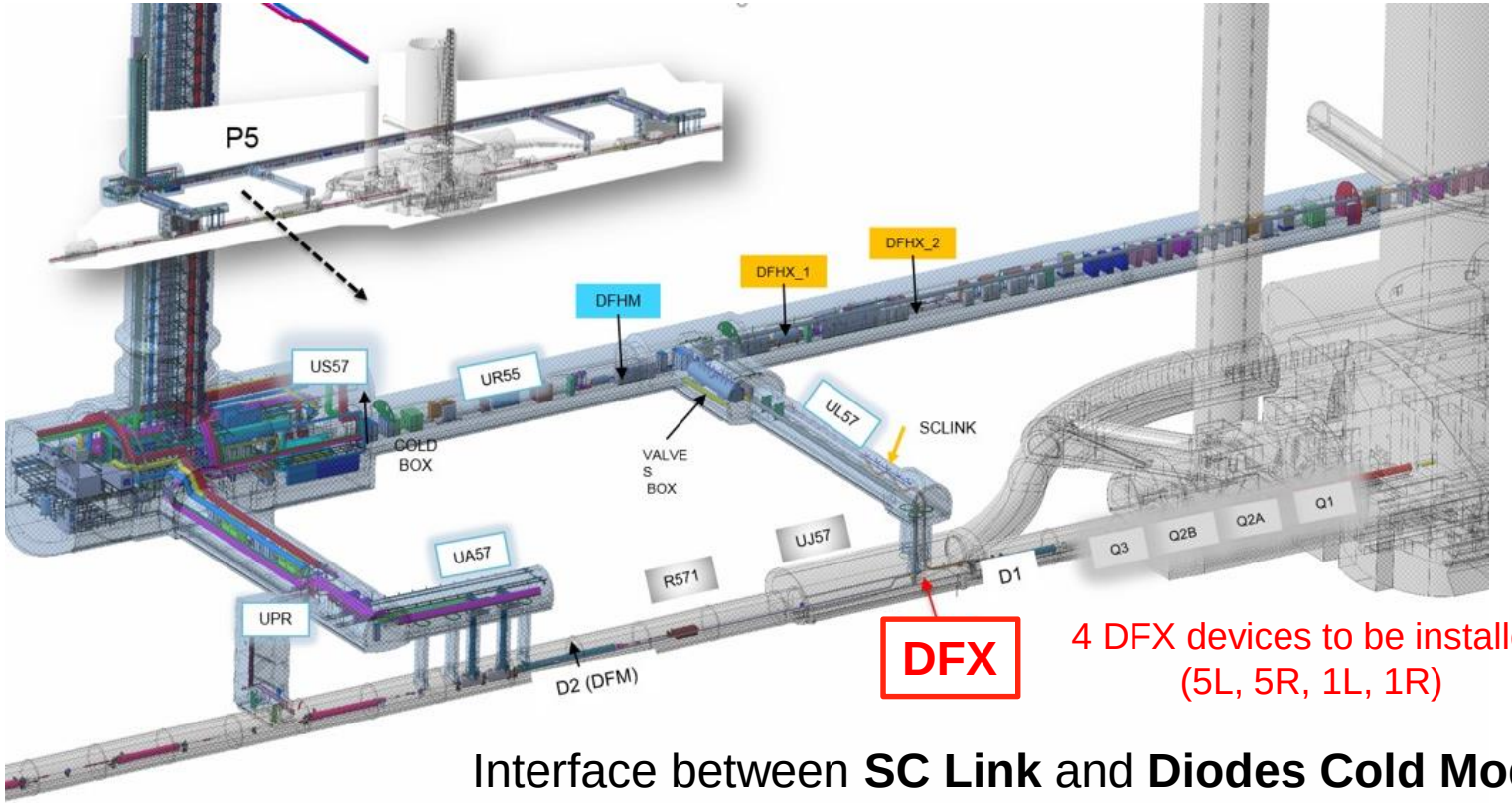
Description of the DFX device, scope & interfaces

P. Cruikshank on behalf of the WP6a team
3 March 2020

Production Readiness Review of the DFX

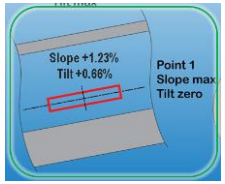
WP6a - DFX



4 DFX devices to be installed
(5L, 5R, 1L, 1R)

Interface between **SC Link** and **Diodes Cold Module** of the **HL-LHC Inner Triplets**

1. INTRODUCTION: Direction of the slope P1 vs P5



L1: DFX has to compensate the slope

POINT 1

R1: DFX follows the slope
(Requirement coming from DFX cryo design)

Horizontal ref

Extract from DFX integration review June 2019

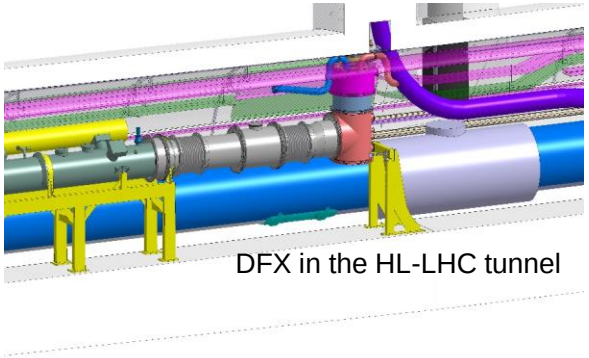
L5: DFX follows the slope

POINT 5

compensate the slope

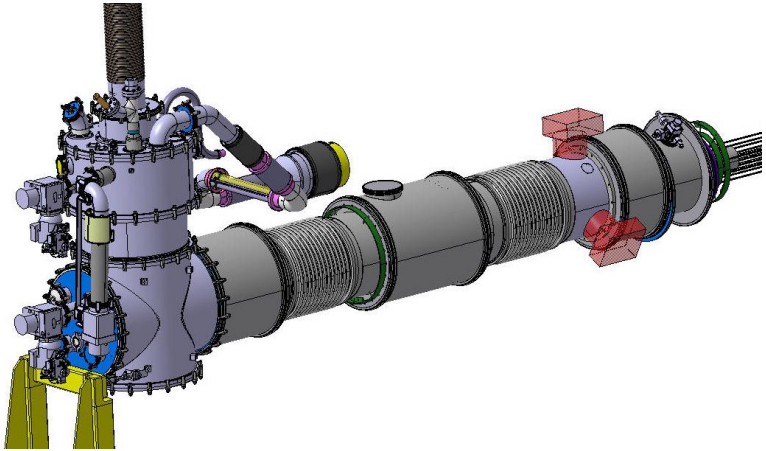
Horizontal ref

DFX – recall of main components



DFX in the HL-LHC tunnel

DFX - WP6a



DFX CDR - xxxx
DFX DDR - xxxx

5 DFX & 5 DFM cryostats required:

- Connection of MgB2 SC link to NbTi leads of cryomagnets in LHC tunnel
- In-kind contribution from UK via collaboration with Southampton University (design & manufacture).
- Supply of DFX prototype within UK1
- 4 DFX series & 5 DFM series in UK2 (not yet signed)

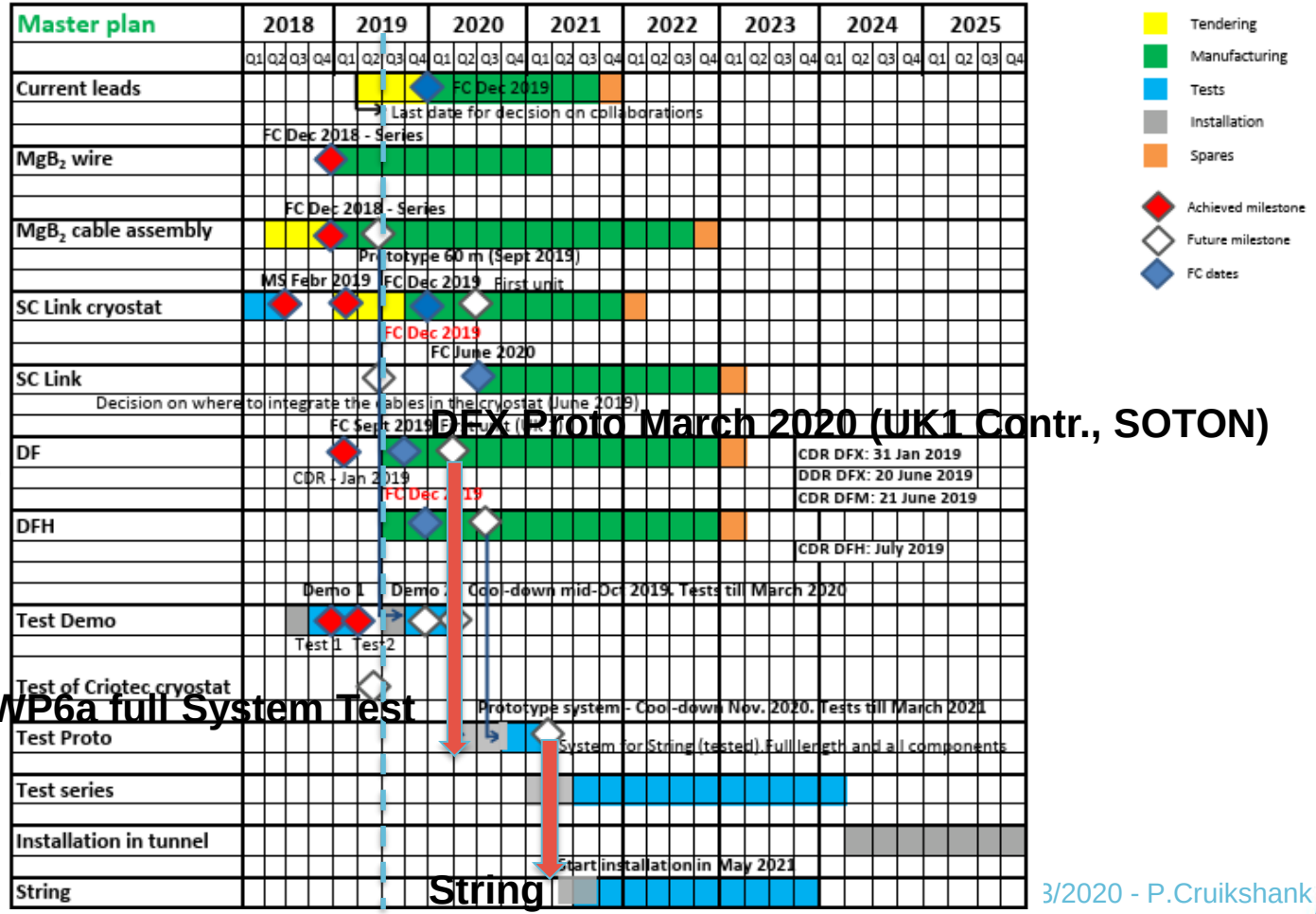
DFX prototype usage at Cern:

- Prototype test of cold power system (SC link, DFHX)
- HL String
- Stored as HL operational spare.

Design & Manufacturing:

- According to harmonized standards EN 13445
- Compliance with PED 2014/68/EU.
- CE marking (not ‘modified approach’ cf HSE advice)
- All quality records to be put in MTF

DFX planning – get latest from Amalia

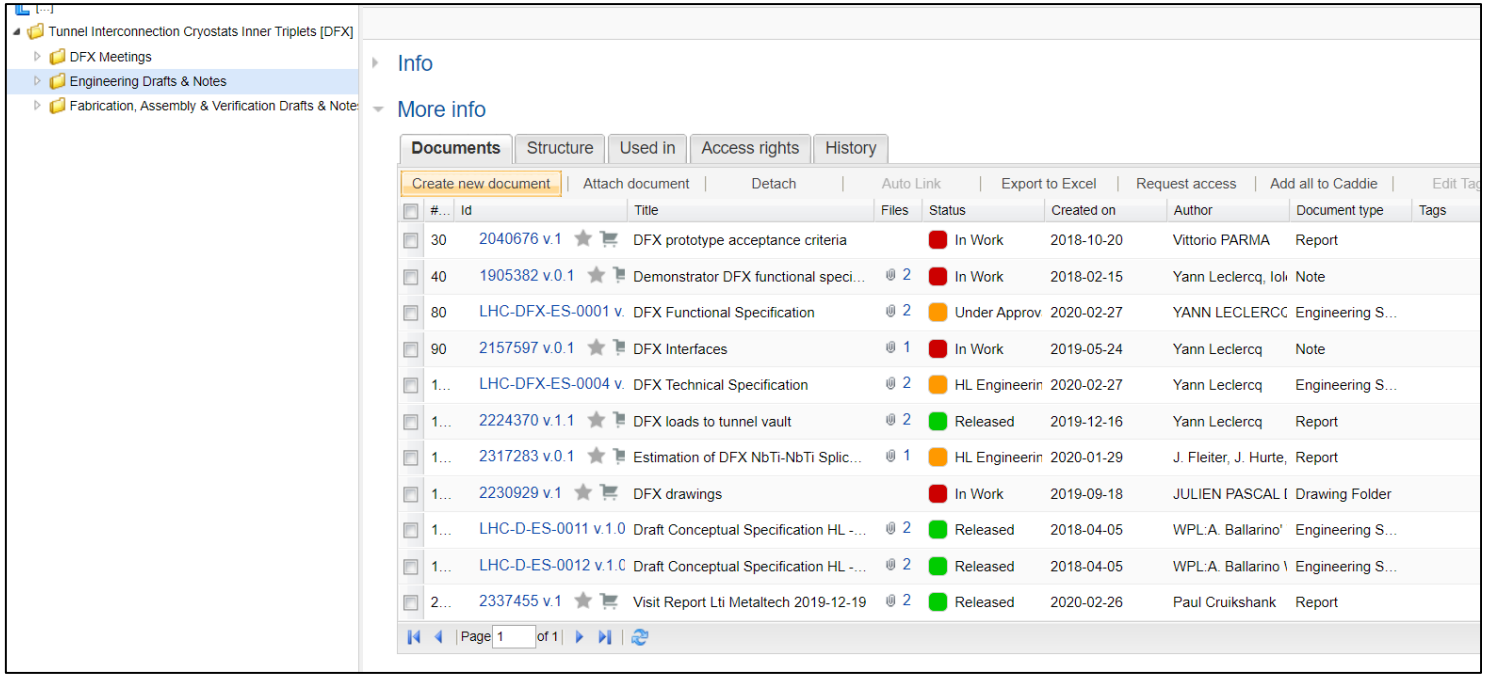


DFX Proto March 2020 (UK1 Contr., SOTON)

Proto WP6a full System Test

String

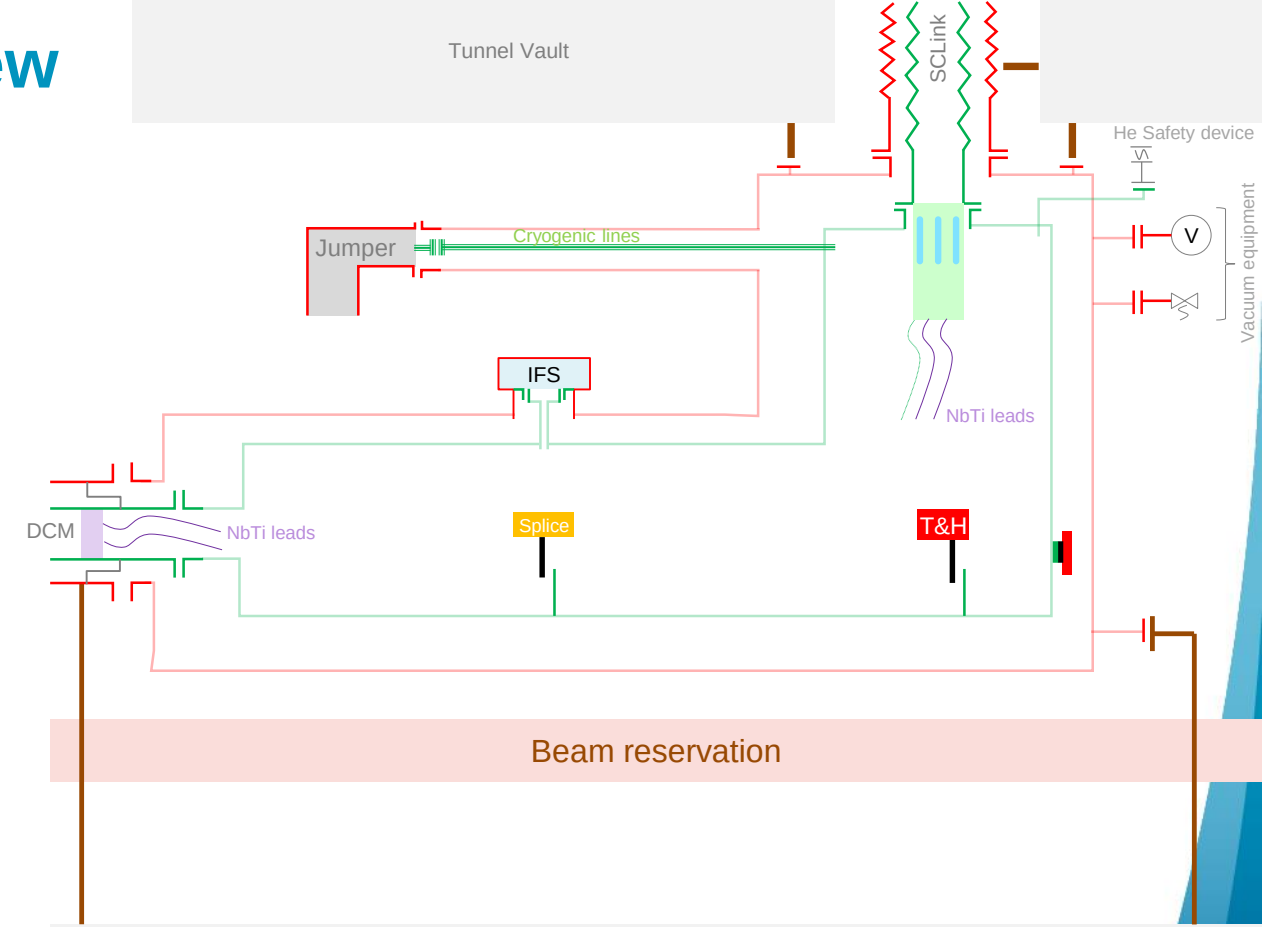
DFX documentation for PRR



All items shall be released prior to start of production

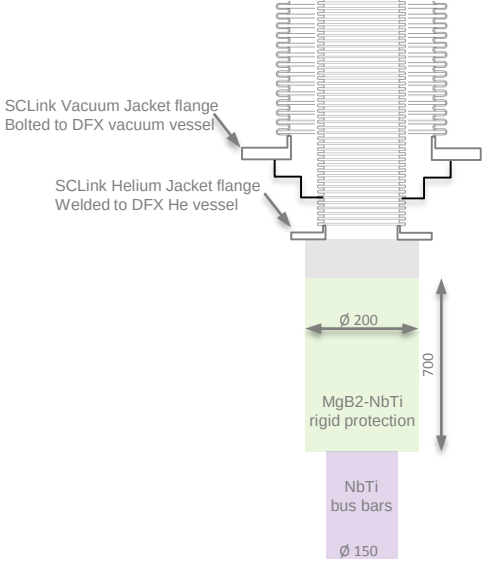
Interfaces overview

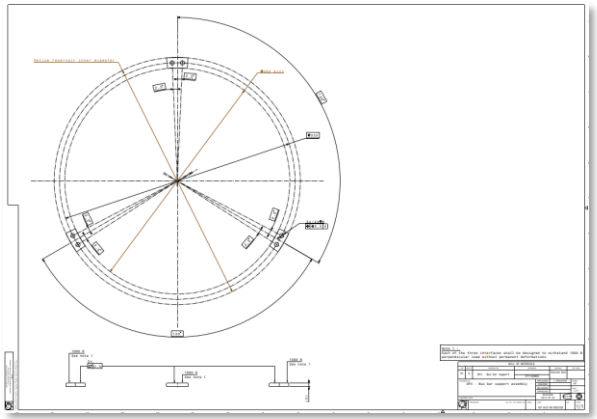
- Tunnel, supports & Beam
- SCLink interface
  - Leads + Instru
  - Jackets flanges
- DCM interface
  - Leads + Instru
  - Jackets flanges
- QXL interface
  - Vacuum jacket flange
  - Cryogenic lines
- Instrumentation
  - Sensors supports + IFS
  - Splices + bus bars support
- External services
  - Vacuum equipment
  - Pressure relief devices
- DFX interfaces
  - Outer & Inner jackets
  - Cryogenics
  - Supports
  - External accessories
  - Instrumentation & cables/splices

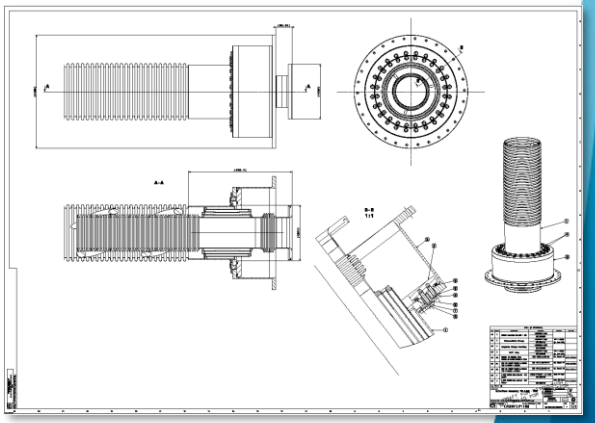


SCLink interfaces

- Vacuum & Helium jackets
  - LHCDHTLP1190
- Helium jacket end
  - Ø200 x 700 mm + NbTi bus bars
- Bus bars
  - Design of supports between bus bars de-scoped from prototype deliverables
  - DFX shall present mechanical interfaces in helium vessel
    - LHCLDQD_0003
- NbTi-NbTi splices
  - Fixed to helium vessel
    - LHCLDQD_0003

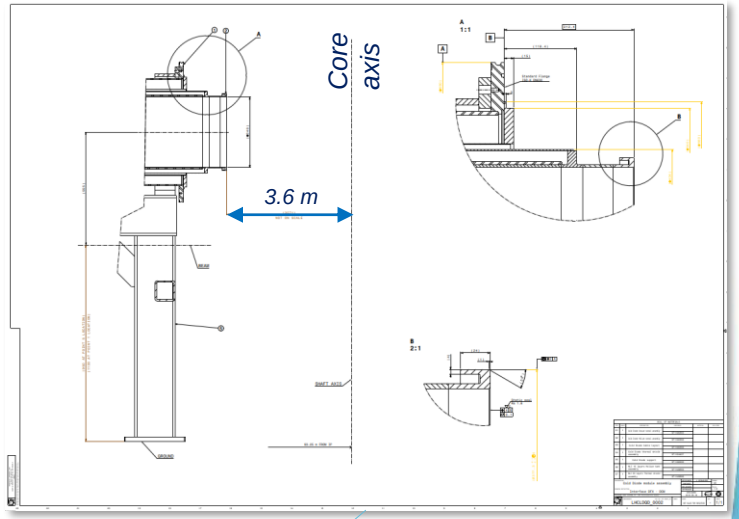


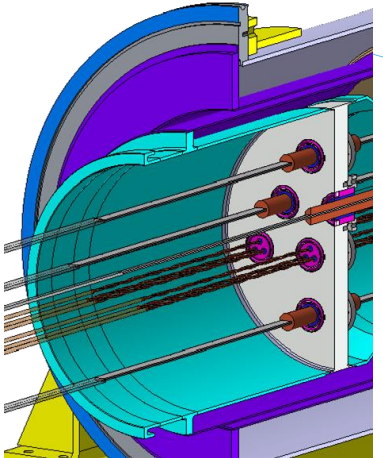


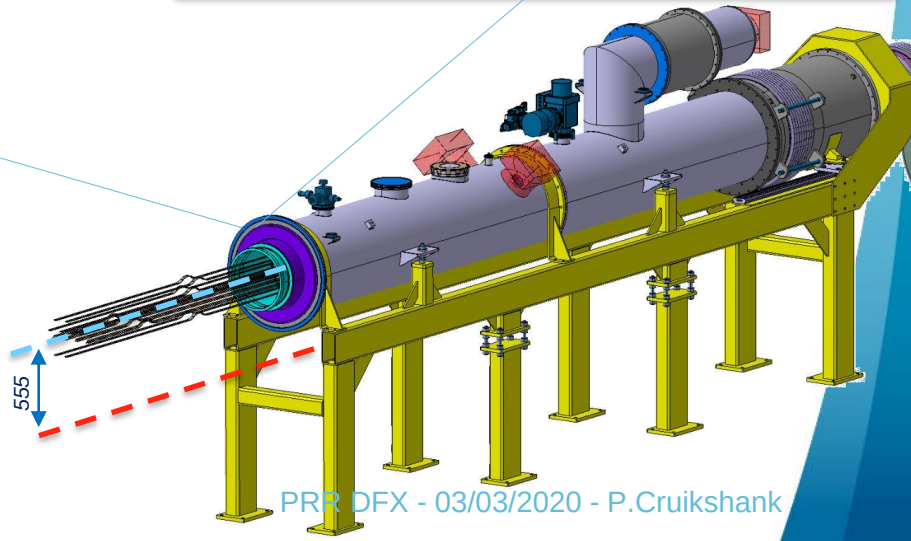


DCM interface

- D1-DFX Connection Module (DCM)
- Vacuum & Helium Jackets
  - ISOK-DN630 with standard O-ring
  - Lip weld
  - Interface Drawing: LHCLDQD_0002
- Bus bars
  - De-scoped from prototype



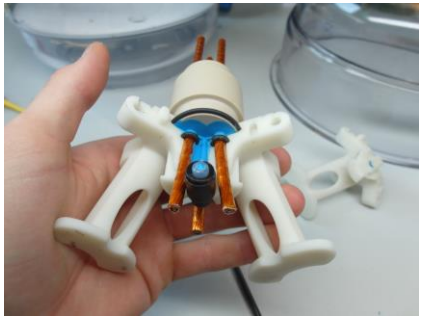


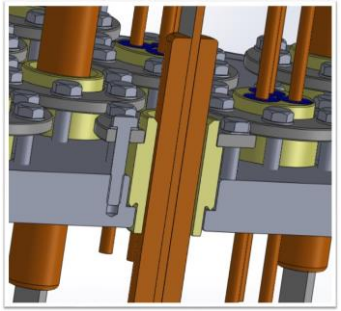


DCM interface : Lambda Plate

- Bus bars overview (see dedicated talk)
- Λ-Plate design based on LHC experience:
  - ΔP=20 bar
  - Nominal operation 1.9K
  - Thermal cycle : 50
  - Insultation @ RT : 4.6 kV
  - Overall leak rate @ RT : 1.10^{-4}mbar.l.$^{-1}$
- R&D activities:
  - Demonstrator completed
    - 6 kA type plug manufacturing R&D complete
    - 18 kA similar type plug being qualified
  - Plug Lab complete
    - Plasma treatment machine
    - Soldering post
- Thermo-mechanical results
  - 100% 6 kA plugs @ 1.10^{-10} mbar.l.s^{-1} after 10 Thermal cycle and Pressure test (electrical qualification pending)
  - 80% 18 kA demo plug @ 1.10^{-10} mbar.l.s^{-1} after 5 Thermal cycles
- Final configuration in progress
  - 6 kA manufacturing procedure complete
  - MQXF cable plug being developed
  - Manufacturing & qualification procedures being finalised
  - Final qualification with current during System test 2020

			Cable type		
	I_{cable} [kA]	N_{cables}	**Triplet side**	**Plug**	**DFX side**
MQXF	18	2	18 kA Nb-Ti round	2 x MQXF leads	See J.Fleiter talk Round
MBXF (D1)	18	2	13 kA Nb-Ti flat		
Trims	7	3	18 kA Nb-Ti round		
MCBXF%	2	12	6 kA Nb-Ti round	LHC 6 kA	See J.Fleiter talk Round



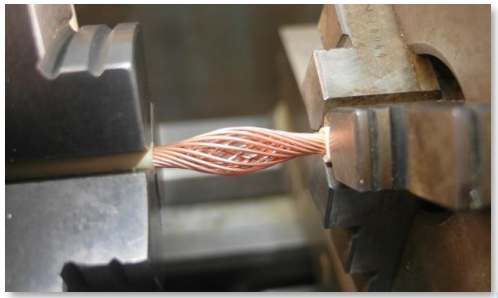


Courtesy S.Donche & E.Andrews

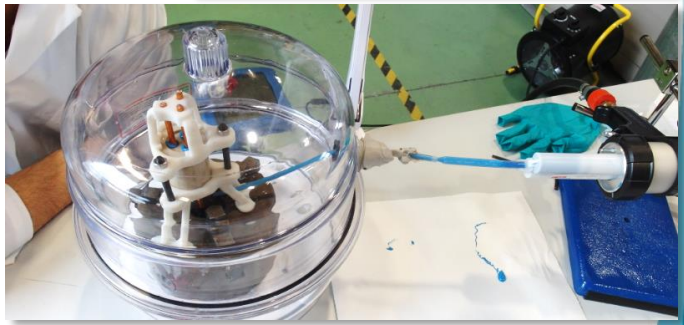
DCM interface : Lambda Plate

- Status:
  - Plug prototype production is up and running (procedures, tooling & equipment)
  - Integration constraints shall now be studied
    - Up to 6m long leads
    - MQXF cable (proto with 13 kA LHC cable)
  - Qualification procedures for series to be finalised
    - Individual follow-up & results archiving in place
    - Manufacturing procedures uploaded to EDMS
- Production Plan
  - Prototype expected by end of 2019
  - Injection moulds, Peek & SS parts sub-contracted
  - Assembly & qualification (thermo-mechanical + insulation) at CERN

Cable opening
Cleaning
Plasma treatment

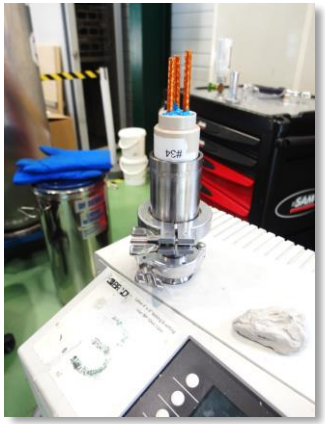


Injection (800 mbar) under vacuum (<1mbar) of pre-heated parts (40°C)



Traceability

Leak test
<1.10^{-8}mbar.l.s^{-1}



Pressure test
1 h at 30 bara

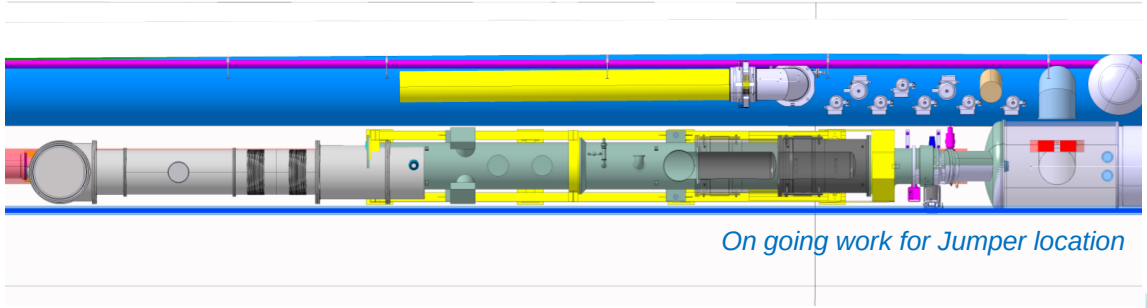
Thermal cycles
X10 to 77K

Demoulding

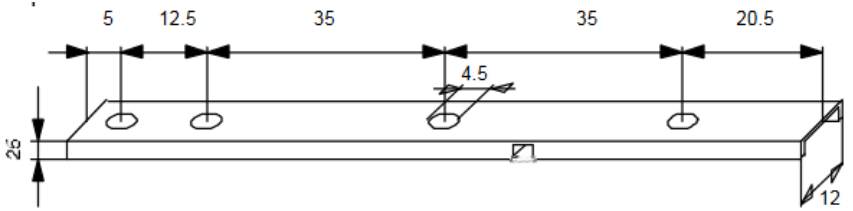
Courtesy S.Donche & E.Andrews

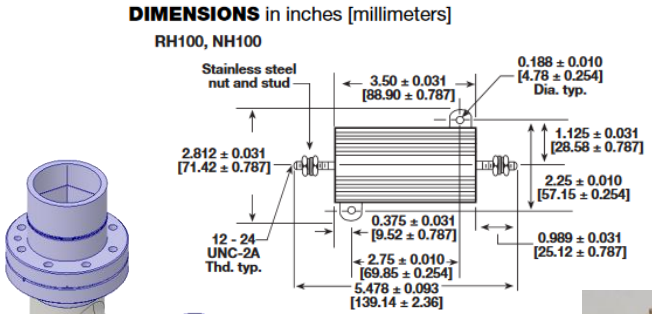
Cryogenics interfaces

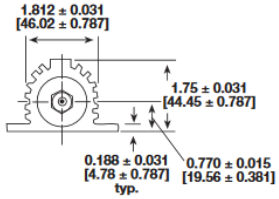
- Jumper interfaces
  - Cryogenic lines defined for DFX
  - Still discussions on DCM new module TS line
  - Jumper location above the QXL
  - DN250, longitudinal position TBC
- Temperature sensors supports
  - Interface long CERNOX
- Heaters Vishay® RH100 interfaces
- Level gauges interfaces
- DeltaP gauge pneumatic fittings to be agreed
- Pressure relief devices
  - See safety dedicated talk

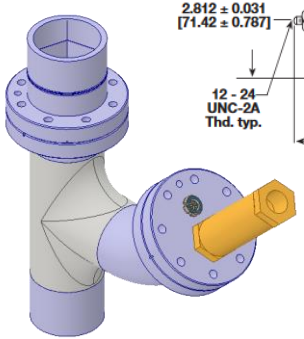


On going work for Jumper location





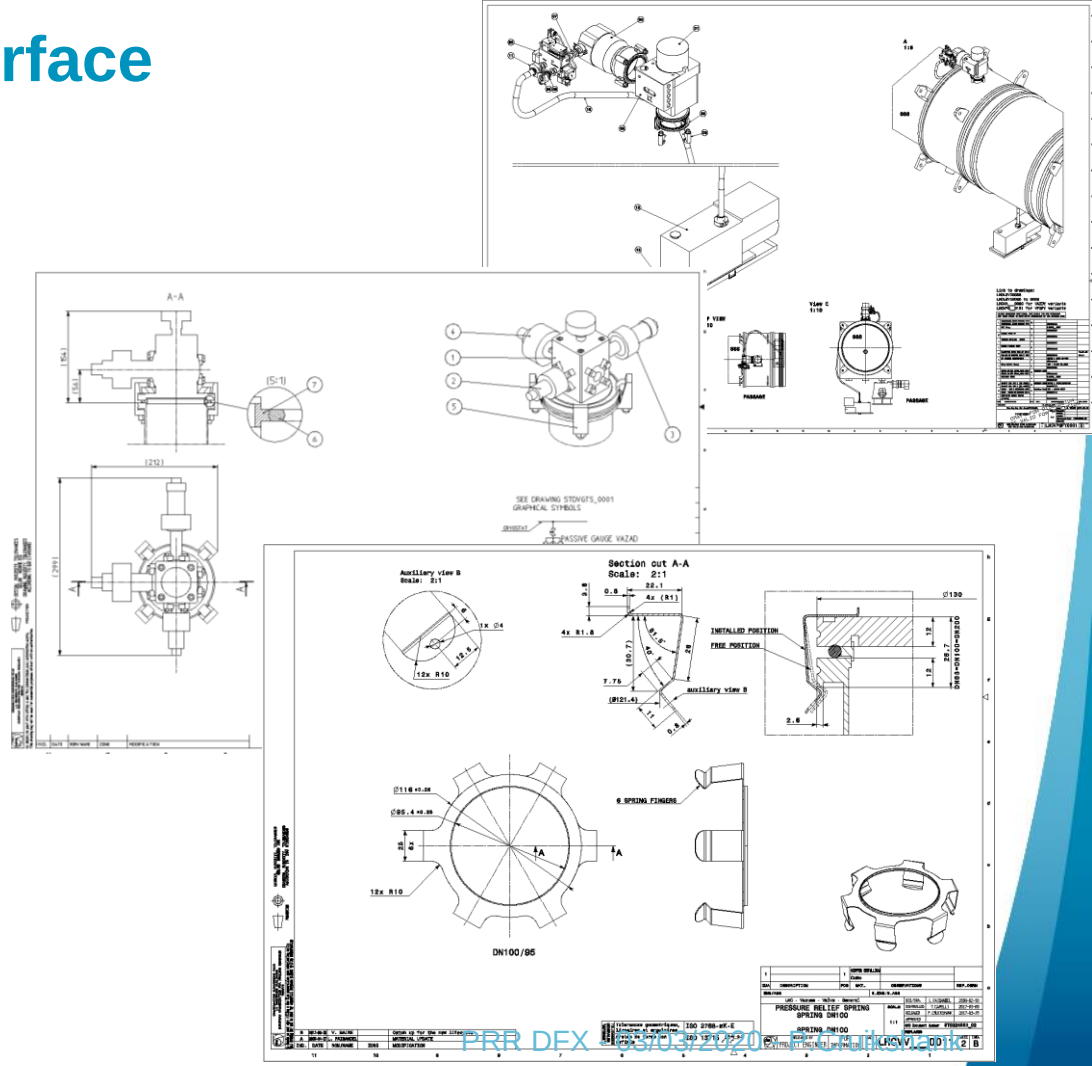




Insulation vacuum interface

- SCLink insulation vacuum volume
  - Pumping equipment :
    - valve + turbopump + primary pump
    - LHCVPGFY0001
  - Gauges interface
    - 3 gauges on one ISO DN100
    - LHCVA___0076
  - Relief plate interface
    - ISO-K DN100
    - LHCVV___0011

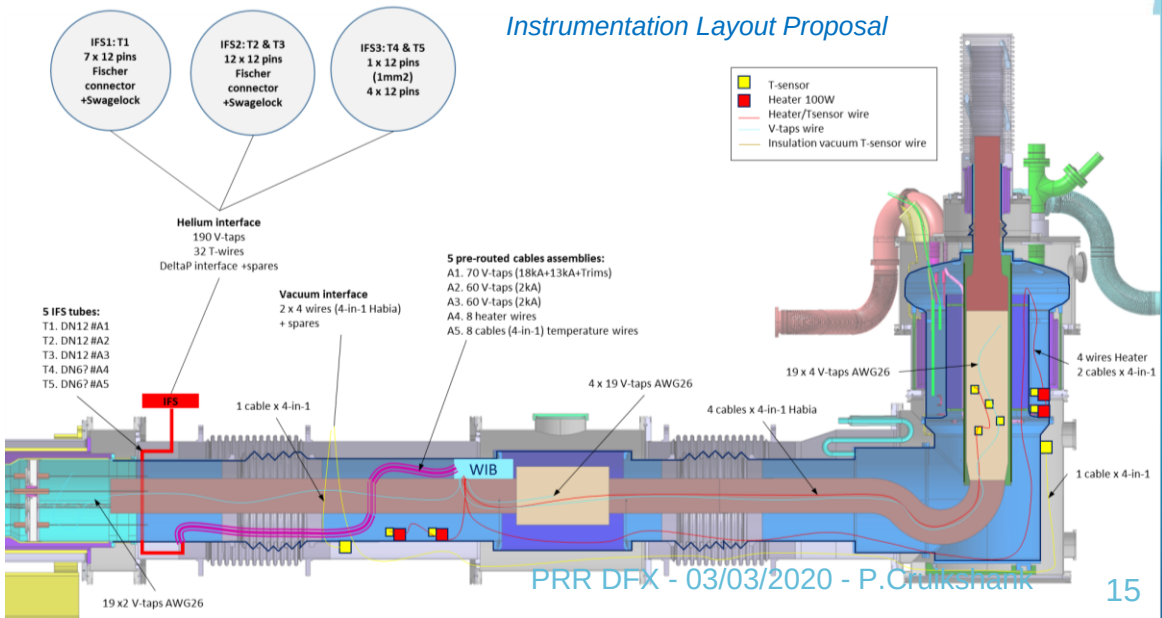
- DFX insulation vacuum volume
  - Pumping equipment
    - Valve + Turbopump + Primary Pump
    - LHCVPGFY0001
  - Gauges interface
    - 3 gauges pn pne DN100
    - LHCVA___0076
  - Relief plate interface
    - ISO-K DN200
    - ST0705009_01



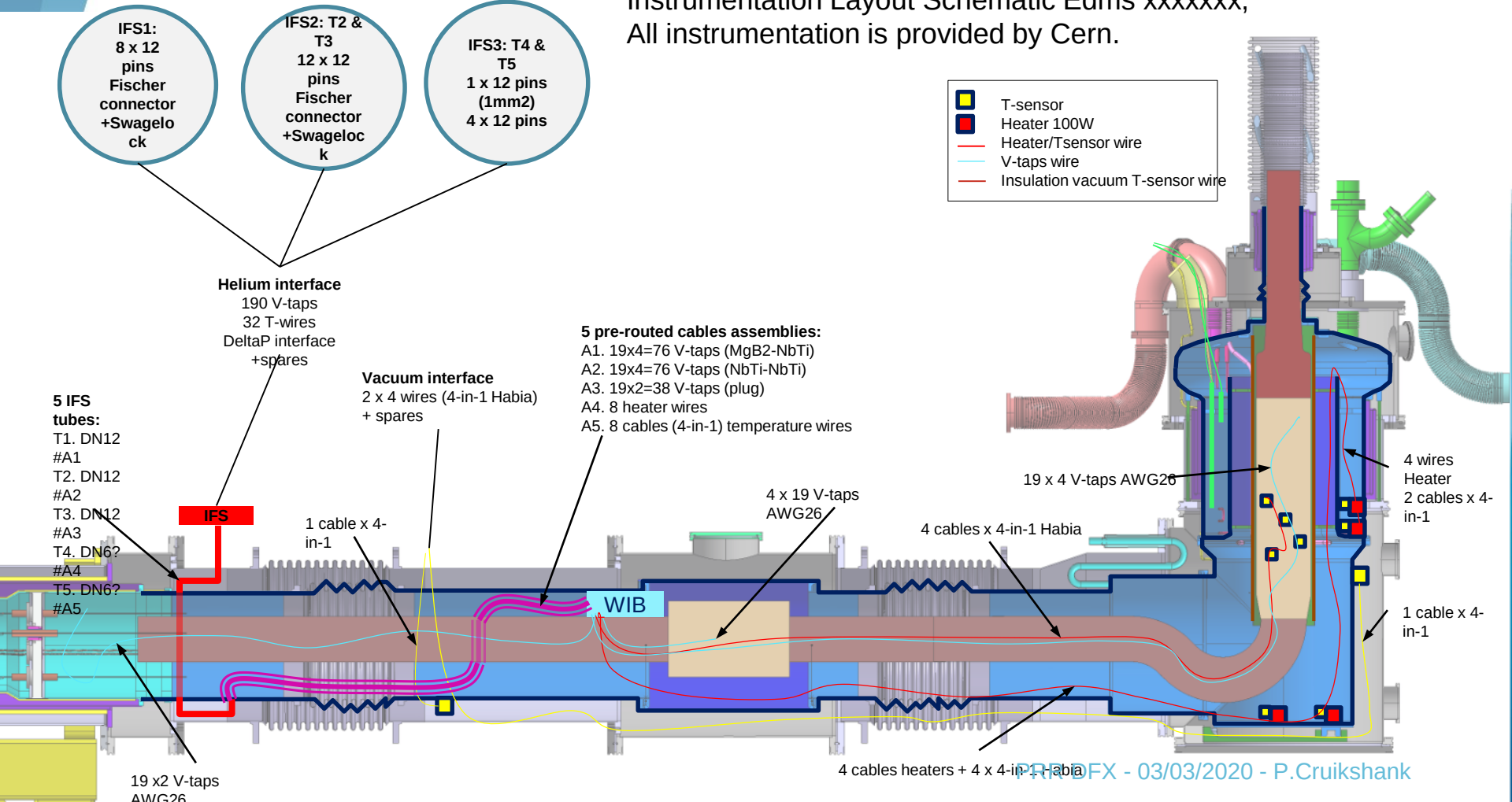
Instrumentation interface

- Mechanical supports
- Wire Instrumentation Box (WIB)
- IFS
  - (CERN design & supply)
  - 3 Flanges
  - 5 tubes sorted by functions
    - 190 V-taps
    - 32 T-wires
    - 8 power wires
- Vacuum instrumentation feedthrough ISO DN100

Instrumentation Layout Proposal

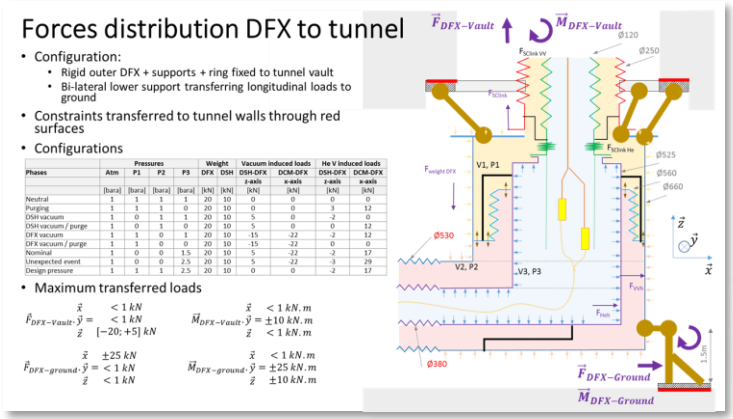


Instrumentation Layout Schematic Edms xxxxxxx, All instrumentation is provided by Cern.

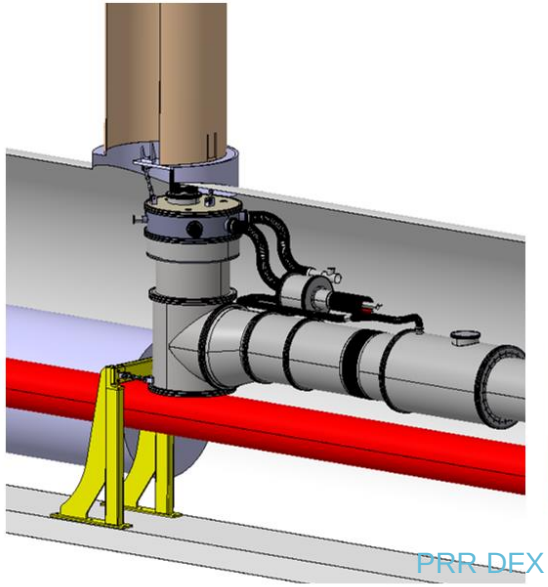


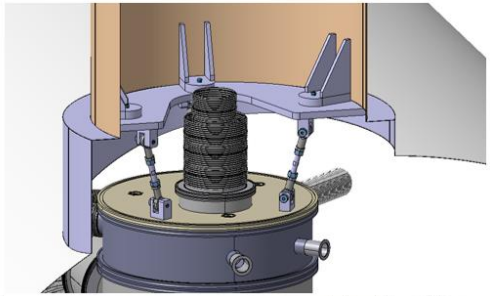
Civil Engineering & Transport Interfaces

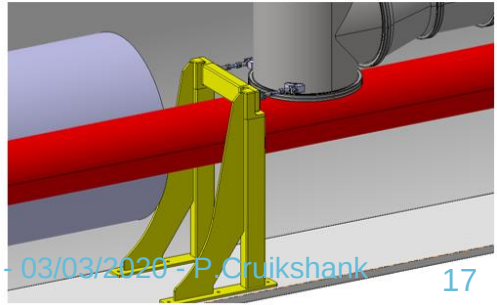
- CERN responsible for supports design to ground/ceiling in the tunnel
- Conceptual proposal to ceiling and ground being discussed at CERN
- DFX interfaces
  - Civil engineering : threaded blocks
  - Transport : adequate lifting points compliant with design
  - Tooling not defined today



On going studies for load transfer to civil engineering

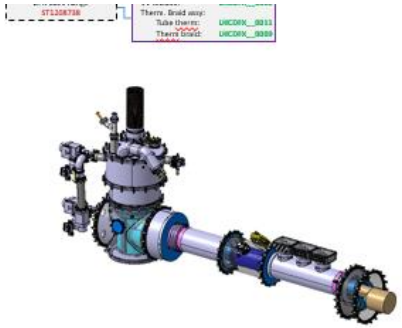


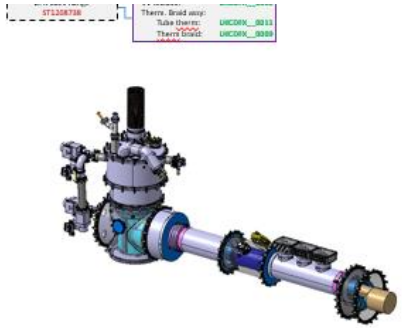




Assembly and P.Test configurations

- Need latest images/x-sections





- System fully assembled in UK to validate assimilability perform pressure test and all pressure configurations.
- To avoid welding/cutting operations at lip welds in UK, the design permits the closing of the helium vessel with elastomer seals prior to cable integration at Cern.
- CE marking is removed at Cern prior to the welding.

Summary