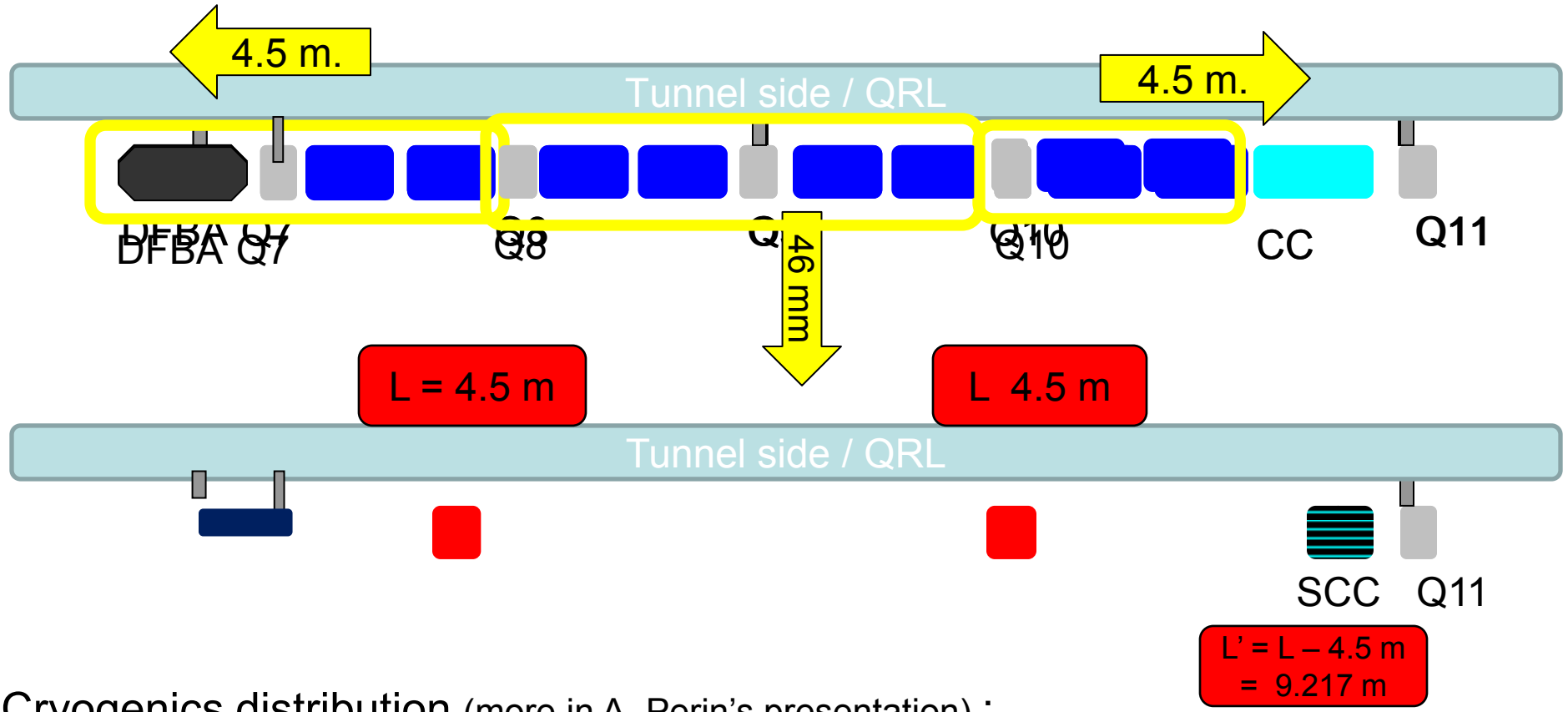
Outline (15 min + 5 min for ?)

- Introduction : Which components are concerned ?
- Short Connection cryostats (Major contribution from A Vande Craen)
  - What is a Connection Cryostat?
  - Differences (Improvements!) of SCC wrt the present design
    - Length reduction ! And the consequent modifications
    - Busbars supports and insulation
    - Shielding
  - Assembly
  - Cold tests
  - Schedule
- Modifications to the SSSs (Major contribution from N Bourcey)
  - Reason for modification : Integration of cryogenics extensions
  - Modifications of the jumpers
  - Schedule
- Conclusions

➢Introduction : Which components are concerned ?

DSR3 as an example



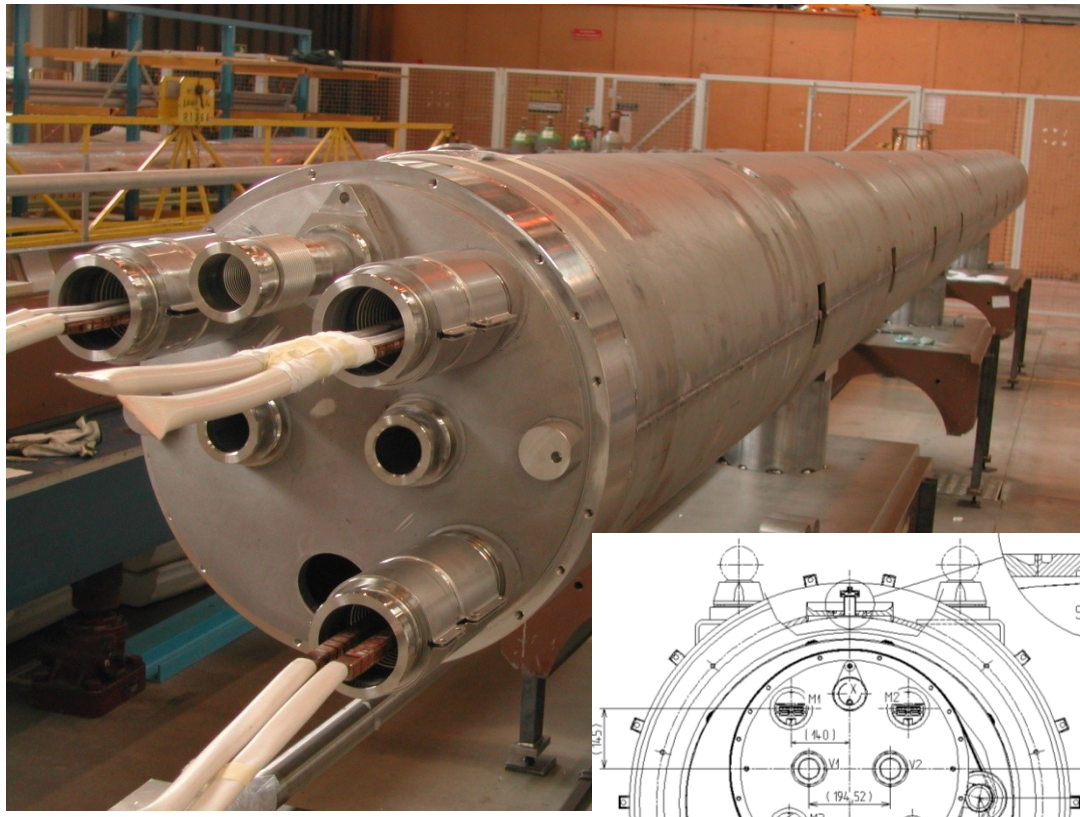
Cryogenics distribution (more in A. Perin's presentation) :

+ requiring to modify the Q7 jumpers
+ Q9 jumper to be extended by 46 mm
+ DFBA jumpers

Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

➢CC: Fill gap close to Q11 but continuity of all systems has to be ensured (Beam & insulation vacua, busbars, cryogenics, thermal insulation,…)

- Pseudo cold mass
  - Tubes for helium continuity
    - M lines (busbars)
    - X line (heat exchanger)
  - Beam lines
    - Actively cooled by V' lines
  - Shuffling module for liras
  - Stainless steel skin for rigidity
    - Same diameter as dipole
    - 10 mm thick
  - Support for tubes every 1,3 m
    - Supporting M and X lines
    - Alignment of beam lines
- Standard thermal shield
- Standard vacuum vessel cross section
- **Same interfaces as a cryodipole**



Courtesy A Vande Craen

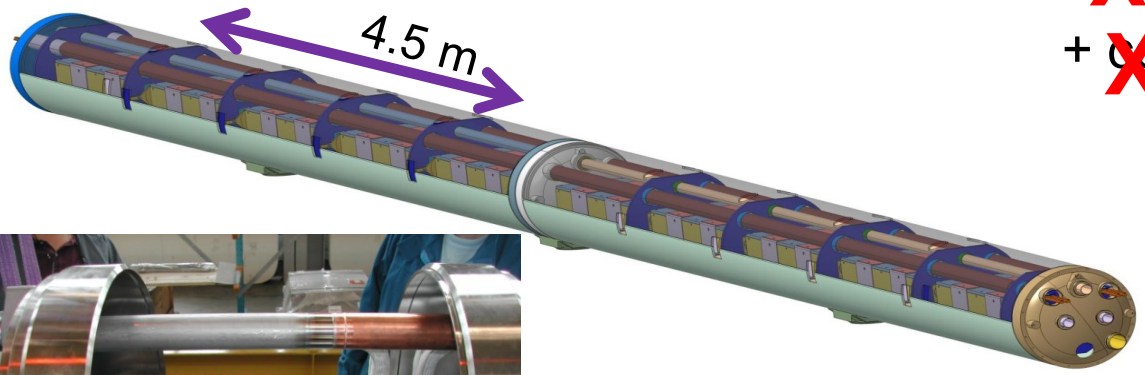
Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

➢SCC: Design principles/requirements

As anticipated in July 2010 review

- Reduce length by 4.5 m
- Correct known weaknesses
- Use proven and available design, components, tooling, procedure with minimum modification
- Same interfaces as a cryodipole
- Ref: LHC-LE-ES-0001

➢ Length reduction by 4.5 m

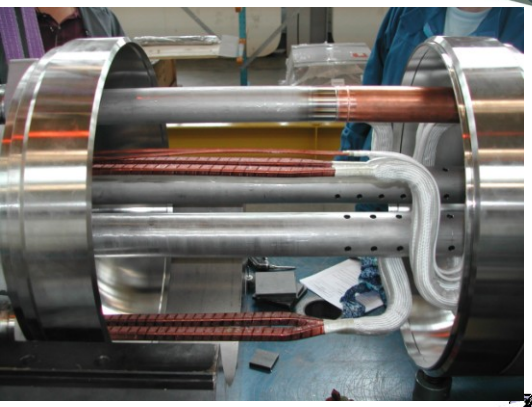


+~~X~~ / 2 support planes

+ ~~central~~ ~~XXX~~ / side “shuffling” module

Accessibility in case of ...

Acceptable for stability



Courtesy A Vande Craen

➢ Support posts position and tooling compatibility

Length (< 9 m)
Cold mass weight (≈ 20 kN)
Tooling availability
} 2 support posts

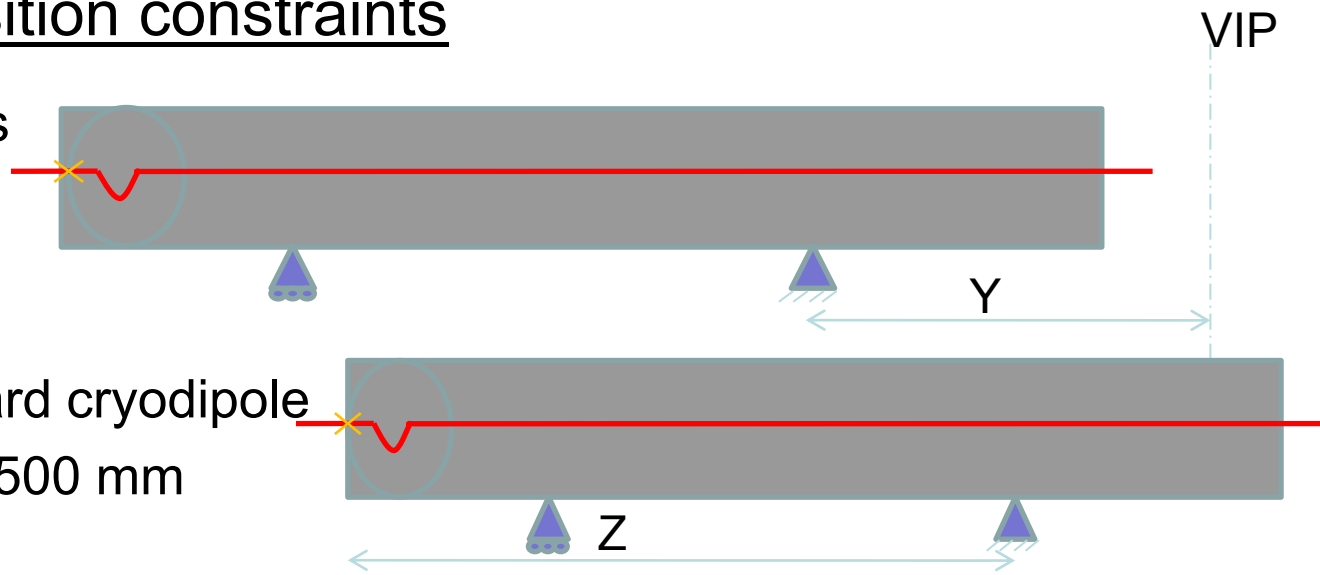
•Use existing tooling (if possible no modification)
•Distance between support
  •If possible = existing one
•Distance between support and extremity of Vacuum vessel
  •If possible = existing one

	ARC/DS-SSS	MS-SSS
Adaptations	Small	Reasonnable
Cradles	Not compatible	Compatible

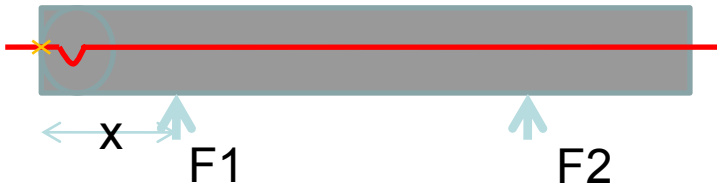
- Maximum distance between support for MS-SSS bench = 4680mm
  Max value taken for stability reasons
- Possible distance between extremity of vacuum vessel and first support
  - 1325
  - 1097
  - 2508.5
  - 2037.5

Courtesy A Vande Craen

➢ Support posts position constraints



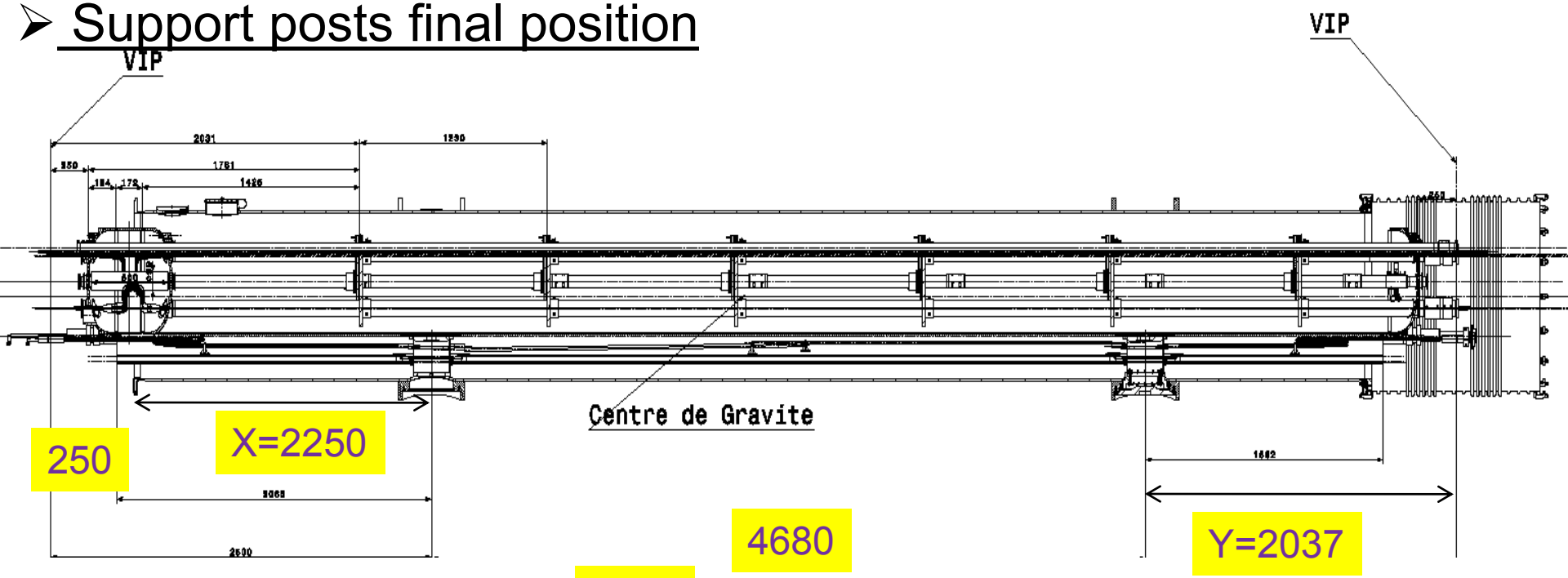
- Opening of W bellows
  - ➢ Y > 1972 mm
- Lira stroke < a standard cryodipole
  - ➢ 1140 mm < Z < 7500 mm
- Stability under IC forces with a light cold mass (< 20 kN)



	Torque				Lira expansion	
Torque	Clockwise		Counter Clockwise		Left Dipole	CC
X	F1	F2	F1	F2		
1397	-2361	21361	17196	1804	31.2	48.7
1625	-1435	20435	18121	879	31.9	48.0
1228.5	-3045	22045	16512	2488	30.7	49.2
1699.5	-1133	20133	18423	576	32.1	47.8
2250	1102	17898	20659	-1659	47.8	32.1

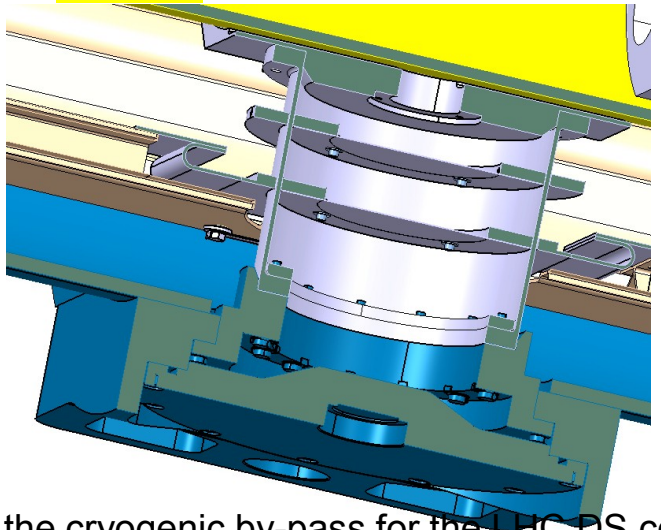
Courtesy A Vande Craen

➢ Support posts final position



Sliding support

Sliding support :
Cryodipole type



Fixed support

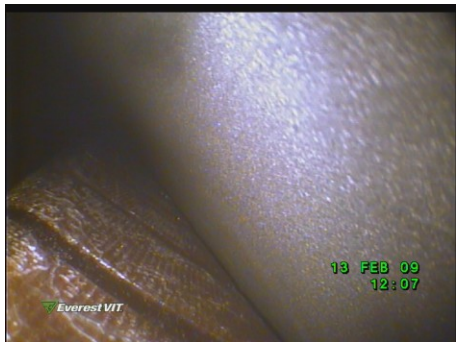
Vertical force

➔ Dipole height, SSS type

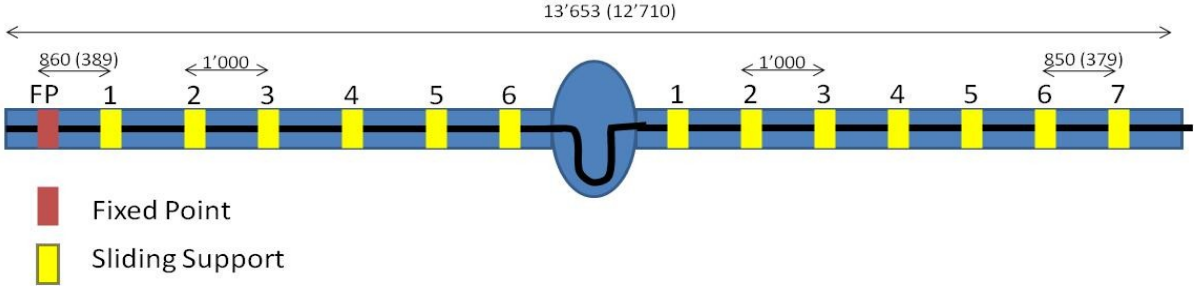
As in the cryo-bypass

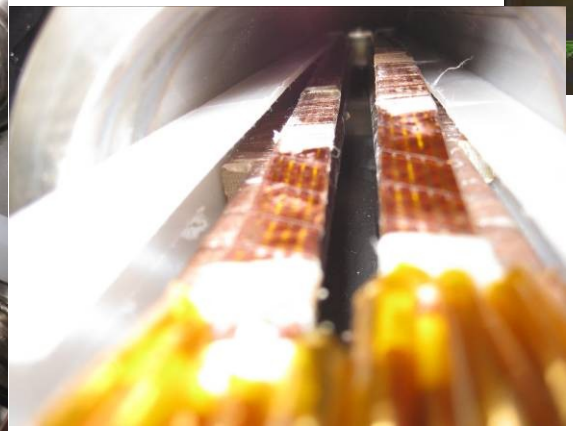
Courtesy A Vande Craen

➢ Busbar support and electrical insulation (1/4)



- Consolidation of the CC busbar (LHC-LE-EC-0003) :
  - Displacement of the BB supports likely during assembly
  - Additional insulation to protect for short to ground
  - Solution to be implemented from the design stage



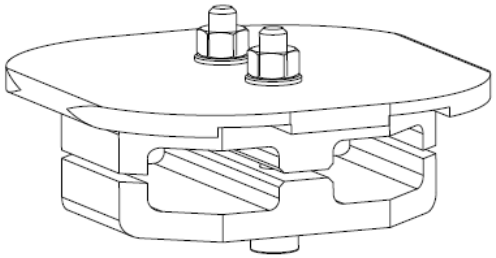


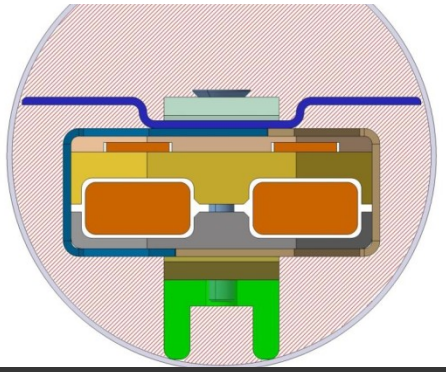
Courtesy A Vande Craen

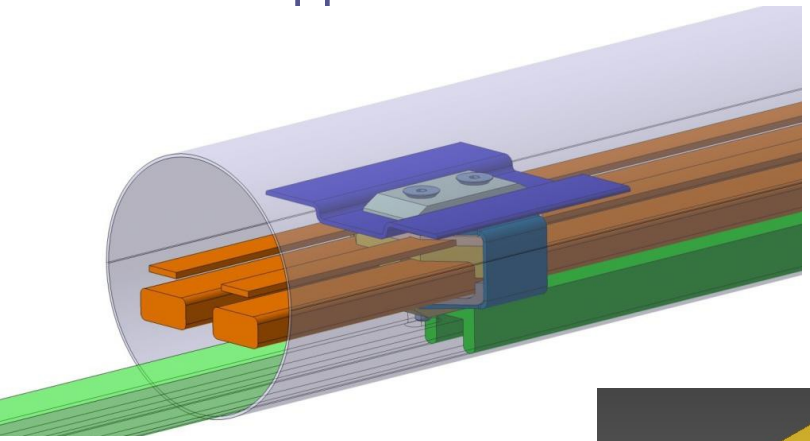
➢ Busbar support and electrical insulation (2/4)

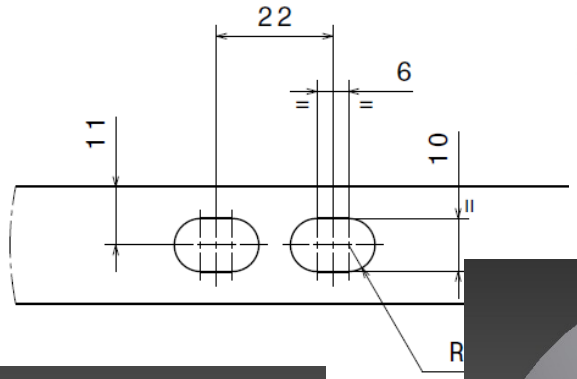
In collaboration with IPNO

- Consolidation of the CC busbar (LHC-LE-EC-0003) :
  - New supports with a supporting PEHD beam
    Fixed distance between supports
  - Rail fixed in shuffling module
  - First support at extremities of M lines

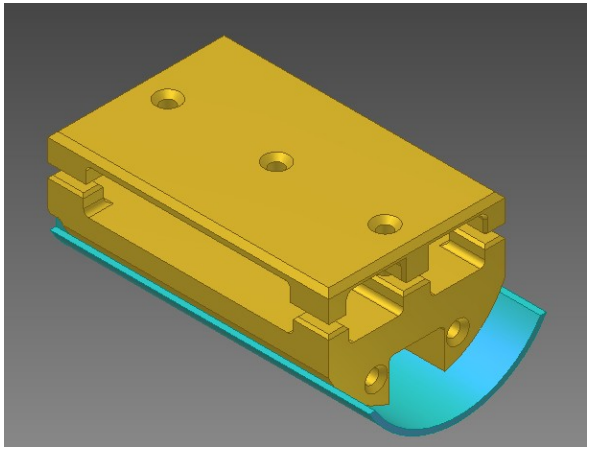


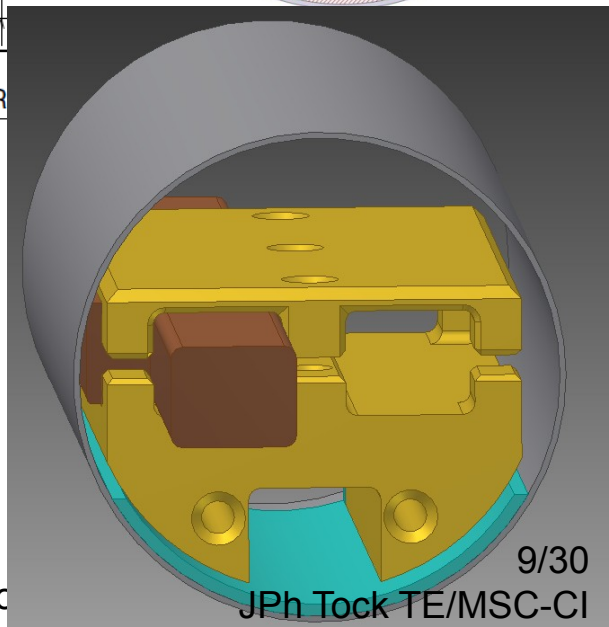






- Fixed support
  - Dismountable
  - Fully insulating

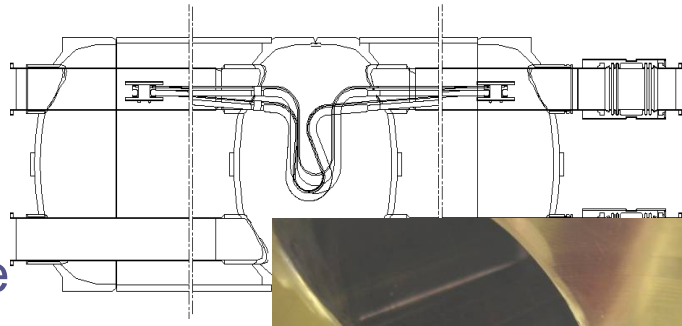


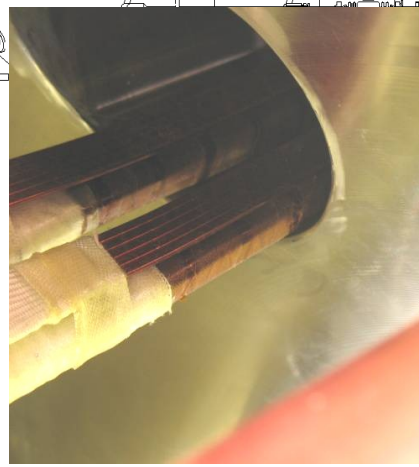


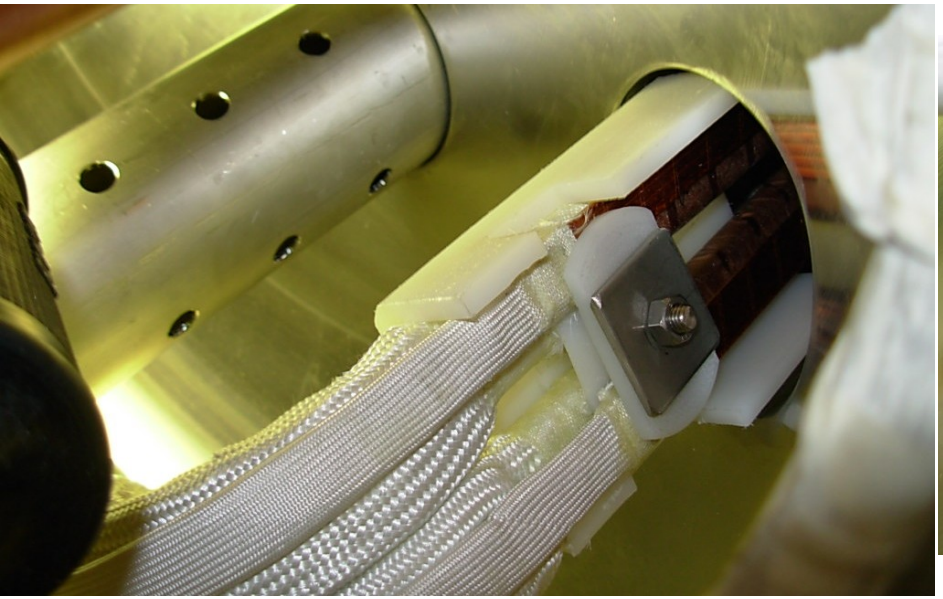
Courtesy A Vande Craen

➢ Busbar support and electrical insulation (3/4)

- Consolidation of the electrical insulation of the CC busbar (LHC-LE-EC-0004):
  - Short to ground in shuffling module
  - Additional insulation for
    - Liras
    - Busbars at extremities of shuffling module
- Solution to be implemented from the design stage



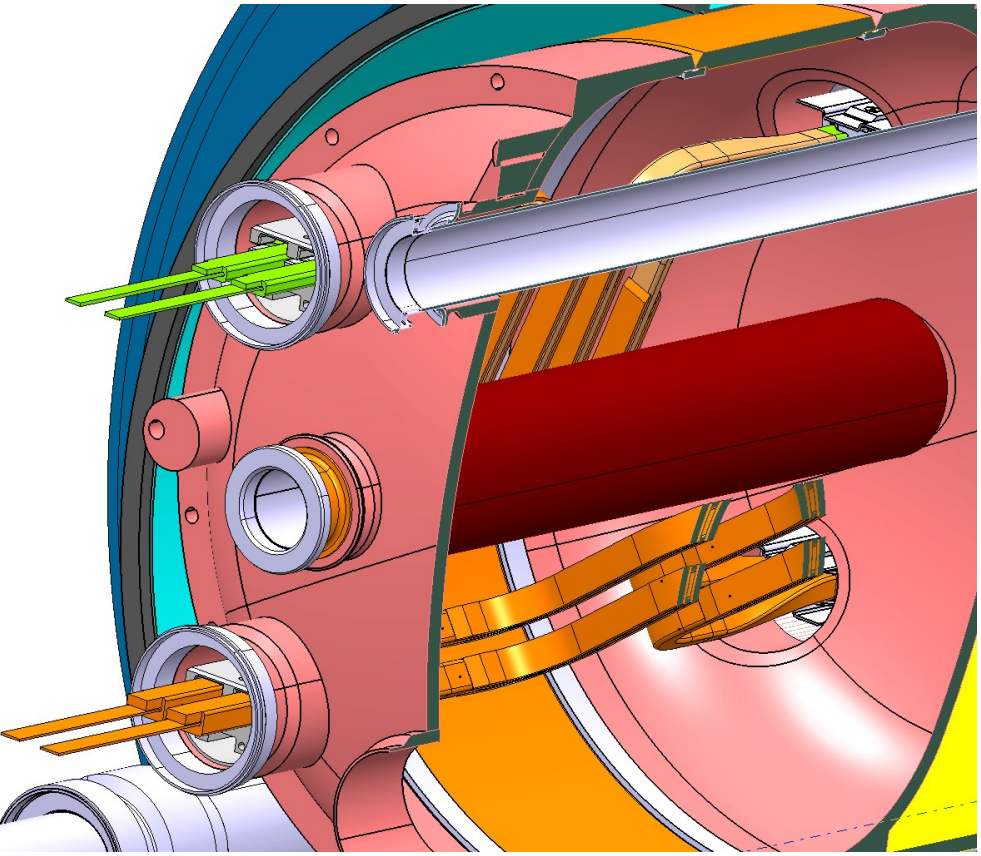


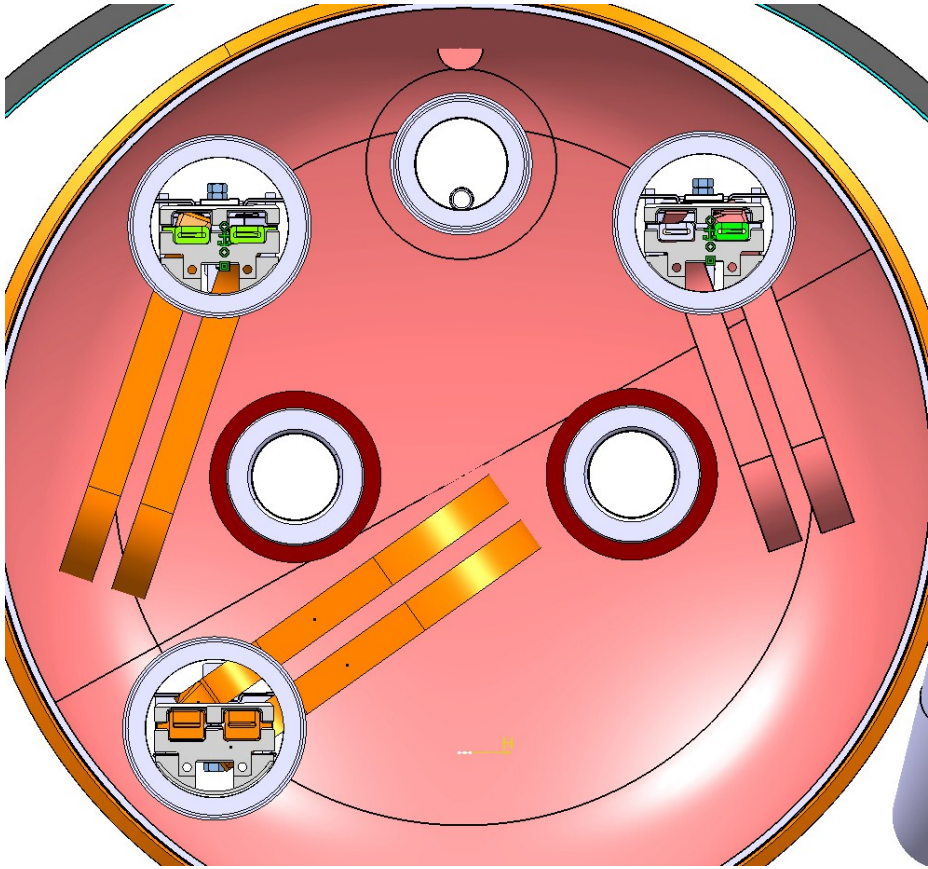


Courtesy A Vande Craen

➢ Busbar support and electrical insulation (4/4)

- Support close to tube extremity
- Lira insulation (PEHD boxes)
- Beam tubes (shielding) insulation

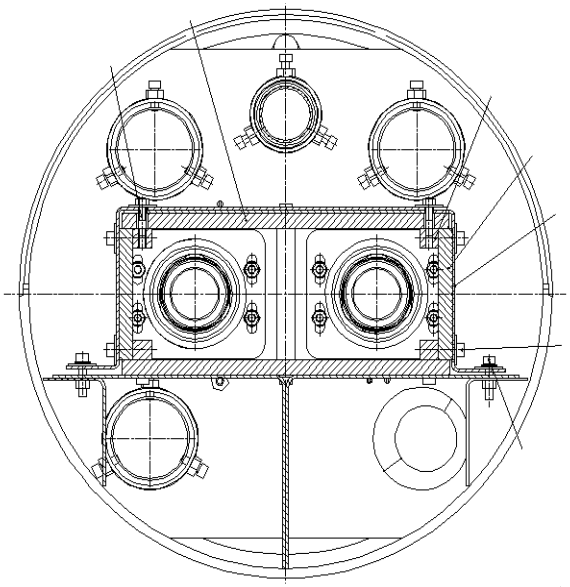




Courtesy A Vande Craen

➢ Radiation shielding (1/4)

- Specification for shielding [From lhc-le-es-0001]
  - The dose maps as given in LHC Project Note 296, which are based on the assumption that no shielding is foreseen, show unacceptable high radiation levels in and around the “LE”. The typical values are of several hundreds to thousands gray per year close to the cryostat. Shielding is required to reduce the annual dose in and around the “LE” to values similar to those of the arc magnet interconnects. Such a shielding might consist of 50 mm thick steel or **15 mm thick lead cylinders, located around the cold bores** (private communication by C.A. Fynbo) and reducing the radiation level to ~100 gray per year. In any case, the shielding shall consist of non-magnetic material



- 112 th LHC Coll Study group (30.08.2010)
  - “From the FLUKA teams point of view the simulations showed that there are no losses expected and therefore a shielding is not needed for Phase II”

➢ ***Consequently, lead shielding was removed***

Courtesy A Vande Craen

➢ Radiation shielding (2/4)

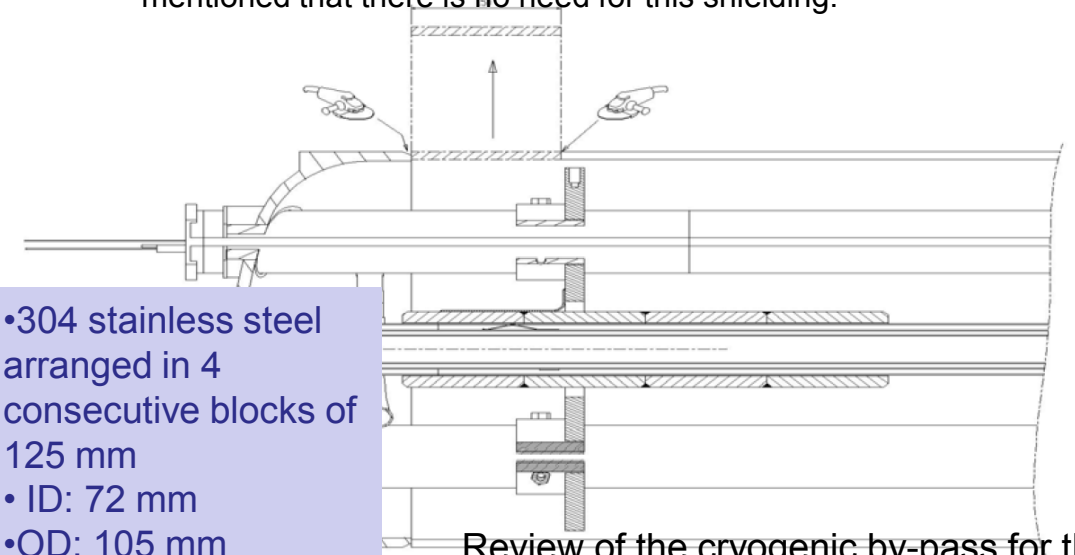
▫ Additional Shielding in the Interconnection Cryostats[From lhc-le-ec-0002]

- During the analysis which followed the cold test of an interconnection cryostat in November 2005 and the subsequent discovery of the superconducting lead shielding problem, the heat loads received by the pseudo cold mass of these assemblies from lost particles originating from IR's were reviewed.
  It appeared then that some requirements concerning the protection of adjacent magnets (e.g. Q11) against these losses had been overlooked, in particular the necessity to shield as close as possible to the beam tube, in order to intercept particles at very low angles. ***This ECR proposes to add stainless steel shielding at each extremity of the connection cryostats, around the beam tubes.***

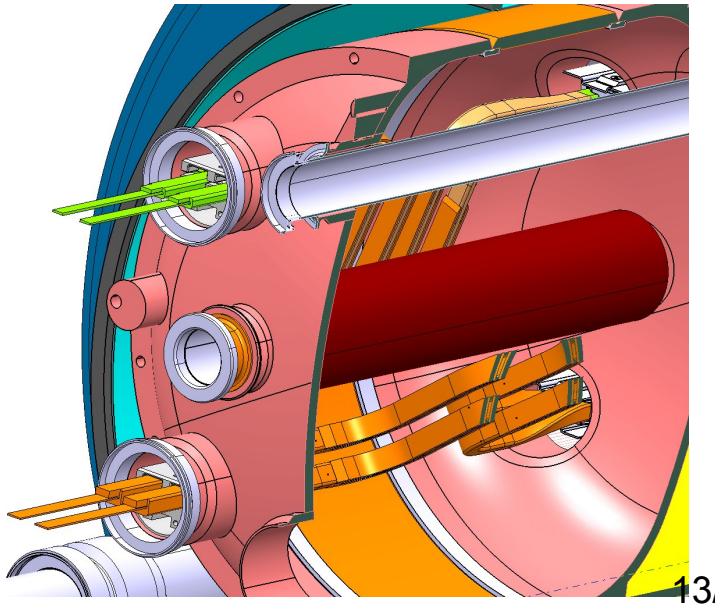
▫ 112 th LHC Coll Study group (30.08.2010)

- "It was mentioned that V. Cerrutti published a paper presenting a shielding of 13mm stainless steel for the Q11 for regular losses. Ralph mentioned that there is no need for this shielding. "

➢ ***Consequently, this shielding has been removed but provisions are made to install it if finally found necessary***

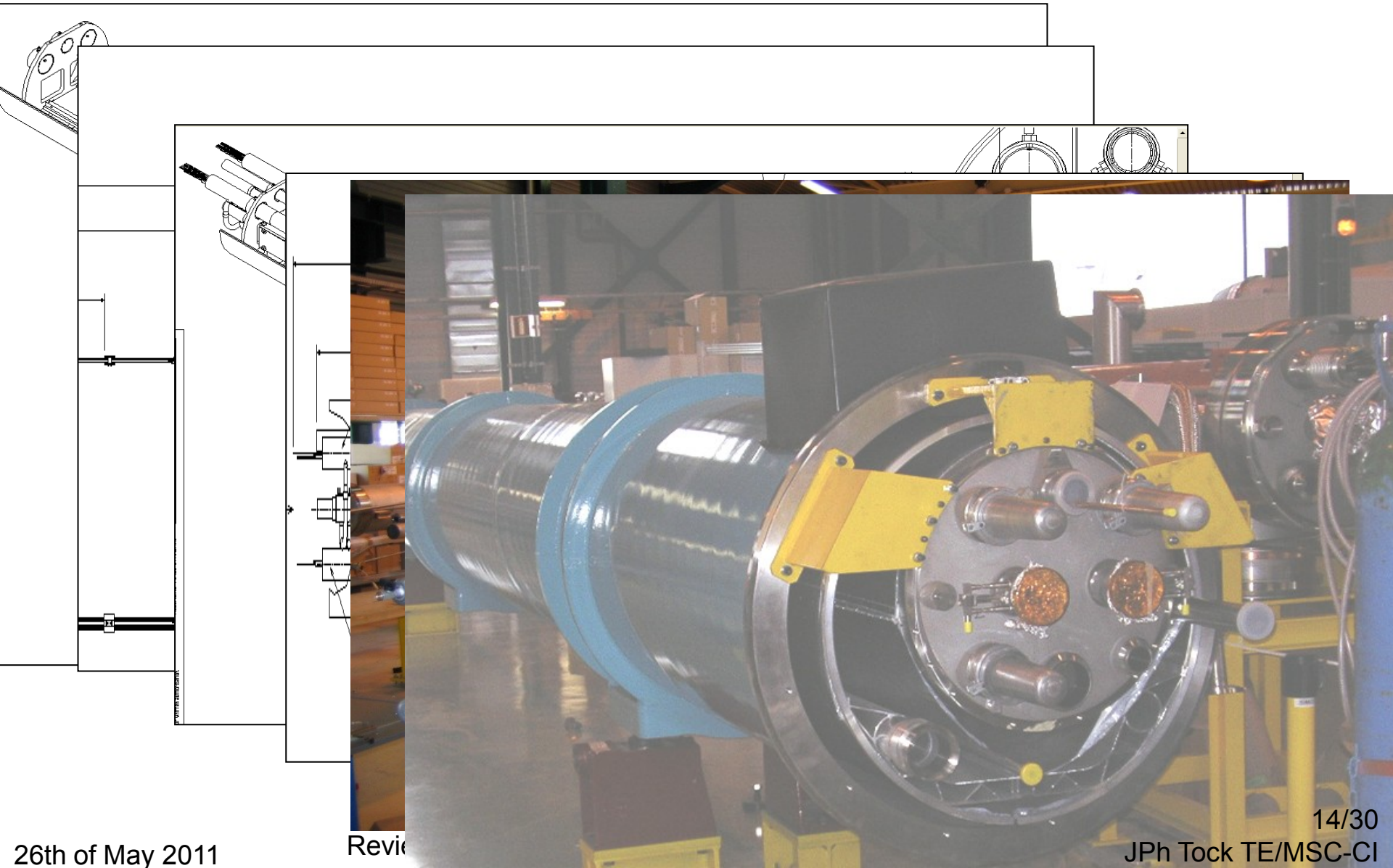


•304 stainless steel arranged in 4 consecutive blocks of 125 mm
• ID: 72 mm
•OD: 105 mm



Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

- Assembly (Same sequence as present CCs)

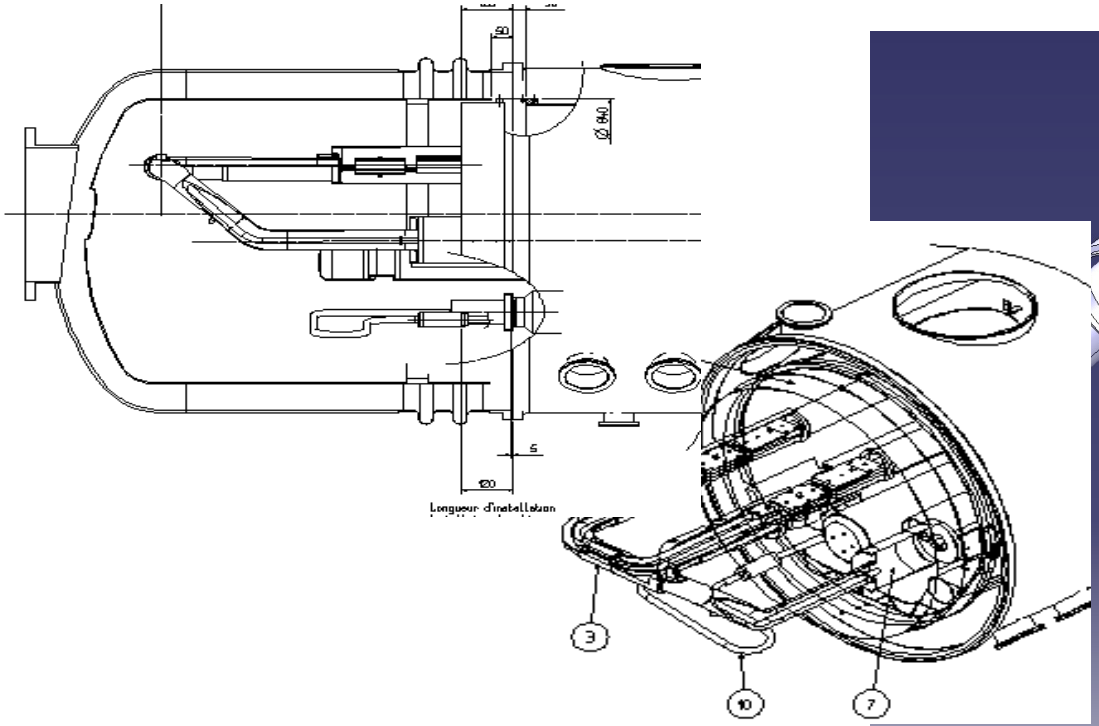


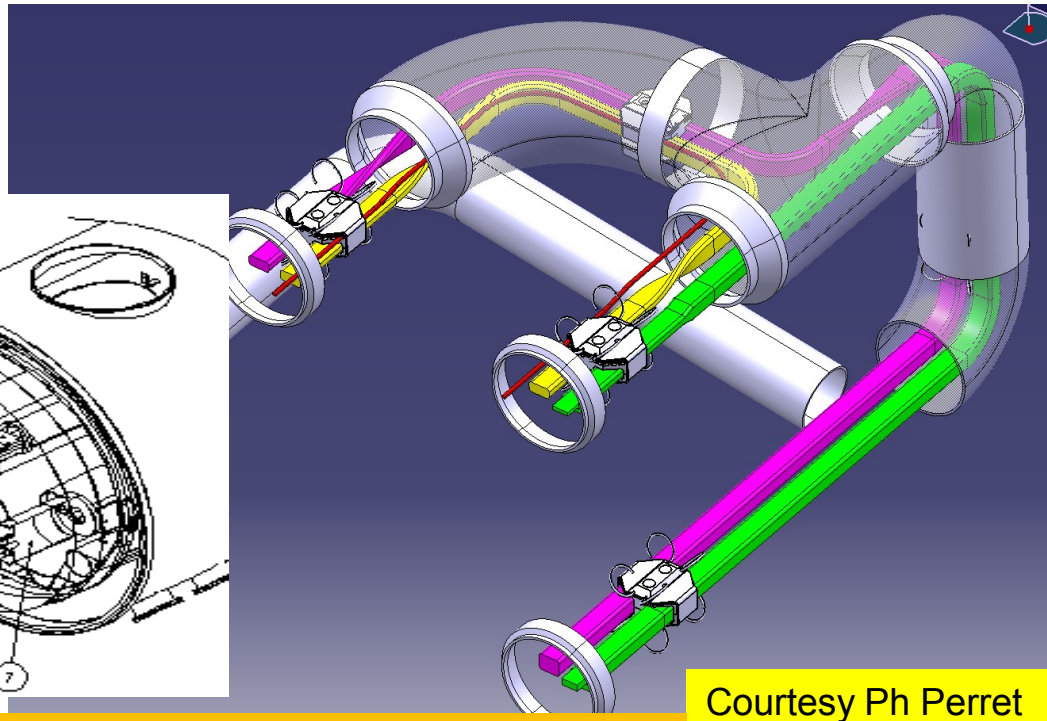
➢ Cold test in SM18 (1/3)

Feasibility study concluded:

- A design to equip the cryoassembly for cold test in SM18 exists
- The cold test bench in SM18 can be adapted with reasonable modifications (M Bajko)

As no show stopper was identified, this work was put on hold, pending the results of the June review.





Courtesy Ph Perret

Probably applicable to QTC with minor or no modification

Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

Probably applicable to QTC with no or minor modification

➢ Cold test in SM18 (2/3)

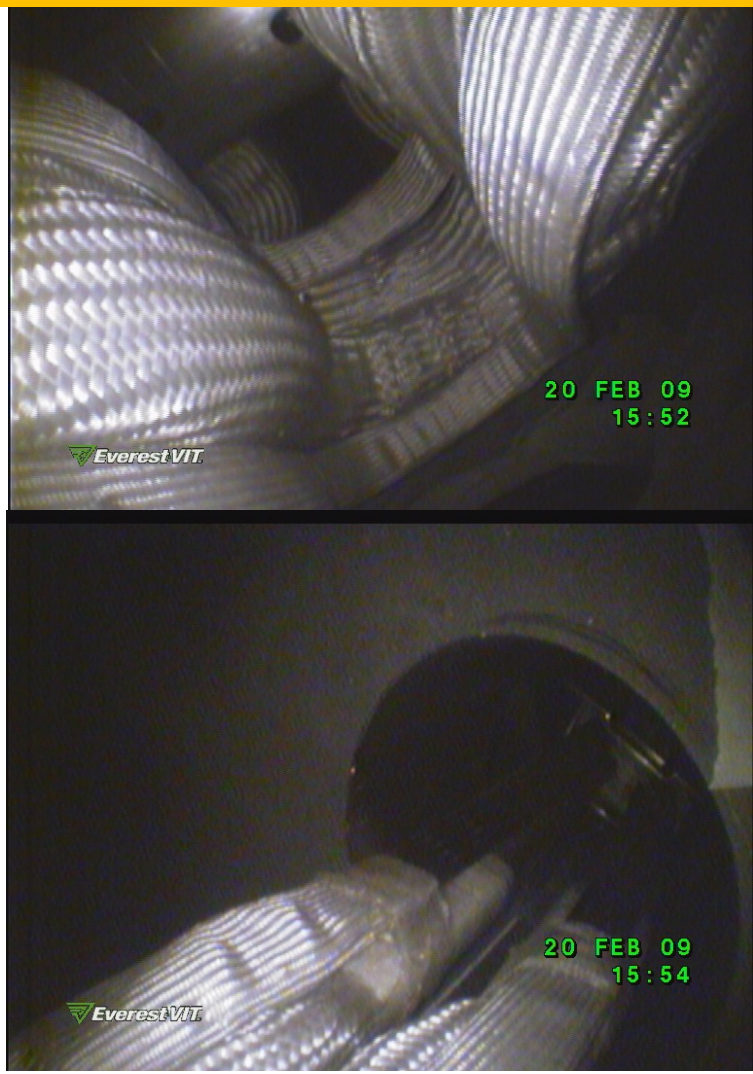
Various configurations:

+ Connected / Disconnected
+ Atm pressure / Under vacuum
+ Room temperature / Cold
+ Current cycling

Tests

As close as possible to machine configuration but not identical!:

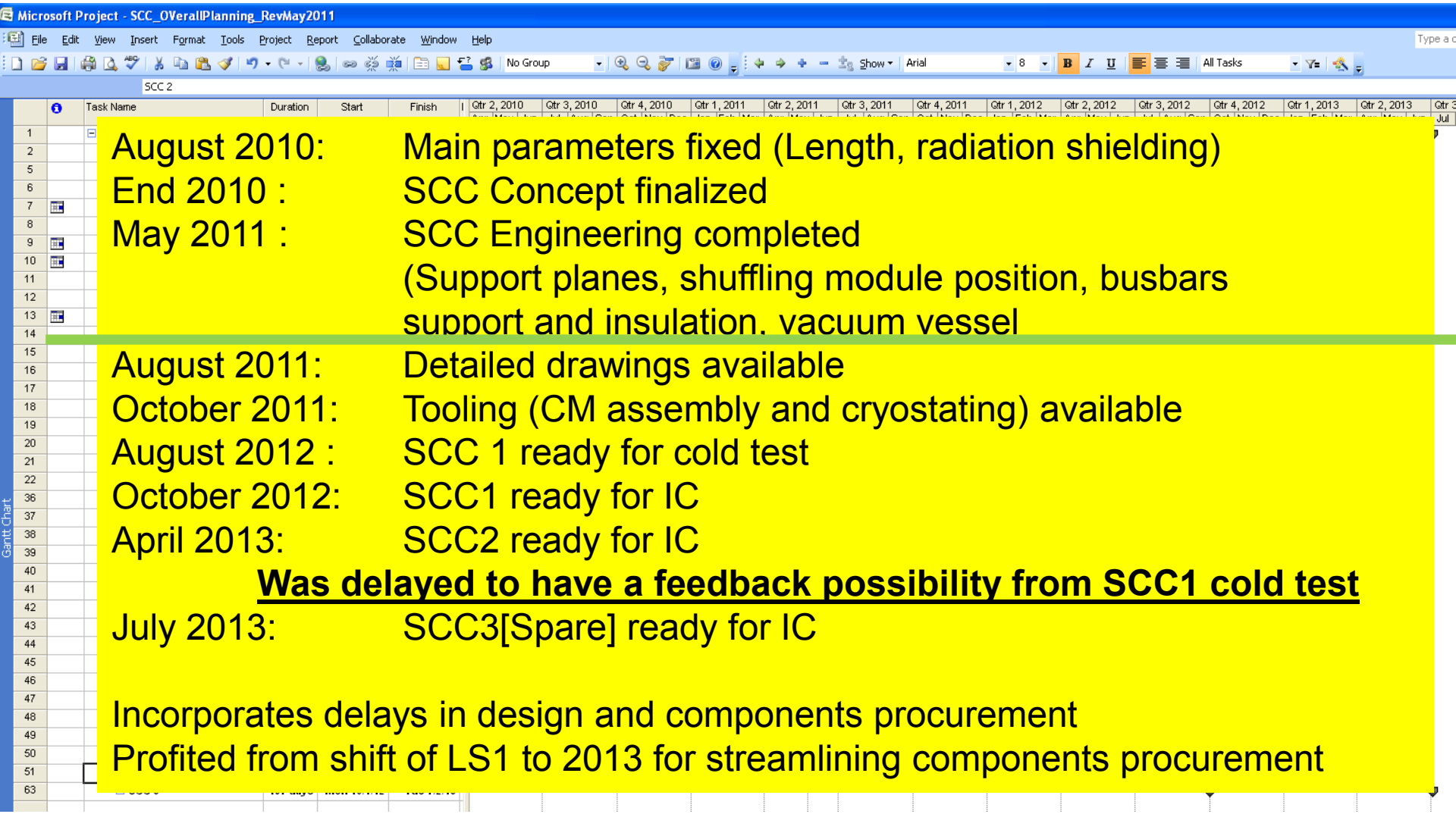
+ Lyra functioning (Motion with endoscope check)
+ Electrical continuity
+ Insulation to ground / between BB [HV]
+ RRR
+ Residual magnetic field (type test / Not for QTC)



Test is feasible in < 4 weeks

Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

➢Schedule



August 2010: Main parameters fixed (Length, radiation shielding)
End 2010 : SCC Concept finalized
May 2011 : SCC Engineering completed
(Support planes, shuffling module position, busbars support and insulation, vacuum vessel

August 2011: Detailed drawings available
October 2011: Tooling (CM assembly and cryostating) available
August 2012 : SCC 1 ready for cold test
October 2012: SCC1 ready for IC
April 2013: SCC2 ready for IC

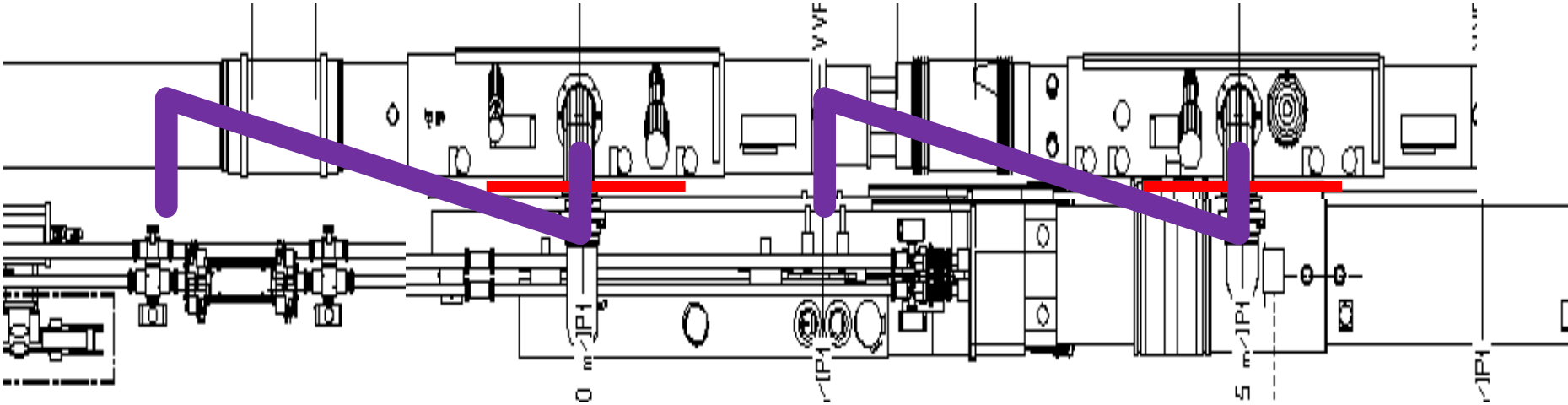
Was delayed to have a feedback possibility from SCC1 cold test

July 2013: SCC3[Spare] ready for IC

Incorporates delays in design and components procurement
Profited from shift of LS1 to 2013 for streamlining components procurement

➢Cryogenics extenstion connection to the SSS

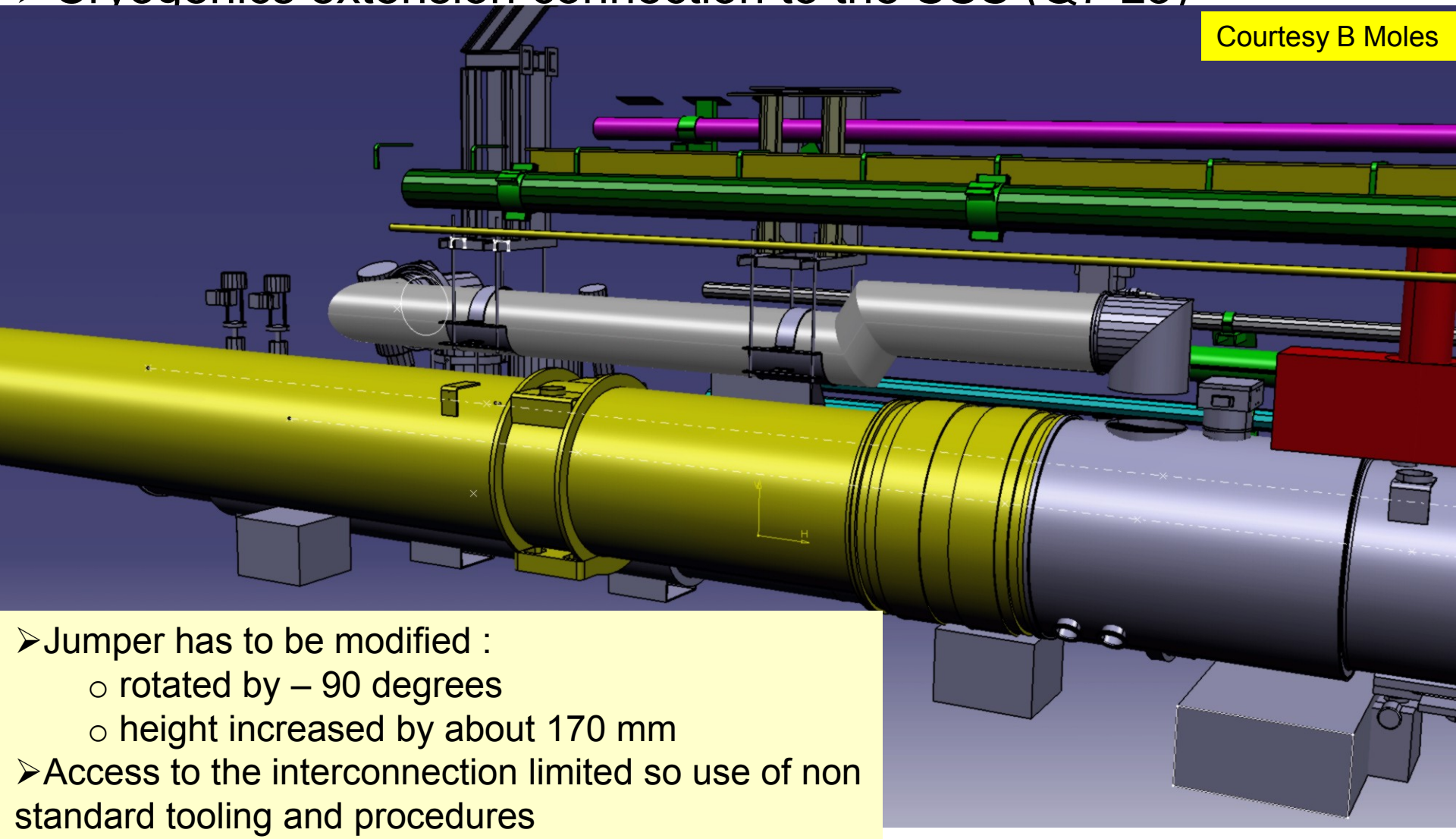
July2010 review : No impact on Q7



Progressing with the integration, it became clear that the most suitable solution was to modify the SSS jumpers

Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

- Cryogenics extension connection to the SSS (Q7 L3)



- Jumper has to be modified :
  - rotated by – 90 degrees
  - height increased by about 170 mm
- Access to the interconnection limited so use of non standard tooling and procedures

Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

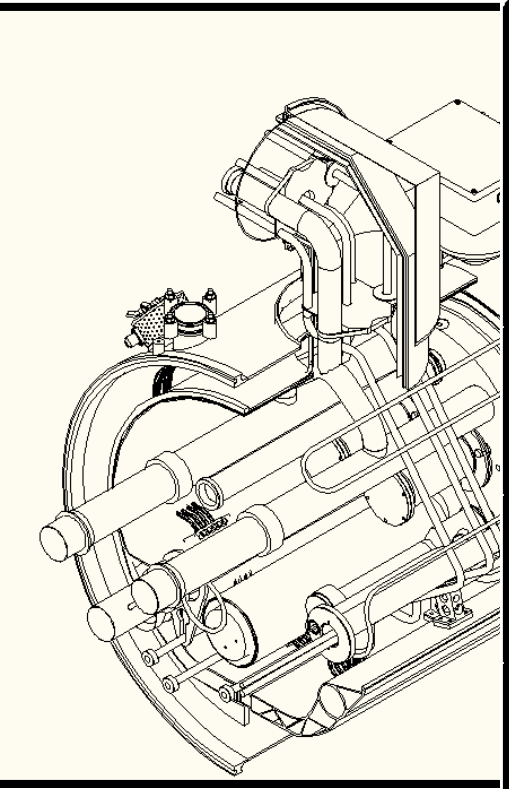
➢Cryogenics extension connection to the SSS (Q7 R3)

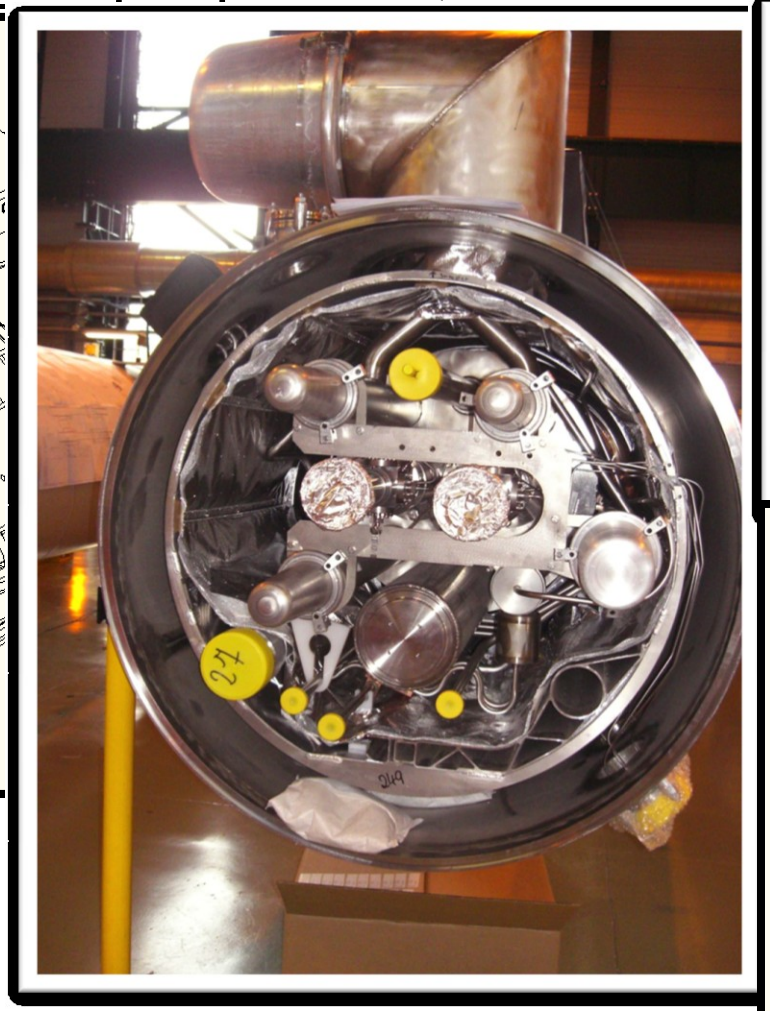
- Jumper has to be modified :
  - rotated by + 90 degrees
  - height increased by about 0.5 m
- Access to the IFS reduced but still comfortable

Courtesy B Moles

Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

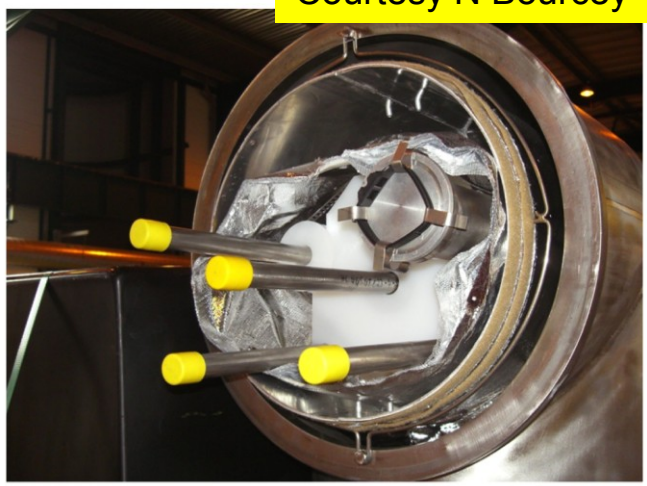
➢Modification of the jumper of Q7 L3

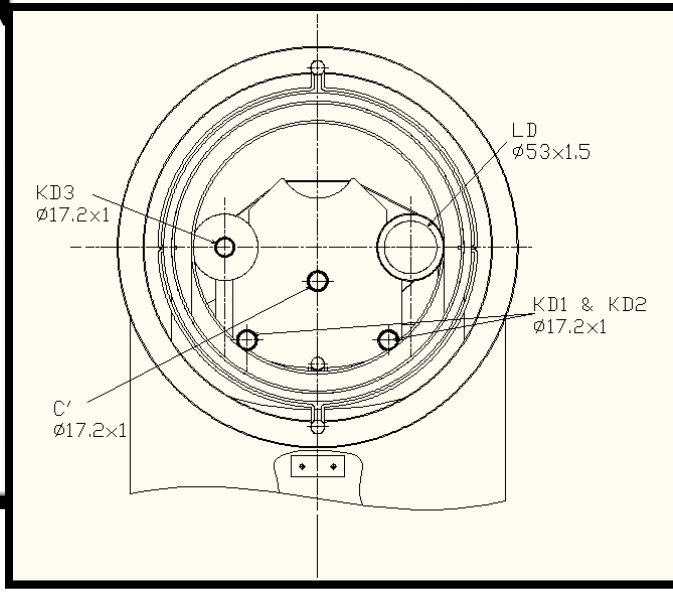




SSS-501 at SMI2 ready for tunnel

Courtesy N Bourcey

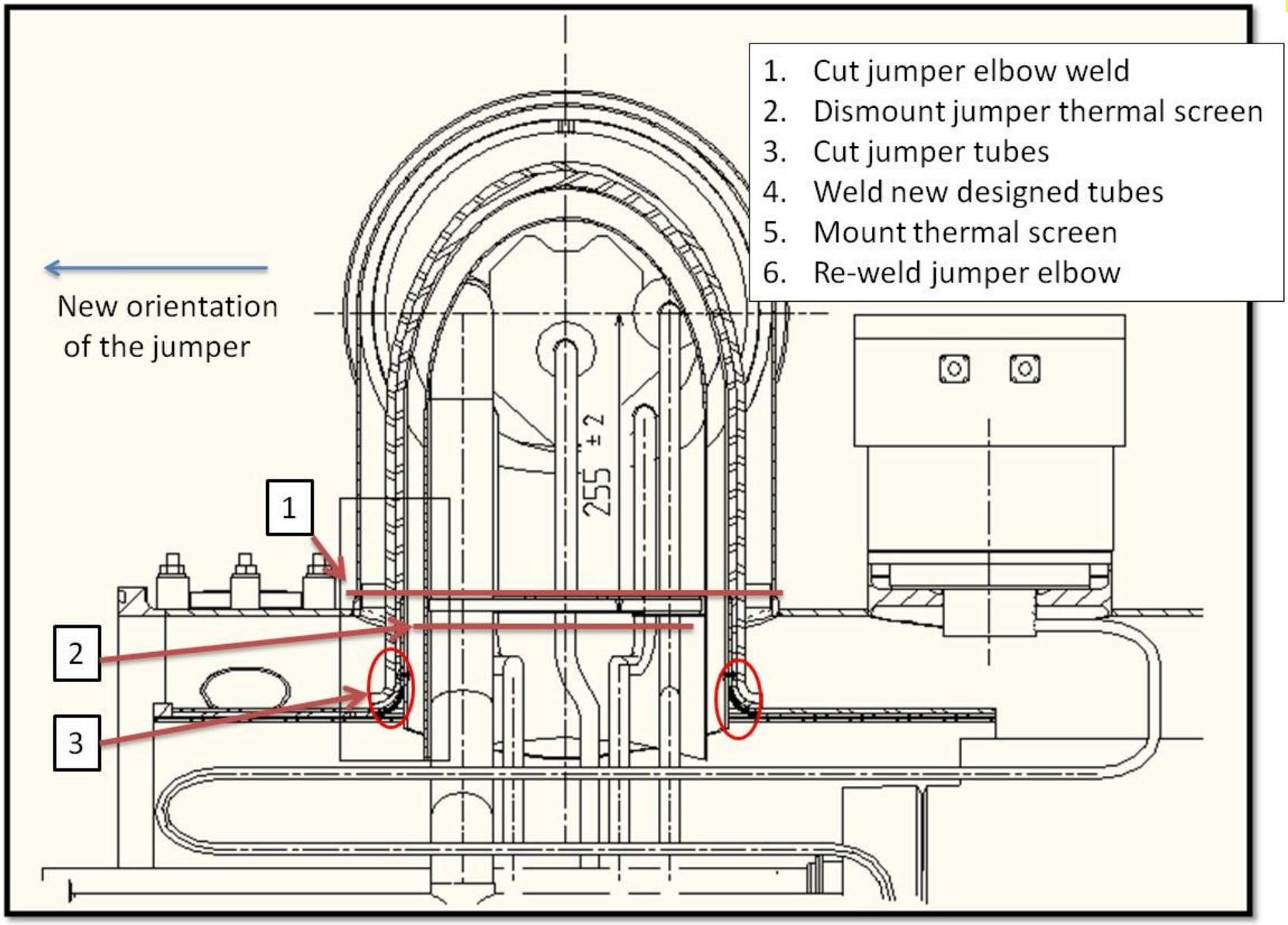




Height standard 680mm from beam axis
No phase separator so no XB & CY tubes
No He level gauge & helium guard

➢Modification of the jumper of Q7 L3

Courtesy N Bourcey

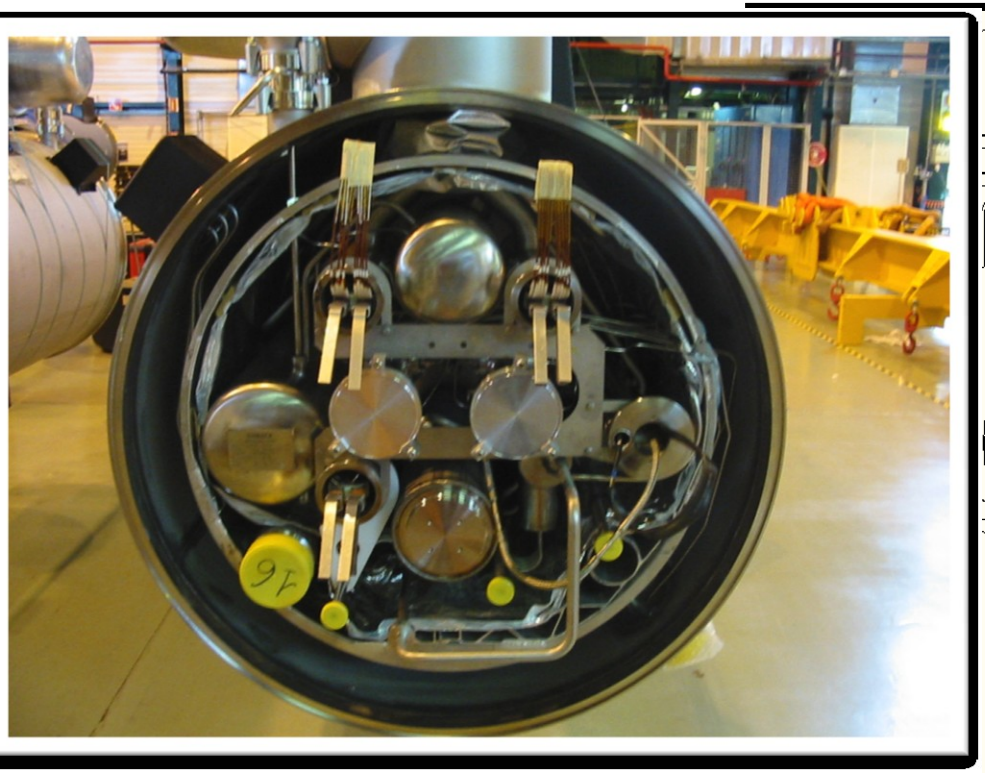


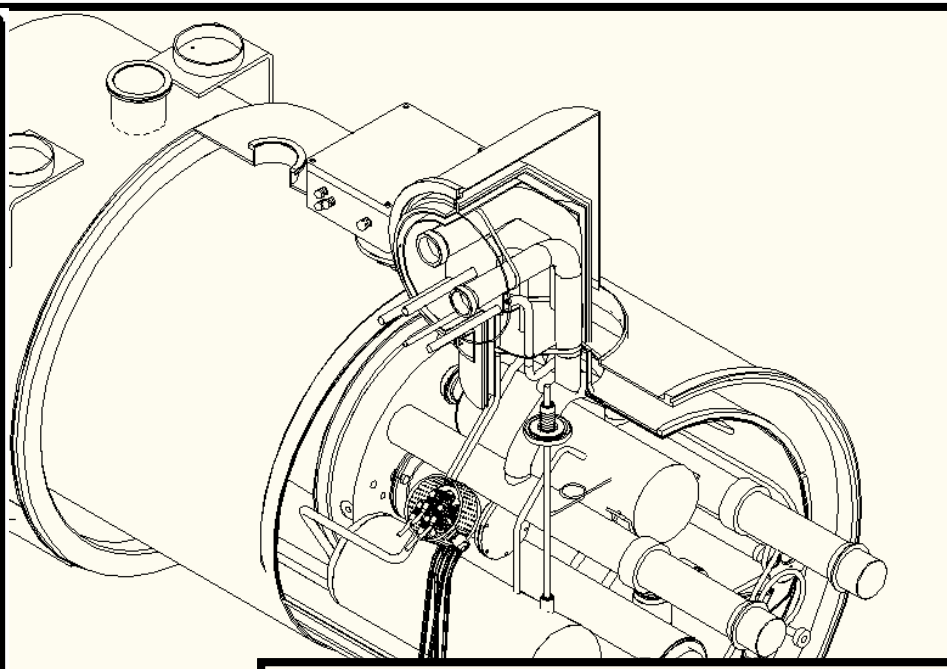
Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

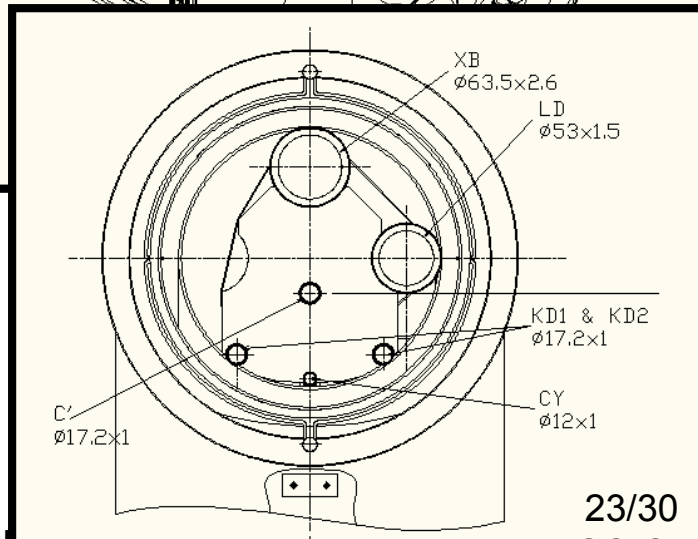
➢Modification of the jumper of Q7 R3

SSS-512 at SMI2 ready for tunnel

Courtesy N Bourcey







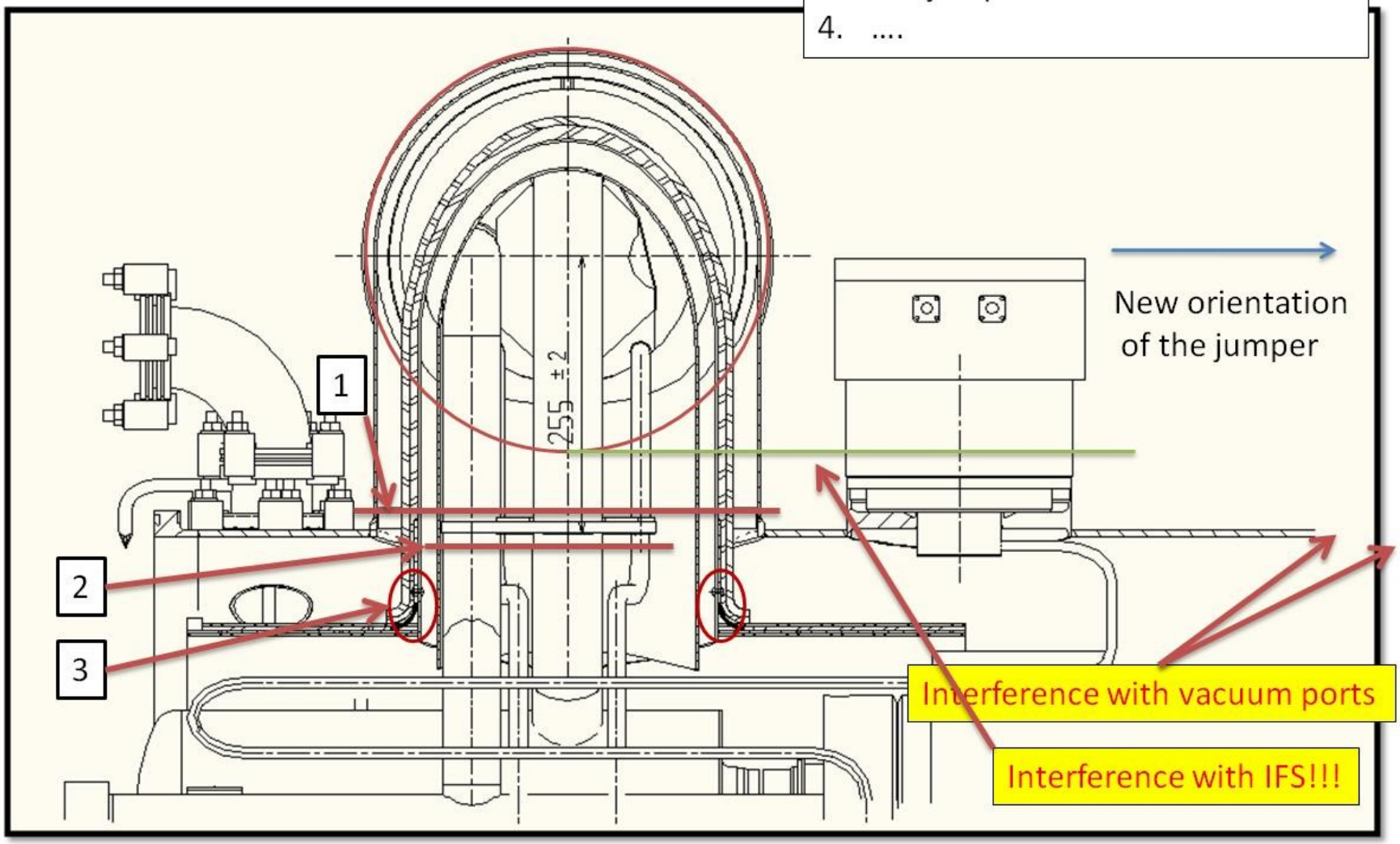
Height standard 680mm from beam axis
Phase separator so XB & CY tubes
He level gauge & helium guard

Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

➢Modification of the jumper of Q7 R3

Courtesy N Bourcey

1. Cut jumper elbow weld
2. Dismount jumper thermal screen
3. Cut jumper tubes
4. ....



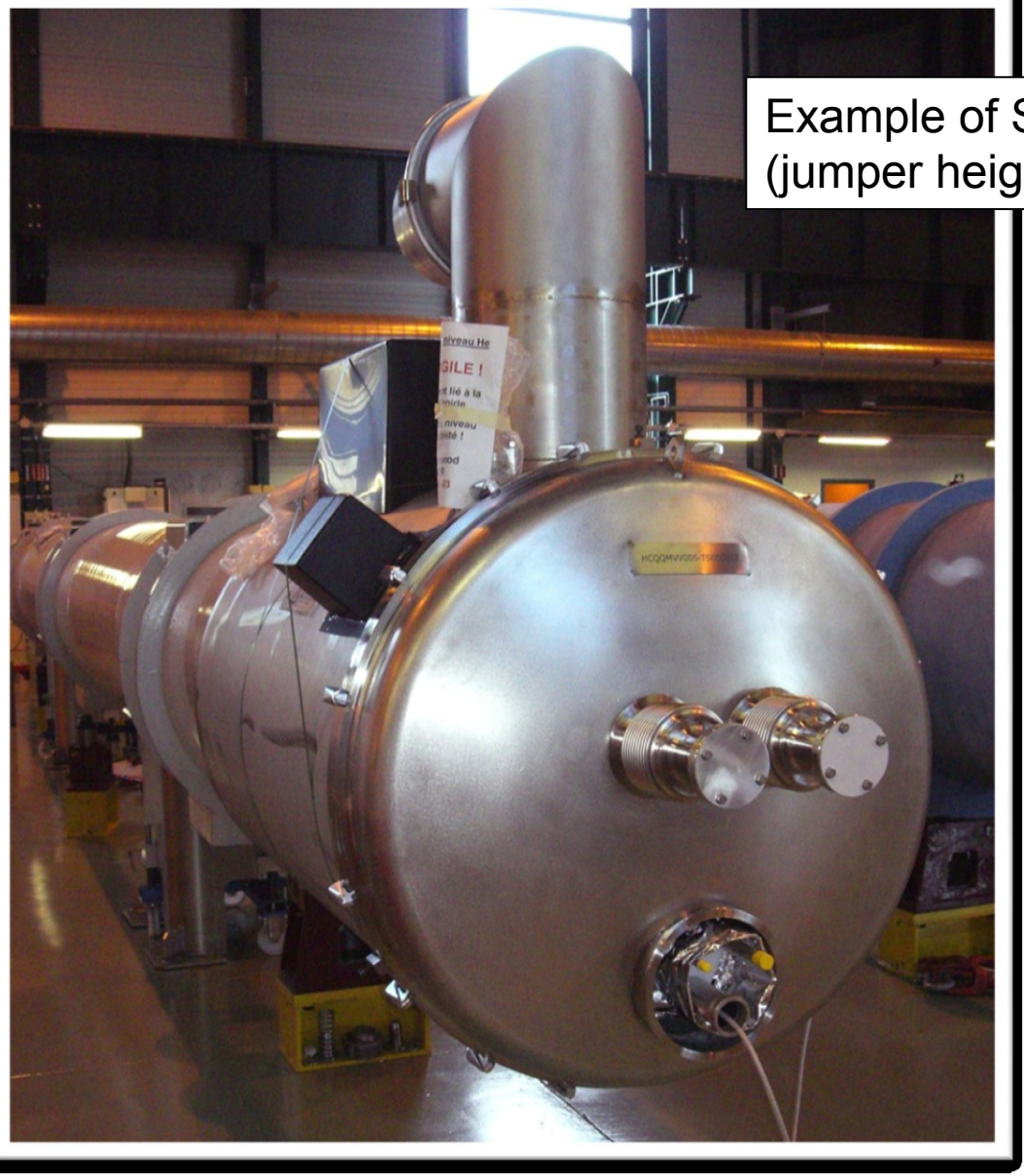
Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

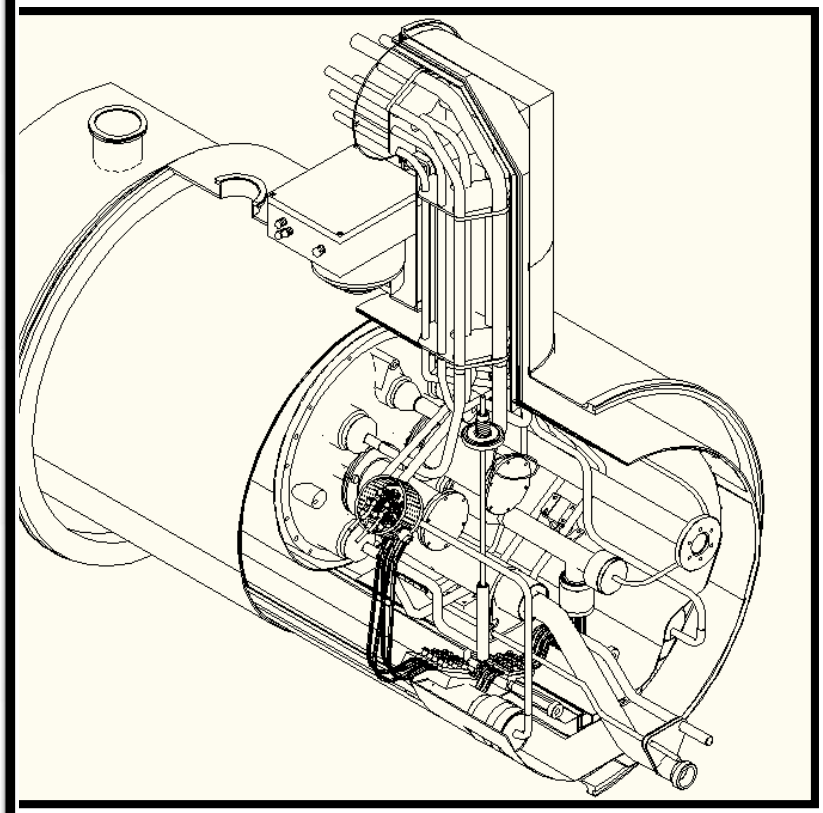
➢Example of similar jumper modification

Courtesy N Bourcey

Q6L3 (Cryostat QQMAL)

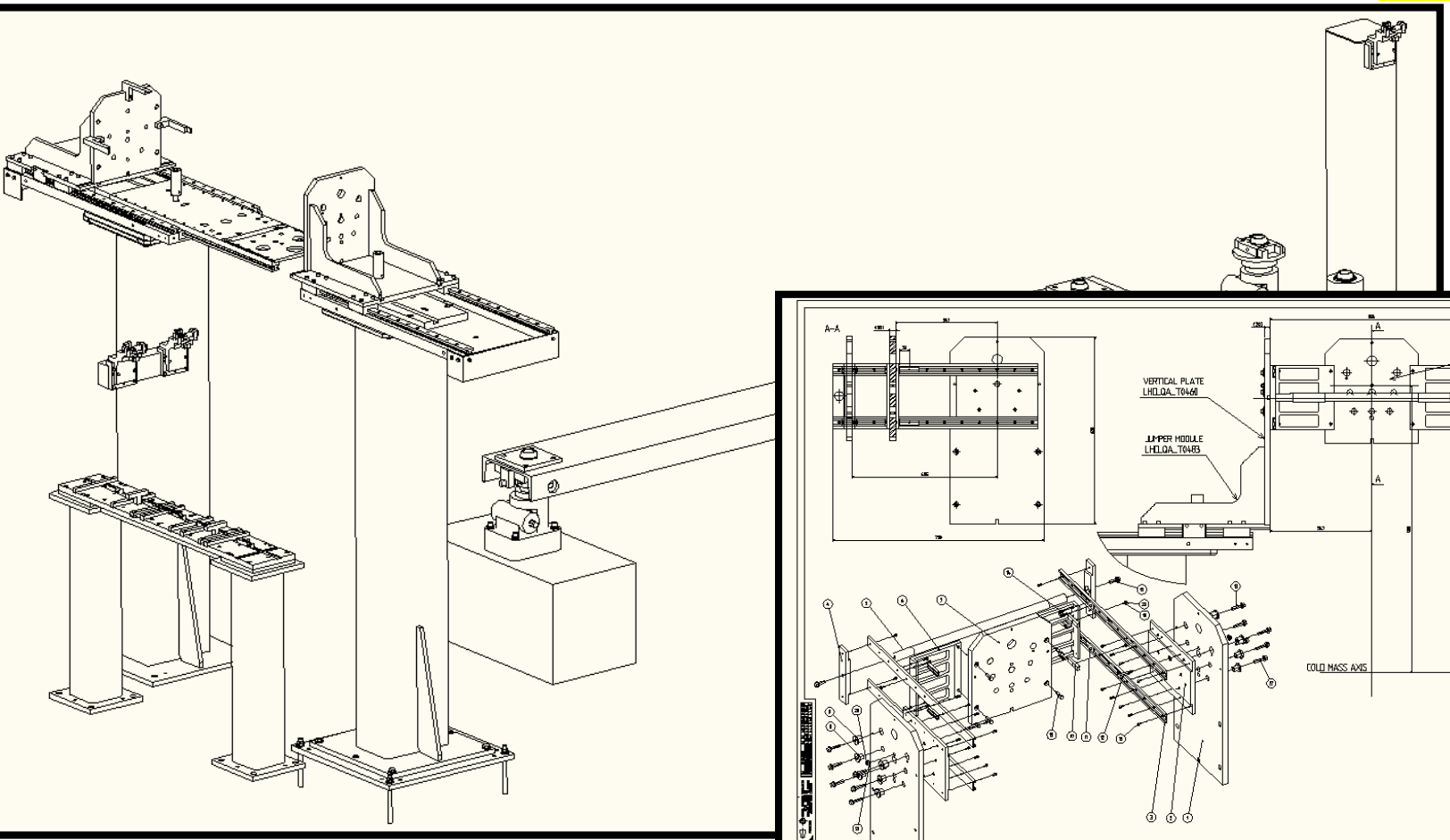
Example of SSS made with jumper in Y direction.
(jumper height 980 mm from beam axis)





➢Tooling for the modification of the jumpers of Q7 L&R3

Courtesy N Bourcey

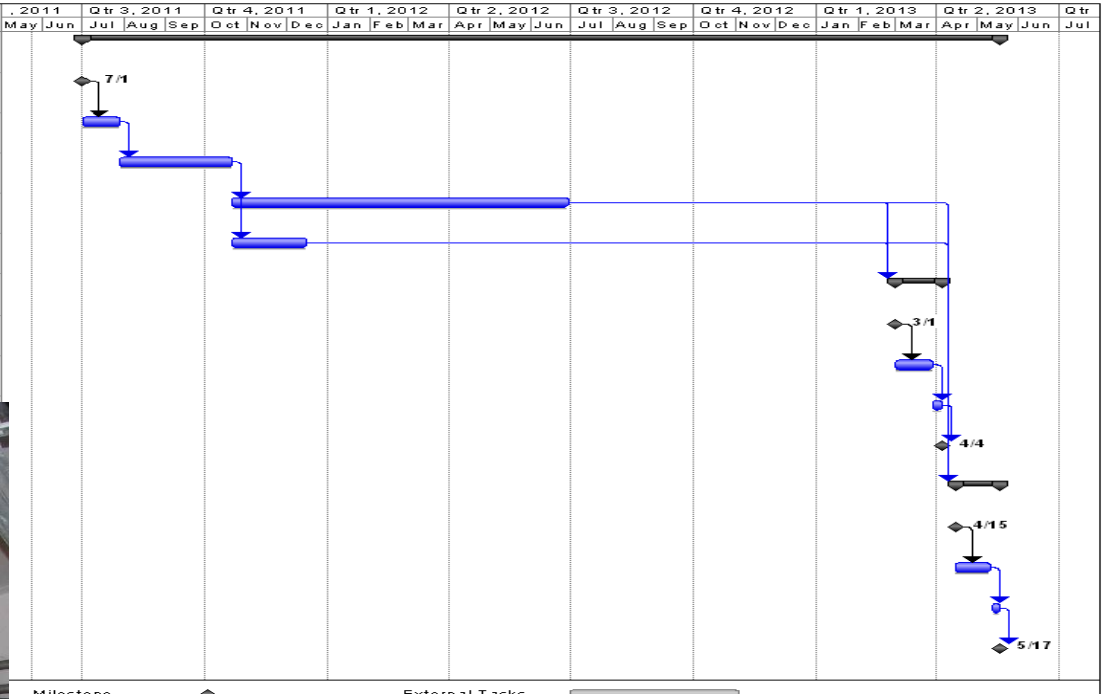


Main parts exist at SMI2.
Small modifications will have to be done to adapt jigs.

Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

➢Schedule for Q7 jumpers modification

ID	Task Name	Duration
1	**Q7 Jumpers modification**	**91 days**
2	Start of project	0 days
3	Parameters validation	1 mon
4	Design	3 mons
5	Procurement/Manufacturing	9 mons
6	Tooling modification	2 mons
7	**Q7L3**	**25 days**
8	Q7L3 at surface	0 days
9	Q7L3 modification	1 mon

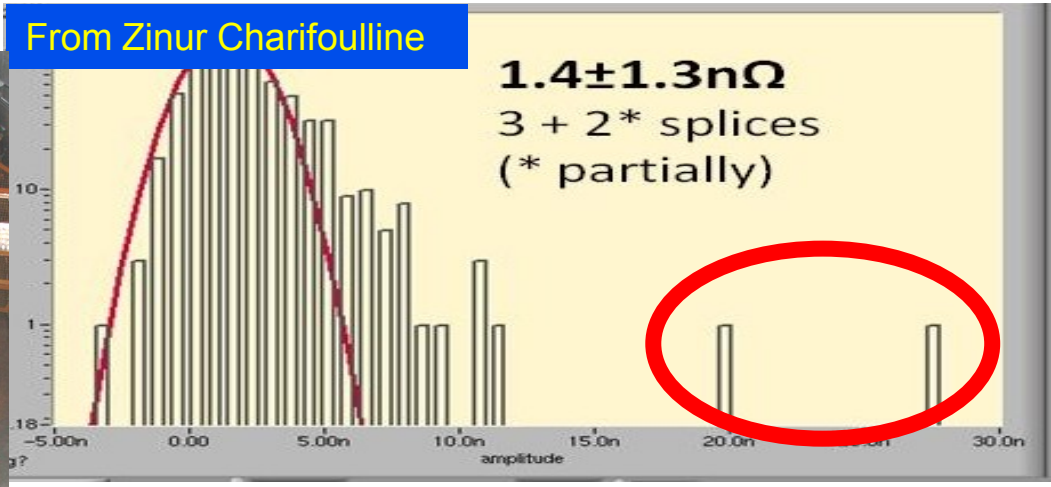


- ➢No cold test (Leak & pressure test @ RT only)
- ➢Transport constraints to be taken into account in jumper height increase (If cannot be transported, jumpers can be assembled in tunnel ; already done for DFBA, Q7 & Q6 @ L2 & R8)
- ➢Huge margins in the schedule
- ➢Some surface activities in parallel with the tunnel work (No complete spare Q7)

Short Connection Cryostats [SCC] & modifications to the SSS [Jumpers]

➢Special guest : Q7R3

From Zinur Charifoulline



- Q7R3 has high inner splice resistance
- Cham 2011: “Foreseen to be exchanged”
  - As an intervention on splices will be required, a cold test will be performed

CONCLUSIONS

- *Short Connection Cryostat engineering almost completed (Fixed point details, radiation shielding need and supports)*
- *Schedule and budget are under control*

- *Modifications to the SSS (Q7L&R3) are not critical and experience exists ; this will involve surface activities in parallel with tunnel work*

- *No show stopper was identified*
- *With the LS1 shift to 2013, contingencies and feedback could be included in the sequence. The delays in design and procurement have been offseted by this shift.*

Many thanks to many colleagues for the large amount of work performed on this project

R Assman, N Bourcey, J Coupard, B Moles, A Musso,Y Muttoni, V Parma, A Perin, Ph Perret, R Principe, T Renaglia, T Sahner, JM Scigliutto, M Souchet, A Vande Craen, N Veillet, L Williams
IPNO

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