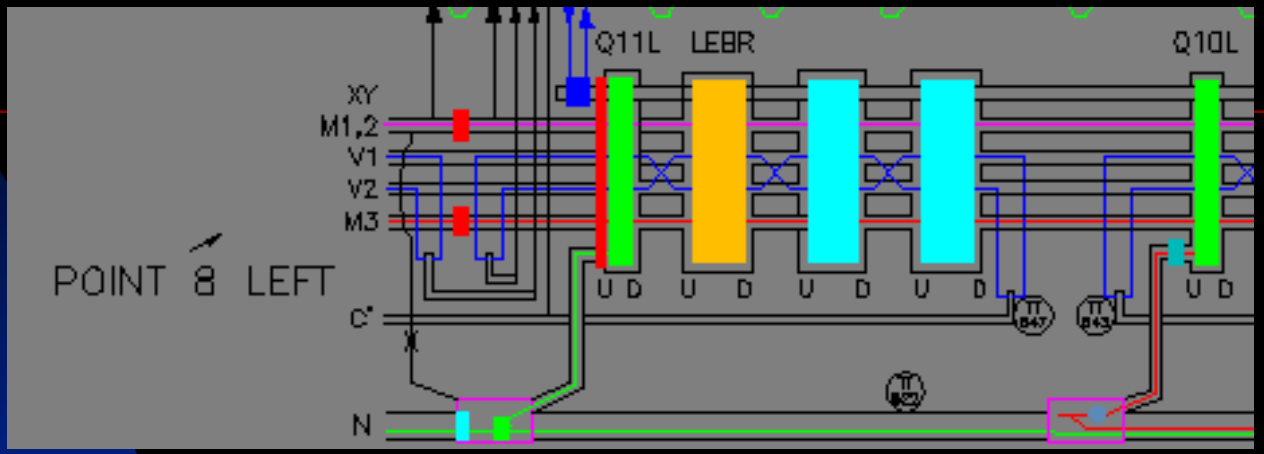
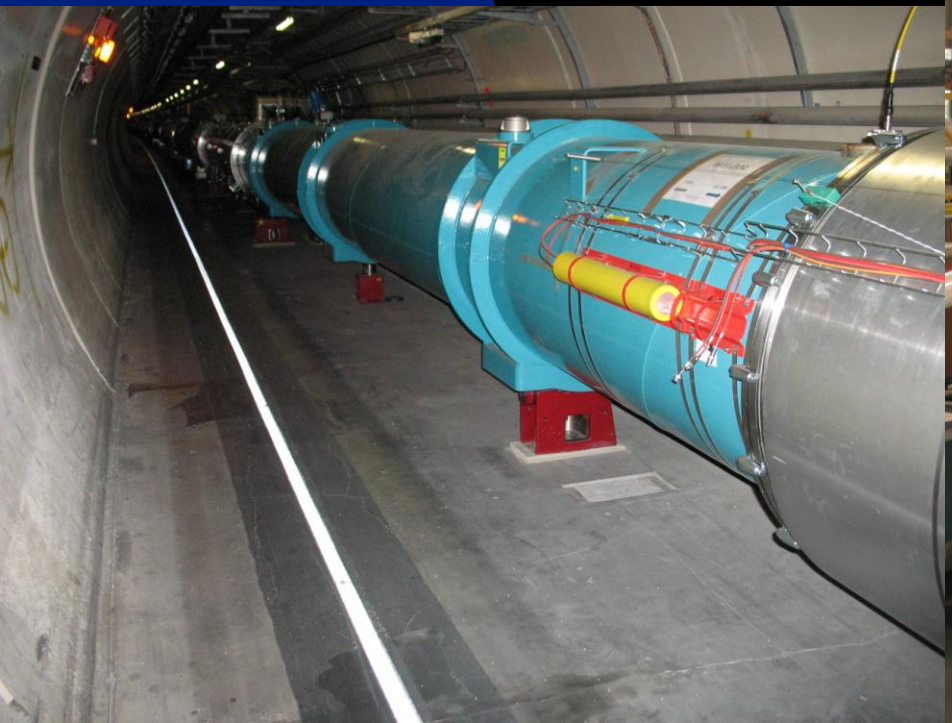
Cryomagnets Interconnections

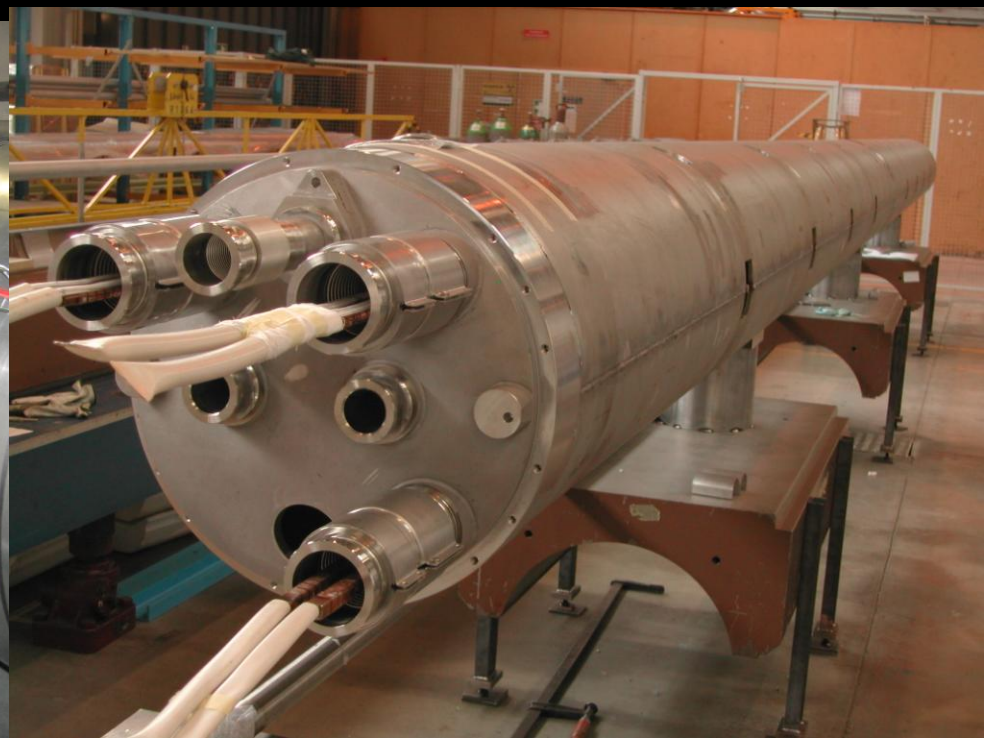
- Connection Cryostats [See also MARIC 06/02/08]
  - Introduction
  - Technical solutions
  - In-situ operations
  - Status
- Consolidation of sector 4-5 [See also MARIC 23/01/08]
  - Foreseen interventions
  - Open points / Risks
- Sector 1-2 : Jack/Ground fixation
- Quick interconnection overview

(Inter)Connection Cryostats

Introduction on ICCs

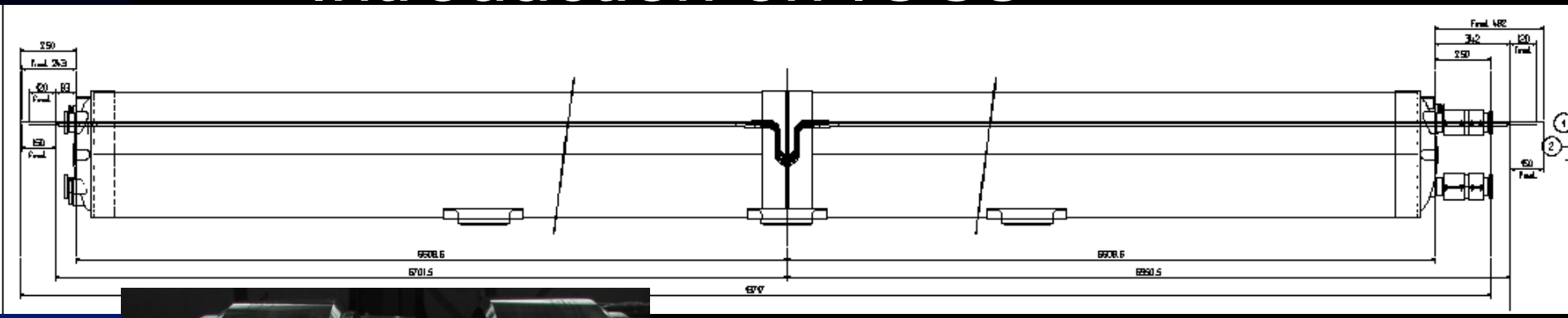


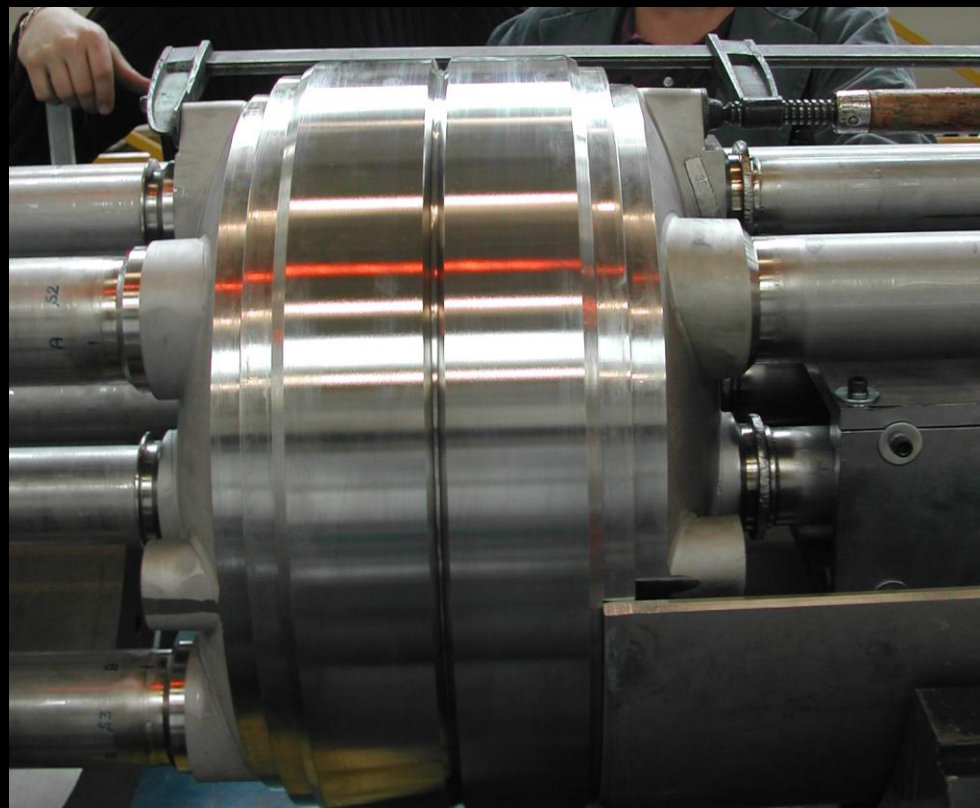




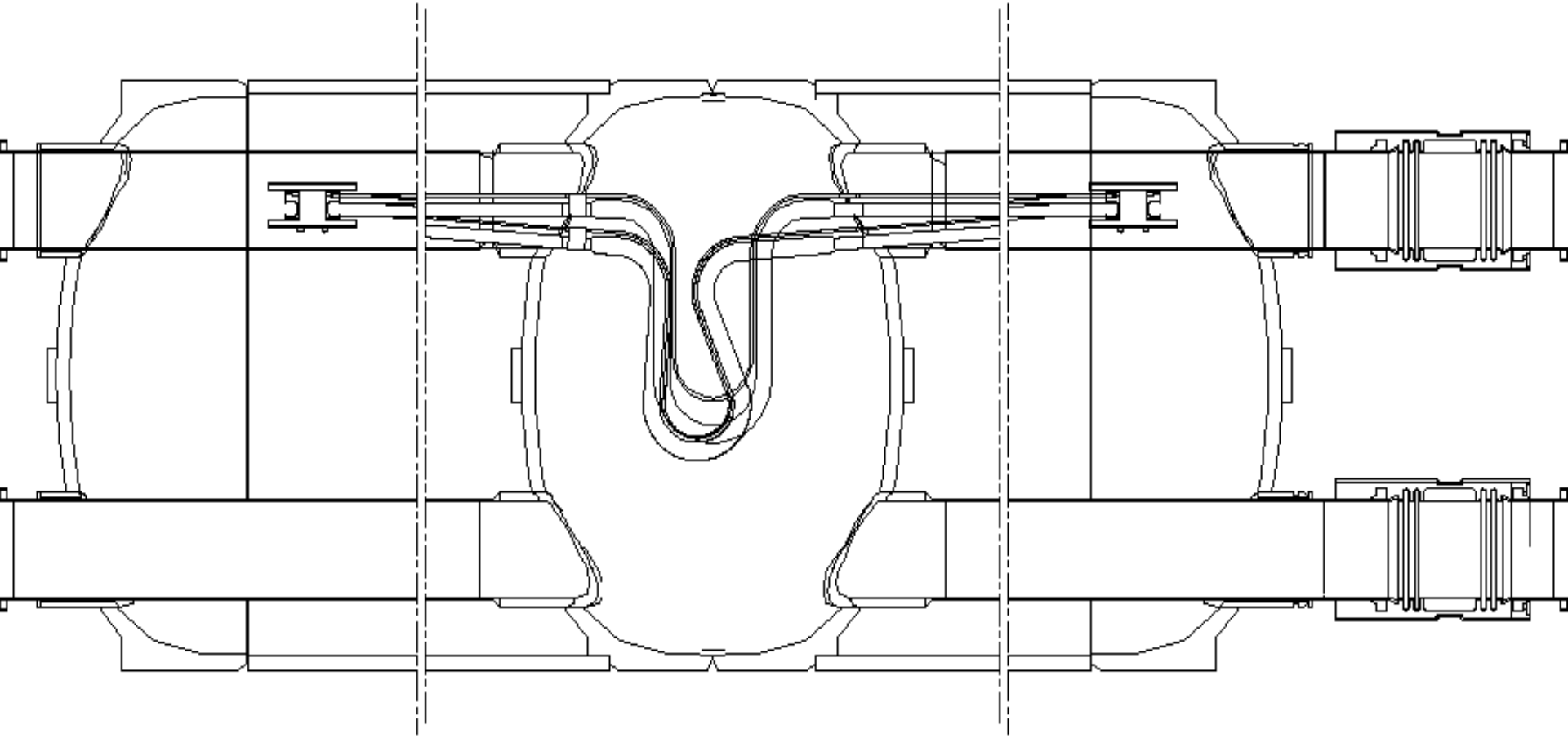
(Inter)Connection Cryostats

Introduction on ICCs





InterConnection Cryostats

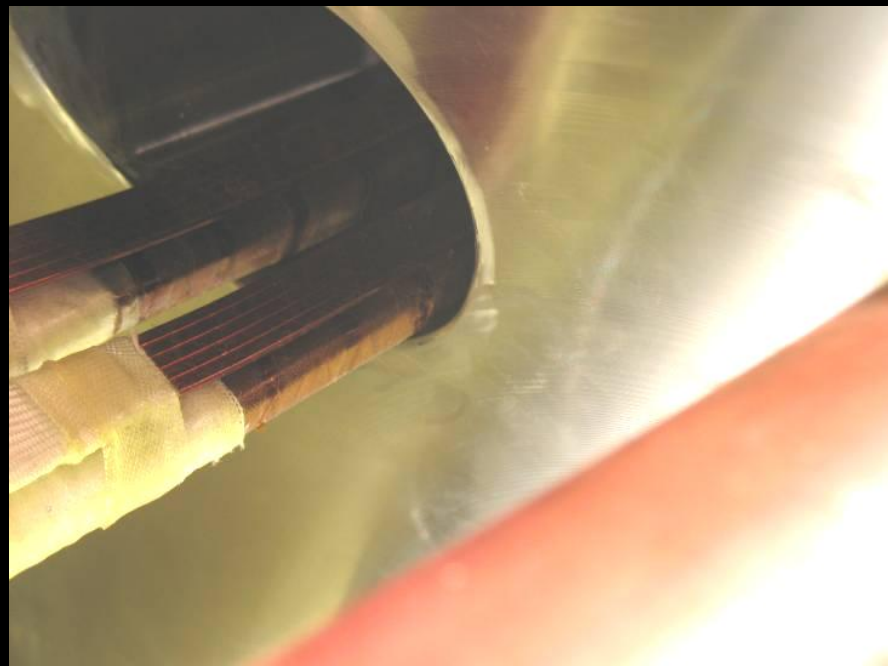


(Inter)Connection Cryostats

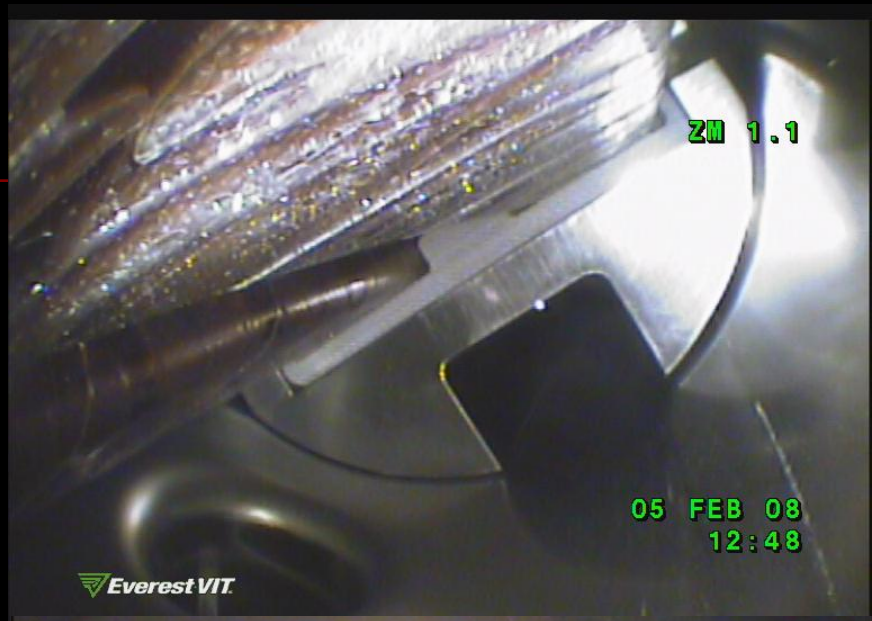
Introduction on ICCs

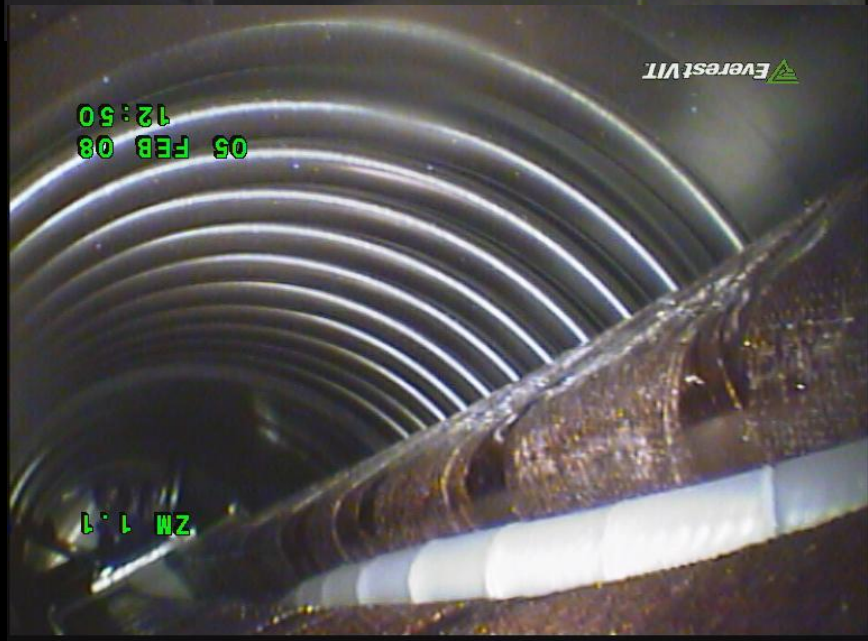
(Inter)Connecti

The problem:



Interconnection Cryostats
Endoscope inspection of CC L8





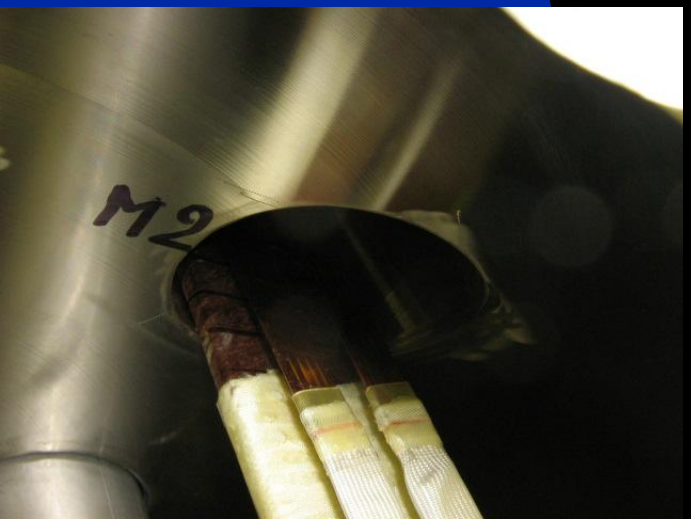
(Inter)Connection Cryostats

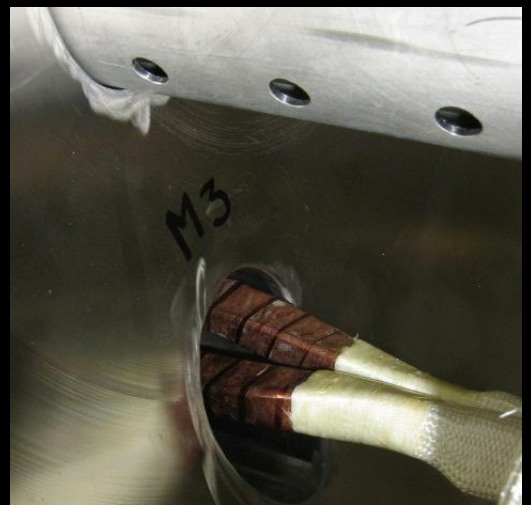
Technical solution(s)

The goal is to reinforce the electrical insulation for the :

- Quadrupole busbars
- Dipole busbars
- Lyras

Solutions presented have been discussed in a WG Friday 8/2/2008 and also on-site with experts

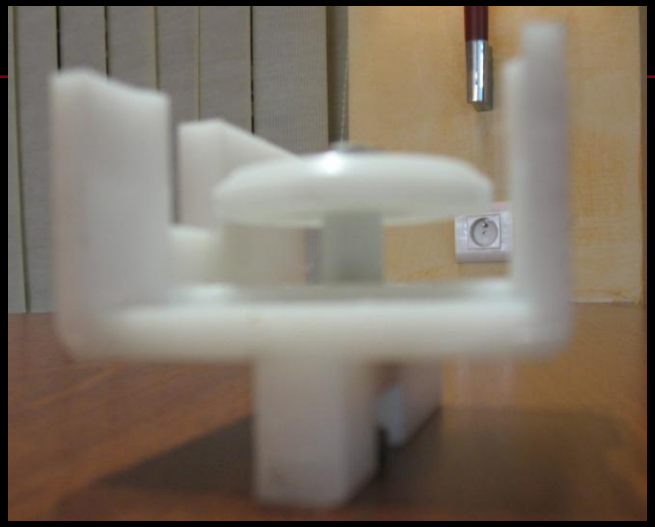


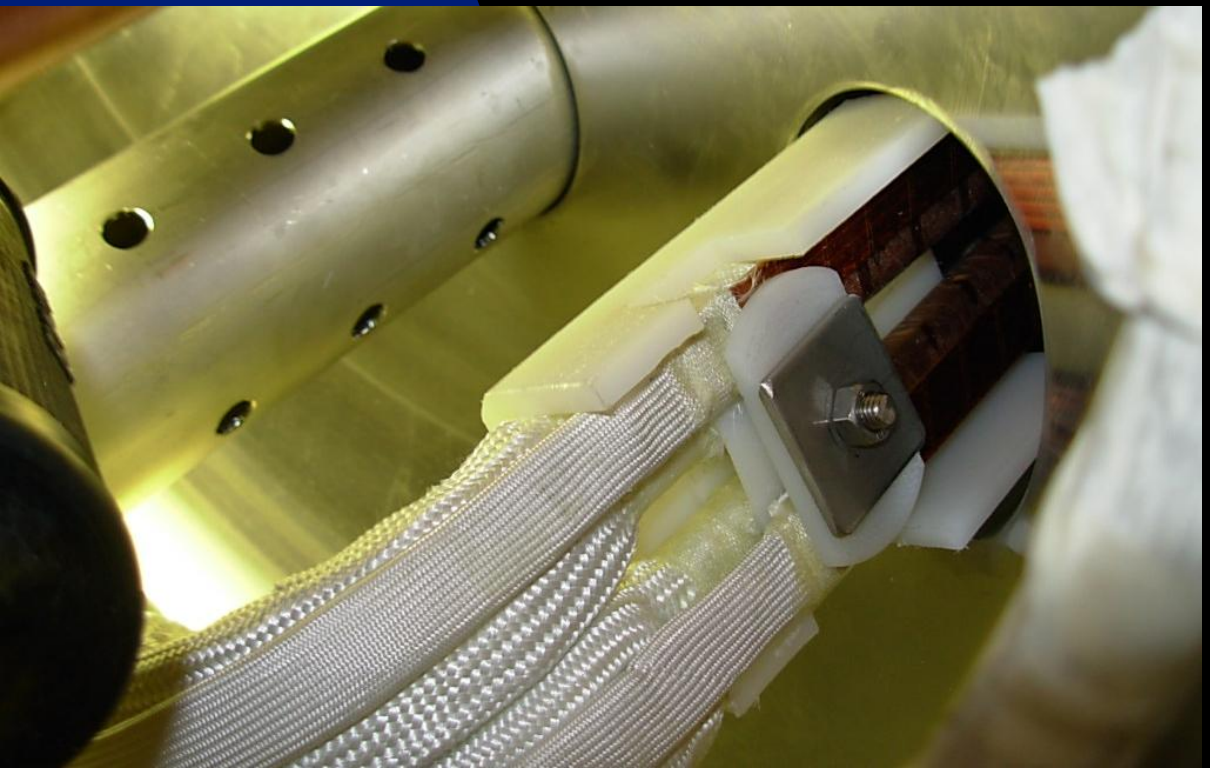


(Inter)Connection Cryostats

Technical solution for the quadrupole busbars (1/2)

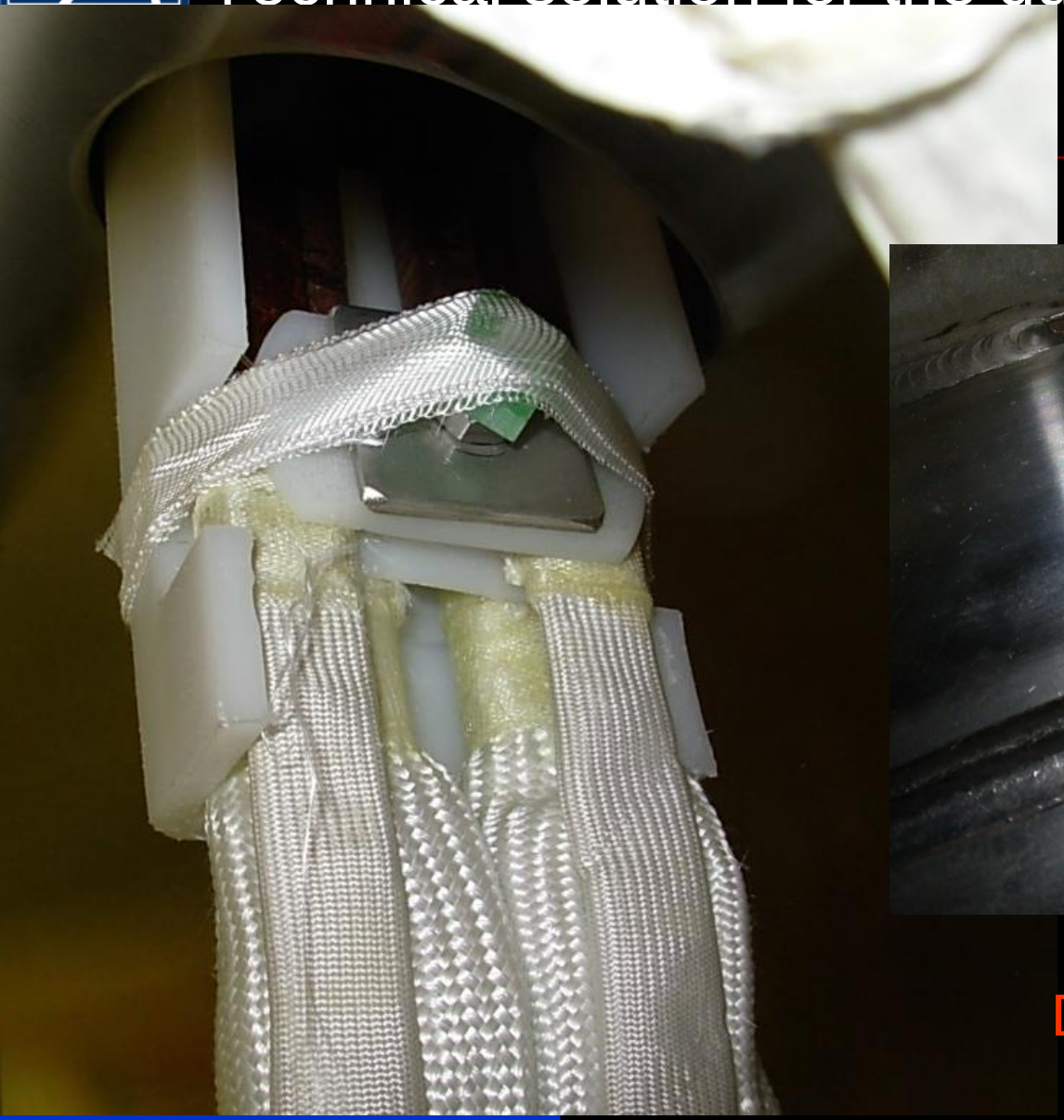
PEHD piece around BB to avoid contact with piping and between BB





(Inter)Connection Cryostats

Technical solution for the quadrupole busbars (2/2)



Difficult access !

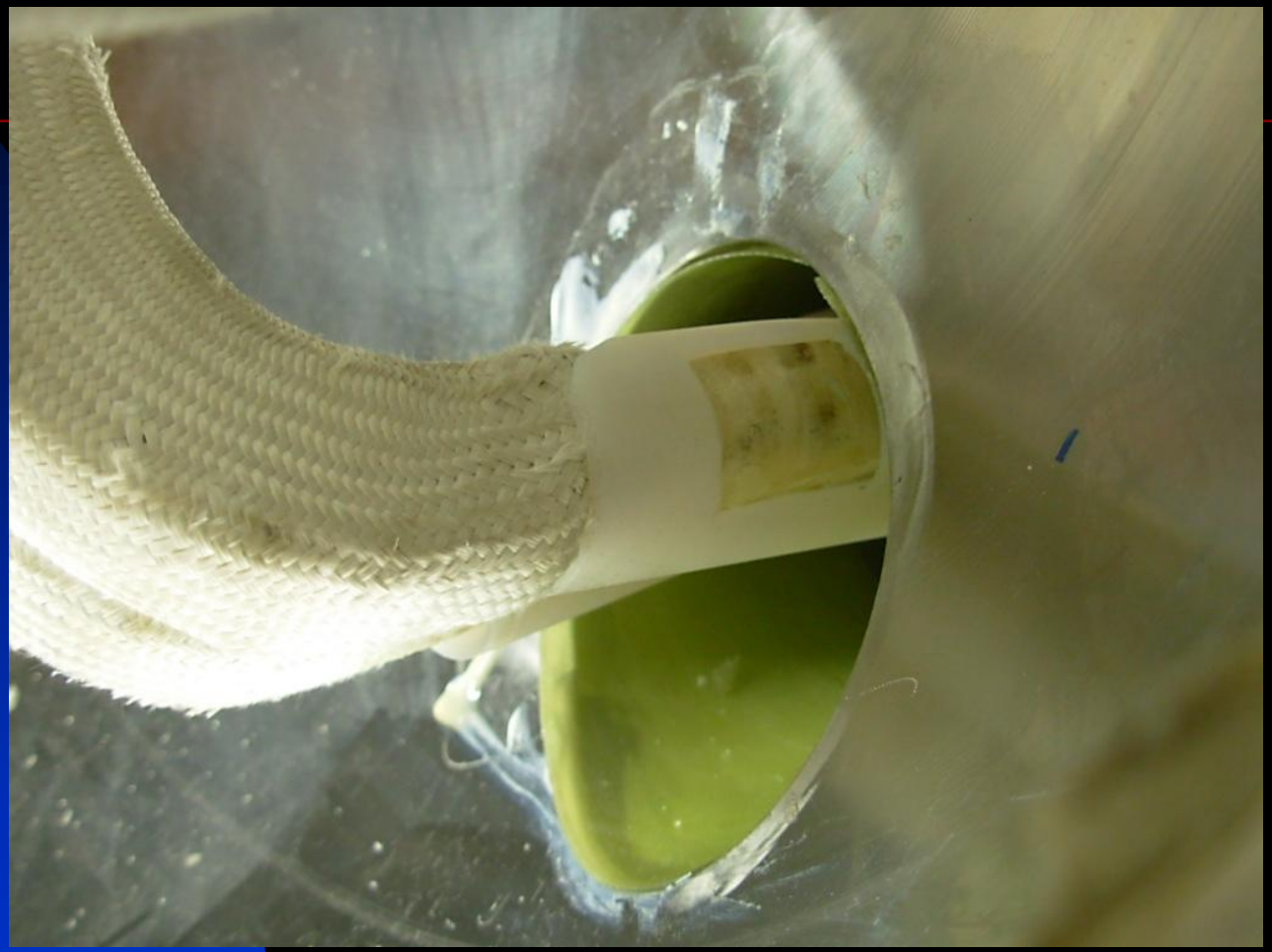
(Inter)Connection Cryos

Technical solution for the dipole

PEHD tube (1.5 mm thick) around each BB;
blocked on spacer and lyras longitudinally ;
fibre tape glued to avoid rotation

(Inter)Connection Cryostats

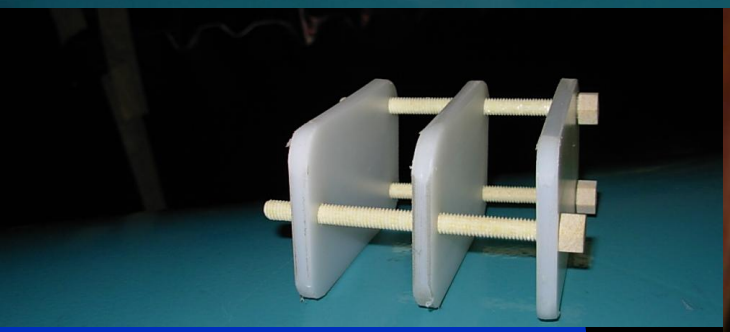
Technical solution for the dipole busbars (2/2)



0.5 mm thick Vetronite (Soie de verre) sleeve glued inside dipole lines ; shaped according to end cover extremity

(Inter)Connection Cryostats

Technical solution for the 3 lyras



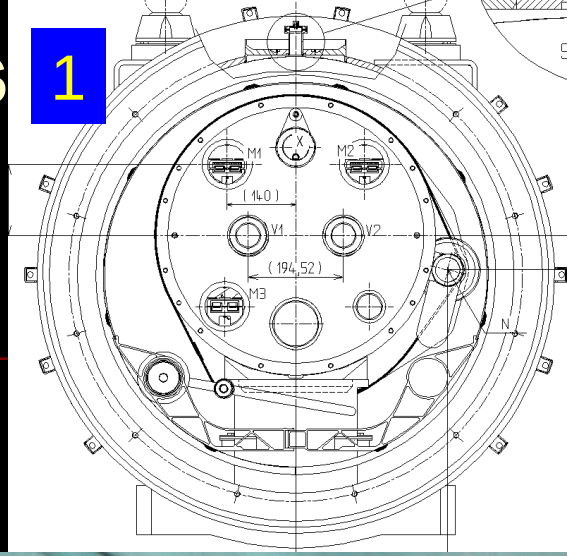
* PEHD plates are installed, holding the 2 lyras branches together and avoiding direct contact on the V' tubes

* Kapton tubes are not installed anymore (test)- not sure of long term stability

(Inter)Connection Cryos
In-situ operations

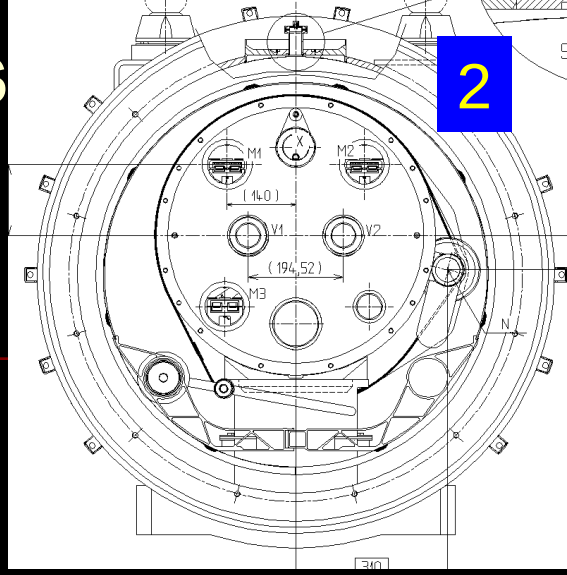
1

1. Opening of cryostat
* 1st ones with grinding machines ; large rectangular opening
* Modified circular sawing machine (4th and on)
+ rounded corners



(Inter)Connection Cryos
In-situ operations

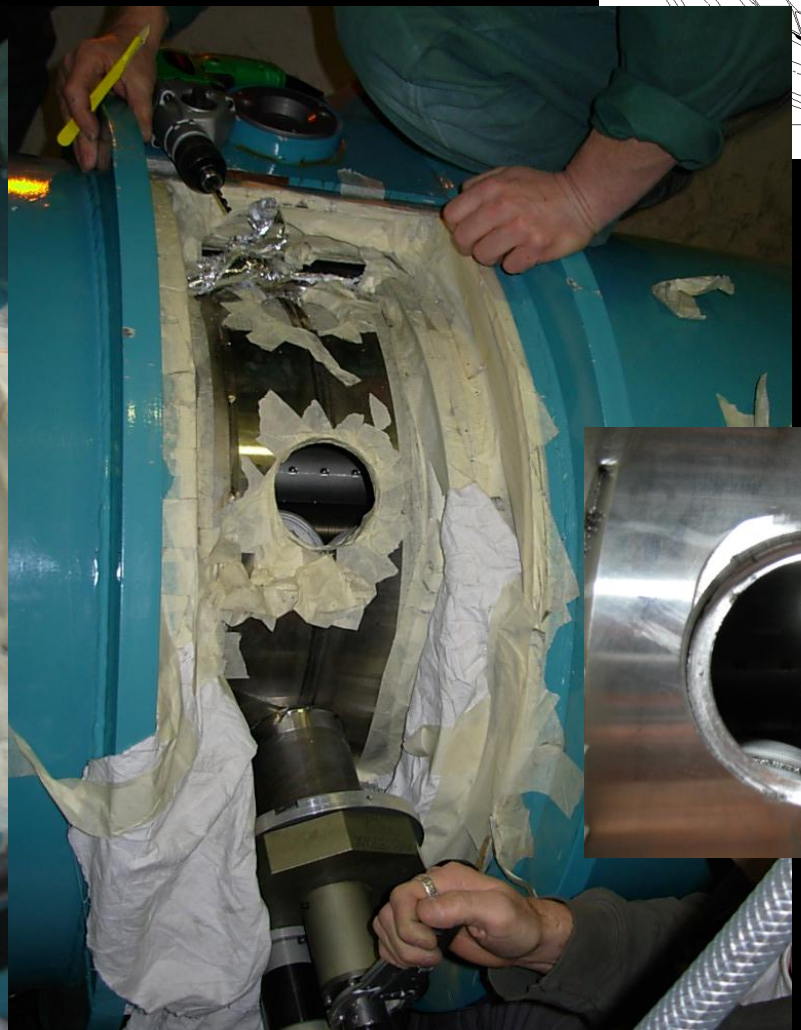
2. Removal of MLI (3 blankets), thermal shield

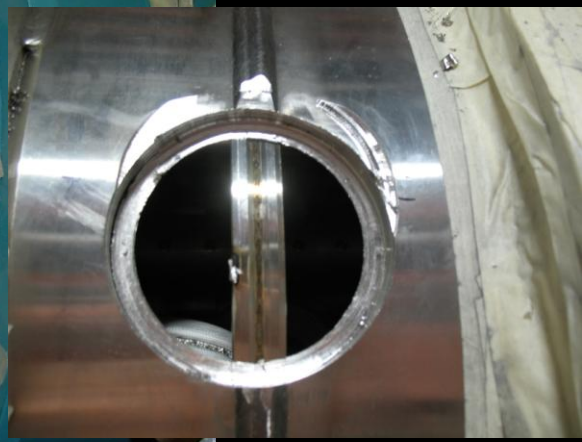


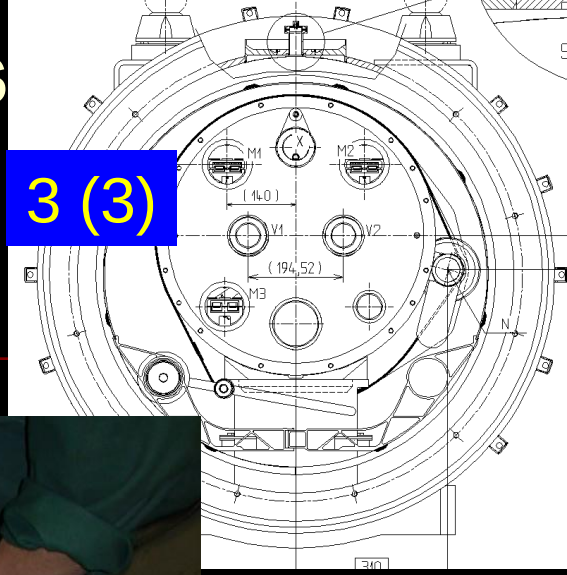
(Inter)Connection Cryos
In-situ operations

3 (3)

3. Opening of the shuffling module
   3 holes / 105 mm diameter

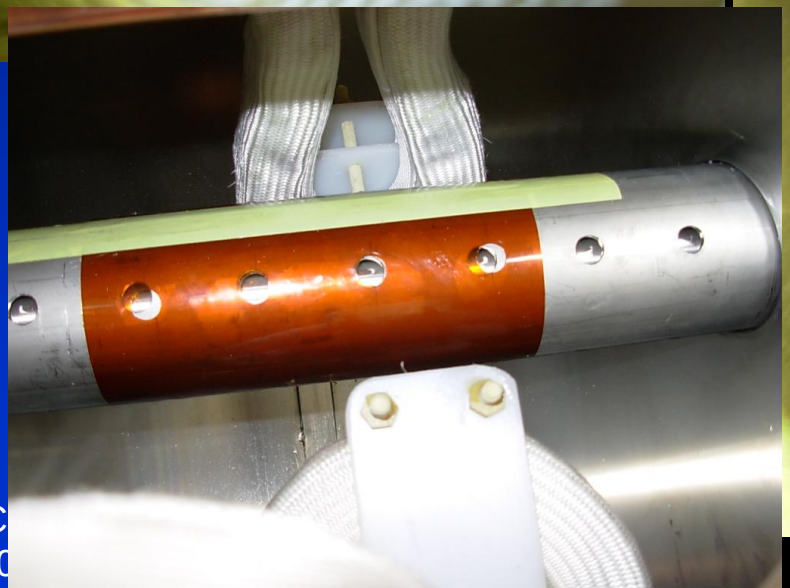


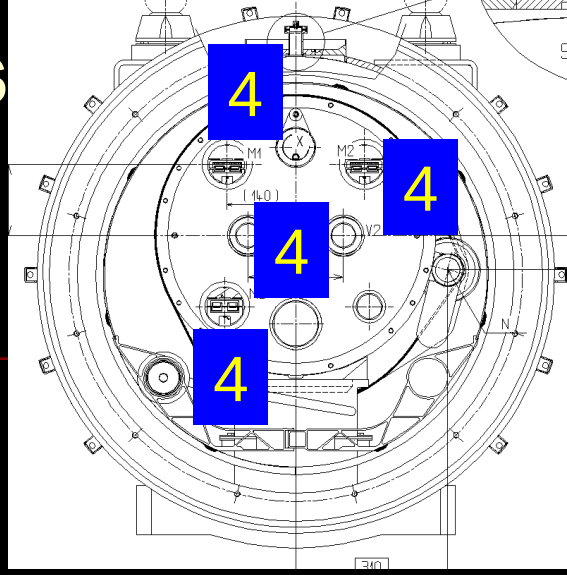


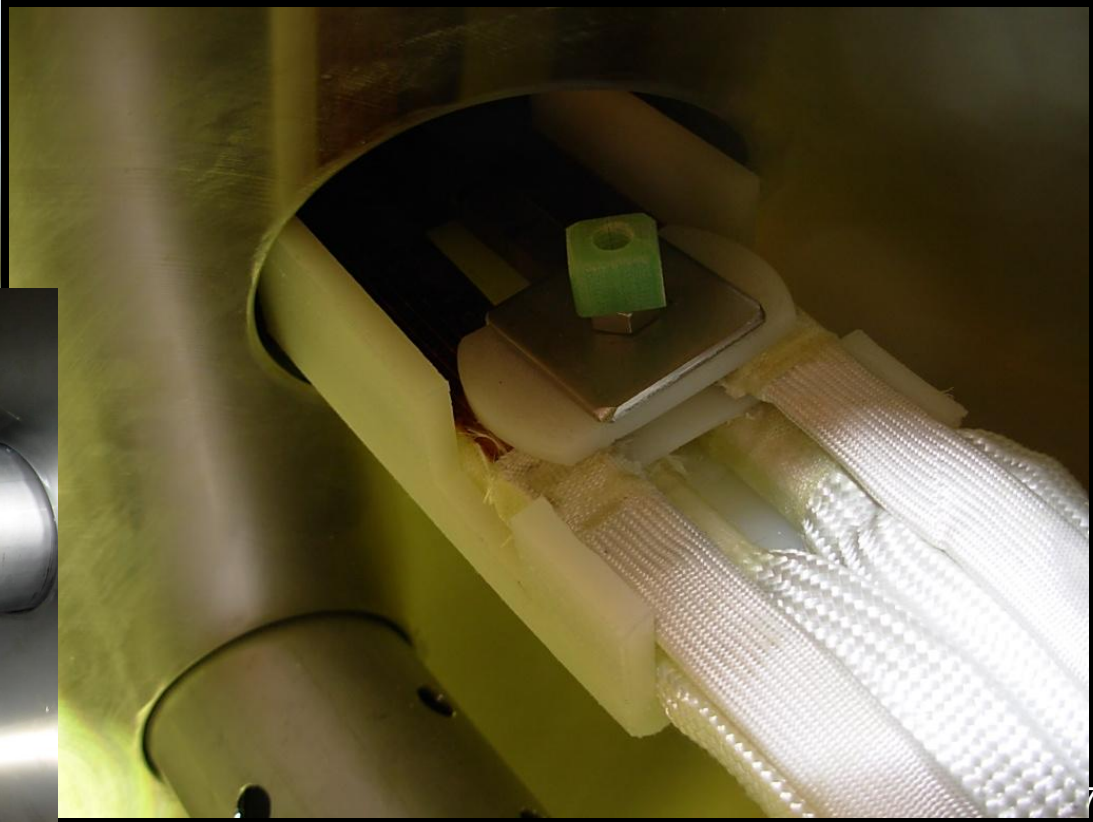


(Inter)Connection Cryos
In-situ operations

4. Reinforcement of electrical insulation

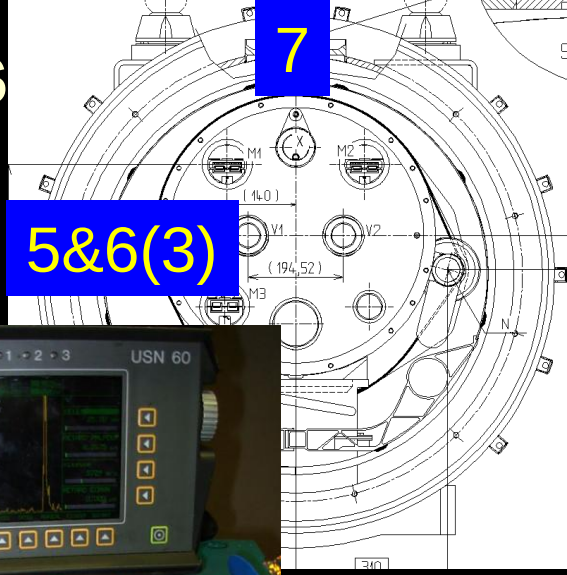


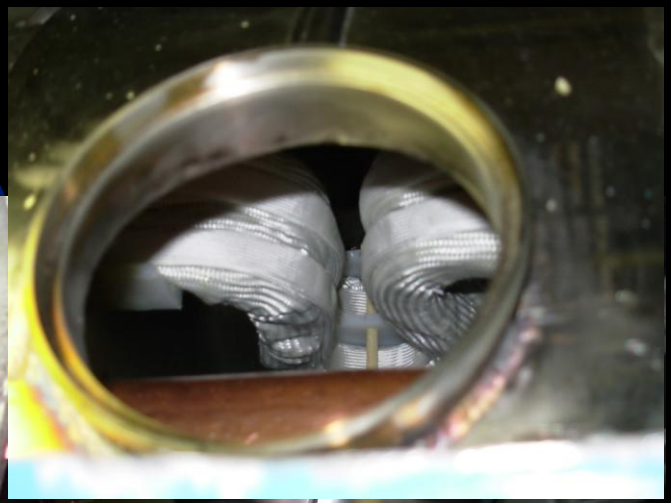




(Inter)Connection Cryos In-situ operations

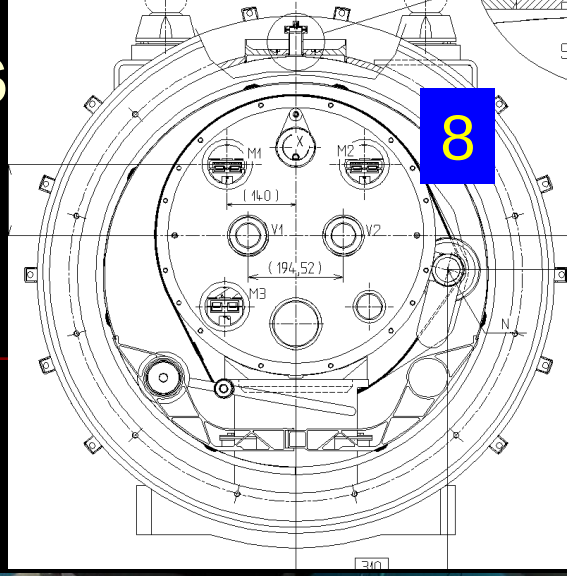
5. Welding of closing covers on the shuffling module (2 steps)
6. Leak and ultrasound test
7. Electrical test





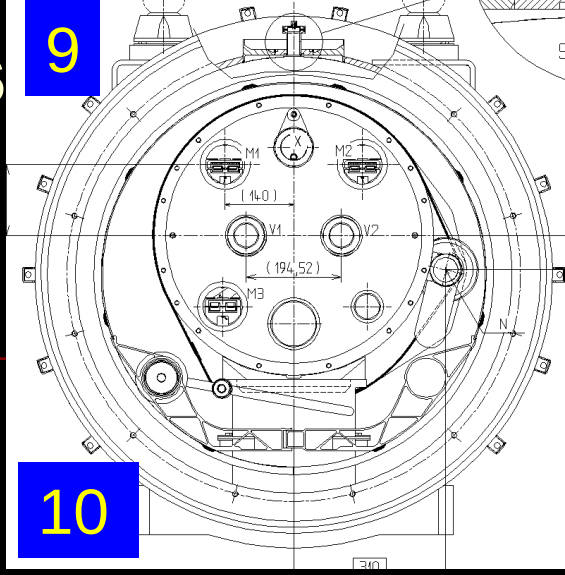
(Inter)Connection Cryos
In-situ operations

8. Installation of MLI and thermal shield (adapted)



(Inter)Connection Cryos In-situ operations

9. Closure of the vacuum vessel
10. Pumping and insulation vacuum leak test



-Problem : Deformation during welding

Geometrical references were taken (cryostat and cold mass extremities)

Test done on a cryostat in SM18 (About 1.5 m banana shape !!)

Compensating welds on opposite side … Minor effect

Reduced opening and weld geometry to be adapted for next ones

Correct position back by acting on central foot or the whole cryostat ?

Depends on result of measurements done presently

What to do for 7-8 ?

(Inter)Connection Cryostats Status

Sector	Repair of ICCs
1-2	Planned (4th)
2-3	Planned (5th)
3-4	Planned (6th)
4-5	Planned (7th) During consolidation
5-6	Afer warm-up (8th) - 3 units ?
6-7	On-going ; R6 : Shuffling module open ; L7 : Opening of shuffling module on-going
7-8	L8 : Reclosed ; R7 : Closure of ICs and vacuum vessel
8-1	Planned (3rd) : Opening starts next Monday

InterConnection Cryostats

Summary conclusions :

1. Additional tooling is under procurement
2. Raw material is ordered for the beginning of the production
3. Start of one intervention every 3 days
4. Shifts and extended days : some non priority surface activities are slowed down
5. Overall schedule worked out with TS/ICC (K Foraz) for intervention on all sectors but 5-6
6. Geometrical problem for reclosure … To be solved
7. Opening in R7 confirmed the systematic aspect of the defect
8. This fast reaction was possible thanks to the availability and competence of experienced technical staff :

- A Bastard, M Duret, D Etiembre, JM Hubert, M Pozzobon, S Triquet, CERN staff
- G Favre, M Jamain, O Mastel, G Maury, FSU
- Ph de Souza, IEG
- P Borowiec, L Hajduk, ICIT

- **+ VAC, MEI, CRG, TS, …**

Consolidation of sector 4-5

Replacement of failed PIMs (X ICs) [1/2]
Arc / Recurrent – Risk level : Medium
Procedure is known but extent of the work not

Sequence of operations (if reasonable # of collapsed PIMs) :

1. Ball test to localise failed PIMs (2 per beam line) to an accuracy of one half cell [Alternate V1/V2 everyday]
2. Venting of the concerned vacuum sector
3. Opening of the QQBI IC of this sector
4. Cutting of the PIM on the relevant line – Endoscopic inspection (+/- 100m)
5. Installation of a replacement or dummy PIM - In parallel radar type measurement
6. Gamma-ray of the other PIM
7. Loop to clear the whole sector
8. Test of the photometer using cut PIMs if possible
9. In parallel, preparation of replacing PIMs
10. Rewelding of PIMs – Ball test to validate the sector
11. Leak test of beam lines – Displace SSS downwards
12. Reclosure of IC
13. Pumping and leak test of insulation vacuum – RF reference measurements

Consolidation of sector 4-5

Replacement of failed PIMs (X ICs) [2/2]
Arc / Recurrent – Risk level : Medium
Procedure is known but extent of the work not

<u>If most of the PIMs are collapsed :</u>

1. Venting of the insulation vacuum
2. Opening of all the QQBI IC [#55]
3. Radar type measurement or Gamma-rays to identify collapsed ones
4. Cutting of the PIMs - Installation of a replacement or dummy one
5. Test of the photometer using cut PIMs if possible
6. In parallel, preparation of replacing PIMs
7. Rewelding of PIMs - Ball test to validate the sector
8. Leak test of beam lines – Displace SSS downwards
9. Reclosure of IC
10. Pumping and leak test of insulation vacuum – RF reference measurements

<u>Risks / Unknowns :</u>

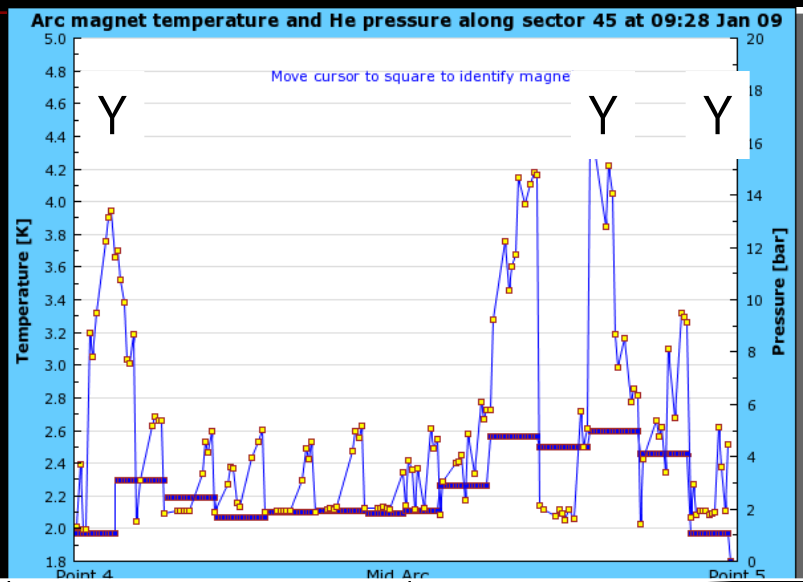
1. Other type of collapsed PIMs
2. Most of the PIMs to replace (Availability is OK from AT-VAC)
3. Flanges material : not possible to change
4. Under investigation in QQBI.12L5 and QBBI.12L5 (Gamma-rays)

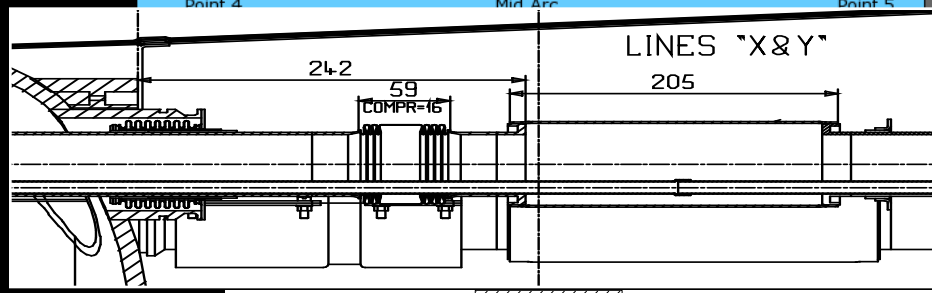
Consolidation of sector 4-5

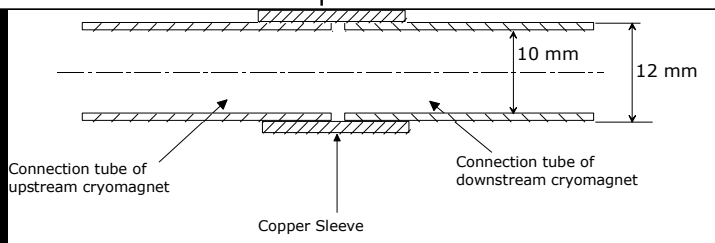
Y-Line to repair (#2 or 3)

Arc / Non-recurrent – Risk level : Low

Loss of time for re-cooldown







Interventions :

1. 3 locations : Q10-Q11R4 : QBBI.11R4 (TBC)
   Q18-Q17L5 : QBBI.B18L5 (TBC)
   Q9-Q7L5 : QQBI.8L5 (TBC)
   (No line Y in Q7 by design)
2. Analysis of data allowed to localise the most likely place of the defect [No need for extra time]
3. Opening of IC and line X
4. Endoscopic inspection
5. Repair – Test – Reweld line X – Leak test
6. Reclosure of IC

Risks / Unknowns :

1. Time to localise the defect
2. Procedure for repair (different type of the one in 7-8)

Consolidation of sector 4-5

Helium guards to repair (#8 TBC – Could be more see 6-7)

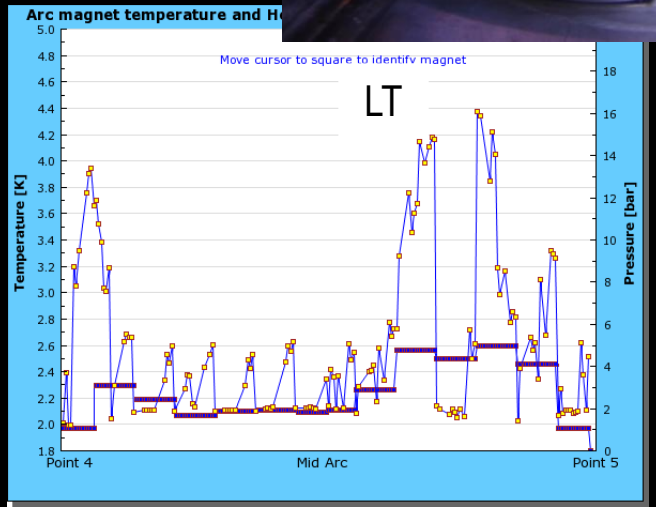
Arc / Non-recurrent – Risk level : Low

Procedure known, improved and validated

Interventions :

1. Vent line X to atmospheric pressure to allow endoscopic inspection and identification/ confirmation of the units to be repaired
2. Cutting of the damaged piece
3. Rewelding and testing

Also, one Helium level gauge to change (CRG)



Risks / Unknowns :

1. Number of replacement required

Consolidation of sector 4-5

Leaks to repair
Arc / Potentially recurring – Risk level : Low
It was possible to leave with it so …

Interventions :

1. VACSEC 7R4 (NC847504) – CM leak to insulation vacuum of 1 10^{-5} mbar l /sec
   In DS zone, additional mobile turbo pumps are used
2. VACSEC 15R4 – C' K leak to insulation vacuum of 6 10^{-6} mbar l /sec
   Disappeared during localisation ; leak tightness to be verified
3. Check of beam lines leak tightness
4. Q17L5 and Q29R4 (NC 826696 and 820313) – leak air to insulation vacuum – temporary solution now but to be consolidated by AT-VQC

Risks / Unknowns :

1. Time for localisation – Extra openings to support leak localisation work
2. New leaks created by/during warm-up

Consolidation of sector 4-5

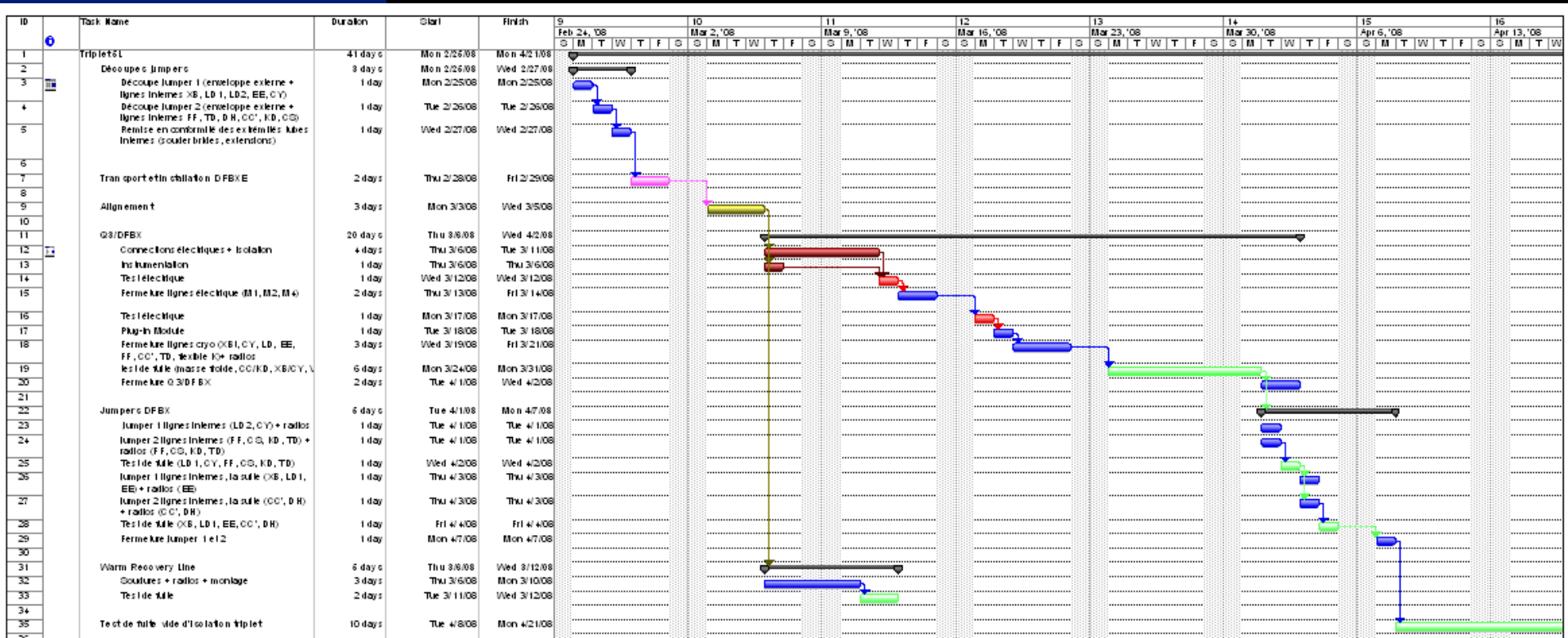
Reconnection of triplet 5L (I Slits replaces C Garion)

LSS / Non-recurrent – Risk level : High

Procedure known but on reworked extremities / on the critical path

Interventions :

1. Cut QRL jumpers to allow DFBX installation
2. Connect Q3 to DFBX and test
3. Connect DFBX to QRL and leak test



ID	Task Name	Duration	Start	Finish
1	Triplet 5L	41 days	Mon 2/25/08	Mon 4/21/08
2	Découpes jumpers	3 days	Mon 2/25/08	Wed 2/27/08
3	Découpe Jumper 1 (enveloppe externe + lignes internes XB, LD1, LD2, EE, CY)	1 day	Mon 2/25/08	Mon 2/25/08
4	Découpe Jumper 2 (enveloppe externe + lignes internes FF, TD, DH, CC', KD, CG)	1 day	Tue 2/26/08	Tue 2/26/08
5	Remise en conformité des extrémités tubes internes (coudes brides, extensions)	1 day	Wed 2/27/08	Wed 2/27/08
6				
7	Transport et installation DFBXE	2 days	Thu 2/28/08	Fri 2/29/08
8				
9	Alignement	3 days	Mon 3/3/08	Wed 3/5/08
10				
11	Q3/DFBX	20 days	Thu 3/6/08	Wed 4/2/08
12	Connections électriques + isolation	4 days	Thu 3/6/08	Tue 3/11/08
13	Instrumentation	1 day	Thu 3/6/08	Thu 3/6/08
14	Test électrique	1 day	Wed 3/12/08	Wed 3/12/08
15	Fermeture lignes électrique (M1, M2, M4)	2 days	Thu 3/13/08	Fri 3/14/08
16	Test électrique	1 day	Mon 3/17/08	Mon 3/17/08
17	Plug-in Module	1 day	Tue 3/18/08	Tue 3/18/08
18	Fermeture lignes cryo (XB1, CY, LD, EE, FF, CC', TD, flexible K)+ radios	3 days	Wed 3/19/08	Fri 3/21/08
19	Test de fuite (masse froide, CC/KD, XB/CY, V	6 days	Mon 3/24/08	Mon 3/31/08
20	Fermeture Q3/DFBX	2 days	Tue 4/1/08	Wed 4/2/08
21				
22	Jumpers DFBX	6 days	Tue 4/1/08	Mon 4/7/08
23	Jumper 1 lignes internes (LD2, CY) + radios	1 day	Tue 4/1/08	Tue 4/1/08
24	Jumper 2 lignes internes (FF, CG, KD, TD) + radios (FF, CG, KD, TD)	1 day	Tue 4/1/08	Tue 4/1/08
25	Test de fuite (LD1, CY, FF, CG, KD, TD)	1 day	Wed 4/2/08	Wed 4/2/08
26	Jumper 1 lignes internes, la suite (XB, LD1, EE) + radios (EE)	1 day	Thu 4/3/08	Thu 4/3/08
27	Jumper 2 lignes internes, la suite (CC', DH) + radios (CC', DH)	1 day	Thu 4/3/08	Thu 4/3/08
28	Test de fuite (XB, LD1, EE, CC', DH)	1 day	Fri 4/4/08	Fri 4/4/08
29	Fermeture Jumper 1 et 2	1 day	Mon 4/7/08	Mon 4/7/08
30				
31	Warm Recovery Line	6 days	Thu 3/6/08	Wed 3/12/08
32	Soudures + radios + montage	3 days	Thu 3/6/08	Mon 3/10/08
33	Test de fuite	2 days	Tue 3/11/08	Wed 3/12/08
34				
35	Test de fuite vide d'isolation triplet	10 days	Tue 4/8/08	Mon 4/21/08

Consolidation of sector 4-5

Intervention on Q5R4
LSS / Non-recurrent – Risk level : High
Location of defect not known

Short circuit on a corrector circuit ; suspected between corrector and D4 busbars

Interventions :

1. Open the D4/Q5 IC
2. Open the busbar line
3. Endoscopic inspection
4. Repair by AT-MCS (Previously MEL)
5. Reclose BB line
6. Electrical and leak tests
7. Reclose IC and leak test

Risks / Unknowns :

1. Location of the defect
2. Possibility to repair ? No spare available
3. The DFBML link could be required to be opened
4. What if it is not accessible from the IC ?

Consolidation of sector 4-5

* Repair of Connection Cryostats

Procedure ? Should be mastered by then…

* Intervention on DFBA (2) and DFBLD cablings ?

Planned interventions : Arc / Non-recurrent

* Improve splices of CC instrumentation (same as 7-8)

1 day work / Risk level : very low

* Intervention on JT valves of the triplets and possibly DFBs (CRG)

In the shadow / Risk level : low

* If QBQI ICs are opened, verification of the instrumentation (CRG)

Consolidation of sector 4-5

Potential critical issues :

* Electrical issues discovered during commissioning :

Nothing up to now but …

* Leaks during the closure phase (impact on schedule)

* Sector 4-5 shutdown is on the critical path for the LHC general schedule

* End of consolidation after 30/4/2008 so F523 (IEG) contract will be terminated

* Cabling of DFBs to be reshuffled ? TBC / Procedure not known

**** Access conditions ?***

Some figures

- About 52 (24 for PIMs) ICs to open [220 in 7-8]
- 40 persons involved (not full time)
- Several teams :

MCS, MEI, CRG, VAC, IEG, FSU, TS-SU, AB-BI, TS-IC, ICIT. TS

From MCS: 18 persons (various proportions)

A Bastard, F Bertinelli , N Bourcey, O Denis, H Dupont, M Duret, D Etiembre, M Felip, JM Hubert, A Jacquemod, A Musso, M Pozzobon, F Savary, I Slits, P Thonet, J Ph Tock, S Triquet, L Williams…

Duration : 8 weeks [6 for work + 2 for pumping and leak test] ;

Starting date : W12

Consolidation of sector 4-5

Sector 4-5 Consolidation

1	Plug-in modules	7 weeks
2	Photometer test	3 days
3	Y lines	3 weeks
4	Helium guards	2 weeks
5	Leaks	3 weeks ?
6	Triplet 5L	8 weeks
7	Q5R4	2 weeks ?
8	Connection Cryostats	5 weeks
9	CC splices	1 day
10	DFBs cables	?

Sector 1-2 : Jack/Ground fixation

IC QQBI.19L2 : Displacement of :

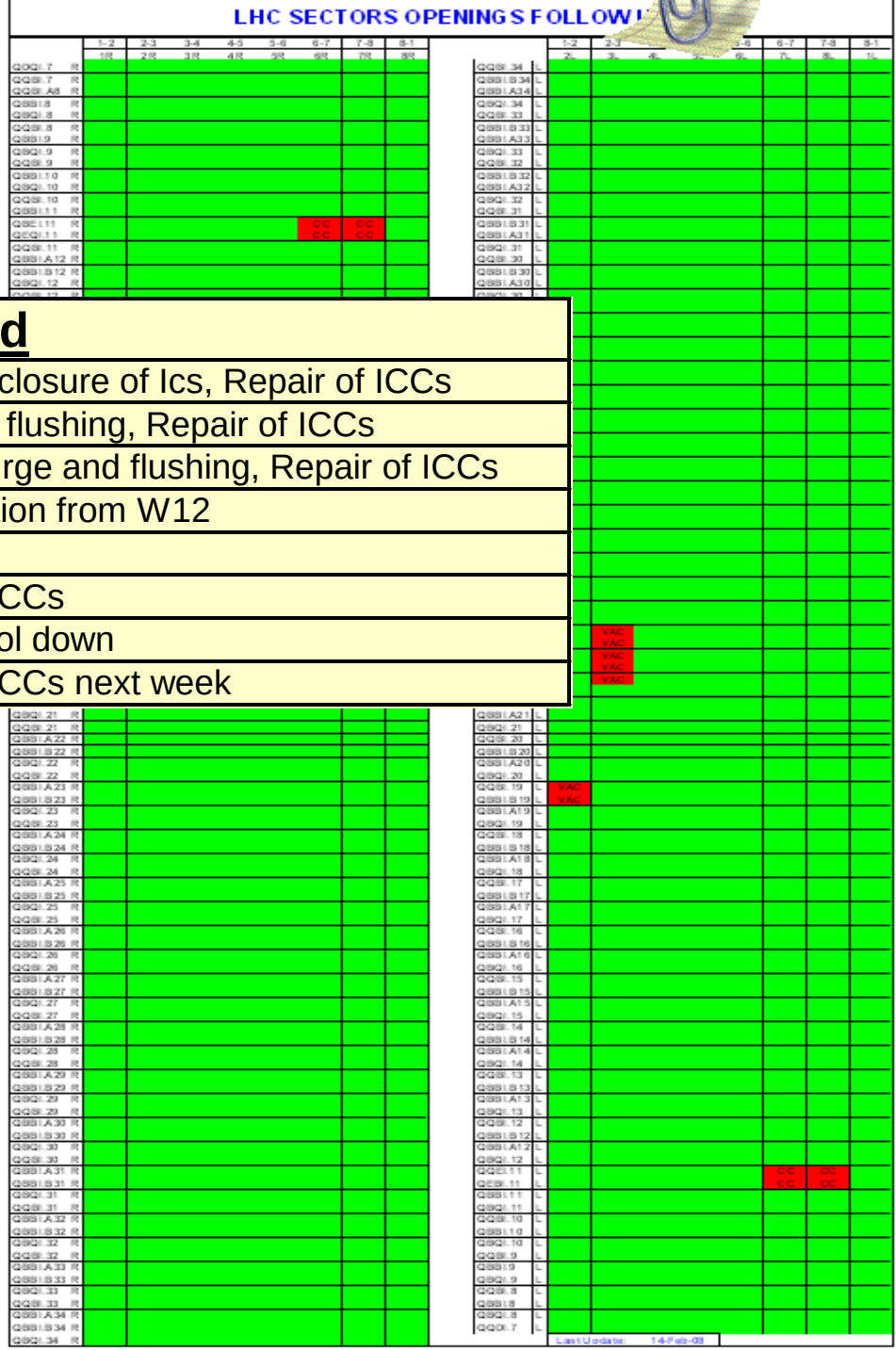
Tilt : 1.5 mrad ; Longitudinal : - 5 mm

Vacuum barrier in the neighbouring SSS

Systematic inspection ?

Quick IC overview

Sector	On-going	Planned
1-2	2 IC opened ; Jack problem	Leak test, closure of Ics, Repair of ICCs
2-3	5 ICs opened for LT in 22L3	Purge and flushing, Repair of ICCs
3-4	NA	ELQA - Purge and flushing, Repair of ICCs
4-5	Q1/Q2/Q3 IC	Consolidation from W12
5-6	Cold	Cooldown
6-7	Repair of ICCs	Repair of ICCs
7-8	Repair of ICCs up to end of W7	Restart cool down
8-1	Under cooldown (central part)	Repair of ICCs next week



20 ICs to close:

15 in the arc:

8 for CC, 5 for LT, 2 for jack

5 in LSS : L5 triplet

Pressure test OK,

Closure next week