
CERN

The SMACC project :
Superconducting Magnets And Circuits Consolidation
Summary and Results

04/06/2015
(30 minutes for 1 000 000 hours worked !)

Jean-Philippe Tock (TE-MSC)

On behalf of the SMACC project

But was for **S**uper **M**icro **A**uxiliary **C**rate **C**ontroller

IEEE Transactions on Nuclear Science, Vol. NS-32, No. 5, October 1985

SMACC

W. Heinze, R. Cailliau, B. Carpenter, G. Cuisinier,
A. Gagnaire, F. Perriollat, W. Remmer

CERN, PS Division, CH-1211 Geneva 23, Switzerland

Abstract

The SMACC is a powerful, MC68000 based Auxiliary Crate Controller for CAMAC. It will be used as principal processing element for the control of the LEP preinjector (LPI) [1] and hence will be part of

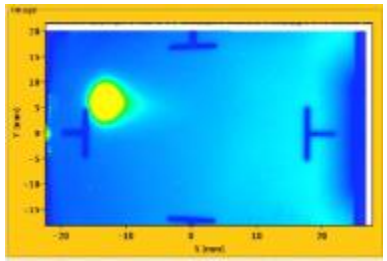
beam emittance measurement loca
crate must also be able to chang
quadrupole which is interfaced
is one of the cases where SMACC-
would be needed.

- LHC Timeline ⇨ Why the LS1 ?
- Scope of the SMACC project *(13 kA splices but not only!)*
  - The main consolidations during LS1 (2013-14)
  - Design of the consolidated 13 kA splices
  - Other consolidation interventions

    Safety relief valves, DFBA, Quadrupole diodes, replacement of cryomagnets, Installation of cryo BLM, shortening of RQ bus, connection cryostats,…
- Preparation phase
  - Project Organisation
  - Planning
  - International Reviews
  - Training
- Sequence of operations - workflow
- Results
  - Safety
  - Quality – Improvements
  - Schedule (Dashboards) and Budget
- Lessons learnt
- Conclusions

LHC Timeline

August 2008
First injection test



September 10, 2008
First beams around

2008 | 2009 | 2010

September 19, 2008
Incident
Accidental release of 600 MJ stored in one sector of LHC dipole magnets

Hard reminder that
"Operating LHC superconducting magnets is like pulling a tiger's tail"
Dixit : KH Mess

LHC Timeline

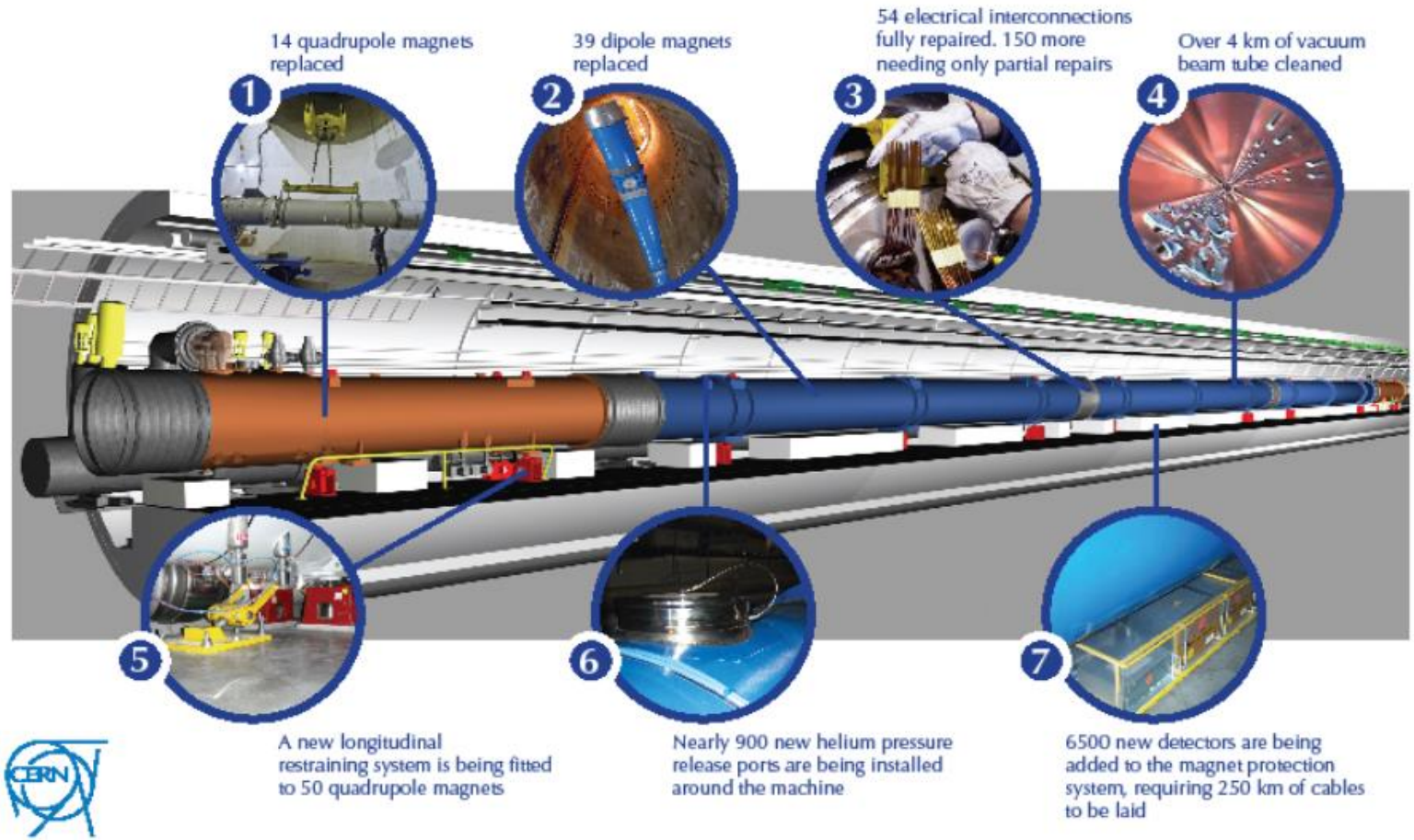
2008-09

- **Repair what is needed,**
- **Reduce consequences of similar failures,**
- **Improve protection**

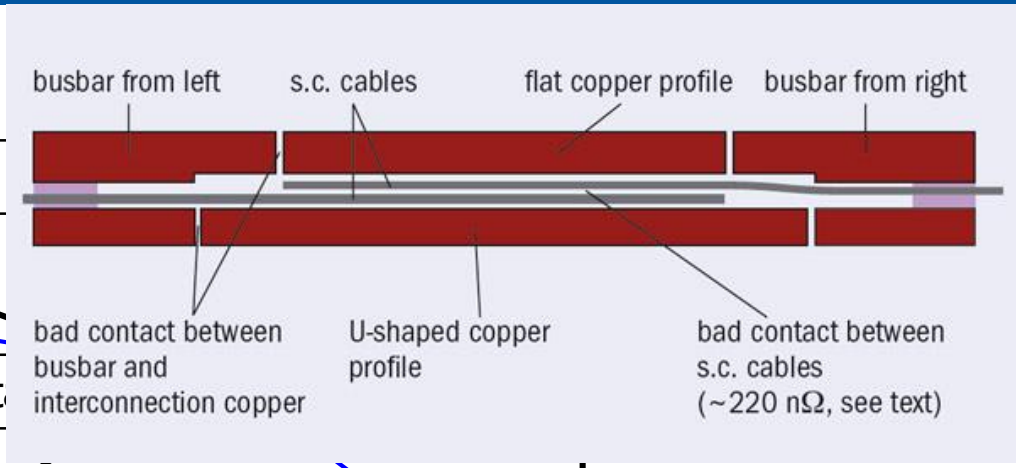
In parallel with

- **Analysis of the cause**
- **Start the developement of long-term solutions**

The LH



LHC Timeline : Analysis of the incident



Absence of soldering

Observed on magnet

Resistance 200 nOhm

Bad cont

Measurement of joint resistance (calorimetry & electrical)

Global measurements (300K and 80K) and local at 300K (opening of the

Additional quench detection on bus bars

Electro-thermal model

Thermal runaway

Mechanical reinforcement of the splices

Reinforce Copper stabilizer

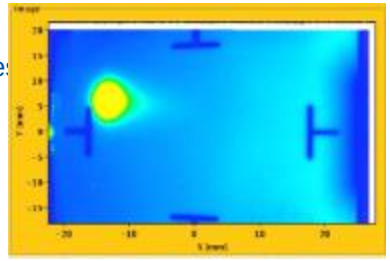
Meltdown, open circuit

Power converter fast discharge

Electrical arc

LHC Timeline

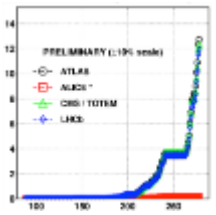
August 2008
First injection te

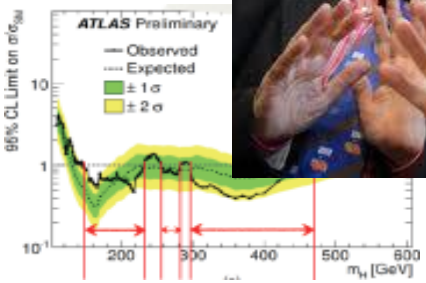


3.5 TeV

4 TeV

November 29, 2009
Beam back





September 10, 2008
First beams around

October 14 2010
1e32
248 bunches

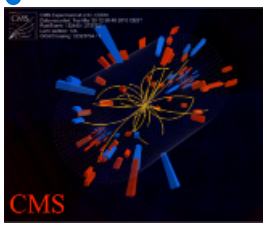
August, 2011
2.3e33, 2.6 fb^{-1}
1380 bunches

4 July, 2012
Higgs discovery

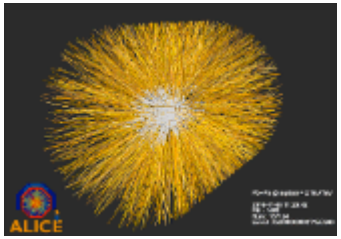
2008 | 2009 | 2010 | 2011 | 2012

September 19, 2008
Incident
Accidental release of 600 MJ stored in one sector of LHC dipole magnets

March 30, 2010
First collisions at 3.5 TeV



November 2010
Ions



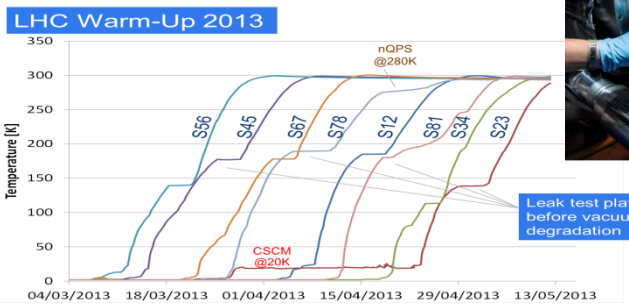
LHC Timeline

Comments (16-Feb-2013 08:25:13)
*** END OF RUN 1 ***

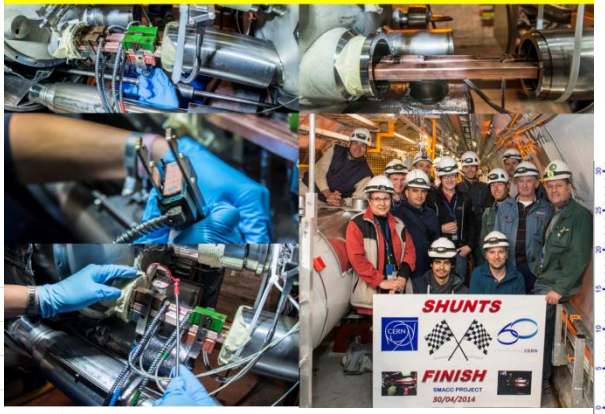
No beam for a while. Access required
time estimate: ~2 years

SHUTDOWN: NO BEAM

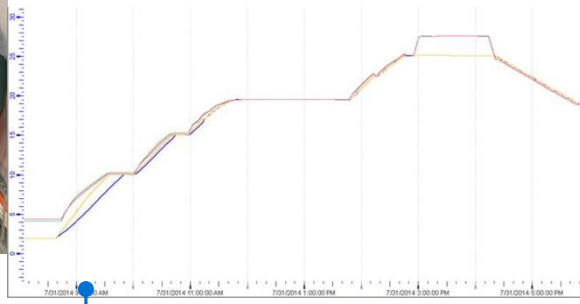
4 TeV



Last shunt soldering > Sector 34 (30.04.2014)



April 28, 2014
Installation of the last shunt



July 31, 2014
Last pressure test

2013 | 2014

April 8, 2013
Opening of the first IC

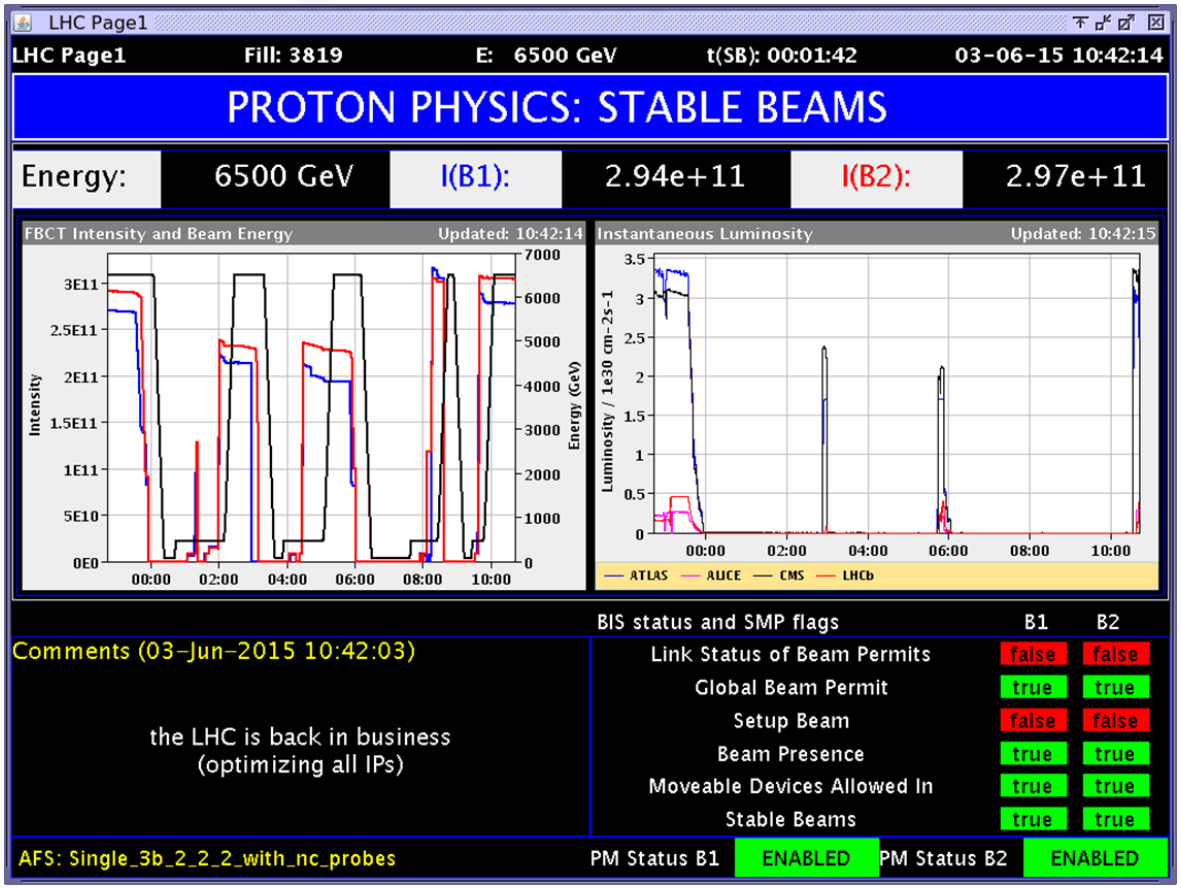
October 8, 2013
Nobel Prize

November 28, 2013
Re-closure of first sector (S67)

Collaborations with NTUA (Athens), WUT (Wroclaw) and support of JINR-DUBNA

LHC Timeline

6.5 TeV



2015 | 2016

The main 2013-14 LHC consolidations

1695 Openings and final reclosures of the interconnections

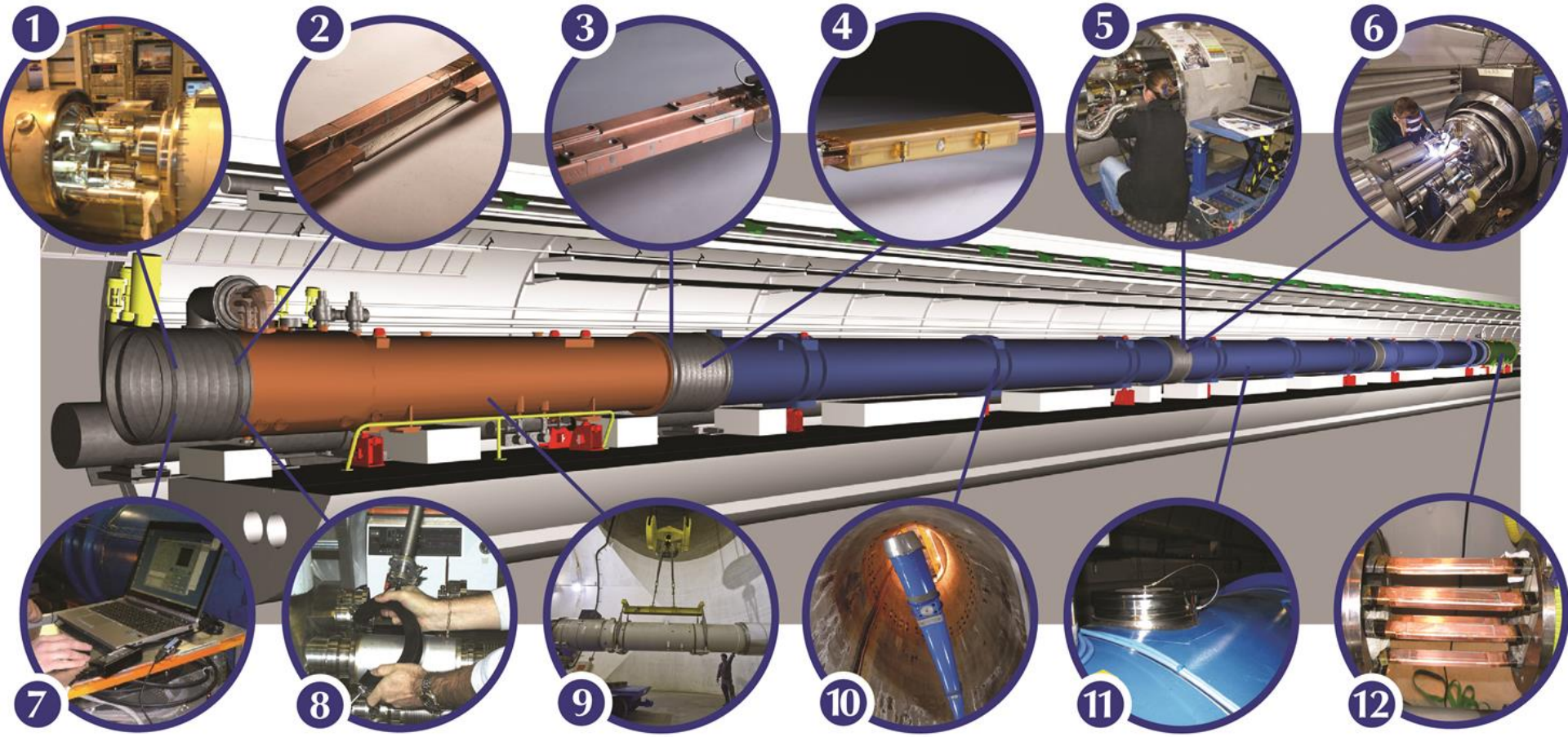
Complete reconstruction of 3000 of these splices

Consolidation of the 10170 13kA splices, installing 27 000 shunts

Installation of 5000 consolidated electrical insulation systems

300 000 electrical resistance measurements

10170 orbital welding of stainless steel lines



18 000 electrical Quality Assurance tests

10170 leak tightness tests

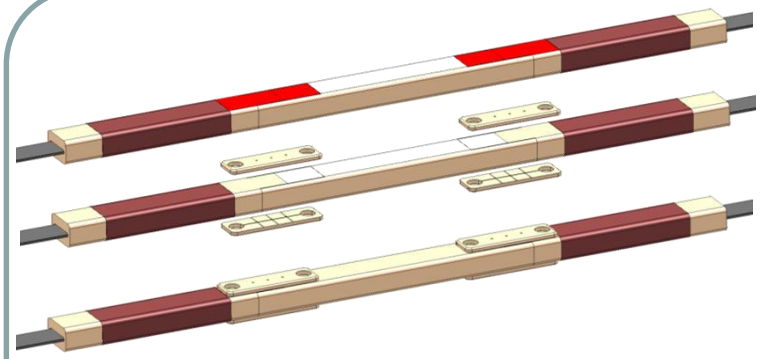
3 quadrupole magnets to be replaced

15 dipole magnets to be replaced

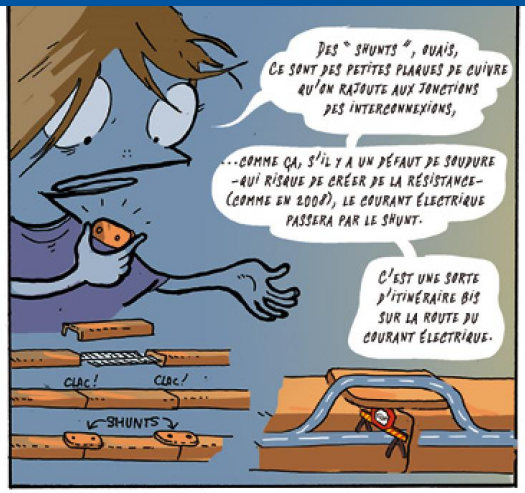
Installation of 612 pressure relief devices to bring the total to 1344

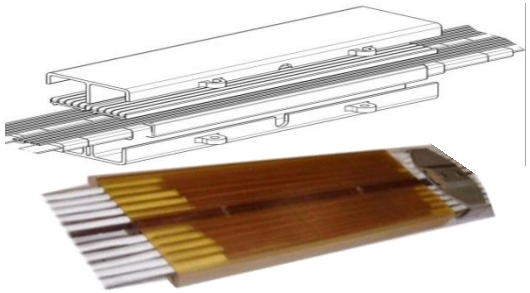
Consolidation of the 13 kA circuits in the 16 main electrical feed-boxes

Design of the consolidated 13 kA splices



Consolidated dipole magnets bus splice

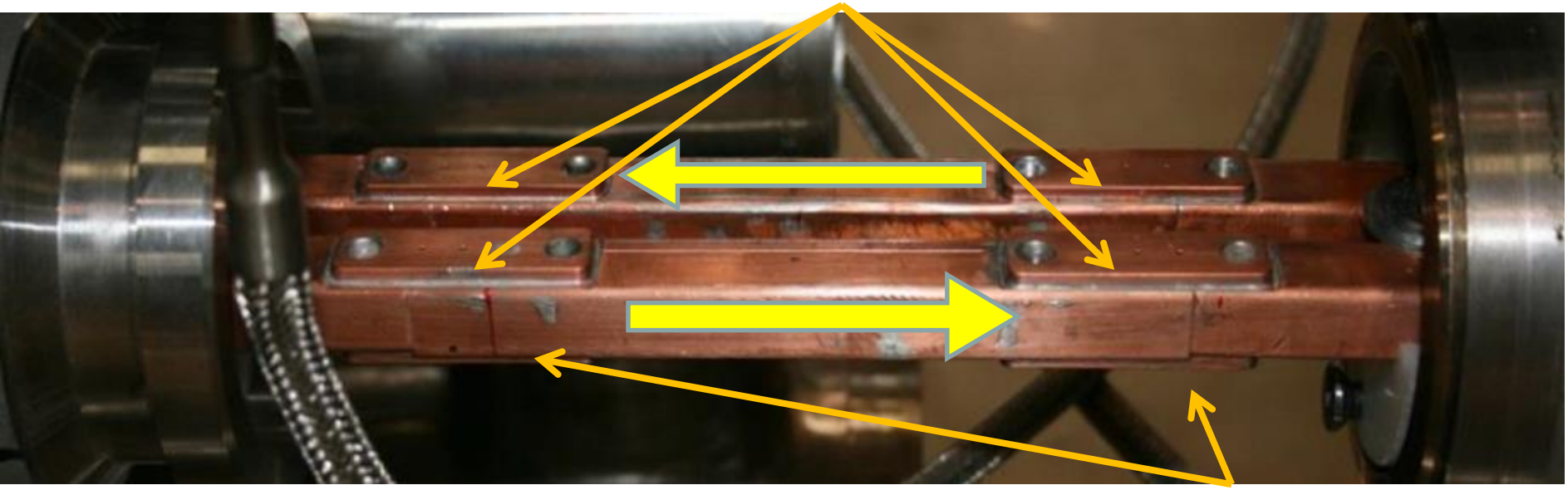




Consolidated electrical insulation system

Lison Bernet, http://lhc-france.fr

4 top shunts



4 bottom shunts (2 not visible)

Project Organisation

SMACC
Superconducting Magnets And Circuits Consolidation

Production		*Quality Assurance (Q A)*
Main arc splices cons. “The train” (93)		General Q A (43)
Open/Close IC (36)	TIG welding (18)	Electrical Q A (28)
Special Interventions (18)	DFBA (13)	Leak Test (19)
Coordination, Support & Infrastructure [CSI] (11)		

- As independent as possible QA team representing 1/3 of the people
- A dedicated team taking care of CSI
- Link persons with safety : General safety and Radioprotection
- A planning link person

Official kick-off meeting on 01.03.2012

Superconducting Magnets And Circuits Consolidation

Open/Close IC [DN200]
A Musso (A Chrul) #36
- -Opening/ Closure of IC
  Partial and complete
  W bellows & ther. shields
- -Installation of DN200

Main arc splices cons.
F Savary (H Prin) #93

Quality Assurance
R Ostojic #43

The right person at the right place
Took 3 years to crystallise
Evolved during the project

TIG welding [EN-MME]
S Atieh (D Rey) #18 (+5)
- - Orbital & manual

Special interventions "SIT"
N Bourcey (G Maury) #18
- -Cryomagnets exchange
- -Connect. Cryostat cons.
- -PIMs
- -Specific issues
- -Heavy NCs

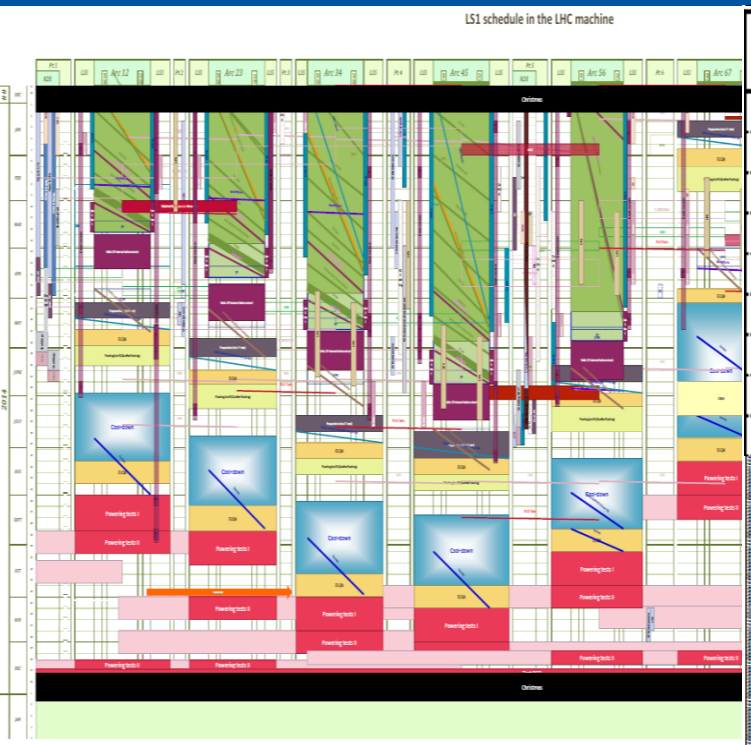
ELQA [TE-MPE]
K Dahlerup
(G D'Angelo) #28
- -Continuity
- -HV test

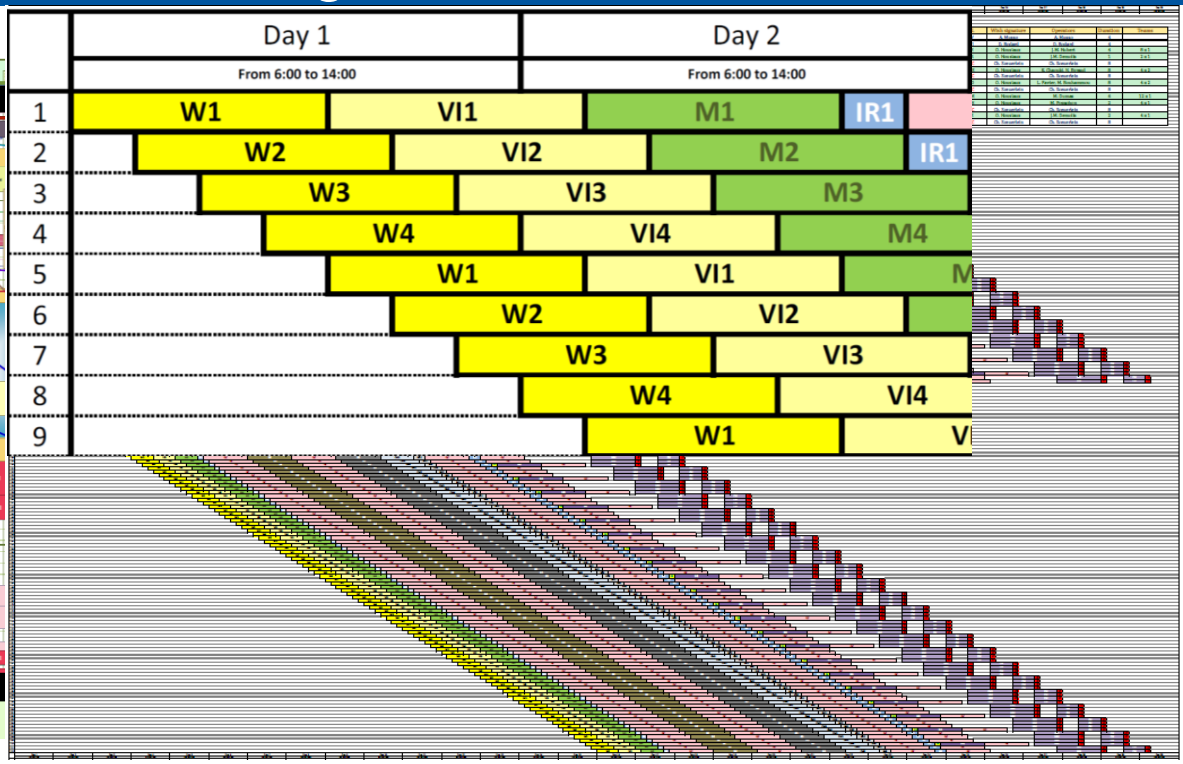
Leak Test [TE-VSC]
P Cruikshank
(C Garion) #19
- -Beam lines
- -Cryogenics lines
- -Insulation vacuum

DFBA [TE-CRG]
A Perin (O Pirotte) [#13]
- -Splices and BB

SMACC CSI (Coordination, Support, Infrastructure) M Pojer (R Giachino) #11
- -Radiation protection
- -Safety, Access
- -General logistics
- -Pressure test
- -Link to visits, media
- -Coordination with
  Survey, BLM, Instrumentation, Transport, planning, QPS, cryogenics, VSC, MPE, CRG, .
  Test teams on a chain of IC
- -Reporting tools
- -Administrative support (Budget, human resources, scientific secretary)

Planning





- Interacted very early with the LS1 coordination team
- To defend our slot in the overall schedule (always possible to negotiate)
- To optimise the number of workfronts
- To size correctly the team
- To anticipate bottlenecks
- To manage the many interfaces

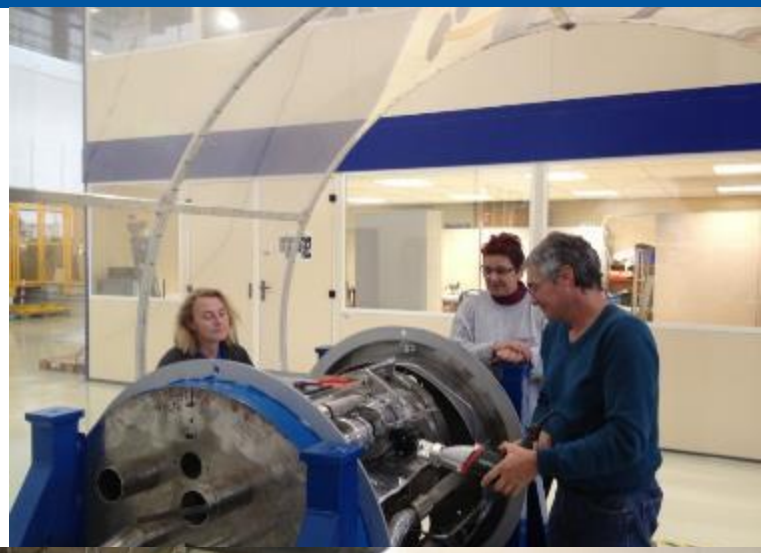
International Reviews

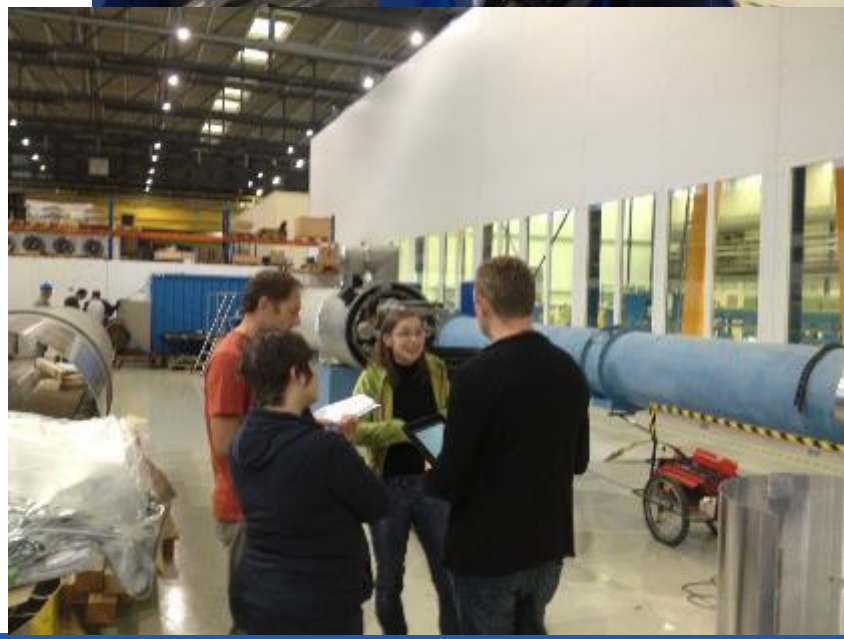
- 4 international reviews (+1 CERN internal for DFBA), planned since the beginning
  - Oct 2010 : Design, plan, risk analysis
  - Nov 2011 : Final design, update of plans and risk analysis
  - Nov 2012 : Production Readiness Review
  - Feb 2013 : DFBA splices
  - July 2013 : Quality Assurance review
- Almost the same review committee members to ensure follow-up
- Issues identified
- Encourages to have strong and documented justifications
- Supporting requests from the project towards the CERN managment

"The planning needs to take account of the possibility of unforeseen developments that will slow down or disrupt the orderly work flow. For example, **a larger number of splices than the currently estimated 15% may be required to be remade...**
Include schedule contingency into the baseline and ensure that additional resources are available to able to maintain the schedule"
From second review

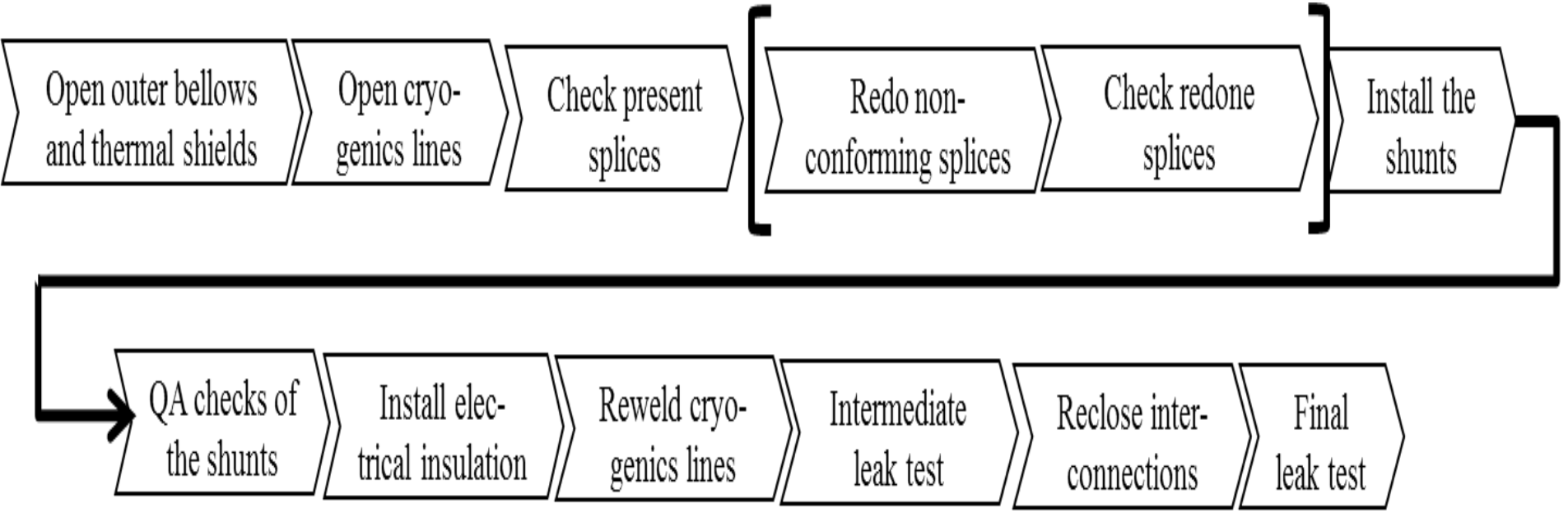
Training

- Preparation on mock-ups
  As realistic as possible (environment,…)
  - To explain the work
  - To practice it
  - To assess the exact time required
  - To have the right person at the right place
  - To integrate
  - To know each other

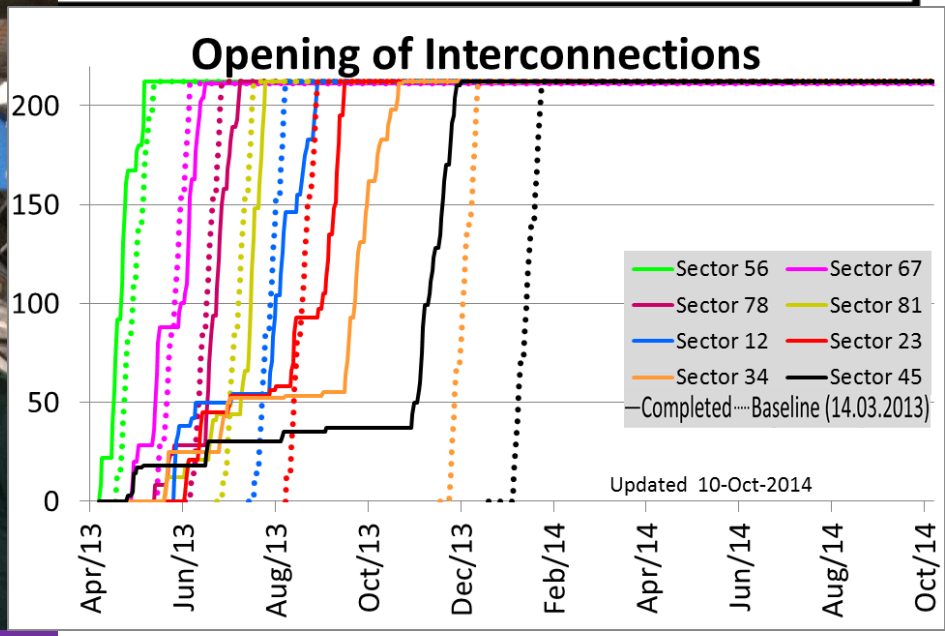




Simplified sequence of operations



Open outer bellows and thermal shields → Open cryo-genics lines → Check present splices → Redo non-conforming splices → Check redone splices → Install the shunts



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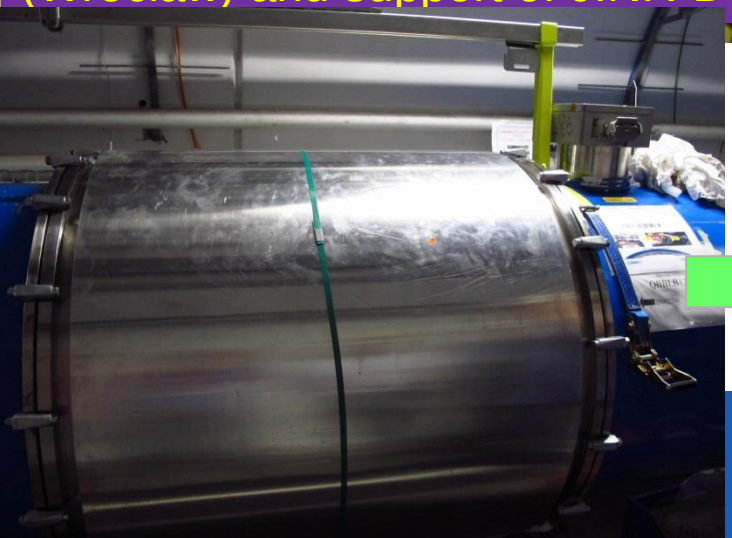


Open outer bellows and thermal shields → Open cryo-genics lines → Check present splices → QA checks of the shunts → Install elec-trical insulation → Reweld cryo-genics lines

Collaboration with PAEC-NCP
(Pakistan Atomic Energy Commission – National Centre for Physics

SMACC Project, Cutting of the M-lines, Thursday 6 February 2014

The Team crosses the 'FINISH' Line !

Open outer bellows and thermal shields → Open cryo-genics lines → Check present splices → Redo non-conforming splices → Check redone splices → Install the shunts → QA checks of the shunts → Install elec-trical insulation → Reweld cryo-genics lines → Intermediate leak test → Reclose inter-connections → Final leak test

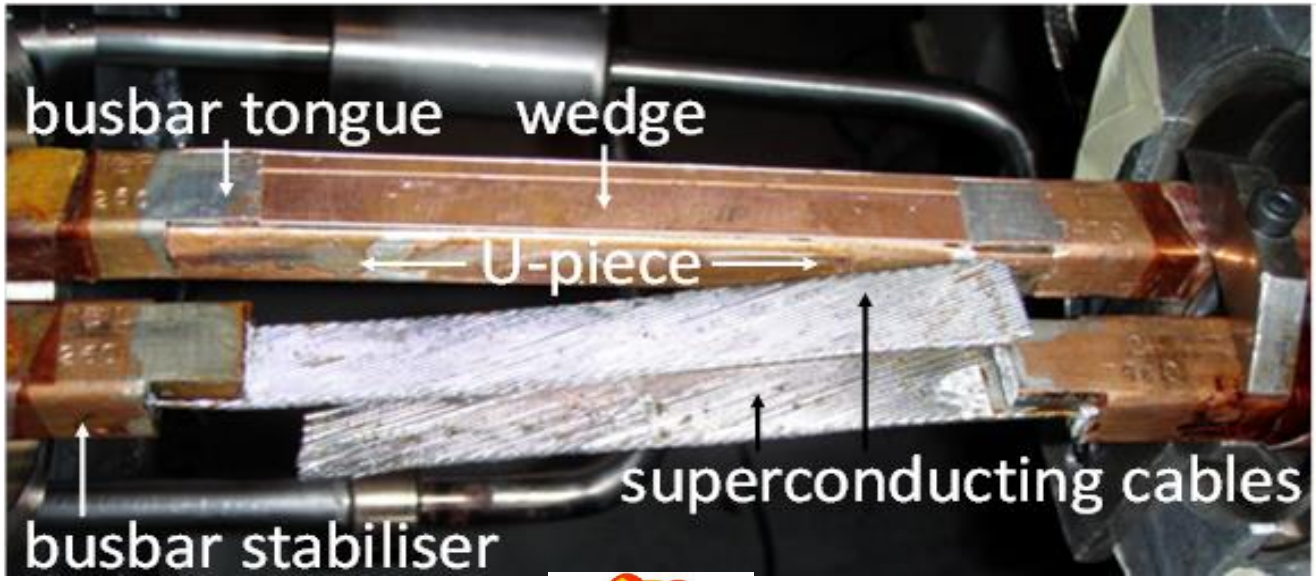
242 el meas/IC
>400.000 electrical measurements
>27.000 shunts
>50.000 visual control
~6.000 cables inspected

Good integration of BE-OP
Fruitful exchange of information

Courtesy
C Scheuerlein & M Solfaroli

Last measurement done on 20.02.2014
Team from BE-OP, TE-MSC, collaborations, FSU

Open outer bellows and thermal shields → Open cryo-genics lines → Check present splices → Redo non-conforming splices → Check redone splices → Install the shunts → QA checks of the shunts → Install elec-trical insulation → Reweld cryo-genics lines → Intermediate leak test → Reclose inter-connections → Final leak test

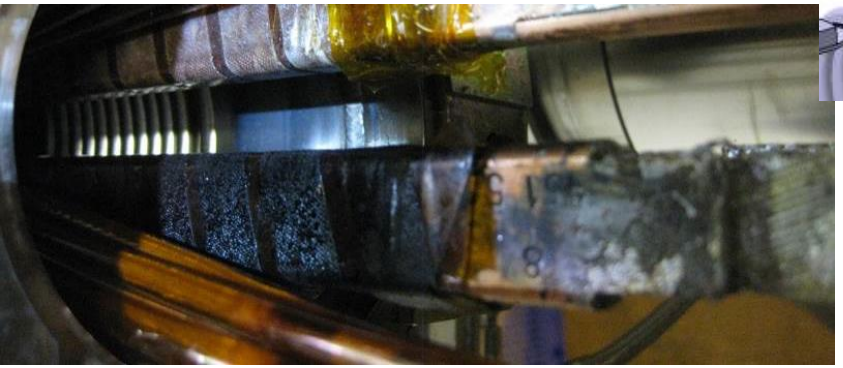


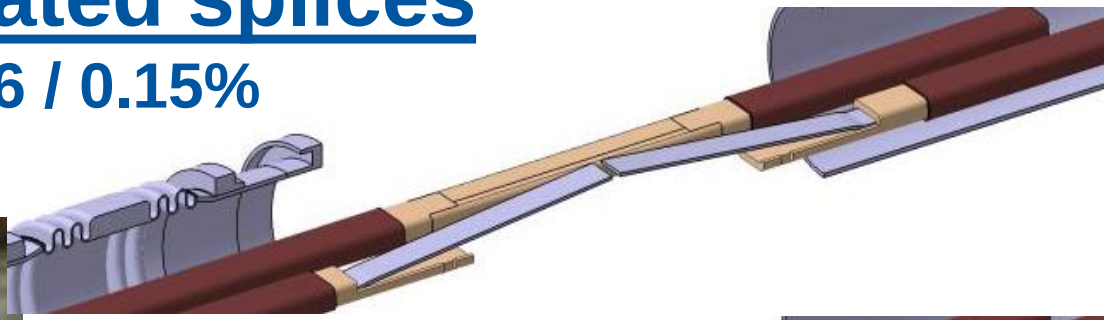
- Planned for 15 %
  - 30 % have to be redone

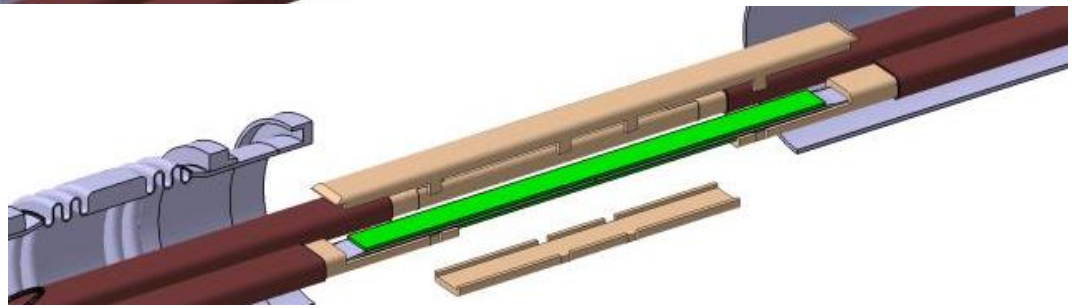
- No compromise on quality
  - Increase of resources (staff, tooling, components)

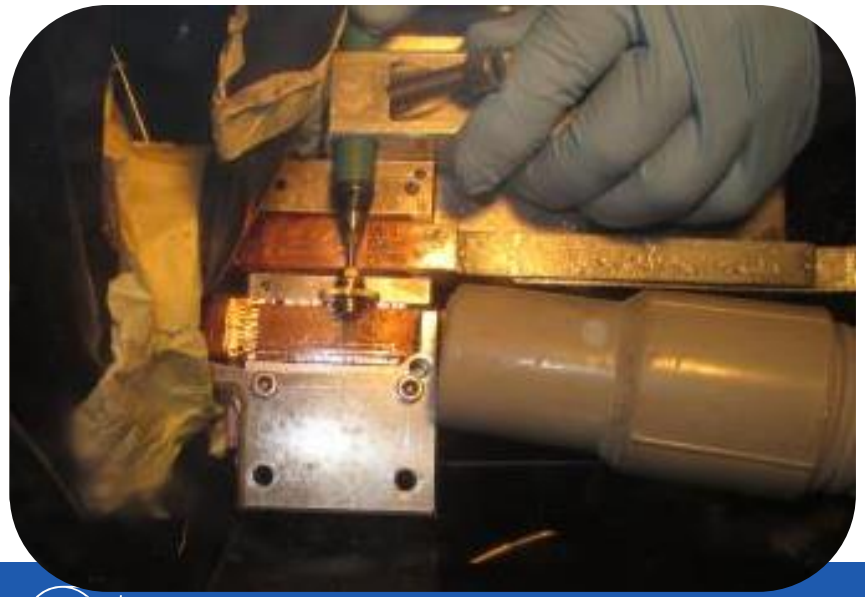
Overheated splices

#16 / 0.15%









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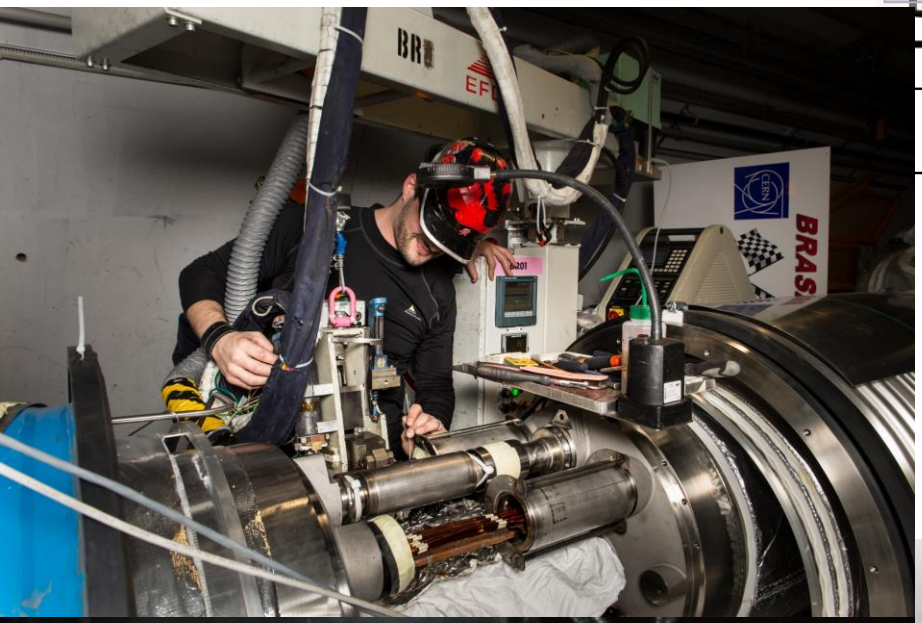
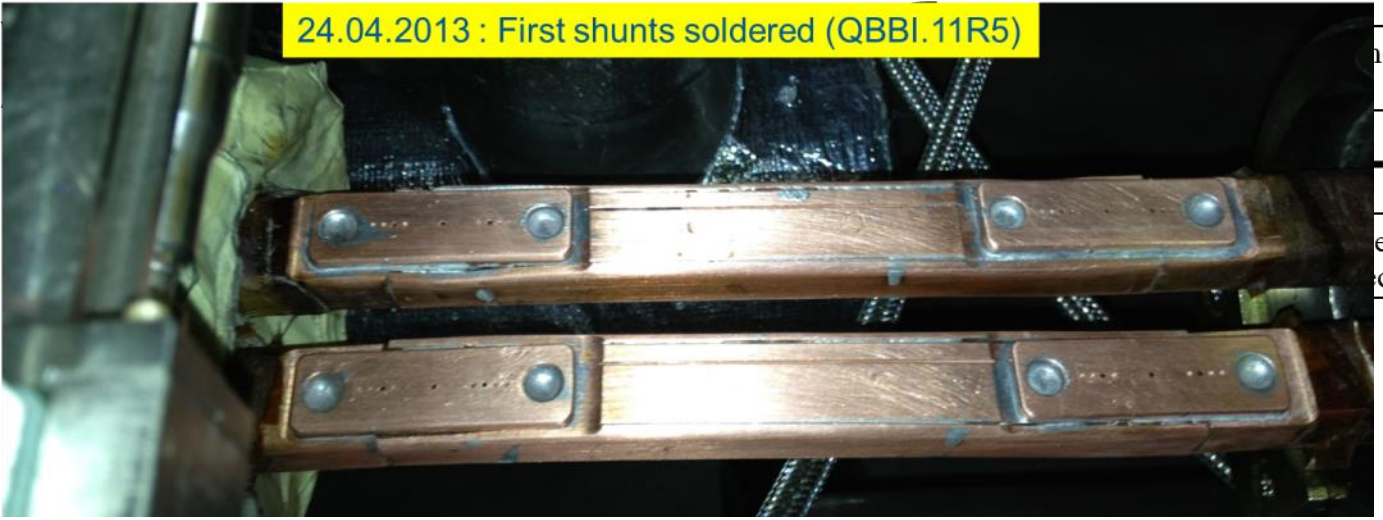
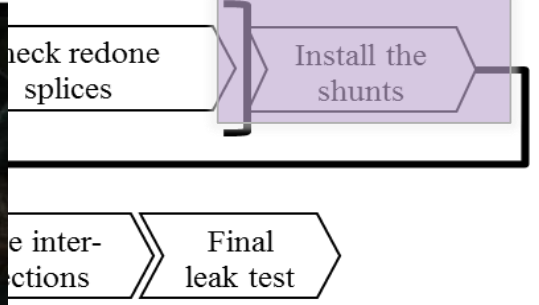


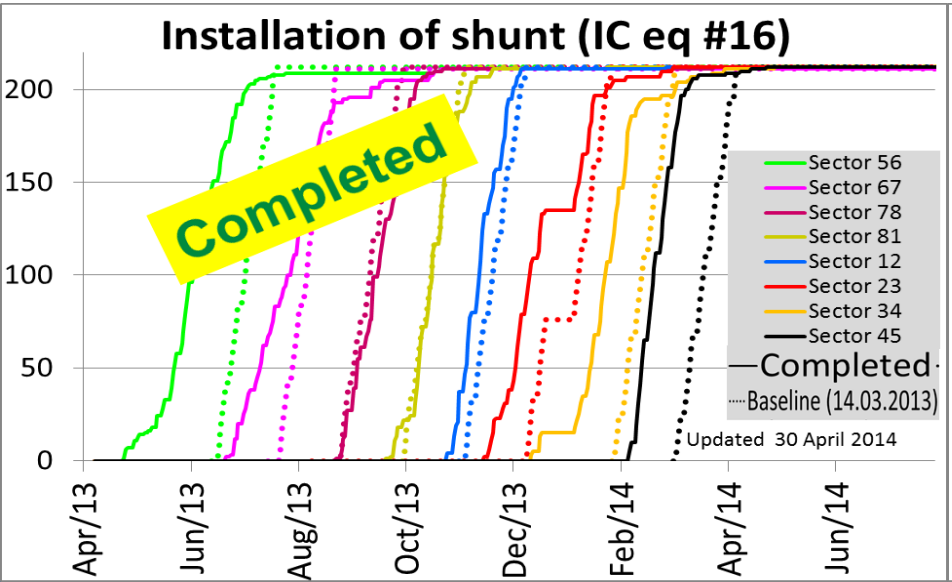
Last unsoldering done on 24.02.2014 / Last resoldering done on 06.03.2014

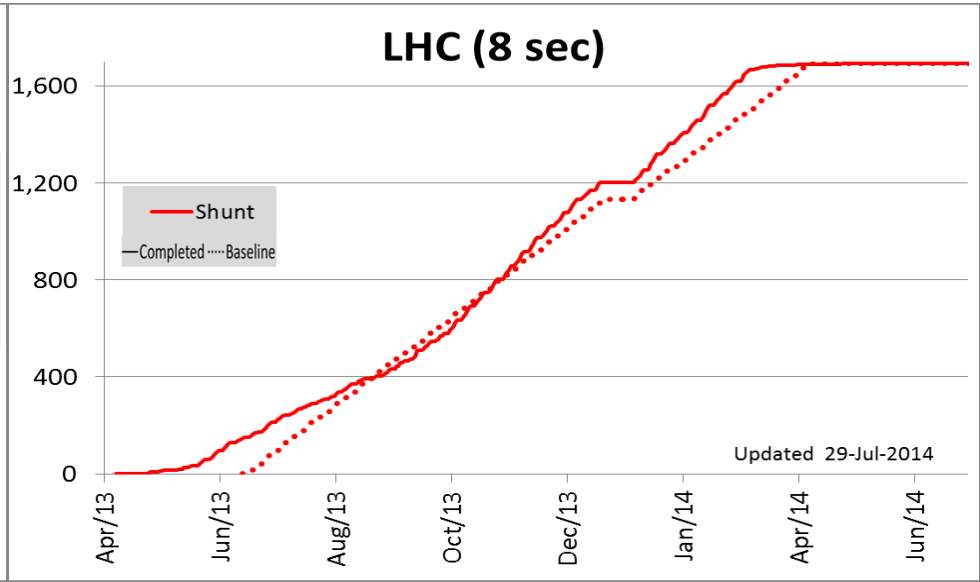




- 27000 shunts to install ⇨ 20 shunts/working hour
- Resistive soldering
- "Only" ≈ 40 persons (15 % of the team)
- Started ahead of schedule, learning in the shadow

⇨ Start new activities as soon as available, even if not efficient in terms of use of resources





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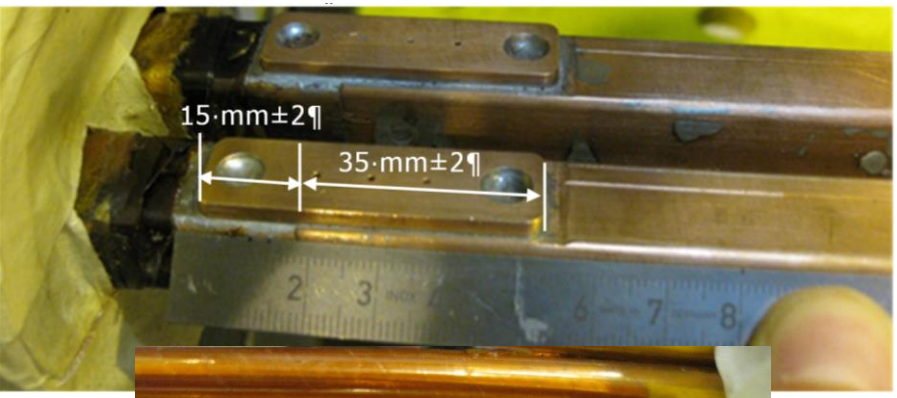

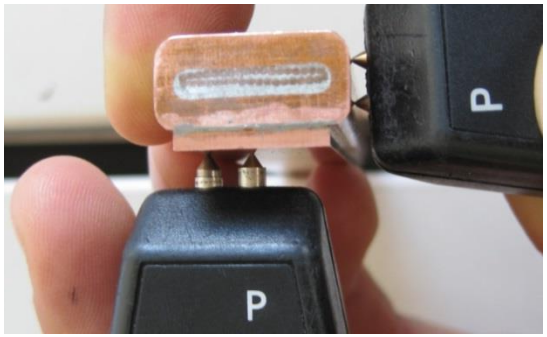

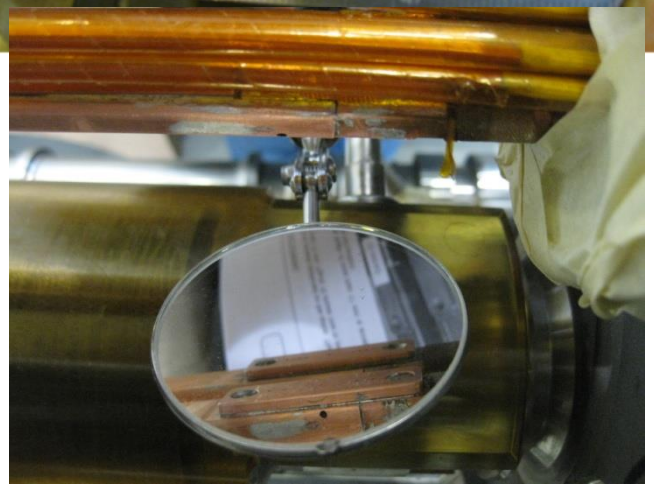

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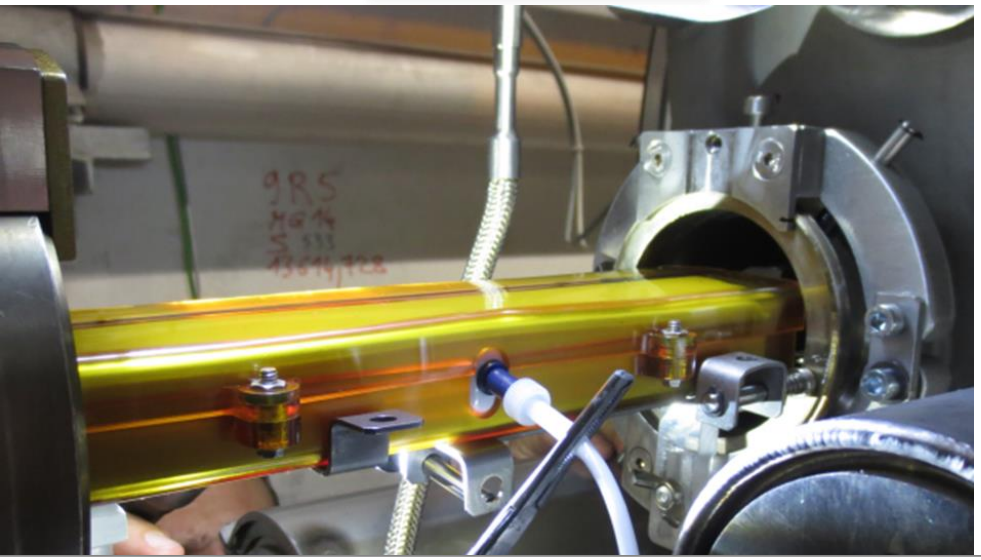
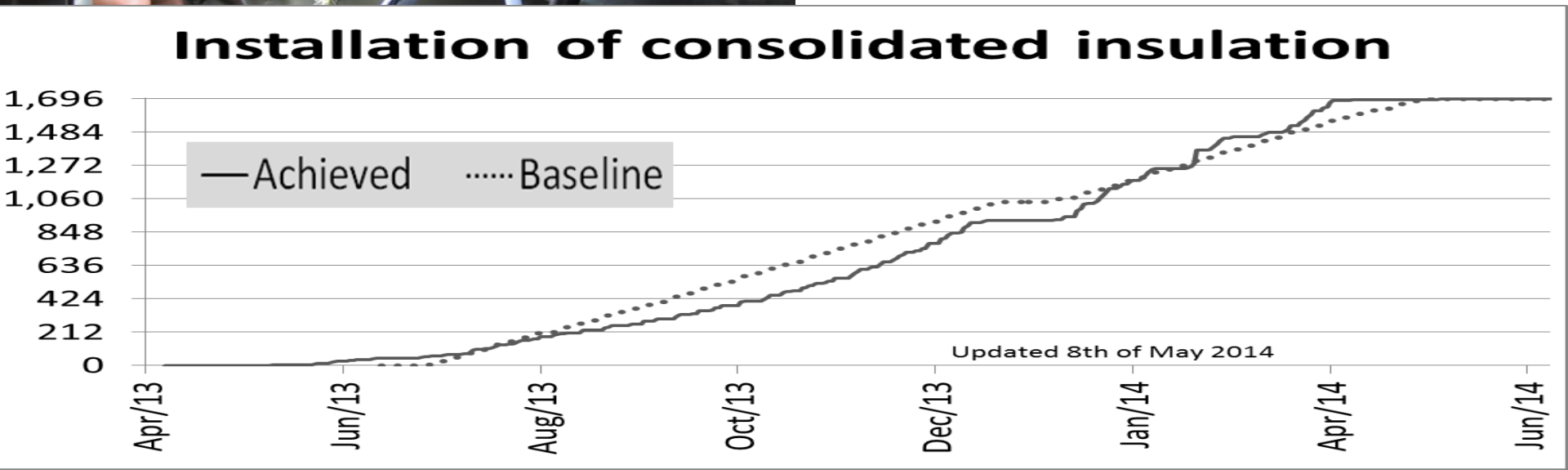
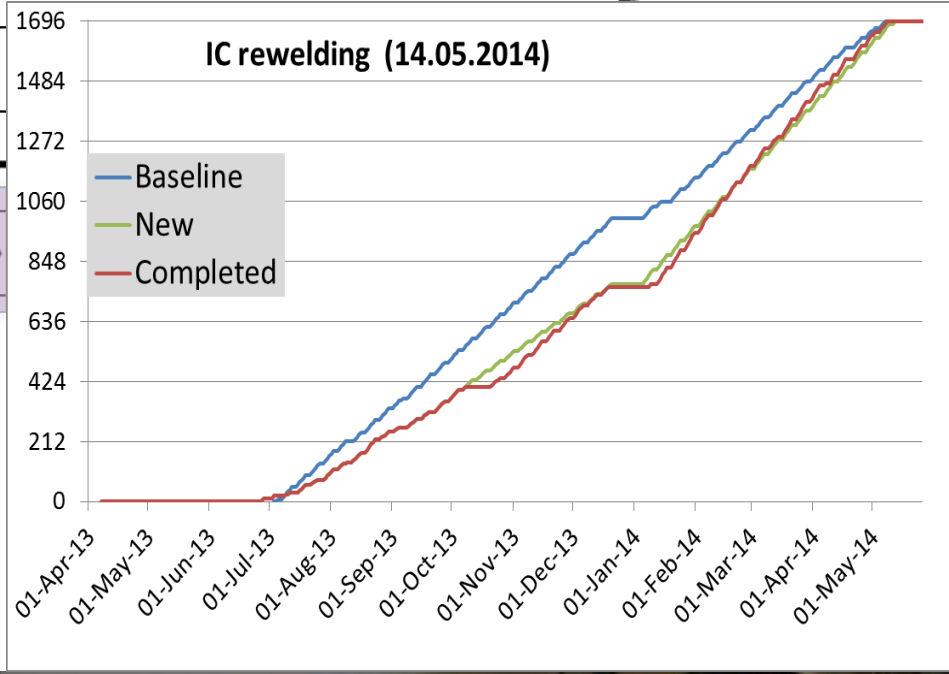


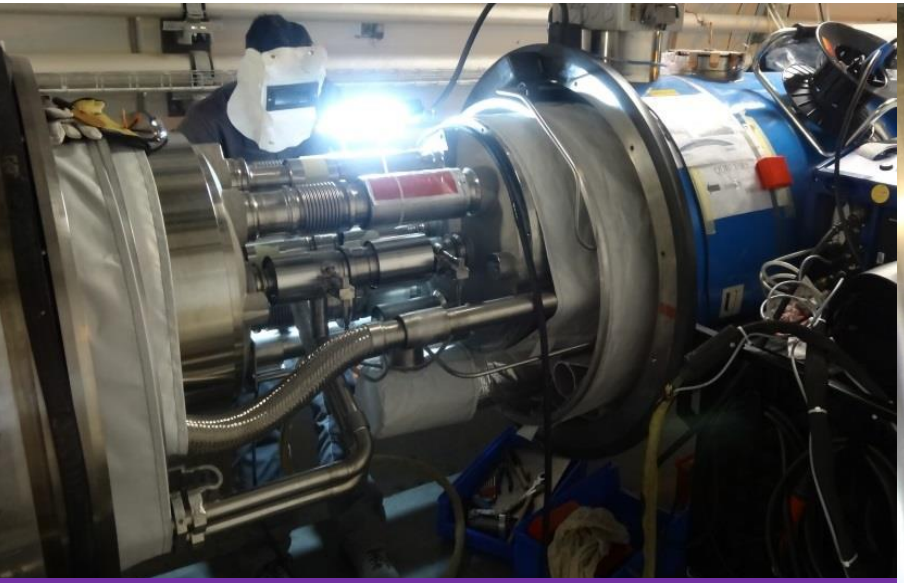
Workload under estimated initially
It took 2-3 months to reorganize and reinforce the team adequately



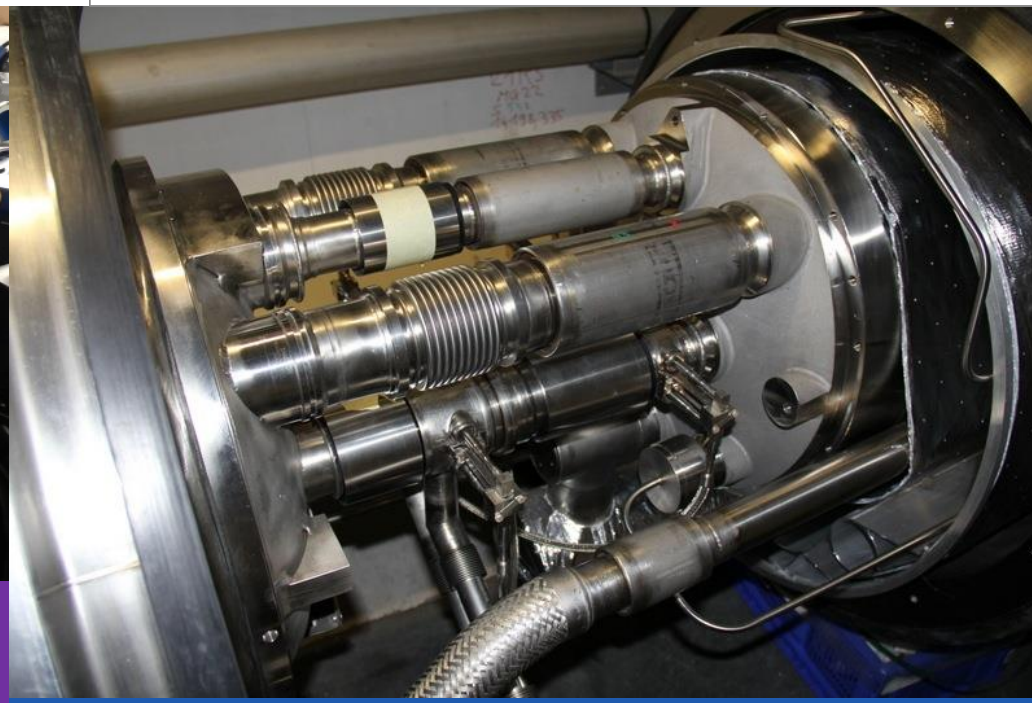
Open outer bellows and thermal shields → Open cryo-genics lines → Check present splices → QA checks of the shunts → Install elec-trical insulation → Reweld cryo-genics lines



- Polyvalent resources redirected to splices redoing
- Delay of > 1 sector was recovered
- Professionally prepared
- Exceptional level of NDT (BE-OP support)



Collaboration with PAEC-NCP (Pakistan Atomic Energy Commission – National Centre for Physics) & FSU

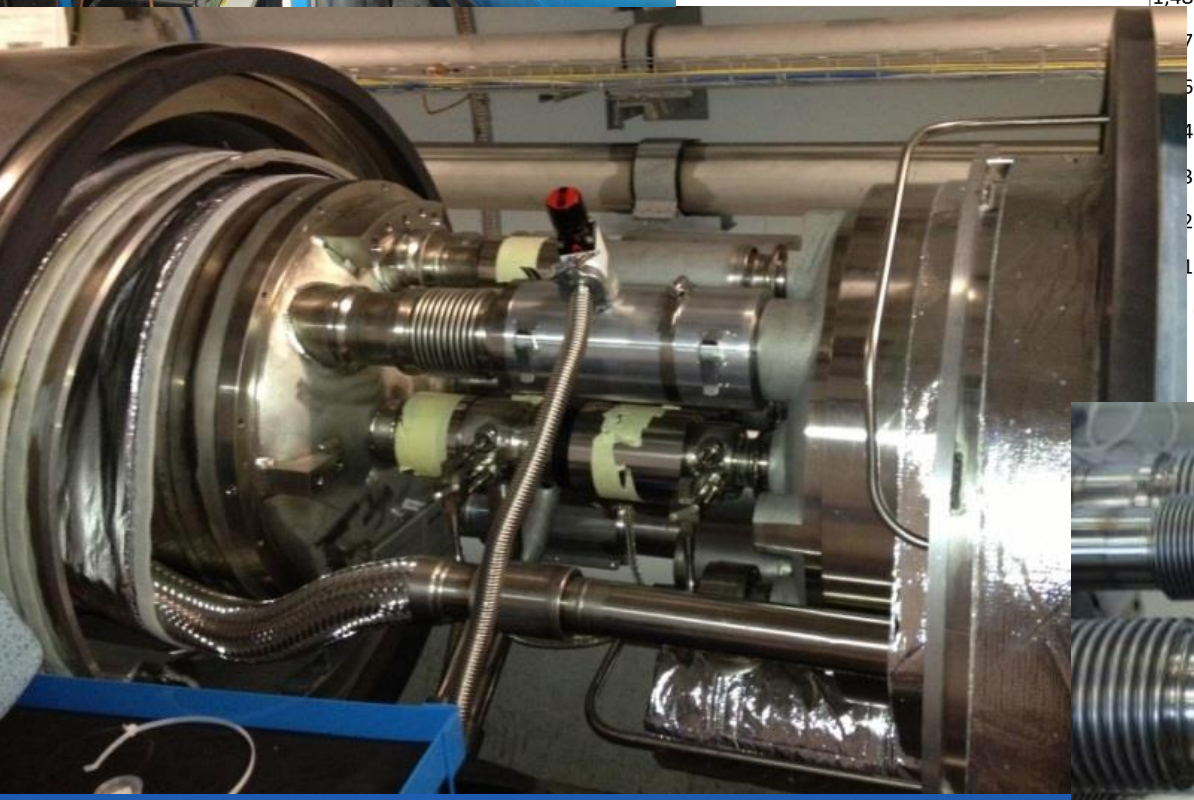


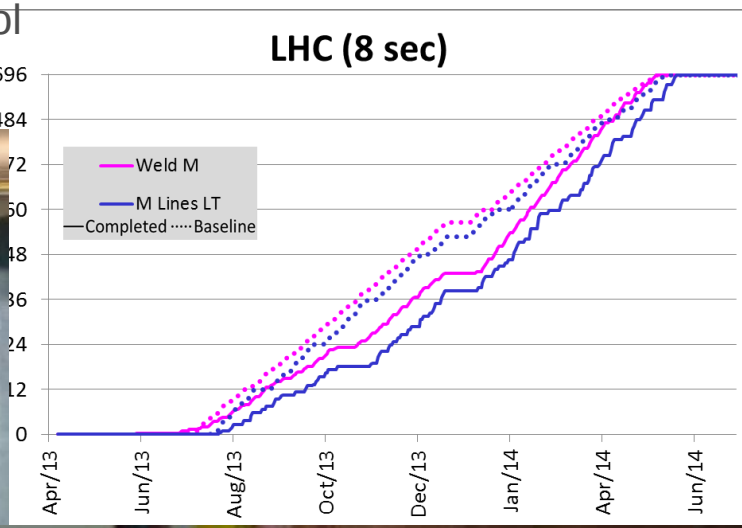
Work under EN-MME responsibility (S Atieh)

Check present splices → Redo non-conforming splices → Check redone splices → Install the shunts

Reweld cryo-genics lines → Intermediate leak test → Reclose inter-connections → Final leak test

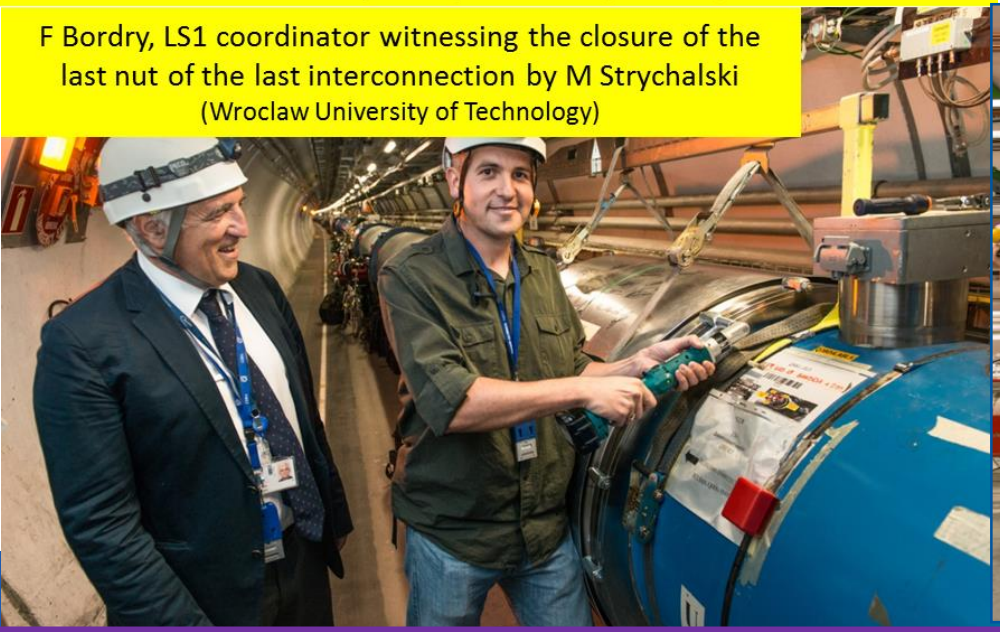
< 2.0 E-9 m.barl/s tightness validation with specially developed clamshell tool





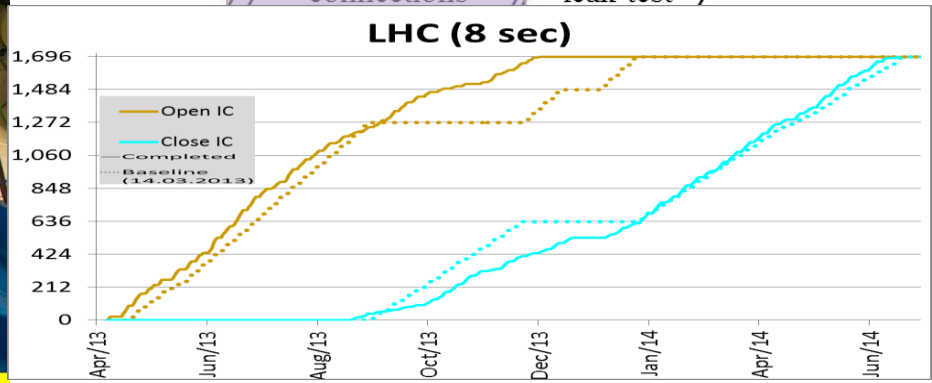
SMACC project : Closure of the last interconnection – 18.06.2014
Activity led by A Musso (TE-MSC)

F Bordry, LS1 coordinator witnessing the closure of the last nut of the last interconnection by M Strychalski
(Wroclaw University of Technology)



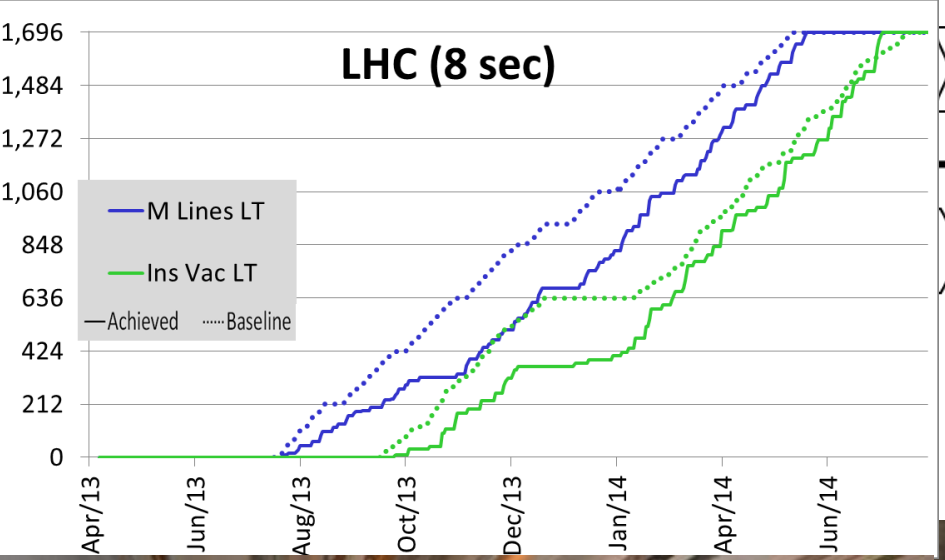
Redo non-conforming splices → Check redone splices → Install the shunts

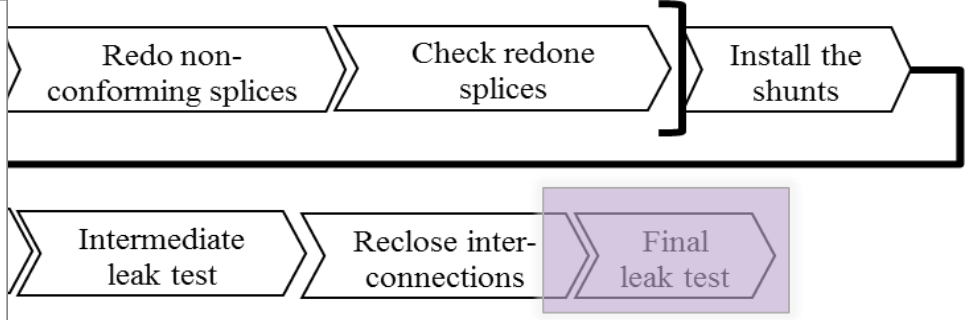
Intermediate leak test → Reclose inter-connections → Final leak test



Wonderful atmosphere till the end

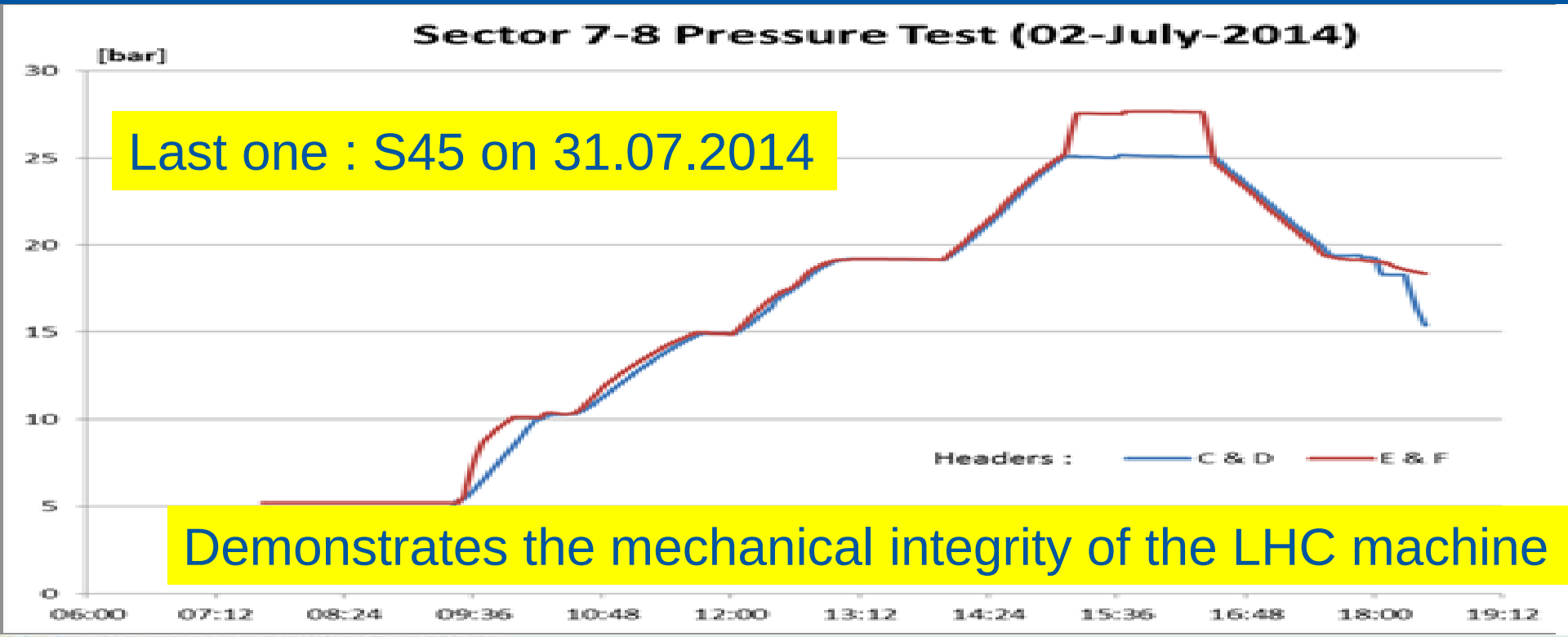
Collaborations with NTUA (Athens), WUT (Wroclaw) and support of JINR-DUBNA





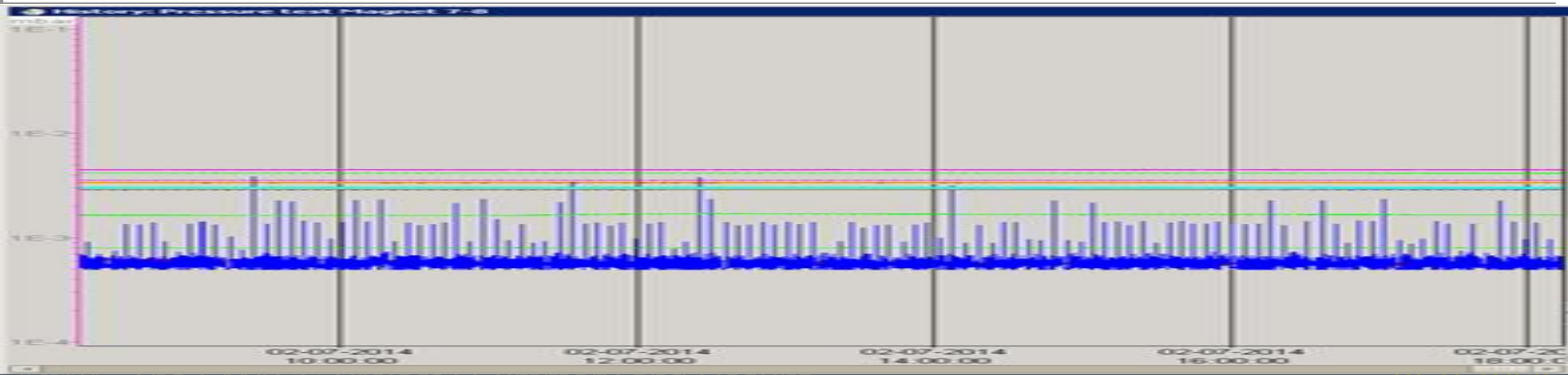
- Last series activities, completed on 4th of July, about 2 weeks ahead of schedule defined in March 2013

Pressure test



Last one : S45 on 31.07.2014

Demonstrates the mechanical integrity of the LHC machine

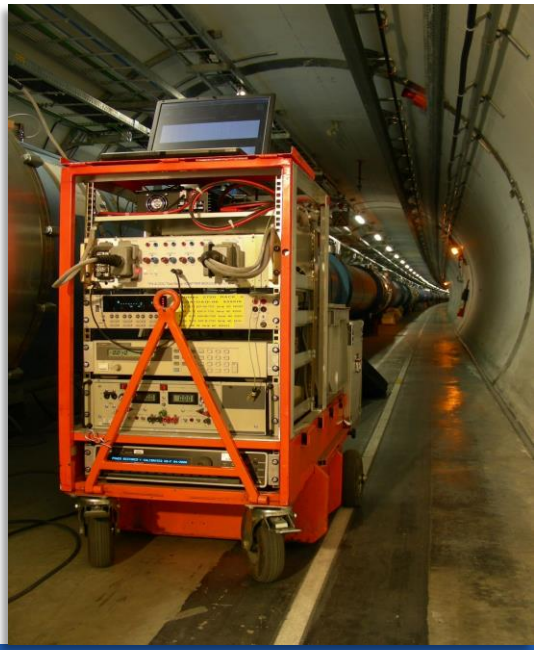


Courtesy O Pirotte

ElQA : Electrical Quality Assurance

Elqa@cold before SMACC → Warm-up → Elqa before → **Elqa during SMACC** → Elqa@warm before cool-down → Elqa during cool-down → Elqa@cold before powering

Demonstrates the electrical integrity of the LHC machine



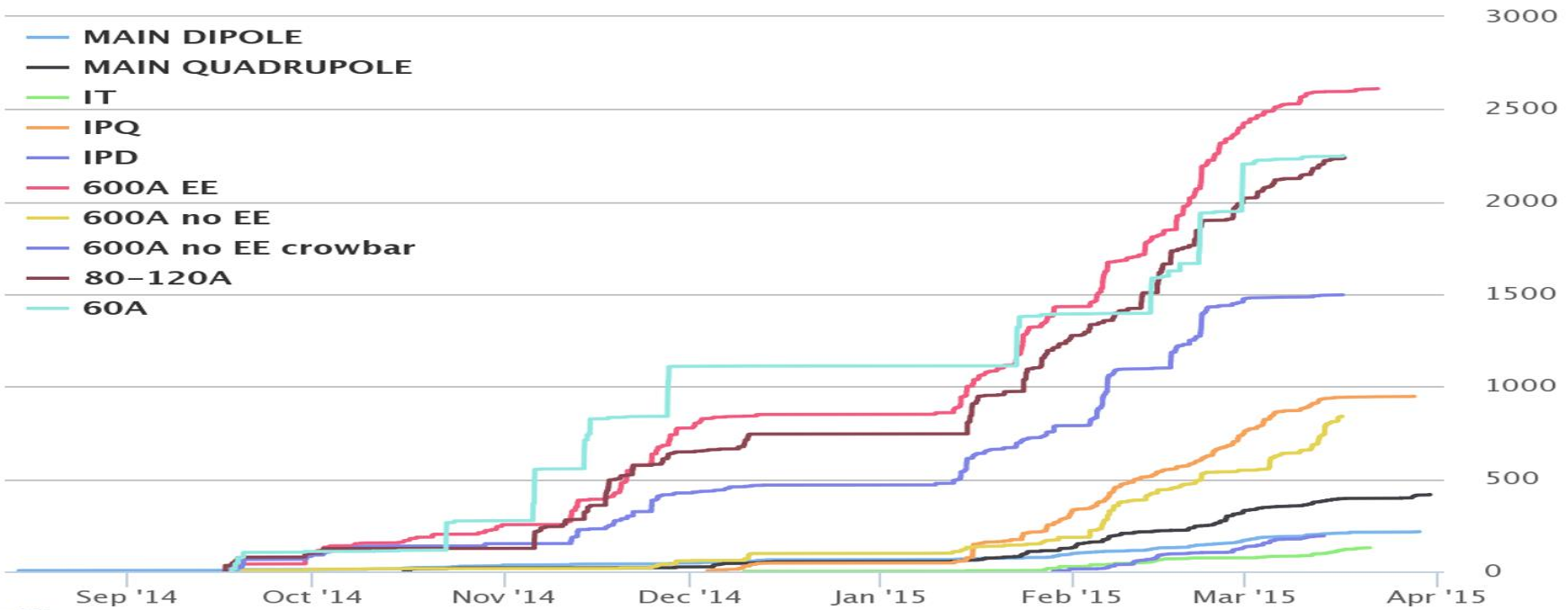
Courtesy G D'Angelo

Powering Tests

THE POWERING TESTS OF THE LHC S/C CIRCUITS AFTER LS1

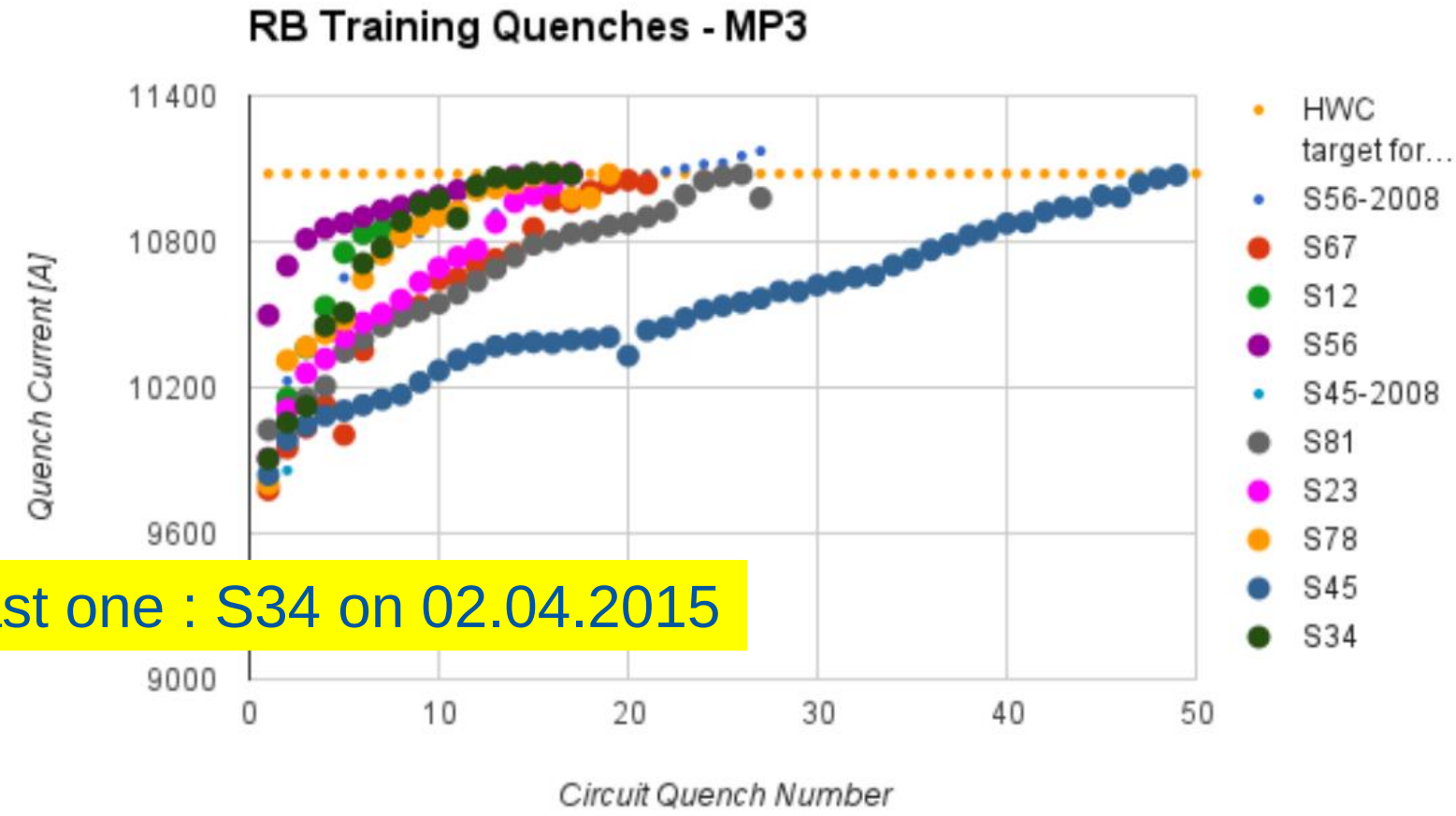
1572 superconducting circuits
Among the **17879** tests, 12212 powering steps and 5667 sign only tests

In total, 22213 tests were executed (including repeated and failed):
16249 powering tests / 5964 sign-only



LHC Magnet Circuits, Powering and Performance Panel - MP3

Final stamp of the quality of the work performed during SMACC



Last one : S34 on 02.04.2015

Results : Safety

- 2013 – July 2014
  - 21 notified accidents
  - 11 minor (no days of absence)
  - 10 with 120 days of absence

- 700 000 hours worked during LS1 period
- Frequency rate: 14
- Severity Rate: 0.17

Don’t forget to protect your head in LHC and restricted workspaces

- Preparation and training are keys to achieve good (safety) results
- Pragmatic solutions are required to solve efficiently emerging issues

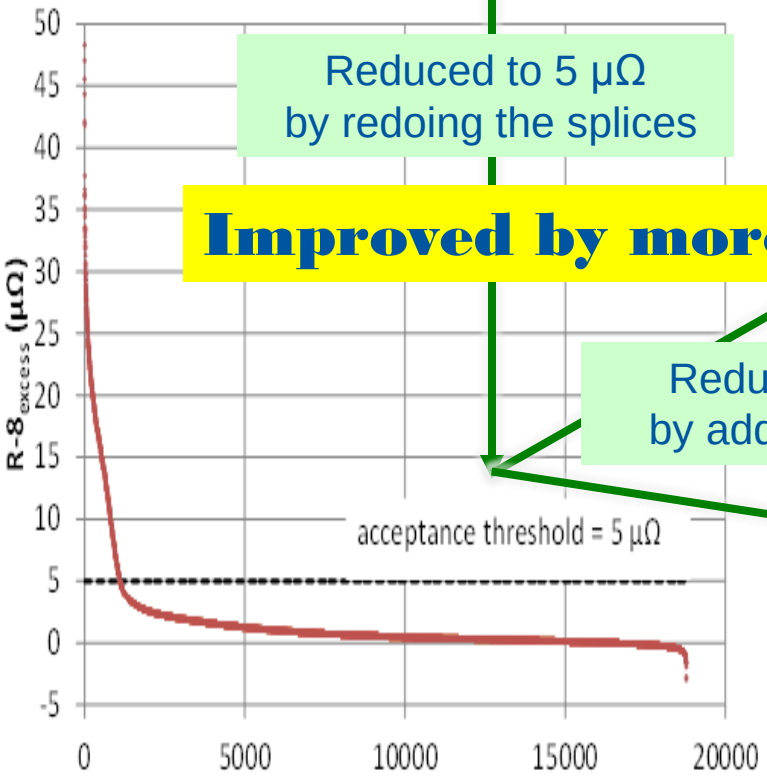
Results : Quality : Cu Continuity

Pre-LS1 : Max = 106 µΩ

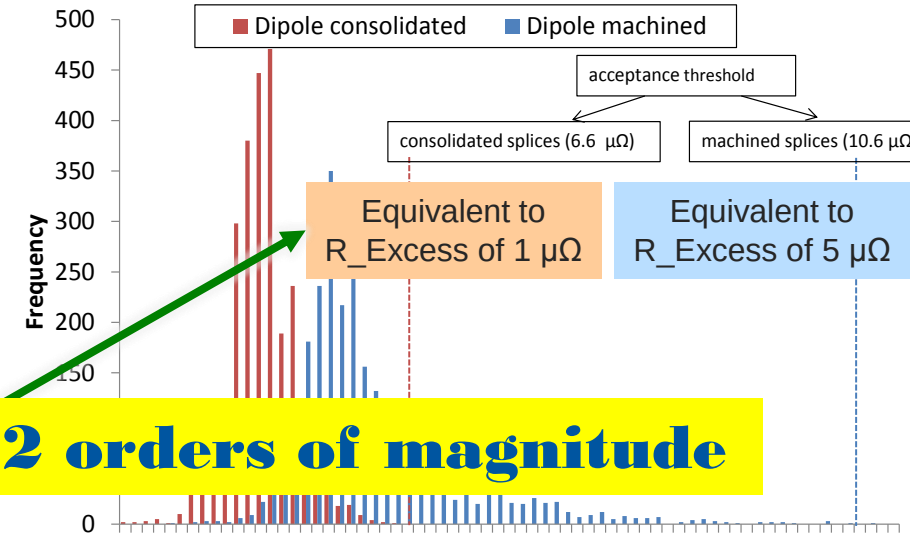
Reduced to 5 µΩ
by redoing the splices

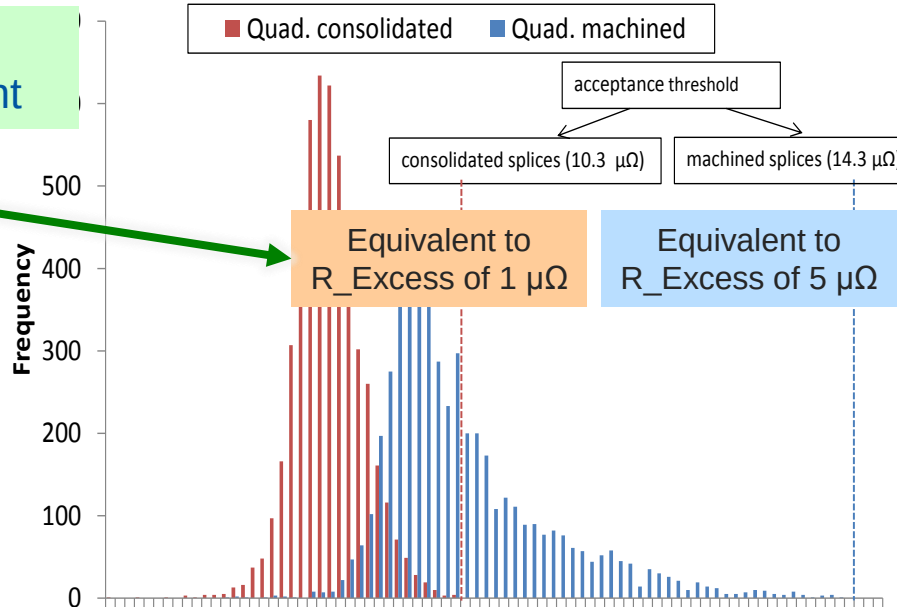
Improved by more than 2 orders of magnitude

Reduced to 1 µΩ
by adding the shunt



Excess resistance distribution sorted descending by resistance values. The two highest R-8 excess values of 106 µΩ and 72 µΩ are not shown.

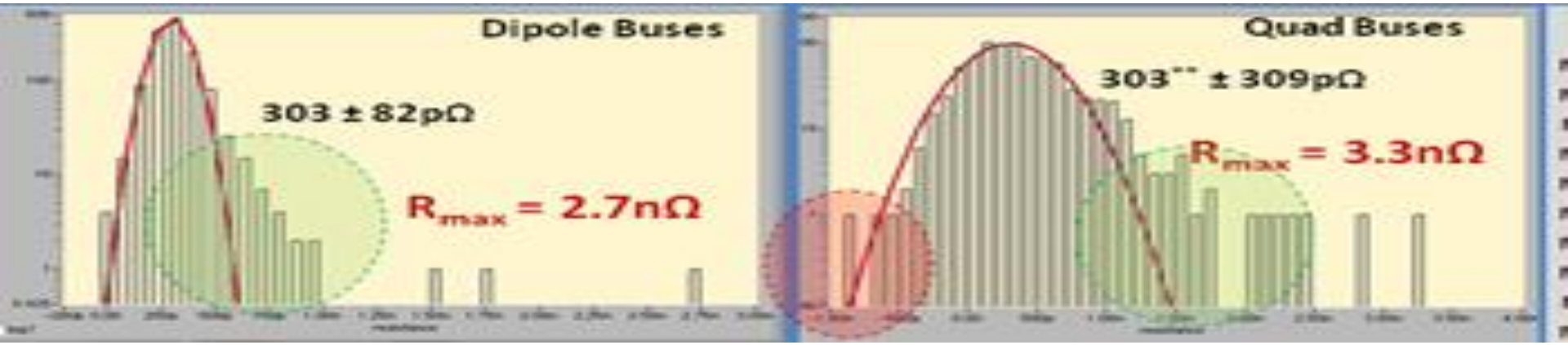




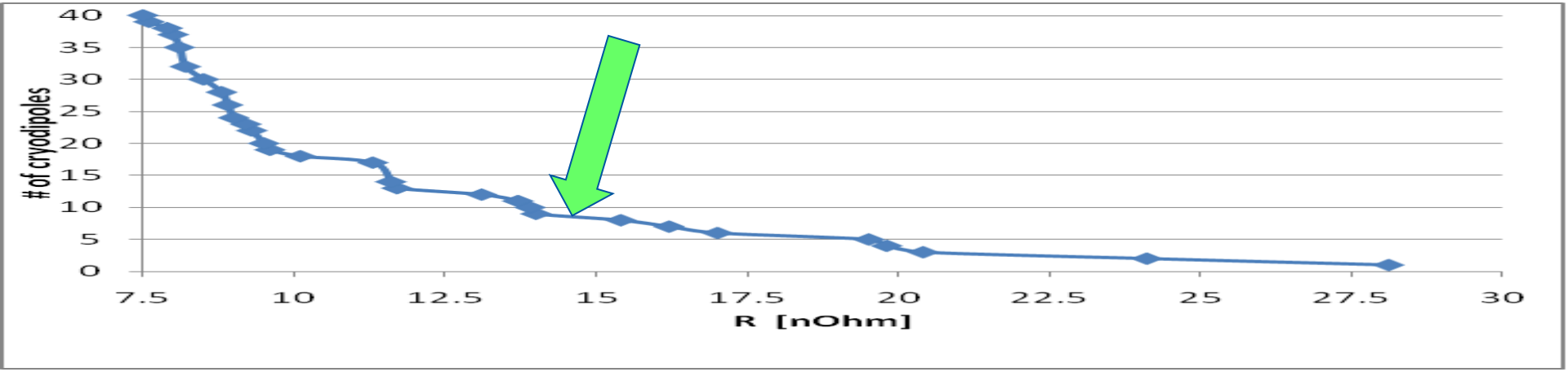
Courtesy C Scheuerlein

Results : Quality : Resitance at cold

1. All splices in segments with excess resistance $R_{1.9K}$>0.82 nΩ and $R_{1.9K}$>2 nΩ for dipole and quadrupole splices have been redone.



2. Cryodipoles with high internal resistance have been replaced (MAX/2)



Improvements : New Thermal shield design

In the dedicated workshop in Bld.183
~**1900** thermal screens sets were upgraded
(a clamp installed instead of the welded lyra; hinge, aluminum bride and snap fasteners were added between the upper and lower shield)

The team:
2 FSU
+ support of Dubna Team
Activity responsible: Graeme Barlow

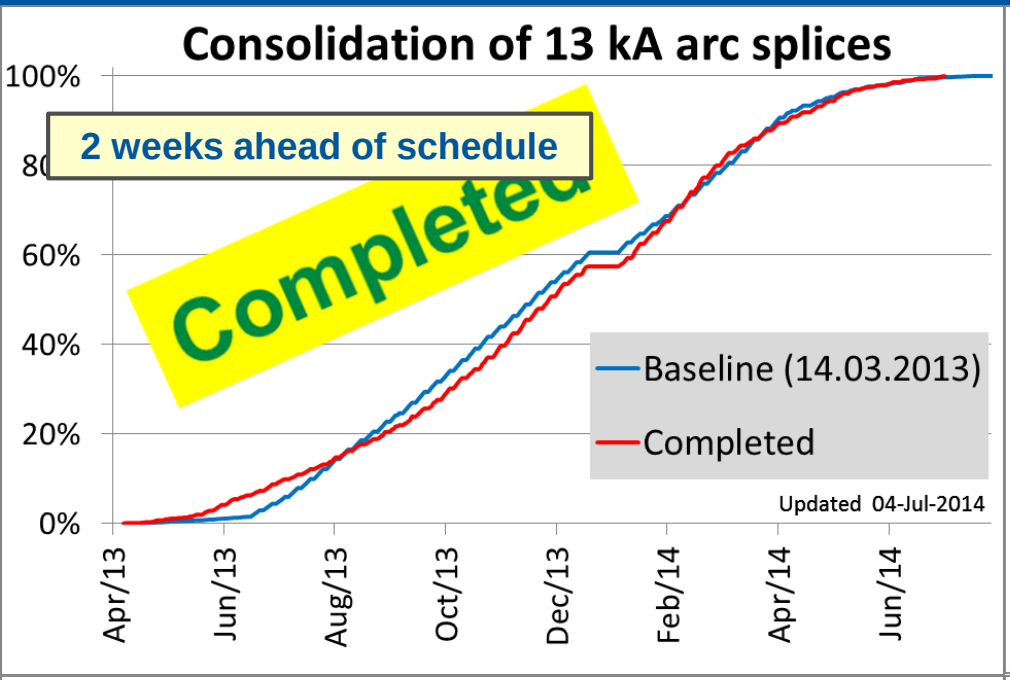
In the tunnel **~8500** holes were punched in the cryostat's thermal screens to prepare the installation of upgraded shields.

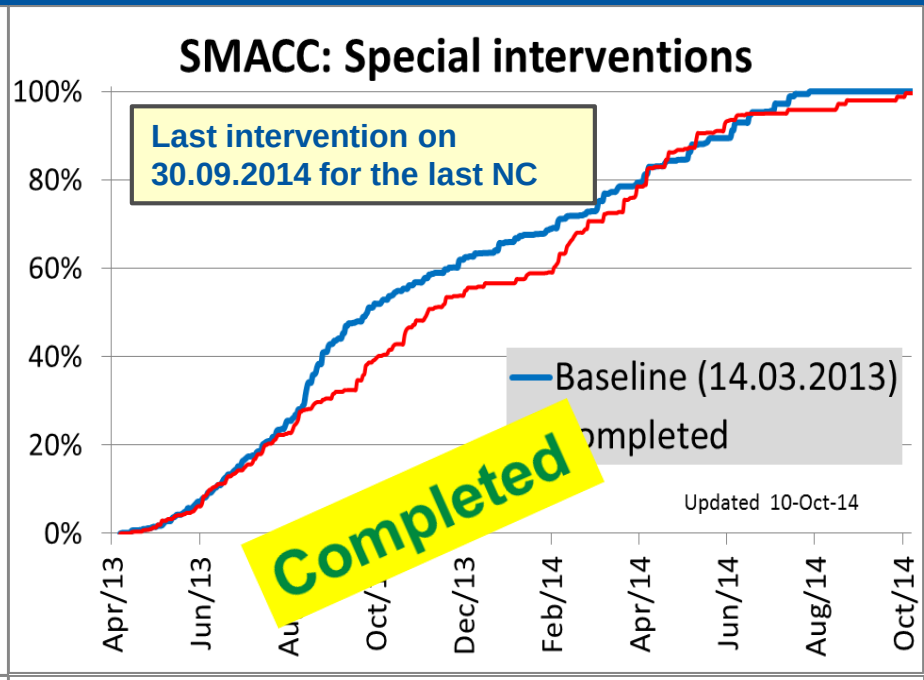
No need to cut / reweld for removing / installing thermal shield
Thermal performance validated on mock-up

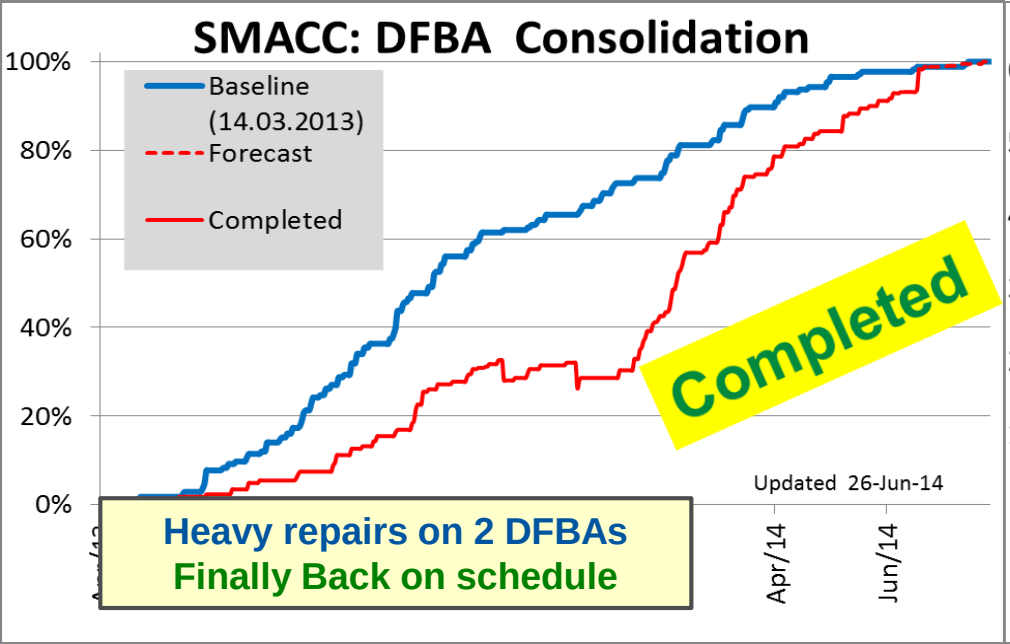
☺ So far, the heat load in the LHC is the same as during run I

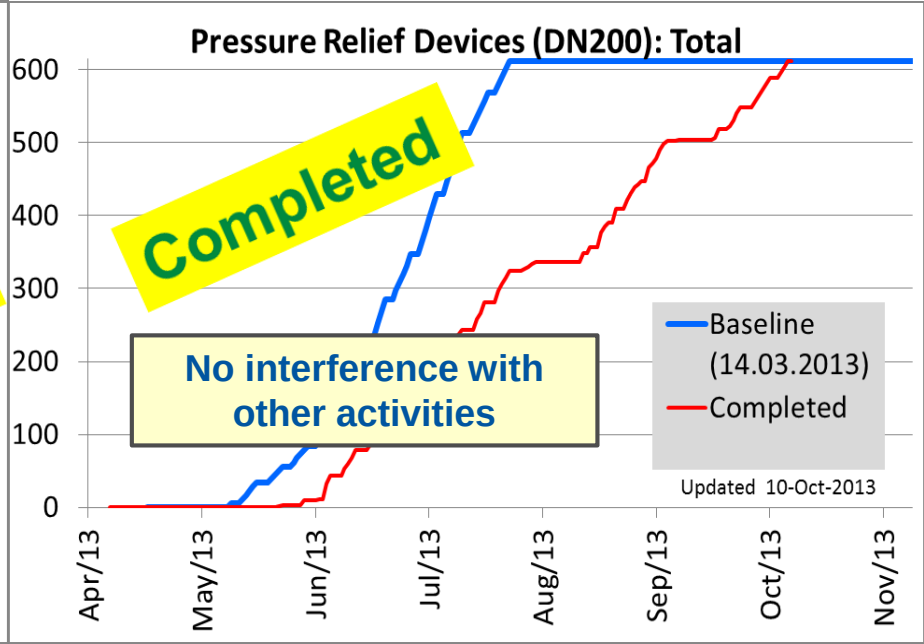
Courtesy A Chrul, A Musso

Results : Planing

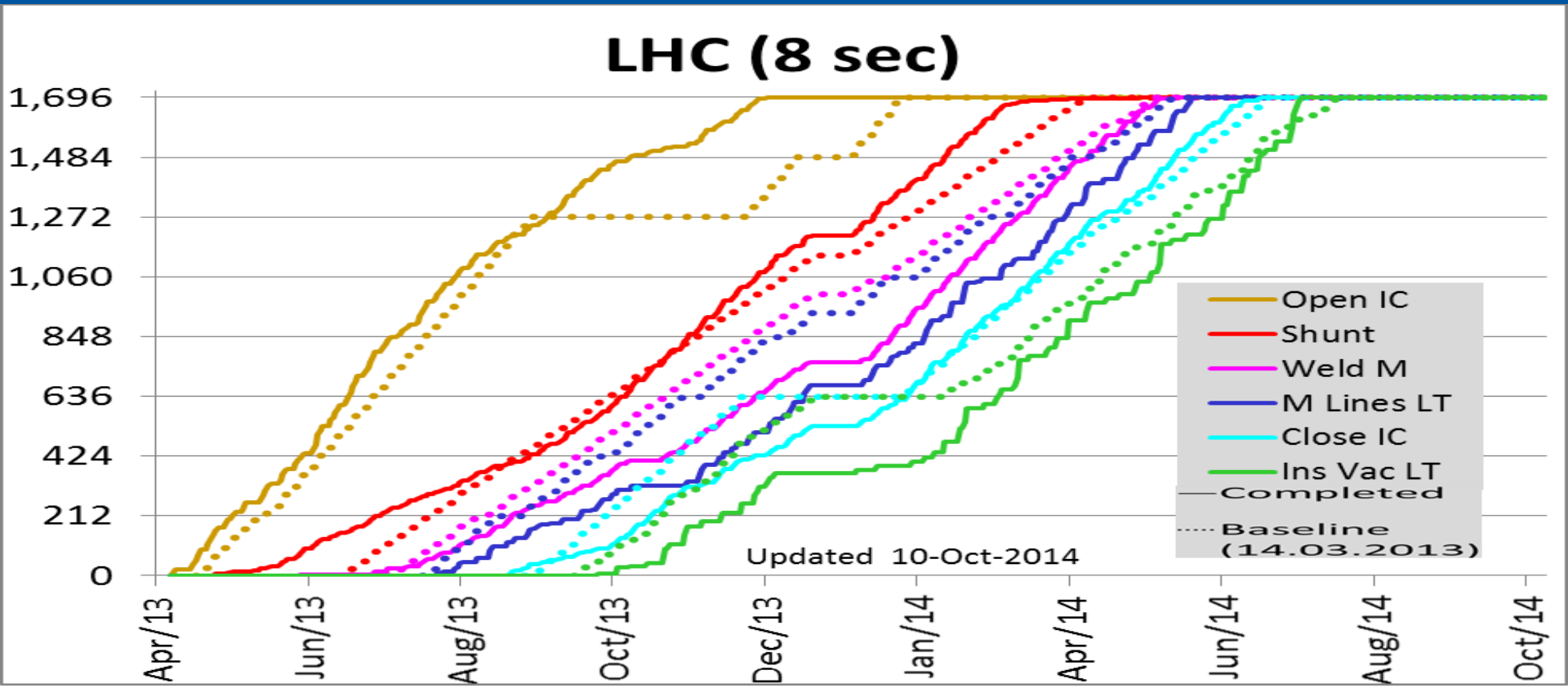






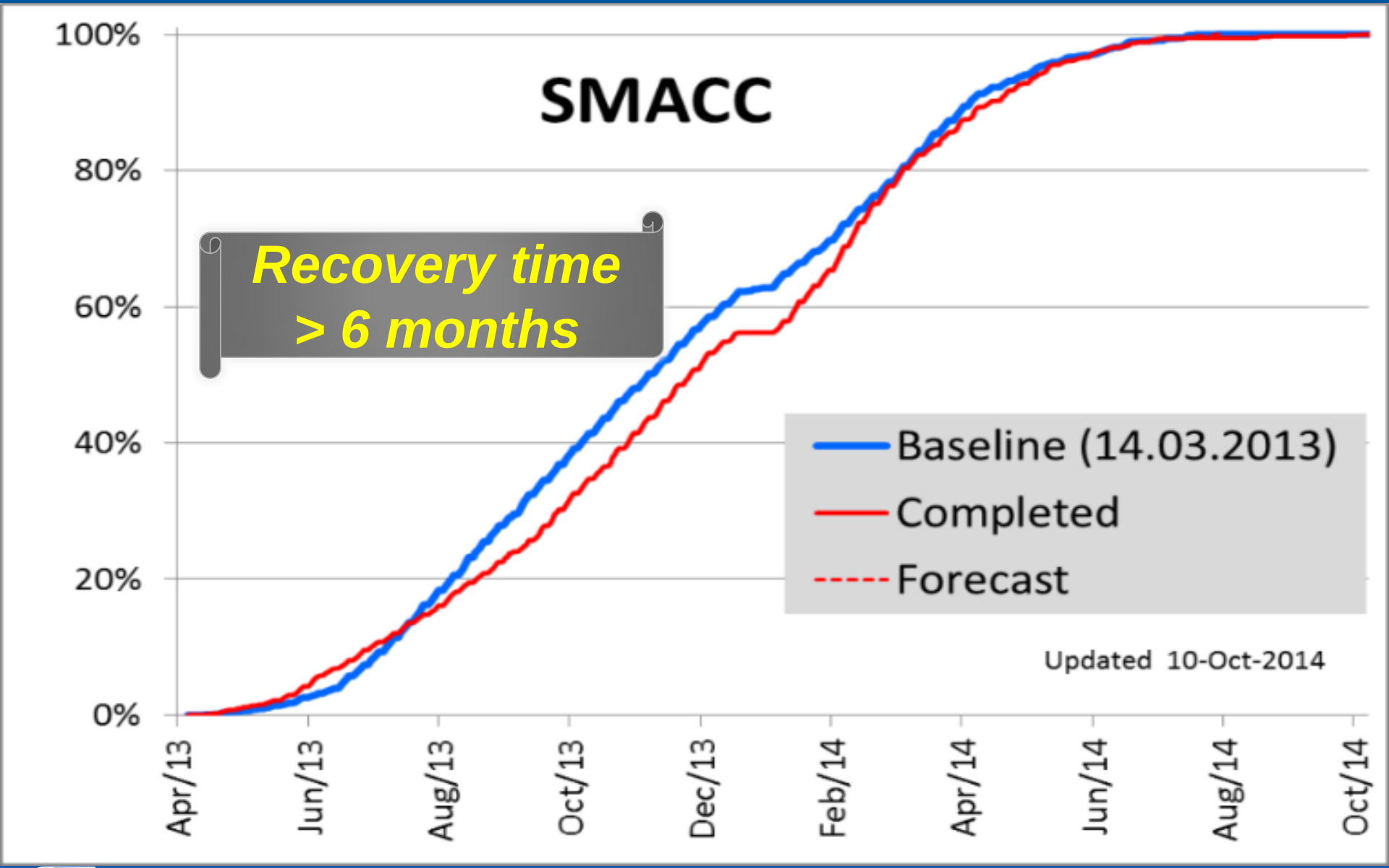


Results : Planing

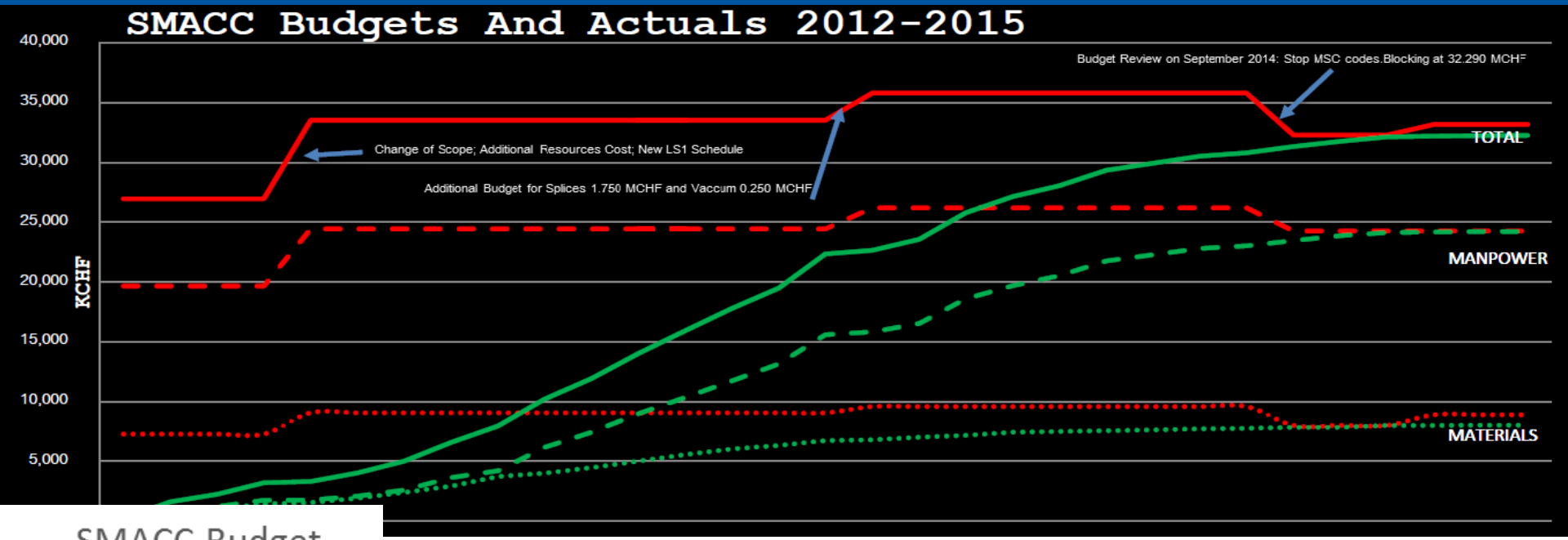


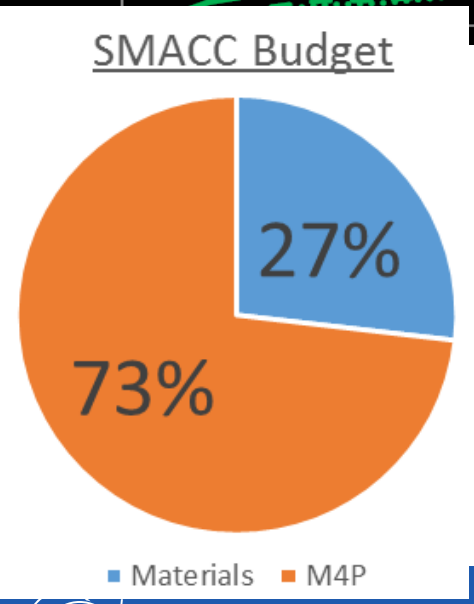
- Activities started as soon as the 1st interconnection was available, better for the schedule
- Rate was lower than planned at the beginning : technical issues and learning
- Reached baseline rate after optimisation (2-3 months)
- Faster than planned in the last 2-3 sectors
- Flexibility is required and possible thanks to polyvalence of key operators
- The reinforcement of a team or a change of strategy takes ≈ 3 months to be effective

Results : Planing



Results : Budget

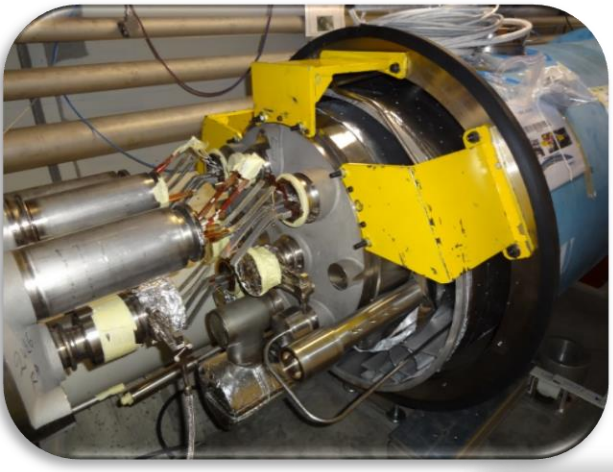


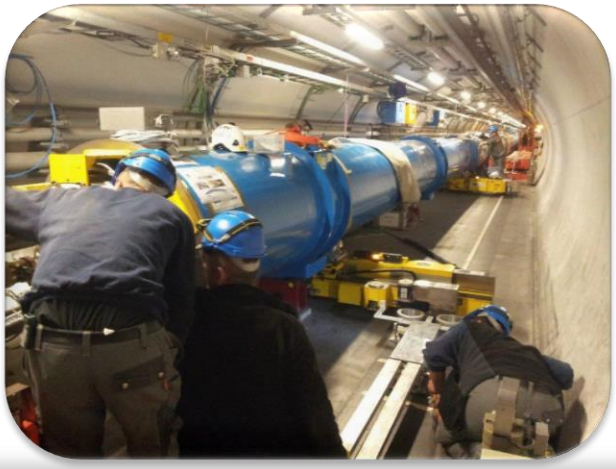


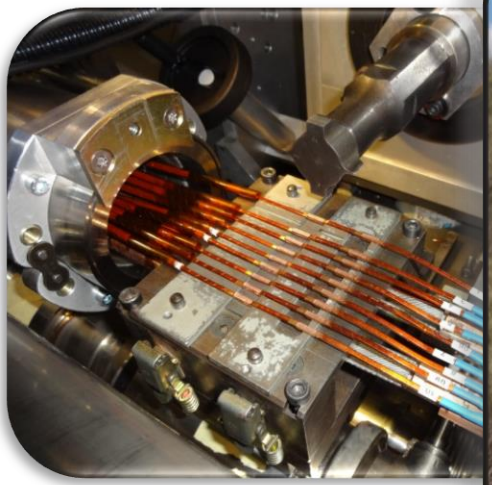
- Important to have a detailed budget as soon as possible
- Budget to be reviewed in case of major changes
  - 30% of splices instead of 15%
  - Reinforcement of QA team (review result)
  - …
- Control of planning implied control of the budget
- Support for the accounting task helped

Splices but also replacement of 18 cryomagnets

Replacement of cryomagnets : 15 cryodipoles & 3 SSS (quad)







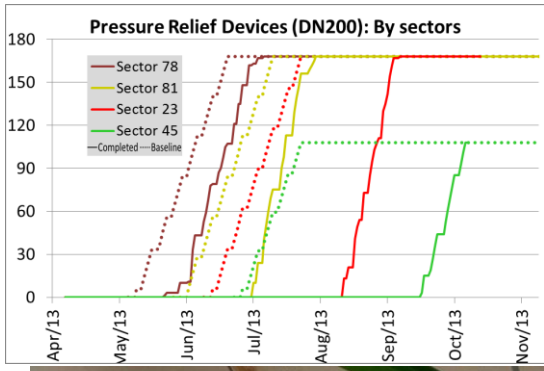
Splices but also Safety Relief Valves (DN200) installation

612 missing DN200 (sec.23, sec.45 [part], sec.78, sec.81)

17 installed on cryo-magnets exchanged during LS1

2 additional DN200 installed for CryoBLM (sec.45 and 78)

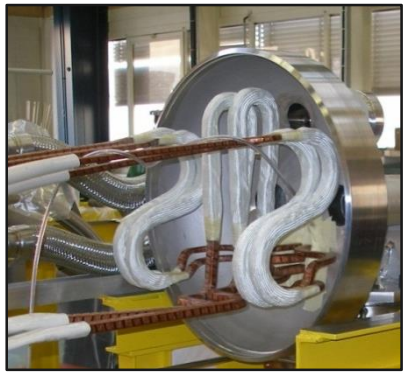
- DUBNA-JINR (+PAEC)
- Completed in Oct-13



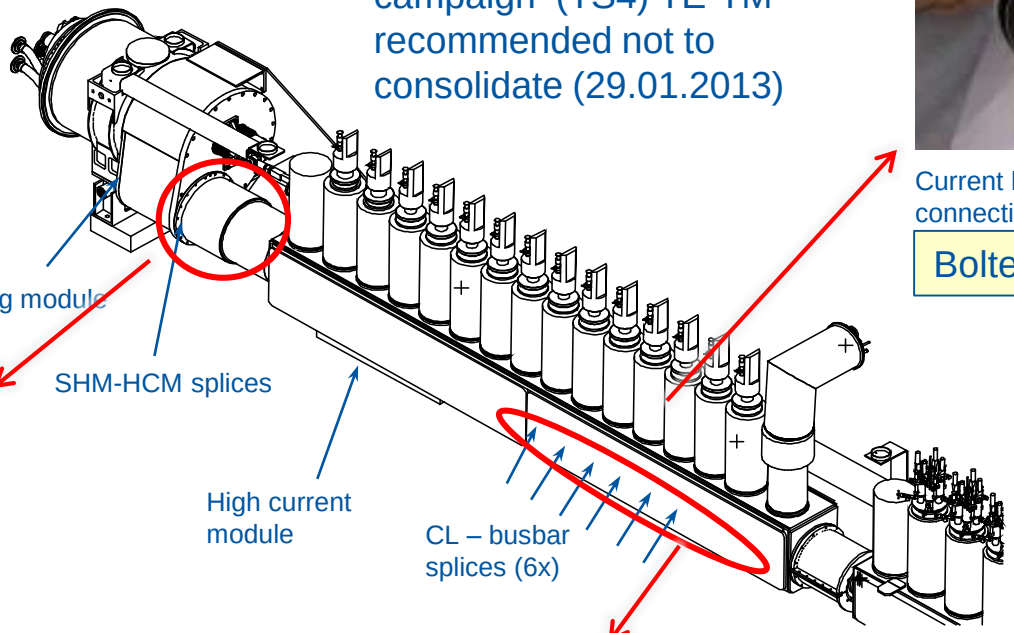
Courtesy J M Gomes de Faria, A Chrul

Splices but also DFBA

- Dedicated review in Feb 13

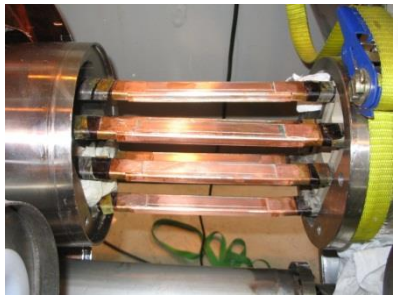


Not consolidated but measured during special measurement campaign (TS4) TE-TM recommended not to consolidate (29.01.2013)

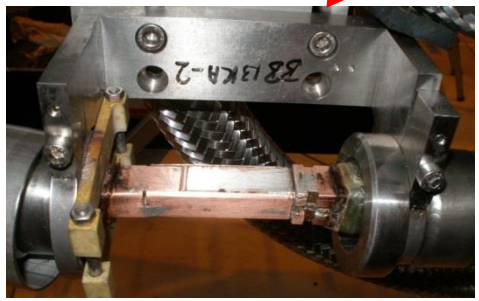


Current lead to pigtail bolted connection

Bolted



Essentially same type as magnet-magnet

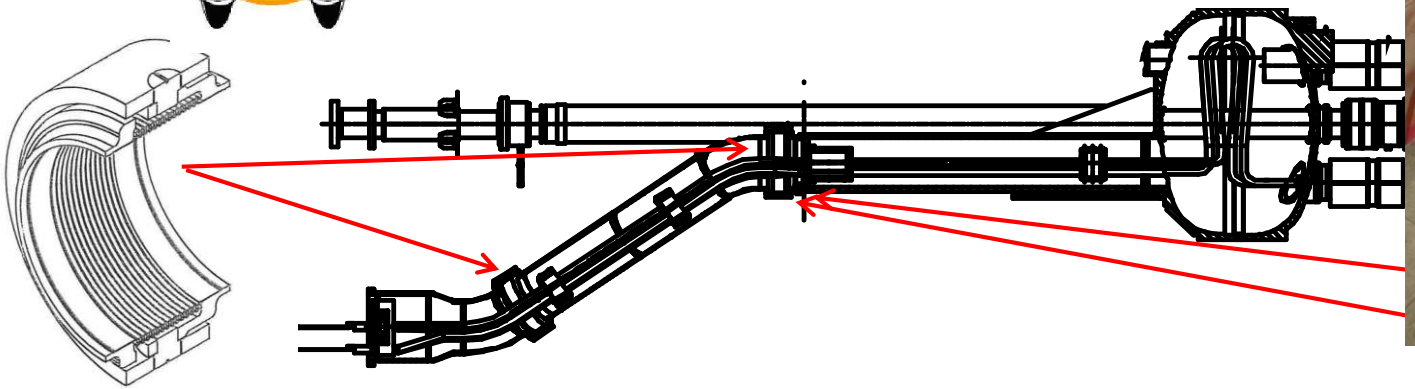


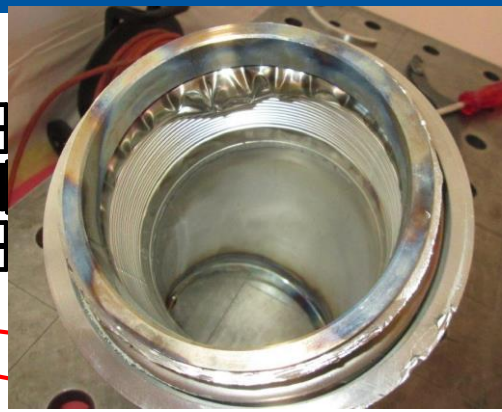
Variant based on magnet-magnet

- 135 splices
- 14 "standard" DFBAs, 2 special cases DFBAP and DFBAK
- Consolidation of the lyras on the right side shuffling modules

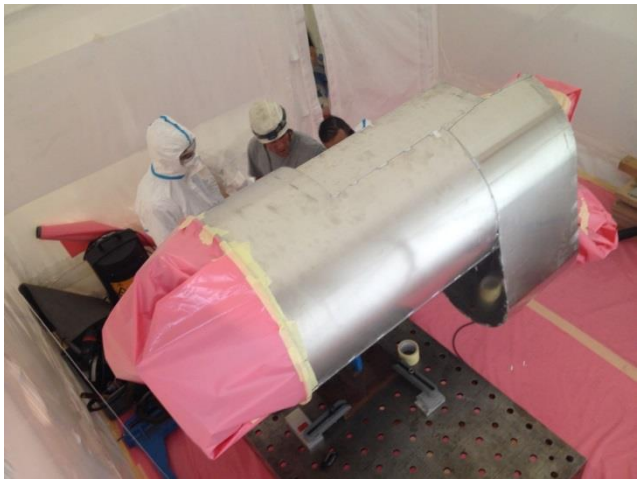
Courtesy A Perin

Splices but also DFBA gimbal bellows



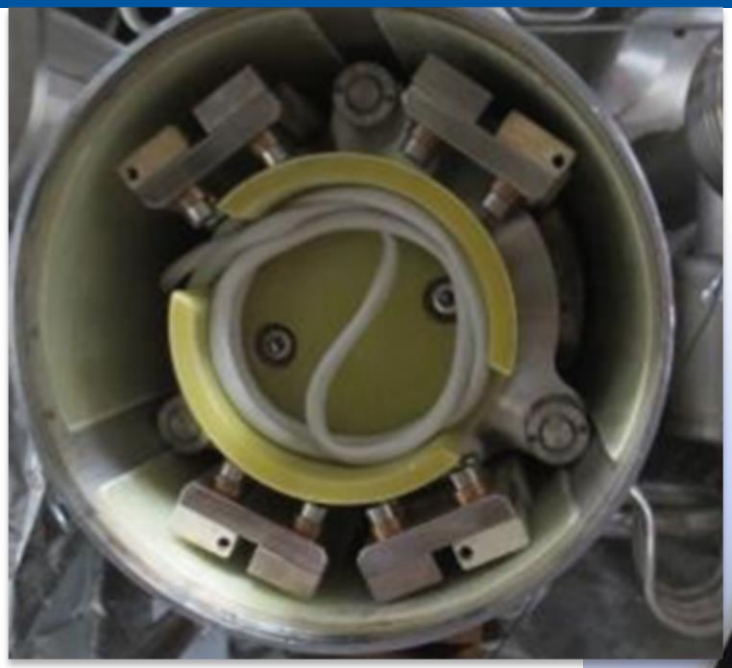


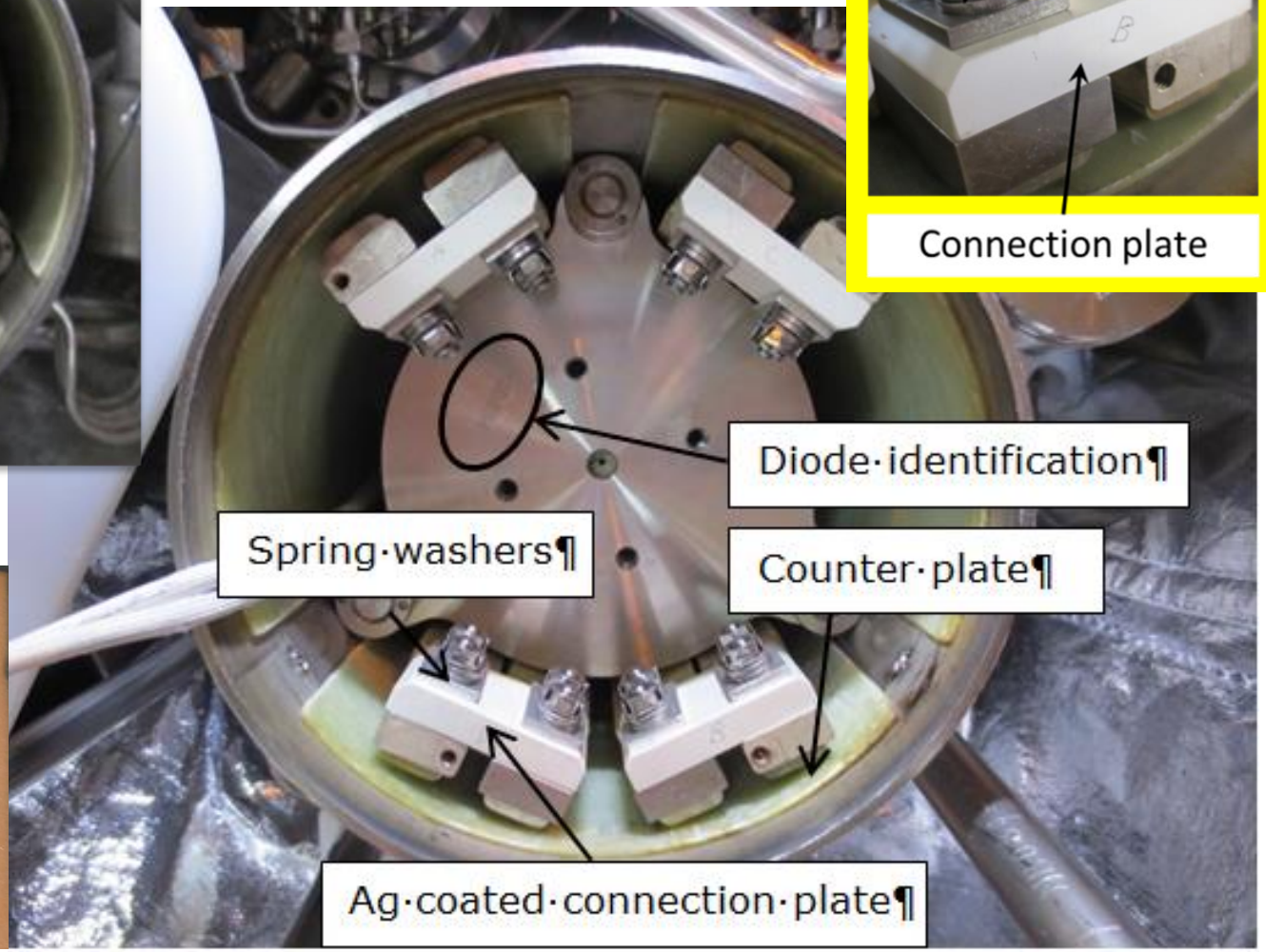
DFBAI & AF (lower gimbal) in-situ repair : blockage
DFBAK (S56) & AO (S78) workshop repair [B112]

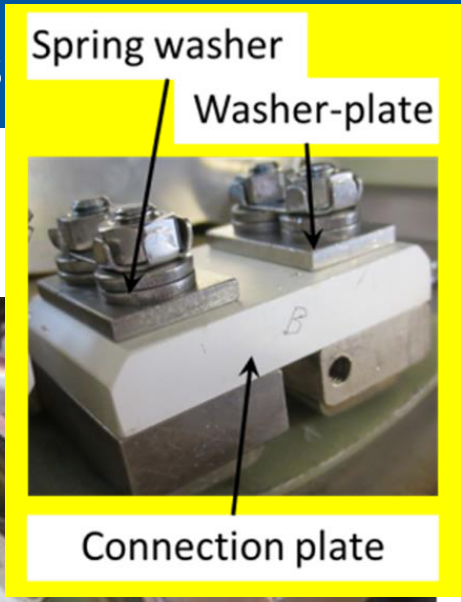


Courtesy A Perin

Splices but also Quadrupole diodes



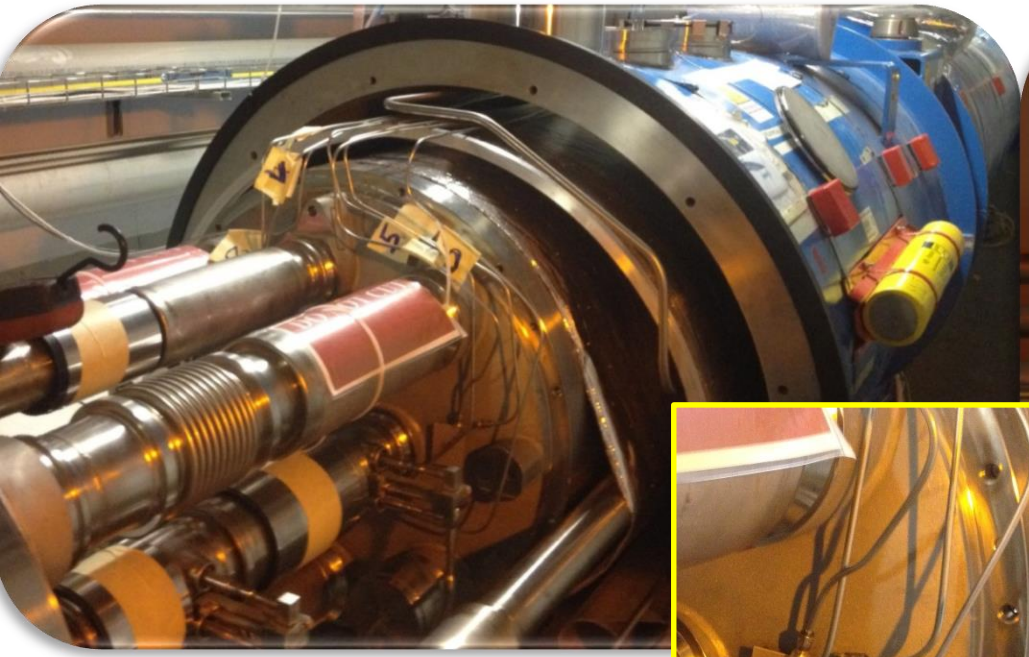


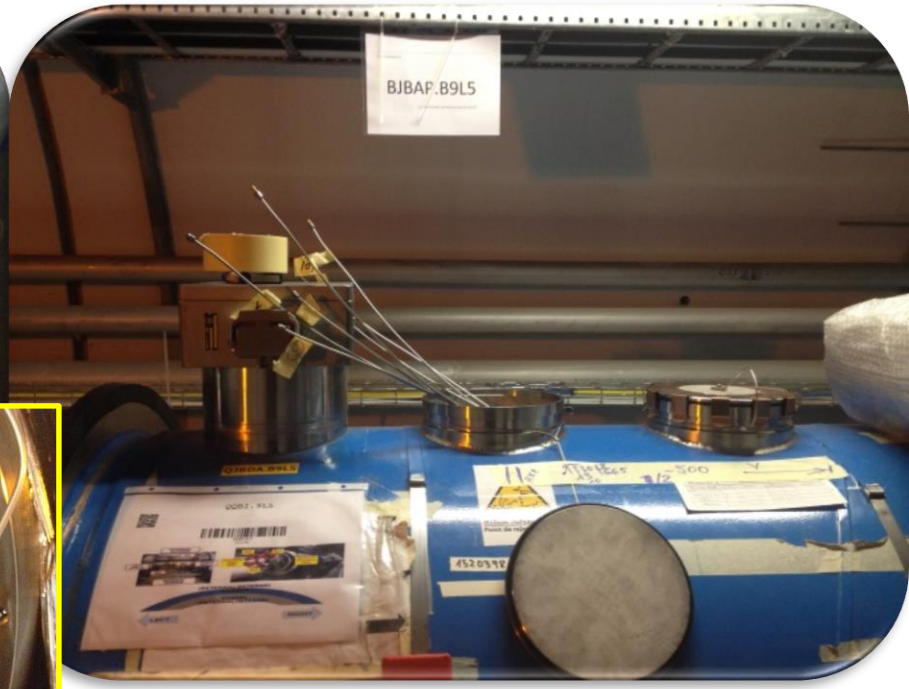


Courtesy L Grand-Clement, R Moron –Ballester, F Savary

Splices but also installation of cryo BLM

- Cryo BLM Installation (R7&L5)

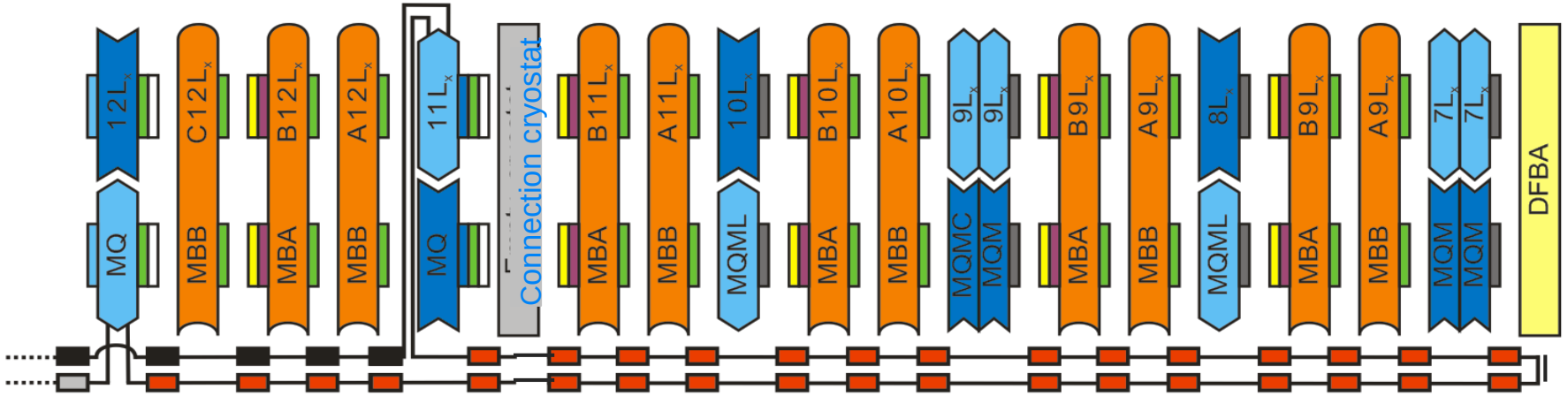


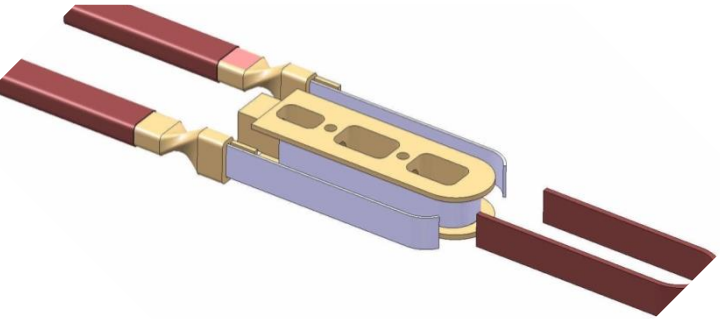


See ECR : "Installation of Cryogenic Beam Loss Monitors on MBs in IR5 and IR7", Doc Nb.LHC-LB-EC-0003

Splices but also improvement of SC circuits

- Shortening of RQ circuits in P1&5

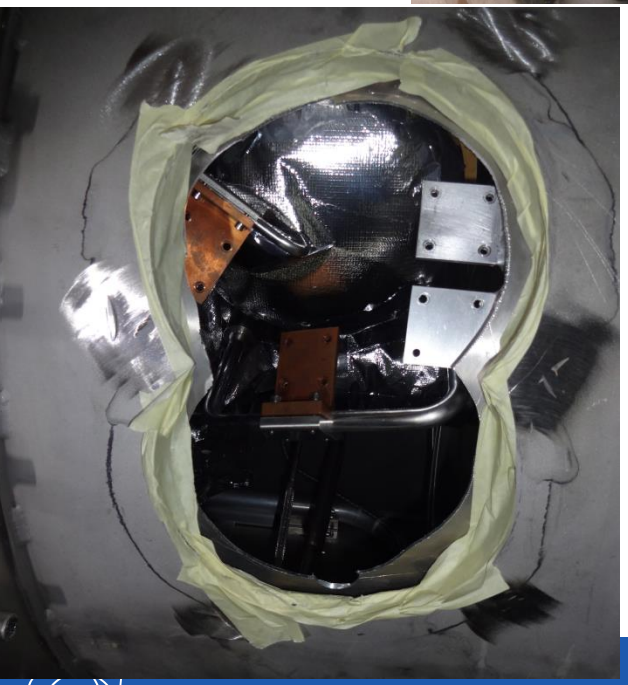


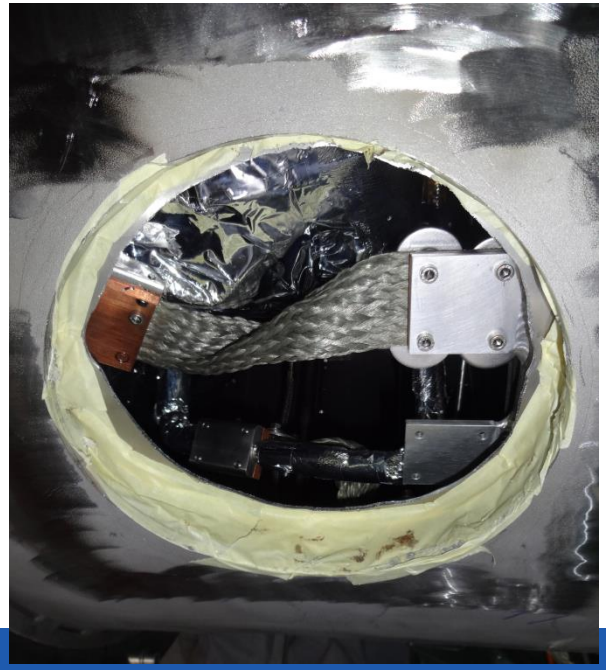


See LMC 24.10.2012 & TE-TM26.03.2013

Splices but also interventions on triplets

- Triplet braid



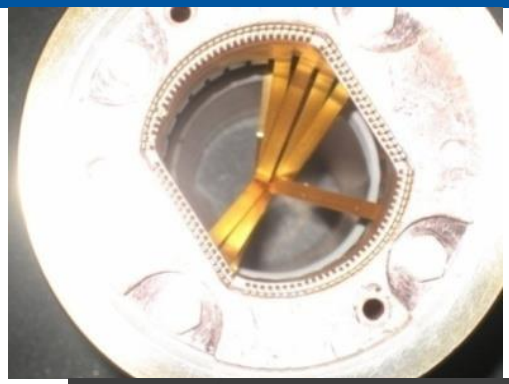


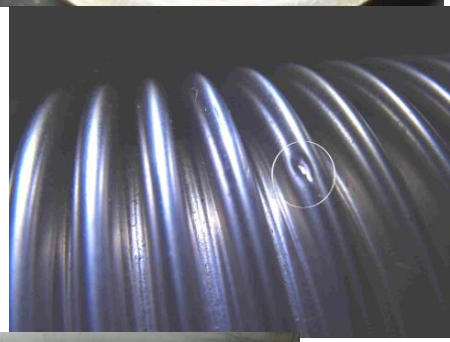
Courtesy N Bourcey

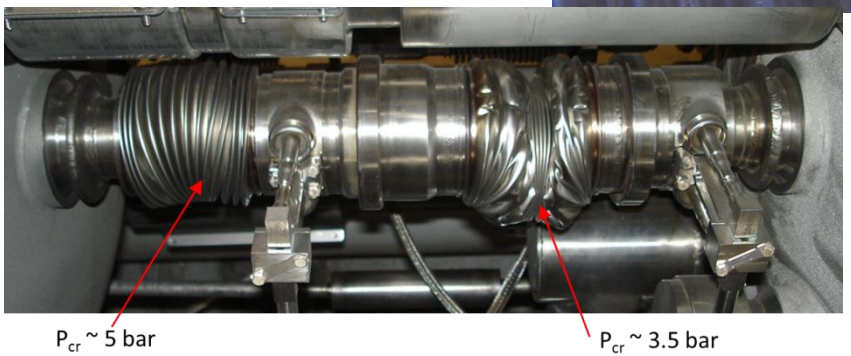
Splices but also interventions pn PIMS

- PIMs consolidation

- 113 PIM consolidated (including those for magnets replacement, undulator and DFB)
  - 18 preventive replacements
  - ≈ 70 due to magnet changes
  - ≈ 23 due to bellows damages (Before and during LS1)
- Only 2 PIM found broken during ball test (1-2 and 8-1)
- Installation of protective shells in PEI



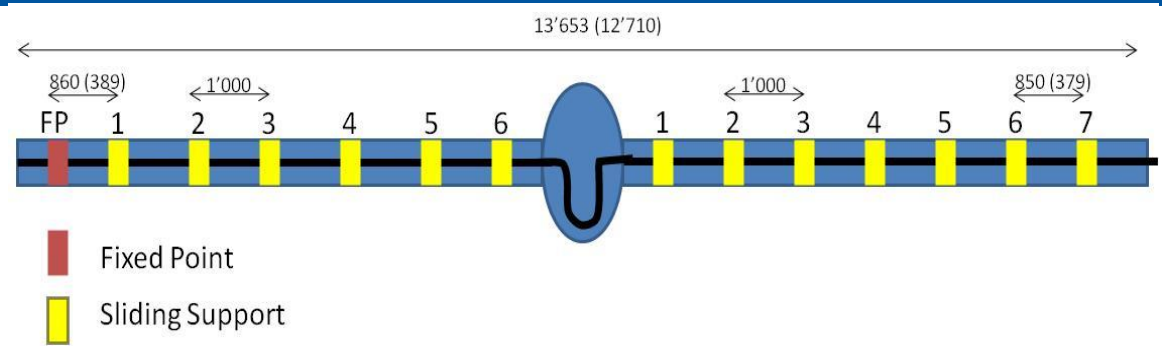




Splices but also interventions on connection cryostats

Connection cryostats

CC	2009 Status	LS1 Status
11R1	Inspected OK	Measured OK
11L2	Inspected OK	Measured OK
11R2	Partially measured OK	Measured OK
11L3	Partially measured → 5 TeV	To Be Consolidated (M3L&R)
11R3	Measured OK	Measured OK
11L4	Measured OK	Measured OK
11R4	Inspected OK	Measured OK
11L5	Measured / M3L cons.	Measured OK
11R5	Measured / M3R cons.	Measured OK
11L6	Measured / M1L&R + M3R cons.	Measured OK
11R6	Measured OK	Measured OK
11L7	Measured / M3L&R cons.	Measured OK
11R7	Inspected OK	Measured OK
11L8	Not measured	Measured OK
11R8	Partially measured OK	Measured OK
11L1	Inspected → 5 TeV	To Be Consolidated (M3R)

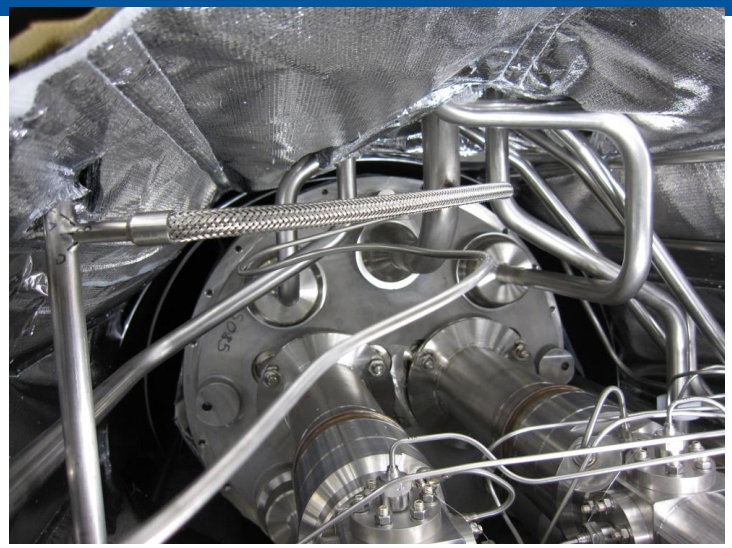


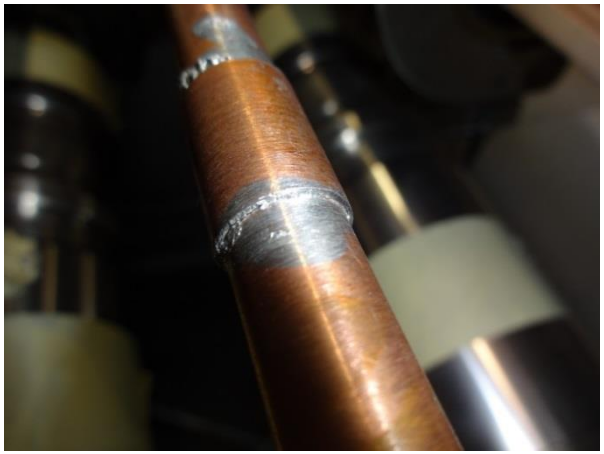
11L8 Was OK, no risk taken

The consolidations have been carried out
All have been inspected and measured and are OK

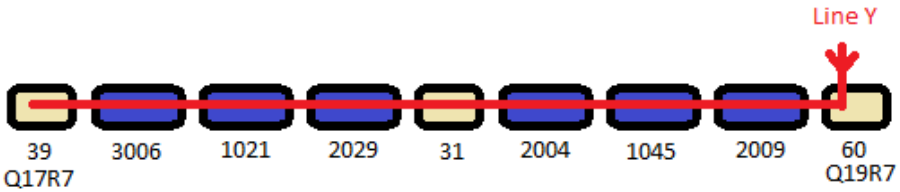
Splices but also special interventions on cryogenics circuits

- SAM He level gauges





- Line Y repair



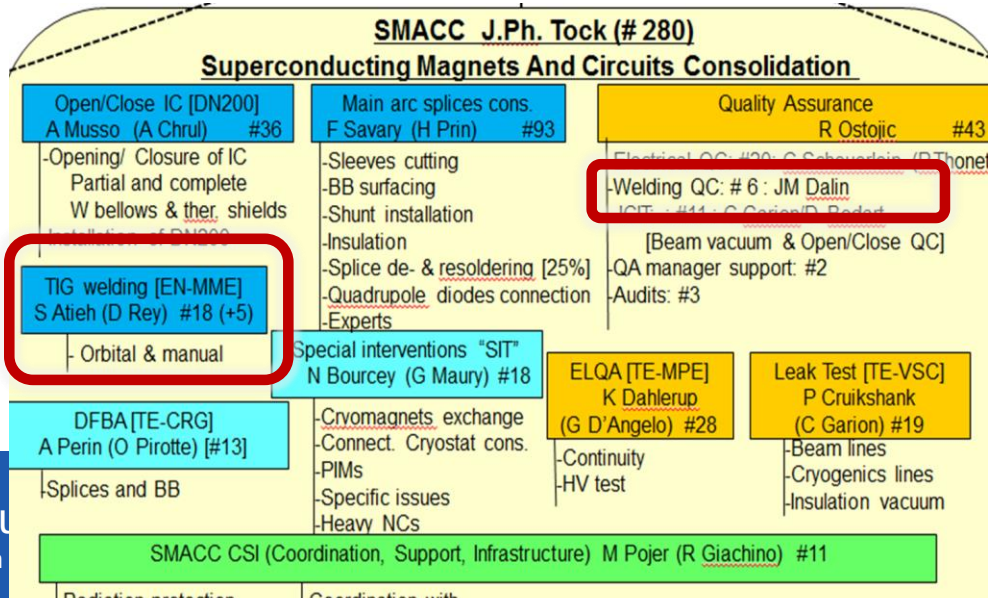
- Leaks repair (still on-going)
- Electrical NC
- …

Lessons learnt: A. Interdepartmental project (1/2)

- Worked well thanks to a detailed preparation well in advance.
  - Started in 2009 …
  - Long lifecycles of CERN processes (MTP, …)
  - Down to the identification of individual persons
  - Experience is more relevant than the status

  RATIO of experienced/non-exp persons.

- Complete «sub-contracting» of a whole activity
  All welding activities done by EN-MME :
  - Management
  - Tooling
  - Technical expertise
  - Reporting
  - QA
  - …



Lessons learnt: A. Interdepartmental project (2/2)

- Temporary detachment of personnal
  Large participation to the ElQC of BE-OP
  - Win-win action, allowing exchange of information
  - Responsibility given for organisation
  - Technical expertise remained with the equipment group
  - Very good training
  - Large series of careful and critical measurements done by the operators of the machine (So very interested)

Activity	Team	Coordinator
Overall coordination and validation of quantitative QC results	C. Scheuerlein, (P. Thonet, S. Heck)	
✓ QC of existing 13 kA splices	BE-OP1, BE-OP2	M. Solfaroli, BE-OP, (J. Wenninger, BE-OP)
✓ QC of new 13 kA splices	BE-OP3, BE-OP4	
✓ QC of consolidated 13 kA splices	BE-OP5, BE-OP6	
✓ QC of splice insulation	BE-OP7, BE-OP8	
✓ QC of disconnected cables	BE-OP9, BE-OP10	
✓ QC of new spool and line N US welds and solder connections	S. Lebada (FSU)	C. Scheuerlein, (P. Thonet, S. Heck)
Support Special Intervention Team	S. Heck, P. Thonet	
QC in DFBAs	S. Heck, P. Thonet	
Special non destructive splice tests, trouble shooting, dedicated test samples	S. Heck	
Surface work, follow up specific NCRs…	R. Lopez (part time)	

Lessons learnt: B. Integration of newcomers

- Collaborators came from institutes around the world

15 months

6 months

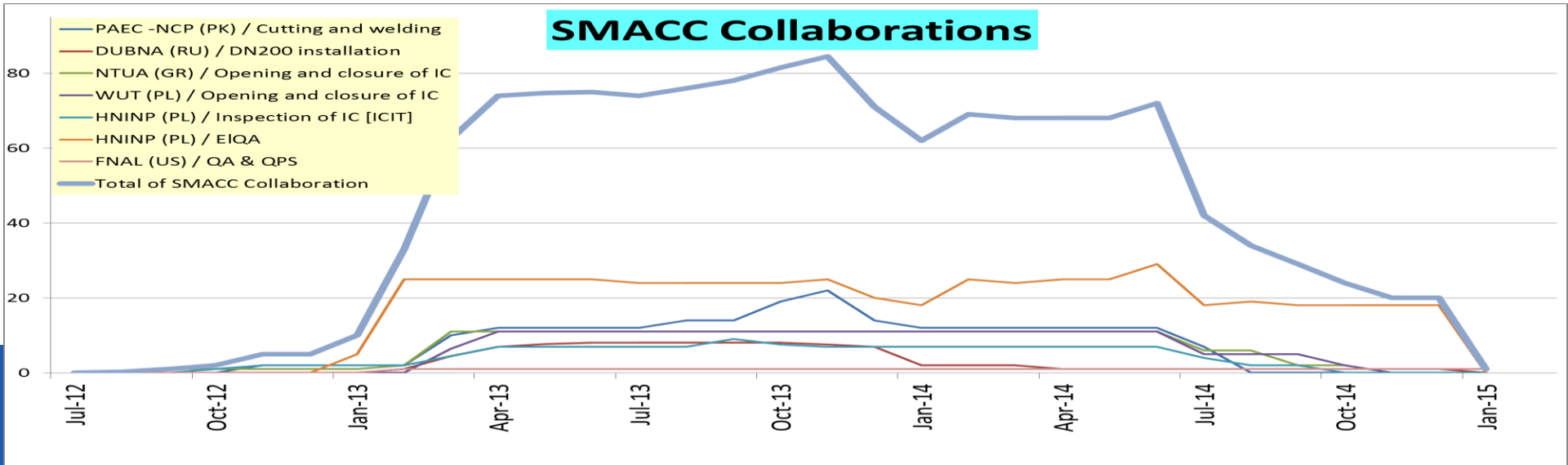
Typical timeline:

- Dec 2011: Call for collaborations
- Feb 2012: First contacts between XXX and SMACC
- July 2012: Signature of collaboration agreement KEXX
- August 2012: Arrival of team leader
- November 2012 : Participation to the splices review
- March 2013: Arrival of the technicians
- Up to 7.04.2013: Training (Safety, Integration, Technical)
- 8.04.2013: Start of the work in the tunnel
- 30.09.2014: End of the work in the LHC tunnel
- 31.12.2014: Reserve in case of unforeseen event, took part in the tooling inventory, storage and refurbishment

⇨ End of the collaboration agreement

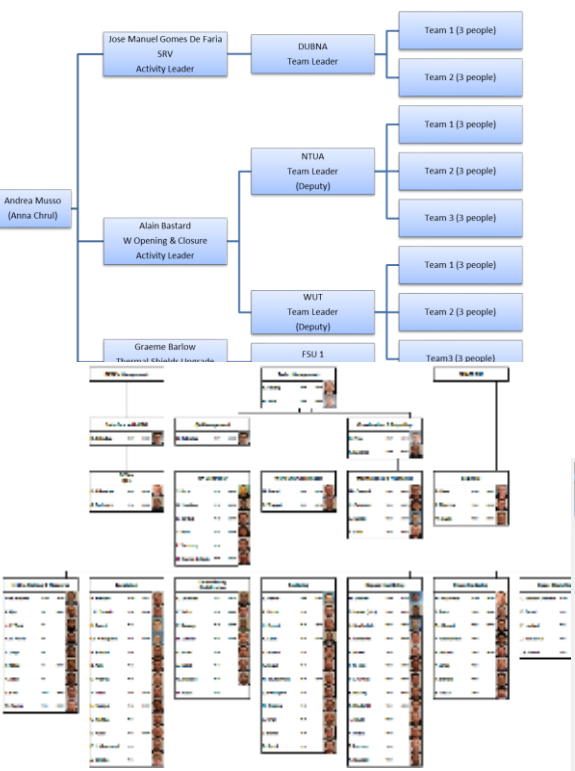
- Early integration of newcomers allows:
  - ✓ the team leader to solve many practical issues
  - ✓ For an appropriate training
  - ✓ For a good integration within the project.
  - ✓ To select people

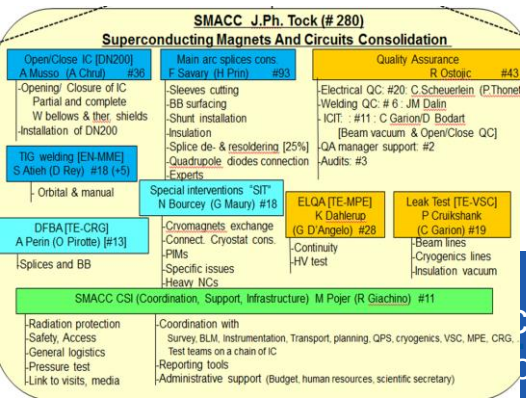
  It's worth the investment



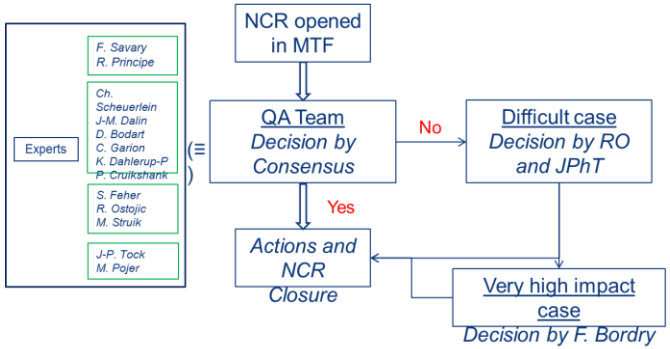
Lessons learnt: C. Communication/Coordination is important

❖ Organization charts (with pictures)

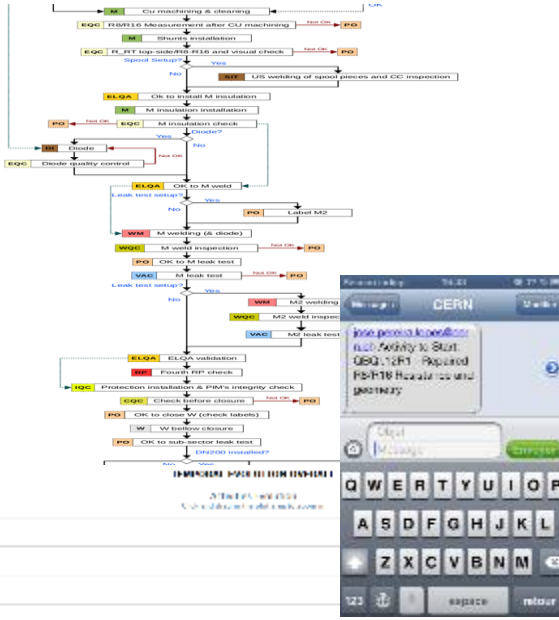




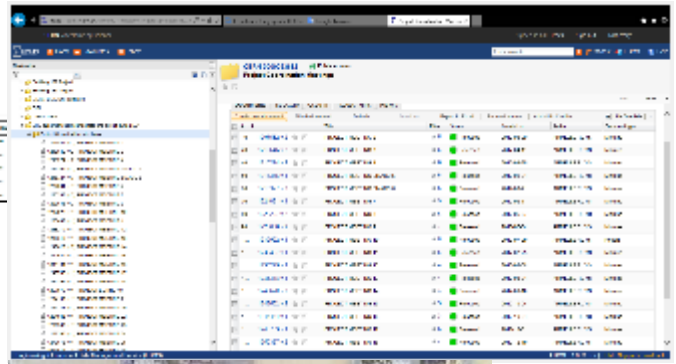
❖ Decision process



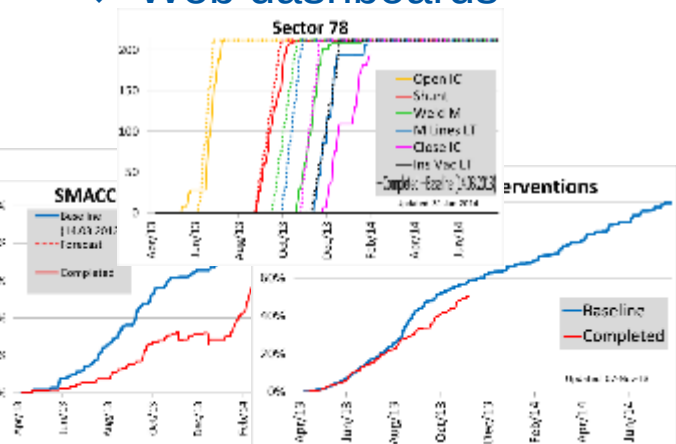
❖ WISh tool



❖ Coordination meetings



❖ Web dashboards



Lessons learnt: D. Logistics

CERN Shuttle *Navette*

7 Circuit 7
SMACC Project

Monday - Thursday (except CERN official holidays)
Lundi - jeudi (excepté lors des congés officiels CERN)

Morning

BLDG 500	Foyer St Genis	Hostel St Genis*	P6 2690	P8 2855	BLDG 500
05:05	05:15	05:17	05:50	06:10	
	06:20	06:22	06:55	07:15	
	07:25	07:27	08:00	08:20	08:35

Afternoon

BLDG 500	P6 2690	P8 2855	Foyer St Genis	Hostel St Genis**	BLDG 500
14:30	15:05	15:25	15:35	15:37	
	16:10	16:30	16:40	16:42	
	17:15	17:35	17:50	17:52	18:02

* After the Fire station Hautains Road
* *Après la caserne des Pompiers Rue des Hautains*

** In front of the Fire station
** *En face de la cas*

Friday (except CERN official holidays)
Vendredi (excepté lors des congés officiels CERN)

Morning

BLDG 500	Foyer St Genis	Hostel St Genis*	P6 2690	P8 2855	BLDG 500
05:05	05:15	05:17	05:50	06:10	
	06:20	06:22	06:55	07:15	
	07:25	07:27	08:00	08:20	08:35

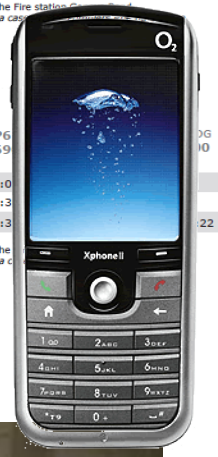
Afternoon

BLDG 500	P6 269
11:30	12:0
	15:3
	16:3

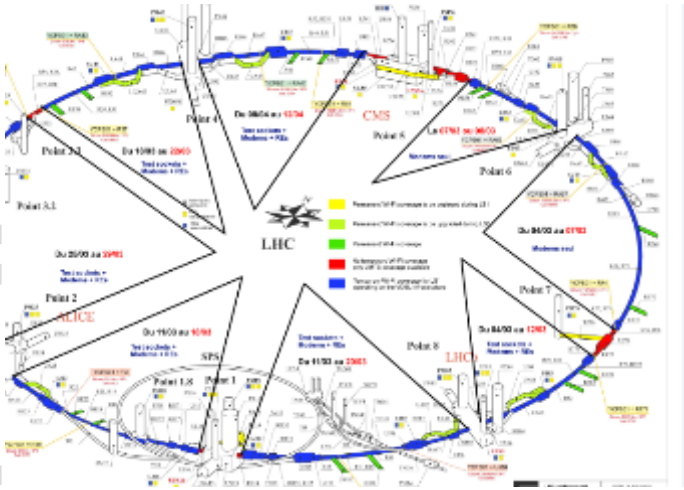
* After the Fire station Hautains Road
* *Après la caserne des Pompiers Rue des Hautains*

** In front of the
** *En face de la c*

GS



❖ WiFi coverage



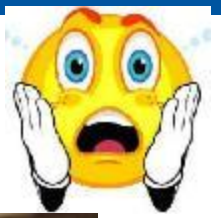
- To be thought and prepared well in advance,
- To be included in the budget
- Include some margin
- Be prepared to unexpected requests

Lessons learnt: E. Clear priority

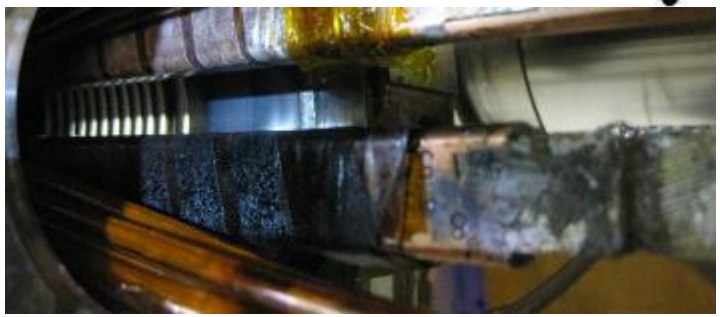
- SMACC was clearly the LS1 priority,
  Accepted and integrated CERN wide
  Supported by the management

Sincere thanks to all who suffered from this

Lessons learnt: F. Dynamic resources allocation



- ***It was not a plain sailing :***
  - 30% of splices to redo instead of 15%
  - DFBA gimbals bellows disrupted the progress of the work
  - Overheated splices
  - Late delivery of some components
  - …



Thanks to:

- **Good ratio of experienced staff**
- Wonderful team spirit
- A completed endorsement of the priority of the project
- The management support (Quality > schedule)

It was each time possible to preserve the high level of quality and to minimize the effect on the schedule by reorganising the work, moving people to other tasks than initially foreseen

CONCLUSIONS

Thanks to :

- Preparation well ahead allowing for training and building of the team
- Detailed training (Technical but also safety and environment)
- Wonderful team spirit despite the different statutes
- Real support at all levels
- Trust and open communication
- International reviews
- CERN wide collaboration (Across departments)
- A fair ratio of experienced / expert staff
- Dynamic resources allocation

Despite surprises (30% of splices to redo, overheated splices, DFBA gimbals, Inconel components,…),

It was possible to safely keep the high level of quality required and stick to the baseline schedule

CONCLUSIONS

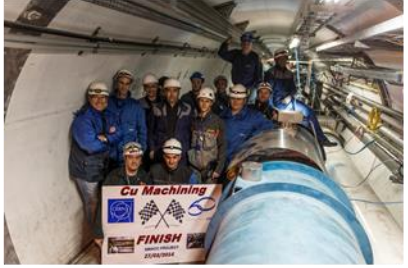
After SMACC/LS1, the LHC machine is improved, not only for the splices but also:

- Reduction of number of leaks
- Resolution of electrical NC ; some circuits are back in operation
- Extra instrumentation (Cryo BLM)
- New thermal shield design
- Resolution of other NC (Triplet braid, line Y, …)
- ….

This was a long but rewarding journey…

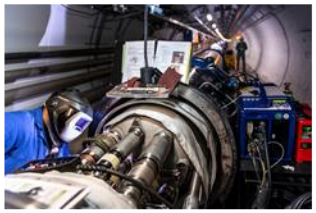
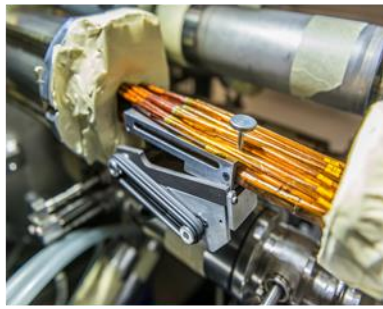
Behind every adventure are the women and men




Cu Machining
FINISH

Cu Machining
FINISH



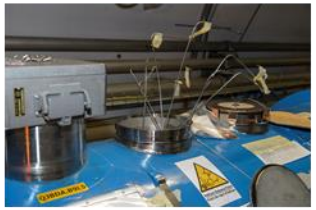






Last burned splice consolidation
FINISH



LAST STANDARD INSULATION
FINISH



LAST STANDARD INSULATION
FINISH

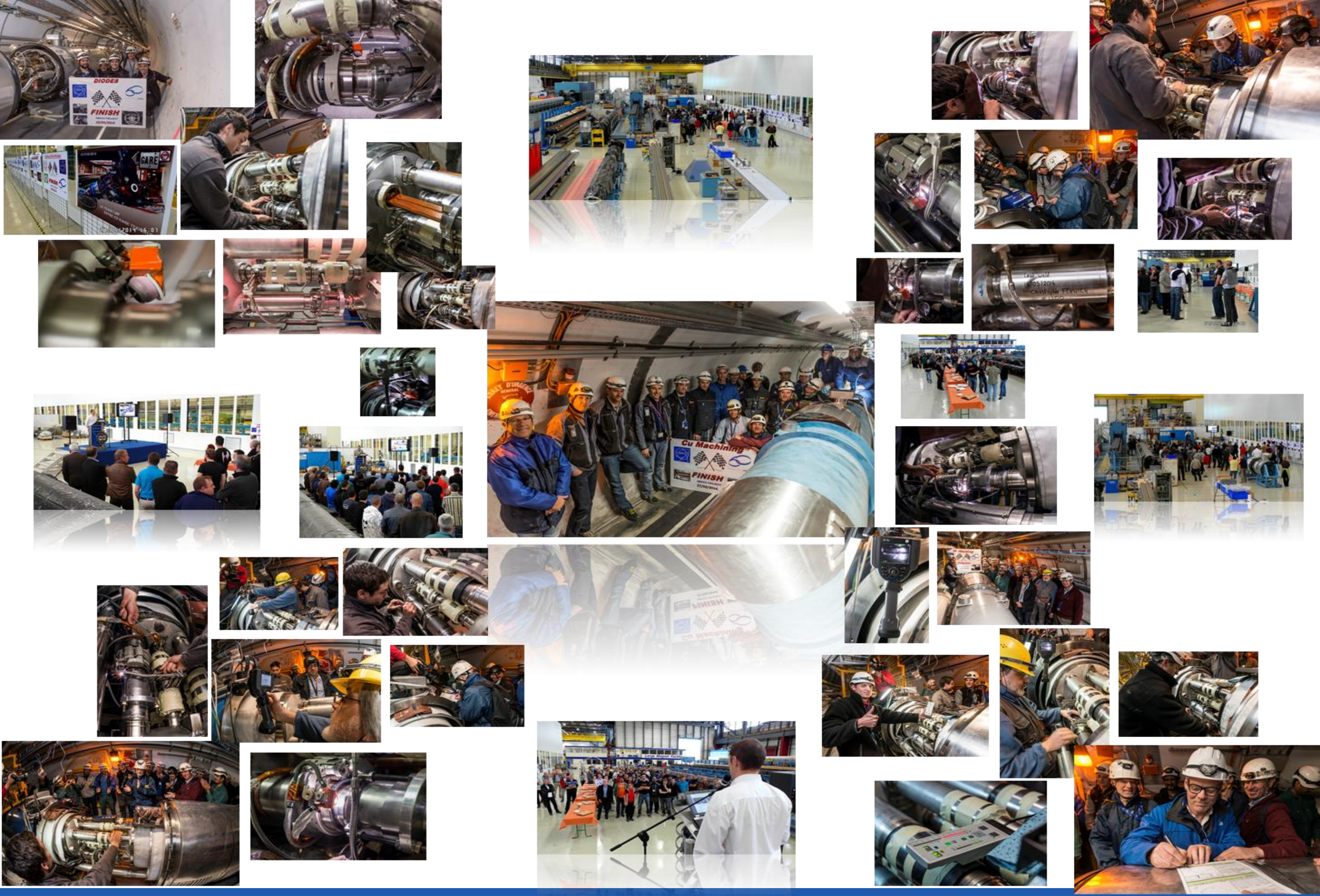




DIODES
FINISH



SHUNTS
FINISH
MERCI
THANK YOU
Personal Protective Equipment
Accelerators, Experimental Halls
Underground Areas
Secteur 56
DFBAs SECURIZEES
OK POUR TRAVAUX SOUS
Jeu. 25/04/2013


DIODES
FINISH
Cu Machining
FINISH

This was a long but rewarding journey...

Behind every adventure are the women and men

www.cern.ch

Location and Types of Accidents

Location	Minor	With absence	Days absence
Surface	3	4	89
LHC Tunnel	8	6	31
	11	**10**	**120**

Type	Minor	with Absence	Days absence
Slip and fall	-	1	51
Moving objects / Handling /	2	2	32
Vehicles	2	3	18
Striking against stationary objects, strenuous movements	3	3	13
Tooling Machines / Handheld tools	1	1	6
Struck by moving objects or particles	3	-	-

Courtesy T Otto

What can we learn for the future ?

Accident due to inappropriate footwear (thongs): Slipped on floor, hit head and back.
51 days absence

3 SMACC Bicycle accidents in LHC.
18 days absence

Is there a safer means of transport ?

Don't forget to protect your head in LHC and restricted workspaces

Courtesy T Otto

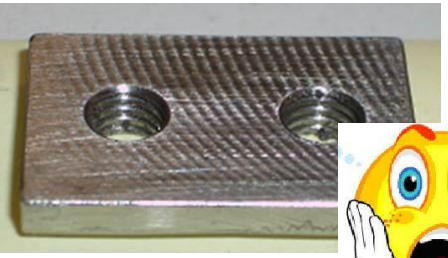
Splices but also Quadrupole diodes

First Splice Review (October 2010)

Add the mechanical connections to the bypass diodes in the main magnets to the list of potential risks that should be assessed.

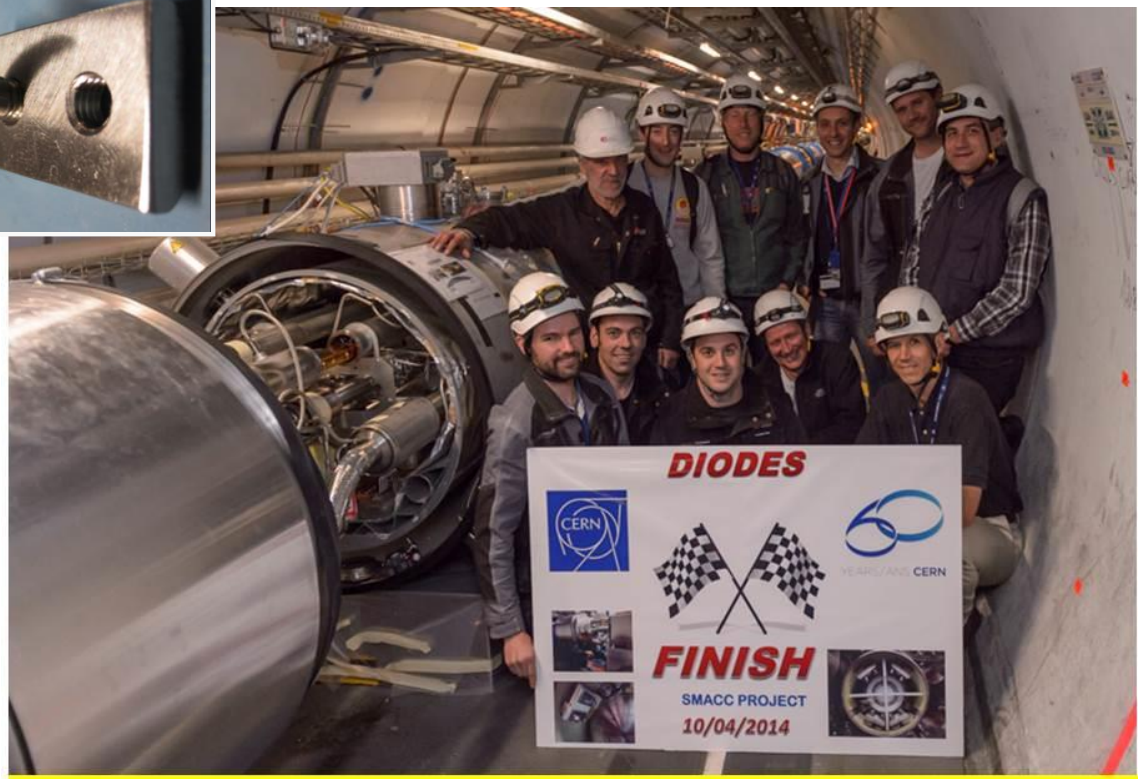
Third Splice Review (November 2012)

… it is recommended to use … of high strength material such as Inconel 718…. (instead of 304L)

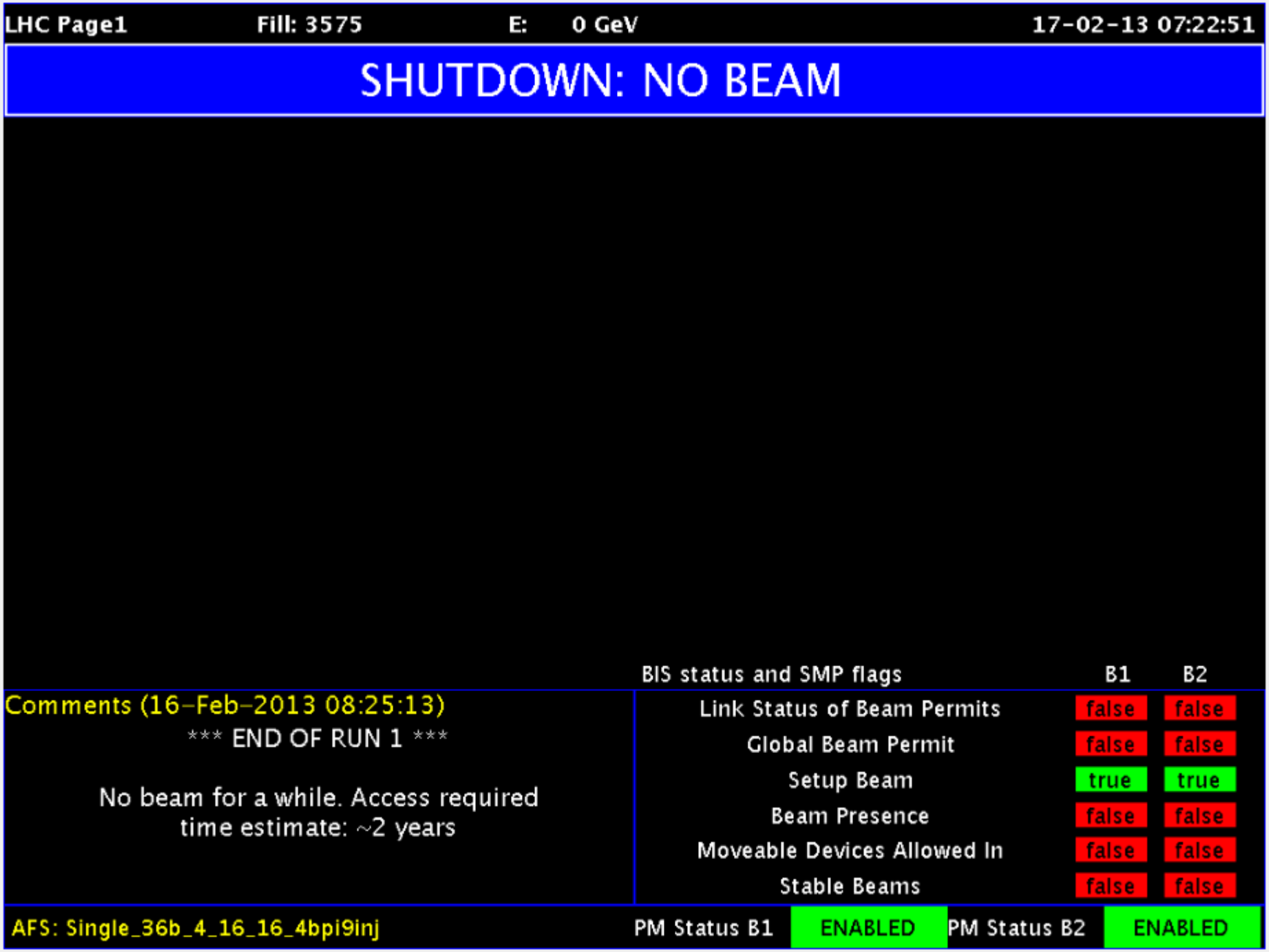


Had to struggle to have components delivered and avoid blocking the train (4 procurement paths instead of 1 !!)

- Small (<0.3 % of budget) pieces can have huge impact
- The latter a task is added, the more likely are such issues



10.04.2013 : Consolidation of the last quadrupole diode


LHC Page1
Fill: 3575
E: 0 GeV
17-02-13 07:22:51
SHUTDOWN: NO BEAM
BIS status and SMP flags
B1
B2
Comments (16-Feb-2013 08:25:13)
*** END OF RUN 1 ***
No beam for a while. Access required
time estimate: ~2 years
Link Status of Beam Permits
false
false
Global Beam Permit
false
false
Setup Beam
true
true
Beam Presence
false
false
Moveable Devices Allowed In
false
false
Stable Beams
false
false
AFS: Single_36b_4_16_16_4bpi9inj
PM Status B1
ENABLED
PM Status B2
ENABLED

BUT ALSO

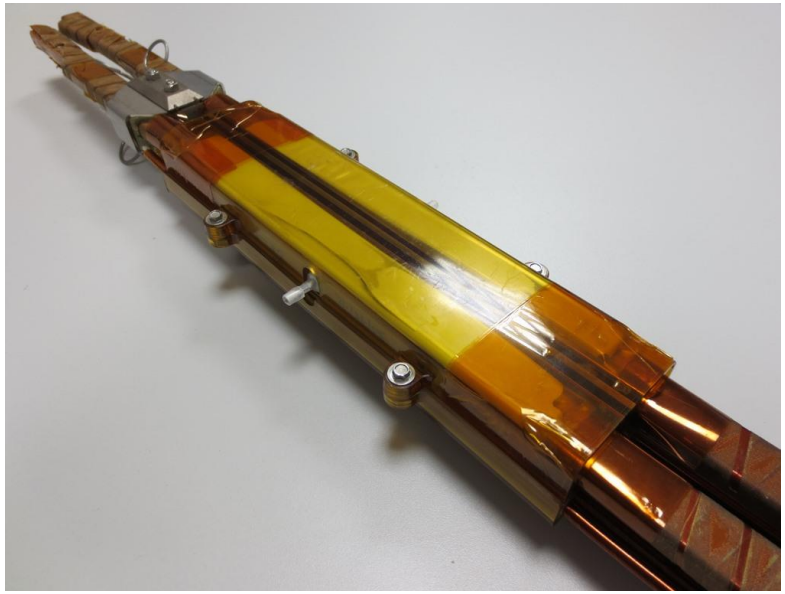
Surprises >
30% splices
Overheated splices
DFBA gimbals

DN200

DFBA

SIT

Q Diodes



Improvements : Thermal shield design, vacuum, ElQA, MP3, cryoBLM

SMACC Post Mortem
LS2 session at Chamonix including LS1 lessons learnt
LS1 post mortem followed by LS2 days