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LS1 Status Report

LS1@LHCC

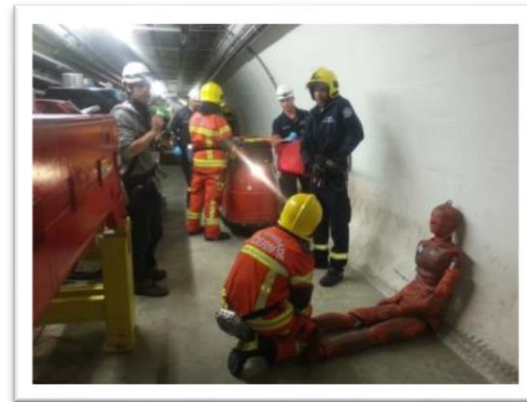
Frédéric Bordry

25th September 2013

LS1 Slogan: 1st Safety , 2nd Quality , 3rd Schedule

LS1 Safety

- ▶ Prevention measures
 - ▶ Training for all categories of personal (safety, procedure, mock-up,...)
 - ▶ Common inspections CERN / Contractor before starting work
 - ▶ Safety Officer / Safety Coordination Patrols
 - ▶ Spontaneous witnesses of hazardous situations
 - ▶ Evacuation exercises
- ▶ Hazardous Situations
 - ▶ **Not wearing of the Personal Protective Equipments (PPE)**
 - ▶ Personnel crossing safety barriers
 - ▶ Smoke generation by vacuum pump motors
 - ▶ False fire alarms and evacuations



*Fire brigade exercise
In SPS*

LS1 Safety

- ▶ Notified accidents in LS 1 (Accelerators)
 - ▶ **Head wound from hitting obstacles (4 x)**
 - ▶ **Hand/Fingers hurt by portable tool (3 x)**
 - ▶ **Eye irritation from glass fibre dust**
 - ▶ Fall from bicycle (during evacuation)
 - ▶ Slipping and hitting a pole
 - ▶ Electrical shock (w/o consequences)
 - ▶ Handling loads

Totaling 45 days of sick leave due to accidents for more than 150'000 man·days worked (very low gravity rate ≈ 0.04)

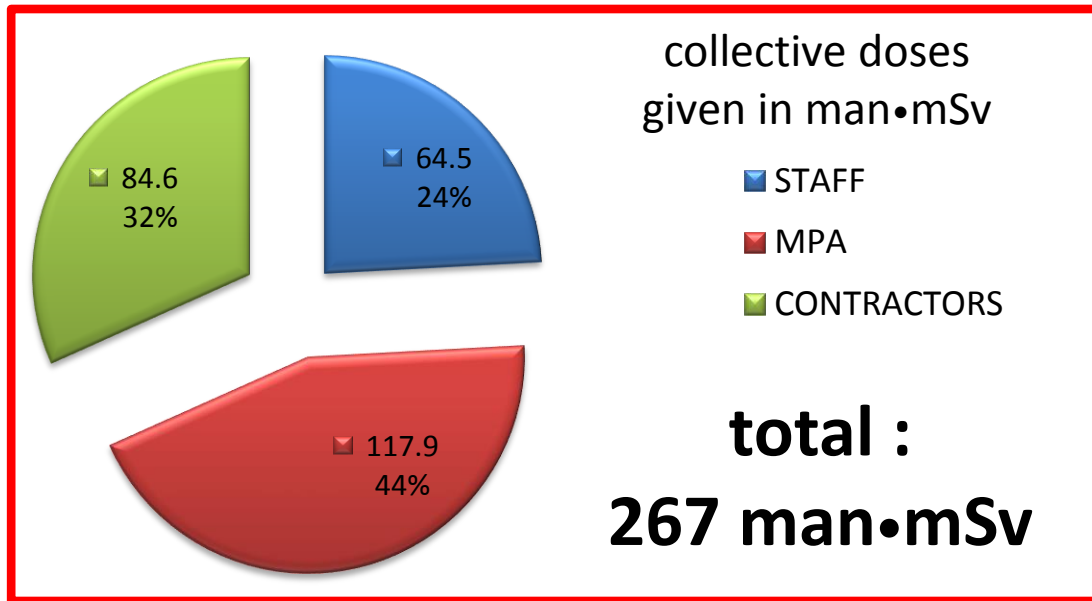
LS1 Personal Dosimetry

Collective dose for the period 1 March – 31 August 2013

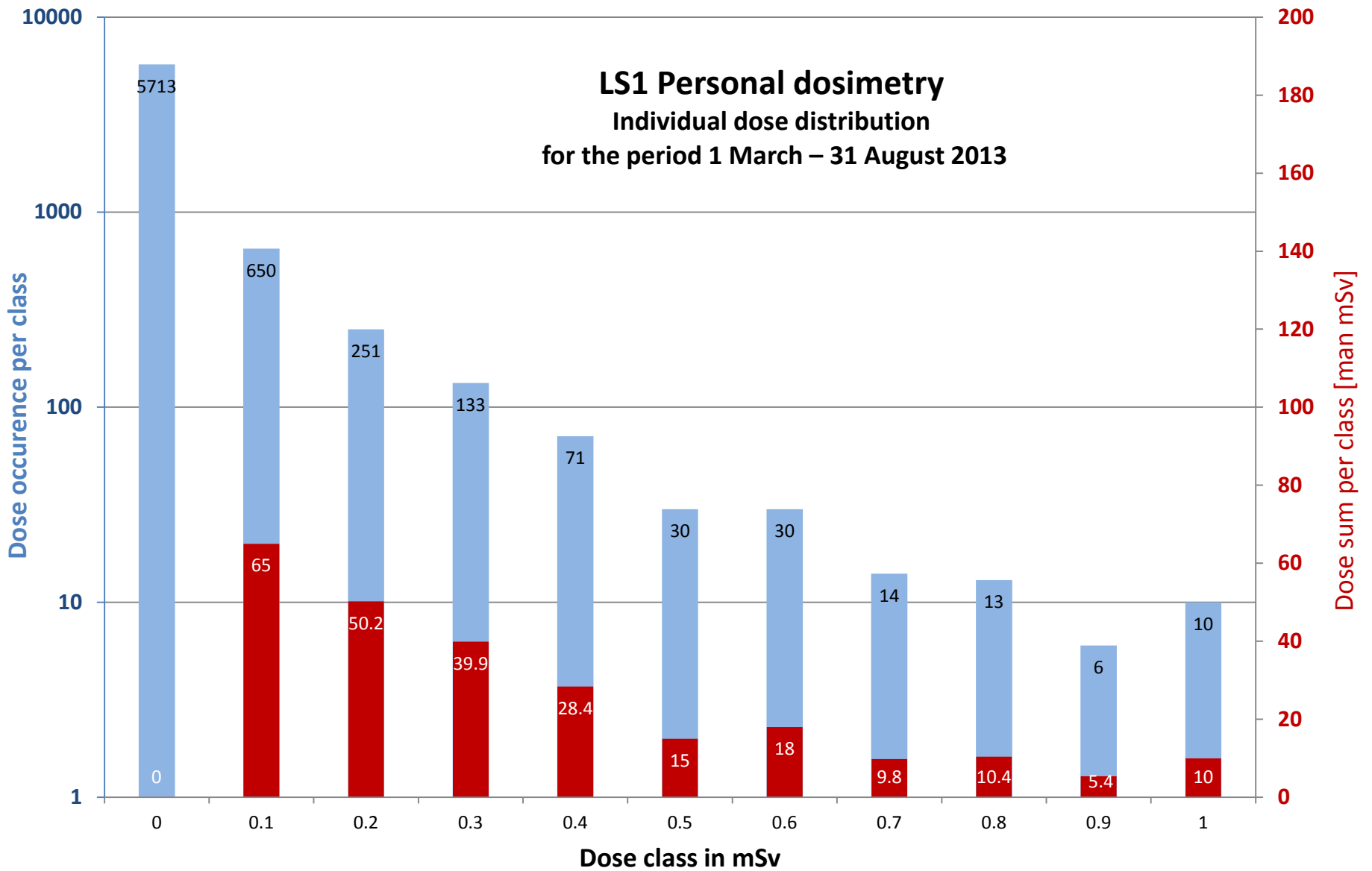
- ▶ obligatory for work in **any CERN Radiation Area** (Supervised and Controlled Radiation Areas)
- ▶ assigned after validation of a successful participation in a radiation protection course.
- ▶ presently 5989 DIS dosimeters in use
- ▶ **maximum individual doses: 0.7-1.0 mSv** (SPS LSS1 cabling, PS/PSB vacuum and magnet maintenance)



DIS Personal Dosimeter
(passive)

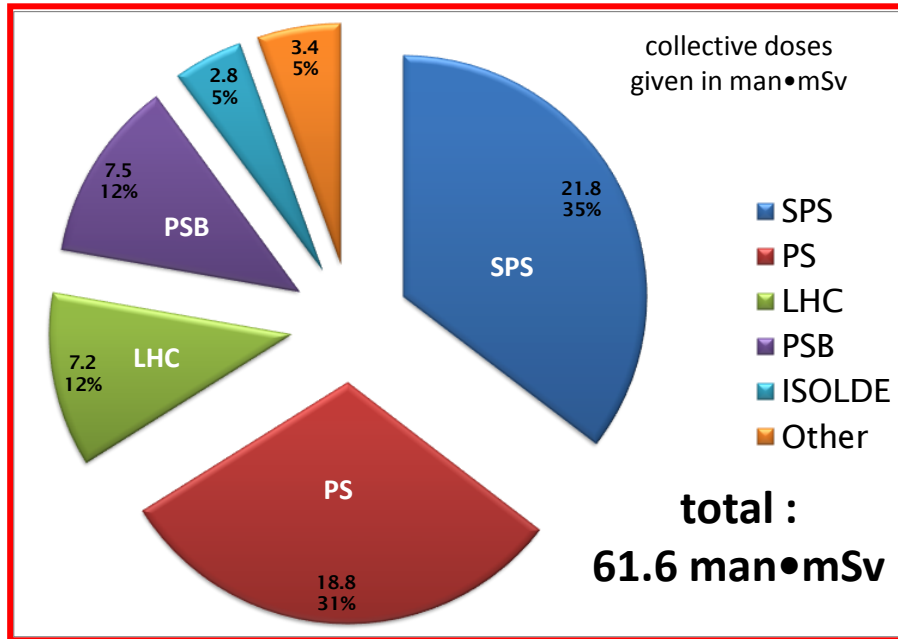


2011: 527 man•mSv
2012: 494 man•mSv



LS1 Operational Dosimetry

Collective dose for the period 18 February
– 31 August 2013



Main contributors:

SPS

- LSS1 activities: 10 mSv
- Other cabling work: 4 mSv
- Survey: 2 mSv

PS

- Ventilation exchange: 10 mSv
- Magnet interventions: 2.5 mSv
- Cabling interventions: 1.5 mSv

PSB

- Cabling interventions: 3.5 mSv
- Dump removal: 1 mSv
- Survey: 1 mSv

LHC

- Vacuum interventions: 4 mSv
- Survey: 1 mSv

ISOLDE

- Robots exchange: 2 mSv
- Cabling interventions: 1 mSv

PS



New crane commissioned



New PS access system

- ▶ New crane installed
- ▶ Ventilation removal in good progress
- ▶ Septum 16 shielding in progress
- ▶ Safety and access system installation in progress
- ▶ Delay in schedule due to the magnet maintenance – this delay has been implemented in the schedule without impact on the end date (experts and workers coming from Russia during autumn)

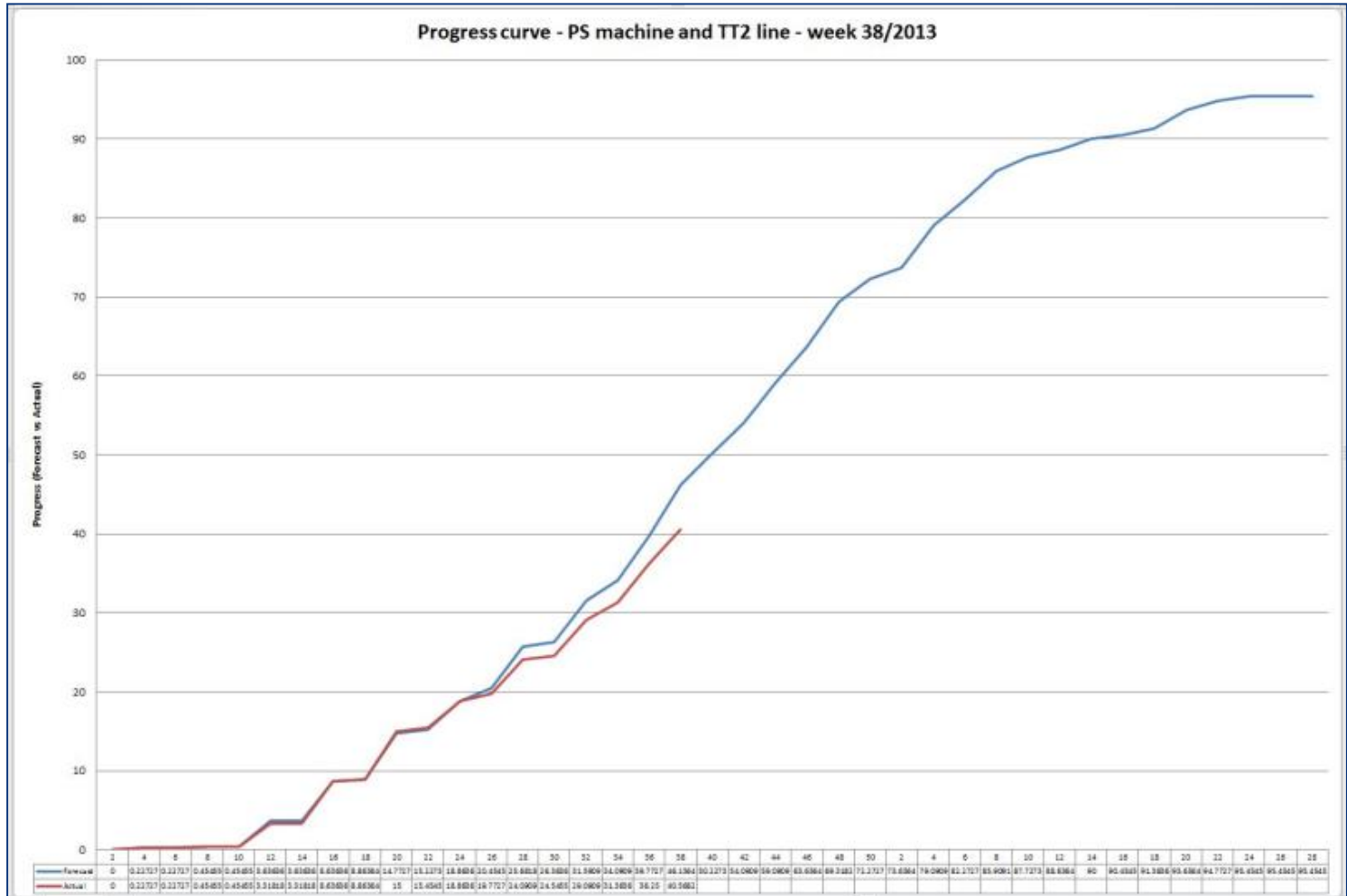


Access system – new door



Installation of piles

PS



Booster

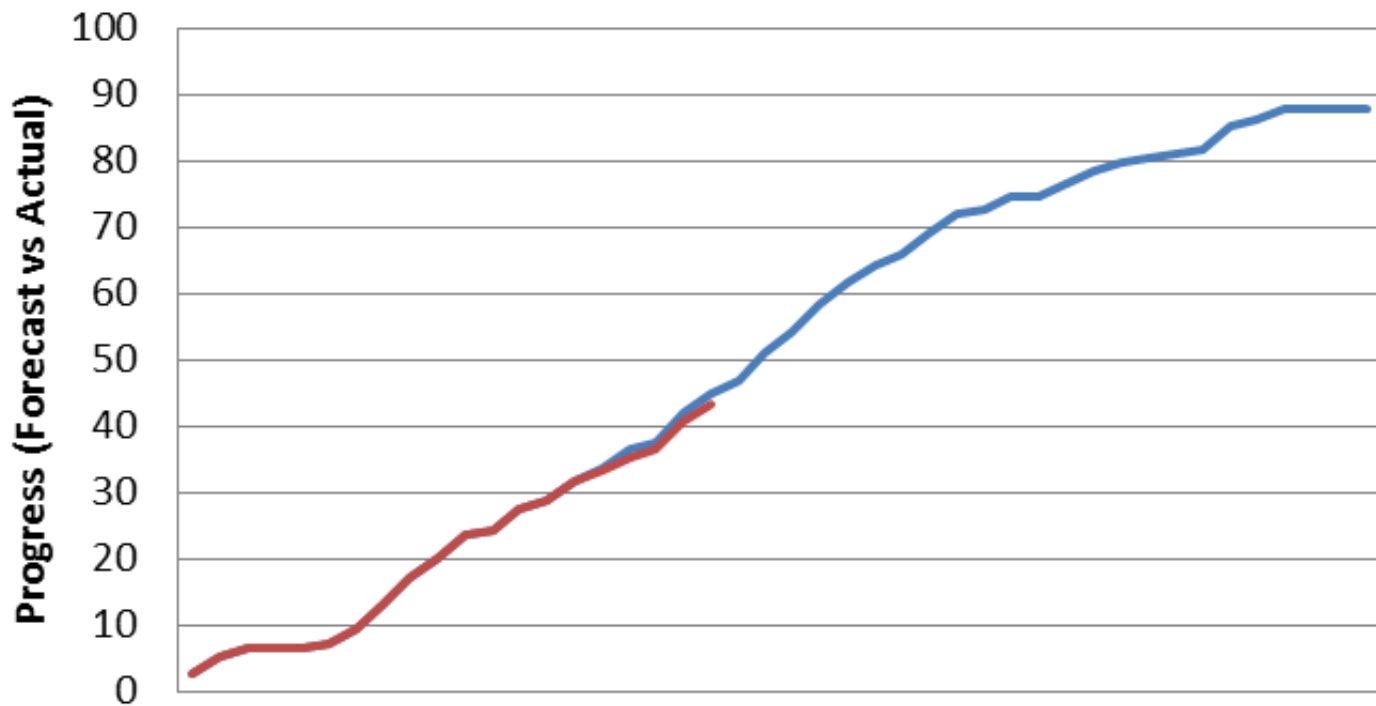
- ▶ New lift installed
- ▶ Beam dump replacement in progress (new dump will be installed from next week)
- ▶ Cabling in progress
- ▶ Maintenance of the different equipment on schedule



Beam dump replacement

Booster

Progress curve - PSB machine - week 36 (13/09/2013)



SPS

- ▶ BA1 - Irradiated cabling campaign
- ▶ Equipment removed to ease the decabling and cabling campaign
- ▶ Cabling campaign will start in October – ALARA meeting next week
- ▶ TT10 – repair of the vault on going
- ▶ Main isolating valves on the raw water circuits being exchanged
- ▶ Transformers exchange in progress
- ▶ Magnet exchange



All new transformers in place



SPS magnet exchange

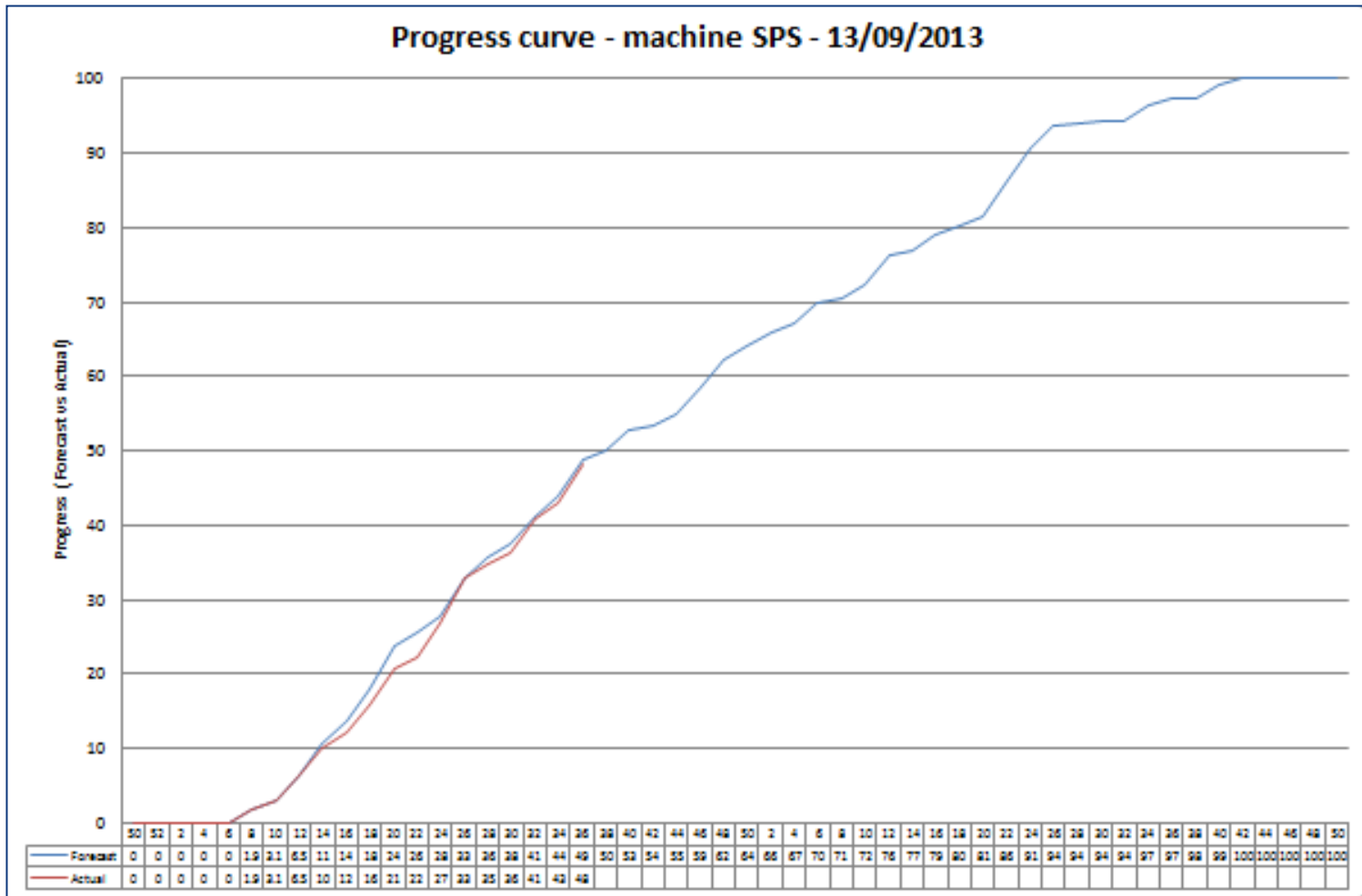


Telemax in BA1

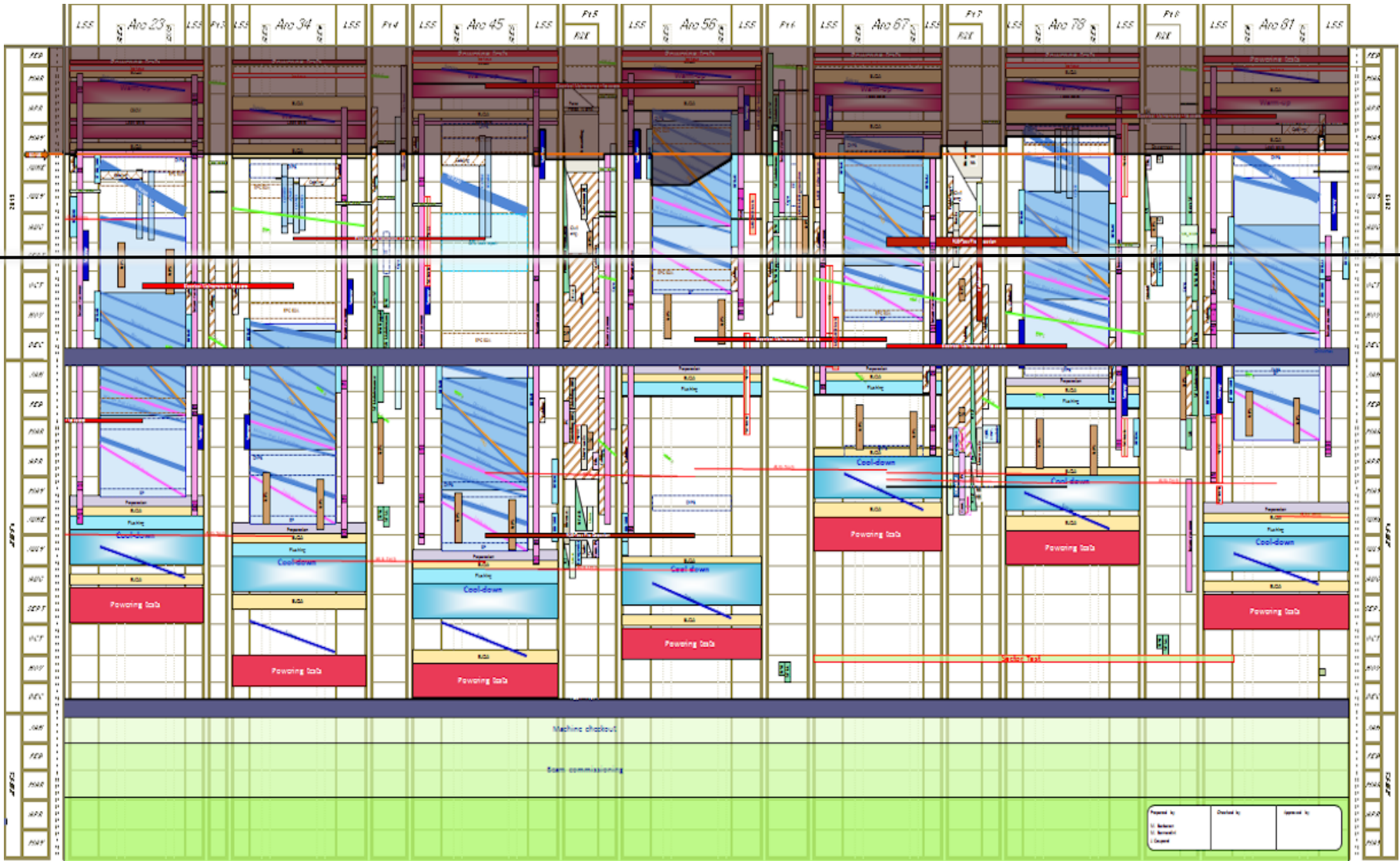


TT10 – vault repair

SPS



114th LHCC Meeting (12th June 2013)



LHC Preliminary leak tests

- ▶ Arc subsectors all tested: 20 internal helium leaks identified
 - ▶ 14 identified to component (for repair).
 - ▶ For 6 leaks not identified to component, further tests to be performed in phase 2.
- ▶ QRL
 - ▶ 2 existing internal leak known
 - ▶ 5 new internal leaks – under investigation



Internal helium leak

QRL S45-Subsector B: Q15R4

Suspected condensed air

Damaged corrugations of

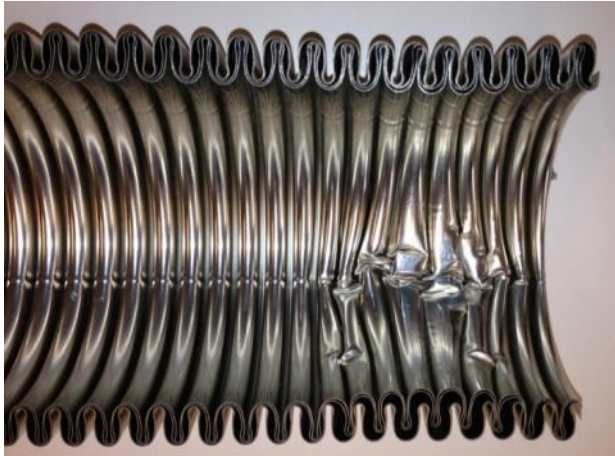
X-rays campaign :

- all C-line compensators inv
- #3 found damaged (Q15Ra)
- additional X-rays of #3 B, D,

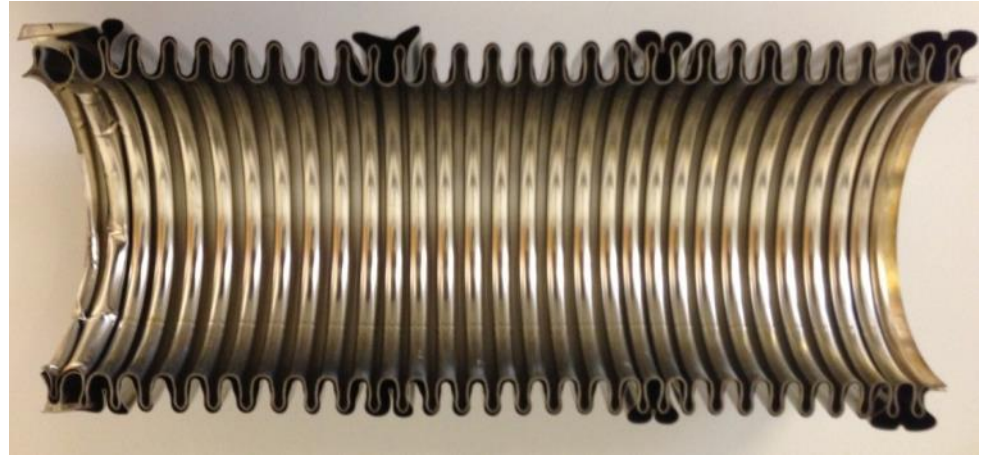
Winter stop 2010-2011

Sector	QRL Insulation vacuum subsectors																
S5-6	I	H	G	F	E	D	C	B	A								
S6-7	A	B	C	D	E	F	G	H	I								
S7-8	I	H	G	F	E	D	C	B	A								
S8-1	A	B	C	D	E	F	G	H	I								
S1-2	I	H	G	F	E	D	C	B	A								
S2-3	A	B	C	D	E	F	G	H	I								
S3-4	I	H	G	F	E	D	C	B	A								
S4-5	A	B	C	D	E	F	G	H	I								
<table border="1" style="border-collapse: collapse;"> <tr> <td style="width: 20px; height: 20px; background-color: white;"></td> <td>Measurements not made yet</td> </tr> <tr> <td style="width: 20px; height: 20px; background-color: #90EE90;"></td> <td>Measurements made - no internal leak problem</td> </tr> <tr> <td style="width: 20px; height: 20px; background-color: #F08080;"></td> <td>Known internal leak problem</td> </tr> <tr> <td style="width: 20px; height: 20px; background-color: #FFD700;"></td> <td>New internal leak problem</td> </tr> </table>											Measurements not made yet		Measurements made - no internal leak problem		Known internal leak problem		New internal leak problem
	Measurements not made yet																
	Measurements made - no internal leak problem																
	Known internal leak problem																
	New internal leak problem																

The damaged compensator (QRL Line C)

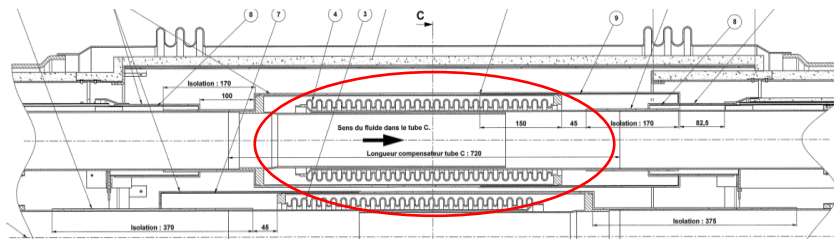
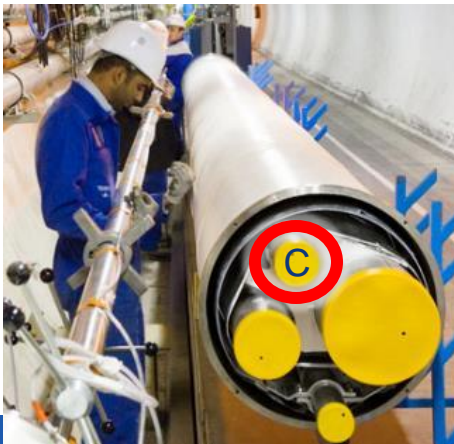


Internal ply damage (S45, 14R4)



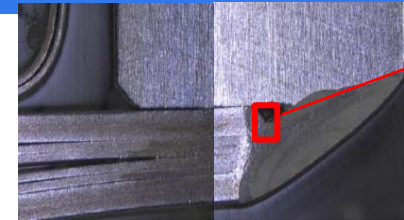
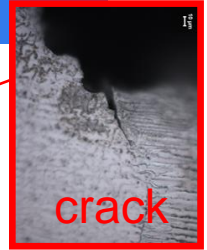
External ply damage (S78, 10R7)

DN100 multi-ply bellows compensators (4 plies of 0.3 mm)

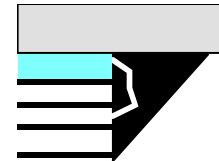


QRL opening sec. 45

The failure mode (QRL as typical)



Metallographic observations (EN-MME)

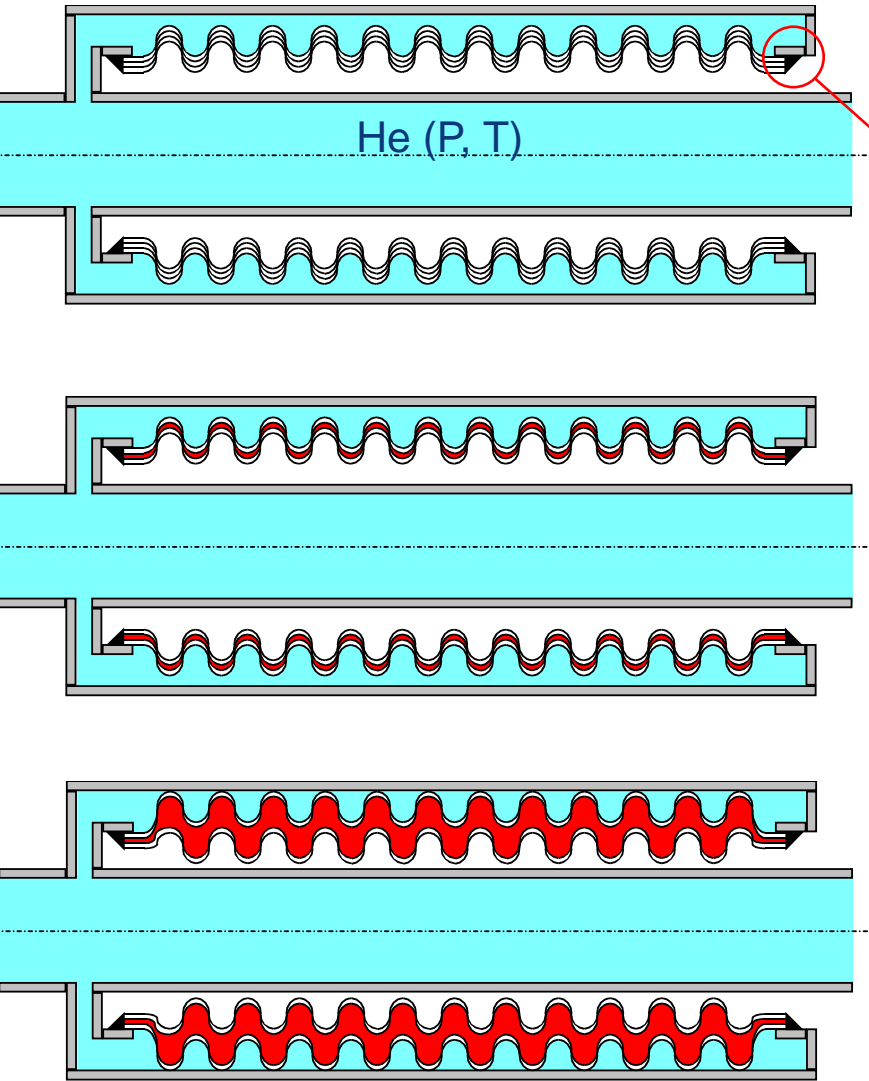


A "virtual" leak
(not seen during global leak test)

Filling of the inter-ply space with time (3-4 years of operation)

Pressure increase of the inter-ply space during warm-up → compensator collapsing !
Maxi pressure with conservative assumption: isochoric transformation and space initially at line conditions (P, T)

- CM: 1500 bar
 - Line C: 1200 bar
 - Line E & F: 120 bar
 - Line D: 20 bar
 - Line B: 1 bar
- ← Difficult to survive !!



Repair plan for QRL compensators

	2013												2014																			
	Aug		Sep			Oct				Nov			Dec		Jan					Feb												
CW	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10			
X-Ray S45 & S56				(CRG & MME)																												
X-Ray of remaining QRL (~5 sectors) TBC				(CRG & MME)																												
CERN spare validation (12 units)				(CRG & VSC)																												
Delivery of new spares (5-10 units)																																
New spare validation (5 units)																																
Sector 8-1				T1	T2	T1	T2				T3																	PT 30.05.2014				
Sector 5-6					T1	T2	T1	T2			T3																	PT				
Sector 6-7									T1	T2	T1	T2			T3													PT				
Sector 7-8										T1	T2	T1	T2			T3												PT				
Sector 7-8												T1	T2	T1	T2				T3									PT				
Sector 3-4													T1	T2	T1	T2												PT 20.06.2014				
Sector 4-5																T1	T2	T1										PT 18.07.2014				
Sector 4-5																	T1	T2										PT 18.07.2014				
Sector 1-2																												PT 23.04.2014				
Sector 2-3																												PT 22.05.2014				

All existing spares fully tested prior to installation

Replacement of the first compensator started in S81

New spares to be ordered with updated welding & QA procedure

T1 Mechanical preparation (CRG)

T2 Compensateur integration/welding and clamshell leak test (CRG & VSC)

T1 Screen and MLI interconnect integration (CRG)

T2 External envelop closure/welding (CRG)

PT Subsector pumping

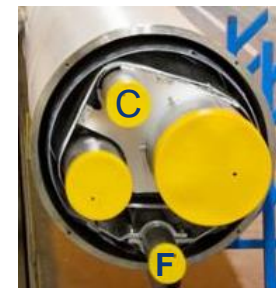
T3 Individual and global leak test (VSC)

PT - preparation for pressure test (QRL to be closed)

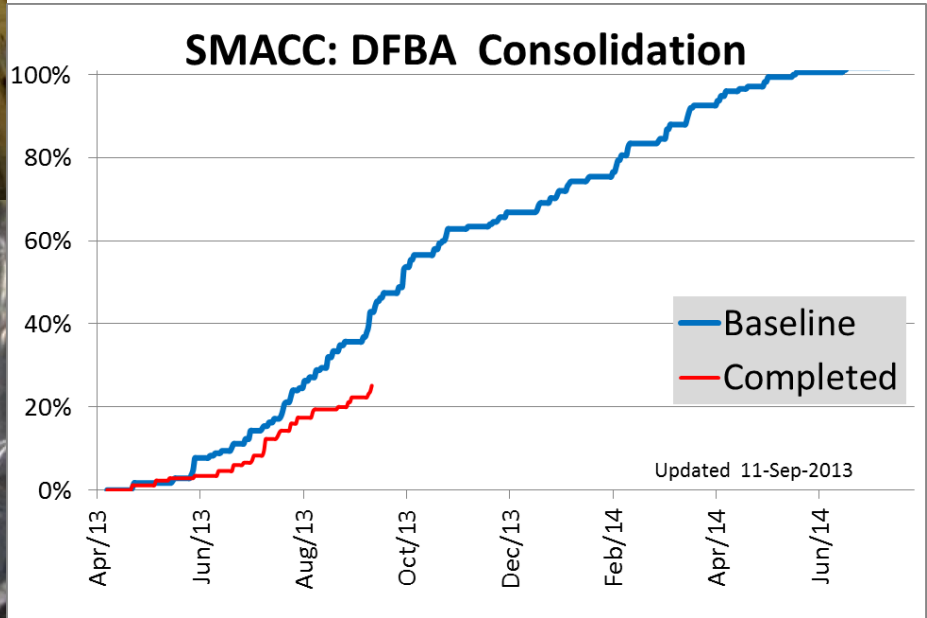
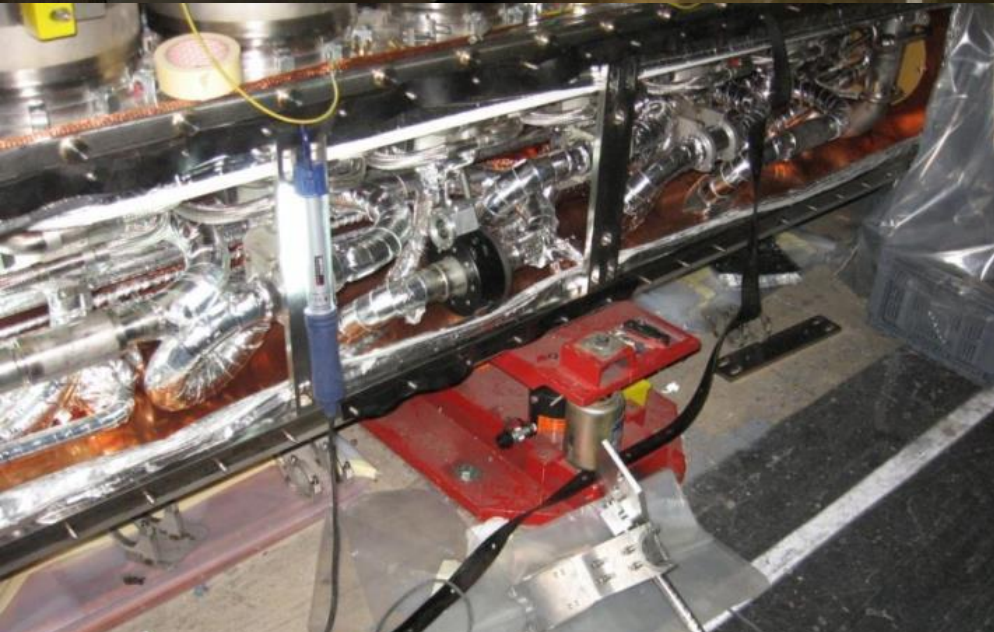
T1 (Team 1): 2 persons (2 technicians)

T2 (Team 2): 2 persons (1 welder + 1 mechanics) (TE-VSC support to be added)

T3 (Team 3): VSC support

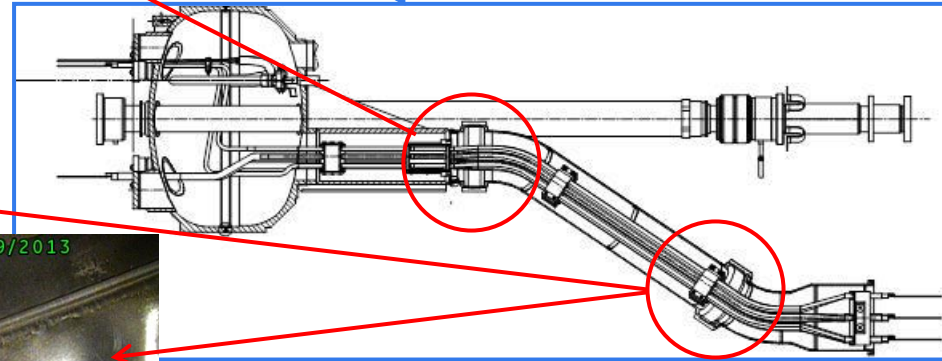
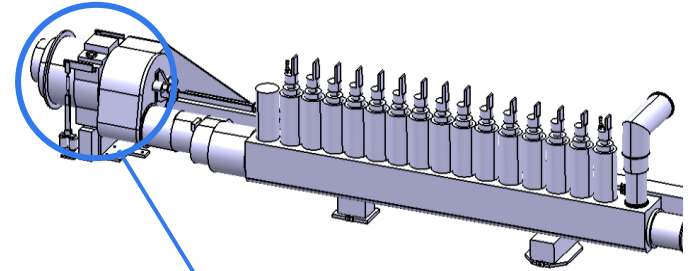


SMACC: Cryo-feedbox (DFBA) consolidation



The damaged compensator (DFBA)

DN120 multi-ply gimbal bellows
(2 plies of 0.2 mm); Identical failure process identified



DFBAK upper gimbal (Sector 5-6)

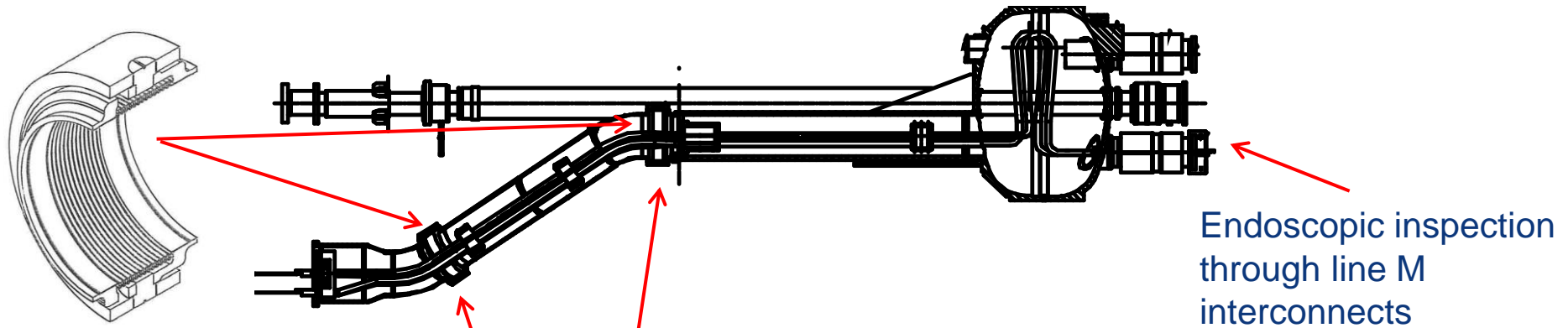


DFBAF lower gimbal
(Sector 3-4)



DFBAI lower gimbal
(Sector 4-5)

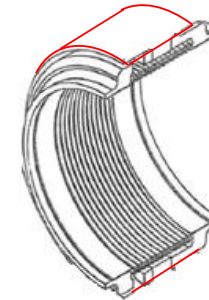
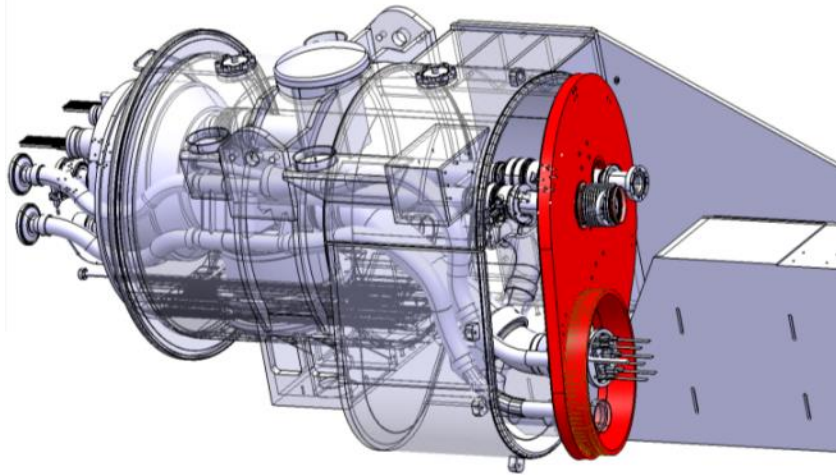
DFBA gimbal bellows status for all DFBAs



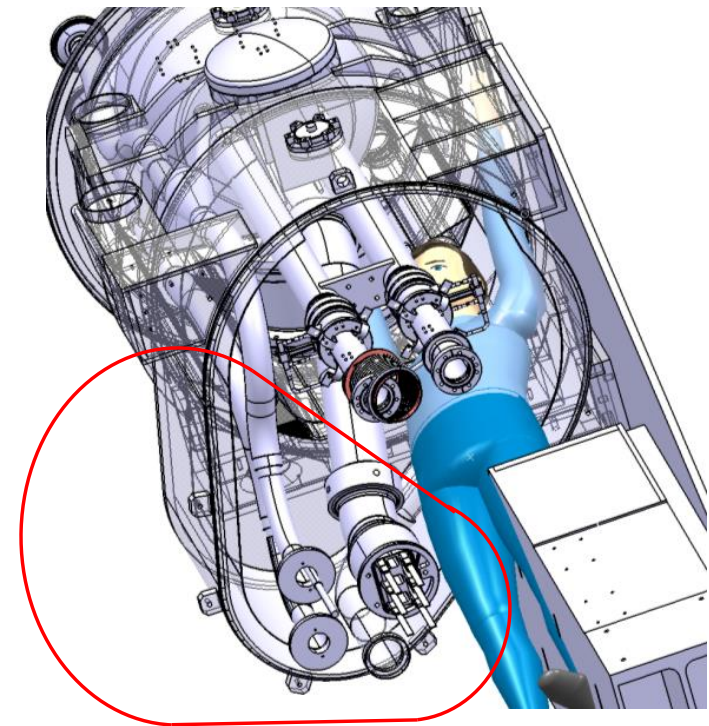
DFBA	IP	Dates		Bellows status		Secteur	DFBA	IP	Dates		Bellows status	
		Découpe M	Inspection	Lower	Upper				Découpe M	Inspection	Lower	upper
DFBAB	1R	07-Aug	08-Aug	ok	ok	1-2	DFBAC	2L	20-Aug	20-Aug	ok	ok
DFBAD	2R	13-Aug	14-Aug	ok	ok	2-3	DFBAE	3L	04-Sep	04-Sep	ok	ok
DFBAF	3R	25-Aug	26-Aug	damaged	ok	3-4	DFBAG	4L	29-Aug	02-Sep	ok	ok
DFBAH	4R	29-Aug	02-Sep	ok	ok	4-5	DFBAI	5L	06-Sep	09-Sep	damaged	ok
DFBAJ	5R	20-Apr	18-Jul	ok	ok	5-6	DFBAK	6L	-	18-Jul	ok	collapsed
DFBAL	6R	25-Apr	18-Jul	ok	ok	6-7	DFBAM	7L	-	26-Jul	ok	ok
DFBAN	7R	15-Jun	02-Aug	ok	ok	7-8	DFBAO	8L	-	02-Aug	ok	ok
DFBAP	8R	-	25-Jul	ok	ok	8-1	DFBAA	1L	07-Aug	08-Aug	ok	ok

Statistics (total 32 bellows all inspected): **3/32 (9.3 %)**

In situ access by cutting the end door: possible solution



Gimbal patching
(Rigid assembly)

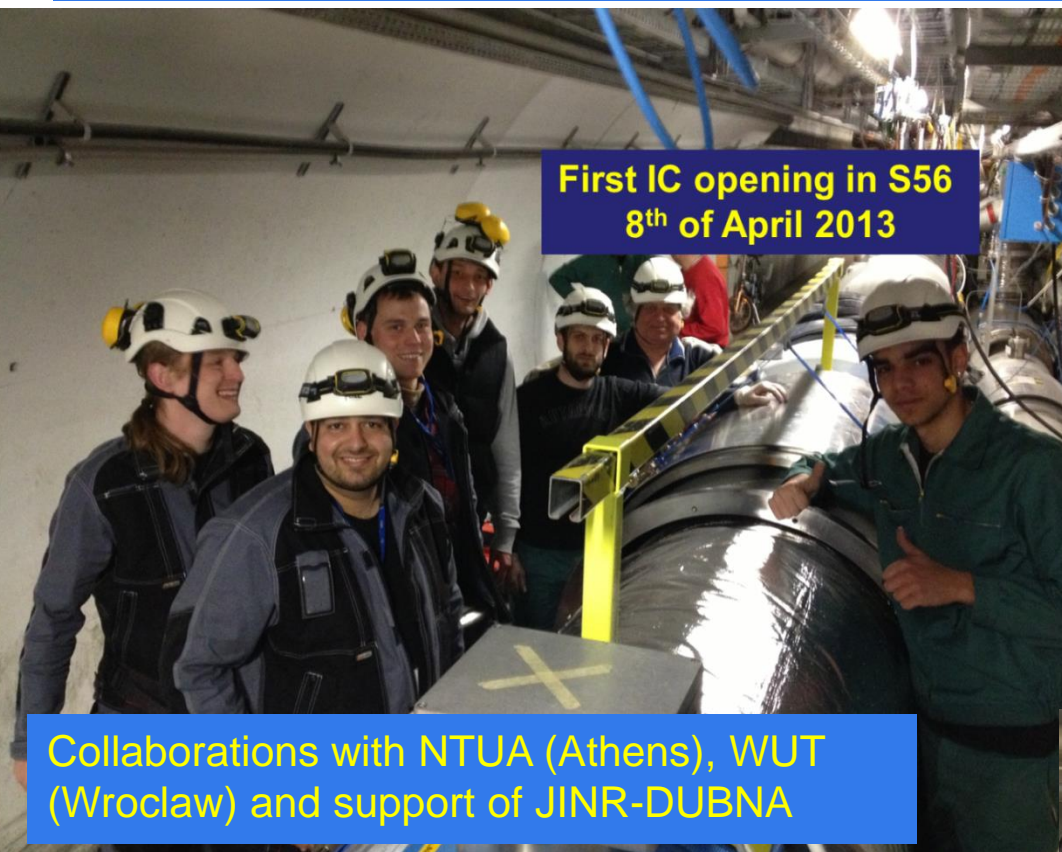


Questions/issues:

- Very limited space to cut/weld the door
- Cutting and welding of beam pipes to be done in very difficult position
- Leak tests of beam pipes?
- Extreme very difficult work positions
- Safety to be assessed

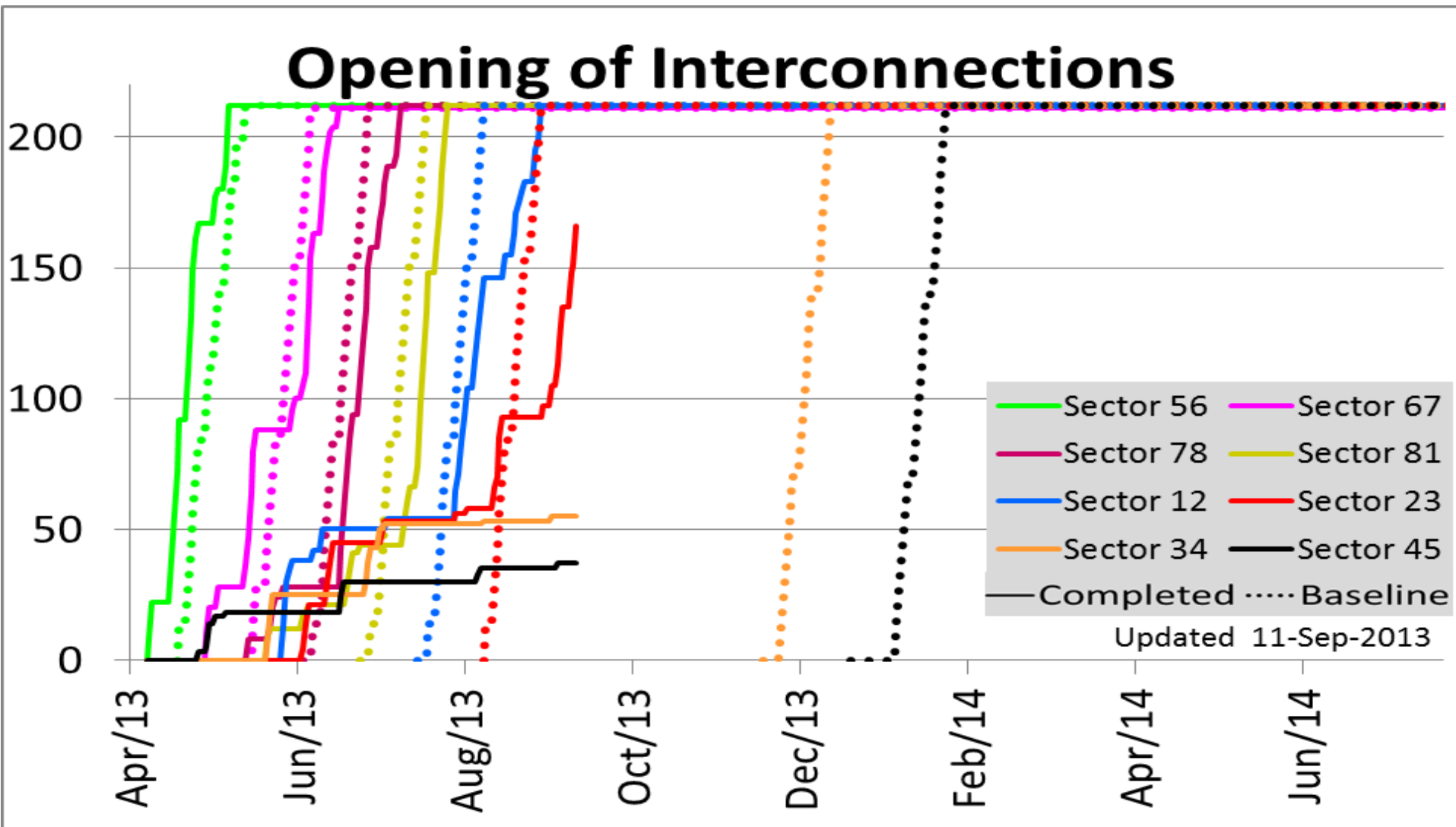
Thanks for EN-MME contribution!

SMACC: Opening of interconnections



**> 6 sectors equivalent
have been opened
around the LHC.**

SMACC: Opening of interconnections



SMACC: Opening of busbar lines

Measurement of > 4100 splices (total 10'170)

Preliminary results of existing splices quality control (7.09.2013).

Sector	Sector 56	Sector 67	Sector 78	Sector 81	LHC
Measured [%]	100	100	100	25	40
To redo [%]	28	32	29	31	30



**+ 8 FTE
and
+ 2 induction
machines**



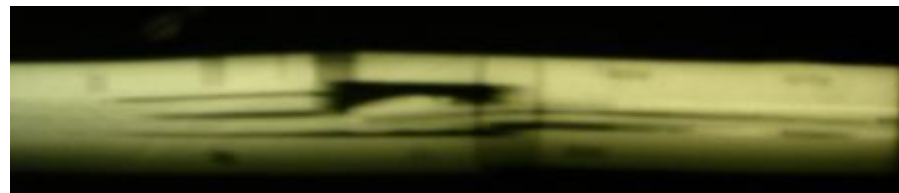
**Collaborations with PAEC-NCP
(Pakistan Atomic Energy Commission –
National Centre for Physics)**



R-8 measurement : top ten outliers

Top ten R-8 M3 (measured
until the 7.9.2013)

1	QBBI.B24R7-M3-Ext	77.5 $\mu\Omega$	R-8 right
2	QQBI.22L8-M3-Ext	52.6 $\mu\Omega$	R-8 left
3	QBBI.A14L8-M3-Ext	49.9 $\mu\Omega$	R-8 right
4	QQBI.16R8-M3-Ext	47.4 $\mu\Omega$	R-8 right
5	QQBI.22R7-M3-Int	43.3 $\mu\Omega$	R-8 left
6	QBQI.32R7-M3-Int	41.6 $\mu\Omega$	R-8 left
7	QBQI.31R6-M3-Ext	40.6 $\mu\Omega$	R-8 left
8	QBBI.B27R7-M3-Ext	39.1 $\mu\Omega$	R-8 right
9	QQBI.30R7-M3-Int	39.0 $\mu\Omega$	R-8 right
10	QQBI.15L8-M3-Ext	36.2 $\mu\Omega$	R-8 right



Sample 2A right (43 $\mu\Omega$)

SMACC: Installation of shunts

24.04.2013 : First shunts soldered (QBBI.11R5)

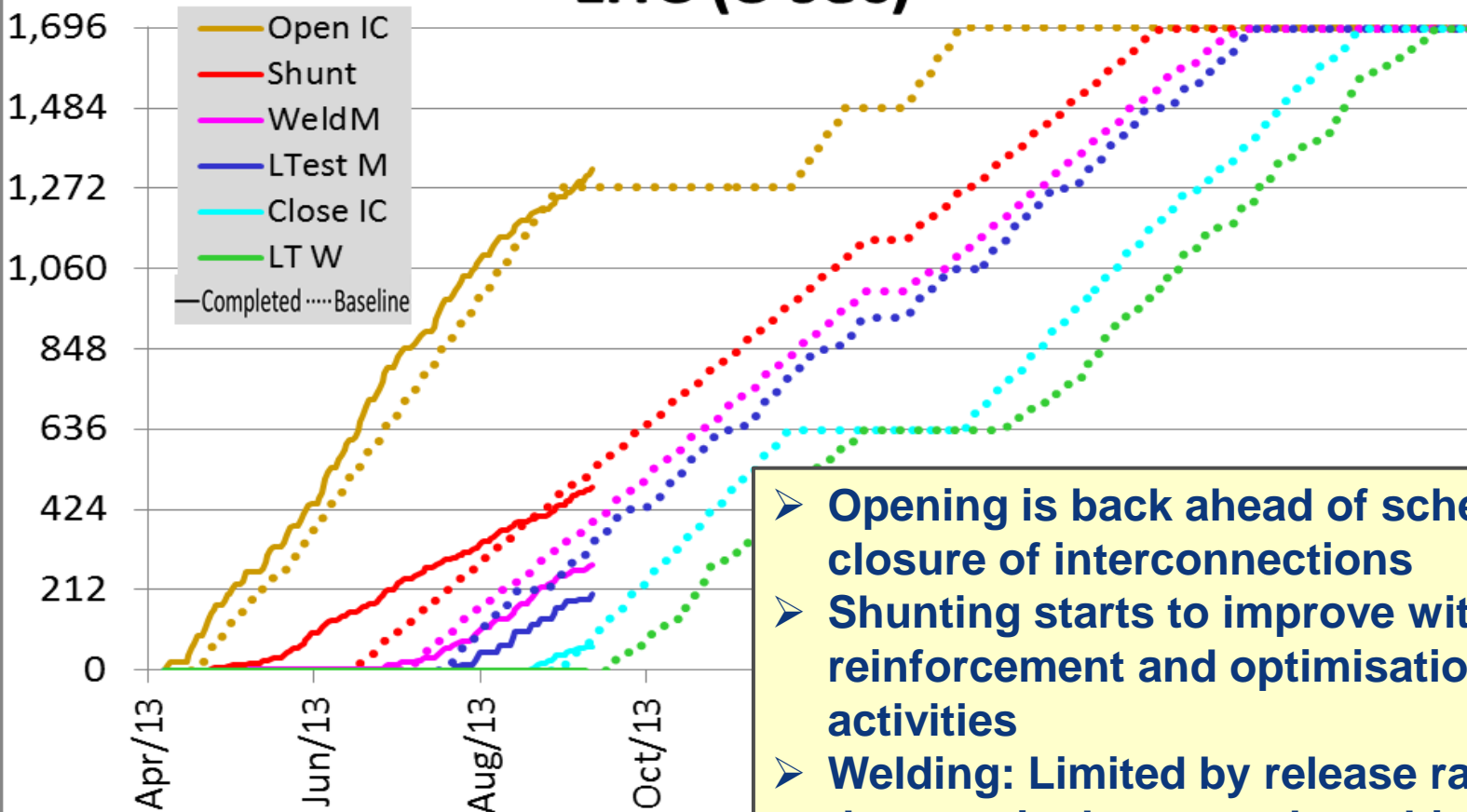


- ❖ 50 ICs behind schedule (About one week at nominal rate)
- ❖ Delay due to 30% of IC to be redone (*forecast was 15%*)
- ❖ Reinforcement of the teams
- ❖ About 8 000 shunts installed (30% of the LHC)

Shunts are installed in more than 2 sectors-equivalent

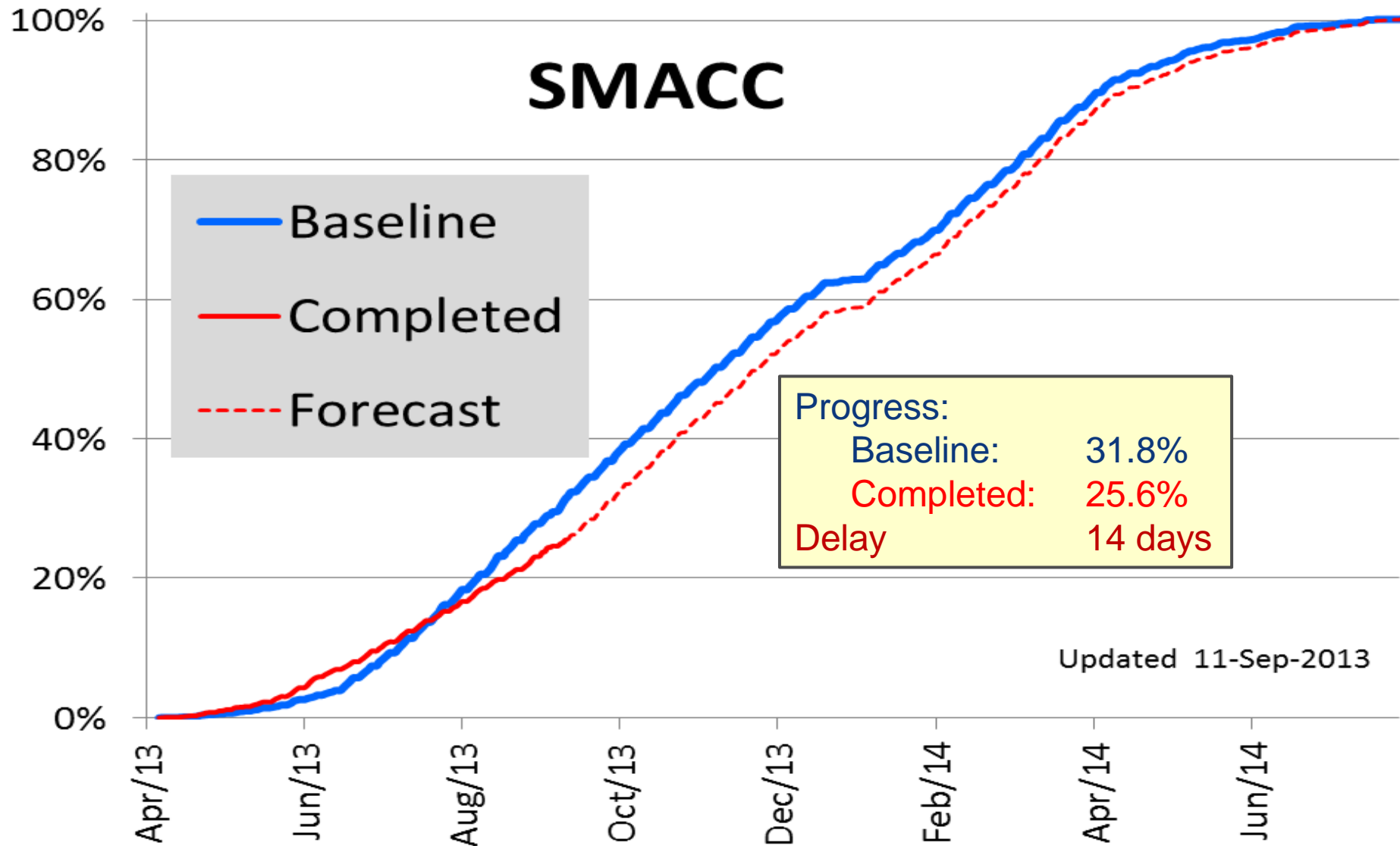
SMACC Dashboards

LHC (8 sec)



- Opening is back ahead of schedule despite closure of interconnections
- Shunting starts to improve with reinforcement and optimisation of critical activities
- Welding: Limited by release rate, confident that nominal rate can be achieved,
- M leak test : Limited by release rate, confident that nominal rate can be achieved,
- ReClosure: started ahead of schedule, now in S67
- Final leak test started (Results in 2 weeks)

SMACC Dashboards



SMACC Organisation chart (simplified)

Long Shutdown 1

SMACC (280 persons)

Superconducting Magnets And Circuits Consolidation

Production (178)

Quality Assurance (Q A) (90)

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)

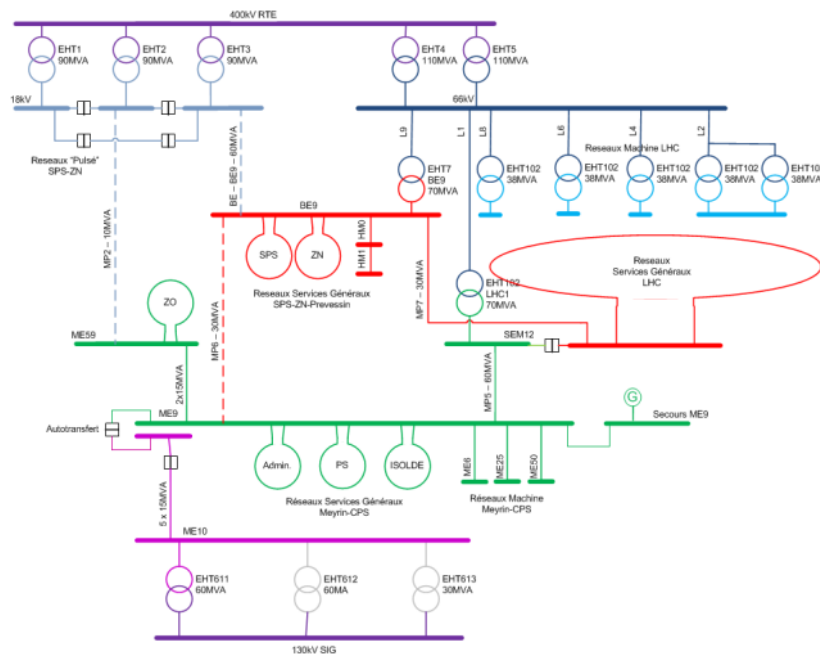
Leak Test (19)

Coordination Support Infrastructure (11)

- ✓ QA Manager reporting directly to the LS1 Coordinator
- ✓ QA/QC steps after each main production step
- ✓ 1/3 of human resources dedicated to QA

Maintenance and Consolidation of the Electrical Distribution System

French Power Source



Swiss Power Source

Ongoing as planned

- ▶ Extensive Maintenance of all the Electrical Network
- ▶ Consolidation & Upgrade of the 66 et 18 kV Networks
 - ▶ Replacement of SPS Power Cables
 - ▶ Redundant powering of the CCC
 - ▶ Enhanced UPS solution for the LHC
 - ▶ Reconfiguration and Upgrade of the Meyrin Electrical Distribution
- ▶ Replacement of UPSs in the LHC Tunnel

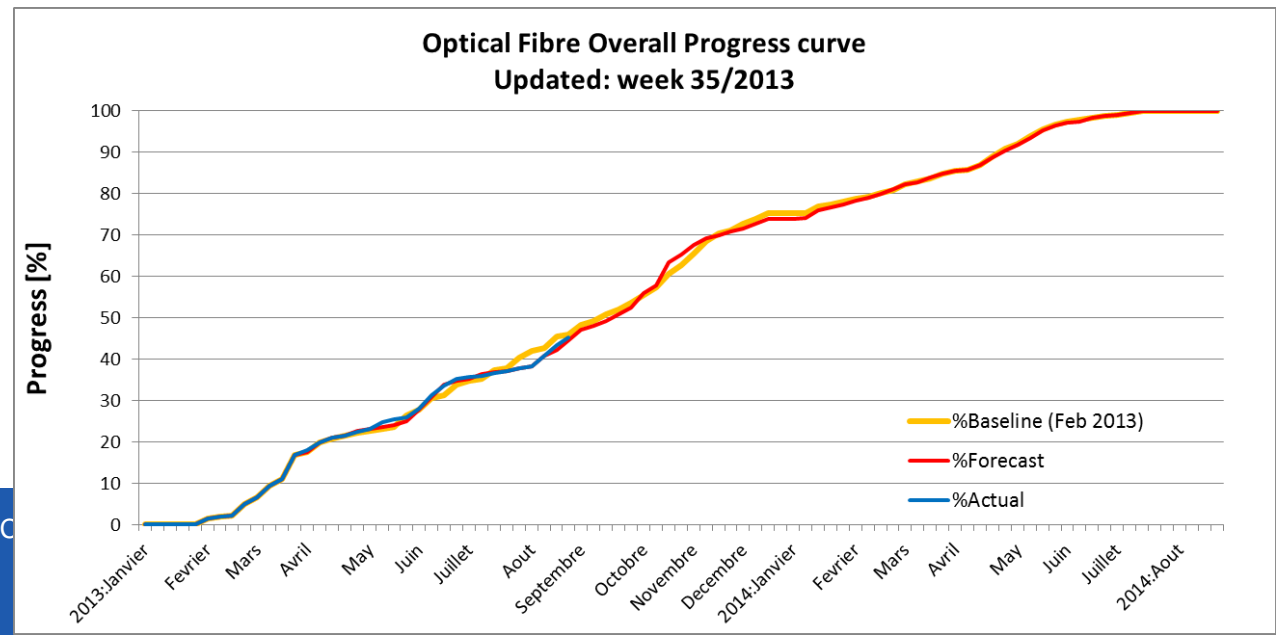
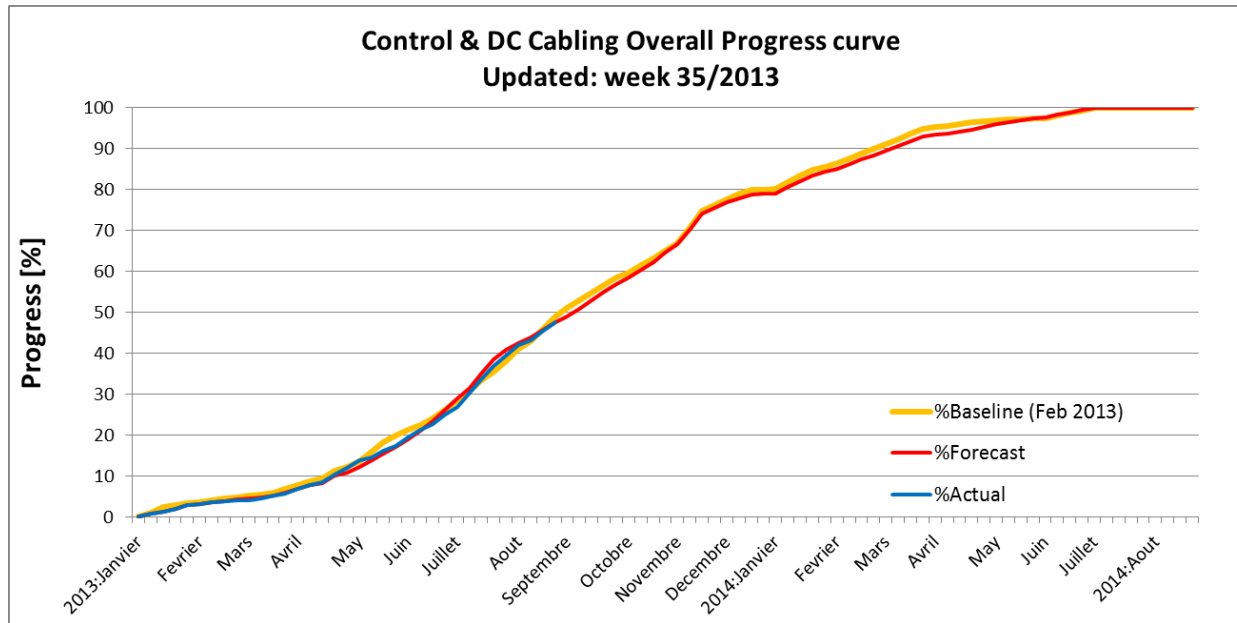
Maintenance and Consolidation of the Cooling and Ventilation System



Ongoing as planned

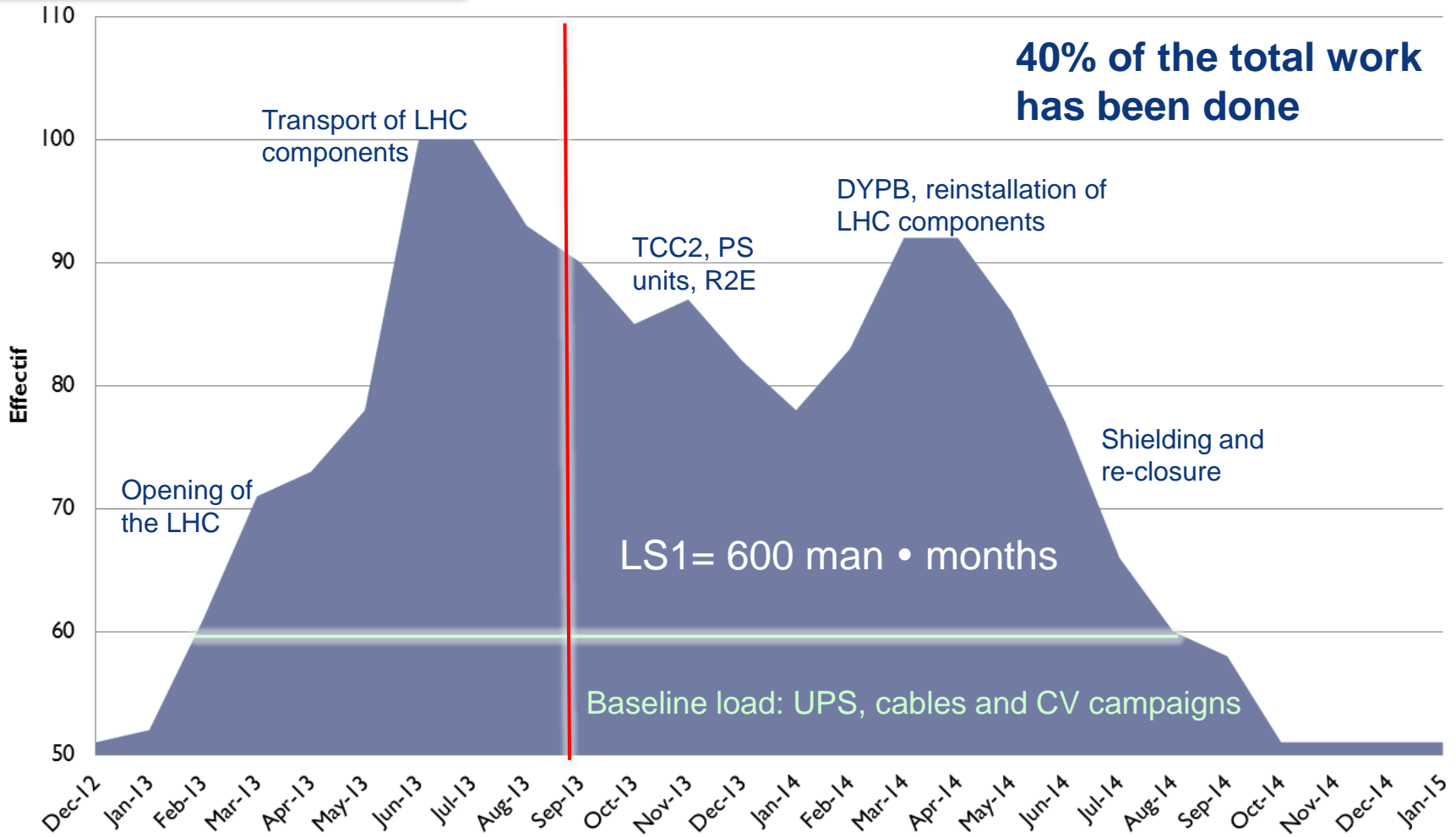
- ▶ Extensive Maintenance of cooling towers, the demineralised water production station, water cooling stations and machinery. The SPS water loop will restart operation this week.
- ▶ Consolidation & Upgrade
 - ▶ New redundant pumps on the demineralised water loop of the LHC
 - ▶ PS Ventilation System
 - ▶ CCC ventilation System
 - ▶ New cooling towers for the LHC to allow operation of the cryogenics during maintenance

Cables & Fibres

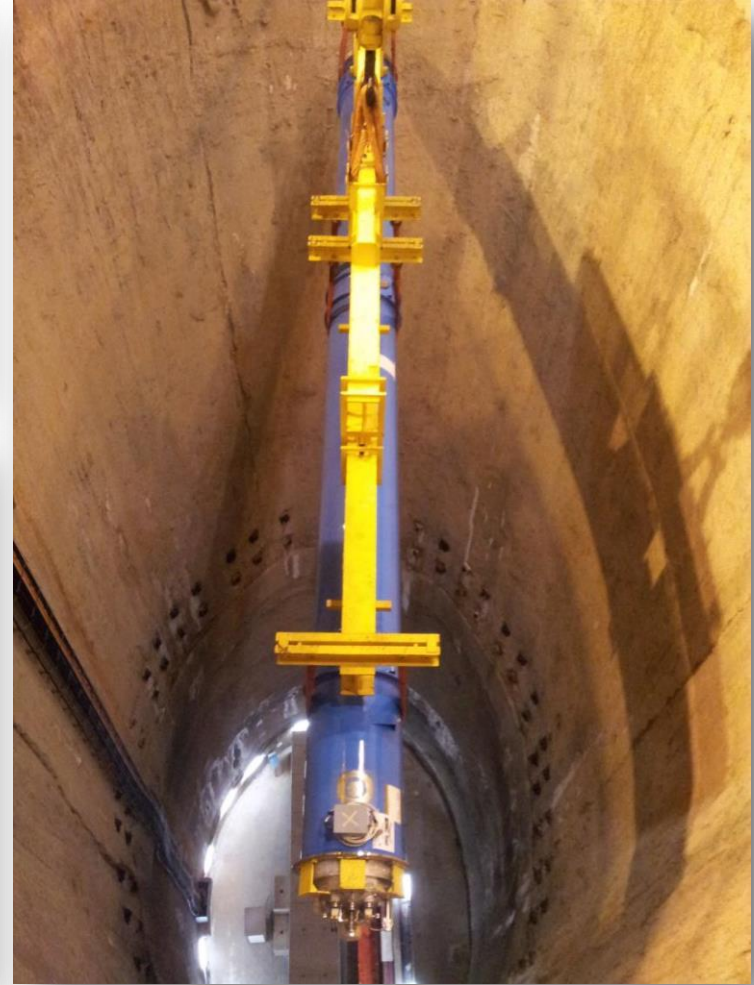


- ▶ Replacement of magnets (15 dipoles + 3 quadrupoles)
- ▶ Removal and re-installation of shielding
- ▶ Removal and re-installation of components (racks, crates, collimators)
- ▶ Transport of cables

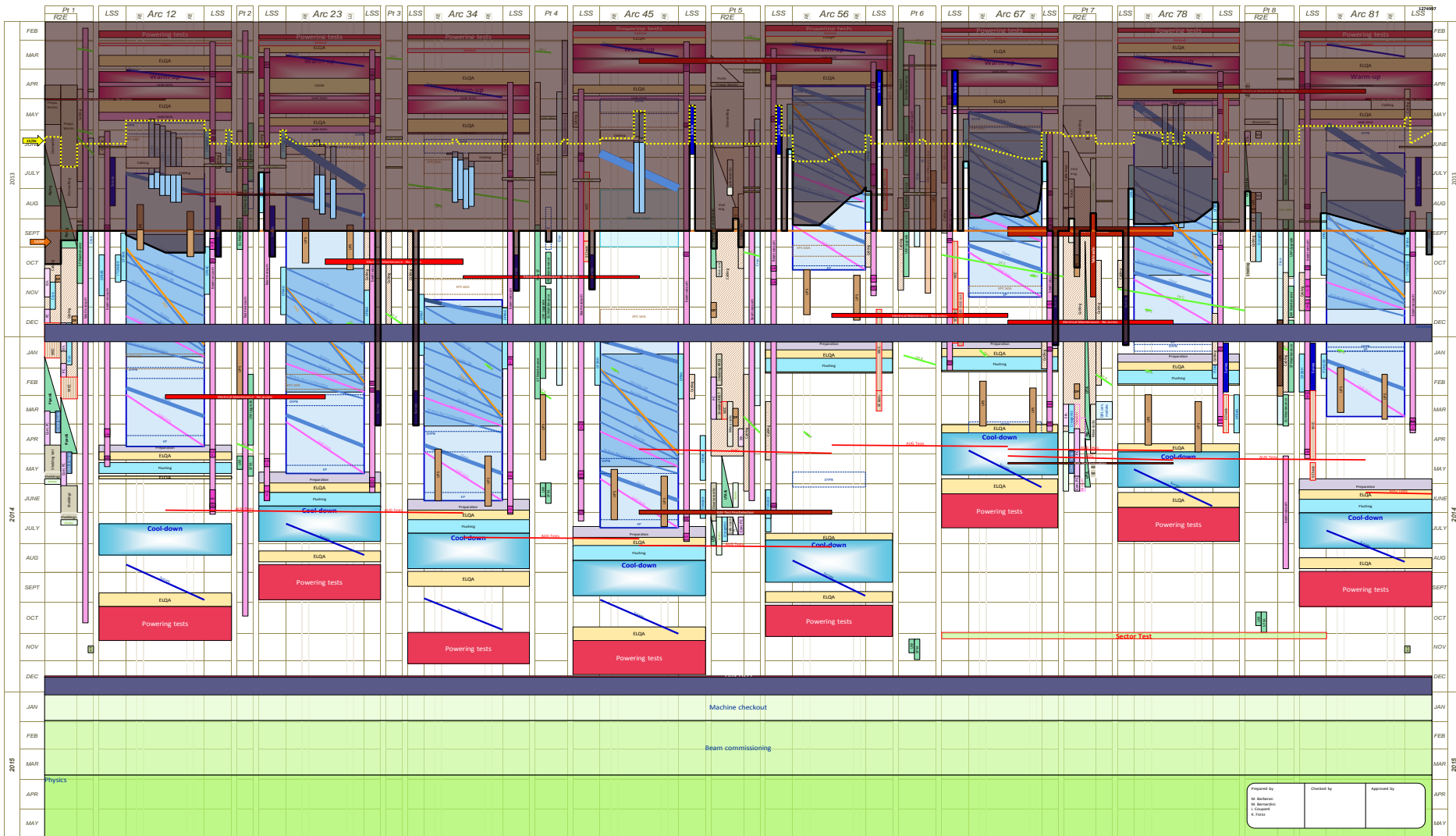
Handling & Transport



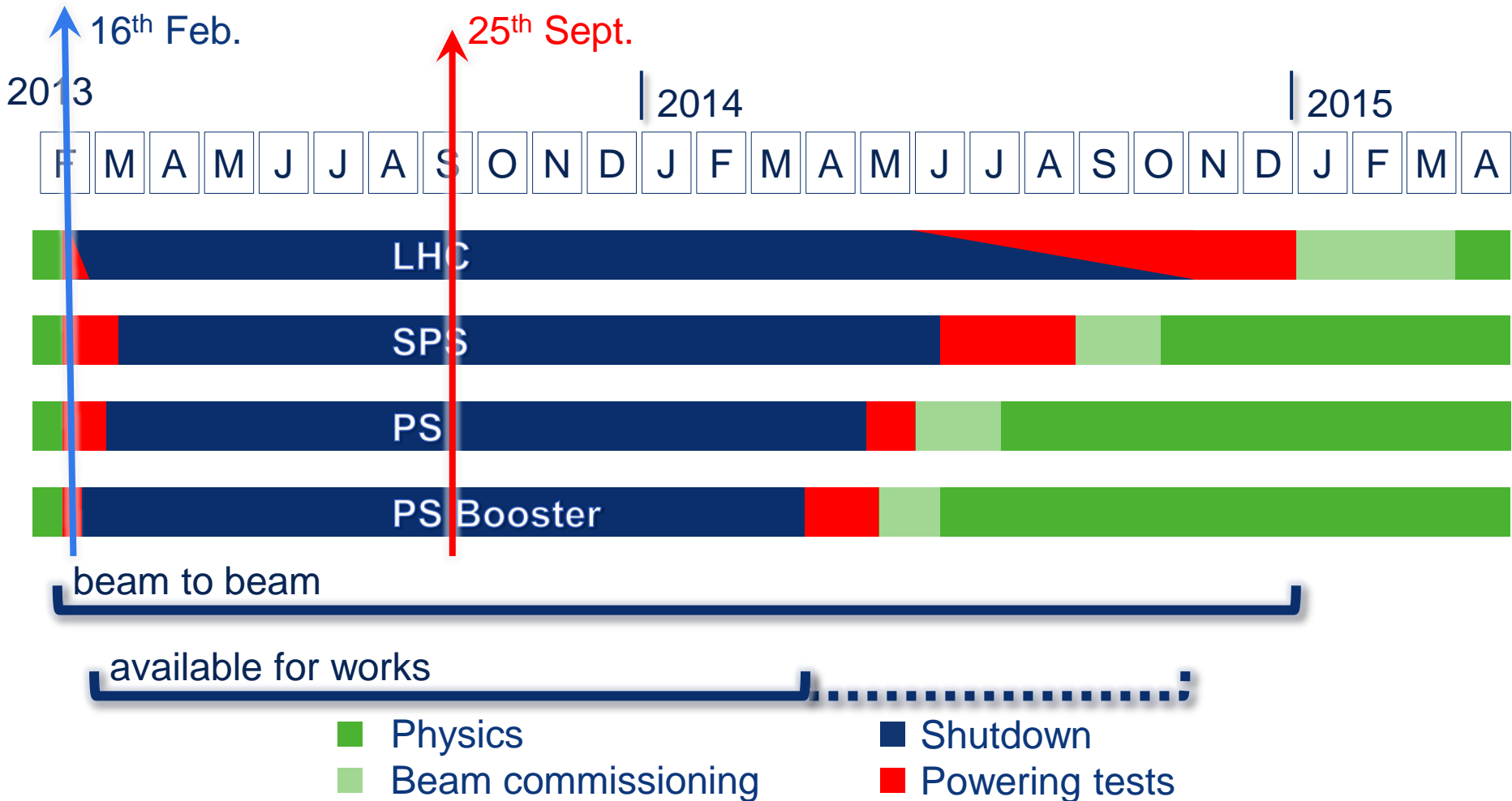
18 magnets were removed and the new ones are in place



Conclusion



LS 1 from 16th Feb. 2013 to Dec. 2014



Conclusion

**LS1 is a marathon:
Already 13km... but still 29 km to run**



Always the same slogan:

Safety > Quality > Schedule and Cost

Thanks to :

- Solid preparation and dedication of numerous persons (Collaborations, industries, staff)
- Early start gave us time for debugging and going through the learning phase

So far, LS1 is on schedule for beams:

- mid-2014 for the injectors
- January 2015 for LHC

Now :

- Some issues to be solved (DFBA and QRL compensators,...)
- Avoid routine effect

keep motivation and high level of quality



So far, LS1 is on schedule for beams
Let's stay tuned !



Bill Fontana
(Artist, Pioneer in sound art)



Thanks for your attention



www.cern.ch

Cables & Fibres

Copper Cables

- R2E & LHC cabling campaigns
- Consolidation of water-cooled cable hoses in LHC Points P8, P6 , P4left
- Consolidation of SPS irradiated cables BA1 + cabling campaigns
- Several projects on the Meyrin site

Progress	Length [km]	Number
Total	835	9368
Installed	461 (55%)	4505 (48%)

Optical Fibre Cables

- Consolidation & replacement of radiation sensitive fibres
- New SPS fibre infrastructure
- Computer centre extension
- PS, LINAC4 and many other users requests

Progress	Length [km]	Number
Total	160	500
Installed	72 (45%)	225 (45%)