



LHC Performance Workshop - Chamonix, 25-29 January, 2010

Session 2 - Magnets and Splices Consolidation Shutdown 2010/2011

Scenarios for Consolidations Intervention

Francesco Bertinelli - TE/MSC

25 January, 2010 (20 minutes)

- What is going on with splice work for 7 TeV?
- Will we need to open all interconnects for 7 TeV consolidation?
- How long will this work take?



LHC Splices Task Force: mandate

- A **Task Force** was set up in November 2009 (35th LMC, 4 Nov. 2009)
- Mandate:
 - To review the status of **all** superconducting splices in the LHC machine and prepare the necessary consolidation actions for 7 TeV operation.

In particular:

- Consider **splices over complete circuits**, within and between different equipments;
- Define electrical and structural specifications for 5 TeV and 7 TeV operation;
- Collect and consider **experience**: rationale for existing design, as-built details, HWC2008 and 2009, other Laboratories, test data;
- Develop design improvements, implementation procedures, quality control, test methods;
- Evaluate the interaction with **other systems** to be consolidated

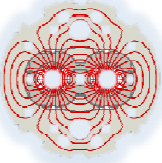


LHC Splices Task Force: membership

- **Time frame: 6-8 months starting November 2009**, so that the shutdown 2010-2011 can be adequately organized.
- Membership and specific tasks:
 - F. Bertinelli / TE-MS: Chairman, coordination
 - N. Catalan Lasheras / TE-MPE: splices overview
 - P. Fessia / TE-MS: 13kA splices
 - C. Garion / TE-VSC: LSS, structural issues, vacuum
 - S. Mathot / EN-MME: soldering alloys and process
 - A. Perin / TE-CRG: DFBs, cryogenics
 - C. Scheuerlein / TE-MS: quality and tests
 - S. Sgobba / EN-MME: metallurgy and physical issues
 - H. Ten Kate (PH/ADO)
 - J.P. Tock / TE-MS: 6 kA splices
 - A. Verweij / TE-MPE: modeling and simulations

Open invitation to interested and involved parties.

WEB site: www.cern.ch/LHCsplices



Task Force LHC Splices Consolidation

Welcome Francesco Bertinelli |

Task Force LHC Splices Consolidation

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Recycle Bin

Mandate

To review the status of all superconducting splices in the LHC machine and prepare the necessary consolidation actions for 7 TeV operation.

In particular:

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- Collect and consider experience: rationale for existing design, as-built details, HWC2008 and 2009, other Laboratories, test data;
- Develop design
- Evaluate the int

Members

- Antonio Perin
- Arjan Verweij
- Cedric Garion
- Christian Scheuerlein
- Francesco Bertinelli, Chairman

Timeframe:

6-8 months starting No

Calendar

20/01/2010 14:30	Meeting
21/01/2010 09:00	Meeting

Add new event

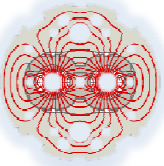
- weekly meetings, Thursdays 10h30-12h30
- many members still very busy with commissioning and MP3: **may run into time/priority problems**, hopefully not ...
- timeframe is tight ...
- **Brainstorming day** on 13 kA (21 January, 2010)
- **Management Issue:** do we want an independent review? If so, need to plan for it in time ...



Open all IC for 7 TeV consolidation of 13kA splices?

For 7 TeV operation (5 TeV is a different story ...):

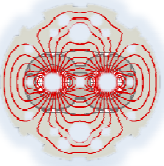
- Experience from 2008-2009 shutdown:
 - 236 splices with R16 measured (**biased sample** from segment measurements);
 - 58 redone from R16, 43 redone from visual (considerable...);
 - by considering unbiased data, ~15% splices would need redoing from R16 alone;
 - but segment measurements cannot identify them precisely enough (for MQ in particular), plus need to open all M sleeves for a given segment, estimate ~90% of sleeves;
 - if in addition we consider repairs from visual and preference towards systematically adding a shunt/clamp, we conclude:
- **Open all W interconnects and cut open all M sleeves, make local R16 measurement, redo ~20% splices, add shunt to 100% splices**



Additional magnets/splices work

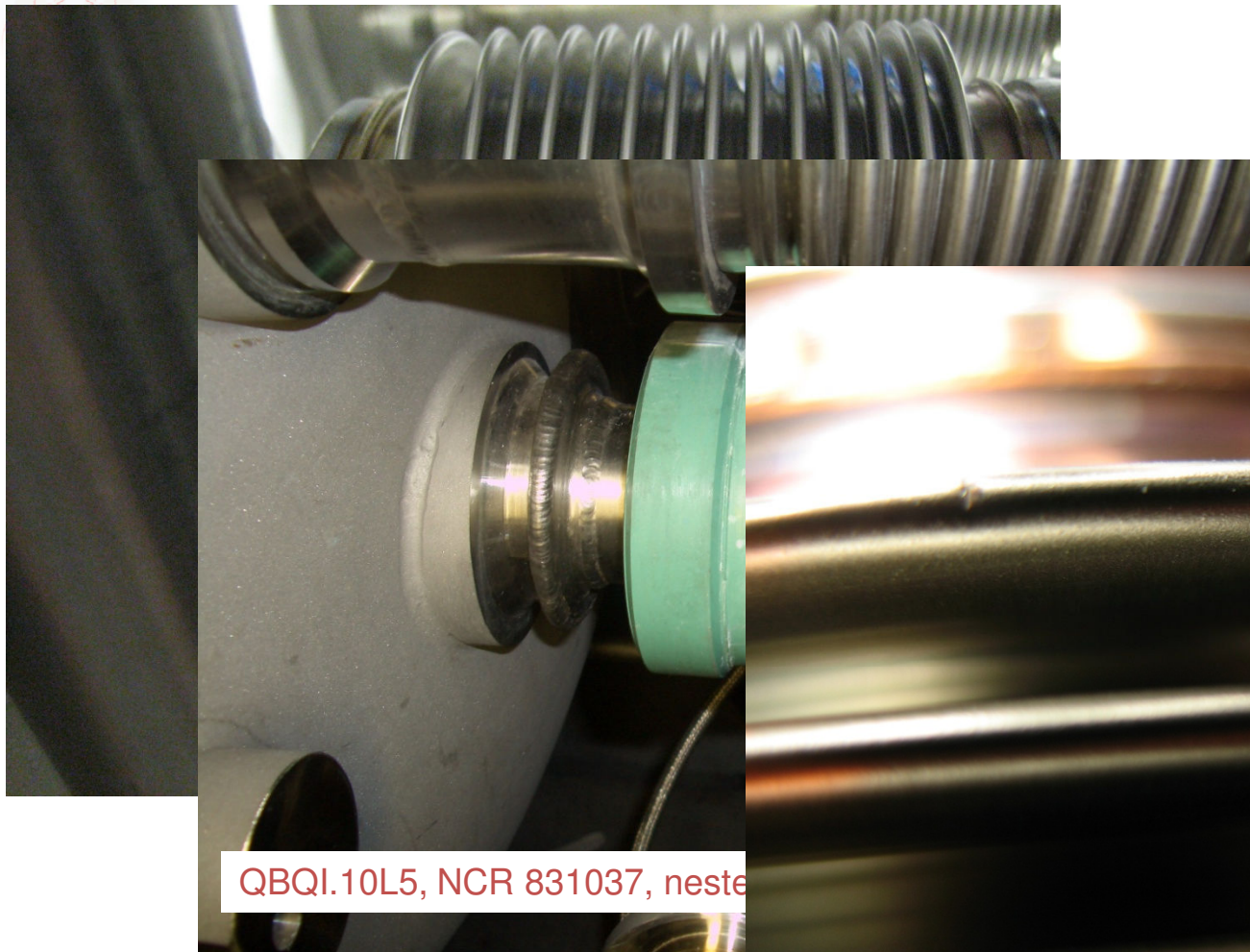
DN200 (arc pressure relief nozzles)	7-8, 8-1, 2-3, 4-5 (partly)
“Single event” splices for 5 TeV (warm)	~10 MB segments above 35μΩ, but MQ?
“Single event” splices for 5 TeV (cold)	~5 segments above 1-2nΩ
Connection cryostats	7-8, 8-1, 2-3, 4-5
Vacuum leaks	3-4, others?
N line connections to check	7-8
6kA praying hands to check	7-8
Spool connections	
Replace magnet bellows, S	10L5
Y-lines	7-8, 8-1, others?
Damaged radiation/thermal screens	All sectors
PIMs	RF ball test, a few preventive replacements, no global replacements?
...	35 NCR, “closed with warning”, HWC cases

➤ a considerable amount of non-standard work !!!

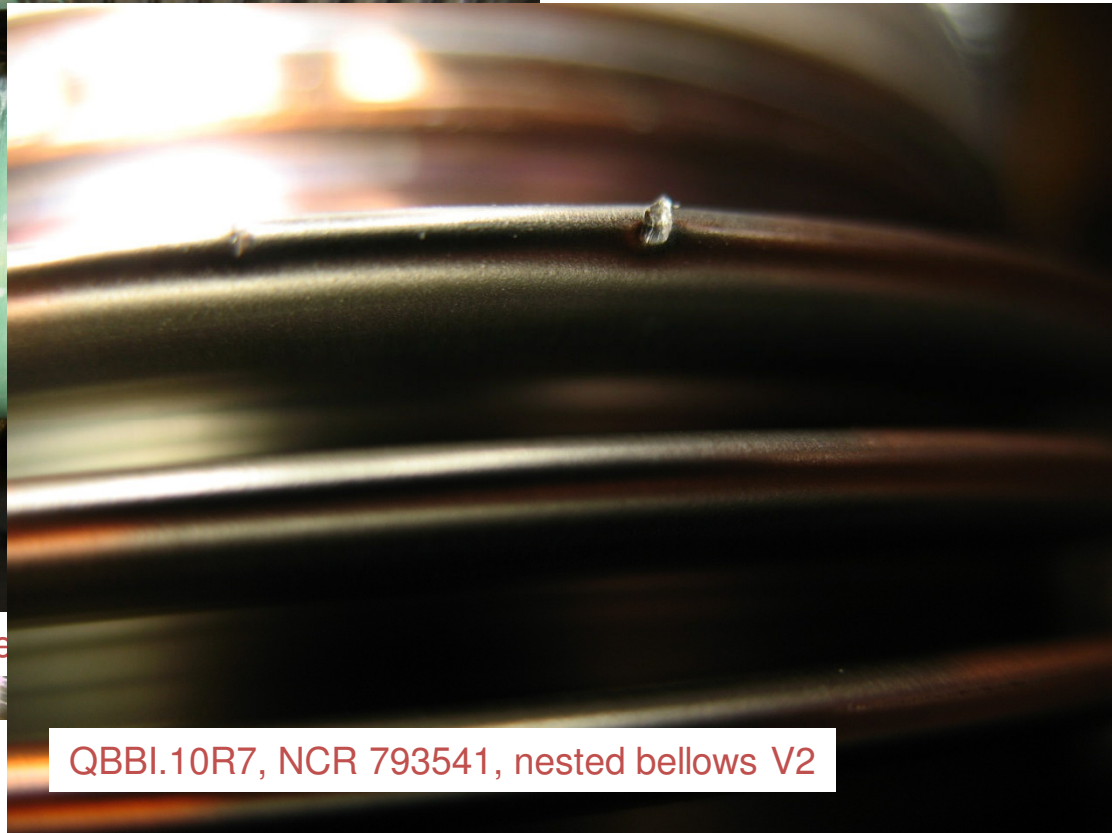


Need to replace magnets?

Don't forget cases of
"closed with warning"



QBQI.10L5, NCR 831037, nested



QBBI.10R7, NCR 793541, nested bellows V2



So how long will a shutdown take?

The size of this new task **compares to series production**:

- will not require some activities (e.g. jumpers, N-line) ...
- but will require to « undo » before « redoing » (e.g. cut welds, desolder): **repair ≠ new**
- on the good side: all magnets are in place (except if ...)

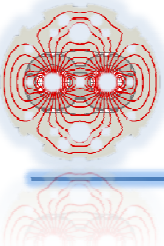
Resources used in IC series production:

- IEG (Main Contractor) ~100 workers
- activities were organised for 40 IC/week
- CERN ~100 workers for coordination, QC (including ELQA and VAC), troubleshooting, special activities
- 2.5-3 years

Resources used in 2008-09 IC shutdown:

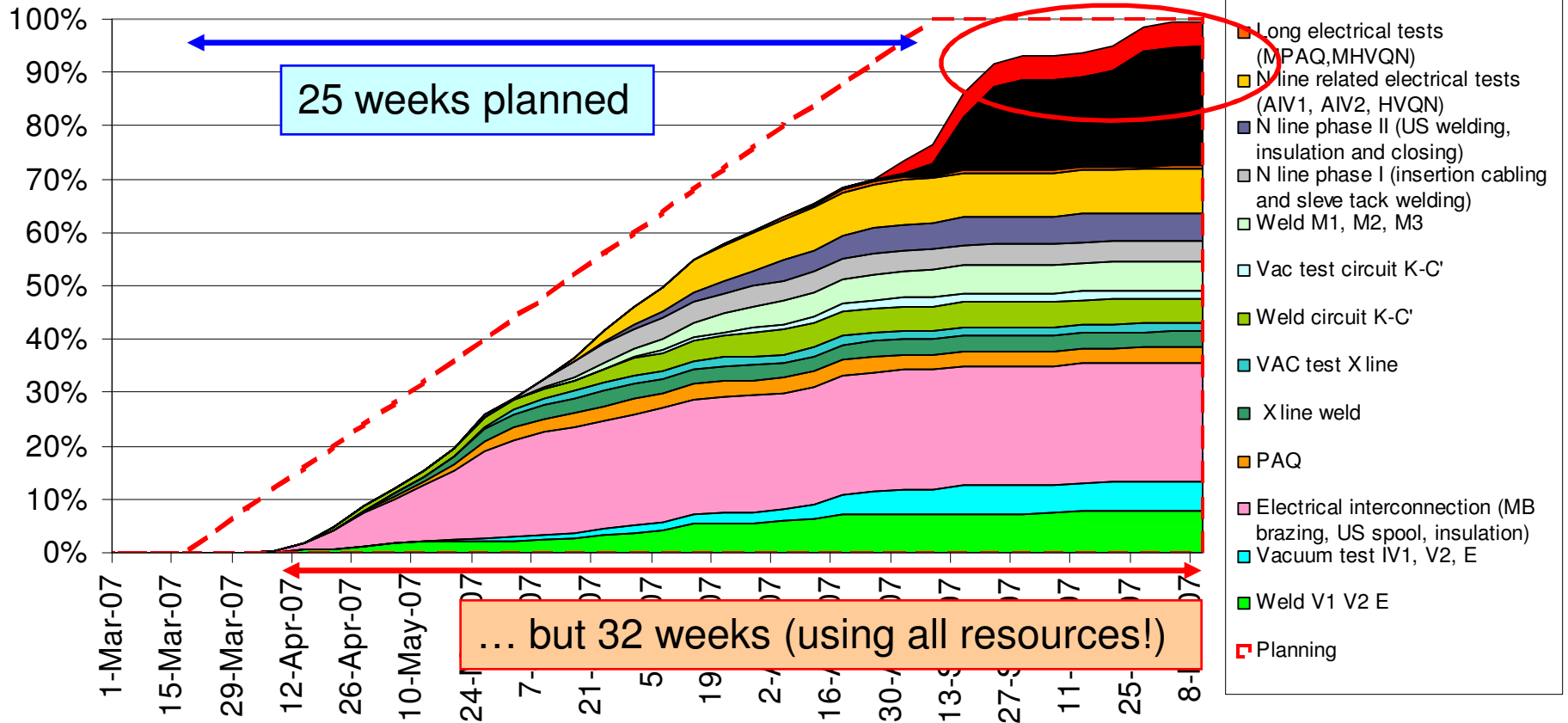
- CERN ~100 workers

Series experience: 1-2, the last sector



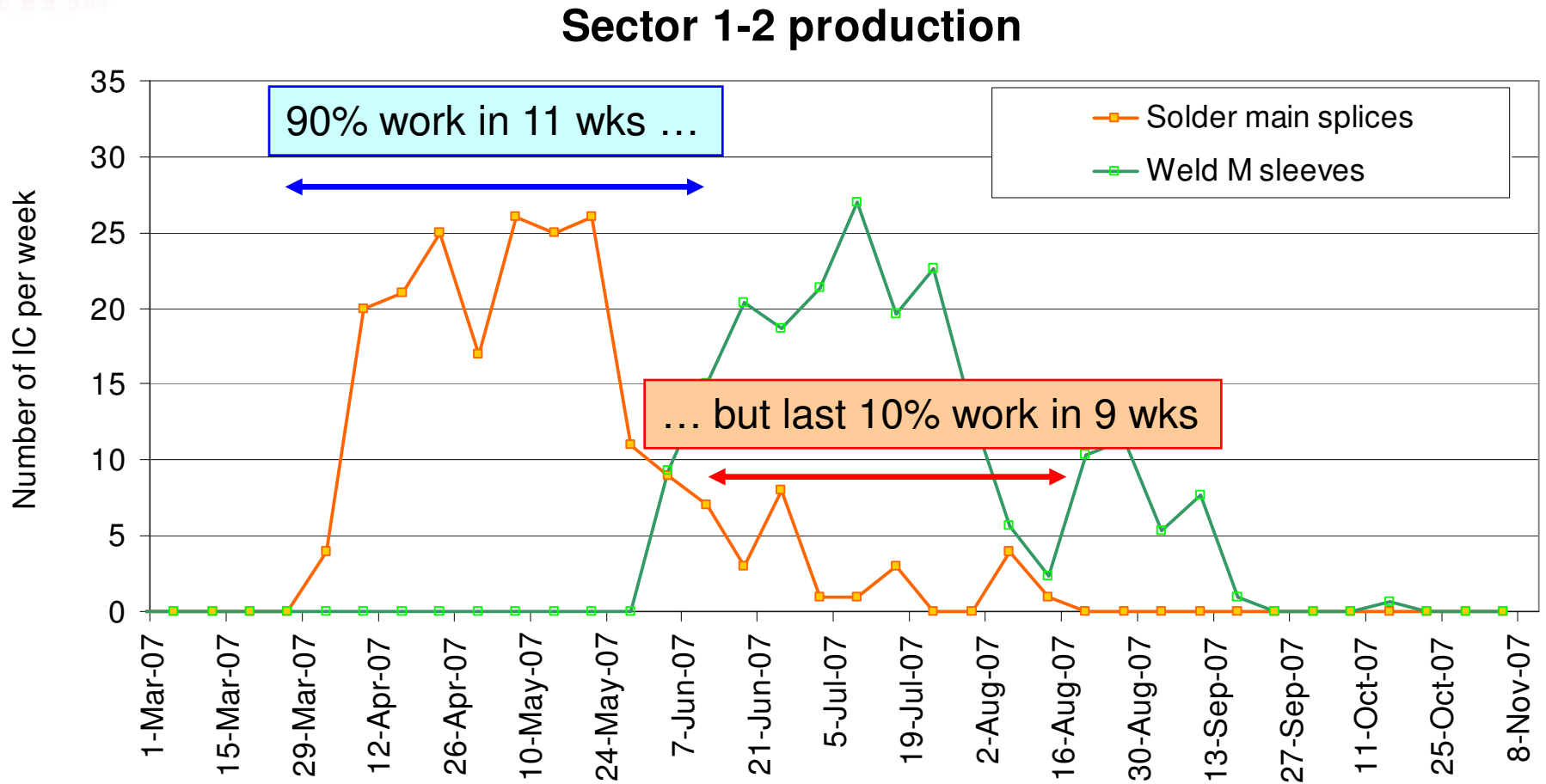
Sector 1-2 work progress

The Killer: the last 10%



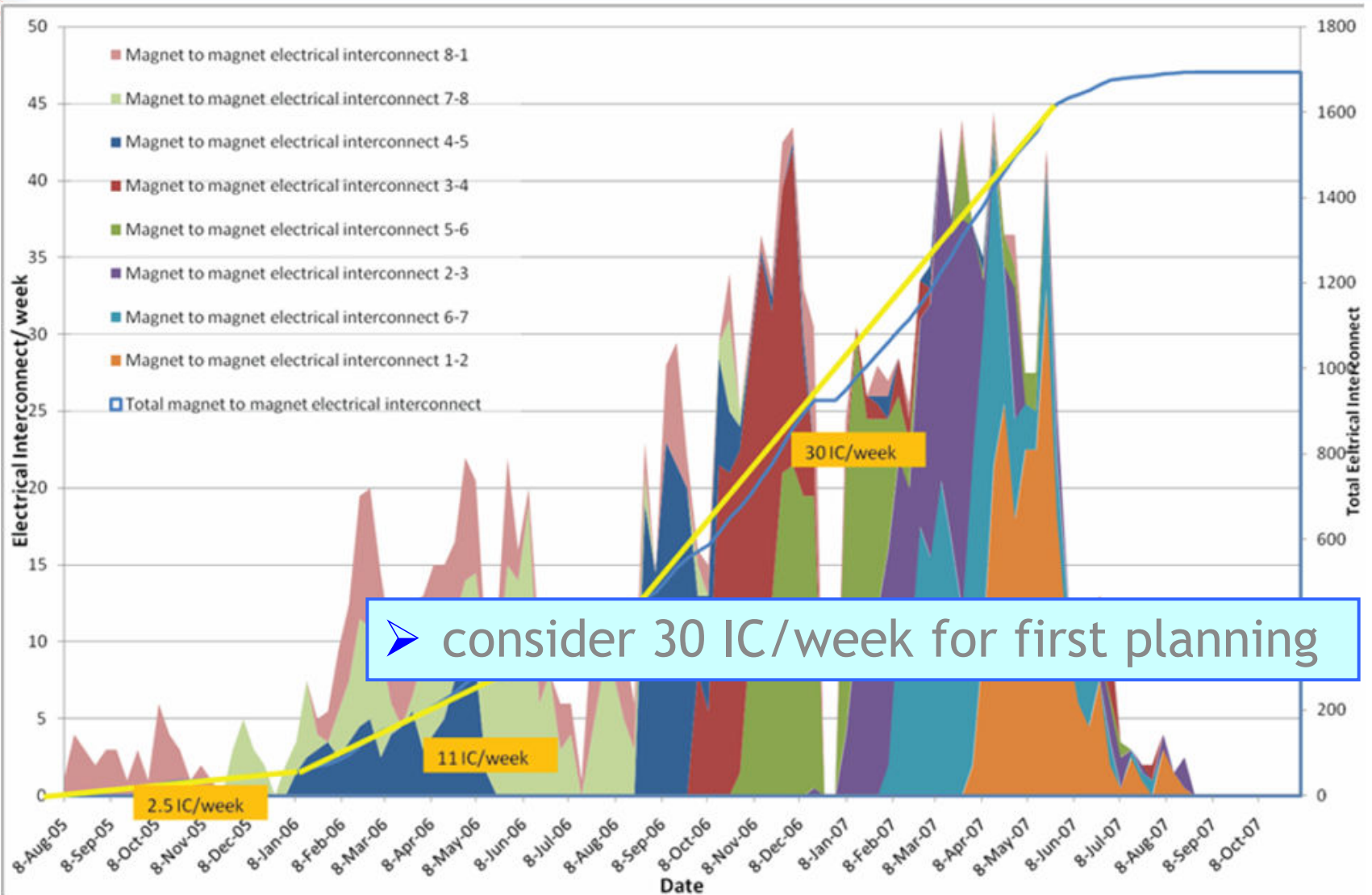
Courtesy P. Fessia

Series experience: soldering busbars

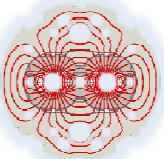


Courtesy P. Fessia

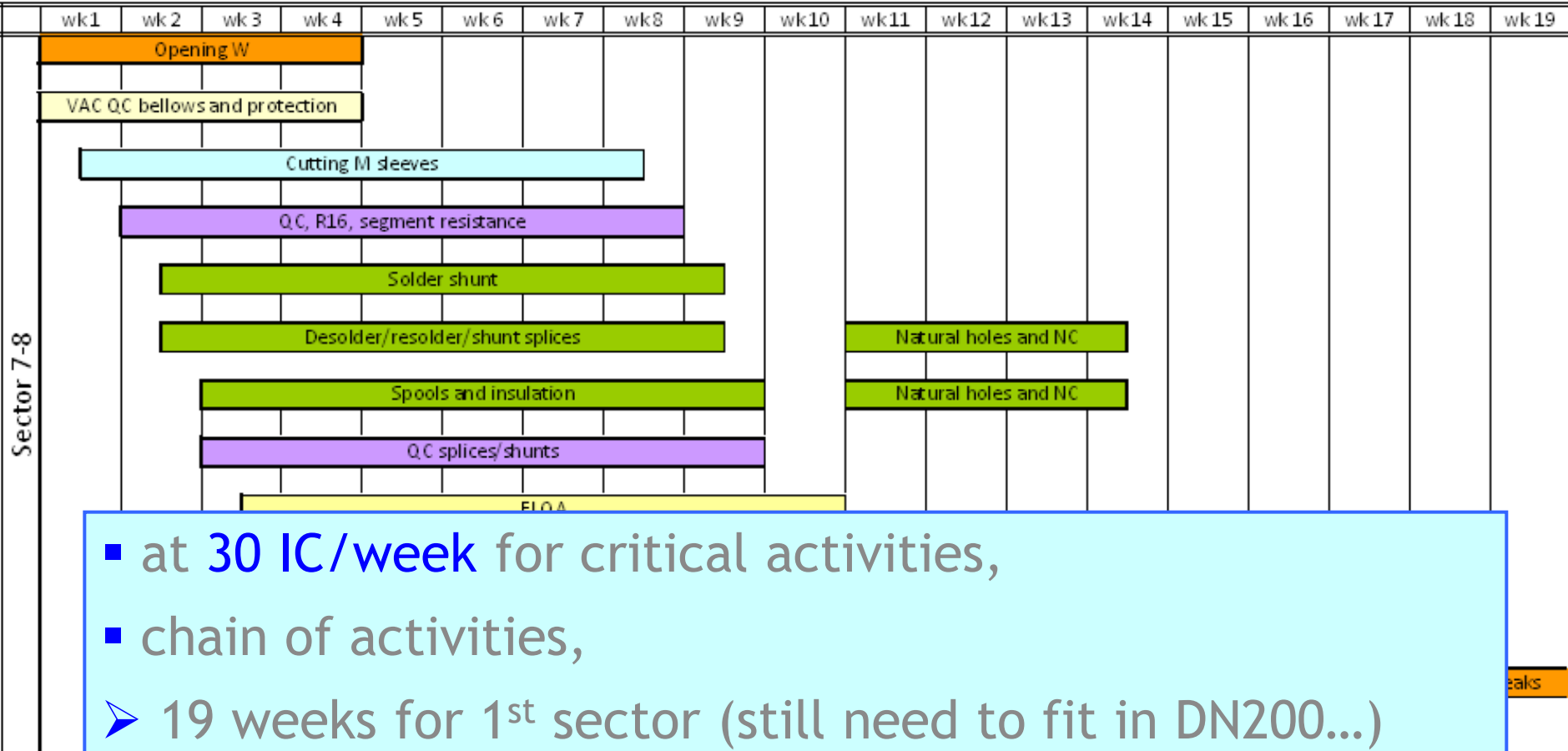
Series soldering: all sectors



Courtesy P. Fessia



Length of shutdown: estimate 1, @30 IC/week



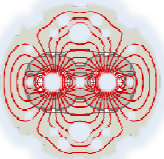
- at 30 IC/week for critical activities,
- chain of activities,
 - 19 weeks for 1st sector (still need to fit in DN200...)
 - 9 weeks later for 2nd sector ...

Estimate of IC resources needed

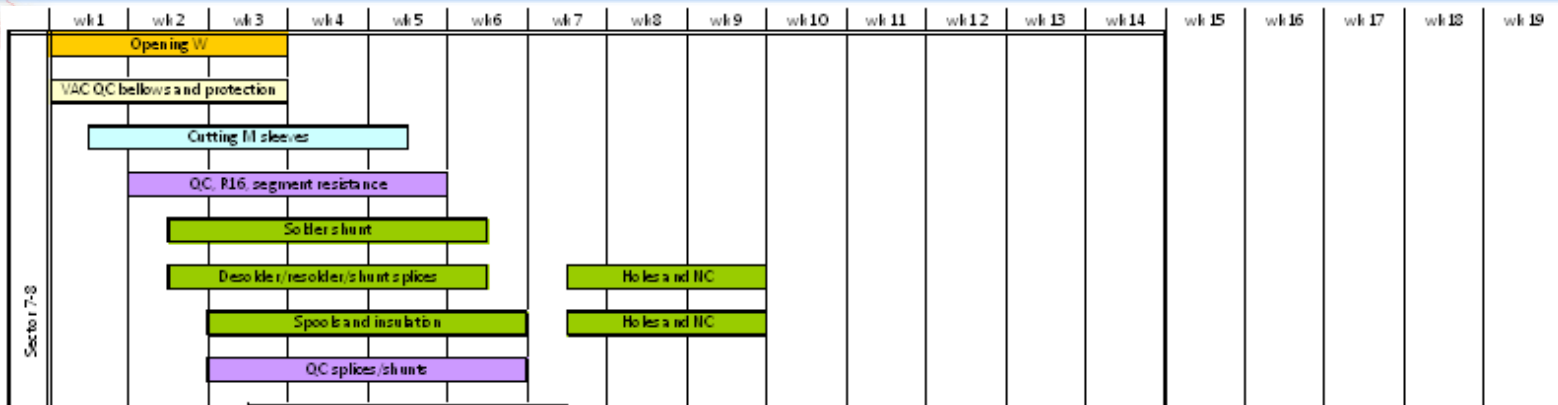
Activity	Quantity	Existing at CERN	To come in addition	Comments
Opening W	100%	0	12	FSUs as in 2008-09
VAC QC bellows and protection	100%	2	2	
Cutting M bellows	100%	6	5	1 Team Leader, 7 mechanics cutting, 2 bellows

- to work on 1 “IC train” (but coordinate 2-3 sectors at the same time),
- **100 persons** needed,
- of which ~ 40-45 are present (at CERN) with skills and experience,
- ~60 need to be integrated in addition (as in 2008-2009), e.g. FSUs, collaborations
- **beware the risk** of excessive parallelism (QC, supervision, coordination)
- remember the “last 10% effect”

Note: impact of this work on magnet repair/rebuilding, triplet project,...
May prefer to introduce additional resources earlier (now?).



Length of shutdown: estimate 2, @50 IC/week



- at 50 IC/week (!!!) for critical activities,
- with a better understanding of work (tooling, methods ...)
- 14 weeks for 1st sector
- 5 weeks later for 2nd sector ...
- still need to fit DN200s and **additional work** but assume (!!!) this can be done in parallel
- consider this for shutdown scenarios



Some shutdown scenarios @50 IC/week

	1 st sector	Last sector	Comments
All sectors	14 weeks	49 weeks	1 shutdown, no physics in 2011
4 sectors 7-8, 8-1			
2 sectors 7-8, 8-1			work, r?
...			

- To get the full picture need to include:
 - Physics time (specifically for 2011),
 - Radioprotection/ALARA principles,
 - Risk of this IC work:
 - Time taken,
 - Number of new resources introduced,
 - Amount of parallelism
 - Additional IC work (specifically for 5 TeV)



Conclusions i/ii

- ✓ What is going on with splice work for 7 TeV?
 - **Task Force** set up and working
 - time frame June-July 2010 for a tested 13kA solution to adequately prepare for shutdown 2010-11
- ✓ Will we need to open all interconnects for 13kA splices?
 - **Yes:**
 - not because all splices cannot hold 13kA, but ...
 - because we do not know how to localise those that do require intervention, and ...
 - because we favour the redundancy and long-term safety of an additional shunt for all splices



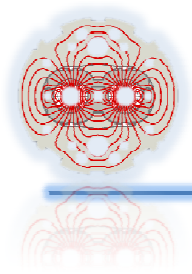
Conclusions ii/ii

✓ How long will the 7 TeV consolidation take?

- very preliminary considerations,
- first, different scenarios discussed

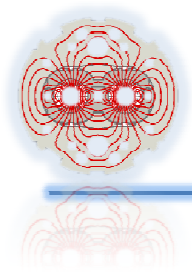
My (personal) favoured scenario today:

- 2 sectors, combined with additional work on all sectors for 5 TeV (should we know where to intervene ...)
- 100 persons, “pushing” to activity work at 50 IC/week
- 19 weeks, ⇒ **January to May 2011**
- full testing at 13kA on 2 sectors (7-8, 8-1) before continuing this work further
- Bias towards: physics in 2011/large amount of non-splice work that will be requested for 5 TeV/IC risks.



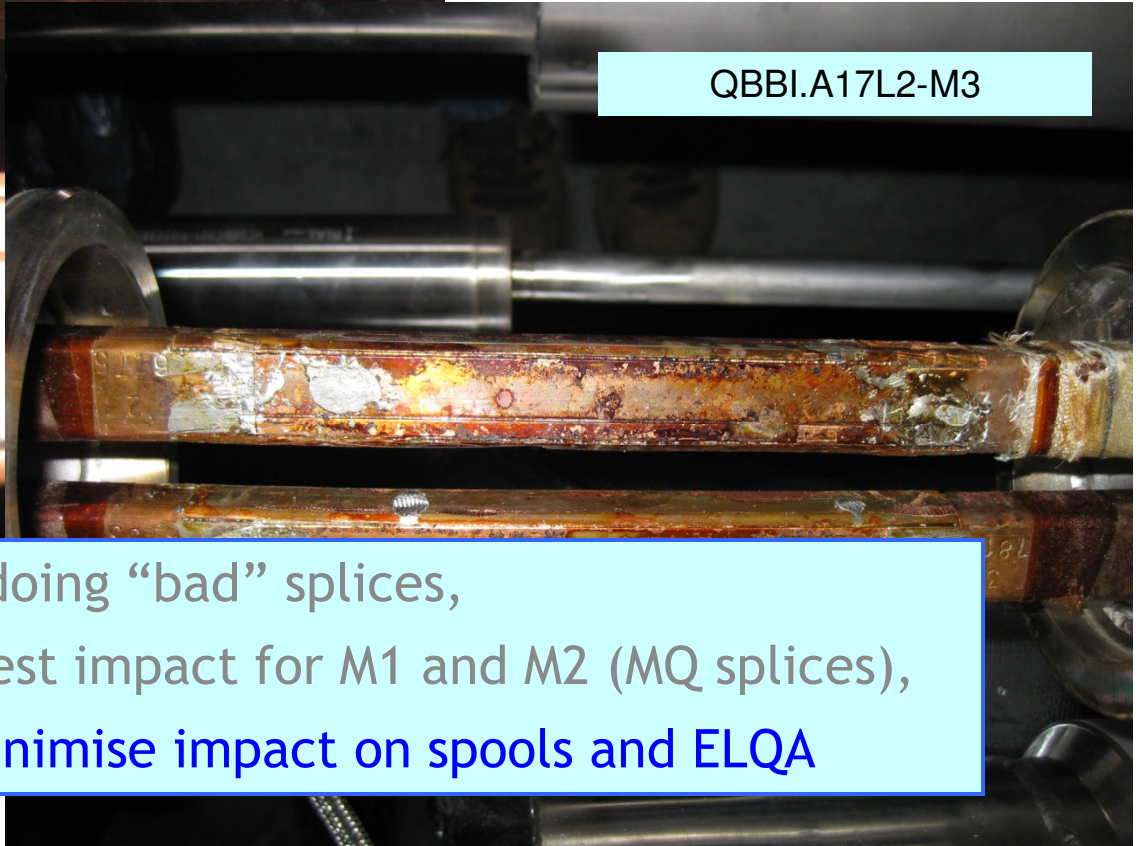
Thanks for your attention

Acknowledgement: work, discussions, experience of Interconnections Teams, LHC Splices Task Force and many others



Supporting slides

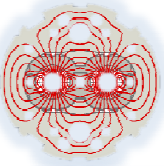
Why redo 20% splices?



QBE

- I recommend redoing “bad” splices,
- this has the largest impact for M1 and M2 (MQ splices),
- study how to minimise impact on spools and ELQA

Courtesy C. Scheuerlein



PIMs?

	1-2	4-5		5-6	6-7
	2008-2009	March 2008	2008-2009	2008-2009	2008-2009
QQB	2: 19L2 (V2), 18L2 (V2)	12*: 12L5 (V1), 28L5 (V1&2), 32L5 (V1&2), 34L5 (V1), 32R4 (V1&2), 30R4 (V1), 26R4 (V2), 21R4 (V1), 16R4 (V2)	0	3: 24R5 (V1), 25R5 (V1), 29R5 (V2)	0
QBQ	1: 18L2 (V2)	0	0	0	1: 32L7 (V1)
QBB	0	0	0	0	0

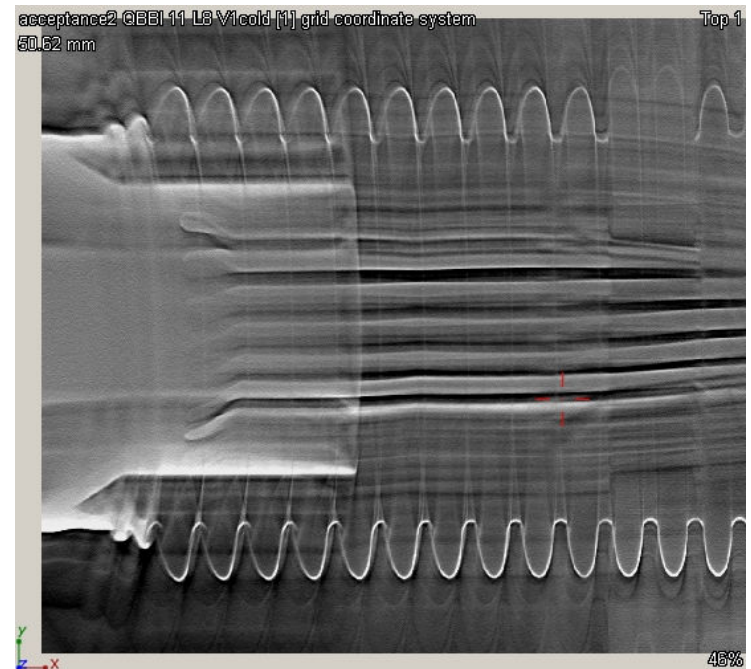
Courtesy C. Garion

*: before SSS displacement

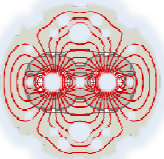
My thinking:

- number of buckled RF fingers is minimal;
- flanges are delicate w.r.t. inclusions, hence stresses from welding;
- the tomograph will help;
- do not embark in a systematic PIM replacement campaign

... but of course will speak with VAC

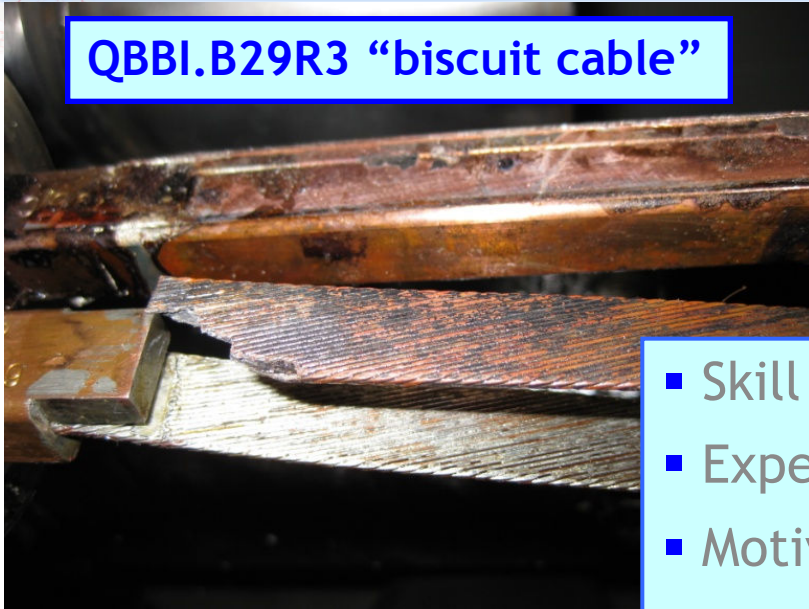


Courtesy L. Williams, A. Musso, JM Dalin



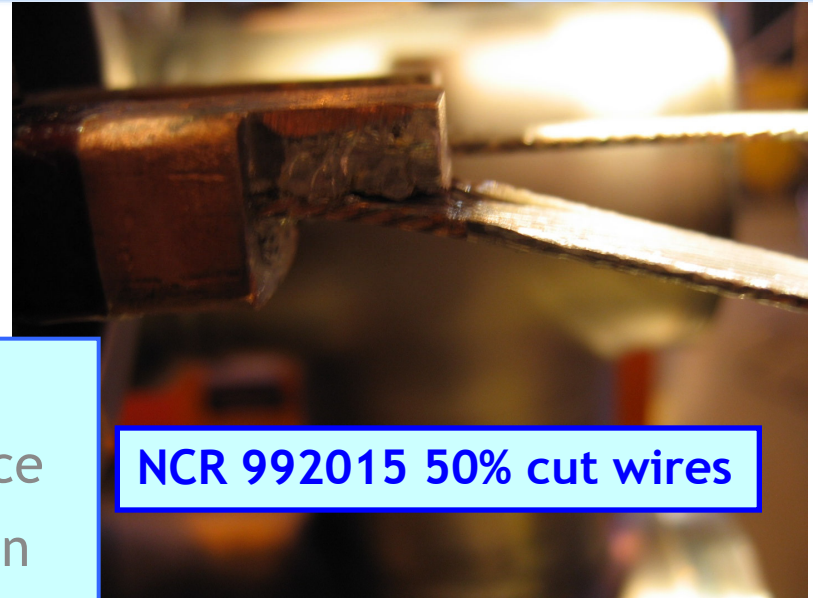
Where skills and experience really count

QBBI.B29R3 "biscuit cable"



- Skill
- Experience
- Motivation
- Courage

NCR 992015 50% cut wires



NCR 990852 cut wire



24 July, 2009: 6-7 MLI fire





Beware of too fast ...

5.4 Speed of work

In the 300 K sectors 1-2, 3-4, 4-5, 5-6 and 6-7 we estimated the mean amount of work made per day and per team thanks to the date of welding: **12.2 splices/day**. As for the bad splices observed with R16 measurements, the ratio is 30% higher: **15.9 splices/day**. Hence a potential guideline for future work is to be attentive to the negative effect of high production speed on quality.

**ANALYSIS OF 13 kA MAGNET INTERCONNECTION SPLICE
QUALITY WITH RESPECT TO PRODUCTION TRACEABILITY**

F. Bertinelli, C. Lorin, E. Todesco / TE Department
Internal Note 2009-11

