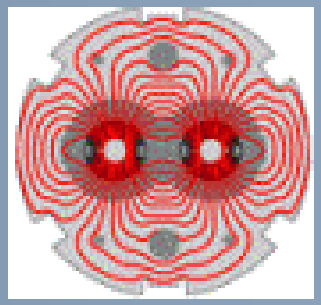
Scope and results of hardware commissioning to 3.5 TeV and lessons learnt

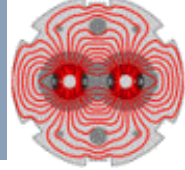


Preconditions for operating at 5 TeV in 2010

Session 1 - 25th January 2010

M.Solfaroli BE/OP

Contents



- Commissioning to 1.18TeV
  - Efficiency
  - 2008/2009
  - Lesson learnt
  - Where can we still improve?
- Commissioning to 3.5TeV
  - Situation
  - Planning (where are we?)
- NCs

Given the scope of the investigation, the outcome is not designed to just prove the success or failure, but rather to establish a way for yet better performance

1.18 TeV

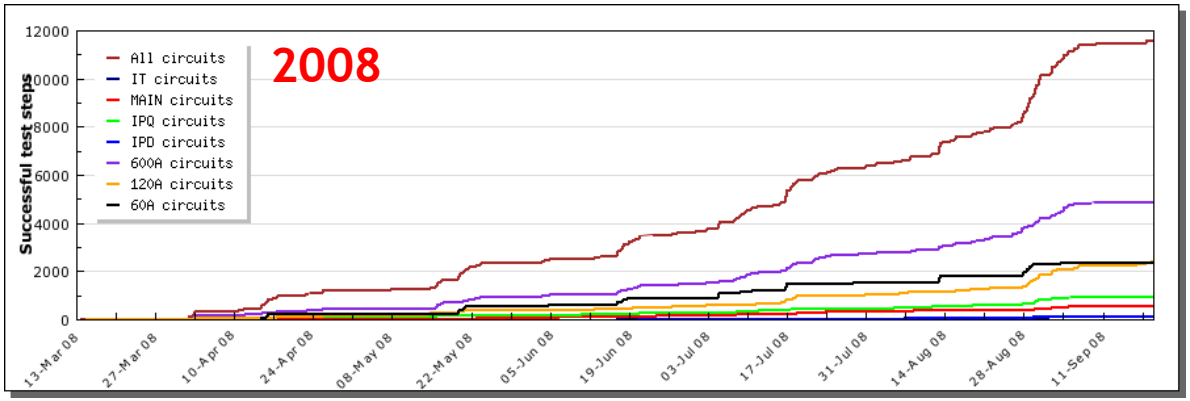
EFFICIENCY: Ability to accomplish a job with a minimum amount of time and effort

01/04/08
10/09/08

164 days

121*MA (2)
3*MAN (3)

251 shifts

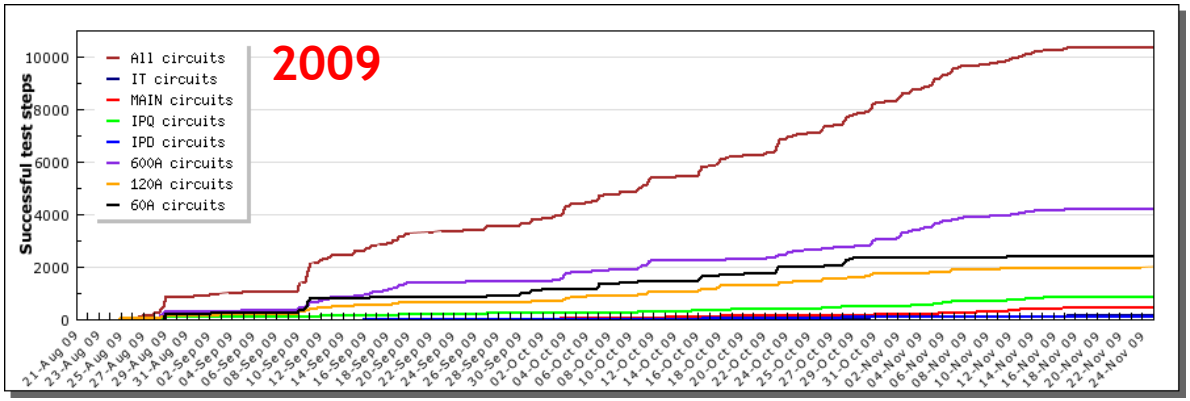


21/08/09
18/11/09

89 days

33*MA (2)
52*MAN (3)

222 shifts

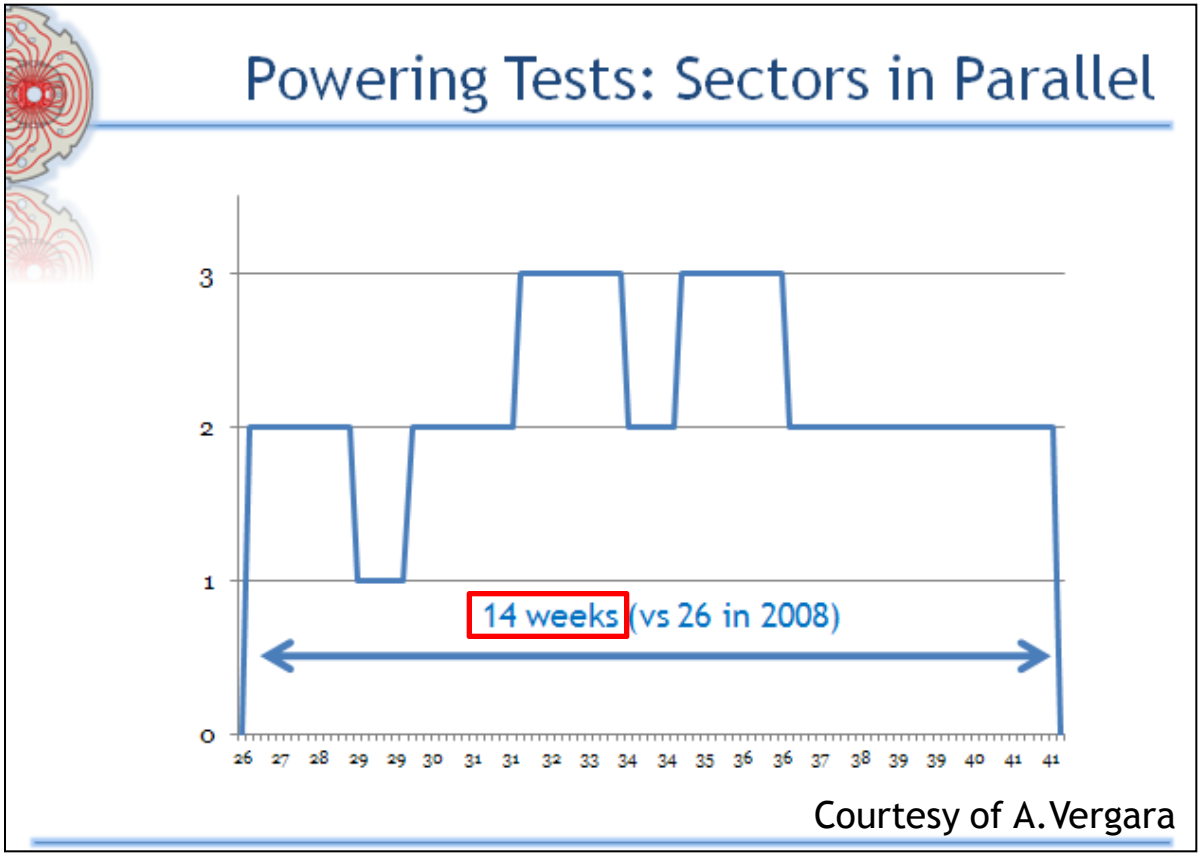


29 shifts and 74 days less…

…resulting in 88% of shiftwork, but almost half of daytime (54%)!!

1.18 TeV

2009 HW Commissioning day - 19th March 2009

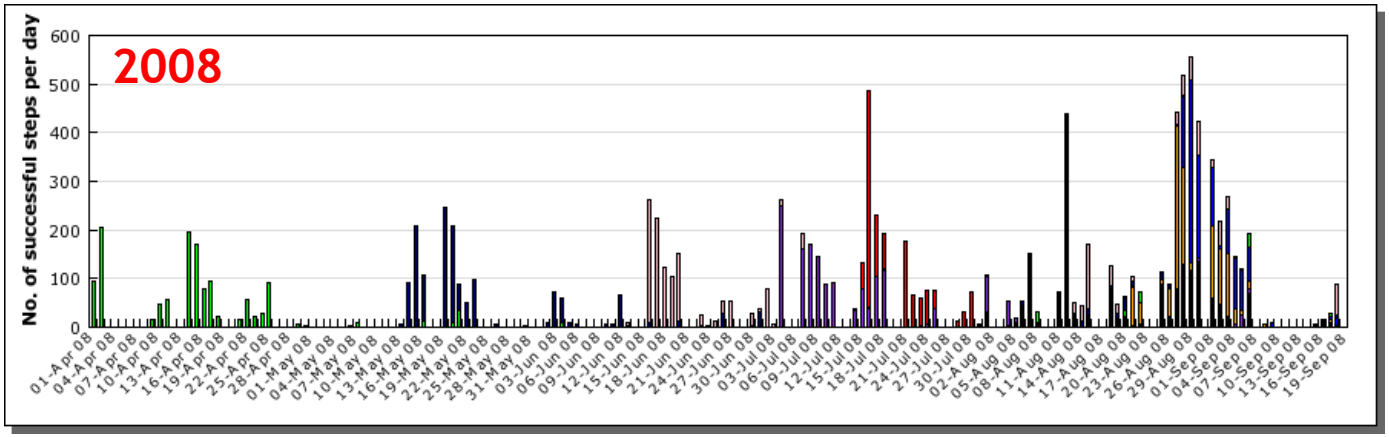


14 weeks * 7 days/week = 98 days (we actually did it in 89!!)

1.18 TeV

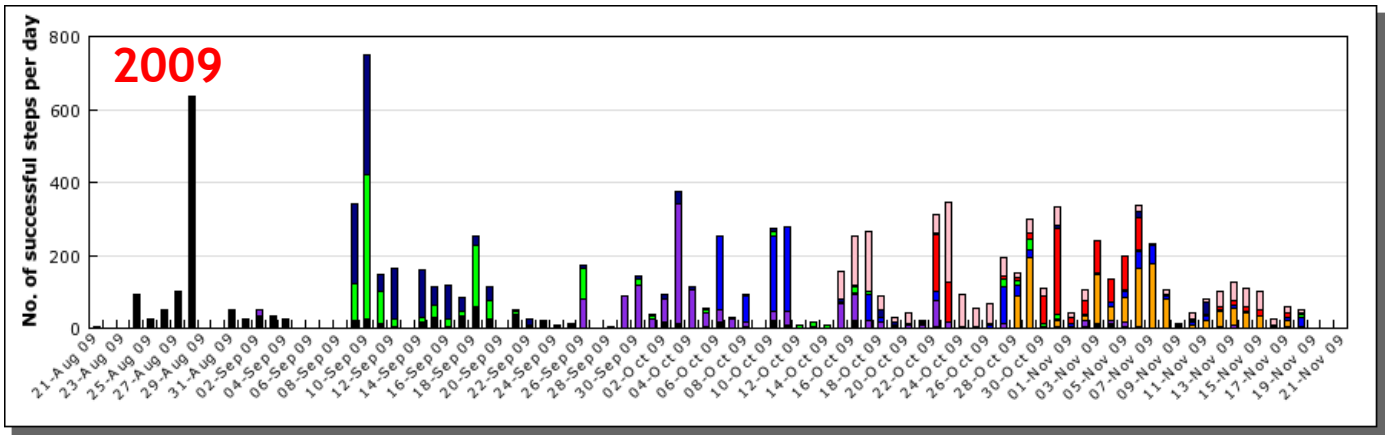
43 days per sector

19 days the fastest one



32 days per sector

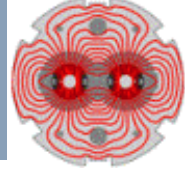
16 days the fastest one



1.18 TeV

…but, all that glitters is not gold!!

1.18 TeV

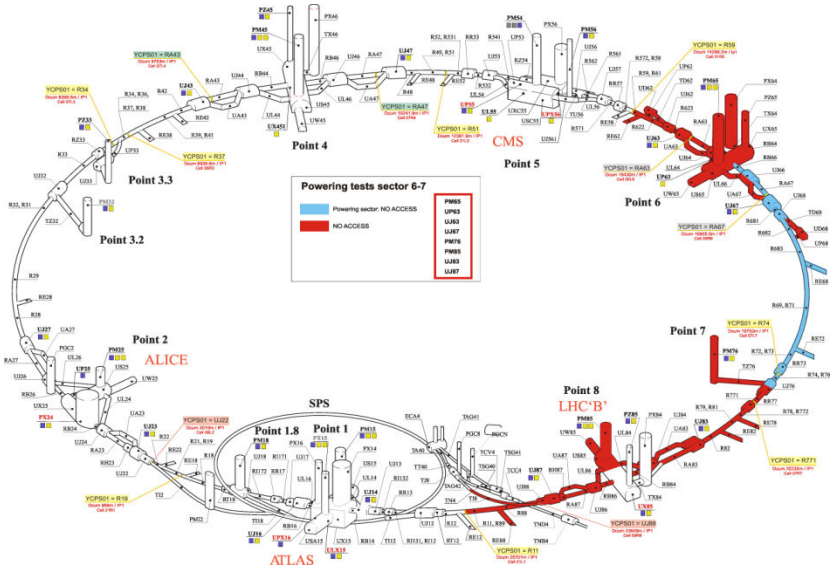


- Many factors/strategies helped to reduce the time:
  - More automated and powerful SW tools
  - Many circuits had been already commissioned in 2008 (few (~4%) less test steps to be performed)
  - Energy level reduced to 1.18TeV for RB, RQD/F
  - Energy level reduced to 3.5TeV for IPQs, IPDs
  - Nominal current lowered after 2-3 training quenches for 600A circuits (compatibly with the requirements for 3.5 TeV (actually commissioned to 5 TeV))
  - Rationalization of the operational parameters for the 600 A circuits based on the 2008 experience
  - Increased stability of cryogenic system

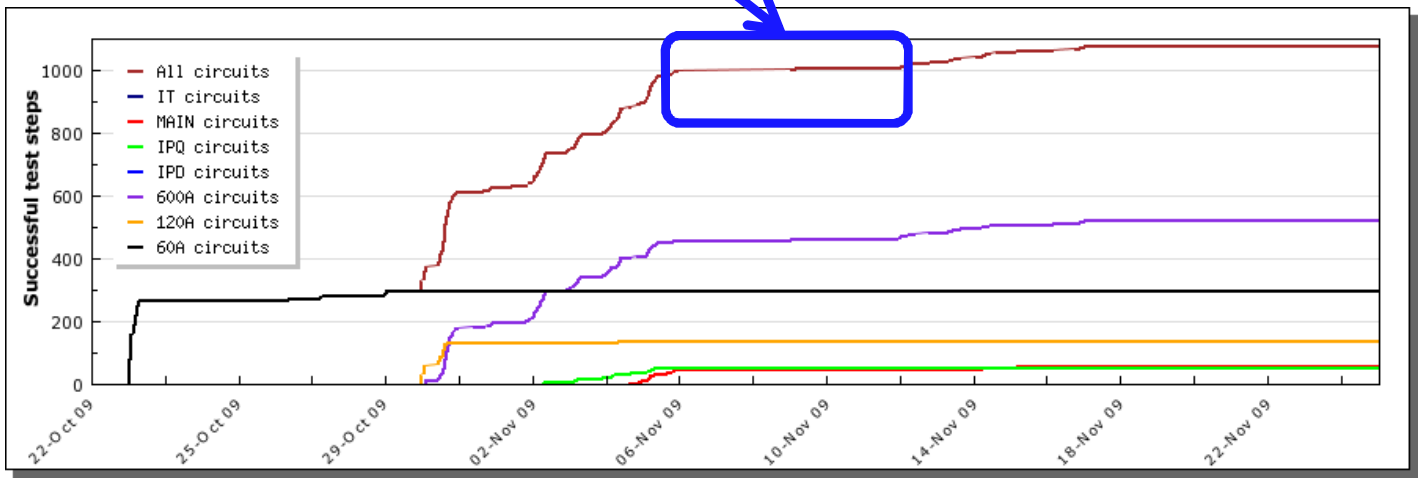
- Some factors increased the time:
  - A new system to be partially commissioned
  - More complex procedures for the RB, RQD/F circuits
  - More constraints in safety measures (no high current powering test even while working in the adjacent sectors)

1.18 TeV

Safety rules enforcement



Powering test in Sector 67



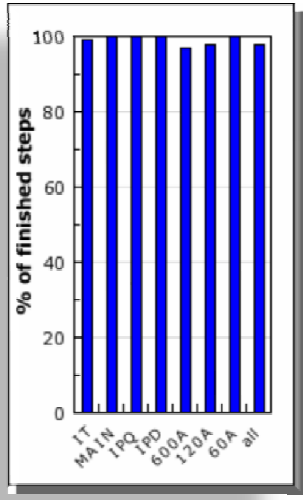
1.18 TeV

EFFICIENCY

Number of successful test steps over total number of executed test steps

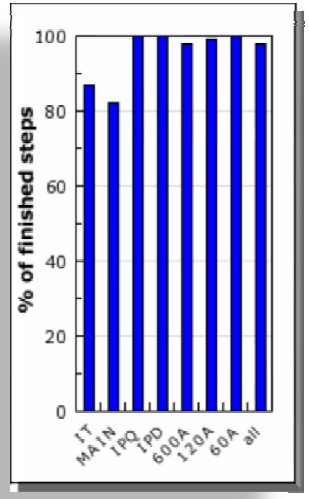
2008
- 15532 tests done
- 12666 tests successful

81.54%

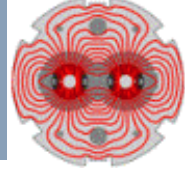


2009
- 13611 tests done
- 11175 tests successful

82.10%



1.18 TeV



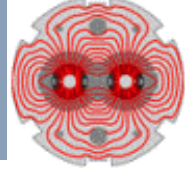
in spite of everything the total time for the commissioning globally dropped from 164 to 89 days!!

We want to do it better, then the question is:

How can this number be further reduced?

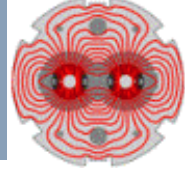
- 1 - By reducing the number of tests to be executed (depending on the circuit history)

1.18 TeV



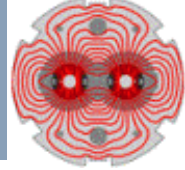
	S12	S23	S34	S45	S56	S67	S78	S81
wk 32	cool-down							
wk 33						cool-down	cool-down	
wk 34	ElQA	cool-down						
wk 35	PT						ElQA	cool-down
wk 36			cool-down	ElQA			PT	
wk 37				PT	cool-down			
wk 38	beam operation							
wk 39				beam operation		ElQA	beam operation	
wk 40		ElQA				PT		
wk 41		PT						ElQA
wk 42			ElQA					PT
wk 43			PT		ElQA	beam operation		
wk 44		beam operation			PT			
wk 45								beam operation
wk 46			beam					
wk 47	Cold Check-out							

1.18 TeV



	S12	S23	S34	S45	S56	S67	S78	S81
wk 32	cool-down			cool-down			cool-down	
wk 33						cool-down		
wk 34	ElQA	cool-down					ElQA	cool-down
wk 35	PT						PT	
wk 36	beam operation		cool-down	ElQA			beam operation	
wk 37				PT	cool-down			
wk 38				beam operation				
wk 39						ElQA		
wk 40		ElQA				PT		ElQA
wk 41		PT				beam operation		PT
wk 42		beam operation	ElQA					beam operation
wk 43			PT		ElQA			
wk 44			beam operation		PT			
wk 45					beam operation			
wk 46	2 weeks							
wk 47	Cold Check-out							

1.18 TeV



in spite of everything the total time for the commissioning globally dropped from 164 to 89 days!!

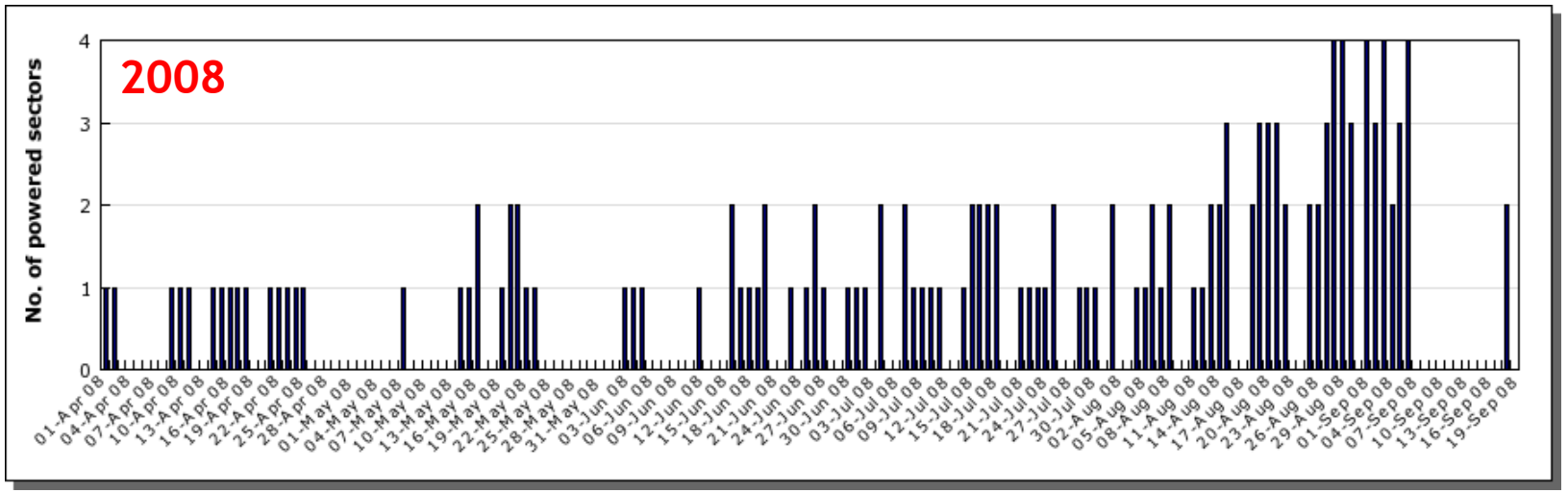
We want to do it better, then the question is:

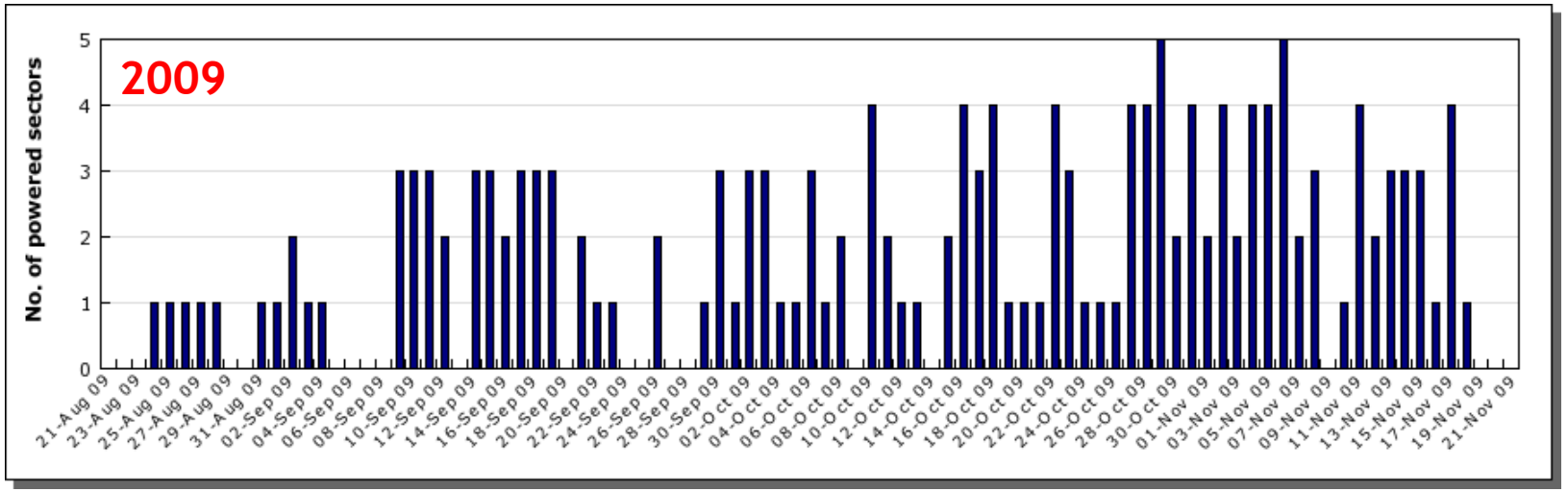
How can this number be further reduced?

- 1 - By reducing the number of tests to be executed (depending on the circuit history)
- 2 - By increasing the number of sectors to be commissioned in parallel

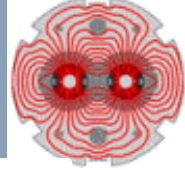
1.18 TeV

Number of sector powered per day





1.18 TeV



	S12	S23	S34	S45	S56	S67	S78	S81
wk 32	cool-down			cool-down				
wk 33		cool-down				cool-down	cool-down	
wk 34	ElQA							
wk 35	PT					cool-down	ElQA	
wk 36				ElQA			PT	cool-down
wk 37				PT				
wk 38	beam operation		cool-down		cool-down			
wk 39		ElQA				ElQA	beam operation	
wk 40		PT		beam operation		PT		
wk 41								ElQA
wk 42			ElQA					PT
wk 43		beam operation	PT		ElQA	beam operation		
wk 44					PT			
wk 45								beam operation
wk 46			beam					
wk 47	Cold Check-out							

3Wks

1.18 TeV

We have to take into account that as now:

• ElQA cannot be performed in parallel due to resources problem

• Between 300-80K the cool-down cannot be carried out in parallel because of nitrogen delivery

	S12	S23	S34	S45	S56	S67	S78	S81
wk 32	cool-down	cool-down	cool-down	cool-down	cool-down	cool-down	cool-down	cool-down
wk 33								
wk 34								
wk 35								
wk 36								
wk 37								
wk 38	ElQA	ElQA	ElQA	ElQA	ElQA	ElQA	ElQA	ElQA
wk 39	PT	PT	PT	PT	PT	PT	PT	PT
wk 40								
wk 41								
wk 42	beam operation	beam operation	beam operation	beam operation	beam operation	beam operation	beam operation	beam operation
wk 43								
wk 44								
wk 45								
wk 46								
wk 47	Cold Check-out							

Obviously this is an ideal plan!!

• Between 20-120K there is no problem (neither technical nor from resources) in having all sector cooled down at the same time

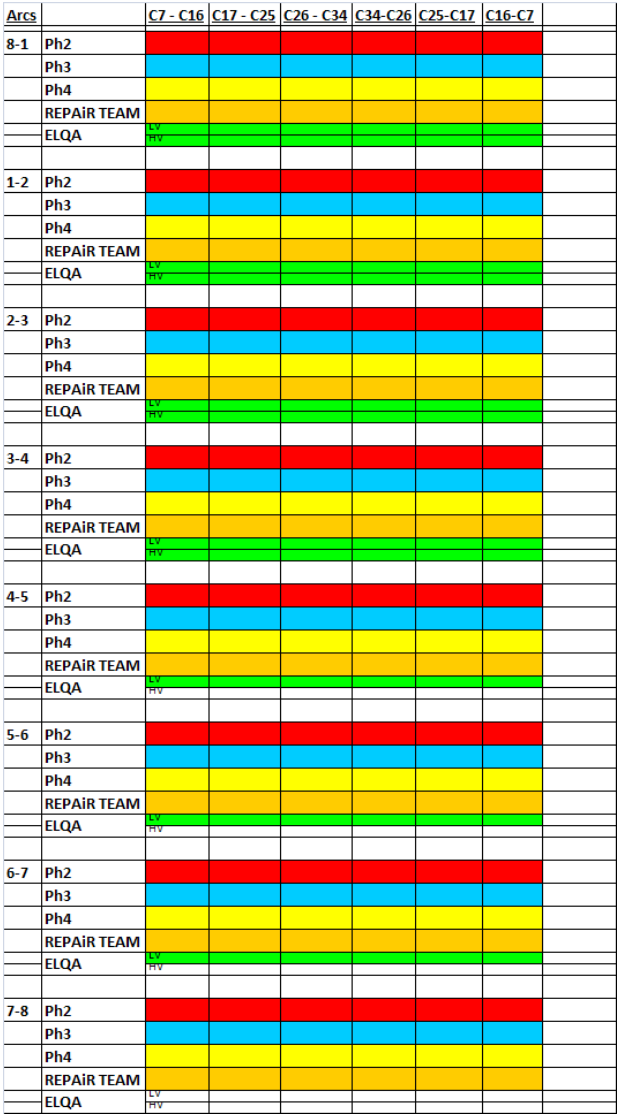
• Parallelization of cryo tuning (1-2wks) cannot be completely performed and it depends on the problems encountered

• Limited number of magnet protection experts (is the way we have done it acceptable as a regular scheme?)

• SW powering tools must be further developed (see Rudiger's)

Moving 3.5 TeV

Actual status of QPS connectors repair



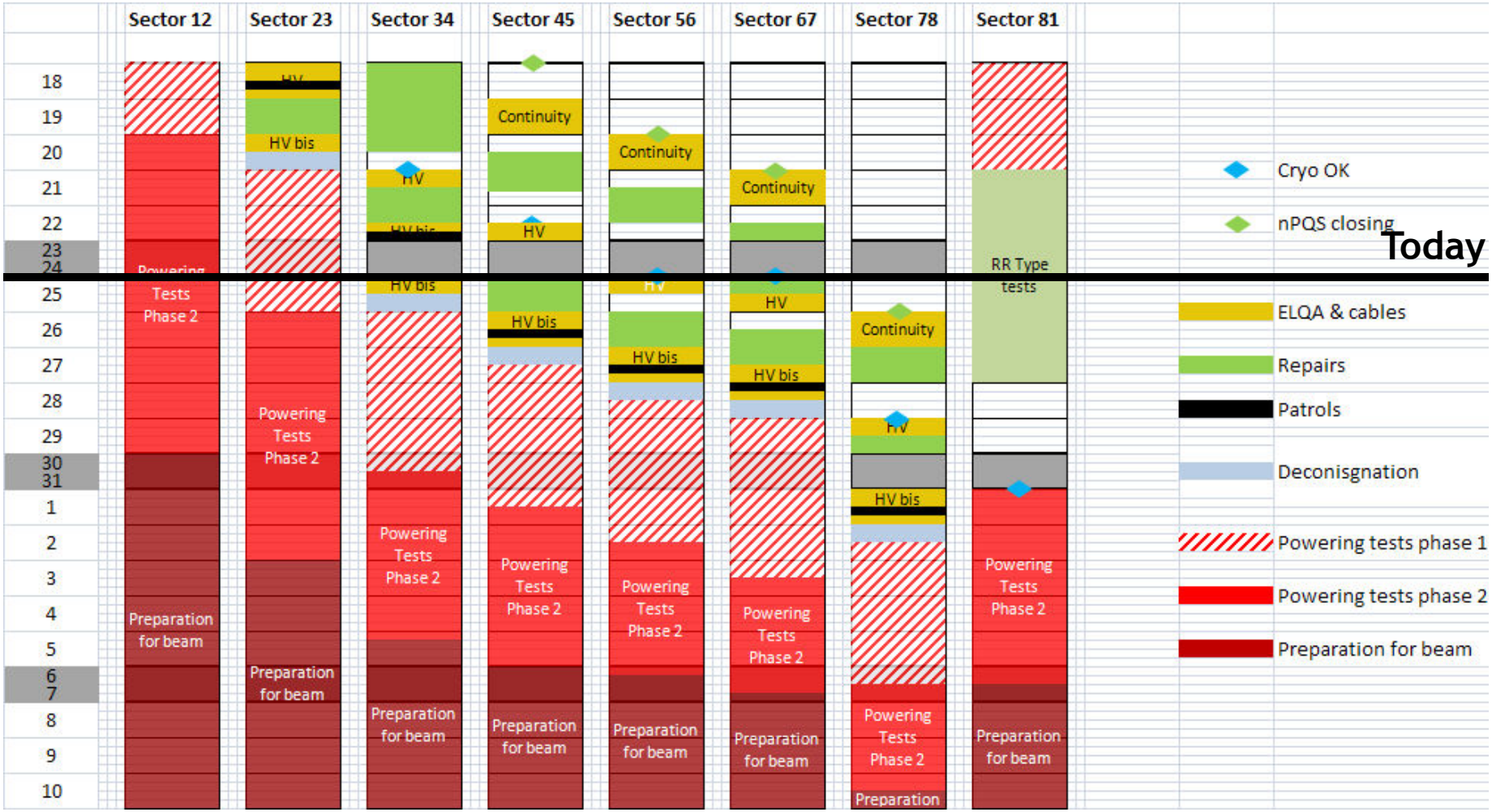
Actual ElQA validation

Sector	HV test	LV test
S12	OK	OK (after repairs)
S23	3 connectors repaired – OK	OK (after repairs)
S34	2 connectors repaired – OK	OK
S45	To be repeated (after repairs)	OK (after repairs)
S56	Not yet done	OK (after repairs)
S67	Not yet done	To be repeated (after repairs)
S78	Not yet done	To be repeated (after repairs)
S81	OK	OK (after repairs)

…thanks to ElQA and QPS teams!

3.5 TeV

3.5 TeV Commissioning planning

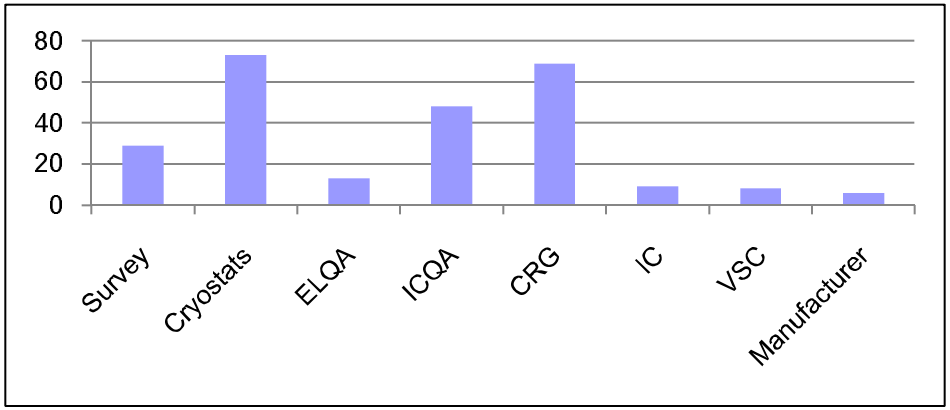


…thanks to K.Foraz

Non Conformities

On week 38: 817 NCR's open (with different status and attached to magnets, interconnections, cryogenic system, vacuum etc…)

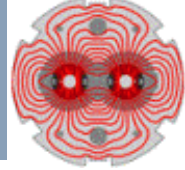
Closed NCs	
Cryomagnet	562
Survey	29
Cryostats	73
ElQA	13
ICQA	48
CRG	69
IC	9
VSC	8
Manufacturer	6



35 planned to be repaired on the next shutdown (not critical to go to 5TeV)

…a special thanks to A.Musso and M.Modena for the huge work done!

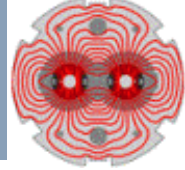
Non Conformities



Not yet commissioned circuits

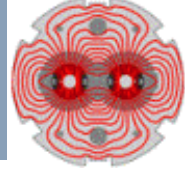
Circuit	Status
RU.L4	Powered up to 400 A, full commissioning procedure needed
RU.R4	Cryogenic problem solved
RCBXH3.L5	FPA problem under investigation
RCO.A78B2	Non-conform (Chamonix 2009): high R may be in a magnet or in the busbar
RCO.A81B1	Ready to be commissioned
RCO.A81B2	Open circuit, cannot be used
RQS.R3B1	Non existing
RCBH31.R7B1	ElQA issue (too resistive)
RCBCHS5.L8B1	Warm magnet instead
RCBCV10.R4B2	Resistance at the limit, PNO.a1 to be repeated
RCBYV5.L4B2	Non-training quench around 63 A. I_PNO could be reduced
RCOSX3.L1	ElQA non conformity
RCSSX3.L1	Several trips at 63 A. Analysis ongoing
RCBXHs	Known problem with operation parameters
RQTDs – RQTFs	Many trips - under investigation

Conclusions



- 1.18 TeV commissioning in 2009 done very well
  - 54% days compared with 2008 campaign
  - 88% shifts compared with 2008 campaign
  - Increased capability of parallel commissioning
- Room for improvements
  - Test procedures to be reviewed in case of sector left floating (adapted to the history of the sector)
  - A more careful study of the possibility of parallelization should be done
- 3.5TeV commissioning is on time
  - Connectors repair quick and well done
  - In spite of some problems found, ElQA is proceeding fast and keeping the schedule

Acknowledges



Thanks to all teams involved in the HWC…

A special thanks to:

- The HWC coordination team for help and discussions
- A.Musso and M.Modena for analyzing and closing a huge number of NCs
- J.Szkutnik for graphs and analysis tools