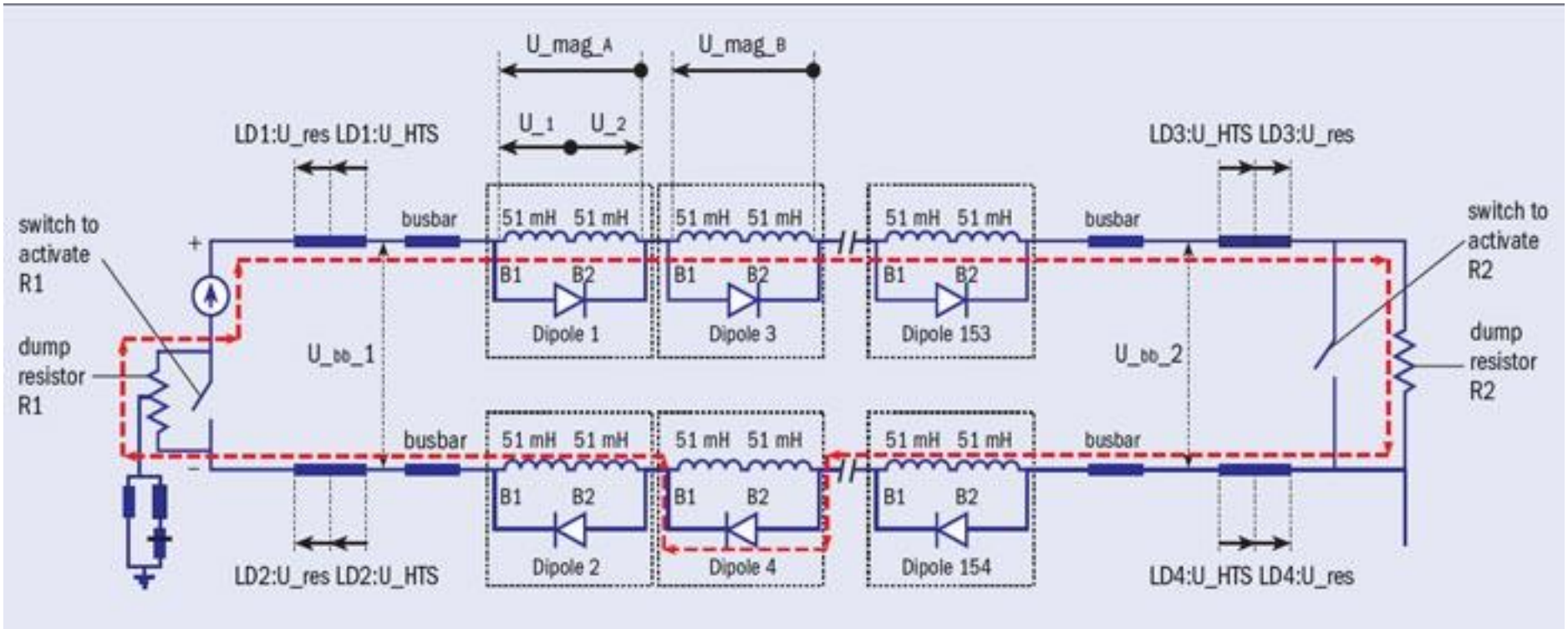
LHC Machine Status Report



Mike Lamont for the LHC team

Acknowledgements: Mirko Pojer, Matteo Solfaroli, Katy Foraz et al

V4.1e

From 7th November, 2014

MPE & LS1 resources loaded schedules

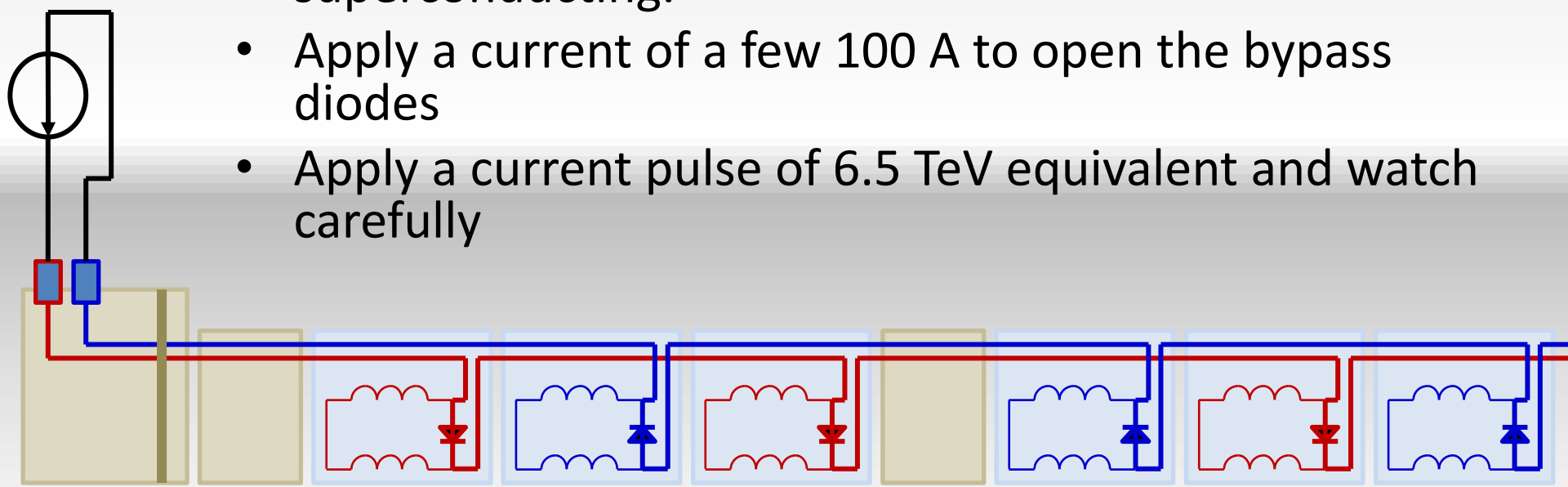
Courtesy Katy Foraz

CSCM (Copper Stabilizer Continuity Measurement)

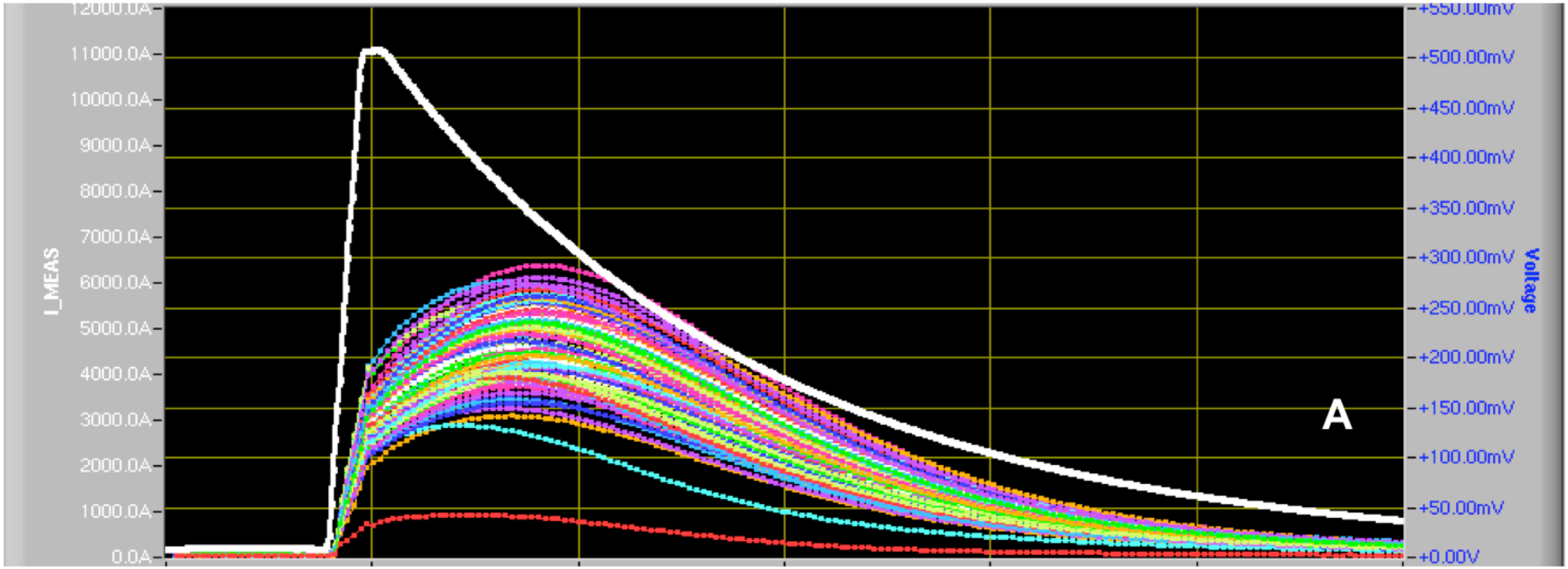
Fully qualify magnet bypass = copper stabilizer of the bus-bar + diode + diode leads

Bypass contains about 3500 connections/joints per sector!

- Connect the two 6 kA/200 V power converters in series
- Stabilize the sector 20 K so the magnets and bus are not superconducting.
- Apply a current of a few 100 A to open the bypass diodes
- Apply a current pulse of 6.5 TeV equivalent and watch carefully



Signals from 11.1 kA run



Conclusion:

- Voltages on the busbars behave as simulated, with a spread due to RRR and length differences. ☺
- There are no outliers! ☺
- All busbar segments (including joints and lyras) are qualified for 6.5 TeV! ☺

CSCM results so far

7 sectors completed

- RRR of the busbars as expected
- The main busbars, including the consolidated joints, behave as expected and are qualified for 6.5 TeV operation.
- The diodes behave as expected and are qualified for 6.5 TeV operation.
- The diode leads behave in a not-fully-understood, but rather predictive way, similar to the previous sectors, and are also qualified for 6.5 TeV operation.

Arjan Verweij, Hugues Thiesen and team

Cool-down - status

Sector 12	1.9 K	CSCM OK
Sector 23	5 K	CSCM OK
Sector 34	26 K	
Sector 45	20 K	CSCM OK
Sector 56	1.9 K	CSCM OK
Sector 67	1.9 K	CSCM OK
Sector 78	5 K	CSCM OK
Sector 81	1.9 K	CSCM OK

Represents a major and successful effort by the cryogenics group

Before powering

Have to ensure that all circuits are safe to power,
all protection functionality is sound.
Small team – a lot of ground to cover

- Electrical quality assurance
  - Cable connection, 2.1 kV, 1.5 kV
- Quench protection system tests
  - Configuration, triggering, thresholds, heater discharge
  - Energy extraction checks
- Interlock tests
  - EE, PIC, permit, quench signal…

And address the inevitable on-conformities

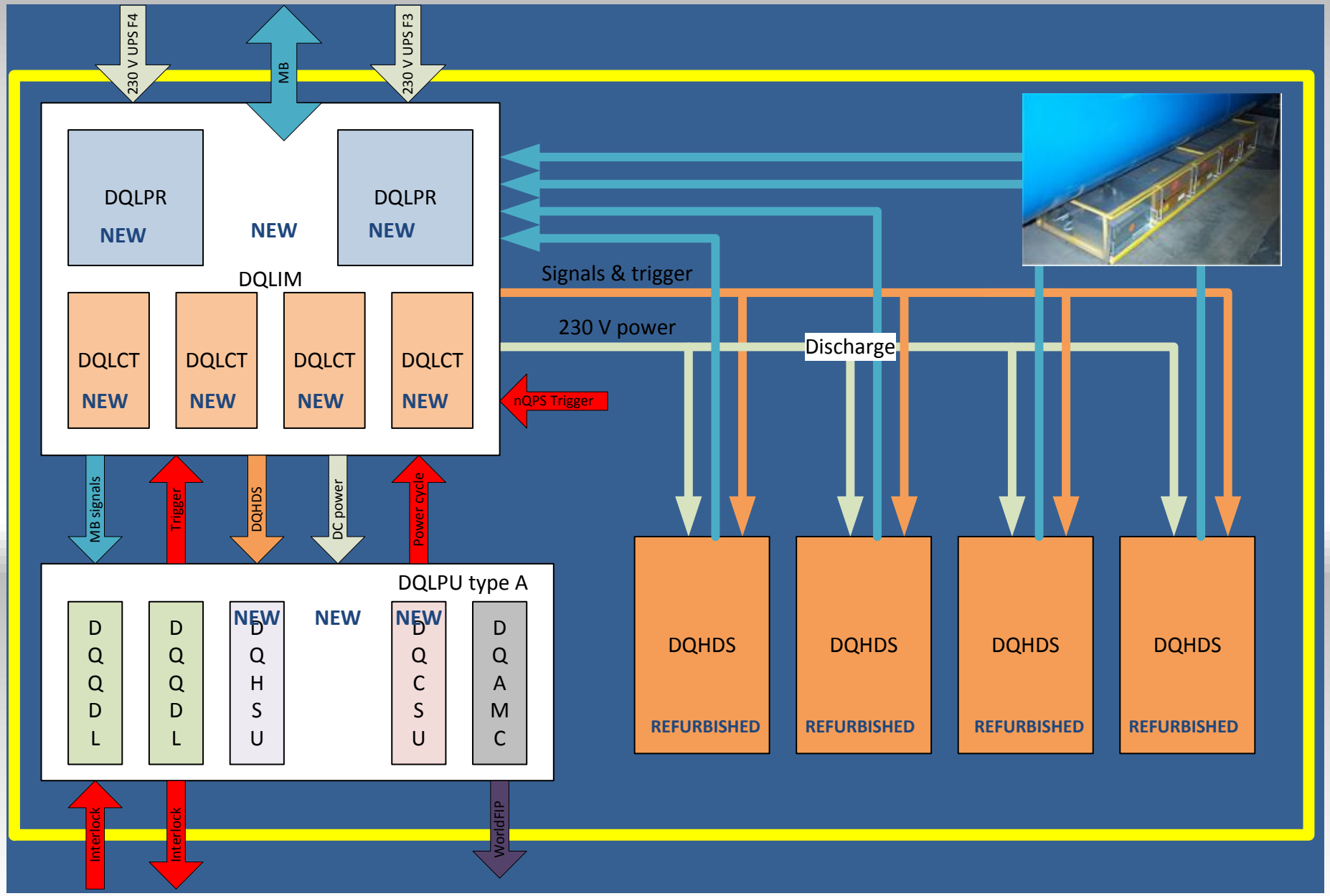
QPS

- Major consolidation and upgrades to the Quench Protection system during LS1
  - First major system upgrade since introduction of the nQPS layer in 2009
- Essential debugging and testing of all:
  - Hardware
  - Firmware
  - Middle and high-level software

"Teething problems during initial exploitation phase to be expected (otherwise something is really wrong …)" Reiner Denz

Reiner Denz

Operation "Yellow rack"



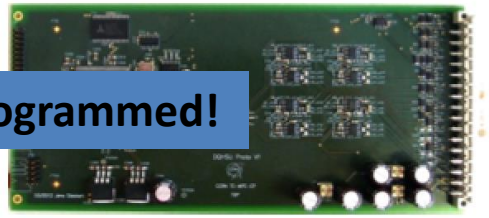
Main dipole protection rack type DYPB – components

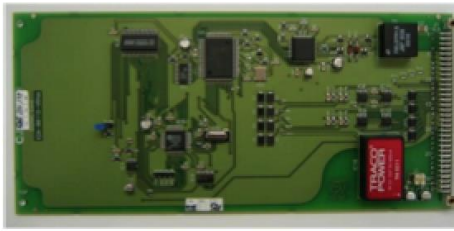
Reiner Denz

Standard QPS

- 1232 x DYPB (yellow rack)
  - 1 x DQLIM (interface module for local quench protection unit)
    - 2 x DQLPP (regulated low voltage power module)
    - 4 x DQCLT (current pulse measurement transformer)
  - 1 x DQLPU A (local protection unit)
    - 2 x DQQDL (quench detector)
    - 1 x DQHSU (quench heater supervision unit)
    - 1 x DQCSU (crate supervision unit)
    - 1 x DQAMC (acquisition & monitoring controller)
  - 4 x DQHDS (quench heater discharge power supply)

17248 items to be tested, 5880 circuit boards programmed!

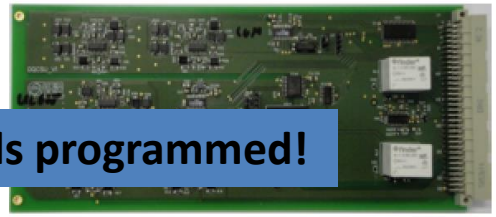




nQPS

- 436 x DQLPU S (nQPS crate installed in DYPB B)
  - 5 x DQQBS (bus-bar splice protection systems)
  - 4 x DQQDS (aperture symmetric quench detection)
  - 3 x DQQDE (earth voltage feeler)
  - 1 x DQAMGS (acquisition & monitoring controller)
- 872 x power packs for DQLPU S (installed in DYPB B)

6160 items to be tested, 5008 circuit boards programmed!

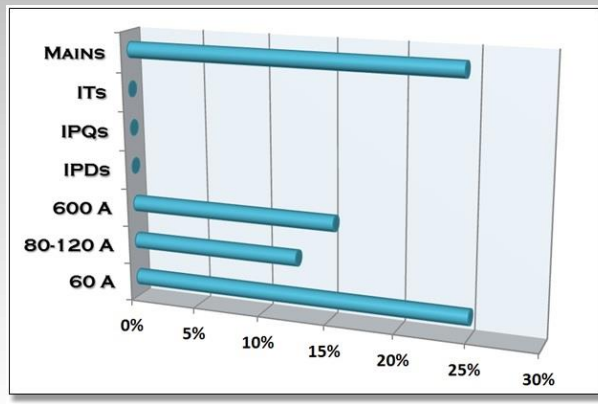


Powering tests

All circuits taken to nominal current level one by one

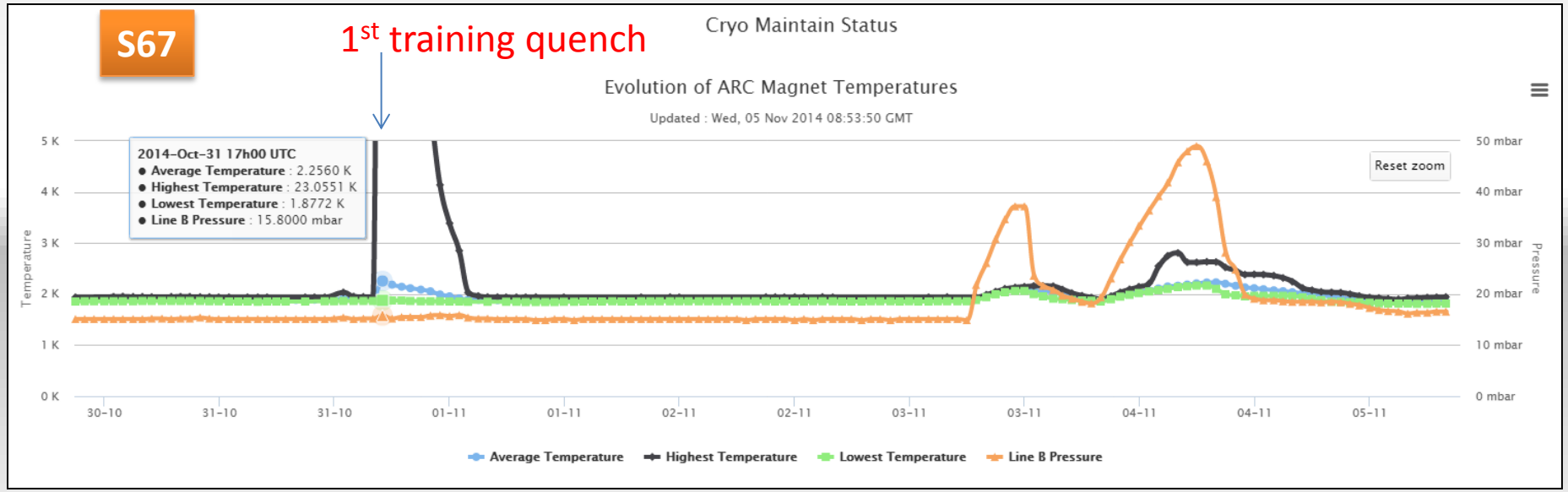
- **Rigorous checks of quench protection, energy extraction, interlocks, power converters…**

- Phase 1
  - low current only – preliminary tests and measurements (QPS, energy extraction…)
  - 60 A, 120 A: low current correctors
  - 600 A: lattice correction circuits (sextupoles etc.)
- Phase 2
  - Full scale tests
  - IPQs: individually powered quadrupoles
  - IPDs: individually powered dipoles
  - ITs: inner triplets
  - MB, MQ (mains): dipoles, quadrupoles



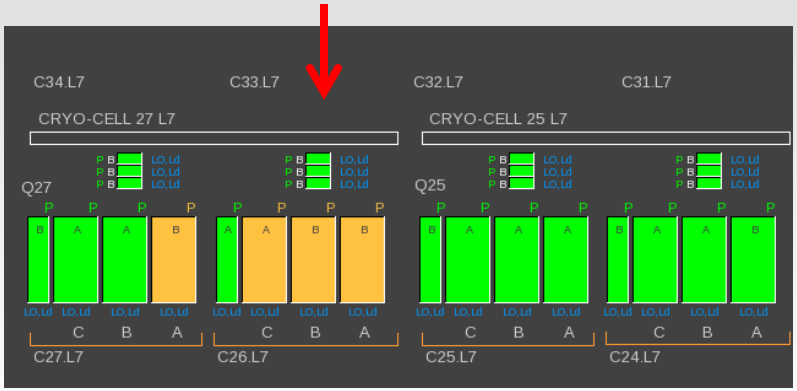
Main dipoles

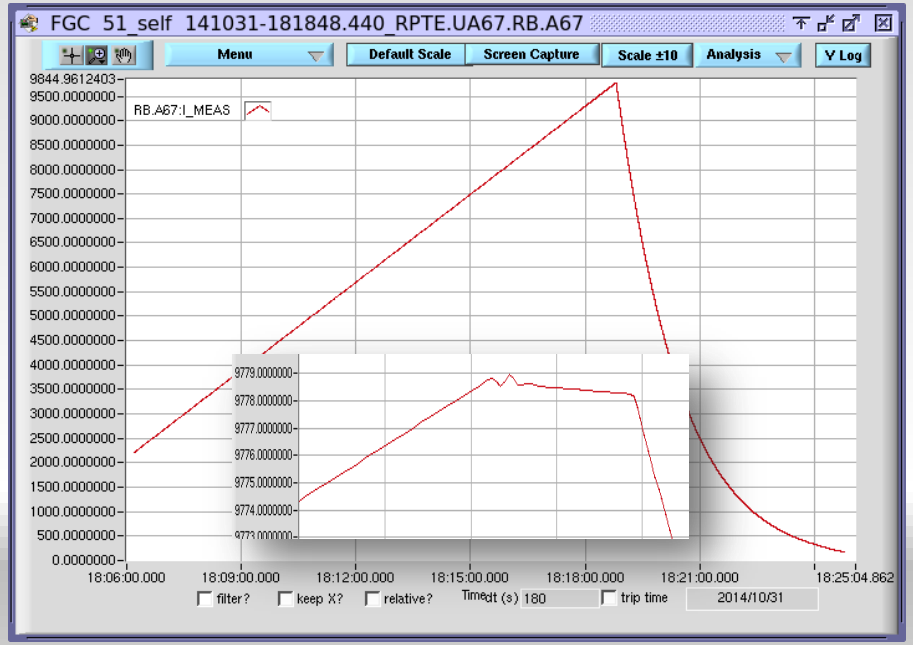
- 800 lb gorilla is the main dipoles
  - 100 or so quenches expected to get to 6.5 TeV
  - One so far in sector 67 at around 5.8 TeV



The first (re)training quench S67

- After the successful execution of the previous steps, the first ramp to nominal current was executed, leading to the first training quench at a current of 9779 A (corresponding to a bit less than 5.8 TeV)





- Secondary quenches were detected
  - A26L7 4248 A
  - C26L7 4235 A
  - A27L7 381 A

SM18 data for the first quenching magnet:

3285	Quench 1	Quench 2
I (A)	8391	12782
B (T)	5.93	8.96
E (TeV)	5.0	7.5

Present status: sectors 12 to 45

S12	• ElQA completed, powering tests in progress • 60/120 A circuits tested • 600 A start today • Preparation of the mains started and progressing well
S23	• On the way to 1.9 K
S34	• Stable at 20 K • **CSCM between 21st November and 4th December**
S45	• **CSCM will finish today** • **Magnet alignment in progress** • Then ElQA and cool-down to 1.9 K

Present status: sectors 56 to 81

S56	• **ElQA will be completed mid next week**
S67	• **Powering tests up to first dipole quench** • **Cooling tower maintenance on-going** • Powering will resume on Nov.24. • Training will resume at the beginning of December
S78	• **Cool-down in progress** • **ElQA in shadow of cooling tower maintenance** • Powering in the New Year.
S81	• **Powering.** Tests will be stopped at the end of this week - to be resumed in January - due to cooling tower maintenance • Powering tests well advanced for 60-120-600 A • Preparation of the mains well advanced

HWC - summary

Based on 4.1e - KF

			Dec				Jan				Feb			
	47	48	49	50	51		2	3	4	5	6	7	8	9
	17/11	24/11	1/12	8/12	15/12		5/1	12/1	19/1	26/1	2/2	9/2	16/2	23/2
S12														
S23														
S34														
S45														
S56														
S67														
S78														
S81														

Powering tests
CSCM
ELQA etc.
Cooling towers

Big thanks due to a relatively small team: Machine Protection and Electrical Integrity (ELQA, machine protection, QPS, magnets), Power converters, MEF, Operations, Survey…

- CSCM will be completed on all sectors within a couple of weeks
- Major QPS upgrade - the debugging of the first sector was important and the result was evident in the following sectors…
- ELQA, QPS prep. etc. mostly cleared by Christmas.
- Experience on extensive training on one sector by Christmas – S12 – benchmark…
- Opening the way to an intensive powering test campaign in the New Year.

V4.1e

P1 12 P2 23 P3 34 P4 45 P5 56 P6 67 P7 78 P8 81

July August September October November December January February March April May June

NC
Cool-down
CSCM
ELQA
PT Φ 1
PT Φ 2
INJECTION
Flushing, nQPS, ELQA
Pressure test
COLLIMATION
RF
BEAM DUMPS
Machine Check-out
Beam Commissioning
Physics

From 7th November, 2014

MPE & LS1 resources loaded schedules

Courtesy Katy Foraz

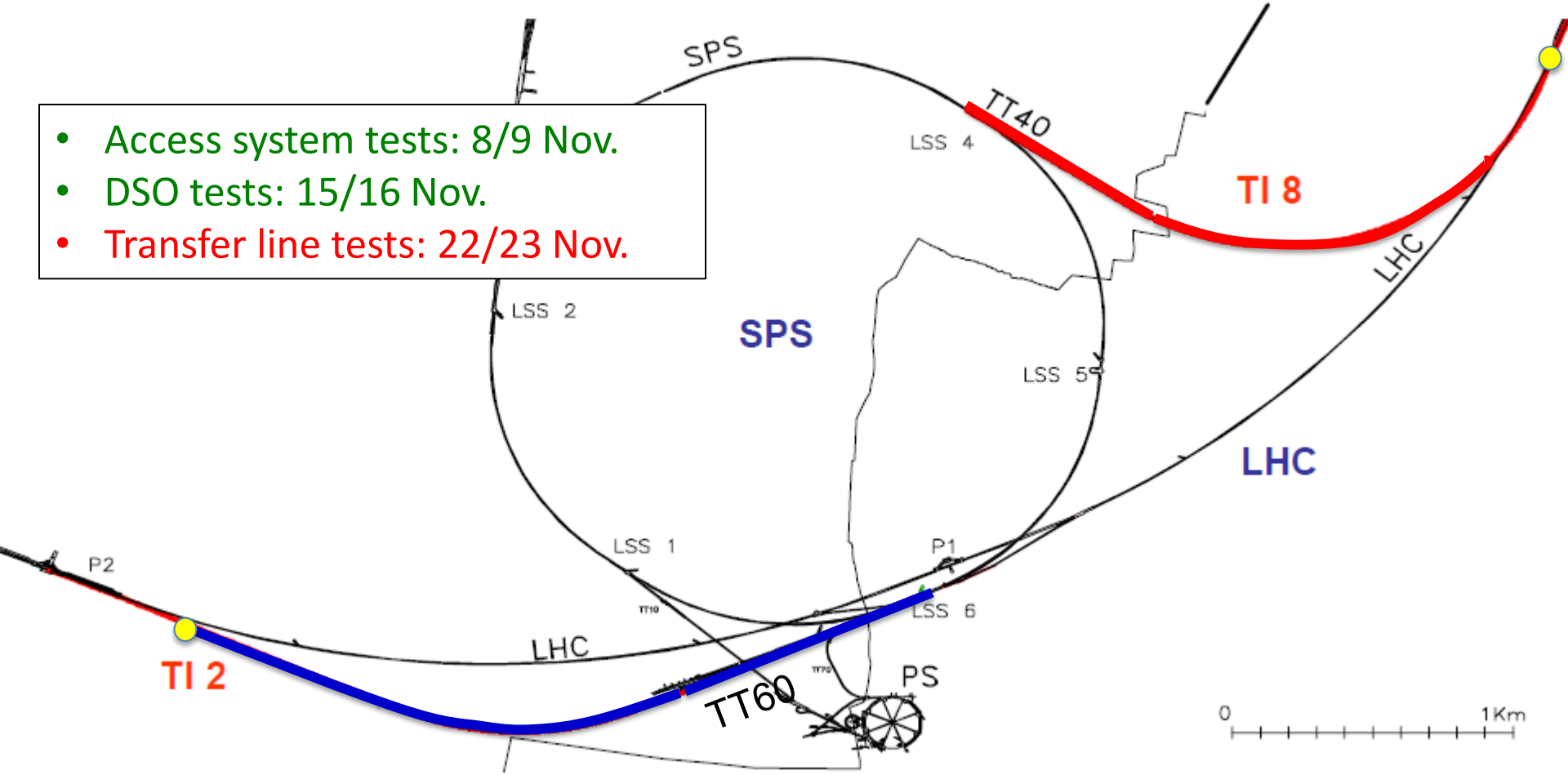
Aside from the magnets

- Beam dumps
  - Reliability run ongoing
- Injection kickers
  - Conditioning, to be OP tested next weekend
- RF
  - Conditioning high-voltage, high-power, cavities, LLRF, hardware/controls…
- Dry runs
  - Full scale tests of: beam instrumentation, controls, timing, software, interlocks, RF synchronization etc. from CCC

Plus: survey, vacuum, transverse feedback, collimators…

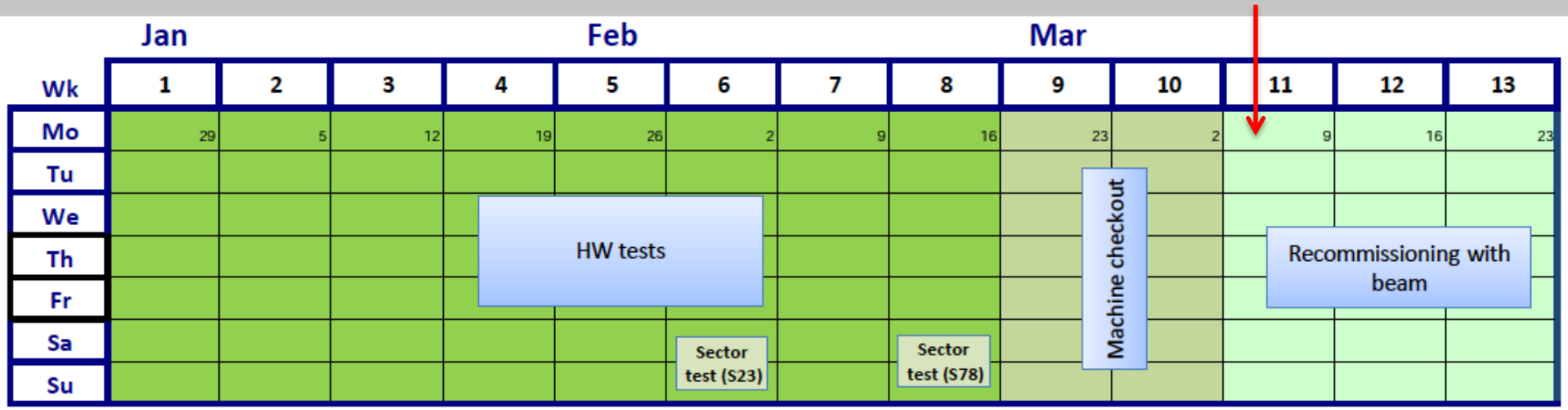
Transfer line tests this weekend

- Access system tests: 8/9 Nov.
- DSO tests: 15/16 Nov.
- Transfer line tests: 22/23 Nov.



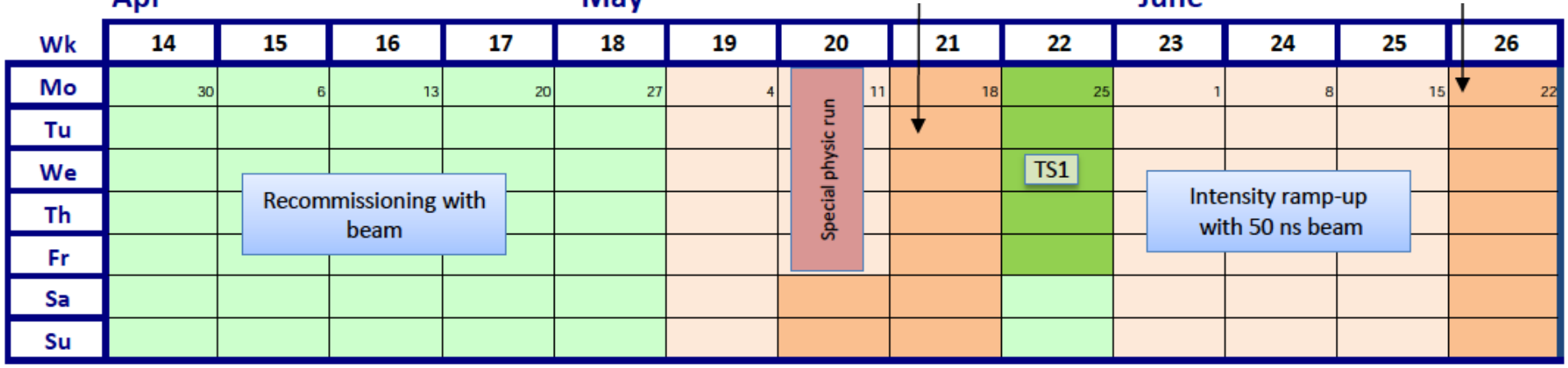
2015 Q1/Q2

FIRST BEAM
9th MARCH

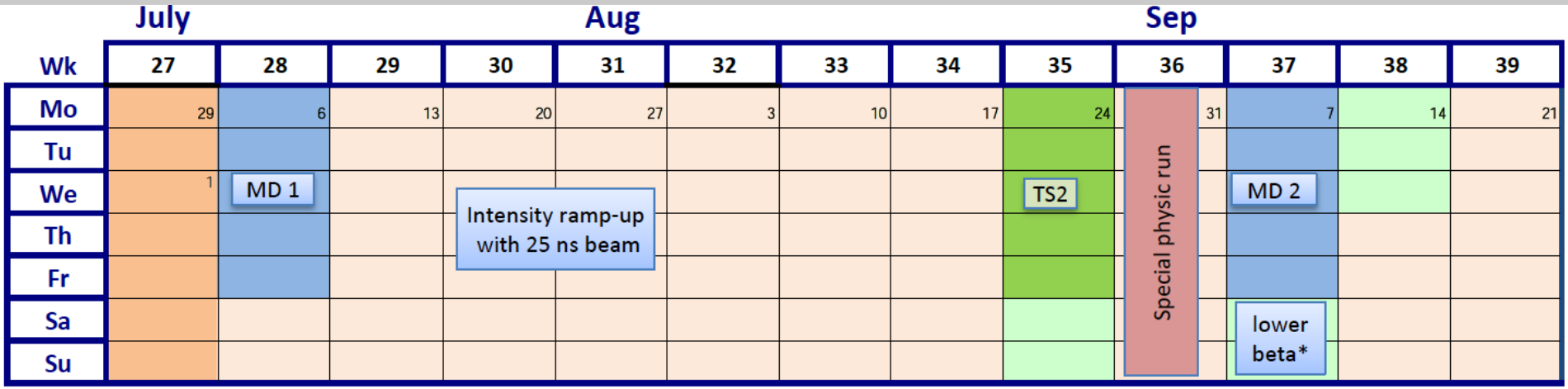


SCRUBBING FOR 50 ns

SCRUBBING FOR 25 ns



2015 Q3/Q4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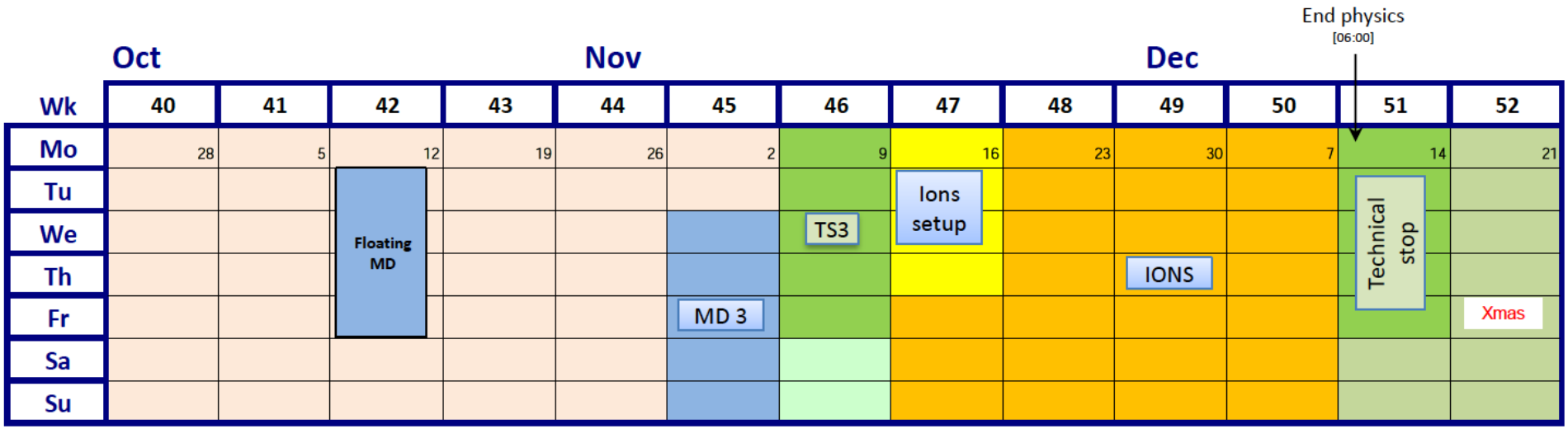
MD 1
Intensity ramp-up with 25 ns beam
TS2
Special physic run
MD 2
lower beta*


End physics
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14
21
Floating MD
TS3
Ions setup
IONS
MD 3
Technical stop
Xmas

2015 version 0.5

Phase	Days
Initial Commissioning	56
Scrubbing	23
Early special physics run (LHCf/VdM)	5
Proton physics 50 ns	**7 + 21**
Proton physics 25 ns – phase 1	**44**
Change in beta*	**5**
Proton physics phase 2 (including ramp-up)	**44**
Special physics runs (TOTEM/VdM) Intermediate energy run - to be scheduled	7
Machine development	19
Technical stops	15
Technical stop recovery	6
Ion setup/Ion run	4 + 24
Total	**280 (40 weeks)**

Conclusions

- Steady progress but little contingency left:
  - Cool-down has gone well
  - CSCM: additional overhead, but invaluable, 7/8 complete – excellent results
  - Important commissioning/debugging of other systems
  - Powering tests thus far have gone well
- Most of the preparation work will completed in 2014, opening the way to intensive powering test campaign in 2015
  - Experience with training in S12 will be the benchmark