

5th Evian wrap-up

4th June 2015

Session 1	Operation in 2015 – part 1
Session 2	Operation in 2015 – part 2
Session 3	Systems 1 - Status and commissioning plans (HW perspective)
Session 4	Systems 2 - Status and commissioning plans (HW perspective)
Session 5	Machine protection and availability
Session 6	Planning and preparation for 2014-2015

The Myth of Sisyphus



...The struggle itself toward the heights is enough to fill a man's heart. One must imagine Sisyphus happy.

Albert Camus

The Myth of Sisyphus



Bugger this - this is bloody heavy.

English philosopher

Run 1 – the eight fold way

- Beam from the injectors
- Beam in LHC
- Exploitation
- Machine protection
- System Performance
- System Availability
- Mitigation



Beams in the injectors

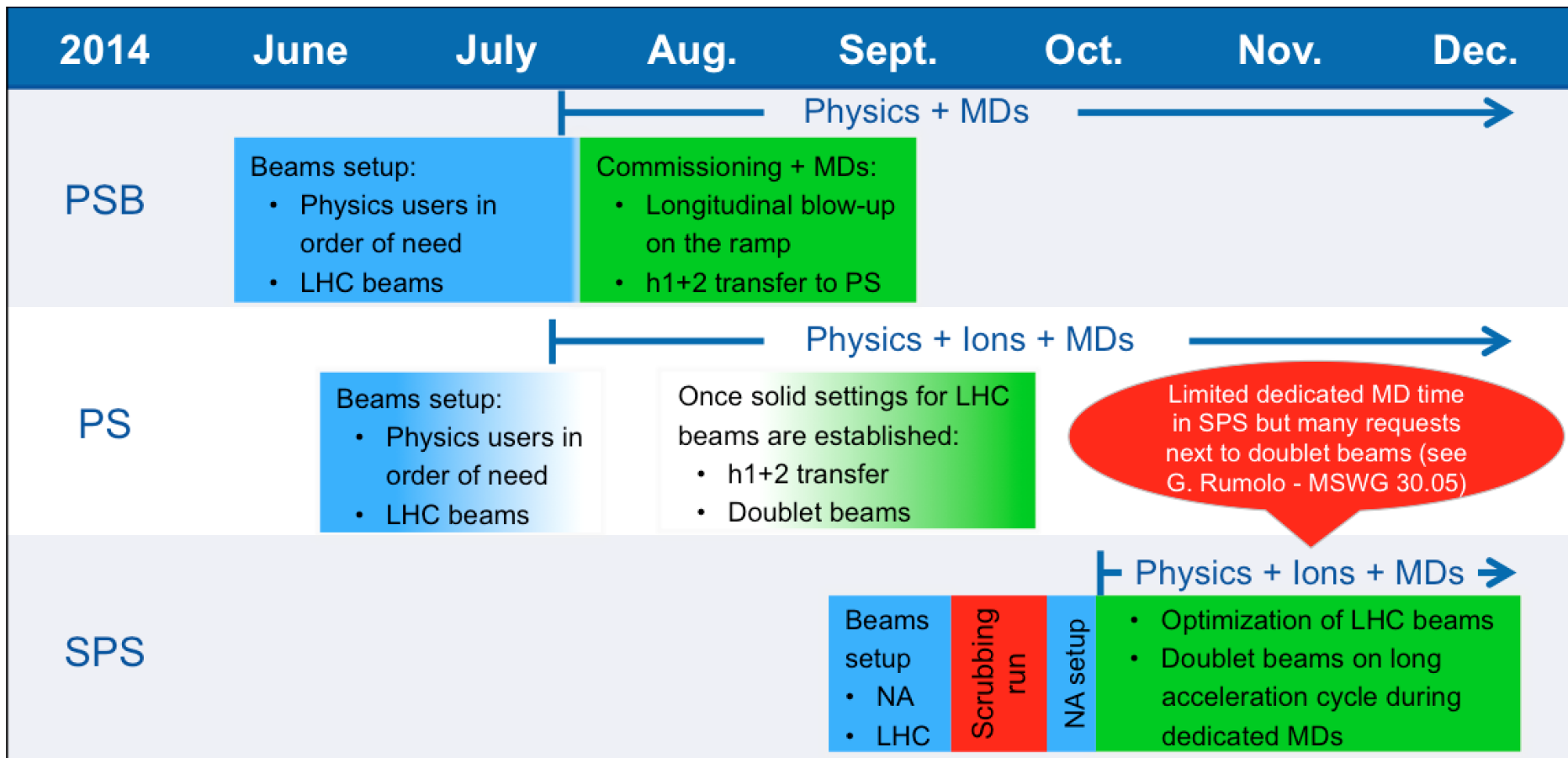
- To be prepared:
 - Single bunch variants
 - 25 and 50 ns standard & BCMS
 - Doublet beam for LHC (and SPS) scrubbing
 - Reaching target intensity (1.6×10^{11} p/doublet) challenging
- 8b+4e beam as low e-cloud option

25 ns	Intensity (p/b)	Emittance (μm)
Standard	1.3×10^{11}	2.4
BCMS	1.3×10^{11}	1.3

Issues

- BCMS: 6 batches from SPS to be tested in sector test
- Some serious validation of protection devices required (TL collimators, TDI...)
 - Survival (possible tests in HiRadMat)
 - Attenuation
- 2014 will be very busy for injectors: physics beams, LHC beams (old and new schemes!), ion beams in preparation for 2015, MDs ...

Milestones (II): New LHC beam production schemes



- Ion beams (Ar) have to be ready in January 2015 for NA physics ... setup will also take lots of time!
- Hopefully able to demonstrate doublet production scheme in 2014 (limited dedicated SPS MD time!)
- 8b+4e beams to be done in 2015 (maybe first tests advanced to 2014) ...

Injectors 2015 – to be revisited

“Very preliminary”

	Jan			Feb					Mar				
Wk	1	2	3	4	5	6	7	8	9	10	11	12	13
Mo	29	5	12	19	26	2	9	16	23	2	9	16	23
Tu													
We													
Th	1	Recommission injectors (protons & ions)			ARGON to NORTH AREA (2 weeks setup, 6 weeks physics)								
Fr													
Sa					OPERATION AS LHC INJECTOR								
Su													

Beam available to LHC (indicated by arrow pointing to week 4)

Stop North Area for TDC2 consolidation (indicated by arrow pointing to week 12)

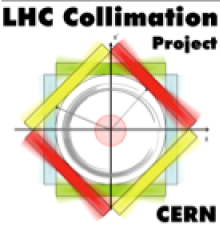
EXPLOITATION: PARAMETERS, CYCLE

Experiments

- Really see 2015 as a commissioning year and an investment
 - 25 ns very strongly favored
 - Will accept up to 1 fb⁻¹ @ 50 ns
- Target energy by the end of the Italian summer (end September) but...
- Max. mean pile-up ~50
- ALICE offset levelling – let's see – potentially interesting as a halo probe



Philosophy for Run 2



- **Startup:**
 - Put focus on **feasibility, stability and ease of commissioning**. Allow comfortable margins for operation and avoid introducing too many untested features at once
 - Where possible, calculate parameters **based on what we know** can be achieved from **Run 1 experience**
 - Performance should not be main focus, but we should also not be overly pessimistic
- **Later in the run**
 - When we know better how the machine behaves at 6.5 TeV through OP experience and MDs, we can **push the performance**

Clear consensus to start relaxed and then step up later in 2015.

Collimation/beta*

- **Run 2:** Many things have changed. Start carefully and push performance later.
 - Cleaning not expected to limit intensity
 - Start-up: $\beta^*=65$ cm, Crossing angle 160 microrad
- Assume
 - assuming 2012 collimator settings,
 - aperture, correction
 - 11 sigma long range separation
 - Standard 25 ns
- Path to intermediate and ultimate presented
- Check check check: stability, asynchronous dumps...

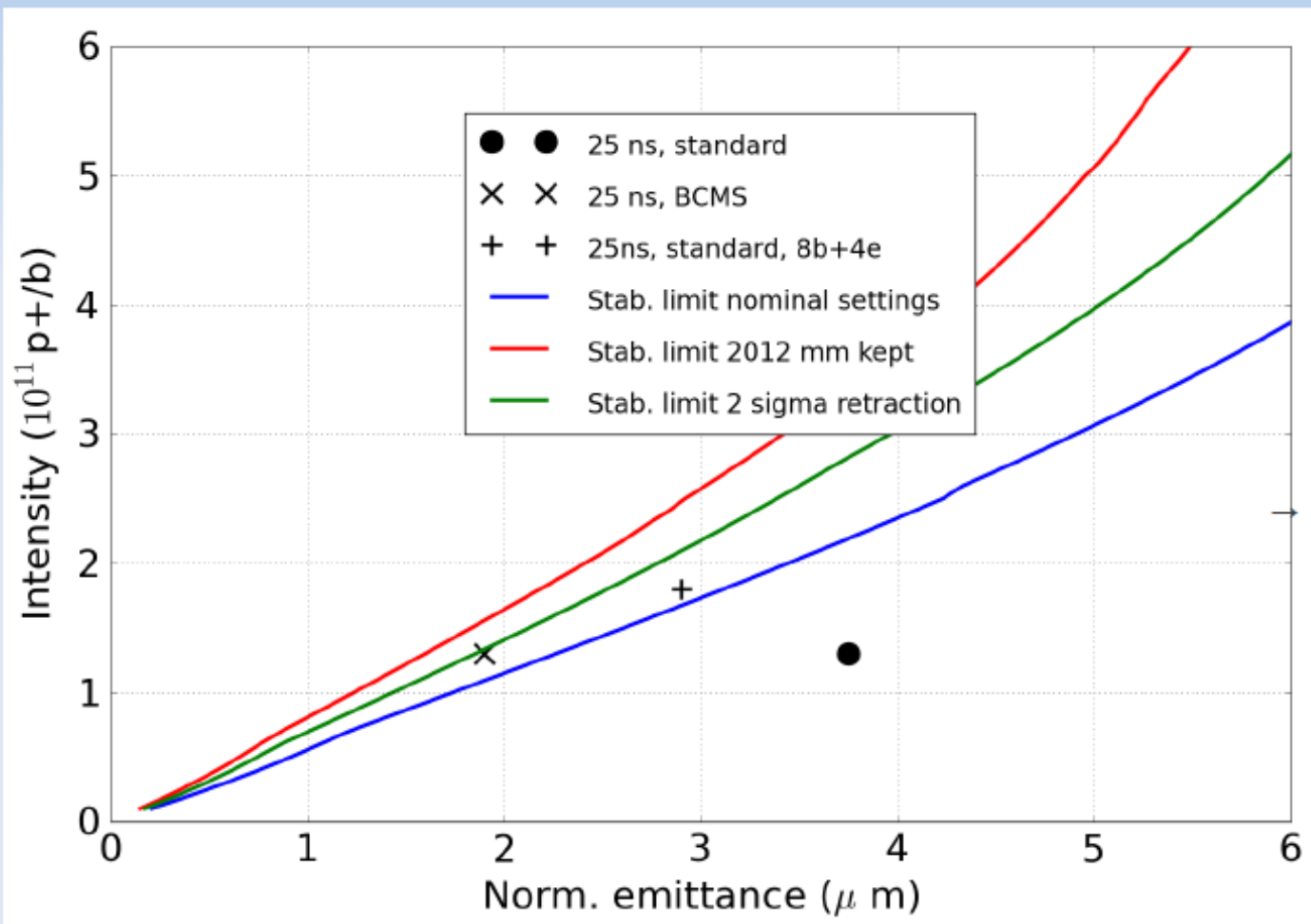
Beta* levelling, collide & Squeeze

- Collide and Squeeze:
 - Robust operational solution will require some effort, testing and commissioning
 - Not for start-up
- Beta* levelling in LHCb looks good to go and seems appropriate as a first test of principle
- Loss maps at intermediate optics points?

- Transfer and injection (Wolfgang)
 - Important upgrades: TDI (**coating**), MKI
 - Improvements: MSE, MSI
 - LICs/IC – blindable BLMs “**deployment strategy to be defined**” **Is it required?**
- Interesting strategy presented to reduce bunch length in Stable Beams (Juan)
 - Not clear that the experiments are too keen on accepting the reduction in luminous region size

Estimate of single-beam stability limits for post LS1 LHC: octupole polarity < 0 ("old")

- Intensity limit vs emittance for 25ns, with negative oct. polarity (6.5 TeV, 570A in octupoles, 50 turns damper, $Q' \sim 15$, 1ns total bunch length): average values only



→ all 25ns beams should be stable with negative polarity, in the 2 foreseen scenarios (but 25ns BCMS marginally stable in "pushed" scenario).

Conclusions

- For single-beam stability, up to the long-range regime (“separated beams”), **negative octupole polarity is significantly better.**
- Only **approximate instability thresholds** can be predicted for post-LS1 operation, from the current knowledge of the LHC machine. **Several scenarios foreseen are close or beyond such limits.**
- It is crucial to get a better knowledge of the machine, from dedicated measurements of **beam instability growth rates vs. chromaticity and damper gain**, in a systematic and progressive manner (i.e. first with single bunch).

From long-range beam-beam perspective “clear preference for positive polarity” but Tatiana’s cool to start with negative!

2015.1 - parameters

Energy	6.5 TeV
Bunch spacing	25 ns
Injection tunes	0.31/0.32
Injection beta*	11-10-11-10
Optics	ATS compatible pending validation (some discussion about MKD to TCT phase advance)
Beta*	65 cm
Beta beating	At least as good as 2012
Chromaticity	High – acceptable (but lower in stable beams)
Collimators	2012 in mm
Octupoles	LOF < 0
Bunch length	~1.25 ns

RF (Philippe),

ADT (Daniel),

Collimation (Gianluca)

Injection (Wolfgang)

Beam Dump System (Nicolas)

Cryogenics (Krzysztof)

Vacuum (Giuseppe)

Beam instrumentation (Georges, Thibaut, Enrico)

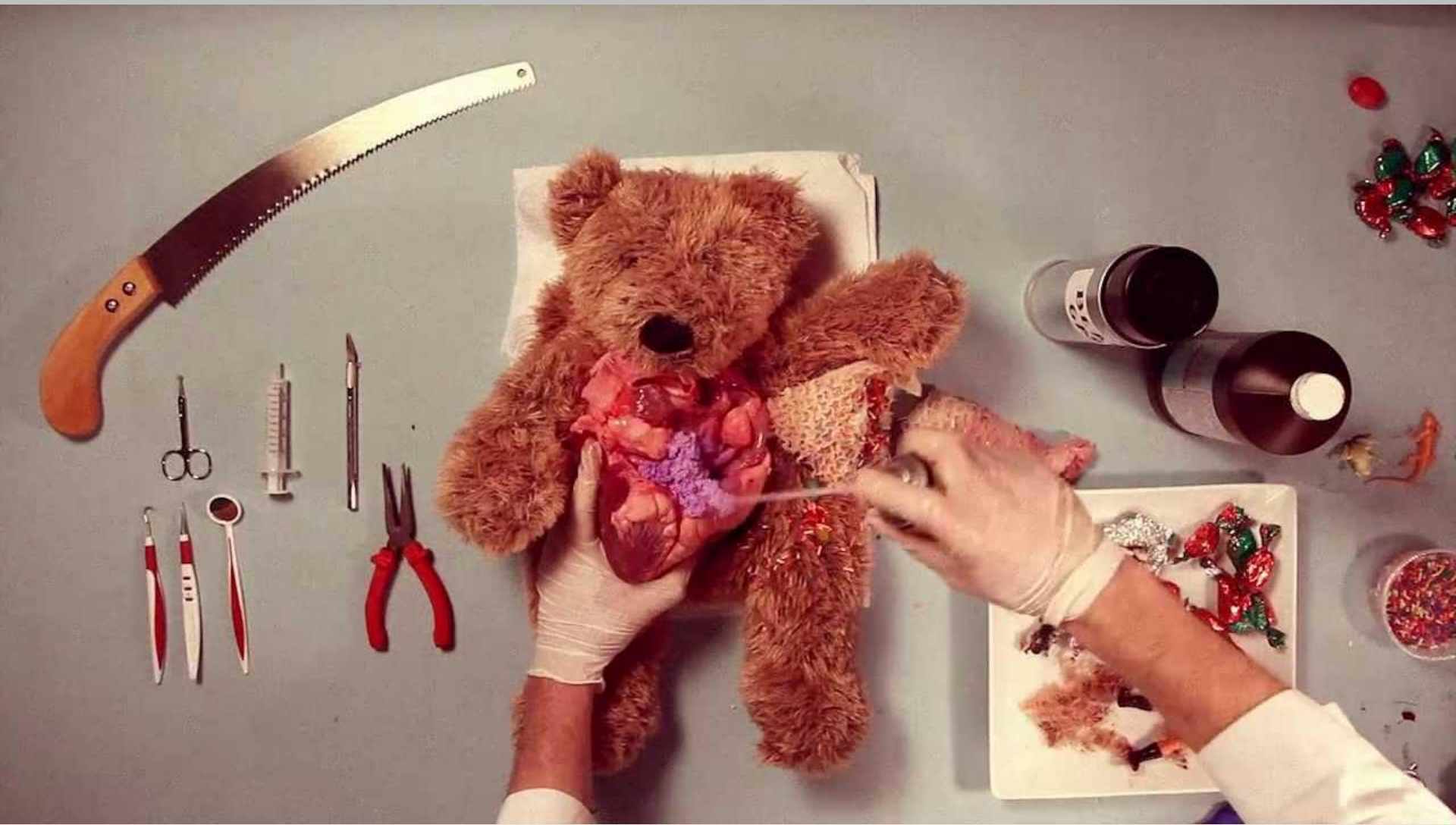
Machine protection backbone, QPS (Ivan)

SYSTEMS

The LHC has undergone open heart surgery



Now the doctor can begin his operation and teddy will not feel a thing.



Systems

Major modifications across the board addressing: reliability, availability, performance, operations and protection.

- A remarkably impressive range of
 - Maintenance & consolidation & repairs
 - Improvements, improvements, improvements, creative thinking based on experience
 - Technology
 - Diagnostics
 - Processing speed
 - Data, data transfer rates, analysis tools
 - Noise reduction
 - Functionality
 - Stability
 - Resolution
 - Better fault tracking
 - Enhance safety

Systems

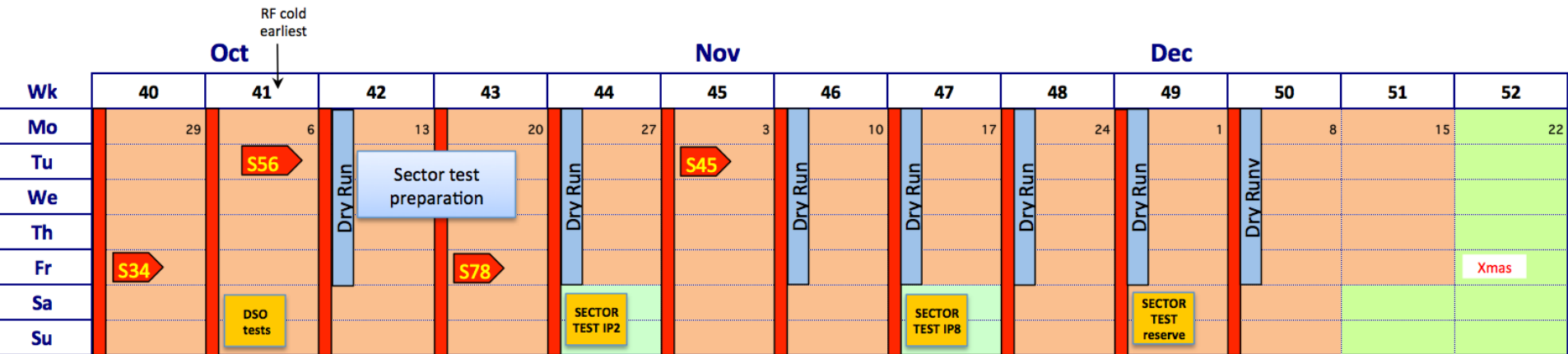
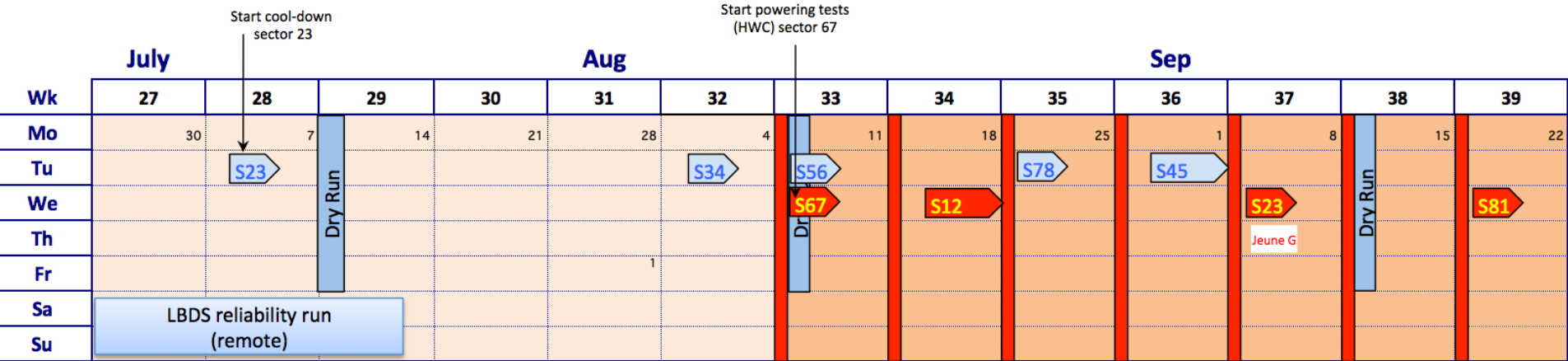
- A huge amount of changes/upgrades:
 - Hardware – all systems
 - Software at all levels
 - Controls at all levels (with knock-on...)
 - Additional interlocks (Hardware and Software)
- Interesting that LS1 was needed. This was the opportunity to upgrade across the board.
- It will be for the good but shaking it out is going to take some time.
- Importance of HWC, dry runs, reliability runs, machine checkout, qualification with and without beam can not be understated.
- There's an awful lot to be re-commissioned with beam – it's going to take some time.

Machine protection

- “Impressive amount of work has already been done in the different MP system following Run 1 experience” (Daniel Wollmann)
 - Backbone (Ivan Romera Ramirez)
 - Circuits, access interlock, QPS, 600 A detection thresholds, Safe machine parameters, re-triggering, user inputs; FMCM, SIS
 - “Quite some changes and upgrades”
 - BLMs (Mariusz Sapinski)
 - Movement, HV, firmware upgrades...
 - Thresholds and the interesting challenge of 6.5 TeV ...
1. Quench tests gave optimistic results for both UFO and Steady-State losses and **multiplied our knowledge** about electro-thermal properties of coils and about loss patterns.
 2. Work to **improve BLM thresholds** is ongoing, however **empirical factors** will remain part of the procedure.

SCHEDULE

2014 Q3 & Q4



“We will have a lot of things to do.” Mirko

Scrubbing

Experience in Run 1 showed that the electron cloud can **limit the achievable performance with 25 ns** beams mainly through **beam degradation at low energy** and **high heat load at high energy**

- To cope with nominal number of bunches **more scrubbing than in 2012 is mandatory**
- **After LS1** several improvements (e.g. cryo, vacuum, injection) will allow for **better scrubbing efficiency**

“Doublet” Scrubbing Beam (5+20) ns being developed for the SPS looks **very attractive for LHC scrubbing**

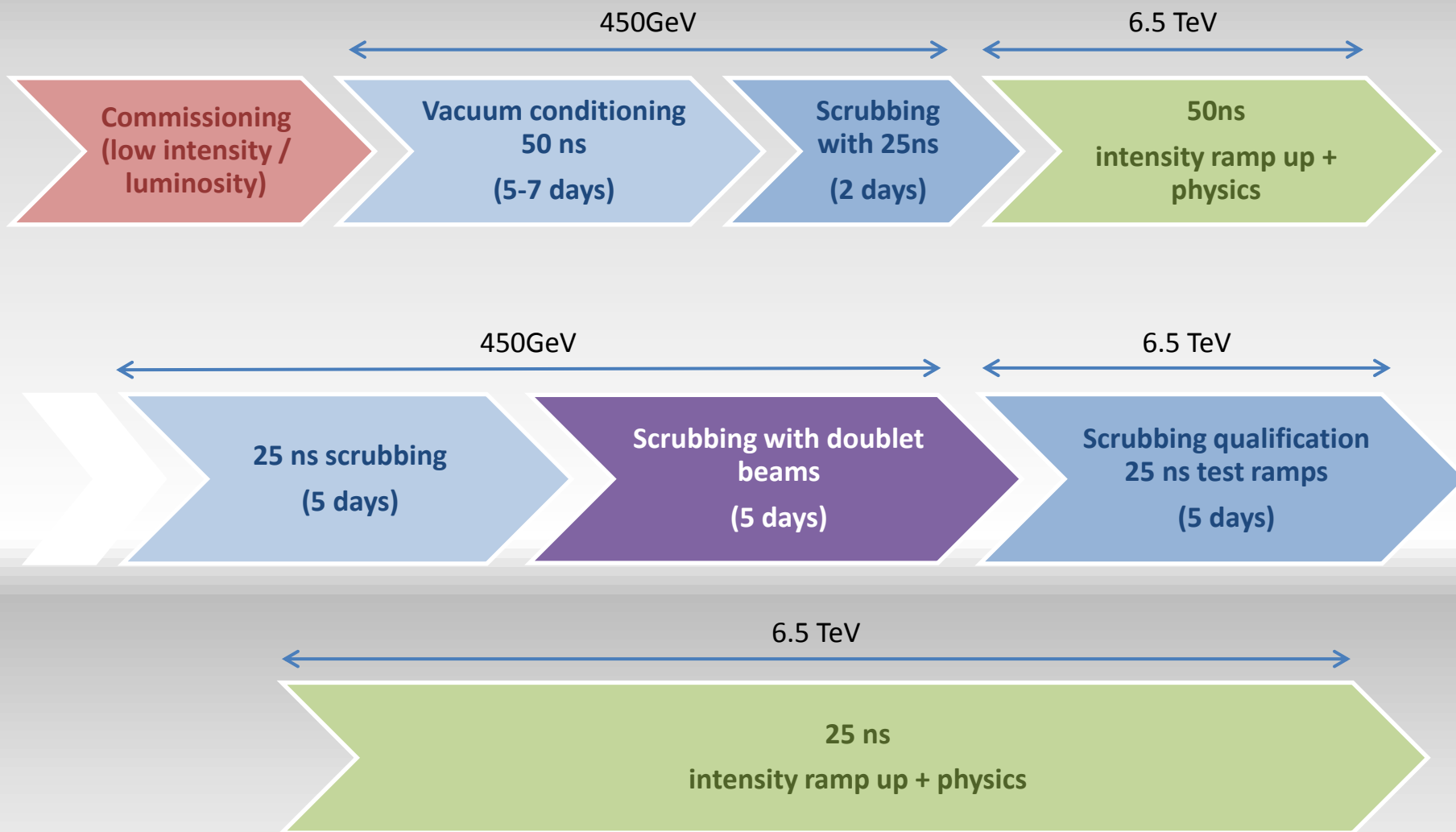
- Production scheme and e-cloud enhancement **proved experimentally at SPS in 2012-13**
- **Compatibility with LHC equipment** reviewed by the LBOC
 - **No major showstopper** has been found
 - Issue with **offset on interlock BPM in IR6** being followed up by BE/BI and TE/ABT

A **two stage scrubbing strategy** is proposed:

- **Scrubbing 1 (50 ns → 25 ns)** to allow for operation with **50 ns beams at 6.5 TeV**
- **Scrubbing 2 (25 ns → Doublet)** to allow for operation with **25 ns beams at 6.5 TeV**



Scrubbing stages



Also note

- Special runs
 - LHCf and VdM early on (~5 days)
 - 90 m for TOTEM/ALFA
 - 2 weeks run requested by TOTEM!
 - VdM later on in the year
- Quite an impressive MD list developing already

2015: Q1 & Q2

	Jan				Feb				Mar				
Wk	1	2	3	4	5	6	7	8	9	10	11	12	13
Mo	29	5	12	19	26	2	9	16	23	2	9	16	23
Tu													
We													
Th			HW tests & machine checkout						Recommissioning with beam				
Fr			HW tests & machine checkout						Recommissioning with beam				
Sa			HW tests & machine checkout						Recommissioning with beam				
Su			HW tests & machine checkout						Recommissioning with beam				

	Apr				May				June				
Wk	14	15	16	17	18	19	20	21	22	23	24	25	26
Mo	30	6	13	20	27	4	11	18	25	1	8	15	22
Tu													
We				TS1	Intensity ramp-up with 50 ns beam								TS2
Th			MD 1		Intensity ramp-up with 50 ns beam								
Fr	LHCf VdM				Intensity ramp-up with 50 ns beam					Intensity ramp-up with 25 ns beam			
Sa					Intensity ramp-up with 50 ns beam					Intensity ramp-up with 25 ns beam		MD 2	
Su					Intensity ramp-up with 50 ns beam					Intensity ramp-up with 25 ns beam			

Laurette – ramp-up: all year in 2010, 4 month ramp-up in 2011, 2 weeks in 2012

2015: Q3 & Q4

	July			Aug				Sep					
Wk	27	28	29	30	31	32	33	34	35	36	37	38	39
Mo	29	6	13	20	27	3	10	17	24	31	7	14	21
Tu							SPECIAL RUNS (VdM, high beta etc.)						
We	1												
Th	Intensity ramp-up with 25 ns beam (continued)				Floating MD [48 h]								TS3
Fr											MD 3		
Sa													
Su													

	Oct			Nov				Dec					
Wk	40	41	42	43	44	45	46	47	48	49	50	51	52
Mo	28	5	12	19	26	2	9	16	23	30	7	14	21
Tu													Xmas
We							MD 4					Technical stop	
Th										IONS			
Fr													
Sa													
Su													

End physics
[06:00]

2015 approximate allocation

Phase	Days
Initial Commissioning	56
Scrubbing	24
LHCf/VdM	5
Proton physics (including ramp-ups)	145 (21 weeks)
TOTEM/VdM (TOTEM request – at least 2 weeks), Intermediate energy run – to be scheduled	7
MD	22
Technical stops	15
Technical stop recovery	6
Ion setup	4
Ions	24
Total	308 (44 weeks)

HARDER

BETTER

FASTER

STRONGER

chamz

Many, many thanks...

- Organization
 - Everything: Sylvia
 - Everything else: Malika & Brennan
 - Technical coordination: Pierre
 - Proceedings: Brennan
- Session chairs
- Speakers
 - Excellent set of talks!

What happens in Evian, stays in Evian!