

# Chamonix 2011

The LHC Performance Workshop at Chamonix is a **technical** meeting which makes recommendations to the CERN management.

These recommendations are considered by the management which also takes into account recommendations/advice from the CERN Machine Committee before making the final decisions.

## Proposals for Decisions

# Sessions

1. Review of 2010 Operations
2. Shutdown 2012 (Part 1)
3. Shutdown 2012 (Part 2)
4. Beam Energy
5. High Intensity: Present and Future
6. Machine Protection in 2011 and beyond
7. Running in 2011 – Luminosity
8. High Luminosity (HL-LHC)
9. LHC Injectors Upgrade (LIU)
10. Summaries and Proposals for Decisions

# Needing " (Proposals for) Decisions "

- Operation after 2011
  - Impact of a delay in **long shutdown** (LS1) from 2012 to 2013.
    - RP (ALARA, ...), maintenance requirements, impact on future projects...
    - Impact on the following long shutdown (LS2;2016)
- Performance in 2011
  - Maximum **safe beam energy**
  - **Luminosity** (Peak and **Integrated**) Baseline still 1fb-1!
    - Bunch spacing (electron cloud, bunch instabilities, scrubbing..)
    - Intensity per bunch (Injectors, beam-beam effects, impedance and instabilities...)
    - collimation, machine protection, UFOs,
    - beta\*, crossing angles, ...
    - SEU ; radiation to electronics
    - ALICE and LHCb; how to operate at low luminosity

# 2012: Physics or Splices? Technical Issues

- RP: ALARA turns out not to be a serious issue
- Splice Consolidation: **benefit** (technical and resources)
- Cryo-Collimation. Delay is **essential** for the project
- Kickers and dumps: **beneficial**
- **CV and EL; delayed maintenance may reduce reliability**
  - (study the possibility of carrying out maintenance during an extended Christmas TS)
- Access and alarms: overall **beneficial**
- Experiments: **in favour** but would like a **new 10 year plan** including Christmas/Technical Stops (CMS need 15.5 months plus possibly 2 additional for bakeout)

# Summary: Physics or Splices?

- Postponing the "2012" shutdown (LS1) to "2013":
  - Will delay the work to be done in LS1 by one year.
  - May allow some tasks already scheduled for LS2 (2016) to be advanced (Injectors, LINAC4, Collimators with BPMs...)
  - Will Increase the need for maintenance and repairs to allow efficient running through 2012 (EN/CV...)
  - May necessitate an increase in the duration of the Technical stop at Christmas (2011-12)

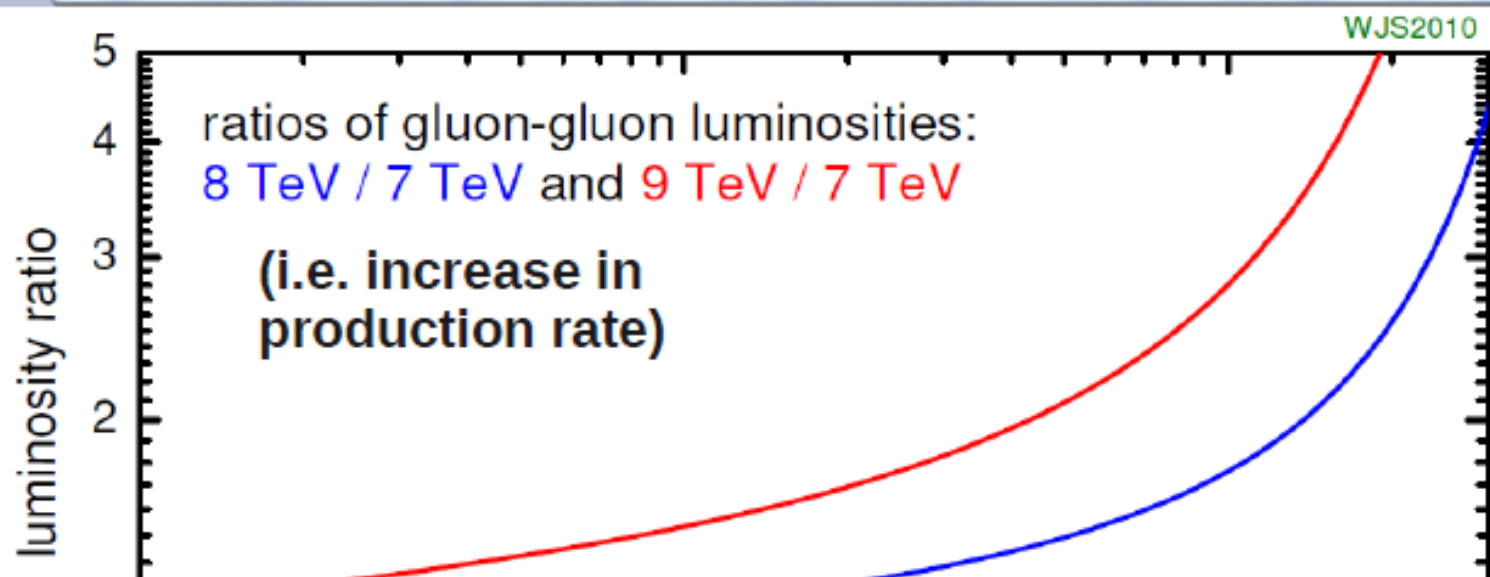
# Proposal

## Do physics in 2012!

- BUT study
  - Maintenance and repairs needs for such a long running period (2009-2012)
    - Consider e.g. how CV/EL maintenance could be carried out during the Christmas in 2011-2012
  - Make a new 10 year plan including all shutdowns and technical stops (LMC + experiments)
  - Try to keep to a minimum the duration of the shutdown in 2013
    - Critical review (in June 2011) of the need for including cryo-collimation system in the LS1 shutdown or delay to LS2



# Effect of raising $E_{\text{CMS}}$



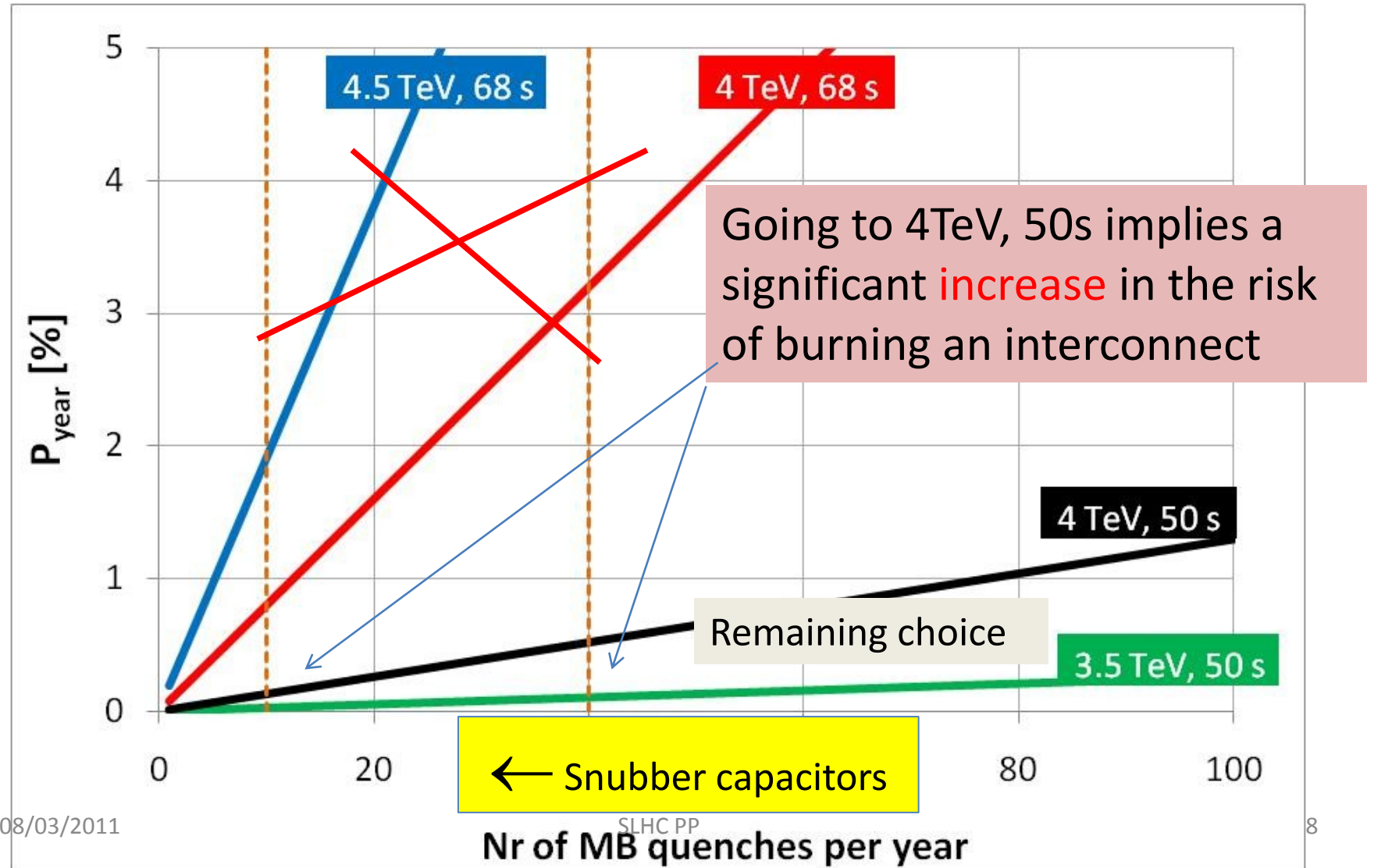
The Return for the Risk associated with energy increase

- Doubled for 9TeV
- Higgs increased by 30% 😊

Thanks to James Stirling

# (Probability) Maximum Safe Energy

Probability per Year of burning an interconnect



# (Impact) Maximum Safe Energy

- Electrical arc in an interconnect:
  - The present consolidation, up to 5 TeV, will suppress mechanical collateral damages in adjacent sub-sectors.
  - Nevertheless, mechanical damage of the MLI in the concerned sub-sector as well as contamination of the beam pipe(s) could require heavy repair work.
  - With the present consolidation status, a new incident will still have a big impact on the machine down time (8 to 12 months)
  - PLUS severe damage to CERN's reputation

# Safety Integration Level (SIL)

To achieve a given SIL, the device must meet targets for the maximum (allowable) probability of dangerous failure.....

PFD (Probability of Failure on Demand) .....for different SILs as defined in IEC EN 61508 are as follows:

SIL	PFD	PFD (power)
1	0.1-0.01	$10^{-1} - 10^{-2}$
2	0.01-0.001	$10^{-2} - 10^{-3}$
3	0.001-0.0001	$10^{-3} - 10^{-4}$
4	0.0001-0.00001	$10^{-4} - 10^{-5}$

4TeV/50s

3.5TeV/50s

3.5TeV/50s with snubber capacitors

LHC safety systems are designed for SIL4 (Beam dump, access safety, ...)

SIL2 is not acceptable. Return/Risk is not favourable

# Proposal

## Stay at 3.5TeV for 2011

We should operate in 2011 with the "snubber" capacitors to reduce further the possible number of quenches (SIL4)

"Thermal amplifier" to be developed during 2011 to allow measurements during Christmas shutdown for a **deterministic** decision on a possible energy increase for 2012.

# Performance: Ions 2011

- Substantial factor in luminosity possible for 2011
  - Options for filling etc, will be clarified in injector commissioning, experiments are flexible
- 2012 appears to be a good opportunity for p-Pb
  - Otherwise it will be a long time
  - Feasibility test in MD can be tried in 2011

Request from ALICE to shoot for design already in 2011

More work needed in the first half of this year

# Running in 2011; Distribution of Days

## Protons

Item	Days
Total p OP - 37 ½ weeks	262
11 MDs (2 days)	-22
6 TS (4+1 days)	-30
Special requests	-10
Commissioning	-28
Intensity ramp up	-40
Scrubbing run	-8
<b>Total HIGH INTENSITY</b>	<b>124</b>

# Start up scenario

## ☐ 75 ns beam re-commissioning – Scrub with 50 ns – 75/50 ns operation

- ☐ Recommissioning with 75 ns bunch spacing - 3 w
- ☐ Increase bunch number (~300b?) – 2 w
- ☐ Scrub with 50ns when needed - 1.5 w

After scrubbing experience, decide on 50/75 ns

- ☐ 50/75 ns operation and increase bunch number -2.5w      300 – 400 –  
600 – 800 – 936 -??1404 MP and OP qualification –
- ☐ Physics operation 50/75 ns – 936/1404 b
- ☐ (Back up: restore 150 ns operation – couple days)

☐ Other possible start up scenari were discussed

# Beam parameters 2011

@ exit SPS

Beam parameters	150 ns	75 ns	50 ns
Bunch intensity [e11 p/b]	1.2	1.2 (1-batch) 1.2 (2-batch) tbc	1.2 (1-batch) 1.6 (1-batch) 1.2 (2-batch)
Normalised Emittance [ $\mu\text{m}$ ]	2 (1.6 achieved)	2 ~1. to 1.5 – tbc	2 3.5 ~1.5

Retained for L calculation (LHC):

Beam parameters	150 ns	75 ns	50 ns
Bunch intensity [e11 p/b]	1.2	1.2	1.2
Normalised Emittance [ $\mu\text{m}$ ]	2.5	2.5	2.5
Colliding bunches	368*	936	1404

\*assume 368 b as proven from 2010 - should be able to go to ~424 b

# Estimated Peak and Integrated Luminosity

- **Baseline is 2E32 Peak and 1fb-1 (integrated)** (expectation management)
- But following 2010, we are confident we will do better

$$\beta^* = 1.5\text{m}$$

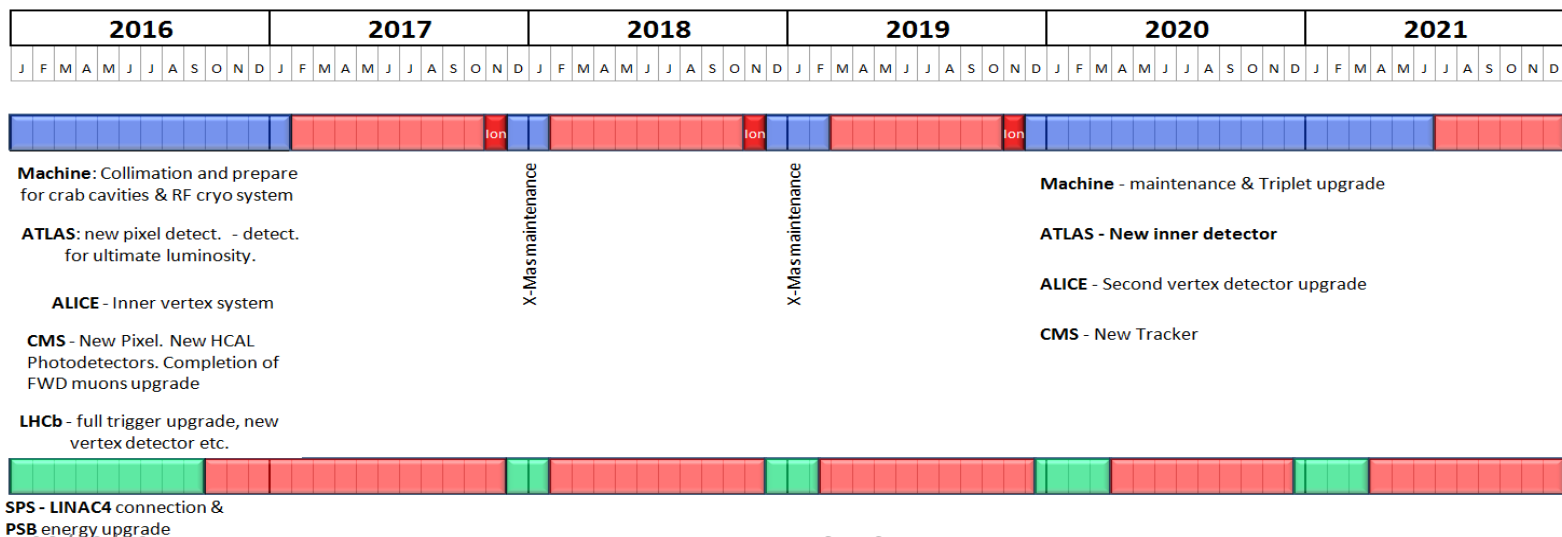
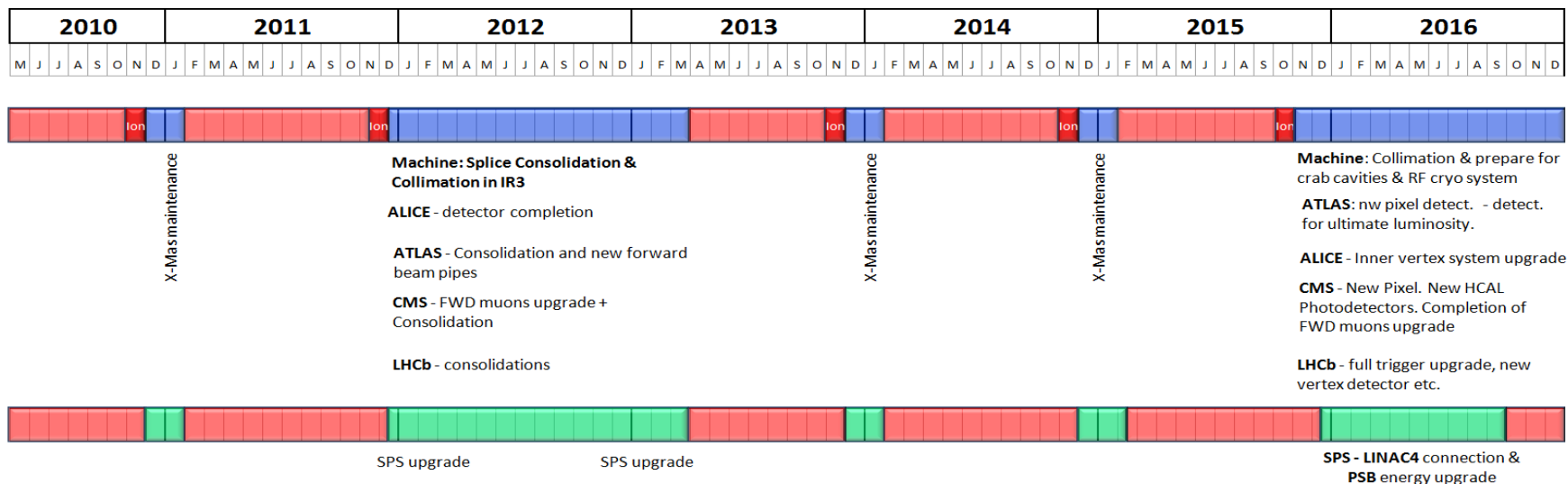
days	H.F	Comm with	Fills with	kb	Nb e11	$\epsilon$ $\mu\text{m}$	$\xi/\text{IP}$	L Hz/cm <sup>2</sup>	Stored energy MJ	L Int fb <sup>-1</sup> 4 TeV	L Int fb <sup>-1</sup> 3.5 TeV
160	0.3	150 ns	150 ns	368	1.2	2.5	0.006	~5.2e32	~30	~2.1	~1.9
<b>135</b>	<b>0.2</b>	<b>75 ns</b>	<b>75 ns</b>	<b>936</b>	<b>1.2</b>	<b>2.5</b>	<b>0.006</b>	<b>~1.3e33</b>	<b>~75</b>	<b>~3</b>	<b>~2.7</b>
						<b>2</b>	<b>0.007</b>	<b>~1.6e33</b>		<b>~3.8</b>	<b>~3.3</b>
						<b>1.8</b>	<b>0.008</b>	<b>~1.8e33</b>		<b>~4.2</b>	<b>~3.7</b>
125	0.15	50 ns	50 ns	1404	1.2	2.5	0.006	~2e33	~110	~3.2	~2.8

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Many technical details being followed up.

# “Old” 10 year technical Plan

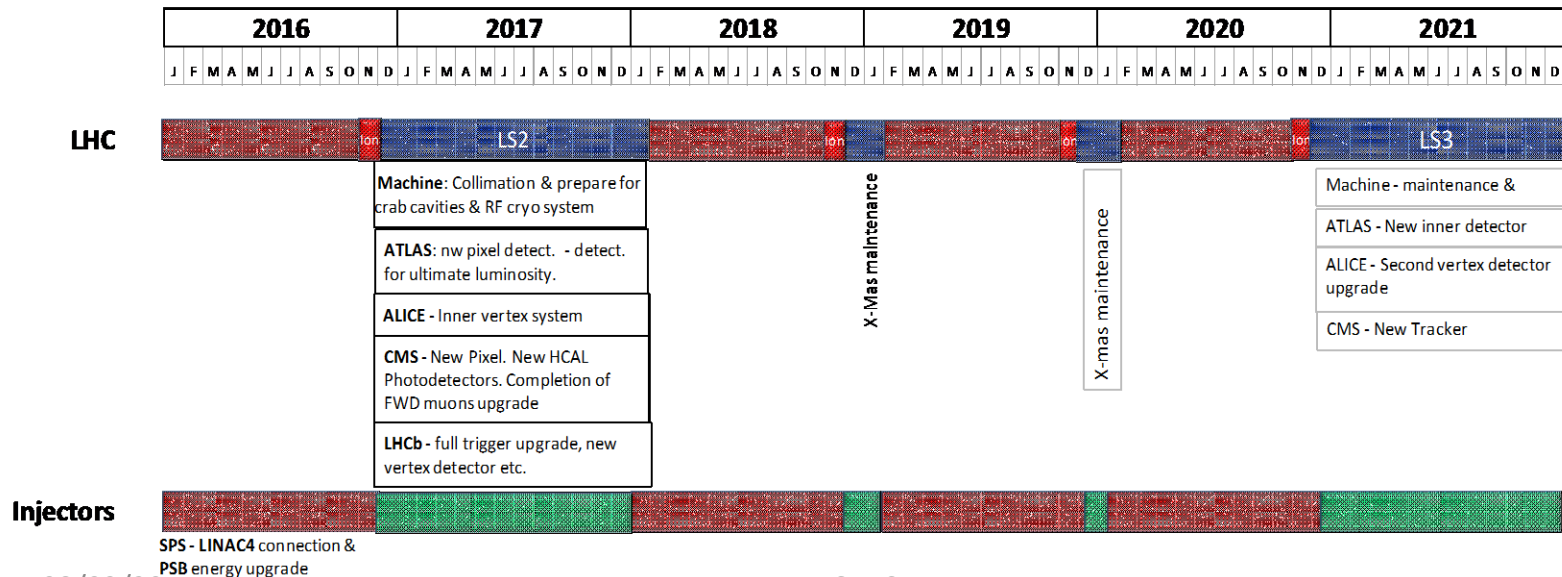
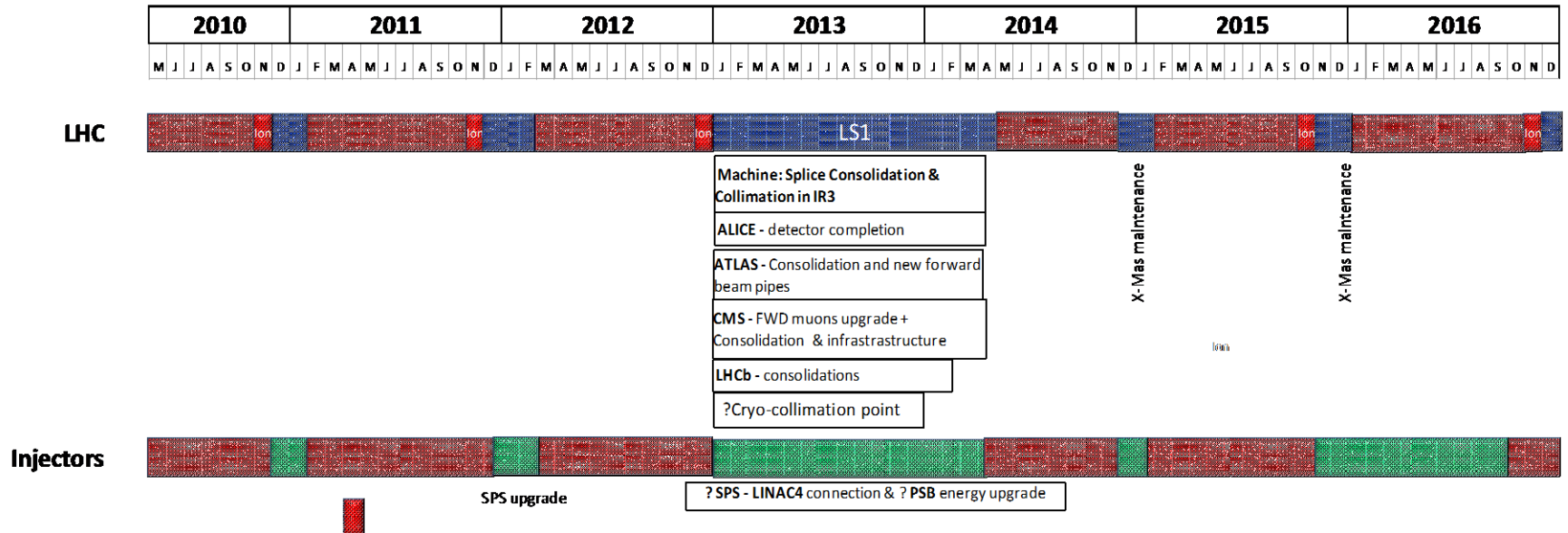


08/03/2011

SLHC PP

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# New Draft 10 year plan



# Where are we today?

# Where are we for 450 GeV?

- Injection optics and orbit OK.
- Aperture OK and measured.
  - Measure DS aperture and response.
- RF system OK.
- Transverse damper OK.
- Feedbacks OK.
- Emittance small **but not controlled**.
- Injection ring collimation OK.
  - Repeat loss maps once preliminary data is analyzed. ~4h.
- Machine protection OK.
  - Some final adjustments to be done.
- Injection transfer line collimation OK.
  - Checks to be completed for Tl8.
- Then move to multi-bunch injection.

# Where are we for the ramp?

- Pilot and nominal bunch. OK.
- Chromaticity, tune, orbit OK.
  - Still requires some work
- RF blowup. OK.
  - Some minor optimizations still ongoing. Philippe.
- Feedbacks OK.
- Transmission and lifetimes OK.
- Collimator ramp:
  - To be done once endpoint is known (3.5 TeV setup)

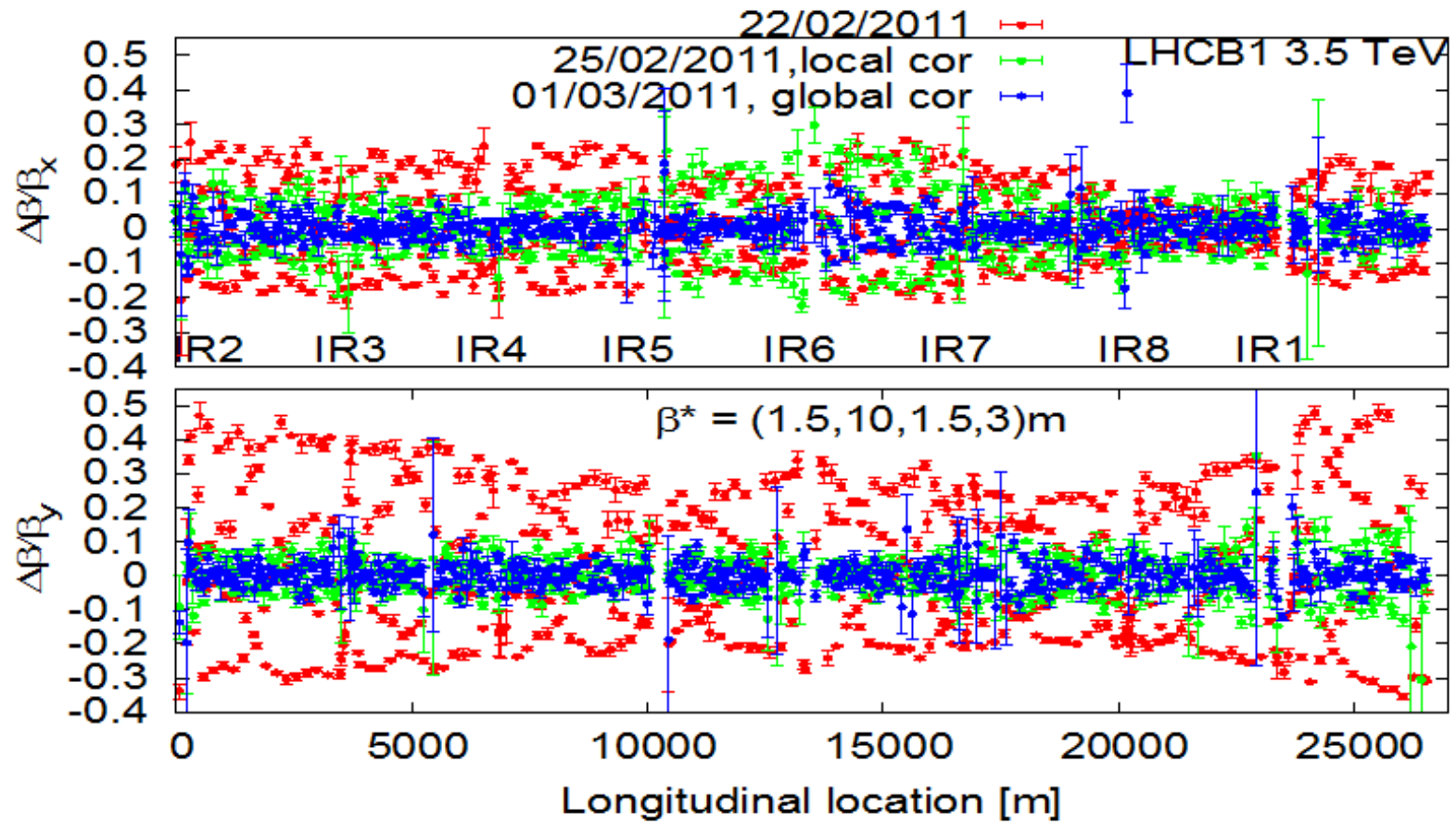
# Ramp with nominal bunch...



# Where are we for 3.5 TeV?

- Chromaticity and tunes OK.
- Beta beat and coupling through squeeze OK.
  - Beta\* correction to be done with **k-modulation**.
- Squeeze with dynamic orbit reference OK.
- Sequence with feedbacks OK.
- Pilot collisions and vernier scans OK.
- Final 3.5 TeV reference orbit defined (nominal bunch).
- 30 – 40% of collimators calibrated for flat top.
  - **To be completed.**
- Dump protection setup and check.
  - **To be done.**

# Correction of beta beating



# Beta at the collision points

*Beam1 (after local and global correction):*

IP	$\beta_x^*$ (ex)	$\beta_y^*$ (ey)	
IP1	1.68 (0.08)	1.62 (0.20)	<b>11.7% imbalance</b>
IP5	1.53 (0.18)	1.45 (0.72)	

*Beam2 (after local correction, no global correction):*

IP	$\beta_x^*$ (ex)	$\beta_y^*$ (ey)	
IP1	1.43 (0.06)	1.62 (0.06)	<b>9.5% imbalance</b>
IP5	1.64 (0.16)	1.48 (0.03)	

# Thank you for your attention

# Issues with 4 TeV (50s)

- Number of Quenches expected
  - In 2010, 20 quenches ( $>5000A$ ) (only one was beam related)
  - Possibility of multiple quenches provoked by asynchronous dumps (sectors 56 and 67)
  - UFOs (event rate will increase with intensity, **however the UFO signal amplitude appears to be independent of beam energy**)
- (Weak dipole limits energy to 4TeV)
- (QPS: strong preference to use snubber capacitors to reduce the possible number of quenches)
- (Little or no impact on set up time)
- Probability is relatively low but the impact is high
  - i.e. **the risk factor is medium**

1. Modifications already done
2. Follow up list
3. Shutdown planning and execution
4. Status of start up