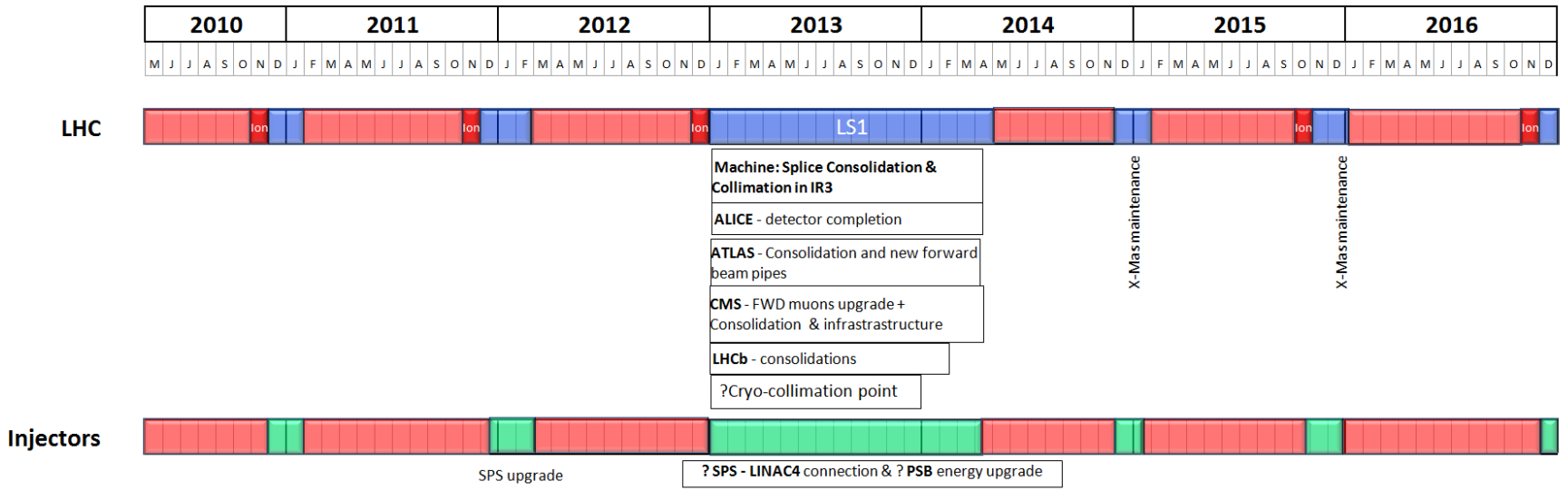
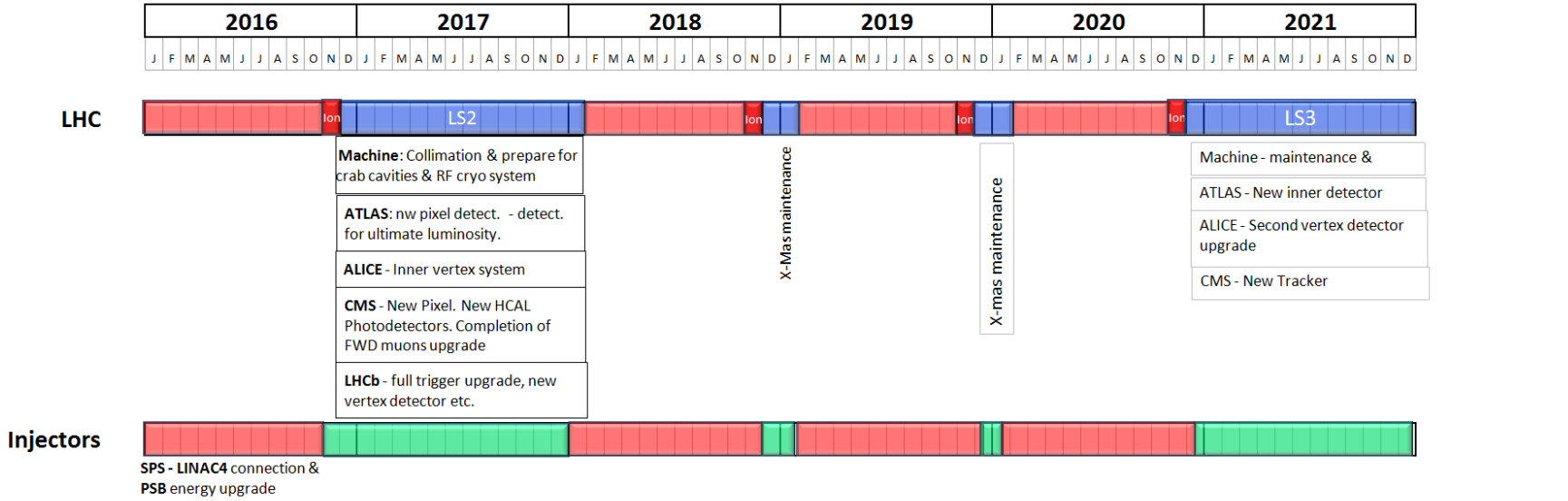
LS1 and LS2 Shutdowns

15th April 2011

FORMER Rough Draft 10 year plan



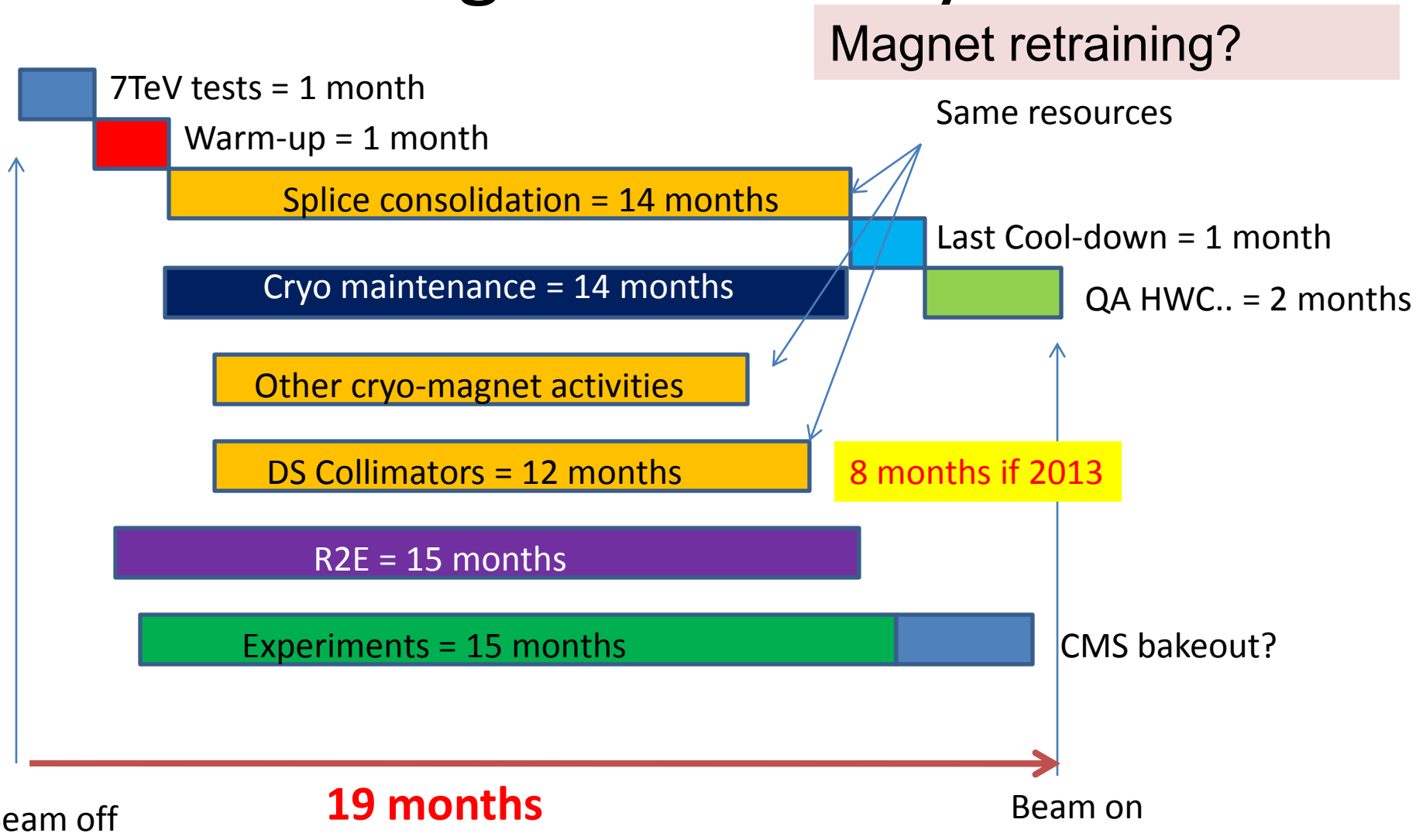


Priorities for 2013 shutdown

- Design energy (6.5-7TeV/beam)
  - splice consolidation
  - Repair of “weak” magnets
  - Magnet retraining
  - ?upgrade of experiments
  - ?R2E
- Design intensity
  - DS collimation system.
    - Risk:
      - Of doing it in 2013 with so much other work
      - if not in 2013 then not possible until 2017.
    - Can we operate 2014-2016 at design intensity without the DS collimation installation in IR3
    - Is it more efficient to construct BPM collimators
  - ?Upgrade of experiments
  - ?R2E

Do we need design intensity 2014-2016?

How long do we really need?



Allowing 14 months of work in the tunnel

Need to consider LS1 and LS2 together

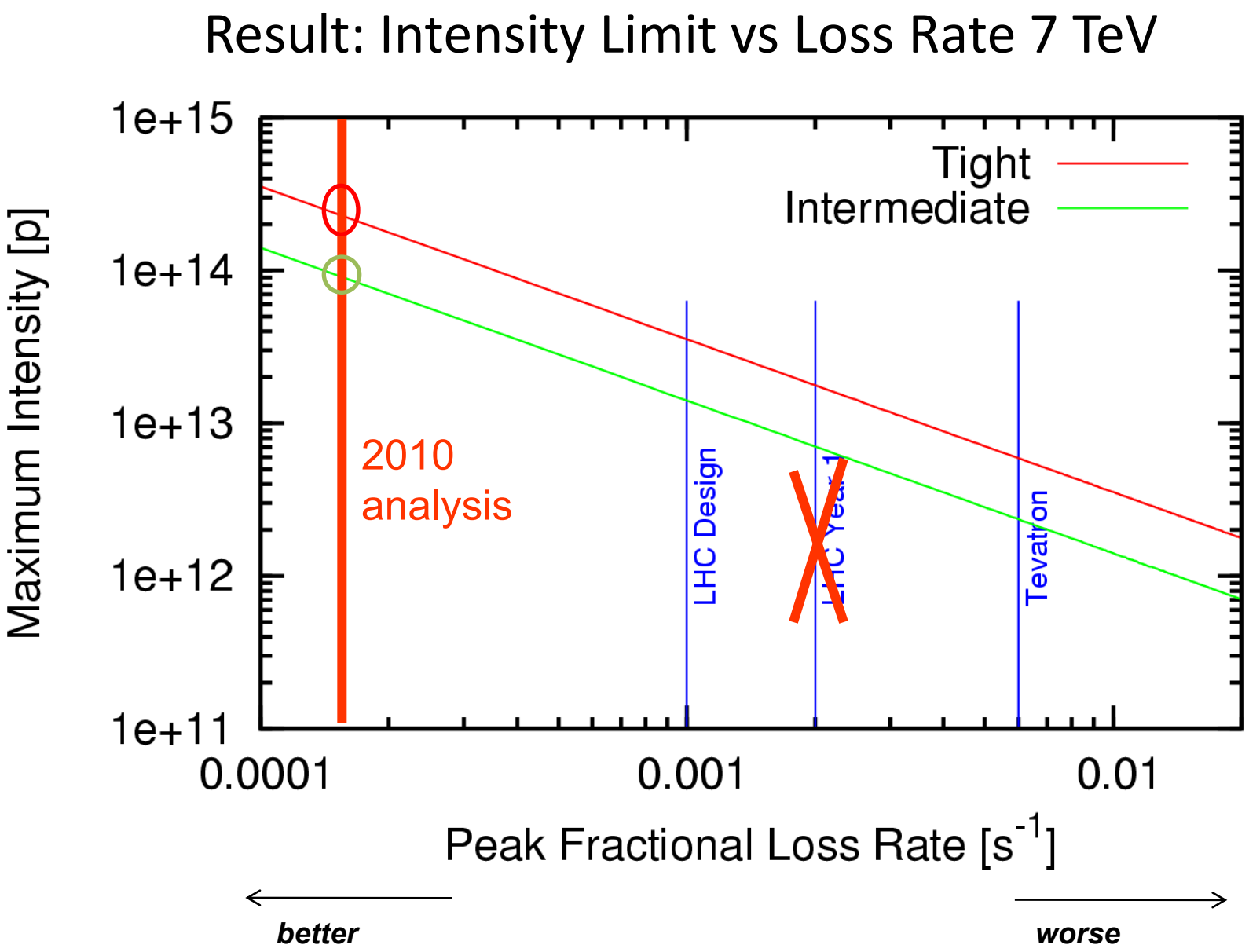
Manpower for Shutdown

- Detailed analysis is needed

Collimation in IR3

- Issues
  - What is the intensity limitation with the present collimation system?
  - Will the installation of the “cryo-collimation” system (in IR3 alone) improve the maximum possible intensity?
  - What is the risk involved in displacing the large number of sc magnets?
  - What are the consequences of delaying the installation in IR3 until LS2?
    - Machine performance in 2014, 2015, and 2016
    - Can the installation of all collimation systems be performed in LS2?

Collimation Intensity Limitations: OLD



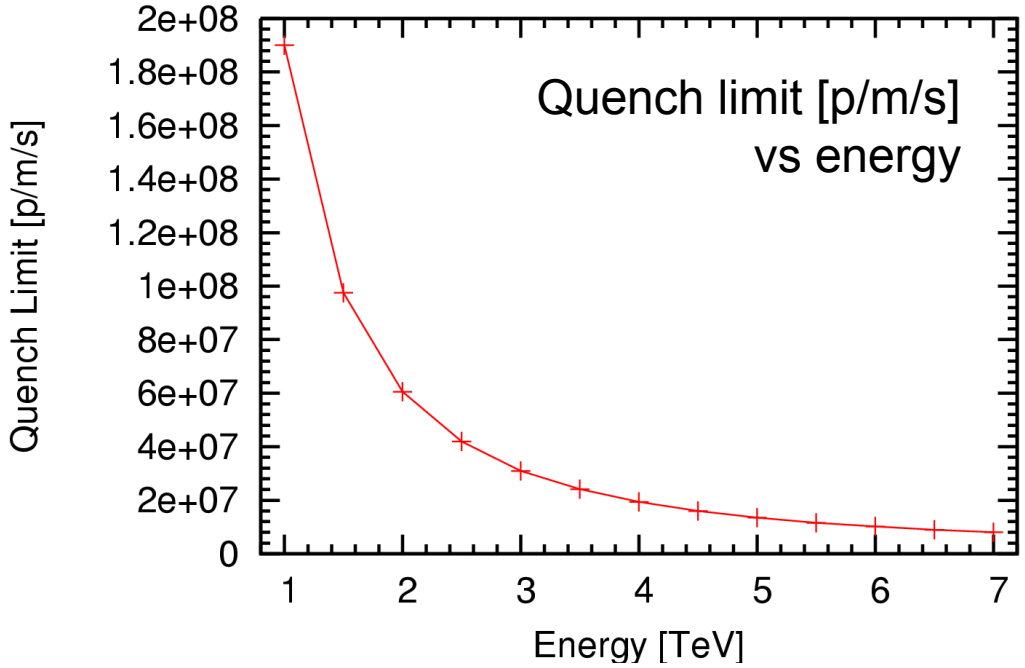
Model LMC March 2009 – Same Plot

Intensity Reach (from collimation)

At 6.5TeV and intermediate settings can reach 1e34 with emittance of 2um

Energy	p Intensity (max)	Ion intensity (max)
3.5 TeV	9.1e14	1.5e13 (q)
5.0 TeV	2.3e14	
7.0 TeV	0.9e14	

2.3e14



No predicted collimation limit on intensity at 3.5 TeV and 4 TeV!

Can imagine up to 2808 nominal or even ultimate bunches, if we only look at cleaning!

Analysis: Daniel Wollmann & Ralph Assmann,
see Daniel's Evian talk!

BUT! New analysis

31.3.2011

Memorandum

From: R. Assmann (Project Leader LHC Collimation)
To: S. Myers (CERN Director for Accelerators)

cc: F. Bordry, R. Bruce, O. Bruening, F. Burkart, P. Collier, B. Dehning, M. Lamont, A. Rossi, L. Rossi, R. Saban, D. Wollmann, F. Zimmermann

1) Executive Summary

The LHC collimation system is conceived as a phased system. The phase 1 system was completed for the LHC startup and is being used for the beam commissioning and operation at 3.5 TeV. Several improvements are under development to complete the system and to guarantee that nominal and ultimate beam intensities can be achieved. In particular, the LHC dispersion suppressors must be equipped with collimators to reduce losses into the super-

The results on the predicted performance reach are summarized in Table 1. Preliminary results based on best available data and analysis give (status March 31st, 2011):

- Intensity reach 6.5 TeV, achieved collimation settings: 1.2% - 5.0%
- Intensity reach 6.5 TeV, tight collimation settings: 3.7% - 15.3%
- Intensity reach 7 TeV, achieved collimation settings: 1.0% - 4.3%
- Intensity reach 7 TeV, tight collimation settings: 2.3% - 9.7%

Based on the present knowledge the **phase 1 collimation system seems optimistically adequate for 5% to 15% of nominal intensity at 6.5 – 7 TeV**. This is limited by losses into the dispersion suppressors of the cleaning insertions. We note:

- The extrapolation is based on very low statistics, namely 3 high intensity fills in 2010 and 6 measurements of cleaning inefficiency at 3.5 TeV.
- With respect to the 2010 analysis we loose a factor 9 in performance reach, based on two more accurate measurements of BLM response in 2011 (compare Figures 6 and 7 to Figure 5). The reason of the change is not understood and under investigation.
- The use of average measured efficiency requires more frequent collimation setups. These are possible with second-generation collimators. If not available, the worst measured performance over 6 measurements should be used, resulting in a factor 4 lower performance reach (see Table 1).

Table 6: Performance estimates for **6.5 TeV and tight collimator settings**. Extrapolation is based on the 3.5 TeV observations and the achieved intermediate collimator settings, extrapolated to 6.5 TeV. New 2011 results (still preliminary) are given in the last two columns. Statistical significance is low, as results are based on a statistics of 5 measurements. It is therefore advised to rely on the worst measured case, representing a probability of 20%.

Parameter	Symbol	Unit	2010 analysis	2010 analysis	2010 analysis	2011 analysis	2011 analysis
			Evian study (Wollmann et al) + update 6.5TeV extrapolation for efficiency	*... + worst measured effciency*	*... + average efficiency*	*average measured efficiency, lifetime with new average calibration, new 2011 BLM response factor*	*worst measured efficiency, lifetime with new worst calibration, new 2011 BLM response factor*
Measured minimum life time (3.5 TeV) over 5 fills	τ_{min}	[h]	1.3	1.3	1.3	0.51	0.29
Calculated quench limit at 6.5 TeV	R_q	[p/m/s]	8.8E+06	8.8E+06	8.8E+06	8.8E+06	8.8E+06
Calculated shower correction (7 TeV)	C_{FLUKA}	[m]	3.5	3.5	3.5	3.5	3.5
Setting BLM threshold factor	$C_{BLM\text{-}threshold}$		0.33	0.33	0.33	0.33	0.33
Measured inefficiency (3.5 TeV)	η_{lineff}		*4.0E-04*	*6.1E-04*	*2.6E-04*	*2.6E-04*	*6.1E-04*
Extrapolated inefficiency (6.5 TeV)	η_{lineff}		3.2E-04	4.9E-04	2.1E-04	2.1E-04	4.9E-04
Measured BLM response factor (3.5 TeV)	$C_{BLM,SC}/C_{BLM,TCP}$		3.6E-01	3.6E-01	3.6E-01	2.0E+00	2.0E+00
Calculated maximum intensity for 6.5 TeV	N_{max}	[p]	**4.1E+14**	**2.7E+14**	**6.4E+14**	**4.6E+13**	**1.1E+13**

Performance Estimates

Table 1: Summary of performance estimates as listed in detail in Tables 3 – 6.

Intensity Reach in % of Nominal Intensity (3e14 p)	Intensity reach 6.5 TeV, achieved settings	Intensity reach 6.5 TeV, tight settings	Intensity reach 7 TeV, achieved settings	Intensity reach 7 TeV, tight settings
2010 analysis	43.00%	137.00%	36.70%	86.70%
2011 analysis: average	5.00%	15.30%	4.30%	9.70%
2011 analysis: worst case with 20% probability	1.20%	3.70%	1.00%	2.30%

Limitation of luminosity to 6e32 (1404 bunches) or 1e33 (936 bunches)

2) Model for collimation intensity reach

The maximum intensity N_{max} reachable in the LHC is a function of the cleaning inefficiency η_{ineff}, the minimum beam lifetime τ_{min} during the fill and the quench limit R_q:

$$N_{max} \approx \frac{\tau_{min} \cdot R_q}{\eta_{ineff}}$$

In practice, this formula needs to be extended by some constants that reflect the distribution of losses (C_{FLUKA}), the fact that BLM thresholds are set below the quench limit ($C_{BLM\text{-}threshold}$) and the different response of BLM's at super-conducting magnets and collimators ($C_{BLM,TCP}/C_{BLM,SC}$). The formula then becomes:

$$N_{max} \approx \frac{\tau_{min} \cdot R_q}{\eta_{ineff} \cdot (C_{BLM,TCP}/C_{BLM,sc})} \cdot (C_{FLUKA} \cdot C_{BLM-threshold})$$

New rough draft 10 year plan