Experiments desiderata

Anders Ryd for Massimiliano Ferro-Luzzi
on behalf of the LHC Experiments

- where we stand, what we wish
- luminosity / pile-up requirements, other parameters
- projections
- special physics requests

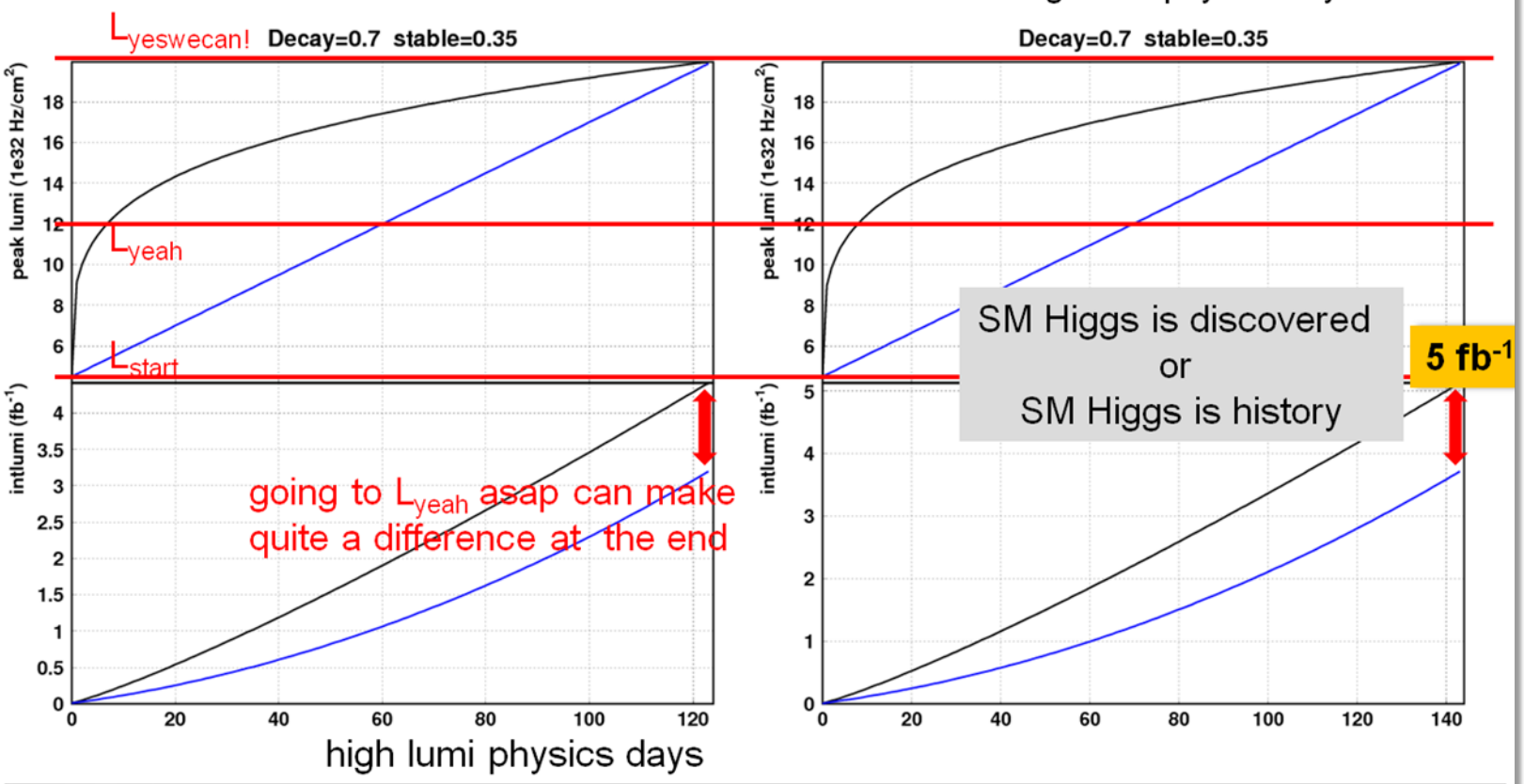
One of these silly slides shown at Chamonix 2011

Pro-jection

(This was the aggressive projection)

- Suppose: L_{start} = 4.5e32 L_{yeah} = ~1.2e33 $L_{yeswecan!}$ = 2e33
- 124 days high lumi physics days
  - 35% of that in stable beams, decay factor 0.7

144 high lumi physics days



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And now it looks like this

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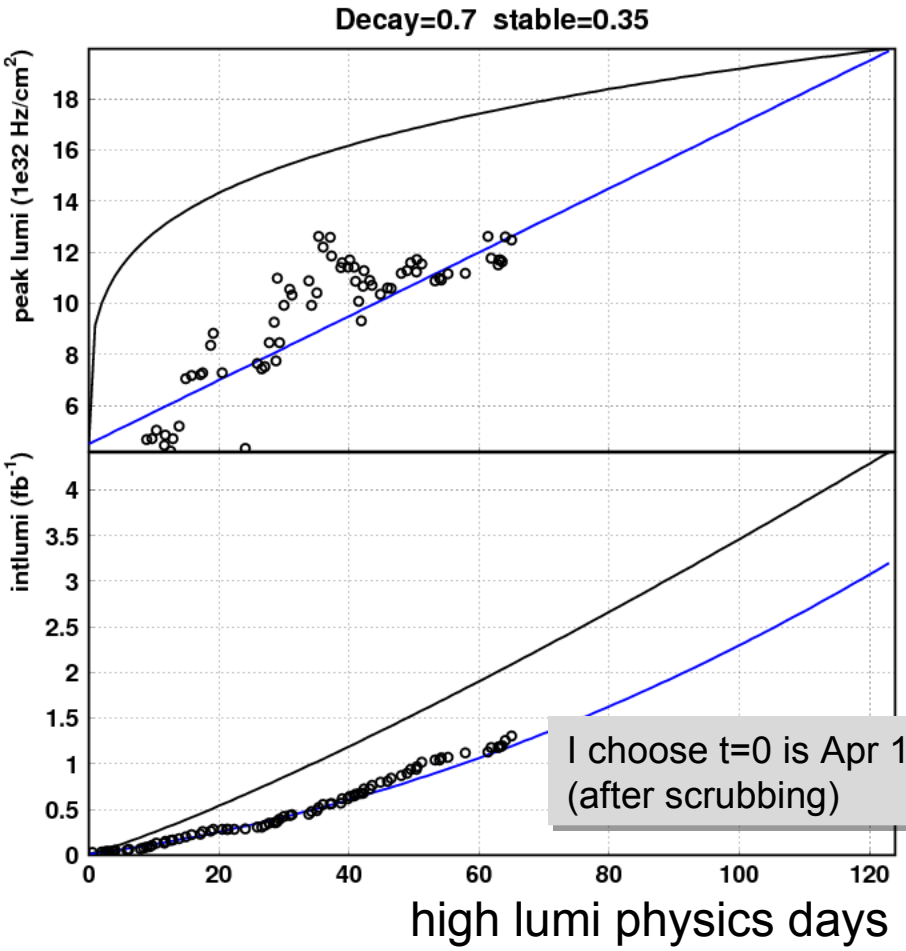
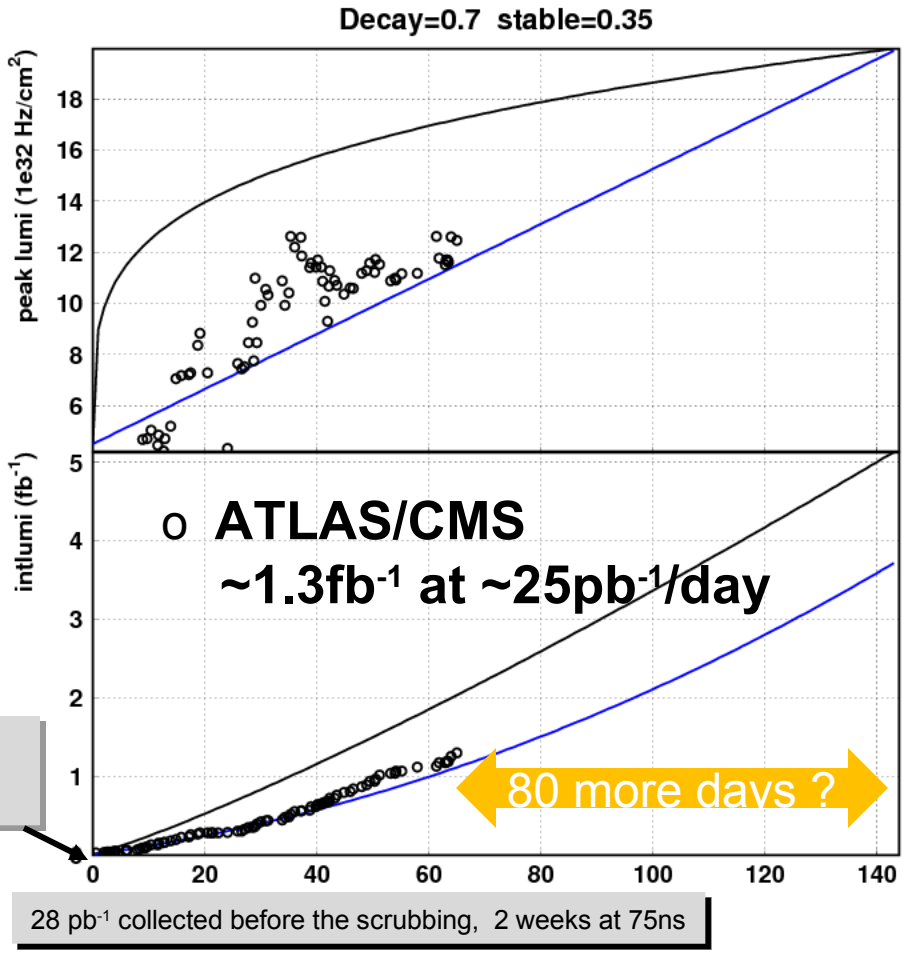
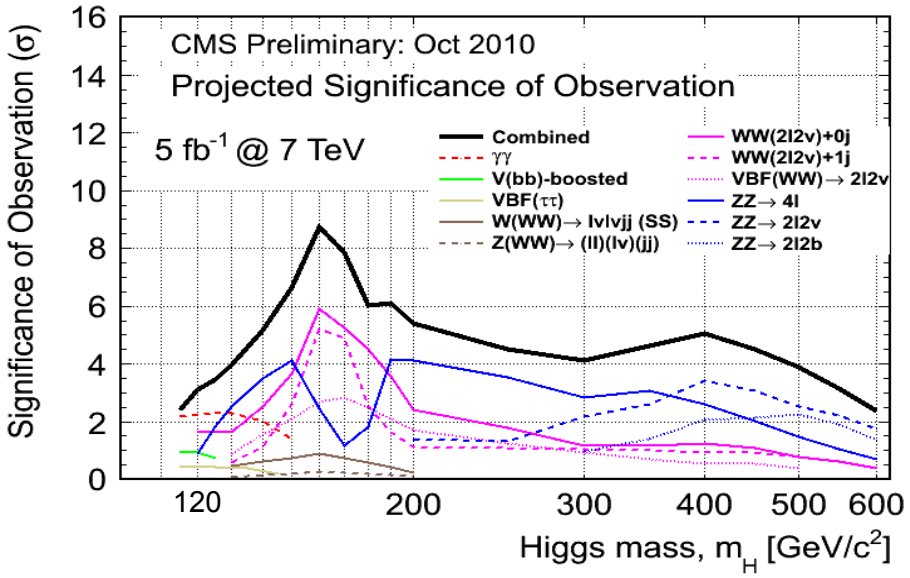


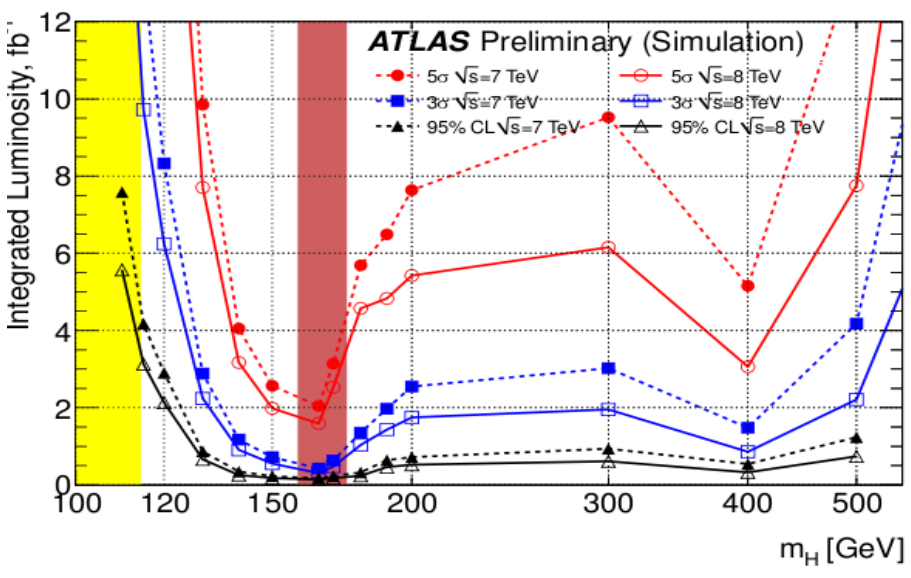


I choose t=0 is Apr 13 (after scrubbing)

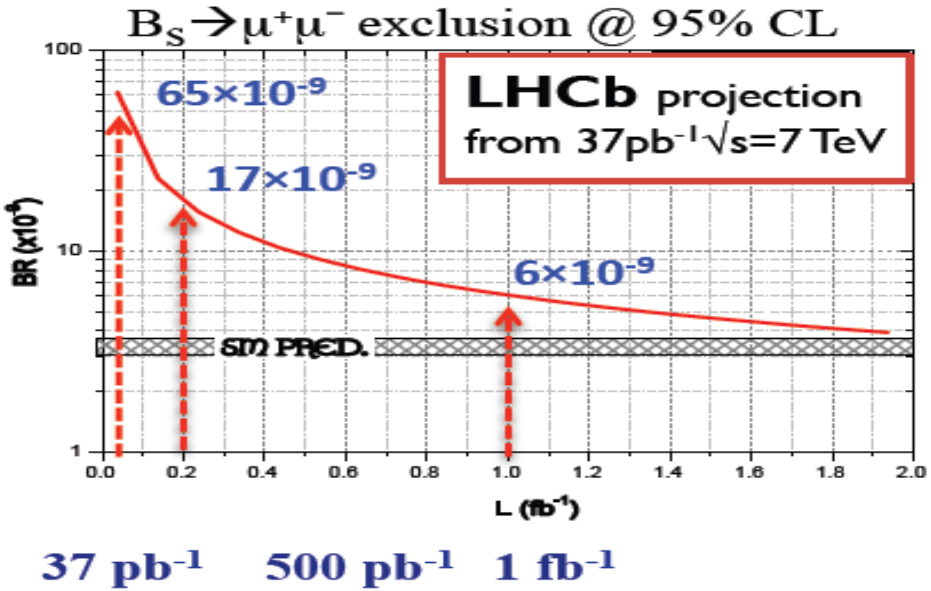
28 pb^{-1} collected before the scrubbing, 2 weeks at 75ns

Physics Reach





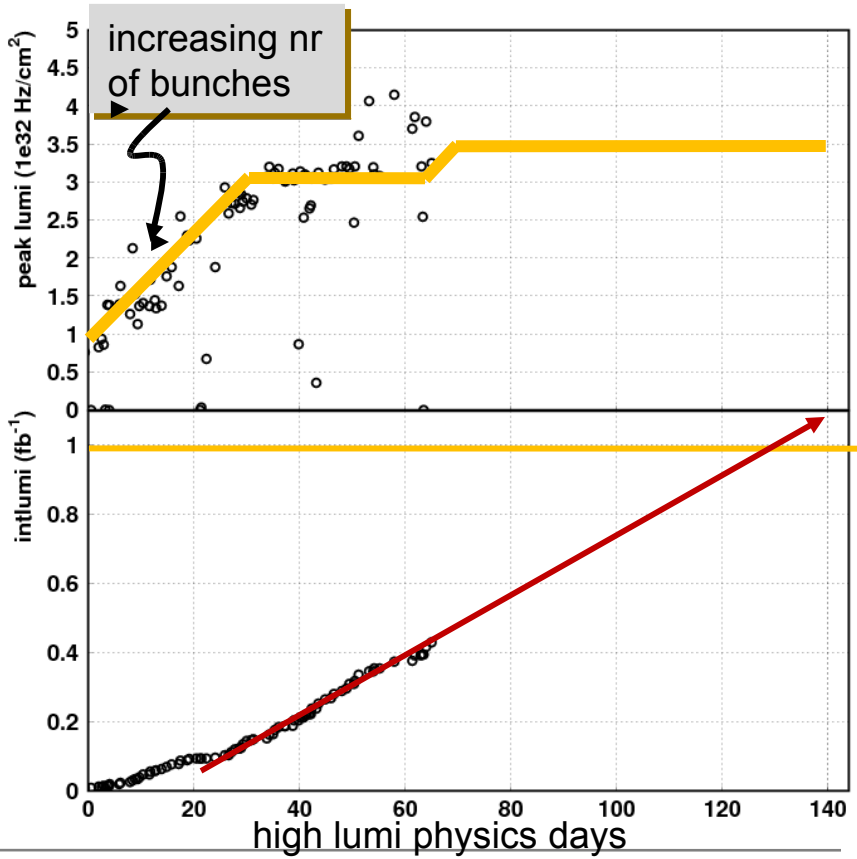
ATLAS + CMS	95% CL exclusion	3σ sensitivity	5σ sensitivity
1 fb^{-1}	120 - 530	135 - 475	152 - 175
2 fb^{-1}	114 - 585	120 - 545	140 - 200
5 fb^{-1}	114 - 600	114 - 600	128 - 482
10 fb^{-1}	114 - 600	114 - 600	117 - 535



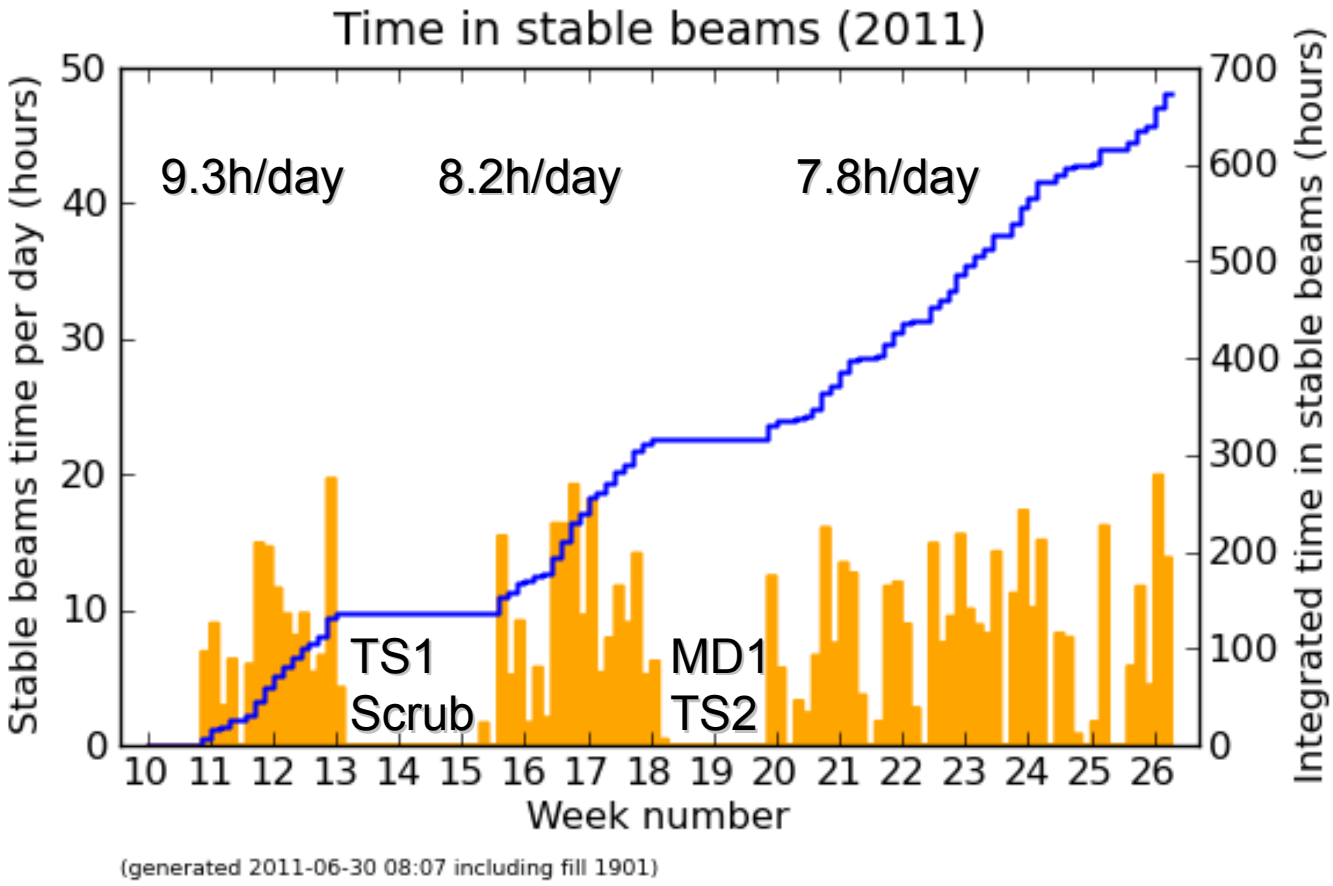
- LHCb will probe the standard model range with 1 fb^{-1} in $B_s \rightarrow \mu^+\mu^-$.

LHCb

- Leveling is a success: gives an extra factor 1.4 on integrated lumi
- LHCb working hard to push upward the working point
  - Operated at 3e32Hz/cm^2 in June, tested up to 4e32Hz/cm^2 and will run at 3.5e32Hz/cm^2 this summer
  - NEED LARGEST POSSIBLE NR OF COLLIDING PAIRS (to keep pile-up under control)
  - NEED LARGEST NR OF HOURS
- Status: ~0.4 fb^{-1} , 9 pb^{-1} / day
- Exceeding the 2011 target of 1 fb^{-1} remains a challenge, though a sensible one.



The rule of thumb



1 day of physics operation for 8h of stable beams

Wishes-to-expectations conformal theory

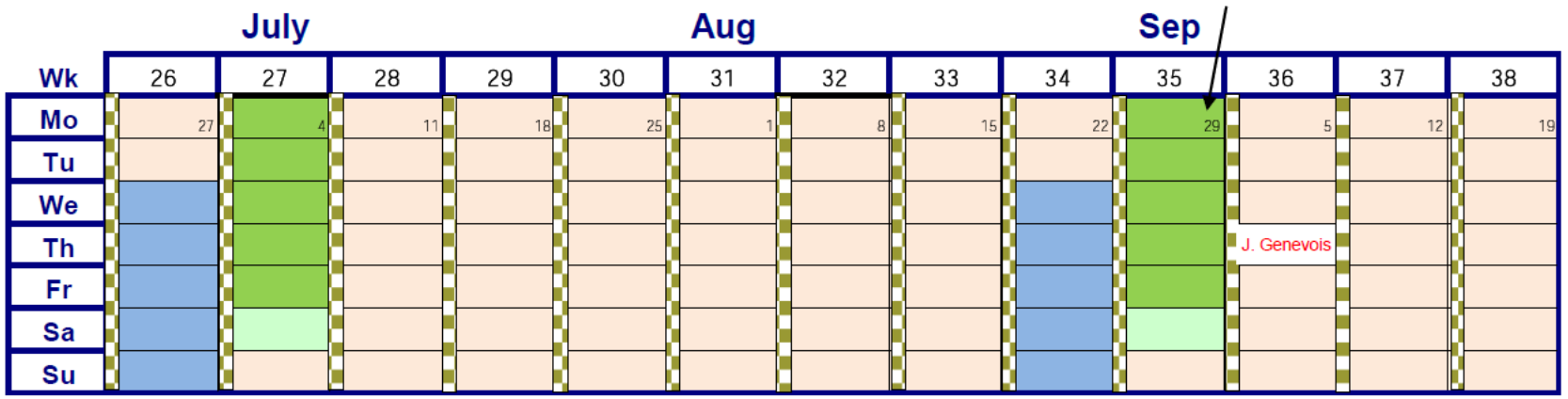
- From the previous slide, everybody think now that
  (with 90 more days of high luminosity physics, see later)

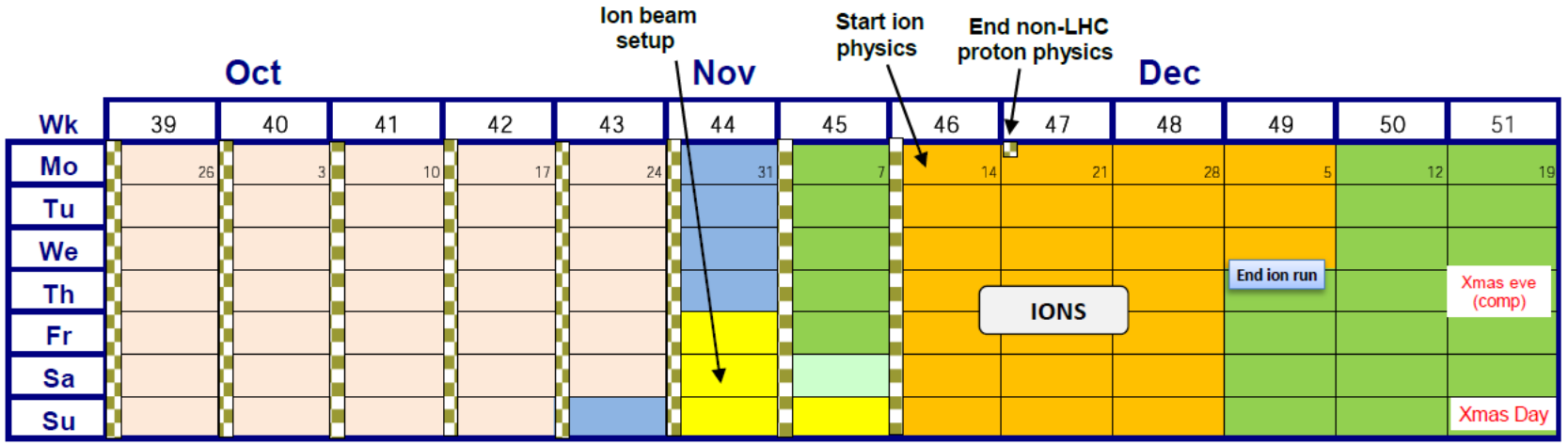
  4 fb^{-1} delivered to IP1 and IP5 each

  1 fb^{-1} delivered to IP8

  are realistic wishes (and even more seems achievable!).

  Thus, any change (improvement) of LHC operation should be considered in the light of these (now realistic) integrated luminosity expectations for 2011.
  Setup time to be balanced with gain in integrated lumi.





- pp physics operation: 101 days
- Post-TS ramp up: 2 x 2.5days
- Special physics: 6 days ?

90 days of high lumi operation

-2 days of floating MD ?

Wishes from experiments: luminosity / pile-up

- In general:
  - Maximum integrated luminosity L_{int}
  - For same integrated luminosity, prefer less pile-up

we assume that μ increases gradually (not in one step)

- ATLAS / CMS:
  - Main aim: maximize L_{int}, push instantaneous luminosity, but without compromising high machine efficiency
  - An extended physics period up to 3e33 before further increase seems like a reasonable strategy
  - Pile-up: might become a challenge when μ > 25
    - Want to explore highest possible PU at end of run

μ = average number of inelastic interactions per bunch crossing (now = ~7 in IP1/5)

- LHCb:
  - Maximize L_{int} , i.e. maximize running time
  - Instantaneous luminosity: run at fixed value, ~3.5e32 Hz/cm^2 ,
    - no luminosity decay, continue with leveling (great, so far !)
  - Pile-up: μ < 2.5
- ALICE:
  - Maximize L_{int} , i.e. maximize running time
  - Instantaneous luminosity: 5e29...5e30 Hz/cm^2 , but
  - Pile-up: μ < 0.05

Special physics activities

		machine-available time
❑ 90m third fill	=> around Sep TS4/MD3	~8h
❑ 90m n x physics fill	=> TBD	n x ~8h

will be discussed with the experiments early Sep

❑ TOTEM/RPs 147m	=> not before Sep TS4	~8h
❑ ALICE field reversal	=> not before Sep TS4	~16h
❑ precise lumi calib	=> not before Sep TS4	2 x ~8h
❑ 25ns physics fill	=> not before end of Sep	~8h

Remember the rule of thumb: 8h of m.a.time = 1 real day of operation

Some of these will have to be dropped / reduced

Integrated luminosity: what will you push ?

$$L_0 = \frac{f_{rev}\ k_b\ N^2}{4\pi\ \beta^*\ \varepsilon_T}$$

$$L = \int L(t)dt \cong L_0\ \tau\ (1-e^{-t_{sb}/\tau})\ \frac{T_{hlp}}{t_{pr}+t_{sb}}$$

Times:
pr=preparation
sb=stable beams
hlp=high lumi physics

- Physics time and k_b: these do not increase pile-up
- While N, β^* and ε_T all do increase pile-up
- Increasing N: fairly small setup time ? (adiabatic changes)
- Reducing ε_T : fairly small setup time ? (adiabatic changes)
- Reducing β^* : how much setup time ?
  - Gain in peak lumi to be balanced with commissioning time => intLumi L
  - Perhaps profitable for next year's planning and perhaps for 2011 ion run
  - For LHCb: no gain from smaller β^*, can only give a loss => 1 fb^{-1} in danger ?
- k_b => 25ns: how much setup time ?
  - 25ns operation is profitable for all expts, **if can achieve same L**
  - Lumi production at 25ns for this year seems inadequate
    - estimate for scrubbing time? some experiments might need time to adapt?
  - Expts wish for **at least one stable beams fill**, but toward end of run
    - prepare for possible use of 25ns during next year's physics production

In Summary

- **LHC routinely operated at >1e33 machine since mid May**
  - 2011 goals for IP1/5 already achieved!
  - 8h stable beams per day (room for improvement ?)
- **Prospects for >1 fb^{-1} at IP8 and >4fb^{-1} at IP1/5 look very good**
- The experiments would favour increasing the luminosity by those means which have the least cost in hours of stable beams

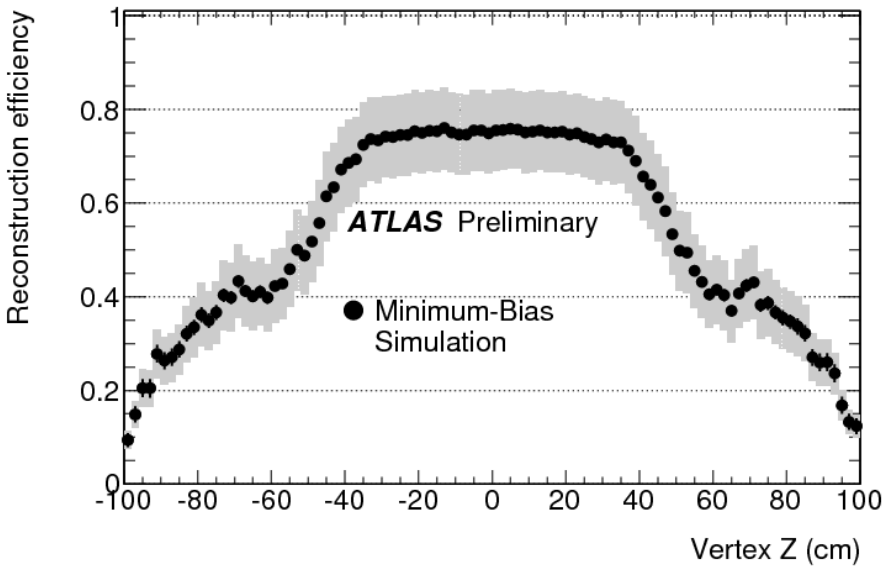
- This probably means:
  - Maximize physics operation time (machine availability)
  - Reduce ε_T (50ns double batch...)
  - Increase bunch charge

- Reducing β^* and increasing k_b (25ns): keep it "exploratory" in view of 2012 and ion run, to be carefully balanced with impact on integrated luminosity

Backup

Bunch length increase ? (1ns → 1.5 ns ??)

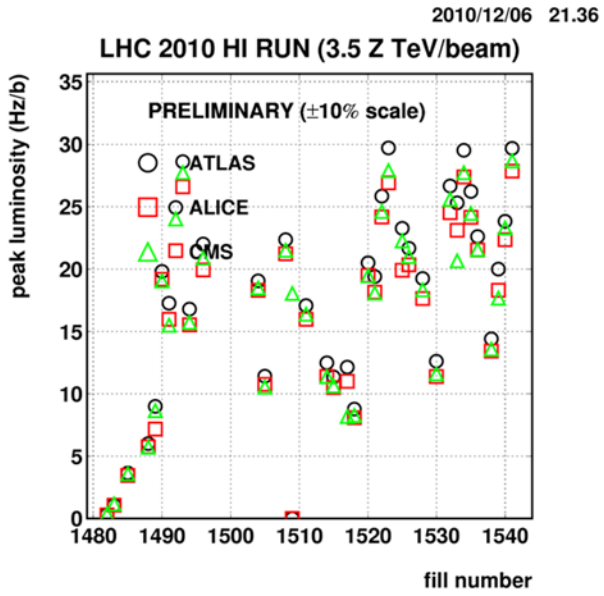
- Possible benefits for machine performance:
  - less resistive losses (cryo, kicker, collimators ?)
  - less intra-bunch scattering (compensate for decrease in ε_T)
- For the experiments?
  - reduction in acceptance ?
  - better separation of vertices ?

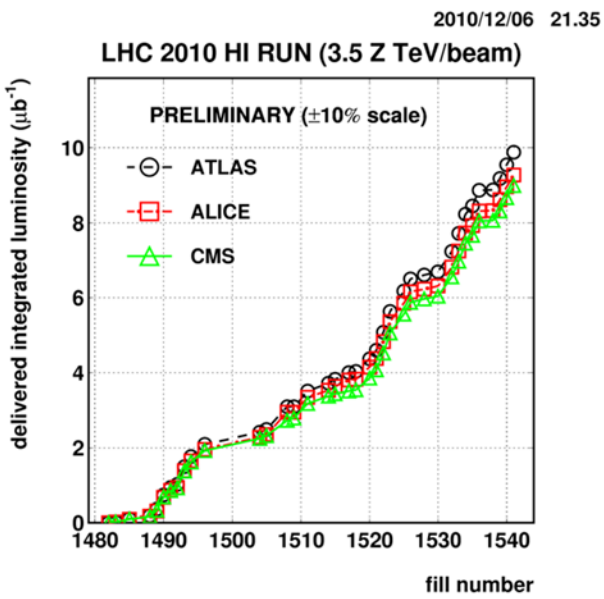


Ions in 2011

- Had no time to discuss
- Will pick this up at mid August

Pb run: Goals for 2011





30 μb^{-1} delivered to each of IP1, IP2 and IP5 at 3.5 TeV

(or higher energy) sounds like a reasonab

- quadruple statistics
- $\beta^* = 1.5$ m or smaller ? L x 2.3
- nominal scheme L x 2-5 ? N/ε_N loss ?

p-A test in 2011 is much welcome (for physics in subsequent ion run)

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LHCb is discussing presently to run during ions (few colliding pairs).

Post-TS intensity ramp up

- How will the LHC reach previously established maximum luminosity after a technical stop ?

- From rMPP 28.06.2011:
  - test ramp with a pilot
  - physics fill with 2x2 nominal bunches
    - also loss maps ?
  - physics fill with ~50 nominal bunches
  - physics fill with ~260 nominal bunches
  - physics fill with ~850 nominal bunches
  - back to 1380 bunches

Total:
~4x5h of
machine-available time,
i.e. 2.5 days of operation

These can all be short
(1-3h stable beams for the expts to collect some data and check out the detectors ?)