



Operational schedule 2011 & potential performance

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Assumed beam parameters for Physics fills

Beam parameters	
Energy	4 TeV – (3.5 TeV considered)
β^* : IP1 – 5 – 2 – 8	1.5 – 1.5 – 10 – 3 m for 2.5 μm
Separation (Injection)	± 2 mm
Separation (Physics)	± 0.7 mm (reduction during the ramp)
B1 $\frac{1}{2}$ external crossing angles (Inj.)	± 170 μrad (all IPs)
B1 $\frac{1}{2}$ external crossing angles (Phys.)	+120 μrad (IP1&5); ± 80 μrad (IP2); - 235 μrad (IP8)

Others:

- b-beat corrected as last year and stable
- Same orbit control as last year – better than $\pm 0.2\text{mm}$
- Prepare squeeze to go to ultimate value - “easy” squeeze extend when needed
- Non-stop squeeze (after beam re-commissioning)
- Note1: Numbers to be qualified by loss maps after the protection device setting-up
- Note2: Aperture measurements to be done at high energy (maybe more/less margin)
- Note3: Other matched optics needed for possible β^* - to be prepared



Beam parameters - cont'd

@ 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 [μm]	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 [μm]	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



How long to re-commissioning?

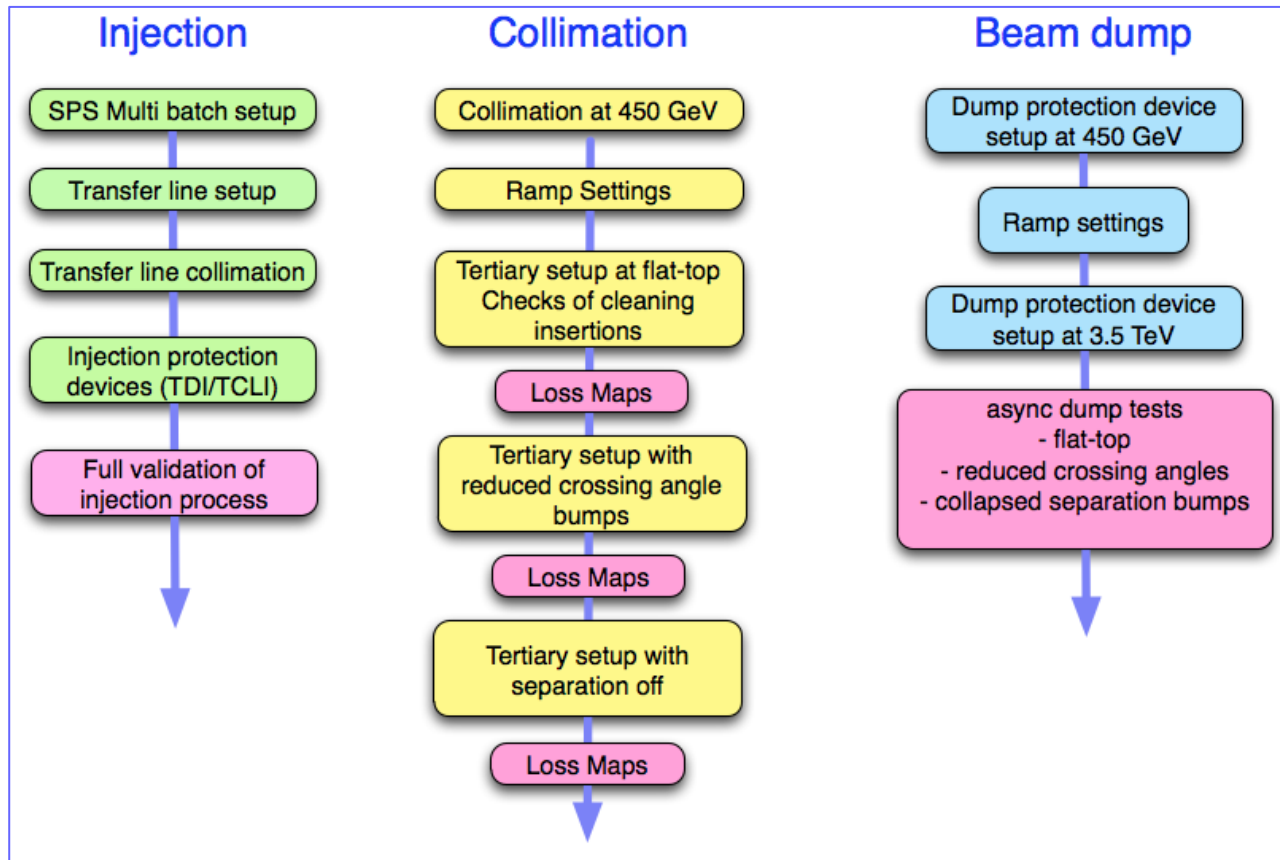
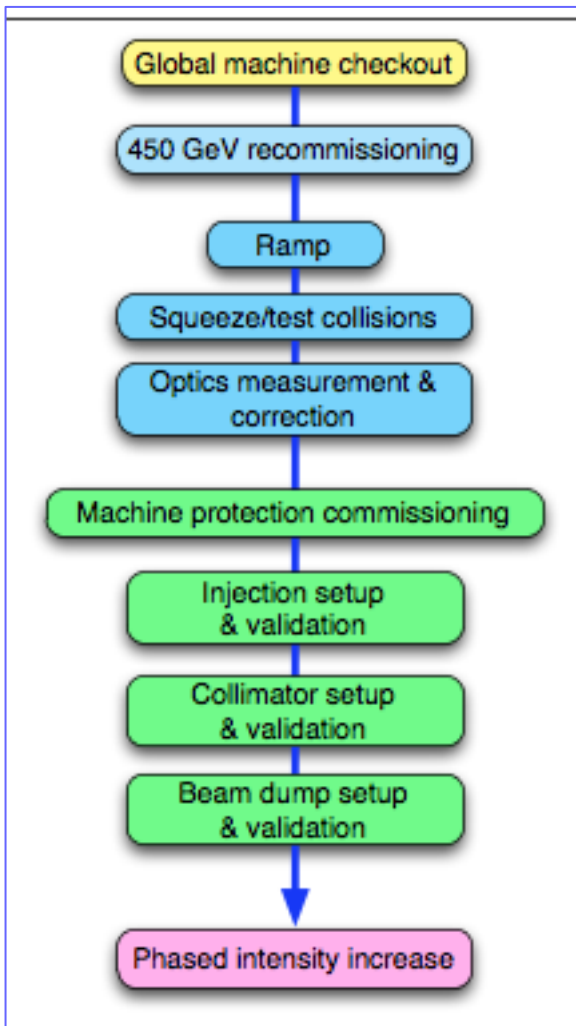
- Starting settings commissioning from scratch
- Regenerate virgin ramp & squeeze (to 1.5 m)
- Cut and paste in relevant experience
- Commission ramp and squeeze
- Full revalidation of LBDS with beam
 - Specific tests also for 4 – 4.5 TeV (BETS, protection)
- Re-set-up collimation and full re-validation
- Machine protection tests with beam
- Configuration and tests of feedbacks, transverse damper, RF etc...

If we start at a higher energy:
squeeze will be fully optimized and commissioned for said energy with
optimum beta* etc.

Switching energy at mid-run will cost extra ~2-3 weeks commissioning



Re-commissioning in 2011



starting 2011 at a new energy would be almost cost free (given, of course, readiness of circuits, QPS etc.)

~3 weeks



Strategy for intensity ramp-up

Intensity steps:

- Before scrubbing run

~50b steps to monitor the pressure and instabilities

~50 (4x12b) - ~100- ~150- ~200- ~250- ~300

Only one fill if all O.K.

~2 weeks

- After scrubbing run:

300 – 400 – 600 – 800 – 900

3 fills + 20 hours stable beams per step for MP and OP qualification

~2.5 weeks

.... Depending on observations

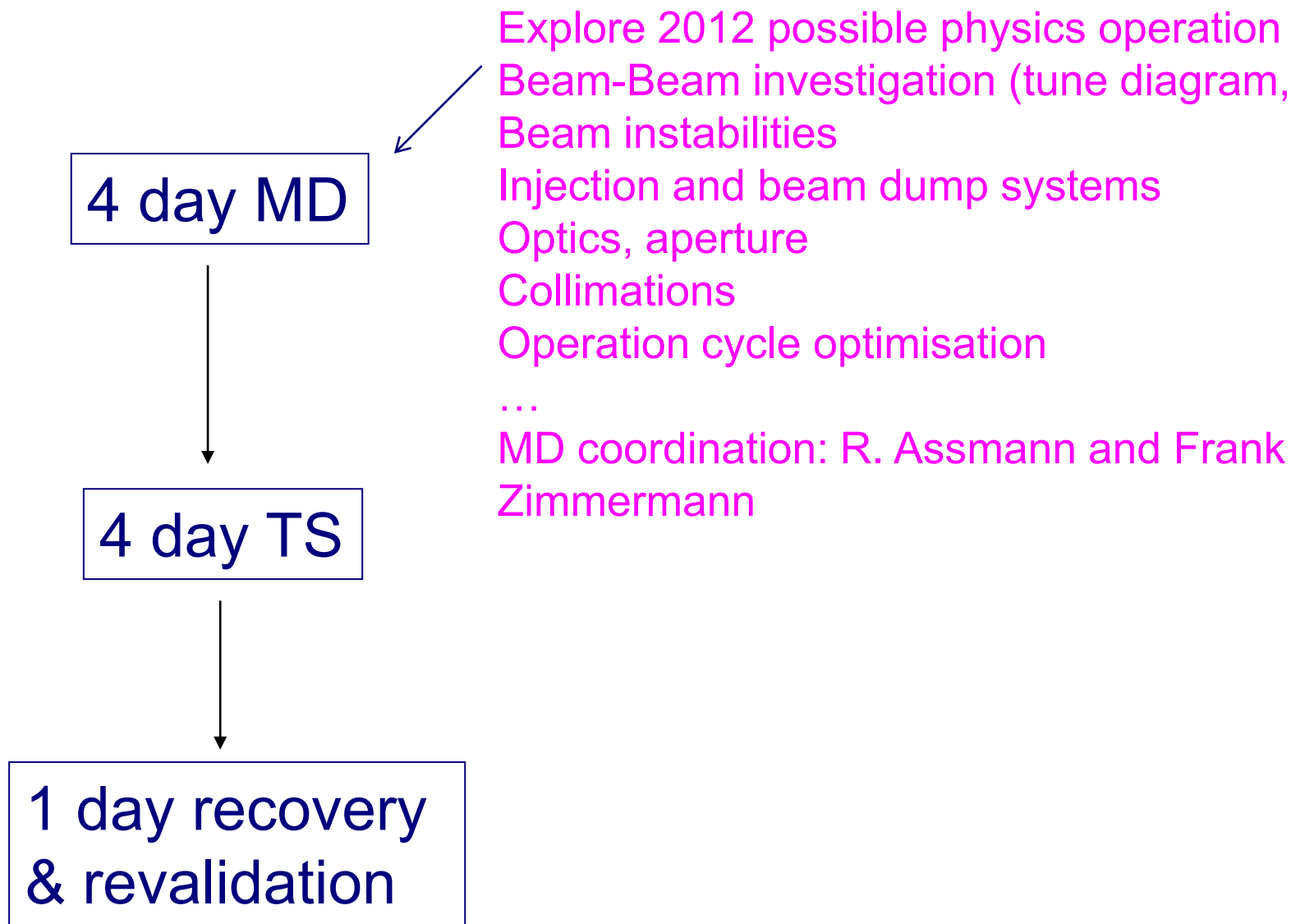
summary special requests from Experiments - Massi

- ❑ E=1.38TeV run
 - 3 shifts setup
 - 35h in stable beams
- ❑ 90m optics
 - 5 shifts MD/setup
 - 4 fills in stable beams
- ❑ dedicated lumi calibration
 - 2 fills in stable beams
 - some “eof” studies

~ 10 days



TS – MD: proposal





Days for Luminosity operation

Item	Days
Total proton operation	264
5 MDs (4 days)	- 20
6 TS (4+1 days)	- 30
Special requests	- 10
Commissioning	- 20 to -30
Intensity ramp up	- 30 to -40
Scrubbing run	- 10
Total High intensity	124 to 144 (135 days for integrated L)

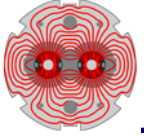
MPS checks with beams ~ 10 days (impressive list of changes, checks needed! injection, collimators, LBDS ...)

HWC : one extra week needed for 4 TeV operation – Mirko Pojer



Start up scenari

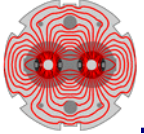
- ❑ **75 ns beam re-commissioning – Scrub with 50 ns – 75 ns operation**
 - ❑ Recommissioning with 75 ns bunch spacing - 3 w
 - ❑ Increase bunch number (~300b?) – 2 w
 - ❑ Scrub when needed - 1.5 w
 - ❑ Resume 75 ns operation and increase bunch number -2.5w
300 – 400 – 600 – 800 – 936 - MP and OP qualification –
 - ❑ Physics operation 75 ns – 936 b
 - ❑ Back up: restore 150 ns operation – couple days
- ❑ **150 ns beam re-commissioning – Scrub with 50 ns – 75 ns operation**
- ❑ **50 ns beam re-commissioning – Scrub with 50 ns – 75 ns operation**
- ❑ **50 ns beam re-commissioning – Scrub with 50 ns – 50 ns operation**



Estimated Peak and Integrated Luminosity

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

day s	H.F	Comm with	Fills with	kb	Nb e11	ϵ μm	ξ /IP	L Hz/cm ²	Stored energy MJ	L Int fb ⁻¹ 4 TeV	L Int fb ⁻¹ 3.5 TeV
160	0.3	150 ns	150 ns	368	1.2	2.5	0.006	~5.2e32	~30	~2.1	~1.9
135	0.2	75 ns	75 ns	936	1.2	2.5 2 1.8	0.006 0.007 0.008	~1.3e33 ~1.6e33 ~1.8e33	~75	~3 ~3.8 ~4.2	~2.7 ~3.3 ~3.7
125	0.15	50 ns	50 ns	1404	1.2	2.5	0.006	~2e33	~110	~3.2	~2.8

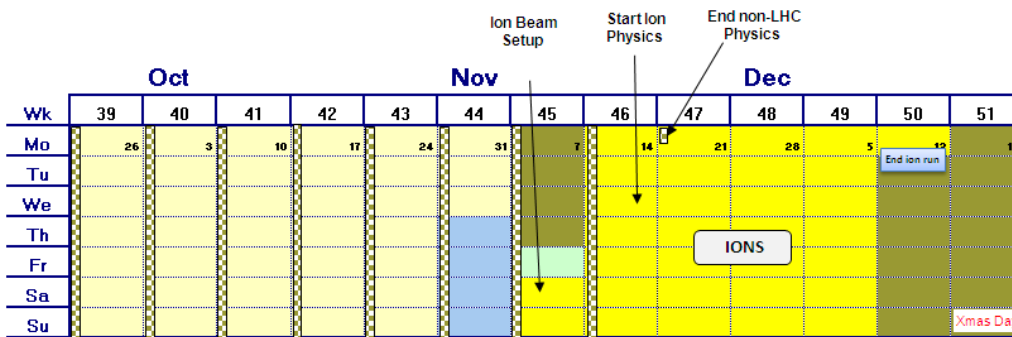
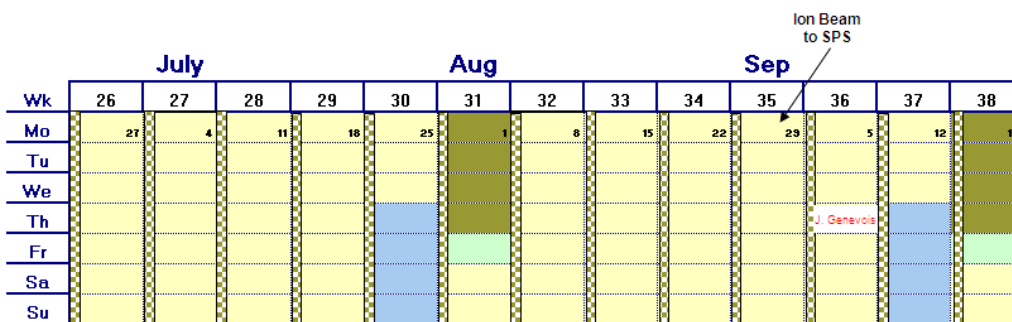
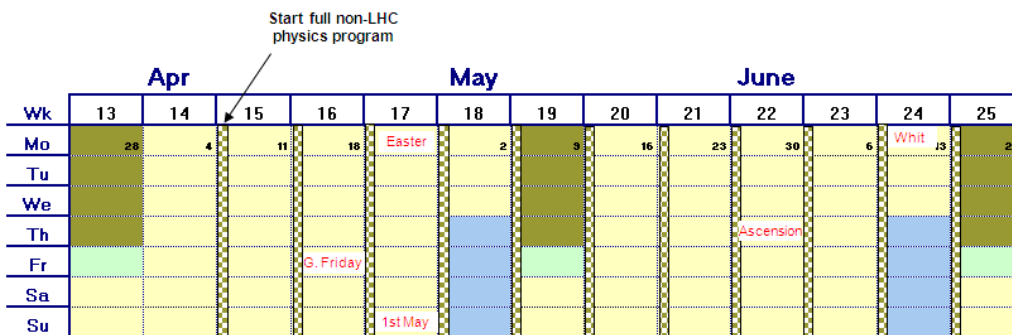
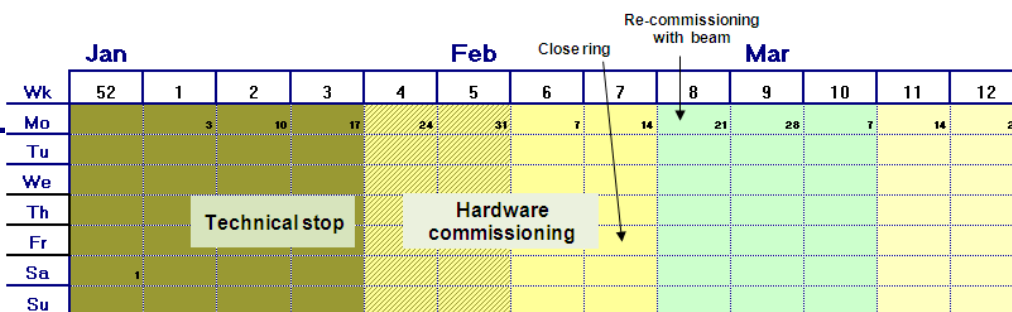


Estimated Peak and Integrated Luminosity

day s	H.F	Bunch spa- cing	kb	β^*	Nb e11	ϵ μm	ξ/IP	L Hz/cm ²	Store d energ y MJ	L Int fb ⁻¹ 4 TeV	L Int fb ⁻¹ 3.5 TeV
135	0.2	75 ns	936	1.5	1.2	2.5	0.006	~1.3e33	~75	~3	~2.7
						2	0.007	~1.6e33		~3.8	~3.3
						1.8	0.008	~1.8e33		~4.2	~3.7
135	0.2	75 ns	936	1.3	1.2	2.5	0.006	~1.5e33	~75	~3.5	~3.
						2	0.007	~1.9e33		~4.3	~3.8
						1.8	0.008	~2e33		~4.8	~4.2

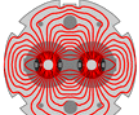


2011 LHC schedule



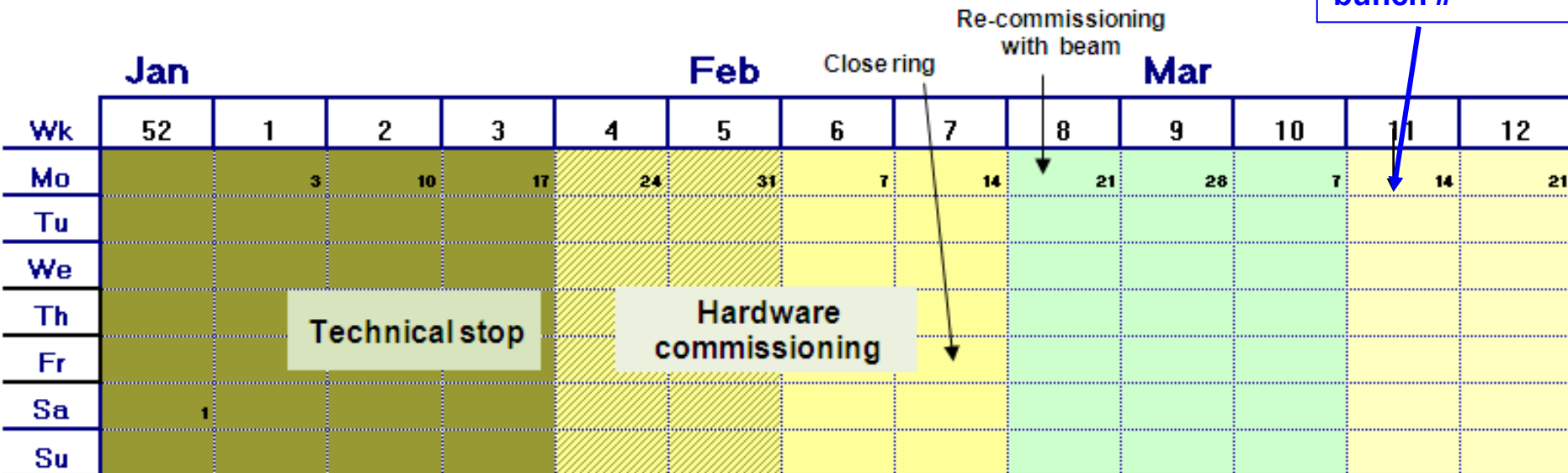
End of year planned anticipating shutdown in 2012 - will stop earlier if run in 2012 is confirmed.

- Technical Stop
- Re-commissioning with beam
- Machine development
- Ion run
- Ion setup
- Injectors - proton physics



2011 LHC schedule

Physics 75ns with increasing bunch #

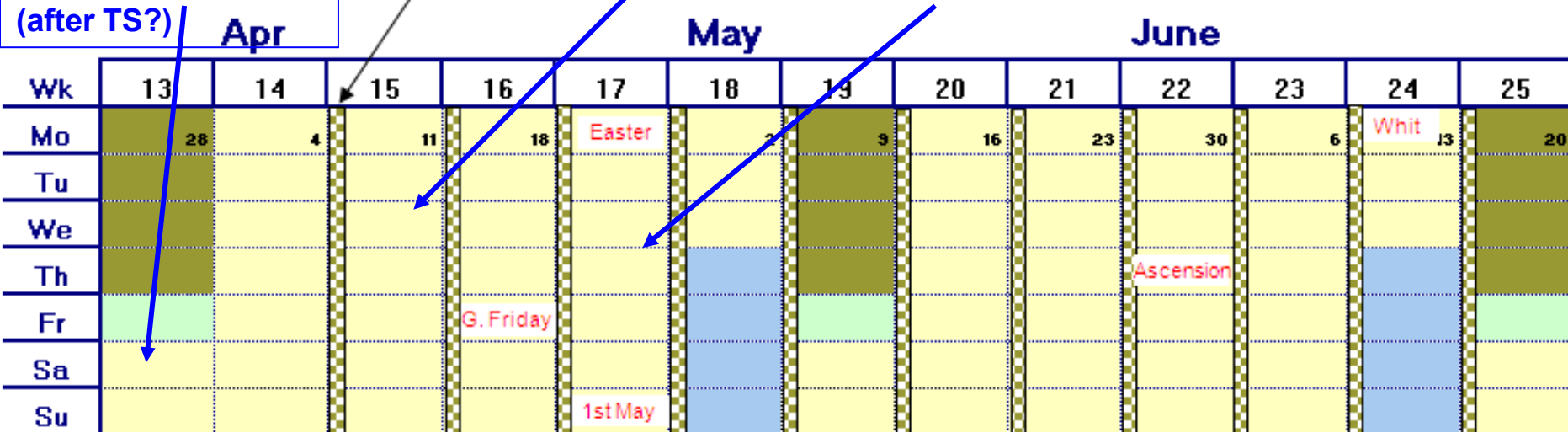


Scrubbing run when needed with 50ns (after TS?)

Start full non-LHC physics program

Going by steps towards 900b, 75ns

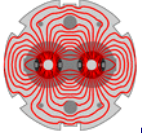
Physics with 900 b

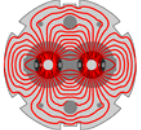




Summary

- Re-start the LHC with 75 ns (gain right away experience with the 2011 mode of operation for Physics, injectors)
Start / run with emittance $\sim 2 \mu\text{m}$ at 450 GeV
- Push the number of bunches and then perform scrubbing run when needed with 50 ns
- Not given yet ...
- Luminosity of $10^{33} \text{ cm}^{-2} \text{ s}^{-1}$ is at reach with 75 ns beams
- Integrated Luminosity $\sim 2\text{-}3 \text{ fb}^{-1}$ (~ 135 days of Physics)





4 TeV – 75 ns / 50 ns – H.B.~ 0.2 – scaled for 100 days of Physics operation:

Physics with	H.F.	β^* m	kb	Nb 10^{11}	ϵ μm	ξ/IP	L Hz/cm^2	L Int fb^{-1}	Stored energy MJ
75 ns	0.2	1.5	936	1.2	2.5	0.006	$\sim 1.3\text{e}33$	~ 2.3	~ 75
50 ns	0.2	1.5	1404	1.2	2.5	0.006	$\sim 2\text{e}33$	~ 3.4	~ 110
50 ns	0.2	1.5	1404	1.6	3.5	~ 0.005	$\sim 2.5\text{e}33$	~ 4.3	~ 145



Start up scenari

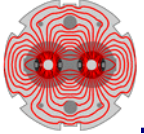
150 ns SCENARIO		
Beam re-commissioning with 150 ns	injection, ramp, squeeze, collide, fdbs, collimators, MP from pilot to ~100 bunches	3 weeks
Physics fills up to 450 bunches	increase bunch number: 200, 300, 450	2 weeks
Beam scrubbing at 450 GeV, 50 ns	prepare injection for scrubbing and scrubb for one full effective week	1.5 weeks
Physics with 75 ns up to 900 bunches	increase bunch number: 200, 400, 600, 800, 900	2.5 weeks
Physics operation with 75 ns and 900 bunches		
Physics operation: back up with 150 ns 450 b		1 day
75 ns SCENARIO		
Beam commissioning with 75 ns	injection, ramp, squeeze, collide, fdbs, collimators, MP, from pilot to ~100 bunches (824b at 450 GeV)	3 weeks
Physics with 75 ns from ~100 to ~x00? bunches	increase bunch number: 150, 200, 250, 300?	2 weeks
Beam scrubbing at 450 GeV, 50 ns	prepare injection for scrubbing and scrubb for one full effective week	1.5 weeks
Physics operation with 75 ns up to 900 bunches	Increasing number of bunches from 300 ?-400-600-800-900	2 weeks
Physics operation with 75 ns and 900 bunches		
Back-up: Restore operation with 150 ns	increase bunch number from xxx to 450	1 week
50 ns SCENARIO		
Beam commissioning with 50 ns	injection, ramp, squeeze, collide, fdbs, collimators, MP, from pilot to 108 bunches	3 weeks
Beam scrubbing at 450 GeV, 50 ns	prepare injection for scrubbing and scrubb	1.5 weeks
Sub-scenario 1		
Physics with 75 ns up to 900 bunches	increase bunch number: 50, 100, 200, 400, 600, 800, 900	4.5 weeks
Physics operation with 75 ns and 900 b		
Sub-scenario 2		
Physics with 50ns up to max possible (1404 bunches)	increase bunch number from 100 to ??? (1440)	6 weeks
Restore operation with 150 ns	increase bunch number from xxx to 450	1 week



Estimated Peak and Integrated Luminosity

150 ns start up scenario – 3.5 TeV – Stay with 150 ns

Mode	days	H.F.	β^* m	kb	Nb 10^{11}	ϵ μm	ξ/IP	L Hz/cm^2	Stored energy MJ	L Int pb^{-1}
Recommis- sioning done with 150 ns	20	0	1.5	~100	1.2	2				
Going to 448b,150ns	14	0.2	1.5	200	1.2	2	0.007	~3e32	~14	~70
Physics operation	160	0.3	1.5	368	1.2	2	0.007	~5.5e32	~25	~2300
4 TeV Physics	160	0.3	1.5	368	1.2	2	0.007	~6.5e32	~30	~2600



Estimated Peak and Integrated Luminosity

50ns start up scenario –3.5 TeV- First 75 ns Physics starts after 1 month

Mode	days	H.F.	β^* m	kb	Nb e11	ϵ μm	ξ /IP	L Hz/cm ²	Stored energy MJ	L Int pb ⁻¹
Recommis- sioning with 50 ns to ~100b	20	0	1.5	100	1.2	2.5				
Scrubbing run	10	0								
75 ns up to 900b	30	0.1	1.5	448	1.2	2.5	0.006	~5.5e32	~30	~140
Physics operation	135	0.2	1.5	936	1.2	2.5	0.006	~1.2e33	~63	~2700
4 TeV Physics	135	0.2	1.5	936	1.2	2.5	0.006	~1.3e33	~72	~3000