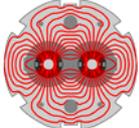


# LHC 2010

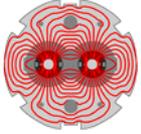
For discussion...



# 2010 part 1 - overview

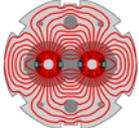
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- Beam commissioning continued
  - Target: colliding, safe, stable, squeezed beams
- Consolidation & routine “pilot” physics
  - For an extended period
  - MD blocks
- Increased intensity phase 1 & associated machine protection qualification
  - Establish secure and reproducible operation
- Consolidation & routine physics
  - For an extended period
- Increased intensity phase 2 & associated machine protection qualification
- ...



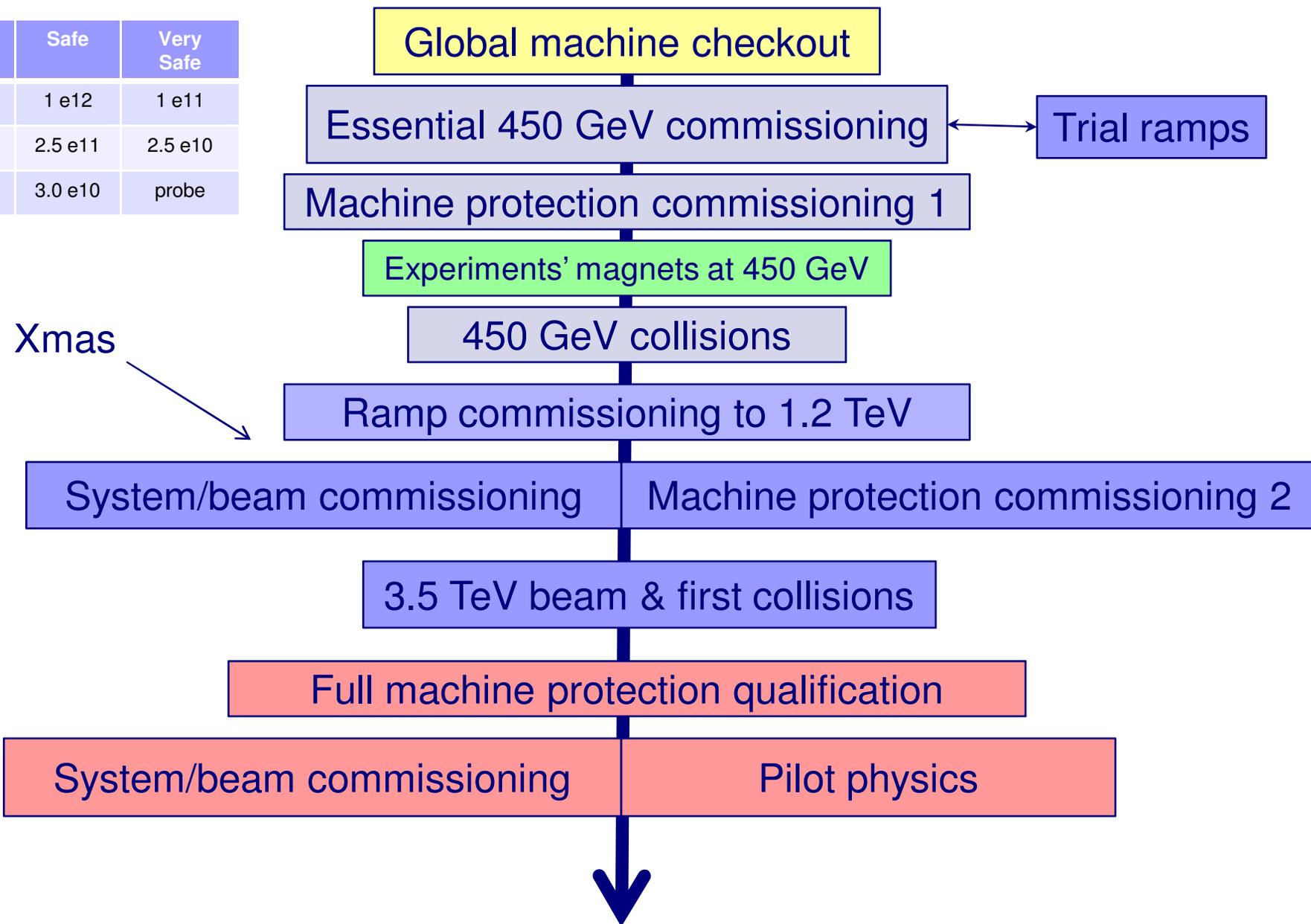
One

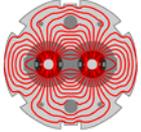
**COMMISSIONING CONTINUED**



# Beam commissioning strategy 2009

Energy	Safe	Very Safe
450	1 e12	1 e11
1 TeV	2.5 e11	2.5 e10
3.5 TeV	3.0 e10	probe

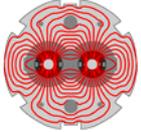




# Re-commissioning 2010 – main steps 1/2

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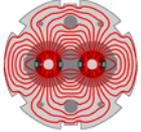
- Global machine checkout
- Essential re-commissioning & checks
- **Mop up outstanding issues from 2009**
- Optics correction and verification
  - To be finalized before optimization of following
- Re-qualification of collimation, LBDS, Machine Protection
- Commission ramp to 3.5 TeV:
  - Machine Protection appropriate for safe beam:
    - FMCs, PIC, collimators, protection devices, BLMs, BPM interlocks, SMPs, RF frequency, LBDS...
  - Beam dumps, collimators, RF...
  - Tune,  $Q'$ , coupling, orbit, feedback systems



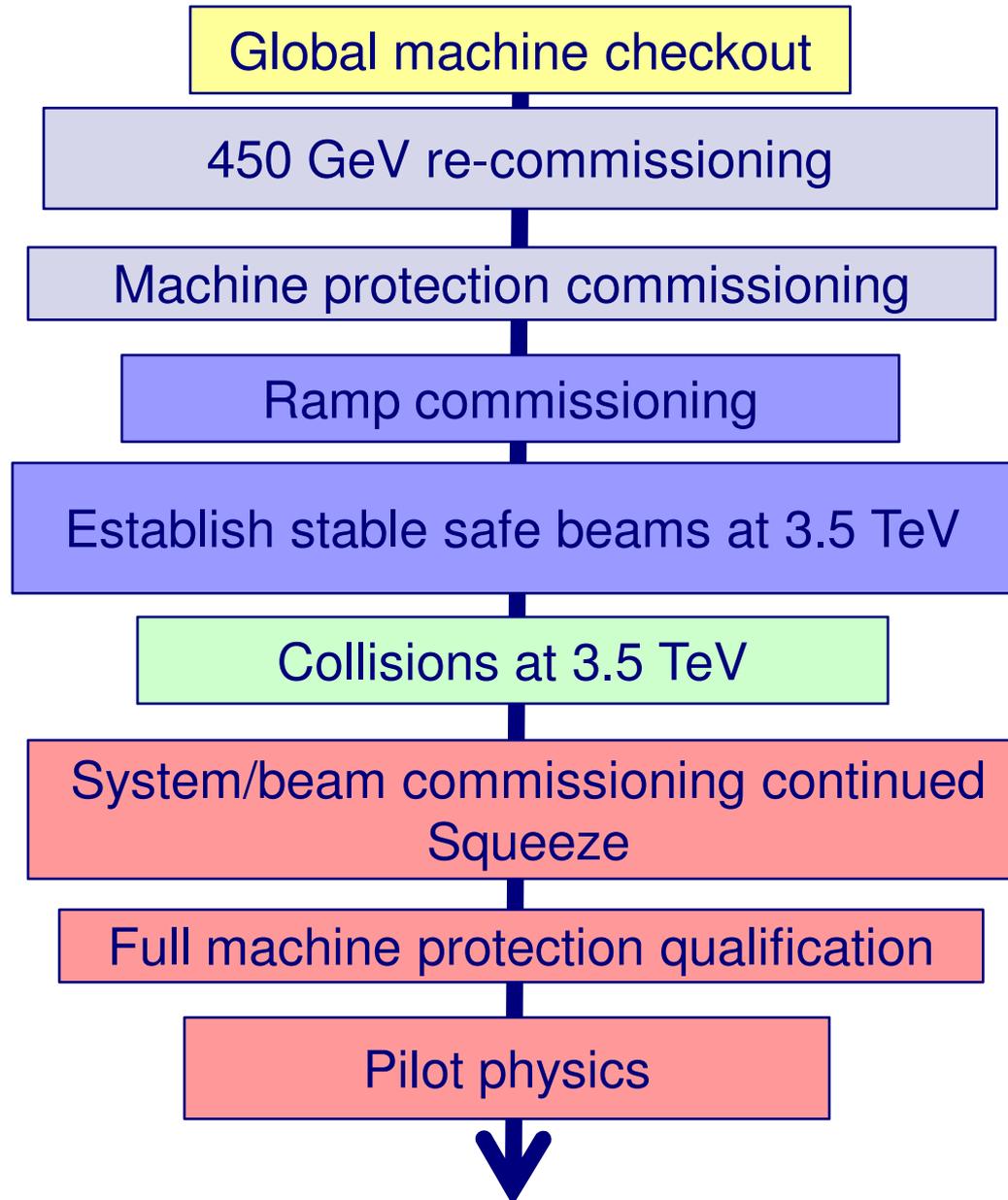
# Re-commissioning 2010 – main steps 2/2

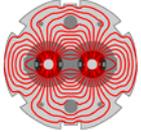
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- Established stable safe beams at 3.5 TeV unsqueezed
- First collisions at 3.5 TeV (**see below**)
- Commission squeeze
  - Collimation, feedbacks, apertures etc.
- Established stable safe beams at 3.5 TeV squeezed
- Collisions with stable beams at 3.5 TeV squeezed



# Beam commissioning strategy 2010





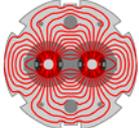
# Day by day planning 1/2

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Detailed shift by shift planning to be drawn up covering first 4 weeks

On the list:

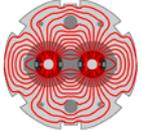
- Settings: updated FIDEL model, harmonics, optics
- Injection setup - final configuration, bumps on
- RF
- Orbit, energy matching
- Tune & orbit feedback
- Tune, Chromaticity investigations
- Measure and correct beating at 450 GeV
- Emittance calibration
- BI commissioning continued



# Day by day planning 2/2

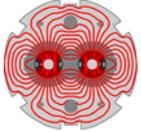
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- Collimation
- Beam dump
- Couple of shifts of collisions at 450 GeV
- MPS qualification
- Ramp
  - Feedbacks
  - Beam dump
  - Collimators
- Flat top parameter and optics checks
- Squeeze commissioning
- Etc. etc.



# Timeline - guesstimate

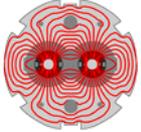
Phase	Days	
Circulating beams	2	Essential checks
450 GeV re-commissioning	7	Injection, tune, Q', C-, orbit, collimators, LBDS, instrumentation
450 optics checks	3	Beating, energy matching optimization
450 two beams	1	bumps as standard set-up, adjust TDI etc
450 GeV collisions	1	experiments on at 450 GeV
Ramp to 3.5 TeV	5	commission essential machine protection, experiments' dipoles on in ramp, orbit and tune feedback
3.5 TeV	2	machine protection, optics
Pilot collisions un-squeezed	3	Safe beams at 3.5 TeV
Commission squeeze	4	orbit and tune feedback, collimation, aperture, bumps, machine protection checks, beam dumps etc.
Collisions squeezed – safe, stable beams	7	Stable beams up to safe beam limit



# Heads-up – first collisions

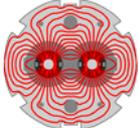
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- **First collisions at 3.5 TeV will be a major media event**
  - And first collisions is first collisions, no Atlas sneaking in there while we're commissioning the ramp
- Commissioning ramp (and possibly squeeze) with non-colliding bunches
- Establish conditions for stable beams with non-colliding bunches
- First attempt to deliver colliding beams will have to be planned at least a couple of days in advance
- **Choreographing the collapsing of separation bumps and subsequent steering would be appreciated (sorry).**



Here be dragons

# **INCREASING INTENSITY**

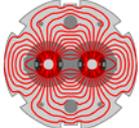


# Increasing intensity – prerequisites 1/1

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Culled from OP's commissioning planning  
Clearly need to re-visit and agree formally.

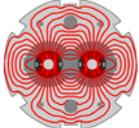
- Aperture & orbit locked
- Beam dump & protection fully locked down
- Collimation fully locked down
- Injection protection (TDI & TCLI) & injection process
- Multi-bunch behaviour of all beam instrumentation
- All systems tested with unsafe@450 GeV
- Transverse dampers operational
- Reproducible emittances and intensities from SPS
  - BQC fully operational
  - Intensity limit interlock fully operational



# Increasing intensity – prerequisites 2/3

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- Scraping in SPS as required
- Abort gap monitor and cleaning
- BIC, WIC, PIC, SIS, SMP
  - Nothing masked, all 100% tested
- Machine protection tests in general
  - See Jorg's long list
- MCS locked down
- RBAC locked down
- RF Locked down

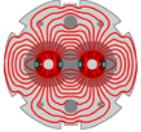


# Prerequisites 3/3

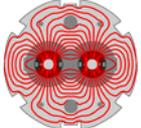
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- Ramp - among other things:
  - Beam dump
  - Collimation
  - BLMs
    - Threshold tables, BIS tests
  - BIS – safe@450, unsafe@3500 - checks
  - Emittance blowup
- Tune feedback
- Orbit feedback

And of course resolution of all procedural, operation, controls, MPS, instrumentation, hardware issue that have been raised in Evian

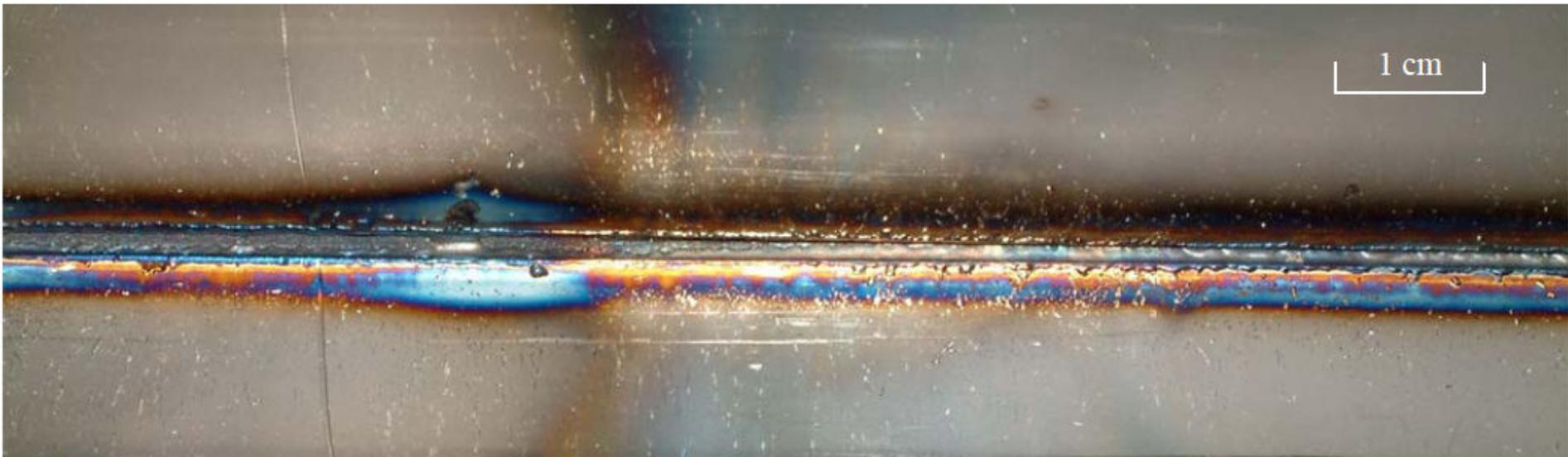


# WHAT'S THE WORST THING YOU CAN DO FOR LUMINOSITY?



# TT40 Damage during 2004 High Intensity SPS Extraction / [Goddard, B](#) ; [Kain, V](#) ; [Mertens, V](#) ; [Uythoven, J](#) ; [Wenninger, J](#)

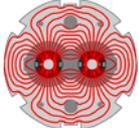
Or what you can do with 2.9 MJ



*Figure 4. Damage observed on the inside of the vacuum chamber, on the beam impact side. A groove approximately 110 cm long due to removed material was clearly visible, starting at about 30 cm from the entrance.*

During high intensity extraction on 25/10/04 an incident occurred in which the vacuum chamber of the TT40 magnet QTRF4002 was badly damaged.

The beam was a 450 GeV full LHC injection batch of  $3.4 \cdot 10^{13}$  p+ in 288 bunches, and was extracted from SPS LSS4 with the wrong trajectory

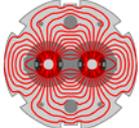


# Phased intensity increase

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Clear that above will not happen overnight and that a full and careful program of tests and checks is required

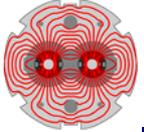
- Extended operational running period (physics) at safe beam limit with all prerequisites in place
  - Operational procedures, controls, instrumentation etc.
  - Machine protection
  - $3 \text{ e}10$  at 3.5 TeV  $\sim 17 \text{ kJ}$
- Circulating unsafe beam variants at 450 GeV
  - Test key systems, behaviour of feedbacks, instrumentation
  - Machine protection
- Step up in intensity
  - Ramp safe beam at 450 GeV, unsafe at 3.5 TeV e.g.
    - $56 \text{ kJ} = 1 \text{ e}11$  at 3.5 TeV
    - $0.5 \text{ MJ} = 7.5 \text{ e}11$  at 3.5 TeV
    - Each step followed by an extended running period



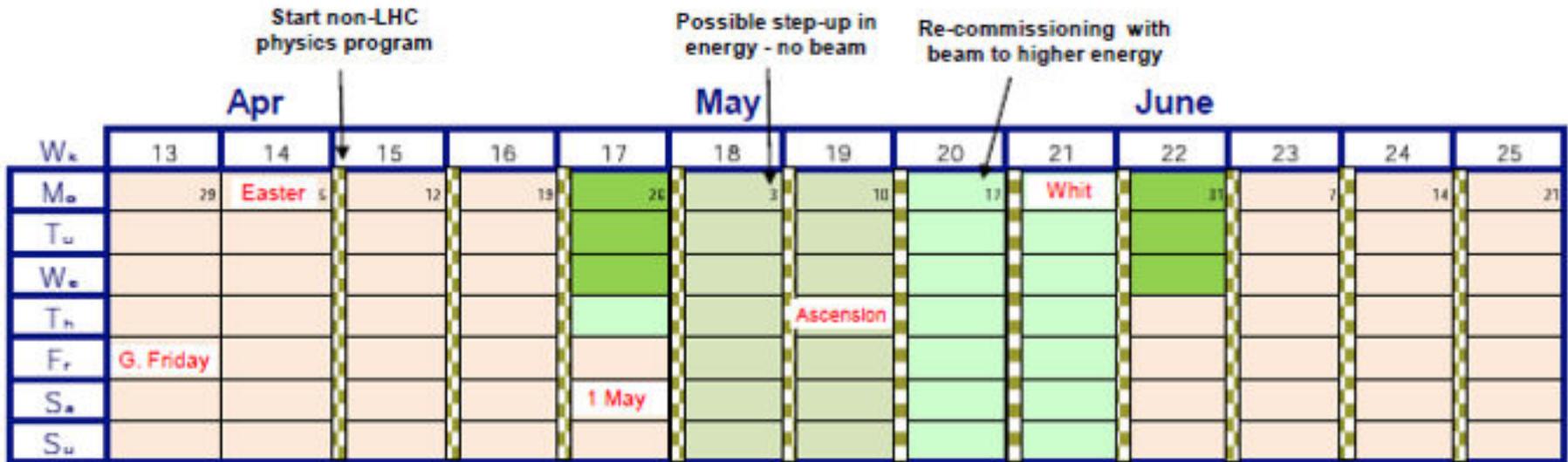
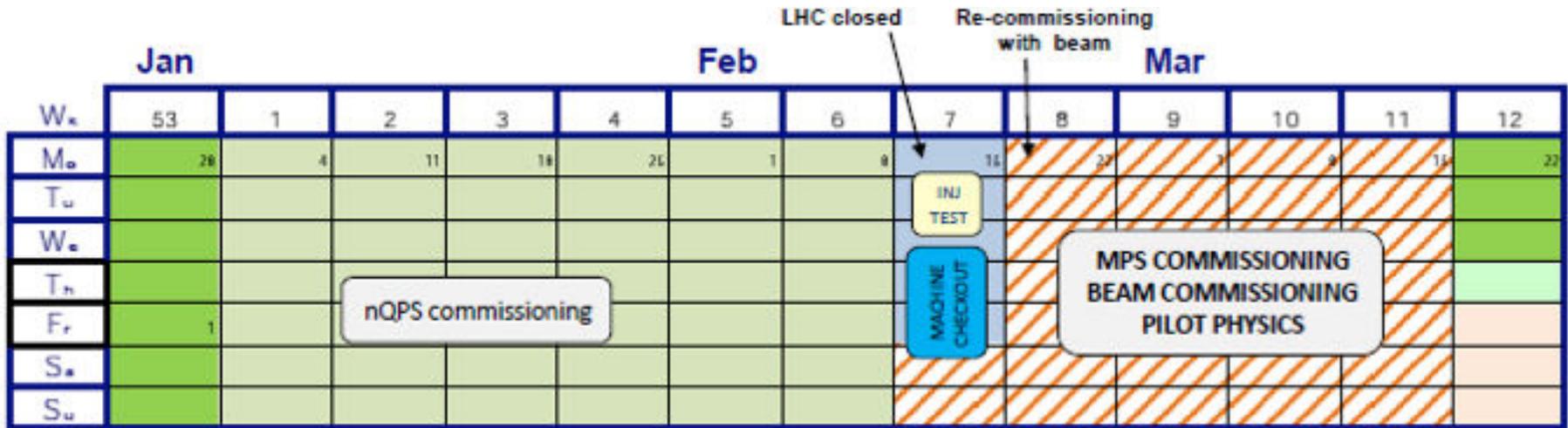
# 2010 - evolution

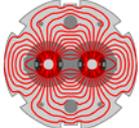
Step	E (TeV)	Fill scheme	N ( $10^{10}$ p/b)	$\beta^*$ (m) IP1 / 2 / 5 / 8	Run time (indicative)
1	0.45	2x2	5	11 / 10 / 11 / 10	Weeks
2	3.5	2x2	2	11 / 10 / 11 / 10	
3	3.5	2x2*	2	2 / 10 / 2 / 2	
4	3.5	43x43	5	2 / 10 / 2 / 2	Weeks/Months
5	3.5	156x156	5	2 / 10 / 2 / 2	
6	3.5	156x156	9	2 / 10 / 2 / 2	Months
7	3.5	50 ns - 144**	7	2.5 / 3 / 2.5 / 3	
8	3.5	50 ns - 288	7	2.5 / 3 / 2.5 / 3	
9	3.5	50 ns - 720	7	2.5 / 3 / 2.5 / 3	Months

A little more detail required here



# LHC schedule 2010 – part II





# 2010 schedule – part II

	July				Aug				Sep				
W <sub>k</sub>	26	27	28	29	30	31	32	33	34	35	36	37	38
M <sub>o</sub>	28	5	12	19	26	2	9	16	23	30	6	13	20
T <sub>u</sub>													
W <sub>e</sub>													
T <sub>h</sub>											Jeune G		
F <sub>r</sub>													
S <sub>a</sub>													
S <sub>u</sub>													

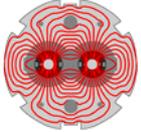
Ion Beam to SPS

	Oct			Nov				Dec					
W <sub>k</sub>	39	40	41	42	43	44	45	46	47	48	49	50	51
M <sub>o</sub>	27	4	11	18	25	1	8	15	22	29	6	13	20
T <sub>u</sub>													
W <sub>e</sub>													
T <sub>h</sub>													
F <sub>r</sub>													Xmas Day
S <sub>a</sub>													
S <sub>u</sub>													

Ion Beam Setup

Start Ion Physics

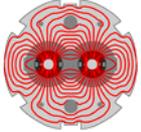
IONS  
(approx 4 weeks)



# Monthly technical stop

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- Programmed
- 3 days including recovery and re-closure of ring
  - QPS plus power converters, controls, R2E etc.
  - Cool-down will become an issue
- Mon – Wed allowing weekday time for re-setup with beam
- Followed by one day set-up with beam and systematic checks of machine protection system
- Clearly if major breakdowns occur at other times – advantage will be taken.
- Injector maintenance in parallel is an option
- [Have not considered scheduling of MD...]



# Conclusions

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- A hell of a lot of stuff to sort out...
- About 4 weeks to establish stable, safe, squeezed beams at 3.5 TeV
  - It will, however, take as long as it takes.
- Extended running period around the safe beam limit
  - With blocked MD periods as required
  
- Formal review process before starting a stepwise increase in intensity
  - Each step followed by extended running period.1/20/10