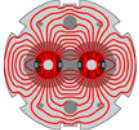




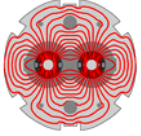
LHC 2010

For discussion...



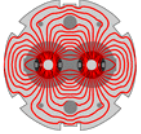
2010 part 1 - overview

- 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
- ...



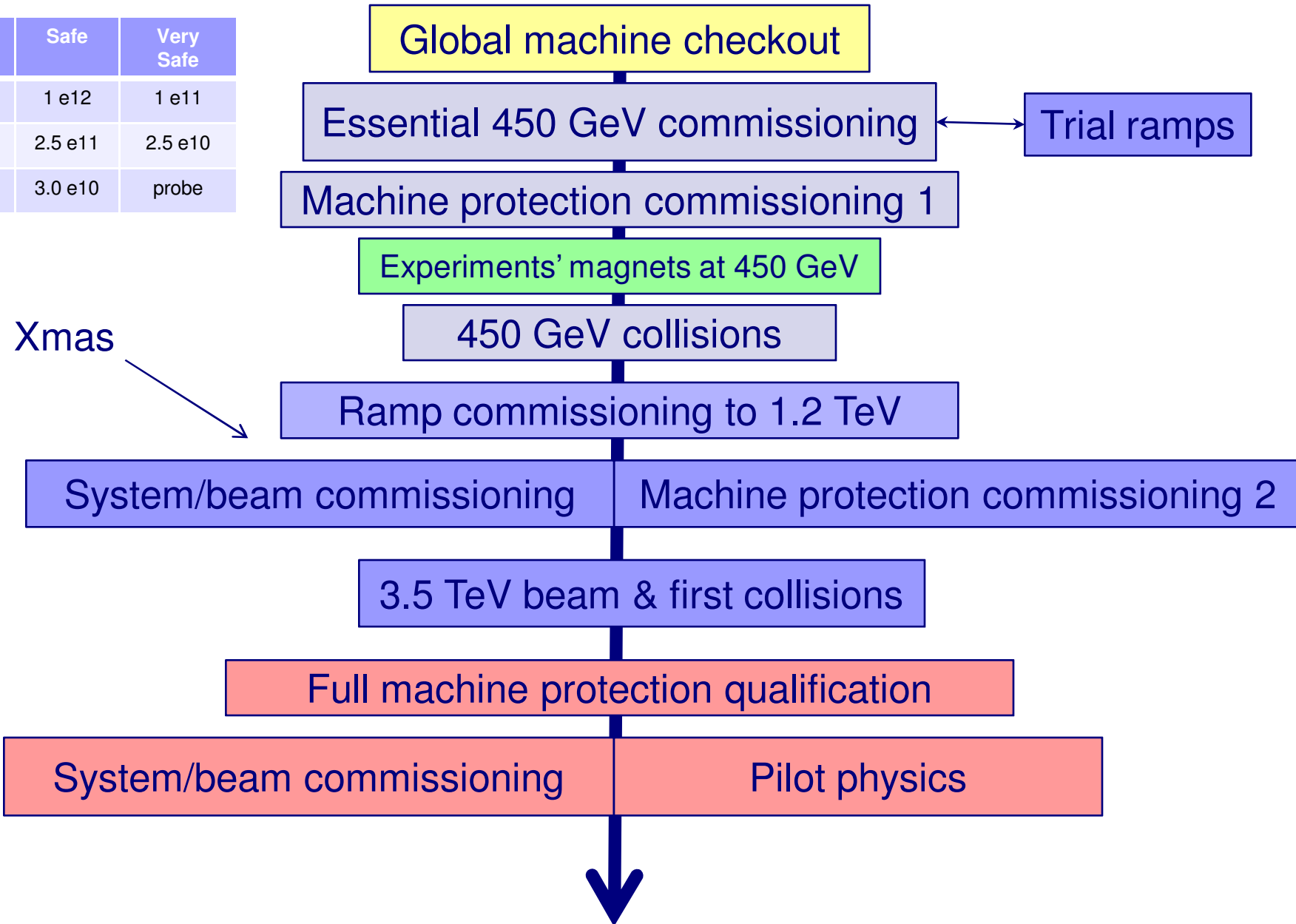
One

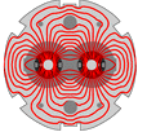
COMMISSIONING CONTINUED



Beam commissioning strategy 2009

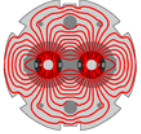
Energy	Safe	Very Safe
450	1 e12	1 e11
1 TeV	2.5 e11	2.5 e10
3.5 TeV	3.0 e10	probe





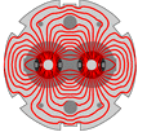
Re-commissioning 2010 – main steps 1/2

- 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

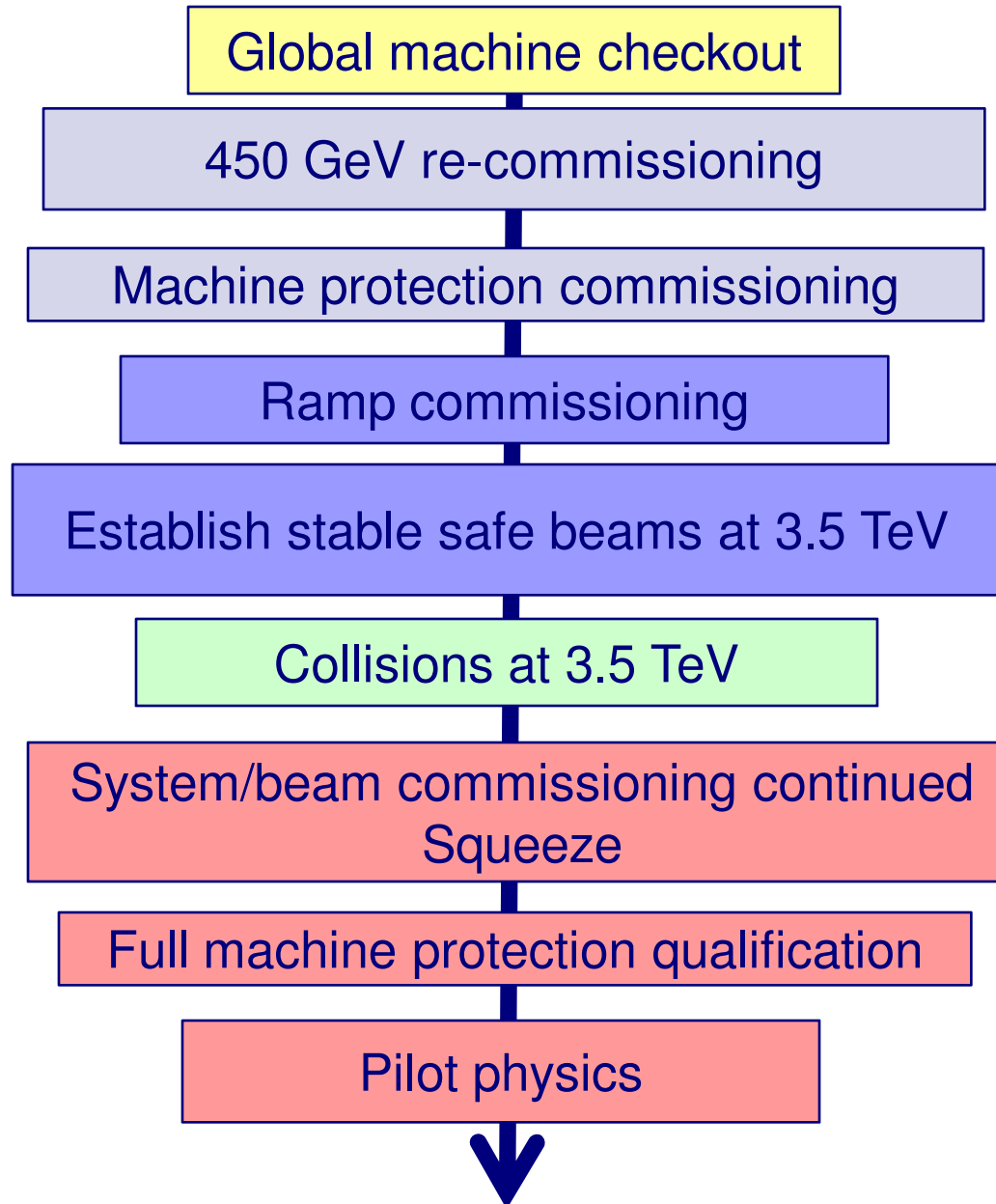


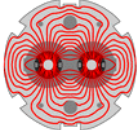
Re-commissioning 2010 – main steps 2/2

- 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



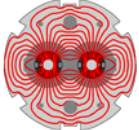


Day by day planning 1/2

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

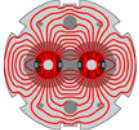
On the list:

- 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



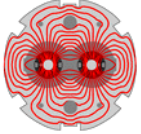
Day by day planning 2/2

- 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.



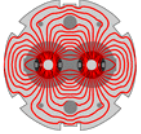
Timeline - guesstimate

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



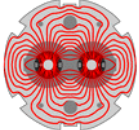
Heads-up – first collisions

- **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

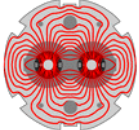
INCREASING INTENSITY



Increasing intensity – prerequisites 1/1

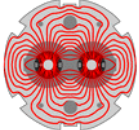
Culled from OP's commissioning planning
Clearly need to re-visit and agree formally.

- 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

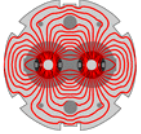
- Scraping in SPS as required
- Abort gap monitor and cleaning
- BIC, WIC, PIC, SIS, SMP
 - Nothing masked, all 100% tested
- Machine protection tests in general
 - See Jorg's long list
- MCS locked down
- RBAC locked down
- RF Locked down



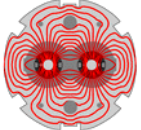
Prerequisites 3/3

- 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

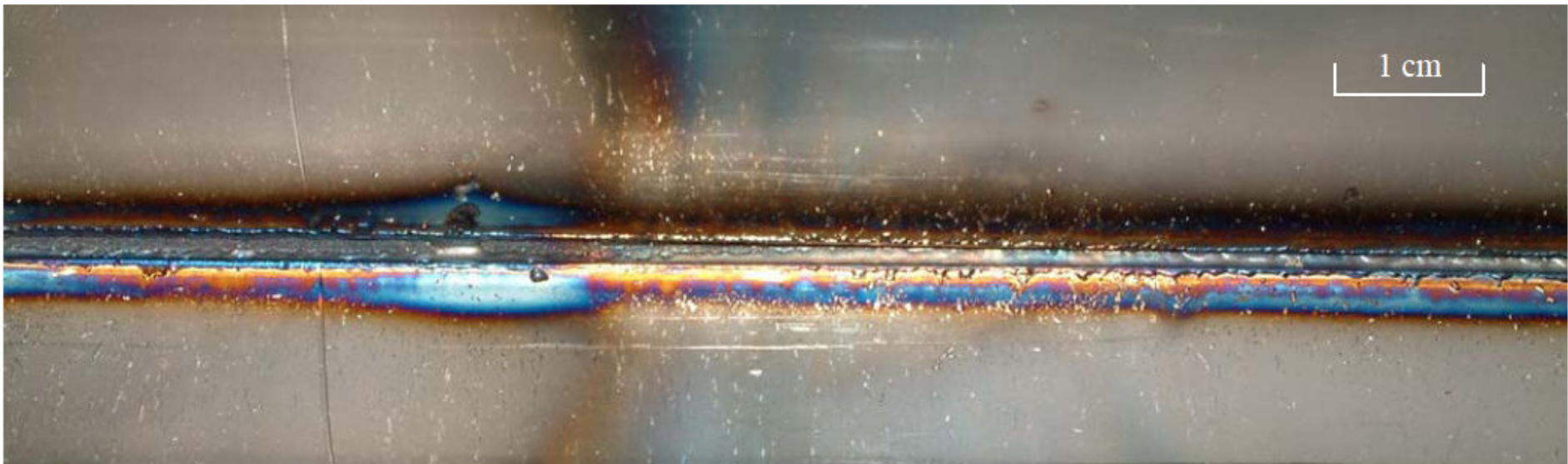
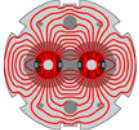


Figure 4. Damage observed on the inside of the vacuum chamber, on the beam impact side. A groove approximately 110 cm long due to removed material was clearly visible, starting at about 30 cm from the entrance.

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

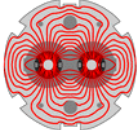
The beam was a 450 GeV full LHC injection batch of $3.4 \cdot 10^{13}$ p+ in 288 bunches, and was extracted from SPS LSS4 with the wrong trajectory



Phased intensity increase

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

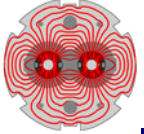
- Extended operational running period (physics) at safe beam limit with all prerequisites in place
 - Operational procedures, controls, instrumentation etc.
 - Machine protection
 - $3 \text{ e}10$ at 3.5 TeV $\sim 17 \text{ kJ}$
- Circulating unsafe beam variants at 450 GeV
 - Test key systems, behaviour 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



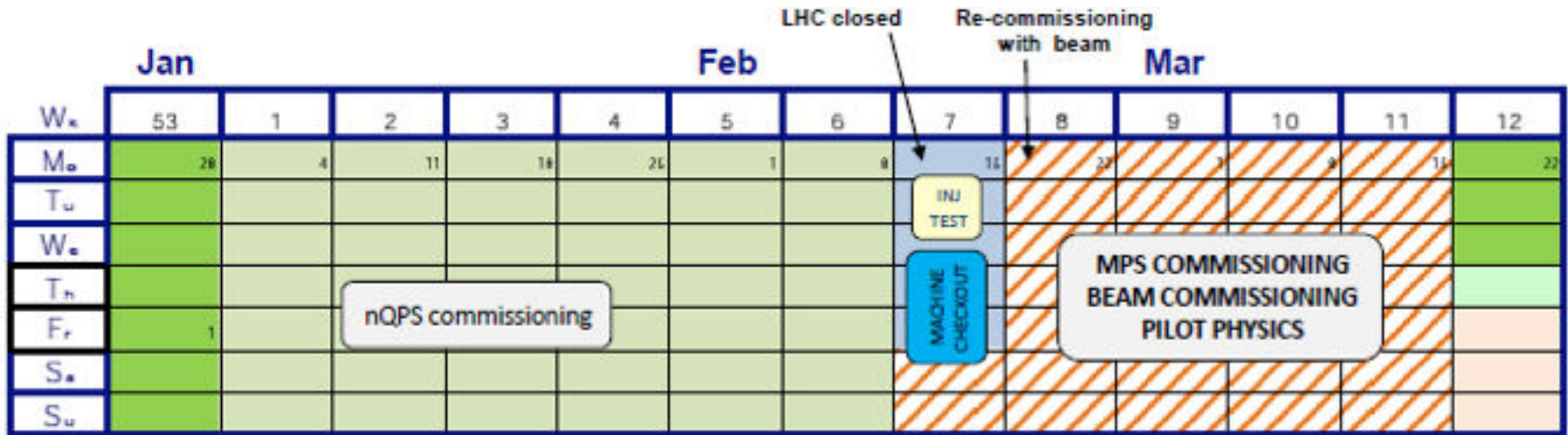
2010 - evolution

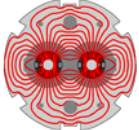
Step	E (TeV)	Fill scheme	N (10^{10} p/b)	β^* (m) IP1 / 2 / 5 / 8	Run time (indicative)
1	0.45	2x2	5	11 / 10 / 11 / 10	Weeks
2	3.5	2x2	2	11 / 10 / 11 / 10	
3	3.5	2x2*	2	2 / 10 / 2 / 2	
4	3.5	43x43	5	2 / 10 / 2 / 2	Weeks/Months
5	3.5	156x156	5	2 / 10 / 2 / 2	
6	3.5	156x156	9	2 / 10 / 2 / 2	Months
7	3.5	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 _k	26	27	28	29	30	31	32	33	34	35	36	37	38
M _o	28	5	12	19	26	2	9	16	23	30	6	13	20
T _u													
W _e													
T _h											Jeune G		
F _r													
S _a													
S _u													

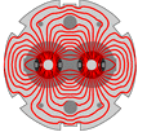
Ion Beam to SPS

	Oct			Nov				Dec					
W _k	39	40	41	42	43	44	45	46	47	48	49	50	51
M _o	27	4	11	18	25	1	8	15	22	29	6	13	20
T _u													
W _e													
T _h													
F _r													Xmas Day
S _a													
S _u													

Ion Beam Setup

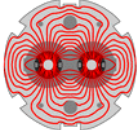
Start Ion Physics

IONS
(approx 4 weeks)



Monthly technical stop

- 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

- 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