LHC Status and Commissioning Plans

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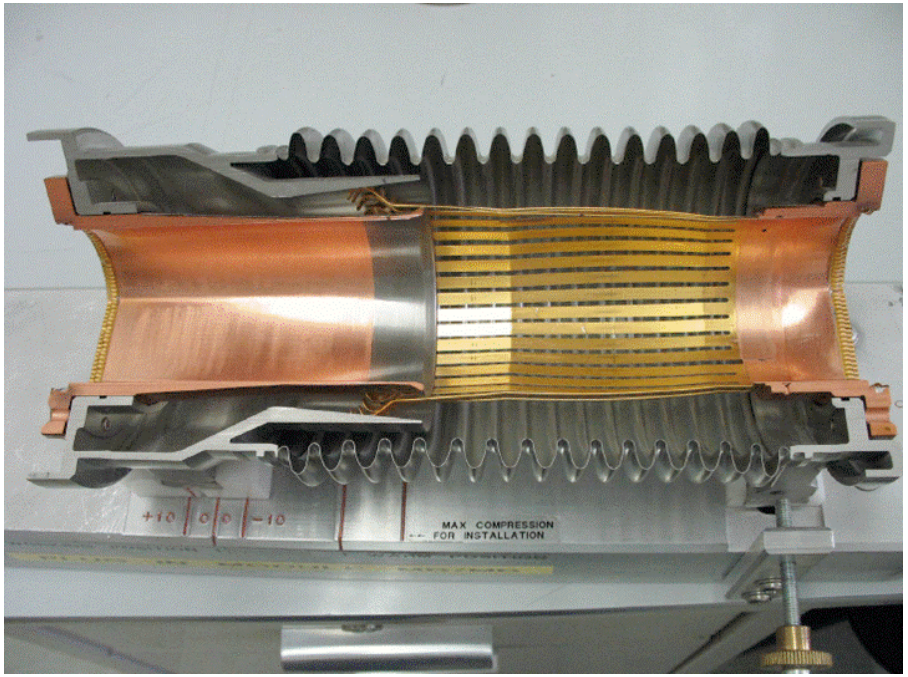
based on material from Roger Bailey and Mike Lamont, CERN AB/OP

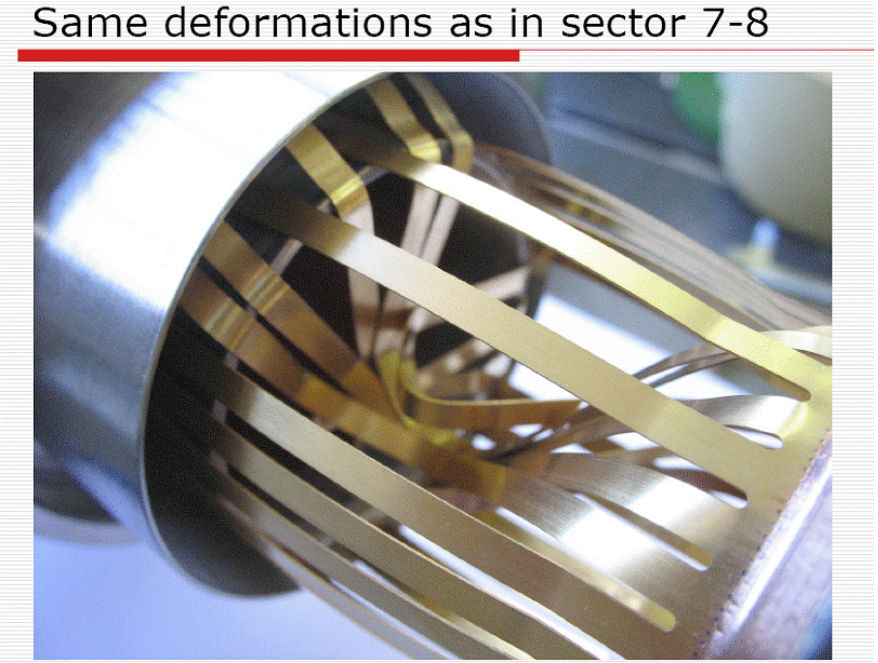
Status: Installation & Equipment Commissioning

- Good progress of installation and interconnection work, proceeding at high pace in tunnel
- Numerous non-conformities intercepted by QA program, but resulting in added work and time
- Technical solutions found for inner triplet problems, but repair of already installed magnets will induce significant delays
- Commissioning of first sectors by isolating faulty triplets, but will have to be re-done with repaired triplets (needing additional warm-up/cooldown cycles)
- First sector cooled down (sector 78) to nominal temperature and operated with superfluid helium; partial power tests performed
- Sector 78 consolidation ongoing
  - problems found with the magnet interconnect plug-in modules
- Second sector cool down started (sector 45)

Interconnect Plug-in Modules Details

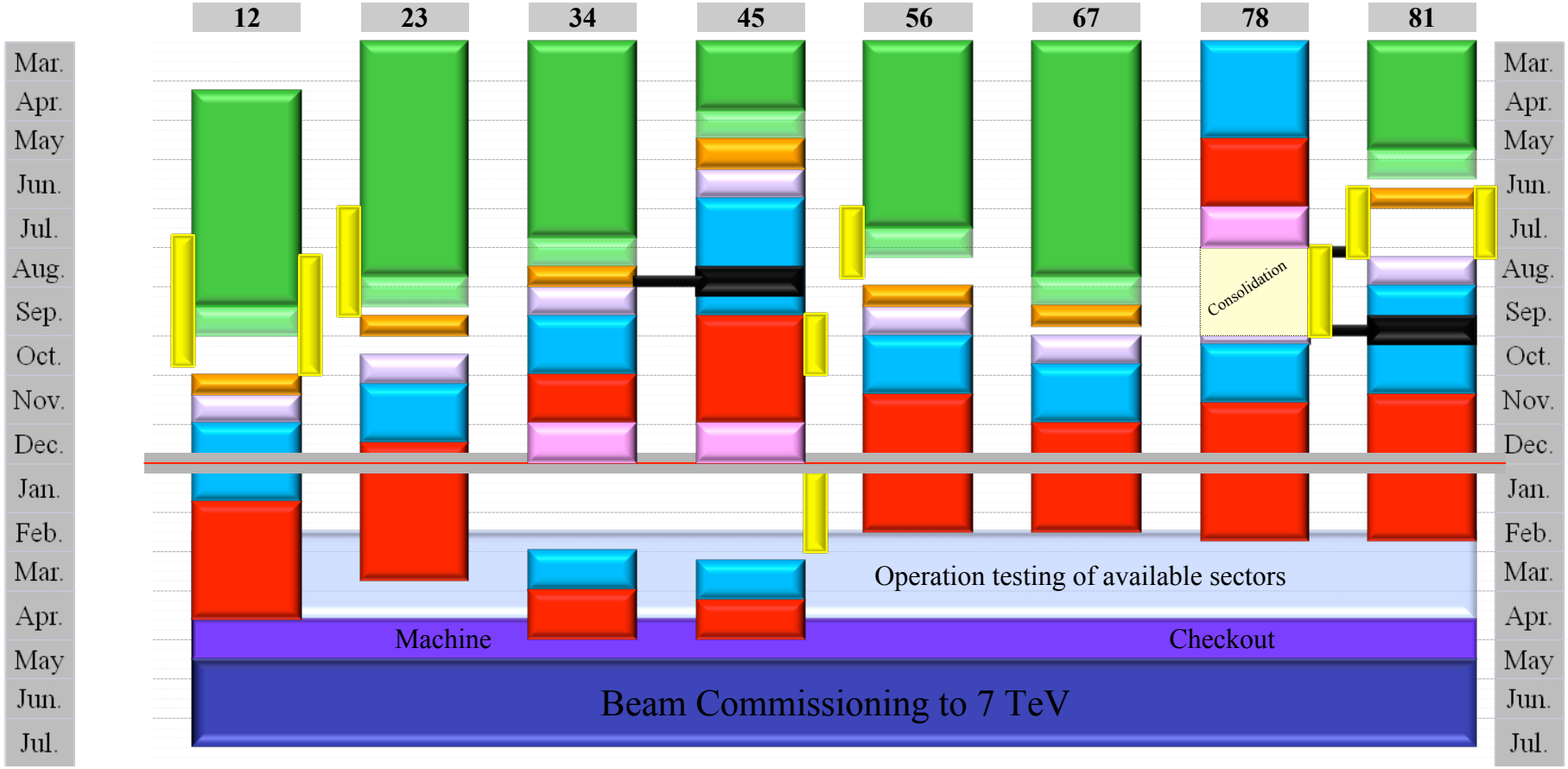


Plug-in module in cold position

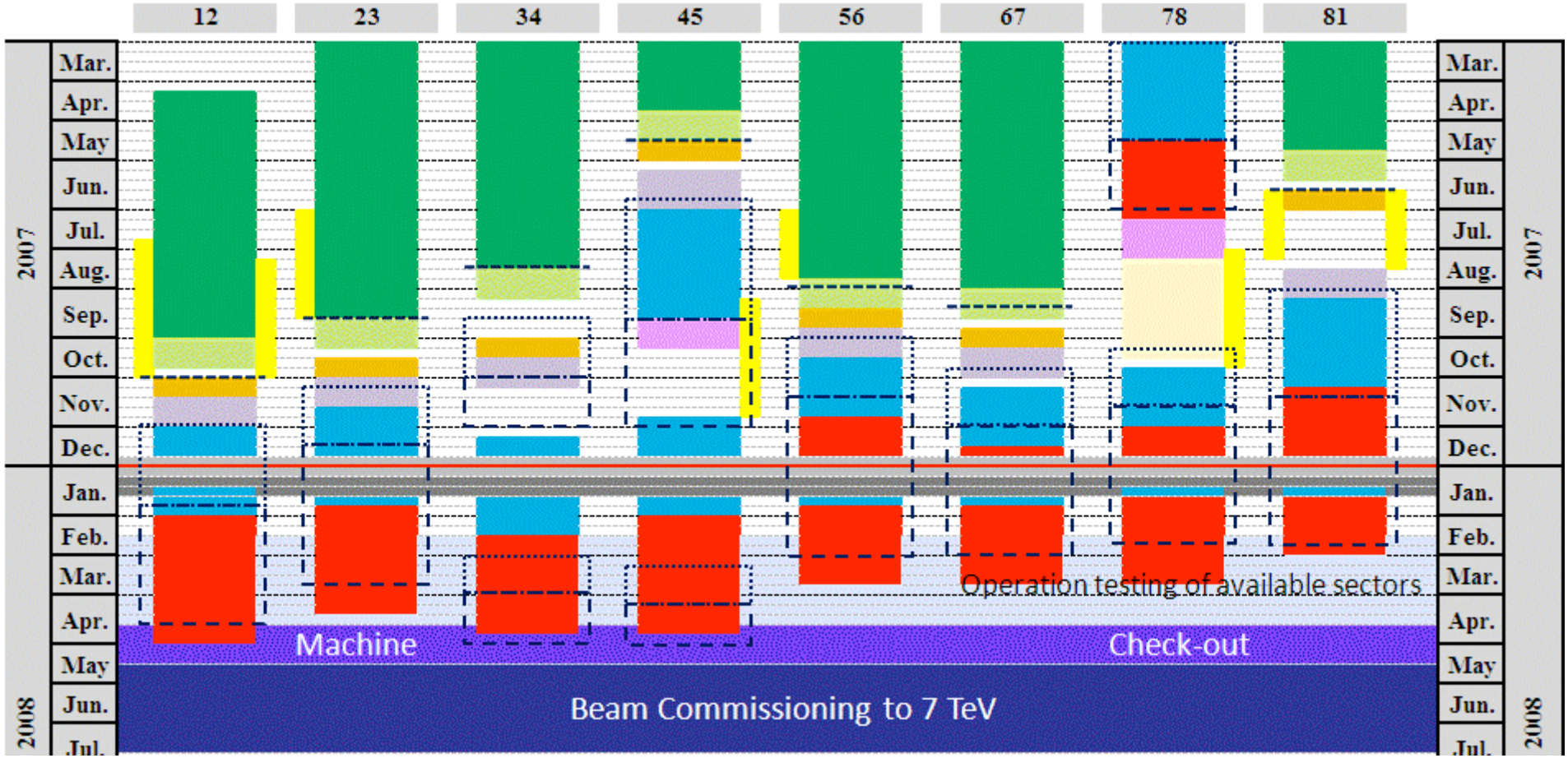


Failure example

Schedule – rev 4.0 – June Council



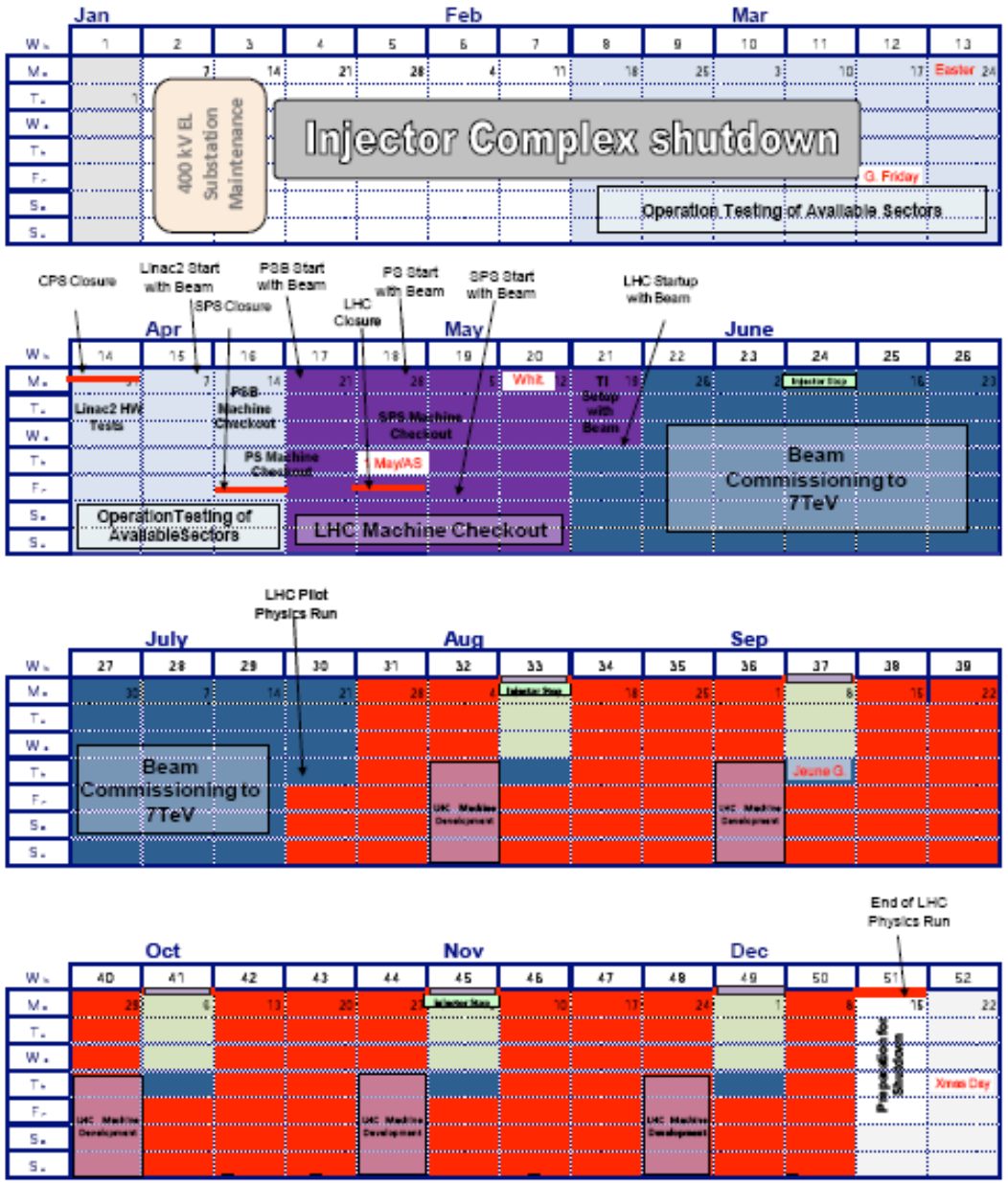
Schedule – Latest Update (August 17)



General schedule Baseline rev. 4.0

- Global pressure test &Consolidation
- Cool-down
- Powering Tests
- Interconnection of the continuous cryostat
- Leak tests of the last sub-sectors
- Inner Triplets repairs & interconnections
- Global pressure test &Consolidation
- Flushing
- Cool-down
- Warm up
- Powering Tests

Schedules – 2008 LHC (draft)

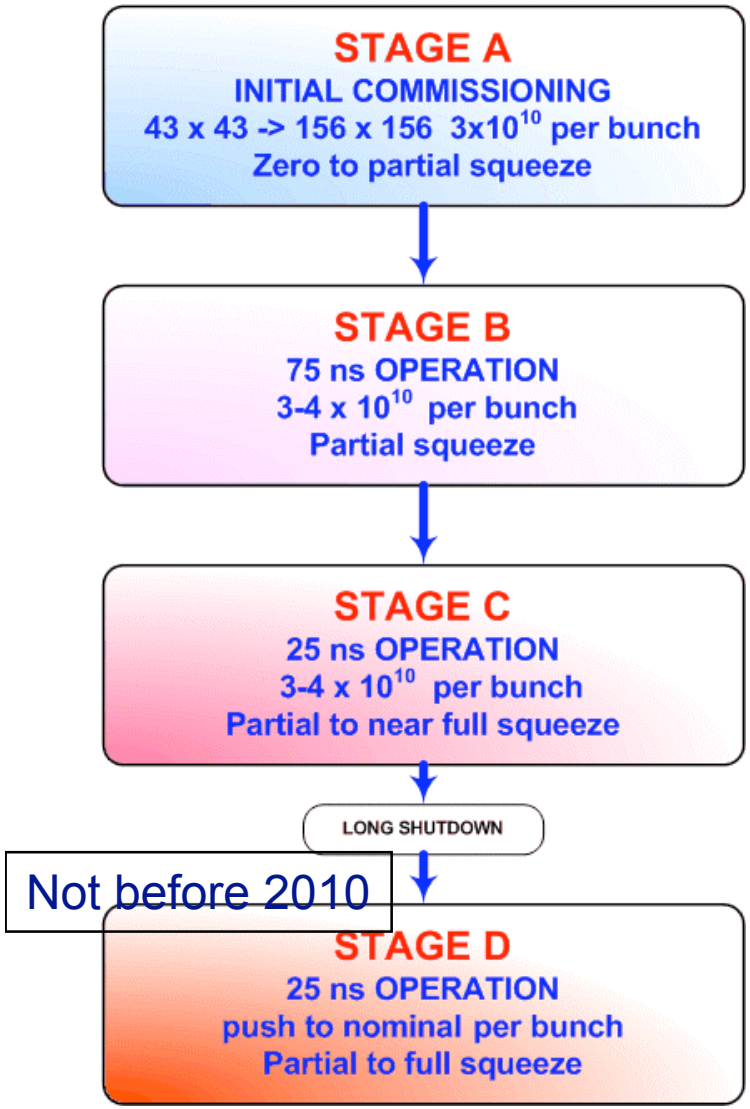


General Schedule

- Engineering run originally foreseen at end 2007 now precluded by delays in installation and equipment commissioning.
- 450 GeV operation now part of normal setting up procedure for beam commissioning to high-energy
- General schedule being reassessed, accounting for inner triplet repairs and their impact on sector commissioning
  - **All technical systems commissioned to 7 TeV operation, and machine closed April 2008**
  - **Beam commissioning starts end May 2008**
  - **First collisions at 14 TeV end July 2008**
  - **If everything goes well, pilot run with low number of bunches (maximum lumi 10^{32} $cm^{-2}s^{-1}$)**
- No provision in success-oriented schedule for major mishaps, e.g. additional warm-up/cool-down of sector

Commissioning Plans

Commissioning Stages



- Establish colliding beams as quickly as possible
- Safely
- Without compromising further progress

- Initial optics:
  - β*= 11 m in IR 1 & 5
  - β*= 10 m in IR 2 & 8
- Crossing angles off
  - 1, 12, 43, 156 bunches per beam
  - No parasitic encounters - no long range beam-beam
  - Larger aperture in IRs

Beam Commissioning to 7 TeV Collisions

		Rings	Total [days]
1	**Injection and first turn**	**2**	**4**
2	**Circulating beam**	**2**	**3**
3	**450 GeV - initial**	**2**	**4**
4	**450 GeV - detailed**	**2**	**5**
5	**450 GeV - two beams**	**1**	**1**
6	**Snapback - single beam**	**2**	**3**
7	**Ramp - single beam**	**2**	**6**
8	**Ramp - both beams**	**1**	**2**
9	7 TeV - setup for physics	**1**	**2**
10	Physics un-squeezed	**1**	**-**
	TOTAL TO FIRST COLLISIONS		**30**
11	Commission squeeze	**2**	**6**
12	Increase Intensity	**2**	**6**
13	Set-up physics - partially squeezed.	**1**	**2**
14	Pilot physics run		

Stage A: First Collisions

- Approx 30 days of beam time to establish first collisions
  - Un-squeezed
  - Low intensity
- Approx 2 months elapsed time
  - Given optimistic machine availability
- Continued commissioning thereafter
  - Increased intensity
  - Squeeze

Stage A - Luminosities

- 1 to N to 43 to 156 bunches per beam
- N bunches displaced in one beam for LHCb
- Pushing gradually one or all of:
  - Bunches per beam
  - Squeeze
  - Bunch intensity

IP 1 & 5

Bunches	β^*	I_b	Luminosity	Event rate
1 x 1	18	10^{10}	10^{27}	Low
43 x 43	18	3×10^{10}	3.8×10^{29}	0.05
43 x 43	4	3×10^{10}	1.7×10^{30}	0.21
43 x 43	2	4×10^{10}	6.1×10^{30}	0.76
156 x 156	4	4×10^{10}	1.1×10^{31}	0.38
156 x 156	4	9×10^{10}	5.6×10^{31}	1.9
156 x 156	2	9×10^{10}	1.1×10^{32}	3.9

Conclusions - 2008

- Beam commissioning
  - Should start May 2008
  - 2 months to get first collisions
  - First collisions - low intensity, un-squeezed.
- Phase A
  - No crossing angle
  - Gradual increase in current - up to 156 bunches/beam
  - Pilot physics: un-squeezed to partial squeeze
  - $\leq 10^{32}$ $cm^{-2}s^{-1}$
- Phase B: if things go really well!!
- Collimation
  - Phase 1 scheme will be in place
  - Full and appropriate machine protection will be pursued
- See also T. Virdee's talk at CHEP

http://cern.ch/lhccwg/

Stage B – 75ns

- Parameter tolerances:
  - Tightened up. Optics/beta beating under control
- Commission crossing angles.
  - Injection, ramp and squeeze
  - long range beam-beam, effect on dynamic aperture,
- Need for feedback
  - orbit plus adequate control of tune and chromaticity through snapback.
- Lifetime and background optimization in physics
  - with a crossing angle and reduced aperture needs to be mastered.
- Bunch train bunch-to-bunch variations, implications for beam instrumentation.
- Emittance conservation through the cycle

Plus Machine Protection with increased intensity

Won't happen overnight

Parameter evolution and rates

$$L = \frac{N^2 k_b f \gamma}{4\pi\varepsilon_n \beta^*} F$$

$$Eventrate/Cross = \frac{L\sigma_{TOT}}{k_b f}$$

All values for nominal emittance, 7TeV and 10m β^* in points 2 and 8

Parameters			Beam levels		Rates in 1 and 5		Rates in 2 (and 8)	
k_b	N	β^* 1,5 (m)	I_{beam} proton	E_{beam} (MJ)	Luminosity ($cm^{-2}s^{-1}$)	Events/ crossing	Luminosity ($cm^{-2}s^{-1}$)	Events/ crossing
43	$4\ 10^{10}$	11	$1.7\ 10^{12}$	2	$1.1\ 10^{30}$	<< 1	$1.2\ 10^{30}$	0.15
43	$4\ 10^{10}$	2	$1.7\ 10^{12}$	2	$6.1\ 10^{30}$	0.76	$1.2\ 10^{30}$	0.15
156	$4\ 10^{10}$	2	$6.2\ 10^{12}$	7	$2.2\ 10^{31}$	0.76	$4.4\ 10^{30}$	0.15
156	$9\ 10^{10}$	2	$1.4\ 10^{13}$	16	$1.1\ 10^{32}$	3.9	$2.2\ 10^{31}$	0.77
936	$4\ 10^{10}$	11	$3.7\ 10^{13}$	42	$2.4\ 10^{31}$	<< 1	$2.6\ 10^{31}$	0.15
936	$4\ 10^{10}$	2	$3.7\ 10^{13}$	42	$1.3\ 10^{32}$	0.73	$2.6\ 10^{31}$	0.15
936	$6\ 10^{10}$	2	$5.6\ 10^{13}$	63	$2.9\ 10^{32}$	1.6	$6.0\ 10^{31}$	0.34
936	$9\ 10^{10}$	1	$8.4\ 10^{13}$	94	$1.2\ 10^{33}$	7	$1.3\ 10^{32}$	0.76
2808	$4\ 10^{10}$	11	$1.1\ 10^{14}$	126	$7.2\ 10^{31}$	<< 1	$7.9\ 10^{31}$	0.15
2808	$4\ 10^{10}$	2	$1.1\ 10^{14}$	126	$3.8\ 10^{32}$	0.72	$7.9\ 10^{31}$	0.15
2808	$5\ 10^{10}$	1	$1.4\ 10^{14}$	157	$1.1\ 10^{33}$	2.1	$1.2\ 10^{32}$	0.24
2808	$5\ 10^{10}$	0.55	$1.4\ 10^{14}$	157	$1.9\ 10^{33}$	3.6	$1.2\ 10^{32}$	0.24