LHC Operations in 2008

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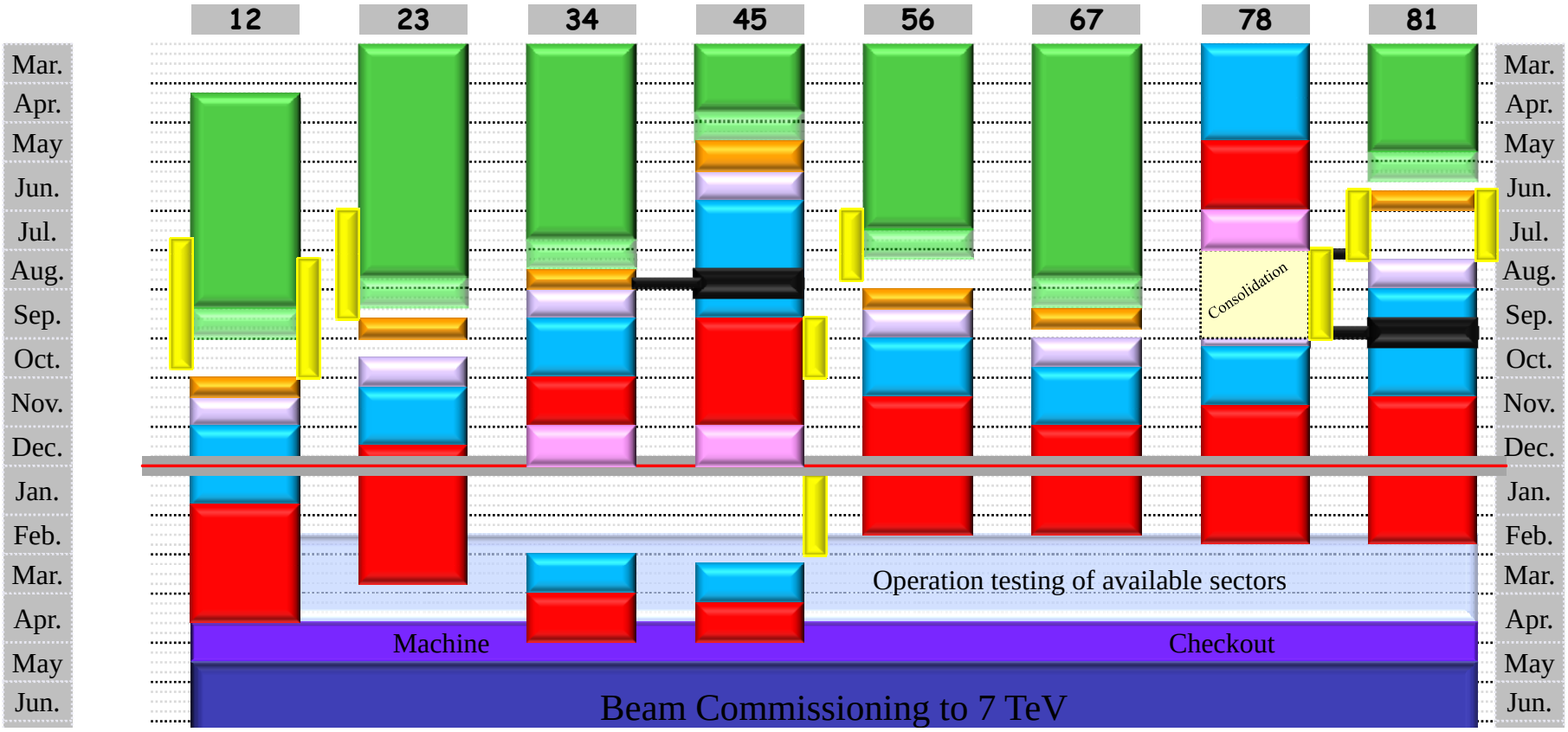
based on material from Roger Bailey, CERN AB/OP

Summary of installation and commissioning

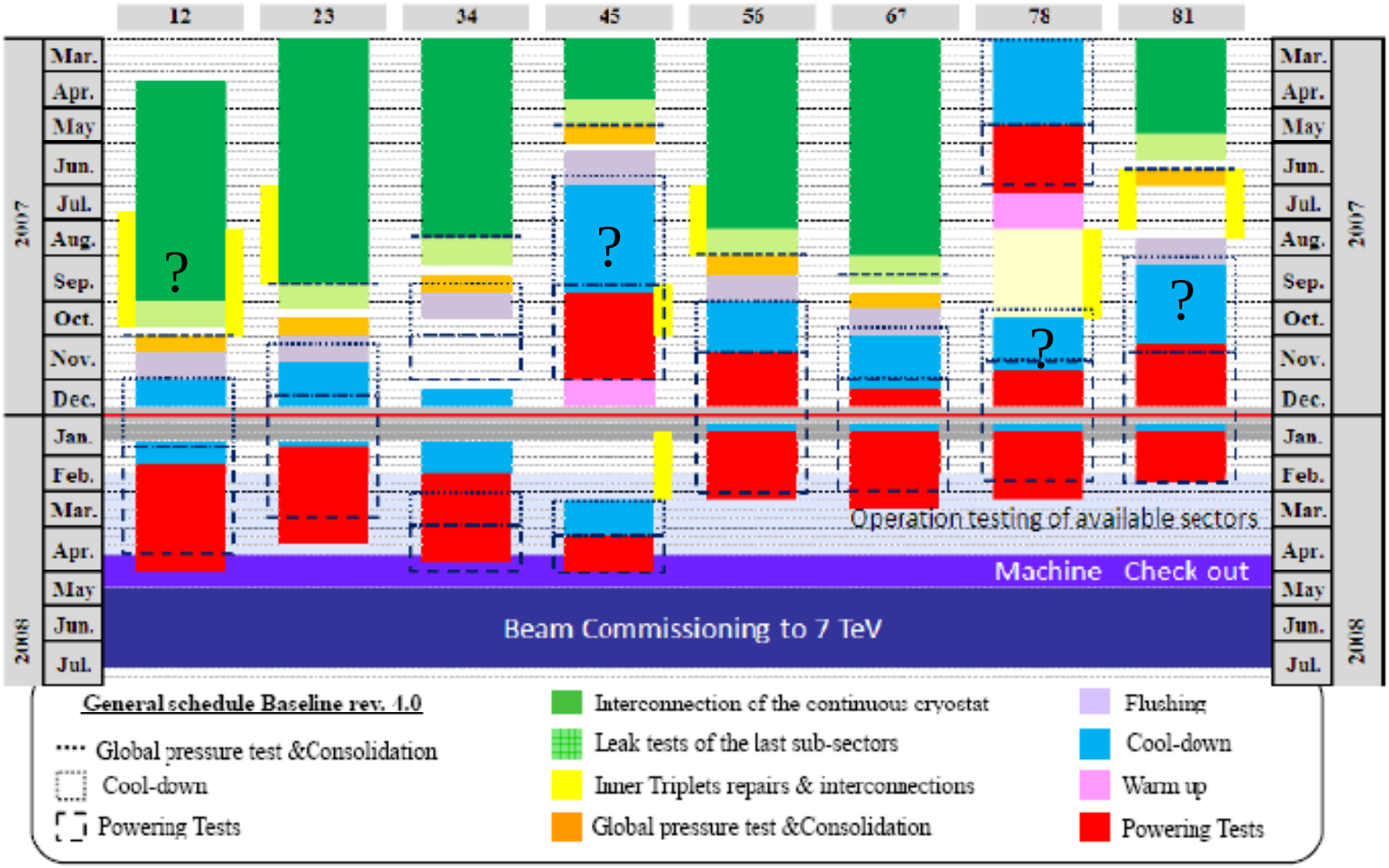
- Procurement problems of remaining components (DFBs, collimators) now settled
- Good progress of installation and interconnection work, proceeding at high pace in tunnel
- Numerous non-conformities intercepted by QA program, but resulting in added work and time
- Technical solutions found for inner 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 (sector 78) cooled down to nominal temperature and operated with superfluid helium
- Partial power tests performed in sector 78
- Sector 78 consolidation ongoing (with a few surprises, notably PiMs - 6 bad/400) and expected to be complete early November
- Second sector 45 cool down restarted after leaks. Power tests mid-November to Christmas
- Sector 81 leak: the faulty quad is out. Spare is going in

Schedule – rev 4.0 – June Council



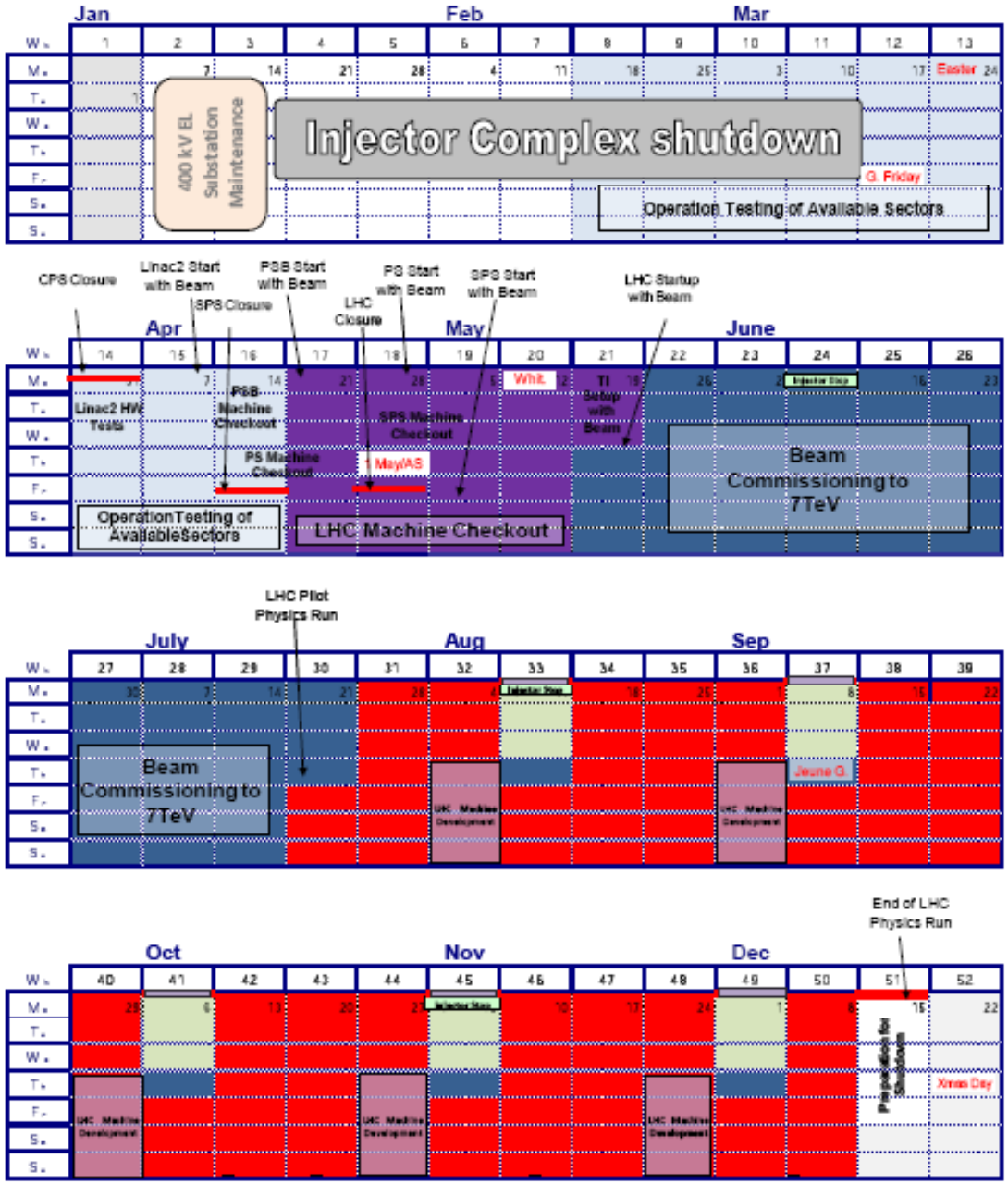
Revised Schedule – August 3rd (last approved)



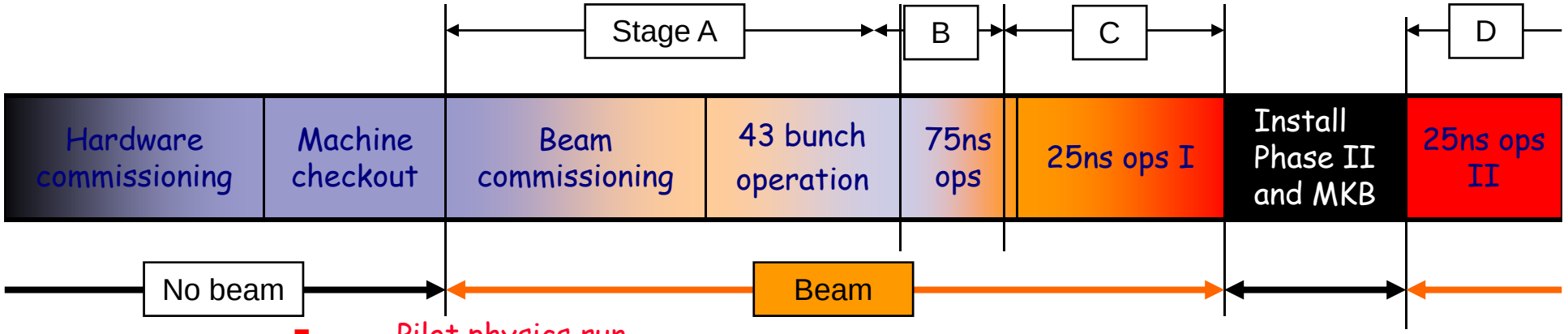
Comments on the schedule

- Priority is to get the machine cold and leak tight
- High parallelism for the power tests (hardware commissioning)
- Problems found at cold cost an additional warm-up/cool-down cycle (3 months)
- With the present experience, expect more changes
- Injection test into point 8 may come back on the scene

Schedules – 2008 LHC (draft)



Commissioning strategy for protons



- Pilot physics run
  - First collisions
  - 43/156 bunches per beam, no crossing angle, no squeeze, moderate intensities
  - Push performance
  - Performance limit 10^{32} cm^{-2} s^{-1} (event pileup)
- 75ns operation
  - Establish multi-bunch operation, moderate intensities
  - Relaxed machine parameters (squeeze and crossing angle)
  - Push squeeze and crossing angle on
  - Performance limit 10^{33} cm^{-2} s^{-1} (event pileup)
- 25ns operation I
  - Nominal crossing angle
  - Push squeeze
  - Increase intensity to 50% nominal
  - Performance limit $2\ 10^{33}$ cm^{-2} s^{-1}
- 25ns operation II
  - Push towards nominal performance

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

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

Early Years Physics Running

- Expect to spend as much time out of physics as in
  - Ramp down, cycle, injection, ramp, squeeze, prepare
  - Faults, access, other problems
- Will be aiming to
  - Fix faults, give access, solve problems, fill, ramp, squeeze by day
  - Provide colliding beams for physics overnight
  - Averaging a 10h fill per day would be good (40% efficiency for physics)

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
  - $\leq 10^{32}$ $cm^{-2}s^{-1}$
  - 10h fill per day is optimistic at this stage

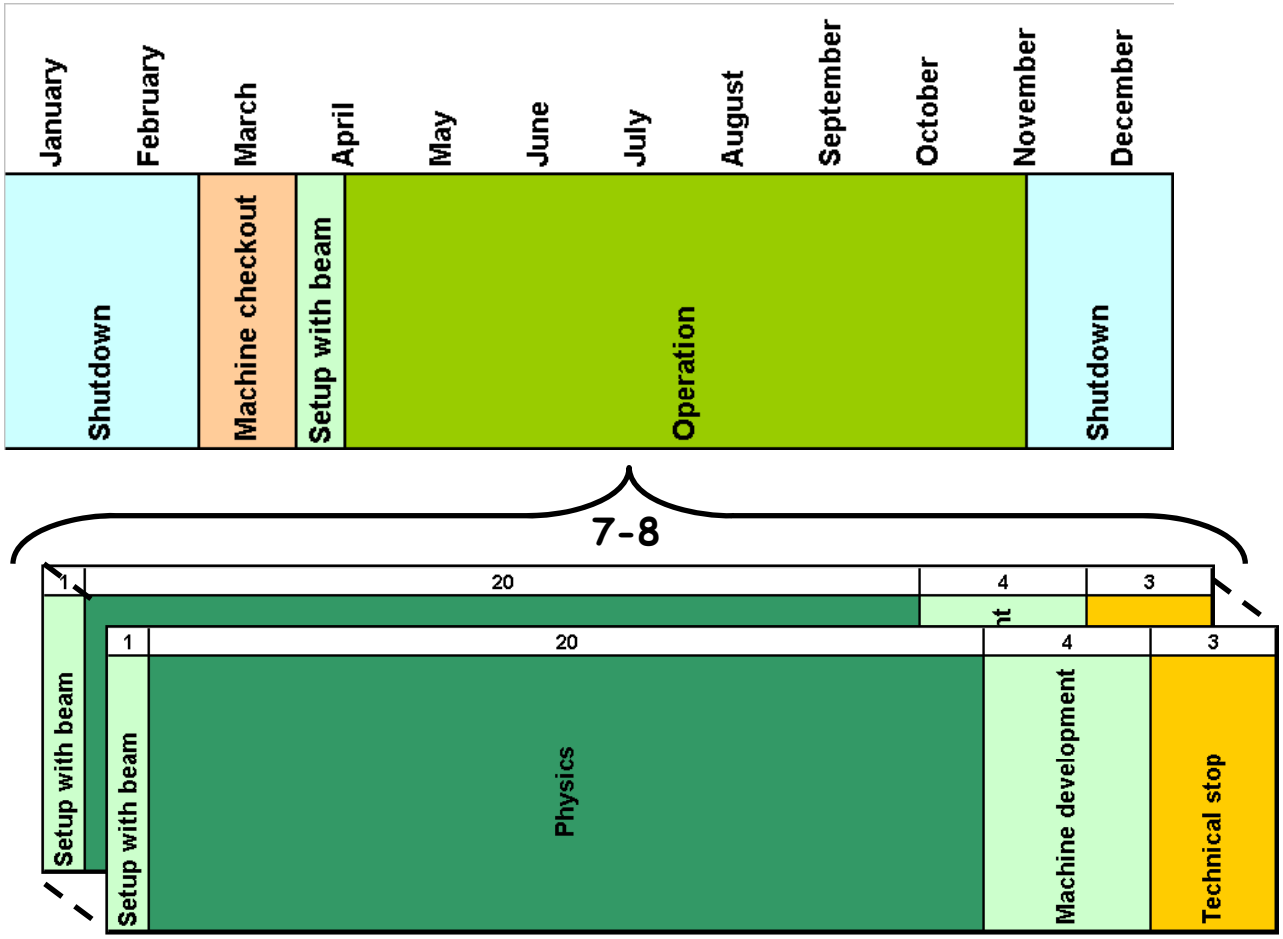
- Phase B: if things go really well!!

- Collimation
  - Phase 1 scheme will be in place
  - Full and appropriate machine protection will be pursued

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		

Breakdown of a Normal Year



~ 140-160 days for physics per year
Not forgetting ion and TOTEM operation
Leaves ~ 100-120 days for proton luminosity running
? Efficiency for physics 50% ?
~ 1200 h or ~ 4 10^6 s of proton luminosity running / year

Normal Year Scheduling

Every year there will be a long shutdown (3-4 months)

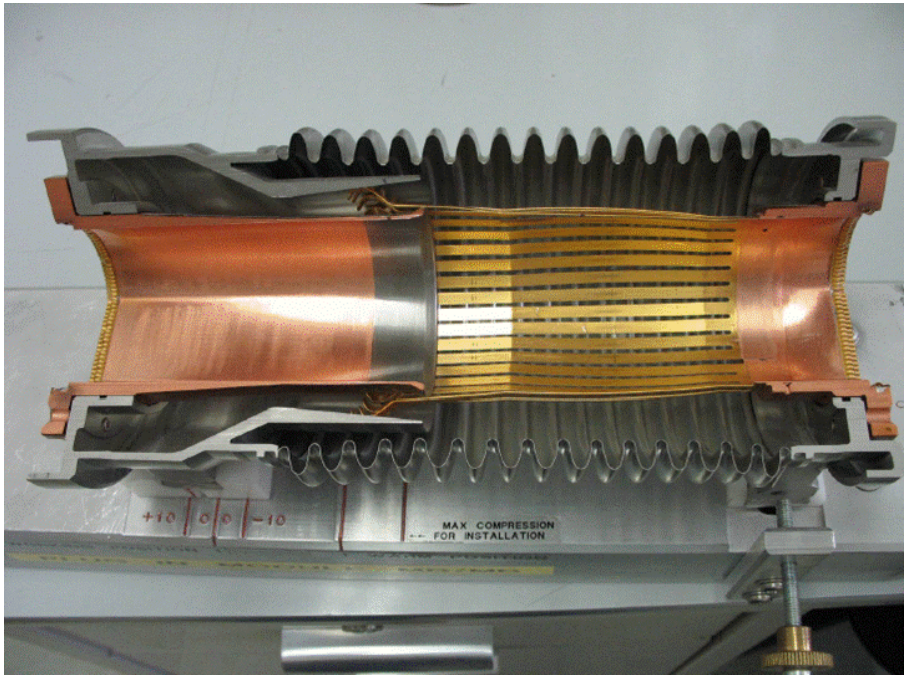
At the end of every shutdown

- Close the machine personnel access system
- Get all equipment ready for beam (machine checkout, ~ 3-4 weeks)
- Get machine ready for operation (setup with beam, 2-3 weeks)

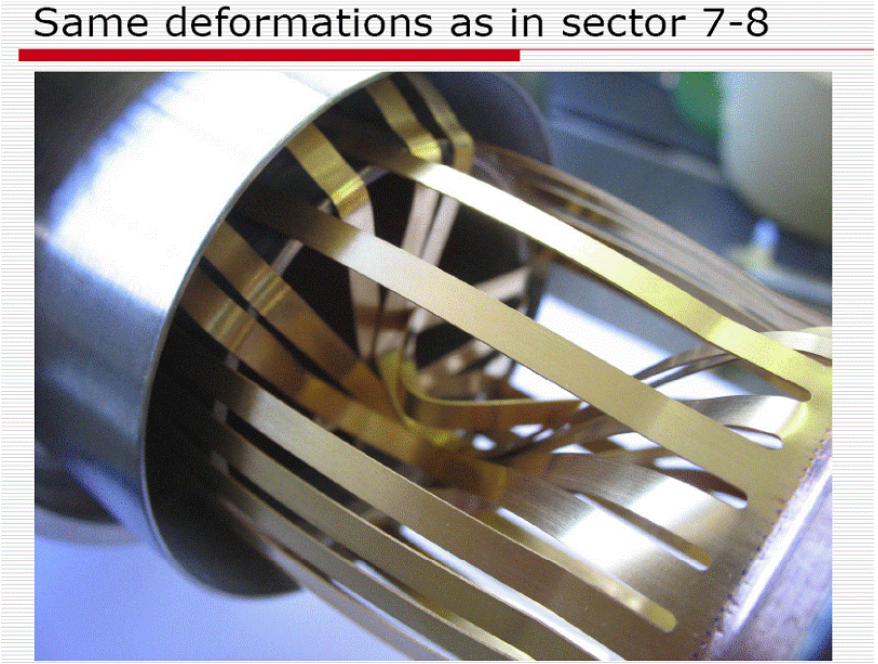
During periods of operation

- Need regular technical stops (3 days every month)
  - Interventions need careful but flexible planning
- Get machine ready for operation (1 day)
- Machine development (around 15% during first years)
- Operations for physics
- Access as required for unscheduled stops

Interconnect Plug-in Modules Details



Plug-in module in cold position



Failure example