Post LS1 Schedule

Mike Lamont 29th October 2013

Thanks to Serge Claudet, Simon Baird, Austin Ball, Fabiola Gianotti, Beniamino di Girolamo, Didier Contardo, Richard Jacobsson

Considerations

Bit of a matrix here: demands on run 2, LS2, run 3, LS3 from: injectors, LHC machine, LHC experiments...

- LHC machine
 - How long can we run for? (Cryogenics, maintenance...)
 - How long can the operations group run for?
 - Ion program North area, LHC
- Injectors
 - Risks of running with Linac2 until 2018/2019
 - Linac4 connection, LIU upgrades
- Experiments
 - Upgrades I & II, YETS
- Longer-term strategy
 - Accelerator technology development time
 - Detector technology development time, funding profiles for the phase II upgrades...

Baseline

								-				
	J	F	M	Α	M	J	J	A	S	0	Ν	D
								_				
2011		1	2	3	4	5	e	5 7	8	9	IONS	
2012			1	2	3	4	5	6	7	8	9	
					•							
2013	IONS	IONS	LS1 - SPLI	CE CONSOLI	DATION							
					•	1.5	51					
2014												
					I							
2015	CHECK-OUT	RECOM	RECOM	1	2	3	4	5	6	7	IONS	
				_	I							
2016		RECOM	1	2	3	RU	N 2	6	7	8	IONS	
					I	_						
2017		RECOM	1	2	3	4	5	6	7	8	IONS	
					I							
2018	LS2 (LIU U	PGRADE: LI	NAC4, BOOS	STER, PS, SP	S)	LS	52					
	-		· · ·									
2019	RECOM	RECOM	1	2	3	4	5	6	7	8	IONS	
					I							
2020		RECOM	1	2	3	RU	N 3	6	7	8	IONS	
				I	I					I		
2021		RECOM	1	2	3	4	5	6	7	8	IONS	
2022	HL-LHC UPGRADE											
							53					
2023	HL-LHC UP	GRADE										

Technical stop or shutdown Proton physics

Ion Physics

Recommissioning

Possible Timeline for upgrades to be installed in LS3





Standard long year

Phase	Days
Christmas technical stop including HWC – beam to beam	91 (13 weeks)
Commissioning with beam (double coming out of a LS)	21
Machine development	22
Scrubbing	7 (to 14)
Technical stops	15 (3 x 1 week)
Technical stop recovery	6
Proton physics including intensity ramp-up	160
lon run set-up	4
Ion physics run	24
Contingency	7 (or 0)
Total	365

	Jan	Jan Feb							Mar			Re-comm with b	eam
Wk	1	2	3	4	5	6	7	8	9	10	11	12	13
Мо	1	8	15	22	29	5	12	19	26	5	12	19	26
Tu												•	
We					01-Feb								
Th		Teo	chnical s	stop					нwс				
Fr													
Sa											Machine		
Su											checkout		

Winter technical stops (including hardware commissioning): 13 weeks beam to beam







3 technical stops through the year: 1 week – 10 week – 1 week

Xmas: ~10 days required before CERN closure to secure the helium inventory (worth ≈ 7 MCHF) and be protected again serious failure with only minimal "on-call" support

Post LS1 schedule

Recall 2009 - 2013

- 2009
 - 23rd November 16th December
- 2010
 - 22nd February 6th December
 - AMS 4th 9th February
- 2011
 - 21st February 7th December
- 2012
 - 14th March 17th December
- 2013
 - 14th January 16th February

Injectors start ~2 weeks before these dates to have beam ready for the LHC

At the limit!

Injectors 2014

	Jan					Feb				Mar			
Wk	1	2	3	4	5	6	7	8	9	10	11	12	13
Мо	30	6	13	20	27	3	10	17	2	4 3	10	17	24
Tu													
We			SHUTD	OWN						PSB and PS	access syste	em	
Th			LS	1						comn olus HW testi	nissioning	vriate)	
Fr											Ing as approv		
Sa													
Su													

	Close PSB Start Start HW tests & checkout Start																				
	Start	source	Start Li	nac2		Clo	se PS	1			Bean	n	to PSB	Argon in L	inac3			Bei	am to	PS	i -
			Apr					May						June	Argo	on to Le			0	lose	e SPS
Wk		14	15	16	17		18	19	20		21		22	23	1	.4		25			26
Мо		31	*	7 14	Easter Mon 21		28	¥ ₅	12		19		26	*	z W	lit g	,↓		16		
Tu																					\square
We				PSB/PS	<u> </u>		,	hardware	tests					PSB s	tup with	beam					beam
Th				dry runs etc.	ests	1	st May						Ascension		old chec	Kout					p with
Fr	1	1		G. Friday									ł					1	r		Ssetu
Sa									PS DSO tests											*	٩
Su																					

Start AD, East hall, nTOF, ISOLDE physics

Star	Start AD, East hall, nTOF, ISOLDE set-up					AD physics								
	July Au			Aug		Argon	to P	5		Sep		4	rgon to SPS	
Wk	27	28	29	30	31	32	33		34	35	36	37	38	39
Мо	30	7	14	21	21	в	•	11	18	25	1	в	15	¥ 22
Tu			•											
We	bear									kout				
Th	ip with	¥								chec	Jeune G	s	PS set-up with b	com
Fr	5 setu									cold				
Sa				SPS EPC comissi	ioning				SPS DSO	SPS				
Su									tests					



LHC RUN 2

Maximum Length? Extended year end technical stop? Linac4 connection?

Extended Year End Technical Stop (EYETS)

- CMS:
 - 4 layer pixel ready to install at end of 2016
 - 4.5 months beam to beam (plus some contingency)
- Other experiments
 - ATLAS don't need it
 - Not of any significant benefit to ALICE and LHCb but...
- Cryogenics
 - magnets would be kept cold below 80K during this "physics break" must ensure we don't lose conditioning
 - could imagine some sectors in nominal conditions for some training quenches in order to push towards 7 TeV.
 - some opportunity for selective maintenance
- Even sandwiching the extended stop with ion runs would appear to be too short for Linac4 connection (~9.5 months see Bettina Mikulec)
- LIU preparation
 - Could use time in Booster/PS e.g. cable cleanup

Extended run 2?

- Four year run without an extended stop
 - Unacceptable to CMS rule out
- With extended stop:
 - Operation of LHC for 3.5 to 4 years with ~5 months out in the middle
 - Operation of injector complex for 4 to 4.5 years with ~5 months out in the middle
- Also buys at least two LHC experiments important contingency in preparation for major upgrades in LS2
- Risk of running with Linac2 until 2018/2019





- Machinery and global cryo maintenance plan have periodicity of maximum 40,000 hrs (5 yrs at 8'000hrs (or 11 months)) including cool-down, HWC before beams and warm-up before next LS, this would give 1 yr of technical setup and 4 yrs of physics
- Experience so far shows that some equipment reliability falls before these accumulated hours, we work on that, some could accept a bit more, but not yet 50% more...

One work-around it could be an intermediate 6 months physics break, to give us time to treat most sensitive machines and allow for 1 to 2 more yrs, t.b.c

Run 2 - options

Baseline



Slipped baseline + 12

2015	CHECK-OUT	RECOM	RECOM	1	2	3	4	5	6	7	IONS	
2016		RECOM	1	2	3	4	5	6	7	8	IONS	
2017	EXTENDED	YEAR END	TECHNICAL	STOP	RECOM	1	2	3	4	5	IONS	
2018		RECOM	1	2	3	4	5	6	7	8	IONS	

Slipped baseline + 6

2015	CHECK-OUT	RECOM	RECOM	1	2	3	4	5	6	7	IONS	
2016		RECOM	1	2	3	4	5	6	7	8	IONS	
2017	EXTENDED	YEAR END	FECHNICAL	STOP	RECOM	1	2	3	4	5	IONS	
2018	RECOM	1	2	3	4	IONS						

Options not shown: 4 year run straight through; extending EYETS to 9 months.

Experiments? Injectors? LHC? Re-commissioning?



LS2 - experiments

- ALICE
 - Major upgrade of ALICE detector, for installation in 2018/19
 - "we assume LS2 is 18 months"
 - "would not violently object if LS2 shifts to 2019" would provide important contingency
- LHCb
 - Requires 18 months
 - A later start of LS2 at end 2018 would be advantageous for LHCb
 - Further delay of the start of LS2 beyond 2018 would be disfavoured
- ATLAS
 - Assumes baseline (LS2 14 months in 2018)
- CMS
 - LS2: 14 to 18 months
 - Prefers LS starting end 2018
 - "to collect sufficient data... LS2 must not start before summer 2018"

Worry about radiation levels forcing potential constraints/cool-down time etc.

LS2 - Injectors

Updated this

	morning	ד
		Approx. months
Linac4	Linac4 connection to the PSB takes place during LS2	
PSB	Total of 16 months for PSB works including 1.5 months of cool-down and 4 months of beam commissioning Cabling! Might be able to claw some time back in EYETS	20.5 to pilot
PS	PS upgrade is determined mainly by magnet program (replacement of the PFWs) – about 1 year – plus 1 month cool-down	13
SPS	12 months for the 200 MHz upgrade 7 months for aC coating of main bending magnets (tbc) Injection upgrade	17.5

Total duration of LS2 works of the injectors 20.5 months Some co-commissioning injectors/LHC might be necessary

LS2 - LHC

- 16 months for Cryogenics and cooling/ventilation (also LS4)
- DS collimators
- Vacuum point 2
- RF cryogenics
- Possible HL-LHC prep. (crabs...)
- Prep. for TAS aperture change?

Clear conclusion – LS2: ~18 months

Run 3 - options

Baseline + 18 month LS2



Slipped baseline + 12

2019	LS2 (LIU UI	PGRADE: LI	NAC4, BOOS	STER, PS, SP	PS)							
2020							RECOM	RECOM	1	2	3	
2021	1	2	3	4	5	6	7	8	9	9	IONS	
2022		RECOM	1	2	3	4	5	6	7	8	IONS	
2023	HL-LHC UPO	GRADE - PH	ASE 1									

Slipped baseline + 6

2019	LS2 (LIU UI	PGRADE: LI	NAC4, BOOS	STER, PS, SP	PS)							
2020	CHECK-OUT	RECOM	RECOM	1	2	3	4	5	6	7	IONS	
2021		RECOM	1	2	3	4	5	6	7	8	IONS	
2022		RECOM	1	2	3	4	5	6	7	8	IONS	
2023	LS3: HL-LH	C UPGRADE										

LS3 – length

- Experiments
 - CMS: 30 months seems feasible
 - ATLAS: 27 months (outside possibility for 35 months)
- LS3 could become longer due to activation aspects, infrastructure increase and maintenance, longevity issues still to discover and... our usual packing in of whatever we can
- LHC:
 - 20 months for cryogenics and cooling/ventilation (also LS4)
 - Major upgrade of insertion regions etc. triplets, 11 T dipoles, collimators, cryogenics, crab-cavities, cold powering...
 - Possible civil engineering in the tunnel (crab-cavities)
 - Possible civil engineering on surface
 - Major infrastructure implications

2.5 years seems a reasonable working hypothesis

Pushing start LS3 to 2023

- Possible considerations:
 - Additional time to cover R&D to production phase for detector upgrades
 - Associated funding profiles
 - Accelerator technology development times



lons

- Ions are part of the HL-LHC program.
- Extended periods of running are not an option.
- Scheduling: longer ion run before LS3 (~2 months) plus any other low luminosity stuff such as pp reference data, high beta*, MD etc.
 is clearly a possibility but a second order concern at the moment.

Conclusions

- Baseline
 - No EYETS
 - 2018 LS2 has to go to 18 months
 - LS3 starts in 2022
- Slipped baseline+6
 - EYETS plus run to mid-2018
 - 3 year run 3 LS3 starts in 2023
- Slipped baseline+12
 - EYETS plus run to end 2018
 - Slightly shortened run 3- LS3 starts in 2023

Adjusted baseline

	J	F	М	Α	М	J	J	Α	S	0	Ν	D
2011		1	2	3	4	5	6	7	8	9	IONS	
2012			1	2	3	4	5	6	7	8		9
							I					
2013	IONS	IONS	LS1 - SPLI		IDATION							
2014												
							I					
2015	CHECK-OUT	RECOM	RECOM	1	2	3	4	5	6	7	IONS	
2010				1	2	5		5		, 1		
2016		RECOM	1	2	3	4	5	6	7	R	IONS	
2010			1	2	5	۲	5	0	/	0	10110	
2017		RECOM	1	2	2	4	F	C	_	0	IONS	
2017		RECOM	T	2	3	4	5	0	/	0	10105	
2019									I			
2010		PGRADE: LI	NAC4, BUUS	51 EK, PS, 51	-5)							
2010										-		
2019							RECOM	RECOM	1	2		3
2020	1	2	3	4	5	6	7	8	9	10	IONS	
2021		RECOM	1	2	3	4	5	6	7	8	IONS	
2022	LS3: HL-LH	C UPGRADE										
2023	HL-LHC UP	GRADE										
	•				•				•			•

Slipped baseline+6

2013	IONS	IONS	LS1 - SPLI		IDATION							
2014												
					· · · · ·							
2015	CHECK-OUT	RECOM	RECOM	1	2	3	4	5	6	7	IONS	
		_										_
2016		RECOM	1	2	3	4	5	6	7	8	IONS	
2017	EXTENDED	YEAR END	TECHNICAL	STOP	RECOM	1	2	3	4	5	IONS	
2018	RECOM	1	2	3	4	IONS						
2019	LS2 (LIU U	PGRADE: LI	NAC4, BOO	STER, PS, SI	PS)							
2020	CHECK-OUT	RECOM	RECOM	1	2	3	4	5	6	7	IONS	
2021		RECOM	1	2	3	4	5	6	7	8	IONS	
2022		RECOM	1	2	3	4	5	6	7	8	IONS	
2023	LS3: HL-LH	C UPGRADE										

Slipped baseline+12

	J	F	м	Α	М	J	J	Α	S	0	N	D	Days/year
2011		1	2	3	4	5	6	7	8	9	IONS		200
2012			1	2	3	4	5	6	7	8	9		200
2013	IONS IONS LS1 - SPLICE CONSOLIDATION												0
2014													0
2015	CHECK-OUT	RECOM	RECOM	1	2	3	4	5	6	7	IONS		130
2016		RECOM	1	2	3	4	5	6	7	8	IONS		160
2017	EXTENDED	YEAR END	TECHNICAL	STOP	RECOM	1	2	3	4	5	IONS		100
2018		RECOM	1	2	3	4	5	6	7	8	IONS		160
2019	LS2 (LIU U	PGRADE: LI	(NAC4, BOO	STER, PS, S	PS)								0
2020							RECOM	RECOM	1	2	3	4	80
2021		1	2	3	4	5	6	7	8	9	IONS		190
2022		RECOM	1	2	3	4	5	6	7	8	IONS		160
2023	HL-LHC UPGRADE - PHASE 1 (Inner triplets)												0
2024	HL-LHC UP	GRADE											0