First HL-LHC LIU meeting (June 2011)

Update (Today OB's talk)

"Stretched" update (Today BG's talk)

- 29%

What we need as minimu[illegible] in operative condition

2.2E11 p/b
1.12 A
15.8 h IBSL

3.5E11 p/b
0.89 A
13.2 h IBSL

Parameter	nominal	25ns	50ns
N	1.15E+11	2.0E+11	3.3E+11
n_b	2808	2808	1404
beam current [A]	0.58	1.02	0.84
x-ing angle [μrad]	300	475	520
beam separation [σ]	10	10	10
β^* [m]	0.55	0.15	0.15
ε_n [μm]	3.75	2.5	3.0
ε_L [eVs]	2.51	2.5	2.5
energy spread	1.00E-04	1.00E-04	1.00E-04
bunch length [m]	7.50E-02	7.50E-02	7.50E-02
IBS horizontal [h]	80 -> 106	25	17
IBS longitudinal [h]	61 -> 60	21	16
Piwinski parameter	0.68	2.5	2.5
geom. reduction	0.83	0.37	0.37
beam-beam / IP	3.10E-03	3.9E-03	5.0E-03
Peak Luminosity	1 10^{34}	7.4 10^{34}	8.4 10^{34}

What LIU is aiming to: L4, PSB 2GeV, SPS up e-cloud suppression + …

- 23%

2.3E11 p/b
2.4 microm

3.4E11 p/b
2.6 microm

Parameter	nominal	25ns	50ns
N	1.15E+11	1.7E+11	2.5E+11
n_b	2808	2808	1404
beam current [A]	0.58	0.86	0.64
x-ing angle [μrad]	300	480	430
beam separation [σ]	10	10	10
β^* [m]	0.55	0.15	0.15
ε_n [μm]	3.75	2.5	2.0
ε_L [eVs]	2.51	2.5	2.5
energy spread	1.00E-04	1.00E-04	1.00E-04
bunch length [m]	7.50E-02	7.50E-02	7.50E-02
IBS horizontal [h]	80 -> 10[illegible]	25	10
IBS longitudinal [h]	61 ->	21	13
Piwinski parameter	0.68	2.56	2.56
geom. reduction	0.83	0.37	0.36
beam-beam / IP	3.10E-03	3.0E-03	5.6E-03
Peak Luminosity	1 10^{34}	5.3 10^{34}	7.2 10^{34}

0 %

+ 50%

25 ns: not that far: 15% more bunch population: but [illegible]ly 30% needed

50 ns: is far, HL-LHC brightness request may be out [illegible] but….

- 28%

- 14%

Other FZ parameters' list for
25 ns seems feasible from LIU: 1.73E11 p/b within 2.8 microm!

PARAMETERS: DOES IT WORK ON PAPER?

- Error bars in the estimates?
  - +/- or 0/-
  - Optimistic or pessimistic?
- LHC requires ~ 10% bunch pop. fluctuations?
  - Same requirement for HL-LHC?
  - % or absolute number of protons?
  - Effect of running "at the limit" of injectors' performances?
- Main assumption for LHC luminosity leveling: 5E34 for 25 ns (due to pile-up => ~ 100 events) => Uncertainty on this number?
- What can be expected from HL-LHC if LIU fails to provide required beams? Worse scenario 25 ns vs 50 ns?
- What can be expected from HL-LHC if the crab cavities do not work (e.g. increase of transverse emittances due to noise)? Worse scenario 25 ns vs 50 ns? 800 MHz RF cavity to have shorter bunches? Heating

Assumptions made:

1) 27% beam loss between PS inj. and LHC top (in fact SPS top?)
2) 33% emittance growth
3) < ~ 5% beam loss from SPS scraping needed (included)
4) Going to 3 microm for 25 ns could may be work for LHC (OB)…

CONTINUOUS OPERATION: SUSTAINABLE?

PROS (25 vs. 50)

- Longer IBS rise-times
- Smaller Xing angle => Smaller aperture needed
- Less PS and SPS longitudinal instabilities and beam loading issues and no (possible) SPS brightness limit
- Smaller beam brightness needed (0.9 instead of 1.2 in a.u.) in the LHC
- 1 "fundamental limit" in the PS: space charge => No limit indentified yet, bunch length could be increased (profile flattened etc.) and could try and use 1 batch inj. instead of 2 (48 b instead of 72) => 8% less bunches in the LHC only
- Less pile-up (exp. upgrade to ~ 100 events / bunch crossing)
- Much better for machine efficiency => Almost impossible for 50 ns (longer fills)

CONS (25 vs. 50)

- Ecloud in LHC (which should not be a problem for 50 ns)
- Ecloud in SPS (but should be removed with a-C coating)
- Larger total beam intensity
  - More heating from trapped modes
  - Unexpected feedback effect: Ecloud feedback on ion instability
  - Possible LHC HW limits and SPS ZS
- Limit to ~ 2E11 p/b due to ecloud whereas we could go much higher with 50 ns (TMCI ~ 3.5E11 p/b can be increased!)

Going from 2.5 to 3 microm for LHC could maybe work (OB) => Much better for LIU

If this can be improved => 50 ns becomes better!

Assuming luminosity limited by pile-up

CAN WE REALLY GO THROUGH?

INJECTORS

- Major consolidations foreseen in injectors
  - Will lose their "scrubbing" => Worse for 25 ns
- Are we sure that Injectors will preserve beam parameters?
- What is the expected impact on overall efficiency of injectors?

LHC

- Ecloud needs Scrubbing & Vacuum cleaning
  - Efficiency high only in presence of huge Ecloud
- Concerns
  - Stability of beam (losses)
  - Desorbed gas accumulation
  - Acceptable background
- What will dominate? Change within scrubbing run?
- Risks for machine: 450 GeV / 7 TeV?

SOME PROVOCATIVE COMMENTS?

- Do we really need an upgrade to reach the HL-LHC parameters => See talk by W. Herr at Chamonix2012 (https://indico.cern.ch/getFile.py/access?contribId=44&sessionId=6&resId=0&materialId=slides&confId=164089) where he said that after LS1 we could have:
  - × 2 nominal as reasonable target
  - × 4 nominal as an ambitious target
  - => "Just run" more years. Reminder: Project ~ 1 BCHF + 1-2 years to reach nominal values => ~ 12 y in total. Cost of operating the LHC and its injectors is ~ 300 MCHF / year (between 2010-2015, MikeL)
  - Is the HL-LHC project performance-driven or HW-driven? => We need to change the triplets (limit ~ 700 fb^-1 and the MCBX ~ half of that, StephaneF). Do we really need 3000 fb^-1?
- Still some new schemes poping-up in the injectors => Maybe just think a bit more with the present machines and optimize them (finding the best filling scheme etc.) instead of making big changes
- LINAC2 has ~ 98% of efficiency… => Predicted efficiency with LINAC4 over the years? Expected performance with PSB 2 GeV only (i.e. without LINAC4)?

APPENDIX

HL-LHC Performance Estimates

Putting it all together:

Parameter	nominal	minimum β* 25ns	minimum β* 50ns		
N	1.15E+11	**2.2E+11**	**3.5E+11**		
n_b	2808	2808	1404		
beam current [A]	0.58	**1.12**	**0.89**		
x-ing angle [μrad]	300	480	550		
beam separation [σ]	10	10	10		
β^* [m]	0.55	**0.15**	**0.15**		
ε_n [μm]	3.75	2.5	3.0		
ε_L [eVs]	2.51	2.5	2.5		
energy spread	1.20E-04	1.20E-04	1.20E-04		
bunch length [m]	7.50E-02	7.50E-02	7.50E-02		
IBS horizontal [h]	80 -> 106	**20.0**	**20.7**		
IBS longitudinal [h]	61 -> 60	**15.8**	**13.2**		
Piwinski parameter	0.68	**2.54**	**2.66**		
geom. reduction	0.83	**0.37**	**0.35**		
beam-beam / IP	3.10E-03	**3.9E-03**	**5.0E-03**		
Peak Luminosity	1 10^{34}	**9.0 10^{34}**	**9.0 10^{34}**		
Events / crossing	19	**171**	**340**	**95**	**95**

6.2 10^{14} and 4.9 10^{14} p/beam

➔ sufficient room for leveling (with Crab Cavities)

Virtual luminosity (25ns) of
L = 9 / 0.37 10^{34} cm^{-2} s^{-1}

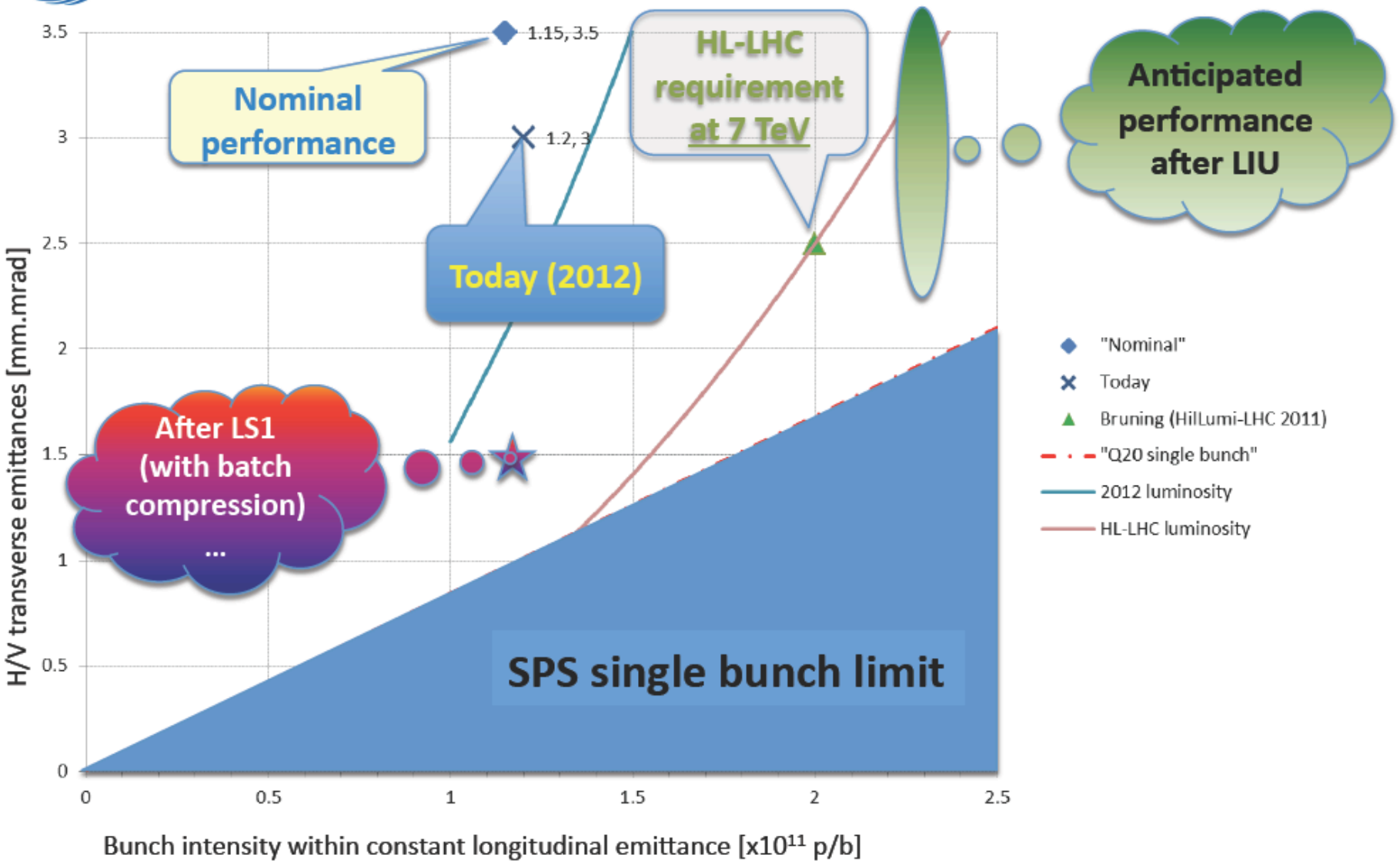
= 25 10^{34} cm^{-2} s^{-1} ('k' = 5)

Virtual luminosity (50ns) of
L = 9 / 0.35 10^{34} cm^{-2} s^{-1}

= 25 10^{34} cm^{-2} s^{-1} ('k' = 10)

(Leveled to 5 10^{34} cm^{-2} s^{-1}
and 2.5 10^{34} cm^{-2} s^{-1})

Beam parameters at LHC injection [25 ns]



Beam parameters at LHC injection [50 ns]