bunch spacing, pile up and all that

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HL-LHC/LIU brainstorming

Jiva Hill, 24 June 2011

no beam-beam limit

limit on total beam current in LHC [& SPS] due to several systems (RF, dump, vacuum, collimator robustness, machine protection, RP, …) at ultimate value

single bunches > 3e11 ppb with 2.5 μm emittance have been accelerated in the SPS

we can get a factor **2 higher peak luminosity with 50 ns** spacing at the same current

in addition we may get **smaller emittance at 50 ns**

→ additional gain in peak luminosity?

pile up replaces beam-beam as HL-LHC constraint

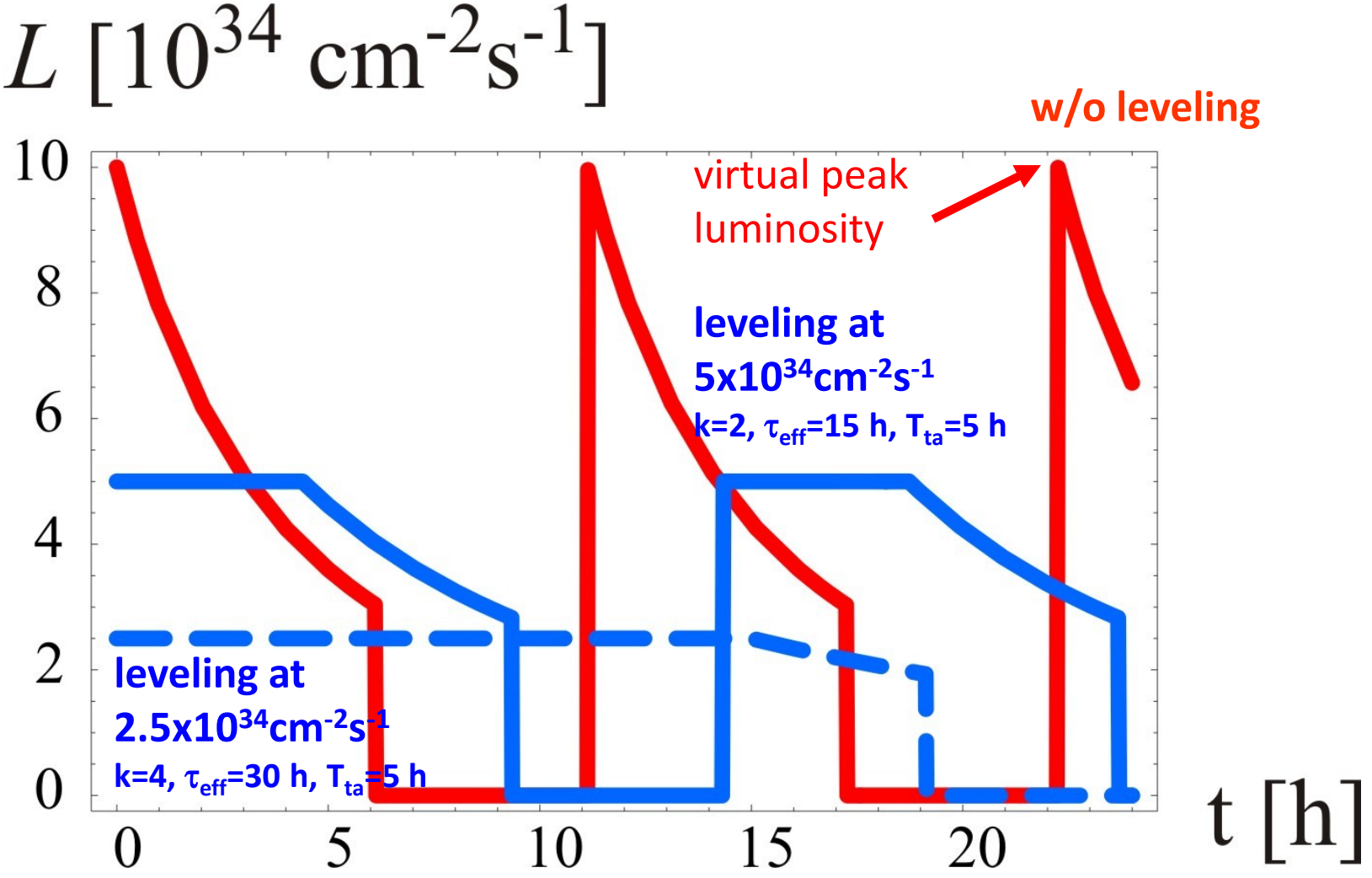
- do we understand it?
- trade off between integrated luminosity & pile up?

leveling works!

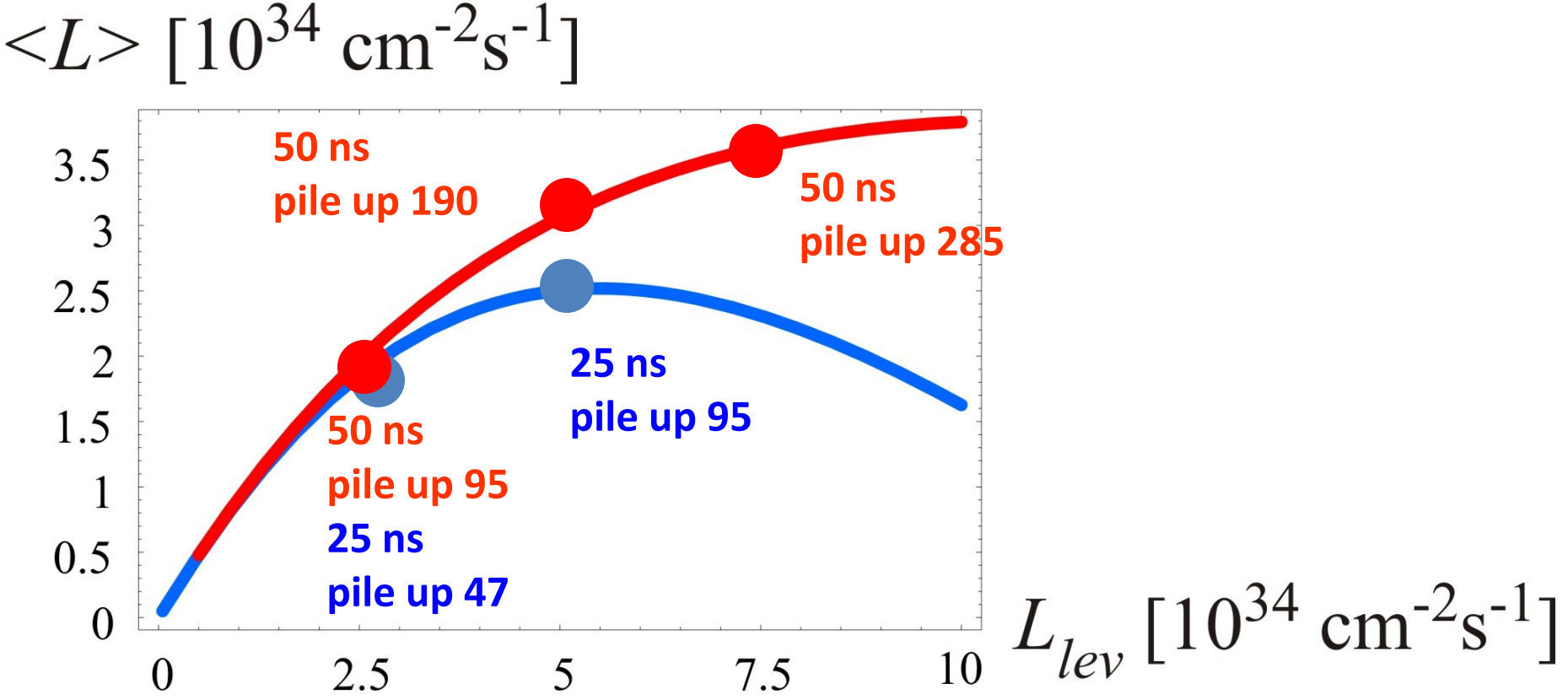
example HL-LHC parameters

parameter	symbol	**nom.**	nom.*	**25 ns, crab, lrc**	**50 ns, crab, lrc**
protons per bunch	N_b [10^{11}]	**1.15**	1.7	**1.7**	**3.4**
bunch spacing	Δt [ns]	**25**	50	**25**	**50**
beam current	I [A]	**0.58**	0.43	**0.86**	**0.86**
rms bunch length	σ_z [cm]	**7.55**	7.55	**7.55**	**7.55**
beta* at IP1&5	β^* [m]	**0.55**	0.55	**0.15**	**0.15**
full crossing angle	θ_c [μrad]	**285**	285	**425**	**425**
normalized mittance	$\gamma\varepsilon$ [μm]	**3.75**	3.75	**2.8**	**2.8**
Piwinski parameter	$\phi=\theta_c\sigma_z/(2*\sigma_x^*)$	**0.65**	0.65	**2.13**	**2.13**
tune shift	ΔQ_{tot}	**0.009**	0.0136	**0.006-0.011**	**0.012-0.015**
potential pk luminosity	L [10^{34} cm^{-2}s^{-1}]	**1**	1.1	**9.6**	**19.3**
actual (leveled) pk luminosity	L_{lev} [10^{34} cm^{-2}s^{-1}]	**1**	1.1	**5**	**5 (2.5)**
events per #ing		**19**	40	**95**	**190 (95)**
effective lifetime	τ_{eff} [h]	**44.9**	30	**13.3**	**13.3 (26.6)**
level time / run time	$t_{level,run}$ [h]	**15.2**	12.2	**3.7 / 8.6**	**6.5 / 10.1 (16.4)**
e-c heat SEY=1.2	P [W/m]	**0.2**	0.1	**0.4**	**0.3**
SR+IC heat 4.6-20 K	P_{SR+IC} [W/m]	**0.32**	0.30	**0.58**	**0.91**
IBS ε rise time (*z*, *x*)	$\tau_{IBS,z/x}$ [h]	**58, 104**	39, 70	**71, 60**	**36, 30**
annual luminosity	L_{int}[fb^{-1}]	**57**	58	**259**	**317 (204)**

luminosity leveling at the HL-LHC



trade off: integrated lumi ↔ pile up



roughly for 2 times more integrated luminosity 4 times the pile up

25 ns or 50 ns?

e-cloud is not the only argument

50 ns beam gives much higher peak luminosity
and has larger reach for integrated luminosity

pile up can be controlled by leveling

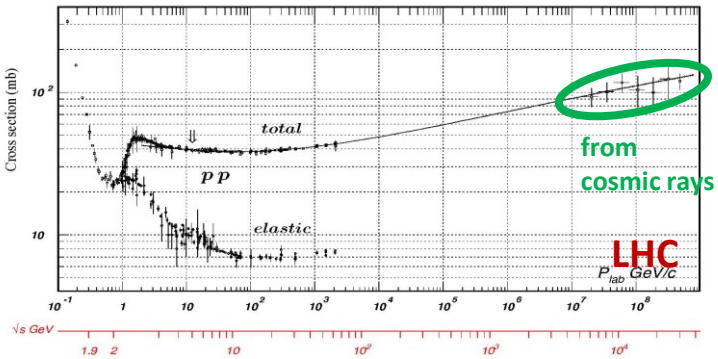
what is the pile up limit (physics dependent?),
and do we calculate the pile up correctly?

pile up

Peak Stable Luminosity (ATLAS)	1.26x10^{33}	Fill 1815	11/05/29, 06:41
Max. Peak Events / Bunch Crossing (ATLAS)	14.01	Fill 1732	11/04/23, 05:47
Max. Average Events / Bunch Crossing over the fill (ATLAS)	**8.93**	Fill 1644	11/03/22, 02:20

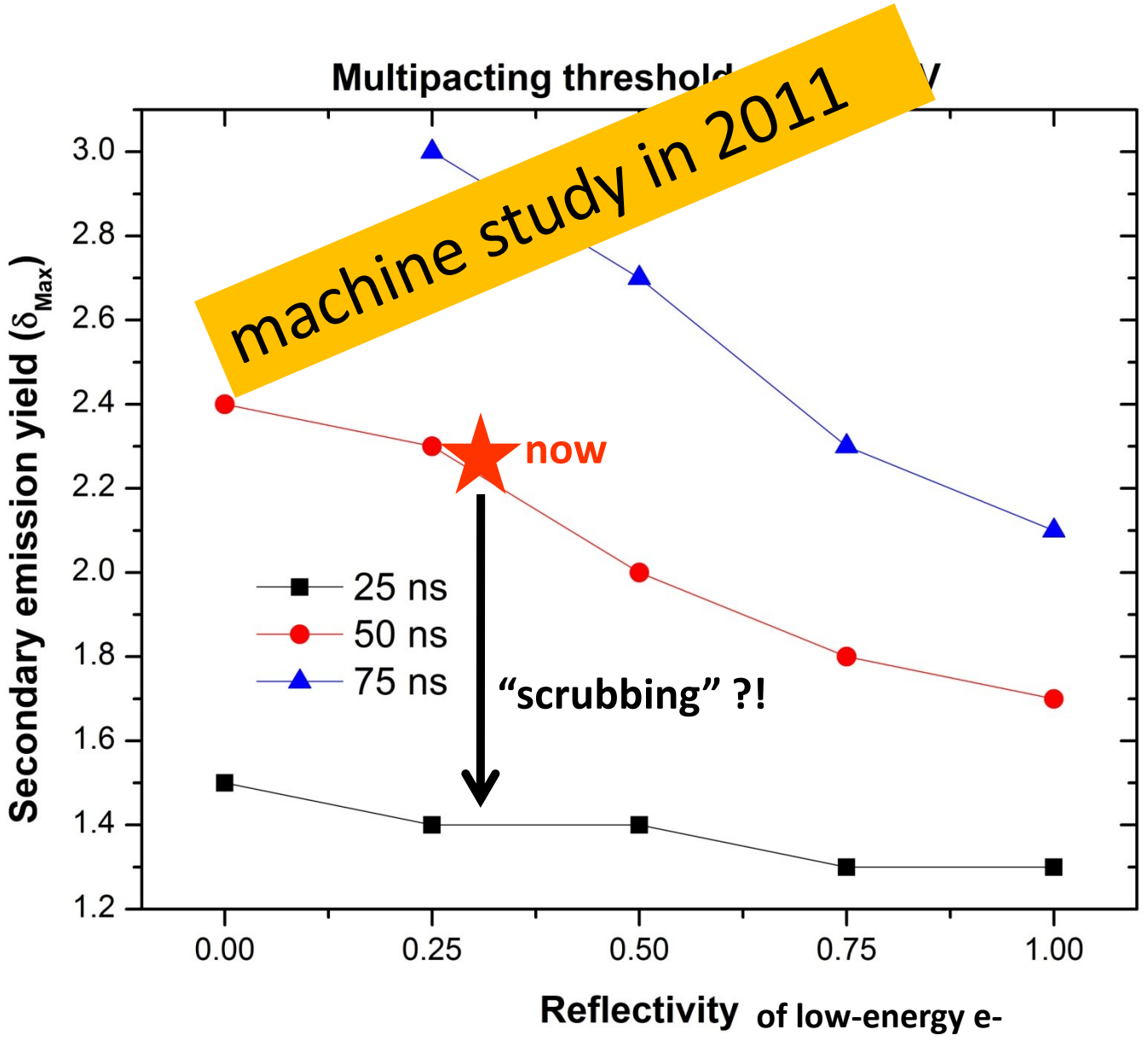
nominal Pile Up LHC Design Report = 19.0
at L=10^{34} cm^{-2}s^{-1} with 2808 bunches

scaling to actual conditions:
present pile up should be
< 19.0 (2808/1092) 0.126
~ 6 ??



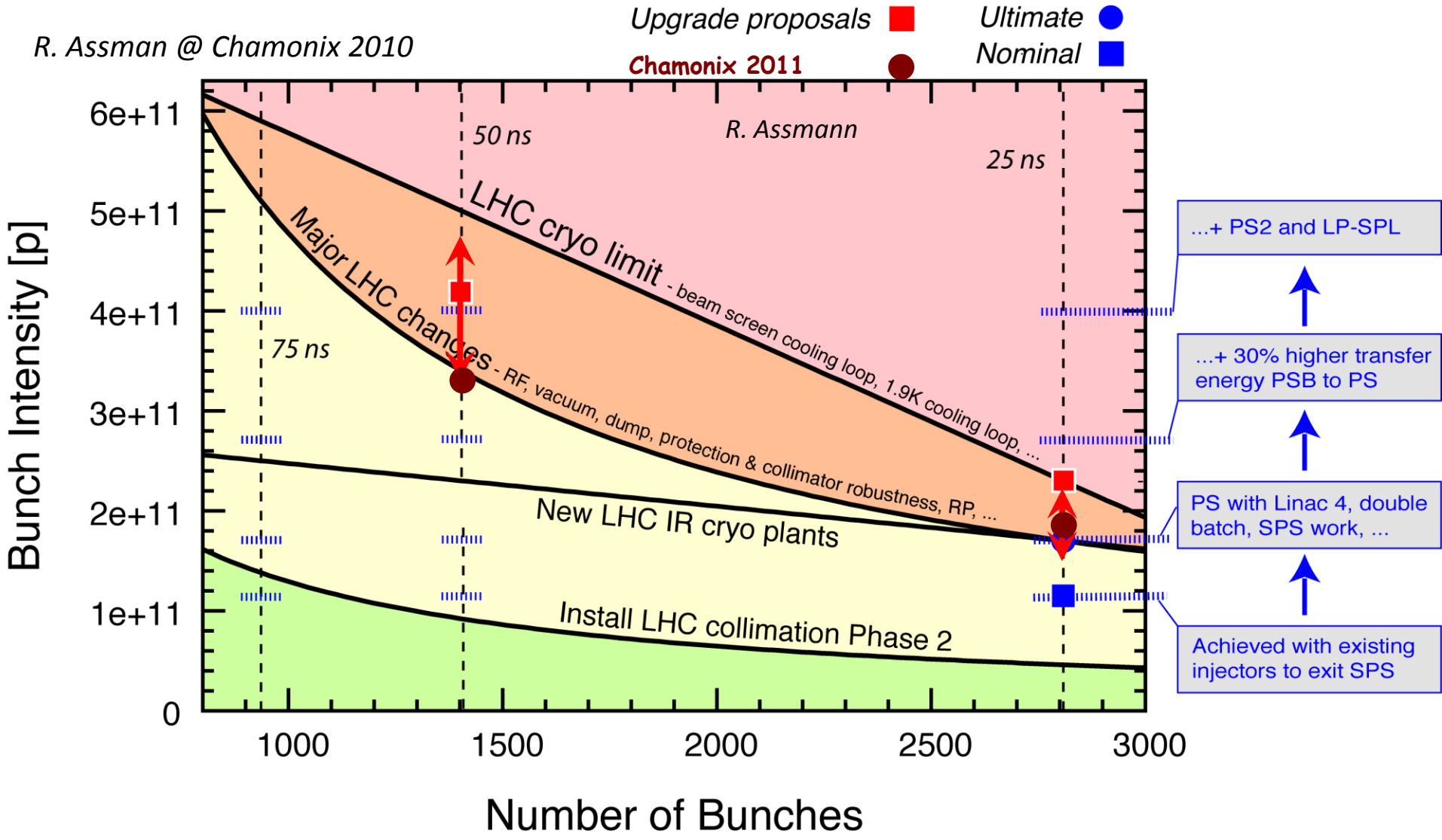
appendix

electron cloud build up at 3.5 TeV



H. Maury

LHC Intensity Limits (7 TeV)



Ideal scenario: no imperfections included!

Note: Some assumptions and conditions apply…