Impressions from Chamonix 2010

Max Klein

Liverpool ATLAS Analysis Meeting

3.2.2010

Indico 67839

Cf Marzio Nessi ATLAS 2.2.10

Friday 5.2.10 CERN summary

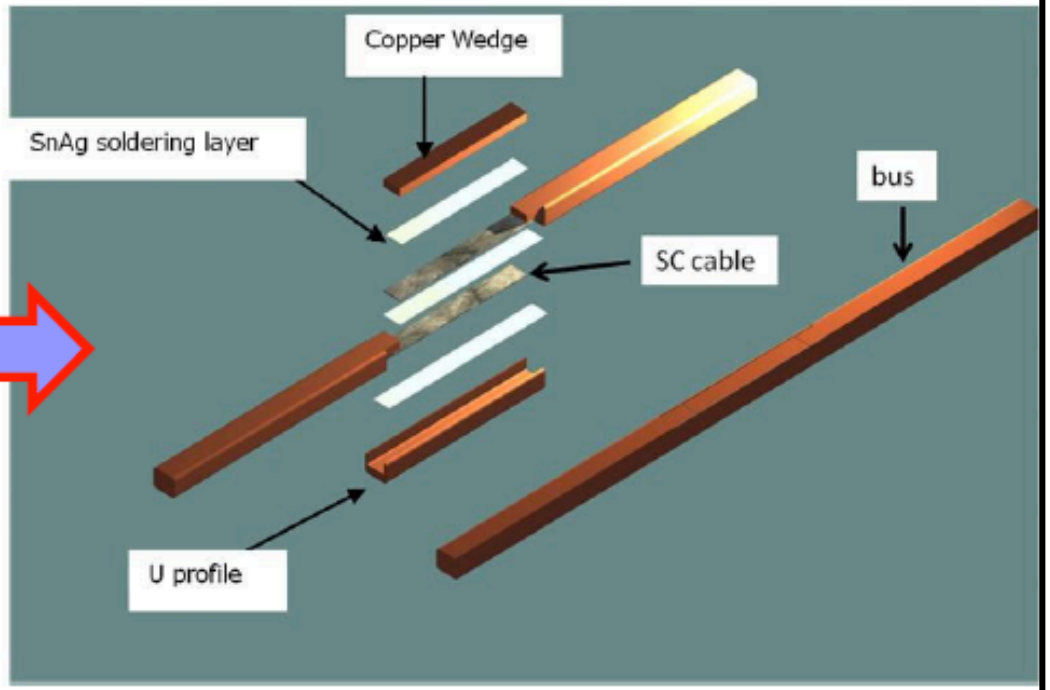
2010/11

M.Koratzinos

The main circuits of the LHC (RB, RQD, RQF) have about 24000 splices.

Out of these there are:
- 10170 interconnect splices and
- 13796 magnet splices

Interconnect splices are not protected by diodes and in the case of a problem all the current of the circuit passes through them



Nominal interconnect splice resistance:
- At cold: **300pΩ**
- At warm (300K): **10μΩ**

For the LHC to operate safely at a certain energy, there is a limit to how big a splice resistance can be

2010/11

M.Koratzinos

- Splices at cold (in the superconducting state) have been measured with excellent accuracy and do not pose a problem.
- Splices at warm (copper stabilizer) have been measured in part of the machine and extrapolated to the whole machine using statistical methods.
  - worse splice measured: **60±1μΩ**
  - worse splice known to exist in the machine: **53±15μΩ**
  - worse splice extrapolated: **90μΩ**
- The current knowledge of the interconnect splices leaves no margin even for operation at 3.5TeV.
- 5TeV running is excluded without major repairs after a warm up.
- Two methods have been proposed to increase our knowledge of the interconnect splices
  - A low current method that can measure the RRR of the busbars
  - A high current method (the Thermal Amplifier) that is sensitive to the worst splices in all bus bar segments
- Using any of the above methods would allow us to either run at a higher energy around 4TeV and/or get a bigger margin at 3.5TeV.

S. Myers

Two Possible Scenarios 2010-2011

1. Run at 3.5 TeV/beam up to a predefined integrated luminosity with a date limit. Then consolidate the whole machine for 7TeV/beam.
   - Need to determine the needs for the shutdown (resources, coactivity etc)

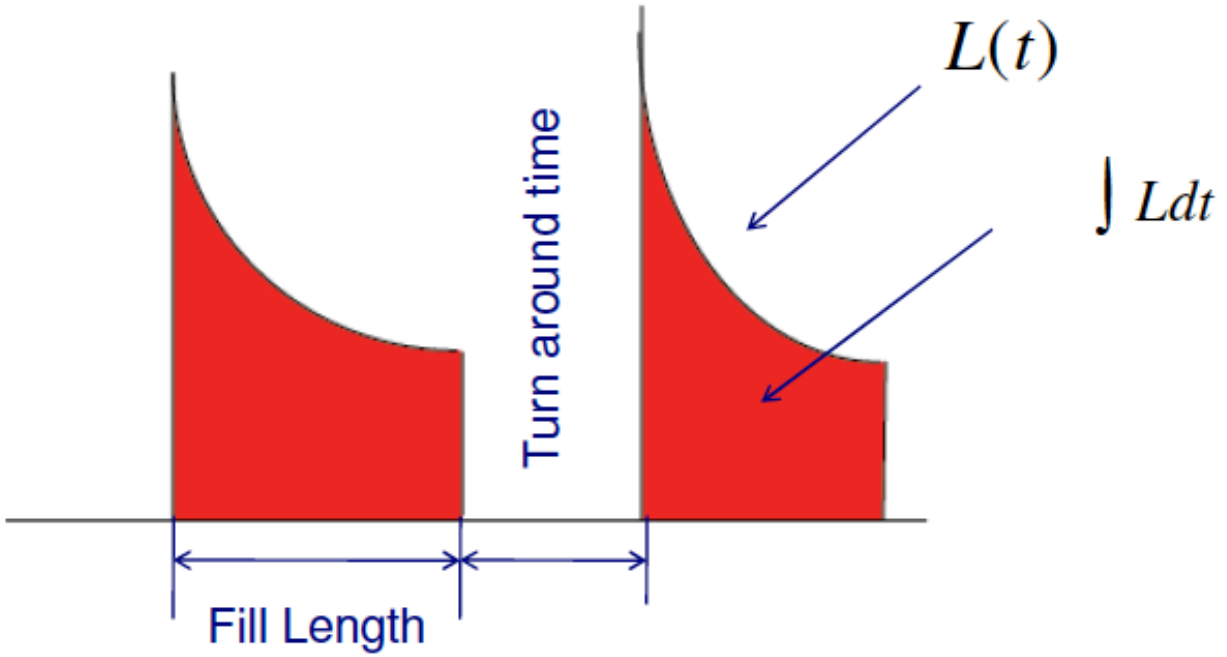
2. Run until second half 2010 then do minimum repair on splices to allow 5TeV/beam in 2011 (7TeV/beam comes much later)
   - ? Do DN200s at same time
   - ? Will we need to **warm** all sectors in order to re-measure (looks like yes to 7 RB octants from Mike's results, and 8 RQ)
   - ? How many splices will we need to repair to reach the "limit" copper stabilizer resistances (what about the RQs?)

Unanimous at Chamonix for 1) → can expect CERN decision, watch for 'date'

M. Lamont

$$\tau_L = \frac{1}{\frac{1}{2\tau_{IBS}^x} + \frac{2}{\tau_{gas}} + \frac{1.54}{\tau_N}}$$

$$\tau_N = \frac{n_b N_b}{2L\sigma_{TOT}}$$



Turnaround time about 3h; 30 days, 3 days stop, 2 days MD, 60% up (!) after 1year

2010

M. Lamont

Step	E [TeV]	Fill scheme	N	β* [m] IP1 / 2 / 5 / 8	Run time (indicative)
1	0.45	2x2	$5x10^{10}$	11 / 10 / 11 / 10	Weeks
2	3.5	2x2	$2 - 5x10^{10}$	11 / 10 / 11 / 10	
3	3.5	2x2*	$2 - 5x10^{10}$	2 / 10 / 2 / 2	
4	3.5	43x43	$5x10^{10}$	2 / 10 / 2 / 2	Weeks/Months
5	3.5	156x156	$5x10^{10}$	2 / 10 / 2 / 2	
6	3.5	156x156	$9x10^{10}$	2 / 10 / 2 / 2	Months
7	3.5	50 ns - 144**	$7x10^{10}$	2.5 / 3 / 2.5 / 3	
8	3.5	50 ns - 288	$7x10^{10}$	2.5 / 3 / 2.5 / 3	
9	3.5	50 ns - 720	$7x10^{10}$	2.5 / 3 / 2.5 / 3	Months

→ 20pb^{-1} per month

* Turn on crossing angle at IP1.

**Turn on crossing angle at all IPs.

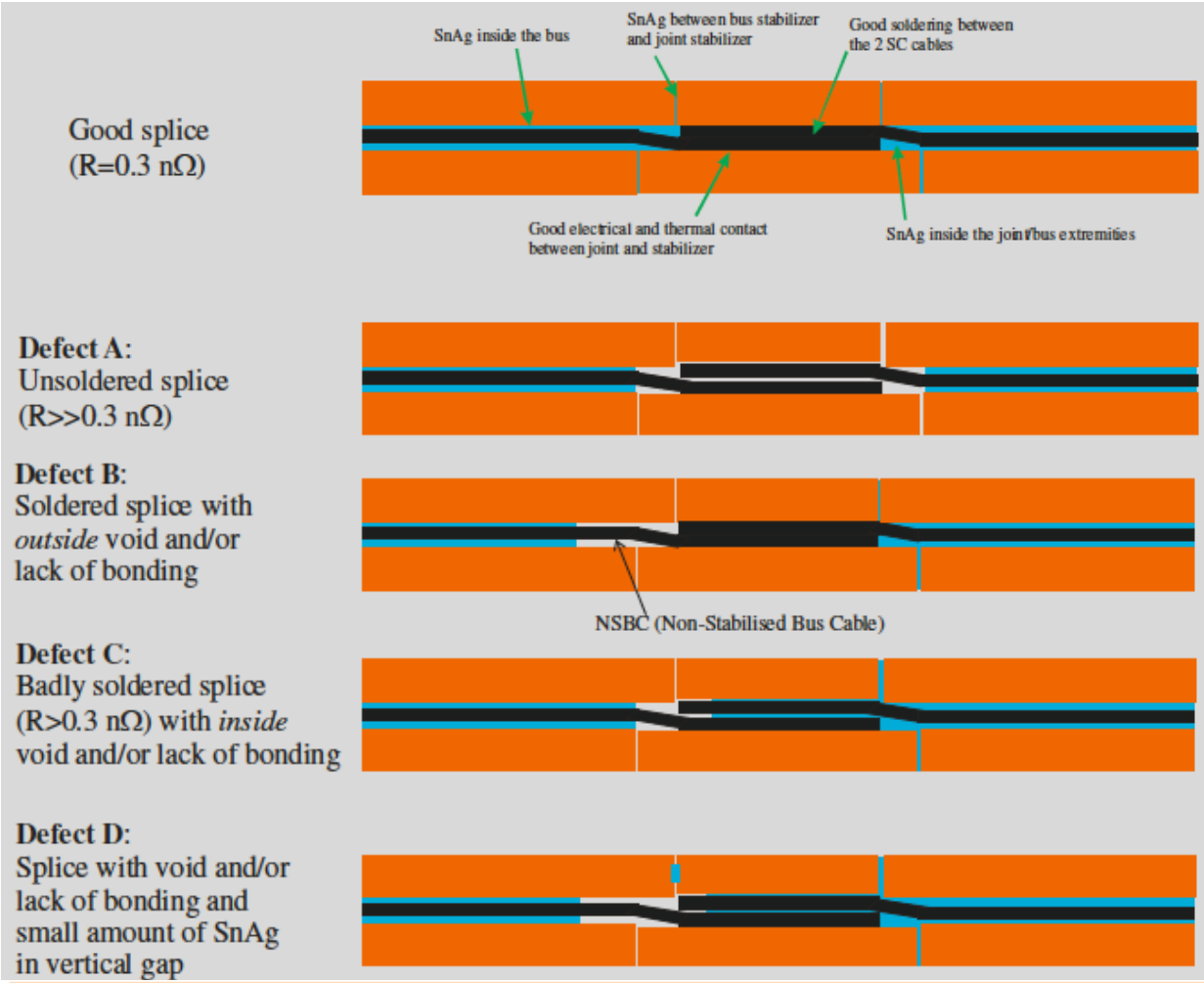
One month: 720 bunches of 7 e10 at beta* = 2.5 m gives a peak luminosity of 1.2 e32 cm^{-2}s^{-1} and an integrated of about 105 pb^{-1} per month

[15% nominal – 28 MJ]

2011: "flat out at 100 pb^{-1} per month"

My guess: by June have ~30pb^{-1} for ICHEP

A. Verweij



12-18 month shutdown starting sometime 2011 for repair of splices and lots of further work.

Conclusion: For safe running around 7 TeV, a shunt has to be added on **all** 13 kA joints, **also on those with small** R_{addit}. Joints with high R_{addit} or joints with large visual defects should be resoldered and shunted.

By 2014 may have 10-30 fb^{-1}

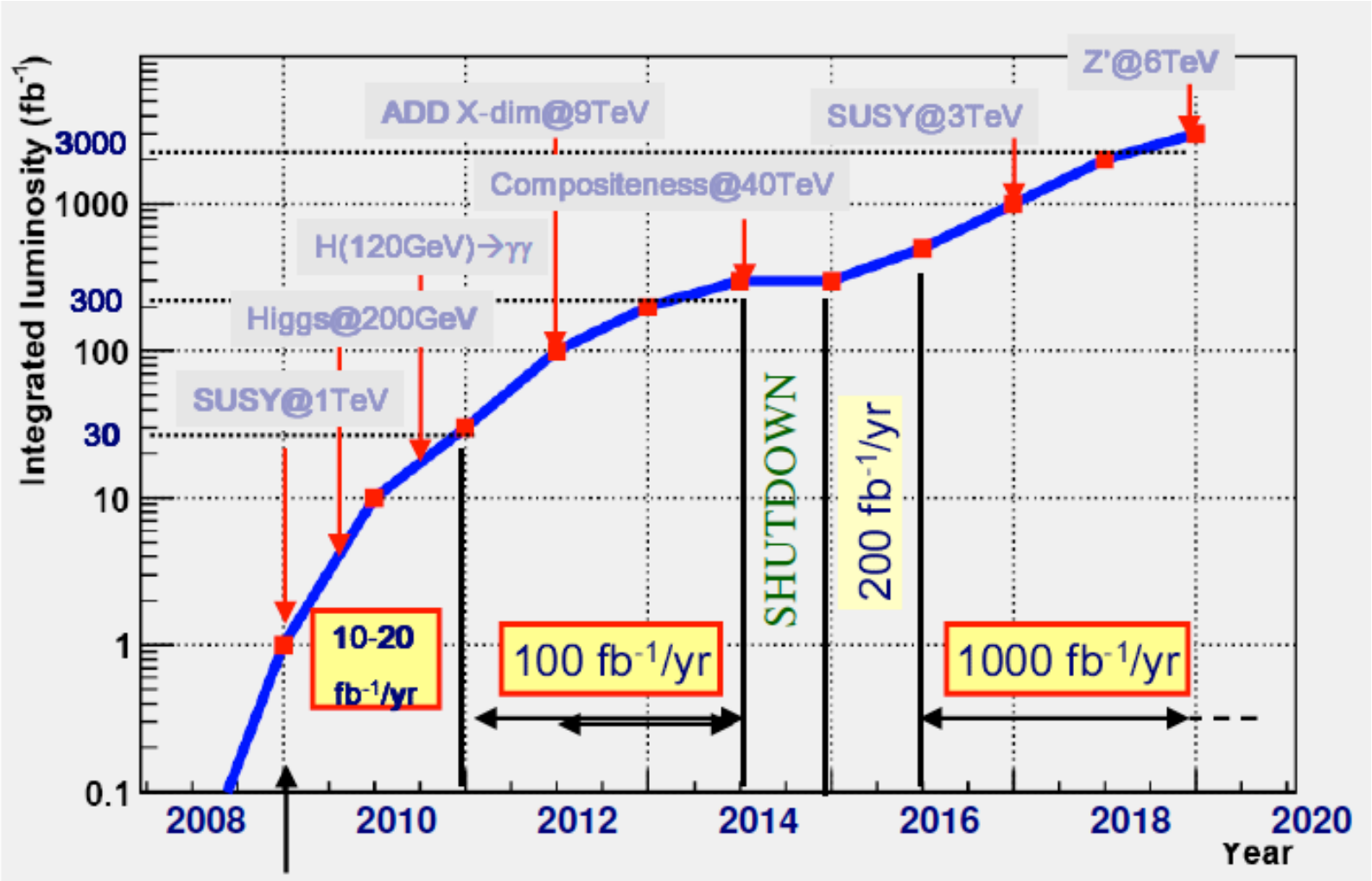
M.Lamont

Year	Months	energy	beta	ib	nb	Peak Lumi	Lumi per month	Int Lumi Year	Int Lumi Cul
2010	8	3.5	2.5	7 e10	720	1.2 e32	-	0.2	0.2
2011	8	3.5	2.5	7 e10	720	1.2 e32	0.1	0.8	1.0
2012									
2013	6	6.5	1	1.1 e11	720	1.4 e33	1.1	7	8
2014	7	7	1	1.1 e11	1404	3.0 e33	2.3	16	24

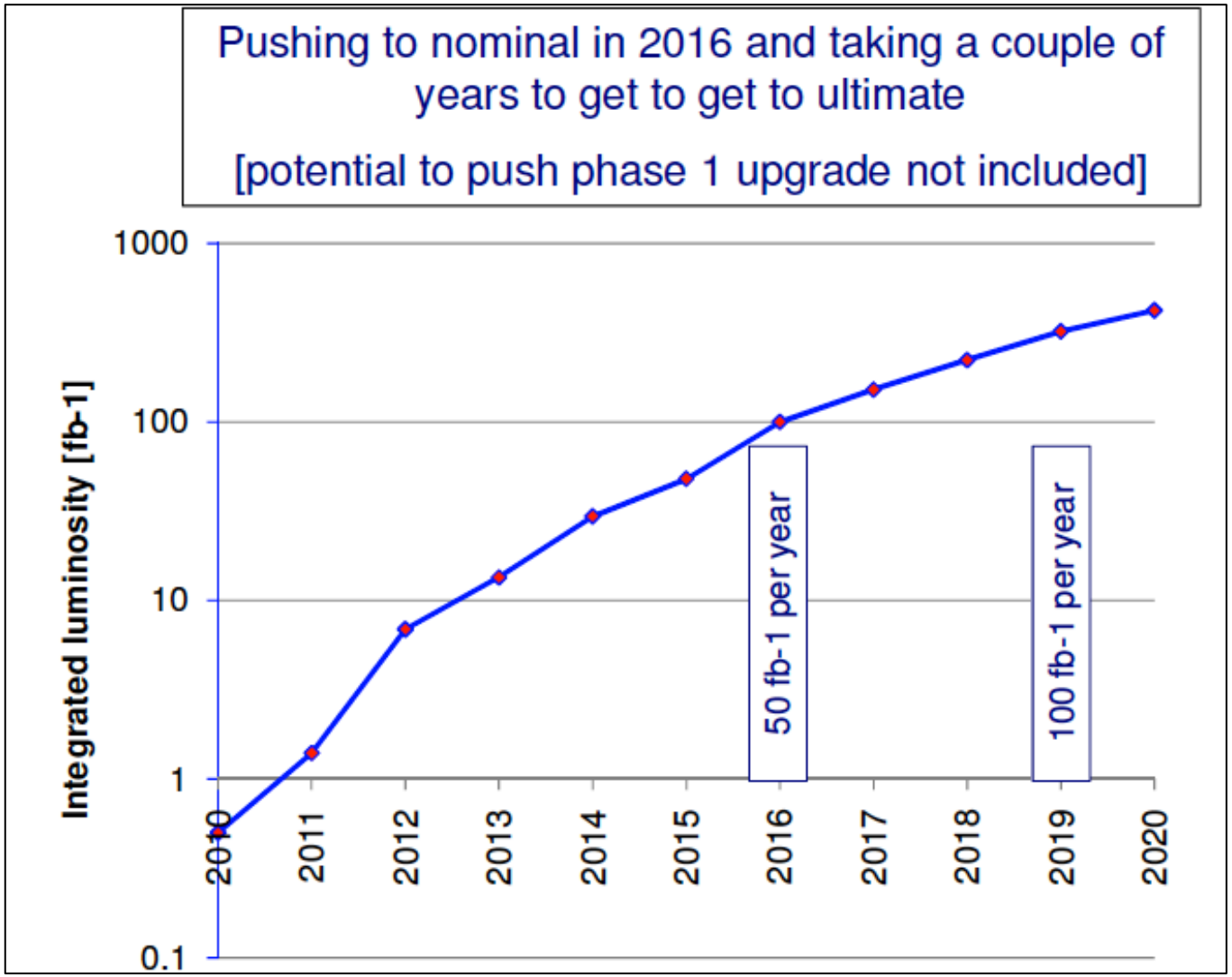
M. Ferro Luzzi

Year	Months	energy	beta	ib	nb	Peak Lumi	Lumi per month	Int Lumi Year	Int Lumi Cul
2010	6	3.5	2.5	7 e10	720	1.0 e32	-	0.1	0.1
2011	9	3.5	2.5	9 e10	720	2.0 e32	0.1	1	1.1
2012									
2013	6	6.5	1	9 e10	720	9 e32	0.45	2.7	3.8
2014	9	6.5	1	9 e10	1404	1.7 e33	0.6	5.3	9.1

Projections – some time ago

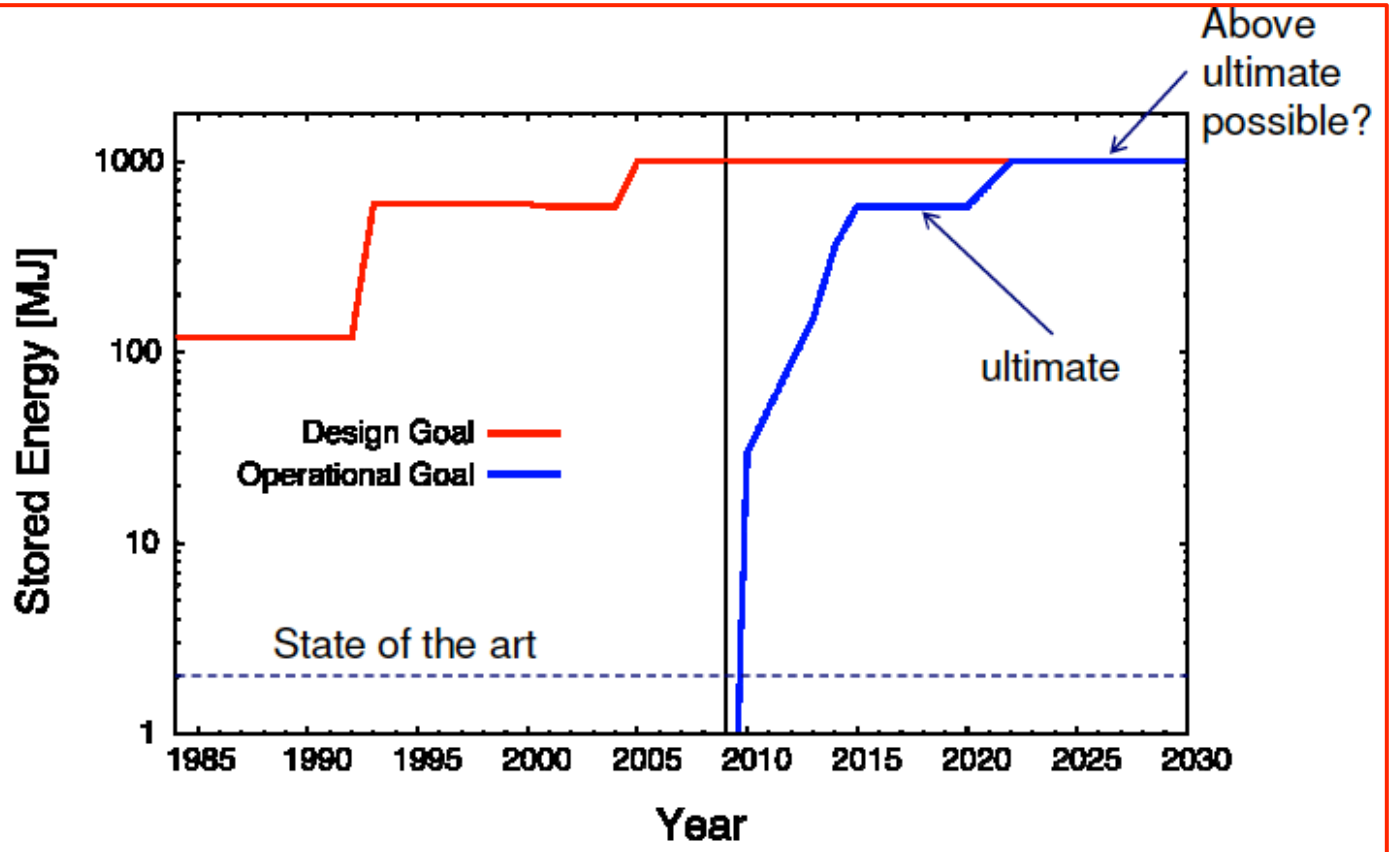


Projections: open perspective until 2030



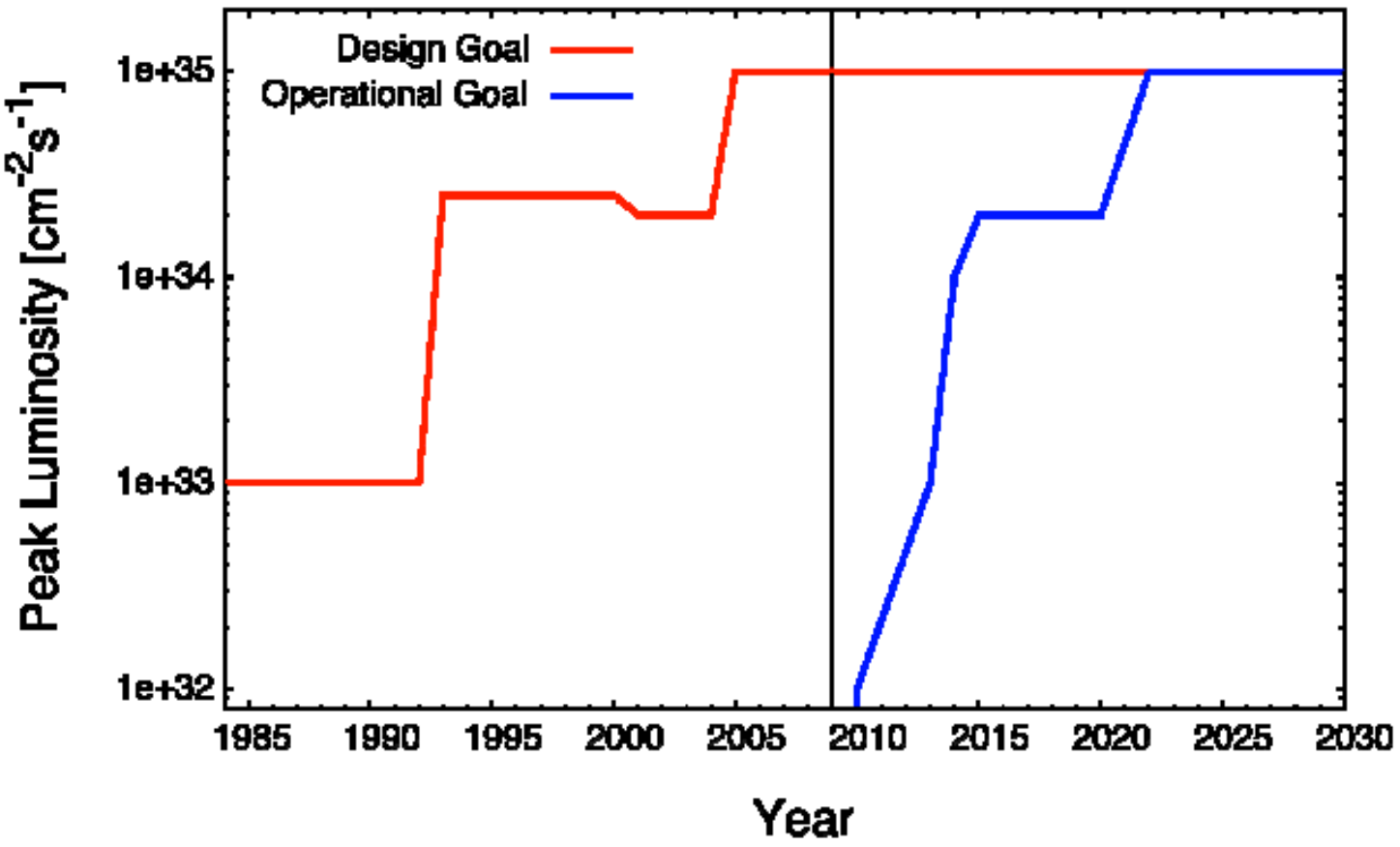
History

R. Assmann



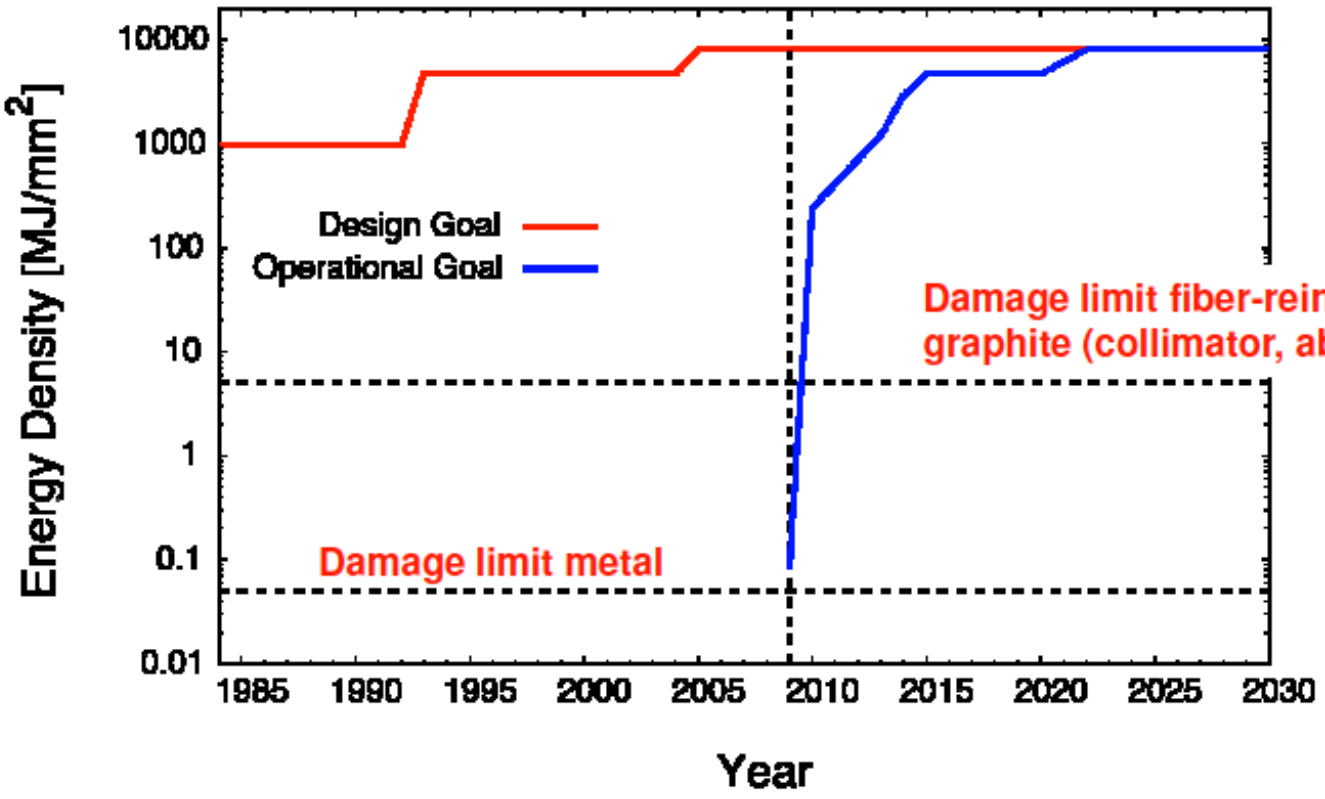
➔ Over time the design stored energy went significantly up. **More demand on RF, cryo, beam stability, collimation efficiency, radiation handling, …!**

History



➔ Nice increase in design luminosity for the experiments…

History



➔ Transverse energy density is pushed further, **way above damage limits of materials!** At some point classical protection is not feasible. Must look at advanced technologies (e.g. SLAC rotatable collimator).

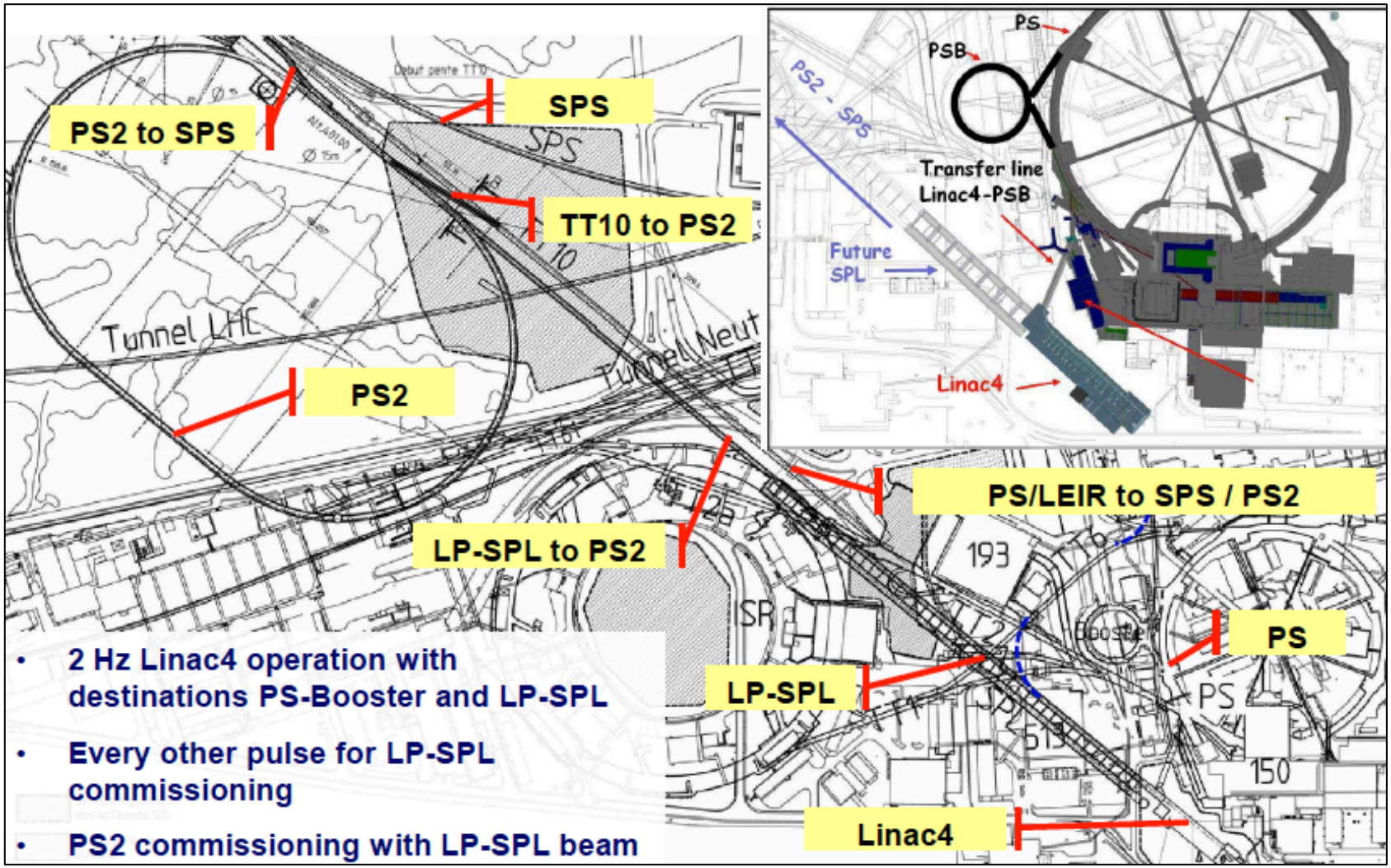
- Ultimate intensity is challenging for the LHC. Many systems at technological limits with little or no margin.
- Long (incomplete) list of required LHC work collected:
  - "New" RF system, possibly requiring civil engineering.
  - New DSL in IR3, review of potted magnets, radiation damage.
  - Two new cryoplants (assuming one installed for ultimate).
  - Essentially all protection devices to be replaced with more robust designs, possibly requiring also layout changes.
  - Upgrade of the beam dump system. Additional hardware.
  - Half of the phase 1 collimation system to be reviewed (replaced).
  - Remote handling mandatory in parts of the machine.
  - Additional service galleries?
  - Absolute filters and modifications of ventilation system.
  - Additional shielding in some areas.
  - Upgrade of permanent vacuum bake-out system.

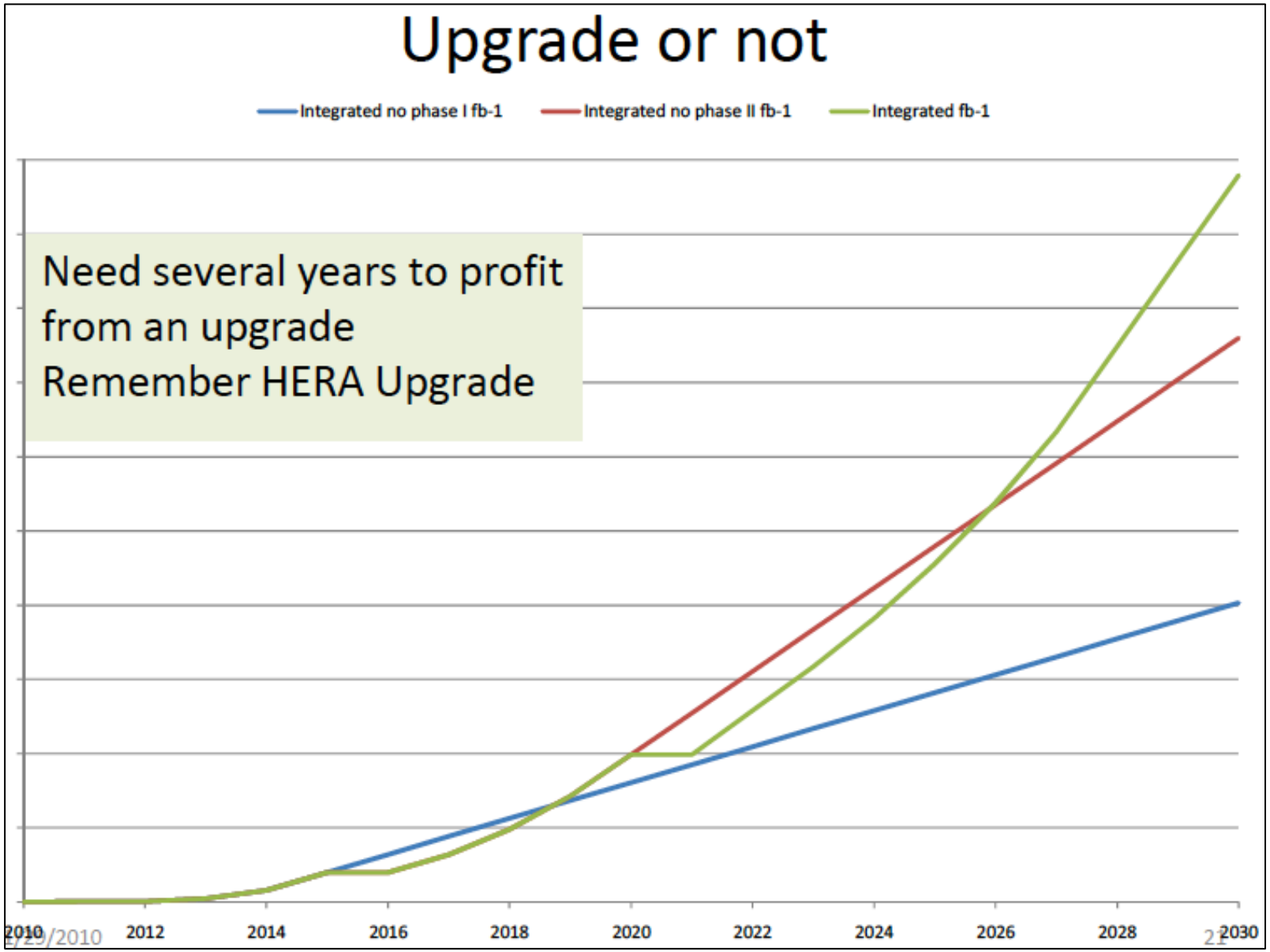
- Nobody argued that an LHC intensity upgrade to beyond ultimate is impossible.
- "With enough money everything is possible…;-)"
- Yes, but effort and cost might be significant…

Thank you Ralf for bringing some sanity into this business. SM

PS2 and SPL

M.Benedikt





Since PS2 would not come before 2020, the existing chain must be maintained anyhow

May expect decision on PS2/SPL

Intensity Limitations (10^{11} protons per bunch)			
	Present	SPL-PS2	2GeV in PS
LINAC4	4.0	4.0	4.0
PSB or SPL	3.6	4.0	3.6
PS or PS2	1.7	4.0	3.0
SPS	1.2	1.2	1.2
LHC	?	?	?

S.Myers

Faster and Cheaper

Then how come to highest Lumi?

Crab cavities (R.Calaga)

Luminosity levelling (JP. Koutchouk)

Stable operation (many)

Upgrade of PSB to 2 GeV (M.Giovannozi)

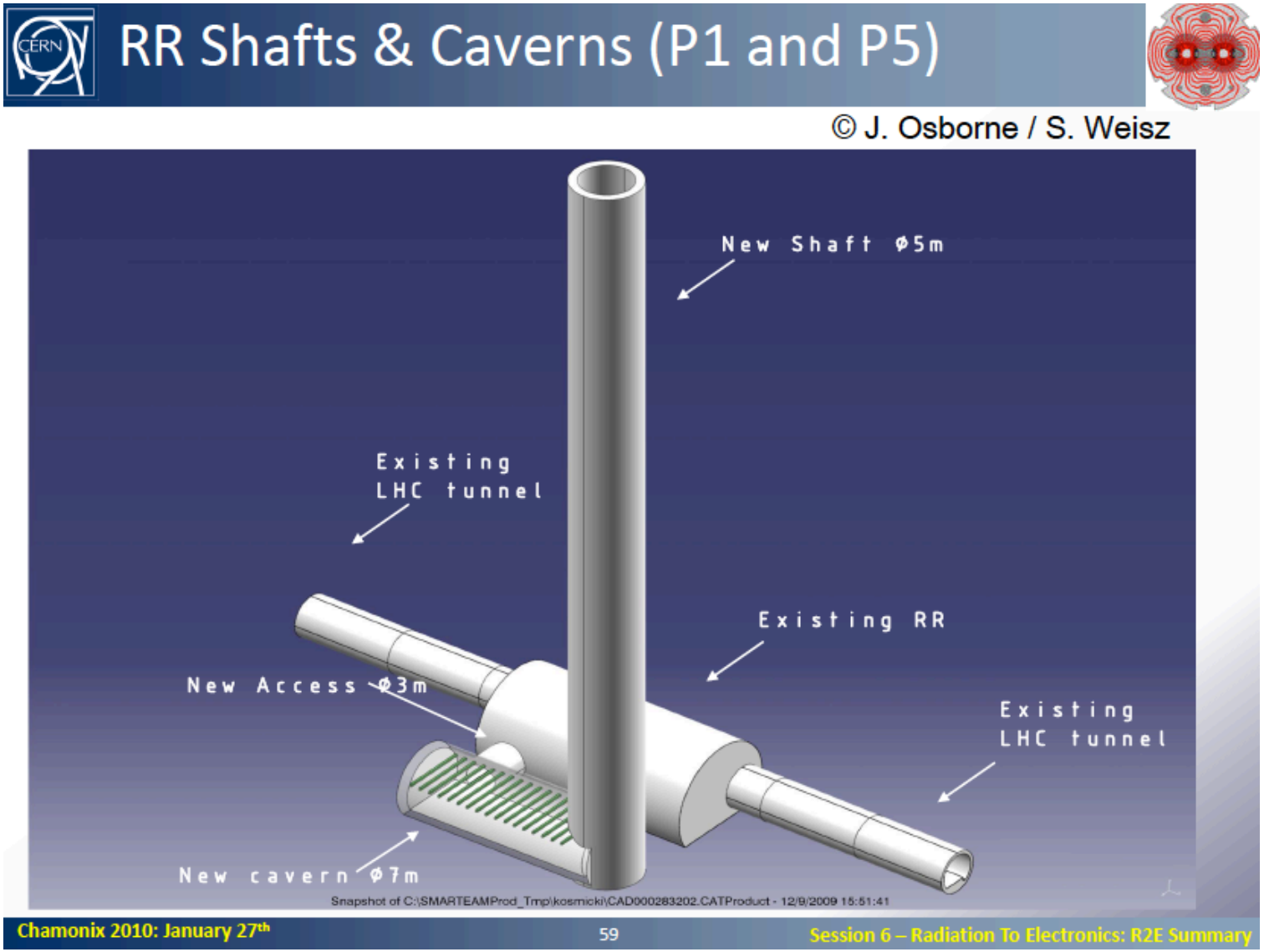
Inner triplet (phase 2 or/and 1)?

Radiation hardness (M.Bugger)

SPS coating of ~700 dipoles against e cloud (Shaposhnikova)

…

Making LHC Radiation Hard



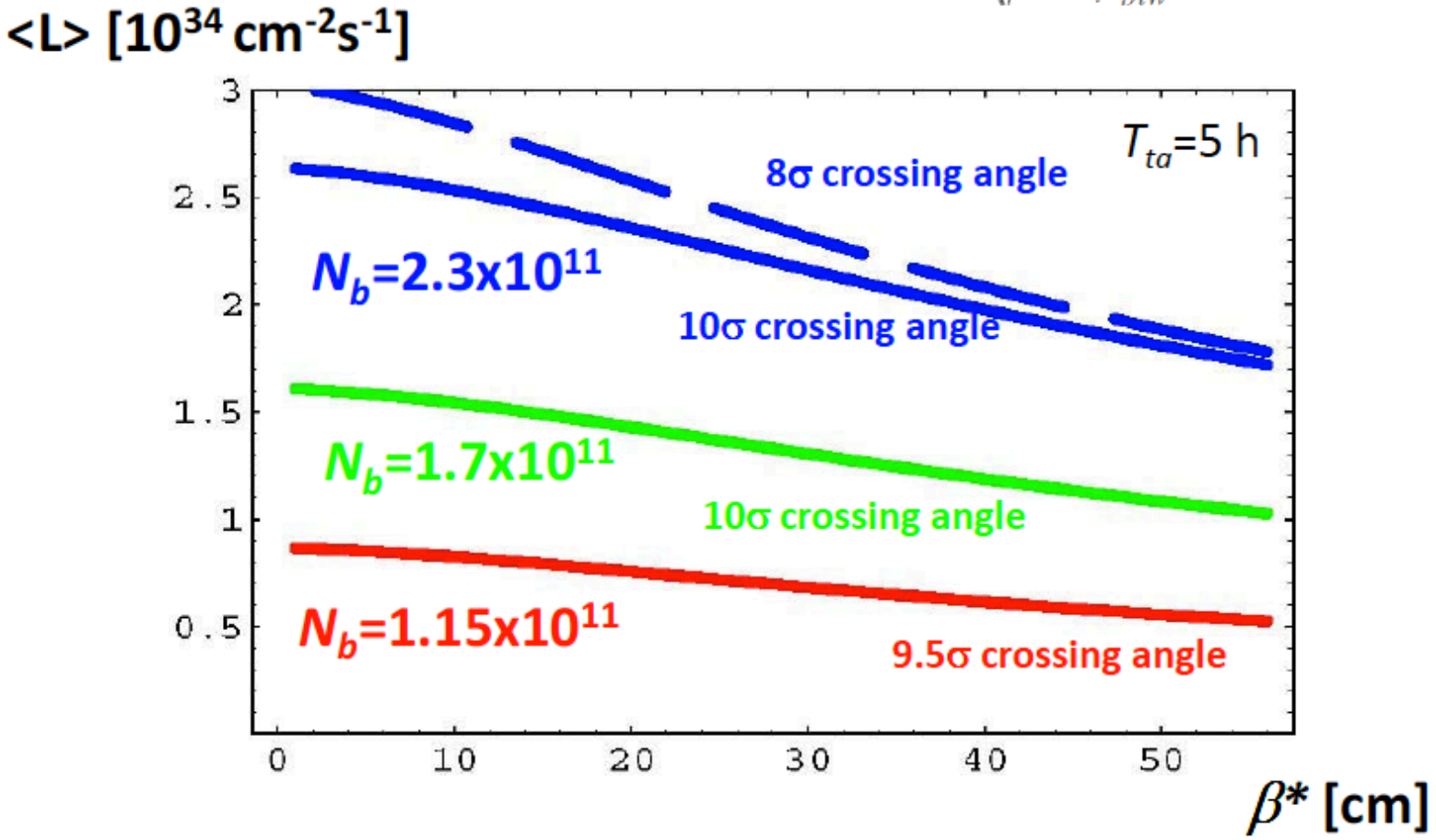
Relocation
Recabling
New electronics
…

Time constrains

M. Bugger

Then how come to highest Lumi?

$$L = \frac{1}{4\pi} f_{rev} n_b \gamma \frac{1}{\beta^*(\gamma\varepsilon)} N_b^2 \frac{1}{\sqrt{1+\phi_{piw}^2}}$$



F. Zimmermann

Personal Summary

1. The LHC is a complex machine which in early design phases was pushed hard.

2. If the splices stand it and all runs well, we get max 50pb^{-1} for ICHEP and 1fb^{-1} in 11.

3. A long shutdown then follows to repair what was overlooked and to improve.

4. By 2014 we may then have 10-30 fb^{-1}, less than projected before, but at 6.5-7 TeV.

5. The investments in stabilizing, maintaining and upgrading the machine will continue to be highly demanding for CERN.

6. Given the huge cost and manpower consumption and its merits I expect the PS2/SPL to not go ahead.

7. The LHC will be with us until 2030 and is run by impressive people.

We did not see the Mont Blanc but we trusted it exists..