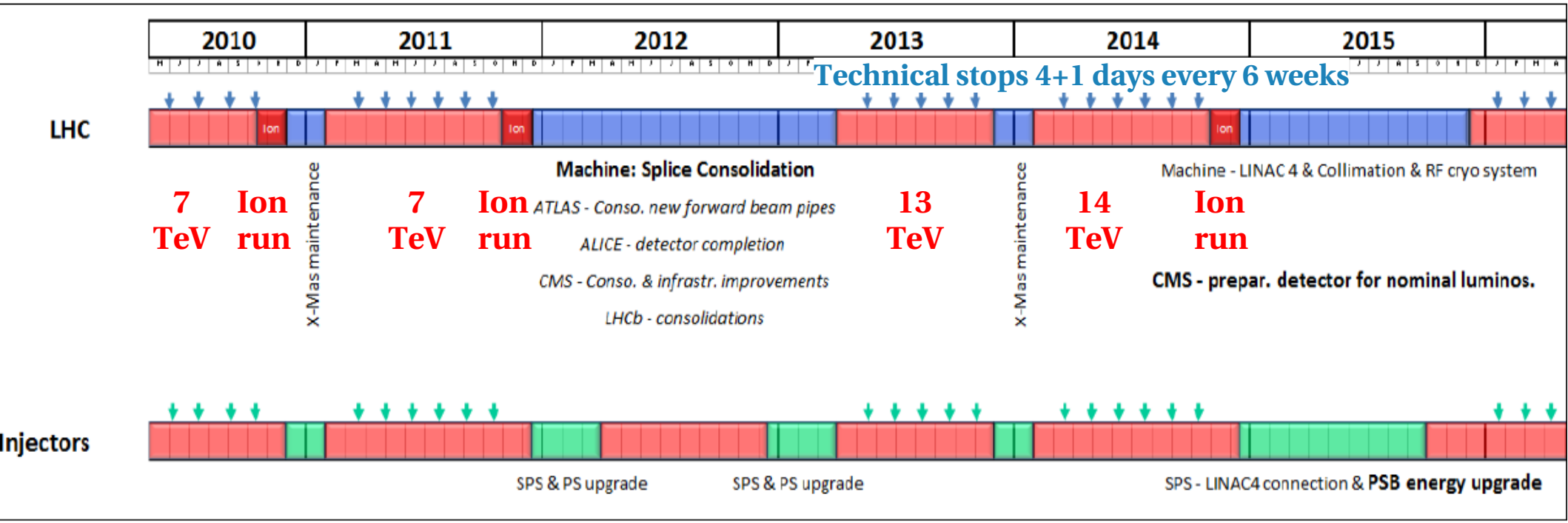
LHCC upgrade session introduction

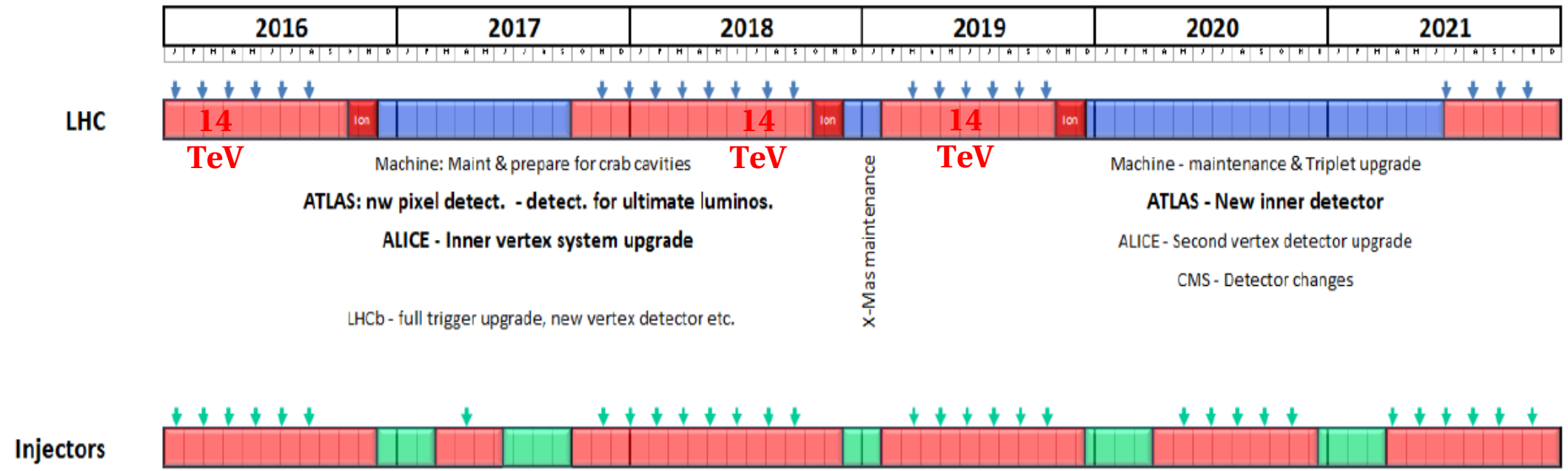
Daniel Pitzl, DESY

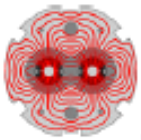
LHCC 6.7.2010

- sLHC public event on Jun 23, 2010
- Scope of the session
- Experiments' upgrade plans and shutdown requirements until 2010:
  - CMS
  - ATLAS
  - ALICE
  - LHCb

Preliminary plan (S. Myers, 23.6.2010)







Main shutdown drivers

Year	Main drivers	Secondary activities
2012	Splice consolidation	Possible collimation phase 2 – IR3 He Relief valves Atlas consolidation, installation of new forward beam pipes R2E
2015	Linac4 Collimation phase 2 CMS consolidation of calorimetry and forward pixel tracker	Booster upgrade RF cryogenics R2E
2017	Atlas phase 1: installation of a new pixel detector plus other upgrades	LHCb upgrade Alice inner vertex upgrade R2E Prepare for crab cavities
2020	HL-LHC upgrade	Atlas phase 2 Alice phase 2

Bunch intensity limitations ($L \sim N^2$)

Intensity Limitations (10^{11} protons per bunch)

Reminder design = 1.15 (for 10^{34}); Ultimate = 1.7 (for 2.3×10^{34})

	Present	SPL-PS2	2GeV in PS
Linac2/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	>1.7?	>1.7?
LHC	1.7-2.3?	1.7-2.3?	1.7-2.3?

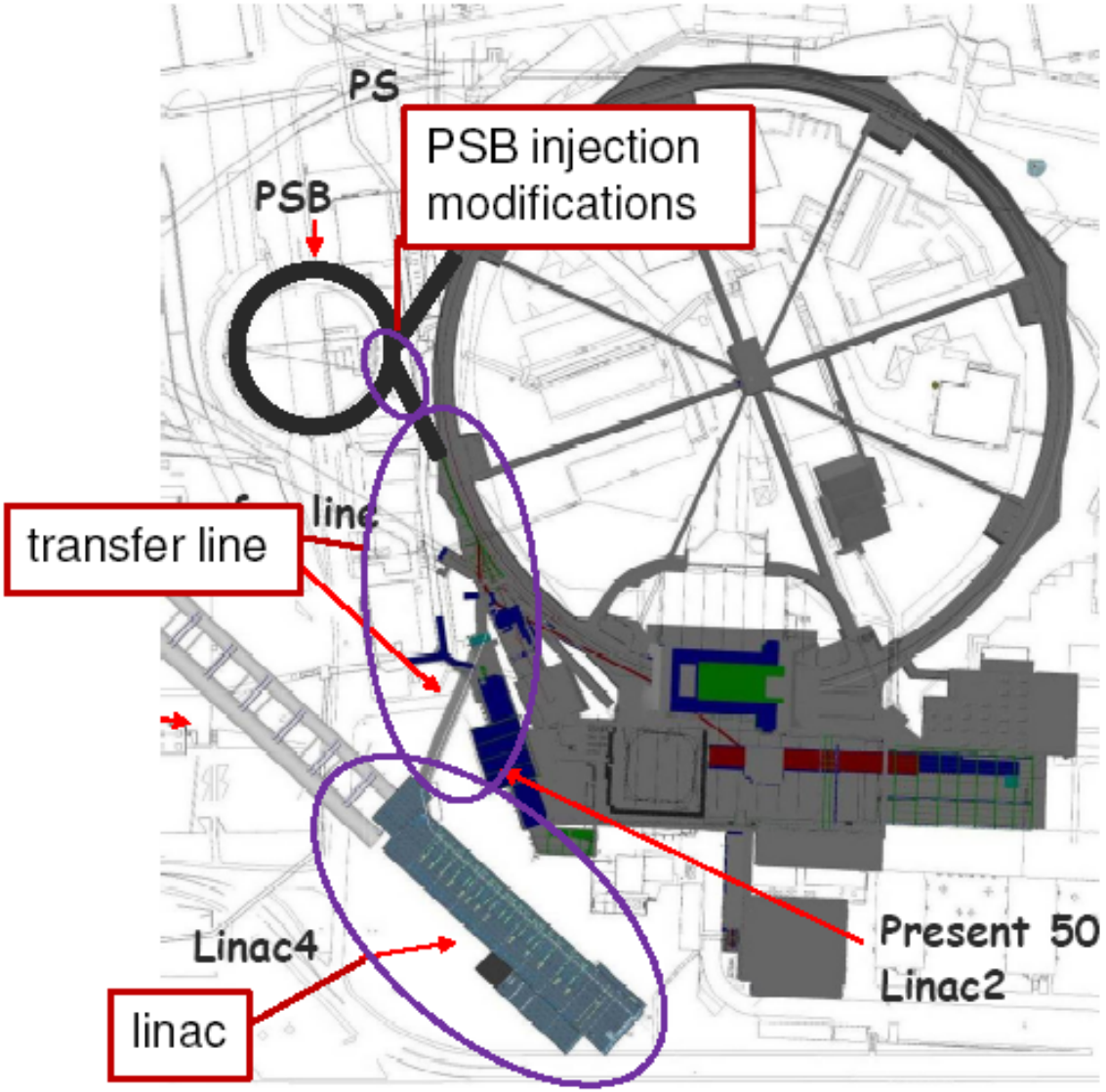
Steve Myers

- Linac4 under construction. Will improve reliability.
- 2 options:
  - new SPL+PS2 (50 GeV), not beore 2018
  - PS Booster upgrade (1.4 to 2 GeV) in 2015.
- SPS bottleneck: e-cloud, transverse instability, RF
  - Task Force installed after Chamonix 2010.
- LHC cryo limit: heat load on beam screen. Need experience.

Linac 4

The "Linac4 Project" is composed of 3 parts:

1. Construction and commissioning of Linac4 *(up to Linac4 dump).*
2. Construction of the transfer line, connection to Linac2 line, upgrade of the measurement lines *(up to PSB wall, LBE dump).*
3. Modification of PSB injection region for H^-, 160 MeV *(commissioning of PSB with Linac4).*



Linac4 ready for connection to PSB by 2014.
No protons for 8 months.
Ions possible!

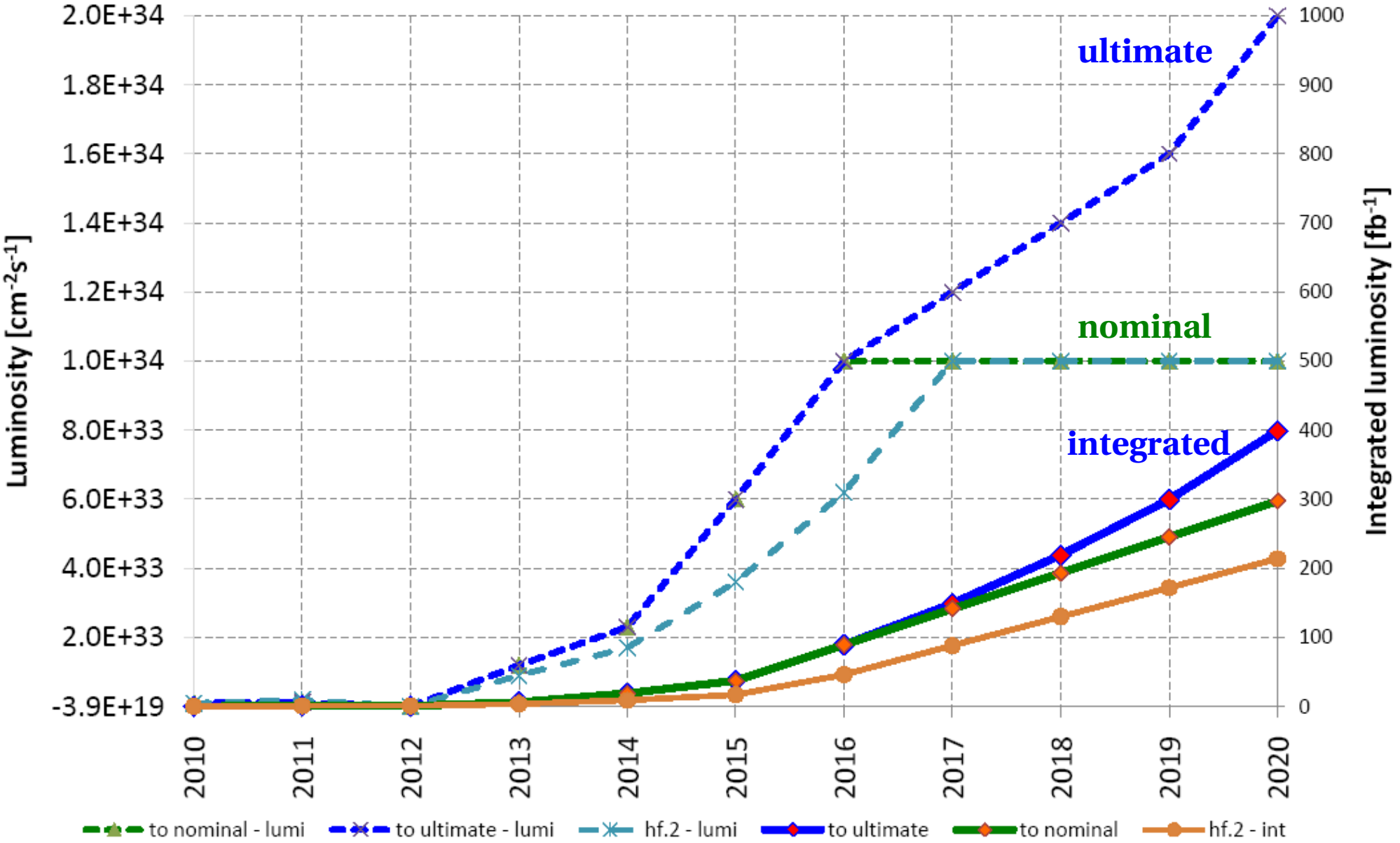
Maurizio Vretenar

LHC in this decade

- 2010-2011: 7 TeV run, reach $10^{32}/cm^2/s$, integrate 1 fb^{-1}. 2 PbPb runs.
- 2012: shutdown: splice consolidation, re-train dipoles, collimators, SPS.
- 2013: 13 TeV run, 25% intensity limited by collimators.
- 2014: 14 TeV run, ion run, 27% intensity.
- 2015: shutdown: Linac 4, PSB, collimators. Probably no inner triplet upgrade.
- 2016: 14 TeV, reach $10^{34}/cm^2/s$, ion run.
- 2017: shutdown for experiments?
- 2018-2019: 14 TeV, reach 2 $10^{34}/cm^2/s$, integrate 300-400 fb^{-1}, ion runs.

Luminosity in this decade

L. Rossi, sLHC public event, 23.6.2010



Limitations in the experiments

Aging and radiation damage: integrated luminosity

- ATLAS b-layer PIXEL ~ L_{int} = 200-300 fb^{-1} — 2018
- ATLAS Silicon Tracker (SCT + PIXEL) ~ L_{int} = 600-700 fb^{-1} — 2021
- ATLAS LAr Hadron Calorimeter FE Electronics ~ L_{int} = 1000 fb^{-1}
- CMS PIXEL ~ L_{int} = 300 fb^{-1} — 2019
- CMS Silicon Tracker ~ L_{int} = 600-700 fb^{-1}

High occupancy and inefficiency: peak luminosity

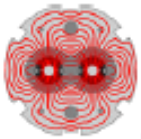
- ATLAS TRT (transition radiation tracker) ~ L = 2-3 10^{34}
- ATLAS FCAL (forward calorimeters) ~ L = 2-3 10^{34}
- ATLAS SS external beam pipes (activation) ~ L = 1 10^{34}
- ATLAS&CMS Silicon trackers ~ L = 2-3 10^{34} — 2018

Marcio Nessi, Chamonix, Jan 2010

Question to the experiments

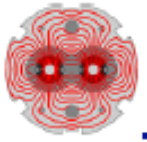
- What upgrades are needed in this decade?
- Are there new aspects to the physics program?
- Shutdowns:
  - when?
  - how long?
- These questions will also be addressed tomorrow between the spokespersons and the DG.
- Let's postpone phase II and the HL-LHC to a later session.

Backup



Summary

- 2010 toward 1e32 $cm^{-2}s^{-1}$
- 2011 at or above 1e32 $cm^{-2}s^{-1}$
- 2012 – splice consolidation and collimation prep.
- 2013 – 6.5 TeV ~24% nominal
- 2014 – 7 TeV ~27% nominal
- 2015 – LINAC4, CMS, collimation phase 2
- 2016: 7 TeV – towards nominal performance
- 2017: long shutdown – short run
- 2018 – 2019 either:
  - a) at or around nominal luminosity
  - b) or push towards ultimate
- 2020 – 2022 – HL-LHC



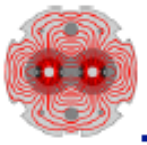
To 2014

- 2012: splice consolidation etc.
- 2013: 6.5 TeV ~24% nominal intensity
- 2014: 7 TeV ~27% nominal intensity

Limits from phase 1 collimation

Year	Months	Energy	Beta [m]	Ib	Nb	Peak lumi [$cm^{-2}s^{-1}$]	Lumi/ month [fb^{-1}]	Int Lumi/ Year [fb^{-1}]
2010	8	3.5	5	10e10	240	4.3e31	-	0.1
2011	9	3.5	2.5	7e10	796	1.4e32	0.1	0.9
2012								
2013	7	6.5	1	1.1e11	720	1.3e33	1	7
2014	8	7	0.55	1.1e11	796	2.9e33	2	16

NB Illustrative numbers: beta*, bunch intensity, number of bunches will be negotiable



2015 – 2016 to nominal

Essentially dedicate 2015 to LINAC4, collimator upgrade etc.

Year	Months	energy	beta	Ib	Nb	Peak Lumi [$cm^{-2}s^{-1}$]	Lumi per month [fb^{-1}]	Int Lumi Year [fb^{-1}]
2016	~9	7	0.55	11e10	2808	1e34	6.7	~60

Might hope to hit nominal in 2016

Beyond 2016/17

- Assumptions
  - Booster, PS at increased injection energy plus LINAC4 are good for ultimate (after a suitable commissioning period)
  - ~1.7 x 10^{11} can be handled by the SPS
  - LHC can handled ultimate intensity
    - Ultimate intensity is challenging for the LHC. Many systems at technological limits with little or no margin.

Stay at or around nominal

Year	Months	Int Lumi [fb^{-1}]
2017	2	13
2018	9	60
2019	9	60

Able to push towards ultimate

Year	Months	Int Lumi [fb^{-1}]
2017	2	13
2018	9	84
2019	9	117

What do the experiments want?

$3000\ fb^{-1}$ on tape

/ experiment (ATLAS, CMS)

$100\ fb^{-1}$ on tape

/ LHCb

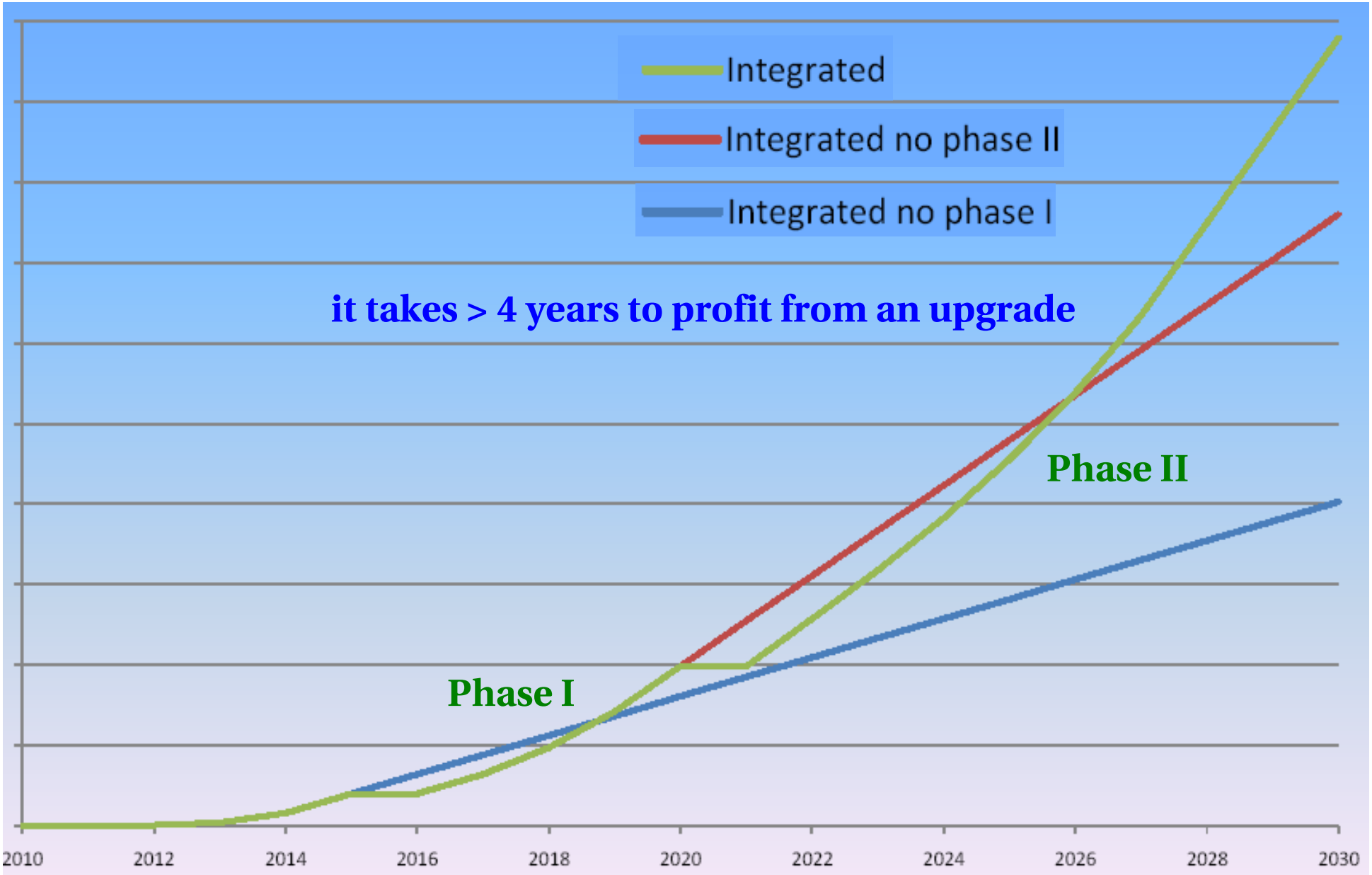
$10\ nb^{-1}$ PbPb (+pA, light ions)

/ Alice

a programme which lasts out to **2030 !**

Marcio Nessi
Chamonix, Jan 2010

Luminosity scenarios at Chamonix 2010



Roger Bailey, Frank Zimmermann
Summary Chamonix S9, 2010 Feb 5

Phase I upgrade open questions

- Is the Phase 1 upgrade still a reasonable option in 2015 given the current delays (Sept 19 & splice consolidation) and the projection of reaching 'only ' 50 fb^{-1} compared to a triplet lifetime of 300 fb^{-1} ?
- Can the injector complex deliver ultimate beam intensities in time for the planned Phase 1 upgrade (2014/2015)?
- Can / should we revise the planning for installation by 2014 / 2015? If yes for what parts of the Phase 1 upgrade (LINAC4, Collimation, RF, Triplet, civil engineering)
- To what extend will a long shutdown for the splice consolidation impact on the Phase 1 upgrade planning (only 1.5 years of operation between 2 long shut downs)?
- Need decisions rather soon as orders and collaboration agreements are being fixed!

Oliver Bruning, Paolo Fessia
Summary Chamonix S8, 2010 Feb 5

Phase I inner triplet upgrade?

- The proposal:
  - New large aperture inner triplet quadrupoles using standard NbTi.
  - Reduce β^* from 0.55 to 0.25 m, gain factor 1.4 in luminosity.
- The problems:
  - Magnet division overloaded: rebuild spares, splices, triplet
  - Installation requires 1 year shutdown.
  - New optics with large sextupole corrections needed.
  - Less flexible machine, learning curve
  - Is it worth it?
- The status:
  - Task Force installed after Chamonix 2010.

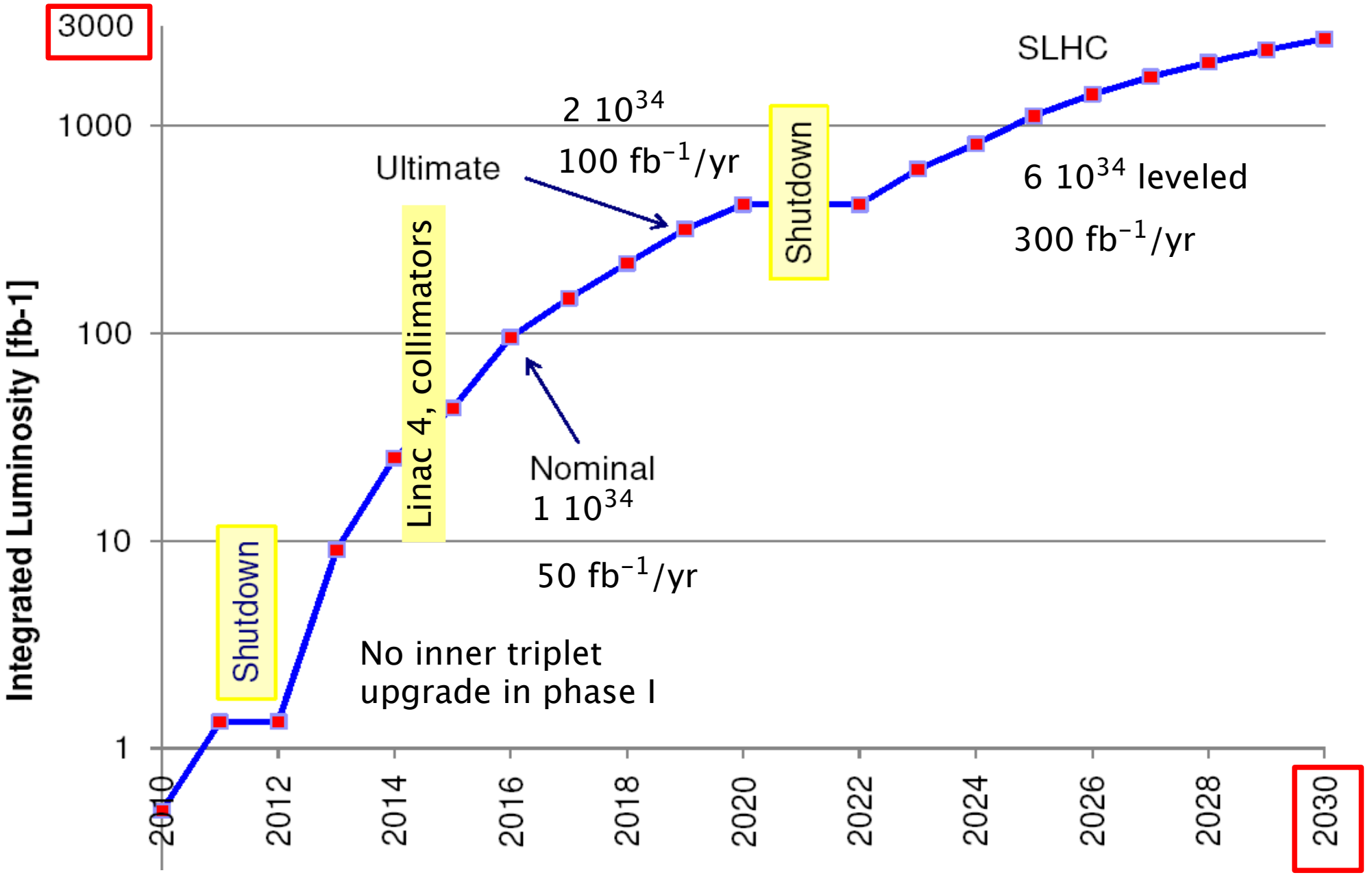
Paolo Rossi, LHCC, 16.2.2010

Machine upgrade program

- The Luminosity Targets set by the detectors are:
  - 3000fb^{-1} (on tape) by the end of the life of the LHC
  - → 250-300fb^{-1} per year in the second decade of running the LHC
- The Upgrades needed to attack these goals are
  1. SPS performance improvements to remove the bottleneck
  2. Aggressive consolidation of the existing injector chain for availability reasons
  3. Performance improvement of the injector chain to allow phase 2 luminosities
  4. a newly defined sLHC which involves
     - At least one major upgrade of the high luminosity insertions
     - luminosity levelling at ~5-6x 10^{34}cm^{-2}s^{-1} (crab cavities etc...)

Steve Myers, LHCC, 17.2.2010

Luminosity scenario 2/2010



Mike Lamont, LHCC, 16.2.2010

CMS upgrades

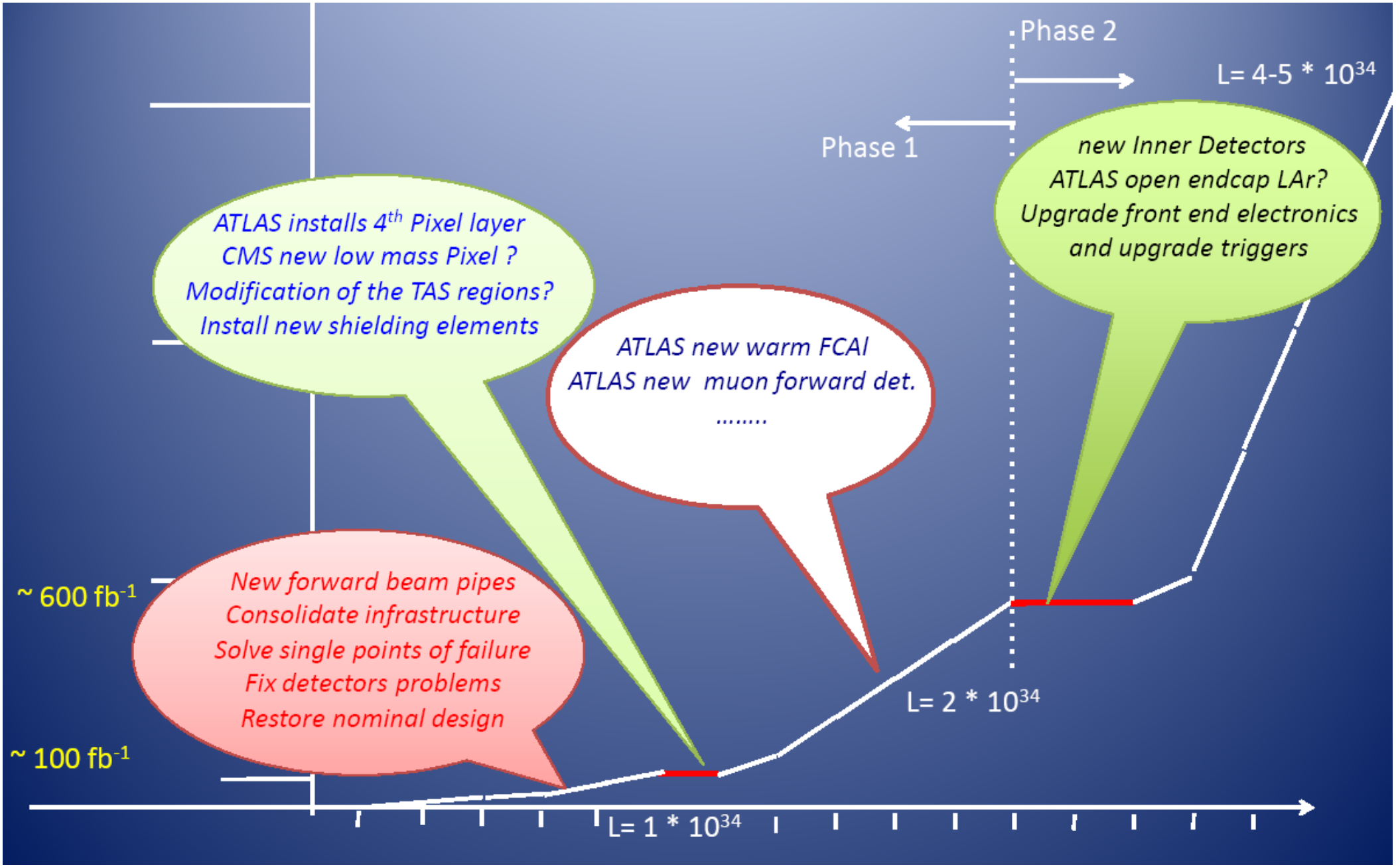
System	Phase 1	Phase 2
Pixel	New Pixel Detector (1 or 2 iterations?) new BP	
Tracker	FEDs?	New Tracking System (incl Pixel)
HCAL	Electronics + PD replacement	HF/HE?
ECAL	TP (Off Detector Electronics) ?	EE?
Muons	ME4/2, ME1/1 ,RPC endcap, Minicrate spares, some CSC Electronics	Electronics replacement
Trigger	HCAL/RCT/GCT to μTCA	Complete replacement

Jordan Nash
LHCC May 2008

Phase I upgrades don't require long shutdowns.

Synchronous with ATLAS,machine

ATLAS and CMS detector upgrades



Marcio Nessi, Chamonix, Jan 2010

ALICE in the sLHC era

- Mode of yearly operation stays:
  - short/medium duration pp run, L < 5 10^{31} (TPC limit).
  - 1 month dedicated running: PbPb or pPb or light ions (ArAr, pAr).
- Desired:
  - PbPb luminosity increase by factor 5 to 5 10^{27} (TPC limit).
- Physics program will be 'data driven', depending on the results of the first few years.

ALICE upgrades

- High rate upgrade:
  - increase rate capability of TPC (faster gas, increased R/O speed)
  - → rare hard probes (Υ, γ-jet, ...)
- DAQ & HLT upgrades:
  - → more bandwidth, more sophisticated and selective triggers
- Particle id upgrade:
  - extend to p_T range for track-by-track identification to O(20) GeV/c
  - → new physics interest, based on RHIC results
- Forward upgrades:
  - new detectors for forward physics (tracking & calorimetry)
  - → low-x in pA, AA
  - → Extend ALICE coverage for diffractive Physics
- Vertex upgrade:
  - 2nd generation vertex detector (closer to beams)
  - → heavy flavour baryons, fully reconstructed B, ...

access to beam pipe
1 year shutdown

Paolo Giubellino, LHCC, 16.2.2010

ALICE silicon tracker upgrade

- **R&D phase: 2010-2013/14**
  - Explore two Pixel technologies:
    - Hybrid pixel detectors: "state of the art"
      - low cost bump-bonding
      - new sensor type (3D, edgeless planar)
      - further thinning (SPD: 200 μm sensor + 150 μm FEE)
    - Monolithic pixel detectors: Mimosa and LePix
      - larger detector areas at considerably lower cost
  - Layout Studies and Technical Design report
- **Production and pre-commissioning: 2014-2016**
- **Installation and commissioning: 2017-2018**

1 year shutdown required

to be adapted to the post-Chamonix schedule

Paolo Giubellino, LHCC, 16.2.2010

LHCb strategy

- Strategy
  - First collect ~10 fb^{-1}
  - Upgrade LHCb to 40MHz read-out (requires ~8-10 month shutdown)
  - Then collect ~100 fb^{-1}
- This requires running LHC at a Luminosity of $5*10^{33}$ at Point 8

This needs to be clarified a.s.a.p.

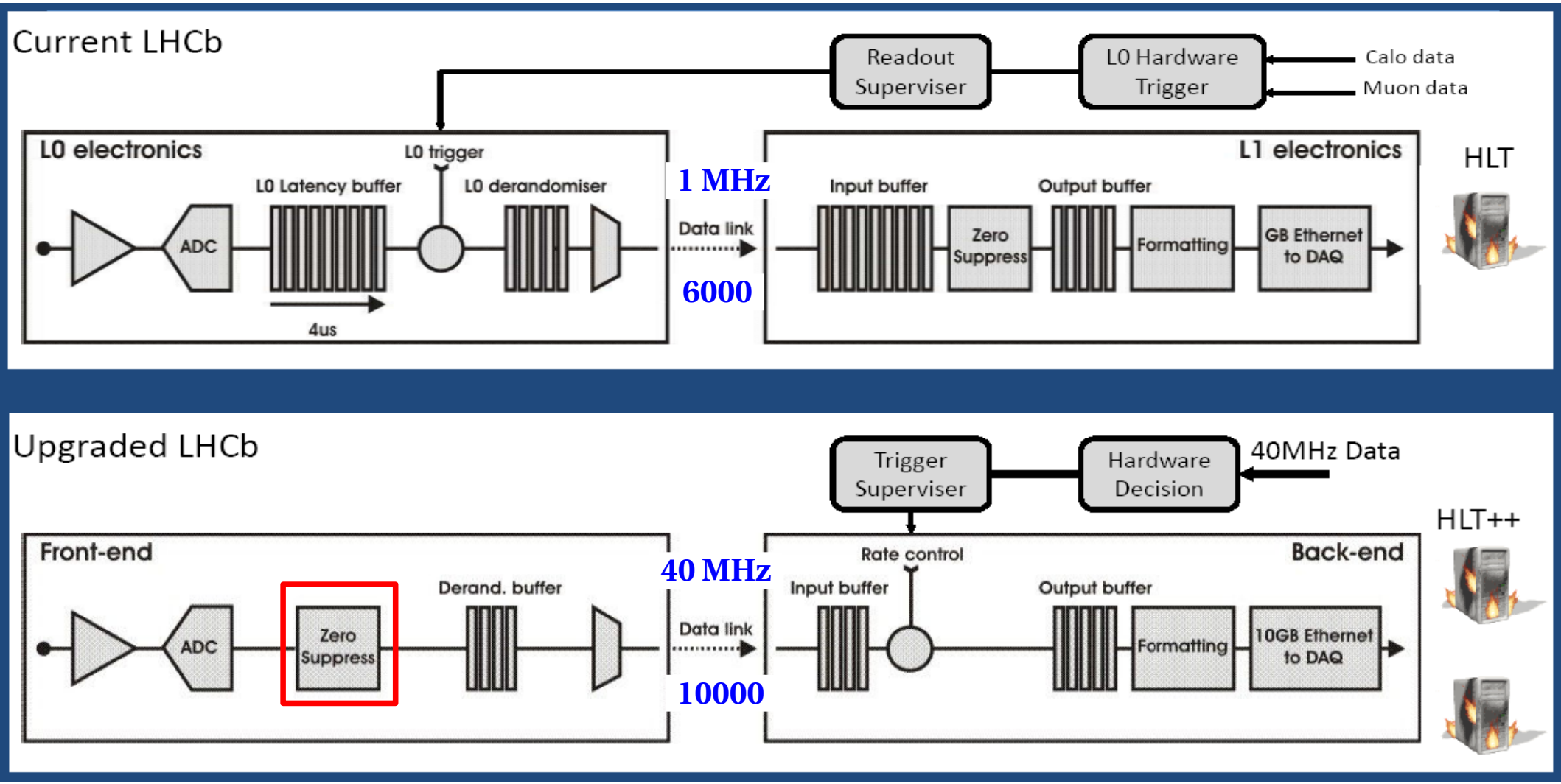
→ LHC and sLHC operation schemes must be designed to allow running of LHCb after 2020 with $L=5*10^{33}$

Need to ensure full compatibility with LHCb requirements in IP8, in particular:

- Compatibility of triplets in IP8 with higher luminosity (at present no TAS in P8)
- Optics and crossing scheme (displaced collision point, de-focussed beams)
- R2E of electronics in UX85, US85…
- Coordination of the Phase-1 shutdown/upgrade activities such to include LHCb upgrade

Marcio Nessi, Chamonix, Jan 2010

LHCb 40MHz FE readout into HLT



All sub detector FEs need to be changed

Ken Wyllie, LHCC, 16.2.2010

Aim: ready for 2016

~8 months shutdown required, staging possible

Acronym dictionary

- **MTP** = medium term planning
- **HL-LHC** = high luminosity LHC (5 $10^{34}/cm^2s$)
- **HE-LHC** = high energy LHC (33 TeV)
- **PSB** = PS Booster between Linac and PS (1.4 GeV)