LS2 and LS3: The Largest Challenges as Known Today

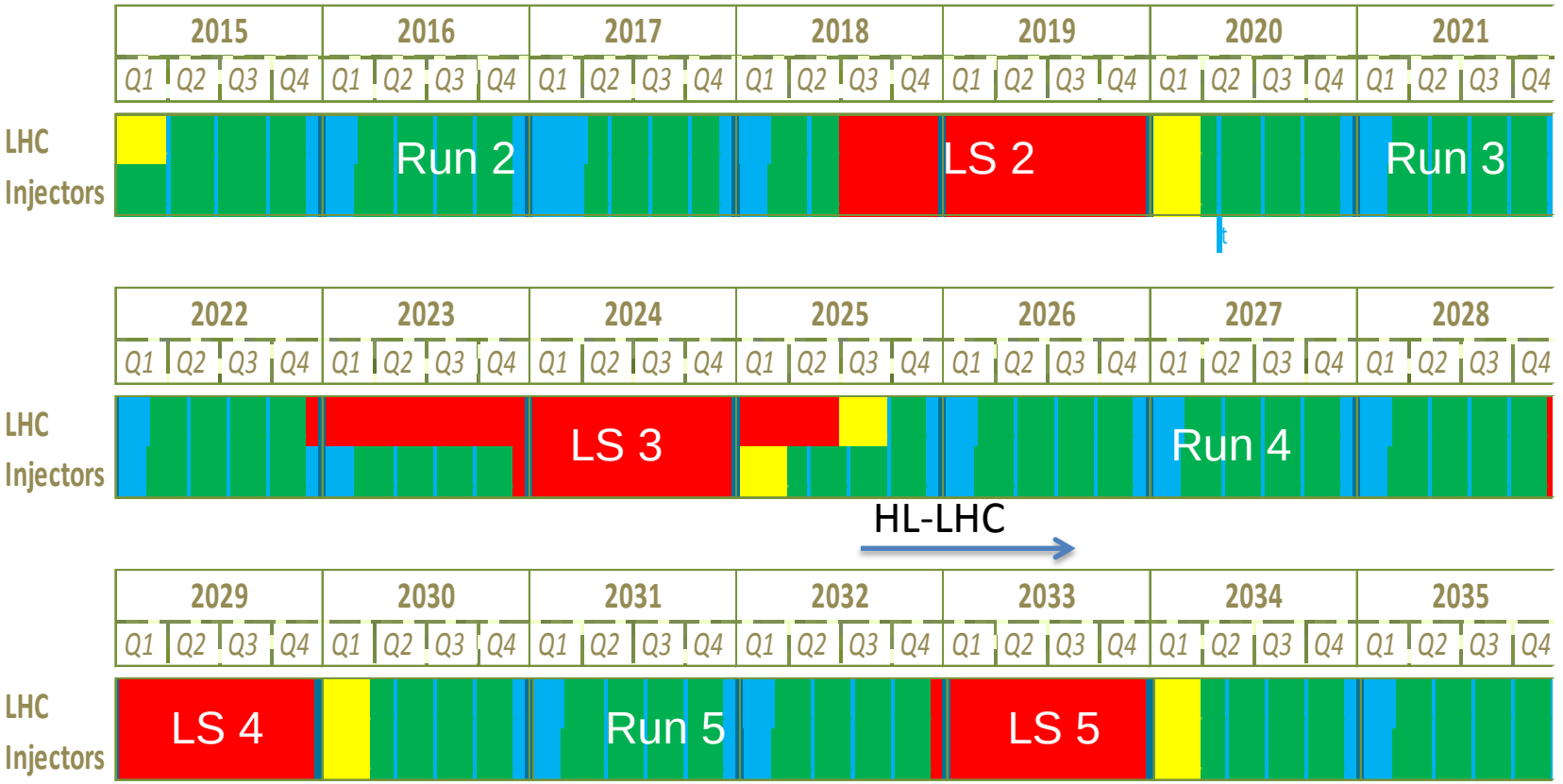
ECFA High Luminosity LHC Experiments Workshop 2014
Wolfram Zeuner CERN

- Reminder – Upgrade Plans
- Challenges
  LS2: Schedule and Resources
  Radiation Protection

  Infrastructure
  Personnel

  LS3: Schedule
  Radiation Protection
  Resources
- Summary

Quick Reminder LS2 and LS3 Main Activities



Main objectives

ALICE - being able analyzing 50kHz Pb-Pb

LHCb - being able analyzing 40MHz pp

Independent of LHC upgrade --- plan for LS2

ATLAS & CMS – being prepared for HL-LHC

HL-LHC or LHC Phase 2 starts after LS3 with a “new” accelerator

Main upgrades have to take place in LS3

ALICE LS2 Upgrades

Upgrade detector to read all PbPb events at 50kHz (L>6x10^{27}) into the online system
Increase data sample of MB physics by a facto 100 !

New Inner Tracking System (ITS)
- improved pointing precision
- less material

Time Projection Chamber (TPC)
- new GEM technology for readout chambers
- continuous readout
- faster readout electronics

New Central Trigger Processor

Data Acquisition (DAQ)/ High Level Trigger (HLT)
- new architecture
- on line tracking & data compression
- 50kHz Pbb event rate

Muon Forward Tracker (MFT)
- new Si tracker
- Improved MUON pointing precision

MUON ARM
- continuous readout electronics

New Trigger Detectors (FIT)

TOF, TRD
- Faster readout

ALICE Support Needs

- **Extension of the computing farm**
  - To be studied whether available space and infrastructure are sufficient (EN-EL, EN-CV)

- **Beampipes, Vacuum, Collimators**
  - New central beampipe + mobile bakeout equipment (TE-VSC)
  - Modification of Miniframe beampipe, displacement of gauge, ion pump in Aluminum (TE-VSC)
  - LSS vacuum consolidation to minimize vacuum pressure (TE-VSC)
  - New TDI to limit high vacuum pressure from outgassing (EN-STI)
  - Collimators in dispersion suppressor region to allow maximum PbPb Luminosity (...)

- **Fibers**
  - Possibly already during EYETS 2016/2017

- **Detector Cooling**
  - New detector cooling plant for upgraded Inner Tracking System (EN-CV)
  - Possible upgrade of ITS dry air ventilation system (EN-CV)

- **Change of elevator**

- **PbPb Luminosity**
  - Infrastructure for increase of PbPb luminosity to >6×10^{27}

LHCb LS2 Upgrades

Change from 1MHz to 40MHz readout with a fully software-based trigger

→ replace all FE-electronics, event builder and new computing farm

Requires to change all sub-detectors with silicon sensors

Velo	→ VeLoPix
RICH HPDs	→ MaPMT
Silicon Tracker Stations	→Fiber Tracker down stream of the magnet
	→Silicon sensors up stream of the magnet

- LS3 is mainly for maintenance and consolidation.

LHCb Support Needs

- New computing farm (2MW)
  - Housed in new surface building or container (GS)
  - Strategy for operational temperature and cooling (EN-CV)
  - Possible needs for UPS (EN-EL)

- Beampipes , Vacuum, Collimators (EN, TE)
  - All beampipes in the cavern must be removed and then reinstalled during LS2, no new beampipes are planned.
  - Probably a TAS will have to be installed around LHCb
  - TDI in TI8 injection line to be changed (LS2 ?)

- Fibers
  - Possibly already during EYETS 2016/2017. (EN-EL ?, other companies ?) make sure CERN frame contracts are adapted.

- Services and Integration:
  - For integration of cables, cable trays, cooling lines, access platforms as well as supervision of the service installation activities LHCb relies on EN-MEF

- Detector Cooling
  - New Fiber Tracker (SciFi) cooling plant (-40C monophase Freon for SiPMs) (EN-CV) & adapt OT/PS/SPD cooling plant for SciFi electronics
  - Possible adaption of TT cooling plant to Fiber Tracker electronics cooling (EN-CV)
  - (Velo and UT CO_2 cooling is done throughP H-DT), but primary cooling with support from EN-CV.

- Change of elevator, crane ? But not during LS2

W. Riegler – Chamonix Sept. 2014

ATLAS Upgrades

LS2

Rebuilding Muon Small Wheels

Will be done on surface without recycling shielding from old ones for scheduling reasons and simplification of construction

Integrating new Muon Small Wheels into trigger

Major upgrade of LAr electronics to cope with higher pile up

New front-end crate backplanes and front-end boards

Completion of the Fast TracKer (FTK) – track trigger at LVL2 – (Phase I)

Completion of trigger and DAQ upgrade to cope with small Wheels, Lar and FTK

ATLAS Upgrades

LS3

- New all Silicon Tracker
- Lar readout electronics upgrade to cope with ultimate pile up
- Upgrade of photo-detectors and electronics for Tilecal, barrel + extended barrel HCAL
- New Trigger architecture

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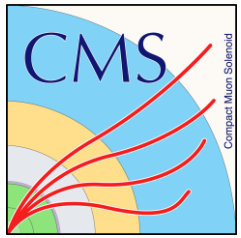
- FCAL – to be decided in 2015 nothing/adding a detector in front/replacement
- MDT/RPC electronic to be decided in the course of LHC operation

LHC@ATLAS

- Replacement of TAS

CMS Upgrades



Final Phase I upgrades and consolidations

Extended **Y**ear **E**nd **T**echnical **S**top 2016/17

- New 4-layer pixel detector installation
- New PMT readout for Forward Hadron Calorimeter
- New L1-Trigger – starting in LS1, running in parallel with current system
  Transition will not require a long shutdown

LS2

- Change photo detectors in Hadron Barrel and Hadron Endcap calorimeters
  HPD →SiPM

- Change beam pipes from stainless steel to Al 2219/(AlBe?) to reduce activation
  Design depends on max. η for HL-LHC.

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- Depending on progress of radiation damage, exchange of scintillating tiles in HE

Preparation for HL-LHC

- New FE electronic for CSC endcap muon chambers

CMS Upgrades

LS3

- New Silicon Tracker (Pixel & Strips) with trigger capabilities
  Requiring re-installation of all services on YB0

- Replace Endcap Calorimeters both electromagnetic and hadronic
  Decision on design early next year

- New L1 trigger with longer latency

- New high eta muon stations - GEM

- New FE electronic for Barrel ECAL to cope with new trigger
  requires removal and refurbishment of all super modules

- New FE crates for barrel muon chambers – requires extraction of all chambers

- LHC@CMS
  Replacement of TAS
  Engineering study by EN-MEF showed that advancing this task to LS2 will NOT be advantageous in terms of ALARA.

Challenges

LS2

Scheduling and Resources

ALICE and LHCb have very tight schedules with heavy load on service groups

ATLAS and CMS schedule is less heavy – however check capacity of service groups

- Survey
- EL frame contract for fiber installation (17k/10k by ALICE/LHCb + some more for ATLAS and CMS)
- Vacuum Group – Many beam pipes to be removed and re-installed + potential TDI exchange in ALICE
- Cooling group – Maintenance everywhere + major installations in LHCb + ALICE
- RP group – expect similar load as for LS1

➔ Start early planning and resource loaded scheduling

Challenges

LS2

Radiation Protection

- In general radiation levels will be not too different from LS1 – see next talk
  Some room for optimization but no fundamental problem

- Continue with the HSE objective for 2013/14 – Individual dosages < 3mSv/y

- Exercise ALARA optimization – try to keep all WP in ALARA level I

Individual dose equivalent	**Level I**	100 μSv	**Level II**	1 mSv	**Level III**
Collective dose equivalent		500 μSv		5 mSv	

- Make sure all parts installed that will remain after LS3 are ALARA optimized for activation and maintenance
  Maintainability after heavy irradiation must become a design criterion

Challenges

Infrastructure - LS2 onward

Many installations at the experimental sites will reach their end of lifetime or will become obsolete around LS3.
Exchange has to be done in LS2/3/4, requiring a long term planning.
Detailed talk last year by Fernando Baltasar Dos Santos Pedrosa
https://indico.cern.ch/event/252045/other-view?view=standard

Progress – exchange of elevators, planning well underway

More work necessary for

- HVAC and air pressure management
- access systems
- safety systems
- cranes

as their upgrade potentially interferes with underground work

- New buildings/workspace have to be constructed for LS3
  e.g. CMS plans for an extension of SX5 by about 1000m^2
  CERN as hostlab – start negotiations now!

Challenges

Infrastructure - LS2 onward

More experiment specific infrastructure

Power distribution
Cryogenics
UPS coverage
Detector cooling
- Water
- CO_2
- Other coolants

Gas systems

Final requests only available when detector design is fixed, but upgrade of most systems will be necessary.
Need to start planning to allow CERN being prepared

Keep reduction of green house gases in mind !

Challenges

Personnel

- LS1 has been performed with a large fraction of experts from the construction phase
- A younger generation of experts both for subdetectors and for the central coordination has to be available latest by LS2
- Without ATLAS and CMS will have difficulties to perform LS3
  LS3 will require additional personnel that has to be trained well before
- The complexity of the detectors require considerable training times and some continuity to be operated and upgraded efficiently
- Difficult to attract enough young people, as for career advancement this work is not considered valuable

Challenges

LS3
Scheduling

- For ATLAS and CMS LS3 will be much more complicated than LS1
  Program is much bigger than in LS1

- Correct scheduling will be most challenging for both experiments
  Have to fit all tasks including re-commissioning into 30 months

- Have to manage very high level of co-activity w/o compromising safety

- Installation of the TAS causes extra concerns
  One of very few activities dealing with very high radiation
  Interference with other work in the cavern

Challenges

Experiment specific difficulties and challenges

ATLAS – Possible exchange of the FCAL and
possible exchange of muon detector might put additional strain on schedule

CMS – Refurbishment of the ECAL barrel electronics drives the schedule and requires enormous infrastructure at PT5

Replacing the DT electronics requires exclusive access to all wheels for a considerable amount of time

Exchange of an entire endcap calorimeter requires a lot of logistics

Warning – Everything must be done in LS3 !
Staging parts of parts of the currently planned upgrades is not a good option

- Compromise the performance – mainly due trigger and bandwidth limitations
- Working on the current detectors in LS4 or later creates serious ALARA problems

Challenges

LS3

Radiation Protection

Except for the forward regions and some parts of the beam pipe radiation levels will still be moderate.
Provided – the cool down time before LS3 is maximized
Any special low luminosity runs and the HI run must be scheduled at the end of Run 3.
Any extended machine studies HL-LHC with low bunch currents should be performed at the end of Run 3

CMS has changed the beam pipe in LS2

Calculations will be presented in the next talk
Need to update and detail the calculations in the future and use possible measurements during Technical Stops or breaks to calibrate them.

Challenges

LS3

Radiation Protection

After LS3 the situation will change radically – see next talk
LS4 and following will have to deal with much larger activation

Everything being installed in LS3 must be designed for minimal activation
Maintenance procedures must be optimized and included in the design.

RP provides a database to choose the optimal material
http://actiwiz.web.cern.ch/

Challenges

LS3

Resources

Human

- LS3 will require much larger central teams
- The load on the CERN services will be higher than in LS1 or LS2
- Review of available human resources has to be foreseen in due time
- More flexibility to bring in additional personnel has to be foreseen
- We must get early support from CERN and from the Funding Agencies

Challenges

LS3

Resources
Financial
Lesson from LS1 – resources for shutdown have to be available well in advance
Preparatory work is considerable

Some of the upgrades belong to both phases I & II – e.g. change of beam pipe
Some of the upgrades have to start in LS2, which formally is still Phase I of LHC.
E.g. CMS CSC electronic upgrade interferes with the endcap calorimeter upgrade
→ Move the CSC upgrade to LS2.

To optimize the schedule further other smaller projects are under consideration to be brought forward

Despite the necessity of controlling the correct use taxpayers money,
some flexibility to react on the unforeseen should be maintained
Strictly ring fencing every single budget item will make management unnecessarily complicated

Summary

- **LS2** will be particularly busy for ALICE and LHCb requiring a lot of support from the technical departments
- Also ATLAS and CMS will need services from the technical groups
- Early resource loaded planning needed to identify and solve shortcomings
- **LS3** – though many details are not known yet, will be a shutdown of a different order of magnitude w.r.t. LS1 and LS2
  LHC, ATLAS and CMS will be very different from today
- **Scheduling and safely performing all tasks in 30 months is the biggest challenge**
- Try to advance some tasks to ease the schedule
- Need for LS3 procedures to easier hire personnel temporarily
- Continuity and generation change of experts is a concern
- Have to make sure that the financial resources are available early enough
  A too strict separation between Phase I and Phase II must be avoided
- **After running at high luminosity in 2016 some plans might have to be adapted**