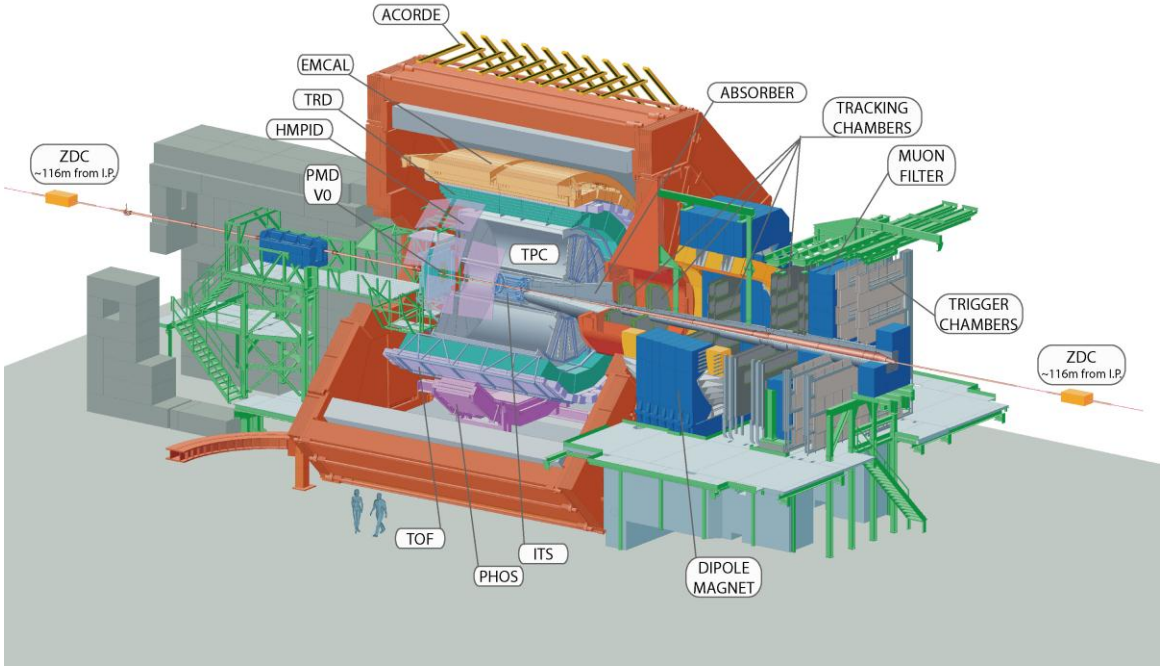
ALICE LS1 Activities, LS2 Upgrade: Items related to the LHC



ALICE LS1 Activities, Background

Since the time the LHC is operating with 1380 bunches at >1.5e11p/bunch, ALICE is severely affected by background from beam-gas collisions due to 'bad' vacuum conditions in the TDI and the large ZDC vacuum chambers.

'Bad' does not mean that the LHC is out of it's global specifications, it just means that the local pressure in these areas significantly exceeds 10^{-8} mbar, which results in a background rate equivalent to a about of $8x10^{30}$ $cm^{-2}s^{-1}$ i.e. equivalent to the nominal collision rate in ALICE !

The issue is in principle addressed:

NEG coated plates ('liner') for the ZDC vacuum chambers are currently being produced by the vacuum group and will be installed in LS1.

The TDI will be completely refurbished during LS1 in order to avoid the 'outgassing, heating, electron cloud effects on uncoated elements …

As we understand the TDIs will be replaced at some point between LS1 and LS2.

→ Excellent Vacuum in LSS around ALICE is of paramount importance for ALICE.

ALICE LS1 Activities, Collimation

LHC Collimation Review June 14th 2012

From the review report:

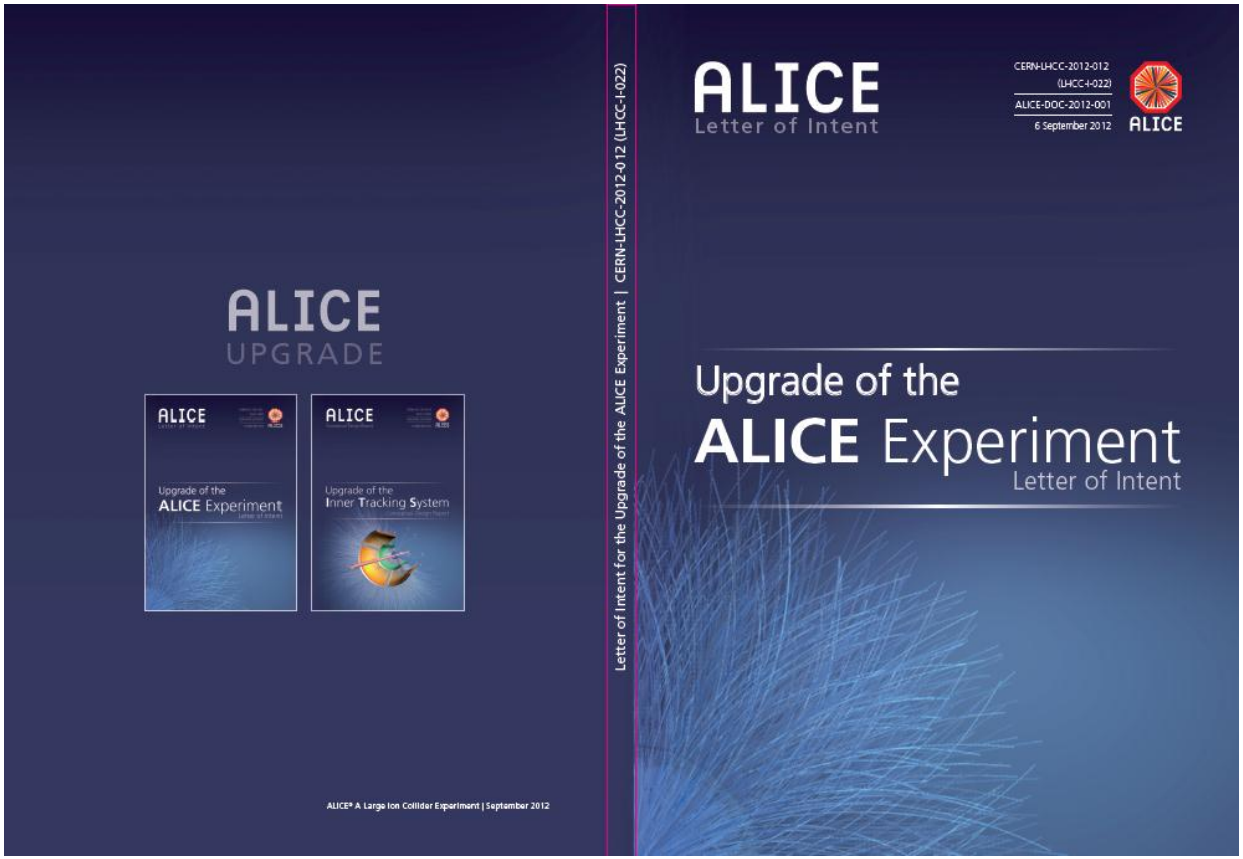
“On the basis of the evidence presented, the committee concludes that the nominal proton beam intensity of LHC at 7 TeV can be achieved without the installation of additional collimators in the IR3 dispersion suppression region during the LS1 shutdown. For heavy ion beams less experimental evidence exists and thus the extrapolation to full energy entails more uncertainty”

“The committee feels nevertheless that the upgrade of collimation in the IR3 and IR7 DS should be carried out in the long term (LS2) as it will allow for increased machine performance. The additional time should be used to complete a proper prototyping of the special cryogenic bypass module”

→ We can just ‘cross fingers’ that this will not limit the HI luminosity between LS1 and LS2 !

ALICE LS2 Upgrade

A Large Ion Collider Experiment



The upgrade proposal was endorsed by the LHCC in September 2012 and we are now in the process of preparing Technical Design Reports of the subsystems for 2013.

→ This will happen !

ALICE LS2 Upgrade, Physics

ALICE will install a major detector upgrade during LS2 in 2018, intended for precision measurements of the Quark Gluon Plasma (QGP).

The plan is to run at Pb-Pb Luminosities in excess of $7x10^{27}$ $cm^{-2}s^{-1}$ between LS2 and LS3 and also beyond LS3.

Highlights of the proposed programme are:

- **Study of the thermalization of partons in the QGP, with focus on massive charm and beauty quarks.**
- **Study of low momentum quarkonium dissociation and, possibly, regeneration pattern, as probe of deconfinement.**
- **Study of the production of thermal photons and low-mass dileptons emitted by the QGP.**
- **Study of in-medium parton energy loss mechanisms through jet structure, jet-jet and photon-photon correlations and jet correlations with identified hadrons and heavy flavor.**
- **Search for heavy nuclear states.**

ALICE LS2 Upgrade, Detectors

The key upgrade items are

- **a new, ultra low mass silicon tracker around a very small beampipe**
- **upgrade of the TPC with GEM detectors for continuous (un-gated) readout**
- **electronics upgrade of the other subdetectors**
- **major upgrade of the online systems to process all Pb-Pb collisions upon a (Minimum Bias) interaction trigger**

In parallel to HL-LHC, a HL-PbPb-LHC program must be established !

ALICE LS2 Upgrade, Pb Luminosity

The ALICE upgrade program assumes an integrated Luminosity of >10nb^{-1} achieved during a 6-7 year program after LS2.

The basic assumption is to continue the pattern of one month LHC Heavy Ion operation per year.

This program therefore asks for a Pb-Pb luminosity in excess of 7x10^{27} cm^{-2}s^{-1} .

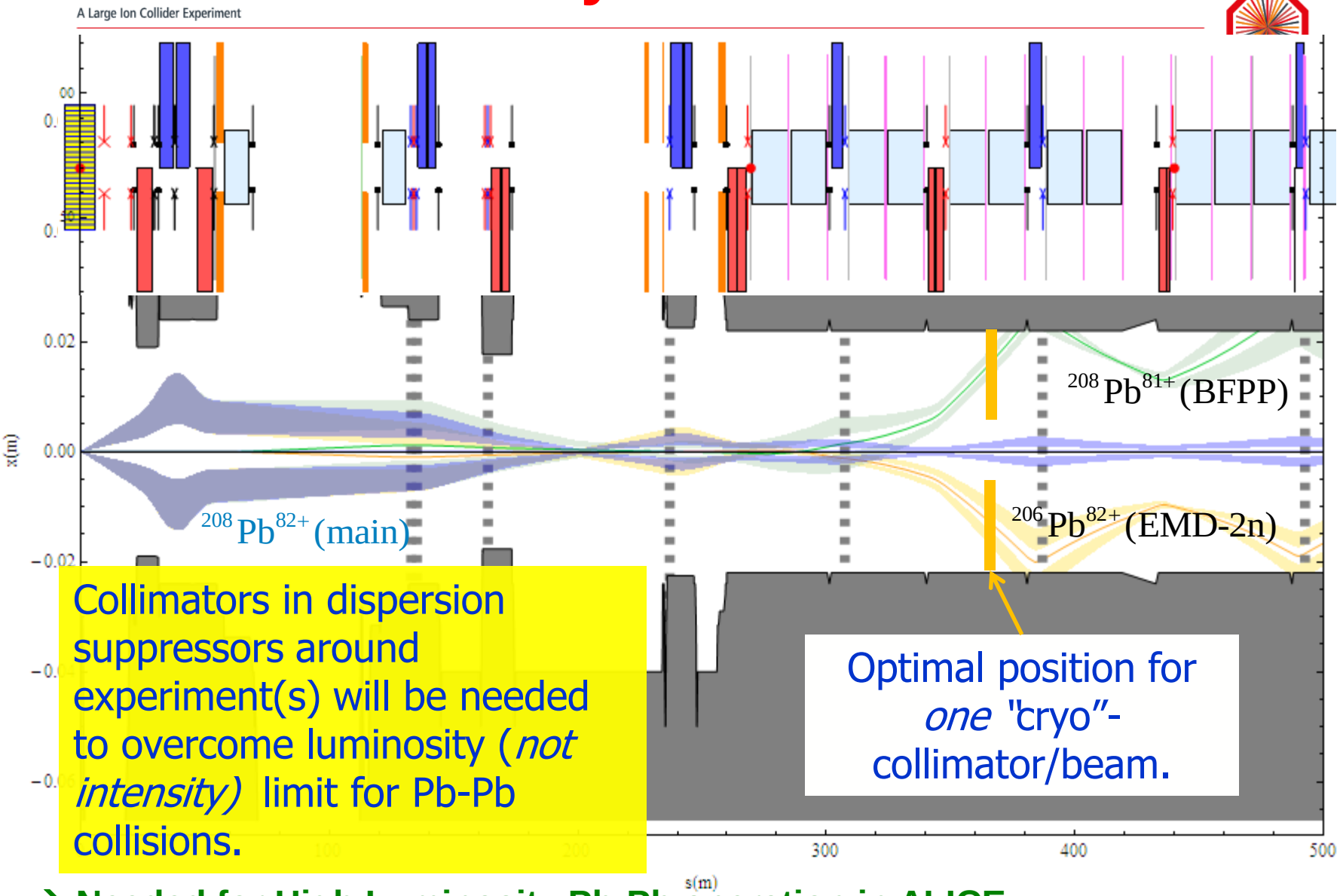
Our present understanding is that scaling the 2011 Pb-Pb luminosity to top energy we might expect a luminosity of 2x10^{27} cm^{-2}s^{-1} between LS2 and LS3. With 'minor' upgrades this might be increased to 3x10^{27} cm^{-2}s^{-1} .

Beyond this number, a major upgrade of the SPS injection kickers with a risetime of the order of 50ns is needed.

To our understanding this represents an investment of the order of 10-15MCHF.

→ Detailed discussion in the Dec. 12th 2012 LMC by John and Django.

Main and secondary Pb beams from ALICE IP



Collimators in dispersion suppressors around experiment(s) will be needed to overcome luminosity (*not intensity)* limit for Pb-Pb collisions.

→ **Needed for High Luminosity Pb-Pb operation in ALICE**

ALICE LS2 Upgrade, Pb Luminosity

In order to achieve the required levels of Luminosity in ALICE after LS2 we need:

- **A major upgrade of the SPS injection kickers during LS2**
- **The installation of collimators in the IR3/IR7/IR2 dispersion regions**

NB:

The Heavy Ion program needs this substantial Luminosity upgrade to enter the next phase of exploration, as a pendant to the increase of the p-p luminosity after LS3.

Considering the projected costs for HL-LHC p-p luminosity, this Pb-Pb luminosity upgrade represents a very small fraction !

Other Parameters

ALICE will use a beampipe with ID of 34.4mm, which has to be compatible with HL-LHC optics and apertures. Up to now this was only verified for nominal LHC running up to LS3.

Although ALICE will not operate during the entire p-p period it will turn on for a few weeks preceding the yearly HI period with a typical luminosity of 10^{31} $cm^{-2}s^{-1}$. Compatibility with HL-LHC operation to be worked out.

The vacuum pressure in the LSS around ALICE during p-p running must be at a level such that the intense HL-LHC beam does not put the ALICE detector and electronics under excessive radiation load, even if the experiment does not operate.

Preliminary:

- → **For the present LHC beam current the pressure must be <$5x10^{-9}$mbar**
- → **The specified vacuum pressure must scale i.e. at least fact 10 lower for HL-LHC.**

All this is at a very early stage, so more boundary conditions may arise.

Summary

LS1:

→ **Mitigation of electron cloud effects in the ZDC vacuum chambers**

→ **Refurbishment of TDI**

→ **No installation of IR3/IR7 collimation in dispersion suppression region**

LS1-LS2:

Installation of new TDI ?

LS2:

→ **Installation of ALICE upgrade, new central beampipe ID34.4mm**

→ **Upgrade of SPS injection kickers to allow Pb-Pb luminosities > 7e27**

→ **Installation of collimation in IR3/IR7 dispersion suppression region**

→ **Installation of collimation in IR2(IR1/IR5) dispersion suppression region**

LS3:

→ **? Stochastic Cooling ?**

Backup

ALICE between LS1 and LS2

The baseline plan is to have 3 Pb-Pb periods (2015, 2016, 2017) and then install the ALICE upgrade in an LS2 of 18 months.

An alternative (very attractive) idea would be an extended Pb-Pb run in 2016 and no Pb-Pb run in 2017, such that the TPC can be removed in the 2016/2017 winter shutdown and the TPC upgrade can already proceed during 2017 on the surface.

→ For this case ALICE could install the upgrade in an LS2 of 14 months duration.

Running scenario after the upgrade

- Pb–Pb
  - int. luminosity per year 2.85 nb^{-1} (peak L = $7x10^{27}$ $cm^{-2}s^{-1}$)
  - needed int. luminosity 10 nb^{-1}, statistics $8x10^{10}$ events
  - 3.5 month of running
  - +1 year of special run at low field for dileptons

- p–Pb
  - max event rate 200 kHz, flat (L = 10^{29} $cm^{-2}s^{-1}$)
  - needed int. luminosity 50 nb^{-1}, statistics 10^{11} events
  - 0.5 month of dedicated p–Pb run

- pp
  - max event rate 200 kHz, flat (L = $3x10^{30}$ $cm^{-2}s^{-1}$)
  - needed int. luminosity 6 pb^{-1}, statistics $4x10^{11}$ events
  - 2 month of dedicated pp run, assumed in 1 year

The list above fulfills the ALICE physics program as presented in the LoI.
A run with lower mass nuclei (e.g. Ar) could be considered in addition, if a physics case for it would emerge.

Assumptions on Pb-Pb Luminosity

- Average to peak luminosity ratio of 40%
- 1 month per year, equivalent to 10^6 s

- Scaling 2011 performance with 200ns beam and 1m beta* to top energy with 0.5m beta*
  - L_{peak} = 2x10^{27} cm^{-2}s^{-1}
  - L_{int}= 0.8 nb^{-1}

- 100ns beam an the same beam intensity (no, or modest upgrade of injectors)
  - L_{peak} = 3.37x10^{27} cm^{-2}s^{-1}
  - L_{int}= 1.35 nb^{-1}

- Reducing beta* from 0.5m to 0.4m
  - L_{peak} = 4.41x10^{27} cm^{-2}s^{-1}
  - L_{int}= 1.76 nb^{-1}

- Considering 50ns beam and same bunch intensity (some upgrade of injectors)
  - L_{peak} = 7.14x10^{27} cm^{-2}s^{-1}
  - L_{int}= 2.85 nb^{-1}

Possible additional handles are optimization of emittance and increase of bunch charge.

See also C.Biscari talk in Cracow, https://indico.cern.ch/conferenceDisplay.py?confId=182232

Possible running scenario

ALICE plans to run 6 years with upgraded detector, i.e. until 2026
(assuming start in 2019 and 2 years break of LS3)

Possible scenario:

2019 – Pb–Pb 2.85 nb^{-1}
2020 – Pb–Pb 2.85 nb^{-1} (low magnetic field)
2021 – pp reference run

2022 – LS3
2023 – LS3

2024 – Pb–Pb 2.85 nb^{-1}
2025 – ½ Pb–Pb 1.42 nb^{-1} + ½ p–Pb 50 nb^{-1}
2026 – Pb–Pb 2.85 nb^{-1}

This would not require pp running during high-luminosity runs, only a short time before a heavy-ion run for setting up and commissioning.