



HL-LHC Options: Evolution and selections after the last Cost & Schedule Review 3 in March 2018



Status 2016: Pre C&S Review 3 and Re-Baselining

2 Types of Options: Hardware and Parameter / Operation

-Costs are only implied for hardware but certain parameter options can imply certain hardware options → implicit cost implications

Hardware Options: five categories

- 1) Considered for machine protection and Risk mitigation
(as auxiliary system for other HL-LHC baseline components)
- 2) Options for facilitating required HL-LHC interventions
- 3) Options for additional diagnostics
- 4) Mitigation against unforeseen performance limitations
- 5) Additional performance improvement

Parameter / Operation Scenarios:

- No explicit budget implications but risk mitigation
- Backup option (with reduced performance) for baseline hardware
- Summary of hardware implications for HL-LHC

HL-LHC Hardware Options @ C&S Review 2

Five Categories: Budget summary

1) Considered for machine protection and Risk mitigation

15.4 MCHF (6.8 MCHF assigned for studies and development)

Norbert Holtkamp @ C&SR2:

These are only options for added scope and no option for de-scoping!

Re-baselining Exercise in 2016 to reduce project Cost

→ What options are still feasible against the background of the rescoping?

Total: **128 MCHF** (23 MCHF assigned for studies)



TCC discussion on which options the project should prioritize

and

Which option can be pursued through in-kind contributions

In preparation of C&S Review 3



HL-LHC Collaboration Board Page:

Pursued in-kind contribution both, for generating budget margins and for implementing high priority options!

Collaboration

BROWSE



Meetings

Indico

Documents

Minutes

Lists

In-kind contribution opportunities (CB)

HLCB Members

HiLumi Calendar

Pictures gallery

Site Contents

The 6th HL-LHC Collaboration Board meeting will take place at the Espace St Martin, Paris on 14 November 2016

by Cecile Noels

17/10/2016 08:17 PM - Indico Website for HiLumi Meetings

<https://indico.cern.ch/event/578025/>

(More Announcements...)

HiLumi Calendar

PAGE

Start Time	Title
14.11.2016 08:30	6th HL-LHC Collaboration Meeti

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Hardware Options that are still being pursued

Options replaced by alternative / new design modifications:

1)

2) Financed by project and consolidation and integrated into the CtC!

3)

fig

Options motivated by recent LHC operation experience:

Decided to integrate this into the HL-LHC baseline!!! [59th TCC – 4th October]

Still looking for in-kind contribution and / or options financing this modification

HL-LHC Hardware Options

H1) Considered for machine protection and risk mitigation:

WP14

-MKB or TDE upgrade

(Dump protection in case of a beam loss event (BLE) at each 3000°).

Implementation into HL-LHC project baseline

[59th TCC – 4th October]


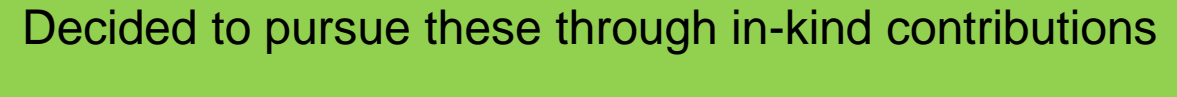
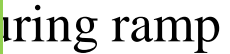
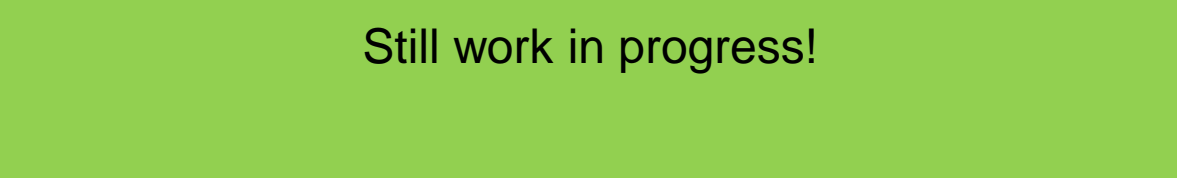
Required with Consolidation!!!

Potential in-kind contributions?!?


- TDE upgrade
- Dump protection during RunIII
- Studies and development included in WP14
- ~~Ca. 3.6 MCHF for dump upgrade implementation~~
- Integration should not be an issue → 6.4 + 1 MCHF for full upgrade

Hardware Options that are still being pursued

Options that are motivated / endorsed by reviews and MDs:

- 1)  ol
- 2) Decided to pursue these through in-kind contributions
 Still work in progress!  ring ramp
- 3) 

New Options I:

- 1) Fully remote alignment for matching section optimization:
beneficial for ALARA, technical solution is being developed by CERN;
should be cost neutral / beneficial with savings in MS upgrades
 Study looks very promising and decision by end 2018 / beginning 2019
- 2) Higher precision current control for PC in S12, S45, S56 and S81
mitigation against increased tune fluctuations due to ATS optics

Hardware Options that are still being pursued

Options retained as backup / alternative to baseline choices:

- 1) LESS → alternative to aC coating baseline choice
- 2) The HL project supported prototype wires and MD studies in the LHC

But recent MD studies make LRBB wires look very interesting

New Options II:

- 2) TCDQ and BETS: TCDQ mechanics upgrade, BETS upgrade [24bits], new absorbers

→ decision by 2020; ca. 0.75 MCHF for full upgrade, integration not an issue

- 3) Cold Diodes for triplet magnets [radiation tolerant diodes!]

Studies look very promising and decision by beginning 2019

Status 2018: Hardware Options that are no longer actively pursued by the project at this stage

Options that could still be implemented at a later stage:

1) Wideband Feedback System

2) ~~Second half of Crab Cavity system~~

→ Excluded at TCC in March 2018

3) ~~Low impedance collimators in IR3~~

→ Excluded at TCC in March 2018

4) New Tertiary collimators in IR2 and IR8

→ Not really pursued anymore
[Cons]

Status 2018: Hardware Options that are no longer pursued by the project

Options that would imply major interventions:

1) Additional Dispersion Suppressor collimators

2) MQYY

3) 2

→ Therefore practically excluded at this stage of the project

→ [17- 200MHz case?]; RF Quadrupole

4) Stochastic cooling for Pb ion beam operation

→ Excluded at TCC 8th March 2018 in preparation of C&S Review 3

Options no longer seen as required / beneficial:

1) Rotatable collimators

Parameter Options that have become part of the project baseline

Optics:

1) Operation with variable crossing angle

➔ luminosity and radiation levelling

2) Operation with β^* levelling

Status 2018: Parameter Options that are still pursued / studies by the project

Optics:

- 1) Flat beam configuration: interesting as backup in case of problems with Crab Cavity operation or together with Crab Cavity operation in case of beam intensity limitations in the HL-LHC

Beam Parameters:

- 1) 8b4e and hybrid filling schemes in case limitations due to e-cloud persist [implies ca. 25% loss in beam intensity and luminosity]
- 2) BCMS filling with $1.7\mu\text{m}$ emittance at injection
- 3) 80 bunch PS filling scheme → more bunches in the LHC

Machine Configuration:

- 1) Operation at ‘ultimate’ beam energy of 7.5TeV if required by the experiments → currently not assumed to be desirable before the commissioning of HL-LHC hardware at nominal energy [→ after LS4]

Parameter Options that are no longer compatible with the project baseline

Optics:

- 1) Crossing angle plane exchange during operation
 - ➔ no longer compatible with half Crab Cavity system installation
 - ➔ implication on peak local radiation dose to triplet magnets
- 2) Crab Kissing scheme
 - ➔ no longer compatible with half Crab Cavity system installation
- 3) Long bunch length operation
 - ➔ only pursued with 200MHz RF system

HL-LHC Hardware Options

Summary

4 Hardware option integrated into HL-LHC baseline

6 Hardware Options still maintained

→ 3 actively being pursued via in-kind

4 Hardware Options added

8 Hardware Options no longer pursued

2 Operation options integrated into baseline

5 Operation Options still maintained

3 Operation Options no longer pursued



HL-LHC In-Kind Contribution Hardware Opportunities

H2) HL-LHC Option

Considered for machine protection and risk mitigation:

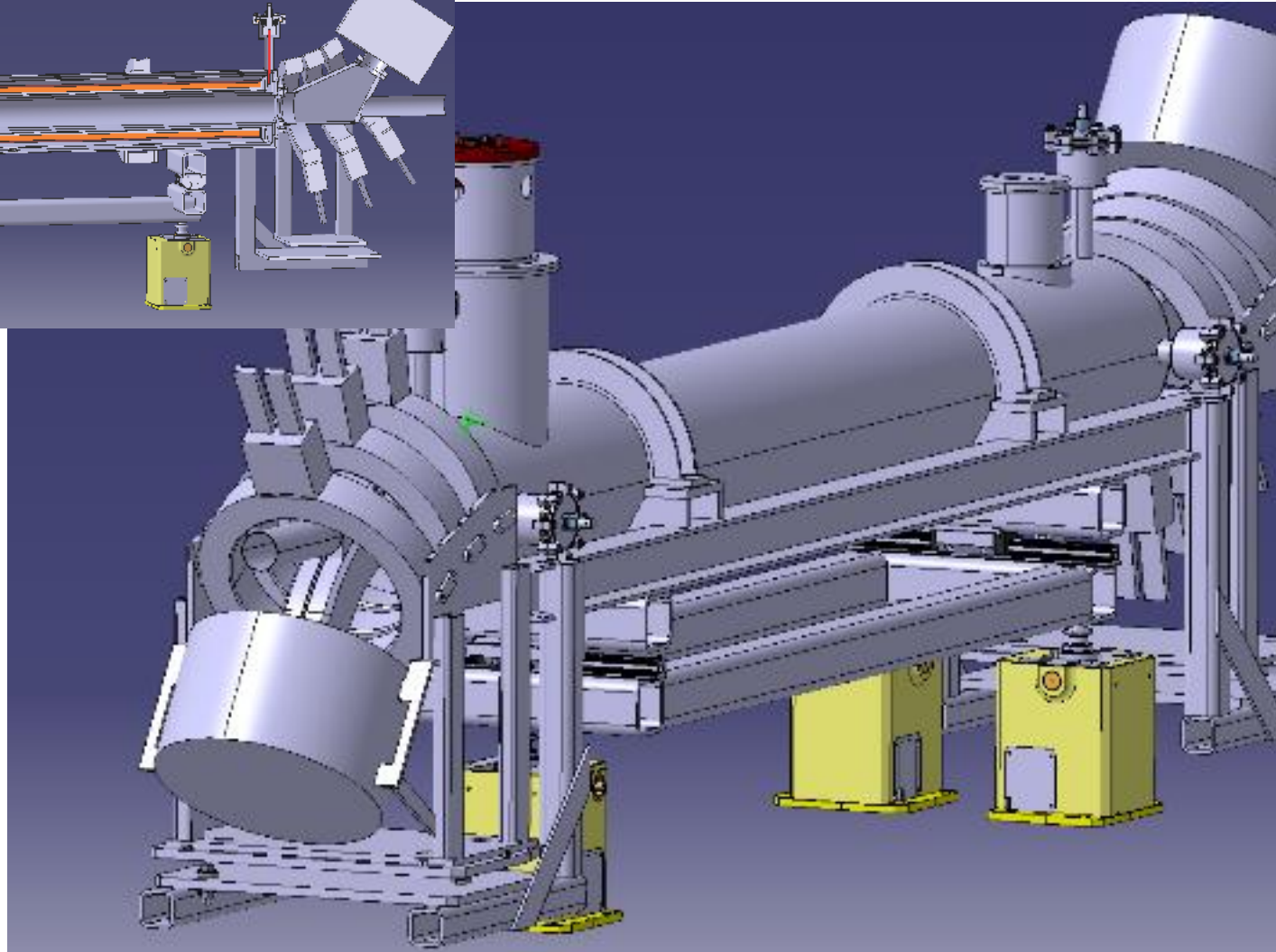
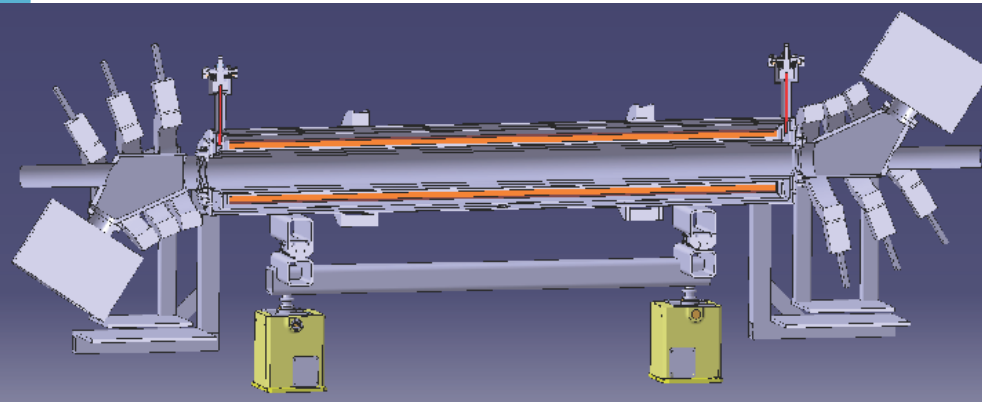
WP5

-**Beam halo depletion devices** (MP for coping with CC failure and loss spikes)

hollow electron lens (TeV)

- Technical solution needs to be ready for LS3; studies LARP & CERN
- Decision required by end RunII (2015-2018) → Review Oct.'16
- 1.3MCHF assigned for studies and development within WP5
- Ca 3.3MCHF for first e-lens development (could be installed in LS2) plus 3MCHF for second beam → ca. 6.3MCHF total (12.8M\$)
- Integration of hollow e-lens assumed for IR4 → space reservation and cryogenic infrastructure ✓ → conflict / exclusion with other options!

Hollow e-lens: 4 m long solenoid and 8 coils (all Sc)



HL-LHC In-Kind Contribution Hardware Opportunities

H3) HL-LHC Option Considered for additional diagnostics:

WP13

-Second Undulator per beam for Synchrotron Light monitor:

Baseline uses dipole radiation as second light source for additional diagnostics

- ➔ existing system does not provide enough light at **injection energy** for additional diagnostics (Streak camera and Coronagraph)
 - ➔ **second undulator or more powerful replacement**
- ➔ **Technical design based on existing undulators**
- ➔ **Decision required in time for implementation in LS3 (4 years) ➔ 2023**
- ➔ **No R&D cost implied**
- ➔ **Ca. 1.1MCHF per undulator ➔ 2.2MCHF for both beams**
- ➔ **Integration and infrastructure needs to be studied!**

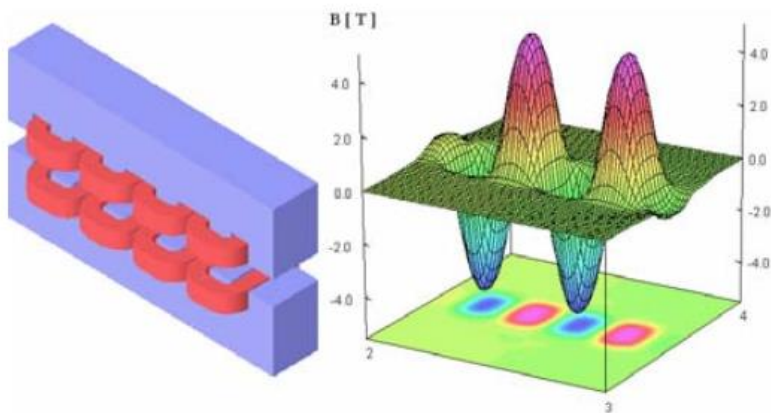


Figure 2: The undulator layout and a 3D view of the gap field distribution on the mid plane.

The undulator will be installed as an independent cold mass housed in a cryostat closing the non-lead end of the D3 dipole. This allows keeping the distance between the magnetic edges D3/undulator as small as 865 mm. The integration design has been already defined (Figure 3).

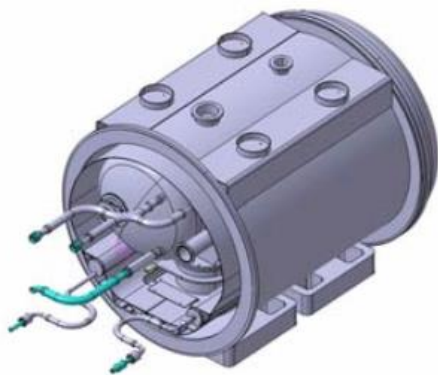


Figure 3: Final Cryostat integration

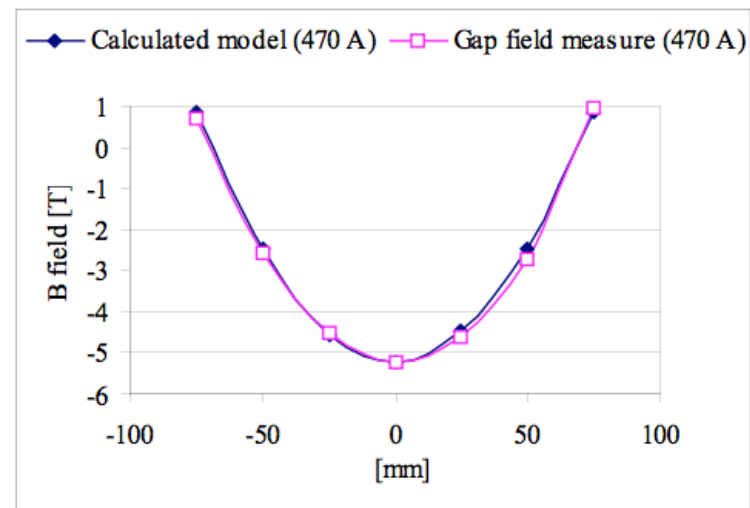


Figure 8: Longitudinal field distribution in the mid plane gap as measured and as simulated with POISSON