HL-LHC luminosity ramp-up
(at the start of the fill and over years)
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Luminosity ramp-up for Nominal

The “Feasible” cryo option is discarded as starts from L=0.

“Target” is shown in red.

1.2% lumi. loss at the end of the fill, but larger loss for shorter fills.

“With experience”: 0.4% loss.
Luminosity ramp-up for Ultimate

Significantly larger lumi loss.
“Target”: 2.7% lumi loss.
“With experience”: 1.3% lumi loss.

1% integrated luminosity in HL-LHC is not negligible
Assumptions for IP1&5

★ 262 fb\(^{-1}\) in 160 days with \(5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}\)
★ 405 fb\(^{-1}\) in 200 days with \(7.5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}\)
★ Integrated luminosity recomputed for different leveled lumi, \(\beta^*\), intensity, etc. **Efficiency = 50%** (see extra slides)
★ 350 fb\(^{-1}\) at the end of Run 3 (to be revised!)
$\beta^*$ and days of proton physics

Nominal $\beta^*$ in 2033

Total days of proton physics = 2090
Nominal intensity in 2029 + HEL & CC
Baseline performance

Peak luminosity \([10^{34} \text{ cm}^{-2} \text{s}^{-1}]\)

- LS3
- LS4
- LS5

Integrated luminosity \([\text{fb}^{-1}]\)

Year

2026  2028  2030  2032  2034  2036  2038  2040

0  500  1000  1500  2000  2500  3000  3500  4000

LS3
LS4
LS5

350 fb\(^{-1}\)

350 fb\(^{-1}\)
Ultimate performance

Peak luminosity \(10^{34}\text{ cm}^{-2}\text{s}^{-1}\)

Year:
- 2026
- 2028
- 2030
- 2032
- 2034
- 2036
- 2038
- 2040

Integrated luminosity \(\text{fb}^{-1}\)

Goal exceeded by about 4%.
LHCb, $L_{lev} = 2 \times 10^{33} \text{ cm}^{-2}\text{s}^{-1}$

For ALICE $L_{lev} = 1.4 \times 10^{31} \text{ cm}^{-2}\text{s}^{-1}$
$\beta^*$ and days of proton physics – $\beta^* = 20 \text{ cm}$
Baseline performance – $\beta^* = 20$ cm
Ultimate performance – $\beta^* = 20\,\text{cm}$

Goal barely achieved, zero margin.
With extra ion runs in Runs 5 & 6

Total days of proton physics = 1850
Baseline performance – With extra ion runs

Peak luminosity [$10^{34}$ cm$^{-2}$s$^{-1}$] vs Year:

- **LS3**: 350 fb$^{-1}$
- **LS4**: 500 fb$^{-1}$
- **LS5**: 700 fb$^{-1}$

Integrated luminosity [fb$^{-1}$] vs Year:

- Year 2026: 0 fb$^{-1}$
- Year 2028: 500 fb$^{-1}$
- Year 2030: 1000 fb$^{-1}$
- Year 2032: 1500 fb$^{-1}$
- Year 2034: 2000 fb$^{-1}$
- Year 2036: 2500 fb$^{-1}$
- Year 2038: 3000 fb$^{-1}$
- Year 2040: 3500 fb$^{-1}$
Ultimate performance – With extra ion runs

Reduction of 11% from baseline ion operation.
Summary

★ Goals are at reach in new baseline.
★ Tight margin of about 4% for the Ultimate goal (comparable to luminosity loss from larger $\beta^* = 20\text{cm}$)
★ Running ions in Runs 5 & 6 reduces total integrated luminosity by 11%.
★ LHCb integrated luminosity reduction between Nominal and Ultimate is about 10%
★ Cryo request to ramp-up fill luminosity should be faster than 20min to lose less than 1% luminosity in Ultimate.
Extra slides
## Luminosity Vs ppb, $\beta^*$, etc.

<table>
<thead>
<tr>
<th>Year</th>
<th>ppb $[10^{11}]$</th>
<th>Virtual lumi. $[10^{34}\text{cm}^{-2}\text{s}^{-1}]$</th>
<th>Int. lumi. $[^\dagger][\text{fb}^{-1}]$</th>
<th>$\beta^*$ $[\text{cm}]$</th>
<th>Crab cavity</th>
<th>HEL</th>
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<tr>
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</tbody>
</table>

Assuming for all years: $\epsilon = 2.5 \, \mu m$ and 160 days of operation,

$[^\dagger]$ Int. lumi. to be rescaled with days of operation.