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## The LHCb Vertex Locator Upgrades

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While the current LHCb Upgrade I is currently being installed and plans to run with increased luminosity and efficiency, the collaboration has already submitted a physics case for an Upgrade II detector to begin operation in 2031. Even at the Upgrade I accumulated statistics of  $50 \text{ fb}^{-1}$ , expected to be achieved by 2030, most physics channels will be statistically limited.

In the upcoming LHC run, the LHCb experiment will read out every bunch crossing and perform the trigger decision in a computing farm with the whole event information. The Vertex Locator (VELO) will be composed of a pixelated detector with  $55 \mu\text{m}$  pitch installed at 5 mm from the beam axis. The front-end has a data-driven readout optimised for high speed operation.

The future upgrade stage is designed to run at instantaneous luminosities of  $2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  and accumulate over  $300 \text{ fb}^{-1}$ . At this intensity, the average pile-up would be 56 with around 2500 particles within the acceptance. Time measurements will be needed to assign correctly each b hadron to its origin primary vertex and to perform the real-time pattern recognition and track reconstruction. To achieve these goals a 4D hybrid-pixel detector with enhanced timing capabilities in the ASIC and sensor will be developed. Improvements in the mechanical design will also be needed to allow for periodic module replacement. The design will be further optimised to minimise the material before the first measured point on a track and to achieve a more fully integrated module design with thinned sensors and ASICs combined with a lightweight cooling solution. As well as improving the VELO performance, quantified by the impact parameter resolution, these changes will be beneficial in improving the momentum resolution of the spectrometer and reducing the impact of secondary interactions on downstream detectors.

In this presentation the VELO Upgrade electronics design and implementation will be shown as well as status of the construction and installation. The design considerations and R\&D studies for the future upgrade will also be discussed.

### Submission declaration

Original and unpublished

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