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Overview of the LHCb Mighty Tracker with focus on the newly developed MightyPix based on HV-CMOS technology

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Beyond Run4 of the LHC the instantaneous luminosity in the LHCb detector is going to be raised to $1.5\text{x}10^{34}\text{cm}^{-2}\text{s}^{-1}$. To achieve stable operations and precise tracking, it is planned to upgrade the complete LHCb tracking system.
The downstream trackers have to be upgraded to withstand the increased radiation and occupancy at a similar or lower material budget than the current detector. A hybrid solution consisting of scintillating fibres in the outer and HV-CMOS MAPS in the innermost region is under development. The detector with an silicon area of 18m^2 will be one of the largest devices built in this technology.

Summary (500 words)

After Long Shutdown 4 LS4 of the LHC the LHCb experiment expects an instantaneous luminosity up to $1.5\text{x}10^{34}\text{cm}^{-2}\text{s}^{-1}$. This results in 300fb^{-1} of recorded data after Run 5 and 6. To achieve the physics goals, the detector needs to be upgraded to ensure efficient tracking and particle identification. Therefore, all subdetectors are planned to be upgraded during LS4. This talk will introduce the planned downstream tracker behind the dipole magnet.
The increased luminosity leads to a higher occupancy˜(≈ 6 times higher maximum occupancy per fibre compared to Upgrade1), a high radiation environment\newline ($(3-6)\text{x}10^{14}\text{n}_{\text{eq}}/\text{cm}^2$ at the end of life) and an overall increased number of simultaneous interactions per bunch crossing $\langle\mu\rangle = 40$.
The technology of the tracking stations is under ongoing development. For the downstream tracker consisting of three stations with four layers per station a hybrid technology with scintillating fibres in the outer detector region and a silicon pixel detector in the innermost region around the beampipe is planned. This is known as the Mighty Tracker.
For the silicon pixel detector HV-CMOS MAPS are proposed to be used. Those guarantee a high granularity˜($\approx 50\text{x}150\mu\text{m}$) and precise timing, which is necessary for an efficient tracking. Initial tests show this is a cost-efficient solution with sufficient radiation hardness.
To match the detector requirements, the power consumption should be less than $150\text{mW}/\text{cm}^2$ and the timing in orders of 3ns. Furthermore, the overall material budget needs to be less than 2% of the radiation length X_0.
The development of the so-called MightyPix is based on previous HV-CMOS MAPS. A first version of the MightyPix with a size of $55\text{x}165\mu\text{m}$ and a chip size of $5\text{x}20\text{mm}$, which is a quarter of the final chip size˜($20\text{x}20\text{mm}$), will be available in Autumn 2022. The readout will be compatible with the LHCb readout scheme. Further investigations to improve the time resolution without increasing the power consumption are ongoing. One ansatz for this is the improvement of the signal shaping in the front-end amplifier. In addition, further testbeams are planned to investigate the performance after irradiation and to find an optimal operation temperature that reduces, e.g, the leakage current but keeps the material budget low.

This presentation covers an overall introduction of the planned Mighty Tracker with focus on the used HV-CMOS technology and the upcoming challenges for this detector. Furthermore, first testbeam results of the irradiated and non-irradiated ATLASPix chips are presented.

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