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Development of a calorimeter with picosecond timing precision for the LHCb Upgrade II

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The LHCb experiment aims to operate in the harsh conditions imposed by the High-Luminosity run of the LHC, corresponding to a peak instantaneous luminosity of 1.5 x 10^{34} cm^{-2} s^{-1}. Elevated resistance to radiation, increased granularity and the capability to measure the time of arrival of particles with a resolution of a few tens of picoseconds will be fundamental for all subdetectors. In the case of the electromagnetic calorimeter (PicoCal) the candidate technologies are Spaghetti Calorimeter (SpaCal) with either crystals or plastic fibres as active and light-transport material, and either tungsten or lead as absorber, and Shashlik with polystyrene tiles, lead absorber and fast WLS fibres. The inclusion of a timing layer based on microchannel plate (MCP) technology has also been studied to reach the ultimate timing precision. A vigorous campaign of R&D and feasibility studies has been conducted in the last years, using accurate simulations, laboratory tests and beam tests at DESY and CERN facilities. Good energy resolutions scaling as $10\%/\sqrt{E}$ was achieved. Time resolutions range from about 20-30 ps for 5-GeV electrons to about 10 ps for 100-GeV electrons. The program has also led to a spin-off project aiming to realise MCP photomultiplier with picosecond time capabilities and much increased lifetime of the photocathode with respect to currently available devices. Details of the various technologies, experimental setups and relevant results will be shown and discussed.

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