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Studies on wide dynamic-range SiPMs with high pixel densities

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The future Circular Electron-Positron Collider (CEPC), as one of future large-scale scientific facilities for high energy lepton collider experiments, aims to accurately measure the Higgs boson, electroweak physics and the top quark. A highly granular crystal electromagnetic calorimeter is proposed within the CEPC 4th detector concept to achieve an excellent EM energy resolution of less than 3%. It is design by a homogenous calorimeter instrumented with crystal scintillator bars as the active material, and silicon photomultipliers (SiPMs) are selected as the major photosensor candidate. To cover a large energy range of a crystal detector unit (typically on the order of magnitude from 100keV to 10GeV) would lead to a stringent requirement on the SiPM dynamic range. Two promising SiPM candidates (from NDL and HPK) with a sensitive area of $3 \times 3\ mm^2$ and 6 micron and 10 micron pixel pitches respectively, have been identified for detailed studies. A dedicated test-stand has been developed to address the challenge of response calibration for the wide dynamic-range SiPMs in a typical range from single photon to the order of 100k photons.
Meanwhile, a Monte Carlo simulation model has been developed for a deeper understanding and comparisons with experimental measurements. The SiPM simulation model includes SiPM's characteristics e.g. Photon Detection Efficiency (PDE), inter-pixel optical crosstalk, after-pulse and pixel recovery time, etc.
In this contribution, the dedicated setup for characterizations of the SiPM dynamic range will be firstly presented, followed by the experimental measurements of SiPMs with high pixel densities and comparisons with the simulation predictions. To the best knowledge of the authors, these results of dynamic range measurements may be the first ones for the NDL-SiPM equipped with ~250k pixels (with the pixel pitch of 6 micron).

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