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Interpolating Silicon Photomultipliers

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We present the novel {\bf I}nterpolating {\bf Si}licon {\bf P}hoto{\bf M}ultiplier (ISiPM) topology which provides the spatial position of photon clusters with high resolution. Individual APD cells of the ISiPM area are not connected to a {\em common} readout electrode, but each cell is connected to {\em one of several} output channels. The most straight forward embodiment is a rectangular device with four outputs located (conceptually) in the corners. The assignment of each cell to one of the channels is chosen such that the center of gravity of an arbitrarily shaped group of cells can be reconstructed as (for instance) the weighted sum of the corner signals. Due to the finite size of the cells, this exact goal can only be approximated and residual systematical errors remain. An algorithm is presented which produces fractal assignment maps with homogeneous reconstruction properties. Simulated limits of the expected spatial resolution as a function of cell size, cluster size, number of fired cells per cluster and readout noise will be presented. A first prototype device with $\{100 \times 100\}$ cells on a total size of $7.5 \times 7.4\,\mathrm{mm}^2$ has been fabricated at FBK and operated successfully. Individual LYSO crystals of $\approx 2\,\mathrm{mm}$ width in a block array can be identified. The ISiPM concept offers good spatial resolution on large areas with a moderate number of readout channels so that it is a promising device for instance for PET detectors.

Primary author: Prof. FISCHER, Peter (Heidelberg University)

Co-author: Dr PIEMONTE, Claudio (Fondazione Bruno Kessler)

Presenter: Prof. FISCHER, Peter (Heidelberg University)

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