Analysis of Time of Arrival Measurement with Low-Gain-Avalanche-Diode

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Introduction

Studies of ToA measurements:

Sensor: Low-Gain Avalanche Diodes in a pixelated structure with the proposed pixels sizes ranging from about 1 mm² to about 3 mm²; typical capacitance of the sensor segment on the order from a few pF up to about a dozen pF (for the largest pixels sizes considered), while the thickness (volume producing charge signal) typically less or equal to 50 μm thick; charge produced by ionization drifts to the zone of high electric field, where multiplication with a typical gain of 10 increases the signal. ToA measurement precision constrained by variation of the total charge (Landau-like distribution with MPV of less than 10fC) and i(t) waveform fluctuation.

Examples of Simulation results

ToA for \( t_p = 2 \) ns and 1 ns, as a function of an assumed SNRs

ToA results (nonlinear fit 5th order polynomial), LGAD signals with MPV=7fC, 10C, 2nd-order \( m \rightarrow 30 \), threshold \( \gamma = 0.25 \), SNR=30

\[ \tau \approx 24.0 \text{ps} \]

Conclusions:

- CFD performs generally 20%-30% better than LE with correction using ToT or amplitude.
- Finite duration of CFD waveforms yields less good ToA measurement precision than CFD; ToT is enough to use TH=20ps and 5 bits.
- Achieving combinations of \( \gamma = 0.25 \) or \( 2 \) ns and SNR > 30 requires significant noise in the input device (first stage).