BIC Digitization/Reconstruction Chain

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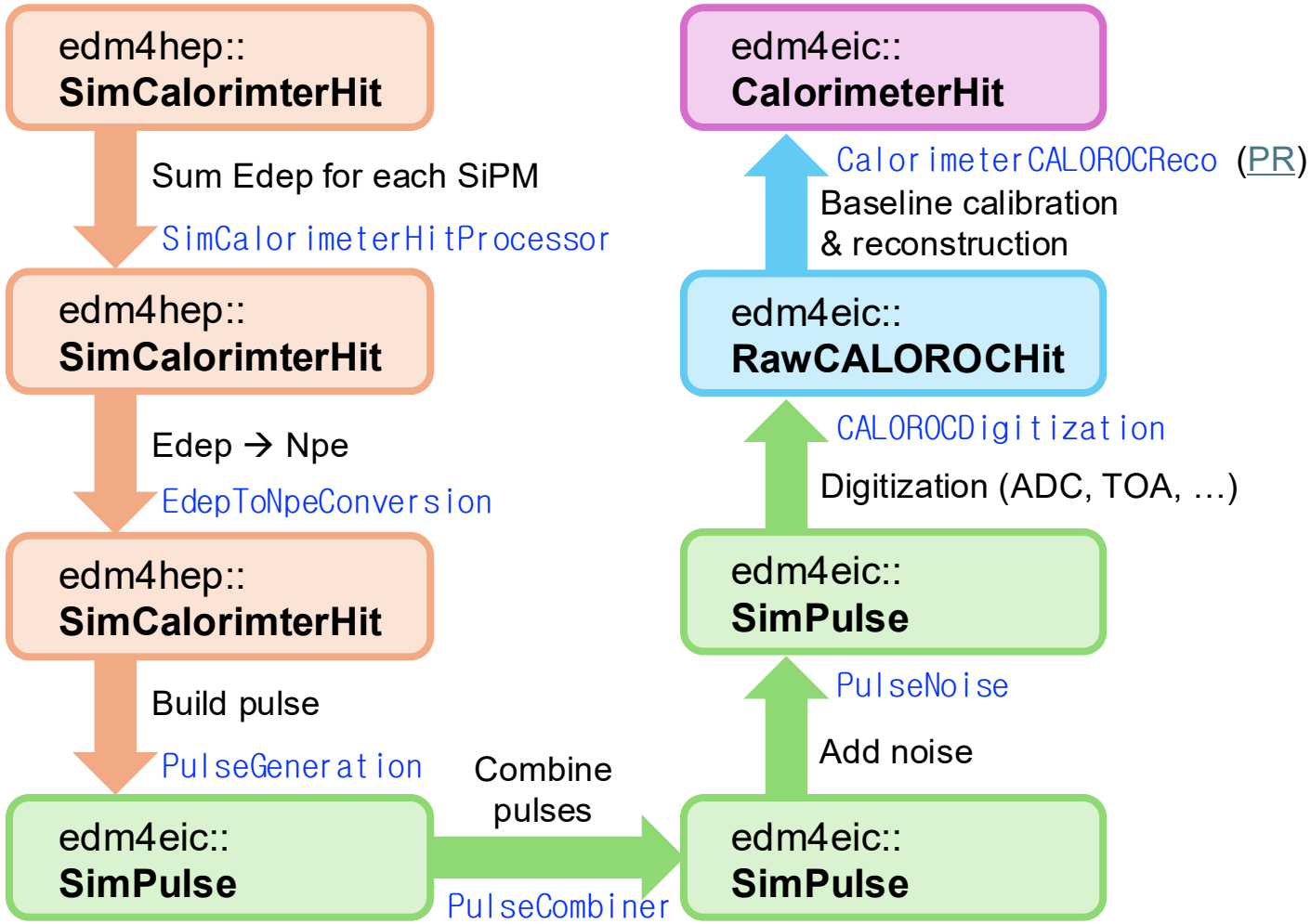
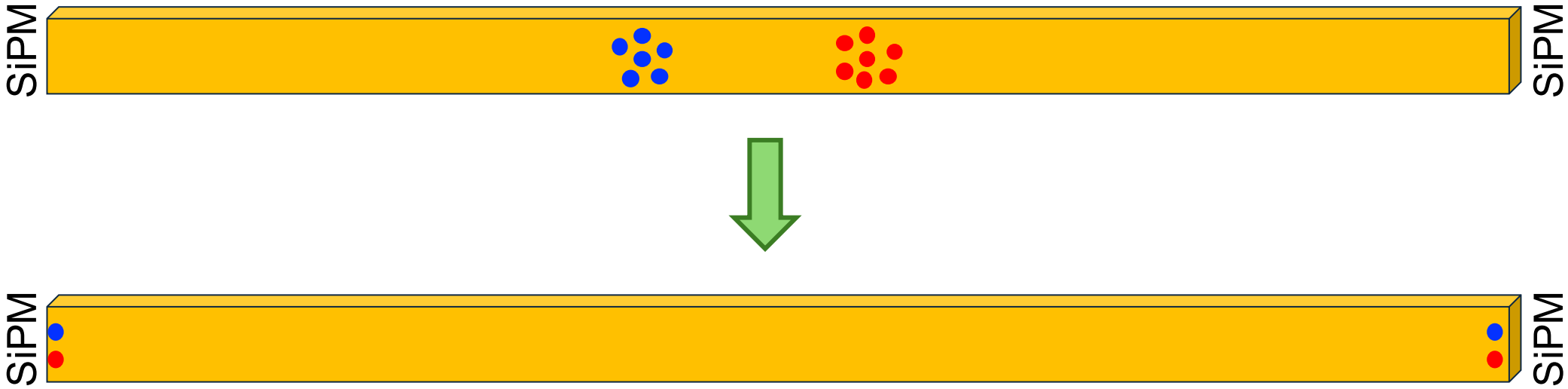
Argonne NATIONAL LABORATORY

BIC Reconstruction Chain

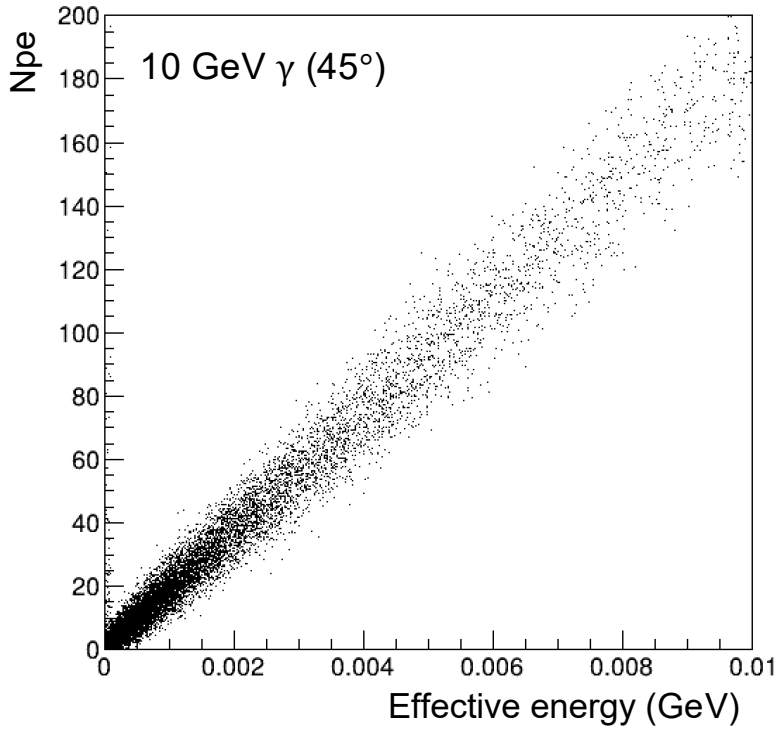


SimCalorimeterHitProcessor



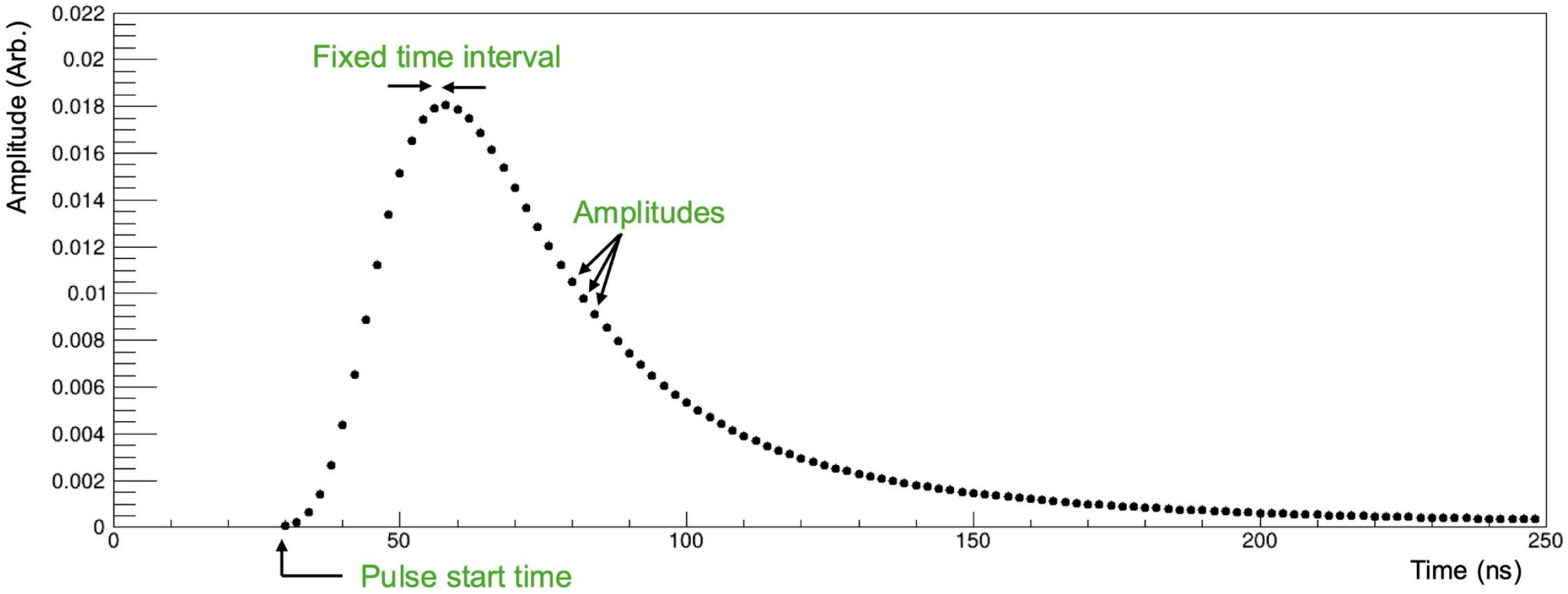
- `SimCalorimeterHitProcessor` sums energy deposits to calculate the effective energy contributing to each SiPM signal, separately for each originating particle.
  - For BIC, attenuation effect in the fiber is taken into account when calculating the effective energy.
  - Keeping the effective energy separately for each originating particle is useful for signal-background separation studies.

EdepToNpeConversion



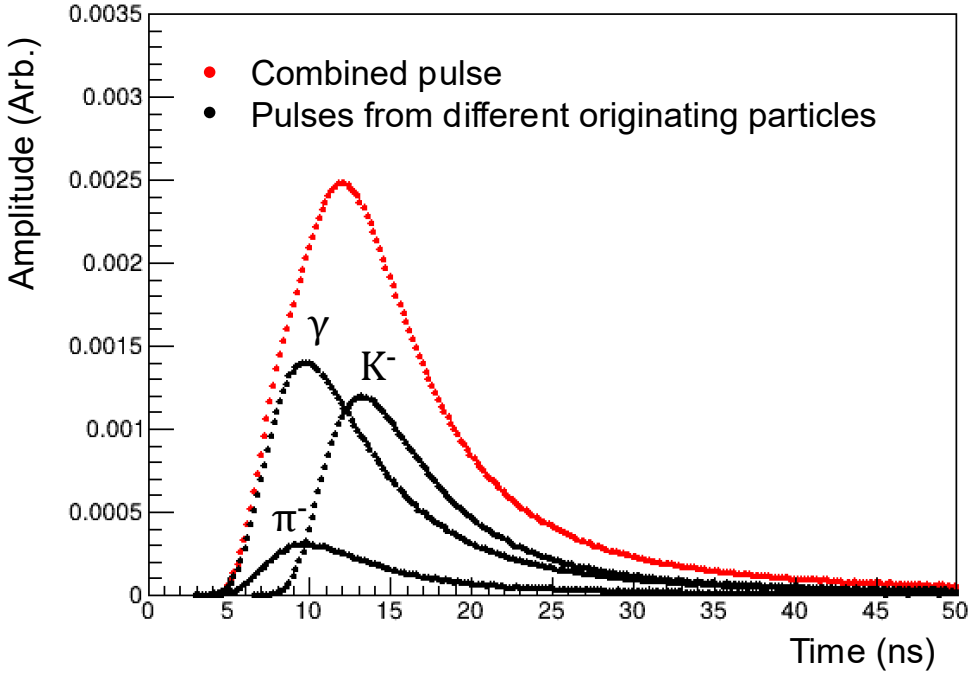
- `EdepToNpeConversion` converts the effective energy to Npe, and then Poisson smearing is applied.

PulseGeneration



- `PulseGeneration` generates pulses based on the Npe values.
- The pulse data model doesn't store the pulse shape itself. It stores amplitude values with a fixed time interval and a pulse start time.
  - With those stored numbers, we can reconstruct the pulse shape on the time axis.

PulseCombiner

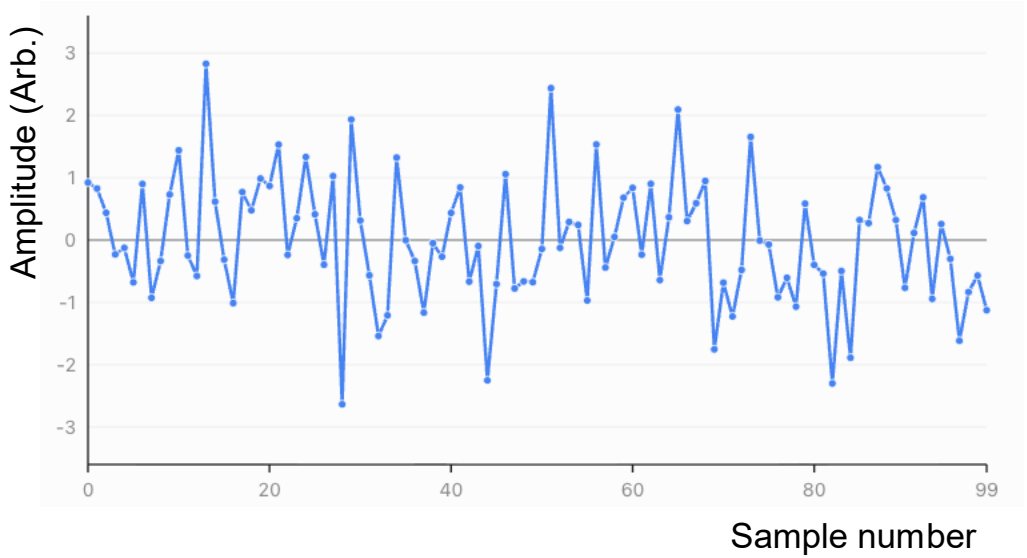


- If there is more than one pulse at a SiPM, `PulseCombiner` combines them by adding the amplitudes.

PulseNoise

dd4hep::FalphaNoise(poles, α, variance)

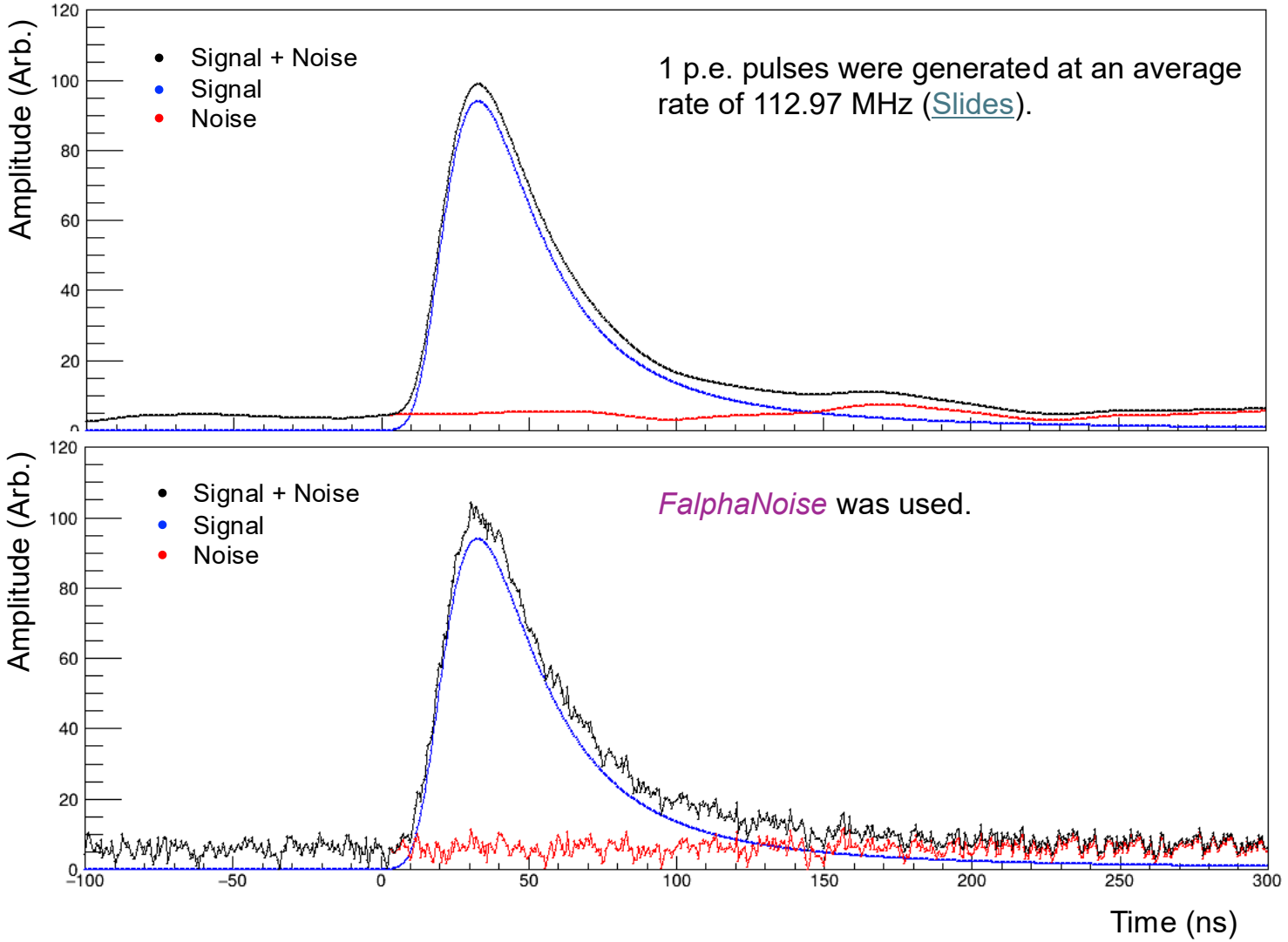
$\alpha = 0$



$\alpha = 2$

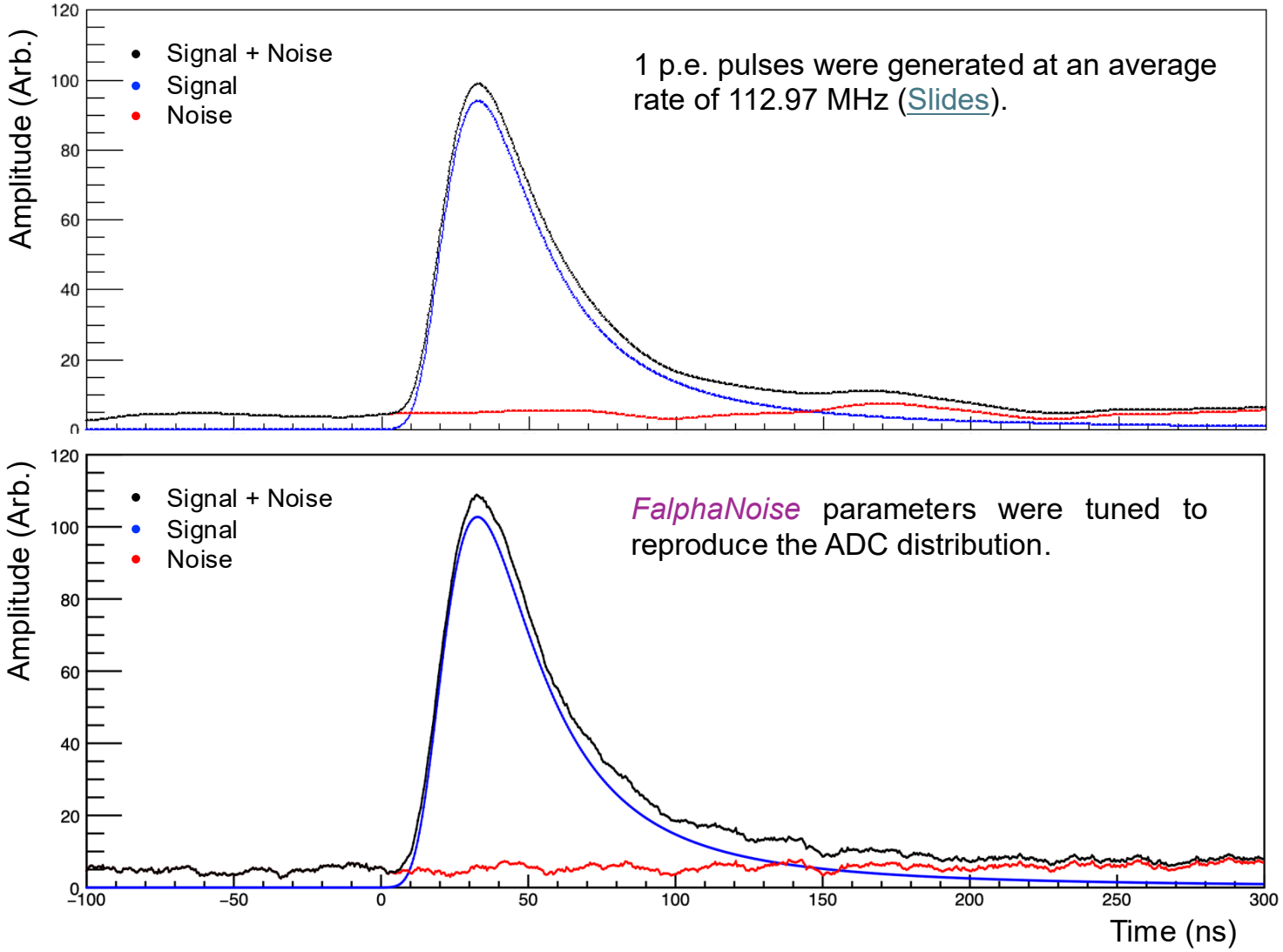
- `PulseNoise` adds noise to the combined pulse using a noise-generation tool called *FalphaNoise*.
- *FalphaNoise* generates random noise with a tunable balance with low- and high-frequency components.
  - Poles and α control the contribution of low-frequency components.
  - Variance controls magnitude of the fluctuation size.

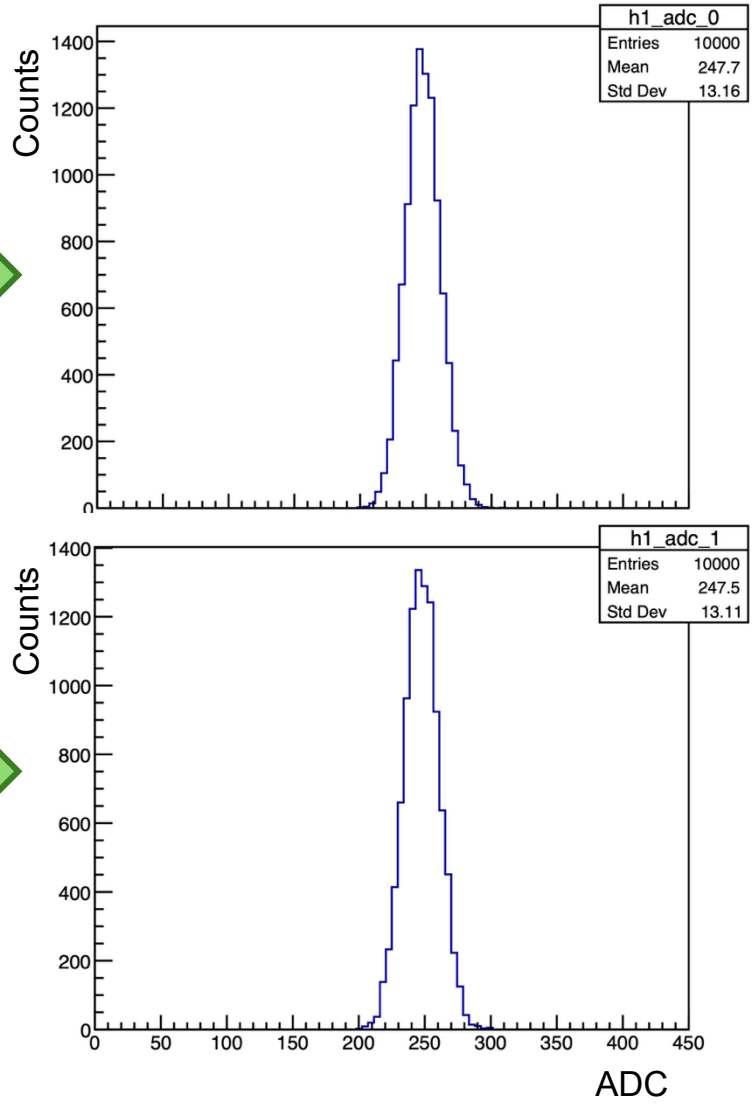
PulseNoise



- Since *FalphaNoise* adds noise on an amplitude-by-amplitude basis, its noise implementation actually differs from how noise is added to the signal in real SiPM.

PulseNoise

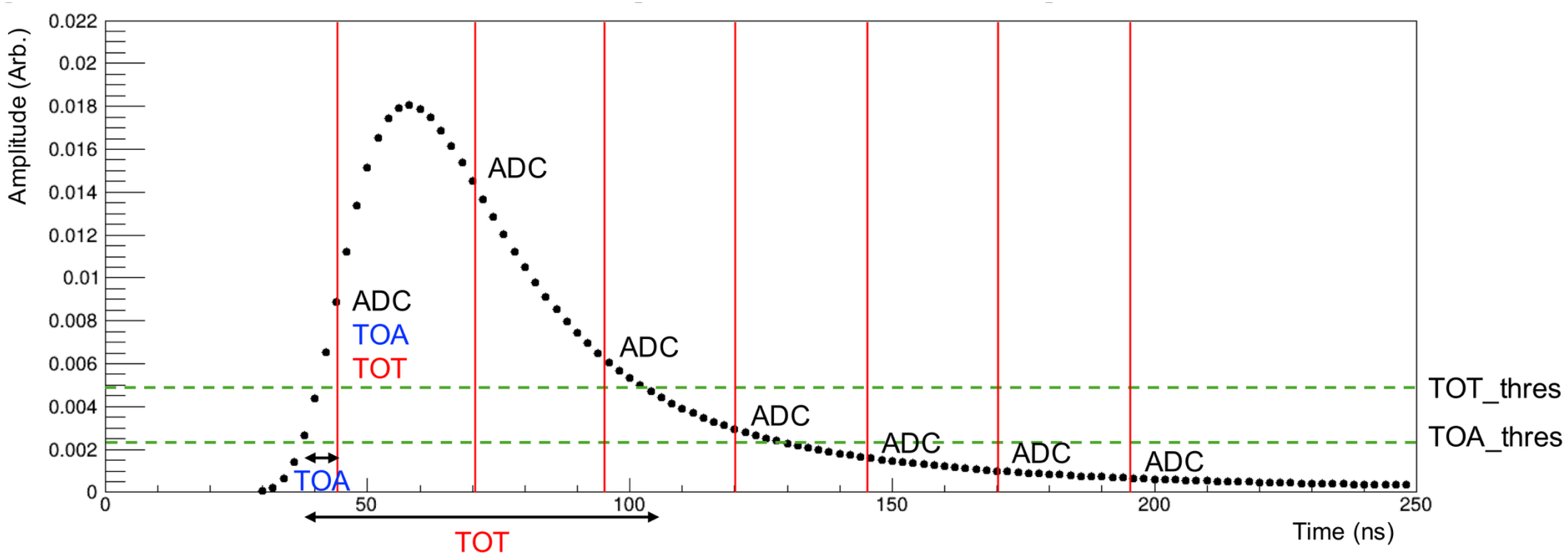




- However, for the detector and physics performance studies, the important quantity we extract from the pulse is the ADC value, not the pulse shape.

CALOROCDigitization

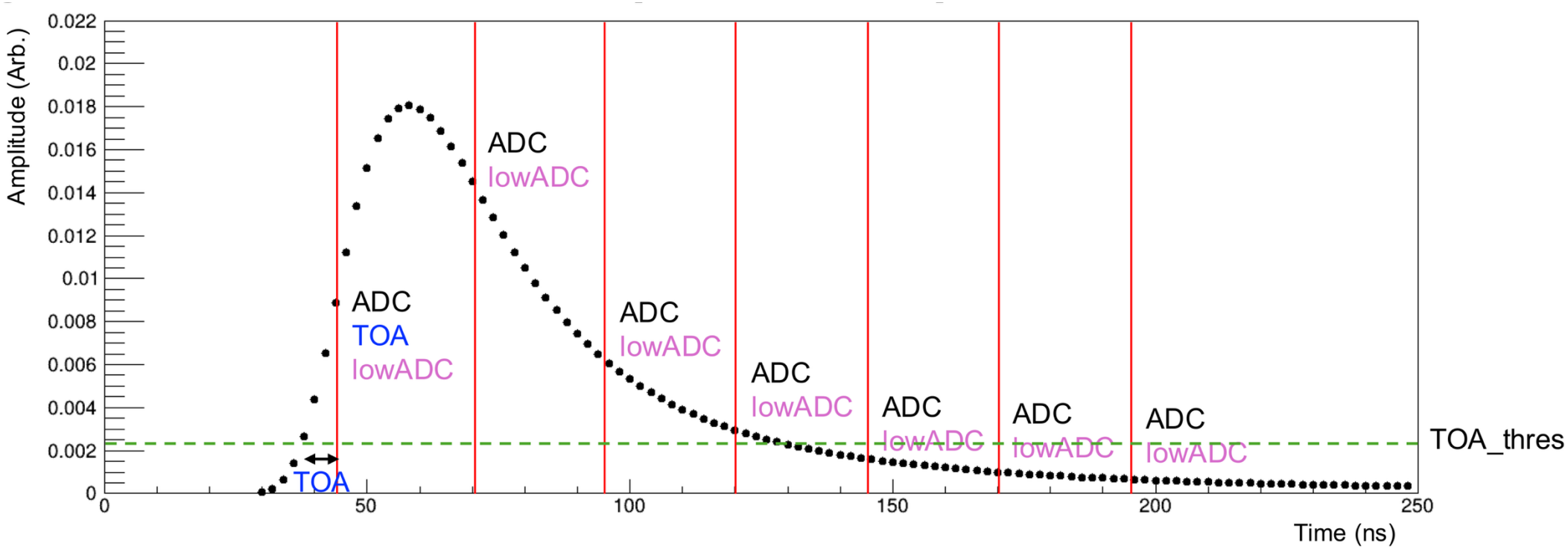
CALOROC1A



- For a given pulse, `CALOROCDigitization` measures a fixed number of samples at 25 ns intervals.
  - TOA is stored in the sample following the up-crossing of the TOA threshold.
  - TOT is stored in the sample where the TOA is stored.
  - ADC is defined as the pulse height and it is stored in every sample.

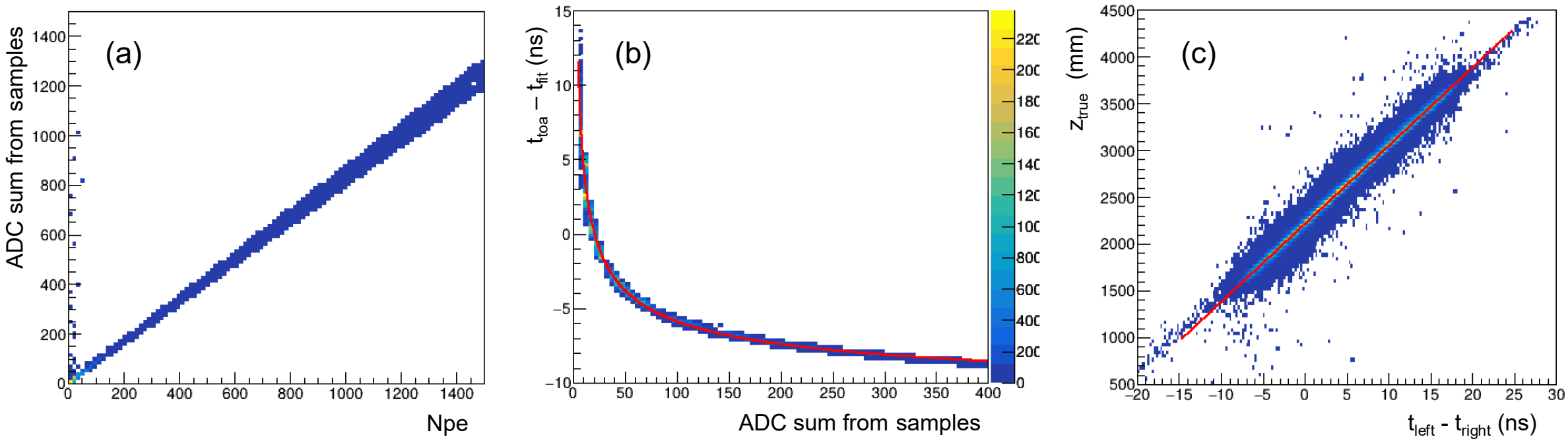
CALOROCDigitization

CALOROC1B



- For CALOROC1B, `CALOROCDigitization` measures low gain ADC values instead of TOT.

Example Studies from CALOROCDigitization



- Using the outputs from the `CALOROCDigitization`, we can perform various studies.
  - (a): The proportional relation between ADC sum from CALOROC samples and Npe indicates that the algorithm measures ADC values correctly.
  - (b): We can also study the time-walk correction.
  - (c): z can be reconstructed by the time difference between p-going and e-going SiPMs.

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