Implementation of digitized hit of the Barrel Imaging Calorimeter

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Executive summary

- We are going to implement digitized hit information of the BIC into edm4hep.

  o Measurement variables for H2GCROC (ADC, TOT, …).

  o True variables for pulse (pulse height, arriving time, …).

- Using the above variables, we will study realistic energy reconstruction and feasibility of the energy splitting.

# Current hit information in EIC simulation
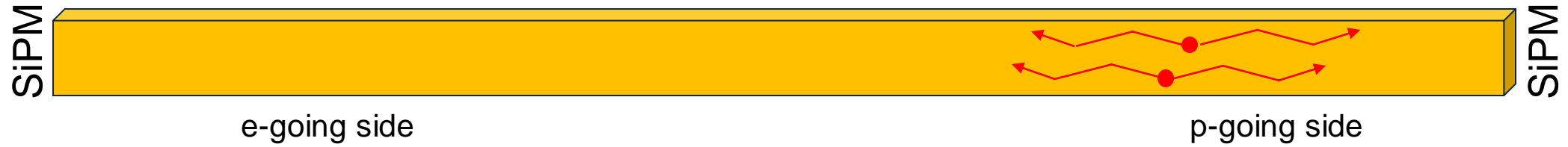
- Current EIC simulation only has energy deposit information of the shower particles.

Pulse implementation

SiPM

e-going side

p-going side

SiPM

Attenuation function

Npe / GeV (1/GeV)

Distance (mm)
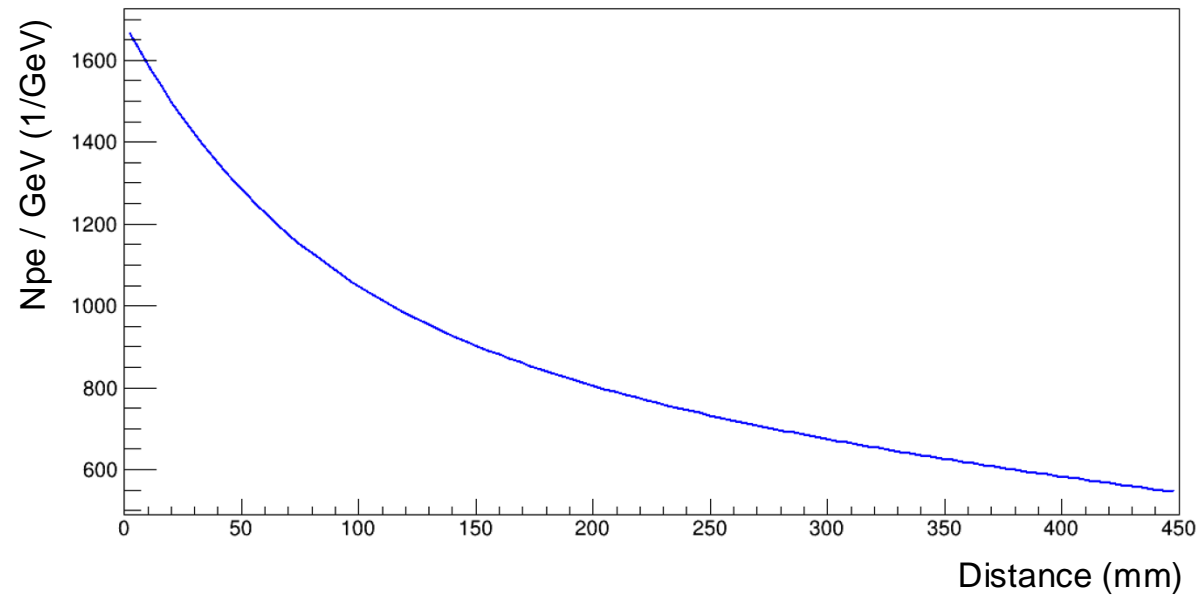
- Each energy deposit was converted to number of photoelectrons (Npe) taking into account the attenuation effect.

- In each SiPM, the Npes were summed up and Poisson smearing was also applied to reproduce the binomial effect on the surface of the SiPM.

Pulse implementation
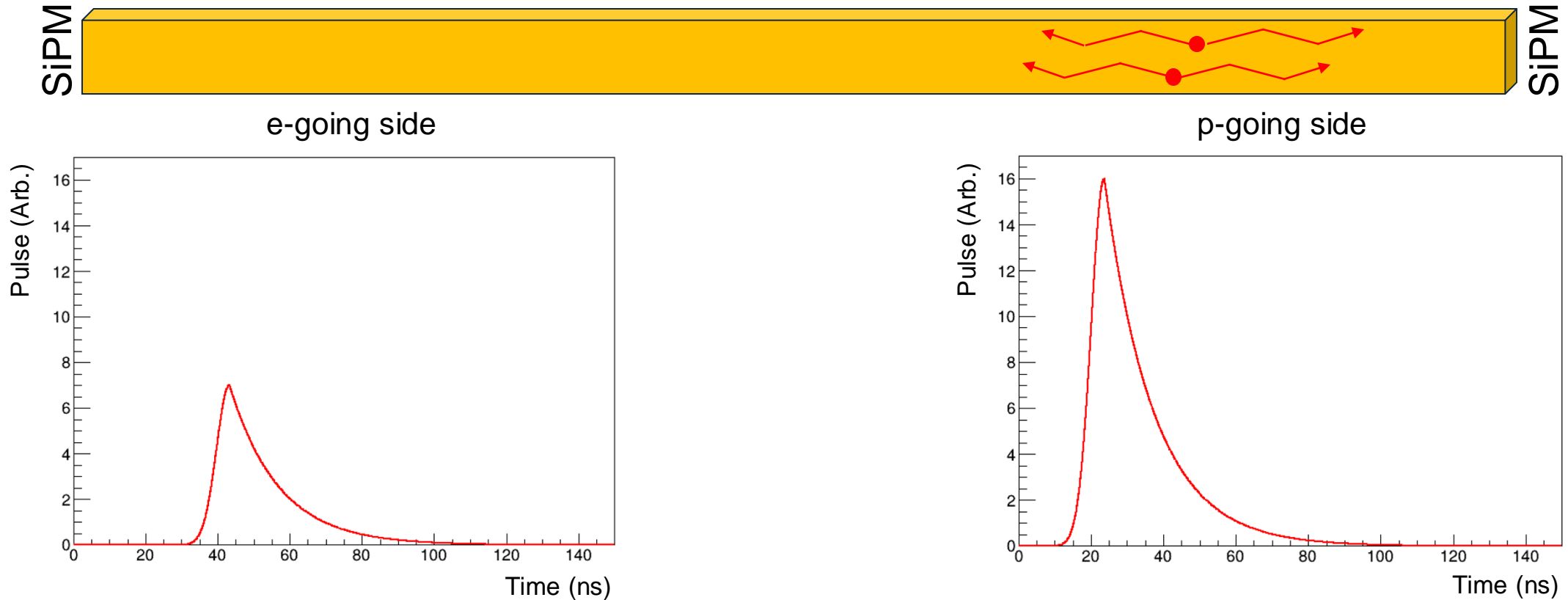
- It was assumed that a pulse implemented by "N" Npe has "N" pulse height.

- The pulse shape was generated referring to Norbert and Henry's studies.

- Assuming a particle was generated at 0 seconds, the times a particle traveled to the BIC (t_{par}) and ScFi hits traveled to the SiPM (t_{ScFi}) were also considered.

What is measured from the pulse?

- The ADC, TOA, and TOT values were obtained from the pulse referring to the principle of the H2GCROC.
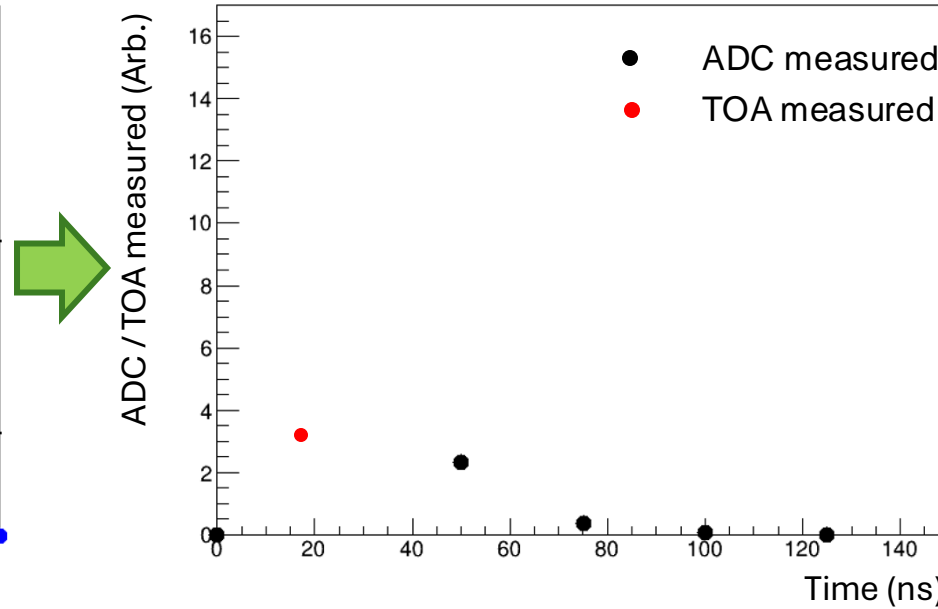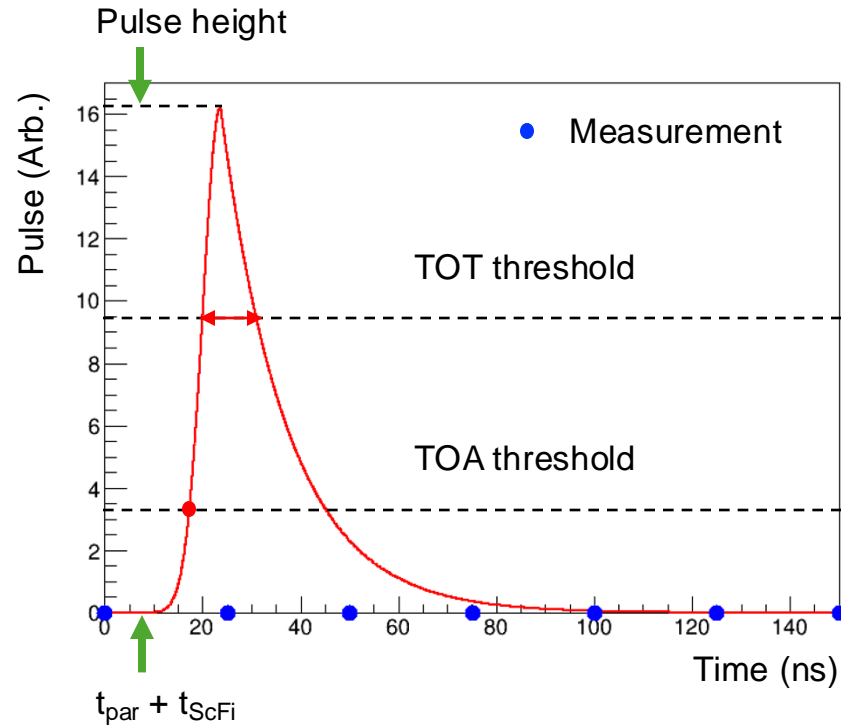
- To implement the measurement and true variables, We can use edm4hep::**RawTimeSeries** with some modification.

Pulse height reconstruction (h ≤ Thr$_{TOT}$)

With TOA

Without TOA

Counts

$h_{true} - h_{rec}$ (Arb.)

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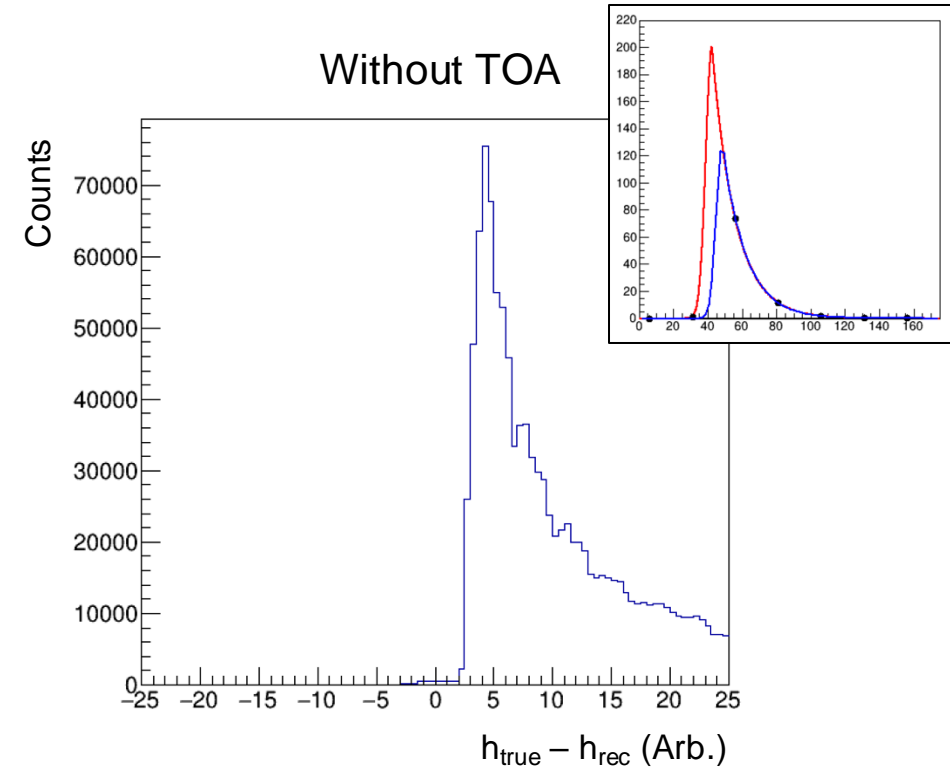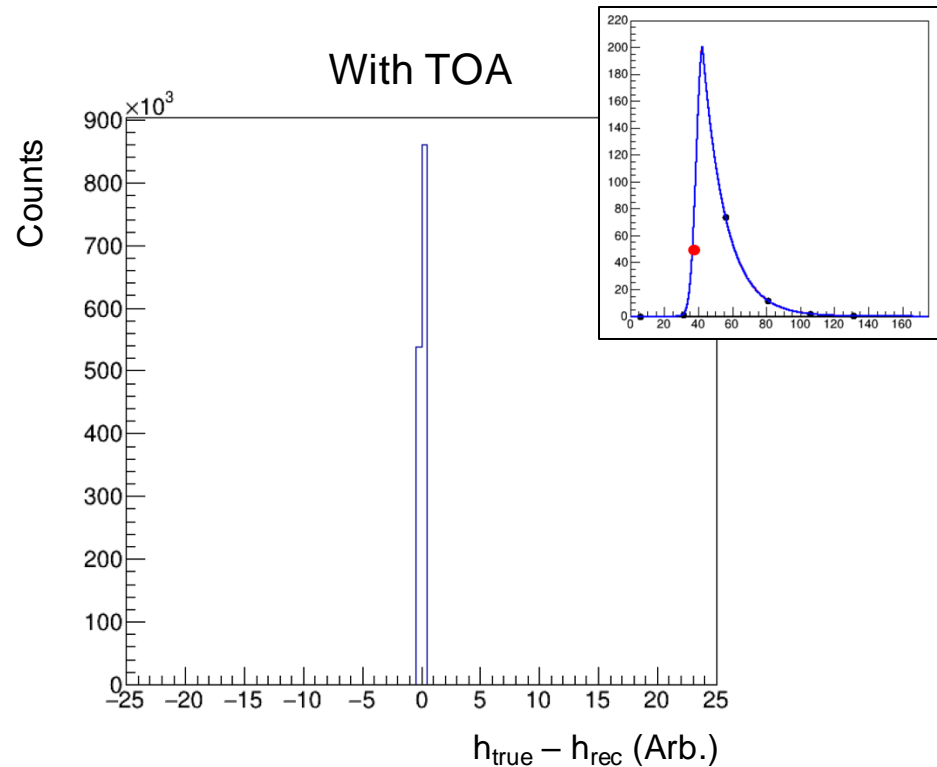
- We expect much better reconstruction performance when we have the TOA value.

- We need to set the TOA threshold as low as possible to make as many channels as possible have TOA values.

Pulse height reconstruction (Thr$_{TOT}$ < h)
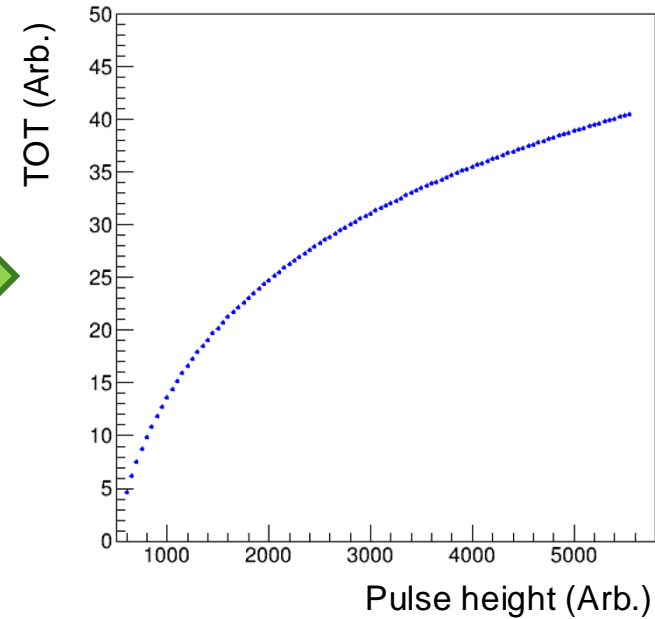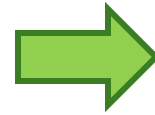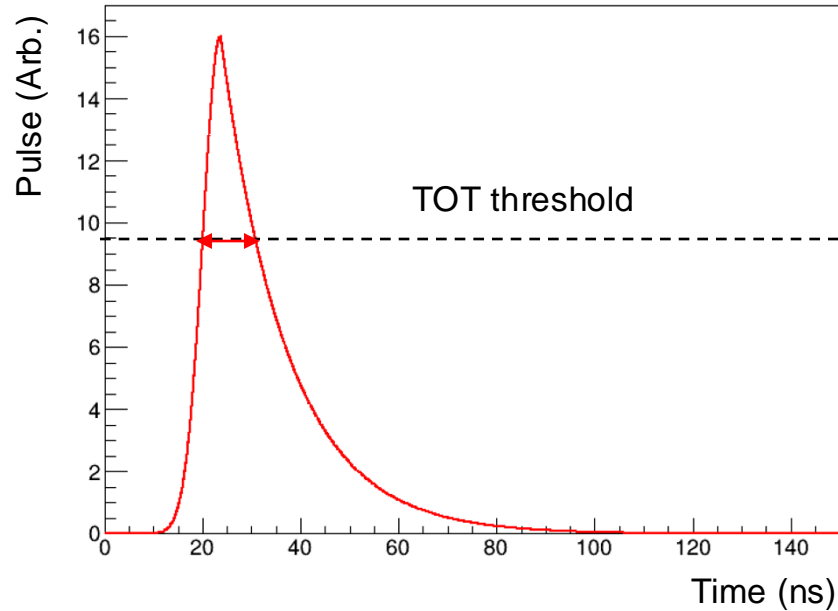
- The TOT value can be 1 vs. 1 matched to the pulse height, thereby the pulse height can be reconstructed precisely.

Attenuation correction
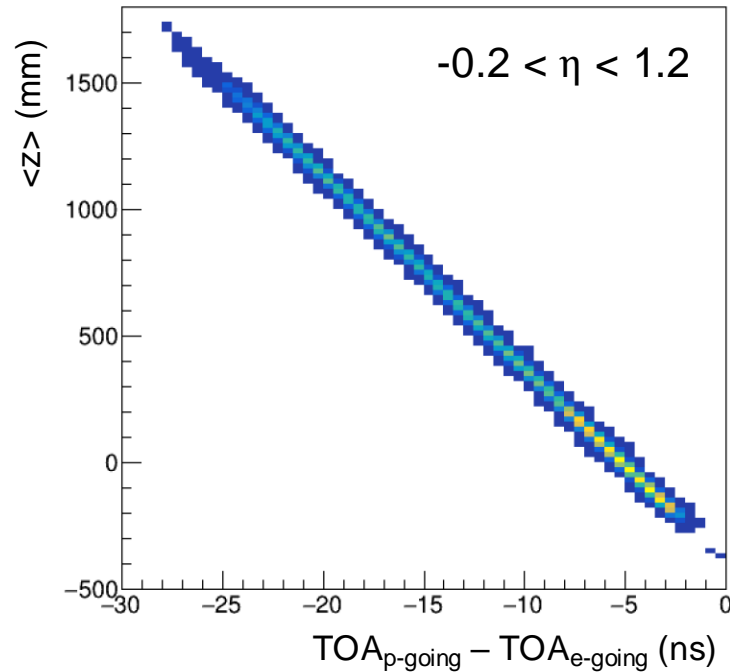
- The attenuation correction was done using the TOA difference between p-going and e-going sides.

- If the TOA was not measured on either side, average value of the TOA was used.

Energy resolution comparison

Single electron ($\eta = 0$)
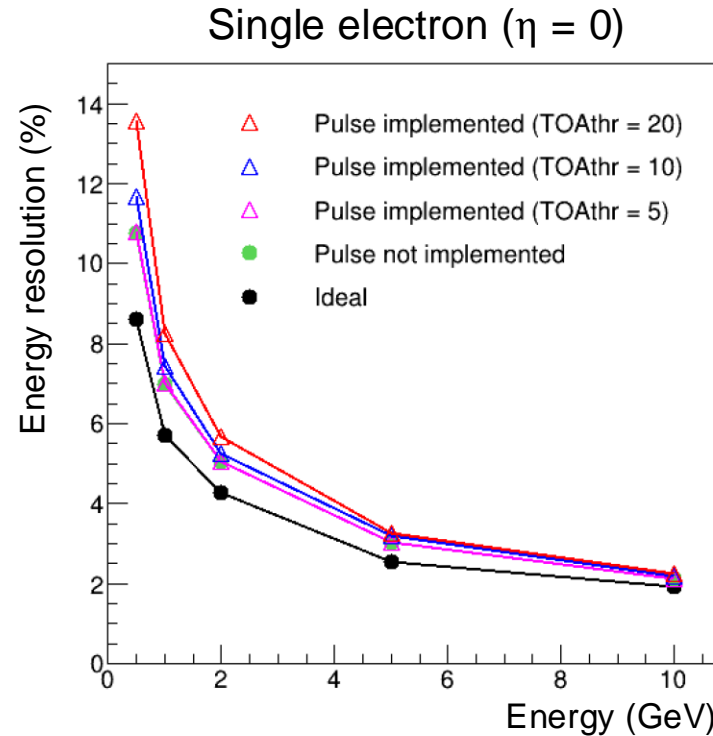
- A threshold of 5 Npe was applied to each SiPM.

- When Thr_{TOA} is 5 Npe, the resolution is almost the same with the "Pulse not implemented". This means the pulses have been implemented and reconstructed well in the simulation.

- Several possible uncertainties (noise, pulse shape, measurement uncertainty, …) were not considered yet, but we are planning to implement the simplest case first.
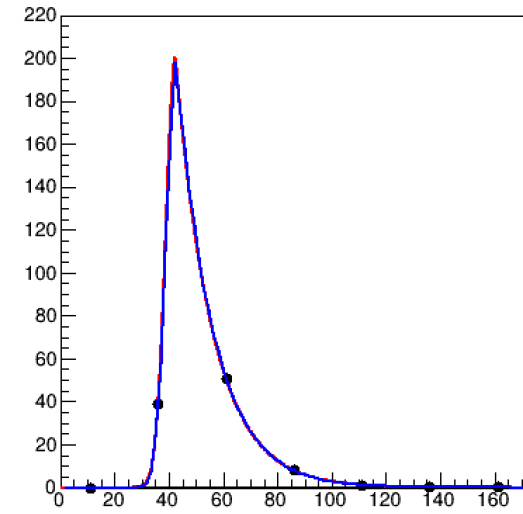
Backup

Pulse height reconstruction (h ≤ Thr$_{TOA}$)
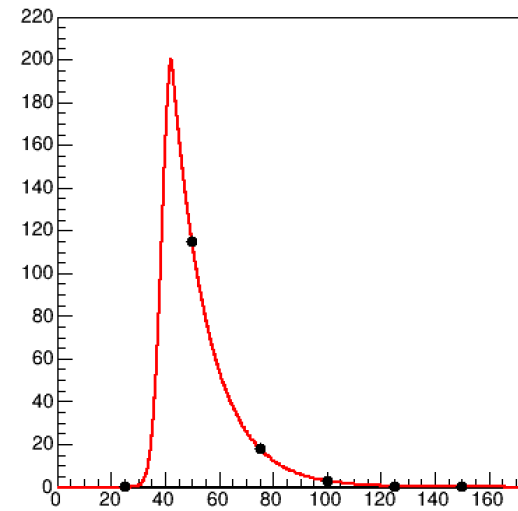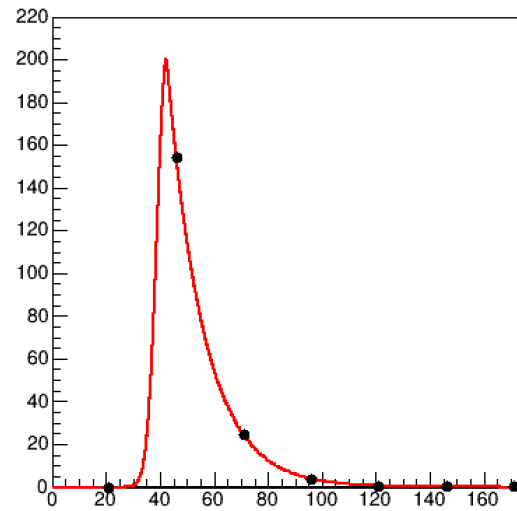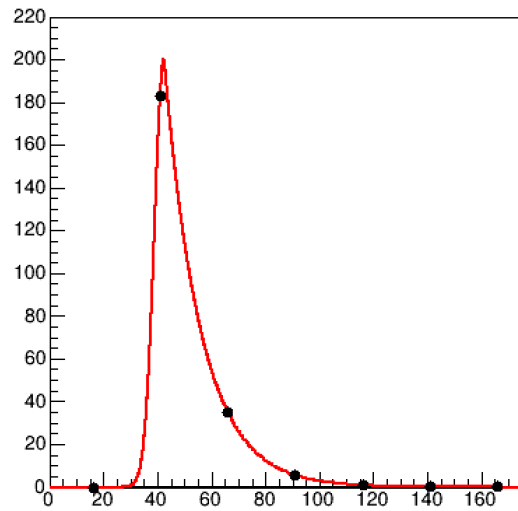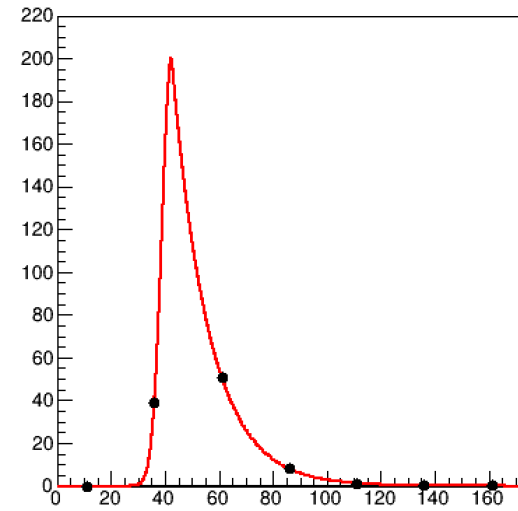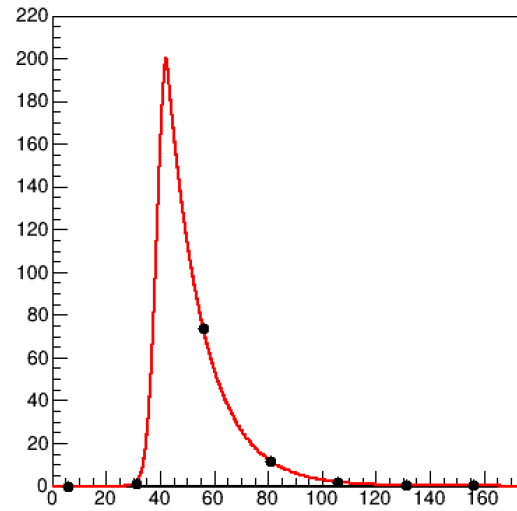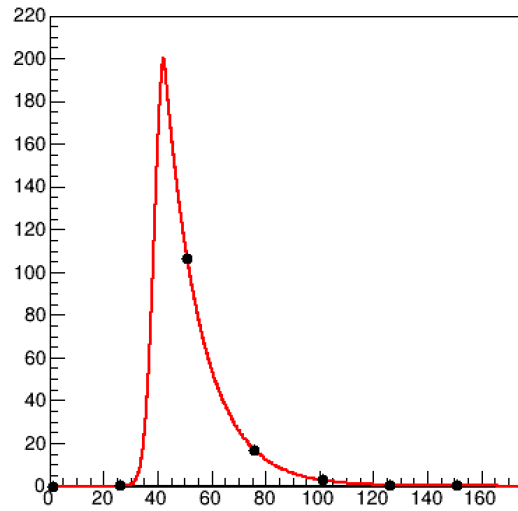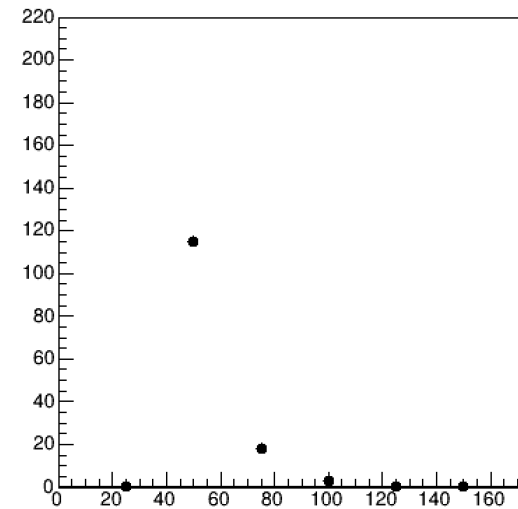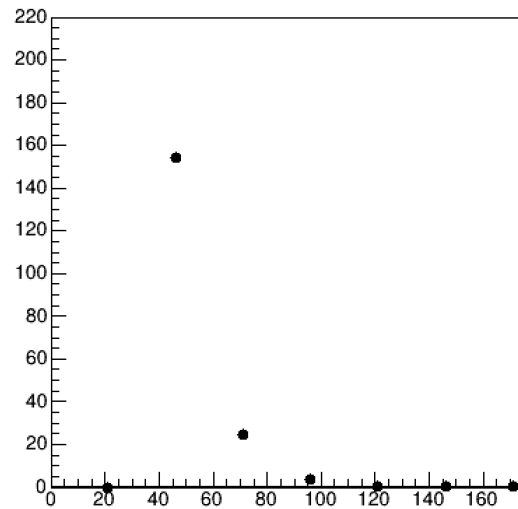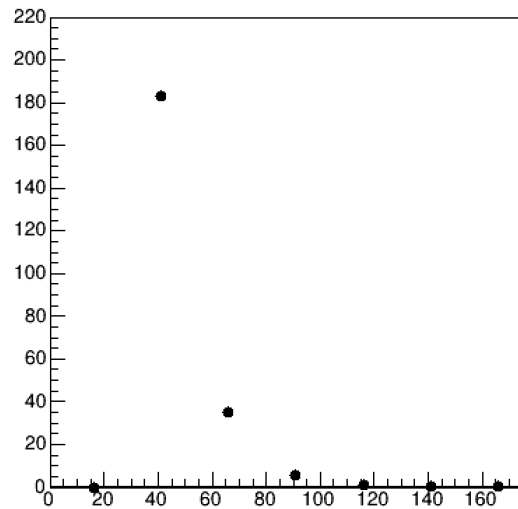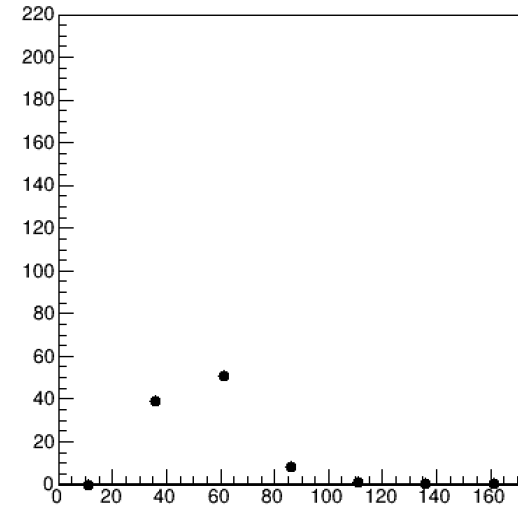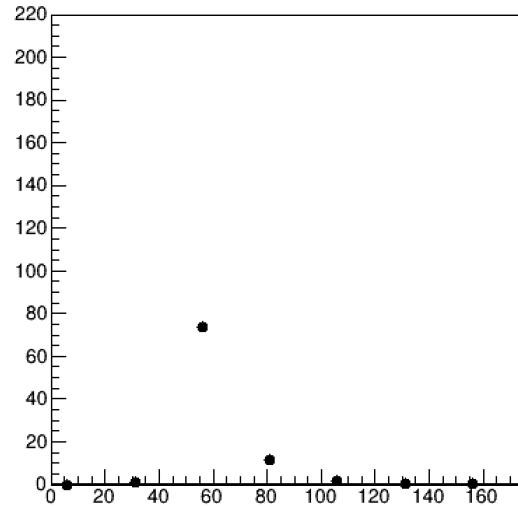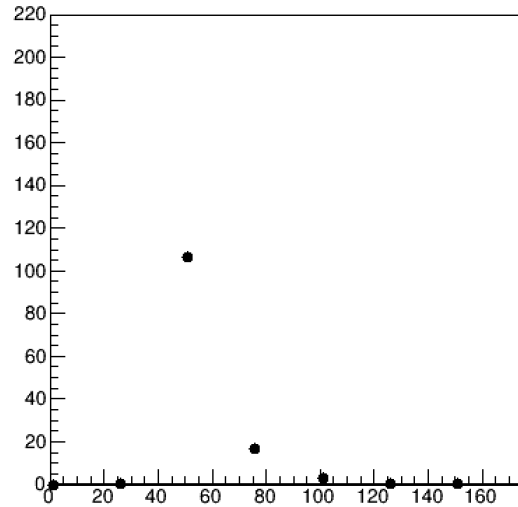
Pulse height reconstruction (h ≤ Thr$_{TOA}$)

Pulse height reconstruction (h ≤ Thr$_{TOA}$)

Pulse height reconstruction (h $\leq$ Thr$_{TOA}$)

Fitting

ADC sum
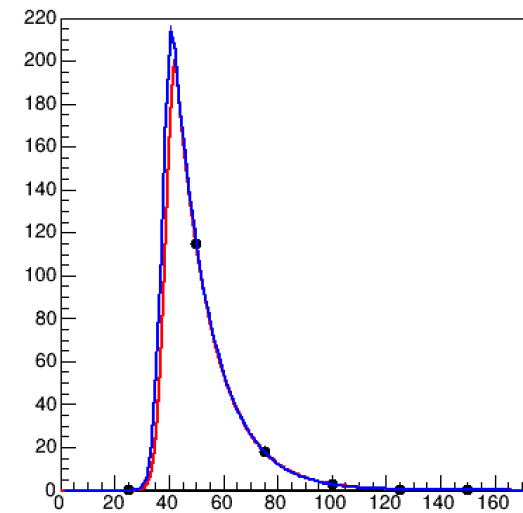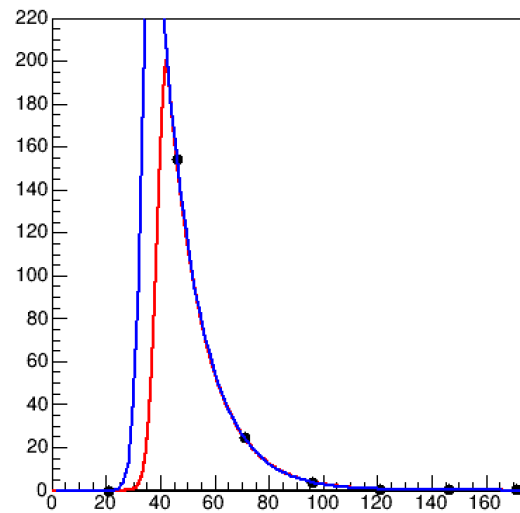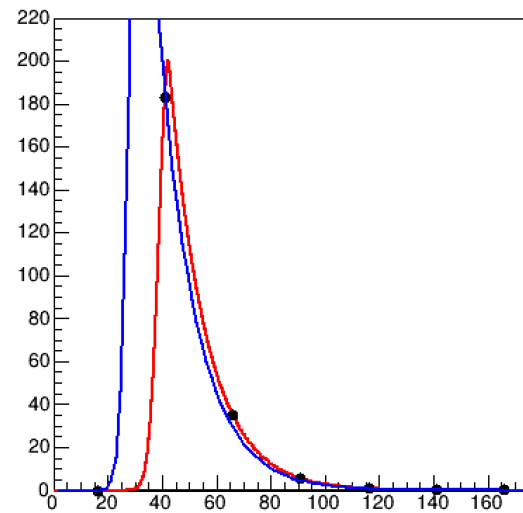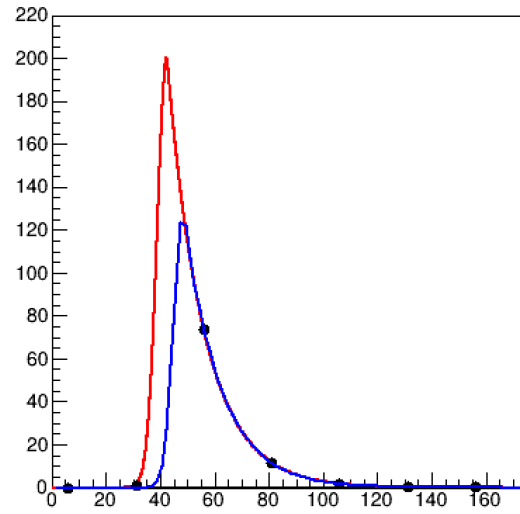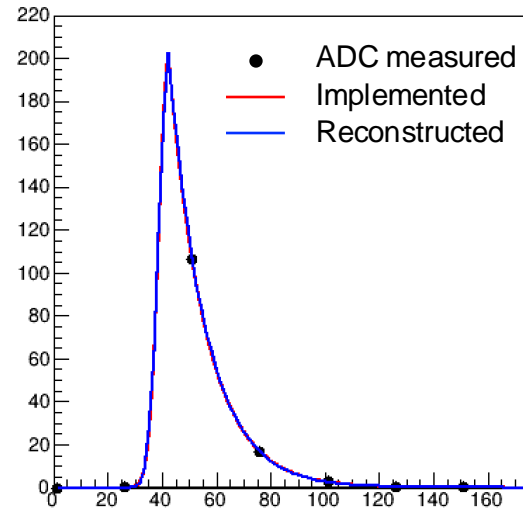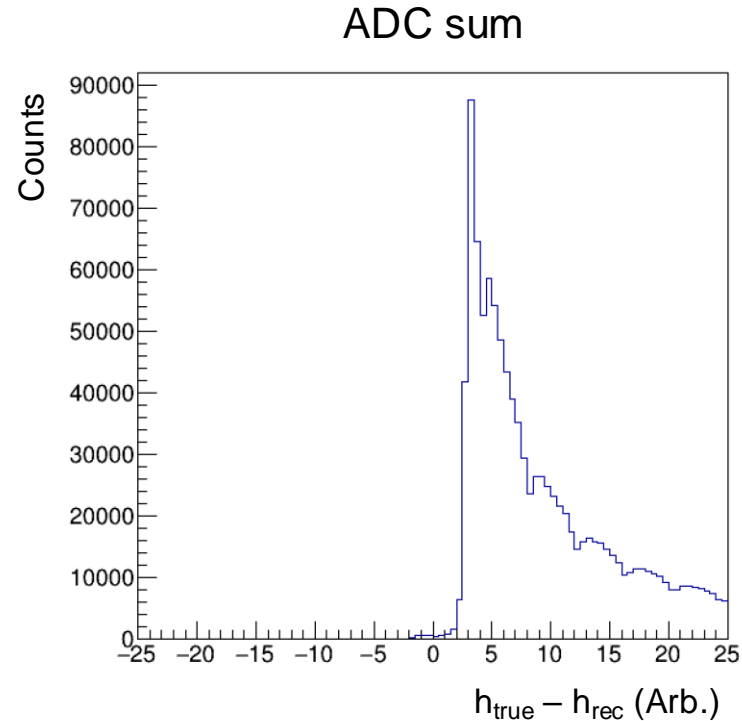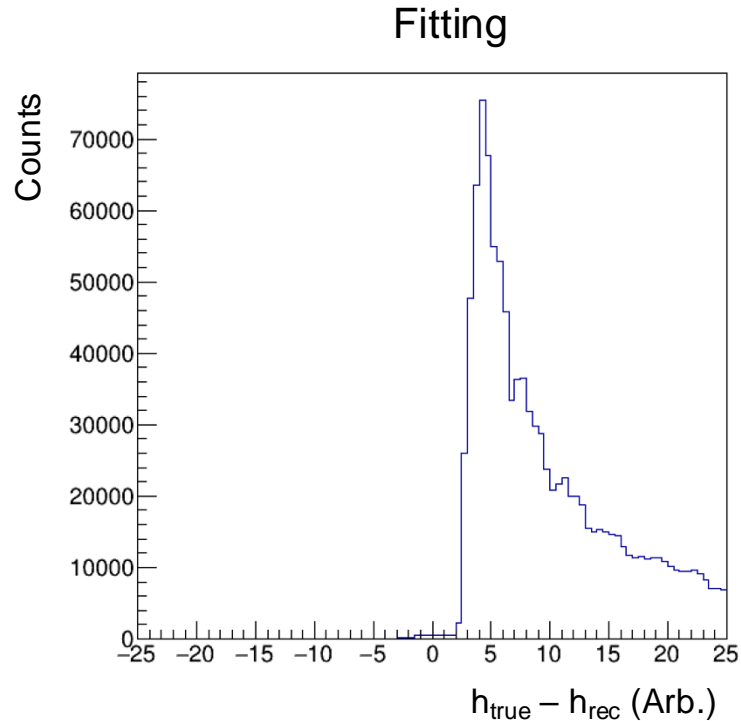
- Because the pulse shape is not reconstructed well, the resolution is quite bad.

- Alternatively, the pulse height was reconstructed by adding up all the ADC values, but it did not solve the problem as well.

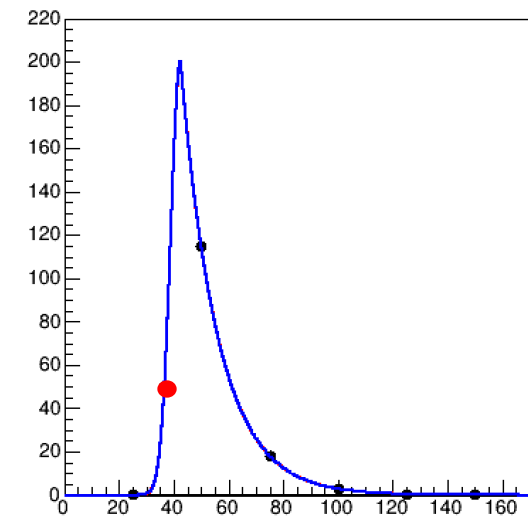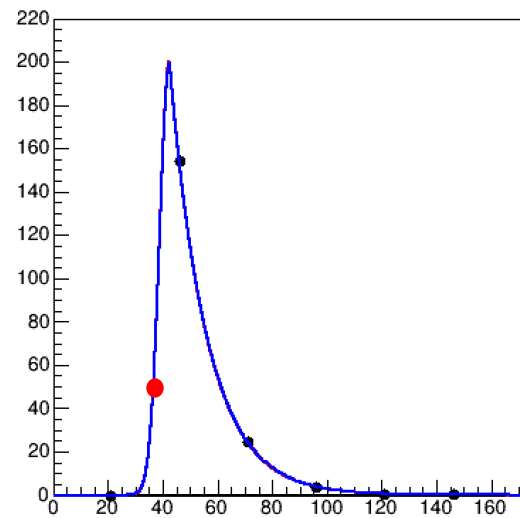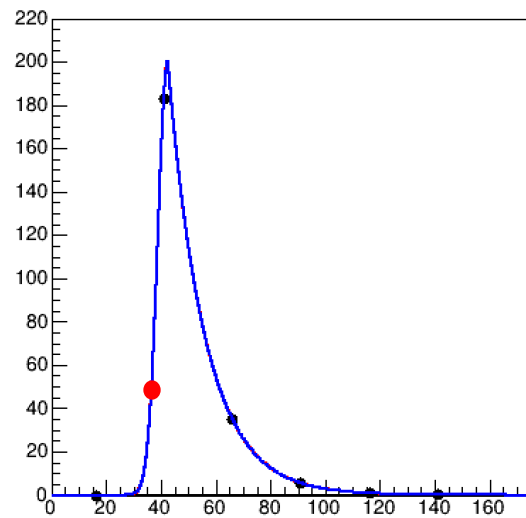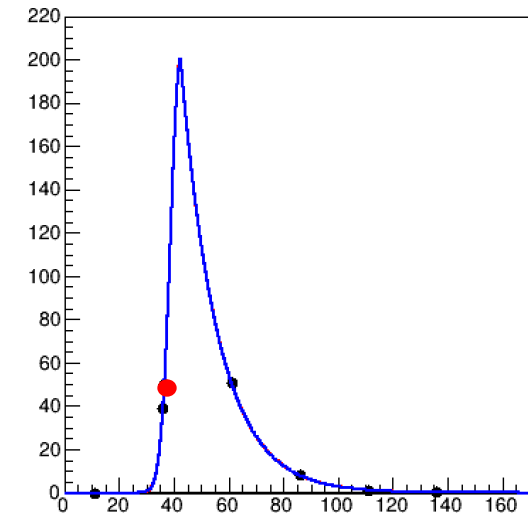- The pulse shape can not be reconstructed properly if we only use the ADC values.

Pulse height reconstruction (Thr$_{TOA}$ < h ≤ Thr$_{TOT}$)
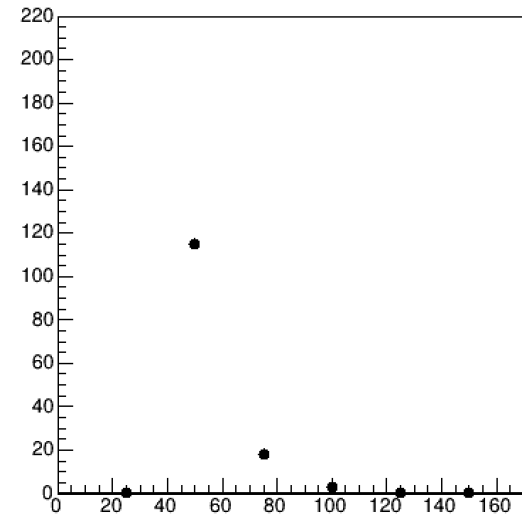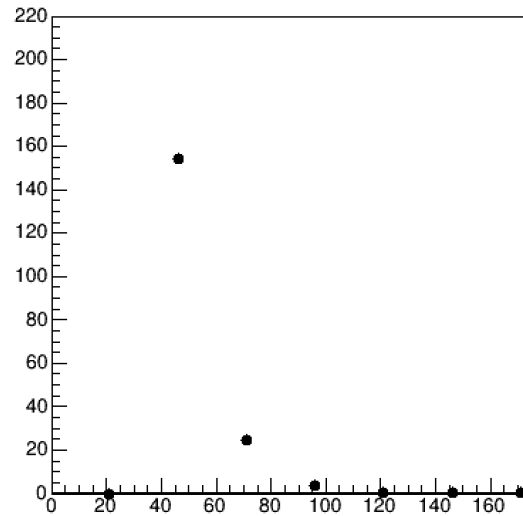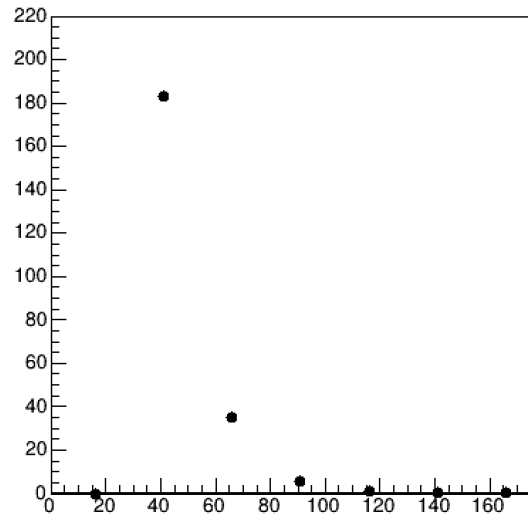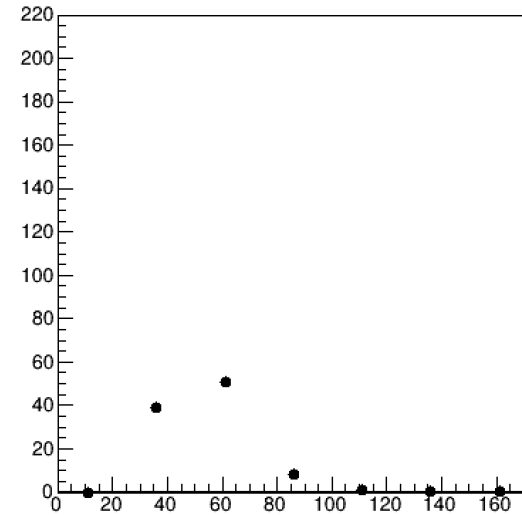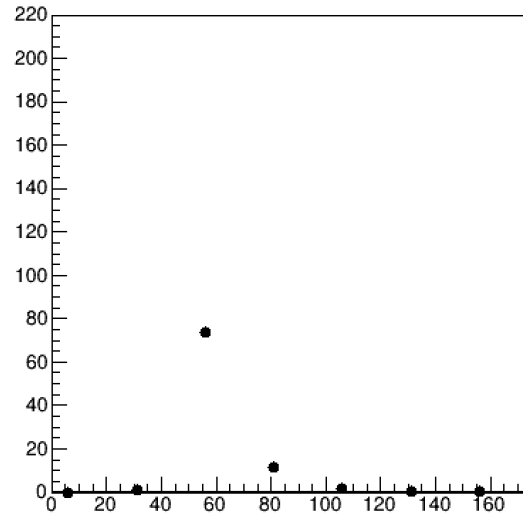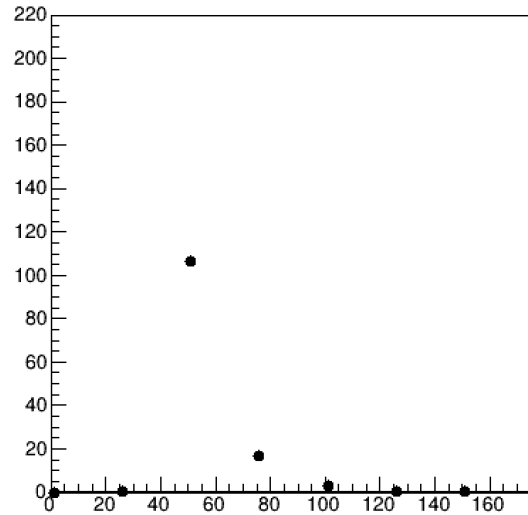
Pulse height reconstruction (Thr$_{TOA}$ < h ≤ Thr$_{TOT}$)
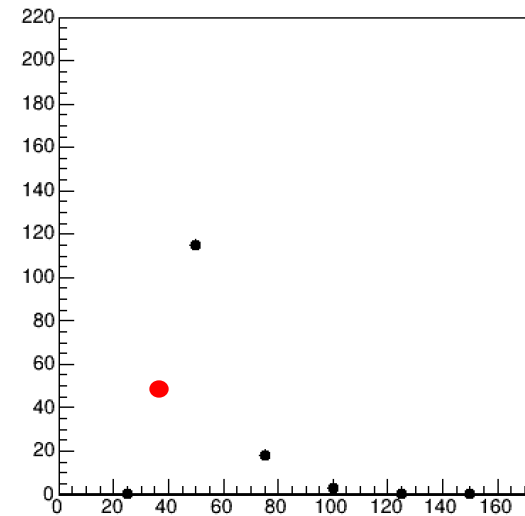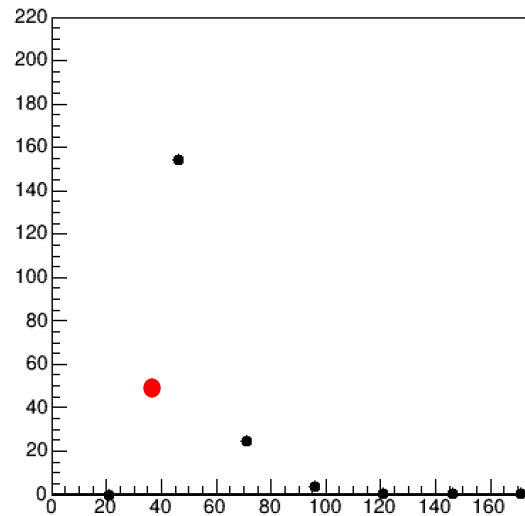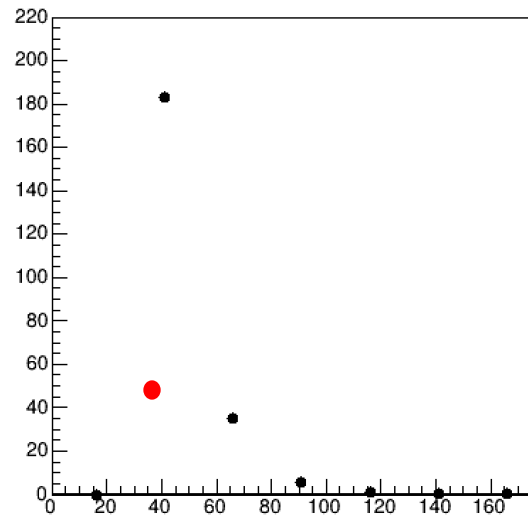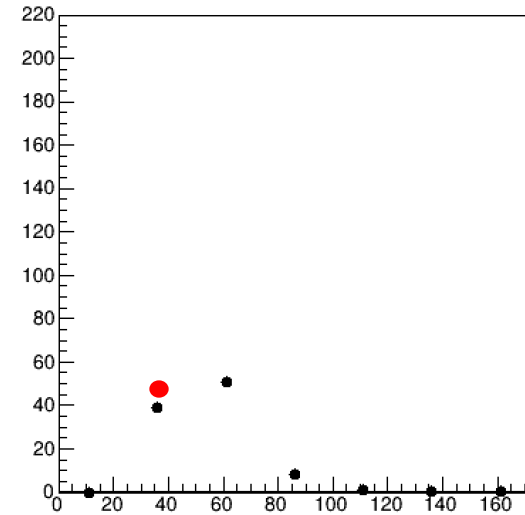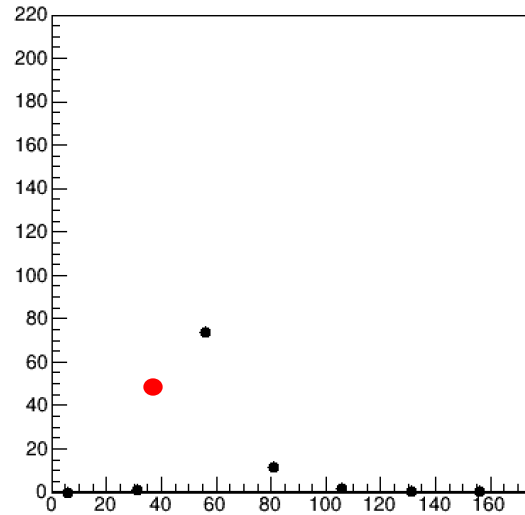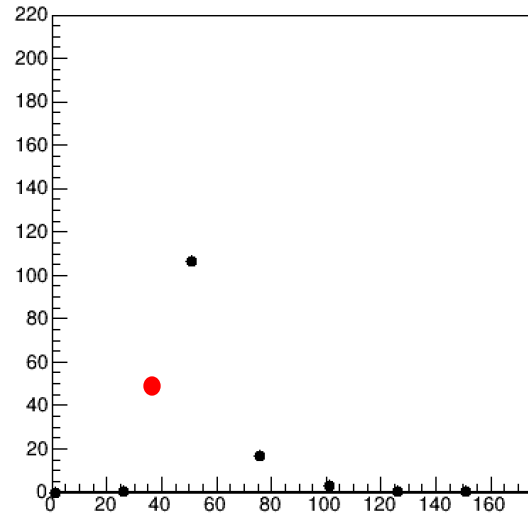
Pulse height reconstruction (Thr$_{TOA}$ < h ≤ Thr$_{TOT}$)
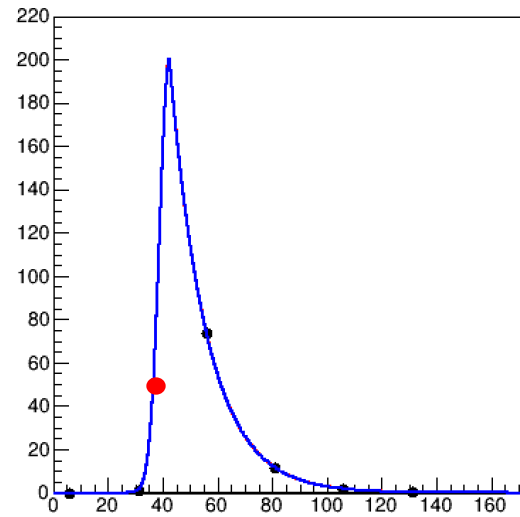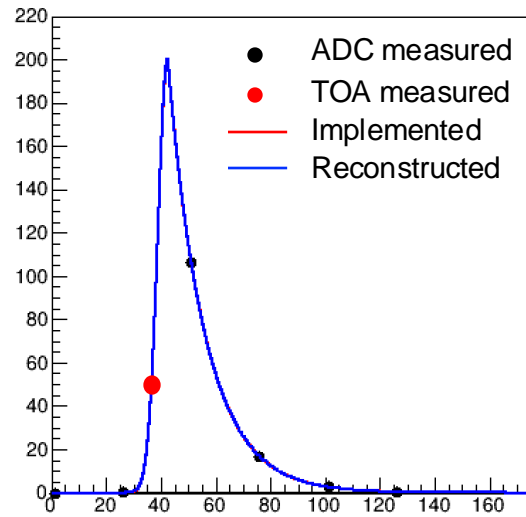
Energy splitting
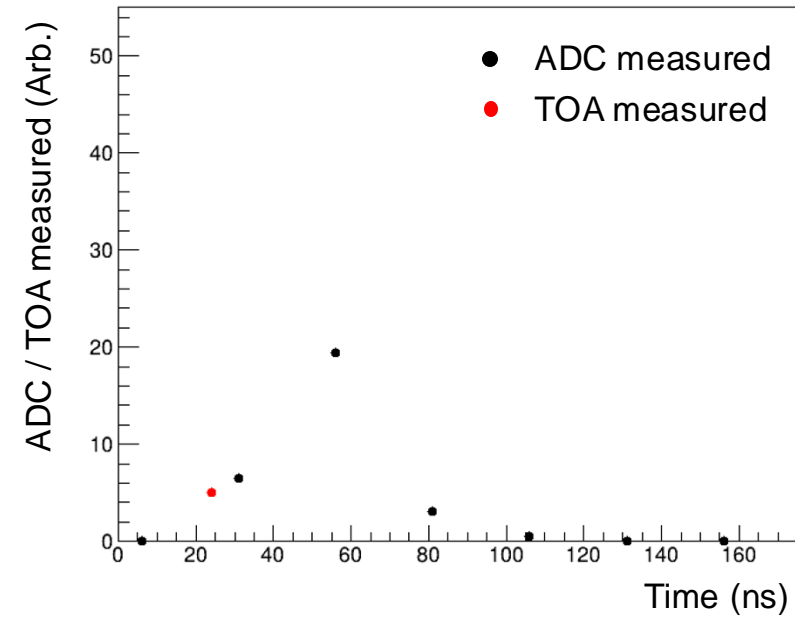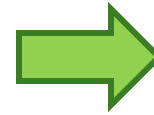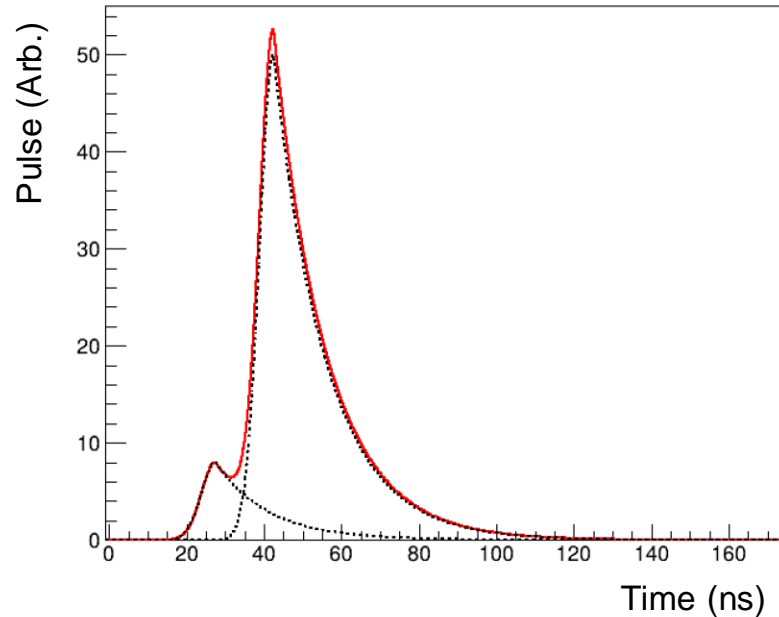
- Realistic electron energy reconstruction when BIC measures other particles together will also be studied.

- How to identify the overlap event and how to extract the electron energy will be studied, and corresponding PYTHIA sample has also been requested.