Electronics validation analysis

Updates from Genoa

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GRAIN Meeting

26 July 2024

Our goals

- **Simulated data**: we simulated photon scintillation emission events in both LAr and in Xenon-doped Argon. Each ROOT output file contains 120 spill events

(**/storage/gpfs_data/neutrino/users/ldn/Samples/Spill_Xe/Spill_opt3_STT1_*/output/sensor_all_*.root**)

(/storage/gpfs_data/neutrino/users/ldn/Samples/Spill_**Ar**/Spill_opt3_STT1_*/output/sensor_all_*.root)

- **Goal**: we want to select most critical and significative samples and validate the architecture on those samples

Selected samples

1. Channels that need a high number of integration windows for some channels

2. Channels with the highest number of photons within an integration window

3. Channels with the highest number of photons within 20 ns from the true interaction time*

4. Channels with the lowest time between the interaction time* and the previous detected photon

Electronics validation

1. For validating the architecture with 2 Wilkinson and conversion time of 40-50 ns

2. For optimizing/validating the dynamic range

3. Is the electronics capable of detecting such a high number of photons in a small time window?

4. Which amount of channels per interactions have not the right t_0, due to previous photons

NEW!

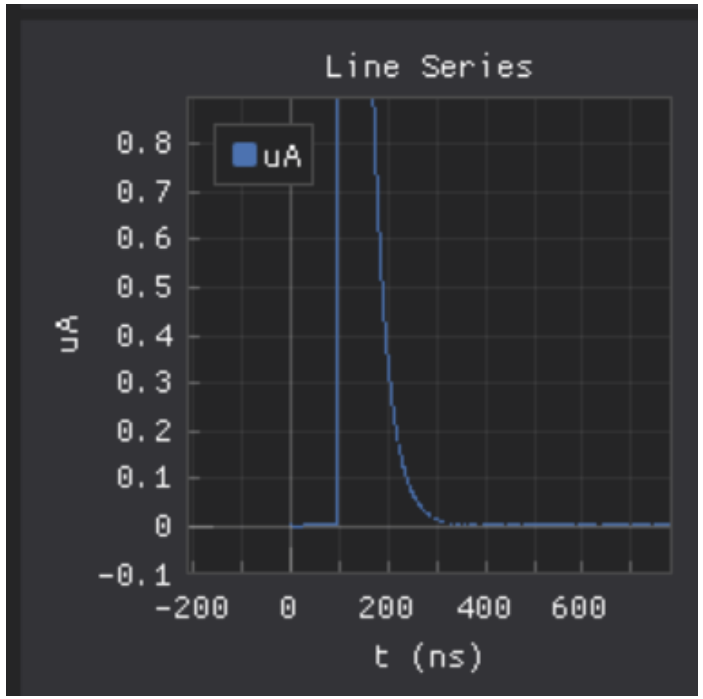
*The interaction time is given by true information from MonteCarlo, if a peak of at least 3 photons is detected in the channel

Single photon waveform

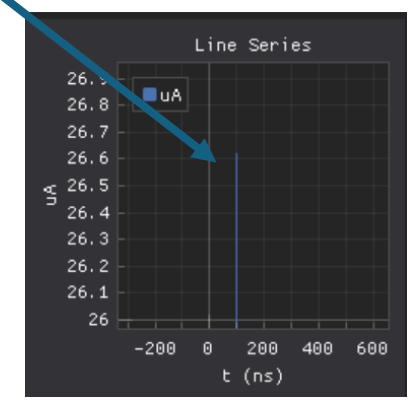
Rq for 2x2 SiPM: 300 kOhm (info from HAMAMATSU)

We use single PE waveform:
`2x2_I2in_interactive5523_300k.csv`

Rq = 300 kOhm



Imax= 26.62 uA

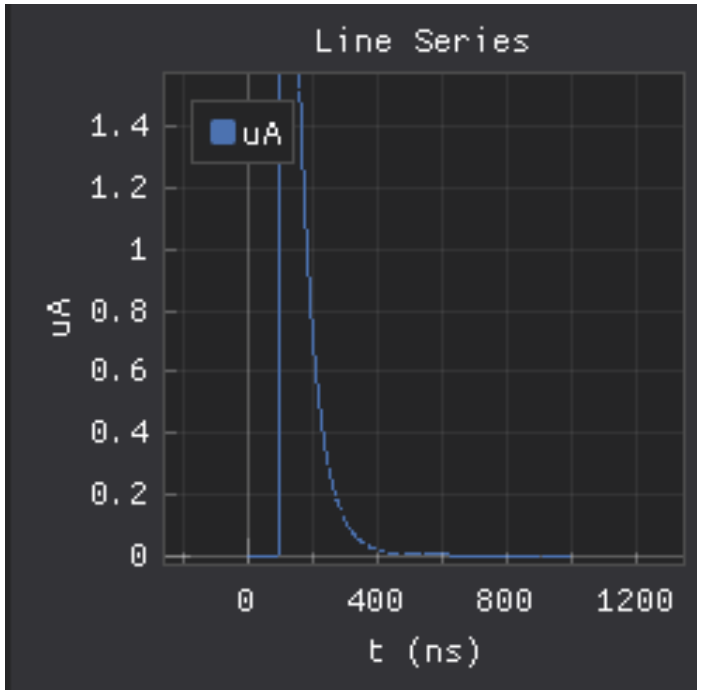


Just for comparison – Bologna's case

Rq chosen for 3x3 SiPM: 500 kOhm

Single PE waveform:
`3x3_I2in_interactive5488.csv`

Broader width



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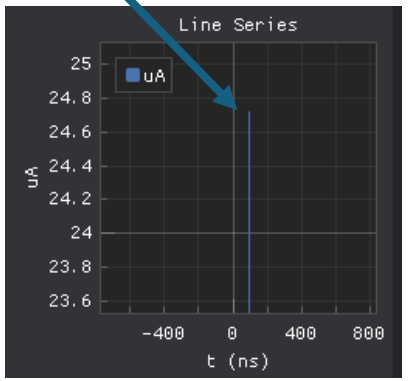


Criterion 1

Events that need a **high number of integration windows** for some channels

New: Results as a function of the clock period

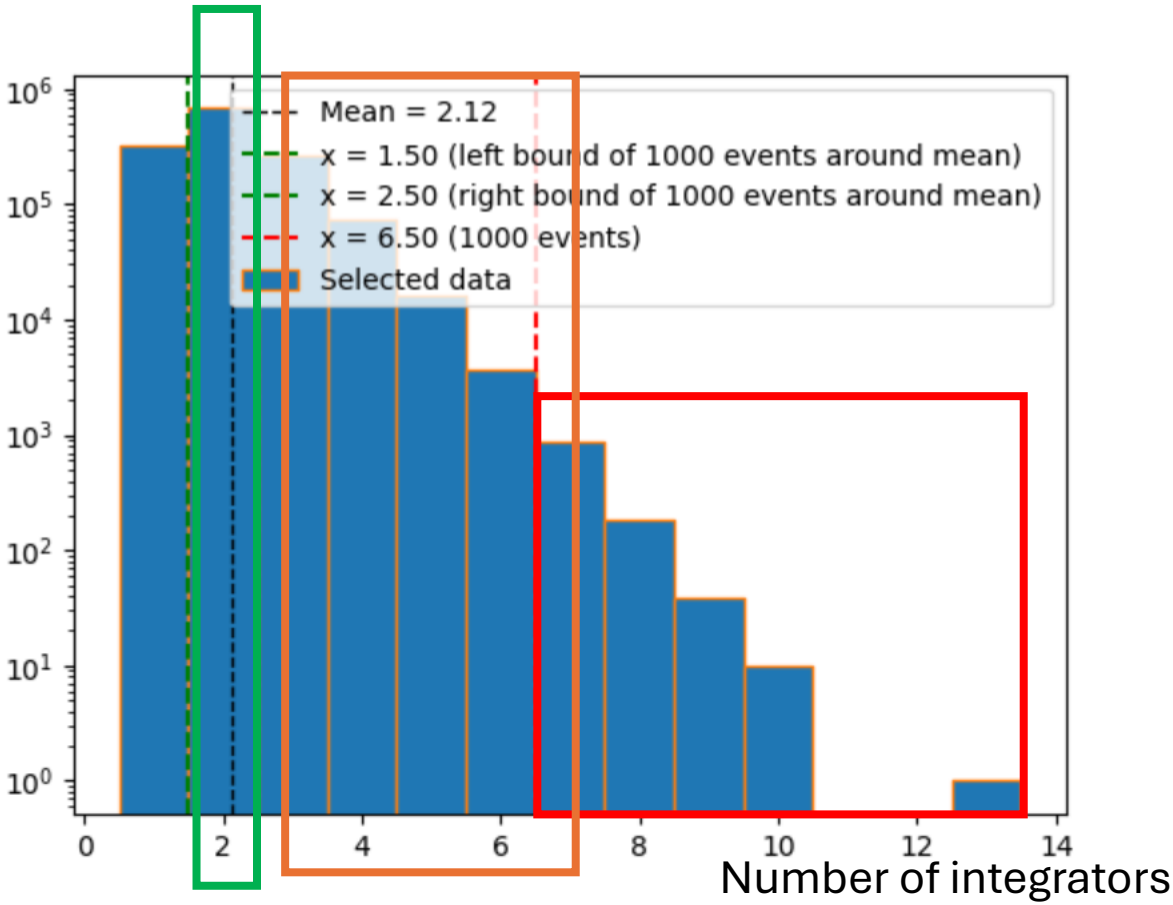
Selected samples: Events that need a high number of integration windows for some channels

Guidelines:

1. Very good reconstruction of the number of photons from the integrated charge for the channels that require 2 integration windows
2. Good reconstruction of the number of photons from the integrated charge for the channels that require between 3 and 7 integration windows

We also select the worst and pathological cases (i.e. the channels that require at least 7 integration windows) but we don't ask for a good reconstruction of the number of photons

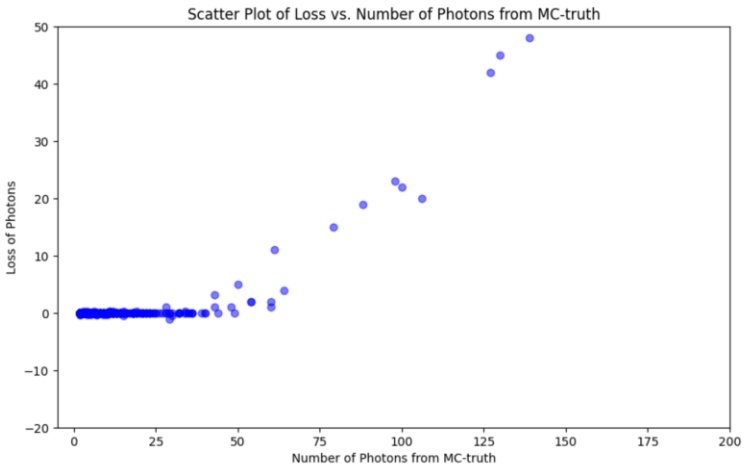
Xenon-doped Ar
720 spill



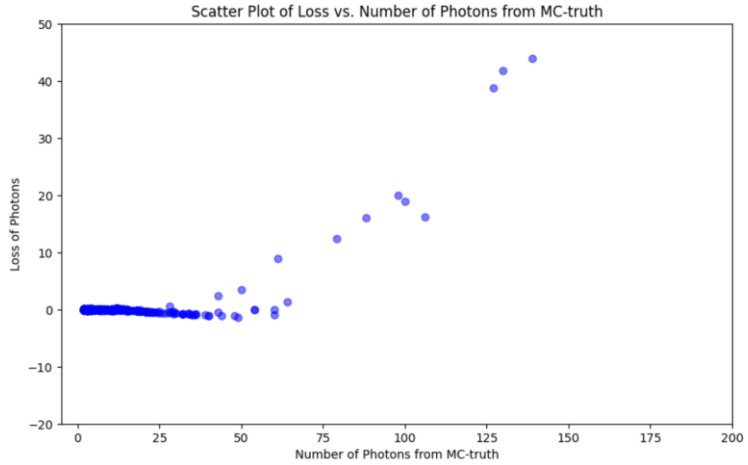
Selected samples: Events that need **about 2 integration windows** for some channels

Xenon-doped Ar
720 spill

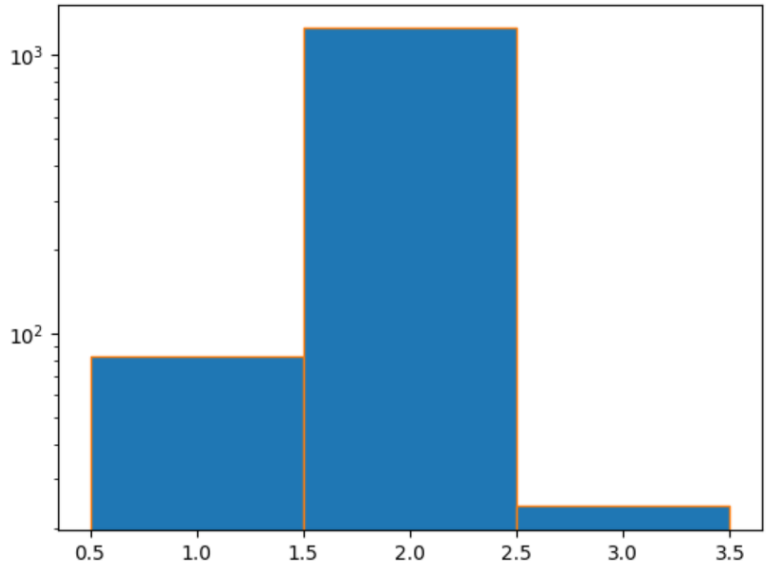
Nintegrators = 2



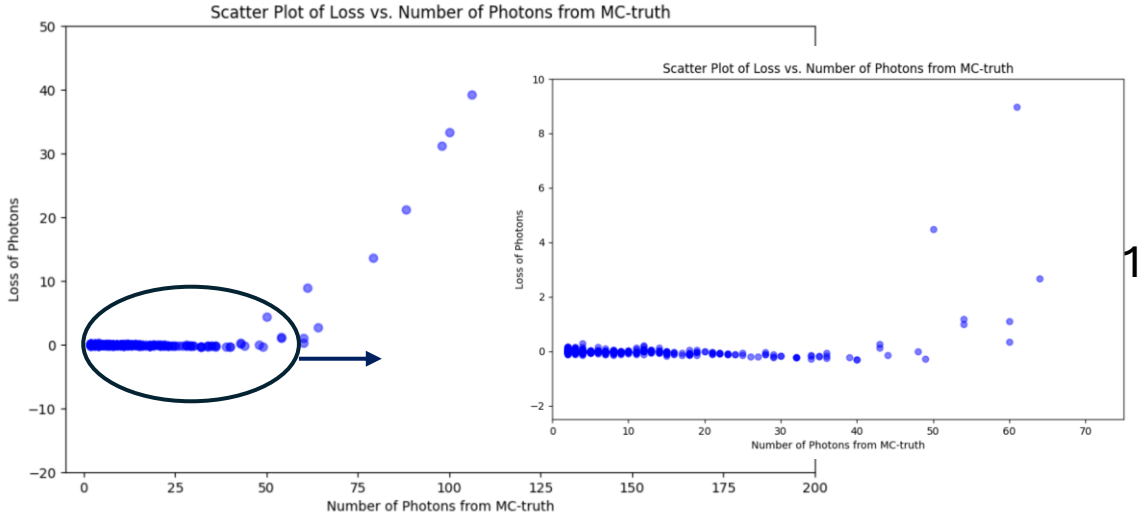
Clock period = 3.333 ns



¼ Clock period = 0.833 ns



Number of integrators from Torino's simulation



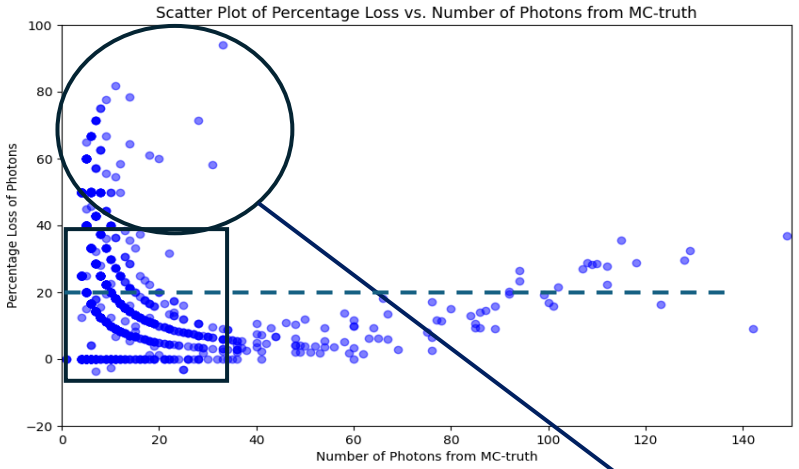
1/8 Clock period = 0.4166 ns

The reconstruction is **accurate until 50 photons**.
Lowering the clock period it's a little bit improved the reconstruction between 50 and 100 photons

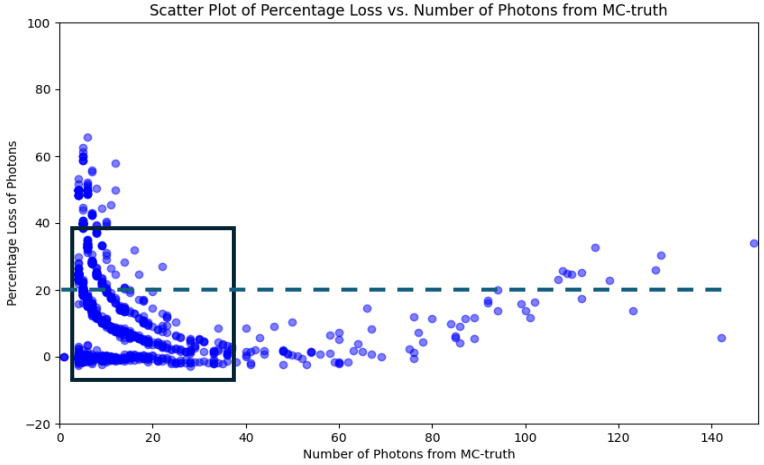
Selected samples: Events that need **between 3 and 7 integration windows** for some channels

3 < Nintegrators < 7

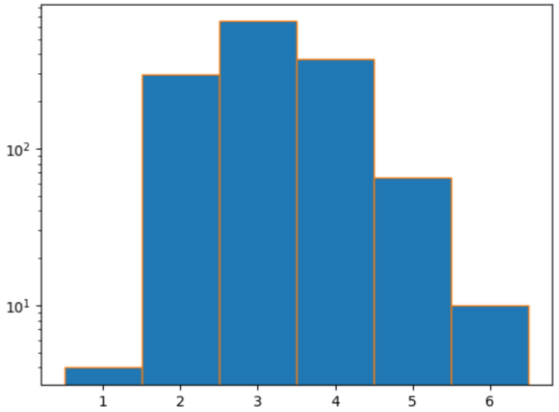
Xenon-doped Ar
720 spill



Clock period = 3.333 ns

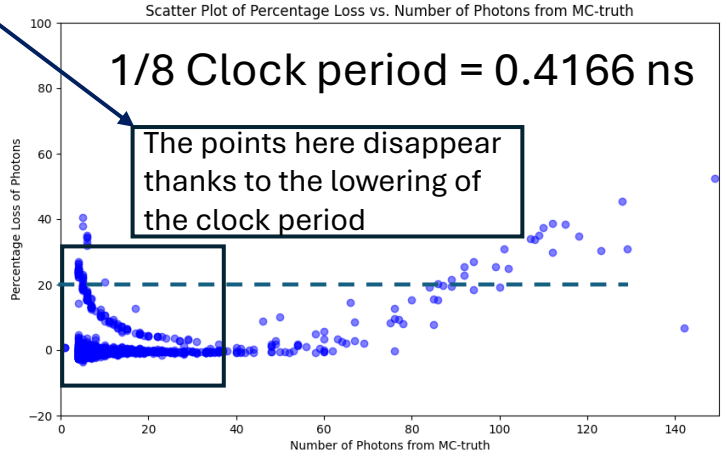


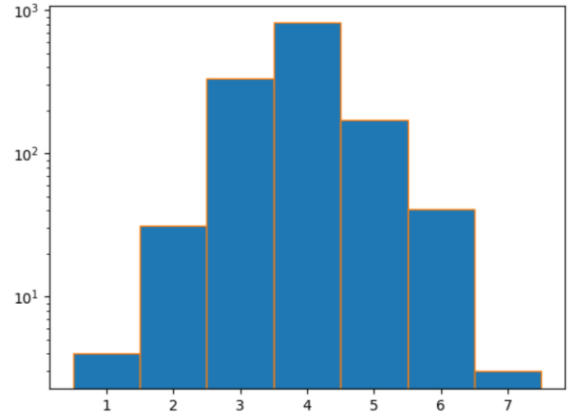
¼ Clock period = 0.833 ns



Number of integrators from Torino's simulation for clock period = 3.333 ns

Only with 1/8 clock period the reconstruction is **acceptable until 60-80 photons**.
Lowering the clock period improves the reconstruction at low energies but worse it at higher energies

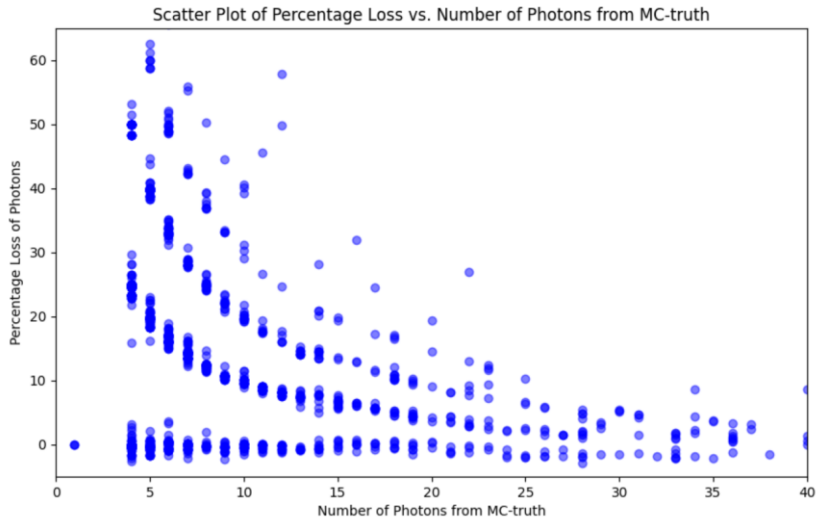


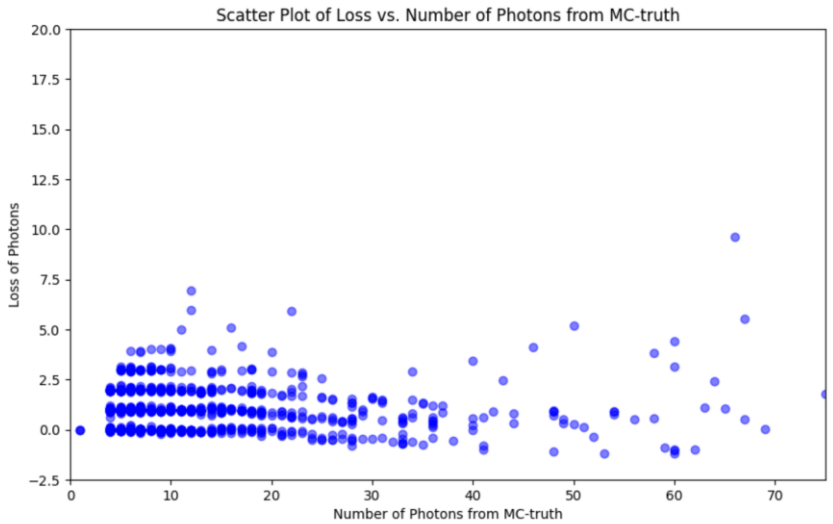


Number of integrators from Torino's simulation for clock period = 0.4166 ns

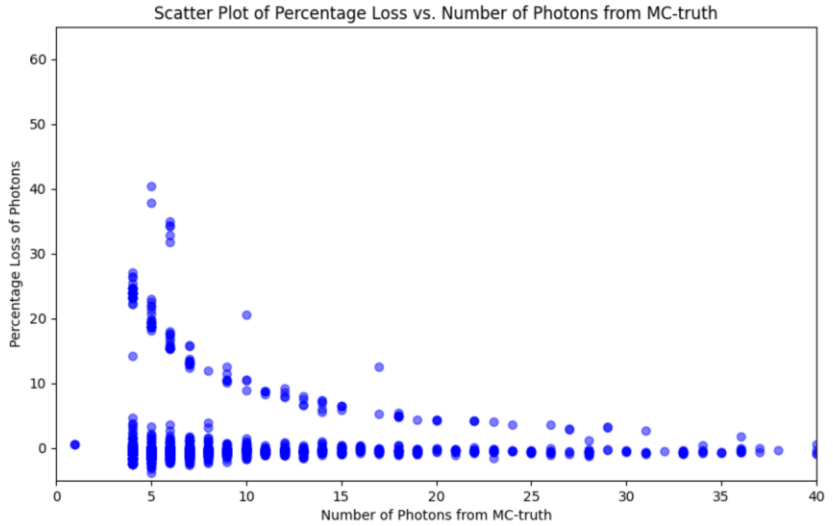
THIS SAMPLE IS IMPORTANT FOR THE VALIDATION

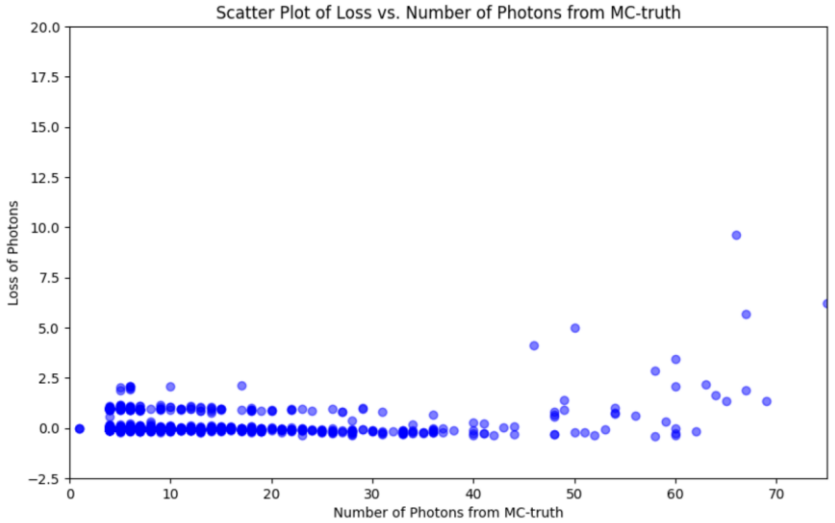
In more details





¼ Clock period = 0.833 ns



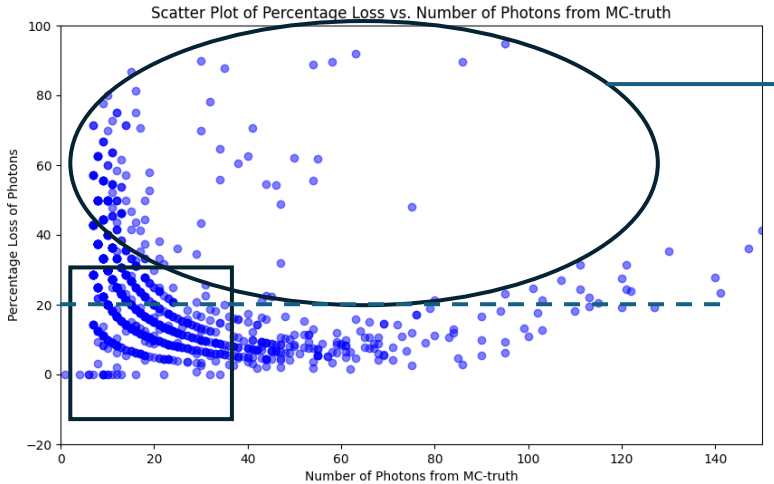


1/8 Clock period = 0.4166 ns

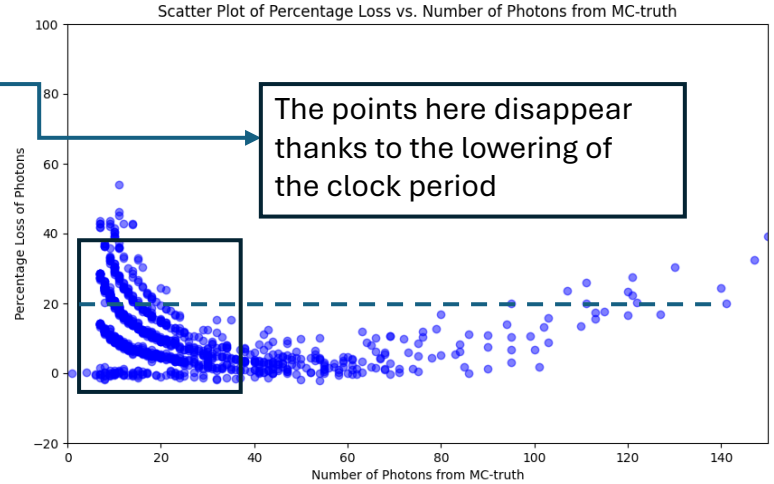
Why do we lose 5 photons with respect to 7 MC-truth photons?

Selected samples: Events that need **more than 6 integration windows** for some channels

Nintegrators > 6

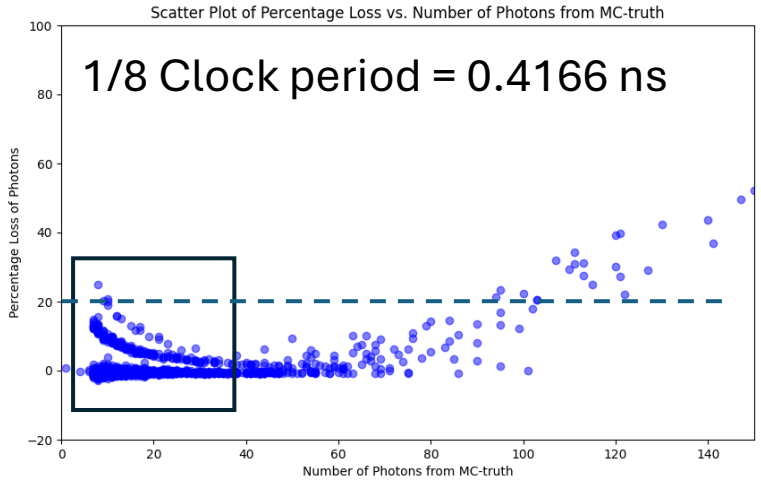


Clock period = 3.333 ns

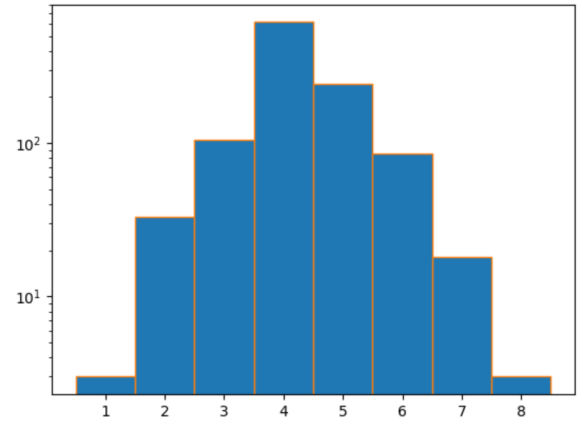


¼ Clock period = 0.833 ns

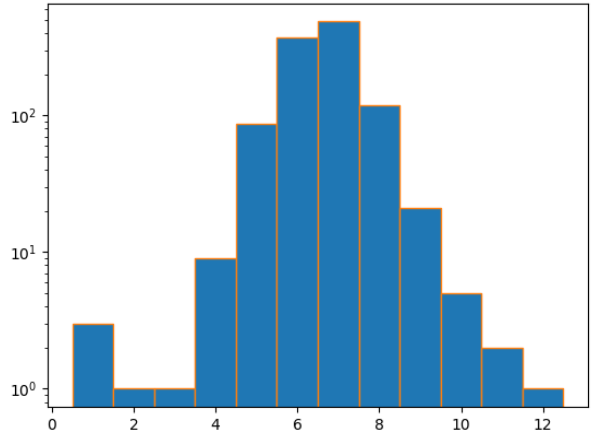
The reconstruction is **good until 60 photons**.
Lowering the clock period improves the reconstruction at low energies but worse it at higher energies



Xenon-doped Ar
720 spill

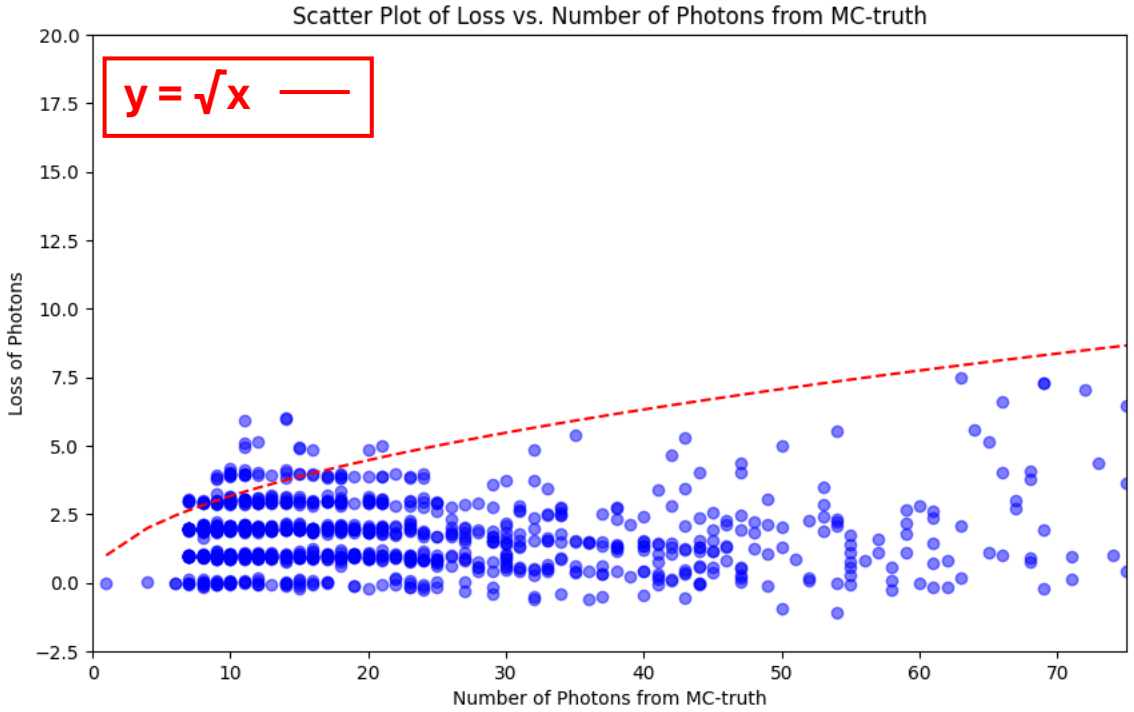


Number of integrators from Torino's simulation for clock period = 3.333 ns



Number of integrators from Torino's simulation for clock period = 0.4166 ns

In more details



Mean: 3.1772839798925228

Criterion 2

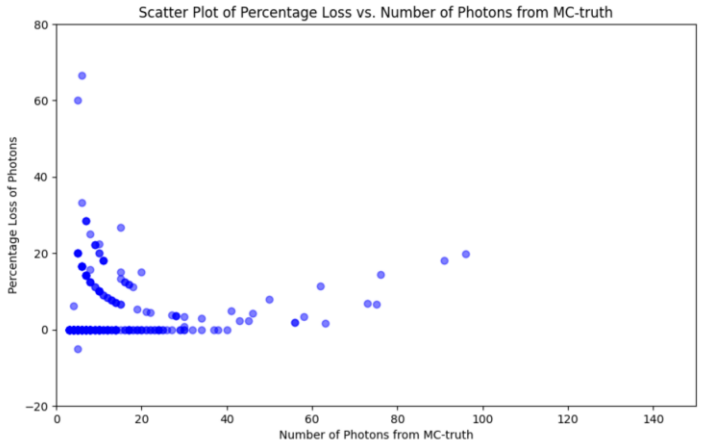
Channels with the **highest number of photons within an integration window**

New: Results as a function of the clock period

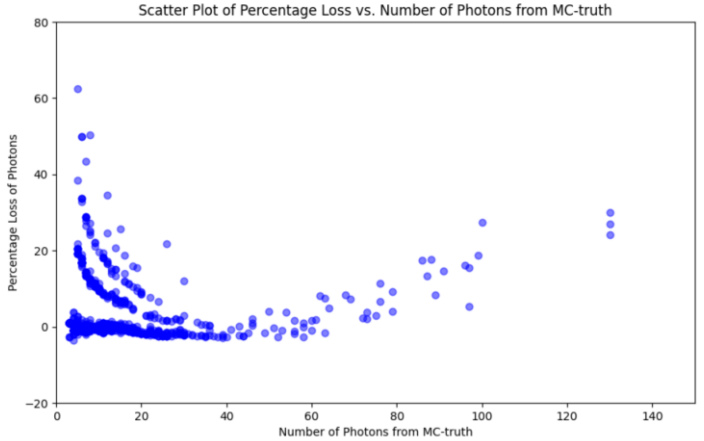
Selected samples: Events with **number of photons between 2 and 100 within an integration window**

2 < Nphotons < 100

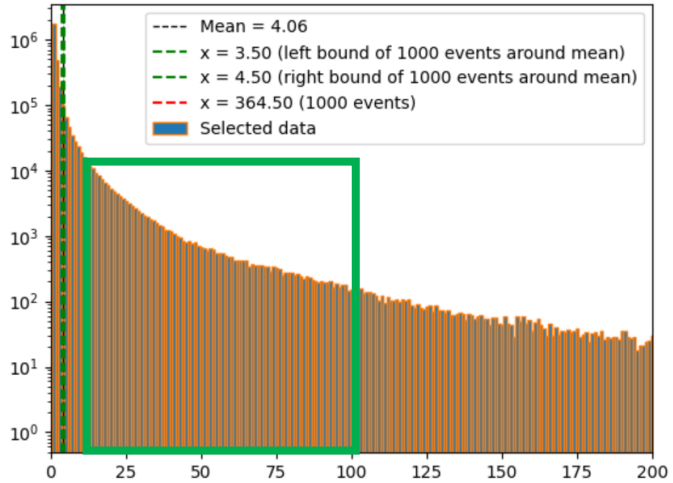
Xenon-doped Ar
720 spill



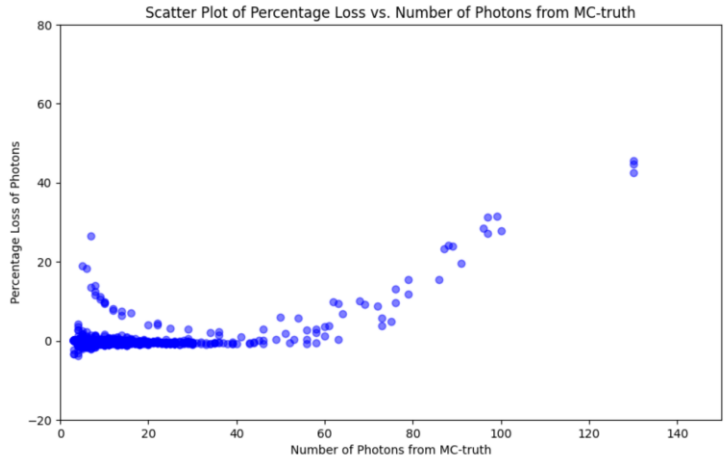
Clock period = 3.333 ns



¼ Clock period = 0.833 ns



Number of photons



1/8 Clock period = 0.4166 ns

Only with 1/8 clock period the reconstruction is good until **60 photons**.
Lowering the clock period improves the reconstruction at low energies but worse it at higher energies

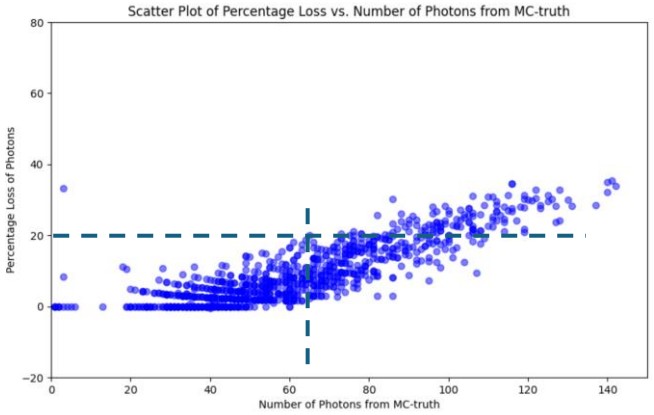
Criterion 3

Channels with the highest number of photons within 20 ns from the true interaction time

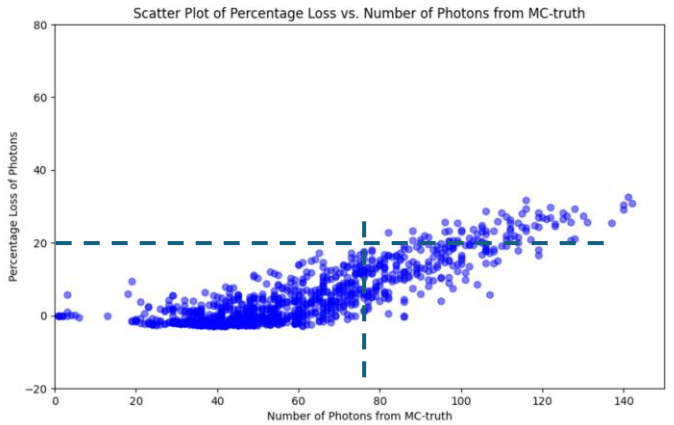
New: Results as a function of the clock period

Selected samples: Channels with **a number of photons between 11 and 80 within 20 ns from the true interaction time**

11 < Nphotons < 80

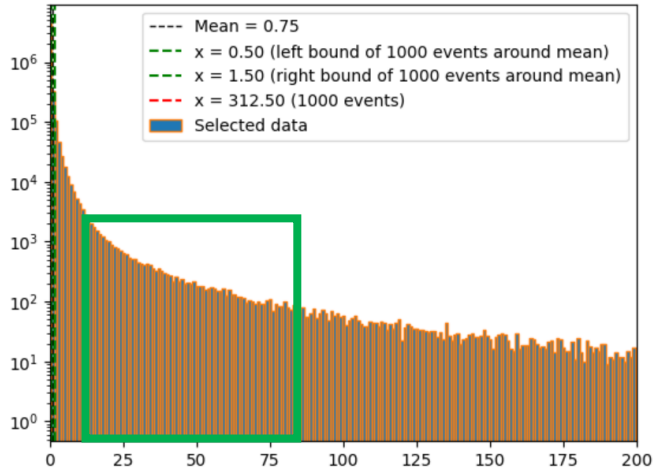


Clock period = 3.333 ns

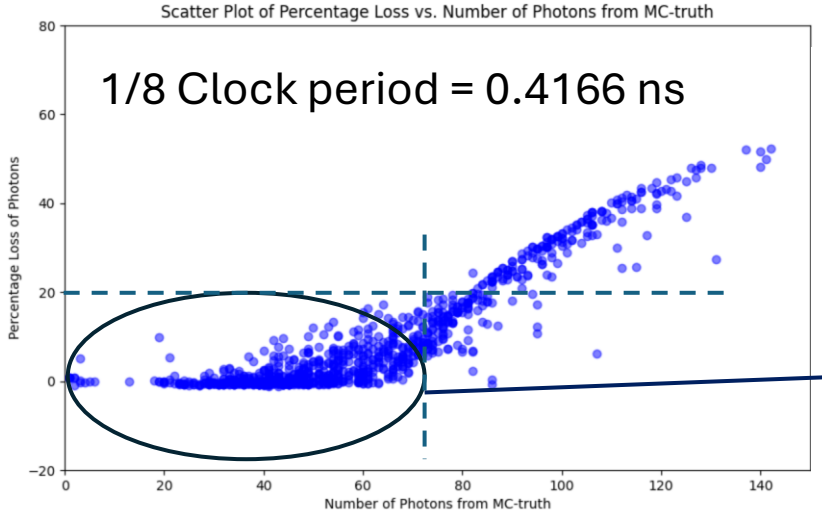


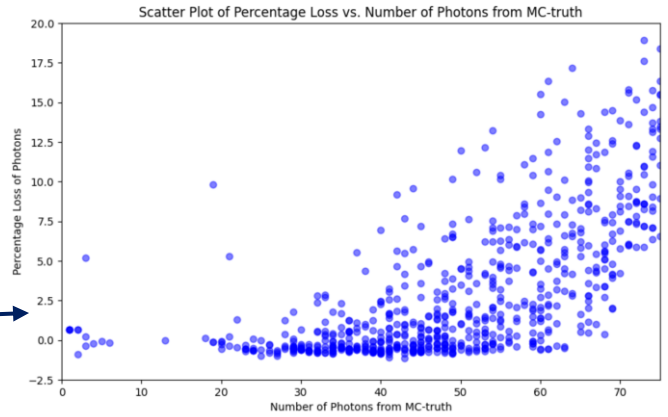
¼ Clock period = 0.833 ns

Xenon-doped Ar
720 spill



Number of photons





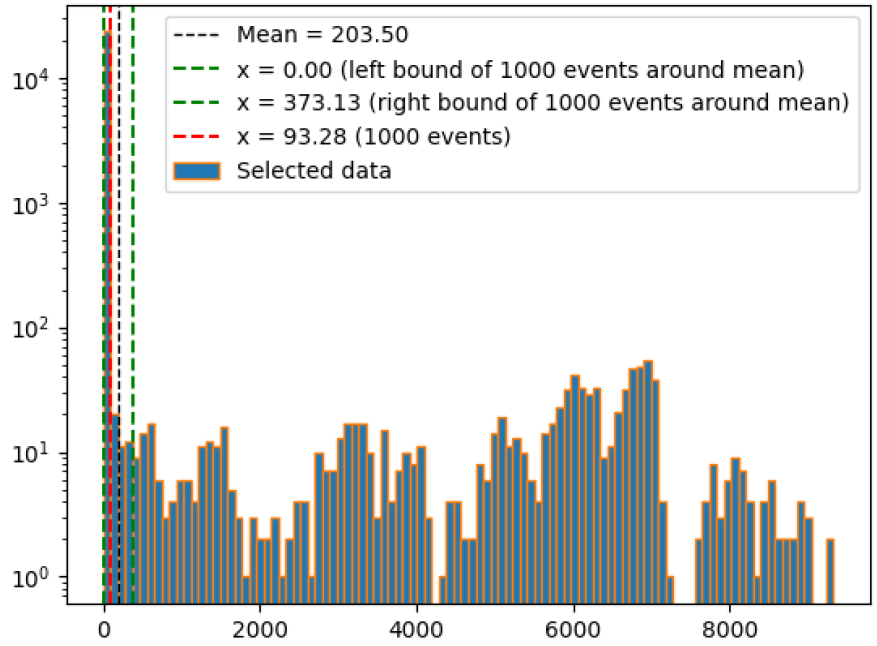
This is probably due to the saturation of the dynamic range

Criterion 4

Channels with the lowest time between the true interaction time and the previous detected photon

Results

dt distribution in Xenon-doped Ar
t_{slow} = 160 ns



Total entries: 29000
About 300 channels with dt < 200 ns

Method used

For each channel:

- Search for the interaction: at least 3 photons within 50 ns from the t_0 of the interaction
- Save the detected time of the interaction t_{int}
- Calculate dt = t_{int} – ($t_{lastphoton}$ before the interaction)

It's not an issue!

But we will check for the pure Argon (t_{slow} = 1600 ns)

Conclusions and open questions

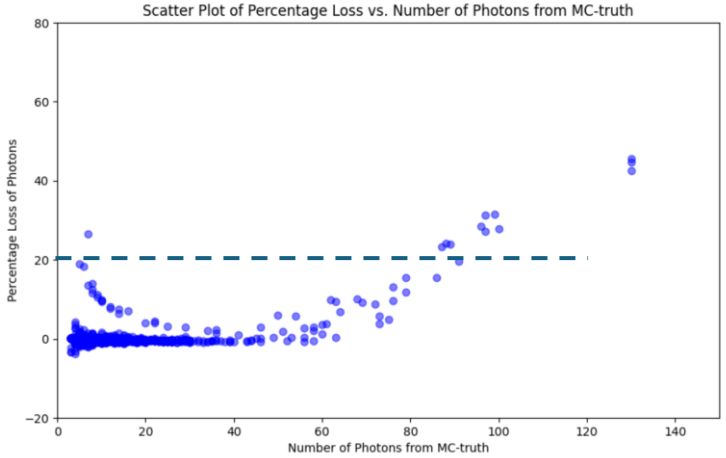
- At low number of photons (lower than 20) the reconstruction is quite good with 1/8 clock period

  What is happening with photons < 10?

Independently on the clock period, if the number of photons is bigger than 80 (or, in the worst cases, bigger than 60) the reconstruction has at least 20% error

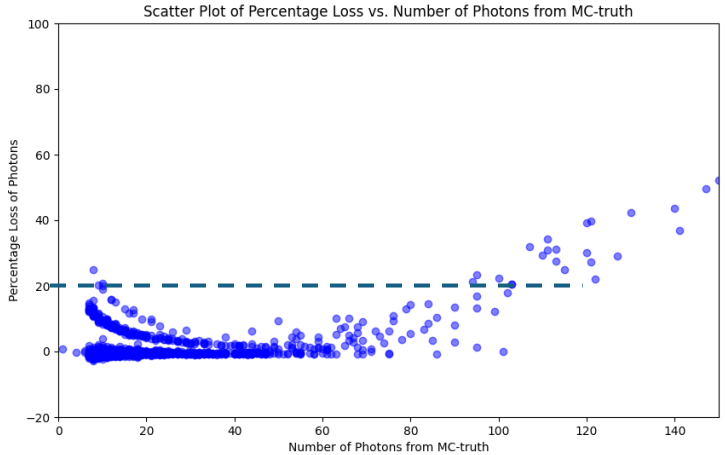
Is there a way to push to 80-100?

1/8 Clock period = 0.4166 ns



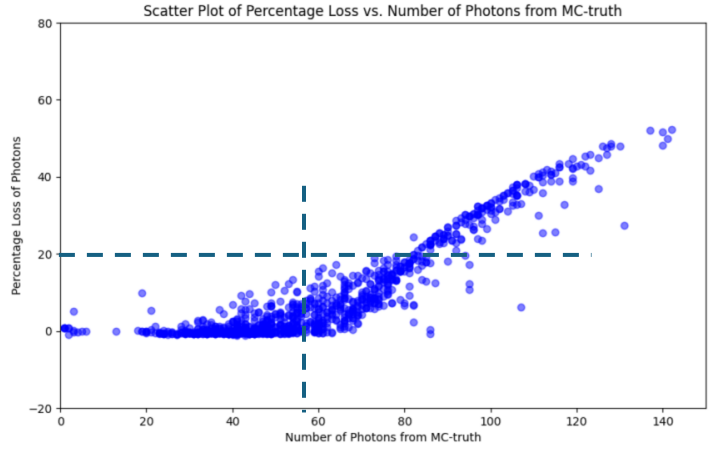
2 < Nphotons < 100 in a single integration window

1/8 Clock period = 0.4166 ns



Integration windows > 6

1/8 Clock period = 0.4166 ns

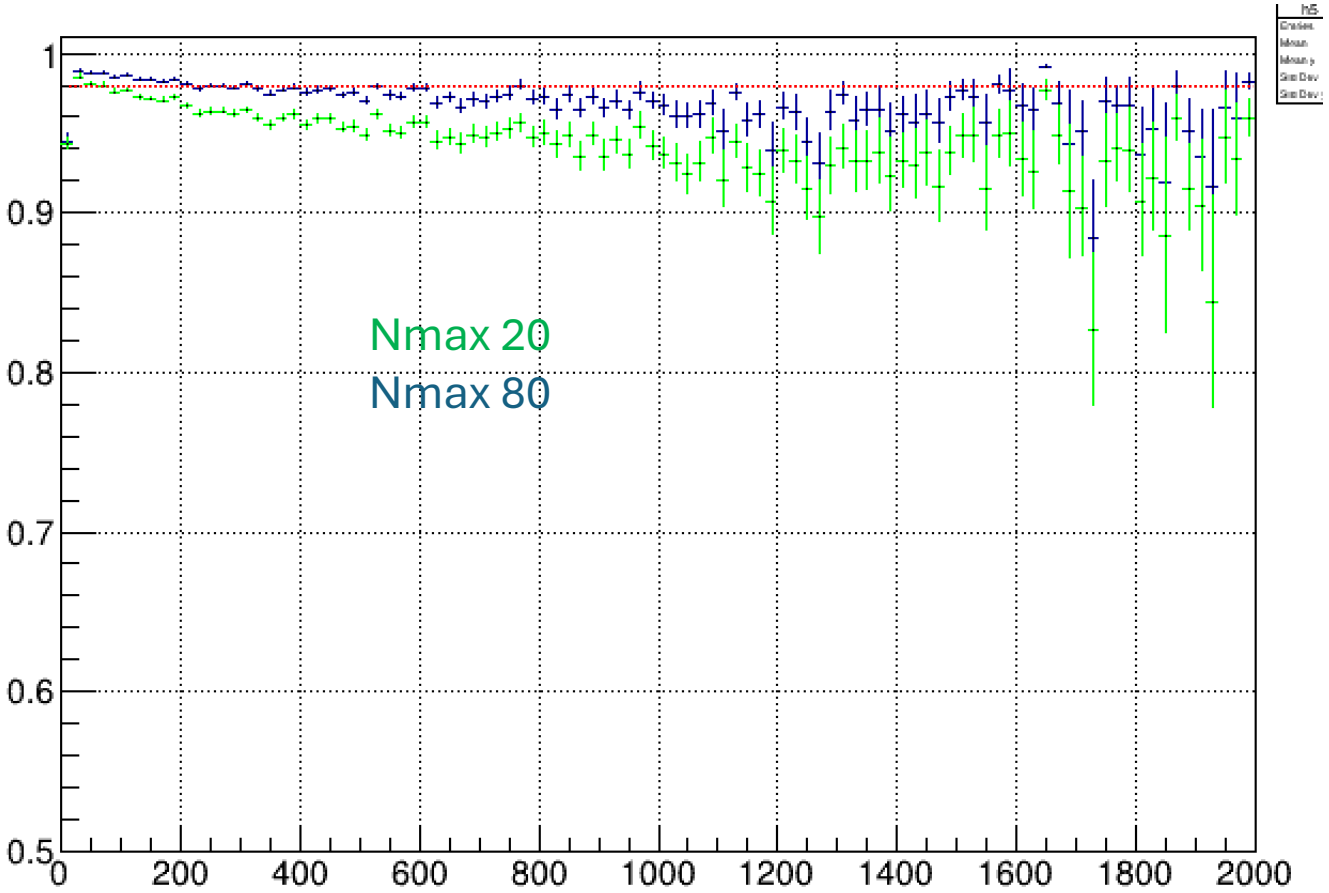


11 < Nphotons < 80 within 20 ns from the true interaction time

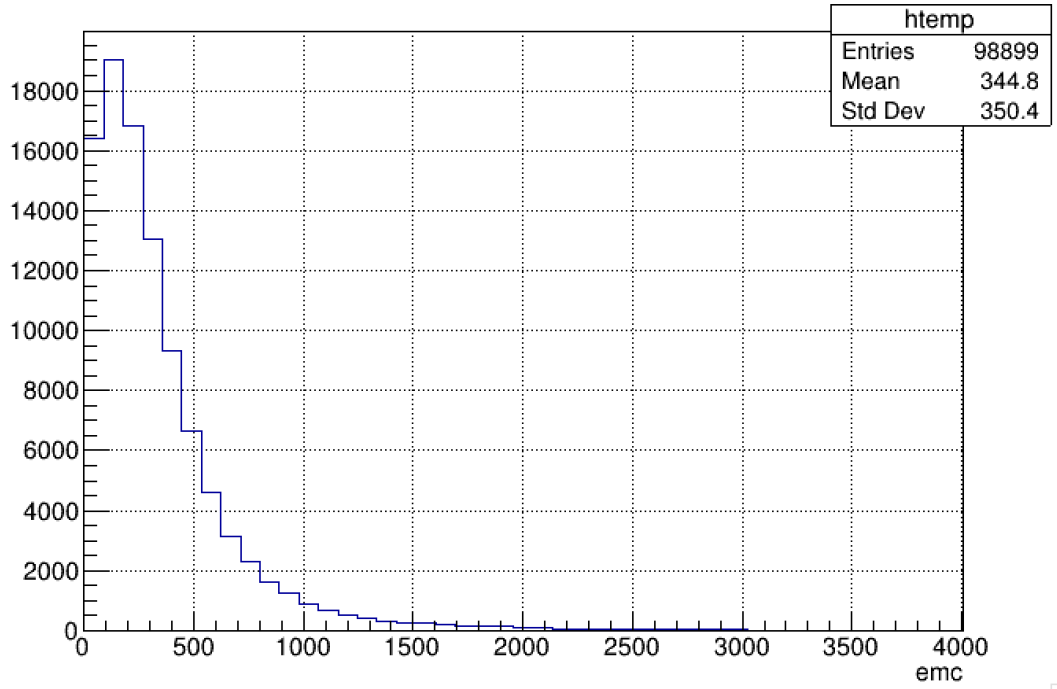
#detected/#detectable vs Edep

Meeting in Genova

9 May 2024



Energy deposit [MeV]



Energy deposit [MeV]