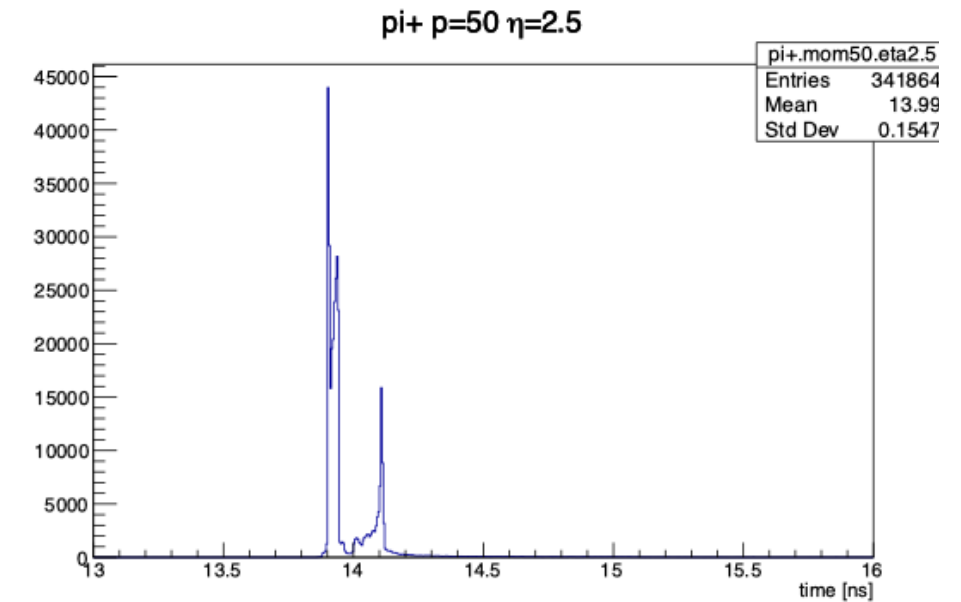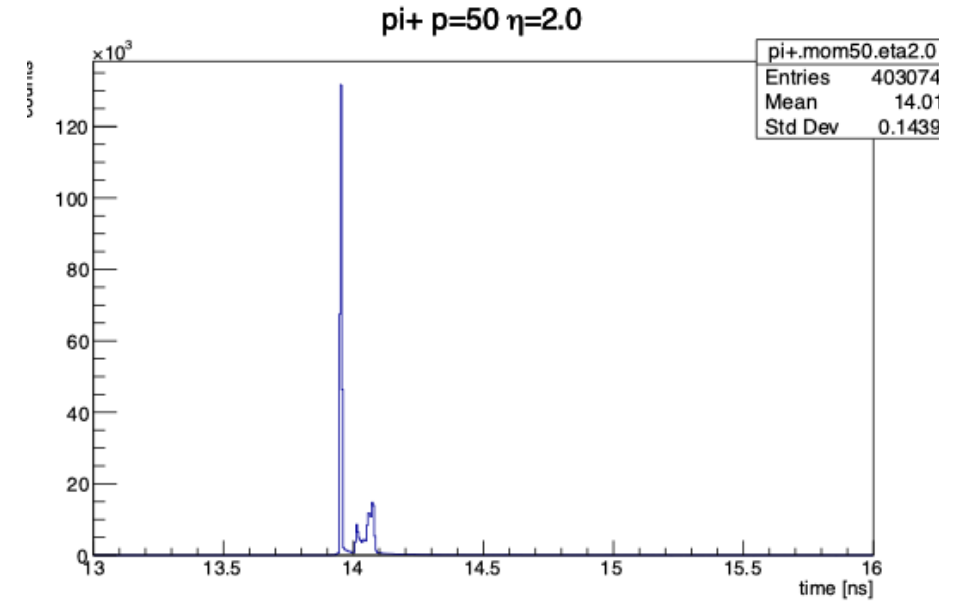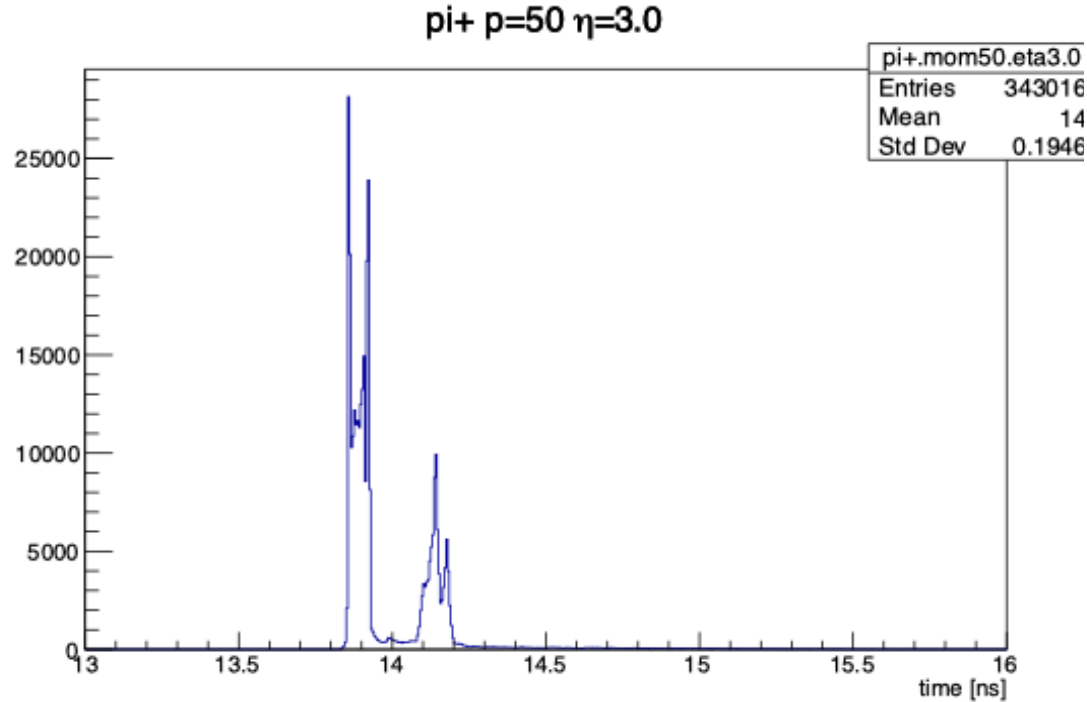# Time distributions and impact of noise on reconstraction

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11 december 2025

- Time distribution shape
  - Fixed ϕ and η
  - Different particles, momentum, pseudorapidity
  - Simulated events

- First look at how performance may change injecting noise in the simulations
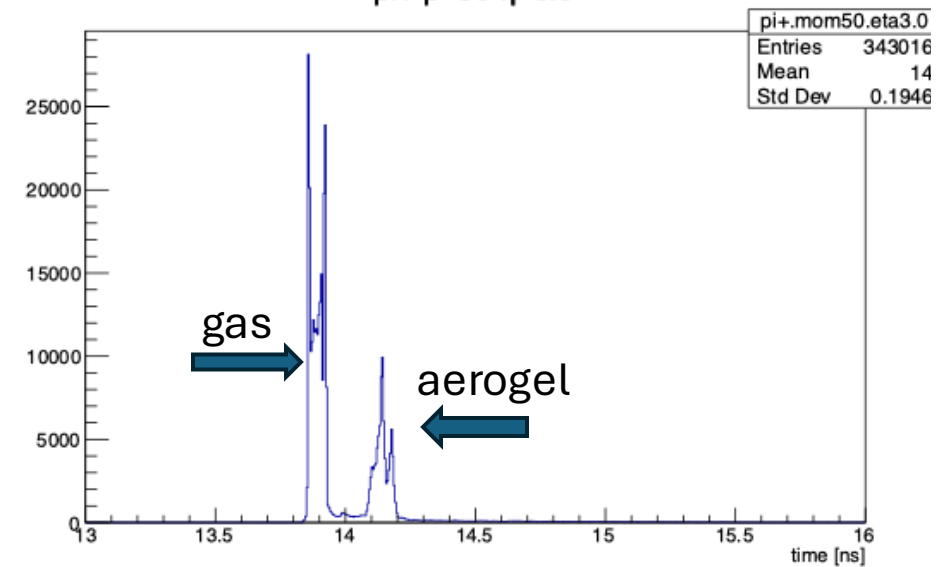
Time distribution shape

pi+ p=50 η=3.0

pi+.mom50.eta3.0	
Entries	343016
Mean	14
Std Dev	0.1946

pi+ p=50 η=2.0

pi+.mom50.eta2.0	
Entries	403074
Mean	14.01
Std Dev	0.1439

pi+ p=50 η=2.5

pi+.mom50.eta2.5	
Entries	341864
Mean	13.99
Std Dev	0.1547

- Pions at fixed φ and momentum (50GeV/c). 3 fixed η values
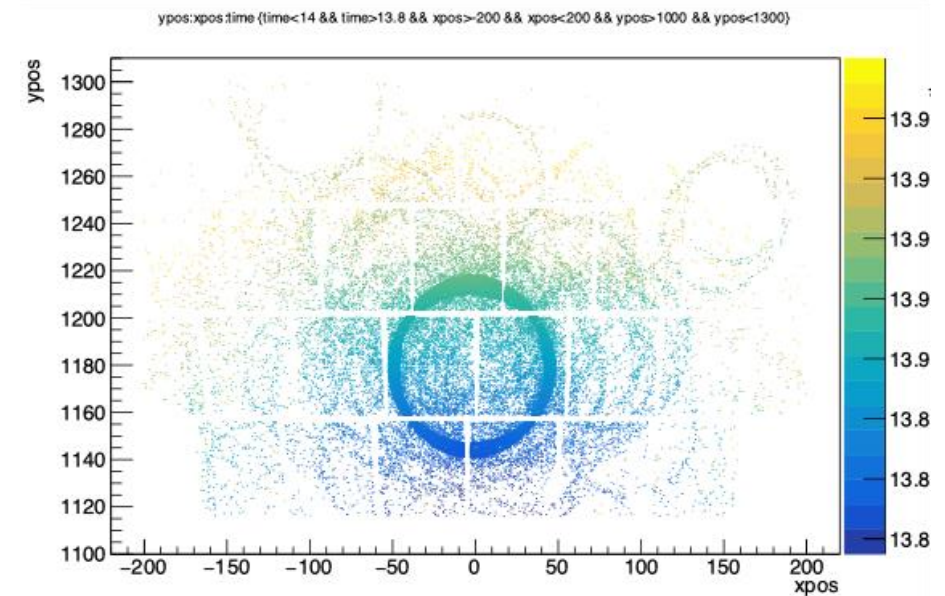- 1000 Single particle events

2

Time distribution shape

- Tof is defined as time of detection – time of event

- It depends on the path made by the particle and the photons

- Aerogel photons are emitted with a bigger angle and takes more time to be detected than gas photons

- Upper and lower part of the ring have different time of detection, each peak have two sub-peaks
  - This depends on pseudorapidity, at η=2.0 the ring is more focalized and we can't see this structures while at η =3.0 we can

Time distribution

pi+ p=50 η=3.0

| pi+.mom50.eta3.0	
Entries	343016
Mean	14
Std Dev	0.1946

gas

aerogel

Gas ring, time<14ns

3

Time distribution shape

- This distribution changes slightly in every case

- To determine the total shape, on the right, all the distributions for the particles, momentums, pseudorapidity bins are summed

- Almost all the photons are detected in a 1ns time window

- ! The distribution needs to be convoluted with a gaussian to resemble the measured distributions. The time window will be larger, and the peaks will be less defined !
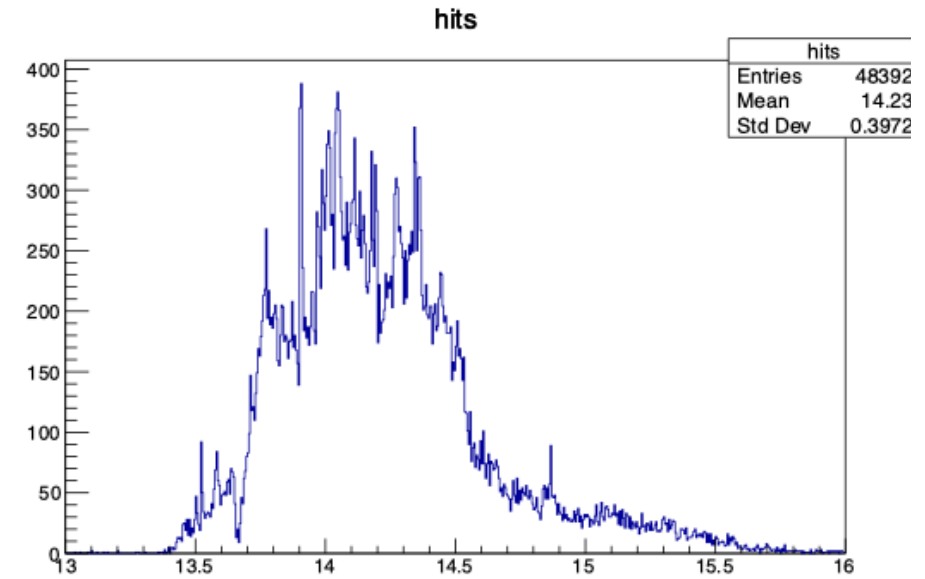

Entries	1.723145e+07
Mean	14.06
Std Dev	0.2195
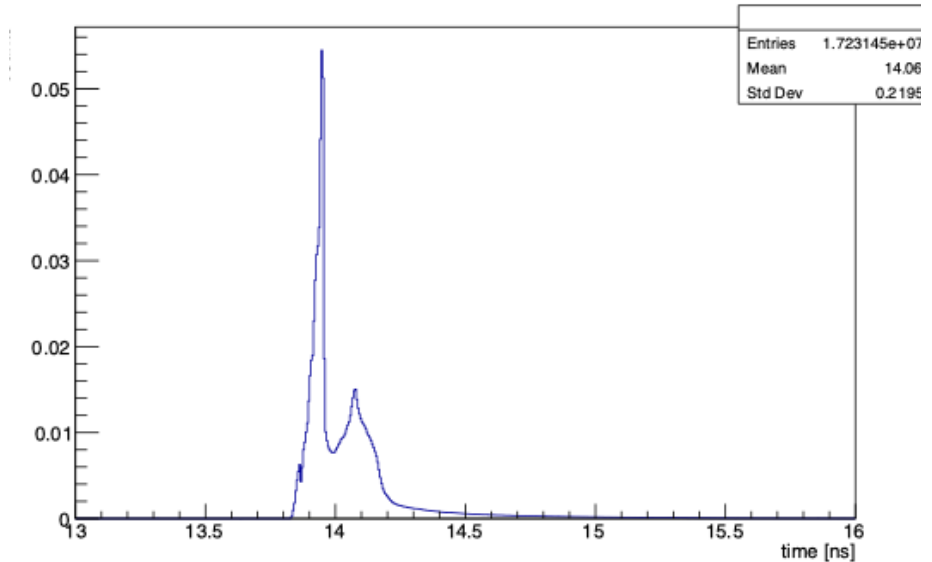
- Protons, π+, e-, K+
- p = {5, 19, 40} GeV/c
- η ∈ [1.5 ; 2.0] , [2.0 ; 2.5]
      [2.0 ; 2.5] , [2.5;3.0]

Time distribution shape

- Instead of single particle events we now look at proton-electron collisions simulated in Pythia.
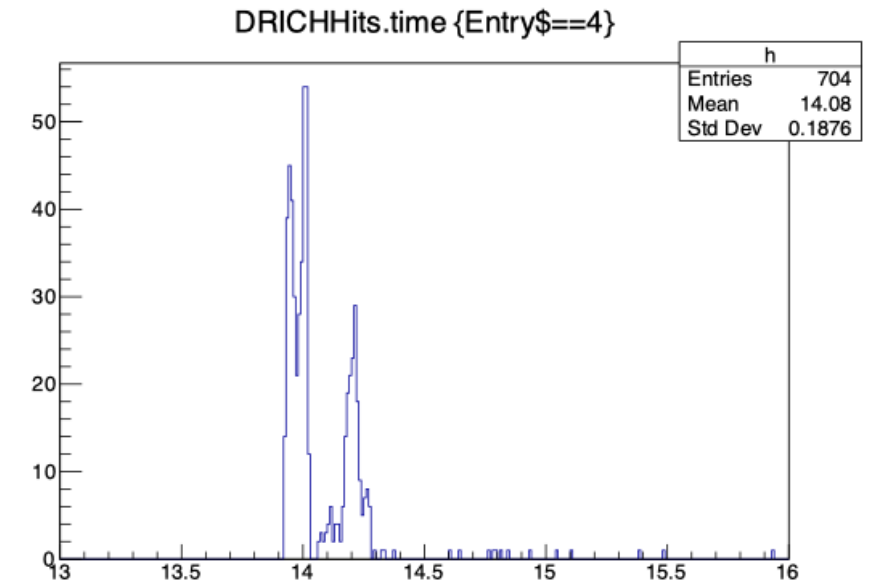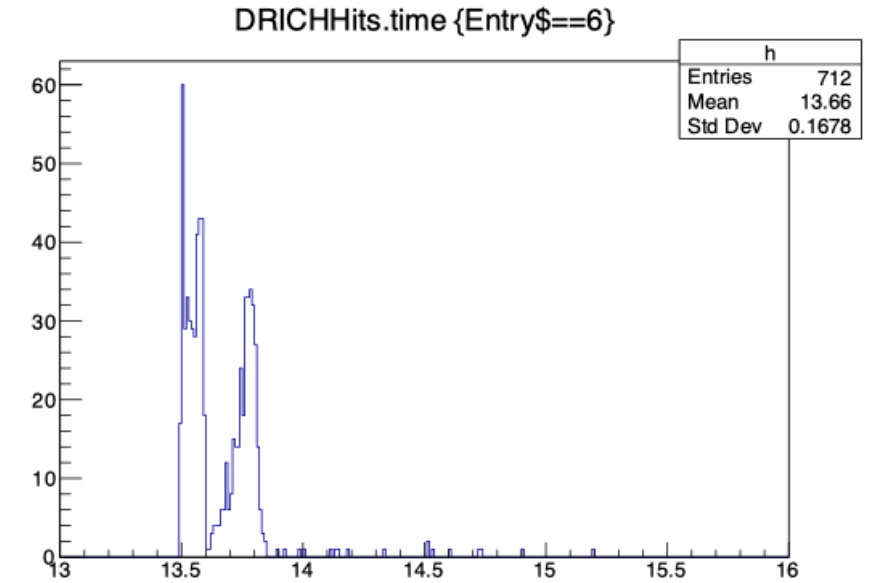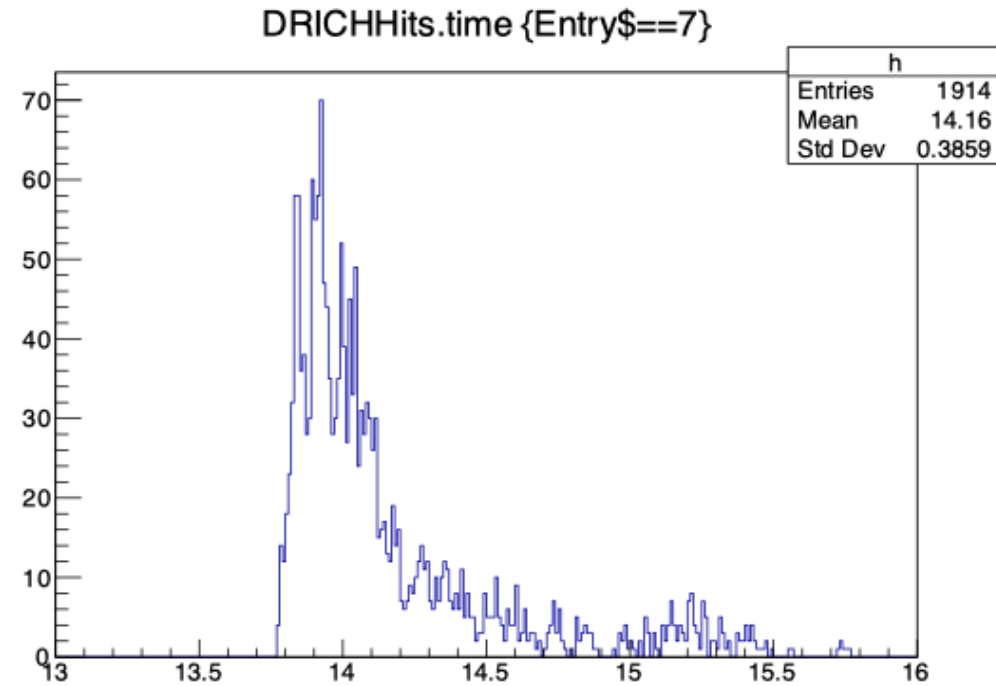
We can observe two things

- We can't appreciate the two peaks

- The time window is larger

- 50 pe- simulated collisions

Time distribution shape

- There are two reasons
  - Similar events may be detected shifted in time
  - Multi particle events have a bigger detection time window (~2ns or even more convoluting it with a gaussian)

Time distribution shape

- Single particle events simulated don't rapprent well the real time distribution

- The detection time window needs to be of the order of 3ns
 - With a noise rate of ~300.000kHz / pixel we expect ~300 noise hits/event

Impact of noise on performances

- This part it's not over yet

- I started studing Aerogel because the impact of noise should be bigger (less photons emitted on a bigger area than gas)

- 75um SiPMs are currently implemented

   (the aerogel performance were not changing a lot between differen SiPMS, but the bigger yield of the 75um could be usefull for a better signal/ratio)
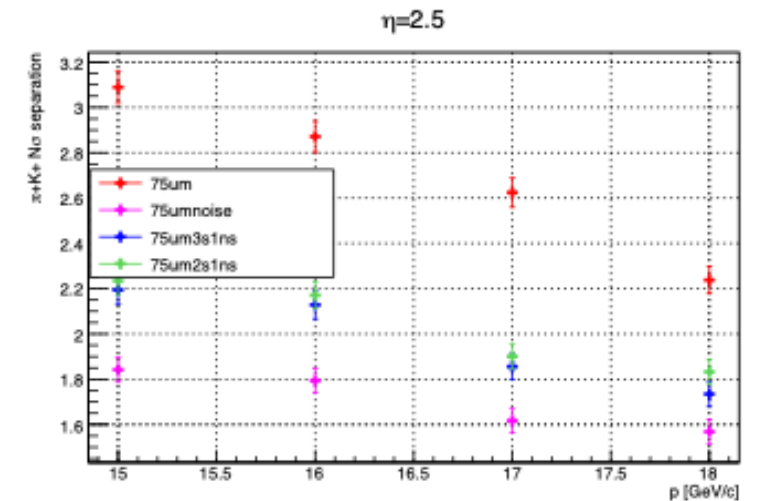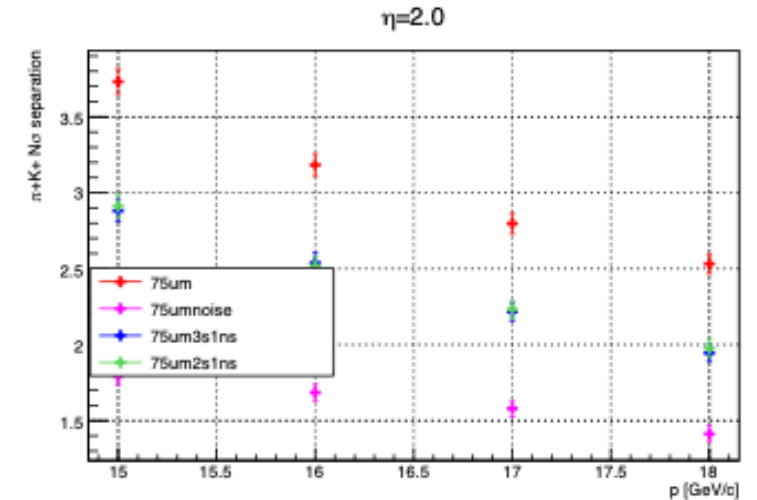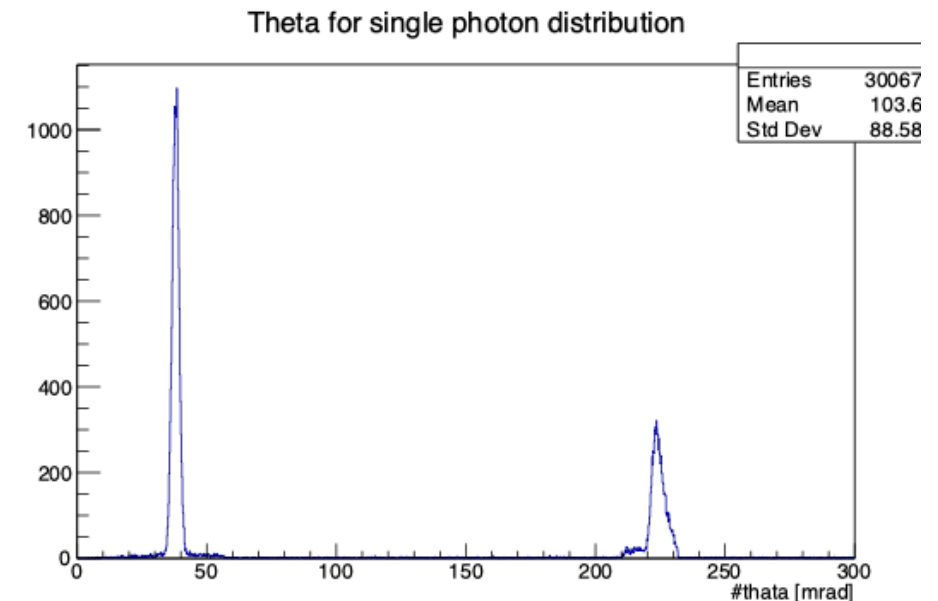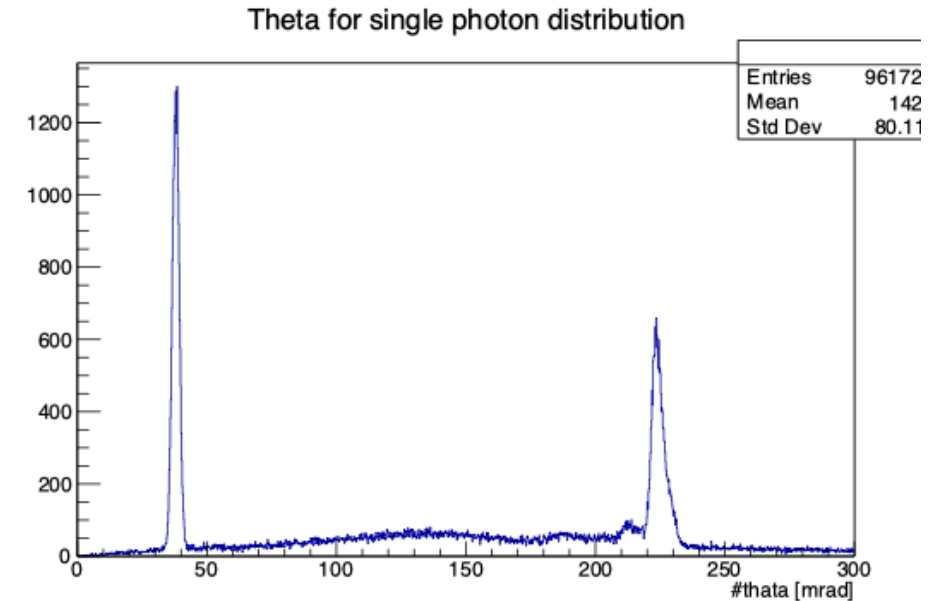
Impact of noise on permormances

- π+ and K+ all over φ in two pseudorapidity bins
  - [2.0 ; 2.5], [2.5 ; 3.0]
  - η labeled on top of the plots is the minum η

- The performances drop down
  - In red without noise
  - In blue with 1ns time window
  - In purple 3ns time window
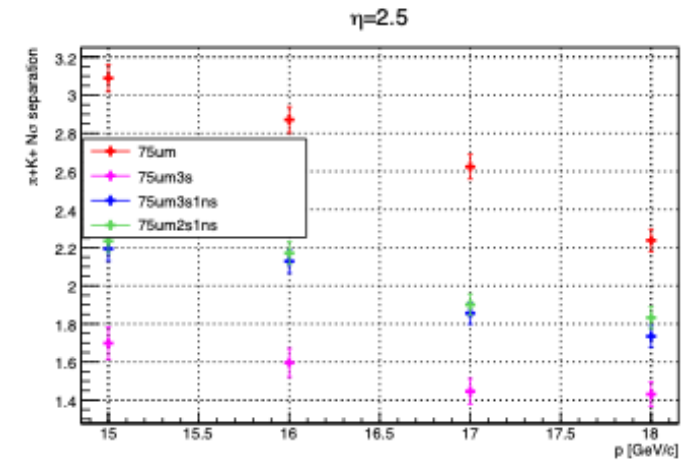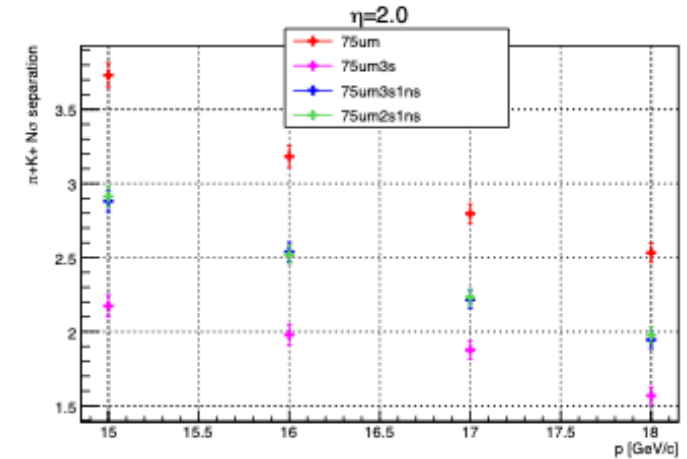
Impact of noise on performances

- To get this results I modified the algorithm selecting only the photons from sectors which have a number of count 3σ above the expected number of noise hits (sector which have signal hits for sure)

- Single photon cherenkov angle reconstructed before and after the modification

- The performance improve slightly, I'm still investigating this

Impact of noise on performance

Still to do:

- Re-check this results
- Try new modifications
- Try other SiPMs
- Check gas performances