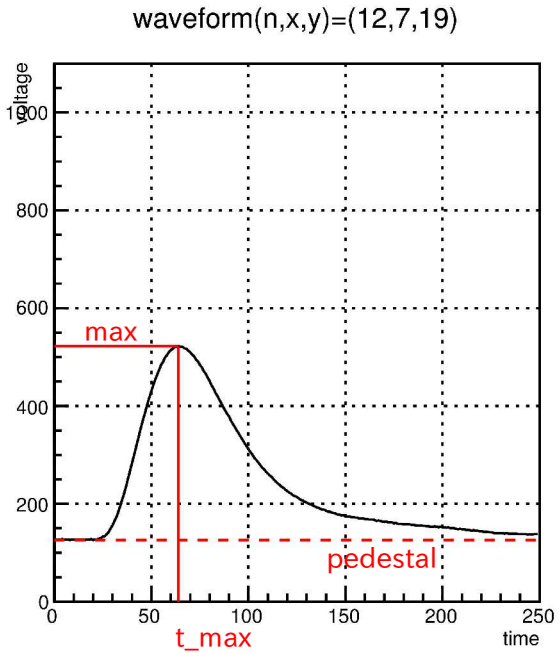
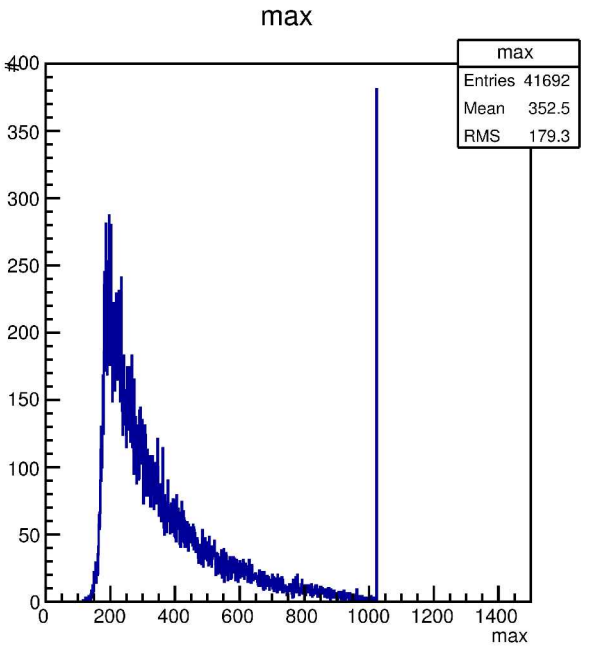
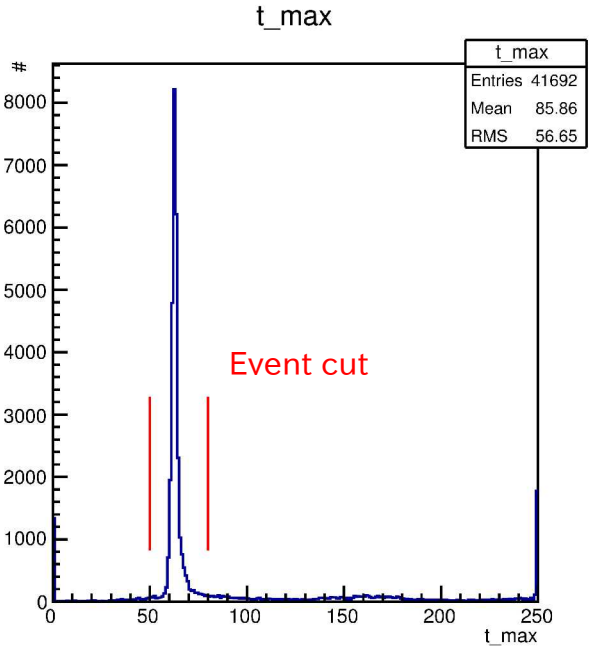
CsI Photon Detector Waveform Analysis

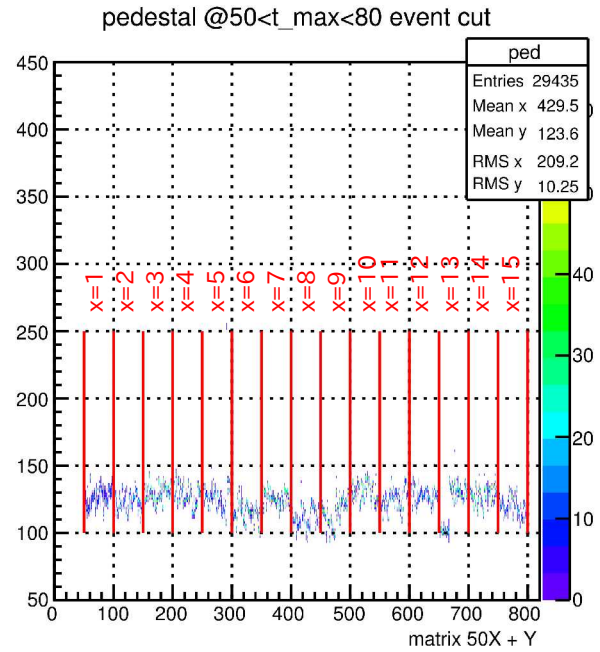
2015/08/26

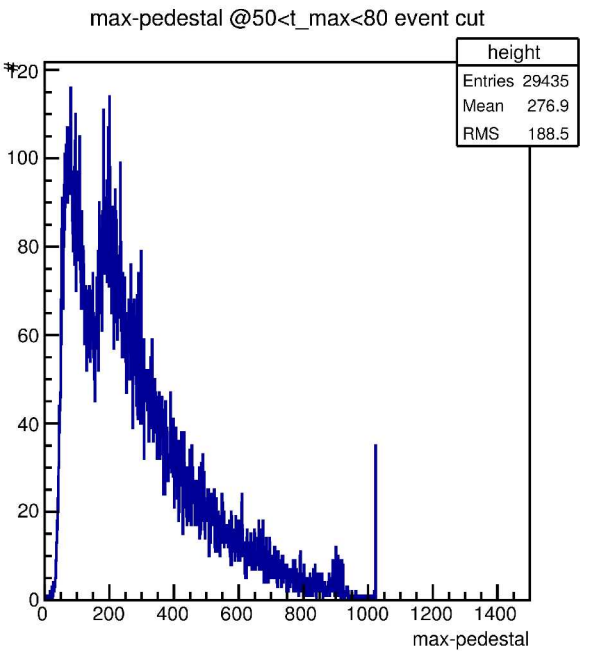
H. Ito

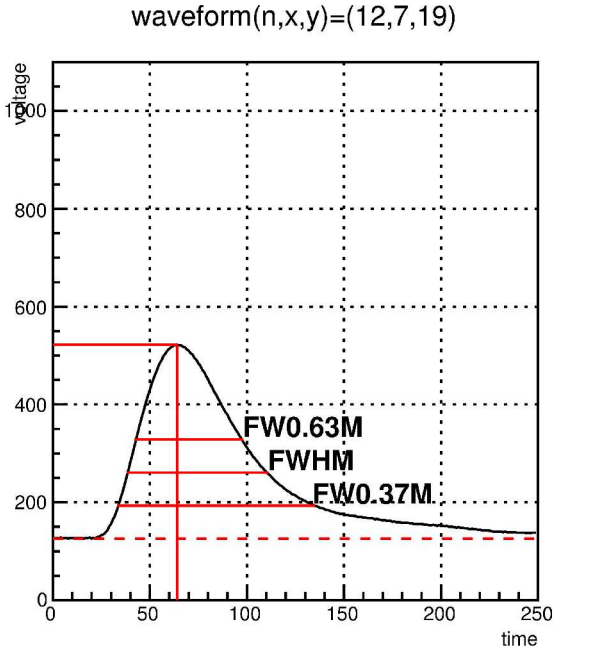

waveform(n,x,y)=(12,7,19)
voltage
time
max
pedestal
t_max

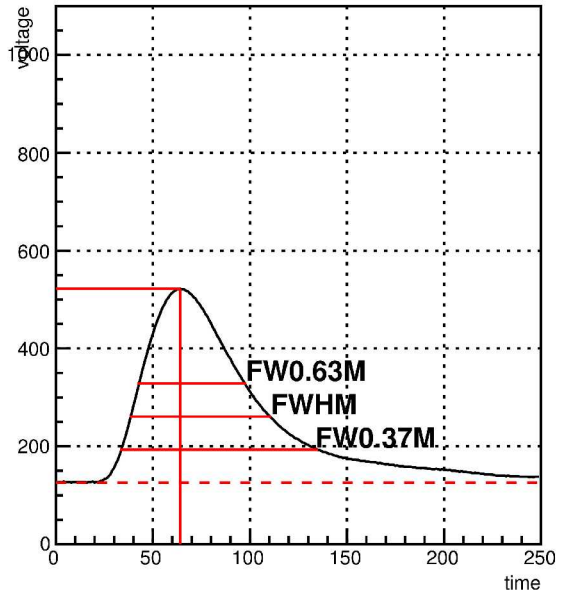

max
max
Entries 41692
Mean 352.5
RMS 179.3


t_max
t_max
Entries 41692
Mean 85.86
RMS 56.65
Event cut


pedestal @50<t_max<80 event cut
ped
Entries 29435
Mean x 429.5
Mean y 123.6
RMS x 209.2
RMS y 10.25
matrix 50X + Y


max-pedestal @50<t_max<80 event cut
height
Entries 29435
Mean 276.9
RMS 188.5
max-pedestal

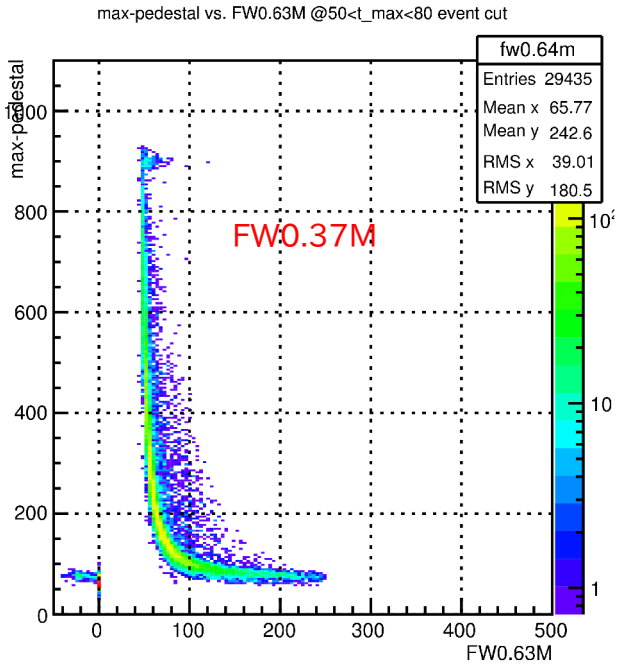

waveform(n,x,y)=(12,7,19)
voltage
time
FW0.63M
FWHM
FW0.37M

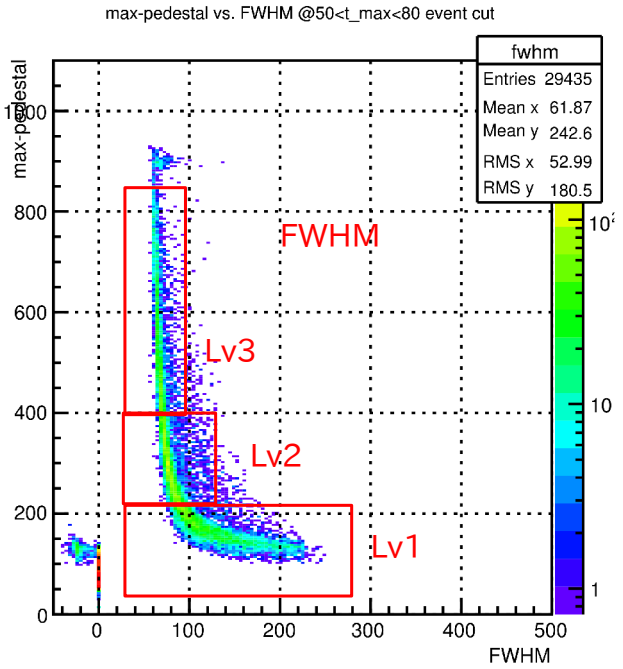


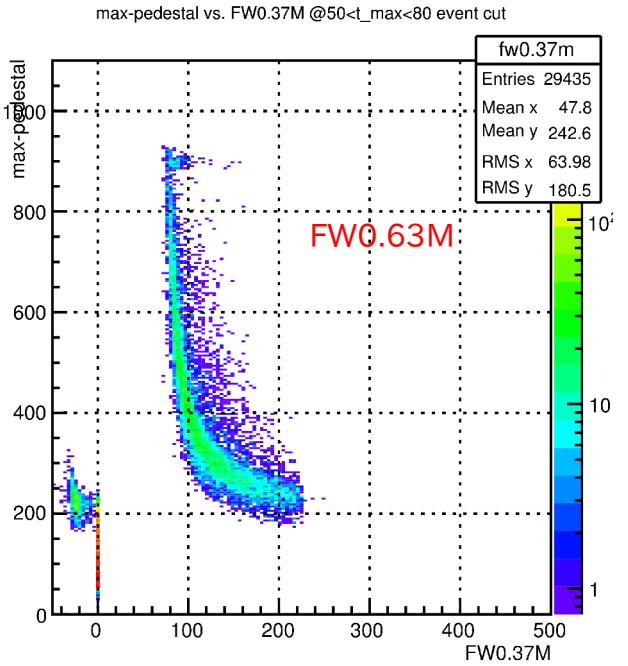
First Motivation: decision of function model

Step1. Divide 3 level in pulse height
Step2. Main Model Fix in each the level
Step3. Decide the Model in all level
Research of the property
Step4. applying Multiple pulse event

$e^{-1} \sim 0.367$





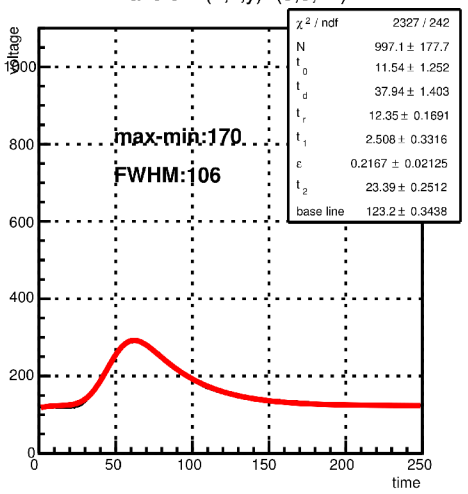


Lv1 waveform

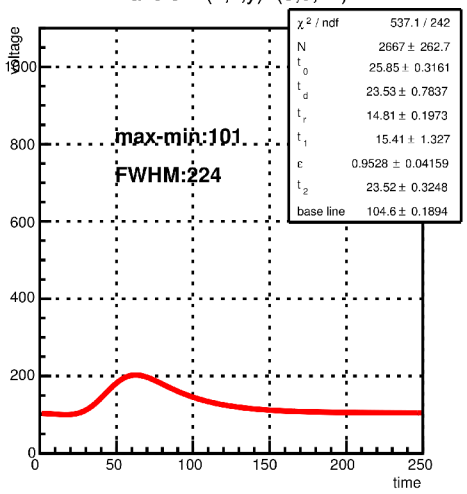
$$V(t) = \mathrm{N}\ \mathrm{Freq}\left[\frac{t-(t_0+t_d)}{\tau_r}\right]\frac{t-t_0}{\tau_1^2}\left(\exp\left[\frac{-(t-t_0)}{\tau_1}\right]+\ \varepsilon\exp\left[\frac{-(t-t_0)}{\tau_2}\right]\right)$$

Model: yamazaki

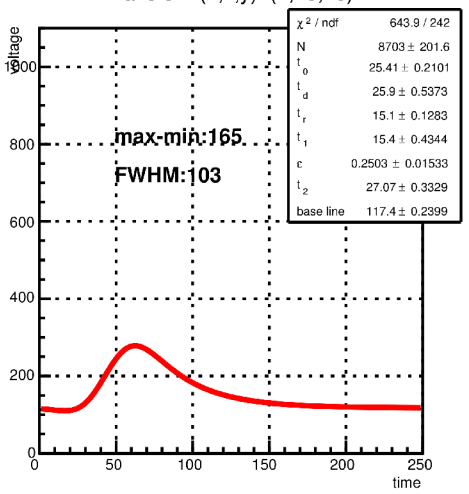
waveform(n,x,y)=(3,3,21)



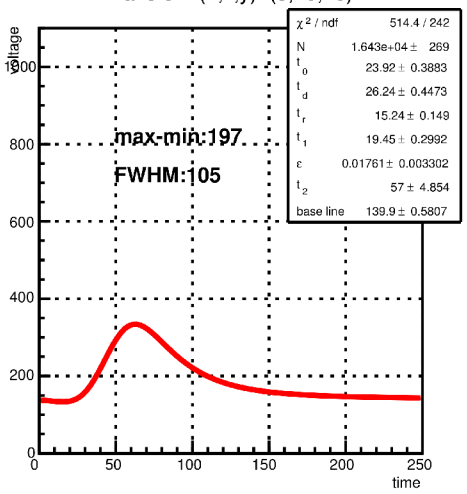
waveform(n,x,y)=(3,9,21)



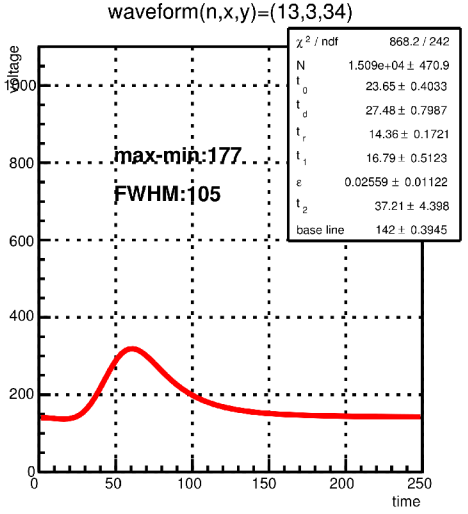
waveform(n,x,y)=(7,15,46)



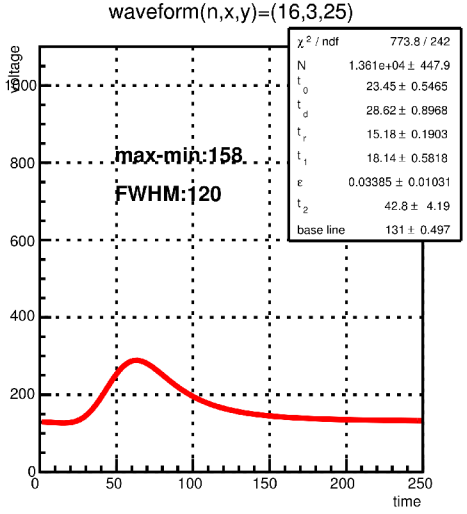
waveform(n,x,y)=(8,10,20)



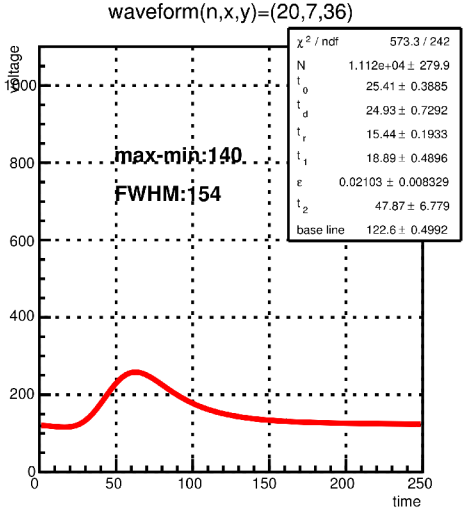
waveform(n,x,y)=(13,3,34)



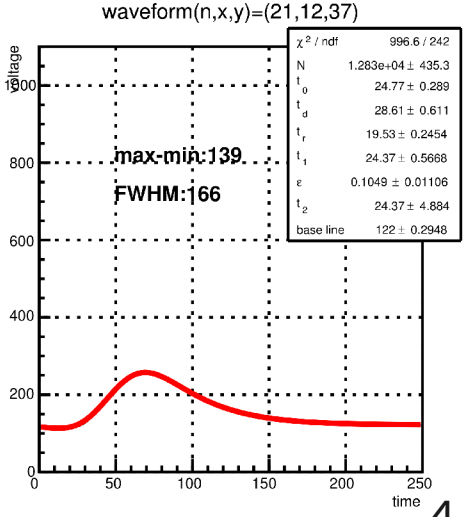
waveform(n,x,y)=(16,3,25)



waveform(n,x,y)=(20,7,36)



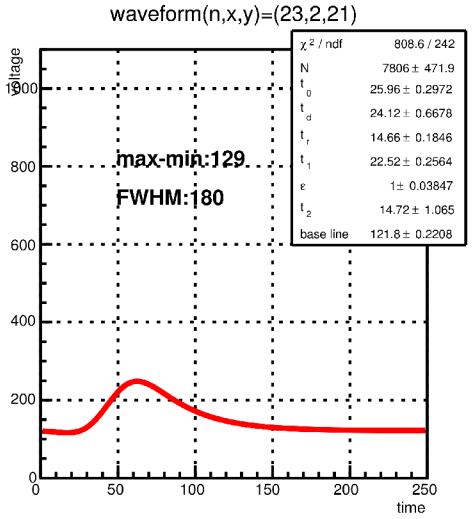
waveform(n,x,y)=(21,12,37)

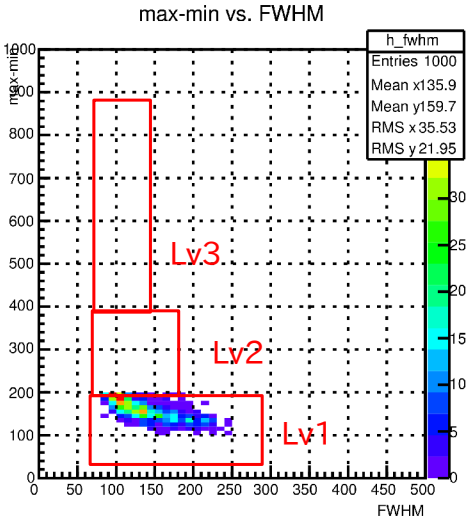


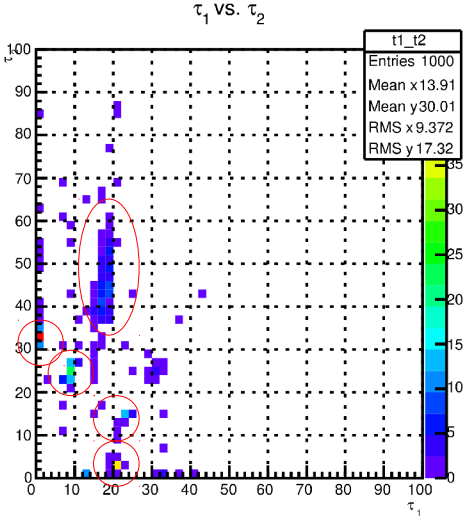
Lv1 waveform

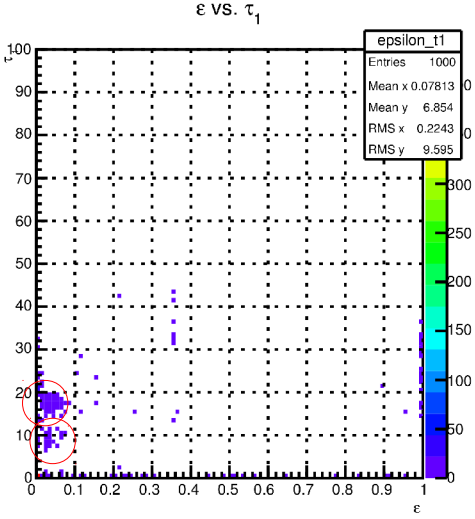
$$V(t) = \mathrm{N}\ \mathrm{Freq}\left[\frac{t-(t_0+t_d)}{\tau_r}\right]\frac{t-t_0}{\tau_1^2}\left(\exp\left[\frac{-(t-t_0)}{\tau_1}\right]+\ \varepsilon\exp\left[\frac{-(t-t_0)}{\tau_2}\right]\right)$$

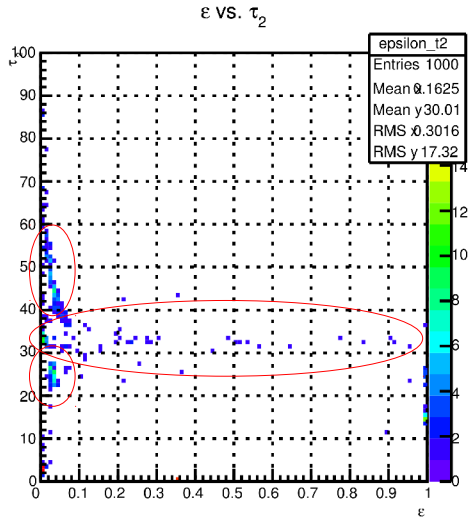
Model: yamazaki

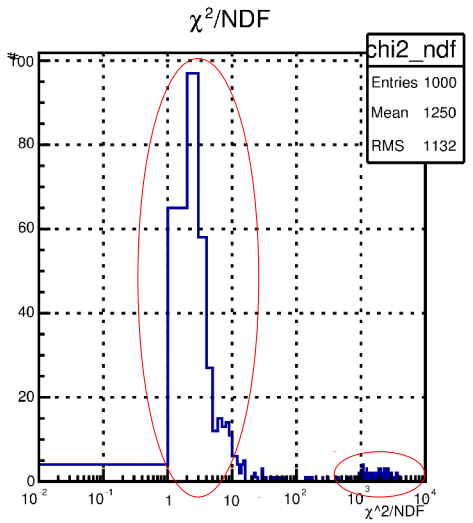












result

τ 1 vs. τ 2 … (0,31),(3,20),(22,15),(18,44),(30,24)

ε vs. τ 1 … mean 0.078 (?), two peak

ε vs. τ 2 … mean 0.078 (?), two peak

χ^2/NDF … two peak

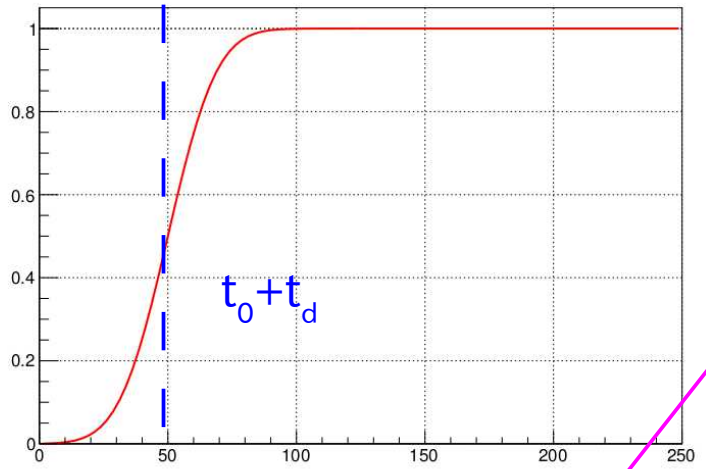
1～10 (main), 10^2 ～10^3 (double pulse?)

Lv1 waveform

$$V(t) = \mathrm{N}\ \mathrm{Freq}\left[\frac{t-(t_0+t_d)}{\tau_r}\right]\frac{t-t_0}{\tau_1^2}\left(\exp\left[\frac{-(t-t_0)}{\tau_1}\right]+\ \varepsilon\exp\left[\frac{-(t-t_0)}{\tau_2}\right]\right)$$

Model: yamazaki

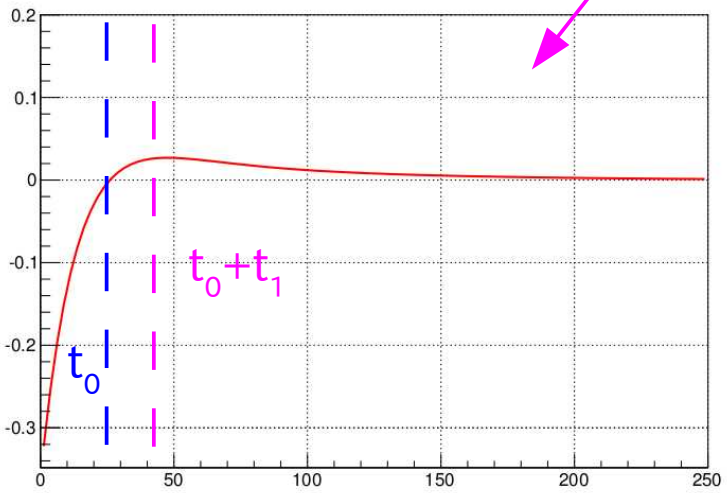
TMath::Freq((x-[1]-[2])/[3])



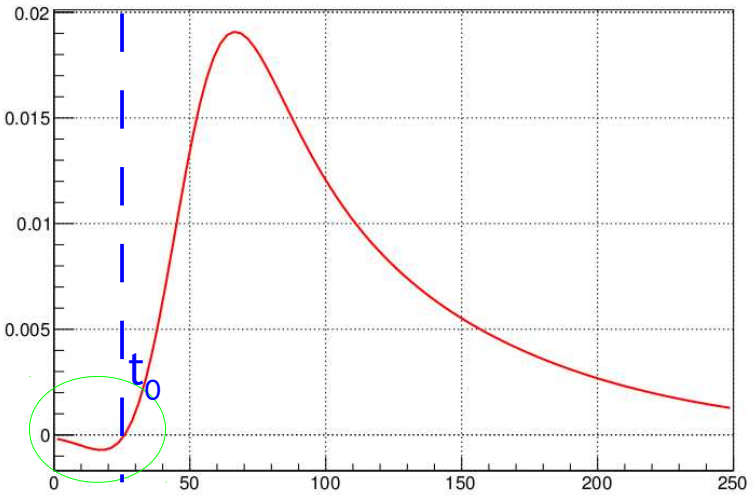
Parameters

N = 1	τ_1 = 18
t_0 = 26	τ_2 = 50
t_d = 24	ε = 0.16
t_r = 15	

(x-[1])/[4]/[4]*(exp(-(x-[1])/[4])+[5]*exp(-(x-[1])/[6]))



TMath::Freq((x-[1]-[2])/[3])*(x-[1])/[4]/[4]*(exp(-(x-[1])/[4])+[5]*exp(-(x-[1])/[6]))



Lv1 waveform

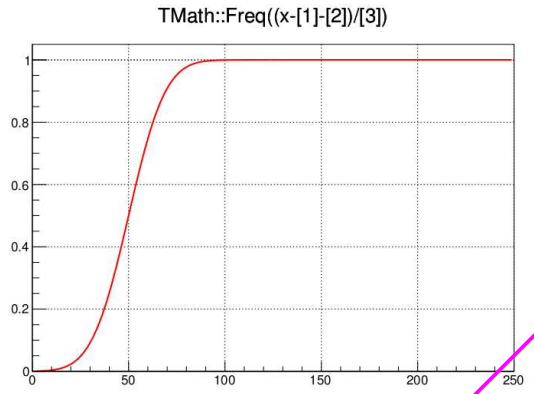
$$V(t) = \mathrm{N}\ \mathrm{Freq}\left[\frac{t-(t_0+t_d)}{\tau_r}\right]\frac{t-t_0}{\tau_1^2}\left(\exp\left[\frac{-(t-t_0)}{\tau_1}\right]+\ \varepsilon\exp\left[\frac{-(t-t_0)}{\tau_2}\right]\right)$$

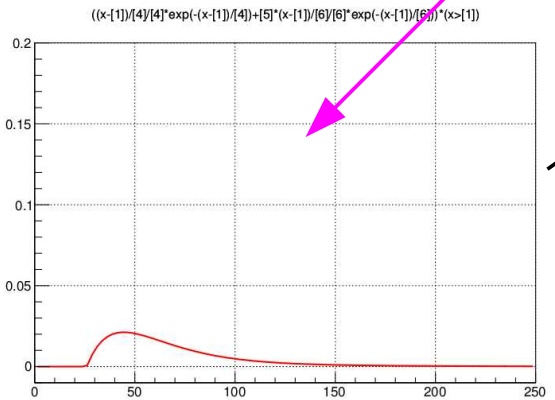
Model: yamazaki

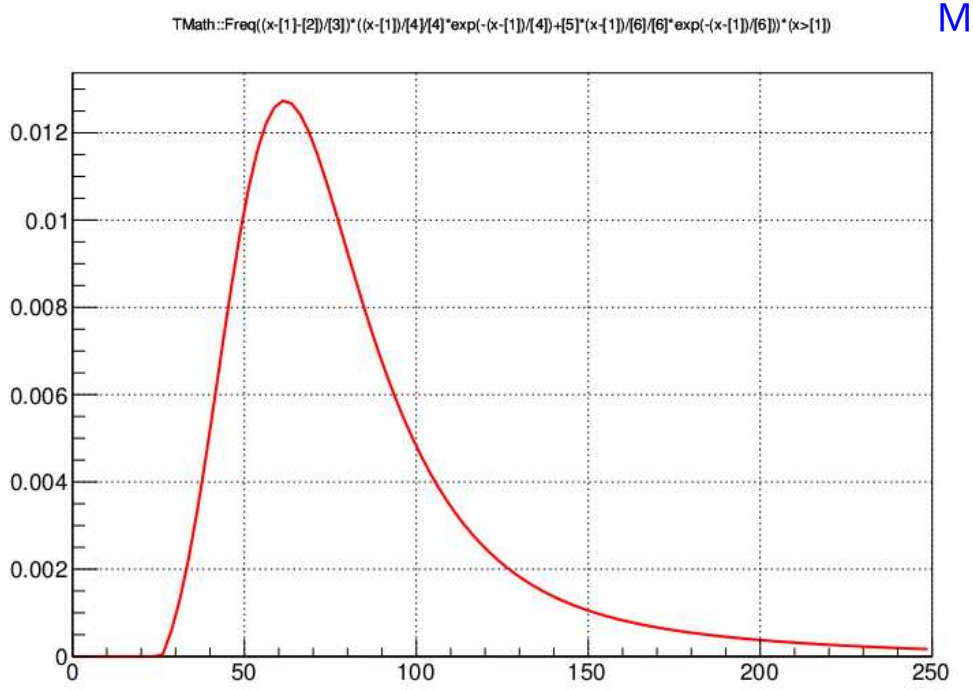
$$V(t) = \mathrm{N}\ \mathrm{Freq}\left[\frac{t-(t_0+t_d)}{\tau_r}\right]\left\{\frac{t-t_0}{\tau_1^2}\exp\left[\frac{-(t-t_0)}{\tau_1}\right]+\ \varepsilon\ \frac{t-t_0}{\tau_2^2}\exp\left[\frac{-(t-t_0)}{\tau_2}\right]\right\}$$

$(t > t_0)$

Model: ito





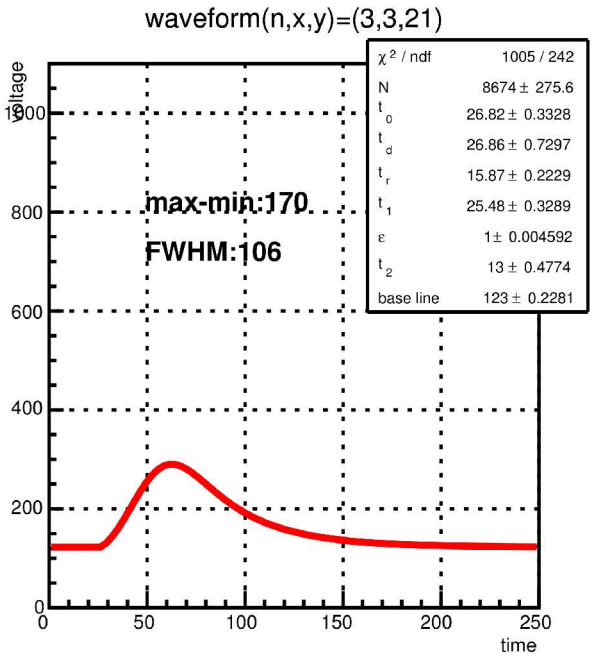


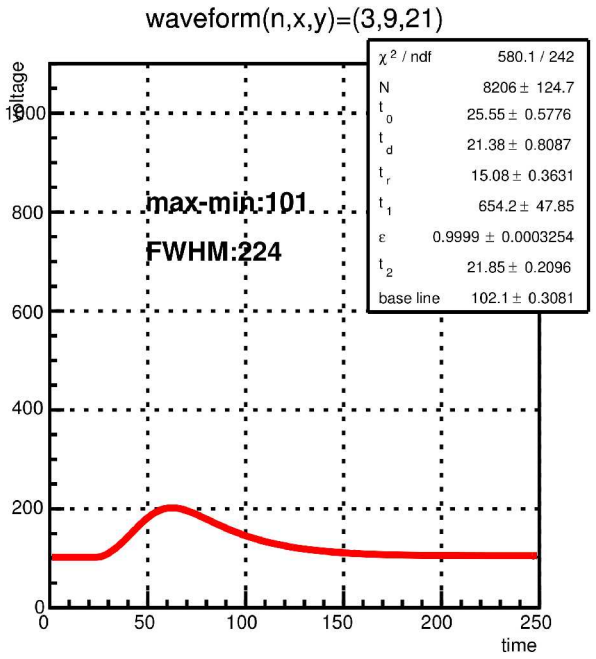
Lv1 waveform

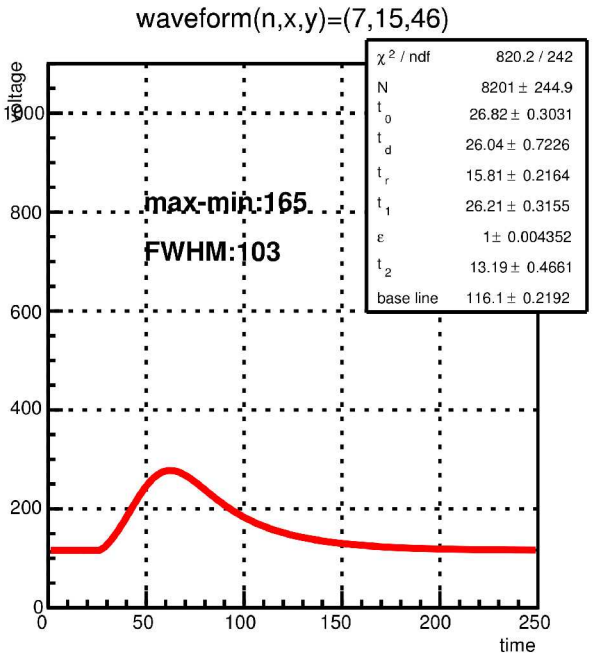
Model: ito

$$V(t) = \mathrm{N}\ \mathrm{Freq}\left[\frac{t-(t_0+t_d)}{\tau_r}\right]\left\{\frac{t-t_0}{\tau_1^2}\exp\left[\frac{-(t-t_0)}{\tau_1}\right]+\varepsilon\ \frac{t-t_0}{\tau_2^2}\exp\left[\frac{-(t-t_0)}{\tau_2}\right]\right\}$$

$(t > t_0)$





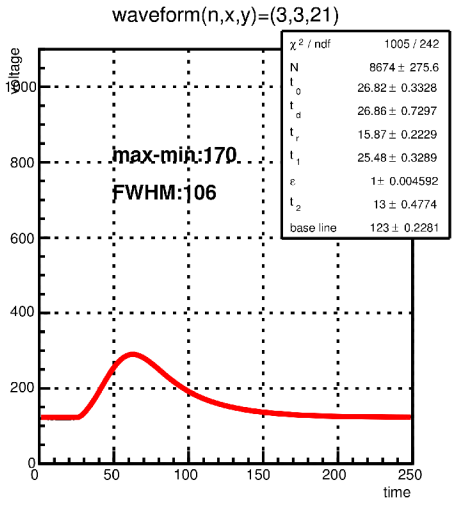


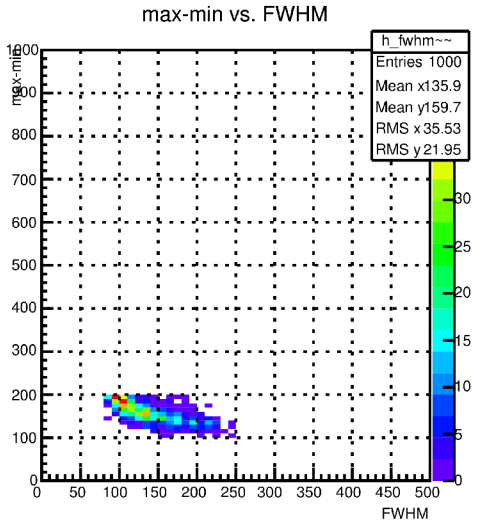
Lv1 waveform

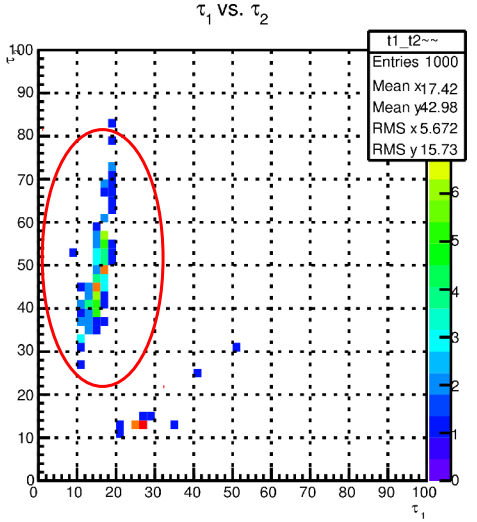
Model: ito

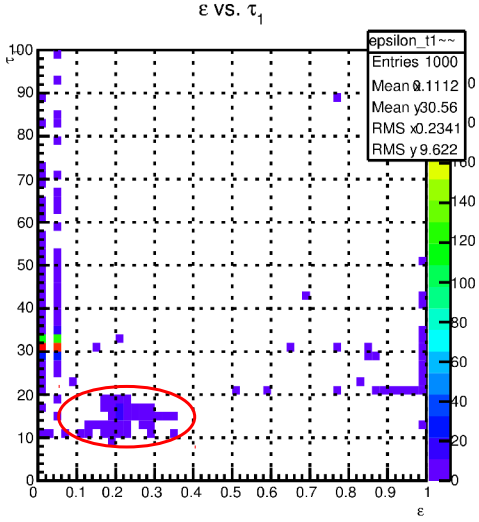
$$V(t) = \mathrm{N}\ \mathrm{Freq}\left[\frac{t-(t_0+t_d)}{\tau_r}\right]\left\{\frac{t-t_0}{\tau_1^2}\exp\left[\frac{-(t-t_0)}{\tau_1}\right]+\varepsilon\ \frac{t-t_0}{\tau_2^2}\exp\left[\frac{-(t-t_0)}{\tau_2}\right]\right\}$$

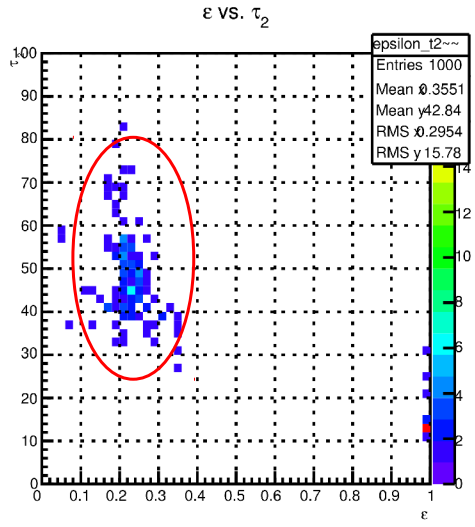
$(t > t_0)$

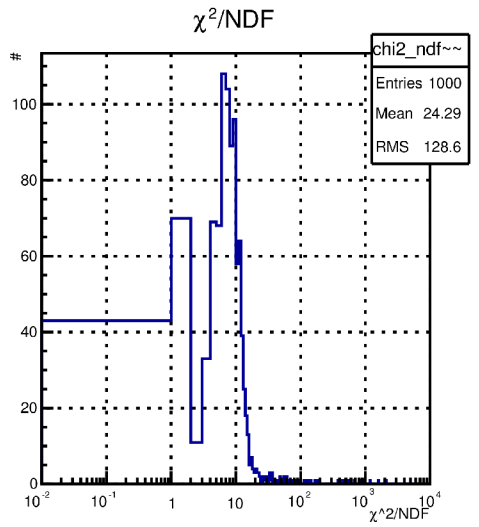


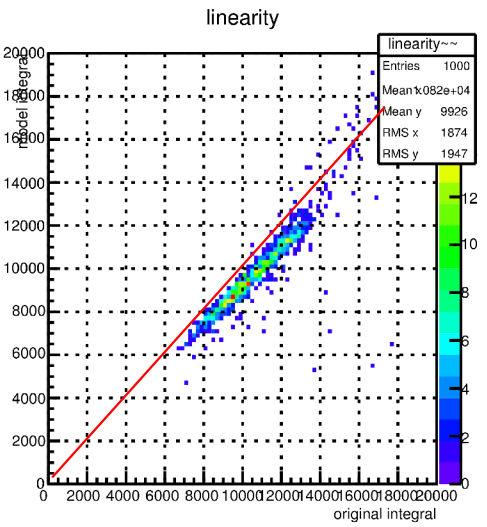












result

$(\tau_1, \tau_2) = (17,42)$

$\varepsilon \sim 0.22$

χ^2/NDF: mean 24

linearity: under the line

Conclusion

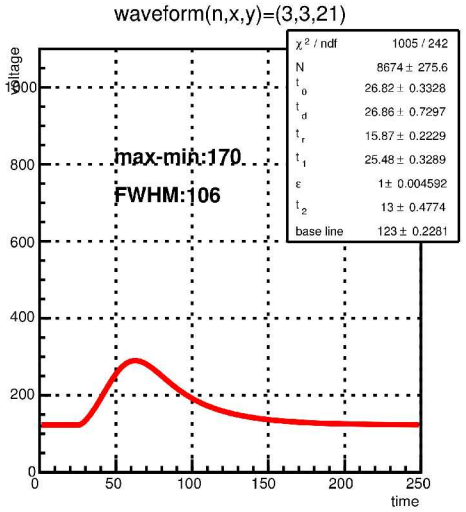
Pulse height vs. FWHM
　　$h \propto 1/\mathrm{FWHM}$

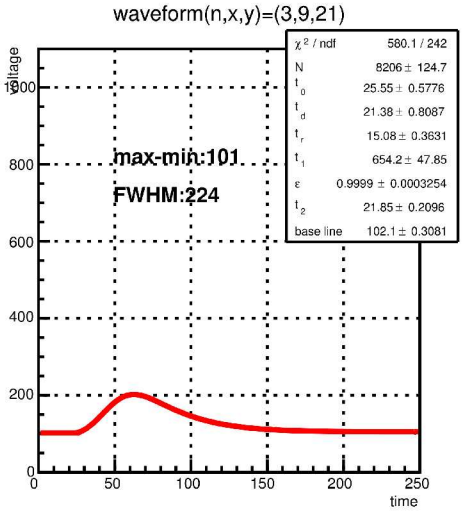
Level 1 waveform analysis
　　Yamazaki model → Ito Model
　　$(\tau 1, \tau 2)=(17,42)$ ← Fixed!
　　$\varepsilon = 0.22$
　　Linearity: so so, under the line
　　$\chi 2/\mathrm{NDF} = 24$ @mean

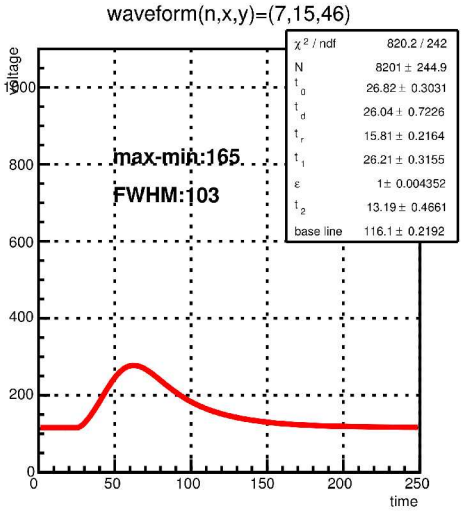
Next work

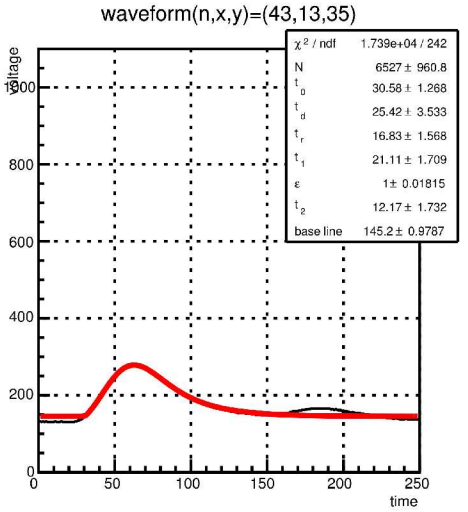
1. Level 2 and 3 waveform analysis
　　Ito Model Fitting
2. Confirm linearity on single-wave events in Level 1
3. improving Ito Model
4. Applying Multi pulse event

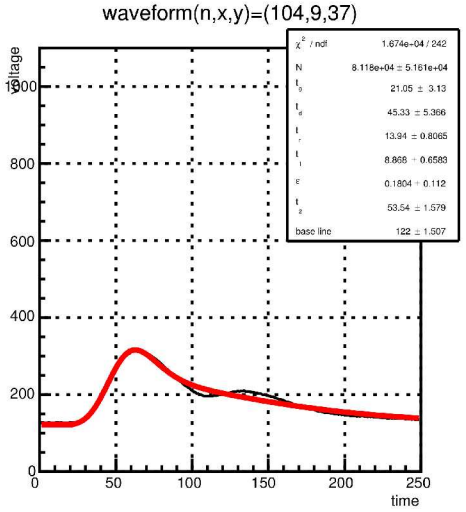
Buck up

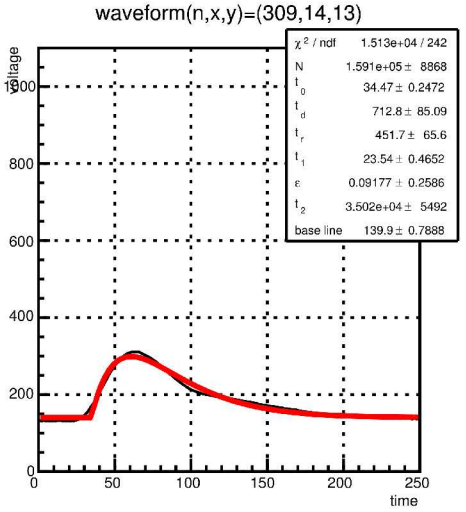

waveform(n,x,y)=(3,3,21)
max-min:170
FWHM:106
χ² / ndf 1005 / 242
N 8674 ± 275.6
t0 26.82 ± 0.3328
td 26.86 ± 0.7297
tr 15.87 ± 0.2229
t1 25.48 ± 0.3289
ε 1 ± 0.004592
t2 13 ± 0.4774
base line 123 ± 0.2281
voltage
time

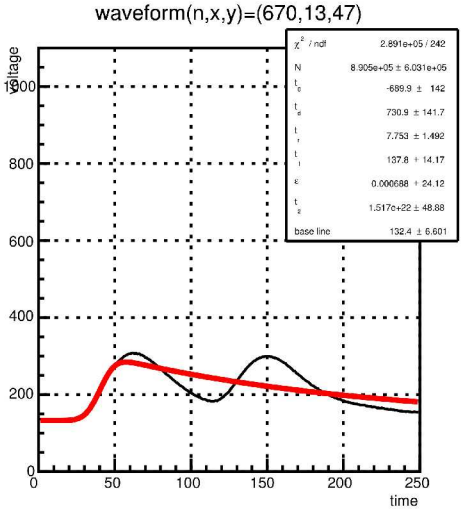

waveform(n,x,y)=(3,9,21)
max-min:101
FWHM:224
χ² / ndf 580.1 / 242
N 8206 ± 124.7
t0 25.55 ± 0.5776
td 21.38 ± 0.8087
tr 15.08 ± 0.3631
t1 654.2 ± 47.85
ε 0.9999 ± 0.0003254
t2 21.85 ± 0.2096
base line 102.1 ± 0.3081
voltage
time

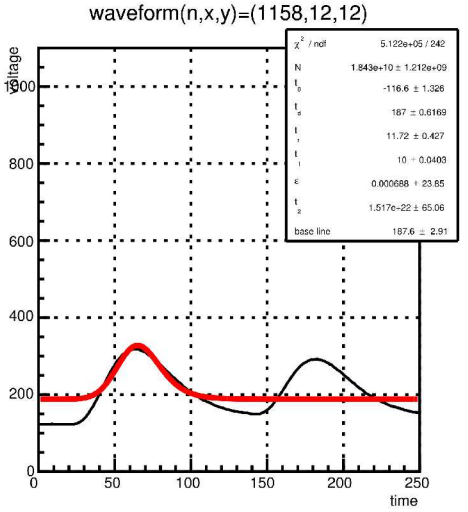

waveform(n,x,y)=(7,15,46)
max-min:165
FWHM:103
χ² / ndf 820.2 / 242
N 8201 ± 244.9
t0 26.82 ± 0.3031
td 26.04 ± 0.7226
tr 15.81 ± 0.2164
t1 26.21 ± 0.3155
ε 1 ± 0.004352
t2 13.19 ± 0.4661
base line 116.1 ± 0.2192
voltage
time


waveform(n,x,y)=(43,13,35)
χ² / ndf 1.739e+04 / 242
N 6527 ± 960.8
t0 30.58 ± 1.268
td 25.42 ± 3.533
tr 16.83 ± 1.568
t1 21.11 ± 1.709
ε 1 ± 0.01815
t2 12.17 ± 1.732
base line 145.2 ± 0.9787
voltage
time


waveform(n,x,y)=(104,9,37)
χ² / ndf 1.674e-04 / 242
N 8.118e+04 ± 5.161e+04
t0 21.05 ± 3.13
td 45.33 ± 5.366
tr 13.94 ± 0.8065
t1 8.868 ± 0.6583
ε 0.1804 ± 0.112
t2 53.54 ± 1.579
base line 122 ± 1.507
voltage
time


waveform(n,x,y)=(309,14,13)
χ² / ndf 1.513e+04 / 242
N 1.591e+05 ± 8868
t0 34.47 ± 0.2472
td 712.8 ± 85.09
tr 451.7 ± 65.6
t1 23.54 ± 0.4652
ε 0.09177 ± 0.2586
t2 3.502e+04 ± 5492
base line 139.9 ± 0.7888
voltage
time


waveform(n,x,y)=(670,13,47)
χ² / ndf 2.891e+05 / 242
N 8.905e+05 ± 6.031e+05
t0 -689.9 ± 142
td 730.9 ± 141.7
tr 7.753 ± 1.492
t1 137.8 ± 14.17
ε 0.000688 ± 24.12
t2 1.517e+22 ± 48.88
base line 132.4 ± 6.601
voltage
time


waveform(n,x,y)=(1158,12,12)
χ² / ndf 5.122e+05 / 242
N 1.843e+10 ± 1.212e+09
t0 -116.6 ± 1.326
td 187 ± 0.6169
tr 11.72 ± 0.427
t1 10 ± 0.0403
ε 0.000688 ± 23.85
t2 1.517e-22 ± 65.06
base line 187.6 ± 2.91
voltage
time