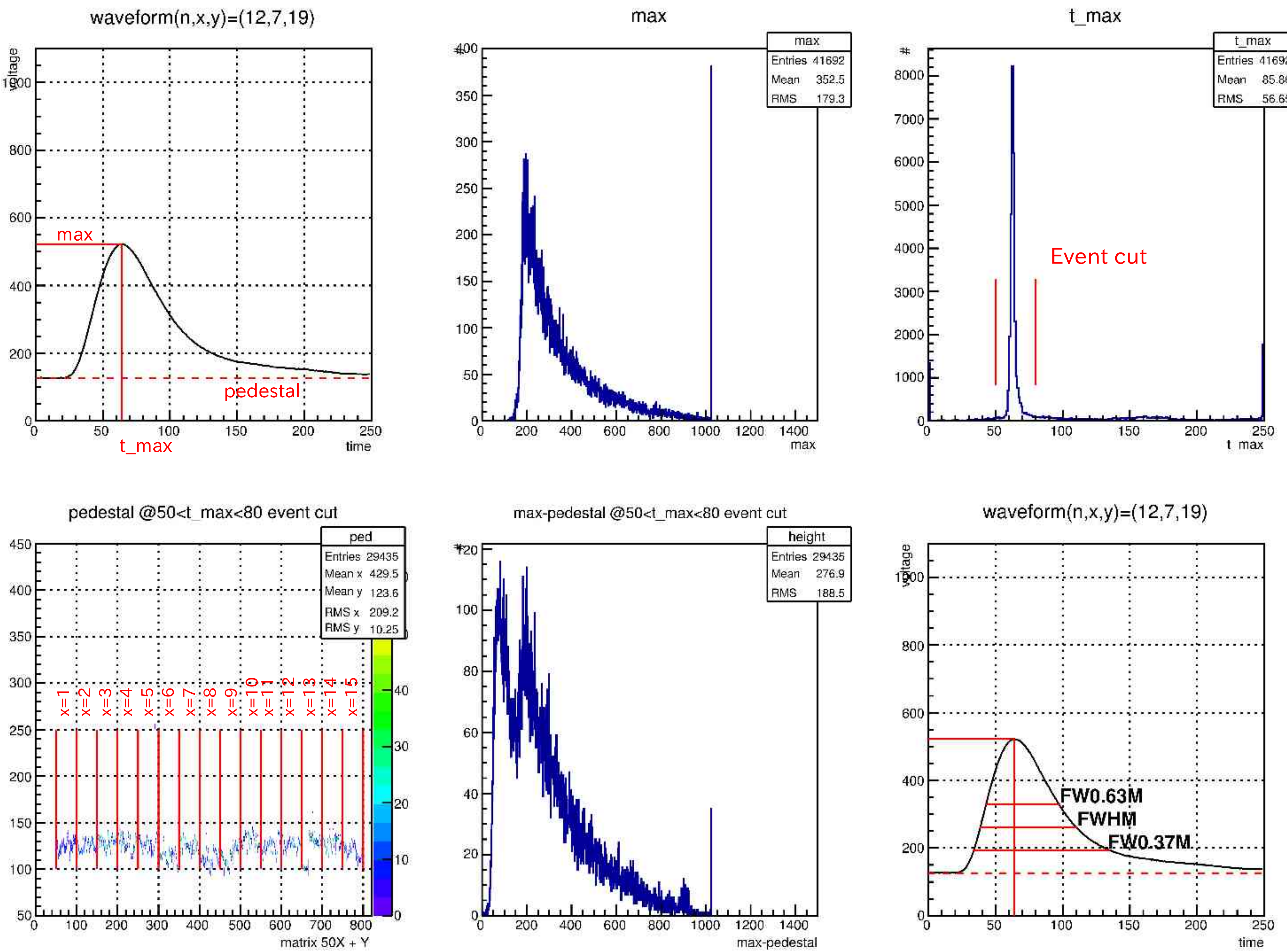
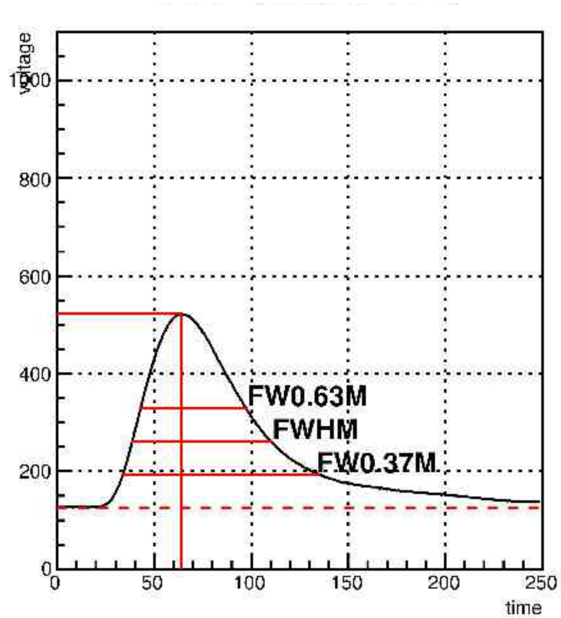
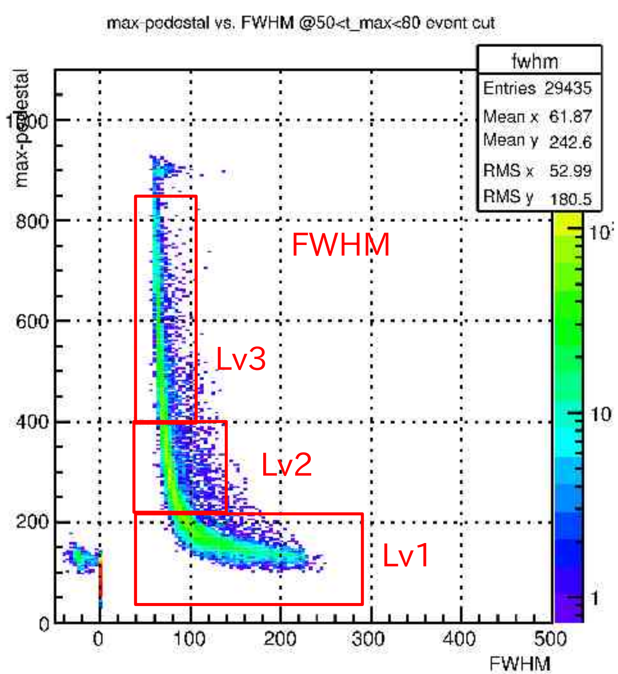
CsI Photon Detector Waveform Analysis

2015/09/08

H. Ito


waveform(n,x,y)=(12,7,19)
voltage
time
max
t_max
pedestal
max
Entries 41692
Mean 352.5
RMS 179.3
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
x=1 x=2 x=3 x=4 x=5 x=6 x=7 x=8 x=9 x=10 x=11 x=12 x=13 x=14 x=15
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)
FW0.63M
FWHM
FW0.37M

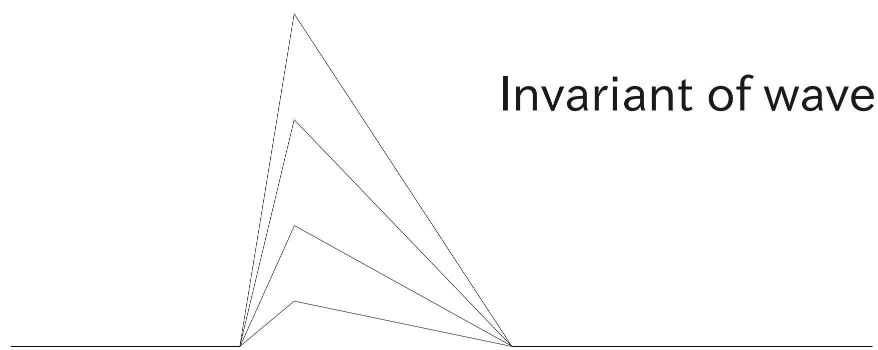




First Motivation: decision of function model

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

Expected waveform



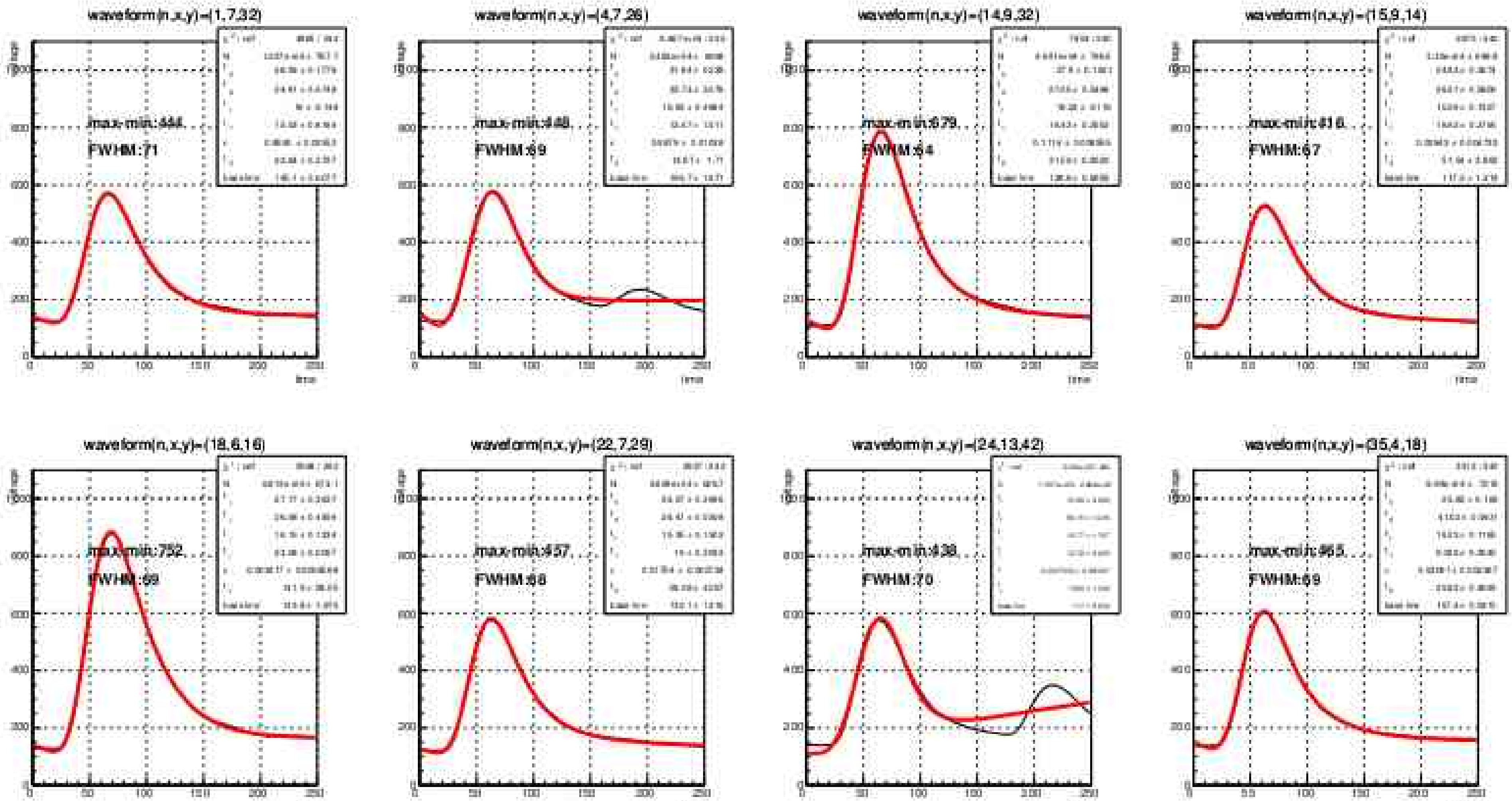
Invariant of wave width

1. Simple Analysis
→ Level 3 waveform fitting

Lv3 waveform

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

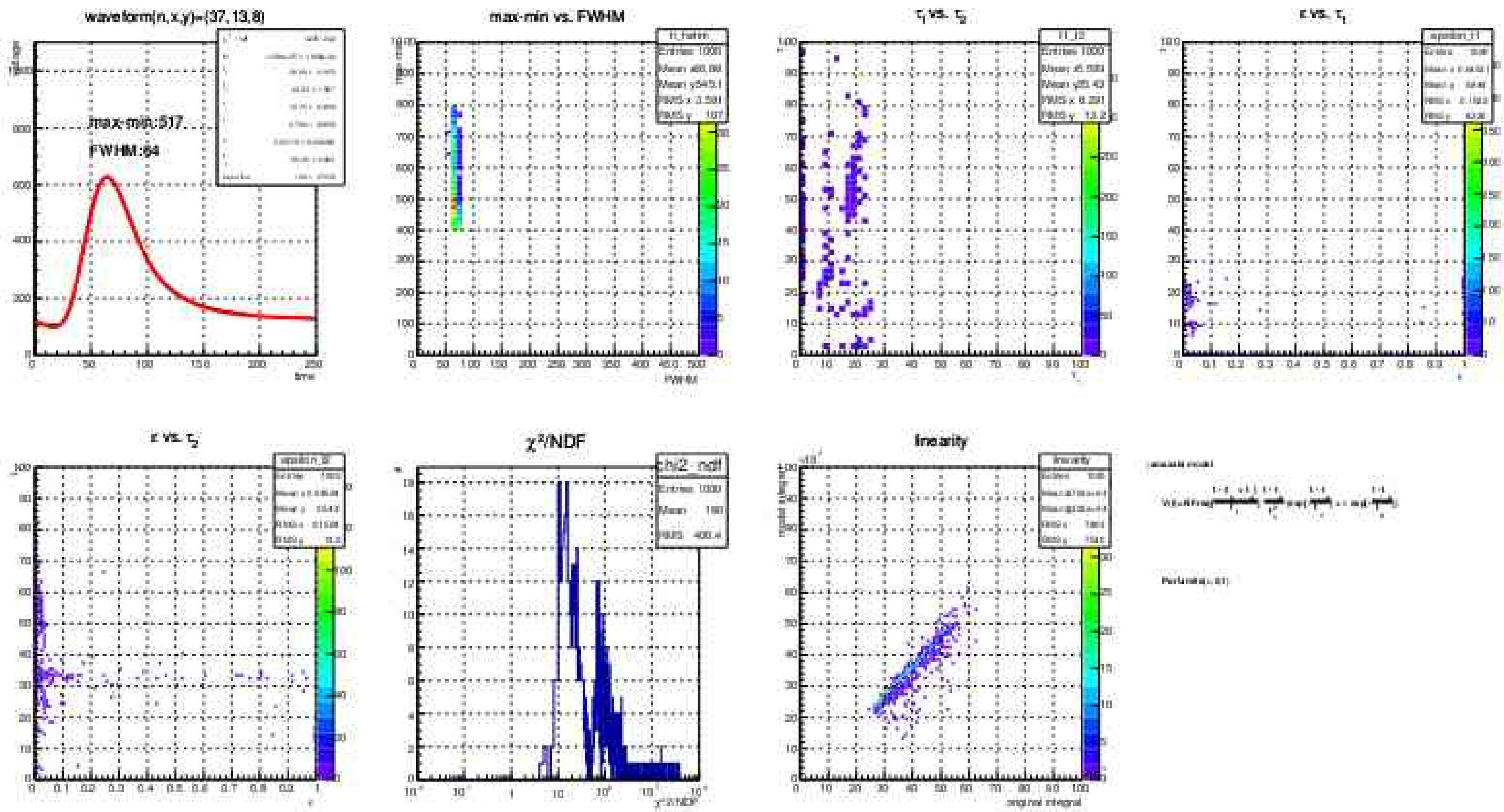
Model: yamazaki



Lv3 waveform

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

Model: yamazaki

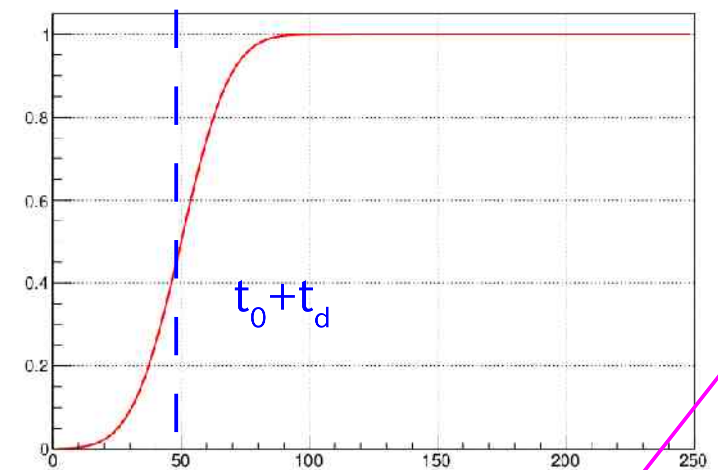


Lv3 waveform

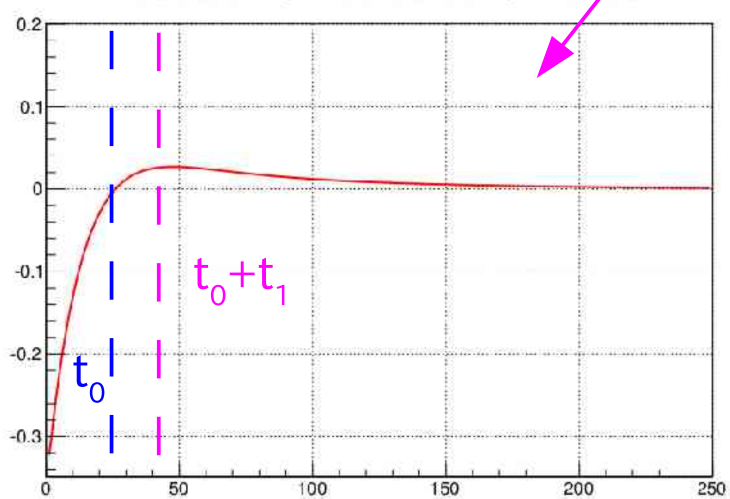
$$V(t) = N \, \mathrm{Freq}\left[\frac{t-(t_0+t_d)}{\tau_r}\right] \frac{t-t_0}{\tau_1^2}\left(\exp\left[\frac{-(t-t_0)}{\tau_1}\right] + \varepsilon \exp\left[\frac{-(t-t_0)}{\tau_2}\right]\right)$$

Model: yamazaki

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



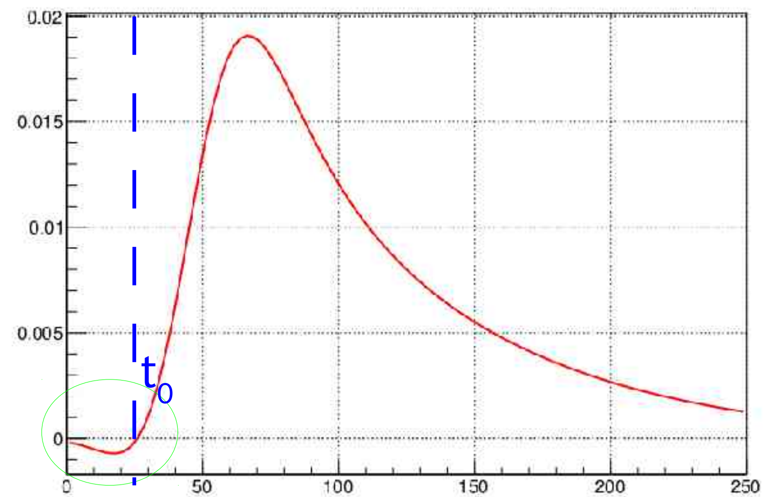
(x-[1])/[4]/[4]*(exp(-(x-[1])/[4])+[5]*exp(-(x-[1])/[6]))



Parameters

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

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



Lv3 waveform

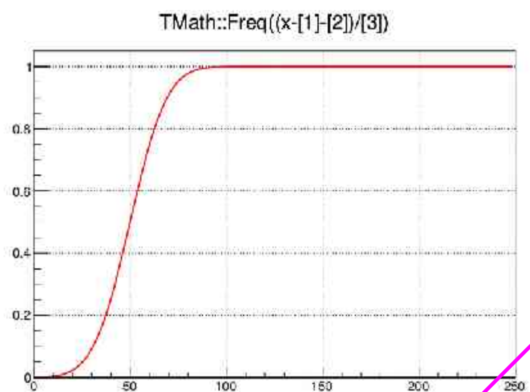
$$V(t) = \mathrm{N}\ \mathrm{Freq}\left[\frac{t-(t_0+t_d)}{\tau_r}\right]\frac{t-t_0}{\tau_1^2}\left(\exp\left[\frac{-(t-t_0)}{\tau_1}\right] + \varepsilon\exp\left[\frac{-(t-t_0)}{\tau_2}\right]\right)$$

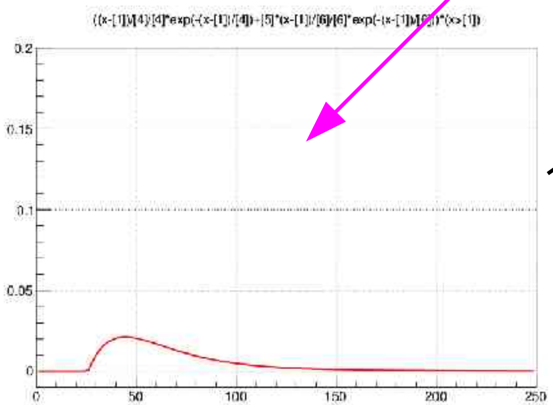
Model: yamazaki

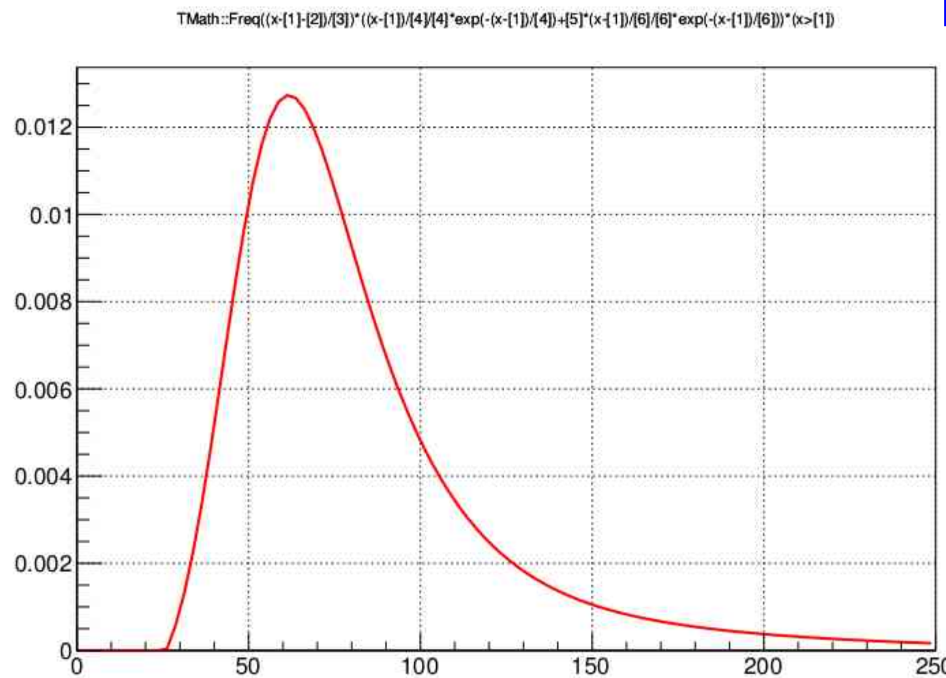
$$V(t) = \mathrm{N}\ \mathrm{Freq}\left[\frac{t-(t_0+t_d)}{\tau_r}\right]\left\{\frac{t-t_0}{\tau_1^2}\exp\left[\frac{-(t-t_0)}{\tau_1}\right] + \varepsilon\frac{t-t_0}{\tau_2^2}\exp\left[\frac{-(t-t_0)}{\tau_2}\right]\right\}$$

$(t > t_0)$

Model: ito





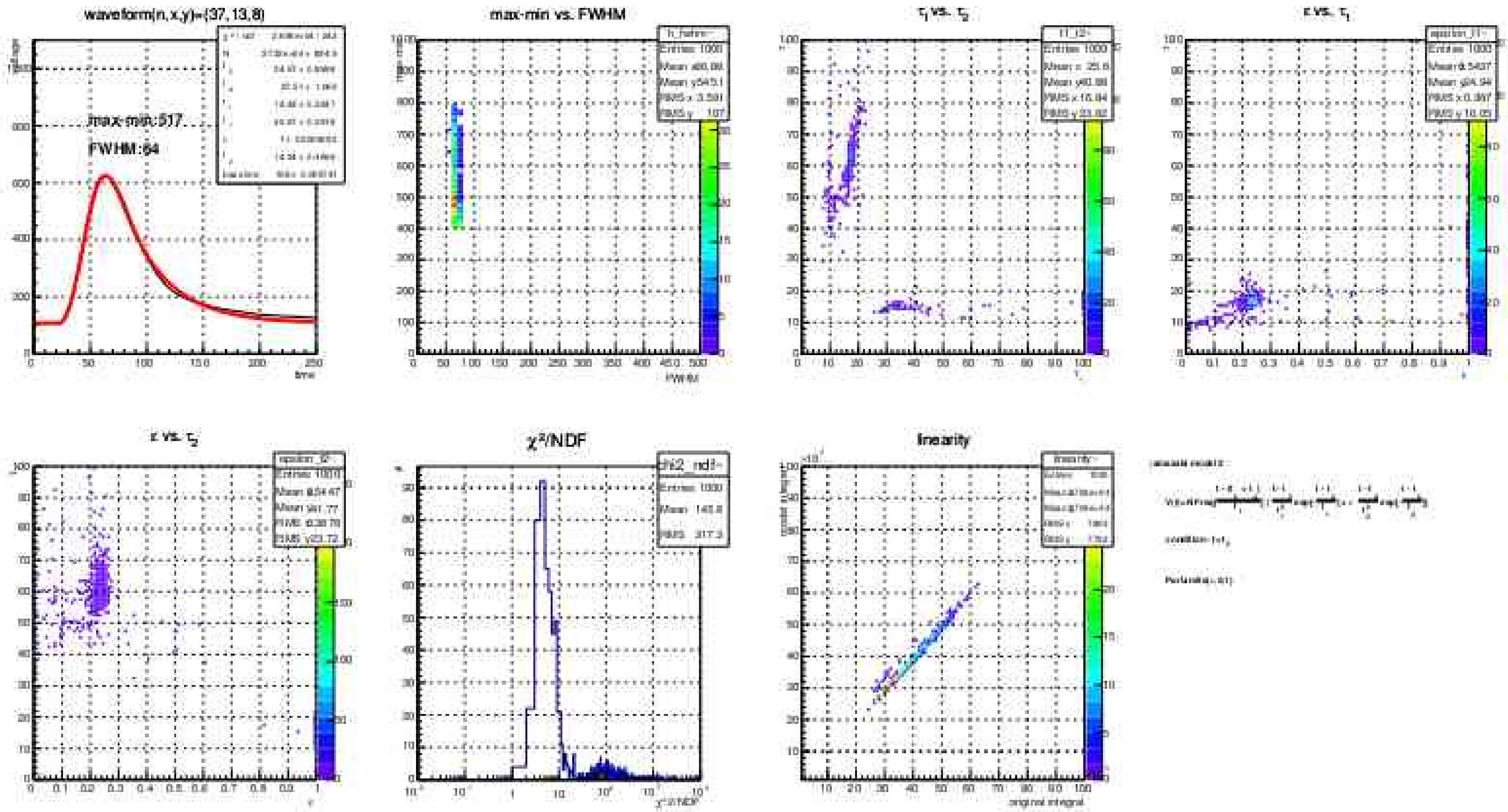


Lv3 waveform

Model: ito

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

$(t > t_0)$

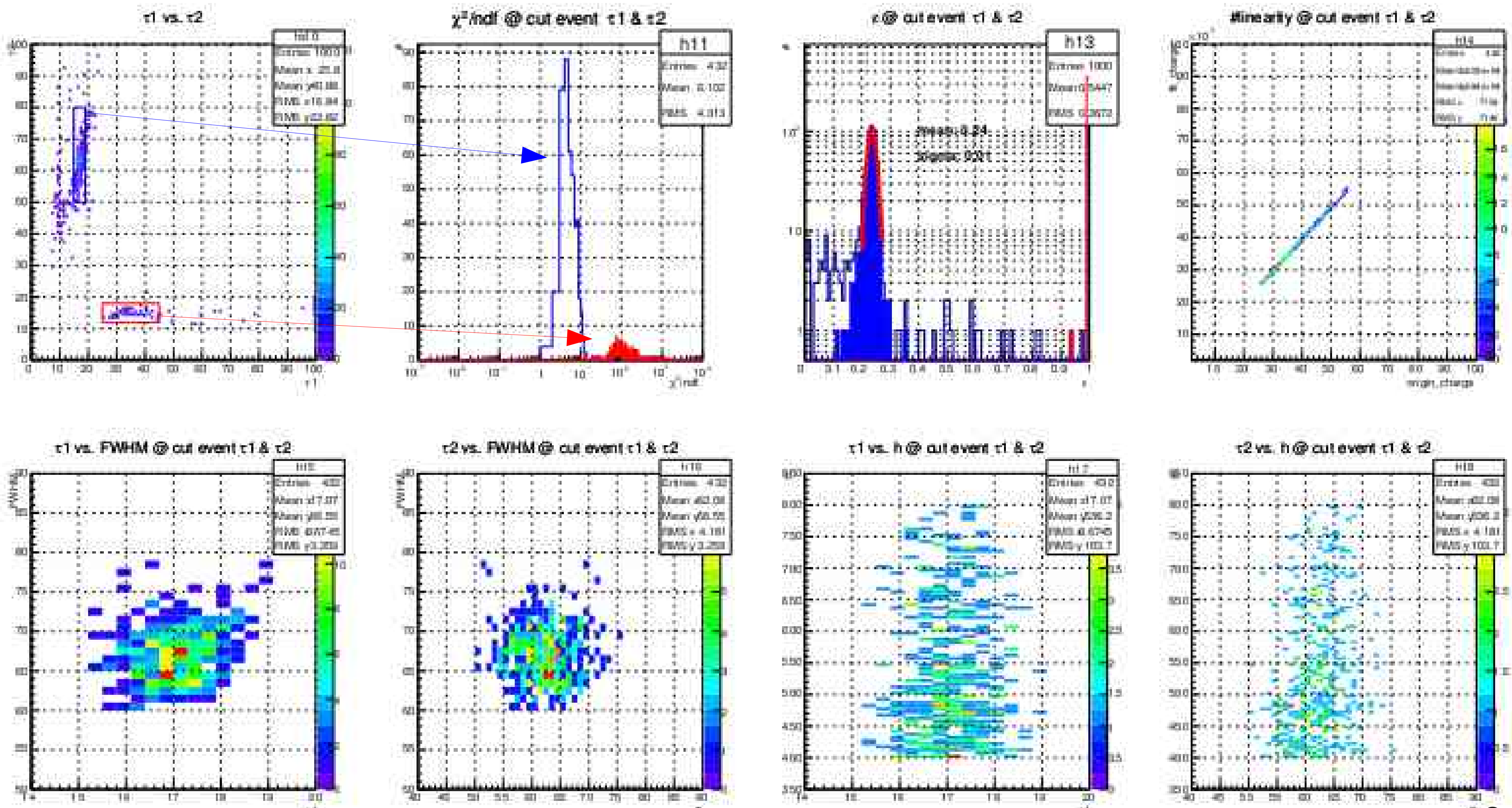


Lv3 waveform

Model: ito

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

$(t > t_0)$



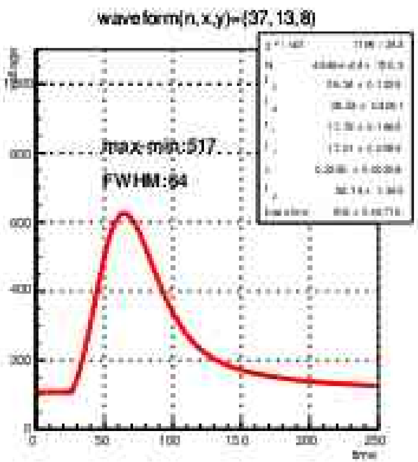
Lv3 waveform

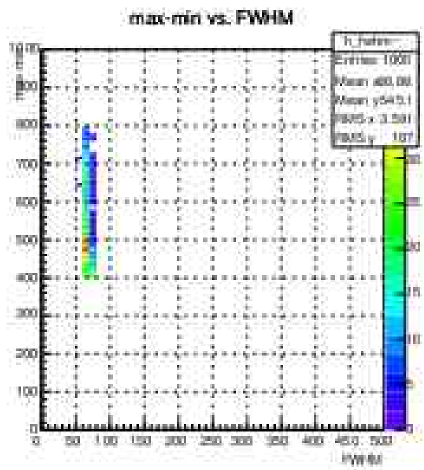
Model: ito

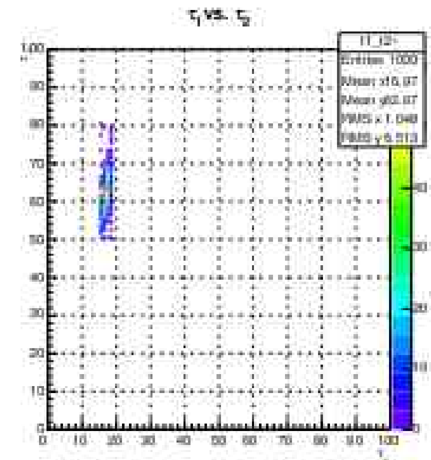
$$V(t) = N\ \mathrm{Freq}\left[\frac{t-(t_0+t_d)}{\tau_r}\right]\left\{\frac{t-t_0}{\tau_1^2}\exp\left[\frac{-(t-t_0)}{\tau_1}\right] + \varepsilon\ \frac{t-t_0}{\tau_2^2}\exp\left[\frac{-(t-t_0)}{\tau_2}\right]\right\}$$

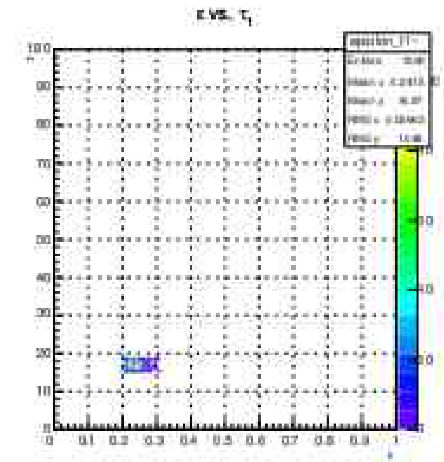
$(t > t_0)$

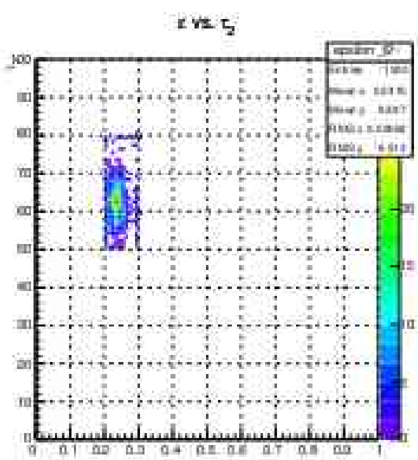
$14 < \tau_1 < 19$
$50 < \tau_2 < 80$
$0.2 < \varepsilon < 0.3$

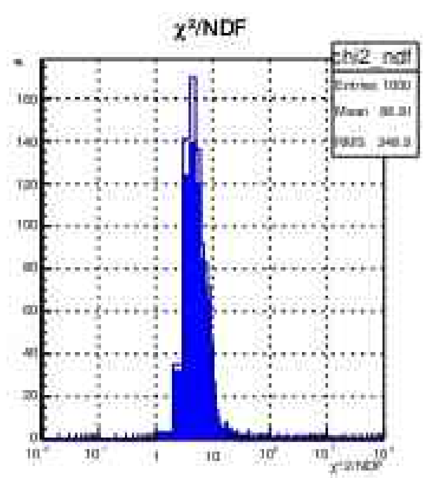


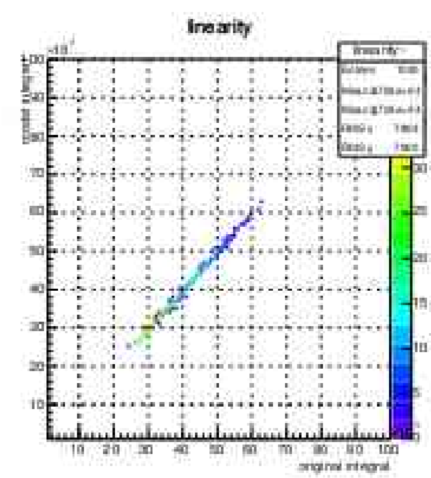












Result

$\tau_1 = 17.07$
$\tau_2 = 62.08$
$\varepsilon = 0.24$

$\chi^2/ndf = 6.1$ @ good model

Conclusion

Pulse height vs. FWHM
　h∝1/FWHM?

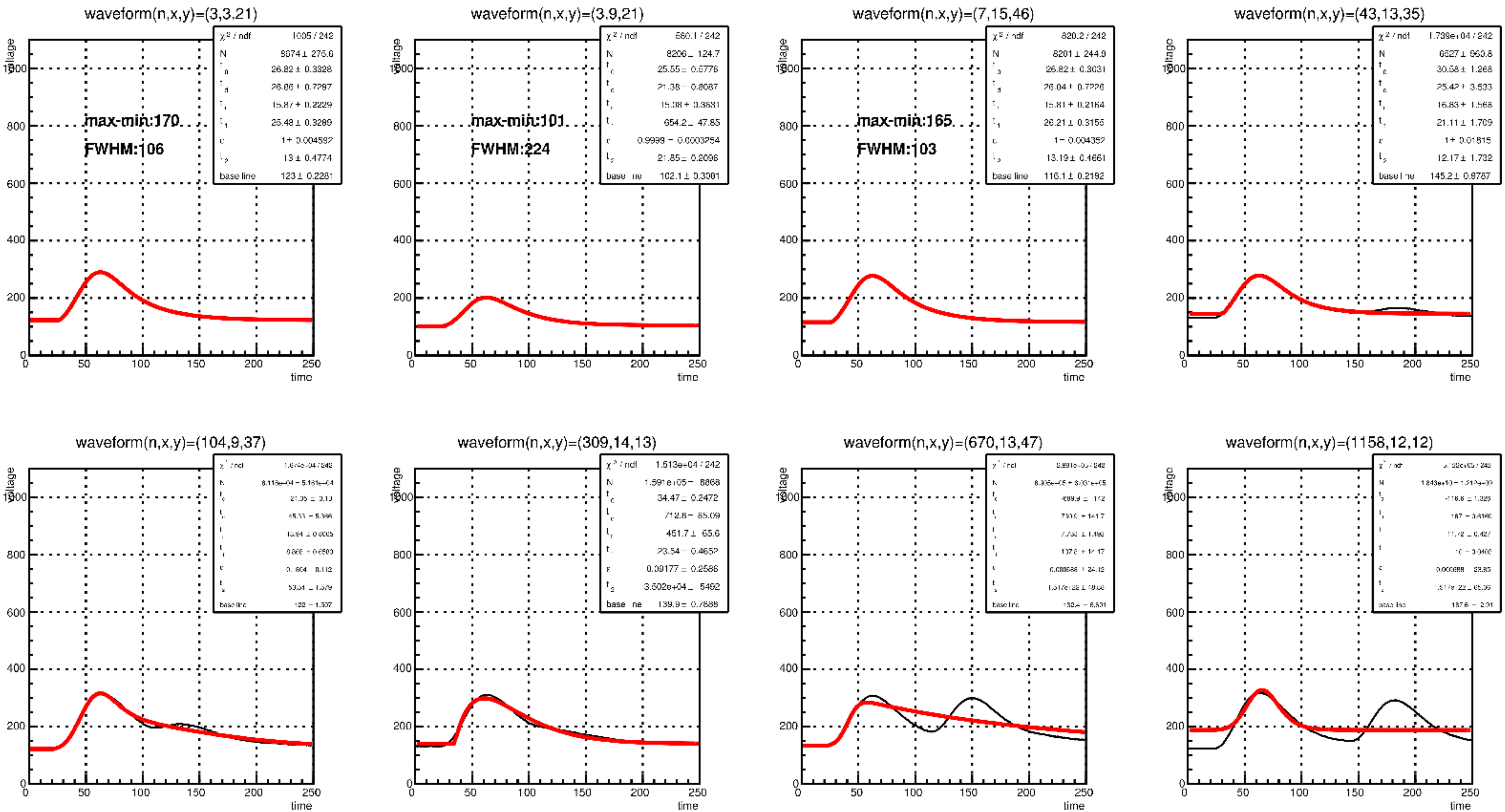
Level 3 waveform analysis
　Yamazaki model → Ito Model
　$\tau_1 = 17.07 \pm 0.67$
　$\tau_2 = 62.08 \pm 4.18$
　$\varepsilon = 0.24 \pm 0.01$
　$\chi^2/NDF = 6.1$ @good event
　Linearity: good

} Fixed parameter for the model

Next work

1. How much is the linearity concretely?
2. Decision of main waveform function model
3. Level 1 and 2 waveform analysis
　Ito Model Fitting ← multi-pulse fitting
4. Applying Multi pulse event

Buck up



waveform(n,x,y)=(3,3,21)
max-min:170
FWHM:106
waveform(n,x,y)=(3,9,21)
max-min:101
FWHM:224
waveform(n,x,y)=(7,15,46)
max-min:165
FWHM:103
waveform(n,x,y)=(43,13,35)
waveform(n,x,y)=(104,9,37)
waveform(n,x,y)=(309,14,13)
waveform(n,x,y)=(670,13,47)
waveform(n,x,y)=(1158,12,12)
voltage
time

Buck up

ROOTさんのχ^2検定法について

例

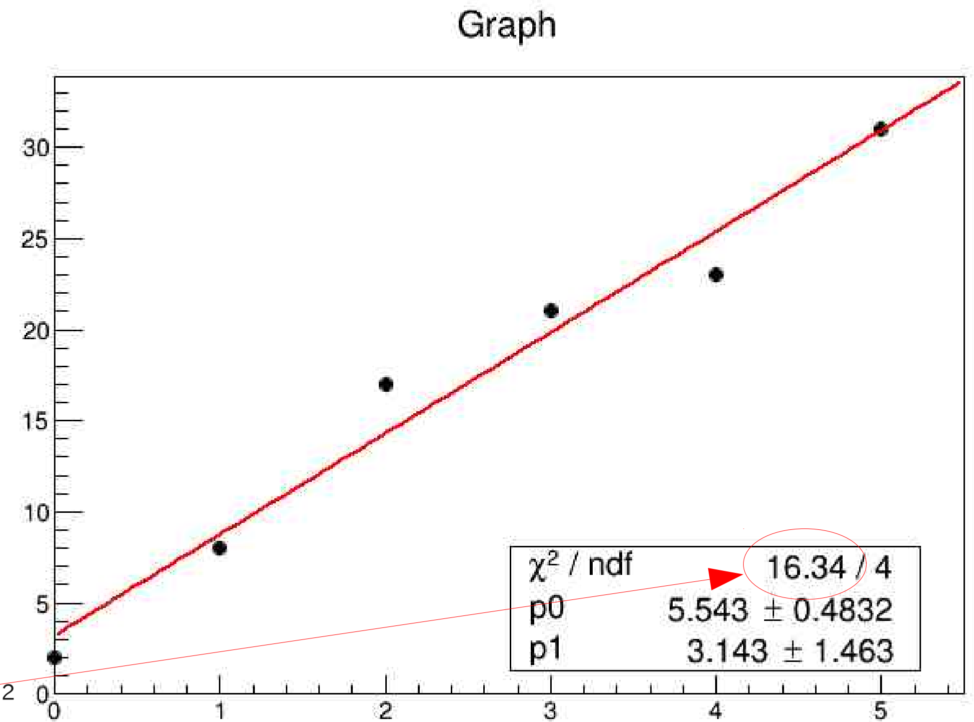
x	0	1	2	3	4	5
y	2	8	17	21	23	31

$$\chi^2 = \sum_x \frac{(f(x) - y(x))^2}{f(x)}$$

$$= \sum_i \frac{(y(x_i; a_1, a_2, \cdots) - y(x_i))^2}{\sigma_i^2}$$

$= (3.143 - 2)^2 + (5.543+3.143 - 8)^2$
$+ (5.543x2+3.143 - 17)^2 + (5.543x3+3.143 - 21)^2$
$+ (5.543x4+3.143 - 23)^2 + (5.543x5+3.143 - 31)^2$

~ 16.34



誤差なしグラフについて、σは
χ^2の計算に入れない
-> というよりも、σ=1ですべて
計算している。

Buck up

ROOTさんのχ^2検定法について

例

x	0	1	2	3	4	5
y	2	8	17	21	23	31
dy	1	2	2	1	3	2

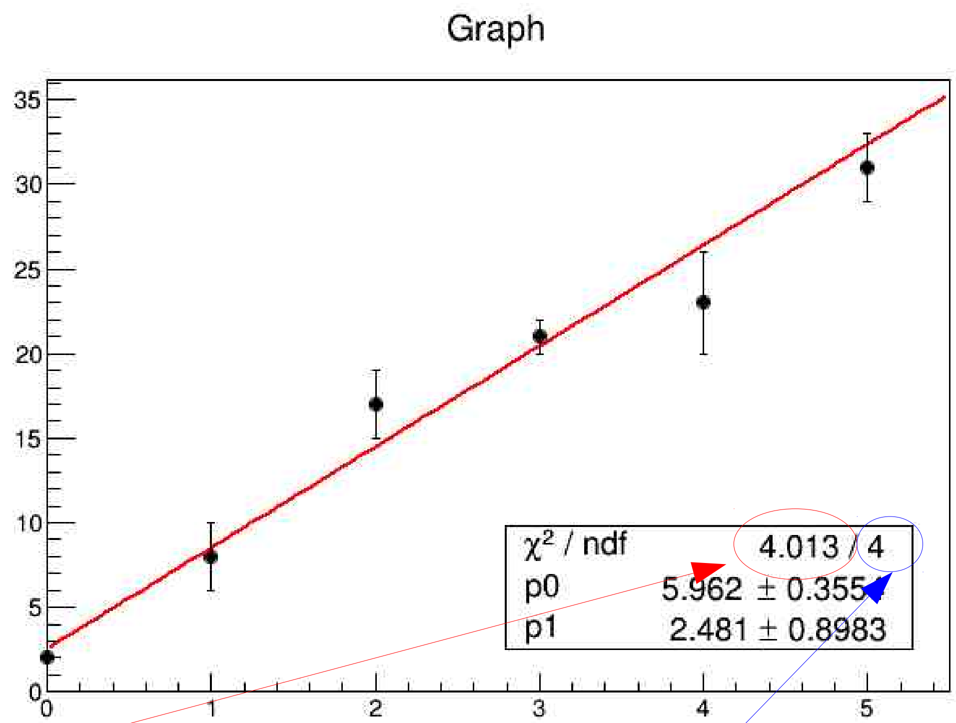
$$\chi^2 = \sum_x \frac{(f(x) - y(x))^2}{f(x)}$$

$$= \sum_i \frac{(y(x_i; a_1, a_2, \cdots) - y(x_i))^2}{\sigma_i^2}$$

誤差ありのグラフでは
σを用いる

$= (2.481 - 2)^2/1^2$
$+ (5.962+2.481 - 8)^2/2^2$
$+ (5.962x2+2.481 - 17)^2/2^2$
$+ (5.962x3+2.481 - 21)^2/1^2$
$+ (5.962x4+2.481 - 23)^2/3^2$
$+ (5.962*5+2.481 - 31)^2/2^2$

~ 4.012



自由度 = グラフの点数 - 関数のパラメータ数