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1. ***Status of the VME based DAQ for the Hjet***
2. ***Evaluation of the Hjet time resolution.***

# VME Based DAQ for the HJet

**Current Status**

- A Prototype is assembled in the Counting Room (Bldg. 1012)
- Alpha source signals in are intensively tested
- Wiener VME Crate was arived but not installed yet.
- We still have no internal trigger.
- DAQ software still need work.

**Know Issues**

- Det. 8 (Ch. 84-95) - Split Gain (permanently)

  Energy resolution 20 keV -> 35 keV (Am)

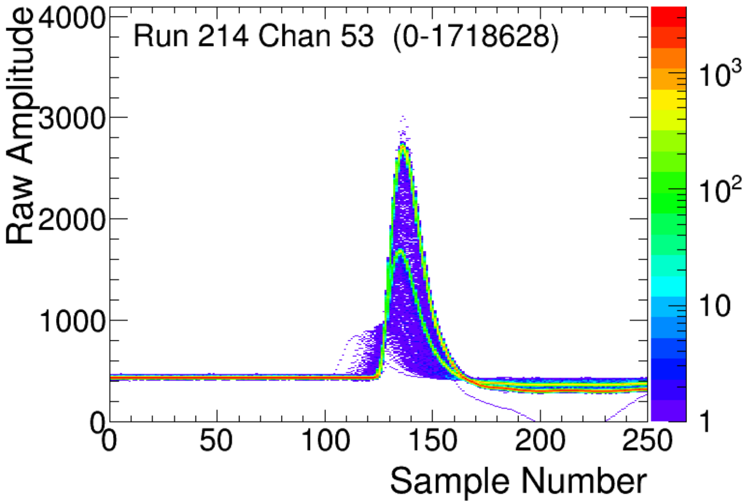
  20 keV -> 25 keV (Gd)
- Det. 5-6 (Ch. 48-71) - Overshoot oscillations (episodically)
- Det. 4 (Ch, 36-47) - Ringing (episodically)
- All detectors (simultaneously) – unstable waveform (episodically)

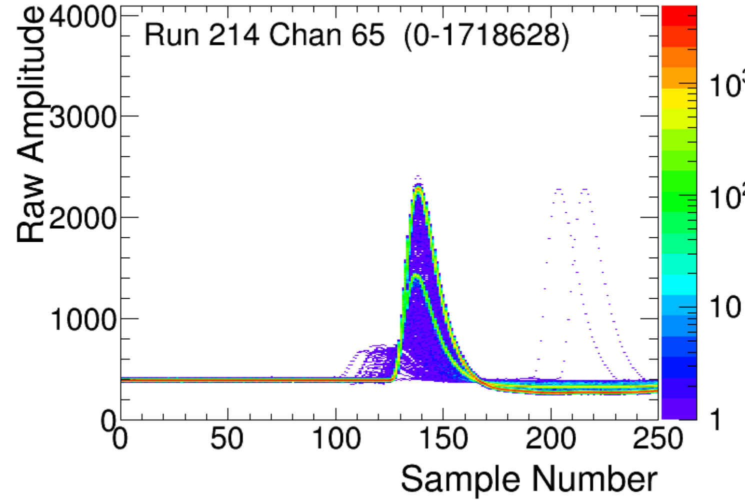
Neither issue is critical for running,

but these are indication of possible instability

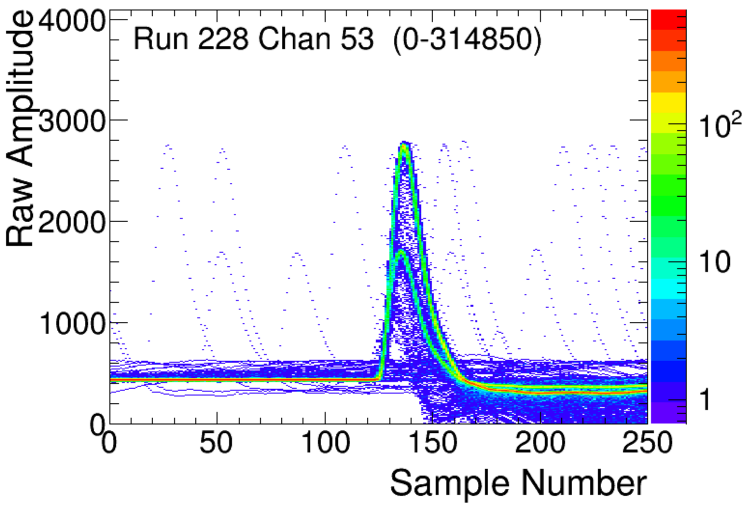
# Detectors 5-6 (Ch. 48-71): High Rate Trigger

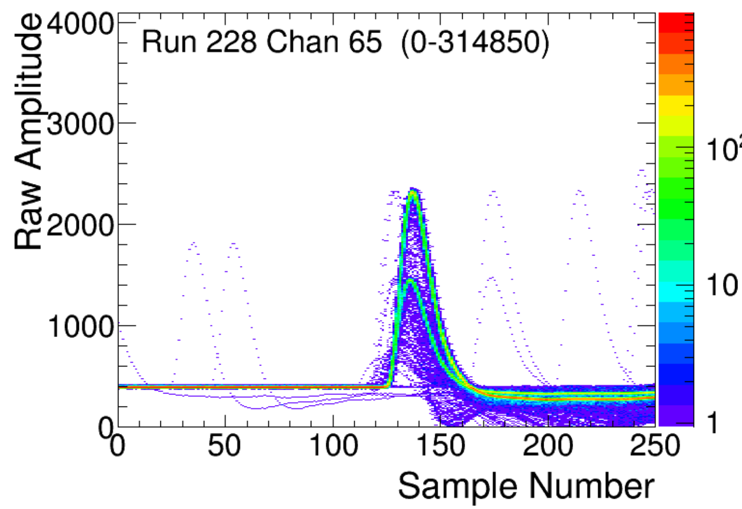
## Good State:



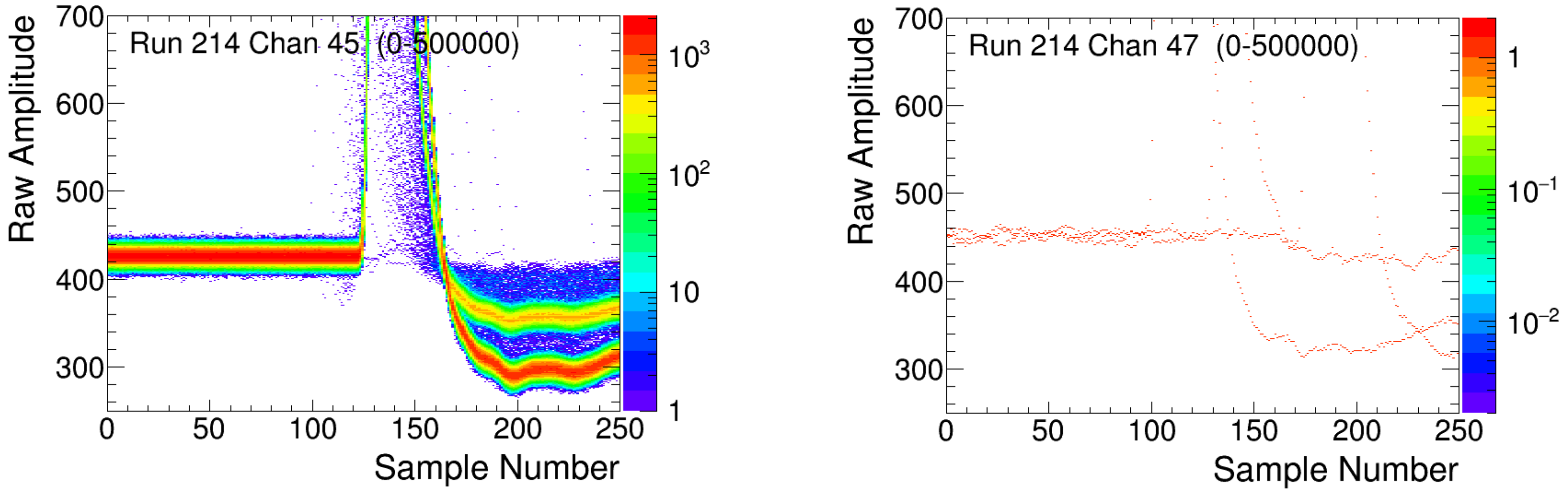

## High Rate Trigger (Trigger is descriminated befor shaping):



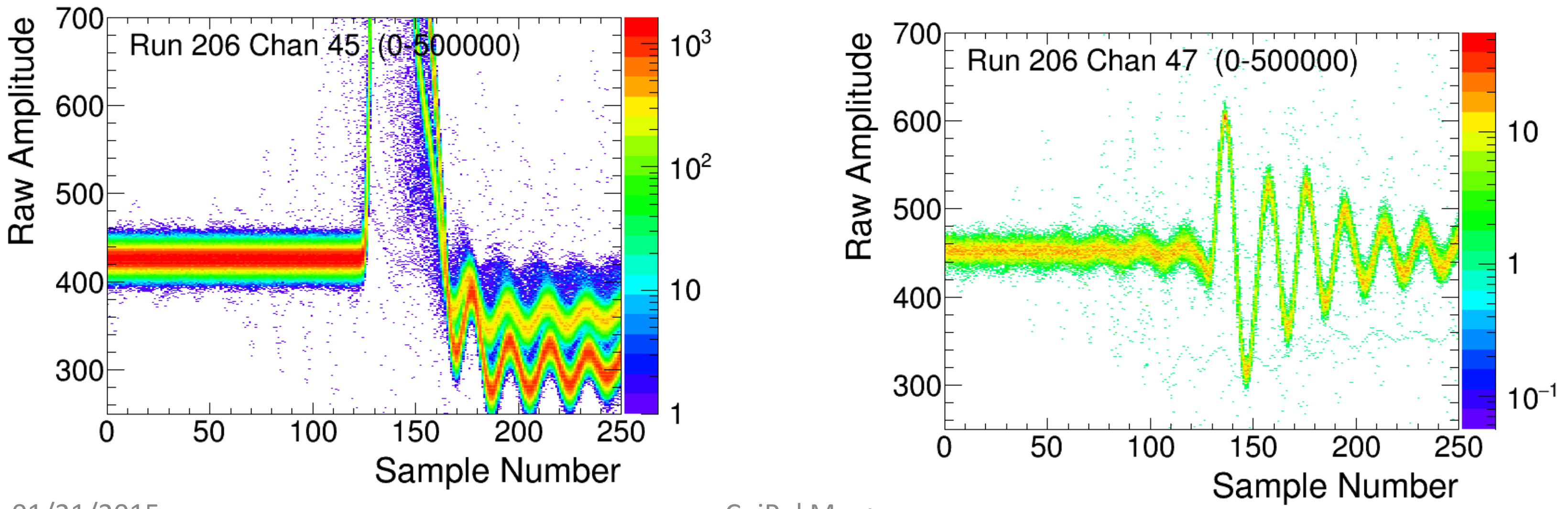



# Detector 4 (Ch. 36-47): Ringing

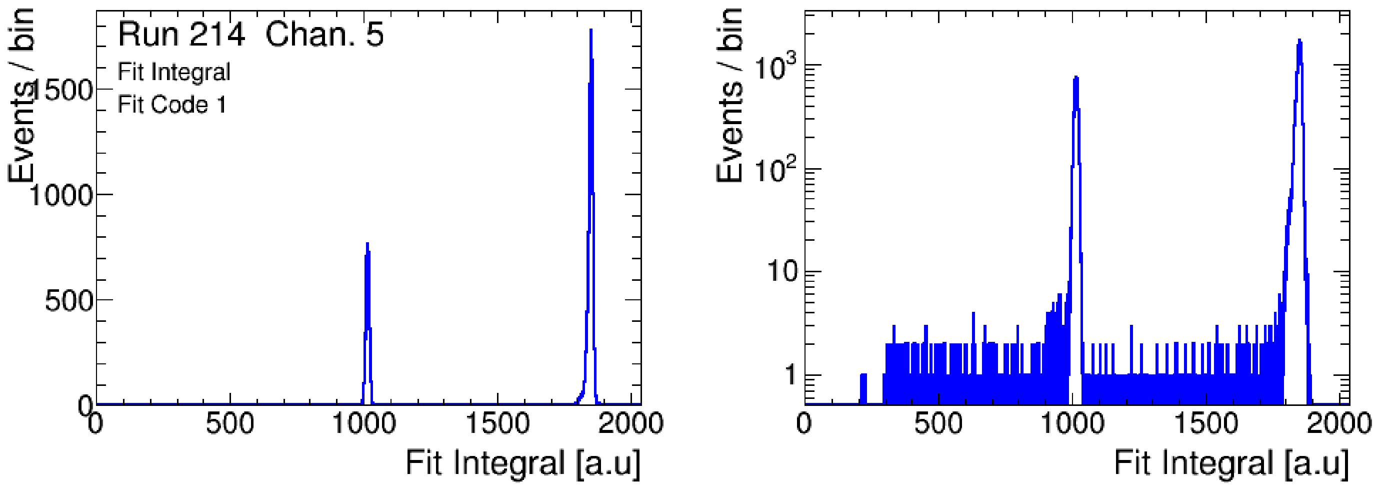
## Good State:

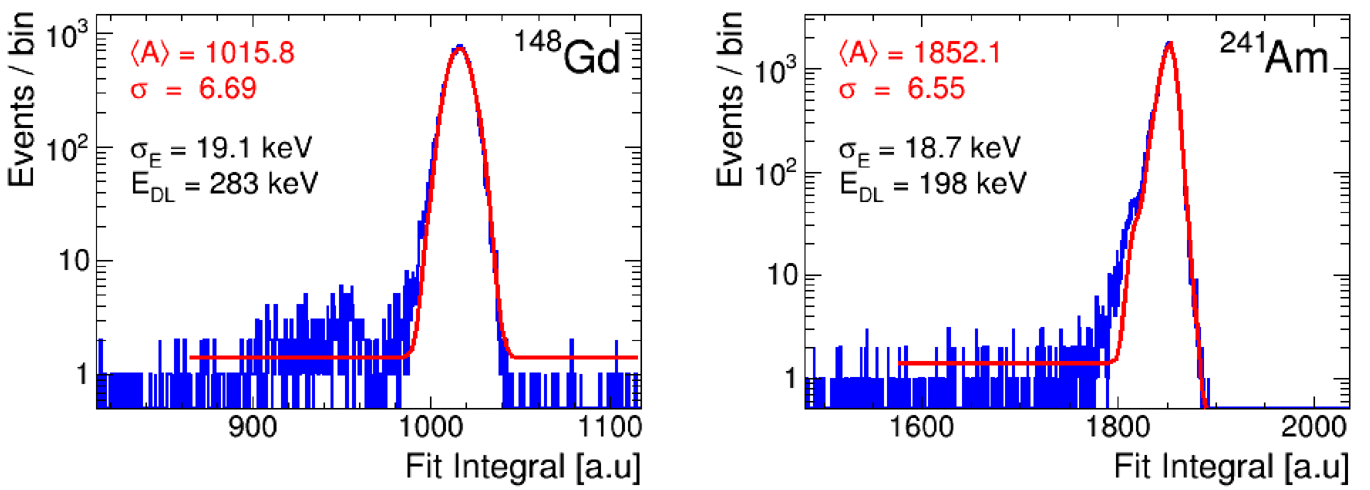



## Ringing State:

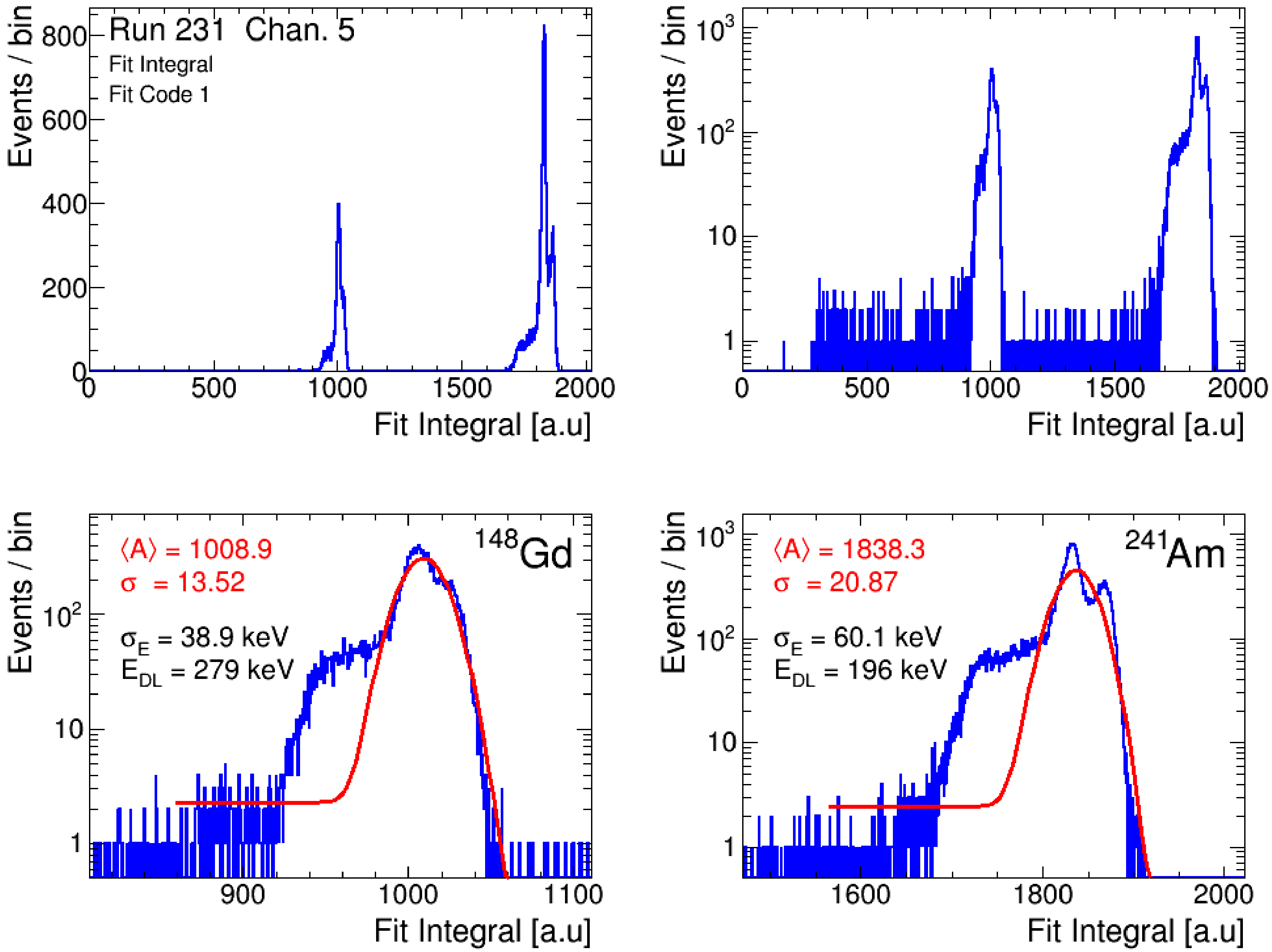


# *Unstable waveform. Run 214. Integral*

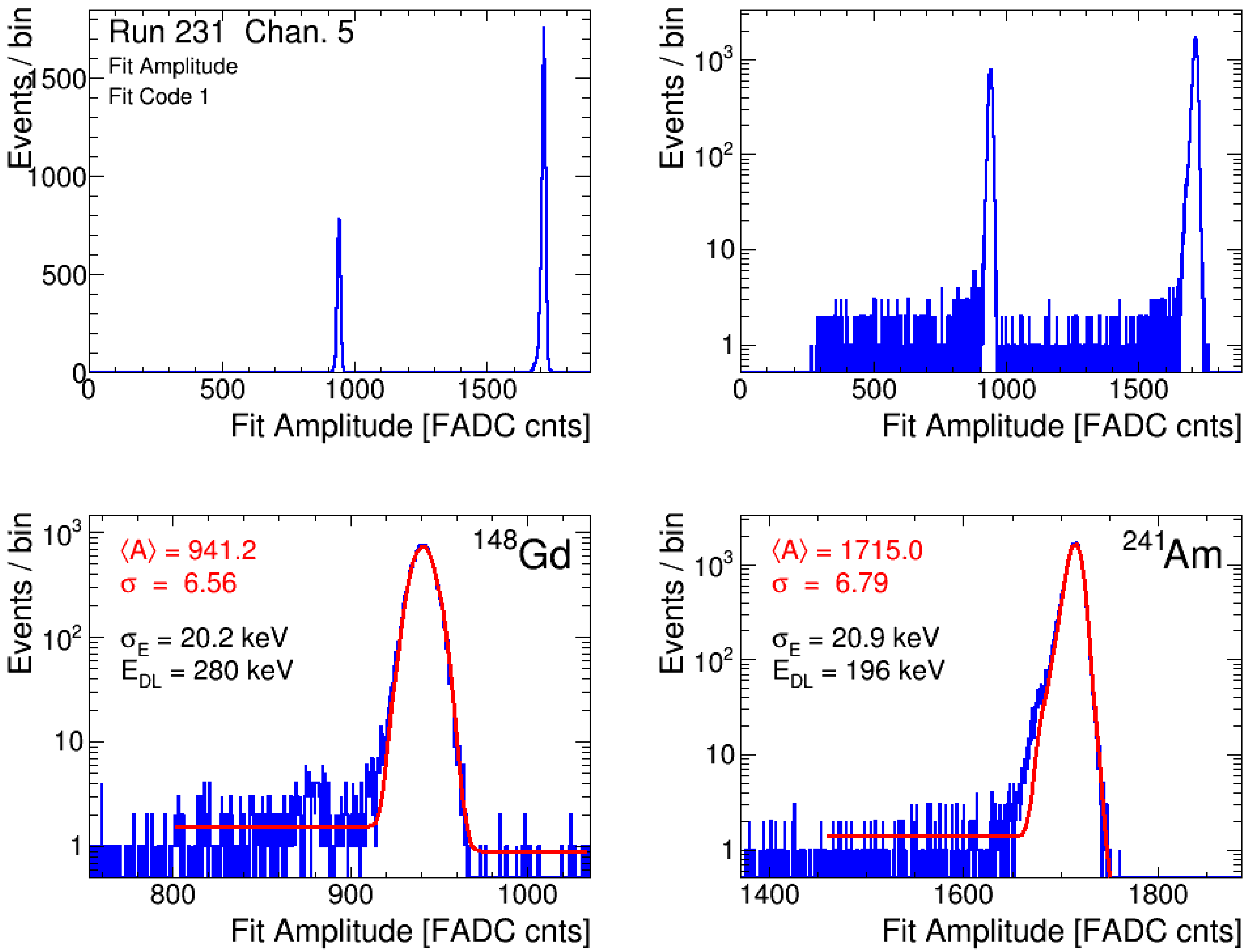


# *Unstable waveform. Run 231 Integral*



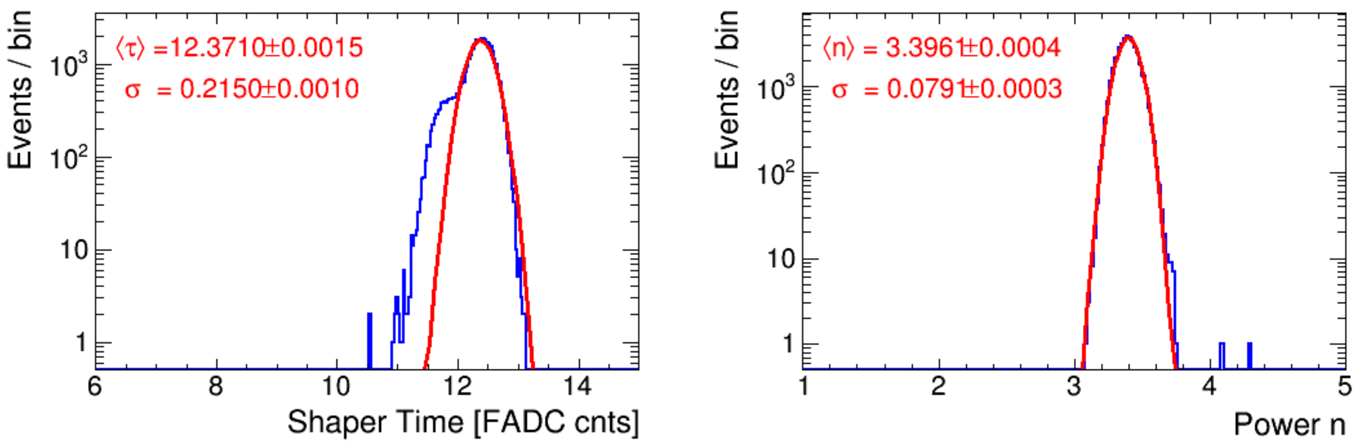
# *Unstable waveform. Run 231 Amplitude*



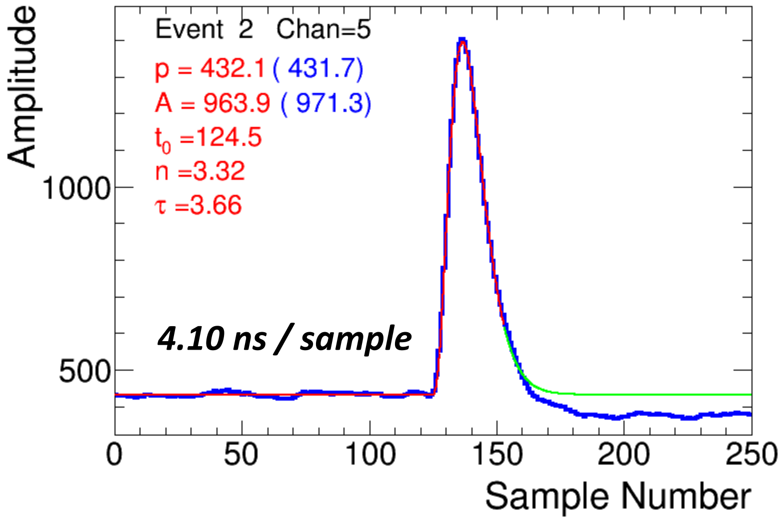
# *Unstable waveform.  Comments.*

- Gain instability is seen only in Integral:   $I = A\,\tau\,I_n$
- Instability of measurements may be related to instability of $\tau$ or $n$
- Usually  the $\tau$ is very stable
- In Run 231 is associated with time scale (e.g. clock stability)

***Run 231. Ch. 5***



# A typical waveform: 3.183 keV α ($^{148}$Gd)




- measured waveform (blue)
- fit function W(t) (red)
- continuation of the fit function (green)

**Parameterization:**
- *p* - pedestal
- *A* - amplitude
- $t_0$ - signal time
- *n* - shaper power
- *τ* - shaper time

**Signal parametrization:**

$$A(t) \sim (t - t_0)^n \, exp\left(-\frac{t - t_0}{\tau/n}\right)$$

**Waveform parametrization:**

$$W(t) = p + A f_n(\xi), \quad \xi = \frac{t - t_0}{\tau}$$

$$f_n(\xi) = e^{n(1+\log\xi-\xi)}$$

$$0 \leq f_n(\xi) \leq f_n(1) = 1$$

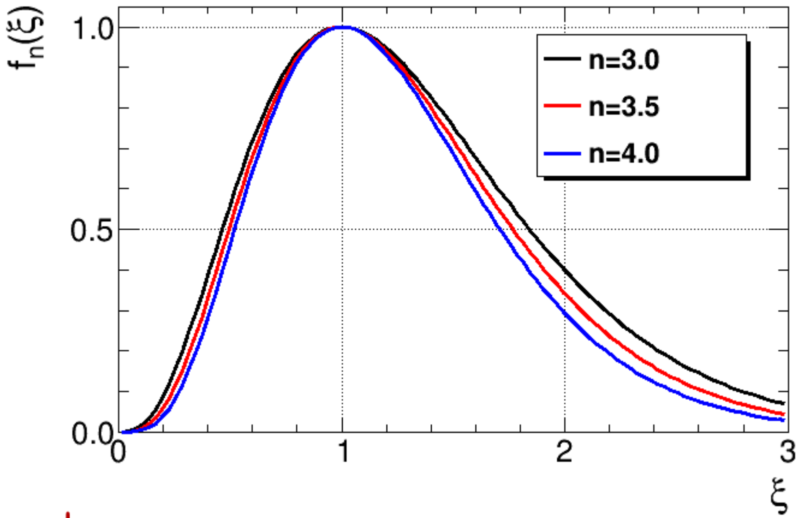
$$I = \int_{t_0}^{\infty} A(t)\, dt = A\tau I_n$$

$$I_n = e^{n(1-\log n)}\Gamma(n) \qquad \Gamma(n) = \int_0^{\infty} x^{n-1} e^{-x} dx$$

# *Understanding of the fit function*

$$W(t) = p + A f_n(\xi), \quad \xi = \frac{t - t_0}{\tau}$$

- *p, A, $t_0$*, and *τ* define linear transformation of the *$f_n(t)$*
- *n* is the only parameter which define the waveform shape.




$$t_m = t_0 + \tau$$

***Errors in the fit (due to noise) may be <u>approximated</u> by:***

$$\langle \delta_{\mathrm{t0}}^2 \rangle^{1/2} = \langle \delta_{\mathrm{tm}}^2 \rangle^{1/2} \oplus \langle \delta_{\tau}^2 \rangle^{1/2}$$

***Time resolution may be evaluated as:***

$$t_0 \to \sigma_t = \langle \delta_{\mathrm{tm}}^2 \rangle^{1/2} \oplus \langle \delta_{\tau}^2 \rangle^{1/2}$$

$$t_m \to \sigma_t = \langle \delta_{\mathrm{tm}}^2 \rangle^{1/2} \oplus \sigma_{\tau}$$

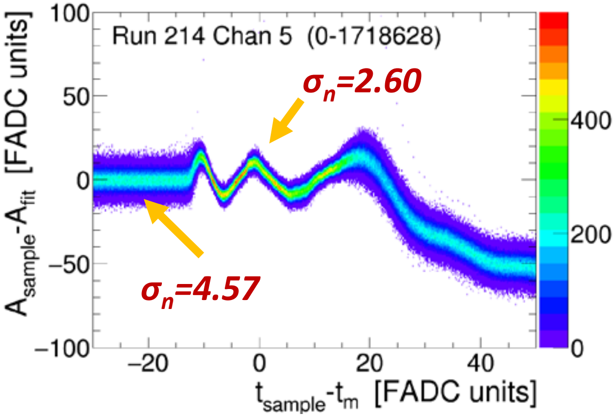
**Fluctuations of the *τ***

***Experimental estimates for*** $^{241}$Am ***signal:***

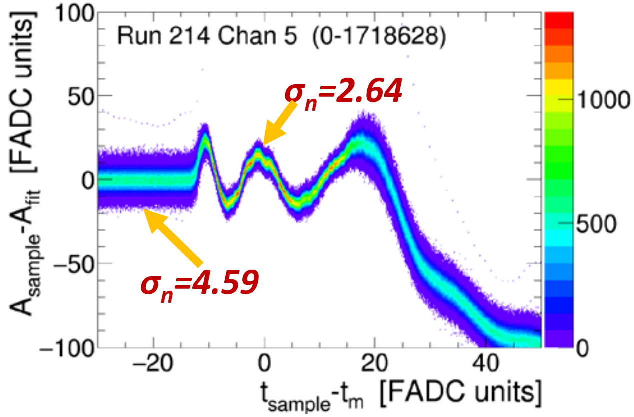
$$\langle \delta_{\mathrm{tm}}^2 \rangle^{1/2} \approx 100 \text{ ps} \qquad \langle \delta_{\tau}^2 \rangle^{1/2} \sim 400 \text{ ps} \qquad \sigma_{\tau} < 80 \text{ ps}$$

# Quality of the Parametrization

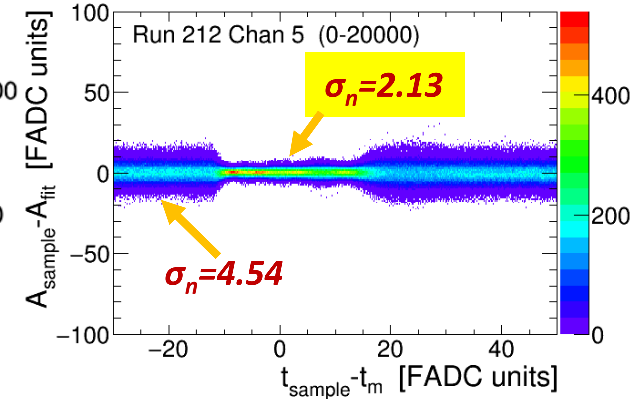
**Gd: A=1015**




**Am: A=1852**

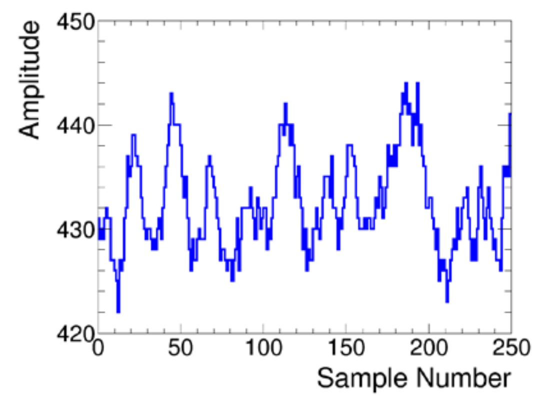



**Noise+Simulation A=1852**




- ***Measured waveform systematically differs (~ 2%) from the simulated one.***
- ***This must not be an issue for the measurements***
- ***In addition to electronic noise, there are fluctuations of the waveform shapes***

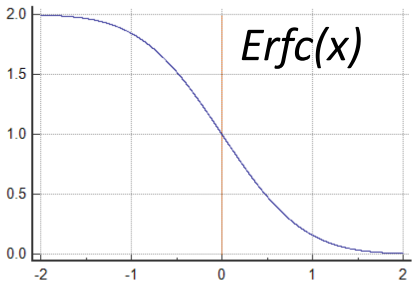
**Typical noise:**



# *How to measure time resolution (relative to external trigger)*

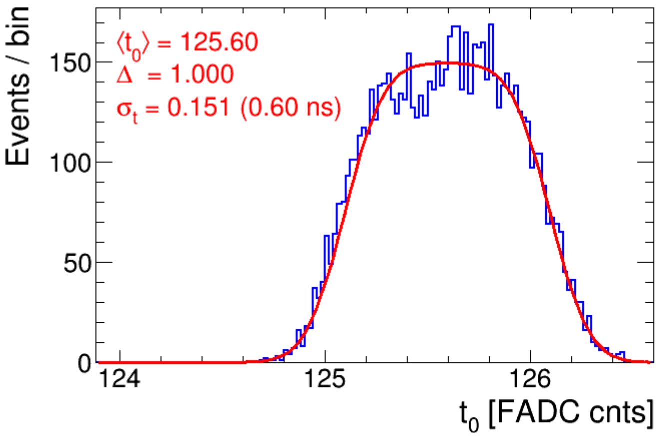
Since trigger is aligned to clock tick, the measured time distribution is non-gaussian.

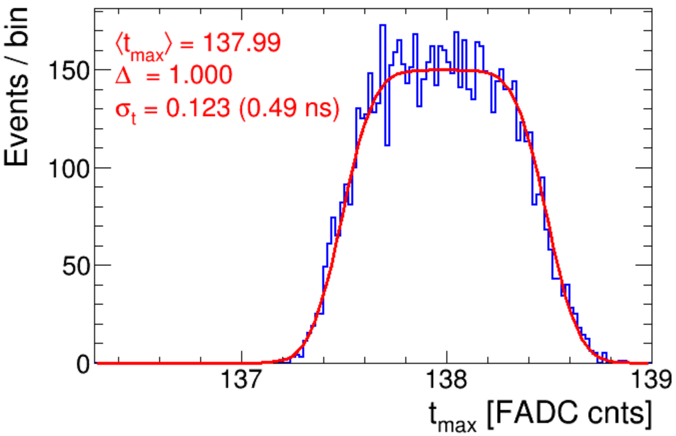
$$f(t) = \int_{\langle t\rangle-\Delta/2}^{\langle t\rangle+\Delta/2} d\tilde{t}\,\exp\frac{(\tilde{t}-t)^2}{2\sigma^2} \;\sim\; \mathrm{Erfc}\left(\frac{t-\langle t\rangle-\Delta/2}{\sqrt{2}\sigma}\right) - \mathrm{Erfc}\left(\frac{t-\langle t\rangle+\Delta/2}{\sqrt{2}\sigma}\right)$$




However, since the distribution is analytical function (to computer) we can determine σ from the fit.

***Run 214. Am***

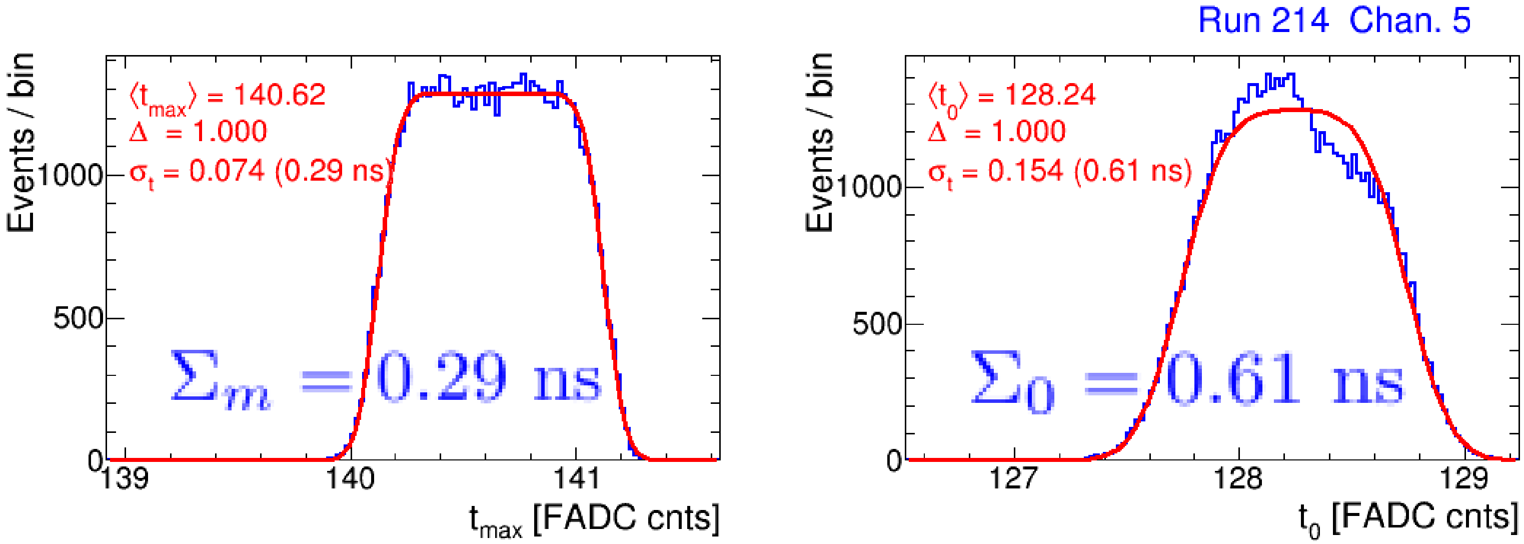



- Result of the fit depends on slewing correction in trigger time and correlation between trigger and signal time
- It may be use for a rough estimate of time resolution but not for a precise measurement

# *Experimental evaluation of time resolution using "software trigger"*

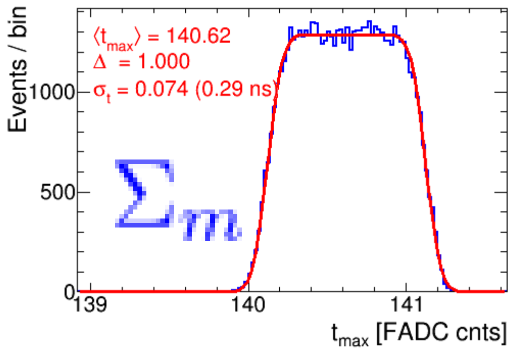
- On previous page, the external trigger was employed only to align samples in different event.
- We can do the same using data offline analysis . Some uncertainties may be eliminated in such a way.
- I found it to be convenient to employ maximum amplitude sample to align all triggers.

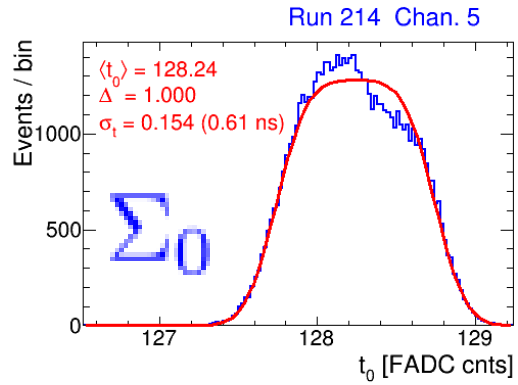


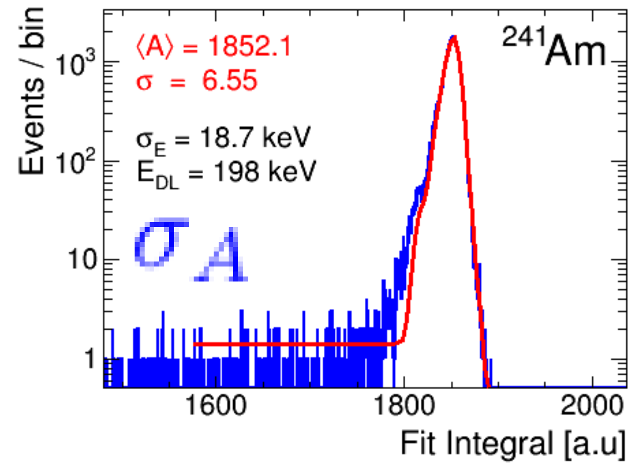

$$\Sigma_m = \langle \delta^2_{\rm tm} \rangle^{1/2} \oplus \sigma_{\rm peak\ sel.}$$

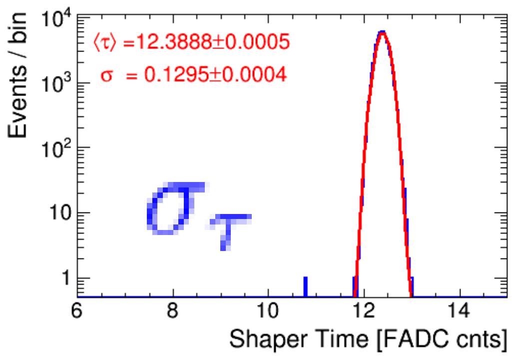
***Depends only on noise at the peak and, thus, may be simulated.***

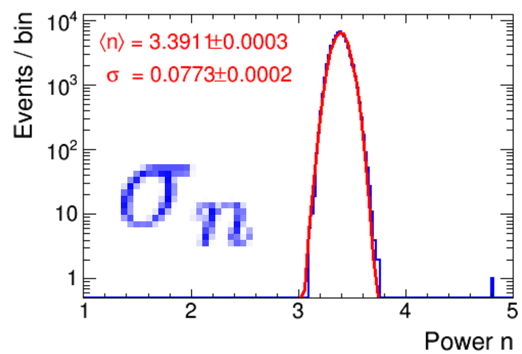
# *Parameters used to tune the simulation*



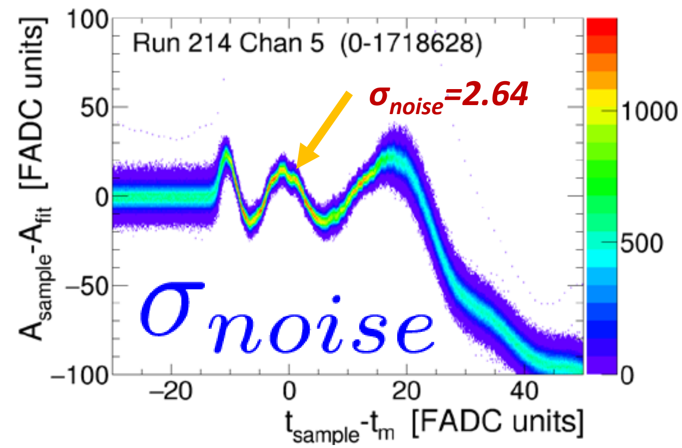




***Simulation is based on mixing measured noise and simulated signals***



# *Simulation of the Am signal (A=1852)*

| | | Simulation | | | | | |
|---|---|---|---|---|---|---|---|
| | | | X | X | X | X | shape correction |
| | Run 214 | 1.000 | 1.000 | 1.195 | 1.000 | 1.17 | noise factor |
| | | 0.000 | 0.000 | 0.000 | 0.065 | 0.02 | $\sigma_\tau$ (waveform fluctuations) |
| | | 0.000 | 0.000 | 0.000 | 0.039 | 0.01 | $\sigma_n$ (waveform fluctuations) |
| $\Sigma_0$ | 0.61 ns | 0.47 ns | 0.49 ns | 0.58 ns | 0.57 ns | 0.58 ns | |
| $\Sigma_m$ | 0.29 ns | 0.21 ns | 0.23 ns | 0.28 ns | 0.23 ns | 0.26 ns | |
| $\sigma_\tau$ | 0.130 | 0.105 | 0.109 | 0.130 | 0.130 ns | 0.129 | |
| $\sigma_n$ | 0.077 | 0.062 | 0.065 | 0.077 | 0.077 ns | 0.077 | |
| $\sigma_A$ | 6.55 | 4.73 | 4.80 | 5.76 | **16.97** | 7.25 | |
| $\sigma_{noise}$ | 2.64 | 2.13 | 2.53 | 2.90 | 2.55 | 2.85 | |
| $\sigma_{t0}$ | | 0.372 ns | 0.392ns | 0.468 ns | 0.395 ns | 0.460 ns | |
| $\sigma_{tm}$ | | 0.088 ns | 0.088 ns | 0.103 ns | 0.276 ns | 0.130 ns | |

**For Americium:**

**Time resolution:** ***100 ps < $\sigma_{tm}$ < 130 ps***

**Noise contribution** ***~ 100 ps***

**Waveform fluctuations:** ***< 80 ps***

- **The main source of uncertainties is fluctuation of the waveform shape**
- ***$t_m$*** **should be used for time measurements**