H2GCROC analysis

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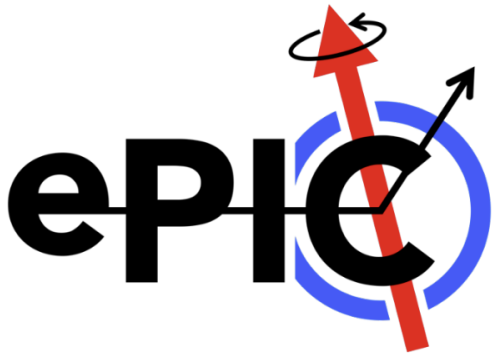
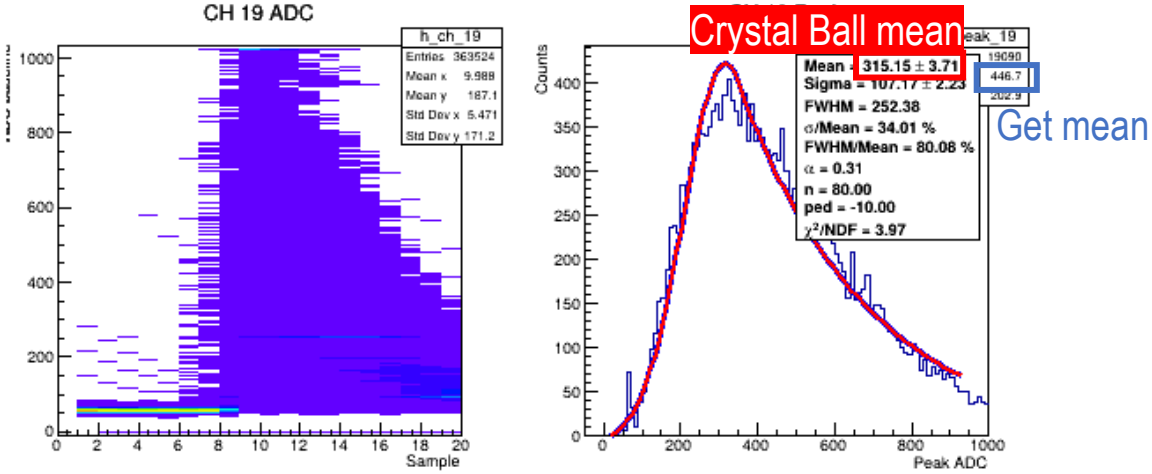
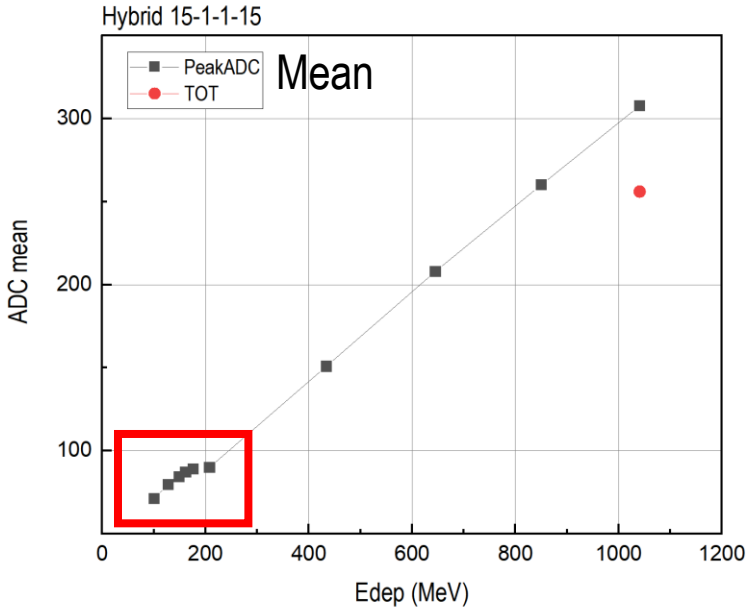
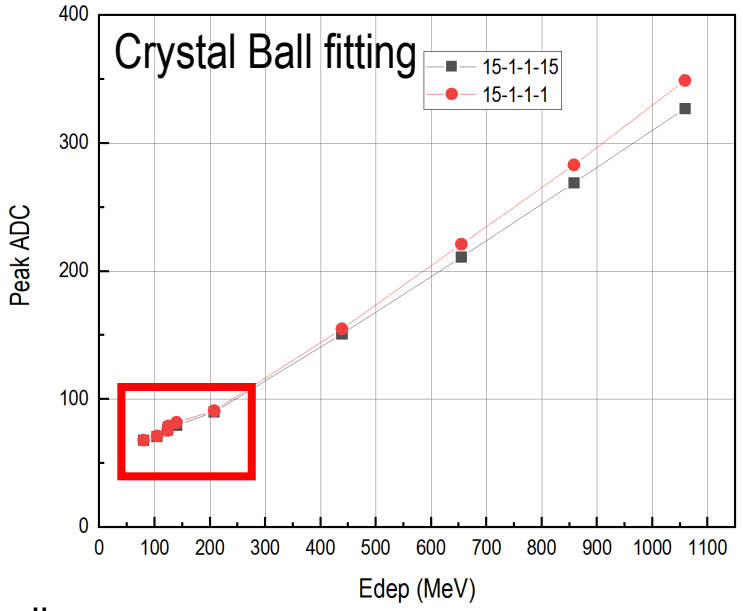


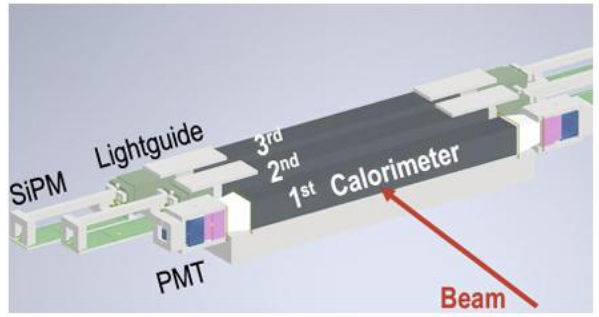
PeakADC – Crystall Ball fitting



- Before : PeakADC per event → Get Mean
- After : PeakADC per event → Crystal Ball Fit

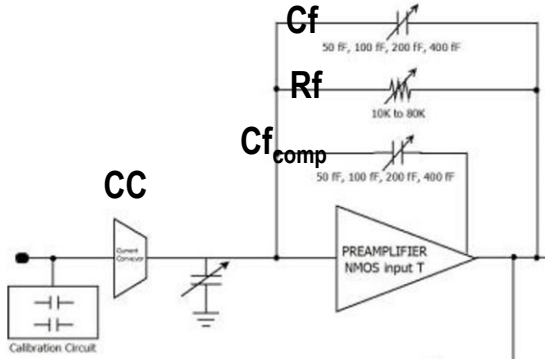






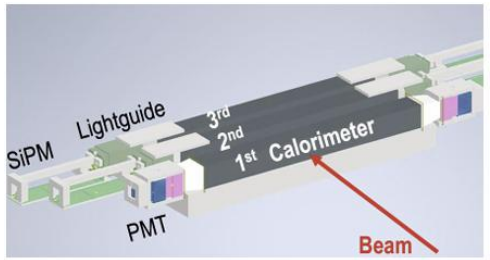
Non linear region at 1st calorimeter got more linear response

May 2026 KEK : Gain Conveyer

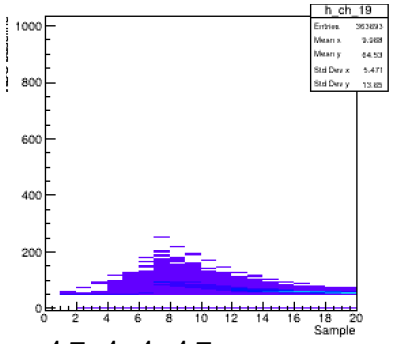


Cd (pF)	5, 10, 20
Rf (Ohm)	10K, 20K, 40K, 80K
Cf (fF)	50, 100, 200, 400
Cf_comp (fF)	50, 100, 200, 400

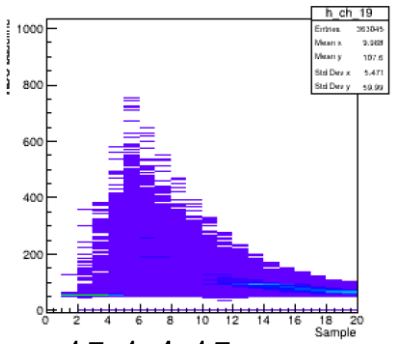
	Rf (Ω)	Cf (fF)	CC	Cf_{comp} (fF)
15-1-1-15	150k	50	**0.025**	750
15-1-4-15	150k	50	**0.1**	750



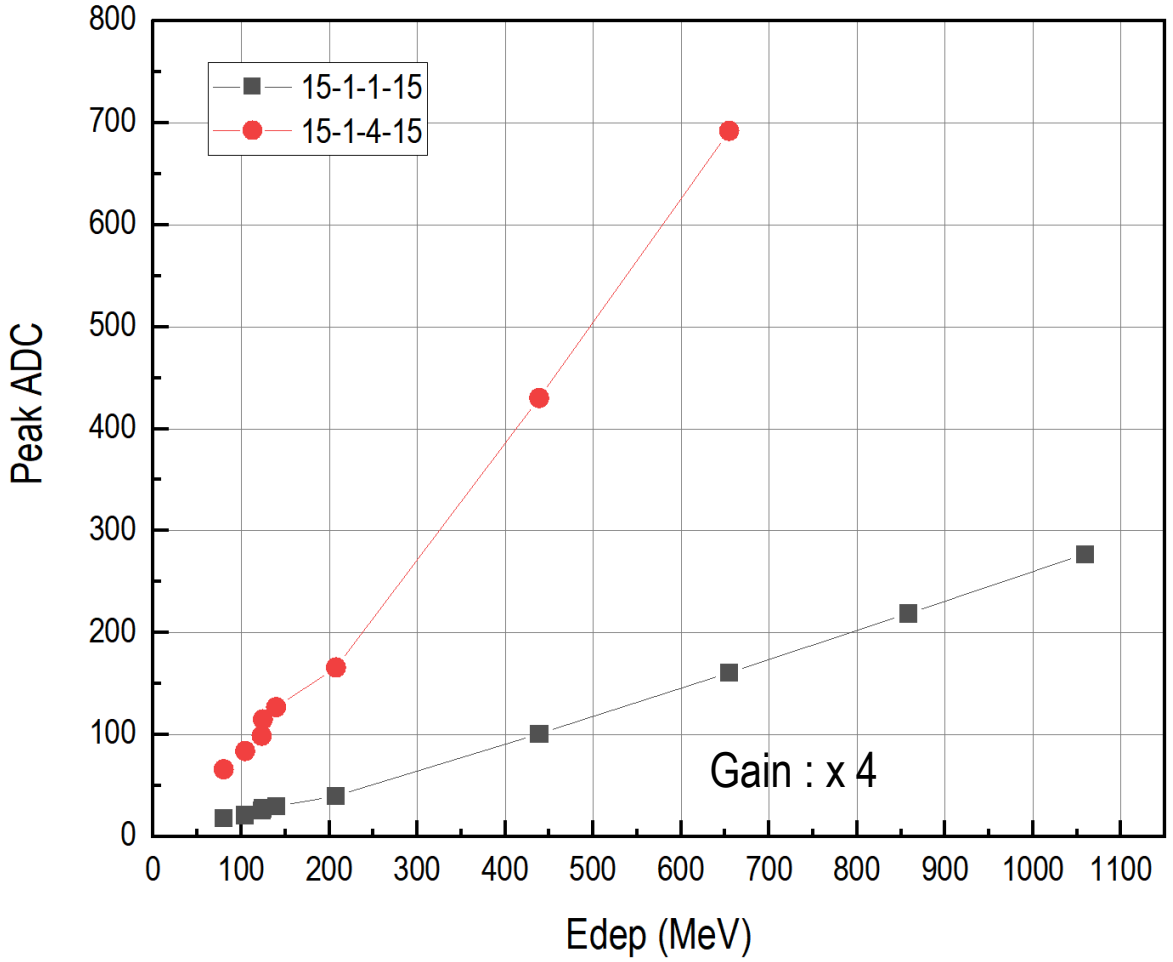
1 GeV/c, 3rd



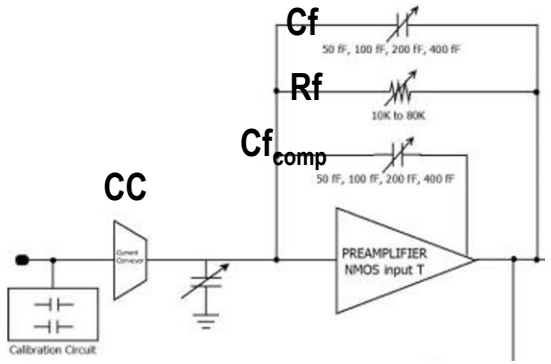
15-1-1-15



15-1-4-15



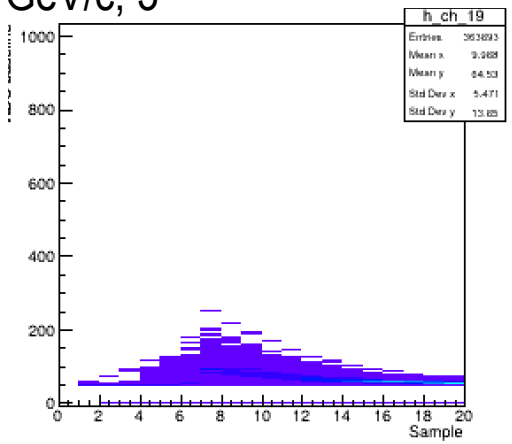
May 2026 KEK : Rf



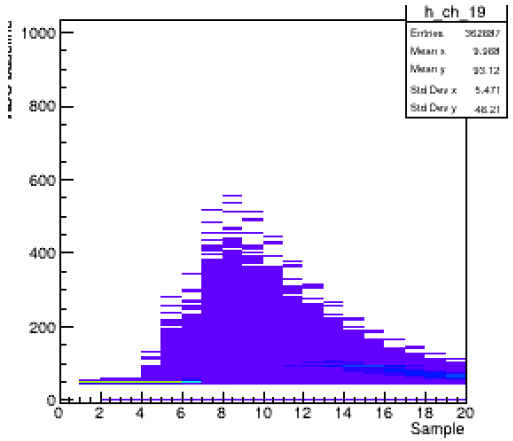
Cd (pF)	5, 10, 20
Rf (Ohm)	10K, 20K, 40K, 80K
Cf (fF)	50, 100, 200, 400
Cf_comp (fF)	50, 100, 200, 400

	Rf (Ω)	Cf (fF)	CC	Cf_{comp} (fF)
4-1-1-15	**40k**	50	0.025	750
15-1-1-15	**150k**	50	0.025	750

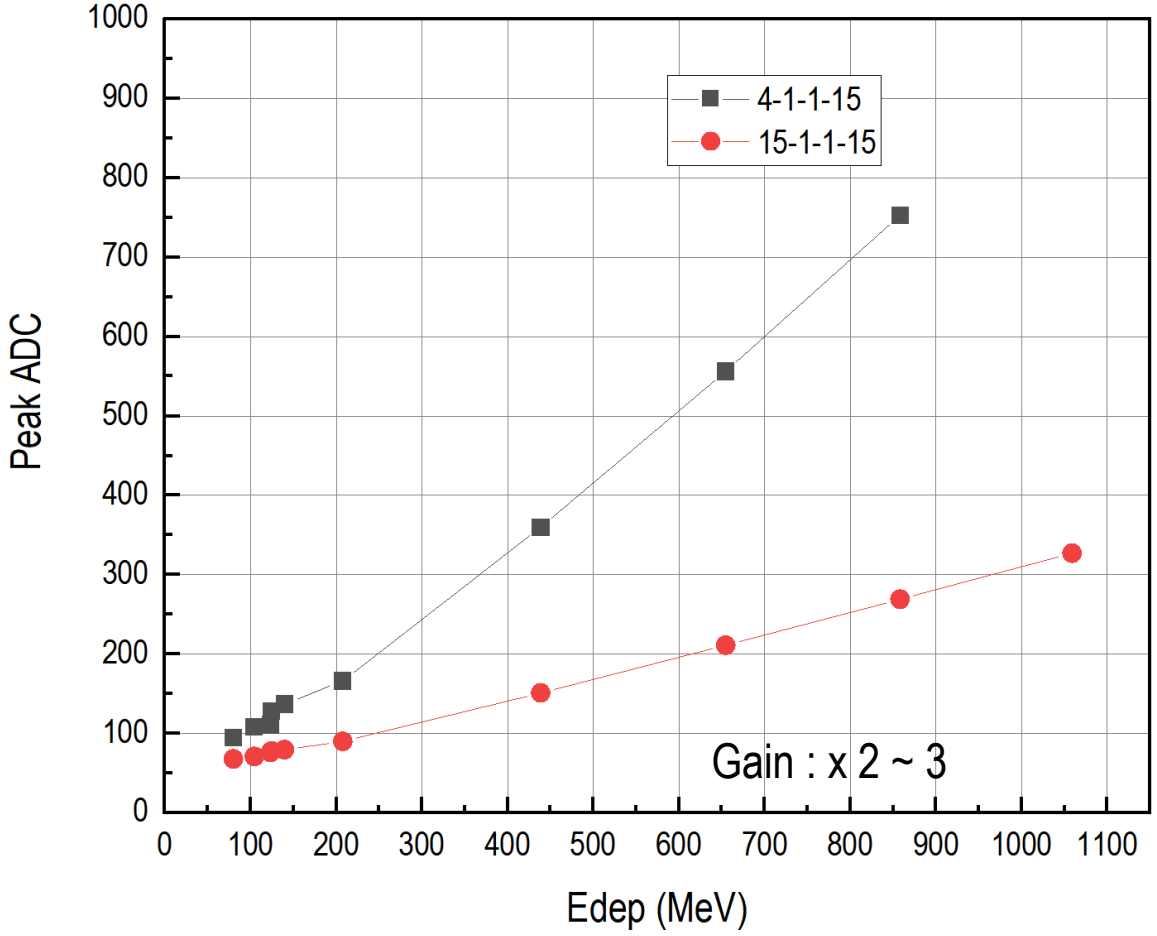
1 GeV/c, 3rd



15-1-1-15

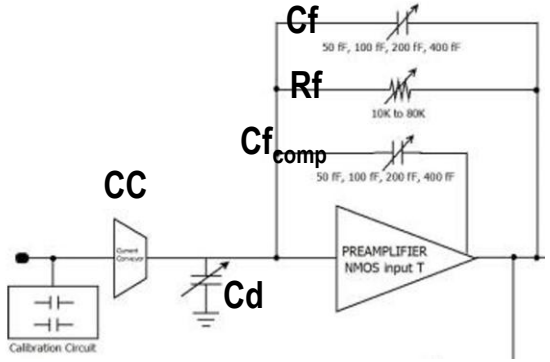


4-1-1-15



$$1 + \frac{40}{}$$

May 2026 KEK : Cf_{comp}



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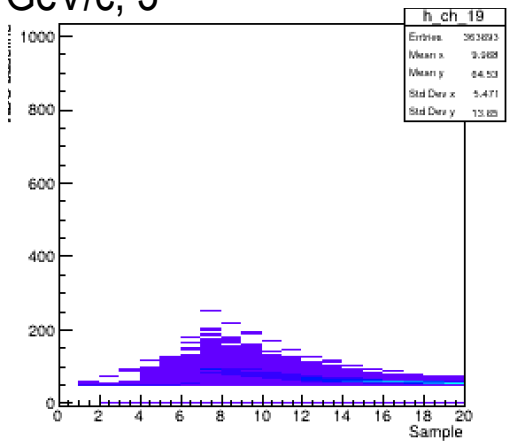
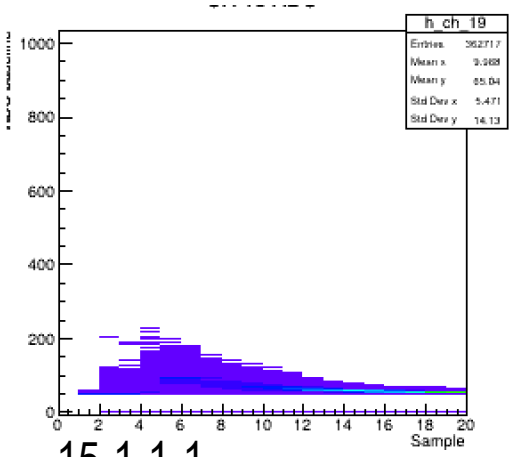
Rf (Ohm)	10K, 20K, 40K, 80K
Cf (fF)	50, 100, 200, 400
Cf_comp (fF)	50, 100, 200, 400

	Rf (Ω)	Cf (pF)	CC	Cf_{comp} (fF)
15-1-1-15	150k	50	0.025	**50**
15-1-1-1	150k	50	0.025	**750**

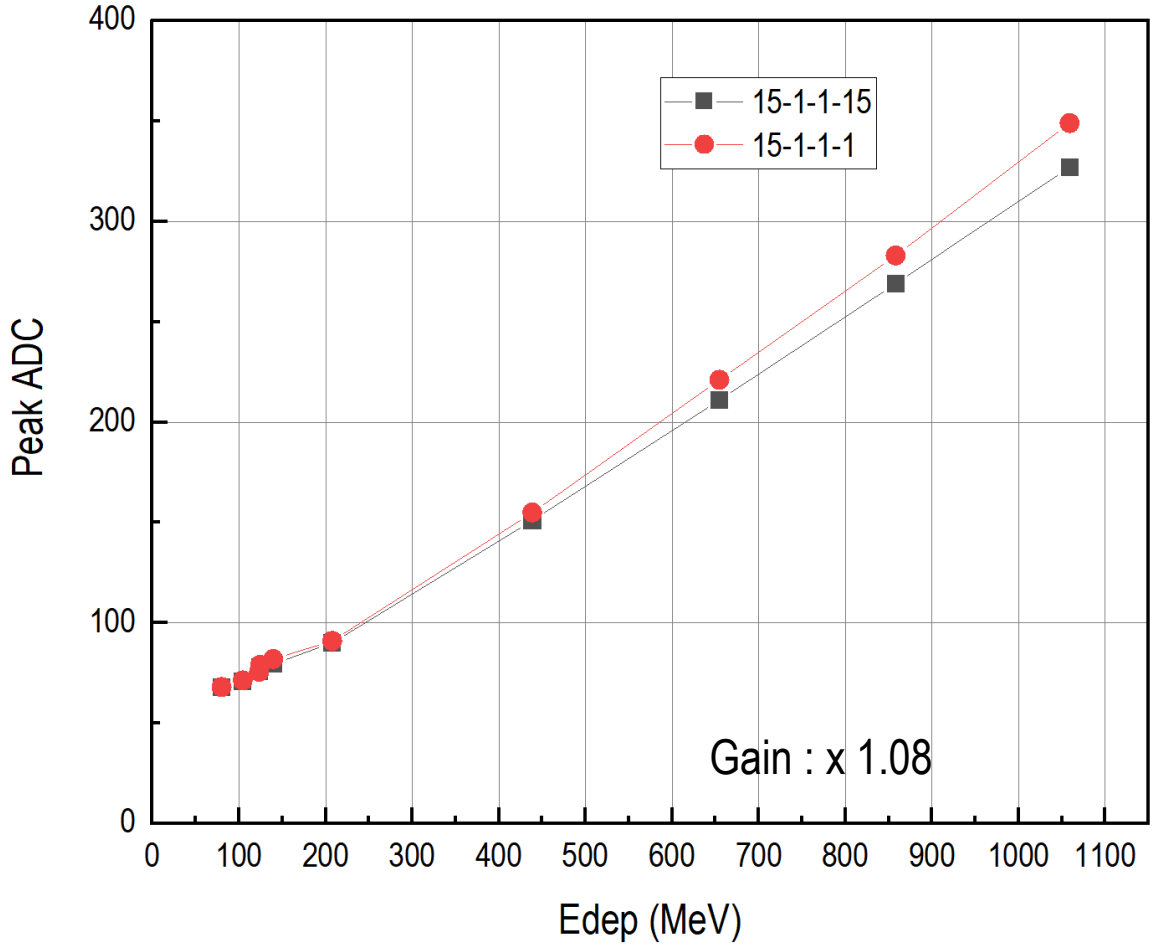
1 GeV/c, 3rd



15-1-1-15

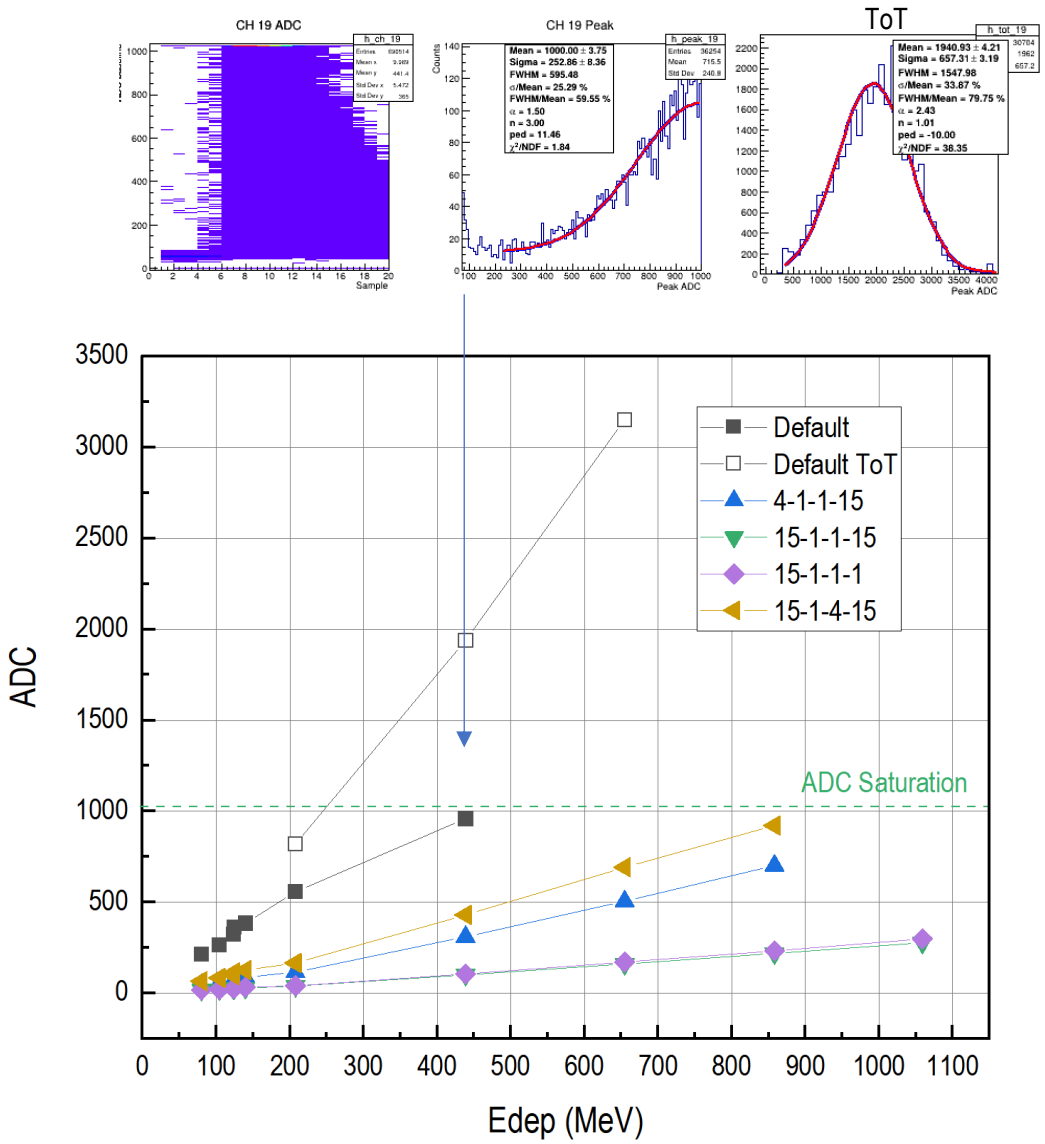


15-1-1-1

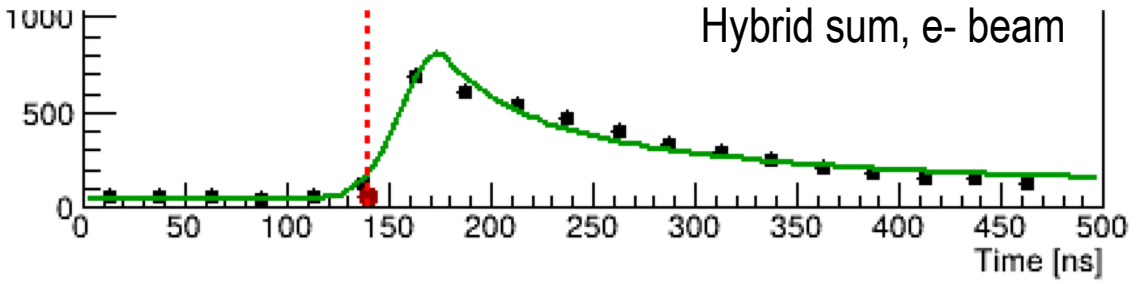


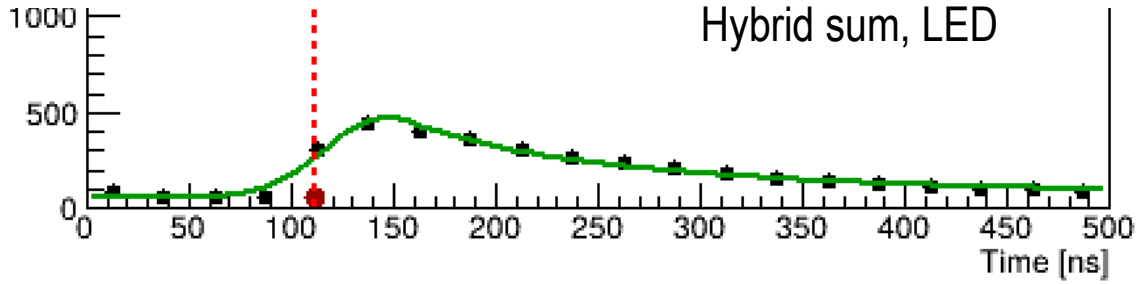
Preamp params

- Overlay for ADC region
- Preamp candidates will be chosen for Aug 2026 CERN TB



Calorimeter – LED response (single event)





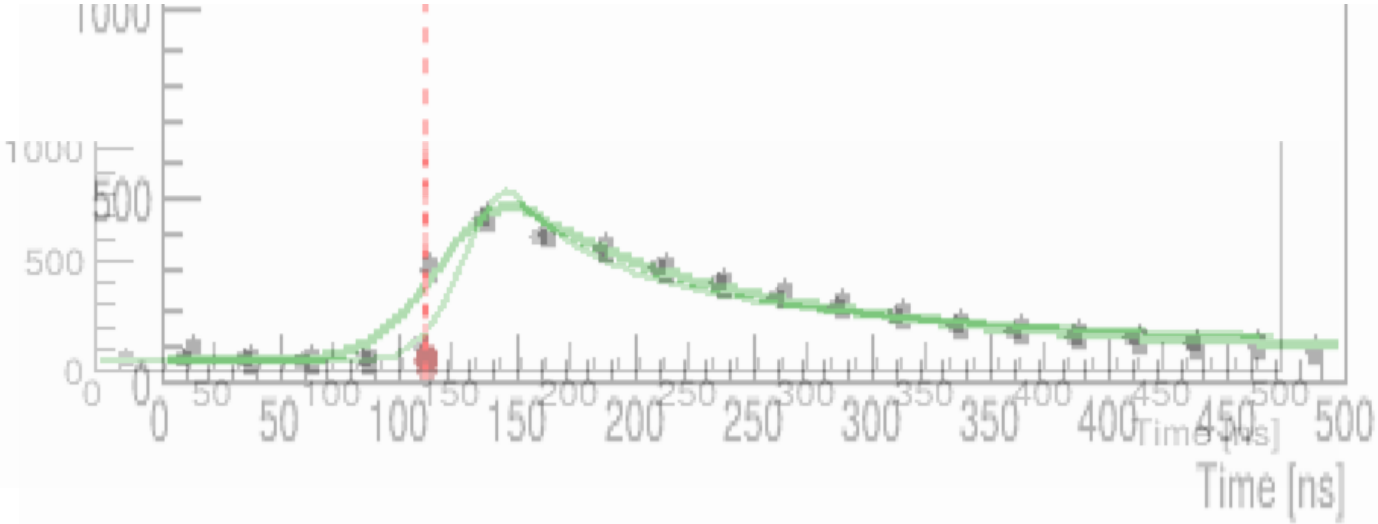
- Check **falling time** of scintillation & LED

Pb/SciFi Calorimeter + electron beam

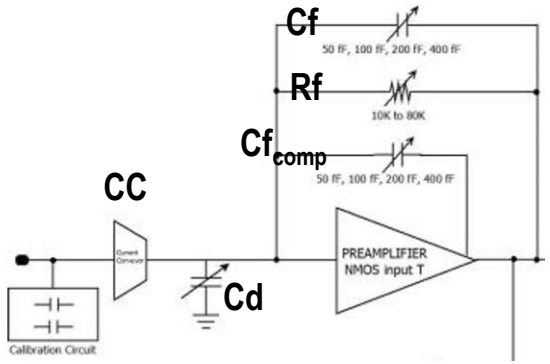
20 ns width LED pulse

- Seems identical…

Overlay



LED : Cf



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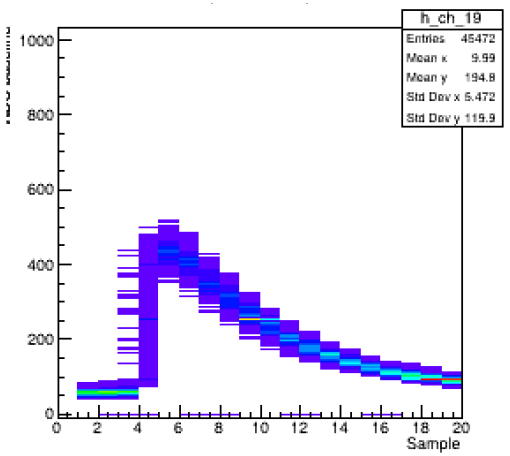
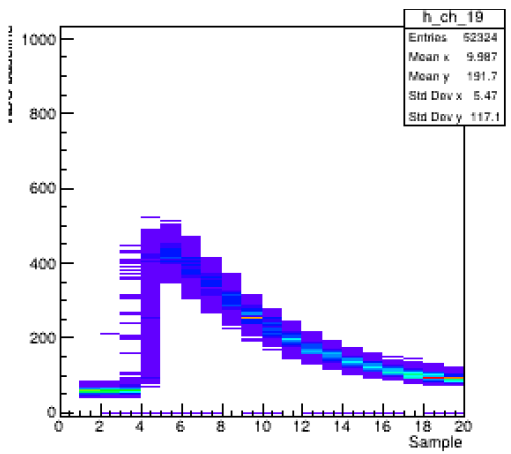
Rf (Ohm)	10K, 20K, 40K, 80K
Cf (fF)	50, 100, 200, 400
Cf_comp (fF)	50, 100, 200, 400

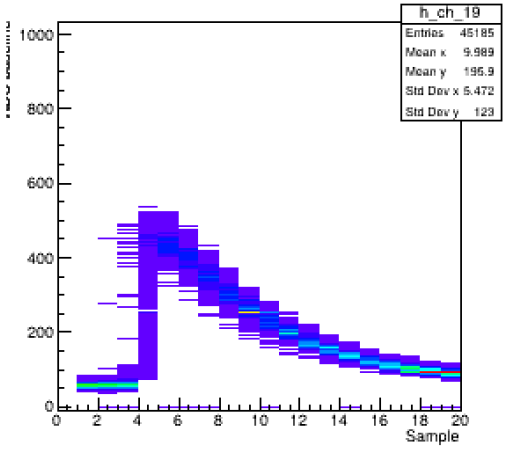
	Rf (Ω)	Cf (pF)	CC	Cf_{comp} (fF)
Def (12-10-12-10)	120k	**500**	0.3	500
12-15-12-10	120k	**750**	0.3	500
12-1-12-10	120k	**50**	0.3	500



Cf 1111

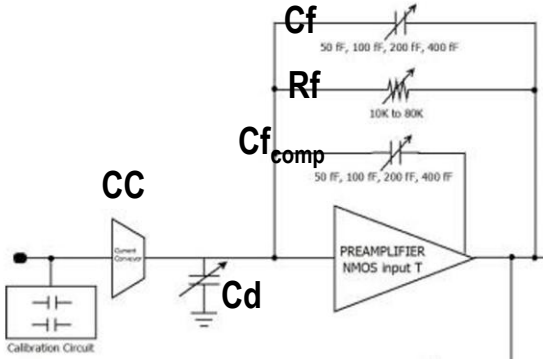


Default



Cf 0001

LED : Cd



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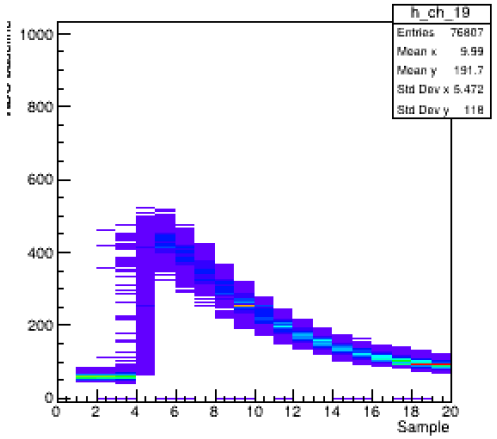
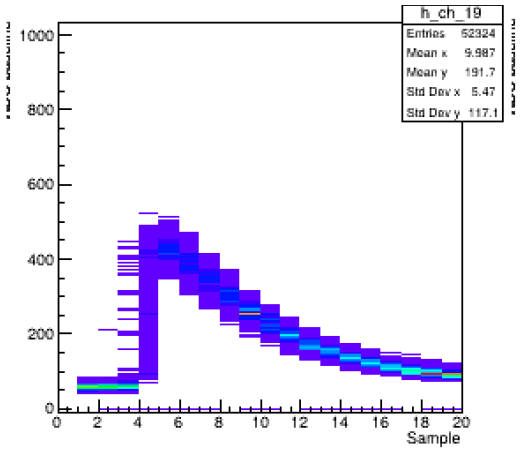
Rf (Ohm)	10K, 20K, 40K, 80K
Cf (fF)	50, 100, 200, 400
Cf_comp (fF)	50, 100, 200, 400

	Rf (Ω)	Cf (pF)	CC	Cf_{comp} (fF)	Cd (pF)
Def (12-10-12-10)	120k	500	0.3	500	**0**
Def (12-10-12-10)	120k	500	0.3	500	**5**
Def (12-10-12-10)	120k	500	0.3	500	**20**
Def (12-10-12-10)	120k	500	0.3	500	**35**

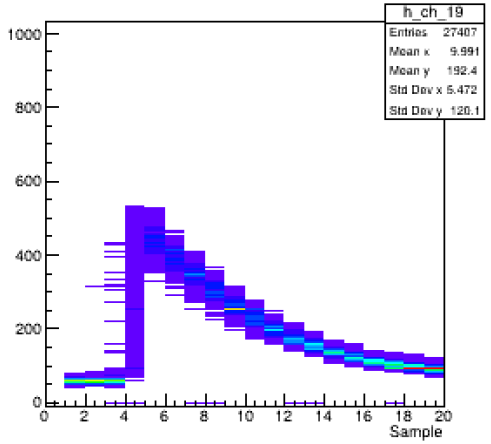
Cf and Cd does not seem to change signal size dramatically



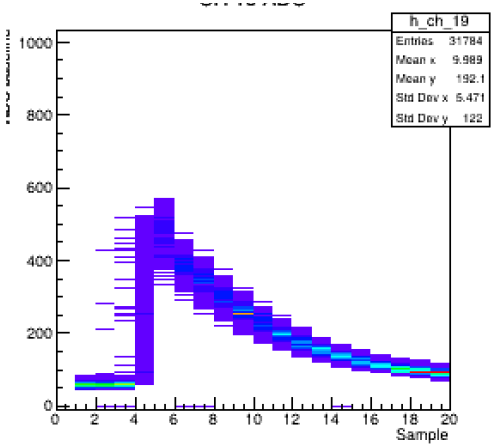
Cd 001



Default

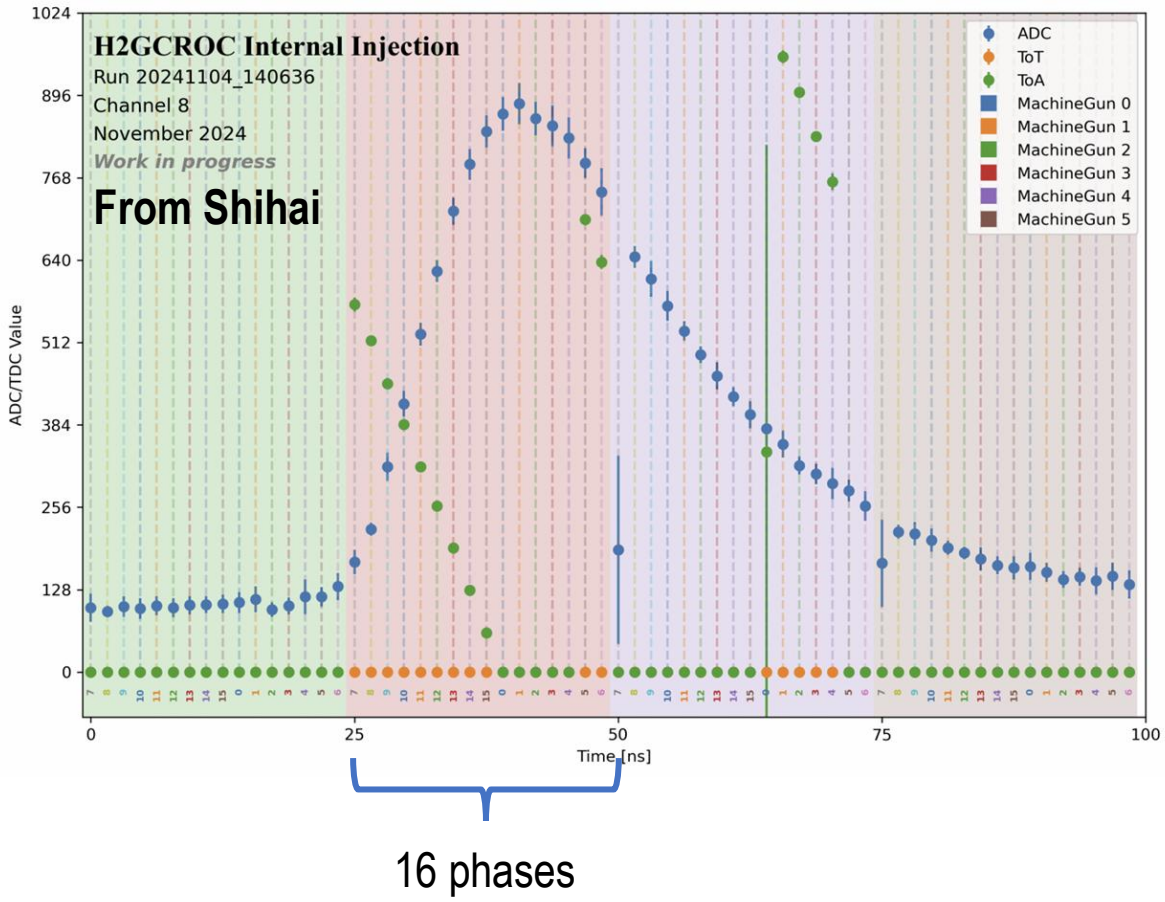


Cd 100



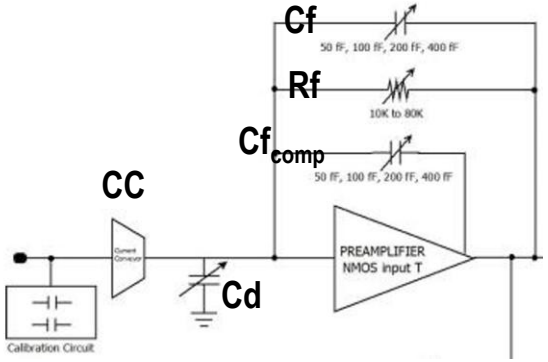
Cd 111

Phase



- Phase : delay the timing of data sampling (in the ASIC chip, for compensating different trace length)
- 16 phases per sample (25 ns / 16 = 1.5625 ns)
- Chose phase 0, 4, 8, 12 for data shaping
- Hybrid summing + S14, LED

LED : Phase



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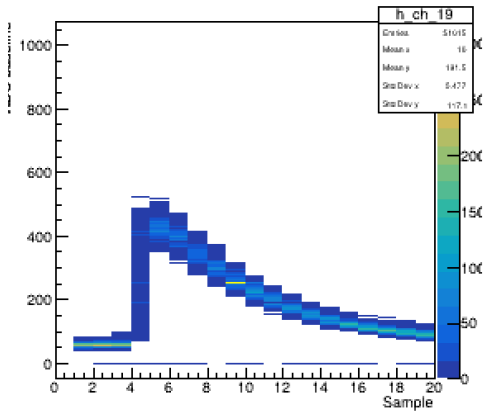
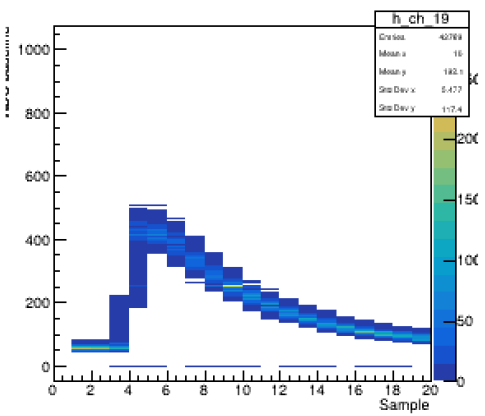
Rf (Ohm)	10K, 20K, 40K, 80K
Cf (fF)	50, 100, 200, 400
Cf_comp (fF)	50, 100, 200, 400

	Rf (Ω)	Cf (pF)	CC	Cf_{comp} (fF)	Phase
Def (12-10-12-10)	120k	500	0.3	500	**0**
Def (12-10-12-10)	120k	500	0.3	500	**4**
Def (12-10-12-10)	120k	500	0.3	500	**8**
Def (12-10-12-10)	120k	500	0.3	500	**12**

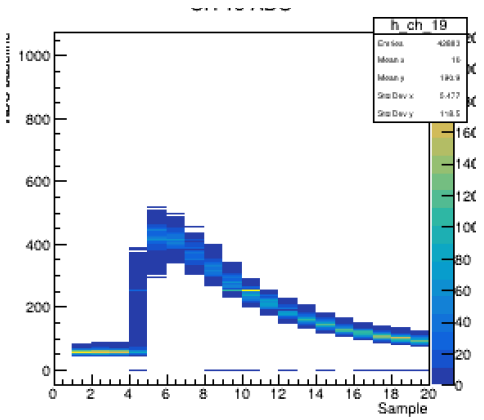
No big changes with overlay



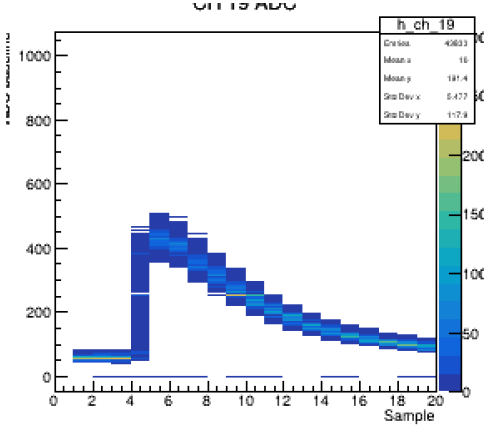
Phase 0000



Phase 0100



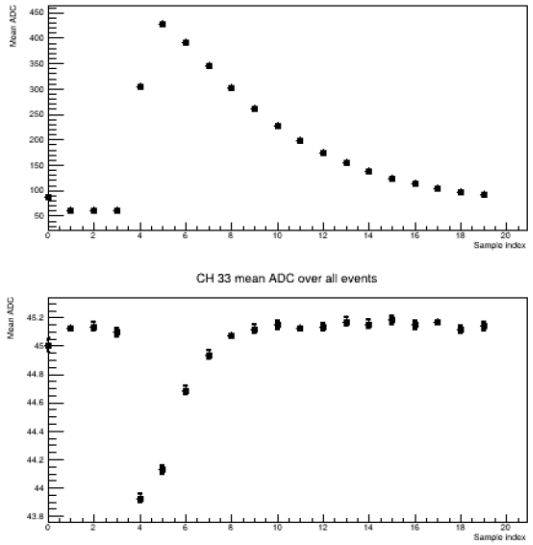
Phase 1000



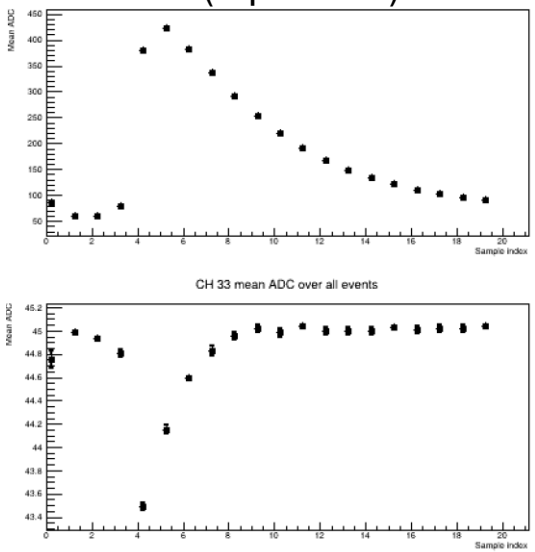
Phase 1000

Phase

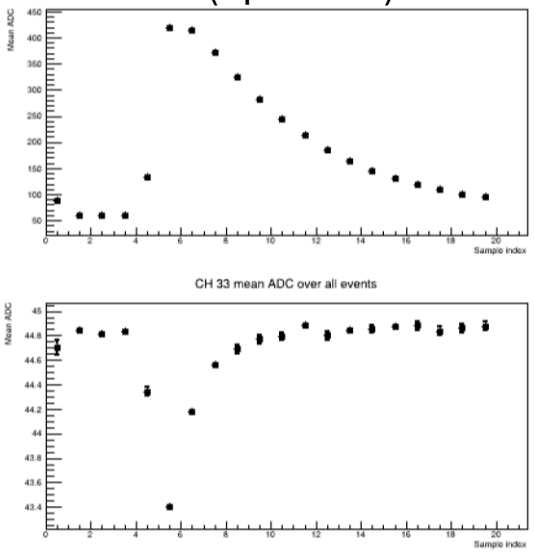
Phase 0



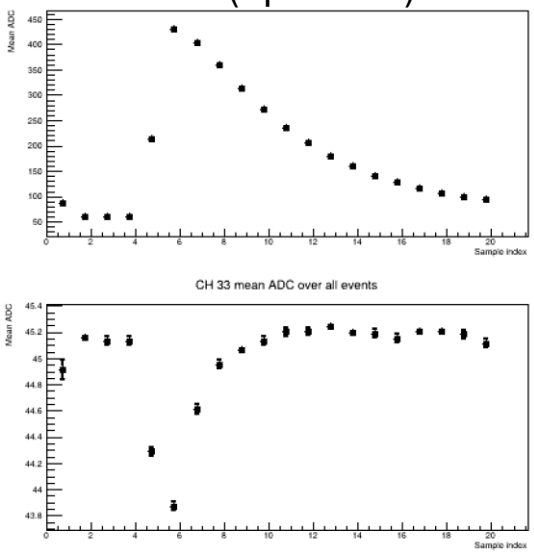
Phase 4 (+ phase 4)



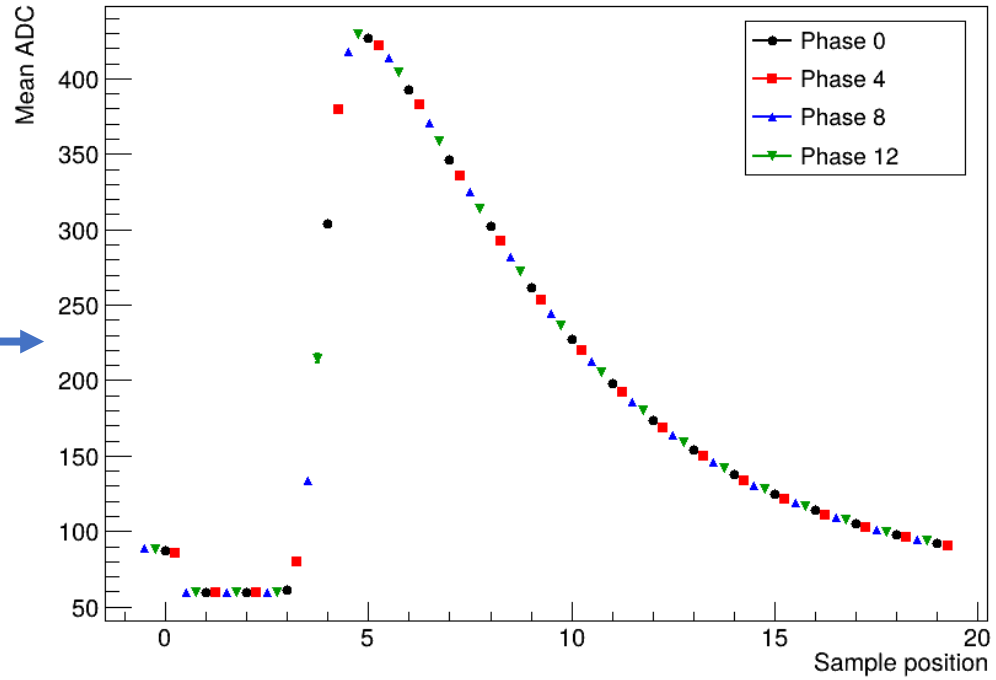
Phase 8 (- phase 8)



Phase 12 (- phase 4)



Overlay

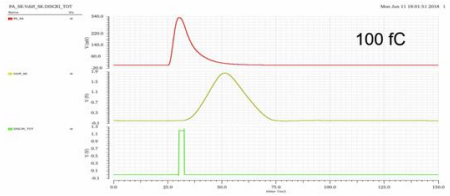


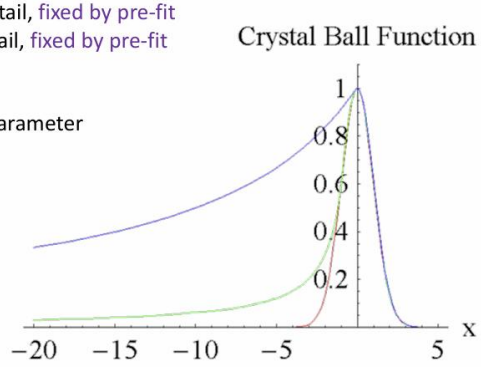
Waveform fitting (Shihai)

Fit with crystal ball (right-sided tail)

$$\text{ADC} = f(x;\ \alpha, n, \bar{x}, \sigma, N, B) = \begin{cases} N \cdot \exp\left(-\dfrac{(x-\bar{x})^2}{2\sigma^2}\right) + B\,, & \text{for } \dfrac{x-\bar{x}}{\sigma} < \alpha \\ N \cdot A \cdot \left(B + \dfrac{x-\bar{x}}{\sigma}\right)^{-n} + B, & \text{for } \dfrac{x-\bar{x}}{\sigma} > \alpha \end{cases}$$

α: the point where the Gaussian transitions to the power-law tail, fixed by pre-fit
n : the exponent that determines the slope of the power-law tail, fixed by pre-fit
$\bar{x}$: peak position, free parameter
σ: the standard deviation of the Gaussian core, fixed
N: a normalization factor, or the amplitude of the peak, free parameter
B: baseline voltage, fixed





Fit with Semi-Gaussian

$$\text{ADC} = A\frac{(t-t_0)^n}{\tau_{rise}^n}\exp\left(-\frac{t-t_0}{\tau_{rise}}\right) + \text{baseline}$$

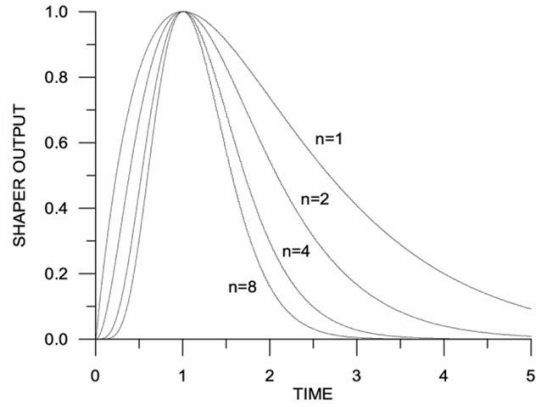
A : amplitude, free parameter
n : order of the shaping, fixed parameter
t_0 : time offset, free parameter
baseline: baseline voltage, fixed parameter
τ_{rise}: time constant for the rising edge, free parameter

1.1.3 Shapers

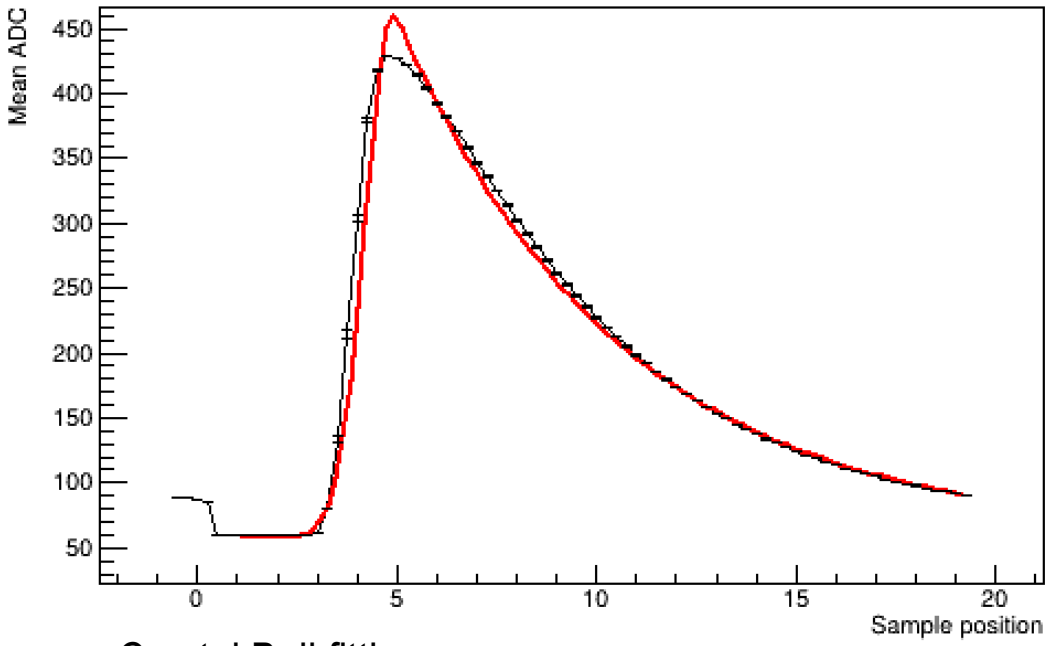
The shaper is divided in three stages:

- A Sallen-Key (S-K) shaper
- A gain 1.1 amplifier and a buffer to drive the ADC

S-K shaper: order = 2
Preamplifier: order 1 ~ 3



Waveform fitting

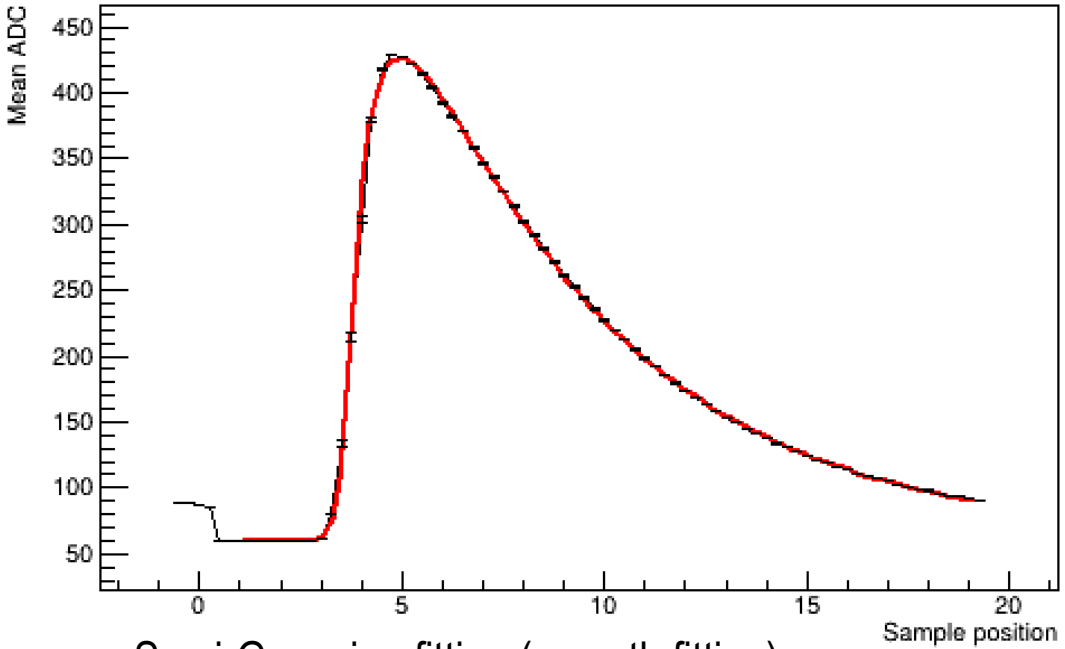


Crystal Ball fitting

$$\text{Pedestal} + N \exp\left[\frac{(x-\mu)^2}{2\sigma^2}\right]$$

$$\text{Pedestal} + NA \exp\left[B + \frac{(x-\mu)^2}{\sigma}\right]^{-n}$$

mu = 4.88 +/- 0.00216
sigma = 0.675 +/- 0.00155
chi^2/ndf = 364



Semi-Gaussian fitting (smooth fitting)

$$\text{Pedestal} + A\left[1 - e^{-(u/\tau_{rise})}\right]^n \times e^{-u/\tau_{Fall}}$$

$z = (t\text{-}t_0)/smooth$

$u = t - t_0 \quad (z > 40)$

$u = smooth\ \ln(1 + e^z) \quad (-40 < z < 40)$

$u = smooth\ e^z \quad (z < -40\ )$

t_0 = 3.70 +/- 0.0275
tau_{Rise} = 0.992 +/- 0.0310
tau_{Fall} = 5.356 +/- 0.00502
n = 0.472
chi^2/ndf = 28.4
Preamp : Default setup

Future plans

1. Fit every event, and redraw peakADC
- Compare sigma before & after signal fitting

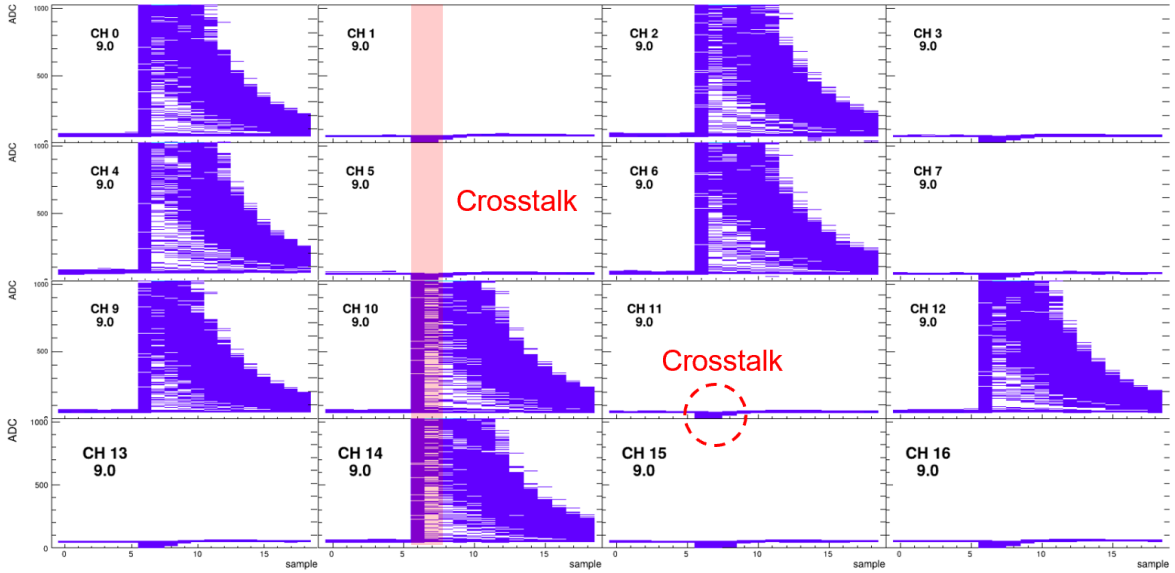
2. Get low & high LED

3. Get fitting function of preamp 15-1-1-15

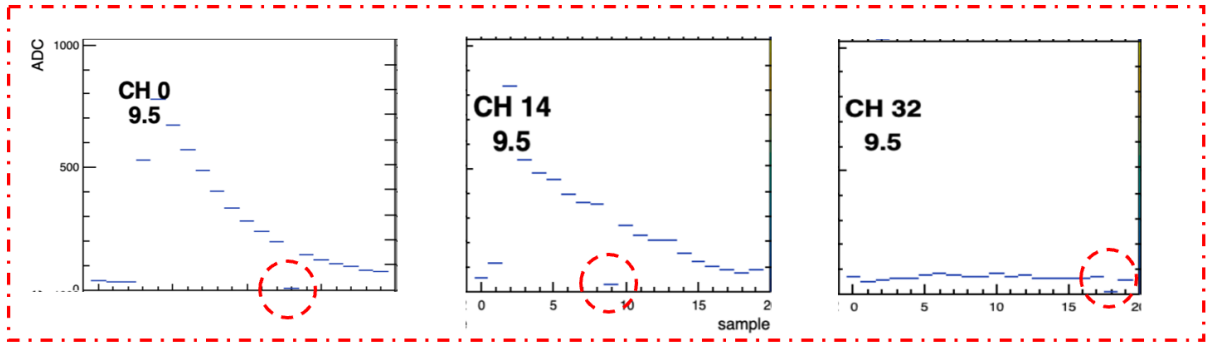
4. Compare linearity, and resolution (if possible)

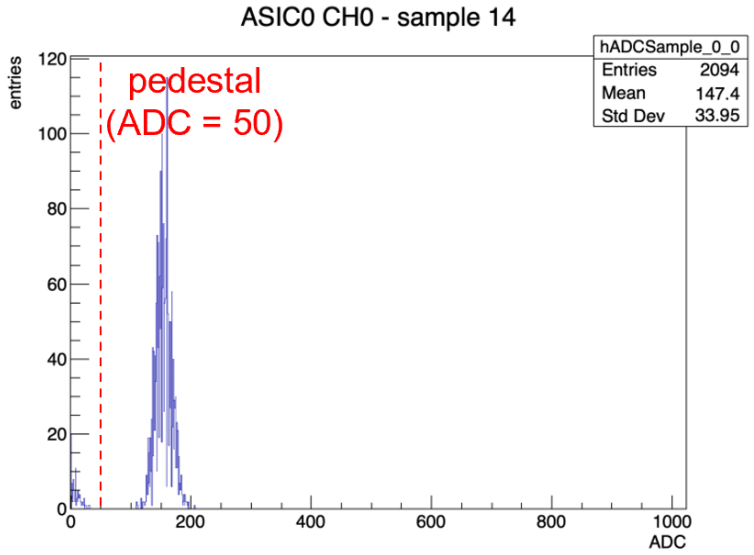
H2GCROC problems

1. Crosstalk



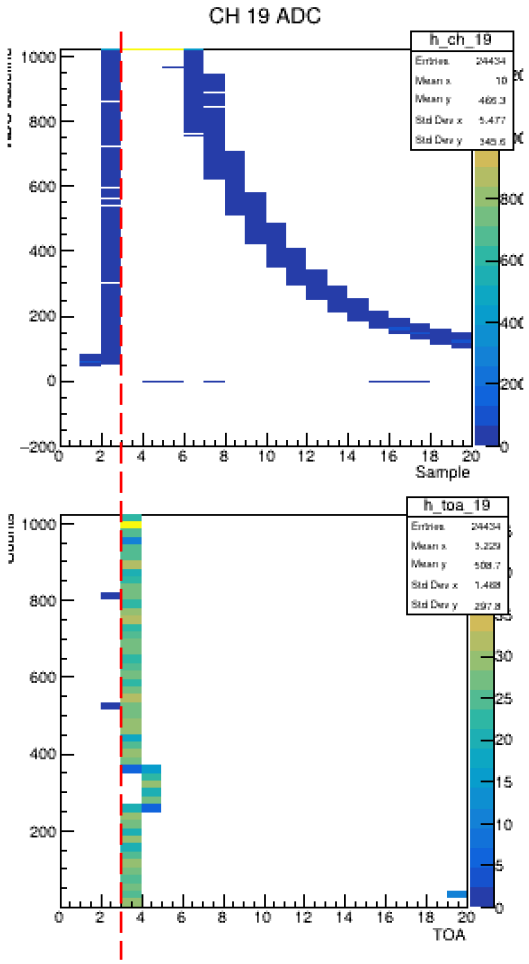
2. Voltage drop





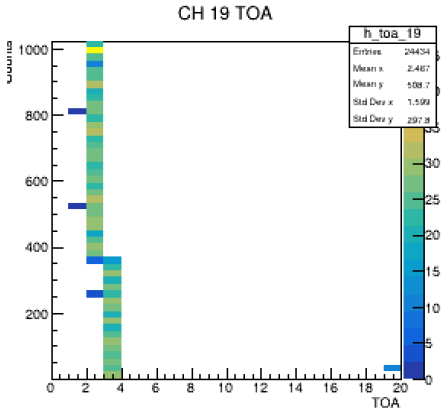
H2GCROC problems

3. ToA debugging

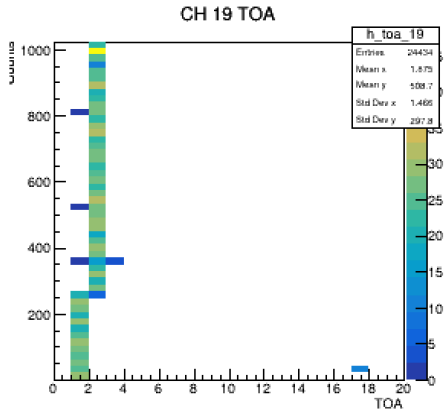


ToA Threshold : ~ 60 ADC

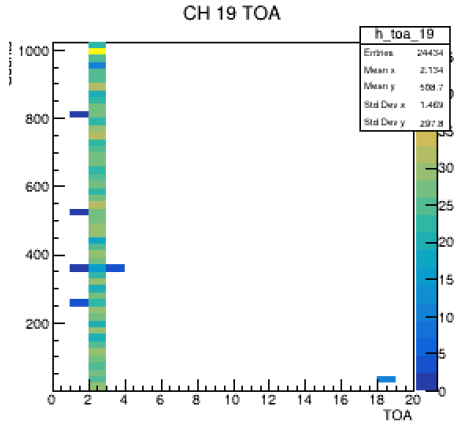
```
h_tot[ch]->Fill(s, tot);
if (toa < 260)
  {h_toa[ch]->Fill(s, toa);}
else
  {h_toa[ch]->Fill(s-1, toa);}
```

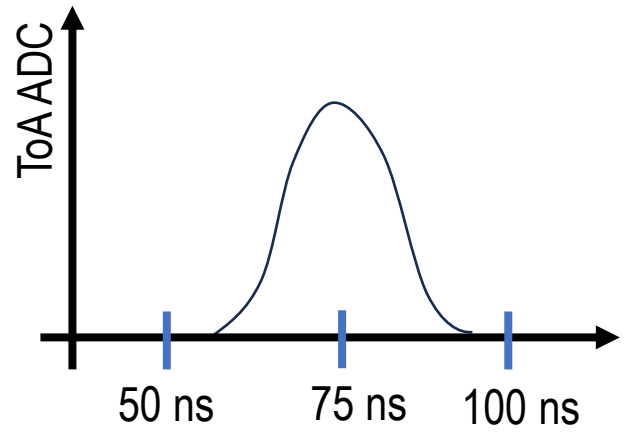



```
h_tot[ch]->Fill(s, tot);
if (toa < 360)
  {h_toa[ch]->Fill(s-2, toa);}
else
  {h_toa[ch]->Fill(s-1, toa);}
```




```
h_tot[ch]->Fill(s, tot);
if (toa > 260 && toa < 360)
  {h_toa[ch]->Fill(s-2, toa);}
else
  {h_toa[ch]->Fill(s-1, toa);}
```





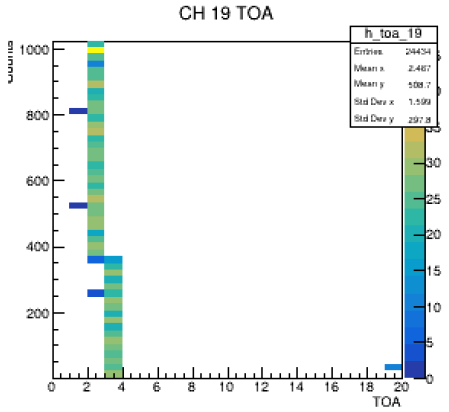
Magic number : ~ 260 by Nobert

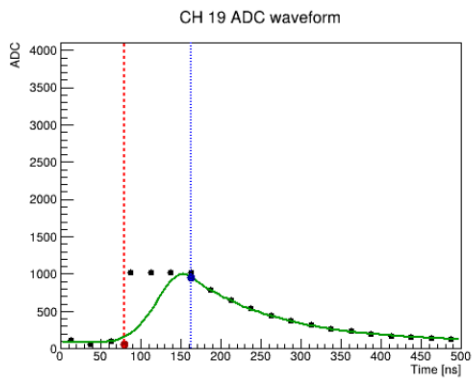
Norbert Novitzky 5 hours ago

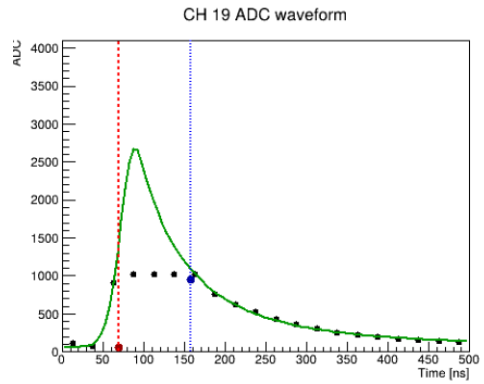
good, but so far I have no explanation 🙂 Just hints or ideas, but need to confirm. I cannot really see inside of the chip somehow

H2GCROC problems

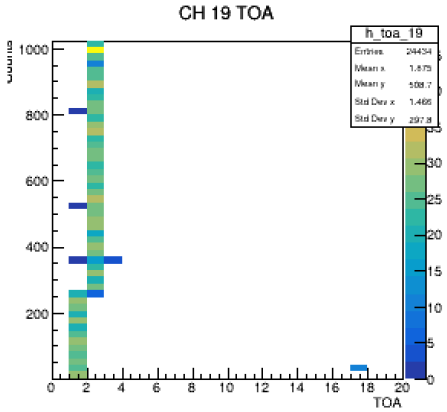
```
h_tot[ch]->Fill(s, tot);
if (toa < 260)
  {h_toa[ch]->Fill(s, toa);}
else
  {h_toa[ch]->Fill(s-1, toa);}
```

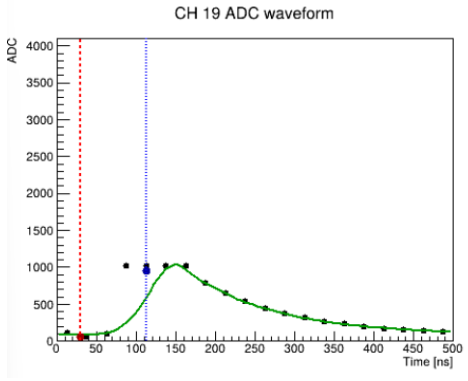


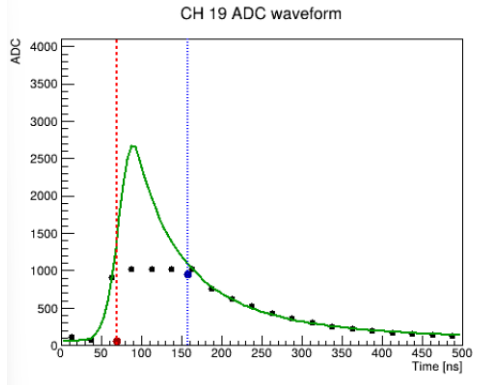




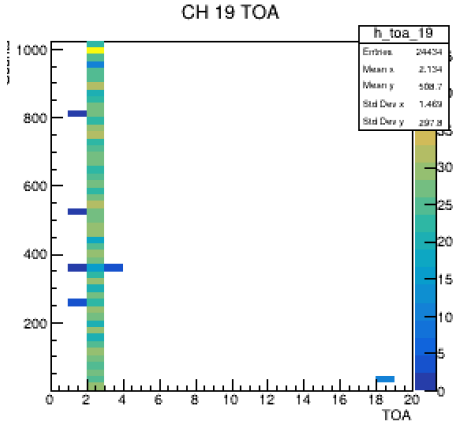

```
h_tot[ch]->Fill(s, tot);
if (toa < 360)
  {h_toa[ch]->Fill(s-2, toa);}
else
  {h_toa[ch]->Fill(s-1, toa);}
```

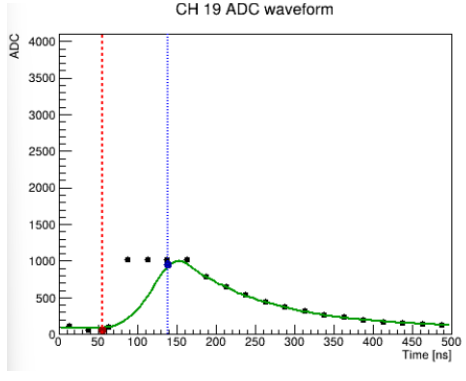


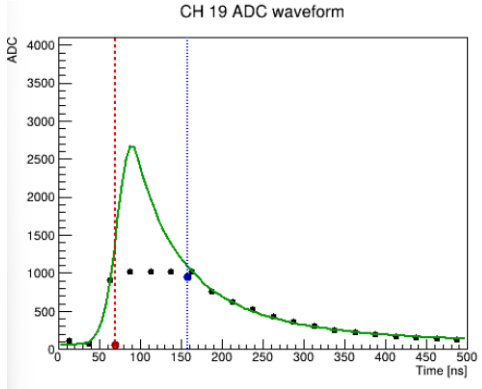





```
h_tot[ch]->Fill(s, tot);
if (toa > 260 && toa < 360)
  {h_toa[ch]->Fill(s-2, toa);}
else
  {h_toa[ch]->Fill(s-1, toa);}
```



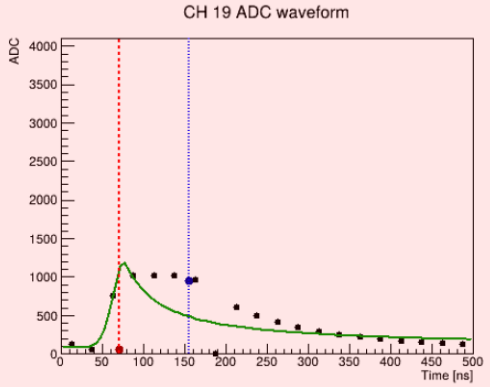




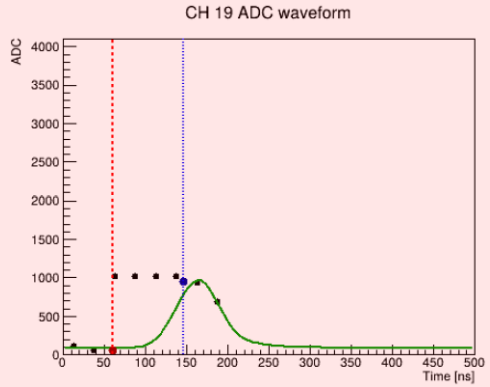
H2GCROC problems

4. Event splitting

Packet 1

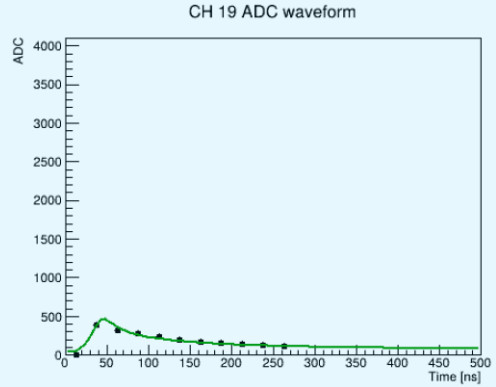


WF = 17/18
ADC = 20 points
Timestamp = 141001

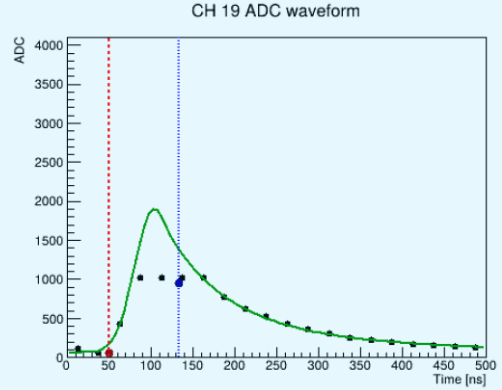


WF = 18/18
ADC = 8 points
Timestamp = 141165

Packet 2



WF = 1/18
ADC = 11 points
Timestamp = 2859661



WF = 2/18
ADC = 20 points
Timestamp = 2859825

164 timestamp = 1025 ns

2718496 timestamp = 17 ms

164 timestamp = 1025 ns

1 kHz LED trigger

1 timestamp = 6.25 ns

Norbert Novitzky 8:13 PM

I am not sure why it would be 17ms + 17us. As your trigger comes in every 1ms, then the separation between waveforms should be 1ms. Or if you have larger dead time, that might affect it. In the rcdaq now it is expecting streaming readout, so just puts the incoming data into arbitrary packages. Therefore, some waveforms can be divided into two packages. Martin has a way to create an event-pool which crosses this bounderies.

there is a way to request 20 samples in the waveform, that would remove these cross-packet waveforms

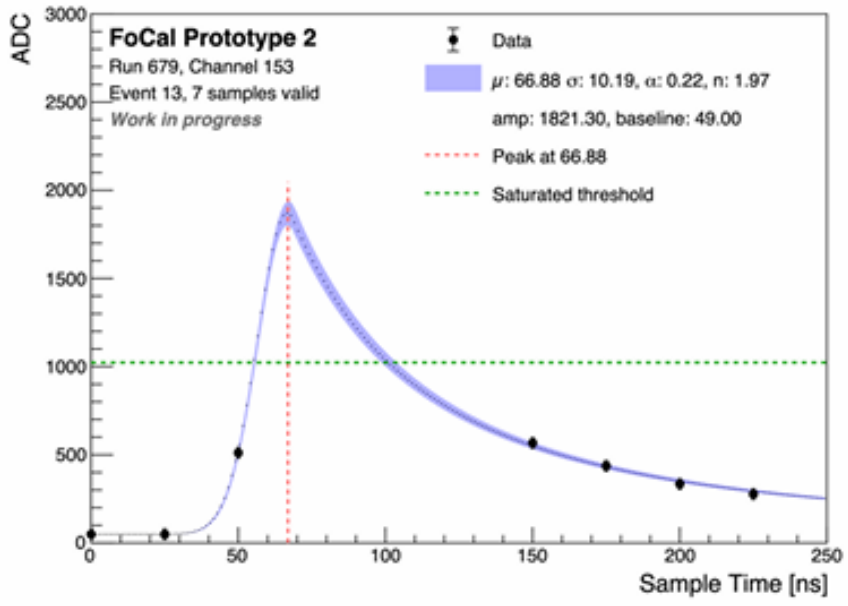
H2GCROC problems

- 1. Crosstalk
- 2. Voltage drop
- 3. ToA mismatch
- 4. Event splitting

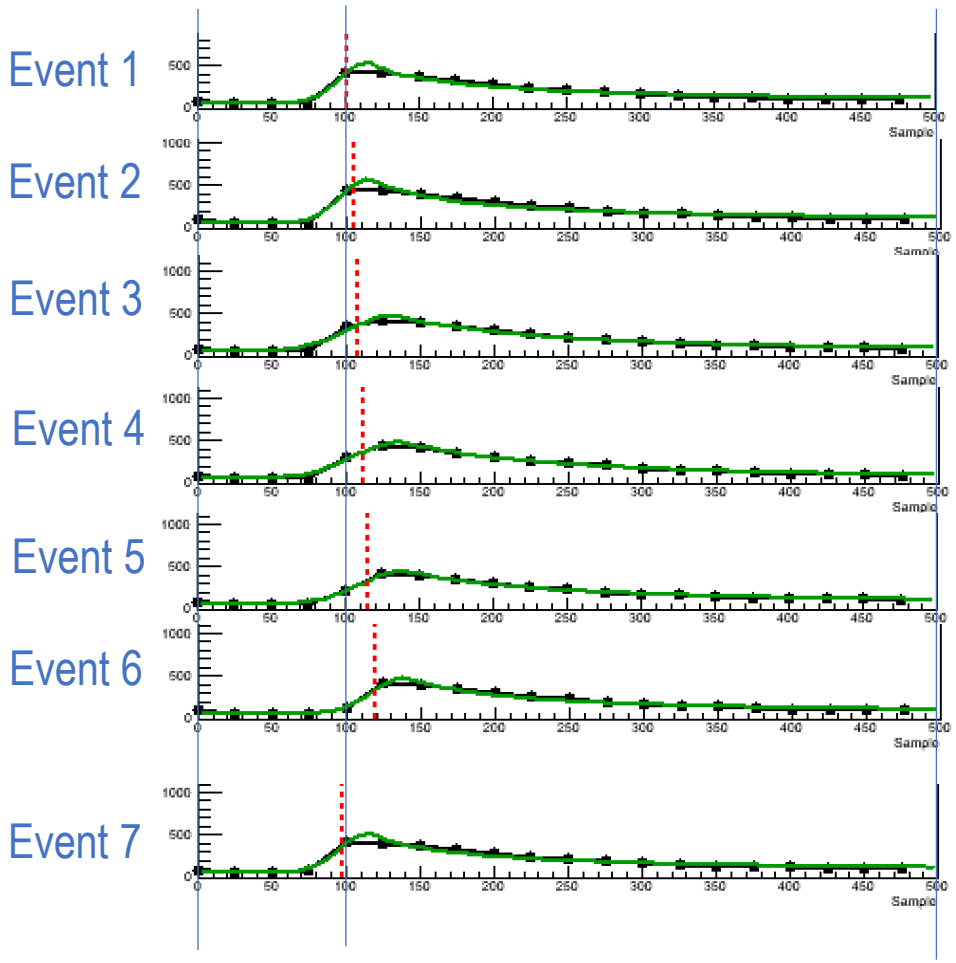
- Where and whom to ask..

Backup

$$\mathrm{ADC} = f(x;\ \alpha, n, \mu, \sigma, N, B) = \begin{cases} N \cdot \exp\left(-\dfrac{(x-\mu)^2}{2\sigma^2}\right) + B, & \text{for } \dfrac{x-\mu}{\sigma} < \alpha \\ N \cdot A \cdot \left(B + \dfrac{x-\mu}{\sigma}\right)^{-n} + B, & \text{for } \dfrac{x-\mu}{\sigma} > \alpha \end{cases}$$

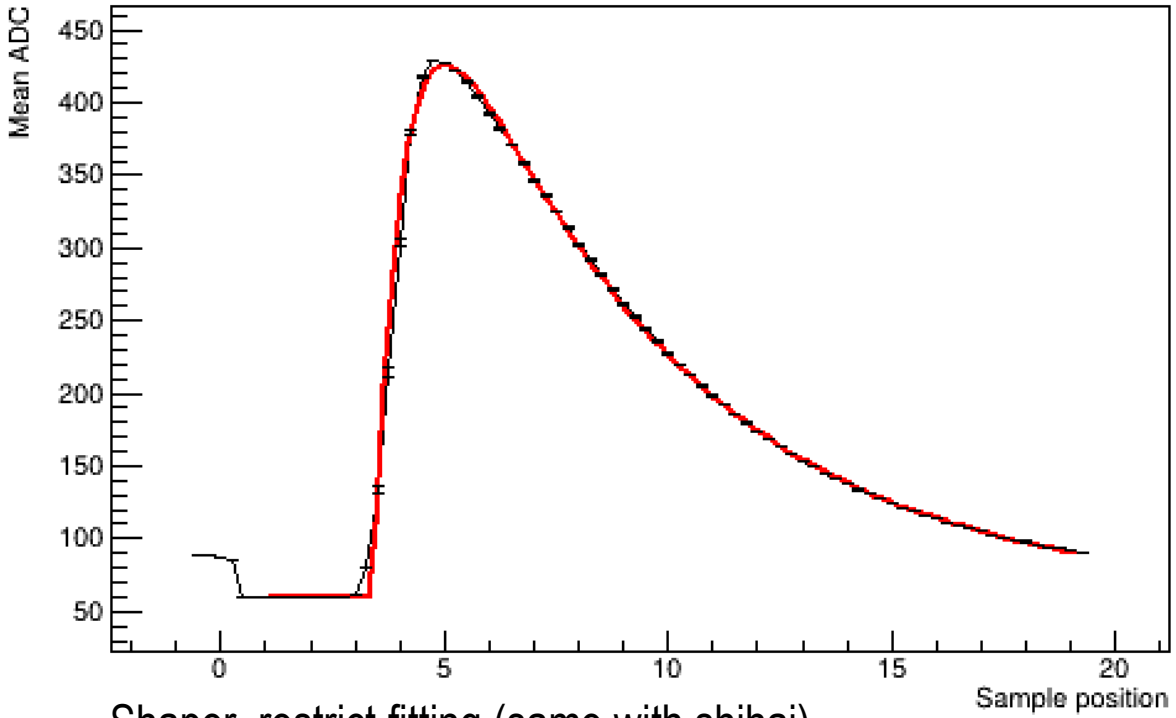


ToA & ADC delay



- LED + SiPM signal (500 Hz, 2 ms per event)
- Fixed signal size, fixed time delay
- ToA & ADC seem to get delay each event, and come back to initial place after 6 events]
- Bad clock synchronization

Single event fit

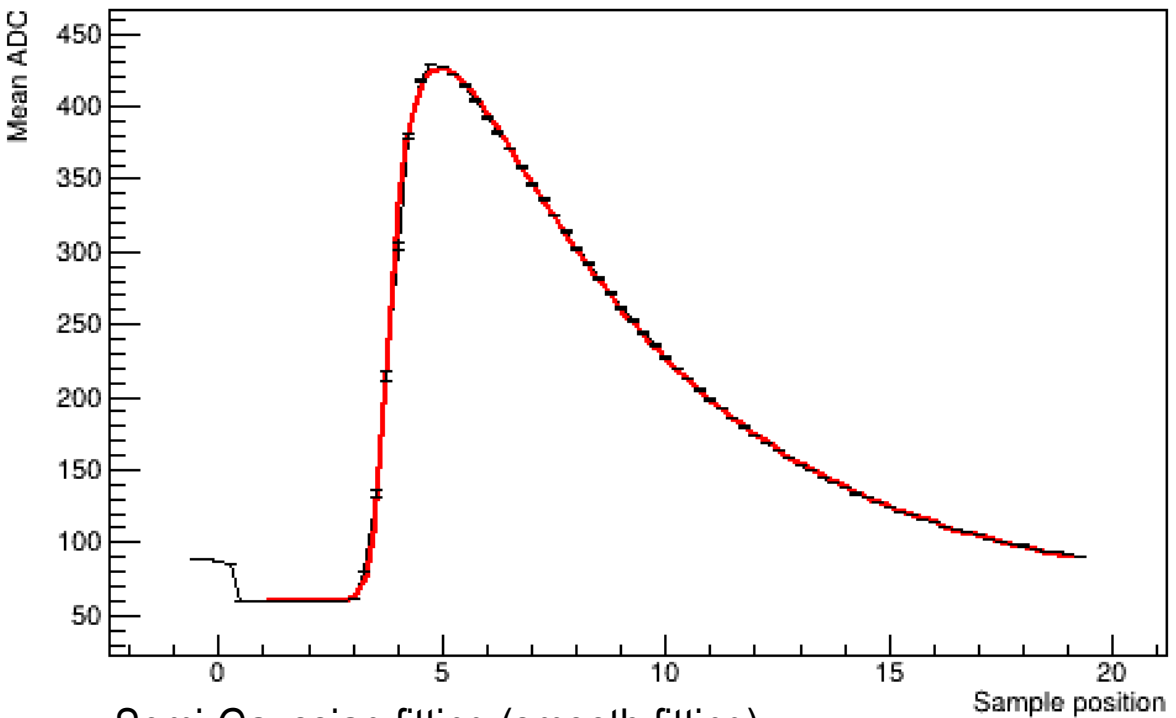


Shaper_restrict fitting (same with shihai)

$$\text{Pedestal} + A\left[1 - e^{-(u/\tau_{rise})}\right]^n \times e^{-u/\tau_{Fall}}$$

$$u = t - t_0$$

t_0 = 3.42 +/- 0.00489
tauRise = 0.832 +/- 0.00922
tauFall = 5.36 +/- 0.00395
n = 0.882
chi2/ndf = 44.9



Semi-Gaussian fitting (smooth fitting)

$$\text{Pedestal} + A\left[1 - e^{-(u/\tau_{rise})}\right]^n \times e^{-u/\tau_{Fall}}$$

$z = (t\text{-}t_0)/smooth$

$u = t - t0$	$(z > 40)$
$u = smooth\ \ln(1 + e^z)$	$(-40 < z < 40)$
$u = smooth\ e^z$	$(z < -40\ )$

t_0 = 3.70 +/- 0.0275
tauRise = 0.992 +/- 0.0310
tauFall = 5.356 +/- 0.00502
n = 0.472
chi2/ndf = 28.4