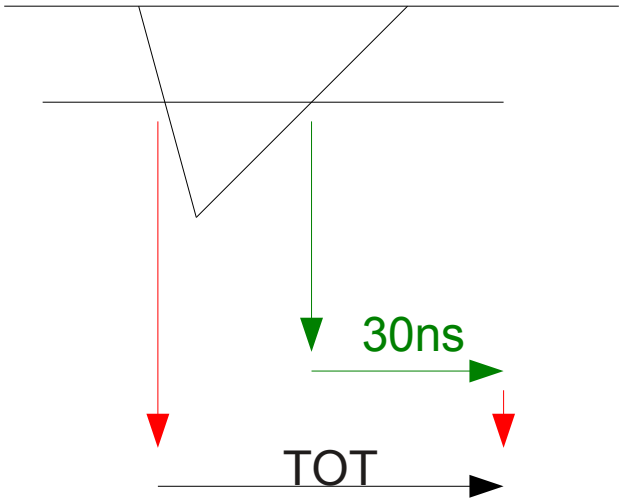
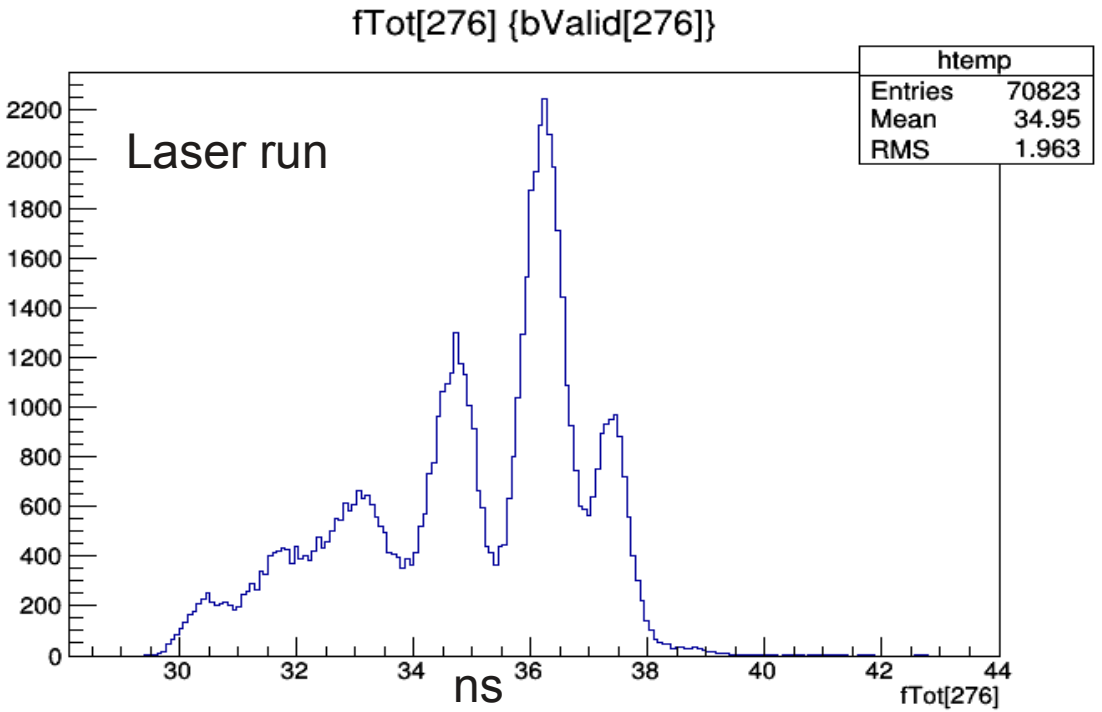
TOT and noise

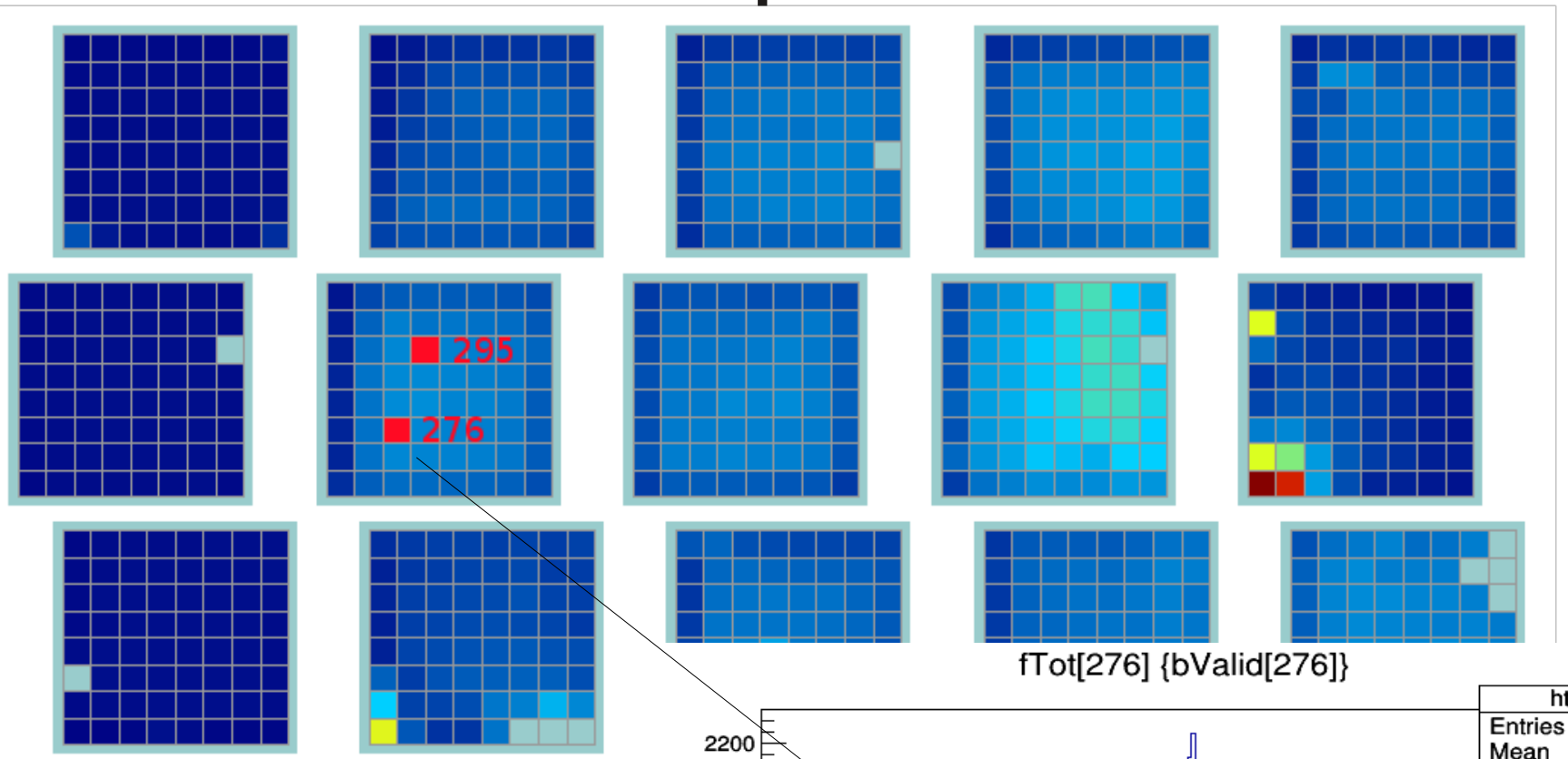
Carsten Schwarz, GSI



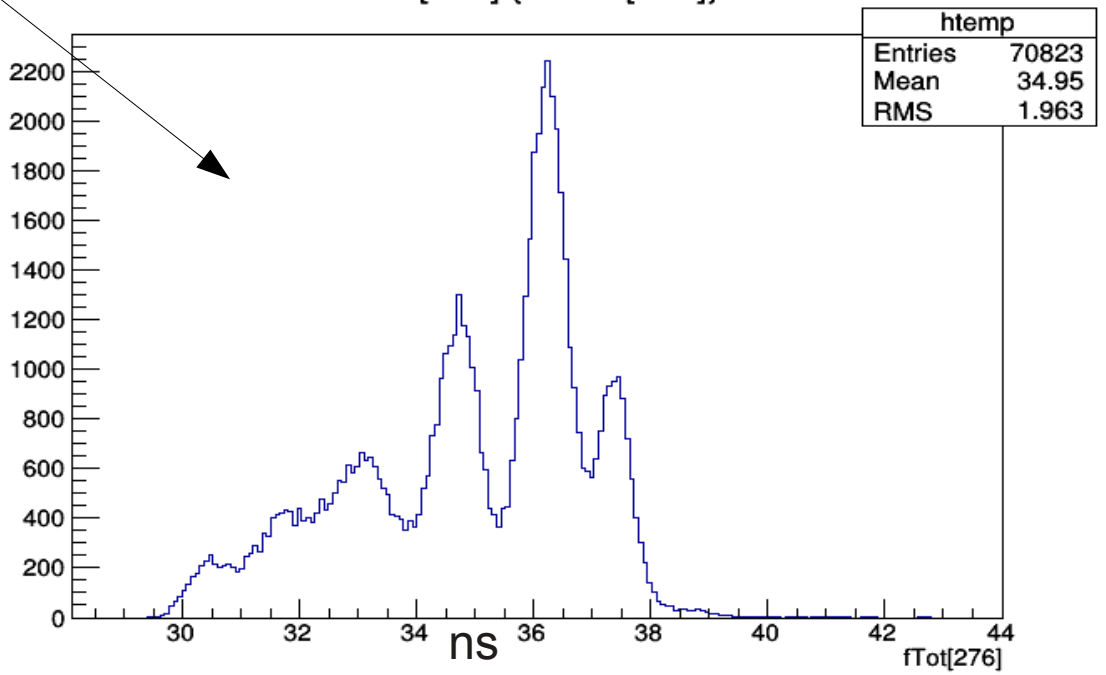


at CERN2015: multiple peak structure of TOT

CERN2015: Multiple Peaks in TOT

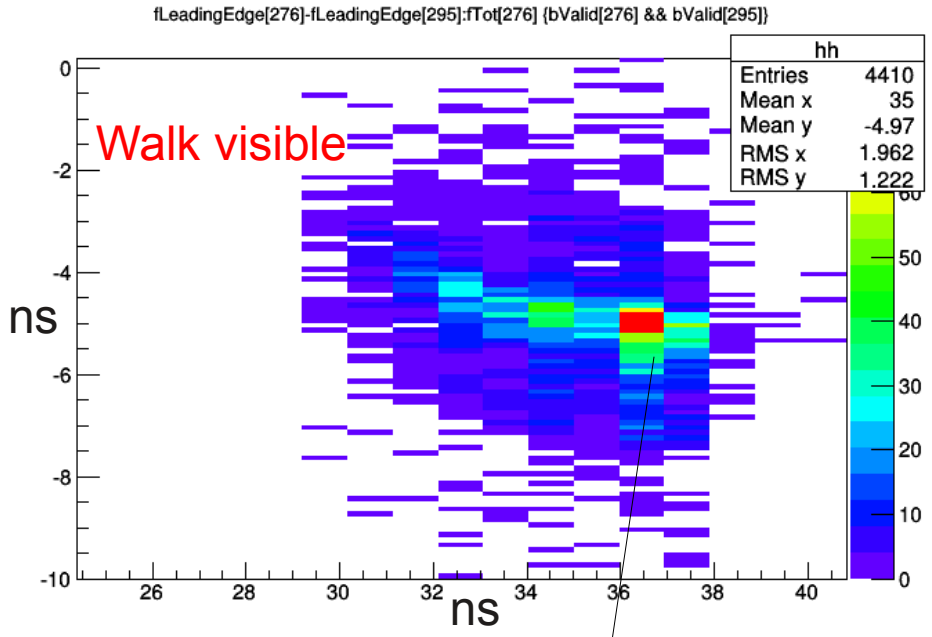


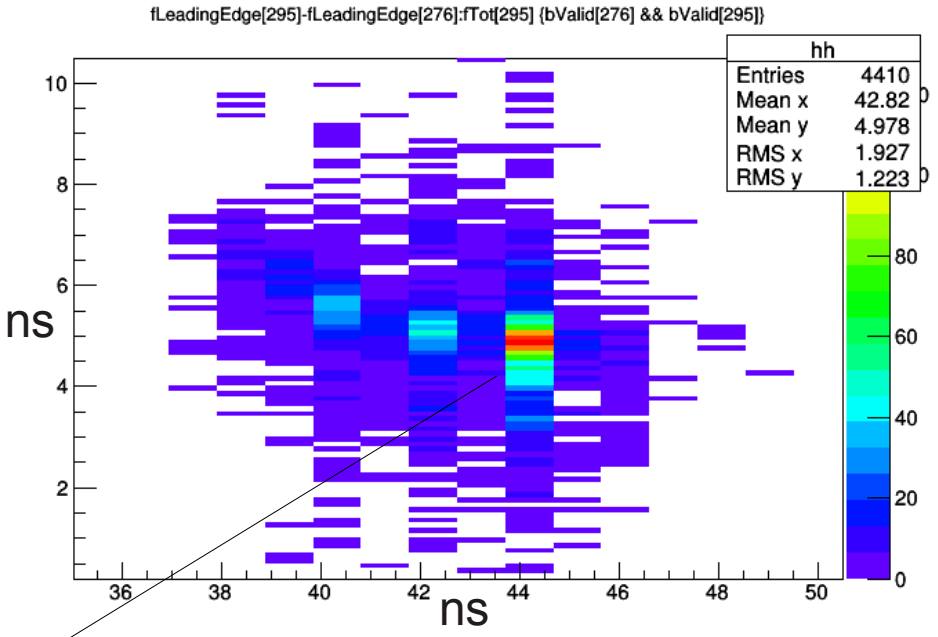
fTot[276] {bValid[276]}

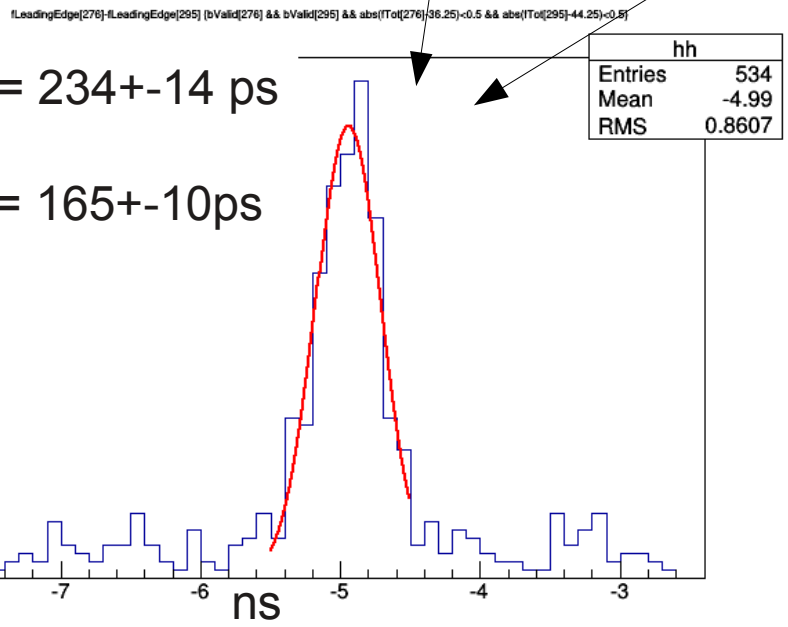


pilas120_15185084004.hld

fLeadingEdge[276]-fLeadingEdge[295] : fTot[276]

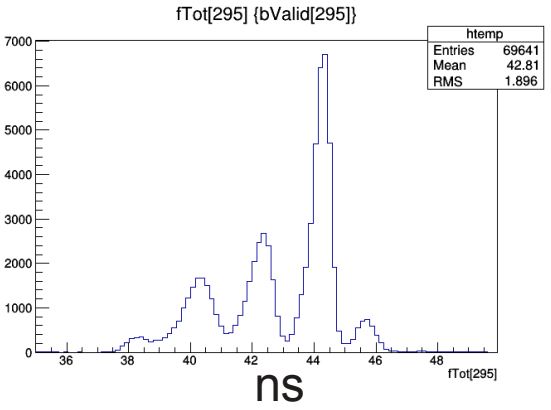






$\sigma(1\text{-}2) = 234\text{+-}14$ ps

$\sigma(1,2) = 165\text{+-}10$ps

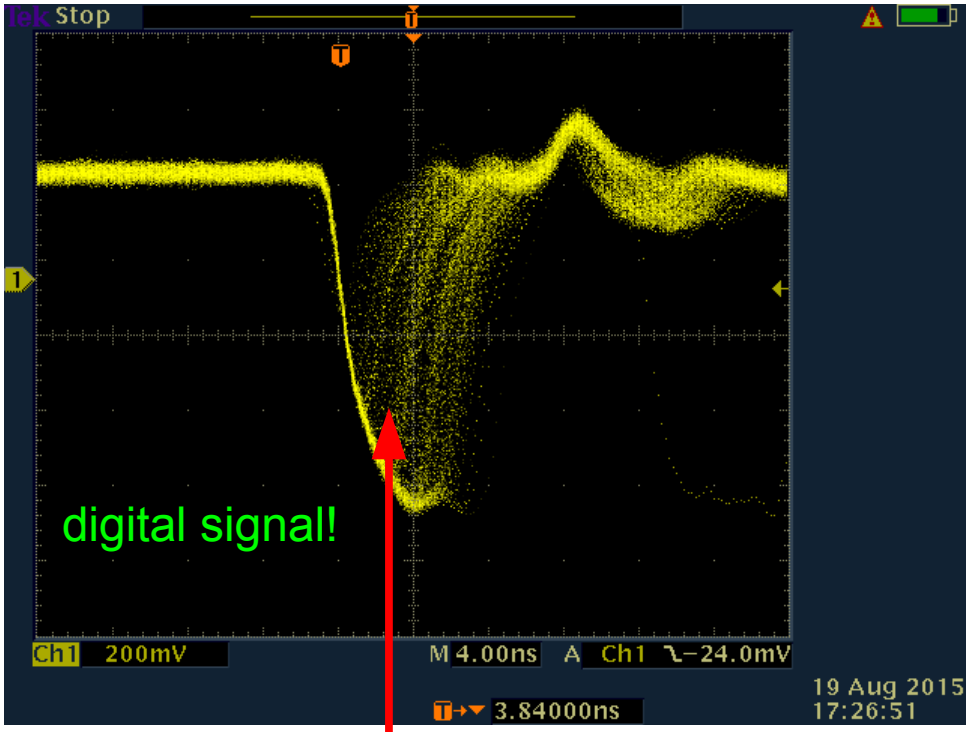


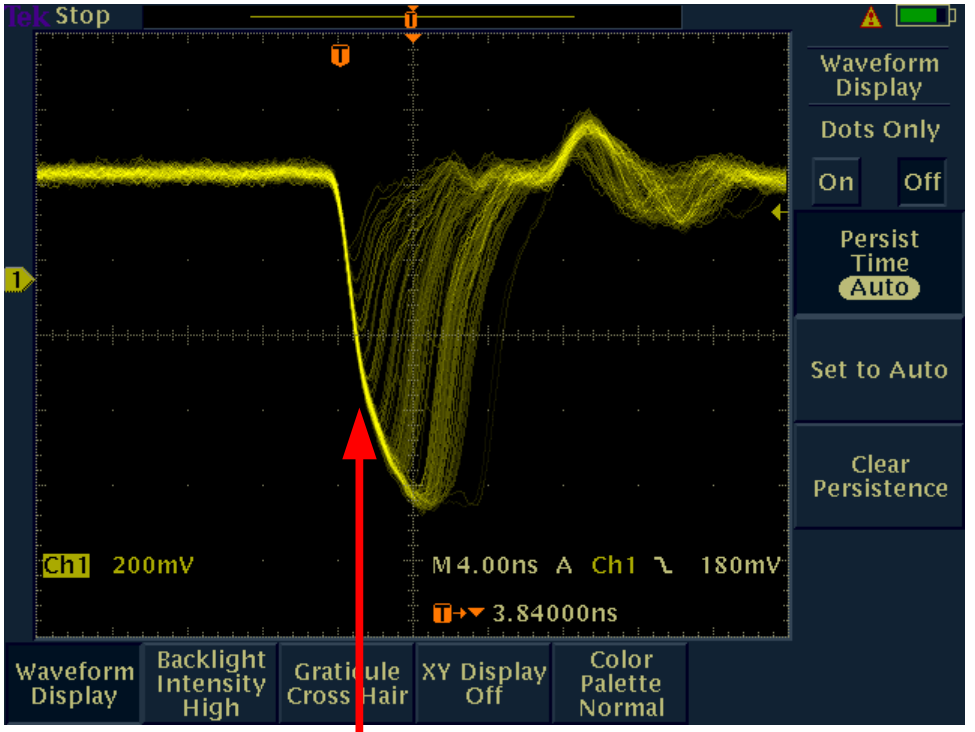
The peaks look not like repeated TOT distributions

Rather like a odd shaped common TOT distribution

Whom to blame: TDC or FEE?

LVDS output of a channel in 0x200f/2





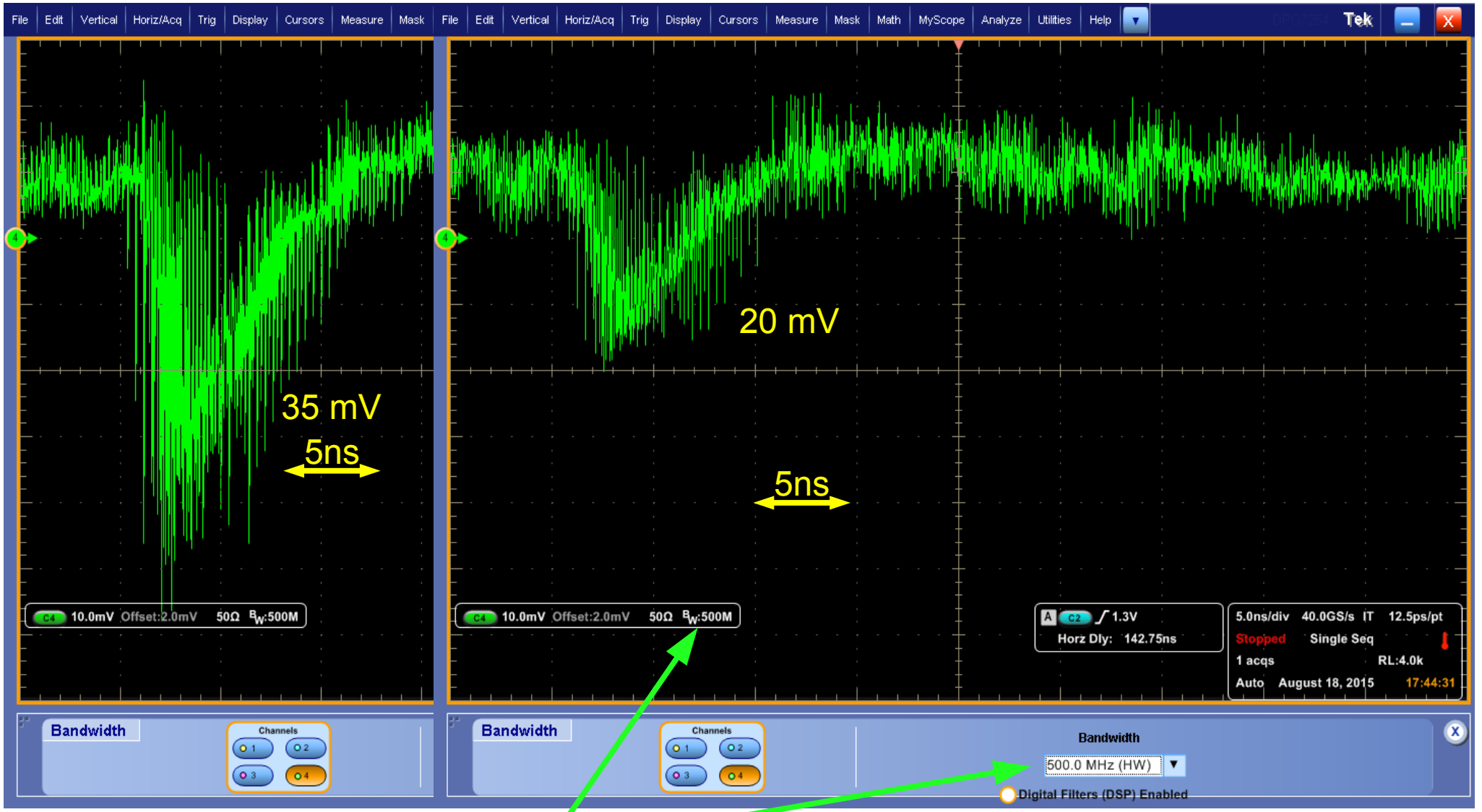
TDS3054

Peak structure visible

Short signals have low amplitudes

it is the FEE...

Signal after PA, just before the discrimination (one of 0x200f/2):



DPO7054

BW limit to “hide”
Digi-noise.
Software is forcing that.

Typical signal amplitude after PA: 10-40 mV

Next: Simulation of ripple

There is a paper describing
multiple peaks with TOT measurements

F. Gonella et al. NA62 NIM A791 (2015) 16

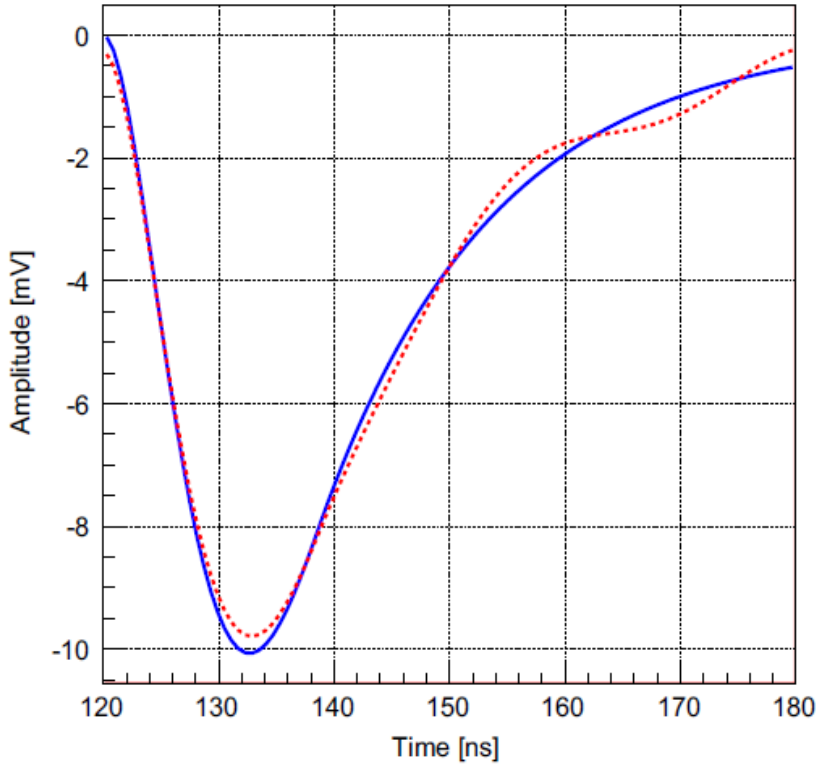


Fig. 5. Simulated shape of the output signal of the system lead-glass block – PMT without (solid curve) and with addition of 300 μV noise at 40 MHz frequency (dashed curve).

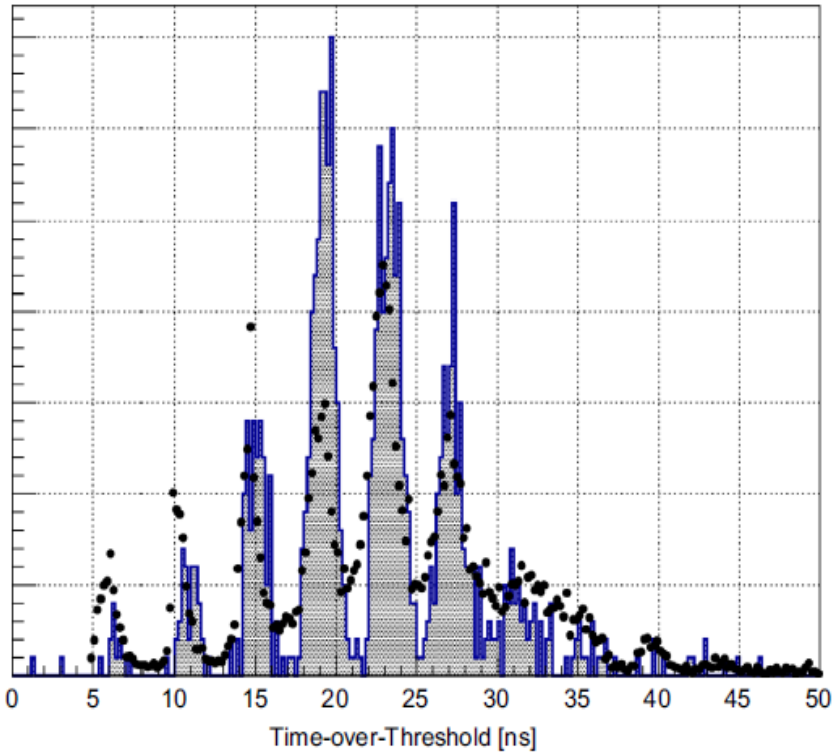
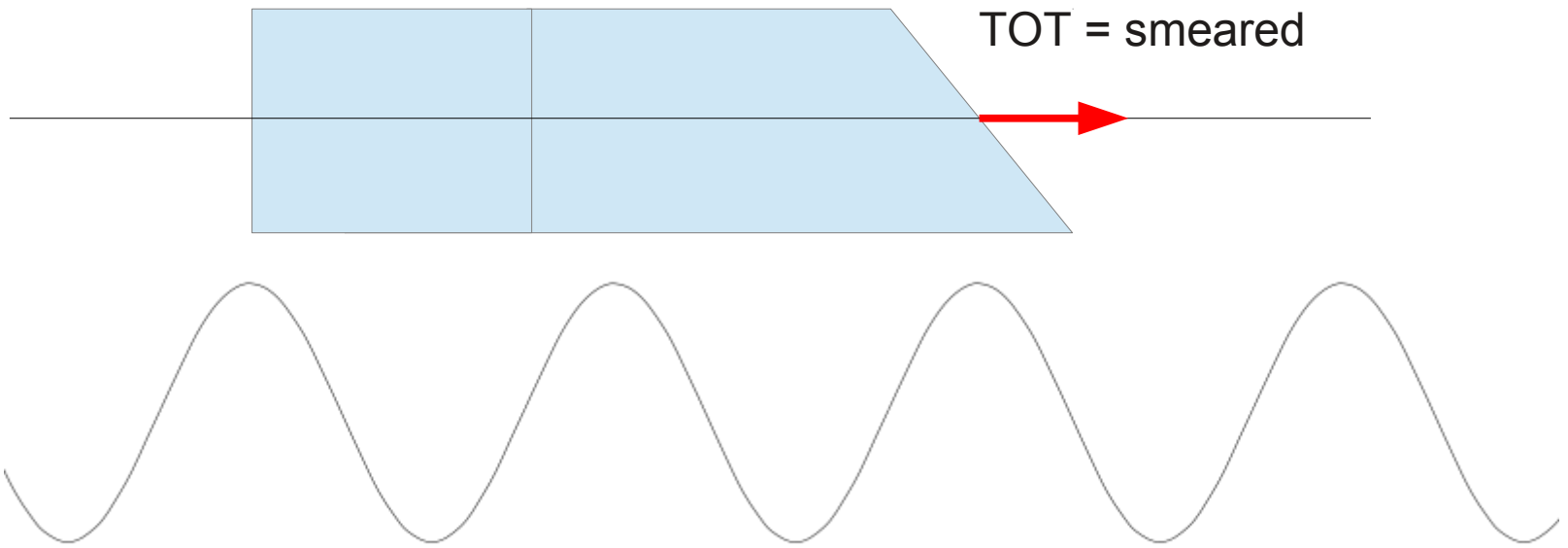


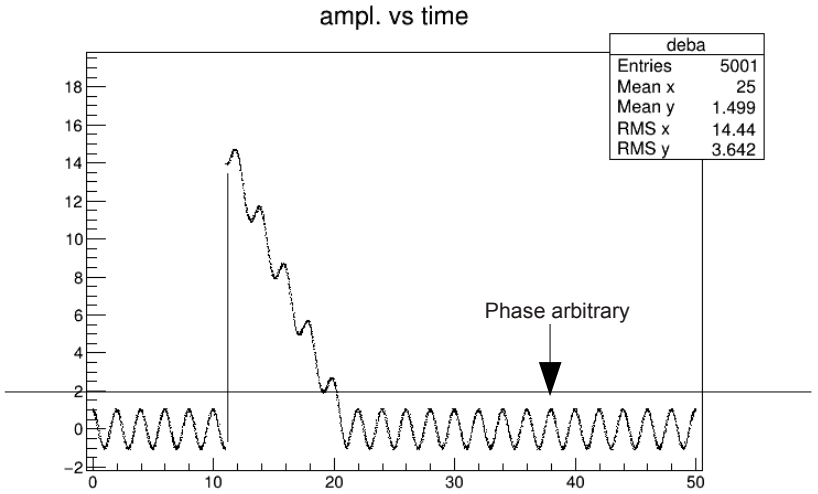
Fig. 11. Comparison between the measured (dots) and the simulated (histogram) ToT. The simulation parameters were noise amplitude=0.9 mV, hysteresis=1.5 mV, noise frequency=240 MHz. The positions of the peaks are well reproduced.

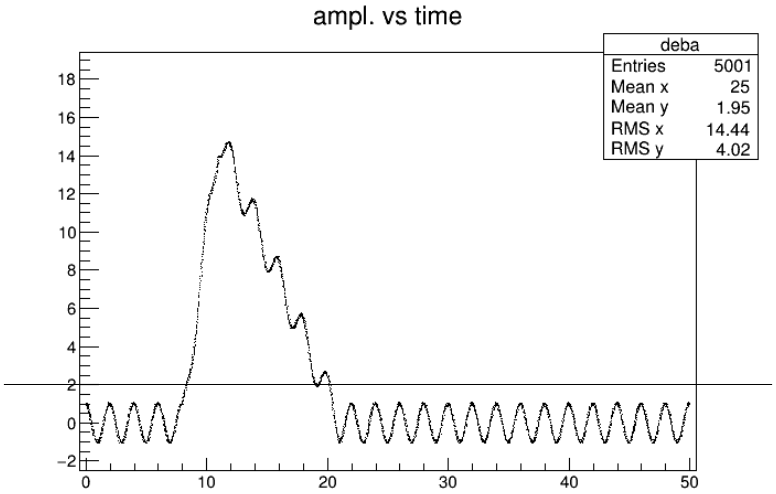
The effect of the inclusion of the extra noise is shown in Fig. 9. The black dots are the expected ToT distribution for a signal from the LAV lead-glass block without noise and the histogram is the result with the additional 500 μV noise. The sinusoidal noise induces a random shift on both the measured leading and trailing edges, correlating them with each other. This decreases the probability of obtaining certain periodic values of the ToT, and increases the probability of obtaining the values in their vicinity, creating the multiple-peak structure. The noise-induced peaks in the ToT distribution are equally spaced and are shifted by half of the period of the noise with respect to zero. This peculiarity can be exploited to determine the noise frequency as shown in Fig. 10. The extracted noise frequency is $f = (239 \pm 1)$ MHz.

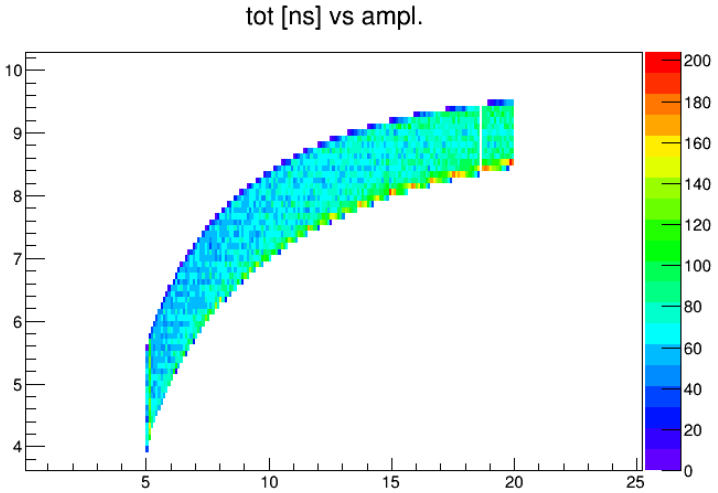
High frequency noise can produce peaks.

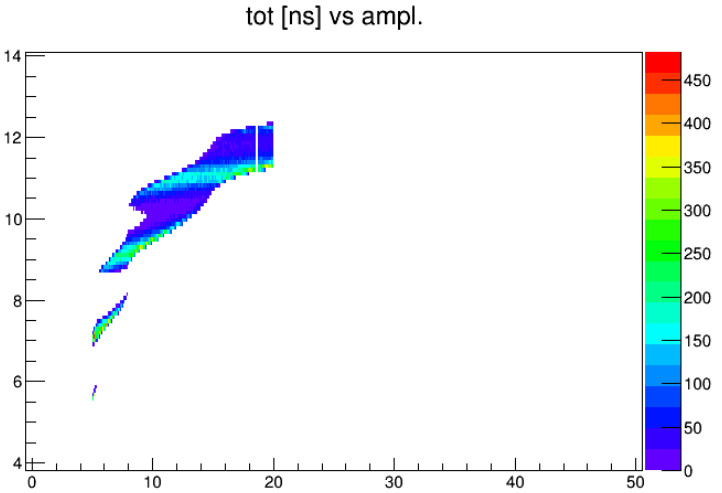
Sinus wiggle on trailing edge
→ smearing, no peaks

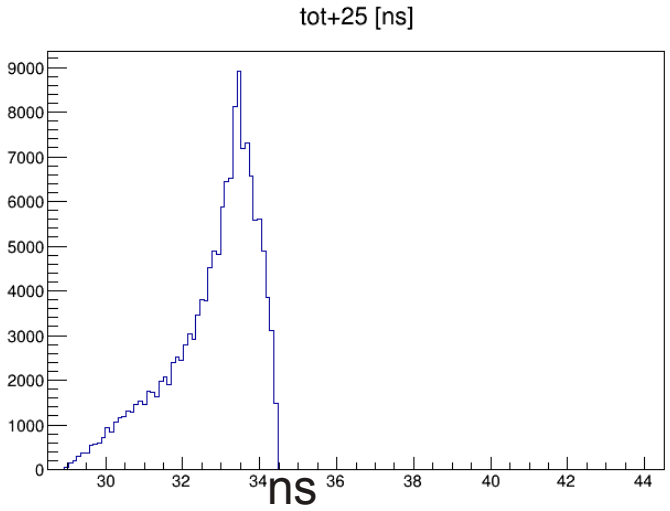


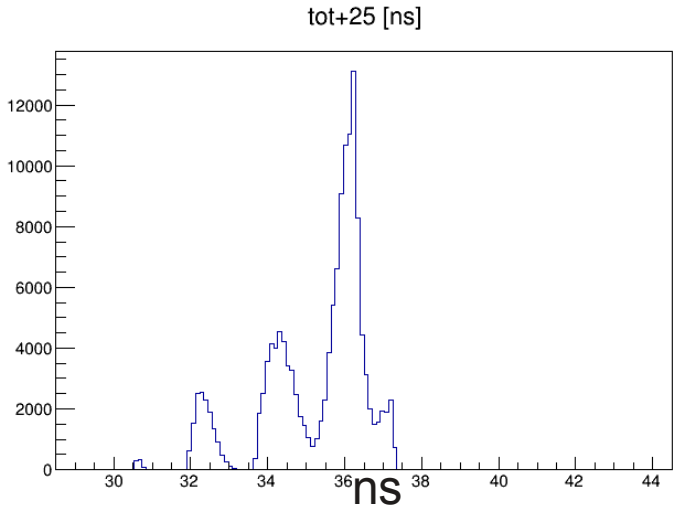




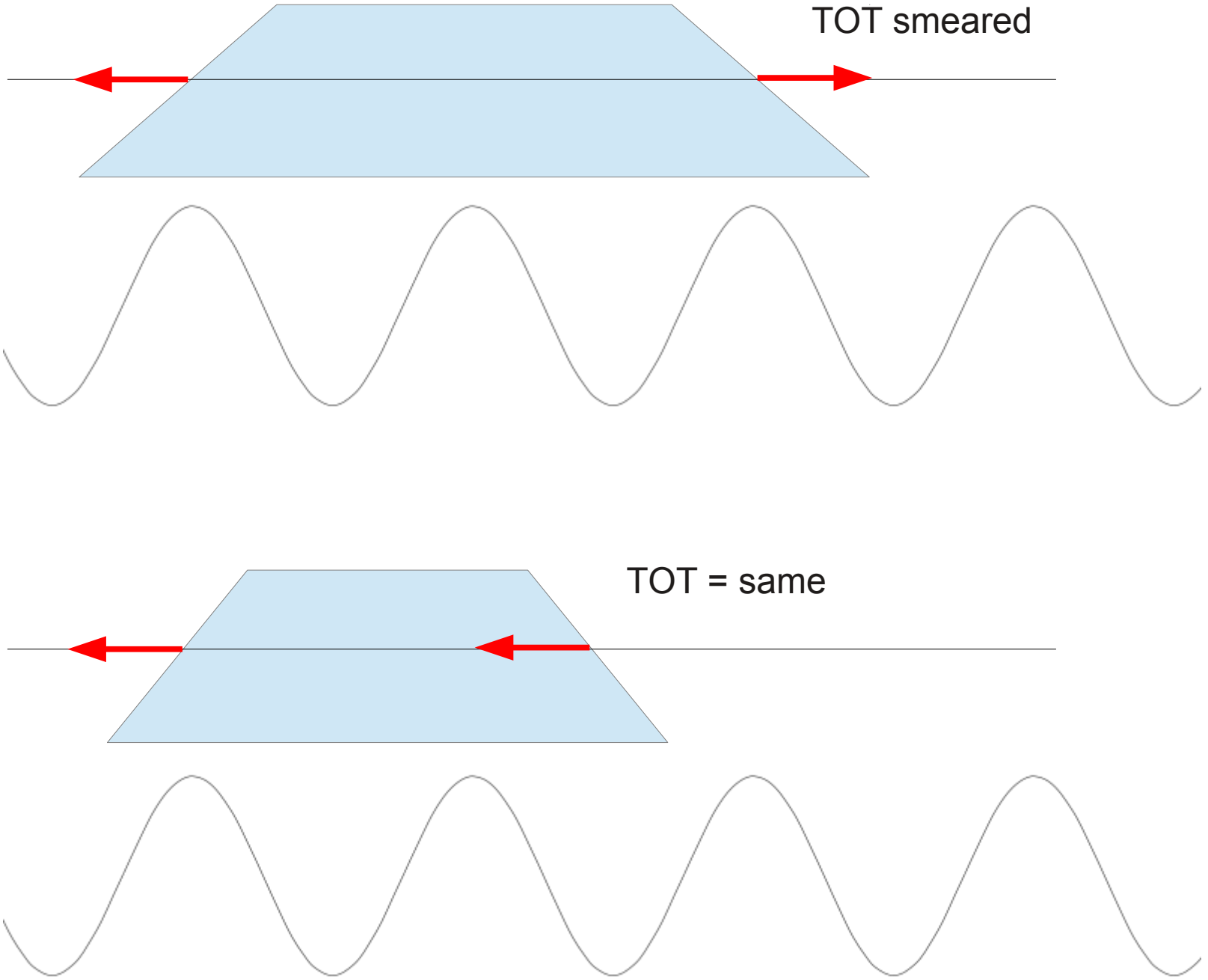


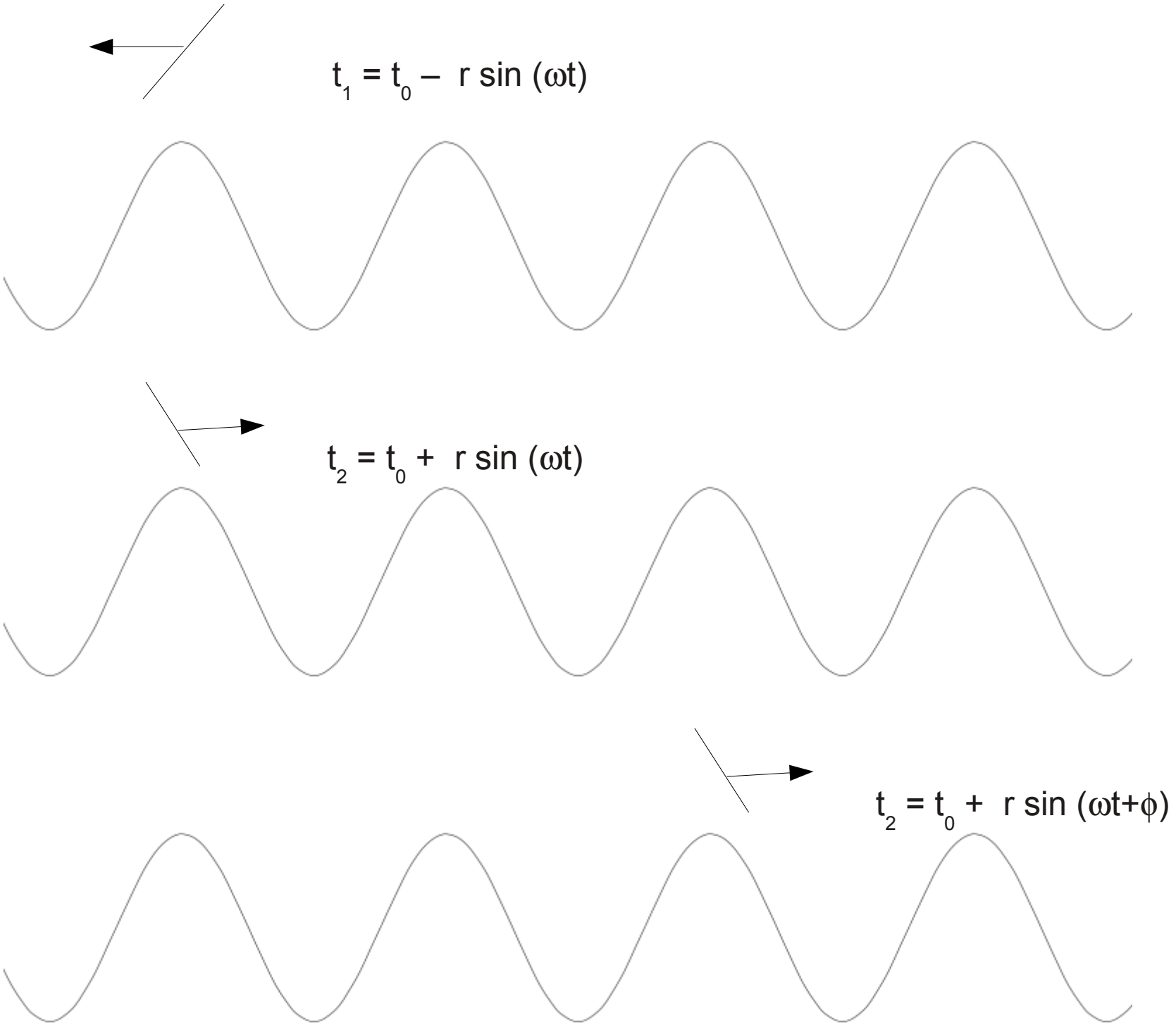






Leading & trailing edge need to move for multiple peaks


TOT smeared
TOT = same


$t_1 = t_0 - r \sin(\omega t)$
$t_2 = t_0 + r \sin(\omega t)$
$t_2 = t_0 + r \sin(\omega t + \phi)$

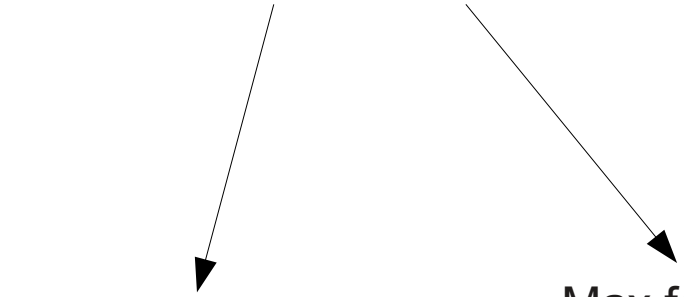
$$TOT = t_2 - t_1$$

$$= [\, t_0 + r \sin(\omega t + \phi) \,] \quad - \quad [\, t_0 - r \sin(\omega t) \,]$$

$$= r \sin(\omega t + \phi) + r \sin(\omega t)$$

$\sin a + \sin b = 2 \sin[(a+b)/2] \cos[(a-b)/2]$

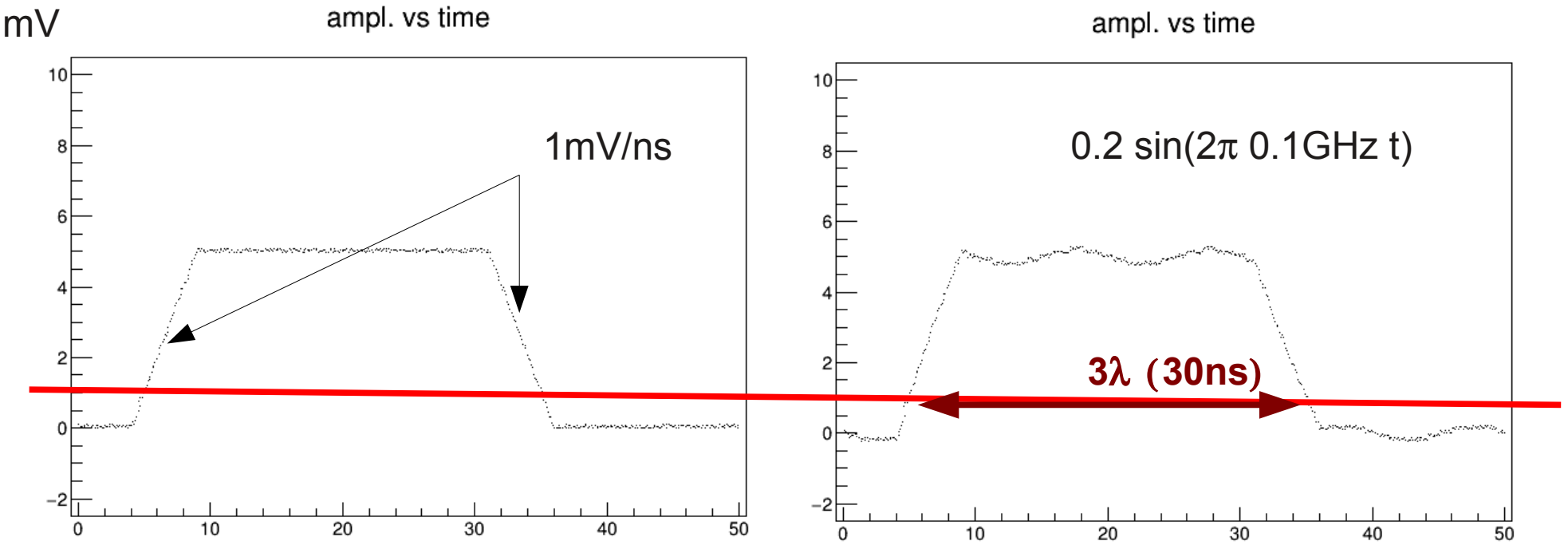
$$= 2 r \sin(\omega t + \phi/2) \cos(\phi/2)$$

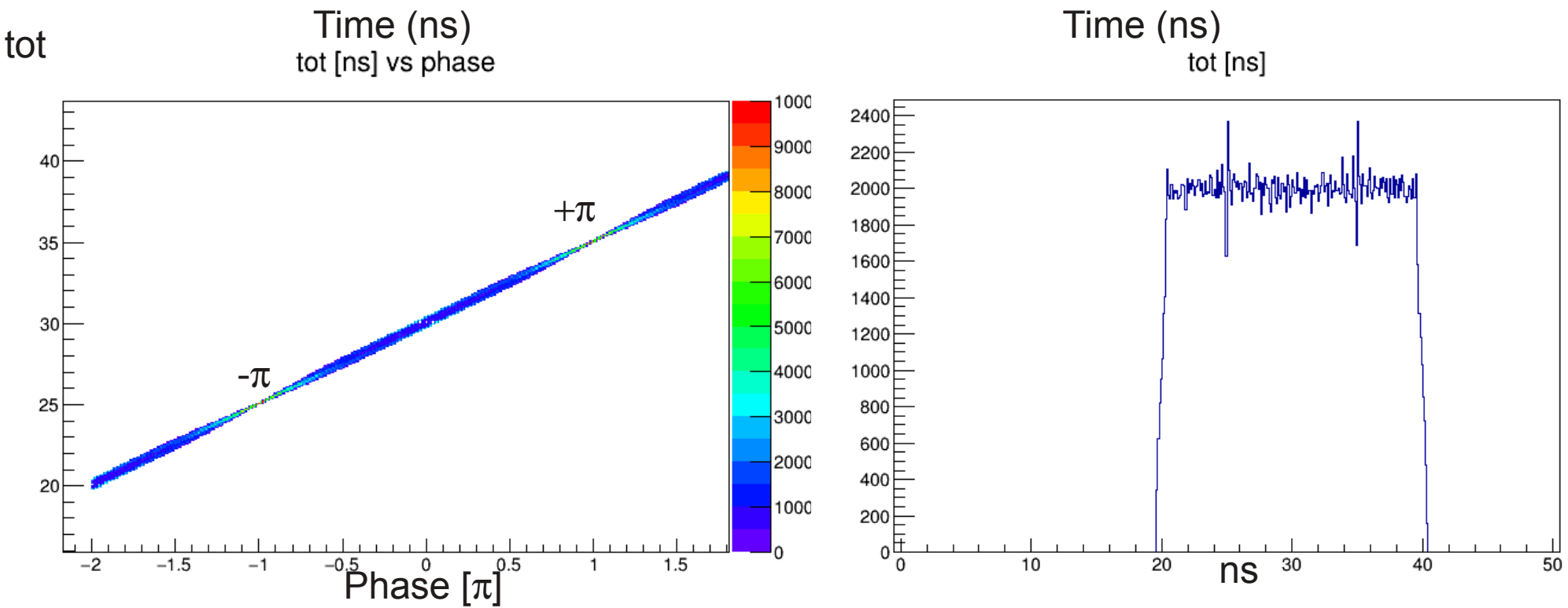


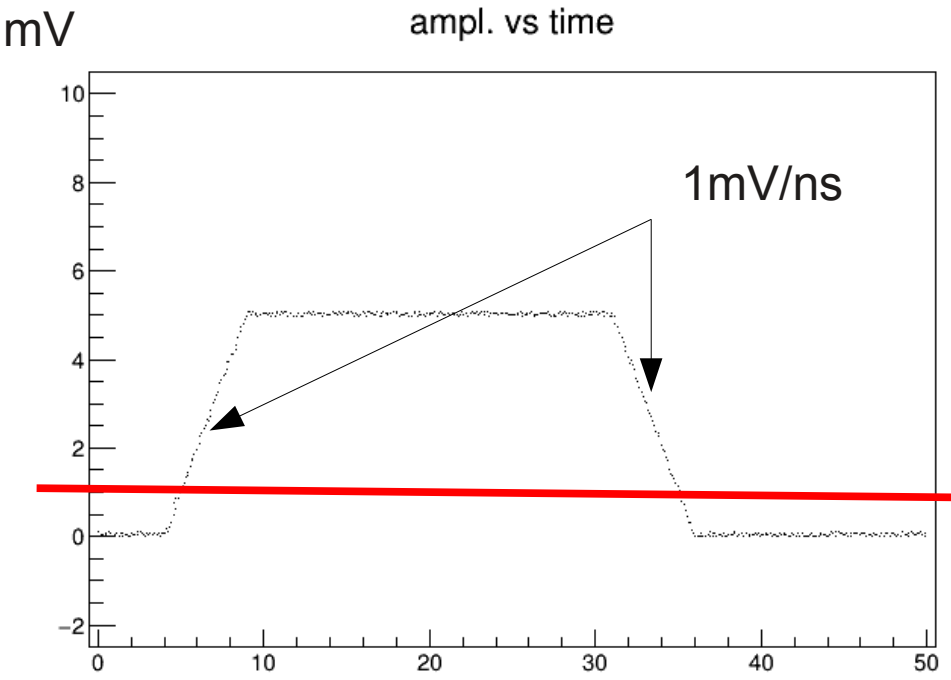
smearing

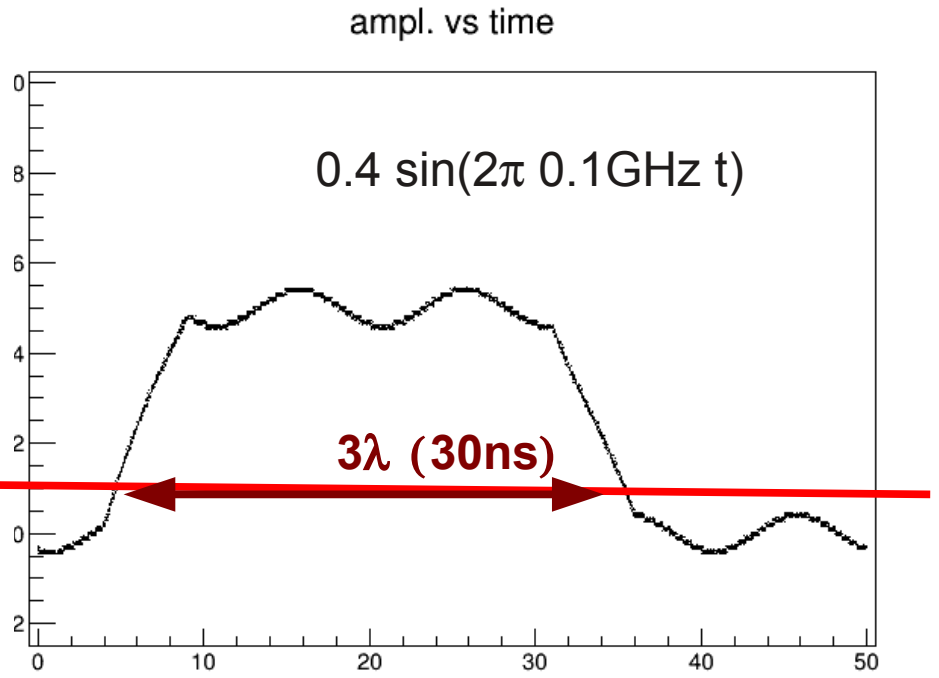
Max for $\phi = 0$

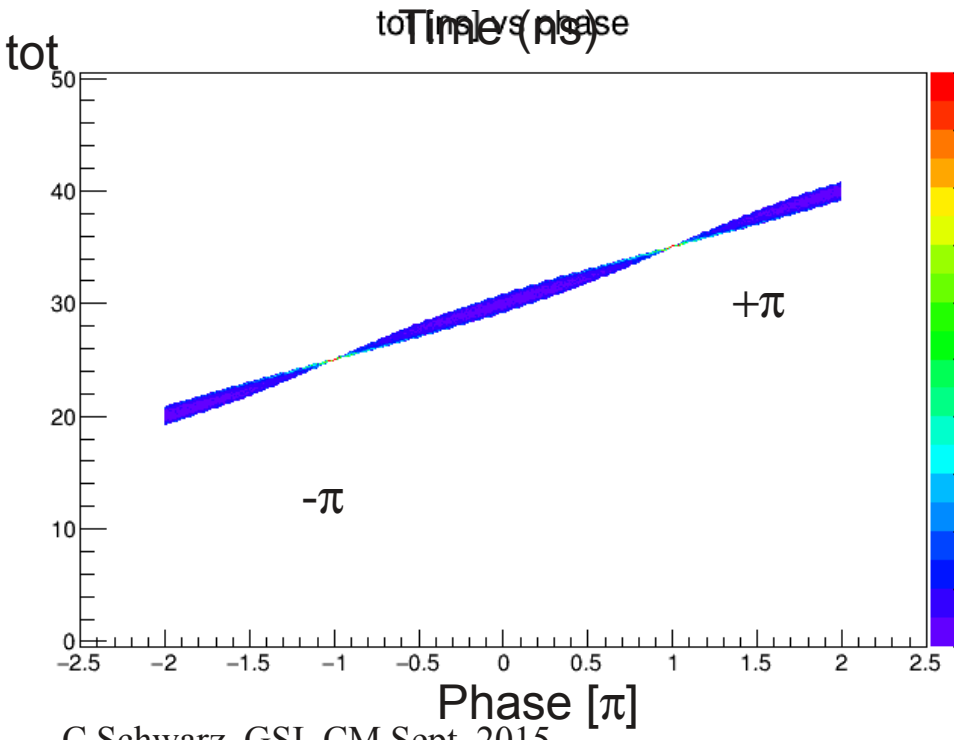
Min for $\phi = +-\pi$

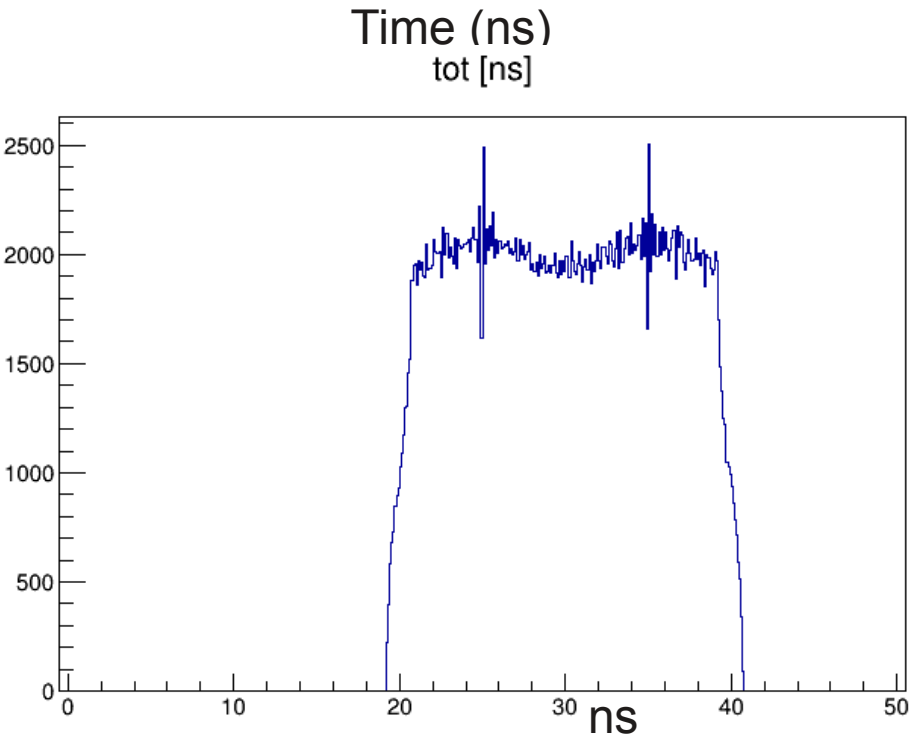

mV
ampl. vs time
1mV/ns
ampl. vs time
0.2 sin(2π 0.1GHz t)
3λ (30ns)

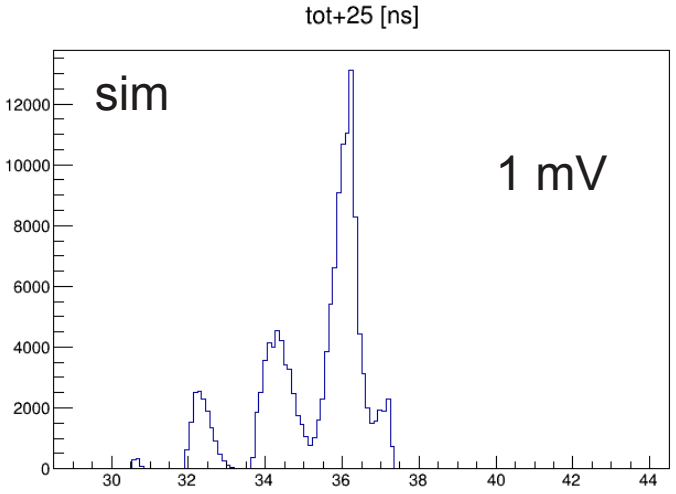

tot
Time (ns)
tot [ns] vs phase
+π
-π
Phase [π]
Time (ns)
tot [ns]
ns

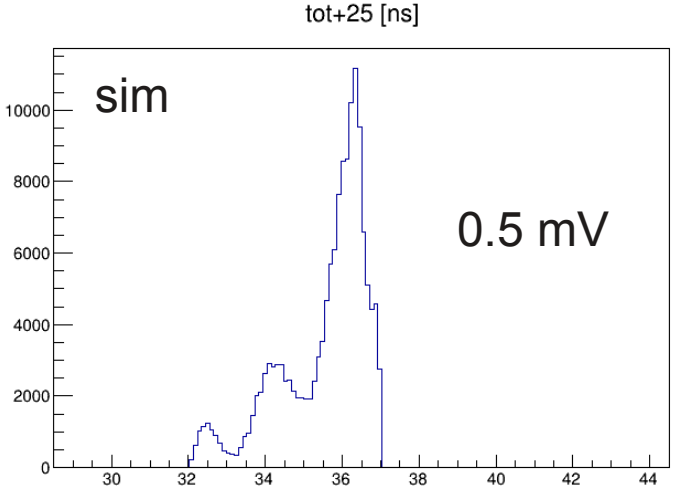

mV
ampl. vs time
1mV/ns

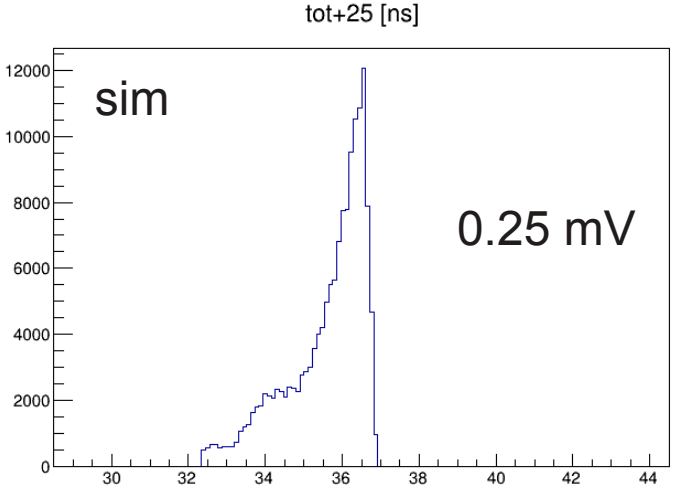

ampl. vs time
0.4 sin(2π 0.1GHz t)
3λ (30ns)


tot
Time vs phase
Time (ns)
+π
-π
Phase [π]

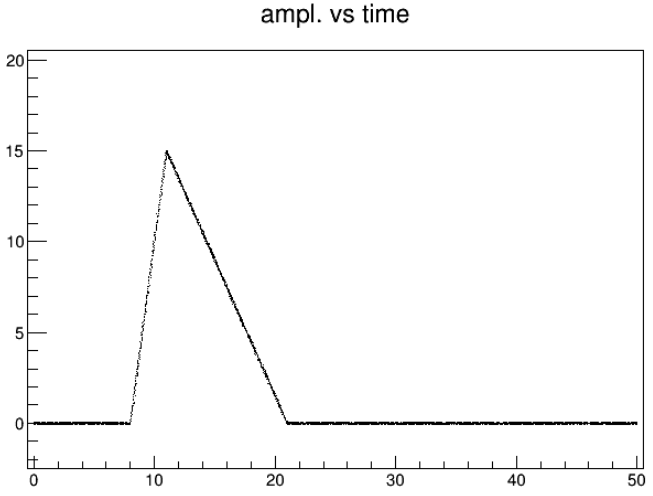

Time (ns)
tot [ns]
ns

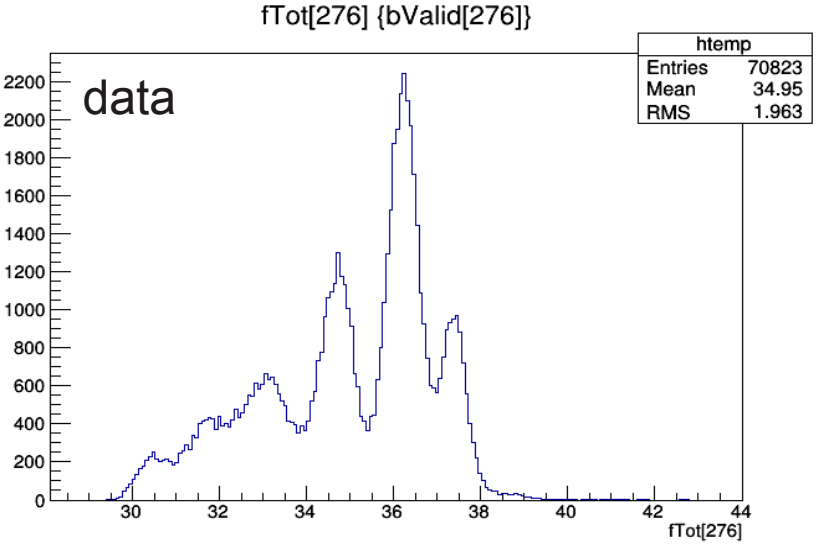






Amplitude: 5-20mV, Threshold: 2 mV
Sinus: 0.5 GHz, 1, 0.5, 0.25mV

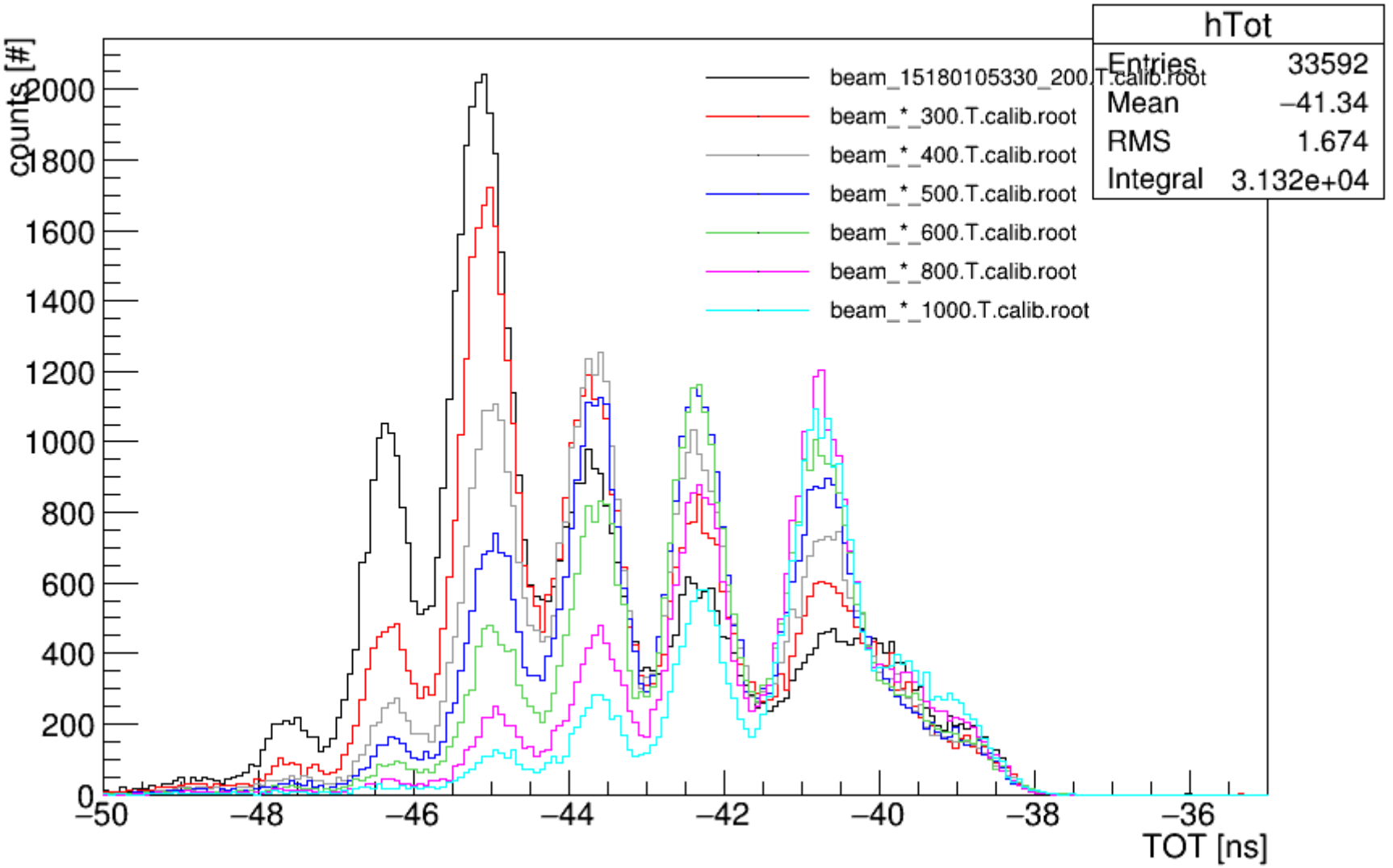




Data in agreement with
0.5 - 1.0mV sinus wiggle (0.5 GHz).

Different thresholds in experiment data:

Logbook, Posted on June 29, 2015 @ 16:05 by pandadrc



Pilas electronic lab

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Padiwa 200f/2 47pf,200R

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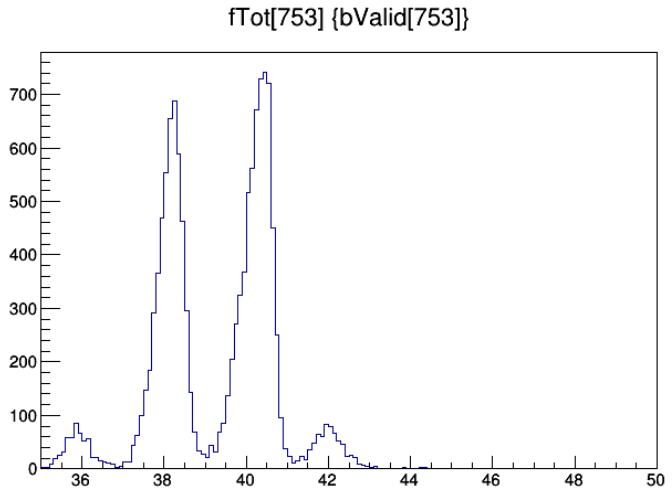

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Padiwa 200f/2 1pF/51R

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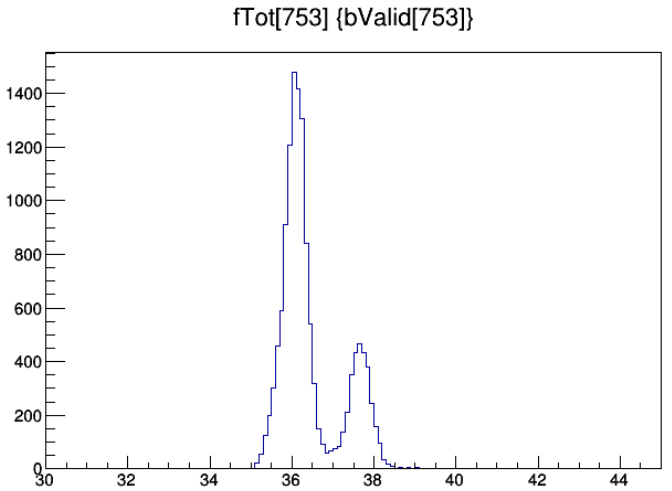

Frequency on PADIWA: 133+-13.3 MHz

133 MHz	266 MHz	399 MHz	532 MHz	798 MHz
7.5ns	3.76 ns	2.51 ns	1.88 ns	1.25 ns

- Multi peaks observed in TOT of experiment.
- Parasitic oscillation cause correlations between leading and trailing edge
- Oscillation of ~500 MHz and ~1mV can explain structure