A. Poblaguev

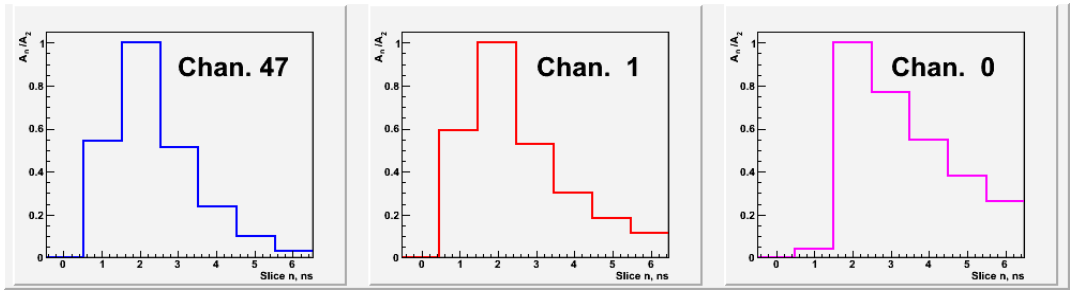
FADC250: Is 4 ns sampling sufficient for the AGS/RHIC pCarbon polarimeters

- ***Limitation on time resolution***
- ***Measured amplitude dependence on clock phase***
- ***Analysis of the "scattering pulse" signals in Si strips***

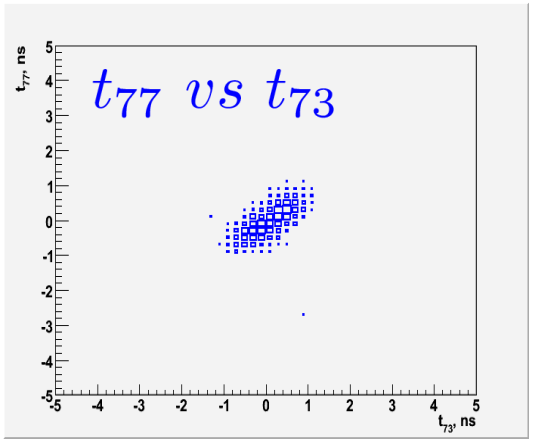
Time measurement in the ATLAS ZDC

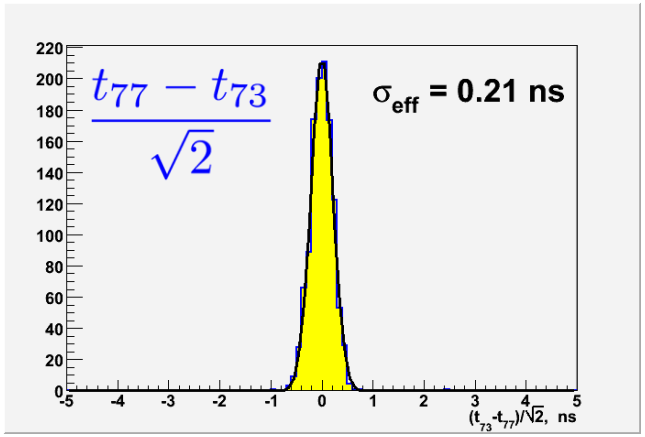
PPM (WFD): 40 MHz, 10 bit
(sampling time 25 ns)

Typical signals:



Comparison of signals in one arm (two different modules hitted by one neutron)





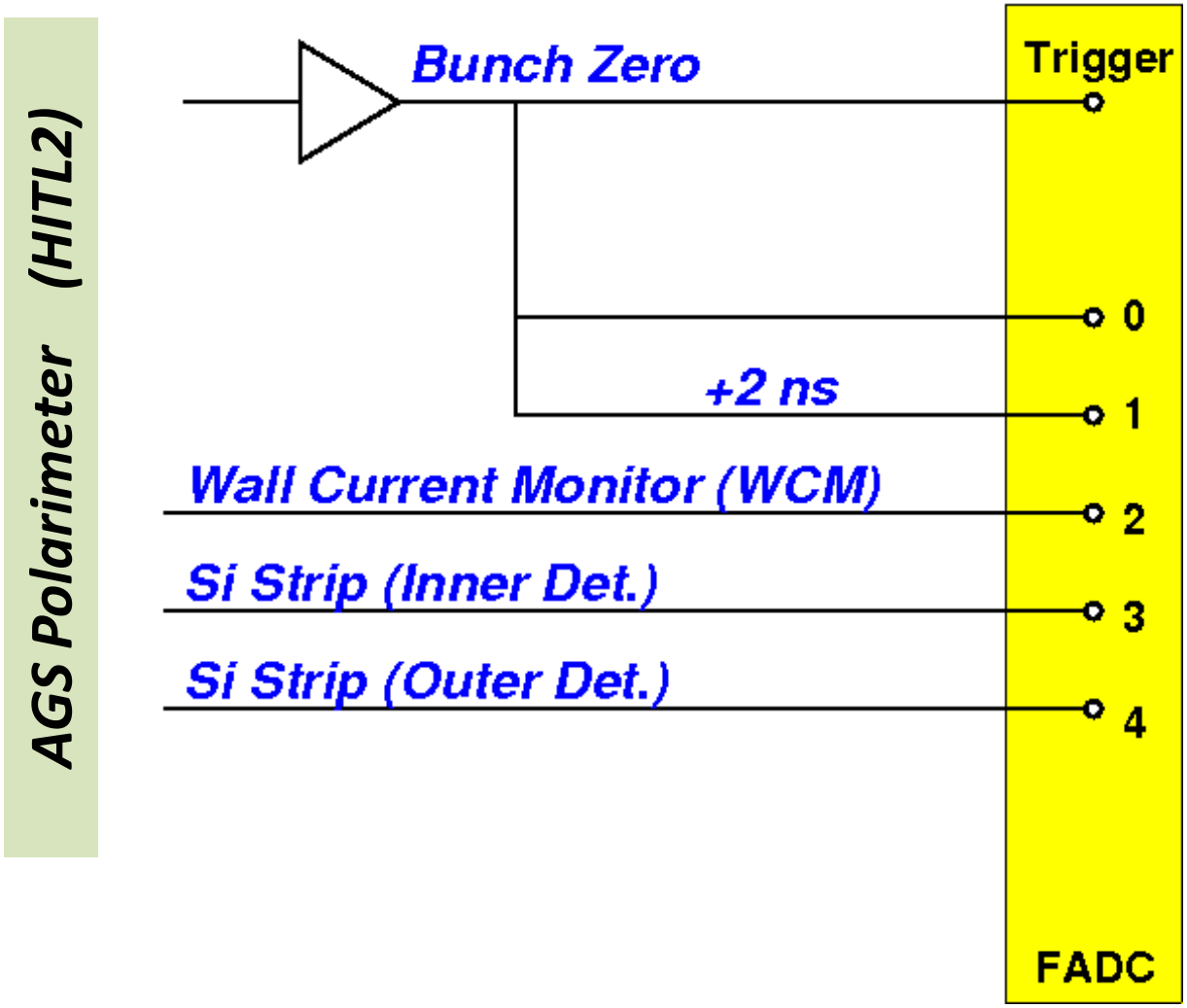
$$t_{\text{meas.}} = t(r_1)$$

Time resolution is less than 1% of the sampling time

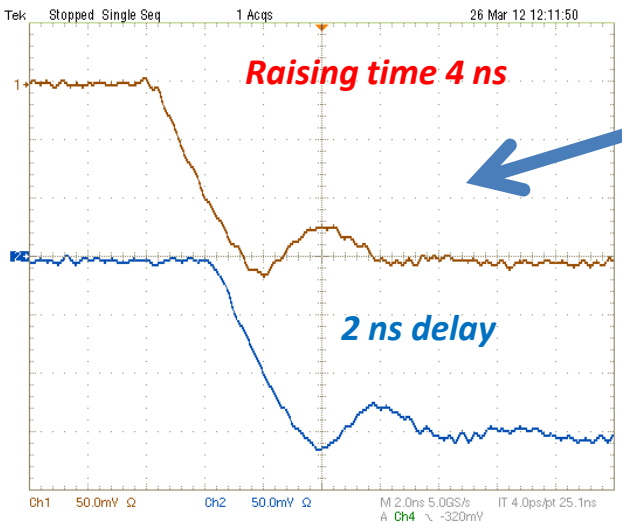
Projection to the FADC

$$\sigma_t \leq 40 \text{ ps}$$

Schema of the measurements



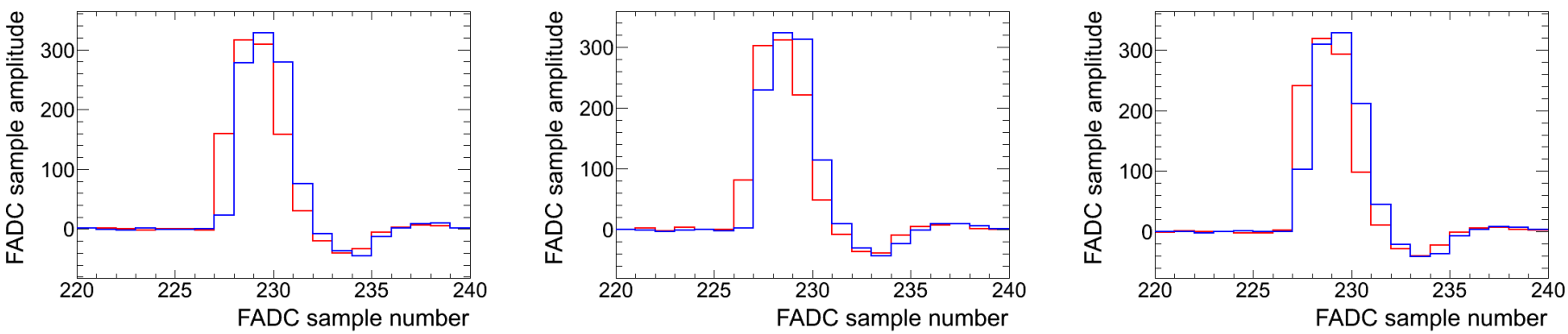
Standard (shaped) BZero signal



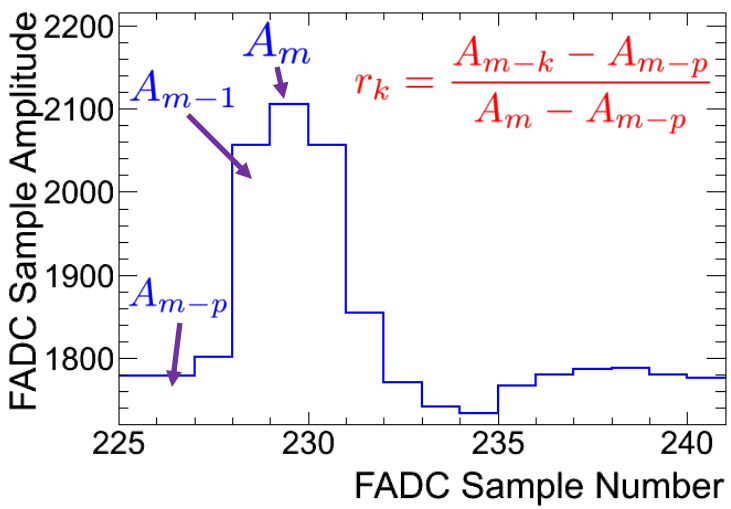
The oscillogram was measured in a different environment. During the FADC measurement rising time was about 6 ns.

- ***Signals are not synchronized with clocks***
- ***Signals are much shorter than regular CNI signals***
- ***It is hard to expect time resolution better than ~ 1 ns in the standard method (emulation of a constant fraction descriminator)***
- ***An alternative method (described below) gives σt≈70 ps.***

FADC measurements. Pedestal subtacted.



A novel method to measure time



- We need to measure only 3 amplitudes:

$$A_m,\ A_{m-1},\ A_{m-p}\ (p=3)$$

- Measured time:

$$t = [m + \varphi(r_1)] \times \tau$$

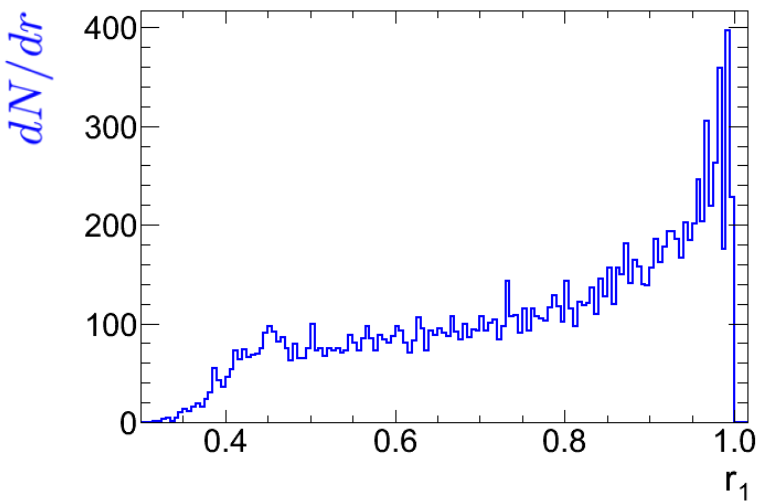
$$\tau = 4\ \mathrm{ns},\ \ 0 \le \varphi(r) \le 1$$

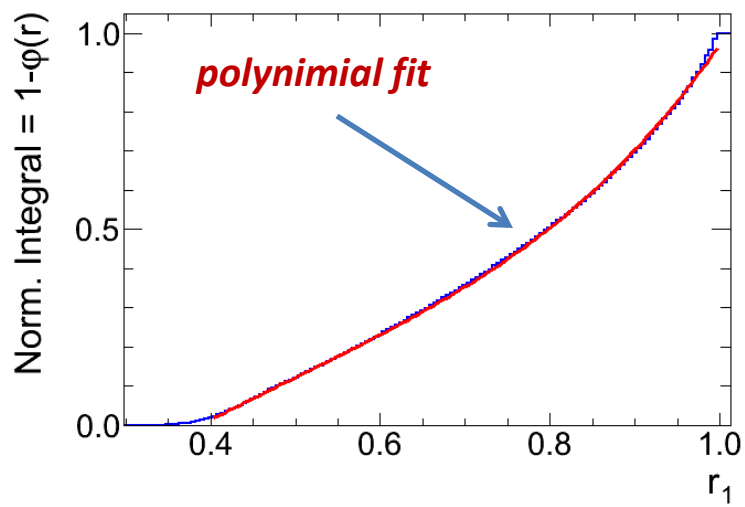
- zero phase definition:

$$\varphi(r_{\max}) = \varphi_{k=1}(1) = 0$$

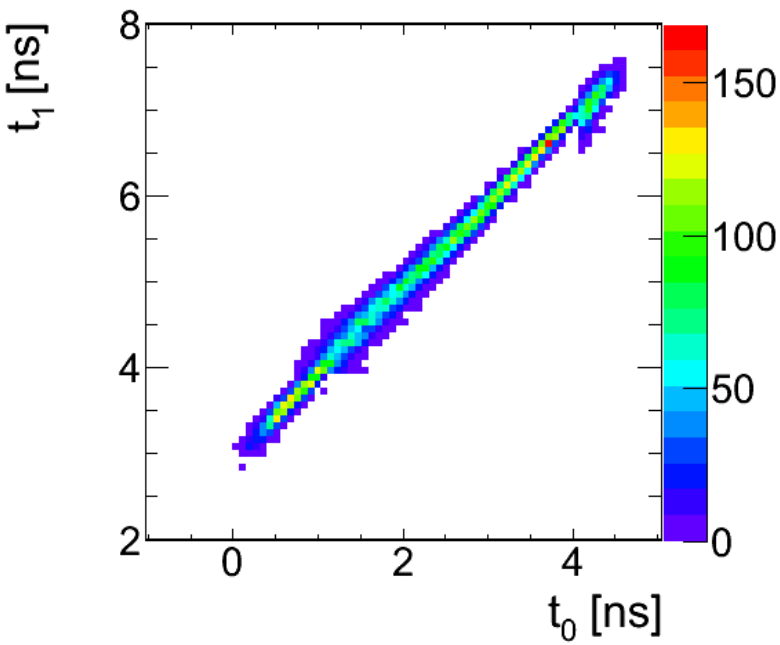
- if FADC clocks are not synchronized:

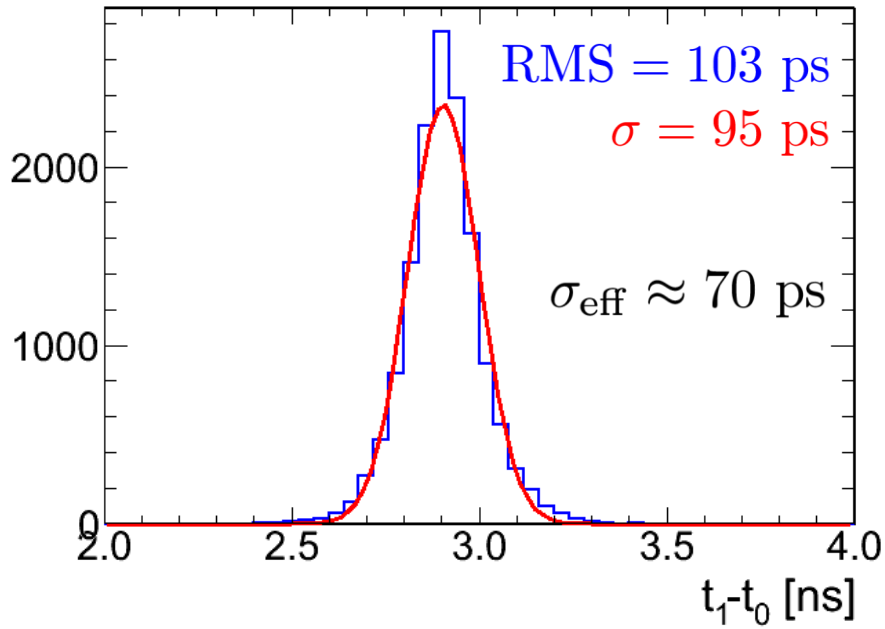
$$dN/d\varphi = \mathrm{const}\ \Rightarrow \varphi(r) = 1 - \frac{1}{\mathcal{N}} \int_0^r \frac{dN}{dr}\, dr$$





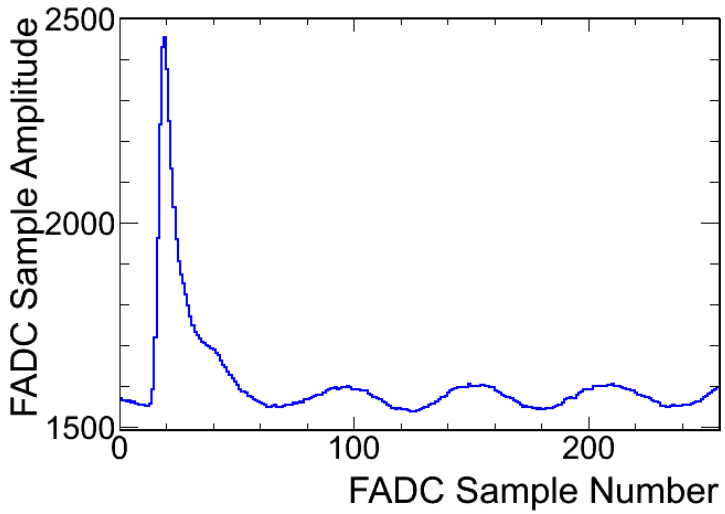
Comparison of two BZ signals

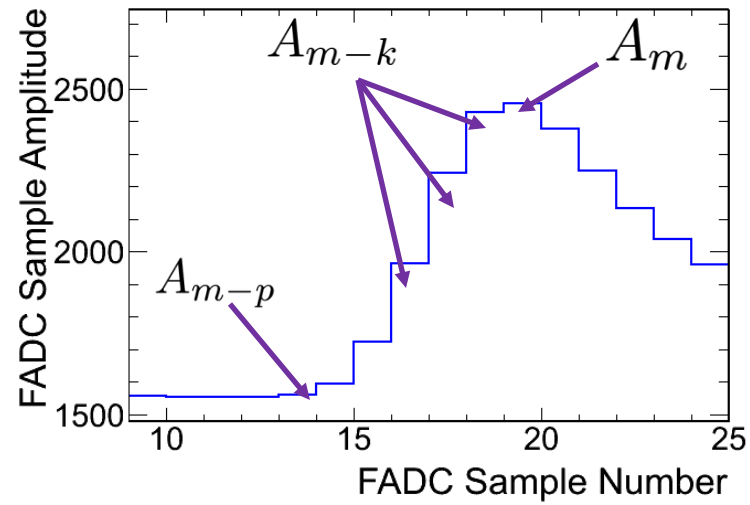


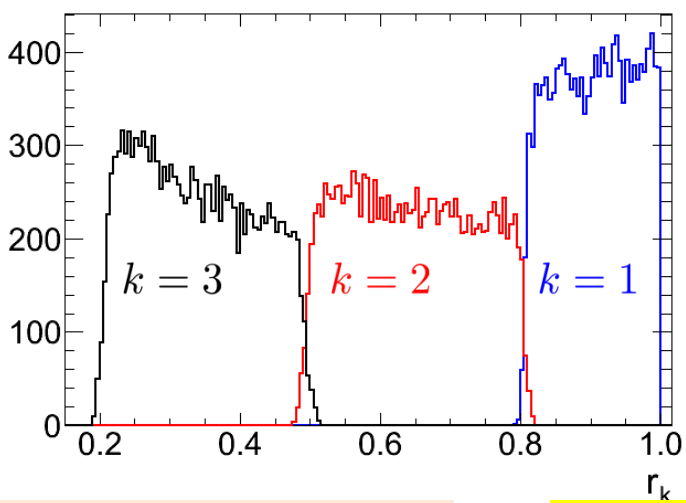


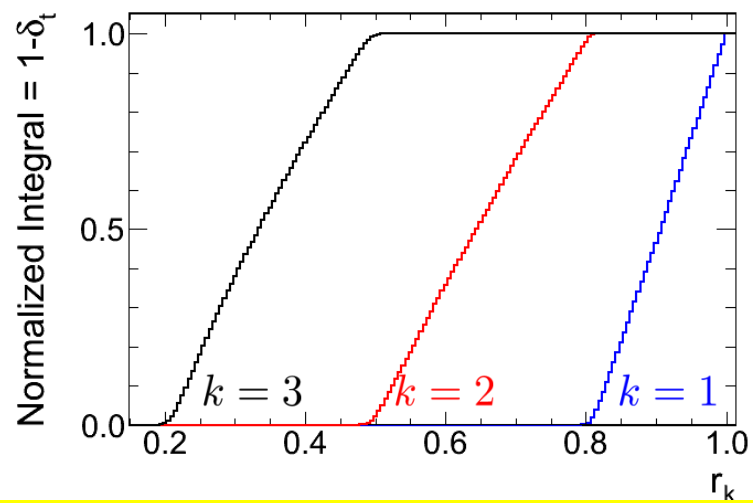
Sampling contribution to the time resolution of short (rising time ~6 ns) signals with amplitude A≈300 <u>does not exceed</u> 70 ps

Wall Current Monitor signals







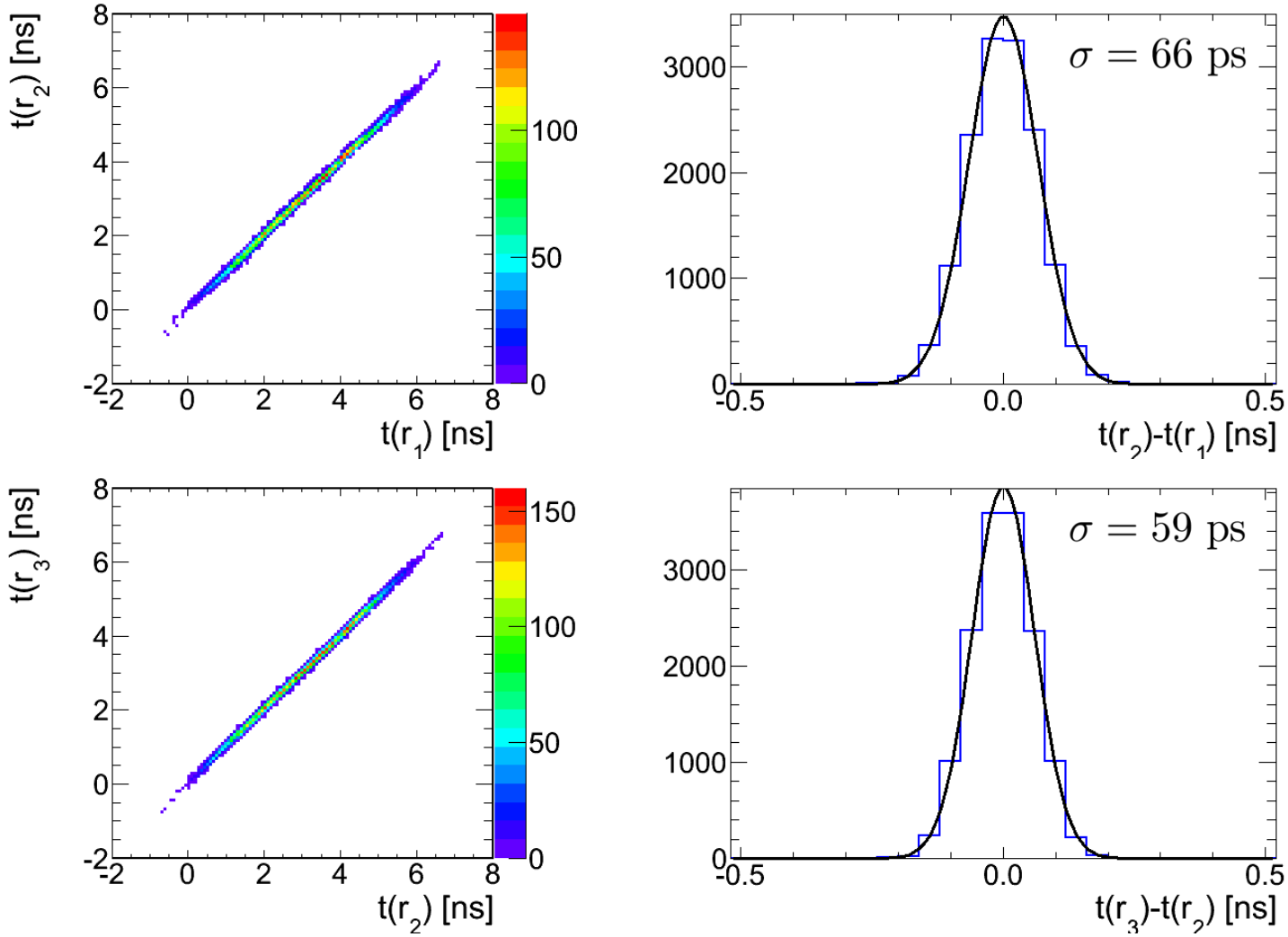


Since WCM signal phase relative to the baseline oscillations is stable, we ignore the baseline oscillations in this analysis.

φ(r) linearly depends on r:

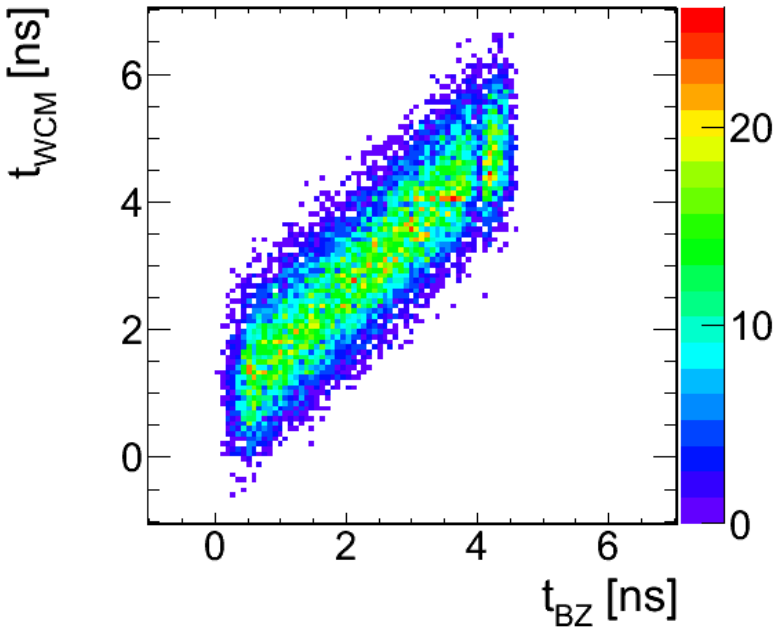
$$\varphi(r) = \frac{r_{\max} - r}{r_{\max} - r_{\min}} \Rightarrow \varphi_{k=1}(r) \approx \frac{1-r}{0.191}$$

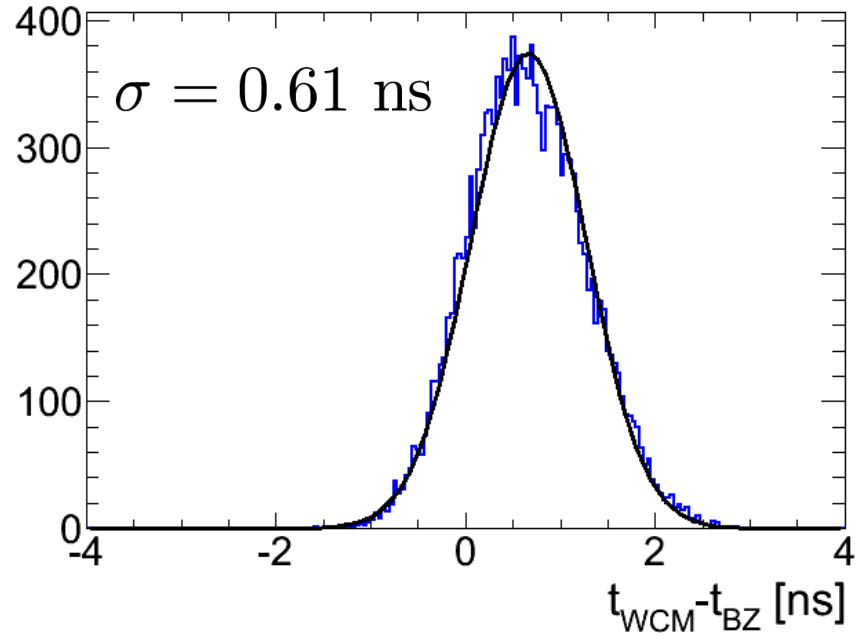
***WCM signals*: comparison of $t(r_1)$, $t(r_2)$, and $t(r_3)$**



A very good correlation between r_1, r_2, and r_3.
To measure time, it is sufficient to know only one value of r_k.

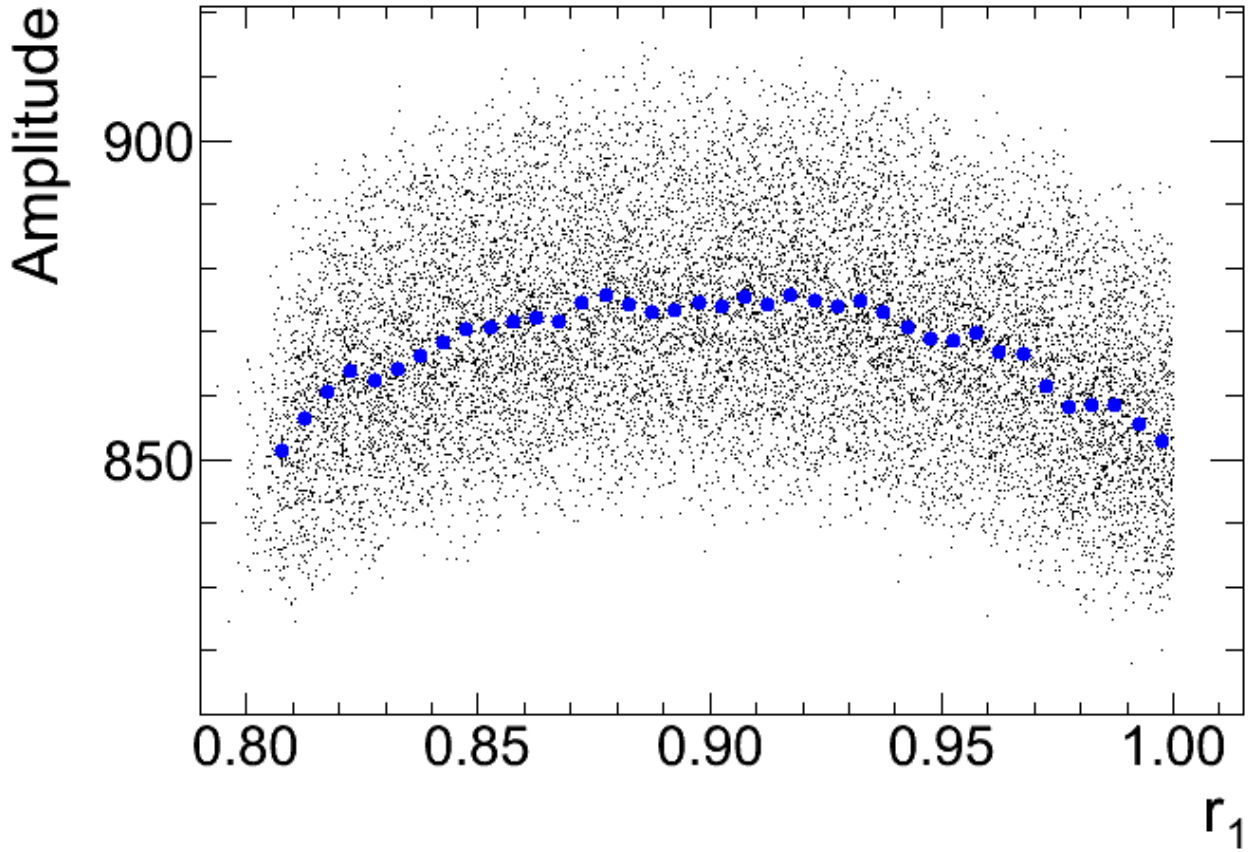
Time difference between WCM and BZ signals





Real signal jitter is much larger (about order of magnitude) than actual time resolution provided by 250 MHz FADC

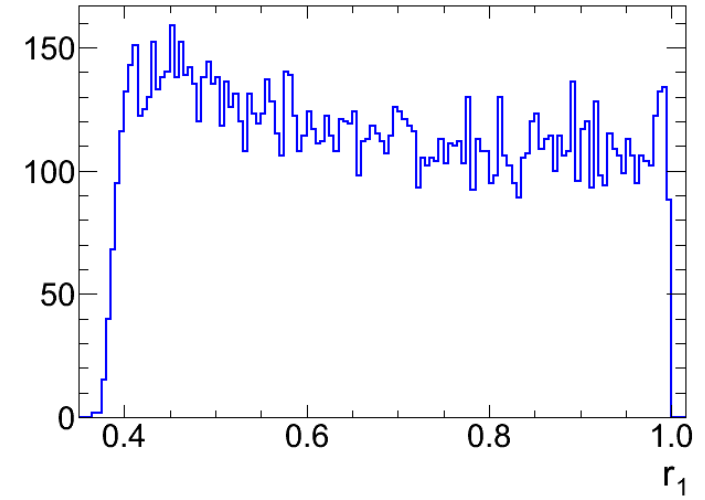
WCM: Amplitude dependence on the clock phase

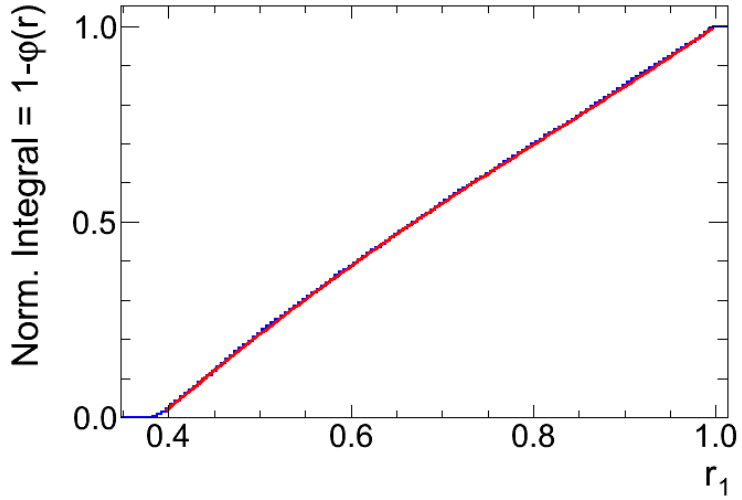


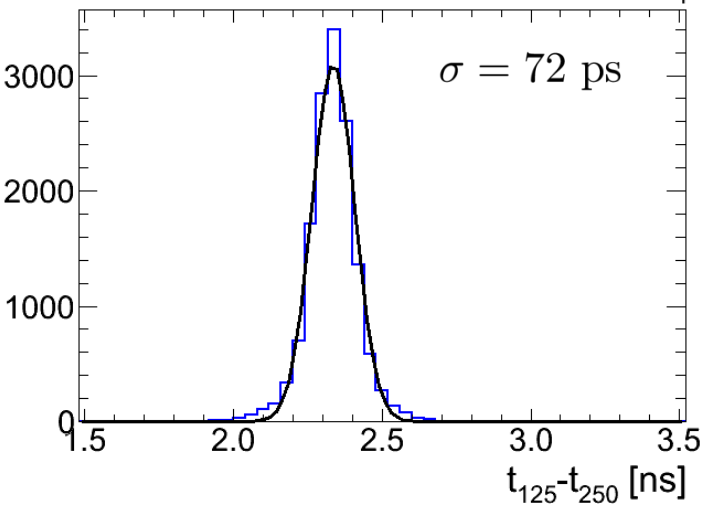
A phase dependent variations of the measured amplitude are about 3%.

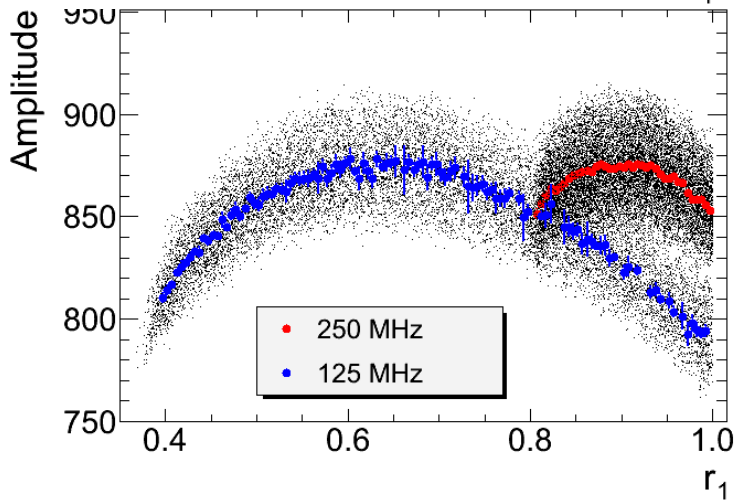
- ***do not exceed white noise fluctuations***
- ***corrections may be determined in a simple way***

WCM: Emulation of 125 MHz WFD





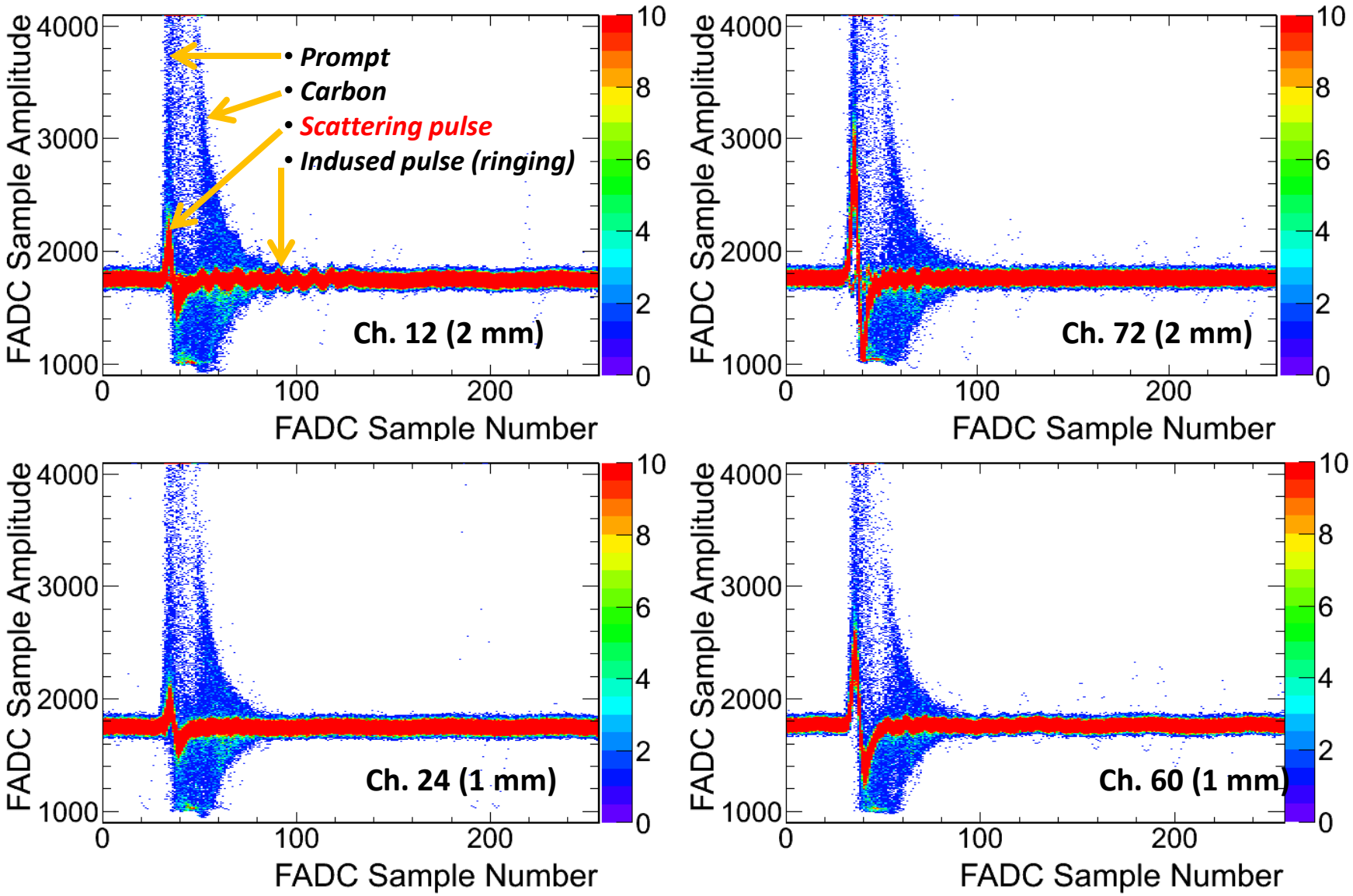




- ***For 125 MHz WFD time resolution is as good as for 250 MHz***
- ***Amplitude dependence on th etime phase is much stronger, but it may be corrected***

"Scattering Pulse". BNL detectors. LateCBM=1.7

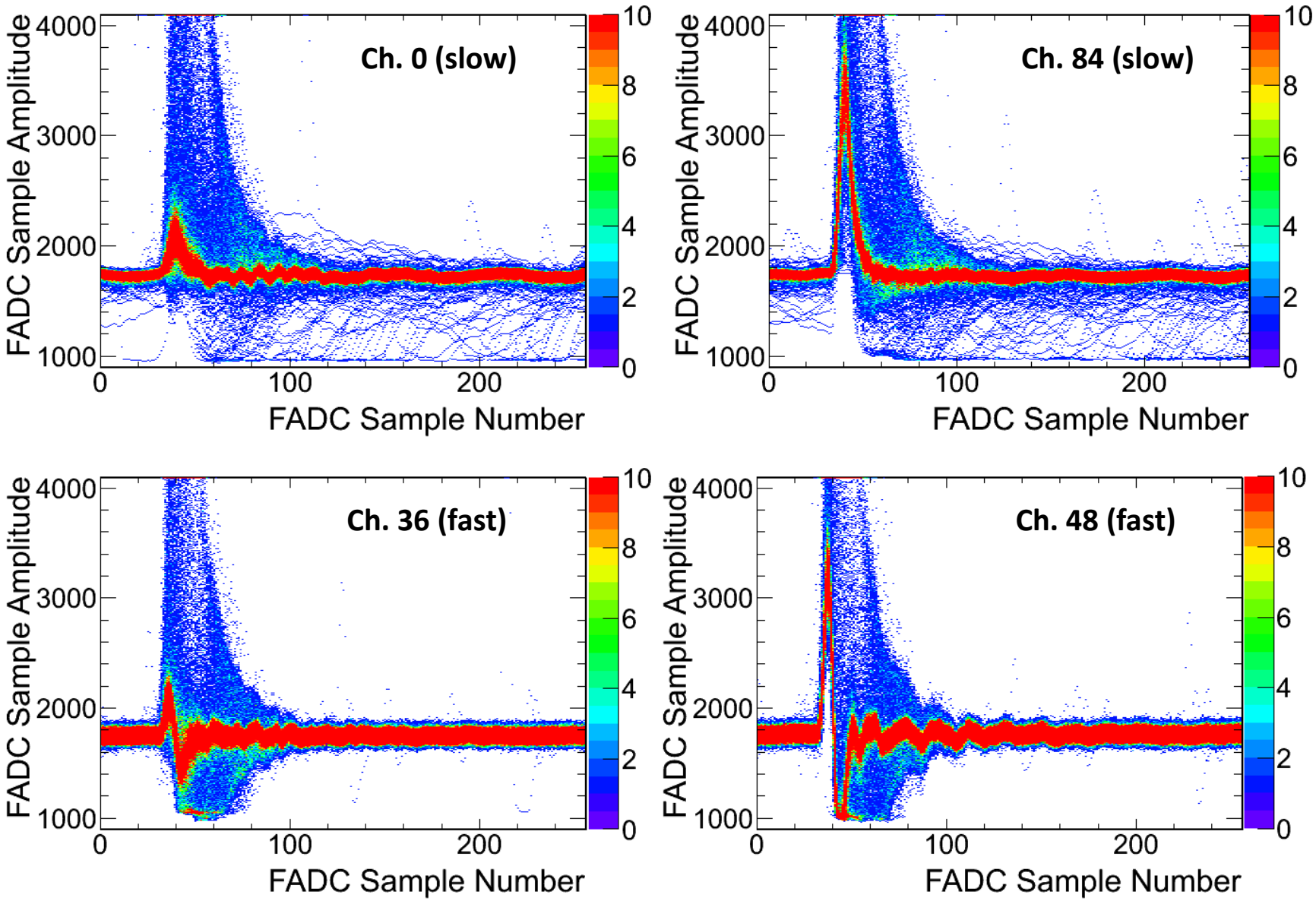
Outer detectors



Inner detectors

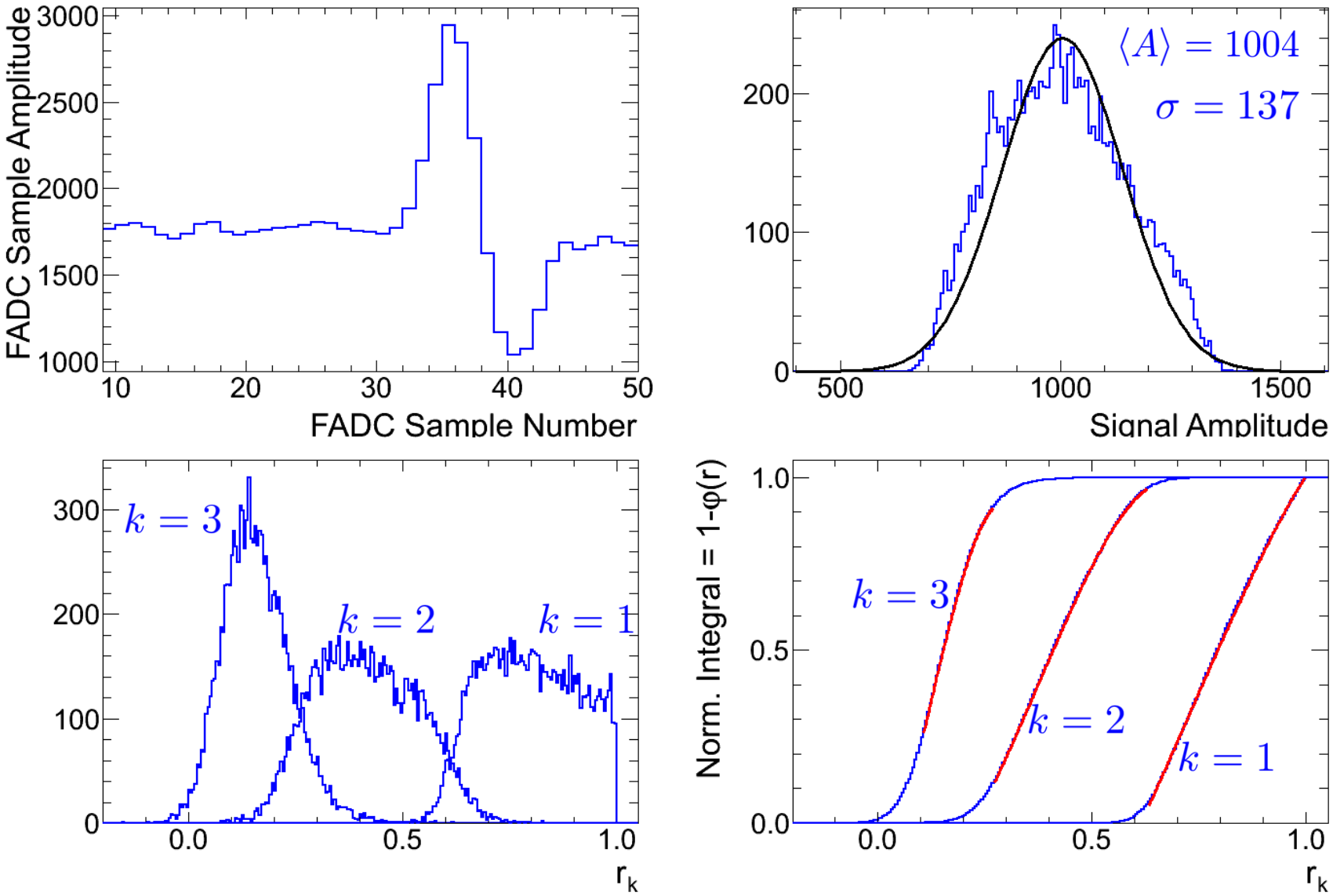
"Scattering Pulse". Hamamatsu det. LateCBM=1.7

Outer detectors

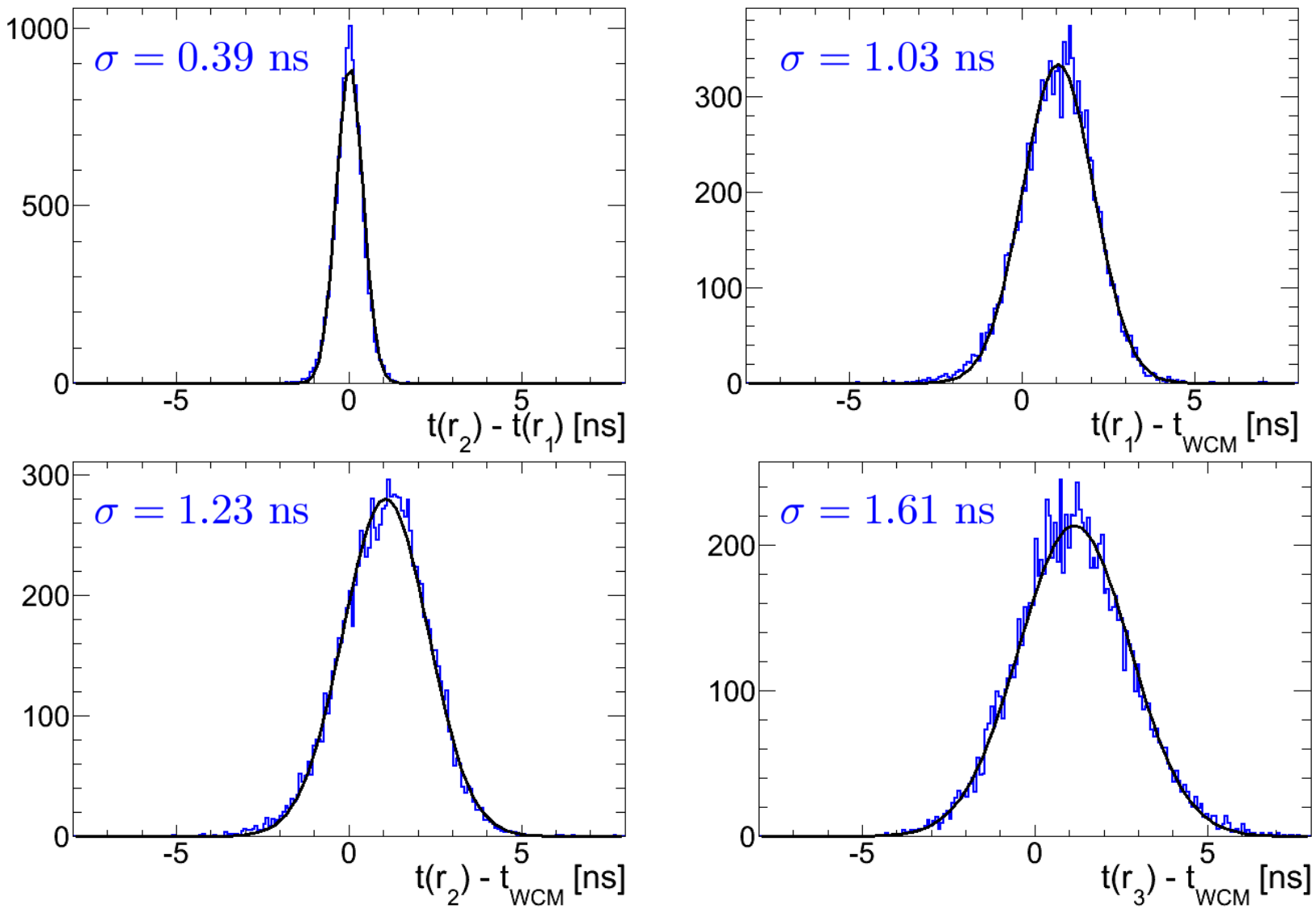


Inner detectors

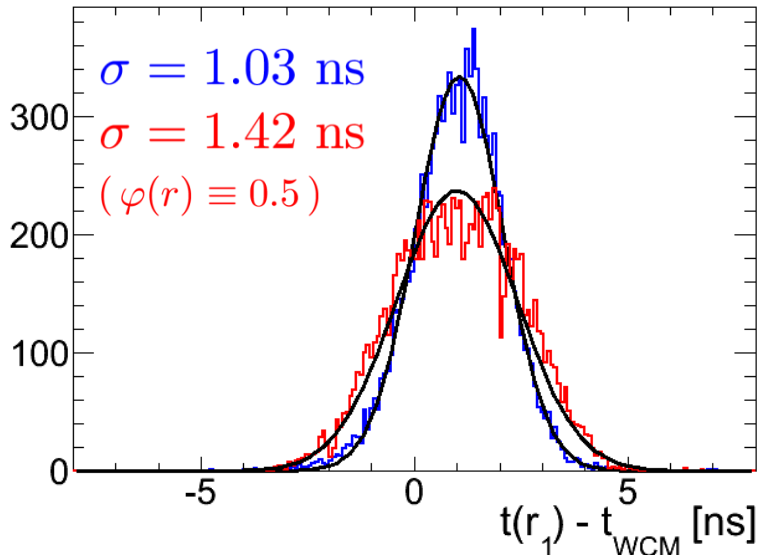
"Scattering Pulse". Ch. 72 (BNL, 2 mm)

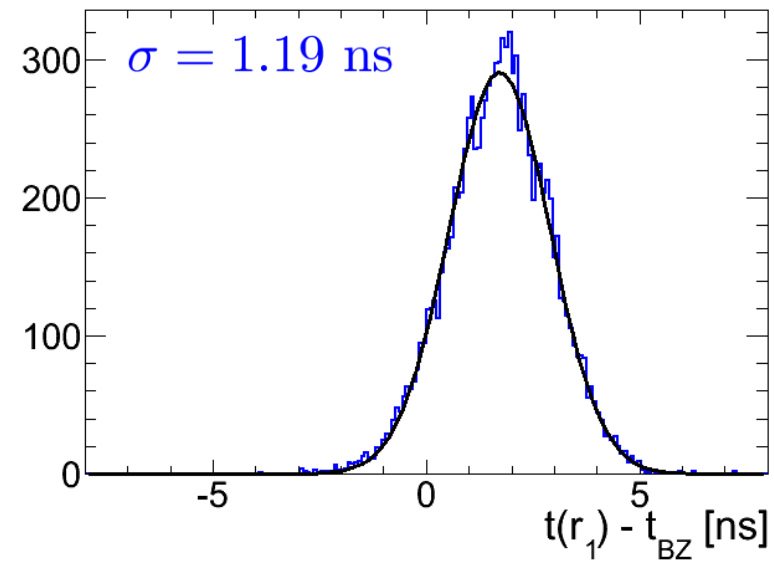


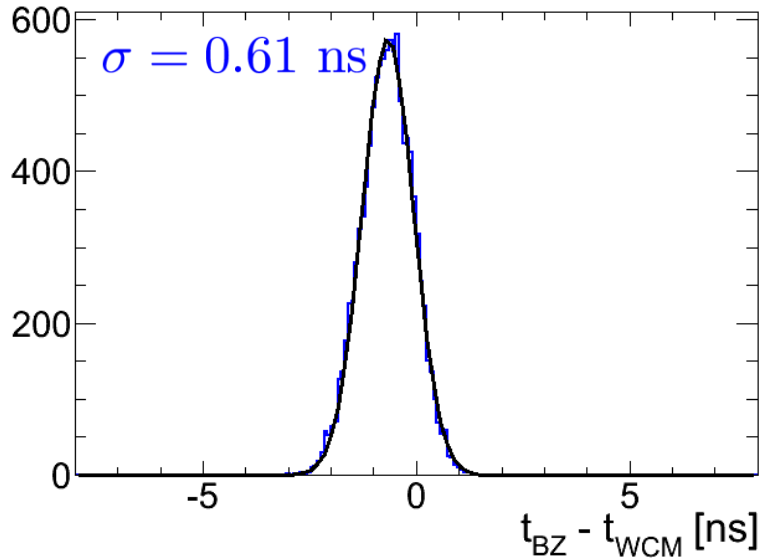
"Scattering Pulse". Ch. 72 (BNL, 2 mm)



"Scattering Pulse". Ch. 72 (BNL, 2 mm)







A very rough estimate

$\sigma_{BZ} = 0.61$ ns ← ***Jitter in BZ ?***

$\sigma_{WCM} = 0.08$ ns

$\sigma_{72} = 1.03$ ns → $\sigma_{pulse} = 0.82$ ns

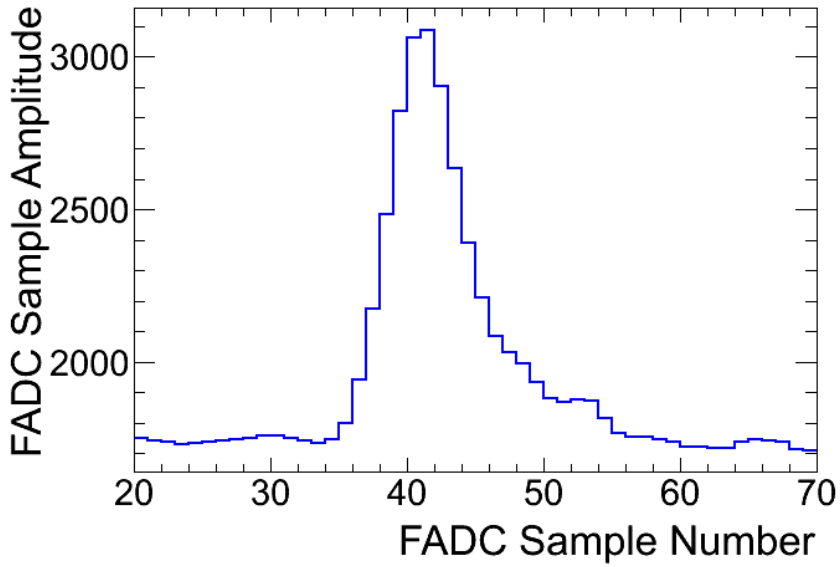
$\sigma_{72} = 1.03$ ns → $\sigma_{meas.} = 0.62$ ns

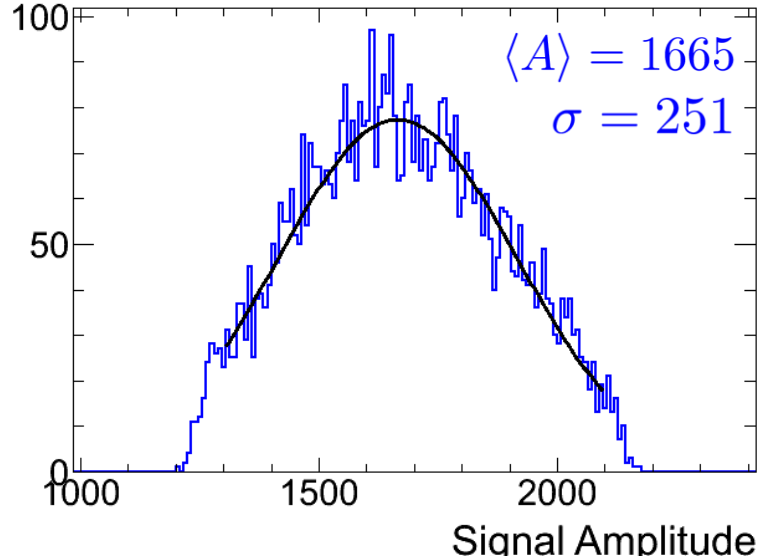
A naive estimate of the noise contribution:

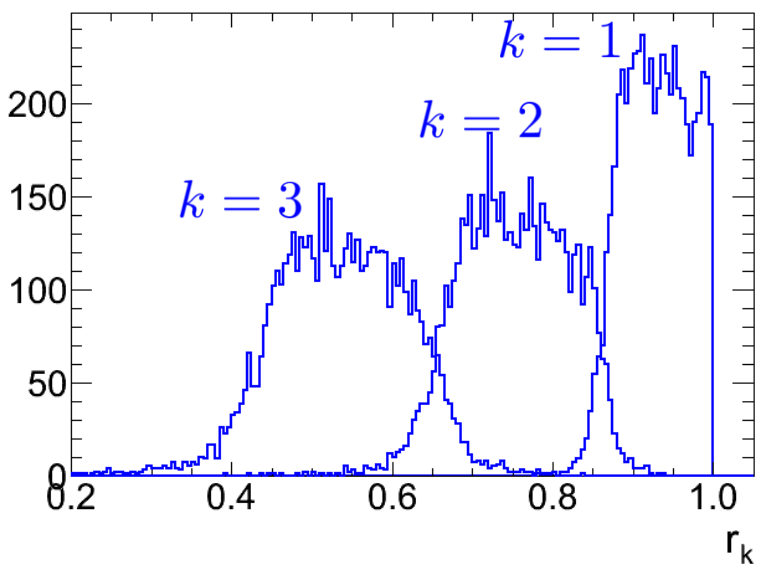
$(\langle A \rangle = 1000 \ \sigma_{ped} = 28 \ \ r_{min} = 0.65)$

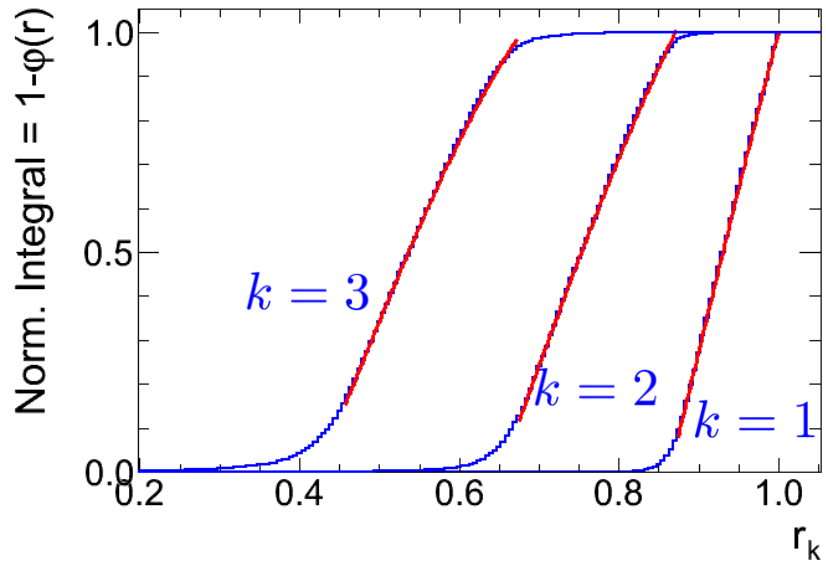
$\sigma_{noise} \approx 0.57$ ns

“Scattering Pulse”. Ch. 84 (Hamamatsu, slow)

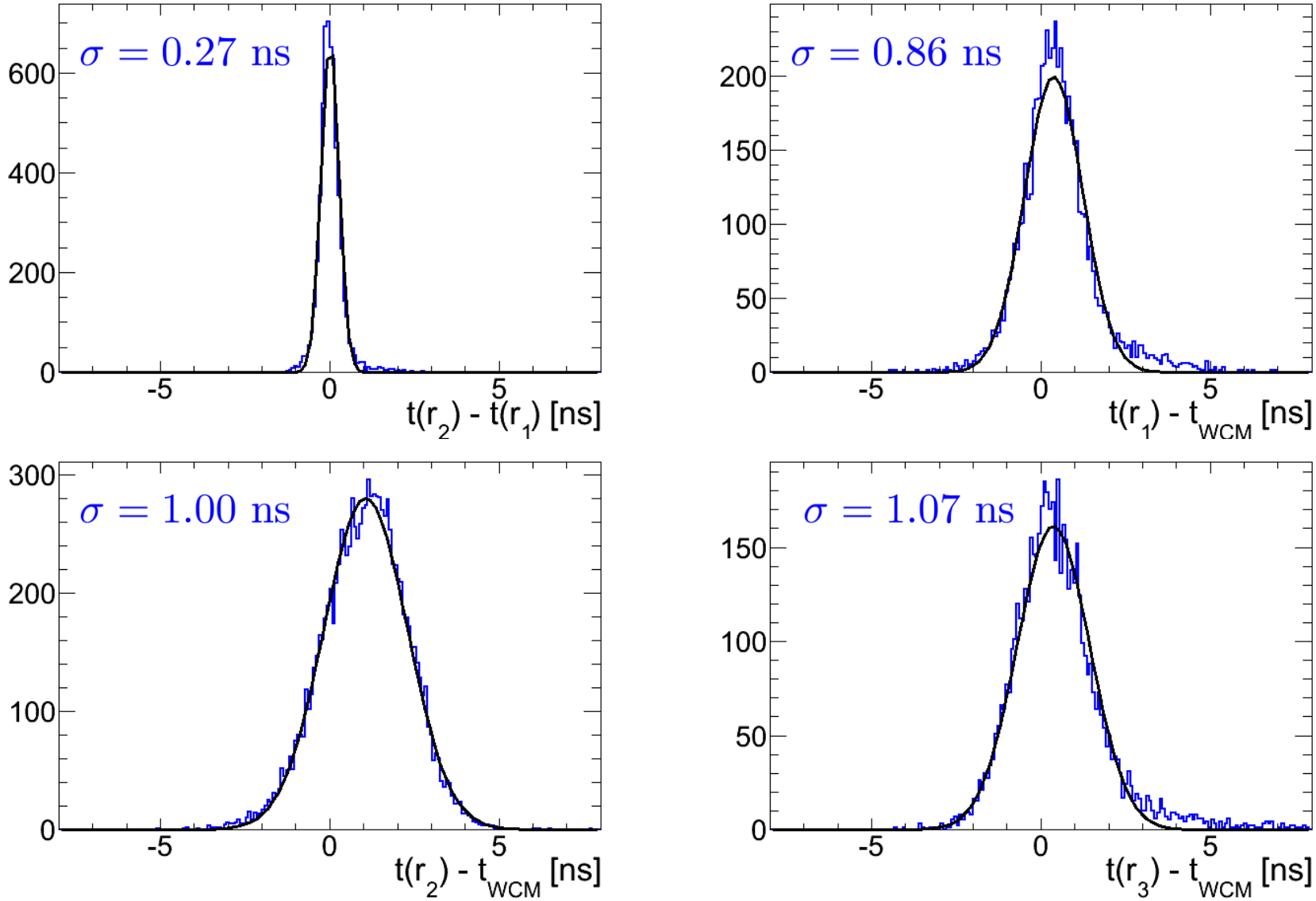




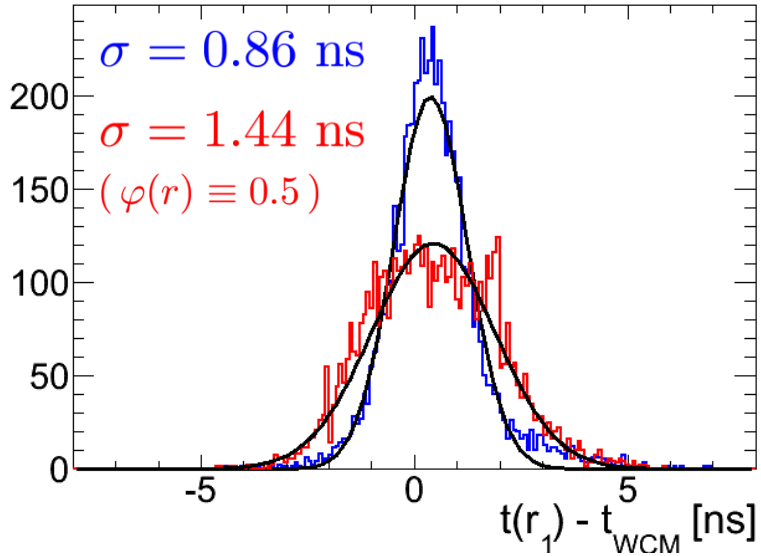


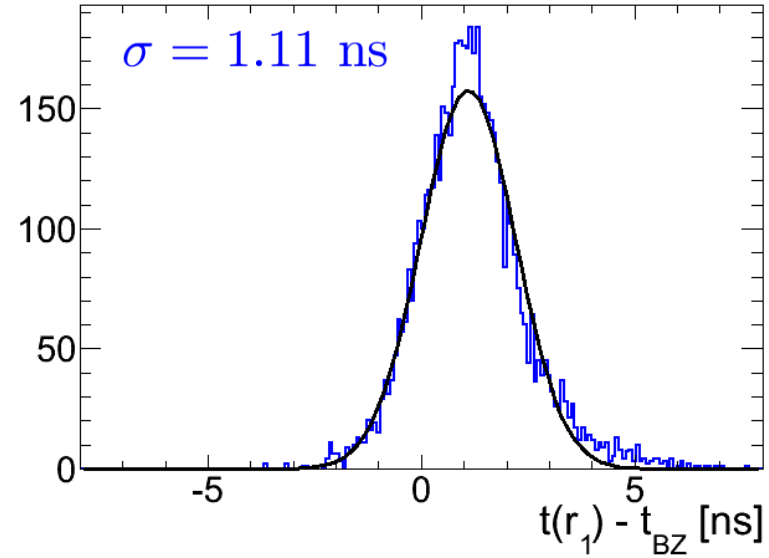


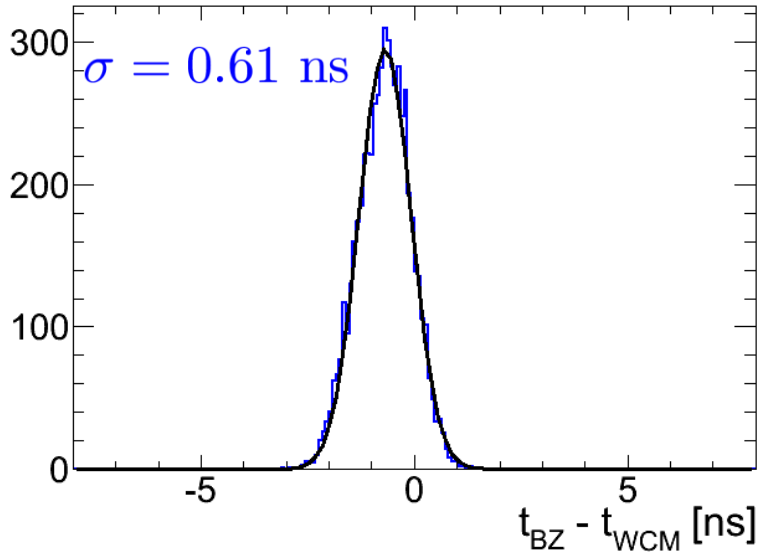
"Scattering Pulse". Ch. 84 (Hamamatsu, slow)



"Scattering Pulse". Ch. 84 (Hamamatsu, slow)







A very rough estimate

$\sigma_{\mathrm{BZ}} = 0.61$ ns

$\sigma_{\mathrm{WCM}} = 0.08$ ns

$\sigma_{84} = 0.86$ ns

$\sigma_{\mathrm{pulse}} = 0.84$ ns

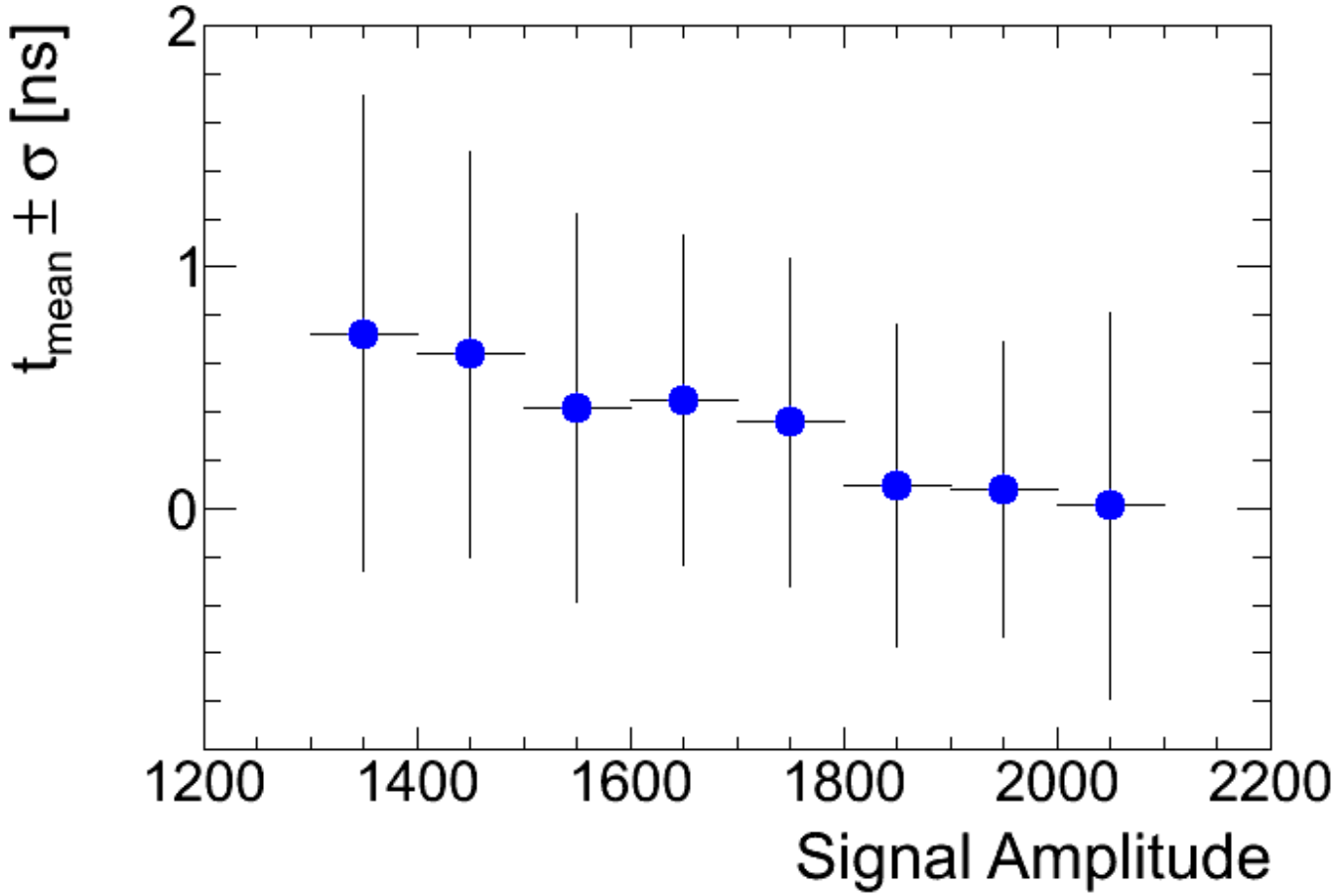
$\sigma_{\mathrm{meas.}} \approx 0.2$ ns

A naive estimate of the noise contribution:

$(\langle A \rangle = 1665 \ \sigma_{\mathrm{ped}} = 17 \ \ r_{\min} = 0.86)$

$\sigma_{\mathrm{noise}} \approx 0.40$ ns

"Scattering Pulse". Ch. 84 (Hamamatsu, slow)



A possible implementation in FADC firmware

- **Currently:** $m(t_{max})$, A_m-ped, t, Int + …

- **Suggested:** m, A_m, A_{m-k}, A_{m-p} + … (actual values of k and p will be determined later)

  + ***more simple firmware:***
    - *no need to measure pedestal*
    - *no need to emulate constant fraction descriminator*
  + ***much more accurate signal time measurement***
  + ***simple offline calibration***
    - *time corrections $\varphi(r)$*
    - *amplitude corrections (dependent on signal phase)*
    - *baseline variation during the bunch*
  + ***a possibility for offline control of the signal waveforms dependence on amplitude $\varphi(r,A)$***

  We might want to add more amplitudes to the recorded data:

  + *pileup events may be suppressed*
  - *event size will be increased*

Summary

- A new method of WFD determination of signal time was discussed
- For the 250 MHz FADC, the **sampling contribution to the time resolution** is less than 100 ps
- A phase dependent variation of the measured signal amplitude is about 3% and may be corrected
- Some requirements for the FADC firmware for the p-Carbon CNI polarimeters was discussed.
- The FADC250 satisfy the requirements for the AGS/RHIC polarimeters.