Signal analysis for PWO readout with 2 LAAPD on one side

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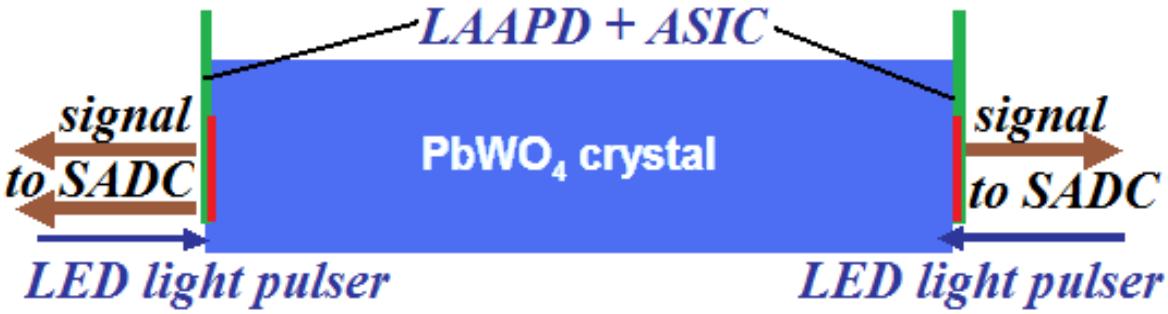
Outline:

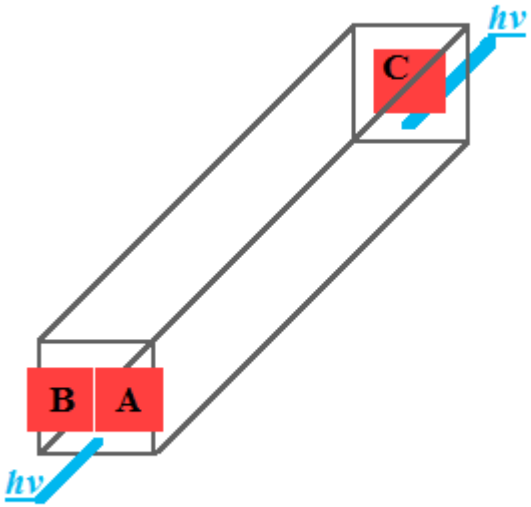
Analysis scheme for 2 LAAPD on one side

Energy analysis

Time analysis

Experimental setup





For measurement were used:

20x20x200 mm $PbWO_4$

1 cm^2 LAAPD gain x 50 @ room temperature

100 MHz 16 Bit SADC (STRUCK)

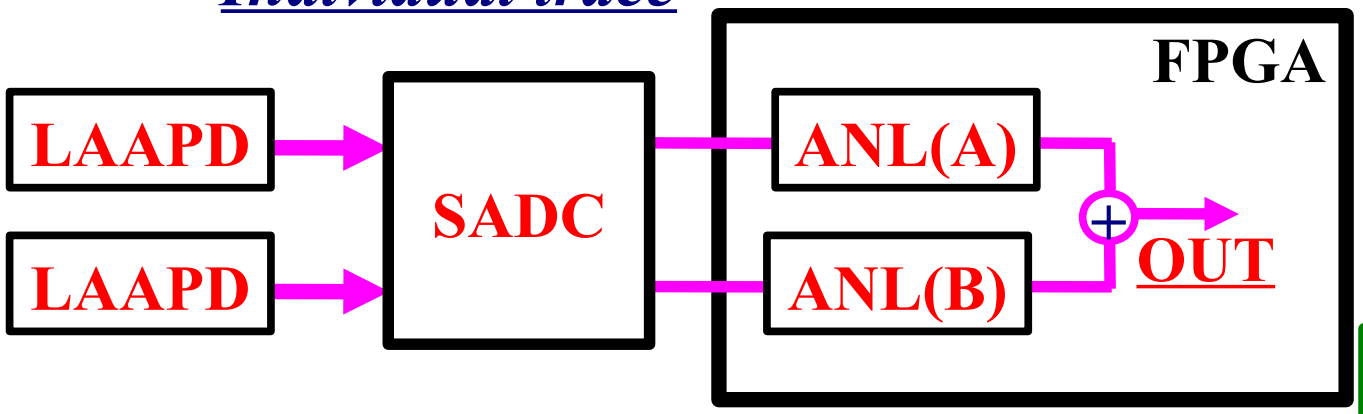
$HV_{B\ and\ A}$ = 393 V; I_d = 37 nA

HV_C = 405 V; I_d = 32 nA

Measurement and analysis scheme:

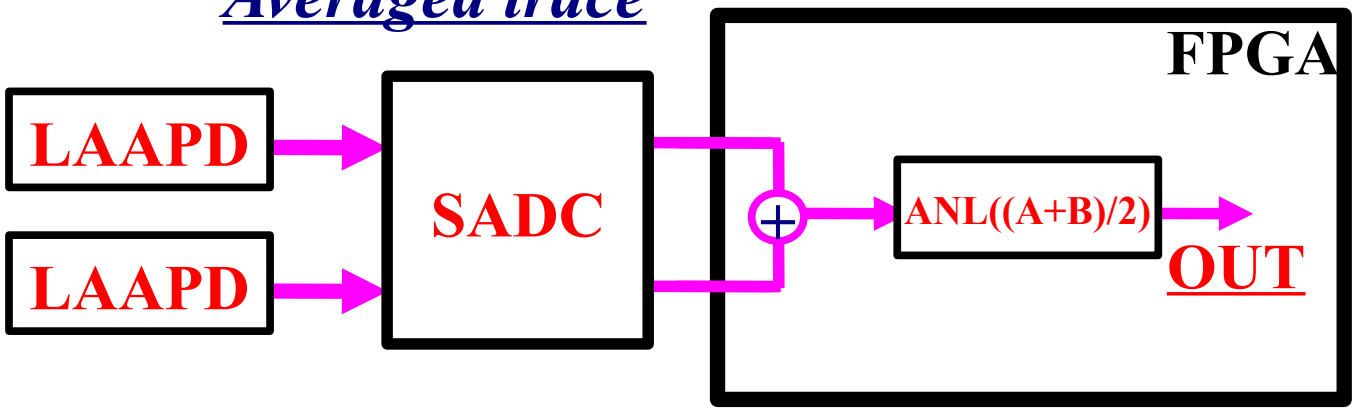
ANL – analysis like in FPGA

Individual trace



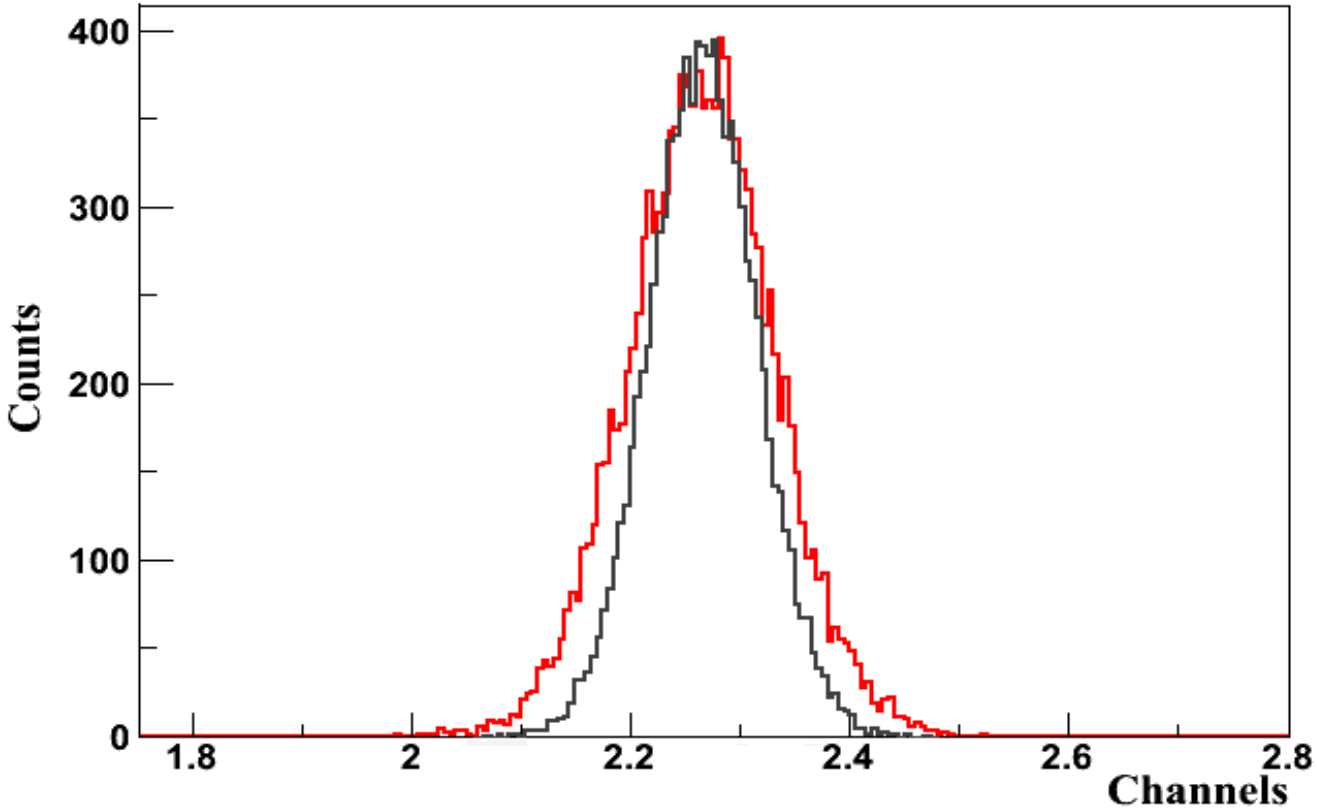
OUT :
Signal amplitude
Time resolution
Noise level

Averaged trace



Less power consumption!

Energy information



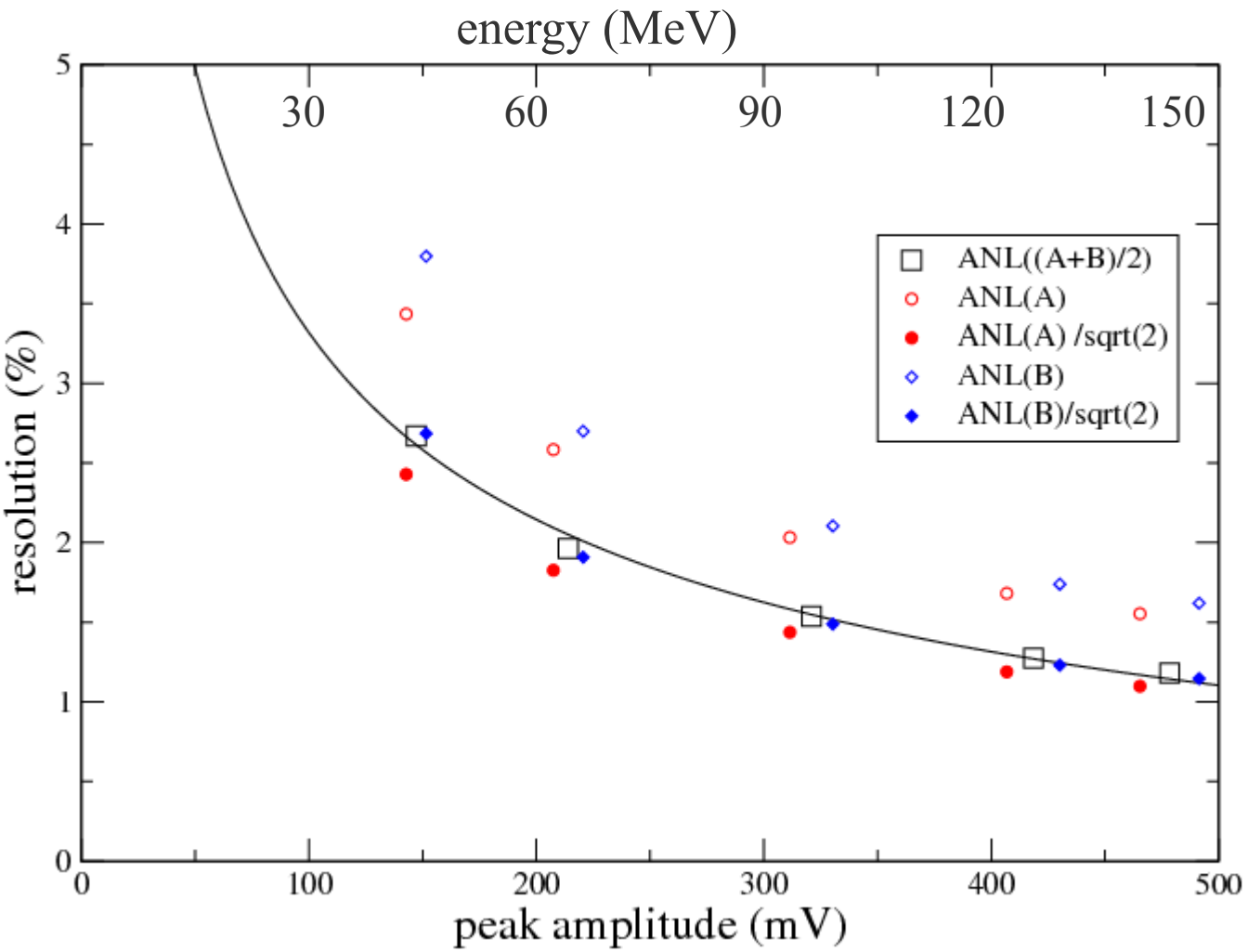
Energy distribution for single and averaged traces

σ from Gauss fitting for

single trace from one LAAPD = 1.7 %

averaged trace from sum of two LAAPD = 1.3 %

Energy information



Single trace

$\sigma_{single}/E = a/\sqrt{E_{A,B}} + b$

Averaged traces

$\sigma_{average}/E = a/\sqrt{(2E_{A,B})} + b$

Energy resolution improved for averaged traces ~√2 times!

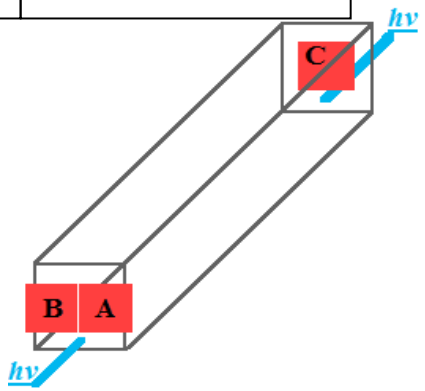
Energy information

{signal amplitude ~ 400 mV}

	Ch A	Ch B	Ch C	Individual trace (ANL(A) +ANL(B))/2	Average trace ANL((A+B)/2)
Energy resolution(%)	1.7	1.7	1.52	1.25	1.27
Noise level (mV)	3.61	3.76	3.78		2.86
Noise ratio	1.27	1.32	1.32		1

Energy resolution better for sum of signals !

Little correlated noise for LAAPD's !



Timing analysis

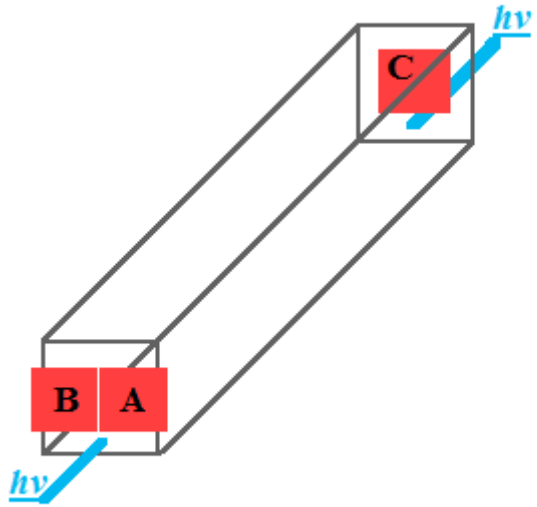
For time resolution we measure the difference of time stamp between:

$\Delta t = t_C - t_A$

$\Delta t = t_C - t_B$

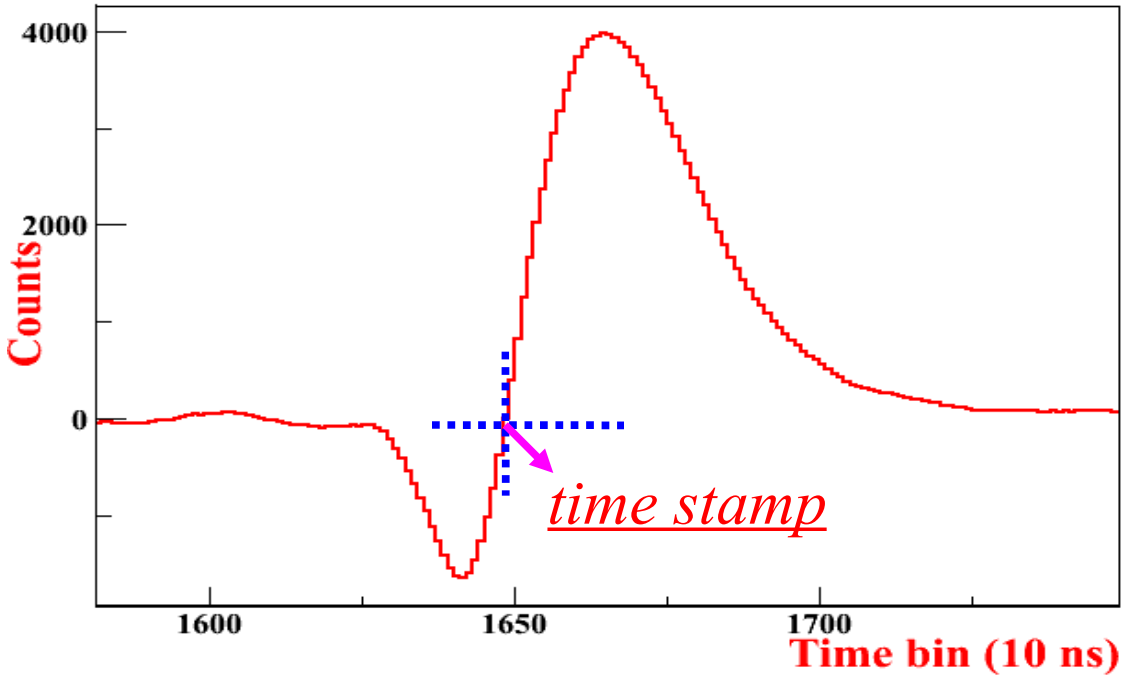
$\Delta t = t_C - (t_A + t_B)/2$

$\Delta t = t_C - t_{(A+B)/2}$

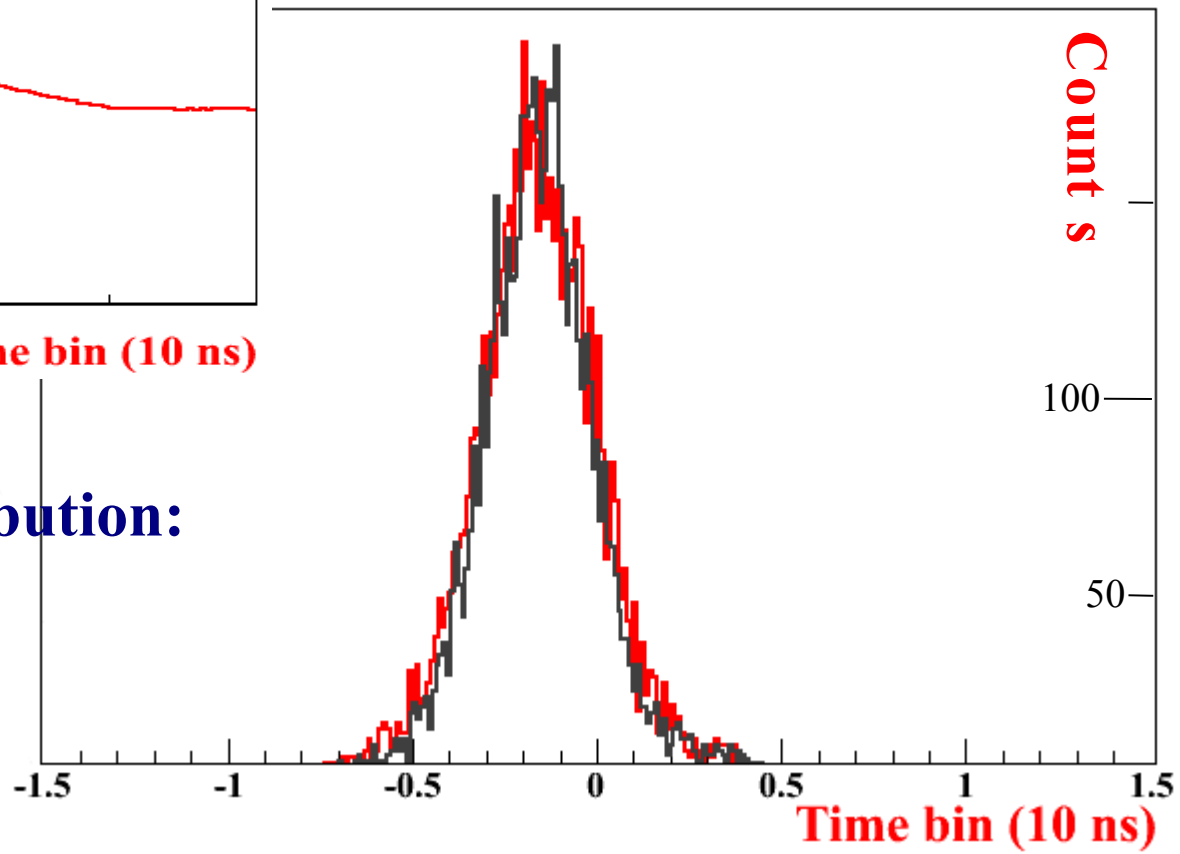


Time resolution = $\Delta t/\sqrt{2}$

Timing analysis



For timing information CFD algorithm was applied!



rms of coincidence time distribution:

Single trace = 1.52 ns

Averaged trace = 1.36 ns

Individual trace = 1.33 ns

Timing analysis

	$\Delta t = t_C - t_A$	$\Delta t = t_C - t_B$	$\Delta t = = t_C - (t_A + t_B)/2$	$\Delta t = = t_C - t_{ANL((A+B)/2)}$
ΔTime(rms) (ns)	1.50	1.52	1.33	1.36
Time resolution, $\Delta t/\sqrt{2}$ (ns)	1.06	1.07	0.94	0.96

Time resolution is improved for 2-LAAPD readout !

Conclusion:

1. For better light collection (and redundancy)
2 LAAPD were coupled to one face of a crystal.

2. For low power consumption of FPGA
and lower threshold
it is useful to sum the digitized signals before the analysis

3. Measured traces were averaged either before or after the digitization.
In both cases the energy and timing resolutions improve.
Energy resolution improved by ≈ 1/√2
and time resolution improved by ≈ 12 %