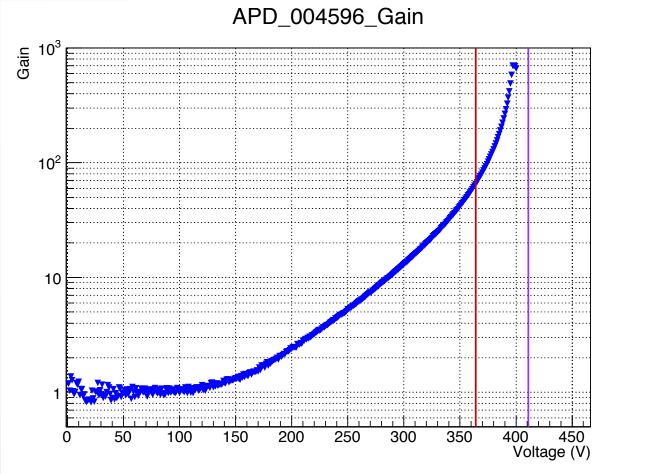
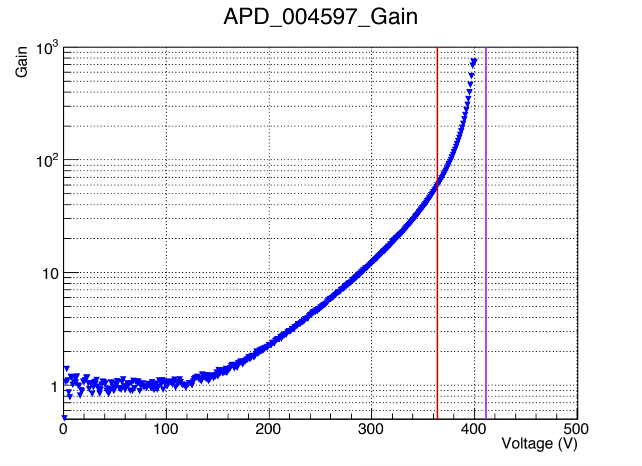
LAAPD with CREMAT CSP

M. Bizzarri, C. Cecchi, P. Lubrano, E. Manoni, A. Papi, A. Rossi, G. Scolieri

LAAPD Gain

- Hamamatsu data for APDs
  - G=50 HV=364V
  - Vbd=411V
  - Based on this info we measured a G=190 @ 400V
- Gain measurement performed with LED
  - Differences with hamamatsu data!
- Gain values based on new measurement
  - G=200 → HV1=385.8V HV2=388.5V
  - Vbd=400V for both APDs



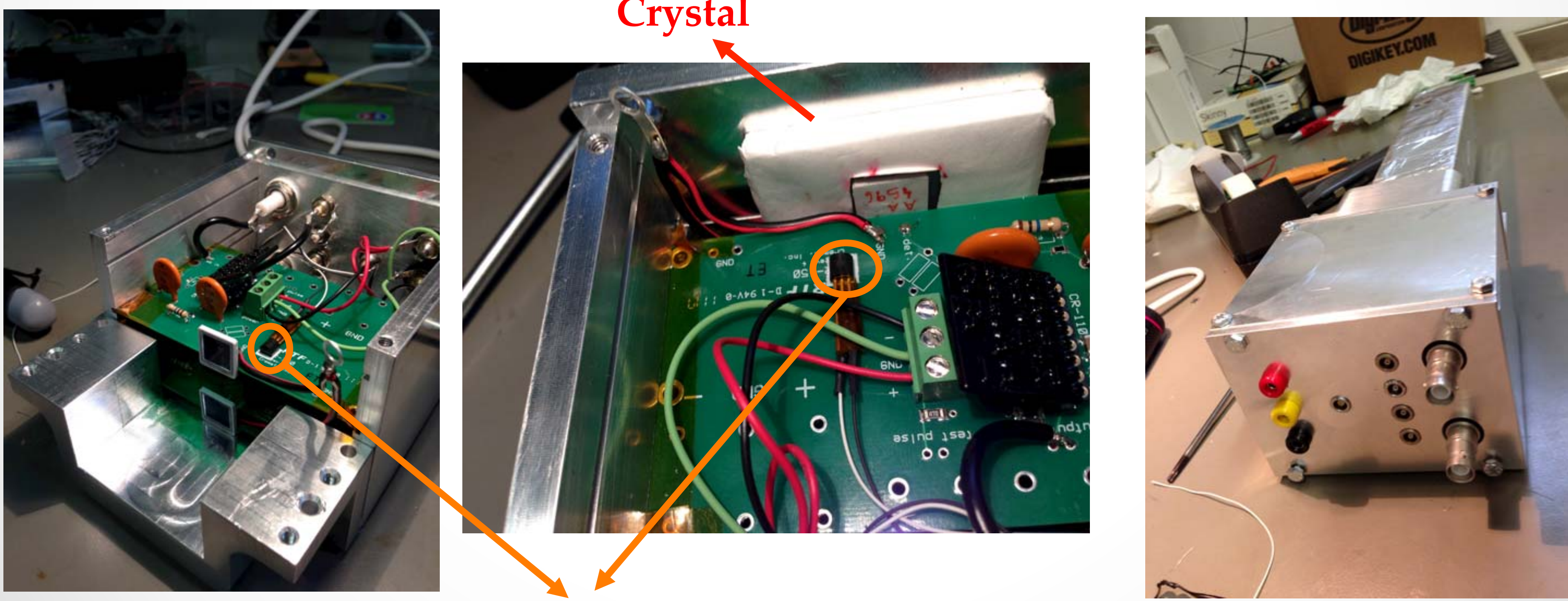


— Hamam. G=50
— Hamam. Vbd

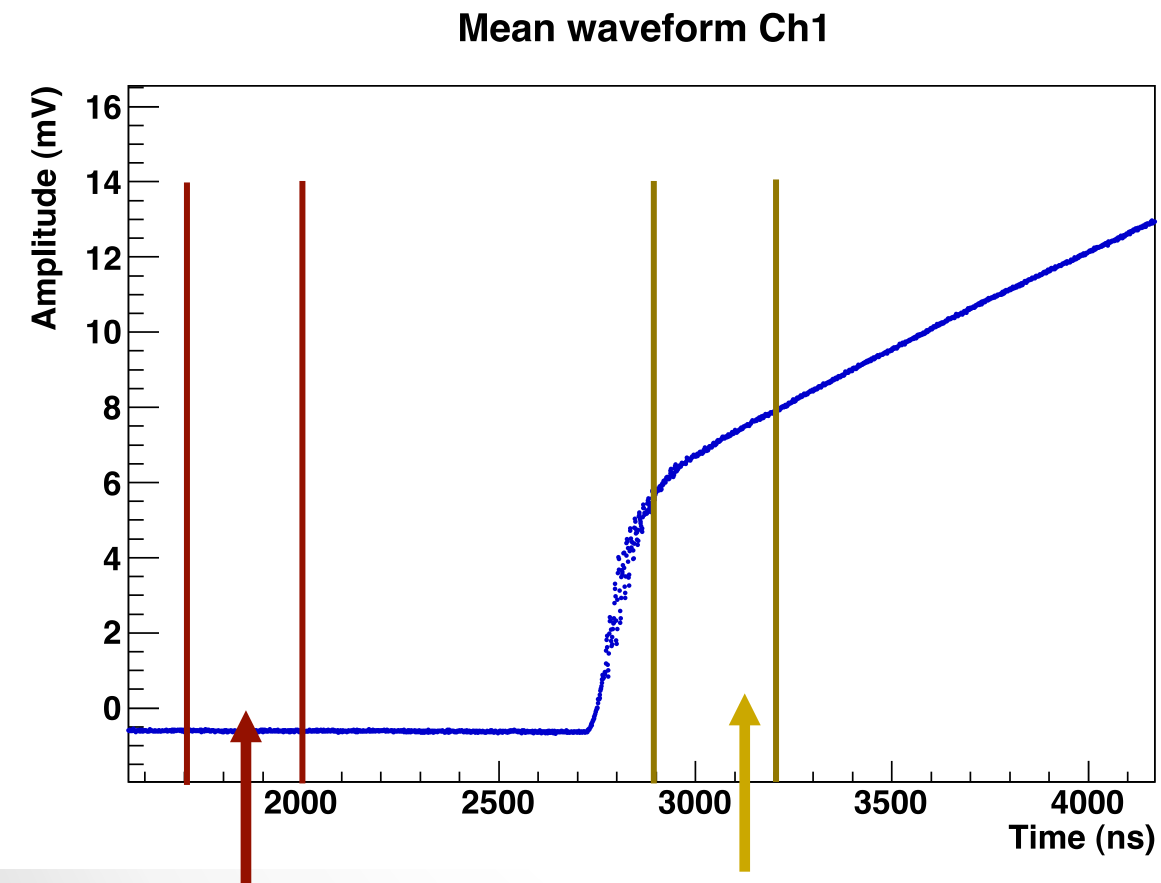
INFN
Istituto Nazionale
di Fisica Nucleare

SetUp

- Two LAAPD Hamamtsu
- Two CR-150 board with CR-110 CSP
- APD soldered directly on PCB board
- Temperature sensor (DS18S20) inside shield



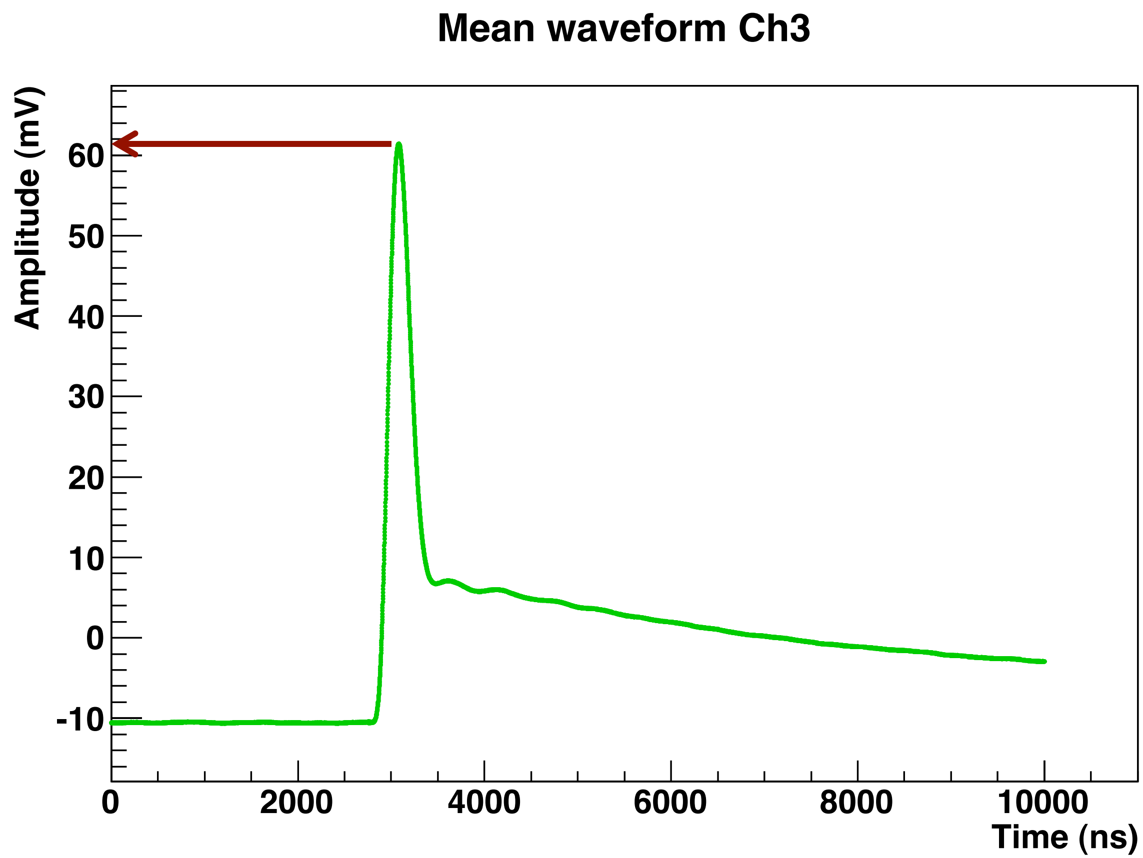
CSP Signal Extraction



Pedestal: Mean value Signal: Mean value

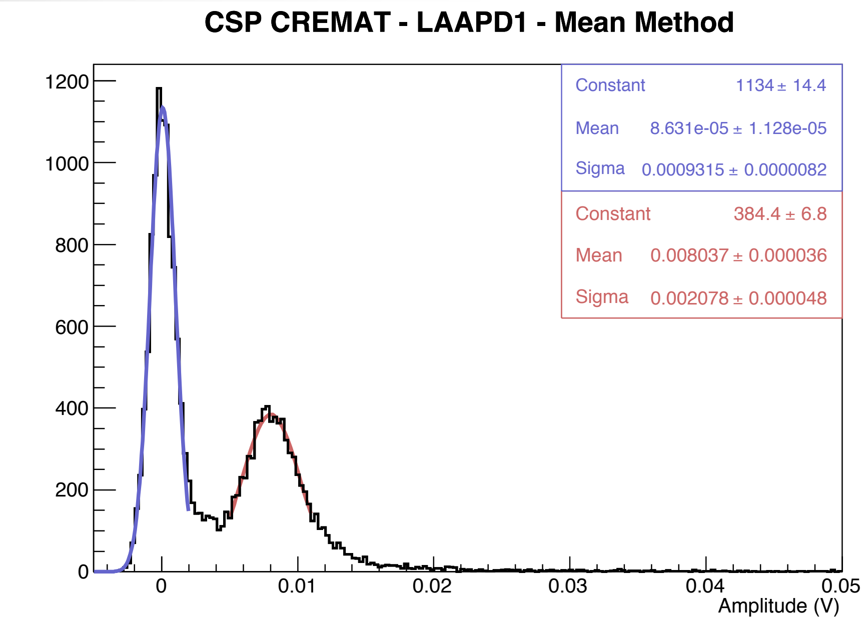
- Pedestal: mean value in a windows 300ns wide
- Signal: mean value in a windows 300ns wide

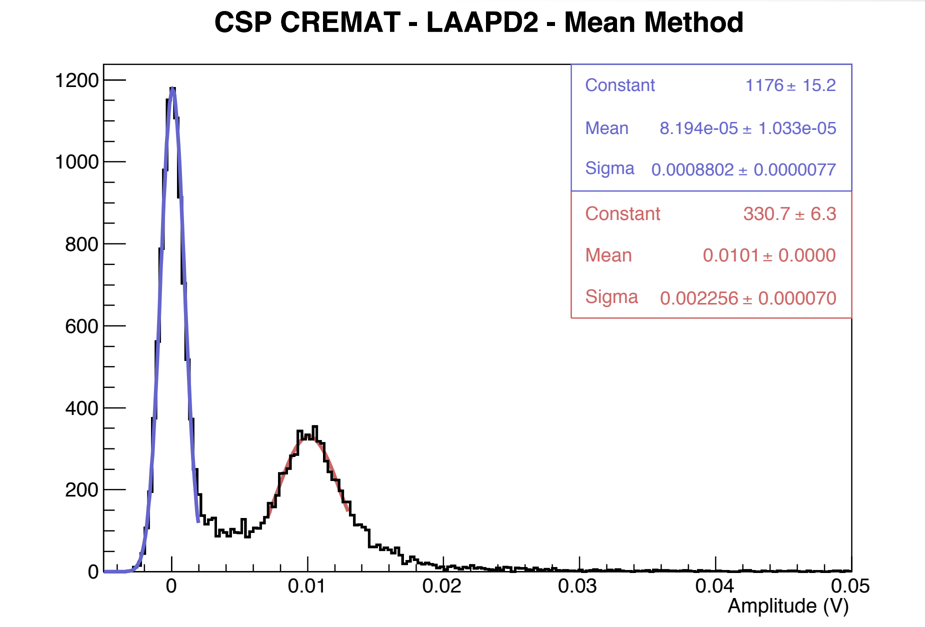
Shaper Signal Extraction



- Signal: Maximum value (all time window allowed)
- No pedestal subtraction performed

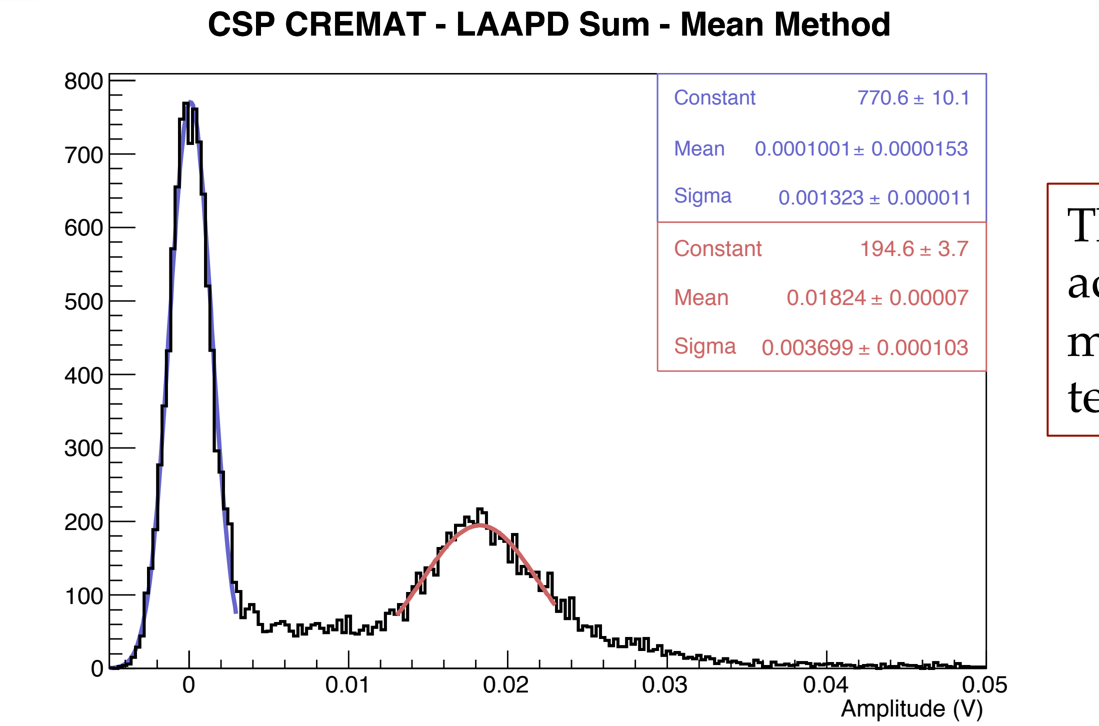
Single LAAPD (50Ω)





	Signal (mV)	Noise (mV)	S/N	ENE (MeV)
LAAPD1	8.04±0.04	0.931±0.008	8.63±0.09	3.48±0.03
LAAPD2	10.10±0.01	0.880±0.008	11.47±0.11	2.61±0.03

LAAPD SUM (50Ω)



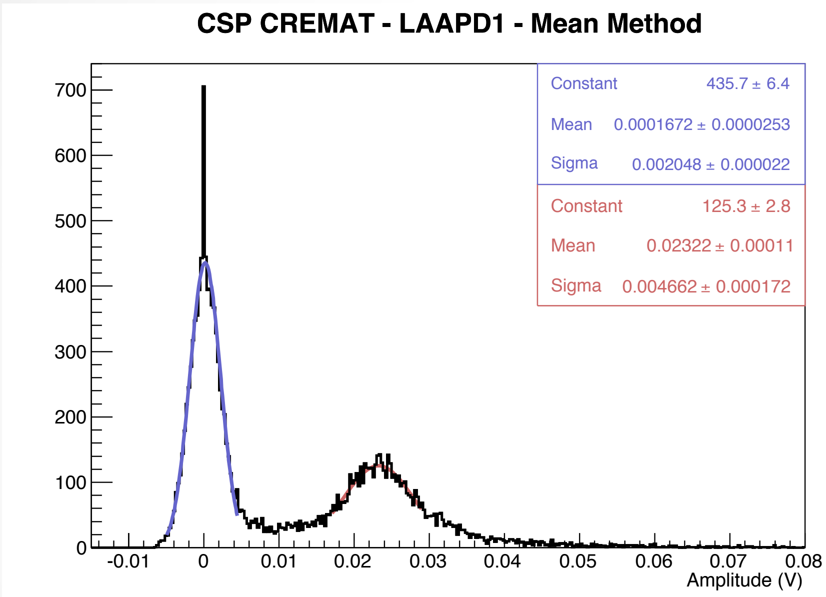
This run was acquired without monitoring temperature

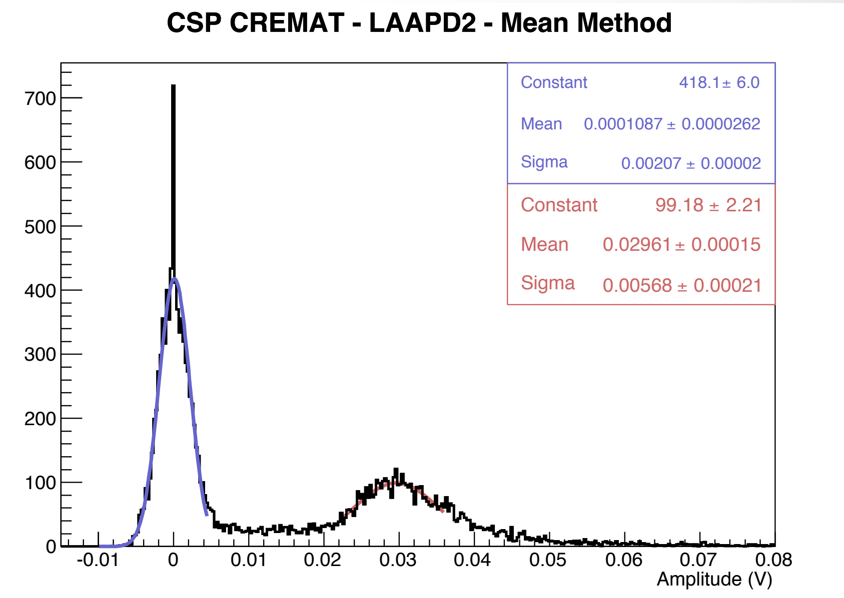
	Signal (mV)	Noise (mV)	S/N	ENE (MeV)
LAAPD1	8.04±0.04	0.931±0.008	8.63±0.09	3.48±0.03
LAAPD2	10.10±0.01	0.880±0.008	11.47±0.11	2.61±0.03
LAAPD Sum	18.24±0.07	1.323±0.011	13.78±0.13	2.18±0.01

Shaper HW

- CREMAT shapers have an input impedance of 1KΩ
  - When we use this devices the CSP signal is terminated with 1KΩ and not with 50Ω
    - Absolute value of signal and noise higher
    - S/N constant

CSP Single LAAPD (1KΩ) – Run SHP100

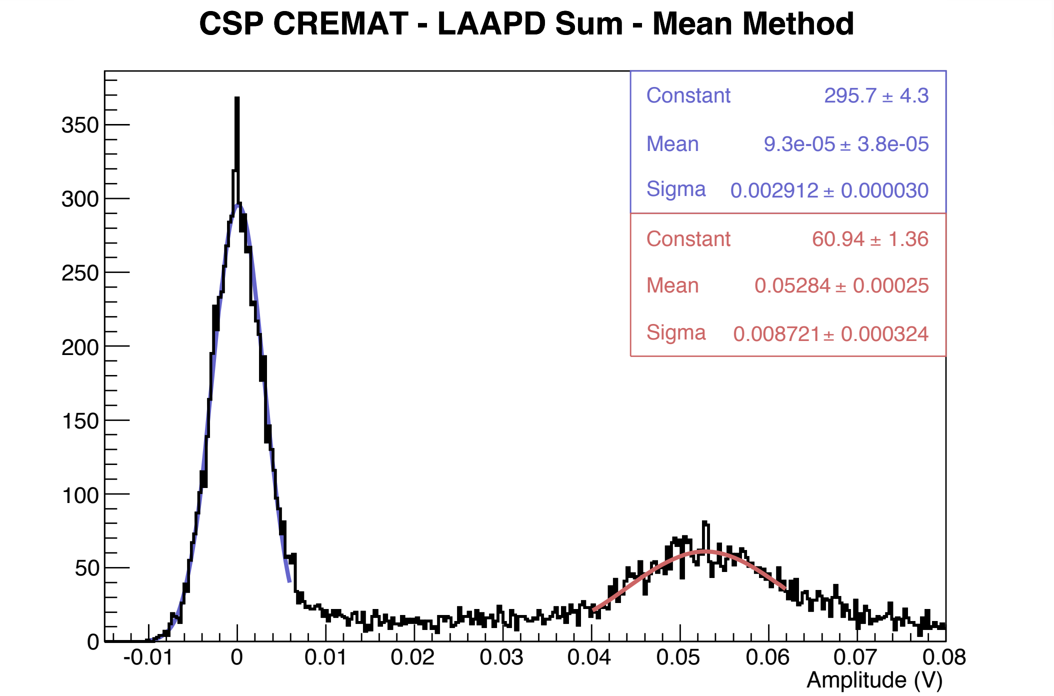




	Signal (mV)	Noise (mV)	S/N	ENE (MeV)
LAAPD1	23.2±0.1	2.05±0.02	11.3±0.2	2.65±0.03
LAAPD2	29.6±0.2	2.07±0.02	14.3±0.2	2.10±0.02

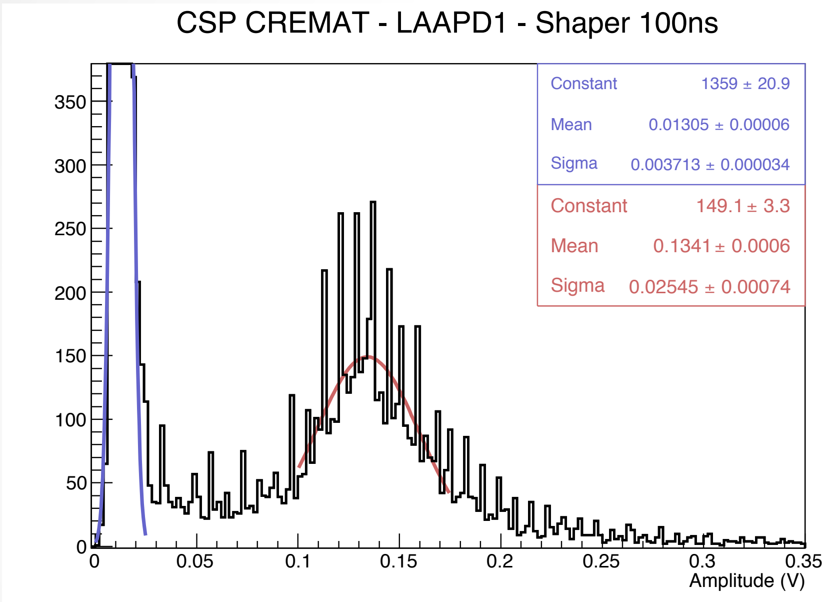
- Run temperature T=19.8±0.2°C

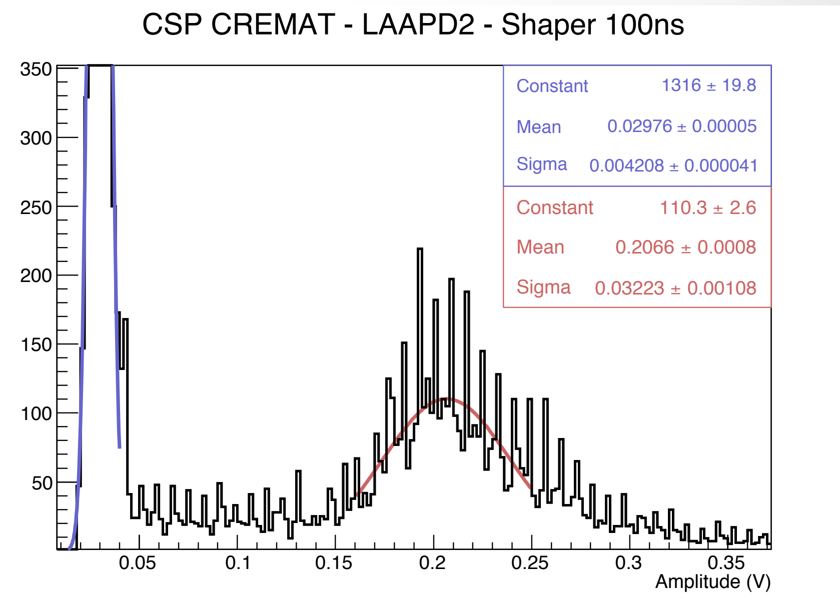
CSP LAAPD SUM (1KΩ) – Run SHP100



	Signal (mV)	Noise (mV)	S/N	ENE (MeV)
LAAPD1	23.2±0.1	2.05±0.02	11.3±0.2	2.65±0.03
LAAPD2	29.6±0.2	2.07±0.02	14.3±0.2	2.10±0.02
LAAPD Sum	52.8±0.3	2.91±0.03	18.2±0.2	1.65±0.02

Shaping 100ns

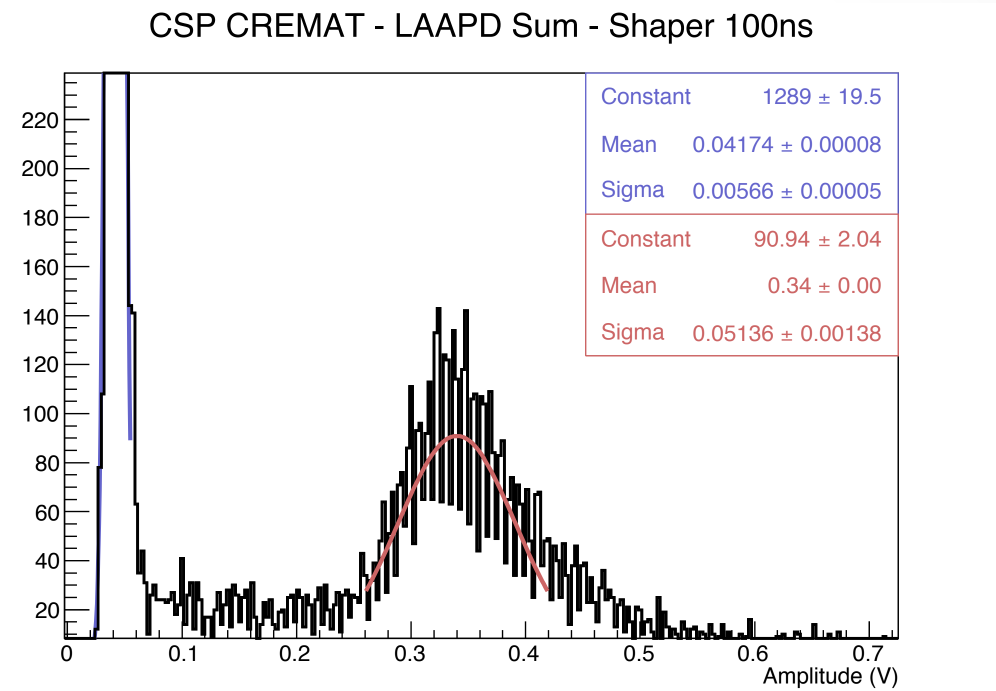




	Signal (mV)	Noise (mV)	S/N	ENE (MeV)
LAAPD1	121.1±0.6	3.71±0.03	32.6±0.3	0.91±0.02
LAAPD2	176.8±0.8	4.21±0.04	42.0±0.5	0.71±0.02

→ Oscilloscope ADC has a problem with one bit (probably)

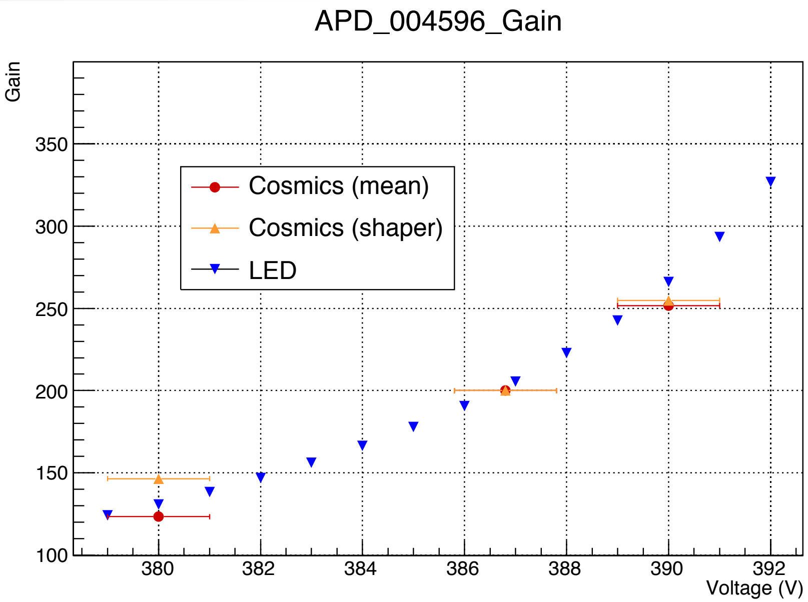
Shaping 100ns - Sum

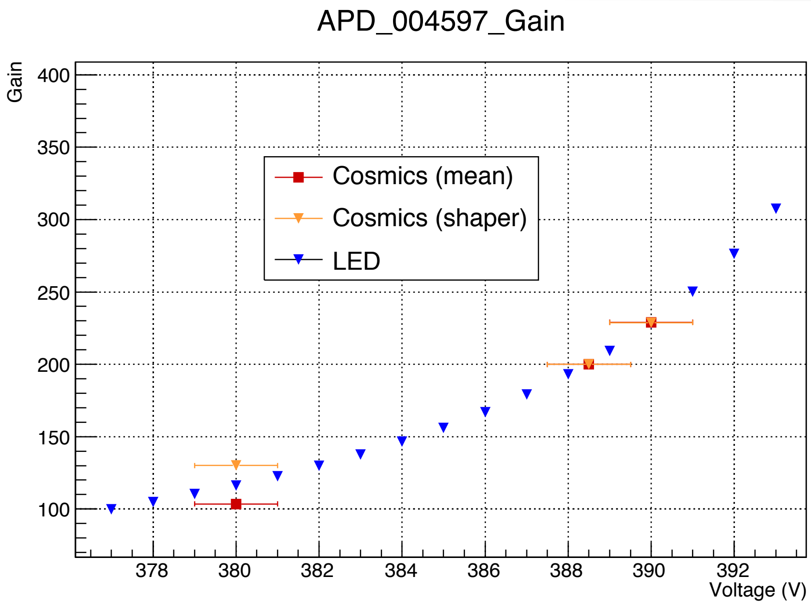


	Signal (mV)	Noise (mV)	S/N	ENE (MeV)
LAAPD1	121.1±0.6	3.71±0.03	32.6±0.3	0.91±0.02
LAAPD2	176.8±0.8	4.21±0.04	42.0±0.5	0.71±0.02
LAAPD Sum	398.3±1.1	5.66±0.05	52.7±0.6	0.55±0.02

Gain vs HV test

- We assume that G=200 point measured with LED is correct
- Cosmics measurement also at 380V and 390V
- Check distribution peak ratio

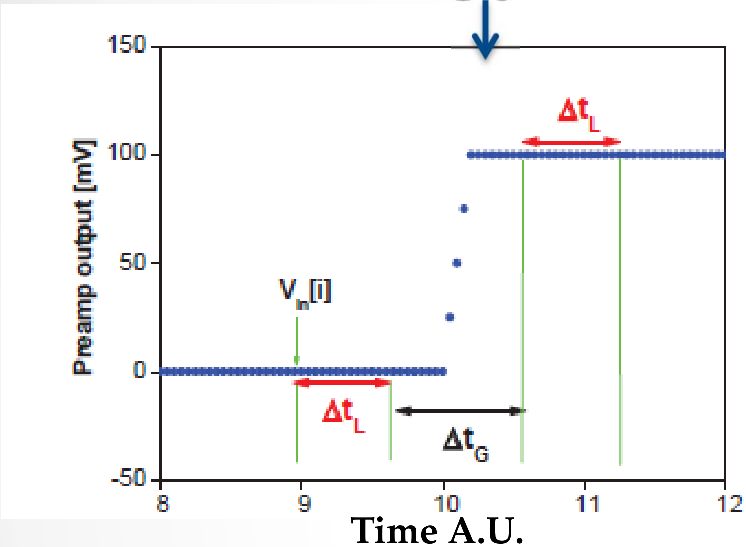


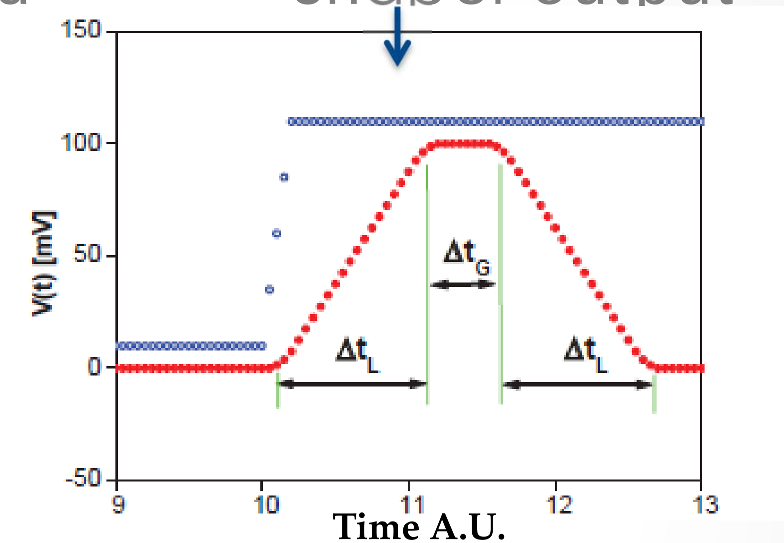


Software shaping

Algorithm details: trapezoidal filter

- Ideal CSP and Shaper output





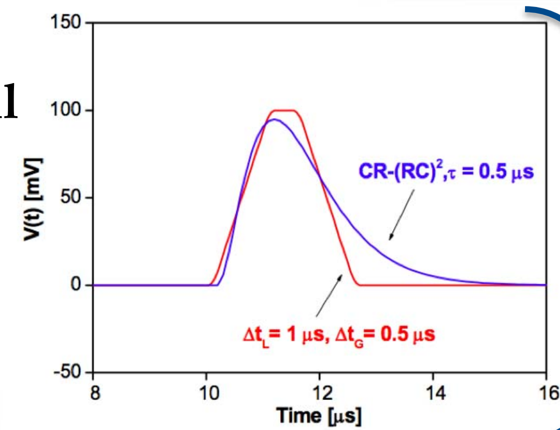
$$V_{av1}[i] = \frac{1}{L}\sum_{j=0}^{L-1} V_{in}[i+j]$$

$$V_{av2}[i] = \frac{1}{L}\sum_{j=0}^{L-1} V_{in}[L+G+i+j]$$

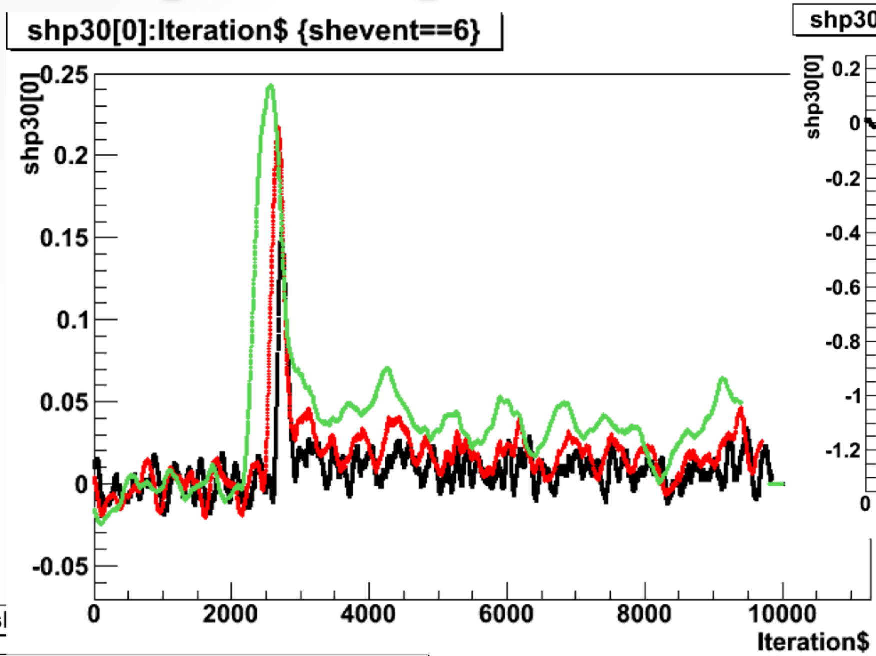
$$V_{out}[i] = V_{av2}[i] - V_{av1}[i]$$

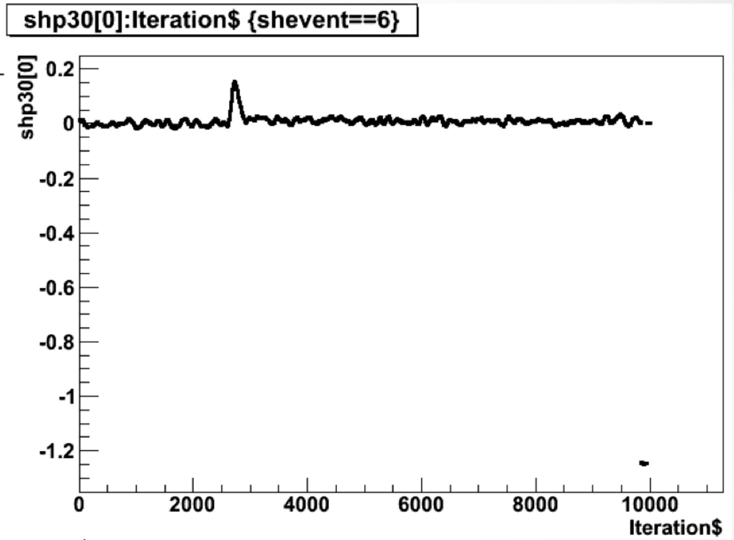
L (G) = number of samples in ΔT_L (ΔT_G)

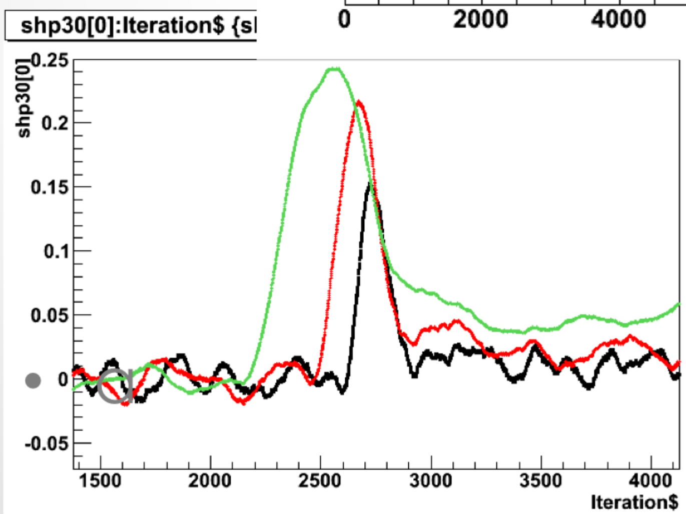
trapezoidal filter vs CR-RC²



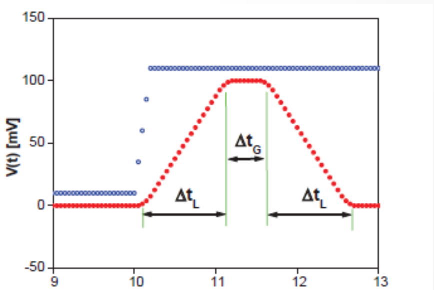
Shaper output and tests on time intervals





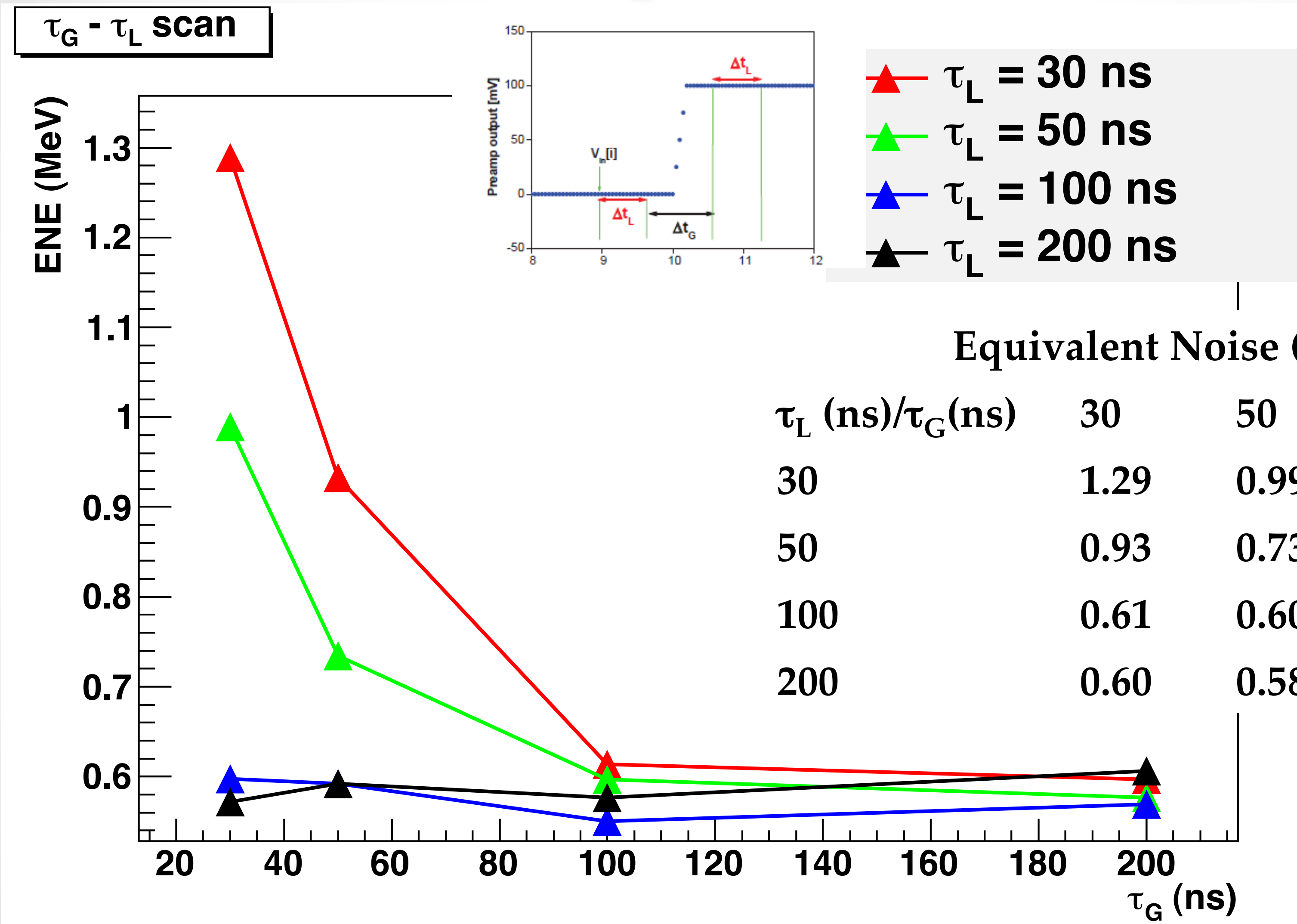


ΔT_L (ns)	ΔT_G (ns)
50	50
100	100
200	200



INFN Istituto Nazionale di Fisica Nucleare

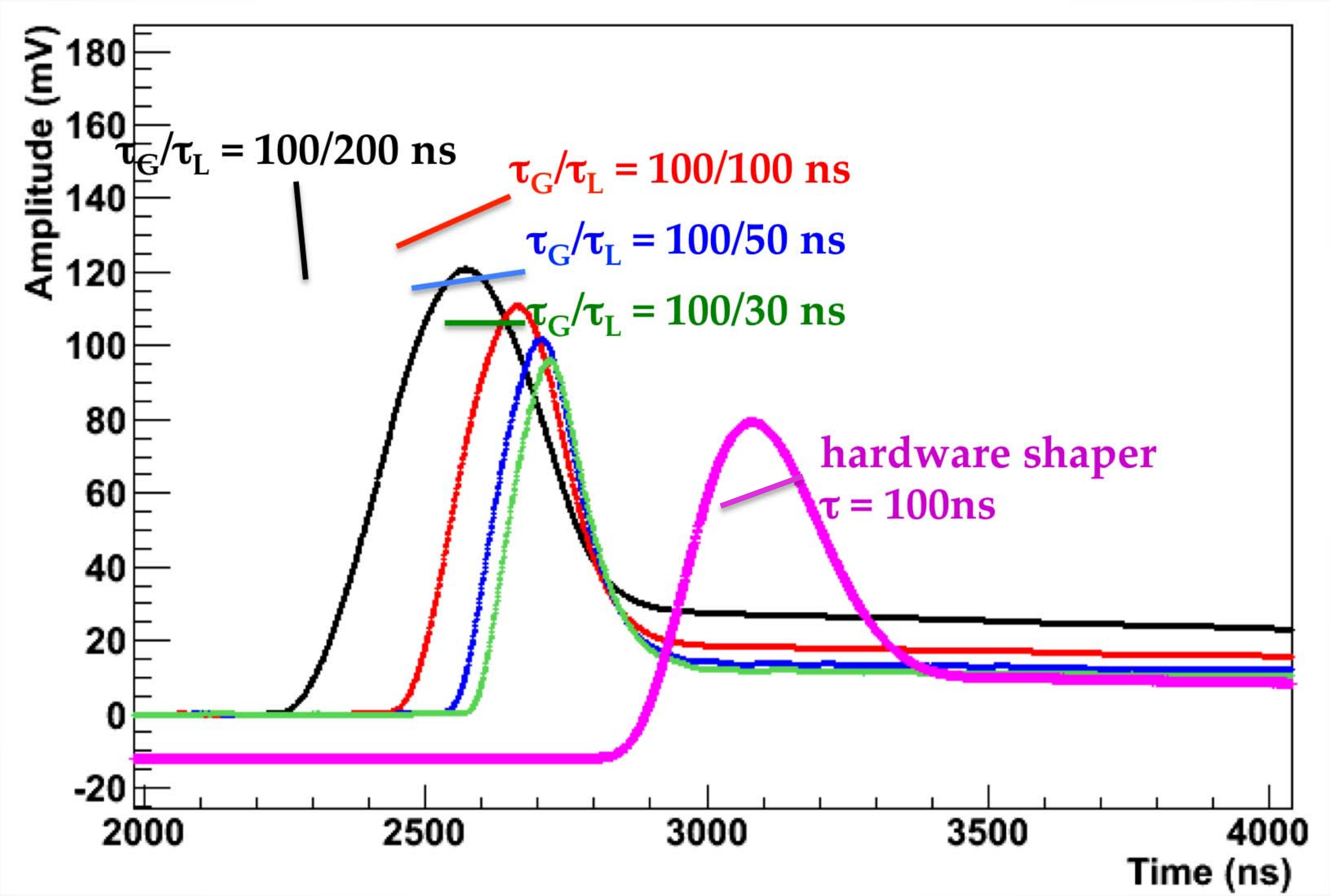
Equivalent noise



Equivalent Noise (MeV)

τ_L (ns)/τ_G(ns)	30	50	100	200
30	1.29	0.99	0.60	0.57
50	0.93	0.73	0.59	0.59
100	0.61	0.60	0.55	0.58
200	0.60	0.58	0.57	0.61

Comparison with hardware shaper



Conclusion (I)

- Checked the APDs gain
  - Some differences with Hamamatsu data
- New working point for both APDs and new mechanical setup
- CSP output with this new configuration down to 1.65MeV (~20°C)
- With a 50ns HW shaper we obtain a ENE=0.96MeV
- With a 100ns HW shaper we obtain a ENE=0.55MeV (~20°C)
- Gain tested and now we are confident to be in the right working point

Conclusion (II)

- Some tests with trapezoidal software shaping based on the code from Paolo
- In some configuration (τ_L=100ns τ_G=100ns) some results as hardware shaping
  - Noise introduced by hardware shaping is negligible
- More studies on the comparison between this shaping method and CR-RC^n are on going

To Do list

- Temperature scan
  - Will be performed in a climatic room in the next days
- Test 4 (small) Hamamatsu APD
  - S8664-55 : active area 5x5 mm^2
- Check APD gain with different wavelength LED
  - At same bias different wavelength have a different response
  - Behavior unknown below 370nm