Update on noise studies with a CsI(Tl) crystal

P.Gauzzi
Roma1 EMC group

4th SuperB Collaboration Meeting
La Biodola – 2/6/2012

Experimental setup

- Aims of this test: evaluate the electronic noise as a function of the FEE integration time and shaping time
- Crystal readout on one side by either an APD or a PIN diode followed by a charge amplifier (CSP) and by a shaper

  PMT on the other side for trigger

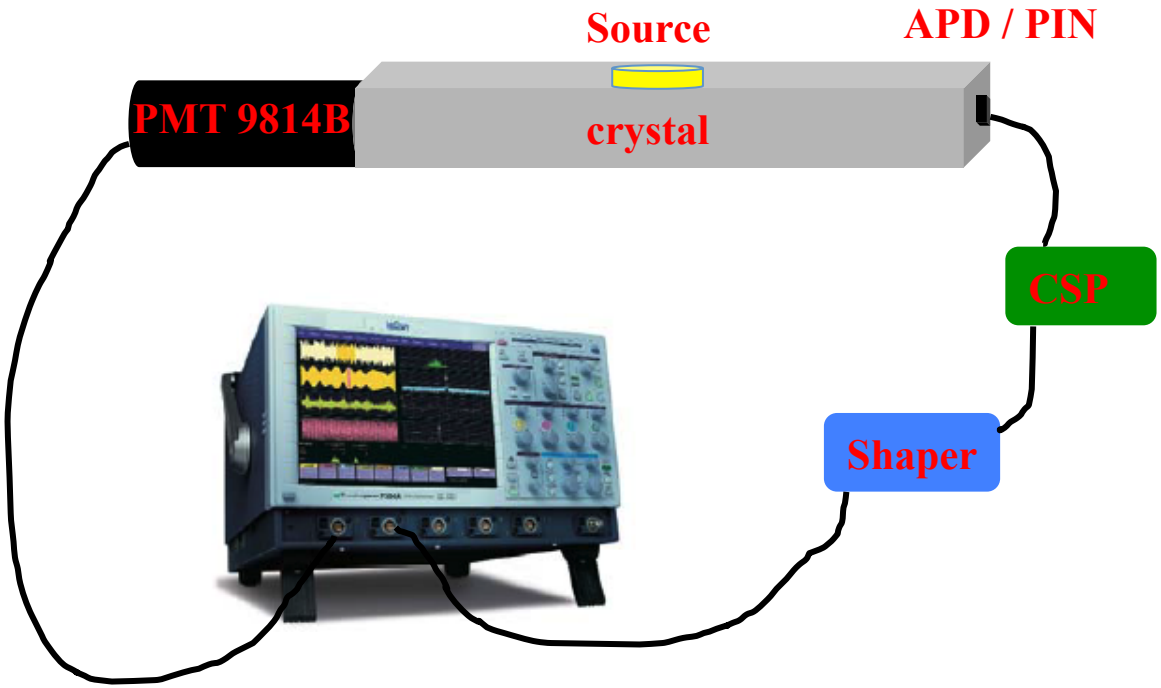
- Crystal under test:
  - CsI(Tl) (BaBar)

    $\sim 6 \times 6 \times 30\ cm^3$

- Source: ^{60}Co

  $\Rightarrow \gamma$: 1.17 MeV

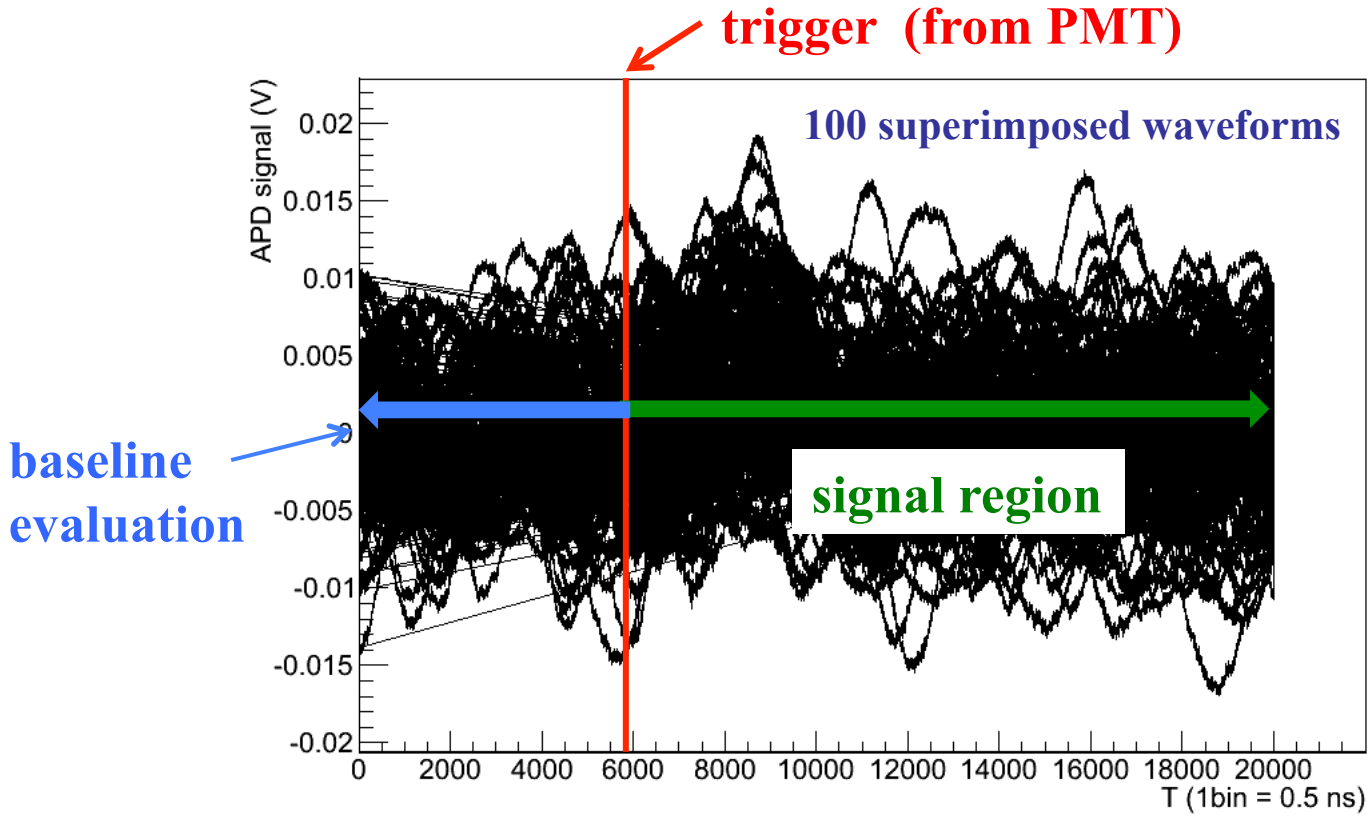
  1.33 MeV



Signal evaluation

- Events acquired by a LeCroy digital oscilloscope (12 bits)
- Waveforms recorded at a sampling rate of 20GS/s

  50000 events / measurement



- The shaper is sensitive to the amplitude:

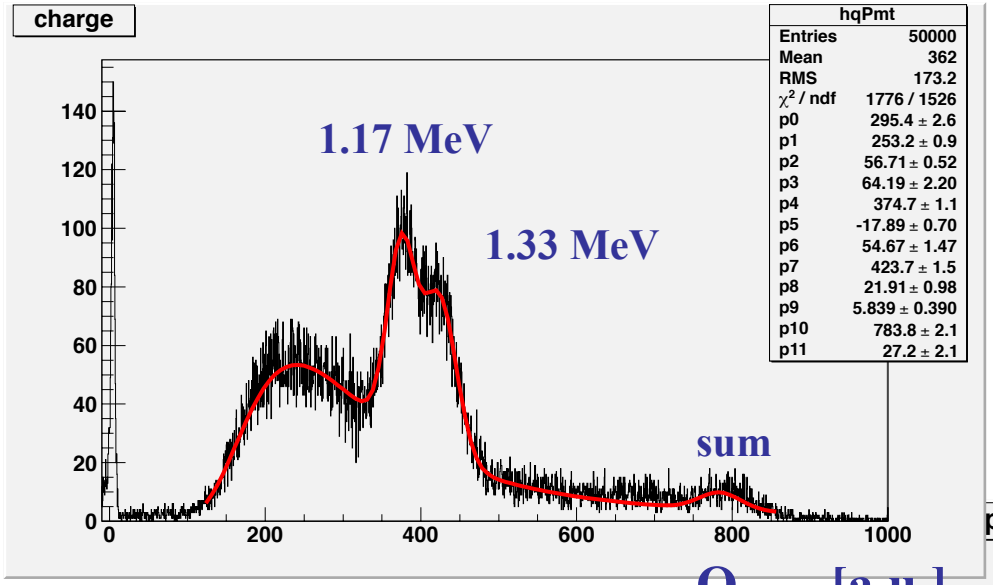
  ⇒ APD / PIN signal = maximum amplitude for T > 6000

Configurations studied

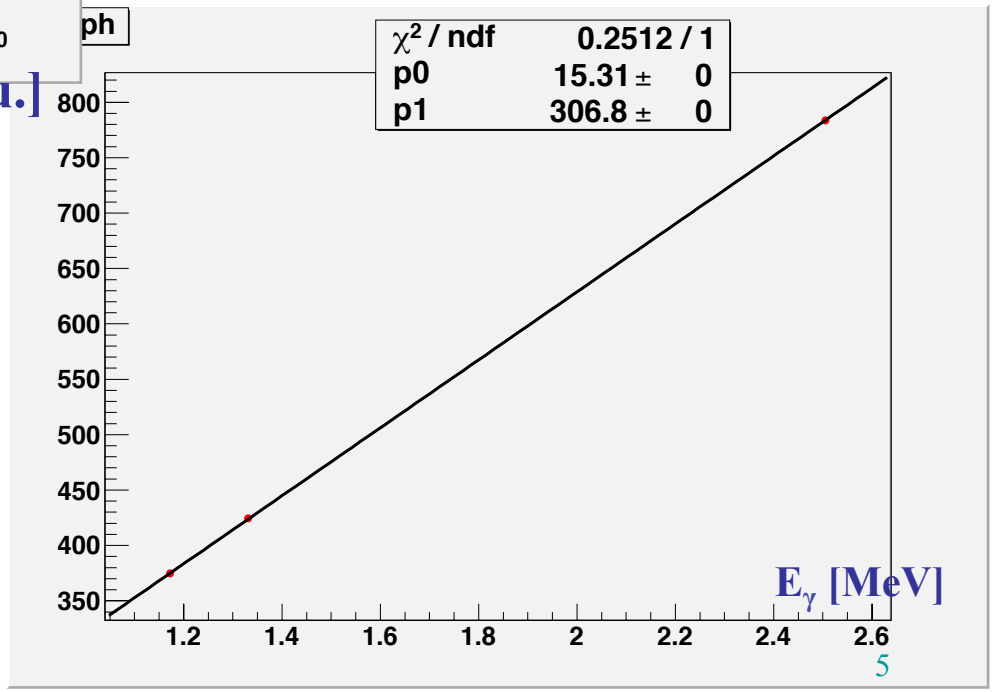
1) APD + CSP: Cremat i.t. 140 μs + shaper 500 ns
2) APD + CSP: Hamamatsu H4083, i.t. 100 ns + shaper 500 ns
3) APD + CSP: Hamamatsu H4083 i.t. 100 ns + shaper 250 ns
4) APD + CSP: Hamamatsu H4083 i.t. 100 ns + shaper 100 ns
5) APD + CSP: LABE Rome-1 prototype (LNA02V0) i.t. 100 ns + shaper 500 ns
6) PIN + CSP: Hamamatsu H4083 i.t. 100 ns + shaper 500 ns
7) PIN + CSP: Cremat i.t. 140 μs + shaper 500 ns

- APD: 0.5 × 0.5 cm^2 size, operated at 340 V and 380 V
- PIN diode from BaBar: 1 × 2 cm^2 size (only one of the two is readout), operated at 60 V

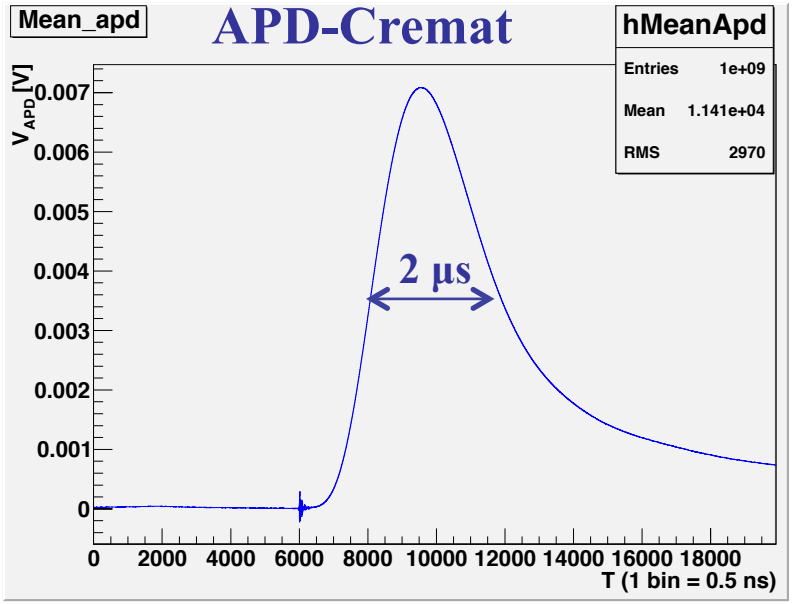
^{60}Co spectrum with PMT

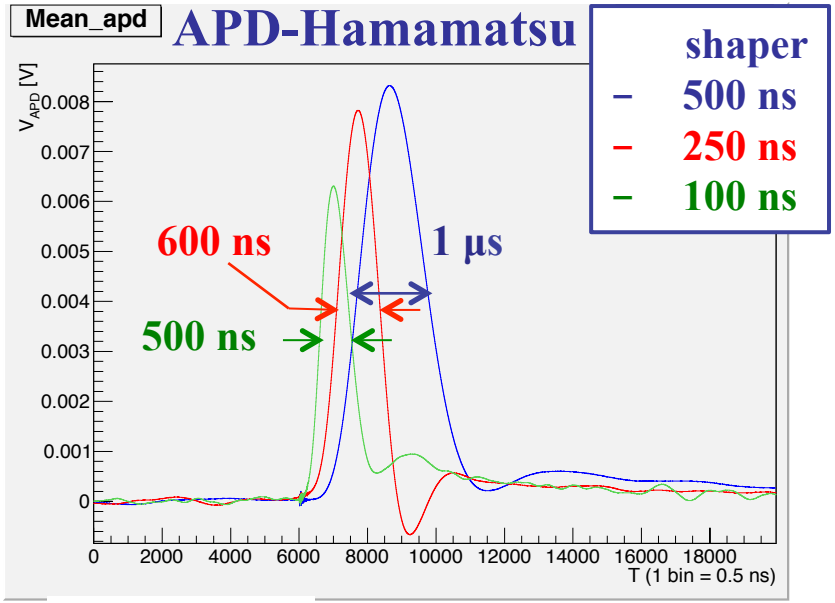


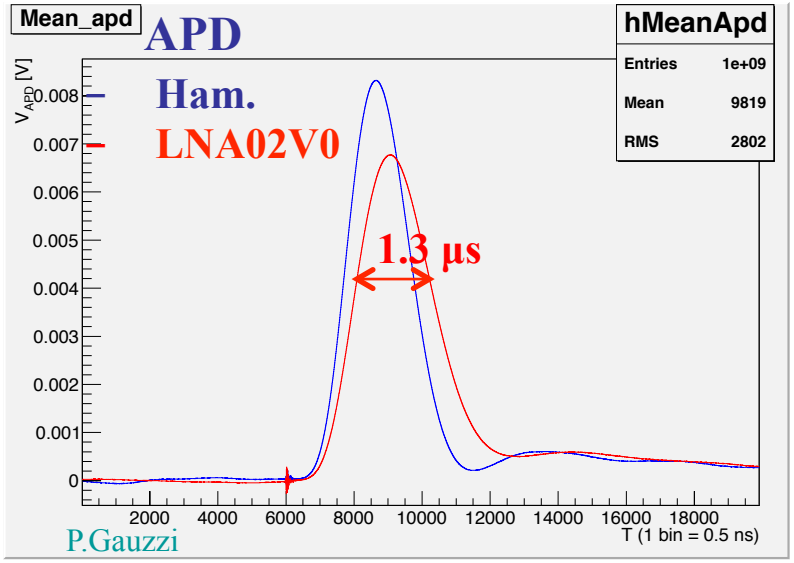
Q_{PMT} [a.u.]

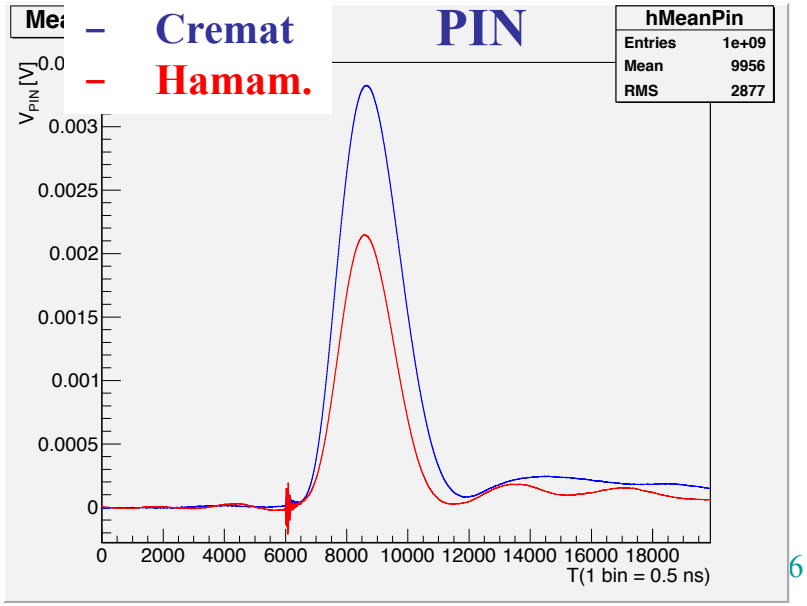


Average signals



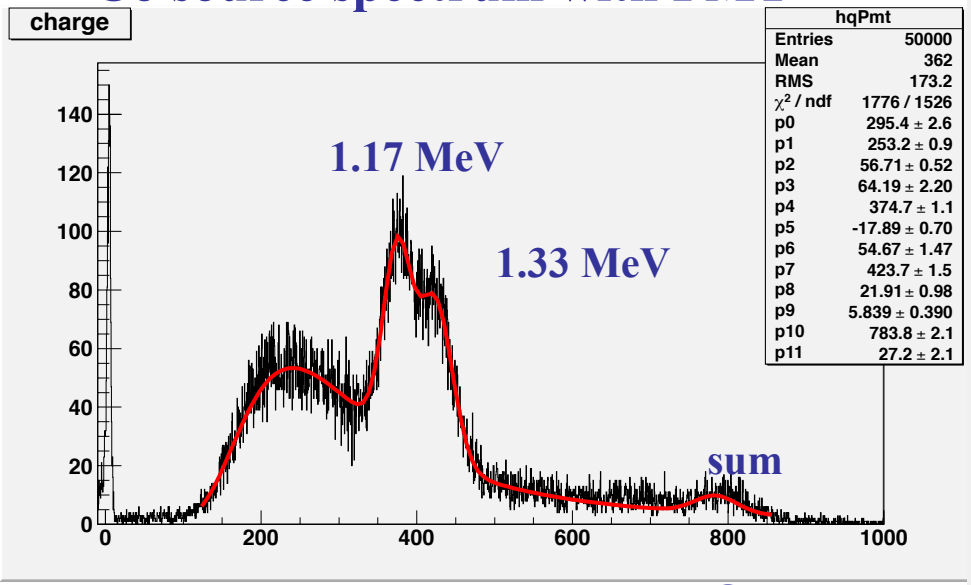


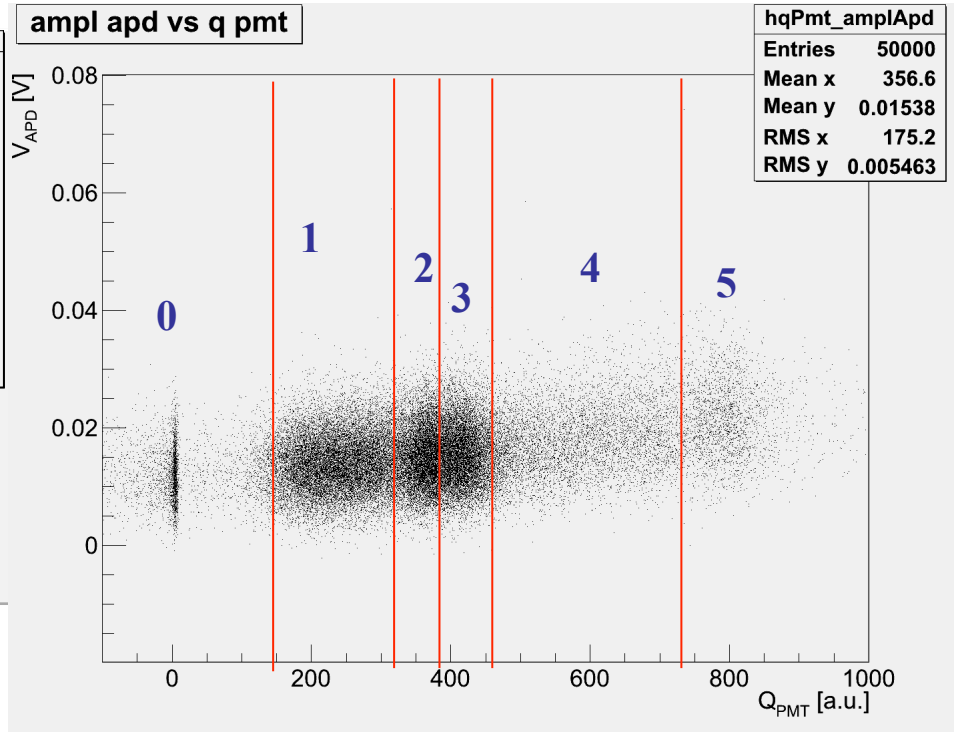




Example: APD - CSP Hamam. i.t. 100 ns – s.t. 500ns

^{60}Co source spectrum with PMT

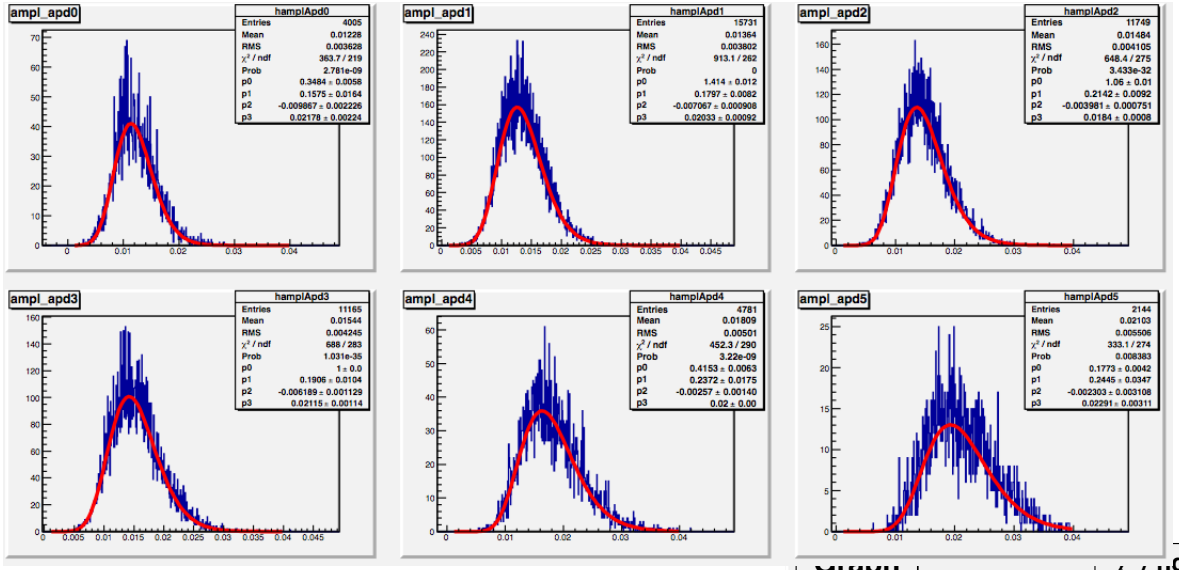




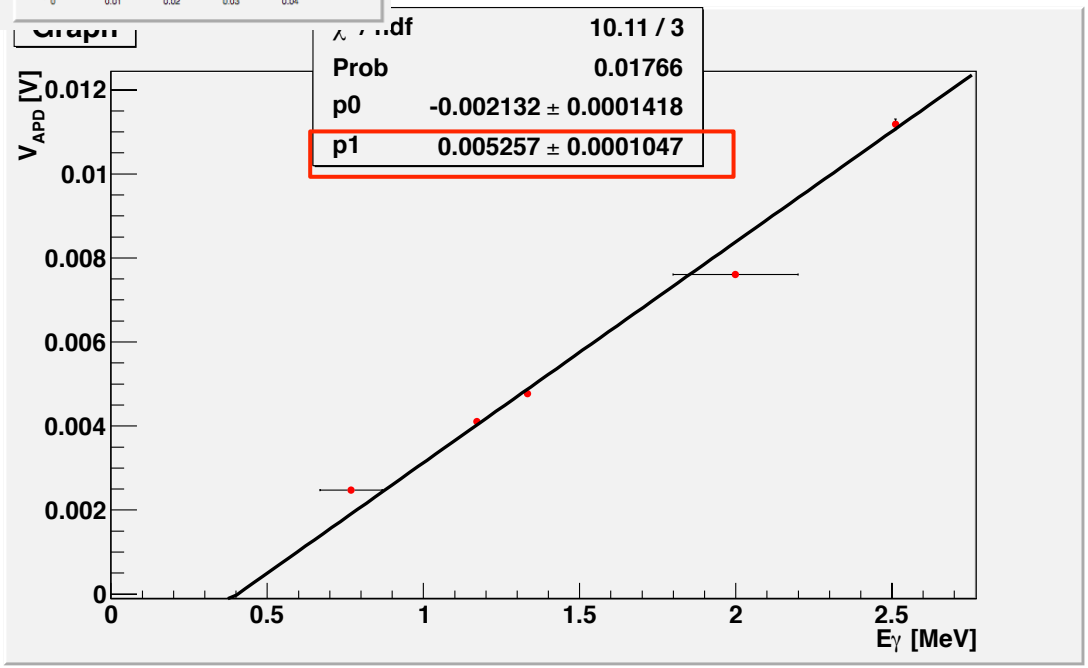
Divide into 6 regions:

0) pedestal
1) crystal bckg
2) 1.17 MeV peak
3) 1.33 MeV peak
4) tail of crystal bckg
5) sum 1.17 + 1.33 MeV

Energy scale

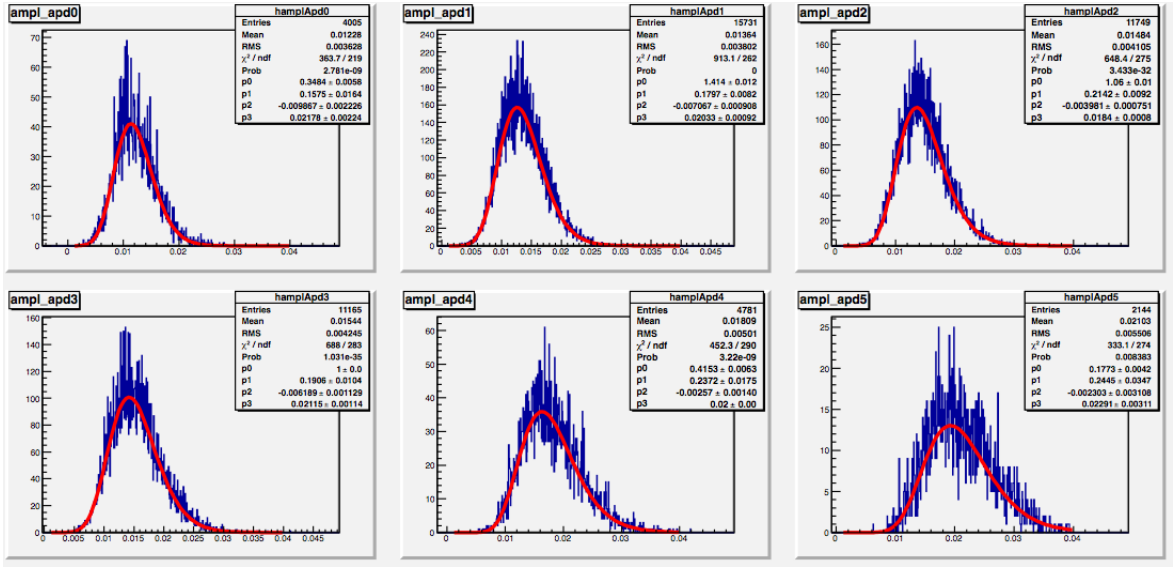


from the peaks of the distributions



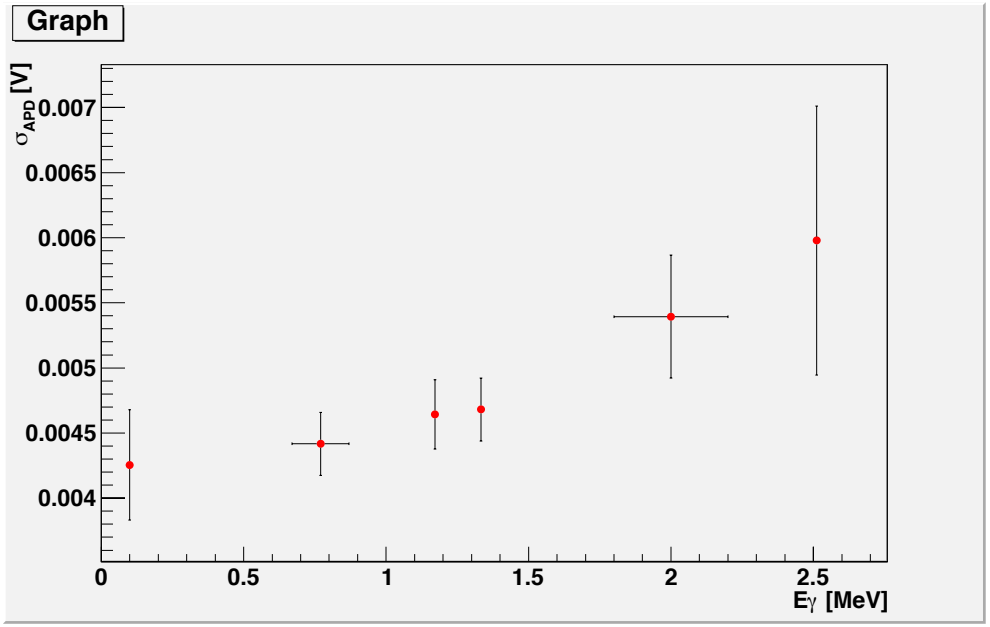
the relevant parameter is p_1 [mV/MeV]

Noise evaluation



from the widths of the distributions

$$\frac{4.5\ \text{mV}}{5.3\ \text{mV/MeV}} = 0.85\ \text{MeV}$$

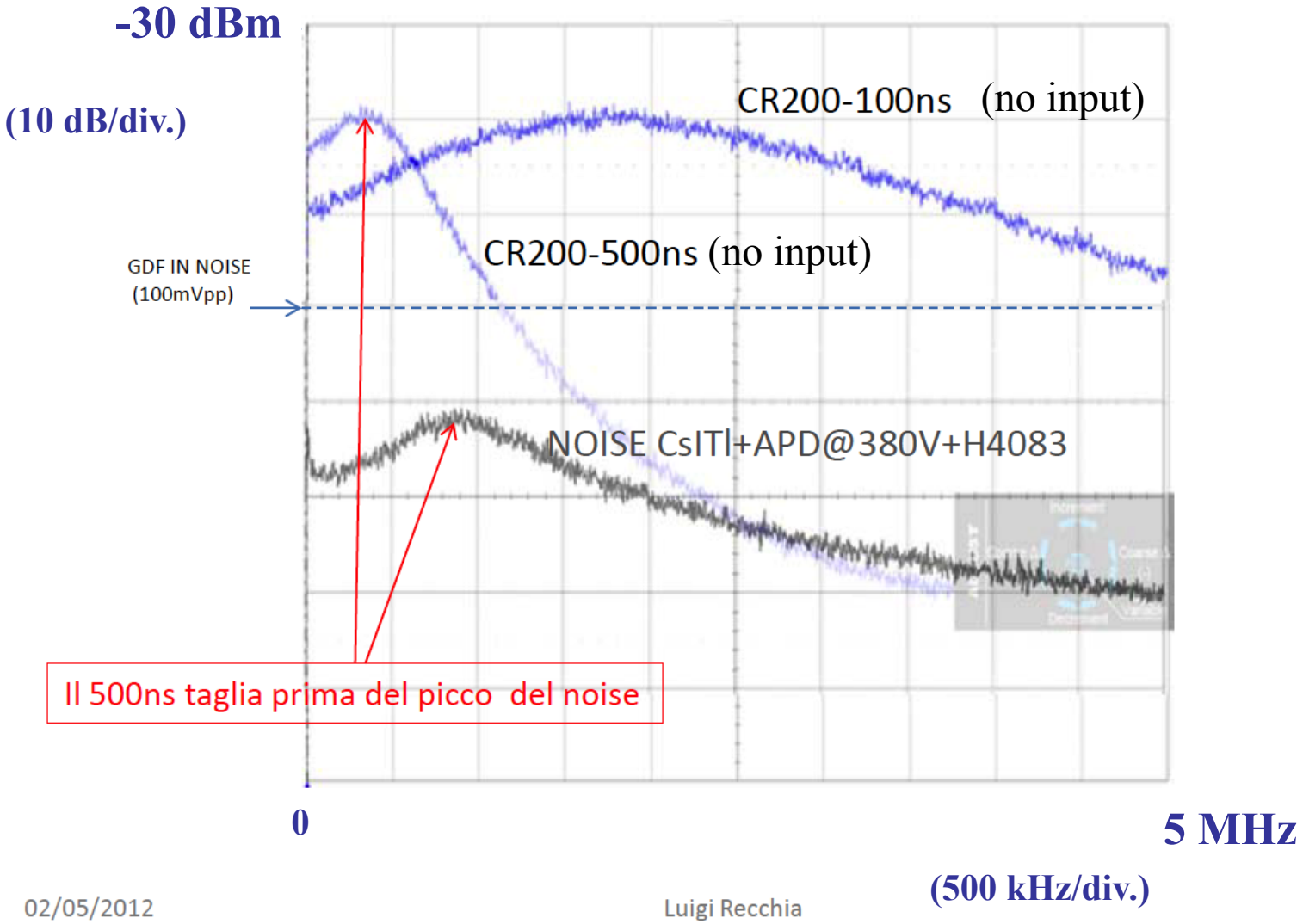


Noise in mV

Configuration	V_{APD} = 340 V	V_{APD} = 380 V	PIN
Cremat + sh. 500 ns	2.4	3.3	1.5
Hamamatsu + sh. 500 ns	2.9	4.5	2.5
Hamamatsu + sh. 250 ns	5.1	6.0	
Hamamatsu + sh. 100 ns	5.3	6.0	
proto. LNA02V0 + sh.500 ns		3.0	

- **The shaper at 500 ns has a narrower bandwith w.r.t. 250 or 100 ns**
  ⇒ lower noise
- **LNA02V0 rise time ≈ 400 ns VS Hamamatsu H4083 ≈ 300 ns**

Frequency analysis



Energy calibration

p_1 [mV / MeV]

Config.	V_{APD} = 340 V	V_{APD} = 380 V	PIN
Cremat + sh. 500 ns	1.8	5.3	2.7
Hamamatsu + sh. 500 ns	2.3	5.3	1.1
Hamamatsu + sh. 250 ns	1.5	4.8	
Hamamatsu + sh. 100 ns	1.2	4.0	
proto. LNA02V0 + sh. 500 ns		5.3	

- **APD Gain(380 V) / Gain(340 V) ≈ 3**
- **Signal amplitude decreases with the shaping time**

Noise [MeV]

Config.	V_{APD} = 340 V	V_{APD} = 380 V	PIN
Cremat + sh. 500 ns	1.3	0.62	0.56
Hamamatsu + sh. 500 ns	1.3	0.85	2.3
Hamamatsu + sh. 250 ns	3.4	1.3	
Hamamatsu + sh. 100 ns	4.4	1.5	
proto. LNA02V0 + sh. 500 ns		0.57	

- **APD: electronic noise (in mV) is increasing from 340 V to 380 V, but signal/noise ratio is improving**

- **PIN: by reading both sensors we expect that signal/noise ratio decreases by a factor of $\sqrt{2}$ (0.4 and 1.5 MeV)**

Conclusions

- **We tested a CsI(Tl) crystal with several configurations of readout electronics**

- **The shaper at 500 ns has a narrow bandwidth and cuts out the peak of the noise from sensor+amplifier chain, while at 100 ns the bandwith is centered on the peak of sensor+amplifier**

- **Electronic noise is greater than 0.5 MeV**