Study of electronic noise with a CsI(Tl) crystal

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Experimental setup

- Aims of this test: study the effect of the FEE integration and shaping time on the crystal performance, in particular evaluate the electronic noise
- Crystal readout on one side by an APD (operated at HV = 340 V) wih the complete FEE chain: CSP + shaper

  PMT on the other side for trigger

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

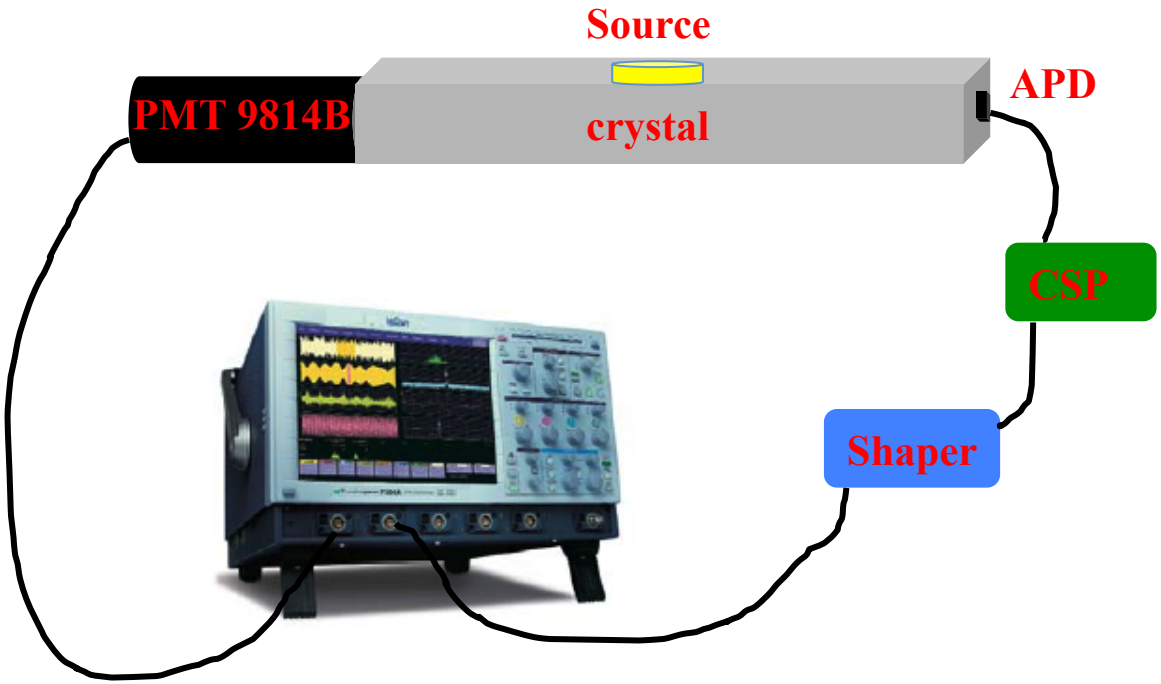
    ~ 6 × 6 × 30 cm^3
- Sources: ^{137}Cs

  ⇒ 662 keV γ

  ^{60}Co

  ⇒ γ: 1.17 MeV

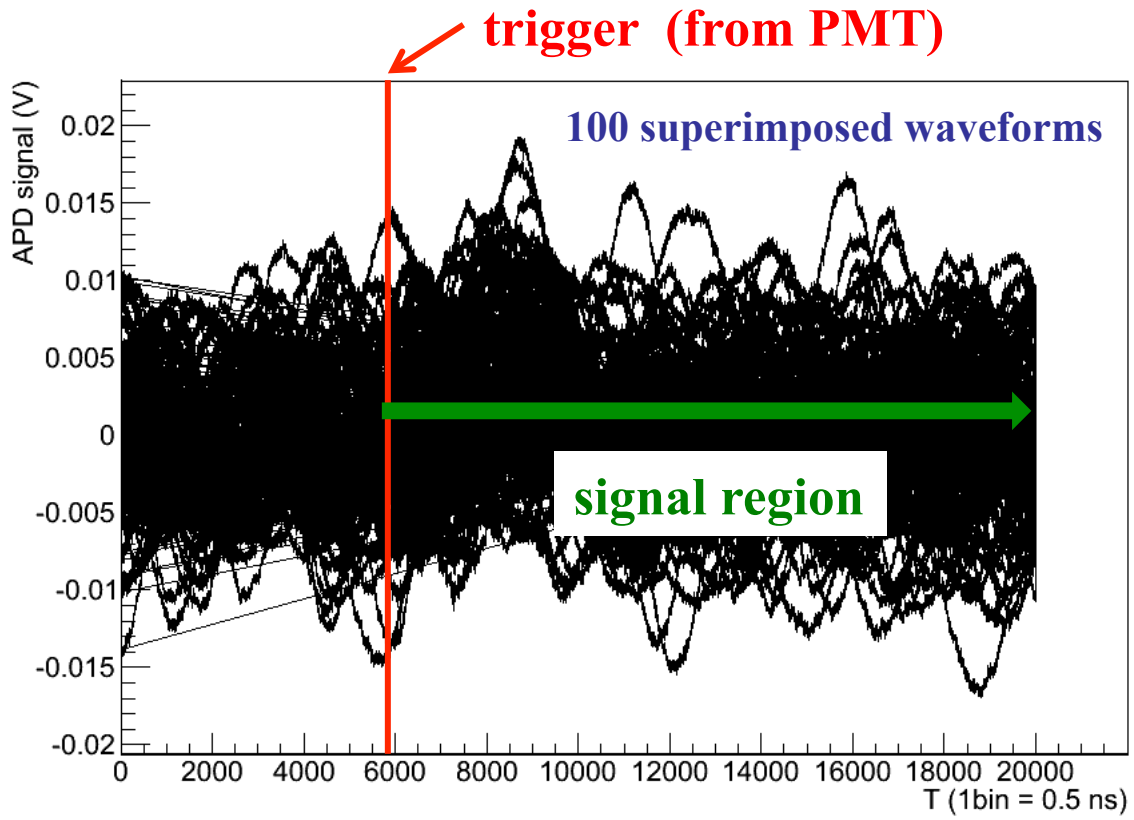
  1.33 MeV



APD signal

- 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

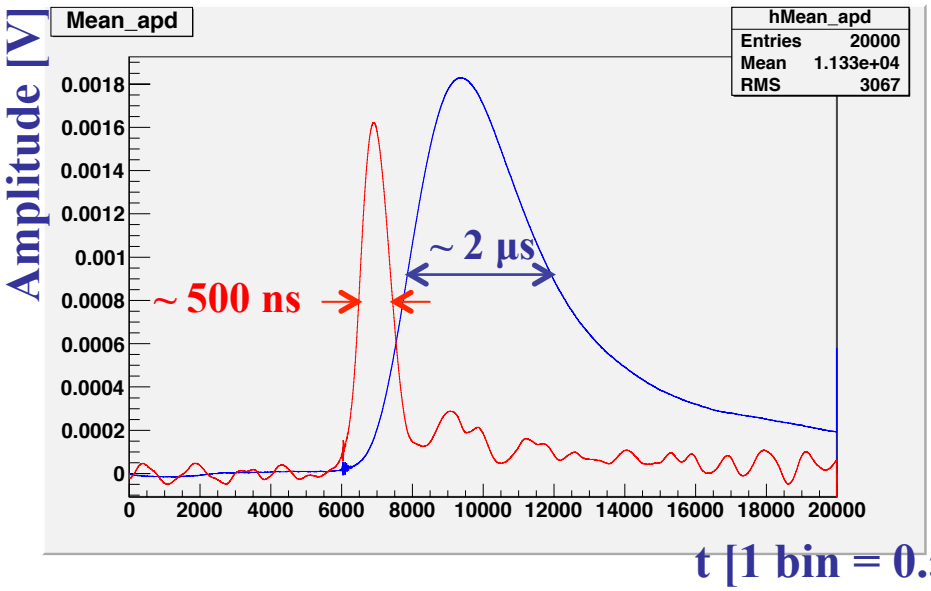
  ⇒ APD signal = maximum amplitude for T > 6000

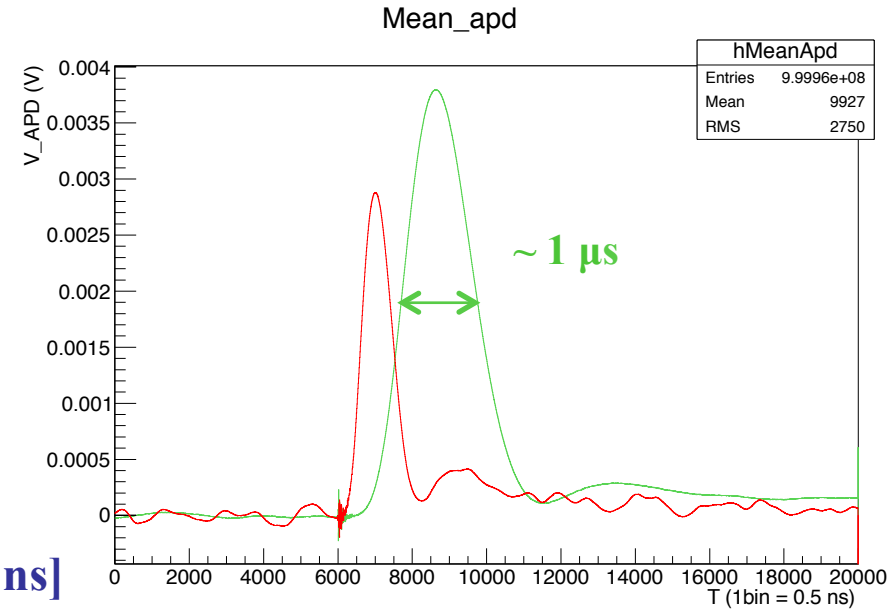
Configurations studied

1) CSP Cremat integr. time = 140 µs + shaping time = 500 ns

2) CSP Hamamatsu integr.time = 100 ns + shaping time = 100 ns

3) CSP Hamamatsu integr.time = 100 ns + shaping time = 500 ns





Averages over
50000 waveforms

Noise expectations

- **BTF test with LYSO crystal readout by APD with Cremat CSP**

  ⇒ electronic noise was ~ 250 keV

- **Assuming that the noise comes essentially from the shaper:**

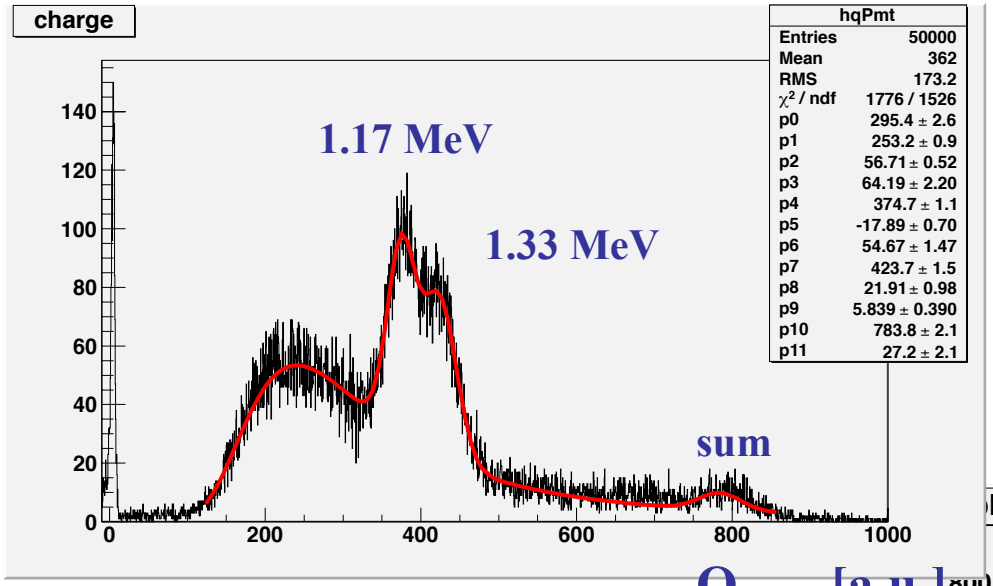
$$\frac{Noise(CsI)}{Noise(BTF)} = \frac{LY_{LYSO}}{LY_{CsI}} \frac{G_{APD}(380\ V)}{G_{APD}(340\ V)} Atten_{BTF} \frac{S(CsI)}{S(LYSO)} =$$

$$= \frac{75}{140} \times 4 \times 0.175 \times \frac{36}{4} \simeq 3.5$$

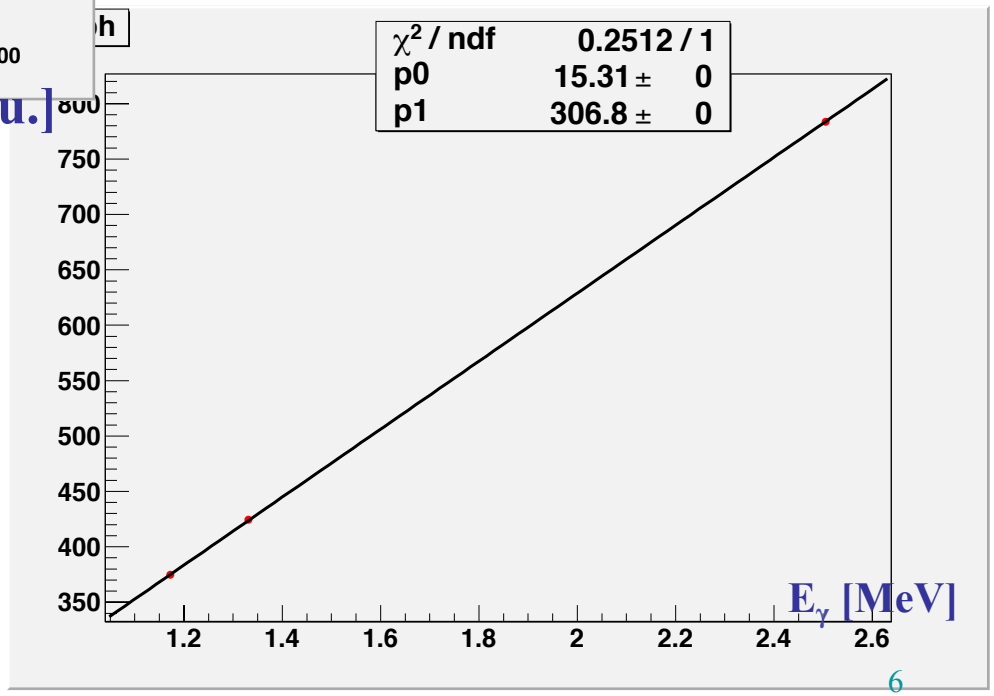
- **The ratio S(CsI)/S(LYSO) takes into account the reduction from the crystal to the APD area (is the ratio between the surfaces of the crystals)**

- **We expect for the CsI(Tl) crystal with Cremat CSP: 0.25 × 3.5 ≈ 1 MeV**

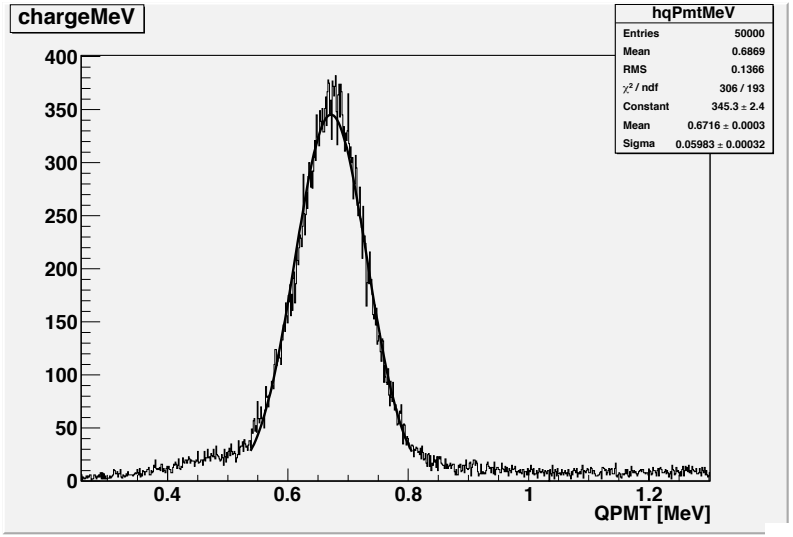
PMT energy calibration



Calibration with the ^{60}Co source



Cremat CSP



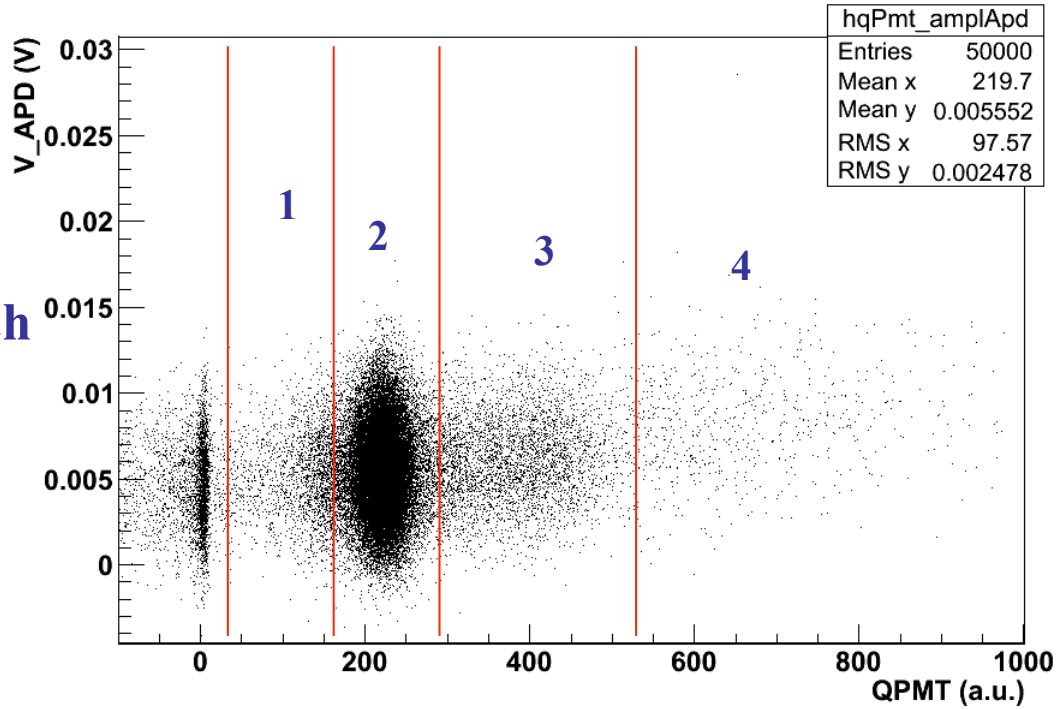
- Int. time = 140 µs; shaping time = 500 ns

- No data with ^{60}Co source, only with ^{137}Cs
- Check of the PMT energy scale:

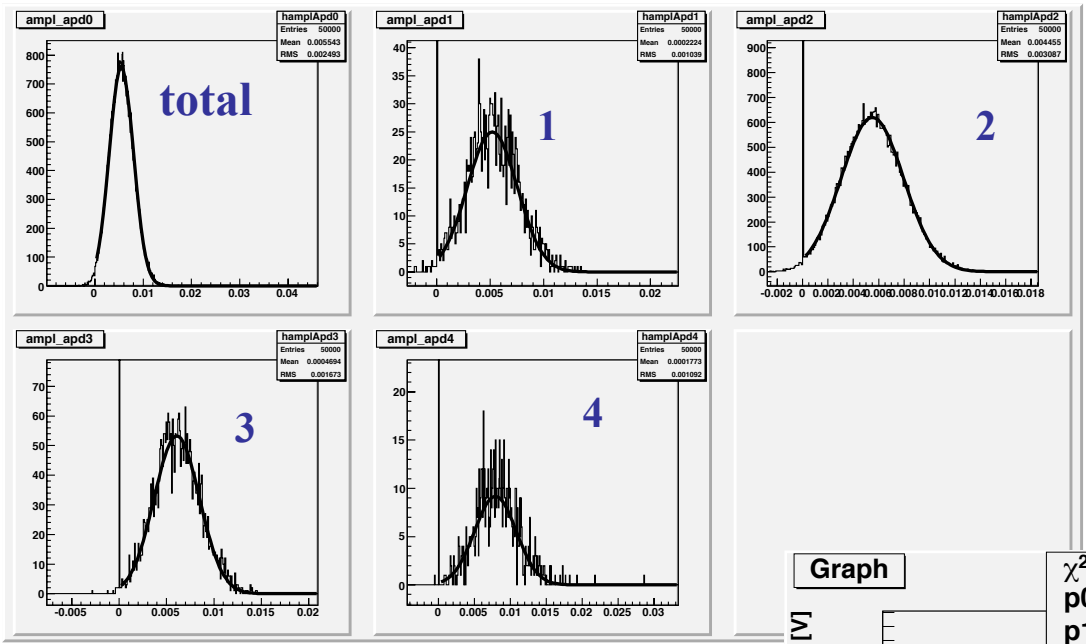
^{137}Cs peak ⇒ 672 keV (662 keV nominal)

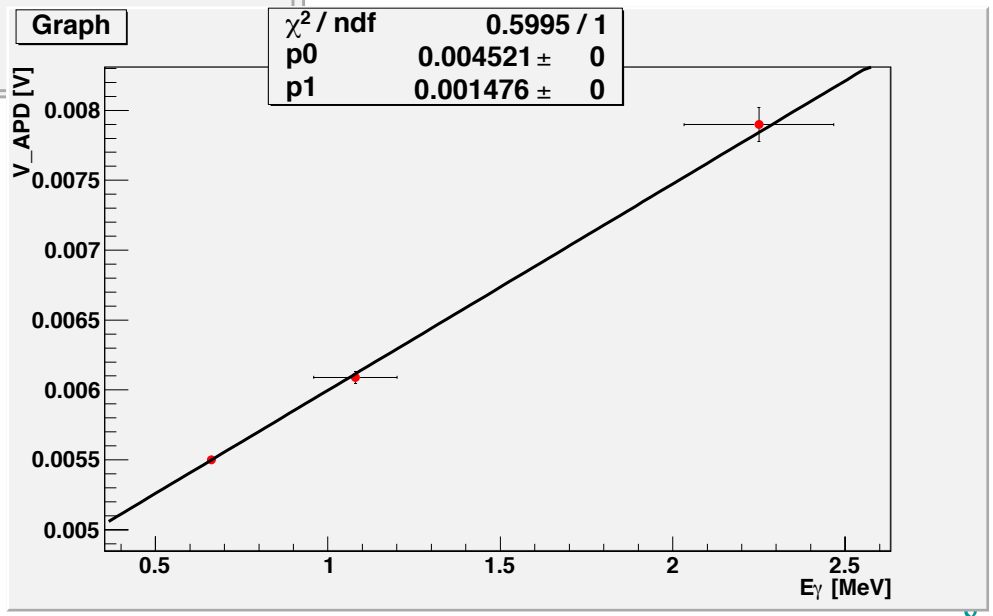
- We use the PMT signal to calibrate the APD response

- We divide the range in 4 regions and perform a gaussian fit to each APD distribution

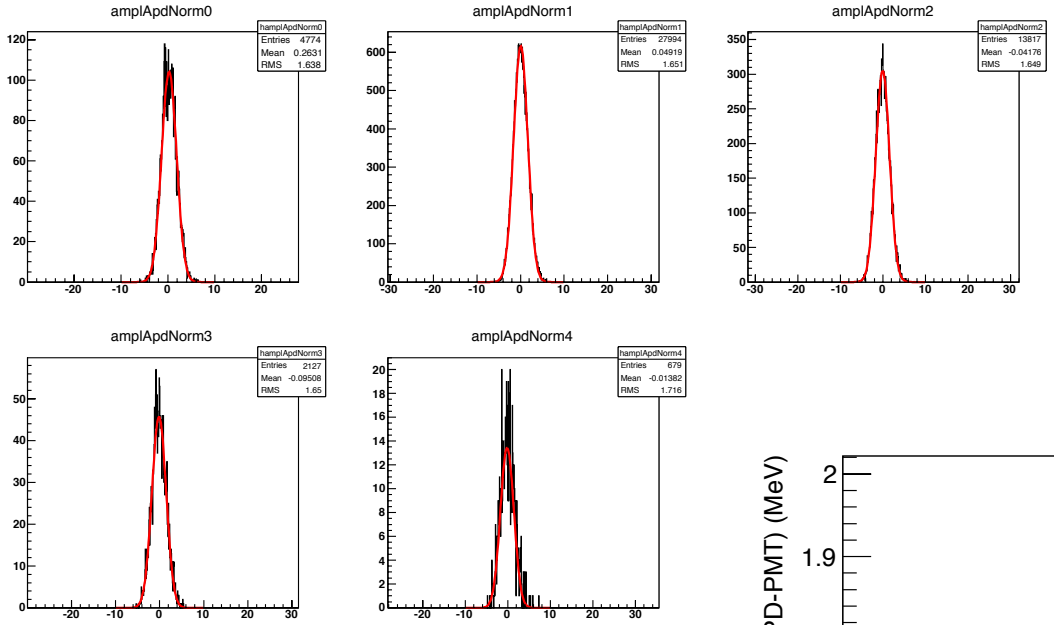


Cremat CSP


ampl_apd0
hamplApd0
Entries 50000
Mean 0.005543
RMS 0.002493
total
ampl_apd1
hamplApd1
Entries 50000
Mean 0.0002224
RMS 0.001039
1
ampl_apd2
hamplApd2
Entries 50000
Mean 0.004455
RMS 0.003087
2
ampl_apd3
hamplApd3
Entries 50000
Mean 0.0004694
RMS 0.001673
3
ampl_apd4
hamplApd4
Entries 50000
Mean 0.0001773
RMS 0.001092
4


Graph
χ² / ndf 0.5995 / 1
p0 0.004521 ± 0
p1 0.001476 ± 0
V_APD [V]
Eγ [MeV]

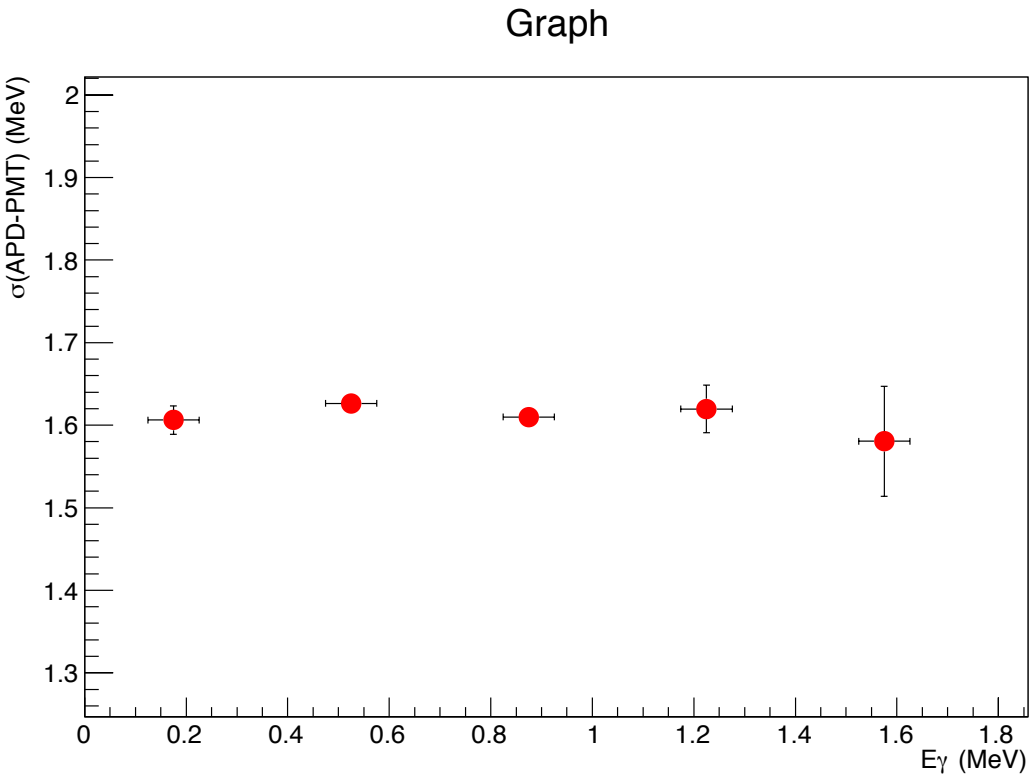
Cremat CSP



Once they are calibrated in MeV

⇒APD signal – PMT signal in slices of 350 keV in PMT signal

σ(APD-PMT) ≈ 1.6 MeV



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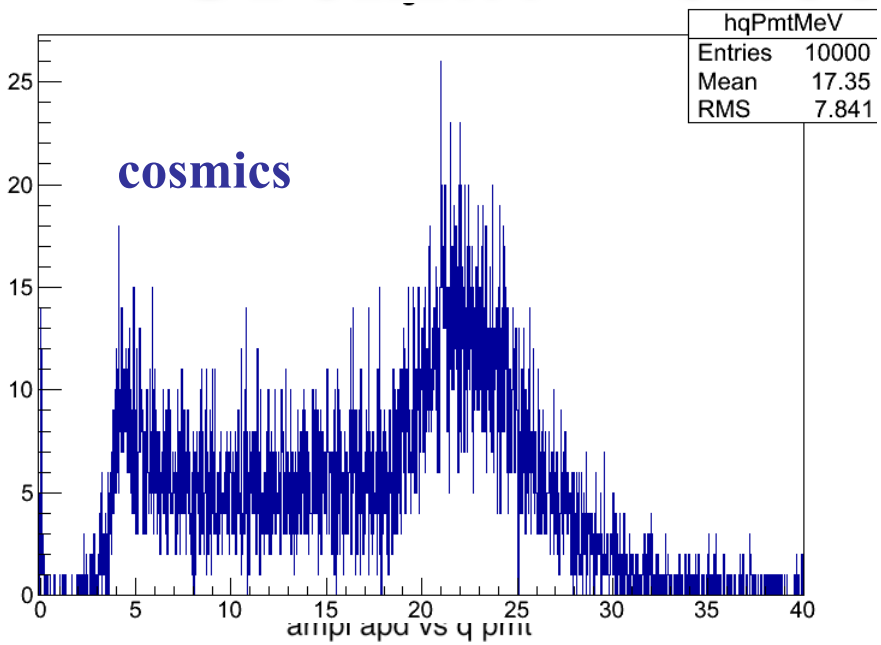
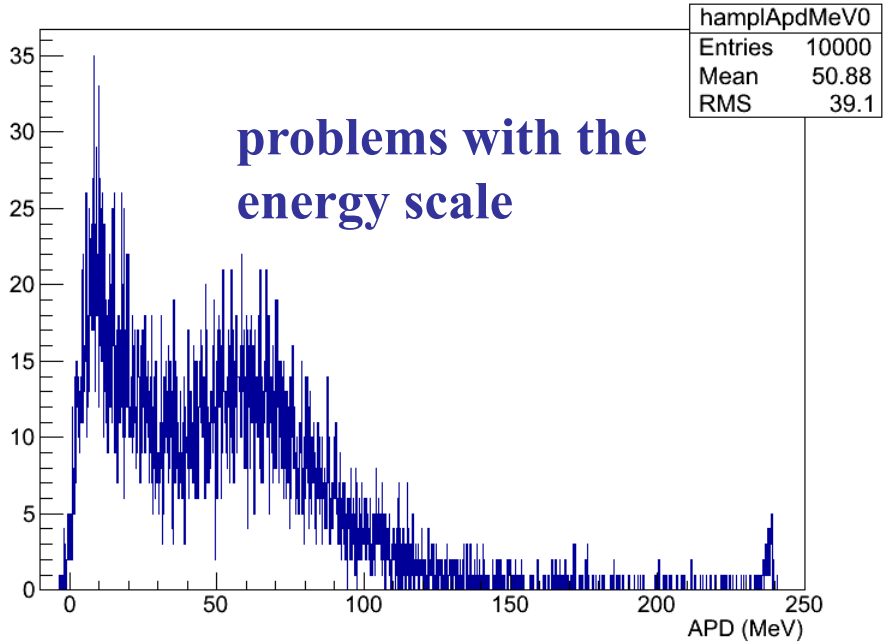
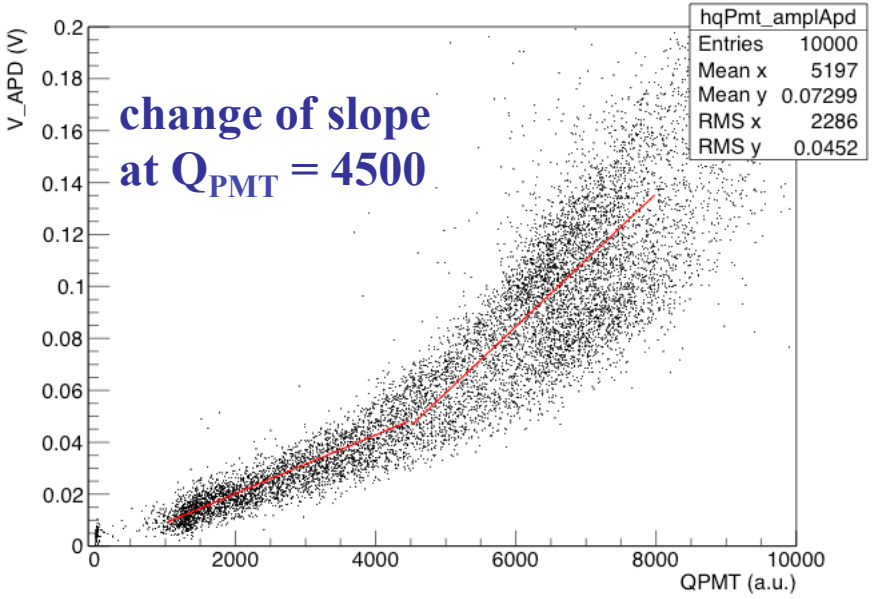
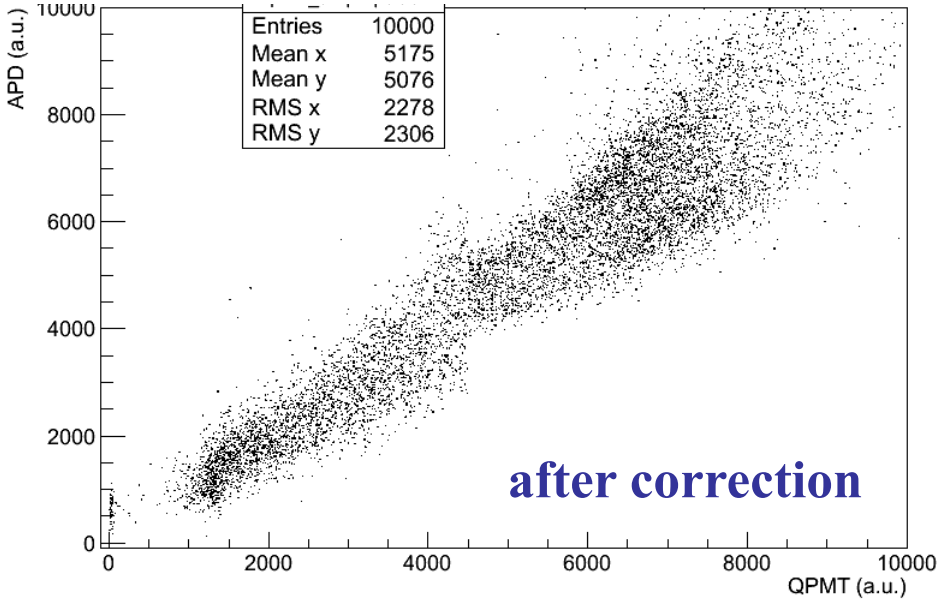
Cremat – check with cosmics

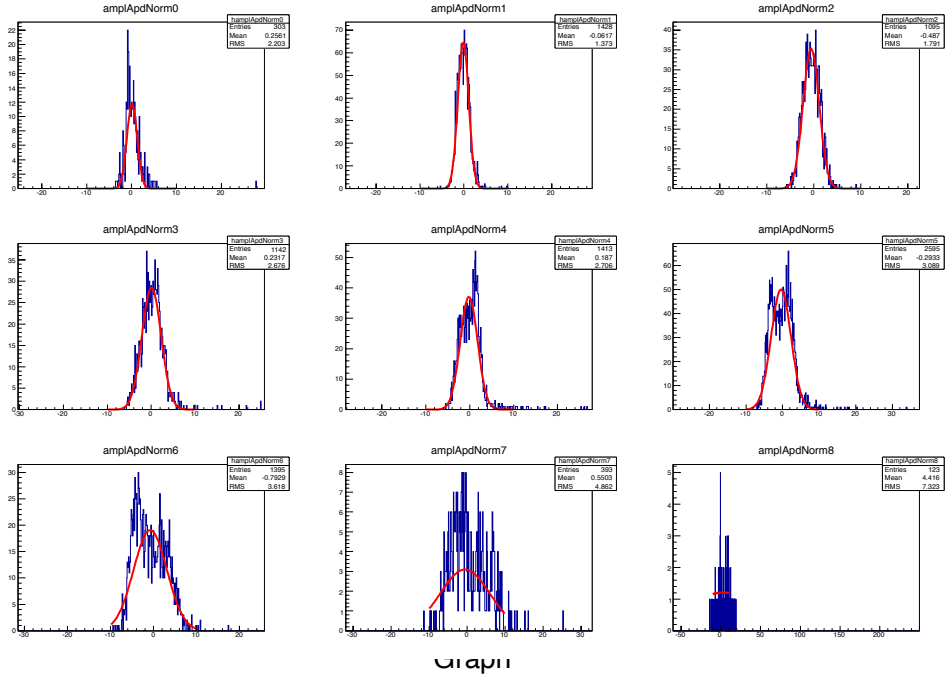




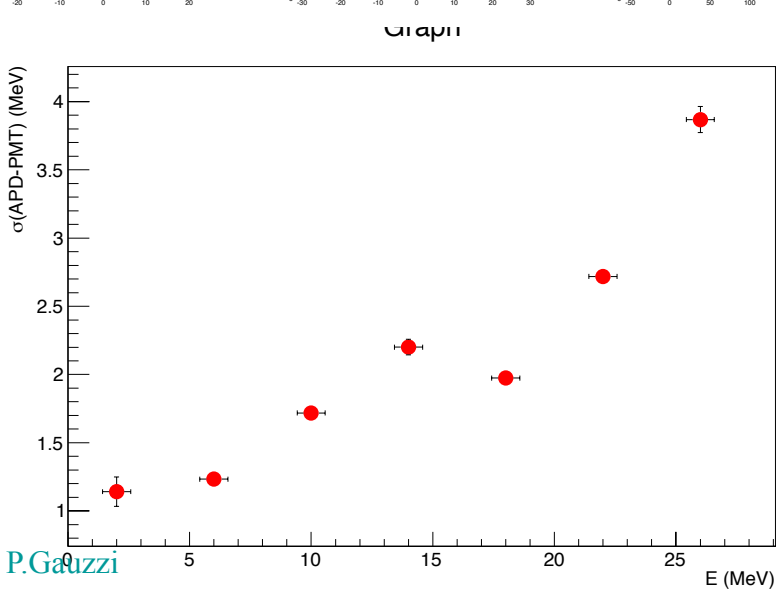


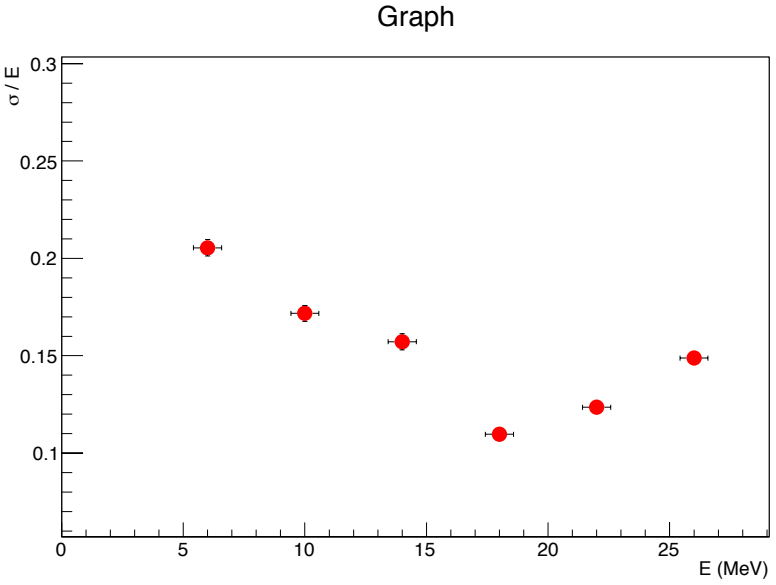


Cremat CSP



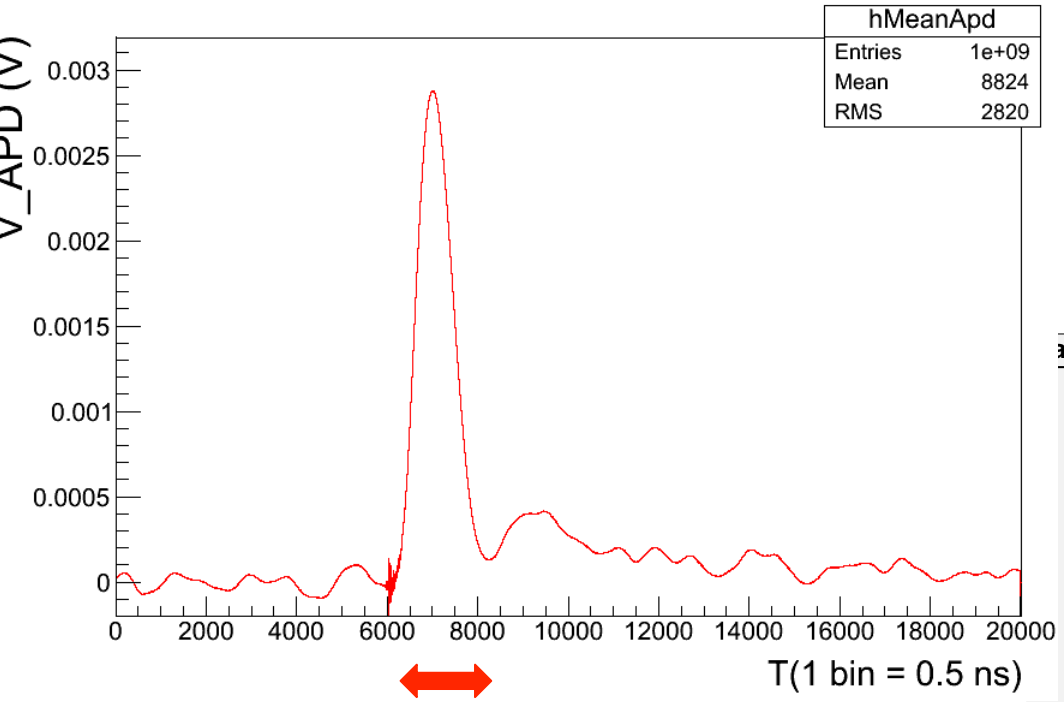
- σ(APD-PMT) compatible with the source measurement
- But the non-linearity has to be understood
  ⇒ maybe a PMT saturation



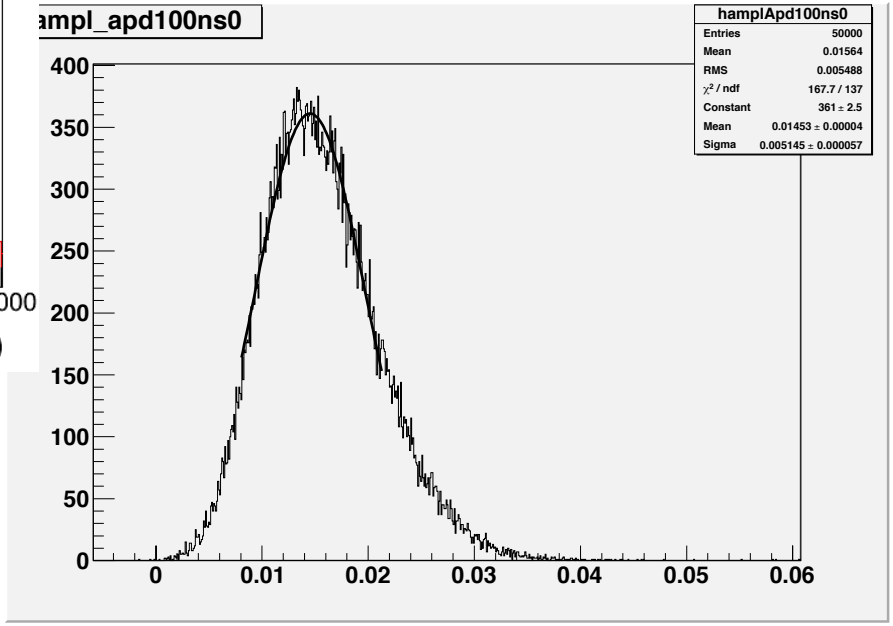


Hamamatsu CSP

- **Int. time = 100 ns; shaping time = 100 ns**

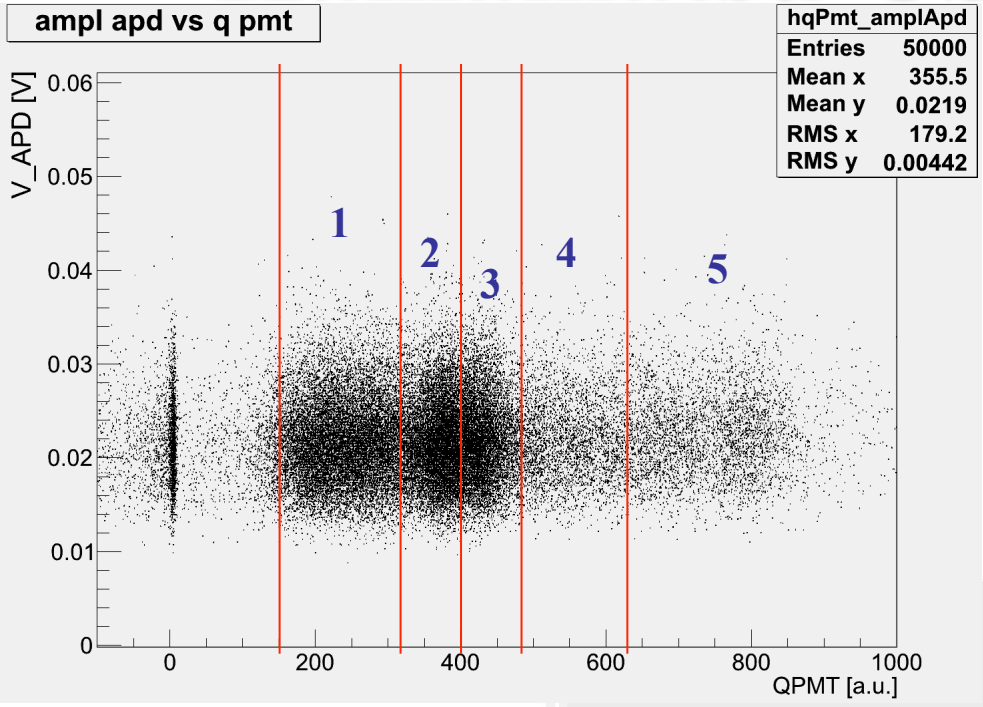


Asymmetric distributions

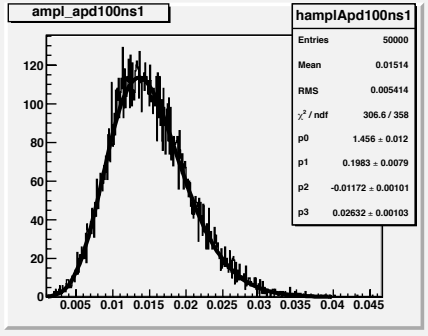


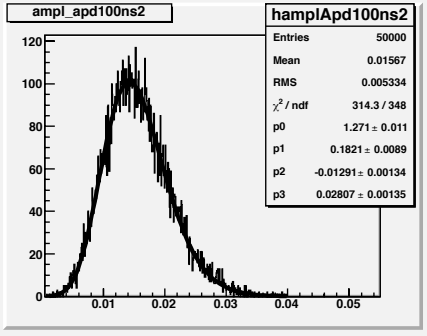
Search for the max amplitude in the range 6000 – 8000 samples (about 1 µs)

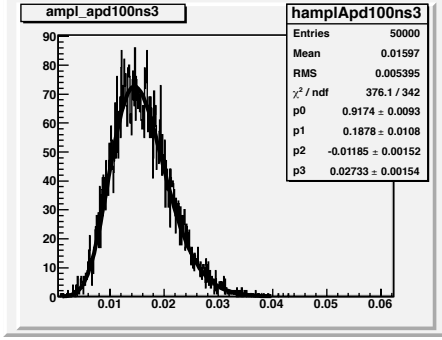
Hamamatsu CSP (s.t.=100 ns)

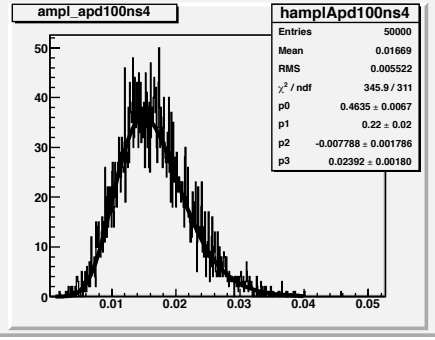


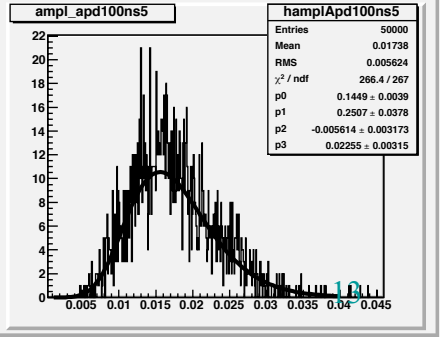
- Data with ^{60}Co source



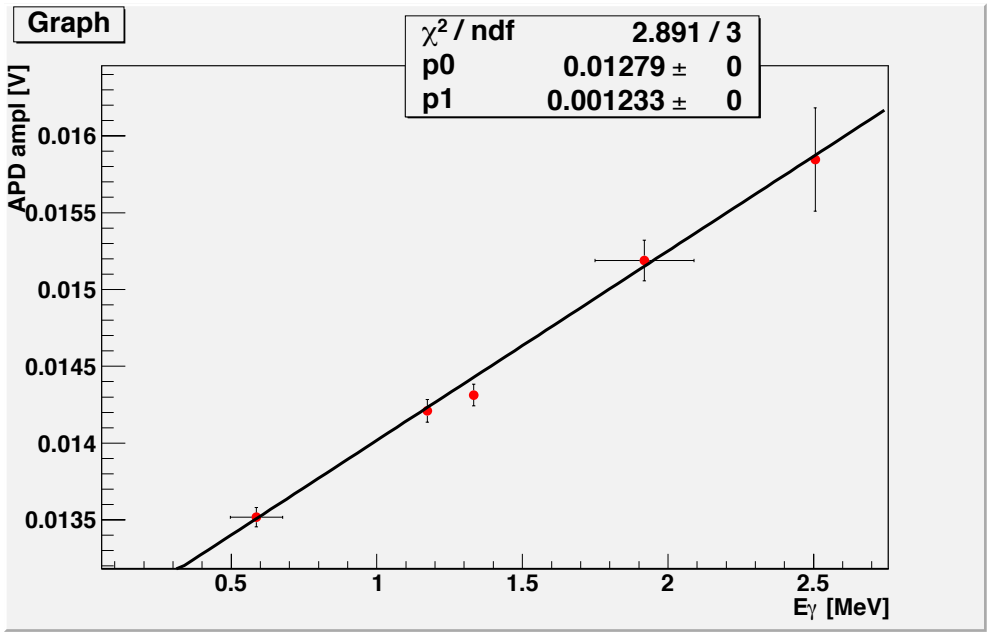




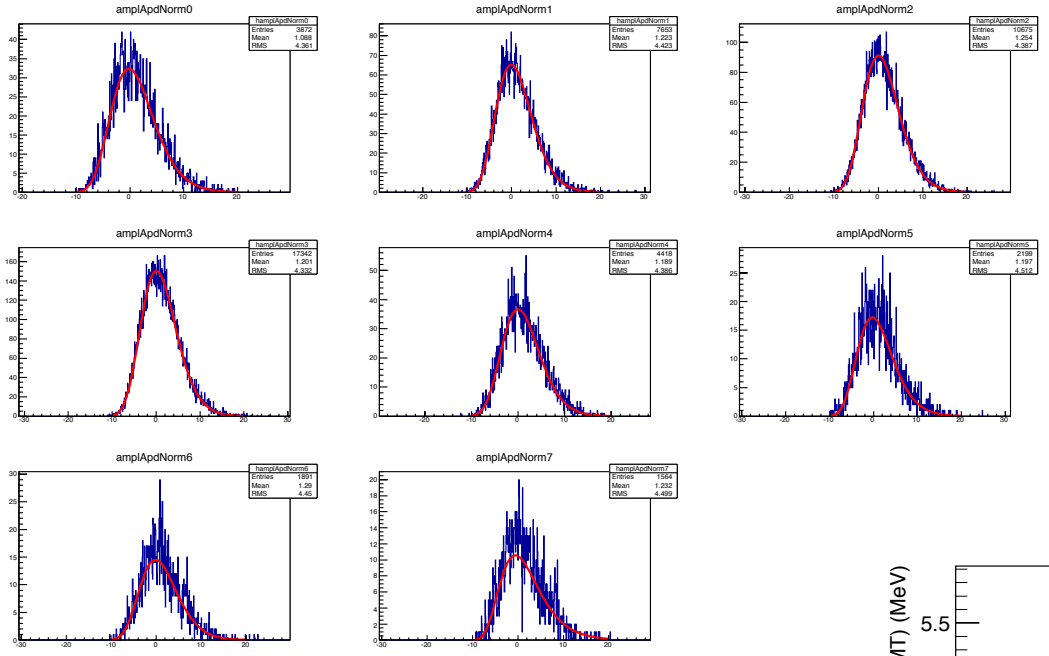




Hamamatsu CSP (s.t.=100 ns)

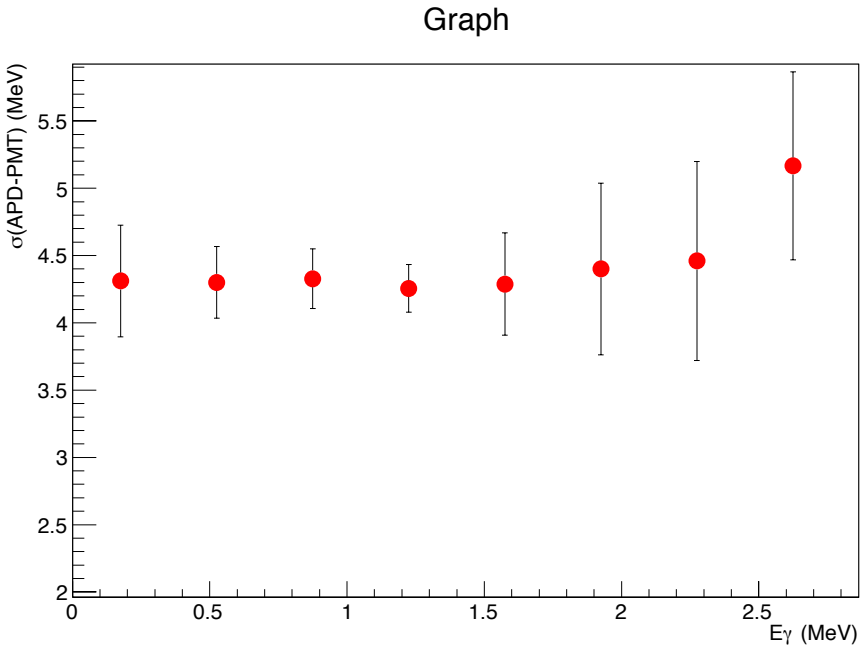


Hamamatsu CSP (s.t.=100 ns)



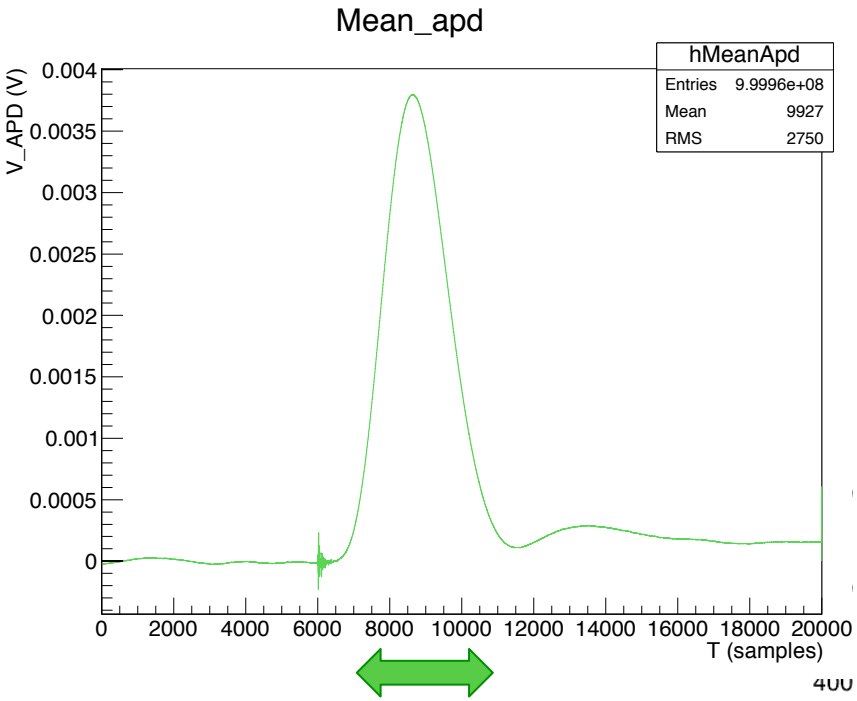
APD signal – PMT signal [MeV], in slices of 350 keV in PMT signal

σ(APD-PMT) ≈ 4.2 – 4.3 MeV

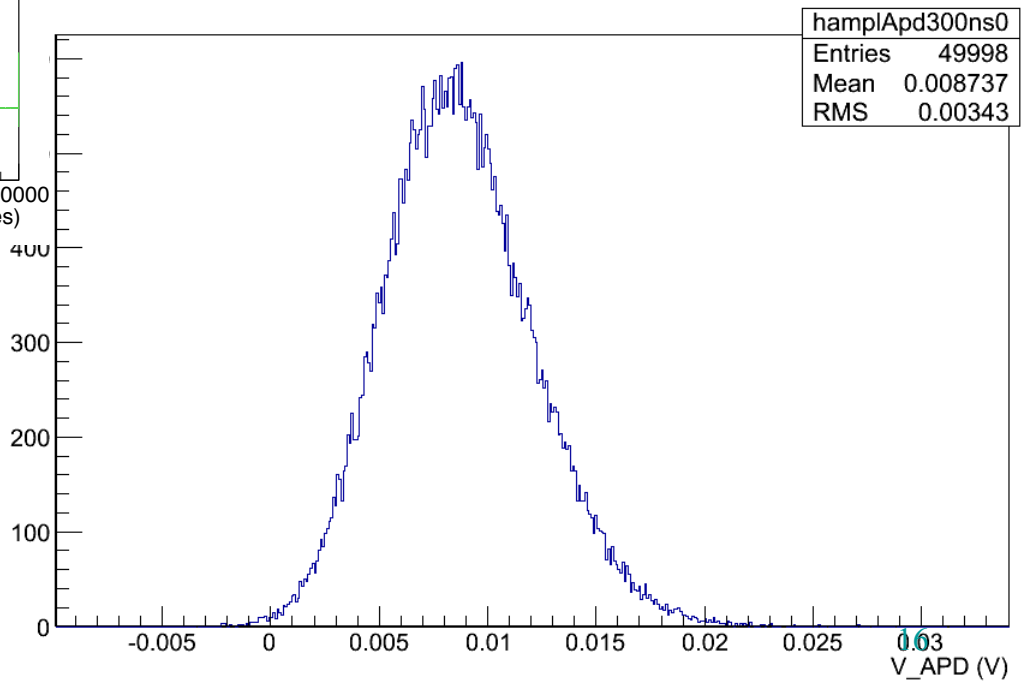


Hamamatsu CSP (s.t.=500 ns)

- **Int. time = 100 ns; shaping time = 500 ns**

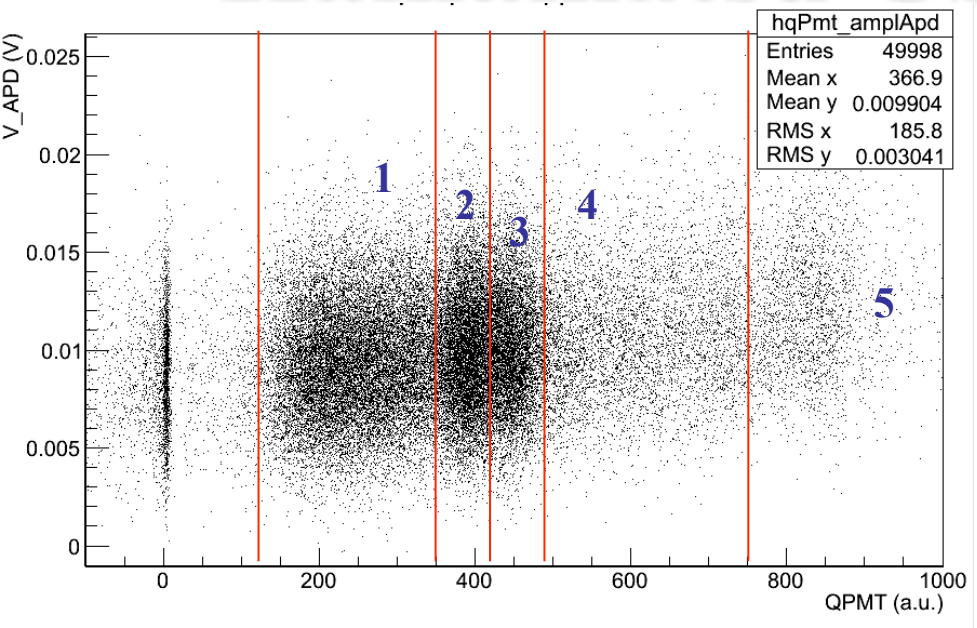


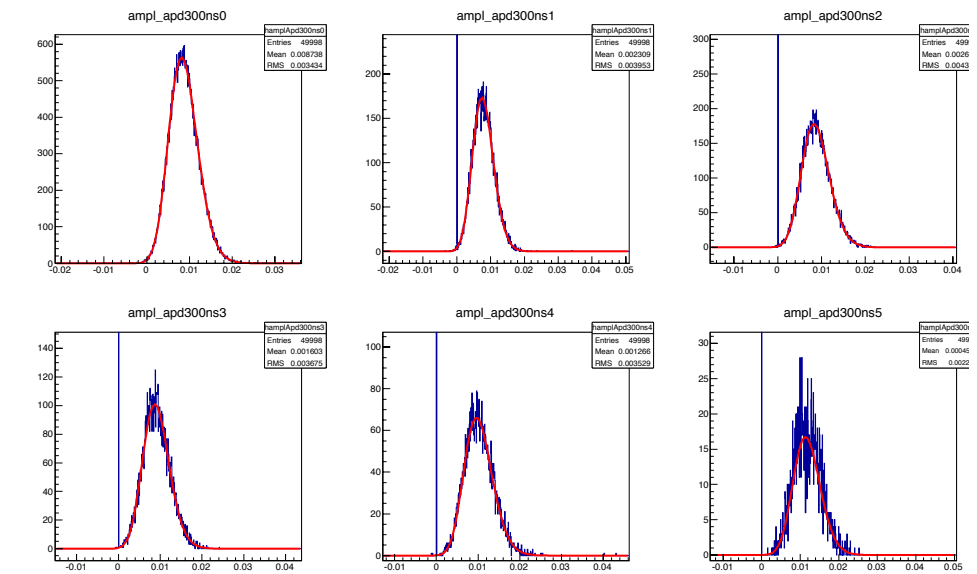
Distributions are symmetric

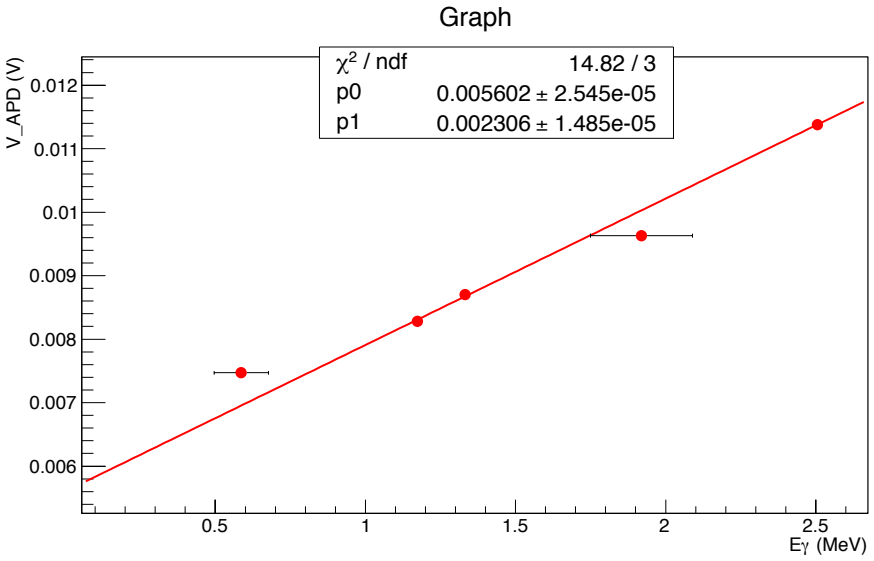


Search for the max amplitude in the range 6500 – 11500 samples (about 3 µs)

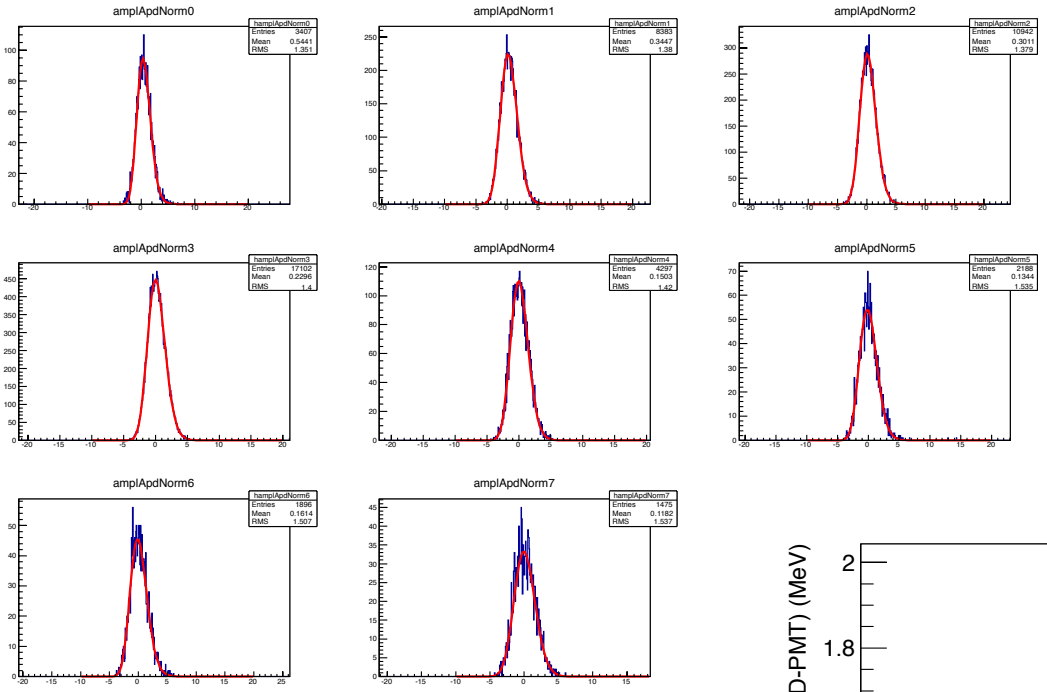
Hamamatsu CSP (s.t.=500 ns)



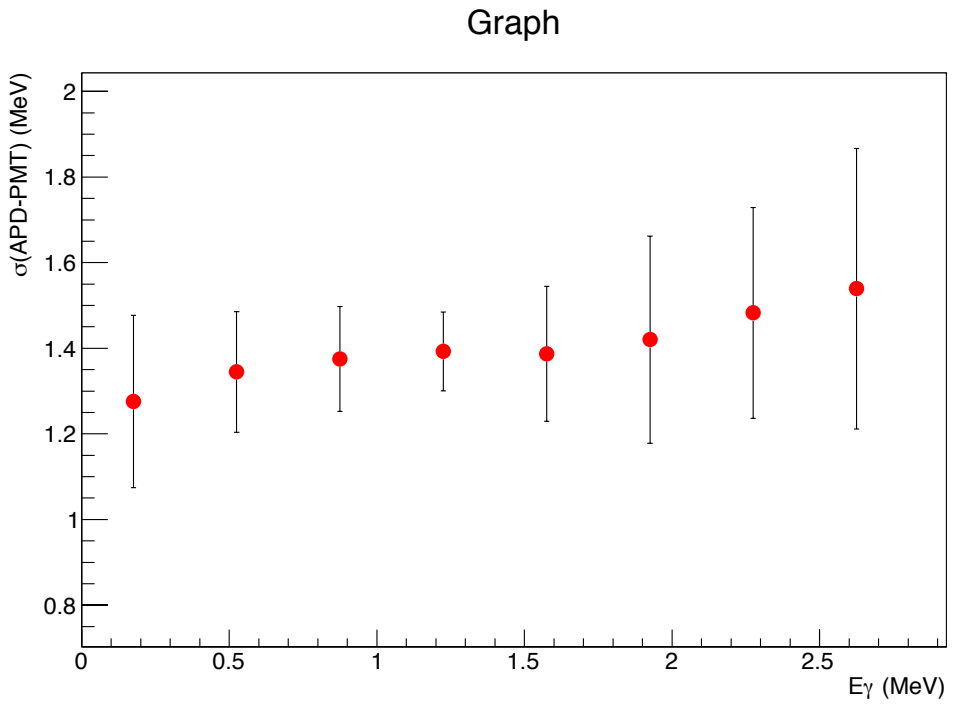




Hamamatsu CSP (s.t.=500 ns)



$\sigma \approx 1.3 - 1.5$ MeV



Conclusions

- **We tested a CsI(Tl) crystal readout by an APD in three different configurations:**

  1) CSP Cremat integr. time = 140 μs + shaping time = 500 ns

  2) CSP Hamamatsu integr.time = 100 ns + shaping time = 100 ns

  3) CSP Hamamatsu integr.time = 100 ns + shaping time = 500 ns

- **With radioactive sources (^{60}Co and ^{137}Cs) we calibrate the energy scale**
- **We evaluate the electronic noise from the difference of the APD and PMT signals**

configuration	σ(APD-PMT)
Cremat	1.6 MeV
Hamamatsu (s.t.=100 ns)	4 MeV
Hamamatsu (s.t.= 500 ns)	1.5 MeV

- **We plan to test other configurations (e.g. Hamamatsu CSP with s.t.=250 ns)**
- **We also want to perform other checks with cosmics, but we have to understand the PMT saturation**

CsI - waveform