Integration time studies with BGO and CsI

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3rd SuperB Collaboration Meeting - LNF

Experimental setup

- **Aims of the test:**
  - **study the effect of the FEE integration time on the crystal performance (continuation of work started by D.Pinci)**
- **Crystal readout on one side by an APD (HV = 340 V) wih the complete FEE chain: CSP + shaper**

  PMT on the other side for trigger

- **Crystals under test:**
  - **BGO (L3) 2 × 2 × 18 cm^3 (wrapped with Tyvek)**
  - **CsI(Tl) (BaBar) ~ 6 × 6 × 30 cm^3**
- **Source: ^{137}Cs**

  ⇒ 662 keV γ

Configurations studied (up to now)

- **BGO: 1) CSP Hamamatsu integr.time = 1μs + shaping time = 500 ns**
  2) CSP Cremat integr. time = 140 μs + shaping time = 500 ns

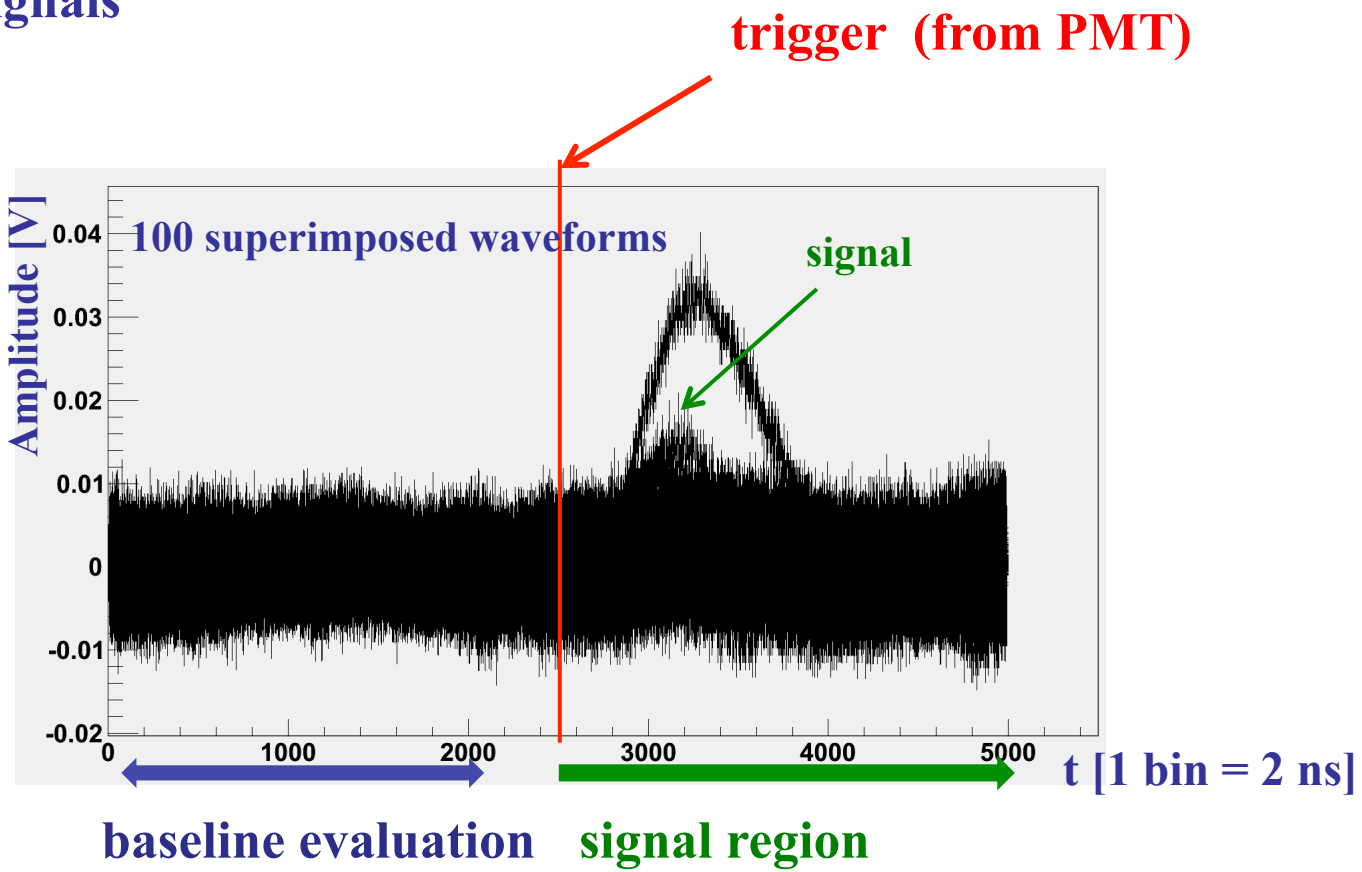
- **CsI: 1) CSP Cremat integr. time = 140 μs + shaping time = 500 ns**
  2) CSP Hamamatsu integr.time = 100 ns + shaping time = 100 ns

- **Events acquired by a LeCroy digital oscilloscope (3 GHz bandwidth)**
  Waveforms recorded at a sampling rate of 5GS/s (20GS/s)
  ~ 50000 events / measurement

- **Data: with and without ^{137}Cs source**
  crystal radioactivity exploited for BGO
  cosmics

BGO - APD signal

- BGO with CSP Cremat – i.t. 140 µs + s.t. 500 ns
- very small signals



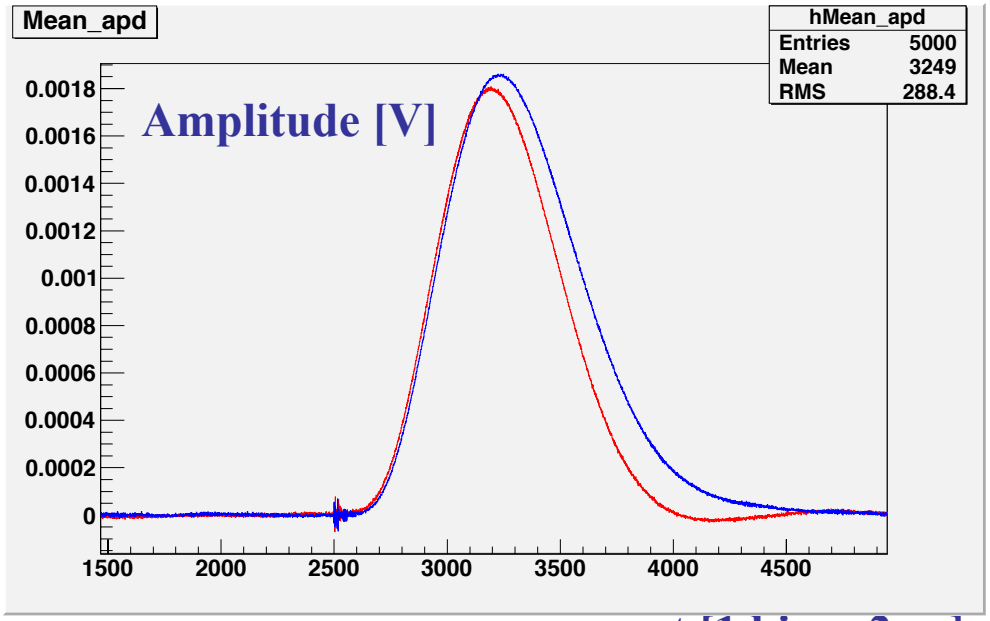
- The shaper is sensitive to the maximum amplitude ⇒ APD signal

BGO - APD signal

- CSP Hamamatsu i.t.= 1 µs
  s.t. = 500 ns
  FWHM =1.2 µs

- CSP Cremat i.t. = 140 µs
  s.t. = 500 ns
  FWHM = 1.4 µs

Bin by bin average over 50000 waveforms



BGO - Setting the energy scale

- BGO activity due to ^{207}Bi contamination (decays to ^{207}Pb, with 4 γ lines)

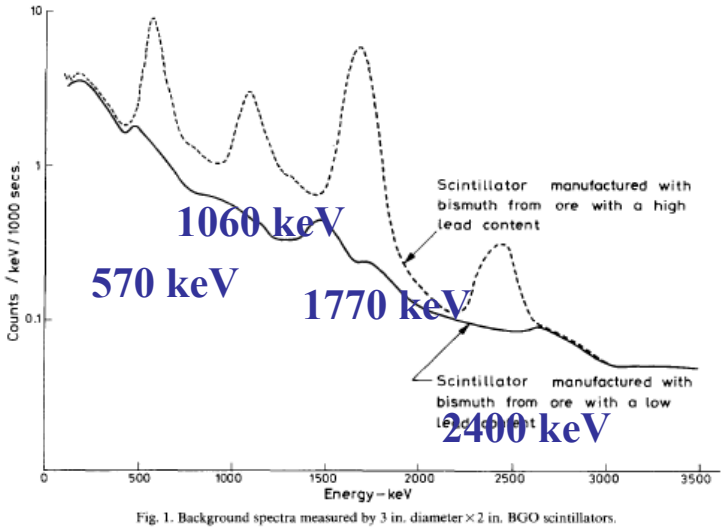
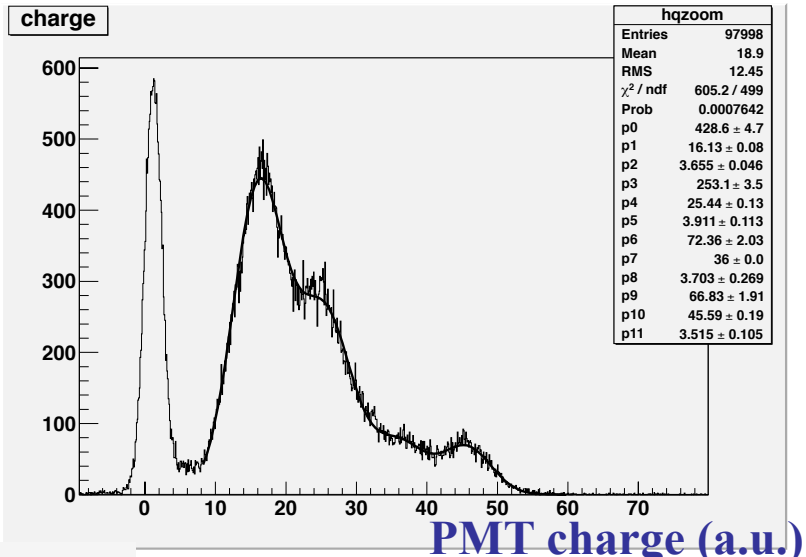
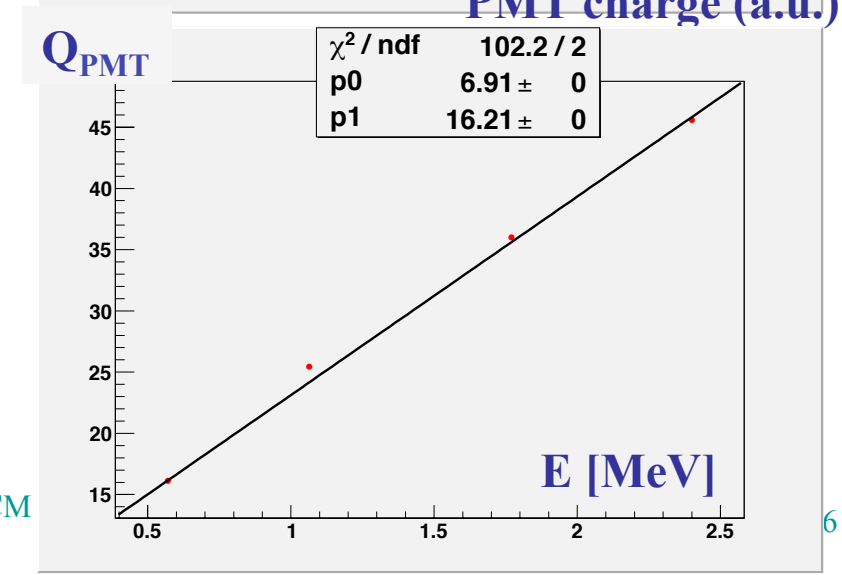


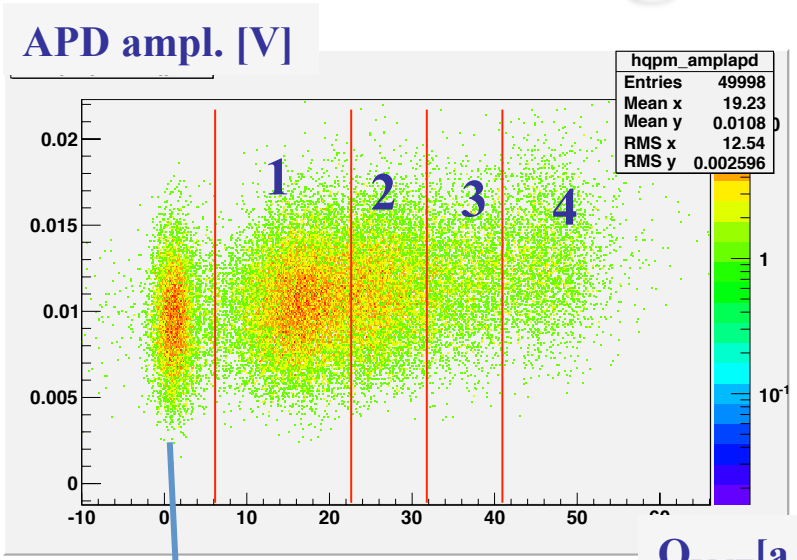
Fig. 1. Background spectra measured by 3 in. diameter × 2 in. BGO scintillators.

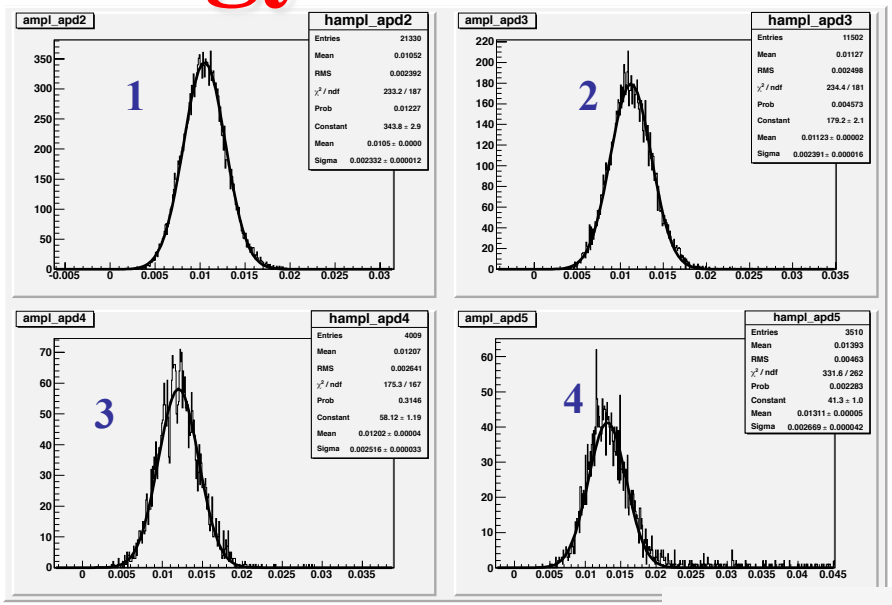
[from Lewis, NIMA264(1988)534]

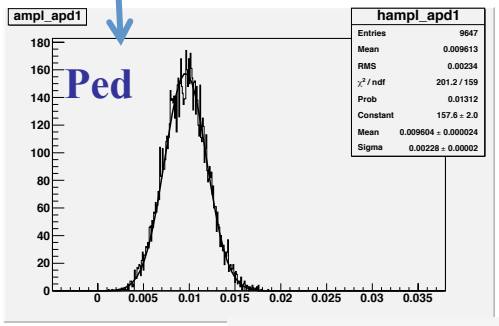




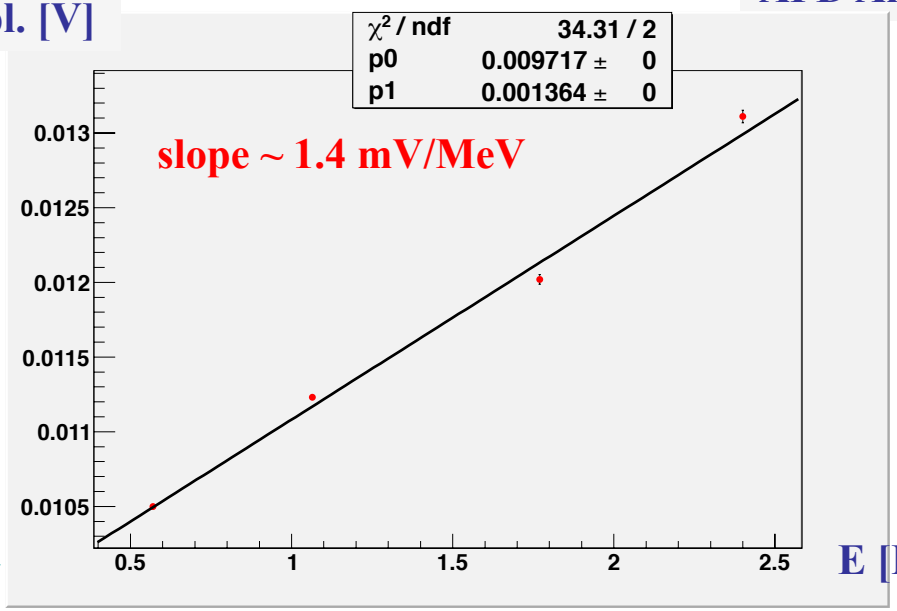
Setting the energy scale



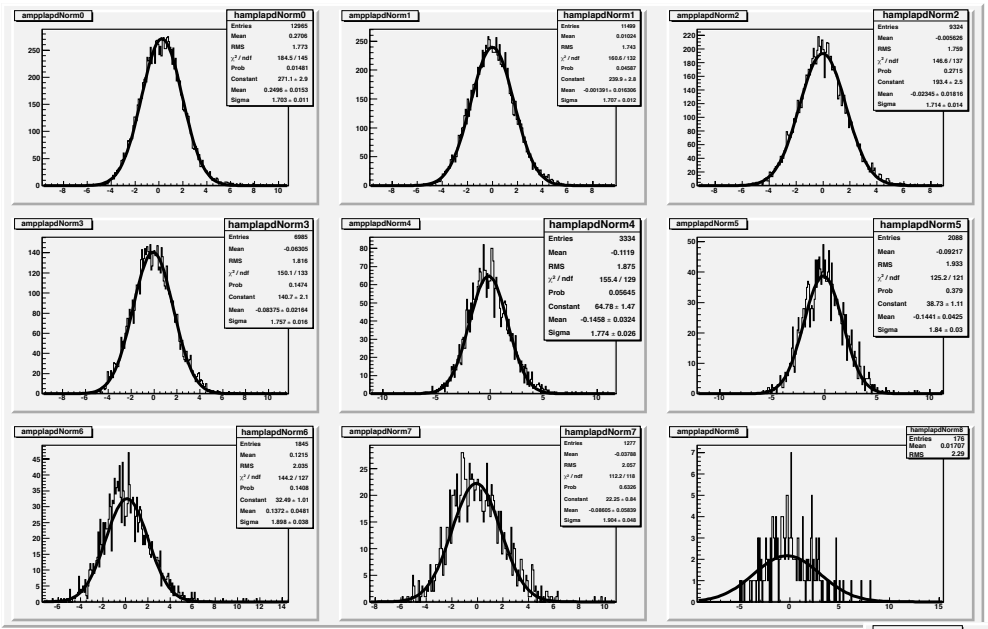




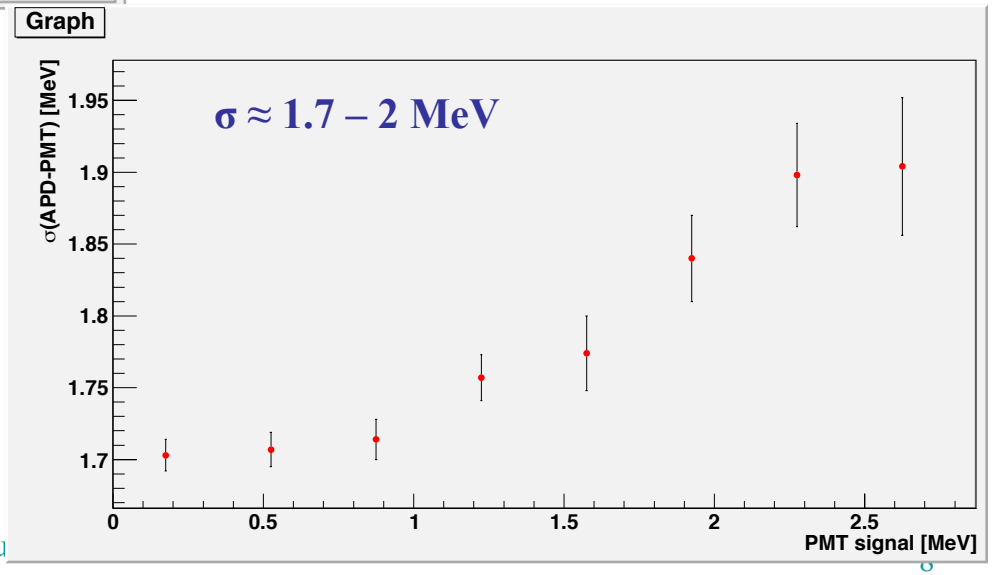
APD ampl. [V]



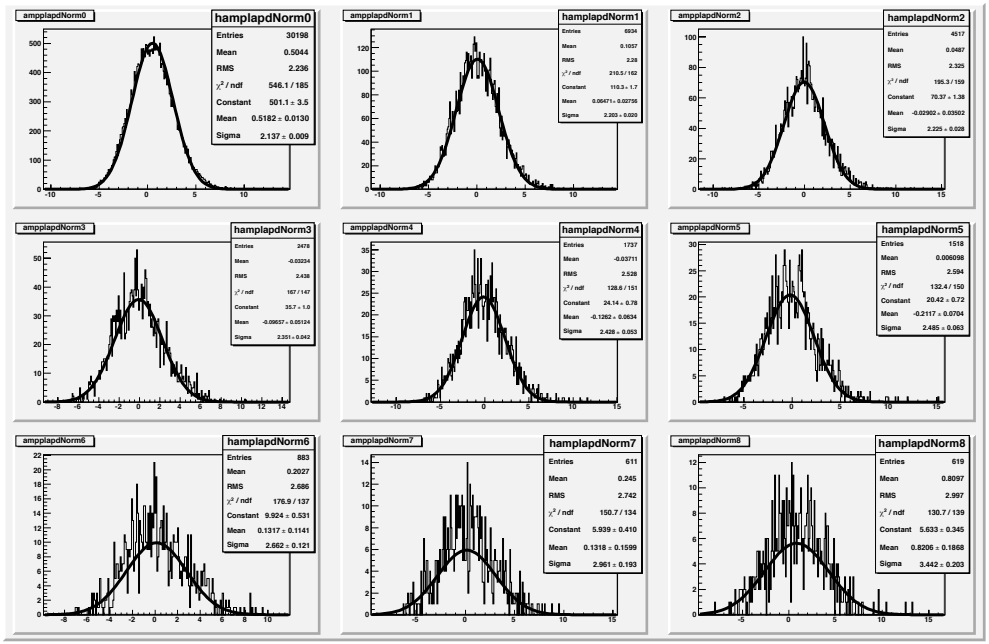
BGO – CSP Cremat

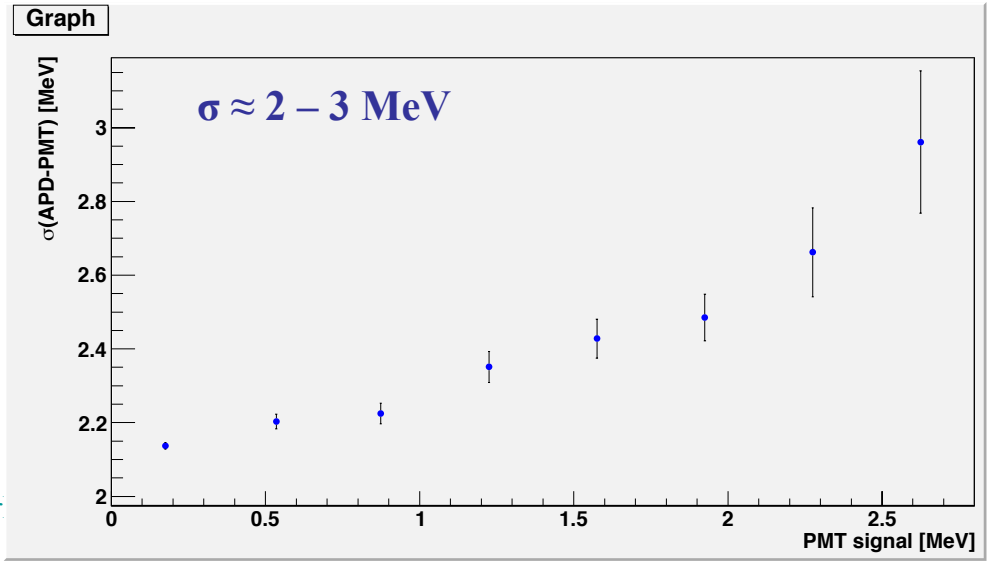


APD signal – PMT signal [MeV], in slices of 350 keV in PMT signal

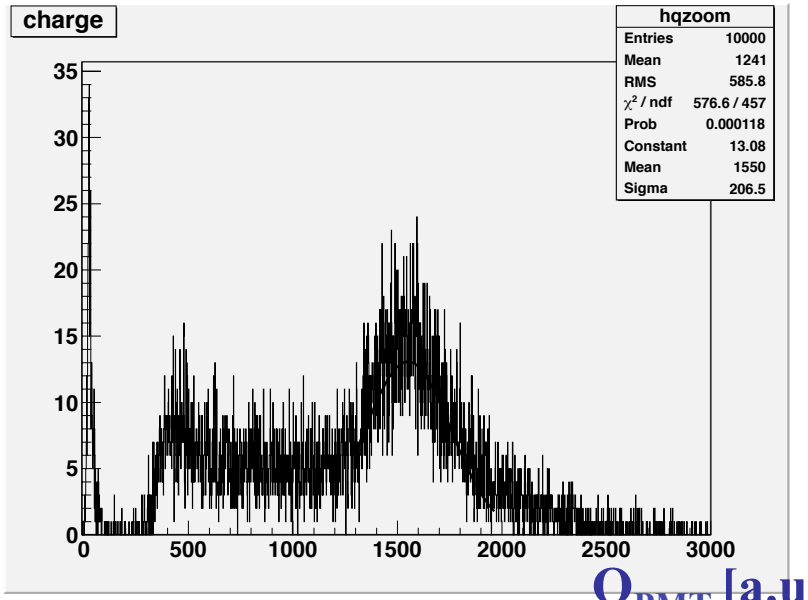


BGO – CSP Hamamatsu

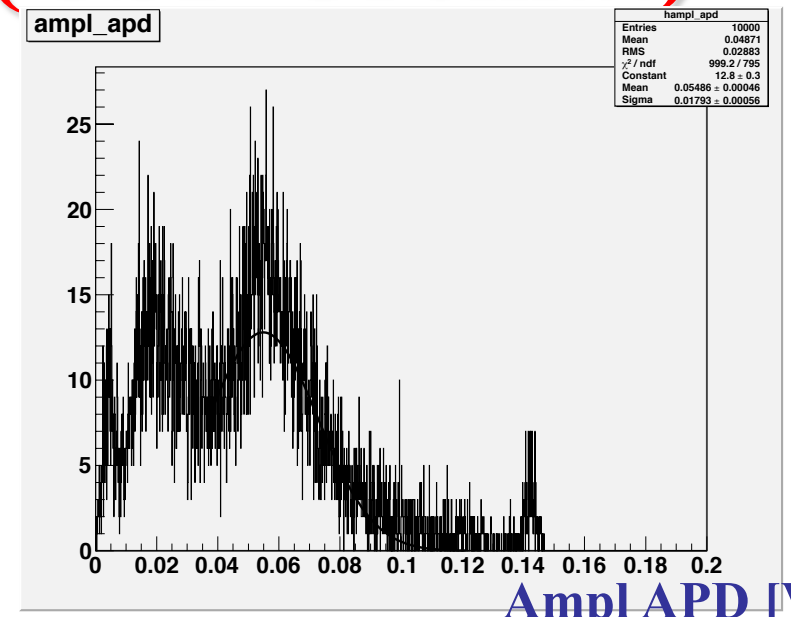




BGO – cosmics (CSP Cremat)

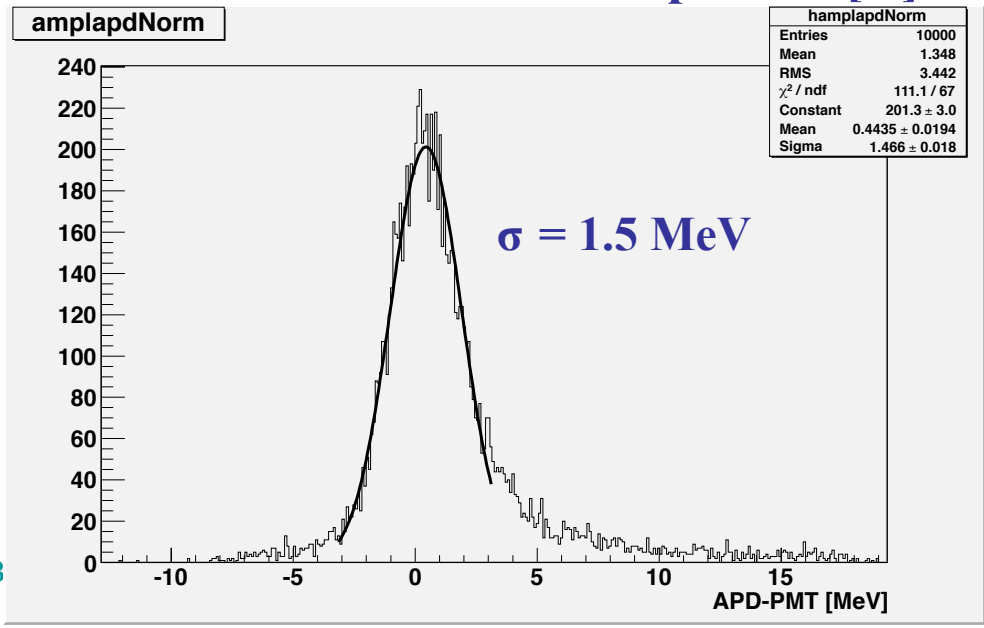


Q_{PMT} [a.u.]



Ampl APD [V]

1 mip ≈ 9 MeV/cm × 2 cm = 18 MeV

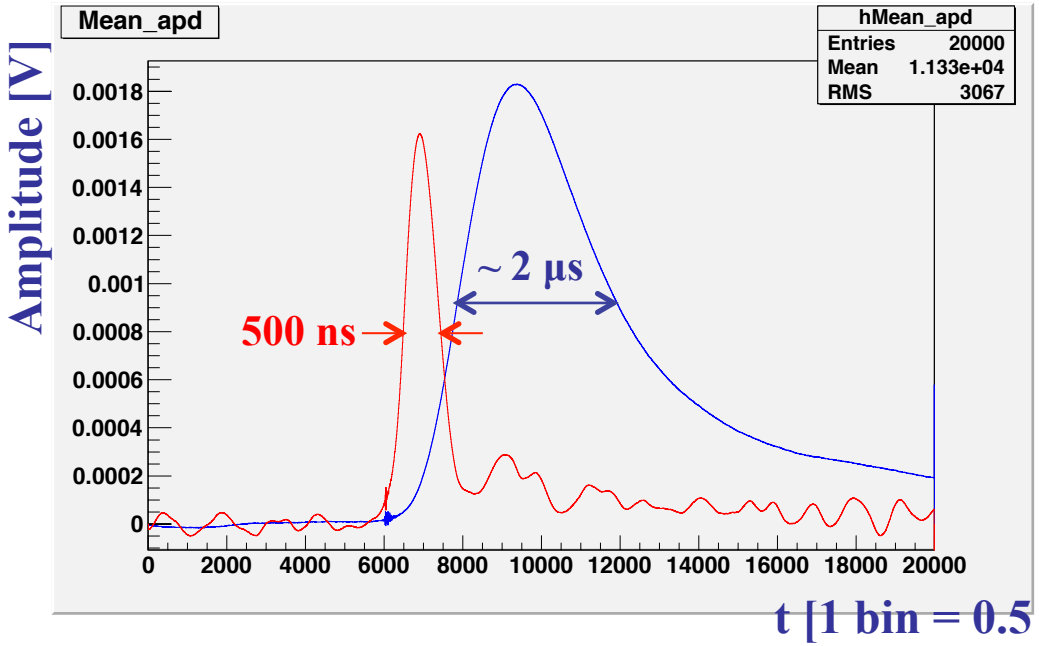


CsI(Tl)

- Few days ago we moved to CsI crystal
- For the moment we tested two extreme configurations:

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

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



Average over 100000 waveforms

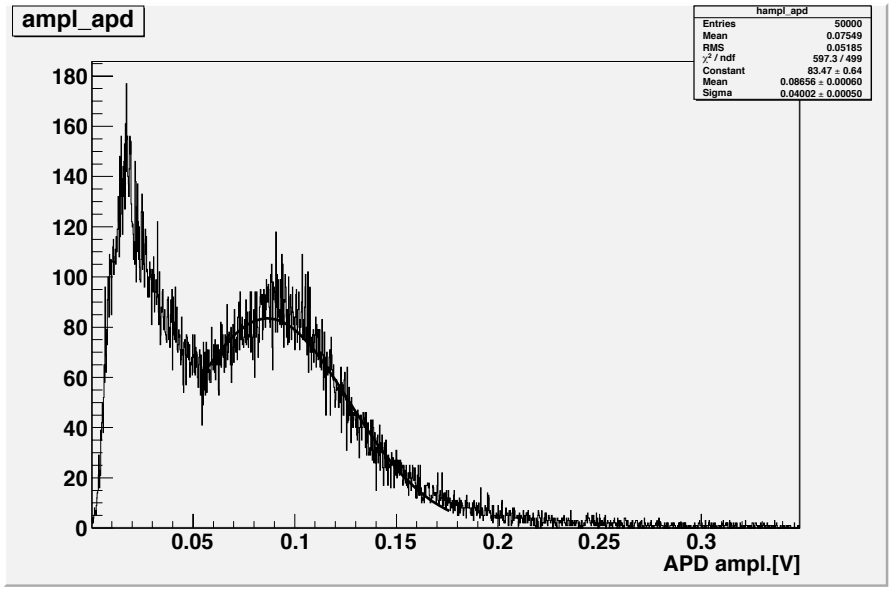
(sampling rate changed ⇒ 20 GS/s)

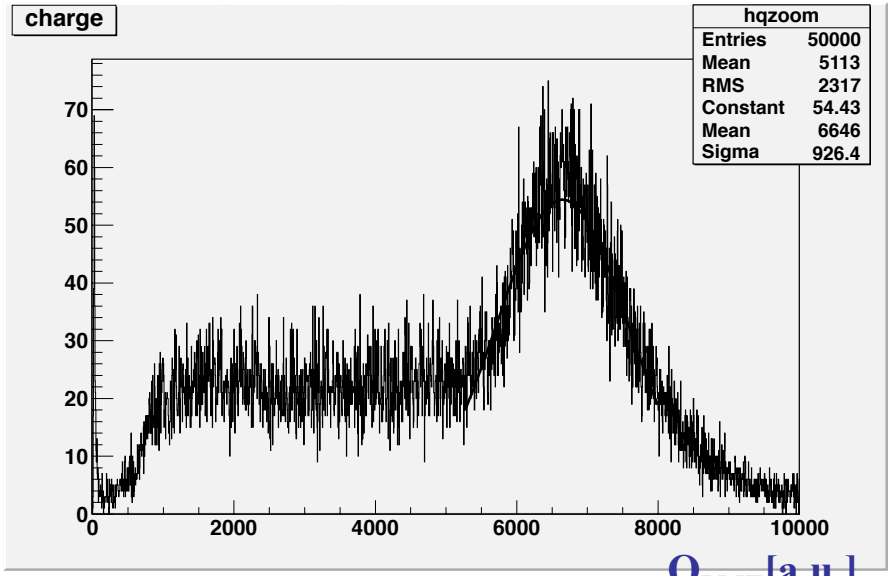
CsI(Tl) – CSP Cremat

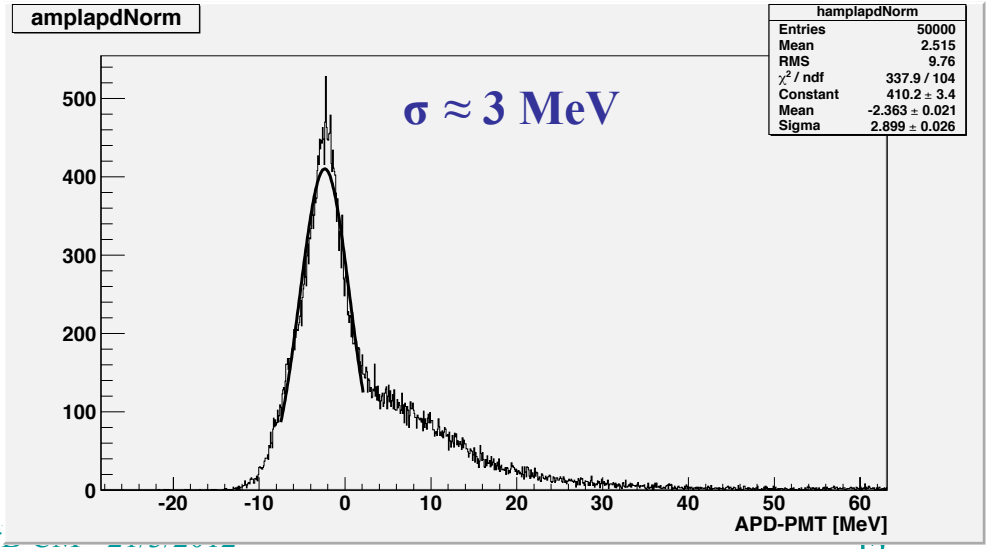
Cosmics: average thick ≈ 5.5 cm

dE/dx = 5.6 MeV/cm

⇒ mip ~ 30 MeV

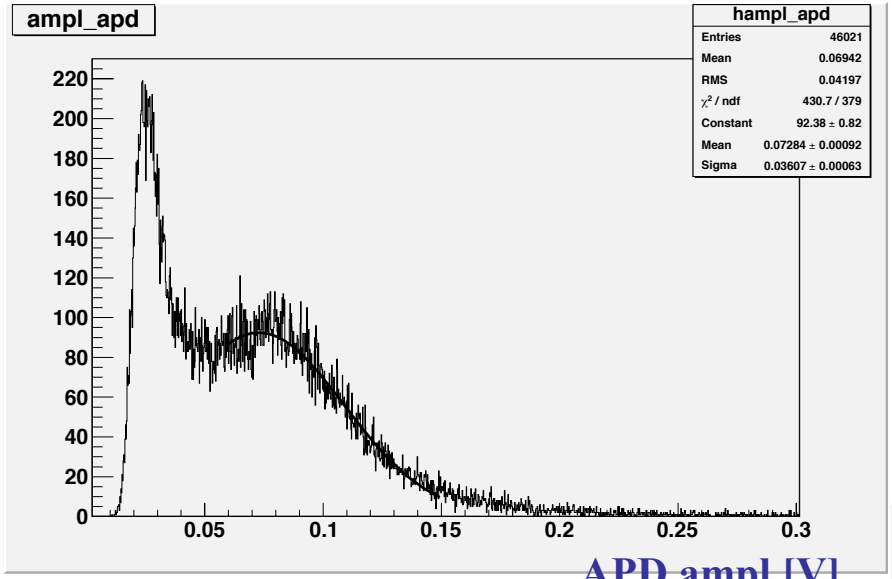


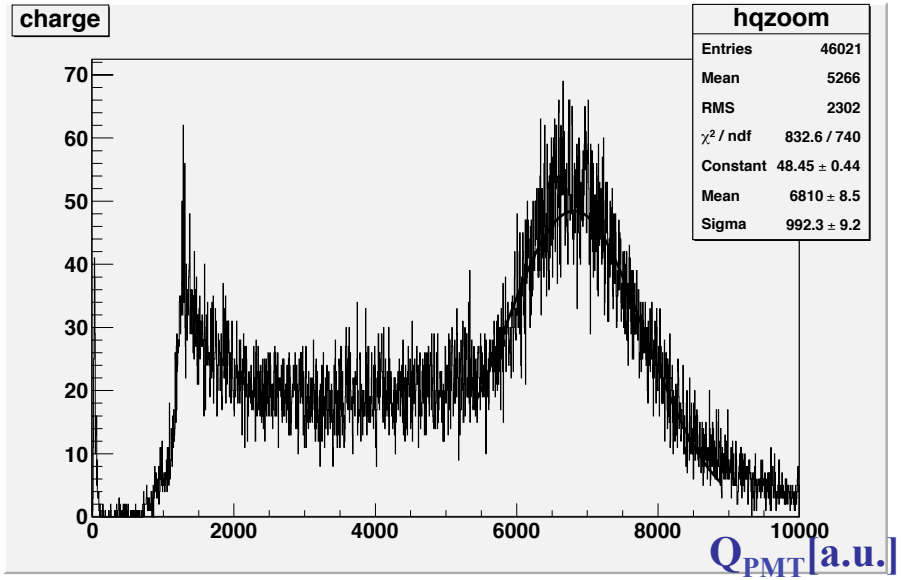


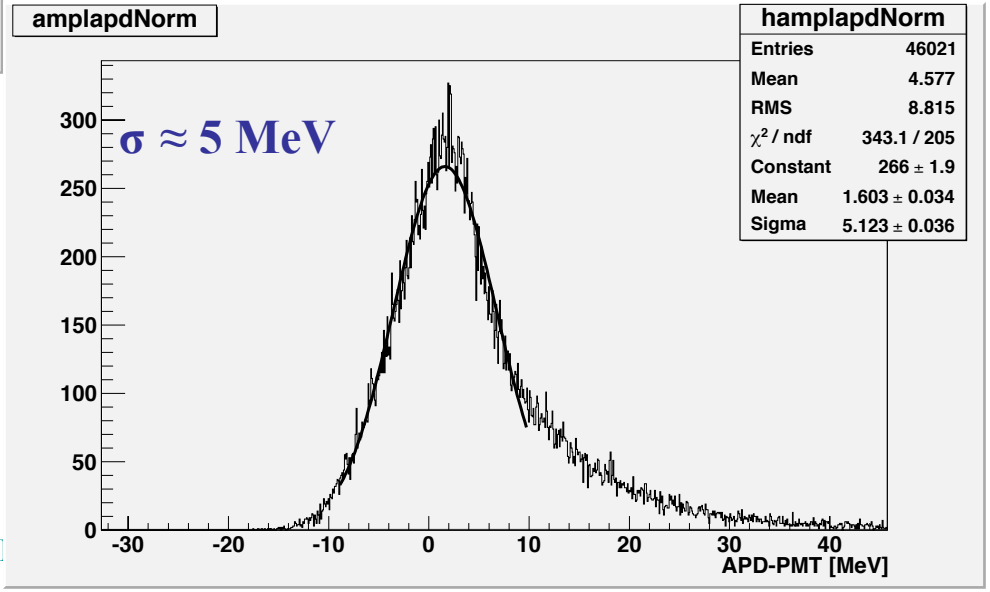


CsI(Tl) – CSP Hamamatsu

- **Cosmics**







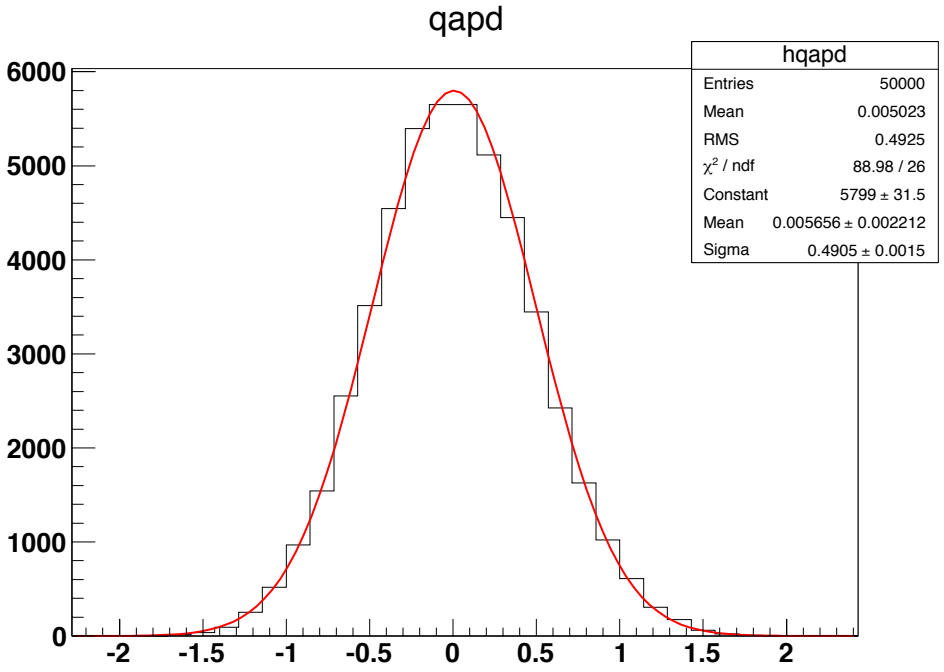
Conclusions

- **We setup a test stand to measure crystals with the complete readout chain**
- **We started some tests on BGO and CsI(Tl) crystals**
- **We plan to perform scans in integration time and shaping time for both crystals, to study the electronic noise and the energy resolution**

Spares

Oscilloscope noise

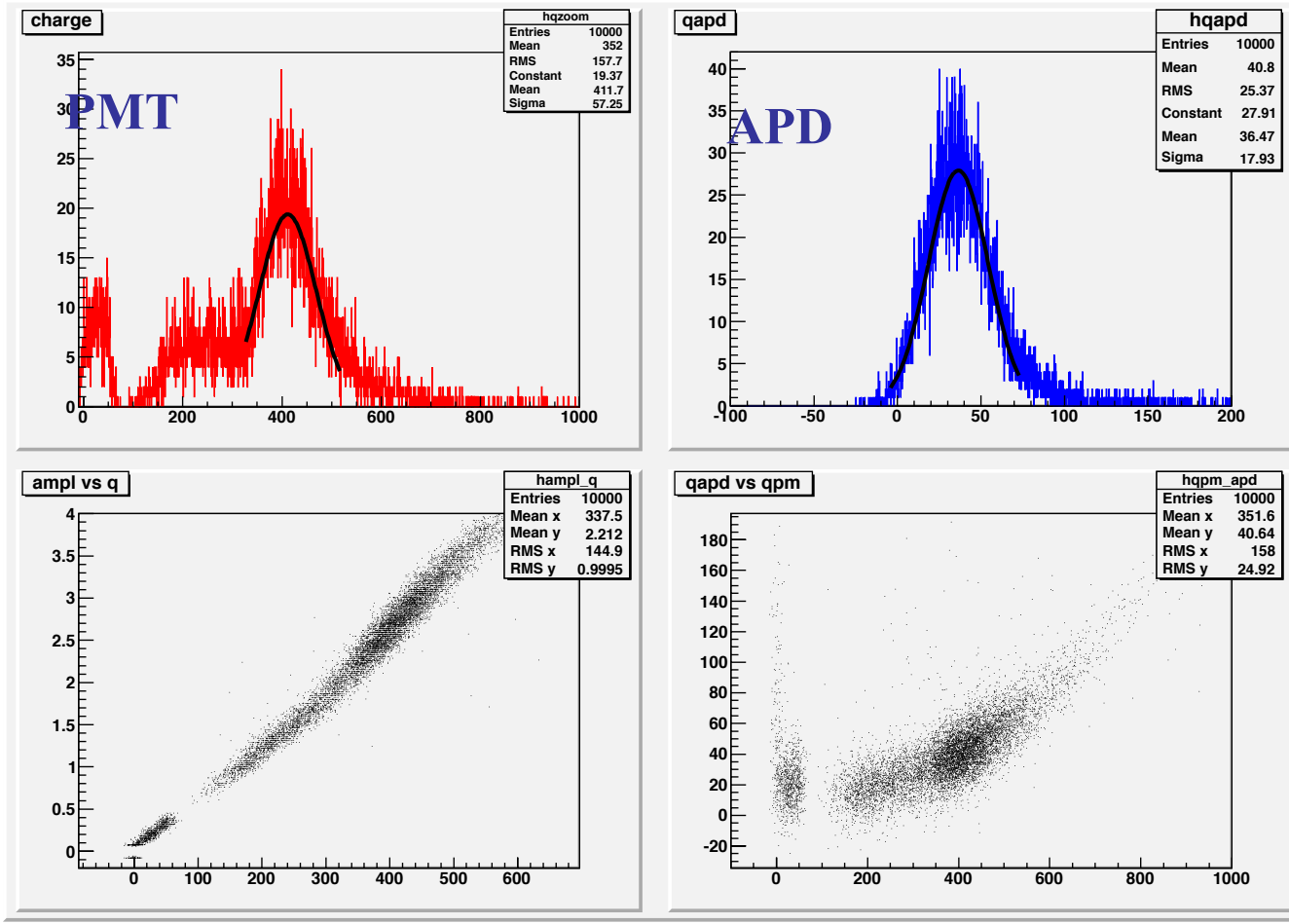
- **Random trigger**



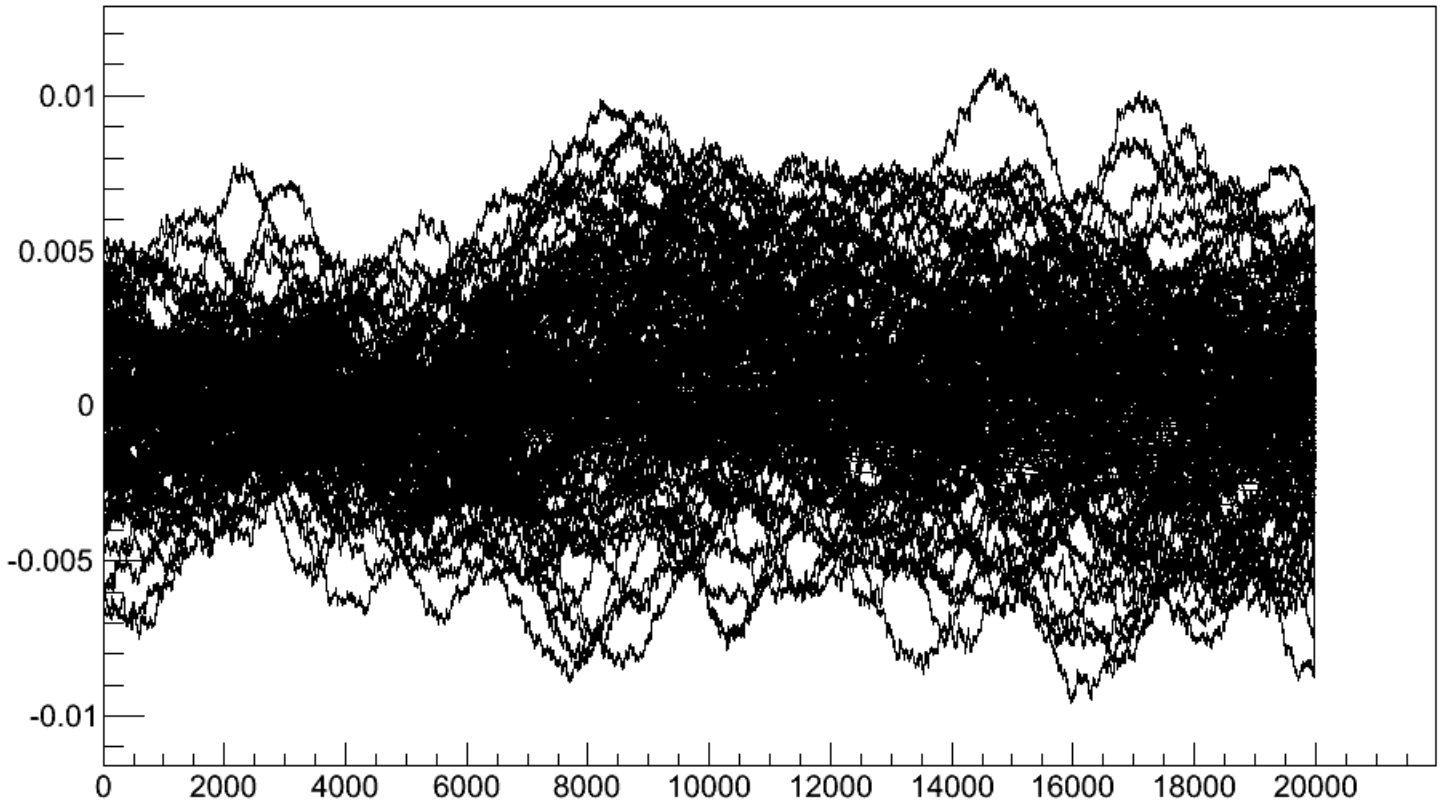
σ = 0.49 ⇒ ~ 300 keV

BGO - cosmics

- 1 mip ~ 18 MeV

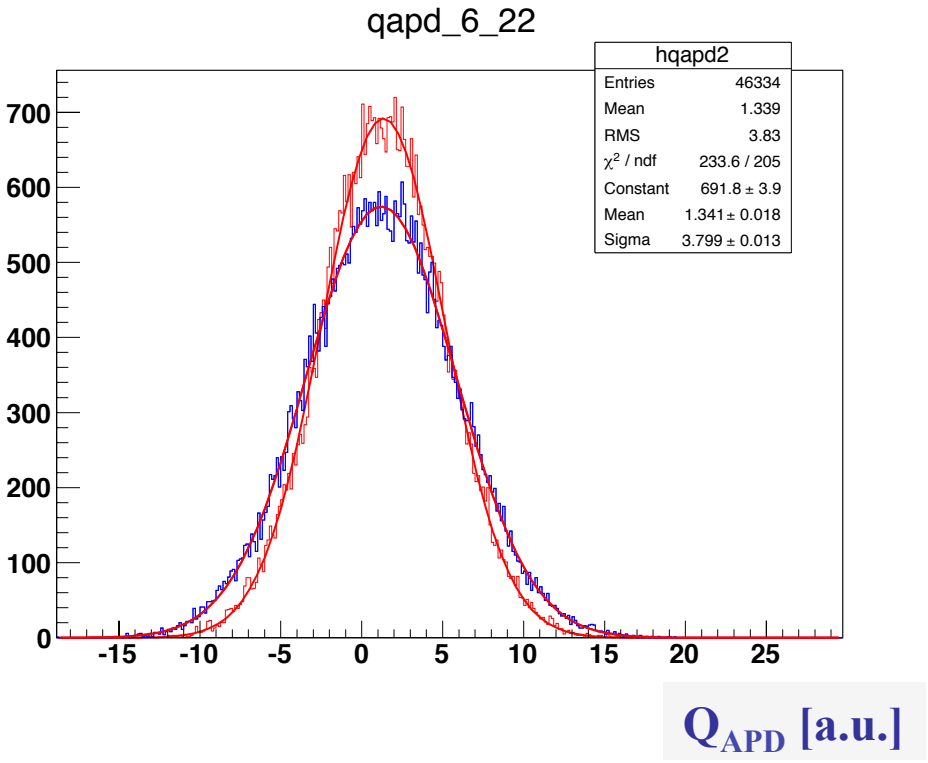


CsI - waveform



BGO with ^{137}Cs source

Comparison with source: Hamamatsu vs Cremat



Electronic noise

- **BTF test with LYSO crystal ⇒ electronic noise was ~ 250 keV**
- **Lab test of BGO ⇒ 1.5 – 2 MeV**

$$\frac{Noise(BGO)}{Noise(BTF)} = \frac{LY_{LYSO}}{LY_{BGO}} \frac{G_{APD}(BGO)}{G_{APD}(BTF)} \frac{1}{Atten_{BTF}} =$$

$$= \frac{75}{9} \quad \frac{1}{4} \quad \frac{1}{0.175} \simeq 10$$