Update on noise studies with a CsI(Tl) crystal

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Experimental setup

- Aims of this test: evaluate the effect of a FEE with short integration time on the EMC performance
- 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

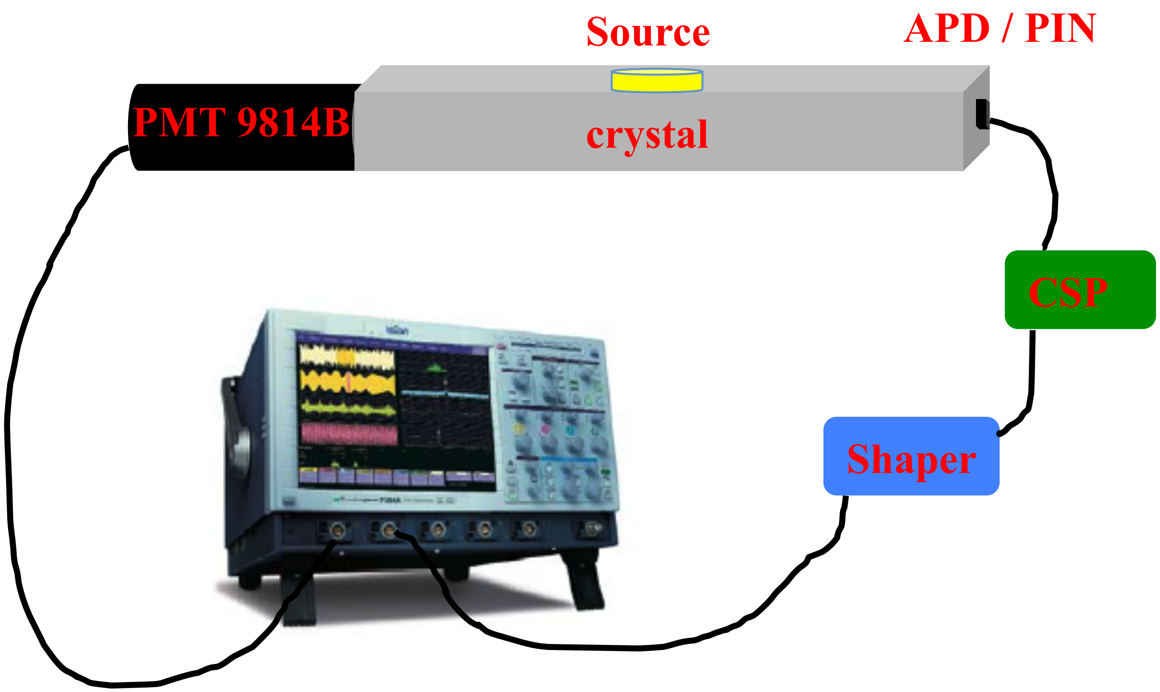
- Crystal under test:
  - CsI(Tl) (BaBar)

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

- Source: ^{60}Co

  ⇒ γ: 1.17 MeV

  1.33 MeV



Configurations studied

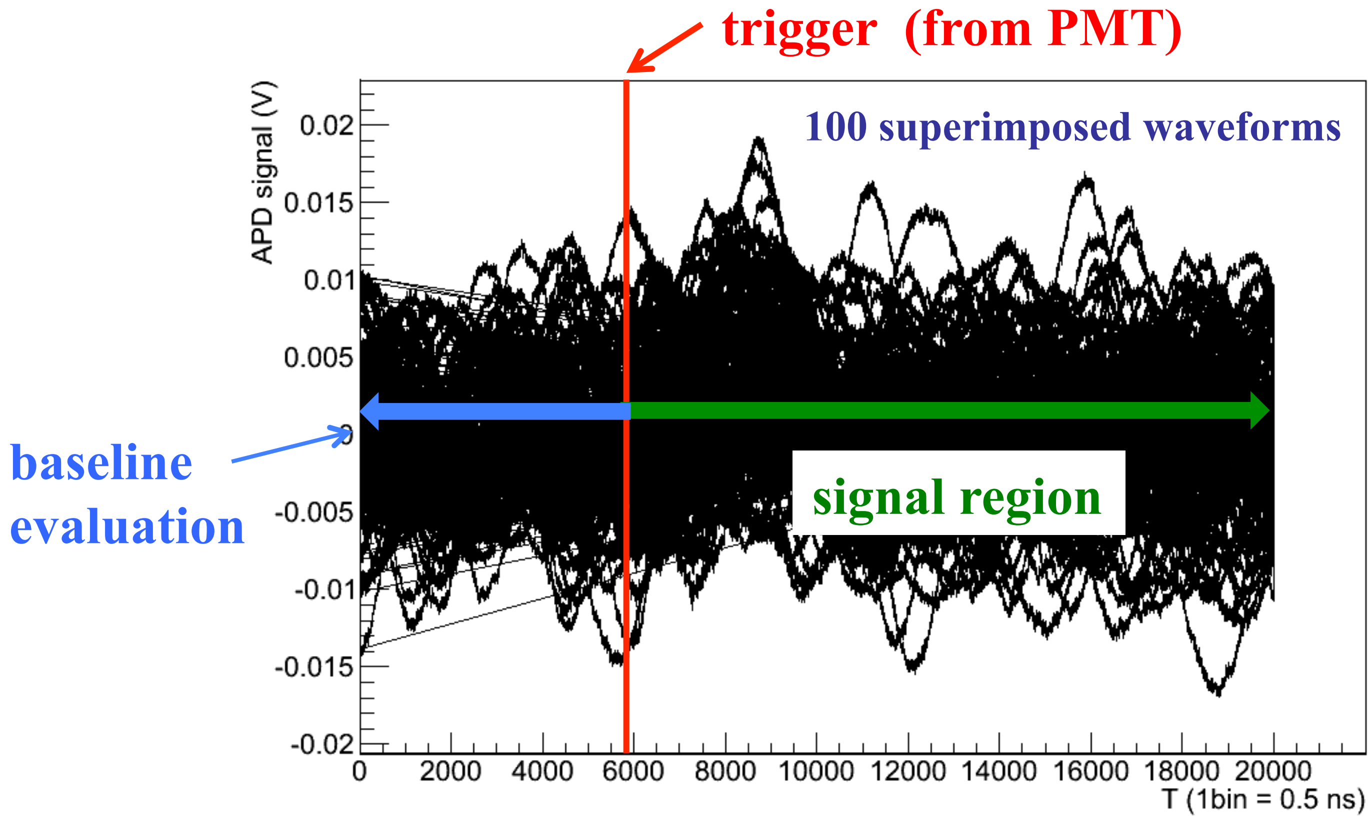
1) APD – CSP Cremat i.t. 140 μs – shaper 500 ns
2) APD – CSP Hamamatsu H4083, i.t. 100 ns – shaper 500 ns
3) APD – CSP Hamamatsu H4083 i.t. 100 ns – shaper 250 ns
4) APD – CSP Hamamatsu H4083 i.t. 100 ns – shaper 100 ns
5) APD – CSP LABE Rome-1 prototype (LNA02V0) i.t. 100 ns – shaper 500 ns
6) PIN – CSP Hamamatsu H4083 i.t. 100 ns – shaper 500 ns
7) PIN – CSP Cremat i.t. 140 μs – shaper 500 ns
8) PIN – CSP LABE Rome-1 prototype (LNA02V0) i.t. 100 ns – shaper 500 ns
9) Check: PIN readout with BaBar electronics

- 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
- LNA02V0 proto. similar to Hamamatsu, but slightly slower (400 ns rise time vs 300 ns)

Signal evaluation

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

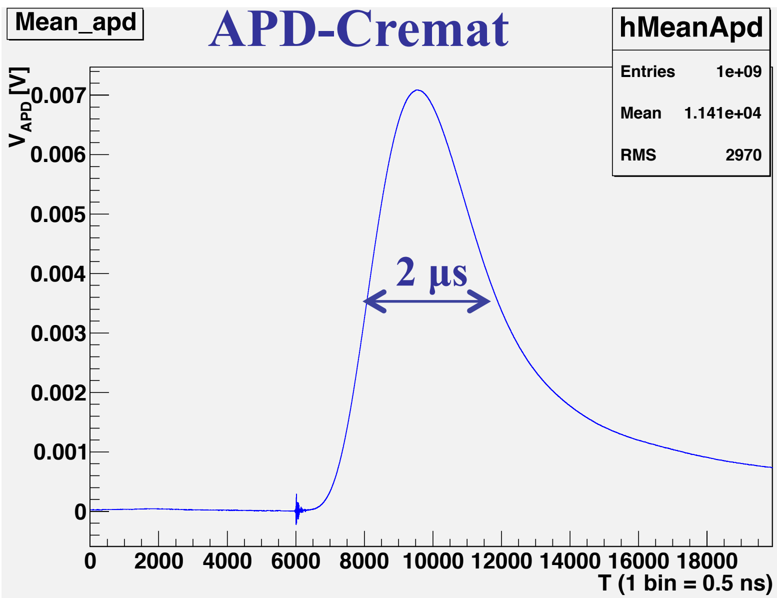
  50000 events / measurement

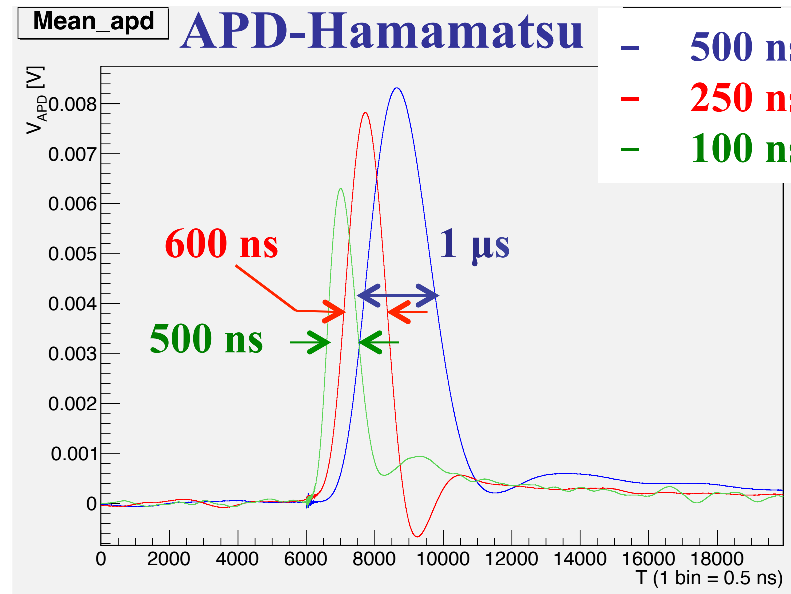


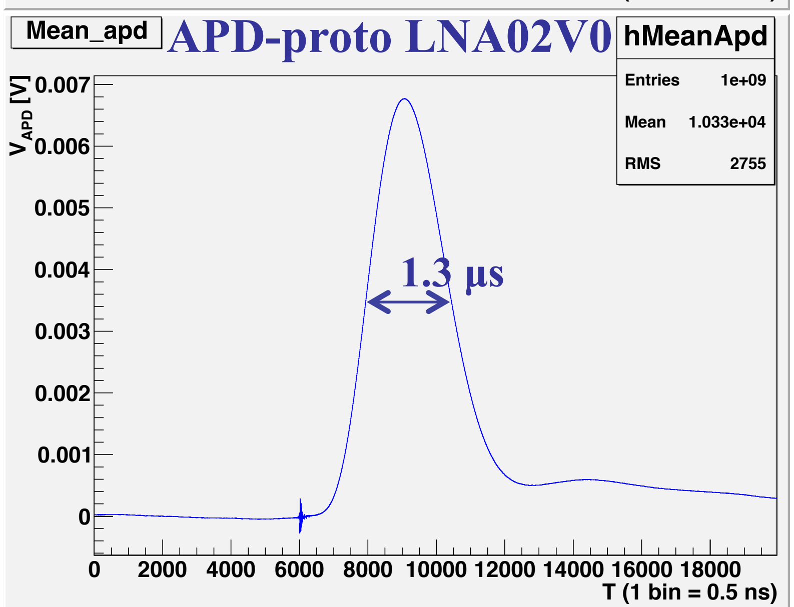
- The shaper is sensitive to the amplitude:

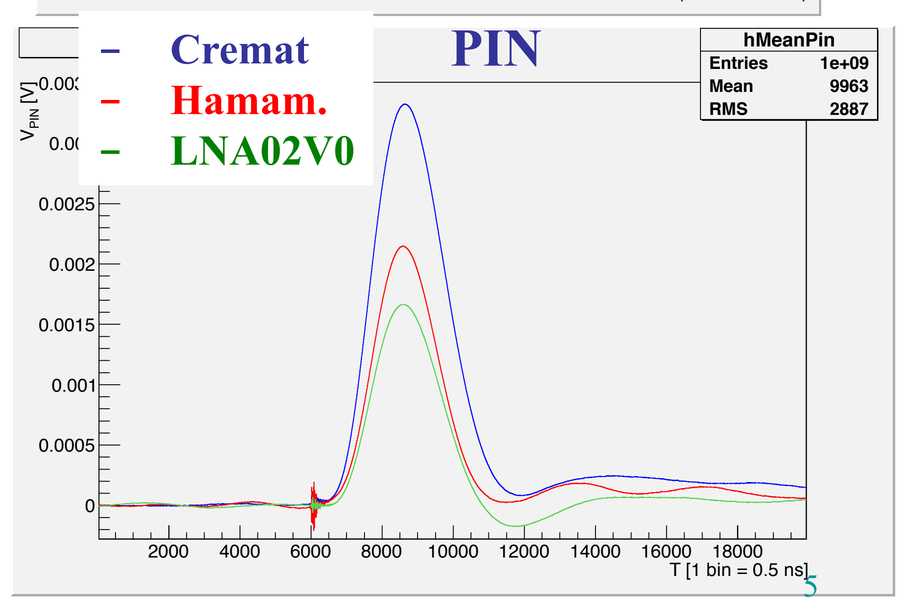
  ⇒ APD / PIN signal = maximum amplitude for T > 6000

Average signals



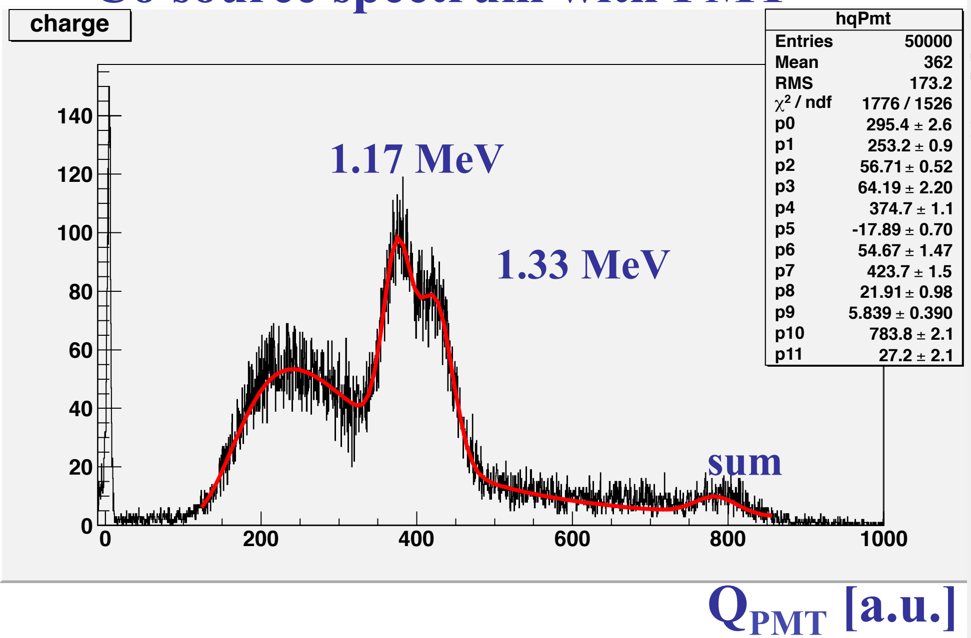


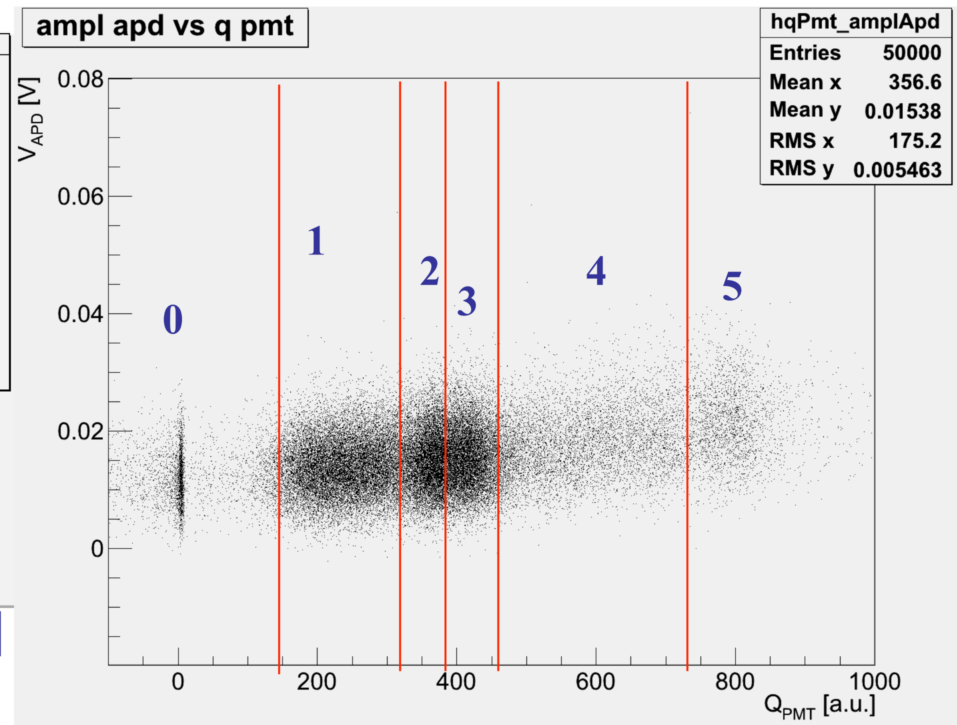




Example: APD - CSP Hamam. i.t. 100 ns – s.t. 500ns

^{60}Co source spectrum with PMT

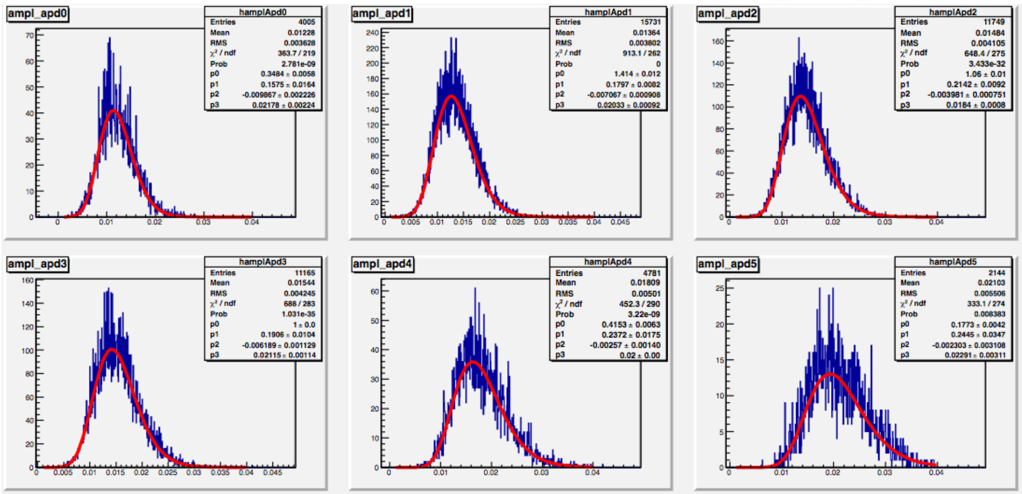




Divide into 6 regions:

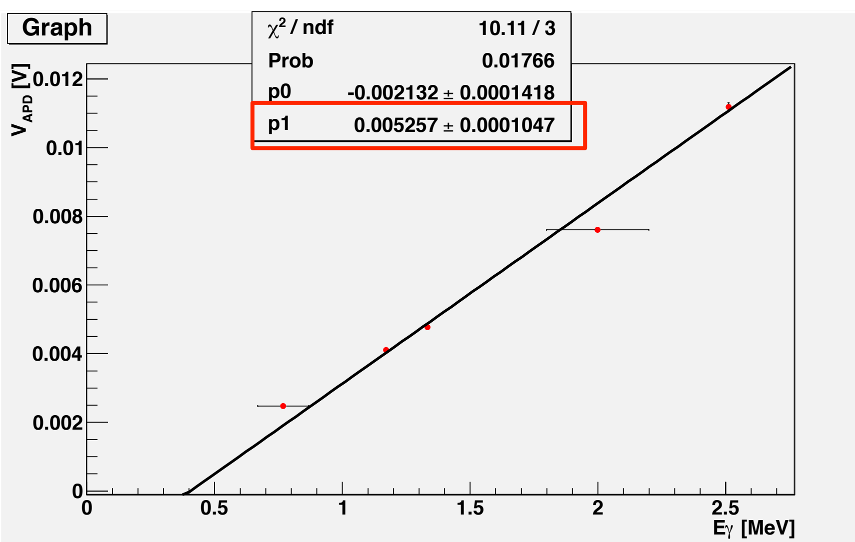
0) pedestal
1) crystal bckg
2) 1.17 MeV peak
3) 1.33 MeV peak
4) tail of crystal bckg
5) sum 1.17 + 1.33 MeV

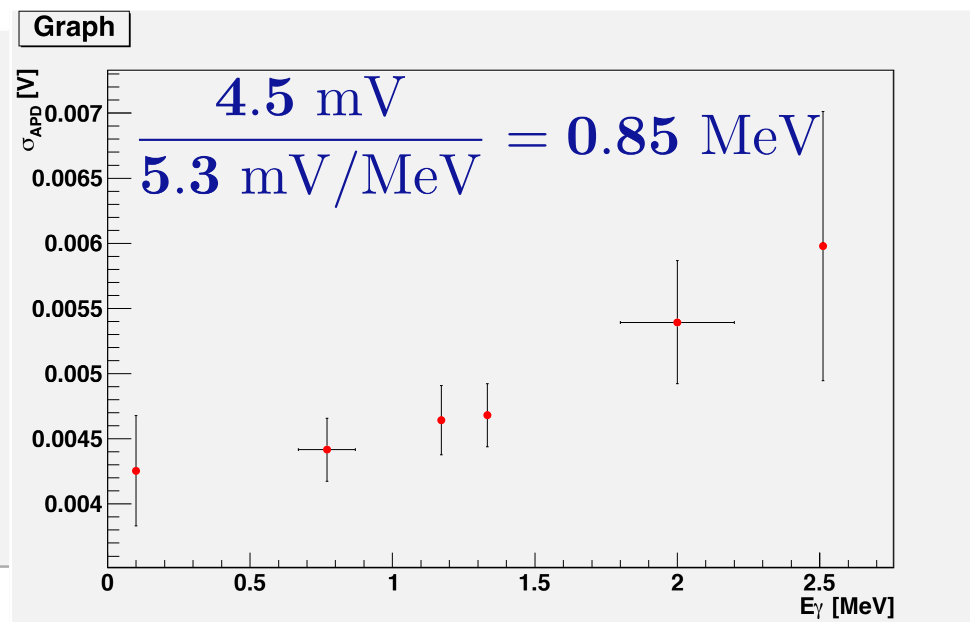
Noise evaluation



from the widths of the distributions

energy scale from the peaks





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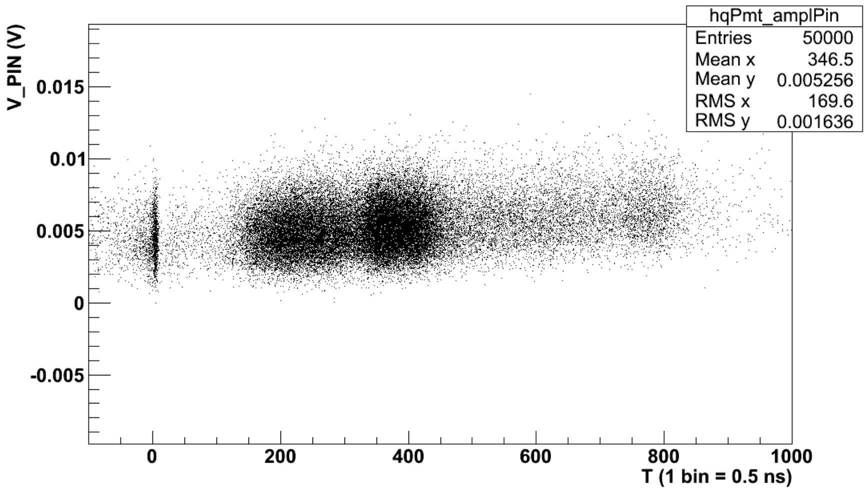
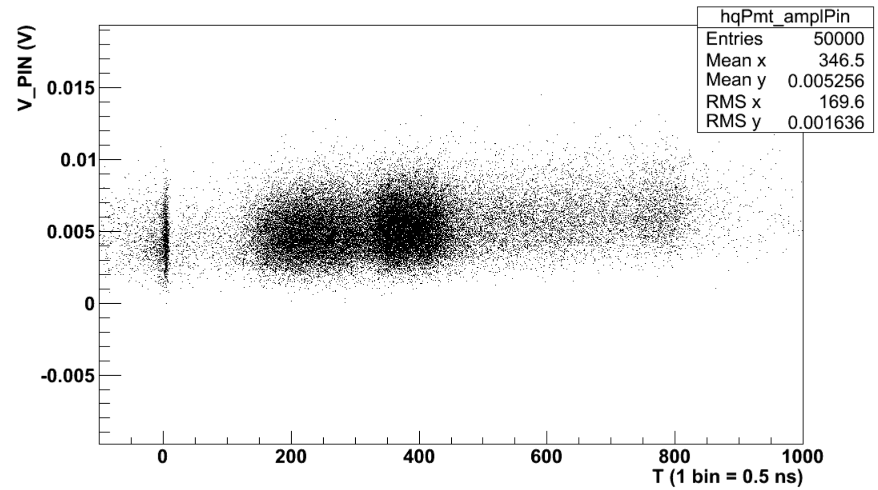
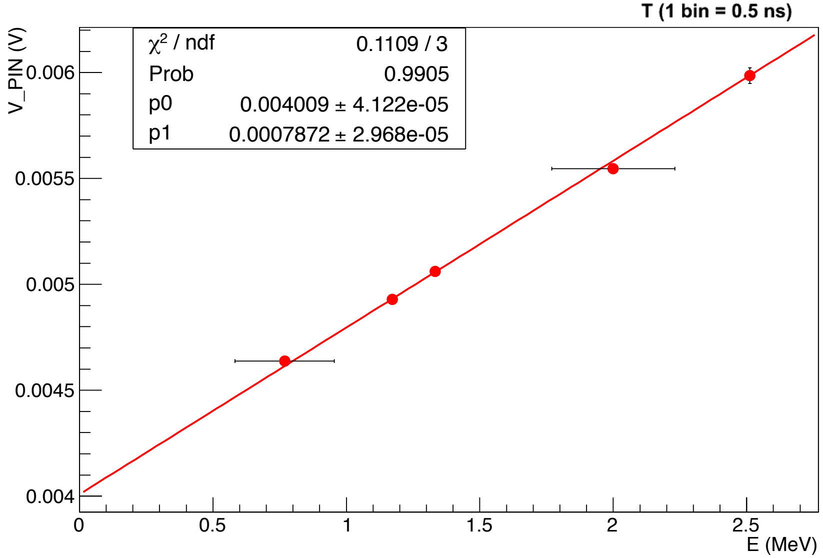
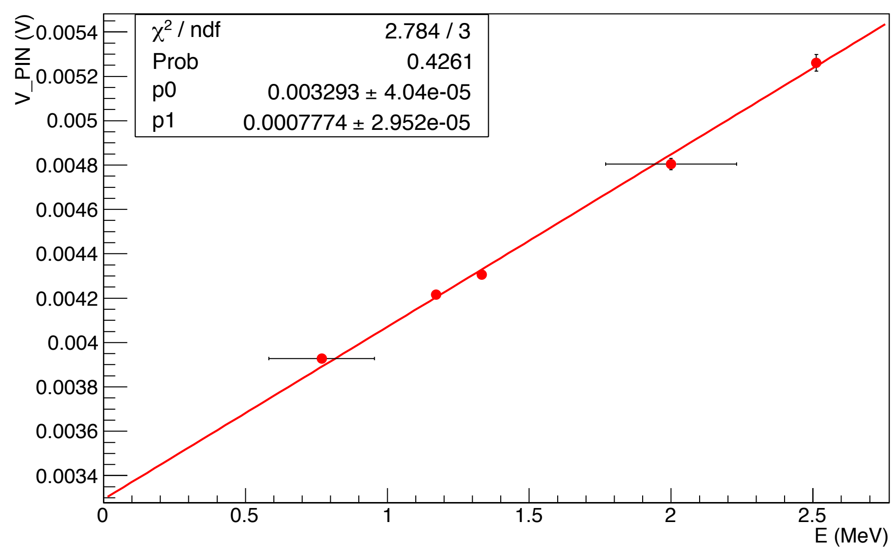
PIN with LNA02V0

- **Two different PINs tested**



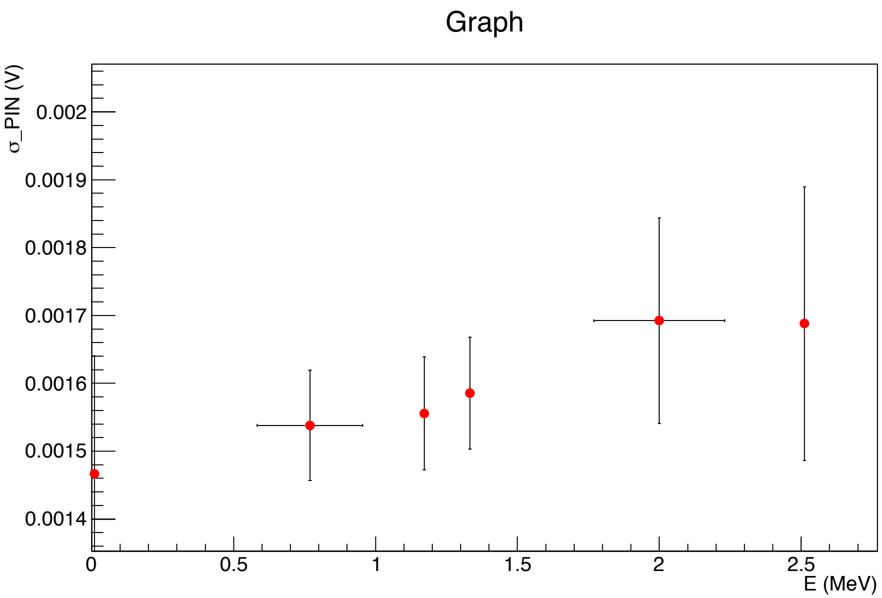


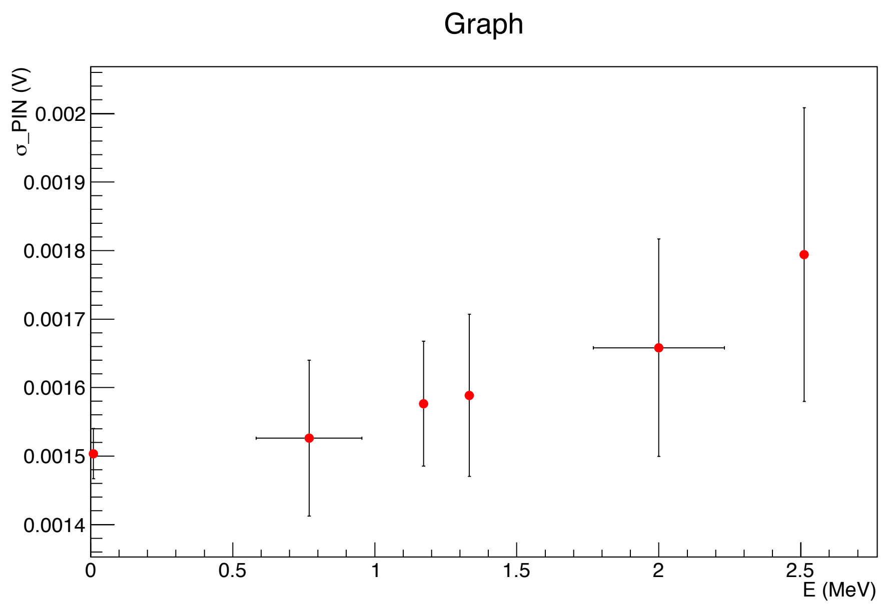




~ 0.8 mV /MeV

Noise evaluation



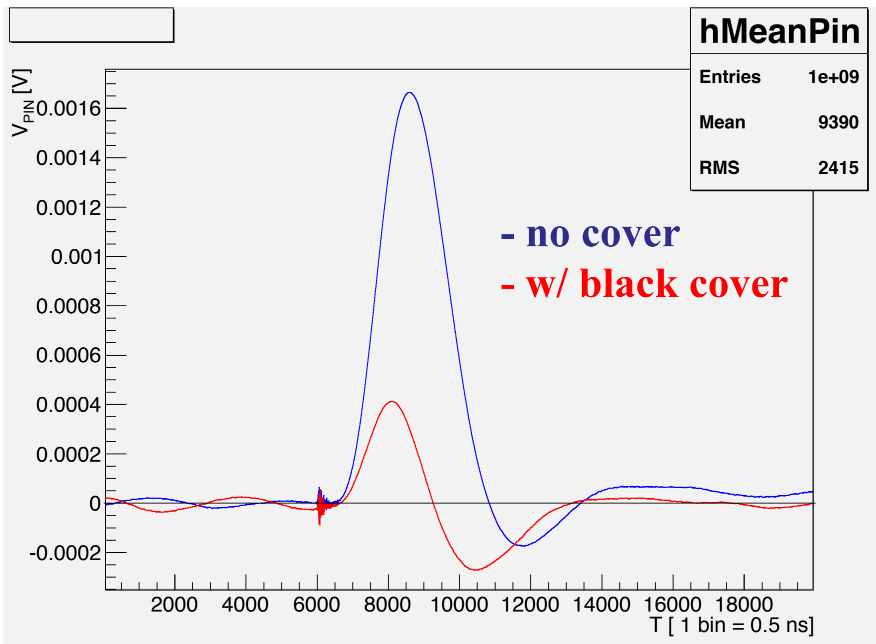


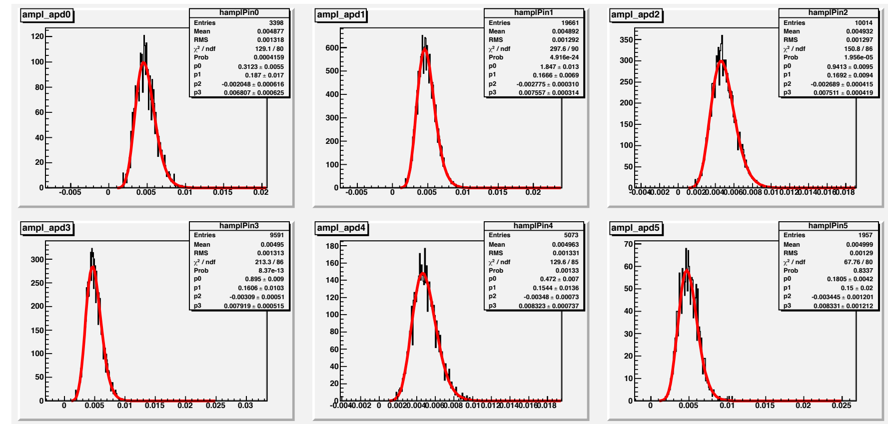
$$\frac{\mathbf{1.5}\ \mathrm{mV}}{\mathbf{0.8}\ \mathrm{mV/MeV}} = \mathbf{1.9}\ \mathrm{MeV}$$

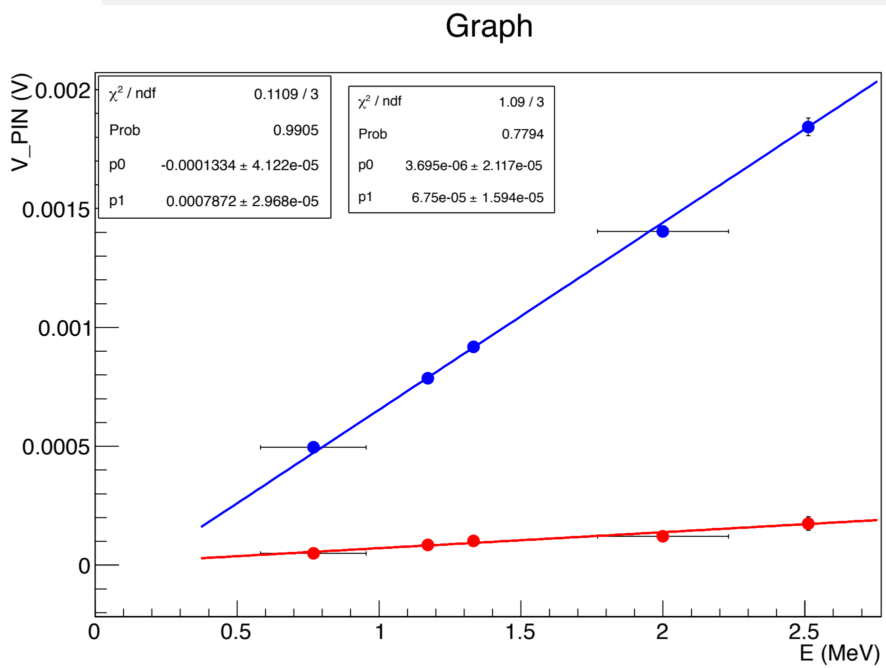
- **Slightly better than the Hamamatsu (2.5 MeV)**

Pick-up of PMT signal

- PIN covered with black paper
- Amplifier: LNA02V0



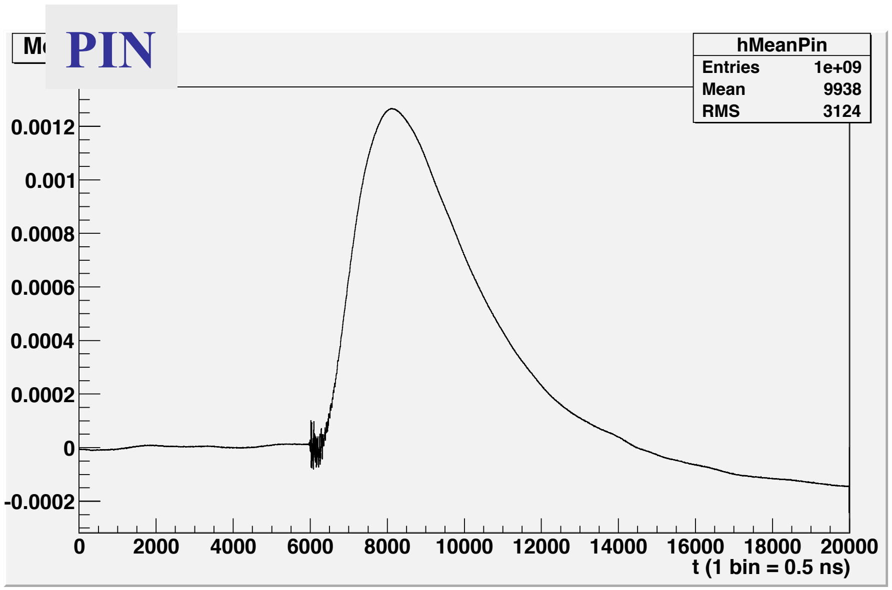


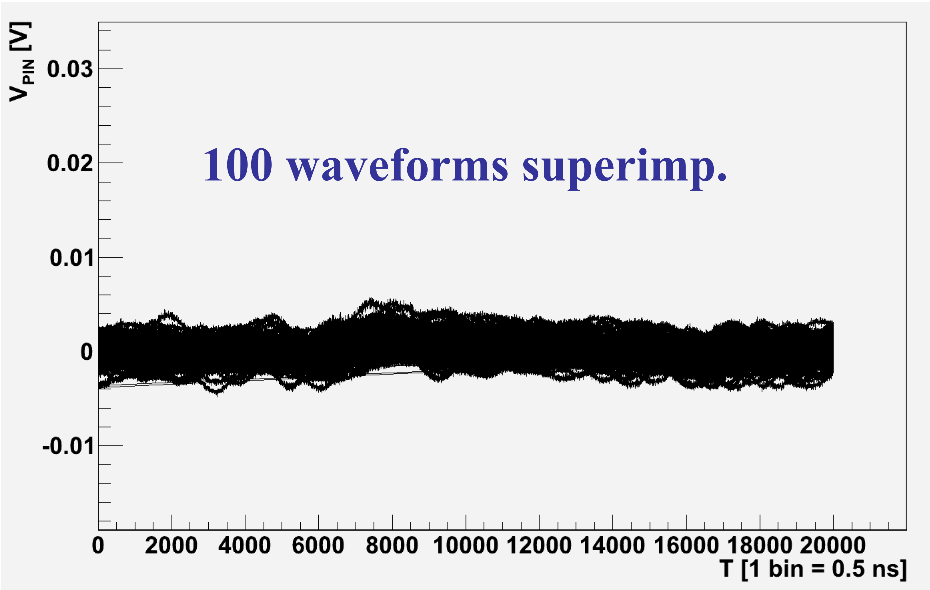


- Small effect
- PIN insulation has been improved
  (still analyzing data)

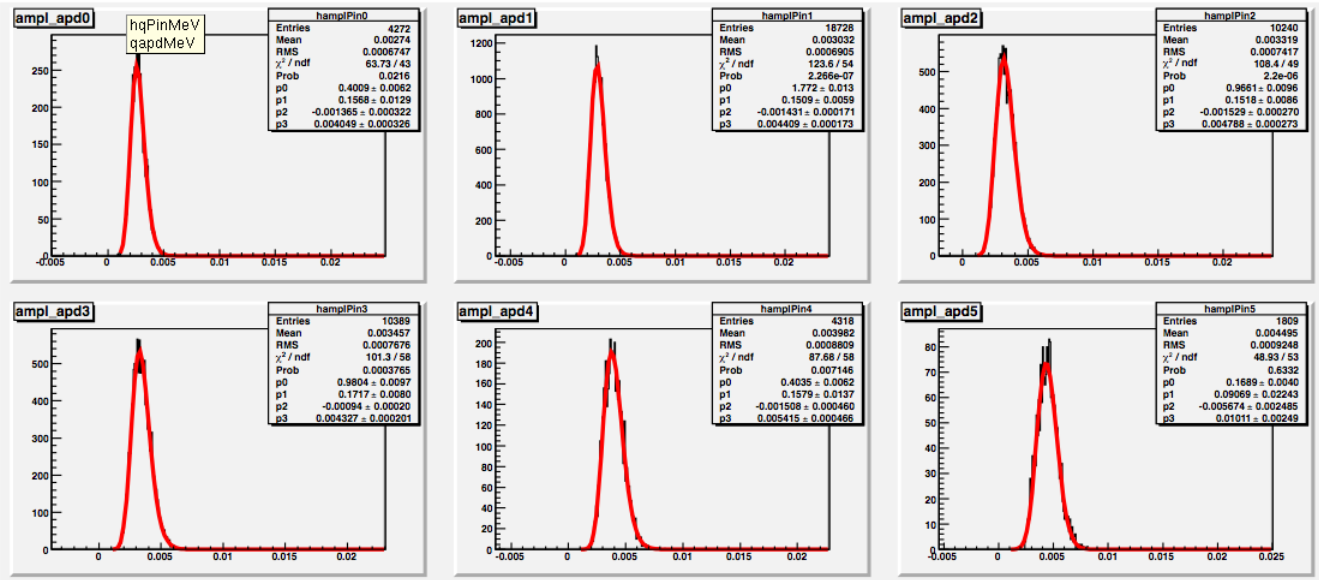
PIN with BaBar FEE

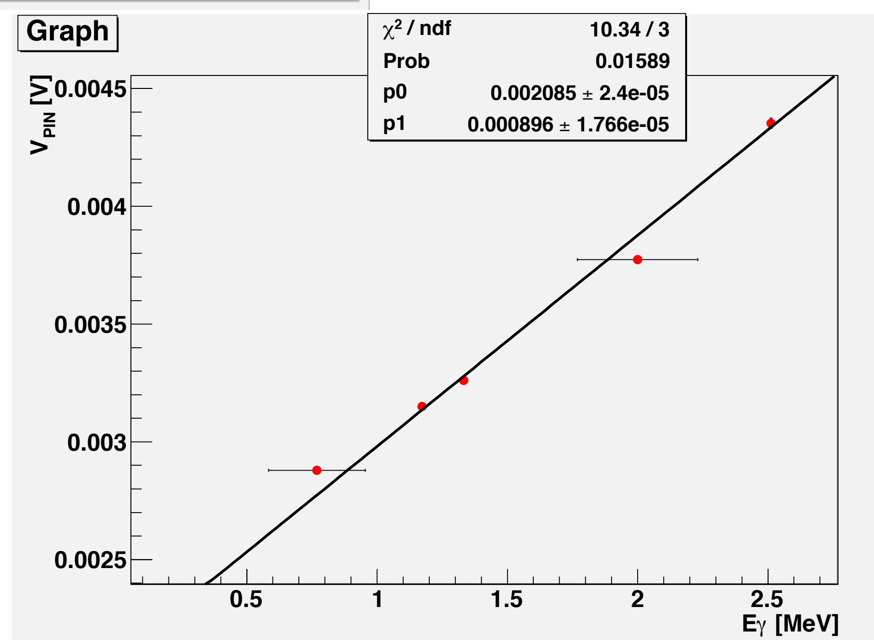
- To check the performance of our experimental setup, we performed the PIN readout with the BaBar FEE





PIN with BaBar FEE





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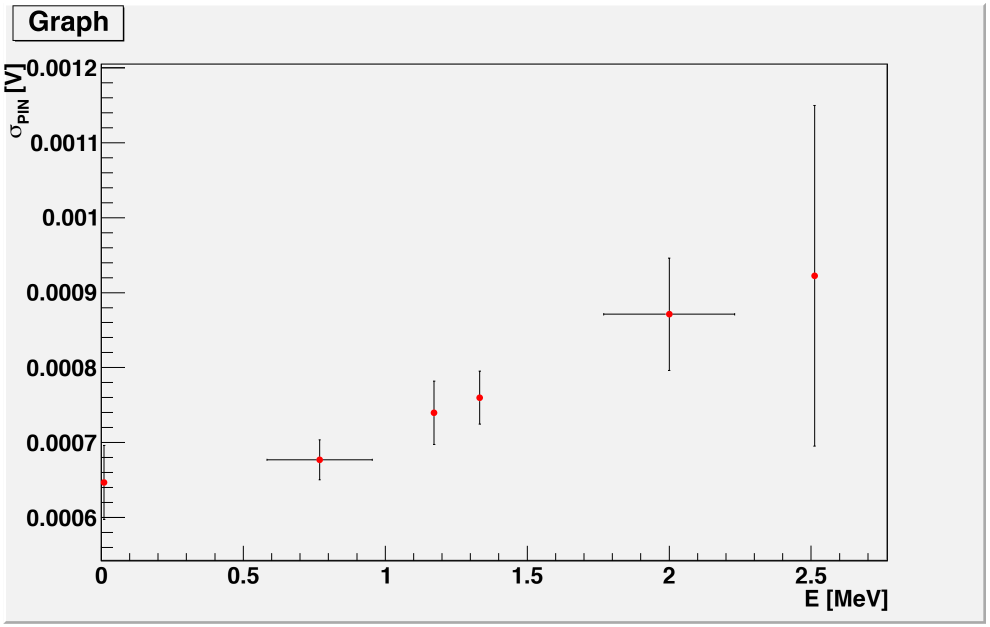
PIN with BaBar FEE



$$\frac{\mathbf{0.7}\ \mathrm{mV}}{\mathbf{0.9}\ \mathrm{mV/MeV}} = \mathbf{0.78}\ \mathrm{MeV}$$

- **780 keV → 550 keV (only one PIN readout)**

Noise in mV

Configuration	V_{APD} = 340 V	V_{APD} = 380 V	PIN
Cremat 140 μs + sh. 500 ns	2.4	3.3	1.5
Hamamatsu 100 ns + sh. 500 ns	2.9	4.5	2.5
Hamamatsu 100 ns + sh. 250 ns	5.1	6.0	
Hamamatsu 100 ns + sh. 100 ns	5.3	6.0	
proto. LNA02V0 100 ns + sh. 500 ns		3.0	1.5
Babar FEE			0.7

Energy calibration

p_1 [mV / MeV]

Configuration	V_{APD} = 340 V	V_{APD} = 380 V	PIN
Cremat 140 μs + sh. 500 ns	1.8	5.3	2.7
Hamamatsu 100 ns + sh. 500 ns	2.3	5.3	1.0
Hamamatsu 100 ns + sh. 250 ns	1.5	4.8	
Hamamatsu 100 ns + sh. 100 ns	1.2	4.0	
proto. LNA02V0 100 ns + sh. 500 ns		5.3	0.8
Babar FEE			0.9

Noise [MeV]

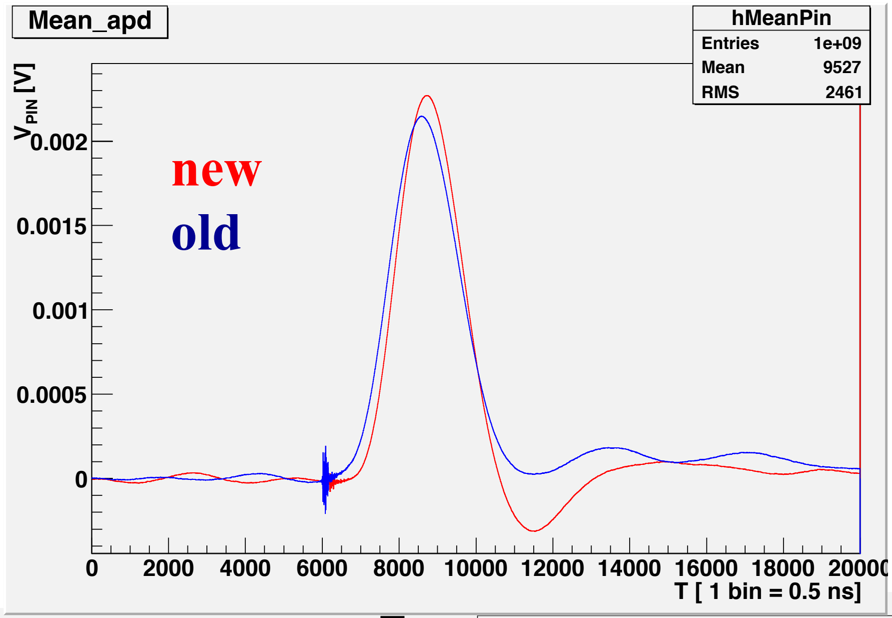
Configuration	V_{APD} = 340 V	V_{APD} = 380 V	PIN	(*)
Cremat 140 μs + sh. 500 ns	1.3	0.62	0.56	→ **0.4 MeV**
Hamamatsu 100 ns + sh. 500 ns	1.3	0.85	2.5	→ **1.8 MeV**
Hamamatsu 100 ns + sh. 250 ns	3.4	1.3		
Hamamatsu 100 ns + sh. 100 ns	4.4	1.5		
proto. LNA02V0 100 ns + sh. 500 ns		0.57	1.9	→ **1.3 MeV**
Babar FEE			0.78	→ **0.55 MeV**

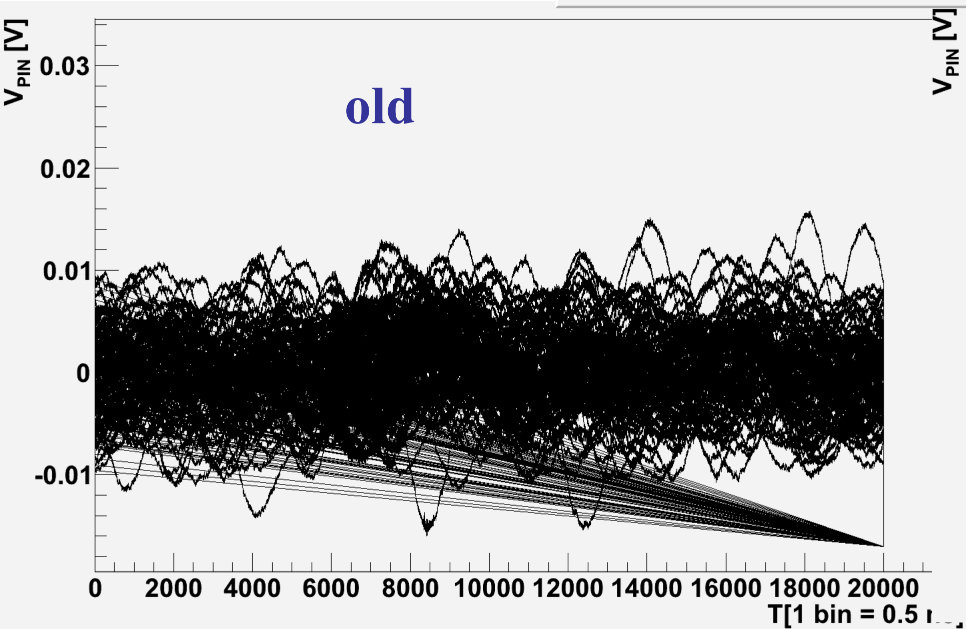
(*) Noise with PIN should be divided by √2, because we readout only one PIN

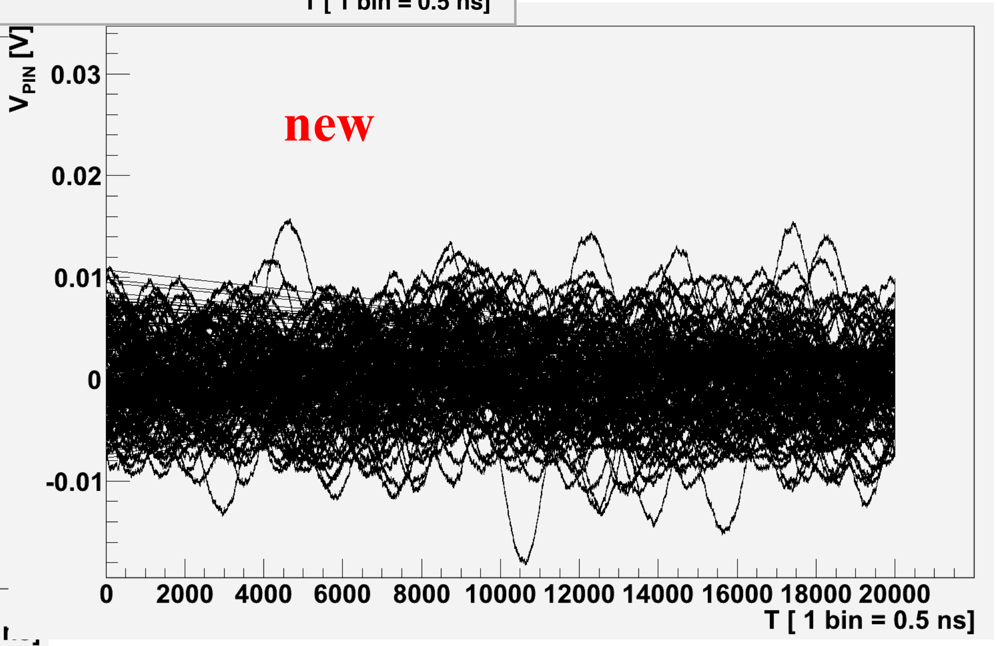
Conclusions

- **We studied the effect of a FEE with short integration time on a CsI(Tl) crystal readout by a PIN diode**
- **Noise at level of 1.3 – 1.8 MeV**
- **Still too high compared to the requirement of 0.5 MeV**

Check: new meas.of Hamamtsu







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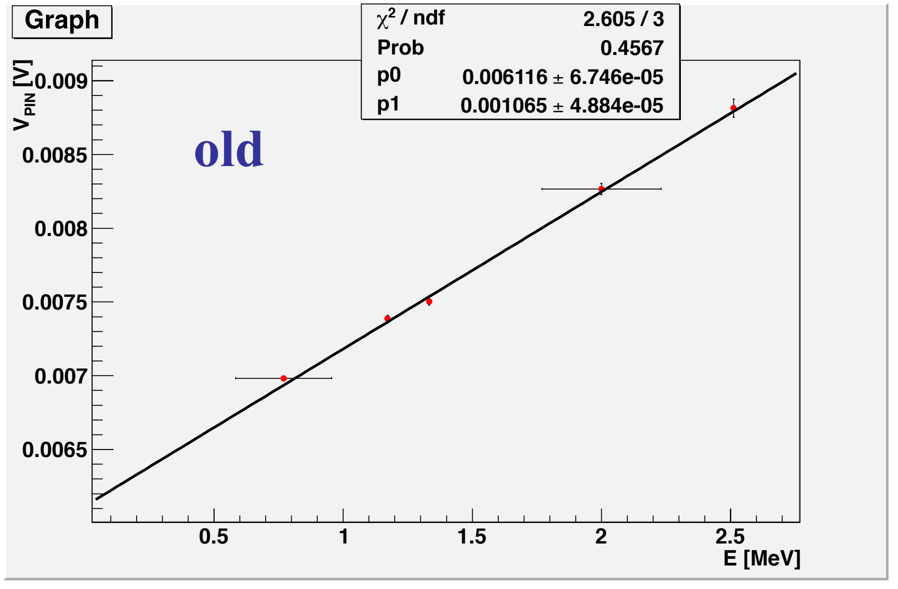
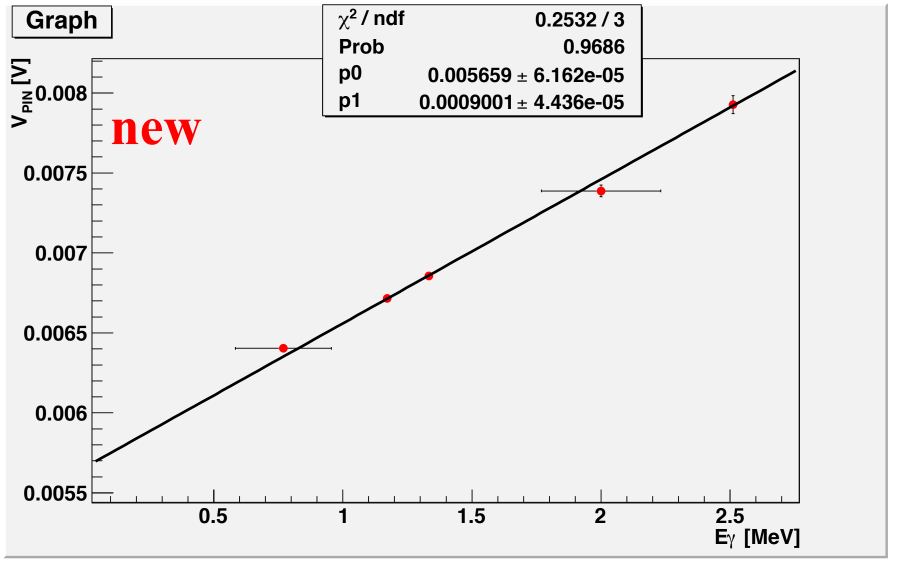
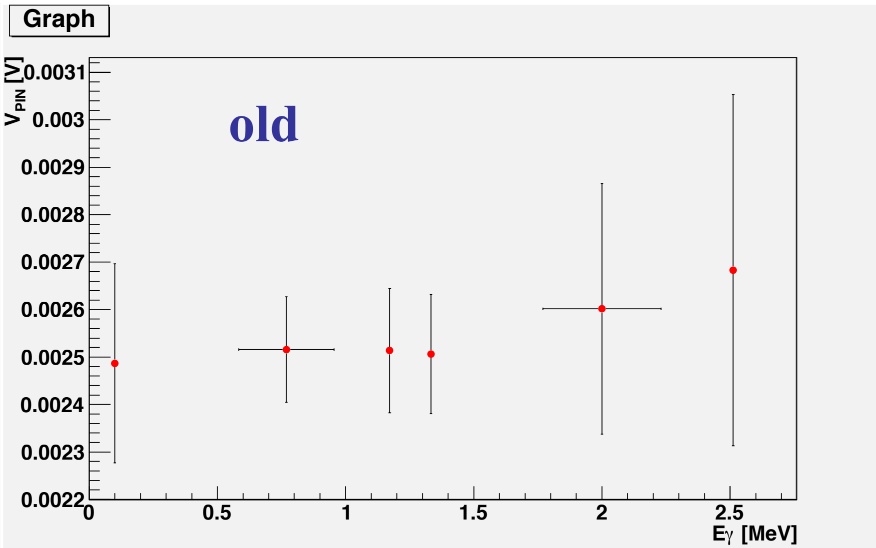
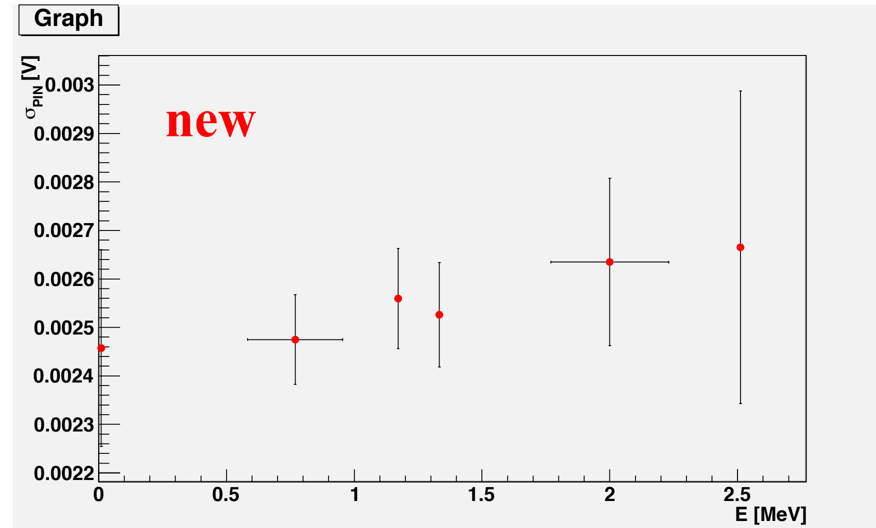




- **Same slope and offset (new: 9/7/2012 – old: 21/5/2012)**

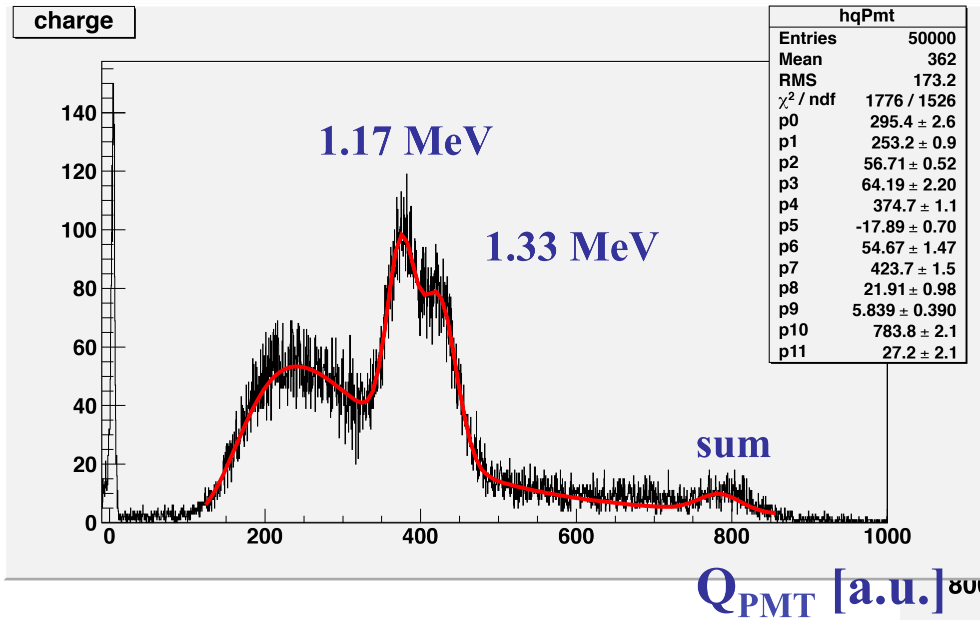
Check: new meas.of Hamamtsu

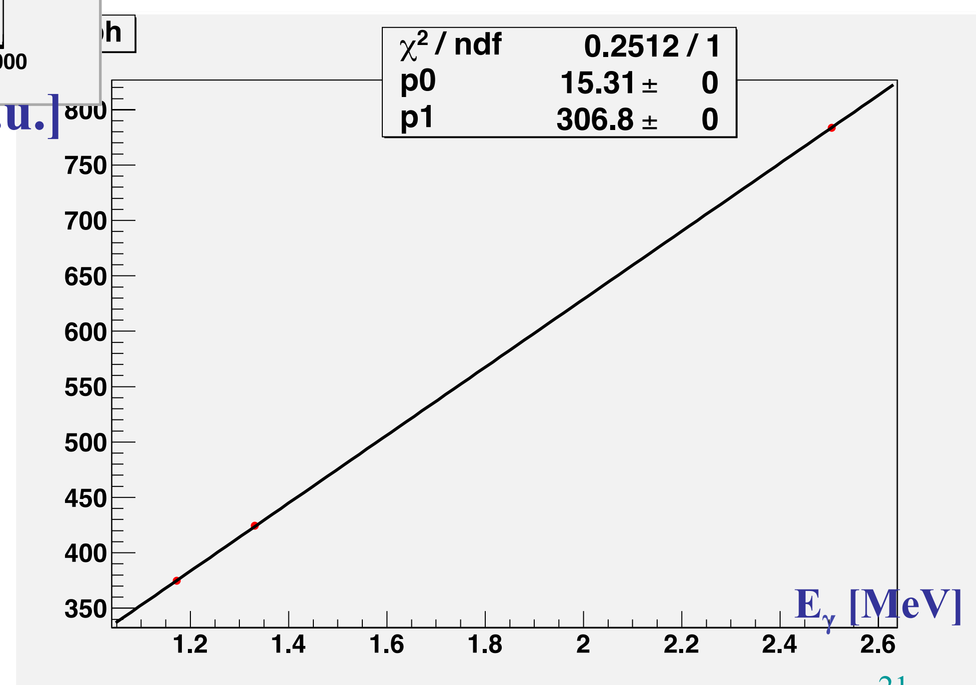




$$\frac{\mathbf{2.5}\ \mathrm{mV}}{\mathbf{1}\ \mathrm{mV/MeV}} = \mathbf{2.5}\ \mathrm{MeV}$$

^{60}Co spectrum with PMT





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