Results of the PZ0 tests with naked prototype detector and PCI DAQ readout

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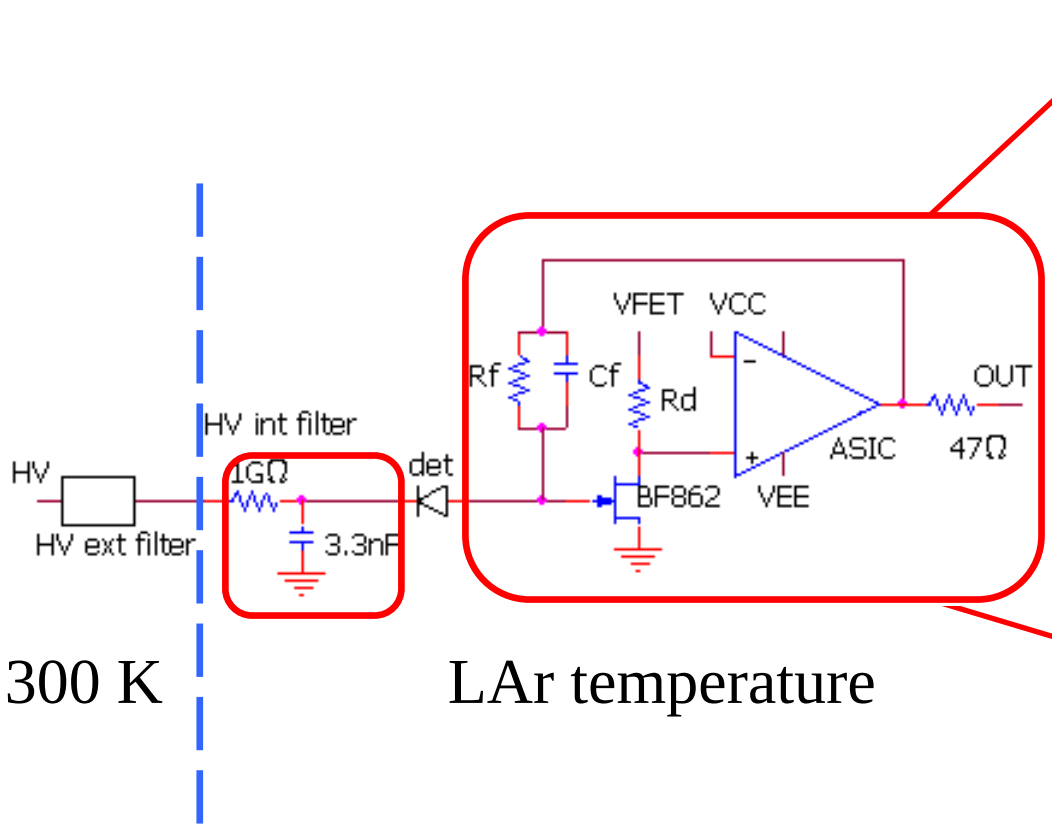
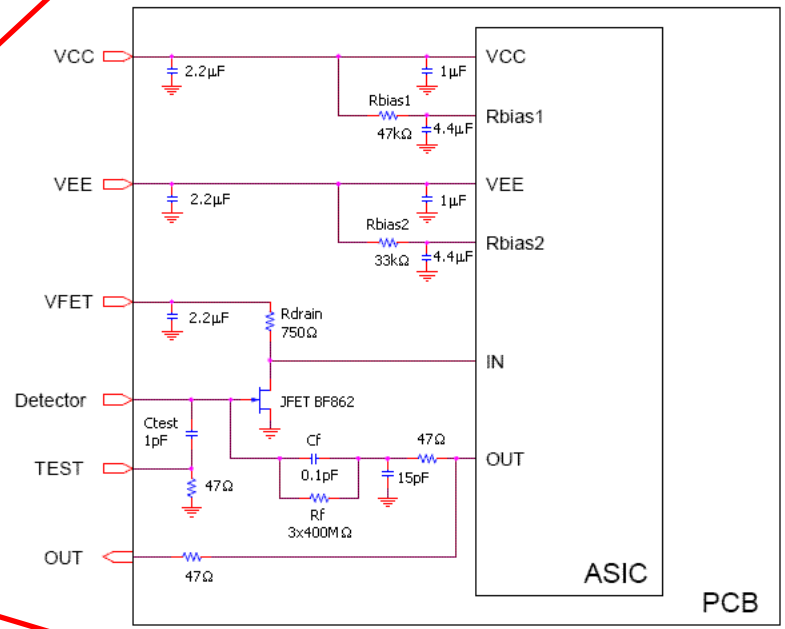
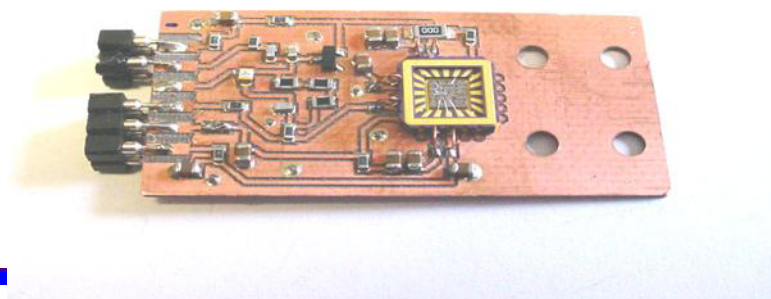
Outline

- Equivalent circuit and PZ0 readout;
- Summary of tests performed during last months (June 2008-October 2008);
- FFT analysis (also for ANG detectors);
- Problems encountered;
- Conclusion and perspectives.

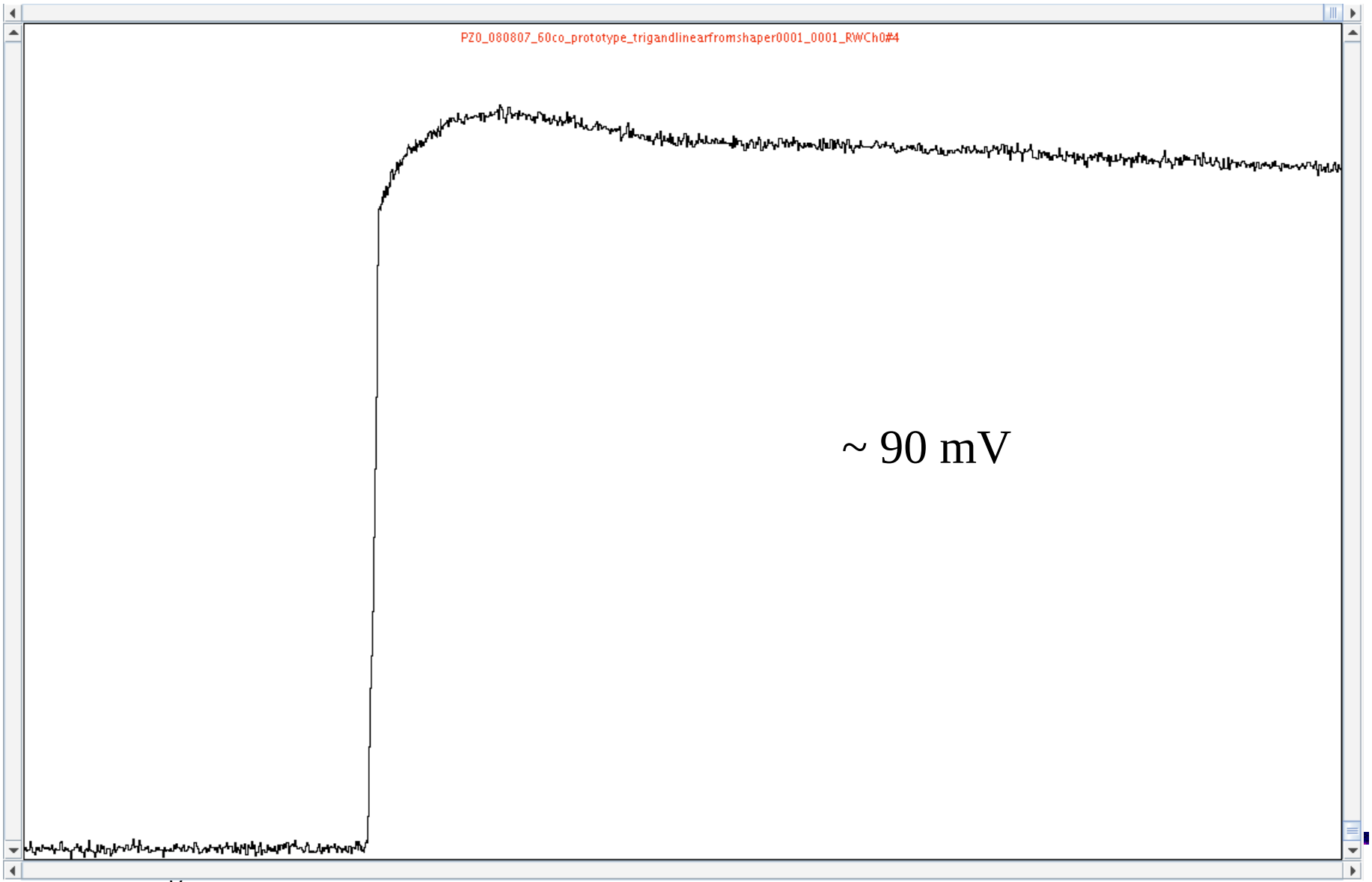
Equivalent circuit adopted to polarize detector and PZ0 readout







A typical pulse acquired irradiating prototype + PZ0 readout with a ^{60}Co



DAQ system and suite for analysis

•PCI Pd DAQ System: four-channel digital pulse processor and waveform digitizer.
14 bit FADC, 100 MHz sampling rate and 40 μs maximum sampling time;

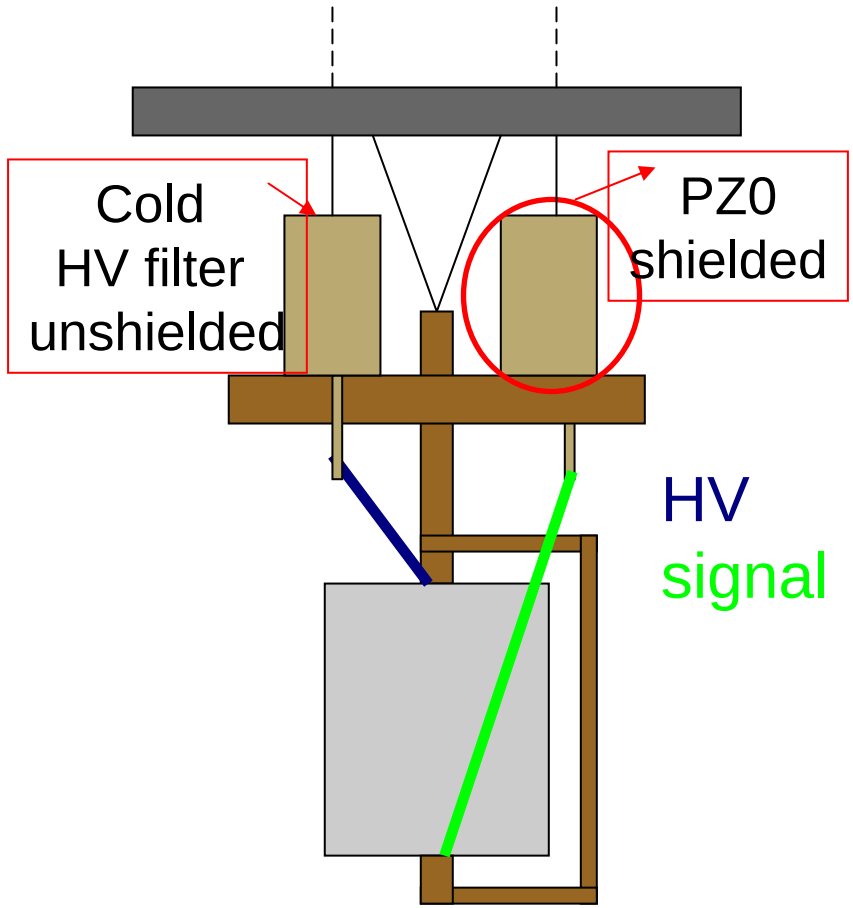
•PCI-NIM based DAQ System

CAEN N1728 four-channel digital pulse processor and waveform digitzier in one unit NIM format
100MHz 14 bit FADC and sampling time up to 10 ms.

jSpecview suite is adopted for pulse processing (FFT analysis, moving window deconvolution alghoritms …)

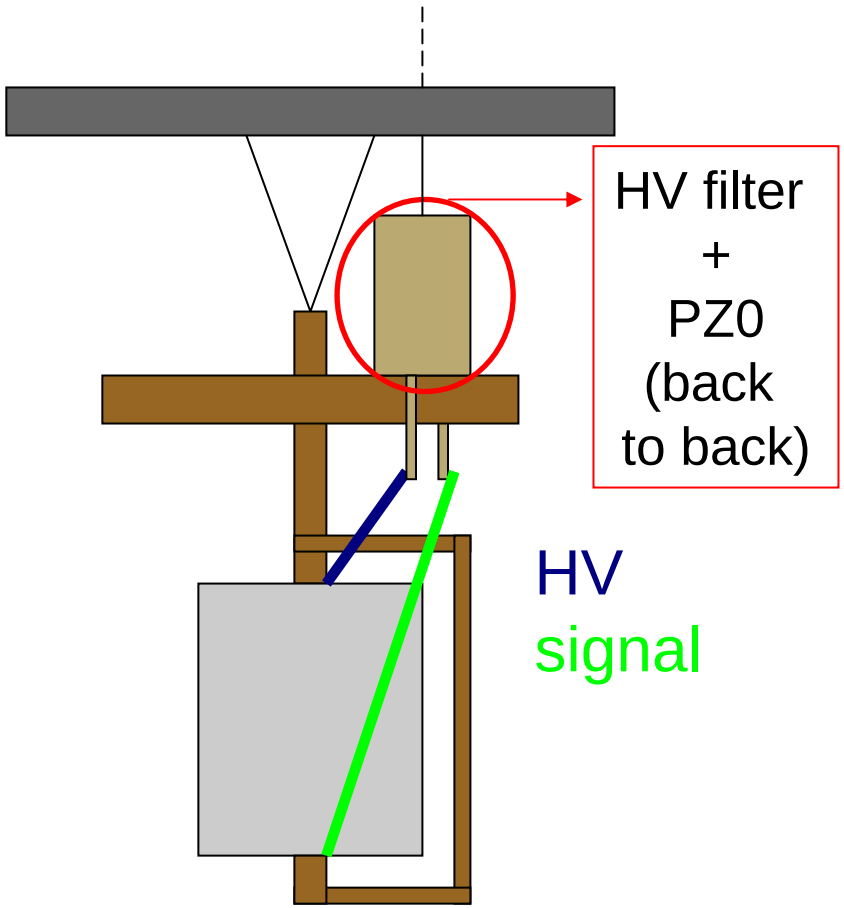
Tested setups (1)

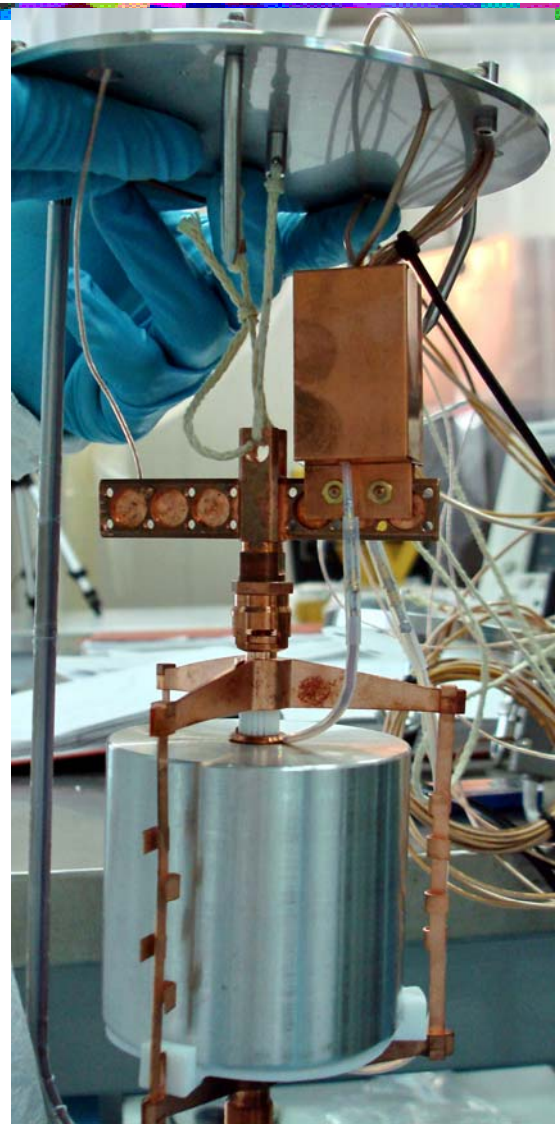
1st configuration --> TEST 1

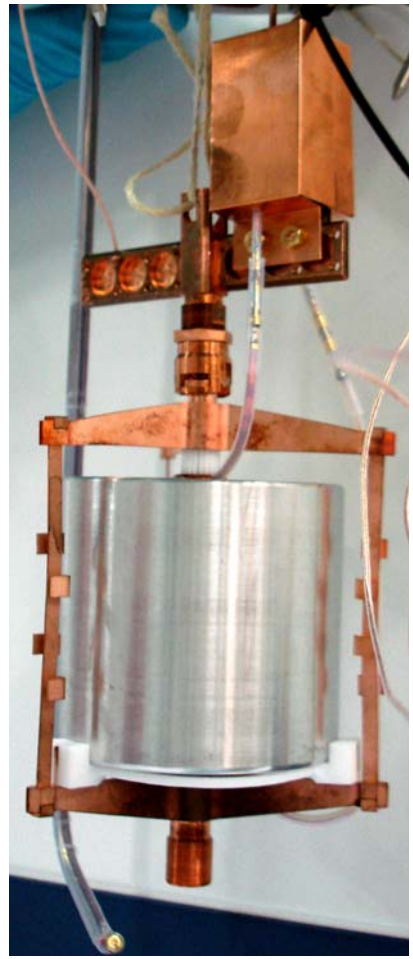


Tested setups (2)

2nd configuration --> TEST 2







Prototype detector (surface fully passivated)– PZ0 readout test on June 2008

Test 0: PZ0 mounted on the cross in Cu box (acting as Faraday Cage)
C_{det}=27pF.
Results: FWHM : 1.5 keV @ Pulser (~1.0 MeV) @LAR, τ = 6 μs
FWHM : 1.2 keV @Pulser (~1.0 MeV) @ 20^0C, τ = 6 μs

Test 1: PZ0 shielded in Cu box on cross, cold - HV filter (1 GΩ, 6.8 nF) unshielded on other side of cross.
HV=3000 V, LC ~ 100 pA.
Results: FWHM 3.3 keV @ ^{60}Co, 2.7 @ Pulser (~1.4 MeV).
Some instability of resolution depending on external HV cable and filter position.

Test 2: As 1 but cold – HV filter in Cu FC back to back to PZ0. Minimized length of signal and HV cable from detector. Improved anchorage of signal cable at vertical bars of detector Cu holder.
HV=2500 V, LC = 190 pA
Results: FWHM 3.7 keV@ ^{60}Co, 3.2 keV @ Pulser
R depends heavily from HV cable and filter positioning

Test performed in August 2008 with reprocessed detector (no PL).

Test 3: Substitute detector with C=100 pF suited to apply HV.

Result: $FWHM_{pulser}$ (setted@1.4 MeV) = 2.6 keV both HV On and OFF. Consistent with noise slope of ~2 e^- r.m.s/pF as measured at Milano test bench, and consistent with FWHM for C_{det}=27 pF

Purpose: To evaluate the resolution worsening related to pick-up of HF (through HV line and ground), LF (50 Hz, bubbling), preamplifier mounting, cabling etc.

Performed spectroscopy and pulse recording

Conclusions: There is no frequency dominating the noise and causing the resolution worsening, but white + maybe some 1/f noise.

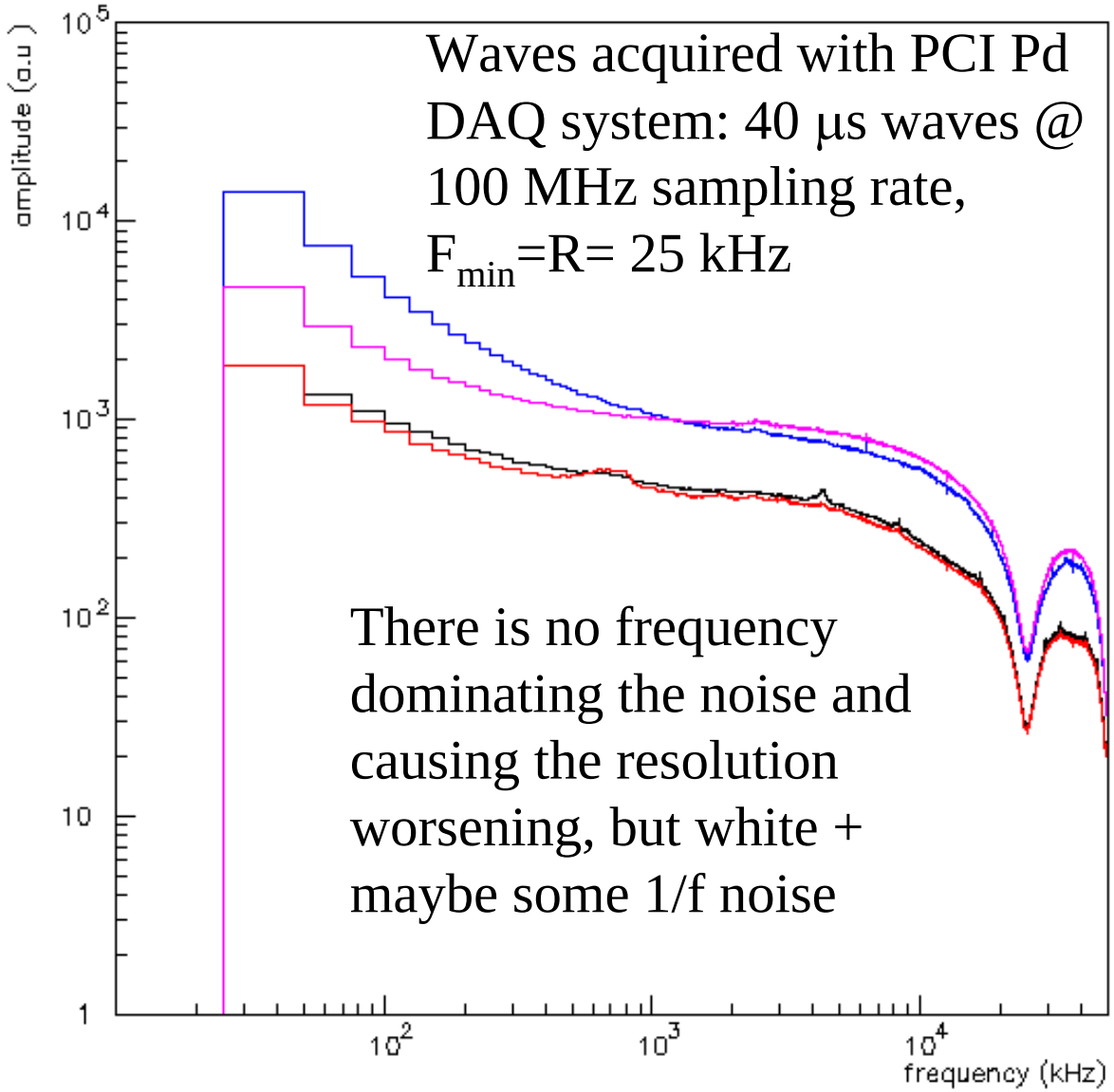
Test 4: Connect again detector reprocessed no PL.

HV=3000 V, LC ~ 40 pA

Results: FWHM 3.2 keV@ ^{60}Co, Pulser not available (ground of cable broke).

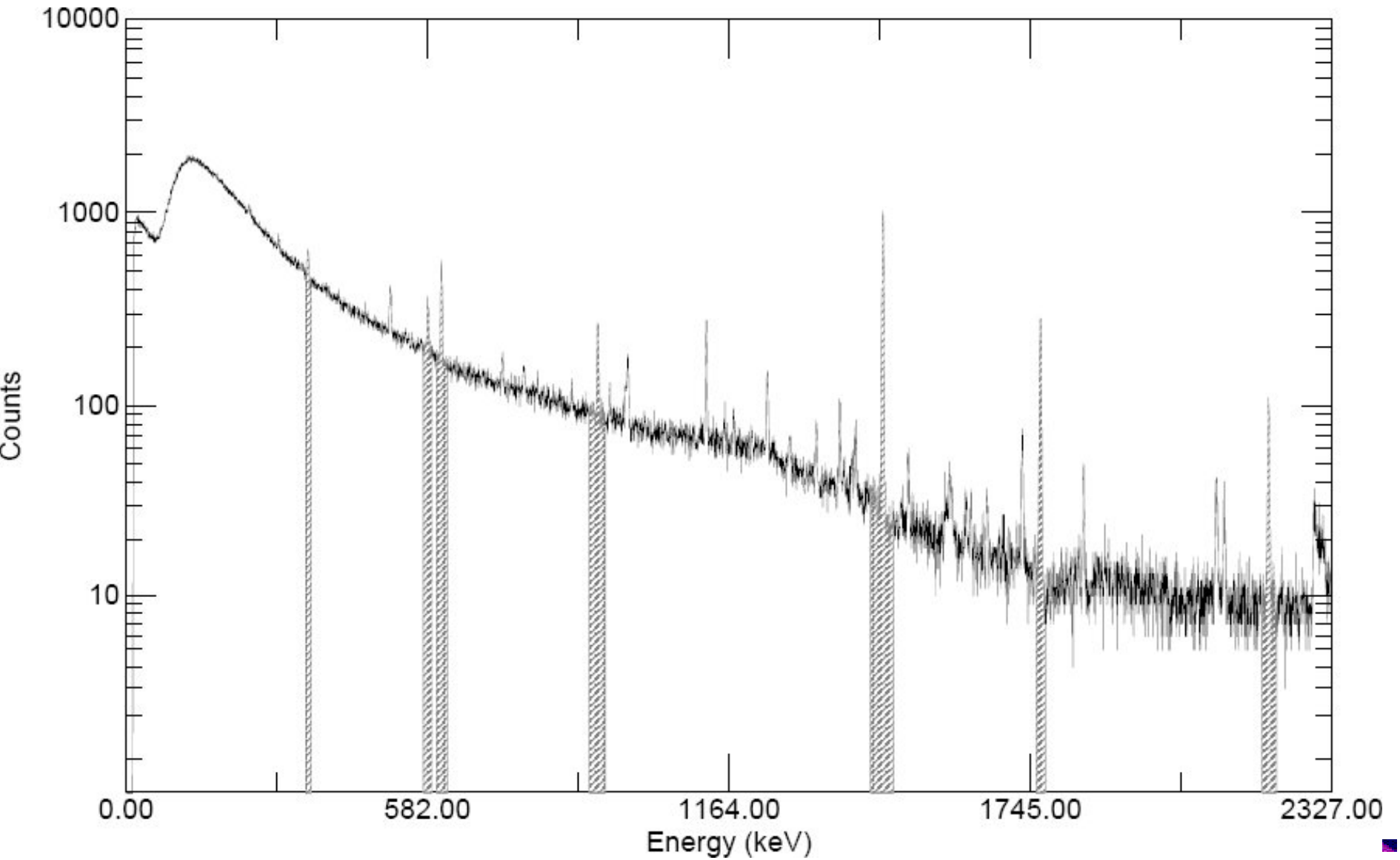
Evaluation of excess noise: $(3.2^2 – 1.5^2 – 1.7^2)$ keV ~ 2.2 keV

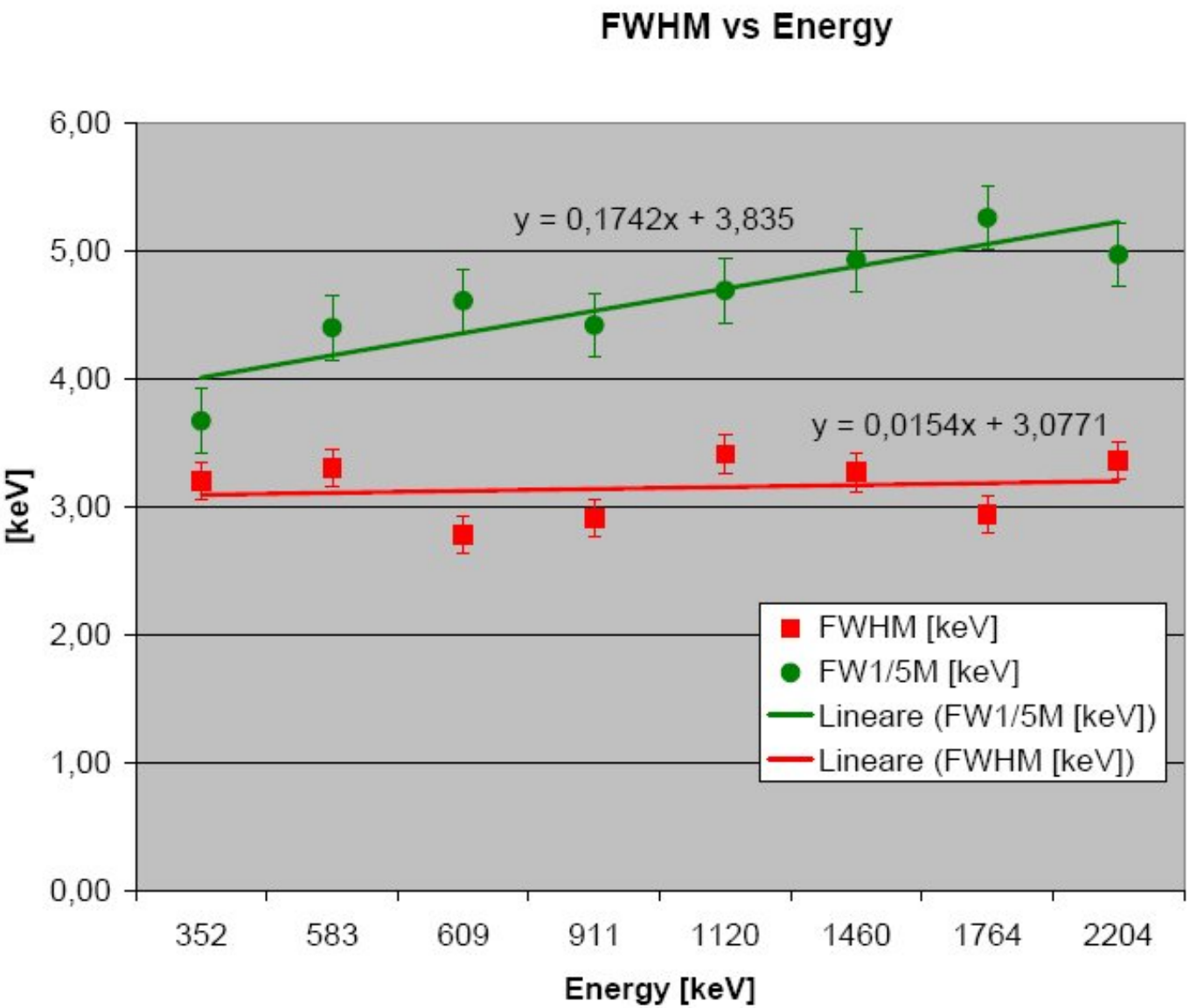
Comparison of FFT: PZ0 + Capacitance PZ0 + Detector



- Detector substituted by 100 pF HV capacitance, HV supply switched on but at 0 kV --> TEST 3;
- Detector substituted by 100 pF HV capacitance, HV= 3 kV--> TEST 3;
- Prototype+PZ0 in test bench 2 (out direct to FADC) --> TEST 4;
- Prototype+PZ0 in test bench 2 (out through a spectroscopy amplifier to make the trigger before going to FADC);

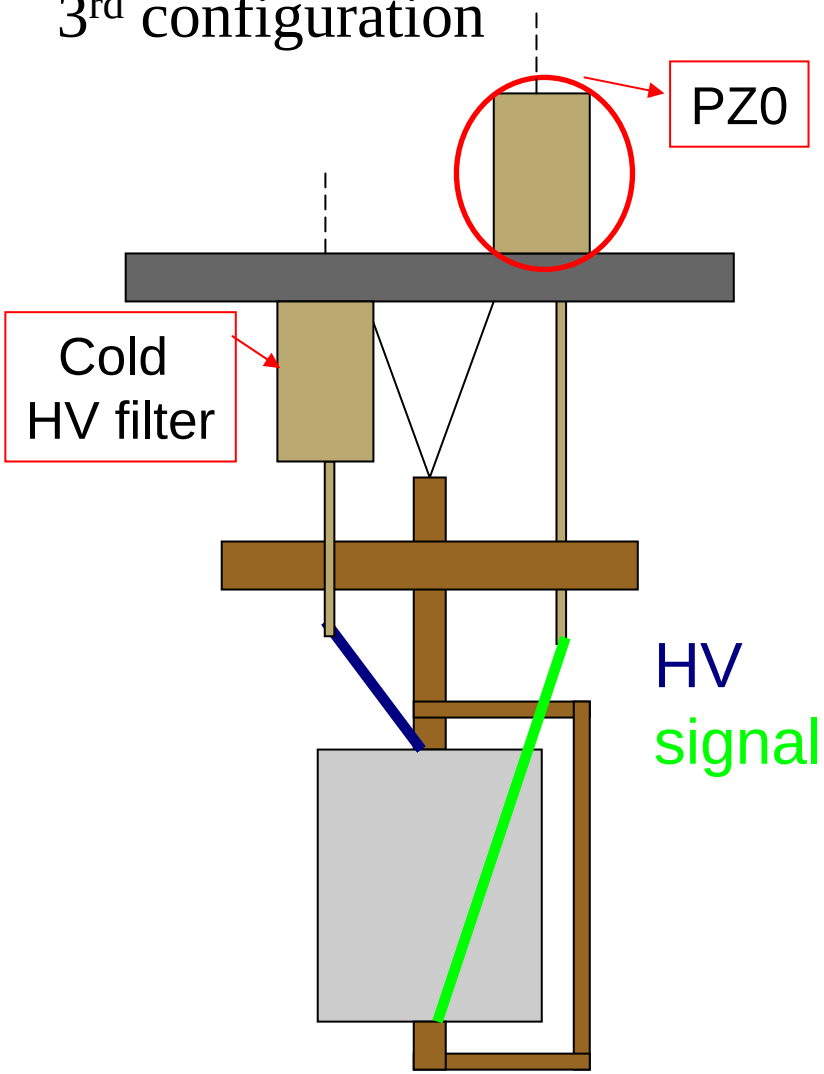
Typical result: Background spectrum 7th August 2008. HV= 3000 V, LC <50 pA, τ = 6 μs




FWHM vs Energy
6,00
5,00
4,00
3,00
2,00
1,00
0,00
[keV]
y = 0,1742x + 3,835
y = 0,0154x + 3,0771
FWHM [keV]
FW1/5M [keV]
Lineare (FW1/5M [keV])
Lineare (FWHM [keV])
352
583
609
911
1120
1460
1764
2204
Energy [keV]

October 2008 Tested setups (3)

3rd configuration

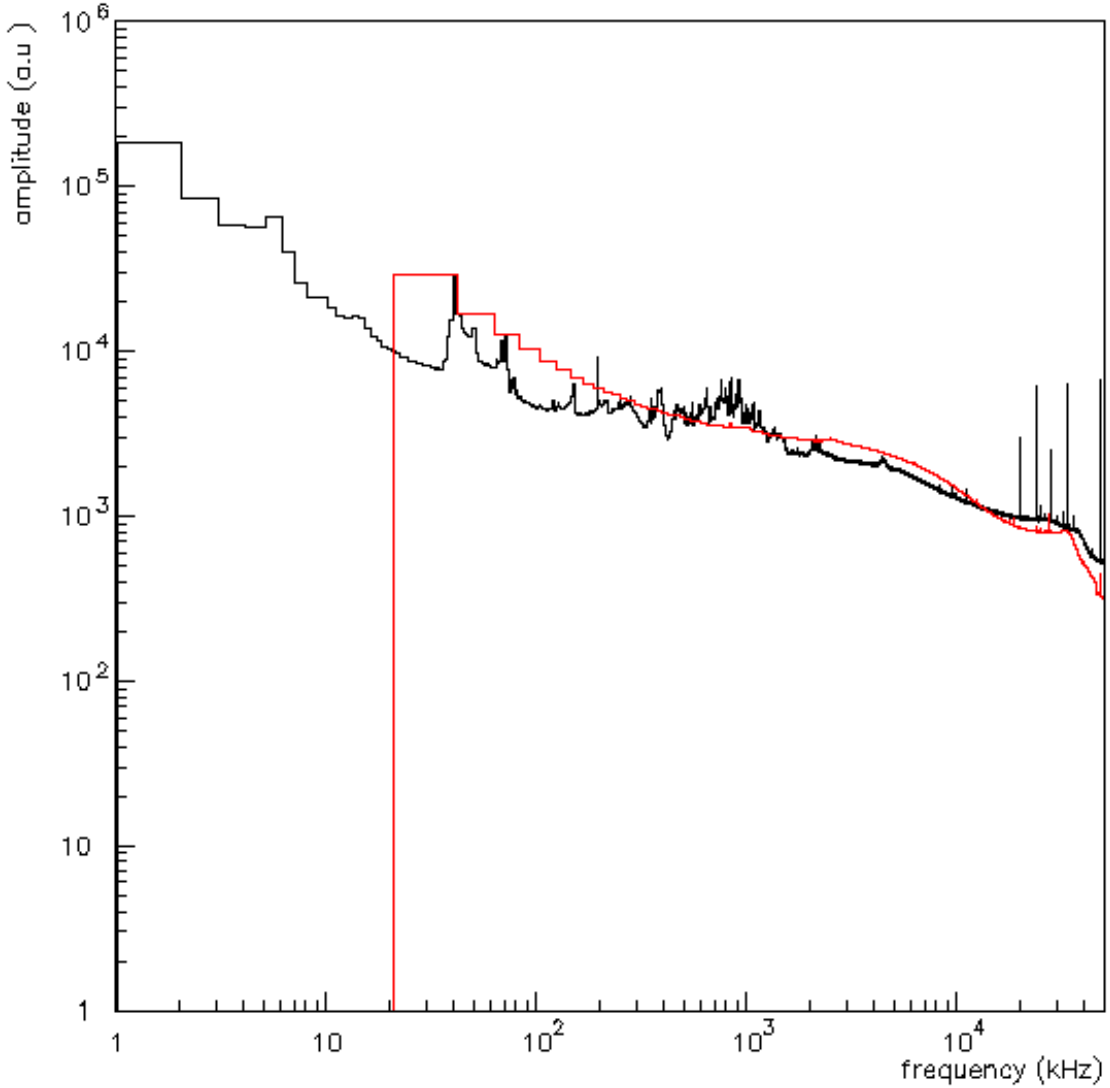


Test 5 (october 2008): PZ0 shielded in Cu box on the lid, unshielded (not in FC) cold - HV filter (1 GΩ, 6.8 nF) just under the LID.

HV=3000 V, LC ~ 40 pF.

Results: FWHM 4.1 keV @ ^{60}Co, 3.8 @ Pulser (~1.4 MeV).

Comparison of FFT from short (50 μs) and long (1 ms) waves



Prototype in TB2 with PZ0 8th August 08

R~ 23 kHz (50 μs waves with 100 MHz sampling rate)

E resolution @ ^{60}Co ~ 3.3kHz

Distance detector-PZ0 ~ 12 cm

Prototype in TB2 with PZ0 30th October 08

R~ 1 kHz (1 ms waves with 100 MHz sampling rate)

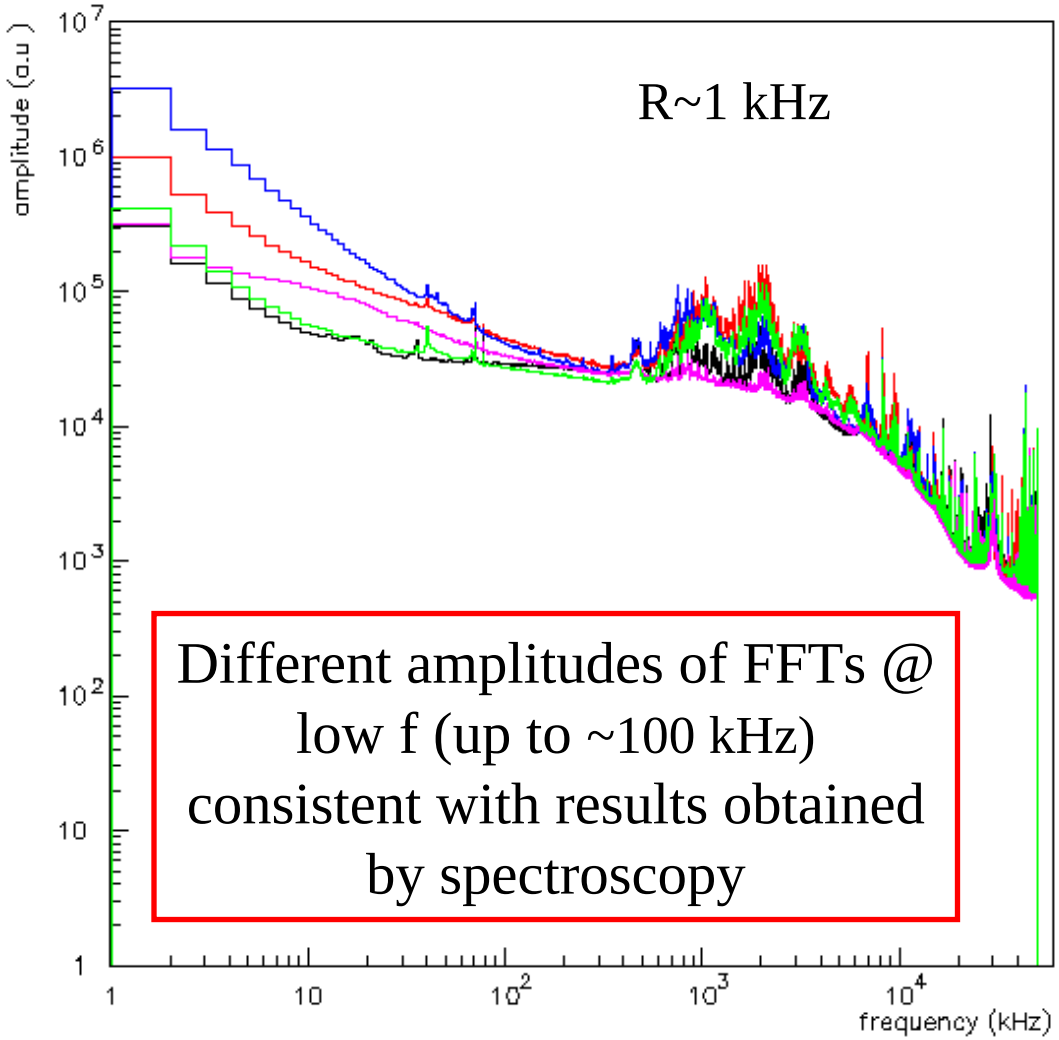
E resolution @ ^{60}Co ~ 4.1 keV

Distance detector-PZ0 ~ 20 cm

Unfortunately in the 1st measurement the waves were not long enough to allow the investigation of low frequency region: R ~ 23 kHz vs R ~ 1 kHz

--> spectra not directly comparable!

FFT analysis of signals from detectors in test bench 1

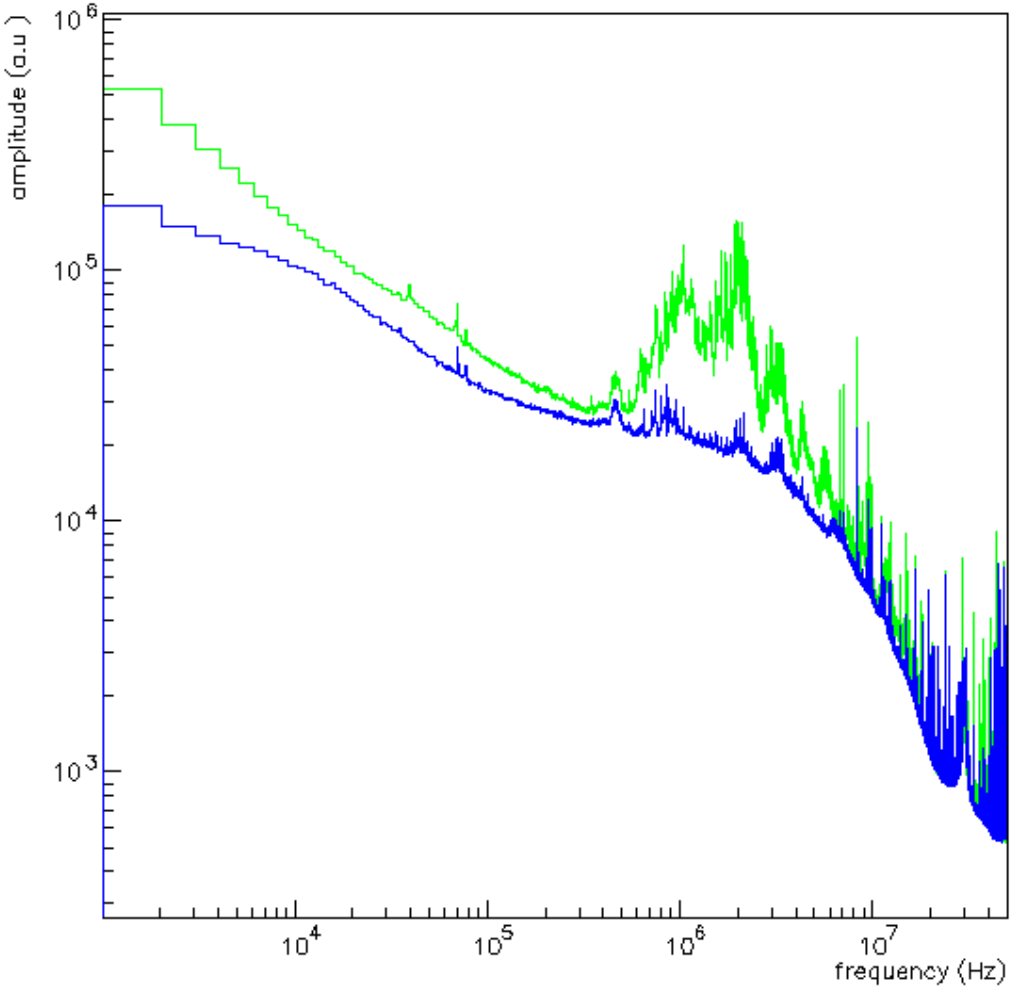


FFT analysis of baselines collected last August with enriched (ANG2, ANG3, ANG5) and non-enriched (prototype) detectors in test bench 1. Waves are 1 ms long and sampling rate is 100 MHz --> F_{max}~50 Mhz and Resolution~1 kHz.

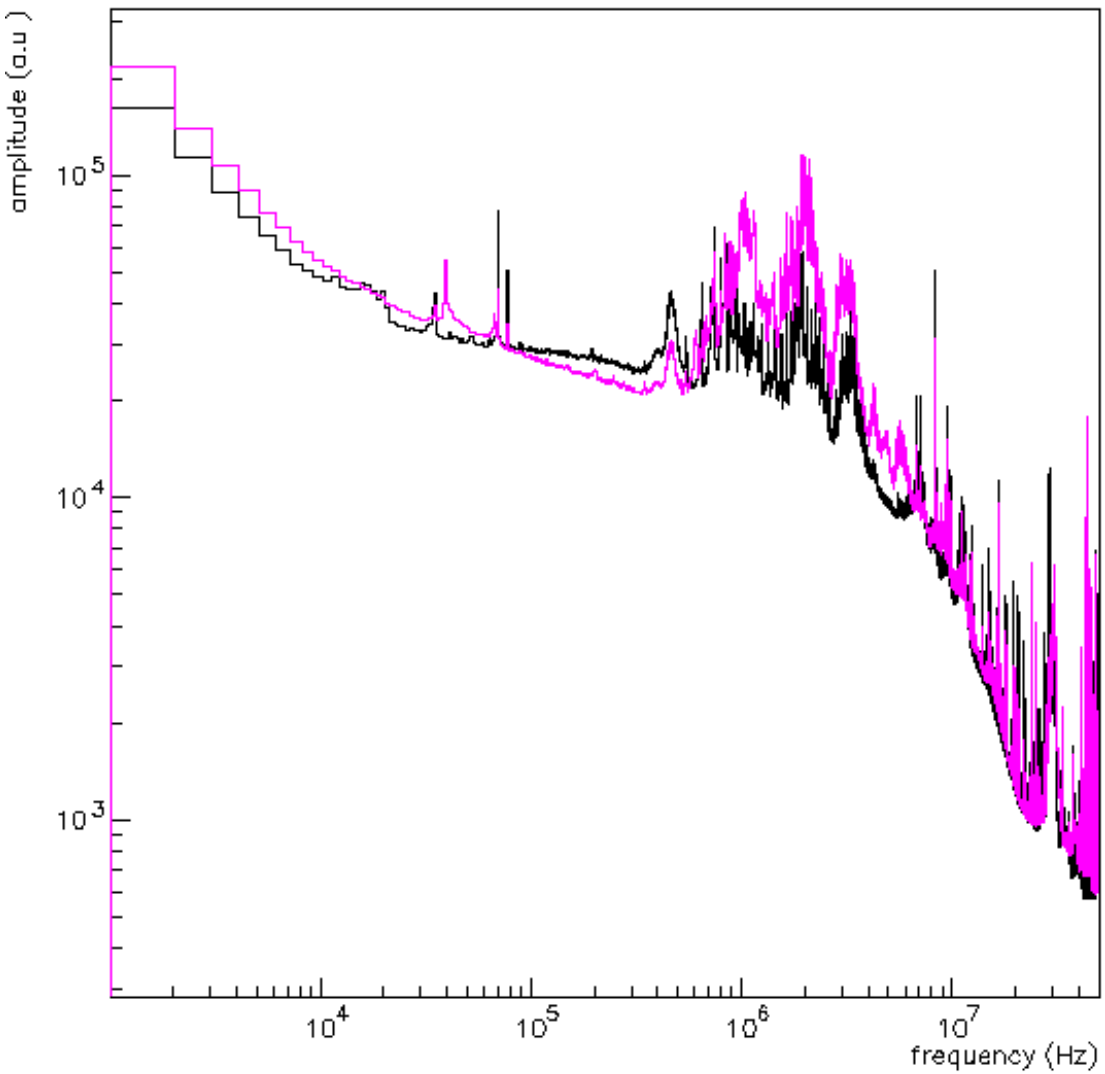
Energy resolution obtained with spectroscopy @ ^{60}Co:

- ANG2: 2.6 keV (26th August 2008);
- ANG3: 5.8 keV (28th August 2008);
- ANG5: 5.2 keV (29th August 2008);
- ANG5: 5 keV (2nd September 08);
- Prototype: 2.8 keV (31st August 08)

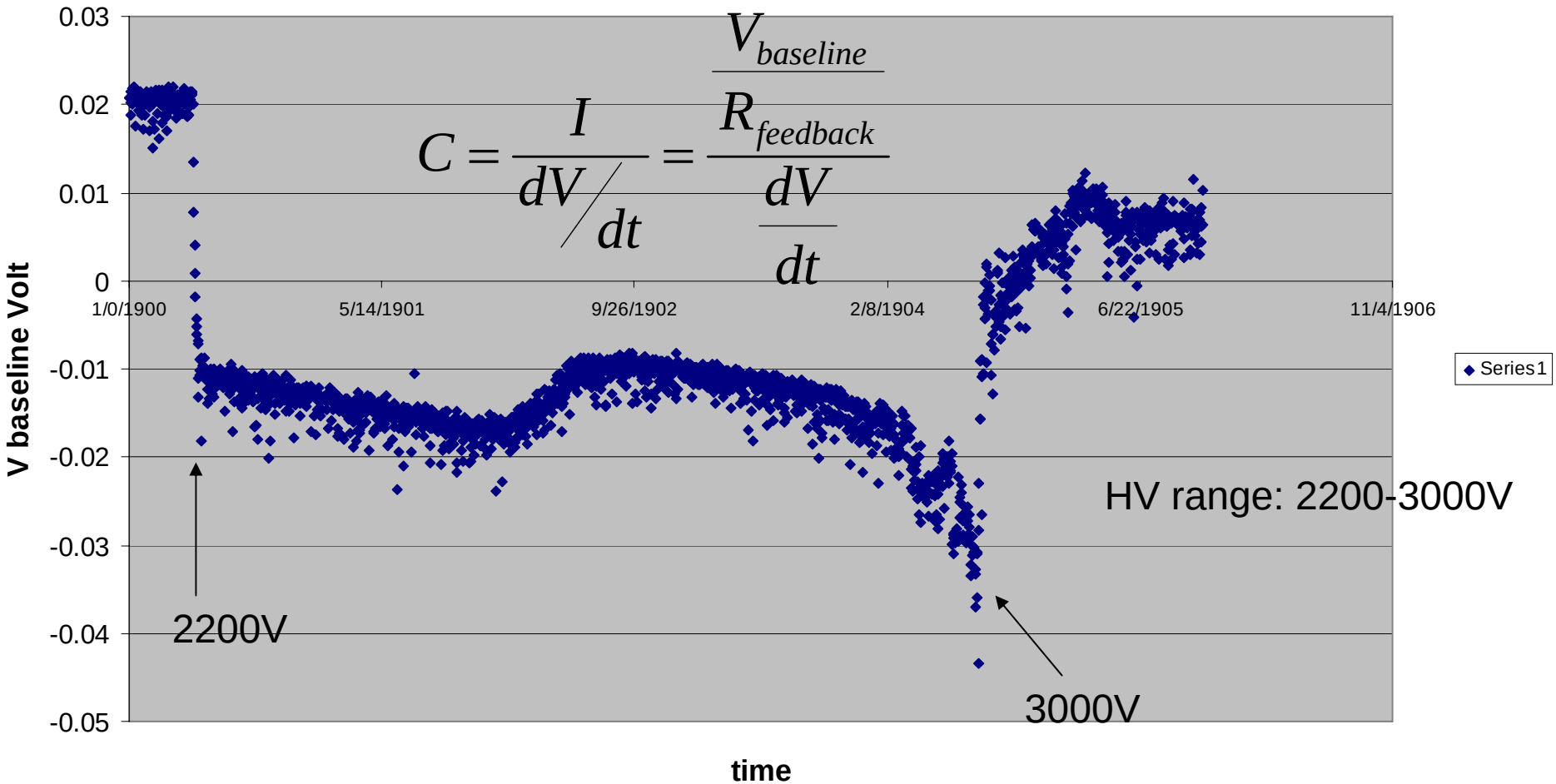
Comparison: ANG5 29/08/2008 and ANG5 02/09/2008



Comparison: ANG2 and Prototype



Measurement of detector capacitance



C_{det}=(40mV/1.2GΩ)/1V/s~34 pF, assuming dV/dt=1 V/s (HV power supply)

Problems encountered during the tests

- HV capacitances for cold HV filter usually break after few cooling cycles;
- Connection and disconnection of detector from readout circuit can produce burning up of the FET due to free space charge;
- Mechanical stress on detector input pin.
- Mechanical stress on cables from top flange to PCB causes breaking of ground socket

Conclusion and perspectives

- PZ0 mounted on the cross in the FC with a C_{det}=27pF simulating the detector in LAr has FWHM=1.5 keV @ Pulser (~1.4 MeV);
- PZ0 mounted on the cross with detector in Cu box on cross has (FWHM=3.2 keV @ ^{60}Co) FWHM = 2.7 @ Pulser (~1.4 MeV), , unconsistent with the FWHM obtained substituing the detector with a 100 pF capacitance.

-->Evaluation of excess noise: $(3.2^2 - 1.5^2 - 1.7^2)$ keV ~ 2.2 keV

- There is no frequency dominating the noise and causing the resolution worsening, but white + some 1/f noise→ indication that the cause of resolution worsening is either a R series or an excess C (but Cdet measure shows that it is not the case).
- FFT analysis on baselines acquired in test bench 2 (enriched detector, ANG2,3 and 5, and prototype) is consistent with the spectroscopy measurements.

Perspective to improve the resolution:

- we plan to remove the cold HV filter;
- improve the HV contact on detector;
- Try to change pins;
- to measure the parasitic capacitance to ground (responsible of the resolution worsening????);
- We need to manipulate prototype detector independently from HD people.