TG3 status report

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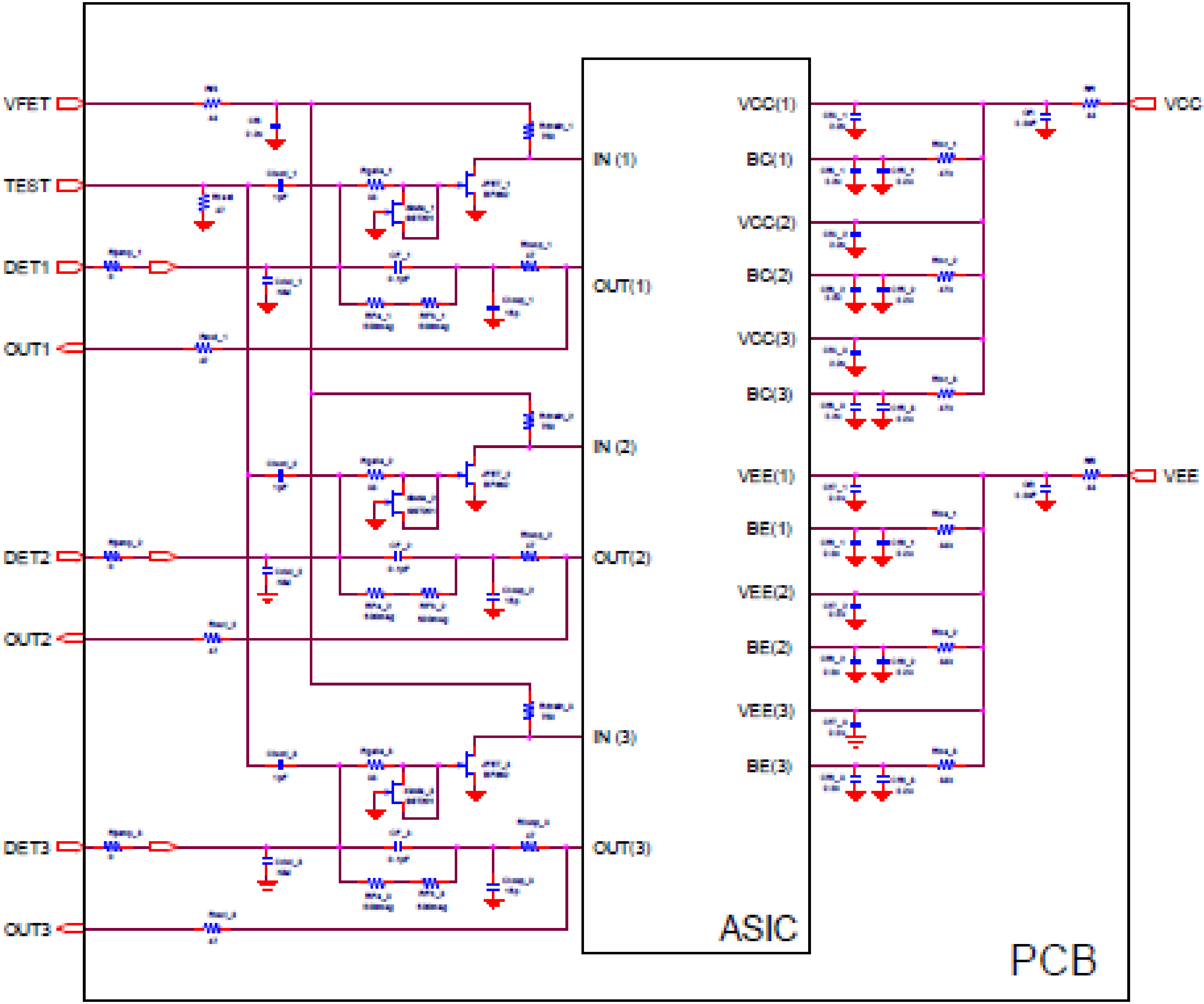
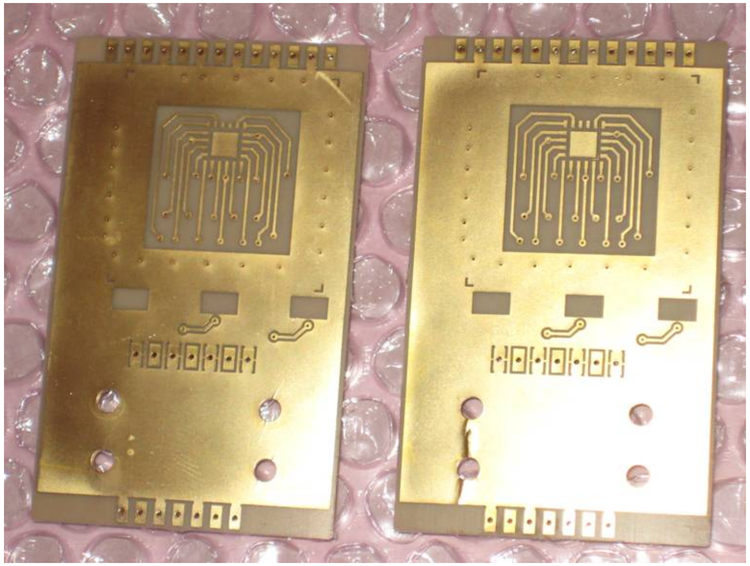
Outline

- 3 ch circuits
  - Production
  - Bench Test results (December 08- January 09)
  - Results from tests with encapsulated detector (SUB) (January 09)
  - Results from tests with naked detector (February 09)
  - PCB radioactivity evaluation (since beginning of January 09) will be treated in details TG11 dedicated talk
- First results on ASIC PZ0 + ASIC line driver
- Design and production of mechanical part for detector string
- POGO pin Matrix modification (in integration session) and cabling

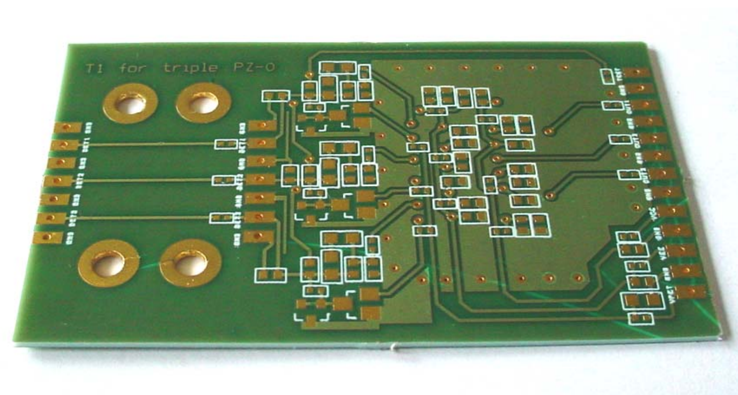
PCBs Production

- Based on schematics and layout presented by F. Zocca at November 08 meeting.
- PCB made of CUFLON + Au/Ni deposition by galvanic process
  - PCB: Photolitography at TVR (Vicenza)
  - Component mounting (SMD) and ASIC bonding at MIPOT (Trieste).
  - Cu Encapsulation of ASIC circuits custom produced at MIPOT (prototype at Milano Bicocca) mechanical workshop.
- Circuits produced
  - 5 with fotoresist
  - 6 no fotoresist


VFET
TEST
DET1
OUT1
DET2
OUT2
DET3
OUT3
IN (1)
OUT(1)
IN (2)
OUT(2)
IN (3)
OUT(3)
VCC(1)
BC(1)
VCC(2)
BC(2)
VCC(3)
BC(3)
VEE(1)
BE(1)
VEE(2)
BE(2)
VEE(3)
BE(3)
ASIC
VCC
VEE
PCB

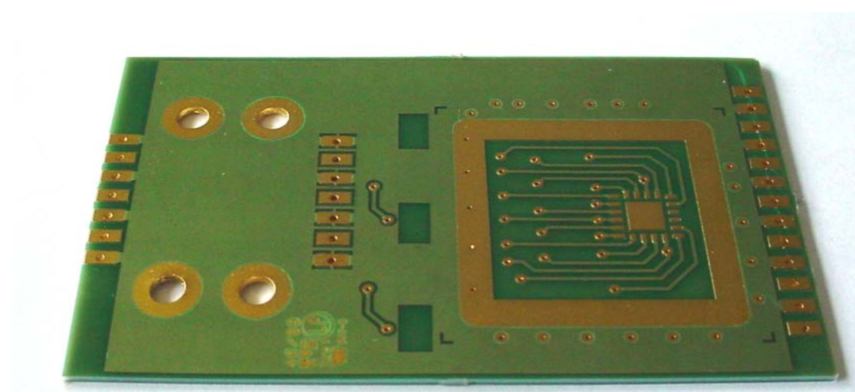


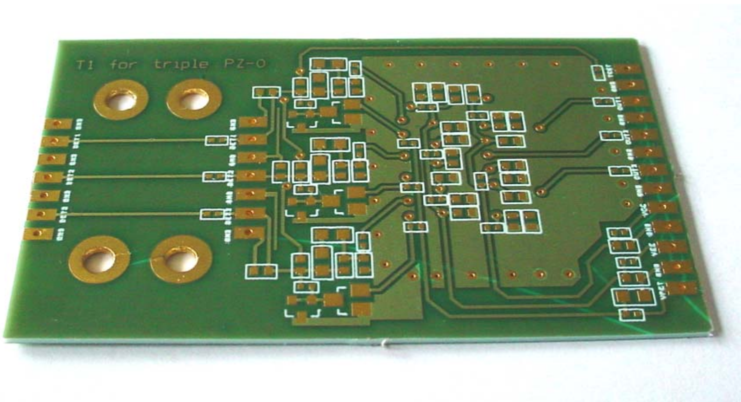
No Photoresist process
For screening measurements

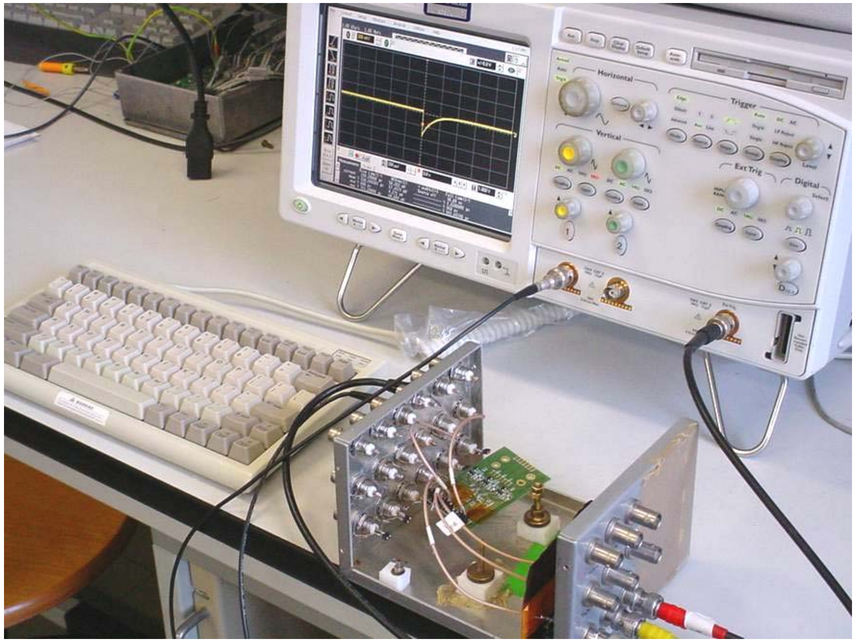


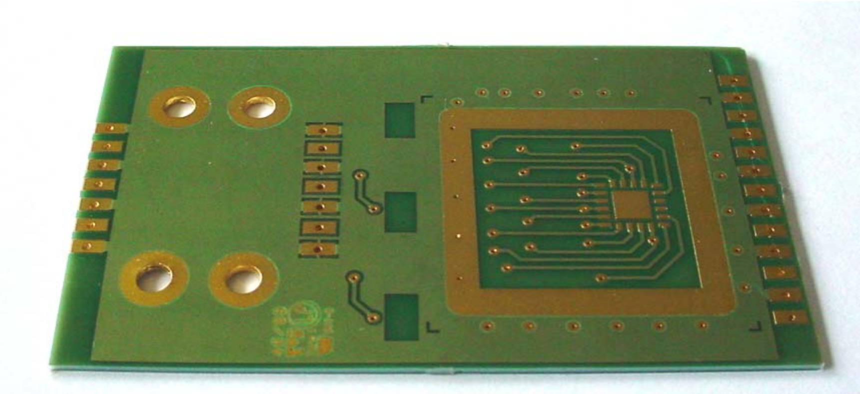
With Photoresist process

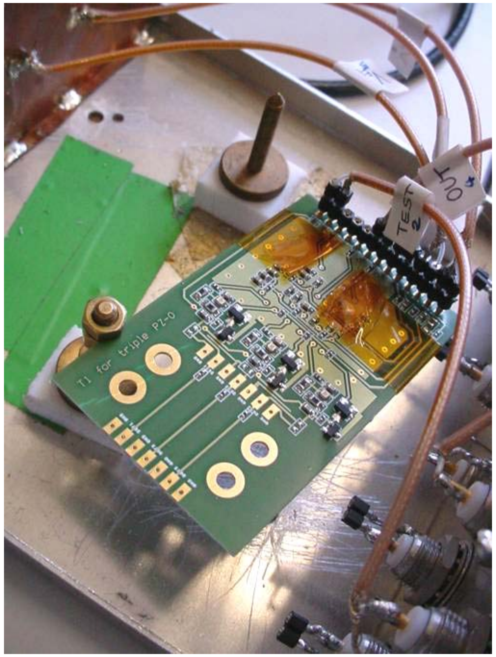
For bench tests and test with detectors




T1 for triple PZ-0


Horizontal
Trigger
Vertical
Ext Trig
Digital




T1 for triple PZ-0
TEST 2
OUT

First test bench characterization

PCB triple PZ-0 as delivered by TVR & Mipot

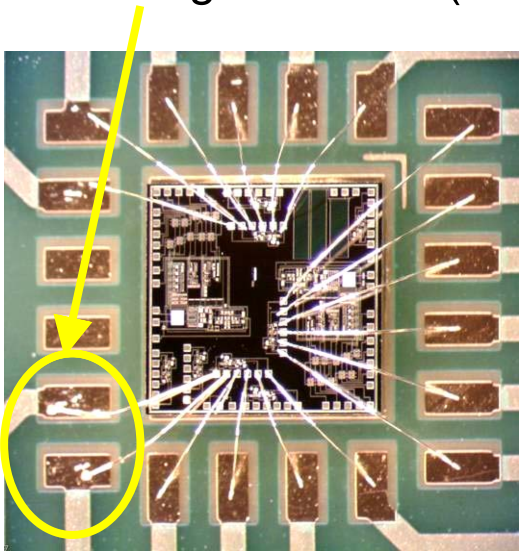
with resistor/diode protection devices for the input JFET

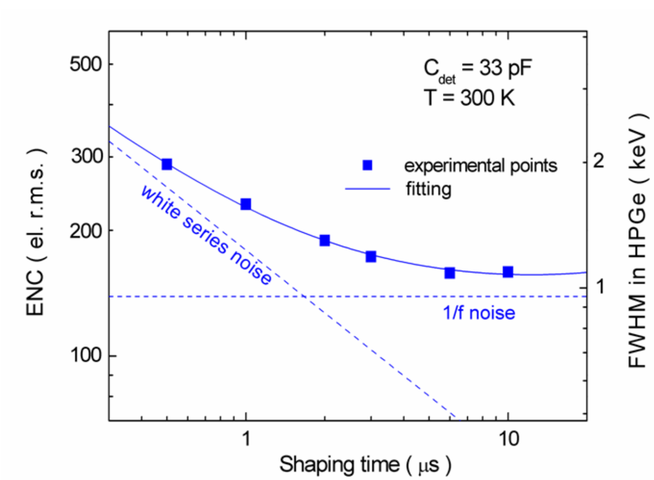
3 channels operating with pretty uniform and good performances

C_F = 0.1 pF, C_{det} = 0 pF	Channel 1	Channel 2	Channel 3
Gain - 1 MΩ term.	404 mV/ MeV	403 mV/ MeV	409 mV/ MeV
Gain - 50 Ω term.	207 mV/ MeV	207 mV/ MeV	213 mV/ MeV
Gain - 150 Ω term.	307 mV/ MeV	306 mV/ MeV	313 mV/ MeV
Output voltage swing - 1 MΩ term.	2.699 V	2.711 V	2.704 V
Input energy dynamic range	6.68 MeV	6.73 MeV	6.61 MeV
ADC energy range (1V) - 1 MΩ term.	2.47 MeV	2.48 MeV	2.44 MeV
ADC energy range (1V) - 50 Ω term.	4.83 MeV	4.83 MeV	4.69 MeV
ADC energy range (1V) - 150 Ω term.	3.26 MeV	3.27 MeV	3.19 MeV
Rise time - 1 MΩ term.	22.6 ns	22.7 ns	22.4 ns
Rise time - 50 Ω term.	30.2 ns	31.5 ns	31.0 ns
Rise time - 150 Ω term.	26.1 ns	26.5 ns	26.5 ns
Fall time	125 μs	131 μs	115 μs
ENC (τ = 3 μs)	**111 e^-**	**109 e^-**	**119 e^-**
FWHM (τ = 3 μs)	**0.765 keV**	**0.749 keV**	**0.818 keV**

After few tests Channel 3 no more operating:

found 2 “ball” bondings (instead of “wedge” bondings) that were made three times + handling the board (flexible cuflon) => the contacts may have broken down





CHANGE: C_F **= 0.2 pF,** C_{det} **= 33 pF**	**Channel 1**	**Channel 2**
Gain - 1 MΩ term.	258 mV/MeV	284 mV/MeV
Gain - 50 Ω term.	134 mV/MeV	148 mV/MeV
Gain - 150 Ω term.	197 mV/MeV	218 mV/MeV
Output voltage swing - 1 MΩ term.	2.745 V	2.770 V
Input energy dynamic range	10.64 MeV	9.75 MeV
ADC energy range (1V) - 1 MΩ term.	3.87 MeV	3.52 MeV
ADC energy range (1V) - 50 Ω term.	7.46 MeV	6.76 MeV
ADC energy range (1V) - 150 Ω term.	5.08 MeV	4.59 MeV
Rise time - 1 MΩ term.	26.4 ns	27.9 ns
Rise time - 50 Ω term.	35.8 ns	38.3 ns
Rise time - 150 Ω term.	31.2 ns	33.6 ns
Fall time	172 µs	175 µs
ENC (τ = 6 µs)	**158 e⁻**	**151 e⁻**
FWHM (τ = 6 µs)	**1.083 keV**	**1.041 keV**

Study of cross talk between the 3 channels in one circuit

Capacitive cross-talk (irrespective of termination)

The cross-talk signals have an opposite polarity (positive) with respect to the main signals (negative): cross-talk is due to the coupling capacitance between the output of one channel and the input of the other channel

Feedback from power supplies with 50-150 Ω term.

The power required by one channel to drive a signal on the low output impedance determines a ringing in the negative power supply voltage that causes a cross-talk waveform on the other channels (superposed to the capacitive cross-talk).

- 1M Ω term. => same behavior at the test bench as with SUB detector:

  cross-talk (capacitive) from channel 1 to channel 2 : 0.5 %
  cross-talk (capacitive) from channel 2 to channel 1 : 2 %
  estimated coupling capacitance values: 1fF and 4 fF

- 150 Ω term. => different behavior at the test bench or with the SUB

  Test bench: feedback from power supply has a long time scale and gets negligible after shaping. Therefore the cross-talk seen after shaping is the capacitive one (0.5 % - 2 %)

  SUB detector: feedback from power supply becomes dominant so that the cross-talk net signal has the polarity of the main signal (negative) and a larger amplitude (~ 7 %)

  ⬇

  This cross-talk effect comes from the use of long power supply cables + cryogenic temperature (further study needed)

Conclusions on capacitive cross-talk:

- it is very low (only 1 fF and 4 fF) thanks to the careful PCB design
- it cannot be eliminated. A further reduction could be obtained using 3 separated channels on different PCBs
- it can be software-corrected for the measured signals: matrix of cross-talk correction with pre-set parameters

Conclusions on feedback from power supply:

- it can be eliminated using no cable-termination (reflections are absorbed by Thevenin termination, provided by the 50 ohm series resistance on the PCB)
- using a 50 ohm cable-termination, currently we could make it negligible only at the test-bench (after shaping).

Next ASIC run:

- use of 0.35 μm CMOS technology (instead of 0.8 μm)
- integration of PZ0 + differential output stage
- new version of PZ0 with improved original output stage
- more spaced bonding pads in order to simplify bonding procedure

Next PCB production:

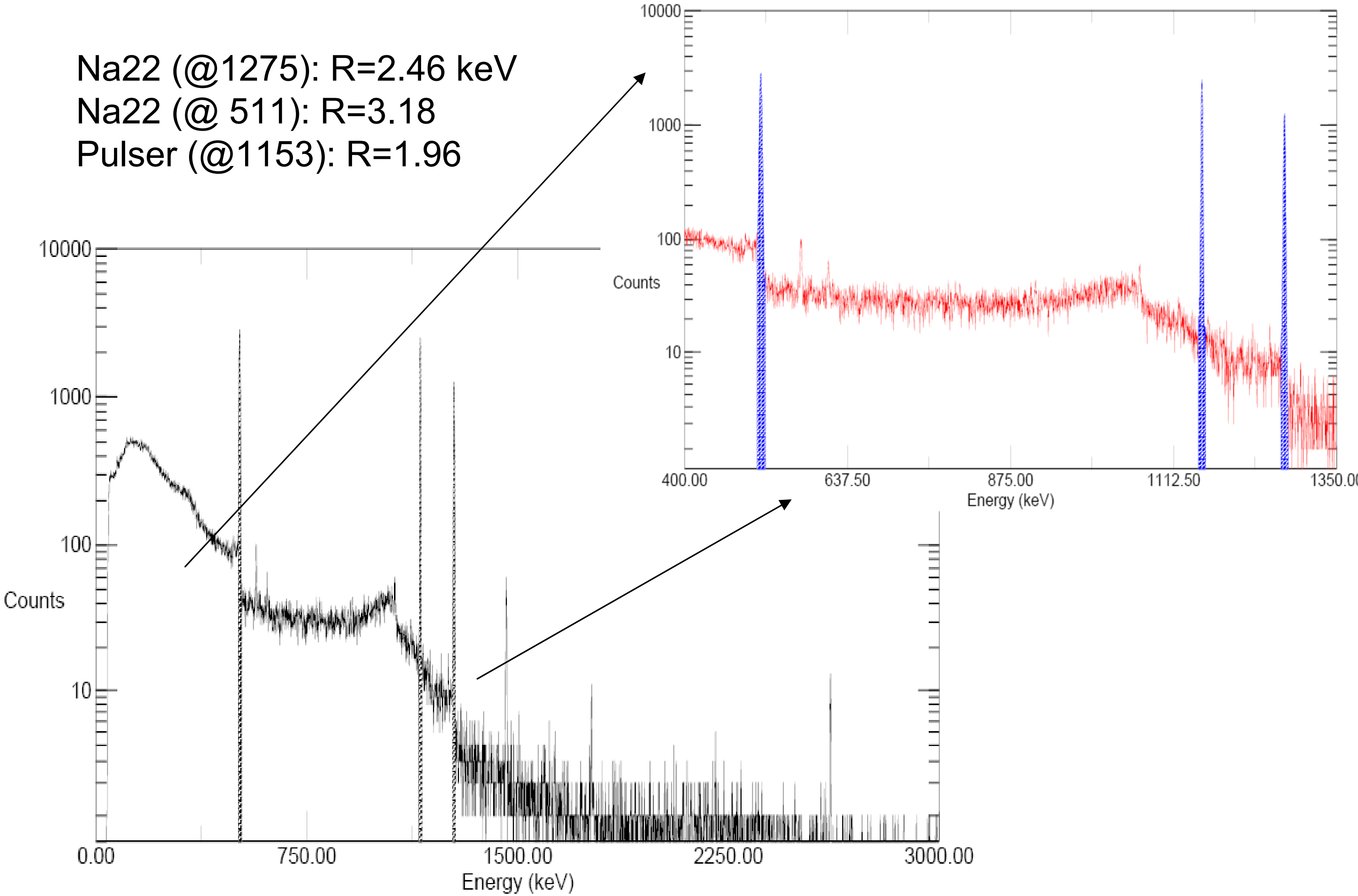
- after finding out the component responsible for Ra contamination (0.9 Bq/kg) not yet determined
- Screened up to now (PCB, FET, Rf, Solder paste, 1 over 3 types of C): no one of the measured component responsible (only for few %) for measured high Ra content in complete circuits. 2 type of C and 1 type of R are t.b.measured. See TG11 talk

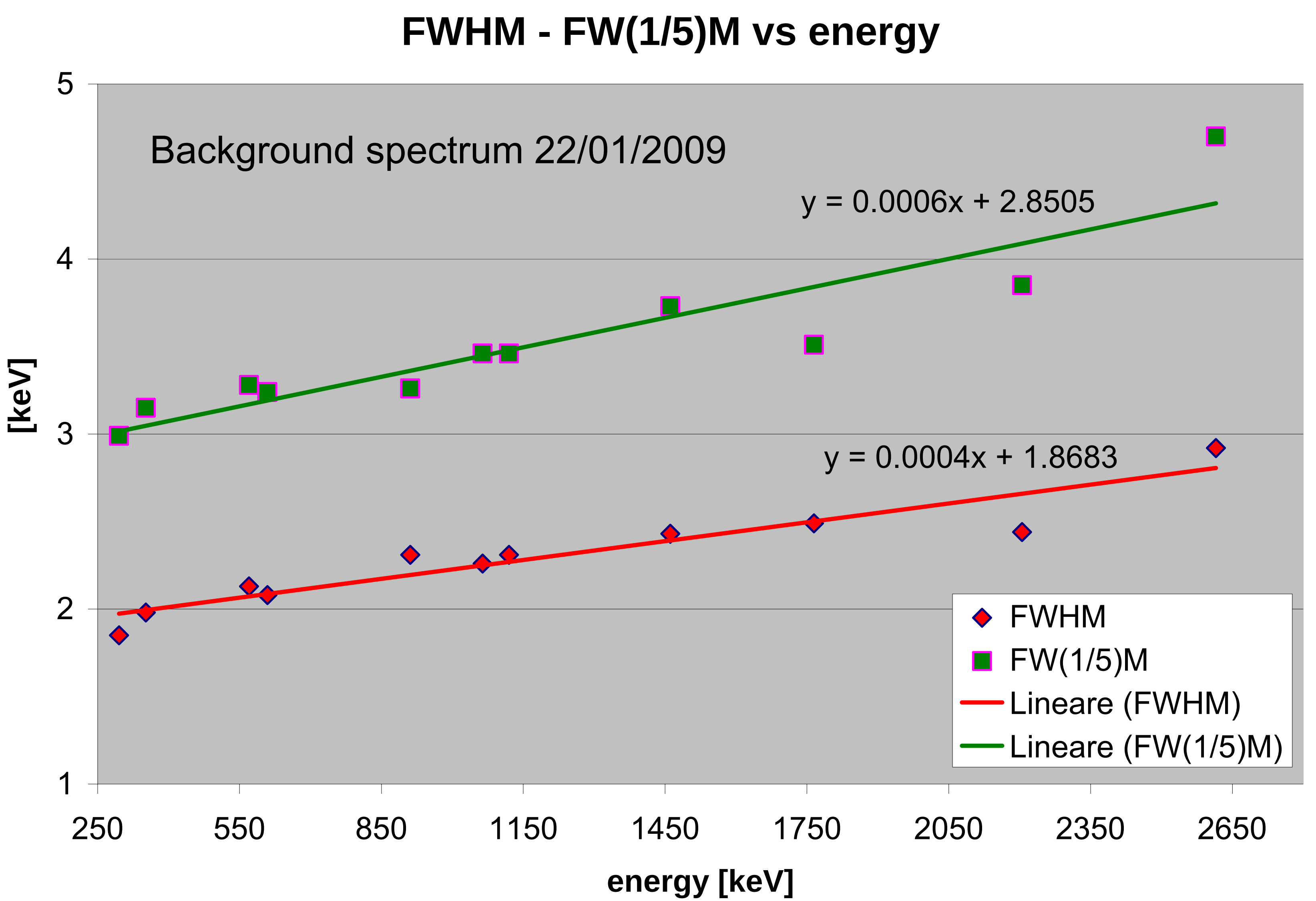
Test of 3ch circuit with encapsulated detector (SUB)

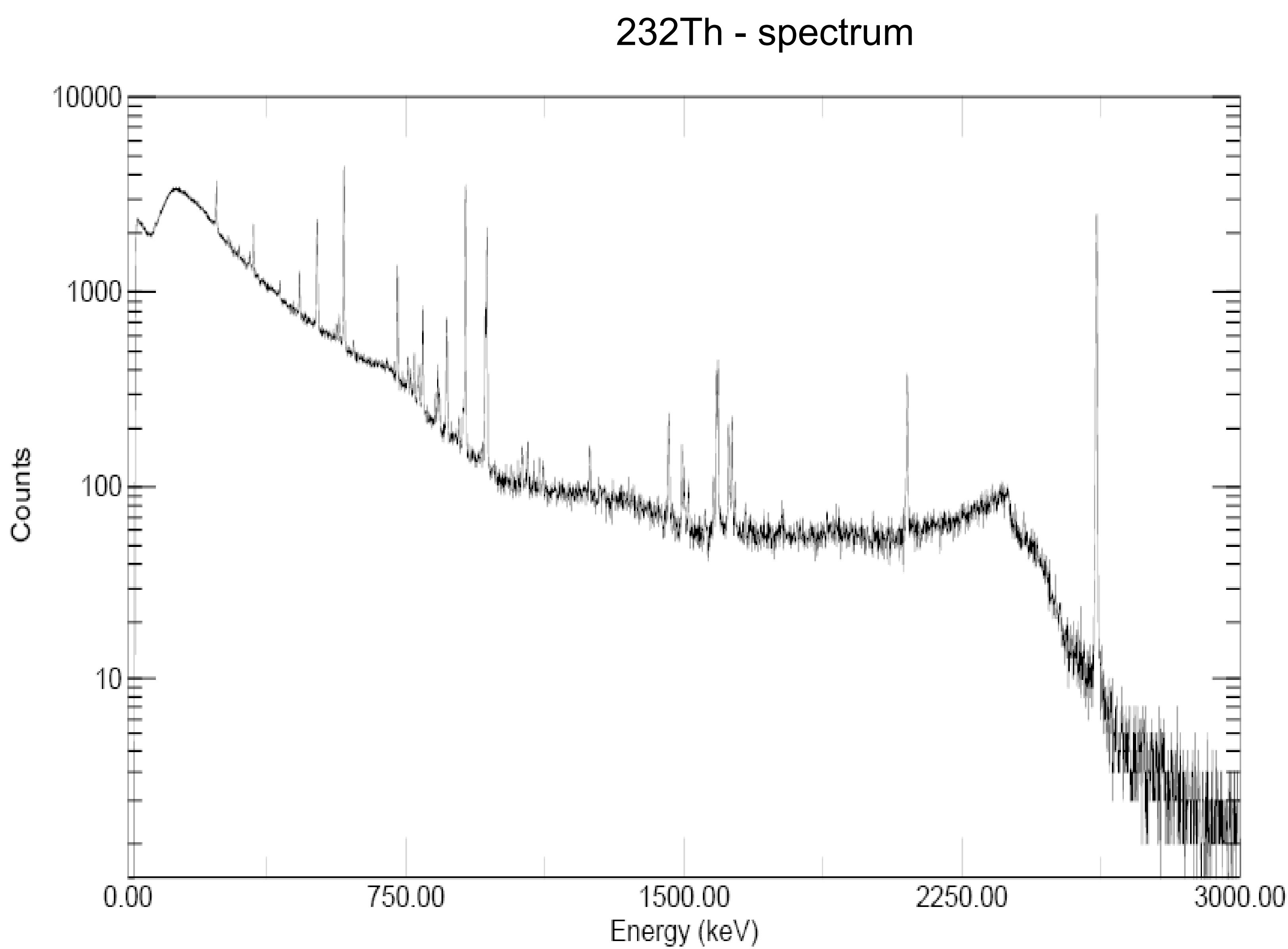
- Performed spectroscopy (^{22}Na,^{232}Th,Bckgrd) measurements and acquired waveform for
  - Determination of performances when coupling the circuit to the detector
  - Cross talk study between the 3 channels
  - Acquire waveform to perform analysis (developed new algoritms) of digitized pulses

^{22}Na + pulser

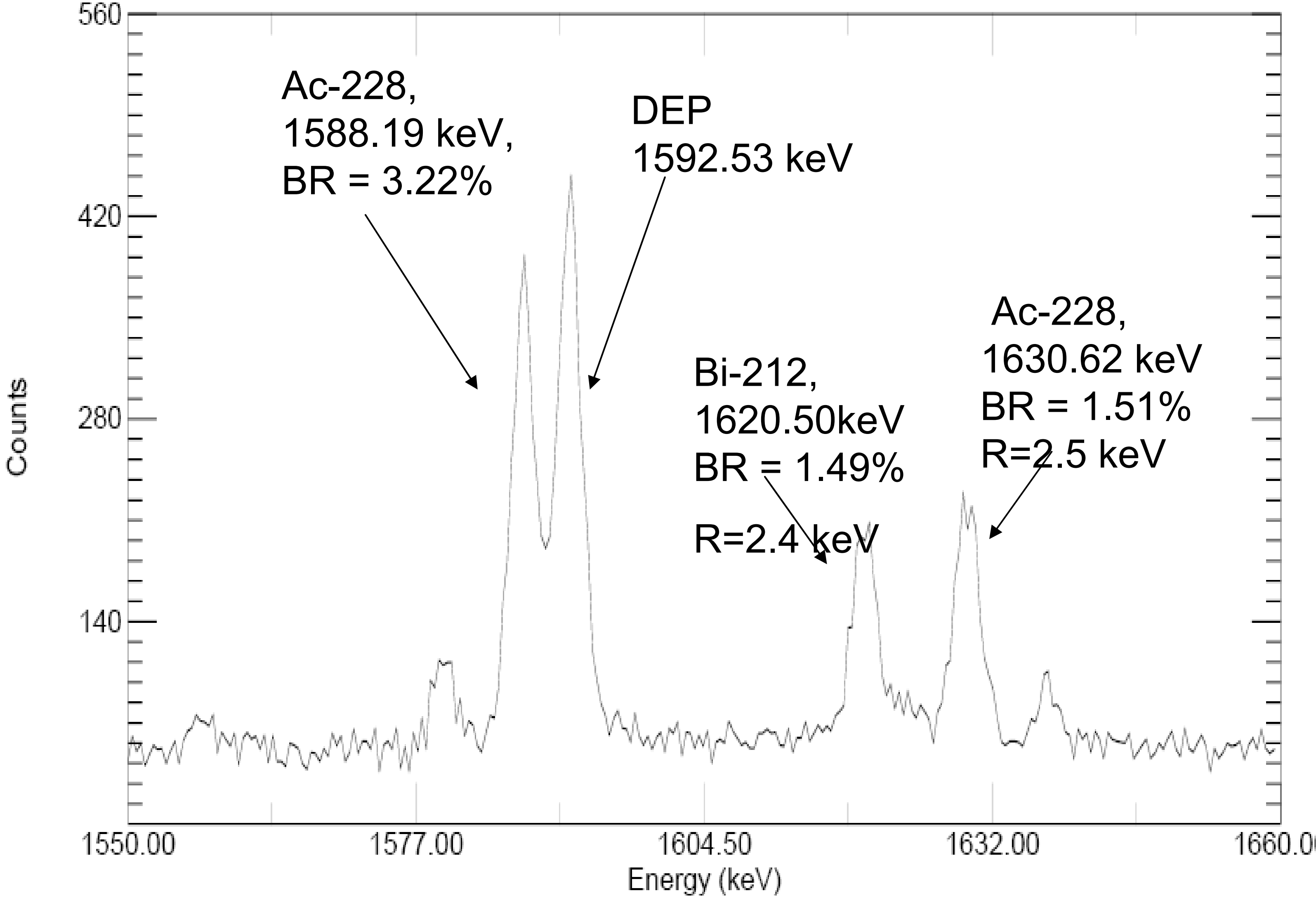
Na22 (@1275): R=2.46 keV
Na22 (@ 511): R=3.18
Pulser (@1153): R=1.96



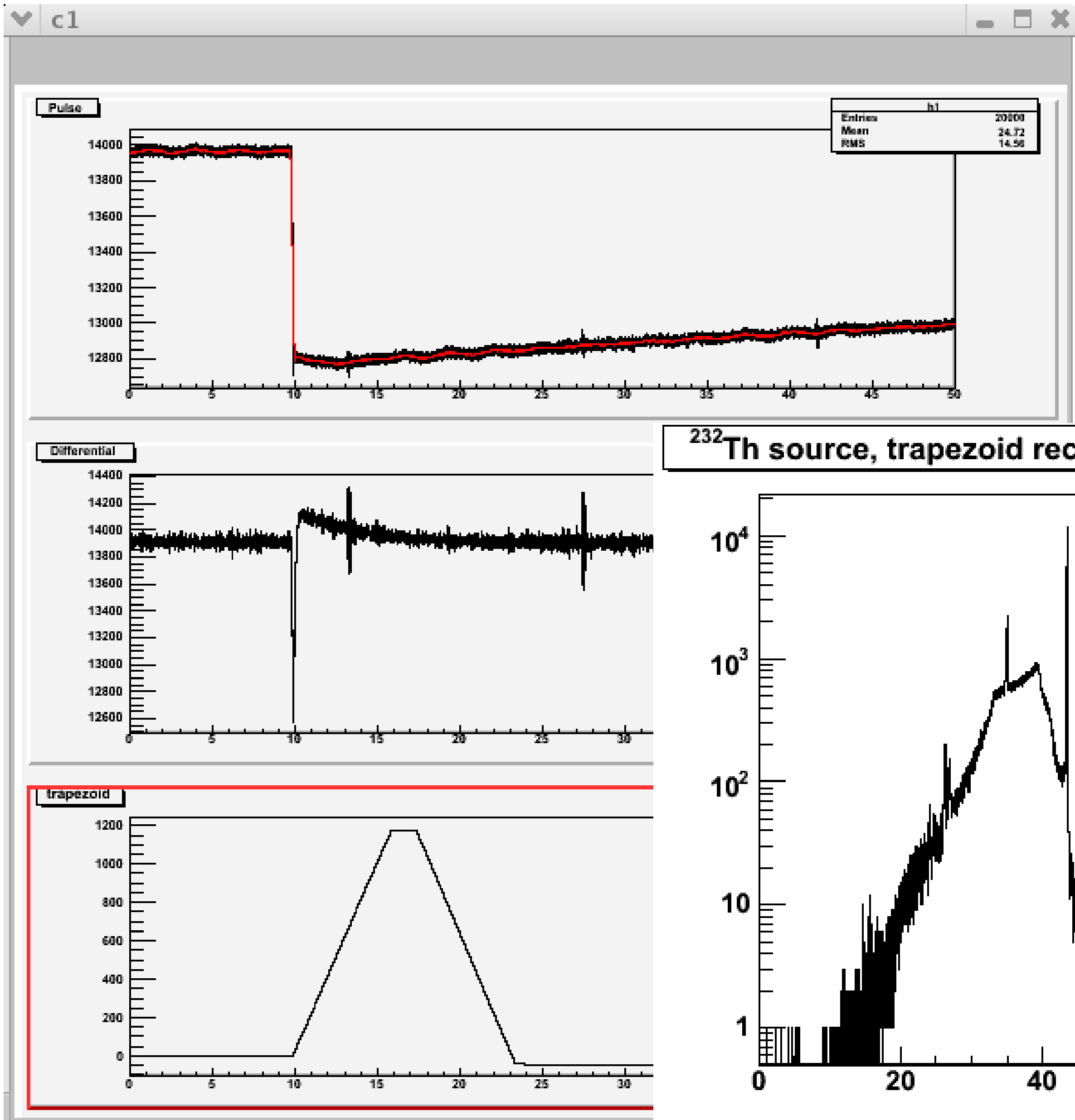

FWHM - FW(1/5)M vs energy
Background spectrum 22/01/2009
y = 0.0006x + 2.8505
y = 0.0004x + 1.8683
[keV]
5
4
3
2
1
250
550
850
1150
1450
1750
2050
2350
2650
energy [keV]
FWHM
FW(1/5)M
Lineare (FWHM)
Lineare (FW(1/5)M)


232Th - spectrum
Counts
10000
1000
100
10
0.00
750.00
1500.00
2250.00
3000.00
Energy (keV)

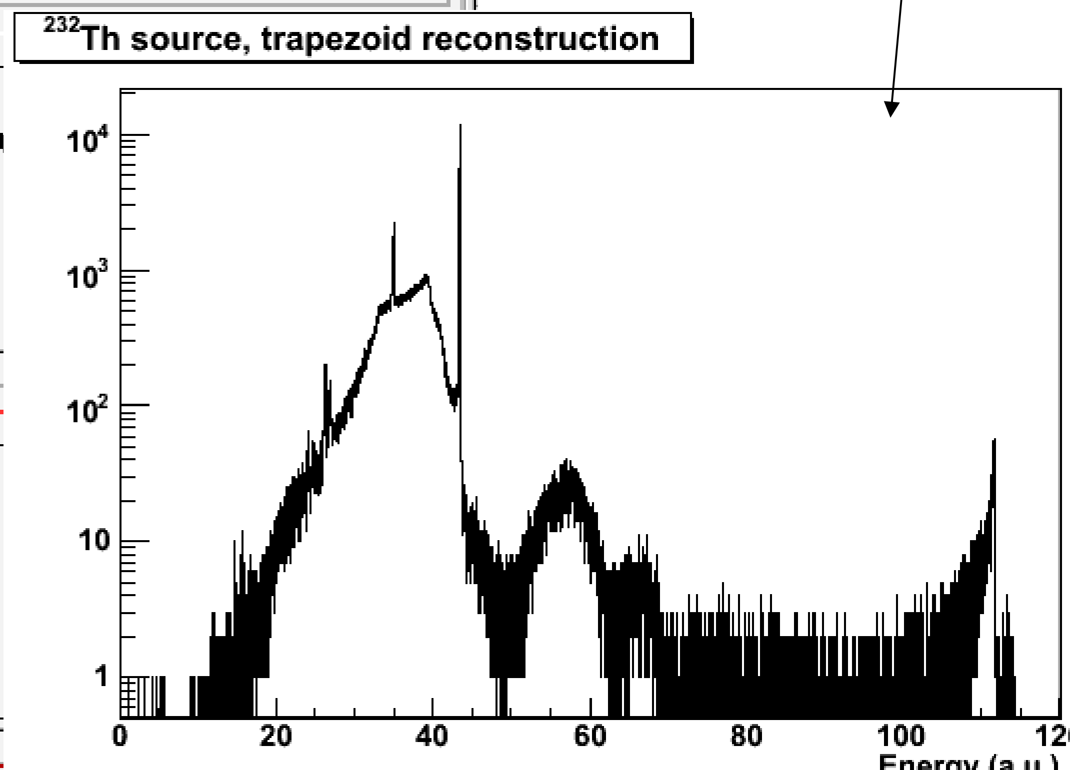
232Th DEP region



Waveform DAQ: ^{232}Th source, high thrs~ 1.3 MeV

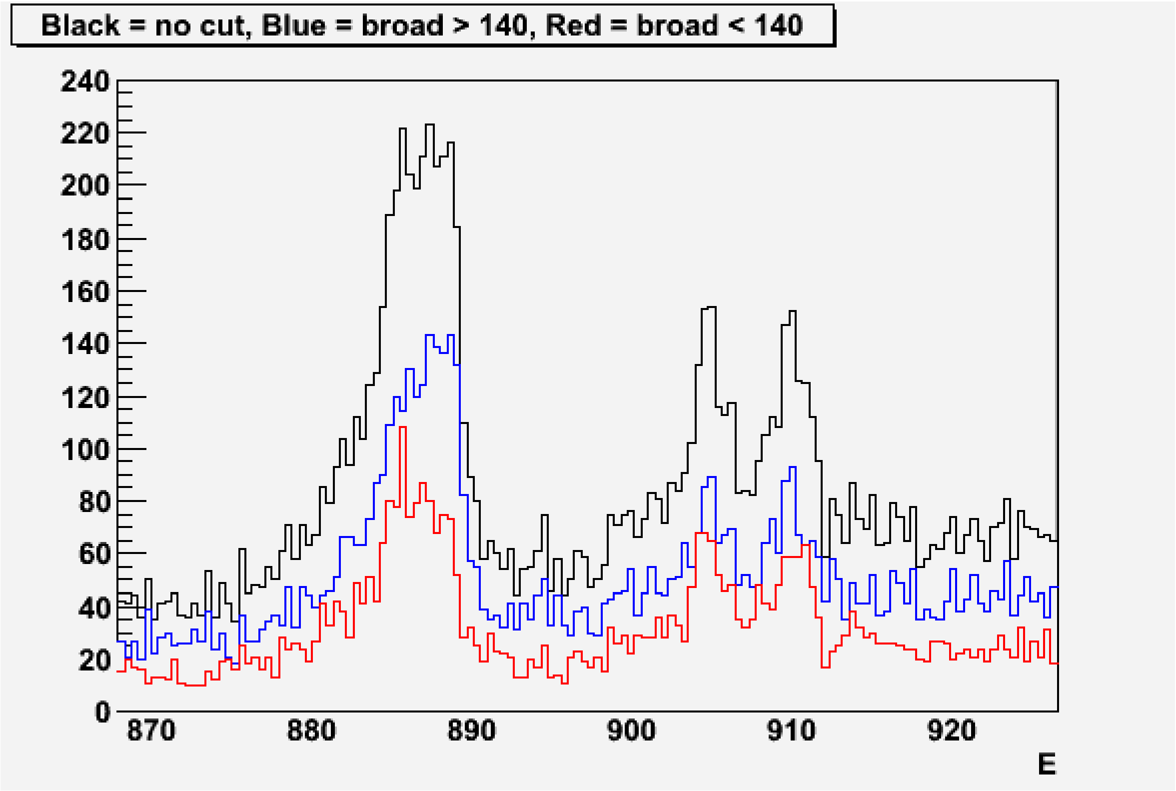


Work in progress: preliminary



Work in progress: preliminary.

Analysis applying “broad” parameter from HdM publication (Hellmig & Klapdor 2004)



Test with Prototype detector at LNGS

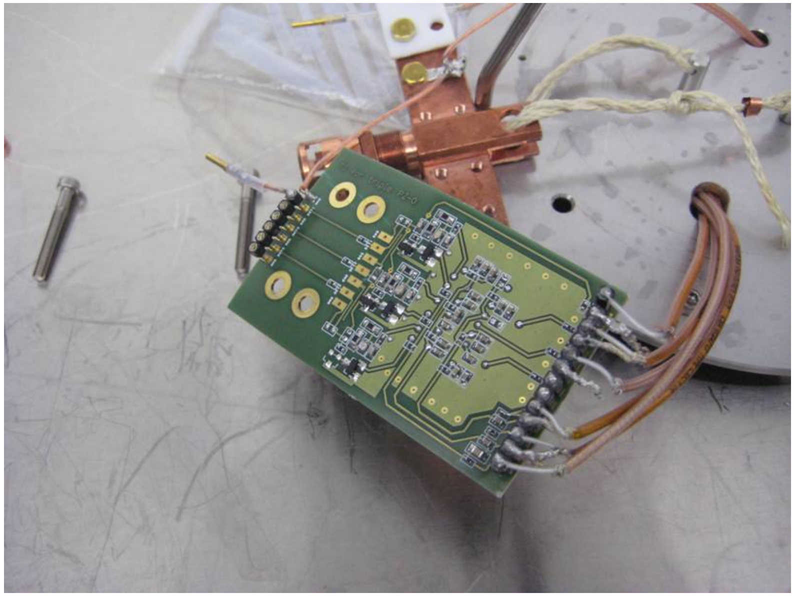
3-ch circuit closed in a Cu box for EM shielding.

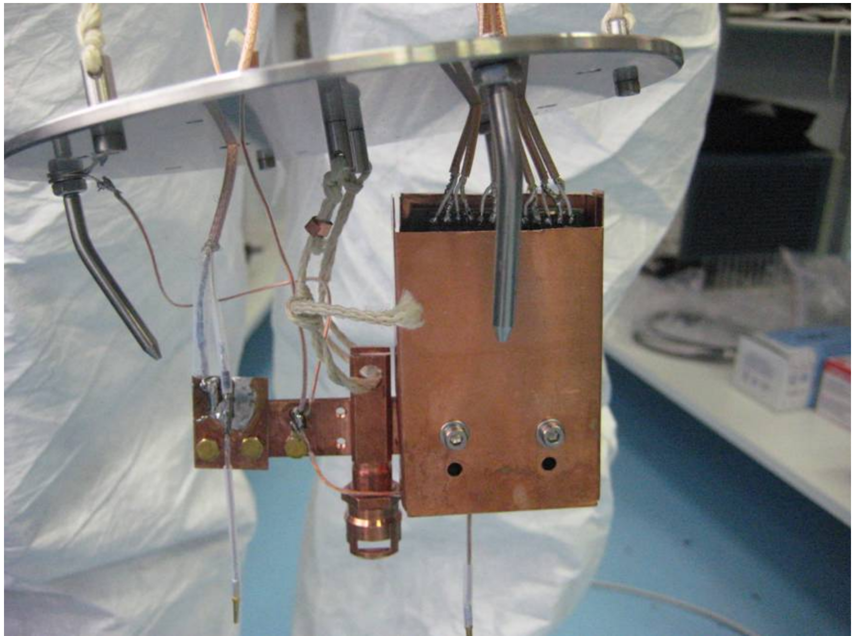
R @pulser(Cdet=0) = 2.0 keV (τ=6μs) (no detector, mounting and cabling as with detector)

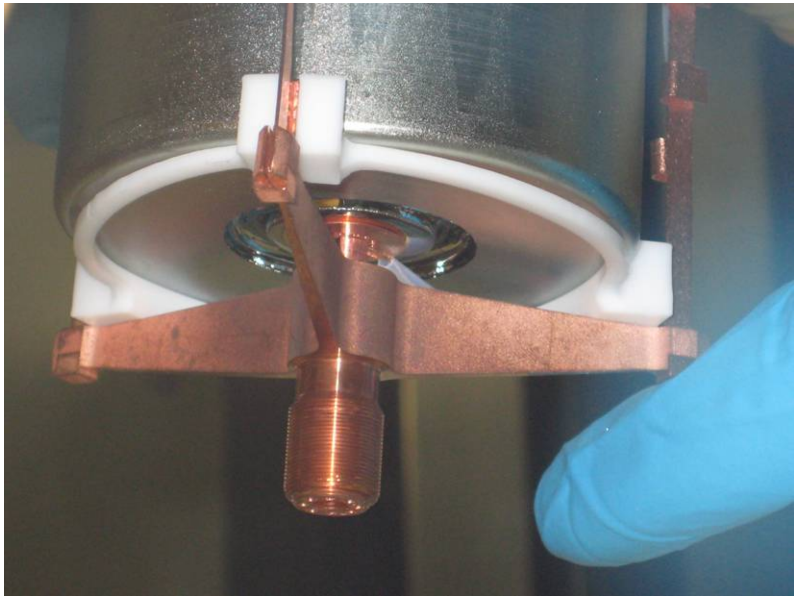
When connected to detector with 1 stage cold HV filter.

R@1332 keV= 3.5 keV (τ=6μs)

R@pulser = 3.0 keV (τ=6μs)

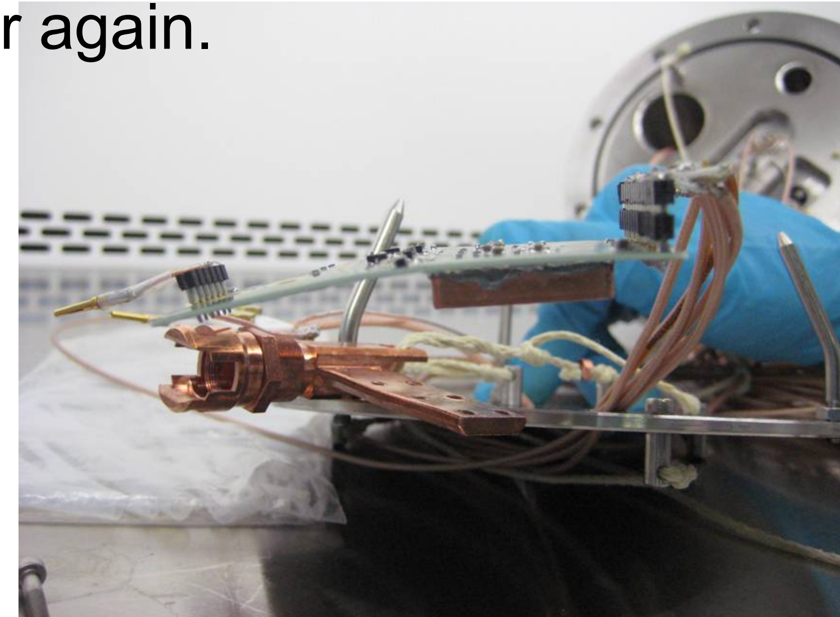






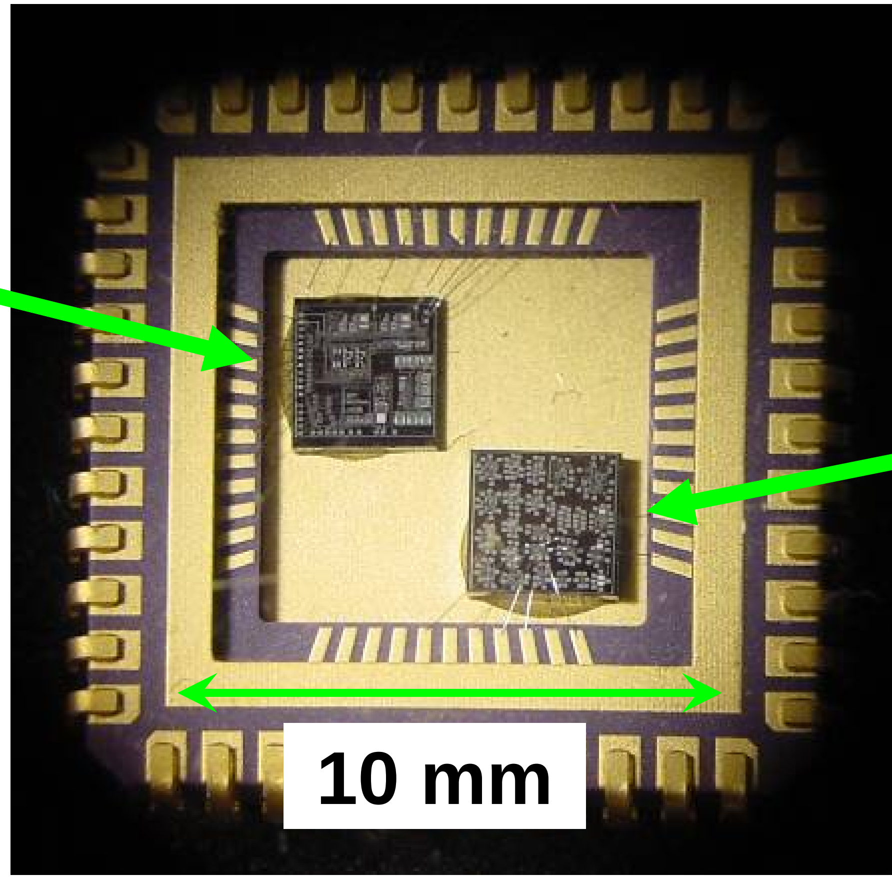
Problems encountered and solved

- Detector took current (1 nA) suddenly after LAr refilling → dismount completely, wash and remount the detector from its holder/contacts.
- OK LC down to 15 pA @ 3.5 kV.
- PCB after some cooling cycles bend show bending and touch the Cu EM shield.
- Problem solved by putting an insulator PTFE sheet between circuit and box, circuit ready to be cooled down and connected to detector again.



Strategy to drive 50 Ohm load and get rid of cross-talk
Preamplifier and Line Driver

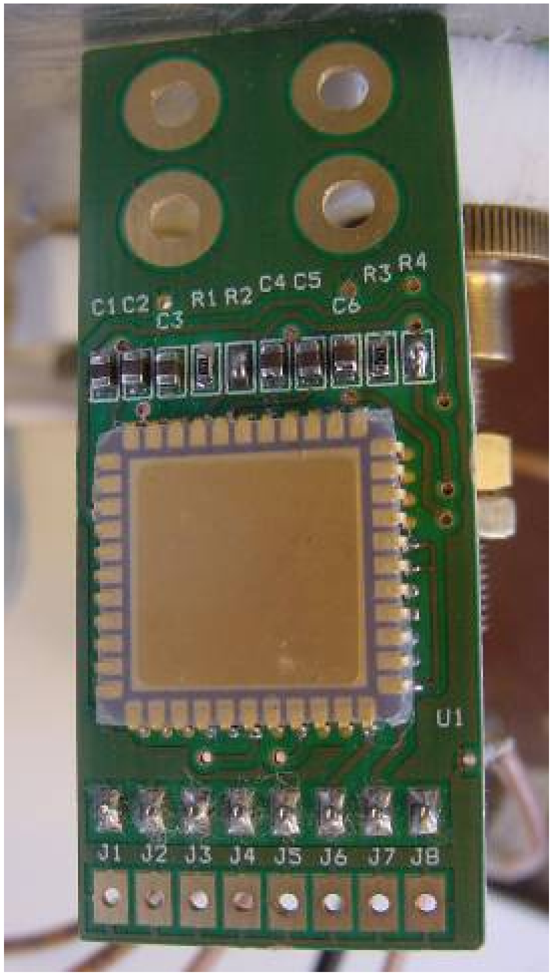
Differential Line Driver



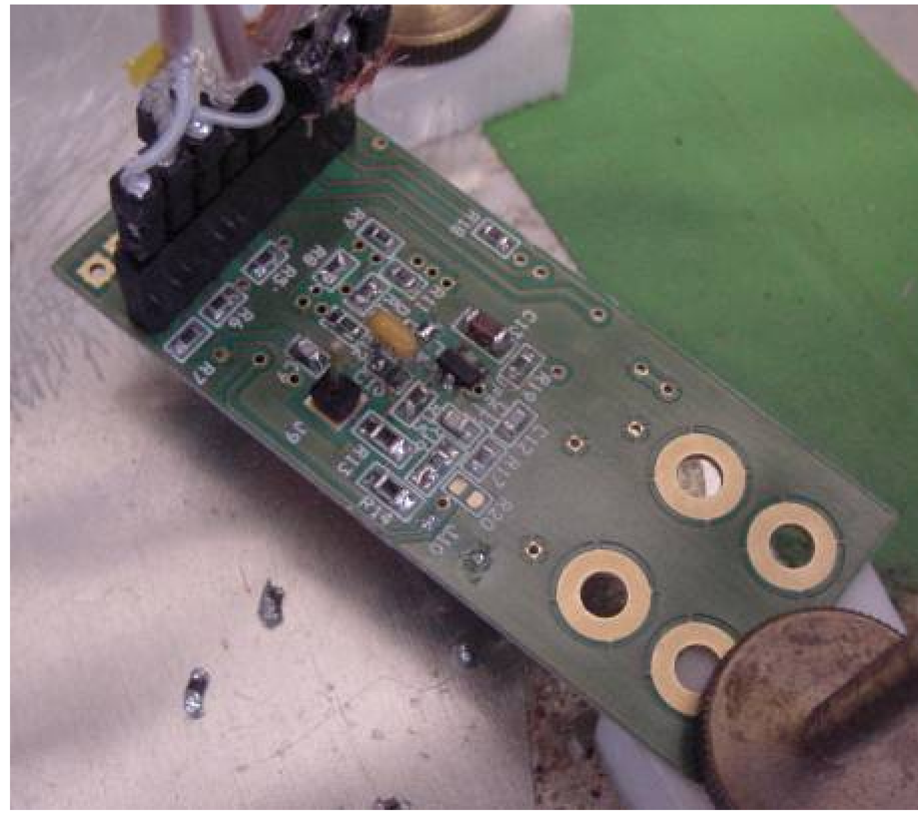
Preamplifier PZ0

Power Supply ≈ ± 2.5 V, Power Cons. ≈ 25 mW,
Differential Output Range ≈ 8V
(before 50 Ohm series resistance on 50 Ohm Terminated Cables)

Populated Printed Circuit Board

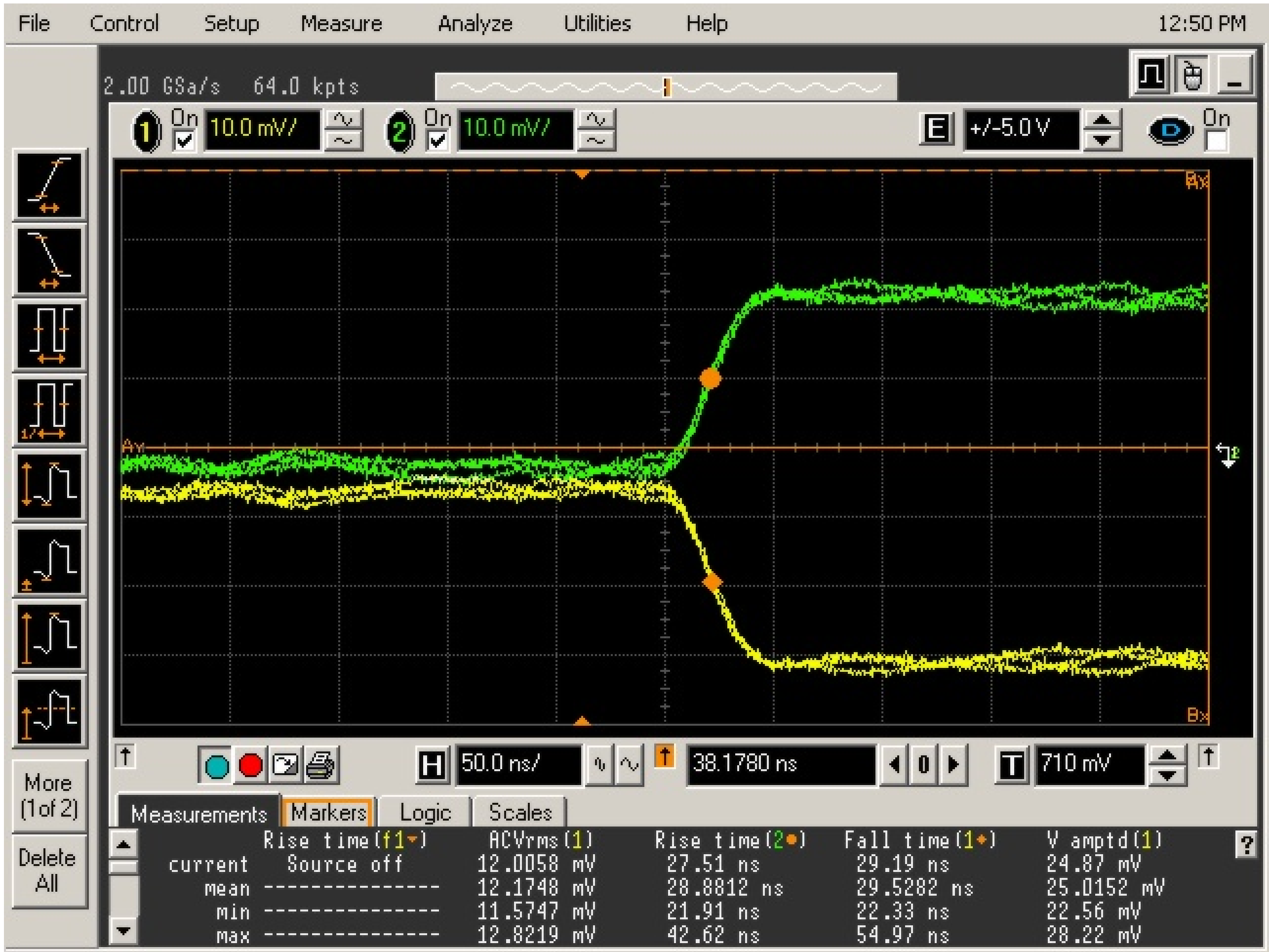


Top



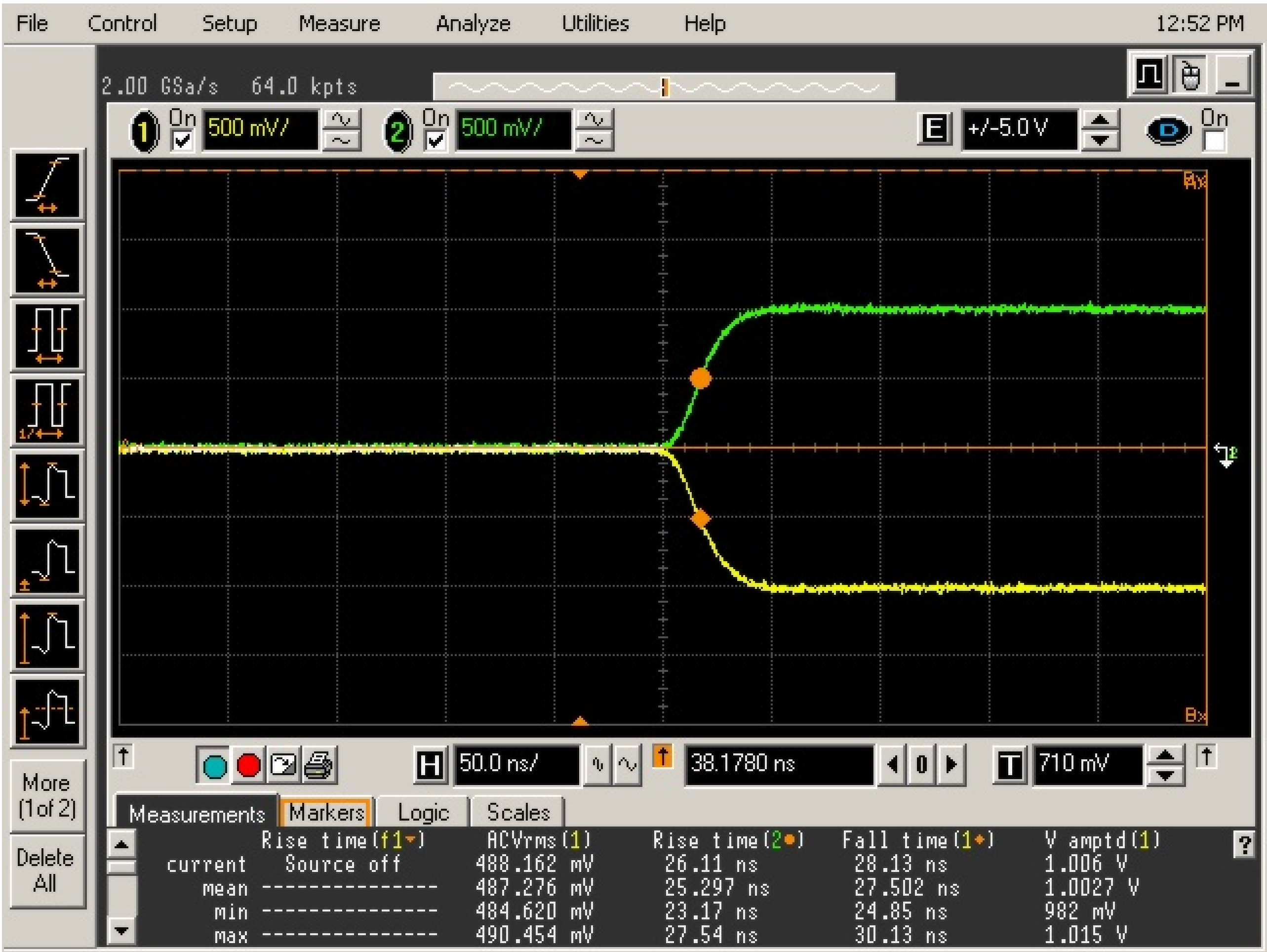
Bottom

Signal Front (50 Ohm termination)



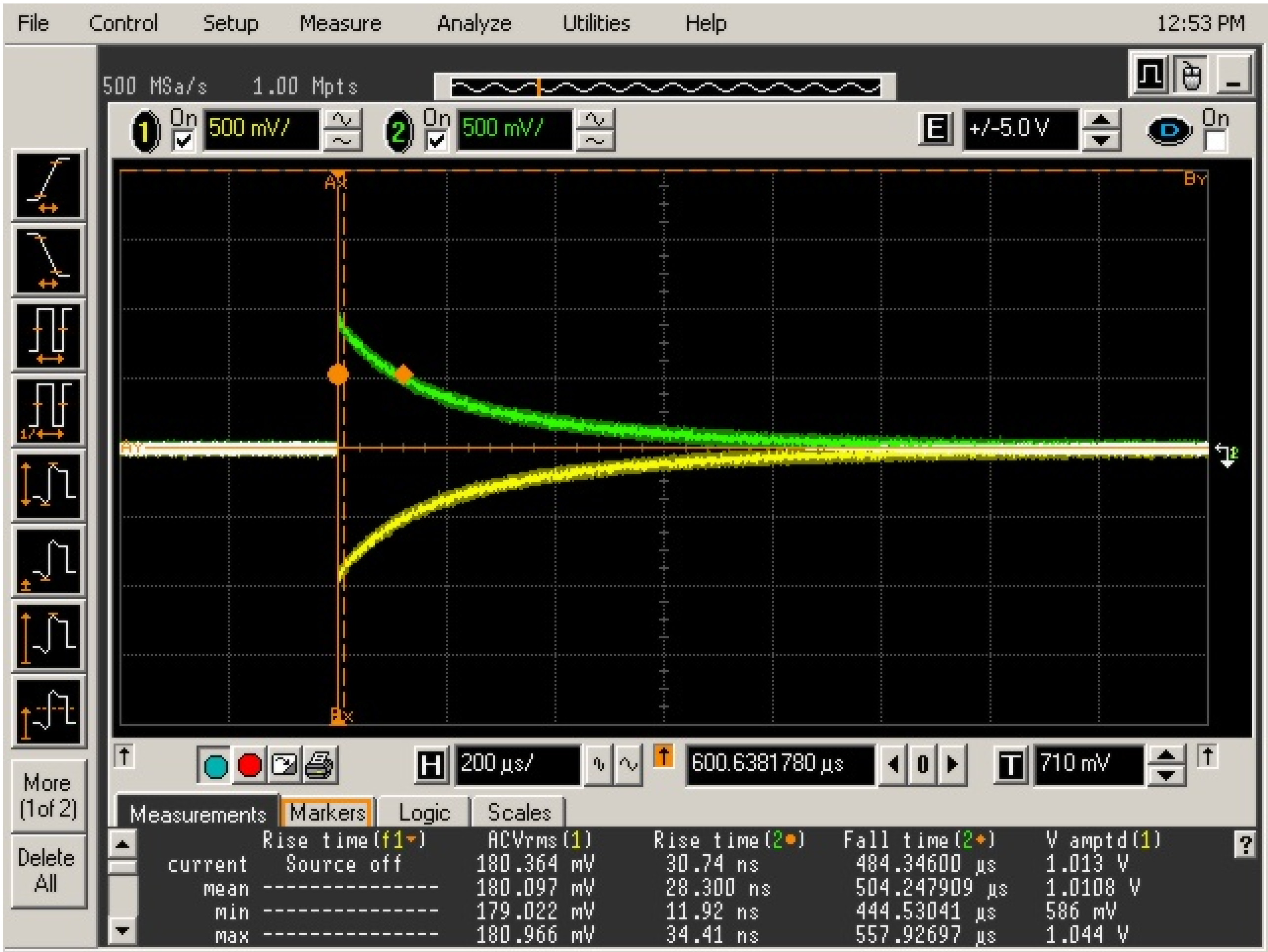
Rise Time for Small Signal ≈ 28 nS

Signal Front (50 Ohm termination)



Rise Time for Large Signal ≈ 25 nS

Signal Decay (50 Ohm termination)



Fall Time ≈ 500 uS

Next Steps

- Solder Mask Removal ? (1 week)

Circuit Test with HPGe (1 week)
(Bicocca University, Milano)

Tests for Output Crosstalk (1 week)
From Power Cables?
Estimation of PSRR – Power Supply Rejection Ratio

Tests for Output Saturation (1 week)
Effect of Cosmic Rays
How Preamplifier and Differential Line Driver
Recover from Saturation at Liquid Nitrogen Temperature?

Conclusions

- PCBs for the 3-ch PZ0 ASIC has been produced and tested.
- 3 ch FE circuits based on the 3-ch PZ0 ASIC has been tested at the bench test. Noise slightly larger than 1 ch circuit due to protection devices (FET and R39 Ohm).
- Connection and measurement to encapsulated detector performed
  - (R=2.5 keV @ 1332 keV, τ= 10 μs)
- Connection and measurement to naked detector performed
  - (R=3.5 keV @ 1332 keV, τ= 6 μs) → confirmation of presence parallel noise
  - Naked detector is in good health LC<15 pA @ 3.5 kV
  - PCB (teflon made) bends after some cooling cycles due to the Cu ASIC lid. Short circuit problem of the LV with EM shield (grounded) solved. Need to continue work to understand and mitigate source of parallel noise appearing when connecting the detector.
- Test with encapsulated detector showed a cross talk problem between channels related to power absorption, resistivity of cables, when the circuit is terminated on 150 Ohm. Need further study, understanding and mitigation actions
- → PZ0 followed by ASIC differential line driver pf PZ1. Already tested at test bench, next week with detector.
- PCBs component screening almost completed but responsible for high Ra content not yet identified.