# Ge Detector Test Bench for Front End and Signal Processing at LNGS

*Gerdella*

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# Outline

- Description of *Gerdella*: the encapsulated detector bench test.

- Test performed
  - 1st test cool down
  - 2nd cool down: warm Amptek 250 CSA readout
  - 3rd cool down: cold IPA4 monolithic jfet CSA readout

# Purposes of the *Gerdella* bench test

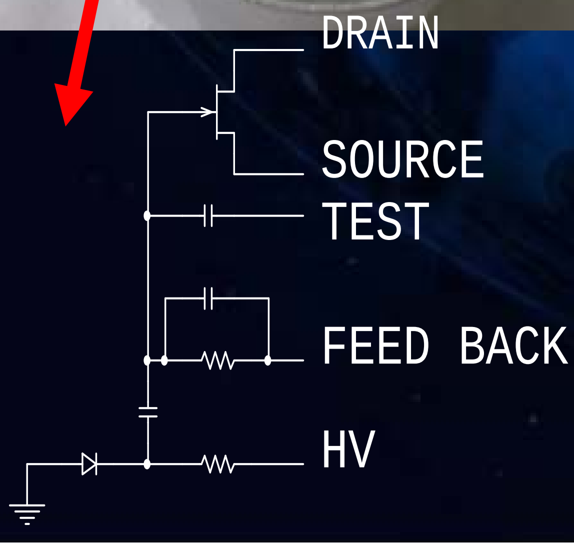
- Test of cold FE circuits in same conditions for comparison and final choice.
- Study of resolution vs FE-detector distance.
- Test and debugging of the FADC based DAQ Gerda-Phase I system (and training of people)
- Further development of Pulse Shape Analysis (PSA) algorithms collected in the Jspecview suite. (Moving Window Deconvolution, Optimum Filter, etc.)

# Goals of present work

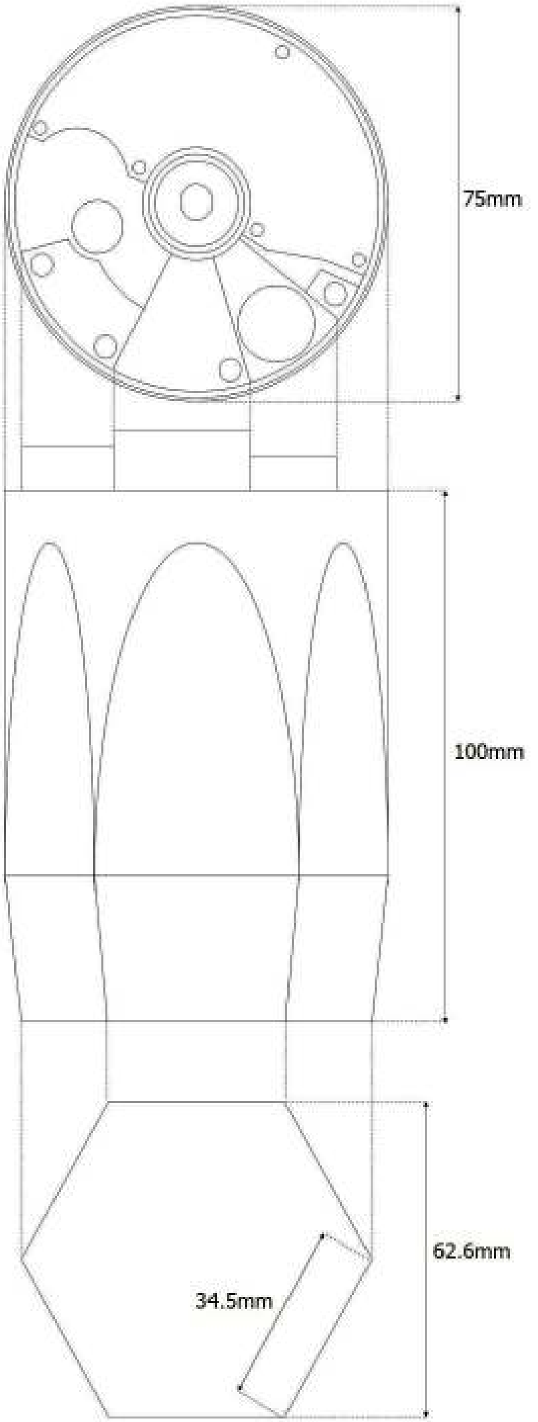
•Tuning of Gerdella (Detector handling, cool down, Front end – Detector connection, cabling, noise reduction, etc.)

# Bench-Test Detector

- Ge capsule of former Euroball exp.
- N-type, positive HV 4500V



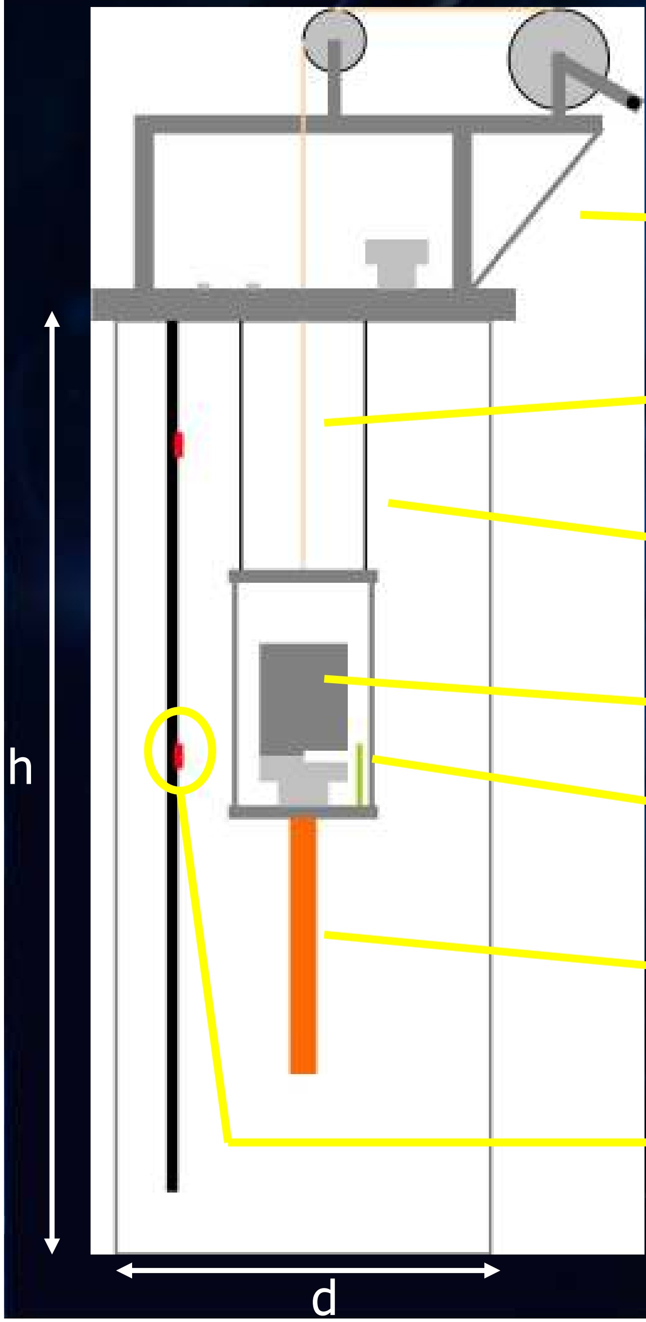

FWHM at 1.33MeV (60Co)
2.2 - 2.4 keV
Rel. Efficiency ~ 23.1%



# Bench-Test

Dewar:

$$\left.\begin{array}{l} d = 27cm \\ h = 75cm \end{array}\right| \Rightarrow V \cong 43l$$




Flange and suspension system

Teflon wire connected at external winch to lower detector

Kevlar safety cord

Detector

FE electronics

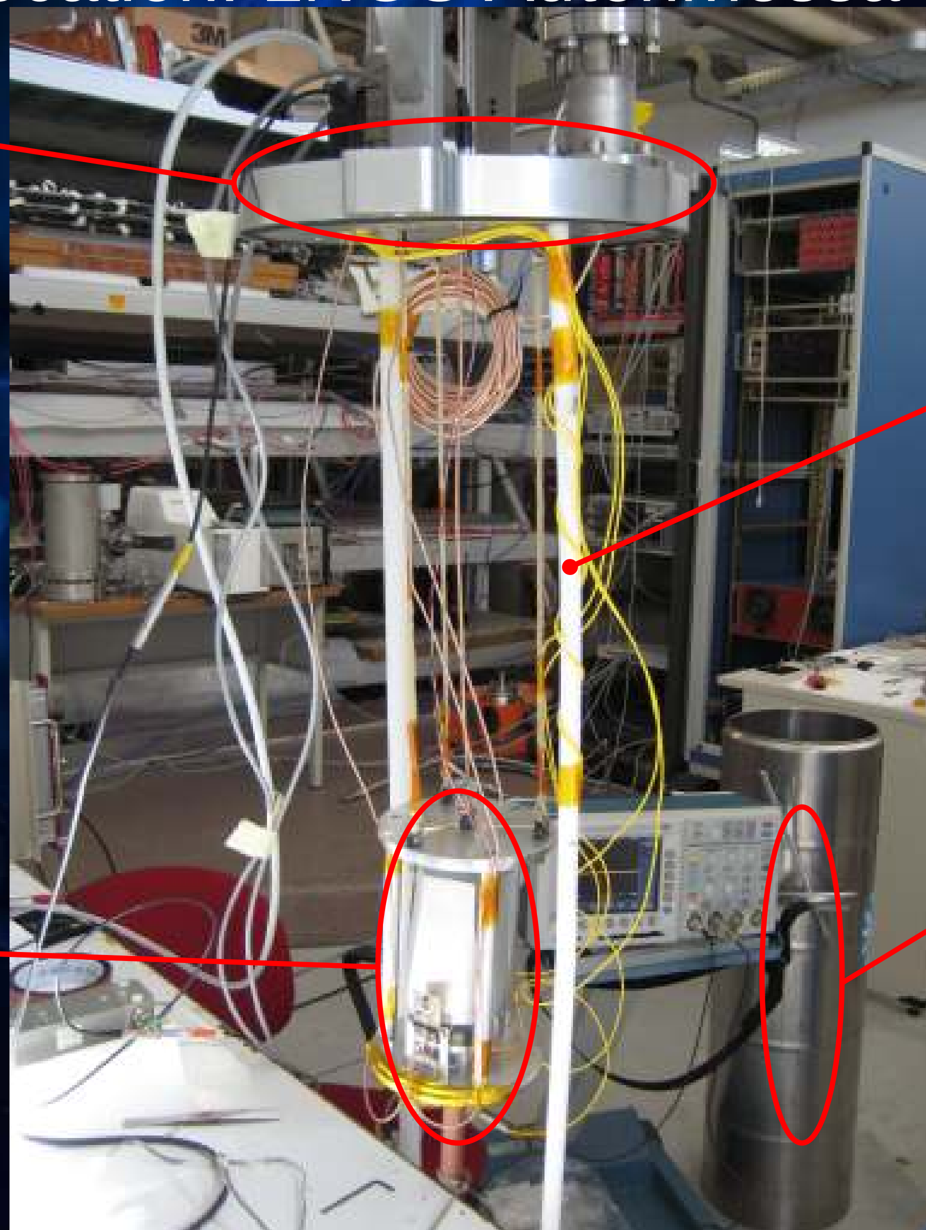
Cu cold finger

3 PT1000:

- 2 on teflon stick
- 1 on the detector

# Bench-Test

Location: LNGS Autorimessa 7



# Bench-Test

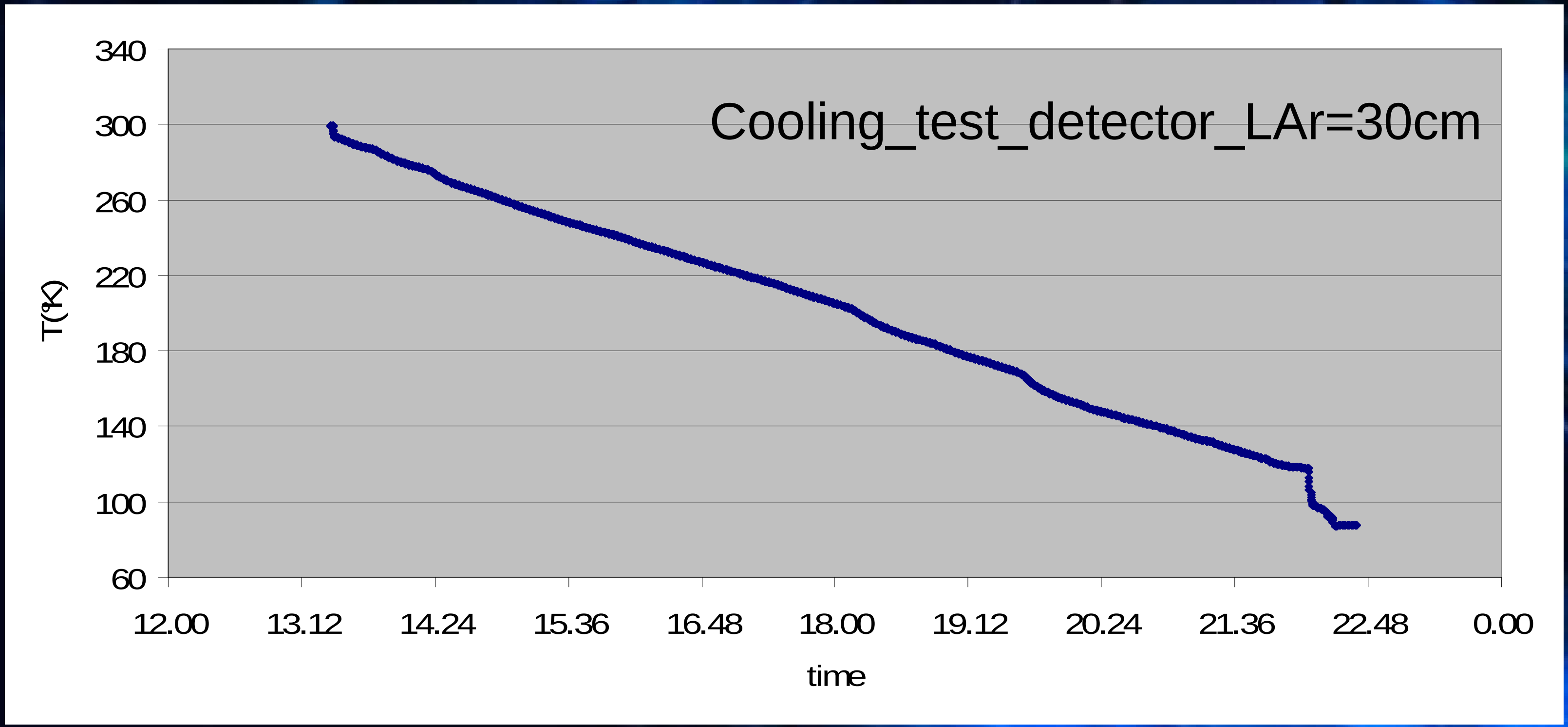
## Flange and suspension system

- Winch used to slowly lower the detector in the cryogenic bath, to allow slow dilatation of materials
- Signal connectors Fischer 102-104 (signals, LVs, PT1000 etc.)
- HV flange: sealed  Padova design equipped with 10 m long HV coaxial cable

# Bench-Test

## Cooling down

- Cooling down speed (20K/h) regulated by:
  detector lowering speed, cold finger, power resistor
- PT1000
  - Monitor detector's temperature
  - to track level of LAr




Before submerging the detector several tests performed with a mock-up to tune the lowering speed

# Performed test of front-end electronics

•Circuits tested with detector:
AMPTEK A250 (warm)
IPA4 (InterFET) (cold)

•Circuit test without detector
CMOS Fully Differential with Integrated Input Transistors

•Pulse Processing:
✓Standard γ-Spectroscopy: ORTEC 672 Spectroscopy Amplifier+919E EtherNIM Multi-Channel Buffer

✓PCI-NIM based DAQ System: CAEN N1728 four-channel digital pulse processor and waveform digitzier in one unit NIM format, 100MHz (10 ns/sample) 14 bit FADC, 10 ms max sampling time
“Oscilloscope” mode and “Energy” mode
(Moving Window Deconvolution algorithms)

# Pulse Readout by AMPTEK 250 CSA +BF862 (warm)

$$LV = \pm 6V\,(Elind)$$

$$C_T = 2\,pF$$

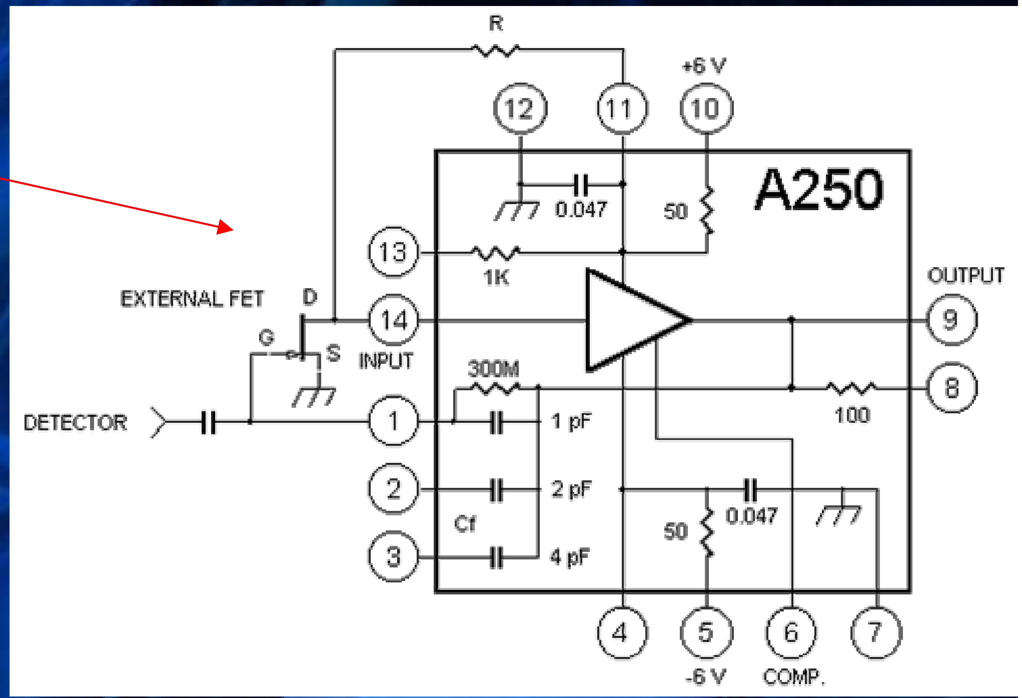
$$R_F = 300 M\Omega$$

$$C_F = 2\,pF$$

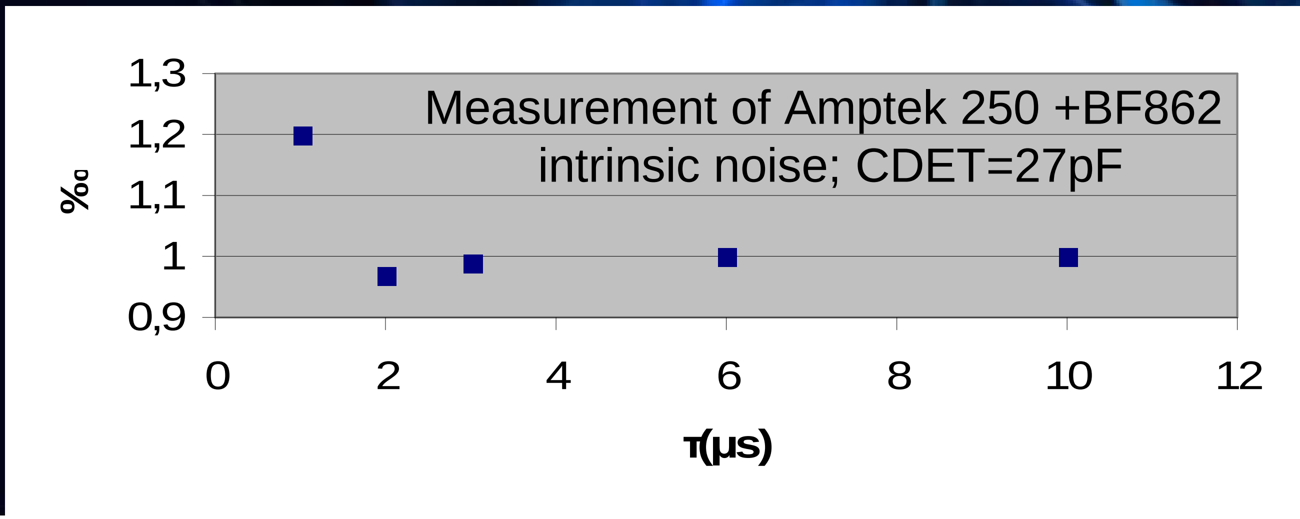
$$V_{IN,PRE}\,(= V_{TEST}) = 33mV$$

$$q_{IN} = 33mV \cdot 2\,pF = 66\,fC \approx 1.2MeV$$

$$|Det - FET| \cong 70cm$$

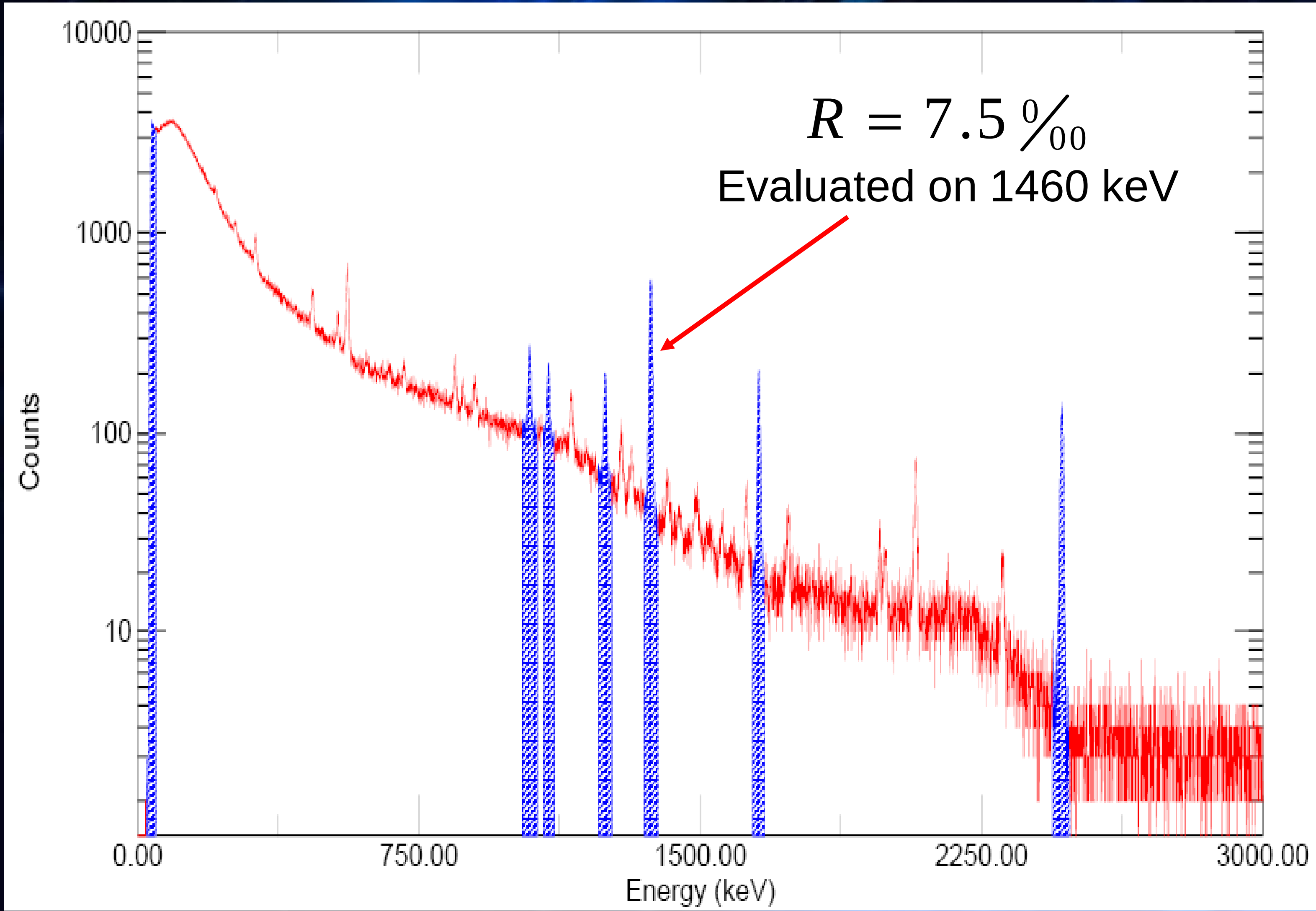




Circuit connected directly on flange to avoid noise introduced by cables




$$R = 1\text{‰} = 1.2keV$$

# Background Spectrum with Detector: Readout: AMPTEK 250 (warm)




Acquired: 24.01.08 19:47:59 Real time 48008.48sec Live time: 47957.08sec

Channels:16384

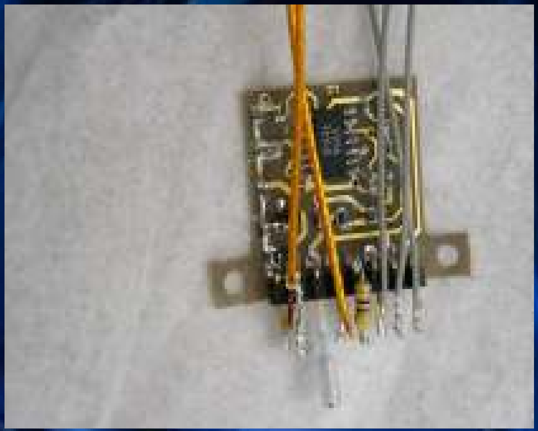
# Measured Intrinsic Noise of IPA4 (warm)

$$\left.\begin{aligned} V_{AL+} &= 12V \\ V_{AL-} &= -3.8V \end{aligned}\right| Elind$$

$$R_F = 1G\Omega, \quad C_F = 1pF$$

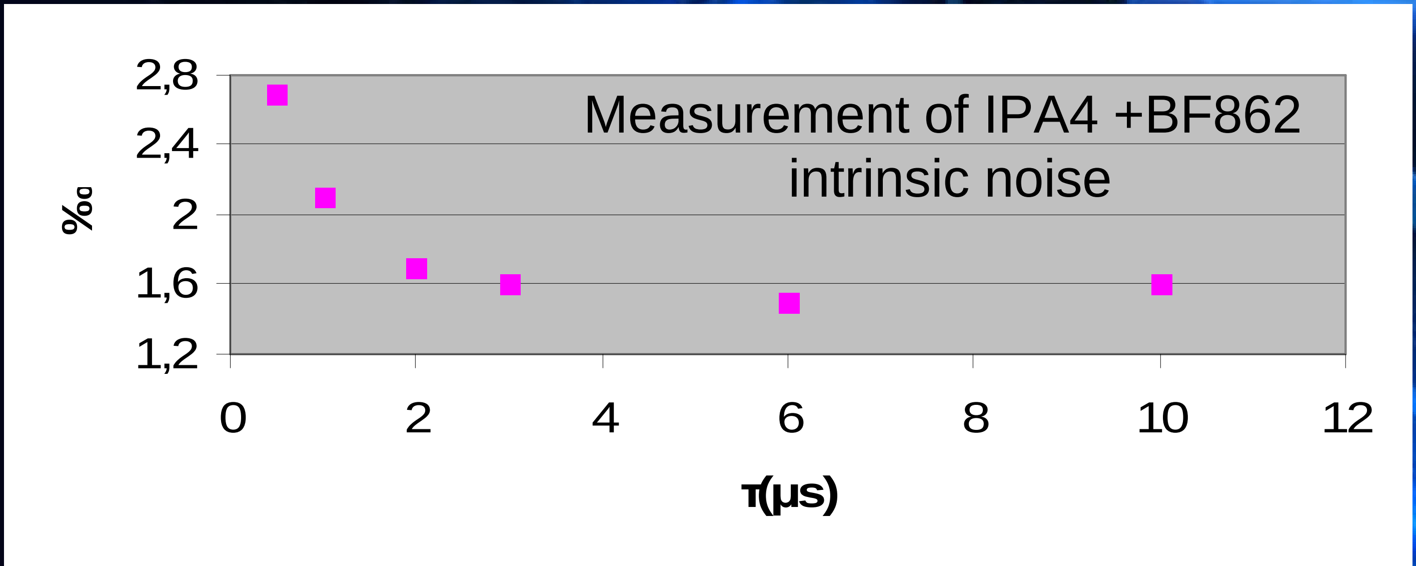
$$C_{DET} = 27\,pF$$

$$C_T = 1pF$$

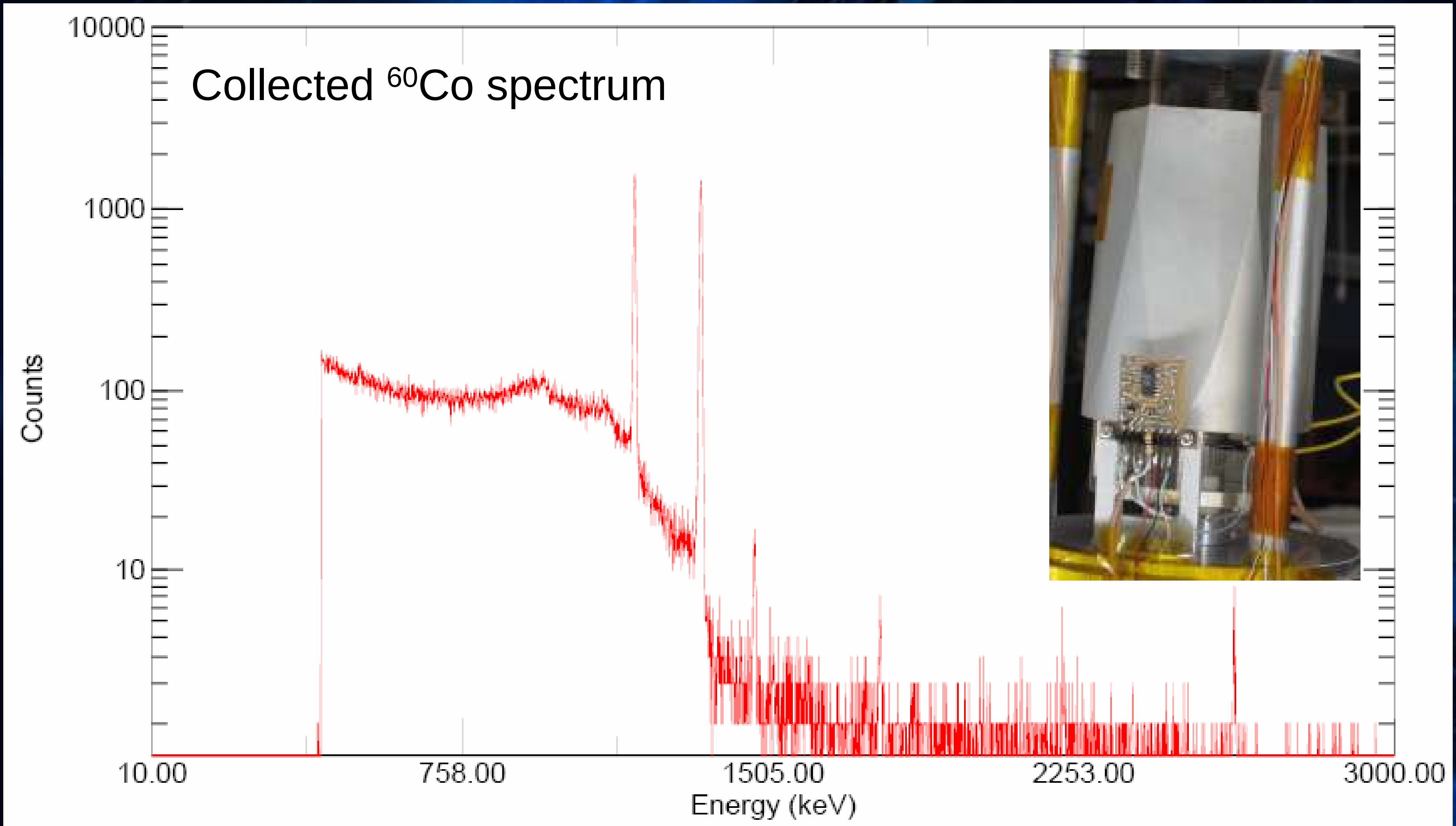


$$R = 2.4keV\ @1600keV$$

$$1.5\,\text{‰}$$

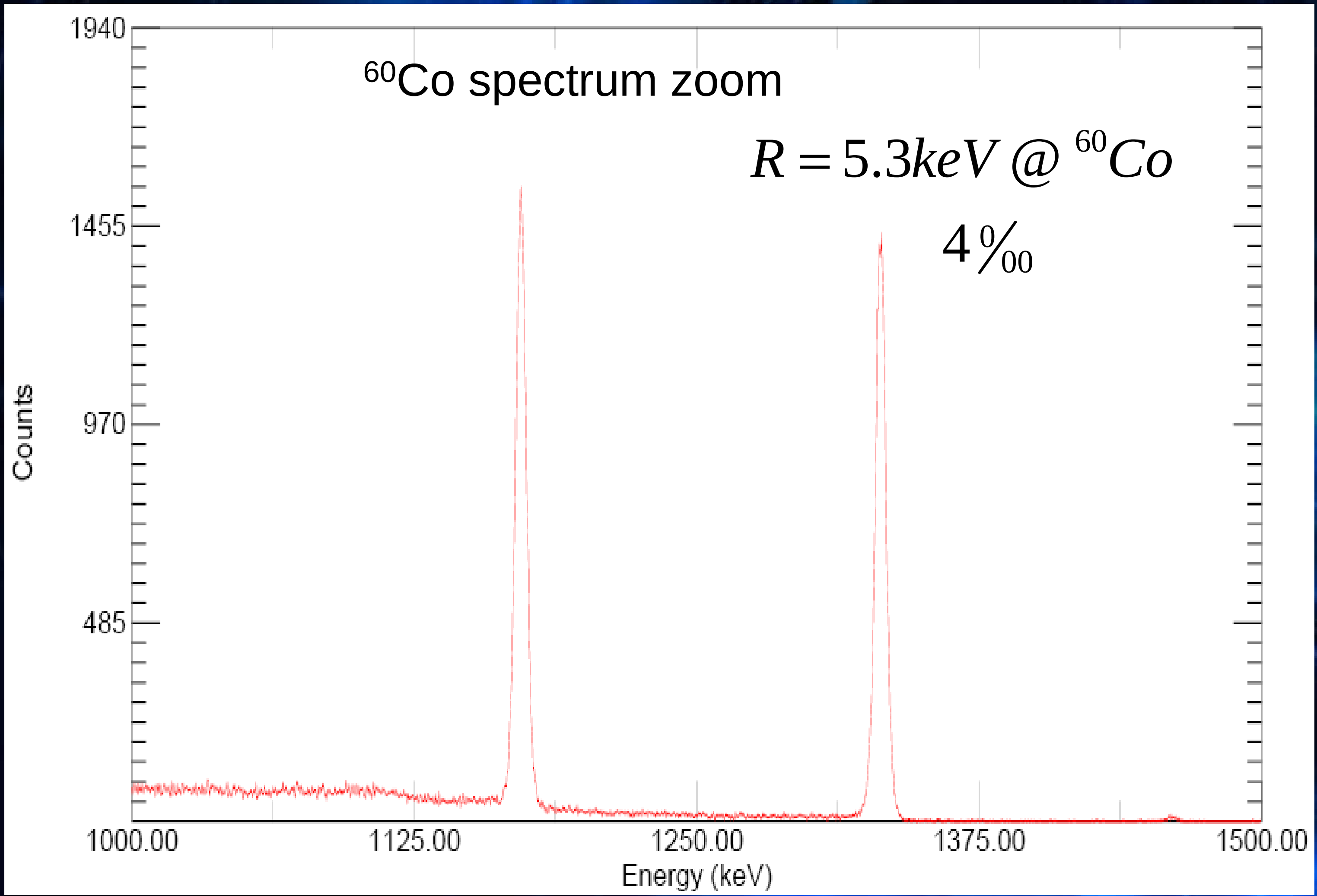


# Detector readout by cold IPA4




Acquired: 06.02.08 14:413:49 Real time 611.06sec Live time: 600.00sec
Channels:16384

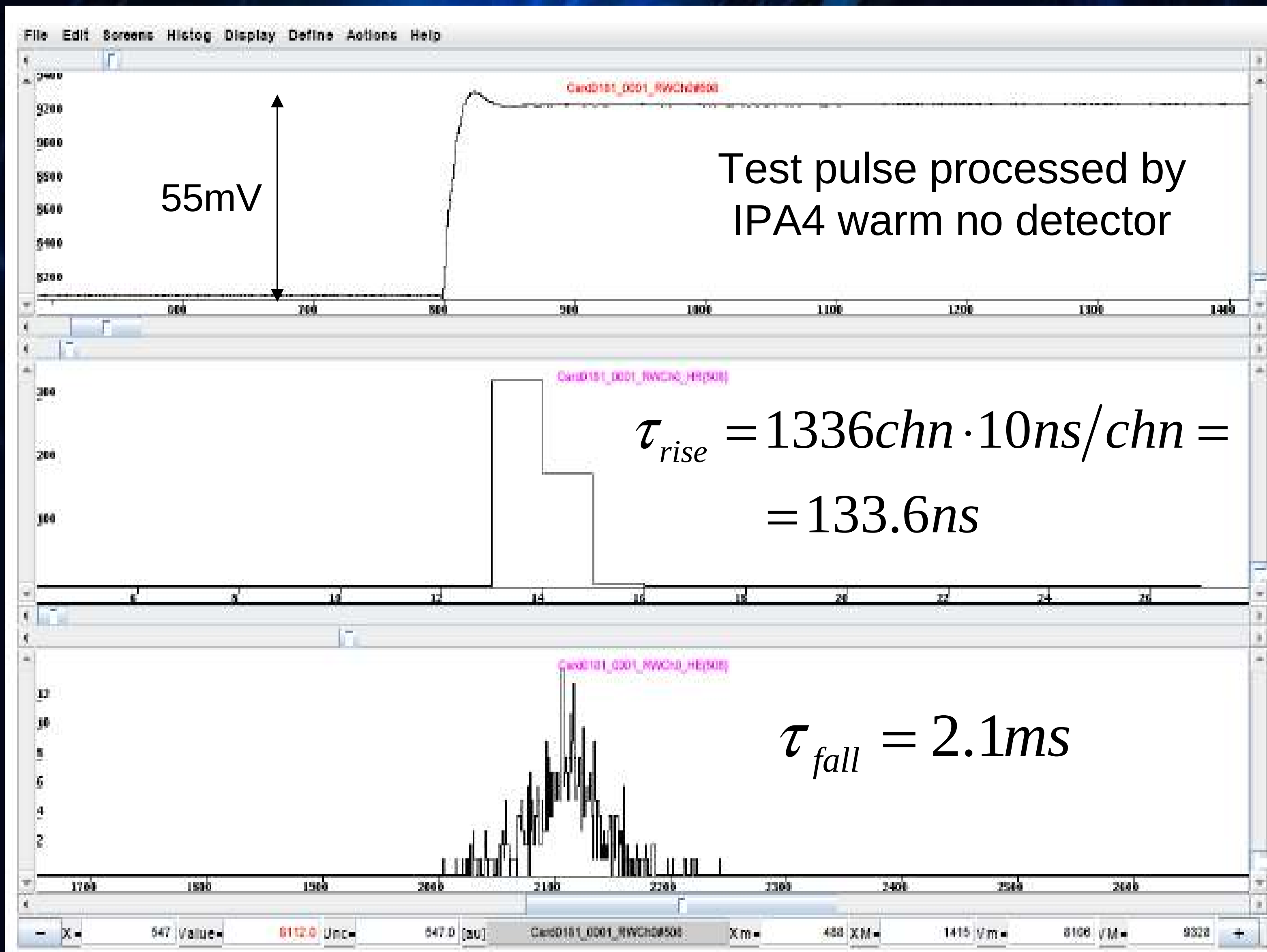
# Detector readout by cold IPA4




Acquired: 06.02.08 14:413:49 Real time 611.06sec Live time: 600.00sec
Channels:16384

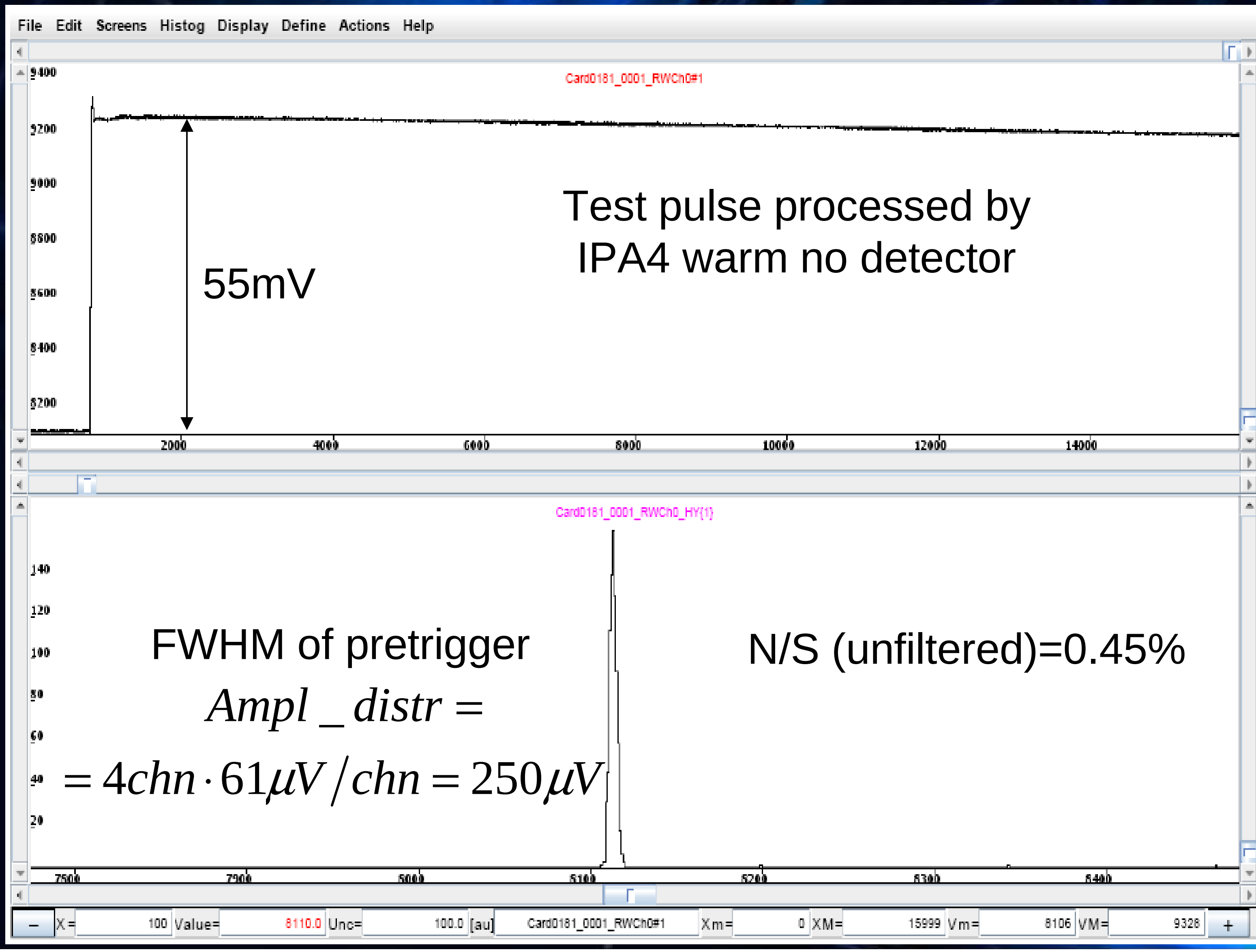
# Pulse acquisition by FADC and processing by JspecView

## IPA4: Pulser – $\tau_{rise}$ – $\tau_{fall}$

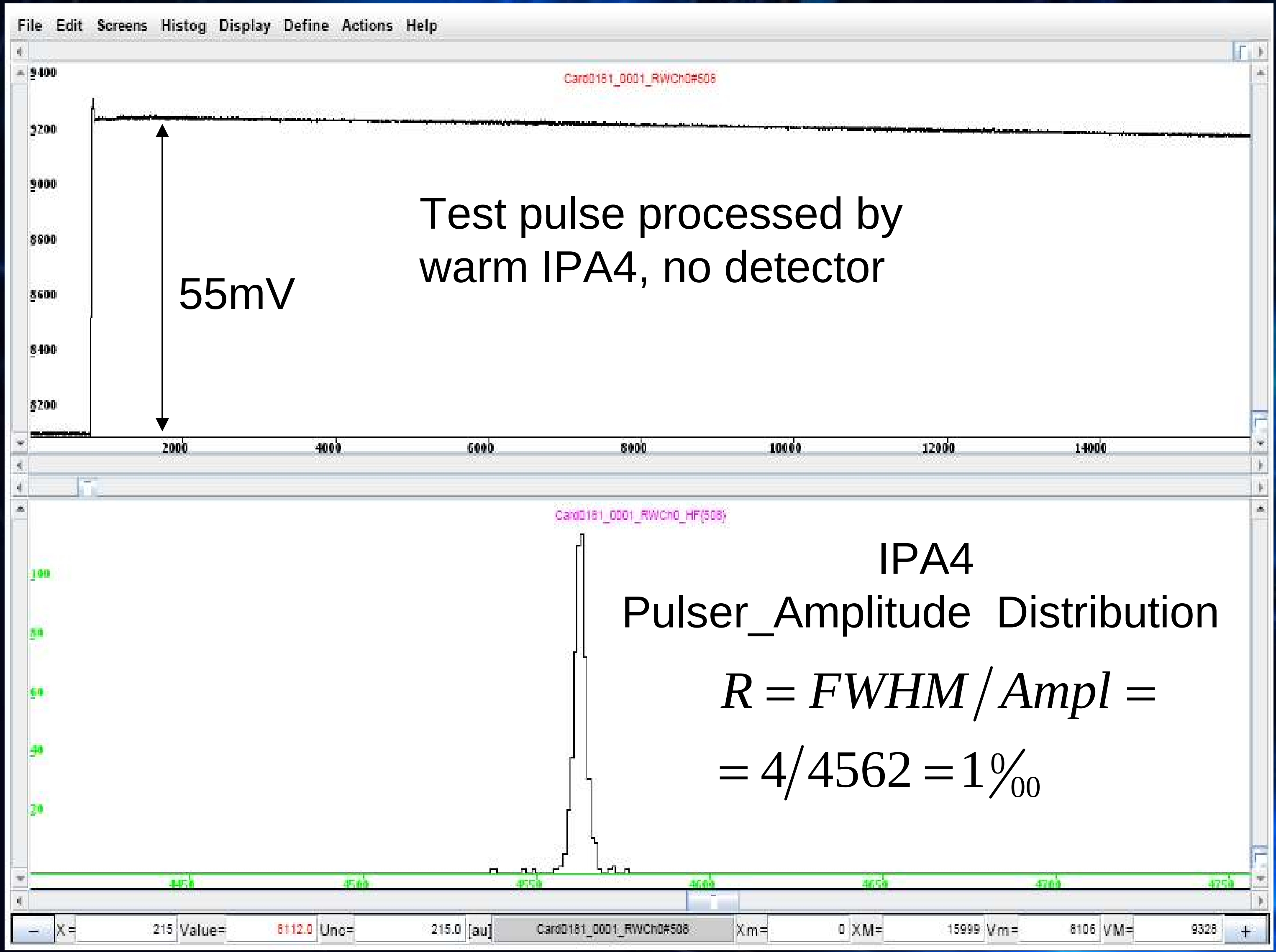


# Measurement of intrinsic noise by FADC IPA4 (warm)

Projection of pre-trigger samples on the y axis: estimation of rms noise



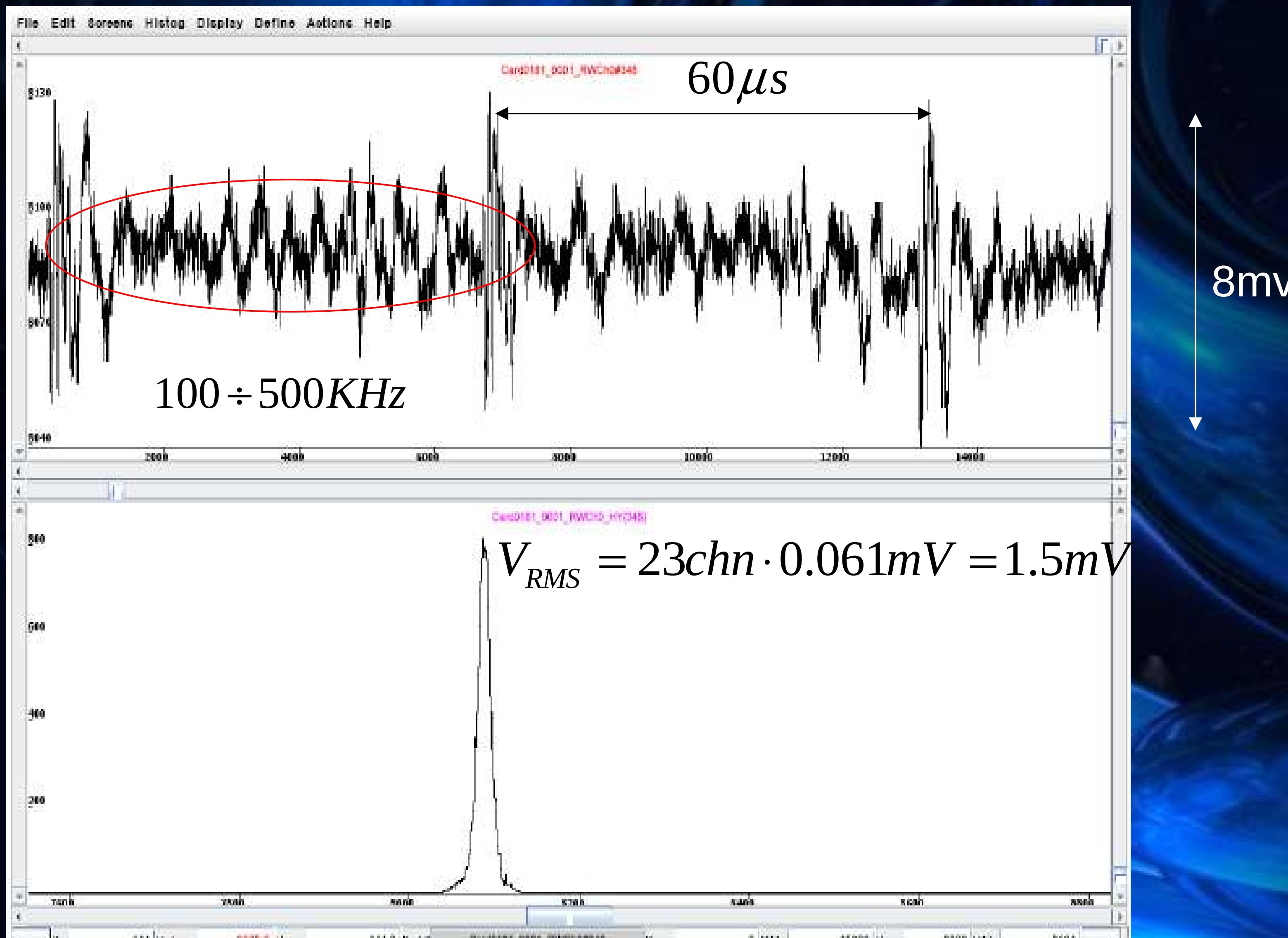
# Pulse Amplitude determination by Moving Window Deconvolution Algorithms: IPA4 (warm)




$$R = FWHM / Ampl =$$

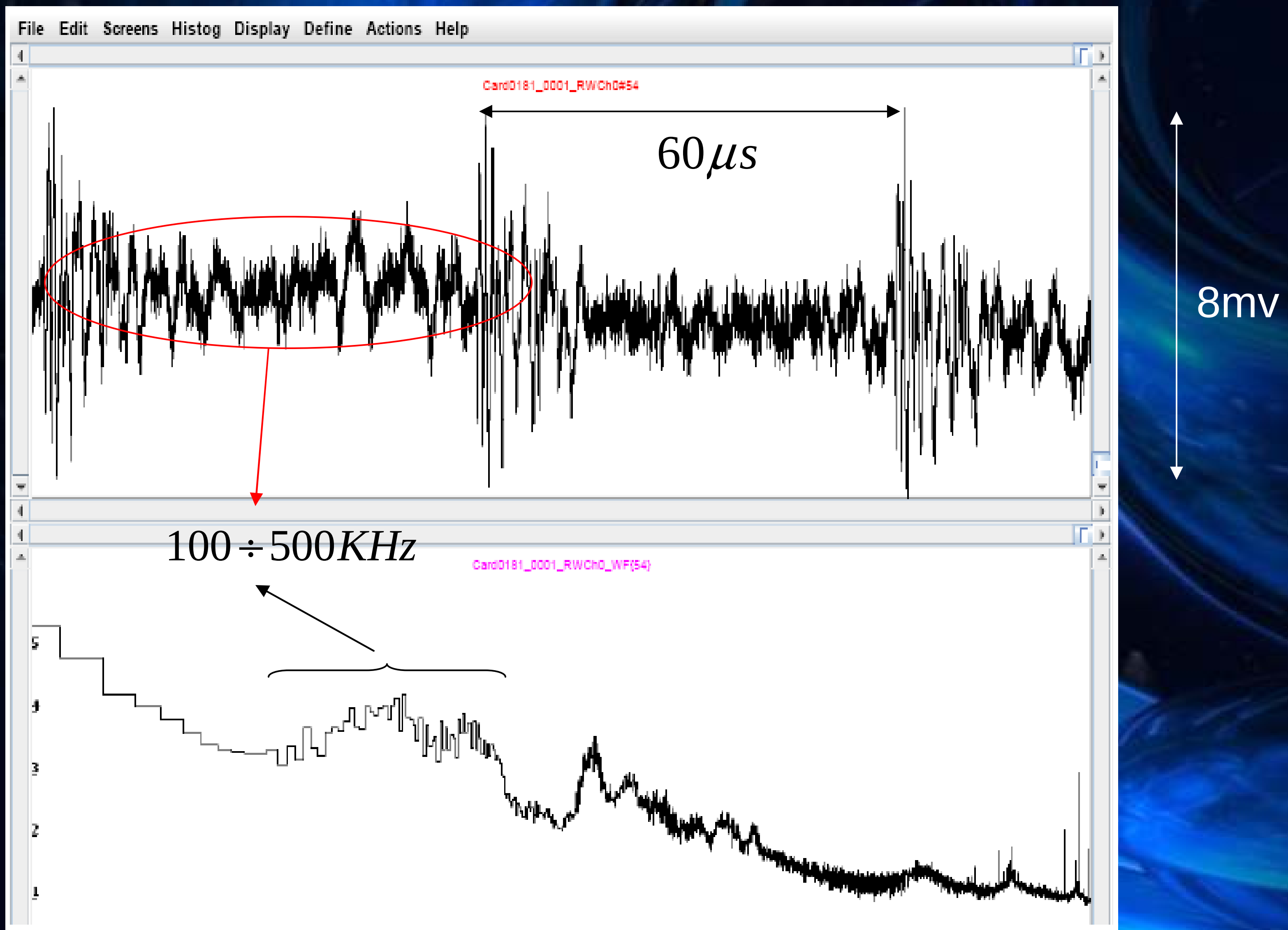
$$= 4/4562 = 1‰$$

# Estimation of rms noise with Detector connected
# Projection of base line samples on the y axis:

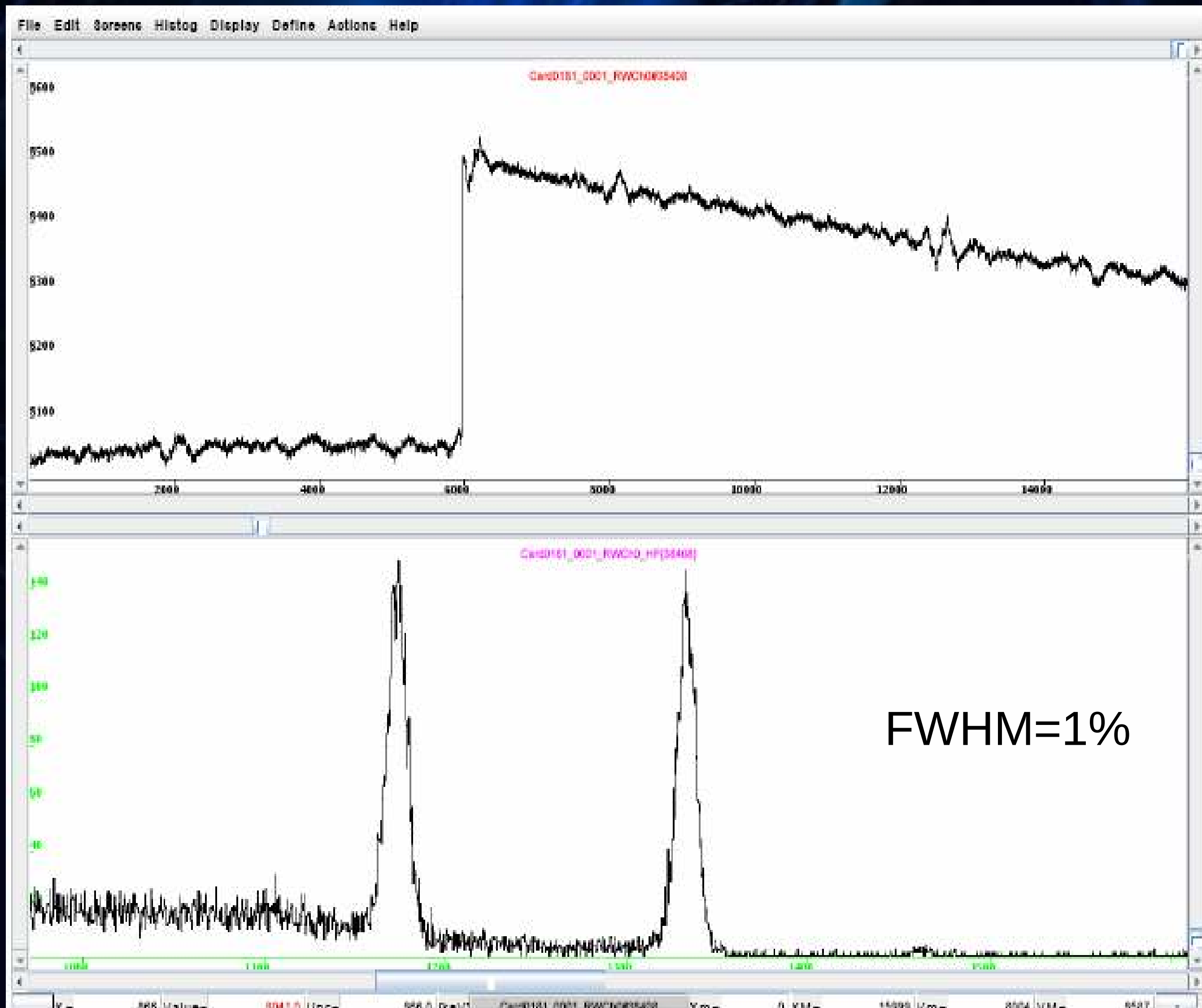



$$V_{RMS} = 23chn \cdot 0.061mV = 1.5mV$$

# FFT
## Bode Plot ($V^2$ vs Hz): Noise identification

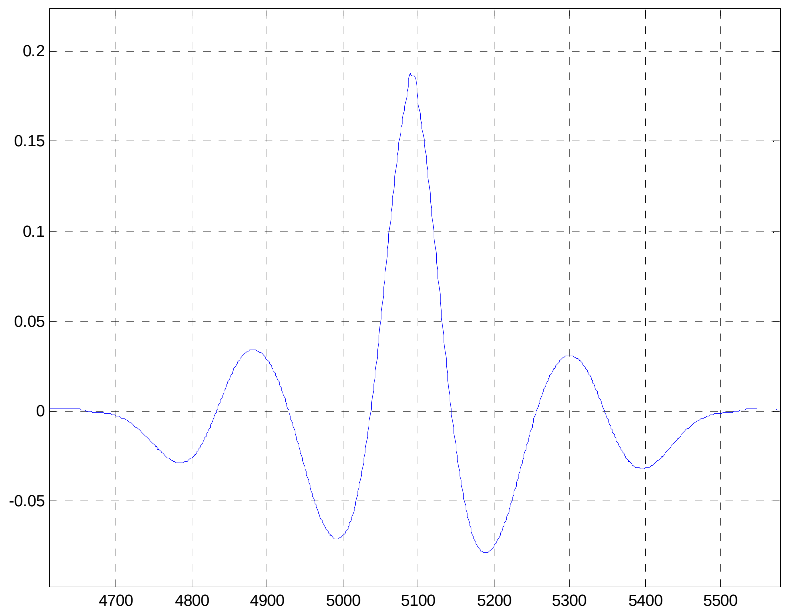


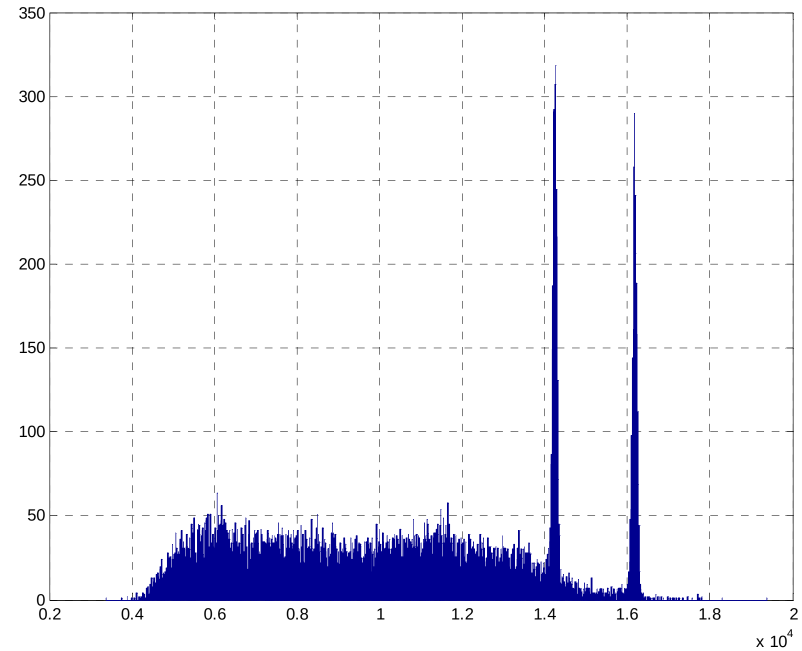
Spectroscopy by Pulse Shape Analysis with present noise situation
Detector irradiated by Co60 – IPA4 cold




Digital PSA must be optimized: $R_{PSA}=2R_{SpectumAmpl}$

# Very Preliminar:
# Optimum Filter analysis from acquired pulses:




R =0.6%
not yet optimized

# Conclusions

- Cooling-down procedure repetible, reproducible and working
- Spectroscopy measurements performed to validate bench test
- PSA analysis performed to study noise, distribution of relevant parameters, and finally produce spectra.
- PSA algorithms working but not yet tuned ($R_{PSA}$ worse than $R_{Spectroscopy}$)
- Results obtained with the detector are not limited by amplifiers but affected by environmental conditions:
    - ✓Argon boil off makes vibrations, introducing low frequency noise
        - → change the dewar (consumption 1.6l/h)
    - ✓High frequency noise (100-500KHz, seen in FFT) caused by ground connection
        - →change grounding scheme
        - Test after modifications with HV capacitors to simulate the detector, acquire pulses, perform FFT/OF.