Work on SiPM for CTA&RD
Bari 28.11.2013

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Sensors:

SiPM from FBK last production 3 mm x 3 mm NUO4-05

Temperature dependence vs Vop

Gain vs Temperature , cross talk

Study of afterpulsing, phe separation

Responce at Cherenkov ligth: setup and prelimilary results

Temperature dependent behavior of the SiPM

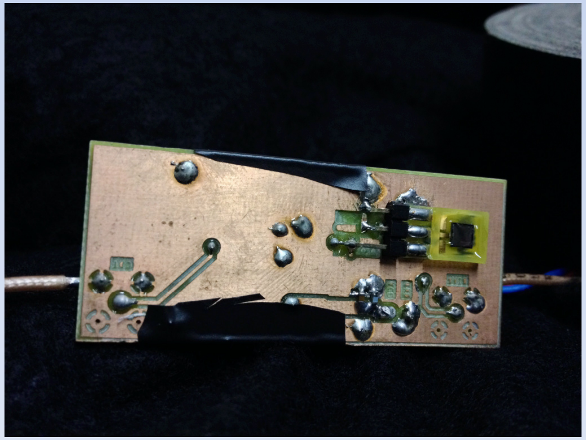
Request:

- Gain of the SiPM's to be *as constant as possible* in function of T

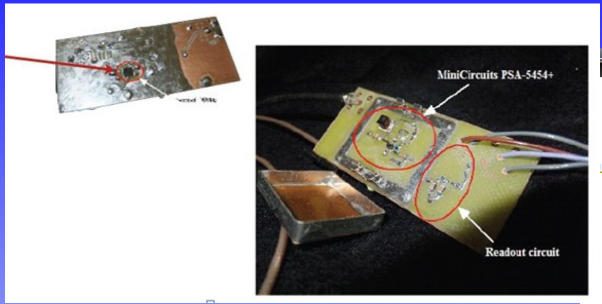
As we know the gain of the SiPM is directly determined by the number of carriers in a Geiger discharge

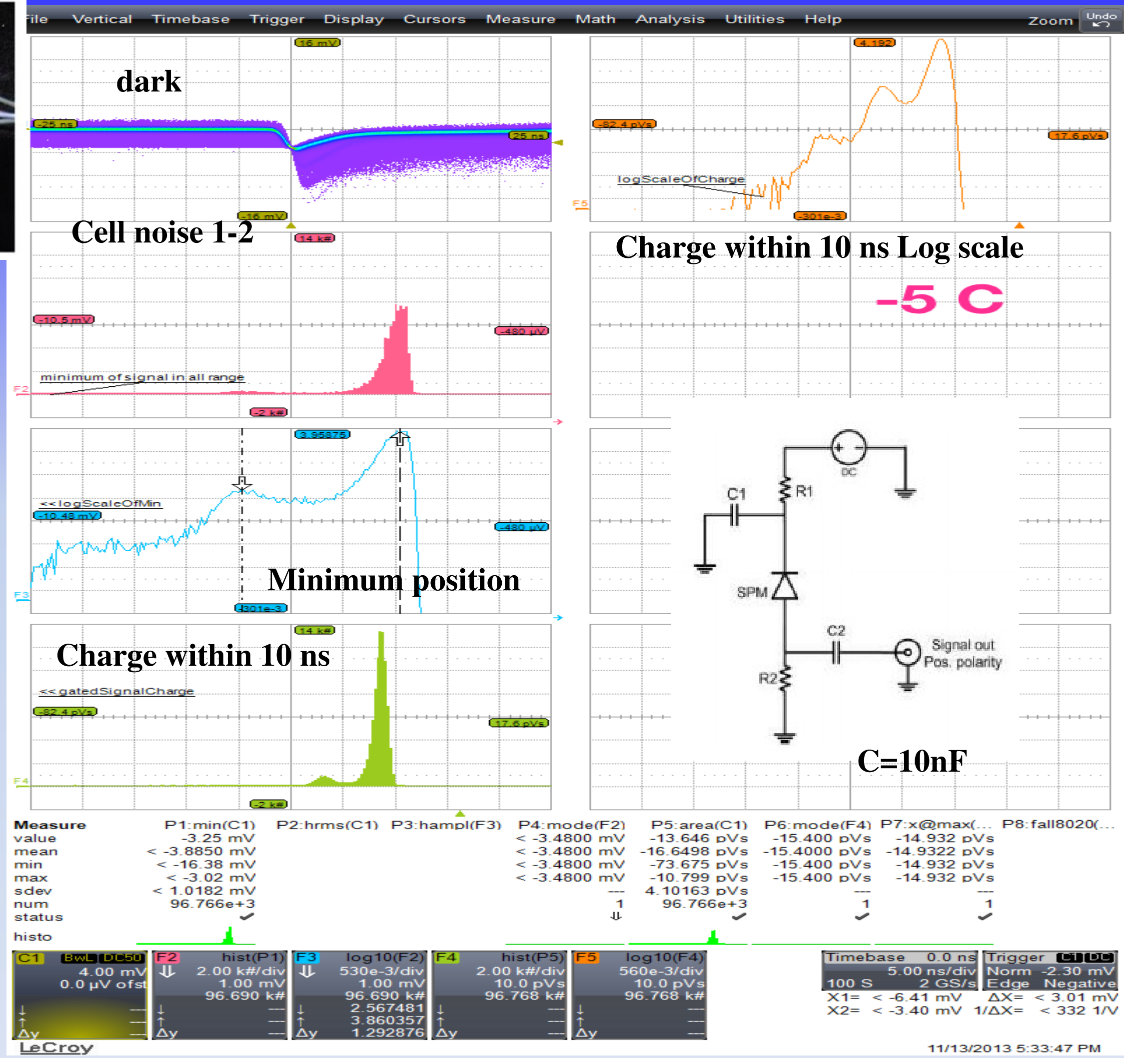
So two ways to measure it

- the charge contained in the Phe spectrum
- or the distance of 1^{st} -2^{nd} Phe (amplitude).



Setup for charaterization FBK-SiPM - dark pulses

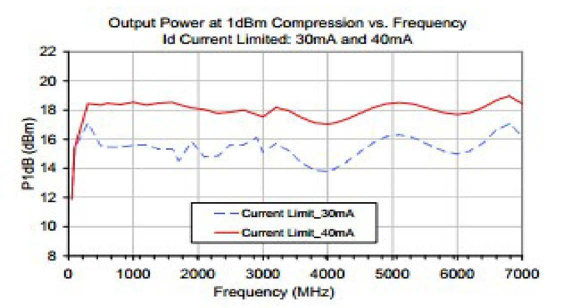




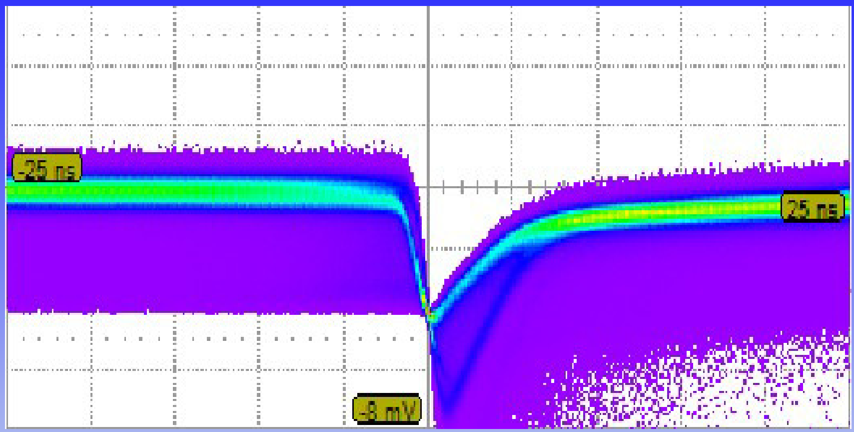
Amplifier 545+ Minicircuit

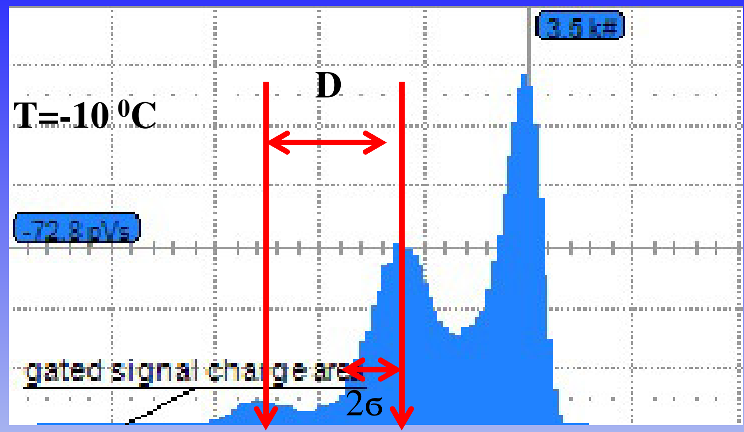
Product Features

- Single Positive Supply Voltage, 3V
- Ultra Low Noise Figure, 0.8 dB typ. at 1GHz
- High IP3, 36 dBm typ. 1GHz
- Gain, 20dB typ. at 1 GHz
- Output Power, up to +20dBm typ.
- Micro-miniature size - 3mm x 3mm

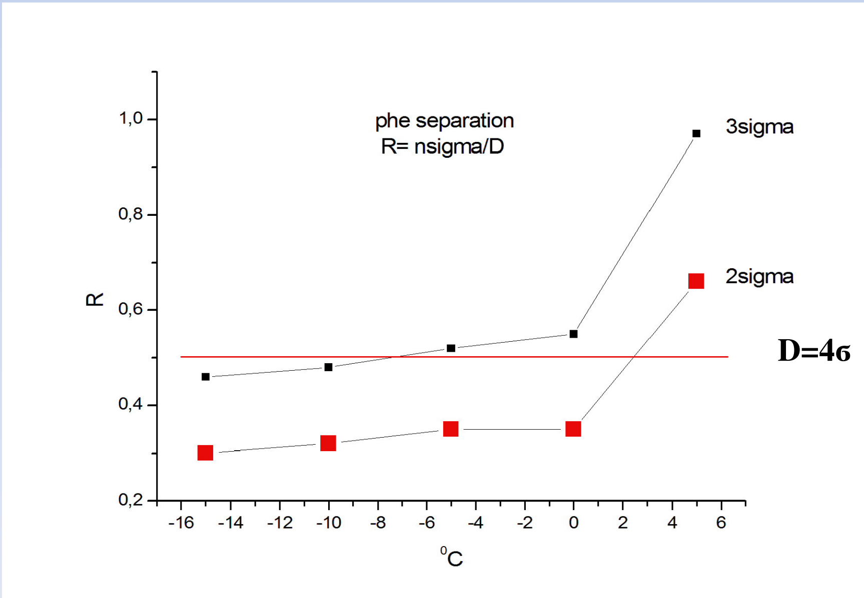


Phe separation measurement



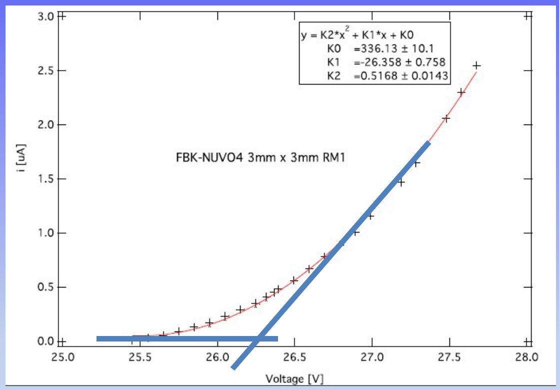


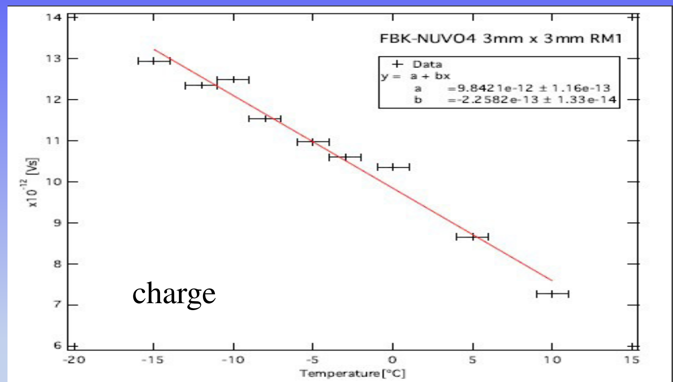
R= nσ/D



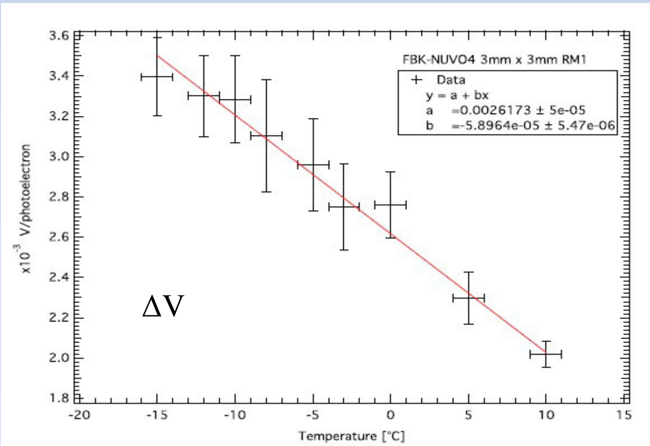
good phe separation below 0 ^{0}C

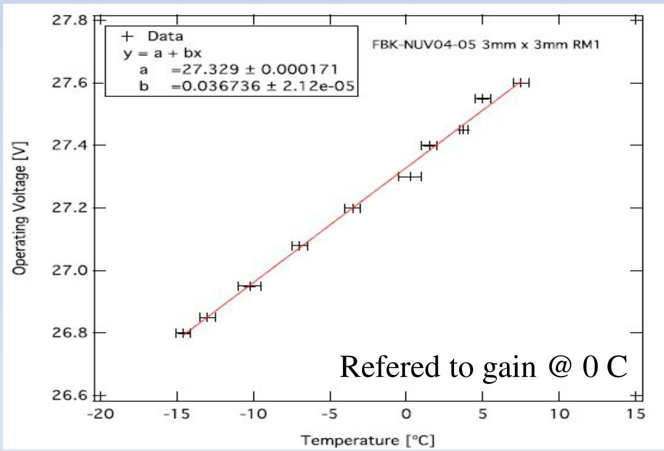
Gain and Vop vs temperature

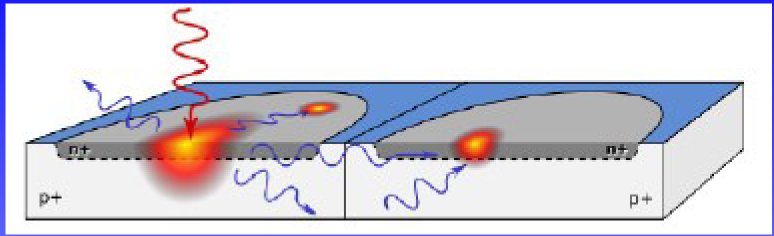




I vs V @ T= 25 C Vb=26.4 V

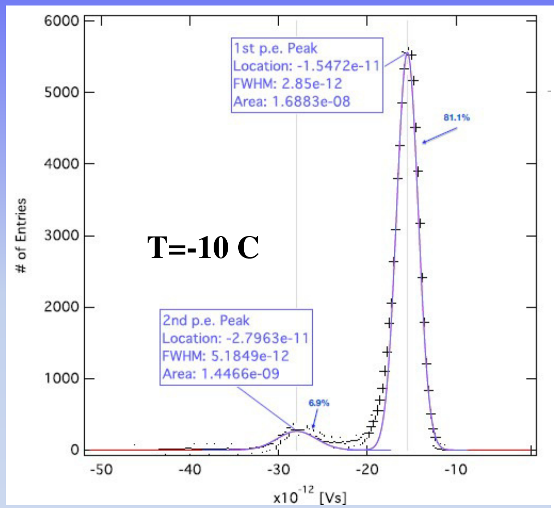


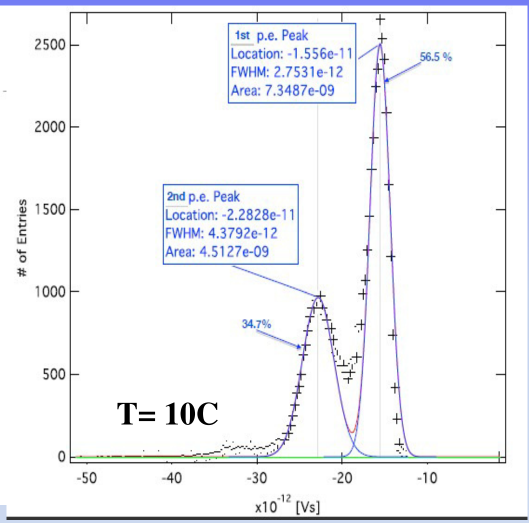


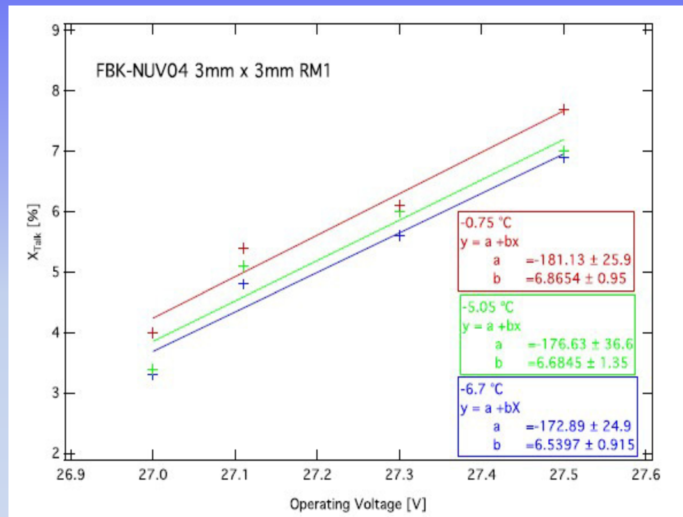


crosstalk

The ratio of rates of double-to-single avalanche pulses is a direct measurement of cross-talk probability at a given bias voltage and temperature.







N1 and N2 events on 1° and 2° peak respectively

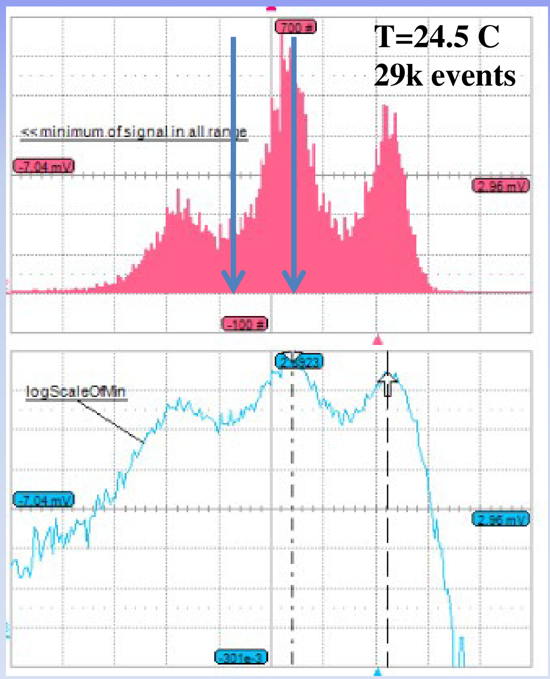
What's about optical crosstalk?

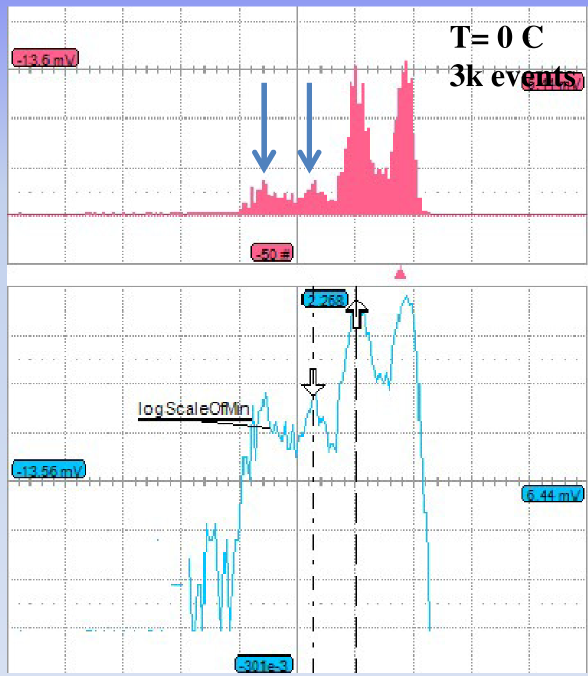
Dark Rate as function of T (in progress)

- *Dark rate* is due to free carriers present in the conduction band.
- It is proportional to the carrier density:n(T) ~ $T^{3/2}\ e^{-\Delta E/kT}$
- Temperature dependence of the *dark current rate* (at fixed overvoltage) yield the information on the effective band gap width: E = 1.11 eV

Peak amplitude by LED vs temperature

- Measurements were taken with the pulse amplifier and blue LED gated at 20 ns at different temperatures.
- In the *peak amplitude* histogram we clearly distinguish P.Es.

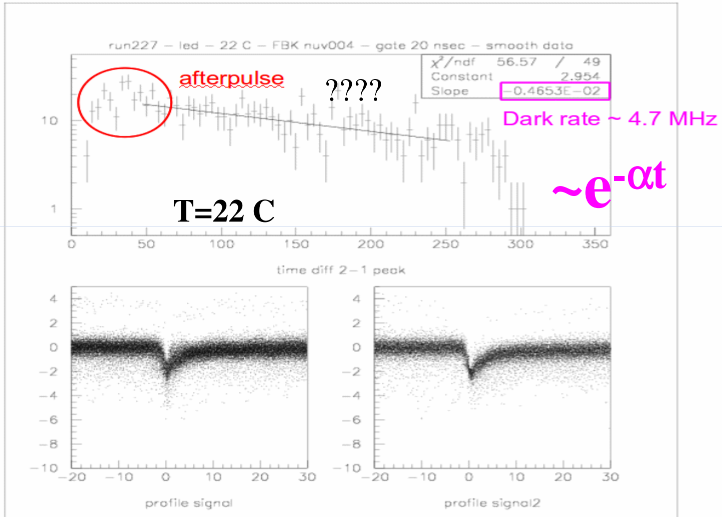




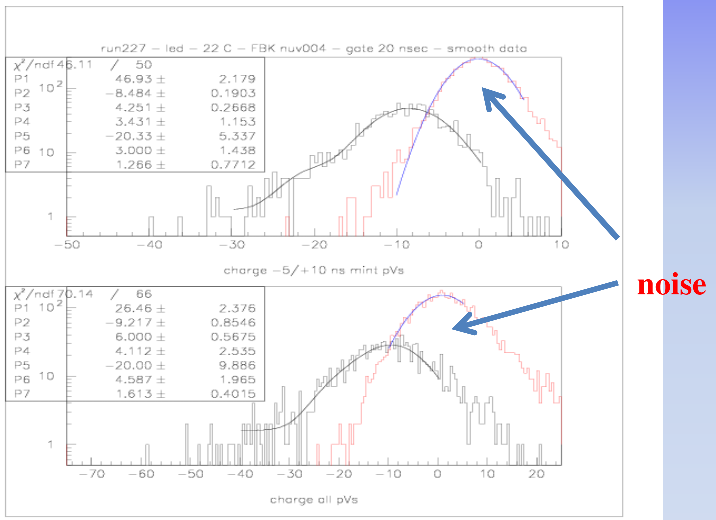
Afterpulsing

afterpulsing are electrons of the avalanche trapped and released with a small delay → they corrupt the photon counting, then impact on trigger

by using pulsed blue LED 20 ns pulse + white fiber +DRS4 triggered

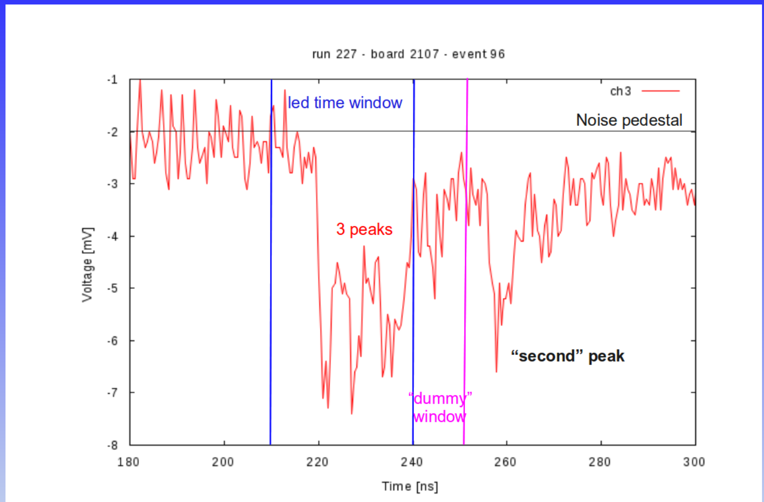


noise subtracted, 1° and 2° peak

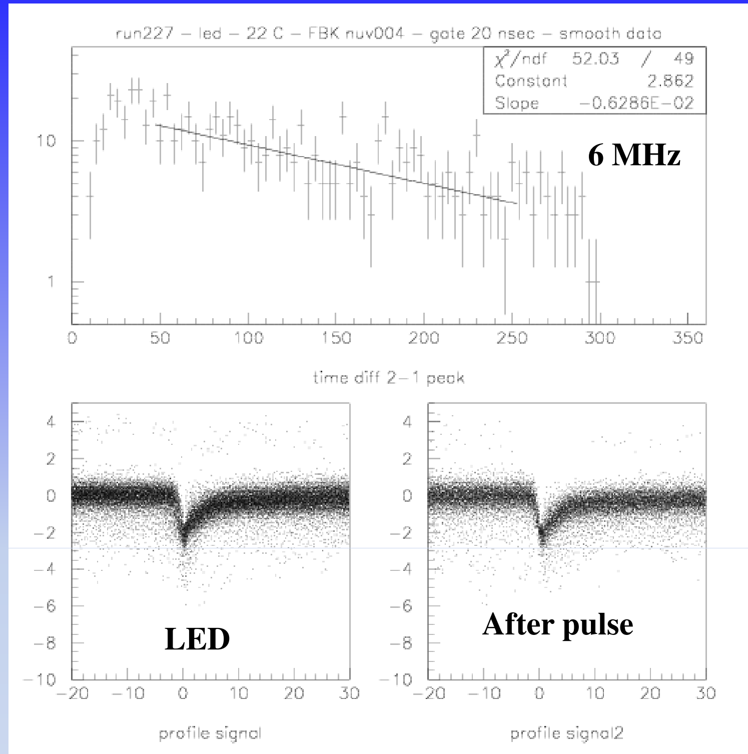


[pVs]

Afterpulsing



After avg noise subtraction : - minimum of LED signal > 26$_{noise}$ and < -1.5 mV - second signal > 2 σ_{noise} and < -1.7 mV

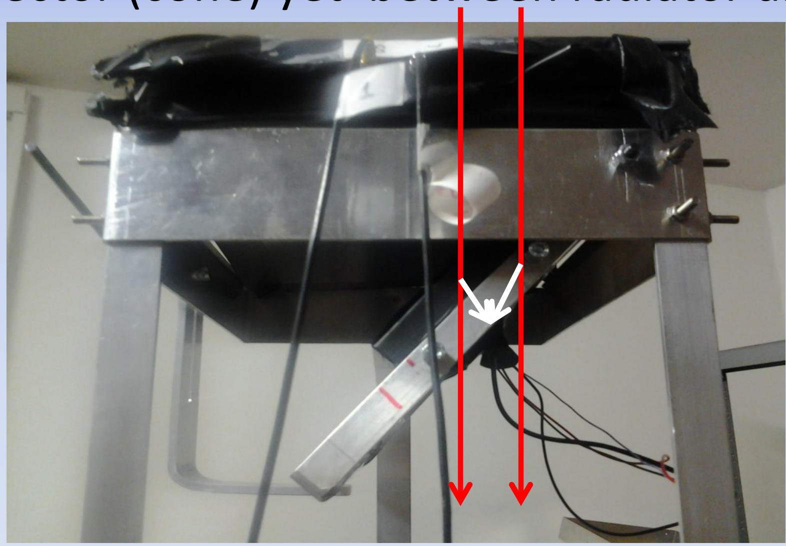


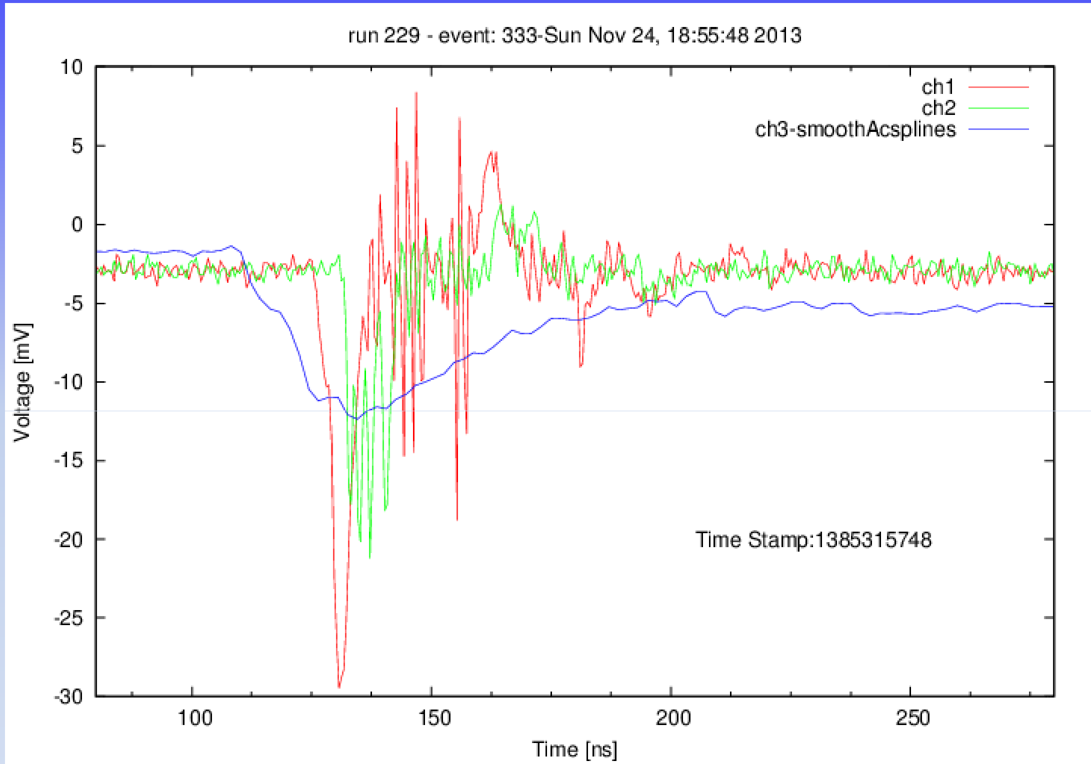
Test on Cherenkov ligth by CR's

Setup is located in the underground Lab:

- we use CR's (muon mainly) + radiator
- Triggered by 2 tiles 15 cm x 15 cm
- SiPM connected directly to a radiator (n=1.5 Cherenkov angle $\theta = 47.8^0$, 2.5 cm tickness, setup to avoid limit angle)geometrical acceptance ($\pm 1^0$)

  3 cm x 3 cm
- no optical connector (cone) yet between radiator and SiPM (Gopt=1)




run 229 - event: 333-Sun Nov 24, 18:55:48 2013
ch1
ch2
ch3-smoothAcsplines
Time Stamp:1385315748
Voltage [mV]
Time [ns]
10
5
0
-5
-10
-15
-20
-25
-30
100
150
200
250

Conclusions and comments

- FBK Tests

  on sample received we have verified low noise, reduced cross talk, linear V,T dependence. Is that stable for a large bunch?
- Afterpulsing less than 1%, Dark rate 3x3 mm^2 ~ 6 MHz @ T=22 C
- Ready to work with C-light