Tests on FBK SiPM sensors with an optimized electronic design for a CTA Camera

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For the CTA-INFN Team

Outline

- ✓ CTA-INFN Groups & Activities
  - ❑ The R&D
  - ❑ Progetto Premiale TECHE.it (TElescopi CHErenkov made in Italy)
    - The industrial partners

- ✓ The Prototype
  - ❑ Sensors
    - FBK NUV SiPMs
  - ❑ FE
    - Preamplifier + Filter
    - Digitizer

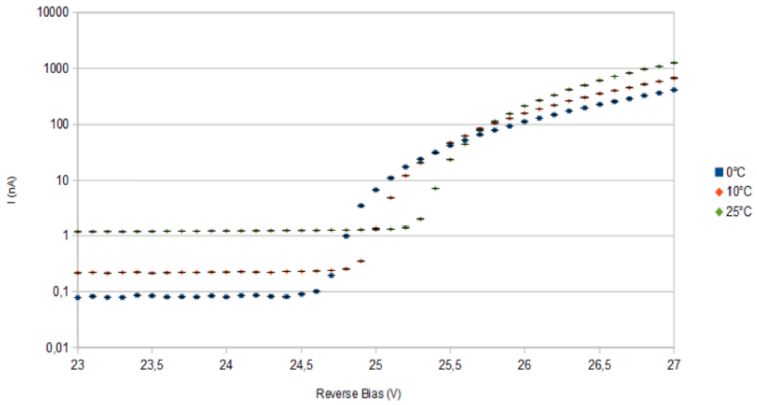
- ✓ Future Work

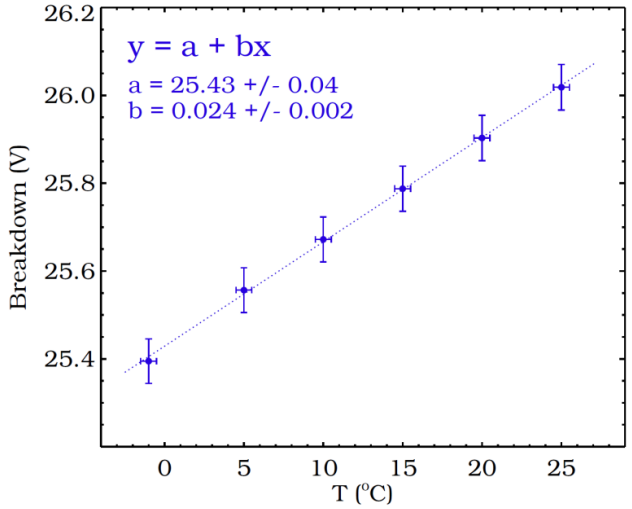
INFN participation to CTA

- ~40 INFN scientists working to INFN CTA-RD since September 2012
  - Seevogh meetings every 2nd week, a few physical meetings (Roma, Venezia, Bari, Napoli, Pisa, …)
- January 2013: proposal of a "premiale" INAF + INFN; SiPM (industrial partnership with FBK) + electronics (CAEN, SITAEL);
- approved in Oct 2013
  - Demonstrate the feasibility of an "all-Italian" SiPM Photosensor Unit
  - 1.3 MEUR for INFN: 2/3 for sensors, 1/3 electronics

Sensors: FBK NUV 3x3 SiPMs

Pro et al. 2013





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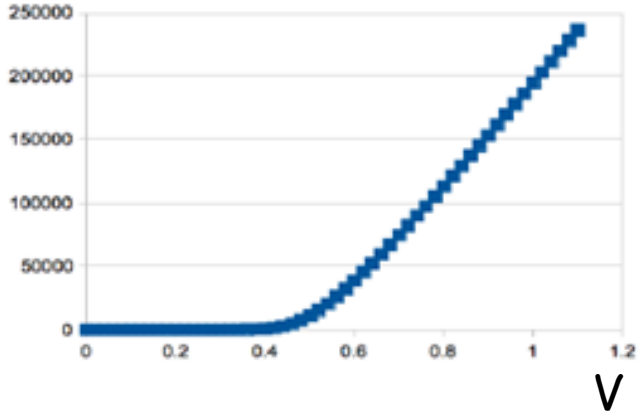
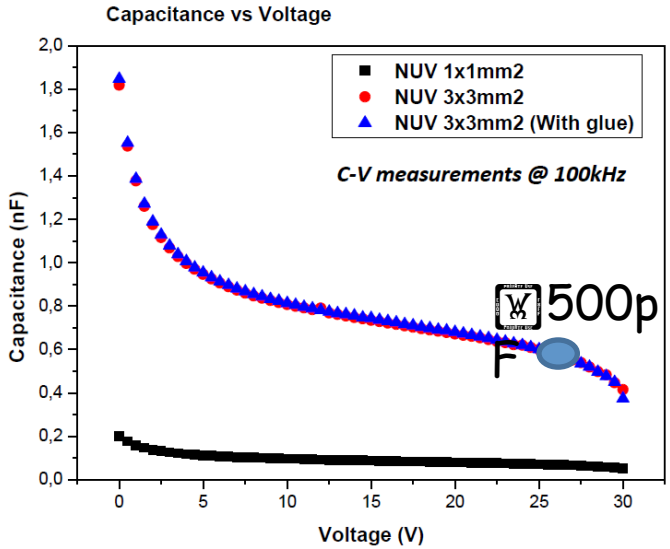




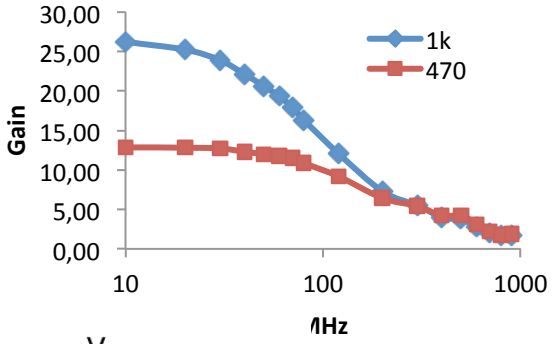
Low break down voltage @ 26V

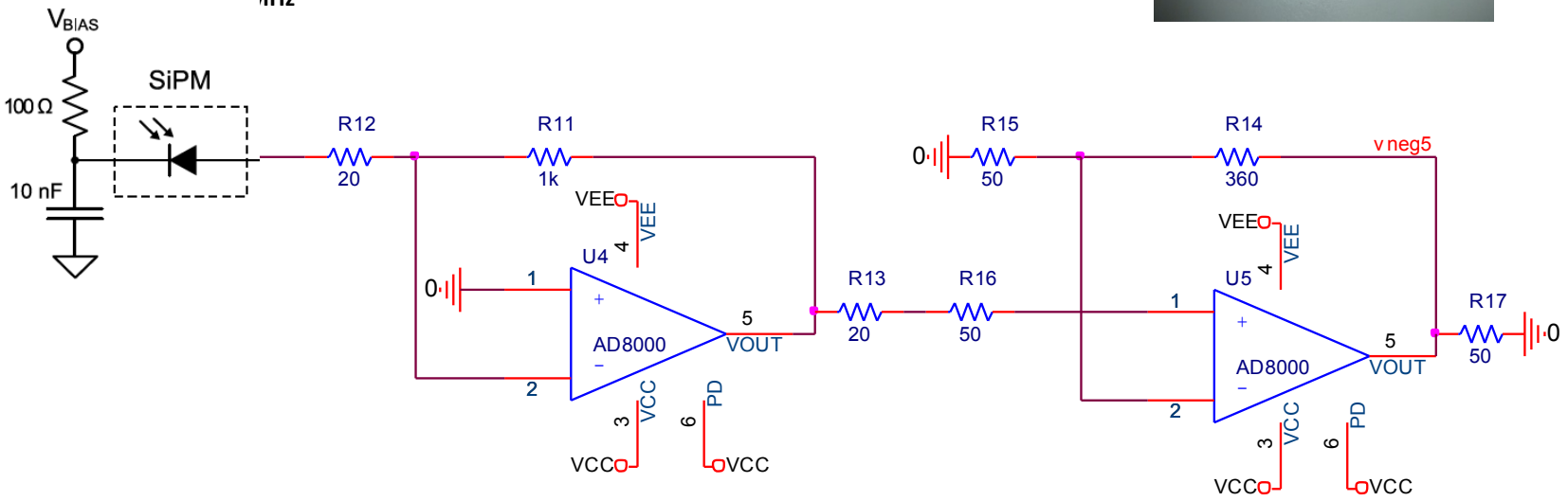
Little Temp. dependance 24mV/C

High Bias resistance >800kΩ

Current sensitive amplifier

AD8000 OPA based FE
1.5GHz wide band





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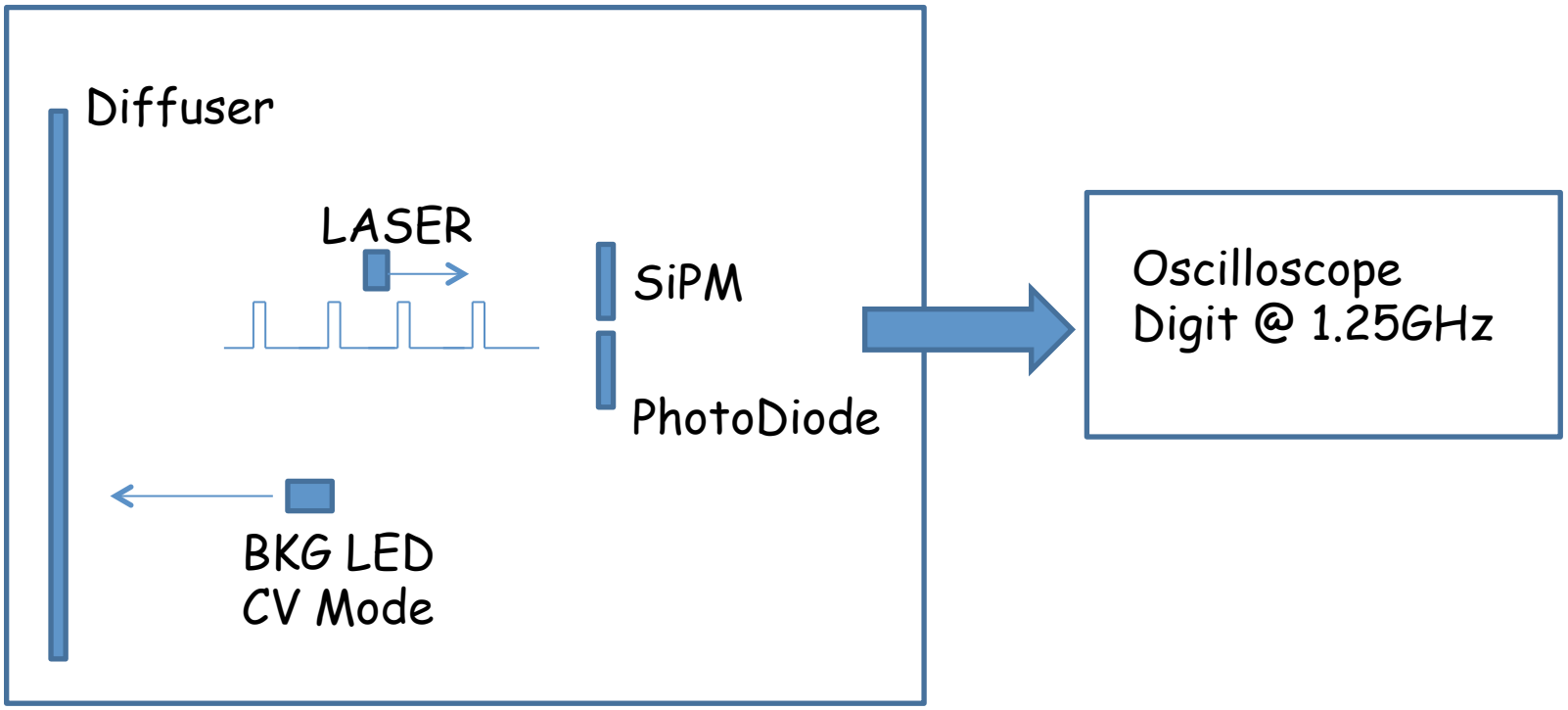
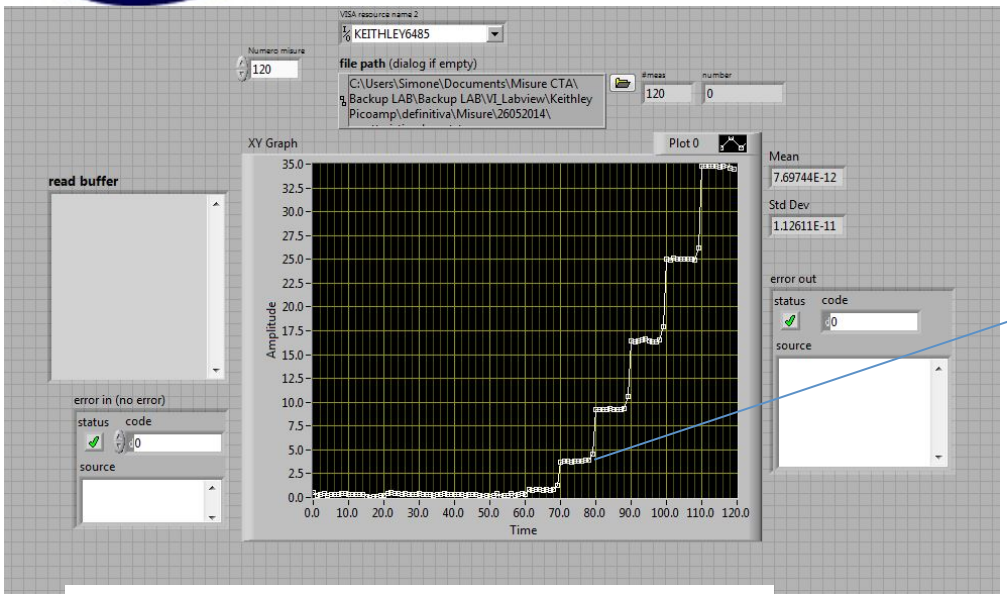
D. Perrino (SITAEL)

Performance studies: Sensors+Electronics

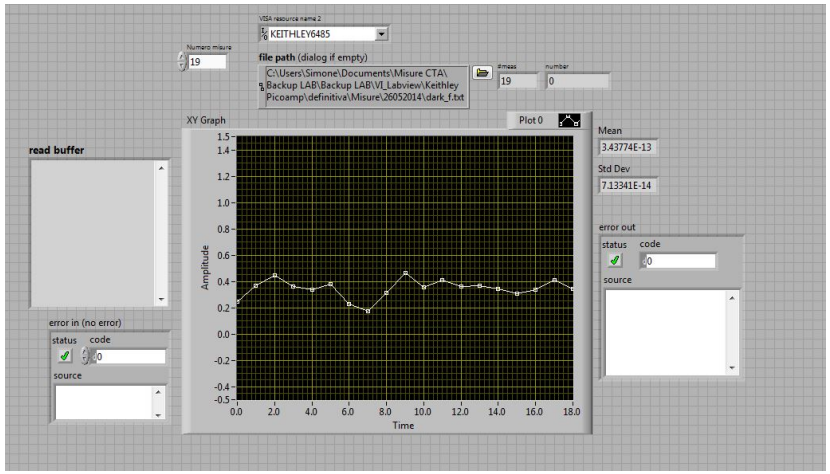


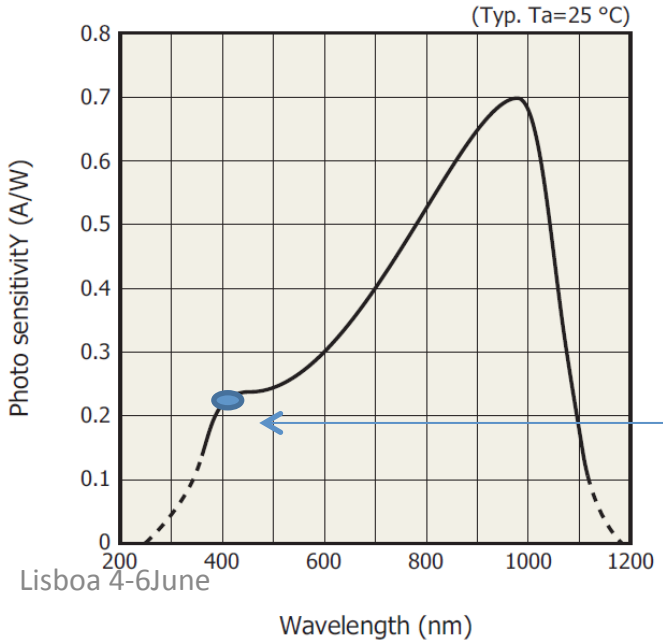
System calibration



A photocurrent of about 3.5pA corresponds to 10MHz/mm²

BKG up to 100 times the SiPM dark Rate



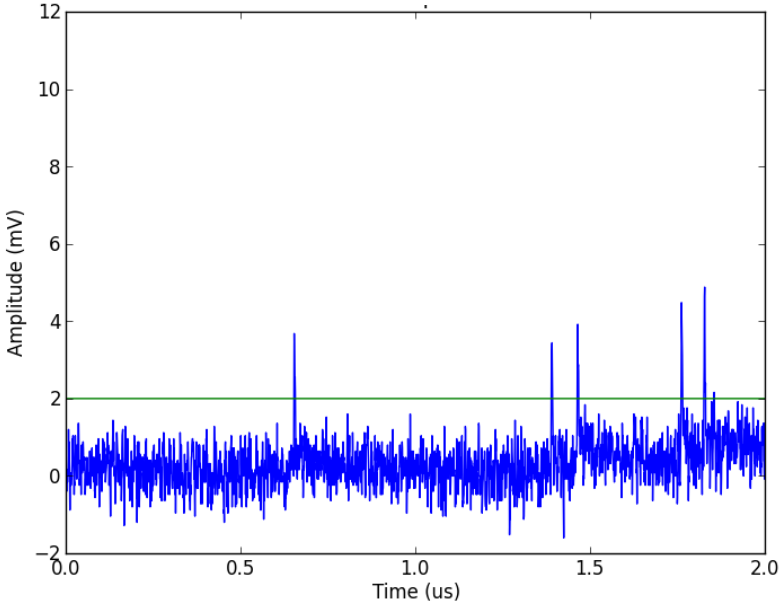


220mA/W @ 400nm

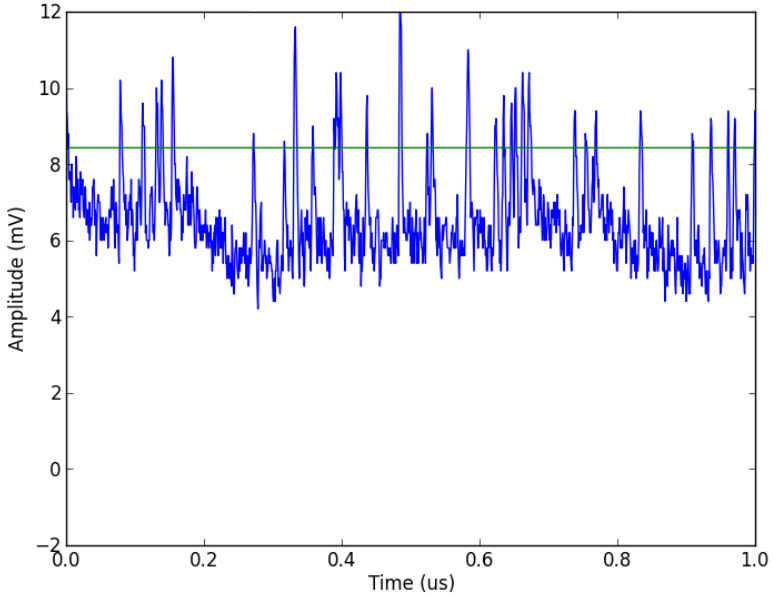
The dark current is 300fA±30fA

Behaviour in High BKG

Dark



10MHz/mm^2



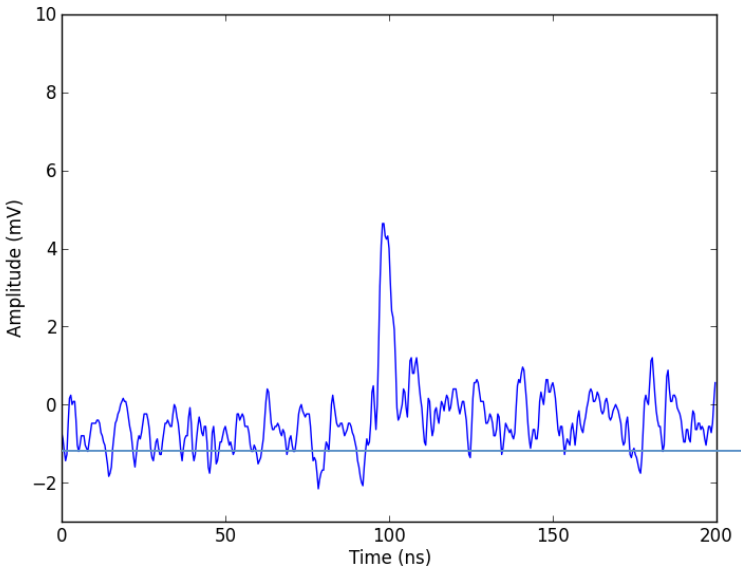
5 photons / 2us

DCR=200kHz/mm^2

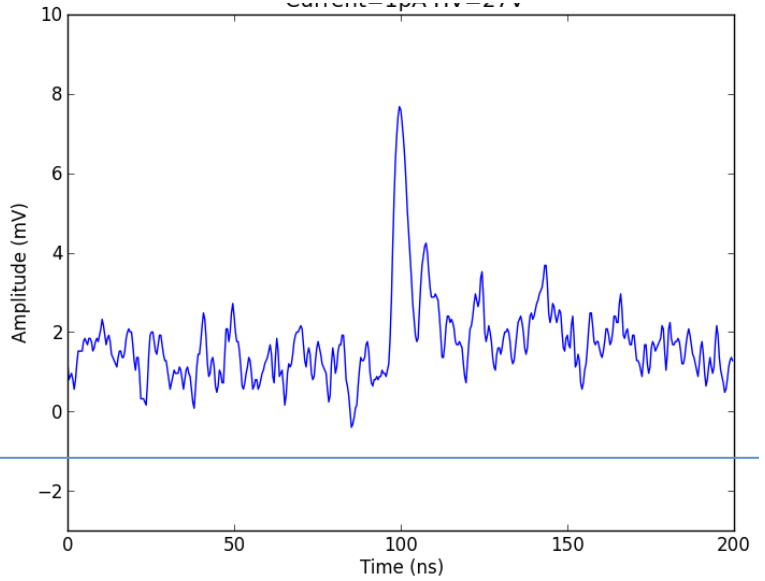
35 photons / 1us

The threshold needs to be adjusted depending on the BKG rate

Preamplifier response with LASER

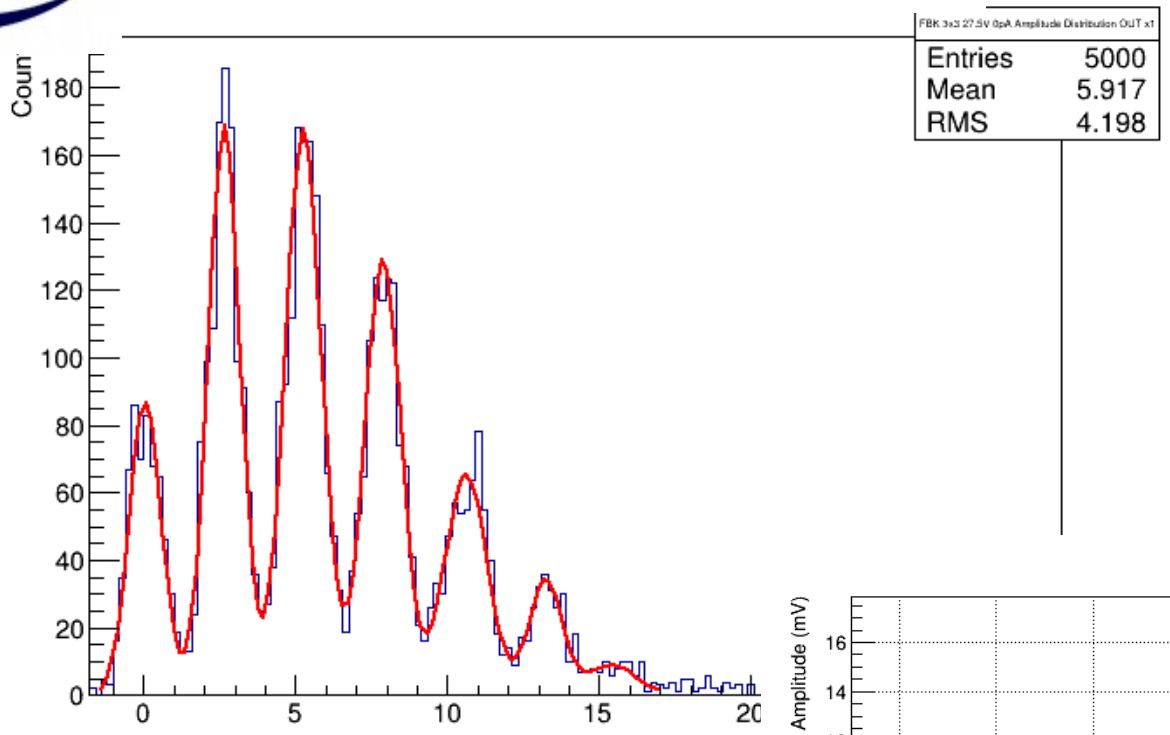


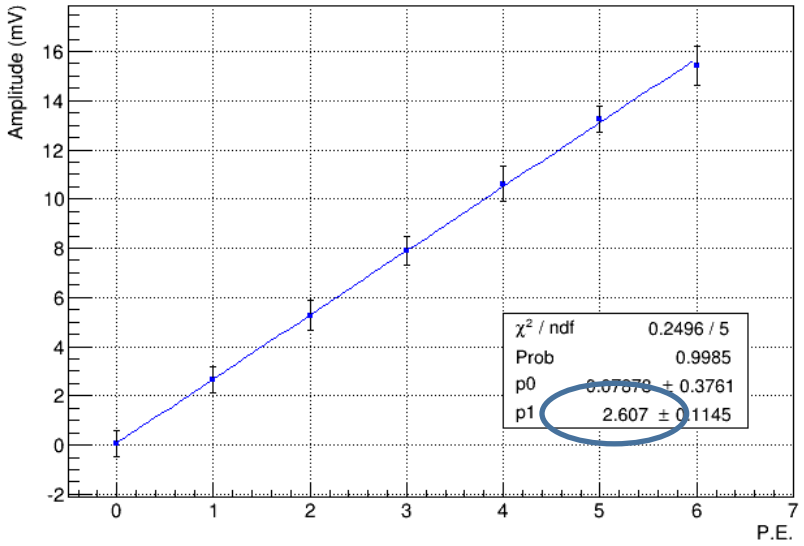
No BKG



BKG @ 10MHz/mm^2

Amplitude distribution @ dark

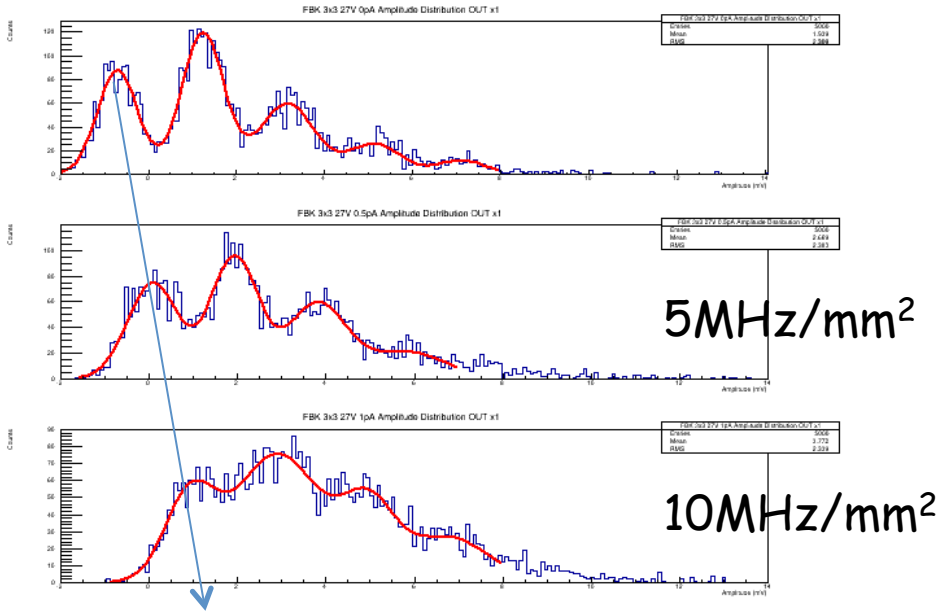




Gain 2.6mV/pe
SNR ≥ 6

Amplitude distribution with BKG

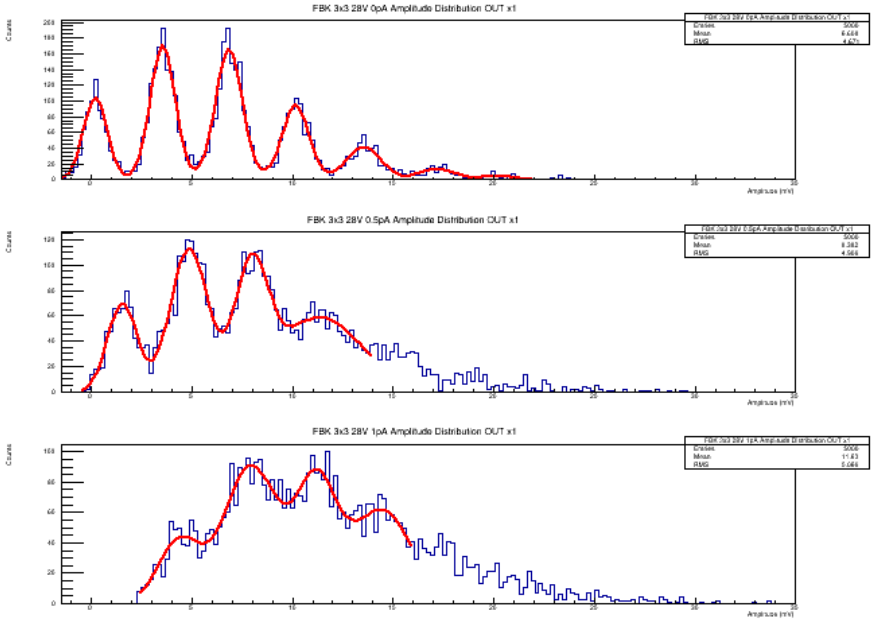
1V OV



5MHz/mm^2

10MHz/mm^2

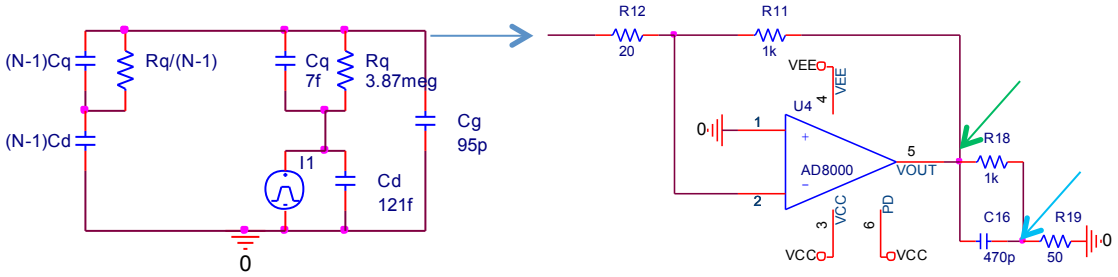
2V OV



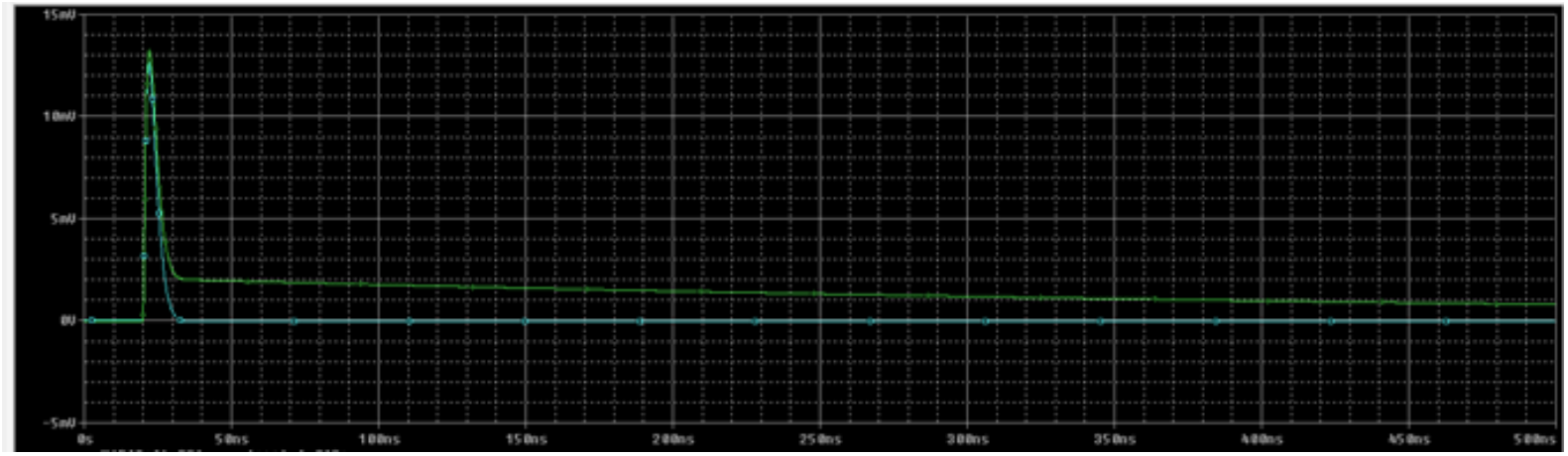
Baseline Shift

Worsening of Signal to Noise Ratio (SNR)

The tail cancellation

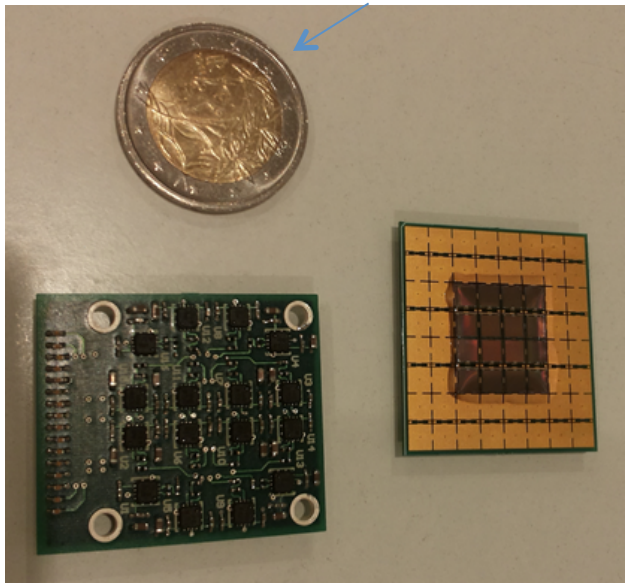


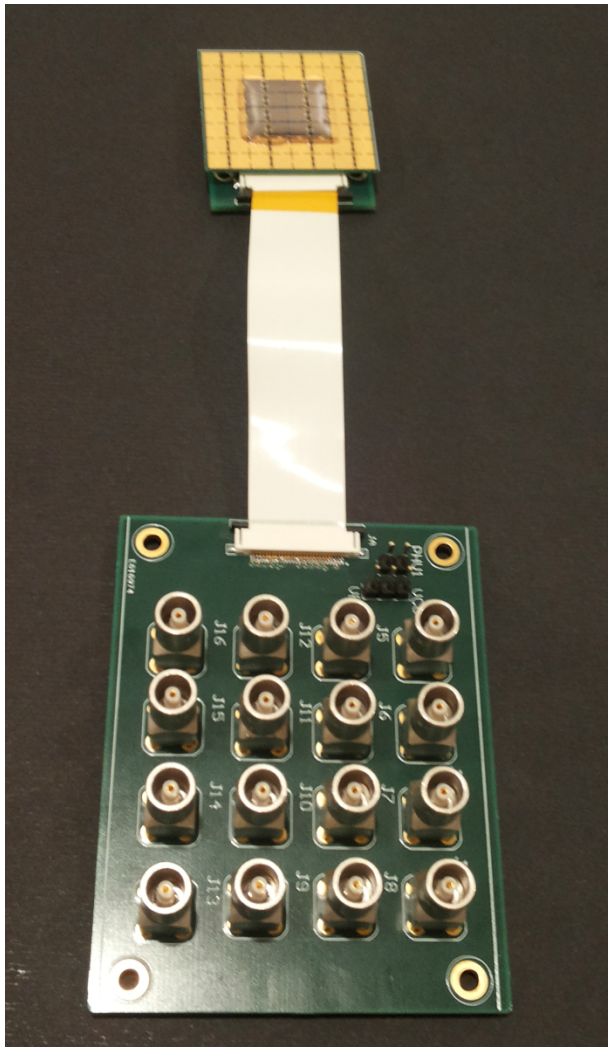
A zero-pole cancellation network has been introduced to reduce the effect of the tail
Trying to not affect the peak



The SiPM matrix

Dante's face

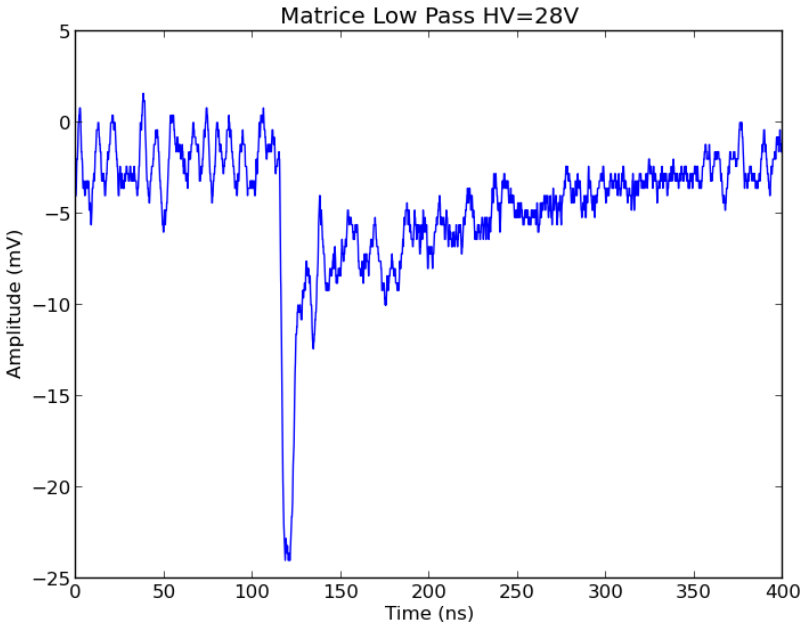




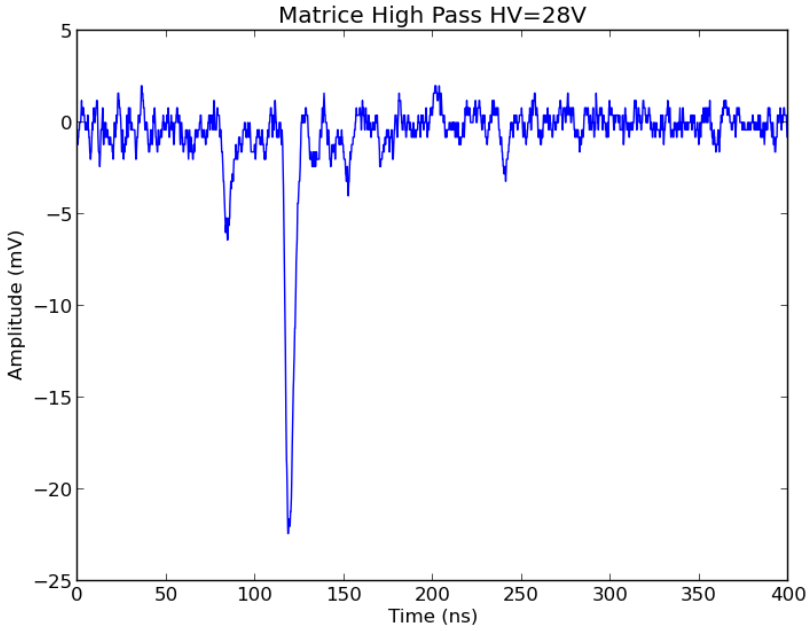
A ad8k OPA based electronics has been designed for conditioning the signals from 16 3x3 SiPMs

The tail cancellation has been implemented on each channel

PCB output

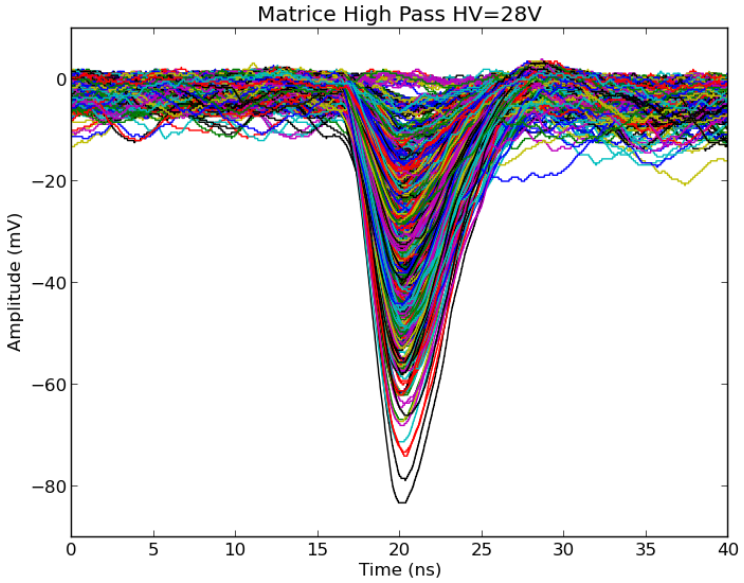


The output from the PSB has been studied before (left) and after (below) the filter implementation



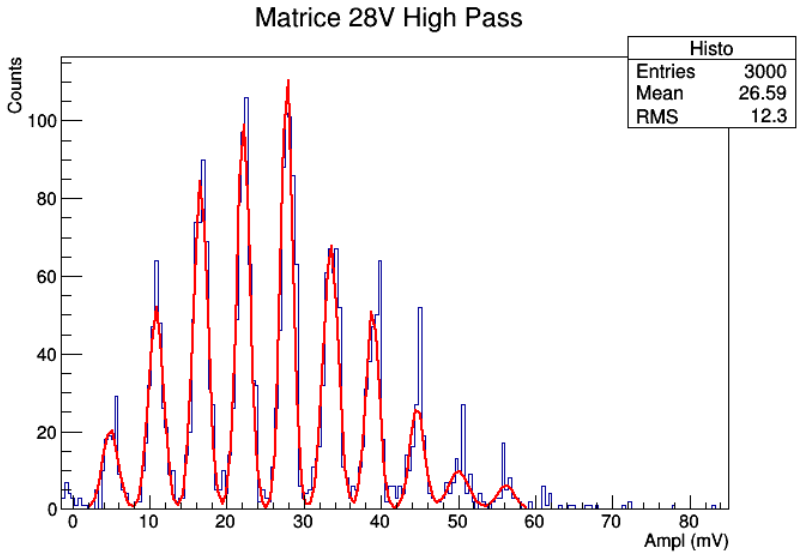
The signal width is about 10ns
The filter capacitance tries to have the same peak without loosing information

The amplitude study with a Laser

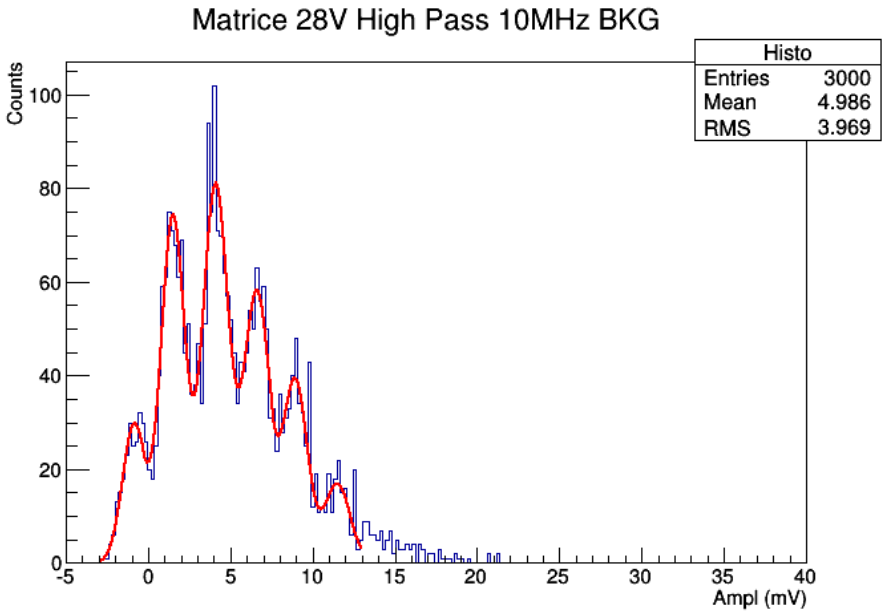


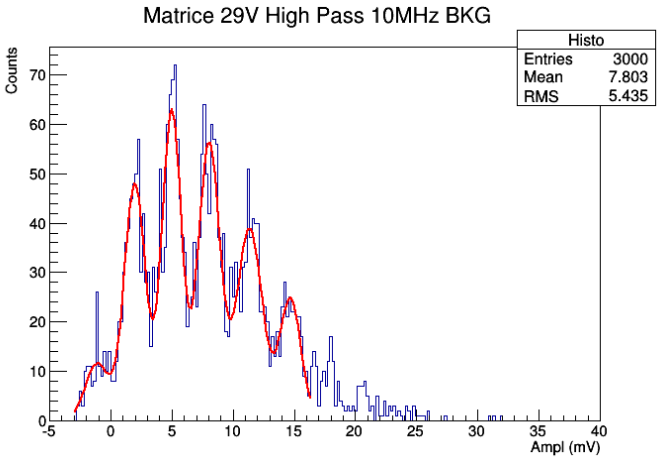
5.6mV/pe

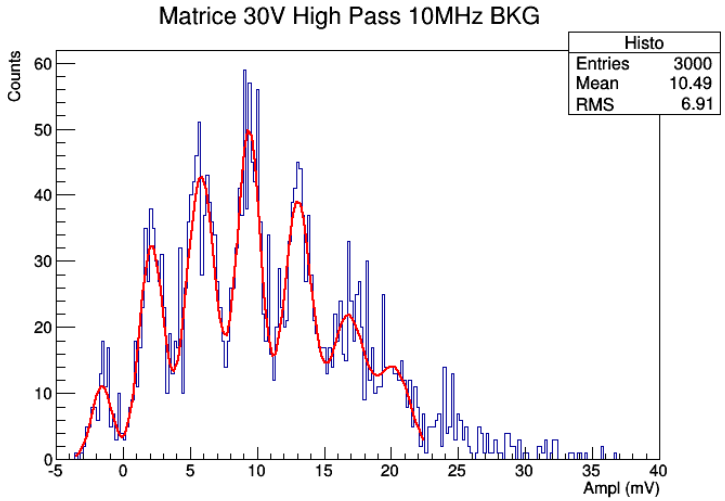
SNR=8



Amplitude spectrum in High BKG



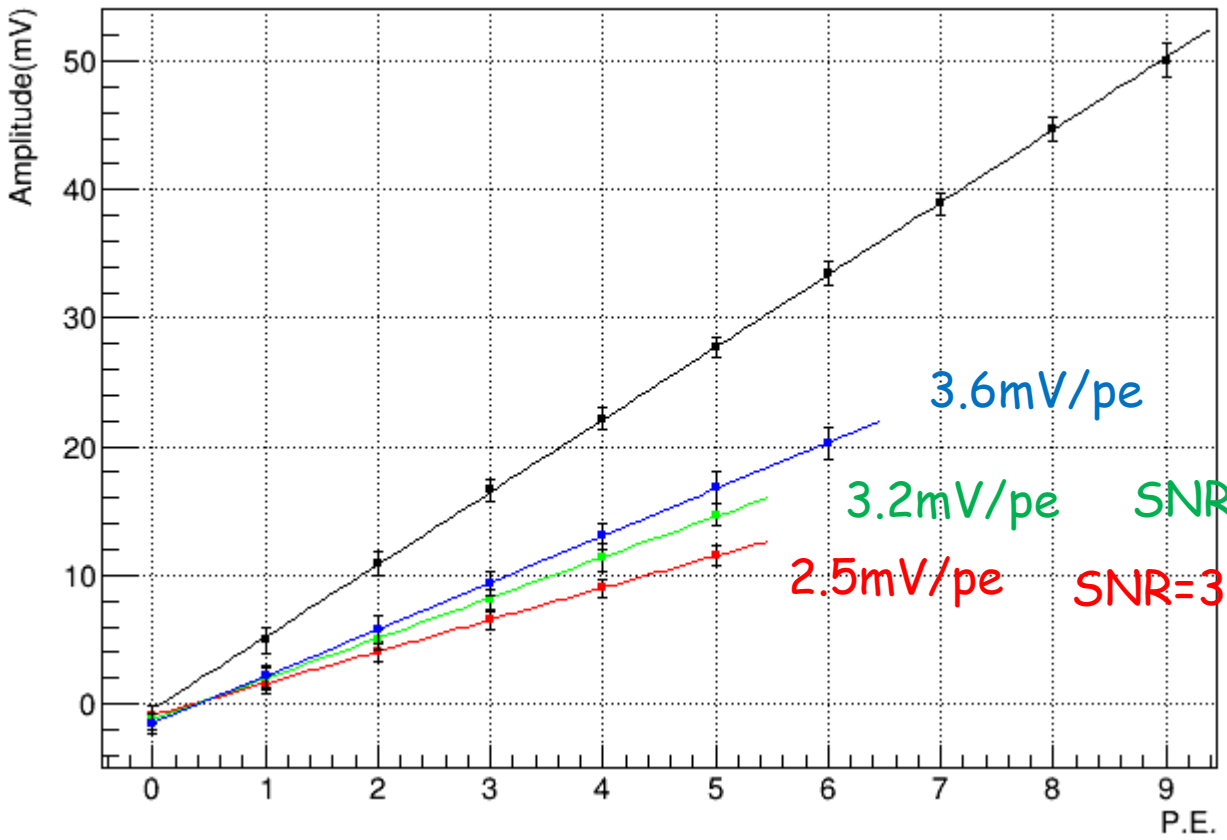




The gain strongly depends on BKG rate

A gain correction Network is under study

GAIN



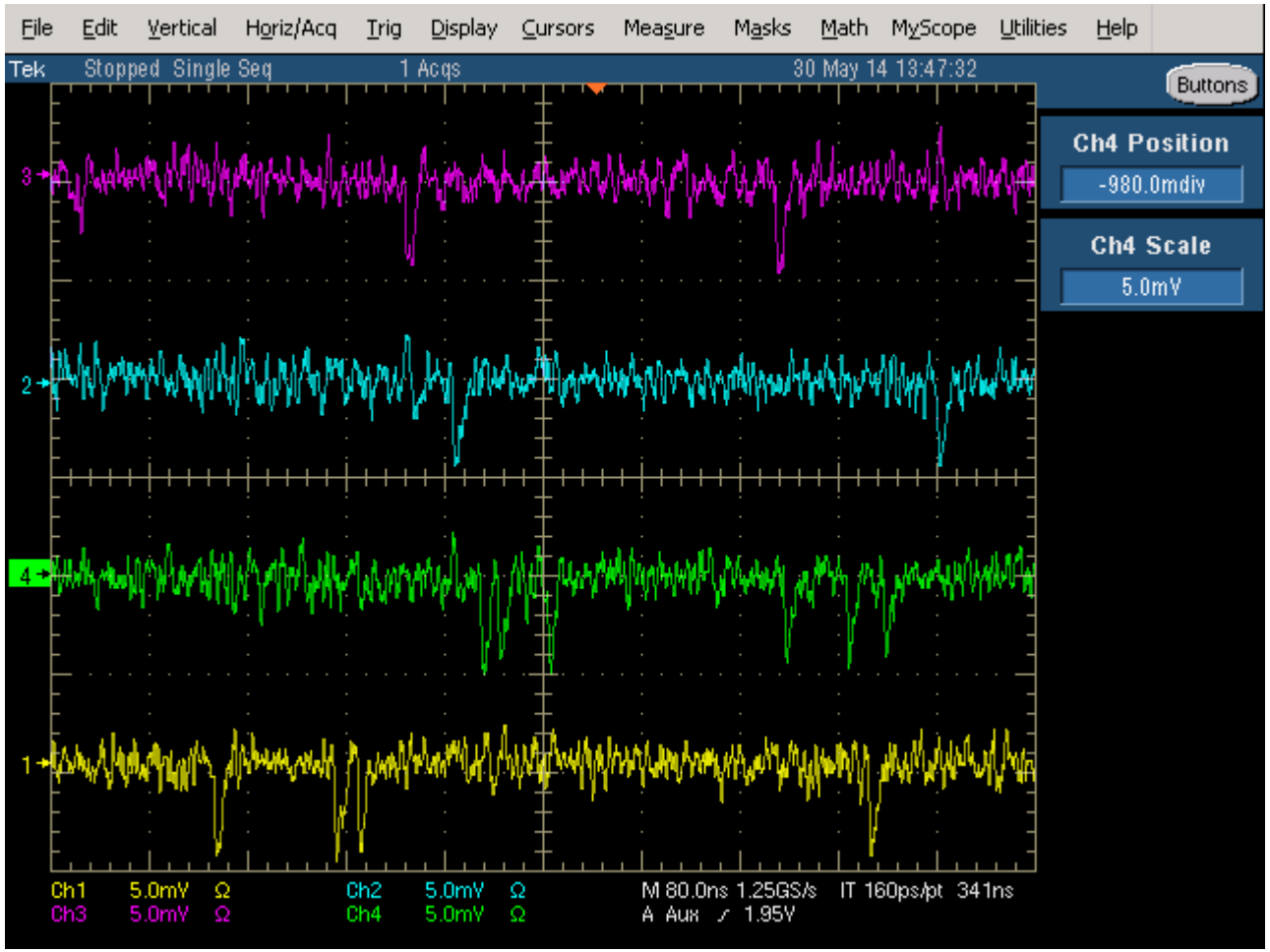
5.6mV/pe SNR=8

3.6mV/pe SNR=4.8

3.2mV/pe SNR=3.6

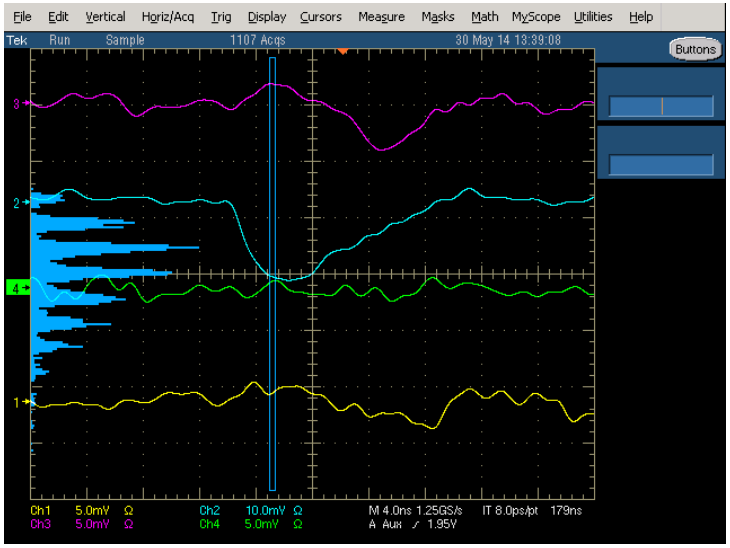
2.5mV/pe SNR=3.2

The CRD of the Matrix



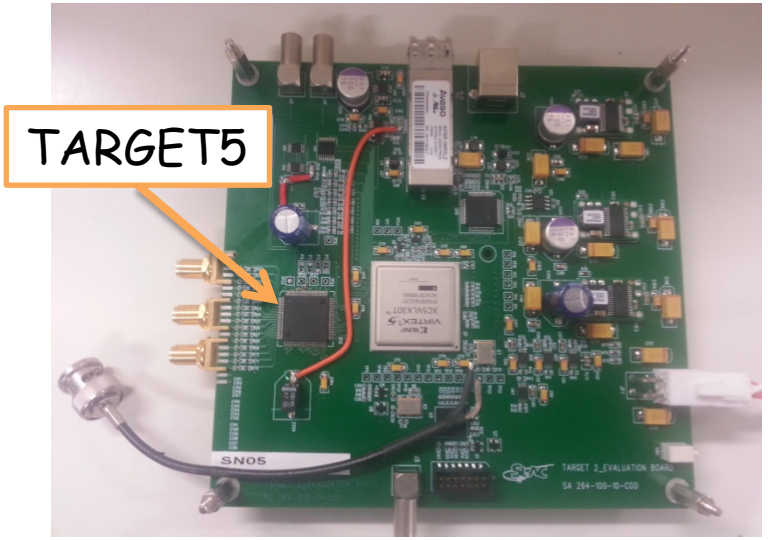
The matrix with the laser

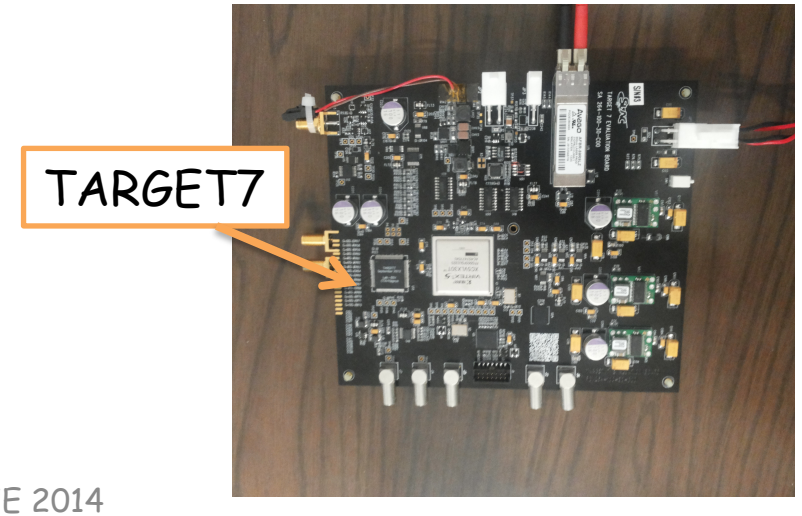
Laser pulse



TARGET5/7 evaluation

- TARGET5 chip
  - Evaluation board by SLAC
  - Control software being developed in Python (testbed for SST camera demonstrator readout software)
  - Short-term future plans
    - Cells calibration
    - Root analysis interface





Conclusions

- FBK sensors are being tested to define the best compromise in terms of gain, PDE and crosstalk
- We are studying the possibility to sum up 4 3mmx3mm SiPMs or producing only one 6mmx6mm
- The first prototype of 16 channel SiPM matrix is under test, as dark, with laser and in high background environment
- Characterization of the digitizer (target7) is ongoing.
- We plan to fed signals from the SiPm matrix to the T7 board by the end of the year