Study of a Cherenkov Camera demonstrator for CTA-INFN

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INFN - Bari
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/Demonstrator
  - ❑ Sensors
    - FBK NUV SiPMs
  - ❑ FE
    - Preamplifier + Filter
    - Sampler

- ✓ 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

FONDAZIONE BRUNO KESSLER

Who we are

SiPM R&D carried out by FBK, a no profit research institute based in Trento, Italy.

SiPM packaging and commercialization done by AdvanSiD (www.advansid.com), spin-off of FBK.

FBK SiPM technology evolution

FONDAZIONE BRUNO KESSLER

1st generation 2006 - 2010

Original technology — discontinued

Electric field engineering

2nd generation 2010 - 2012

RGB-SiPM (Green peak sensitivity)

NUV-SiPM (Near-UV peak sensitivity)

commercialized by AdvanSiD Advanced Silicon Detectors

New cell border

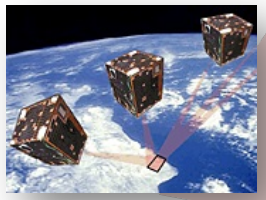
3rd generation 2012 -

RGB-SiPM_HD (Red-Green-Blue SiPM – high density)

NUV-SiPM_HD

soon available by AdvanSiD Advanced Silicon Detectors

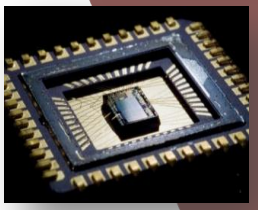
Space Competences and main Customers



Systems
- Microsatellites

Sub-Systems
- Small instruments
- Sensors and Detectors
- Electric Propulsion
- AOCS

Equipments
- Spacecraft Electrical Power
- Control Electronics for Complex Systems
- Spacecraft Data and Communications
- Electrical Ground Support Equipments



Microelectronic Devices
- Rad tolerant Analog, Digital and Mixed-Signal ASICs
- Digital IP Cores for Complex FPGAs

esa | NASA | JAXA
cnes | asi | INFN
ThalesAlenia Space | ASTRIUM | OHB CGS
COM DEV | AIR LIQUIDE | ENERGIA
ATMEL | SRON | Selex ES A Finmeccanica Company

SITAEL

Recent success stories: Curiosity and AMS-02

With Curiosity on Mars

On 5 August 2012 10:31 p.m. PDT, NASA's Mars Science Laboratory ("Curiosity" Rover) landed on Mars surface. SITAEL developed a key component in the mission, the **REMS ASIC**, a miniaturized device able to withstand Mars' extreme radiations and temperatures. Installed inside the weather monitoring station of the rover, the integrated circuit is currently taking measurements for five minutes every hour, on Mars' environmental parameters (Wind, Humidity, Temperature), giving an invaluable contribution to the mission.

With AMS-02 on the International Space Statio

On May 19th 2011, the AMS-02 has been safely installed on the ISS and then successfully activated. For 10 years the experiment will use the unique environment of Space to study the Universe and its origin by searching for antimatter, dark matter while performing precision measurements of cosmic rays composition and flux. SITAEL provided about **80% of electronic devices** for all the AMS-02 sub-detectors, working perfectly since payload switch on, thus allowing AMS-02 data collection.

Optical Plane

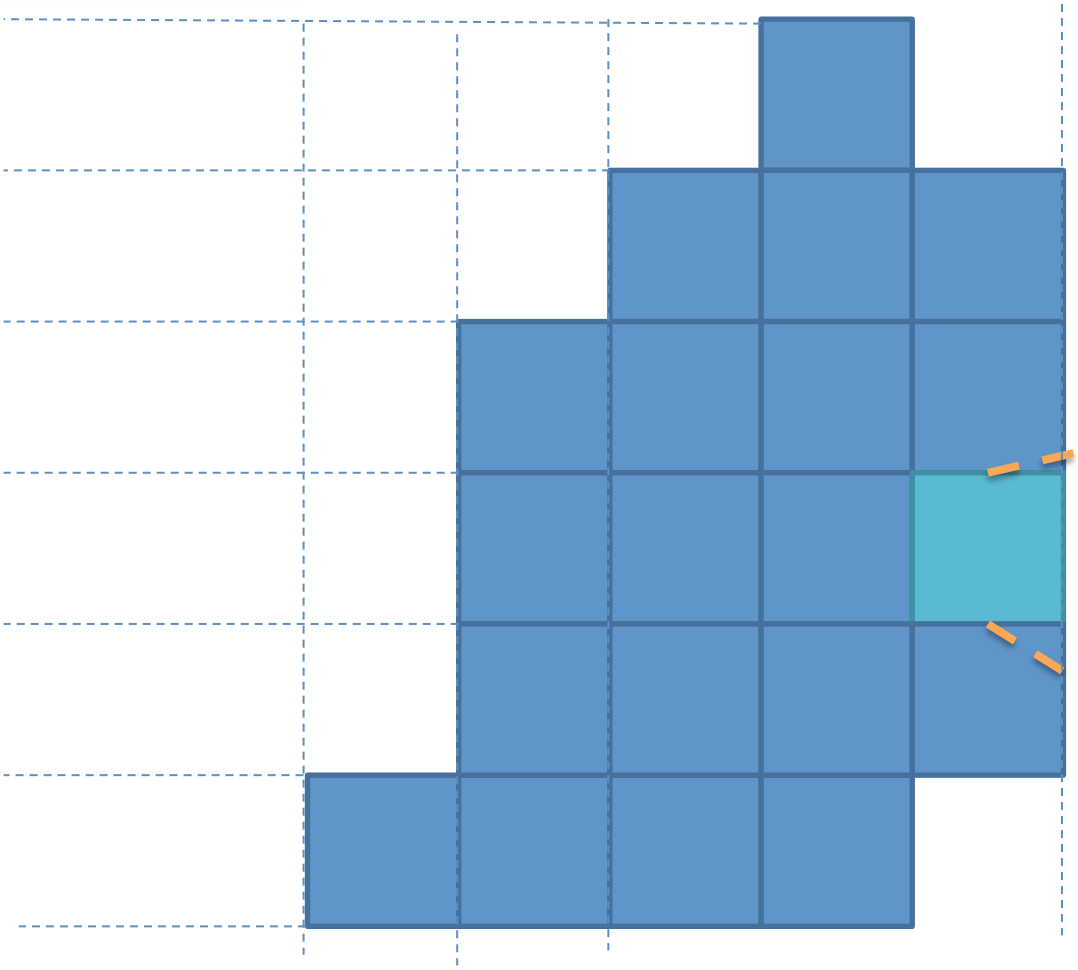
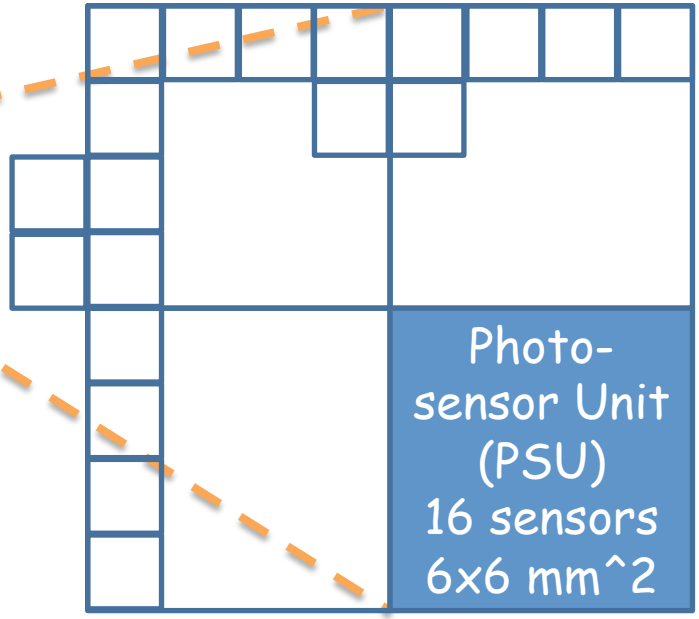
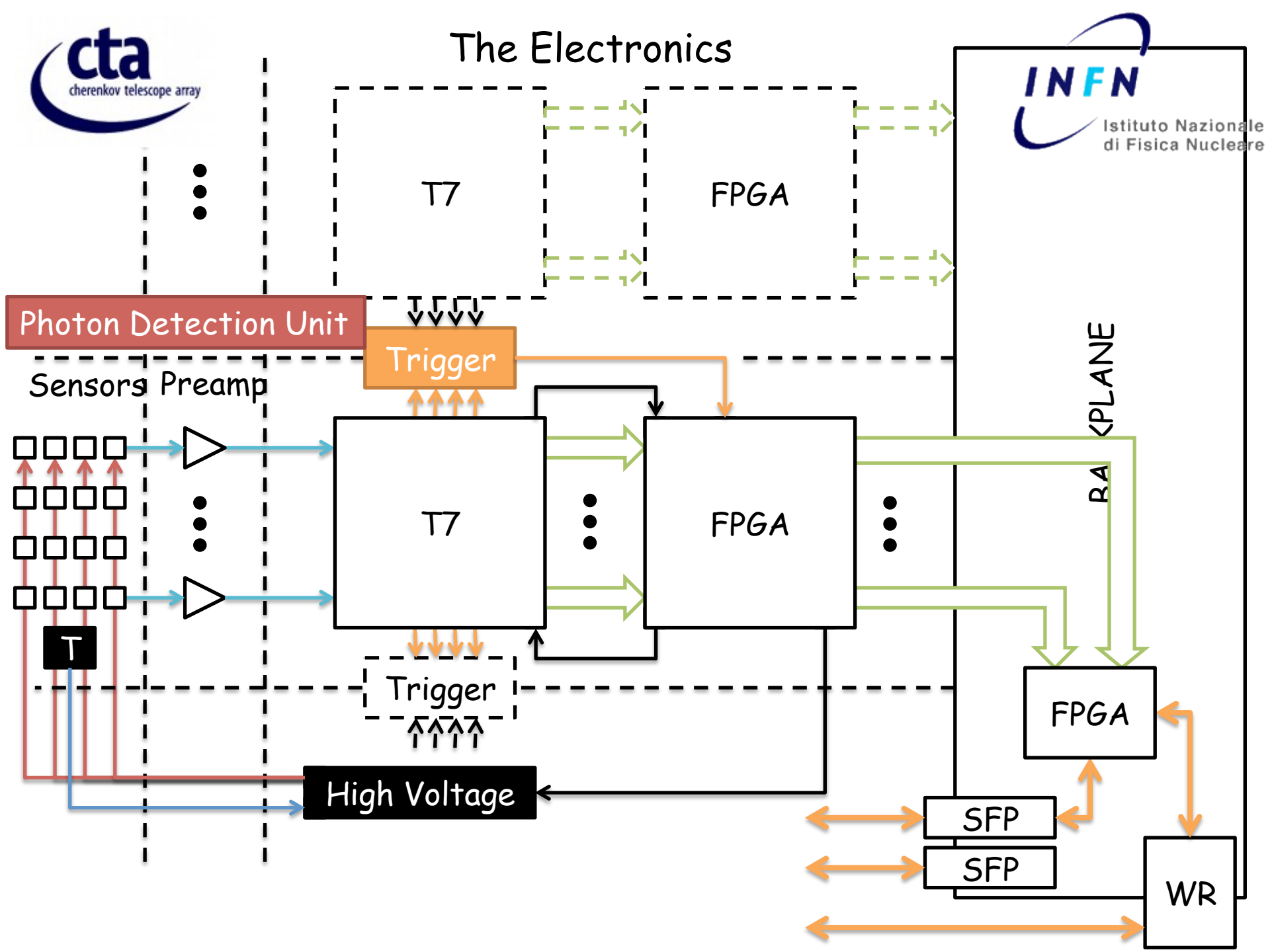
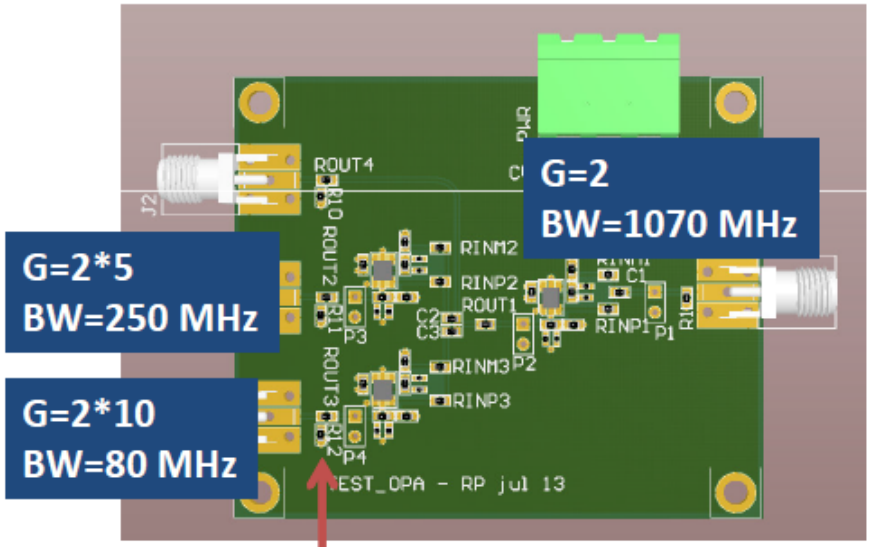


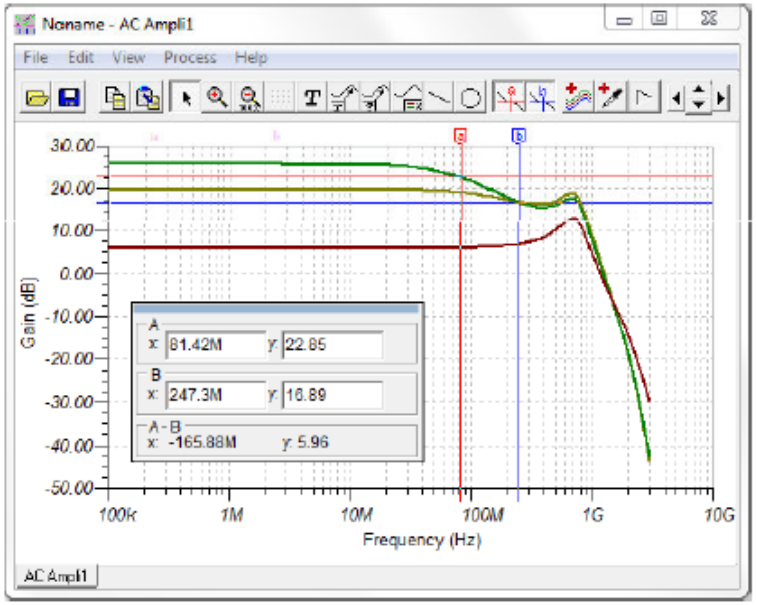
Photo-sensor module (PSM)
64 sensors 6x6 mm^2




The Electronics
cta
cherenkov telescope array
INFN
Istituto Nazionale
di Fisica Nucleare
T7
FPGA
Photon Detection Unit
Trigger
Sensors Preamp
T7
FPGA
BACKPLANE
T
Trigger
FPGA
High Voltage
SFP
SFP
WR

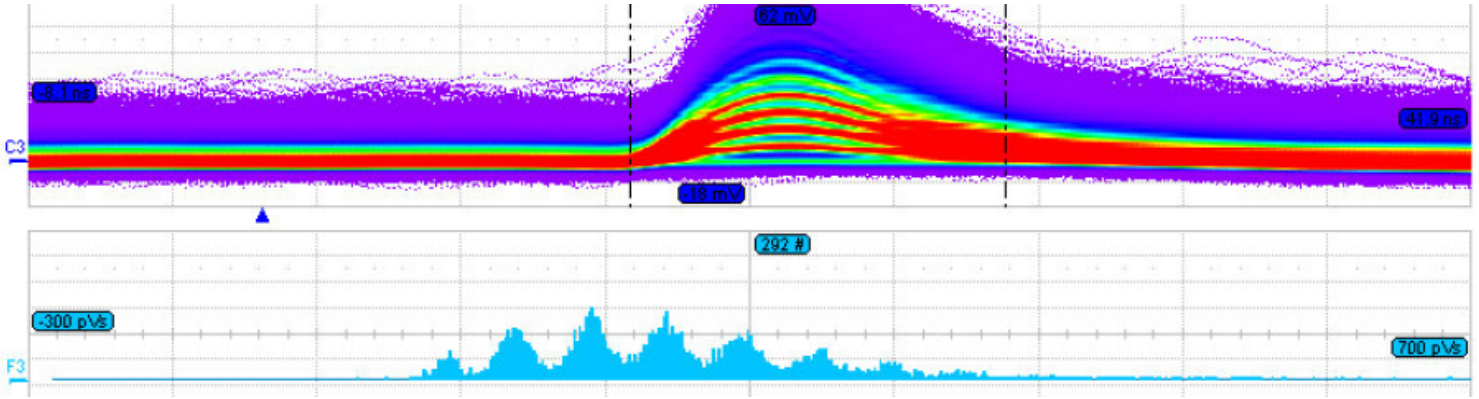
OPA657 by TI based design





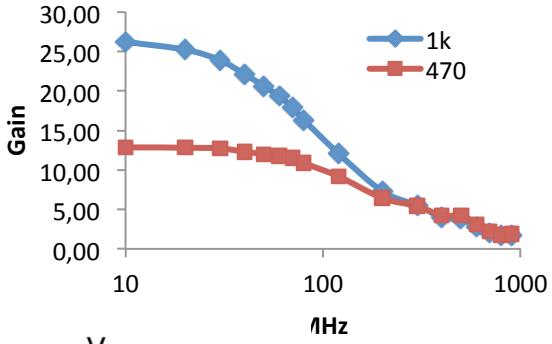
High Pass filter
f_c~90 MHz

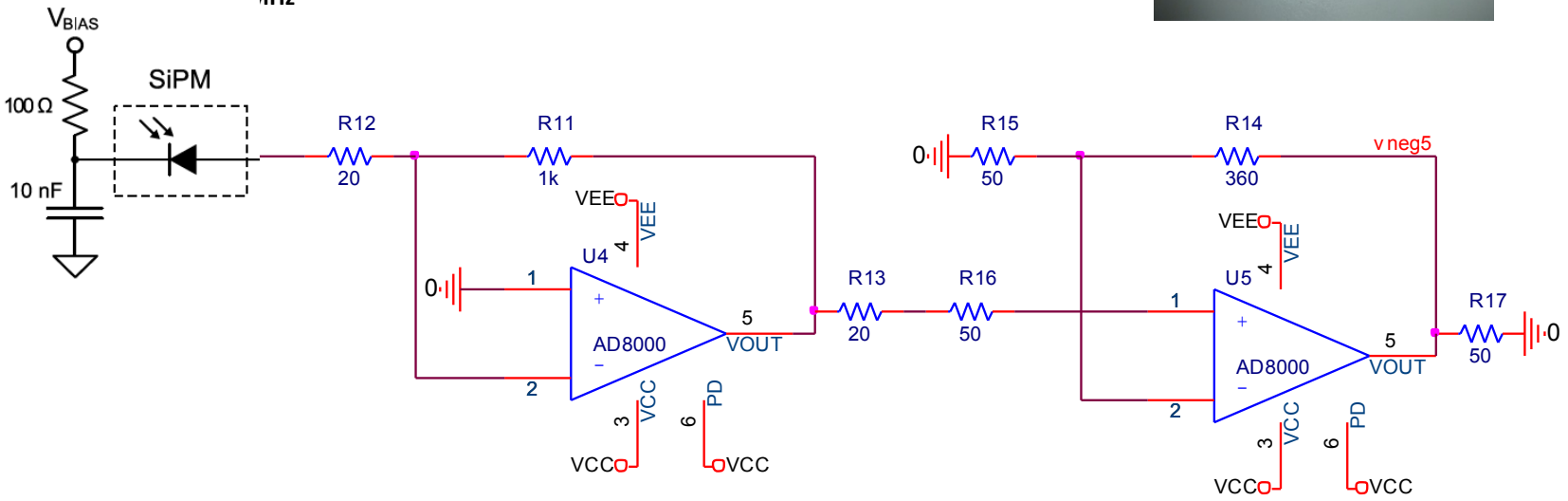
G=+25



Current sensitive amplifier

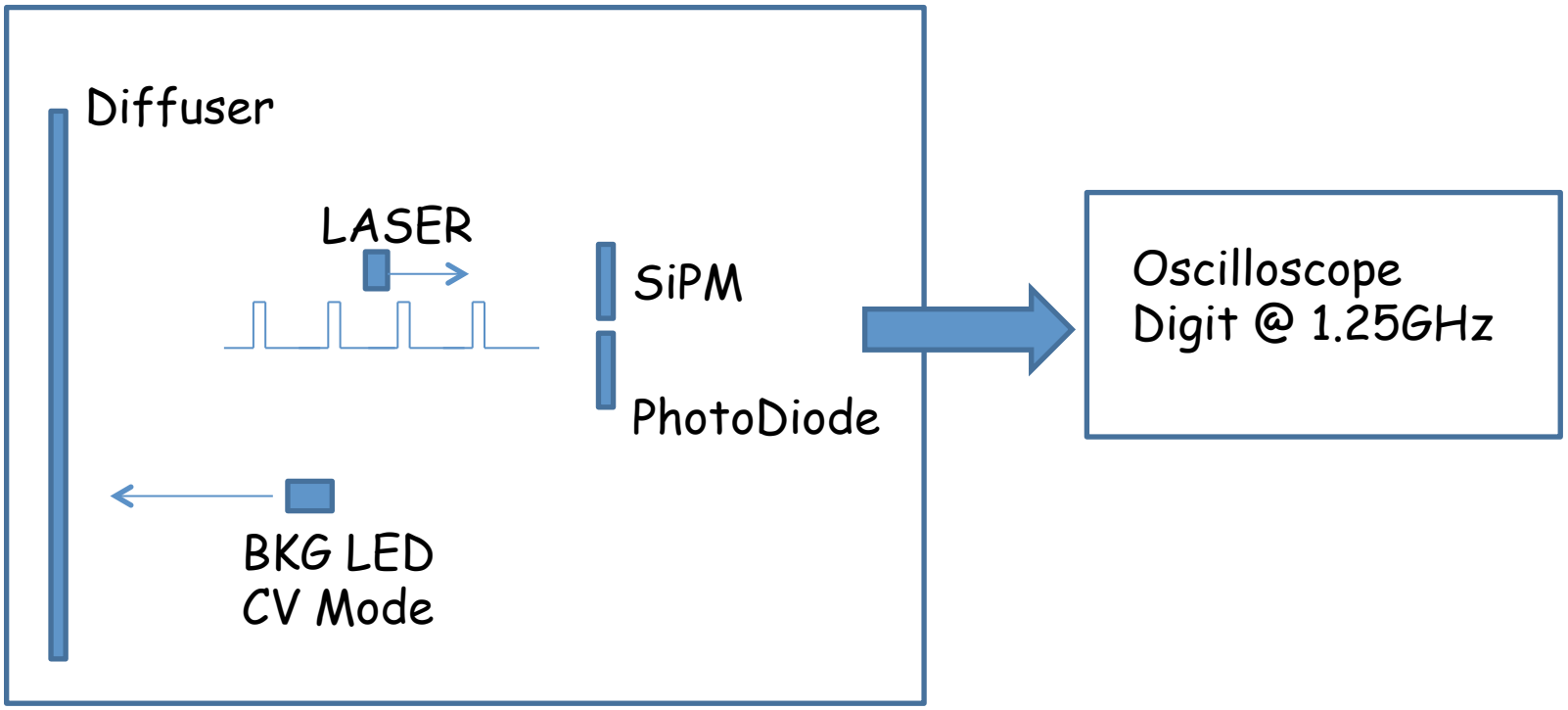
AD8000 OPA based FE
1.5GHz wide band



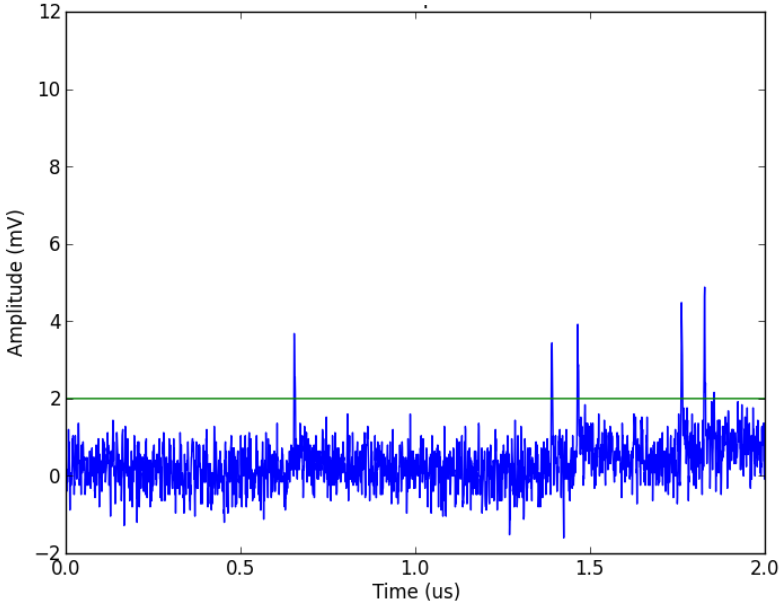


F. Giordano
D. Perrino (SITAEL)

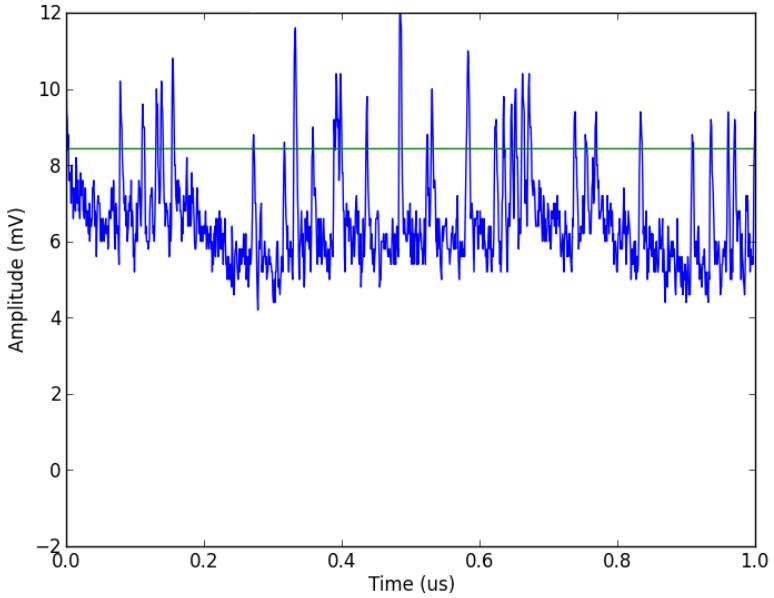
Performance studies: Sensors +Electronics



Dark



10MHz/mm^2



5 photons / 2us

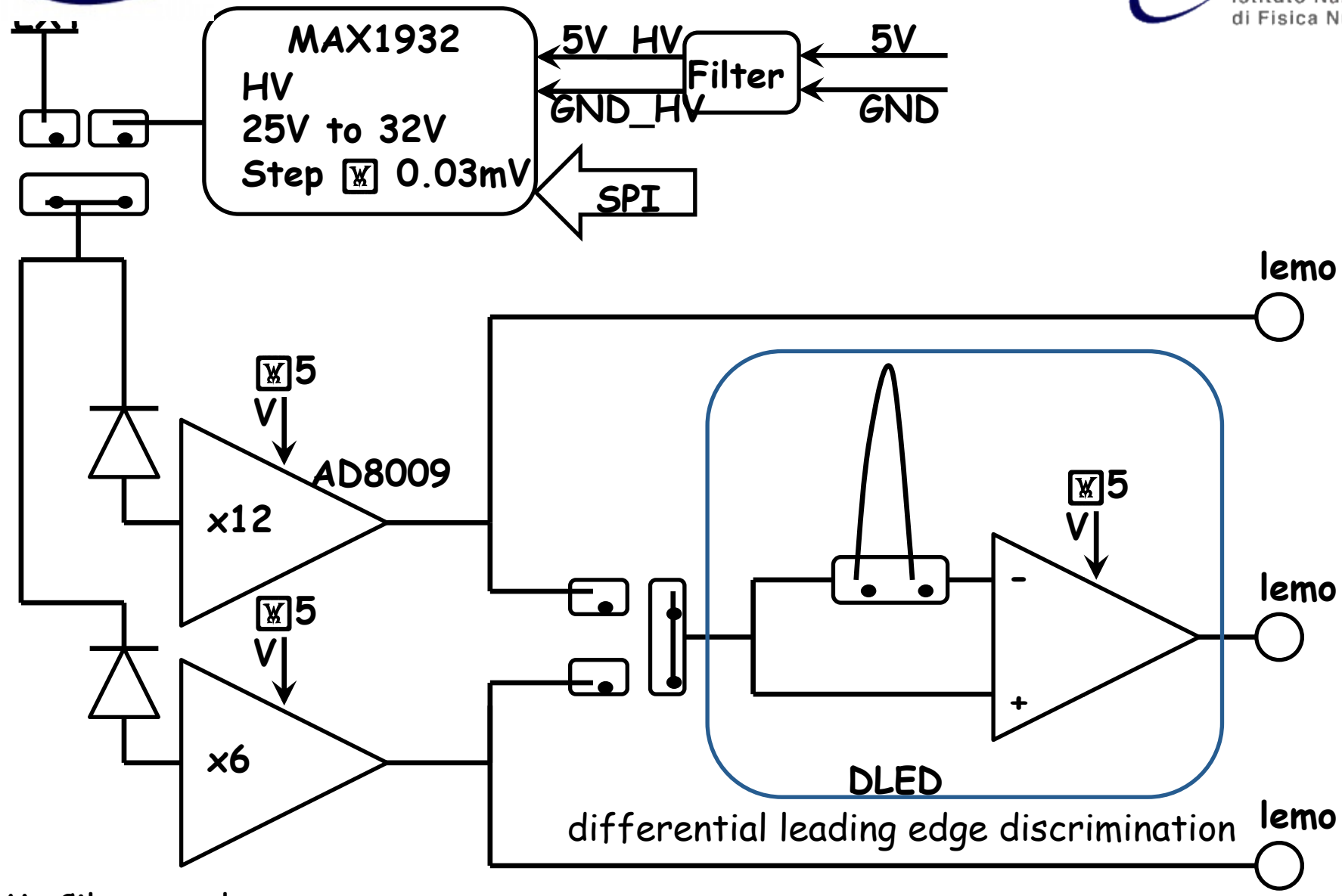
DCR=200kHz/mm^2

35 photons / 1us

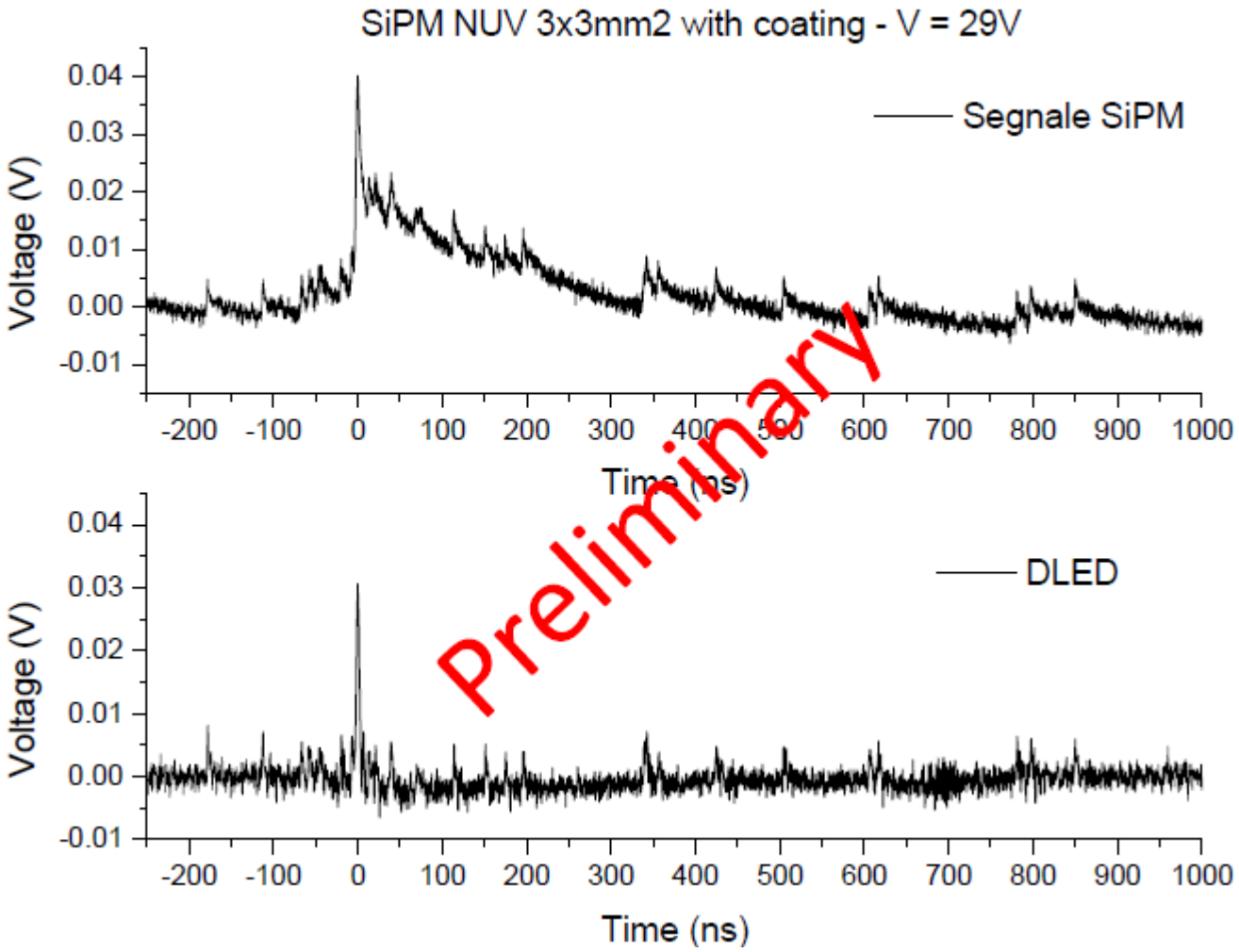
The threshold needs to be adjusted depending on the BKG rate

Pre + DLED + HV

Gola, Piemonte and Tarolli, Nuclear Science, IEEE Transactions on (Volume:59 , Issue: 2)



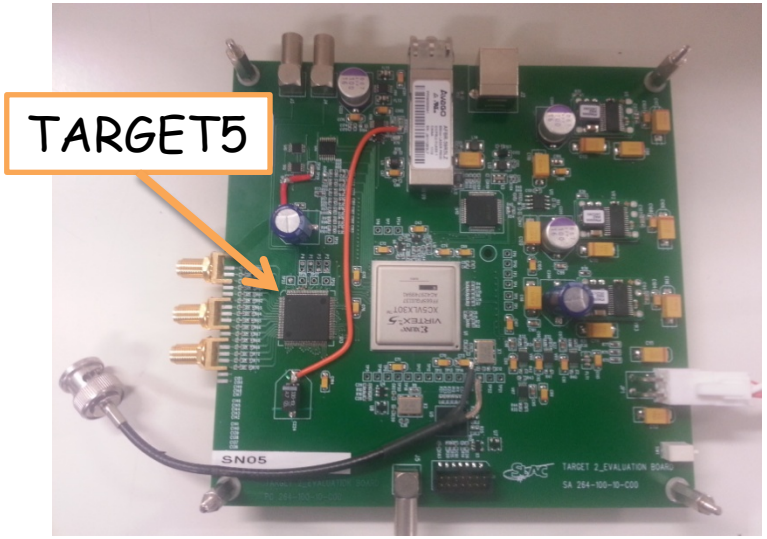
M. Cilmo et al.


SiPM NUV 3x3mm2 with coating - V = 29V
Segnale SiPM
Voltage (V)
0.04
0.03
0.02
0.01
0.00
-0.01
-200
-100
0
100
200
300
400
500
600
700
800
900
1000
Time (ns)
DLED
Voltage (V)
Time (ns)
Preliminary

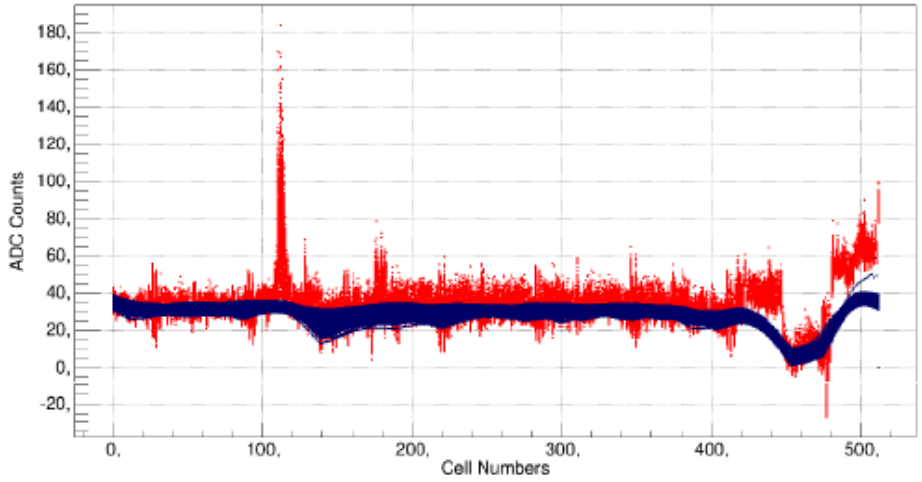
M. Cilmo et al.

TARGET5/7 evaluation

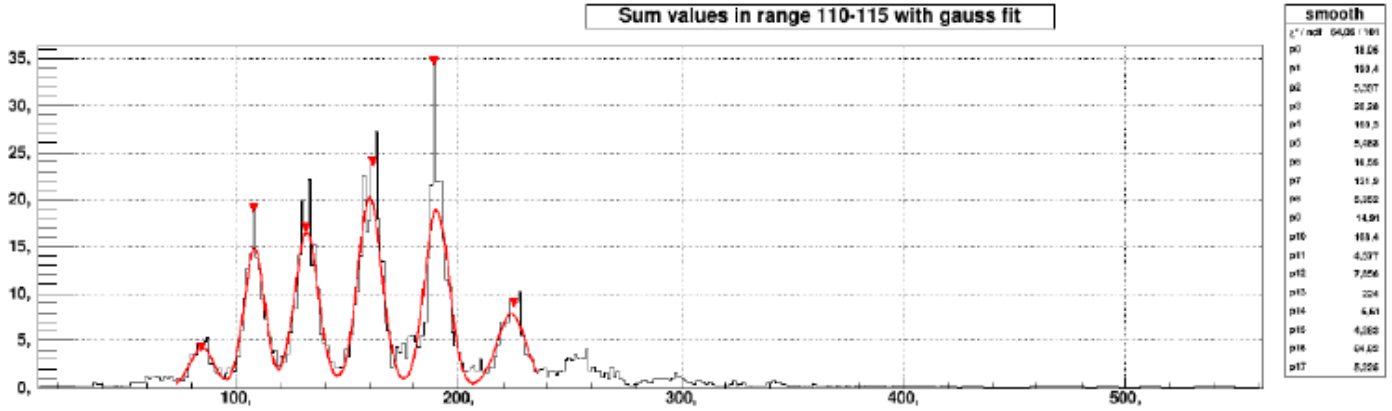
- TARGET5 chip
  - Evaluation board by SLAC
  - Control software being developed in Python (testbed for SST camera demonstrator readout software)
  - Short-term future plans
    - Cells calibration
    - Root analysis interface



Sampling of SiPM signal with T5

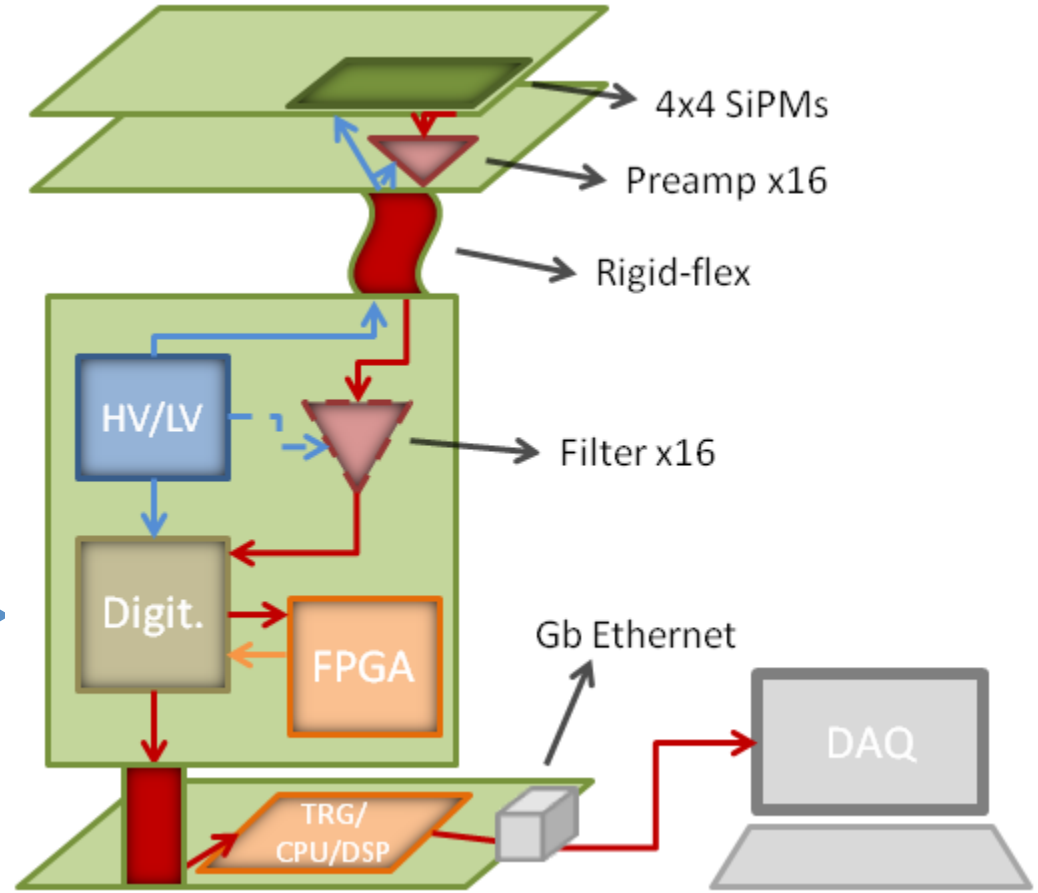


Sampling @ 1GHz

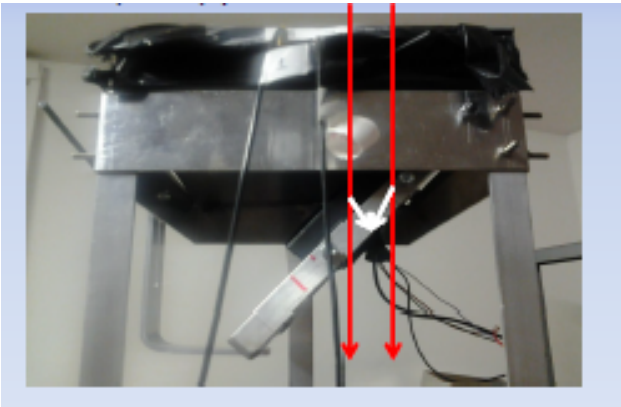


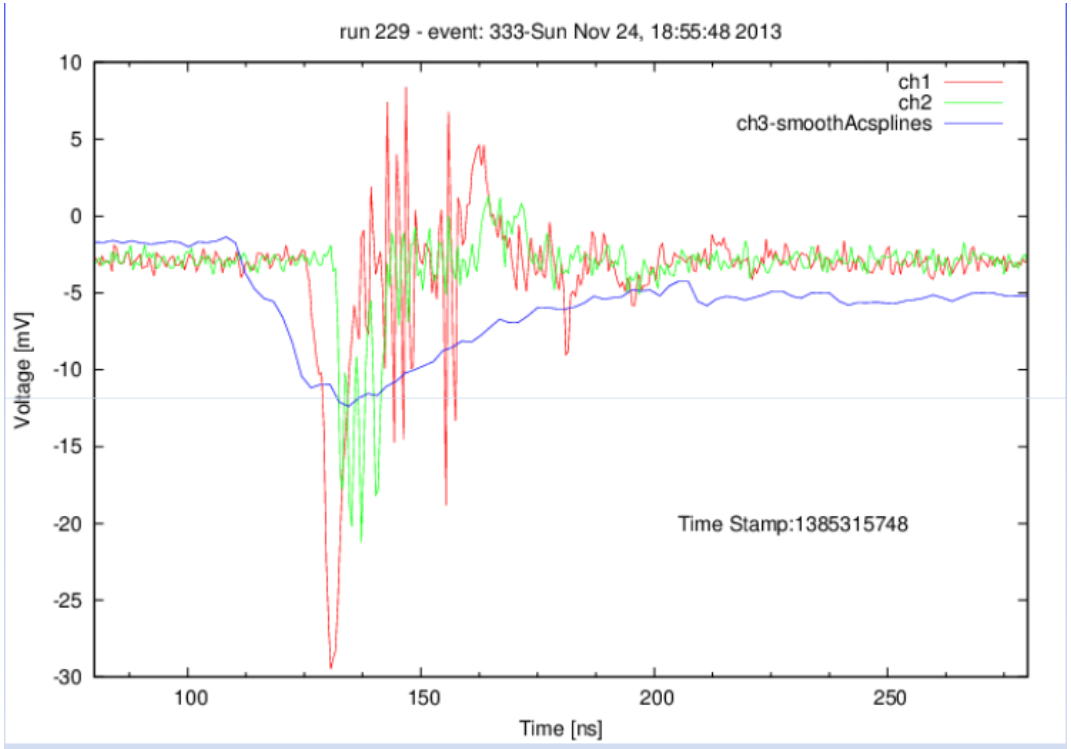
The TECHE.it demonstrator architecture

- Target7
- DRS4
- Flash adc option



Cosmic ray facility for Cherenkov light





M. Iori, F. Ferrarotto

Premiale schedule

- Tests on the Matrix are ongoing
- Eval board on T7 is under study and development
- Engeneering process started
- First complete prototypes by the end of the year