Silicon Photon Multipliers light response properties:

first results

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Outline

- Motivation
- **Activity on silicon radiation detectors at Rome:**
  - **Test setup**
  - **SiPM samples**
- Properties and characteristics measurements
- Conclusions and Perspectives

Motivation

Solid state small photosensor segmenteted in n microcell

- Low bias voltage operation
- High gain
- Insenistivity to magnetic field
- Mechanical properties: compact dimension, low weight
- Fabrication technology compatible with standard processes of microelectronics industry

Suitable to be used in medical application, astrophysics and **particle phyiscs.**

Electromagnetic and hadron calorimeter in future collider experiments :

- **HCAL issues at ILC** : understanding hadron showers

using as active medium scintillators: new possibilities with SiPMs.

SiPM characteristics

- **Gain**: ~ Best to have 10^6 , at least 10^5
- **Dynamic range**: determined from number of pixel:
  for ideal 1000 pixel SiPM ~ 1-1000 p.e.
- **Photon Detection Efficiency** ~ 30 %
  - to distinguish MIP signal
- **Noise rate** : < 1 MHz
- **Good uniformity, small cross-talk**
- **Timing Resolution** < 1 nsec
  - Necessary for bunch identification
- Pixel size: (25 x 25) μm^2 (50 x 50) μm^2

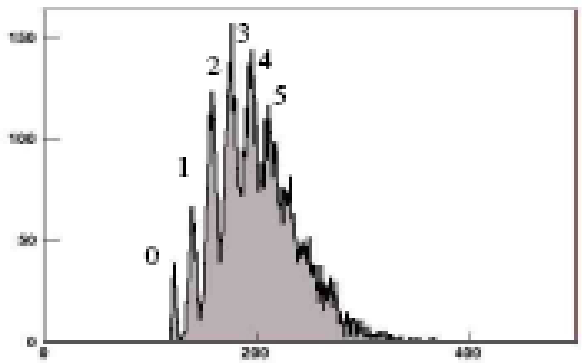
SiPM Studies at Rome

- Development of a test set up and measurement procedure
- General of the SiPM response to LED light

comparison of SiPM produced by **different manufacturers**

Measurements:

- **Current-Voltage characteristics**
- **Response to low intensity light (UV, green light)**

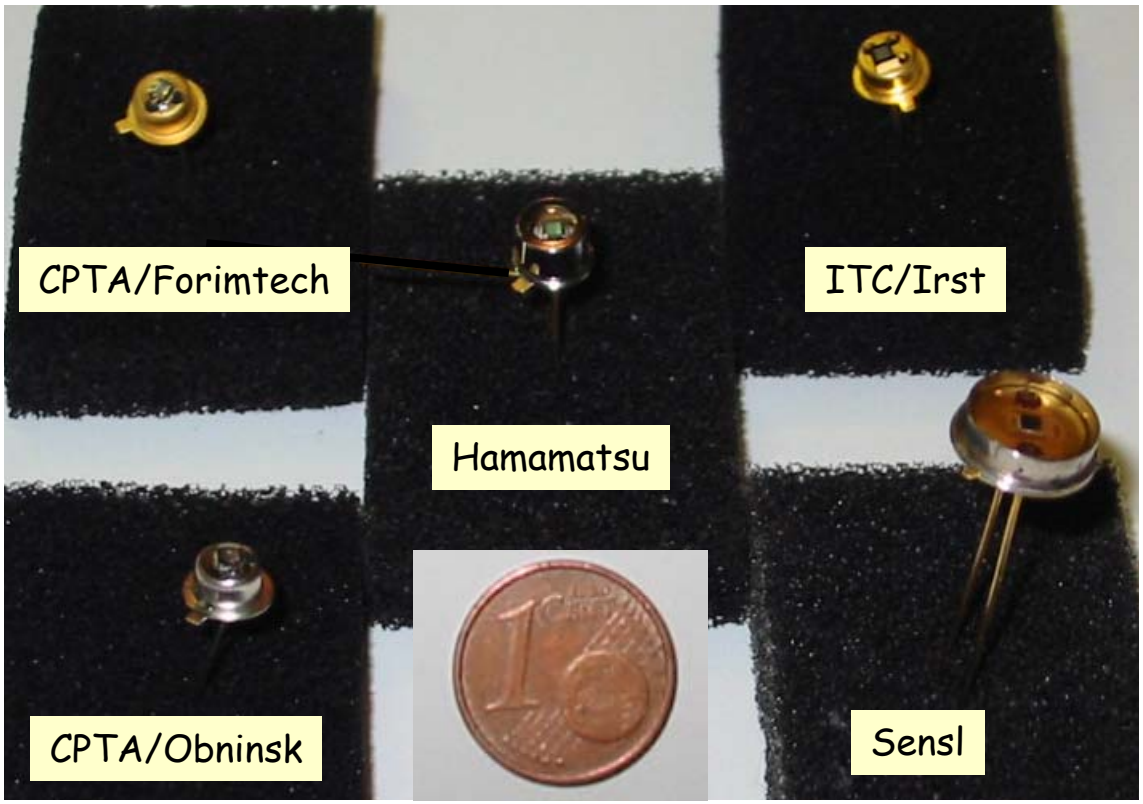


Single electron spectrum

Parameters:

- Gain
- Width of pedestal and single peak
- Efficiency of light registration
- Crosstalk between pixels

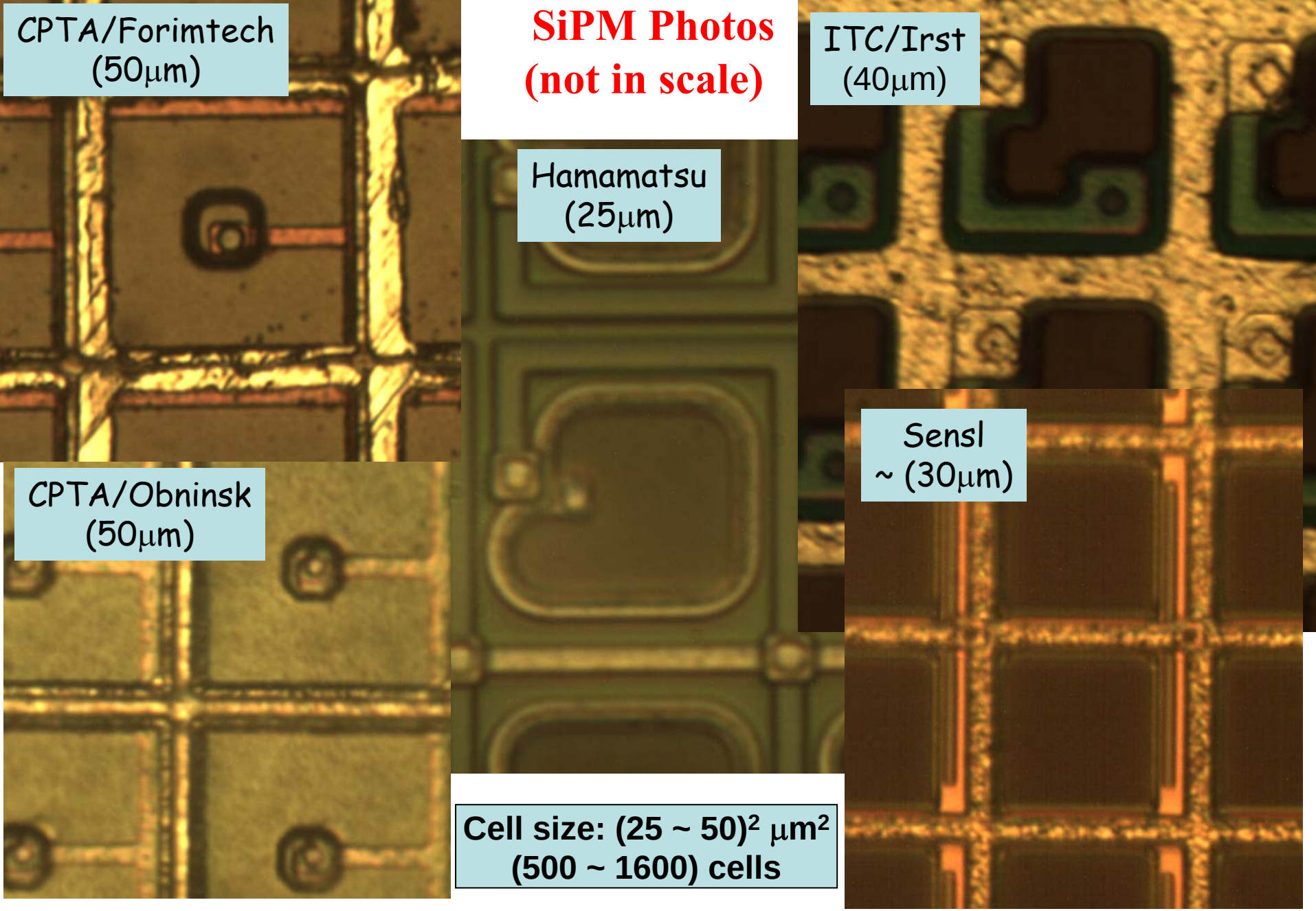
SiPM



Different packages

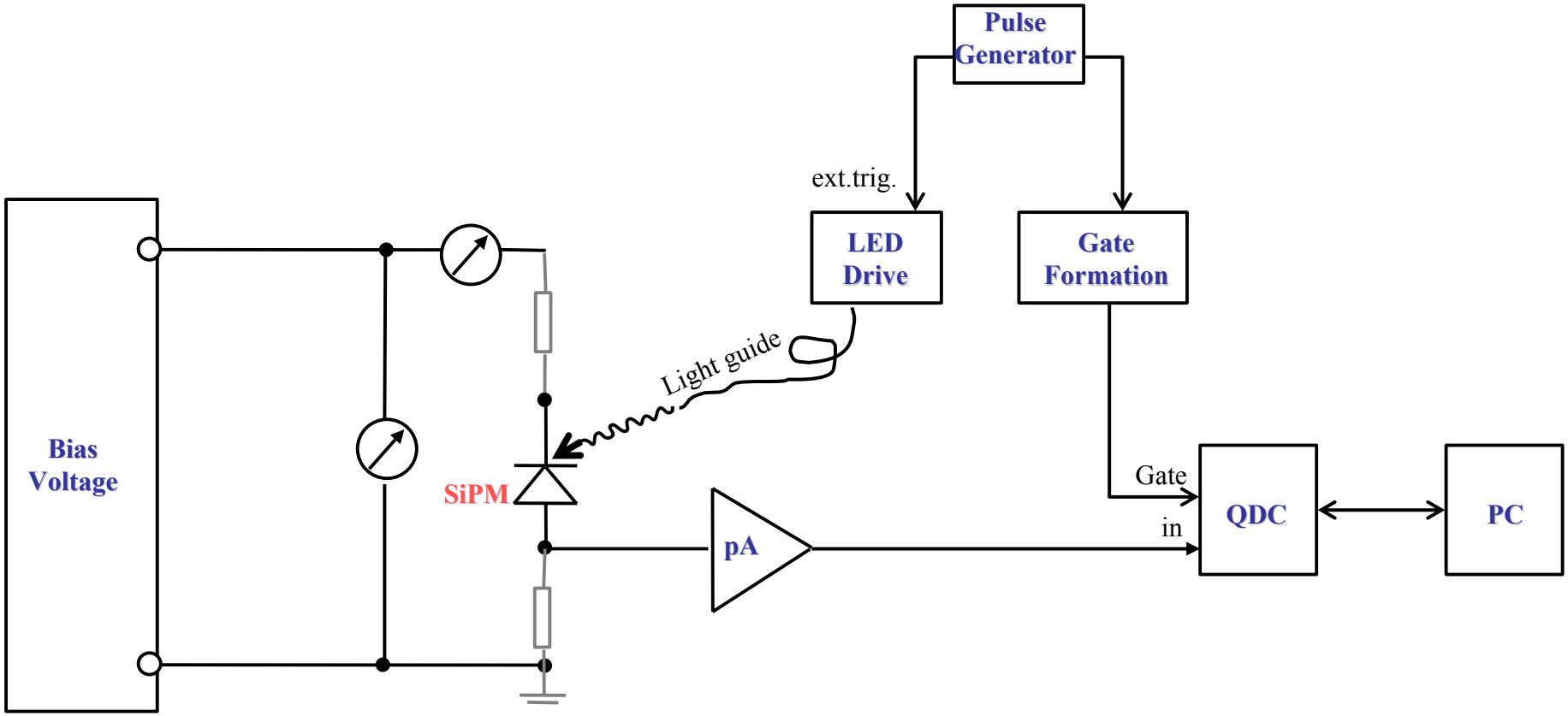
Different names

Silicon Photo-Multiplier (**SiPM**: used by MEPHI, **SPM**: used by SensL)
Multi-Pixel Photon Counter (**MPPC**) is a trademark of Hamamatsu Photonics
….for short here we use as achronime SiPM

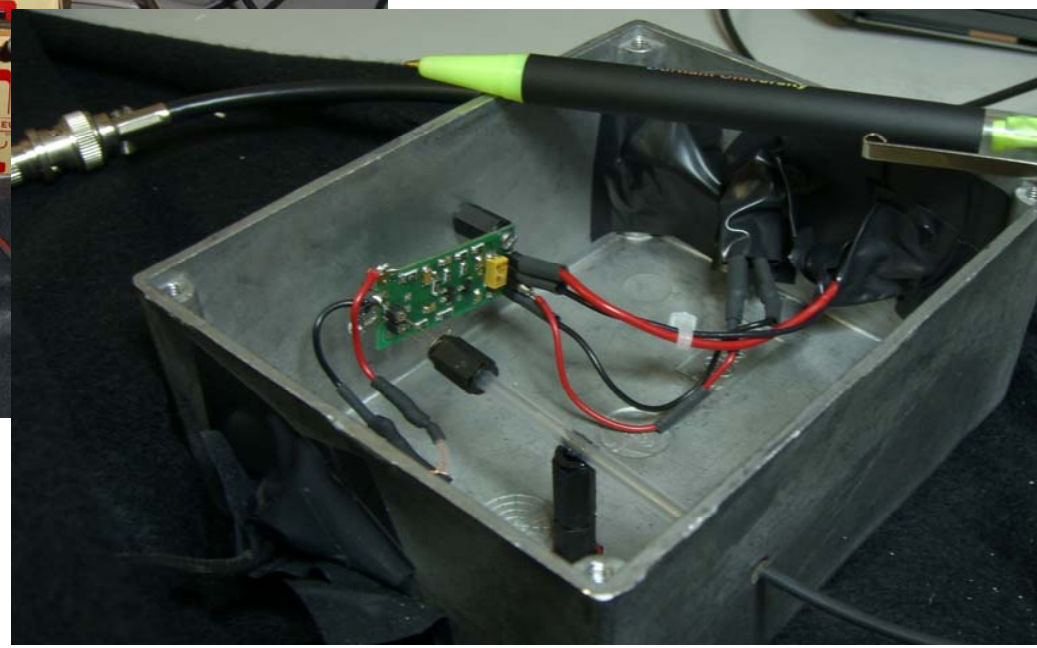


Different faces

Measurements set up



Measurement set up

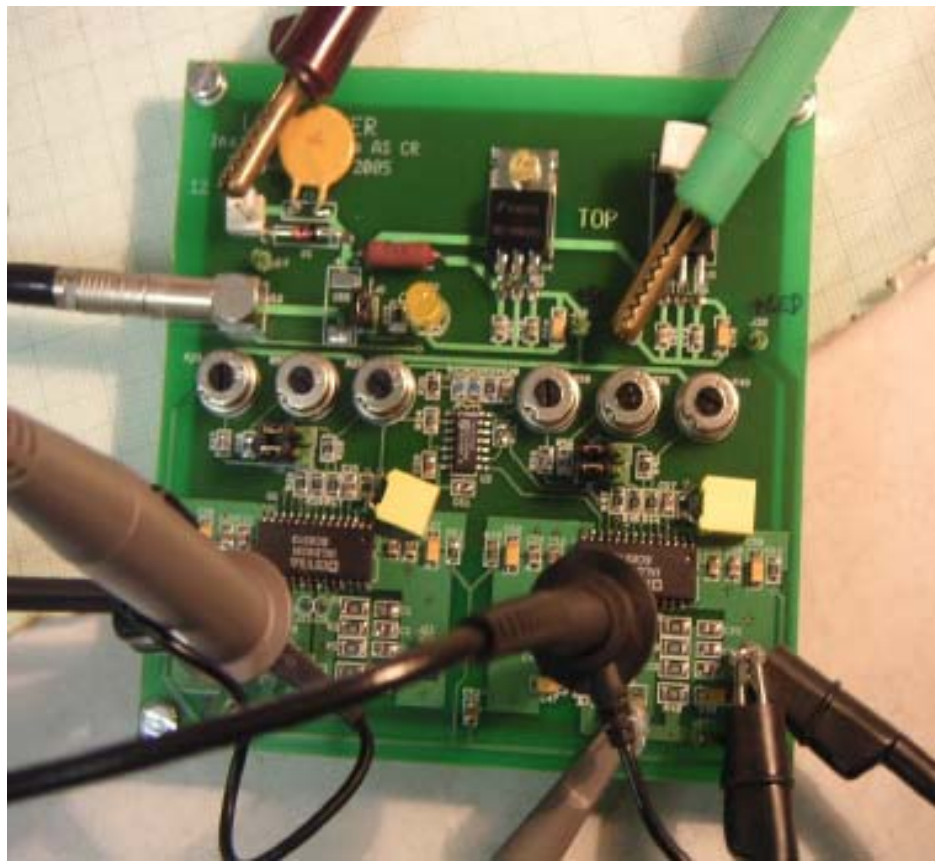


- External light protection
- No temperature control

LED driver

Low intensity fast light pulses : LED drive from Institute of Physics ASCR Prague (Ivo Polak)

- developed for Calibration and Monitoring Board (Calice Collaboration)
- external trigger
- variable current pulse width
- variable current pulse amplitude
- rise time 2ns



Samples

- **CPTA distributed by Obninsk University, Russia**

  http://www.zao-cpta.ru (3)

- **CPTA distributed by Forimtech SA, Swiss**

  http://www.forimtech.ch.com ~ 1.3 mm^2, ~500 cells, size ~$(50\mu m)^2$ (*)

- **HAMAMATSU, Japan** 1.0 mm^2, 40x40=1600 cells, size $(25\mu m)^2$

  http://www.hamamatsu.com

- **ITC-irst, Italy** ~ 1.3 mm^2, 25x25=625 cells, size ~$(45\mu m)^2$ (*) (1)

  http://www.itc.it/irst **(RUN2 del Maggio 2006)**

- **SensL, Ireland** ~ 1.0 mm^2, 32x36=1152 cells, size ~$(30\mu m)^2$ (*)

  http://www.sensl.com (*) Measured by microscope

- **MEPhI/PULSAR (RUSSIA)** (2)

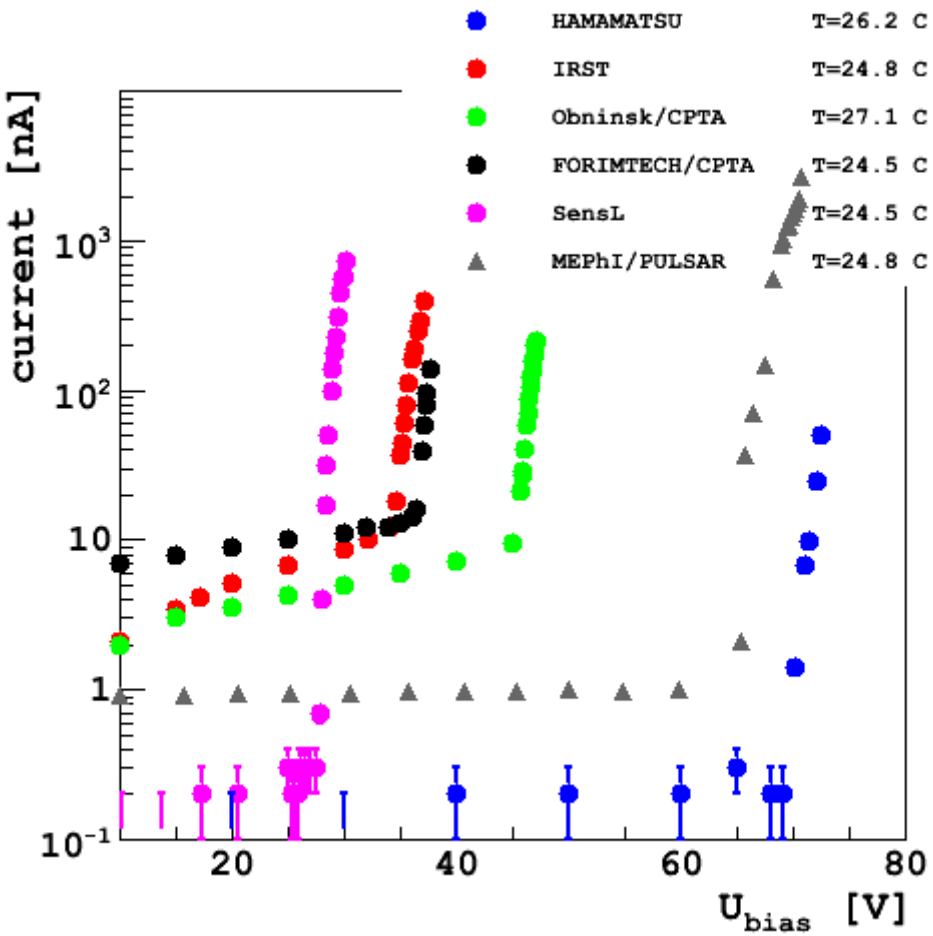
(1) specimen kindly provided from Prof. R.Battiston

(2) specimen kindly provided from Prof. M.Danilov

(3) specimen kindly provided from Prof. V.Saliev

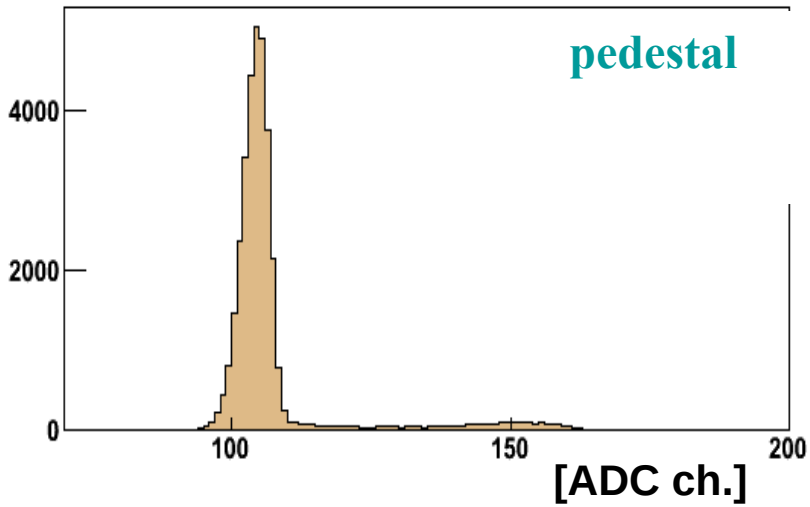
NEW -Nov 2, 20

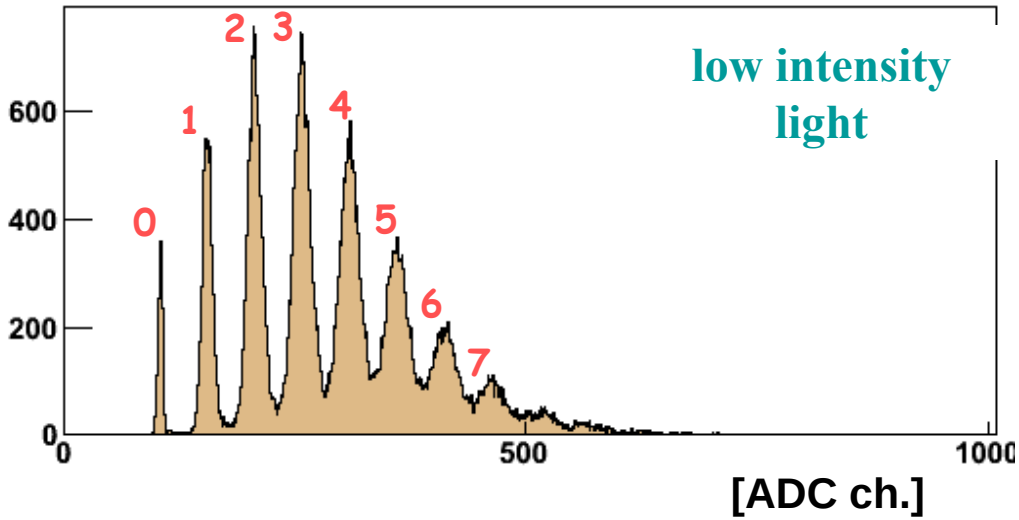
Current-Voltage characteristics



Single Photoelectron Spectrum

Typical spectra for CPTA/Obninsk SiPM





Fit parameters :

- pedestal (μ_0)
- peak distance (g)
- gauss N_i
- gauss σ_i

$$\sum_i G(N_i, \mu_i, \sigma_i) = \sum_i G(N_i, \mu_0 + i \cdot g, \sigma_i)$$

(… no efficiency of light detection, nor x-talk consideration yet implemented …)

Single photon spectra information

di Fisica Nucleare

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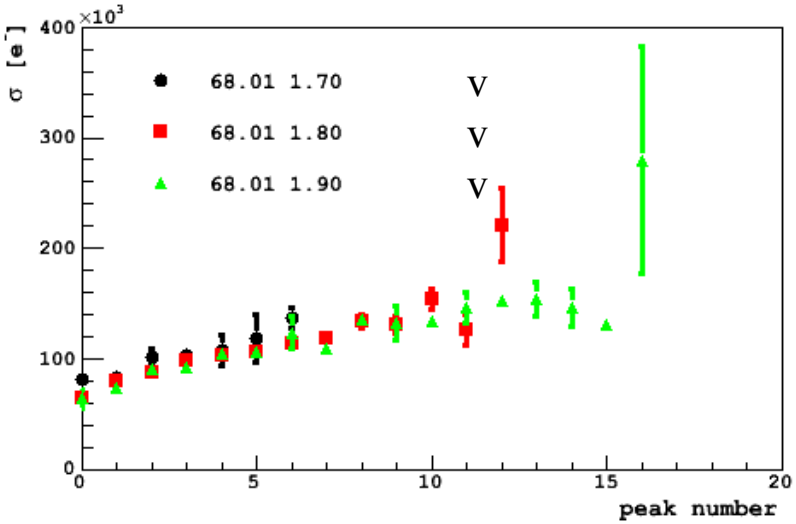
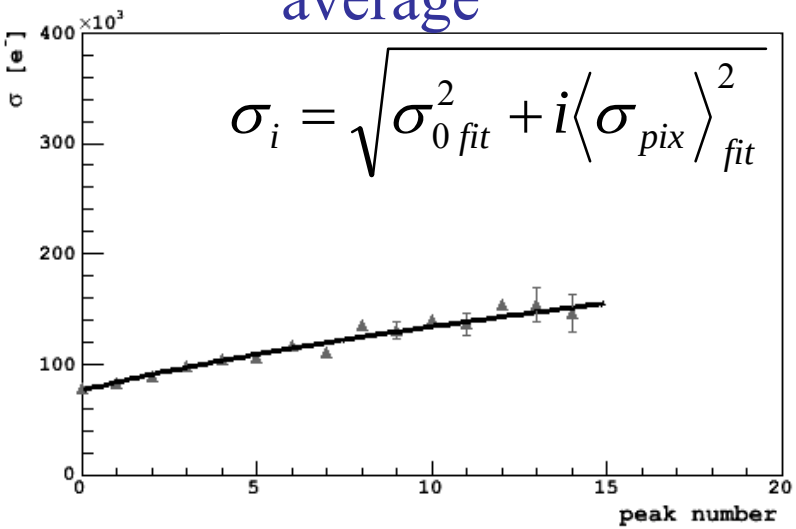
MEPhI/PULSAR sample

Intensity scan at U_{bias}=const.



- σ_i vs. peak number at various light intensity

average



$$\sigma_i = \sqrt{\sigma_{0\,fit}^2 + i\left\langle \sigma_{pix} \right\rangle_{fit}^2}$$

fit parameters:

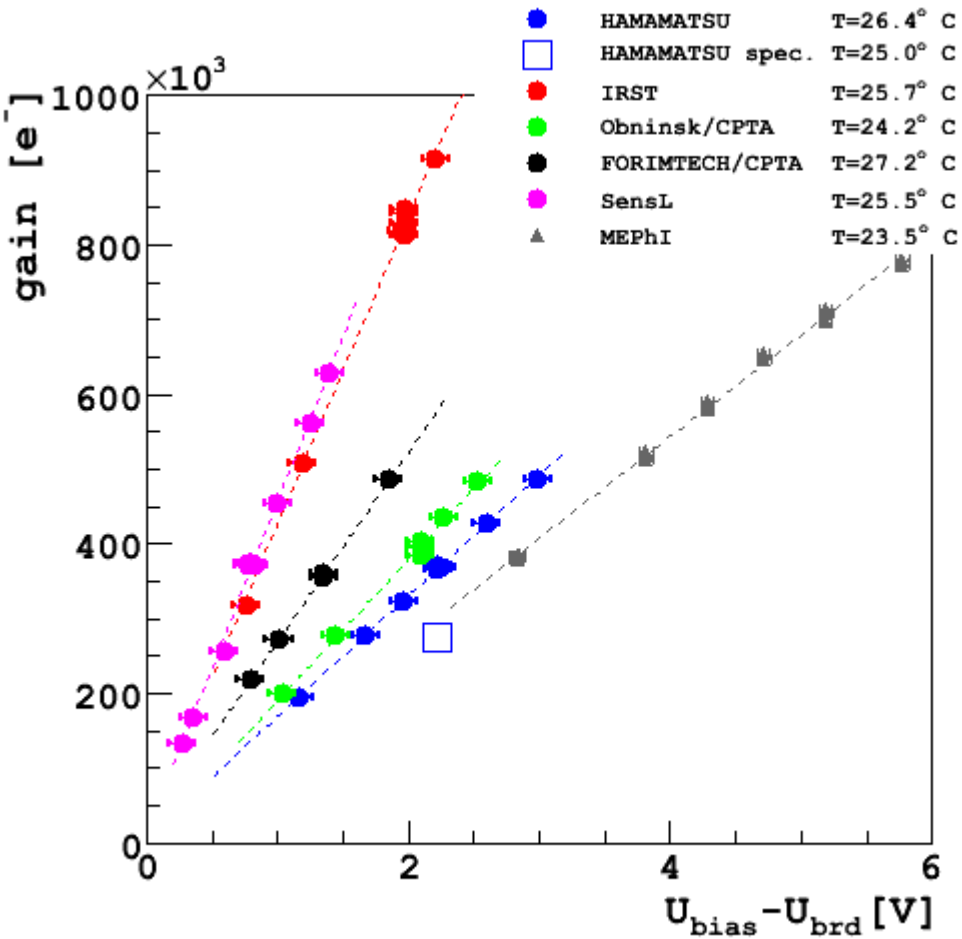
$$\sigma_{0\,fit}^2 = 1.2 \cdot 10^9 \pm 4.2 \cdot 10^7$$

$$\left\langle \sigma_{pix} \right\rangle_{fit}^2 = 5.8 \cdot 10^9 \pm 1.2 \cdot 10^7$$

$\langle\sigma_{px}\rangle$: single pixel response dispersion averaged on SiPM matrix

onetta Gentile
IEEE 2007

Relative gain

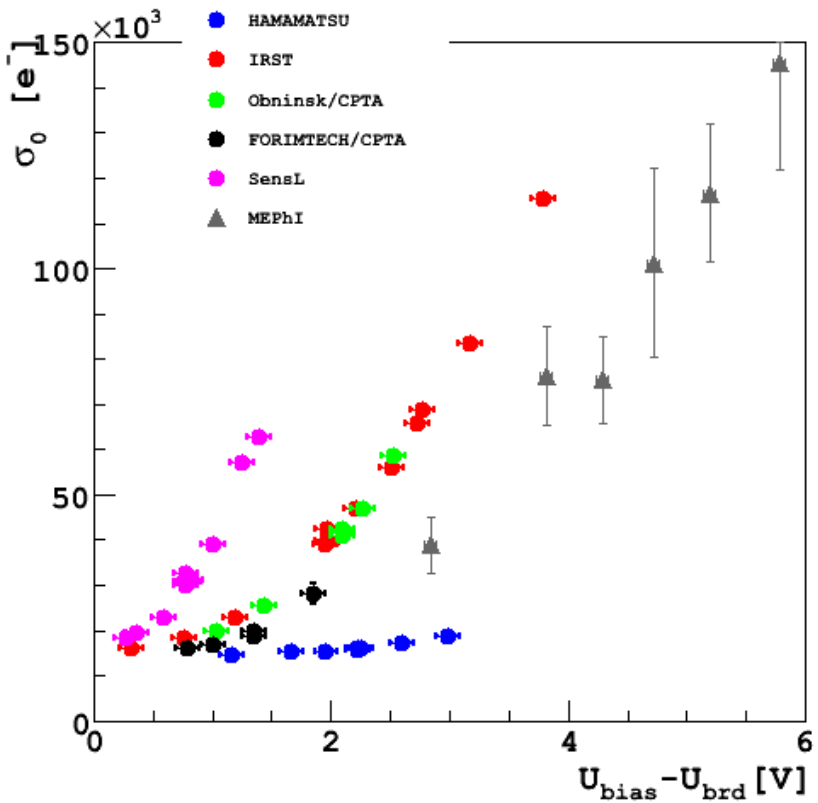


Measurement at room temperature: <T> ~ 24 C

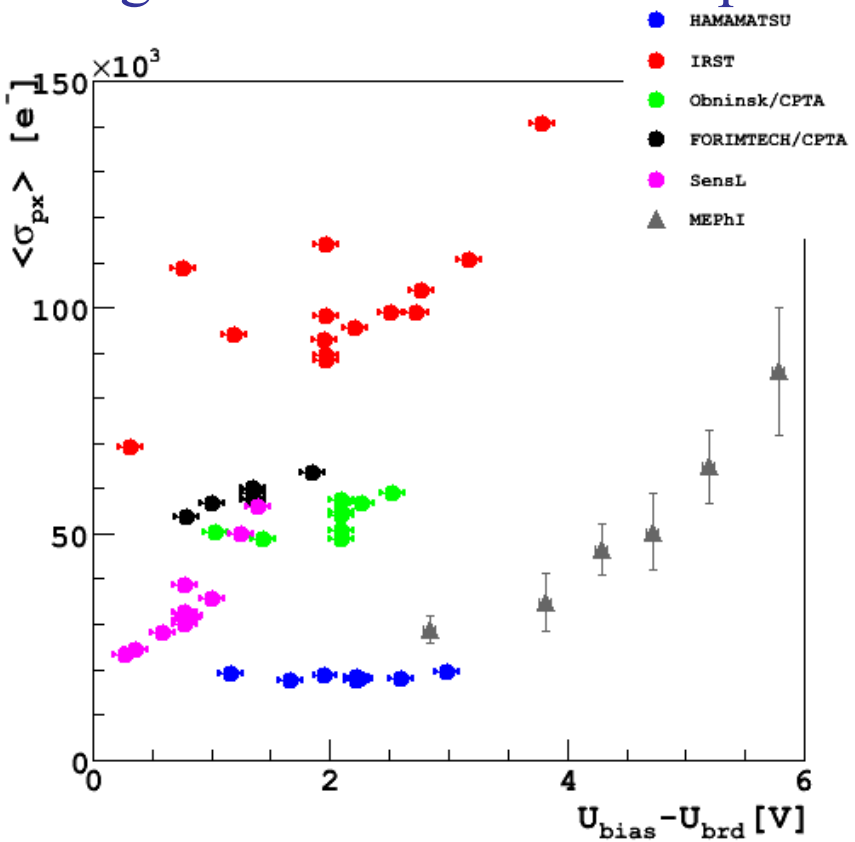
In a single sample **ΔT** ± 1 C
In all sets ΔT ± 2 C

Single photon information

Pedestal width

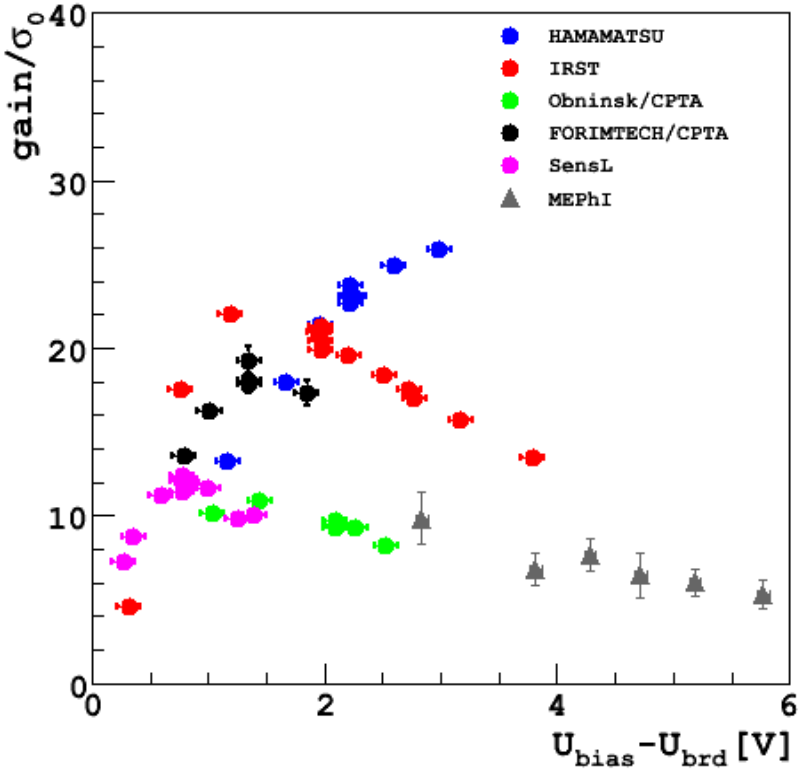


Average width of one cell response

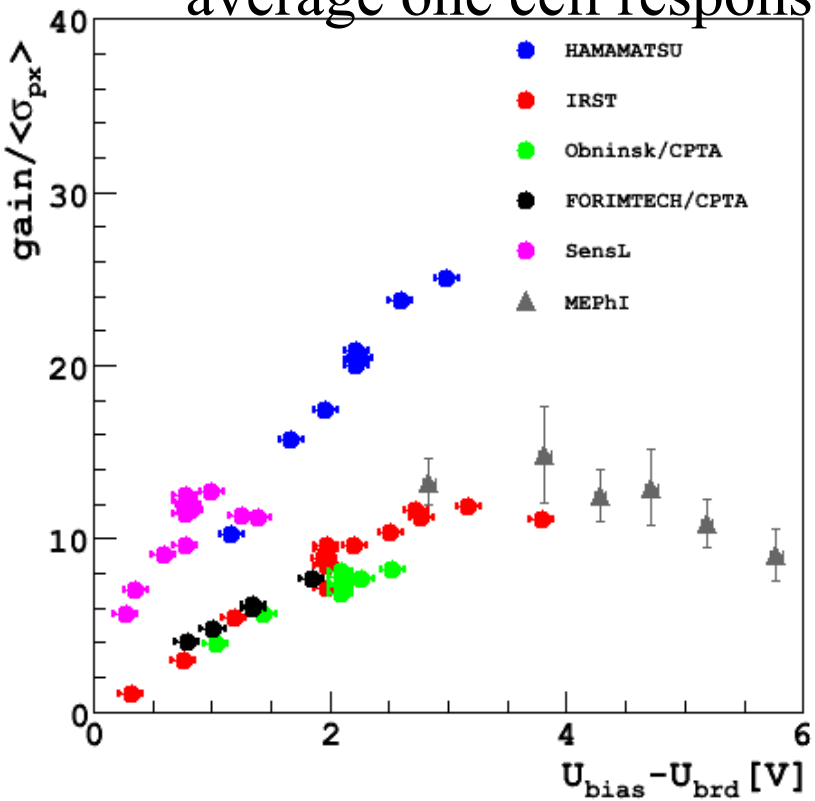


Single photon information

Gain normalized to pedestal with



Gain normalized to average one cell response



Conclusions

- Some fundamental Silicon Photon Multipliers light response properties have been measured for few bench mark samples in Rome.
- A determination of interpixel x-talk and termogenaration from dark counting rate and deviation from Poissonian law peaks is in progress and the results will be ready shortly.
- An improvement of the set up is in progress.
- The behaviour of such compact and robust device is astonishining and it is easy to forsee a large use in many fields in the next decades. In particularly its charateristics make it suitable to be used in large scale detectors generations high energy physics expertiments.