UNIVERSITA' DEGLI STUDI DI CATANIA

FACOLTA DI SCIENZE MATEMATICHE E FISICHE NATURALI

CORSO DI LAUREA IN FISICA

CARATTERIZZAZIONE DI UN DISPOSITIVO FOTOMOLTIPLICATORE AL SILICIO

Paola Francesca Chiara Maugeri

Relatore:
Marcello Lattuada
Correlatori:
Concettina Sfienti
Paolo Finocchiaro

ANNO ACCADEMICO 2009/2010

SiPM, *Silicon Photomultiplier* nato nel 1996 da un brevetto di Z. Sadygov

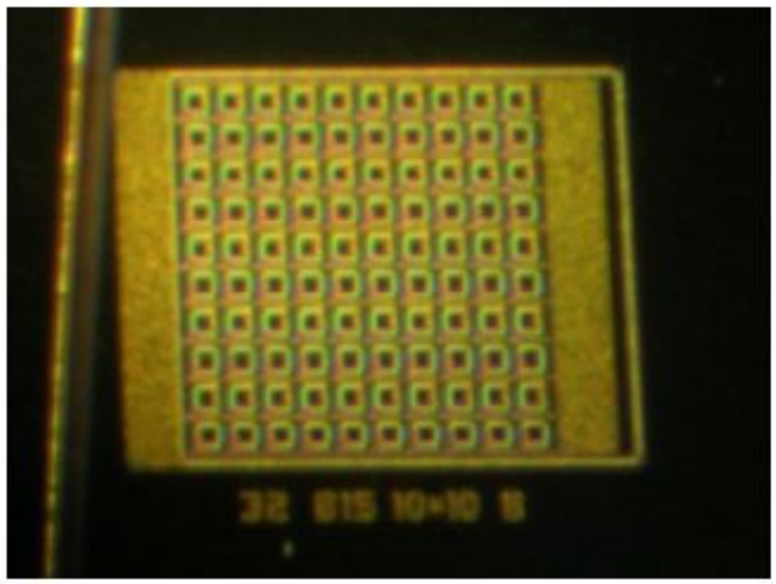
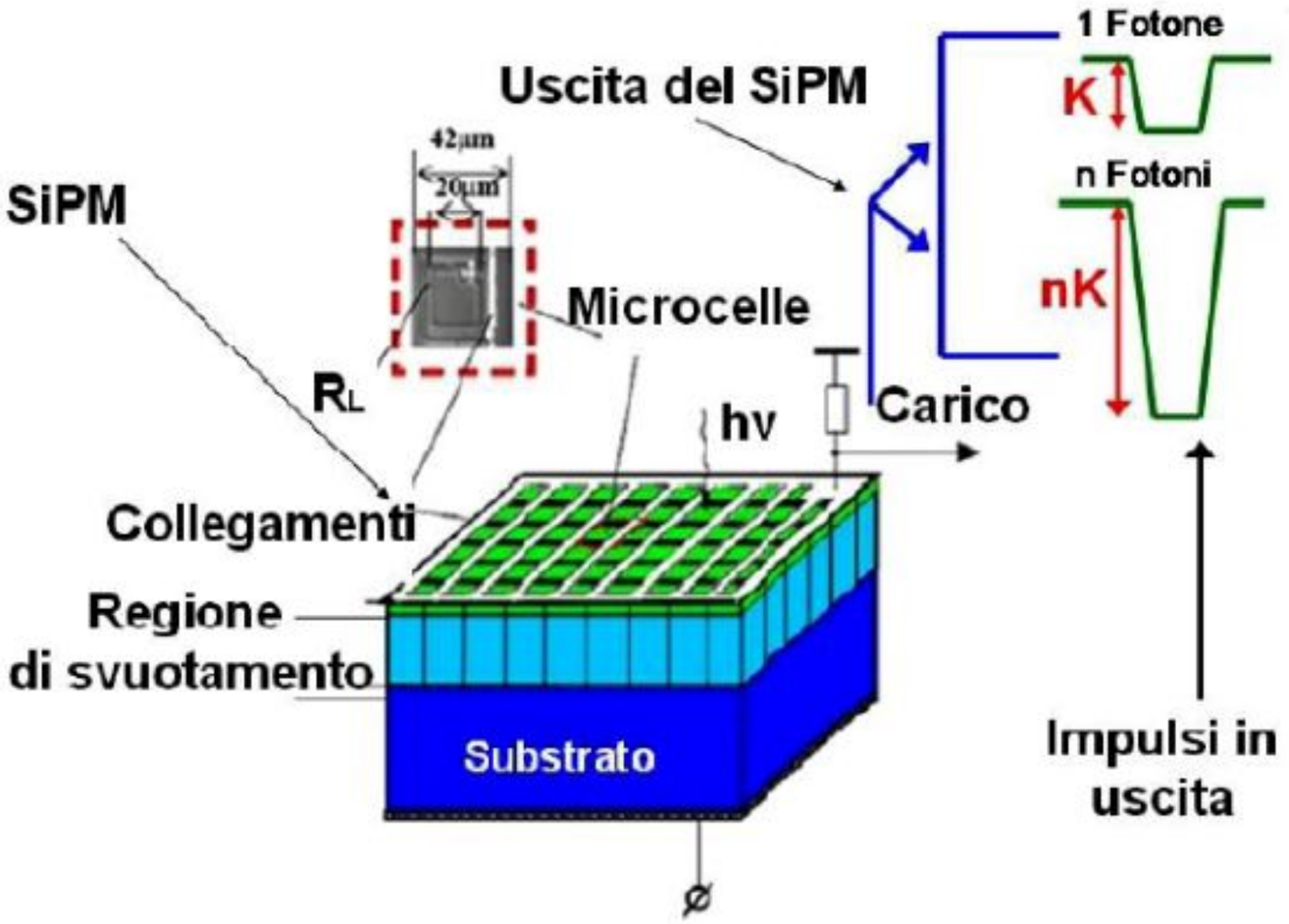
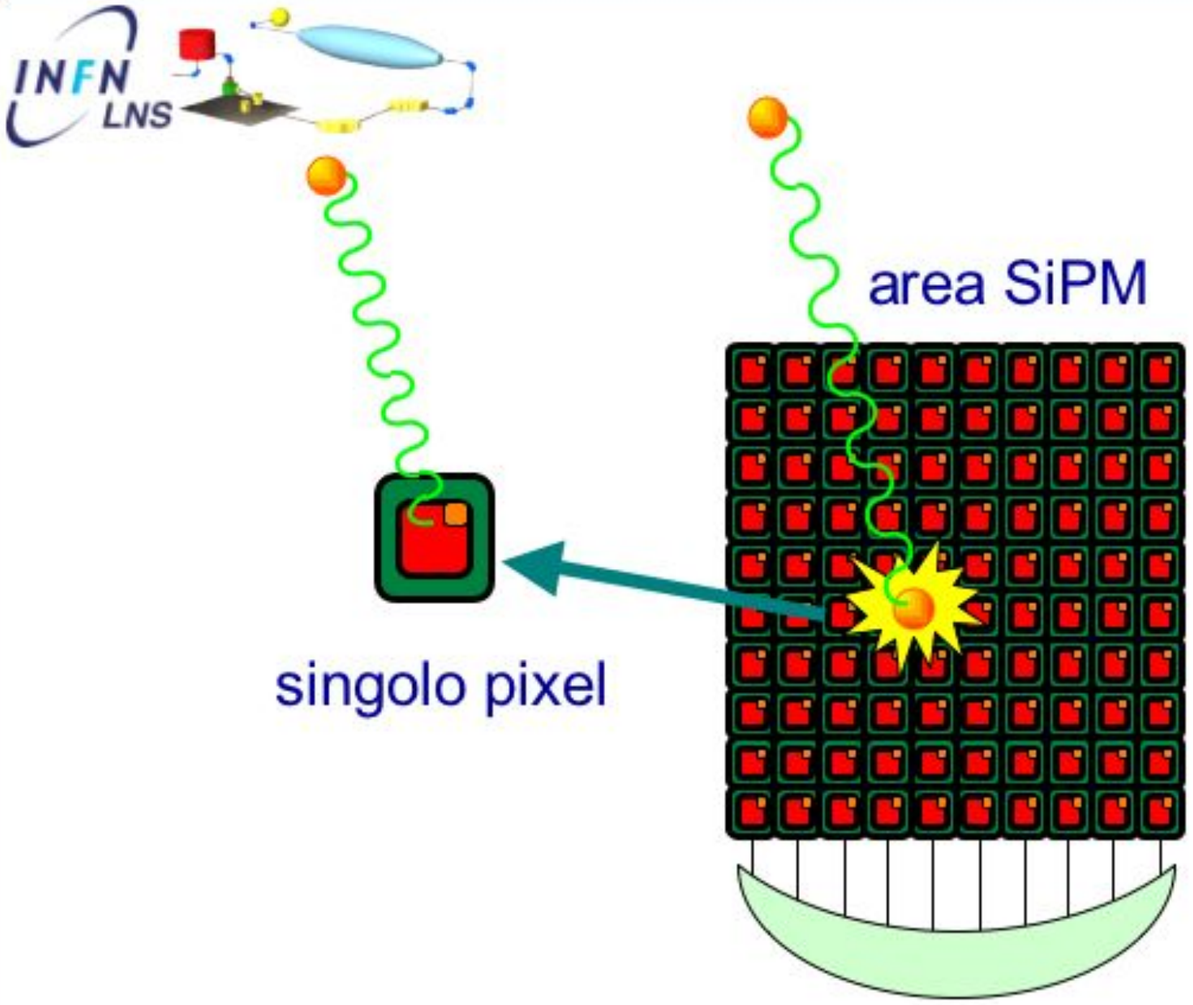


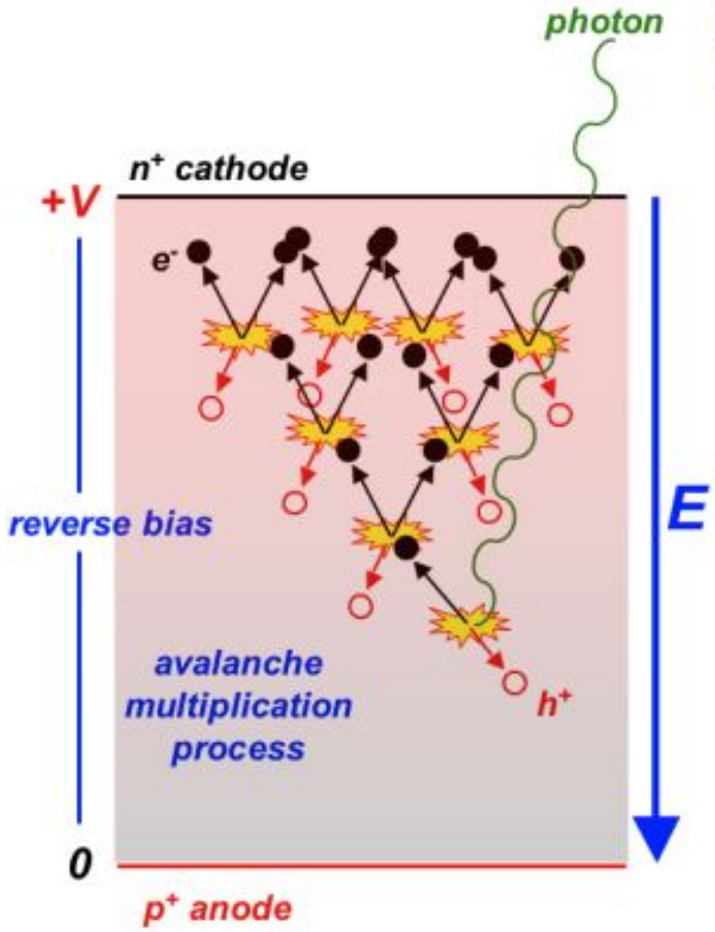
immagine ingrandita



Matrice planare di n_dispositivi

SPAD (*Single Photon Avalanche Diode*)



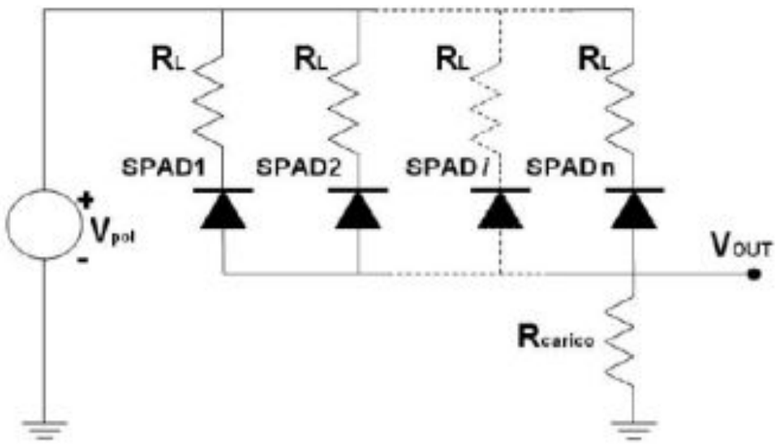


generazione valanga

opera a tensione $V_{pol} > V_{bd}$

Resistore di Quenching

- Spegne la valanga $V_{pol} < V_{BR}$
- disaccoppia elettricamente i pixel



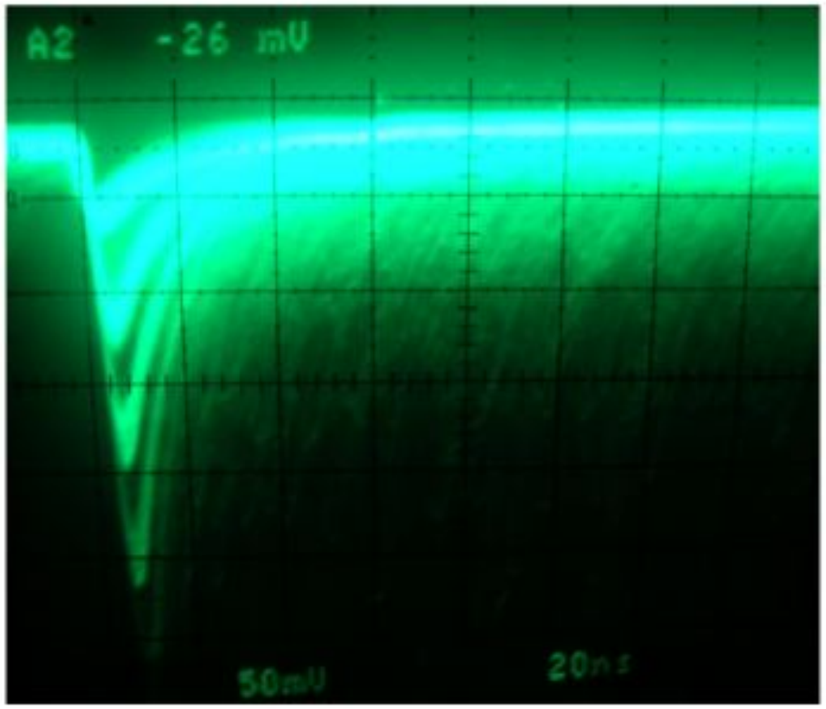
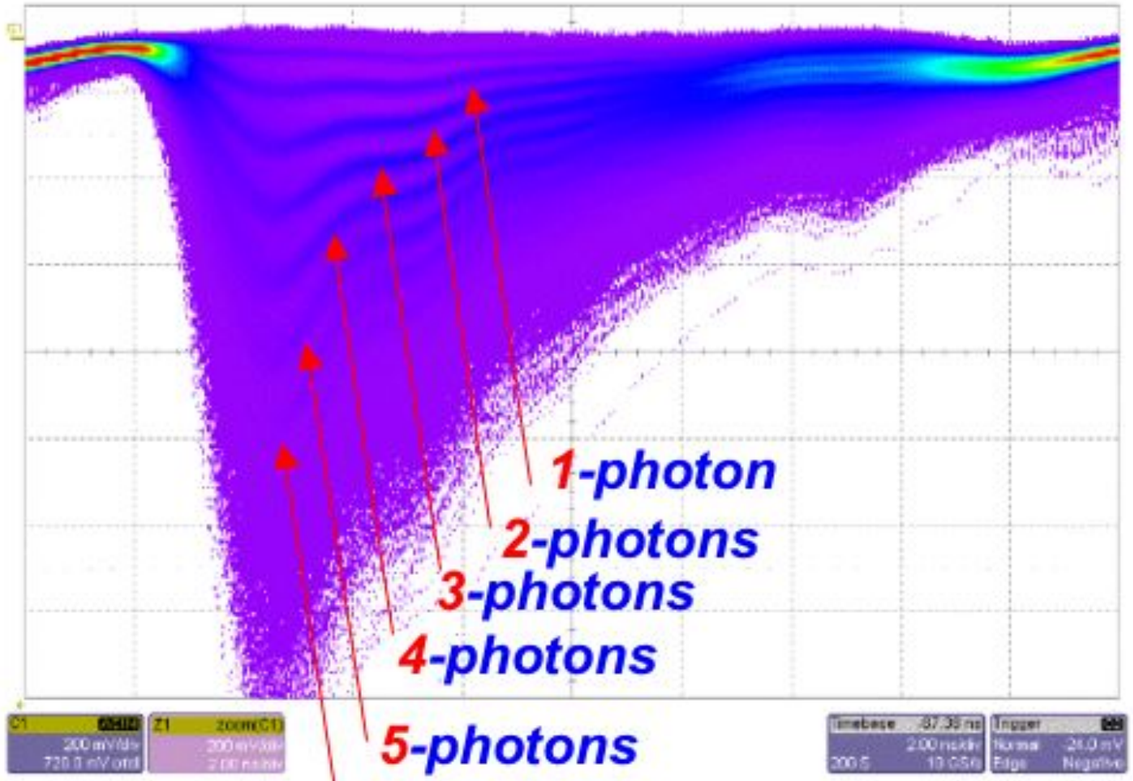


immagine oscilloscopio analogico

immagine oscilloscopio digitale

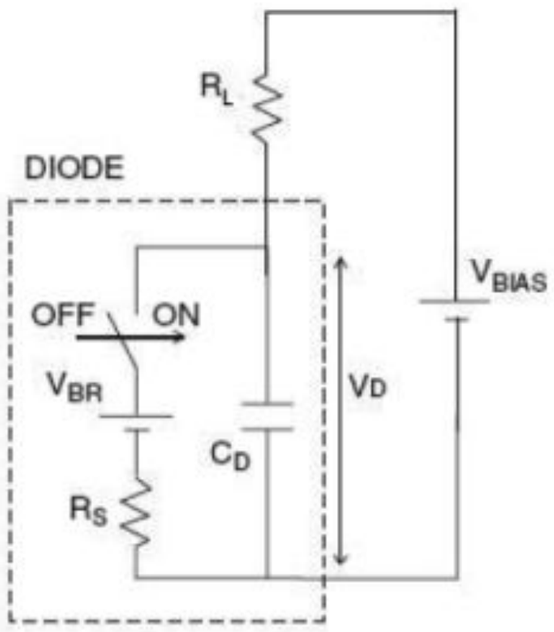


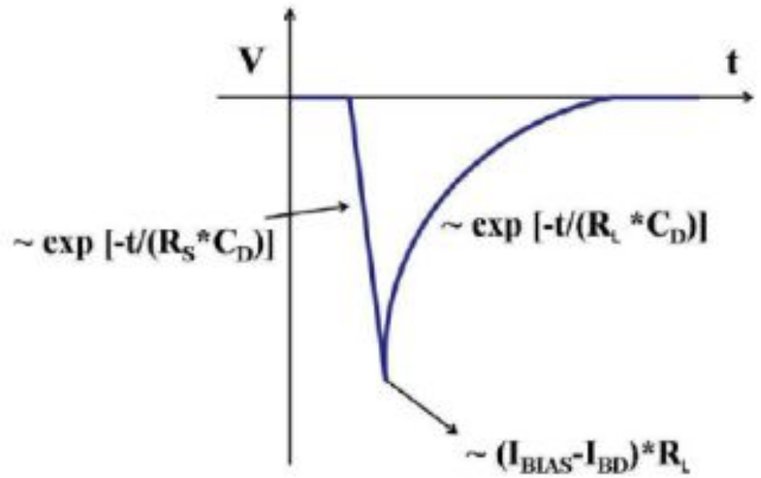
PDE (*Photon Detection Efficiency*)

$$PDE = QE \cdot \_\_{geom} \cdot P_t$$

$$QE = (1-R)\,(1-e^{-\pi n}) \qquad \_\_{geom} = A_{act} / A_{tot}$$

Circuito equivalente



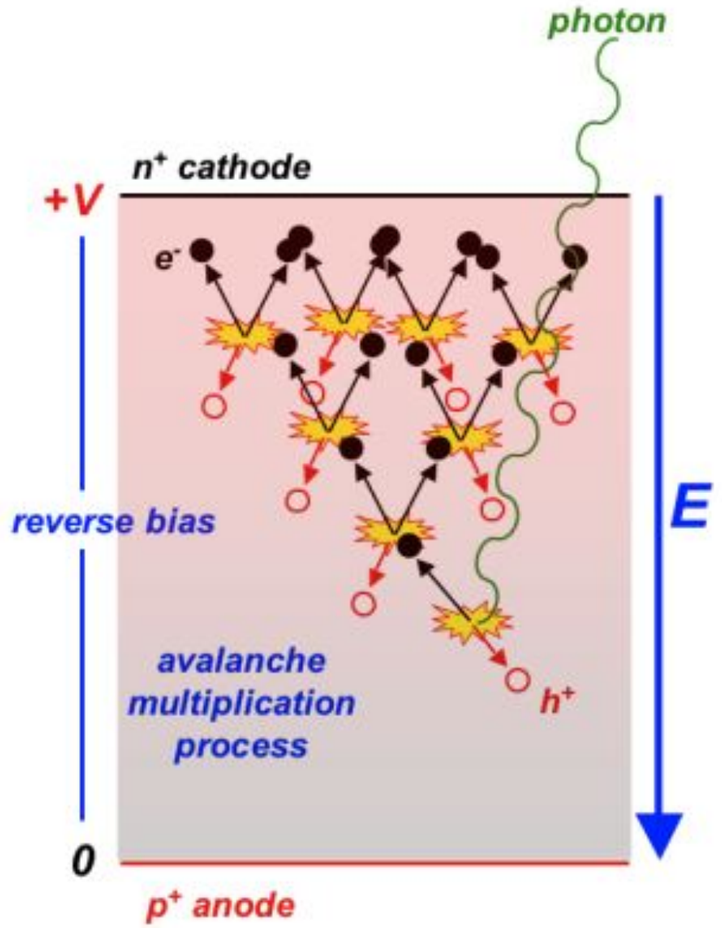


Guadagno del SiPM:

GUADAGNO $G = Q_{tot}/q = C_{pixel} \cdot (V_{pol}-V_{bd} / q)$

Parametri che influenzano il guadagno:

- Dimensioni pixel ⟶ C_{pixel}
- Tensione polarizzazione V_{pol}

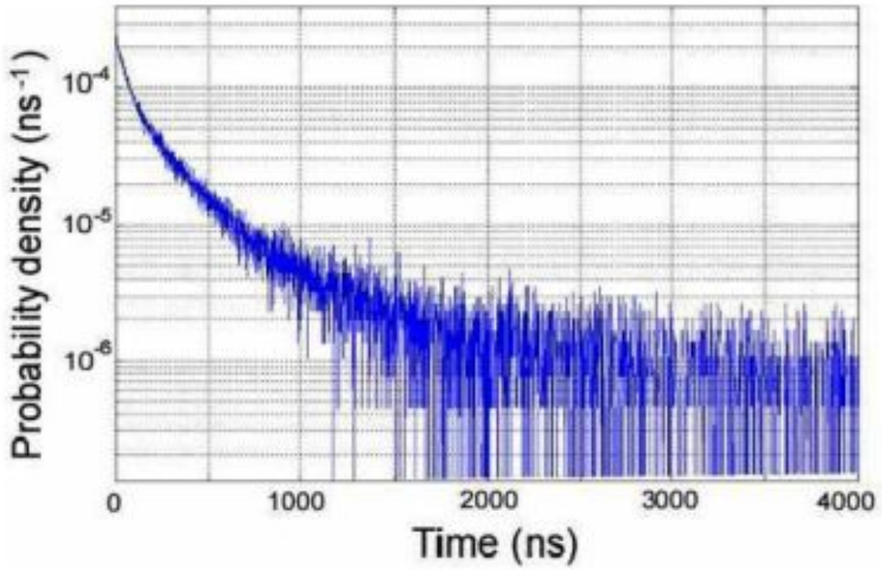


generazione valanga

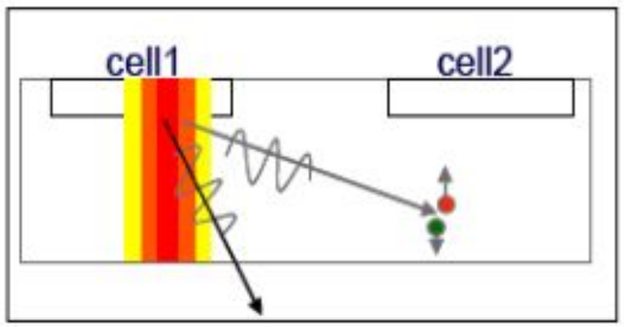
Rumore del SiPM (*noise*):

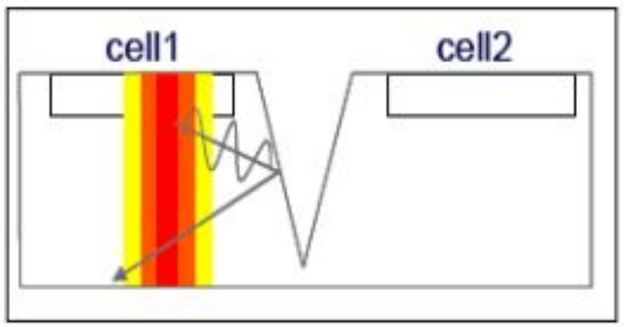
- Dark counts

- Afterpulsing



- Cross-talk





CARATTERIZZAZIONE SiPM → studiare il rumore di fondo

- Hamamatsu *S10362-11-100C*

- *SensL SPMMicro 1035X13-400C*

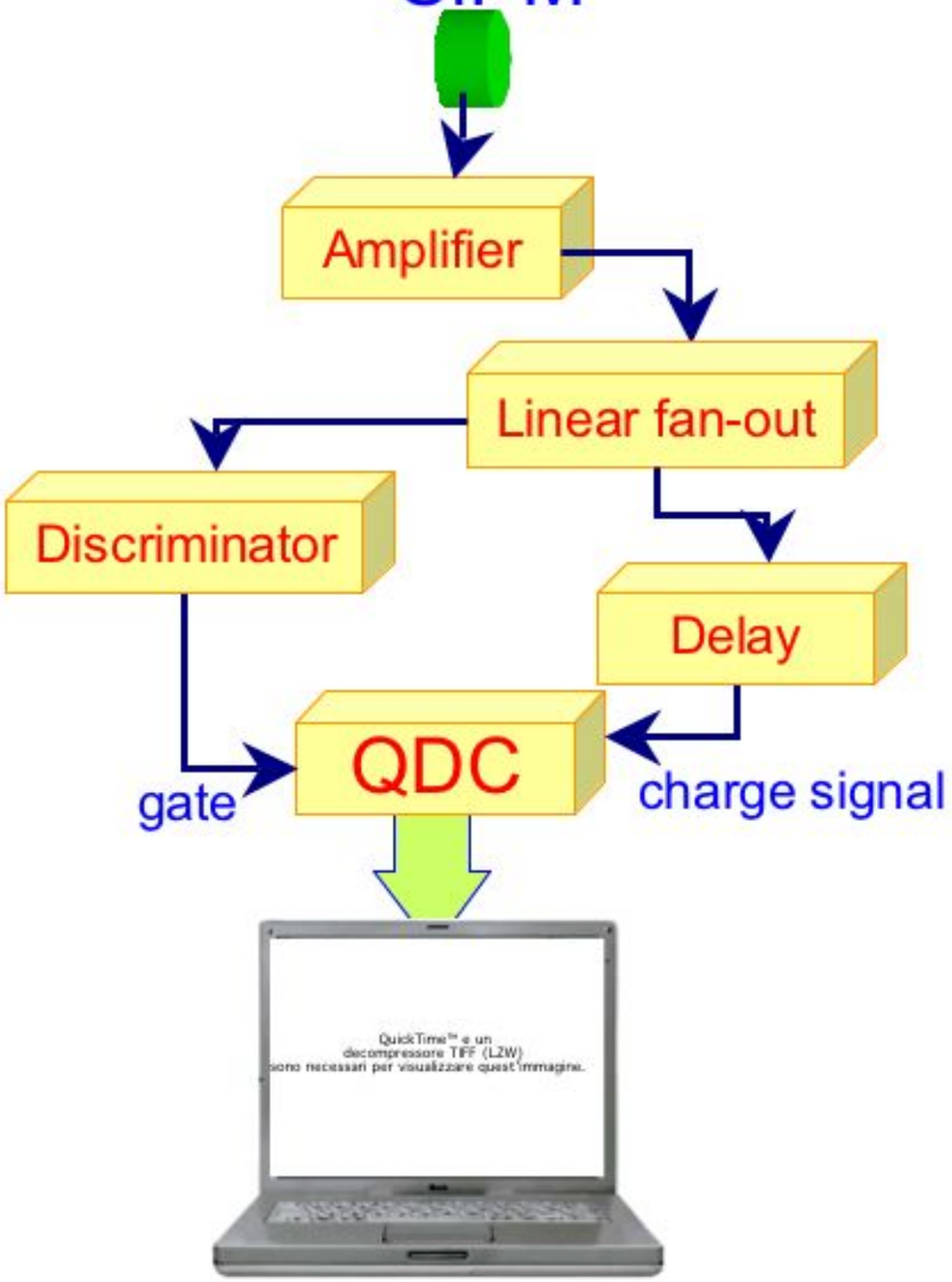
APPARATO SPERIMENTALE

Standard **NIM** (*Nuclear Instruments and Measurement*) e **CAMAC** (*Computer Automated Measurement and Control*)

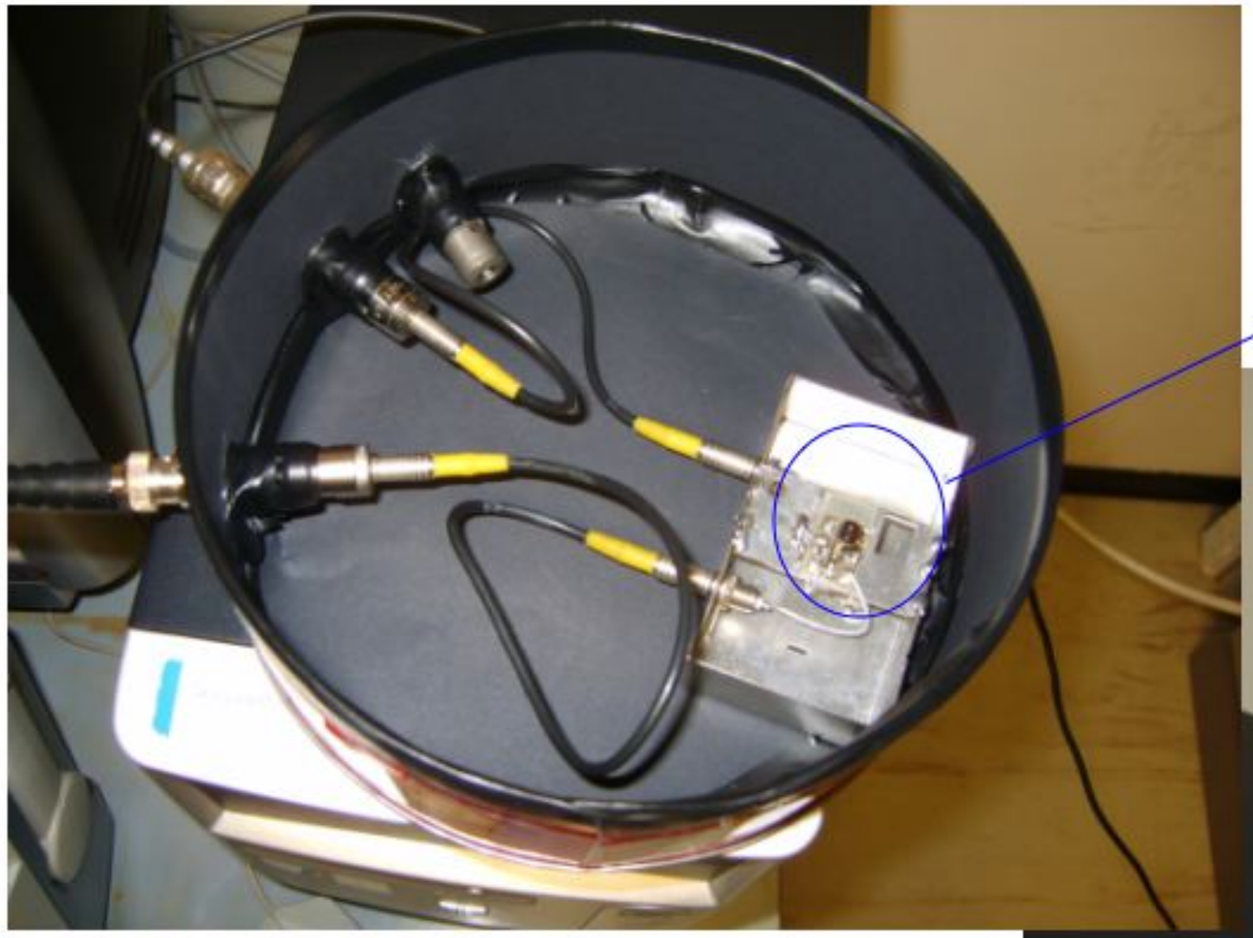
- rivelatori
- elettronica di front-end
- logica di trigger
- logica di lettura

tempo di acquisizione: *5 minuti*

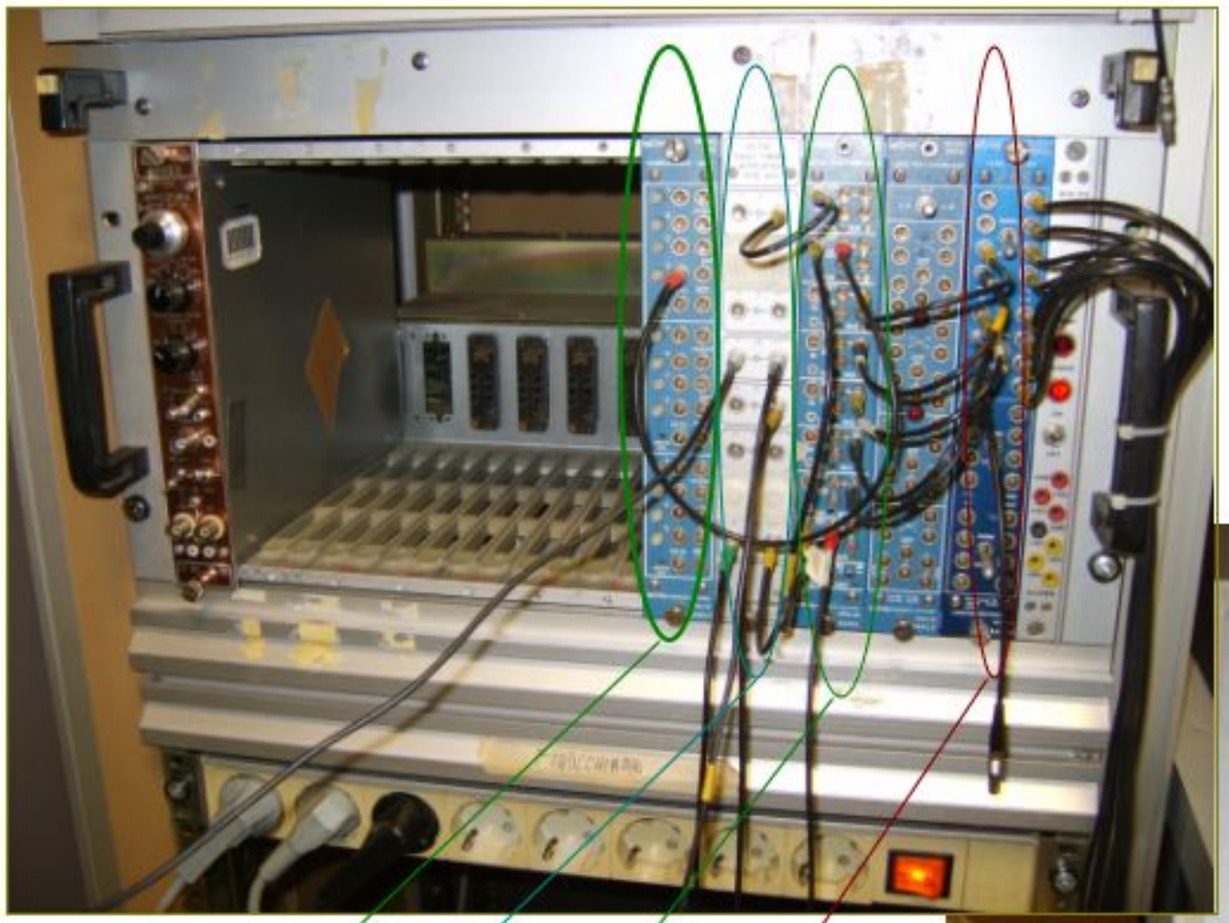
apparato sperimentale



rivelatori



Logica di front-end



delay

discriminatore

amplificatore

fan-in/fan-out

NIM

CAMAC TINA

QDC

crate controller

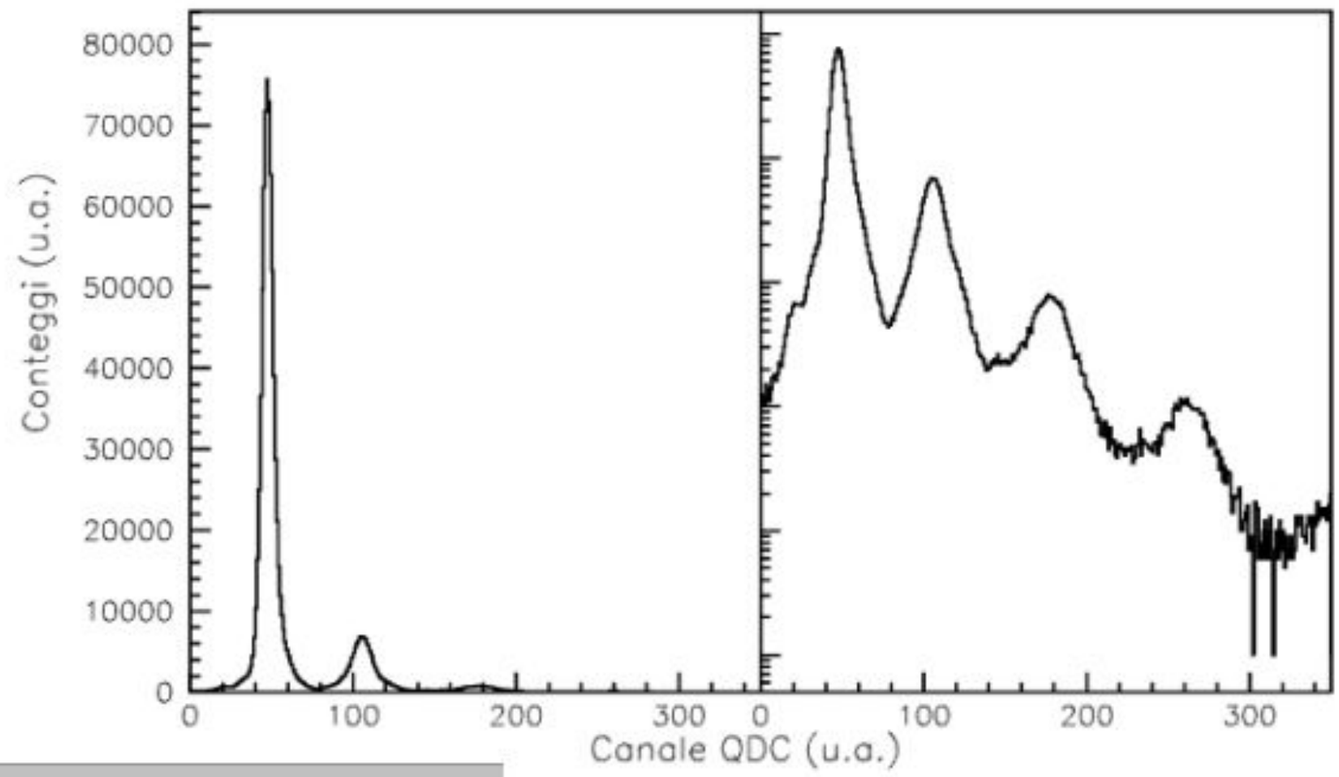
Logica di trigger

scala lineare / logaritmica

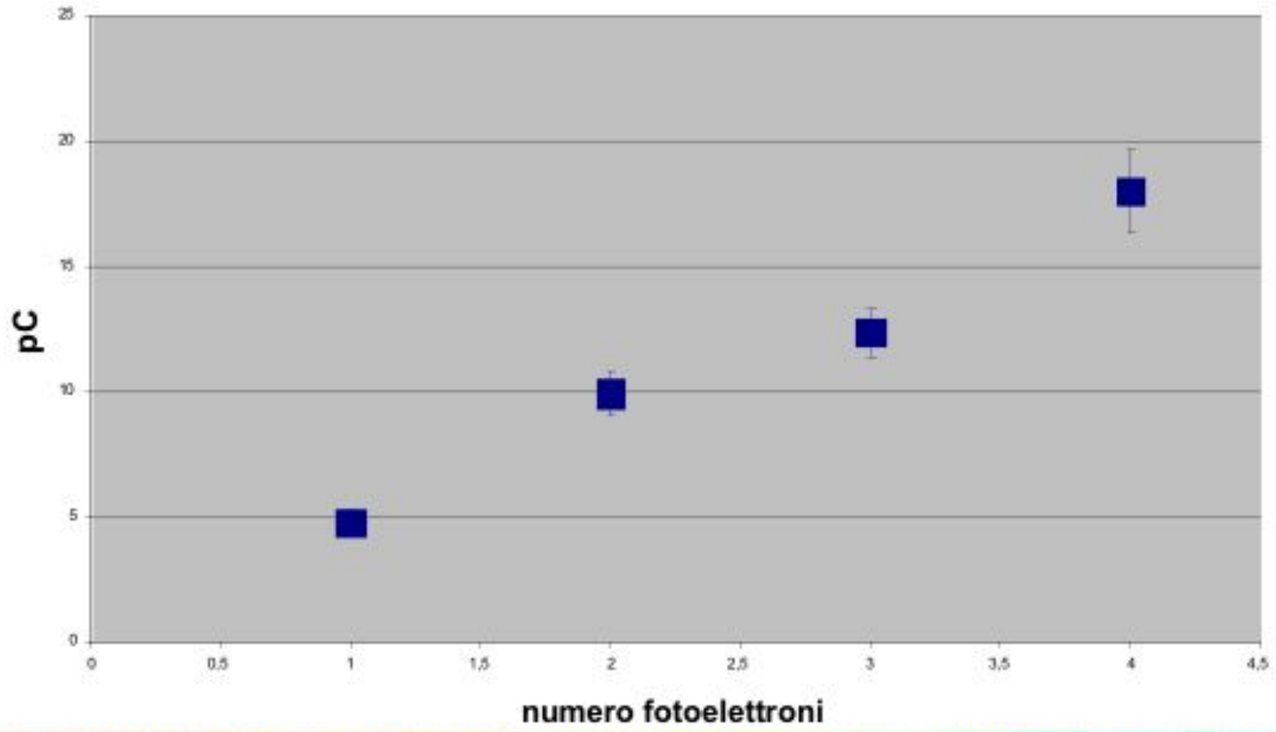
Hamamatsu S10362-11-100C

Posizione del 1° picco

canale 48 → A= 4.7 ± 0.5 pC



Test linearità



Tensione 70.8 Volt

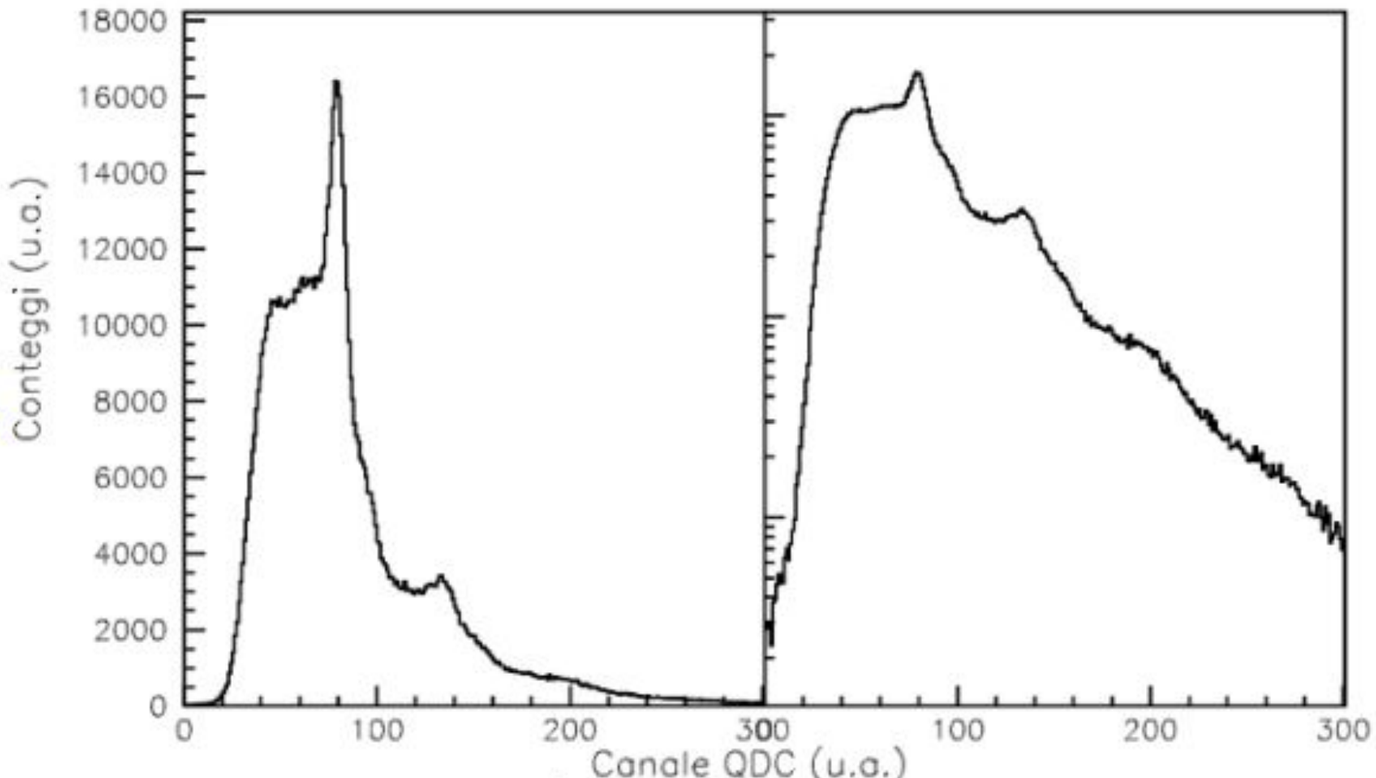
N° celle 10 x 10

Dimensioni 1mm x 1mm

Guadagno ≈ 150'000

SensL SPMMicro 1035X13

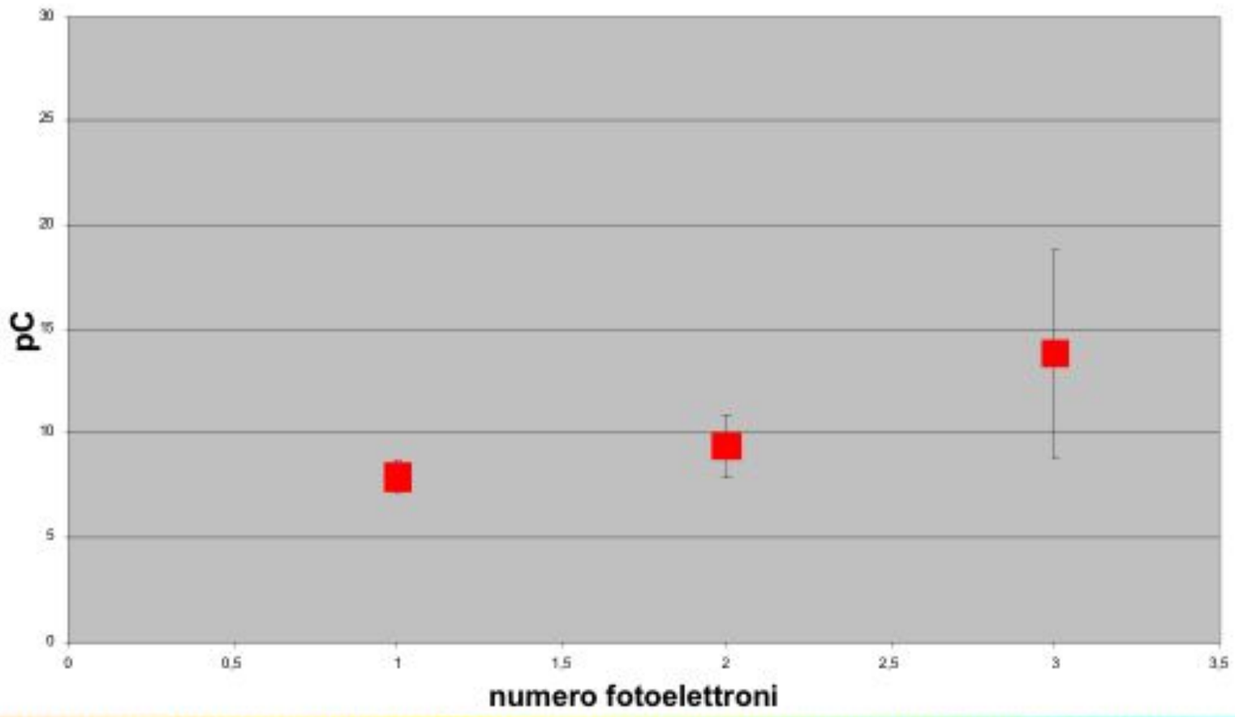
scala lineare / logaritmica



Posizione del 1° picco

canale 80 ⟶ A= 7.9 ± 0.8 pC

Test linearità



Tensione 30.5 Volt

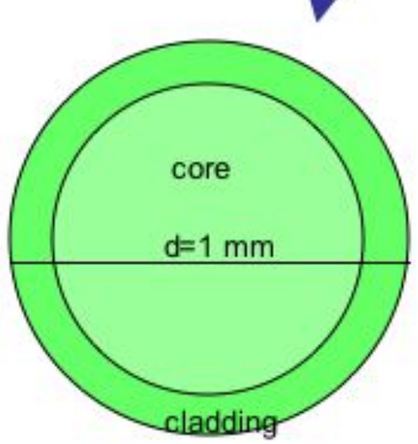
N° celle 20 x 20

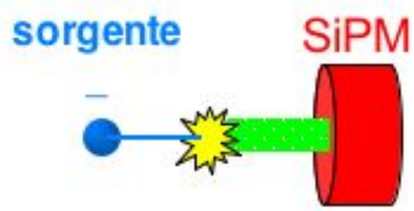
Dimensioni 1mm x 1mm

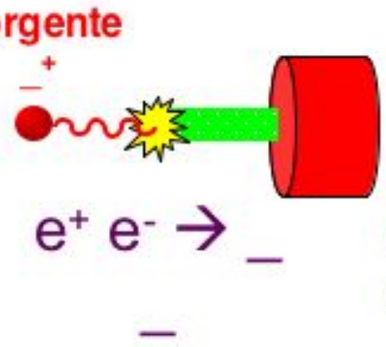
Guadagno ≈ 80’000

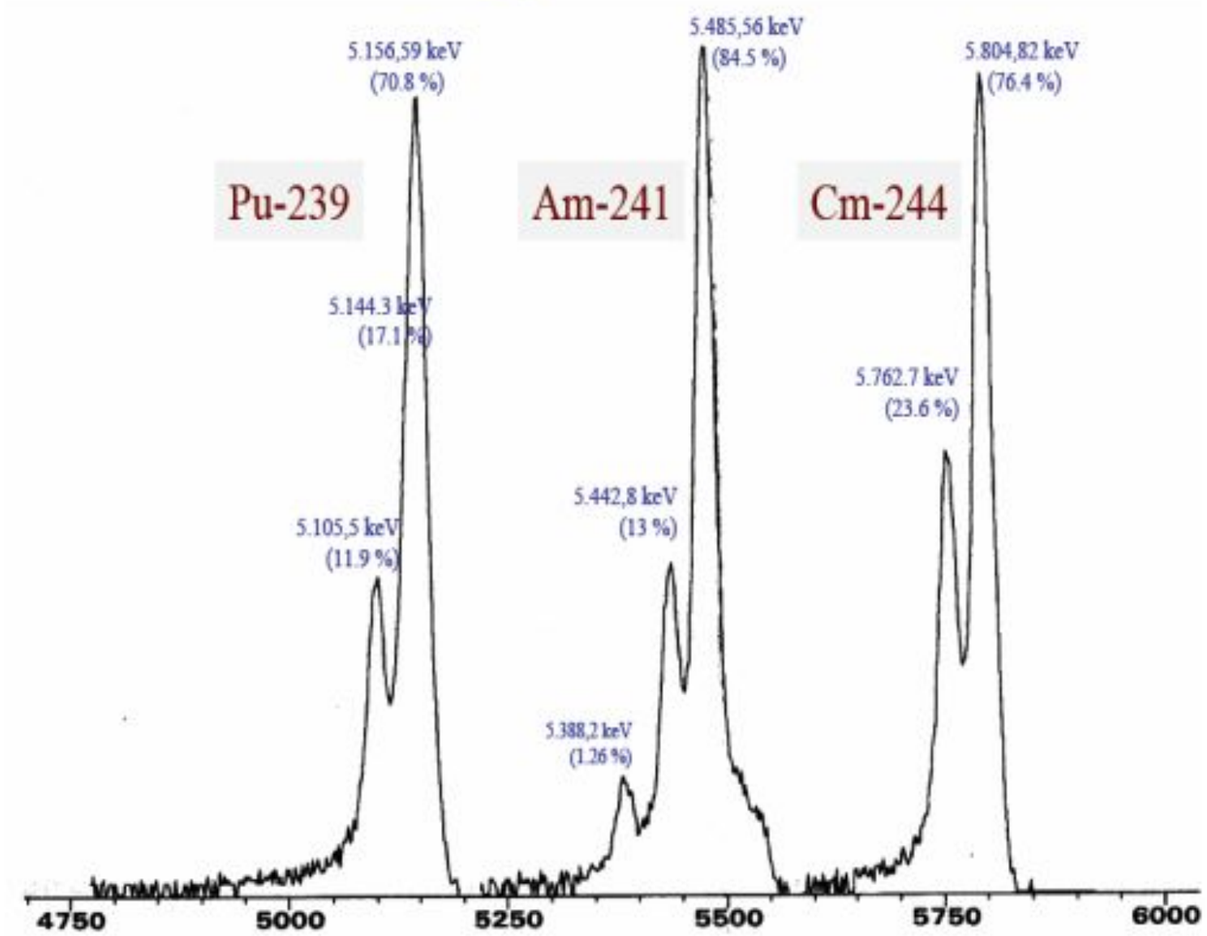
APPLICAZIONI

SiPM + fibra scintillante + sorgente nota

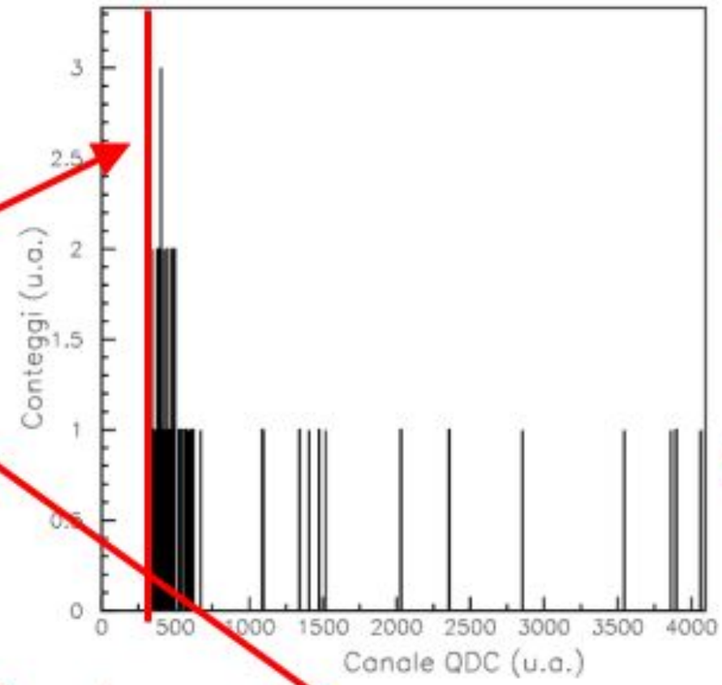








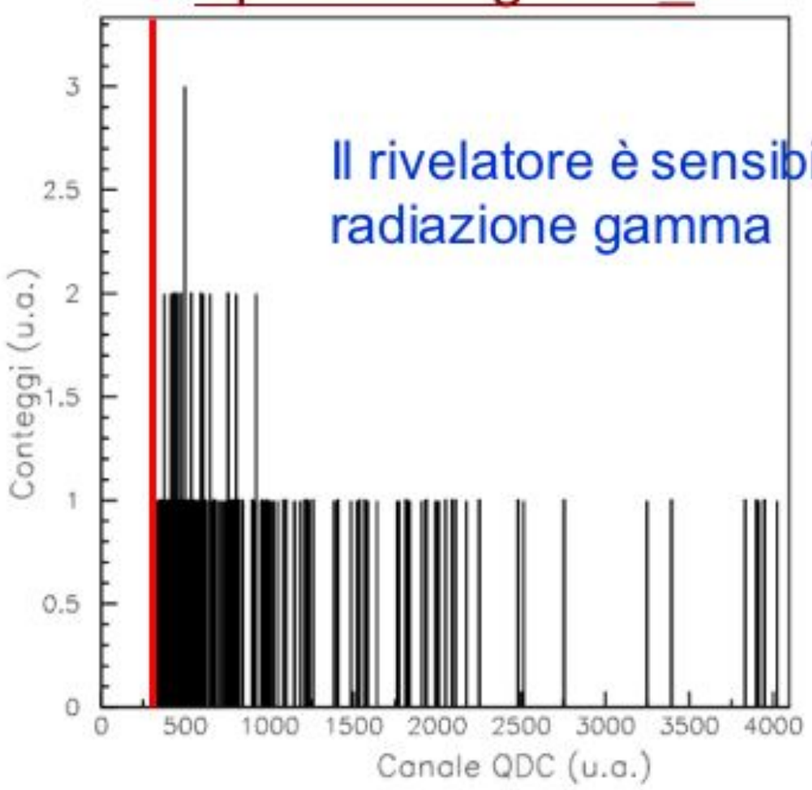
soglia di rumore discriminata



Spettro senza sorgente

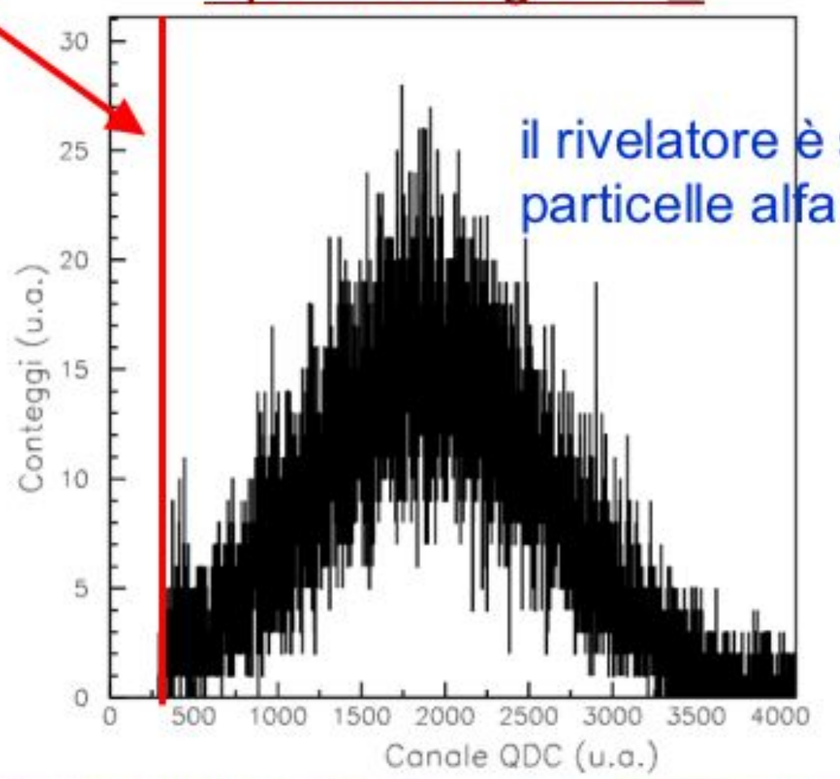
tempo di acquisizione: *5 minuti*

Spettro sorgente $_{-}^{+}$



Il rivelatore è sensibile a radiazione gamma

Spettro sorgente $_{-}$



il rivelatore è sensibile a particelle alfa

CONCLUSIONI

- buoni strumenti di fotorivelazione

- buone prestazioni

- robustezza meccanica ed elettrica ⟶ (urti, sbalzi di tensione, …)

- non danneggiati da esposizione a luce ambientale

RINGRAZIAMENTI