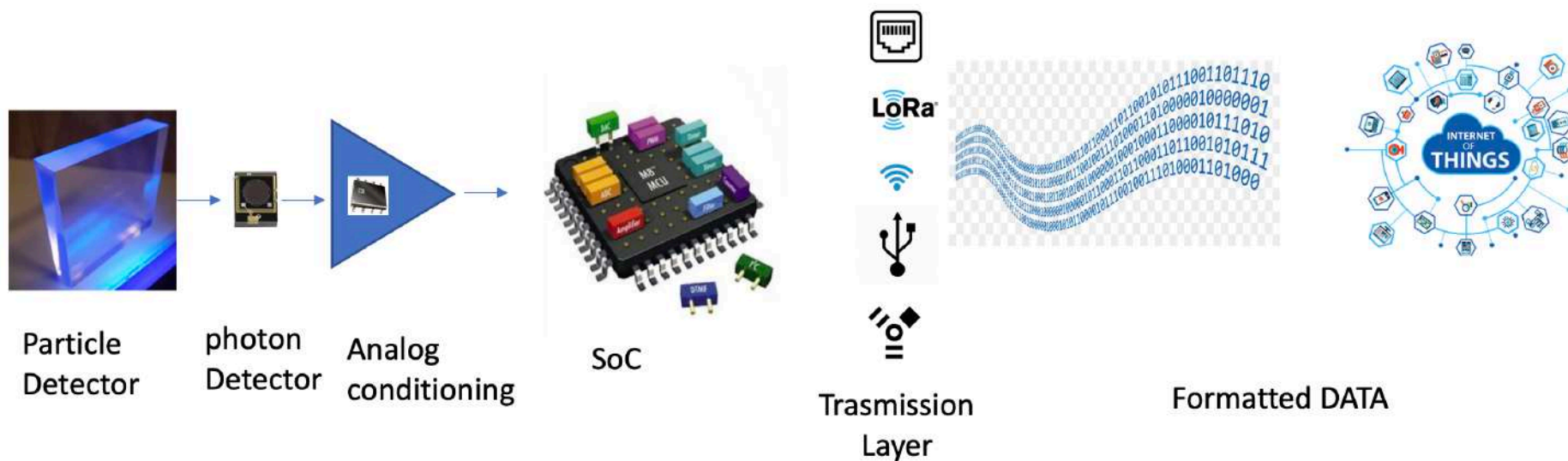


ArduSiPM a small, light and low power, All-In-One particle detector

Valerio Bocci

(Email: Valerio.Bocci@roma1.infn.it)

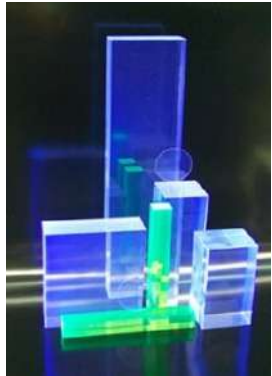
Istituto Nazionale Fisica Nucleare (INFN Roma)



SLICE (Soc eLEctronics Compact dEtector)



In 2013-2014 our question was ?
Is it possible to build a complete particle detector and data acquisition system using SAM3X8E Arduino microcontroller?



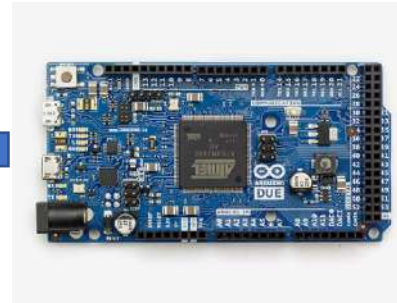
Scintillator



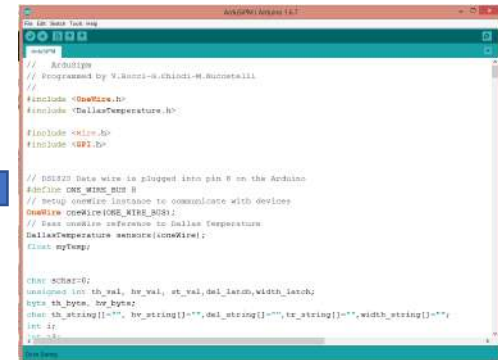
Photons Sensor
(SiPM)



Custom Electronics
(ArduSiPM Shield)



Arduino DUE

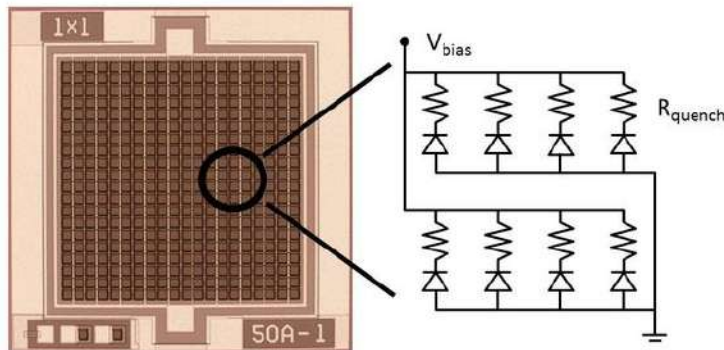
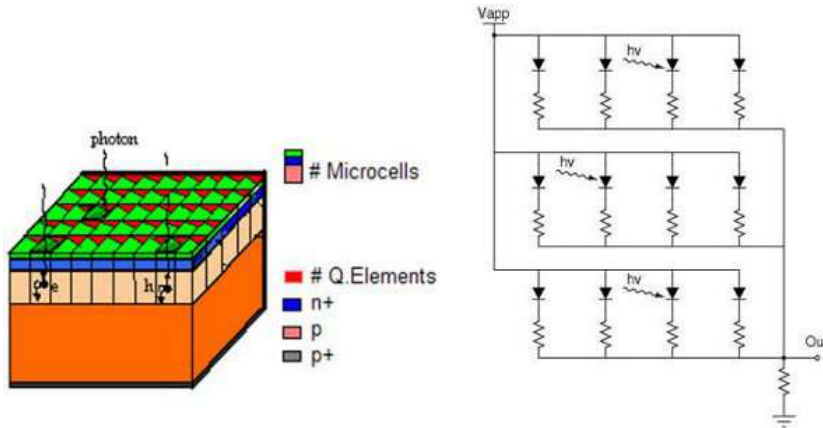
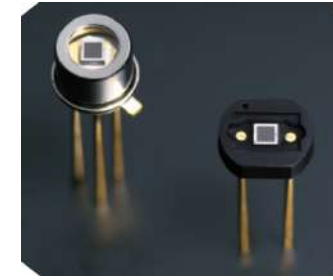


ArduSiPM Software

Particle Detector

ArduSiPM

SiPM (Silicon Photo Multiplier)



The idea behind this device is the detection of single photon events in sequentially connected SiAPDs.

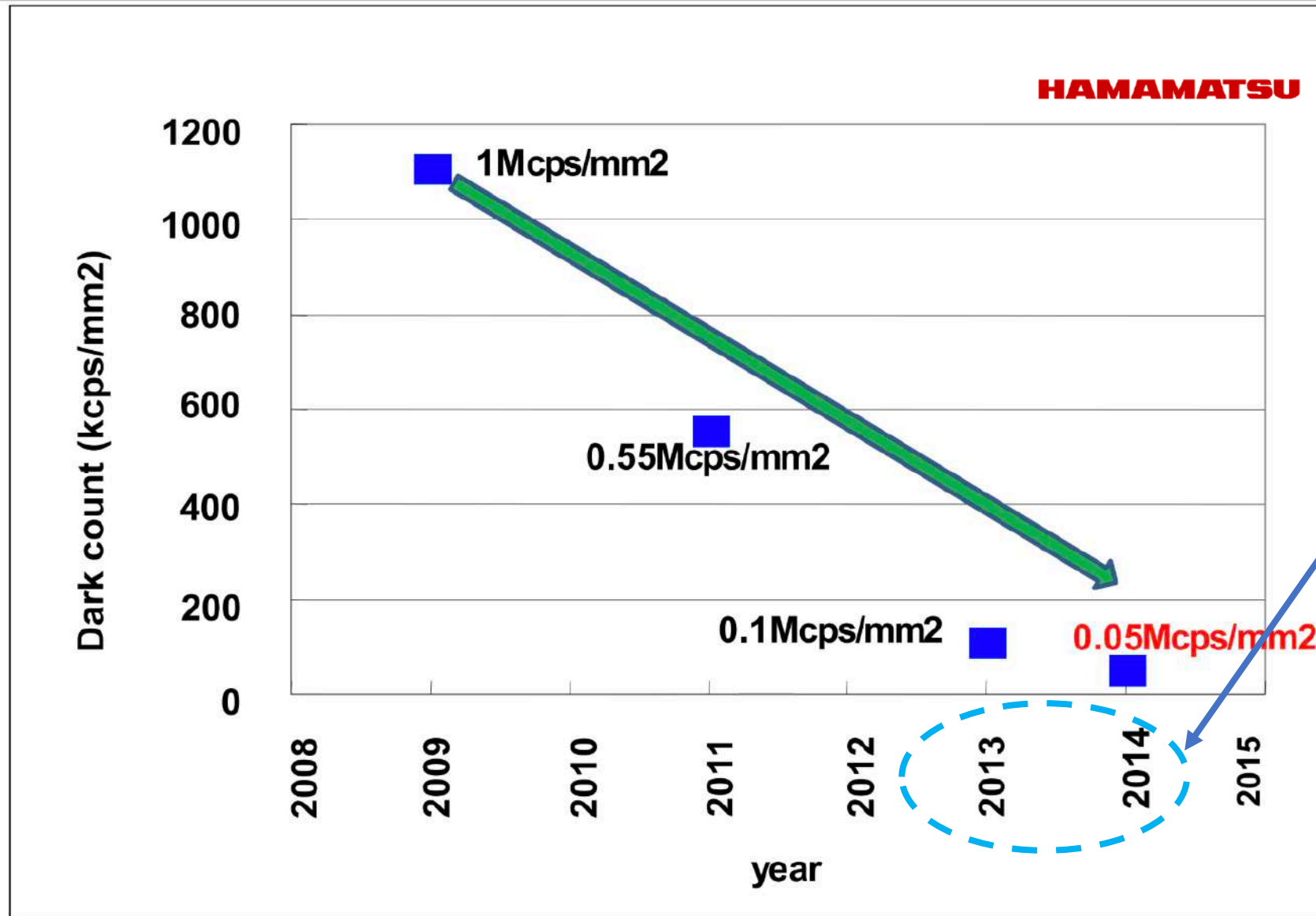
The dimension of each single APD can vary from 20 to 100 micrometres, and their density can be up to 1000 per square millimeter.

Every APD in SiPM operates in Geiger-mode and is coupled with the others by a polysilicon quenching resistor.

Although the device works in digital/switching mode, the SiPM is an analog device because all the microcells are read in parallel making it possible to generate signals within a dynamic range from a single photon to 1000 photons for just a single square millimeter area device.

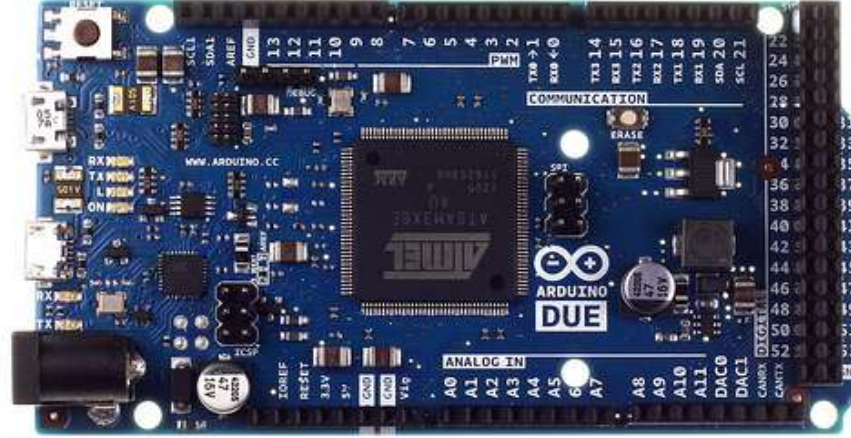
The supply voltage (V_b) depends on APD technology used, and typically varies between 20 V and 100 V, thus being from 15 to 75 times lower than the voltage required for a traditional photomultiplier tubes (PMTs) operation.

Dark Counts reduction



First ArduSiPM
Prototype

Arduino Due (2013)



- Arduino is an open-source electronics platform based on easy-to-use hardware and software.
- Arduino Due is the first Arduino board based on SoC (System on Chip) SAM 3X8E a 32-bit ARM core microcontroller.
- Main features available on Arduino Due to build up around an acquisition system are:
 - 16 Channel Multiplexed Analog to Digital converter with 12 bit and 1 MHz sample rate
 - Multiple Input output pins
 - 9 fast Counter and pulse generator
 - 2 Digital to Analog converter with 12 bit resolution
 - Different serial interface like I2C, SPI, onewire, RS232, Ethernet MAC in SAM3X8 (not routed ☹)
 - An easy to use development software, with high level instruction for main program and interrupt handling, with the possibility to use all the complex features of the SoC SAM3X8.

ArduSiPM is a system to control and acquire a SiPM (Silicon Photo Multiplier)

its main components are :



- Arduino Due: a microcontroller board based on the 84 MHz Atmel SAM3X8E ARM Cortex-M3 CPU open software and open hardware.



- A custom piggy-back board called ArduSiPM Shield to interface Arduino Due with SiPM.

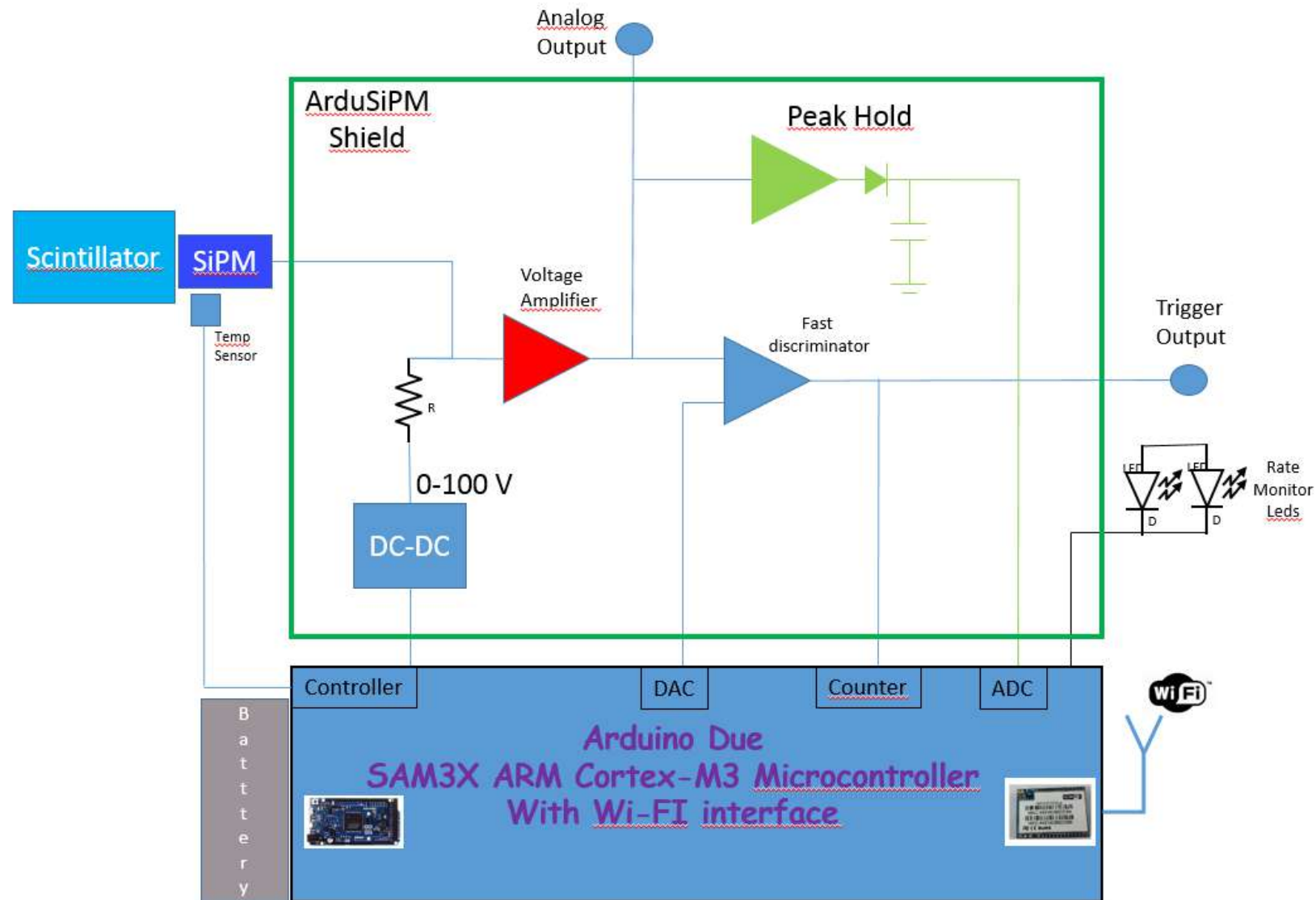


- A Wi-Fi module with an embedded a high performance 360 MHz MIPS24KEc CPU core, for TCP/IP serial communication

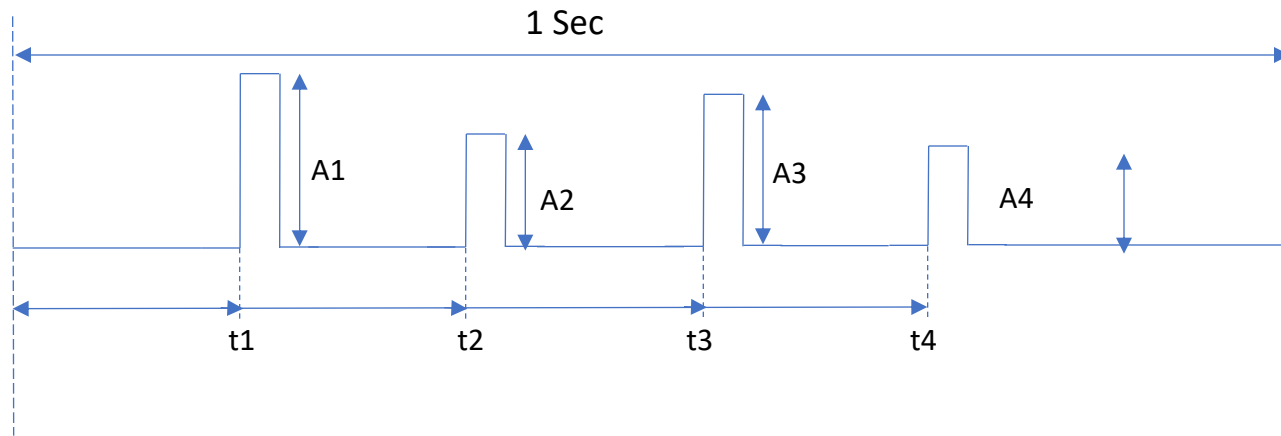


- Client software for PC or Tablet app

ArduSiPM Block Diagram



ArduSiPM measurements



We split the measurements in 1 second windows, acquiring number of pulses, amplitude and time of each one.

Using a 200KBits/s serial stream

We can measure and dump (depending from amplitude and distribution of pulses):

- Only the frequency up to tens of MHz
- ADC value up to 4-6 KHz
- ADC, TDC and rate 1 -2 KHz

Using the SAM3X8 built-in USB2.0 it is possible to increase the throughput.

Data Stream example:

Only rate:

```
$10  
$50  
$244
```

ADC+Rate:

```
v1Fv1Dv22v27v1Dv19v20v23v20v1Cv19v1F$12  
v18v1Ev1Ev1Bv19v1Bv29v19v1Av1Dv1Bv1Dv2Av18v1B$15  
v15v20v21v21v1Dv1Fv1Av1Av1A$9  
v19v17v1Bv18v1Cv1Dv1D$7
```

TDC+ADC+RATE:

```
taedvataf0v7tv9v3$3
```

Legend:

vXXX ADC Value in HEX MSB zero suppressed

tXXXXXXXXX TDC value in HEX MSB zero suppressed

\$XXX rate in Hz

Application Example 1: Intraoperative β - Detecting Probe



A novel radioguided surgery technique exploiting β^- decays

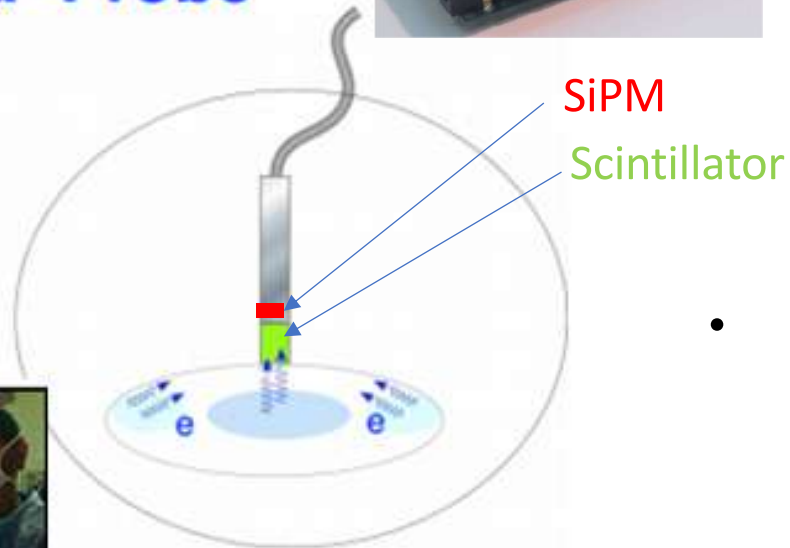
E. Solfaroli Camillocci, G. Baroni, F. Bellini, V. Bocci, F. Collamati, M. Cremonesi, E. De Lucia, P. Ferrolì, S. Fiore, C. M. Grana, M. Marafini, I. Mattei, S. Morganti, G. Paganelli, V. Patera, L. Piersanti, L. Recchia, A. Russomando, M. Schiariti, A. Sarti, A. Sciubba, C. Voena & R. Faccini

Beta- Probe

ArduSiPM

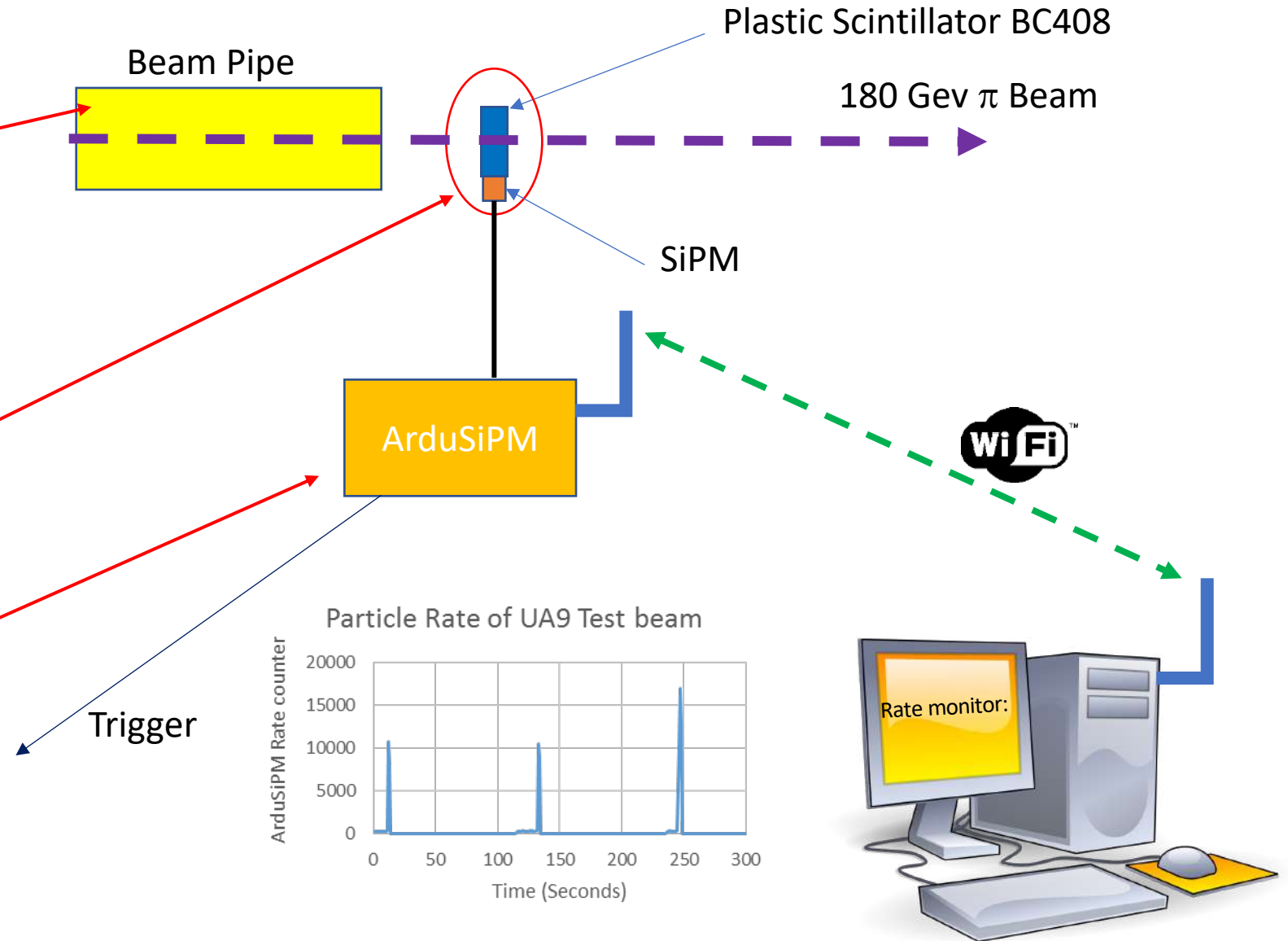
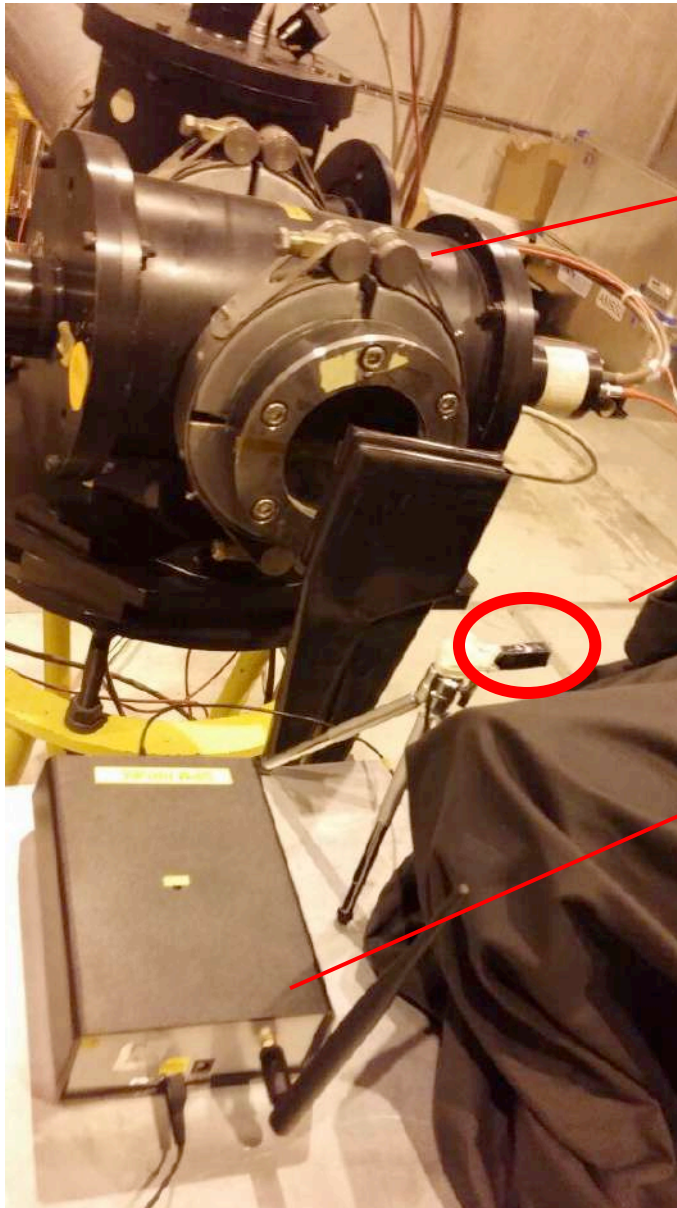


Control and readout
Android App



- Radioguided **intraoperative beta probe**, with scintillation material coupled with SiPM detector.

CERN UA9 Beam monitor



Misura dei raggi cosmici su un aereo di linea

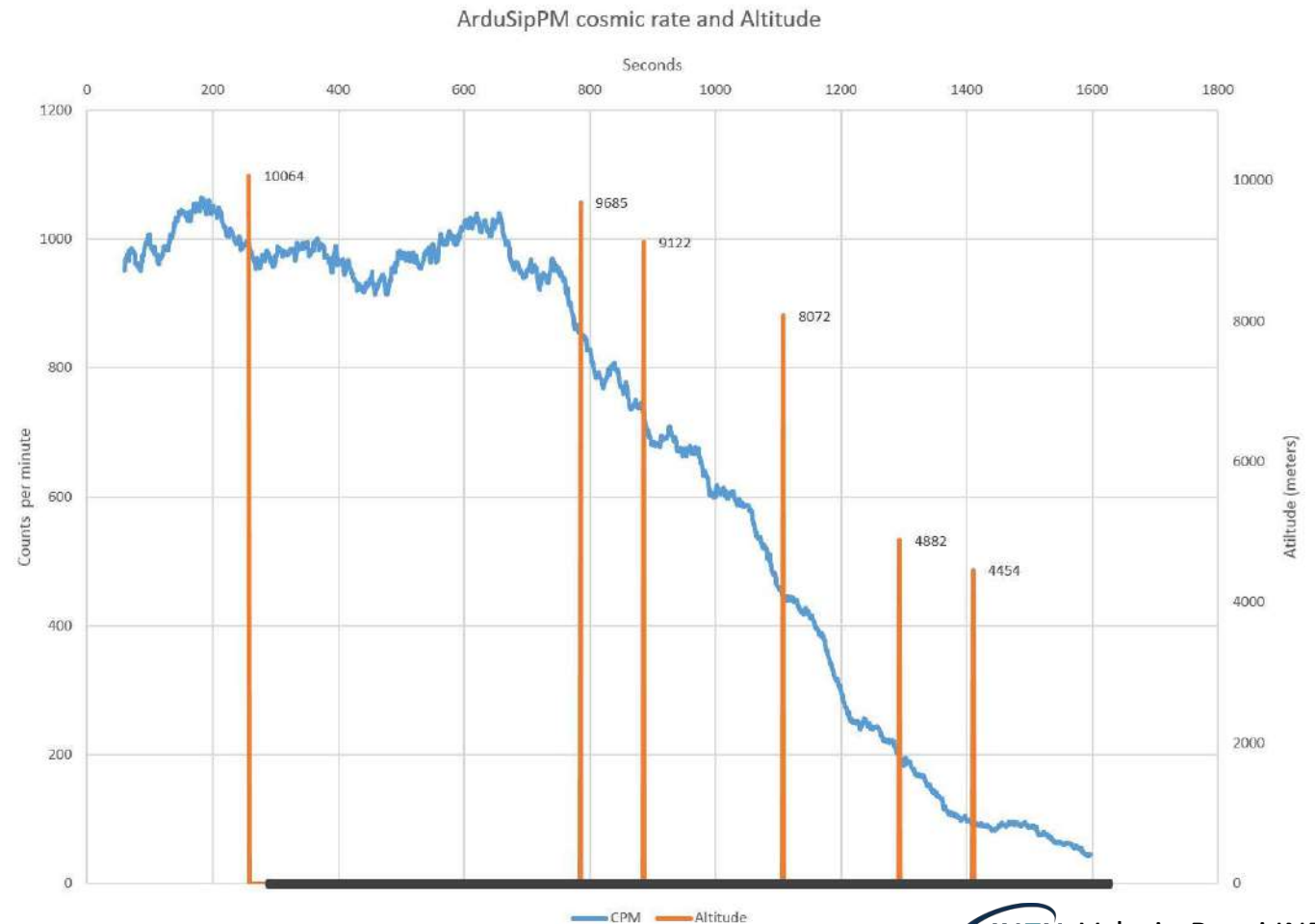
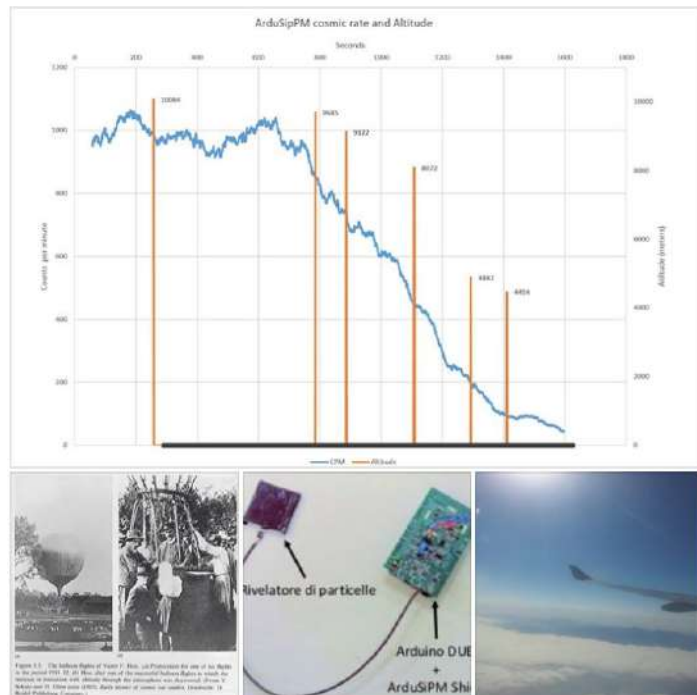


Valerio Bocci

July 6 at 12:57am

Il buon Victor Hess, nel 1911 misurò il flusso di raggi cosmici fino ad una quota di 5300 metri a bordo di un pallone aerostatico usando degli elettroscopi e una buona dose di avventurismo. Nel 1936 le sue misure gli valsero il Nobel per la fisica.

Più di cento anni dopo grazie ad un tranquillo viaggio in Aereo una misura con ArduSiPM passando da 10000 Metri e scendendo fino a circa 4000 metri giusto per il gusto di replicare un famoso esperimento.

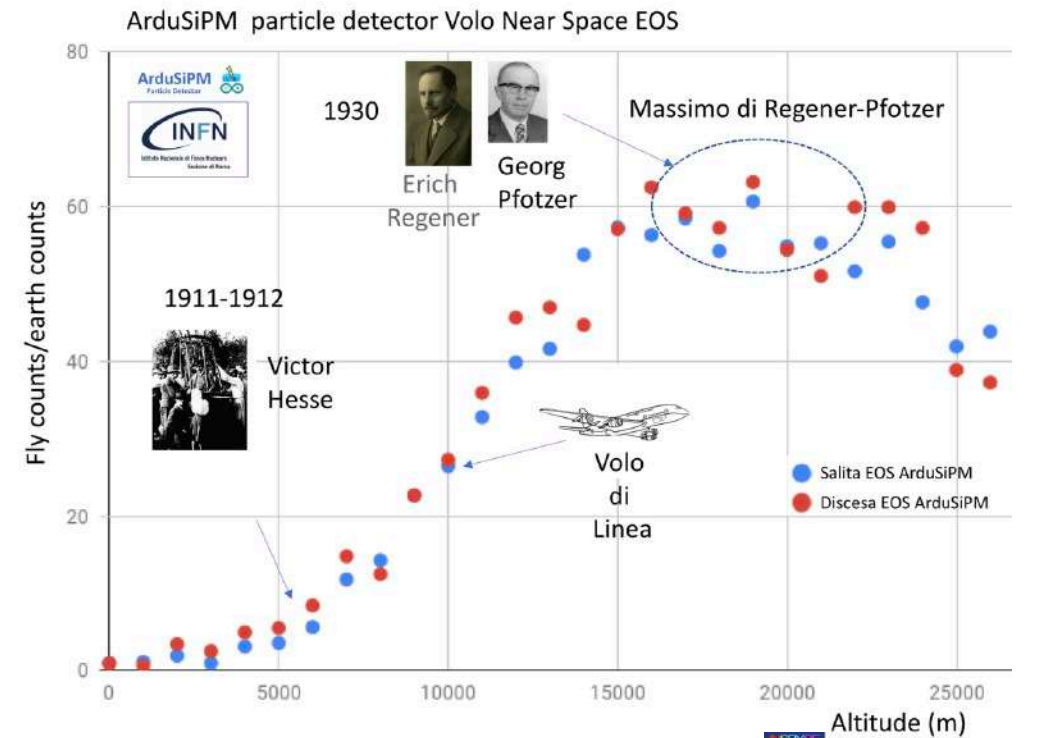
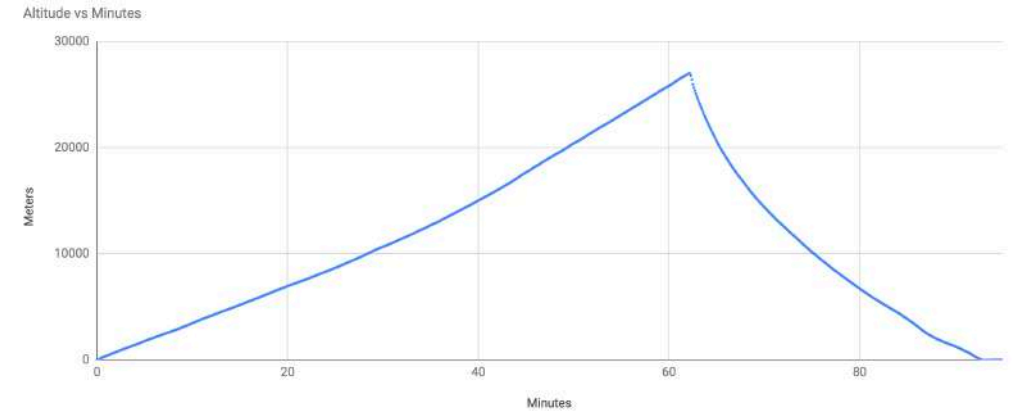
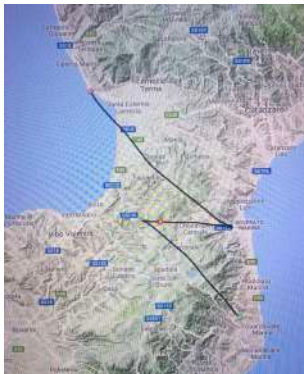


EOS Space project 30 Giugno 2018
ITI A. Russo Nicotera, AB Project, INFN Sezione di Roma



EOS Space project 30 Giugno 2018





ITI A. Russo Nicotera, AB Project, INFN Sezione di Roma




Lancio Mocris 2019

Sabato 8 GIUGNO 2019
LANCIO NELLA STRATOSFERA
PROGETTO SPAZIALE MOCRIS

In Collaborazione con:



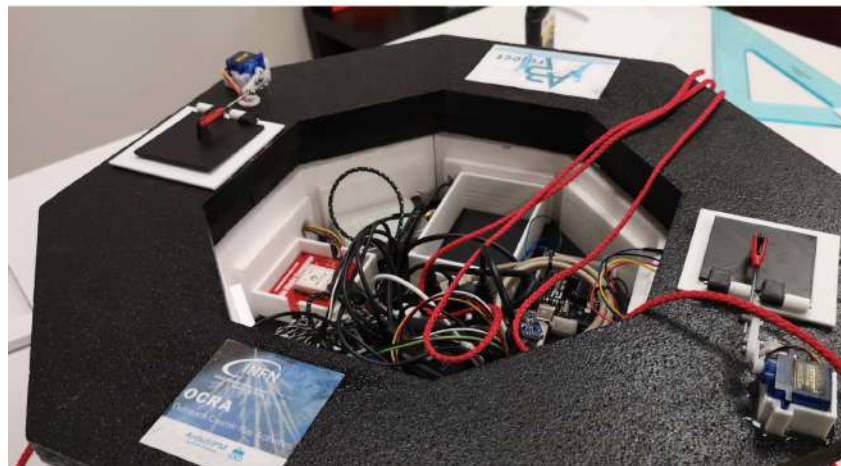
Le operazioni e il lancio si svolgeranno alla Chiesa di San Lorenzo in Camigliatello Silano (CS)

PROGRAMMA
Inizio ore 09:30 - Raduno dei partecipanti al campo sportivo
Ore 10:00 - Saluto alle autorità e inizio delle operazioni
Ore 10:30 - Trasferimento elio nel pallone e test finali

Ore 11:00
"Lancio della Sonda MoCRIS"

Siete tutti invitati a partecipare

<https://www.mocris.it/area-utente/area-utente>



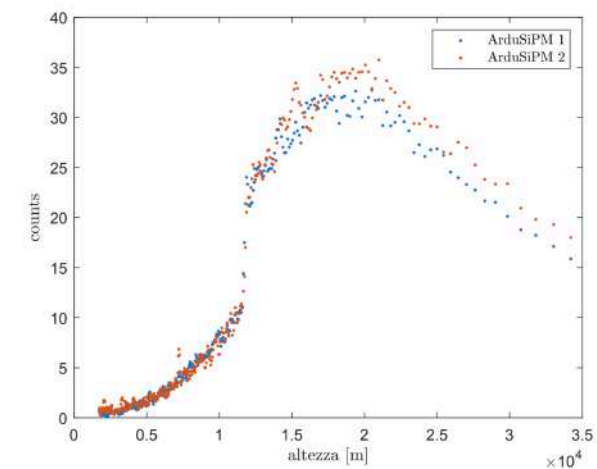


Figura 4.2. Misure di conteggi in fase di salita ottenute dai due rivelatori ArduSiPM in funzione della quota. Il massimo di ionizzazione è evidente intorno ai 20km.



<https://sites.google.com/view/particle-detectors/home/>

✕ Home

Where to Buy

▼ ArduSiPM Literature

▼ HOW-TO

Software

▼ Firmware

MAYA (Mini ArraY ArduSiPM)

Social activity

ArduSiPM Video

Main Achievements

Public Python software


ArduSiPM in the World

Particle detectors

Home Where to Buy ArduSiPM Literature HOW-TO Software Firmware MAYA (Mini ArraY ArduSiPM) Social activity ArduSiPM Video Main Achievements Public Python software ArduSiPM in the World

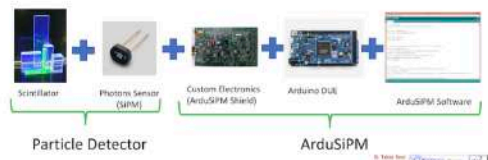
ArduSiPM

a Low cost Particle Detector



ArduSiPM, developed within the INFN, is the first detector in the scientific literature (DOI: 10.1109 / NSSMIC.2014.7431252) to use a microcontroller and a limited number of external components to control and acquire a scintillation detector using the new photomultiplier technology the Silicon Photo Multiplier (SiPM). ArduSiPM is the result of decades of research experience in the construction of particle detection systems that takes advantage of microcontroller digital analogue integration technologies exploiting them to the maximum with a wise use of the available hardware software resources.

Is it possible to build a complete particle detector and data acquisition system using Arduino microcontroller and Arduino Language ?



Particle Detector

ArduSiPM

We would like to introduce to you the ArduSiPM

– an easy hand-held battery operated device with an Arduino board, which is used to detect cosmic rays and nuclear radiation.





Is ArduSiPM /SLICE style detectors usable for space ?



- Minimum number of components (high MTBF)
- Compact (few cm³)
- Light detector <200 gr all inclusive (scintillator electronics DAQ)
- Low power (< 1 Watt full operational)
- The design is upgradable for new generation of microcontrollers
- The firmware can be adapted to different situation
- Can be used with different Scintillator (neutrons,gamma,protons,electrons)
- Small instruments monitor of radiation inside satellite
- Cubesat

