Telescopio di Muoni low cost

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Caratteristiche

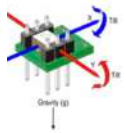
- Basso Costo (< ~1000 Euro)
- Facilmente realizzabile
- Interattivo: utilizzo manuale / automatico
- Possibilità di staccare i rivelatori (parte più costosa) e utilizzarli per altri scopi
- Curva della dipendenza angolo flusso realizzabile in qualche ora

Componenti necessari

- 2 rivelatori ArduSiPM ~850 Euro


- 1 Sistema di controllo e acquisizione con display (M5Stack) ~40 Euro

- 1 Accelerometro digitale 3 assi (misura dell'angolo rispetto allo zenith) ~5 Euro

- 1 Servomotore (impostazione angolo per misura automatica) ~10 Euro

- Struttura meccanica ~20-50 Euro

ArduSiPM
(acquistabile su MEPA sotto licenza INFN)

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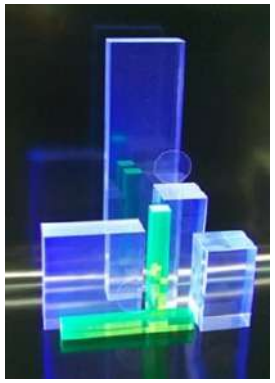
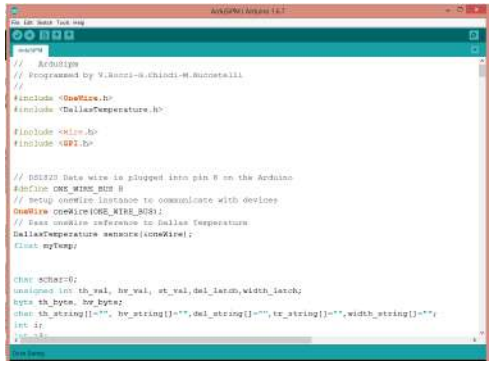

Scintillator


Photons Sensor (SiPM)

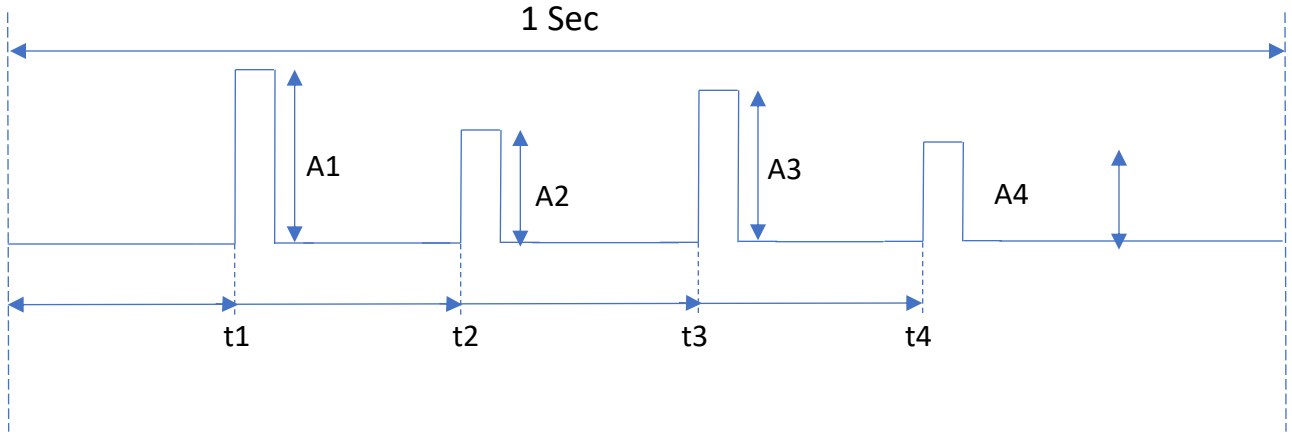

Custom Electronics (ArduSiPM Shield)


Arduino DUE


ArduSiPM Software

ArduSiPM

ArduSiPM measuraments



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

Using a 200KBits/s serial stream

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
tXXXXXXXX TDC value in HEX MSB zero suppressed
$XXX rate in Hz

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

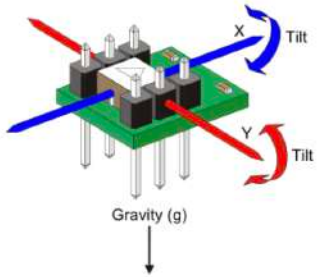
- Only the frequency up to 40 MHz
- ADC value up to 4-6 KHz
- ADC,TDC and rate 1 -2 KHz

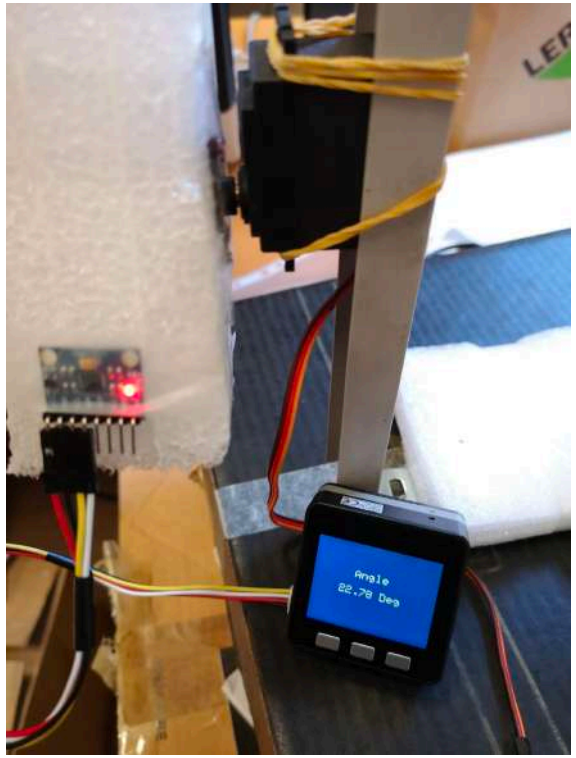
Using the SAM3X8 built-in ethernet it is possible to increase data acquisition performance.

Componenti misura angoli e acquisizione dati

MPU-6050 sensor module

GY-521





M5Stack

https://m5stack.com/

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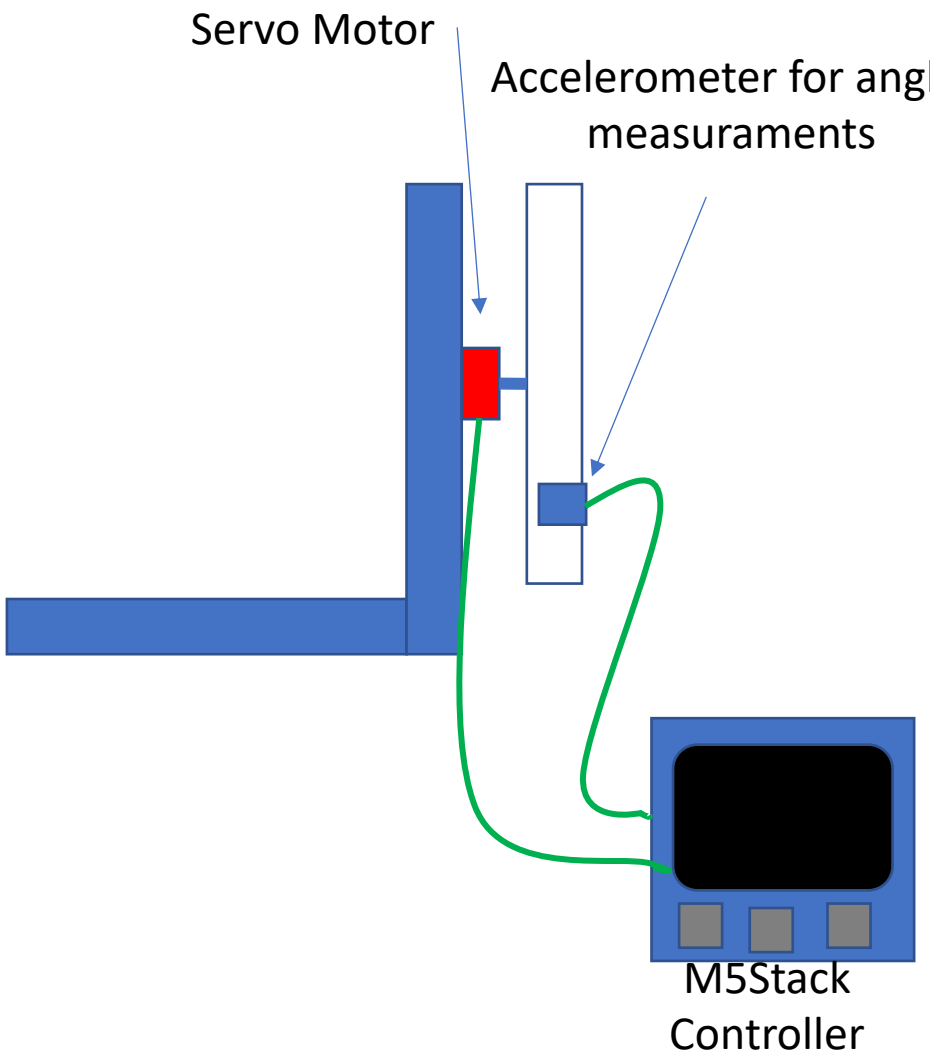
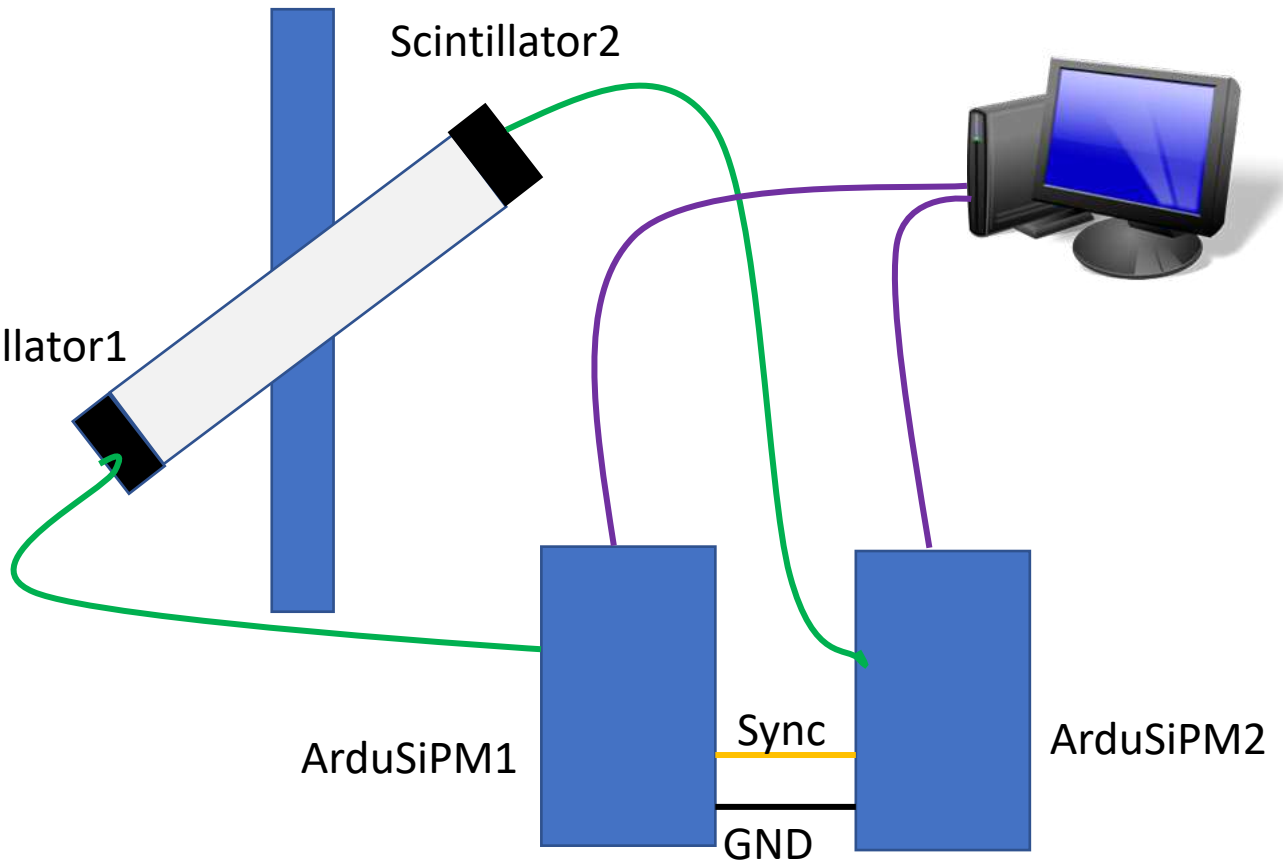
Muon Telescope with ArduSiPM





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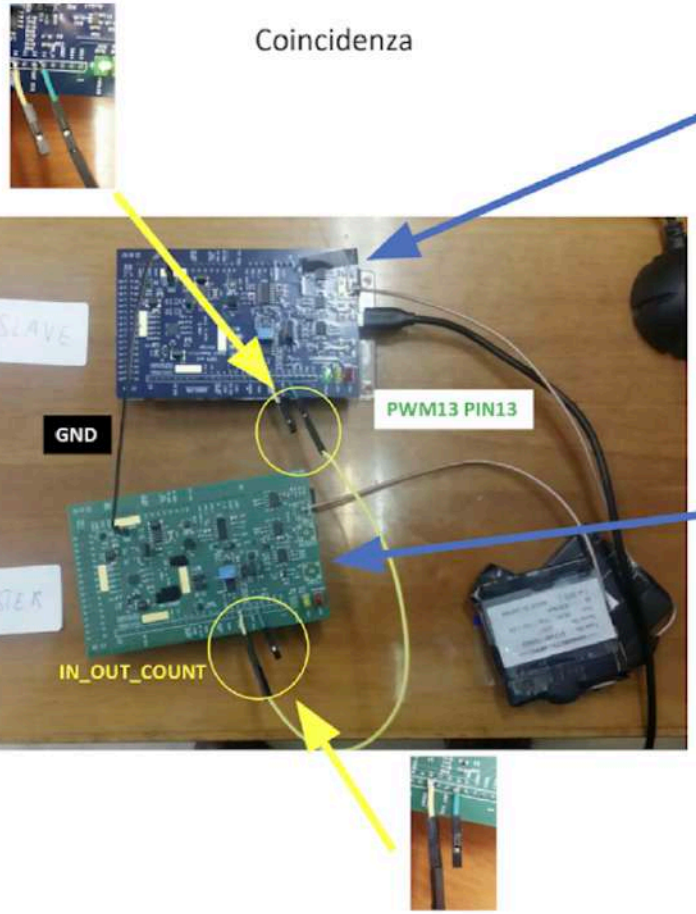
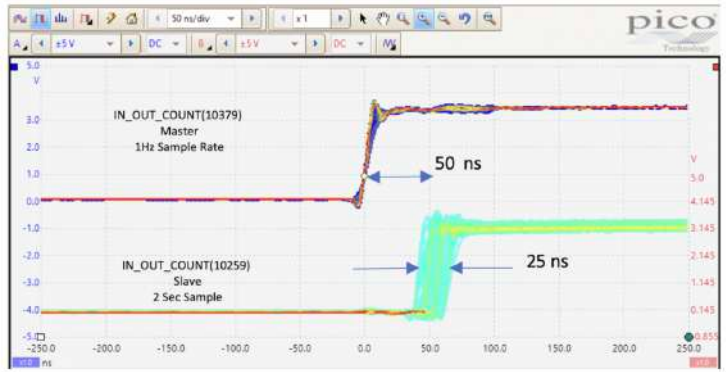
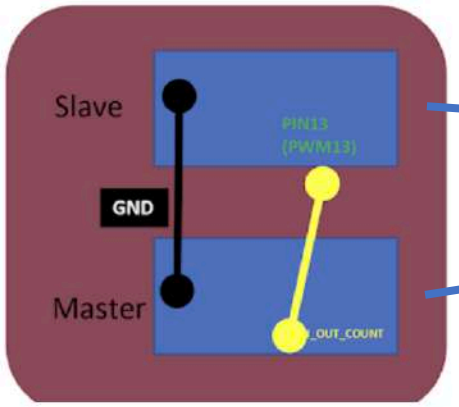
Coincidenza usando TDC interni (offline)
(didatticamente più interessante)



Setting the acquisition time to 2 Sec
Using the command "/2" appear @SR2Se



/1



Dati ArduSiPM1

Dati ArduSiPM2

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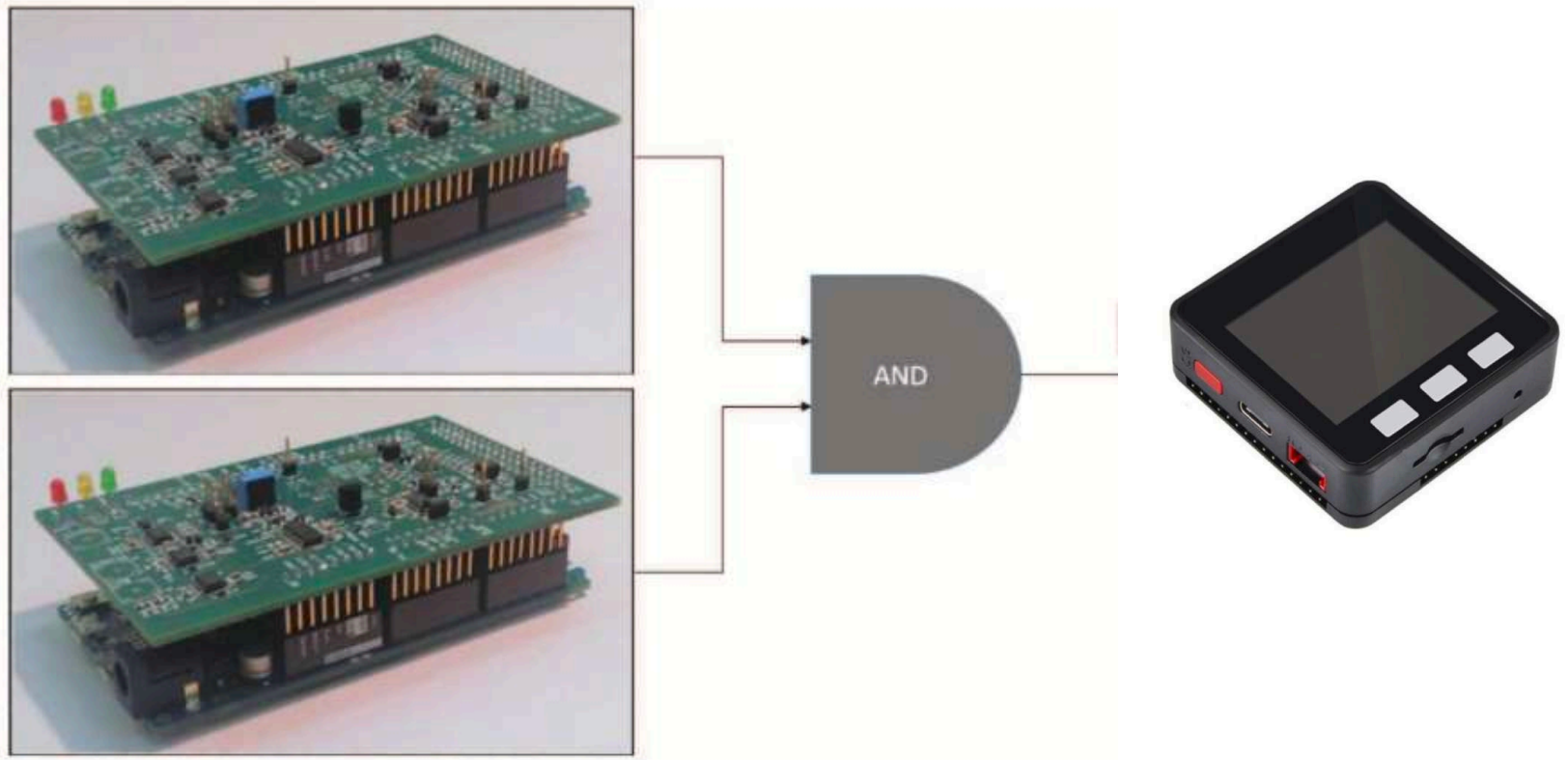
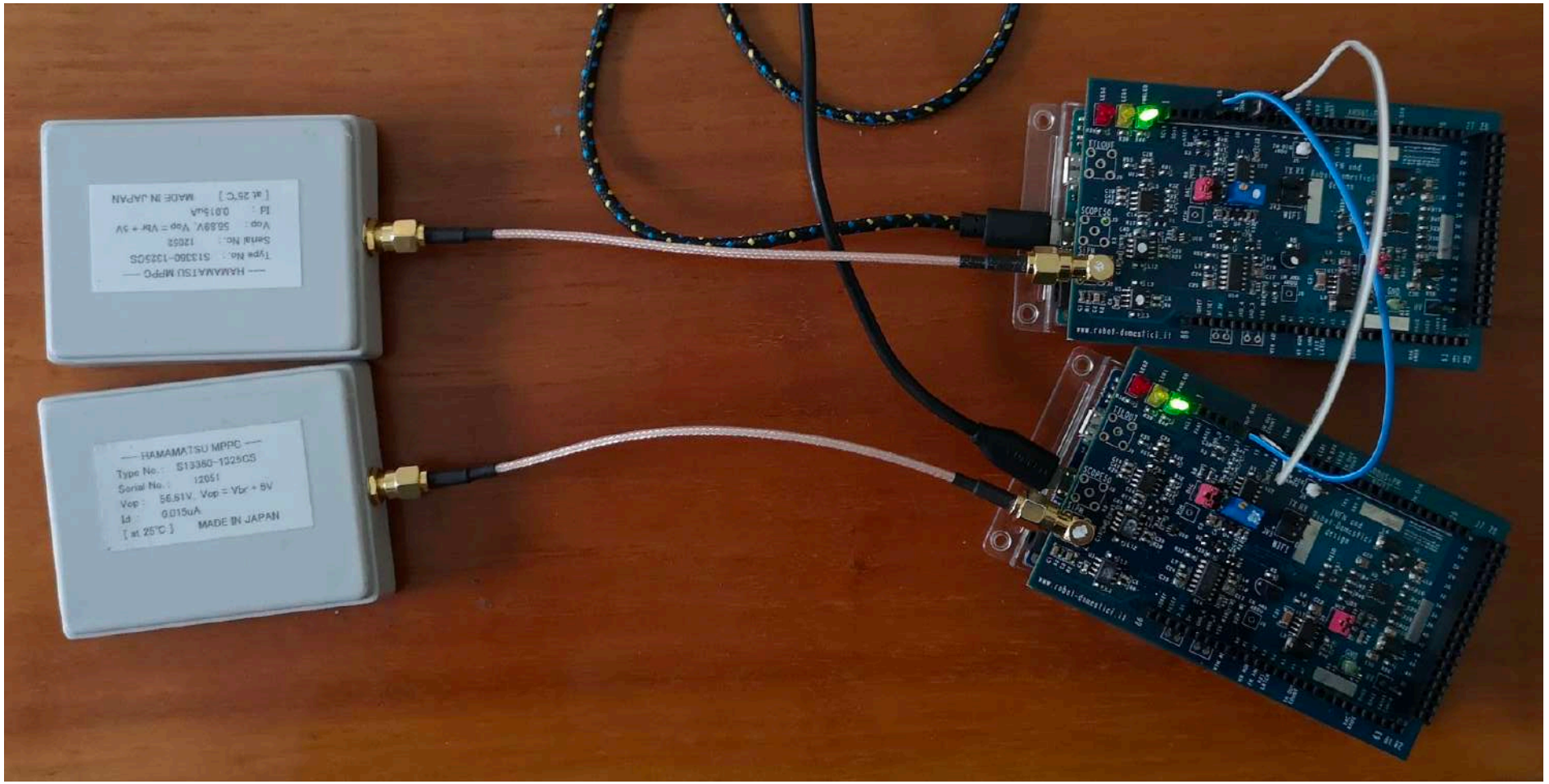
Coincidenza con AND



ArduSiPM and scintillator



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Probably is better to use the version without plastic case

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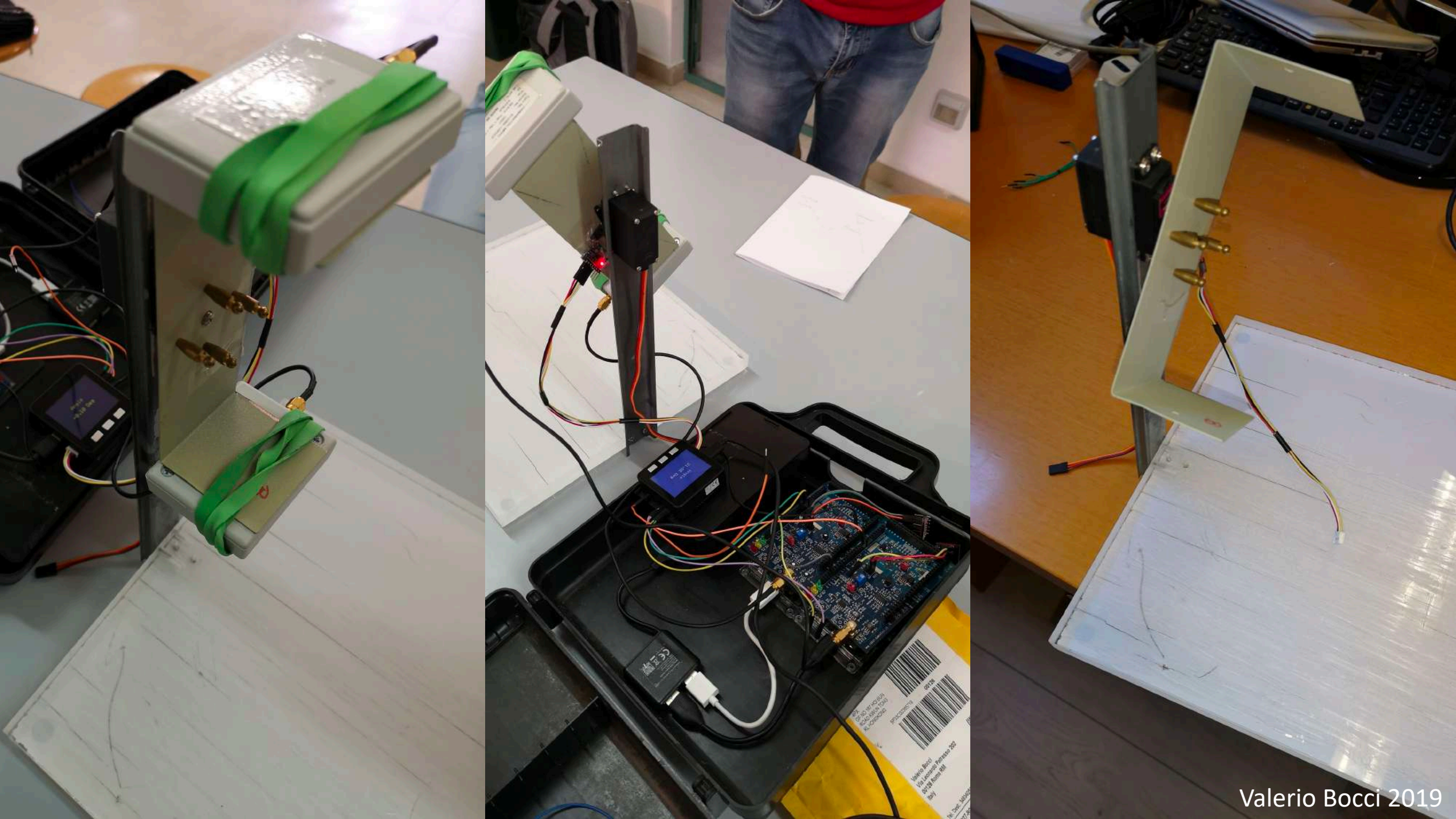
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Teachers: Luca Elisa Battistella, Cristina Chiuso
External collaborators: Valerio Bocci, Daniele Tortora
Technicians: Antonio Errico, Giovanni Panzica
Student's speakers:
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Students: Ada Balducci, Luca Balducci, Federico Banfi, Irene Benassi, Lavinia Boca, Nicolò Bolzoni, Alessia Bonfà, Beatrice Bottura, Cristina Cacchino, Mirco Fava, Sarah Golini, Emanuele Mazzali, Diego Noseda, Alessandra Pinosano
Student's parent: Fuchsberg Cassetta
Liceo Giulio Casiraghi, Cinisello Balsamo (Mi)

ANGULAR DISTRIBUTION OF COSMIC RAYS

Image credit: DESY, Science Communication Lab

Abstract

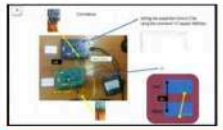
After a short introduction, we used a cloud chamber to observe and classify the tracks of the particles, looking in special way at cosmic rays tracks. Then, using our ArduSiPM detectors, we managed to do some measurements to verify the relationship between the rate of cosmic rate and the zenith angle.

Experimental

We had done several measurements with the plastic scintillators (5x5cm) of the two ArduSiPM overlapping to get the coincidence rate of muons (see photo below).
Our detector ArduSiPM is made of :

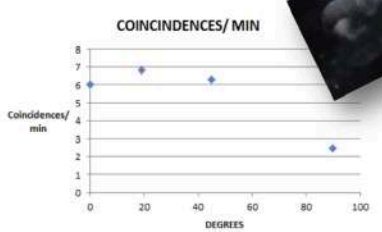
- A scintillator covered by an Aluminium layer and a black tape, to avoid external light and not interesting radiation;
- A photomultiplier which converts the light signal into an electric impulse;
- An Arduino DUE connected with a dedicated shield for detecting cosmic radiation and ~~the~~ detector's signals.

The equipment was oriented west and, after some measurements, we changed the zenith angle α, modifying the slope of the board (see photo below)



Analysis

ZENITH ANGLE	# of COINC.	TIME (Min)	COINC / MIN
0	30	5	6
19	75	11	6,82
45	63	10	6,3
90	27	11	2,45



These are our measurements and the diagram of the relation between the coincidences and the zenith angle. It seems that the values are too high for our detectors, probably for background noise, but the trend is quite good, except for the 0° cause of the short time of the measurement.
We couldn't find out the cause of the noise, but we verified that the flux of cosmic rays decreases with the zenith angle with a trend similar to $f(\theta)=f(0)\cos^2(\theta)$.

Results

We found that the flux of cosmic rays decreases when the zenith angle changes from 0° to 90° and the $f(\theta)=f(0)\cos^2(\theta)$ function is quite near to fit our data as per expected results .

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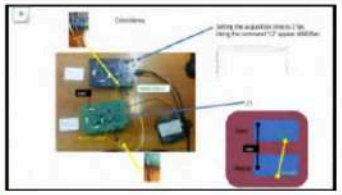

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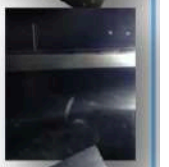

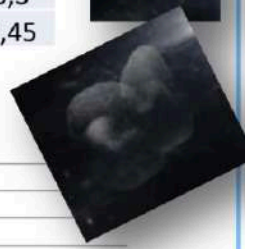

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Stima tempi

Gradi	Rate coinc/min	acq time (min)	eventi		ore
0	2	20	40		0.33
30	1.52	20	30.36		0.33
45	1.03	30	30.94		0.50
60	0.54	60	32.20		1.00
				Ore Totali	2.17

Conclusioni

- Si può realizzare un telescopio a basso costo utilizzando due ArduSiPM
- Realizzazione semplice **DIY** (**Do It Yourself**) con componenti acquistabili facilmente
- Gli ArduSiPM sono indipendenti e riutilizzabili per altri esperimenti.
- Grazie al modulo con display siamo completamente svincolati dal computer.
- Possibilità di usarlo in maniera manuale
- Possibilità di trasmettere i dati direttamente in internet.
- Possibilità di misura completamente automatizzata
- La componente Firmware/Software molto importante

  -> nuove funzionalità inseribili in futuro semplicemente con upgrade Firmware