ArduSiPM (Aduino+SiPM)
Un rivelatore di raggi cosmici e radiazioni nucleari
Utilizzo per divulgazione e didattica.

ArduSiPM

Low cost Cosmic ray and
Nuclear Radiation Detector


Cosmic Ray Survey

Medical application


Dosimetry

Nuclear Waste monitor

Dr. Valerio Bocci
Istituto Nazionale Fisica Nucleare
Sezione di Roma

Application Example 1: Intraoperative β- Detecting Probe

nature.com > scientific reports > articles > article

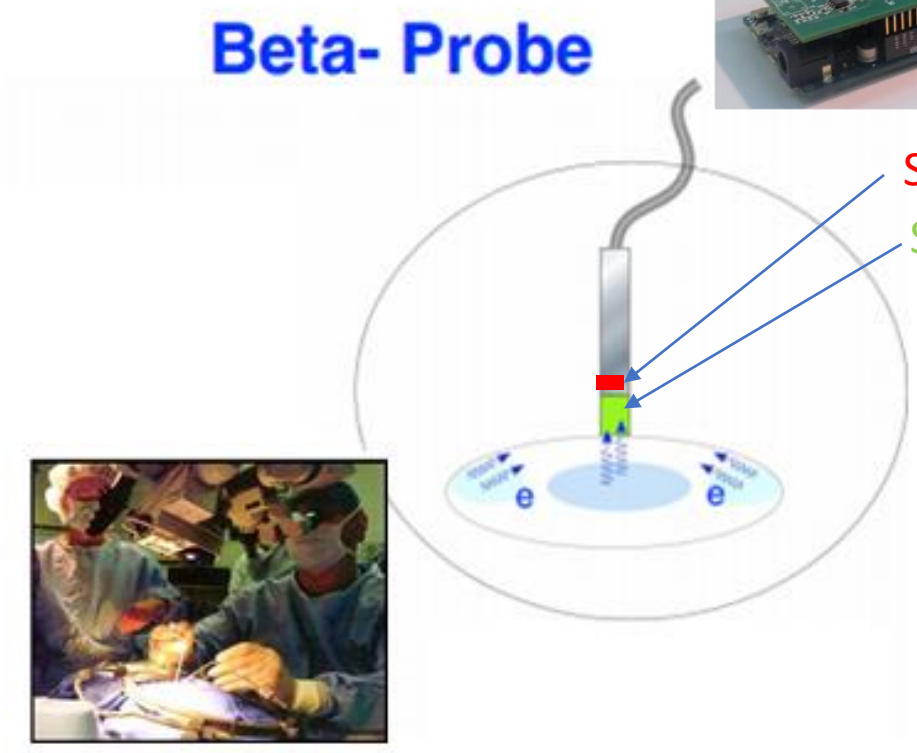
SCIENTIFIC REPORTS

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. Ferroli, 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

ArduSiPM

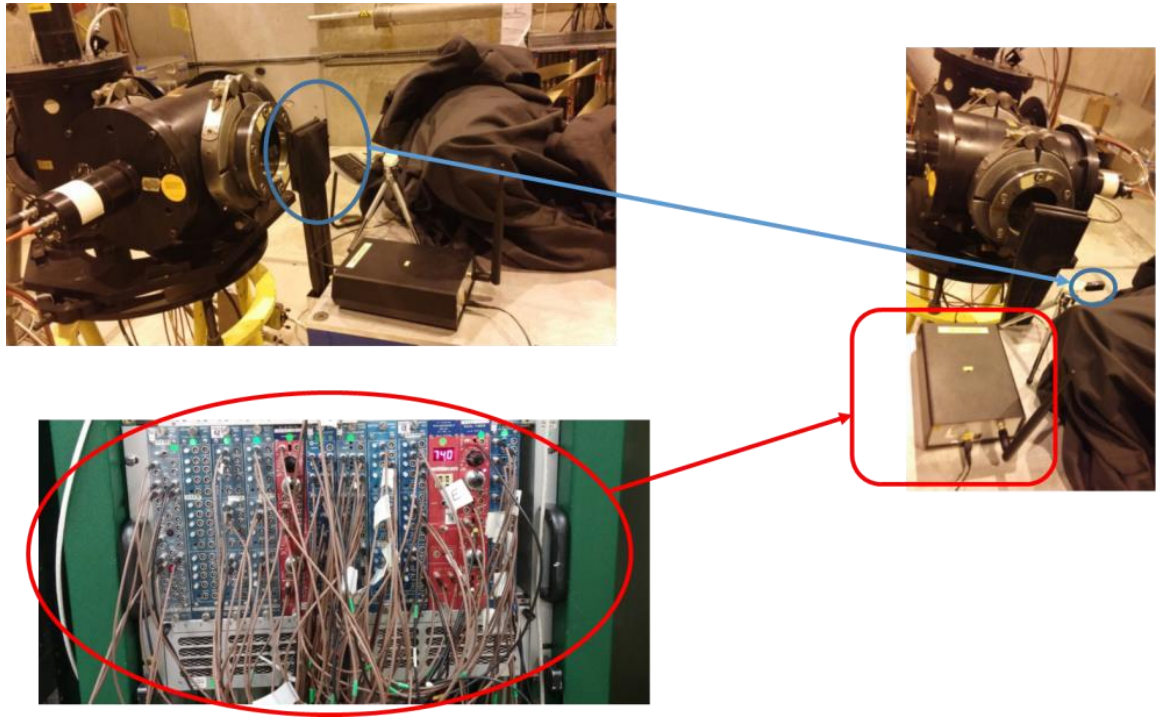
Control and readout
Android App



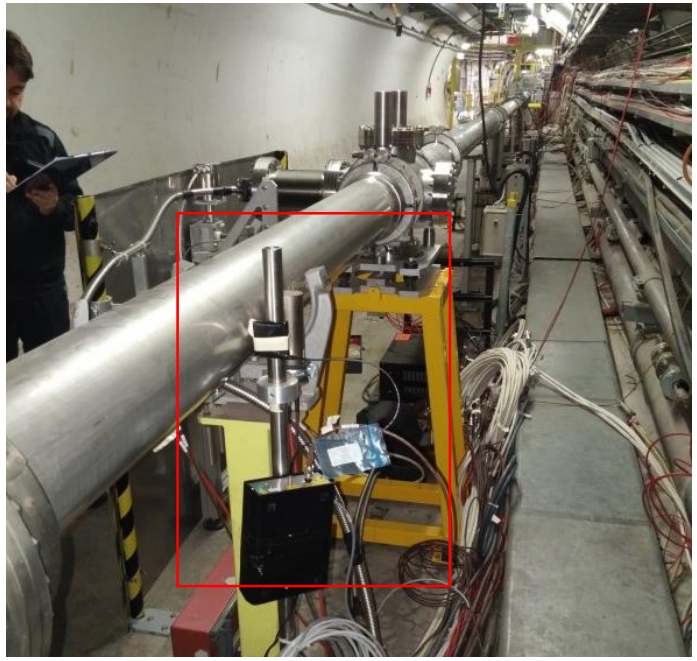
- Radioguided **intraoperative beta probe**, with scintillation material coupled with SiPM detector.

Application Example 2:
Use of ArduSiPM in the CERN UA9 and CRYSBEAM activity

(substitute old Scintillator and electronics for PM)



- As beam trigger @ extracted beam line H8 (CERN)



- As beam losses counter @ SPS

- *This work has been supported by the ERC Ideas Consolidator Grant*
- *No.615089 "CRYSBEAM".*

ArduSiPM è stato utilizzato per la dimostrazione della fattibilità del Brevetto n.**102015000040903** “**Sonda intraoperatoria**”,

JINST

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Use of bremsstrahlung radiation to identify hidden weak β^- sources: feasibility and possible use in radio-guided surgery

D. Carlotti,[a,b,c] F. Collamati,[a] R. Faccini,[a,e,1] P. Fresch,[a] F. Iacoangeli,[a] C. Mancini-Terracciano,[a] M. Marafini,[a,f] R. Mirabelli,[a,d] L. Recchia,[a] A. Russomando,[g,h] E. Solfaroli Camillocci,[a,e] M. Toppi,[i] G. Traini[a,d] and V. Bocci[a]

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ABSTRACT: The recent interest in β^- radionuclides for radio-guided surgery derives from the feature of the β radiation to release energy in few millimeters of tissue. Such feature can be used to locate residual tumors with a probe located in its immediate vicinity, determining the resection margins with an accuracy of millimeters. The drawback of this technique is that it does not allow to identify tumors hidden in more than few mm of tissue. Conversely, the bremsstrahlung X-rays emitted by the interaction of the β^- radiation with the nuclei of the tissue are relatively penetrating.

To complement the β^- probes, we have therefore developed a detector based on cadmium telluride, an X-ray detector with a high quantum efficiency working at room temperature. We measured the secondary emission of bremsstrahlung photons in a target of Polymethylmethacrylate (PMMA) with a density similar to living tissue. The results show that this device allows to detect a 1 ml residual or lymph-node with an activity of 1 kBq hidden under a layer of 10 mm of PMMA with a 3:1 signal to noise, i.e. with a five sigma discrimination in less than 5 s.

KEYWORDS: Intra-operative probes; X-ray detectors

[1] Corresponding author.

https://doi.org/10.1088/1748-0221/12/11/P11006

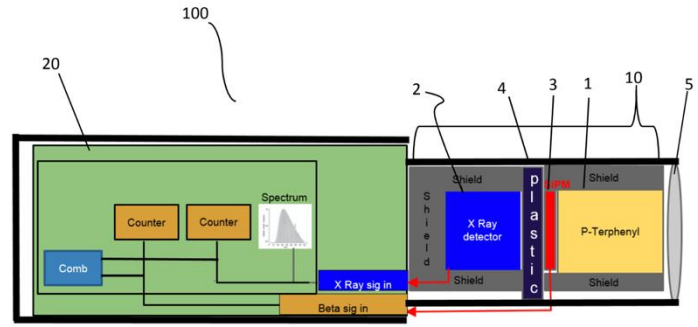

Fig. 1

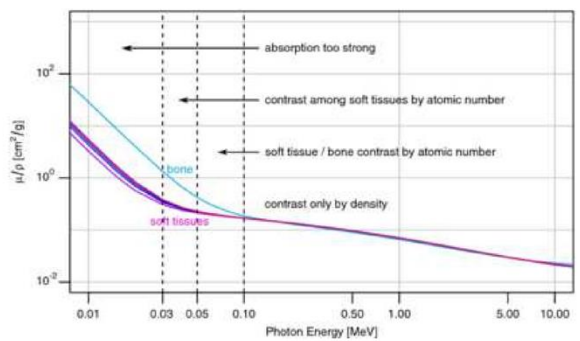

Fig. 2

Loredana Guglielmetti Firmato da: uibm-brevetti Roma, 2 gennaio

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Ministero dello Sviluppo Economico

Direzione generale per la lotta alla contraffazione

Ufficio Italiano Brevetti e Marchi

ATTESTATO DI BREVETTO PER INVENZIONE INDUSTRIALE

Il presente brevetto viene concesso per l'invenzione oggetto della domanda:

N. 102015000040903

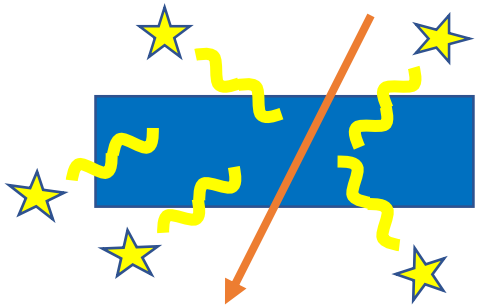
TITOLARE/I:	• ISTITUTO NAZIONALE DI FISICA NUCLEARE Balzano Francesca
DOMICILIO:	IP Sextant S.r.l. via Antonio Salandra 18 00187 Roma
INVENTORE/I:	• Bocci Valerio • Giordano Raffaele
TITOLO:	SONDA INTRAOPERATORIA
CLASSIFICA:	G01T
DATA DEPOSITO:	31/07/2015

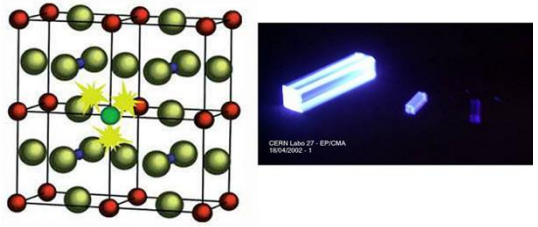
Roma, 02/01/2018

Il Dirigente della Divisione
Loredana Guglielmetti

Using Scintillation materials

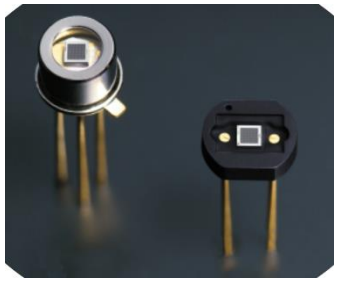
The use of scintillation materials is not for everyone in the past.
The only way was to use photomultiplier.

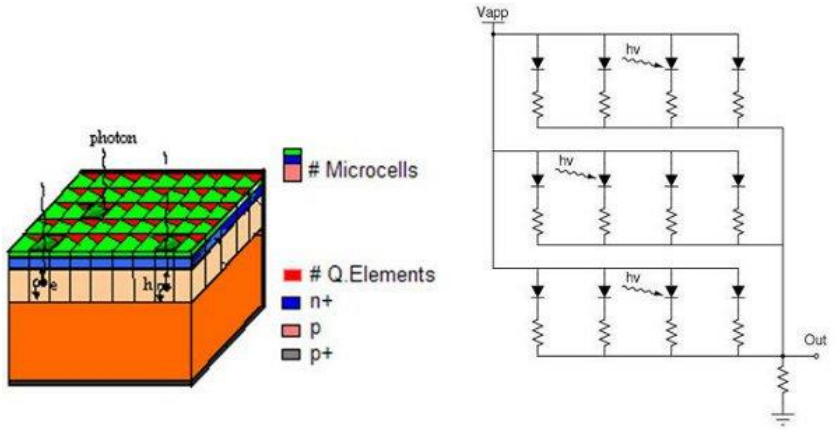


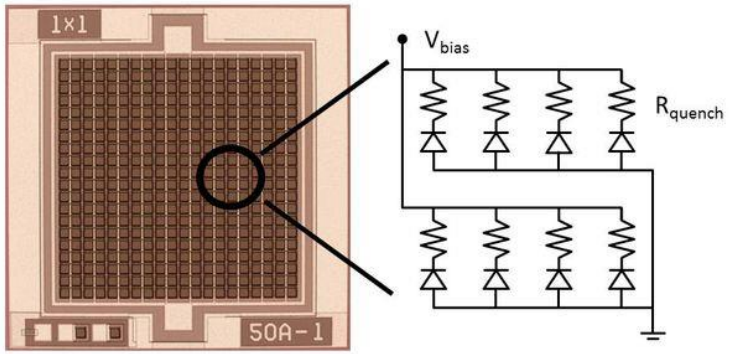


The Photomultiplier (1934).
Based on Photoelectric effect (1921 Einstein Nobel) and electron secondary emission.
The Photomultiplier are expensive and need high voltage(1000 Volt).

SiPM
(Silicon Photo Multiplier)







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

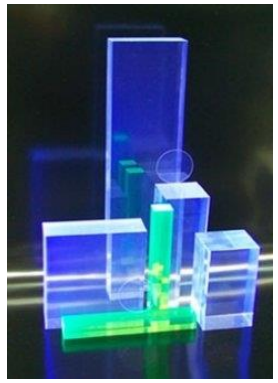
The dimension of each single APD can vary from 20 to 100 micrometres, and their density can be up to 1000 per square millimeter.

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 (Vb) 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.

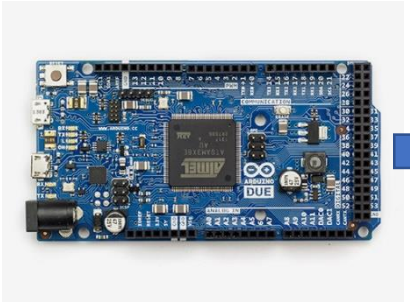
Is it possible to build a complete particle detector and data acquisition system using Arduino microcontroller and Arduino Language ?



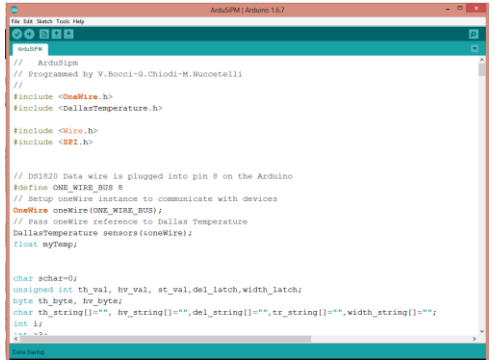
Scintillator

Photons Sensor (SiPM)

Custom Electronics (ArduSiPM Shield)



Arduino DUE

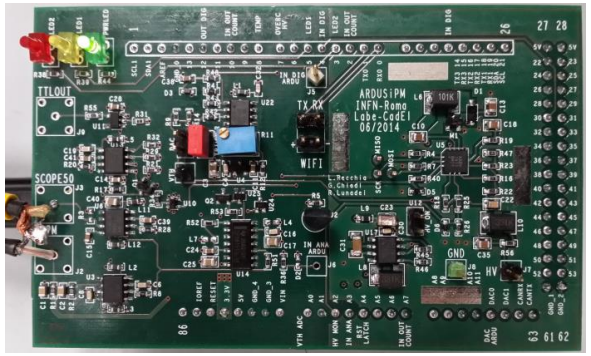


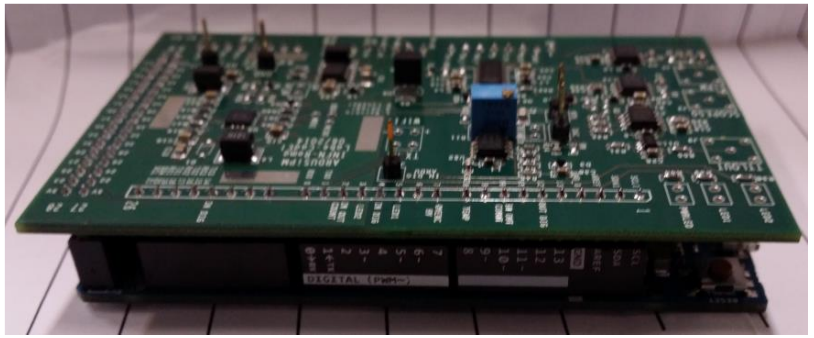
ArduSiPM Software

Particle Detector

ArduSiPM

ArduSiPM Shield






Dr. Valerio Bocci

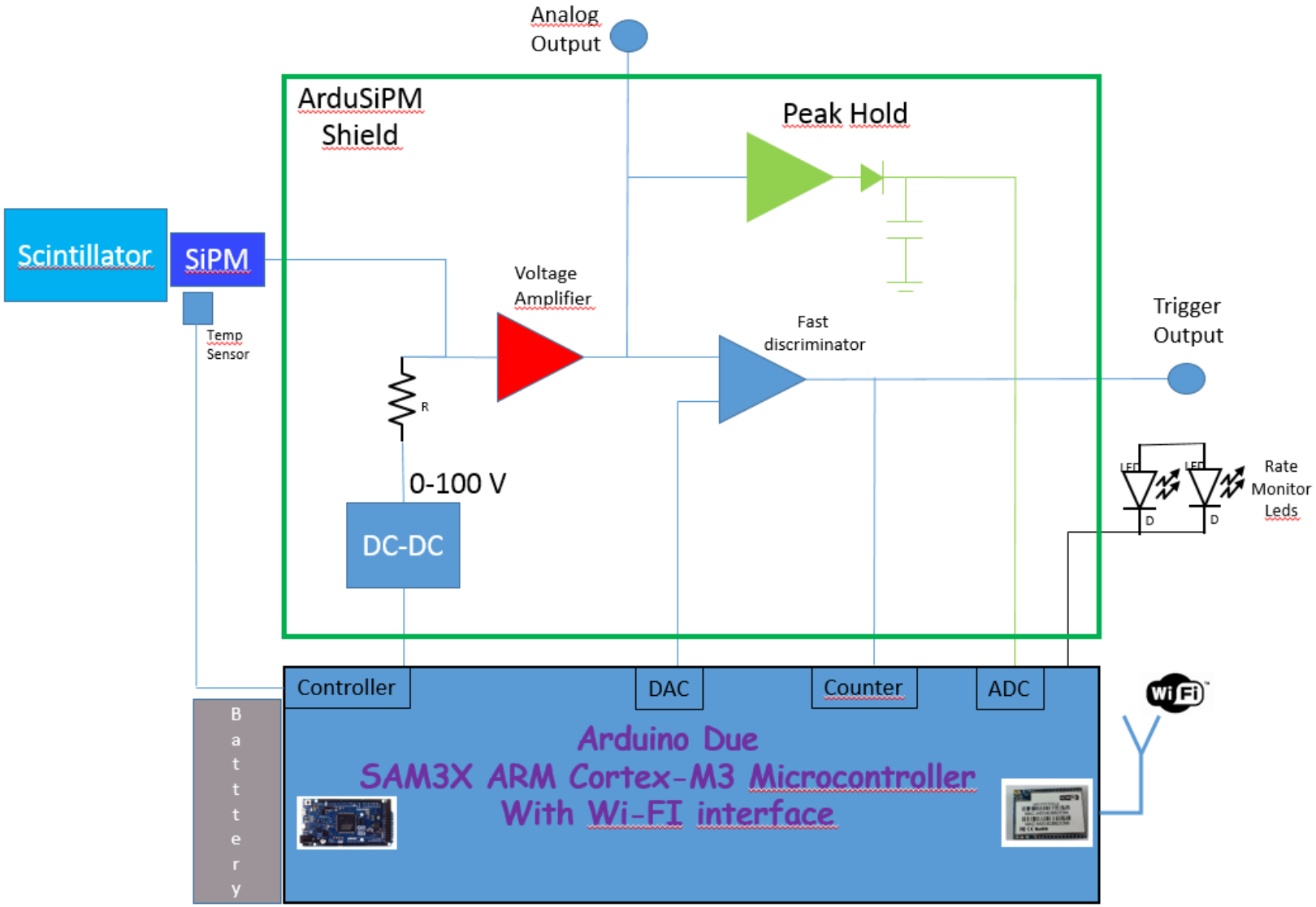

Giacomo Chiodi


Dr. Francesco Iacoangeli

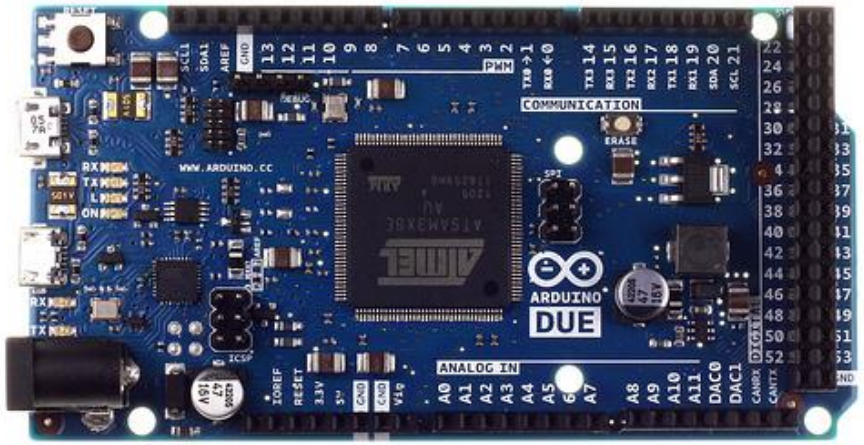

Eng. Luigi Recchia

- Shield for Arduino DUE : a custom designed piggy-back board with all the analog parts
- Same form factor of Arduino DUE
- The ArduSiPM Shield contains:
  - Fast preamplifier
  - Analog Output monitor
  - Fast discriminator with threshold and pulse output width (both digitally programmable).
  - Trigger output
  - Peak hold circuit with programmable sample window.
  - Digitally controlled voltage bias up to 90 Volt (8 bits precision for temperature compensation)
  - Monitor of: temperature,threshold ,HV Bias

ArduSiPM Block Diagram

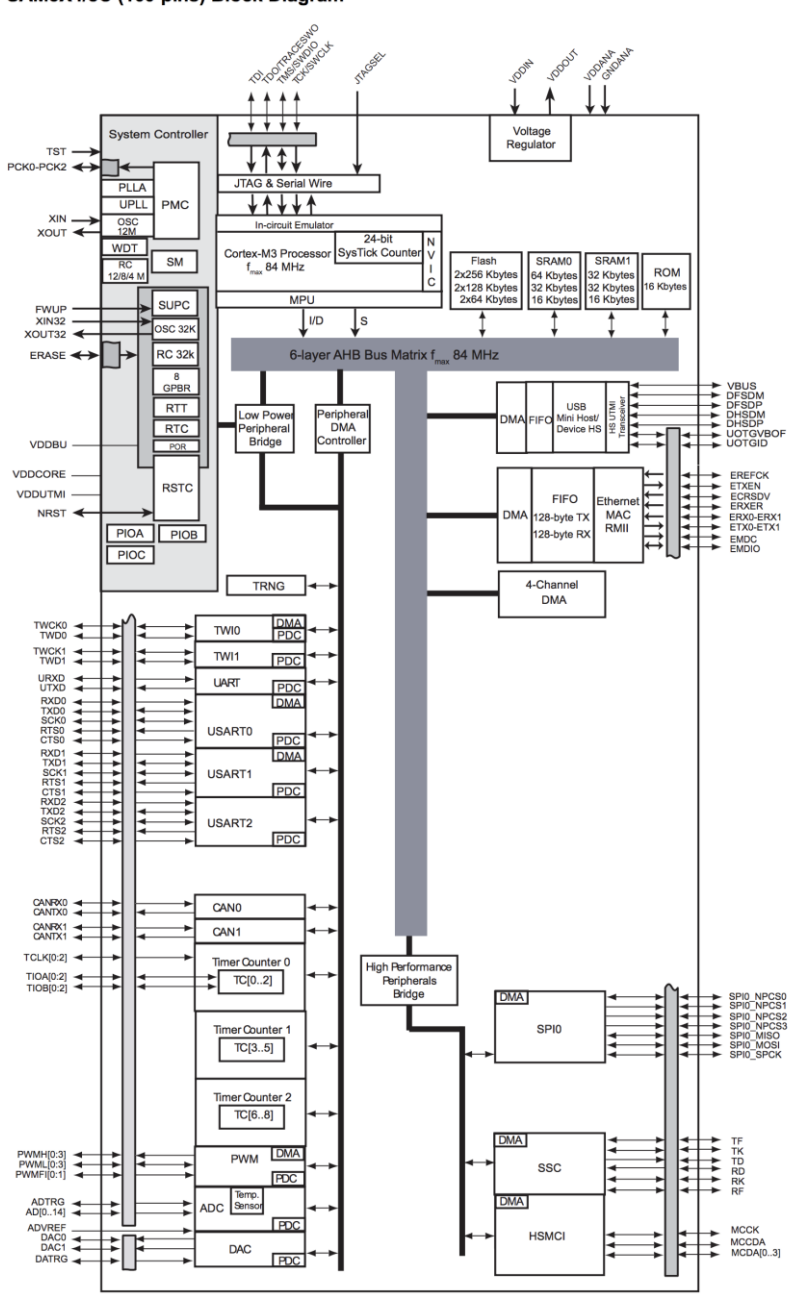


Arduino Due

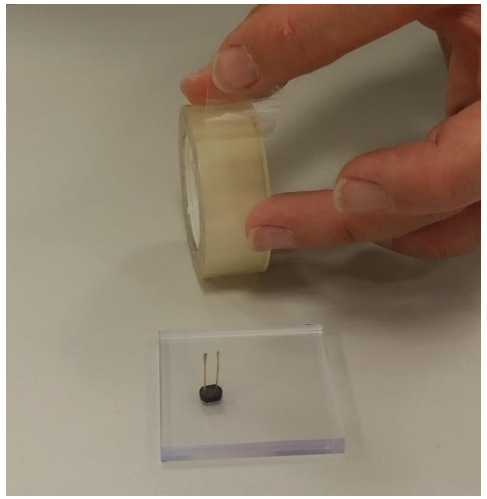


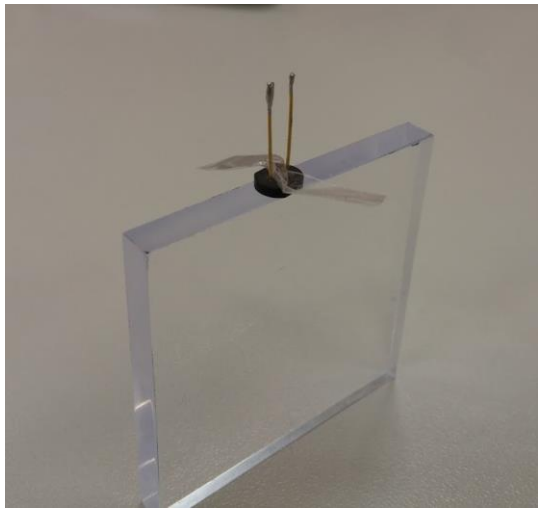
- Arduino is an open-source electronics platform based on easy-to-use hardware and software.
- Arduino Due is the first Arduino board based on SoC (System on Chip) SAM 3X8E a 32-bit ARM core microcontroller.
- Main features available on Arduino Due to build up around an acquisition system are:

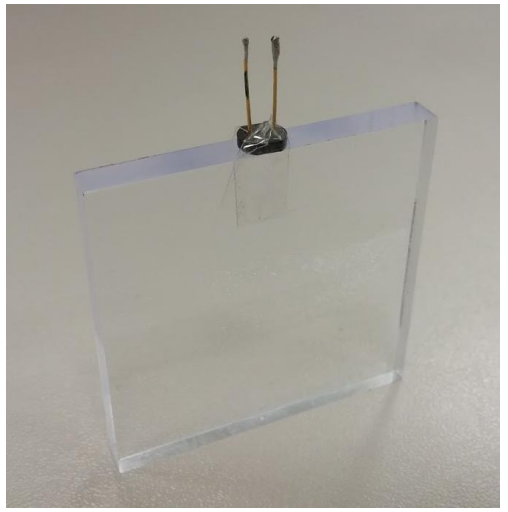
- 16 Channel Multiplexed Analog to Digital converter with 12 bit and 1 MHz sample rate
- Multiple Input output pins
- 9 fast Counter and pulse generator
- 2 Digital to Analog converter with 12 bit resolution
- Different serial interface like I2C,SPI,onewire, RS232, Ethernet MAC in SAM3X8 (not routed ☹)
- 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.



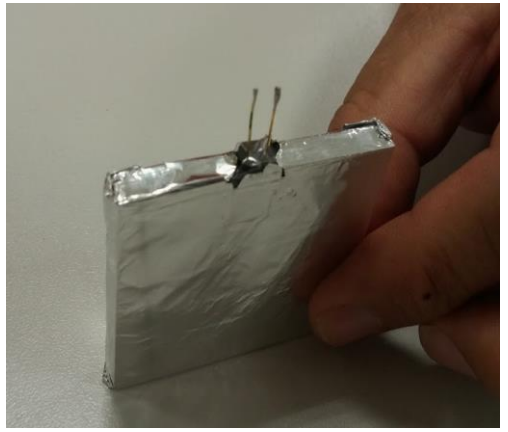
How to build a Scintillation detector with SiPM(1/2)





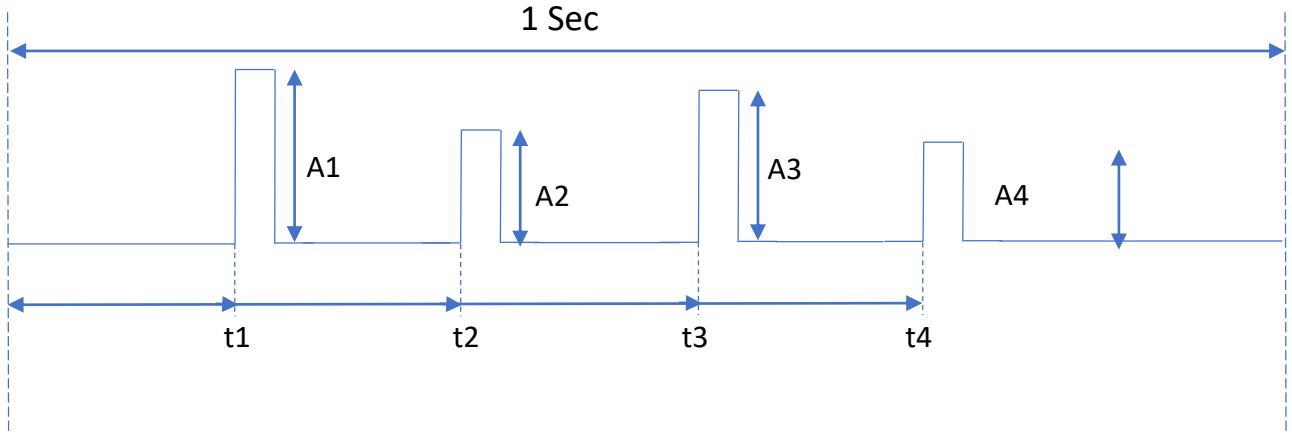


Attaching a SiPM to the scintillator with the scotch



Package with cooking alluminium foil

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.

Trasferimento Tecnologico del progetto per la produzione (non in esclusiva)

ROBOT DOMESTICI
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Prodotti Idea Chi siamo Contatti MEPA Supporto KIT Sviluppo progetti Cerca prodotto

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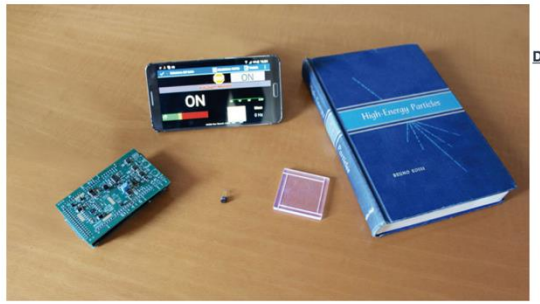
Sistema di misura ArduSiPM Shield KIT

ArduSiPM - Un rivelatore di raggi cosmici e radiazioni nucleari

COD : RD-ArduSiPMKIT



596,83 € (excl. VAT)
728,13 € (incl. IVA)

Disponibilità : in arrivo in magazzino

728,13 € 1 Aggiungi

Chiedi informazioni per questo prodotto (Ask a question about this product)

PRODOTTO DISPONIBILE SUL MEPA CON IL SEGUENTE CODICE : RD-ArduSiPMKIT

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OFFERTA PER 2 ARDUSIPM 1.149,50 € + iva

OFFERTA PER 4 ARDUSIPM 2.179,50 € + iva

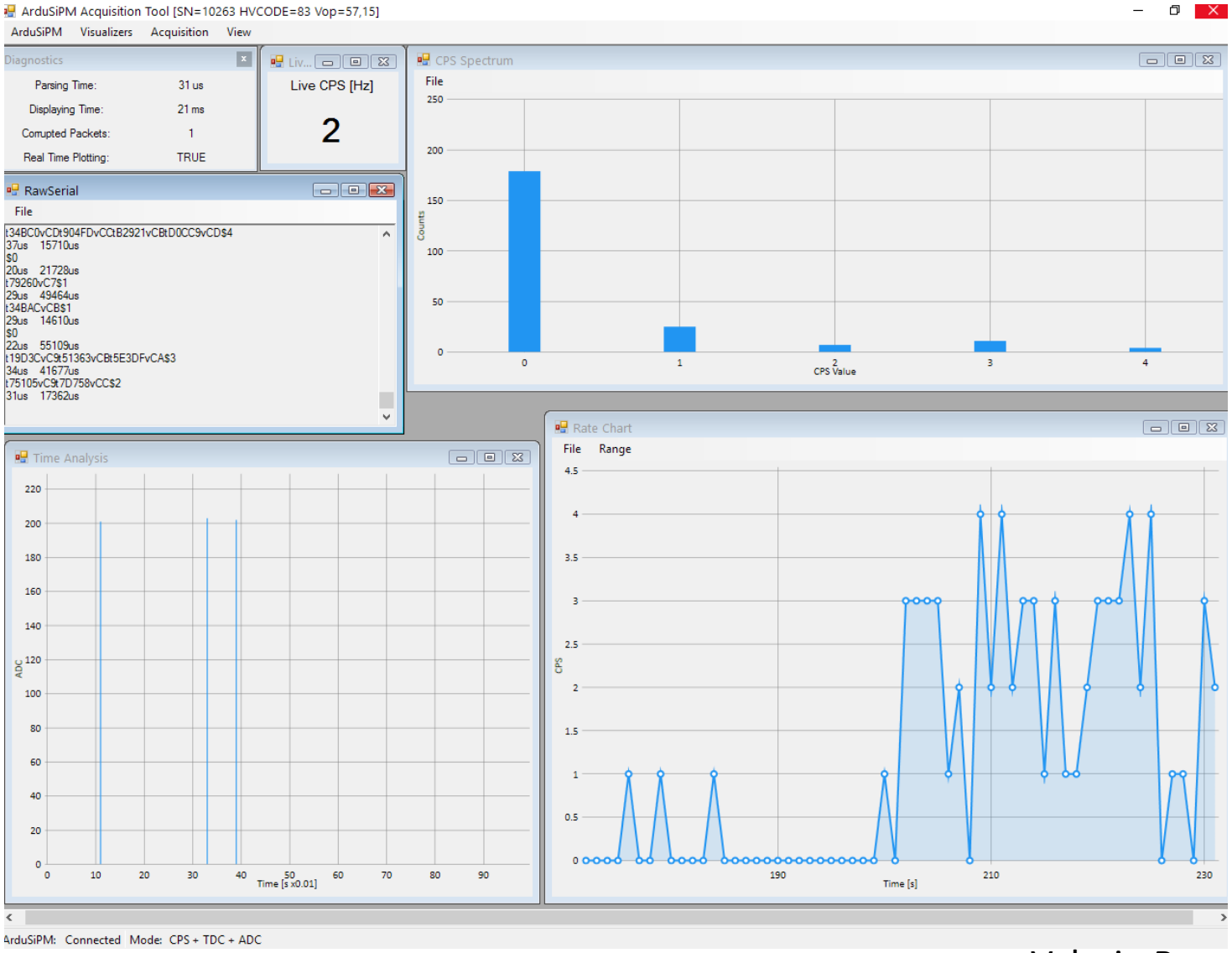
OFFERTA PER 8 ARDUSIPM 3.878,50 € + iva

OFFERTA PER 16 ARDUSIPM 6.786,50 € + iva

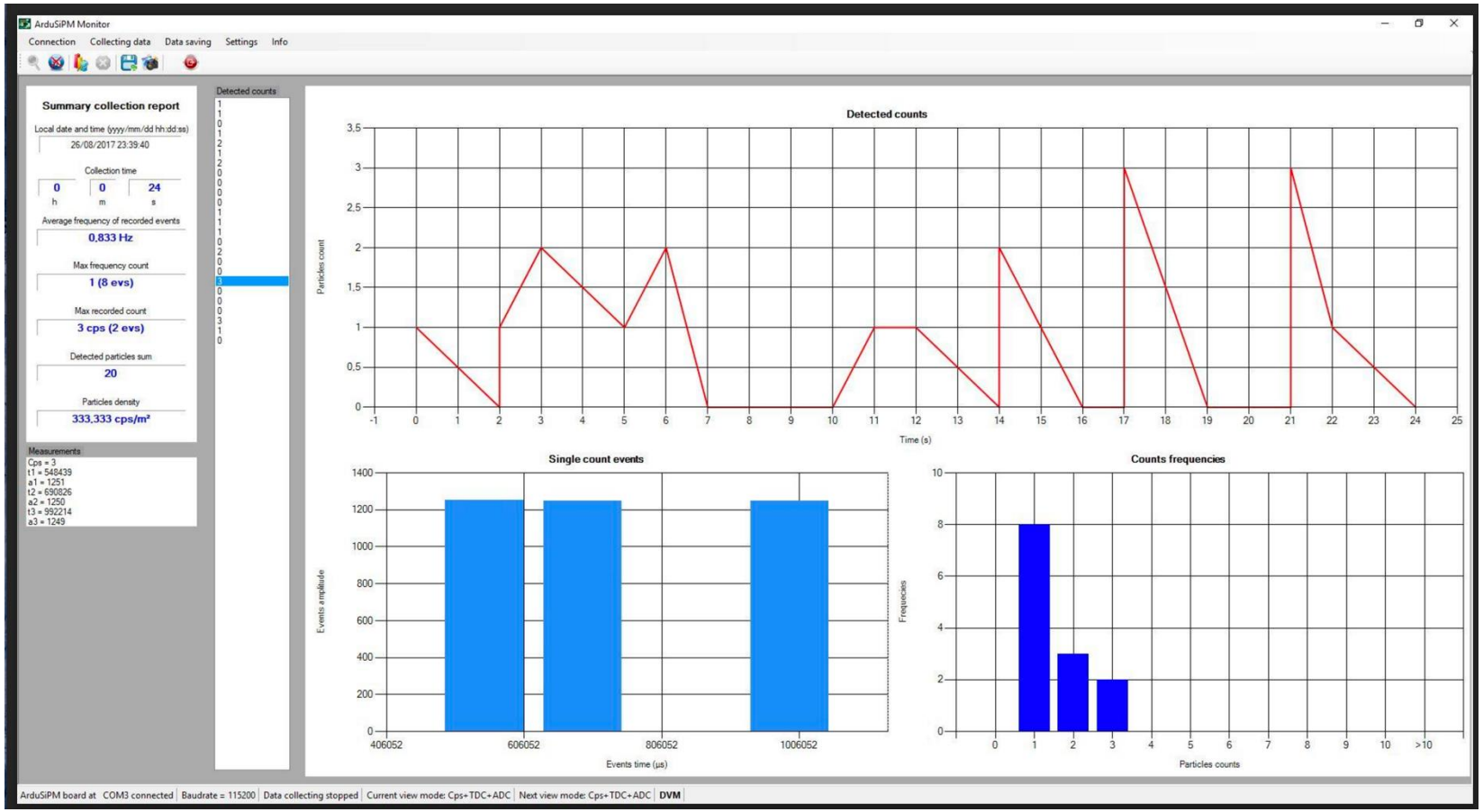
Valerio Bocci Febbraio 2018

The ArduSiPM Data format is open…Users can write custom programs for data aquisition and visualization.

Example 1. **ArduSiPM Acquisition Tool** by Filippo Curti (Filippo.curti1@gmail.com)
(written in C#, fast running also with high rate, at the moment poor in documentation freeware)



Example 2. **ArduSiPM Monitor** by Ciro e Dario Chiaiese (cirochiaiese@gmail.com)
Written in VisualBasic (slow good for cosmic and low rate source) well documented.



ArduSiPM Monitor 1.2.0.2

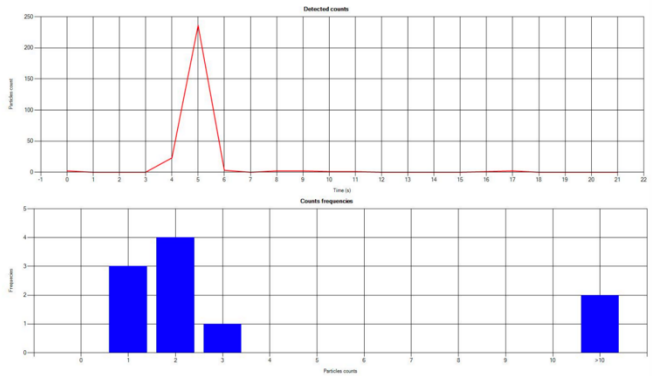
realizzato da Ciro e Dario Chiaiese

GUIDA UTENTE

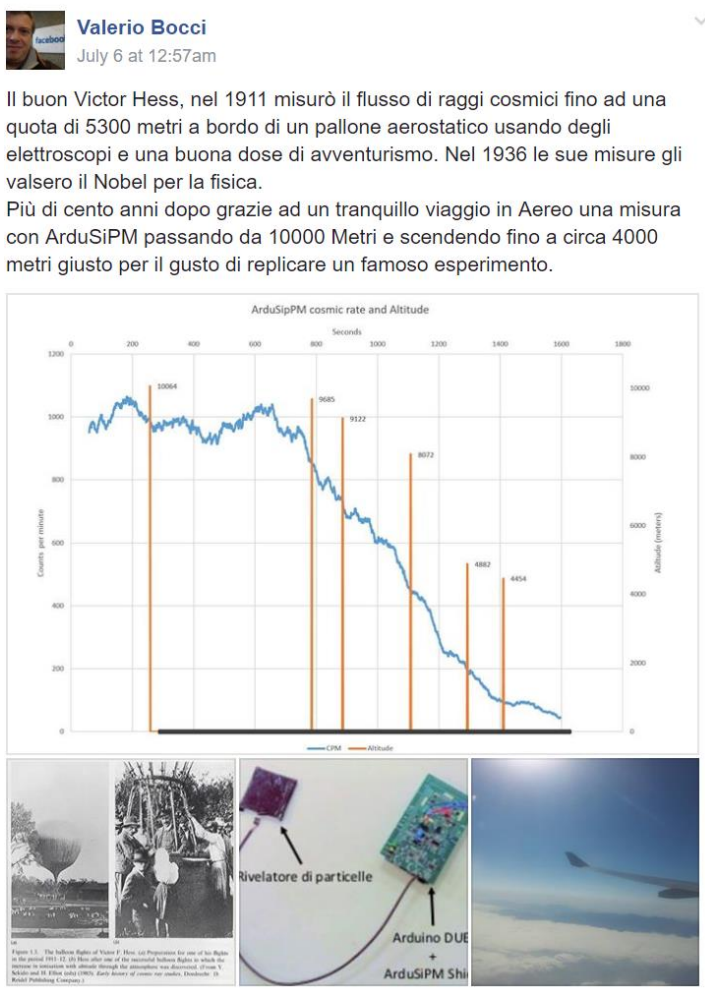
Questo software è stato realizzato per interfacciarsi con la scheda ArduSiPM (da cui il nome) equipaggiata con firmware 2.1.5. Non è stato testato sul firmware precedente e probabilmente andrebbe in errore. Si sconsiglia assolutamente di tentare di usare il software con altri tipi di schede (la qual cosa non avrebbe alcun significato, fra l'altro).

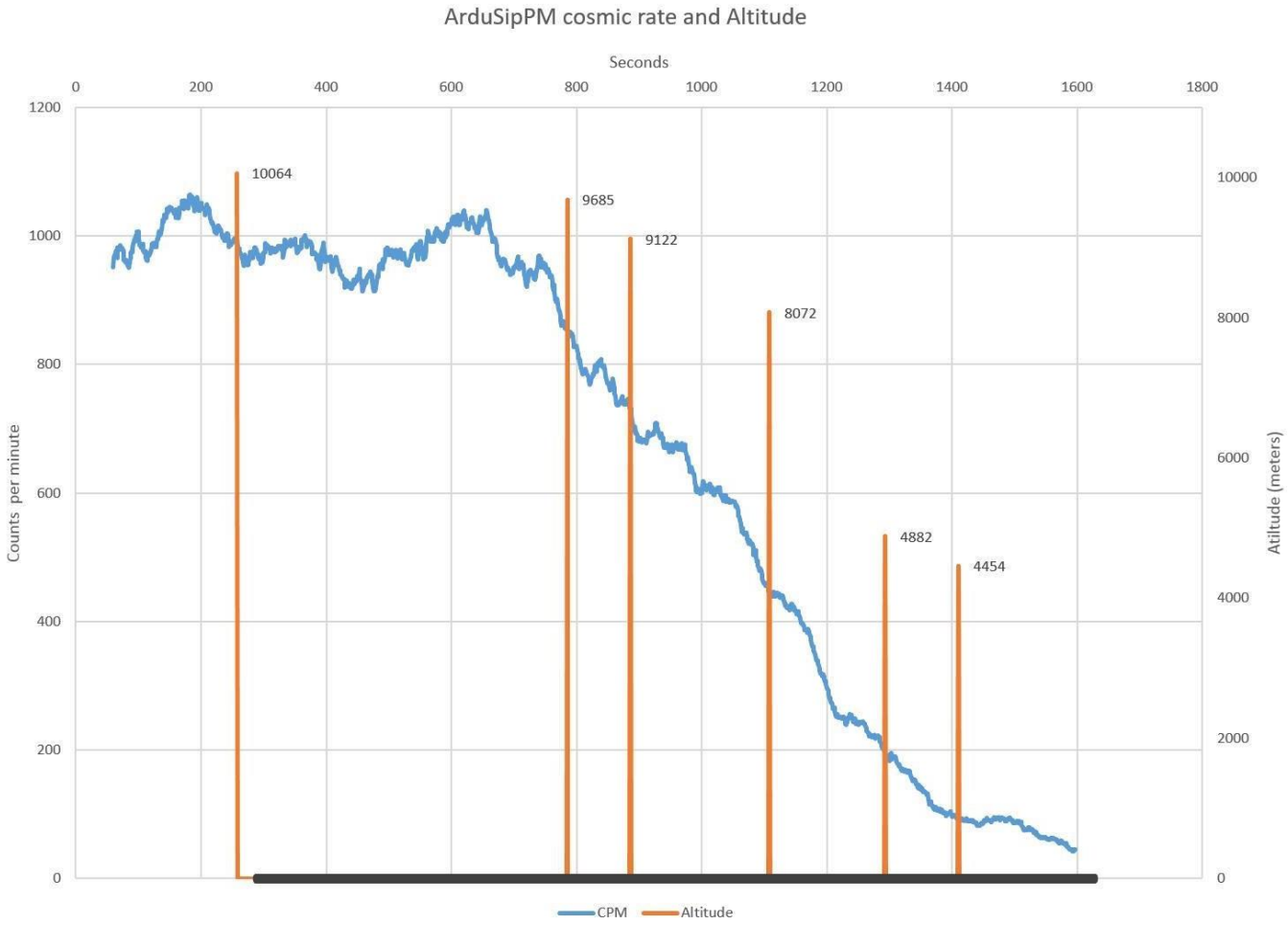
Il programma ha una funzione di riconoscimento della corretta versione di scheda (Autodetect) che è fortemente consigliata. E' comunque possibile usare il *manually detect* ( ) per visualizzare tutti i dispositivi connessi alle USB e scegliere la porta cui è collegata ArduSiPM.

A connessione avvenuta, si può richiedere di raccogliere e graficare i dati tramite apposito pulsante ( ) o voce di menu. La raccolta che si richiede può, precedentemente, essere stabilita in 4 diverse modalità, in seguito descritte, dal menu *Settings/Measurements*. Le modalità più ricche d'informazioni hanno una raccolta dati con frequenza più bassa (perché richiedono più tempo). La durata della raccolta può essere prima stabilita con un timer (in s) o fermata manualmente. Appena inizia la raccolta vengono visualizzati i grafici dei conteggi delle particelle rilevate per ogni secondo (Cps) e, sotto, è riportato il grafico delle frequenze dei conteggi registrati (i conteggi superiori a 10 sono accomunati in un'unica classe di frequenze ">10").



Misura dei raggi cosmici su un aereo di linea



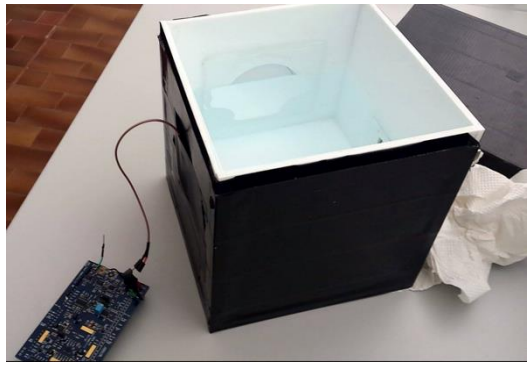


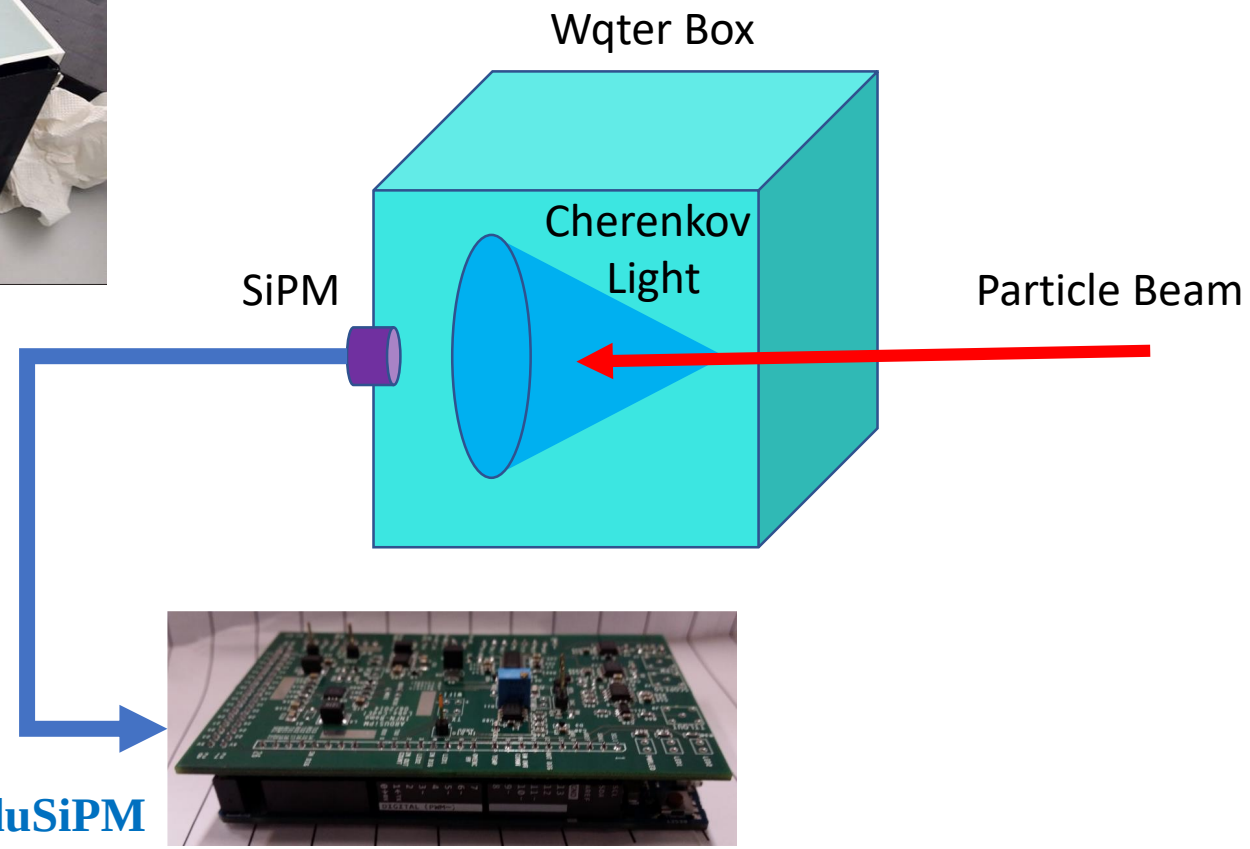
Valerio Bocci International Cosmic Day 2017

A School made Cherenkov light detector

(Winner of CERN “A beamline for schools”2017)

LICEO SCIENTIFICO STATALE T. C. ONESTI (prof Maria Rita Felici)

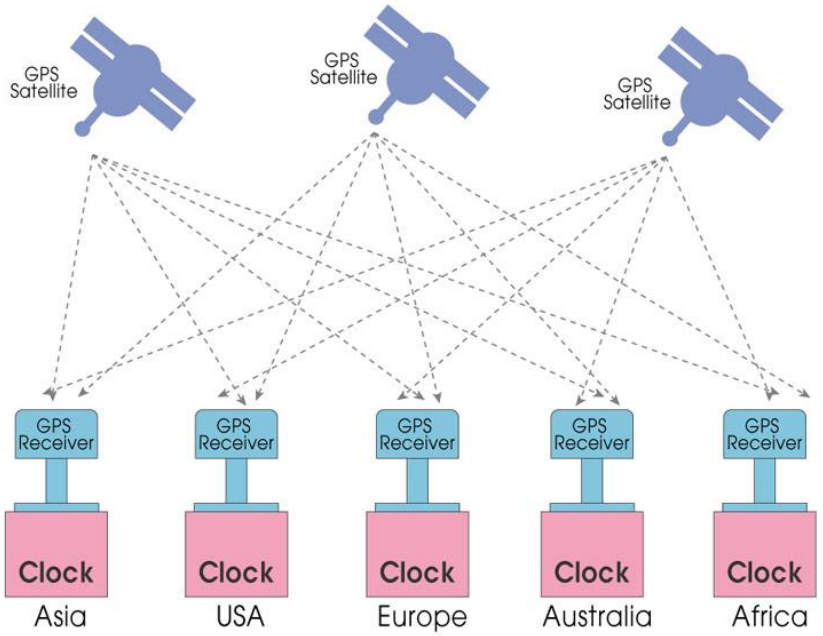


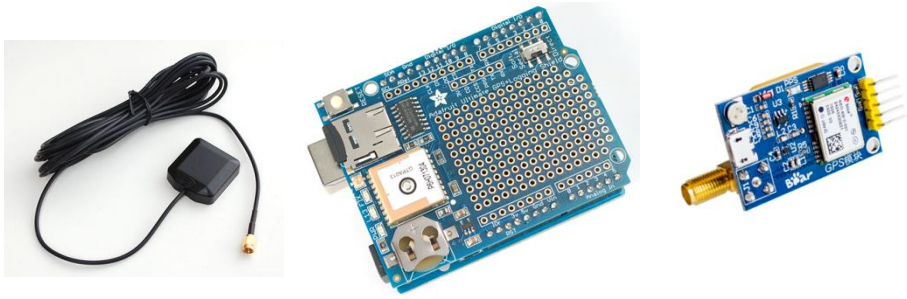


Valerio Bocci International Cosmic Day 2017

Precise time distribution methods

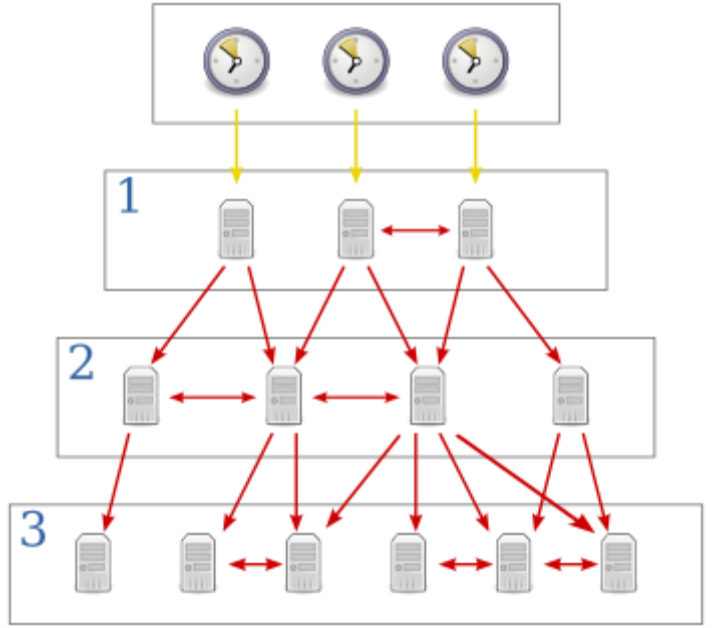
GPS time (from Global Position Systems satellite)





Low cost GPS module (<30 Euro) 25 ns precision

Network Time Protocol (from internet)

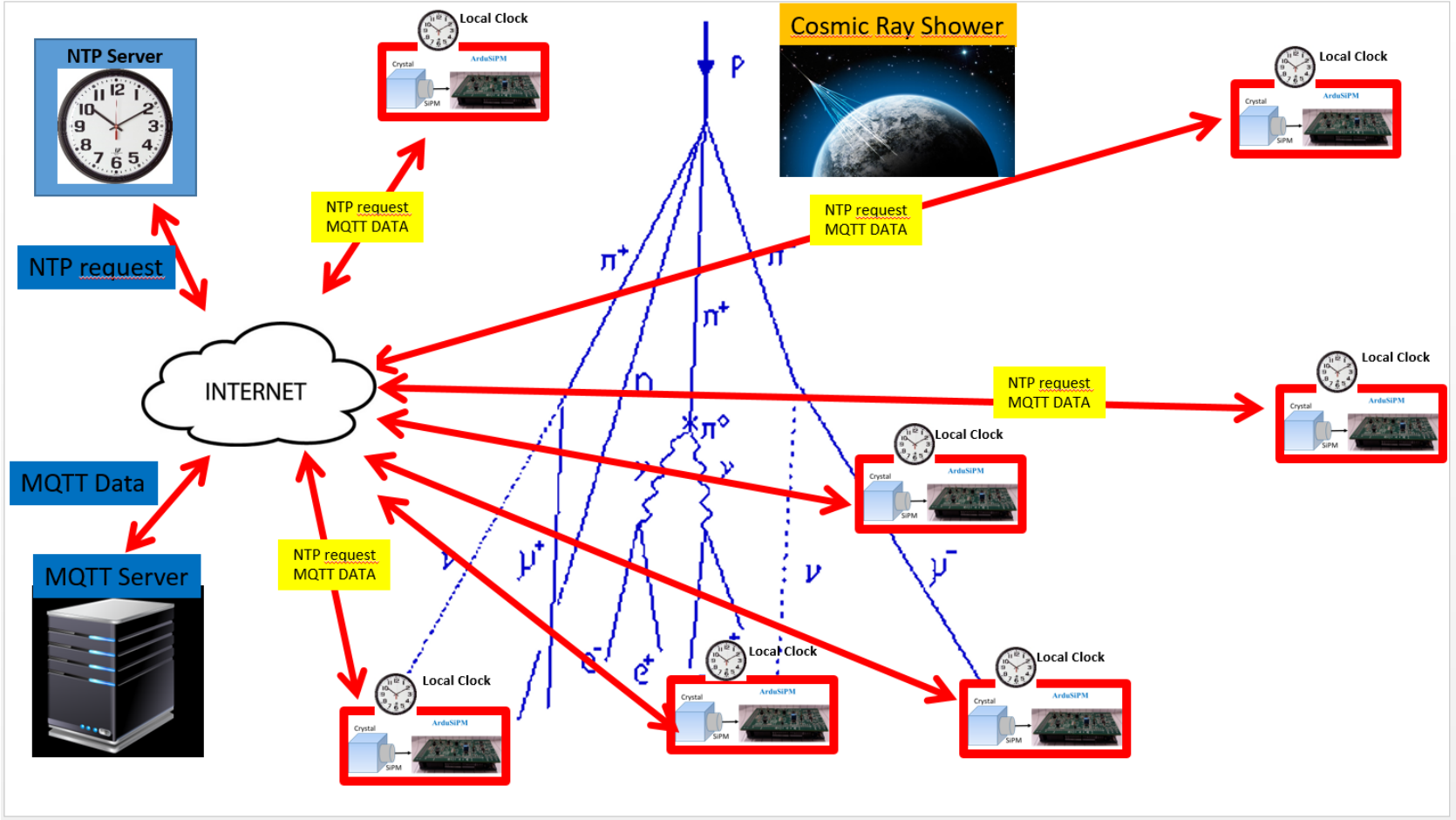


Low cost wi-fi internet processor precision <10 ms

Search of cosmic Airshower in a wide area using ArduSiPM

Multiple ArduSiPM can be used for the research extended AirShower

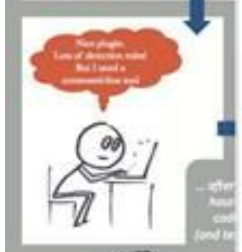
The advent of microcontrollers with enough CPU power and with analog and digital peripherals give the possibility to design a complete acquisition system in one chip. The existence of an world wide data infrastructure as internet allows to think at distributed network of detectors capable to elaborate and send data or respond to settings commands.
The internet infrastructure allow us to do things unthinkable a few years ago, like to distribute the absolute time with tens of milliseconds precision to simple devices far apart from a few meters to thousands of kilometers and to create a Crowdsourcing experiment platform using simple detectors.



Web Application Detection (WAD)

for asset inventory and vulnerability management

Sebastian Łopieński / CERN Computer Security Team



An educational distributed Cosmic Ray detector network based on ArduSiPM using microcontrollers as data acquisition node NTP protocol as time distribution and IoT technology for data aggregation.

Valerio Bocci , Giacomo Chiodi, Paolo Fresch, Francesco Iacoangeli, Luigi Recchia

INFN Roma, Piazzale A.Moro, 2 - 00185 Roma
valerio.bocci@roma1.infn.it

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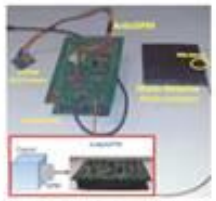

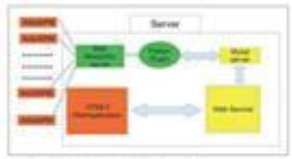

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ESP8266 MQTT, NTP and WiFi processor

The ArduSiPM sends data over rs232, the WiFi Processor elaborate the data and send them using the MQTT protocol to the server. We use as network processor the Espressif ESP8266 a low-cost Wi-Fi chip with full TCP/IP stack and a 32-bit RISC CPU running at 80 MHz. The ESP8266 can be used to send and configure MQTT packets,NTP request and configure ArduSiPM device.

Using Network Time Protocol (NTP) the absolute time from the network, with a precision of tens milliseconds. The network time can be used from a cloud of ArduSiPMs to detect offline coincidence events linked to Ultra High Energy Cosmic Ray

ArduSiPM web configuration pages.

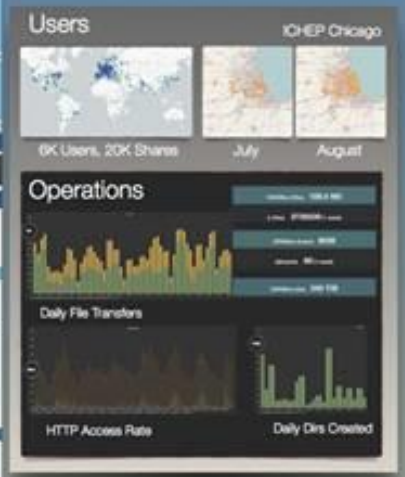
CERN Document Server

Towards the Next Generation CERN Institutional Repo

nt Services

h (CERN, IT-CDA)

ff, visitors, conference participants, anyone!
worked print devices in 230 buildings
a robust and **user-focused service**



[as] illuminazioni

Rivelatori fai da te.

Assemblare a scuola o a casa un vero rivelatore di particelle con tanto di sistema di acquisizione, come quelli funzionanti in questi giorni al Cern di Ginevra, può diventare un gioco da ragazzi.
Questo grazie alla scheda *Arduino Shield "Arduisipm"*, sviluppata per esigenze sperimentali reali nella sezione di Roma dell'Infn, e al suo software. Con materiali reperibili in rete è possibile costruire un rivelatore di particelle con annessa elettronica e sistema di acquisizione dati, che nulla ha da invidiare ai suoi fratelli maggiori funzionanti in Lhc (vd. in Asimmetrie n. 8 p. 24, ndr).
Il progetto proposto può essere realizzato usando un Arduino Due (https://www.arduino.cc/), una piattaforma elettronica *open-source* pensata per chiunque voglia sviluppare progetti interattivi. Sono necessari soltanto altri tre componenti: un Arduisipm, un *fotomoltiplicatore* e uno *scintillatore*. I dati raccolti da uno o più rivelatori potranno essere condivisi tramite wi-fi su una piattaforma social visibile su internet o visualizzati da uno smartphone, un tablet o un Pc. Vediamo in dettaglio di che cosa si tratta.
Uno dei compiti principali dei rivelatori di particelle è registrare il passaggio di particelle, come elettroni, muoni, fotoni ecc. Tra i sistemi di rivelazione possibili è stato scelto quello che utilizza la proprietà di alcuni materiali di *scintillare*, ossia di emettere deboli quantità di luce quando vengono attraversati dalle particelle. La luce emessa viene convertita in segnale elettrico tramite un fotomoltiplicatore. I fotomoltiplicatori, ancora in uso, sono oggetti costosi costituiti da un tubo di vetro fragile e ingombrante e che per funzionare hanno bisogno di tensioni di qualche migliaio di Volt. Grazie all'evoluzione tecnologica alla fine degli anni '90 sono stati sviluppati dei fotomoltiplicatori a stato solido, chiamati Sipm (Silicon Photo Multiplier), molto più piccoli dei loro progenitori (appena qualche millimetro), che funzionano con tensioni di poche decine di Volt e che costano qualche decina di euro (a confronto delle migliaia di euro di quelli tradizionali).
L'esperimento che vi proponiamo è di accoppiare un Sipm a uno scintillatore, e "osservare" la luce prodotta al passaggio dei raggi cosmici, particelle cariche – principalmente muoni – che raggiungono continuamente la Terra. Niente vieta, utilizzando scintillatori opportuni, di rivelare altre particelle come fotoni gamma o neutroni prodotti dalla radioattività ambientale o artificiale, trasformando il sistema in un rivelatore di radiazioni nucleari.
In sintesi, il sistema sopra descritto consente di avere uno strumento compatto, non fragile, con bassi consumi e che non necessita di un computer sempre acceso per funzionare. La struttura proposta replica in piccola scala tutte le componenti degli "esperimenti veri". [Valerio Bocci]

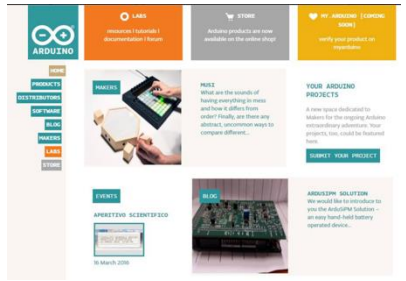
Le istruzioni per l'acquisto dei materiali e il montaggio del rivelatore di particelle possono essere consultate su www.asimmetrie.it/index.php/as-illuminazioni-rivelatori-fai-da-te.

Elettronica Open Source

I maker INFN a Bruxelles per #Makerstown

Anche l'INFN è in questi giorni allo Square Meeting Centre di Bruxelles, per la #Makerstown, un'occasione di confronto tra i protagonisti della tradizione manifatturiera europea, promossa dalla Commissione Europea e da Maker Faire...

HOME.INFN.IT



Il Festival renderà visibili i raggi cosmici

L'ESPERIMENTO

Riuscire a scorgere l'invisibile si può? Sì, specie quando c'è di mezzo l'arte, in questo caso TolfArte, il festival internazionale dell'arte di strada, che venerdì alle 21 nella sala di Palazzo Buttaoni inaugura "WunderKammer, raggi cosmici a TolfArte", speciale allestimento curato da due eccellenze locali conosciute in tutto il mondo, il fisico dell'Istituto nazionale di fisica nucleare Valerio Bocci e la professoressa e pittrice Eugenia Serafini. Una "camera delle meraviglie" nella quale, con il potere ipnotico dell'arte, i fruitori potranno vedere ciò che di solito rimane invisibile.
«I raggi cosmici primari provenienti dal profondo universo – spiega Bocci – colpiscono l'atmosfera creando un insieme di particelle energeticamente instabili. Compito dell'atmosfera è di assorbire una parte della radiazione. Molte particelle però, quelle più energetiche, arrivano sulla terra. La maggior parte di esse sono i muoni». Scopo della "WunderKammer" è proprio quello di mostrare questa pioggia di luce che circonda gli esseri umani, pur non essendone consapevoli. Come? «Installeremo due o tre rivelatori di particelle a scopo didattico – prosegue Bocci – sistemi denominati ArduSiPM, grandi come un pacchetto di sigarette ma capaci di ricevere, immagazzinare informazioni e trasformarle in luce. Combinando l'elemento artistico fornito dalla prof Eugenia Serafini, creeremo un ambiente affascinante e suggestivo».
«La Scienza spesso si avvale dell'arte della metafora per farsi comprendere – dice Serafini, che prima di essere professoressa di Storia dell'arte all'Accademia di Belle arti di Carrara e di Disegno all'Università della Calabria, ha insegnato Lettere alla scuola media di Tolfa –. Vedere l'invisibile non è sempre possibile, ma con l'aiuto dell'arte si può dare una rappresentazione della realtà scientifica. Di questo, tanto Bocci che io siamo sempre stati convinti». Nato dalla collaborazione di due menti votate alla ricerca, "WunderKammer, raggi cosmici a TolfArte" si preannuncia come un'istallazione da non perdere. Una stanza nella quale si riverberanno i muoni provenienti dal profondo universo, "catturati" dai rivelatori di precisione dell'Infn, assieme alle immagini delle esplosioni solari e dei viaggi intergalattici raffigurati nei dipinti realizzati negli anni dall'artista di Tolfa.

Vincenzo Sorì

A PALAZZO BUTTAONI IL PROFESSOR BOCCI E LA PITTRICE SERAFINI ALLESTIRANNO UN'ATTRAENTE "CAMERA DELLE MERAVIGLIE"

UNIVERSO A Palazzo Buttaoni si vedranno le luci invisibili del cosmo

StartupItalia!

/eBlog Makers

I 110 migliori progetti della aker Faire Rome

call for makers della Maker Faire Rome è data alla grande, con centinaia di progetti posti da FabLab e makers. Ecco una selezi 110 migliori (secondo noi)

43. INFN – ArduSiPM

I fotomoltiplicatori al silicio SiPM sono rivelatori di luce piccoli e poco costosi. Un SiPM può essere accoppiato a un cristallo scintillante per costruire un piccolo rivelatore di radiazione. Un sistema di acquisizione dei SiPM, facilmente replicabile, chiamato ArduSiPM è stato costruito sulla piattaforma Arduino Due. Il dispositivo può operare a batterie e può essere connesso ad una rete di dispositivi dello stesso tipo tramite internet realizzando

betamarkt.nl

Hieronder een overzicht van deelnemers en projecten op de Bètamarkt 2017. Zelf meedoen? Geef je op via dit deelnameformulier of stuur een mailtje naar info@betamarkt.nl Overzicht van Deelnemers Op ...

BETAMARKT.NL

ArduSiPM Social Media

http://www.roma1.infn.it/conference/ArduSiPM/

https://www.facebook.com/groups/ardusipm/

@ardusipm

@ArduinoSiPM

https://groups.google.com/forum/#!forum/ardusipm

Attività più importanti

Attività di didattiche all'interno dell'INFN:

- Laboratorio didattico per insegnanti nell'ambito degli Incontri di Fisica IDF (LNF)
- Laboratorio didattico per studenti dell' INternational School on modern PhYsics and Research (LNF)

Riconoscimenti ed inviti

- Tra i 110 migliori progetti del Maker Faire 2015 (primo tra gli scientifici)
- Invito Makers Town di Bruxelles (tra I migliori 50 progetti Makers in europa) (2016)
- Invito al EU-Institutional Maker Faire at European Parliament (tra I migliori 10 progetti in europa) (2016)

Il progetto grazie all'idea di utilizzare il canale del trasferimento tecnologico (10 % Royalty INFN o sconto 15 % per acquisto INFN) ha diffuso il rivelatore a costo zero.

Diverse scuole hanno iniziato ad usarlo con risultati anche eccelsi :

- vincitori CERN Beam Line for school 2017 (Liceo Onesti Fermo (FM)),
- Articolo su rivista Associazione Insegnanti Fisica "La Fisica nella Scuola" (Liceo Scientifico Cariati (CS))
- Sperimentazione didattica (20 classi tra elementari e medie ,oltre 500 alunni) (Istituto Comprensivo Largo Cocconi Roma)

Le scuole di loro iniziativa e atonomamente hanno utilizzato ArduSiPM in eventi di divulgazione scientifica

- International Cosmic Ray (Liceo Scientifico Casiraghi (MI))
- A caccia di raggi cosmici sul grattacielo Pirelli (Liceo Scientifico Casiraghi Casiraghi (MI))
- Stand al Global Junior Challenge (Liceo Scientifico Manicini Avellino)
- Utrecht Science Festival. (Amadeus Lyceum di Utrecht)

Seminari in cui si è parlato di ArduSiPM:

- 3rd Hamamatsu Photonics "Technology Days 2016 (Prof. Massimo Caccia)

Quale futuro per ArduSiPM ?

- ArduSiPM è una novità nel panorama mondiale (2014), ma anche altri si stanno attrezzando con dispositivi simili.
  Esempi: Progetto MIT uscito su Symmetry magazine (2016) che ci onora citandoci ma che sempre pù assomiglia ad ArduSiPM ,
  Cosmic PI al CERN(2016) prodotto e regalato dal CERN in occasioni specifiche.

- Il mercato italiano è limitato per pensare a grandi produzioni che diminuirebbero sensibilmente il costo del Kit.

- Trovare altri laboratori esteri che lo utilizzino o partecipino a progetti di ricerca comuni per nuove versioni possibili (Contatti con SUPSI per una versione spazializzata).

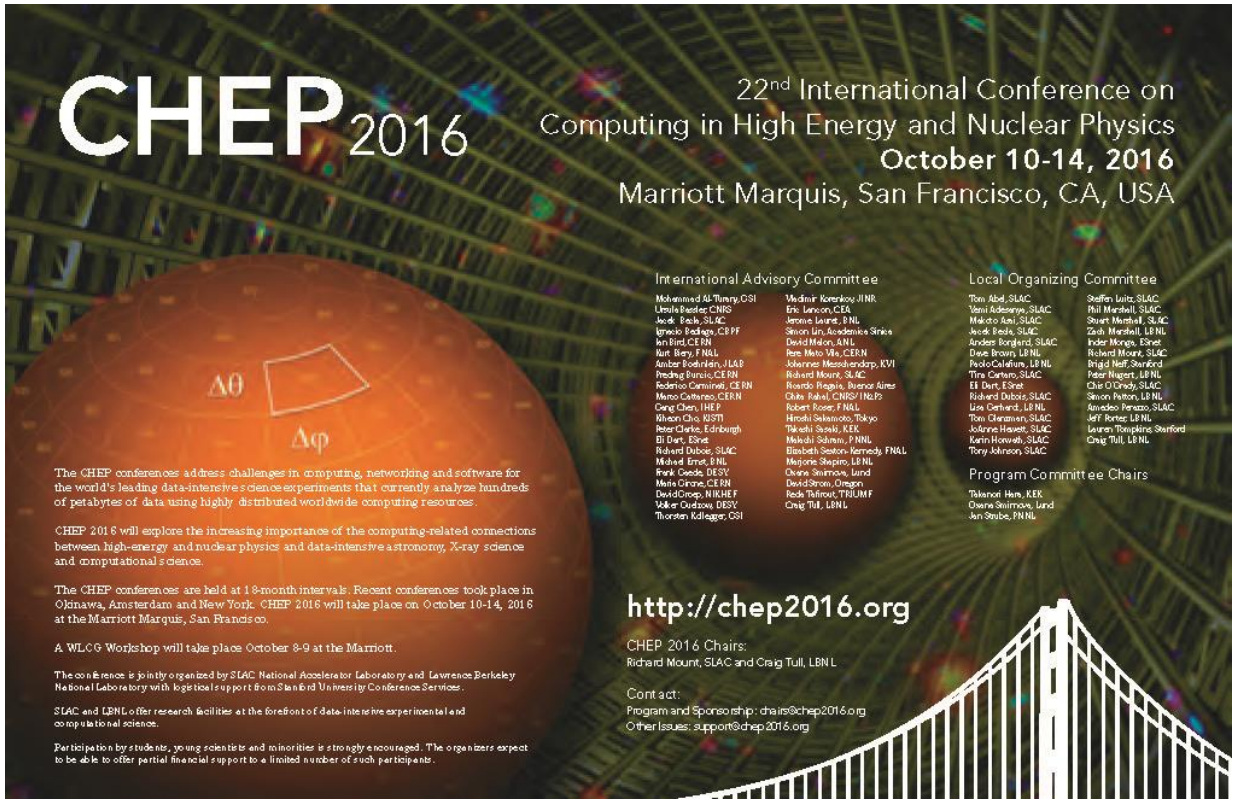
- Realizzazione di laboratori didattici in vari paesi (Ottimo anche per i paesi in via di sviluppo).

- Creazione di una rete di sedi INFN in grado di dare il supporto tecnico /scientifico ma anche di pensare nuovi esperimenti ed applicazioni (contatti con INFN Pavia, Roma 2, Lecce, Milano, LNF, Roma 3, Milano Bicocca).

- Consolidare o trovare nuovi patner industriali disposti non solo a produrre ma anche ad investire e rischiare risorse su scala globale.

- Necessità di internazionalizzazione e divulgazione della sua esistenza
  (presentazione a conferenze scientifiche ma anche a conferenze internazionali di insegnanti)

Backup Slides



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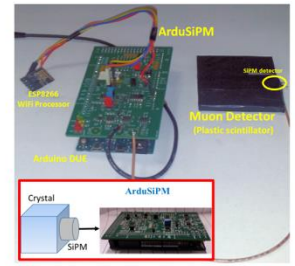

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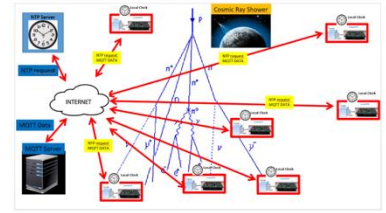
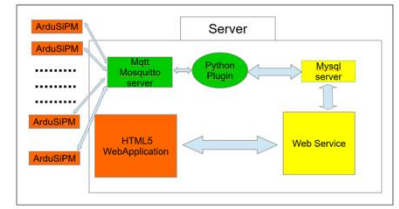
(1) **The ArduSiPM a compact trasportable Software/Hardware Data Acquisition system for SiPM detector V. Bocci et al. IEEE NSS/MIC 2014 Pages: 1 - 5, DOI: 10.1109/NSSMIC.2014.7431252 arXiv:1411.7814**



Using Network Time Protocol (NTP) the absolute time from the network, with a precision of tens milliseconds. The network time can be used from a cloud of ArduSiPMs to detect offline coincidence events linked to Ultra High Energy Cosmic Ray



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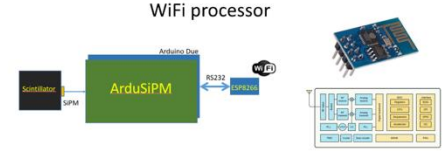
ESP8266 MQTT, NTP and WiFi processor



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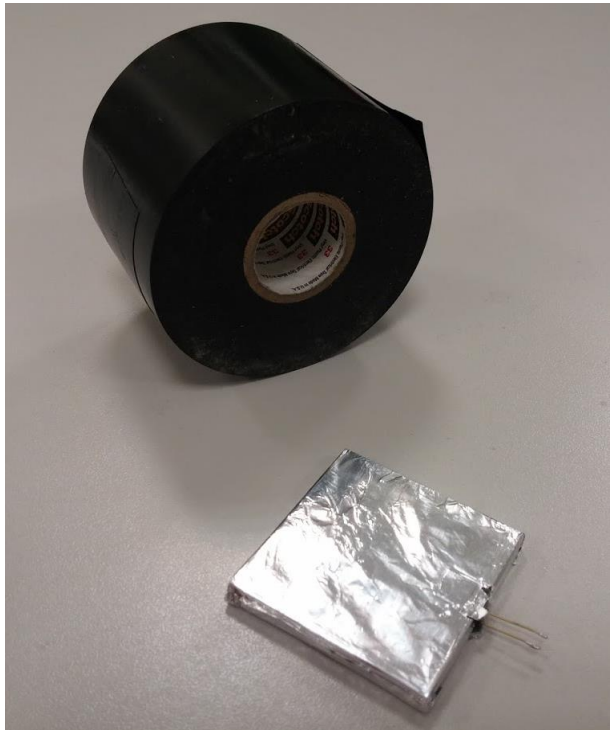
ArduSiPM web configuration pages.

The ArduSiPM in the World

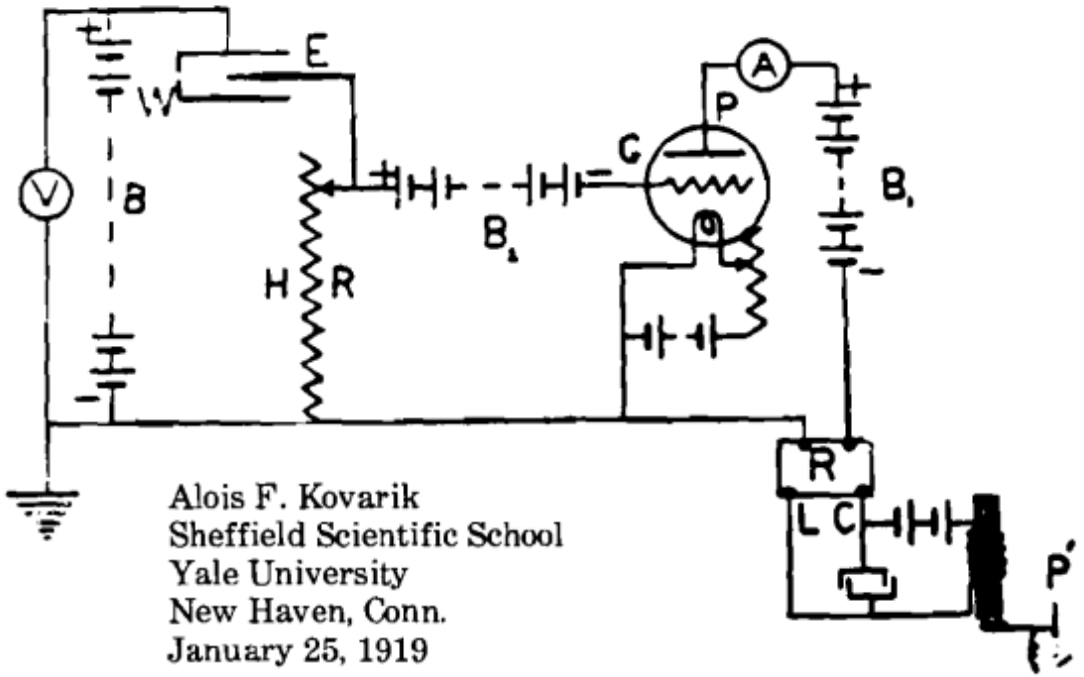
How to build a Scintillation detector with SiPM(2/2)



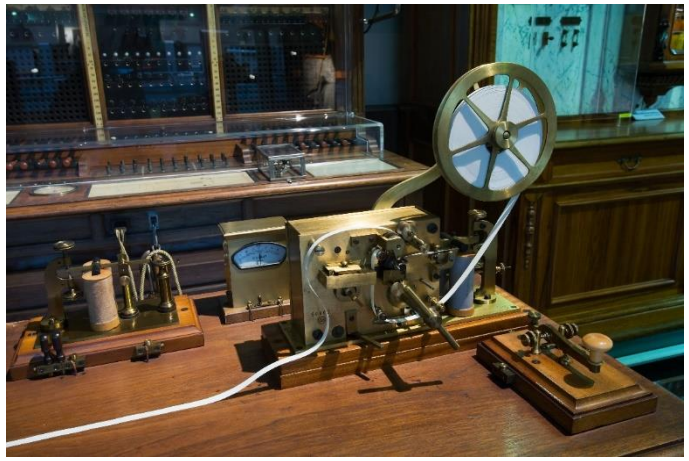
Using a black tape to avoid extenal ligth.

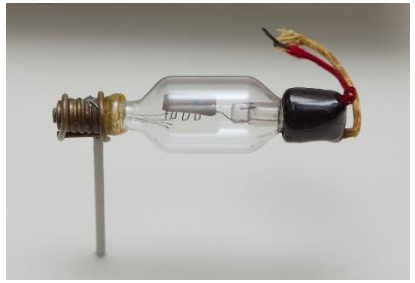
First Electronic particle detector 1919

ON THE AUTOMATIC REGISTRATION OF α-PARTICLES, β-PARTICLES AND γ-RAY AND X-RAY PULSES



Alois F. Kovarik
Sheffield Scientific School
Yale University
New Haven, Conn.
January 25, 1919

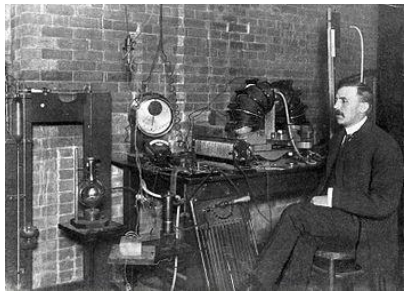




Lee De Forest Audion tube from 1908, the first triode. its ability to amplify was recognized around 1912.

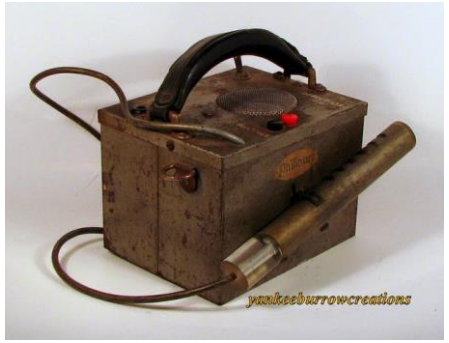
The Geiger-Muller: A ‘900 detector.

- Robust Technology 100 years old
- Economical
- Easy to find
- There are some Makers project
- The detector is preassembled from the factory

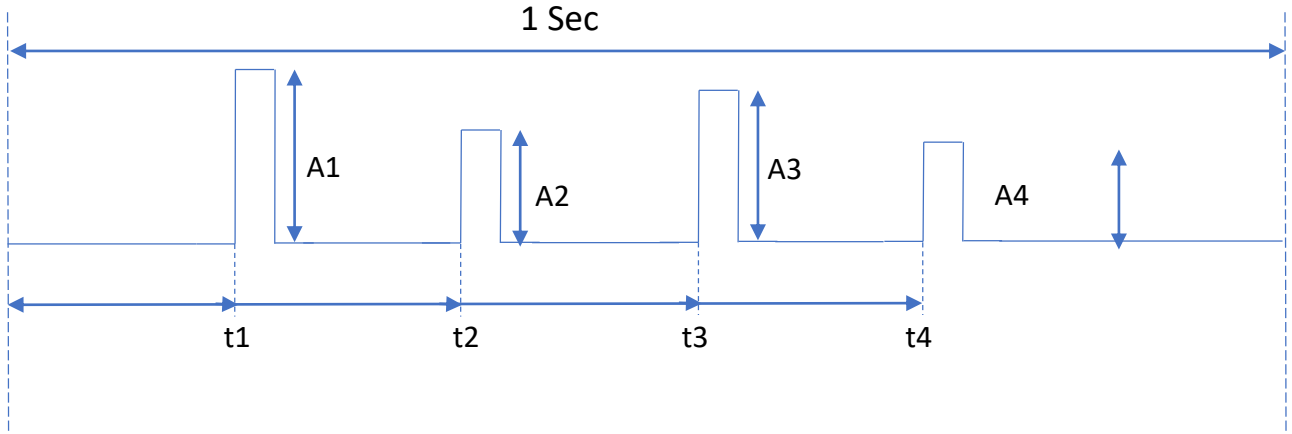


The discovery of atomic nuclei. Rutherford Hans Geiger and Ernest Marsden

- High voltage discharge (need robust electronics)
- Low efficiency.
- Yes or No detector
- Fragile.



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.

What time is it ?

International Atomic Time

From Wikipedia, the free encyclopedia

International Atomic Time (**TAI**, from the French name ***Temps Atomique International***[1]) is a high-precision atomic coordinate time standard based on the notional passage of proper time on Earth's geoid.[2] It is the basis for Coordinated Universal Time (UTC), which is used for civil timekeeping all over the Earth's surface, and for Terrestrial Time, which is used for astronomical calculations. As of 31 December 2016 when another leap second was added,[3] TAI is exactly 37 seconds ahead of UTC. The 37 seconds results from the initial difference of 10 seconds at the start of 1972, plus 27 leap seconds in UTC since 1972.

UTC (1958)=TAI Time

UTC(2017)=TAI+37 sec

Coordinated Universal Time

From Wikipedia, the free encyclopedia

Coordinated Universal Time (French: *Temps universel coordonné*), abbreviated to **UTC**, is the primary time standard by which the world regulates clocks and time. It is within about 1 second of mean solar time at 0° longitude;[1] it does not observe daylight saving time. It is one of several closely related successors to Greenwich Mean Time (GMT). For most purposes, UTC is considered interchangeable with GMT, but GMT is no longer precisely defined by the scientific community.

The first Coordinated Universal Time was informally adopted on 1 January 1960.[2]

The system was adjusted several times, including a brief period where time coordination radio signals broadcast both UTC and "Stepped Atomic Time (SAT)" until a new UTC was adopted in 1970 and implemented in 1972.[2] This change also adopted leap seconds to simplify future adjustments.

GPS=TAI+19 sec

Global Positioning System

From Wikipedia, the free encyclopedia

Universal Time (UTC), the atomic clocks on the satellites are set to GPS time (GPST; see the page of United States Naval Observatory). The difference is that GPS time is not corrected to match the rotation of the Earth, so it does not contain leap seconds or other corrections that are periodically added to UTC. GPS time was set to match UTC in 1980, but has since diverged. The lack of corrections means that GPS time remains at a constant offset with International Atomic Time (TAI) (TAI − GPS = 19 seconds). Periodic corrections are performed to the on-board clocks to keep them synchronized with ground clocks.[126]

The GPS navigation message includes the difference between GPS time and UTC. As of January 2017, GPS time is 18 seconds ahead of UTC because of the leap second added to UTC on December 31, 2016.[127] Receivers subtract this offset from GPS time to calculate UTC and specific timezone values. New GPS units may not show the correct UTC time until after receiving the UTC offset message. The GPS-UTC offset field can accommodate 255 leap seconds (eight bits).

UTC (1980)=GPS Time

Leap Second

Just a second

A leap second will be added on June 30, 2015, to allow the Earth's rotation to synchronise with atomic clocks.

Diagram not to scale

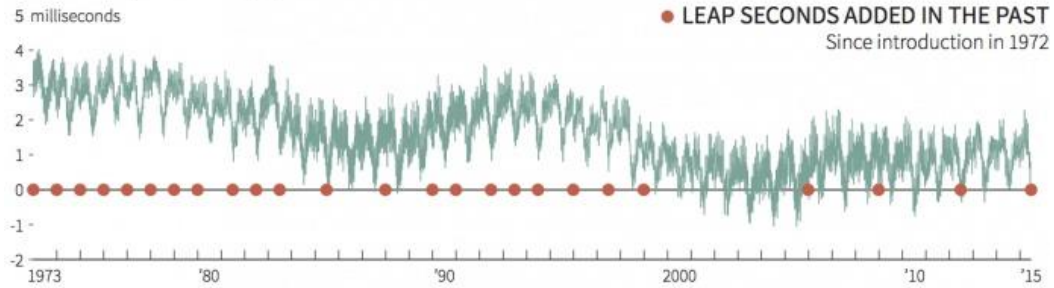
Official world time is kept using atomic clocks, which can be accurate to within one second every 300 million years

The gravity of the Sun and the Moon, the atmosphere or earthquakes can slow the Earth's rotation by milliseconds a day

Over time, the milliseconds add up, so a leap second is added to the world time to synchronise it with the Earth's rotation

VARIATIONS IN THE LENGTH OF A DAY

The speed of the Earth's rotation is not constant, which in turn affects the length of each day by a few milliseconds.

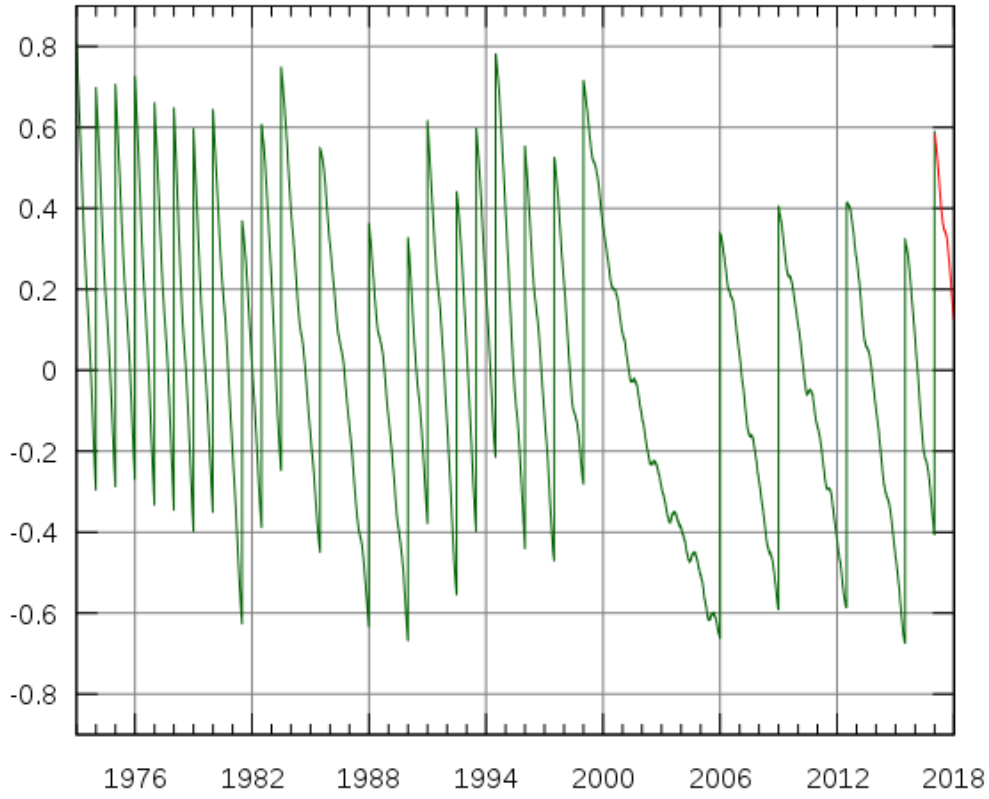


Sources: Space Geodesy Project, NASA; National Institute of Standards and Technology (NIST), U.S. Dept. of Commerce; International Earth Rotation and Reference Systems Service

1 millisecond = 0.001 second

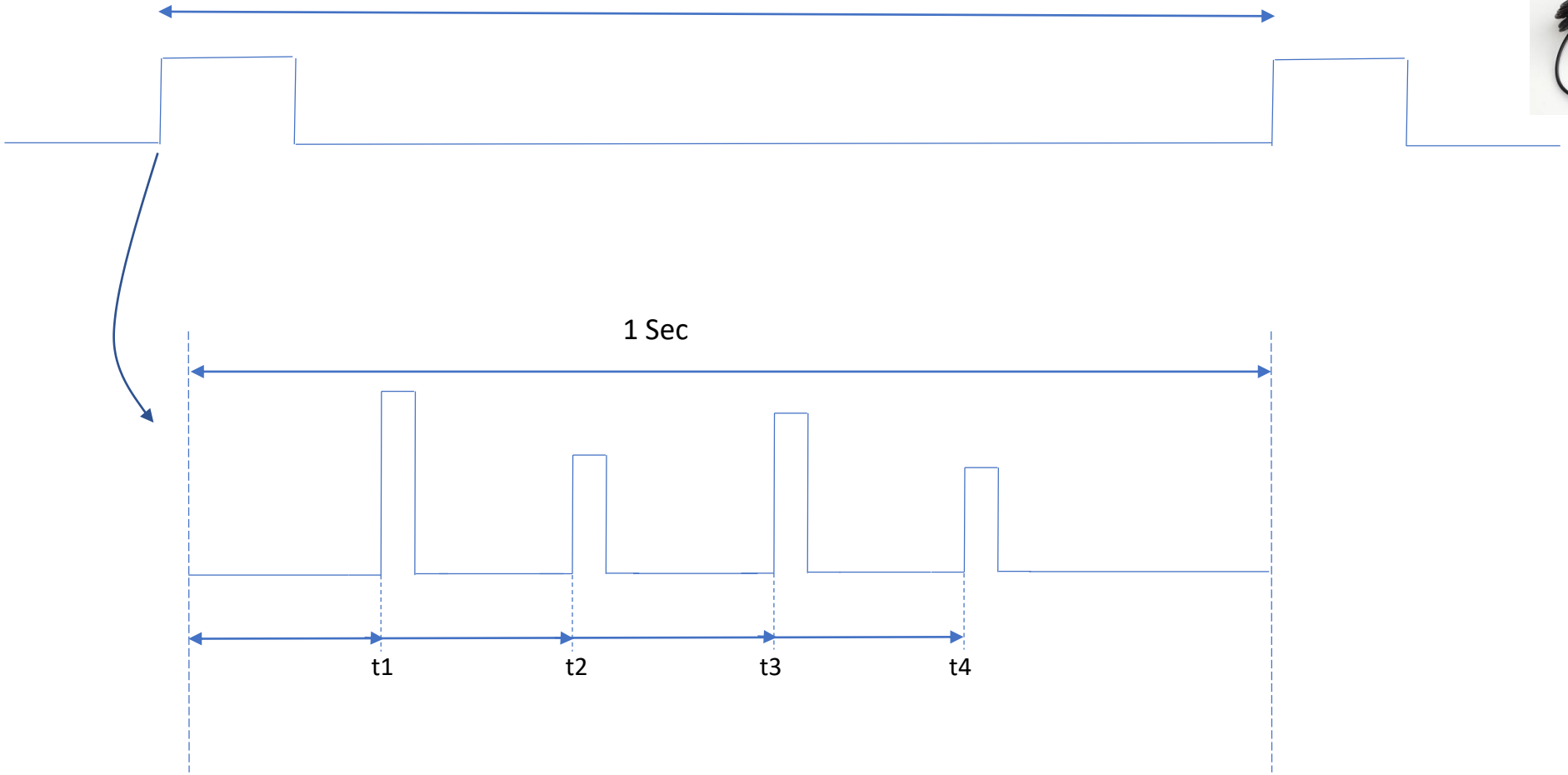
F. Chan, 30/06/2015

REUTERS



Graph showing the difference between UT1 and UTC. Vertical segments correspond to leap seconds.

Synchronization with ArduSiPM



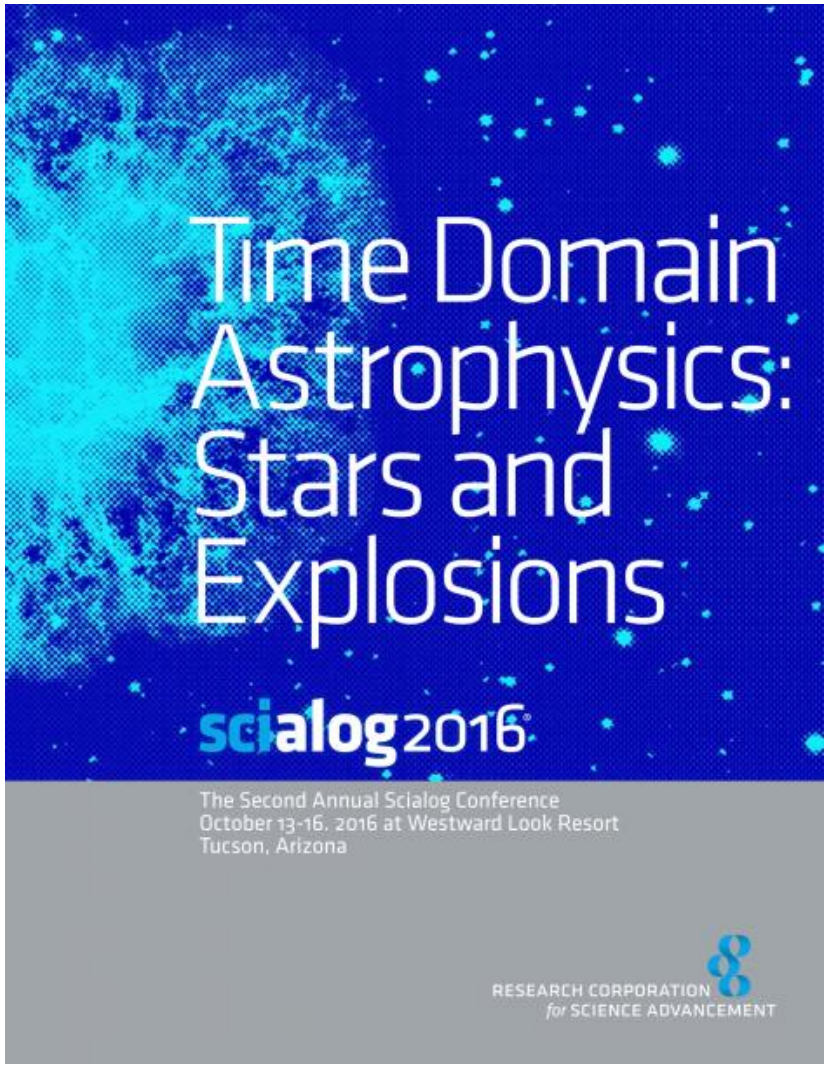
Dr. Valerio Bocci INFN Roma
Matinees di scienza 21 Apr 2017 LNF

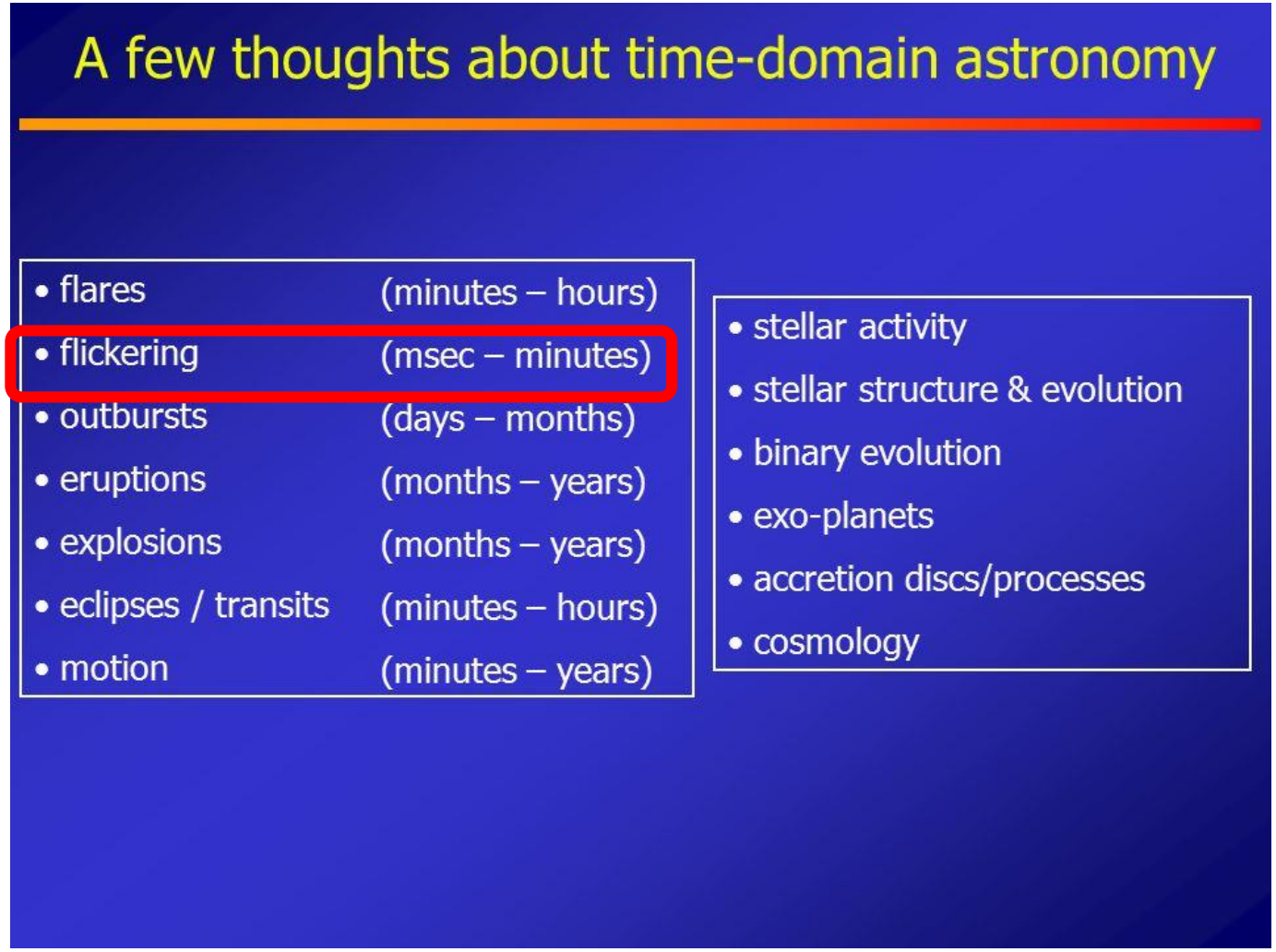
Nuove idee di utilizzo diArduSiPM

Pronti per raccogliere nuove idee e progetti…

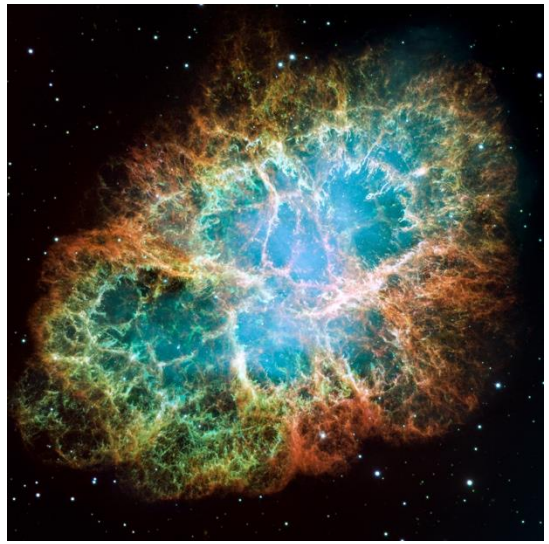
Is it possible to use ArduSIPM in Time domain Astrophysics ?

Photons counting capability with timing resolution in the order of hundreds of nanoseconds





Optical pulsar Real time photon detection



Fast astronomical photometers based on new technology detectors are presently used by a limited number of research groups: for instance the OPTIMA team of the Max Planck Institute (Kanbak 2003), the AQUEYE/IQUEYE team of the Padova University (Barbieri et al. 2009, Naletto et al. 2009), the S-Cam device (Oosterbroek et al. 2008), the Ultracam device (Dhillon 2008), the GASP device (Collins et al. 2008) .

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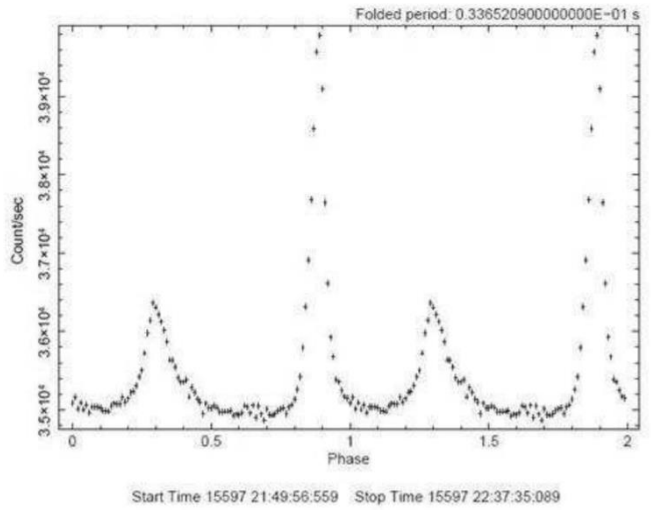
A New Fast Silicon Photomultiplier Photometer

F. Meddi, F. Ambrosino, C. Rossi, R. Nesci, S. Sclavi,
A. Ruggieri, S. Sestito, I. Bruni, R. Gualandi

Abstract

The Crab pulsar is one of the most intensively studied X-ray/optical objects, but up to now only a small number of research groups have based their photometers on SiPM technology. In early February 2011, the Crab pulsar signal was observed with our photometer prototype. With low-cost instrumentation, the results of the analysis are very significant: the processed data acquired on the Crab pulsar gave both a good light curve and a good power spectrum, in comparison with the data analysis results of other more expensive photometer instrumentation.

Keywords: Silicon PhotoMultiplier detector (SiPM), photometer, fast variability, Pulsar.



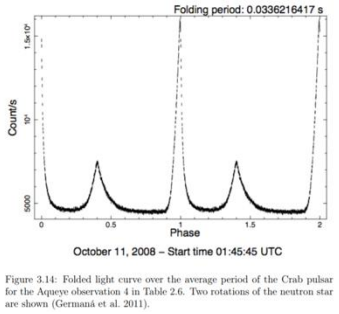
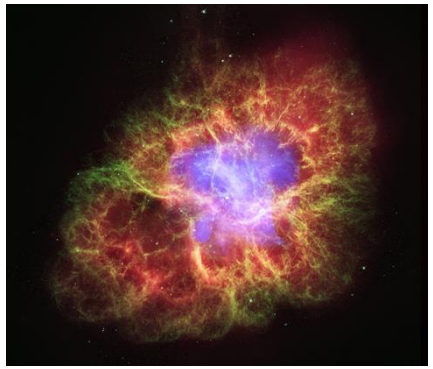


Figure 3.14: Folded light curve over the average period of the Crab pulsar for the Aqueye observation 4 in Table 2.6. Two rotations of the neutron star are shown (Germaná et al. 2011).

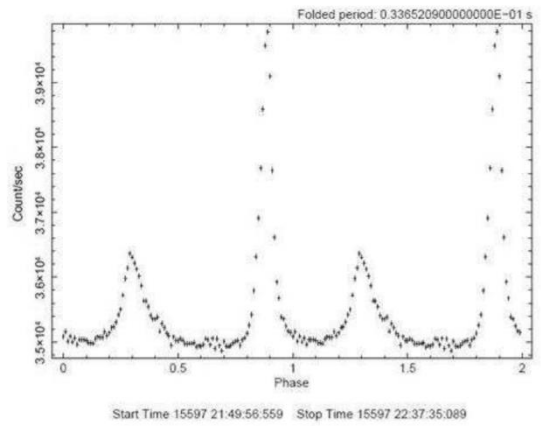
Valerio Bocci GAD 2017

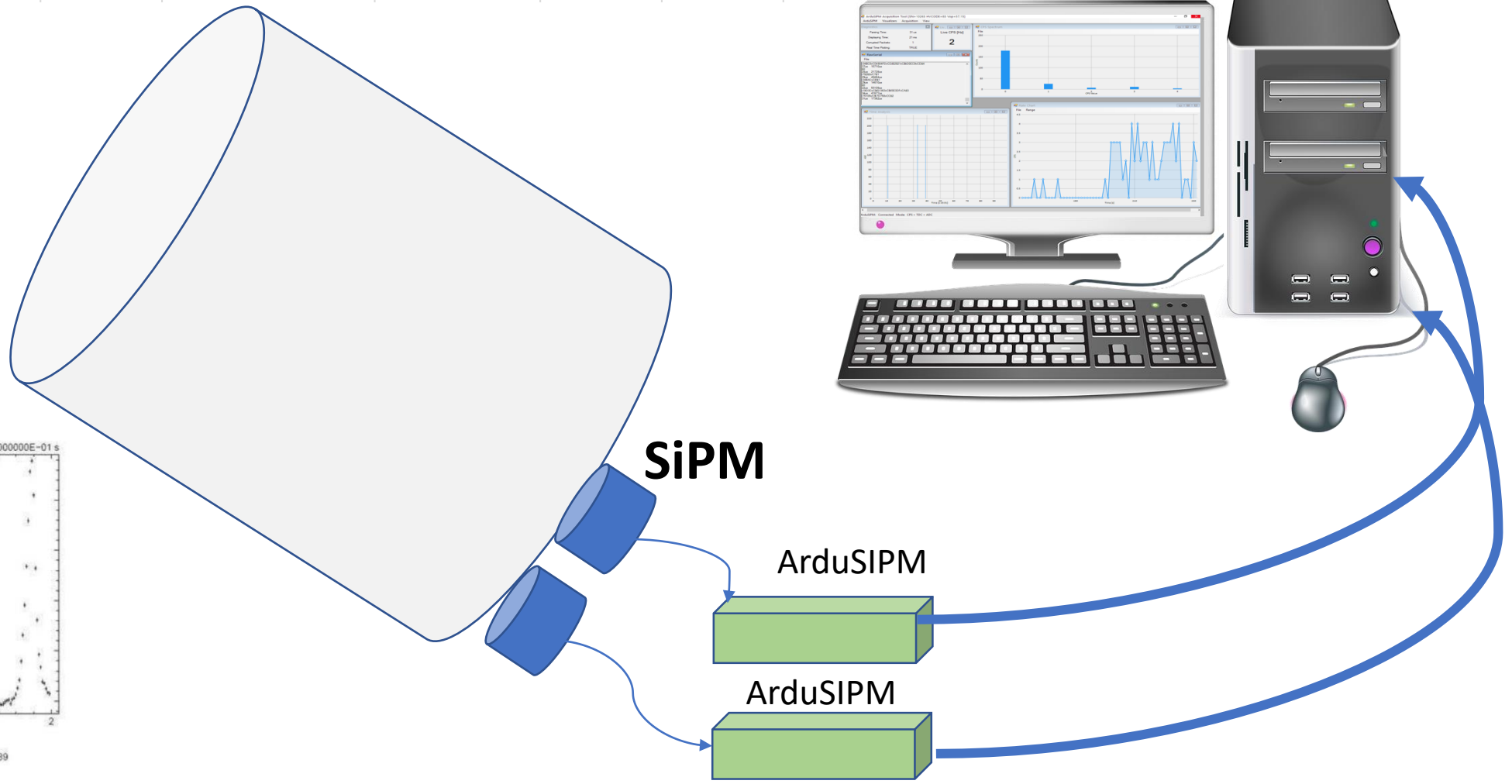
Raw design of ArduSiPM as fast photometer

Magnitudo	Telescope diameter cm	telescope Area cm2		
17	50	7853.981634		
	photons/cm2/s	Photons telescope/s	every us	every 5 ns
	1584.391685	12443783.2	12.4437832	0.06221891598



Optical Pulsar
Crab Pulsar
(CM Tauri, PSR B0531+21)
M17





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