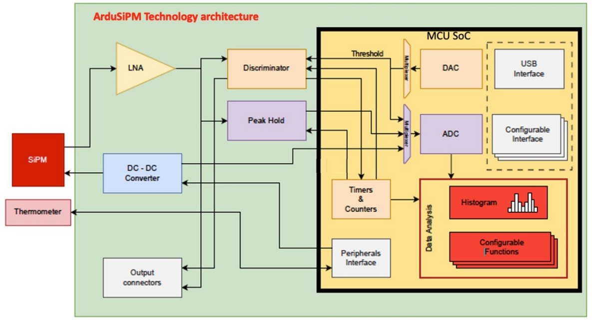
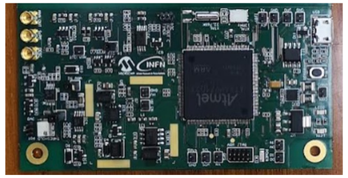


Tecnologia ArduSiPM
ALL-IN-ONE SiPM based detector

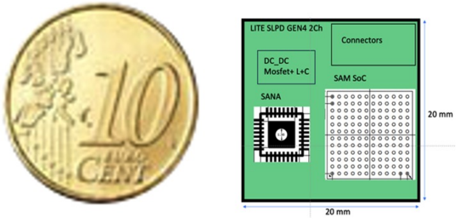
Introduzione alle Tecniche di Trigger e Data Acquisition in Esperimenti di Fisica

Napoli 9-12 Ottobre 2023

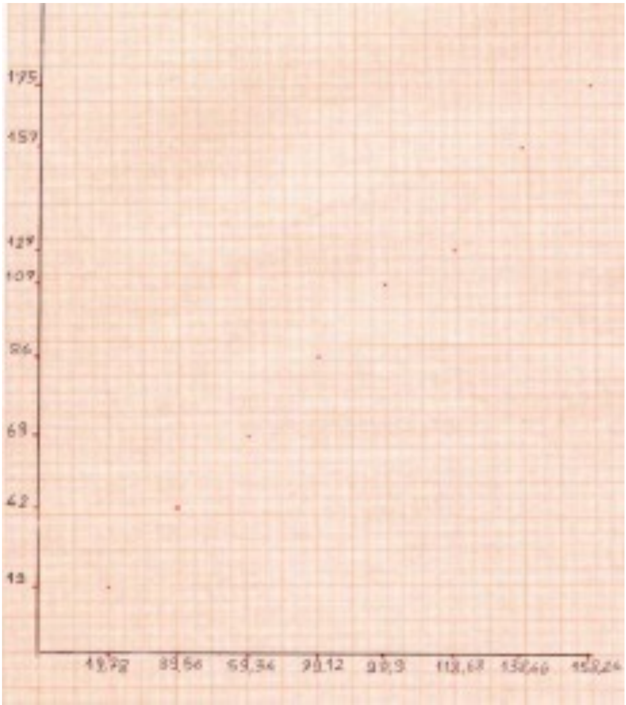
Valerio Bocci
INFN Roma
Valerio.bocci@roma1.infn.it



2 Ch. LITE-SPLD GEN4 Board (2026)

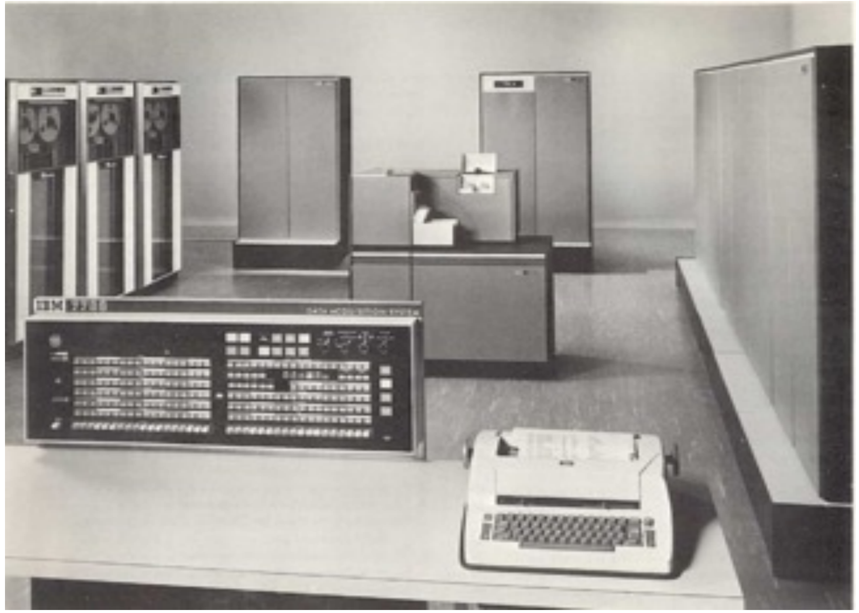


Measurement and data elaboration before 1963

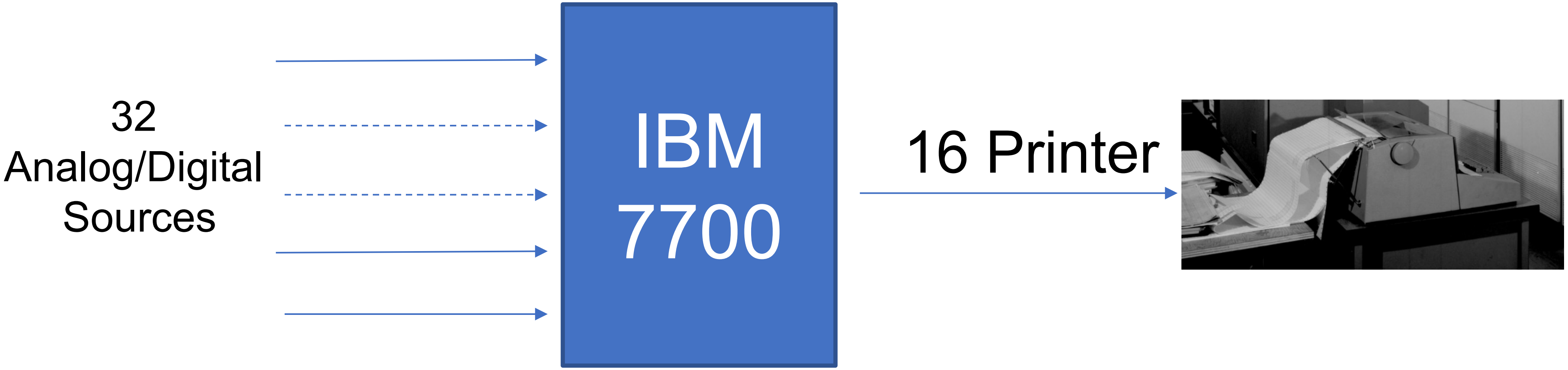


IBM 7700 Data acquistion System(DAS)

Dicember 1963



- The IBM 18-bit system,
- instructions 2x 18-bit words.
- Arithmetic instructions two or three machine cycles,
- Multiply, 8 cycles, and divide, 12 cycles.
- machine cycle 2 microseconds ½ MHz **(0.0005 GHz)**
- two machines known to have been built had 16,384, 32,768 or 49,152 words.
- 25 KHz ADC
- Two IBM 7700 are known to have existed: one at the University of Rochester[2][3] and the other at Stanford University.[4][5] Both were donated by IBM.



IBM 1800

Use [edit]

The IBM 1800 systems were used mainly in the process industry plants worldwide.[4]

In June 2010 the last four operating IBM 1800s operating at Pickering Nuclear Generating Station in Pickering, Ontario, Canada were removed from service. Pickering is still using four ES-1800 computers which are IBM 1800 hardware emulators built by Cable & Computer Technologies.[5] A video showing the end of the Pickering IBM 1800 boot sequence is available on YouTube [6]

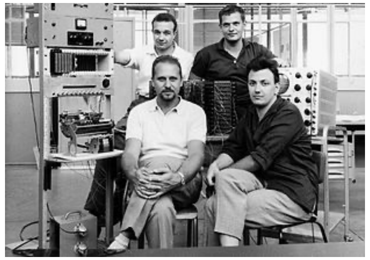
Until 1984, Exxon USA (EUSA) had 18 IBM 1800 systems deployed at all 5 of its refineries. They were replaced with Honeywell TDC3000 process control systems.

The **IBM 1800 Data Acquisition and Control System** (DACS) was a process control variant of the IBM 1130 with two extra instructions (CMP and DCM), extra I/O capabilities, 'selector channel like' cycle-stealing capability and three hardware index registers.[1]
IBM announced and introduced the 1800 Data Acquisition and Control System on November 30, 1964, describing it as "a computer that can monitor an assembly line, control a steel-making process or analyze the precise status of a missile during test firing."

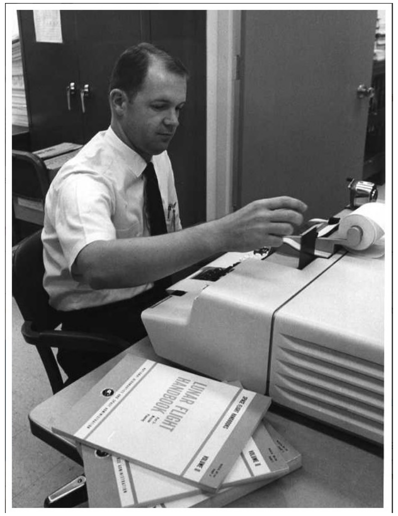
Typical 1800 systems designed for process control applications could be rented for $2,300 to $6,600 a month or purchased for between $95,000 and $274,000. When used in a data acquisition environment, the monthly rental ranged between $2,770 and $11,100, including magnetic tapes, and the purchase price varied between $125,000 and $534,000.

La programma 101 (P101) Olivetti Italia the first desktop computer (1965)

- 35 KG
- 120 instructions
- Memory card
- Memory 120 Byte



Pier Giorgio Perotto,
Giovanni De Sandre, Gastone Garziera



NASA bought at least 10 Programma 101s and used them for the calculations for the 1969 Apollo 11 moon landing.

SAN RAFAEL, CALIF.
INDEPENDENT JOURNAL
D. 36,000

OCT

COMPUTER ON DESK TOP

An operator inserts a program card into Olivetti Underwood's new desktop computer, the first such unit to be completely self-contained, in a New York City demonstration Thursday. (UPI Telephoto)

BUSINESS WEEK October 23, 1965
Fifty cents
A McGraw-Hill publication

'Desk-top' computer is typewriter size

Olivetti Underwood Corp. has developed a desk-top computer that's truly small enough to fit on top of a desk. About the size of an office typewriter, it is classified as a computer because it does such tasks as payroll computation and interest calculations by referring to an internally stored program. Called the Programma 101, it is priced at $3,200.

A payroll clerk would put a magnetic program card in the machine; as many as 120 instructions for such jobs are preprinted on each card. Then the clerk would keypunch in an employee's earnings, and the machine would print out programmed deductions for taxes, medical plans, and the like. End

BUSINESS WEEK October 23, 1965

November 11, 1965 • ENGINEERING NEWS-RECORD

Keyboard Computer Sits on Desk

The Olivetti Underwood Corp. has introduced a desktop computer that the company says will bridge the gap between desk calculators and full scale computers.

It is a keyboard-operated machine that prints input data, instructions and answers at the rate of 30 characters per second. Programs involving up to 120 instructions may be entered manually through the keyboard, or, if it is a program that is used repeatedly, it may be fed to the machine automatically from a coded magnetic card.

Once programmed, the machine will solve a problem when the variables are entered on the keyboard; no operation instructions are needed, the machine follows the program, printing out the answers automatically.

The machine can solve differential equations, bessel functions and perform numerical integration. Spokesmen for Olivetti Underwood say the machine's program language is extremely simple and can be learned by anyone familiar with mathematical calculations in a very short time.

COMPUTER can take 120 instructions.

In addition, the company is developing and will maintain a library of standard programs in most fields of mathematics, including engineering.

The machine can be bought outright for $3,200 or leased on a monthly basis. OLIVETTI UNDERWOOD CORP., 581 CAPITOL AVE., HARTFORD, CONN.

New York Journal American
NEW YORK'S LARGEST EVENING NEWSPAPER
MONDAY, OCTOBER 25, 1965 21

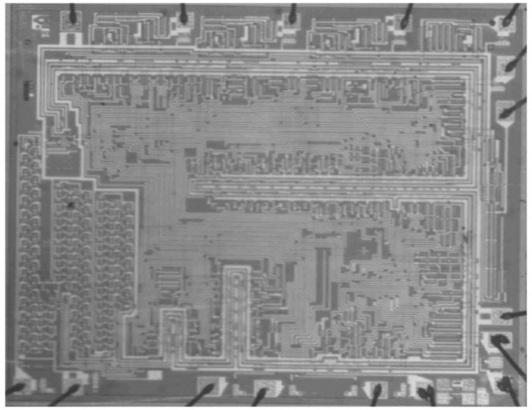
A DESK TOP COMPUTER

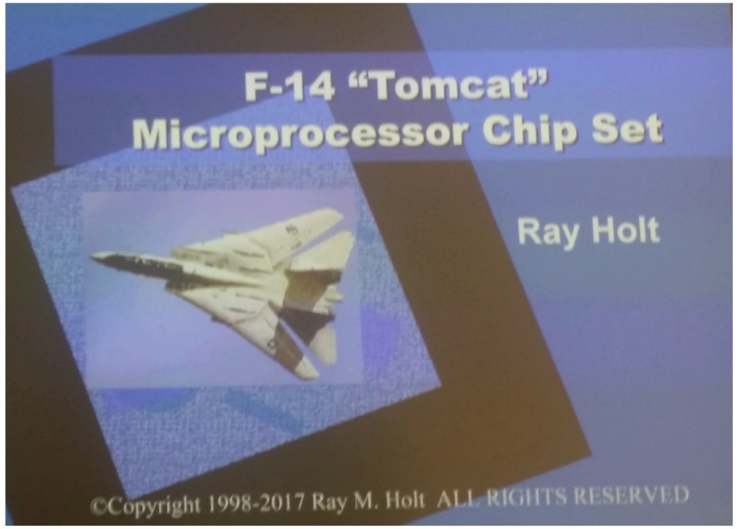
We may see a computer in every office even before there are two cars in every garage.

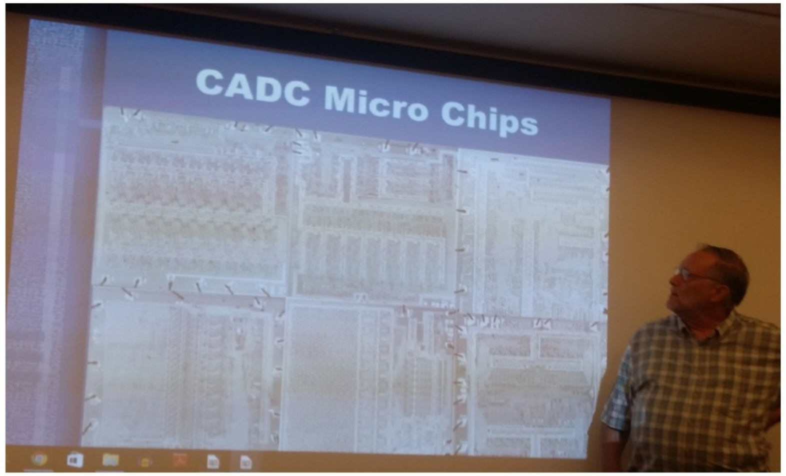
This outlook for business machines drew near reality this week when Olivetti Underwood unveiled PROGRAMMA 101 — a desktop computer which businesses can use and own outright.

A manager can now have his secretary pro-rate the expenses of all departments in a company with instant speed at her own desk. Other fundamental business applications like amortization, mortgage, and payroll are also easily computed on PROGRAMMA 101.

The real first microprocessor ? F14 Tomcat Microprocessor Chip set







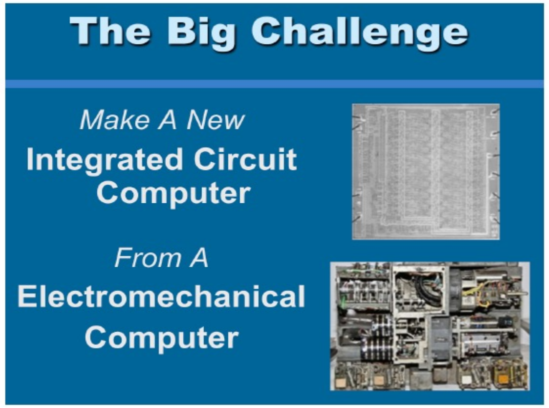
INTRODUCTION

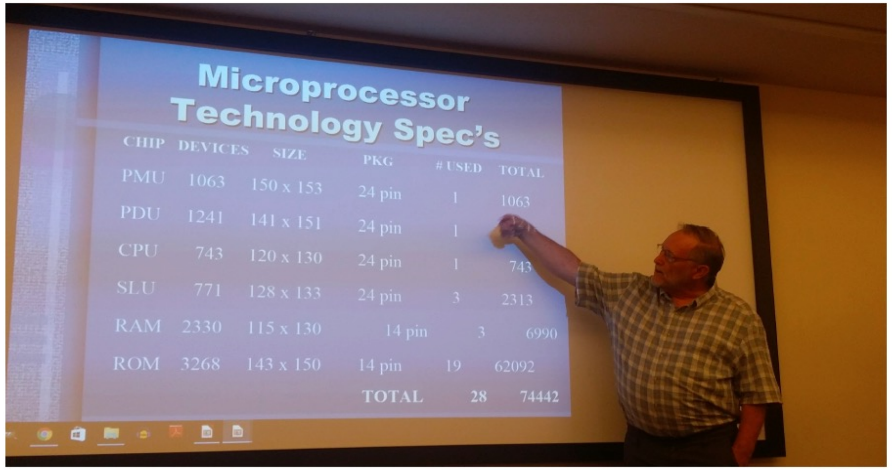
This paper describes the architecture of the CPU and Memory for the Central Air Data Computer (CADC) System used in the Grumman/Navy F14A carrier-based fighter aircraft. The CADC performs specialized computational functions in response to input stimuli such as pressure sensors, temperature sensors and closed loop feedback inputs. Outputs from the CADC system are used to drive pilot visual displays (such as, altimeter, temperature indicator, mach number indicator, etc.) and to provide control inputs for other aircraft systems. The outputs from the CADC are in the form of digital and analog signals. Figure 1 illustrates a block diagram for the CADC.

Being in a flight environment meant that certain constraints must greatly reflect the architecture of the CPU and Memory. These constraints were size, power, real-time computing capability and cost, not necessarily in that order. Other constraints such as temperature, acceleration and mechanical shock affected the overall design of the CADC.

The size of the CPU-Memory was limited to a maximum of 40 square inches. This included the arithmetic section, read-only memory, and read/write memory. Since the unit was to be packaged on a printed circuit card the number of layers of the p.c. card was an important consideration. The power consumption had a limit of 10 watts at ambient 25°C. This was principally a function of the capabilities of the p.c. card to withstand the heat.

The required computing capacity for the CPU was not defined at the beginning. This meant that the system had to be somewhat flexible to changes in computational load. Of course limits had to be set to be able to work within the other constraints. What was known about the computation was the form of the equations to be implemented. This included polynominal evaluations, data limit-





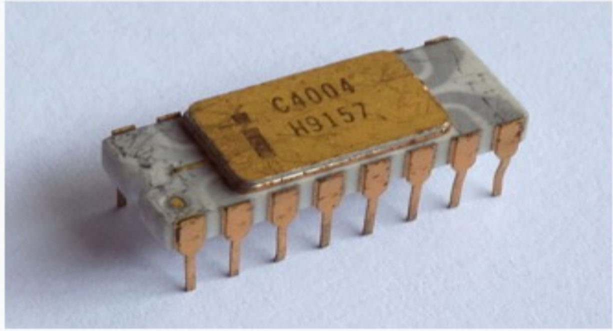
In 1968, Garrett AiResearch (who employed designers Ray Holt and Steve Geller) was invited to produce a digital computer to compete with electromechanical systems then under development for the main flight control computer in the US Navy's new F-14 Tomcat fighter. The design was complete by 1970, and used a MOS-based chipset as the core CPU. The design was significantly (approximately 20 times) smaller and much more reliable than the mechanical systems it competed against, and was used in all of the early Tomcat models. This system contained "a 20-bit, pipelined, parallel multi-microprocessor". The Navy refused to allow publication of the design until 1997. For this reason the CADC, and the MP944 chipset it used, are fairly unknown.Ray Holt's autobiographical story of this design and development is presented in the book: The Accidental Engineer.[15][16]

The birth of microprocessors 1971

Federico Faggin (1972)

The 4004 was built for the Busicom 141-PF Desk Calculator

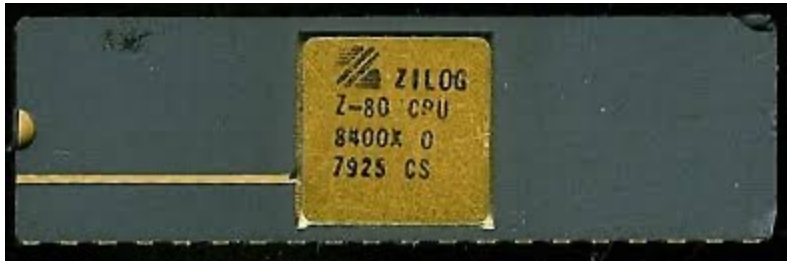
Intel 4004



Intel C4004 microprocessor

Produced	From late 1971 to 1981
Common manufacturer(s)	Intel
Max. CPU clock rate	740 kHz
Min. feature size	10 µm
Instruction set	4-bit BCD-oriented
Transistors	2300 [1]
Data width	4
Address width	12 (multiplexed)
Successor	Intel 4040 Intel 8008
Application	Busicom calculator, arithmetic manipulation
Package(s)	16-pin DIP

Federico Faggin started Zilog in 1974 .



Zilog Z80 1974

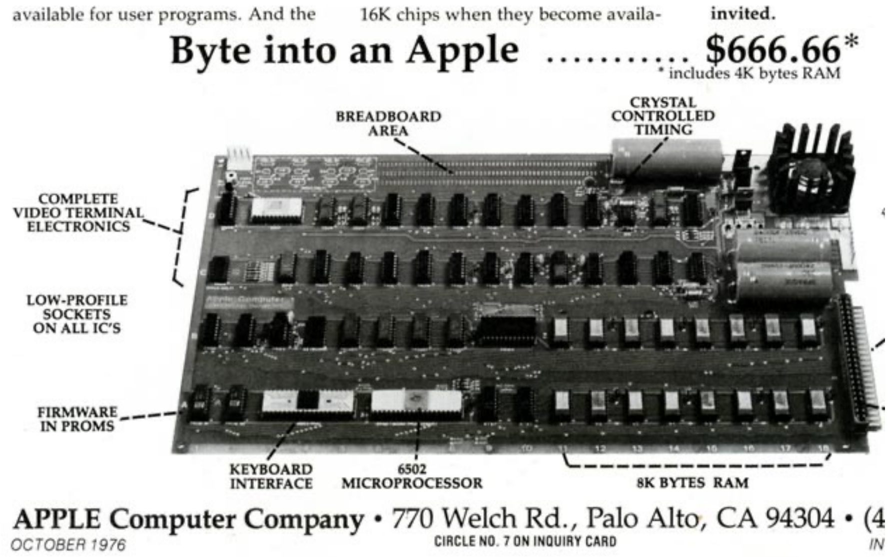
Think of your next microcomputer as a weapon against horrendous inefficiencies, outrageous costs and antiquated speeds. We invite you to peruse this chart.

Features:	8080A	Z80-CPU	Features:	8080A	Z80-CPU
Power Supplies	+5,−5,+12	+5	Instructions	78	158*
Clock	2Φ,+12 Volt	1Φ,5 Volt	OP Codes	244	696
Standard Clock Speed	500 ns	400 ns	Addressing Modes	7	11
Interface	Requires 8222,8228 & 8224	Requires no other logic and includes dynamic RAM Refresh	Working Registers	8	17
			Throughput	Up to 5 times greater than the 8080A	
Interrupt	1 mode	3 modes; up to 6X faster	Program Memory Space	Generally 50% less than the 8080A	
Non-maskable Interrupt	No	Yes	*Including all of the 8080A's instructions.		

Microprocessor as building block of modern computer
1975 Homebrew Computer Club

Steve Jobs and Steve Wozniak

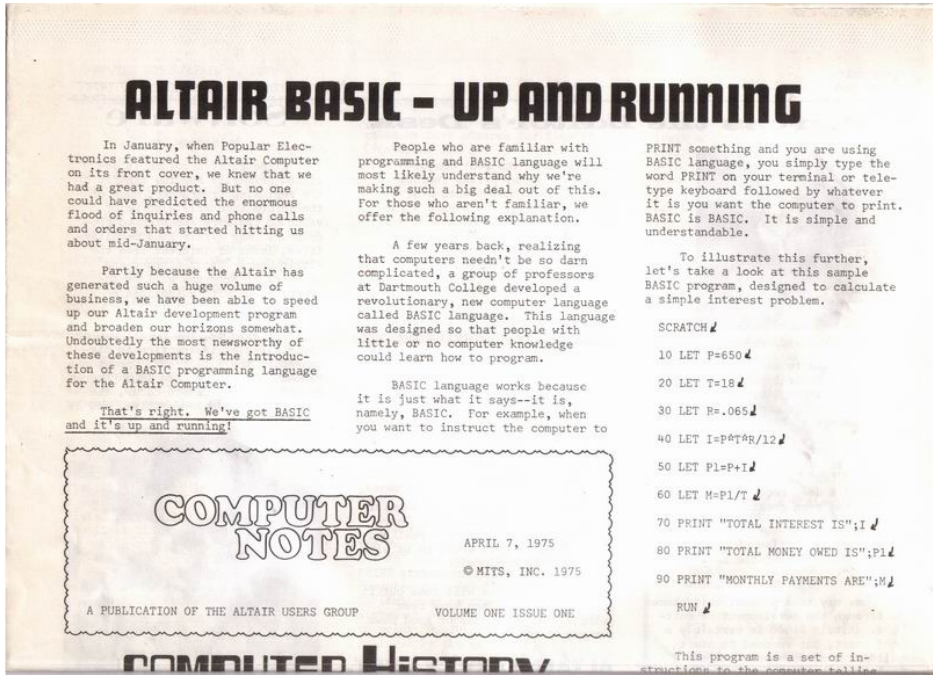
Hombrew computer club
meeting
Stanford Linear ACCelerator (SLAC)
Auditorium



1975 Not only Hardware but also software
The first BASIC language for microprocessor.

Altair Basic
The first Microsoft product

Bill Gates and Paul Allen



ALTAIR BASIC - UP AND RUNNING

In January, when Popular Electronics featured the Altair Computer on its front cover, we knew that we had a great product. But no one could have predicted the enormous flood of inquiries and phone calls and orders that started hitting us about mid-January.

Partly because the Altair has generated such a huge volume of business, we have been able to speed up our Altair development program and broaden our horizons somewhat. Undoubtedly the most newsworthy of these developments is the introduction of a BASIC programming language for the Altair Computer.

That's right. We've got BASIC and it's up and running!

People who are familiar with programming and BASIC language will most likely understand why we're making such a big deal out of this. For those who aren't familiar, we offer the following explanation.

A few years back, realizing that computers needn't be so darn complicated, a group of professors at Dartmouth College developed a revolutionary, new computer language called BASIC language. This language was designed so that people with little or no computer knowledge could learn how to program.

BASIC language works because it is just what it says--it is, namely, BASIC. For example, when you want to instruct the computer to PRINT something and you are using BASIC language, you simply type the word PRINT on your terminal or teletype keyboard followed by whatever it is you want the computer to print. BASIC is BASIC. It is simple and understandable.

To illustrate this further, let's take a look at this sample BASIC program, designed to calculate a simple interest problem.

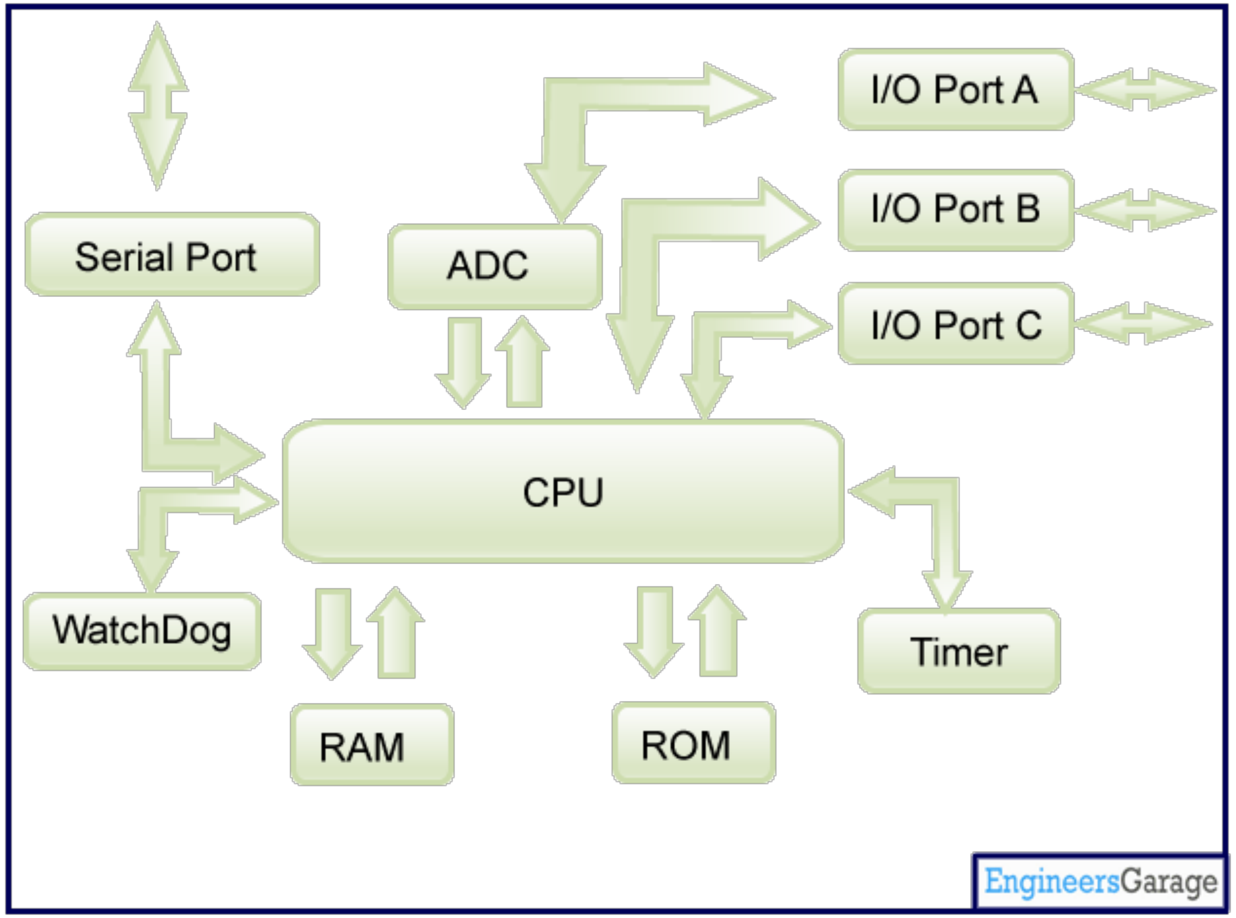
```
SCRATCH
10 LET P=650
20 LET T=18
30 LET R=.065
40 LET I=P*T*R/12
50 LET P1=P+I
60 LET M=P1/T
70 PRINT "TOTAL INTEREST IS";I
80 PRINT "TOTAL MONEY OWED IS";P1
90 PRINT "MONTHLY PAYMENTS ARE";M
RUN
```

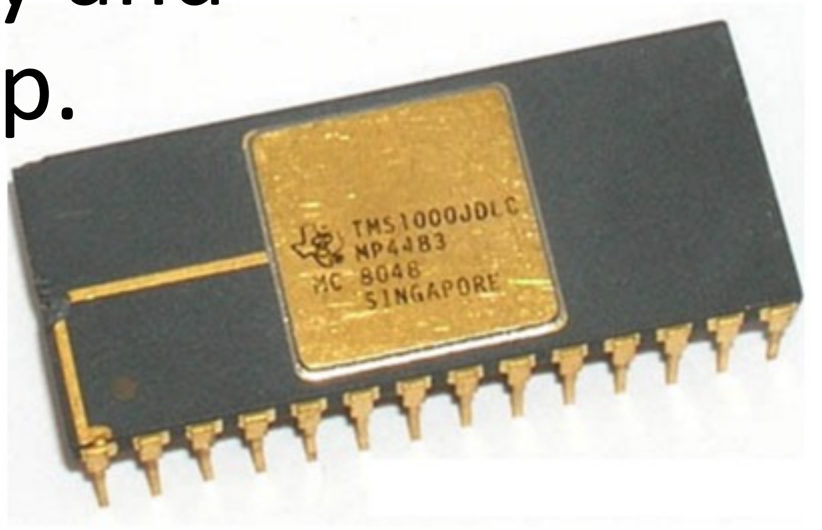
This program is a set of in-

COMPUTER NOTES
APRIL 7, 1975
© MITS, INC. 1975
A PUBLICATION OF THE ALTAIR USERS GROUP
VOLUME ONE ISSUE ONE

Microcontrollers (MCU)
System on Chip (SoC) Memory and peripheral in the same chip.

The Texas Instruments Speak & Spell from 1978 was a typical use for the TMS1000. FozzTexx (CC-SA 4.0)

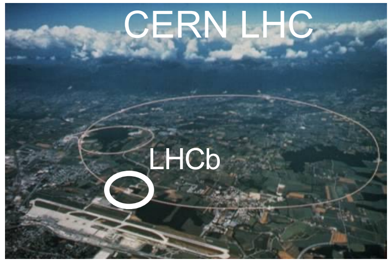




TMS 1000 (1974)

Texas Instrument 4-bit TMS 1000, was the first microprocessor to include enough RAM, and space for a program ROM, and I/O support on a single chip to allow it to operate without multiple external support chips, making it the first microcontroller.

LHCb Muon Detector Control System



IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 57, NO. 6, DECEMBER 2010

The Muon Front-End Control Electronics of the LHCb Experiment

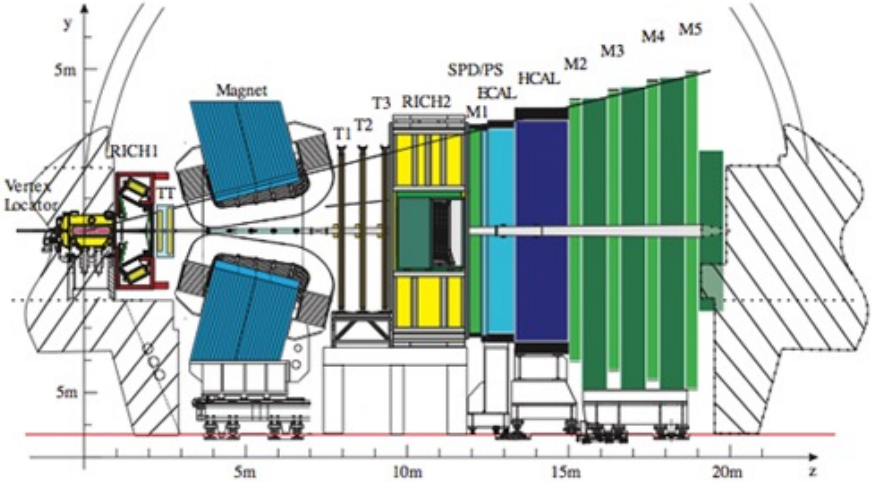
Valerio Bocci, Giacomo Chiodi, Francesco Iacoangeli, Francesco Messi, and Rafael A. Nobrega

***Abstract*—The LHCb muon readout apparatus is made of 1368 Multi-Wire Proportional Chambers (MWPC) and 24 Gas Electron Multiplier (GEM) chambers connected to 7632 16-channel front-end boards, resulting in 122.112 channels to be read out.**

....

The large-scale of the system and the time constrains naturally led to the development of a custom and complex control system made of about 600 microcontrollers (μC) and 150 flash-based FPGAs which are directly connected to the front-end electronics and handled by six computers.

Muon Chambers

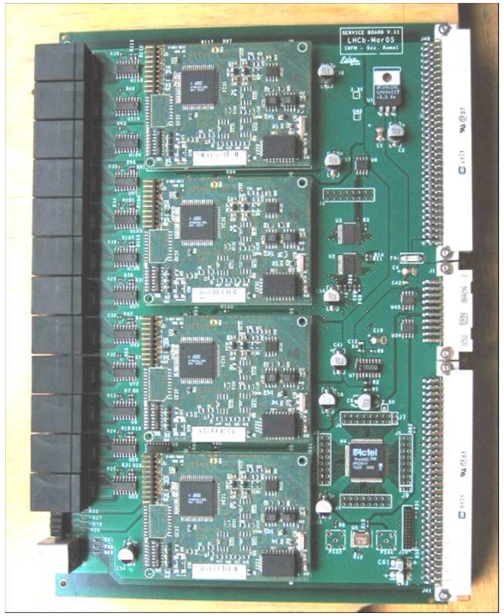


ELMB the Arduino of HEP (ATMega128 MCU)

Henk Boterenbrood Nikhef

Björn Hallgren CERN

156 x Service Board (SB)

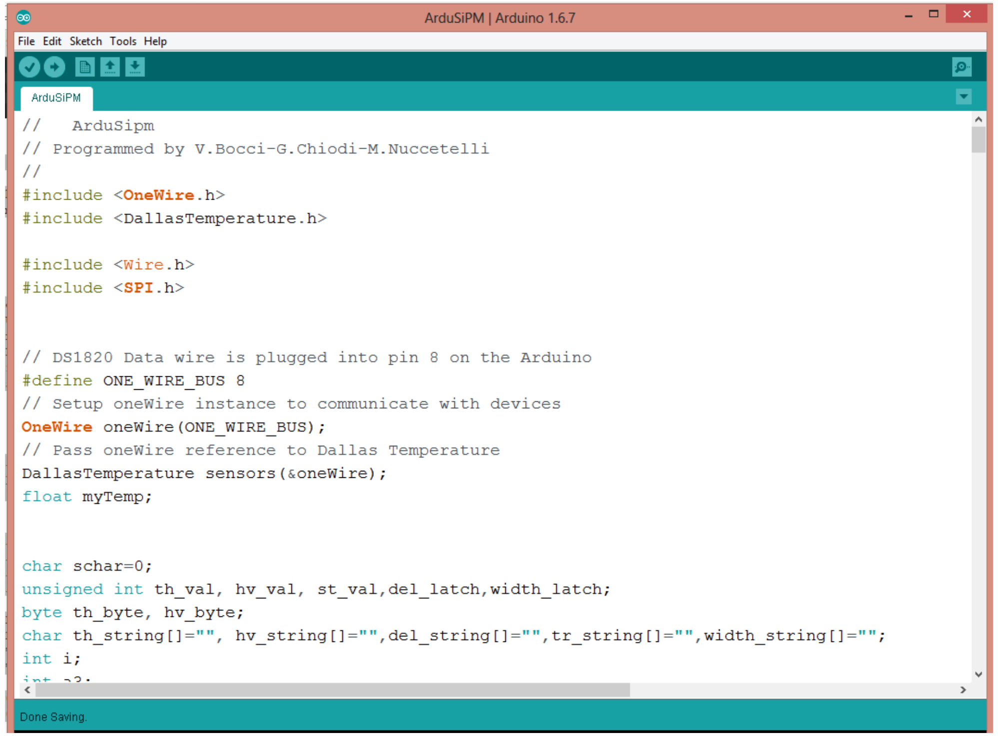


Complex Software only for real expert.
C programming.
Automotive CANBus in radiation environment.

The Arduino revolution (2005)

Hardware: Microcontrollers boards

Software :Arduino Language



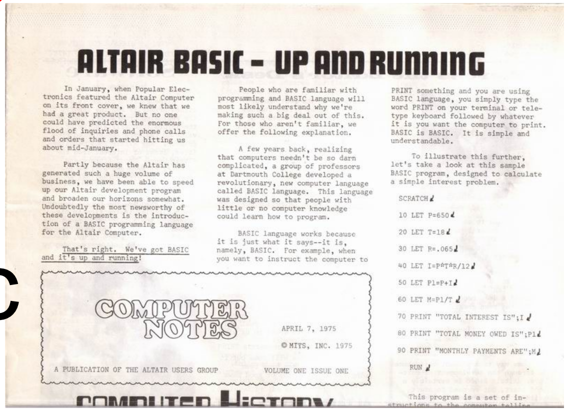
The world of microcontrollers for anybody.
Simple programming language to program MCU.

Similarities with the beginning of the personal computer era

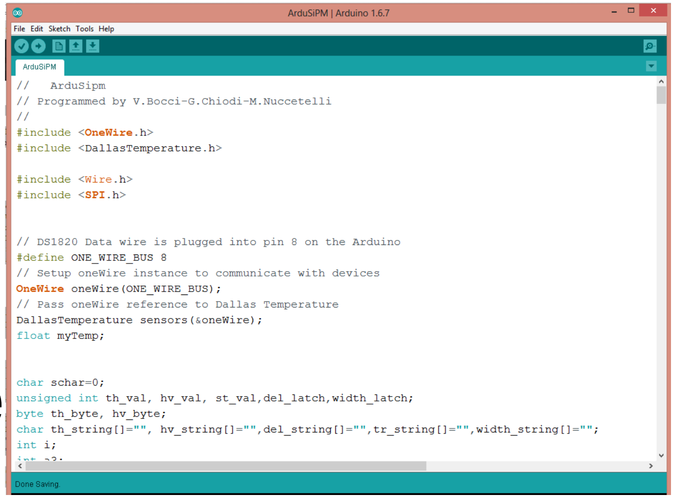
CPU

MCU

=



Basic

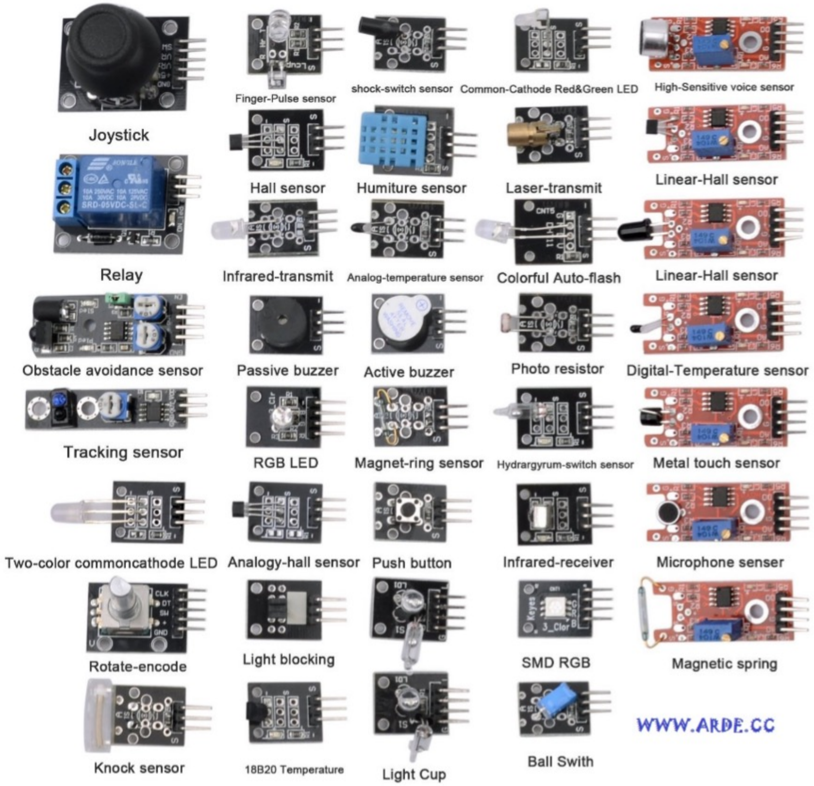


Arduino Language

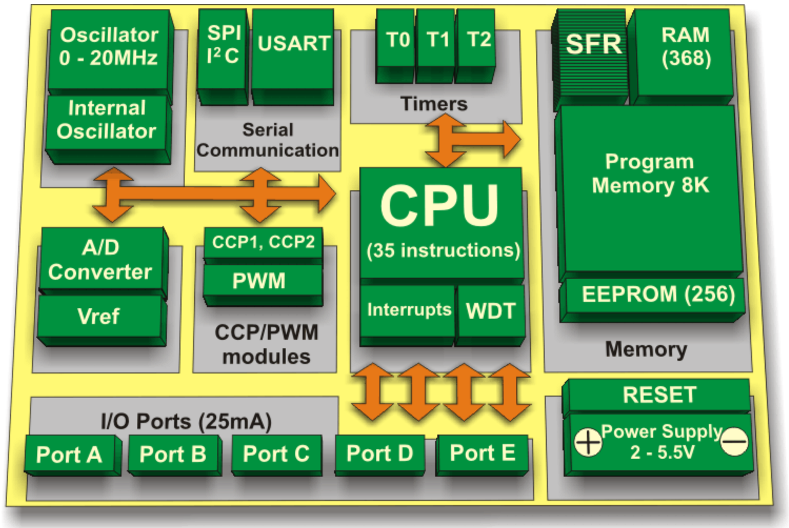
The world of microcontrollers for anybody. Simple programming language to program MCU.

The MCU as building block for Internet of Things

Sensors/Actuators



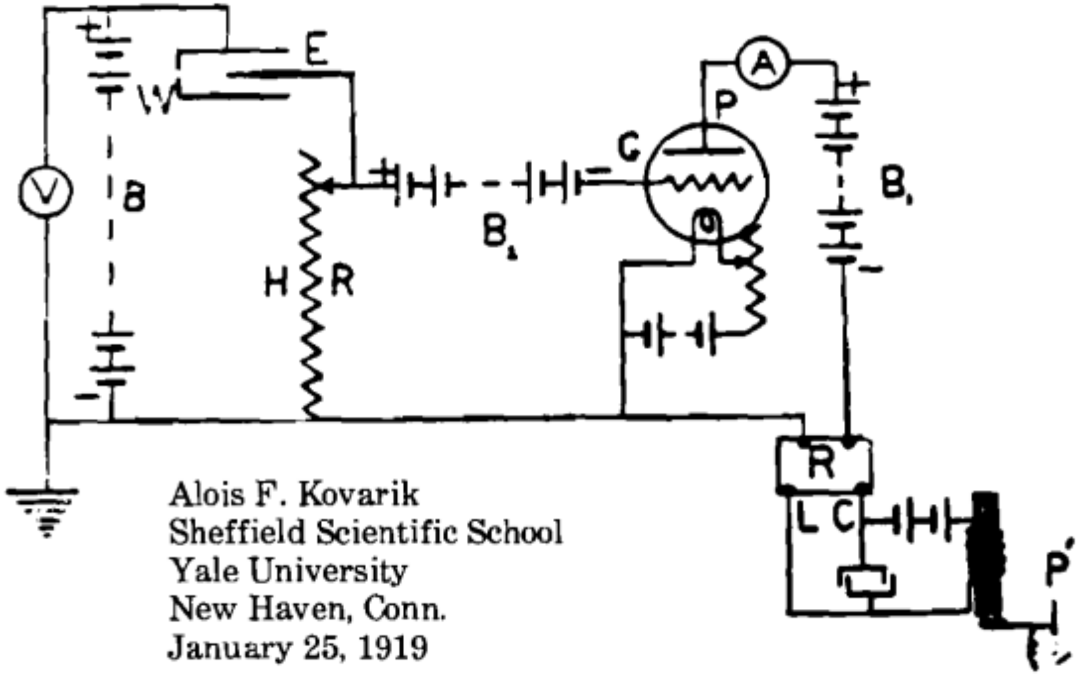
Microcontroller



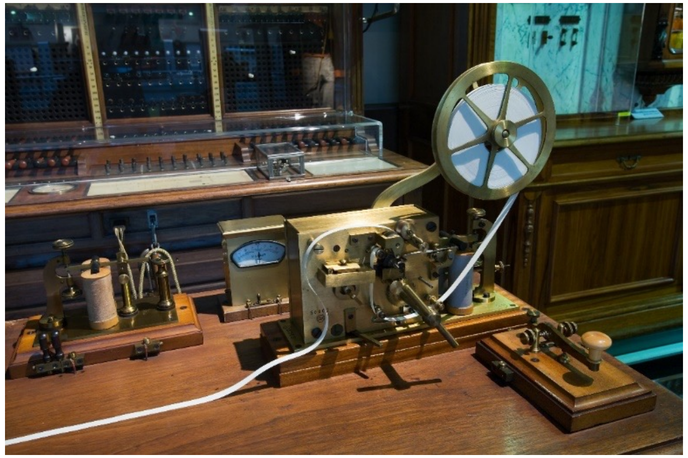
Internet Connection

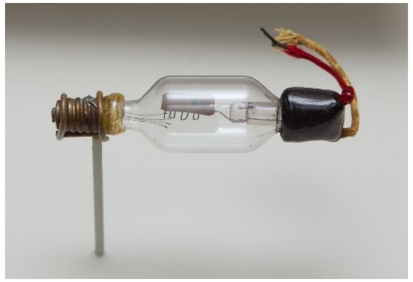
First Electronic particle detector 1919

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.

Da ArduSiPM GEN1 a LITE SPLD (CSN5)

(Progetto Incrementale con fondamenta solide)

Nel vasto mondo dell'elettronica, **individuare tecnologie con potenziale di sviluppo incrementale decennale** è come cercare un faro nella notte, una sfida ardua dove **il rischio di smarrirsi nei binari dell'obsolescenza è sempre in agguato**. Quando un percorso ha dimostrato proficuità e offre opportunità di crescita ulteriore, perché non **continuare a percorrerlo con determinazione**?

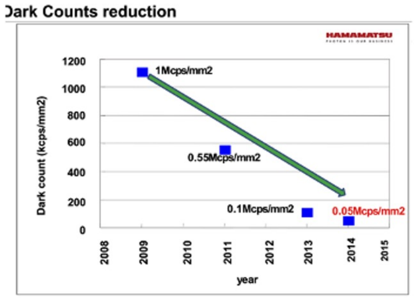
The ArduSiPM idea 2012-2014 IEEE NSS/MIC Seattle

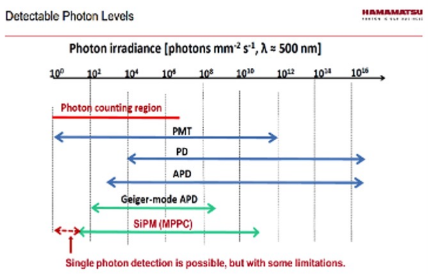
In the last years we have seen a fast increasing and positive trend of SiPMs performances

MPPC Performance Has Been Remarkably Improved

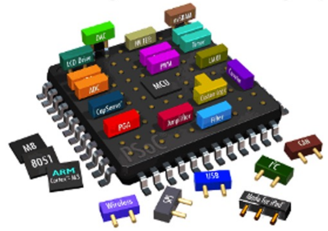
HAMAMATSU

- ✓ Dark Count
- ✓ Afterpulse
- ✓ Crosstalk
- ✓ PDE (Photon Detection Efficiency)
- ✓ Timing Resolution
- ✓ Larger Area (with Assembly Technology)





An even greater increase is that shown by the features and peripherals available in system-on-chip (SoC)

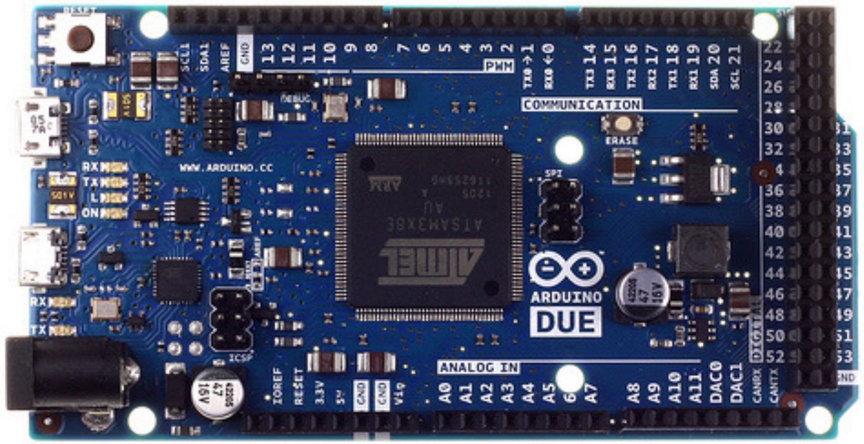


- In early 2000s Soc featured cheaper and smaller mobile phones
- In 2001, it was the release of the iPod that was based on the twin-core ARM SoC
- The emergence of IoT further boost the evolution of SoC

SoC integrate more and more functions into a single chip!

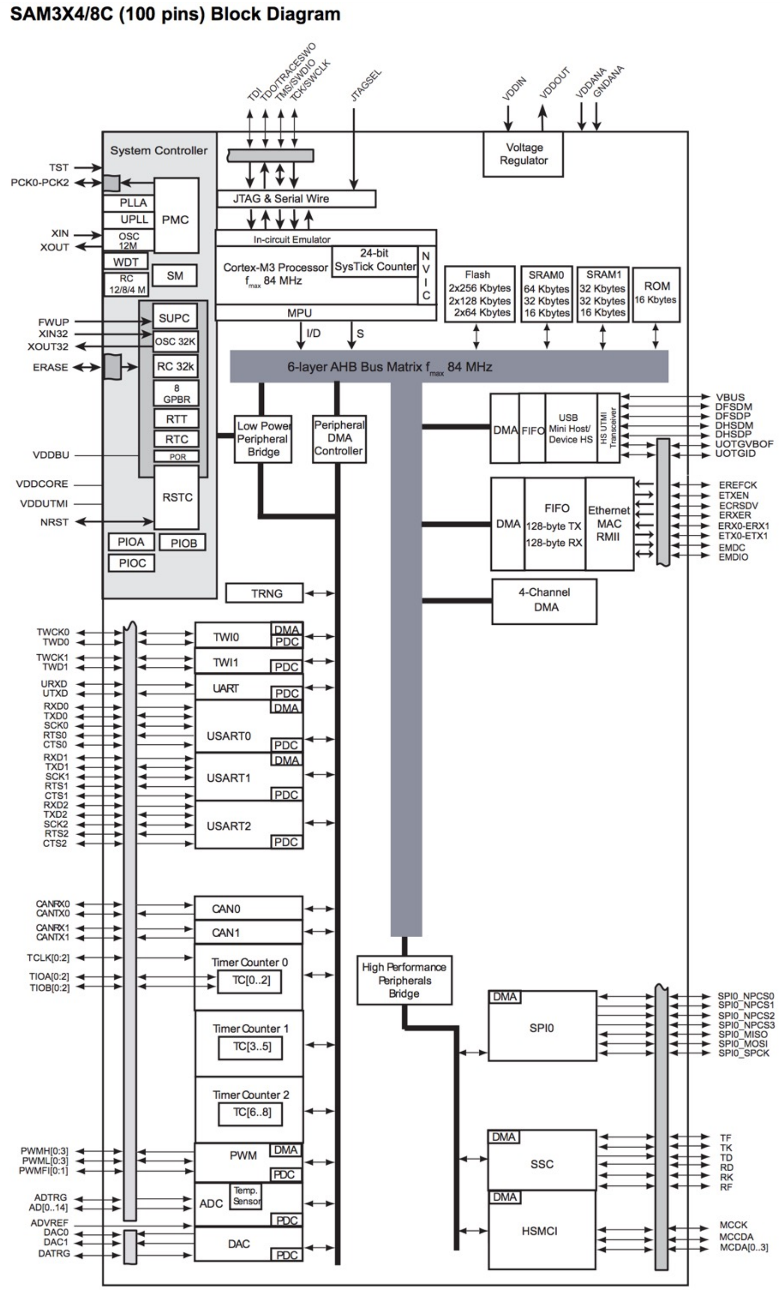
- general-purpose microcontroller unit (MCU)
- numerous high-performance peripherals (amplifiers, ADCs, DACs, counters)
- non-volatile memory
- Network interfaces

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.



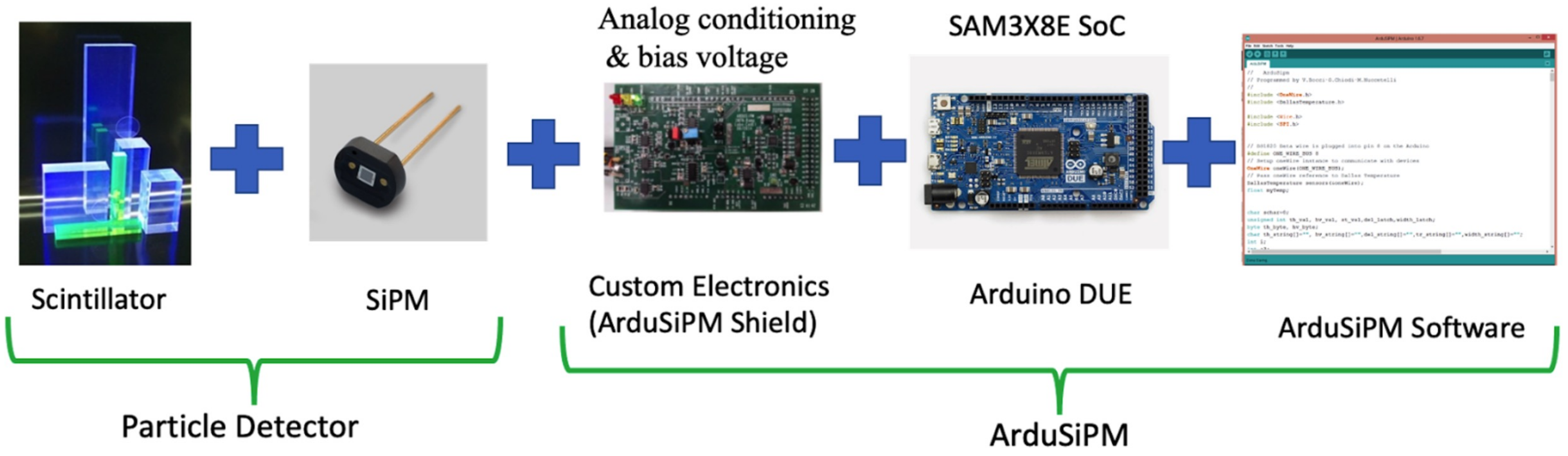
The ArduSiPM idea (Gen1)

In 2014 we have created and published a new kind of detector using the new generation of **SiPM** and System on Chip (**SoC**).

V. Bocci, G. Chiodi, F. Iacoangeli, M. Nuccetelli and L. Recchia, **"The ArduSiPM a compact trasportable Software/Hardware Data Acquisition system for SiPM detector,"** *2014 IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC)*, 2014, pp. 1-5, doi: 10.1109/NSSMIC.2014.7431252.

The ArduSiPM technology joins the innovation of the system on a chip (SoC) and the simultaneous improvement of Silicon photomultiplier detectors in a new generation of all-in-one scintillation detectors conceived from INFN Roma in 2014.

The basic idea is to minimize the use of COTS components (typically fast analog) and develop a large part of the peripherals inside the SoC, thus obtaining compact electronics without using ASICs and an external data acquisition system.



Animma 2015

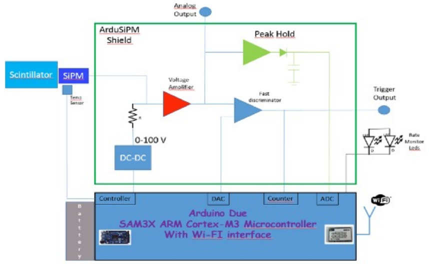
A low cost network of spectrometer radiation detectors based on the ArduSiPM a compact transportable Software/Hardware Data Acquisition system with Arduino DUE

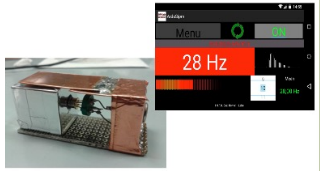
Valerio Bocci , Giacomo Chiodi, Francesco Iacoangeli, Massimo Nuccetelli, Luigi Recchia

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

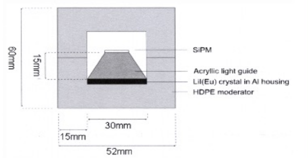
The necessity to use Photo Multipliers (PM) as light detector limited in the past the use of crystals in radiation handled device preferring the Geiger approach.
The Silicon Photomultipliers (SiPMs) are very small and cheap, solid photon detectors with good dynamic range and single photon detection capability, they are usable to supersede cumbersome and difficult to use Photo Multipliers (PM). A SiPM can be coupled with a scintillator crystal to build efficient, small and solid radiation detector. A cost effective and easily replicable Hardware software module for SiPM detector readout is made using the ArduSiPM solution.
The ArduSiPM is an easily battery operable handled device using an Arduino DUE (an open Software/Hardware board) as processor board and a piggy-back custom designed board (ArduSiPM Shield), the Shield contains all the blocks features to monitor, set and acquire the SiPM using internet network.

The peripheral card can connected piggyback using the same form factor of the Arduino, in the Arduino world this pluggable boards are called Shields.
Looking to the potentiality of the SAM3X8E ARM Cortex-M3 CPU, we decide to build up a custom shield to acquire Silicon photomultiplier.
The ArduSiPM Shield is our custom designed board with all electronics interface from Arduino DUE and a SiPM photodetector. The ArduSiPM Shield plugged in the Arduino DUE create an easily transportable system including Front end electronics and data acquisition system.
The global architecture of the system is in the right figure.



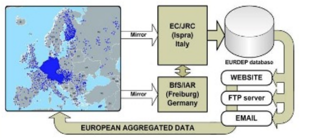


The SiPM of the acquisition board can be coupled with a scintillator crystal to build efficient, small and solid radiation detector. The gamma radiation monitoring is an interesting field of application for the ArduSiPM. The gamma radiation can be used to identify the type of radioactive sources using the gamma spectra analysis. The first component to convert the gamma ray to light detectable from the SiPM is a crystal. There are different kind of crystals for the scope like as the common *NaI(Tl)*, the *CsI(Tl)*, the *BGO* and the *LSO (LYSO)*. Scintillation materials can be small, low-cost, and efficient for gamma detection, can operate at room temperature, and are capable of being used in spectroscopy systems. The volume of crystal necessary to detect gamma ray can be in the order of one cube centimeter.
The lack of Graphical user interface can be brightly resolved using as client a PC or a Tablet. We developed an Android App that can control and display data in raw or in graphical way after post processing



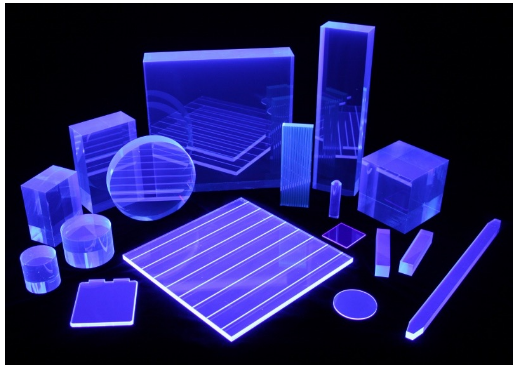
One of the use of the ArduSiPM can be the detection of Neutrons. The common neutron's detectors are complex and heavy systems, mainly based on light conversion and PM readout.
One proved technics is to use a *LiI* crystal viewed by a SiPM. An interesting ready to use design for the detector is published [1]. The neutron moderation is provided by high-density polyethylene (HDPE), then the slow neutrons interact with the *LiI* crystal. Lithium iodide, when suitably activated, scintillate under slow neutrons' irradiation as a result of the 6Li(n,a)3H reaction in which the a-particle and triton share an energy of 4.79 MeV. The scintillation efficiency is 11000 ph/MeV. The Acrylic light guide conveys the light to the SiPM detector. This kind of detector can be easily read from the ArduSiPM device and can meet the DNDO (Domestic Nuclear Detection Office) specification for a handheld radiation detector.

[1] M Foster and D Ramsden A compact neutron detector based on the use of a SiPM detector. , IEEE NSS MIC (2008) Dresden

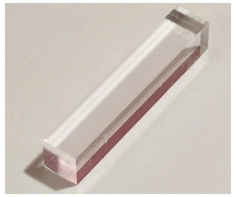


After the nuclear accident in Fukushima, Japan, in 2011 the public demand of radiation monitor increase considerably.Many people were unsure what level of radiation they were being exposed.
There are projects like EURDEP (EUropean Radiological Data Exchange Platform) that show radioactivity and emergency preparedness in the Europe area. EURDEP makes radiation dose rate data from 37 European countries, there are 4500 automatic stations available on an hourly basis. The freely accessible Public map allows the public to view the European monitoring data. The EURDEP network use as standard exchange format IRIX (International Radiation Information eXchange) an xml-based format standard for data exchange that has been developed under the IAEA action plan, in closed cooperation with the EC. The IRIX is well designed to exchange of environmental radiation data include appropriate metadata with the results of monitoring. The ArduSiPM can easily output the data in IRIX format and can be integrated in EURDEP or in other radiation network like RadiationNetwork.com.

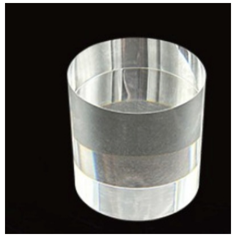
Readily Available Scintillators



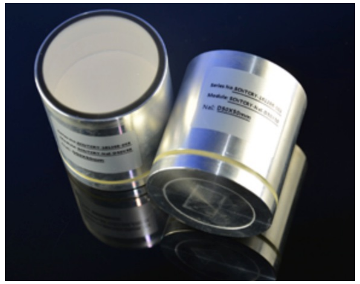
Plastic BC408:
density 1
Yeld 10 000 ph/MeV



Lyso
density 7
Yeld 30 000 ph/MeV



BGO
density 7
Yeld 10 000 ph/MeV



Encapsulated NaI
Density 3.7
Yeld 40 000 ph/MeV

Application Example 1: Intraoperative β- Detecting Probe

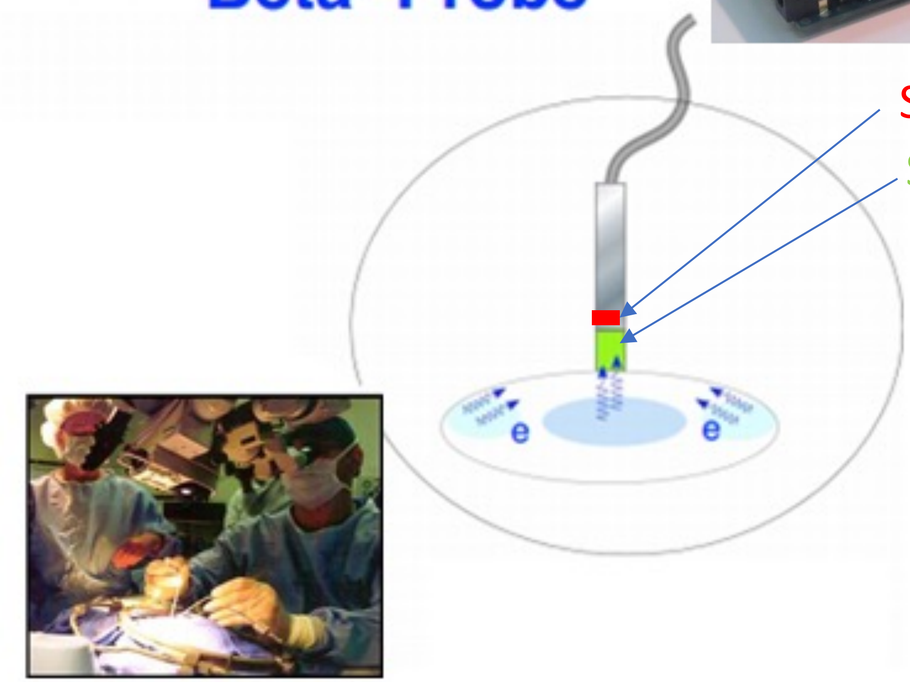
nature.com > scientific reports > articles > article

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

Beta- Probe



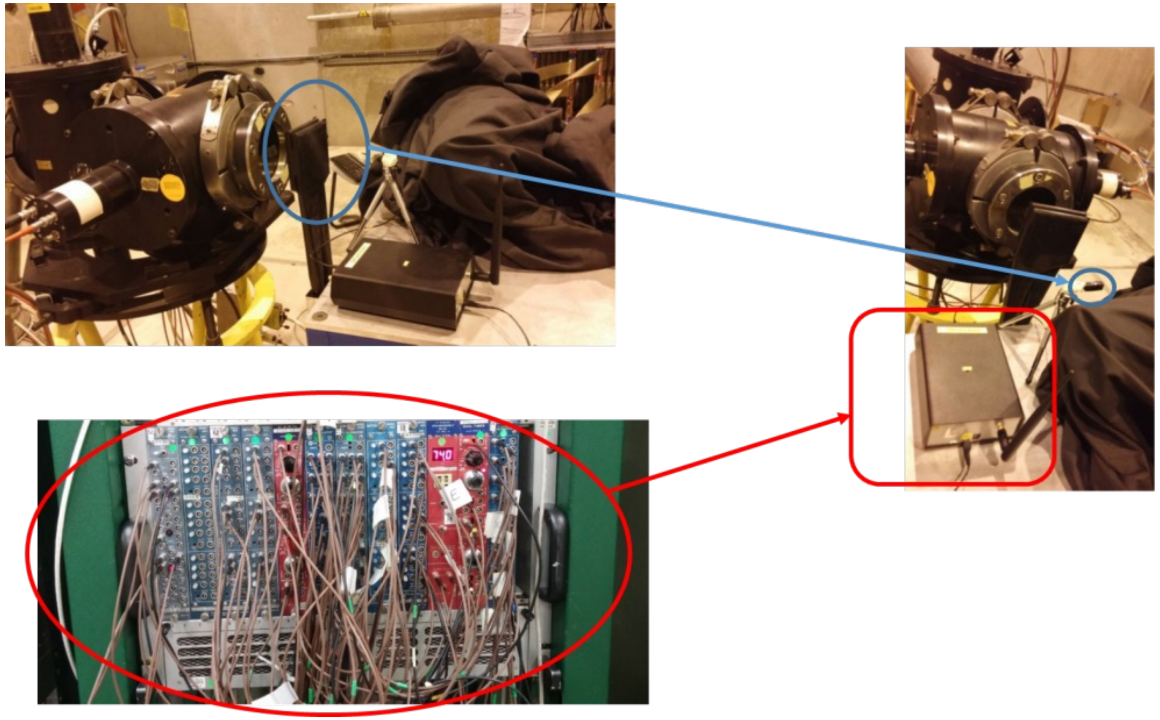
ArduSiPM

Control and readout Android App

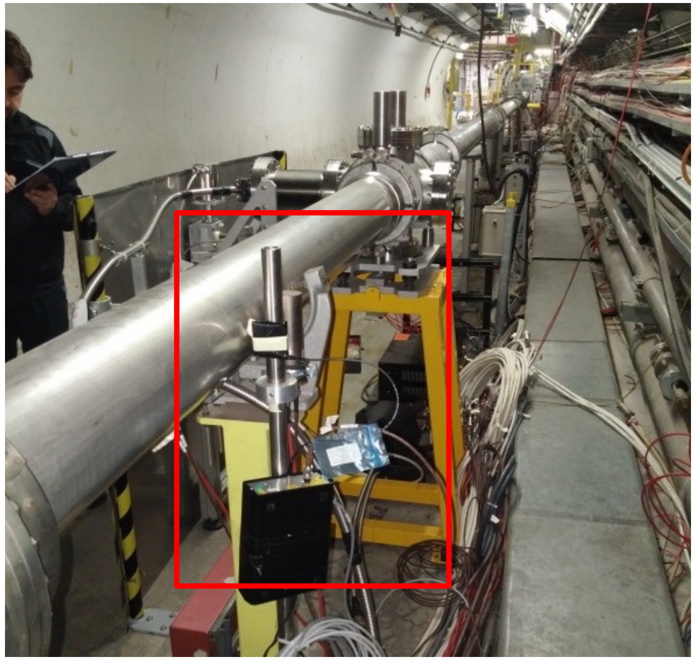
- Radioguided **intraoperative beta probe**, with scintillation material coupled with SiPM detector.

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

European Research Council

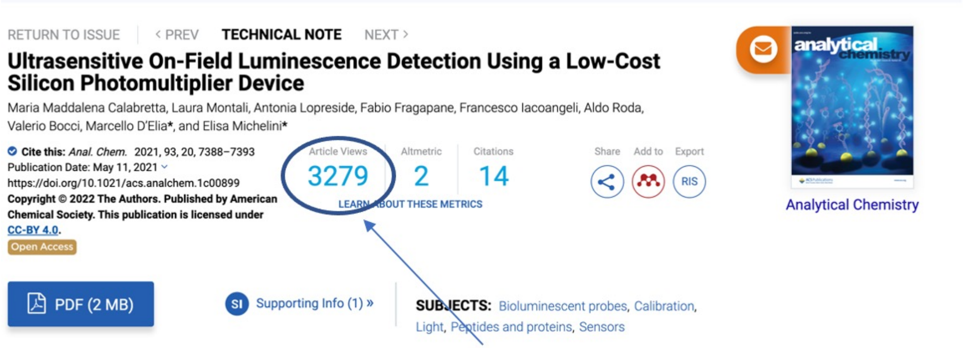
- *This work has been supported by the ERC Ideas Consolidator Grant*

The first ArduSiPM detector

- SoC: SAM3X8E ARM Cortex-M3 on ArduinoDue Board
- Compatible with Arduino Shield
- On the market as technological transfer of INFN

Dissemination in fields other than those of high energy physics

example : analytical chemistry using chemiluminescence and bioluminescence


RETURN TO ISSUE | < PREV | TECHNICAL NOTE | NEXT >

Ultrasensitive On-Field Luminescence Detection Using a Low-Cost Silicon Photomultiplier Device

Maria Maddalena Calabretta, Laura Montali, Antonia Lopreside, Fabio Fragapane, Francesco Iacoangeli, Aldo Roda, Valerio Bocci, Marcello D'Elia*, and Elisa Michelini*

Cite this: Anal. Chem. 2021, 93, 20, 7388–7393
Publication Date: May 11, 2021
https://doi.org/10.1021/acs.analchem.1c00899
Copyright © 2022 The Authors. Published by American Chemical Society. This publication is licensed under CC-BY 4.0.
Open Access

Article Views 3279 | Altmetric 2 | Citations 14
LEARN ABOUT THESE METRICS

Share | Add to | Export RIS

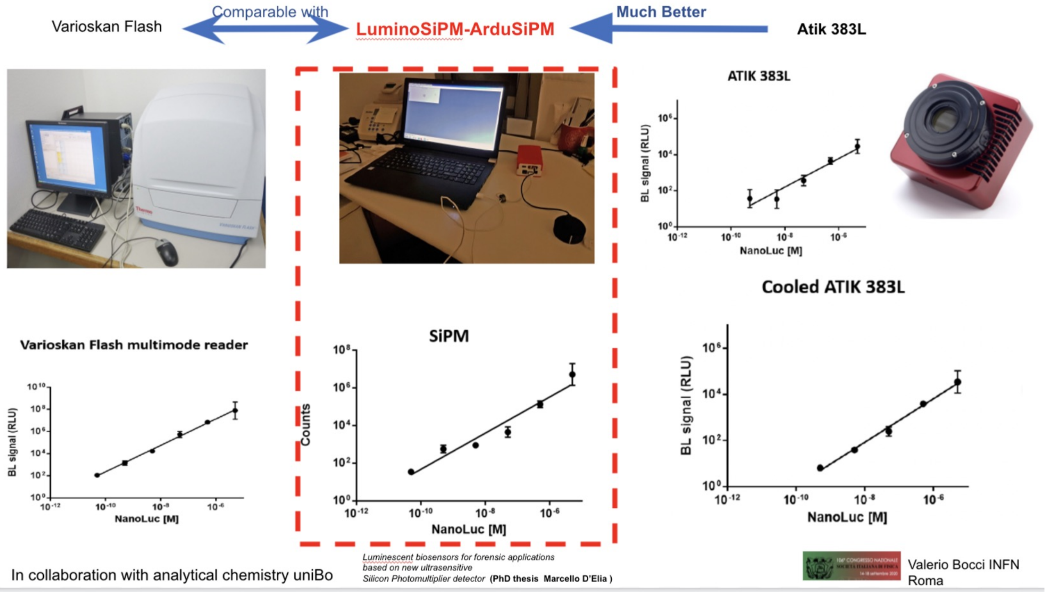
analytical chemistry
Analytical Chemistry

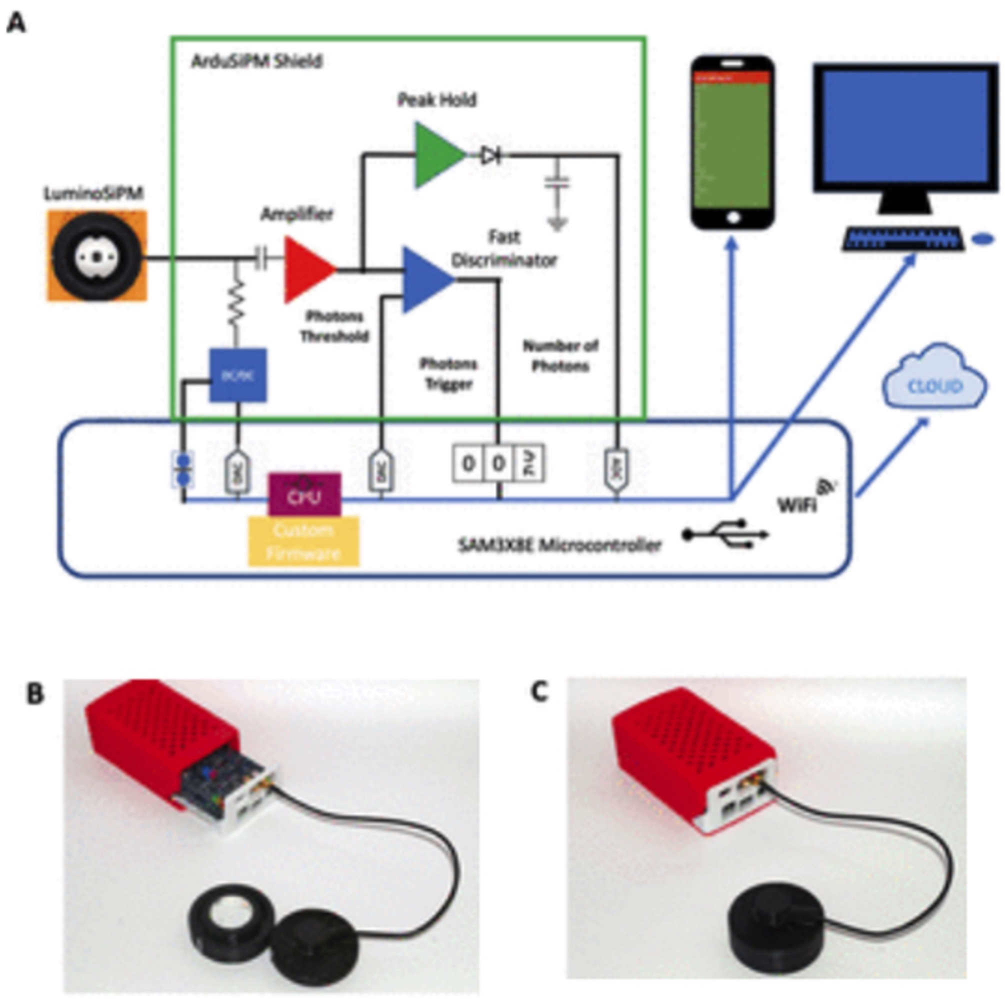
PDF (2 MB) | Supporting Info (1) »

SUBJECTS: Bioluminescent probes, Calibration, Light, Peptides and proteins, Sensors

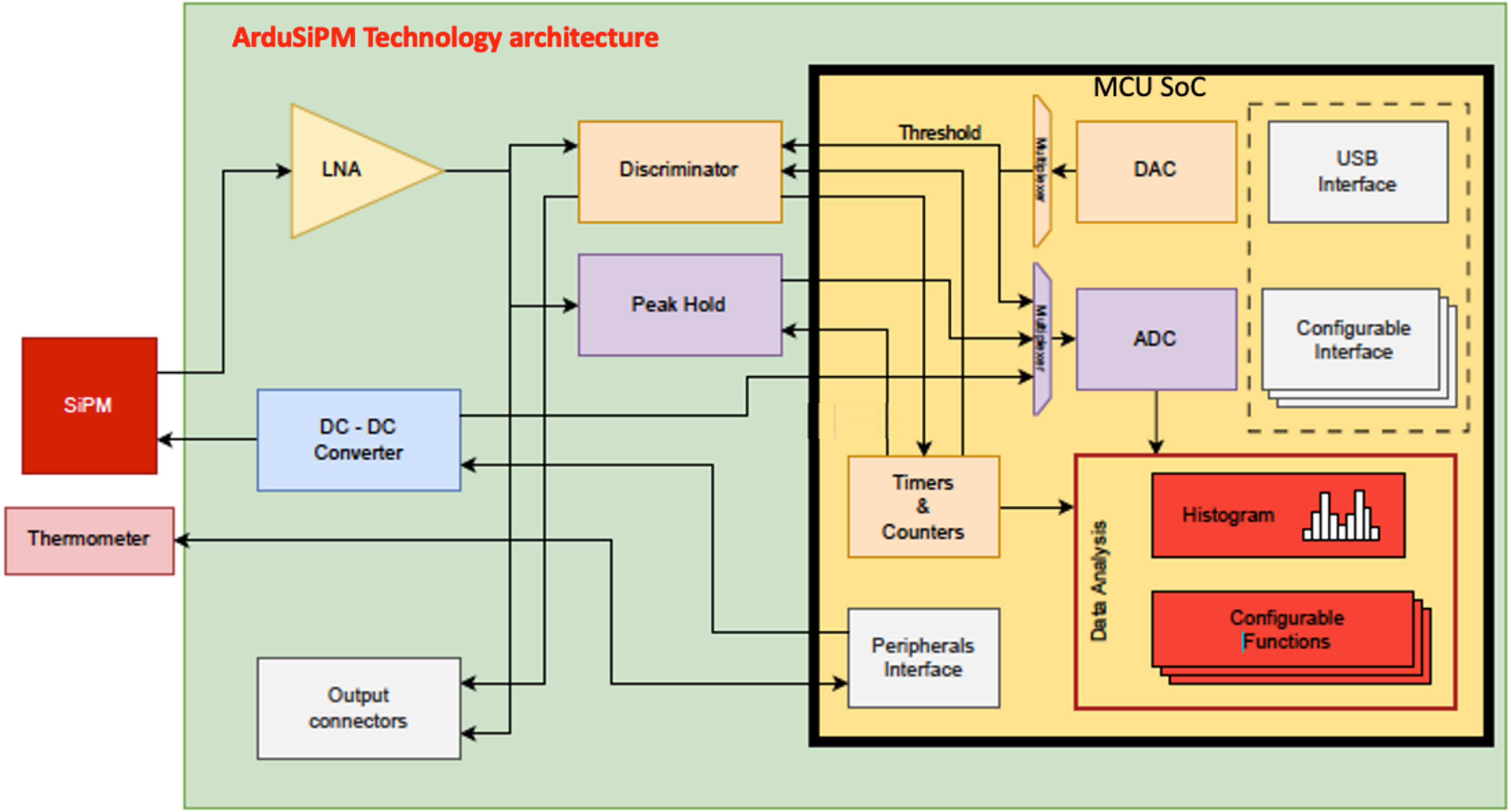
Mean value for the journal article 300-400
Mean value for cover article 1200-1400

IF:6.986





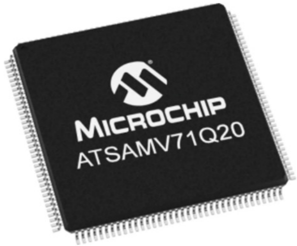
ArduSiPM tecnology block diagram



The ArduSiPM architecture can scale with SoC Growth

2014

2019



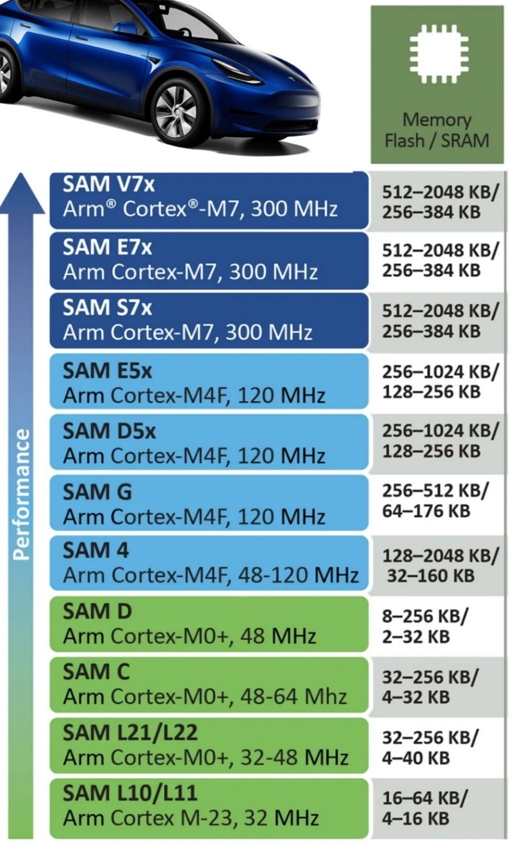
- Better time resolution.
- More memory –> RT histogram

SAM3X8E

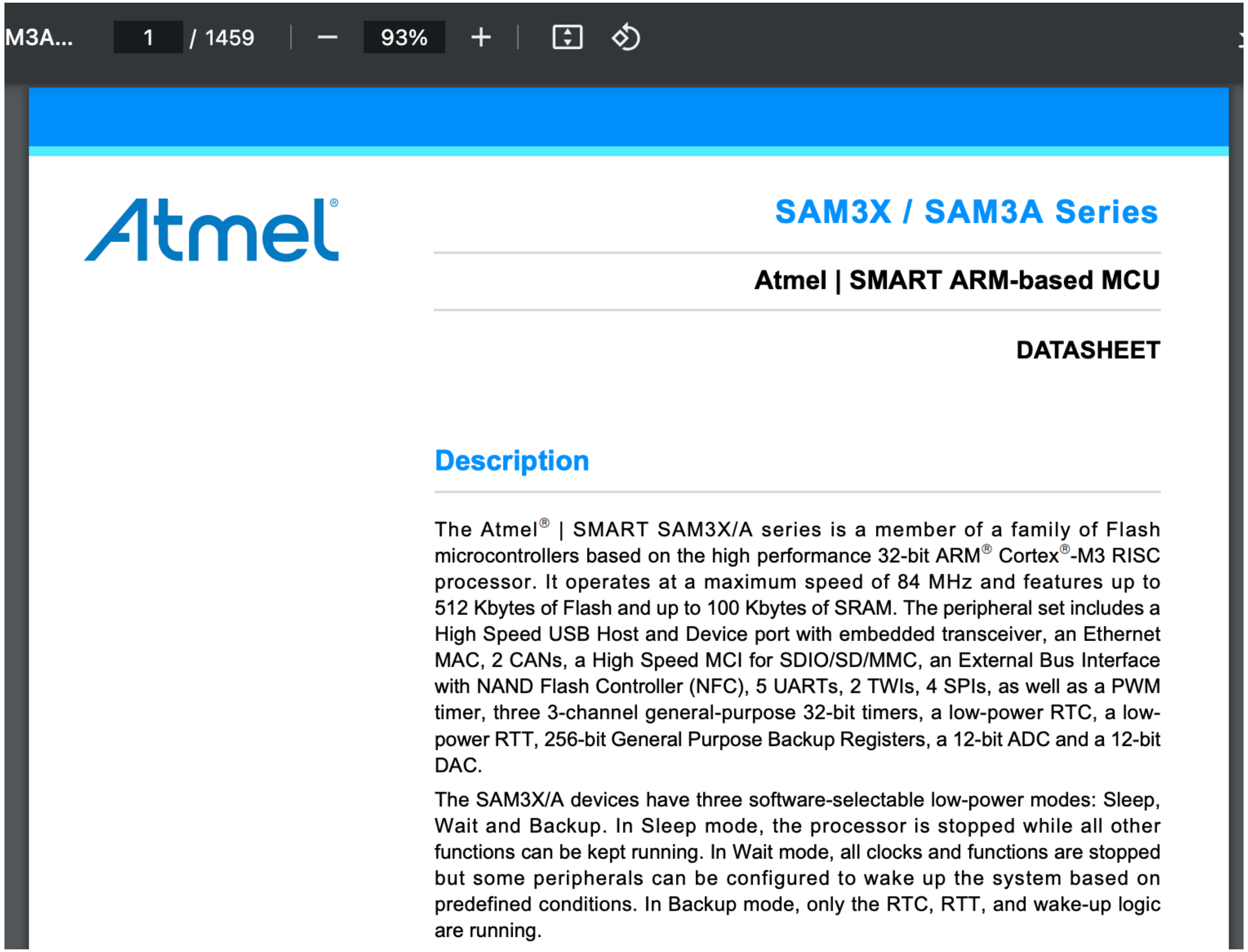
- 32-bit ARM ® Cortex®-M3 RISC
- 84 MHZ
- 12 bits 1 Msamples/s ADC
- SRAM 64 + 32 Kbytes
- Flash 2 x 256 Kbytes

SAMV71

- 32-bit ARM® Cortex®-M7 RISC
- 300 MHZ
- 12 bits 2 Msamples/s ADC
- Multi port SRAM 384 Kbytes
- Flash 2048 Kbytes
- Cache 16/16 Kbytes
- Two Analog Front-End Controllers (AFEC), allowing dual sample-and-hold at up to 1.7 Msps. Offset and gain error correction feature.



SAM3X8E



M3A... 1 / 1459 93%

Atmel

SAM3X / SAM3A Series

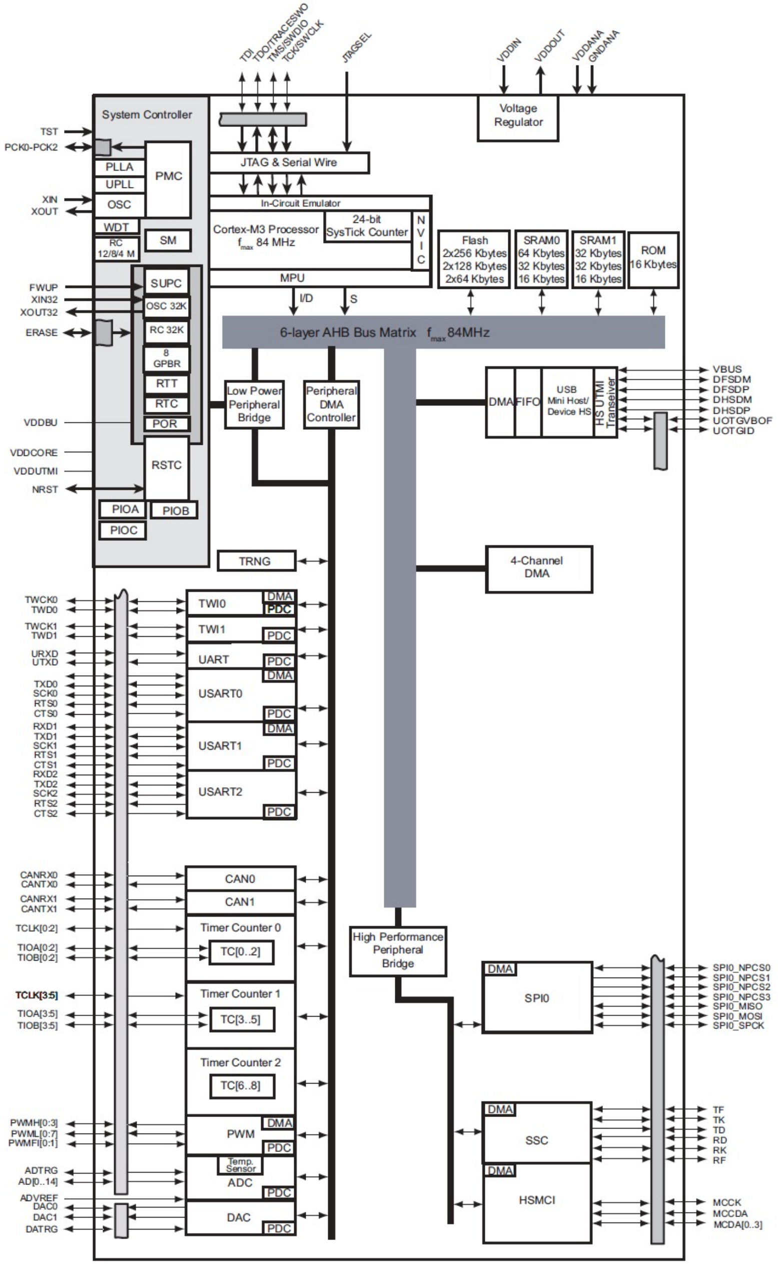
Atmel | SMART ARM-based MCU

DATASHEET

Description

The Atmel® | SMART SAM3X/A series is a member of a family of Flash microcontrollers based on the high performance 32-bit ARM® Cortex®-M3 RISC processor. It operates at a maximum speed of 84 MHz and features up to 512 Kbytes of Flash and up to 100 Kbytes of SRAM. The peripheral set includes a High Speed USB Host and Device port with embedded transceiver, an Ethernet MAC, 2 CANs, a High Speed MCI for SDIO/SD/MMC, an External Bus Interface with NAND Flash Controller (NFC), 5 UARTs, 2 TWIs, 4 SPIs, as well as a PWM timer, three 3-channel general-purpose 32-bit timers, a low-power RTC, a low-power RTT, 256-bit General Purpose Backup Registers, a 12-bit ADC and a 12-bit DAC.

The SAM3X/A devices have three software-selectable low-power modes: Sleep, Wait and Backup. In Sleep mode, the processor is stopped while all other functions can be kept running. In Wait mode, all clocks and functions are stopped but some peripherals can be configured to wake up the system based on predefined conditions. In Backup mode, only the RTC, RTT, and wake-up logic are running.



SAMV71

32-bit Arm Cortex-M7 MCUs with FPU, Audio and Graphics Interfaces, High-Speed USB, Ethernet, and Advanced Analog

SAM E70/S70/V70/V71

MICROCHIP

Features

Core

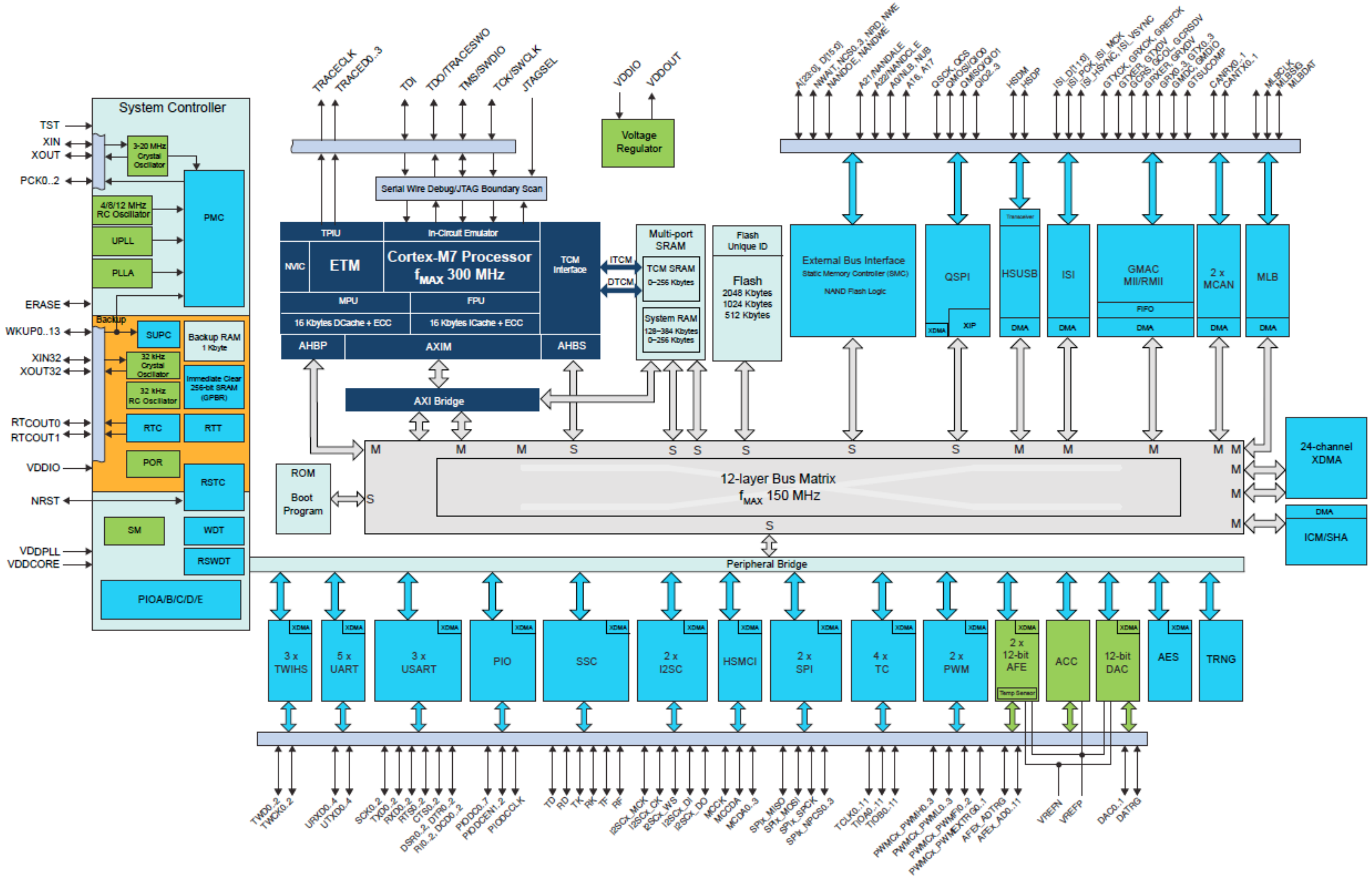
- Arm® Cortex®-M7 running at up to 300 MHz
- 16 Kbytes of I-Cache and 16 Kbytes of D-Cache with Error Code Correction (ECC)
- Single-precision and double-precision HW Floating Point Unit (FPU)
- Memory Protection Unit (MPU) with 16 zones
- DSP Instructions, Thumb®-2 Instruction Set
- Embedded Trace Module (ETM) with instruction trace stream, including Trace Port Interface Unit (TPIU)

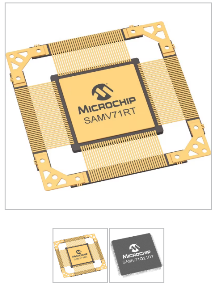
Memories

- Up to 2048 Kbytes embedded Flash with unique identifier and user signature for user-defined data
- Up to 384 Kbytes embedded Multi-port SRAM
- Tightly Coupled Memory (TCM)
- 16 Kbytes ROM with embedded Bootloader routines (UART0, USB) and IAP routines
- 16-bit Static Memory Controller (SMC) with support for SRAM, PSRAM, LCD module, NOR and NAND Flash with on-the-fly scrambling

System

- Embedded voltage regulator for single-supply operation





SAMV71Q21RT

Radiation Tolerant Cortex M7 MCU

Status: In Production.

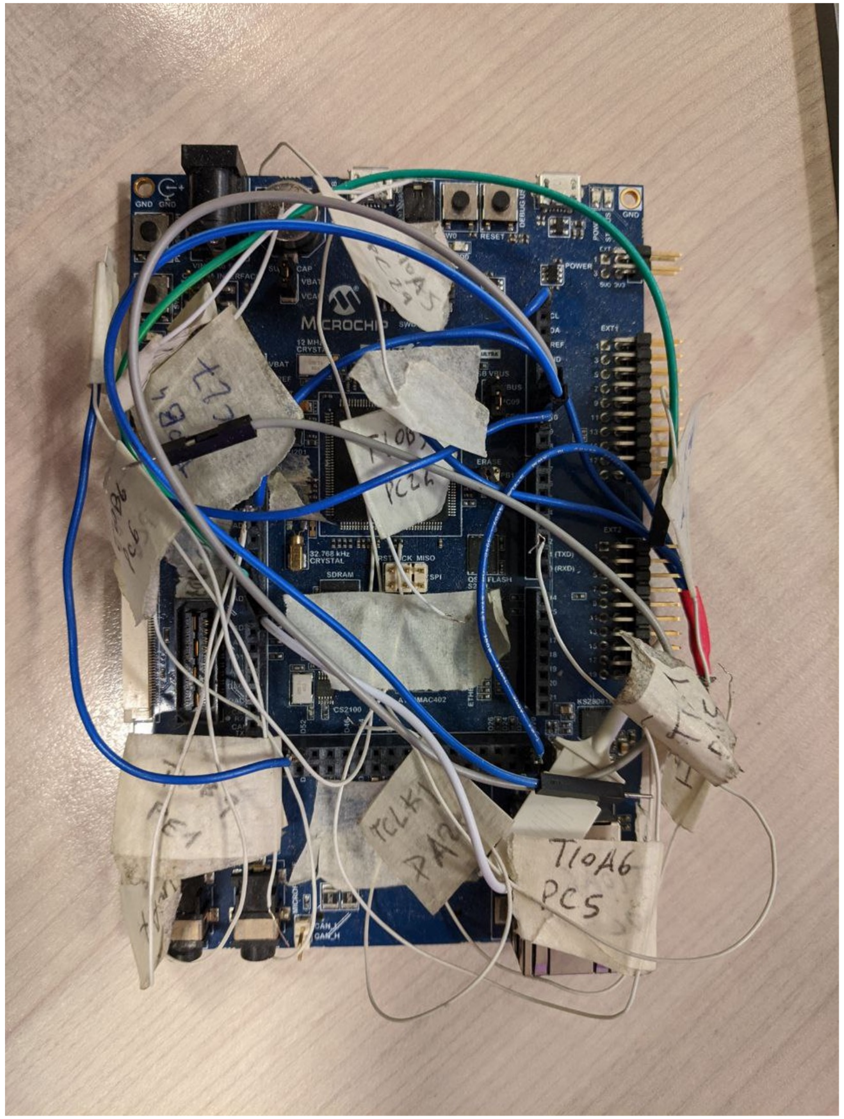
Documentation

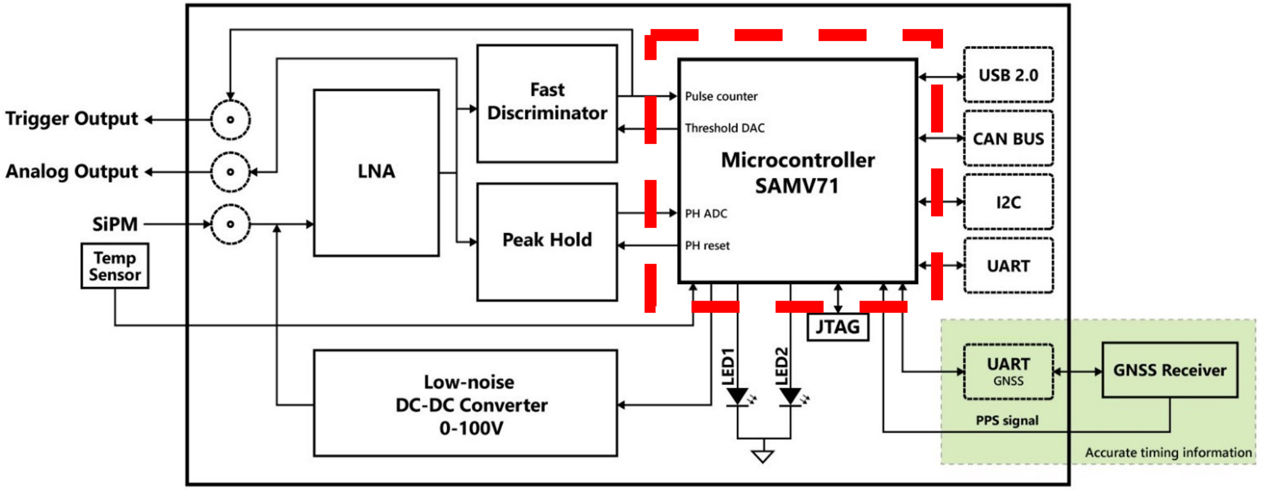
SAMV71Q21RT Radiation-Tolerant 32-bit Arm® Cortex®-M7 Microcontroller: PDF

The SAMV71Q21RT is the radiation tolerant version of the popular Microchip SAMV71Q21 based on the high-performance 32-bit ARM Cortex-M7 processor with a Double Precision Floating Point Unit (FPU). These devices operate at up to 300MHz and feature up to 2048 Kbytes of Flash, and up to 384 Kbytes of multi-port SRAM which is configurable Instruction and Data Tightly Couple Memories to leverage the advanced DSP capabilities of the core.

Purchase Options

Firmware development adapted SAMV71 EVB

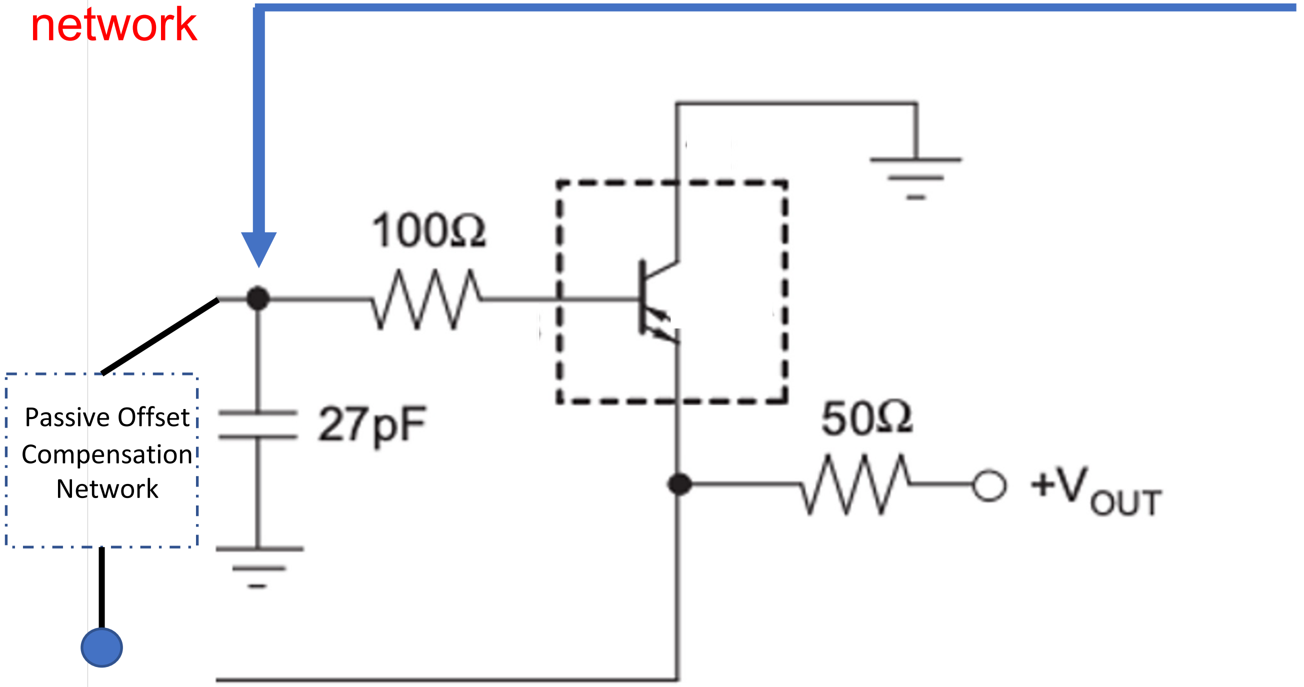




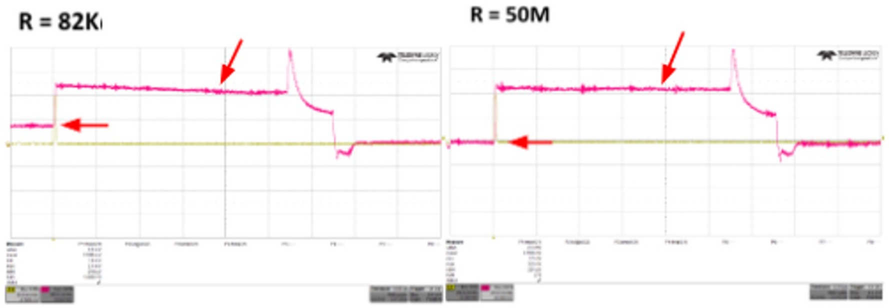
Unfortunately, for the chip shortage problem of having only a Cosmo ArduSiPM board, we tried to emulate analog connections and signals on the SAMV71 evaluation board.

Some peak hold chip comes with a strange tens of mV offset

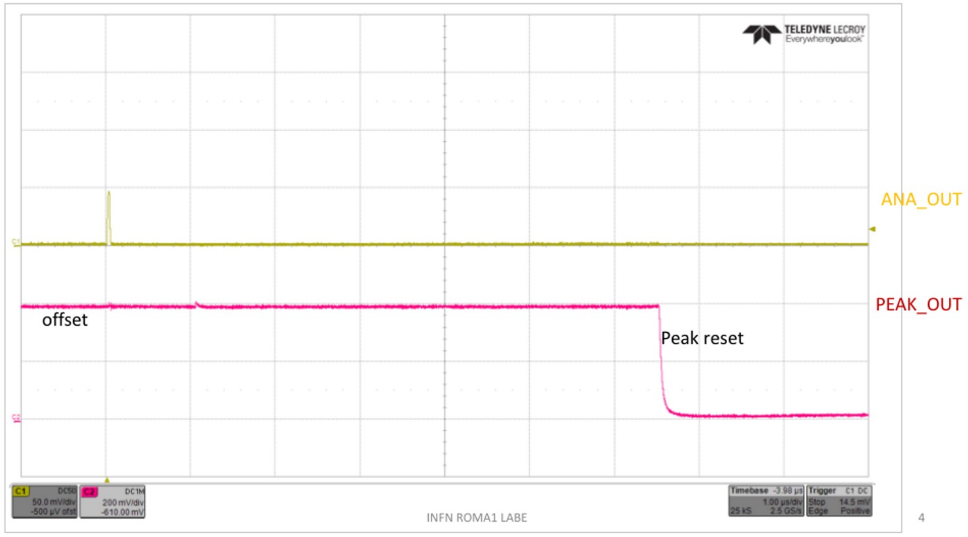
We have reported the issue to the manufacturing company.
Solution 1) component preselection 2) offset compensation network



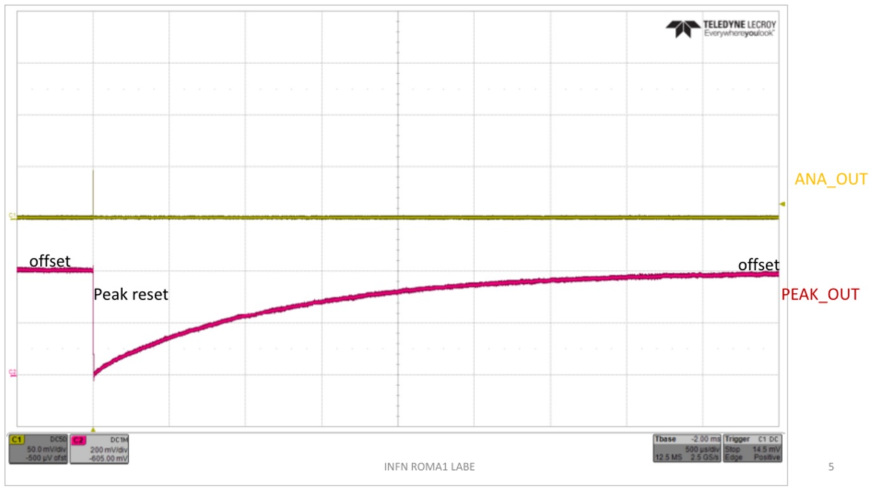
Solved



PEAK PROBLEM (OFFSET)



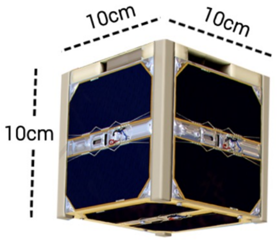
PEAK PROBLEM (OFFSET)

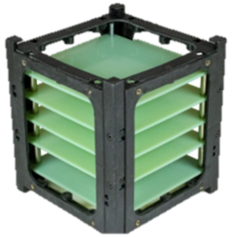


Cosmo ArduSiPM (GEN2)

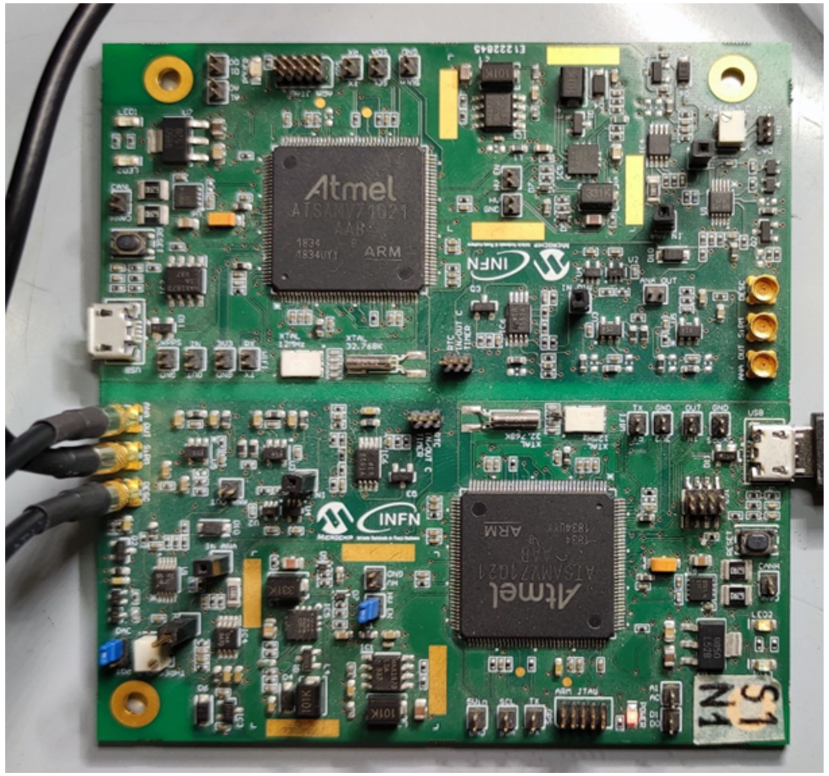
ArduSIPM analog + SAMV71

INFN-Microchip Technology
Collaboration Agreement ref. TTD 19RM1 020



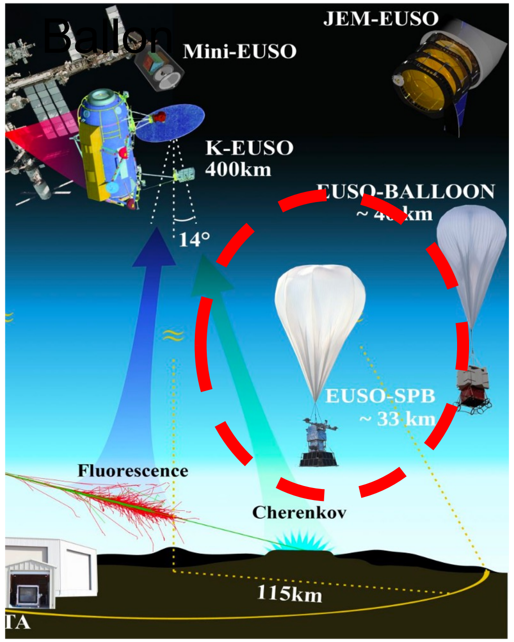


9.6 cm



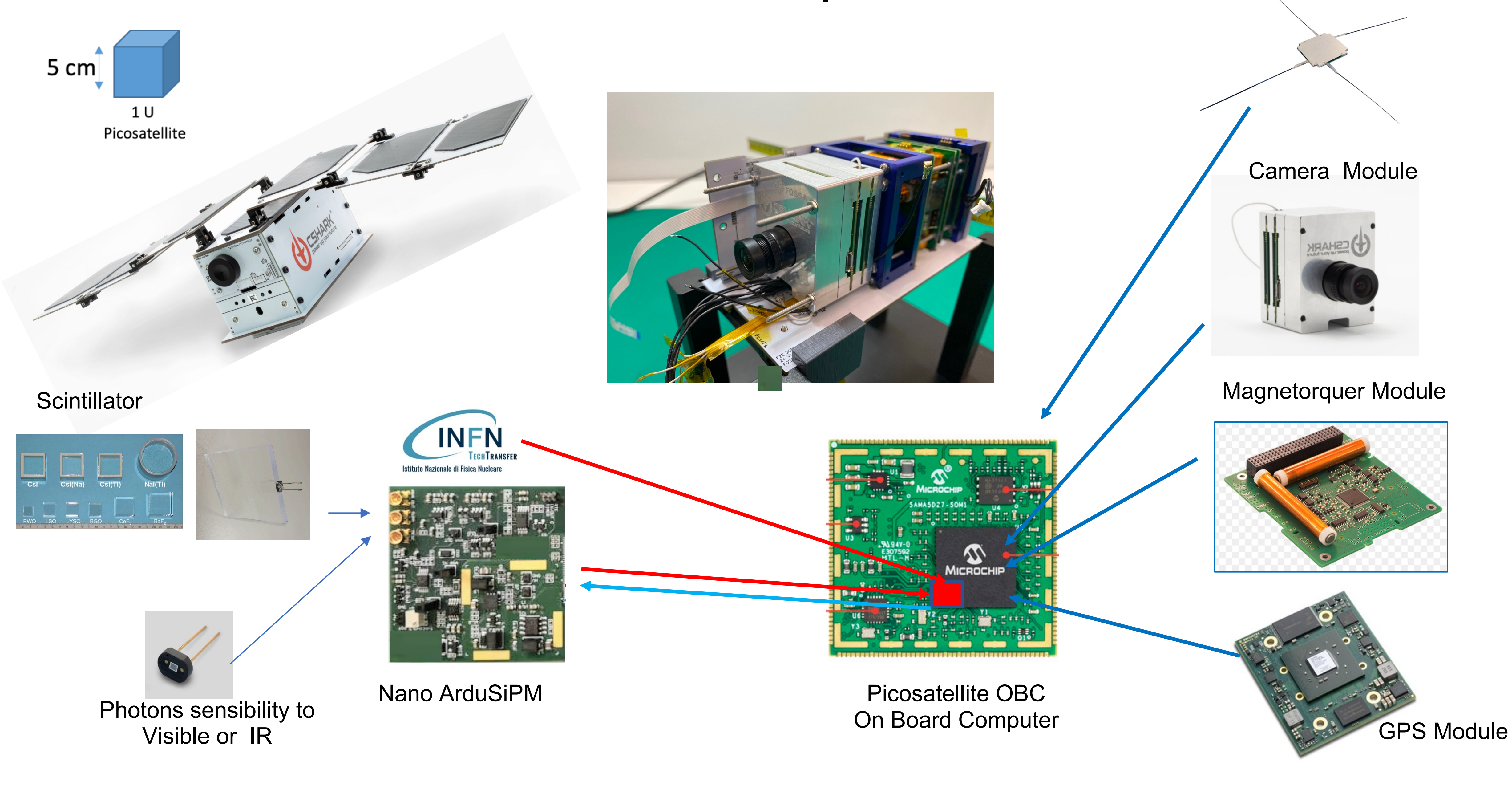
Cubesat LEO or MEO

Euso SPB2 33 Km Ballon



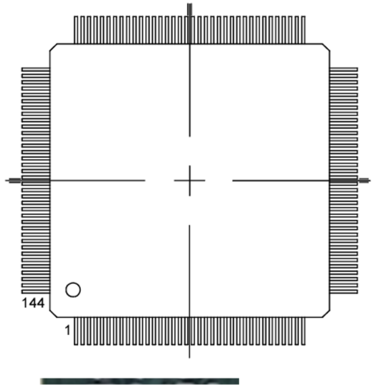
- 0.1 CubeSat Unit occupancy
- 2 channels
- Weigh 42 grams
- Low Power consumption <1Wh
- Rad-tolerant version of MCU availability on market

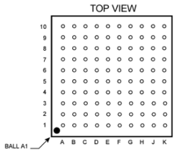
Next STEP picosatellite



Nano ArduSiPM Gen3 (2023)

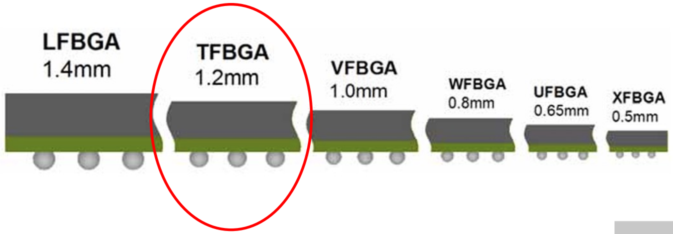
22 mm

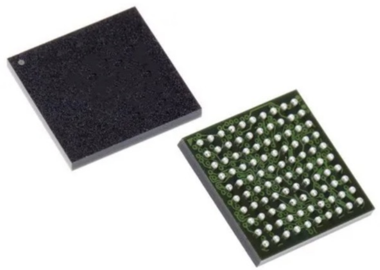


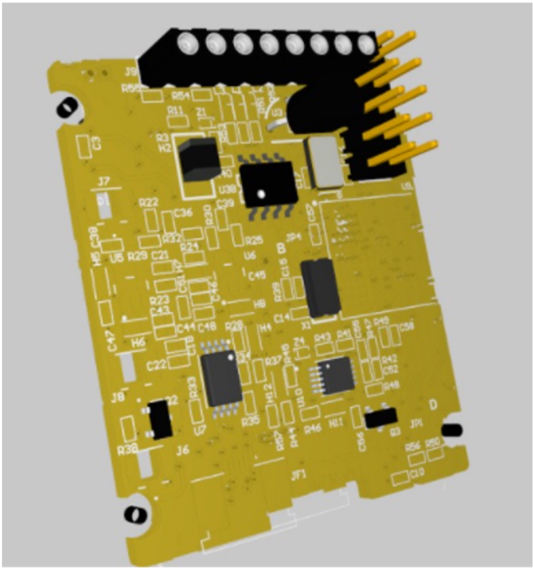


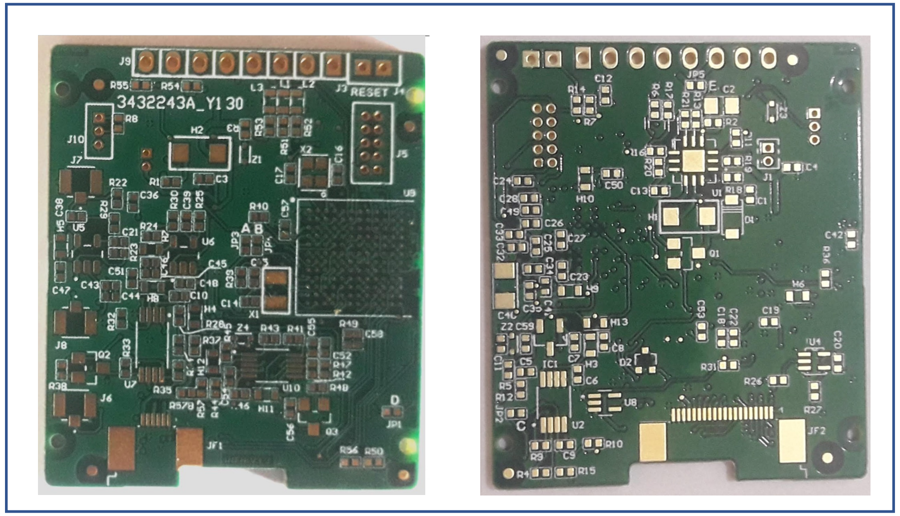
9 mm

TFBGA (**Thin Fine-Pitch Ball Grid Array**)









50 mm

Evoluzione Tecnologia ArduSiPM

GEN1

1 channel
ArduSiPM (TT 2014)

2 x 100 mm x 50 mm

2x 55 cm^2
100g/ch

GEN2

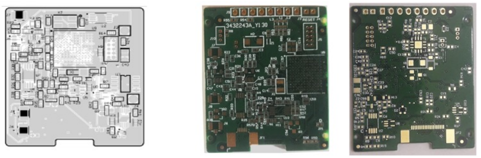
1 channel
Half Cosmo
ArduSiPM (2021)

100 mm x 50 mm

50 cm^2
21 g/ch

GEN3

1 channel
Nano ArduSiPM
(2023)

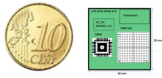


50 mm x 50 mm

25 cm^2
10 g/ch

GEN4

2 channel
LITE SPLD (2026)



20 mm x 20 mm

2 cm^2/ch
3 g/ch

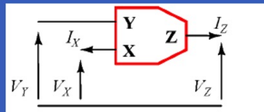
Decremento della dimensione e peso
Del singolo canale

Istituto Nazionale di Fisica Nucleare

SEZIONE DI ROMA TOR VERGATA

LITE – SLPD – il CHIP (1/2)

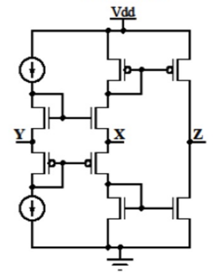
L'idea è partire da un progetto di chip 'Front-End per MPPC' già sviluppato, che include tutte le funzionalità analogiche di GEN2 ed è ottimizzato in termini di dimensioni e numero di canali. Il chip iniziale era destinato alle applicazioni TOF e dovrà essere modificato (in modo significativo), pur mantenendo la tecnologia scelta per la convenienza economica e la conoscenza del design.



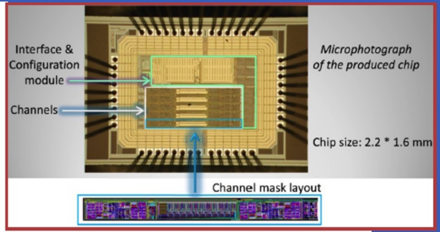
$$\begin{bmatrix} I_Y \\ V_X \\ I_Z \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} V_Y \\ I_X \\ V_Z \end{bmatrix}$$

Second generation Current Conveyor
Block representation and main ideal characteristics

CCII CMOS



Conventional version based on current mirrors



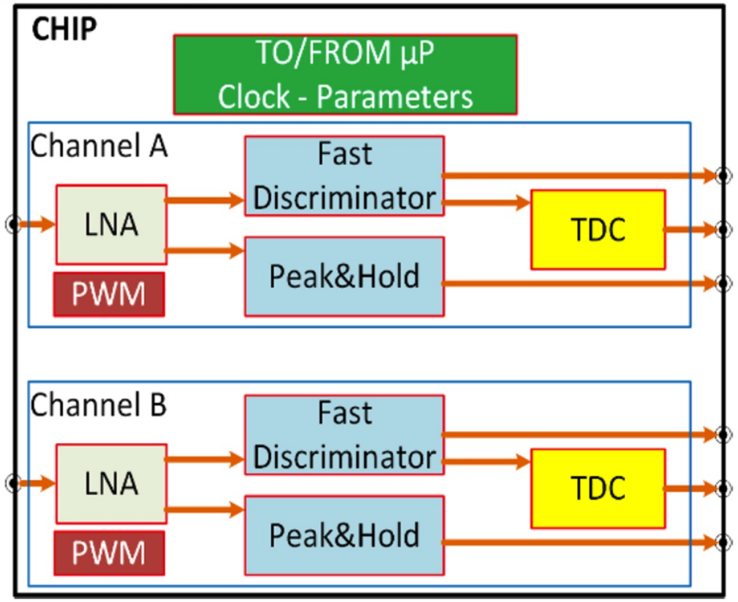
FULL-CUSTOM

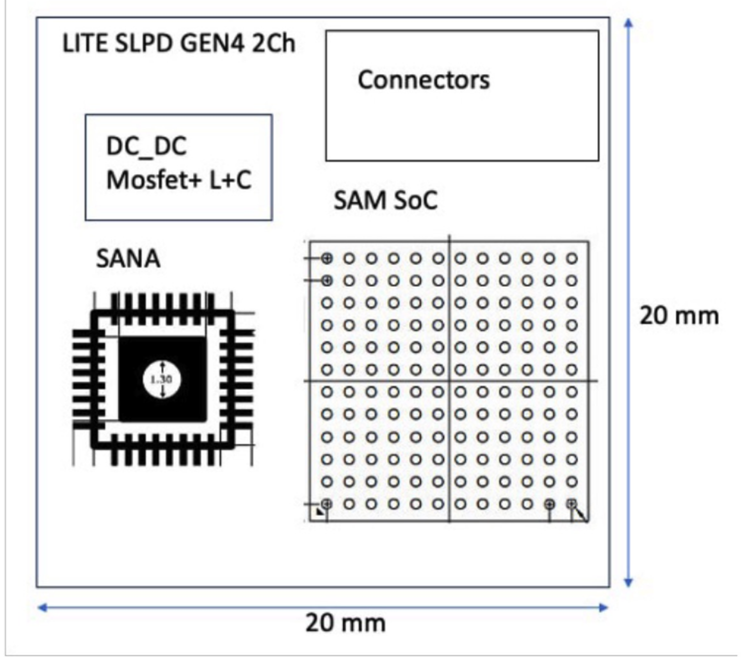
Front-End chip for MPPC in tecnologia standard CMOS 0.35 um:

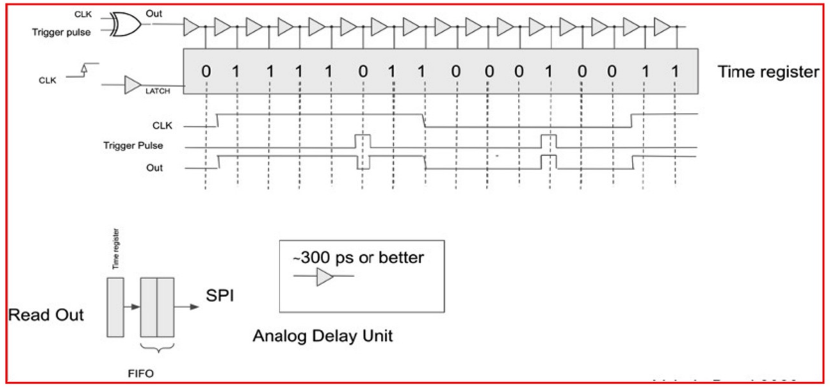
- Bassa impedenza di ingresso al fine di ridurre il tempo di ripristino il più possibile
- Tutti i segnali e le soglie sono processati nel dominio della corrente utilizzando comparatori di corrente veloci e una versione modificata dei Conveyors di Corrente di seconda generazione (CCII) basati su specchio di corrente come blocchi di costruzione per gli amplificatori.

The pilot chip

LITE – SLPD – il CHIP (2/2)



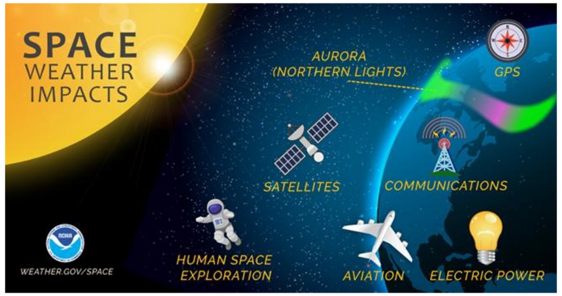




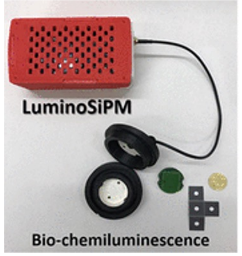
Una delle innovazioni e caratteristiche peculiari introdotte da questo chip è il TDC segmentato (Convertitore Tempo-Digitale segmentato), che consente un miglioramento della risoluzione temporale pari a una frazione del clock utilizzato.

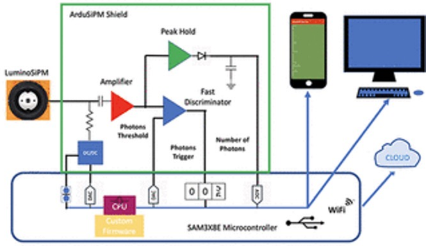
I rivelatori ottenuti sono compatti e leggeri possono essere utilizzati in vari campi
in MICRO individuati due tipologie principali di applicazioni lasciando aperto l'utilizzo all'interno della comunità HEP.

Rivelatore di particelle a scintillazione
Applicazione in cubesat o picosatellite.
Orbita LEO.
Monitoraggio delle radiazioni in picosatellite
e in costellazioni di picosatelliti (Space Weather)



Rivelatore di flussi di fotoni
Bioluminoscenza per strumentazione
portatile da usare nel campo
(user : Chimica Analitica Univ. Bologna,
CNR IMM)





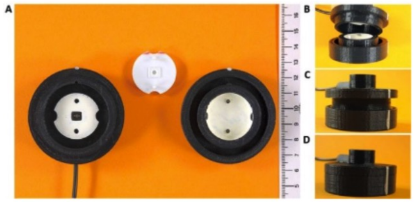


Figure S1. (A) The three components of LuminoSiPM dark box. (B) The assembly of sample holder in the dark box. (C) Mechanical protrusions and complementary alignment holes guarantee light tightness. (D) The box closed and ready for measurement.

Fisica delle particelle: Dispositivi portatili per trigger.
Tutti i casi dove si ha un rivelatore distribuito in cui i SiPM sono accessibili con cavi e non si trae vantaggio nell'utilizzo di chip multicanali.

Test dell’elettronica e del sistema di comunicazione tramite palloni stratosferici Light

Esperienza sul campo in sinergia con scuole e OCRA C3M

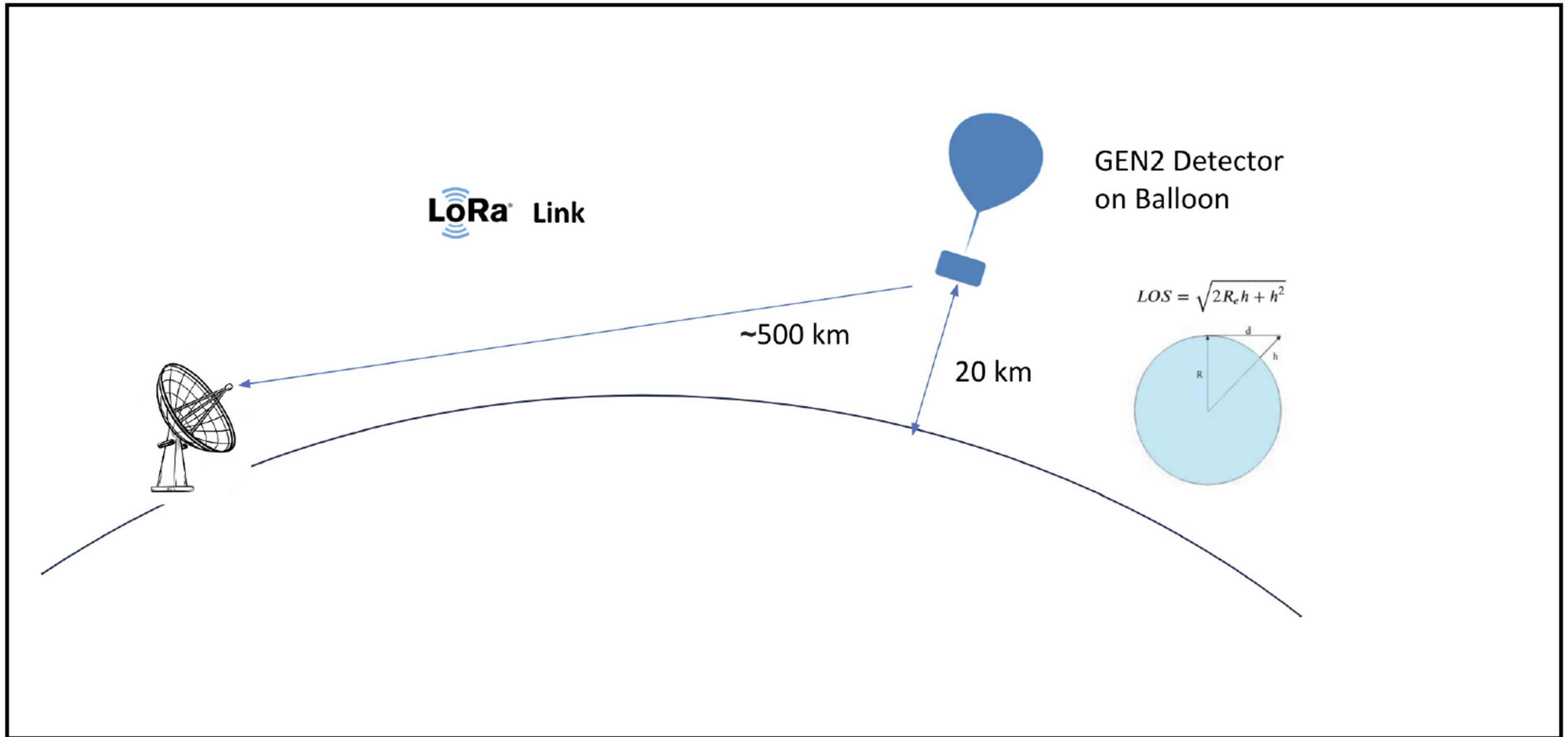


Fig. 5. Utilizzo del pallone stratosferico per test rivelatori in quota e test trasmettitori LoRA per orbita LEO trasmissione dati a terra.

EOS
Participating parties: INFN Roma, ABproject, Istituto "A. Russo" Nicotera

Launch Location: Nocera Scalo (CZ) Italy (Lat:39.02693,Long:016.10657)

Launch time: 09:04:24 UTC June 30, 2018

Max altitudine: 27000 meters

Landing Location: Badolato Marina (CZ) Italy (Lat:38.57403,Long:016.60350)

Landing Time: 10:38:12 UTC June 30, 2018,

Crow flies distance: 66.5 Km

MoCRiS (Measurement of Cosmic Ray in Stratosphere)

Participating parties: INFN Roma, ABproject, Liceo Scientifico Cariati

Launch Location: Camigliatello Silano (CS) Italy (Lat:39.36704, Long:16.48968)

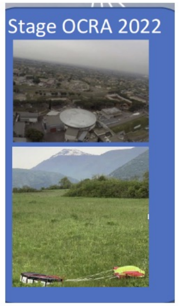
Launch time: 09:22:48 UTC June 8, 2019

Max altitudine: 34.111 meters

Landing Location: Parenti (CS), Italy, (Lat:039.15436,Long:16.40214)

Landing time: 11:09:30 UTC June 8, 2019

Crow flies distance: 24.8 Km



Stage INFN OCRA 2022
Participating parties: INFN OCRA,INFN Roma, ABproject

Launch Location: INFN Laboratori Nazionali di Frascati (LNF) (RM) Italy (Lat:041.82436,Long: 012.67331)

Launch time: 09:02:24 UTC 5 May, 2022

Max altitudine: 28381 meters

Landing Location: Capistrello AQ Italy (Lat:42.00009,Long:13.40148)

Landing Time: 10:32:54 UTC 5 May, 2022
Crow flies distance: 63.4 Km

MiraCosmos 2022
Participating parties: Liceo Scientifico R. Steiner Milano,INFN Roma, ABproject

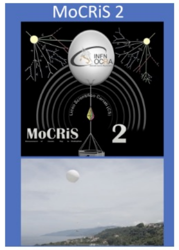
Launch Location: Abbazia Mirasole, Opera (MI) Italy (Lat:045.38743,Long: 09.20188)

Launch time: 09:11:06 UTC 27 Sep, 2022

Max altitudine: 30225 meters

Landing Location: Alfiano Nuovo (CR) Italy (Lat:42.00009 045.23732,Long: 010.13041)

Landing Time: 10:48:42 UTC 27 Sep, 2022
Crow flies distance: 74.4 Km



MoCRiS2 2023

Participating parties: INFN Roma, ABProject Space, Liceo Scientifico Cariati, Dipartimento di Fisica UNICAL, ADA Project Laboratory, ArpaCal, Lab. Fisico E. Majorana, Catanzaro, OCRA Collaboration

Launch Location: Stadio Comunale di Paola (CS) Italy (39°22'24"N 16°1'40"E)

Launch time: 09:00:00 UTC June 14, 2023

Max altitudine: 33.205 meters

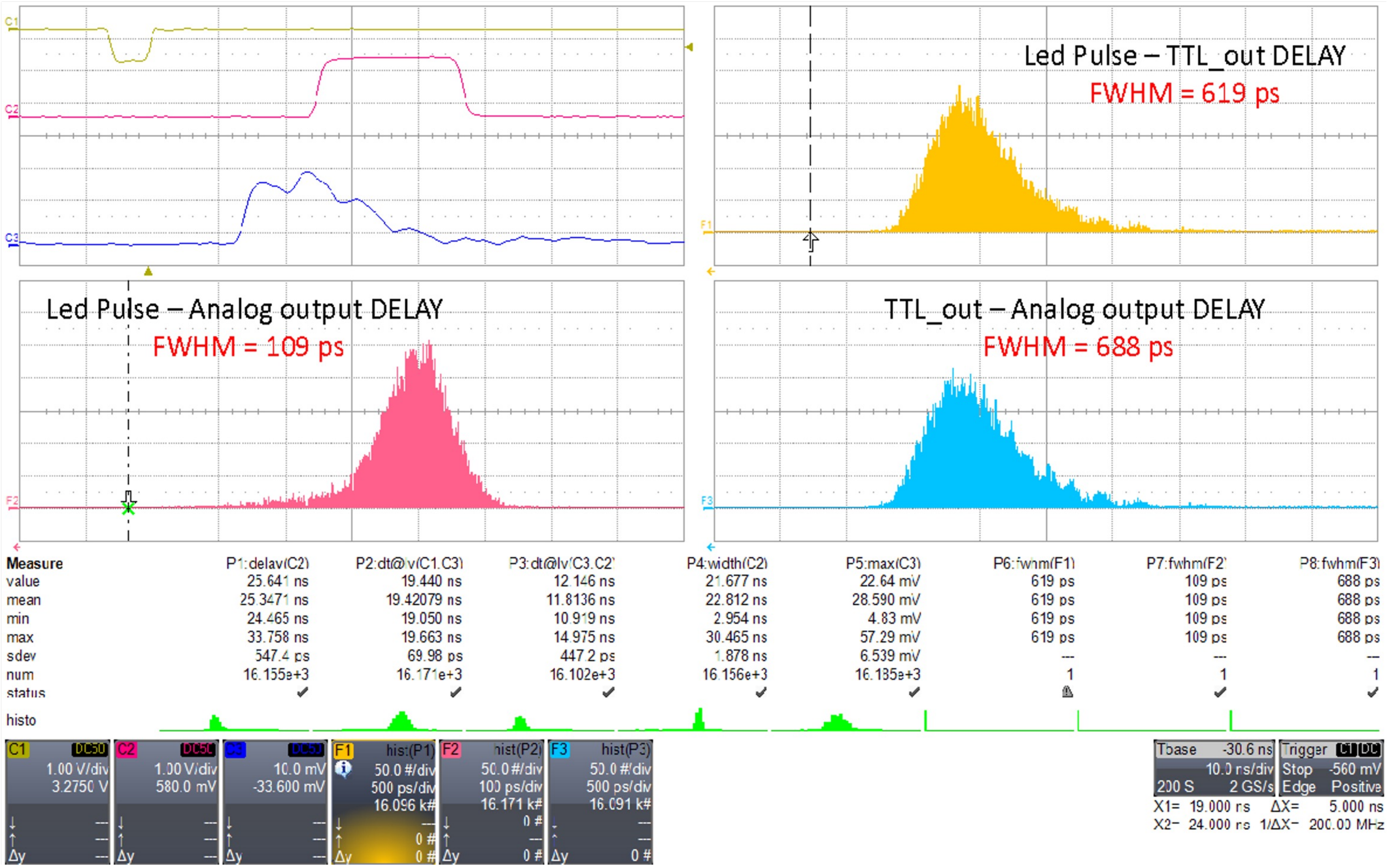
Landing Location: Acri (CS), Italy, (Lat: 39,4679 ,Long: 16,4917)

Landing time: 10:40:00 UTC June 14, 2023

Crow flies distance: 46 Km

Timing Measuraments

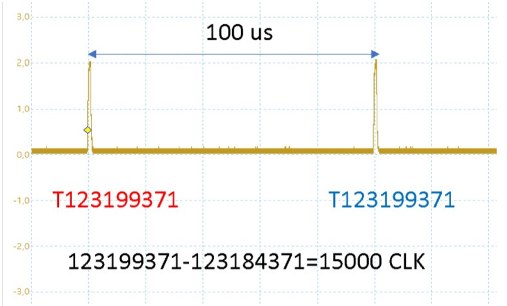
Sync signal from LED driver — CosmoArduSiPM TTL Output — CosmoArduSiPM Analog Autput



TTL_out jitter ~ 600ps

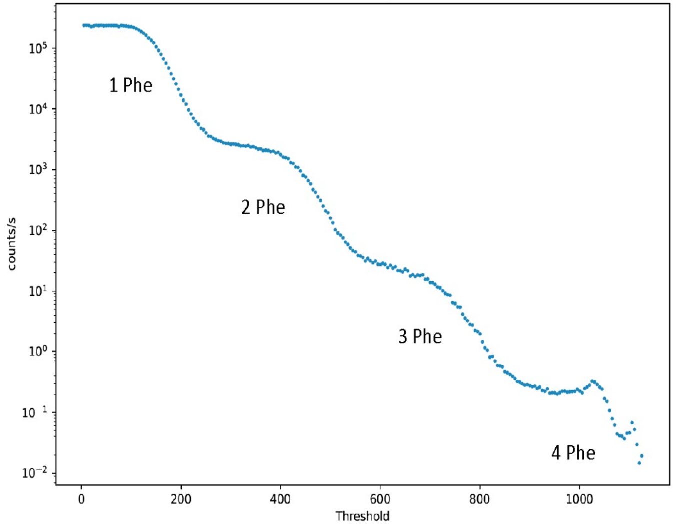
worse than oscilloscope but better than internal TDC resolution

Maximum CosmoArduSiPM time resolution:
TDC_CLK= CPU_CLK/2 = 150 MHz → 6.6 ns

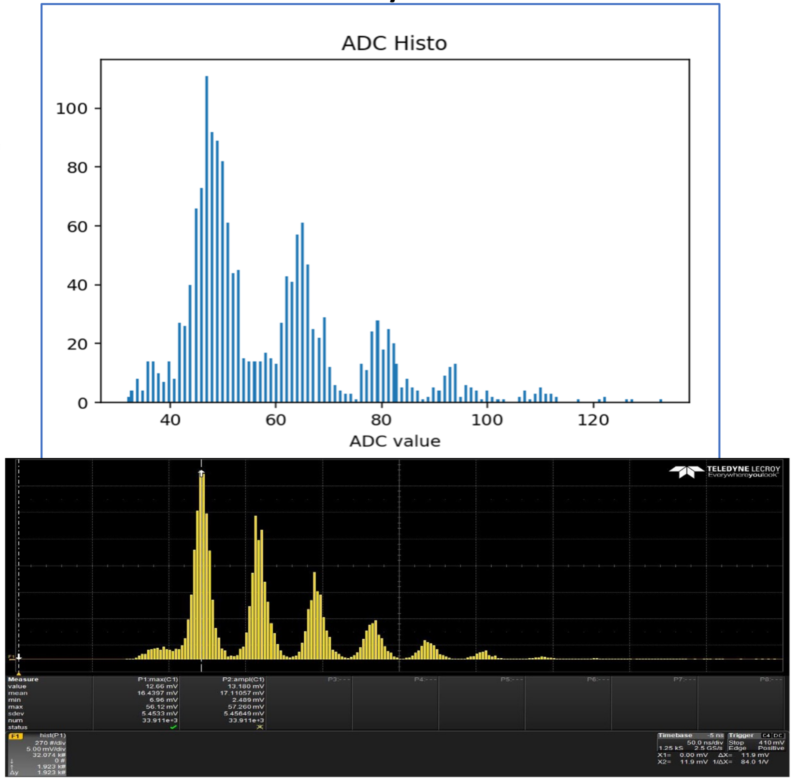


Performance dei rivelatori di GEN2 (Cosmo ArduSiPM)

Threshold Scan Plot

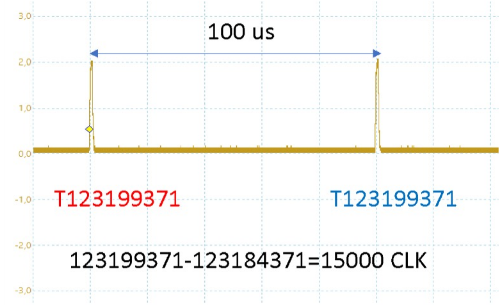


Istogramma Spettro di fotoni visti dall’ADC vs Scope Le Croy



Misure di tempo sincronizzabili con sistema GPS

Maximum CosmoArduSiPM time resolution:
TDC_CLK= CPU_CLK/2 = 150 MHz 6.6 ns



Tecnologia ArduSiPM
ALL-IN-ONE SiPM based detector

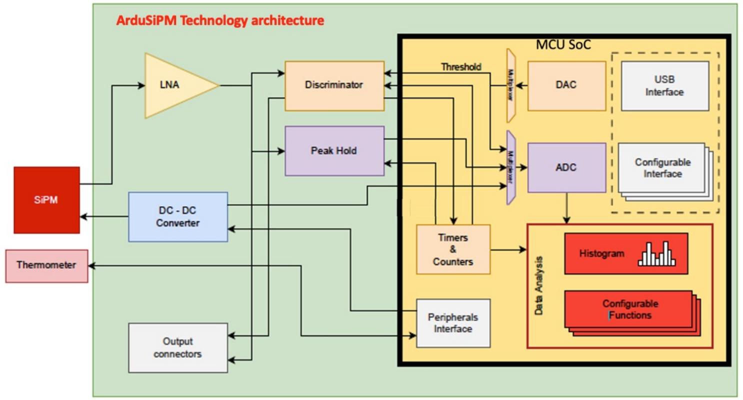
Introduzione alle Tecniche di Trigger e Data Acquisition in Esperimenti di Fisica

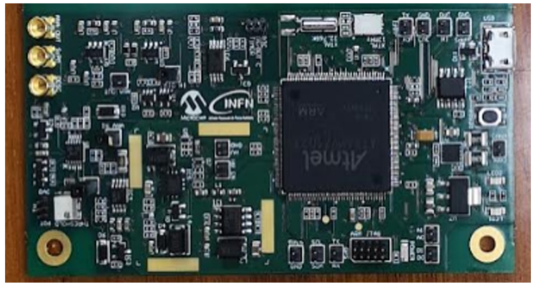
Napoli 9-12 Ottobre 2023

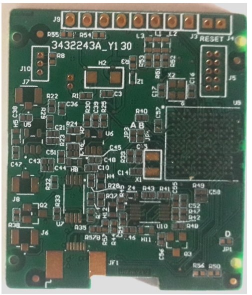
Valerio Bocci

INFN Roma

Valerio.bocci@roma1.infn.it







2 Ch. LITE-SPLD GEN4 Board (2026)