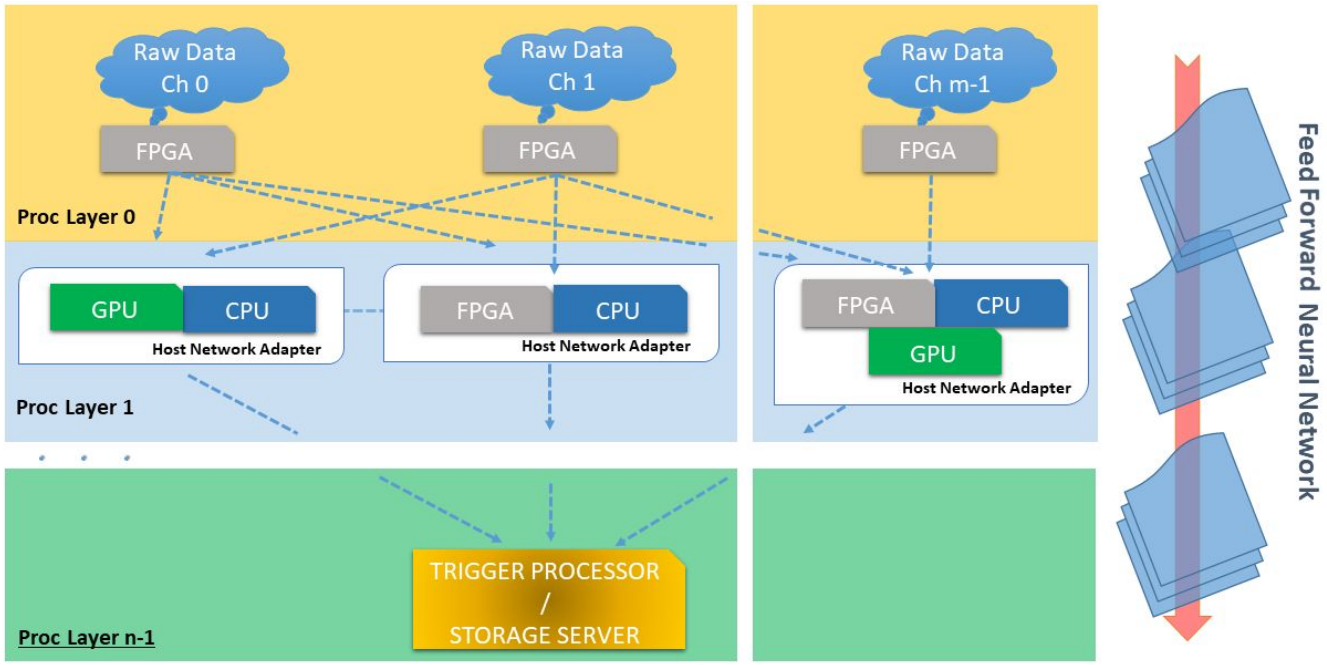
APEIRON rationale

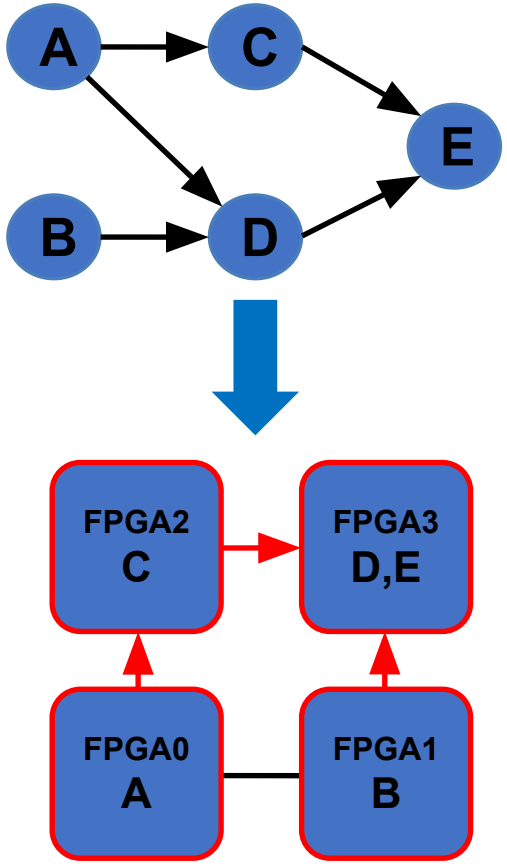
Abstract **P**rocessing **E**nvironment for **I**ntelligent **R**ead-**O**ut systems based on **N**eural networks



- Input data from several different channels (data sources, detectors/sub-detectors).
- **Data streams** from different channels recombined through the processing layers using **a low-latency, modular and scalable network infrastructure**
- Distributed online processing on heterogeneous computing devices in *n* subsequent layers.
- Features extraction will occur in the first NN layers on FPGAs
- More resource-demanding NN layers can be implemented in subsequent processing layers.
- Classification produced by the NN in last processing layer (e.g. pid) will be input for the **trigger processor/storage online data reduction stage for triggerless systems**

APEIRON Goals

- Goal: offer hardware and software support for the execution on a system of **multiple interconnected FPGAs of applications developed according to a dataflow programming model**
- Map the directed graph of tasks on the distributed FPGA system and offer runtime support for the execution.
- Allow users with no (or little) experience in hardware design tools to develop their applications on such distributed FPGA-based platforms
  - Tasks are implemented **in C++ using High Level Synthesis tools (Vitis).**
  - Simple **Send/Receive** C++ communication API.

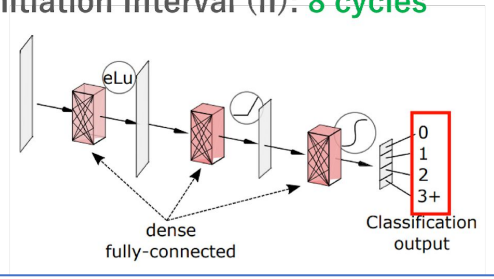


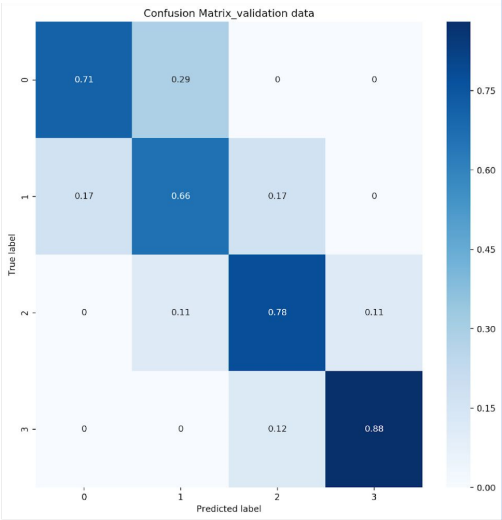
APEIRON 2022

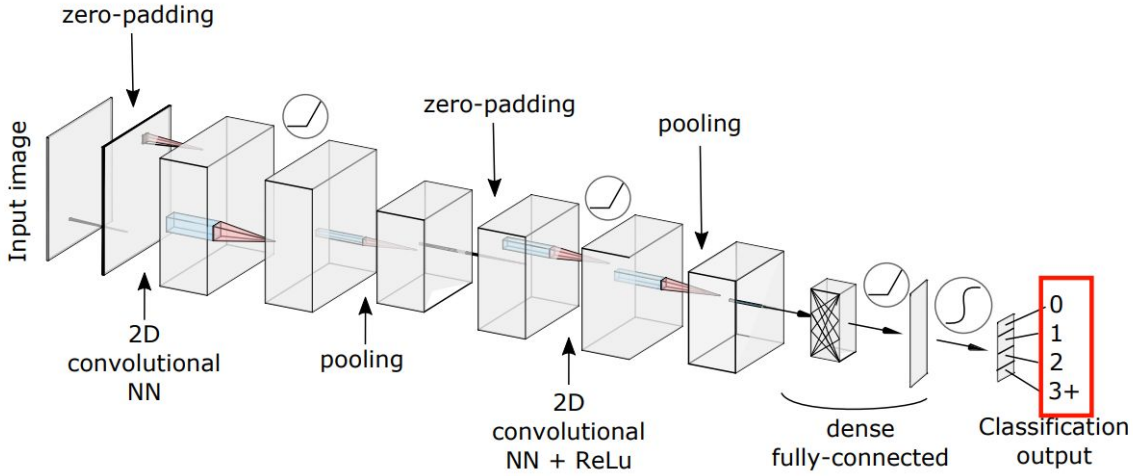
- **Attività in completa sinergia con il progetto H2020-JTI-EuroHPC-2019-1 “TEXTAROSSA”.**
- **Sviluppate tutte le componenti hardware necessarie e lo stack software.**
- **Validazione tramite use case NA62 RICH pattern matching ed altri test.**

Fully Connected

- Input: 64 hits per event
- Architecture: 3 fully connected layers
- Output: 4 classes (0, 1, 2, 3+ rings per event)
- Qkeras, quantization aware training:
  - ~75% average accuracy with low resource usage: LUT 14%, DSP 2%, BRAM 0% (VCU118)
- Latency: 22 cycles @ 150MHz
- Initiation Interval (II): 8 cycles



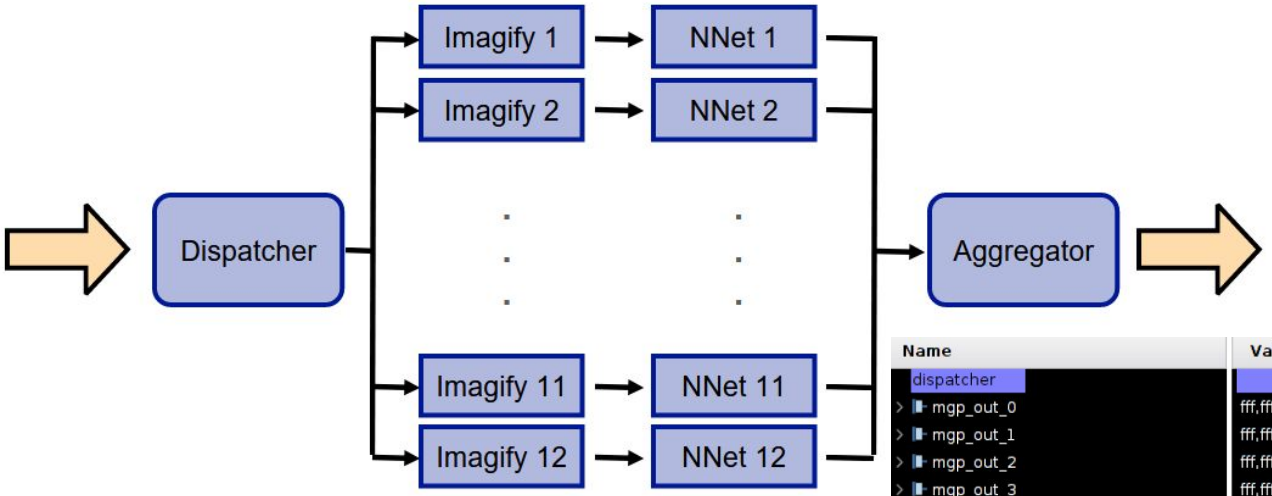




- Input: PMT channels into image 16x16 pixels
- Architecture: 2 conv layers and 2 dense
- Output: 4 classes (0, 1, 2, 3+ rings per event)
- Qkeras, quantization aware training:
  - ~83% average accuracy with low footprint: LUT 5.2%, FF 1.5%, DSP 4.8%, BRAM 0.05% (Alveo U200)
- Latency: 388 cycles @ 220MHz
- Initiation Interval (II): 369 cycles

Convolutional model – Kernel replication

Throughput is not enough to sustain L0 rate, but we can replicate the network multiple times, also on multiple devices if necessary.



Resources usage for 12 replicas:

- LUT 74%
- FF 17%
- DPS 61%
- BRAM 1.4%

Processing time @220MHz: 137 ns per event

APEIRON 2023 TOR VERGATA

Richiesta estensione di 1 anno per terminare tutti gli sviluppi e le collaborazioni con i progetti europei

Attività RM2:

1. Collaborazione sviluppo dell'Host Interface: testbed di simulazione multinodo, logica di trasmissione dati
2. Collaborazione con progetto INTEFF_APECAST (finanziato MISE) per sviluppo congiunto sull'Host Interface: trasmissione dati di tipo collettivo
3. Sviluppo di blocchi di accelerazione hardware, tipo FFT in floating point doppia precisione

Anagrafica RM1: 1.6 FTE
Anagrafica RM2: 0.2 FTE

- Roberto Ammendola 20%

Richieste Finanziarie

- Missioni: 2k€

Richieste Servizi Sezione

Non previste

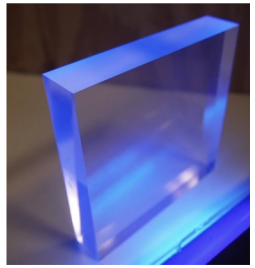
MICRO

(co**M**pact-electron**I**cs so**C** pa**R**ticle-detectors and bi**O**luminesceNce)

INFN Roma: Valerio Bocci (Responsabile Nazionale),Francesco Iacoangeli
INFN Roma2: Davide Badoni (Responsabile Locale) , Marco Casolino, Laura Marcelli, Matteo Salvato, Gianmaria Rebustini

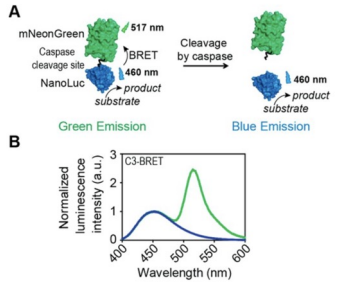
Sviluppo di rivelatori All-In-One (detector, elettronica, daq), utilizzando sistemi su circuiti integrato (SoC) commerciali di ultima generazione, per la rivelazione di particelle o la misura di flussi di bio(luminescenza).

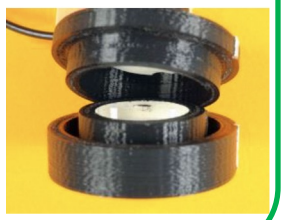
Scintillator o Cherenkov radiator



~3-100 photons in few ns

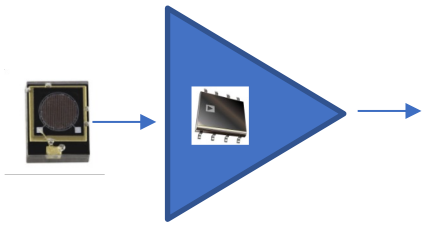
Bio(luminoscence) flux measurements

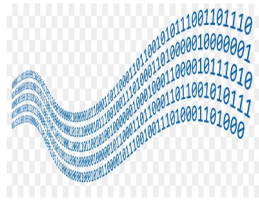




~10^5-10^6photons/s

MICRO device





Risultati ottenuti nelle applicazioni di bioluminoscenza

Attività con il Gruppo di Chimica Analitica Uni Bologna (Prof. Michelini)

- Pubblicazione su una delle maggiori riviste del settore **Analytical Chemistry**
- **Impact Factor 7**

DOI:10.1021/acs.analchem.1c00899

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*

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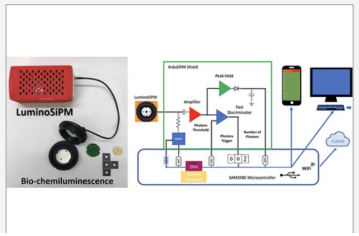
SUBJECTS: Bioluminescent probes, Sensors, Peptides and proteins, Light, Calibration

Analytical Chemistry

Abstract

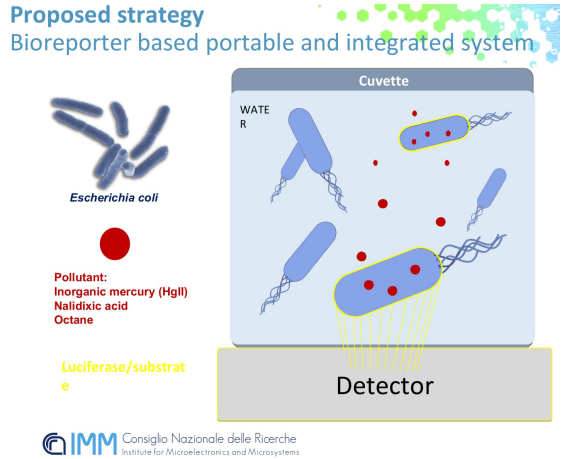
The availability of portable analytical devices for on-site monitoring and rapid detection of analytes of forensic, environmental, and clinical interest is vital. We report the development of a portable device for the detection of biochemiluminescence relying on silicon photomultiplier (SiPM) technology, called LuminoSiPM, which includes a 3D printed sample holder that can be adapted for both liquid samples and paper-based biosensing. We performed a comparison of analytical performance in terms of detectability with a benchtop luminometer, a portable cooled charge-coupled device (CCD sensor), and smartphone-integrated complementary metal oxide semiconductor (CMOS) sensors. As model systems, we used two luciferase/luciferin systems emitting at different wavelengths using purified protein solutions: the green-emitting *P. pyralis* mutant Ppy-GR-TS (λ_{max} 550 nm) and the blue-emitting NanoLuc (λ_{max} 460 nm). A limit of detection of 9 femtomoles was obtained for NanoLuc luciferase, about 2 and 3 orders of magnitude lower than that obtained with the portable CCD camera and with the smartphone, respectively. A proof-of-principle forensic application of LuminoSiPM is provided, exploiting an origami chemiluminescent paper-based sensor for acetylcholinesterase inhibitors, showing high potential for this portable low-cost device for on-site



Ulteriori sviluppi sono sotto studio utilizzando un nuovo Hardware più performante (controllo fine a basso valore della soglia)

Attività con il Gruppo CNR IMM (Dott. Libertino)

Utilizzo di batteri geneticamente modificati bioluminoscenti per ricerca contaminazione di mercurio nelle acque



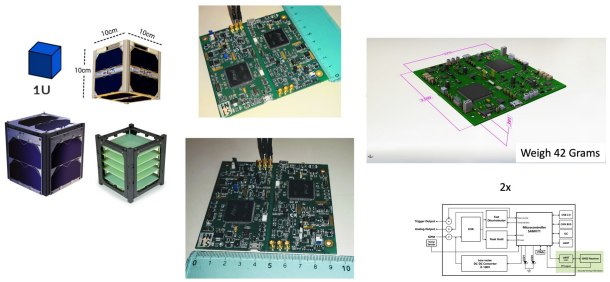
- Batteri geneticamente modificati per assorbire mercurio ed emettere luce durante tale assorbimento OK
- Realizzazione dell'holder per utilizzare i nostril SiPM OK
- Inizio prime misure OK
- Problemi nel lavorare a bassa soglia con il Vecchio Hardware (in attesa del nuovo).
- Rottura Incubatore in attesa di riparazione

Risultati nelle applicazioni di rivelatori particelle ALL-in-ONE spazio/ esperimenti terra

CubeSat

Talk 15th Pisa meeting e paper NIM A

Cosmo ArduSiPM
a double channel PC104 Board (0.1 U)



ArduSiPM technology: compact and light All-in-One detectors for space application

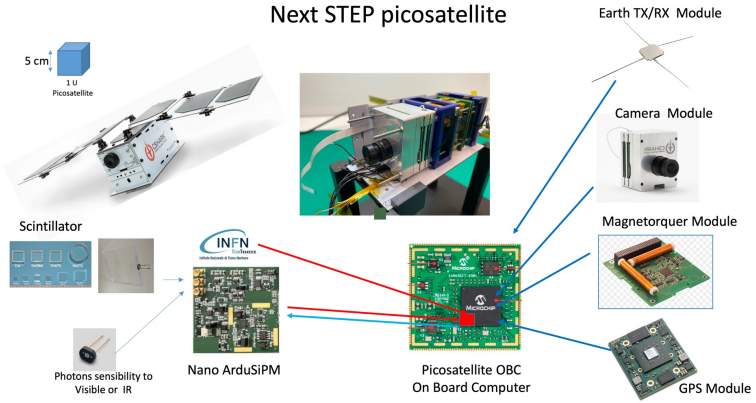
Valerio Bocci[a,*], Babar Ali[c,d], Davide Badoni[b], Marco Casolino[b], Giacomo Chiodi[a], Francesco Iacoangeli[a], Dario Kubler[c], Laura Marcelli[b], Luigi Recchia[a], Matteo Salvato[b]

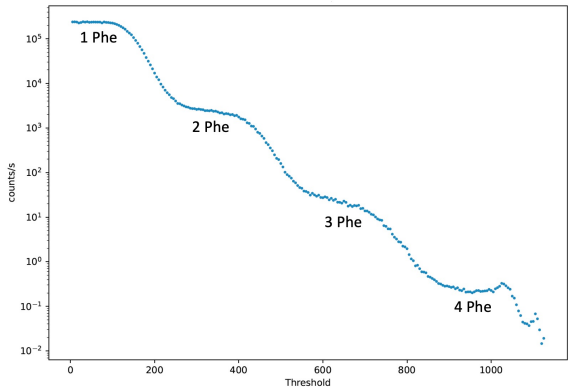
[a] INFN Sezione di Roma, Rome, Italy
[b] INFN Sezione di Roma "Tor Vergata"., Rome, Italy
[c] Microchip Technology, Milan, Italy
[d] Sapienza University of Rome, Rome, Italy

Abstract

The ArduSiPM technology join the innovation of the system on a chip (SoC) and the simultaneous improvement of Silicon photo-multiplier detectors in a new generation of all-in-one scintillation detector conceived from INFN Rome since 2014. The basic idea

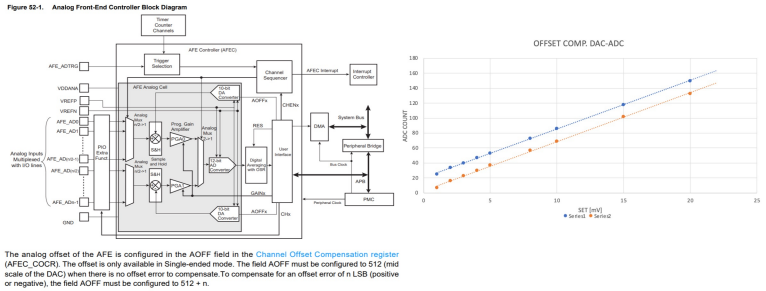
Next STEP picosatellite



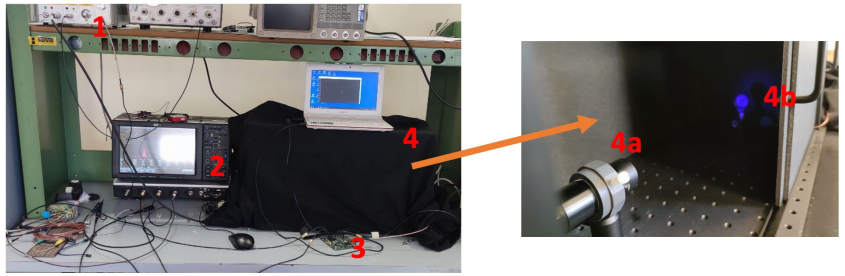


Soglia sotto il fotoelettrone

ADC internal offset compensation



- Test Hardware e scrittura firmware della scheda Cosmo ArduSiPM.



IE

Richiesta di prolungamento su dotazioni, motivazioni e richieste specifiche

- Lo scorso anno sono stati effettuati ordini per ulteriori prototipi ma causa ChipShortage mondiale tali ordini sono in forte ritardo, al momento senza data di consegna.

- Abbiamo già preventivamente discusso con i referee per un prolungamento di MICRO su dotazioni con lo stesse persone e FTE.

		Cost (euro)	QTY	TOT
Consumo	SiPM tipo HM-S13360-1325CSMPPC	100	10	1k
Inv.	Digital discovery	0.35 k	1	4 k
	Oscilloscopio Pico Technology PC based, 4+16 canali, 200MHz, Cert. ISO	3.5 k	1	
Missioni				2k

La strumentazione richiesta è specifica necessaria ed a completamento del banco ottico di test per coprire i tipi di schede prodotte.

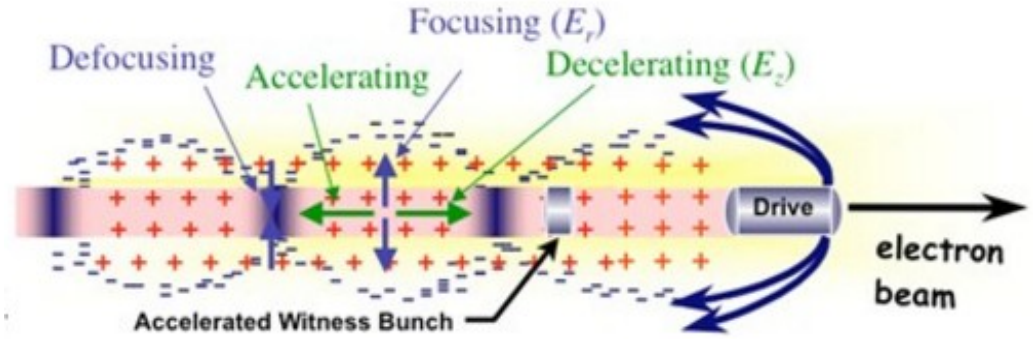
SL_COMB2FEL

(Resp. Naz.: E. Chiadroni, LNF)

Sezioni coinvolte:

LNF (Resp. Loc.: E. Chiadroni),
Roma (Resp. Loc.: A. Mostacci),
Roma Tor Vergata (Resp. Loc.: A. Cianchi)
Lecce (Resp. Loc.: A. Lorusso),
Napoli (Resp. Loc.: R. Fedele)

Why SL_COMB2FEL

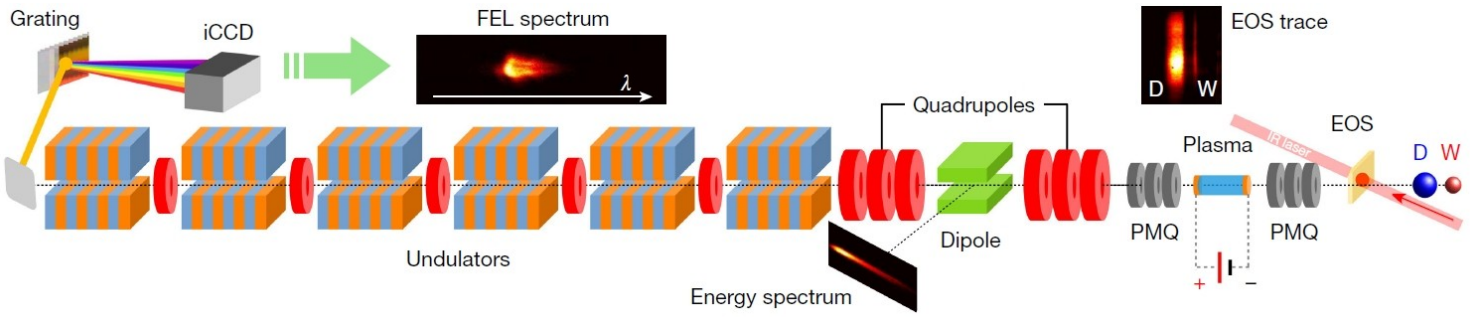


In this scheme a driver beam creates a plasma wake, while a witness bunch is accelerated in the back of the plasma bubble. The aim of the experiment is:

- Demonstration of high-quality plasma accelerated electrons beam through the final measurement of the FEL gain curve
- Miniaturization of ancillary components to move towards a compact facility (accelerating modules, diagnostics, measurement stations, beam position monitors)
- **R&D on diagnostics**
- Path towards EuPRAXIA@SPARC_LAB test user facility (founded with 110 Meuro)

Recent BIG achievement

- First ever evidence of FEL lasing with a beam plasma accelerated.
- Paper published in Nature



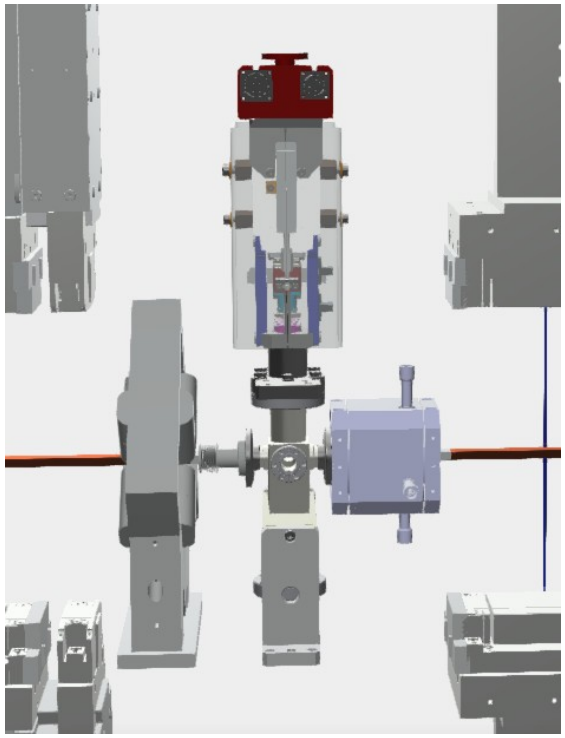
Pompili, R., et al. "Free-electron lasing with compact beam-driven plasma wakefield accelerator." *Nature* 605.7911 (2022): 659-662.

PNRR in the same framework

- EuAPS (EuPRAXIA Advanced Photon Source) has recently won the PNRR call for infrastructure
- We are arrived 1st in Italy
- The project foresees the construction of a compact, fast X-rays source @LNF driven by betatron radiation produce in plasma acceleration

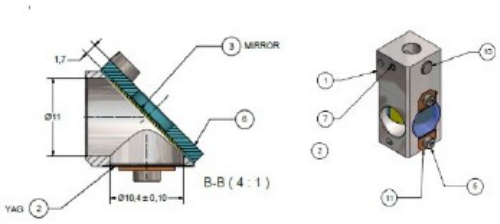
Intra-undulator diagnostics

- It is fundamental to improve the intraund-ulator diagnostics.
- In the current configuration at SPARC_LAB we cannot test view screen+cavity BPM between undulator modules
- There is not enough space for transitions between different pipes
- There are constrains that prevent to increase this space, for instance moving the undulator modules
- We can test just the view screen alone or the cavity BPM alone.
- We decided to test the view screen



E. Di Pasquale

Insert a new compact view screen



Courtesy Valerio Lollo

- Improved version of crystal holder
- Reduction of overall length
- Two new scintillator materials,GAGG: Ce and YAP.
- Higher saturation with respect to YAG:Ce
- Between GAGG and YAP the best in these terms seems the YAP but it also has an emission at 370 nm, which is at the limit of the quantum efficiency of normal cameras that we use.

2023 request

- 20k equipment (actuator, electronics, vacuum chamber, crystal)
- 4k travel
- 3 FTE (Cianchi, Catani, Galletti 100%)

MC-INFN

La sigla MC-INFN riunisce le comunita’ che lavorano sui codici MonteCarlo Geant4 e FLUKA

La sezione di Tov partecipa all’attivita’ FLUKA

Il lavoro e' rivolto sia allo sviluppo di tools per il codice, sia alla simulazione, come utenti, di diversi esperimenti .

SVILUPPO

L'attivita' si concentra su tools per la trattazione 'point wise' delle interazioni di neutroni di bassa energia. In particolare è in corso l’implementazione di codice per la riproduzione dei prompt gamma emessi in reazioni di cattura di neutroni lenti.
Spesso i dati disponibili nei DB sono incompleti e riportano solo la parte dello spettro gamma di minore energia. Il goal è predire con il MC la parte di spettro non misurata, riproducendo al tempo stesso in maniera corretta i livelli di bassa energia ed I relativi branching ratios.

Uso da utenti

- Simulazione completa dell'esperimento ALTEA-LIDAL (ASI), in acquisizione dati sulla ISS.

- Partecipazione alla simulazione dell’ esperimento FOOT (INFN-CSN3) per la misura di sezioni d'urto rilevanti per l'adroterapia e la radioprotezione nello spazio.

ANAGRAFICA e PREVENTIVI 2023

- M.C.Morone, 30%

Le richieste finanziarie vengono effettuate dalla sola sezione di Milano, sede del coordinatore nazionale, per evitare residui nelle varie sezioni.