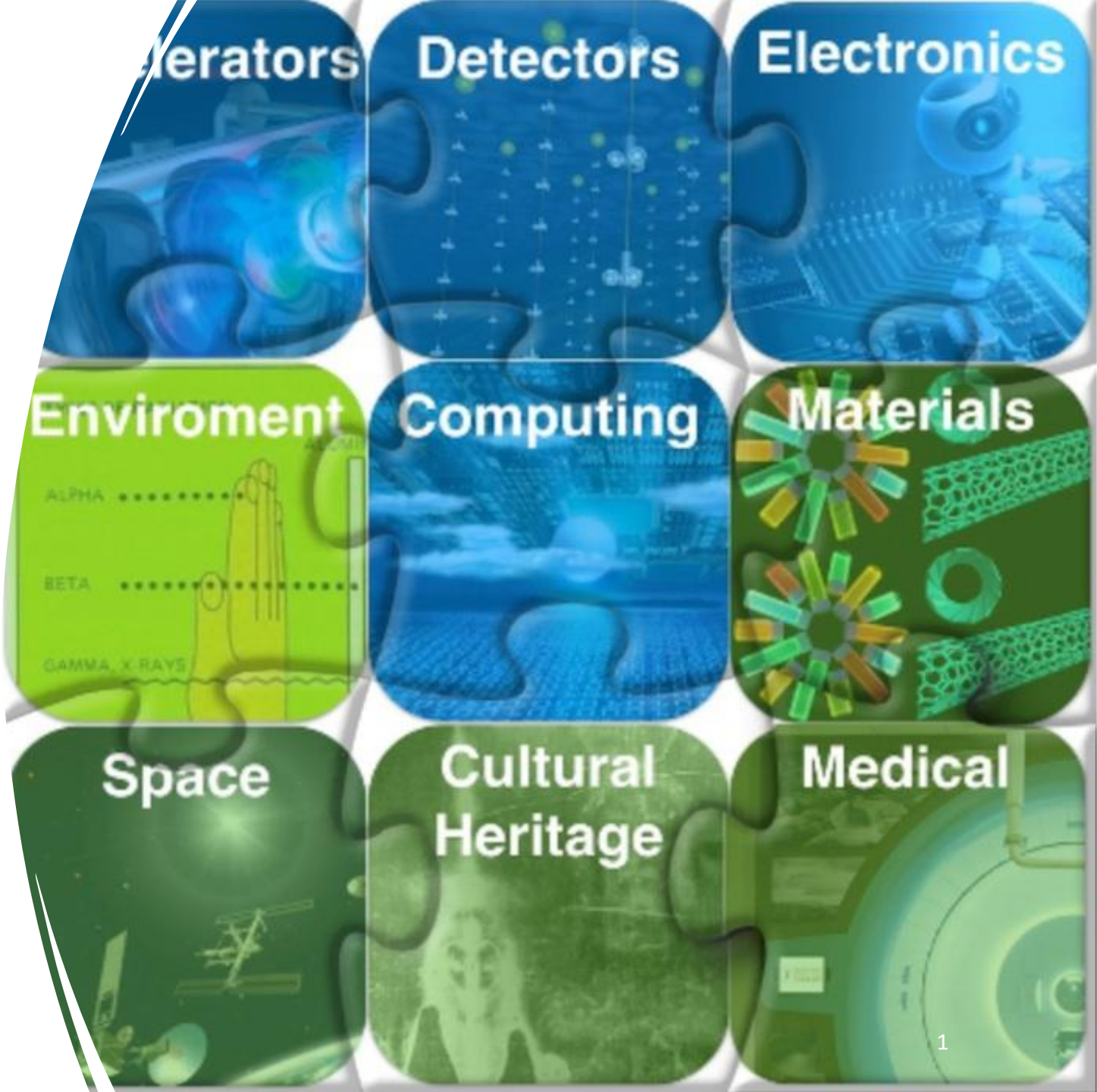
CSN5
Ricerca
Tecnologica

Commissione Scientifica Nazionale 5

Ricerche tecnologiche, interdisciplinari e di fisica degli acceleratori

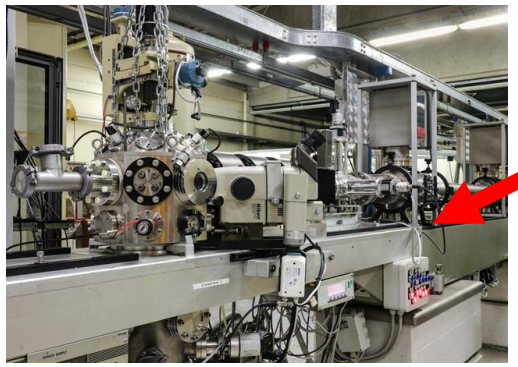


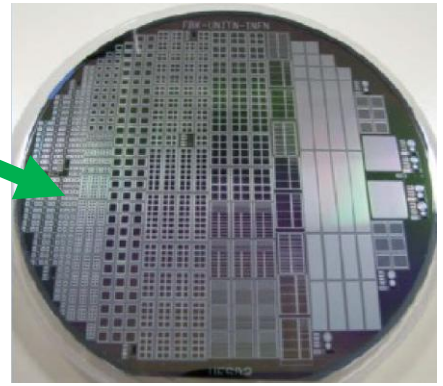
Linee di Ricerca in CSN5

INTERDISCIPLINARY

ACCELERATORS

DETECTORS AND ELECTRONICS





Numero di Sigle

➤ ~ 1300 ricercatori con ~ 600 FTE.

	2015	2016	2017	2018	2019	2020	2021
Standard Experiments	**53**	**48**	**57**	**59**	**60**	**62**	**83**
CALLs	3	6	7	6	6	6	9
GRANTs	9	12	12	12	12	13	19
TOT	**65**	**66**	**76**	**77**	**78**	**81**	**111**

	2022	2023	**2024**
Standard Experiments	**73**	**63**	**65**
CALLs	12	9	8
GRANTs	12	12	12
TOT	**97**	**84**	**85**

Categorie di Esperimenti

- **Sigle Standard**: progetti di 2-3 anni a budget medio-basso (∼ 50k€/y).
  - Incubatori di attività e idee promettenti.
  - Supporto ad attività di più ampio respiro di altre commissioni.
  - Possono avere livelli di rischio elevati.

- **Grant Giovani**: Esperimenti (max 75k€/y) di 2 anni per giovani (PhD ≤ 6y). Viene finanziata l'attività sperimentale e del PI
  - Supporto per giovani ricercatori che presentino idee originali.
  - Sostegno per l'autonomia scientifica e le capacità direzionali di giovani ricercatori.

- **Call**: Progetti ad alto budget e ampio network (∼1M€ max su 3y da bando).
  - Supporto alla formazione di network ampi per progetti di frontiera su argomenti strategici.
  - Finanziamento di Assegni di Ricerca…. **Non più dal 2025**

Timeline

Scadenze per i proposal:

- ***Call***: 31 Maggio
- ***Exp. Standard***: 5 Luglio (**entrambi necessitano approvazione in Consiglio di Sezione/Laboratorio per tutte le sezioni coinvolte**)

Riunione Luglio:

- ***Call***: Report del Panel esterno di valutazione
- ***Exp Standard***: Prima analisi dei proposal nella sottocommissione di afferenza
- Discussione e prima selezione per entrambi-Assegnazione Referee

Prima della riunione di Settembre:

Incontro proponenti-referee ed eventuale rimodulazione

Riunione Settembre :

- Presentazione in Plenaria
- Approvazione definitiva
- Assegnazione fondi

Riunione Aprile (anno successivo):

- Inserimento Consuntivi (tutti … non quelli appena iniziati)
- Presentazione Call –Exp Standard che hanno chiuso l'anno precedente

SIGLE ATTIVE PER 2025

- In corso
- In chiusura
- Richiesta prolungamento

SIGLE ATTIVE

R.N. = Responsabile Nazionale, R.L. = Responsabile Locale

1. ADA_5D – RN P.S. Marrocchesi
2. AIM_MIA – RN A. Retico
3. AI_INFN – RL F. Lizzi
4. ANNA – RL N. Belcari
5. ARTEMIS – RN A. C. Kraan
6. ASIX – RN M. Minuti
7. FRIDA (tipo CALL) – RL M. G. Bisogni - EXT
8. HIDRA2 (tipo CALL) – RL C. Roda – EXT
9. MIRO – RL Ciarrocchi Esther
10. NGSA (tipo CALL) - RL F. Frasconi
11. PROVIDE – RL M. G. Bisogni
12. QUARTET – RL C. Puglia
13. SPHERE_X – RL P. Delogu
14. STEEP – RN F. Paolucci
15. TIMEPIX4 – RL V. Rosso
16. UTMOST – RN F. Pilo

3 NUOVE PROPOSTE per il 2026

PER TUTTI: maggiori dettagli scrivendo a RN o RL (nome.cognome@pi.infn.it)

85 progetti di CSN5 nazionali – nel 2025

(16 sigle a Pisa)

Accelerators 0/10

ALPHA_DTL_BETA
ASTERIX
BOND
CROWN
FUSION
HB2TF
HISOL_NEXT
PLASMA4BEAM2
SL_BETATEST
SUPERMAD

Interdisciplinary Research 7/32

ADMIRALD - **AIM_MIA**
ARTEMIS - ATHENAE
ATOMIQA – AURORA
BIOHOT – BRAINSTAIN
CHNET_BRONZE
CHNET_MAXI - COLOMBA
CUPRUM_TTD - DISCOVER22
EPISE - FORM_3D
FRIDA - GEANT4INFN
HARDLIFE - MATHER3D
MIRO - MOZART
NEXT_NAMASSTE - **NGSA**
PRAD – **QUARTET** - SEGNAR -
SPHERE_X - SPOC - SPRITZ
TEMPURA - VI_HI
VITA_5

Detectors, Computation and Electronics 9/43

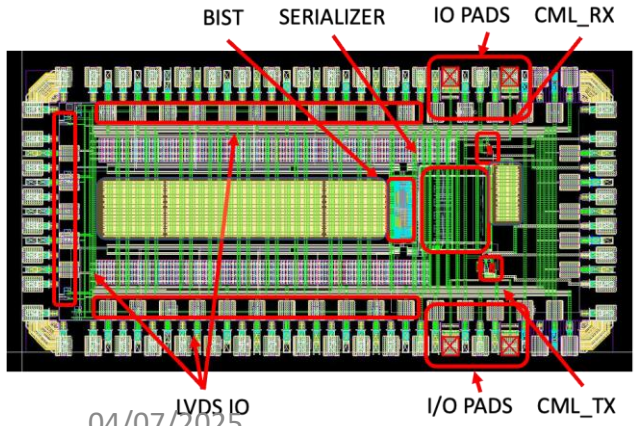
4DSHARE
ACE_SUPERQ - ACROMASS
ADA_5D - **AI_INFN**
ANNA – APLOMB - ARDE
ASIX - ASPIDES
ASTAROTH_BEYOND
DOCET - DIANA - FEROCE
FERRAD - GREEAT
HASPIDE - **HIDRA2**
IBIS_NEXT - IONOTRACK
LITE_SLPD - MANIFOLDD
MEMPHYS – NEIS PRIMUS –
OPTIME - OREO - **PROVIDE**
QUANTEPD - QUTE_FDS
QUISS – QURE - RD_PTOLEMY
RIPTIDE – SHINE - SPECTRE
SQUEEZE – **STEEP** - T4QC - TEMAN
TIMEPIX4 – UNIDET - **UTMOST**

Design of Integrated Circuits at INFN-PI

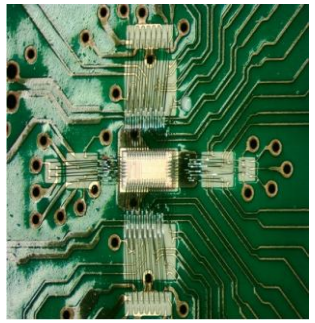
- **INFN-Pisa has a long (> 30 years) standing tradition in the design and test of digital and analog Integrated Circuits (IC) for High-Energy Physics (HEP) experiments and massively parallel computers (APE family)**

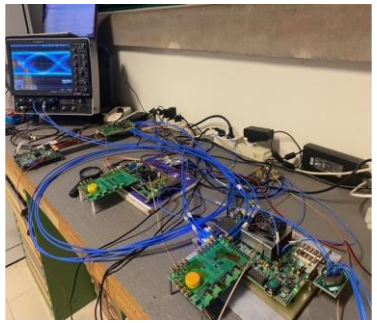
- INFN-Pisa IC designers had a leading role in the design of circuits for the APE parallel computers and for different mainstream HEP experiments
  - the full-custom associative memory for SVT trigger of CDF experiment (Panofsky prize to L. Ristori and A. Menzione)
  - the processor of the APE 1000 and of the apeNEXT parallel computers
  - the Neutral-Trigger-Processor (NTP) for the NA48 experiment at CERN
  - the Detector Control Unit (DCU) for the monitoring of Silicon detectors and of Front-End electronics in CMS and in most of the LHC experiments
  - the RD53 Front-End ASIC, the CMS-ATLAS Pixel Front-End circuit for the Phase-II LHC upgrade

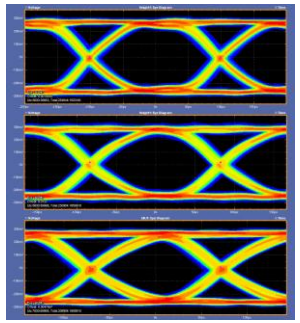
- **INFN-Pisa designers have been always deeply involved in all the development phases (design, development of the test setups, test and characterization, irradiation tests for TID and SEU characterization)**



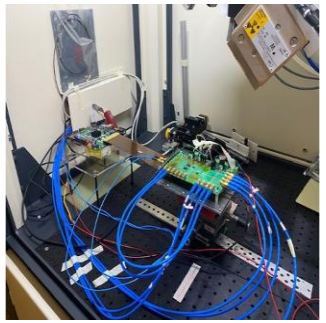
6.25Gbps / 1GRad Serializer in 28nm CMOS technology (SER28_V1)



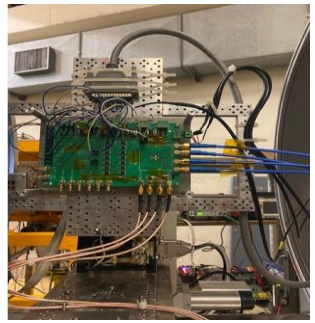




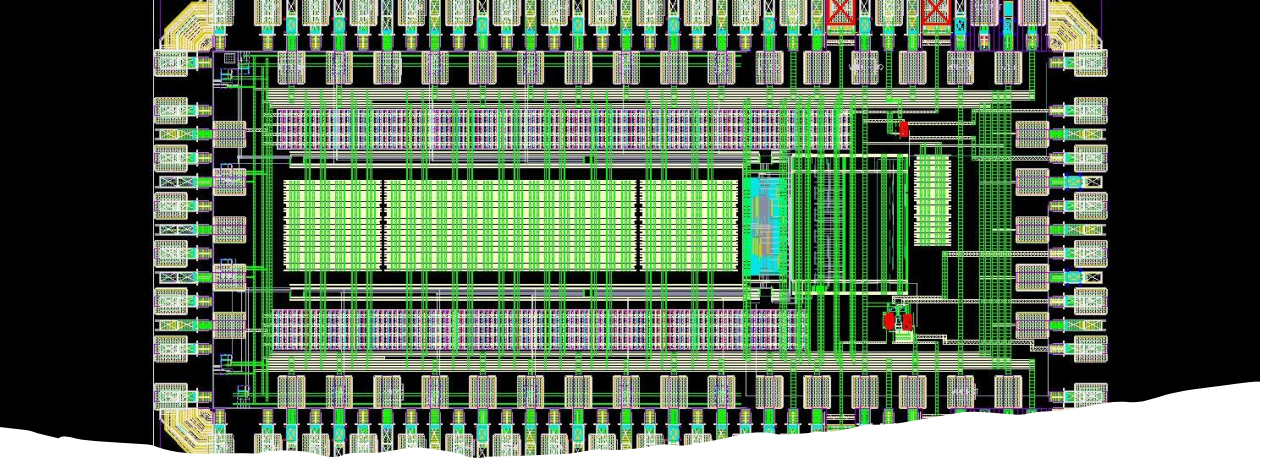
SER28_V1 Test Setup and Eye Diagrams (Eye Diagrams at 5,6,7 Gbps)

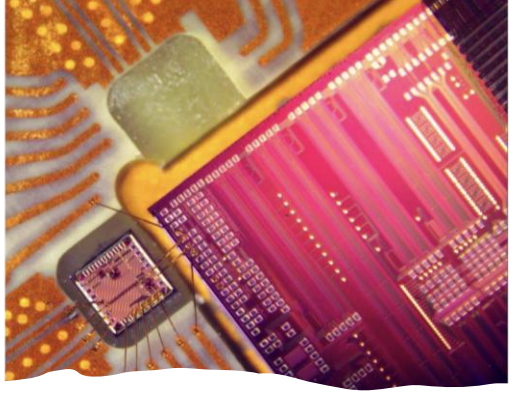


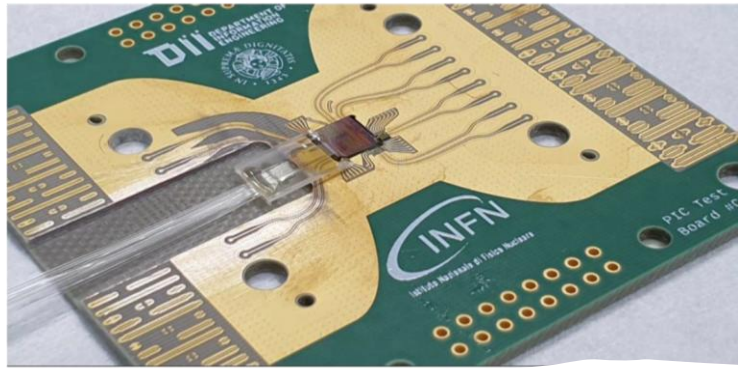
SER28_V1 TID Test INFN-PI)



SER28_V1 SEU Test (LNL)



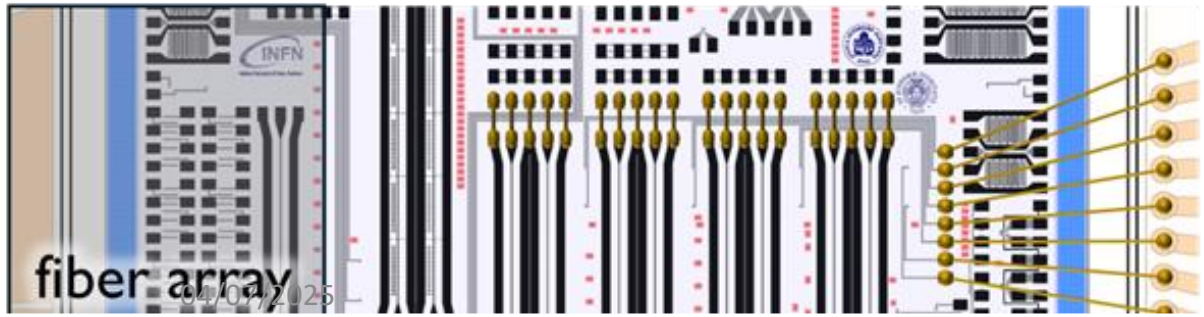


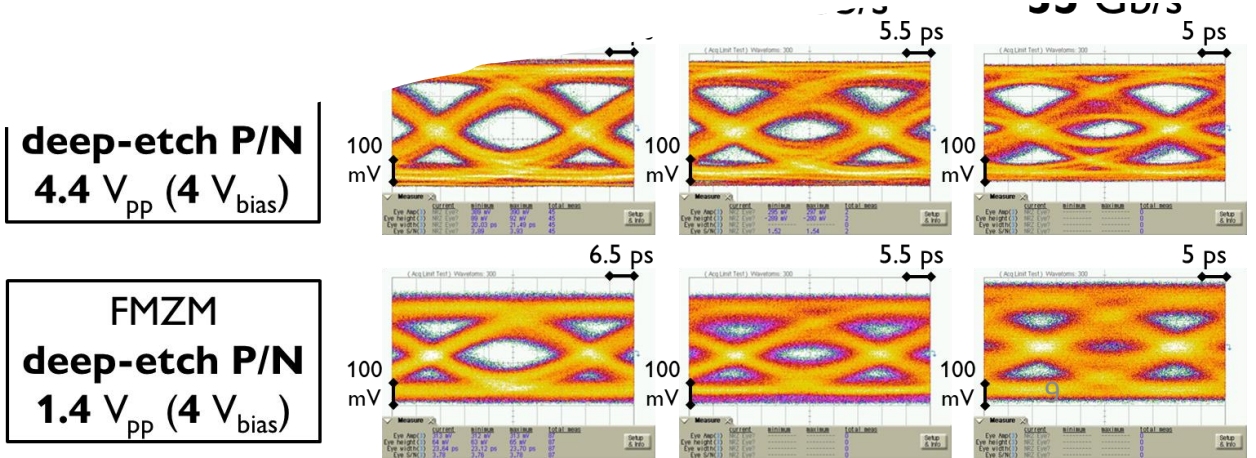


PHOS4BRAIN & FALAPHEL

fabrizio.palla@pi.infn.it

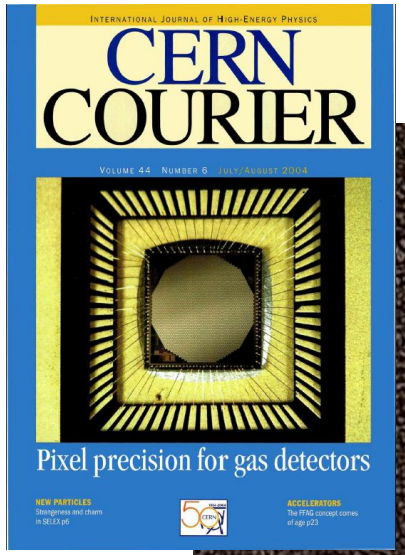
INFN-Pisa IC designers contributed also to many R&D projects (several for MAPS devices, FF-LYNX, PHOS4BRAIN, FALAPHEL, CHIPX65, PiXFEL and others) aiming at the development of IP-cores that could be used by designers in the HEP community with a specific focus on the design in advanced technology nodes like 28nm and 65nm of radiation tolerant (> 1Grad) high-speed (3.125Gbps -> 25Gbps) SERDES devices and high-speed drivers for integration with photonics devices and on the development of readout logic for new generation pixel detectors





A long history of X-rays detectors

from a first step in CSN5 … to the IXPE mission in orbit

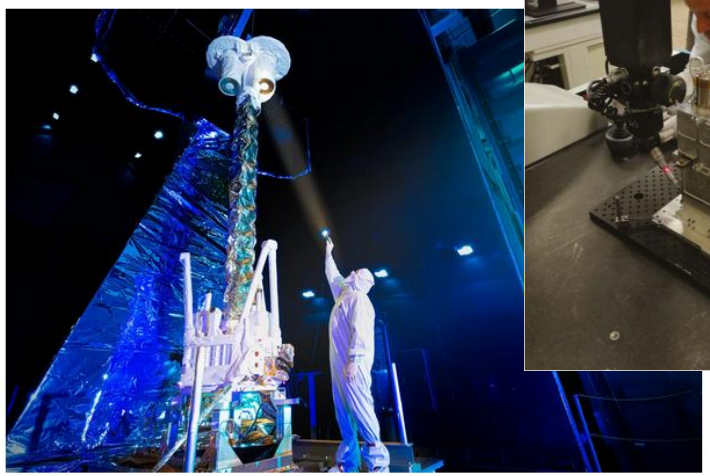


The New York Times

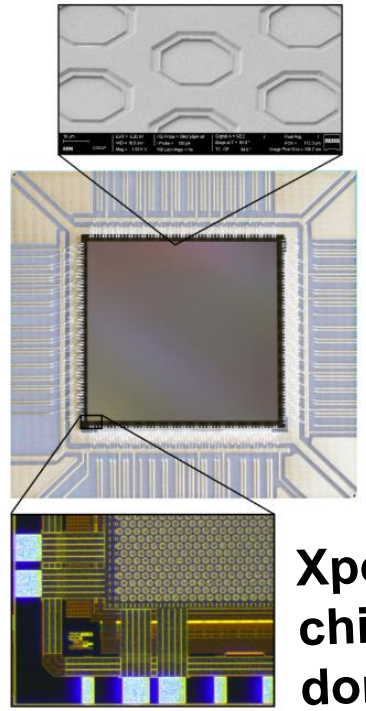
New NASA Telescope Will Provide X-Ray Views of the Universe

The IXPE spacecraft will use X-ray polarimetry to better measure black holes, supernovas and other astronomical phenomena.

Share full article



The Imaging X-ray Polarimetry Explorer underwent tests at Ball Aerospace in Boulder, Colo. The spacecraft will, for the first time, perform imaging X-ray polarimetry in orbit. Ball Aerospace



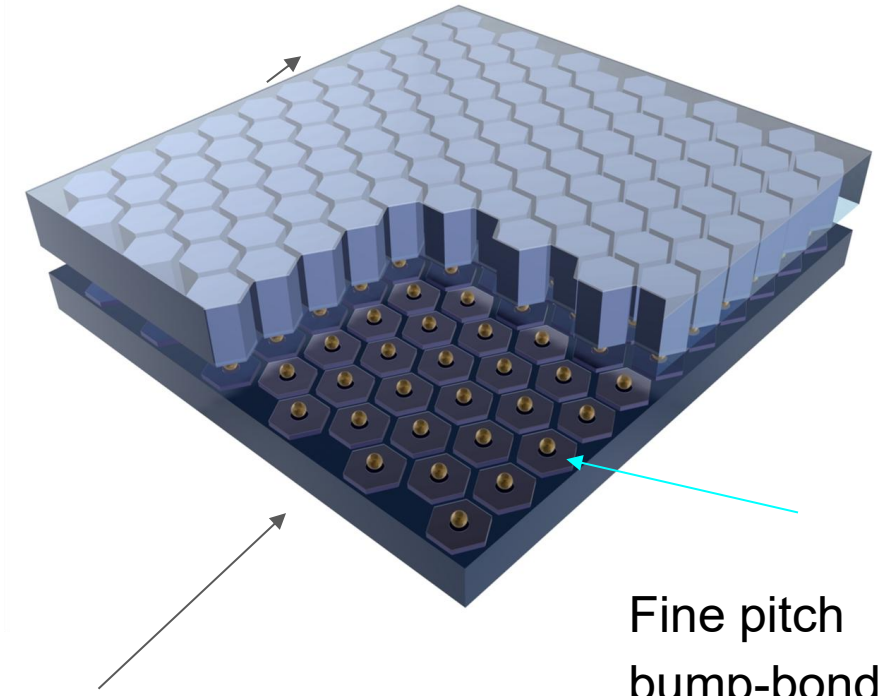
Xpol 3 chip done

..and beyond

Analog Spectral Imager for X-rays

RN: M.Minuti INFN Pisa

Pixelated sensor



Fine pitch bump-bonding

full custom CMOS readout ASIC

ASIX will deliver a small-scale (5 X 5 mm^2) technology demonstrator for new class of **hybrid pixel detectors** (2D) with **fine-pitch pixels** (50 um), single-photon sensitivity and fast event-driven analog read-out for **High-resolution X-ray spectral imaging, X-ray based material science** (**XRD), analysis of chemical and biological samples**.

!Single Photon Position, Energy and Time in one shot!

-) 50u pixels with analog readout (sub-pixel resolution)
-) High energy and spatial resolution (~350eV FWHM at 8 keV) (~10 μm)
-) ultra-low readout noise (< 30e- ENC)
-) Hybrid, extended energy range (2-60 keV)
-) High speed event-driven readout for one-shot single photon energy, position and time-of-arrival measurement
-) better than 10^8 cnts/cm^2/s maximum count rate

ADA_5D

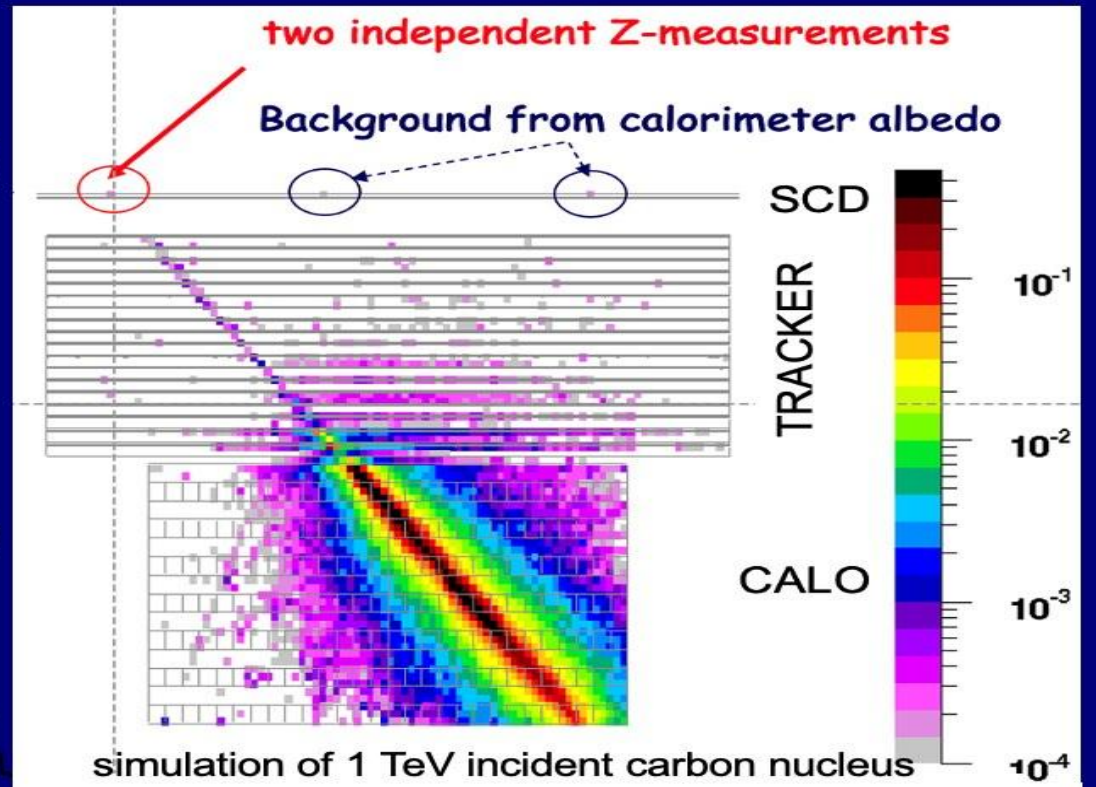
Charge & Timing **5D detector** (x,y,z, charge, time) based on **LGAD sensors** for the next generation of multi-TeV calorimetric experiments in space.

CHARGE IDENTIFICATION of cosmic-ray ions with charge $1 \leq Z \leq 30$ via multiple $dE/dx \propto Z^2$ in a pixelated sub-ns **Charge-ToF detector** (SCD)

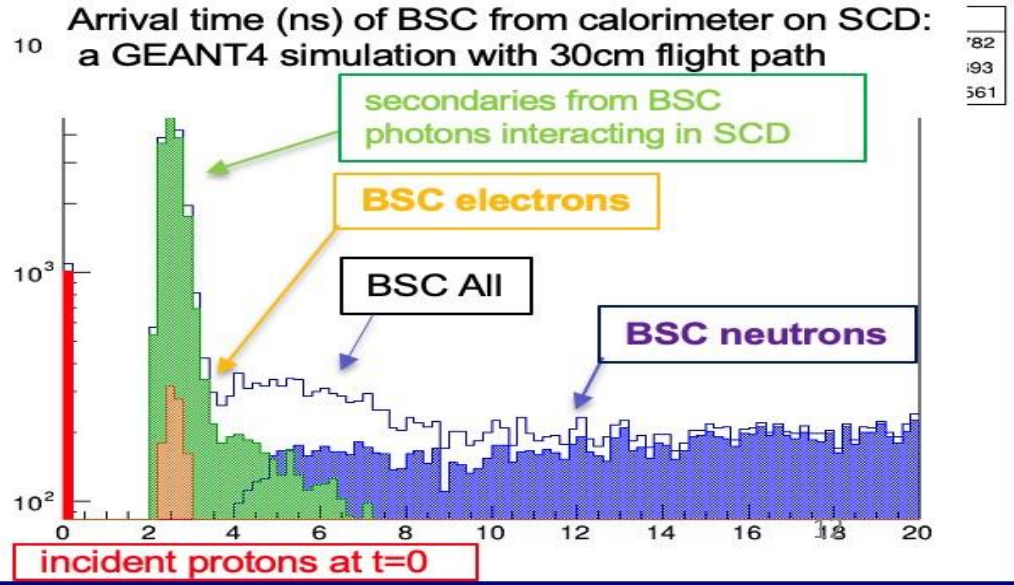
Backscattering (BSC) from calorimeter generates fake hits in SCD and tracker, degrading charge-ID as energy increases.

ADA_5D concept: BSC rejection with a high resolution ToF measurement

- large dynamic range > 1000 m.i.p
- 100 ps time resolution (e.g. for 20 cm flight path)
- large pixels (3mm x 3mm) to cover large O(m^2) sensitive area
- indipendent TRACKER for fine track resolution
- challenging power budget < 150 W/m^2
- modest Rad Hardness required in space < 10^{11} 1 MeV neq

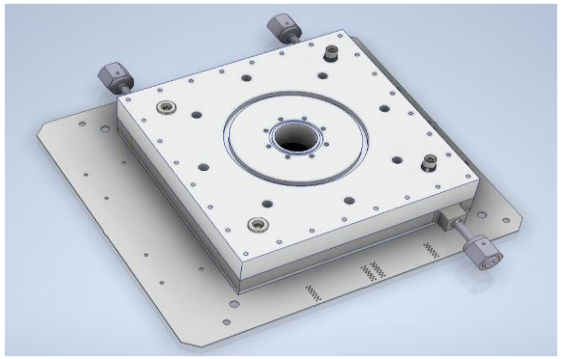


simulation of 1 TeV incident carbon nucleus



SWEATERS (Space WEAther Ena Radiation Sensor)

RN federico.pilo@pi.infn.it



The detector protype

- Development of an INNOVATIVE instrument for detecting low energy ionizing particles and also neutral atoms, as Energetic Neutral Atom (ENA), for possible Space Weather application

- A «gas calorimeter» based on Micro-Pattern Gas Detector (MPGD) technique and a read-out system able to provide a 3D track reconstruction of the particles

SWEATERS @ INFN CSN5

- Started on 2020/01
- 3 years
- Local/National coordinator: F. Pilo

CSN5 Ricerca Tecnologica

SWEATERS ASI-INAF – Phase B

- **Starts TODAY!!!**
- 3 years
- P.I.: E. De Angelis (IAPS/INAF)
- INFN Pisa is responsible for
  - WP5000 – Gas Cell Detector (F. Pilo)
  - WP6000 – Electronics (F. Morsani)

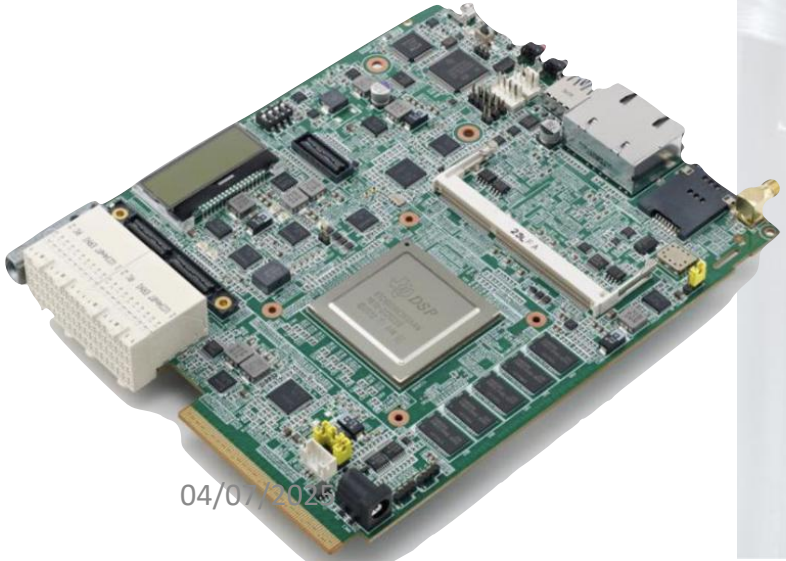
Agenzia Spaziale Italiana

Gravitational Waves Detectors @Pisa: a 20-year-long heritage

INFN Pisa has long and consolidated tradition in the development and operation of complex structure (**Superattenuator**) devoted to filtering seismic noise and local disturbances at the level of optical components for laser interferometric detectors.

The INFN Pisa group leads the development of **feedback control electronics** for Superattenuators.

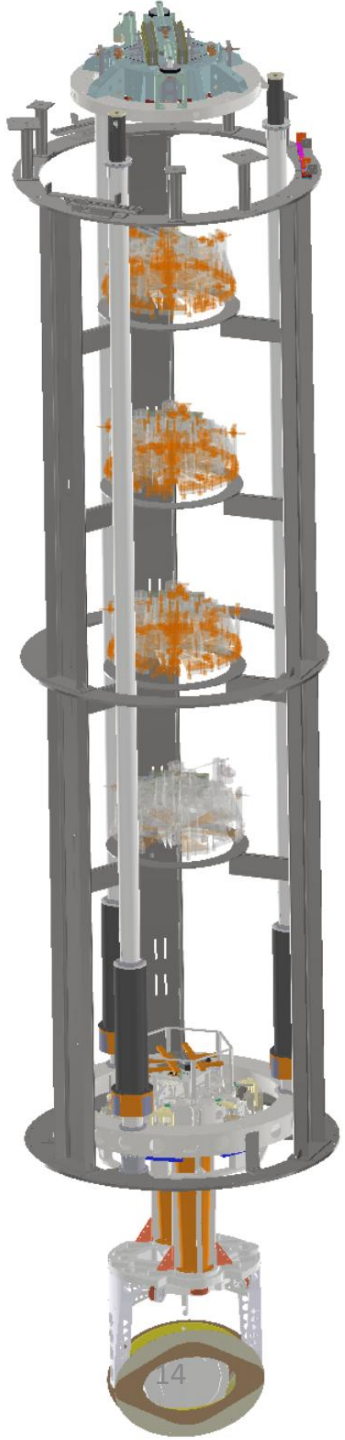
The group expertise is crucial for the **upgrade of the VIRGO detector** and for the next generation of gravitational wave detectors, such as the **Einstein Telescope.**



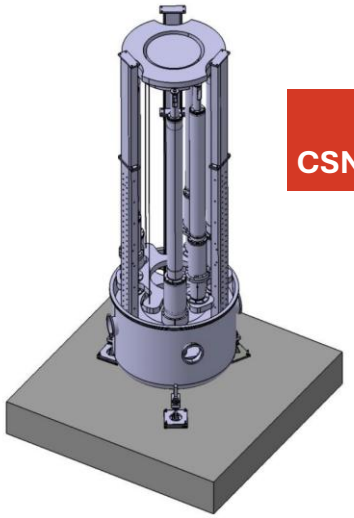
The group is involved in several projects

- **NGSA (Open Call CSN5)** improve passive performance of mechanical filter of a Superattenuator and investigate the introduction of a new Inverted Pendulum in Nested configuration (NIP).

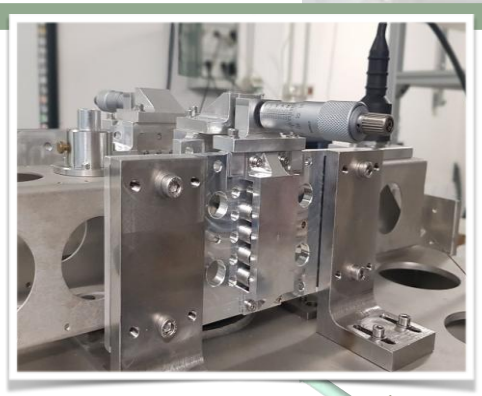
- **BHETSA (PRIN)** Development of a novel prototype filter for the ET Superattenuator based on a Pendulum-Inverted Pendulum system
- **CAOS (PNRR) Project @ University of PG**: construction of two long Superattenuators (about 15 m high) for future GW detectors



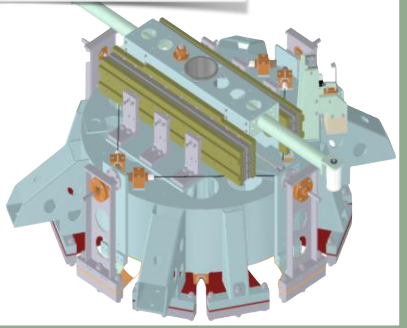
NGSA
CSN5 open call



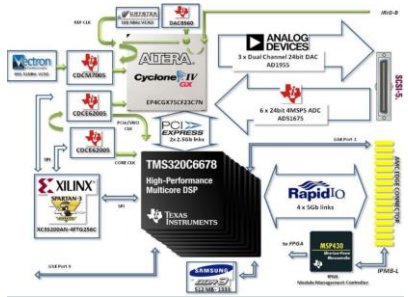
Development of a **Nested Inverted Pendulum (NIP)** and its feedback control strategy to maintain the total length of the suspension within 12 m. In collaboration with colleagues of INFN Napoli and University of Sassari.



R&D on **new Magnetic Anti-Spring** (nMAS) with the use of rare earth magnets (SmCo) improving the attenuation performance in vertical direction of each mechanical filter of the SA.

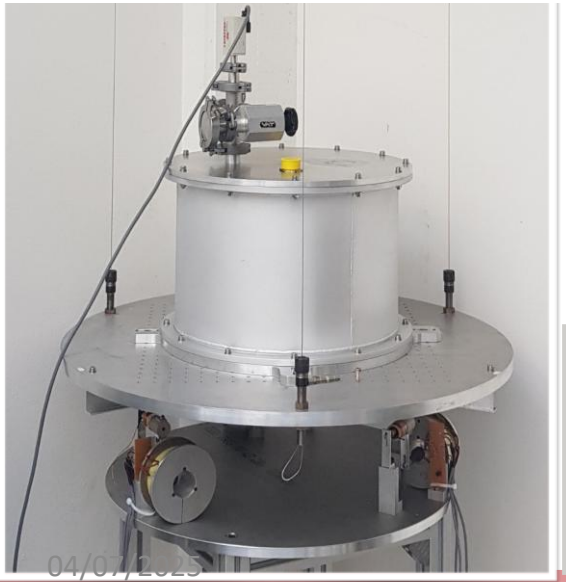


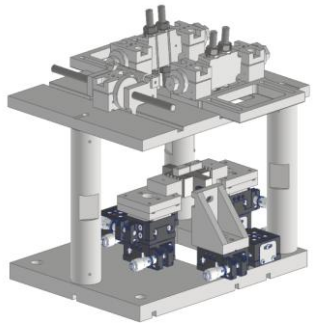
Inertial platform, as base structure of the Inverted Pendulum, as monitoring system and compensation of seismic noise in 6D

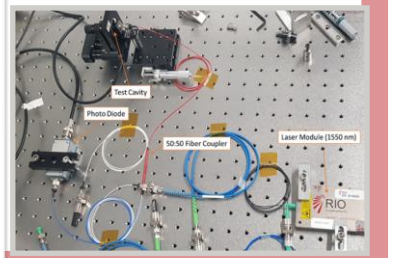


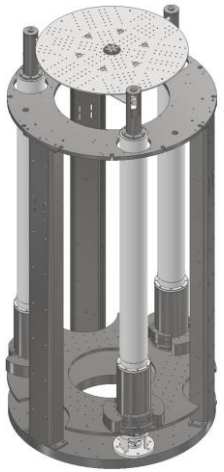
Project of a **Real Control System** based on new feedback control boards and DSP

New-concept accelerometer sensor with optical read-out

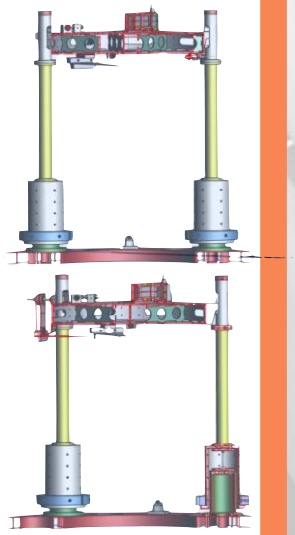






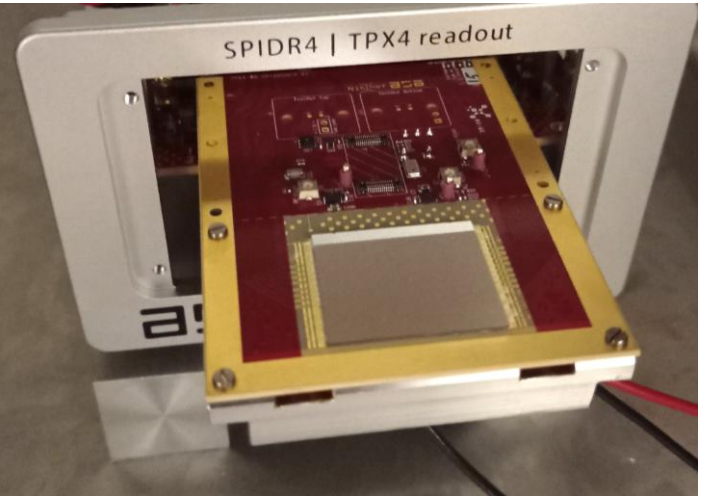


New mechanical top stage (**DiskZero**) equipped with positioning sensors and accelerometer for future Superattenuators



Study on **Pendulum-Inverted Pendulum (PIP)** to soften a suspension stage and keep heigth under 10 m

Timepix4 – A Large Area-, Spectroscopic-, High Rate-Detection System



Timepix4 is one of the most advanced hybrid pixel readout chips available:

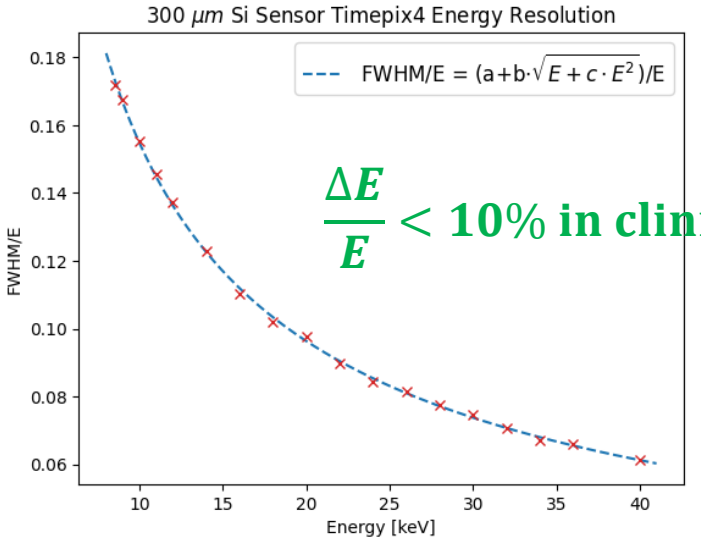
- High spatial resolution (55 µm pixels)
- Sub-nanosecond time resolution (<200 ps)
- Zero dead time
- Designed for fast, high-rate, event-by-event readout

It's a key technology for next-generation detectors in **physics, medicine, and space science**.

Specifications of the detection system used during data acquisition at SYRMEP beamline, Elettra synchrotron:

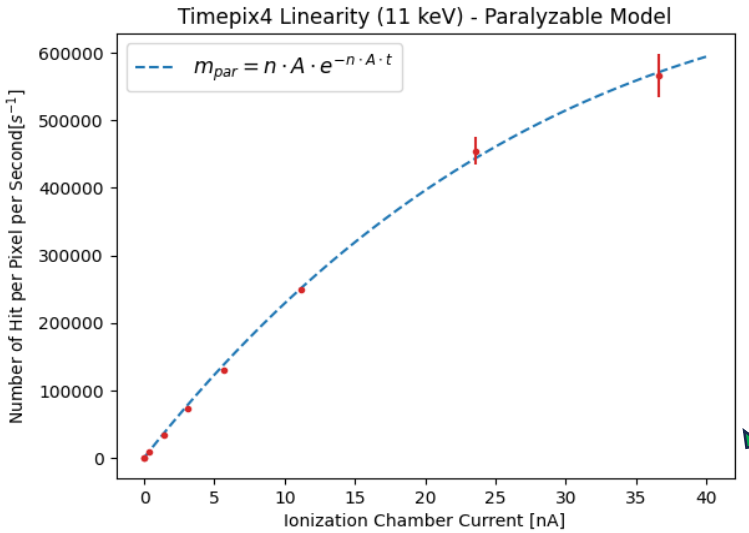
- 300 µm Si detector: 448x512 pixel (55 µm pitch) 7.41 cm^2 area
- ToT-ToA data driven opertion mode : ToA time bin 195ps
- Energy threshold: ~1000 e- (3,6 keV)
- SPIDR4 (Nikhef) readout system
- Cooling system (15 °C)

Energy resolution



$\frac{\Delta E}{E} < 10\%$ in clinical range

Dead time measured on a 5x5 pixels area



τ-paralyz ≃ 544 ns

τ-non−paralyz ≃ 746 ns

max-absorp-rate :

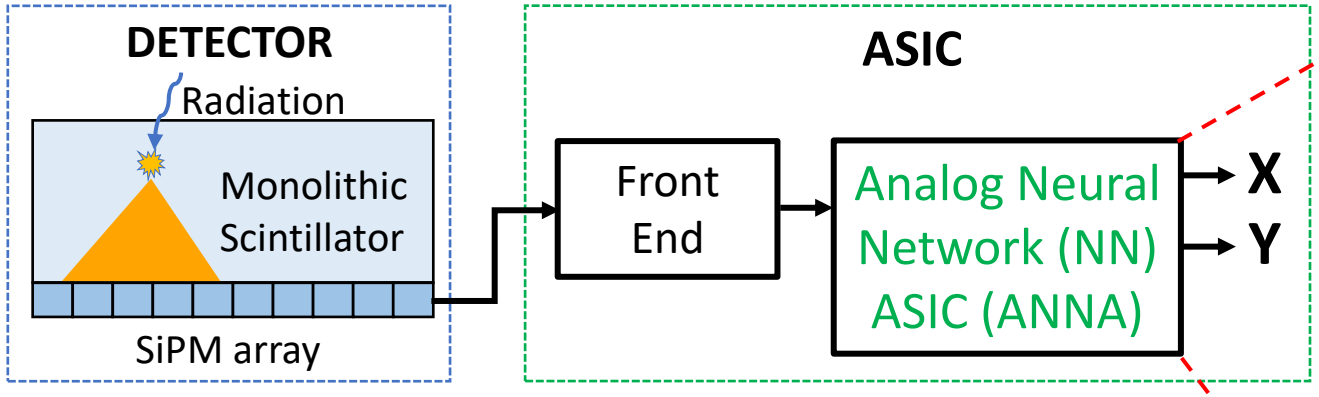
1,75 10^8 /mm²/s

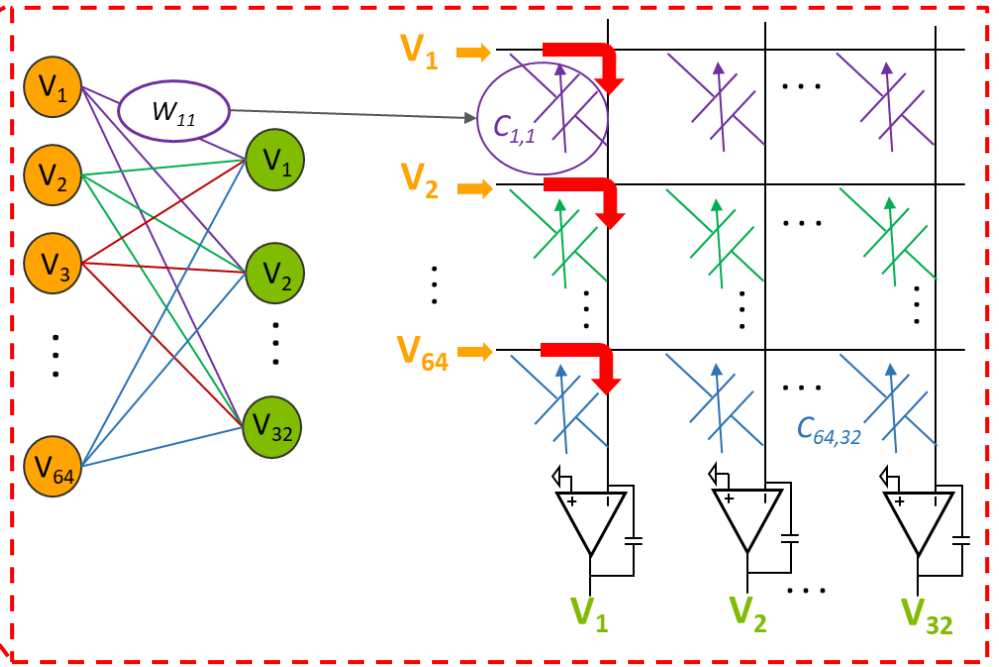
(full matrix: 3.6 Mhits/mm^2/s)

These results open the way to applications in spectroscopic imaging

ANNA - Analog Neural Network ASIC

GOAL: development of an ASIC for full-analog NN reconstruction of detector events





Application: **localization of the radiation event** from detector signals, as Anger Camera for PET (but also segmented solid-state detectors).

Strategy:

→ Crossbar array of **programmable switched capacitors**

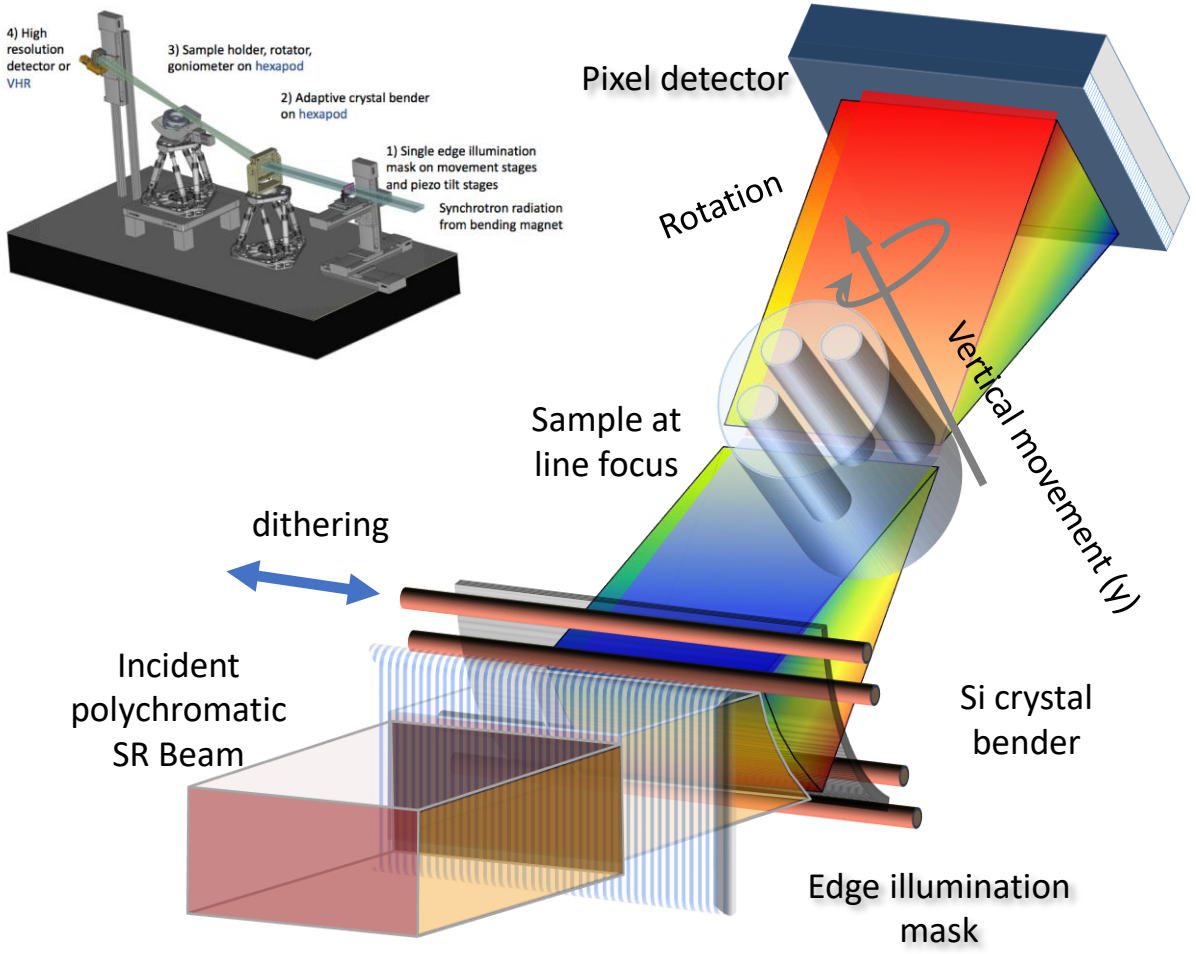
→ **Analog operations** performed directly on **analog signals** coming from photodetectors

→ **No need for ADC and FPGA** for embedded processing

→ **Interaction coordinates (X,Y)** directly at the output of the **ASIC**

Sphere-X (Spectral PHasE REtrieval X-ray imaging

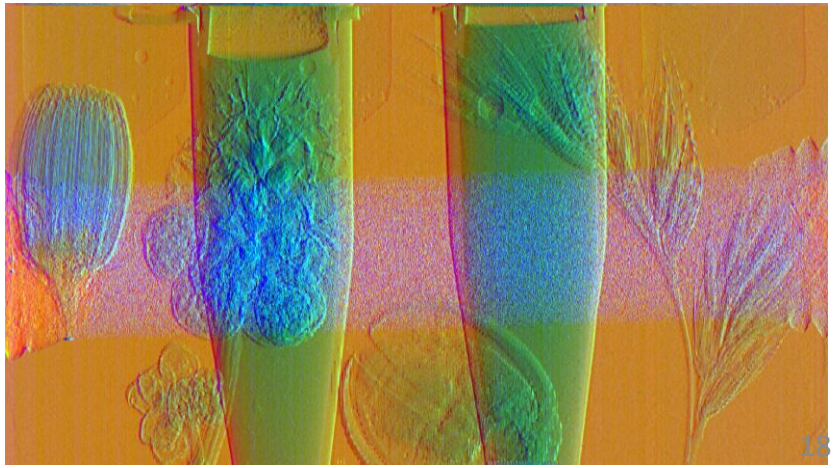
PI: Fulvia Arfelli (INFN TS)
Partecipating Units: INFN FE (RL L. Bandiera), INFN PI (RL P. Delogu)



Objective:
Development of a new imaging technique to recover the entire refractive index from a sample in a simultaneous acquisition modality using synchrotron radiation x-rays.

Method:
material separation with spectral K-edge imaging (using perfect bent crystal) while capturing simultaneously weakly absorbing features with phase contrast imaging (using edge illumination technique)

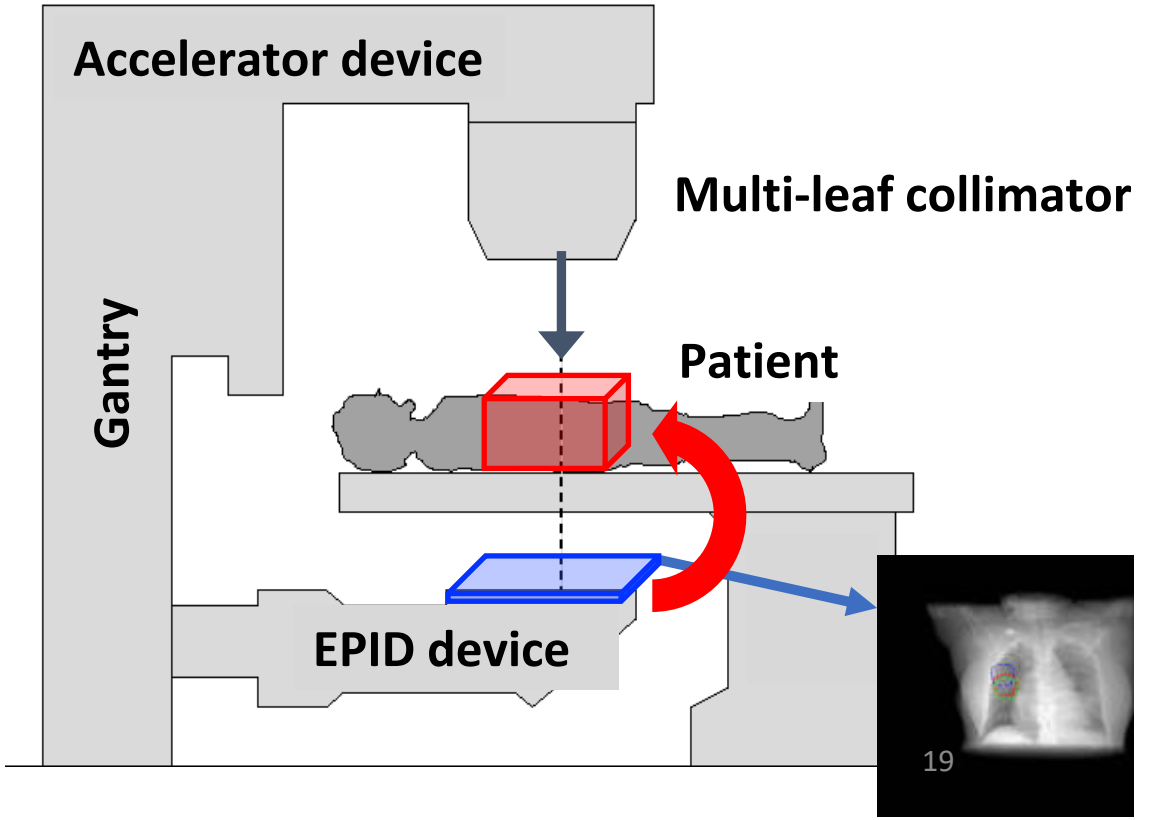
The sample is composed of various flowers, an insect, two silver solutions (10 and 5 mg/ml) and 48μm-diameter PMMA spheres.



ARTEMIS: Artificial Intelligence in RadioTherapy with EPID MonItoring System

- Project regards advanced radiotherapy dose delivery (X-rays with typical energy 5-20 MeV)
- Technological developments have led to high quality treatments, but complexity has increased →more prone to errors
- In-vivo dosimetry (IVD) needed (by law): verify delivered dose in patient
- **Electronic Portal Imaging Devices** can be used to obtain dosimetric information (originally introduced for positioning)
- ARTEMIS is aimed at:
  - **3D patient dose reconstruction**
    - **Using artificial intelligence**
    - Focusing on inhomogeneous geometries, including customized 3D phantoms
  - Development of alert system

2 INFN units:
INFN-PI (Resp. Naz): Aafke Kraan
INFN-FI unit: C. Talamonti

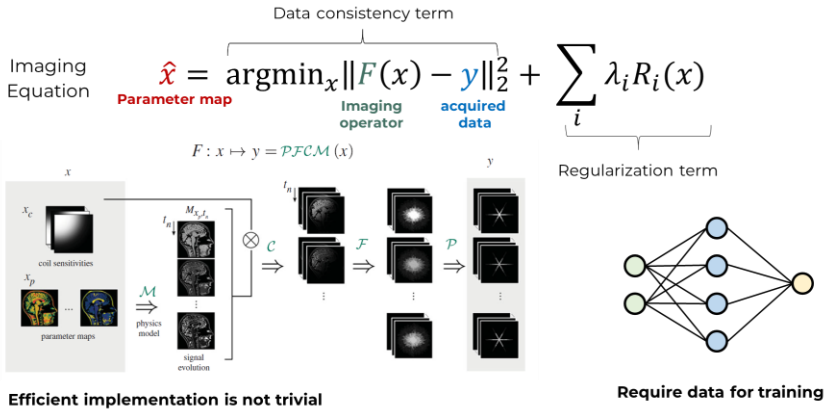


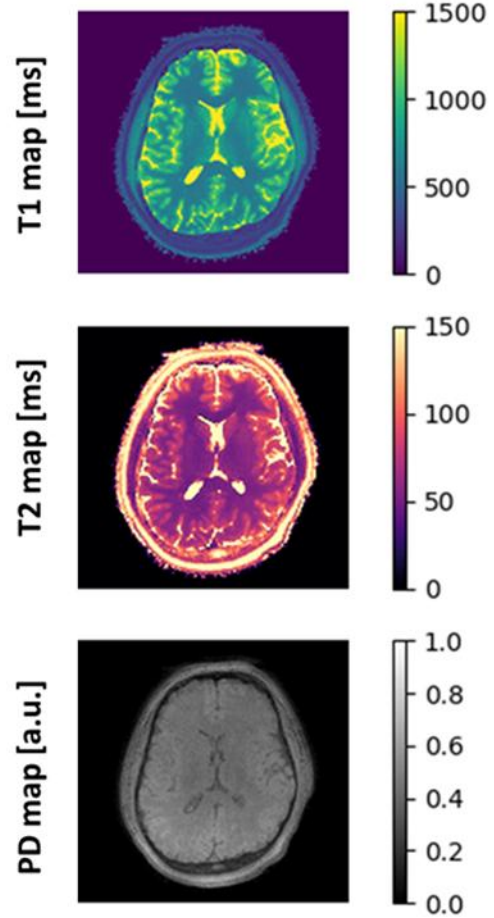
PREDATOR project

Quantitative Magnetic Resonance Imaging (qMRI) represents a powerful tool for the diagnosis and longitudinal evaluation of pathologies and the comparisons of exams from different clinical centers. Conventional qMRI has a clinically unfeasible acquisition time - acceleration is possible, but efficient reconstruction becomes challenging.

AIM

To develop **computationally-efficient reconstruction algorithms** for real-time reconstruction of accelerated qMRI acquisitions and **provide free, reusable and easy-to-use tools** to the MR community.





Project design

- Development of an open-source framework for development of advanced qMRI reconstruction
- Application to real-world MR acquisition (retrospectively and prospectively)
- Implement on-line reconstruction on MR scanner and measure scalability

People:

- **Matteo Cencini** (Principal Investigator; INFN Pisa)
- Alessandra Retico (INFN Pisa)
- Marta Lancione (FSM)
- Michela Tosetti (FSM)
- Laura Biagi (FSM)
- Mauro Costagli (FSM)
- Luca Peretti (FSM)

Related contribution: 1) Cencini et al., ISMRM 2024 – Abstract #4341; Public SW release: 1) https://github.com/INFN-PREDATOR/deep-mr

State of art and open issues

AIM_MIA
Artificial Intelligence in Medicine: focus on Multi-Input Analysis

Durata: 2025-2027

Area di Ricerca: Interdisciplinare

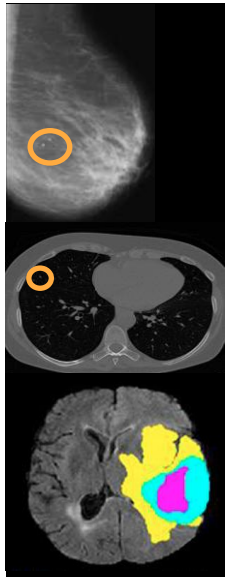
Responsabile nazionale: A. Retico (PI)

Unità partecipanti:
BA, BO, CA, CT, FE, FI, GE, LE, LNS, MI, PI, PV

Artificial Intelligence (AI) is already *pervasive* in many domains of our daily life including the Healthcare sector.

Since the 80s the scientific community has been developing **AI-based Decision Support Systems (DSS)** to support clinicians, especially for screening programs based on diagnostic imaging.

INFN contributed to this field of research by funding numerous interdisciplinary projects **since the end of the 90s**.

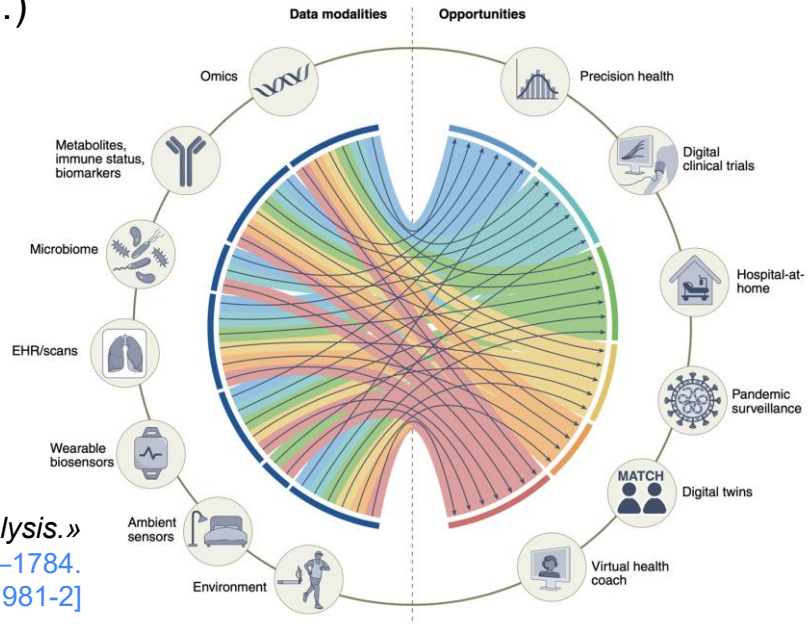


Currently, many AI-based DSS (including most **CE-marked products**):

- **lack in-depth validation** on large and independent data samples
- **have a *narrow* scope**, i.e. they can only do one task (e.g. segmentation of specific organs/tumors, prediction of a specific outcome, …)

To **widen the scope of AI-tools** and enable them to make an **important contribution** to achieving the goal of **precision medicine**, the complementary information encoded in electronic health records, omics and imaging data, and other relevant factors should be exploited.

AI methods to mine multi-input data should be developed



«… we are far better at collating and storing data, than we are at data analysis.»
[Acosta et al (2022). Multimodal biomedical AI. *Nature Medicine*, *28*(9), 1773–1784. https://doi.org/10.1038/s41591-022-01981-2]

AIM_MIA

https://www.pi.infn.it/aim/

AIM [2019-2021]
next_AIM [2022-2024]

Artificial Intelligence in Medicine: focus on Multi-Input Analysis

INFN, CSN5: 2025-2027

Istituto Nazionale di Fisica Nucleare
Sezione di PISA

General goal: *to take a step forward in the development and validation of AI-based tools for medical data analysis*

Resp. Naz.: A. Retico

12 Research Units:
- Bari (S. Tangaro)
- Bologna (D. Remondini)
- Cagliari (P. Oliva)
- Catania (M. Marrale)
- Ferrara (G. Di Domenico)
- Firenze (C. Talamonti)
- Genova (A. Chincarini)
- Lab. Naz. Sud (G. Russo)
- Lecce (G. De Nunzio)
- Milano (C. Lenardi)
- Pavia (A. Lascialfari)
- Pisa (M.E. Fantacci)

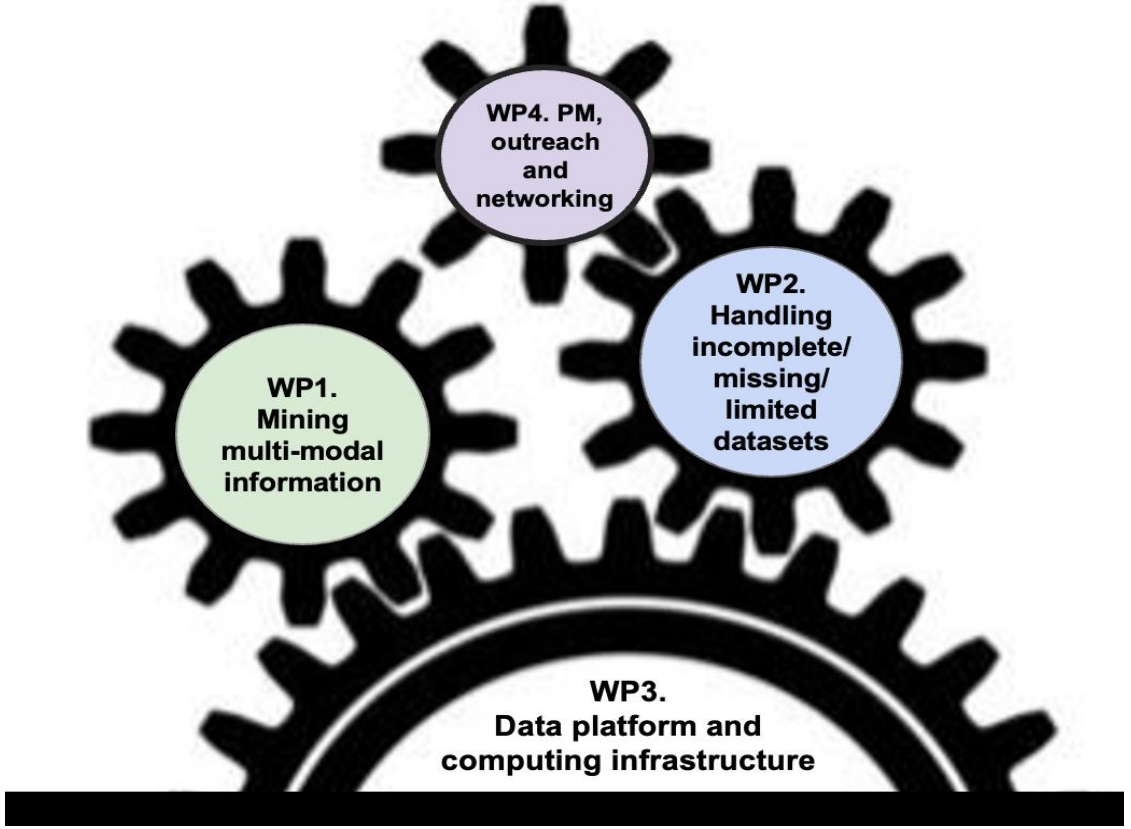
+ Napoli (DTZ, G. Mettivier)

- **Precision medicine** promises improved health by accounting for individual variability in genes, environment, and lifestyle.
- **Big data collections** and **advanced analytics approaches** (including AI-based methods) are needed to fully exploit the potential of the large amount of digital information available today for each patient.

Objectives

- Mining multi-modal information
- Handling incomplete/missing/limited datasets
- Development of a dedicated data and computing platform:

⇒ **FAIR Guiding Principles:**
Scientific data should be **F**indable, **A**ccessible, **I**nteroperable, and **R**eusable



AI INFN - Artificial Intelligence at INFN

AI_INFN is both a **strategic program** and a **community** within INFN that focuses on applying AI — including machine learning (ML), deep learning (DL), and other data-driven techniques

WP1 Infrastructure and Resource Provisioning

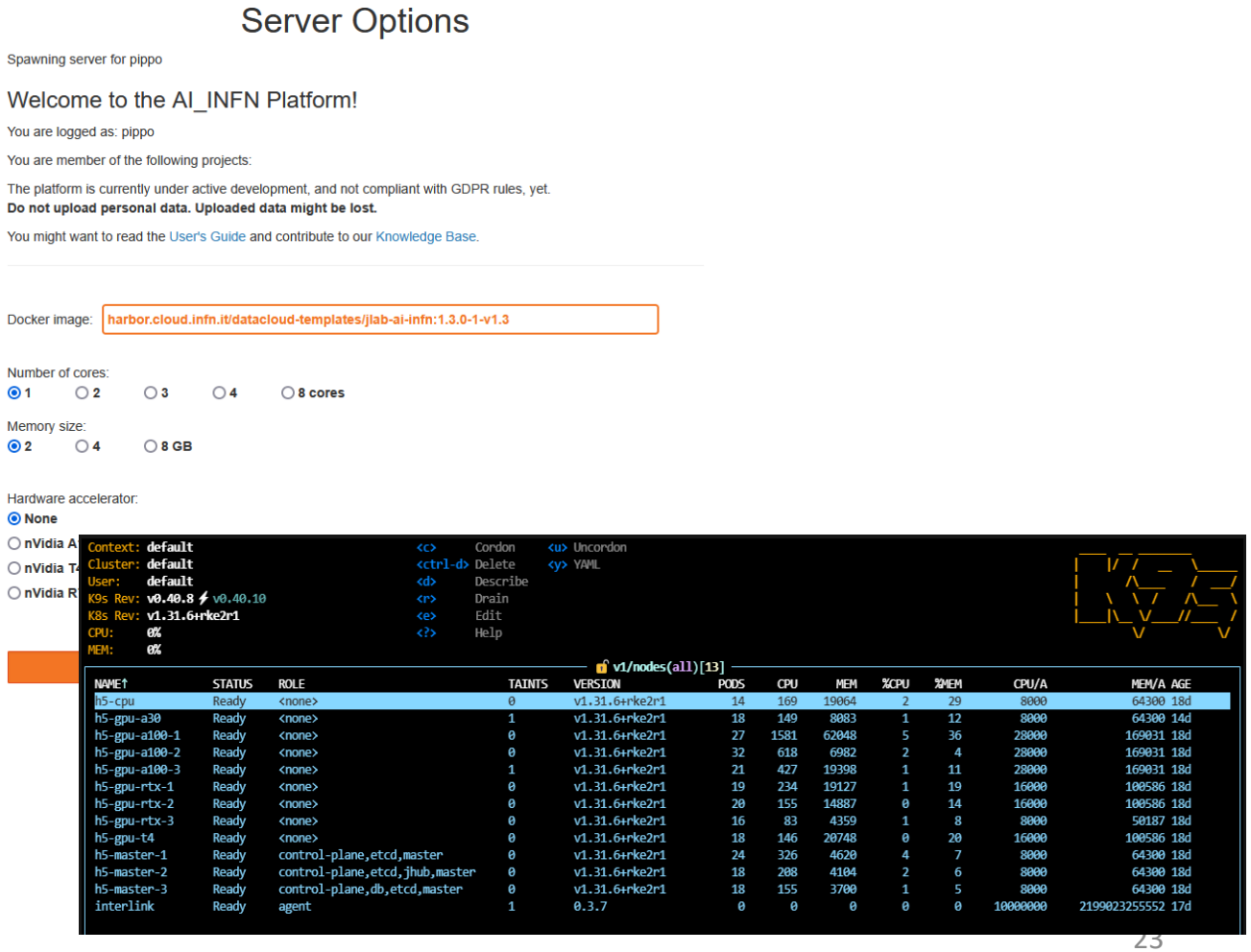
WP2 Open Data Science e Formazione Avanzata

First AI INFN Hackathon in 2024 @ Padova
https://agenda.infn.it/event/43129/

WP3 Scientific Use Cases

1st AI-INFN User Forum 11-12 Giugno a Bologna:
https://agenda.infn.it/event/40489/abstracts/

WP4 ML on FPGAs and Quantum Processors



- Centro multidisciplinare per lo sviluppo e l'implementazione della Flash radiotherapy
- LINAC dedicato (ElectronFlash con cannone a triodo)
- Flash Lab dedicato

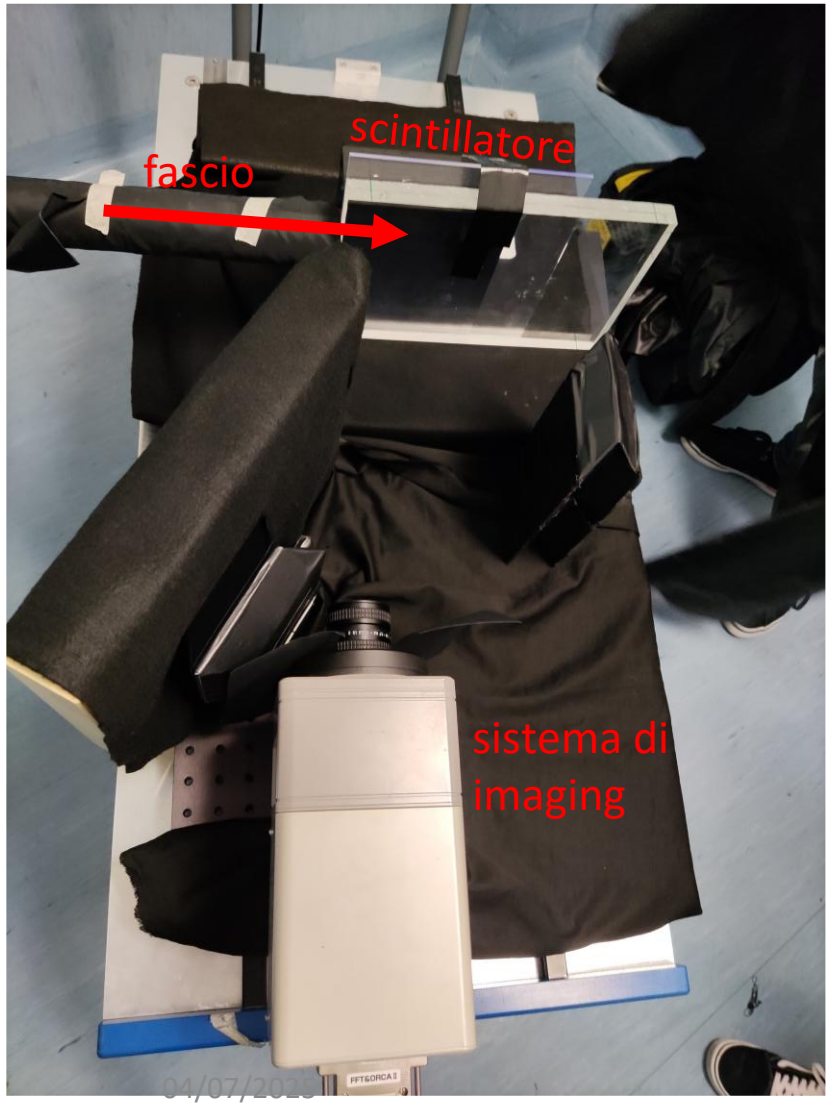
Comitato scientifico

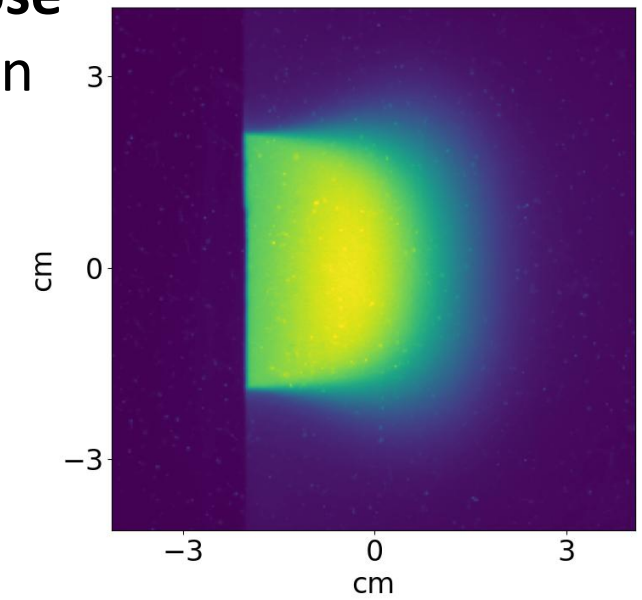
- Direttore scientifico (Prof.ssa Fabiola Paiar, UniPi/INFN)
- Direttore tecnico e responsabile del LINAC (Dr Fabio Di Martino, AOUP/INFN)
- un membro nominato all'interno del CNR di Pisa (Mario Costa, CNR/INFN);
- un membro nominato all'interno dell'INFN Pisa (Prof.ssa Giuseppina Bisogni, UniPi/INFN);
- un esperto della materia membro CISUP (Prof. Aldo Paolicchi).

Attività che coinvolgono INFN

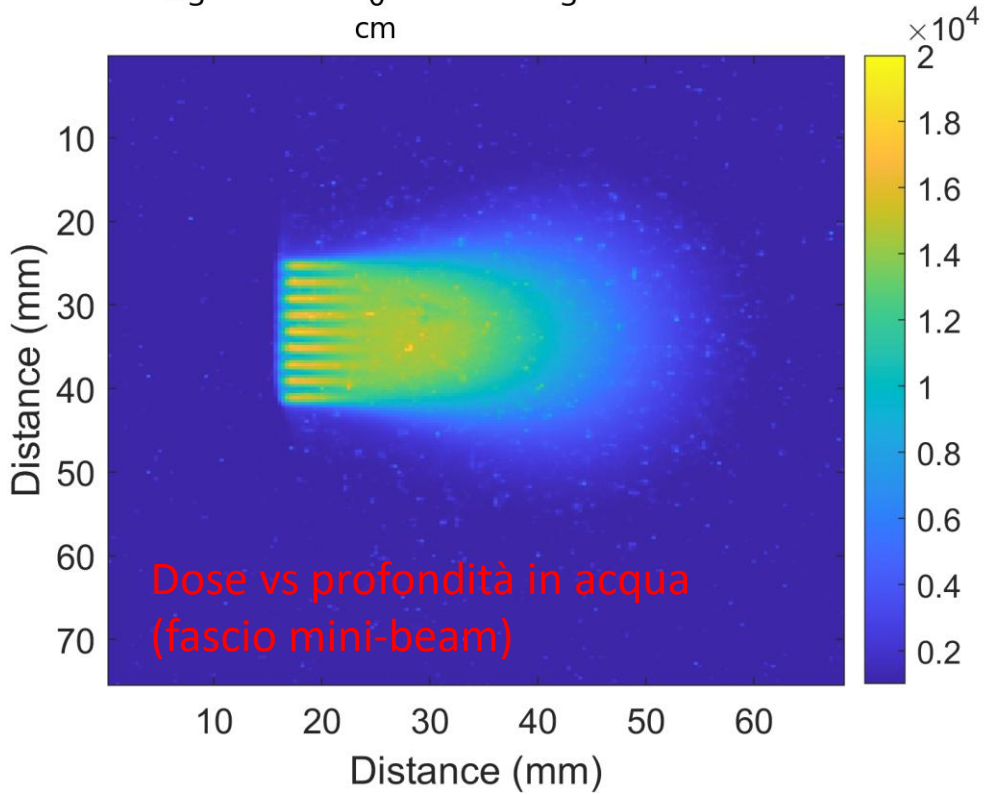
- Utilizzo Linac e lab per esperimenti teonologici/dosimetrici/radiobiologici – FRIDA/MIRO
- Sviluppo di ottiche di fascio per generare fasci mini-beam - MIRO
- Sviluppo camera ALLS – FRIDA
- Sviluppo metodi correttivi per uso CI su fasci UHDP – MIRO
- Sviluppo sistemi per dosimetria cerenkov – MIRO
- Esperimenti radiobiologici quantitativi vitro – FRIDA/MIRO
- Esperimenti radiobiologici quantitativi vivo – MIRO
- Modelling multiscala - MIRO

Immagini della distribuzione di **dose** in acqua-equivalente, ottenute con fogli di **scintillatori** plastici





Dose vs profondità in acqua (fascio ultra-high dose rate)



FLASH Radiotherapy with hIgh Dose-rate particle beAms

MIRO Minibeam Radiotherapy

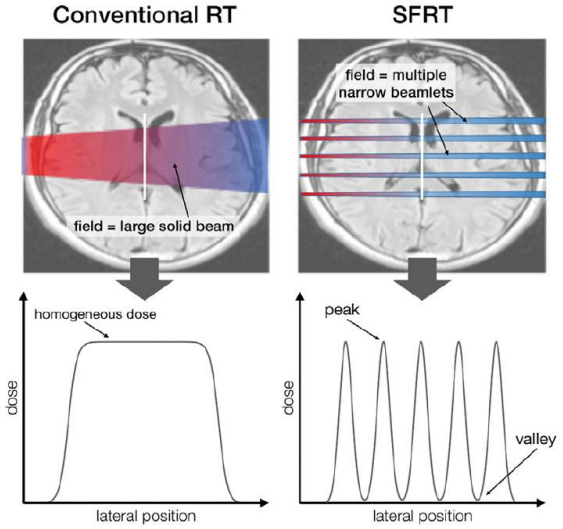
INFN PISA

Centro Pisano Flash Radiotherapy CPFR

MIRO (2024-2026)

Istituto Nazionale di Fisica Nucleare
Sezione di PISA

What is a mini-beam?

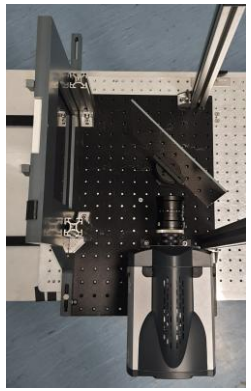


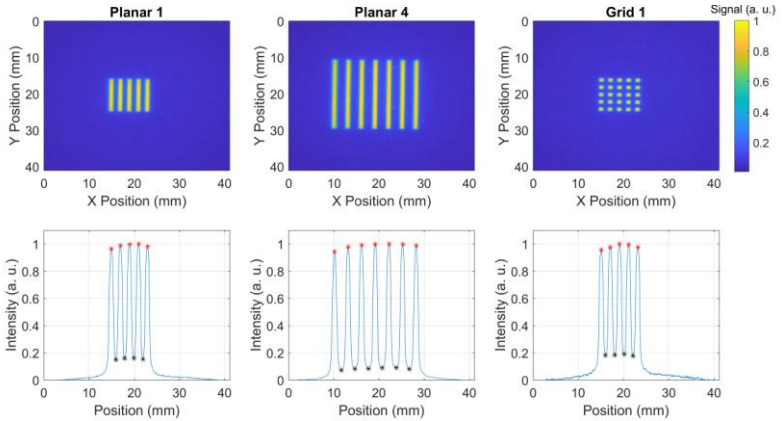
2026:

- *In vitro and in vivo experiments*
- *In vivo dosimetry*
- *Evaluation of clinical translation*

WP1: Beam delivery *-> First beams produced, simulated and characterized*

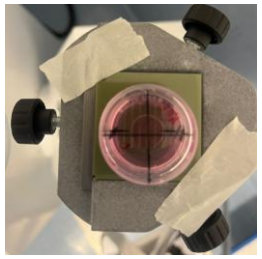
WP2: Dosimetry



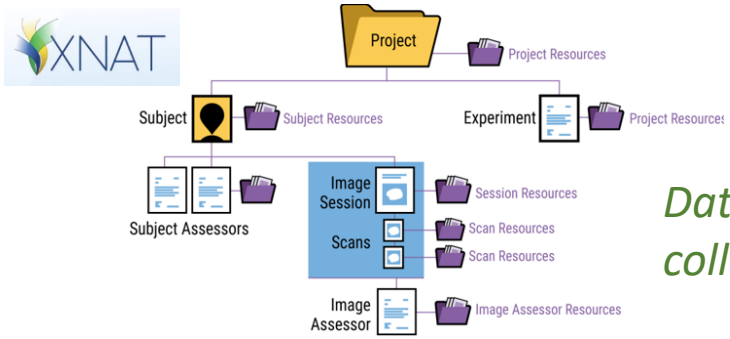


First dosimeter prototypes developed and tested (e.g. plastic scintillator sheets)

WP3: Radiobiology and modeling



First in vitro experiments



Database for data collection developed

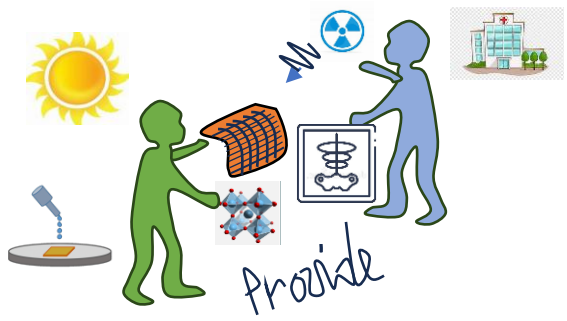
PROVIDE - PeROVskIte DEtectors for innovative strategies ir radiation therapy and diagnostics

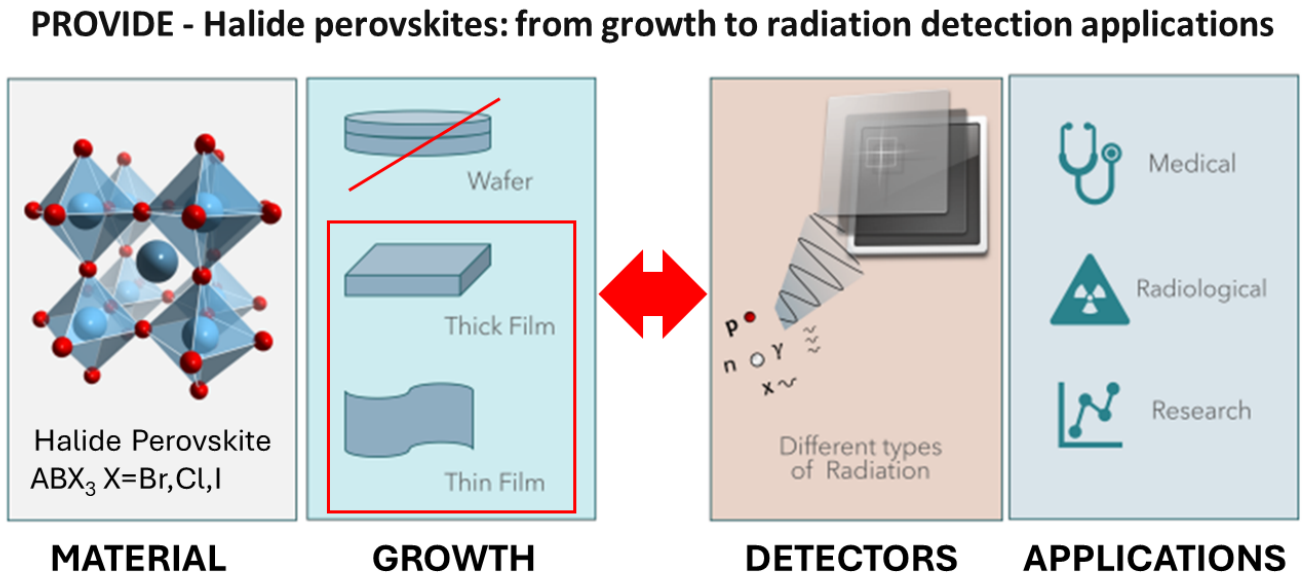
Istituto Nazionale di Fisica Nucleare
Sezione di PISA

Resp locale INFN PI: MG Bisogni

🔬 **What are Perovskites?**

Perovskites are materials with a crystal structure similar to **calcium titanium oxide ($CaTiO_3$)**, which is the original perovskite mineral. They have the general formula **ABX_3**, where:
A is a large cation (e.g., methylammonium, cesium)
B is a metal ion (e.g., Pb^{2+}, Sn^{2+})
X is a halide (e.g., I^-, Br^-, Cl^-)

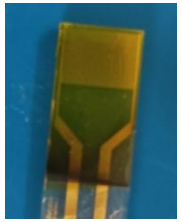


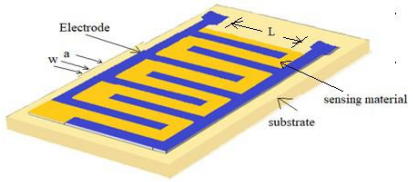


PROVIDE: stato

1) manufacturing and testing novel perovskite detector systems (direct and indirect), improving their relevant figure-of-merit, 2) Explore novel functionalities in radiation therapy and diagnostics for optimized perovskite-based detection systems.

IDE structures INFN FI

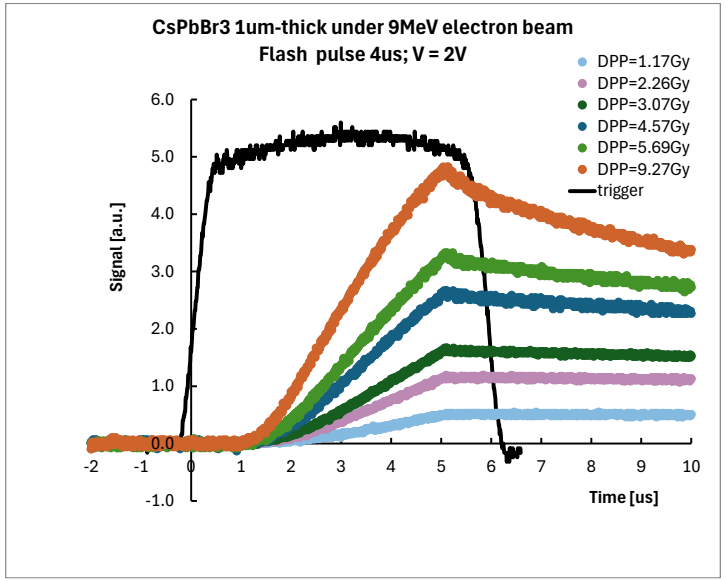


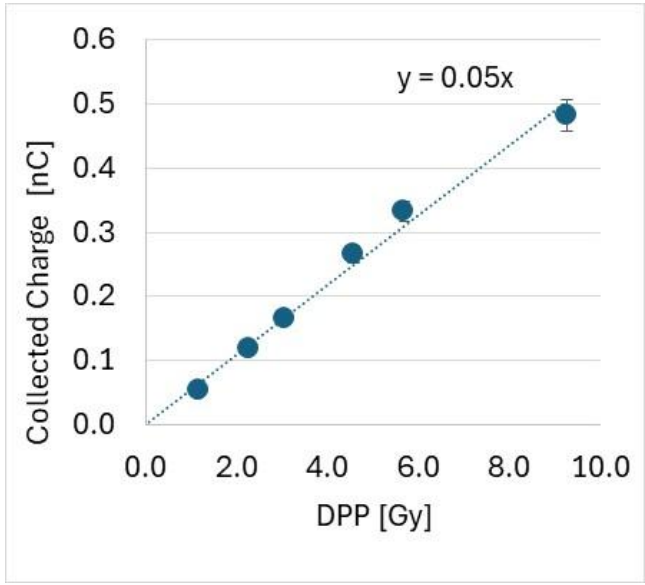


IDE = Au/Ti
Number of digits: 125 x 2
Digit length: 6760μm
Digit width and gaps 10mm

Perovskite film:
$CsPbBr_3$ 1mm thick

Stato 2025
Strutture IDE realizzate a INFN Firenze (Mara Bruzzi) Magnetron sputtering
Test beam a CPFR Pisa Hospital LINAC 9 MeV Electrons Flash Therapy





R&D su nuove tecnologie
I nuovi laboratori della Sezione

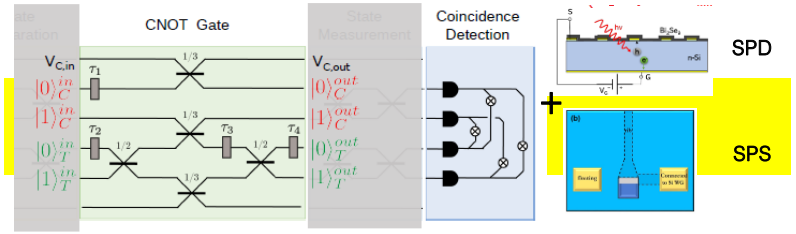
- Clean Room WET
- Laboratorio di criogenia

QUANTEP: QUANtum Technologies Experimental Platform

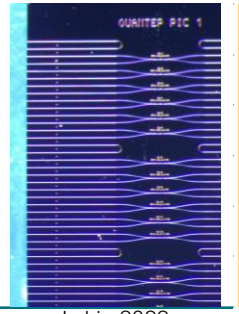
Call tematica 2021-2024 (estensione), resp. naz. **A. Salamon** - resp. loc. Pisa **F. Spinella**

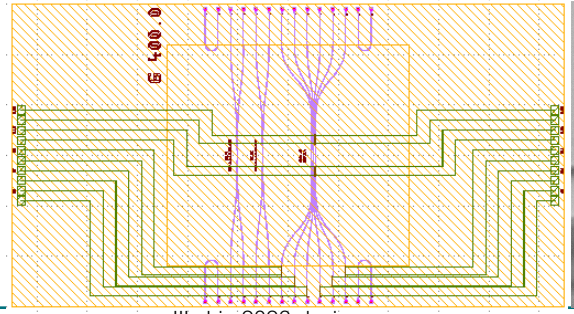
Obiettivi:
- Sviluppo di chip con tecniche di fotonica su silicio: know out non presente nell'INFN
- Integrazione di strutture ottiche per la realizzazione di una porta C-NOT e test in regime di single photon
- Sviluppo di un singolo chip fotonico con integrati rivelatore e sorgente di singolo fotone

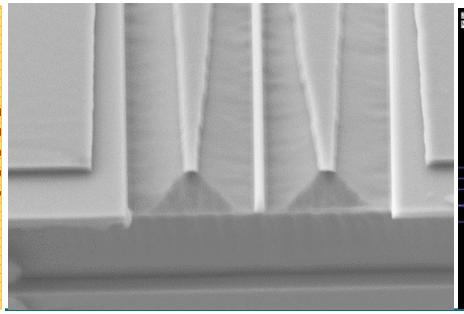
Pisa ha contribuito:
- Progetto e simulazione FEM delle strutture ottiche integrate
- Progetto e simulazione delle strutture elettriche (thermal phase shifter)
- Bonding, analisi SEM, analisi AFM
- Test (lab. ottico allestito a Roma 2)

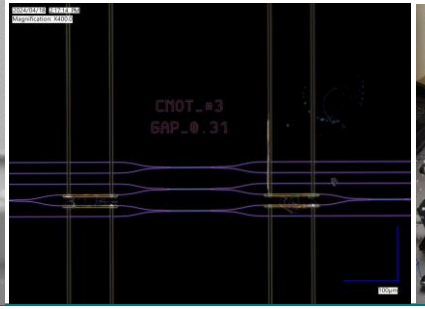


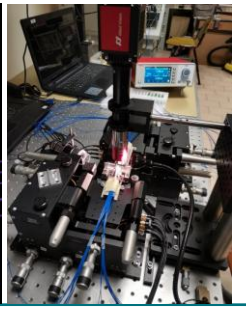
Sguardo al futuro:
- I tempi e i costi delle fonderie sono poco compatibili con progetti di questo tipo ...
- **Vogliamo acquisire il know-how e le tecnologie per produzione dei chip qui in sede (PNRR NQSTI -> acquisto macchina etching RIE)**
- C-NOT e' il primo mattone per gli algoritmi quantistici
- **Proposta per un chip piu' complesso, multi-gate ma anche single photon detectors avanzati (Bi2Se3 nanowire)**


I chip 2022
Edge coupled fibers


III chip 2023 design
Grating arrays coupling


Edge coupler @ SEM


III chip C-NOT gate


test @ Roma2

SIMP & Qub-it

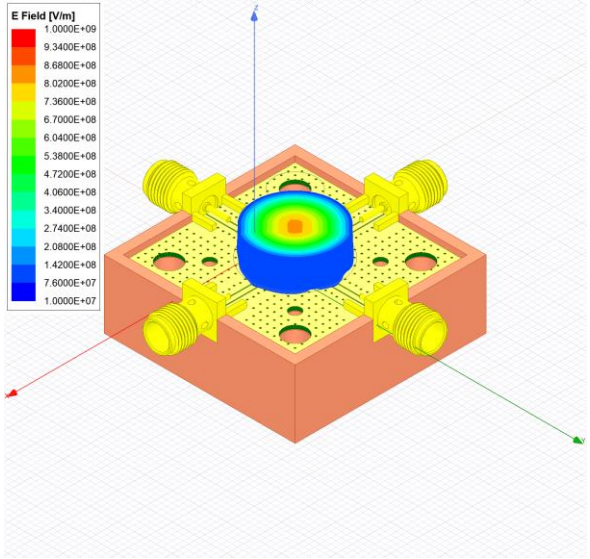
Sfruttare le tecnologie quantistiche per la rivelazione di segnali molto deboli (quantum sensing) -> detection di materia oscura e/o assioni

- **SIMP (->2021):** studio di diverse tecniche quantistiche per rivelazione di singoli fotoni nelle microonde
- **Qub-it** (on going): studio dell'impiego dei **transmoni superconduttori** (classici qubit superconduttori) come rivelatori di fotoni itineranti

Fortissima sinergia con il laboratorio di **Criogenia** (test e misure), il laboratorio **CR Wet** (costruzioni di prototipi), il **dipartimento di eccellenza** (utilizzo di elettronica di controllo e di macchina per la litografia)

Collaborazione con il dipartimento di ingegneria elettronica per la simulazione e il disegno di sensori 3D+

L'obiettivo finale è realizzare un sistema di 2 qubit debolmente accoppiati letti con cavità 3D per rivelare la presenza di un fotone nel range delle 10 GHz, con lo scopo di andare sotto il rumore quantico dei tradizionali amplificatori criogenici



Esempio di simulazione e realizzazione in officina di portacampione a basso rumore per qubit a 8 GHz

QUART&T

QUANTUM ARCHITECTURES FOR THEORY & TECHNOLOGY

Istituto Nazionale di Fisica Nucleare
Sezione di PISA

Responsabile Nazionale: **Andrea Giachero**
Responsabile Locale: **Claudio Puglia**

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Il progetto QUART&T mira a sviluppare architetture quantistiche per simulare sistemi complessi di fisica teorica, superando i limiti dei computer tradizionali. Sfruttando computer quantistici analogici basati su superconduttori, il progetto si propone di studiare le interazioni tra particelle in ambiti come la fisica nucleare e la gravità quantistica.

INFN Pisa Coordina i WP4: Sviluppo di processi di microfabbricazione e packaging per qubit transmon 2D e 3D; studio di nuovi materiali; produzione dei dispositivi finali. **Responsabile Locale: Claudio Puglia**

Attività a Pisa 2025

- Caratterizzazione criogenica di
  - Giunzioni Josephson ✓
  - Risuonatori superconduttivi ✓
  - Qubit ~
- Packaging dei dispositivi
  - Portacampione dedicato ~

Attività a Pisa 2026

- Caratterizzazione criogenica di
  - Sistemi multi-qubit
- Packaging avanzato dei dispositivi
  - Portacampioni modulari

STEEP
Sub-kelvin Transition-Edge sensors for low Energy Physics

RN: F. Paolucci
INFN Pisa

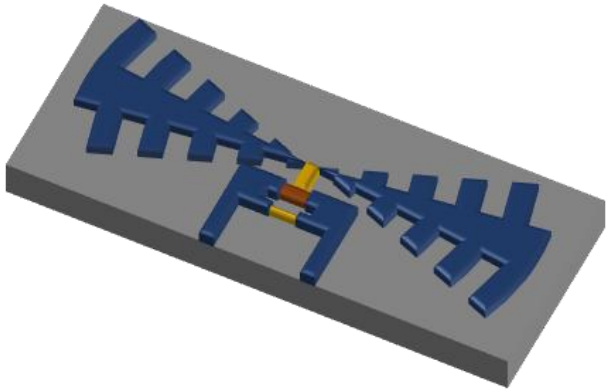
- INFN CNS5 Preventivi 2026

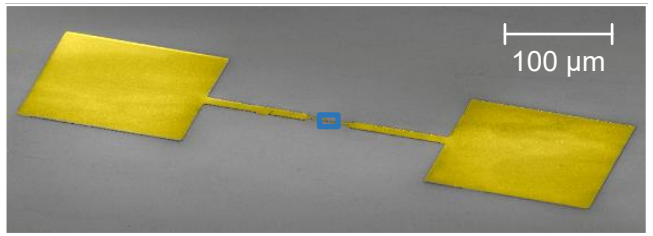
STEEP – Obiettvi

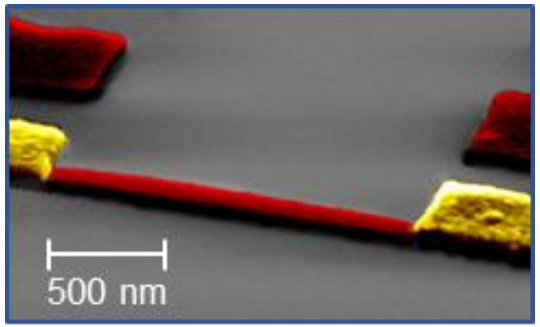
L'obiettivo di STEEP è lo sviluppo di ***detector*** con ***performance superiori allo stato dell'arte*** in un ampio spettro di energia per radiazione elettromagnetica e particelle con applicazioni sia in fisica delle *interazioni fondamentali*, *cosmologia/astronomia* e *imaging su tessuti biologici*.

Gli ***obiettivi tecnologici*** sono:

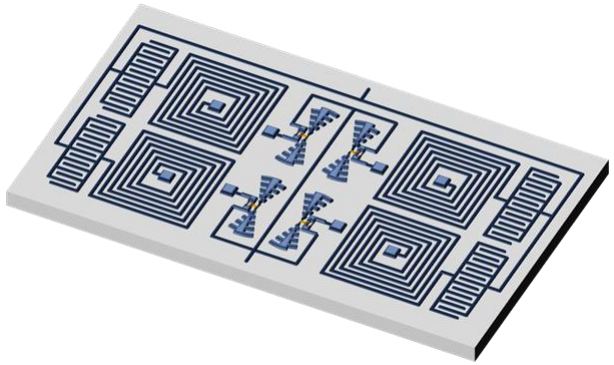
1. la realizzazione di singoli ***bolometri*** e ***calorimetri*** basati su ***Trasition-Edge Sensor (TES)*** operanti nelle bande visibile (1.6 - 3.3 eV) e THz (1.6 - 41.0 meV) con sensibilità mai raggiunte: ***NEP~10^{-20} WHz$^{-½}$*** e ***δE~400 μeV***;
2. l'implementazione di ***matrici 2x2 di detector*** TES completamente fabbricate on-chip e lette attraverso multiplazione a divisione di frequenza (FDM).







FP et al., Phys. Rev. Appl. 14, 034055 (2020)
FP et al., J. Appl. Phys. 128, 194502 (2020)



Gli ***obiettivi di sviluppo di INFN*** sono:

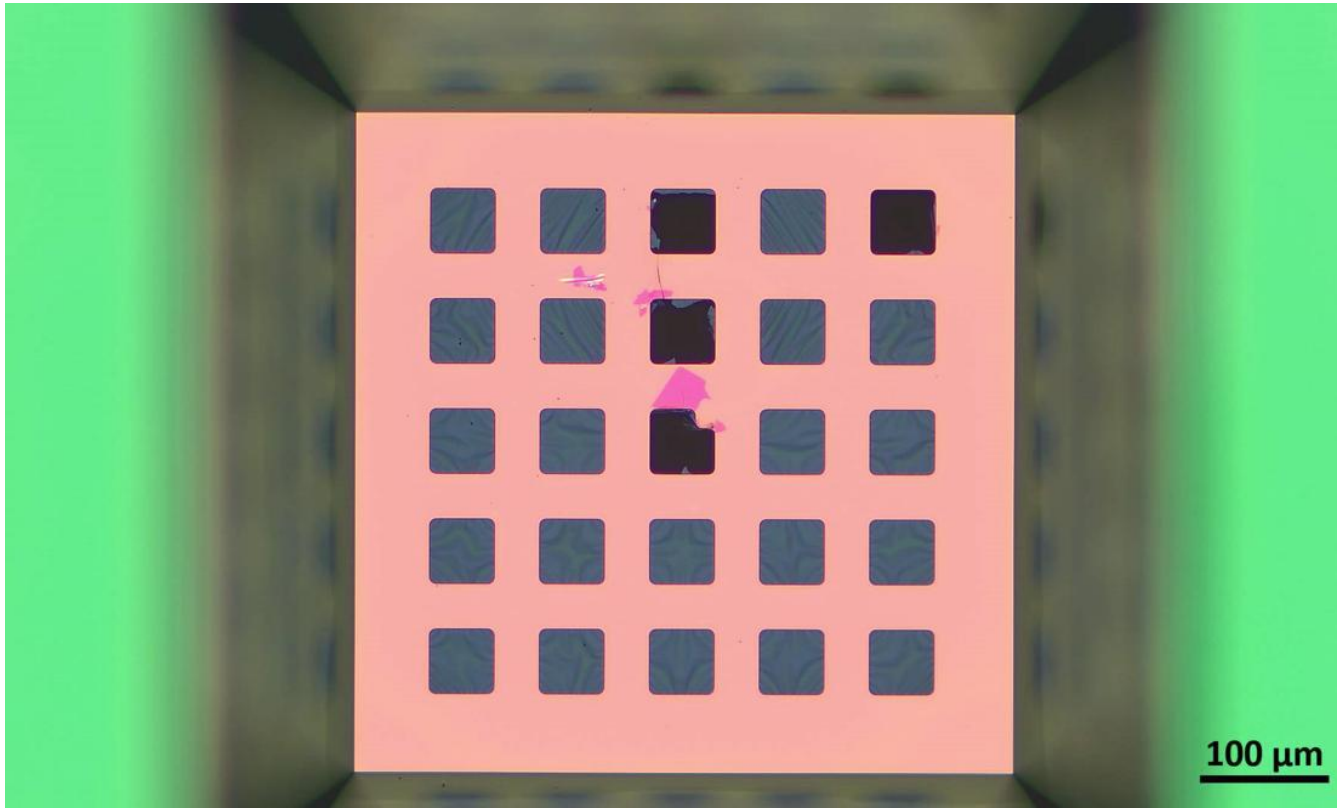
I. Rendere ***INFN-Pisa completamente autosufficiente*** per una rapida prototipazione di nuovi detector superconduttivi;

II. Possibilità per ***tutte le Sezioni di INFN*** interessate di ***sfruttare le conoscenze e le infrastrutture*** create a Pisa, senza dover *esternalizzare* la ricerca e sviluppo.

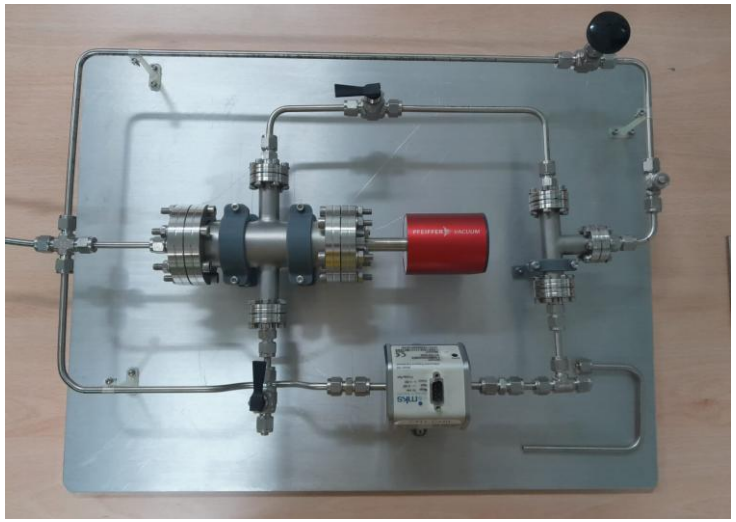
UTMOST

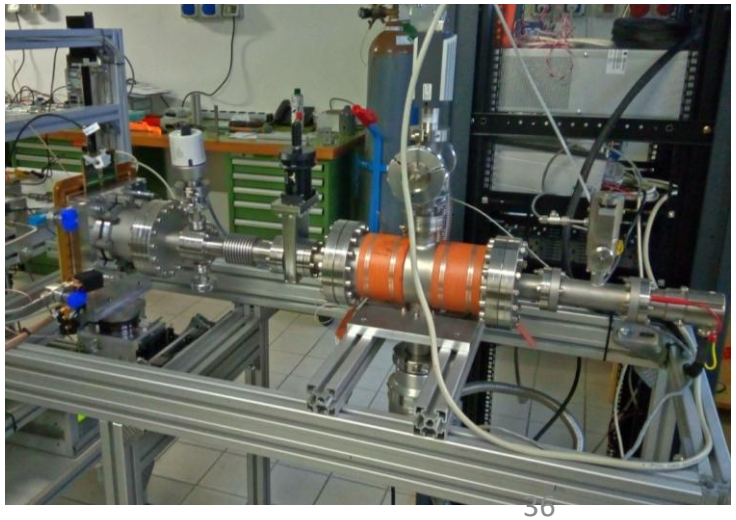
(UlTrathin Materials for gaSeous deTectors)

Integrare tecnologie basate su materiali ultrasottili in un rivelatore a gas altamente innovativo basato su tecnologia MICROMEGAS



Membrana di Si3N4, spessore: 8 nm



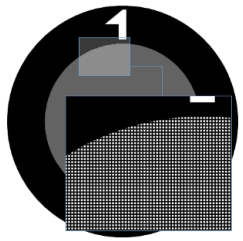


UTMOST
Attività in corso

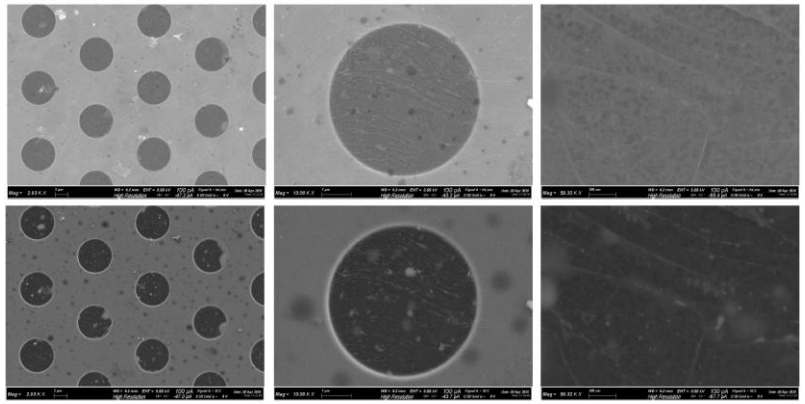
RN F. Pilo INFN PISA
INFN Pisa, INFN Roma 3, IIT

G2000HA

Mesh Specifications	
Mesh (lines/inch)	2000
Pitch (um)	12.5
Bar Width (um)	6
Hole Width (um)	6.5
Rim Specifications	
Rim width (mm)	0.5
Centre Mark	None
Rim Mark	Yes



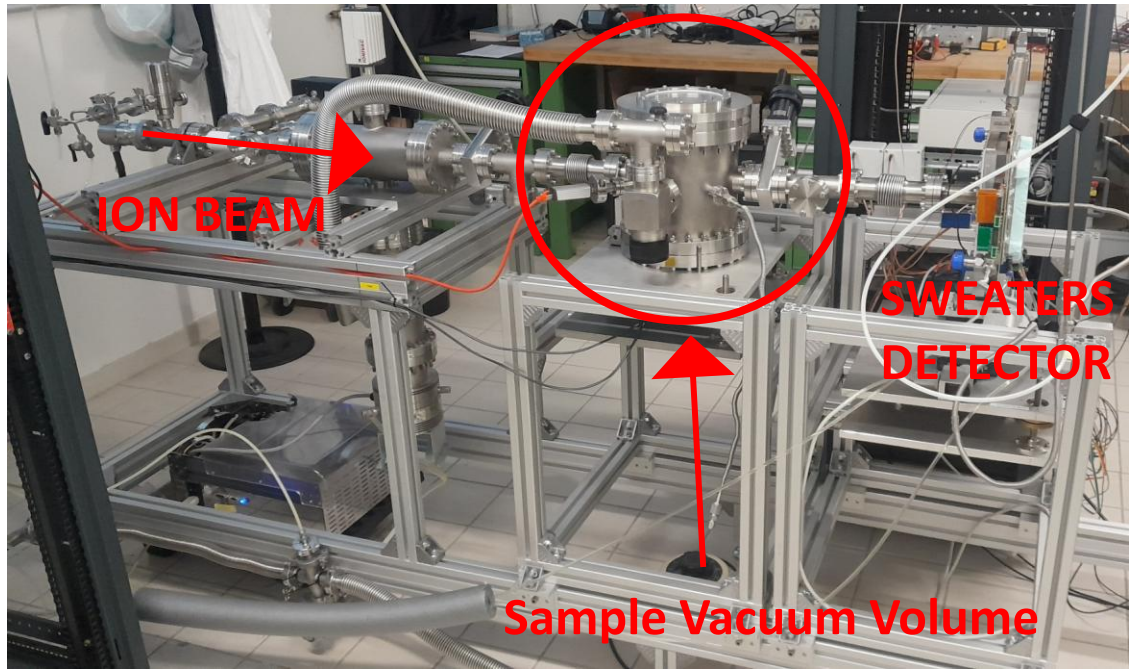
click image for larger view



Graphene on Sample Holder

Sample Holder Assembly

Differential pressure test



INFN Pisa ION BEAM FACILITY (Lab81)