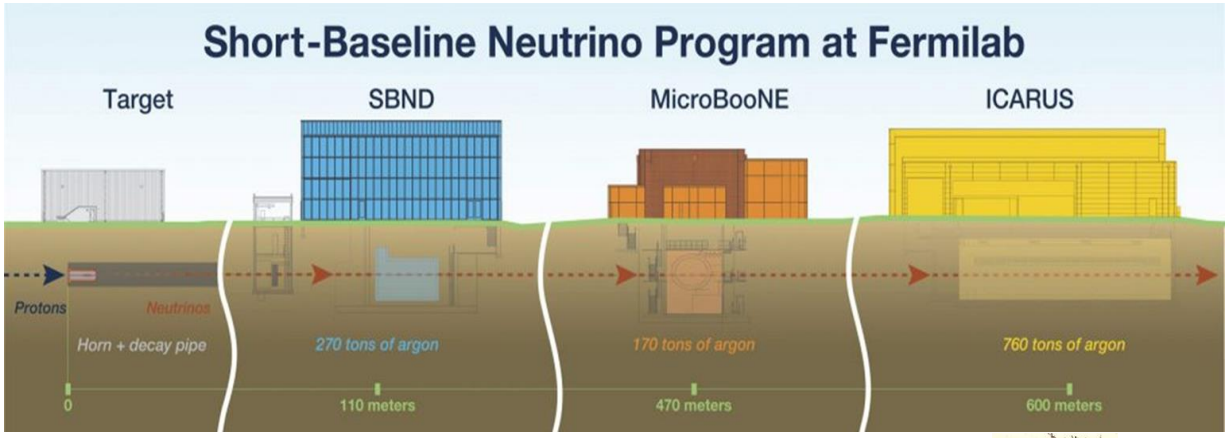
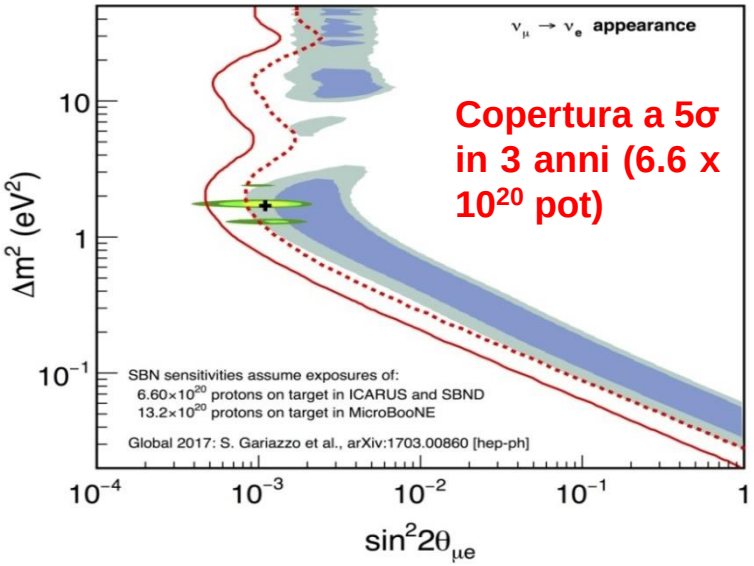
ICARUS ed il programma SBN

SBN: un programma sperimentale congiunto al fascio Booster di Fermilab per la ricerca di transizioni mediate da stati di neutrino sterile nel range Δm^2=0.1÷10 eV^2. La zona dei parametri di oscillazione esplorata è quella indicata da altri esperimenti sulle oscillazioni di neutrini ("puzzle dei neutrini sterili").





In fase di montaggio.
Inizio della fase di commissioning autunno 2023.
Presa dati dal 2024.

Presa dati nel periodo 2015-2021

In presa dati

Sala sperimentale ICARUS dopo l'installazione dei 3m di Overburden

ICARUS: run di fisica

- Le attività relative al commissioning di ICARUS si possono trovare nel paper inaugurale Eur. Phys. J. C 83, 467 (2023).

- Dati raccolti con i fasci BNB e NuMI:
  - Run 1: 9 Giugno 2022 - 10 Luglio 2022
  - Run 2: 20 Dicembre 2022 - 14 Luglio 2023.
  - Run 3: 13 Marzo 2024 - in corso.

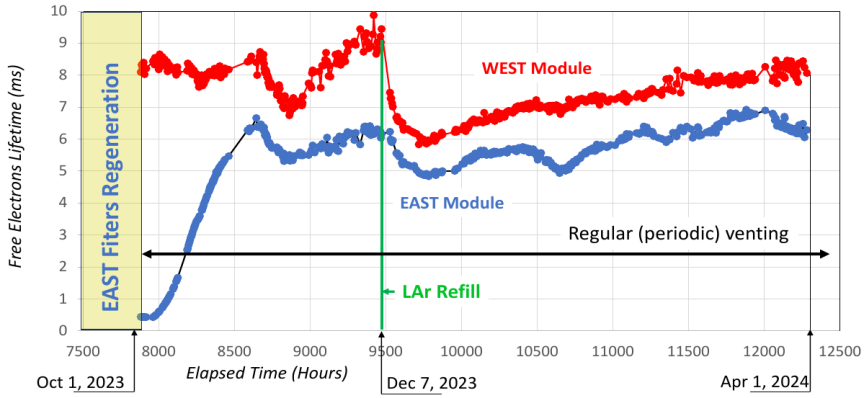
Statistica di ICARUS (RUN1 + RUN2):

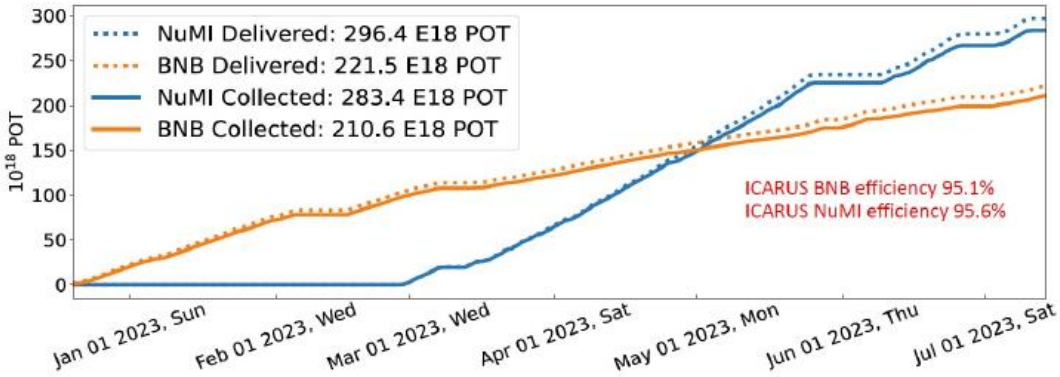
- BNB: 4.1 10^{19} + 2.1 10^{20} POT
- NuMI: 6.8 10^{19} + 2.8 10^{20} POT

Target BNB : 6.6 10^{20} POT (38%)

- Vita media degli elettroni di drift ~ 6-8 ms.

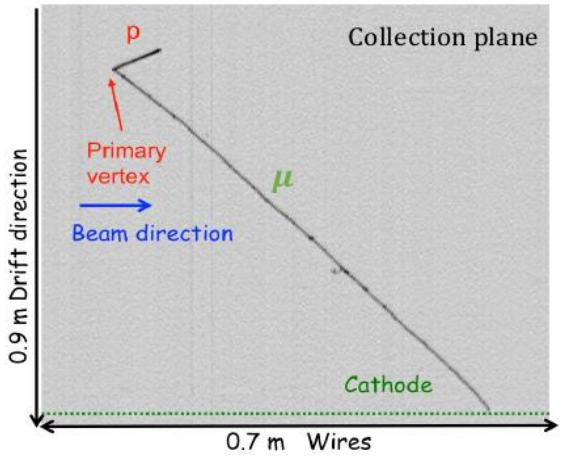
- Trigger: segnale dei PMT (scintillazione) in coincidenza con i gate di BNB e NuMI Efficienza complessiva ~ 93 %.



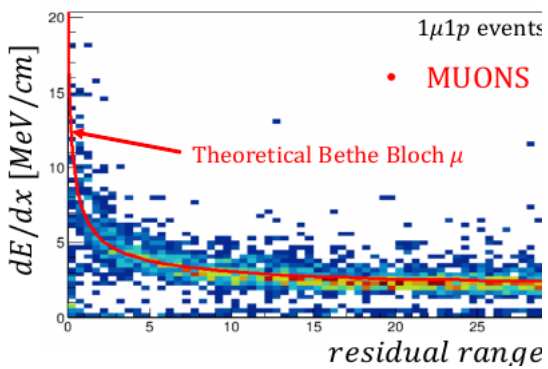


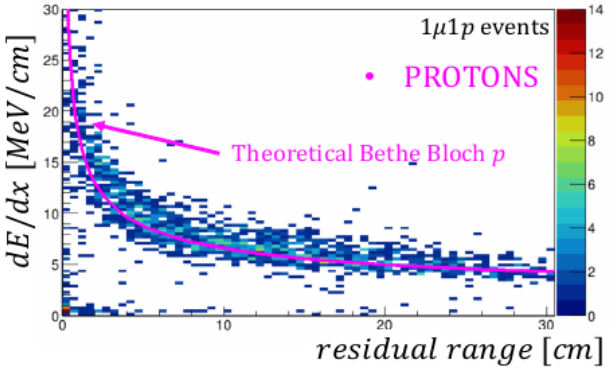
ICARUS: primi studi di ricostruzione degli eventi

- Prima che SBND entri nella fase di presa dati, i run di ICARUS standalone si possono utilizzare per una prima misura di oscillazione tramite il canale di $\nu\mu$ disappearance con eventi BNB di interazione $\nu\mu$ *CC quasi-elastica* ("1μNp"):



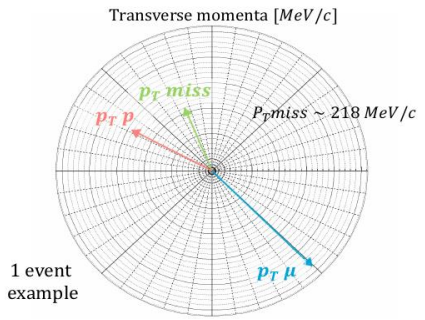
Identificazione delle particelle dal range

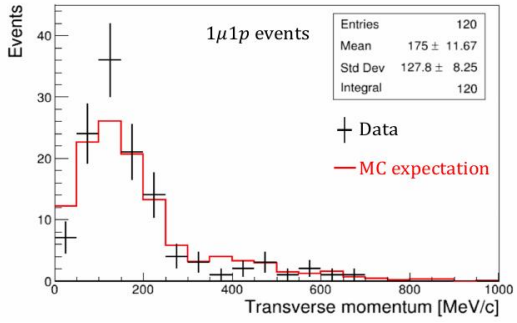




- Strategia per la selezione e ricostruzione automatica di un campione di eventi $\nu\mu$ *CC QE*.
- Validazione dei tools di identificazione di muone e protone tramite range.
- Valutazione della capacità di ricostruzione delle variabili cinematiche nel piano trasverso.
- Primi risultati pubblici a Neutrino 2024 (17 giugno).

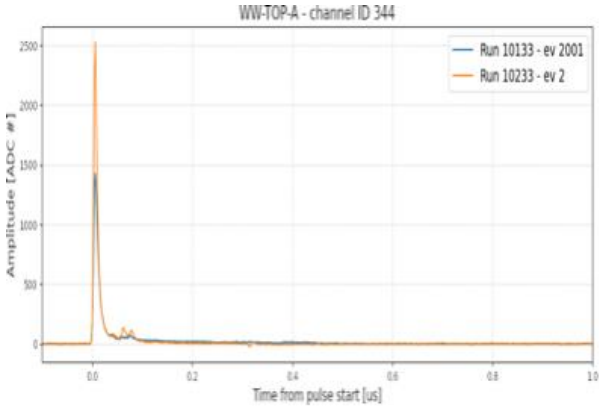
Confronto dati/MC (momento trasverso)

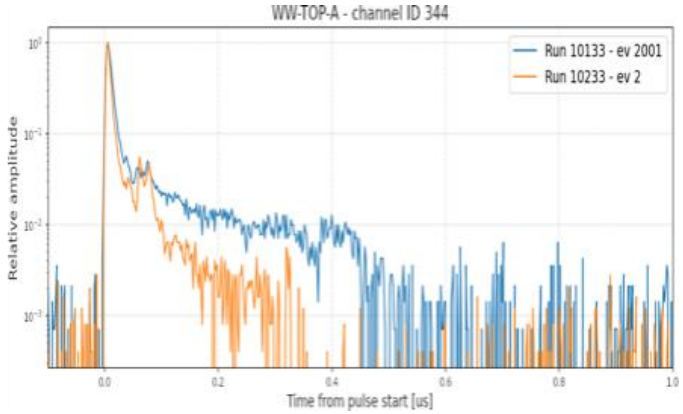




Attività durante il summer shutdown 2023

- Durante lo spegnimento tecnico del fascio nell'estate 2023, sono state effettuate sul rivelatore alcune attività con il fine di migliorarne la stabilità e le prestazioni. Il contributo del gruppo di Pavia è stato fondamentale in questo periodo, in particolare nelle seguenti attività:
  - Nuove implementazioni sul sistema di trigger con il fine di migliorarne la stabilità, l'efficienza e permettere più elevati flussi di dati (G.L. Raselli e M. Rossella).
  - Milglioramento del sistema di purificazione dell'argon liquido con la sostituzione di una pompa difettosa e la rigenerazione dei filtri Lar del criostato Est (C. Montanari, F. Vercellati, S. Gigli).
  - Sostituzione di tutti (360) cavi segnale dei PMT con cavo coassiale ad alte prestazioni WL195N (G. Raselli, M. Rossella, D. Calabro').

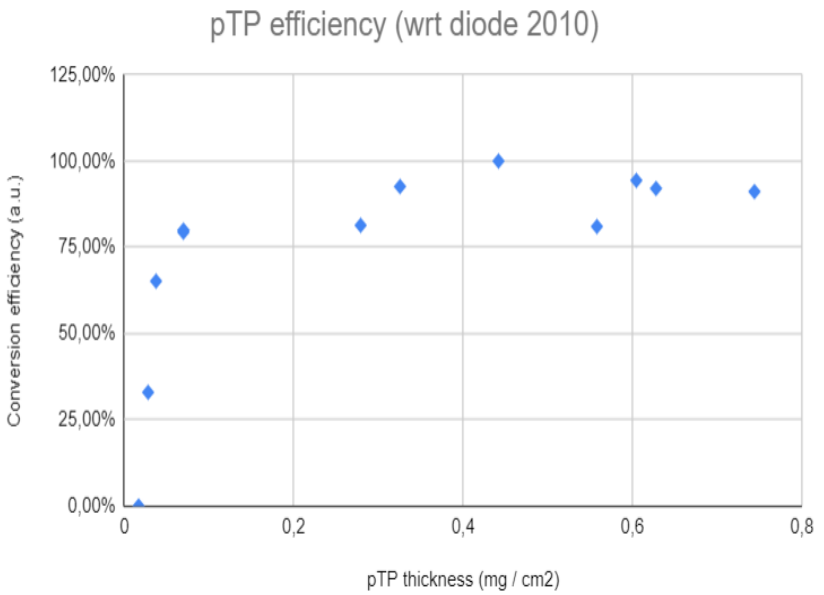




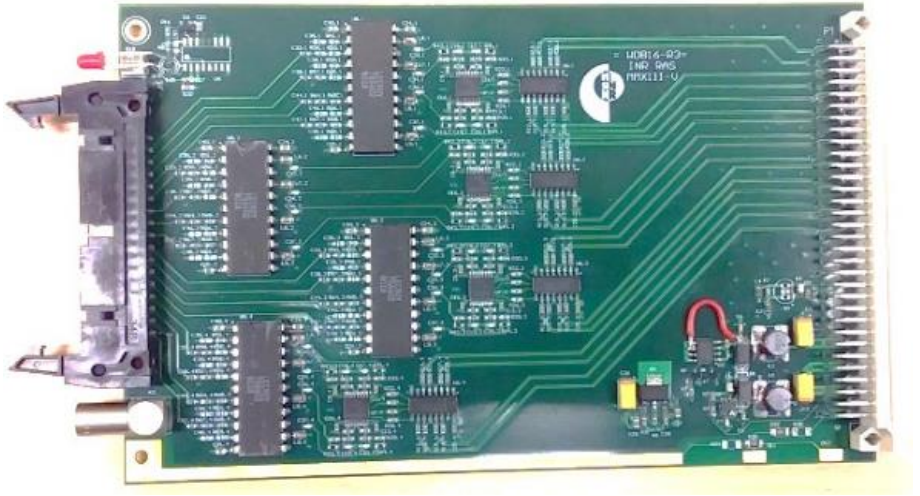
Il nuovo cablaggio permette un incremento dei picco segnali dei PMT pari ad un fattore 2% ed una riduzione del contributo in carica della coda dal 35% al 6%.

Attività DUNE 2023/2024

Nel 2023 abbiamo lavorato, in collaborazione con il gruppo di Milano Bicocca, alla caratterizzazione delle finestre degli X-Arapuca per il FD di DUNE studiando l'efficienza di conversione del para-Terphenyl, da noi evaporato, e di trasmissione dei filtri dicroici.



In collaborazione con il gruppo di Bologna stiamo effettuando (D. Calabro') degli studi sull'elettronica di lettura della camera tracciante dell'apparato SAND (Near Detector).



ICARUS: partecipazione

- La collaborazione ICARUS è una collaborazione internazionale comprendente 27 istituzioni (12 gruppi INFN, 12 istituzioni USA, il CERN, 1 istituzione messicana, 1 istituzione indiana).

- Il gruppo ICARUS PV è costituito da:
  - Simone Copello: Ricercatore INFN, 0.5 FTE
  - Alessandro Menegolli: Professore Associato Univ. di Pavia, Chair ESB, 0.5 FTE
  - Claudio Montanari: Dirigente di Ricerca INFN, ICARUS Technical Coordinator, 0.6 FTE
  - Fabrizio Boffelli: Docente a contratto Univ. di Pavia 0.5 FTE
  - Andrea Rappoldi: Primo Tecnologo INFN, 0.3 FTE
  - Gian Luca Raselli: Primo Ricercatore, responsabile locale, responsabile PMT, 0.6 FTE
  - Massimo Rossella: Dirigente Tecnologo INFN, 0.3 FTE

TOT 7 persone, 3.2 FTE in database.

ICARUS: pubblicazioni e partecipazioni Pavesi a conferenze

ARTICOLI

- *ICARUS at the Fermilab Short-Baseline Neutrino program: initial operation*
  Eur. Phys. J. C (2023) 83:467 https://doi.org/10.1140/epjc/s10052-023-11610-y

CONFERENZE

16th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD23)

G. L. Raselli et al.
Time calibration and synchronization of the scintillation light detection system in ICARUS-T600
JINST 19 (2024) C01027

S. Copello et al.
Experimental setup for the measurement of optical properties in the vacuum ultraviolet region
JINST 19 (2024) C04036

ENUBET
Enhanced **NeU**trino **BE**ams from kaon **T**agging
http://enubet.pd.infn.it
Progetto European Research Council (ERC) 06/2016 – 06/2022 [concluso]
ERC-Consolidator Grant-2015, no 681647 (PE2)
P.I.: **A. Longhin** - Padova, Host Institution: INFN

CERN experiment: **NP06/ENUBET**
Spokesperson: A. Longhin INFN-PD, F. Terranova INFN-MIB
Technical Coordinator: **Valerio Mascagna - INFN PV**

Dal 2023 esperimento finanziato da CSNII con sigla **ENUBET_2** (resp. naz. F. Terranova)

Consuntivo **ENUBET_2** dotazioni PAVIA **2023** (assegnati 500 €)

Anagrafica: Valerio Mascagna (RUTDB, Università di Brescia), 10%

Attività: installazione nuovi canali @LNL

Test beam @CERN - East Hall, T9 beamline
2 settimane

Pubblicazioni: *Design and performance of the ENUBET monitored neutrino beam*, EPJ C **83**, 964 (2023)

Conferenze: The Demonstrator: a large scale prototype of the instrumented decay tunnel for the ENUBET monitored neutrino beam
V. Mascagna @ IPRD2023 - Siena
(elenco completo collaborazione: ENUBET → dissemination)

GAPS

Consiglio di Sezione INFN Pavia

05 giugno 2024

General AntiParticle Spectrometer

The General Antiparticle Spectrometer (GAPS) is an Antarctic balloon experiment designed to detect low-energy cosmic antinuclei as an indirect signature of dark matter

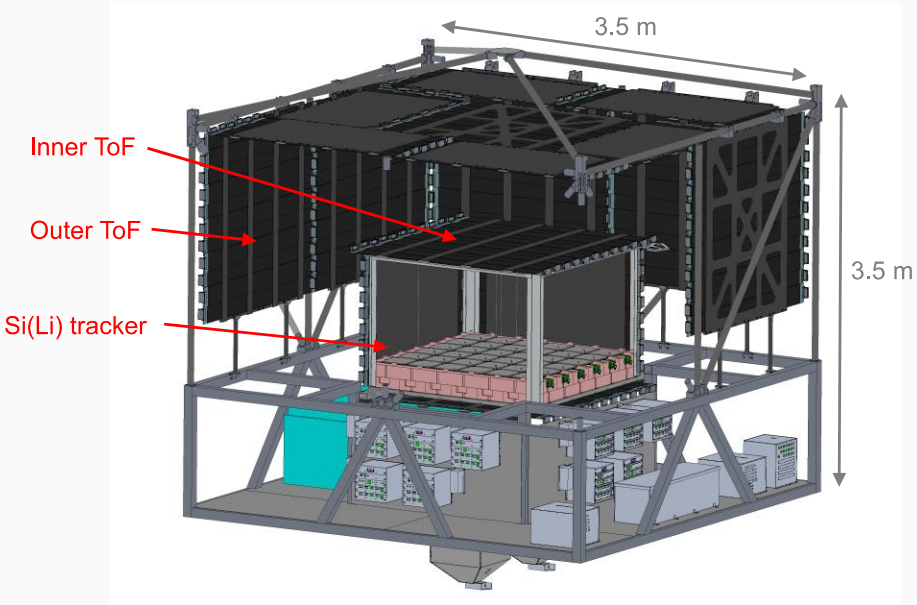
The Instrument

Time-of-Flight System (TOF)

- 220 plastic scintillator paddles with Si-PM readout

Si(Li) Tracker

- About 1000 lithium-drifted silicon (Si(Li)) detectors
- 10 layers with 10 cm spacing
- 12x12 Si(Li) detectors per layer
- Modular structure (360 modules)

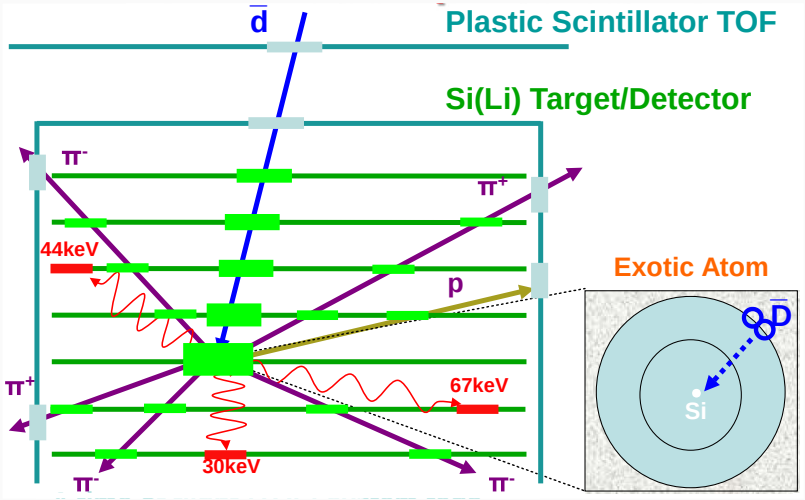


Particle identification

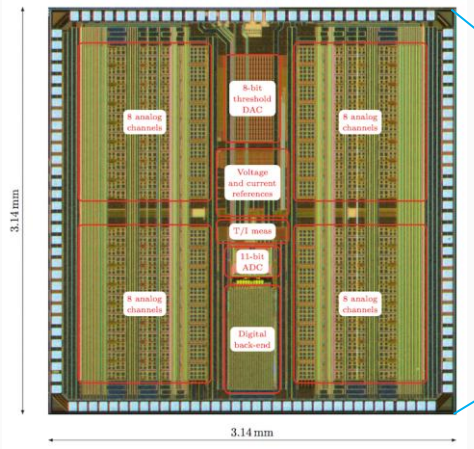
Time-of-flight system measures velocity and dE/dx

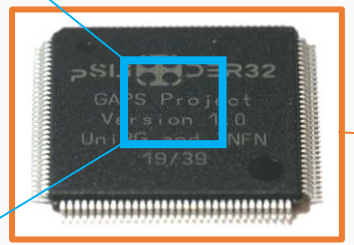
Si(Li) Tracker functions as

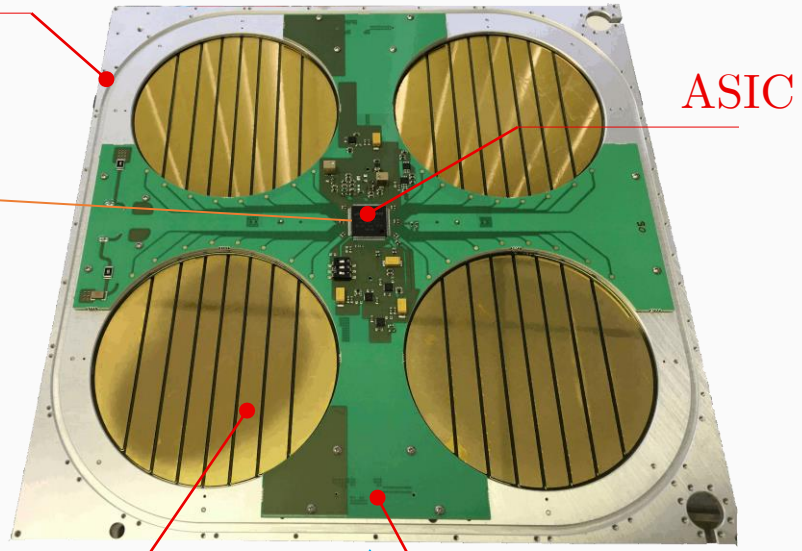
- **target** to slow an incoming antiparticle and capture it into an exotic atom in an excited state
- **spectrometer** for de-excitation X-rays
- **tracker** to measure antinucleus dE/dx and stopping depth, and annihilation products from nuclear decay



Si(Li) Tracker





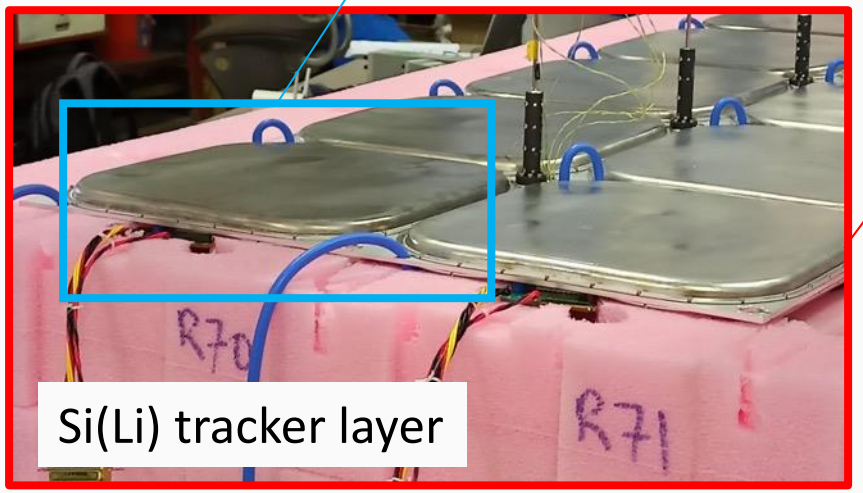


Module

- 4 Si(Li) detectors (8 strips each)
- 1 readout ASIC
- 1 front end board
- Frame

Front-end electronics requirements

- Channels per ASIC: **32**
- Operating temperature: **-40 °C**
- Power dissipation: **≤10 mW/ch**
- Signal polarity: **electrons**
- Dynamic range: **10 keV-100 MeV**
- Analog Resolution: **4 keV (FWHM)** detector capacitance 40 pF
- Threshold: **20 keV**
- Detector leakage current: **5 nA**



Si(Li) tracker layer


Gondola

Attività 2023 – missioni

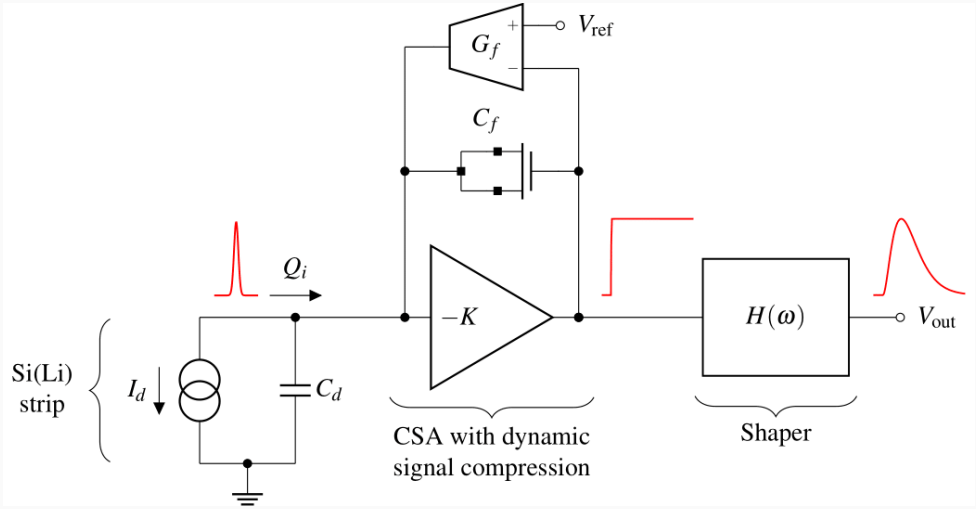
Supporto negli Stati Uniti per l'integrazione dello strumento così distribuite

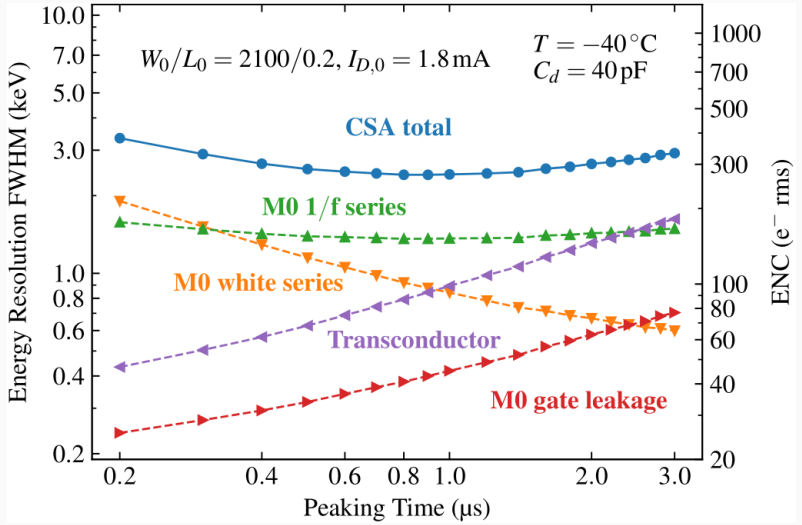
- Space Science Laboratory (SSL – Berkeley) → 4 settimane
- University of California Los Angeles (UCLA – Los Angeles) → 2 settimane
- National Technical System (NTS – Los Angeles) → 5 settimane
- University of Hawaii at Manoa (UHManoa – Honolulu) → 2 settimane
- Nevis Laboratories – Columbia University (Yonkers) → 4 settimane

- **Totale 17 settimane/uomo**

Next-generation readout ASIC in 65 nm CMOS technology

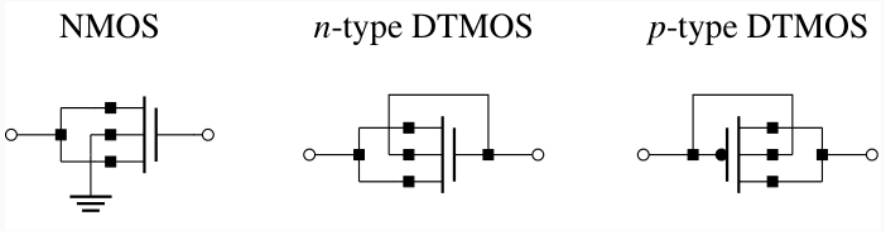
- A **next-gen Si(Li) readout channel** is being developed as a **possible upgrade** of the current ASIC in 180 nm CMOS technology
- Transition from 180 nm to 65 nm CMOS technology
- Motivations:
  - **Technology availability**
  - Reduced power consumption
  - Higher integration density, reduced footprint
  - Alternative detector topologies can be evaluated
- R&D activity is **ongoing**
- Charge sensitive amplifier with dynamic signal compression has been developed
  - Variable feedback capacity wrt incoming energy
  - High sensitivity in the 10 keV – 100 keV x-ray detection region (>250 µV/keV)
  - Wide input energy range of 10 keV – 100 MeV is supported
  - Total ENC < 4 keV with 40 pF detector capacitance

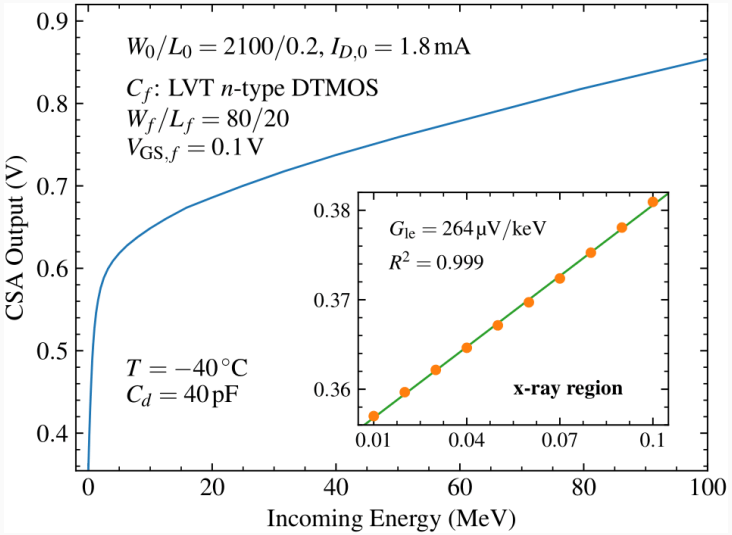




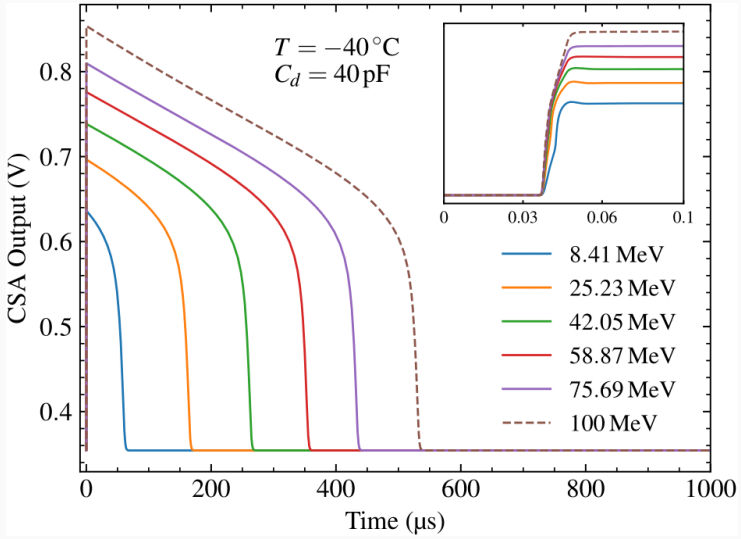
Next-generation readout ASIC in 65 nm CMOS technology

- A **novel approach** for the feedback capacitor implementation has been investigated, employing **Dynamic Threshold MOSFETs (DTMOS)**
  - Device bulk is connected to the gate
  - Threshold voltage is reduced with the increase of the gate to source voltage
  - Reduced area occupation wrt to standard MOS
  - Increased compression factor wrt to standard MOS





- Comparison with the 180 nm implementation suggests **promising results**:
  - 67% area saving
  - 26% reduced power consumption
  - 2.41 keV FWHM energy resolution
  - 285 e- rms Equivalent Noise Charge (ENC)
  - ~ 15 ns rise time
  - ~ 540 µs recovery time @ Einj = 100 MeV



Presentazioni

Presentazioni a Conferenze

- Massimo Manghisoni, **The SLIDER32 front-end chip for X-ray spectrometry and tracking in the GAPS experiment**, XII Front-End Electronics Workshop (FEE) **(Talk)**
- Luca Ghislotti, **L'esperimento GAPS per l'indagine della materia oscura**, Incontri di Fisica delle Alte Energie (IFAE) 2023 **(Poster)**
- Elisa Riceputi, **32-channels mixed-signal processor for the tracking system of the GAPS dark matter experiment**, Topical Workshop on Electronics for Particle Physics - TWEPP 2023 **(Poster)**
- Elisa Riceputi, **Experimental results from the characterization of a 32-channels mixed-signal processor for the GAPS experiment**, 2023 IEEE NSS MIC RTSD **(Talk)**

Personale INFN Pavia - 2023

- Valerio Re (PO) 20%
- Massimo Manghisoni (PO) 50%
- Elisa Riceputi (RTDa) 50%
- Luca Ghislotti (Dottorando) 100%

Totale FTE: 2.2

Consuntivo 2023 HERD Pavia

05-06-2024

The INFN Pavia HERD group

Anagrafica HERD 2023

Paolo Walter Cattaneo	PR	40 %
Marco Pullia	Ric. CNAO	20 %
Gianluca Raselli	PR	10 %
Carlo De Vecchi	PT	30%
Andrea Rappoldi	PT	40 %
Cristiani Ilaria	PO	10 %
FTE		1.5

Attività HERD

Beam tests CNAO:

Supporto a diversi test con prototipi PSD di Bari/GSSI e di SCD (Silicon Charge Detector) di Perugia.

Articoli da confereza

ICRC 2023

Nuclei identification performances studies of the Plastic Scintillator Detector (PSD) for the future HERD space mission, D. Serini et al., Pos ICRC2023 (2023) 112

The Plastic Scintillator Detector of the HERD space mission, D. Kyratzis, Pos ICRC2023(2023) 140

IWASI 2023

Characterization of the nuclei identification performances of the plastic scintillator detector prototype for the future HERD satellite experiment, D. Serini et al., 9th International Workshop on Advances in Sensors and Interfaces, (2023)

15th Pisa Meeting on Advanced Detectors: Frontier Detectors for Frontier Physics (PM2021)

Status of the plastic scintillator detector for the HERD experiment, F. Alemanno et al., Nucl. Instrum. & Meth. 1051 (2023) 168237

INFN – PAVIA
Consuntivo Esperimento
Consiglio di Sezione, Gruppo II, 12 Giugno 2023

XRO

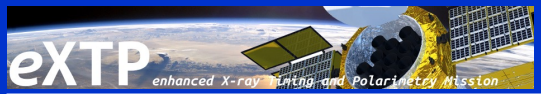
X RAY OBSERVATORIES

Piero Malcovati and Marco Grassi

University of Pavia and INFN Pavia

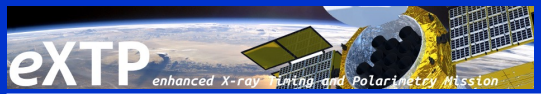
XRO – X-RAY OBSERVATORIES

- Riunisce le attività sulle missioni
  - IXPE : Imaging X-Ray Polarimetry Explorer (già in CSN2)
  - eXTP: enhanced X-Ray Timing and Polarimetry (nuova)
- Responsabili nazionali
  - L. Baldini (PI) e V. Bonvicini (TS)
- Strutture partecipanti:
  - TS, PI, TO, MI, PV, BO, TIFPA, PG, RM2
- Man power
  - > 20 FTE complessivi



eXTP Mission

- **eXTP: a flagship X-ray observatory mission**
  - Being developed by the Chinese Academy of Sciences
  - a large contribution by a European Consortium inherited from the ESA-M3 LOFT mission study
- **Currently in Phase B**
  - The launch date is planned in 2027, mission lifetime goal 8 years
  - The progam is strongly behind schedule due to the difficulty of the relations with China
- **Observatory open to the worldwide scientific community**
  - Observing plan based on:
    - Core Program observations
    - Guest Investigator Program



eXTP Consortium

PI – China: Prof. Shuang-Nan Zhang IHEP/CAS – Beijing
PI – Europe: Dr. Marco Feroci – INAF IAPS Roma

CAS

CNSA

IHEP

Tsinghua University

Tongji University

CAST Beijing

Microsat Shanghai

Italy

Spain

Germany

France

Switzerland

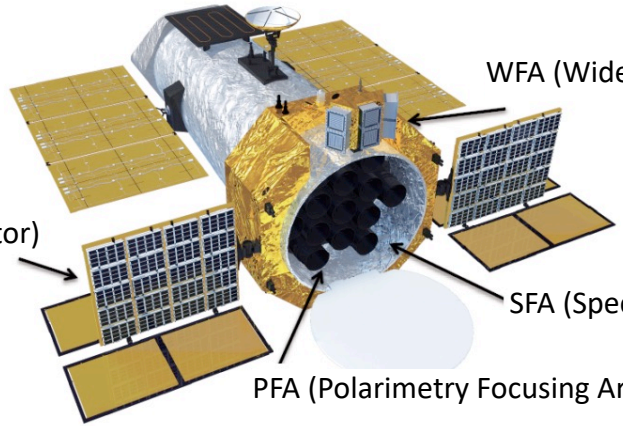
Czech Republic

Poland

Denmark

The Netherlands

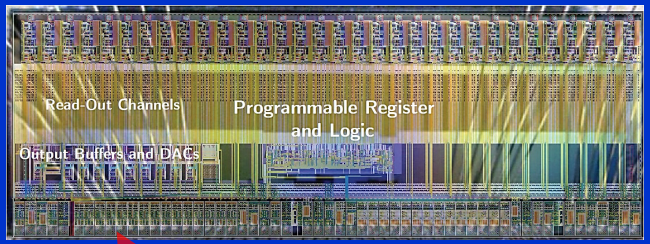
eXTP Concept

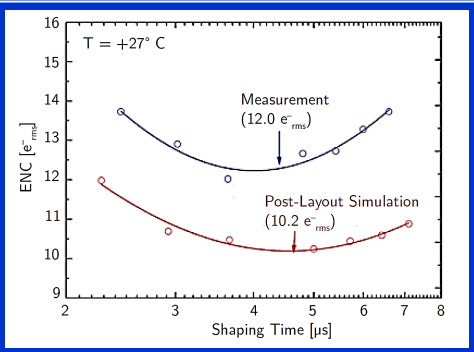


Payload	Configuration	Optics	Detector	Eff. Area (cm^2)	Energy Range (keV)
SFA	9 Telescopes	Nickel Replica	SDD	5000 – 7000	0.5 - 10
LAD	40 Modules	MCP Collimator	SDD	34000	2 - 30
PFA	4 Telescopes	Nickel Replica	GPD	900	2 - 10
WFM	6 Cameras	1.5 Coded Mask	SDD	FOV > 4sr	2 - 50

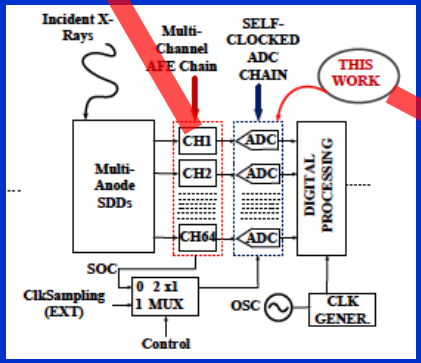
Development of an ADC for the VEGA ASIC

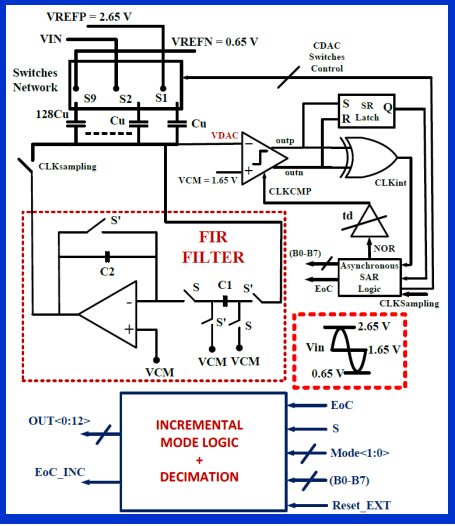
VEGA ASIC (32 Channels)





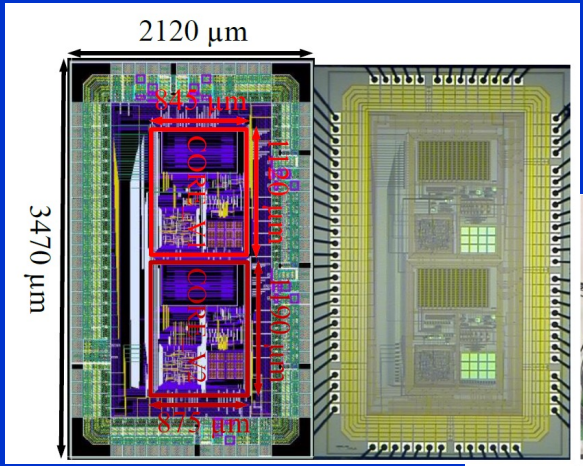
Originally designed for LOFT



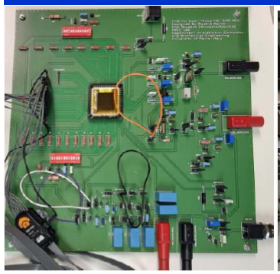


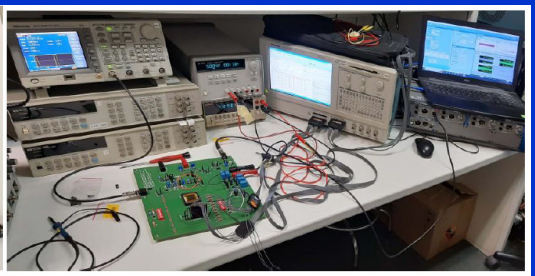
Asynchronous Noise-Shaping SAR ADC
12-bit resolution
Programmable sampling frequency

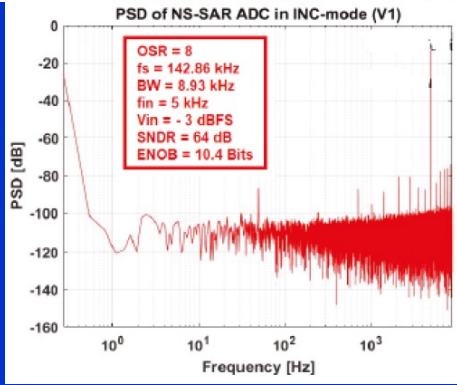
Development of an ADC for the VEGA ASIC

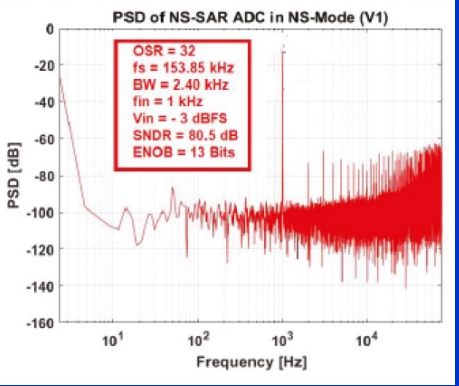


The ADC has been designed, fabricated and tested









Budget and Publications

- **INFN Pavia:**

Piero Malcovati – Responsabile locale	(0.2 FTE)
Marco Grassi – Postdoc	(0.2 FTE)
Elisabetta Moisello – Postdoc	(0.3 FTE)
Alessandro Gemelli – PhD student	(1.0 FTE)

- **Budget:**

Missioni (assegnati 5 k€)	2.308,82 €
Consumo (assegnati 8 k€)	5.132,98 €

- **Publications:**

R. Karim, M. Grassi, and P. Malcovati, "1st-Order Error-Feedback Sampling-Rate Reconfigurable Noise-Shaping SAR ADC for Multi-Channel CMOS Front-End ASICs for Space Applications", Proceedings of IEEE Northeast Workshop on Circuits and Systems (NEWCAS), Edinburgh, Scotland, UK, pp. 1-5, June, 2023, DOI: 10.1109/NEWCAS57931.2023.10198081.

R. Karim, M. Grassi, and P. Malcovati, "An 8 Bit-ENOB Sampling-Rate Reconfigurable Asynchronous SAR ADC with Metastability Watchdog Circuit for Activity-Driven Multi-Channel CMOS Readout ASICs for Space Applications", AEU — International Journal of Electronics and Communications, vol. 173, no. 154979, pp. 1-13, January, 2024, DOI: 10.1016/J.AEUE.2023.154979.