Attività Limadou @ TIFPA

Riunione per i preventivi del 2026 - TIFPA, 1 July 2025

Francesco Maria Follega, Ester Ricci e Roberto Iuppa on behalf of the Limadou Team @ TN

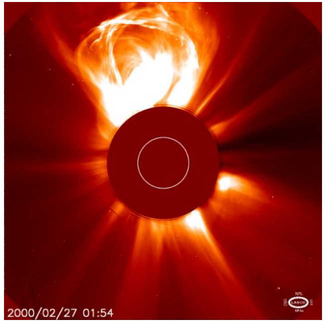
The CSES scientific mission

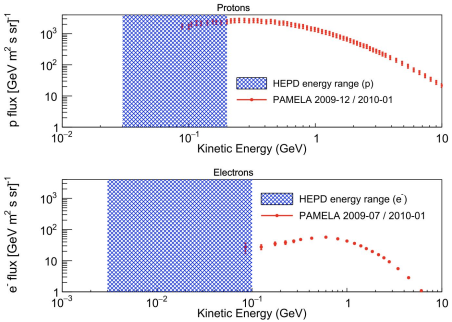
The **CSES mission** is a scientific collaboration between Italy and China.

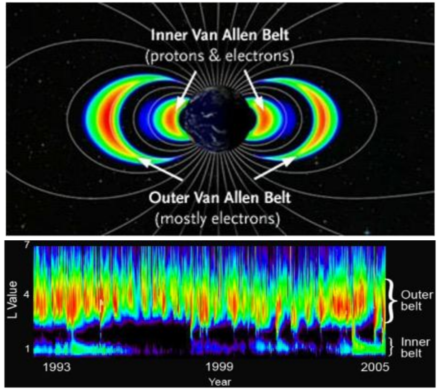
Scientific goals:

- **Investigate the ionosphere** and gather world-wide data;
- Study solar-terrestrial interactions and solar physics: CMEs, SEPs, solar flares;
- Study and extend **low energy spectrum of cosmic rays;**
- Measure the particles and plasma **perturbations in the ionosphere and magnetosphere:** natural sources (EQs) and anthropic emitters;

Interaction with trapped particles







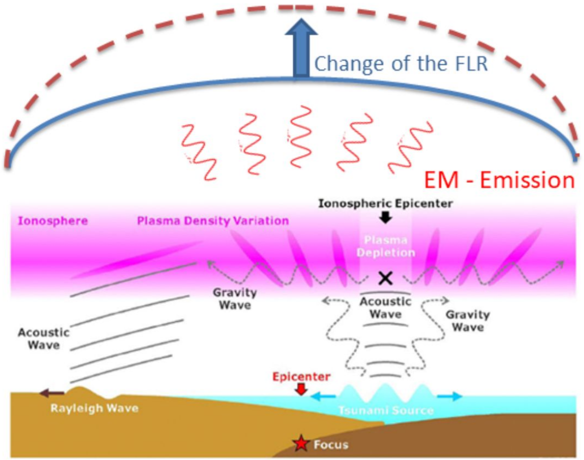


Figure 10. Cartoon describing the basic components of the proposed M.I.L.C. model.

The CSES scientific mission

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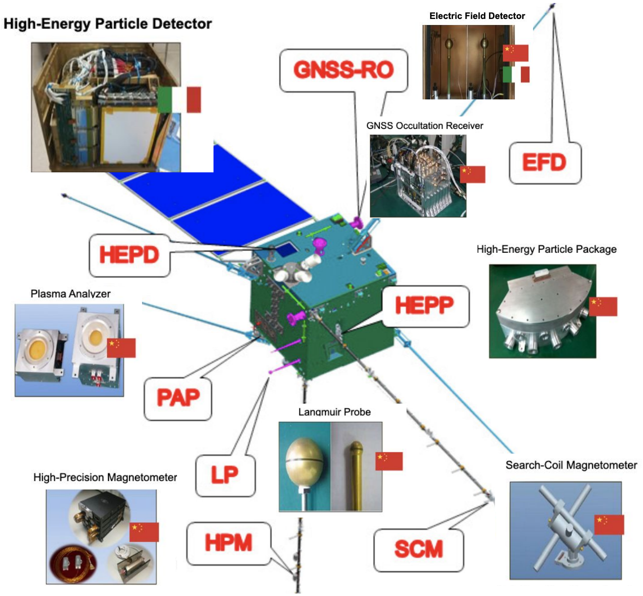
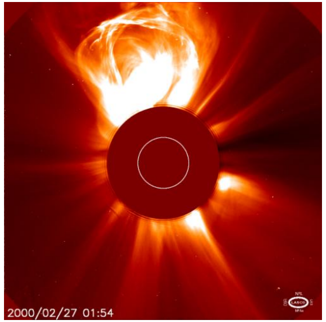
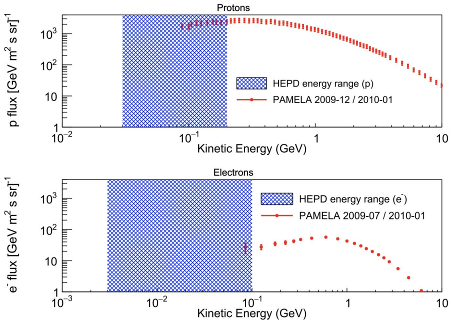
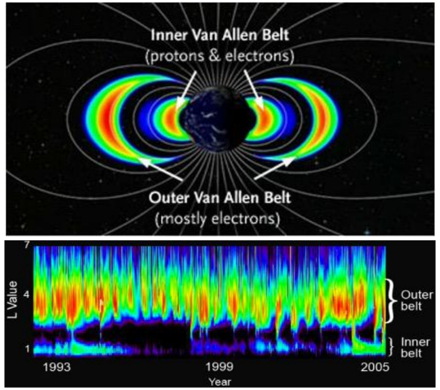
Instruments on board CSES-01 satellite





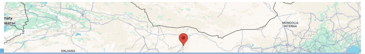




The launch of CSES-02

Jiuquan Satellite Launch Center (Inner Mongolia)

on the 14 of June 2025



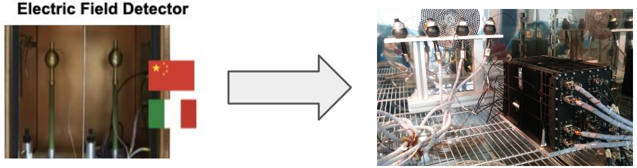
The CSES mission: multi-point era

The new phase of the CSES mission started with the **launch of the second satellite the 14 June 2025**.

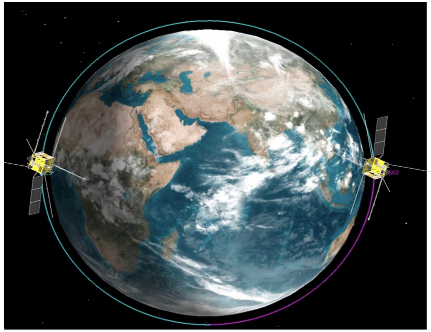
- A new particle detectors suite for CSES-02 with improved detectors (i.e. HEPD-02) with **energy range from tens of KeV to hundreds of MeV (three orders of magnitude);**
- Improved version of EFD-02 (developed by INFN) working in conjunction with EFD-01 for electromagnetic field detection;
- Another point of observation and **improved coverage and latitude span with sensitivity to GRB;**

Electric Field Detector

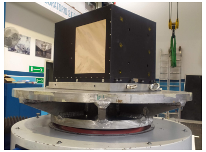
EFD-02

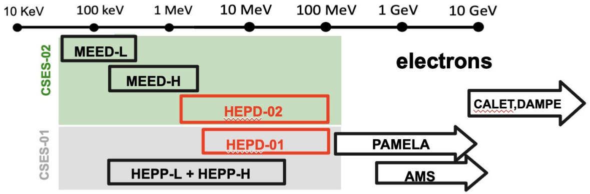


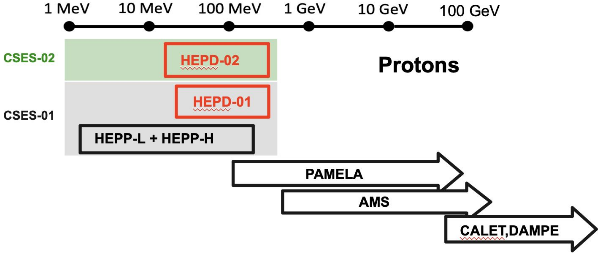
- **Upgraded platform with CSES-02:**
  - system with orbit manoeuvre capability
  - X-Band Data Transmission 120Mbps →150Mbps
  - Total Mass: 730kg→900kg
  - Peak Power Consumption: ~900W
  - Design Life-span: 5 years→6 years



HEPD-02



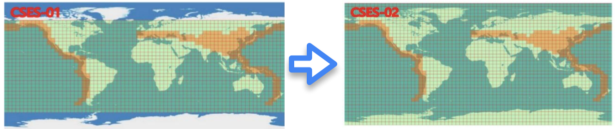




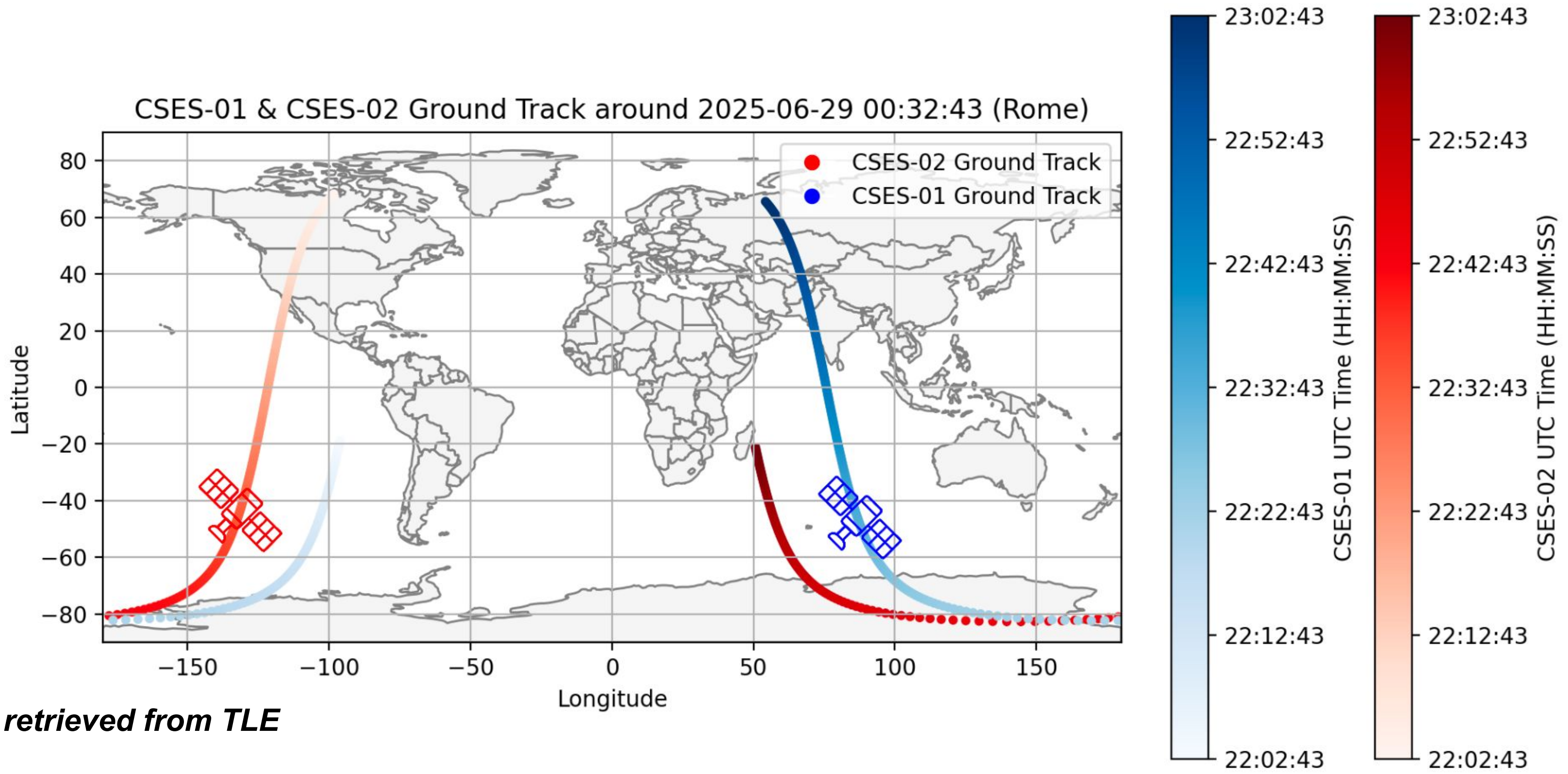
- **Complementary Orbit with CSES-01**
  - Same Orbit Plane but shifted by 180°;
  - Return cycle: 5 days→2.5 days

Operation area between lat [-65,65]

Full coverage at extreme latitudes



The CSES mission: multi-point era



Data retrieved from TLE

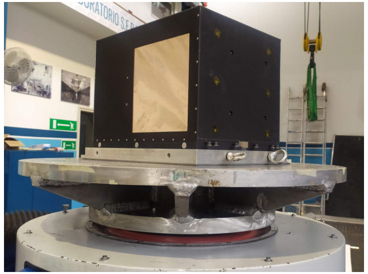
CSES-02 (HEPD-02/EFD-02): road to launch

Shipment of HEPD-02/EFD-02 to DFH (China)
11/12/2023

Arrival of HEPD-02/EFD-02 to DFH (China)
21/12/2023

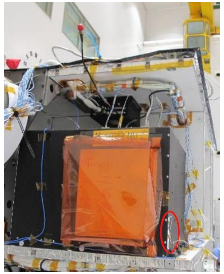
CSES-EFD-02/HEPD-02 interface (TC and automatic procedure) verification
8-24/01/2024

HEPD-02 on board CSES-02 full functional test
26-28/02/2024



CSES-02 Vibration Test
19-21/04/2024

CSES-02 Thermal Vacuum Test
20/07/2024 - 04/08/2024



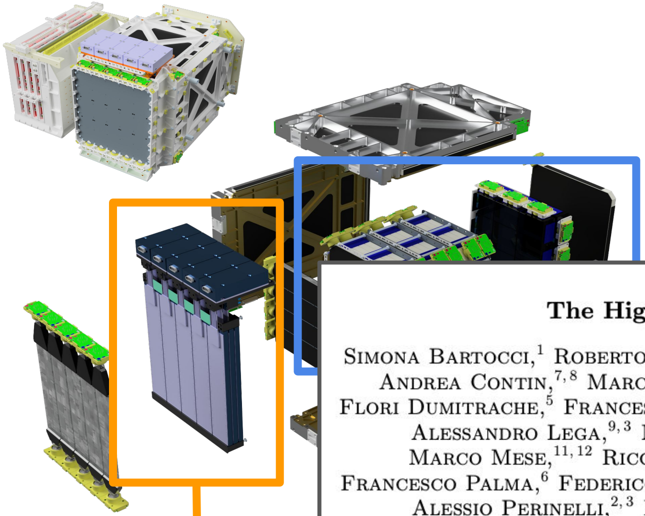
CSES-02 Shipment to launch site
15/05/2025

Launch of CSES-02
14/06/2025
Start of constellation era

We are here

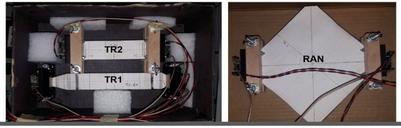
Commissioning started-June 2025

Limadou HEPD-02 detector activities



Direction Detector
First Silicon Pixel (MAPS) tracker in space

Characterization and calibration of HEPD-02 scintillators

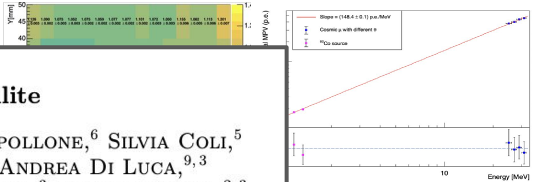


Article

The Scintillator Counters of the High-Energy Particle Detector of the CSES-02 Satellite

Simona Bartocci[1], Roberto Battiston[2,3], Stefania Beolè[4,5], Franco Benotto[5], Piero Cipollone[6], Silvia Coli[5], Andrea Contin[7,8], Marco Cristoforetti[9,10], Cinzia De Donato[6], Cristian De Santis[6], Andrea Di Luca[9,10], Flori Dumitrache[5], Francesco Maria Follega[2,10], Simone Garrafa Botta[5], Giuseppe Gebbia[2,10], Roberto Iuppa[2,10], Alessandro Lega[2,10], Mauro Lolli[8], Giuseppe Masciantonio[6], Matteo Mergè[11], Marco Mese[12,13], Riccardo Nicolaidis[2,10], Francesco Nozzoli[10], Alberto Oliva[8], Giuseppe Osteria[13], Francesco Palma[6], Federico Palmonari[7,8], Beatrice Panico[12,13], Stefania Perciballi[4,5], Francesco Perfetto[13], Piergiorgio Picozza[14,6], Michele Pozzato[8], Marco Ricci[15], Marco Ricci[2,10], Sergio Bruno Ricciarini[16], Zouleikha Sahnoun[7,8], Umberto Savino[4,5], Valentina Scotti[12,13], Enrico Serra[10], Alessandro Sotgiu, Roberta Sparvoli[14,6], Pietro Ubertini[17], Veronica Vilona[10], Simona Zoffoli, and Paolo Zuccon[2,10]

Published



The High-Energy Particle Detector on board the CSES-02 satellite

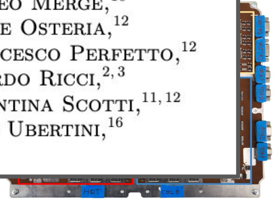
Simona Bartocci,[1] Roberto Battiston,[2,3] Stefania Beolè,[4,5] Franco Benotto,[5] Piero Cipollone,[6] Silvia Coli,[5] Andrea Contin,[7,8] Marco Cristoforetti,[9,3] Cinzia De Donato,[6] Cristian De Santis,[6] Andrea Di Luca,[9,3] Flori Dumitrache,[5] Francesco Maria Follega,[2,3] Simone Garrafa Botta,[5] Giuseppe Gebbia,[3] Roberto Iuppa,[2,3] Alessandro Lega,[9,3] Mauro Lolli,[8] Matteo Martucci,[6] Giuseppe Masciantonio,[6] Matteo Mergè,[10] Marco Mese,[11,12] Riccardo Nicolaidis,[3] Francesco Nozzoli,[3] Alberto Oliva,[8] Giuseppe Osteria,[12] Francesco Palma,[6] Federico Palmonari,[7,8] Beatrice Panico,[11,12] Stefania Perciballi,[4,5] Francesco Perfetto,[12] Alessio Perinelli,[2,3] Piergiorgio Picozza,[13,6] Michele Pozzato,[8] Ester Ricci,[2,3] Leonardo Ricci,[2,3] Marco Ricci,[6,14] Sergio Bruno Ricciarini,[15] Zouleikha Sahnoun,[7,8] Umberto Savino,[4,5] Valentina Scotti,[11,12] Enrico Serra,[3] Matteo Sorbara,[13,6] Alessandro Sotgiu,[6] Roberta Sparvoli,[13,6] Pietro Ubertini,[16] Veronica Vilona,[9,3] Simona Zoffoli,[10] and Paolo Zuccon[2,3]

Close to submission

The Monolithic Active Pixel Sensors Tracker System of the High Energy Particle Detector aboard the Second Chinese Seismo-Electromagnetic Satellite

Simona Bartocci[a], Roberto Battiston[b,c], Stefania Beolè[d,e], Franco Benotto[e], Piero Cipollone[f], Silvia Coli[e], Andrea Contin[g,h], Marco Cristoforetti, Cinzia De Donato[f], Cristian De Santis[f], Andrea Di Luca[i,j], Flori Dumitrache, Francesco Maria Follega, Simone Garrafa Botta[e], Giuseppe Gebbia[b,j], Roberto Iuppa[b,j], Alessandro Lega[b,j], Mauro Lolli[h], Giuseppe Masciantonio[f], Matteo Mergè[k], Marco Mese[l,m], Riccardo Nicolaidis[b,j], Francesco Nozzoli[j], Alberto Oliva[h], Giuseppe Osteria[m], Francesco Palma[f], Federico Palmonari[g,h], Beatrice Panico[l,m], Stefania Perciballi[d,e], Francesco Perfetto[m], Piergiorgio Picozza[n,f], Michele Pozzato[h], Marco Ricci[o], Ester Ricci[b,j], Sergio Bruno Ricciarini[p], Zouleikha Sahnoun[g,h], Umberto Savino[d,e], Valentina Scotti[l,m], Enrico Serra[j], Alessandro Sotgiu[f], Roberta Sparvoli[n,f], Pietro Ubertini[q], Veronica Vilona[j], Simona Zoffoli[k] and Paolo Zuccon[b,j]

Published



Optimized DAQ for the HEPD-02 tracker

Control and readout of the CSES-02 HEPD tracker system

Simona Bartocci[1], Roberto Battiston[2,3], Stefania Beolè[4,5], Franco Benotto[5], Piero Cipollone[6], Silvia Coli[5], Andrea Contin[7,8], Marco Cristoforetti[9,10], Cinzia De Donato[6], Cristian De Santis, Andrea Di Luca[9,10], Flori Dumitrache[5], Francesco Maria Follega[2,10], Simone Garrafa Botta[5], Giuseppe Gebbia, Roberto Iuppa[2,10], Alessandro Lega[2,10], Mauro Lolli[8], Giuseppe Masciantonio[6], Matteo Mergè[11], Marco Mese[12,13], Riccardo Nicolaidis[2,10], Francesco Nozzoli[10], Alberto Oliva[8], Giuseppe Osteria[13], Francesco Palma[6], Federico Palmonari[7,8], Beatrice Panico[12,13], Stefania Perciballi[4,5], Francesco Perfetto[13], Piergiorgio Picozza[14,6], Michele Pozzato[8], Ester Ricci[2,10], Marco Ricci[15], Sergio Bruno Ricciarini[16], Zouleikha Sahnoun[7,8], Umberto Savino[4,5], Valentina Scotti[12,13], Enrico Serra[10], Alessandro Sotgiu[6], Roberta Sparvoli[14,6], Pietro Ubertini[17], Veronica Vilona[10], Simona Zoffoli[11], and Paolo Zuccon[2,10,18]

Under revision

TIFPA people involved
E.Ricci, R.Iuppa, R.Nicolaidis, P. Zuccon, F.Nozzoli, A. Lega

HEPD-02 Monte Carlo simulation

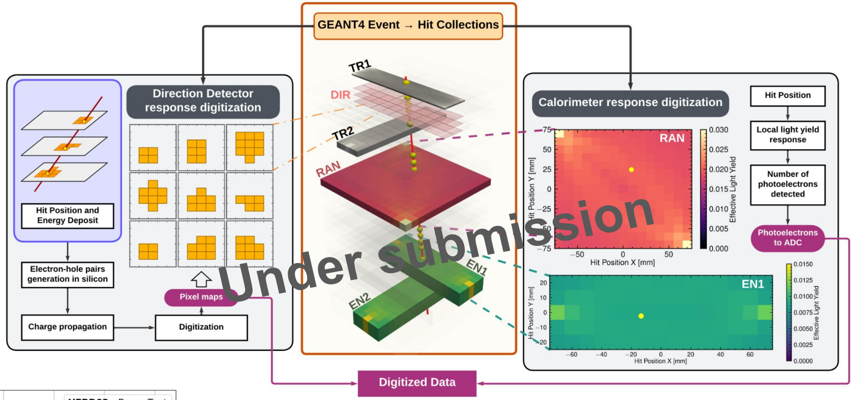
Here in Trento we have developed the full Monte Carlo simulation of HEPD-02: starting from **Geant4 to signal digitization of the calorimeter and pixel tracker (spin-off with TROPix)**. We are also in charge of the maintenance of the code and of the supervision of the MC production.

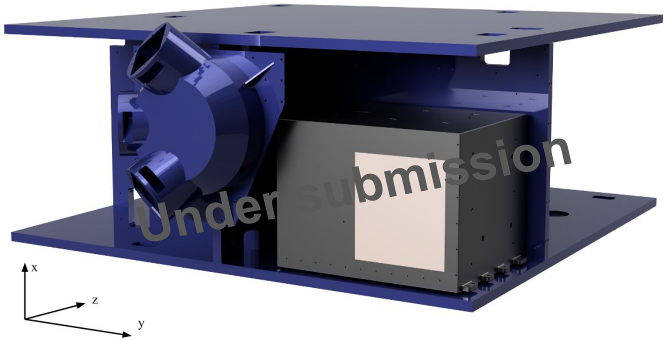
(Courtesy of R. Nicolatids)

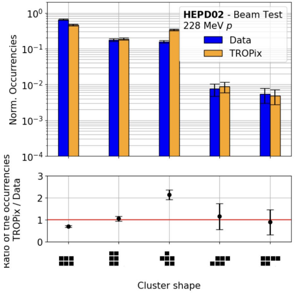
Geant4-based detector virtual model for an Astroparticle Physics experiment: the case of the High-Energy Particle Detector onboard the CSES-02 satellite

Simona Bartocci, Roberto Battiston, Stefania Beolè, Franco Benotto, Piero Cipollone, Silvia Coli, Andrea Contin, Marco Cristoforetti, Cinzia De Donato, Cristian De Santis, Andrea Di Luca, Emiliano Dumitrache, Francesco Maria Follega, Simone Garrafa Botta, Giuseppe Gebbia, Roberto Iuppa, Alessandro Lega, Mauro Lolli, Matteo Martucci, Giuseppe Masciantonio, Matteo Mergè, Marco Mese, Riccardo Nicolaidis, Francesco Nozzoli, Alberto Oliva, Giuseppe Osteria, Francesco Palma, Federico Palmonari, Beatrice Panico, Stefania Perciballi, Francesco Perfetto, Alessio Perinelli, Piergiorgio Picozza, Michele Pozzato, Marco Ricci, Ester Ricci, Leonardo Ricci, Sergio Bruno Ricciarini, Zouleikha Sahnoun, Umberto Savino, Valentina Scotti, Enrico Serra, Matteo Sorbara, Alessandro Sotgiu, Roberta Sparvoli, Pietro Ubertini, Veronica Vilona, Simona Zoffoli, Paolo Zuccon

Close to submission







TROPix: A parametric tool reproducing the output of the HEPD-02 pixel detector

Published

Simona Bartocci[a], Roberto Battiston[b,c], Stefania Beolè[d,e], Franco Benotto[e], Piero Cipollone[f], Silvia Coli[e], Andrea Contin[g,h], Marco Cristoforetti[i,c], Cinzia De Donato[f], Cristian De Santis[f], Andrea Di Luca[i,c,*], Francesco Maria Follega[b,c], Simone Garrafa Botta[e], Giuseppe Gebbia[b,c], Roberto Iuppa[b,c], Alessandro Lega[b,c], Mauro Lolli[h], Giuseppe

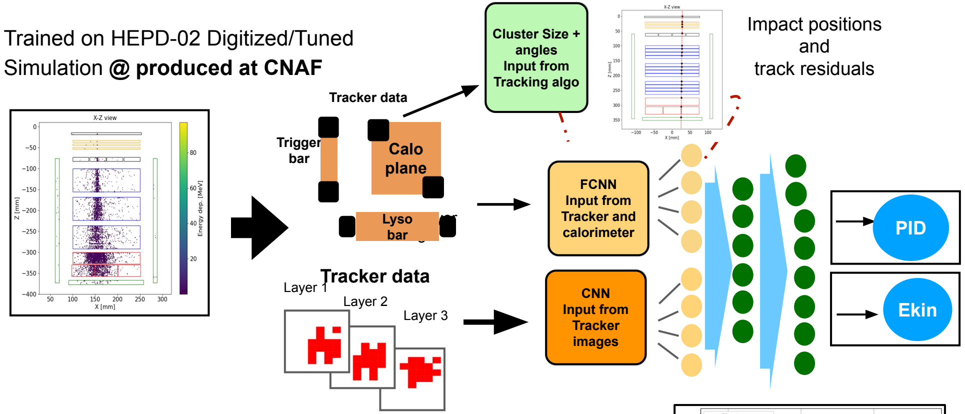
TIFPA people involved
R. Nicolaidis, F.M.Follega,R.Iuppa, F. Nozzoli, A. Di Luca, E.Ricci

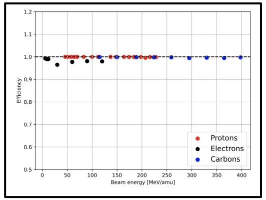
Limadou HEPD-02 perfomance/Data Quality

Here in Trento we have the responsibilities about the **Computing, Scientific Performance** and **Data Quality** and coordination during the commissioning phase of Limadou HEPD-02

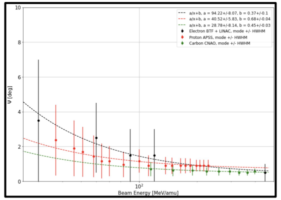
HEPD-02 evReco (with DL)

Trained on HEPD-02 Digitized/Tuned Simulation **@ produced at CNAF**

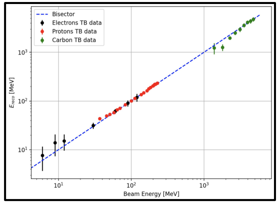




particle identification

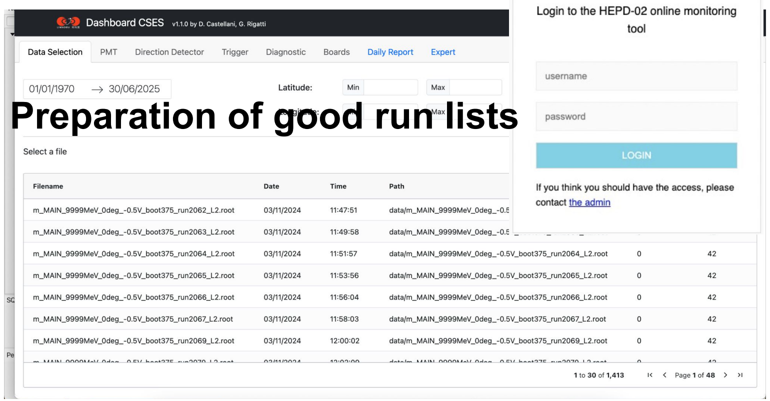


direction reco

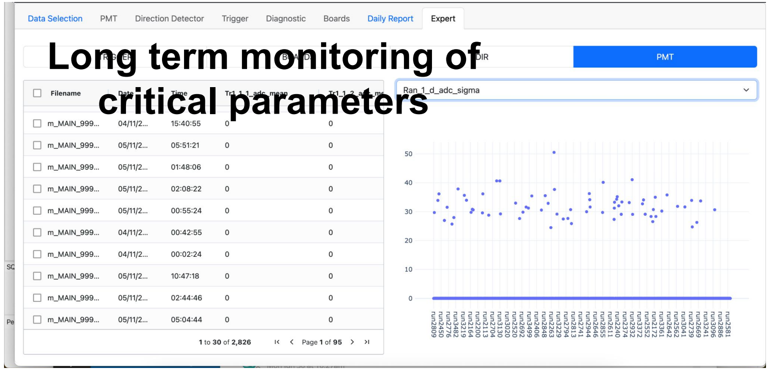


energy reconstruction

Preparation of good run lists

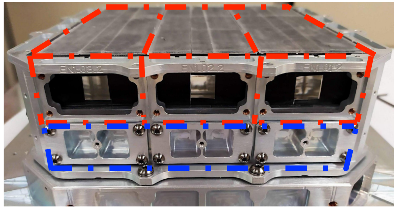


Long term monitoring of critical parameters

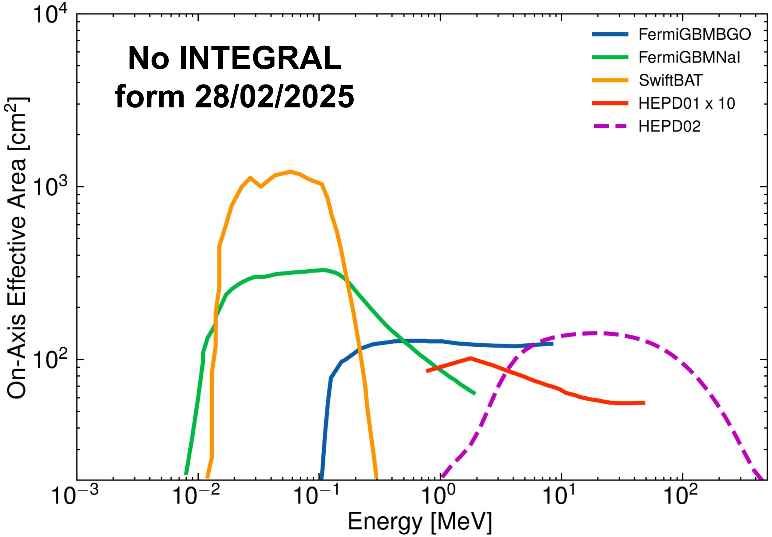


TIFPA people involved
F.M.Follega, E.Ricci, A. Di Luca, R.Iuppa, A. Perinelli, R. Nicolaidis, C. Neübuser

GRBs detection with HEPD-02



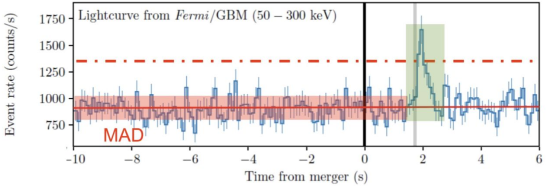
LYSO crystals allow for detection of high-energy photons > 2 MeV

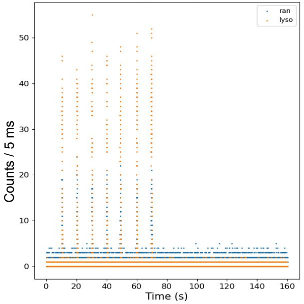


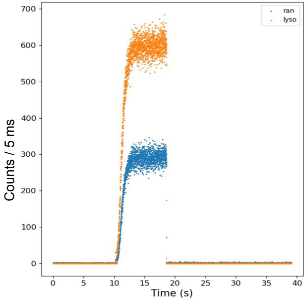
HEPD-02 ~ **10 x eff.area HEPD-01**
HEPD-02 count sampling freq **200 Hz**, while **HEPD-01 1Hz**

New physics case enabled:

- Dedicated GRB triggers for HEPD-02
- Ev. acquisition/counting mode;
- Time resolution ~ 5 ms





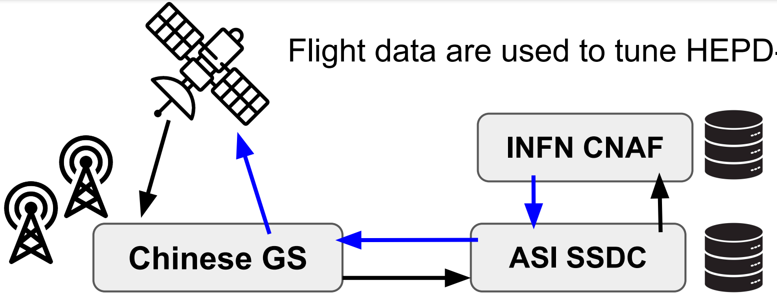


GRB trigger algorithm tested and designed in Trento

TIFPA people involved
F.M.Follega, R.Iuppa, E.Ricci, F. Nozzoli, A. Lega

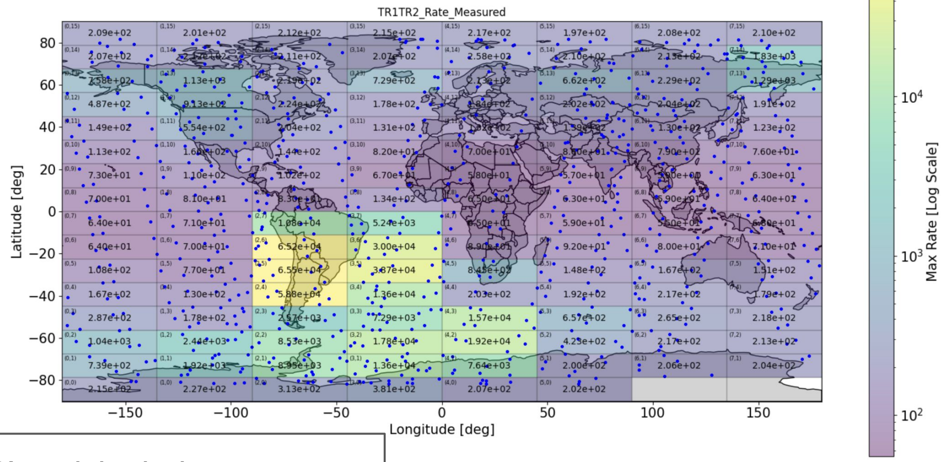
In-flight tuning during commissioning

Flight data are used to tune HEPD-02 parameters

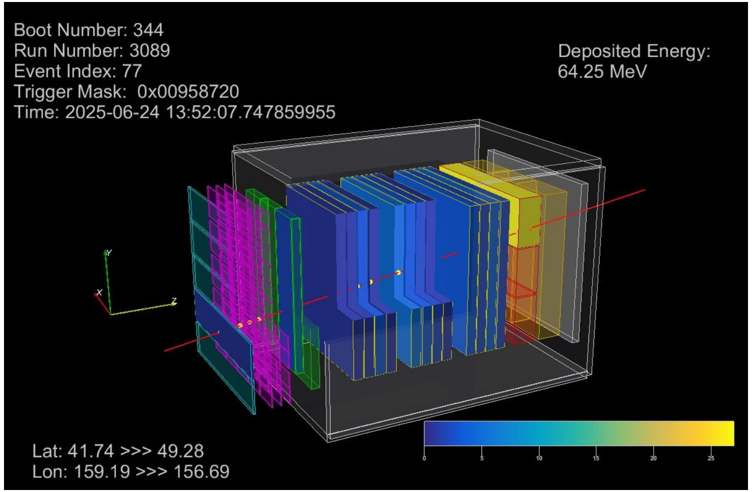


several months to reach nominal/ideal acquisition

First in flight rates measured by HEPD-02



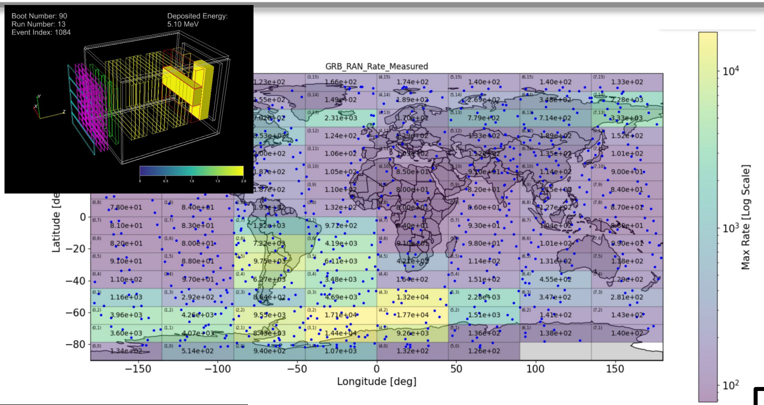
Event display of particle acquired during the first orbots with HEPD-02

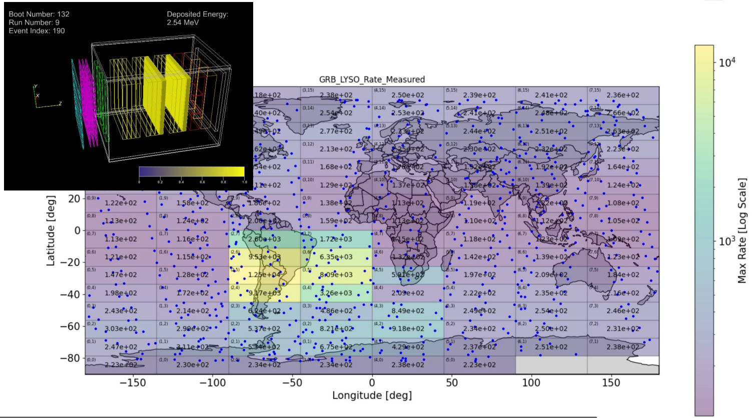


In Trento we will contribute:
- **tuning acquisition** strategies (trigger masks, patterns…)
- **pixel tracker calibration and tuning** of parameters (thresholds and masking)
- **GRB algorithms parameters and enabled regions**

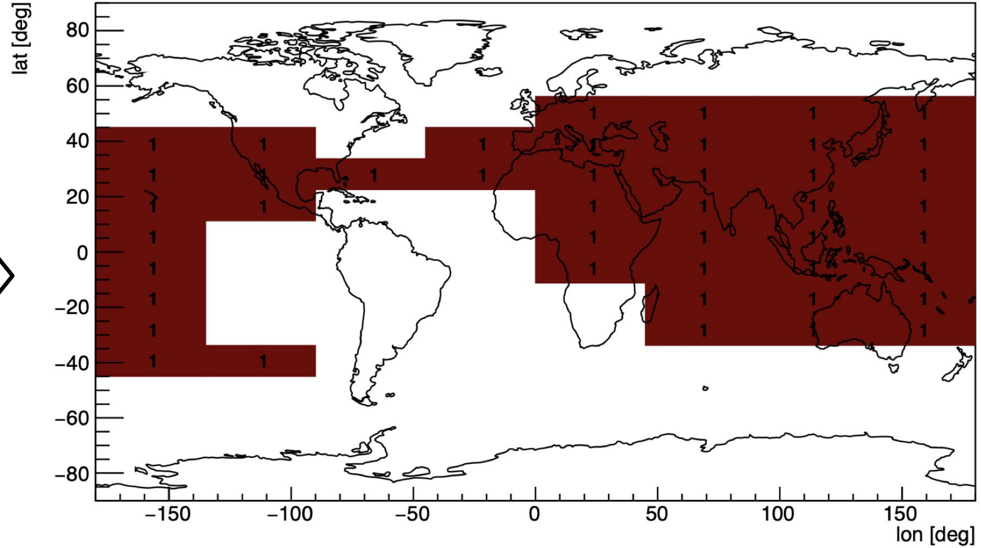
TIFPA people involved
R.Iuppa, F.M.Follega, E.Ricci, P. Zuccon
F. Nozzoli, R.Nicolaidis, R.Battiston

GRB algo tuning in-flight





In orbit tuning of configuration to enable GRB masks



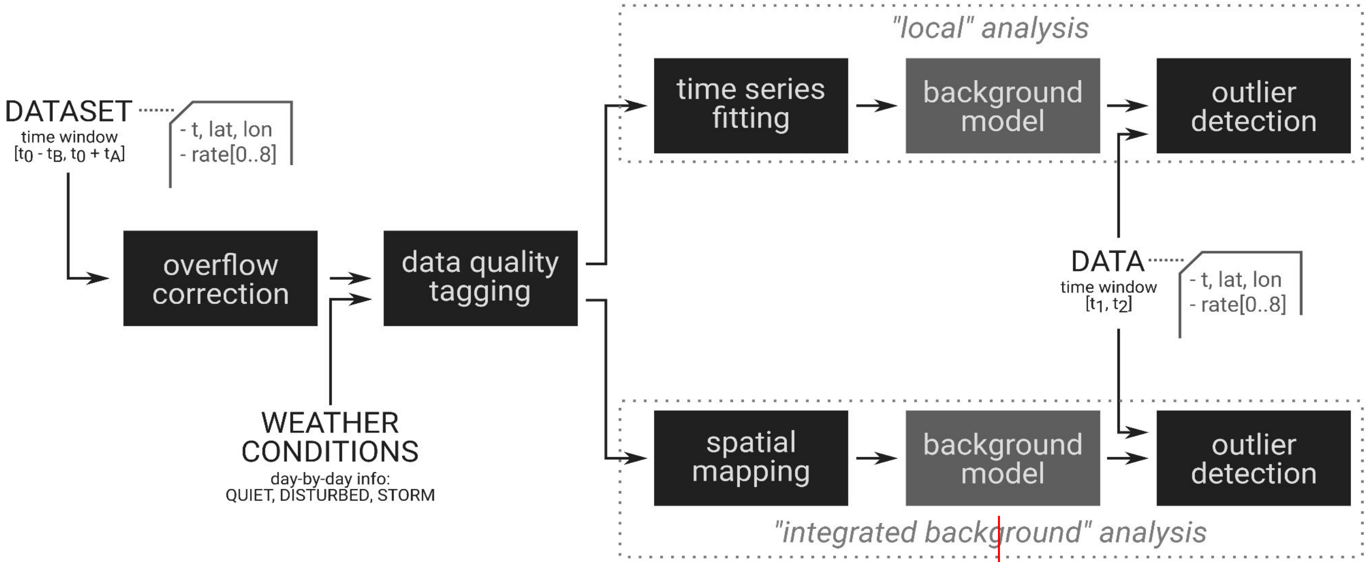
- A GRB trigger mask (coincidence of plastic scint. or LYSO crystals) in many orbital zones

TIFPA people involved
R.Iuppa, F.M.Follega, E.Ricci, P. Zuccon, F. Nozzoli, R.Nicolaidis, R.Battiston

Recent analysis with HEPD-01

→ A statistical framework to analyze **HEPD-01 ratemeter data**

→ two analysis approaches → two targets

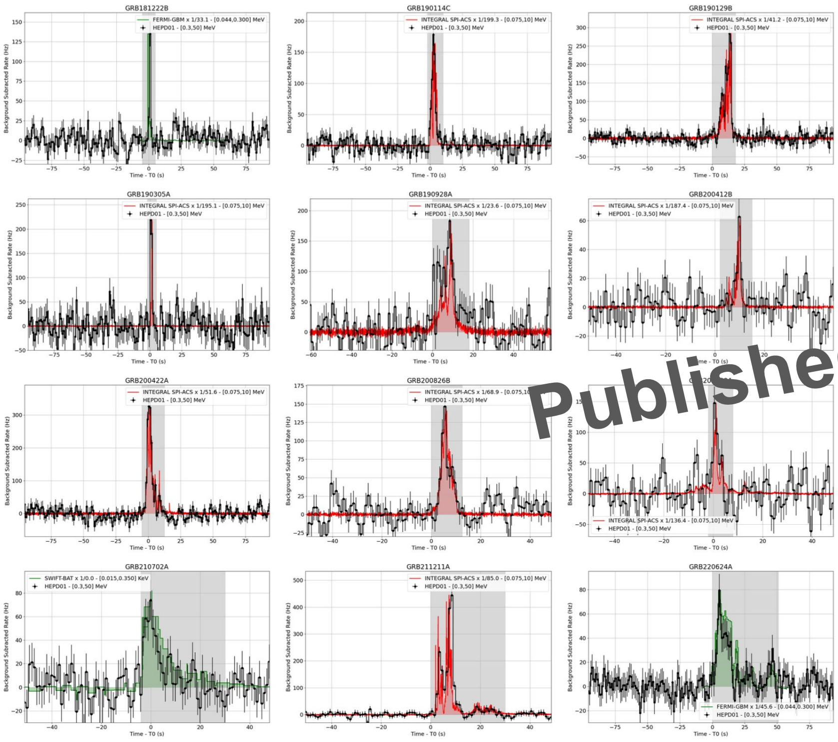


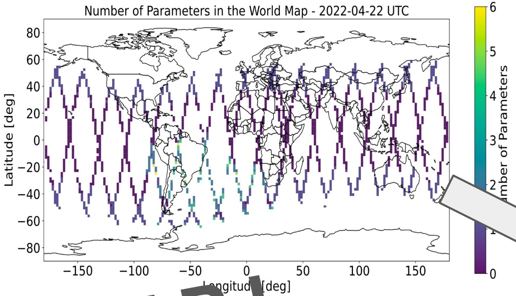
→ applied to: GRB detection

applied to: SAA analysis

TIFPA people involved
F.M.Follega, A.Perinelli, R.Iuppa, L.Ricci, R.Battiston

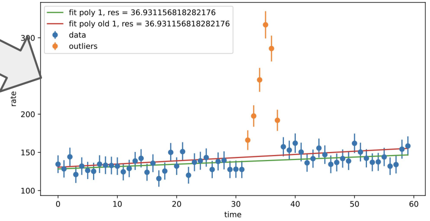
GRBs detection with HEPD-01





bkg estimation
(parametric approach)

bkg subtraction



Published on APJ

This **analysis framework allowed for the identification of Gamma Ray Burst** as significative outliers in the particle rate

→ **12 GRBs** *a posteriori* matched with other instruments

→ fluences, T90 and Tpeak have been estimated

→ HEPD-01 GRB catalogue over the full data taking

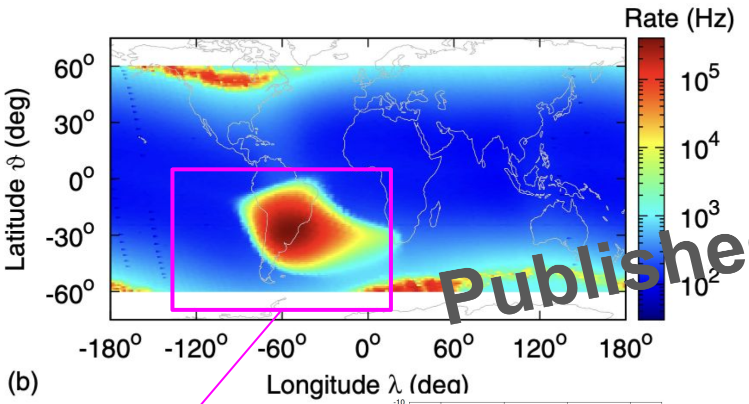
"The catalogue of Gamma-Ray Bursts observations by HEPD-01 in the 0.3-50 MeV energy range", Published on APJ

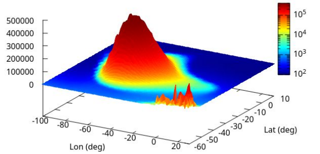
TIFPA people involved
F.M.Follega, A.Perinelli, R.Iuppa, L.Ricci, R.Battiston

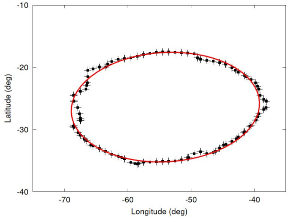
HEPD-01's map of the SAA

- **Study of geographical position of SAA → energy shift, day/night shift, temporal drift**
- **HEPD-01's integral flux estimate → validate AP9 model**

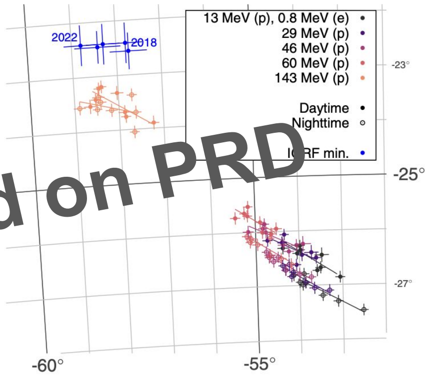
Synergy with COSI people for bkg estimati due to SAA passages





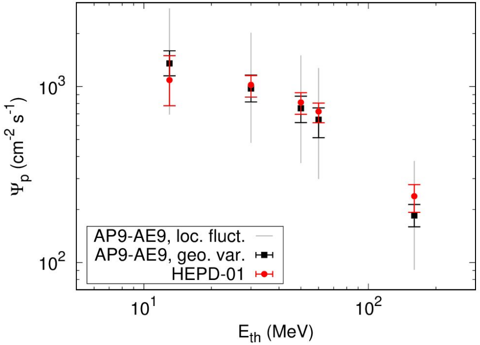


Shift of SAA centroid



Published on PRD

Proton integral flux above threshold



"Mapping the South Atlantic Anomaly via charged particle measurement by the HEPD-01 detector on board the CSES-01 satellite", Published on PRD

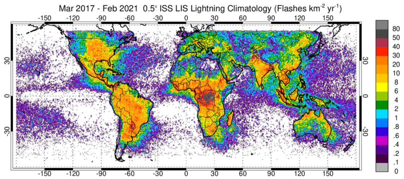
TIFPA people involved
A.Perinelli, F.M.Follega, R.Iuppa, L.Ricci, R.Battiston

Time correlation and multi-payload analysis

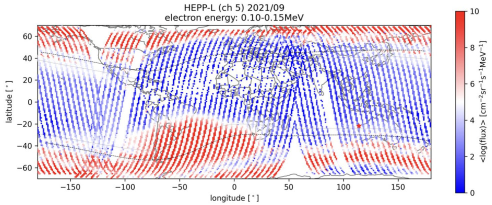
TIFPA people involved
R.Battiston, F.M.Follega,C. Neubüser, A.Perinelli, R.Iuppa, L. Calzà, M.Cristoforetti, M. Babu, D. Recchiuti

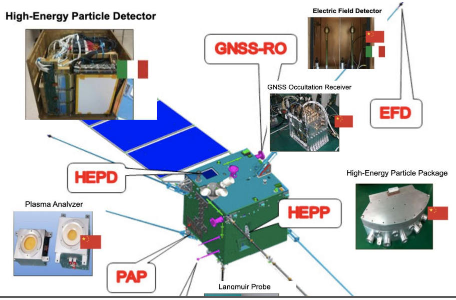
Time correlation group searches for space-time correlation between CSES observations and external phenomena: **i.e. strong earthquakes, lightnings and VLF transmitters.**

PB - lightnings (WWLLN 2019 - 2022)



Correlation PB - transmitters (i.e NWC)





...ti-payload and
...ulti satellite
strategy

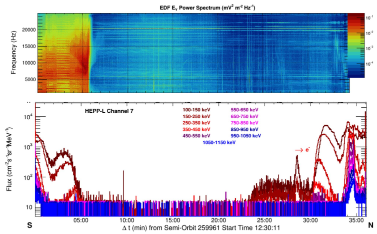
Submitted, under revision

MDPI

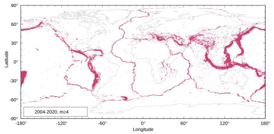
Article

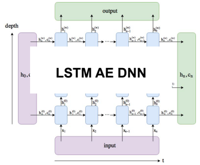
CSESpy: A unified framework for data analysis of the payloads on board the CSES satellite

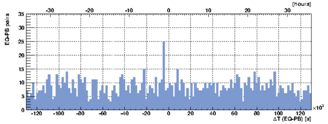
Particle Wave Interaction (PB - VLF)

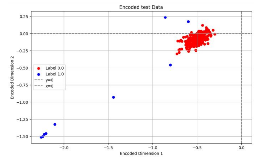


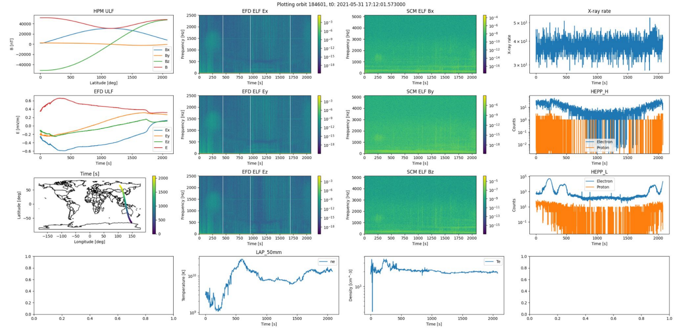
PB/VLF - EQ correlation







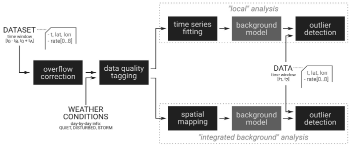


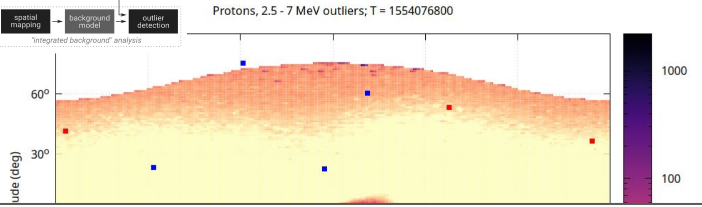


Data analysis with SW events with CSES-01

TIFPA people involved
F.M.Follega, A.Perinelli, R.Iuppa,
C. Neubuser, R.Battiston

Time correlation with Space Weather events





DRAFT VERSION JUNE 30, 2025
Typeset using LATEX **twocolumn** style in AASTeX631

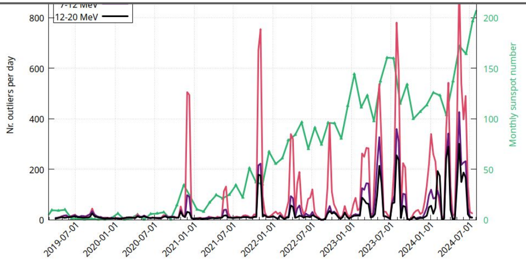
Characterization of Major Solar Events with the HEPP-L Particle Detector Onboard CSES-01 during Solar Cycles 24 and 25

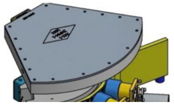
Article in preparation

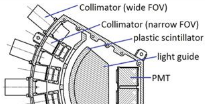
ABSTRACT

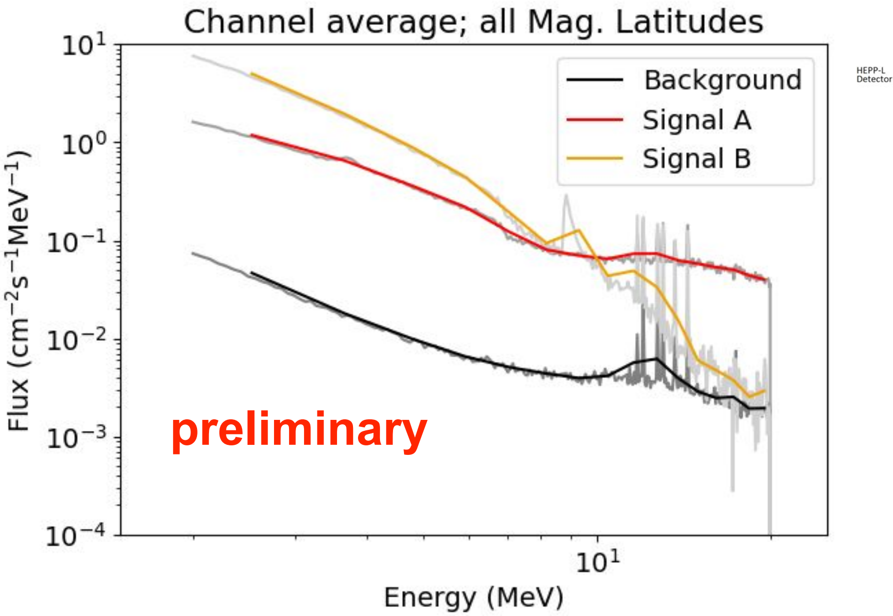
Understanding the impact of solar disturbances on the Earth's ionosphere is essential for space weather research. The China Seismo-Electromagnetic Satellite (CSES-01), a low-Earth orbit mission equipped with a comprehensive suite of nine scientific instruments, plays a critical role in this do-

Number of anomalous events increases with solar cycle







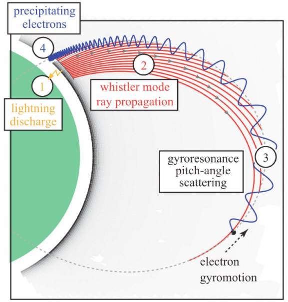


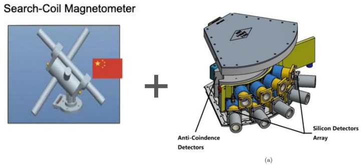
Data analysis of LEP events with CSES-01

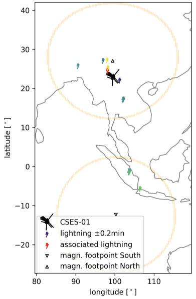
TIFPA people involved
C. Neubüser, R.Battiston, D. Recchiuti

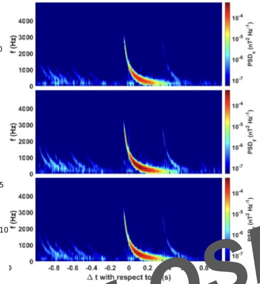
(slide courtesy of C. Neubüser)

Particle-wave interaction





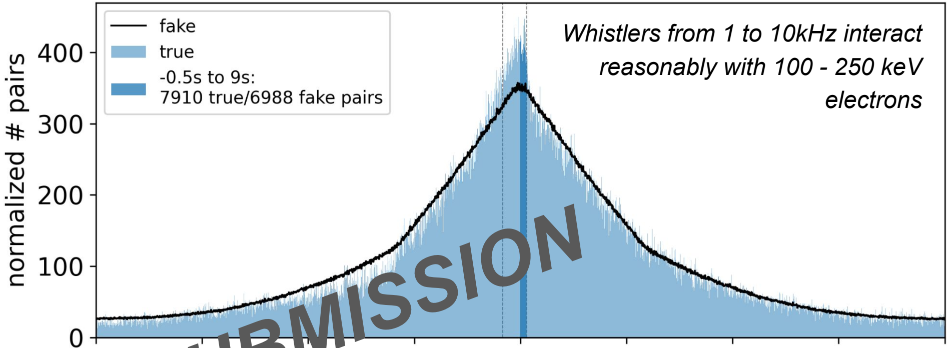




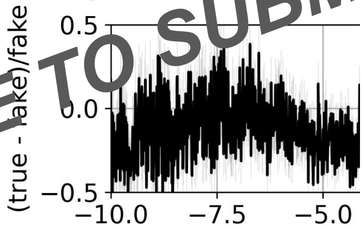
SCM VLF has 80ms resolution in burst mode.

Lightning strikes from WWLLN associated if:

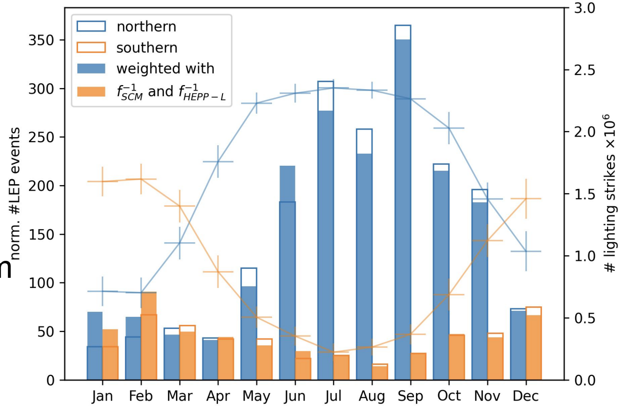
- within 120ms before Whistler detection
- within 15º cone around magnetic foot-points



Whistlers from 1 to 10kHz interact reasonably with 100 - 250 keV electrons



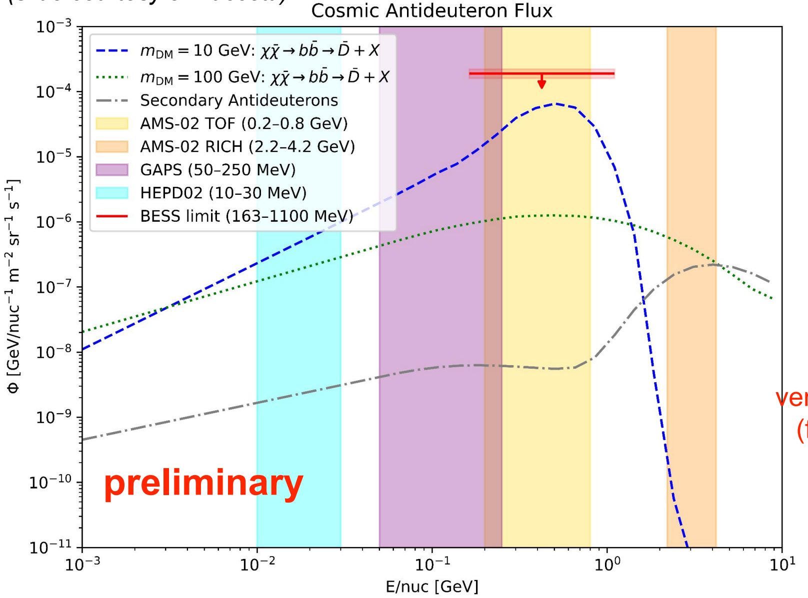
Seasonality compared to lighting on earth from WWLLN



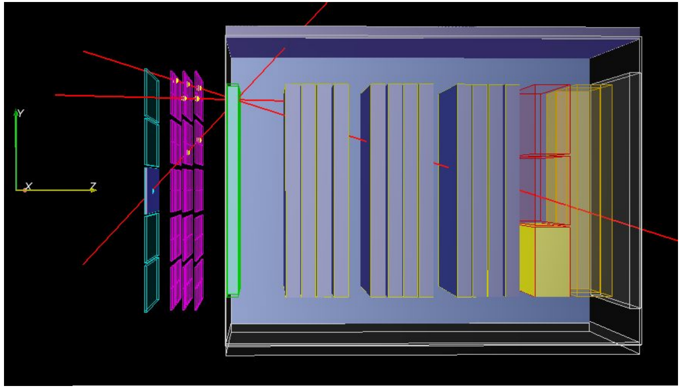
Quest for antimatter with HEPD-02

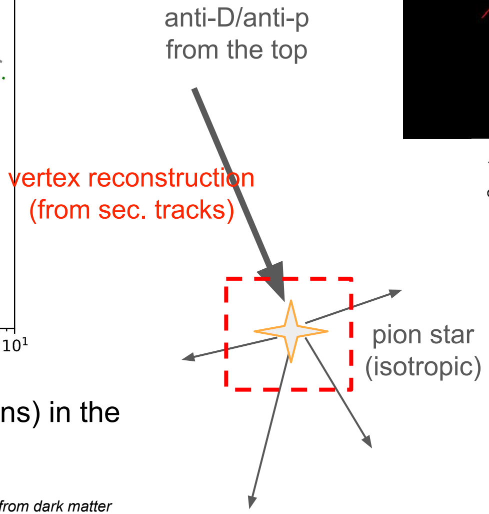
TIFPA people involved
N. Puccetti, F.M.Follega, R.Iuppa, F. Nozzoli

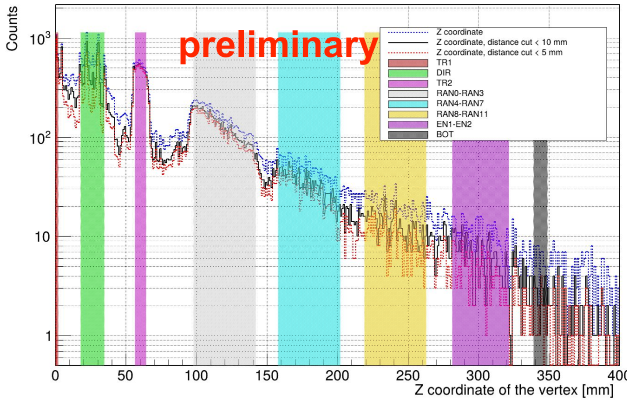
(slide courtesy of Puccetti)



Example of annihilation process in TR2.







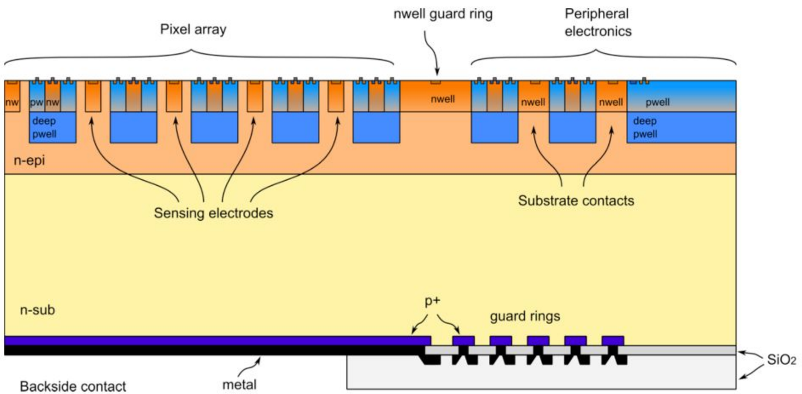
HEPD-02 may be sensitive to anti-deuterons (anti-protons) in the range between 10 MeV/n and 30 MeV/n.

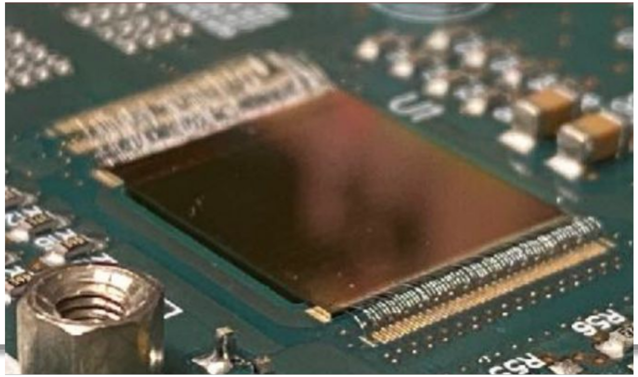
Antideuteron spectra from J. Heisig et al, *DarkRayNet: Emulation of cosmic-ray antideuteron fluxes from dark matter*
Sensitivieties of AMS-02 from F. Giovacchini et al. *Cosmic Rays Antideuteron Sensitivity for AMS-02 experiment*
Sensitivieties of GAPS from The GAPS experiment: low-energy antinuclei measurements for dark matter searches

R&D for future missions: new detector tests

TIFPA people involved
E.Ricci, R.Iuppa, P.Zuccon,D.Schlewdewitz

Fully depleted MAPS: ARCADIA





- Better time resolution
- Less charge sharing between pixels
- Innovative readout architecture
- Designed to be space compliant
- Power reduction mode on chip

Requirements	
Pixel pitch [μm]	25
Thickness [μm]	50 - 500
Scalability [cm]	Up to ~ 4x4
Timing resolution [ns]	10
Power consumption [mW/cm^2]	~10
Radiation hardness [Mrad]	1

ARCADIA power consumption characterisation

- The **analog** line is **stable** at **6 mA** in both the modes and is not reported
- For the **digital** line, we can see some peaks during **power on** (normal mode)
- The setup is **not optimised** for the reduction of the peak consumption
- The current in **normal mode** is about **40 mA**
- When **the low rate mode** is activated, the current goes down to **8 mA**
- The total current is then 14 mA on the 1.2 V power supply

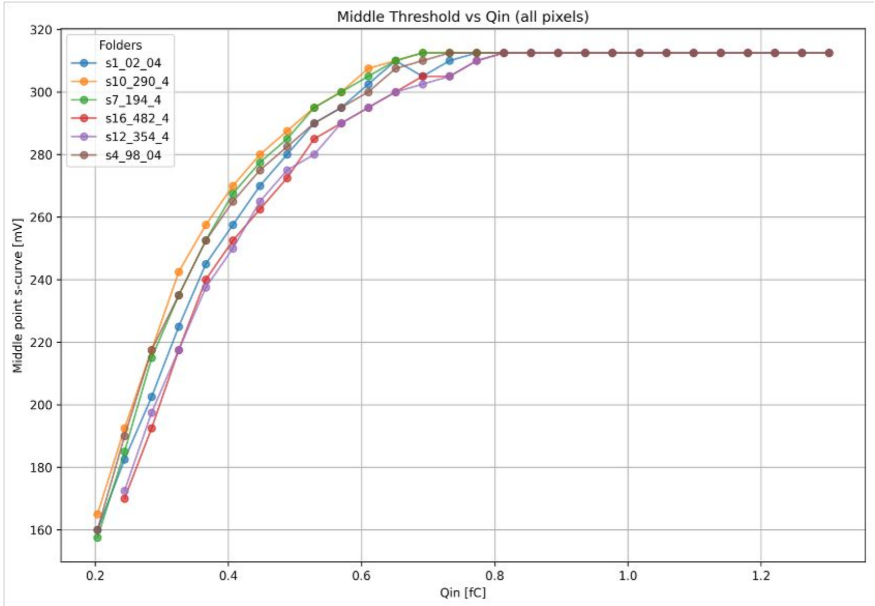
Current measure setup:

- current probe Tektornik TCP 0020
- Lecroy oscilloscope

TIFPA people involved
E.Ricci, R.Iuppa, P.Zuccon,D.Schlewdewitz

ARCADIA characterisation results

TIFPA people involved
E.Ricci, R.Iuppa, P.Zuccon,D.Schlewdewitz

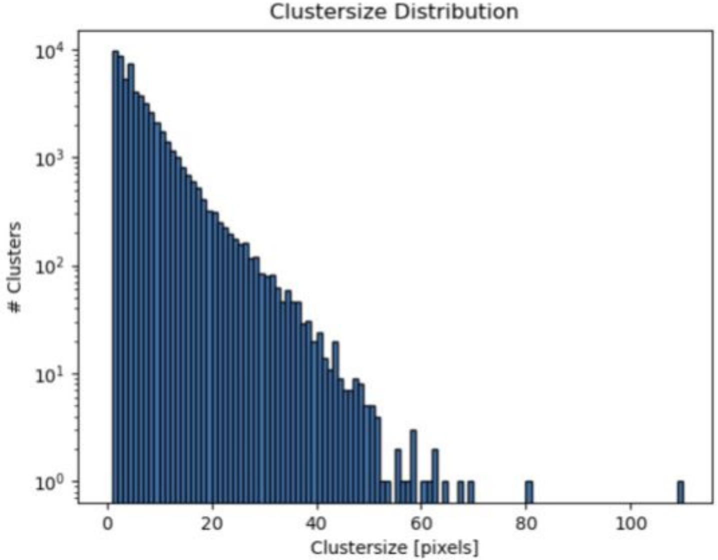


Threshold characterisation:

- Study of the response of different pixels along the detector
- **good uniformity** along the matrix

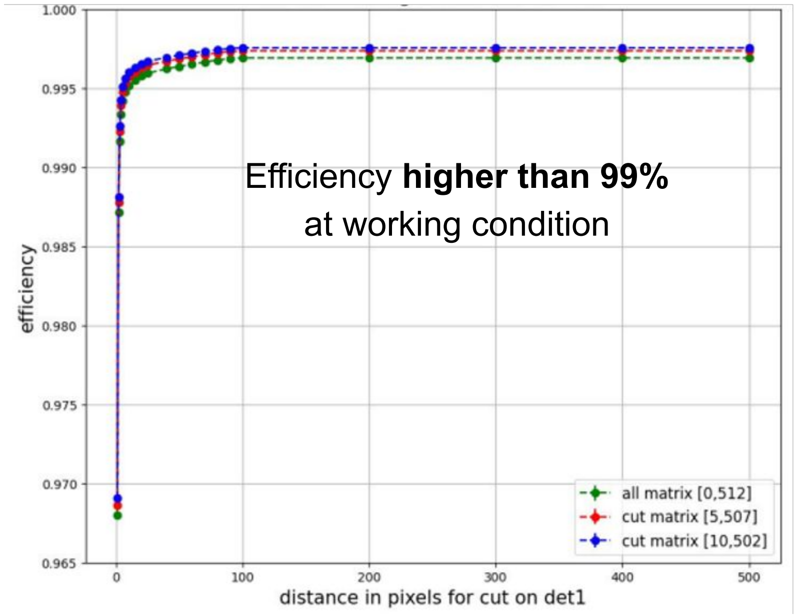
Clustering strategies:

- Study of the detector response to particle
- Optimization of the clustering algorithms



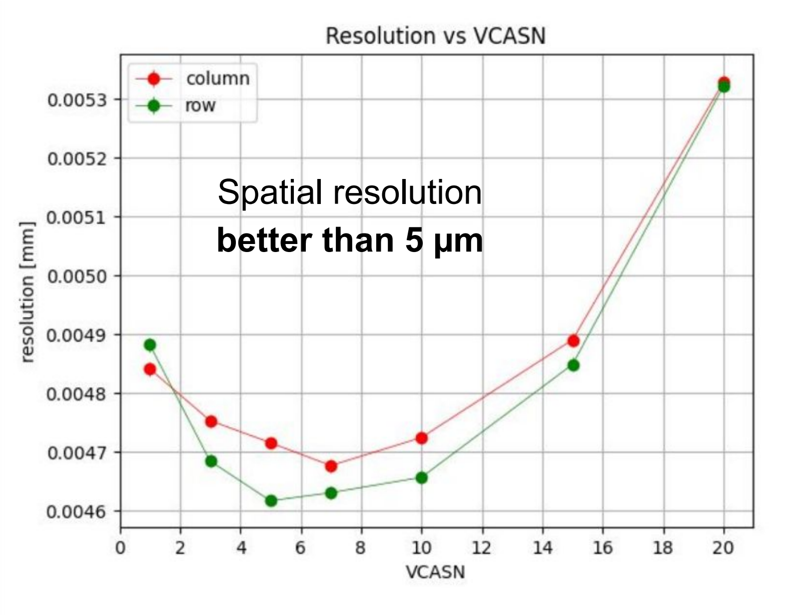
ARCADIA characterisation results

TIFPA people involved
E.Ricci, R.Iuppa, P.Zuccon,D.Schlewdewitz



$$Efficiency = \frac{\#\,3\ layer\ coincidences}{\#\,3\ layer\ coincidences + \#2\ layer\ coincidences}$$

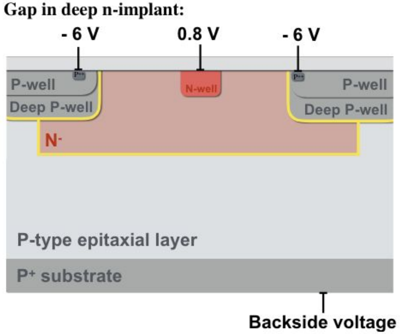
- Results obtained from test beam at FNAL
- All the characteristics are **in line or exceeding the design requirements**

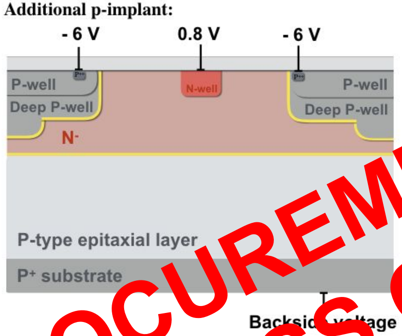


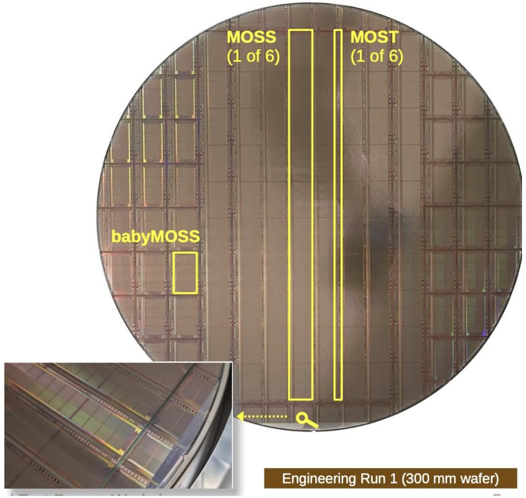
R&D for future missions: plans

TIFPA people involved
E.Ricci, R.Iuppa, P.Zuccon, R. Nicolaidis, A. Lega, F.Nozzoli

Tower semiconductor new prototypes under test @CERN







PROCUREMENT OF babyMOSS ONGOING

- Fully depleted
- The insertion of a gain layer is under study
- Technology improvement from 180 nm of ALPIDE to 65 nm od MLR1
  - Improved space management
  - reduction of power consumption

Stitching
Advantages:
- Realisation of wafer scale modules
- Significant reduction of circuit density

To be investigated:
- Long-range power distribution and signals transmission
- Large number of independent power domains
- Leakage currents

Pubblicazioni e presentazioni 2024-2025

8 presentations (at least) scheduled to the end of 2025

2025	SIF	A Novel Analysis of Particle Bursts with the CSES-01 Satellite	L. Calzà	talk
2025	SIF	Deep Learning Model for Identifying Seismic-Induced Ionospheric Electric Field Perturbations	M. Babu	talk
2025	SIF	Extending Cosmic Antimatter Searches with HEPD-02: A MAPS-Based Detector Aboard CSES-02	N. Puccetti	talk
2025	COSPAR Syı	Observation of electron bursts in coincidence with Terrestrial Gamma-ray Flashes (TGFs) by the High-E	C. Neubuser	talk
2025	COSPAR Syı	The High Energy Particle Detector (HEPD) onboard the CSES satellites: a space weather monitor	C. Neubuser	talk
2025	ICRC	In-depth analysis of selected major solar events with the HEPP-L particle detector onboard CSES-01 in	A. Perinelli	talk
2025	ICRC	Advancing Solar and Heliospheric Studies with the CSES Programme	R. Iuppa	talk
2025	ICRC	Time and energy resolved detection of gamma-ray transients with the High-Energy Particle Detectors o	R. Nicolaidis	talk

17 presentations given from July 2024 up to today

2025	ASAPP	Event reconstruction strategies for the High-Energy Particle Detector (HEPD-02) onboard the ready-to-l	A. Perinelli	poster
2025	ASAPP	Advancing Monolothic Active Pixel Sensors for space applications: results form the ARCADIA MD3 den	E. Ricci	talk
2025	EGU	A statistical study of lighting-induced electron precipitation (LEP) events observed by the CSES-01 satellite	C. Neubuser	talk
2024	AGU	Automatic detection of whistler waves in the top-side ionosphere	D. Recchiuti	talk
2024	TEVPA	Space weather monitoring and forecasting: a data-driven approach	M. Cristoforetti	talk
2024	PIXEL	The first MAPS based tracker for space applications	E. Ricci	talk
2024	RICAP	Results from the space-borne High Energy Particle Detector (HEPD-01) after 6 years in orbit	A. Perinelli	talk
2024	ECRS	Expected performance of the HEPD-02 detector onboard the CSES-02 satellite	E. Ricci	talk
2024	ECRS	Gamma Ray Bursts detection with the CSES satellites: recent findings and future outlook with the Limadou High Energy Particle Detectors	F. M. Follega	talk
2024	Workshop "Trento Proton Beam Line Facility"	The beam test journey of the HEPD-02 detector at Trento Proton therapy center	E. Ricci	talk
2024	IAC	Advancements in Earth Observation with CSES-02: HEPD-02 and EFD-02 as Cutting-Edge Non-Imaging Instruments	R. Iuppa	talk
2024	IAC	The CSES Constellation : non imaging Earth remote sensing for natural hazards mitigation	R. Battiston	invited talk
2024	IAC	KEYNOTE: Earth orbiting small satellites constellations: towards using the Earth surrounding layers	R. Battiston	talk
2024	COSPAR	Automatic detection of whistler waves in the top-side ionosphere: a physical based method	D. Recchiuti	talk
2024	COSPAR	Assessment of charged particle fluxes within the South Atlantic Anomaly with the HEPD-01 detector on board the CSES-01 satellite	A. Perinelli	talk
2024	COSPAR	Identification of nine Gamma Ray Bursts with the HEPD-01 detector on board the CSES-01 satellite	F. M. Follega	talk
2024	CRIS	Advancements in Gamma-Ray Burst science with High Energy Particle Detectors on CSES Satellites: current status and prospects	R. Iuppa	talk
2024	URSI	Automatic detection of whistler waves in the top-side ionosphere: a physical based method	D. Recchiuti	talk

9 publication from July 2024 up to today

HEPD-01

HEPD-02

2024	Astroparticle Physics	*Measurements of low-energy, re-entrant albedo protons by the HEPD-01 spa*	10.1016/j.astropartphys.2024.102993
2024	The Astrophysical Journal	*Multispacecraft Observations of Protons and Helium Nuclei in Some Solar E*	10.3847/1538-4357/ad7395
2024	The Astrophysical Journal	*The Catalogue of Gamma-Ray Burst Observations by HEPD-01 in the 0.3-50*	10.3847/1538-4357/ad822c
2024	Remote Sensing	*The Scintillation Counters of the High-Energy Particle Detector of the China*	10.3390/rs16213982
2025	Physical Review D	*Mapping the South Atlantic Anomaly charged particle environment with the*	https://doi.org/10.1103/PhysRevD.111.022001
2025	IEEE (TIM)	*Trigger and calorimeter data acquisition of the High-Energy Particle Detecto*	10.1109/TIM.2025.3555671
2025	JINST	*Development of the power supply of HEPD-02 instrument on board CSES-02*	10.1088/1748-0221/20/06/P06005
2025	NIMA	*TROPix: A parametric tool reproducing the output of the HEPD-02 pixel dete*	https://doi.org/10.1016/j.nima.2025.170756
2025	IEEE (MAES)	*The Monolithic Active Pixel Sensors Tracker System of the High Energy Par*	10.1109/MAES.2025.3568361
2025	NIMA	*New measurements of light yield quenching in EJ-200 and LYSO scintillators*	10.1016/j.nima.2025.170612
2025	The Astrophysical Journal	*Multi-spacecraft Observations of the 27-day Periodicity in Galactic Protons*	Accepted

…at least other six publication at the internal review, close to submission or already submitted to target Journals (and 6 proceedings)

Anagrafica Limadou 2026

Limadou TIFPA

Anagrafica 2026
20 persone / 13.1 FTE

Tempative FTE

Cognome	Nome	Qualifica	Funding	LIMADOU (FTE)
Calzà	Lucas	PhD	SST	1
Recchiuti	Dario	Postdoc	SIU	1
Perinelli	Alessio	RTDa	UniTn	1
Neubuser	Coralie	Tecnol. TD	INFN	1
Mascione	Daniela	Postdoc	FBK	1
Babu	Megha	PhD finisce	SST	1
Nicolaidis	Riccardo	PhD finisce	UniTn	0,7
Puccetti	Niccolo'	PhD	Fisica	0,7
Battiston	Roberto	PO	UniTn	0,7
Lega	Alessandro	Postdoc	FBK	0,7
Novel	David	Ric. TD	FBK	0,7
Schledewitz	David	PhD	SST	0,5
Iuppa	Roberto	PA	UniTn	0,5
Follega	Francesco	RTDa	UniTn	0,5
Ricci	Leonardo	PA	UniTn	0,5
Di Luca	Andrea	Ric. TD	FBK	0,5
Giordano	Davide	RTDa	SIU	0,4
Tosi	Paolo	PA	UniTn	0,3
Zuccon	Paolo	PA	UniTn	0,2
Ricci	Ester	RTDa	UniTn	0,2

Totale = 13.1 FTE

Spese 2025 / Richieste 2026

SPESE

Voce di spesa	Stanziato	Spesi
Strumenti tecnico-specialistici	24.500,00€	- €
Viaggi e Missioni	65.000,00€	17.876,00€
Altri servizi	5.500,00€	- €
Attrezzature scientifiche	7.000,00€	- €

RD silici spazio

Titolo:

Innovative silicon radiation detectors for future space applications

Persona di riferimento:

R. Iuppa – Università di Trento e INFN - TIFPA

Altre persone coinvolte:

Gruppo di Trento: P. Zuccon, F. Nozzoli, E. Ricci, D. Novel, L. Ricci, A. Perinelli

Gruppo di Perugia: M. Duranti, G. Ambrosi, M. Ionica, M. Barbanera, G. Silvestre

Gruppo di Torino: S. Beolé, S. Coli, U. Savino, S. Bufalino, M.Masera

Altri gruppi o enti coinvolti:

Parte del gruppo Limadou. Parte del gruppo HERD-DMP. Altri colleghi da Università di Trento, INFN-TIFPA, Fondazione Bruno Kessler, INFN - Perugia, Università di Perugia, Università di Torino, INFN-Torino

Richieste 2026

Missioni: 50k (supporto attività post-commissioning, meeting nazionale/internazionale, beam test QM)
Servizi: 5k contributo facility di fascio (test su QM posposti per campagna di lancio)
R&D: ~42k (DRD tracciatori al silicio nuova generazione, insieme a Torino e Perugia)

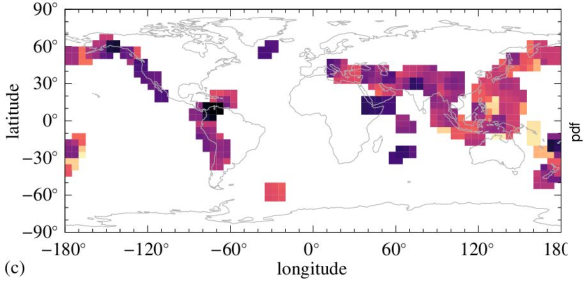
Backup slides

Lithosphere complexity and fault models

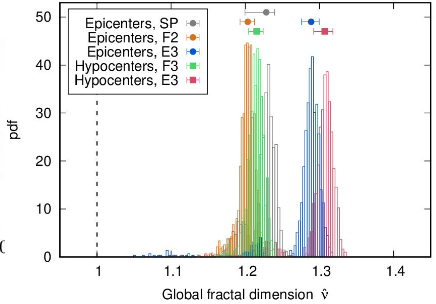
Studying the fractal geometry of earthquakes distribution

→ non-integer fractal dimension

Local fractal dimension

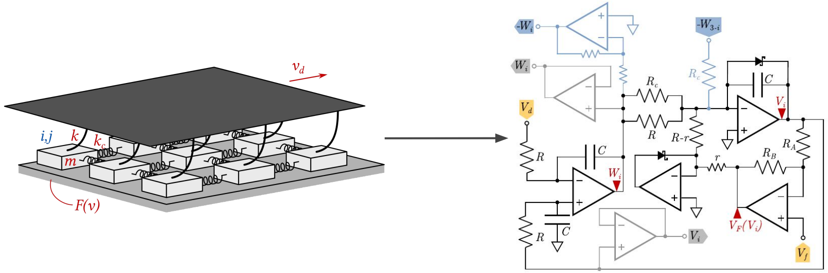


Global fractal dimension

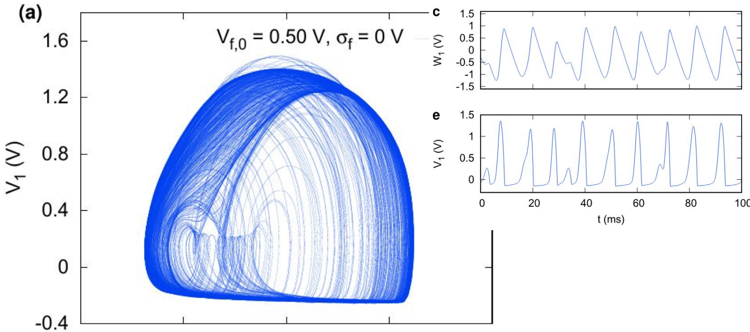


Burridge-Knopoff model of earthquake faults

→electronic analog platform

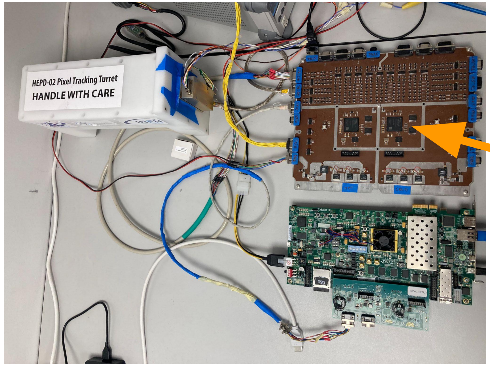


Chaotic dynamics & noise-induced chaos

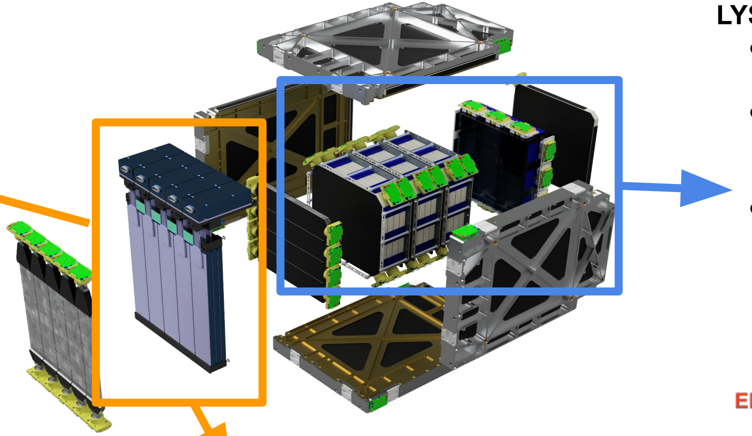


TIFPA people involved
A.Perinelli, L.Ricci, R.Iuppa

Limadou HEPD-02 detector activities

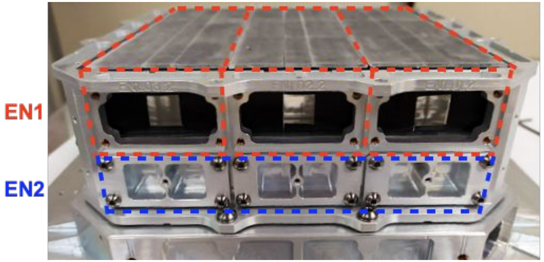


TDAQ
Support in the design of HEPD-02 SW automatic in flight concerning TDAQ

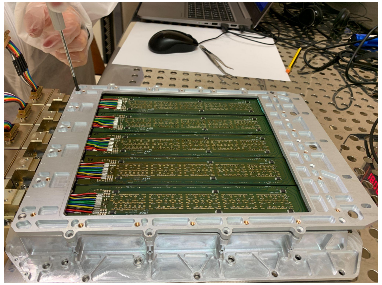


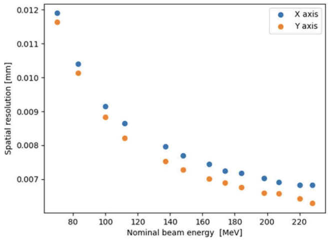
LYSO calorimeter structure:

- Among the largest LYSO crystal ever fabricated 15x5x2.5 cm3;
- Two layers of LYSO bars and a layer contains three bars (read-out by two PMTs each) ~ 4.3 X0
- Optical features and light propagation properties compatible within 5%.



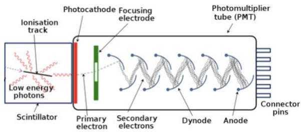
Tracker



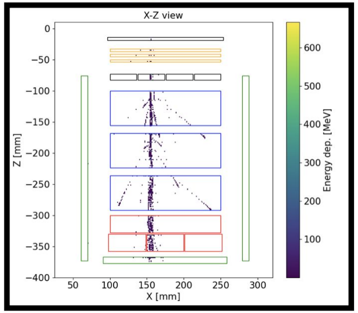


TIFPA people involved
E.Ricci, R.Iuppa, R.Nicolaidis, P.Zuccon, F.Nozzoli, A. Lega

Monte Carlo Simulation of HEPD-02



G4



Truth level information:

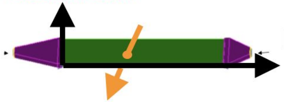
- Hit position (x,y,z);
- Hit Edep;
- Detector ID

Digitized information:

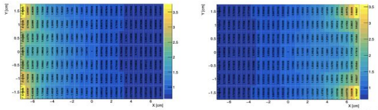
- PMTs ADC signal;
- Pixels and clusters

Digitization

STEP1 (x,y,z,Edep) of all the hits on TR1

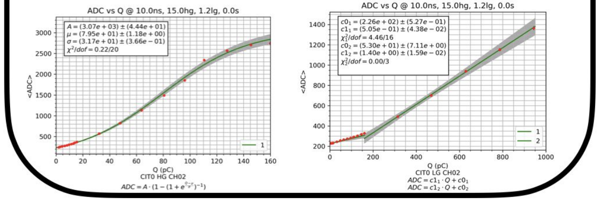


STEP2

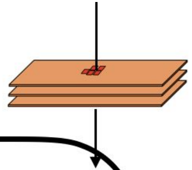


$$NPE_{hit} = F(E^{hit}_{dep}) \times fact(x^{hit}, y^{hit})$$

$$NPE^{PMT0}_{tot} = \sum_{i=1}^{N_{hits}} Poiss(NPE^{PMT0}_{hit_i}) \qquad NPE^{PMT0}_{tot} = \sum_{i=1}^{N_{hits}} Poiss(NPE^{PMT0}_{hit_i})$$

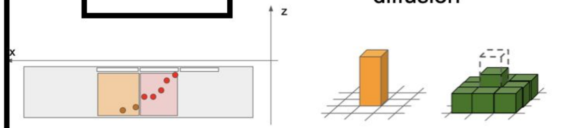


TROPix (pixels) + Mapping code

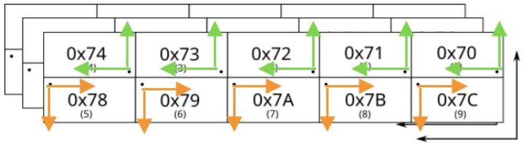


TROPix

STEP1 Pixel generation + charge diffusion

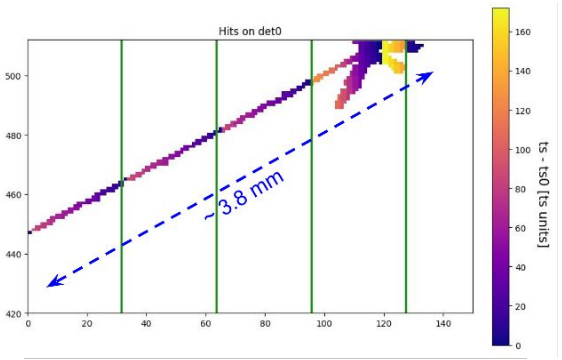


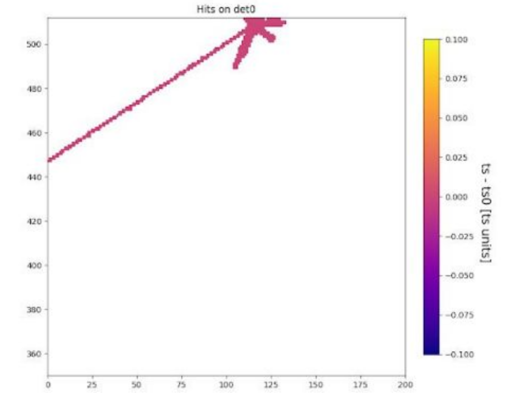
STEP2 Remapping to HEPD-02 tracker pixel coordinates



TIFPA people involved
F.M.Follega, A. Di Luca, E.Ricci, R.Iuppa

Clustering strategies





- ARCADIA MD3 is a **triggerless** detector
- First step for the analysis is to **study the timestamp** to reconstruct correctly the events
- The existence of **long tracks** that require several clock cycles to be read has to be taken into account

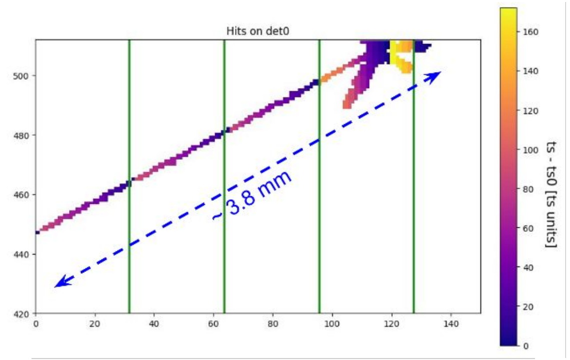
Clustering procedure:

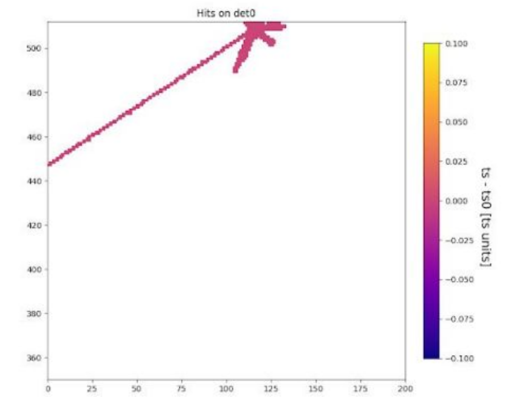
- **Dynamic selection** of data with contiguos timestamp
- Definiton of **frames**
- **Clustering** of pixels

Current status:

- **DBSCAN** library used for both the time and spatial clustering
- **Parameter optimisation** ongoing on the available data (beam test data, radioactive sources, cosmic rays)

Clustering strategies





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Sat EFD Analysis for EQ Forecasting

- **Data and Feature**

  •**Source:** DEMETER satellite (ICE mission), Ionospheric electric field time series from VLF power spectrum (cdpp-archive.cnes.fr)

  •**Features:** 11 frequency bands (<3 kHz) extracted for analysis

- **Methodology**

  •**Anomaly Detection:** Leveraged Deep Learning (LSTM Autoencoder) to identify anomalies in the time series data.

  •**EQ Association:** Correlated detected anomalies with earthquake events within a defined spatial (20 ⁰ square width along the orbit) and temporal windows (48 hours following the orbit)

- **Key Findings**

  - Observed anomaly-to-earthquake association ratio exceeded random expectations.
  - As shown in the figure, certain frequency band features are displayed **higher deviations beyond the 68th percentile interval of the random sampling test. suggests that anomalies in specific frequency bands of the ionospheric electric field may carry meaningful precursory signatures linked to seismic activity.**