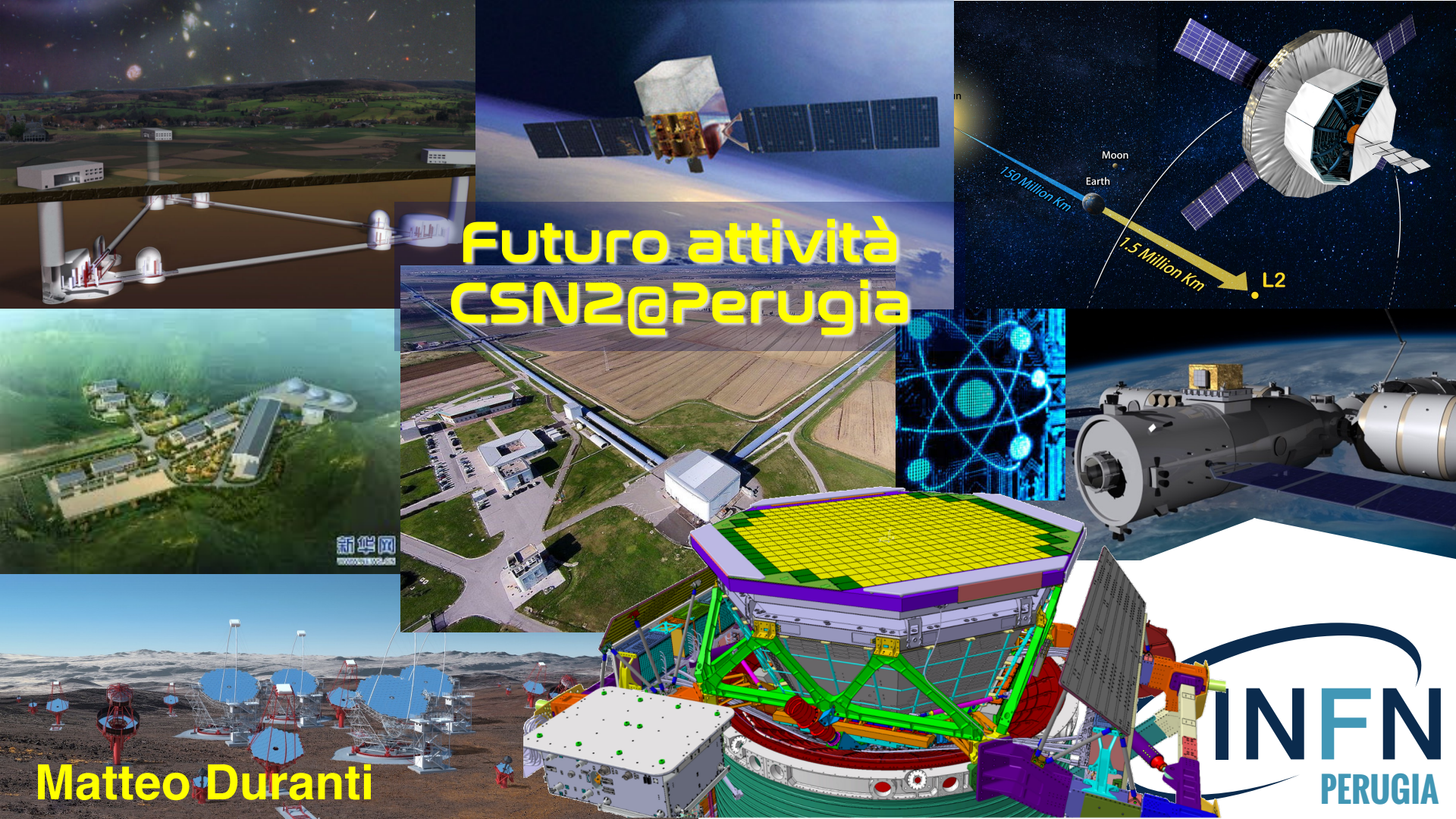

Futuro attività
CSN2@Perugia
Moon
Earth
150 Million Km
1.5 Million Km
L2
新华网
Matteo Duranti
INFN
PERUGIA

Presente CSN2 – Sez. Perugia

- ruolo di primo piano nel campo della rivelazione di onde gravitazionali (VIRGO);
- ruolo di primo piano nella rivelazione di Raggi Gamma (Fermi-LAT e CTA, DAMPE);
- ruolo di primo piano nella rivelazione di Raggi Cosmici Carichi (AMS, DAMPE);
- ruolo di primo piano in ambito quantistico (HUMOR);
- competenze specifiche foto-fisiche e foto-chimiche (BOREX);

VIRGO, E.T.

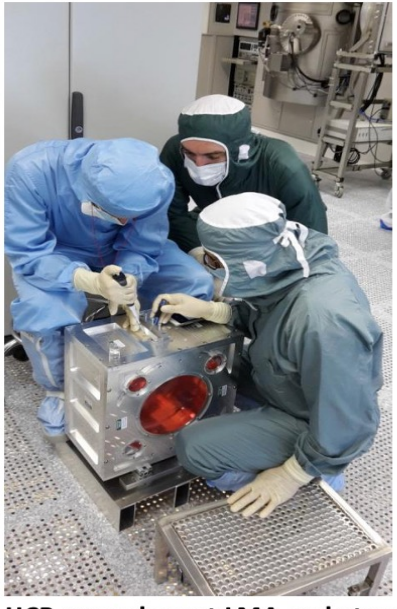
Esperienza e il ruolo maturato con VIRGO → E.T.

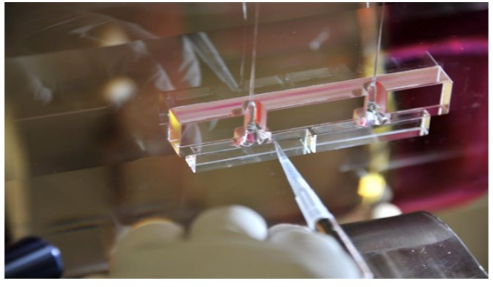
- sospensioni di fused silica e silicon;
- coating criogenici;
- large test masses per O5;
- squeezing;
- VO e low latency in O5 e E.T.;
- post-O5 e E.T.
- modellizzazione e comprensione teorica

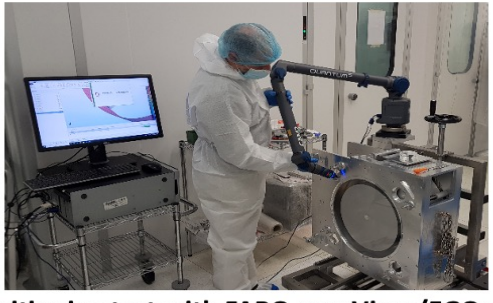
Ricerca sulle sospensioni

Main research topics:

- Design and test of suspensions (responsibility)
- Mechanical loss measurements and thermal noise modelling
- HCB development and realization
- Structural characterizations
- Mechanical characterization







HCB procedure at LMA and at positioning test with FARO arm Virgo/EGO site

Experimental facilities

- FARO-CAM2 arm
- Setup for mechanical losses measurement at room and cryogenic temperature
- Materials Testing Machine
- Microscopy (SEM-EDX)
- FTIR spectroscopy
- X-ray diffraction and x-ray fluorescence

Responsibilities

- AdV+ SUM (Suspensions&Mirrors) System coordination
- Monolithic suspension assembling coordination

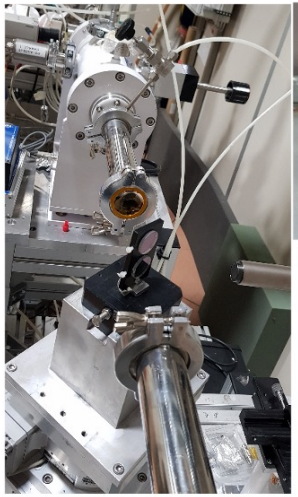
People

A. Di Michele, F. Travasso, H. Vocca, A. Piluso, D. Aisa, S. Aisa

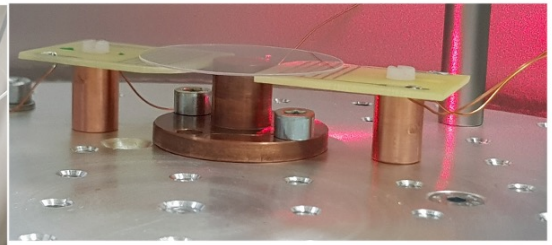
Coating criogenici

Main research topics:

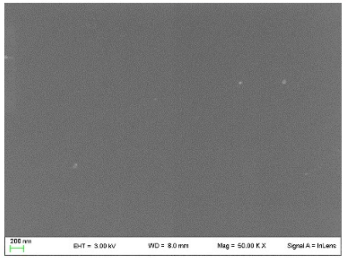
- Mechanical loss measurements and thermal noise modelling
- Morphological and compositional characterizations
- Structural characterizations
- Mechanical characterization



XAS expt @ELETTRA synchrotron



GeNS setup



SEM analysis

Experimental facilities

- Ovens for high-temperature treatments
- GeNS room temperature and cryogenic
- Materials Testing Machine
- Microscopy (SEM-EDX and AFM)
- Raman spectroscopy
- FTIR spectroscopy
- Brillouin spectroscopy
- X-ray diffraction and x-ray fluorescence
- Synchrotron based experiments (XAS)

People

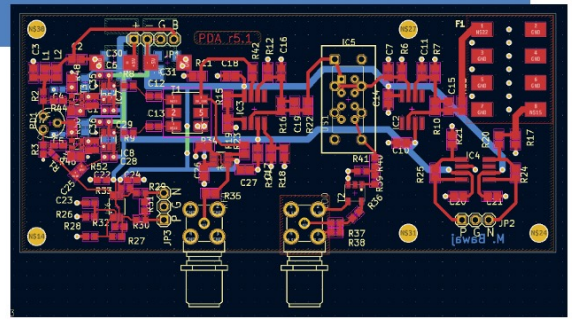
S. Corezzi, A. Di Cicco, A. Di Michele, P. Sassi, L. Silenzi, A. Trapananti, F. Travasso, H. Vocca

Squeezing

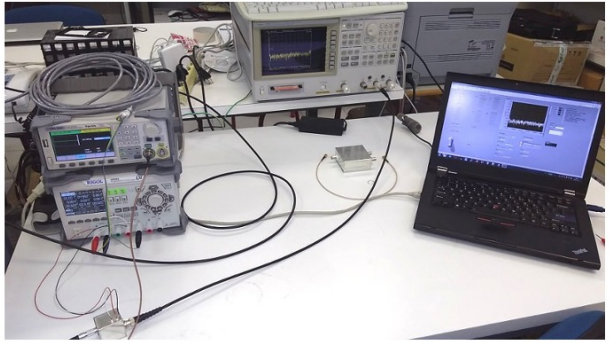
Main research topics:

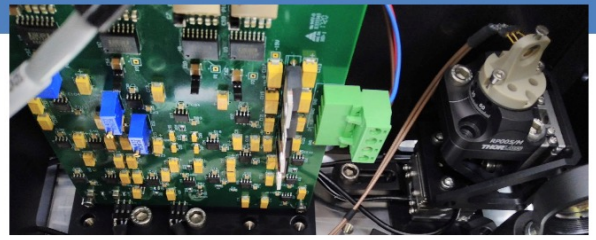
- Frequency dependent squeezed states injection: design of optical homo-dyne low-noise electronic, development of automation algorithms for the Virgo QNR subsystem
- EPR squeezing demonstration: fast photo-detectors development, development of the precise positioning system

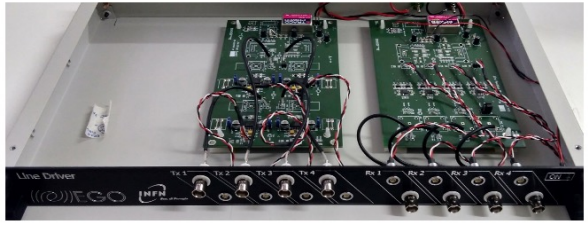
Photo-detector design



Fast amplitude modulated laser & electronic test bench







Electronic circuits built for Virgo

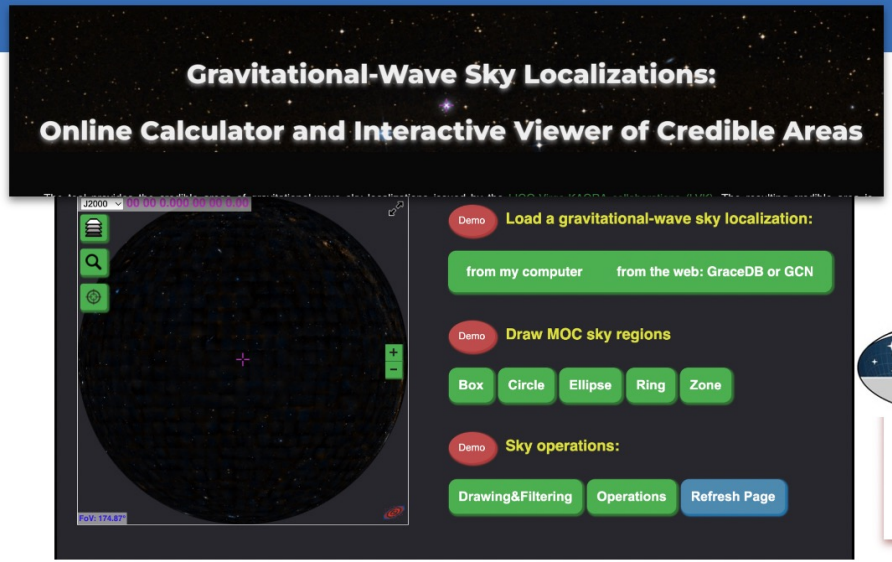
People

M. Bawaj

Multi-messenger – Virtual Observatory

Main research topics:

- Development of Virtual Observatory standards and tools for the MMA community
- IVOA (International Virtual Observatory Alliance) and ESFRI achievements
- Web tools supported in the INFN servers
- Low-Latency, DetChar, Cosmology and open data tutorials in the Virgo Collaboration

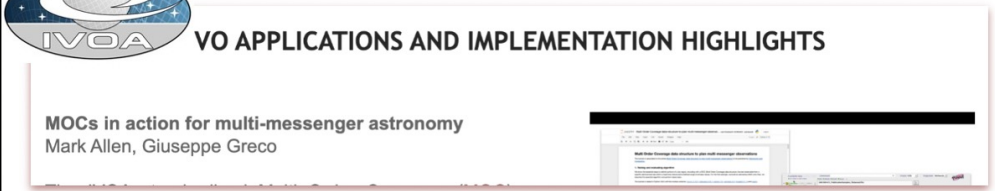


AHEAD 2020

ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research infrastructures

People: G. Greco, M. Bawaj, M. Punturo, H. Vocca, F. Travasso and ML Brozzetti

IVOA

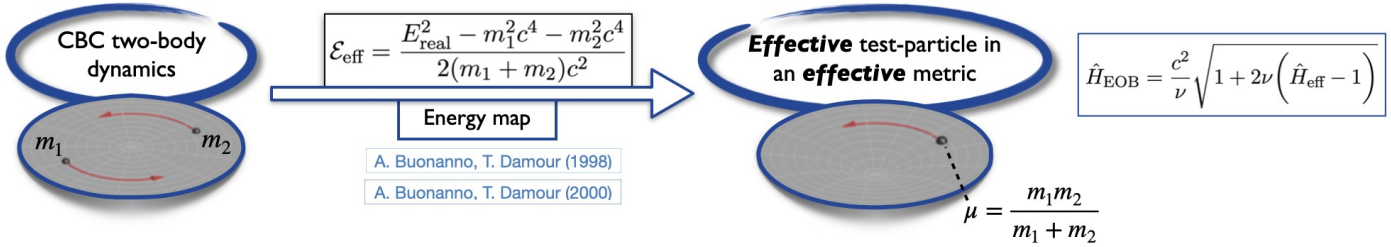


Modellizzazione e comprensione teorica

Main research topics:
- Application of the effective-one-body approach to build templates for gravitational waves sourced by compact binary systems
- Inclusion of eccentricity effects
- Inclusion of memory effects

Recent papers of the group:
- arXiv:2112.05448
- arXiv:2202.10063
- arXiv:2203.16286 (extension in preparation)
- Memory effects paper in preparation

EOB approach



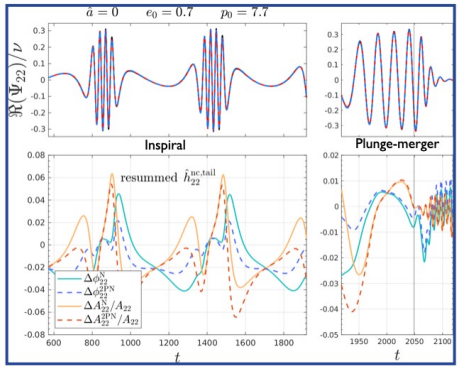
$$\hat{H}_{\rm EOB} = \frac{c^2}{\nu}\sqrt{1+2\nu\left(\hat{H}_{\rm eff}-1\right)}$$

Improvements on the TEOBResumS waveform model (Prometeo Virgo group)

$$h_+ - \mathrm{i}h_\times = D_L^{-1}\sum_{\ell=2}^{\ell_{\rm max}}\sum_{m=-\ell}^{\ell} h_{\ell m}\,{}_{-2}Y_{\ell m}$$

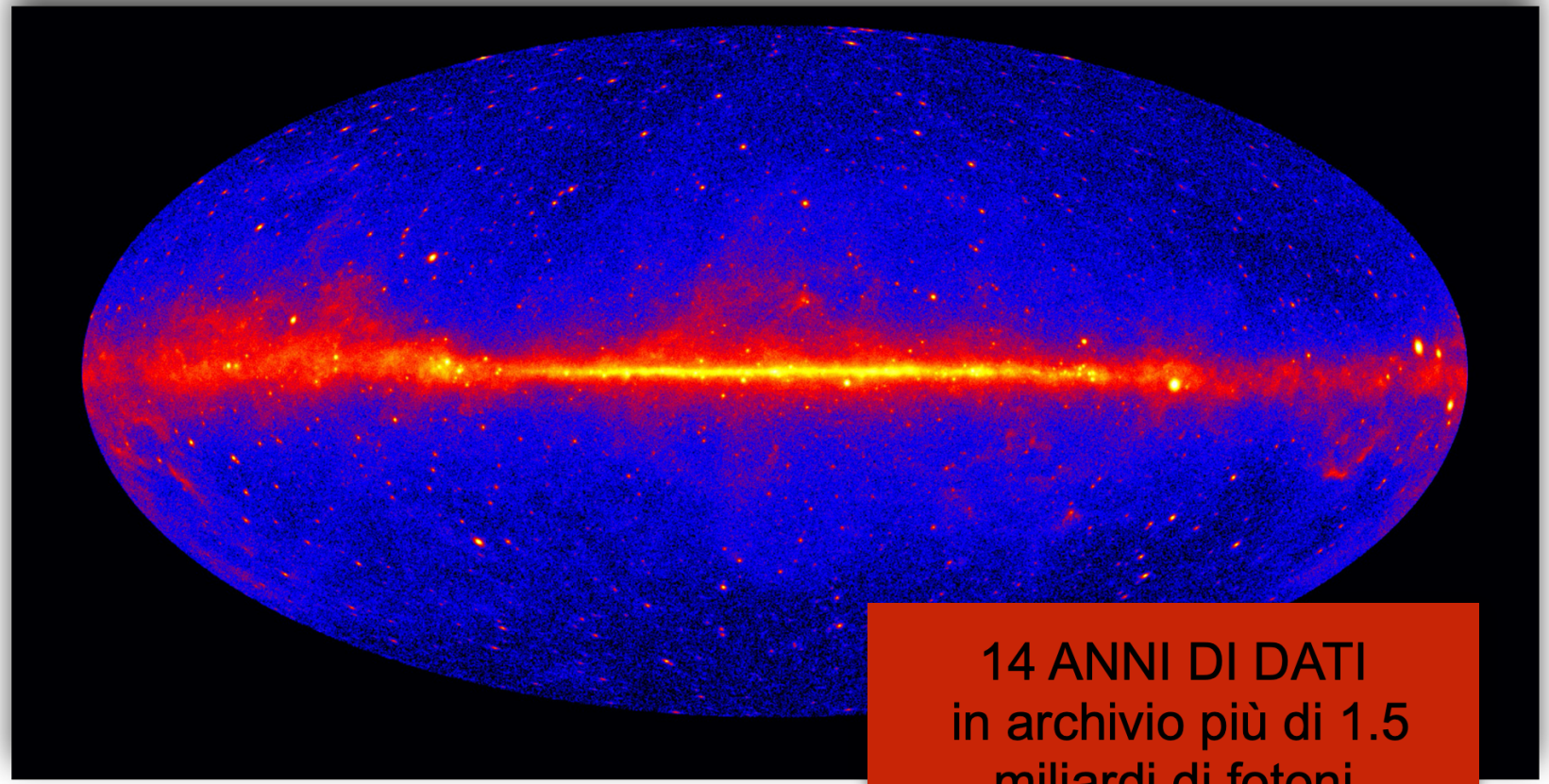
$$h_{\ell m} = h_{\ell m}^{(N,\epsilon)}\,\hat{h}^{\rm c}_{\ell m}\,\hat{h}^{\rm nc}_{\ell m}$$

Extra noncircular factors (inst, tail, memory)



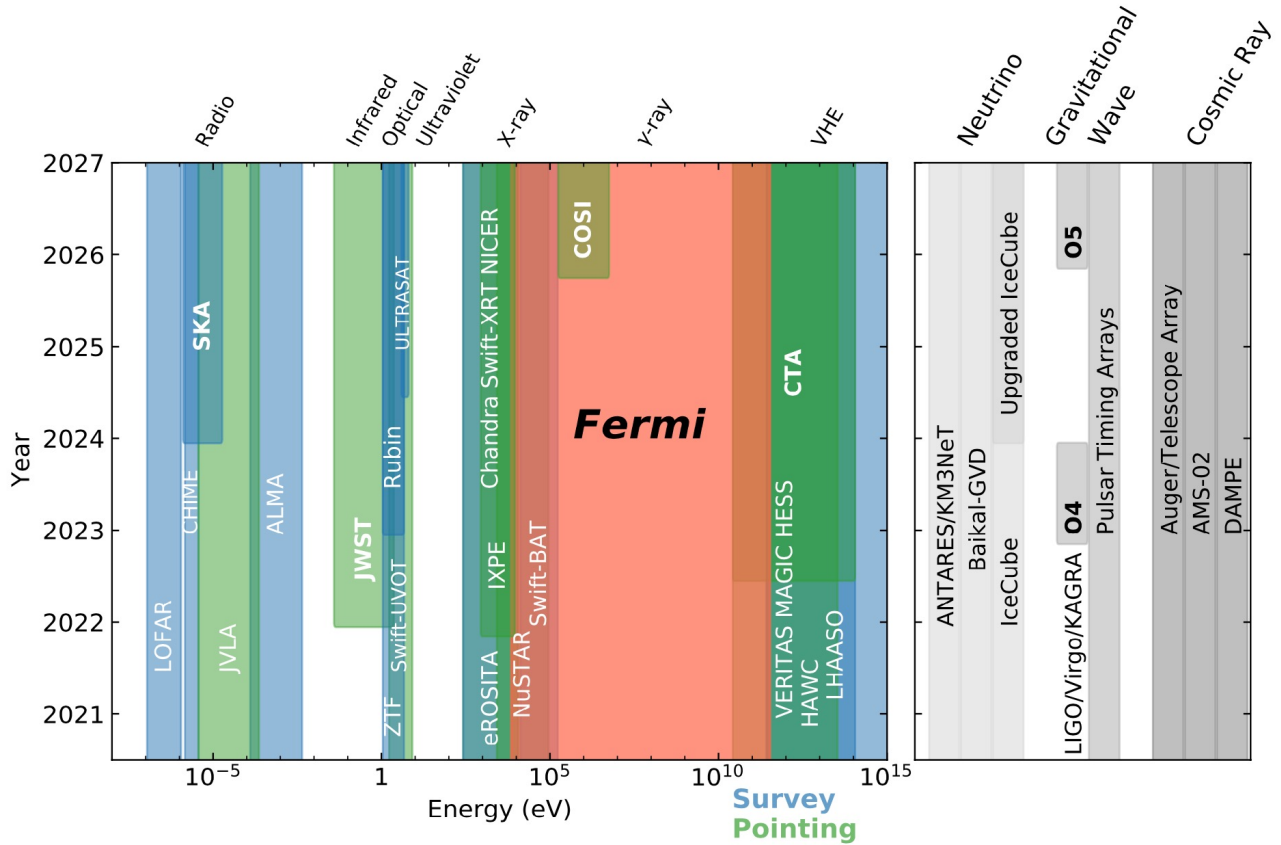
People:
G. Grignani,
T. Harmark,
R. Oliveri,
M. Orselli,
A. Placidi

Raggi-γ e multi-messenger – Fermi-LAT



14 ANNI DI DATI
in archivio più di 1.5
miliardi di fotoni

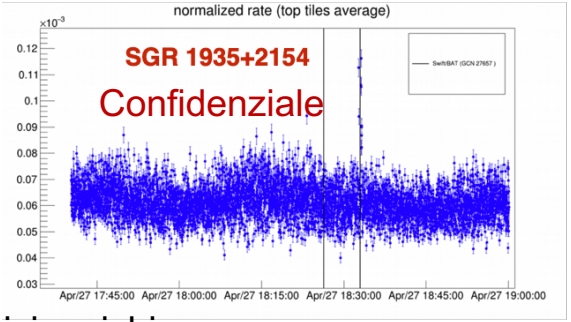
Raggi-γ e multi-messenger – Fermi-LAT



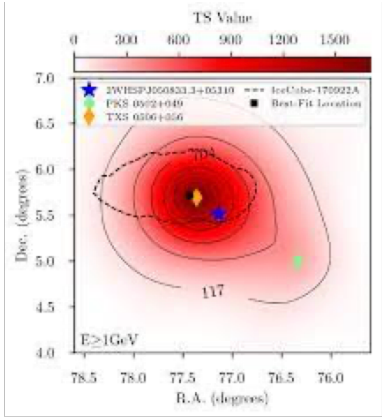
Fermi per i prossimi anni ricopre un ruolo chiave in relazione agli altri strumenti multifrequenza e multimessaggero

Raggi-γ e multi-messenger – Fermi-LAT

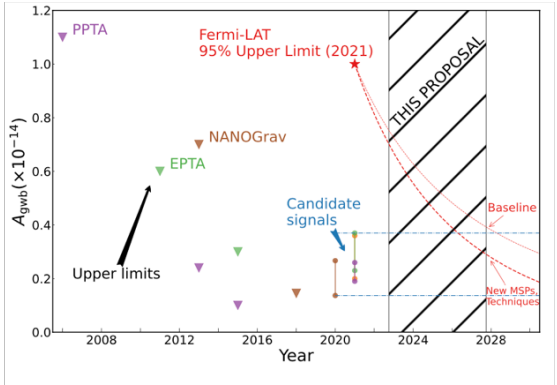
Follow-up di onde gravitazionali: sviluppo di una nuova tecnica di analisi che sfrutta tutte le potenzialità del satellite → utilizzo dello schermo di anticoincidenza nominalmente usato per la reiezione dei cosmici carichi



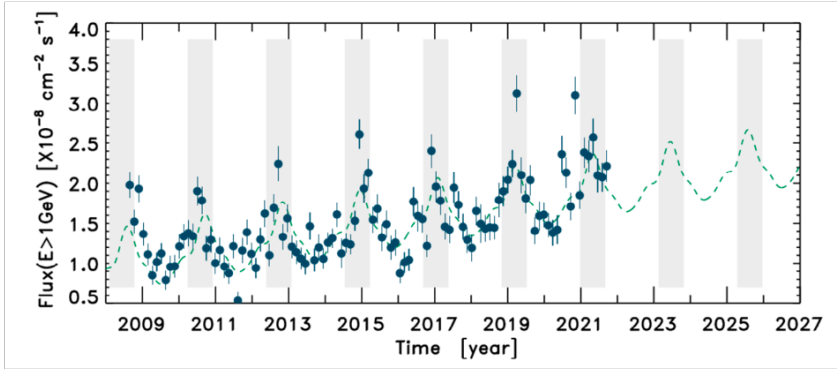
Follow-up di Neutrini di altissima energia → siti di accelerazione dei raggi cosmici



Ricerca di pulsar timing per lo studio del background di onde gravitazionali

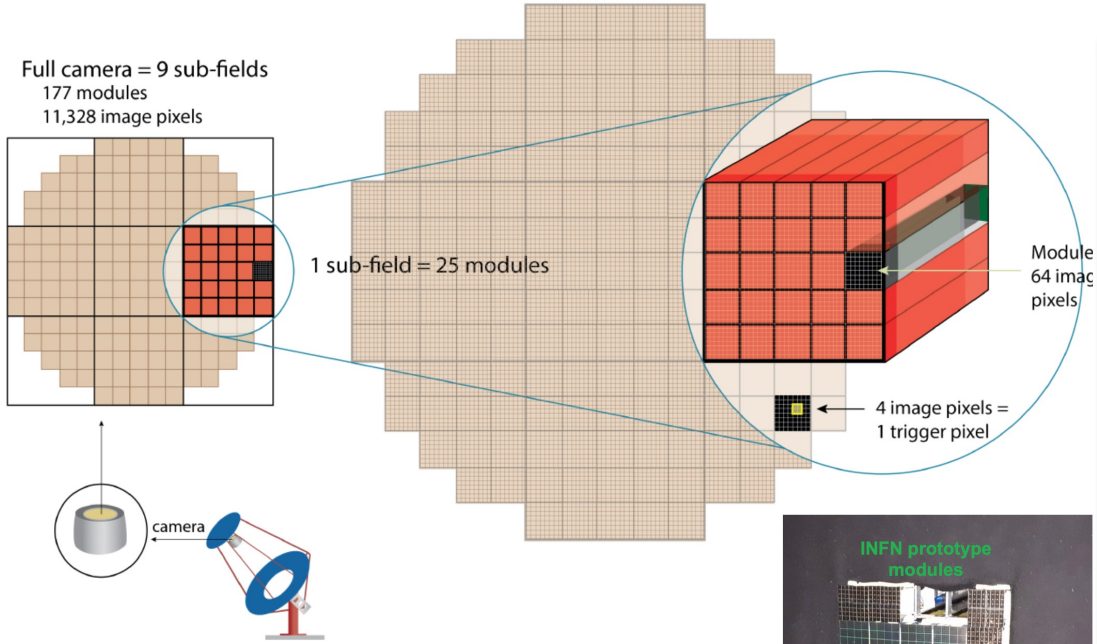


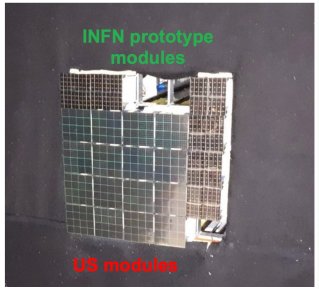
Studi di periodicità e variabilità su lunga scala di AGN



Raggi-γ e multi-messenger – CTA

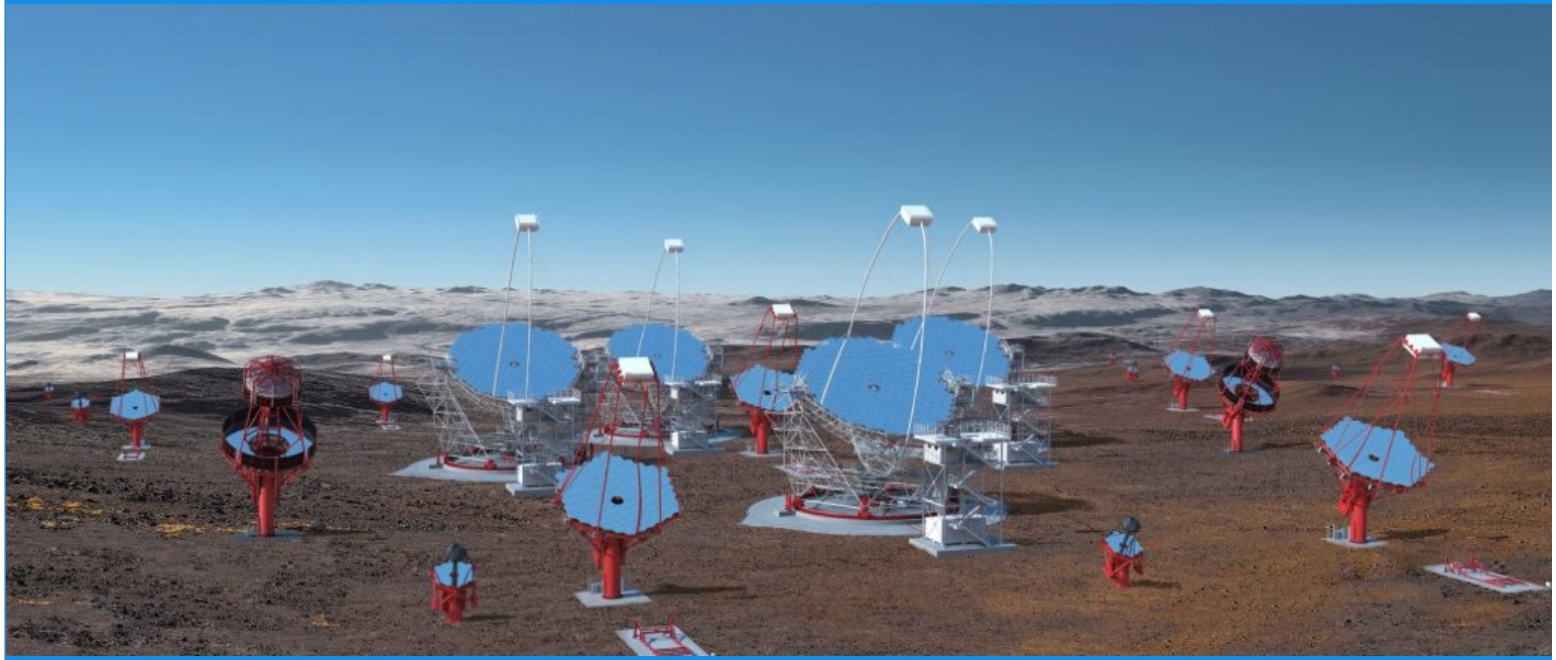
Il Piano Focale





Raggi-γ e multi-messenger – CTA

CHERENKOV TELESCOPE ARRAY - SOFTWARE



Attività locale legata allo sviluppo :

- Telescopi SST (Hw e Sw di controllo)
- Software di controllo per CTAO (Monitoraggio e Allarmi)

Raggi-γ e multi-messenger – CTA

FENOMENI TRANSIENTI - MACHINE LEARNING

CTA è ottimizzato anche per la reazione a fenomeni transienti

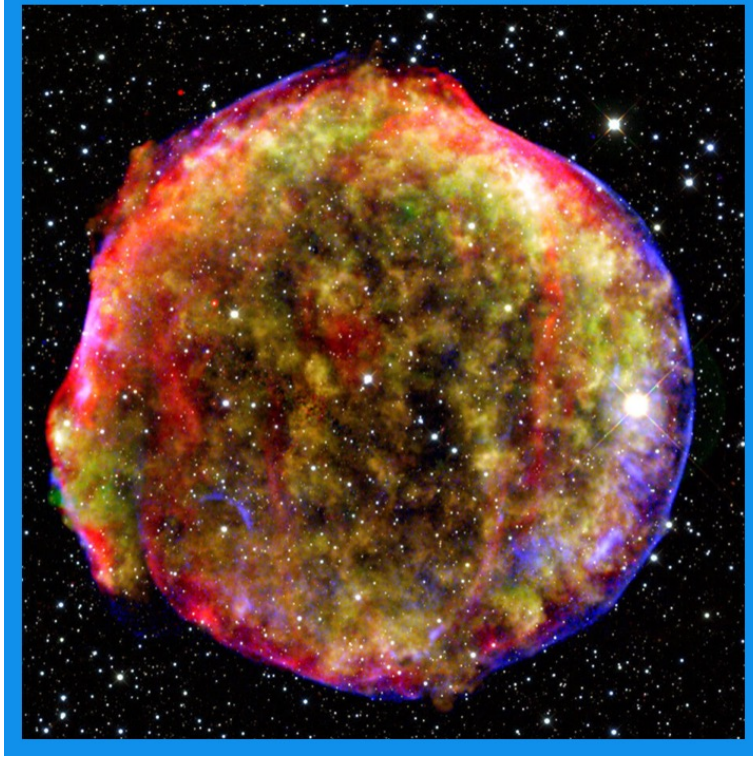
Interesse accresciuto dalla rivelazione di GRB da parte egli IACT attuali

L'attività locale sullo studio di fenomeni transienti e dell'osservabilità di eventi multimessaggero si estende naturalmente all'astrofisica al TeV e CTA

Diverse attività locali legate al machine learning su immagini e curve di luce da estendere e potenziare per

Raggi-γ e multi-messenger – CTA

PEVATRONI



Identificazione dei PeVatroni

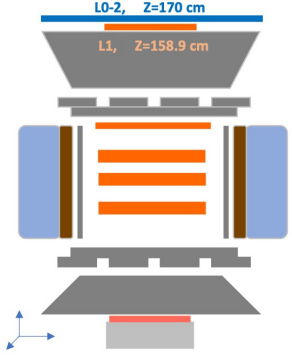
Importanti risultati ottenuti da diversi esperimenti

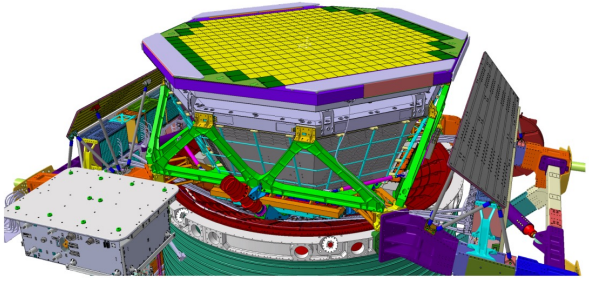
Sfrutta la sensibilità alle energie multi-TeV legata a telescopi di diverse dimensioni

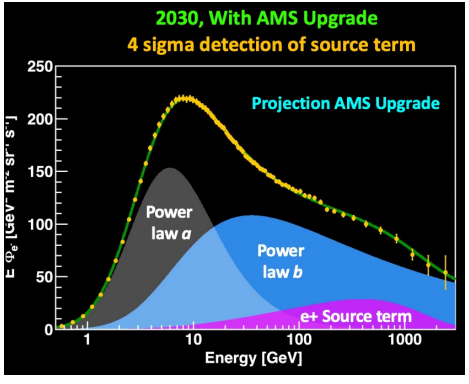
Raggi Cosmici Carichi – AMS Upgrade

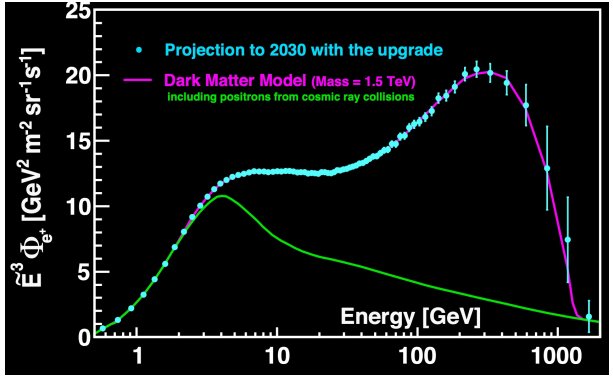
AMS-02 Upgrade

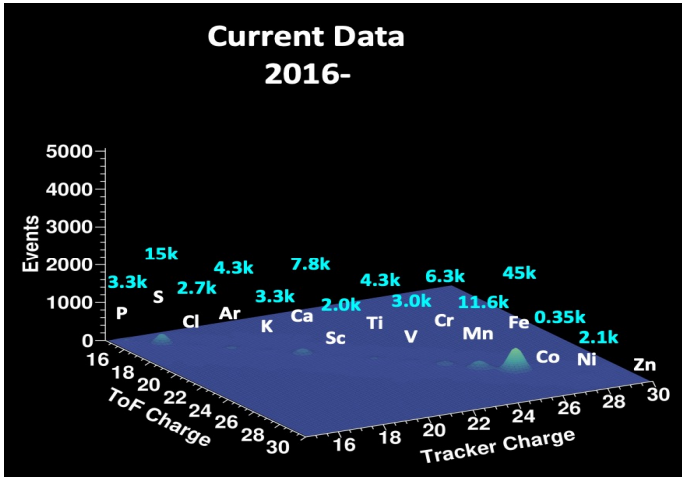
- How ? L0, an additional two side silicon layer (~7 m^2) on top AMS-02
- What you gain? 300% increase in the acceptance for most of the channels
- When? install L0 in 2024, the sooner is L0 installed, the larger is the statistics gain

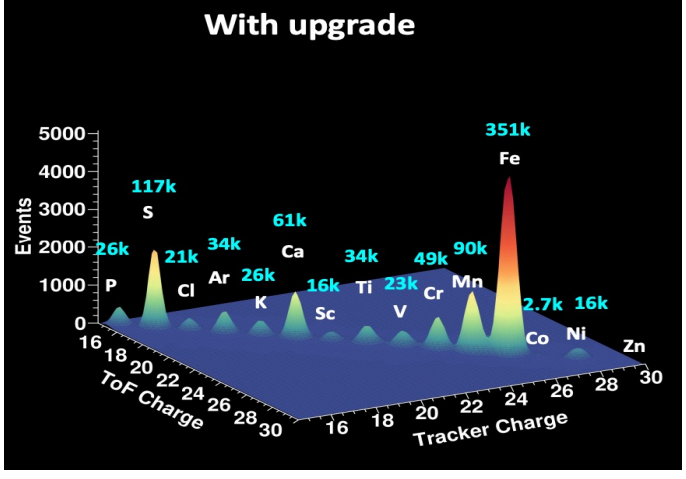




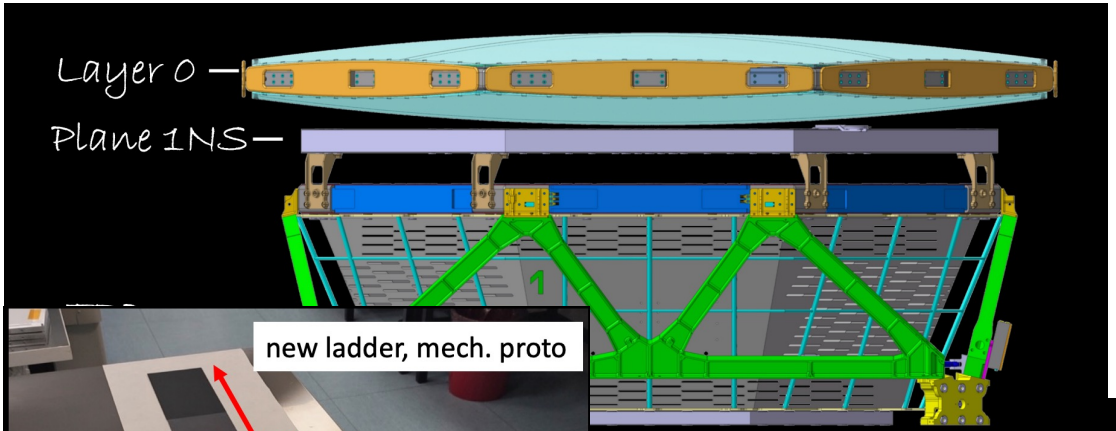


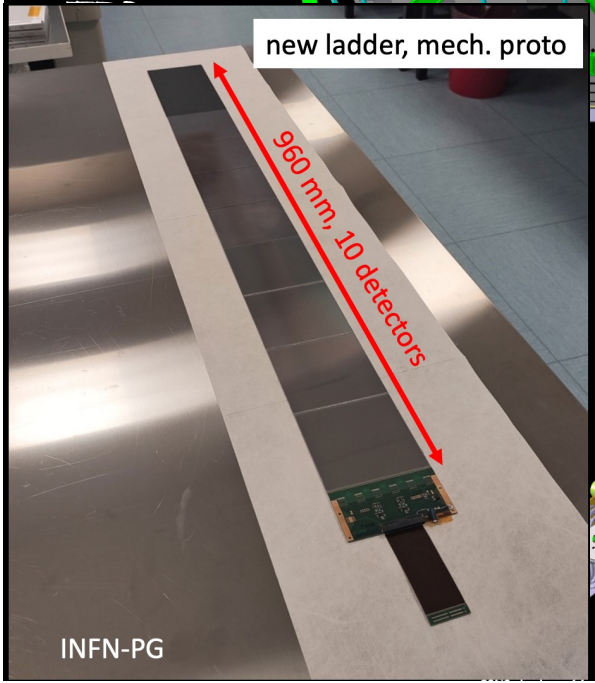


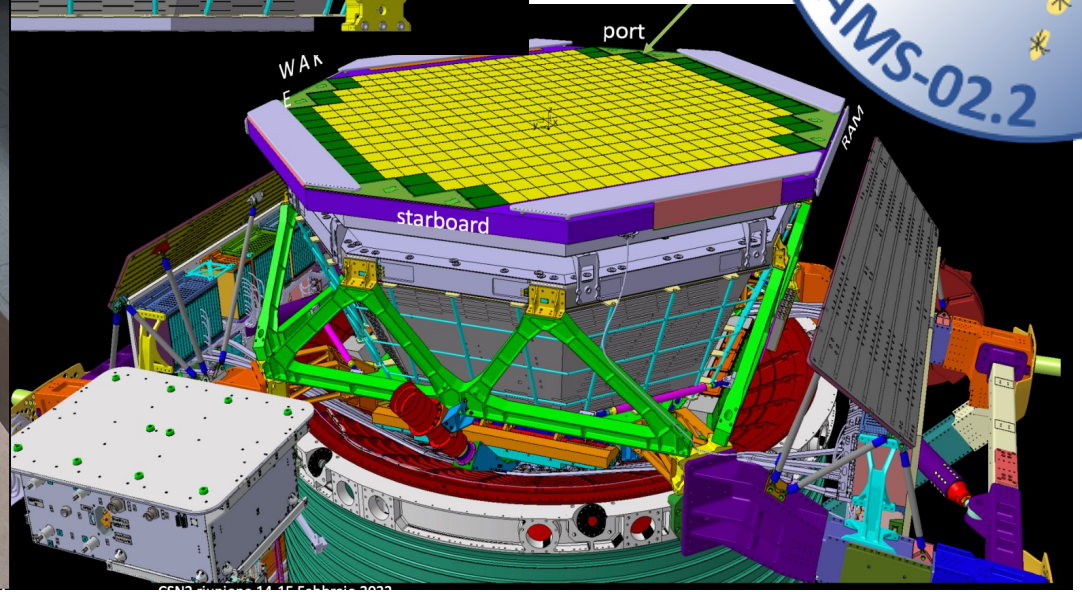




Raggi Cosmici Carichi – AMS Upgrade



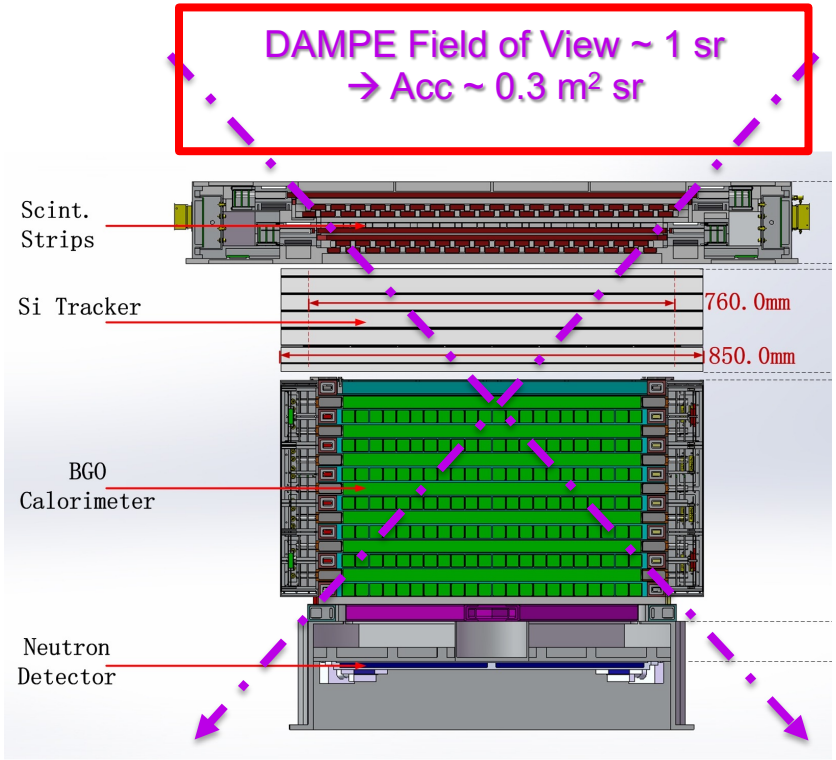


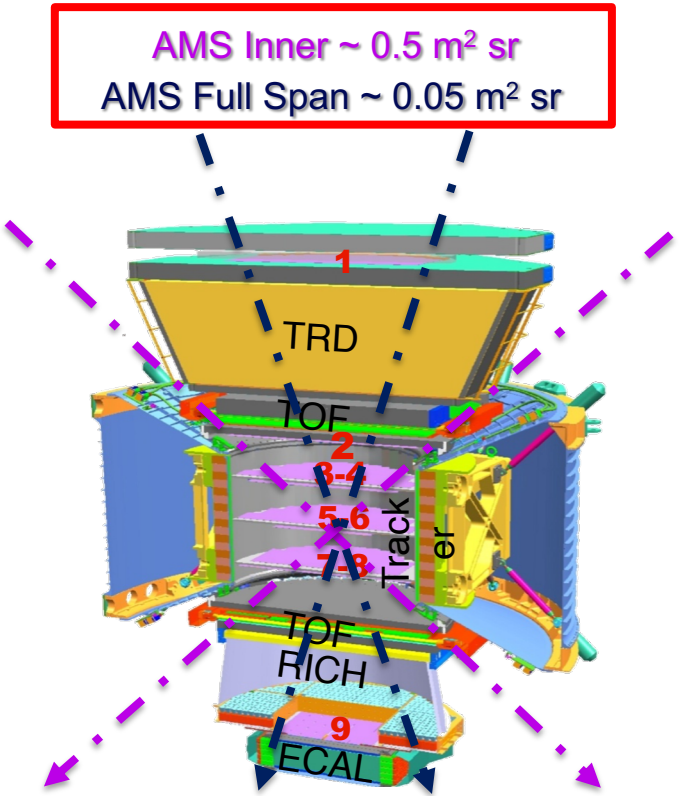


Alpha Magnetic Spectrometer

AMS-02.2

Raggi Cosmici Carichi – Futuro





Tutti gli esperimenti passati ed attuali sono disegnati come "telescopi": sensitivi solo a particelle "da sopra

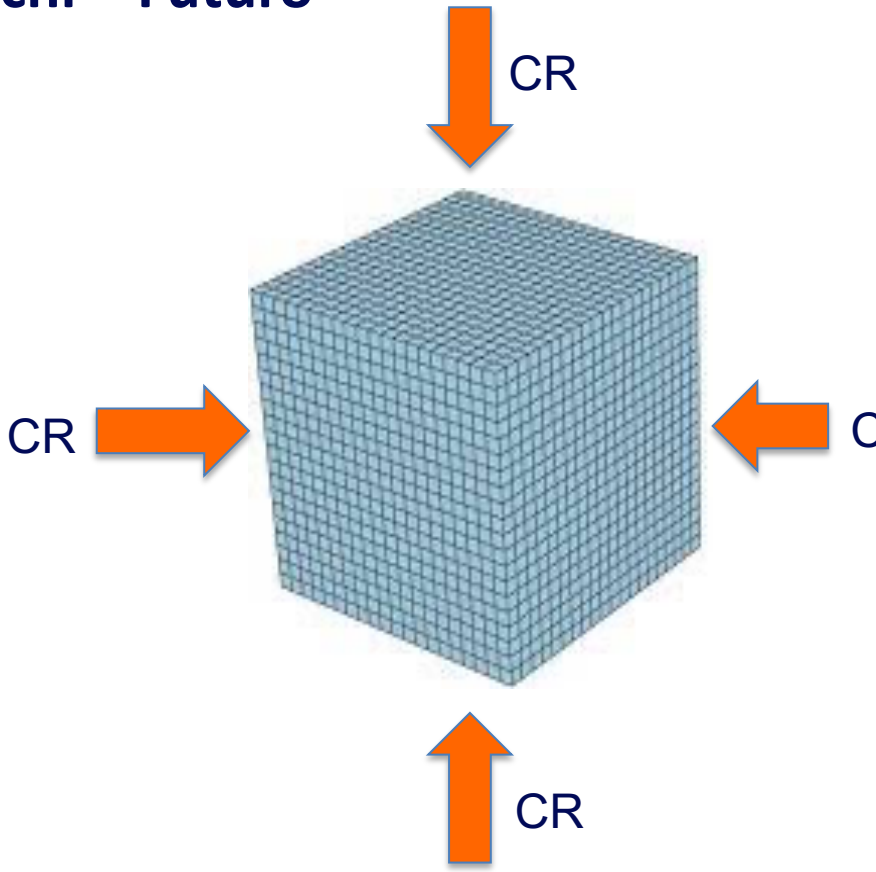
FoV limitato → accettanza limitta

Raggi Cosmici Carichi – Futuro

- utilizzo dell' isotropia dei RC sfruttando tutte i lati dell'apparato (idealmente FoV $\Omega = 4\pi$)

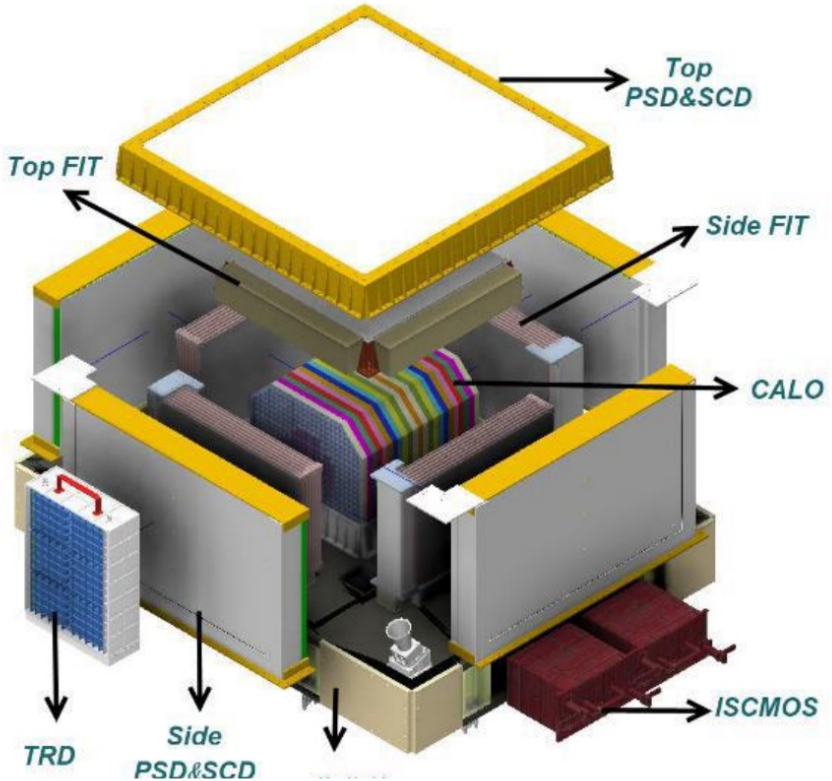
- calorimetro omogeneo, "isotropo":
  - profondità garantita per ogni posizione di incidenza
  - segmentazione per ogni direzione di incidenza

  → CaloCube!



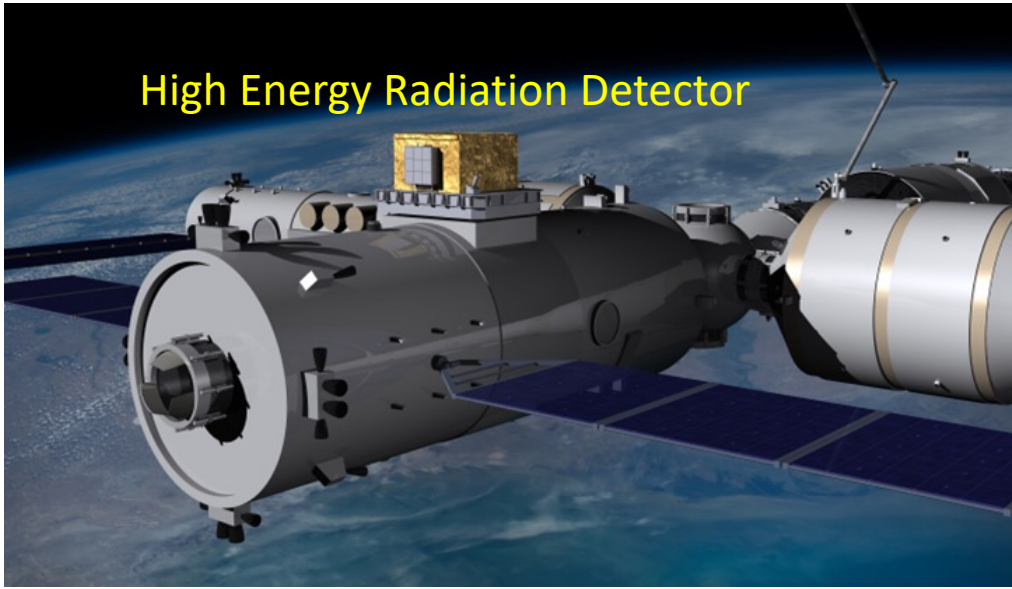
CaloCube è un R&D iniziato dal gruppo INFN-Firenze (O. Adriani) che sta ispirando la nuova generazione di rivelatori di RCC nello spazio (HERD, ALADInO, AMS-100…)

Raggi Cosmici Carichi - HERD



Based on the DAMPE and AMS heritage:

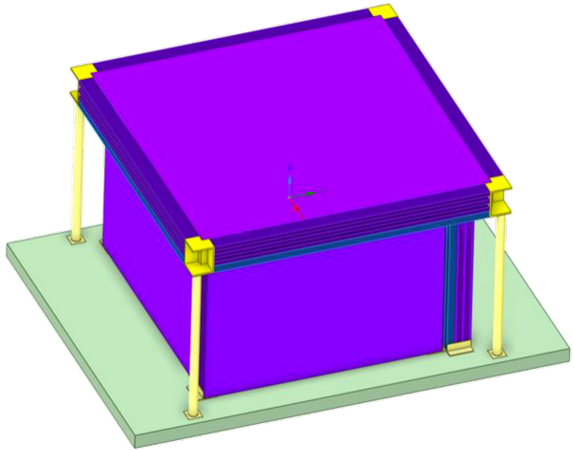
- central "isotropic" calorimeter
- Fiber Tracker
- Plastic Scintillator Detector
- Silicon Charge Detector / tracker
- TRD on one side to calibrate the absolute energy scale

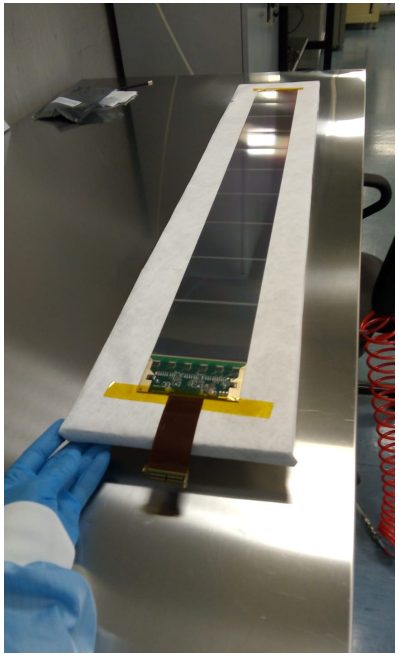


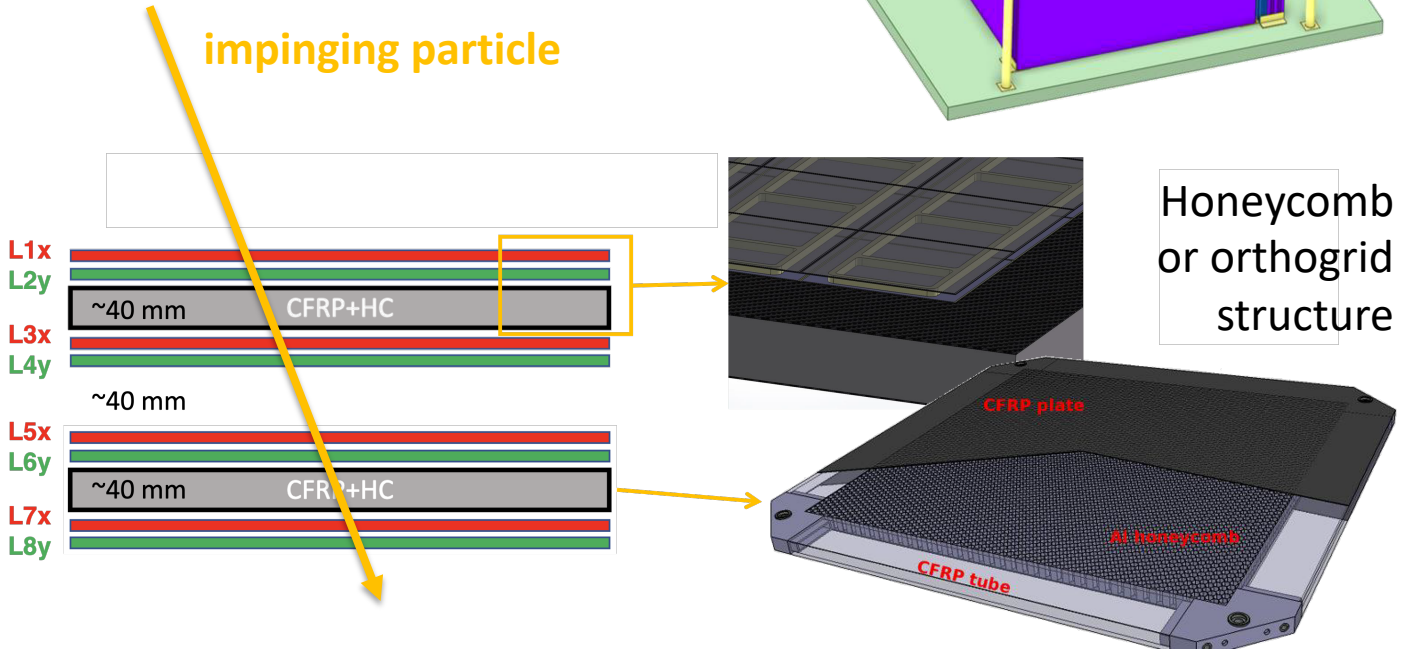
Raggi Cosmici Carichi - HERD

The Silicon "tracker" is mainly used as Silicon Charge Detector:

- microstrip silicon detectors, 50 (150) µm implant (readout) pitch
- 6 layers (3 *y* + 3 *x*), 2 super-planes
- material before the first layer as less as possibile (< 1 mm CFRP)
- long silicon ladders (~ 1 m) to save channels







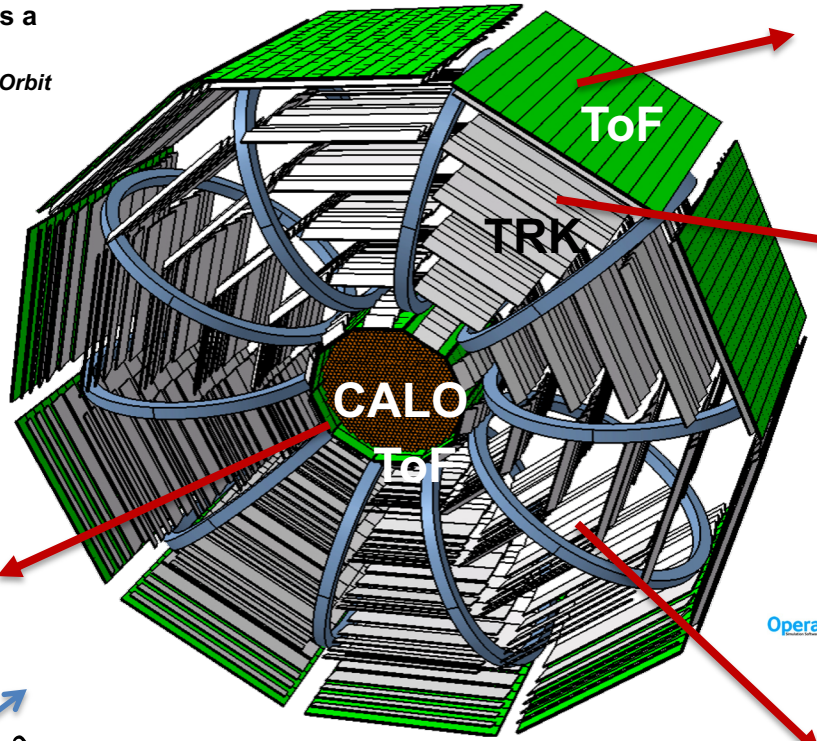
Honeycomb or orthogrid structure

Raggi Cosmici Carichi - ALADInO

High Precision Particle Astrophysics as a New Window on the Universe

with an Antimatter Large Acceptance Detector In Orbit

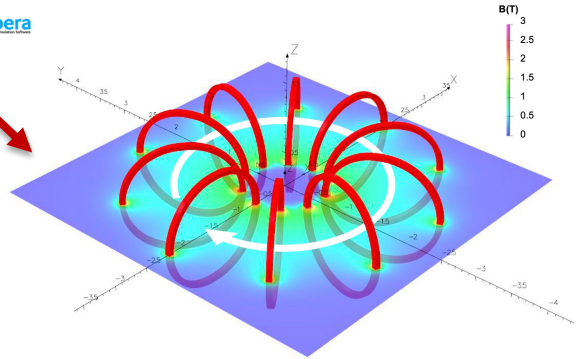
(ALADInO)

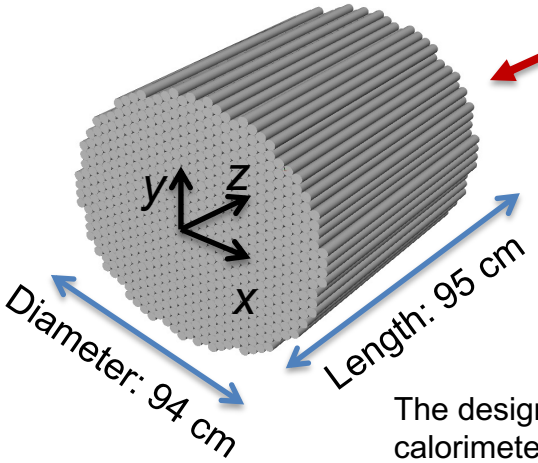


Plastic Scintillator Detectors read-out by SiPM

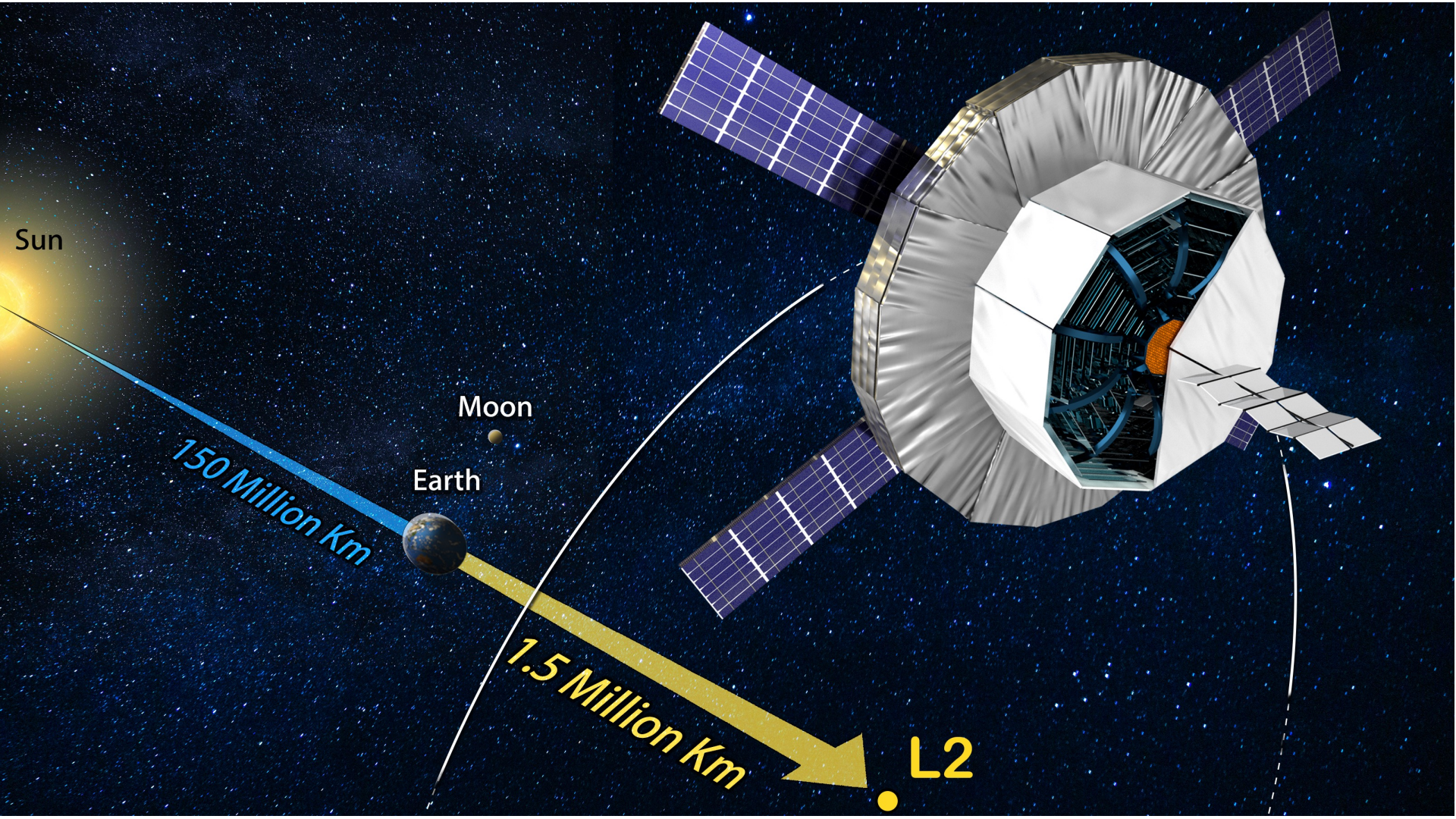
Microstrip Silicon Sensors (3-5 μm) (LGAD? MAPS?)

High Temperature (15 – 40 K) Superconducting Magnet





The design is based on the HERD calorimeter one and will benefit of its R&D


Sun
Moon
Earth
150 Million Km
1.5 Million Km
L2

HUMOR → GrafiQO

Attività legate alle Tecnologie Quantistiche:

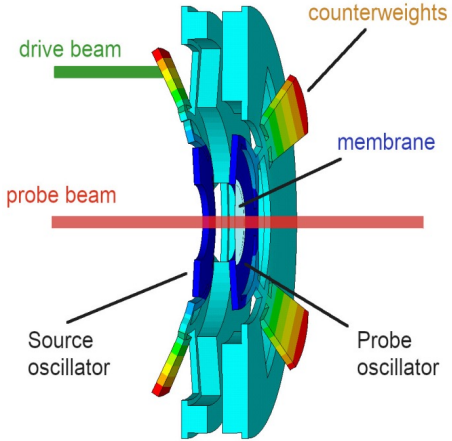
- conclusa l'attività di HUMOR
- nuova sigla (2021): QUANTEP (Gr5)
- nuova sigla (2022): GrafiQ0

Table-top tests on “the quantum & the gravity”

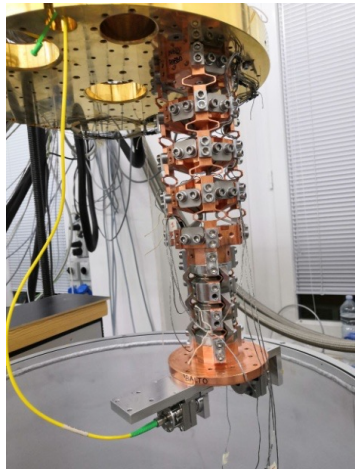
D. Vitali, G. Di Giuseppe, N. Malossi, R, Natali, P. Piergentili

1. HUMOR: 2014-2021. Best upper bound on commutator deformation parameters (nonrelativistic limit of quantum gravity theories); (Bawaj et al, Nat Comm 2015)

2. New experiment GRAFIQO: measurement of gravitational force between two nanomechanical oscillators in a quantum state (at least with quantum limited fluctuations)



Forza gravitazionale 10^{-18} N, rumore termico 6 x 10^{-16} N $\Rightarrow$ S/N = 1 per un tempo di integrazione di 10^5 secondi



QUANTEP, GrafiQO

BOREX, DarkSide, JUNO …

Competenze specifiche (ambito foto-fisico e foto-chimico) impiegate nello studio delle caratteristiche (lunghezza attenuazione, spettri di assorbimento, …) degli scintillatori liquidi utilizzati nei rivelatori di neutrini o di Dark Matter:

- conclusa l'attività di BOREX

- JUNO in fase di allestimento

Perugia e ASI-SSDC

Storicamente Perugia ha gestito l'Accordo ASI-INFN per SSDC. La cosa è stata confermata anche per l'Accordo 2022-2025 (ACCORDO ATTUATIVO N. 2021-43-HH.0). L'accordo:

- finanzia borse PhD (UniPG, UniBo, 2 x UniToV, UniFe)
- finanzia AdR (24 annualità)

- è trasversale a molte attività/esperimenti di CSN2:
  - RCC (AMS, HERD, DAMPE, CSES1&2, …);
  - RG (Fermi-LAT, IXPE, …);
  - Cosmologia (Planck, LiteBIRD, LSPE, Euclid, …);
  - GW/Multi-messenger (Virgo, E.T.);
  - Space Weather / Fisica Solare (CSES1&2, AMS, PAN, …);
  - IT e AI (Machine Learning, Cloud, …);

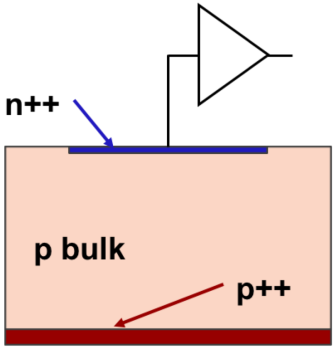
Perugia e PNRR

Ampio coinvolgimento di Perugia nelle varie forme del PNRR:

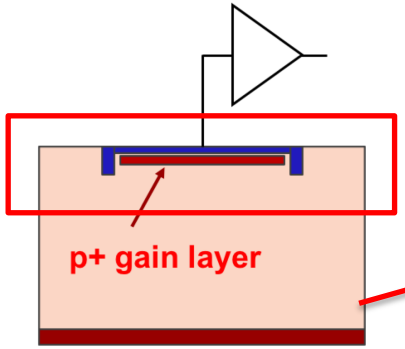
- Infrastruttura E.T. – ETIC - vedi talk M. Punturo
- Centro Nazionale HPC - Spoke 3: P. Lubrano (co-leader), S. Cutini e M. Duranti – 1 TD Tecnologo + 1 borsa PhD per Perugia
- proposta per Partenariato Esteso su Tecnologie Quantistiche a Camerino - vedi talk D. Vitali
- contatti per Partenariato Esteso Spazio (ASI) su Sensoristica – LGAD per lo spazio (M. Duranti, G. Ambrosi, M. Ionica, …)

Backup

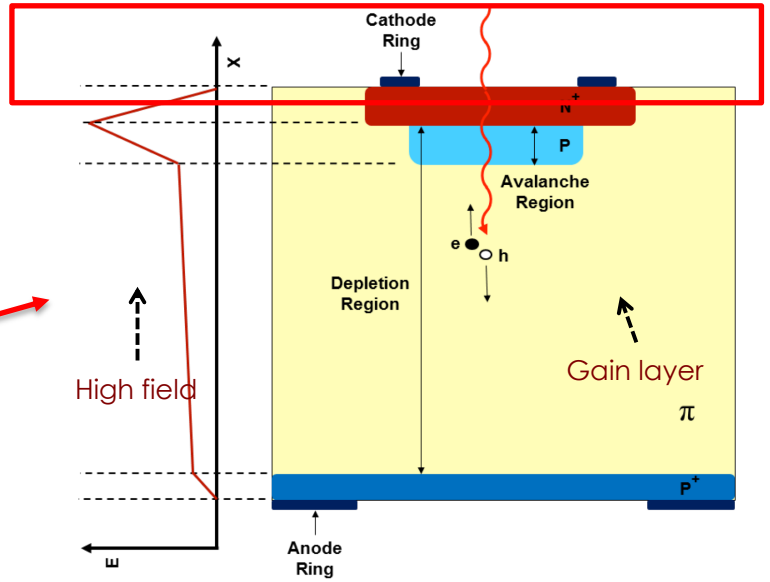
LGAD silicon sensors

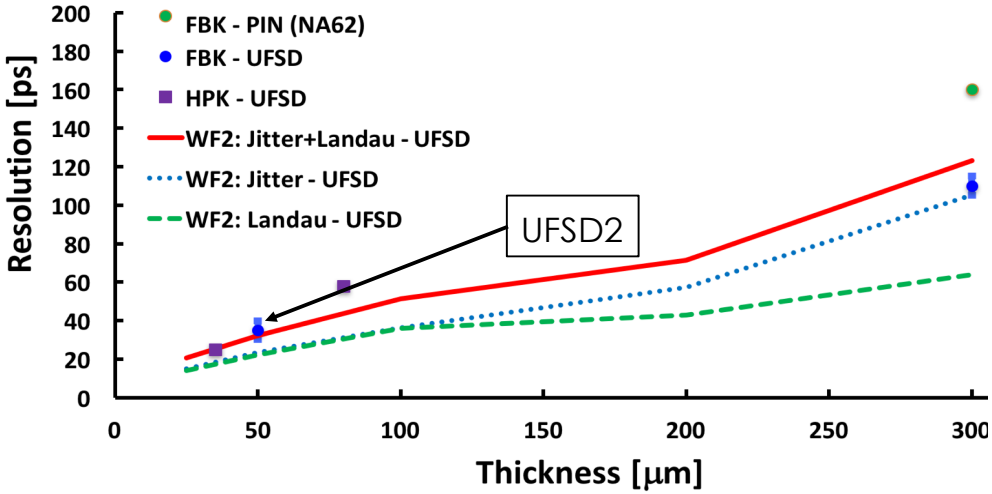


Traditional silicon diode



Low Gain Avalanche Diode





UFSD2

UFSD1

300 μm "traditional"(PIN) silicon detector without gain

Strcit collaboration with:

- one of the "father" of the Ultra Fast Silicon Detectors is from INFN-TO (N. Cartiglia)
- one of the foundries more involved in the R&D of LGAD's is FBK (M. Boscardin)