

Space mission Gamma-400

GAMMA-400 Collaboration

- Lebedev Physical Institute (leading organization)



- National Research Nuclear University MEPhI



- Ioffe Physical Technical Institute



- Open Joint Stock Company "Research Institute for Electromechanics" (Istra)



- Institute for High Energy Physics (Protvino)



- Space Research Institute



- Istituto Nazionale di Fisica Nucleare, INFN, Italy



Gamma-400: the Italian collaboration in 2013

INFN Trieste

INFN and University of Florence

INFN Pavia

INFN and University of Roma Tor Vergata

INFN Pisa and University of Siena

Gamma-400

Approved by ROSCOSMOS

Originally devoted to study of: γ rays (30 GeV–1 TeV)
& high-energy electrons and positrons.

Availability for a revision of the project that does not
alter the original objectives

·The characteristics of the satellite:

- scientific payload 2600 kg,
- power budget 2 kW,
- expected lifetime > 5 years

provide excellent opportunities to configure the apparatus for
**extremely important physics tasks, beyond the current
generation of space missions.**

The Italian contribution to the project would concentrate on:

Study of p and He spectra close to the “knee” region (10¹⁴ – 10¹⁵ eV)
Extension of the gamma capability in the 30–300 MeV region

Gamma-400: a unique instrument

Combine for the first time photon and particle (electrons and nuclei) detection in a unique way

**Excellent Silicon Tracker (30 MeV – 1 TeV),
breakthrough angular resolution 4-5 times better than
Fermi-LAT at 1 GeV**

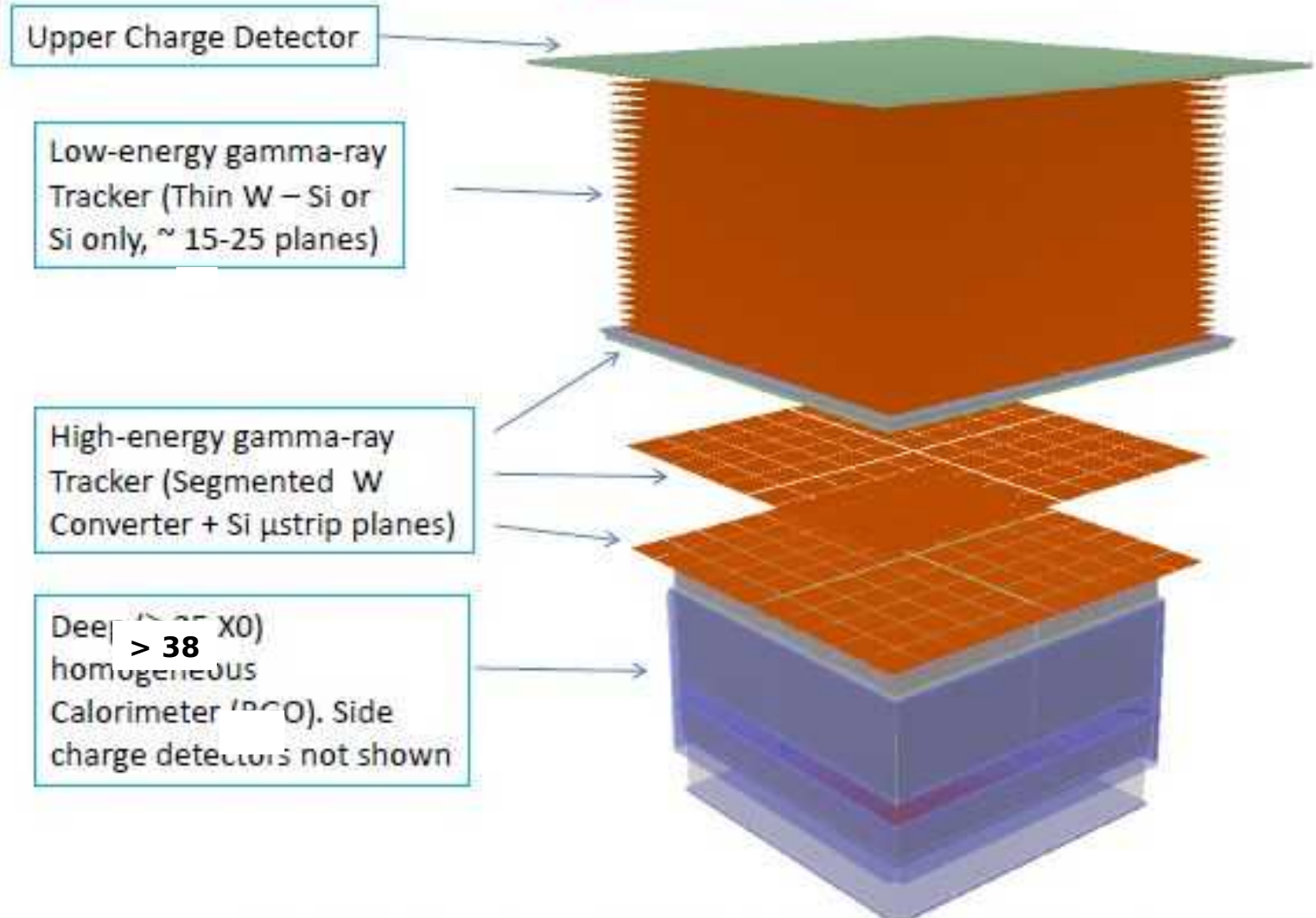
**improved sensitivity compared with Fermi-LAT by a
factor of 5-10 in the range 30 MeV–10 GeV**

**Heavy Calorimeter (40 X0), homogeneous and
isotropic, with optimal energy resolution and
particle discrimination**

Electron/positron detection up to TeV energies

Nuclei detection up to 10^{15} eV energies

Gamma-400

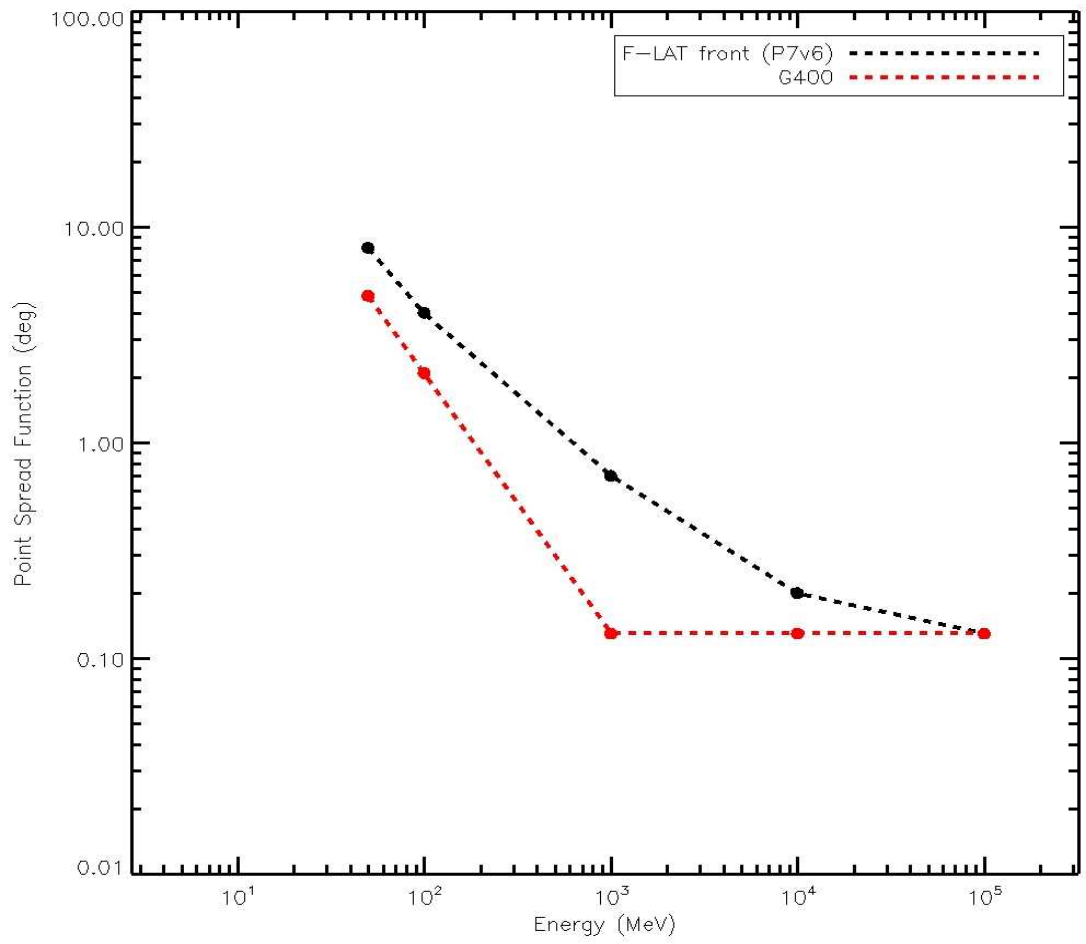


apparatus versions used in one of the preliminary simulations.

Tracker

- **Simulation work on the tracker has been tuned:**
 - **Geometry implemented in the software framework;**
 - **Hit digitization (hit to the strip association) implemented;**
 - **Clusterization of the tracker hits implemented;**
 - **Energies of 10, 30, 50, 100 and 400 MeV; 1 and 10 GeV simulated;**
 - **Investigation with lower tungsten thickness (0%, 1.5%, 2%) being finalized**

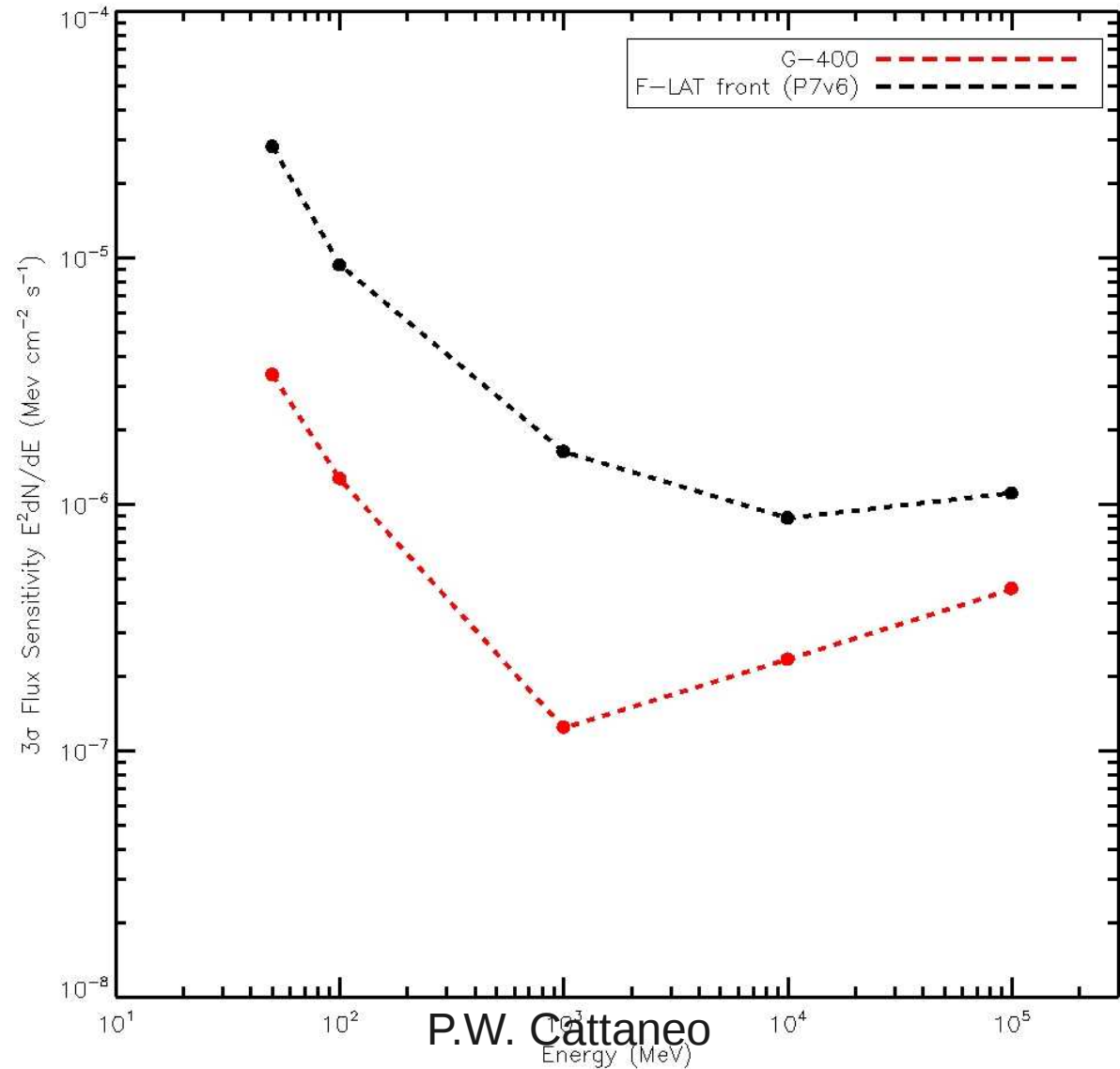
Gamma-400 set-up: 25 planes, 0.03 X0 W, 2.8 cm spacing, Si pitch 120 micron, analog (alternate) readout, Kalman reconstruction, assumed bkg rejection eff. 10⁻⁴.



Gamma-400 vs. Fermi PSF (68% containment radius) (Fermi: 0°; G-400:30°)

Gamma-400 vs. Fermi 3 σ flux sensitivity (2-week observing time)

Fermi-LAT in sky scanning mode,
G-400 in pointing mode with no Earth occultation



Calorimeter

| | |
|---|---|
| Scintillating material | CsI(Tl) |
| N _x N _y N _z | 20 \times 20 \times 20 |
| L (cm) | 3.6* |
| Crystal volume (cm ³) | 46.7 |
| Gap (cm) | 0.3 |
| Mass (Kg) | 1683 |
| N.Crystals | 8000 |
| Size (cm ³) | 78.0 \times 78.0 \times 78.0 |
| Depth (R.L.) " (I.L.) | 39 \times 39 \times 39 1.8 \times 1.8 \times 1.8 |
| Planar GF (m ² sr) (fiducial**) | 1.72 \times 1.72 \times 1.72 |

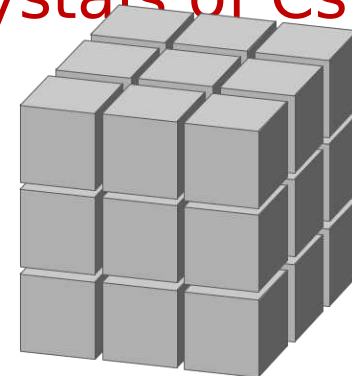
(* one Moliere radius)

(** within a reduced perimeter of size (N-1)*L)

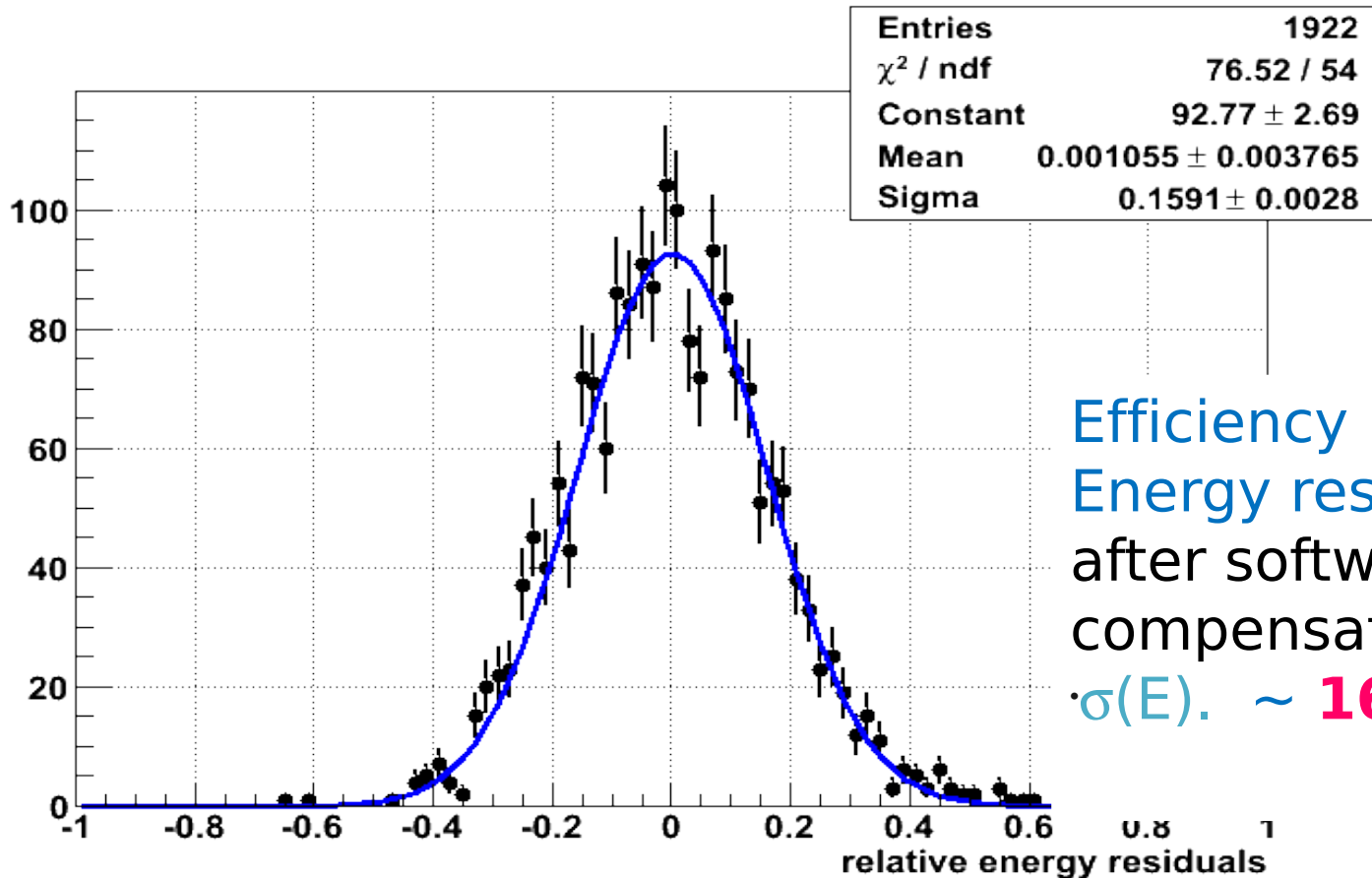
- Scientific requirements:
 - **Homogeneous** and **isotropic** design
 - Highly **segmented** in **3 dimensions**
- Several configurations have been simulated, both with BGO and CsI(Tl) crystals.

Selected configuration:

à **Cubic crystals of CsI(Tl)**



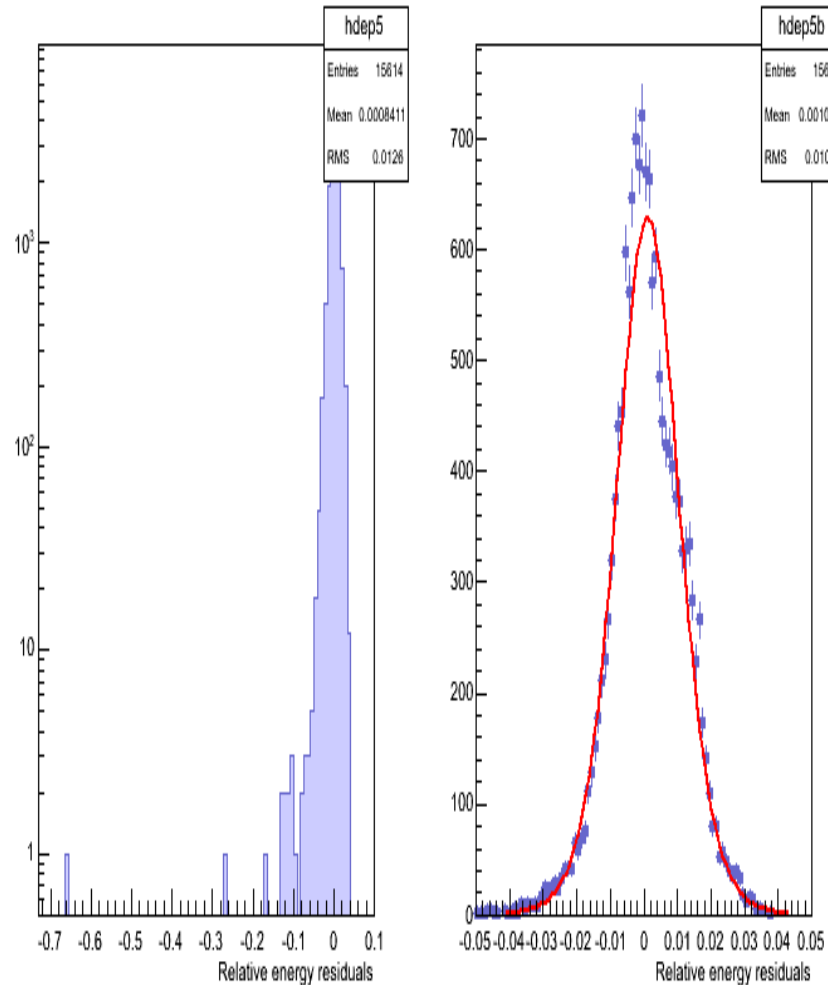
Calorimeter resolution: Protons (1 TeV)



Efficiency \sim **44%**
Energy resolution
after software
compensation:
 $\sigma(E)$ \sim **16%**

Calorimeter resolution: Photons (100 GeV)

Gamma rays traversing the top detectors (AC) and the top calorimeter surface, with contained shower maximum



Energy resolution:

- RMS ~ **1.26%**
- $\sigma(E)$ ~ **0.87%**

Gamma-400: next steps

Presentation at the July 23rd CSN2 meeting on the progresses on the design of the modified apparatus and on the scientific capabilities;
Preparation of a paper on the proposed instrument (in progress);
Preparation of a first draft of the Gamma-400 Technical Design Report (in progress).

Gamma-400-RD

Responsabile Nazionale: A. Vacchi

Responsabile locale: P.W. Cattaneo

Sezioni partecipanti: FI, PI, PV, RM2, TS

Partecipanti e FTE:

Paolo W. Cattaneo (I Ric) 40

Andrea Rappoldi (I Tec) 40

Heads: 2, FTE: 0.8

Richieste

MI 2 k€ (riunioni di collaborazione)

ME 6 k€ (riunioni e contatti con i russi,
test su fascio dei prototipi)

Cons. 5 k€ (metabolismo,
materiale per realizzazione prototip)

Inv. 5 k€ (macchine calcolo per MC)

Tot. 18 k€

Servizi: ??.