THE POSSIBILITIES OF SIMULTANEOUS DETECTION OF GAMMA RAYS, COSMIC-RAY ELECTRONS AND POSITRONS ON THE GAMMA-400 SPACE OBSERVATORY

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for the GAMMA-400 collaboration

The GAMMA-400 collaboration

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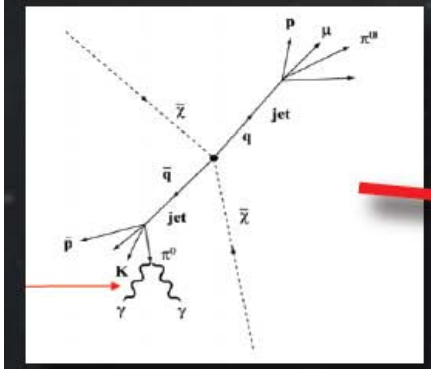
Main problems of the high-energy gamma-ray astronomy ($E\gamma > 100$ MeV)

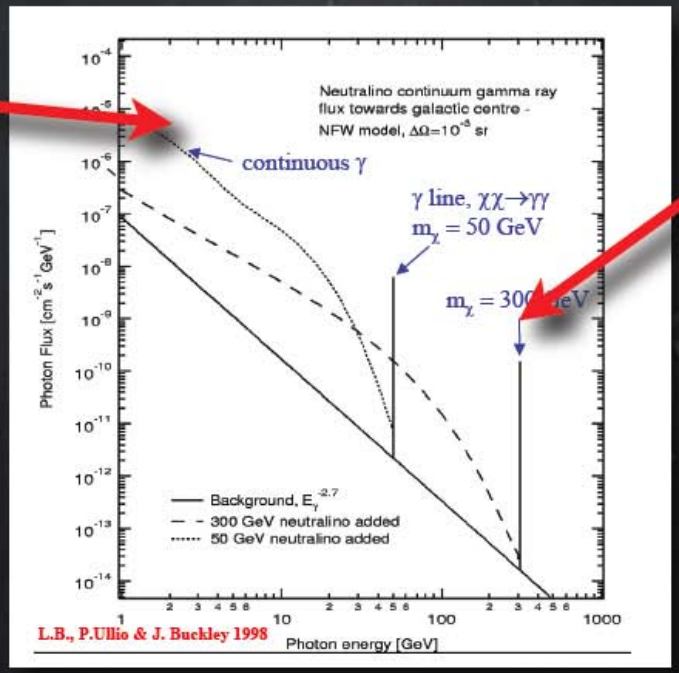
- Study of the nature of high-energy particle generation processes occurred in **discrete** extragalactic and galactic sources, including the Sun, connected with the appearance of high-energy gamma-ray fluxes.
- Measurements of energy spectra of galactic and extragalactic **diffuse** gamma-radiation. Search for spectral anomalies.
- Study of the nature of **dark matter** particles by their annihilation and decay, which are accompanied by the appearance of high-energy gamma-ray, electron, and positron fluxes.

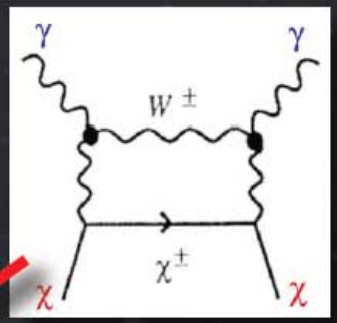
Dark matter

- In regions of the highest dark matter density, dark matter particles and their antiparticles are expected to annihilate into gamma-rays, either directly into a gamma-ray line (with energy equal to the mass of the dark matter particle times the speed of light squared $E_\gamma = m_\chi c^2$) or a broad spectrum of gamma-rays.



(Bergstrom 2006)

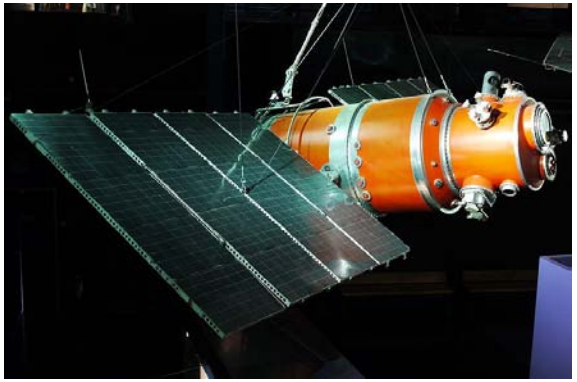




(Jungman and Kamionkowski, 1994)

High-energy gamma-ray space telescopes

historical part

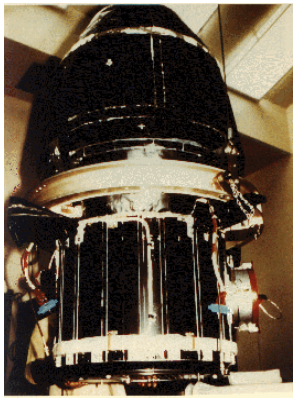


ANNA-3

(KOSMOS - 251, 264)

1968, 1969

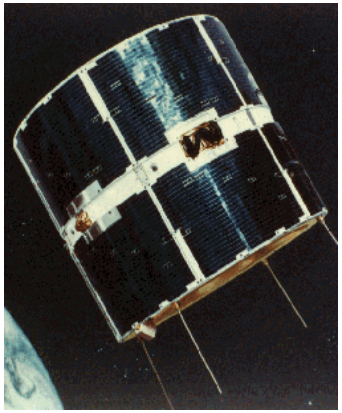
200 **M**eV – 1 GeV



SAS-2

1972 – 1973

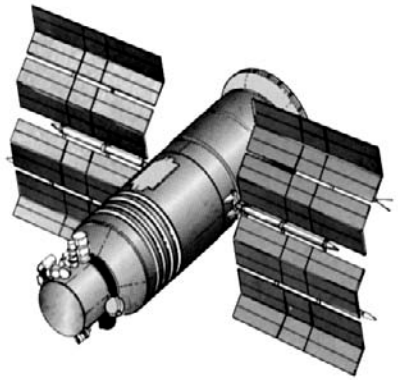
20 Mev – 1 GeV



COS-B

1975 – 1982

30 MeV – 5 GeV

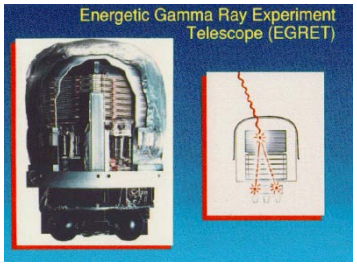


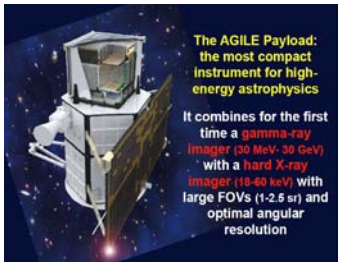
GAMMA-1

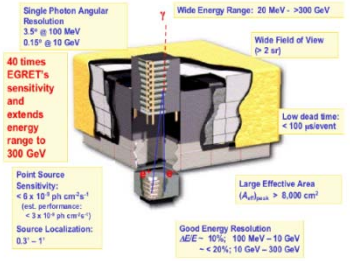
1990 – 1992

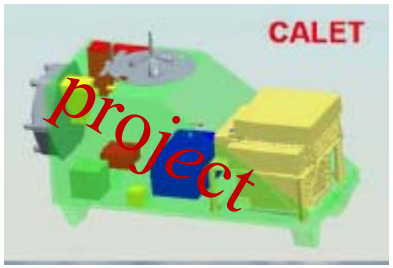
30 MeV – 5 GeV

High-energy gamma-ray space telescopes









EGRET	AGILE	FERMI	CALET
1991- 1998	2007 – 2010	2008	2013
30 MeV - 30 GeV	100 MeV – 50 GeV	100 MeV – 100 GeV	10 GeV – 10 TeV
Third EGRET Catalog	**First AGILE Catalog**	**First Fermi Source Catalog**	
271 discrete sources, 170 unidentified sources	47 discrete sources, 8 unidentified sources	1451 discrete sources, 630 unidentified sources	

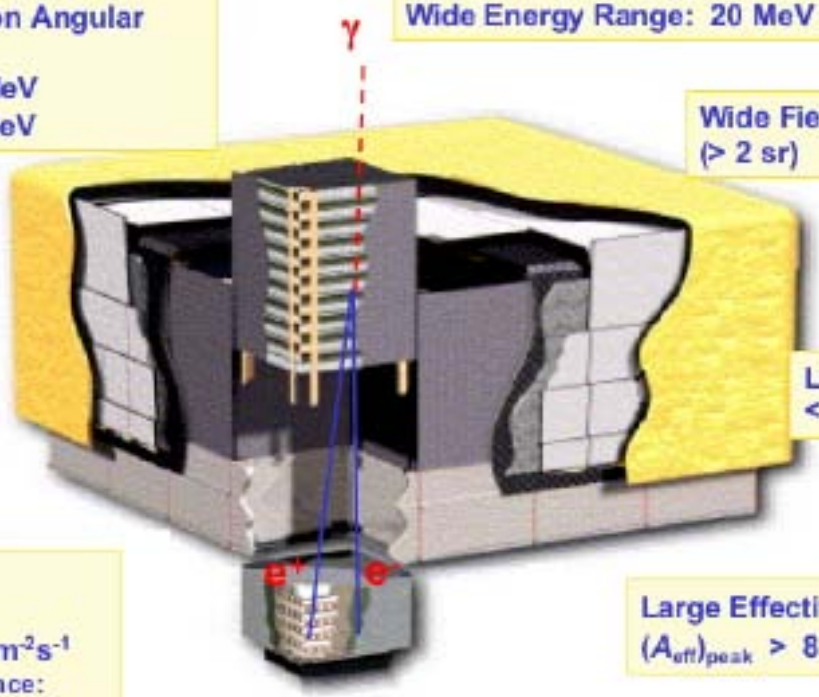
Launch data	June 11, 2008
Orbit	565 km
Inclination	25.6 °

Single Photon Angular Resolution
3.5° @ 100 MeV
0.15° @ 10 GeV

Wide Energy Range: 20 MeV - >300 GeV

Wide Field of View (> 2 sr)

40 times EGRET's sensitivity and extends energy range to 300 GeV



Low dead time: < 100 μs/event

Point Source Sensitivity:
$< 6 \times 10^{-9}$ ph cm^{-2}s^{-1}
(est. performance: $< 3 \times 10^{-9}$ ph cm^{-2}s^{-1})

Source Localization:
0.3' – 1'

Large Effective Area
$(A_{eff})_{peak} > 8{,}000$ cm^2

Good Energy Resolution
$\Delta E/E \sim$ 10%; 100 MeV – 10 GeV
~ < 20%; 10 GeV – 300 GeV

FERMI LAT 1FGL Source Classes

(1451 discrete sources, 630 unidentified sources)

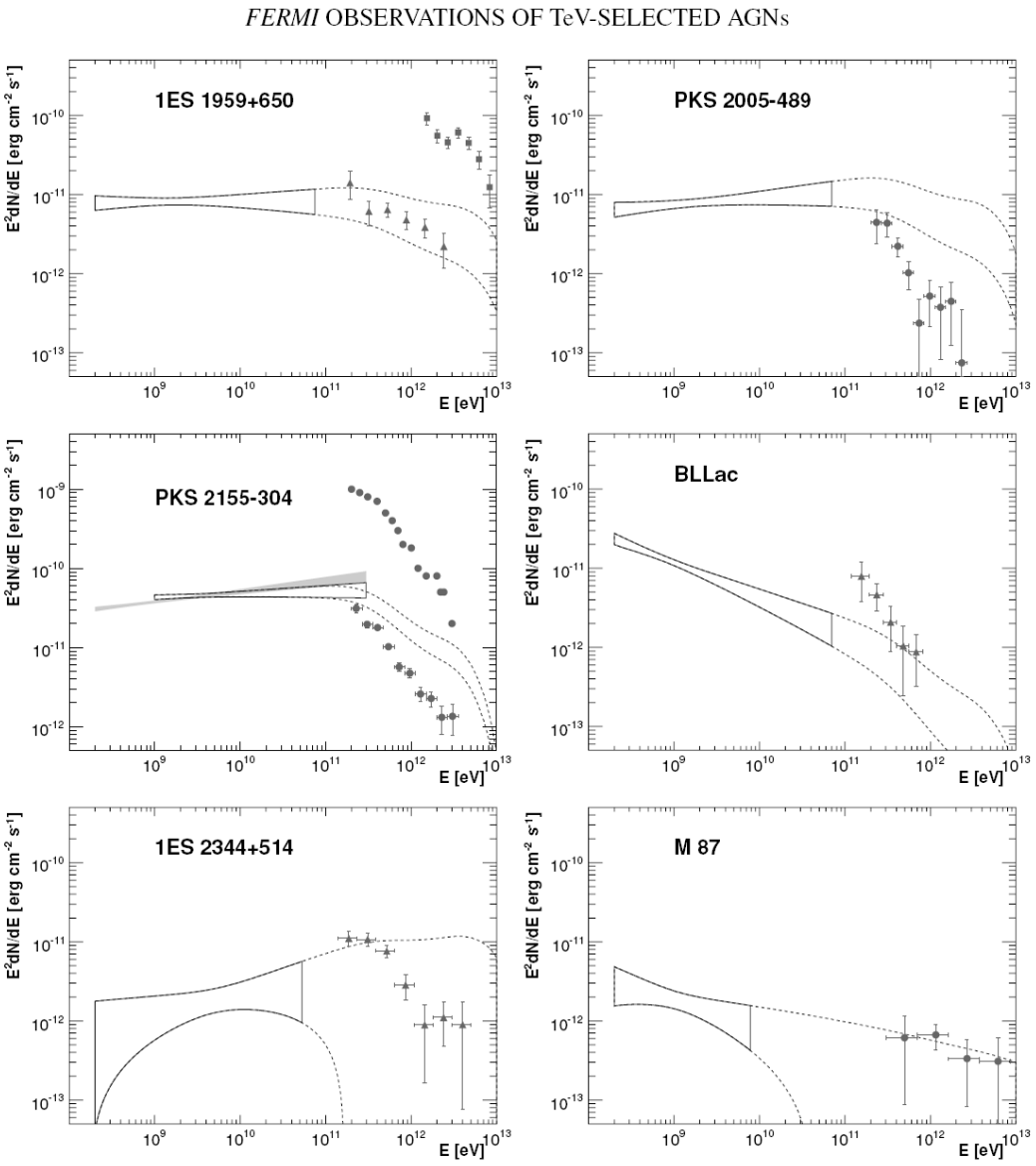
$E\gamma$ = 100 MeV – 100 GeV

Source localization 20´ (0.33º)

Only 107 of EGRET 271 sources coincide with FERMI sources.
(arXiv:1002.2280v1 “The First Fermi-LAT catalog”).

Description	Designator	Number Assoc.
Pulsar, X-ray or radio, identified by pulsations	psr (PSR)	7 (56)*
Pulsar, radio quiet (LAT PSR, subset of above)	PSR	24
Pulsar wind nebula	pwn (PWN)	2
Supernova remnant	(SNR)	41
Globular Cluster	glc (GLC)	8
BL Lac type of blazar	bzb (BZB)	295
FSRQ type of blazar	bzq (BZQ)	274
Non-blazar active galaxy	agn (AGN)	28
Active galaxy of uncertain type	agu (AGU)	92
Normal galaxy	gal (GAL)	6
Starburst galaxy	sbg (SBG)	2

* Number of unidentified pulsars



Energy spectra of TeV-selected AGNs by FERMI and ground-based gamma-ray telescope observations (ApJ, 707 (2009), 1310-1333).

To explain many new problems occurred after the EGRET, AGILE, FERMI observations it is necessary to:

1. Extend the energy range up to 3000 GeV (to explain space-based and ground-based observation data).
2. Improve angular resolution up to ~0.01° (to identify discrete sources).
3. Improve energy resolution up to ~1% (to reveal features in the energy spectra of gamma rays, electrons, and positrons, which are found to be connected with the dark matter).
4. Increase the efficiency of gamma-ray selection.

GAMMA-400 main goals

1. Continuation of EGRET, AGILE and Fermi observations of variable sources.
2. Identification of gamma-ray sources.
3. Investigation of the fine structure of extended objects (eg, the Magellanic Clouds) .
4. Investigation of Dark Matter by it annihilation and decay, which are accompanied by the appearance of high-energy gamma rays, electrons, and positrons.
5. Study of high-energy electron-positron component.

AC - anticoincidence detectors

Converter

C1- C6 6x 0,14Xo W

CD1 - CD6 6x Si (x,y) strip detectors (pitch 0,1 mm)

CD7 - CD8 Si (x,y) strip detectors (pitch 0,1 mm)

S1, S2 - TOF detectors

TRD - transition radiation detectors

CC1 - imaging calorimeter (9Xo)

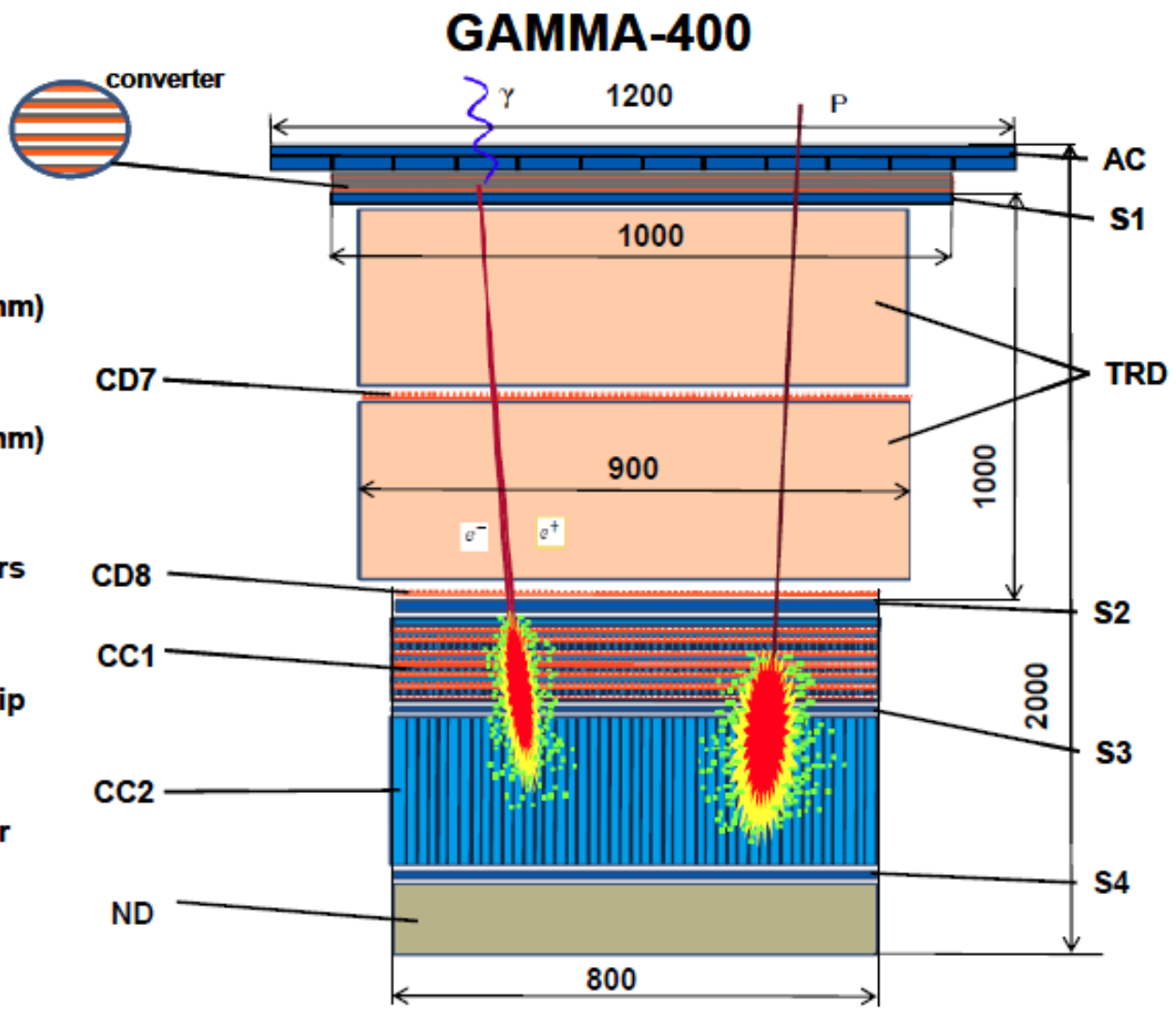
10 layers BGO + Si (x, y) strip detectors (pitch 0,5 mm)

CC2 - electromagnetic calorimeter

BGO (21,5Xo)

S3, S4 - scintillator detectors

ND - neutron detectors

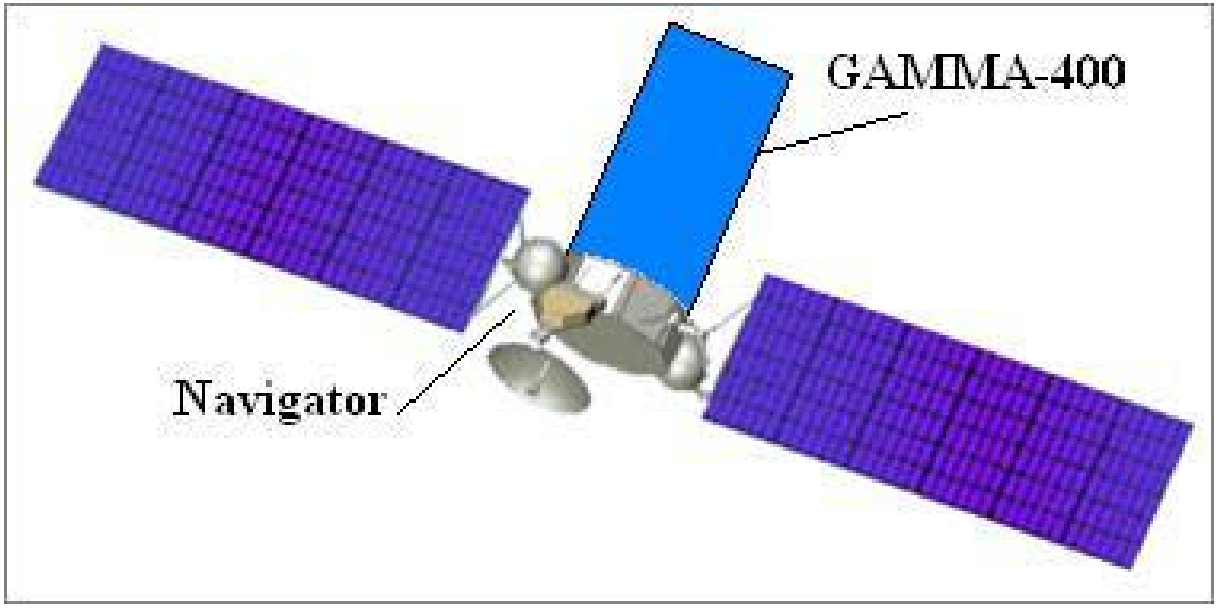


GAMMA-400 Main parameters

Gamma-ray energy range	0.1-3000 GeV
Converter	100 x 100 cm^2 0.84 Xo
Calorimeter	80 x 80 cm^2 ~ 30 Xo
Field of view	± 45°
Angular resolution (Eγ > 100 GeV)	~ 0.01°
Energy resolution (Eγ > 20 GeV)	~ 1%
Proton rejection	10^6
Point source sensitivity, ph/cm^2 s (Eγ > 100 MeV)	~ $5x10^{-9}$
Telemetry downlink	100 GB/day
Power consumption	2000 W
Dimensions	2×2×2.5 $м^3$
Total GAMMA-400 mass	~ 2500 кг
Lifetime	> 5 years
Gamma ray Burst Monitor (KONUS FG)	
Energy range FOV	10 KeV – 10 MeV 4 x 1.5 π 2 x 2π

Comparison of the GAMMA-400 and FERMI-LAT performances

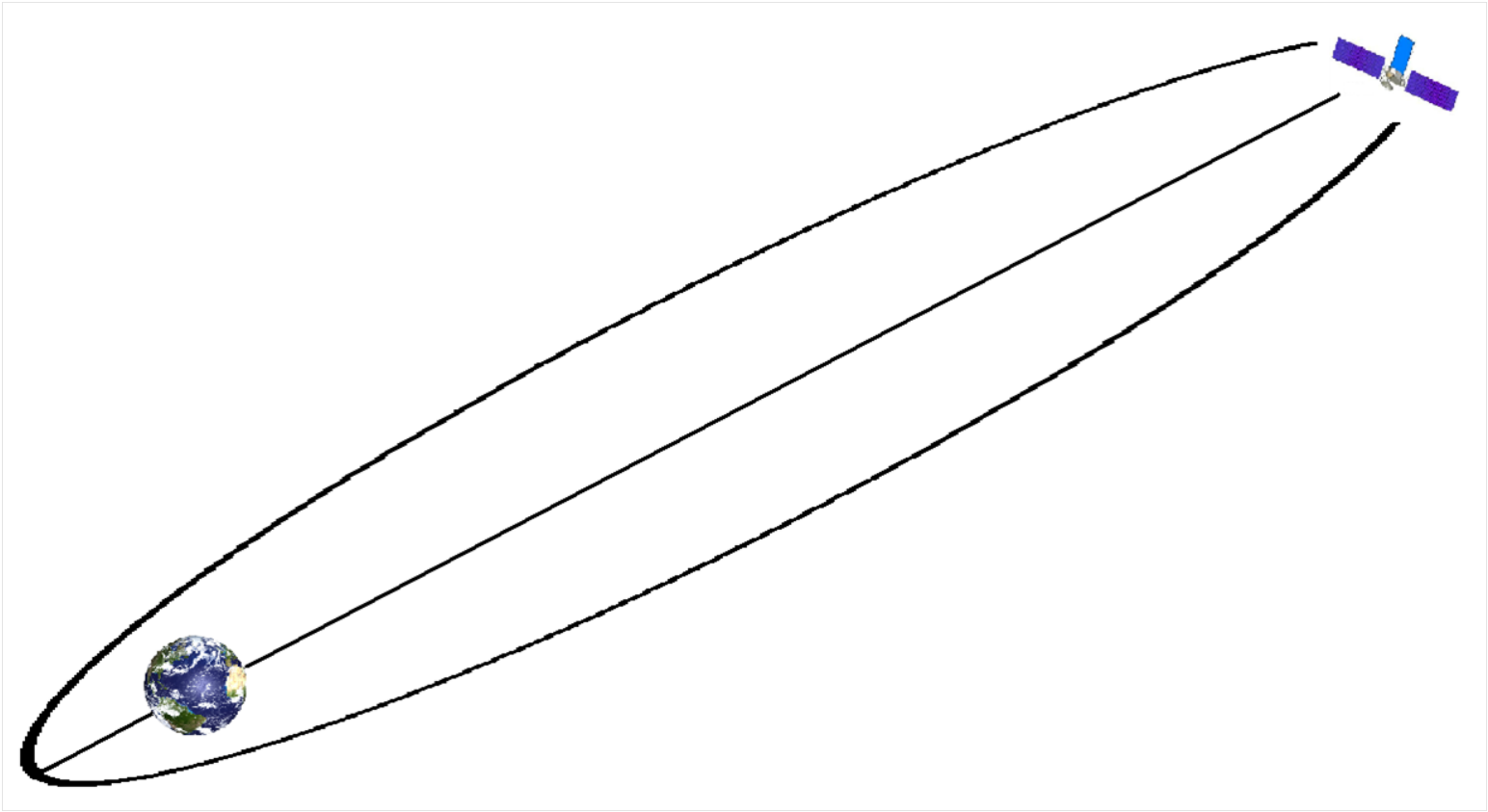
	GAMMA-400	FERMI-LAT
Gamma-ray energy range	**100 MeV - 3000 GeV**	**100 MeV - 100 GeV**
Sensitivity area	**0.64 m^2**	**1.7m^2**
Coordinate detectors	**Si strips with 0.1-mm pitch**	**Si strips with 0.22-mm pitch**
Angular resolution (Eγ > 100 GeV)	**~0.01°**	**~0.1°**
Calorimeter - thickness, Xo.	**BGO + Si strips** **30**	**CsI** **8.5**
Energy resolution (Eγ > 20 GeV)	**~1%**	**~10%**
Proton rejection	**10^6**	**10^4**
Point source sensitivity, ph/cm^2 s (Eγ > 100 MeV)	**~5x10^{-9}**	**~5x10^{-9}**
Orbit	**500-300000 km**	**560 km**



Total GAMMA-400 mass	2500 kg
Power consumption	2000 W
Telemetry downlink	100 GB/day
Launch date	2015
Lifetime	> 5 years

The GAMMA-400 space observatory will be installed on the Navigator service module.

GAMMA-400 ORBIT



GAMMA-400 space observatory will be launched by Zenit-2SB rocket into a high-apogee orbit
(apogee 300000 km, perigee 500 km, inclination 51.8°).

Thank you for attention