Russian Academy of Sciences
P.N.Lebedev Physical Institute
LPI

GAMMA-400
SPACE OBSERVATORY

A.M. Galper

for the GAMMA-400 collaboration

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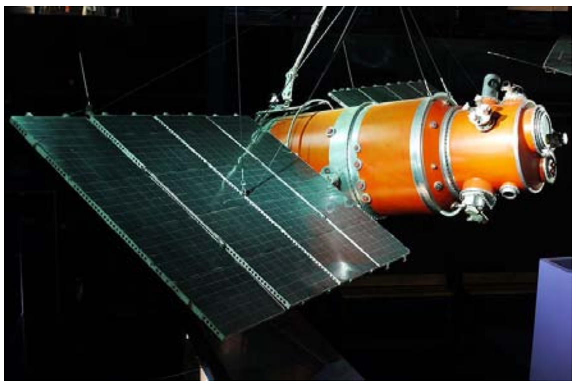
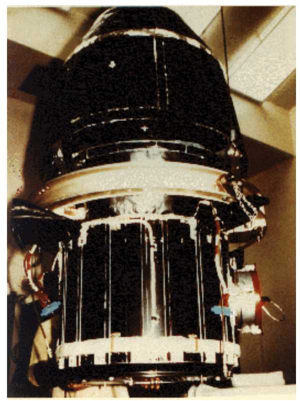
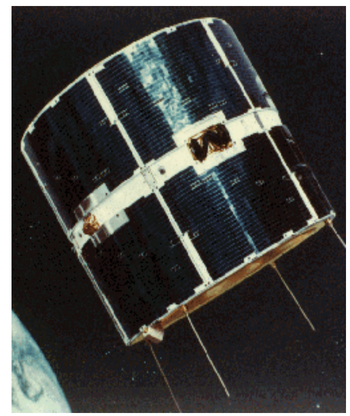
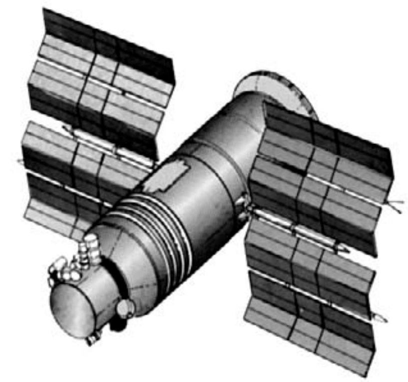
High-energy gamma-ray space telescopes







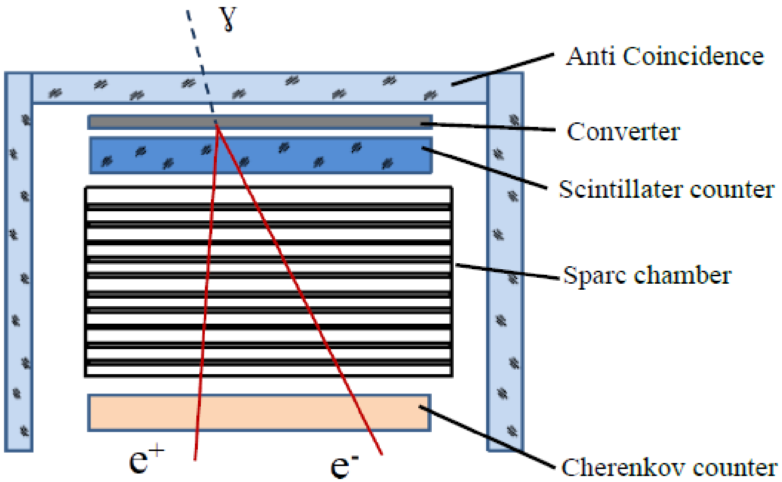


ANNA-3
(KOSMOS - 251, 264)
1968, 1969
200 MeV – 1 GeV

SAS-2
1972 – 1973
20 Mev – 1 GeV

COS-B
1975 – 1982
30 MeV – 5 GeV

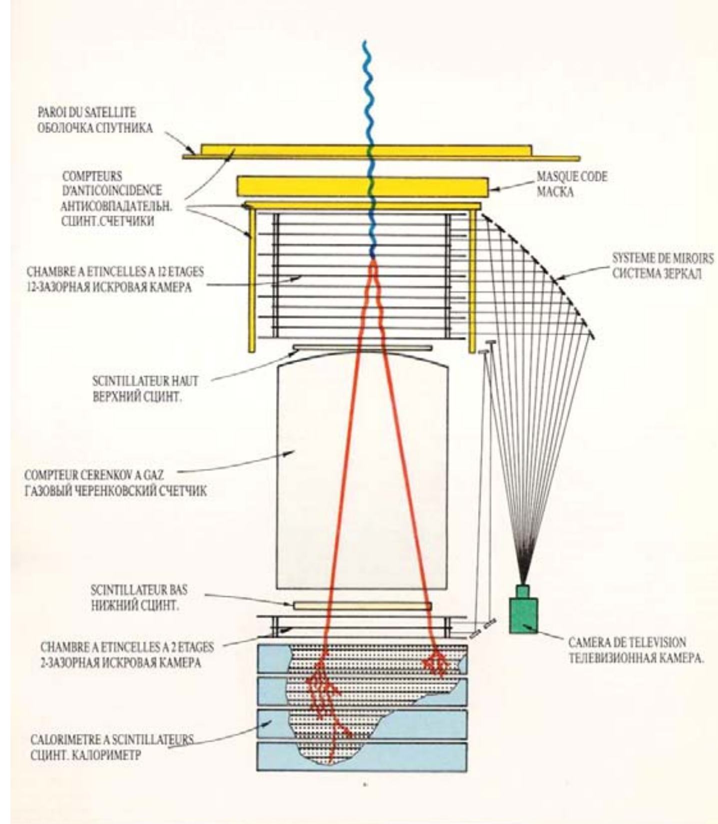
GAMMA-1
1990 – 1992
30 MeV – 5 GeV



ANNA-3
1968-1969, E = 200 MeV – 1 GeV

Scientific results opening flash of gamma radiation from the radio galaxy 3C120 at 100 MeV, the measurement of surface brightness of the cosmic gamma background (upper limit) in energy range

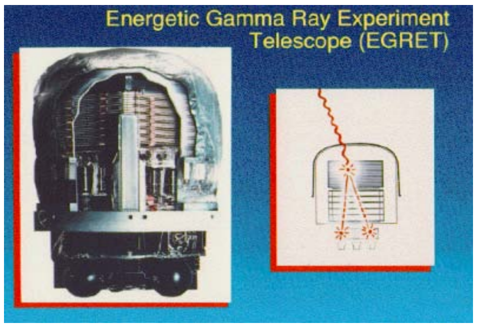
> 100 MeV

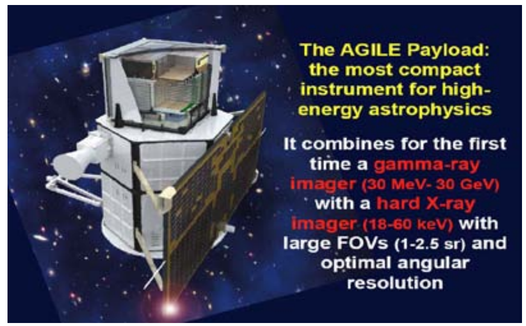


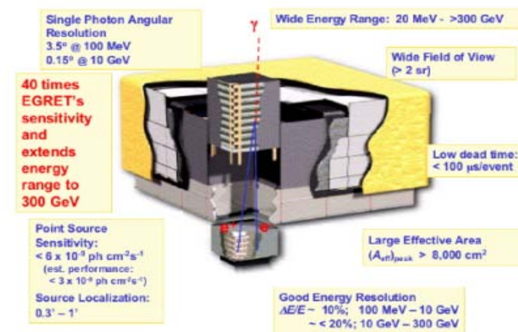
GAMMA-1
1990-1992, E = 30 MeV – 5 GeV

Scientific results: Recorded gamma-emission from the Galactic center, Geminga, Crab, Hercules-X1, Cygnus-X3, Vela. In 1991, during maximum solar activity, GAMMA-1 was recorded high-energy (up to 5 GeV) gamma-emission from solar flares.

High-energy gamma-ray space telescopes







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

Problems

• Around 40% of discrete sources of gamma rays are remained unidentified.

• What causes gamma emission in remnant of Super Novas (RSN) - pulsars or shock waves?

• Discrete sources of gamma emission in Center of Galaxy.

• What is the nature of gamma rays in the Large Magellan Clouds?

• Contradiction between diffusion gamma-ray spectrum of Fermi and EGRET observations.

• Contradiction between ATIC and Fermi observation regarding electron-positron high-energy spectrums.

• Contradiction between Fermi and ground-based gamma-ray telescopes observations for energy more than 100 GeV.

New requirements

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 and electron selection.

AC - anticoincidence detectors

C - multilayer converter

C1- C6 6 x 0,14Xo W

CD1 - CD6 6 x 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

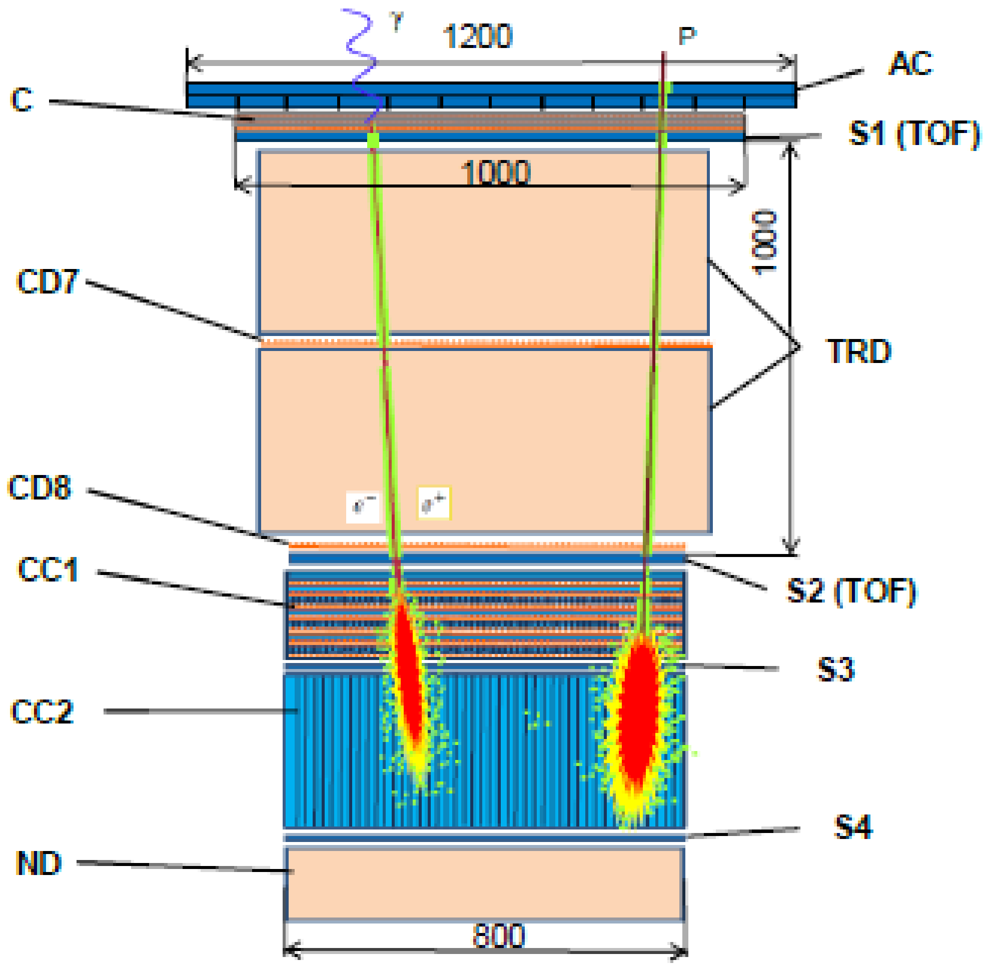
CC1 - imaging calorimeter (9Xo) 10 layers BGO + Si (x, y) strip detectors (pitch 0.5 mm)

CC2 - BGO imaging calorimeter (21.5Xo)

S3, S4 - scintillator detectors

ND - neutron detectors

GAMMA-400



Main GAMMA-400 parameters

Gamma-ray energy range	0.1-3000 GeV
Multilayer converter	100 x 100 cm^2 0.84 Xo
Calorimeter	80 x 80 cm^2 ~ 30 Xo
Angular resolution (100 GeV)	~ 0.01°
Energy resolution (100 GeV)	1%
Proton rejection	10^6

GAMMA-400 additional goals

Calorimeter possibilities:

30 r.l. and 1.5 nucl.l. in vertical axis

70 r.l. and 3.5 nucl.l. in perpendicular axis

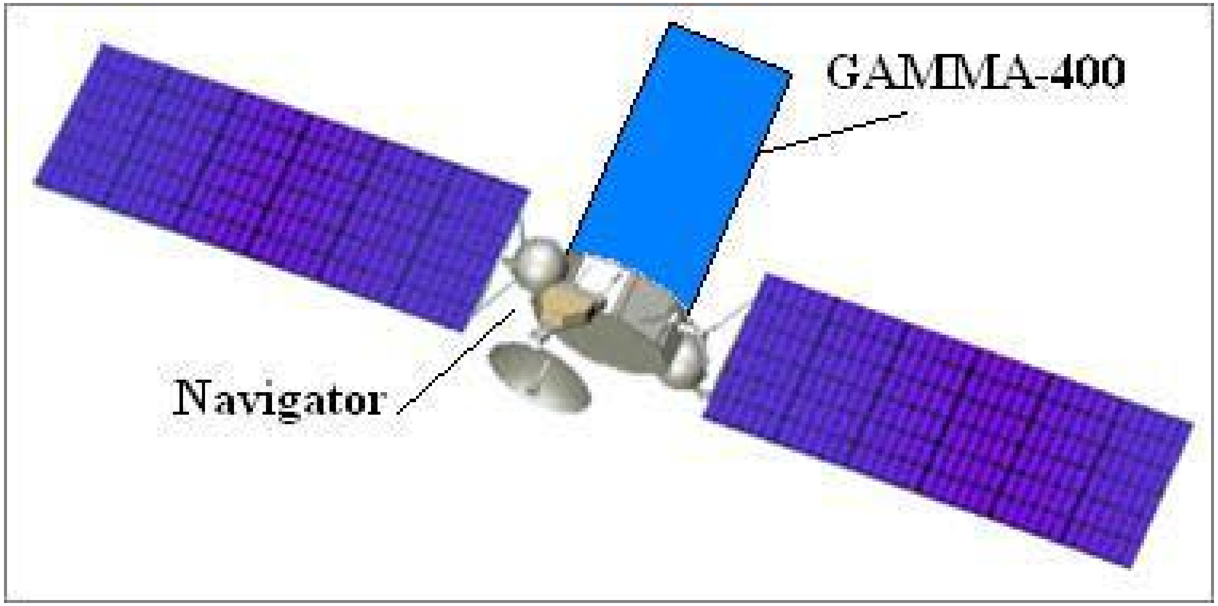
1. Study of high-energy electron-positron component;
2. Study of nuclei component.

COMPARISON OF THE MAIN PERFORMANCES OF GAMMA-RAY TELESCOPES

	DIRECT MEASUREMENTS					INDIRECT MEASUREMENTS		
	SPACED-BASED					GROUND-BASED		
	EGRET	AGILE	FERMI	CALET	**GAMMA -400**	H.E.S.S.-II	MAGIC-II	VERITAS
ENERGY RANGE, GeV	0.03-30	0.03-50	0.1-100	10-10000	**0.1-3000**	> 50	> 50	> 50
ANGULAR RESOLTION, deg (E_γ > 100 GeV)	0.5	0.1	0.1	0.1	**0.01**	0.1	0.1	0.1
ENERGY RESOLUTION, % (E_γ > 100 GeV)	20	50	10	2	**1**	20	15	15

Comparison of the GAMMA-400 and FERMI-LAT performances

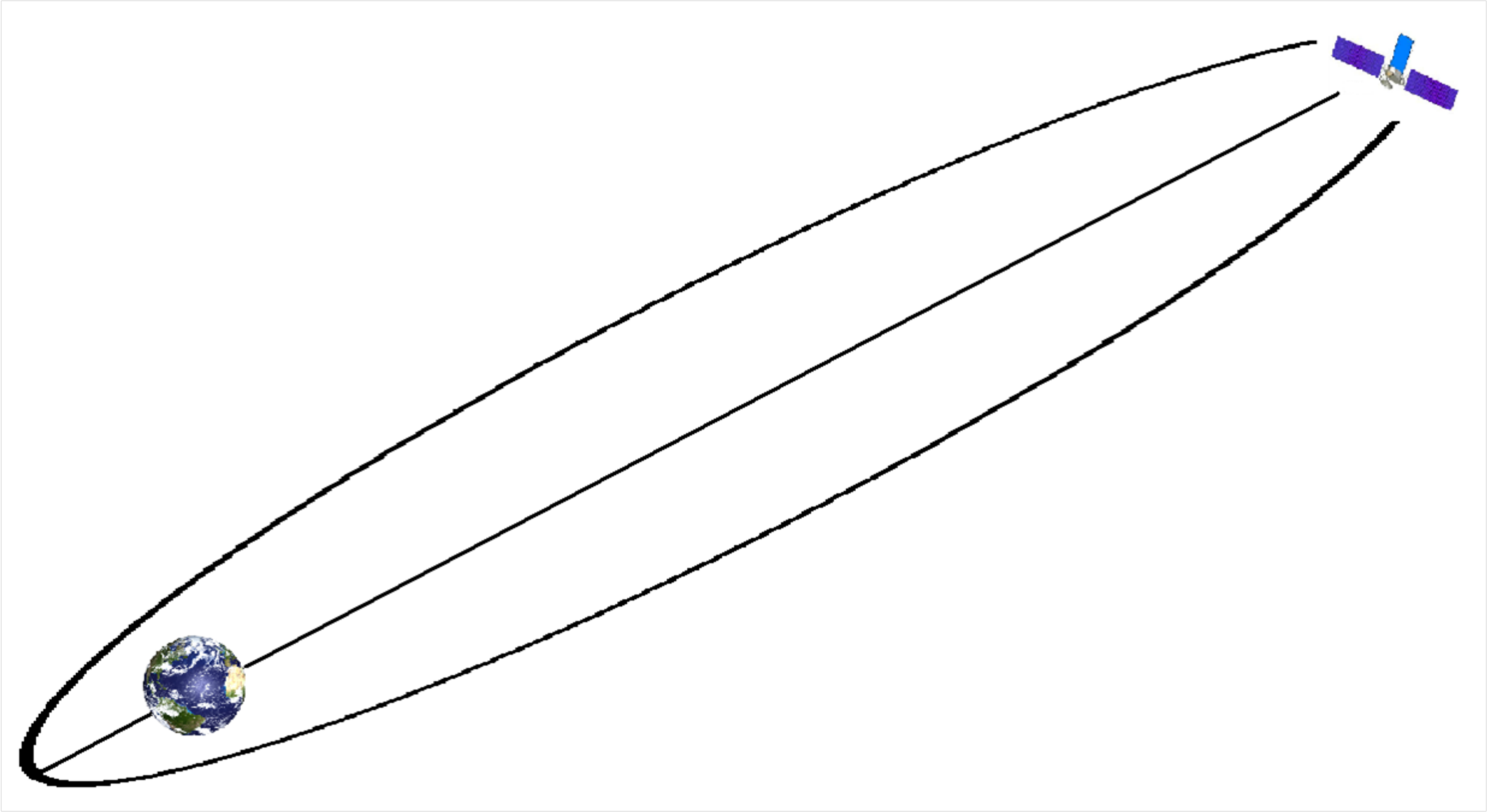
	GAMMA-400	FERMI-LAT
Orbit	**500-300000 km**	**560 km**
Gamma-ray energy range	**0.1 - 3000 GeV**	**0.1 - 100 GeV**
Sensitivity area	**0.64 m^2**	**1.6 m^2**
Angular resolution (Eγ =100 GeV)	**~0.01°**	**~0.1°**
Calorimeter - thickness, r.l.	**BGO + Si strips** **30**	**CsI** **8.5**
Energy resolution (Eγ =100 GeV)	**~1%**	**~10%**
Proton rejection	**10^6**	**10^4**



Total GAMMA-400 mass	2500 kg
Power consumption	2000 W
Telemetry downlink	100 GB/day
Launch date	2016
Lifetime	> 7 years

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

GAMMA-400 ORBIT



GAMMA-400 space observatory with the Navigator service module 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