GAMMA-400 gamma-ray telescope construction features

S.I. Suchkov, A.M. Galper, M.D. Kheymits, A.A. Leonov, N.P. Topchiev, Yu.T. Yurkin et. al

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

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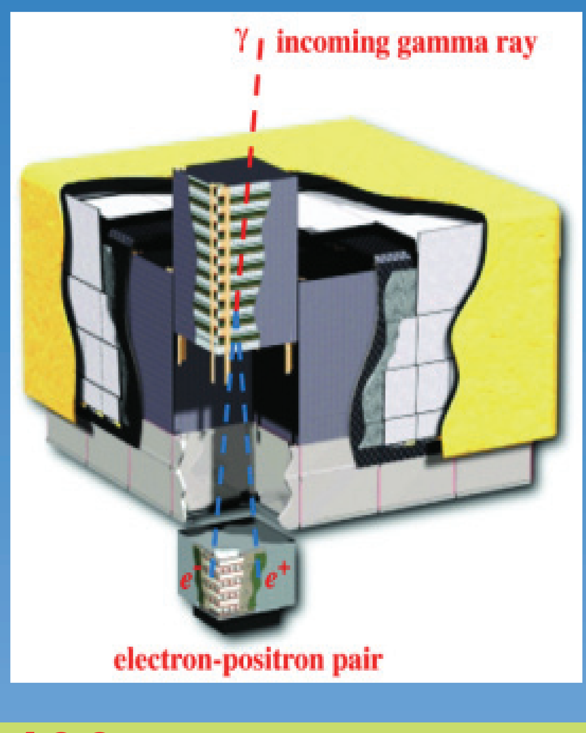
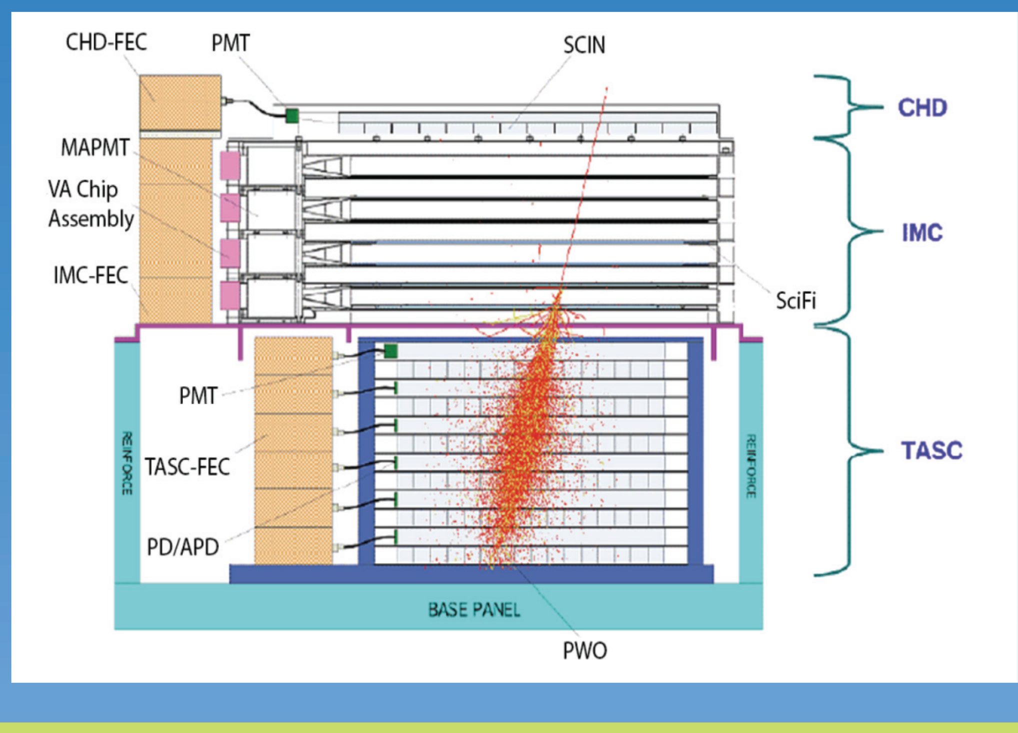
AGILE
2007

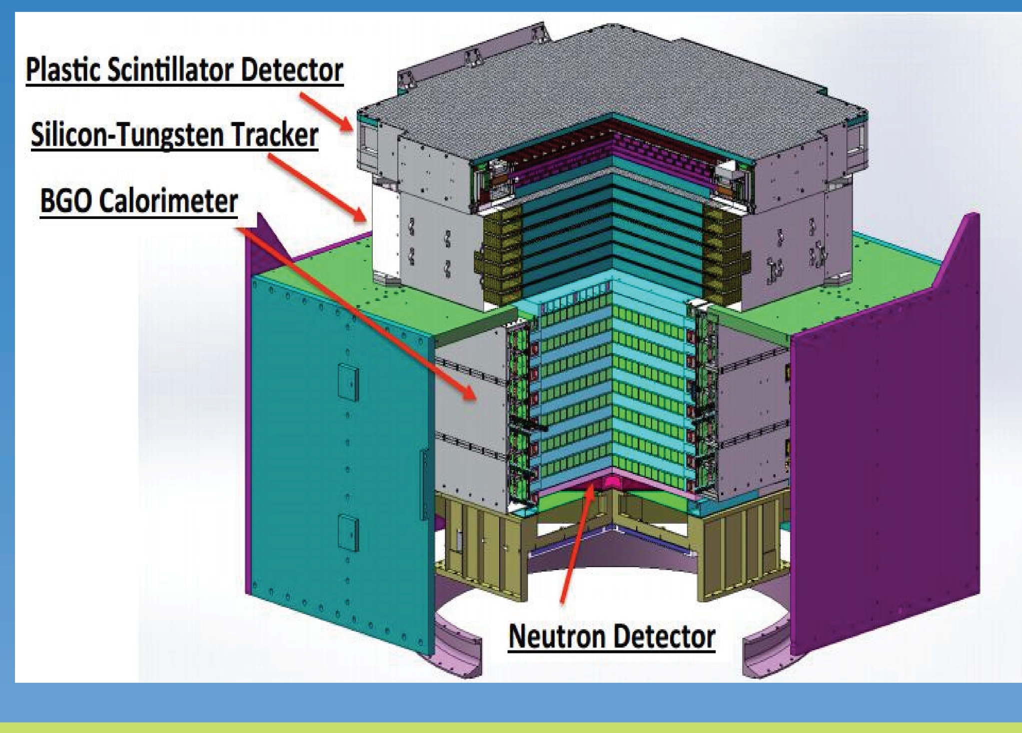
Fermi-LAT
2008
main mode - sky survey



CALET
2015



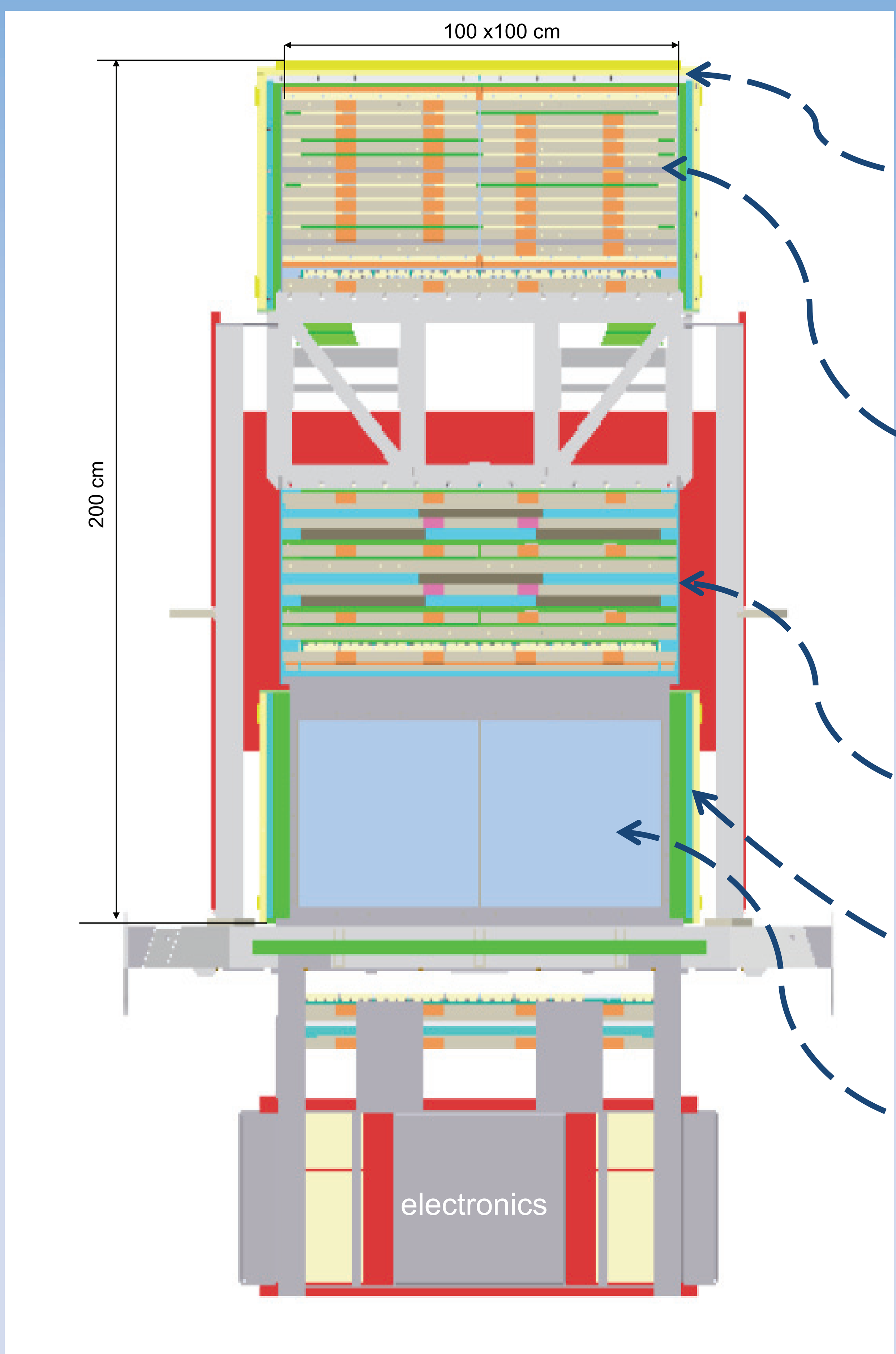
DAMPE
2015

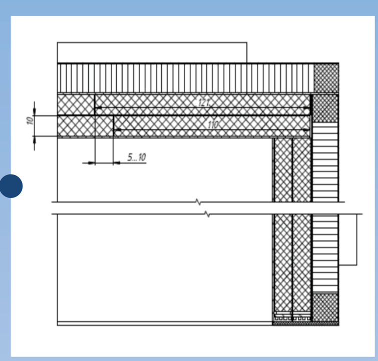


GAMMA-400 gamma-ray telescope main mode is point source (region of interest) observations

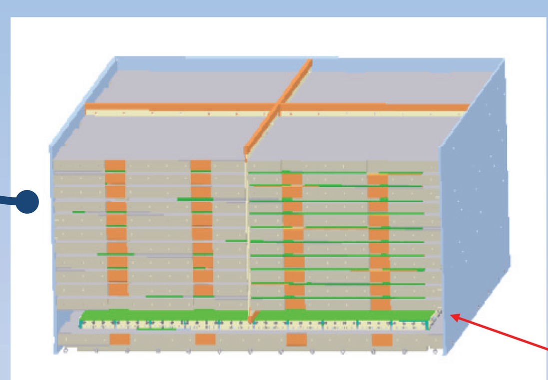
According to the Russian Federal Space Program 2016-2025 GAMMA-400 continues to be funded by Roscosmos and the GAMMA-400 space observatory is scheduled to launch in ~ 2025.
GAMMA-400 is intended for precision measurements of gamma rays in the energy range from 20 MeV to several TeV of discrete sources, especially in the Galactic plane, Galactic Center, etc., measuring the energy spectra of galactic and extragalactic diffuse gamma rays, and gamma-ray lines, which may be associated with the annihilation or decay of dark matter particles. Main parameters of the gamma-ray telescope are: angular resolution is ~0.01° at E_γ =100 GeV; energy resolution is ~1% at E_γ =100 GeV; proton rejection is ~5x10^5.

Main systems



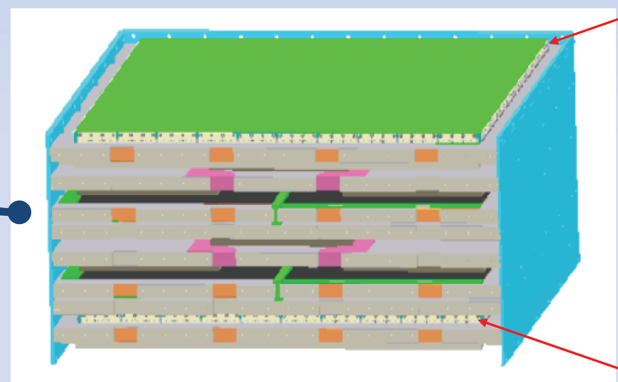


AC anticoincidence
double layer thickness 10×2 mm, overlay 5 –10 mm
Efficiency is 0.999995



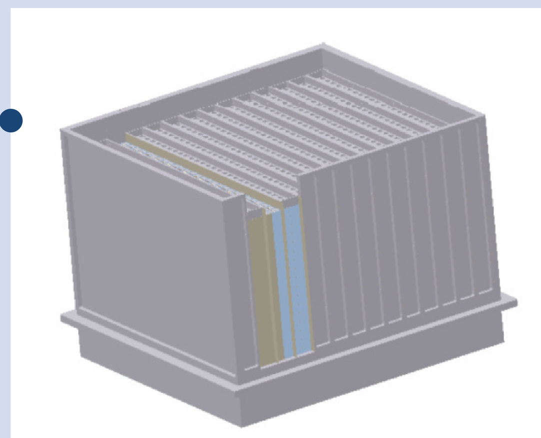
CONVERTER-TRACKER 100X100 cm
- The single-sided SSDs strips with 80 µm pitch,
- 13 pair SSD (X, Y)
- 7 paired layers (W 0.1 radiation lengths)
- 4 paired layers (W 0.02 radiation lengths)
- Last 2 paired layers no W.
- **Analog readout**

TOF time of light
- C1 top counter - two layers of fast plastic scintillators
- C2 bottom counter - two layers of fast plastic scintillators
- distance C1 – C2 500 mm



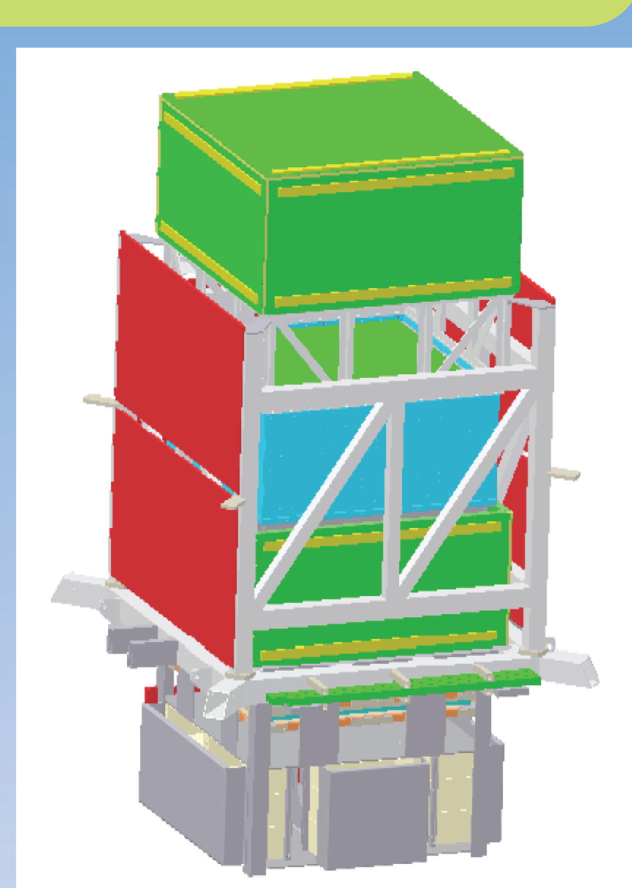
CC1 imaging calorimeter
- Two super layers
- CsI(Tl) 20 mm + Si strip detectors (X,Y SSD, pitch 80 µm)
- 2 radiation lengths

C3 calorimeter trigger counter
two layers of fast plastic scintillators



CC2 electromagnetic calorimeter 100x100 cm
- CsI(Tl) crystals 20 radiation lengths
- The total vertical thickness of the calorimeter CC1+CC2 is **22 radiation lengths**
- e/p rejection is ~5x10^5

C_{lat} calorimeter lateral detectors
two layers of fast plastic scintillators



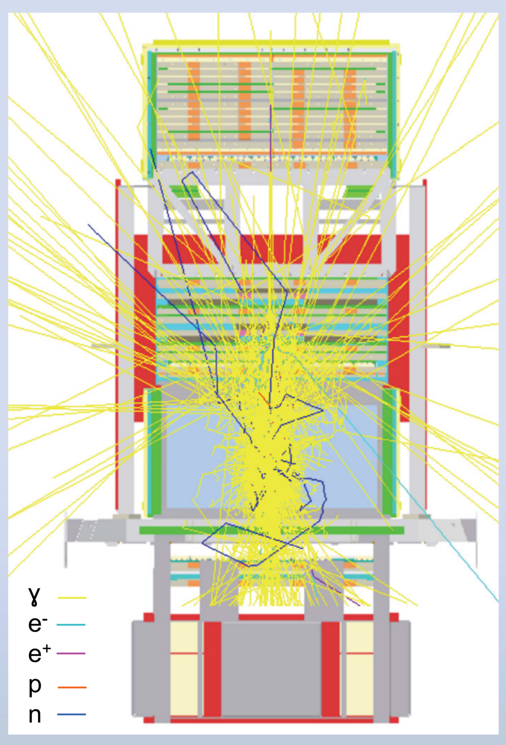
GAMMA-400 more deep calorimeter allows to determine more precisely the shower axis and therefore in the reconstruction of the track to reduce the number of hits strips (noise) and thereby improve the angular resolution (~0.01°)
- improve energy resolution (~1%)
- improve proton rejection (~10^5)
- additional possibilities – observations from lateral direction of the calorimeter

GAMMA-400 trigger system (fast signal)
- TOF
- VETO AC
- S3 (LO or HI)

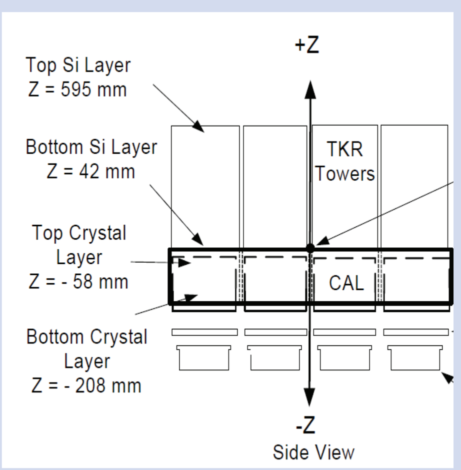
The time between a particle interaction in GAMMA-400 that causes an event trigger and the latching is ~50 ns.

Backsplash influence

Backsplash influence in GAMMA-400 significantly reduced.
Distance from calorimeter crystal CsI to bottom tracker SSD:
GAMMA-400 **110 cm** Fermi-LAT **10 cm**.



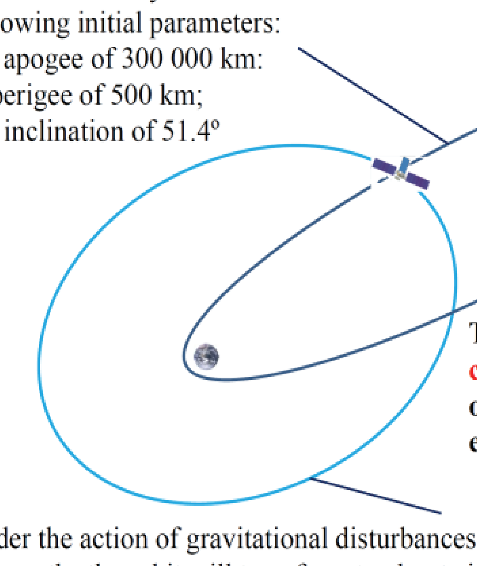
Backsplash at E_γ = 30 GeV



- **GAMMA-400** is further development of gamma-ray telescopes after Fermi-LAT in energy range 20 MeV-10 TeV.
- Allow to measure astrophysical objects with qualitatively new parameters in the high-energy range, the angular resolution is 2-10 times better, energy resolution is 5-10 times better.
- In this range, **GAMMA-400** parameters are also superior being developed ground-base CTA gamma-ray telescope: angular resolution is 10 times better, energy resolution is 5 - 10 times better.
- Allow to search for signatures of decay and annihilation of dark matter particles.

The GAMMA-400 orbit evolution and observation modes

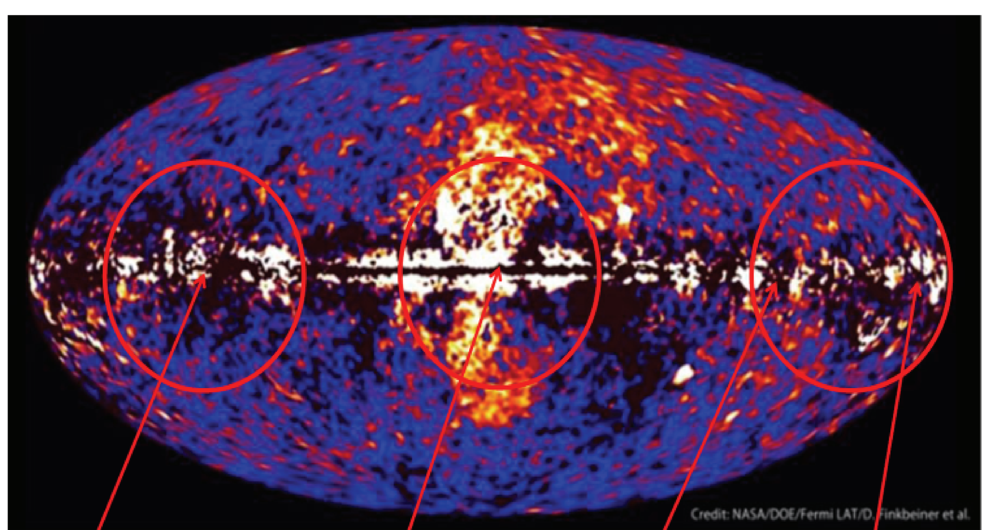
The orbit of the GAMMA-400 space observatory will have the following initial parameters:
-an apogee of 300 000 km:
-a perigee of 500 km;
-an inclination of 51.4°



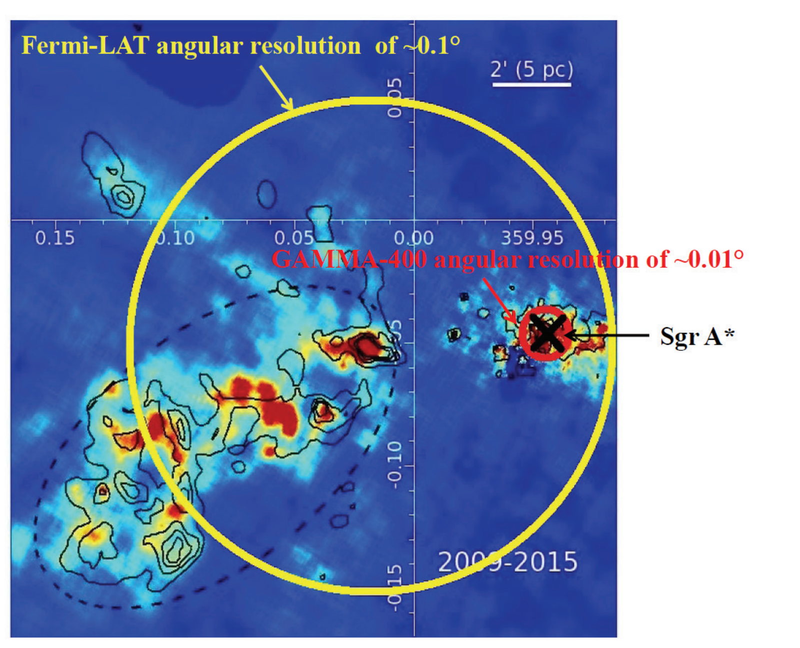
The main observation mode is continuous long-duration (~100 days) observations of the Galactic Center, extended gamma-ray sources, etc.

Under the action of gravitational disturbances of the Sun, Moon, and the Earth after ~6 months the orbit will transform to about circular with a radius of ~200 000 km and will be without the Earth's occultation and out of radiation belts.

Galactic Center, Fermi Bubbles, Crab, Cygnus, Vela, Geminga, and other regions will be observed with the GAMMA-400 aperture of ±45°



Cygnus Galactic Center, Fermi Bubbles Vela Crab, Geminga



Comparison of the capabilities to study Galactic Center by Fermi-LAT with the angular resolution of ~0.1° for E_γ = 100 GeV (yellow circle) and GAMMA-400 with the angular resolution of ~0.01° for E_γ = 100 GeV (red circle), using Chandra X-ray observation. The Sgr A* position is marked by cross.