# International research project GALA:

## Monitoring of high energy gamma-ray astrophysical sources

# Preface

Several hundreds of point high-energy gamma ray astrophysical sources were discovered to date, but more then half of those sources are still not identified.

Taking in to account that gamma-ray emission is associated mainly with active variable objects, the continuous monitoring of celestial sphere using the telescope with high angle and time resolutions allow to identify a noticeable part of known unidentified sources and to discover new high-energy gamma-ray sources.

To realize the continuous monitoring of gamma-ray astrophysical sources it is proposed to develop wide-aperture gamma telescope GALA with high angle resolution in 10-100 MeV energy range and install it as additional payload onboard Meteor-M satellite. Meteor-M is the Russian meteorological low polar orbit satellite designed by Russian Space firm VNIIEM.

# GALA scientific objectives

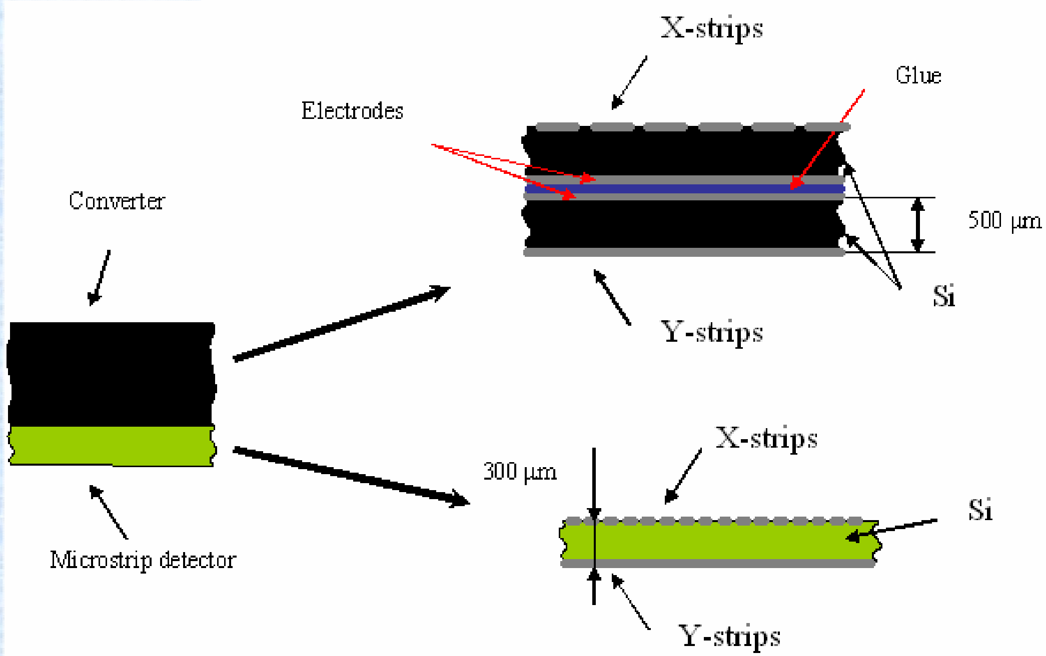
The main task of project GALA is continuous, during several years, monitoring of celestial sphere aimed for:

- Clarification the nature of unidentified point high-energy gamma-ray sources; search of new gamma-transients.
- Study of discovered gamma-ray pulsars; search the pulsed gamma-ray emission from unidentified sources.
- Search of high-energy gamma-radiation from galactic binaries and supernova remnants.
- Investigation of known Active Galactic Nuclei; search new extragalactic high-energy gamma-ray discrete sources.
- Study of diffuse high-energy gamma-ray emission.

The additional scientific goal of GALA project:

Study of cosmic ray isotope fluxes in 20-200 MeV/n energy range in near-Earth space.

# GALA instrument diagram




## Telescope systems:

### 1) Silicon tracker.

**Purpose:**

γ-quantum conversion and $e^+e^-$ pair detection.

**Structure:**

16 detecting planes 400×400 mm each.
Distance between planes – 20 mm.
Each plane consists of two layers.
First layer – active converter SN1-SN16 (Each of these views is the single-sided, AC-coupled, 500 µm thick silicon strip detector with a readout ).
Second layer - double-sided (X, Y), 300 µm thick silicon microstrip detector S1-S16 with readout peach 250 µm).

### 2) Anticoincidence.

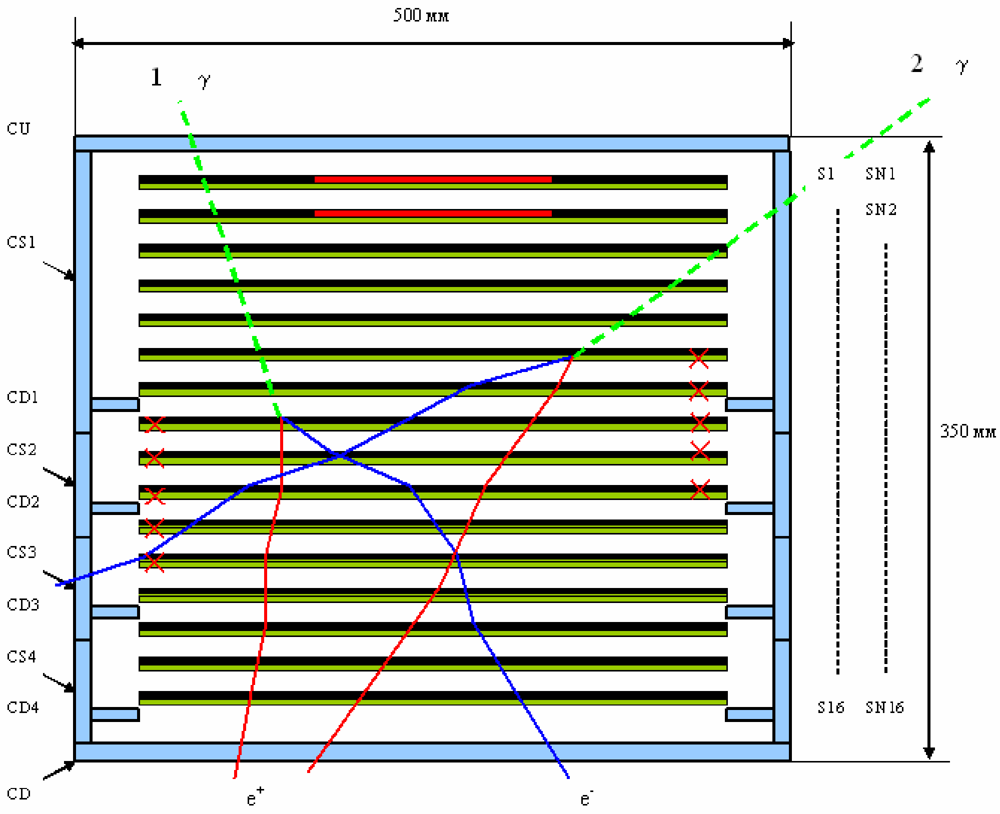
**Purpose:**

Rejection of cosmic ray charged particles.

**Structure:**

CU – the upper anticoincidence detector
CS1-CS4 – side anticoincidence detectors
CD1-CD4, CD – down anticoincidence detectors

# Trigger




## Gamma-ray trigger:

$$M_\gamma = ANTI(CU) \times \sum_{k=1}^{12} M_k \quad \text{, where}$$

$$M_k(k = 1 \div 3) = \prod_{i=k}^{k+4} Si \times ANTI(CS1 + CD1)$$

$$M_k(k = 4 \div 6) = \prod_{i=k}^{k+4} Si \times ANTI\left(\sum_{i=1}^{2} CSi + \sum_{i=1}^{2} CDi\right)$$

$$M_k(k = 7 \div 9) = \prod_{i=k}^{k+4} Si \times ANTI\left(\sum_{i=1}^{3} CSi + \sum_{i=1}^{3} CDi\right)$$

$$M_k(k = 10 \div 12) = \prod_{i=k}^{k+4} Si \times ANTI\left(\sum_{i=1}^{4} CSi + \sum_{i=1}^{4} CDi\right)$$

## Isotope trigger:

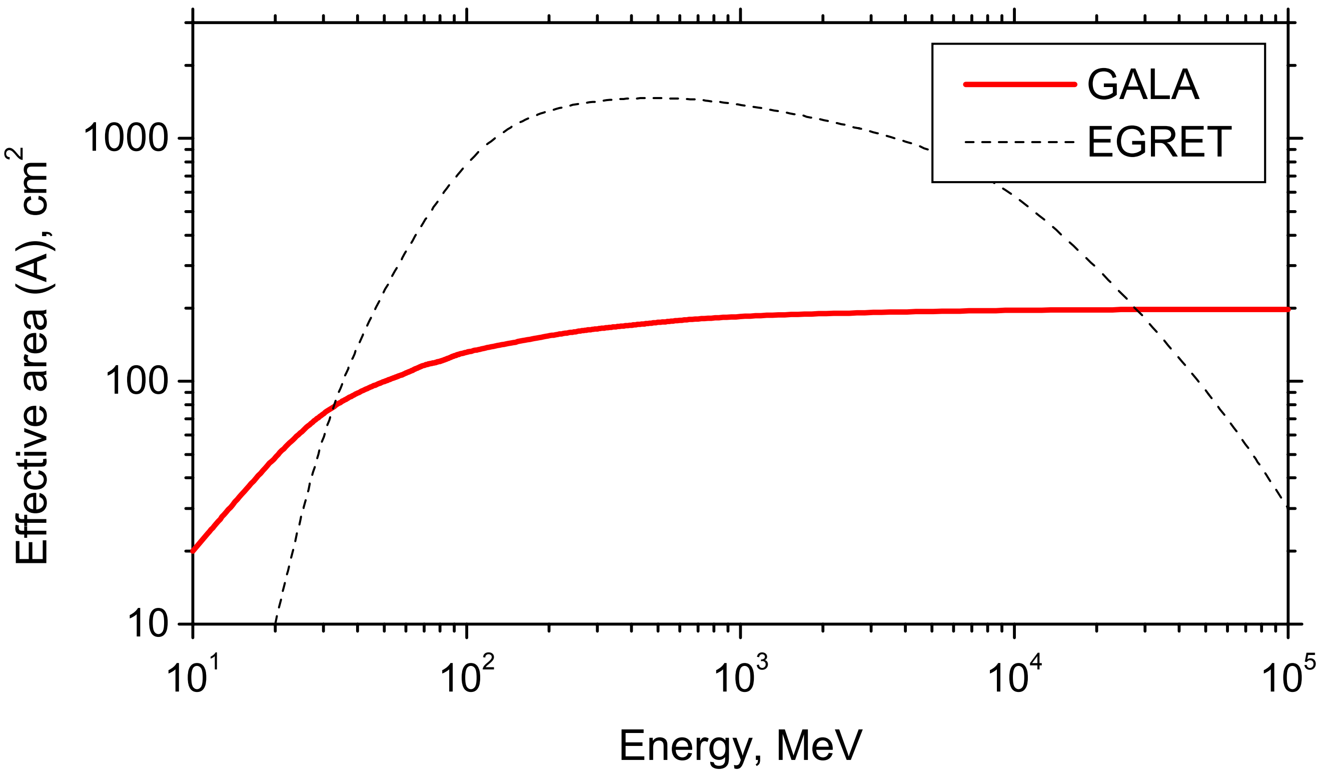
$$M_N = SNc1 \times SNc2 \times AC$$

$$AC = ANTI\left(\sum_{i=1}^{4} CSi + \sum_{i=1}^{4} CDi + CD\right)$$

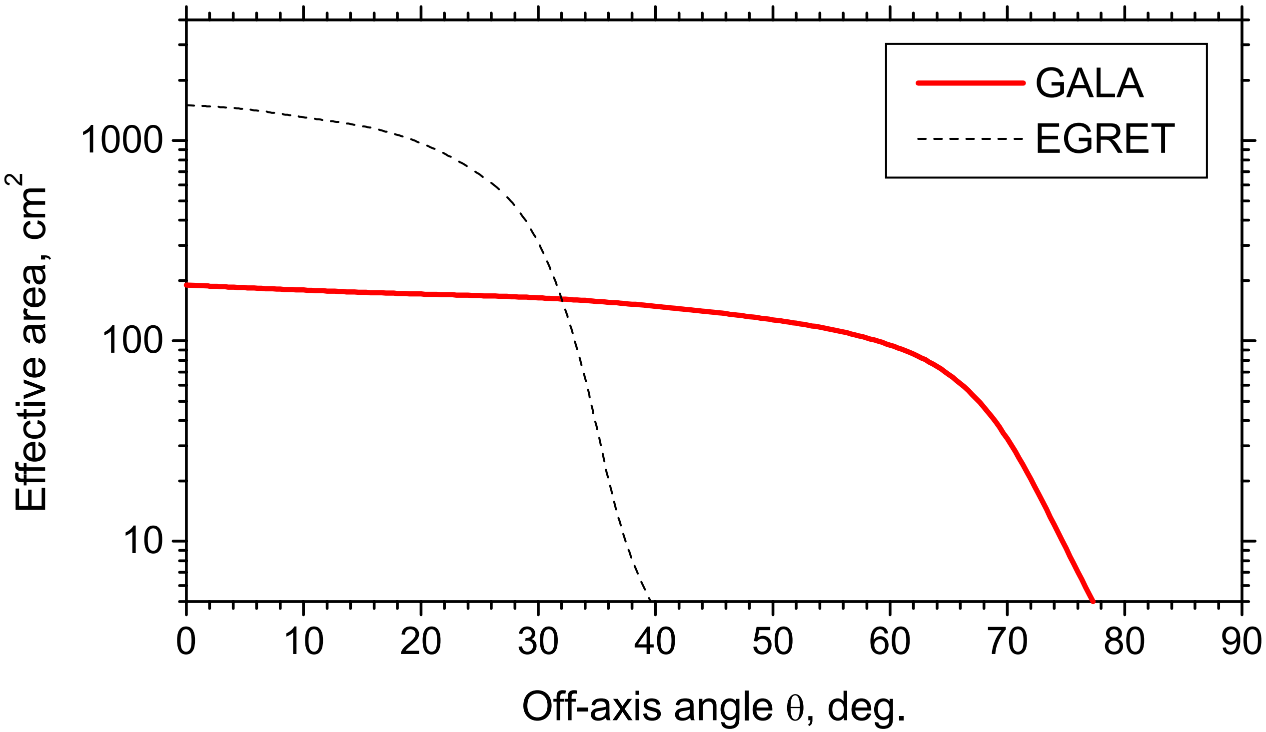
# Main physical characteristics

| Characteristics | EGRET | GALA |
|---|---|---|
| Energy range | 30 MeV - 30 GeV | >10 MeV |
| Field of view | 0.5 sr | 3 sr |
| Angle resolution | ~15° (30 MeV)<br>5.5° (100 MeV)<br>1.2° (1 GeV) | 4.9° (30 MeV)<br>1.6° (100 MeV)<br>0.3° (1 GeV) |
| Sensitive area | 1500 $cm^2$ | 200 $cm^2$ |
| Energy resolution | 10% | 30% (10-100 MeV) |
| Dead time | >100 ms | <1 ms |

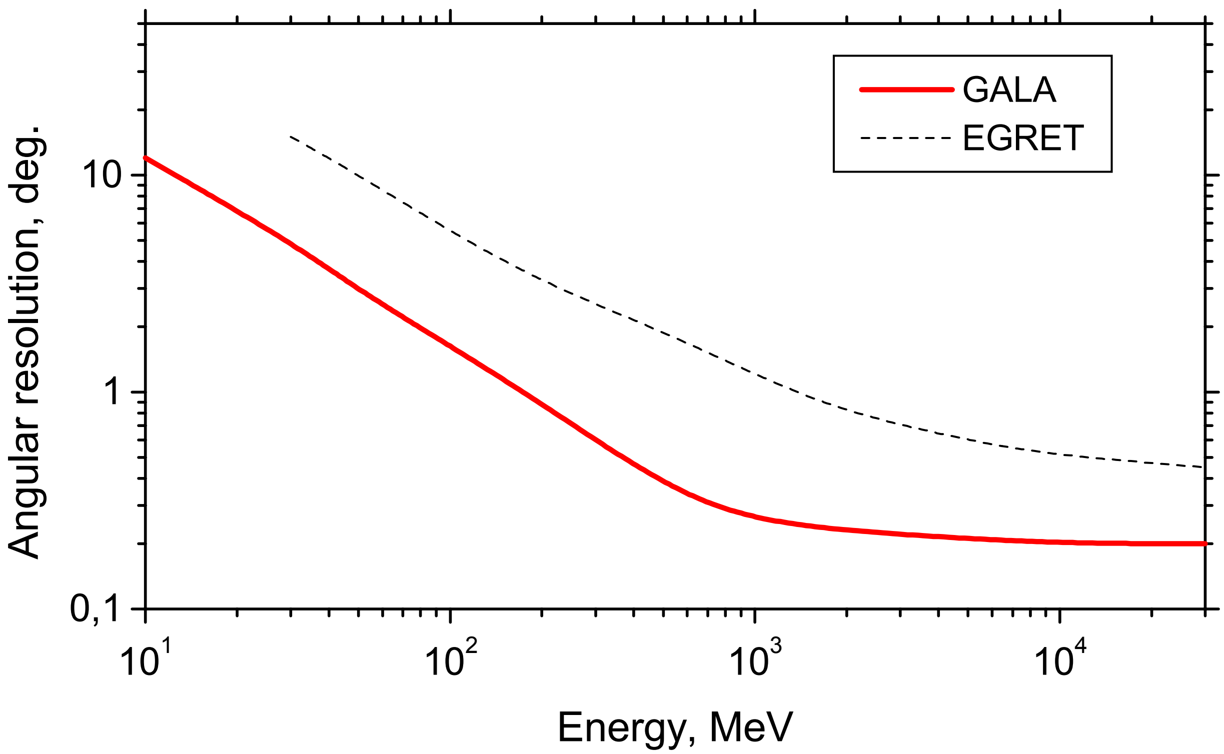
# Effective area



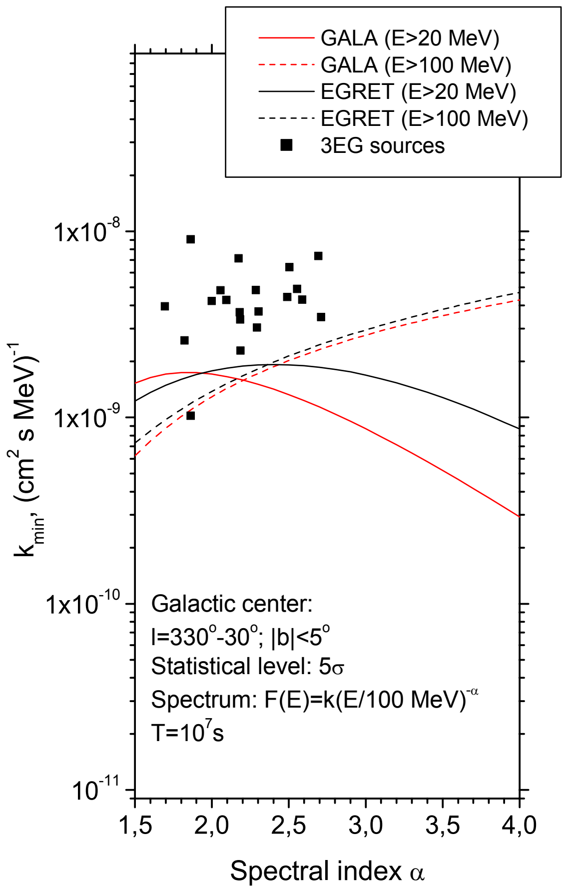
# Field of view

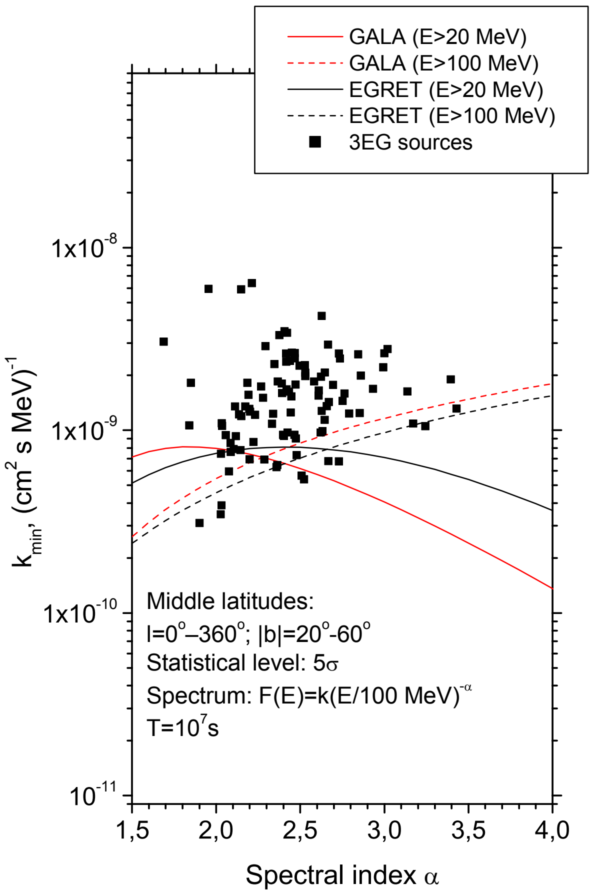


# Angular resolution



# Sensitivity to point sources

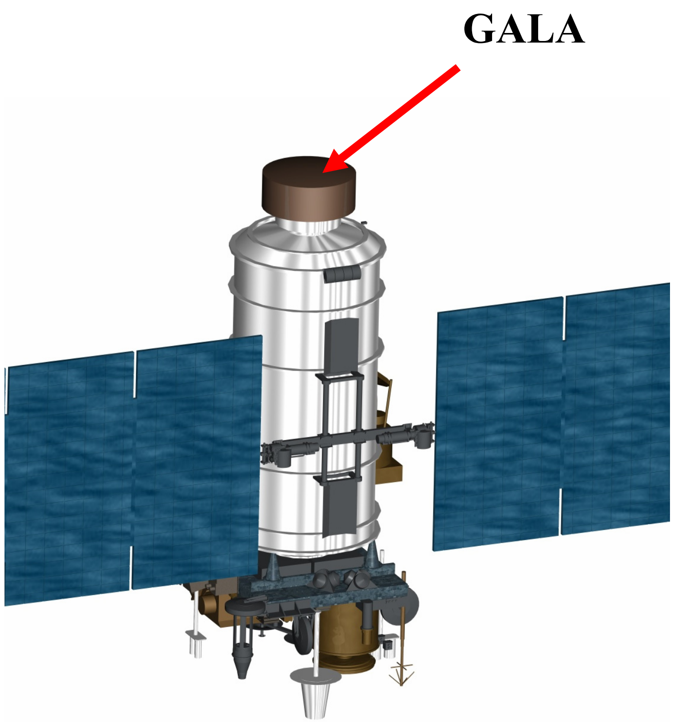


# Meteor-M satellite

## Main characteristics

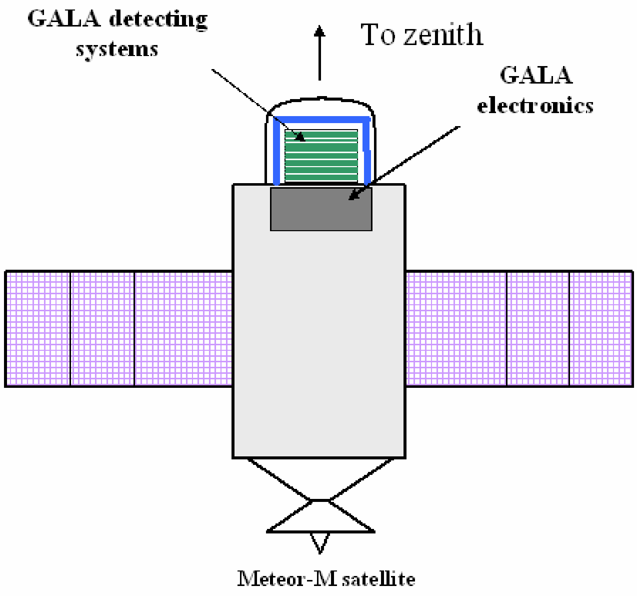
| | |
|---|---|
| Orbit | Circular, sun-synchronous |
| Altitude | 835 km |
| Inclination | 98.68° |
| Pointing configuration | Orbital |
| Pointing accuracy | 0.1° |
| Positioning | Better then 30 m |
| Accuracy of onboard time synchronization with UT | 2 μs |
| Satellite mass | 800 kg |
| Payload mass | 320 kg |
| Power | 1.4 kW |
| Telemetry | 122 Mbit/s |
| Satellite lifetime | More then 5 years |



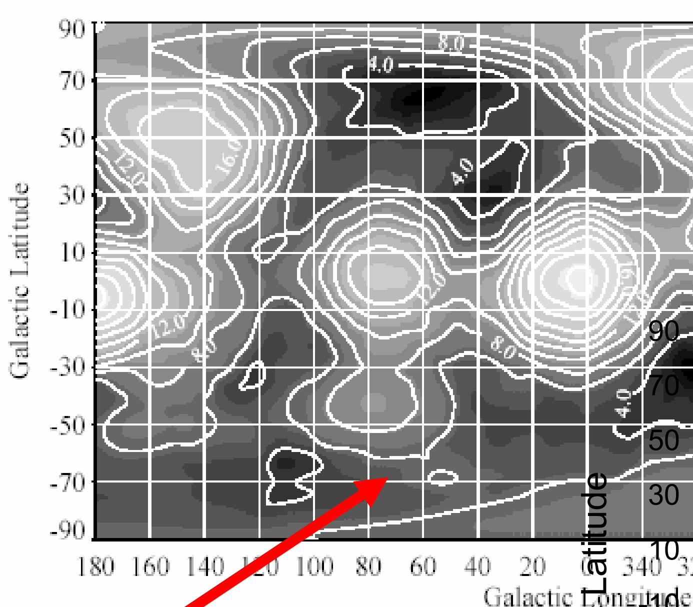
# Telescope GALA onboard Meteor-M

## GALA technical characteristics

| | |
|---|---|
| GALA overall dimensions | 600×600×600 mm |
| Instrument  mass | ~100 kg |
| Power consumption | ~150 W |
| Mass memory | 2 Gbytes |
| Required pointing accuracy | 0.1° |
| Required accuracy of onboard time synchronization with UT | Better then 10 μs |



# Comparison between EGRET and GALA exposures



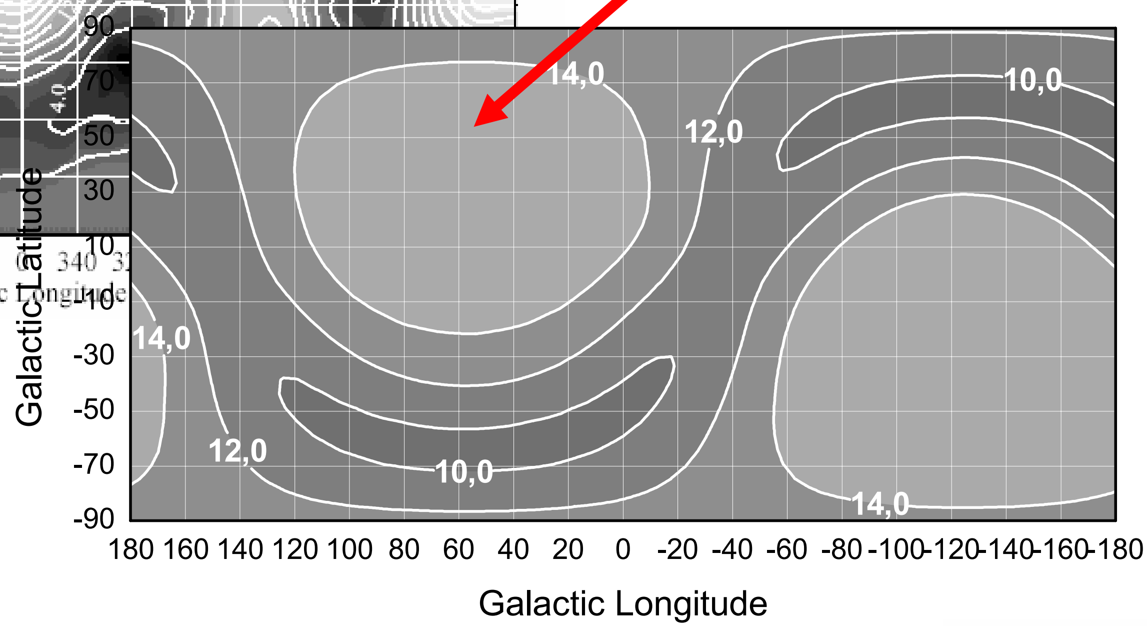

**EGRET**

**Cycles: 1, 2, 3, 4**

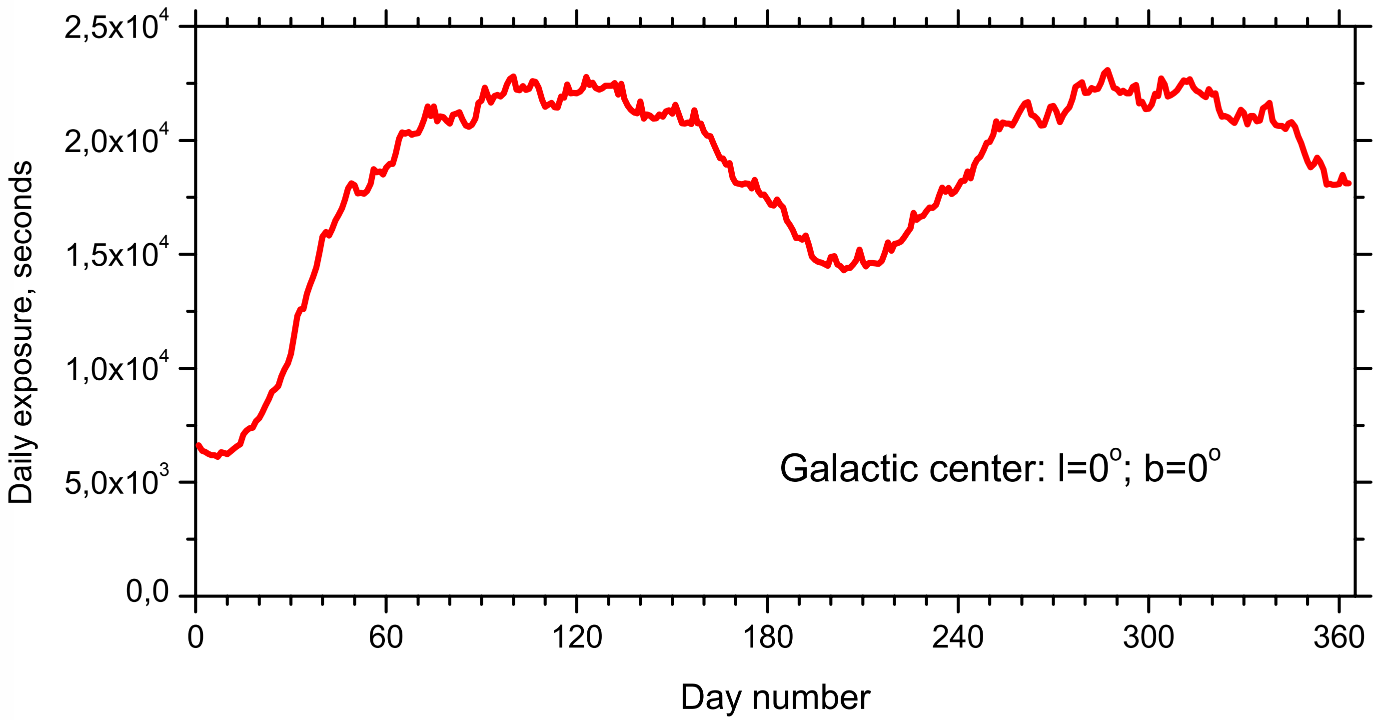
**Units: $10^8$ cm$^2$s**

**GALA**

**1 year of observations**

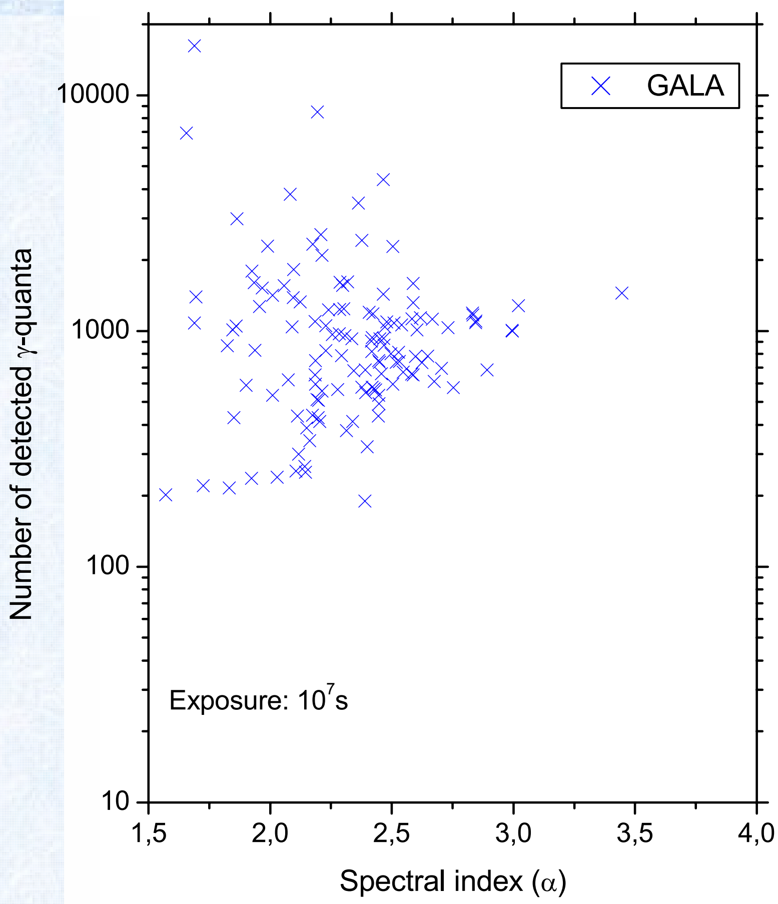


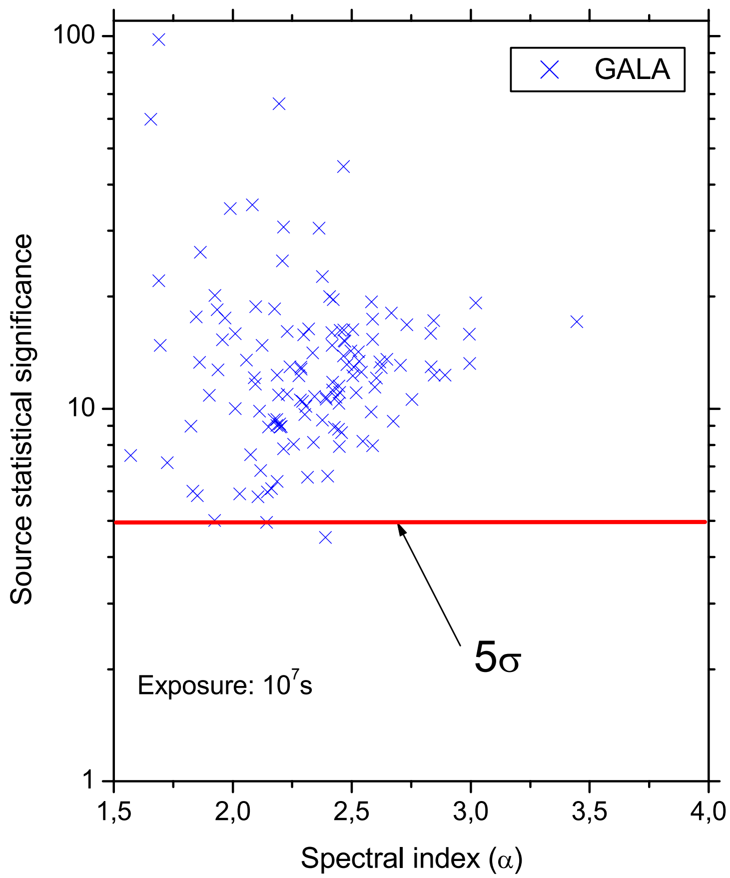
# GALA exposure for point source vs. time



# Expected results of observations:

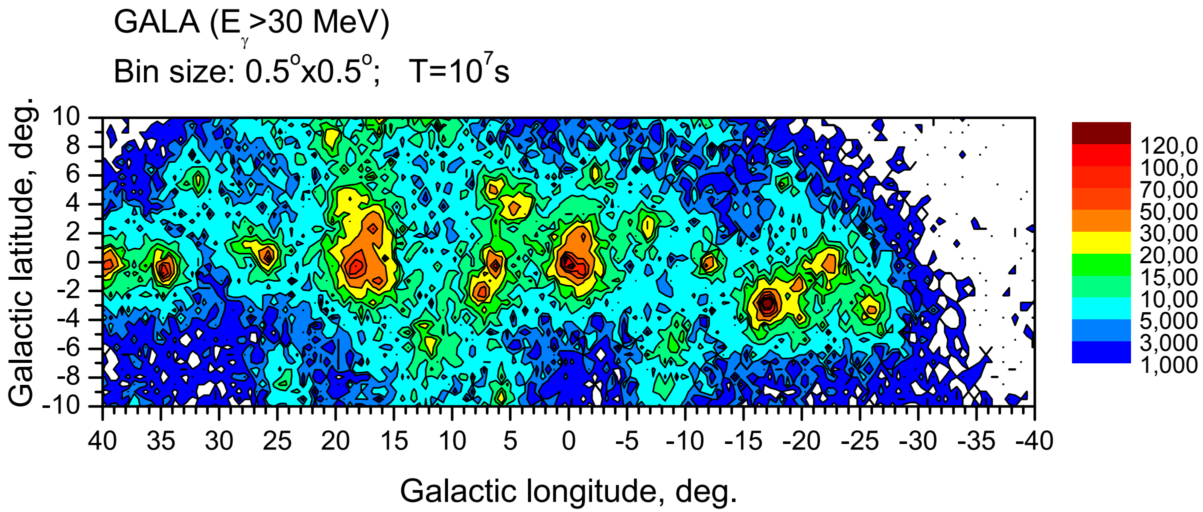
**Number of detected gamma-quanta with energy >30 MeV versus spectral index $\alpha$ of 3EG sources demonstrated very low time variability**

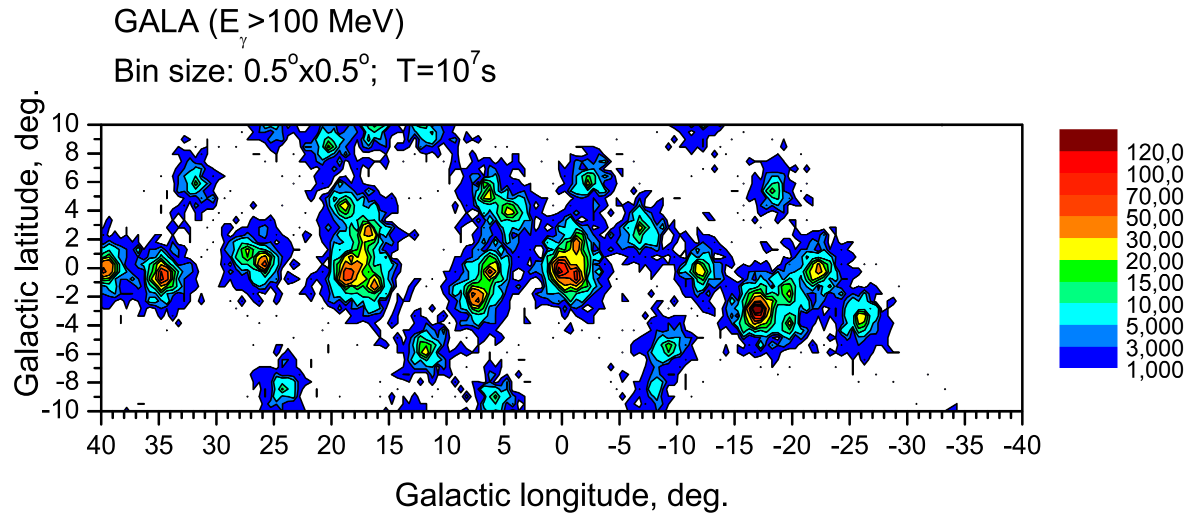


# Expected results of observations:

## Expected GALA count maps of Galactic center region



# GALA collaboration

- **Collaborators from Russian side:**
  - Moscow Engineering Physics Institute (State University)
  - Sternberg Astronomical Institute (Moscow State University)
  - Institute of Astronomy RAS
  - Lebedev Physical Institute RAS
  - All Russian Scientific and Research Institute of Electro mechanics (VNIIEM)
- **Foreign collaborators:**
  - National Institute of Nuclear Physics (INFN), Italy