Status of the GAMMA-400 Project

V.L. Ginzburg *, A.M. Galper * †, V.A. Kaplin †, M.F. Runtso †, N.P. Topchiev *, M.I. Fradkin * and V.G. Zverev †

* *Lebedev Physical Institute, Russian Academy of Sciences (Russia, Moscow)*
† *MEPhI (Russia, Moscow)*

***Abstract*. Optimized version of the GAMMA-400 gamma-ray telescope for detecting gamma rays and electrons (positrons) in the energy range 1-3000 GeV on space observatory is described. Its performance (angular resolution $\sim 0.1^o$ and energy resolution $\sim 1\%$) enables to search gamma-ray lines and electron-positron fluxes from annihilation or decay of dark matter components, as well as to detect very high-energy gamma rays from galactic and extragalactic astrophysical objects, to measure their energy spectra and luminosity, to measure energy spectra of galactic and extragalactic diffuse gamma-ray emission, to search and investigate high-energy gamma-ray bursts (more than 1 GeV).**

***Keywords*: gamma-astronomy, gamma-telescope**

I. Goal of the GAMMA-400 project

Modern status of fundamental researches on cosmology, astronomy, high-energy physics, and cosmic-ray physics sets a number of the problems, which is impossibly to solve without attraction of the results of investigations on extraterrestrial very high energy (10^9-10^{12} eV) gamma-ray astronomy and simultaneous investigation of electron-positron component of galactic cosmic rays. From the above reasoning we formulate next main goals of the GAMMA-400 project.

1) To search for physical processes in astrophysical objects, where very high energy gamma-ray emission arises;
2) To search for the nature and properties of weakly interacting massive particles (dark matter components) by processes of their annihilation and decay into gamma rays and electron-positron pairs
3) To search and investigate high-energy gamma-ray bursts (more than 1 GeV)

II. The GAMMA-400 gamma-ray telescope

To realize these scientific problems the GAMMA-400 gamma-ray telescope is developed. The main GAMMA-400 parameters are shown in Table 1.

The physical scheme of the GAMMA-400 gamma-ray telescope is shown in Fig. 1. Two-layer anticoincidence scintillation detector AC and tungsten converter C (W, 0.8 rl) are located at the top. Two scintillation detectors S1, S2 of time-of-flight (TOF) system and three two-layer silicon strip detectors CD1, CD2, CD3 are located below. Silicon strip detectors allow us to determine conversion point and particle trajectory. Coordinate-sensitive calorimeter for determination of particle energy and shape of secondary particle shower is located in the middle and consists of three modules CC1, CC2, CC3. CC1 (2 rl) and CC2 (4 rl) consist of eight thin tungsten converter layers (0.25 and 0.5 rl, respectively) and silicon strip detectors between them. CC3 consists of eight layers of $PbWO_4$ crystals (22.5 rl) with silicon strip detectors between them. Scintillation detectors S3, S4, S are located after each of modules. Neutron detector ND for detecting neutrons arising, when particles interact with calorimeter matter, is located in the bottom. To select events from electromagnetic or hadron cosmic-ray components we use some methods: (1) by the depth of shower vertex in the calorimeter; (2) by the longitudinal and transverse shower profiles in the calorimeter; (3) by the correlation of total energy release in the calorimeter and energy release in scintillation detector S; (4) by the number of neutrons in the neutron detector ND. GAMMA-400 electronics uses three methods (temporal, amplitude, coordinate) to eliminate events of backsplash particles from calorimeter that allows us to detect gamma rays, electrons, and positrons up to 3000 GeV. The GAMMA-400 angular resolution is calculated by the Monte Carlo method and its energy dependence is shown in Fig. 2. At present we continue to optimize the physical and electronic schemes and simulate some

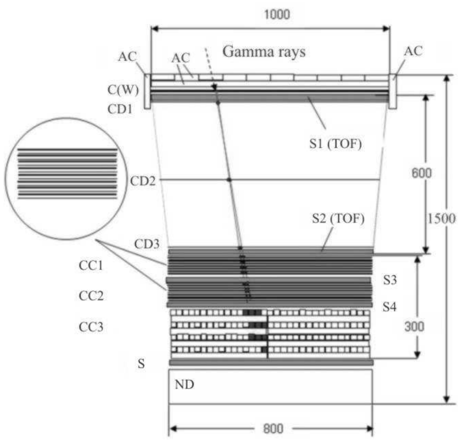

Fig. 1: The GAMMA-400 physical scheme.

TABLE I: GAMMA-400 parameters.

Energy range	1-3000 GeV
Detection area	$1.0 \times 1.0 m^2$
Geometrical factor	$0.7 \cdot m^2 sr$
Point source sensitivity (>100 MeV)	$\sim 5 \cdot 10^{-9} ph \cdot cm^{-2} \cdot s^{-1}$
Angular resolution	$\sim 0.1°$
Energy resolution (E = 100 GeV - 3 TeV)	$\sim 1\%$
Calorimeter depth	$\sim 28.5 rl$
Total mass	$\sim 1700 kg$
Power consumption	800 W
Telemetry downlink	20 GB/day
Mission duration	not less than 5 years

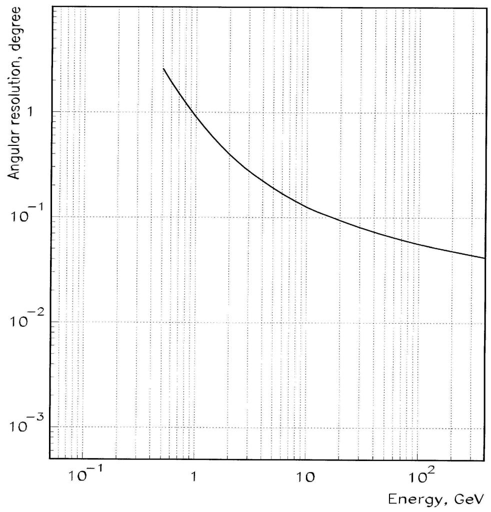

Fig. 2: Energy dependence of GAMMA-400 angular resolution.

parameters of the GAMMA-400 gamma-ray telescope in order to obtain the best modern performance of our apparatus. Planned GAMMA-400 launch data is 2017.

This study was performed within the Federal Space Program of the Russian Federation.