A New Project for High Energy Gamma-Ray Astronomy:

Space Gamma-Ray Telescope GAMMA-400

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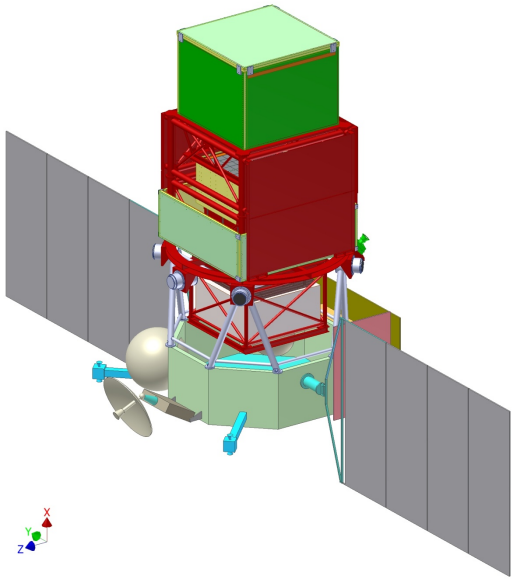
What is Gamma-400 ?



Energy range: 0.1 – 3,000 GeV ★
Converter: 100 x 100 cm^2, 0.84 r.l.
Calorimeter: 80 x 80 cm^2 , ~30 r.l.
Field of view: ±50 degrees
Angular resolution (> 100 GeV): ~0.01^0 ★
Energy resolution (> 1 GeV): ~ 1%
Telemetry downlink: 100 GB/day
Power consumption: 2,000 W
Max. dimensions: 2 x 2 x 3 m^3
Mass: ~ 2,600 kg
Launch: 2018
Lifetime: > 7 years

KONUS-FG gamma-ray burst monitor:
Energy range 10 keV – 10 MeV

- A new high-energy space gamma-ray telescope
- **An approved and fully funded** by Russian Space Agency Russian, included in Federal Space Program
- **Uses the Navigator service module** made by Lavochkin Association, recently used for the RadioAstron mission, planned for other missions
- Uses technology similar to Fermi Large Area Telescope (tracker/converter, energy measurement system, anticoincidence detector), but with better angular and energy resolution
- **Launch is planned for 2018-2019**, and the final design will be frozen next year (2013)

★ Italian scientists proposed to INFN and ASI to provide additional 25 Silicon strip planes which will enhance Gamma-400 performance at energy <200 MeV with significantly better than Fermi LAT angular resolution

Main Scientific Objectives

- search for dark matter particle annihilation and decay signatures;

- study of processes in active astrophysical objects both Galactic and extragalactic, including the Galactic center;

- study of origin and propagation of CR electron + positron and nuclear component of very high energy;

- study of gamma-ray bursts.

- **Focus on high-energy gamma-ray tasks which Gamma-400 will perform better than Fermi-LAT due to its better energy and angular resolution**
  - **Source localization and identification (puzzle of non-ID Fermi LAT sources)**
  - **Discovery of new sources in crowded regions (e.g. Galactic Center, Cygnus)**
  - **Study of spectral structure of diffuse radiation (addresses Dark Matter)**
  - **Study of gamma radiation from Supernova Remnants at low energy (addresses origin of cosmic rays)**
- **Extend high-energy gamma-ray observations after the end of the Fermi LAT mission for multiwavelength analysis in synergy with:**
  - **Radio, optical, X-ray and TeV gamma-ray observations (CTA)**
  - **Neutrino observations (IceCube, KM3NeT)**
  - **Gravitational radiation observations (ALIGO)**

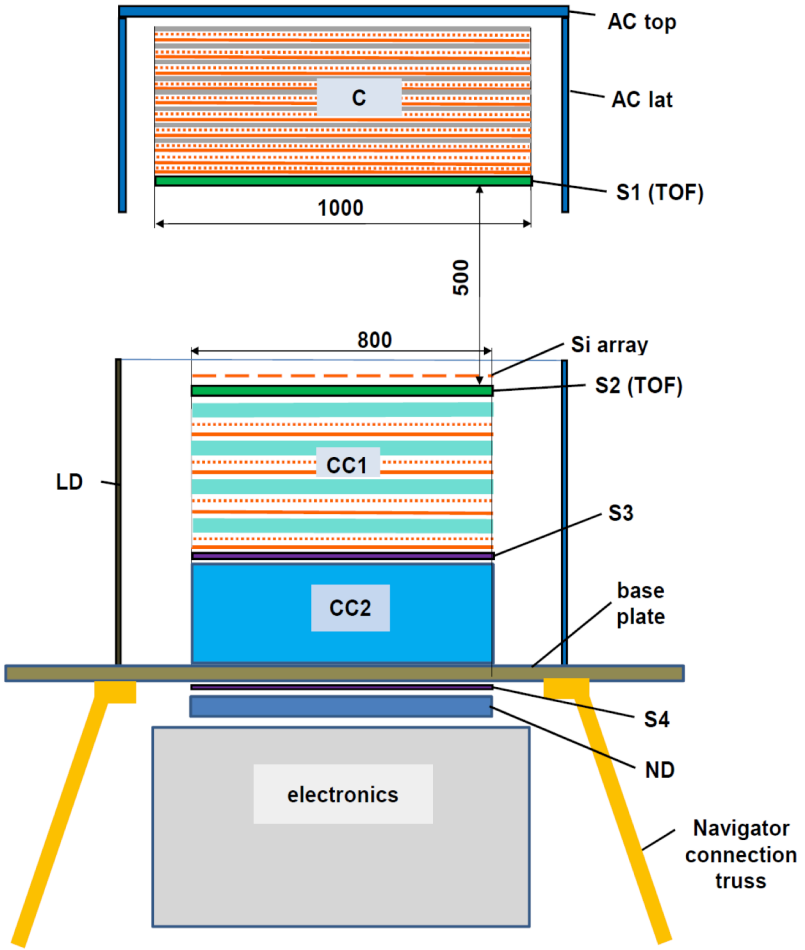
Currently no space-borne high-energy gamma-ray observations are planned after Fermi LAT observations end (~ 2018).

The main scientific interest of the Russian Gamma-400 team is in high energy (above ~ 10 GeV), however, in order to best exploit its promise as a NEXT GENERATION GAMMA-RAY MISSION, it is critical for Gamma-400:

- To be capable of precise measurements in the very important energy range from ~20 MeV to a few hundred MeV, where the LAT energy resolution, angular resolution and background rejection are relatively poor

Currently the possibility to add 20+ additional tracker planes to provide enhanced capability is under consideration by INFN

Instrument Outline



AC - anticoincidence detectors (AC top + AC lat)

C - Converter-Tracker - 1 Xo
10 Si(x,y) (pitch 0.1 mm) + 8 W (0.1 Xo)

S1, S2 - TOF detectors

Si array - Si pad (1x1 cm^2) detector

S3, S4 - calorimeter scintillator detectors

CC1 - imaging calorimeter 3Xo
4 layers: CsI 0.75 Xo + Si(x,y) (pitch 0.5 mm)

CC2 - electromagnetic calorimeter 22Xo
BGO (1024 crystals 2.5x2.5x25 cm^3)

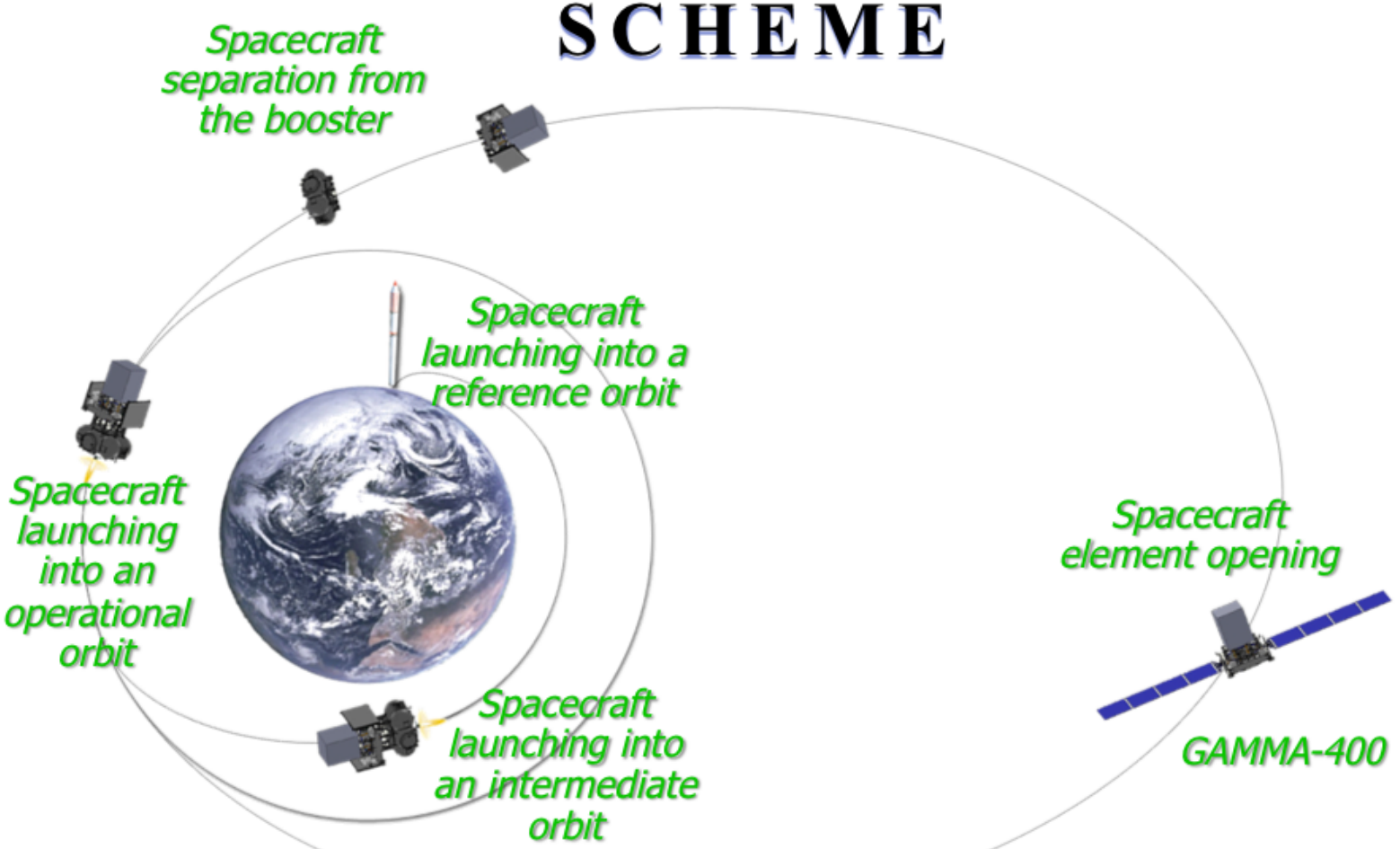
LD - 4 lateral calorimeter detectors 50x120 cm^2

ND - neutron detector

Table 2. Comparison of basic parameters of space-based and ground instruments

	Space					Ground
	EGRET	AGILE	FERMI-LAT	CALET	**Gamma-400**	H.E.S.S., MAGIC, VERITAS
Energy range, GeV	0.03 - 30	0.03 – 50	0.02 – 1,000	10 – 10,000	**0.1 – 3,000**	> 100
Angular res. E>100 GeV	0.5^{O}	0.1^{O}	0.1^{O}	0.1^{O}	**$\sim 0.01^{O}$**	0.1^{O}
Energy res. E>100 GeV	20%	50%	~10%	2%	**~1%**	10-20%
AΩ E>100 GeV cm^2 sr	750	1,500	25,000	1,200	**~8,000**	$\sim 10^7$

GAMMA-400 LAUNCHING SCHEME



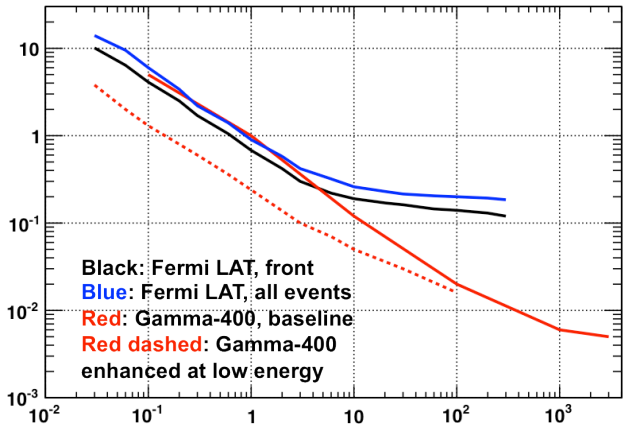
Initial orbit : apogee 300,000 km, perigee 500 km, inclination 51.8, period 7 days**. After ~ 230 days** the orbit will change to ~ circular with radius 150,000 km

SUMMARY

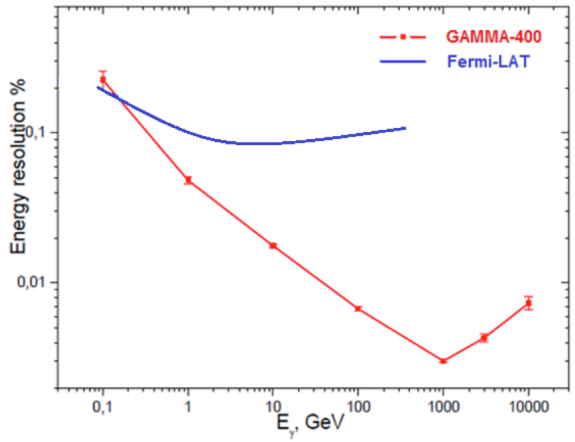
- The project is approved and funded by Russian Space Agency (RosCosmos); all critical items and participants are defined; the launch is planned for 2018
- INFN is considering to make significant contribution to enhance Gamma-400 capability at low energy
- We (GSFC, Stanford U and NMSU) proposed to NASA (APRA) to contribute to this mission too, but the proposal was declined

Back-up slide: Simulated Performance for Gamma-400 (preliminary)

Angular Resolution (68%)



Energy resolution



Effective area