A New Project for High Energy Gamma-Ray Astronomy:

Space Gamma-Ray Telescope
GAMMA-400

Alexander Moiseev (NASA/GSFC/CRESST and UMCP), for the Gamma-400 Collaboration
What is Gamma-400?

- 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

<table>
<thead>
<tr>
<th>Energy range: 0.1 – 3,000 GeV ★</th>
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<tbody>
<tr>
<td>Converter: 100 x 100 cm², 0.84 r.l.</td>
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<tr>
<td>Calorimeter: 80 x 80 cm², ~30 r.l.</td>
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<td>Field of view: ±50 degrees</td>
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<td>Angular resolution (&gt; 100 GeV): ~0.01° ★</td>
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<td>Energy resolution (&gt; 1 GeV): ~1%</td>
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<td>Telemetry downlink: 100 GB/day</td>
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<tr>
<td>Power consumption: 2,000 W</td>
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<tr>
<td>Max. dimensions: 2 x 2 x 3 m³</td>
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<tr>
<td>Mass: ~2,600 kg</td>
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<tr>
<td>Launch: 2018</td>
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<td>Lifetime: &gt;7 years</td>
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KONUS-FG gamma-ray burst monitor:
Energy range 10 keV – 10 MeV

Alexander Moiseev  GammaSAG
August 15, 2012
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

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August 15, 2012
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 cm²) 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 cm³)
LD - 4 lateral calorimeter detectors
50x120 cm²
ND - neutron detector
Table 2. Comparison of basic parameters of space-based and ground instruments

<table>
<thead>
<tr>
<th></th>
<th>EGRET</th>
<th>AGILE</th>
<th>FERMI-LAT</th>
<th>CALET</th>
<th>Gamma-400</th>
<th>Ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy range, GeV</td>
<td>0.03 - 30</td>
<td>0.03 – 50</td>
<td>0.02 – 1,000</td>
<td>10 – 10,000</td>
<td>0.1 – 3,000</td>
<td>H.E.S.S., MAGIC, VERITAS</td>
</tr>
<tr>
<td>Angular res. E&gt;100 GeV</td>
<td>0.5°</td>
<td>0.1°</td>
<td>0.1°</td>
<td>0.1°</td>
<td>~0.01°</td>
<td>0.1°</td>
</tr>
<tr>
<td>Energy res. E&gt;100 GeV</td>
<td>20%</td>
<td>50%</td>
<td>~10%</td>
<td>2%</td>
<td>~1%</td>
<td>10-20%</td>
</tr>
<tr>
<td>AΩ E&gt;100 GeV cm² sr</td>
<td>750</td>
<td>1,500</td>
<td>25,000</td>
<td>1,200</td>
<td>~8,000</td>
<td>~10⁷</td>
</tr>
</tbody>
</table>
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%)