The space gamma-ray observatory AGILE

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Abstract

AGILE (*Astro-rivelatore Gamma a Immagini LEggero*) is an innovative, cost effective gamma ray mission selected by the Italian Space Agency (ASI) as first payload of the Program for Small Scientific Missions. It is designed to detect and image gamma-ray sources in the energy range 30 MeV–50 GeV and operate as an Observatory open to the international community. Primary scientific goals include the study of AGN's, gamma ray bursts, Galactic sources, unidentified gamma ray sources, solar flares and diffuse gamma ray emission.

AGILE is planned to be operational during the year 2002 for a 3-year mission. It will an ideal 'bridge' between EGRET and GLAST, and support space observations and ground based multiwavelength studies of high energy sources

1 Introduction:

High-energy gamma-ray astrophysics is currently in a period of discovery and vigor unparalleled in its history. The CGRO-EGRET discoveries of gamma-ray blazars, pulsars, high-energy gamma-ray bursts and a large class of unidentified high-energy sources have given us a new view of the high-energy sky , while raising fundamental new questions about the origin, evolution and destiny of high-energy sources. It is now clear that to address these questions it is necessary to study the gamma-ray emission and correlate these observations with those at other wavelengths; increase the sample of high-energy sources detected, including objects at large distance; measure high-energy spectral turnovers in a large sample of sources distributed over a large range of redshifts; determine if the average spectrum is consistent with that of the isotropic component of the high-energy gamma-ray background. To fulfill these task some next generation experiments has been proposed. For the low energy part of the spectrum (20 MeV-50 GeV) the use of the satellite experiments is unavoidable and at higher energies is highly desirable to have an overlap with the ground experiments and to have a monitoring and an alert system with a large field of view for all the transient phenomena.

2 the AGILE detector

AGILE is based on silicon tracking detectors developed for space missions by INFN and Italian University laboratories during the past years (Barbiellini et al., 1995; Morselli et al., 1995). AGILE is both very light (~ 60 kg) and highly efficient in detecting and monitoring gamma-ray sources in the energy range 30 MeV–50 GeV. The accessible field of view is unprecedently large ($\geq 1/5$ of the whole sky) because of state-of-the-art readout electronics and segmented anticoincidence system. The goal is to achieve an on-axis sensitivity comparable to that of EGRET on board of CGRO (a smaller background resulting from an improved angular resolution more than compensates the loss due to a smaller effective area) and a better sensitivity for large off-axis angles (up to $\sim 60°$). A schematic view of the detector AGILE is shown in 1. A more complete description and references can be found at *http://www.ifctr.mi.cnr.it/Agile/* .

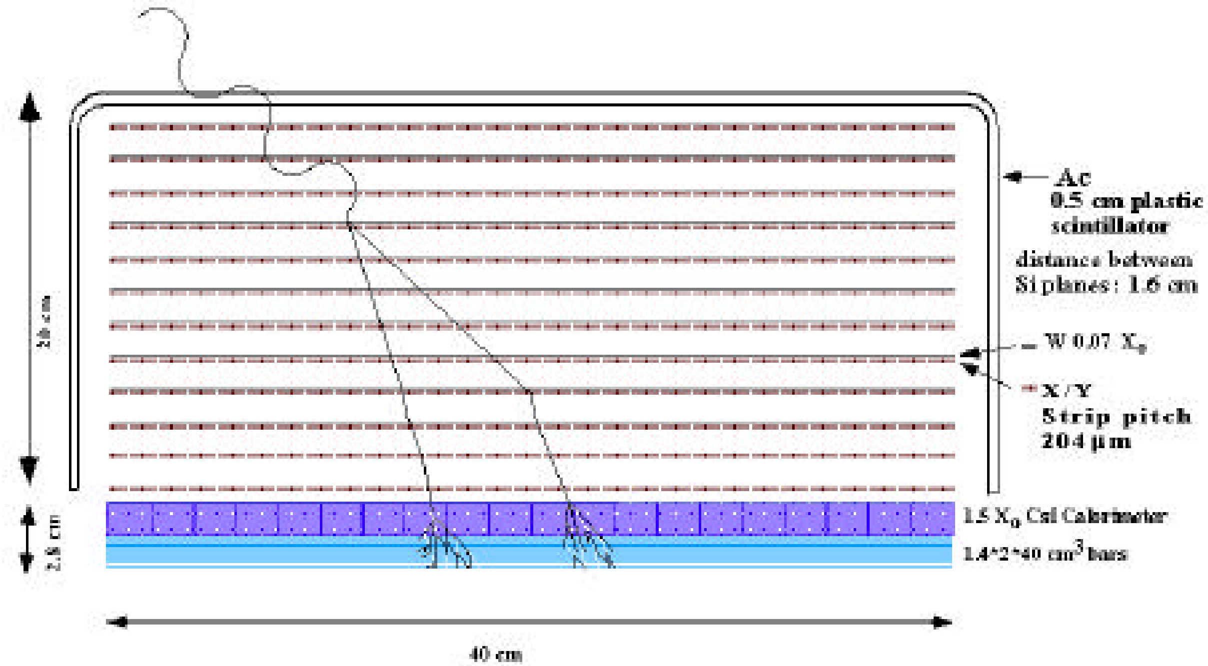

Figure 1: *Schematic of the AGILE baseline instrument.*

We are also studying the possibility of adding an ultra-light coded mask imaging system sensitive in the energy band ∼10–40 keVon top of AGILE. Super-AGILE is an innovative concept, combining silicon technology to simultaneously detect gamma-rays and hard X-rays with accurate imaging. The expected performance of AGILE in angular and energy resolution, as derived from Montecarlo simulations, are shown in Fig 2 .

In figure 3 (on the left) is shown the AGILE sensitivity compared with the others present and future detectors in the gamma-ray astrophysics range The predicted sensitivity of a number of operational and proposed Ground based Cherenkov telescopes, is for a 50 hour exposure on a single source. EGRET, GLAST, MILAGRO and AGILE sensitivity is shown for one year of all sky survey. Note that on ground only MILAGRO and ARGO will observe more than one source simultaneously. In figure 3 (on the right) is shown the Energy range covered by the different experiments versus the activity period. Note that AGILE will covered an interval were no other experiments will be present.

3 Scientific Objectives

Because of the large field of view AGILE will discover a large number of gamma-ray transients, monitor known sources, and allow rapid multiwavelength follow-up observations because of a dedicated data analysis and alert program. Table 1 summarizes the expected performance of AGILE vs. that of EGRET.

• *Active Galactic Nuclei.* For the first time, simultaneous monitoring of a large number of AGNs per pointing will be possible. Several outstanding issues concerning the mechanism of AGN gamma-ray production and activity can be addressed by AGILE including: (1) the study of transient vs. low-level gamma-ray emission and duty-cycles; (2) the relationship between the gamma-ray variability and the radio-optical-X-ray-TeV emission; We conservatively estimate that for a 3-year program AGILE will detect a number of AGNs 2–3 times larger than that of EGRET. Super-AGILE will monitor, for the first time, simultaneous AGN emission in the gamma-ray and hard X-ray ranges.

• *Diffuse Galactic and extragalactic emission.* The AGILE good angular resolution and large average exposure will further improve our knowledge of cosmic ray origin, propagation, interaction and emission

Table 1: Comparison between AGILE and EGRET

	EGRET	AGILE
Mass (kg)	1830	60
Energy band	30 MeV – 30 GeV	30 MeV – 50 GeV
Field of view (sr)	$0.15\,\pi$	$0.8\,\pi$
Sensitivity	8×10^{-9}	6×10^{-9} (@ 0.1 GeV)
for pointlike sources†	1×10^{-10}	4×10^{-11} (@ 1 GeV)
$(\mathrm{ph\,cm^{-2}\,s^{-1}\,MeV^{-1}})$	1×10^{-11}	3×10^{-12} (@ 10 GeV)
Required pointing reconstruction	∼10 arcmin	∼1-2 arcmin

(*) FWHM of the point spread function ($E > 100$ MeV) calculated for an incidence angle less than 20° and a photon spectrum $\sim E^{-2}$). (†) Obtained for a typical exposure time near 2 weeks at high galactic latitude for both AGILE and EGRET.

processes. We also note that a joint study of gamma-ray emission from MeV to TeV energies is possible by special programs involving AGILE and new-generation TeV observatories of improved angular resolution.

• *Gamma-ray pulsars.* AGILE will contribute to the study of gamma-ray pulsars in several ways: (1) improving photon statistics for gamma-ray period searches (2) detecting possible secular fluctuations of the gamma-ray emission from neutron star magnetospheres; (3) studying unpulsed gamma-ray emission from plerions in supernova remnants and searching for time variability of pulsar wind/nebula interactions, e.g., as in the Crab nebula.

• *Galactic sources, new transients.* A large number of gamma-ray sources near the Galactic plane are unidentified, and sourcessuch as2CG 135+1 or transients(e.g., GRO J1838-04)can be monitored on timescales of months/years.

• *Gamma-ray bursts.* About ten GRBs have been detected by EGRET's spark chamber during ~ 7 years of operations (Schneid et al., 1996a). This number appears to be limited by the EGRET FOV and sensitivity and not by the GRB emission mechanism. GRB detection rate by AGILE is expected to be a factor of ~ 5 larger than that of EGRET, i.e., ≥5–10 events/year). The small AGILE deadtime (≥ 100 times smaller than that of EGRET) allows a better study of the initial phase of GRB pulses. The remarkable discovery by EGRET of 'delayed' gamma-ray emission up to ~ 20 GeV from GRB 940217 (Hurley et al., 1994) is of great importance to model burst acceleration processes. AGILE is expected to be highly efficient in detecting photons above 10 GeV because of limited backscattering. Super-AGILE will be able to locate GRBs within a few arcminutes, and will systematically study the interplay between hard X-ray and gamma-ray emissions.

• *Solar flares.* During the last solar maximum, solar flares were discovered to produce prolonged high-intensity gamma-ray outbursts. AGILE will be operational during part of the next solar maximum and several solar flares may be detected.

4 Conclusion

AGILE ideally conforms to the *faster, cheaper, better* philosophy adopted by space agencies for scientific missions. AGILE's data will provide crucial support for ground-based observations and several space missions including AXAF, INTEGRAL, XMM, ASTRO-E, SPECTRUM-X.

References

Barbiellini G. et al: 1995, *Nucl. Instrum. & Methods* **354**, 547

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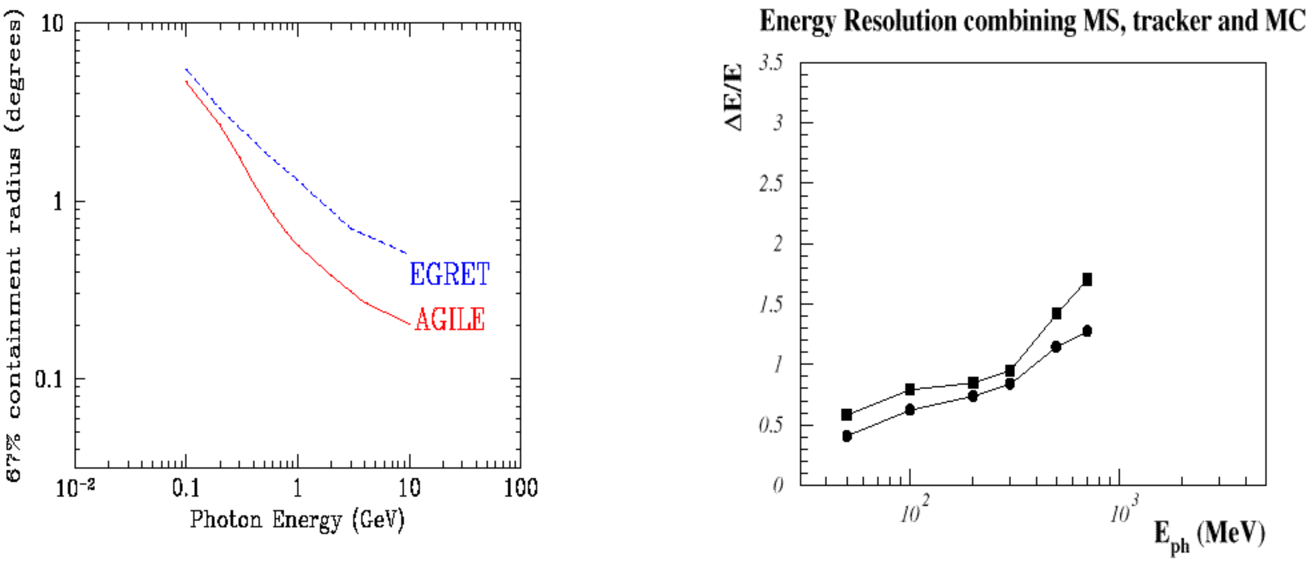

Figure 2: *Three dimensional PSF (67% containment radius) as a function of photon energy for AGILE and EGRET (on the left). AGILE expected energy resolution (on the right) obtained combining the multiple scattering method (MS), the energy released into the mini-calorimeter (MC) and into the tracker for a photon converted in the frst plane (circles) and in the last plane (squares).*

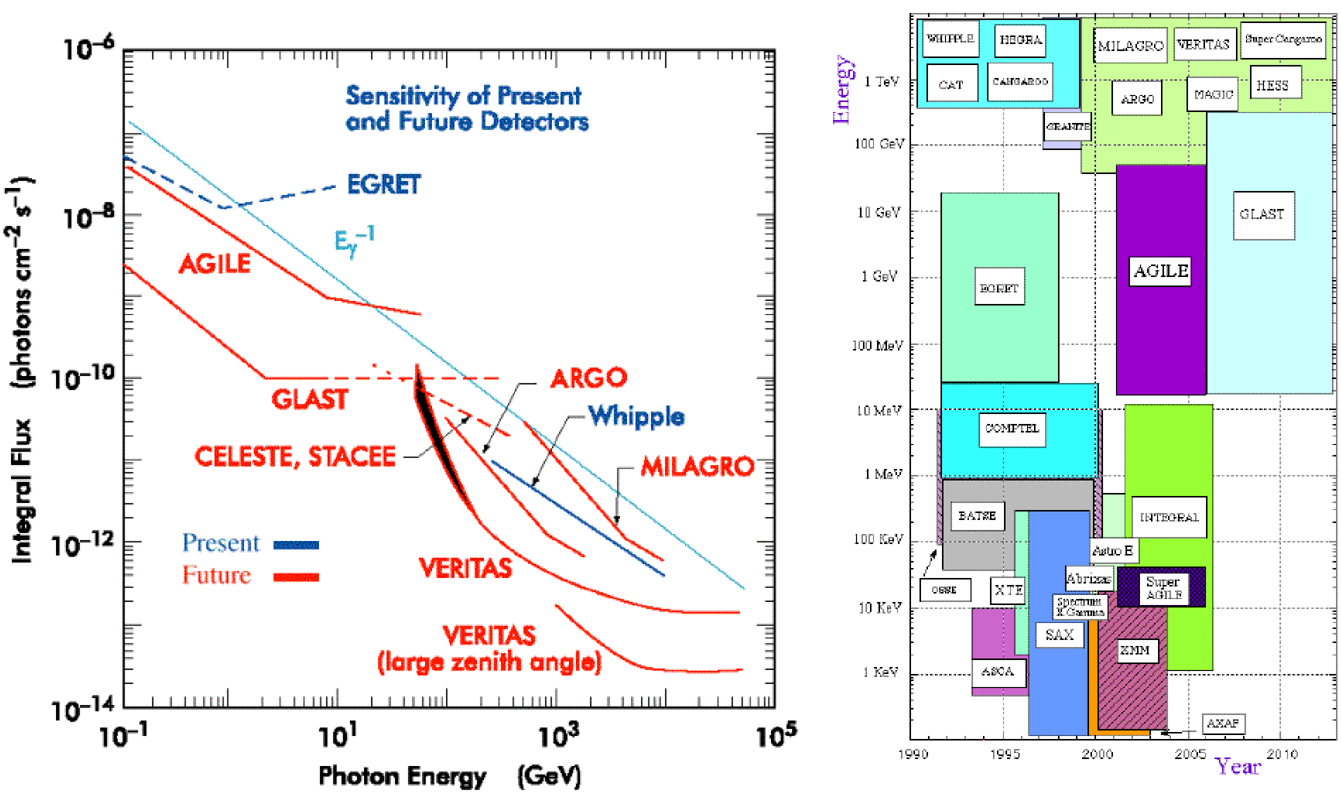

Figure 3: *Sensitivity of present and future detectors in the gamma-ray astrophysics (on the left) and their timeline schedule (on the right)*