The AGILE Mission: the first 3 years in a nutshell

M.Tavani

8th AGILE Workshop, 28 April 2010

AGILE: ~3 years in orbit...

• ~ 15.400 orbits, April 15, 2010.

very good scientific performance

- Cycle-1: Dec. 2007- Nov. 2008
- Cycle-2: Dec. 2008- Nov. 2009
- Cycle-3: Dec. 2009- Nov. 2010

AGILE: an Italian scientific mission

- Devoted to high-energy astrophysics
- Optimized for a low-lost/high efficiency of scientific performance
- Launched on April 23, 2007 from India
- Active in sinergy with other satellites and observatories around the world
- Very important scientific results
- An observatory also for Terrestrial phenomena

Some of the highlights

- Black hole astrophysics
 - Discovery of gamma-ray emission from Cyg X-3 and Cyg X-1: microquasar patterns, extreme particle acceleration (not Comptonized !)
 - massive black hole jet ejections, particle acceleration
- Origin of cosmic rays, SNR surprises
- New Galactic gamma-ray transients
- Pulsars and Pulsar Wind Nebulae
- GRB surprises
- Terrestrial gamma-ray Flashes





AGILE Satellite (IABG, Munich 16 June, 2006)

350 kg satellite

The AGILE Payload: the most compact instrument for highenergy astrophysics

It combines for the first time a gamma-ray imager (30 MeV- 30 GeV) with a hard X-ray imager (18-60 keV) with large FOVs (1-2.5 sr) and optimal angular resolution

AGILE: a very innovative instrument

 AGILE combination of co-aligned gamma-ray (50 MeV – 5 GeV) and hard X-ray (20-60 keV) imagers

- AGILE-GRID is optimized near 100 MeV
 good PSF (~3° at 100 MeV)
 - typical daily exposure of ~ 10⁷ cm² sec

AGILE: inside the cube...

HARD X-RAY IMAGER (SUPER-AGILE)

ANTICOINCIDENCE

GAMMA-RAY IMAGER SILICON TRACKER

(MINI) CALORIMETER

AGILE's scientific strengths

- combination of co-aligned gamma-ray (50 MeV – 5 GeV) and hard X-ray (20-60 keV) imagers
- optimal sensitivity near 100 MeV
- millisecond data acquisition
- Cosmic and Terrestrial phenomena studied by the same Mission

A quick comparison

	AGILE-1	FERMI/LAT
A _{eff} (100 MeV) (cm ²)	~400	~ 1000-2000
A _{eff} (1 GeV) (cm²)	500	~ 8000- 10000
FOV (sr)	2.5	2.5
sky coverage	1/5	whole sky
Energy resolution (~ 400 MeV)	50 %	10 %
PSF (68 % cont. radius) 100 MeV 1 GeV	3° - 4°	4º - 5º
	< 1º	<1º

AGILE two lifes

	AGILE-1	AGILE-2
time period	Jul.07 – Oct.09	Nov. 2010 -
attitude	fixed	variable (spinning, 1%sec)
sky coverage	1/5	~ 70%
source livetime fraction	~ 0.5	~ 0.2
1-day exposure (30 degree off-axis, 100 MeV)	~ 2 10 ⁷ (cm ² sec)	(0.5-1) 10 ⁷ (cm ² sec)

a comparison: 1-day exposure

	AGILE-1 (GRID)	AGILE-2 (GRID)	FERMI (LAT)
FOV (sr)	2.5	2.5	2.5
Attitude	fixed	variable (spinning)	variable
sky coverage	1/5	~ 70%	whole sky
Source livetime fraction	~ 0.5	~ 0.2	~ 0.16
1-day exposure (30 degree off-axis, 100 MeV)	~ 2 10 ⁷ (cm ² sec)	(0.5-1) 10 ⁷ (cm ² sec)	~(1-2) 10 ⁷ (cm ² sec)

The AGILE gamma-ray sky (E > 100 MeV) 2 year exposure: July 2007 – June 2009

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AGILE-1: 1-day exposure (E > 100 MeV) (30 Nov. 2008)



spinning AGILE: 2-day exposure (E > 100 MeV) (10-11 Jan. 2010)



100 200 300 400 500 600	700

AGILE-in-spinning: 5-month intensity map (E > 100 MeV) (Nov. 2009 – Mar. 2010)

5E-05	0.0001	0.00015	0.0002	0.00025	0.0003	0.00035	0.0004	0.00045	0.0005

AGILE-in-spinning: 5-month intensity map (E > 100 MeV) (Nov. 2009 – Mar. 2010)

001	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009

a very efficient Ground Segment !

Malindi (Kenya)



TZP

FUCINO

AGILE: the "fastest" Ground Segment



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8327	7:09:34:12 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.17 (20.2, -10.9, 182.049) - 31 - FM3.11	9 KB
8326	6(07:53:08 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 5.11 (65.0, 30.0, 238.079) - 11 - FM3.119_2	11 KB
8326	5:07:29:05 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.45 (20.2, -10.9, 176.214) - 31 - FM3.11	9 KB
8326	5107:23:05 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.35 (121.3, 29.5, 305.147) - 13 - FM3.11	9 KB
8326	5(06:54:02 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.57 (195.2, 3.4, 410.441) - 1AGL_J0634	11 KB
8326	5:06:25:00 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.41 (43.8, 32.9, 209.845) - 13 - FM3.115	9 KB
8326	5406:25:00 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 5.11 (65.0, 30.0, 250.057) - 11 - FM3.115	9 KB
8326	5:06:20:00 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.29 (121.3, 29.5, 319.167) - 13 - FM3.11	9 KB
8326	5:06:15:00 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.21 (20.3, -10.9, 183.684) - 31 - FM3.11	9 KB
8326	5′05:48:53 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.43 (195.2, 3.4, 434.909) - 1AGL_J0634	11 KB
832	5:04:26:52 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 5.11 (65.0, 30.0, 238.949) - 11 - FM3.119	10 KB
8325	5:04:26:52 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.41 (43.8, 32.9, 201.619) - 12 - FM3.115	10 KB
8325	5704:11:47 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.29 (121.3, 29.5, 306.323) - 13 - FM3.11	9 KB
8325	5(03:36:46 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.55 (195.2, 3.4, 422.139) - 1AGL_J0634	11 KB
8325	5:03:09:45 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.87 (65.0, 30.0, 245.936) - 11 - FM3.119	9 KB
832	5403:09:45 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.37 (43.8, 32.9, 209.043) - 12 - FM3.115	9 KB
832	5:03:01:45 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.03 (55.8, 22.0, 197.644) - 13 - FM3.119	9 KB
8325	5:02:30:43 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 5.84 (194.7, 3.4, 442.803) - 22 - FM3.115	11 KB
8325	5′01:33:46 AM	GCN Circulars	INTEGRAL trigger 5994 (GRB100331A): Swift/XRT observations	3 KB
8324	4701:12:41 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.37 (43.8, 32.9, 199.124) - 12 - FM3.115	10 KB
8324	4(01:12:41 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.9 (65.0, 30.0, 235.626) - 11 - FM3.119_	10 KB
8324	4:01:12:41 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.27 (39.3, 1.2, 205.399) - 21 - FM3.119_	10 KB
8324	4:12:48:41 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 4.04 (121.4, 29.4, 307.164) - 14 - FM3.11	9 KB
8324	4:12:19:40 AM	Utente GRID1 BUILD17	[gridalert] ALERT LEVEL 5.96 (194.7, 3.4, 428.447) - 22 - FM3.115	11 KB

many results many surprises

Construction of the Second Second

AGILE-GRID quicklook, April 13, 2010



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0.0002	0.0004	0.0006	0.0008	0.001	0.0012	0.0014	1

2 Astronomical Telegrams in spinning mode (Apr. 13, 2010)

AGILE detects enhanced gamma-ray emission from the blazar PKS 2142-758

ATel #2551: F. Verrecchia (ASDC). E. Striani (Univ. Roma Tor Vergata), C. Pittori, F. Lucarelli (ASDC), S. Vercellone (INAF/IASF-Pa), M. Tavani (INAF/IASF-Rm), A. Bulgarelli (INAF/IASF-Bo), F. D'Ammando (INAF/IASF-Pa), I. Donnarumma (INAF/IASF-Rm), V. Vittorini, E. Del Monte, Y. Evangelista, M. Feroci, F. Lazzarotto, L. Pacciani, P. Soffitta, E. Costa, I. Lapshov, M. Rapisarda, A. Argan, G. Piano, G. Pucella, S. Sabatini, A. Trois (INAF/IASF-Rm), F. Fuschino, M. Galli, F. Gianotti, C. Labanti, M. Marisaldi, M. Trifoglio, G. Di Cocco (INAF/IASF-Bo), A. Chen, A. Giuliani, S. Mereghetti, P. Caraveo, F. Perotti (INAF/IASF-Mi), A. Pellizzoni, M. Pilia (INAF/OA-Cagliari), G. Barbiellini, F. Longo, E. Moretti, E. Vallazza (INFN Trieste), A. Morselli, P. Picozza (INFN and Univ. Roma Tor Vergata). M. Prest (Universita` dell'Insubria). P. Lipari, D. Zanello (INFN and Univ. Roma Sapienza). P.W. Cattaneo, A. Rappoldi (INFN Pavia), P. Santolamazza, S. Colafrancesco, P. Giommi (ASDC), L. Salotti (ASI) on 13 Apr 2010: 14:50 UT

AGILE detection of the new unidentified gamma-ray source AGL J0906-1241

ATel #2552; C. Pittori, F. Verrecchia (ASDC), E. Striani (Univ. Roma Tor Vergata and INFN Roma), M. Tavani (INAF/IASF-Rm), S. Vercellone (INAF/IASF-Pa), S. Sabatini (INAF/IASF-Rm), A. Bulgarelli, F. Gianotti, M. Trifoglio (INAF/IASF-Bo), and Univ. Tor Vergata), A. Chen, A. Giuliani, S. Mereghetti, P. Caraveo, F. Perotti (INAF/IASF-Mi), I. Donnarumma (INAF/IASF-Rm), F. D'Ammando (Univ. Roma Tor Vergata and INAF/IASF-Rm), E. Del Monte, Y. Evangelista, M. Feroci, F. Lazzarotto, L. Pacciani, P. Soffitta, E. Costa, I. Lapshov, M. Rapisarda, A. Argan, G. Piano, G. Pucella, A. Trois, V. Vittorini (INAF/IASF-Rm), F. Fuschino, M. Galli, C. Labanti, M. Marisaldi, G. Di Cocco (INAF/IASF-Bo), A. Pellizzoni, M. Pilia (INAF/OA-Cagliari), G. Barbiellini, F. Longo, E. Moretti, E. Vallazza (INFN Trieste), A. Morselli, P. Picozza (INFN and Univ. Roma Tor Vergata), M. Prest (Universita` dell'Insubria), P. Lipari, D. Zanello (INFN and Univ. Roma Sapienza), P.W. Cattaneo, A. Rappoldi (INFN Pavia), F. Lucarelli, P. Santolamazza, S. Colafrancesco, P. Giommi (ASDC), L. Salotti (ASI) on 13 Apr 2010: 15:14 UT

Main scientific discoveries

- Multifrequency studies of the brightest gamma-ray blazars: (3C 454.3, PKS 1510-089, TX 0716+714, Mrk 421)
- ~10 new Pulsars and PWNs
- discovery of gamma-ray transients in the Galaxy
- discovery of gamma-ray emission from Cygnus X-3 and Cyg X-1
- microquasar studies, Gal. compact objects
- SNRs and origin of cosmic rays, evidence for proton acceleration
- gamma-Ray Bursts, delayed emission, short GRBs
- best detector for Terrestrial Gamma-Ray Flashes



some important topics for transients

- AGILE provides a new and unique view of the gammaray sky near 100 MeV in conjunction with hard X-ray monitoring
- AGILE-GRID and Fermi-LAT provide complementary information: sometimes transients are simultaneously detected below 1 GeV, sometimes they cannot.
- two crucial ingredients (AGILE vs. Fermi)
 - exposure near 100 MeV
 - livetime, real time-coverage of emission
- AGILE is confirmed to be ideal for microquasars, compact objects, Galactic transients and bright blazars
- the best and fastest reaction to gamma-ray transients

Example: Fermi Galactic Centre 1-month integration (20 Feb-20 Mar 2010) off-axis angle vs. time and cumulative histogram (Sabatini etal. 2010)





Conclusions

- AGILE rushing into its 4th year of life in orbit
- spinning AGILE is very successful, good monitoring capabilities, optimal coverage at 100 MeV
- AGILE and Fermi are complementary, often they have different chances of detection (especially for transients)
- discovery potential is high for both Galactic and extragalactic sources
- surprises (GRBs: the big one; some new black hole ?)
- optimized Ground Segment, fastest alerts
- best detector for Terrestrial Gamma-Ray Flashes: also an Earth observatory !
- long life to AGILE !