The AGILE Data Center: data archive and processing, GOP and AO3

Carlotta Pittori, on behalf of the ADC

8th Agile Meeting - The Third Birthday
Bologna, April 28, 2010
The AGILE Payload: the most compact instrument for high-energy astrophysics: only ~100 kg ~60 x 60 cm

ASI Mission with INFN, IASF-CNR e CIFS participation

γ-ray astrophysics: 30 MeV - 30 GeV energy range and simultaneous X-ray capability between 18 - 60 keV
April 23, 2007: Launch!

April 23, 2010: happy third birthday!

Equatorial orbit: 550 Km, < 3° inclination angle
AGILE orbital parameters
Baseline equatorial orbit: 550 Km, 3° inclination

Semi-major axis: 6922.5 km (± 0.1 km)
Requirement: 6928.0 ± 10 km

Inclination angle: 2.48° (±0.04°)
Requirement: < 3°

Eccentricity: 0.002 (±0.0015)
Requirement: < 0.1°

TPZ orbital decay estimate:
Height < 500Km **08 Agosto 2014**

(Jan 13, 2010 **updated estimate**, using recent solar flux “Schatten” forecasts + 2σ)
Telespazio data (from last ASI contractual milestone PM1)

Acquired passages
from May 12, 2009 to December 12, 2009: 97,5% efficiency

Percentages of passages
from 12/05/09 (Pre-OVR4/RF) to 31/12/09 (PM1)
(Total predicted 3295)
AGILE GS Architecture

**AGILE Operation Control Center**
- Satellite Control Center
- Mission Control Center
- Flight Dynamics Center

**ASINet**
- Command, HK, Sci raw data

**Fucino Gateway**

**Fucino, Italy**
- Command, HK, Sci raw data

**ASINet**

**Fucino, Italy**

**ASINet**

**Fucino Gateway**

**Fucino, Italy**

**AGILE Data Center**
- TM L0 & Aux Data
- Long Term Plan Obs Planning File
- AGILE Team Processing Group
- AGILE Science Support Center at ASDC

**AGILE Data Center**

**AGILE Team**
- Calibration, SW for data analysis, ...

**Agile Pointing Program**

**APPC**
- Products and SW

**Scientific Community**
- AO/GOP

**internet**
The AGILE Data Center at **ASDC – ESRIN**

- The ADC, based at ASDC-ESRIN, is in charge of all the scientific oriented activities related to the analysis and archiving of AGILE data:

  From scientific telemetry (TM) Level–0:
  - ✓ Preprocessing → Level-1 data
  - ✓ Quick-Look Analysis (transient detection)
  - ✓ Standard analysis → Level-2 data (photon list)
  - ✓ Scientific analysis (source detection, diffuse gamma-ray background)
  - ✓ Archiving and distributing all scientific AGILE data

**INPUT**: Row data (TM Level-0)

Preprocessing: Level-1 data

Primary data generation: Quicklook & Standard analysis Level-2 data (photon list and logfile)

Scientific analysis: Level-3 data

**OUTPUT**: High level data products (count maps, spectra, light curves…)**
AGILE: “very fast” Ground Segment (with contained costs)

- Satellite
  - Malindi Ground Station
    - Fucino TZP MOC
      - ASDC
        - AGILE Team
          - Guest Observers
            - Public data access
          - Automatic data processing
            - ~ 1 hr
            - ~ 0.5 hr
            - ~ 0.5-1 hr
            - ~ (2-2.5) hr

Record for a gamma-ray mission!
AGILE Science Alert System

• The system is distributed among the ADC @ ASDC and the AGILE Team Institutes (Trifoglio, Bulgarelli, Gianotti et al.)

• Automatic Alerts to the AGILE Team are generated within $T_0 + 45 \text{ min (SA)}$ and $T_0 + 100 \text{ min (GRID)}$

• GRID Alerts are sent via email (and sms) both on a contact-by-contact basis and on a daily timescale

• Refined manual analysis on most interesting alerts performed every day (daily monitoring)
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<thead>
<tr>
<th>#</th>
<th>Date</th>
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<th>Thread</th>
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**Mailbox snapshots**
A recent example:
AGILE-GRID quicklook, April 13, 2010
Two AGILE Atels published on April 13, 2010:

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


on 13 Apr 2010; 14:50 UT

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


on 13 Apr 2010; 15:14 UT
Summary of ASDC activities for AGILE:
(from Agile Science Management Plan)

• Running the Quick Look Analysis
• Running the standard data reduction Analysis
• Performing, when necessary, the Interactive data Analysis
• Managing Announcement of Opportunities
• Contributing to the management of the AGILE Pointing Program
• Archiving all the data (raw, cleaned and calibrated, scientific)
• Distributing the data to the scientific community
• Providing scientific support to the users community
• Officially interface the project for both data and proposals via dedicated web pages
• Providing the standard software support for the data analysis
First AGILE GRID light
ADC 24/5/2007

Commissioning Phase:
AGILE Vela PSR Count Map
(~ 20000 s)
AGILE: 3 years in orbit

• AGILE demonstrates for the first time the covering of ~ 1/5 of the entire gamma-ray sky (FoV ~ 2.5 sr) with excellent angular resolution and competitive sensitivity.
• AGILE shows for the first time an optimal performance of its gamma-ray and hard X-ray imagers.
• > 15530 orbits, April 27, 2010
• Pointing observation mode up to October 18, 2009 (~ 94% Fine Pointings)
• > 2700 orbits in **spinning observation mode** since October

• **Very good scientific performance, especially at ~ 100 MeV**
• **Guest Observer Program open to the scientific community:**
On November 4, 2009, toward the end of Cycle-2, AGILE scientific operations were reconfigured following a malfunction of the reaction wheel. The satellite is currently operating in a **spinning observing mode** and it is now surveying a large fraction of the sky every day. AGILE current spinning sky view:
On December 3-4, 2009 the AGILE satellite detected the strongest $\gamma$-ray flare ever observed ($E > 100$ MeV). The flaring $\gamma$-ray source is in the active galaxy 3C454.3 ($z=0.859$, $F_\gamma > 2 \times 10^{-5}$ ph cm$^{-2}$ s$^{-1}$, $L_{\text{iso}} = 6 \times 10^{49}$ erg s$^{-1}$).
AGILE in pointing mode: 24-month intensity map (E > 100 MeV) (July 2007 – August 2009)
AGILE in spinning: 5-month intensity map (E > 100 MeV) (Nov. 2009 – Mar. 2010)

- Cygnus Region
- Carina-Vela Regions
- Galactic Center
First AGILE Catalog of High Confidence Gamma-Ray Sources

• First year of scientific operations: observations from July 9, 2007 to June 30, 2008. Conservative analysis, with a high-quality gamma event filter.

47 high confidence sources E > 100 MeV:
• 21 confirmed and candidate Pulsars,
• 13 Blazars (7FSRQ, 4BL Lacs, 2 unknown type),
• 2 possible HMXRBs,
• 2 possible SNRs,
• 1 Colliding-wind Binary System (Eta-Car)
• 8 Unidentified sources.

Interactive on-line version of the the First AGILE-GRID Catalog from ADC web page http://agile.asdc.asi.it/
The First AGILE GRID Catalogue of $\gamma$-ray Sources
Period July 2007 -- June 2008

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<tr>
<th>Entry number</th>
<th>AGILE Name</th>
<th>RA (J2000)</th>
<th>Dec (J2000)</th>
<th>Position Error 95% (deg)</th>
<th>sqrt(TS)</th>
<th>Mean Flux E&gt;100MeV (10^-9 pri/cm2/s)</th>
<th>Mean Ring Exposure (cm2 day)</th>
<th>Classification</th>
<th>Confirmed Counterpart</th>
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<td>1</td>
<td>1AGL J006+7311</td>
<td>00:06:34.2</td>
<td>+73:11:06.6</td>
<td>0.63</td>
<td>5.1</td>
<td>23 +/- 5</td>
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<td>GammaPulsar*</td>
<td>CTA1</td>
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<td>+61:11:06.7</td>
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<td>5.3</td>
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Move mouse on a source and click.

- Gal. Center II: 359.970 0.627 265.701
- Anti-Center I: 132.637 8.108 100.844
- SA Crab (8.24): 188.961 16.936 108.283
- SA Crab (15.26): 100.000 22.200 111.702
- Anti-Center II: 197.296 15.717 110.404
- Vulpecula Field: 53.039 6.474 286.259
- North Gal Pole: 104.852 35.439 250.075

Current position: R.A. = 20 21 00.0 Dec. = +40 17 59.9, L = 78.05 b = 2.03

Opt-DSS from eso
NBO

Search radius: 0.2' arcmin
- STSCI MAST
- GSC2
- 2MASS
- NED
- SIMBAD
- SDSS DRA Navigate tool
The X-ray imager SuperAGILE: public source list from interactive pages at ADC:
http://agile.asdc.asi.it/

**SuperAGILE Source Catalog**
(Webspace updated twice a day)

**Available parameters**

- Maxima
- Flux
- Error
- Exposure
- Orbit

**NOTE** for the proper user of the data contained on this Webpage.

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<td>-26 31 44.3</td>
<td>2009-09-27T11:32:14</td>
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<td>0.0045</td>
<td>4.68</td>
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<td>18 01 12.2</td>
<td>-25 44 34.7</td>
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<td>-01 27 07.1</td>
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<td>18 23 46.5</td>
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<td>GX 5-1</td>
<td>18 01 08.1</td>
<td>-25 04 44.4</td>
<td>2009-09-25T05:07:47</td>
<td>0.022</td>
<td>0.0033</td>
<td>7.61</td>
<td>3627</td>
<td>012504</td>
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</tbody>
</table>

46 X-ray (18-60 keV) validated sources, up to October 2009
SuperAGILE public light curves (pointing mode data)
Update: all SuperAGILE detected sources in 3 years including spinning mode data
SOME AGILE HIGHLIGHTS
Gamma-ray brighter blazars detected by AGILE during first year

- 3C 454.3
- PKS 1510-089
- PKS 0716+714
- W Comae
- PKS 0537-441
- BZQ 2025-0735
- 3C 279
- 3C 273
- Mkn 421
- UNID
- BZQ 1849+6705
- UNID
- 3C 454.3
- UNID
AGILE first-year blazar studies summary:

• AGILE (as EGRET and now Fermi) detected only few objects with flux greater than $100 \times 10^{-8}$ ph cm$^{-2}$ s$^{-1}$. Selection effects or there is a subclass of blazar with peculiar characteristics?

• AGILE observations has brought to light a more complex behaviour of blazars with respect to the standard models:
  - the presence of two emission components in any BL Lacs
  - the possible contributions of an hot corona as source of seed photons for the EC in FSRQs

• The study of multi-wavelength correlations is the key to understanding the structure of the inner jet and the origin of the seed photons for the IC process
AGILE Pulsars... three years after...

AGILE detected about 20 gamma-ray pulsars and tens of candidates from the spatial analysis (GO source: Halpern)

AGILE data on 13 Pulsars published so far including >40% of AGILE Team pulsar targets (AO1 & AO2)

Slide adapted from: Alberto Pellizzoni - The Bright Gamma Ray Sky, ASI-ESRIN ‘09
Among the newcomers from timing analysis:

• the remarkable PSR B1509-58 with very high rotational energy losses, with a magnetic field in excess of $10^{13}$ Gauss

• PSR J2229+6114 providing a reliable identification for the previously unidentified EGRET source 3EG 2227+6122.

• Moreover, the powerful **millisecond** pulsar B1821-24, in the globular cluster M28, is detected

• Structured **energy-dependent peaks** (more than two) are evident in pulsar light curves.

• Full exploitation of <100 MeV band in progress (exposure competitive with Fermi)
Galactic gamma-ray sources

- **Carina region**: $\gamma$-ray detection of the colliding wind massive binary system $\eta$-Car with AGILE
  

- **Cygnus region microquasars:**
  - AGILE detects several gamma-ray flares from Cygnus X-3, and also weak persistent emission above 100 MeV
    
  - AGILE observations of Cygnus X-1, one detected gamma-ray flare
    
    Del Monte et al., A&A 2010

- **Detection of Gamma-Ray Emission from the Vela Pulsar Wind Nebula with AGILE**
  
Impulsive events: GRBs and TGFs

- **SuperAGILE** has detected several GRBs in its energy band (18-60 keV) at a rate of about 1 per month while the AGILE Minicalorimeter (MCAL) observes about 1 GRB per week in the energy range 0.7-1.4 MeV on several time scales (Marisaldi et al.). **GRID energies**: only three confirmed GRBs up to now with HE component E > 50 MeV.

- The AGILE Minicalorimeter also detects **Terrestrial gamma-ray flashes**, very interesting events up to 40 MeV on timescales < 5 ms (Marisaldi et al., JGR 115, A00E13, 2010, available online from ADC webpage)

⇒ See afternoon special session
Welcome to the AGILE Data Center Home Page at ASDC

These pages provide updated information and services in support to the general scientific community for the mission AGILE, which is a small Scientific Mission of the Italian Space Agency (ASI) with participation of INFN, IASF/INAF and CIFS.

AGILE is devoted to gamma-ray astrophysics and it is a first and unique combination of a gamma-ray and an hard X-ray imager. It will simultaneously detect and image photons in the 30 MeV - 50 GeV and in the 18 - 60 keV energy ranges.

The AGILE Mission Board (AMB) has executive power overseeing all the scientific matters of the AGILE Mission and is composed of:

- AGILE Principal Investigator: Marco Tavani, INAF/IASF Rome (Chair)
- 1 ASI representative: Paolo Giommi, ASDC
- ASI Mission Director: Luca Salotti, ASI
- AGILE Co-Principal Investigator: Guido Barbieri, INFN Trieste
- Project Scientist: Sergio Cussoni, ASDC

As specified in the Announcement of Opportunity Cycle-2, it is not possible to propose for ToO observations in response to AGILE Announcement of Opportunity. However, observers can propose a ToO at any time during the mission by contacting directly the PI or one of the AMB members.

A proposal, including the ToO proposal and approval will be taken by the full AMB. AGILE Team or other scientists for advice or will belong jointly to the proponent and to the

http://agile.asdc.asi.it
AGILE AO-3

The Italian Space Agency (ASI) announces the release of the third Announcement of Opportunity to solicit proposals for the Guest Observer Program (GOP) of the AGILE mission.

This announcement solicits proposals for observations to be carried out during the observing time beginning on December 1st, 2009, and lasting twelve months.

AGILE-GRID data for sources not reserved to the AGILE Team can be requested within the AGILE Guest Observer Program. AO3 Guest Observers can request data for:

- specific 1AGL, 1FGL and 3EG catalogue sources;
- pulsars;
- Active Galactic Nuclei.

Top level documentation regarding the AO3 can be found here:

- Agile AO3 Policies and Procedures
- Agile AO3 Team Reserved Sources

Proposals may be prepared and submitted using a set of dedicated ASDC GOP on-line services (Proposal Preparation).

Please remember that users must register in order to access the "proposal submission tool" and to prepare and update their proposals before final submission.
AGILE AO1: completed
Submitted proposals: 29
Approved/P. Approved: 24
Requested Targets: 122
Approved Targets: 100
Pulsars: 39
AGN: 31
3EG sources: 30

Cycle-1 GOP Schedule

- SW build GO 1.0 + test dataset: released on May 22, 2008
- Cycle-1 data distribution:
  - first delivery (17 OBs) on June 5, 2008
  - second delivery (3 OB) on July 17, 2008
  - last complete data release on Dec 23, 2008
AGILE AO2:
Submitted/Approved proposals: 15
14 PI, 74 co-PI
Requested/Approved Targets: 93
Pulsars: 21
AGN: 62
3EG sources: 10

AGILE SW & AO2 Data Distribution Schedule

- First public SW build + test dataset: delivered on May 22, 2009
- New SW release (4.0): delivered on October 6, 2009
- AO2 (+ AO1 reprocessed) GO data packets ready: delivered on October 6, 2009
AGILE AO3 now open!!!

Proposals can be submitted up to April 30, 2010

AGILE in spinning is now surveying a large fraction of the sky every day and during Cycle-3 it will not follow a predefined Baseline Pointing Plan as in previous observing Cycles.

Guest Observers can apply for data rights of AGILE Cycle-3 observations, from December 1, 2009 to November 30, 2010.

AO3 key dates:
- Release of AO3: March 30, 2010
- Due date for proposals: April 30, 2010
- AO3 Observing Period (Cycle-3): December 1, 2009 - November 30, 2010

The complete documentation for this AO3 can be found on-line at the AGILE-ASDC web pages http://agile.asdc.asi.it/ao3.html
AGILE Public Data Distribution from the ASDC MMIA

• **First public delivery** (17 OBs): June 5, 2009
• **Second public delivery** (3 OBs): July 17, 2009
• **Publication of a reprocessed Cycle-1 (20 OB) dataset**: October, 2009
• **Complete Cycle-1 public data release**: Dec 23, 2009
Conclusions

• AGILE is operating nominally producing data in spinning with quality similar to that obtained when operating in pointing mode (15 ATels and 1 GCN since November 2009)

• All ADC functionalities and data processing promptly adapted to the new spinning configuration

• In progress: new optimized attitude reconstruction, improvement both for spinning and pointing data

• Complete reprocessing of AGILE data will be done during the next few months. New reprocessed archive and new source catalog will be available from ADC webpages
AGILE Data Center

AOCC

Long Term Plan/Obs Planning File

Data Analysis System

Mission Planning System

Data Archive System

Data and SW Distribution System

Data Analysis System

L1, L2, L3 Products,
Data analysis
SW
TM, L0, Aux Data

SW Development and Integration System

Agile Pointing Program

APPCC

AGILE Team

Calibration,
SW for data analysis

Data (Aux, L0, L1, L1cor)

internet

Scientific Community

AO/Guest Observer Program

AO/Guest Observer Program

Data (Aux, L0, L1, L1cor)

Data Archive System

SW Development and Integration System

Data and SW Distribution System

Products, Catalogues,
SW for Data Analysis

GOP

AO
AGILE data flow and Ground Segment organization (from Agile Science Management Plan)
<table>
<thead>
<tr>
<th><strong>Gamma-ray Imaging Detector (GRID)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy Range</strong></td>
<td>30 MeV – 50 GeV</td>
</tr>
<tr>
<td><strong>Field of view</strong></td>
<td>$\sim 3 \text{ sr}$</td>
</tr>
<tr>
<td><strong>Sensitivity at 100 MeV (ph cm$^{-2}$ s$^{-1}$ MeV$^{-1}$)</strong></td>
<td>$6 \times 10^{-9}$ (5$\sigma$ in 10$^6$ s)</td>
</tr>
<tr>
<td><strong>Sensitivity at 1 GeV (ph cm$^{-2}$ s$^{-1}$ MeV$^{-1}$)</strong></td>
<td>$4 \times 10^{-11}$ (5$\sigma$ in 10$^6$ s)</td>
</tr>
<tr>
<td><strong>Angular Resolution at 1 GeV</strong></td>
<td>35 arcmin (68% cont. radius)</td>
</tr>
<tr>
<td><strong>Source Location Accuracy</strong></td>
<td>$\sim 5$–20 arcmin S/N$\sim 10$</td>
</tr>
<tr>
<td><strong>Energy Resolution</strong></td>
<td>$\Delta E/E \sim 1$ at 300 MeV</td>
</tr>
<tr>
<td><strong>Absolute Time Resolution</strong></td>
<td>$\sim 1 \mu$s</td>
</tr>
<tr>
<td><strong>Deadtime</strong></td>
<td>$\sim 200 \mu$s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Hard X-ray Imaging Detector (Super-AGILE)</strong></th>
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<tbody>
<tr>
<td><strong>Energy Range</strong></td>
<td>10 – 40 keV</td>
</tr>
<tr>
<td><strong>Field of view</strong></td>
<td>$10^7 \times 68^\circ$ FW at Zero Sens.</td>
</tr>
<tr>
<td><strong>Sensitivity (at 15 keV)</strong></td>
<td>$\sim 5 \text{ mCrab}$ (5$\sigma$ in 1 day)</td>
</tr>
<tr>
<td><strong>Angular Resolution (pixel size)</strong></td>
<td>$\sim 6$ arcmin</td>
</tr>
<tr>
<td><strong>Source Location Accuracy</strong></td>
<td>$\sim 2$–3 arcmin S/N$\sim 10$</td>
</tr>
<tr>
<td><strong>Energy Resolution</strong></td>
<td>$\Delta E &lt; 4$ keV</td>
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<tr>
<td><strong>Absolute Time Resolution</strong></td>
<td>$\sim 4 \mu$s</td>
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<tr>
<td><strong>Deadtime (for each of the 16 readout units)</strong></td>
<td>$\sim 4 \mu$s</td>
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<tr>
<th><strong>Mini-Calorimeter</strong></th>
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<td><strong>Energy Range</strong></td>
<td>0.3 – 200 MeV</td>
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<tr>
<td><strong>Energy Resolution</strong></td>
<td>$\sim 1 \text{ MeV}$ above 1 MeV</td>
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<tr>
<td><strong>Absolute Time Resolution</strong></td>
<td>$\sim 3 \mu$s</td>
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<tr>
<td><strong>Deadtime (for each of the 30 CsI bars)</strong></td>
<td>$\sim 20 \mu$s</td>
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