AGILE and Blazars

S. Vercellone – INAF / IASF Milano

on behalf of the AGILE Team
1. Status of the AGILE Mission and AGILE Performance
2. AGILE Pointing Plan and In-Flight Calibrations
3. Blazar Studies and The AGILE Team AGN Working Group (AT-AWG)
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AGILE is a Scientific Mission supported by ASI with scientific and programmatic participation by INAF and INFN.

AGILE will monitor and detect sources in the energy bands 30MeV – 50 GeV (GRID) and 20 – 45 keV (Super-AGILE).

Total satellite mass ~ 350 kg (Small Explorer - SMEX - class).

Scientific Instrument mass: 120 kg.

A highly innovative Instrument!
AGILE Satellite
Flight Model
(CGS, Tortona)

See [http://agile.iasf-roma.inaf.it](http://agile.iasf-roma.inaf.it) for a detailed description of the Instrument
1. **Scientific Payload**
   - Integrated, Calibrated and under final functional testing

2. **Satellite**
   - Integrated and under final functional testing

3. **Software**
   - Standard Analysis SW (V1.0) delivered to the ASI Science Data Centre

4. **Launch windows**
   - October 2006
   - January - February 2007
## Gamma-ray Imaging Detector (GRID)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Range</td>
<td>30 MeV – 50 GeV</td>
</tr>
<tr>
<td>Field of view</td>
<td>( \sim 2.5 \text{ sr} )</td>
</tr>
<tr>
<td>Sensitivity at ( (F&gt;100 \text{ MeV}) )</td>
<td>30 ( \times 10^{-8} \text{ ph cm}^{-2} \text{ s}^{-1} )</td>
</tr>
<tr>
<td>Angular Resolution (68% cont. radius at 400 MeV)</td>
<td>1.2°</td>
</tr>
<tr>
<td>Source Location Accuracy</td>
<td>( \sim 15 \text{ arcmin} )</td>
</tr>
<tr>
<td>((S/N \sim 10, 90 \text{ c.l. radius at high GLAT}))</td>
<td>( \Delta E/E \sim 1 ) \text{ (at 400 MeV)}</td>
</tr>
<tr>
<td>Energy Resolution</td>
<td>( \sim 2 \mu s )</td>
</tr>
<tr>
<td>Absolute Time Resolution</td>
<td></td>
</tr>
</tbody>
</table>

## Hard X–ray Imaging Detector (Super-AGILE)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Range</td>
<td>20 – 45 keV</td>
</tr>
<tr>
<td>Field of view</td>
<td>( 107° \times 68° )</td>
</tr>
<tr>
<td>( (\text{of each half detector FW at Zero Sens.}) )</td>
<td>( \sim 15 \text{ mCrab} )</td>
</tr>
<tr>
<td>Sensitivity ( (5\sigma \text{ in 50 ksec, on-axis}) )</td>
<td>( \sim 6 \text{ arcmin} )</td>
</tr>
<tr>
<td>Angular Resolution (sky pixel size on-axis)</td>
<td>( \sim 2-3 \text{ arcmin} )</td>
</tr>
<tr>
<td>Source Location Accuracy (for sources at 10( \sigma ))</td>
<td>( \Delta E=8 \text{ keV} )</td>
</tr>
<tr>
<td>Energy Resolution</td>
<td>( \sim 5 \mu s )</td>
</tr>
<tr>
<td>Absolute Time Resolution</td>
<td></td>
</tr>
</tbody>
</table>
Super-AGILE, AGILE-GRID $|\theta|<10$ deg Sens.

- Super-AGILE
- AGILE-GRID

Sensitivity ($\gtrsim E$) [ph.cm$^{-2}$s$^{-1}$]

- $10^{-2}$
- $10^{-1}$
- $10^{-0}$
- $10^{-1}$
- $10^{-2}$
- $10^{-3}$
- $10^{-4}$

Energy [MeV]

- $10^{-2}$
- $10^{0}$
- $10^{2}$
- $10^{4}$

1 Crab

- 2 days
- 2 weeks
- 1 year

Part. bkg.: 0.01–0.1 Hz

20% occultation

30 degrees off-axis
The AGILE Gamma Ray Imaging Detector calibration at BTF is aimed at obtaining data for all relevant geometries and background conditions. BTF can provide data in the energy range (30-700 MeV)

**BTF-AGILE Schedule**
- photon tagging system (PTS)
- spectrometer PTS calibration
- final equipment test (Oct. 2005)
- AGILE calibration, 3 weeks of data collection
On-axis photon beam
Gamma-Rays detected by the AGILE-GRID during the May 2006 final functional test campaign.

WIDE Field of View and GOOD $\gamma$-ray sensitivity

(Courtesy of A. Giuliani)
1. Status of the AGILE Mission and AGILE Performance

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AGILE overall schedule

<table>
<thead>
<tr>
<th>Phase</th>
<th>Duration [months]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch</td>
<td>$T_0$</td>
</tr>
<tr>
<td>Commissioning</td>
<td>$T_0 - (T_0 + 2)$</td>
</tr>
<tr>
<td>Science Performance Verification</td>
<td>$(T_0 + 2) - (T_0 + \text{TBD})$</td>
</tr>
</tbody>
</table>
AGILE pointing Constraints:

1. Solar panels always orthogonal to the Sun vector.
2. On-axis pointing directions are limited to a great circle, changing day-by-day

...BUT...

AGILE-GRID wide field of view (60 deg radius)

- Easy to include particular sources with a fine-tuning of the pointing direction
- Increased chances to detect a transient source
Sources visible on 25/5 \( D \leq 60.0 \)
AGILE Science Management Plan

- High level document issued in February 2004
- Defines:
  - Scientific Management of the mission
  - Guidelines for Pointing Program
  - High level project organization and share of responsibilities for ground segment
  - Scientific Programs and Data Rights Policies
AGILE Scientific Program

- Pointing Plan defined *a priori*
  - to optimize sky coverage, multi-\(\lambda\) programs, etc....
  - "Data" allocation instead of "Time" allocation

- SuperAGILE (20 - 40 keV) → publicly available RESULTS (no SuperAGILE data distributed)

- GRID data (30 MeV – 50 GeV)
  → AGILE Team Projects
  → Guest Observers Program

AO document in Preparation (AT + ASI)
1. **Calibration Sources**

   - Sources with known X-ray and gamma-ray flux
   - Intense and steady
   - **PULSARS!**

2. **Calibration strategy**

   - Calibration of the entire field of view: *large amount of time*
   - GRID and SA calibration: *small off-axis required (SA)*
In-Flight Calibration & SPV Issues

Theta < 10°

10° < Theta < 60°

Theta > 60°
Crab

Vela
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Multi-λ Studies: so many Blazars!

- EGRET IDEN. AGNs: 67
- EGRET CAND. AGNs: 27
- KUEHR BLLAC OBJ.: 26
- KUEHR FSRQ OBJ.: 203
- VERON BLLAC OBJ.: 447
- VERON QSO OBJ.: 1426
Not all blazars are gamma-ray emitters…

1. **Blazar gamma-ray duty-cycle**
   - Stecker and Salamon, 1996
   - Vercellone et al., 2004

2. **Radio – gamma-ray relationship**
   - Padovani et al., 1993
   - Dondi & Ghisellini, 1996
   - Mucke et al., 1997
   - Jorstad et al., 2001

3. **Lorentz factor and Doppler factor**
   - Kellermann et al., 2004

4. **Structured Jets (radio galaxies)**
   - Ghisellini et al., 2005
Multi-\(\lambda\) Studies

We expect:

- to detect about 2 – 3 times more AGNs than EGRET.
- a dozen of AGNs simultaneously within the GRID FoV during each viewing period.
- 5 – 10 blazars flaring above 100x10\(^{-8}\) ph/cm\(^2\)/s (E>100MeV) during the first year of AGILE observations.
Multi-λ Studies: hottest AGNs?
3C454.3 - ROQUE DE LOS MUCHACHOS - GRID Dist.: 30 deg.
Multi-λ Studies : 3C454.3

Tavani, Vercellone, Vittorini et al., in prep.
Multi-λ Studies: 3C454.3

$\nu F(\nu)$ [erg cm$^{-2}$ s$^{-1}$]

$\nu$ [Hz]

$F(\nu)$ [erg cm$^{-2}$ s$^{-1}$]

Frequency [Hz]

Tavani, Vercellone, Vittorini et al., in prep.

SA

GRID

Swift/XRT PC Spectra

Stefano Vercellone, AGN7, 25/05/2006, p. 30
AT – AWG current members (alphabetical order):

- PI, co.PI and members of the AGILE Team Science Board, or their representatives;
- A. Ferrari (Turin University), Chair.
- 1 representative ENIGMA Network
- 1 representative INAF-IRA, Bologna
- 1 representative Perugia Observatory
- 1 representative REM project, Brera Observatory
- 1 representative Turin Observatory
- 1 representative University of Como
- 1 representative University Tor Vergata, Rome
- 1 representative WEBT Consortium.
Multi-\(\lambda\) Studies : AT-AWG

AT – AWG role:

- optimizing the scientific return of future proprietary data obtained by the AGILE Team for the study of AGNs.

AT – AWG Scientific goals:

- provide the forum for general discussion and coordination between the AGILE Team and the Community

- rapid reaction to alerts for AGN flaring activity carrying out ground-based multiwavelength observations simultaneously with AGILE. In particular, a primary AT-AWG goal is to obtain, for a selected set of sources, a continuous coverage of optical observations of AGNs during gamma-ray flares lasting several days/weeks.

- long-timescale (months-years) monitoring of a selected number of AGNs to be used jointly with AGILE data for correlative multiwavelength (optical-radio) studies.

- VLBI/VLBA deep radio imaging of AGNs, with regular monitoring and through ToO observations following high-energy flaring activity of interest to AGILE.
Some example of AGNs Science with AGILE:

- The study of the **acceleration and radiation processes** of AGNs jets thanks to multi-\(\lambda\) studies and \(\gamma\)-X-ray detections.

- The **AGN duty-cycle** of the \(\gamma\)-ray flare and “plateau” states, because of its large FOV and long-term monitoring programs.

- The study of **AGN SEDs** with X-ray and \(\gamma\)-ray simultaneous data.

- The study of the correlation between \(\gamma\)-ray flares and **radio plasmoid** ejections.
http://agile.iasf-roma.inaf.it
THE END
Gamma-Rays detected by the AGILE-GRID during the May 2006 final functional test campaign.

WIDE field of view and GOOD gamma-ray sensitivity

(Courtesy of A. Giuliani)
Reconstructed Energy: 
$E = 400$ MeV
Incoming Direction: 
$\theta = 20$ degrees
18 pointings (21 days each)
To be approved!

Exposure Map (cm$^2$ s $\Phi$ $E>100$ MeV)

AGILE Pointing Plan: current status

Stefano Vercellone - AGN7 - 25/05/2006 - p. 39
Agile: FIRST and unique combination of a gamma-ray imager and an X-ray imager
(30 MeV-30 GeV) (15-45 keV)
B) SuperAgile - Sviluppo Unità PFM

COLLIMATORE-MASCHERA

Collimatore

Assembly

Maschera