One year of Gamma Ray Bursts observation with AGILE

E. Del Monte

on behalf of the AGILE team
Gamma Ray Bursts and AGILE

- Gamma Ray Bursts are among the most important scientific objectives of AGILE;

- The bursts can be triggered onboard by SuperAGILE and MCAL and can be localized onboard by SuperAGILE;

- The GRB position reconstructed by SuperAGILE is delivered by using the ORBCOMM alert system, independent on the telemetry downlink;

- Ground trigger software procedures are active on the SuperAGILE and MCAL telemetry data;

- SuperAGILE, MCAL, INTEGRAL as well as Swift-BAT GRBs are searched for in the GRID data;

Ettore Del Monte, INAF IASF Roma
AGILE instrumentation

The AGILE payload is composed of two imaging instruments:

**Gamma Ray Imaging Detector (Silicon Tracker & Mini-calorimeter):**
- 30 MeV – 50 GeV;
- ~2.5 sr FoV;
- 0.3 – 200 MeV (non imaging);

**SuperAGILE:**
- 18 – 60 keV;
- ~0.8 sr FoV;
- 10 mCrab (3σ in 1 day);
- 1 Crab (3σ in 10 s);

Ettore Del Monte, INAF IASF Roma
SuperAGILE: imaging performances

SuperAGILE is a twice 1-D coded aperture imager. The field of view is composed of two crossing regions of $107^\circ \times 68^\circ$. The source location accuracy is 1 arcmin for intense sources and the error box is 3 arcmin.

Ettore Del Monte, INAF IASF Roma

Seminario ICRA, 24 July 2008
Experimental tests of the on-board GRB detection system

[Diagram showing support structure, satellite, SuperAGILE, shutter, source accommodation, x axis image, z axis image]

Ettore Del Monte, INAF IASF Roma

Seminario ICRA, 24 July 2008
GRB 070622 has been detected early by SuperAGILE during the Commissioning Phase. This Gamma Ray Burst was localized by the Interplanetary Network (IPN) and was well outside the SuperAGILE FoV: $\sim 100^\circ$ off-axis.
GRB 070724B: the first gamma ray burst localized by SuperAGILE and its Swift X-ray afterglow


Ettore Del Monte, INAF IASF Roma

Seminario ICRA, 24 July 2008
GRB 071104: AGILE is Up and Running, waiting for the “big one”

SA Position (GCN 7042, Donnarumma et al.)

X-ray Afterglow with Swift
(GCN 7043, Page et al.)

NIR Afterglow: $I_{mag}=20.5$ @ hrs
(GCN 7130, TNG, Antonelli et al.)
Seminario ICRA, 24 July 2008
Current performances: on-board localization of GRB 080408

- SuperAGILE and MCAL on-board triggers are currently running with timescale of 64 ms – 8 s;
- the uncertainty of the on-board position is \( \sim 20 \) arcmin;
- the burst alert message is delivered with a typical delay of 10 – 30 minutes;
- the uncertainty of the refined (off-line) position is 3 arcmin;
- MCAL, SuperAGILE, Swift-BAT and INTEGRAL GRBs are automatically searched for in the GRID data;
In the period July '07 – June '08: 49 GRBs detected (~1 GRB / week)
9 localized by SWIFT
8 localized by IPN (many more expected)
5 localized by SuperAGILE (other SuperAGILE localizations without MCAL detection)
MCAL GRB detections

Detections with scientific ratemeters, 1 s time resolution, 11 energy bands, before Feb. 2008

Detections with onboard trigger logic, any time and energy resolution, Dec. 2007 and since Feb. 2008
Ettore Del Monte, INAF IASF Roma

MCAL & GRB: spectral coverage

GRB070825: significant detection in the 5.6-11 MeV band

GRB080407B: the highest fluence GRB detected with onboard trigger logic
GRBs also detected by MCAL at $\theta<90^\circ$

GRBs also detected by MCAL at $\theta>90^\circ$

GRB at $\theta<90^\circ$

NOT detected by MCAL

All spectral data point taken from Suzaku WAM GCN, sensitivity curves computed following Band (2003)

Ettore Del Monte, INAF IASF Roma

Seminario ICRA, 24 July 2008
GRID upper limits

<table>
<thead>
<tr>
<th>GRB</th>
<th>localization</th>
<th>off-axis [deg]</th>
<th>upper limit [10^{-4} ph/cm^2]</th>
</tr>
</thead>
<tbody>
<tr>
<td>080210</td>
<td>Swift/BAT</td>
<td>36.5</td>
<td>3.6</td>
</tr>
<tr>
<td>080413</td>
<td>Swift/BAT</td>
<td>48.5</td>
<td>1.4</td>
</tr>
<tr>
<td>080430</td>
<td>Swift/BAT</td>
<td>40.1</td>
<td>6.0</td>
</tr>
<tr>
<td>080506</td>
<td>Swift/BAT</td>
<td>50.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>
AGILE and the Interplanetary Network

SuperAGILE and MCAL are active members of the Interplanetary Network, a collaboration of Konus-Wind, Mars Odyssey, INTEGRAL, Suzaku, RHESSI, MESSENGER and other satellites. GRB and other intense transients are localized by using the triangulation method, based on the delay of the arrival time of a burst to different and far experiments.

Ettore Del Monte, INAF IASF Roma  
Seminario ICRA, 24 July 2008
GRB 070824 has been detected by SuperAGILE but it was at 48° off-axis and could be imaged only in 1-D. The combination of the annulus from the Interplanetary Network and the SuperAGILE 1-D strip gives a localization reducing the error box area from ~9 square degrees (without SuperAGILE) down to ~1 square degree (with SuperAGILE, see GCN 6767).

Ettore Del Monte, INAF IASF Roma

Seminario ICRA, 24 July 2008
AGILE detects the first gamma-ray emission from a GRB in the afterglow era: GRB 080514B

GRB 080514B has been localized jointly by SuperAGILE and IPN (GCN 7715) and shows a significant gamma ray emission (GCN 7716).

Ettore Del Monte, INAF IASF Roma

Seminario ICRA, 24 July 2008
Gamma-ray observation of GRB 080514B

SuperAGILE lightcurve

4/12 photons

8/12 photons

Ettore Del Monte, INAF IASF Roma

Seminario ICRA, 24 July 2008
Flux and fluence of the prompt emission of GRB 080514B

fluence
3.2 \times 10^{-5} \text{ erg/cm}^2

peak flux
2.1 \times 10^{-5} \text{ erg/cm}^2/s

E_{\text{peak}}
224 \text{ keV}

All measured by Konus-Wind in 20 keV – 5 MeV (GCN 7751).

In the BATSE 50 – 300 keV band the peak flux belongs to the top 1% of the Fourth BATSE Catalogue.
The flux measured by SuperAGILE (18 – 60 keV) is \sim 2 \times 10^{-7} \text{ erg/cm}^2/s.
The fluence in 350 – 700 keV is \sim 7 \times 10^{-6} \text{ erg/cm}^2
Follow-up by Swift (GCN 7723 and 7750) provided the afterglow in X-rays.

I=20.4 mag at 17.3 hours (IAC80, GCN 7719), g’=21.2 mag at 21 hours with slow fading (GROND, GCN 7722), R = 22.5 mag at 1.8 days (NOT, GCN 7734) and R = 23.9 mag at 24.1 days (Keck, GCN 7874).

The photometric redshift from UVOT (GCN 7759) and NOT (GCN 7734) is in the range $1.9 < z < 2.3$.

The properties in X-rays and optical are typical for the GRB afterglows.
Latest news: detection of the bright and hard GRB 080721

SuperAGILE and MCAL detected GRB 080721 (~49° off-axis), already localized by Swift/BAT (GCN 7988 and 7992). The GRB was inside the GRID FoV and the analysis is still in progress. The burst had a fluence of about $8 \times 10^{-5}$ erg/cm$^2$ in 20 keV – 5 MeV with $E_{\text{peak}}$ of 485 keV (Konus-Wind, GCN 7995) and it was at redshift 2.6 (GCN 7997).

The GRB is at \( \sim 13^\circ \) off-axis. The average flux corresponds to \( \sim 10 \) Crab in 18 – 60 keV \( (7.6 \times 10^{-8} \text{ erg/cm}^2/\text{s}) \).

No significant gamma-ray emission is detected, with a 99% c.l. upper limit of 0.03 photons/cm\(^2\) for energy greater than 50 MeV (GCN 8006).

The fluence in the 350 – 700 keV range is \( (8 \pm 2) \times 10^{-6} \text{ erg/cm}^2 \) (GCN 8006).
…not only GRBs: galactic X-ray bursts as well

On 26 March 2008 SuperAGILE detected and localized a type I X-ray burst from IGR J17473-2721/XTE J1747-274 (Atel 1445). The source, still unidentified, can thus be classified as a LMXB. For more information see Atel 1445, 1459, 1460, 1461 and 1468;

SuperAGILE detected a bright burst from the Soft Gamma Repeater SGR 1806-20 on 9 March 2008. The burst was so bright that it could be observed with 10 ms resolution;
Conclusions

SuperAGILE routinely localizes about 1 GRB every two months. About a factor of 2 more GRBs are detected outside the field of view.

MCAL detects about 1 GRB/week with on-board trigger and photon-by-photon data;

SuperAGILE and MCAL are active members of the Interplanetary Network (IPN), which localizes the GRBs by using the triangulation method. Among the IPN SuperAGILE cooperated in the localization of GRB 080407B, the Gamma Ray Burst with the maximum duration ever detected;

The reconstruction of the GRB positions by SuperAGILE has improved up to a source location accuracy of 1 arcmin and an error box of 3 arcmin;

GRID detected a significant gamma ray counterpart of GRB 080514B, the first one after EGRET and in the afterglow era;

The onboard trigger and imaging system of SuperAGILE has successfully detected and localized not only GRB but also X-ray bursts from SGR and unidentified galactic sources.