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Authors	BULGARELLI, ANDREA; TRIFOGLIO, MASSIMO; GIANOTTI, Fulvio; DI COCCO, GUIDO; TAVANI, Marco
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AGILE-GRID Automated Web-based Analysis System for Fast Detection of Gamma-ray Transients

A. Bulgarelli,[1] M. Trifoglio,[1] F. Gianotti,[1] G. Di Cocco,[1] and M. Tavani[2]

Abstract. AGILE is a Scientific Mission dedicated to high-energy astrophysics supported by the Italian Space Agency (ASI) with scientific participation of INAF and INFN. The AGILE Payload is designed to detect and image photons in the 30 MeV-50 GeV and 15-45 keV energy bands. It was successfully launched on 23 April 2007.

This paper describes the AGILE GRID Science Monitoring system (AGILE `WebMon-GSM`) developed by the Agile Team to perform the automatic analysis of the AGILE Gamma-Ray Imaging Detector (GRID) observations. The primary design goal for this tool is to provide a simple, fast, world-wide accessible technique for detection and alerts on galactic and extra galactic transients in the Field of View (FOV) of the GRID detector. The use of automatic detection algorithms based on driven-search and blind-search methods will be discussed.

1. Introduction

The AGILE Payload (Tavani et al. 2009) is composed of three detectors: a Tungsten-Silicon Tracker (ST), with a large field of view ∼2.5 sr), optimal time resolution and angular resolution, and good sensitivity (Barbiellini et al. 2002; Prest et al. 2003); a Silicon-based X-ray detector, Super-AGILE (SA) for imaging in the energy range 18 keV-60 keV (Feroci et al. 2007), and a CsI(Tl) Mini-Calorimeter (MCAL) that detects gamma-rays or particle energy depositions between 300 keV and 100 MeV (Labanti et al. 2006). The instrument is surrounded by an anti-coincidence (AC) system to reject particle background (Perotti et al. 2006). Accurate timing, positional and attitude information are provided by a Global Positioning System (GPS) receiver and two Star Sensor (SS) units. The Payload Data Handling Unit (PDHU) is in charge of managing the data coming from all the above Payload components. In particular, the PDHU generates the GRID event data telemetry by gathering the event data of the ST, MCAL, AC detectors, and the auxiliary information of the GPS and SS.

Due to the low equatorial orbit, the AGILE telemetry (TM) is down-linked every 100 minutes to the ASI ground station at Malindi, Kenya. Within a few minutes of a satellite pass, all TM packets are relayed in raw format to the Mission Operations Centre at Fucino, and then to the ASI Science Data Center (ASDC) in Frascati (Roma). At ASDC, the raw data are translated by the Telemetry Pre-Processing System (Trifoglio et al. 2008) into one FITS file for

[1]INAF/IASF Section of Bologna, Italy

[2]INAF/IASF Section of Roma, Italy

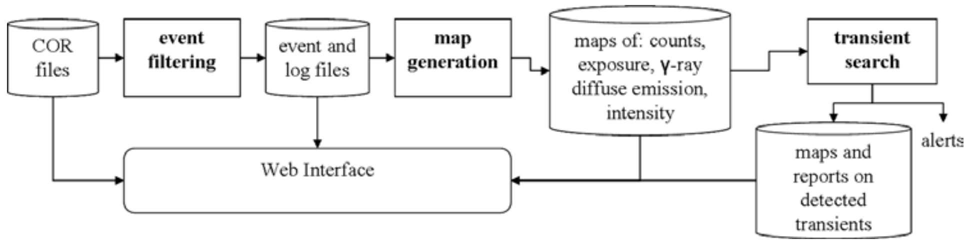

Figure 1.: AGILE WebMon-GSM overall architecture.

each different telemetry layout in order to form a Level-1 (LV1) Archive. The LV1 files are available to the scientific pipelines and to the monitoring tasks within 25 minutes from the end of the contact.

2. System Description

The AGILE `WebMon-GSM` system runs in the framework of the AGILE `WebMon` system (Bulgarelli et al. 2008) which processes on an orbit-by-orbit basis the LV1 files to provide worldwide access to the sensible data related to the Payload instrument health and science monitoring. The input data to AGILE `WebMon-GSM` are the COR files that AGILE `WebMon` generates by duplicating the relevant LV1 files (GRID event, SS, GPS, payload and spacecraft housekeeping files) amended with all data times aligned to terrestrial time and corrected for satellite attitude information.

As sketched in Figure 1, the system foresees three main stages: (a) event filtering, which applies the software modules of the AGILE standard analysis (Vercellone et al. 2006) to reconstruct the event characteristics and filter out the background events, (b) map generation, which executes the software modules of the AGILE scientific analysis (Chen et al. 2009) to build maps of the last 24 hours of GRID observation, and (c) transient search, which exploits blind-search and driven-search techniques to check for the presence of galactic or extra-galactic transients in the field of (FOV) view of the GRID detector. The system operations are sequenced and controlled by Ruby scripts. Any input and output data is made available to the Agile Team by the web interface in the framework of the AGILE `WebMon` system. E-mail and SMS alert messages are sent to the AGILE Team in case the significance of the detection is above predefined thresholds. The alerts are generated within 60-90 minutes from the end of the contact.

2.1. Event Filtering

The direction of the GRID events is reconstructed by a Kalman filter technique. To reduce the particle background contamination, the event selection is performed with a background filter. Orbit-by-orbit, this step applies all the available background filters to the GRID events contained in the COR files of the given orbit. At the time of writing we typically use two background filters called $F4$ and $FT3ab$. Other filters are under development and testing. For each filter, an event file for each orbit is produced which contains the corresponding

J2000 RA and DEC coordinates calculated for each event. In addition a log file that contains the attitude of the spacecraft is produced.

2.2. Map Generation

The events and the log files generated by the previous step are processed to produce a set of maps to be used for the next step. The maps of counts, exposure, gamma-ray diffuse emission, and intensity are generated at each new orbit with a bin dimension of 0.5°, a FOV of 100° and 120° (depending on the type of transient search) and a standard integration period of one day. A spectral index of -2.1 and the energy range of 100-50000 MeV are used. Each map is centered in the pointing direction corresponding to the mean value of the RA/DEC values provided by the log file for each orbit. This takes into account the drift of the AGILE satellite during the whole pointing period.

2.3. Transient Search

As mentioned above, the detection of transient sources is based on driven-search and blind-search methods. The former takes the position of known sources from various catalogues and performs the Maximum Likelihood ratio test statistic methods (ALIKE) (see Mattox et al. 1996; Chen et al. 2009) on the data contained in the AGILE maps having a FOV of 120°. Further details are given in Bulgarelli et al. (2008).

The blind-search is new functionality we added by developing a new task called SPOT. This task uses as input the maps having FOV of 100°. As a first step, it extracts from the intensity map the list of the more intensive spots. Hence, it applies on these spots the ALIKE method mentioned above. To this purpose, the SPOT task reads the list of the spots and the GRID maps of exposure, counts, and diffuse emission. Then, it calculates the test statistic, significance, counts and flux of each of the point sources at their given positions in the presence of simultaneously optimized fluxes of all nearby sources in the list, and it saves the results to a text file. An input parameter sets the minimum test statistic threshold below which sources are discarded at the first iteration. At the second iteration, sources may dip below the threshold. The sources are sorted by flux before the optimization occurs. An example of the SPOT output is shown in Figure 2.

3. Conclusion

The AGILE GRID Science Monitoring system is being successfully used by the AGILE Team to support orbit-by-orbit, through the WEB, the regular activities for the science monitoring of the AGILE GRID data. Alerts to the AGILE team are sent automatically in case a transient is found with high significance, thus allowing a fast reaction and a deeper analysis (the alerts are generated within 60-90 minutes from the end of the contact). Moreover the AGILE `WebMon-GSM` provides a development and test bed for the software modules procured by the AGILE Team for the standard and scientific pipelines running at the ASI AGILE Science Data Centre.

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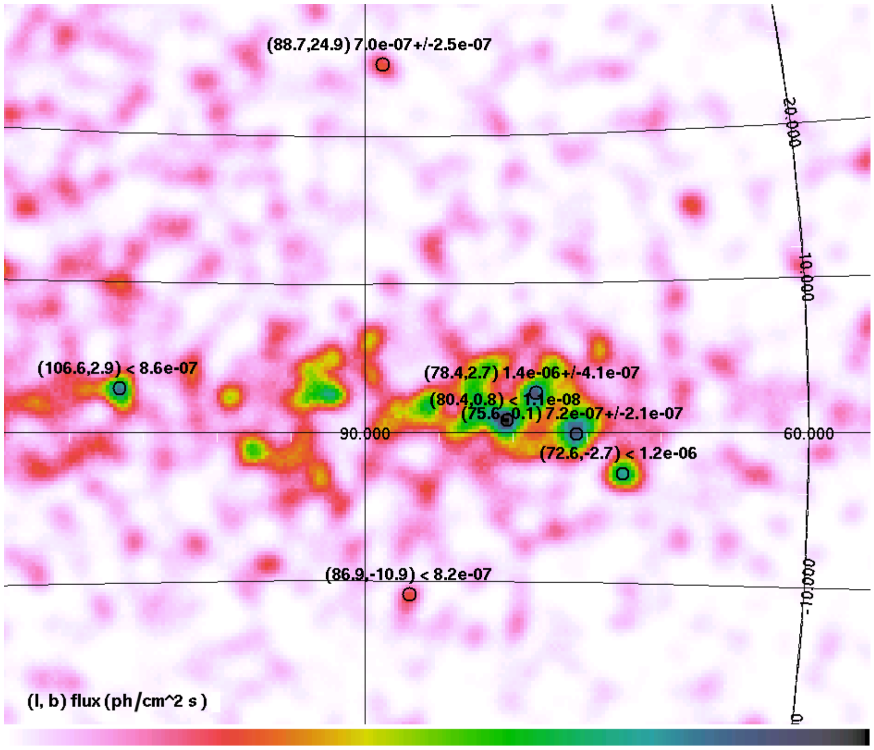

Figure 2.: An example result from the SPOT task. It shows an AGILE gamma-ray sky counts map of the Cygnus region in Galactic Coordinates (l, b) and the estimated flux in photons cm^{-2} s^{-1} for each spot confirmed by the ALIKE analysis. Black circles identify the spot position but not the confidence level. The "<" symbol means that the measured flux is an upper limit.

Institute of Astrophysics (INAF) and the Italian Institute of Nuclear Physics (INFN).

References

Tavani M., et al. 2009, submitted to A&A, arXiv:0807.4254v1 [astro-ph]
Barbiellini G., et al. 2002, Nucl. Instrum. and. Meth. in Phys. Res. A, 490, 146
Prest M., et al. 2003, Nucl. Instrum. and. Meth. in Phys. Res. A, 501, 280
Feroci M., et al. 2007, Nucl. Instrum. and. Meth. in Phys. Res. A, 581, 728
Labanti C., et al. 2006, Nuclear Physics B ProcṠuppl., 150, 34
Perotti F., et al. 2006, Nucl. Instrum. and. Meth. in Phys. Res. A, 556, 228
Bulgarelli A., et al. 2008, IEEE NSS-MIC Conference Record, Dresden 19-25 October, IEEE 2008, catalog #CFP08NSS-CDR, 2153
Trifoglio, M., Bulgarelli, A., & Gianotti, F. 2008, Proc. of SPIE, 7011, 70113E-1
Vercellone, S., et al. 2006, CORrection and Standard Analysis, AGILE-IFC-OP-010
Chen, A., et al. 2009, GRID Scientific Analysis User Manual, AGILE-IFC-OP-009
Mattox, J. R., et al. 1996, ApJ, 461, 396