



Tutorial for the *AGILE-LV3* online analysis

June 2018

1. Introduction

The gamma-ray satellite *AGILE*, launched in April 2007, is dedicated to the observation of astrophysical sources of photons with energy $E > 100$ MeV. The main detector of the satellite is the Gamma Ray Imaging Detector (GRID), sensitive to photon energies between 30 MeV and 50 GeV. The GRID is composed by the tungsten-silicon tracker for converting photons to e^+/e^- pairs, by a iodine-cesium crystals mini-calorimeter (MCAL) and by an anti-coincidence shield for suppressing the cosmic ray background. The scientific payload of the satellite is completed by coded mask X-ray detector, Super*AGILE*, and the mini-calorimeter, which can operate independently of the GRID and reveal transient events of photons and charged particles in the rank of energy 300 KeV - 100 MeV. The *AGILE* mission operations, nominally scheduled for two years, have currently been extended beyond the 11th year.

After the first two years of observations in the so-called "Ponting Mode", in November 2009, due to a broken stabilization wheel, the satellite has been placed in "Spinning" observation mode. At present, the satellite rotates around the boresight axis (perpendicular to the solar panels), making one complete rotation in about 6 min.

The scientific analysis using the official *AGILE* SW over long time scales may require long processing times. For example, to produce "deep" exposure maps over a time interval of about seven months, centered on the Crab Nebula position, can take at least 2 hours on 3 GHz Xeon CPUs.

To speed up the scientific analysis, an archive of *AGILE* pre-compiled exposure (EXP), count (COUNTS) and diffuse background (GAS) maps over 1-day integration time was created at the *AGILE* Data Center in SSDC. This archive, called **GRID Level 3 archive**, can be used as basis for scientific Maximum Likelihood analysis on time scales that may vary from weeks to months or longer intervals.

The centers of the maps, their size and other relevant parameters are fixed, and have been chosen in such a way as to cover the whole sky. The best division of the sky has been obtained using the HEALPix pixelization algorithm. A property of the HEALPix grid is that the pixel centers (black dots in Fig. 1), occur on a discrete number of rings of constant latitude, being the number of constant-latitude rings dependent on the resolution of the HEALPix grid. By fixing the size of the maps at 30 deg radius, the optimal number of centers for the whole sky coverage is found to be 48 (see Fig. 1).

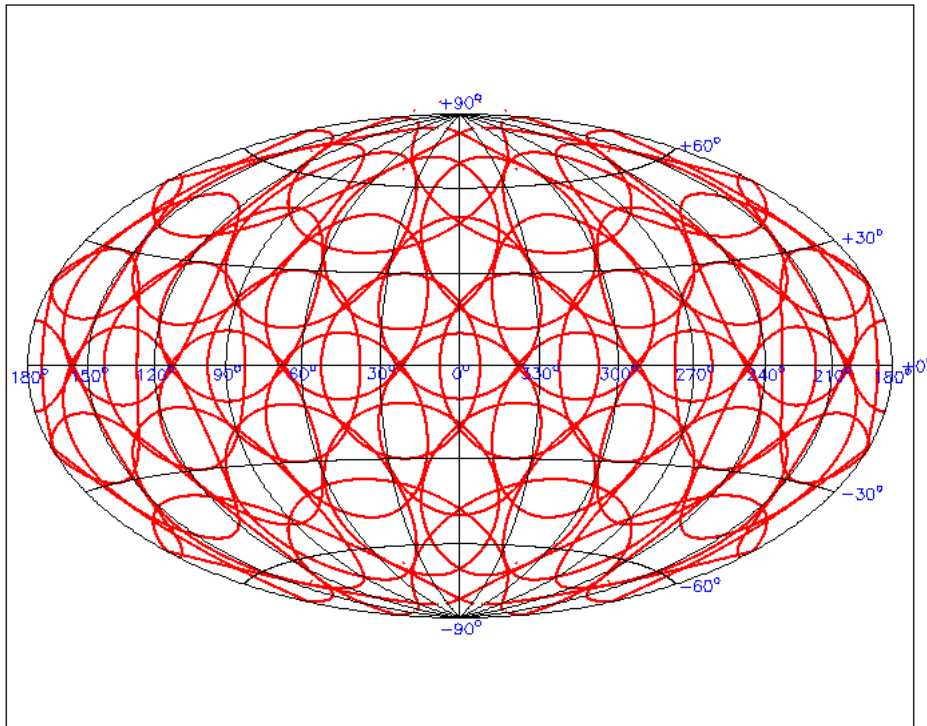


Figure 1. Centres and dimensions of the 48 rings used as basis for the creation of the GRID Level 3 Archive. The Galactic coordinates of every centre have been calculated by using the Healpix algorithm.

2. THE GRID LV3STD ARCHIVE

The Level 3 archive is created from the Level 2 Official GRID standard data (LV2STD). The LV2STD data archive is divided into blocks of observation (OB). Pointing OBs can cover intervals ranging from a few days to month, while the Spinning OBs always cover a period of 15 days. For the creation of the standard LV3 archive (LV3STD) we have used the OBs processed with the latest standard reduction software available at this date (Pointing: 5_19_18_17; Spinning: 5_21_18_19).

The LV3STD archive is composed by a full set of EXP, COUNTS and GAS daily maps, centered on each of the 48 centers listed in App. A, across the 100 – 50000 MeV band. All the LV3STD maps are generated, respectively, using the *AG_expmapgen*, *AG_ctsmapgen* and *AG_gasmpagen2* tasks available with the last AGILE scientific SW (BUILD 5.0 [ref]).

As for the input parameters to the AGILE scientific tasks, we chose values that go well both for the Pointing period and the Spinning one, where it is recommended to use more stringent parameters to prevent the background contamination due to the Earth albedo. The maximum gamma photon inclination angle with respect to the central axis in a given position (FOVRAD parameter) was set to 60°, while for the suppression of terrestrial albedo it was chosen a minimum angle of 90° between the photon incident direction and the Earth-Satellite vector (ALBRAD parameter). As previously mentioned, the maps size (MDIM parameter) was fixed at 60°, in order to obtain full sky coverage and even a partial overlap between a ring and another one, while the maps binning was set at 0.25deg. The latest set of GRID calibration, I0023

matrices, have been used for the LV3STD production. Appendix B lists all parameters and values used in the creation of the LV3STD archive.

At this date, the LV3STD archive covers all public AGILE data from December 1st, 2007, until 30 May 2018. The 1-day LV3STD maps have been merged together to create scientific maps 7- and 28-days long. These maps form the GRID LV3MERGED archive and they can be used for deep analysis and light curve generation over long periods.

3. ONLINE ANALYSIS WITH THE AGILE-LV3 ARCHIVE

The AGILE-LV3 archive is publicly available from the “Multi-mission Archive” menu on the SSDC home page.

Once the user has selected the “AGILE-LV3” item, the standard MMIA query page is opened (see Fig. 2). Here, the user can enter the source name or coordinates of the object he wants to analyze, the period of interest and he can choose the duration (1, 7 or 28 days) of the LV3 maps to be used in the analysis.

**Multi-Mission
Interactive Archive**

Mission Selected
AGILE-LV3

Enter source name or coordinates: RA, DEC L, B Lon, Lat
(e.g. CYGX-1 or 19 58 21.7, +35 12 05.8 or 299.590333, 35.201611 or 71.334960, 3.066917)

Name Resolver: Local SIMBAD NED

Start Date: (dd-mm-yyyy) End Date: (dd-mm-yyyy)

Duration: Day(s) Equinox: 2000 1950

Max lines retrieved:

Figure 2

Once the “Submit” button is clicked, a table with the AGILE-LV3 data of the selected duration and covering the request period are presented to the user (see Fig. 3). The query automatically selected the best maps for the analysis of the requested source, that is, the maps with the minimum distance between the source and the map center (out of the 48 predefined centers).

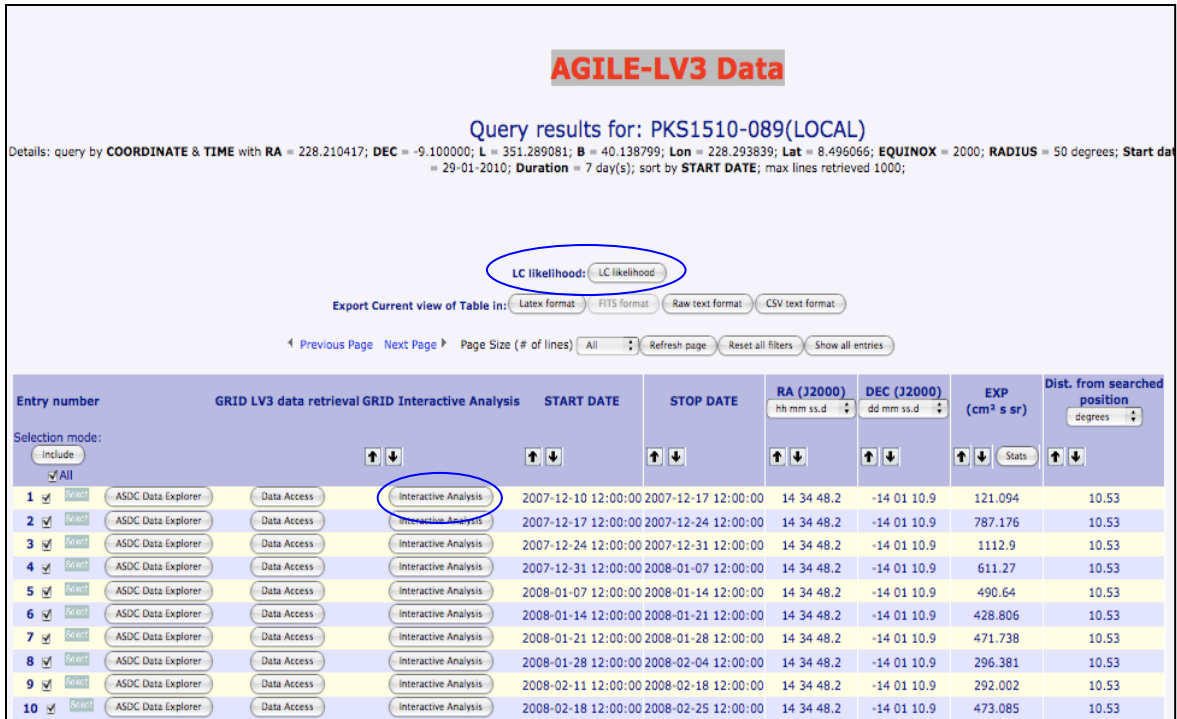


Figure 3

The table also displays the value of the Mean Exposure for each map, which can be used to select the highest exposed maps. The LV3 maps with very low exposure (under 100 [cm² s sr]) are not displayed.

From the LV3 table, the user can execute two types of scientific analyses: a Maximum Likelihood (ML) analysis on a single map at the query coordinates or, by selecting more than one LV3 map, he can generate the gamma-ray light curve above 100 MeV over the selected period. Both analyses are made by means of the official ML AGILE task available with the latest AGILE SW.

By clicking on one of the “Interactive Analysis” button displayed for each table entry, the LV3 COUNT map correspondent to the START DATE-STOP DATE interval of the selection is presented to the user (Fig. 4). The user now can run the Ximage detect task to search for significant excess over the map or he can perform the GRID ML analysis on the initial query coordinates by clicking on the “Run GRID ML” button.

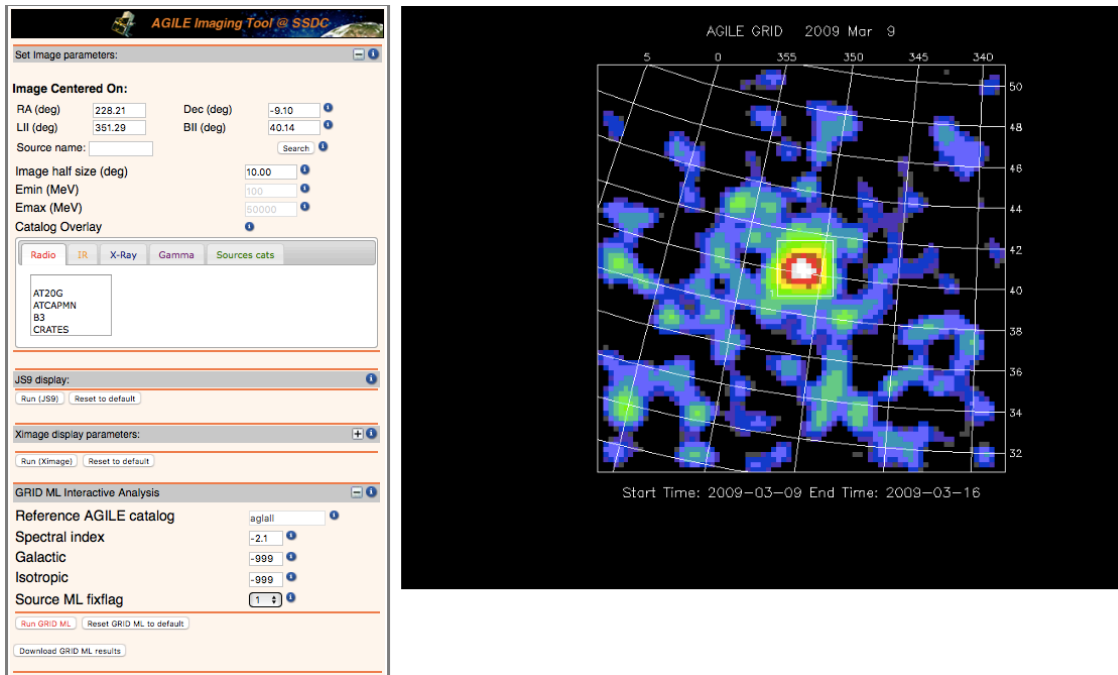


Figure 4

Once the analysis is completed, the report of the ML AGILE task is displayed on a separate web page, showing the result of the ML analysis over the position requested.

The list of known AGILE gamma-ray sources within the analysis radius (10° from the input position) that can contribute to the source signal are extracted from the public AGILE source catalogs (ref 1AGL e CATV).

By default, the Galactic and Isotropic coefficients of the gamma-ray background models are left free during the ML fitting process (both are set to the “-999” value). Nevertheless, the user can fix the two coefficients (see AGILE SW ref. manual) to the values estimated over a long period, with the warrant that this can cause artificial detections.

As we said before, the user can also generated from the LV3 archive the gamma-ray light curve of the input source above 100 MeV. First, the user selects the maps to be included in the light curve, then by clicking on the “LC likelihood” button the ML analysis starts. Once the analysis is finished, a pop-up window is opened showing the light curve over the requested period (see Fig. 5).

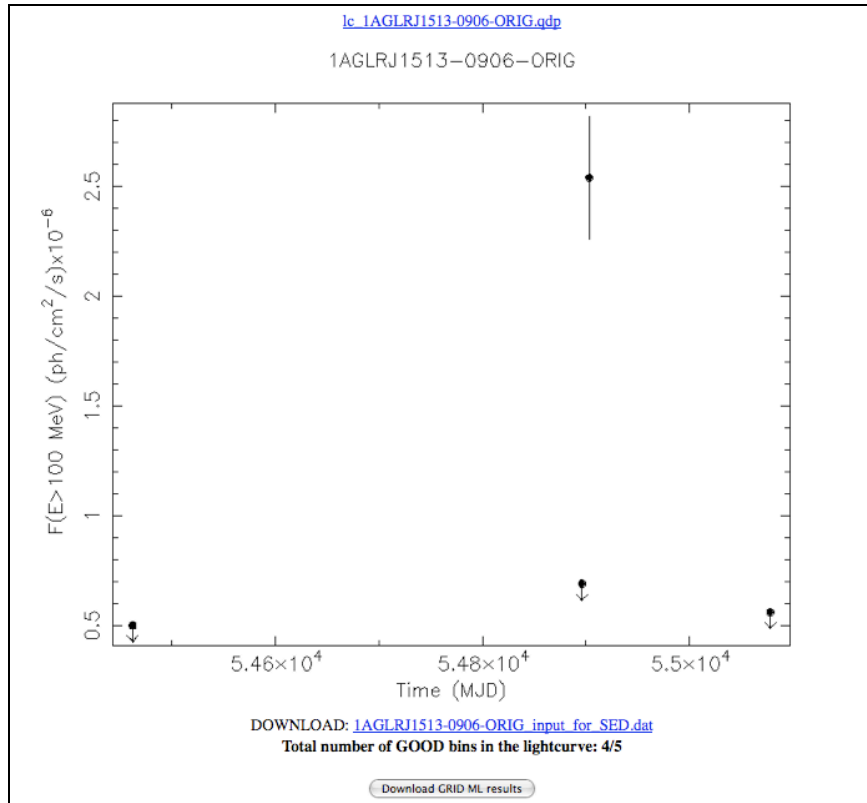


Figure 5. Example of gamma-ray light curve created from the AGILE-LV3 archive.