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## Multi messenger astronomy with the $\gamma$ -ray satellite AGILE: gravitational-wave events and ultra high energy astrophysical neutrinos

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The gamma-ray satellite AGILE, launched on 2007, has just completed its eleventh year of operations in orbit. The main on-board instrument is the gamma-ray imaging detector (GRID) sensitive to gamma-rays in the energy range 30 MeV–30 GeV. The GRID is composed by the gamma-ray silicon tracker, the mini-calorimeter (MCAL) and the anti-coincidence (AC) system for particle background rejection.

Since Nov. 2009, AGILE is operated in the spinning observation mode, in which the satellite rotates around its Sun-satellite vector performing a complete rotation in approximately 7 minutes

(200 times per day). Thanks to the very large field of view (FoV) of 2.5 sr and the spinning mode, the GRID is capable to observe 80% of the whole sky every day, with a sensitivity (at 5 sigma detection level) to gamma-ray fluxes above 100 MeV better than  $2 \times 10^{-6}$  ph cm<sup>-2</sup> s<sup>-1</sup> over two-day integration time intervals.

AGILE in spinning mode is a very effective instrument in performing all-sky searches for gamma-ray counterparts to multimessenger transient events like the IceCube neutrino HESE/EHE events and the LIGO-VIRGO gravitational-wave events.

Despite the small size (approximately a cube of side ~60 cm), the AGILE–GRID achieves an effective area of the order of 500 cm<sup>2</sup> between 200 MeV and 10 GeV for on-axis gamma-rays, and an angular resolution (FWHM) of the order of 4° at 100 MeV, decreasing below 1° above 1 GeV.

Besides the GRID, the AGILE–MCAL can be used independently to search for burst-like events (particularly adequate for detecting GRB-like phenomena in coincidence with gravitational-wave events) on timescales ranging from sub-milliseconds to tens of seconds in the energy range of 0.35–100 MeV.

Results on searches for precursor and delayed emissions for the gravitational-wave events GW150914, GW170104, and GW170817 as well as for the IceCube-160731 neutrino event are presented.

AGILE is sentinelling the sky continuously watching for gamma-rays in coincidence with gravitational-wave and neutrino events.

### Summary

The potential of the gamma-ray satellite AGILE for multi-messenger astronomy is introduced. Its first results in conjunction with

the gravitational wave events as well as the high energy IceCube neutrino events are presented. Prospects for the future are sketched.

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