AGILE observations of MWC 656, the first Be/black hole binary system

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Abstract

AGILE discovered the transient source AGL J2241+4454 in 2010 which triggered the study of the associated field allowing for the discovery of the first Be/black hole binary system: MWC 656. This binary was suggested to be the counterpart of AGL J2241+4454, but this association is still not firm. In this work we explore the archival *AGILE* data in order to find more transient events compatible with AGL J2241+4454 and address the possibility to link them to the accretion/ejection processes of MWC 656. With *AGILE* we found a total of 9 other transient events compatible with the position of AGL J2241+4454, besides the 2010 one. We folded these events with the period of the binary system and we could not associate the gamma-ray activity to any particular orbital phase. By stacking the 10 transient events, we obtained a spectrum that extends between 100 MeV and 1 GeV, and we fitted it with a power law with photon index $\Gamma = 2.3 \pm 0.2$. *e-ASTROGAM* will be a key instrument in the study of soft gamma-ray sources with its state-of-the-art sensitivity and cappabilities to observe in the $\sim$1 MeV energy band.

The MWC 656 system

- MWC 656 is a galactic high-mass X-ray binary (Munar-Adrover et al. 2014), and the only known to **host a Be star and a black hole**, with a mass between 3.8–6.9 $M_\odot$ (Casares et al. 2014)
- The companion star has a B1.5-B2 III spectral type with a mass between 10–16 $M_\odot$
- The orbital period of the system is 60.37 days
- The *AGILE* detection of a transient source in this field, AGL J2241+4454 (Lucarelli et al. 2010), triggered the study of this field yielding to the discovery of this intriguing binary system
- Recently, Ribó et al. (2017) reported the **detection** of the source in **radio and X-rays**, both at very low luminosities

The MWC 656 field

- Although MWC 656 seems to be the most favoured candidate to produce the transient emission that has been detected by *AGILE*, we cannot discard another source as the countepart
- There are nearby sources that have been identified as possible counterparts of the gamma-ray emission:
  - A known quasar near MWC 656, RX J2243.1+4441 (Brinkmann et al. 1997), which appears also in the X-ray images taken by Munar-Adrover et al. (2014). This source can be classified as a radio galaxy through its radio morphology which resembles the classical FR-II type radio galaxies. This kind of radio galaxies seems to be more rare in the GeV sky (Abdo et al. 2010; Grandi et al. 2012), disfavouring, although not excluding, RX J2243.1+4441 as the putative counterpart of AGL J2241+4454
  - A new unidentified X-ray source has been discovered by Ribó et al. (2017) at a few arc seconds from the position of MWC 656

AGILE observations and analysis

- *AGILE* first detected AGL J2241+4454 in 2010 thanks to its scanning observation mode, covering most of the sky every few hours
- Further study of archival data revealed 3 detections of this source during the *pointing* mode observation, between 2007 and 2009
- *AGILE* detected the source up to 6 more times between 2009 and 2013, making a total of 10 detections
- We analyzed the data from the 10 flares between 2007 and 2013 together by stacking the data
- Spectral analysis performed in the 100 MeV to 3 GeV energy band
- Data fitted using a single powerlaw with a photon index $\Gamma = 2.35 \pm 0.16$
- A best fit position at galactic coordinates $(l, b) = (100.^\circ37, -12.^\circ39) \pm 0.^\circ35$
- Post trial probability of $P = 6.8 \times 10^{-7}$ was obtained for the total of 902 time bins analyzed, imposing a minimum test statistic $TS > 9.0$
- All these results were published in Munar-Adrover et al. (2016)

Future prospects with *e-ASTROGAM*

e-ASTROGAM is the future in the study of gamma-ray sources from the space, and will open a window in the MeV energy band with unprecedented sensitivity, allowing us to clearly stablish the true nature of the emission in many systems. Specifically, in the case of MWC 656, *e-ASTROGAM* will allow us to study the emission below 100 MeV and discriminate between leptonic and hadronic models. Also, thanks to its superb sensitivity in short (2-day) integrations, gamma-ray flares from this system will be detected clearly.

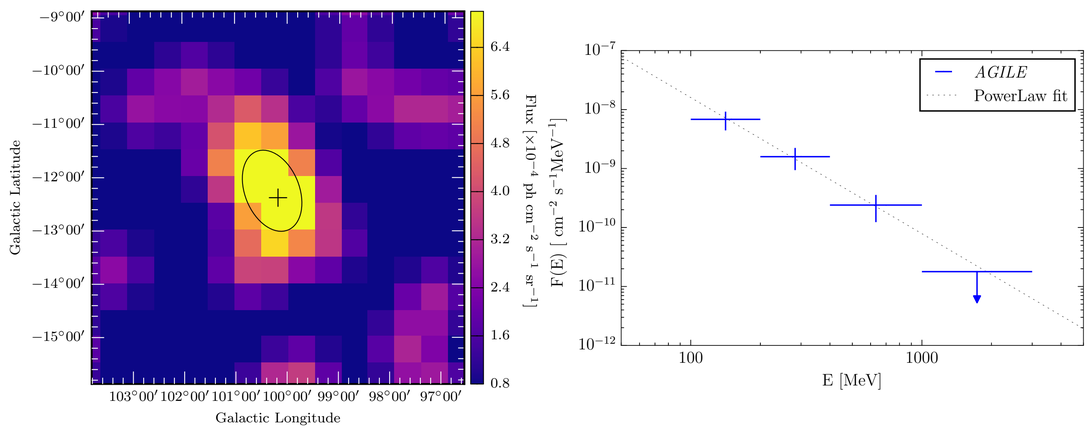

Figure 1: *Left panel*: *AGILE* 2-day integration intensity map corresponding to data published in Lucarelli et al. (2010) at date 2010–07–25 (MJD 55402). Black ellipse: 95% c.l. containment of gamma-ray flux; black cross: optical position of MWC 656. *Right panel*: *AGILE*/GRID photon spectrum between 100 MeV and 3 GeV of MWC 656 integrating all flaring episodes in pointing and spinning mode. Dotted line: best powerlaw fit with a photon index $\Gamma = 2.35 \pm 0.16$.

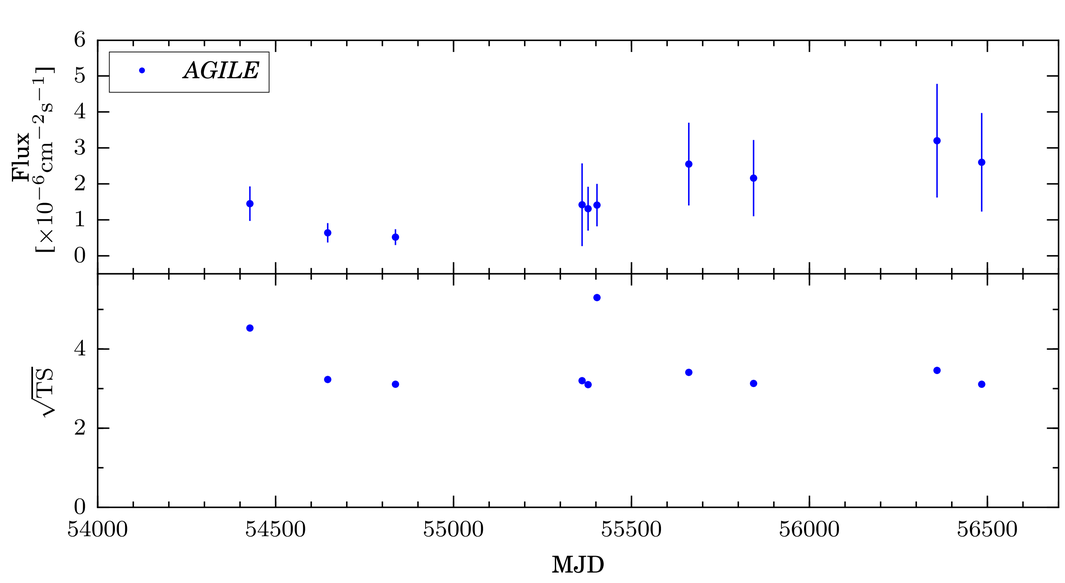

Figure 2. *AGILE* detections plotted over time. *Upper panel*: gamma-ray flux and 90% uncertainty. *Lower panel*: significance of the detections, in $\sqrt{TS}$ units.

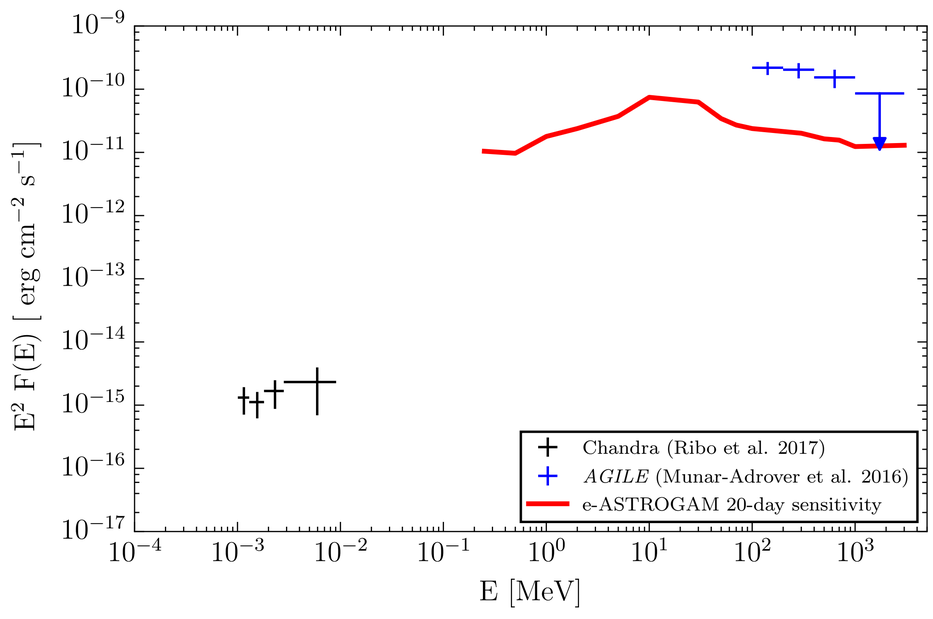

Figure 3. SED of MWC 656. Red line represents the *e-ASTROGAM* 20-day sensitivity.

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