

The MAGIC VHE GRB program

F.Longo on behalf of the MAGIC collaboration.

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Abstract

Since the beginning of their operations, the MAGIC telescopes were optimised to perform fast observations of gamma-ray bursts (GRBs). The follow-up strategy and the specific design of these telescopes, namely a fast slewing system (7 deg/s), a low energy threshold (around 50 GeV) and the possibility of performing observations in not standard conditions (such as large zenith angle of observations and/or with moderate moonlight), allowed them to perform the first detections of GRBs in the very high energy (VHE, $E > 100$ GeV) domain. These discoveries are shedding light on the physical processes at play in GRB sources. This contribution will highlight the current status of GRB studies with MAGIC, including the detection of GRB 190114C and GRB 201216C and the studies performed for the hint of detections from GRB 160821B and GRB 201015A.

The MAGIC telescopes

The Major Atmospheric Gamma Imaging Cherenkov telescopes [1,2]

Located in La Palma, Canary Islands, Spain (28°N, 18°W)

System of two 17-m parabolic primary mirrors with PMT camera



Energy range : 50 GeV - 30 TeV

Energy resolution of ~20% @100 GeV, 15% @1 TeV

Angular resolution of ~5 arcminutes @100 GeV ~3 arcminutes @1 TeV

Effective area: $\sim 10^4$ m² @100 GeV, $\sim 10^5$ m² @1 TeV

Integral sensitivity: ~0.6% Crab unit

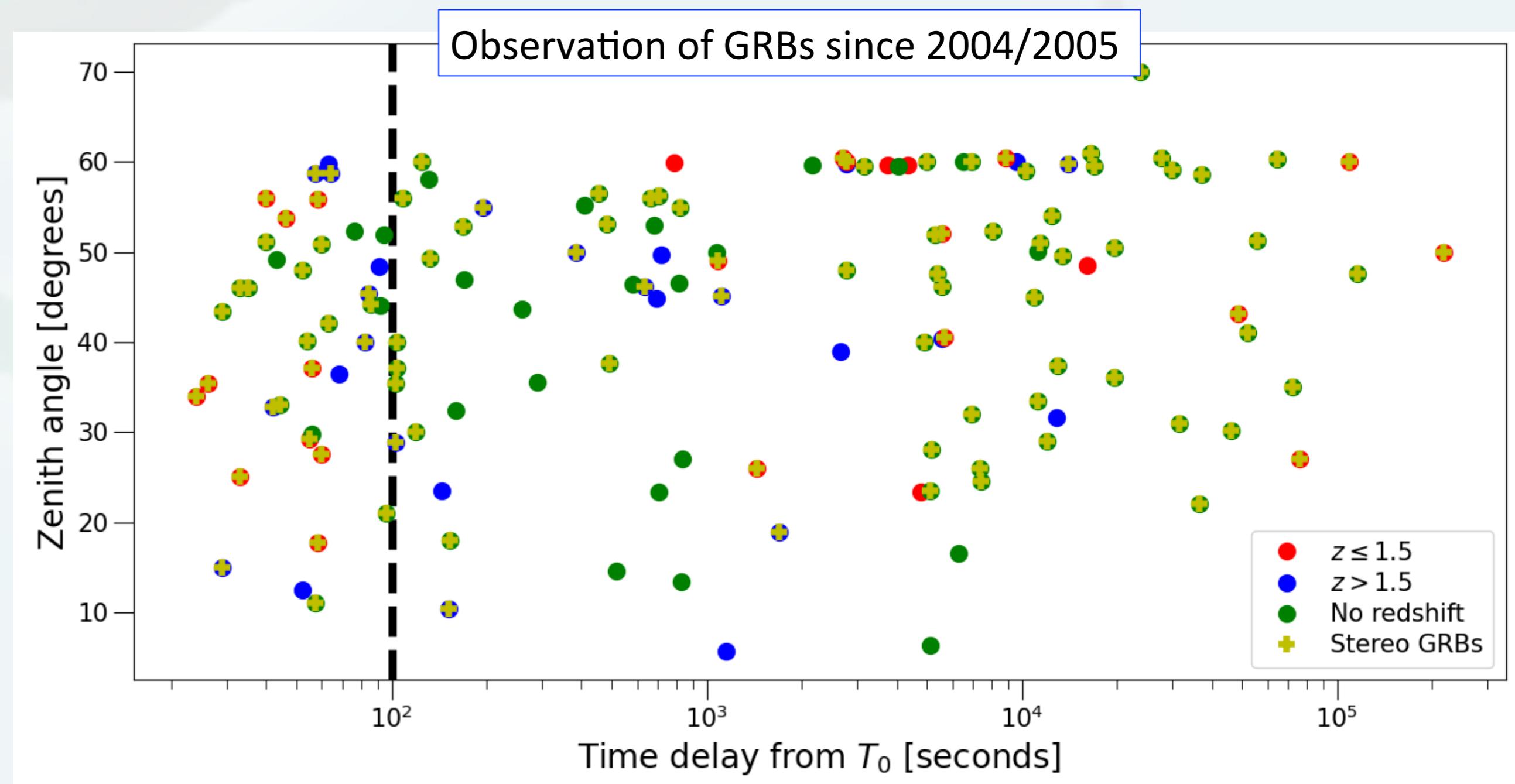
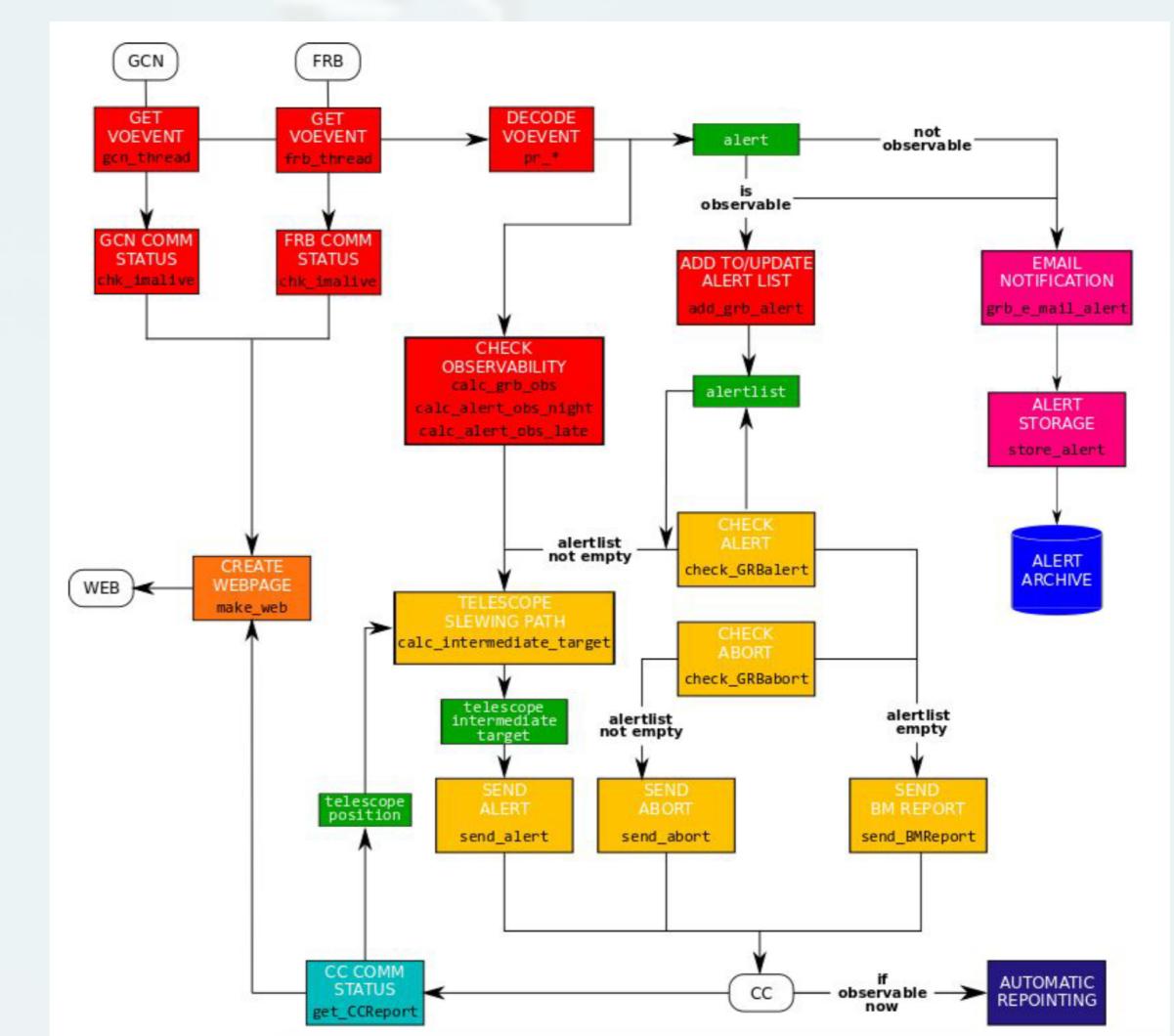
Field of view: 3.5° (0.1° for 1 pixel)

Automatic reaction to alerts and fast slewing (~7deg/s in fast mode)

Possibility to operate in moderate moonlight [3]

The MAGIC Autonomous Alert System

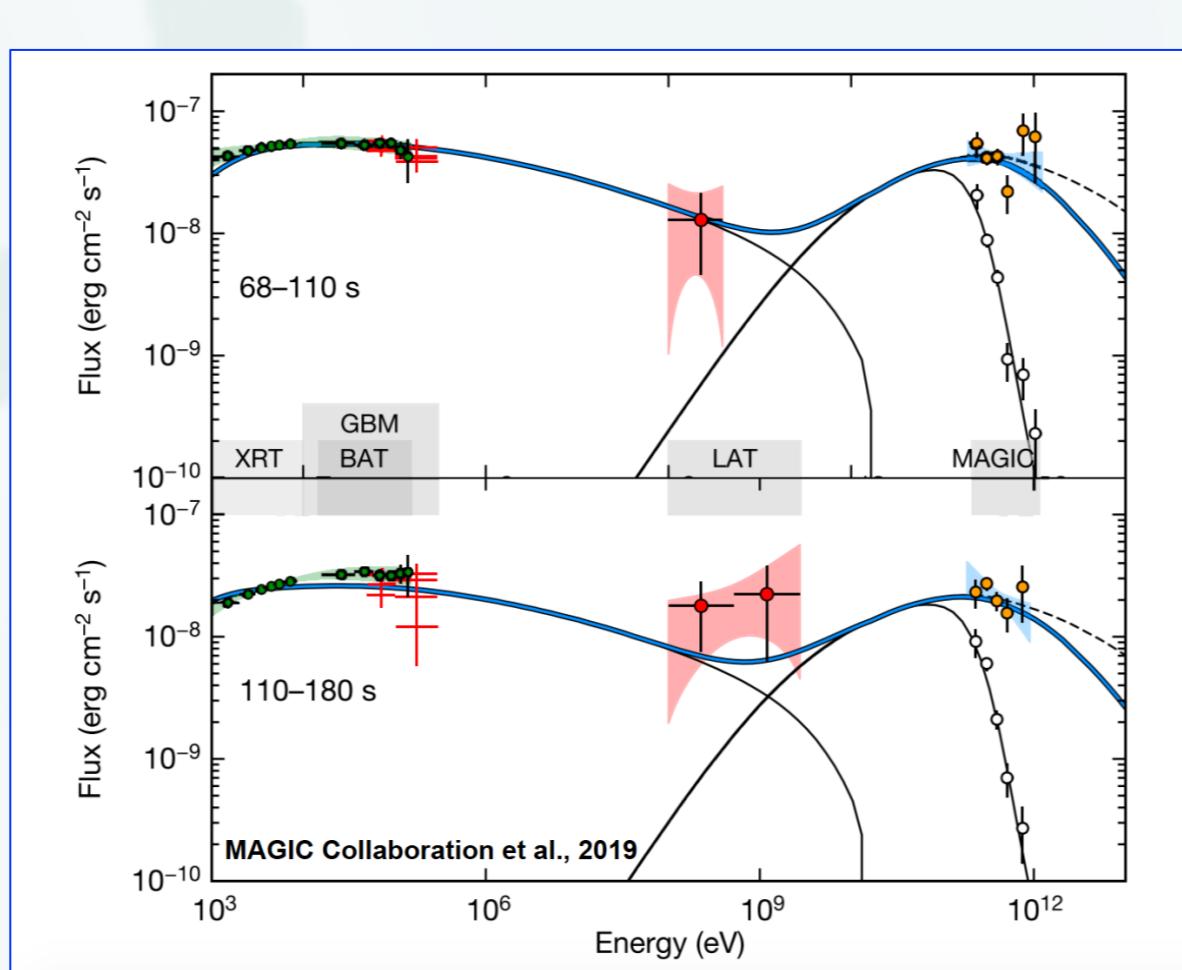
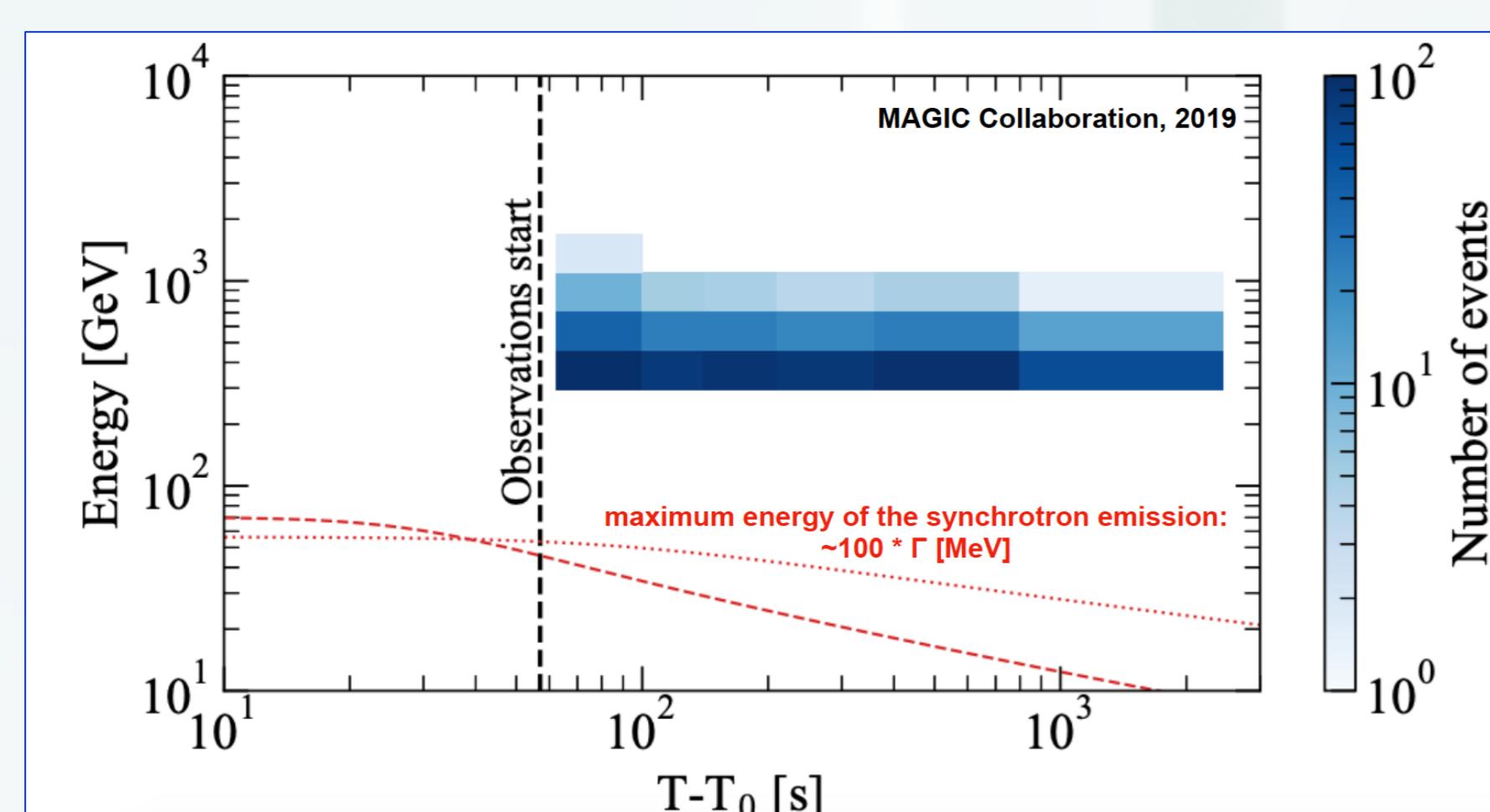
- Active since 2003
- Listens to GCN Alerts, but also to other brokers (e.g. FRB)
- Automatic repointing for GRBs and neutrinos
- Able to receive VOEvents
- Several follow-up strategies
- AAS as a multimessenger system [4]



GRBs detected by MAGIC

GRB 190114C - Long GRB [5]

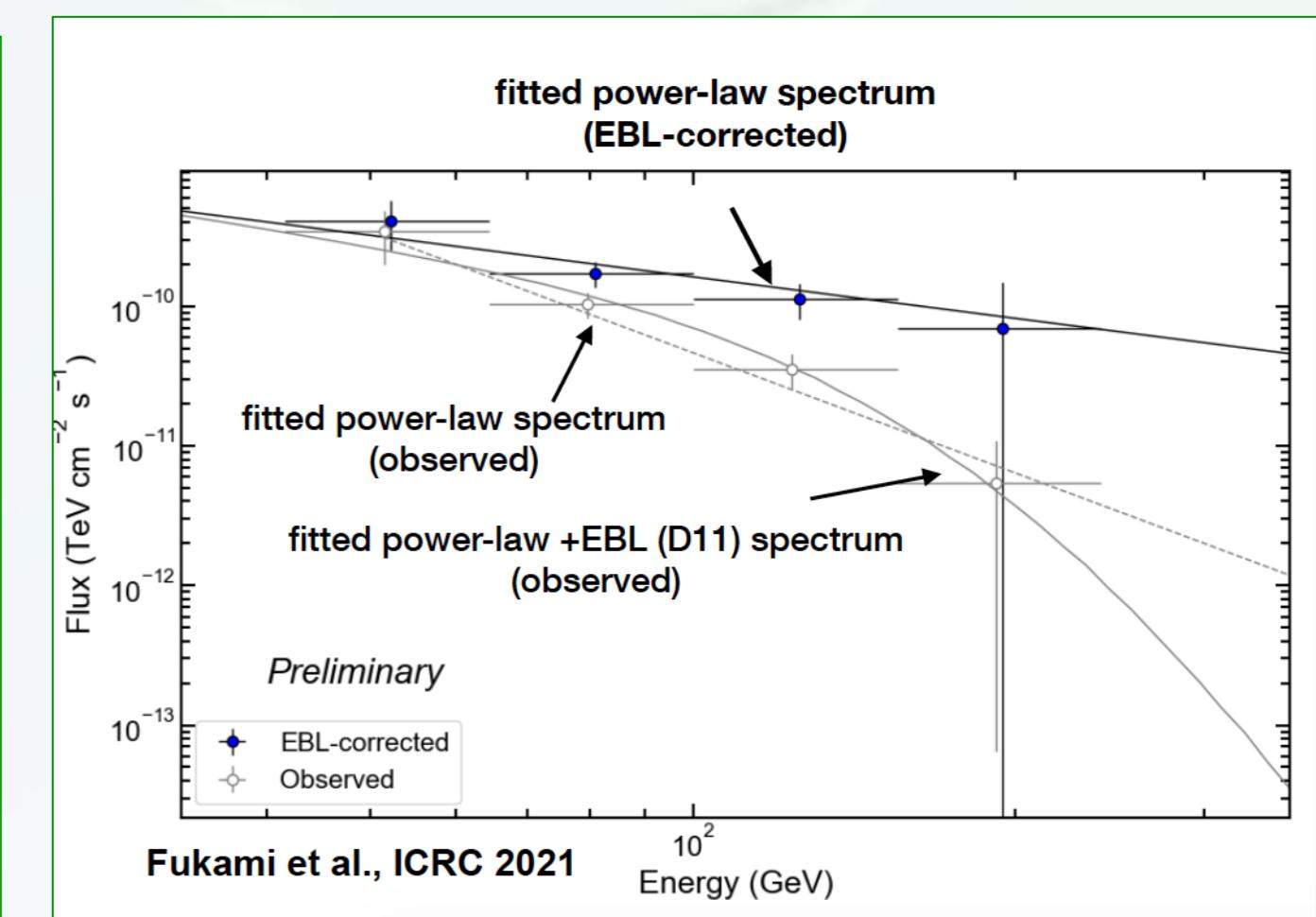
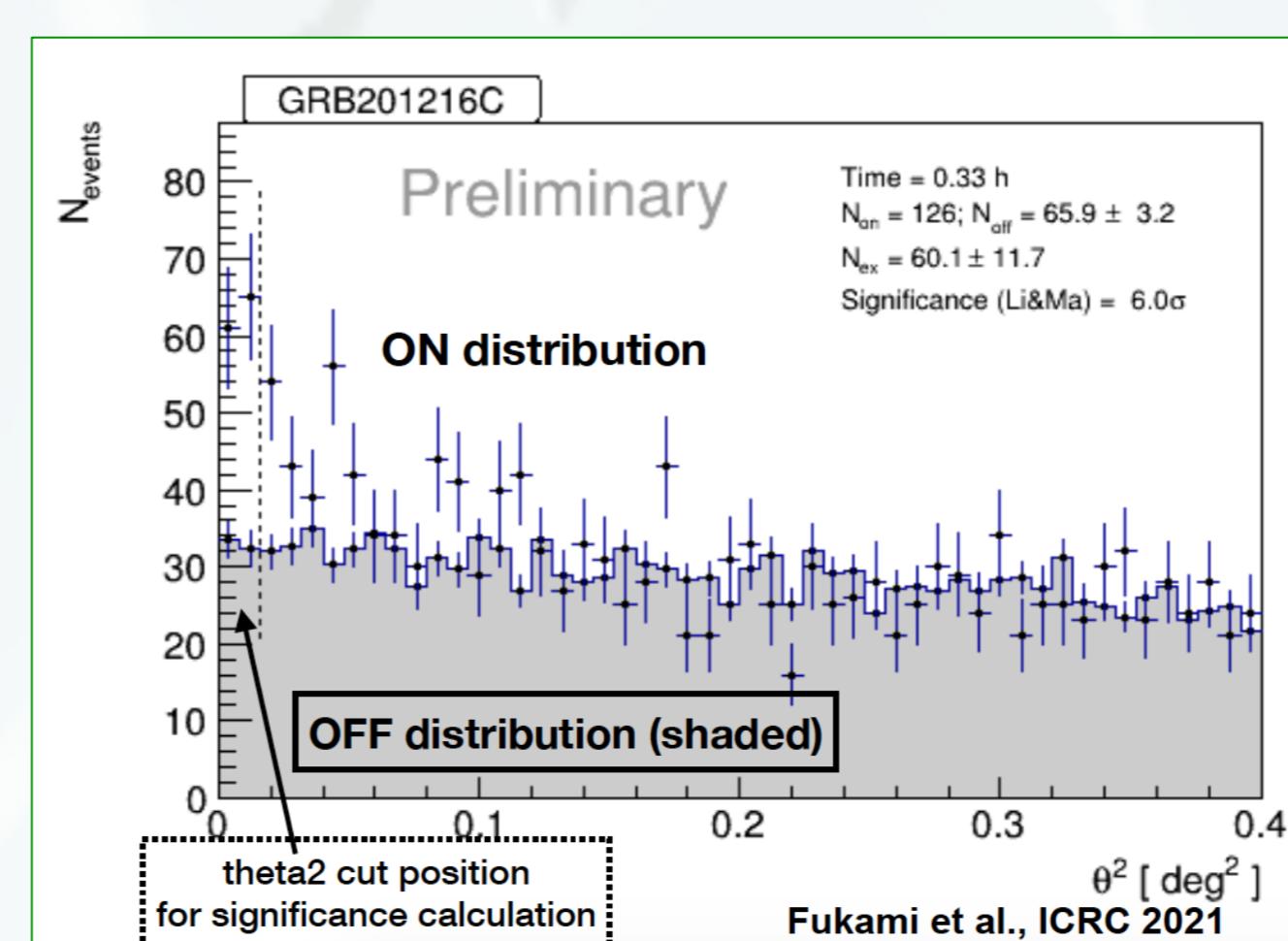
- $E_{\gamma, \text{iso}} \sim 2.5 \times 10^{53}$ erg
- $z = 0.42$
- $T_{\text{delay}} \sim 57$ s
- $> 50\sigma$ in 20 minutes
- Detection up to 40 min
- 0.3 - 1 TeV energy range
- moon conditions and Zenith angle >50



GRB 201216C - Long GRB [7]

- $E_{\gamma, \text{iso}} \sim 4.7 \times 10^{53}$ erg
- $z = 1.1$
- $T_{\text{delay}} \sim 56$ s
- 6σ in 20 minutes
- Energy threshold ~0.1 TeV

- MAGIC photon flux decays monotonically with time
- Observed spectrum shows a steep slope due to strong attenuation by EBL [8]

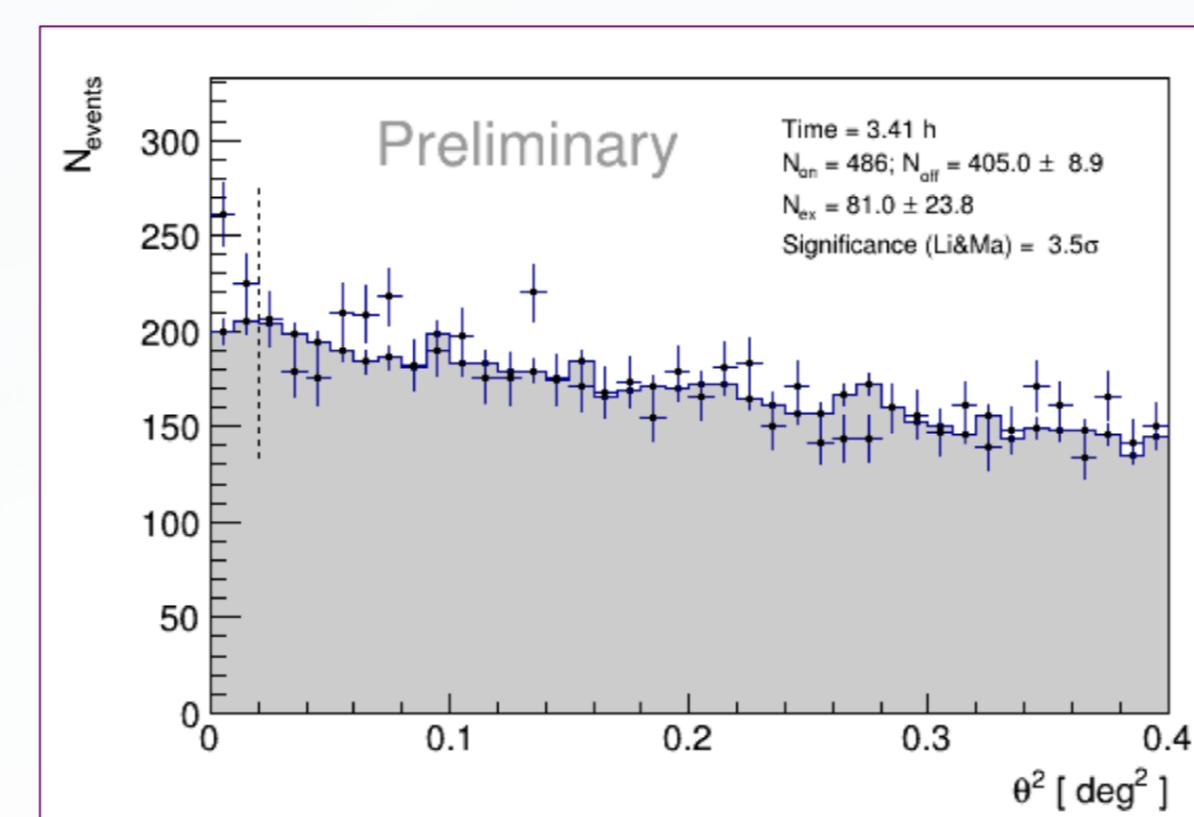
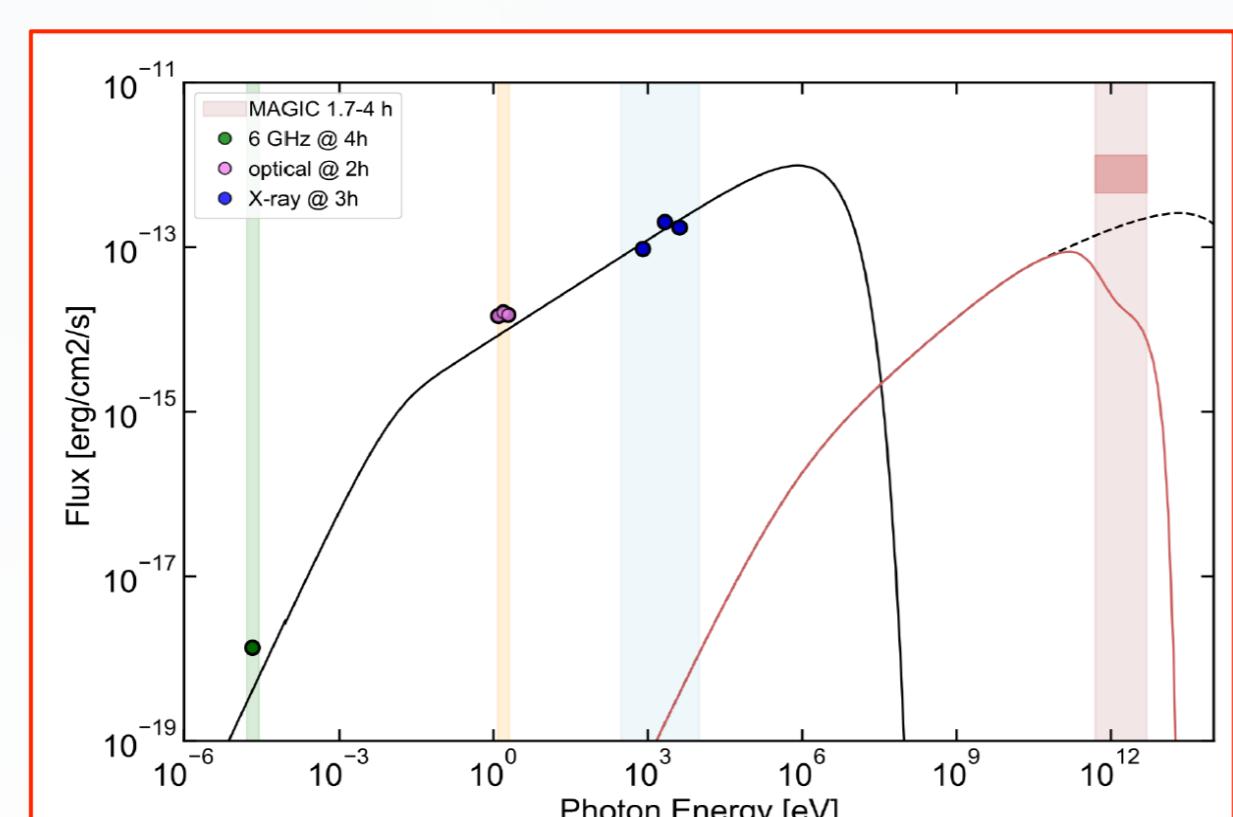


Hints of GRB detection

GRB 160821B short GRB [9]

- $E_{\gamma, \text{iso}} \sim 1.2 \times 10^{49}$ erg
- $z = 0.162$
- associated with a kilonova[10,11]

- $T_{\text{delay}} \sim 24$ s
- 3σ in 4 hrs
- 0.5 - 5 TeV
- moon conditions, dedicated analysis



References

- [1] Aleksic et al. Astropart. Phys. 72, 61 (2016)
- [2] Aleksic et al. Astropart. Phys. 72, 76 (2016)
- [3] Ahnen et al., Astropart. Phys. 94, 29 (2017)
- [4] Berti et al.; PoS (ICRC2019) 633
- [5] Acciari et al., Nature 575, 455 (2019)
- [6] Acciari et al., Nature 575, 459 (2019)
- [7] GCN Circular #29075 (2020)
- [8] Fukami et al., PoS (ICRC2021) 788
- [9] Acciari et al., ApJ 908, 90 (2021)
- [10] Lamb et al., ApJ 883, 48 (2019)
- [11] Troja et al., MNRAS 489, 2104 (2019)
- [12] GCN Circular #28659 (2020)
- [13] Suda et al., PoS (ICRC2021) 797