Observation of a relatively low luminosity long duration GRB 201015A by the MAGIC telescopes

Yusuke Suda
(Hiroshima University)
M. Artero, K. Asano, A. Berti, L. Nava, K. Noda and
K. Terauchi on behalf of the MAGIC Collaboration

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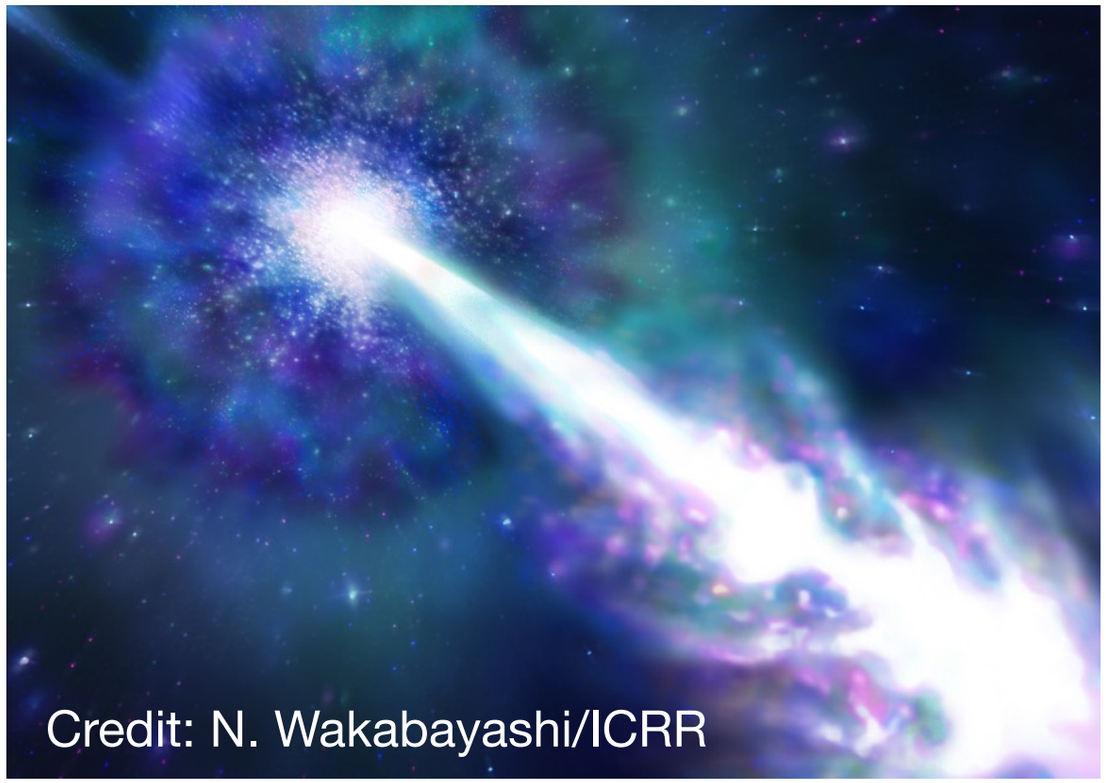
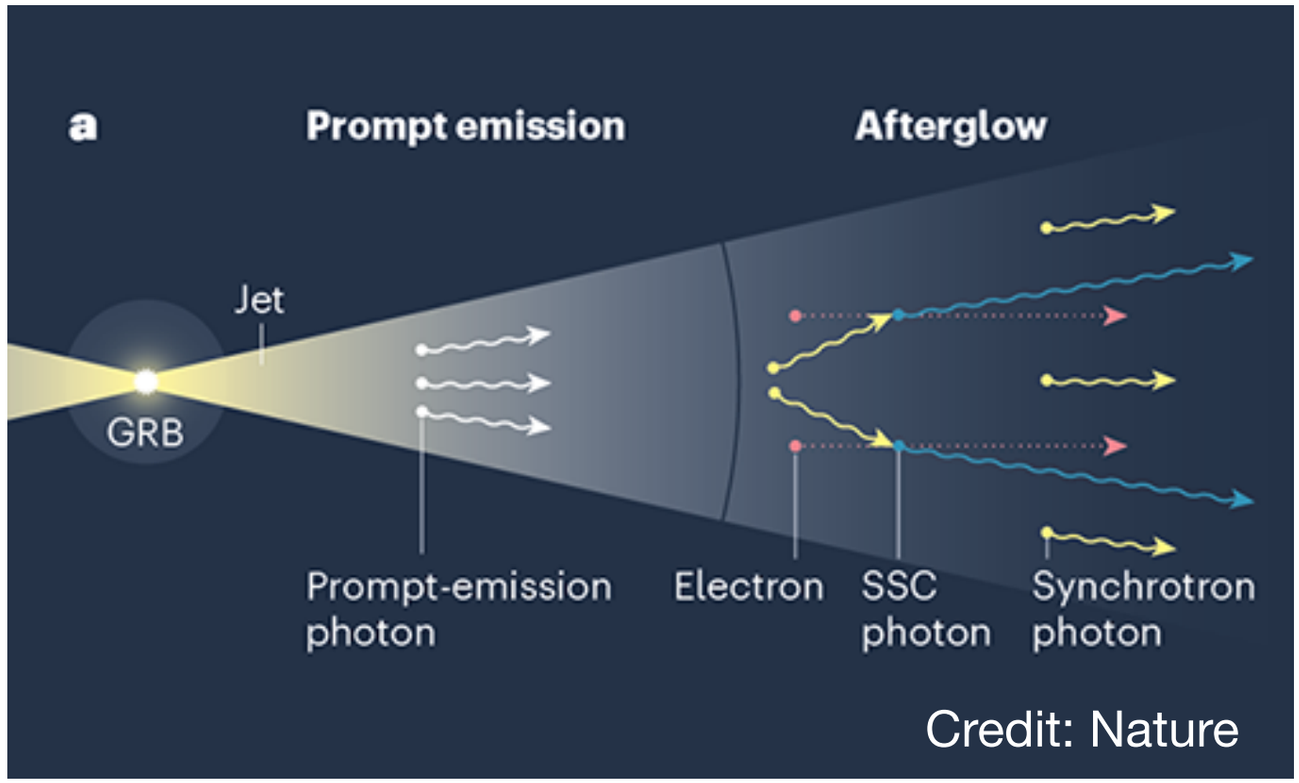
Gamma-Ray Bursts



Credit: N. Wakabayashi/ICRR

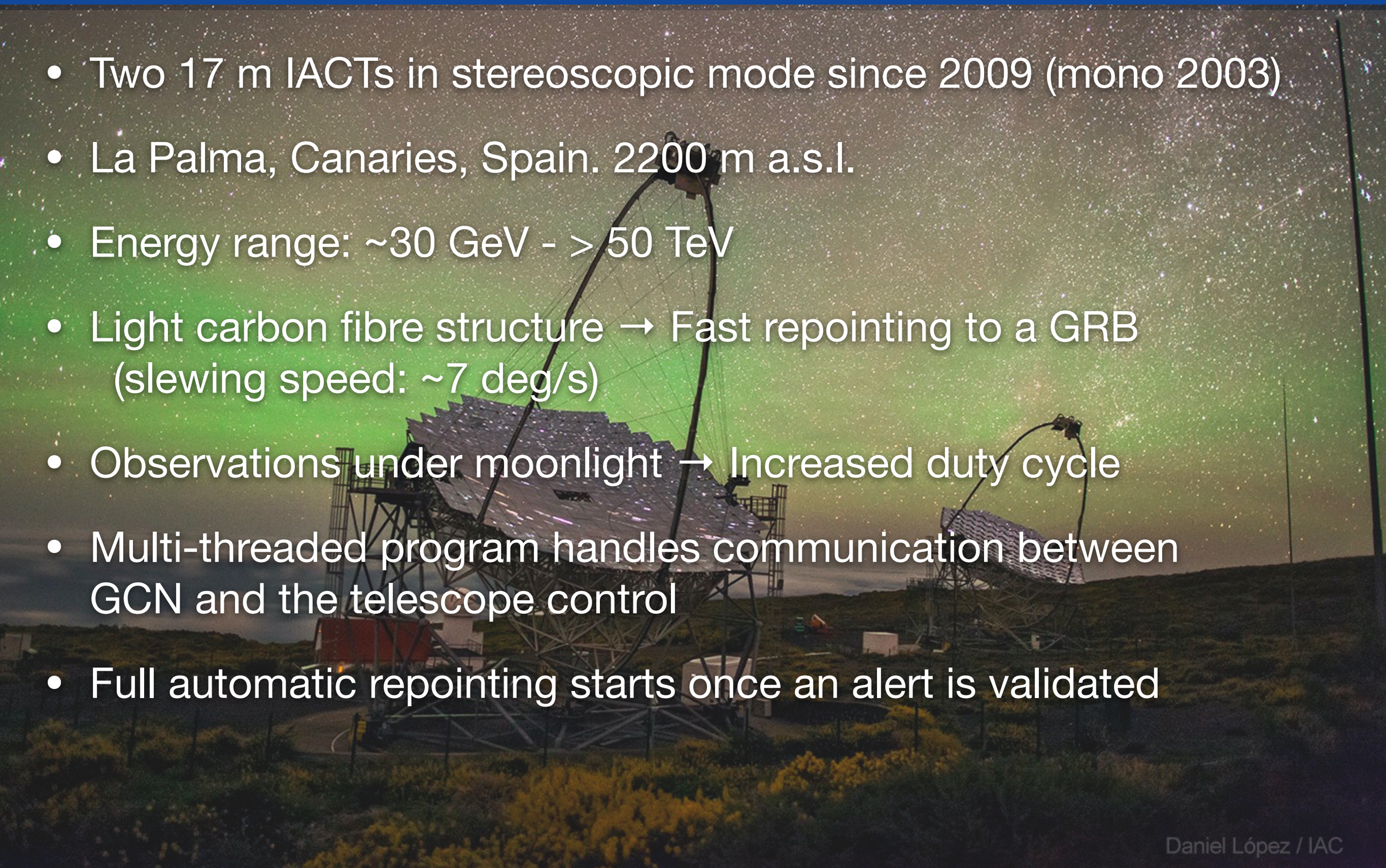


Credit: Nature

- TeV gamma-ray emission from GRBs were long awaited
- In 2019 Imaging Atmospheric Cherenkov Telescopes (IACTs) opened a new era of GRB study
- Synchrotron self-Compton (SSC) is a natural explanation at least for some GRBs. More GRBs are necessary

MAGIC Telescopes

- Two 17 m IACTs in stereoscopic mode since 2009 (mono 2003)
- La Palma, Canaries, Spain. 2200 m a.s.l.
- Energy range: ~30 GeV - > 50 TeV
- Light carbon fibre structure → Fast repointing to a GRB (slewing speed: ~7 deg/s)
- Observations under moonlight → Increased duty cycle
- Multi-threaded program handles communication between GCN and the telescope control
- Full automatic repointing starts once an alert is validated



History of GRB Follow-up

- 2005 - 2018: No clear detection (~8 GRBs/yr)
  - "Upper limits" paper (GRBs from 2013 to 2019) in prep.

See F. Longo's poster

- 2016: 3σ hint of gamma-ray emission from GRB 160821B
  - Short GRB associated to a kilonova

See K. Noda's poster

- 2019: Discovery of TeV emission from GRB 190114C
  - SSC as a new emission mechanism in GRB afterglow

See A. Berti's talk

- 2020: GRB 201015A (this talk)
- 2020: Detection of VHE emission from GRB 201216C
  - Farthest IACT source at z = 1.1

See S. Fukami's talk

GRB 201015A

- GRB discovered by Swift-BAT on 15 Oct. 2020, 22:50:13 UT
- XRT from T_0+~53min. Fermi-GBM sub-threshold detection
- MAGIC reported a hint of detection with > 3σ in GCN
- One of the closest GRBs for MAGIC: z = 0.426 (GTC)

TITLE: GCN CIRCULAR
NUMBER: 28659
SUBJECT: MAGIC observations of GRB 201015A: hint of very high energy gamma-ray signal
DATE: 20/10/16 16:48:37 GMT
FROM: Oscar Blanch at MAGIC Collaboration <blanch@ifae.es>

O.Blanch (IFAE-BIST Barcelona), M. Gaug (UAB Barcelona), K. Noda (ICRR University of Tokyo),
A. Berti (INFN Torino), E. Moretti (IFAE-BIST Barcelona), D. Miceli (University of Udine and INFN Trieste),
P. Gliwny (University of Lodz) S. Ubach (UAB Barcelona), B. Schleicher (University of Wuerzburg),
M. Cerruti (University of Barcelona) and A. Stamerra (INAF Rome) on behalf of the MAGIC collaboration
report:

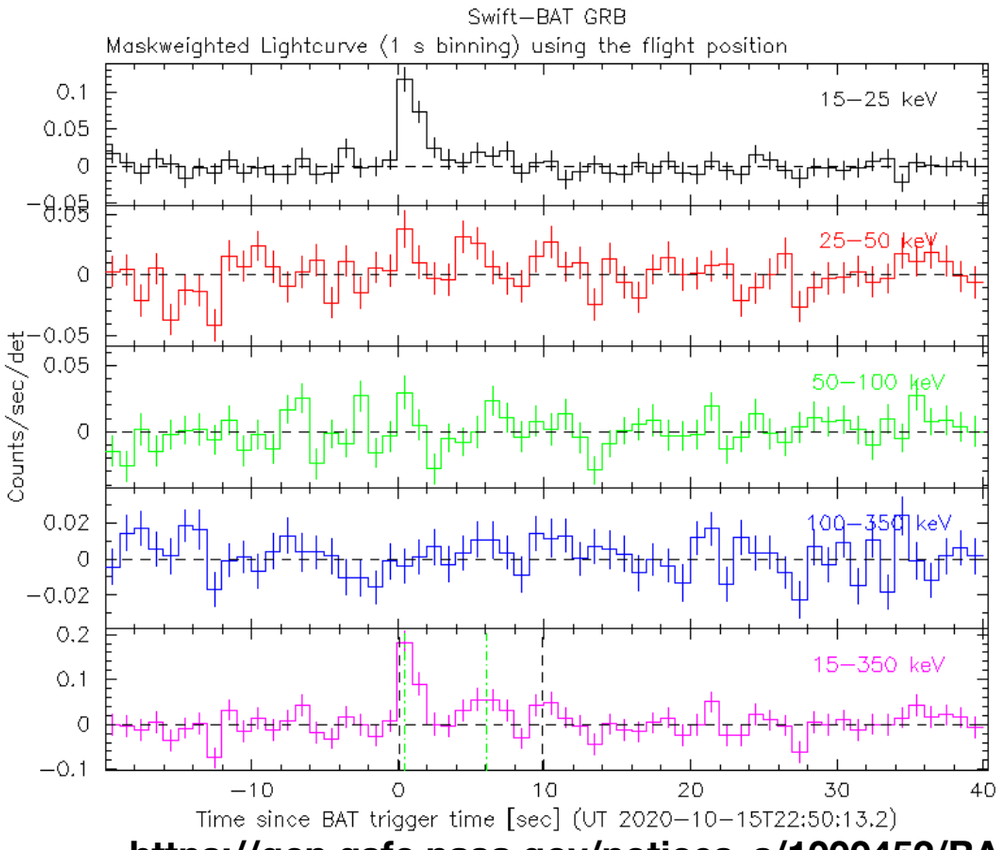
On October 15, 2020, the MAGIC telescopes observed GRB 201015A following the Swift-BAT trigger (D'Elia et al., GCN 28632).
MAGIC started observations under good conditions about 40 seconds after the initial Swift trigger, revealing a hint of signal
with significance >3 sigma in the very high energy band. Refined off-line analyses of the data are ongoing.

Further MAGIC observations on GRB 201015A are planned in the coming night. We strongly encourage follow-up
observations by other instruments at all wavelengths.

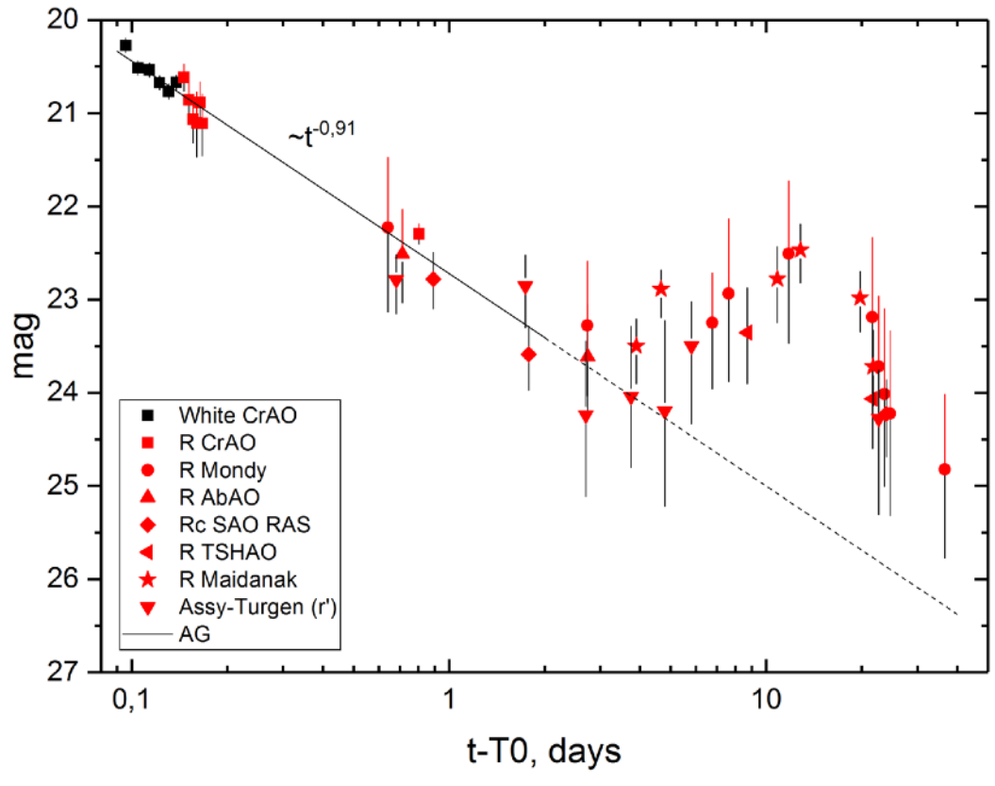
The MAGIC point of contact for this burst is O. Blanch (blanch@ifae.es). Burst Advocate for this burst is
M. Gaug (Markus.Gaug@uab.cat)

Relatively Low Luminosity Long GRB

- Swift-BAT refined analysis reported GCN 28658
  T_{90} = 9.78 ± 3.47 s, Fluence (2.0 ± 0.6)×10^{-7} erg/cm^2 (15-150keV)
- Optical, X-ray, radio afterglows were observed
- Relatively low luminosity long GRB
  - Eiso = (1.1 ± 0.2)×10^{50} erg GCN 28668
- Supernova emerged after ~5 days (max 18-21 days) GCN 29033



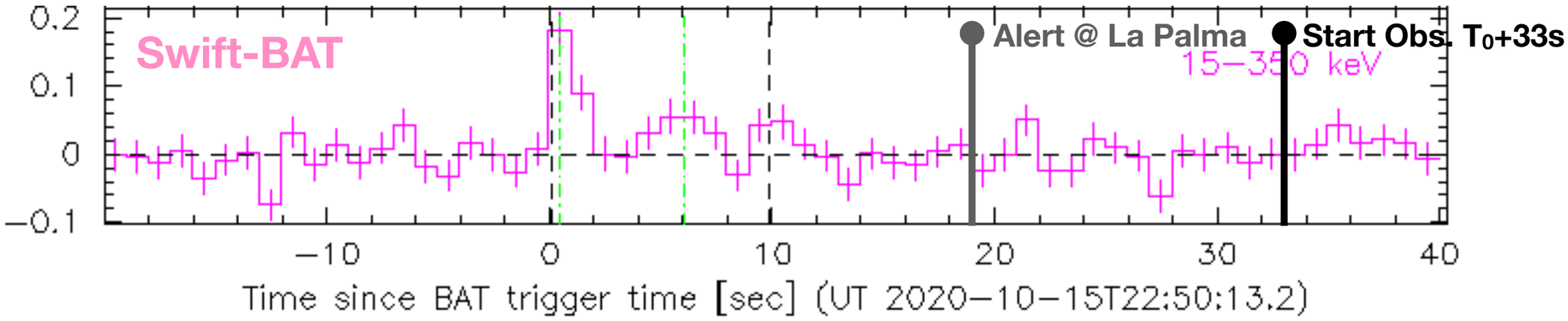
https://gcn.gsfc.nasa.gov/notices_s/1000452/BA



A. Pozanenko et al. GCN 29033

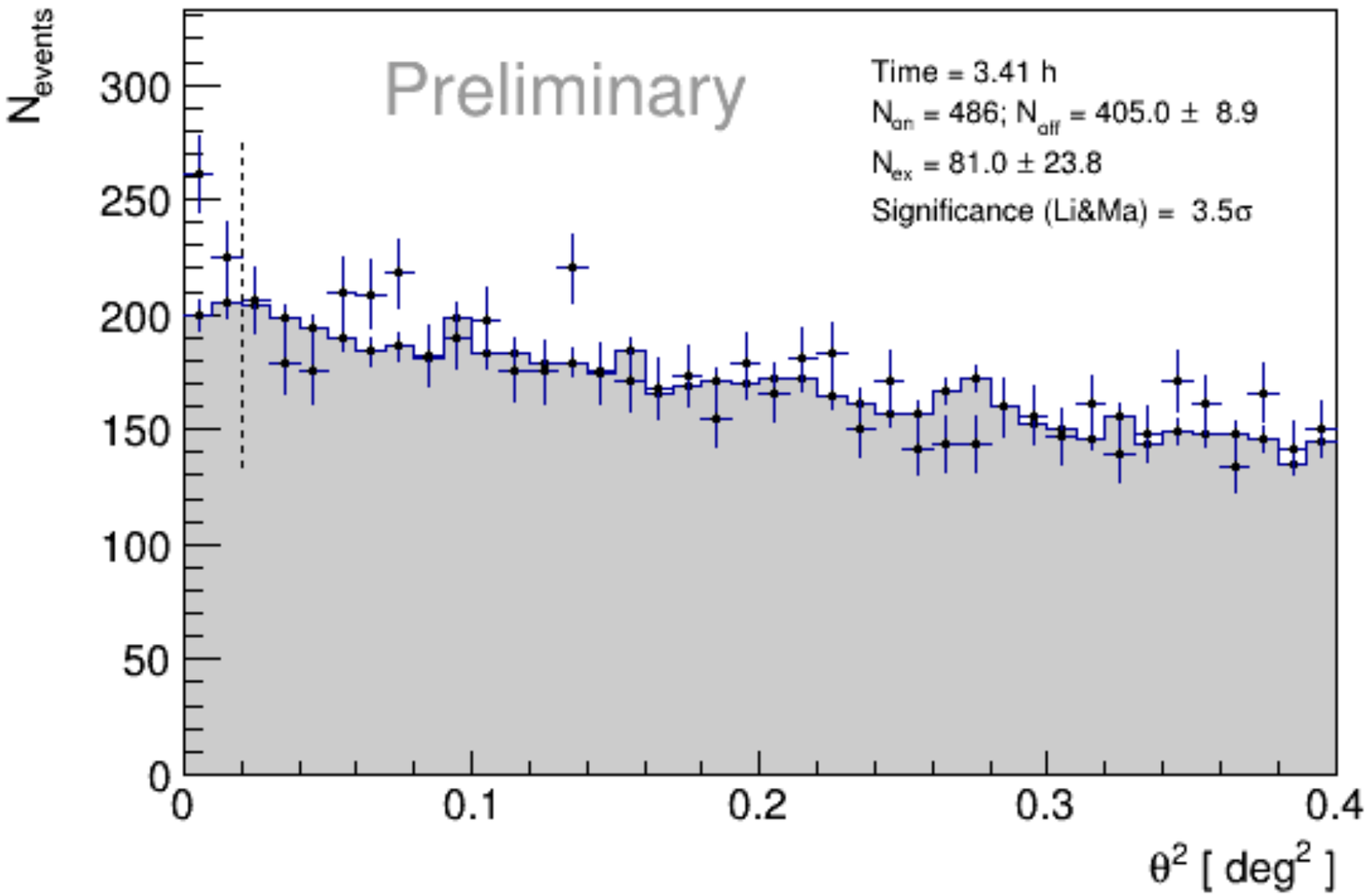
MAGIC Observations

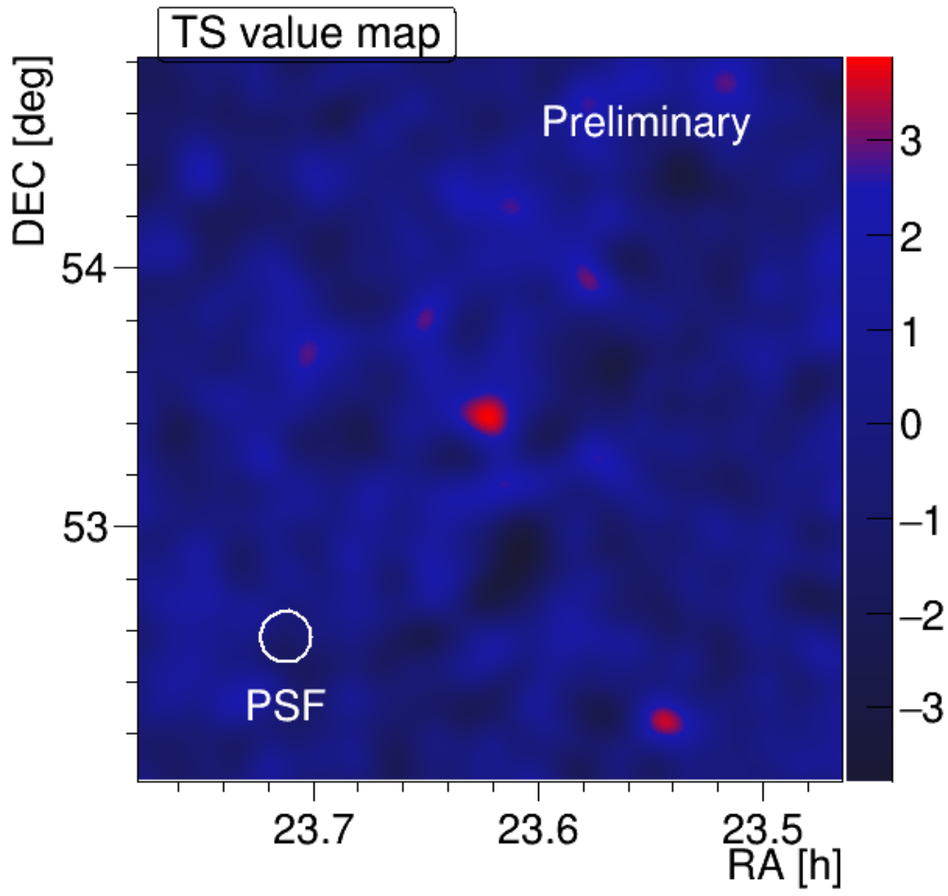
https://gcn.gsfc.nasa.gov/notices_s/1000452/BA



- Only 14 seconds to start the observations after the alert arrived at La Palma (one of the fastest MAGIC observations)
- Low-mid zenith angles: 24 → 48 deg
- Dark time, good weather condition
- Quality cuts: some of the data affected by passing clouds removed
- Analysis method: standard MAGIC analysis (R. Zanin et al. ICRC 2013 proceedings)

Theta2 & Skymap

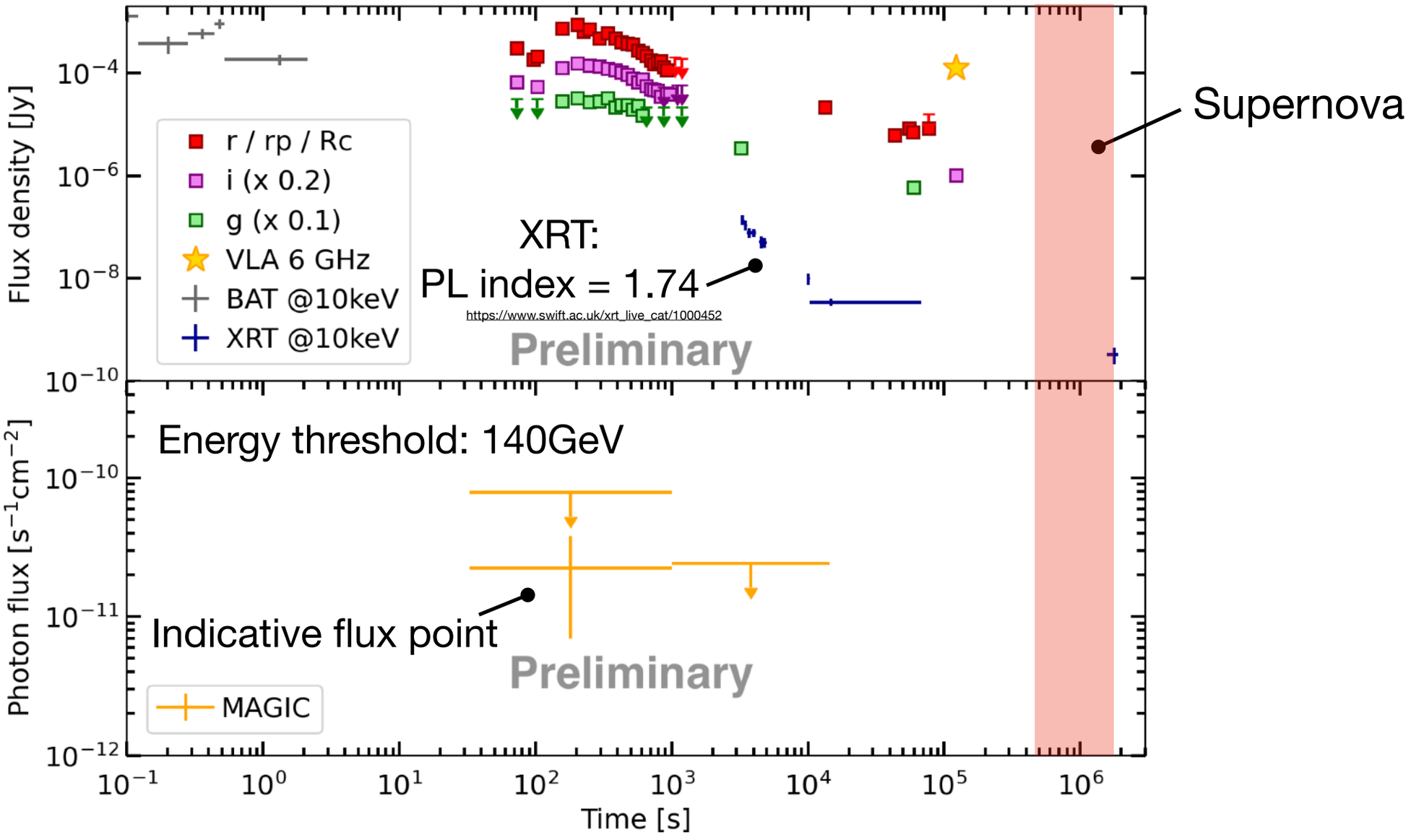




Coordinates by NOT GCN 28637:
RA = 23h 37m 16.41s
Dec = +53d 24min 56.5s

- A hint of gamma-ray emission from GRB 201015A with 3.5σ!

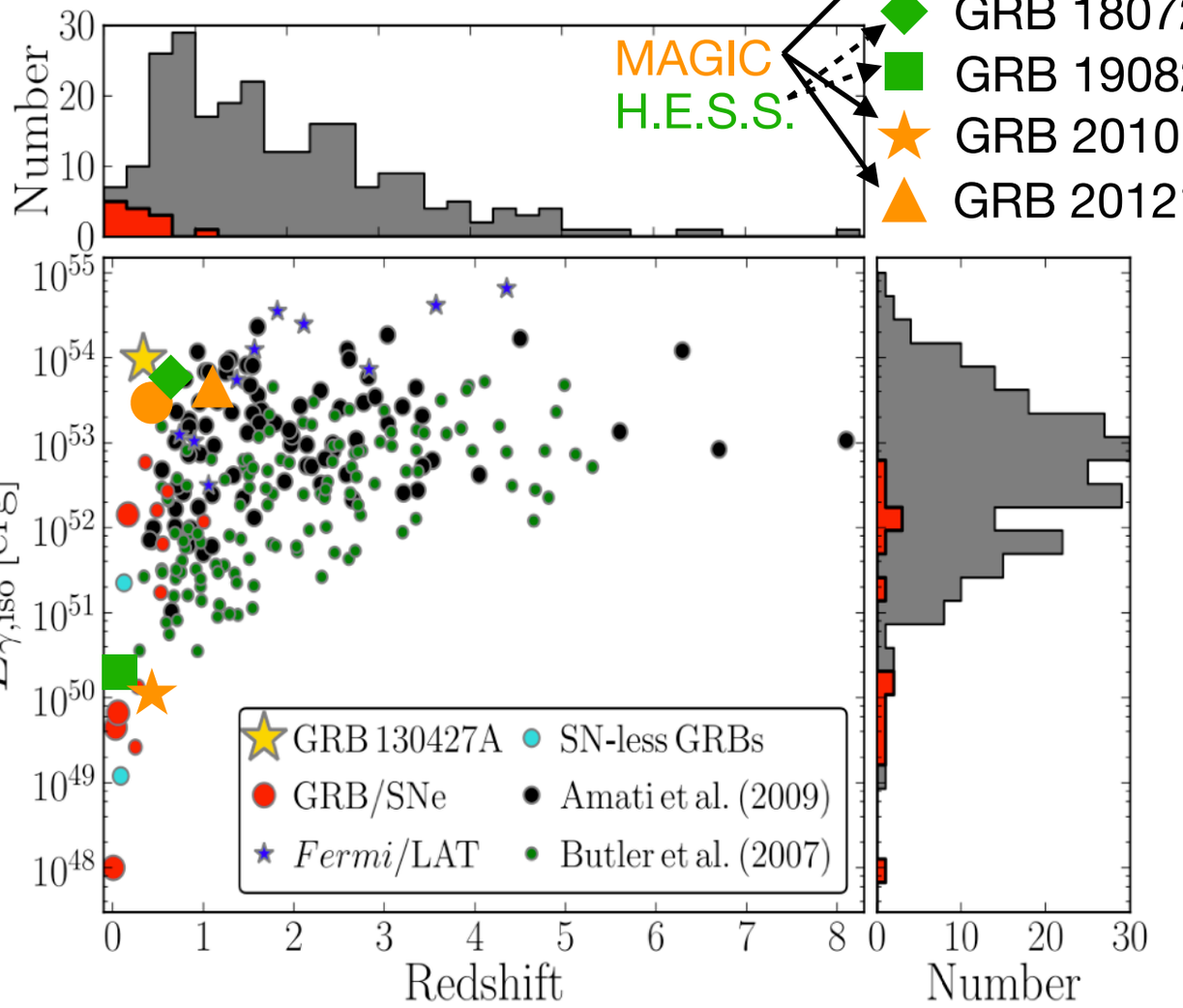
MWL Light Curves



- Only upper limits from the MAGIC standard analysis
- $E_{MAGIC\ (T0+33s\ -\ T0+1000s)} \sim E_{XRT}$ if we extrapolate back in time the XRT integrated flux LC

GRB 201015A vs. TeV GRBs

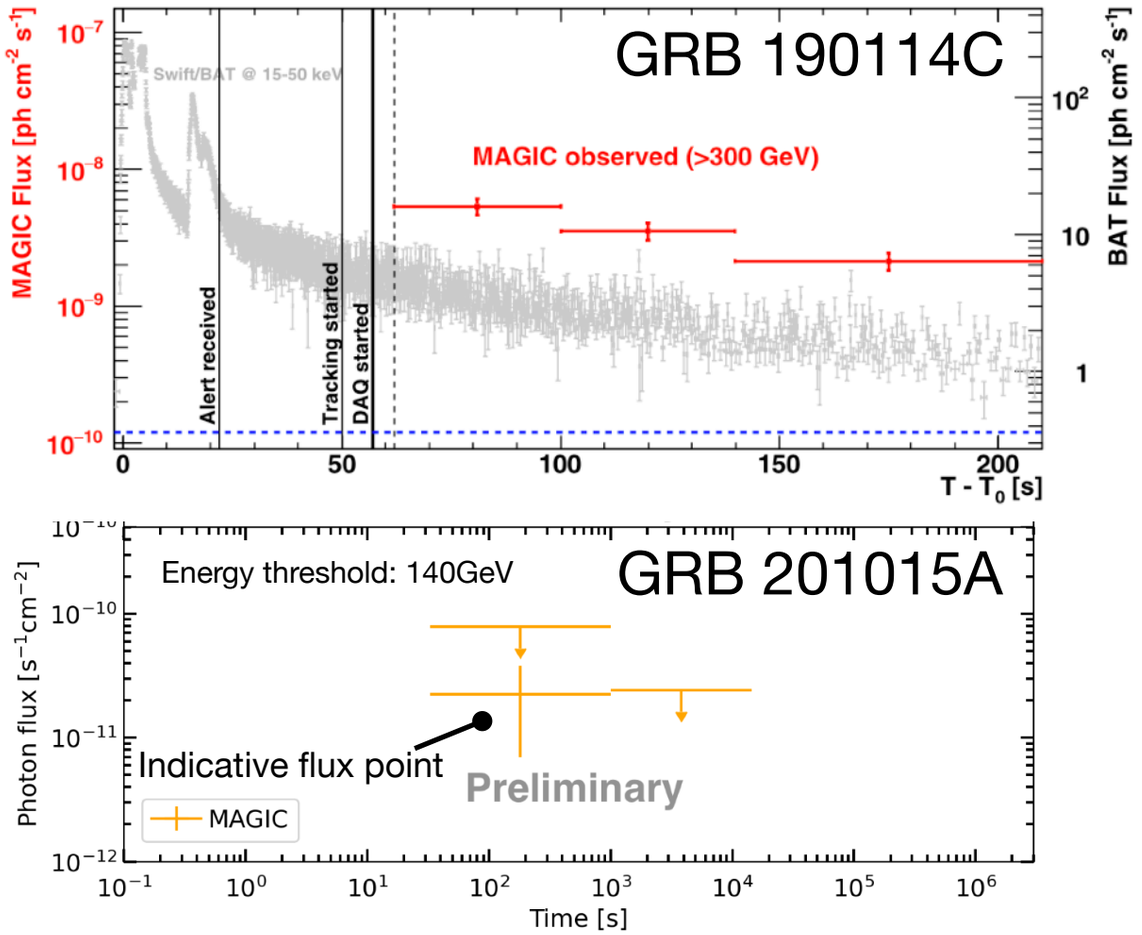
D. Xu et al. ApJ 776 98 (2013)



	z	E_{iso}
GRB 190114C	**~0.42**	~3e53
GRB 180720B	~0.65	~6e53
GRB 190829A	~0.08	~2e50
GRB 201015A	**~0.42**	~1e50
GRB 201216C	~1.10	~5e53

Same z, but 10^3 dimmer

Naively 10^3 lower MAGIC flux can be expected



- Assuming MAGIC detected GRB 201015A, it is in a dimmer class of the TeV-GRB family

Summary

- GRB 201015A is a relatively low luminosity GRB associated with a supernova
- MAGIC quickly performed smooth observations under a good weather condition
- MAGIC saw a hint of gamma-ray emission with 3.5 sigma from GRB 201015A
- Only flux upper limits from the MAGIC standard analysis were obtained
- $E_{MAGIC\ (T0+33s\ -\ T0+1000s)} \sim E_{XRT}$ if we extrapolate back in time the XRT integrated flux LC
- Compared to GRB 190114C (same z, but 10^3 brighter), this less significance for GRB 201015A is reasonable
- Assuming MAGIC detected GRB 201015A, it is in a dimmer class of the TeV-GRB family
- paper in prep.