

2021 TEV Particle Astrophysics Conference

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MAGIC Observations of Gamma-Ray Bursts

Yusuke Suda (Hiroshima U.)
on behalf of the MAGIC Collaboration

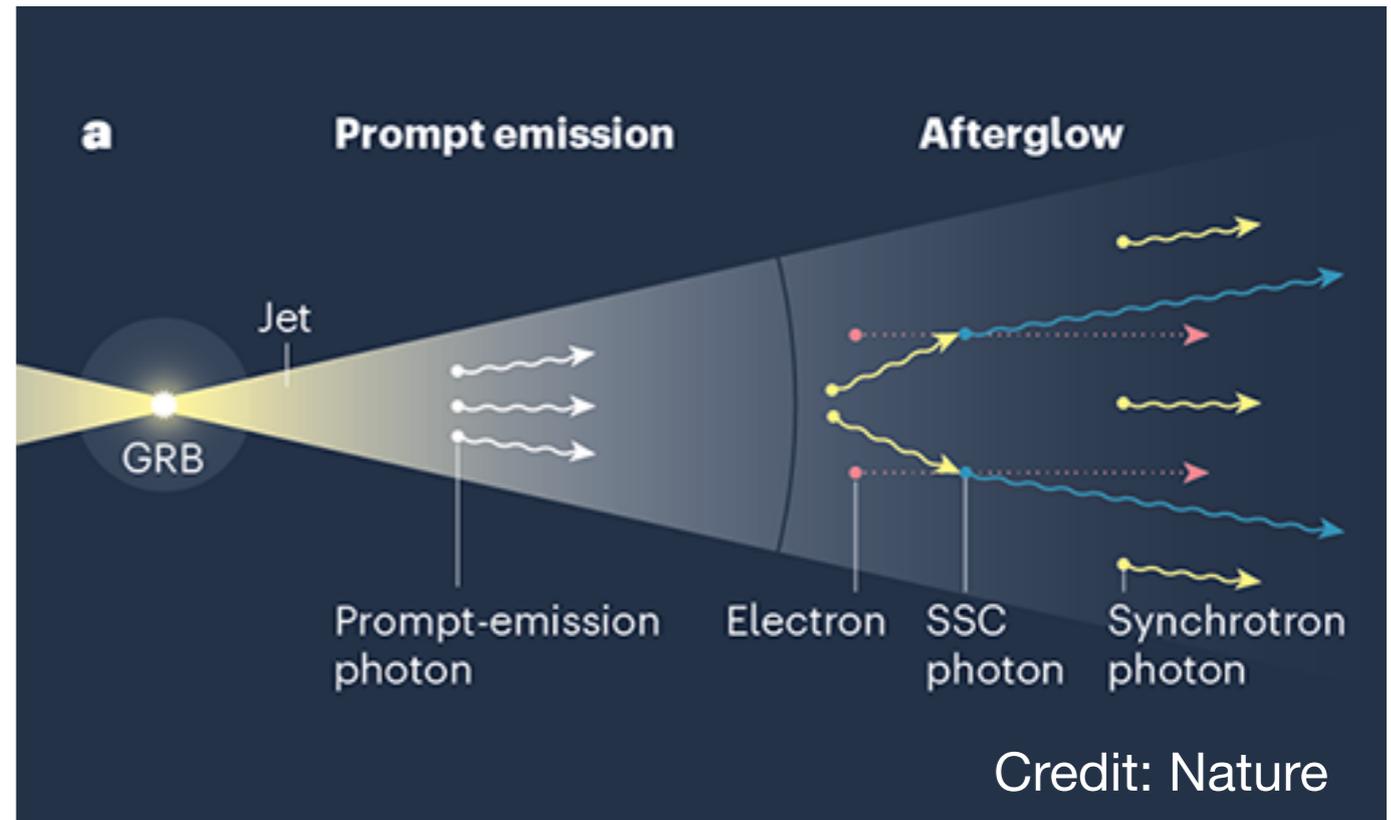


TeV Gamma-Ray Bursts

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Credit: N. Wakabayashi/ICRR

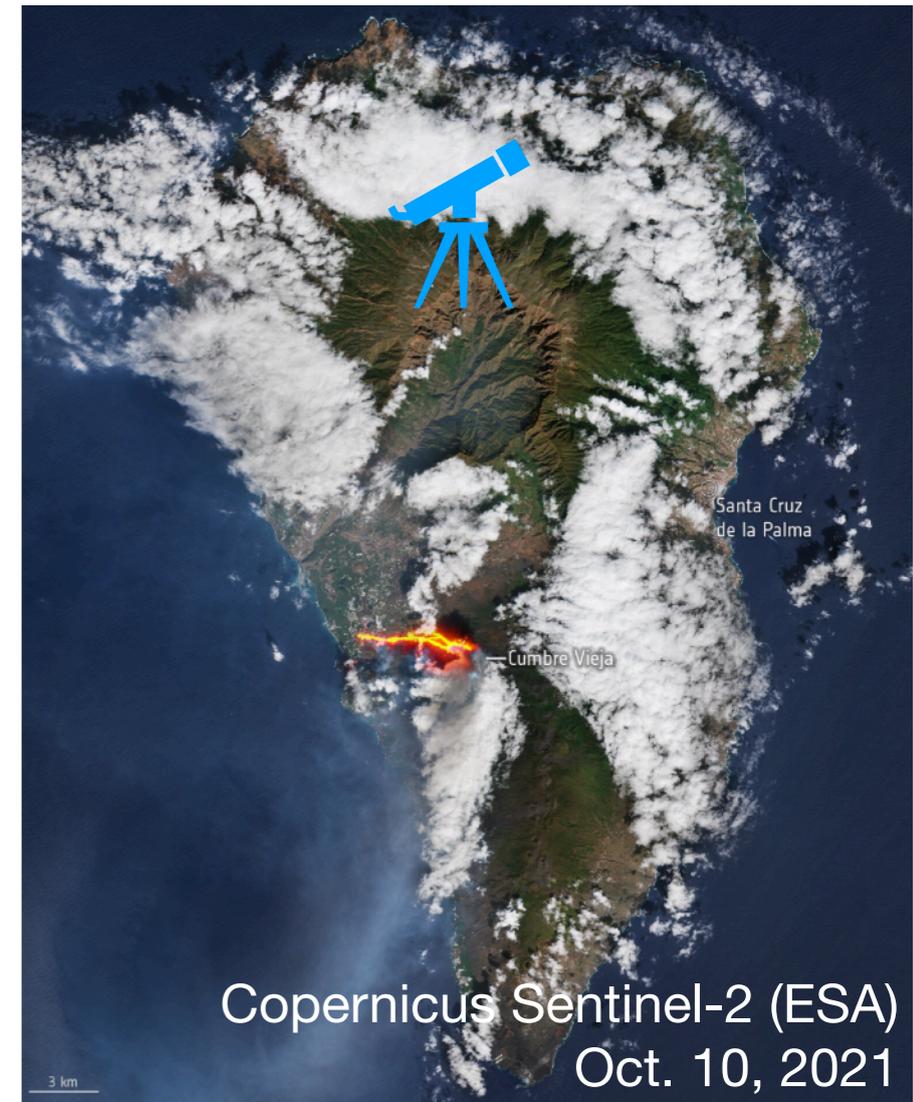


Credit: Nature

- TeV gamma-ray telescopes are exploring the highest energy frontier in GRB studies
 - Some long GRBs have been detected by IACTs in afterglow phase
- What emission mechanism(s)? Common in GRBs? Short GRBs? etc.
 - Synchrotron self-Compton (SSC) model is a natural explanation at least for a few long GRBs
- Need more TeV GRB detections to deepen understanding of GRBs

MAGIC Telescopes

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- Two 17 m IACTs since 2009 (mono 2003)
- La Palma, Canaries, Spain. 2200 m a.s.l.
- Energy range: 30 GeV - 100 TeV
- Fast repointing ~ 7 deg/s
- Fully automatic repointing&DAQ

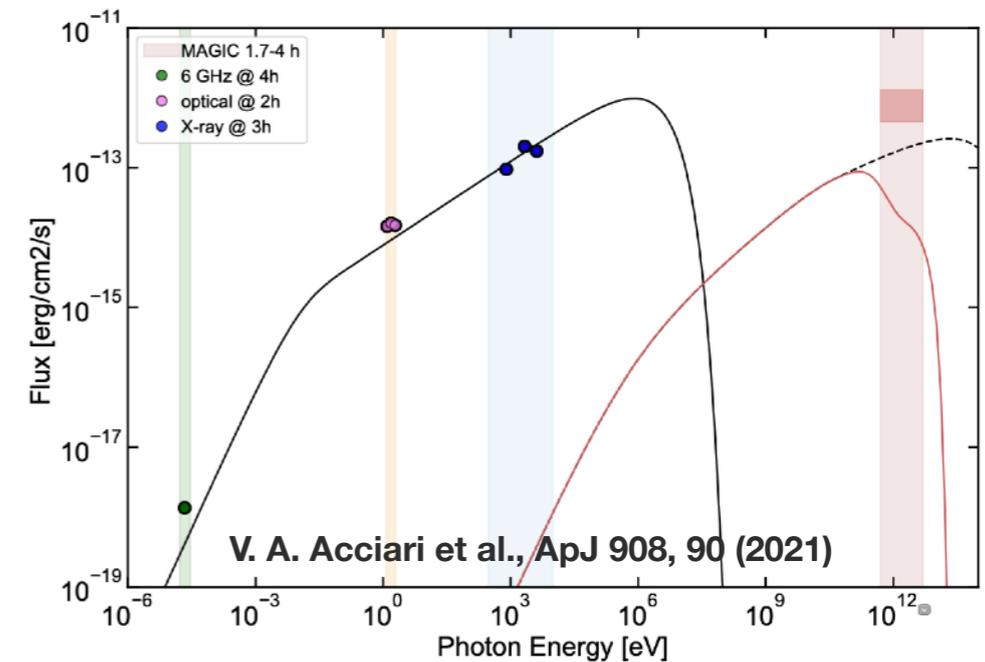
Volcanic activity (eruption on 2021.09.19) keeps preventing MAGIC operations.
No damage to the telescopes.
Will resume when the Earth has calmed down.

GRB Follow-Up Program

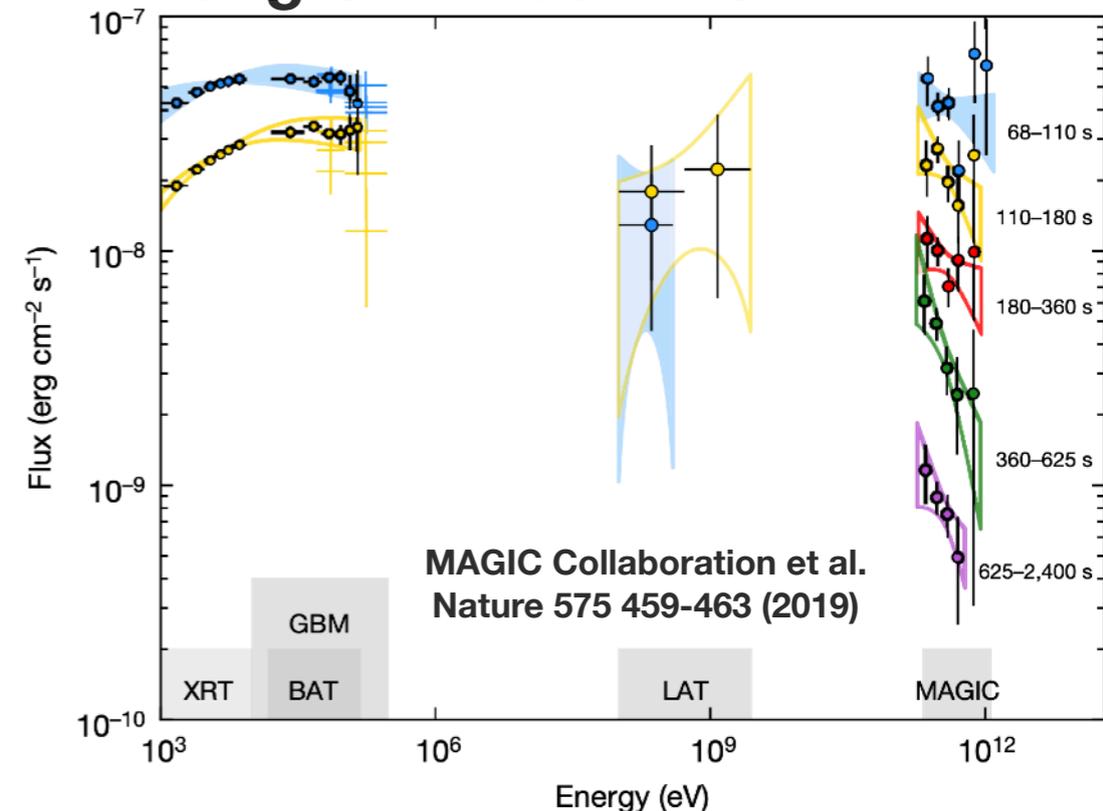
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- Starting from 2005, >130 GRBs followed (~8 GRBs/year)
 - 2005 - 2013: ON pointing mode
 - 2013 - now: Wobble pointing mode
- **GRB 160821B**: short GRB associated to a kilonova
 - 3σ hint of gamma-ray emission
 - If detected, challenging to explain with SSC
- **GRB 190114C**: bright long GRB
 - Discovery of TeV gamma-ray emission from a GRB
 - SSC as a new emission mechanism in GRB afterglow
 - Reported at TeVPA 2019
- IACTs can detect GRBs! Interesting to study our large sample of not-detected GRBs
→ “Upper limits” paper is in prep.

Short GRB 160821B



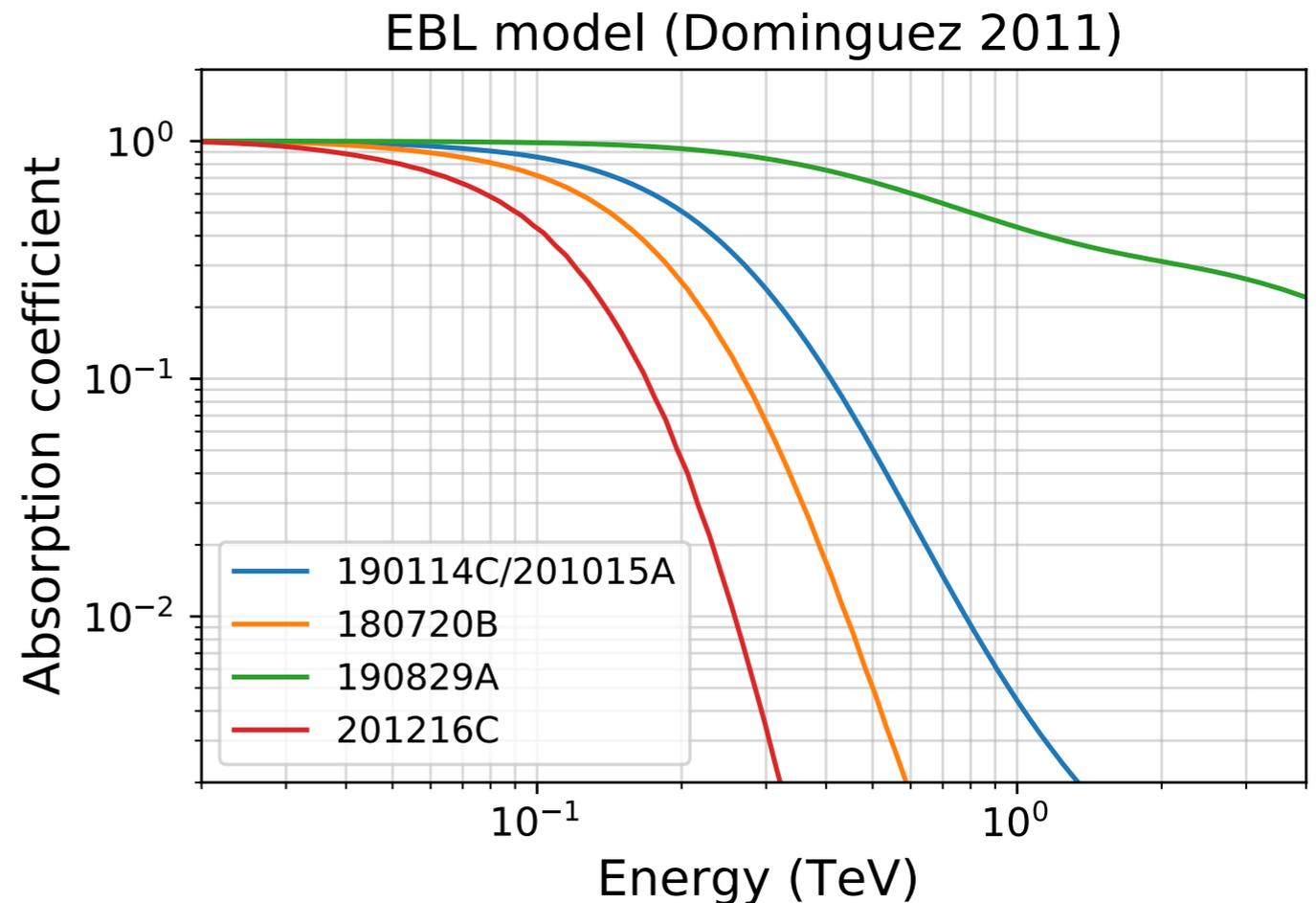
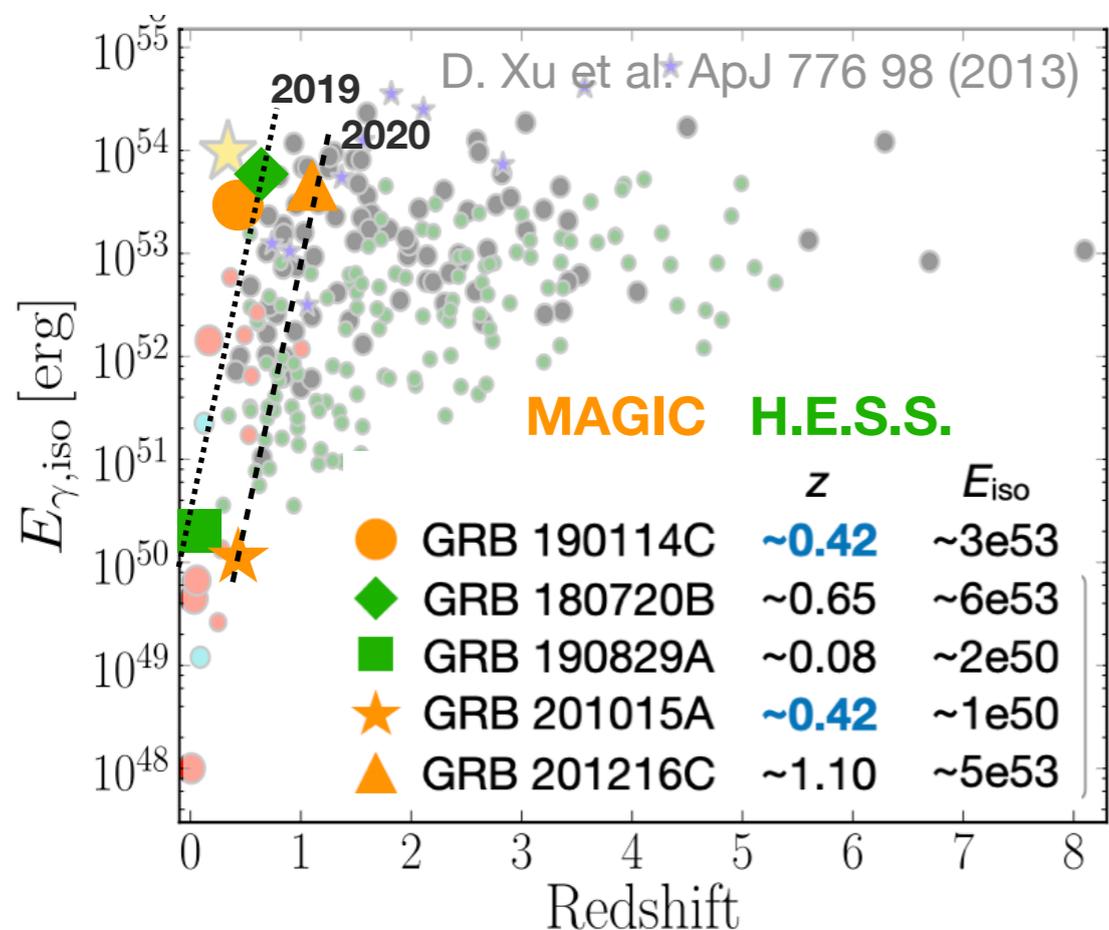
Long GRB 190114C



GRB Follow-Up Program

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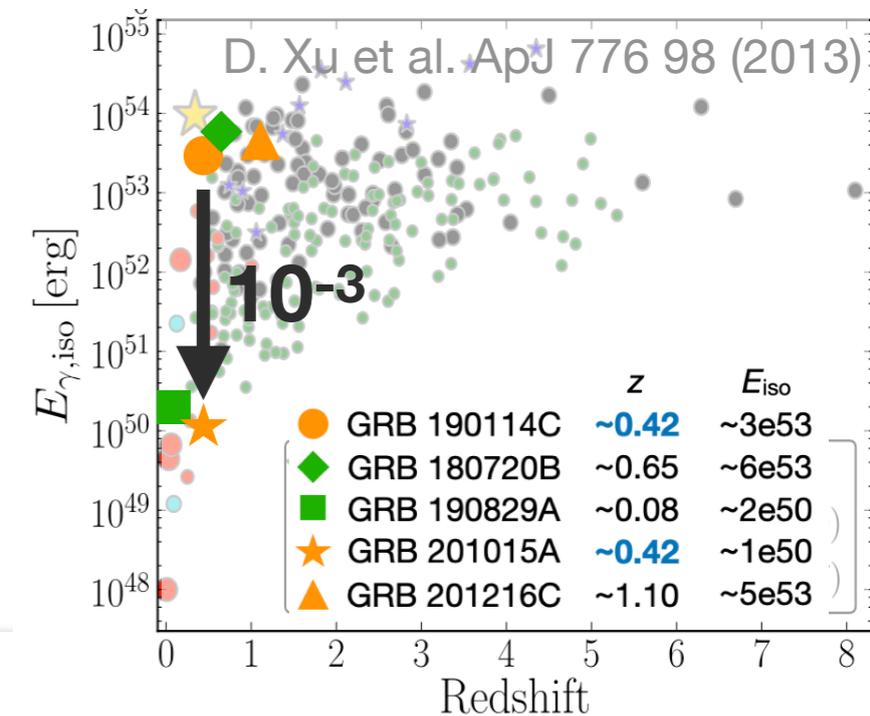
- GRB 201015A: relatively low luminosity long GRB
 - As dim as 190829A detected by H.E.S.S., but much more distant
- GRB 201216C: bright long GRB
 - As bright as 190114C, but much more distant



GRB 201015A

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- Relatively low luminosity long GRB triggered by Swift-BAT
 - $T_{90} = 9.78 \pm 3.47$ s [GCN 28658](#)
 - $E_{\text{iso}} = (1.1 \pm 0.2) \times 10^{50}$ erg [GCN 28668](#)
 - $z = 0.426$ [GCN 28649](#)
 - Supernova found (max 18-21 days) [GCN 29033](#)
- MAGIC quick analysis showed $> 3\sigma \rightarrow$ GCN



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:

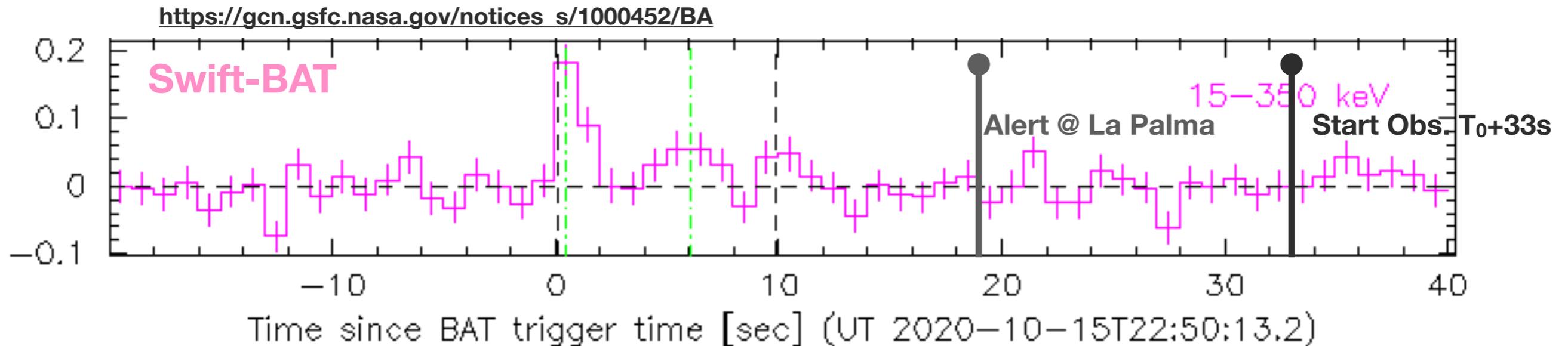
On October 15, 2020, the MAGIC telescopes observed GRB 201015A following the Swift-BAT trigger (D'Elia et al., GCN 28632). MAGIC started observations under good conditions about 40 seconds after the initial Swift trigger, revealing a hint of signal with significance > 3 sigma in the very high energy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

GRB 201015A: MAGIC Observations

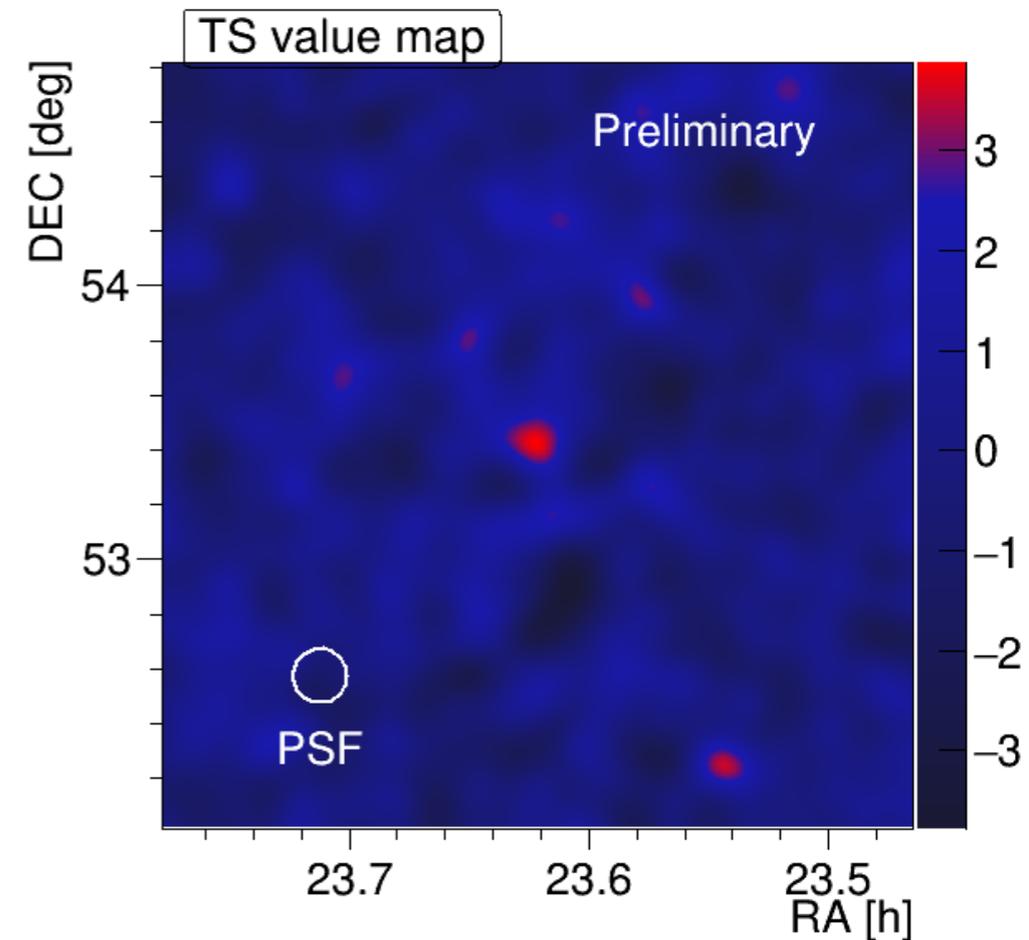
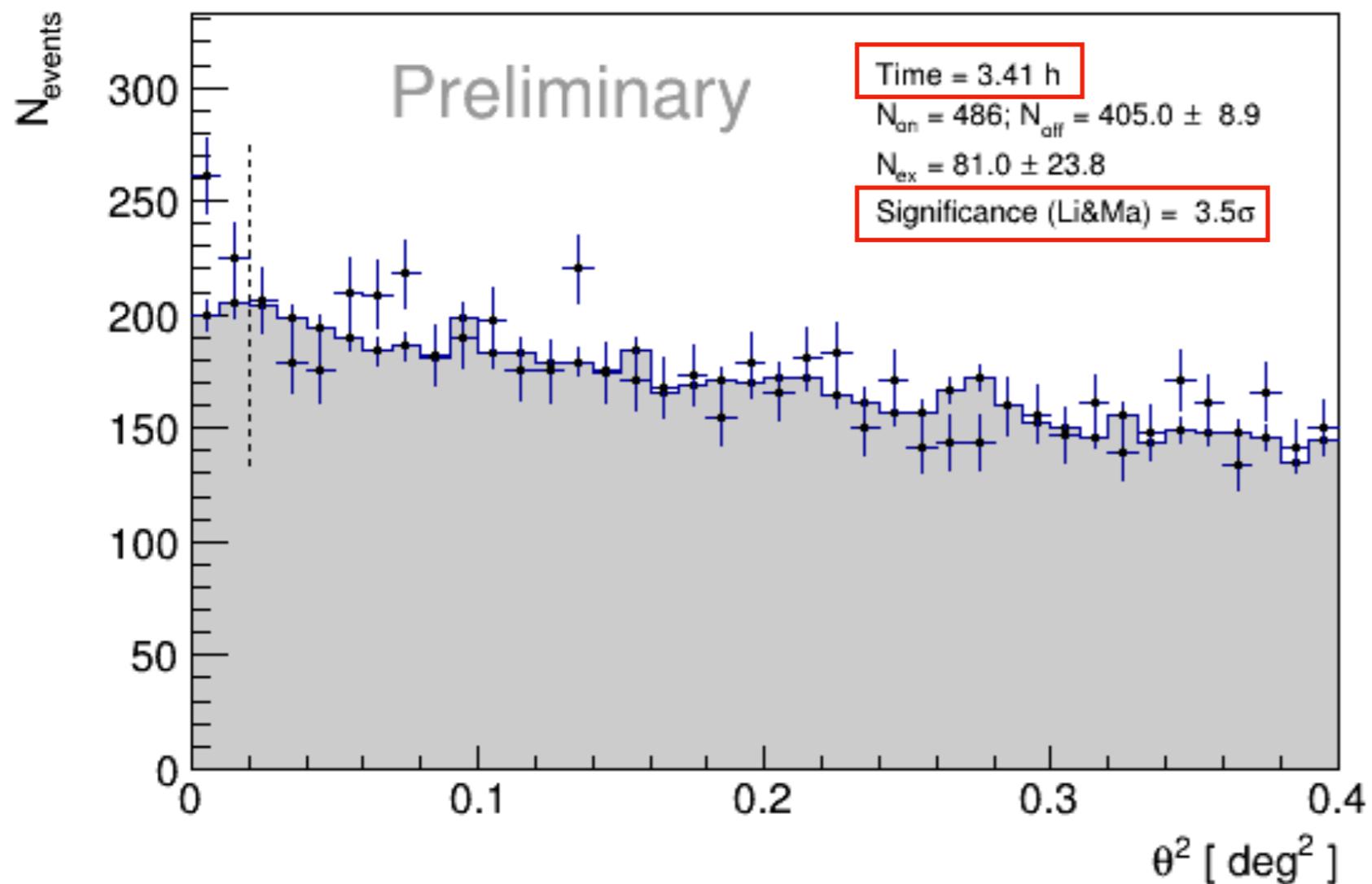
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- **Only 14 seconds** to start the observations after the alert arrived (T_0+33s). One of the fastest MAGIC observations
- Low-mid zenith angles: 24 → 48 deg
- Dark time, good weather condition
- Quality cuts: some of the data affected by passing clouds removed
- Analysis method: standard MAGIC analysis

GRB 201015A: Theta2 & Skymap

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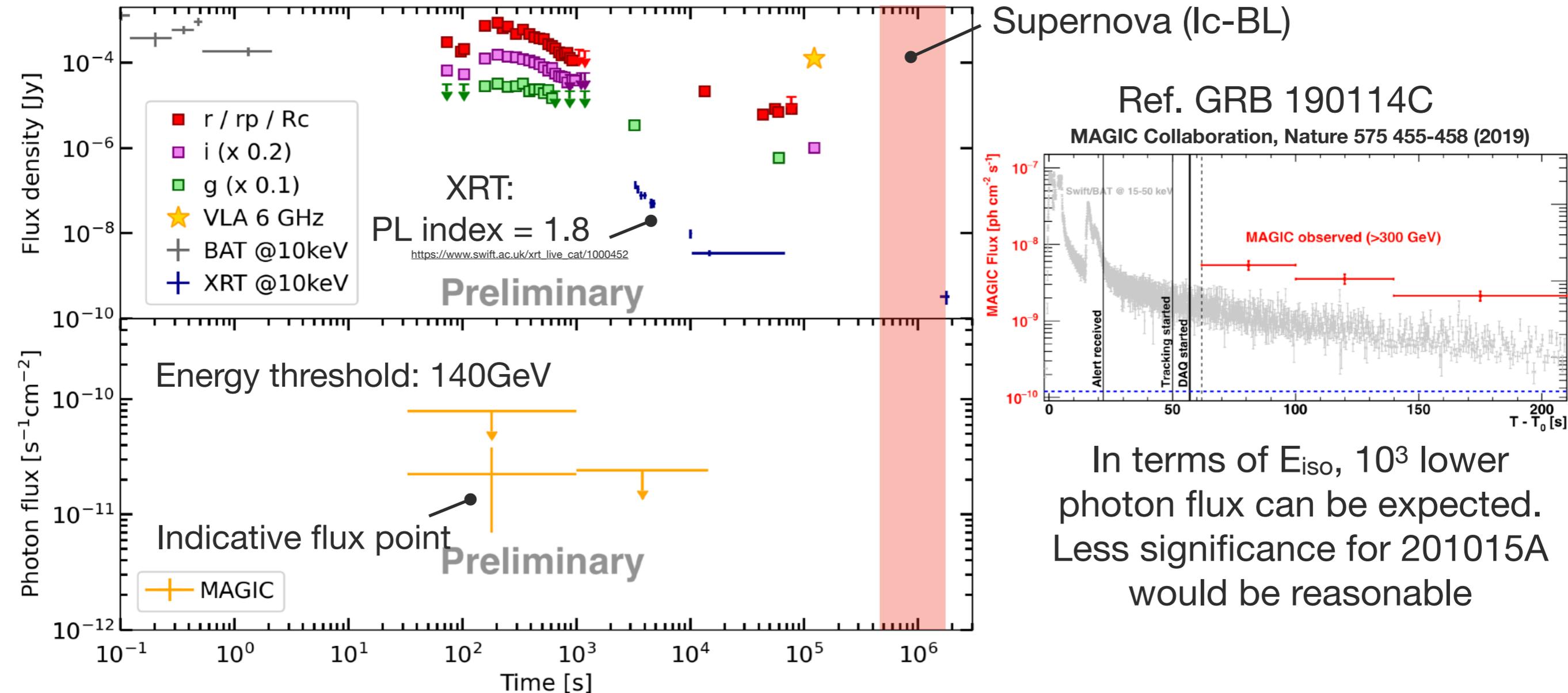


Coordinates by NOT [GCN 28637](#):
RA = 23h 37m 16.41s
Dec = +53d 24min 56.5s

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

GRB 201015A: Light Curve

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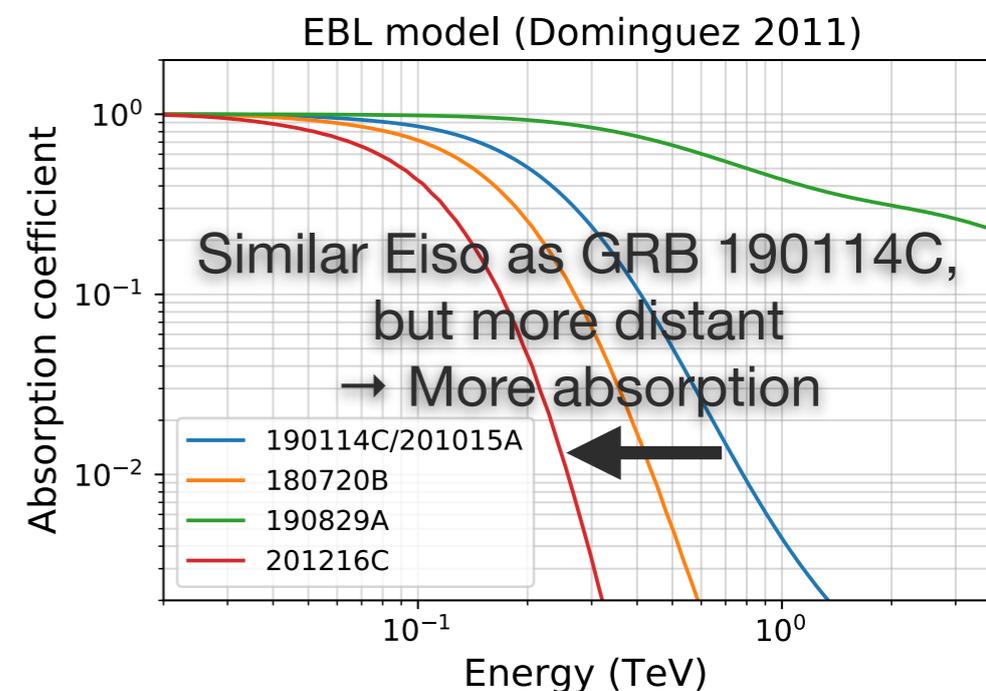


- Only upper limits from the MAGIC standard analysis
- If detected, TeV emission is estimated to be smaller, but comparable to the power in prompt emission (keV - MeV)

GRB 201216C

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- Bright long GRB triggered by Swift-BAT
 - $T_{90} = 48 \pm 16$ s [GCN 29080](#)
 - $E_{\text{iso}} = (4.71 \pm 0.16) \times 10^{53}$ erg [GCN 29077](#)
 - $z = 1.1$ [GCN 29077](#)
- MAGIC: $> 5\sigma$ detection \rightarrow ATel & GCN
- Farthest IACT source so far



GRB 201216C: MAGIC detection in very high energy gamma rays

ATel #14275; *Oscar Blanch (IFAE-BIST) on behalf of the MAGIC Collaboration*
on 17 Dec 2020; 17:23 UT
Credential Certification: Oscar Blanch (blanch@ifae.es)

Subjects: Gamma Ray, >GeV, TeV, VHE, Gamma-Ray Burst

Referred to by ATel #: 14277

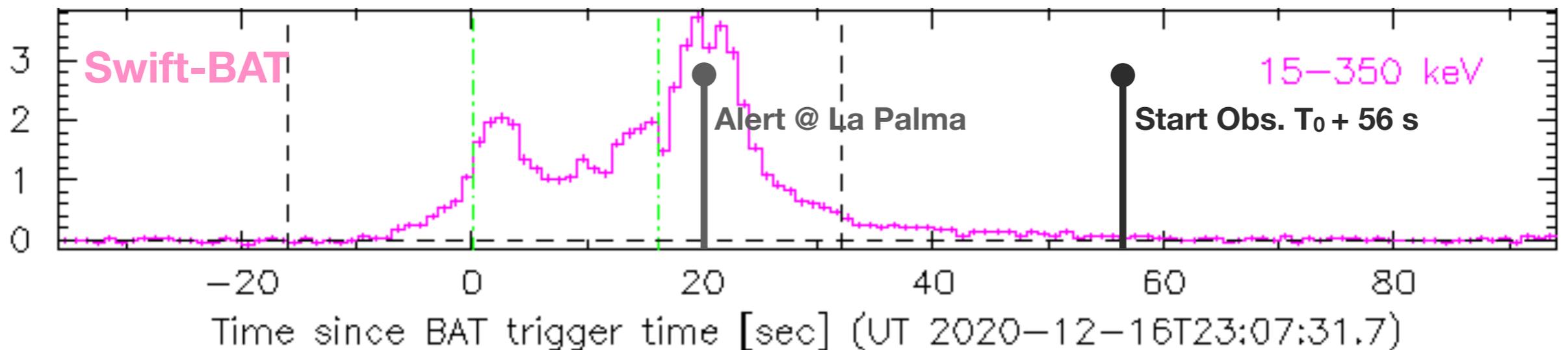
[Tweet](#)

On December 16, 2020, the MAGIC telescopes observed GRB 201216C following the trigger by Swift-BAT and Fermi-GBM (Beardmore et al., GCN 29061, Fermi/GBM team GCN 29063). MAGIC started observations under good conditions about 57 seconds after the GRB onset. The preliminary off-line analyses show an excess above 5 sigma, compatible with the GRB position reported by the Swift and Fermi teams. Refined off-line analyses of the data are ongoing.

GRB 201216C: MAGIC Observations

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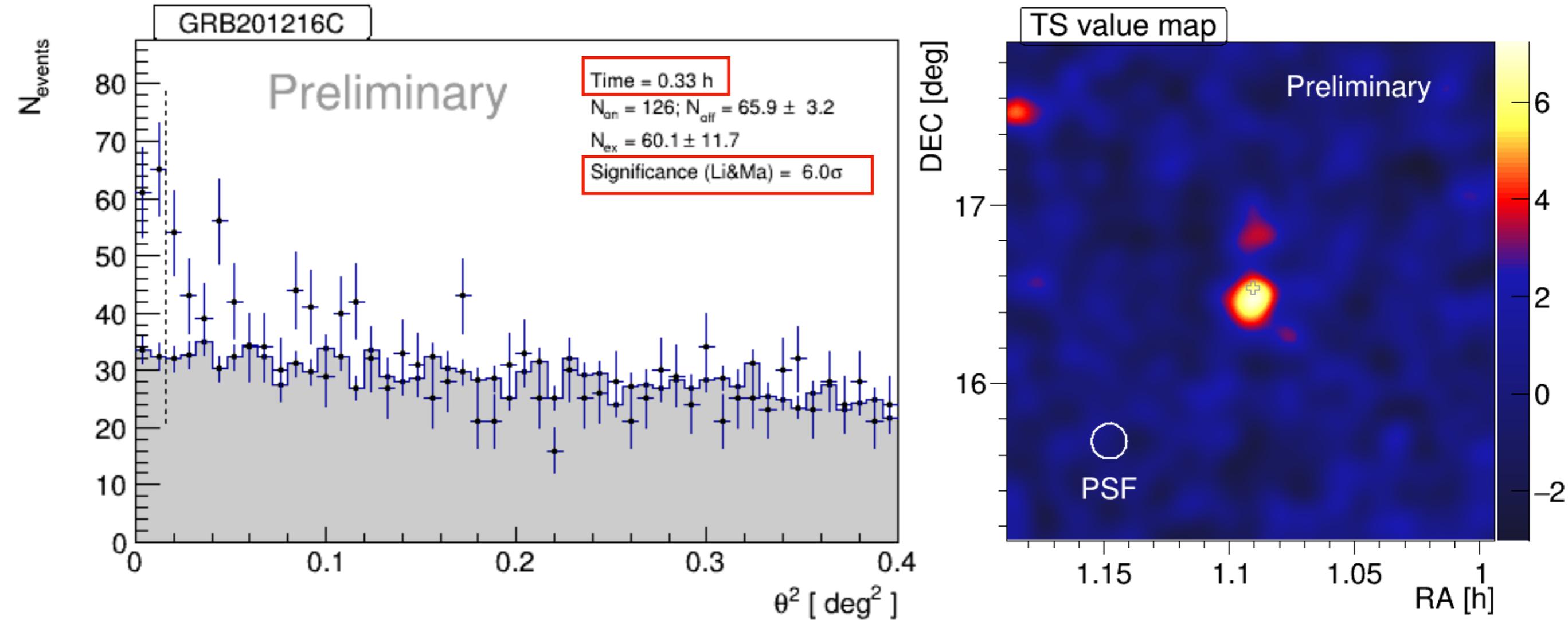
https://gcn.gsfc.nasa.gov/notices_s/1013243/BA



- 36 seconds to start observations after the alert arrived (T_0+56 s)
- Mid-high zenith angles: 37 → 68 deg
- Dark time, good weather condition
- Strong EBL absorption ($z=1.1$) suppresses higher energy gamma-rays
- MAGIC low energy analysis method applied

GRB 201216C: Theta2 & Skymap

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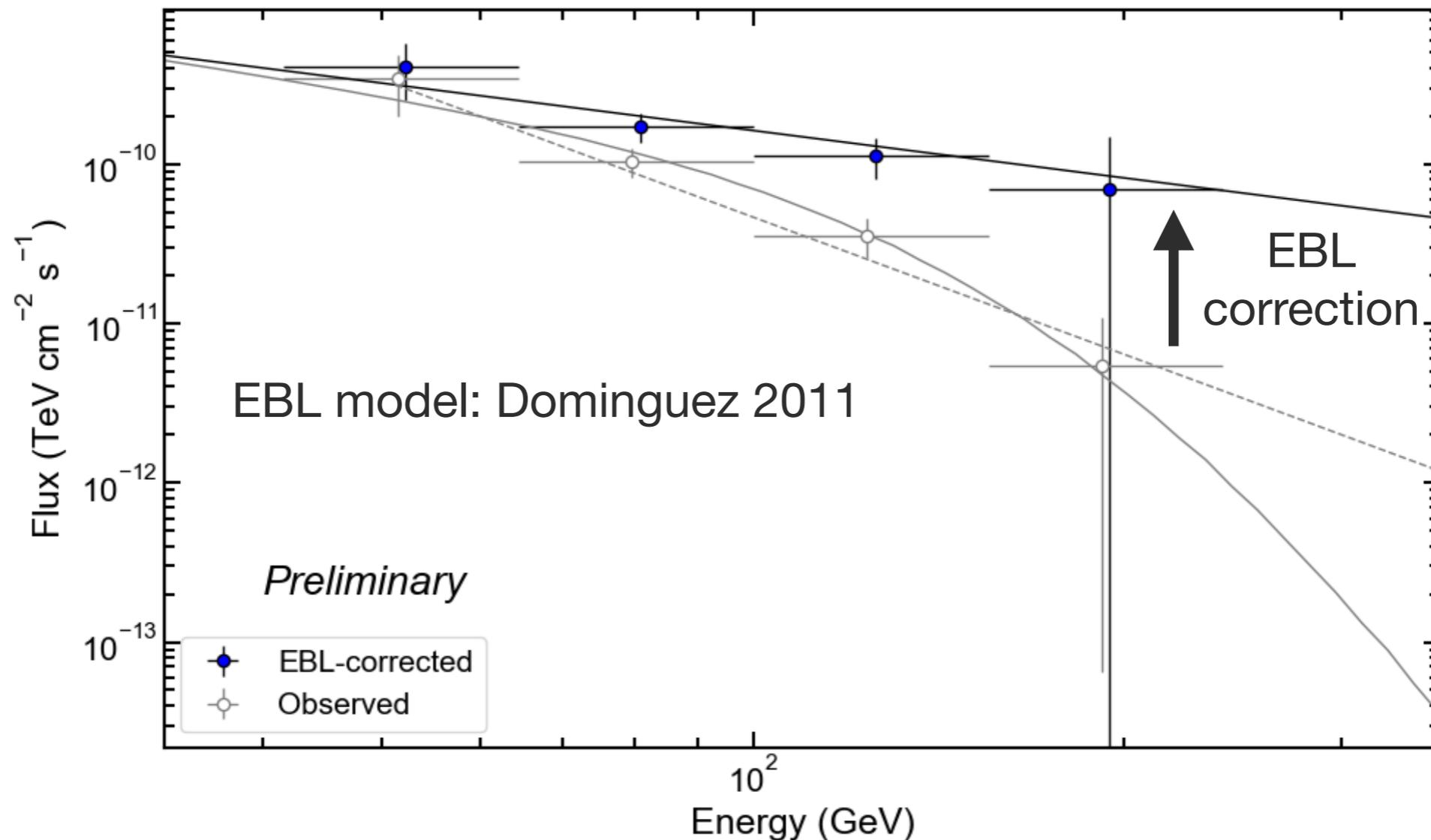


- Detection of gamma-ray emission from GRB 201216C (6σ)

GRB 201216C: SED

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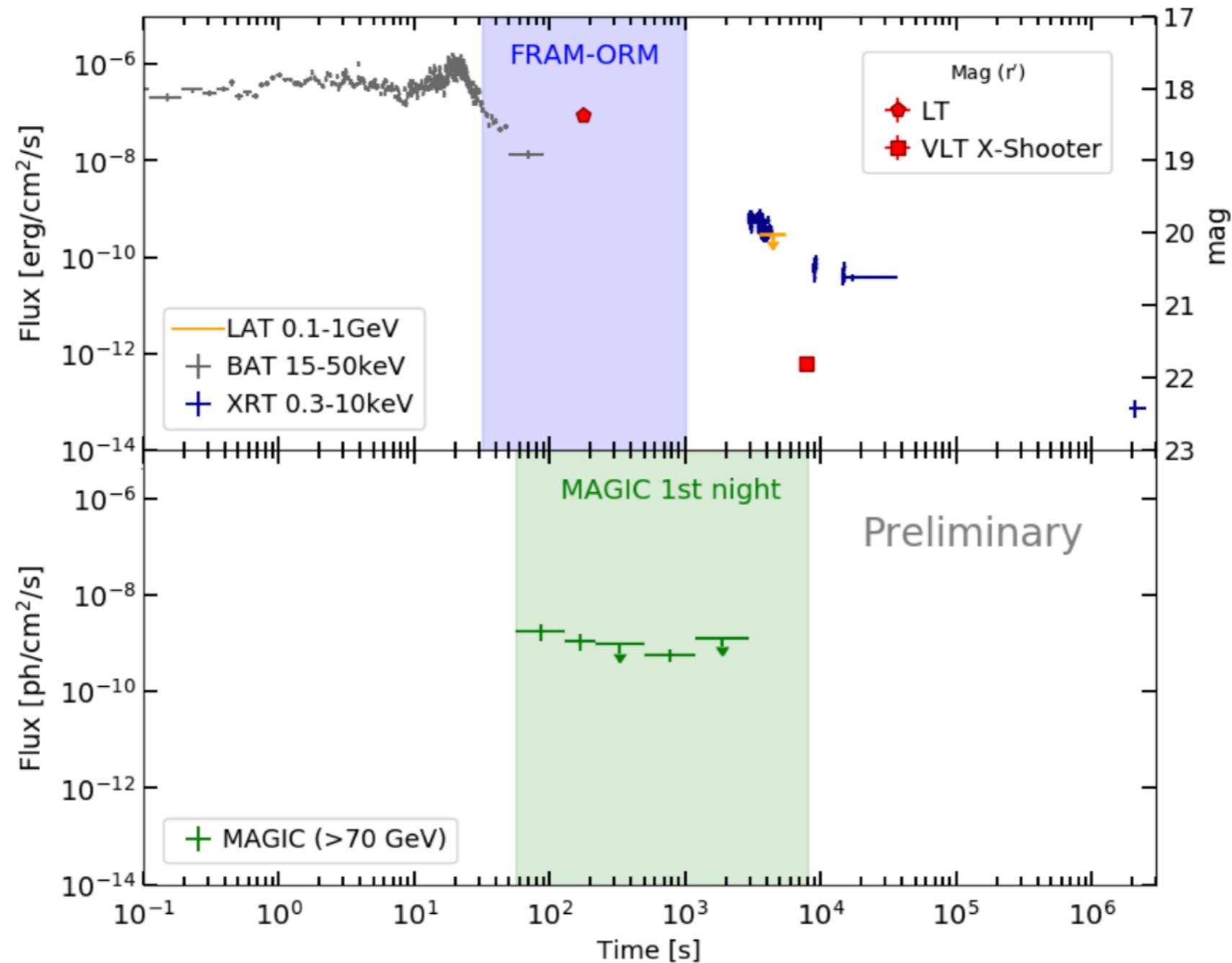
Unfolded spectra (points)
& forward folded spectra (fitted lines) for the first 20 min



- Both observed and de-absorbed spectra are well fitted by a power law function

GRB 201216C: Light Curve

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- Monotonic decay of photon flux observed by MAGIC ($T_0+56s - \sim 10^3s$)
→ What MAGIC saw could be only afterglow

Summary

- TeV gamma-ray telescopes are exploring the highest energy frontier in GRB studies
- Long term efforts (since the design phase) to detect GRBs by the MAGIC Collaboration are getting paid off
 - Long GRBs: 2 clear detections & 1 hint of detection
 - Short GRBs: 1 hint of detection
 - Not-detected GRBs: many. “Upper limits” paper is in prep.
- GRB 201015A and 201216C are GRBs which are more difficult to detect by IACTs compared to the previous GRBs
 - GRB 201015A: 3.5σ hint of detection
 - GRB 201216C: 6σ clear detection. Power law spectrum. Monotonic decay in light curve
 - papers in prep.