



Credit: N. Wakabayashi (ICRR)

Yusuke Suda

(Max Planck Institute for Physics → Hiroshima University)

A. Berti, S. Covino, S. Fukami,

S. Inoue, D. Miceli, E. Moretti,

L. Nava, K. Noda, I. Vovk

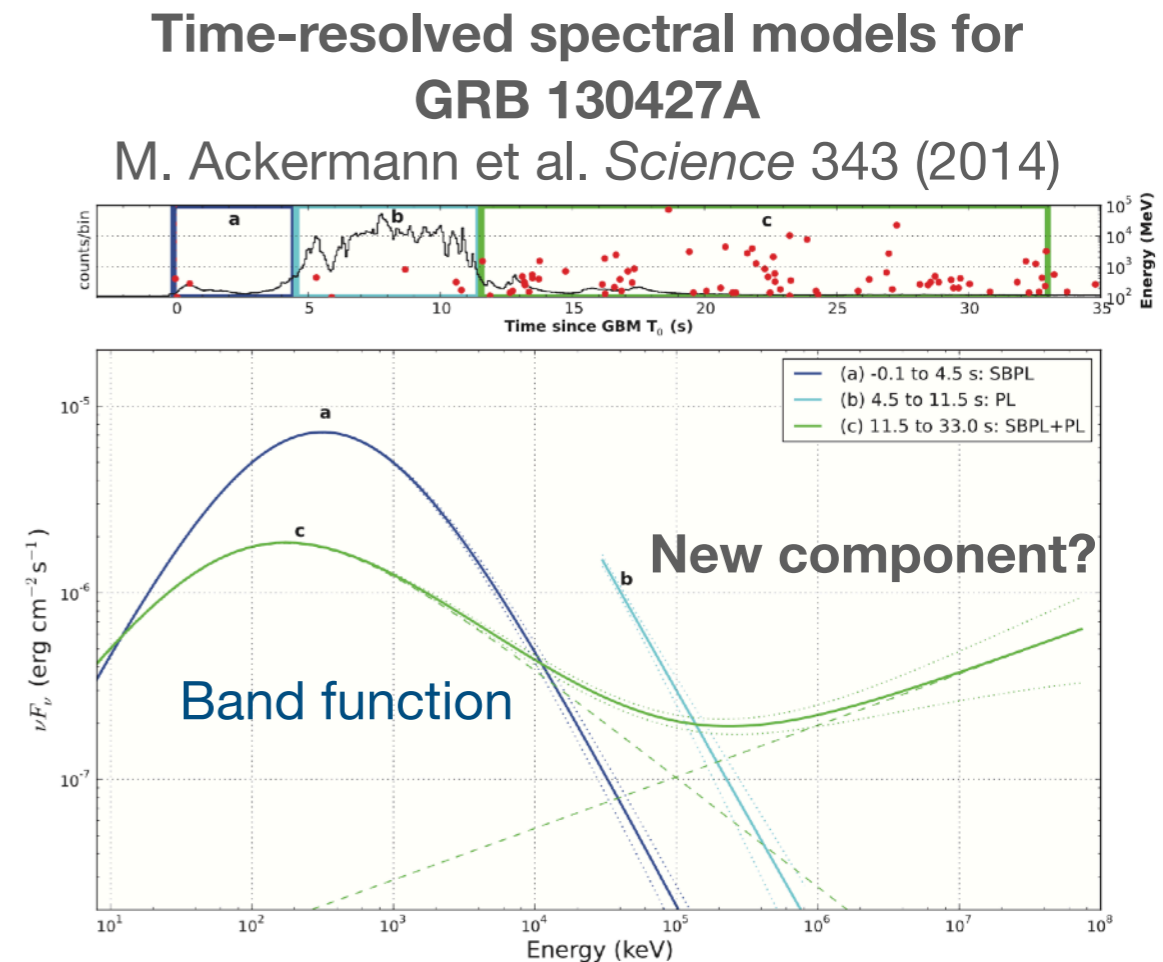
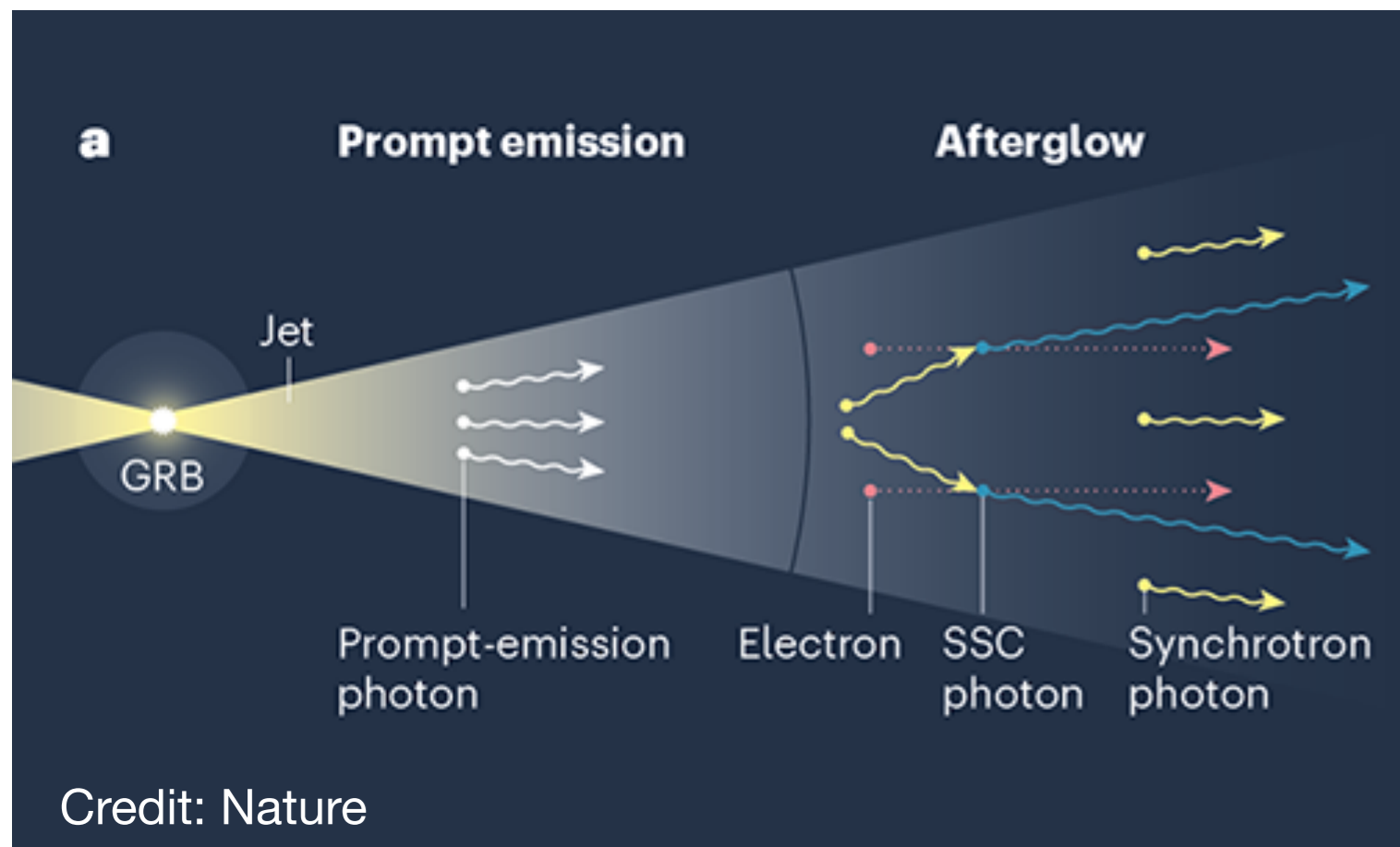
on behalf of the MAGIC Collaboration

Apr. 12th, 2021

First Detection of Very High Energy Emission from a Gamma-Ray Burst

Gamma-Ray Bursts

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- HE photons detected by Fermi/LAT challenge synchrotron origin
- **Synchrotron Self-Compton (SSC)** mechanism had been naturally expected to produce Very High Energy (VHE) photons (> GeV)
- Higher statistics & higher energy photons are necessary → **IACTs**

MAGIC Telescopes

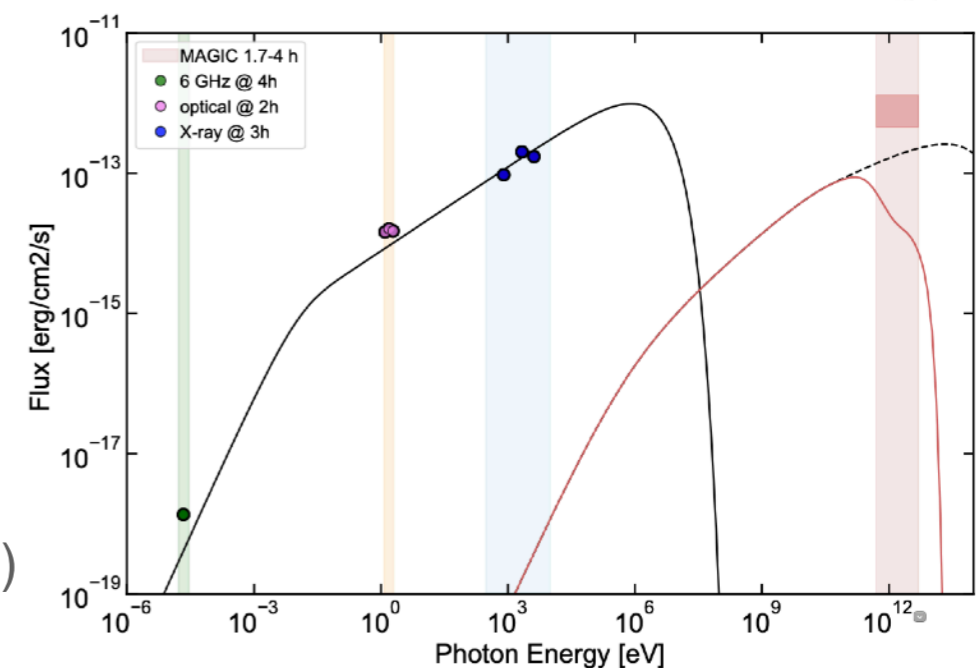
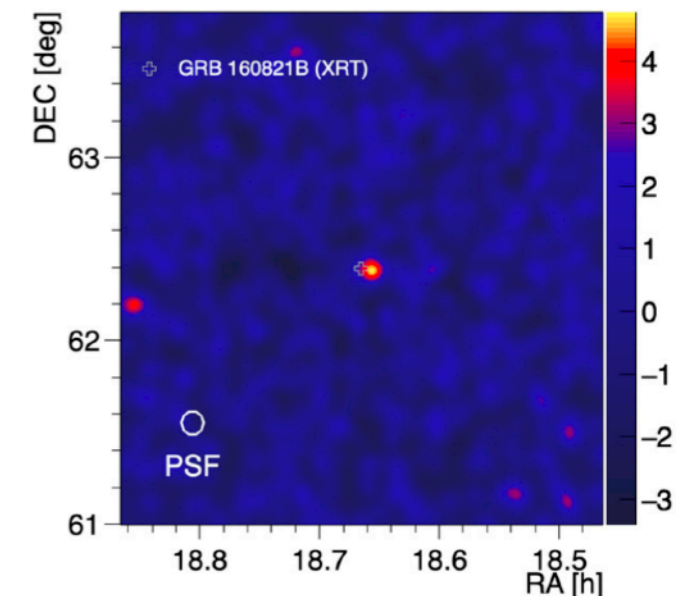
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- Two 17 m IACTs in stereoscopic mode since 2009 (mono 2003)
- La Palma, Canaries, Spain. 2200 m a.s.l.
- Energy range: ~ 30 GeV - > 50 TeV
- Light carbon fibre structure \rightarrow Fast repointing to a GRB (slewing speed: ~ 7 deg/s)
- Observations under moonlight \rightarrow 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

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- Before 2019, no clear detection since 2005 (~8 GRBs/yr)
- 3σ hint of gamma-ray emission from GRB 160821B
 - Short GRB associated to a kilonova
 - One of the closest GRBs for MAGIC: $z = 0.16$
 - Fastest obs.: $T_0 + 24$ s - $T_0 + 4$ h
 - Bright moon, adverse weather
 - Results were published in ApJ



V. A. Acciari et al., *ApJ* 908, 90 (2021)

First time detection of a GRB at sub-TeV energies; MAGIC detects the GRB 190114C

ATel #12390; *Razmik Mirzoyan on behalf of the MAGIC Collaboration*
on 15 Jan 2019; 01:03 UT

Credential Certification: Razmik Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de)

Subjects: Gamma Ray, >GeV, TeV, VHE, Request for Observations, Gamma-Ray Burst

Referred to by ATel #: [12395](#), [12475](#)

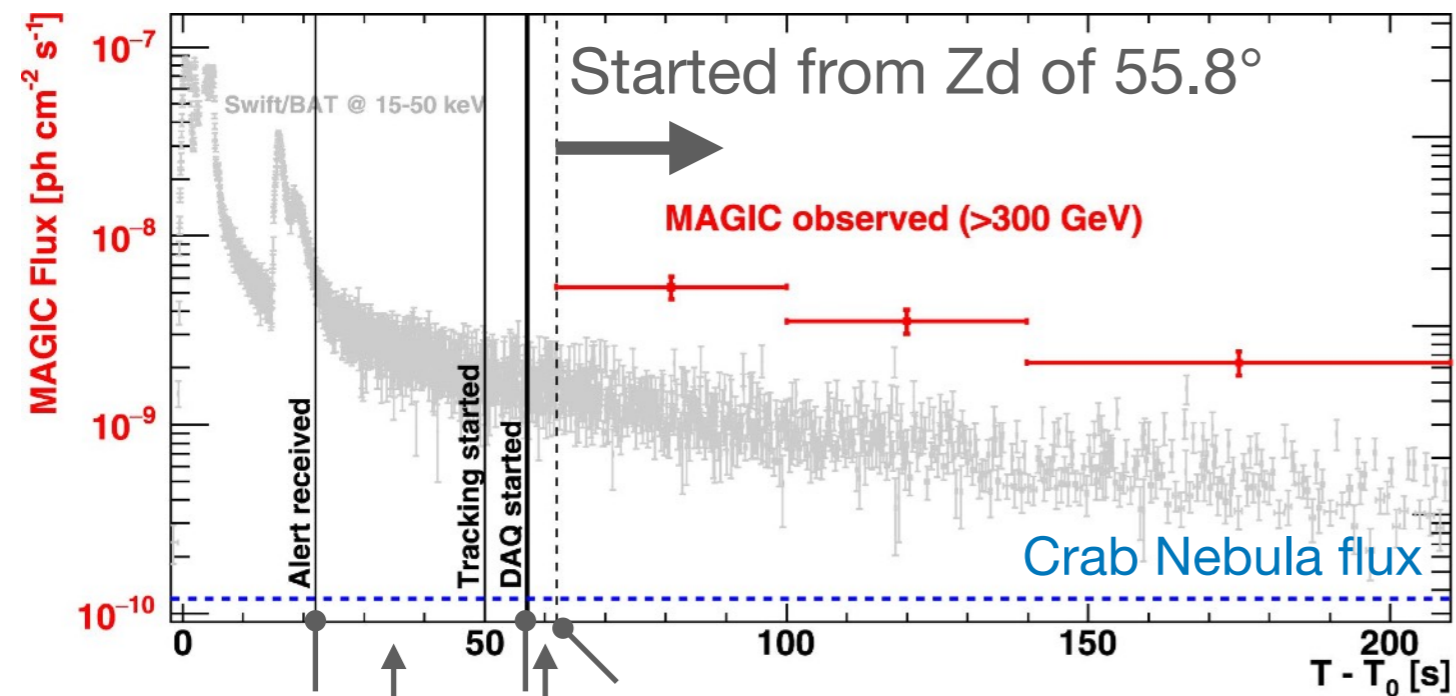
- A long GRB discovered by Swift/BAT and Fermi/GBM on 14 Jan. 2019, 20:57:03 UT
- MAGIC real-time analysis shows a significance > 20 sigma in the first 20 min of observations
 - First unequivocal detection of VHE gamma-rays from a GRB
- One of the closest GRBs for MAGIC: $z = 0.4245$
- Triggered the most extensive MWL campaign for a GRB (Radio - VHE gamma)
 - No neutrino detected by IceCube

MAGIC Observations

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Light curves & Timeline

MAGIC Collaboration, *Nature* 575, 455-458 (2019)



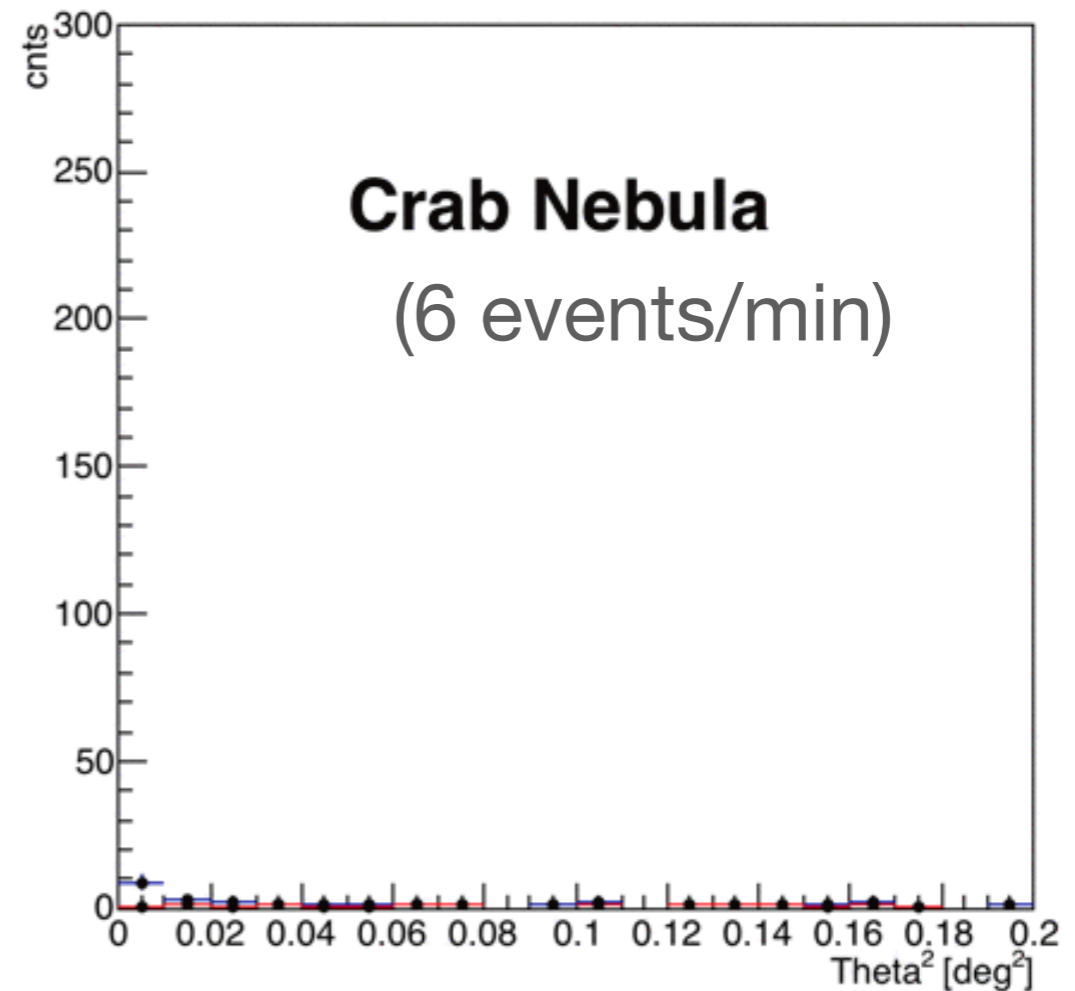
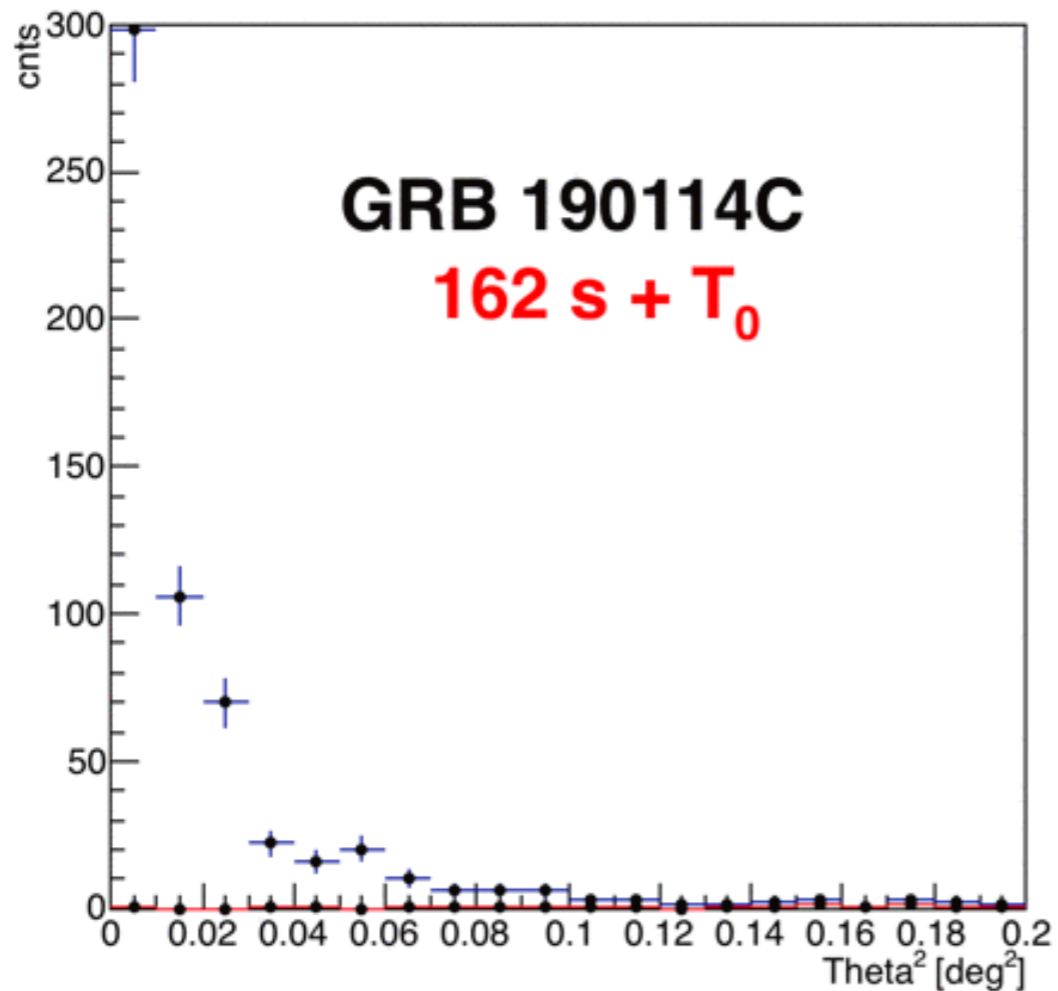
Fast repointing (28 s)
DAQ stabilization + safe margin (5 s)

Automatic alert system worked perfectly

- Good weather, but under moderate moonlight
- Night sky background noise (NSB) is $6 \times$ NSB in dark
- Follow our standard procedure for data taken under moonlight
- Dedicated Monte Carlo γ simulation was produced
 - Matching the trigger settings
 - Zenith-Azimuth distribution
 - NSB level

Brightest TeV Source

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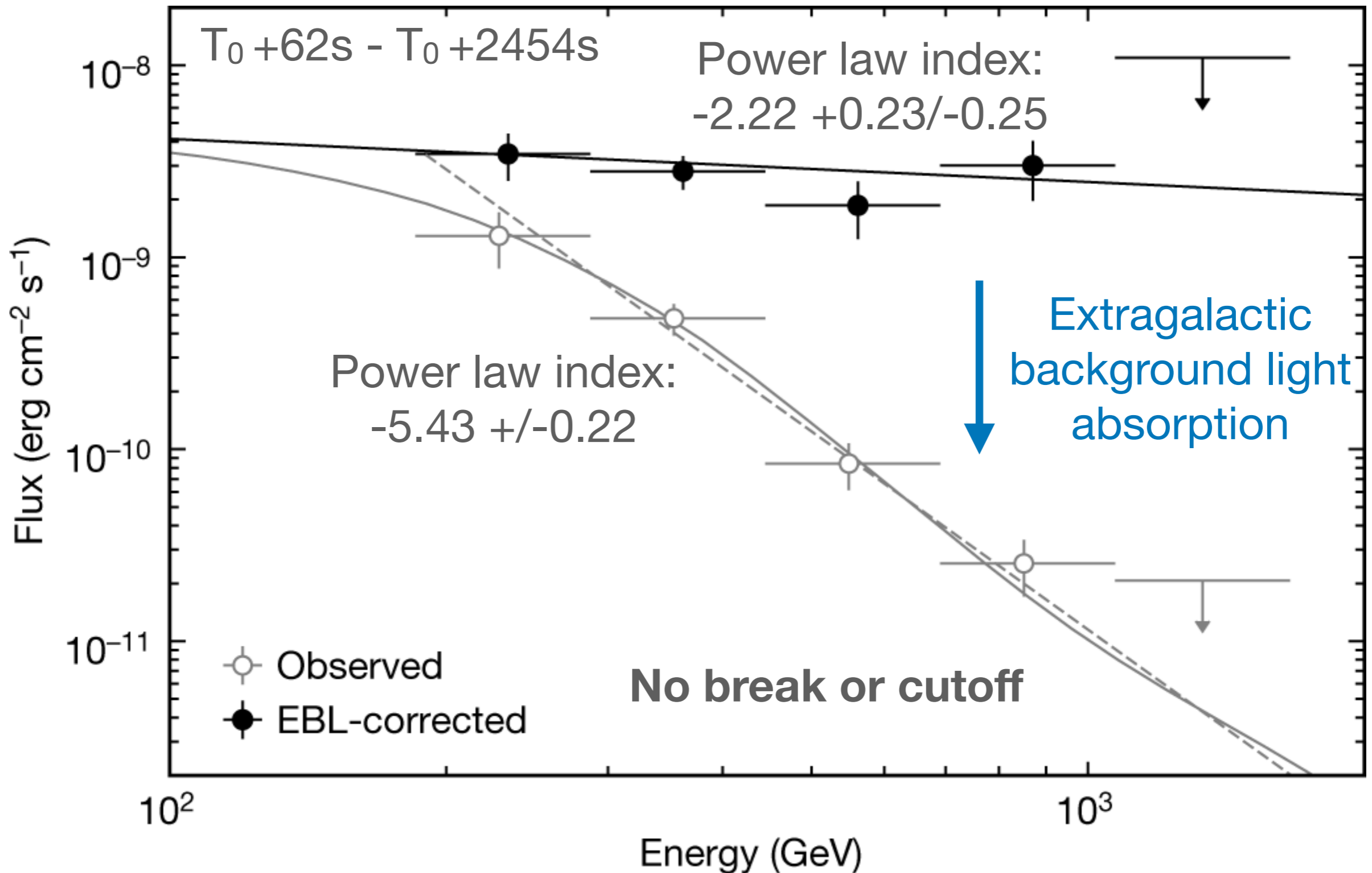


Credit: K. Noda

- Event rate of GRB190114C: ~ 0.1 kCrab @ 0.3 TeV
- Brightest TeV source ever detected

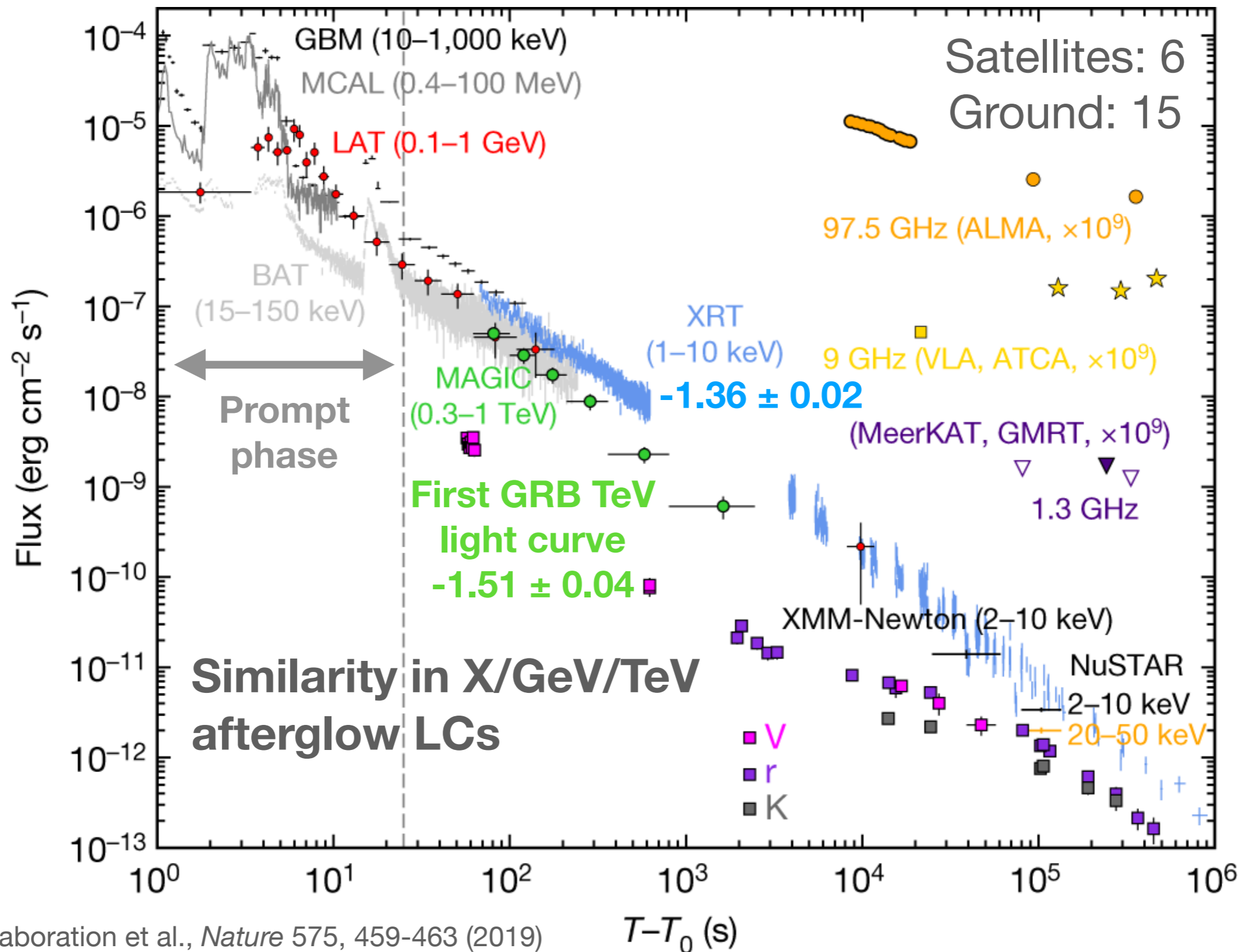
MAGIC SED

MAGIC Collaboration, *Nature* 575, 455-458 (2019)



Extensive MWL Campaign

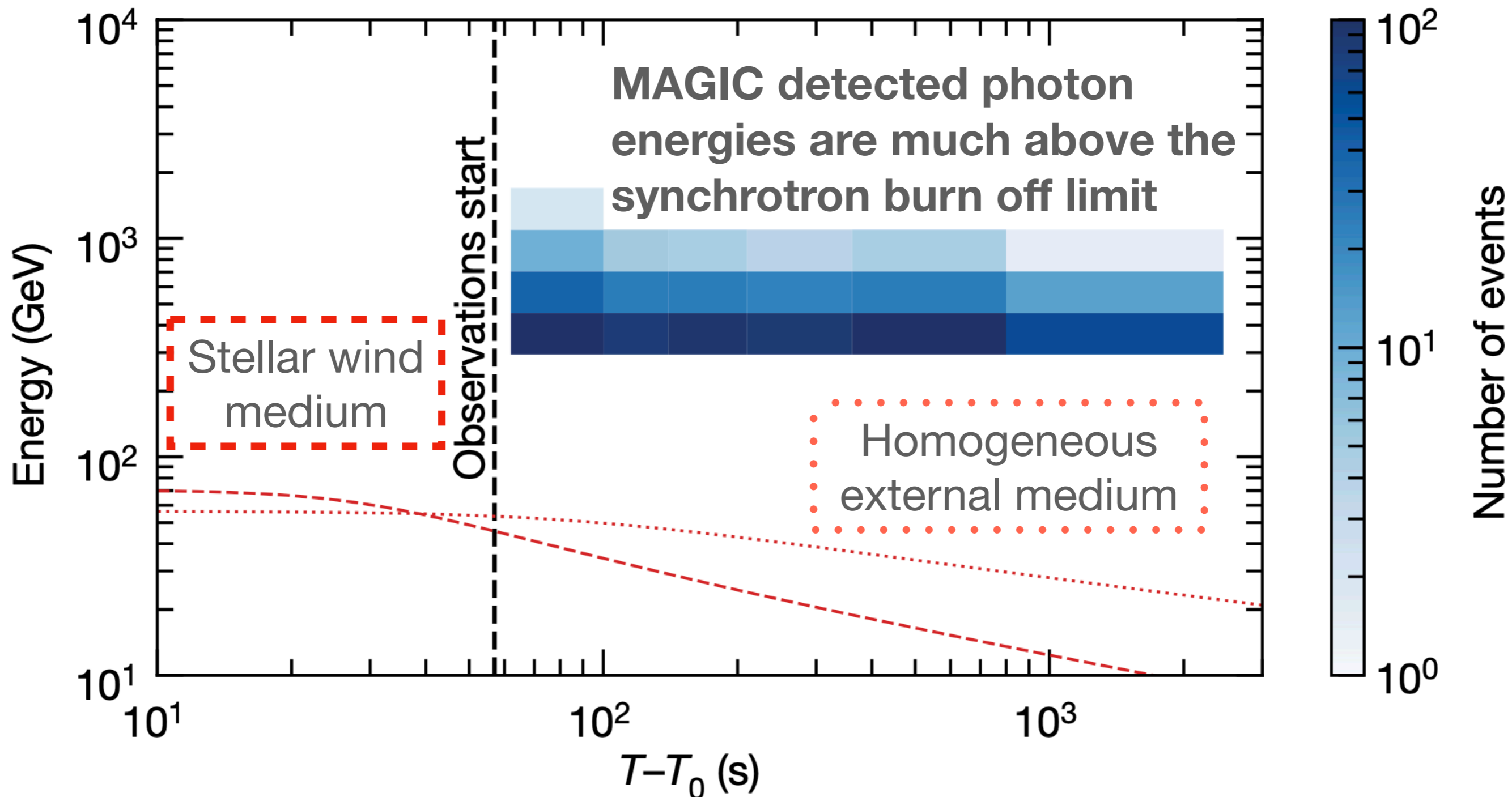
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Beyond Synchrotron

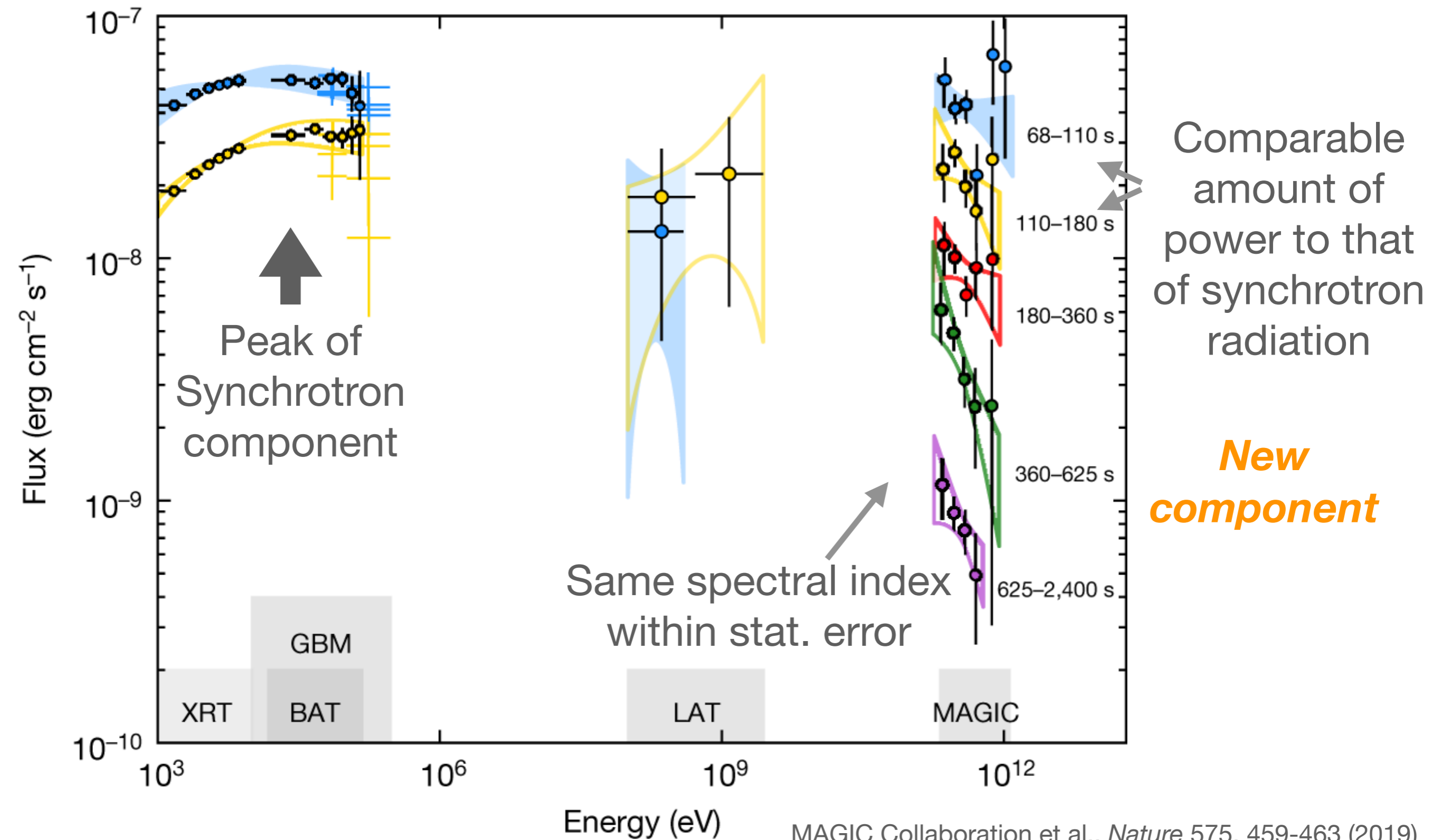
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MAGIC Collaboration, *Nature* 575, 455-458 (2019)



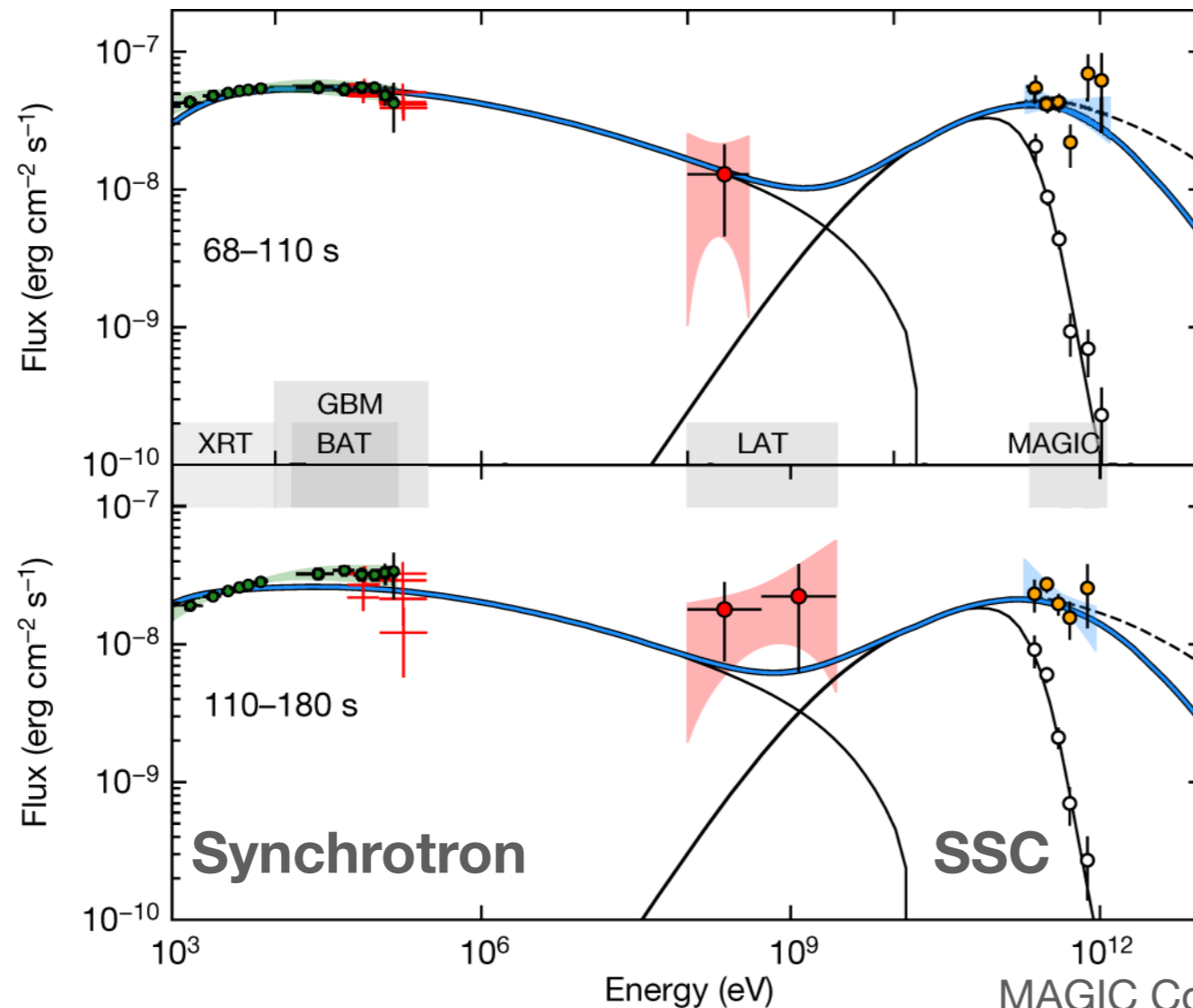
Time-Resolved SEDs

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Synchrotron + SSC Model

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No γ - γ absorption

EBL-deabsorbed

Observed

MAGIC Collaboration et al., *Nature* 575, 459-463 (2019)

- First modeling of TeV emission from a GRB
- Discovery of SSC afterglow radiation
- Obtained parameters indicate that this GRB is a relatively common kind of bursts → SSC might be a common component of GRB afterglows. However, SSC has difficulty accounting for the putative TeV flux of GRB 160821B. Need more GRBs

More GRBs coming!

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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

- Relatively low luminosity long GRB @ $z=0.42$
- Strong hint of detection of VHE emission

GRB 201216C

- Long GRB @ $z=1.1$
- Clear detection of VHE emission
- Most distant source for IACTs

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.

- Breakthrough detection of a GRB afterglow emission by the MAGIC telescopes, which triggered the most extensive MWL campaign for a GRB
- MAGIC could start the observations of GRB 190114C in a minute after the Swift/BAT trigger
- MAGIC found a significant energy release in VHE regime, which can be naturally explained by a synchrotron + SSC model
- GRB 190114C is a bright GRB, but seems not atypical. SSC component might be common in GRB afterglows
- More GRBs coming. Stay tuned!

Thank you very much!



[YouTube "The MAGIC telescopes detect the first GRB at TeV energies"](#)