20 YEARS OF SCIENCE WITH MAGIC

A. STAMERRA - ON BEHALF OF THE MAGIC COLLABORATION

5.1 Active Galactic Nuclei

The observation of nearby blazars at TeV energies with
been extremely fruitful. The fast flux variations observe

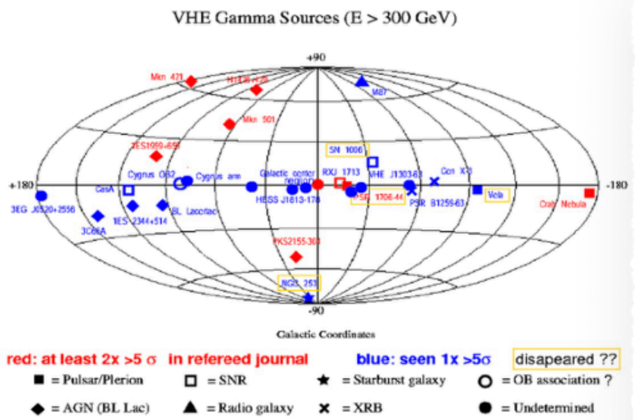

FIGURE 7. Sources discovered in the VHE region. Status or
March 2005.

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Nuclear Physics B (Proc. Suppl.) 114 (2003) 247–252

NUCLEAR PHYSICS B
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2003

The MAGIC telescope

C. Baixeras for the Magic Collaboration*
Grup de Física de les Radiacions, Universitat Autònoma de Barcelona,
Edifici Cc, E-08193, Bellaterra, Spain

An overview of MAGIC, the 17 m diameter Cherenkov telescope currently on its latest building stages at El Roque de los Muchachos observatory in La Palma (Canary Islands), is given. The suitability of the telescope for high energy astrophysics and fundamental physics is reviewed taking into account its unique registration capabilities for gamma radiation below 50 GeV.

1. INTRODUCTION

The field of ground based gamma rays astronomy is rapidly expanding. Gamma rays are messengers of high energy particle processes in the Universe. Up to now, gamma rays above a few GeV cannot be detected by satellite experi-

2. PHYSICS GOALS

The observation of very high energy (VHE) gamma rays is a new field of fundamental research developing as an intersection of particle physics, nuclear physics, astrophysics and cosmology. Gamma rays are normally produced either

5.2 The Gamma-ray Horizon

Due to the absorption of gamma-rays through interactio
light, only a few nearby blazars have been observed up t

5.3 Gamma-ray Pulsars

Two different models have been proposed to explain the me
observed by EGRET from six galactic pulsars. The models
region: near the magnetic poles (polar cap) or in the out

The MAGIC telescope for gamma-ray astronomy above 30 GeV

A. Moralejo[1] * C. Baixeras[2], D. Bastieri[1], W. Bednarek[13], C. Bigongiari[1], A. Biland[4], O. Blanch[5], R. Böck[6], T. Bretz[7], A. Chilingarian[8], J. A. Coarasa[6], E. Colombo[7], S. Commichau[4], J. L. Contreras[9], J. Cortina[5], A. De Angelis[3], R. De los Reyes[9], B. De Lotto[3], C. Domingo[2], E. Domingo[5], D. Dorner[7], D. Ferenc[1] E. Fernández[5], J. Flix[5], V. Fonseca[9], L. Font[2], N. Galante[12], M. Gaug[5], M. Garczarczyk[6], J. Gebauer[6], R. Giannitrapani[3], M. Giller[13], F. Goebel[6], T. Hengstebeck[14], P. Jacon[13], O. C. de Jager[10], O. Kalekin[14,16], M. Kestel[7], K-S. Kim[4], T. Kneiske[7], M. Laatiaoui[6], A. Laille[11], E. Lindfors[15], F. Longo[3], M. López[9], J. López[5], E. Lorenz[6], F. Lucarelli[9], K. Mannheim[7], M. Mariotti[1], M. Martínez[5], K. Mase[6], M. Merck[7], M. Meucci[12], R. Mirzoyan[6], S. Mizobuchi[6], A. Moralejo[1], E. Oña-Wilhelmi[9,10], R. Orduña[2], D. Paneque[6], R. Paoletti[12], M. Pasanen[15], D. Pascoli[1], F. Pauss[4], N. Pavel[14], R. Pegna[12], L. Peruzzo[1], A. Piccioli[12], M. Pin[3], A. Robert[2], A. Saggion[1], A. Sánchez[2], P. Sartori[1], V. Scalzotto[1], K. Shinozaki[6], A. Sillanpaa[15], D. Sobczynska[13], A. Stamerra[12], L. S. Stark[4], A. Stepanian[16], R. Stiehler[14], L. Takalo[15], M. Teshima[6], N. Tonello[6], A. Torres[2], N. Turini[12], G. Viertel[4], V. Vitale[6], S. Volkov[14], R. Wagner[6], T. Wibig[13] and W. Wittek[6]

[1] Dipartimento di Fisica "Galileo Galilei", Università di Padova e Istituto Nazionale di

5.4 The Origin of Cosmic Rays

More than 90 years after their discovery, the orig
shell-type supernova remnants have long been consi

2.6. Unidentified EGRET sources

Most of the sources seen by EGRET experiment on board the CGRO satellite can not be associated with a stellar object. MAGIC obser-

5.5 Gamma Ray Bursts

Among new generation IACTs, MAGIC is the only o
its low threshold (30 GeV in the first phase), and also

Detect more sources!
VHE Gamma Sources (E > 300 GeV)
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1. INTRODUCTION
NOKIA
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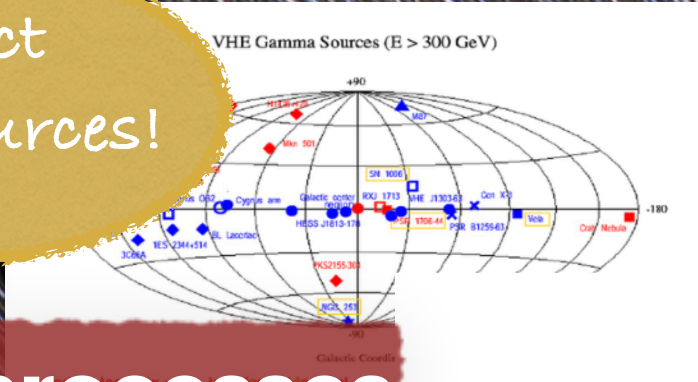
Select
The MAGIC te ... above 30 GeV

Gamma-ray emission processes

- Leptonic/hadronic acceleration
- Blazar zone
- Jet feeding and interactions

Detect more sources!



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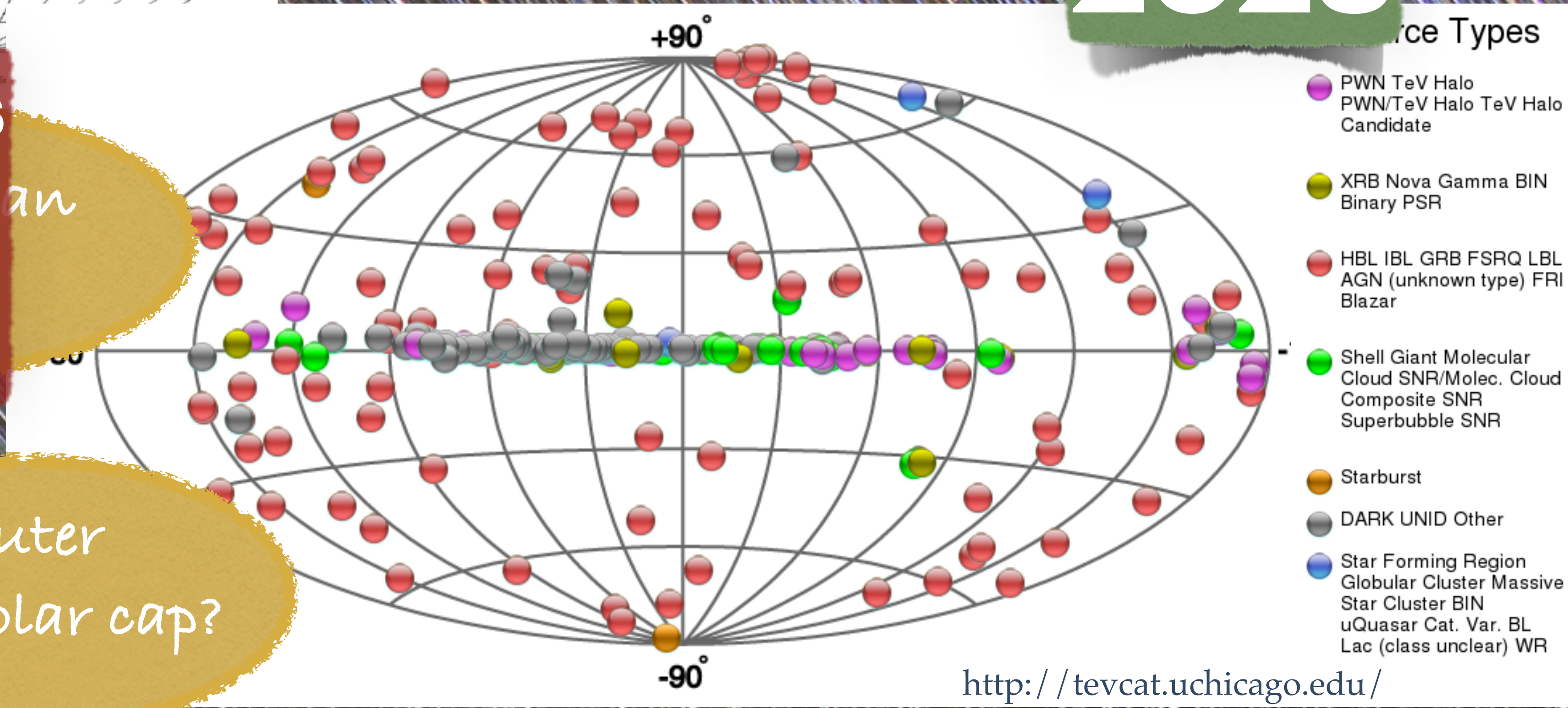

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The first sources by MAGIC

2005

Markarian 501

The Astrophysical Journal, 669:862–883, 2007 November 10

VARIABLE VERY HIGH ENERGY γ-RAY EMISSION FROM MARKARIAN 501

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... January 31; accepted 2007 June 13

ABSTRACT
The blazar Mrk 501 was observed at energies above 0.10 TeV with the MAGIC Telescope from 2005 May through July. The high sensitivity of the instrument enabled the determination of the flux and spectrum of the source on a night-by-night basis. Throughout our observational campaign, the flux from Mrk 501 was found to vary by an order of magnitude. Intranight flux variability with flux-doubling times down to 2 minutes was observed during the two

1st Most cited MAGIC (only) paper

30th International Cosmic Ray Conference

ICRC'07 Mérida, Yucatán, Méx.

Contribution ID : 1098 Type : Oral

Study of the Variable VHE emission from Markarian 501 with the MAGIC Telescope

Monday, 9 July 2007 09:18 (0:12)

Abstract content

The blazar Markarian 501 (Mrk 501) was observed at energies above 100 GeV with the MAGIC Telescope from May through July 2005. The high sensitivity of the instrument enabled the determination of the flux and spectrum of the source on a night-by-night basis. Throughout our observational campaign, the flux from Mrk 501 was found to vary by an order of magnitude, and to be correlated with spectral changes. Intra-night flux variability with flux-doubling times down to 2 minutes was also observed. The strength of variability increased with the energy of the gamma-ray photons. The energy spectra were found to harden significantly with increasing flux, and a spectral peak clearly showed up during very active states. The position of the spectral peak seems to be correlated with the source luminosity. In the conference, the details of this unprecedented spectral and temporal analysis of Mkn501 observations in the very high energy range will be reported, and the implications of these results will be discussed.

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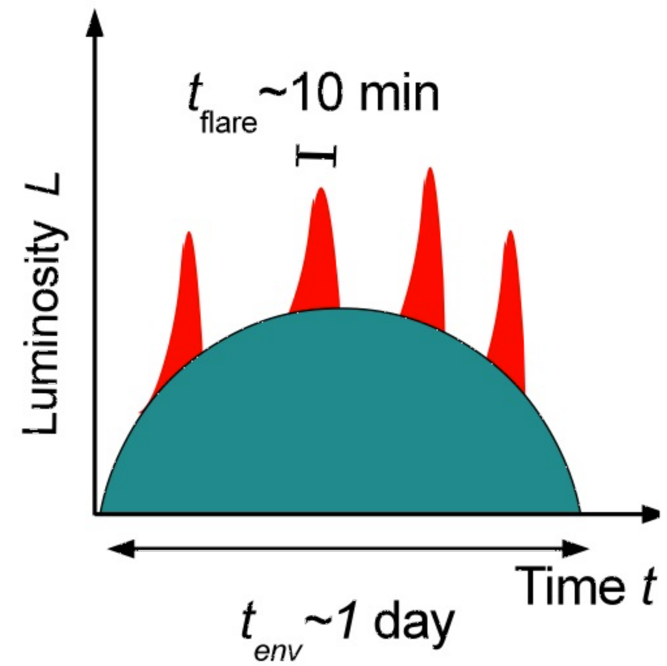
MAGIC collaboration

- Cooling/acceleration mechanism in jets



- LIV constraints

Physics Letters B 668 (2008) 253–257

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Probing quantum gravity using photons from a flare of the active galactic nucleus Markarian 501 observed by the MAGIC telescope

MAGIC Collaboration

J. Albert[a], E. Aliu[b], H. Anderhub[c], L.A. Antonelli[d], P. Antoranz[e], M. Backes[f], C. Baixeras[g], J.A. Barrio[e], H. Bartko[h], D. Bastieri[i], J.K. Becker[f], W. Bednarek[j], K. Berger[a], E. Bernardini[k], C. Bigongiari[i], A. Biland[c], R.K. Bock[h,i], G. Bonnoli[l], P. Bordas[m], V. Bosch-Ramon[m], T. Bretz[a], I. Britvitch[c], M. Camara[e], E. Carmona[h], A. Chilingarian[n], S. Commichau[c], J.L. Contreras[e], J. Cortina[b], M.T. Costado[o,p], S. Covino[d], V. Curtef[f], F. Dazzi[i], A. De Angelis[q], E. De Cea del Pozo[r], C. Delgado Mendez[o], R. de los Reyes[e], B. De Lotto[q], M. De Maria[q], F. De Sabata[q], A. Dominguez[s], D. Dorner[a], M. Doro[i], M. Errando[b], M. Fagiolini[l], D. Ferenc[t], E. Fernández[b], R. Firpo[b], M.V. Fonseca[e], L. Font[g], N. Galante[h], R.J. García López[o,p], M. Garczarczyk[h], M. Gaug[o], F. Goebel[h], M. Hayashida[h], A. Herrero[o,p], D. Höhne[a], J. Hose[h], C.C. Hsu[h], S. Huber[a], T. Jogler[h], D. Kranich[c], A. La Barbera[d], A. Laille[t], E. Leonardo[l], E. Lindfors[u], S. Lombardi[i], F. Longo[q], M. López[i], E. Lorenz[c,h], P. Majumdar[k], G. Maneva[v],

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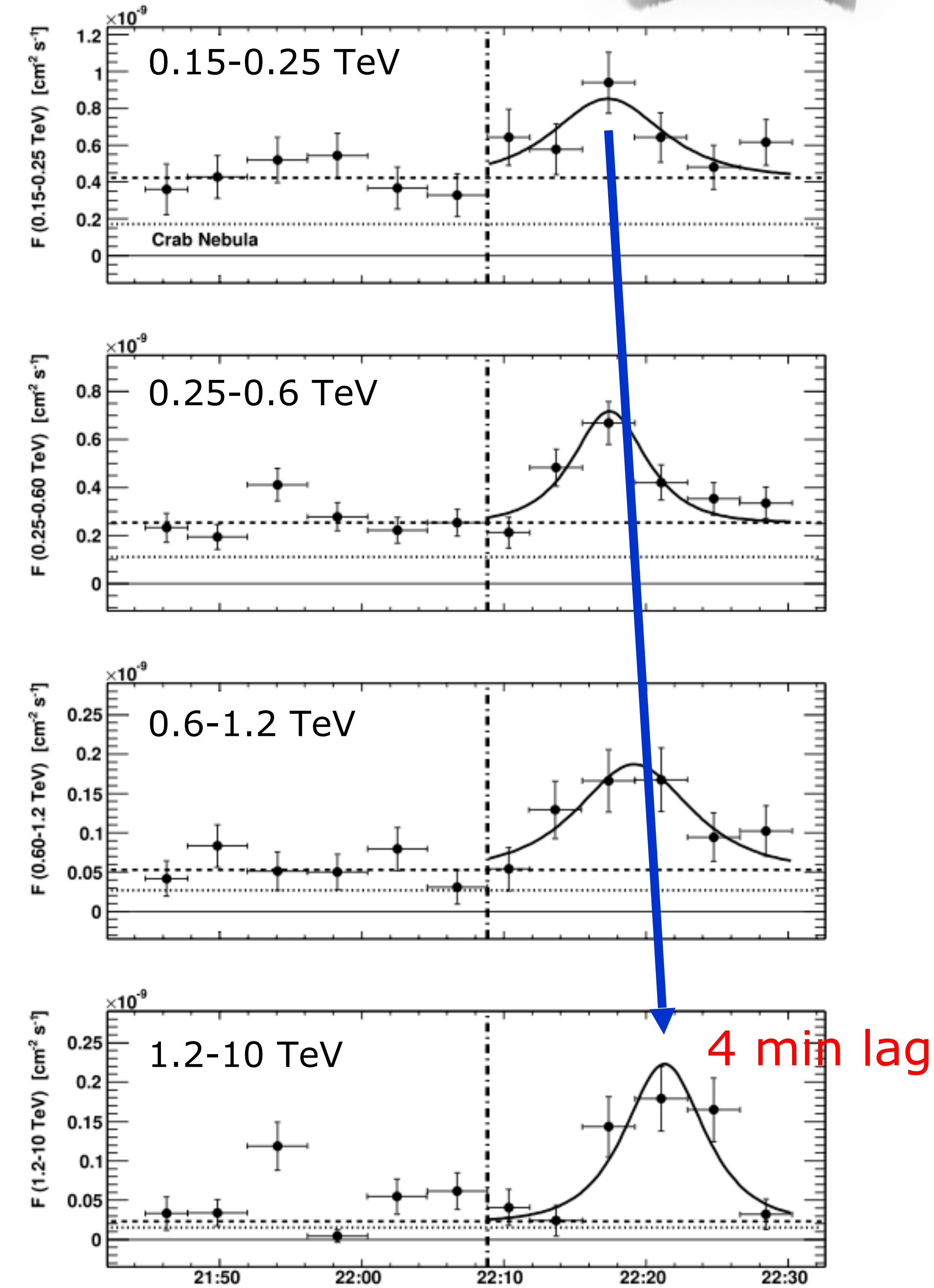
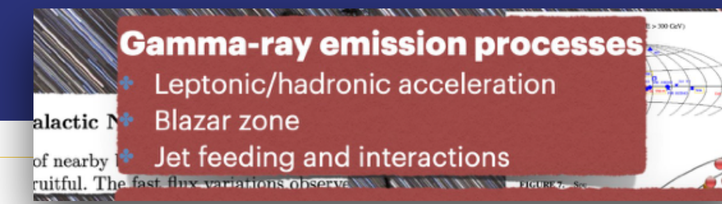


The first sources by MAGIC



2005

Markarian 501


The Astrophysical Journal, 669:862–883, 2007 November 10
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VARIABLE VERY HIGH ENERGY γ-RAY EMISSION FROM MARKARIAN 501

ABSTRACT

The blazar Mrk 501 was observed at energies above 0.10 TeV with the MAGIC Telescope from 2005 May through July. The high sensitivity of the instrument enabled the determination of the flux and spectrum of the source on a night-by-night basis. Throughout our observational campaign, the flux from Mrk 501 was found to vary by an order of magnitude. Intranight flux variability with flux-doubling times down to 2 minutes was observed during the two

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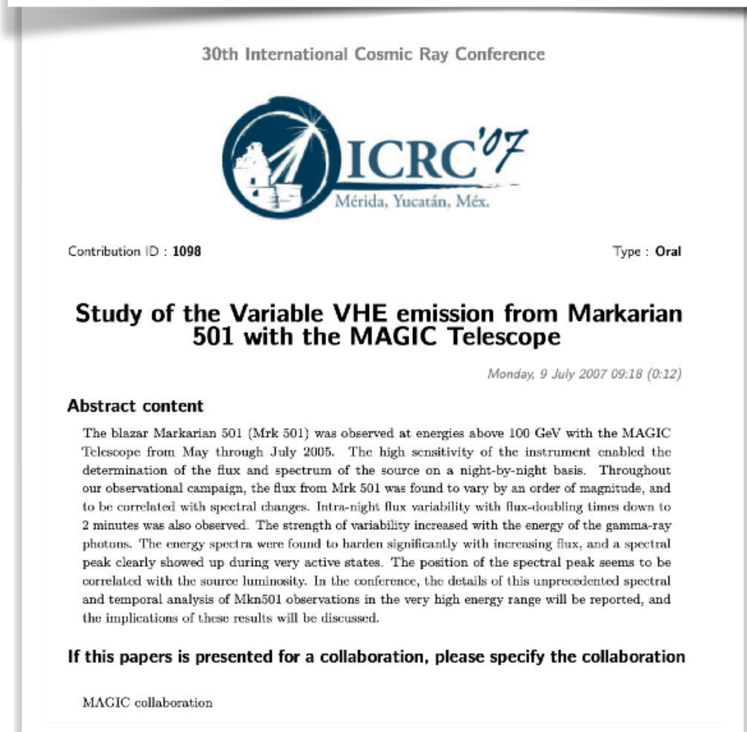
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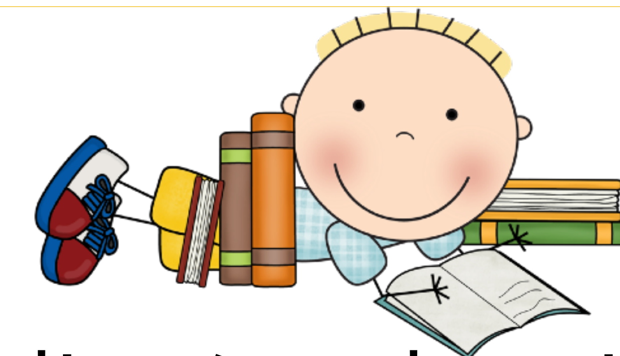

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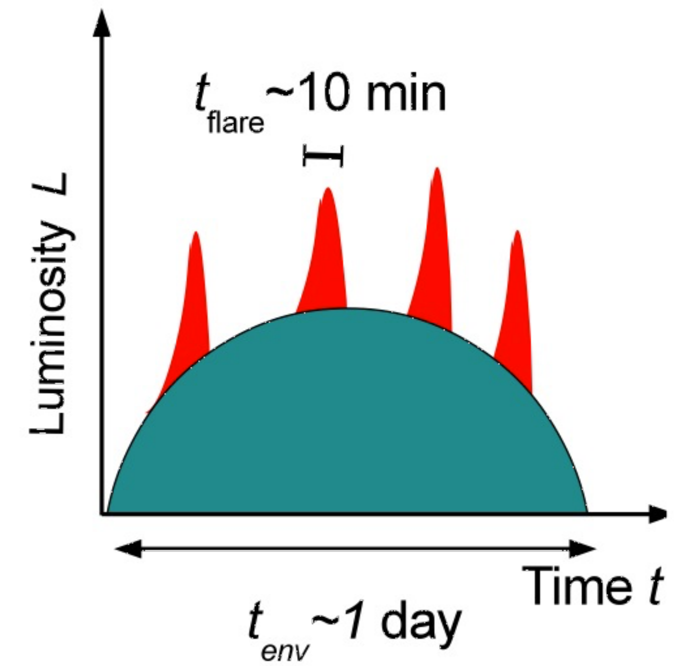

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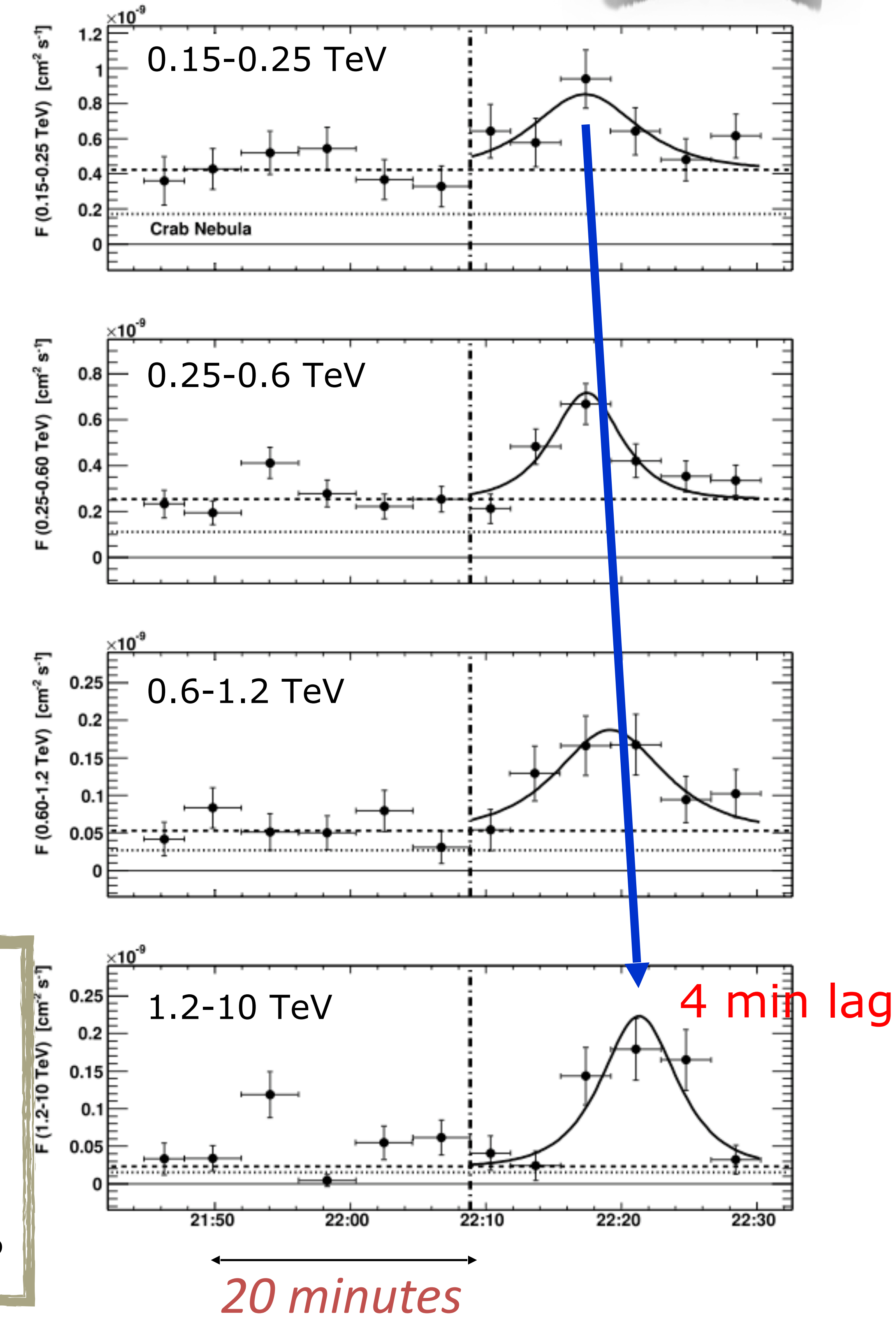
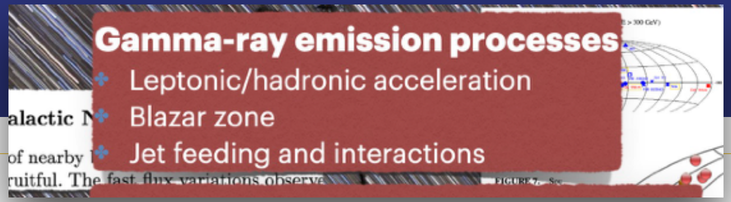


- Detection of first new sources 1ES1218+30.4, LSI +61 303, Mrk 180, 1ES1011+496, PG1553+113
- Limits on GRB 050713A and other GRB

The first sources by MAGIC



2005

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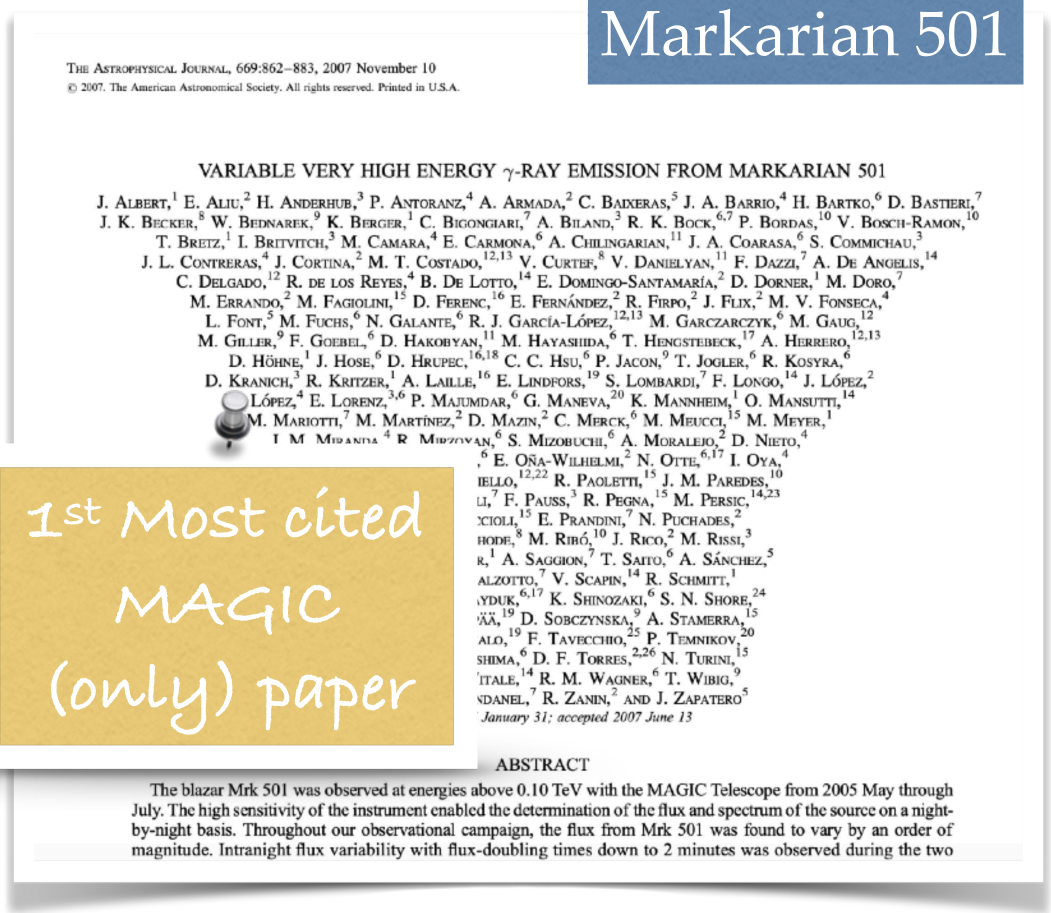
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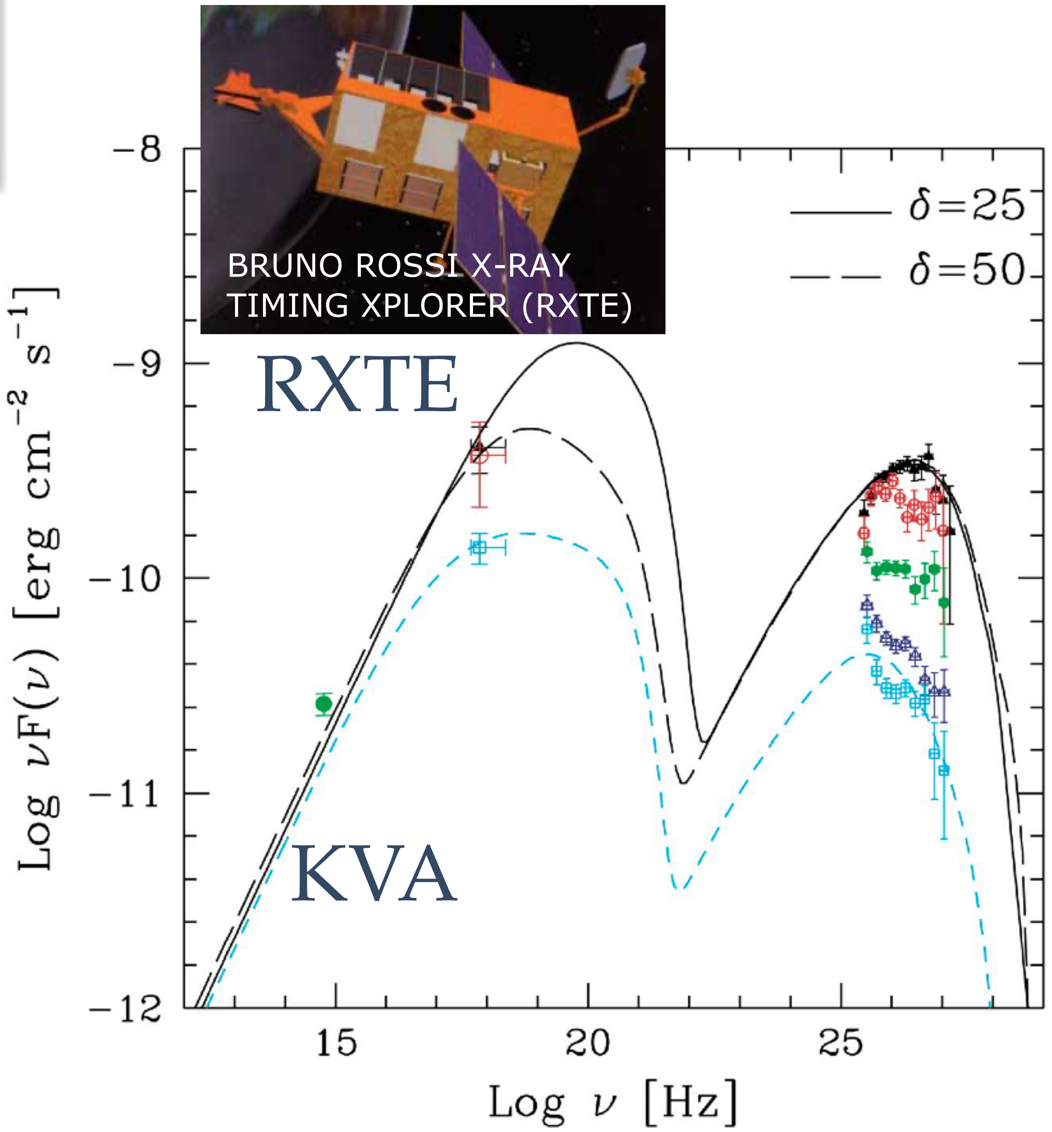
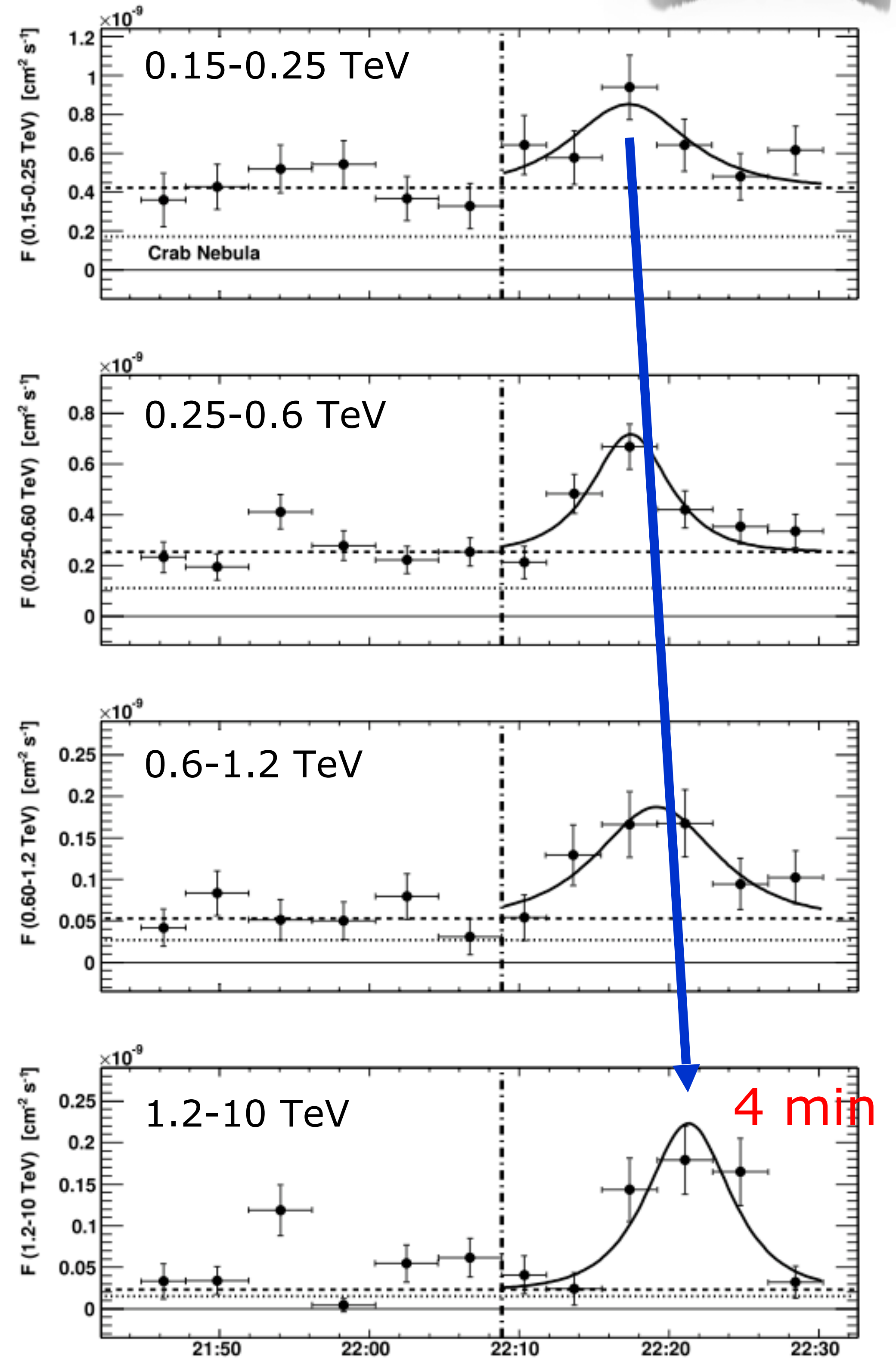




Evidence of blazar zone outside the BLR

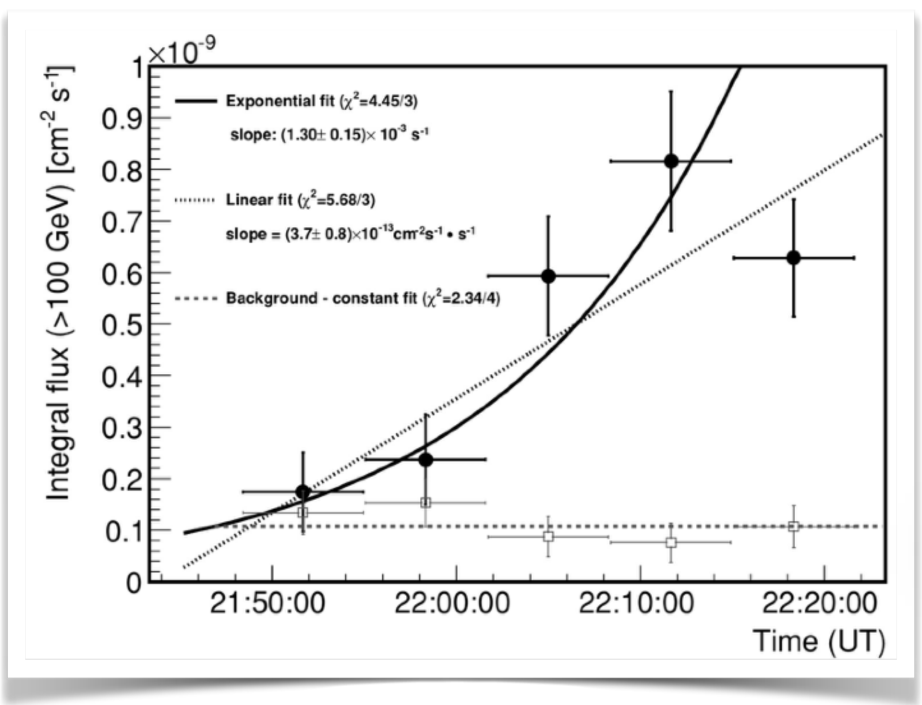
2011

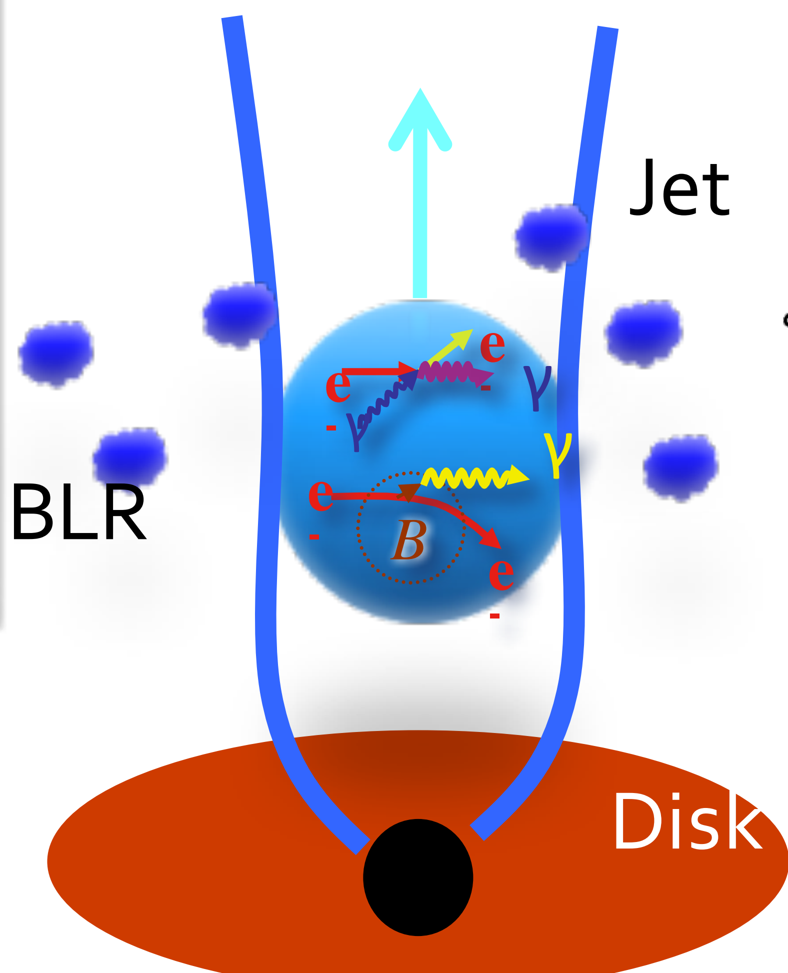
BLR: broad line region

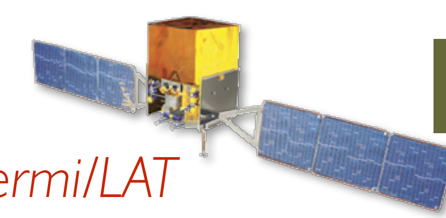
PKS 1222+216 (z=0.435) - a flat spectrum radio quasar (FSRQ)

- ★ no cutoff up to ~130 GeV
- ✓ no internal absorption due to UV radiation of the BLR
- ➡ emission region outside the BLR!

- ➡ Fast variability (10 min)
- ✓ Small emitting region

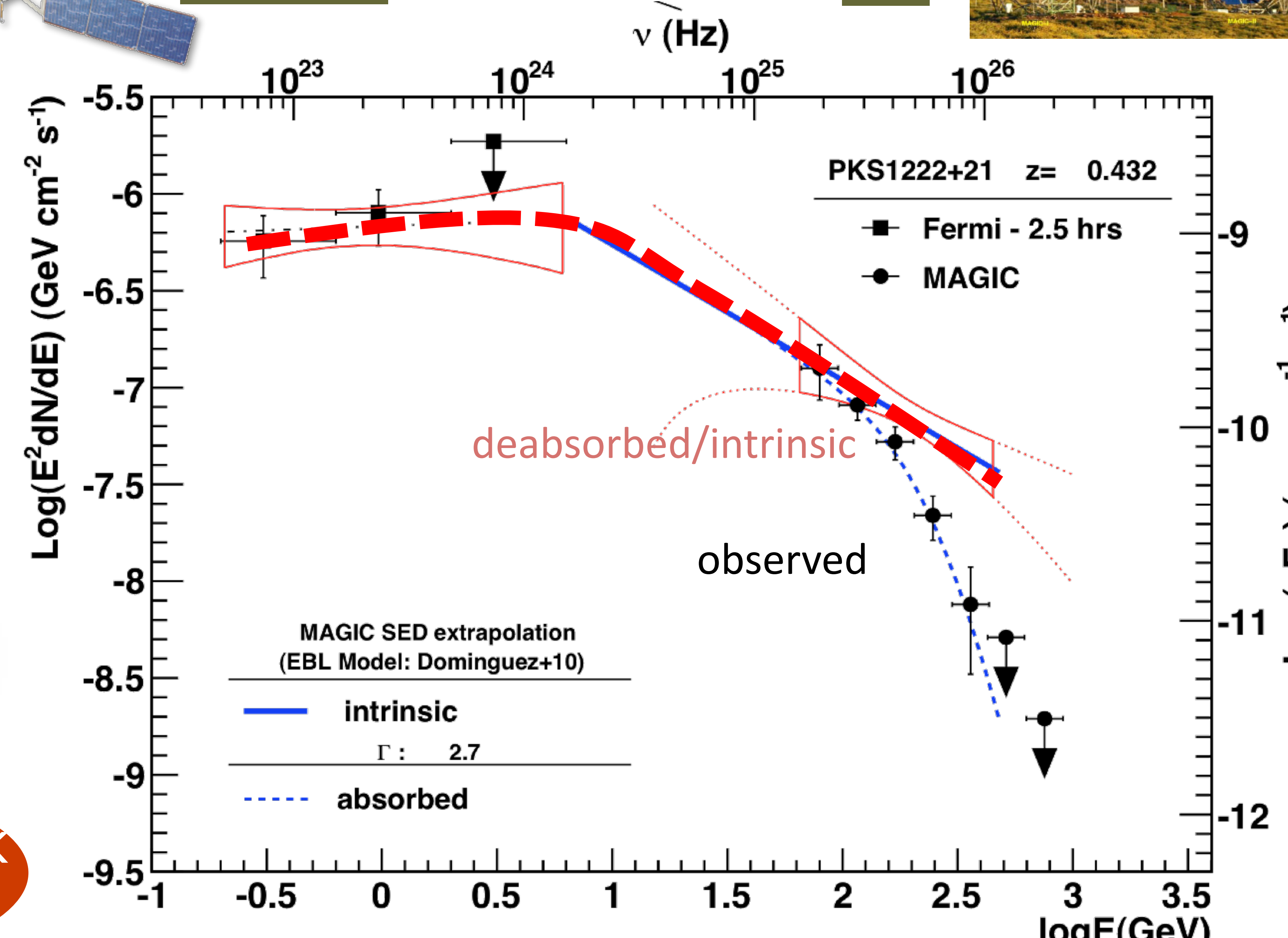






MeV-GeV

TeV



MAGIC Coll. ApJL 730 (2011)

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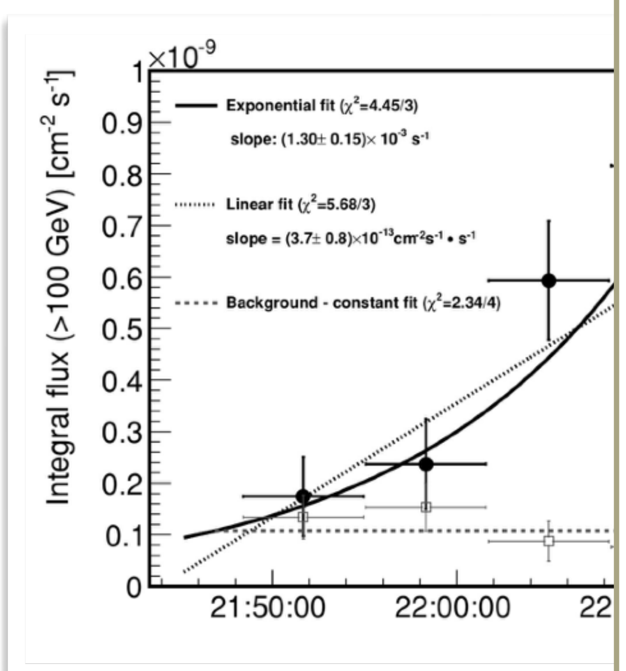
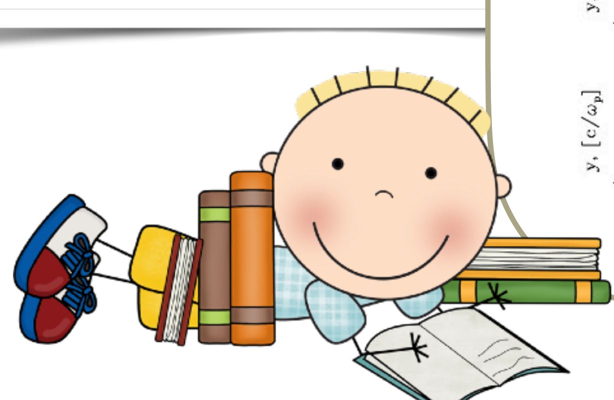
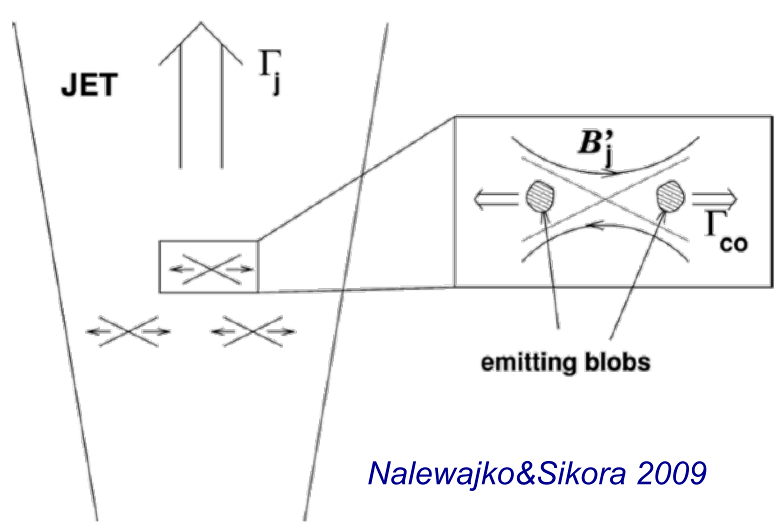
✓ Small emittin

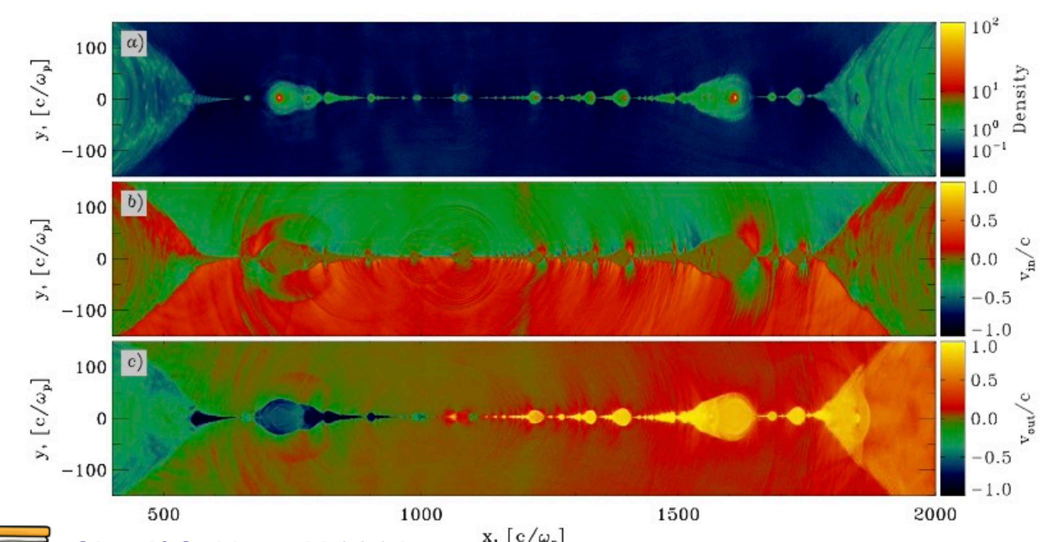




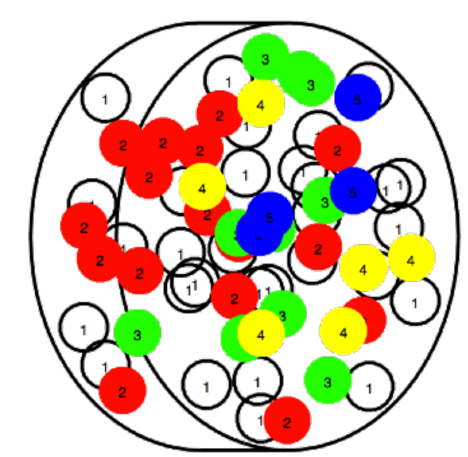


Nalewajko&Sikora 2009

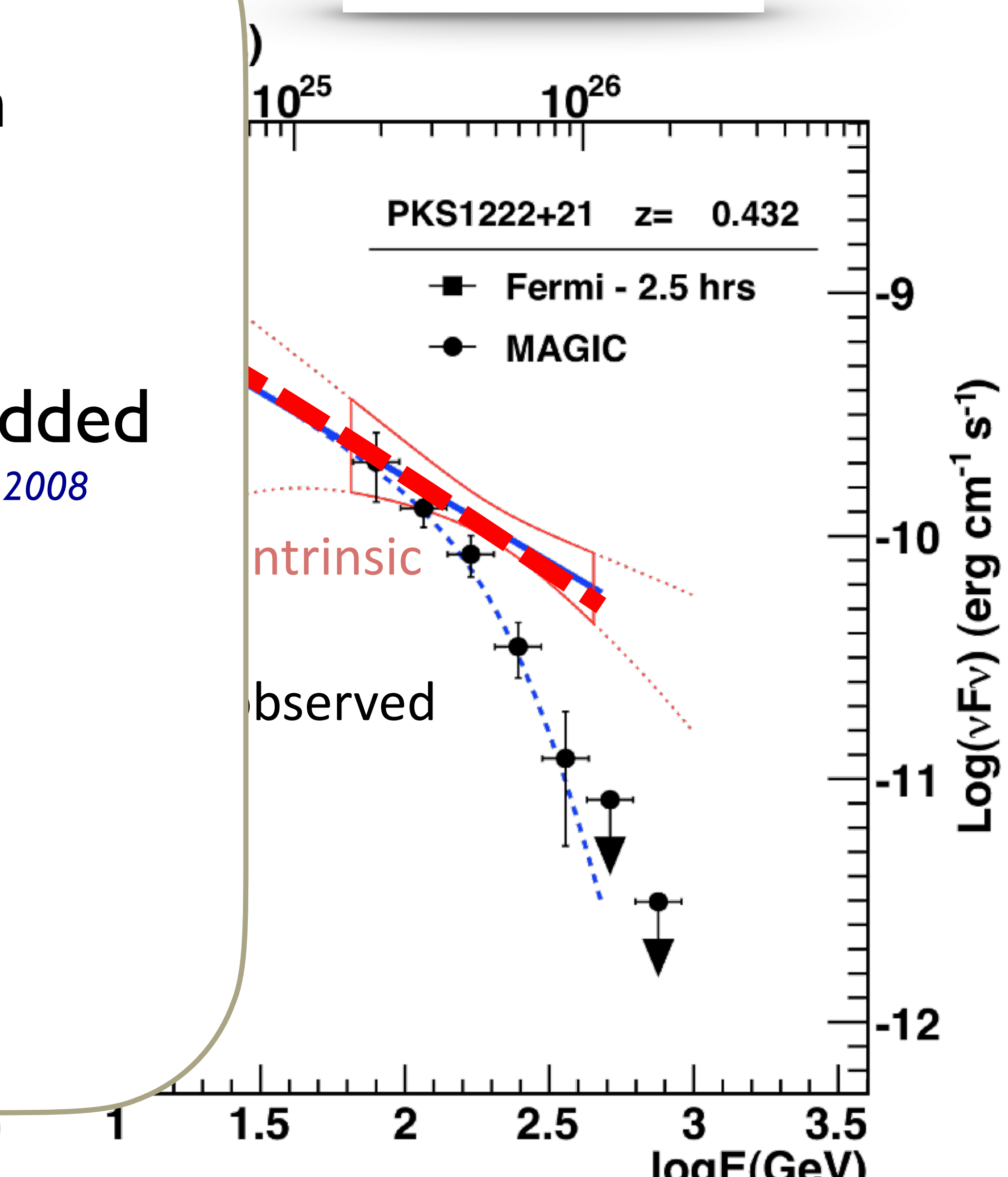
- Recollimation
  Marscher 1980, Bromberg&Levinson 2009
- Magnetic Reconnection
  Giannios 2009, Sironi&Spitkowski 2014
- Reconfinement shocks
  Nalewajko&Sikora 2009, Stawarz 2006
- Compact region embedded
  Marscher&Jorstad2010, Ghisellini&Tavecchio 2008



Sironi&Spitkowski 2014



Marscher&Jorstad 2010

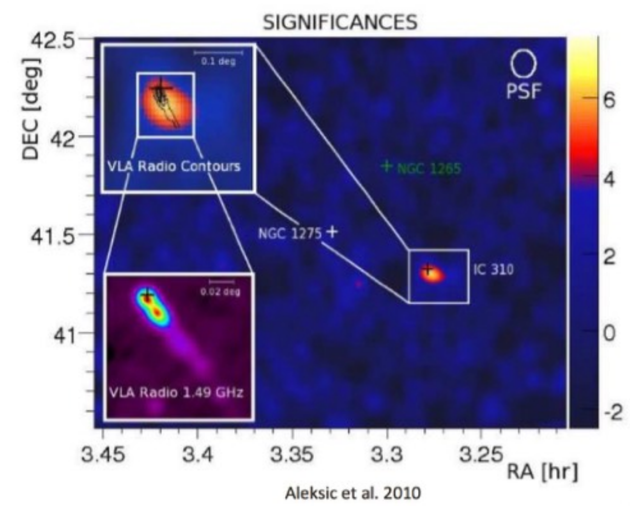


MAGIC Coll. ApJL 730 (2011)

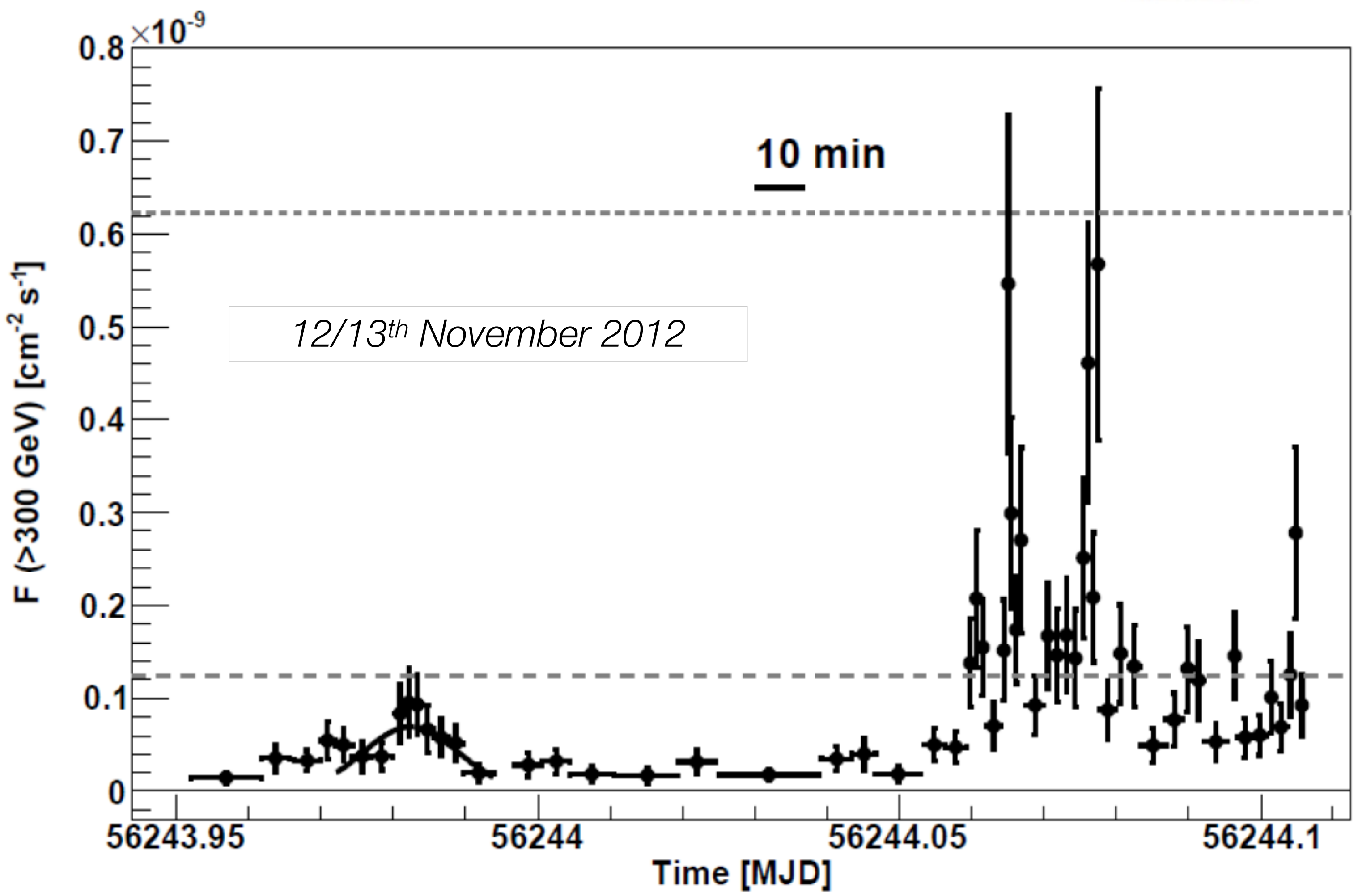
Down to the SMBH: the case of IC 310

2010-2014

- Nearby radiogalaxy (intermediate FR-I and BL Lac)
  - z=0.0019 (~80 Mpc) in the Perseus Cluster
  - M_{BH} = 1-7·10^8 $M_\odot$ ⇒ Δt_{BH} =8 min–1hour
- single jet - VLBI (5GHz): θ ≤ **20°** δ<6
- Serendipitously discovered in VHE by MAGIC
- Fast TeV variability ~minute



Aleksić et al. (MAGIC) Science 346, 2014

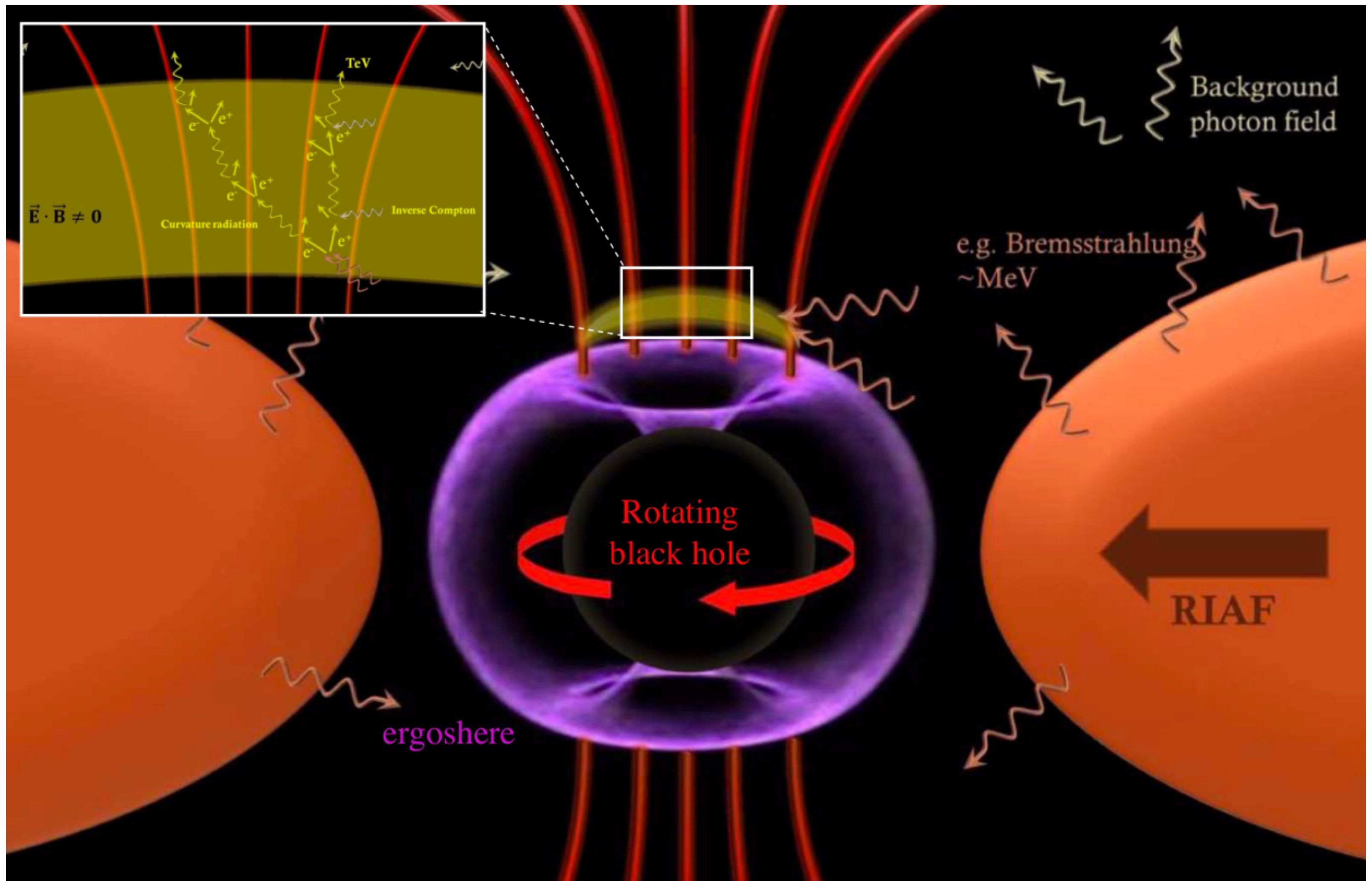


Emission region ≤ δ·0.2 R_{Sch} ≤ ~ R_{Sch}

Possible scenarios

- Jets-in-jet (magnetic reconnections)
- Star or cloud entering the jet (hadronic emission)
- Magnetospheric model (~pulsar)

Each scenario corresponds to different radiation properties at the base of the jet, near the BH horizon



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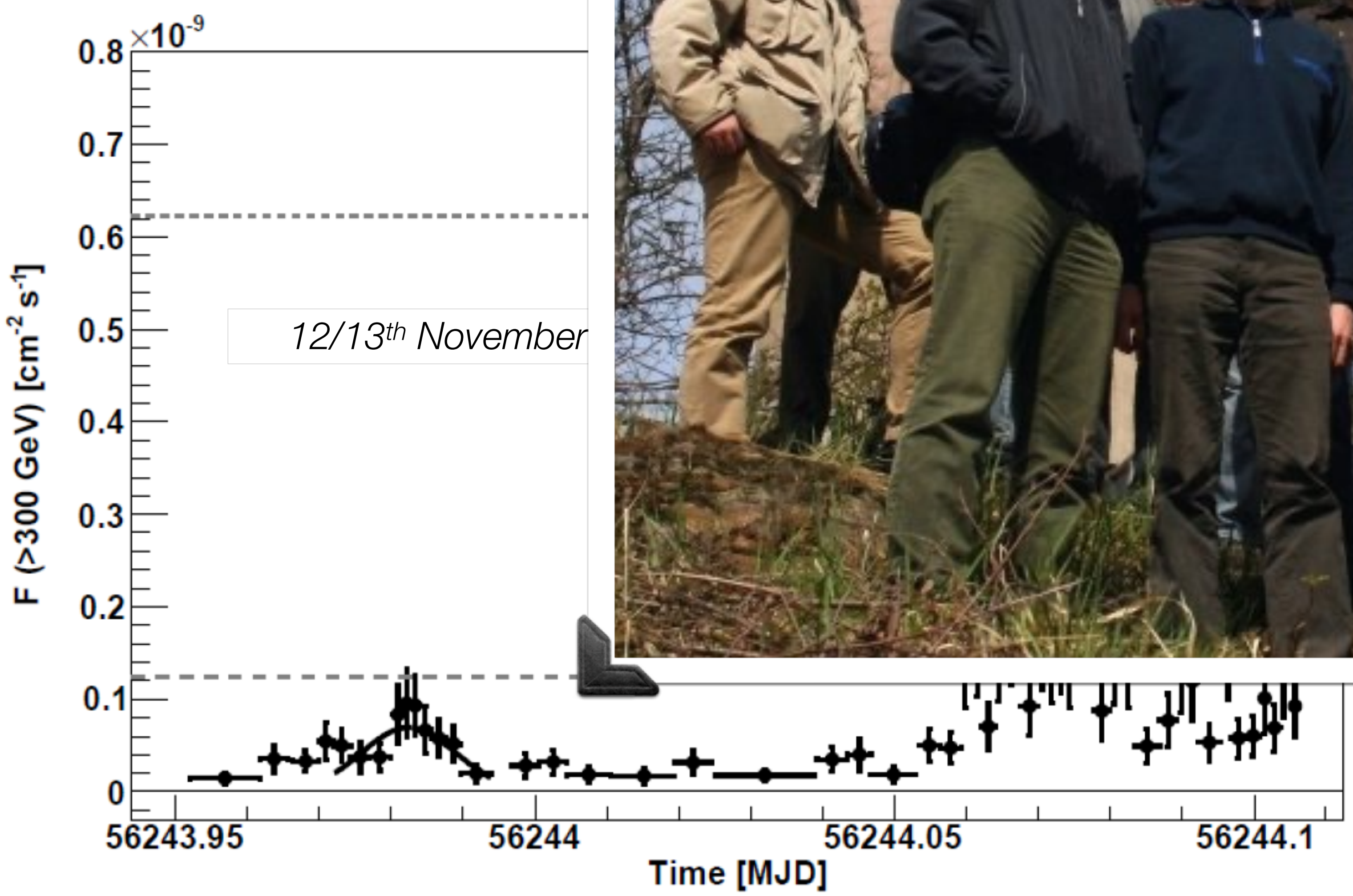
Aleksić et al. (MAGIC) Science 346, 201



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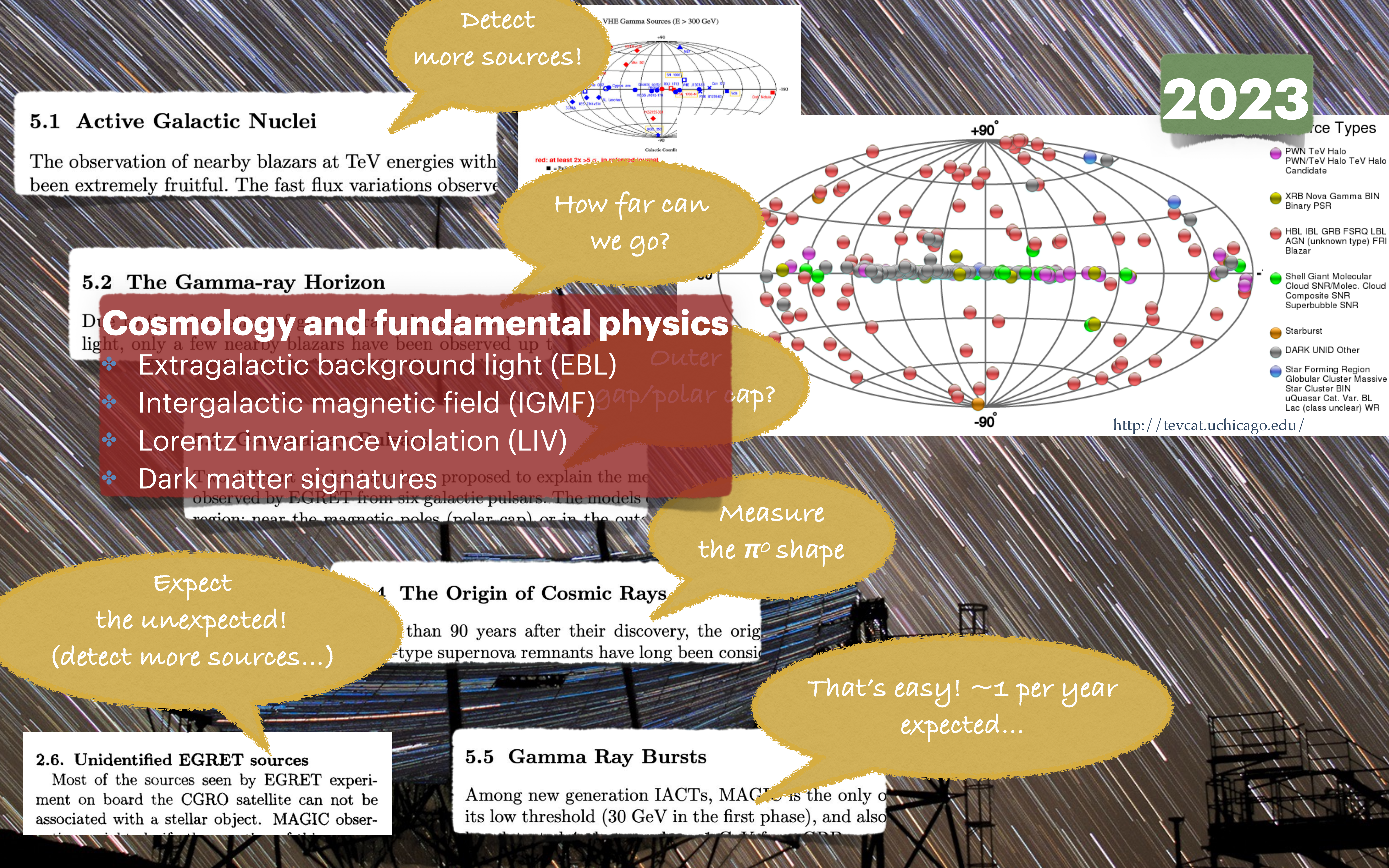
Detect more sources!
5.1 Active Galactic Nuclei
The observation of nearby blazars at TeV energies with
been extremely fruitful. The fast flux variations observe
VHE Gamma Sources (E > 300 GeV)
+90
-90
red: at least 2x >5 σ, in refereed journal
How far can we go?
5.2 The Gamma-ray Horizon
light, only a few nearby blazars have been observed up t
Cosmology and fundamental physics
Extragalactic background light (EBL)
Intergalactic magnetic field (IGMF)
Lorentz invariance violation (LIV)
Dark matter signatures
Outer gap/polar cap?
proposed to explain the me
observed by EGRET from six galactic pulsars. The models
2023
+90°
-90°
Source Types
PWN TeV Halo PWN/TeV Halo TeV Halo Candidate
XRB Nova Gamma BIN Binary PSR
HBL IBL GRB FSRQ LBL AGN (unknown type) FRI Blazar
Shell Giant Molecular Cloud SNR/Molec. Cloud Composite SNR Superbubble SNR
Starburst
DARK UNID Other
Star Forming Region Globular Cluster Massive Star Cluster BIN uQuasar Cat. Var. BL Lac (class unclear) WR
http://tevcat.uchicago.edu/
Measure the π⁰ shape
The Origin of Cosmic Rays
than 90 years after their discovery, the orig
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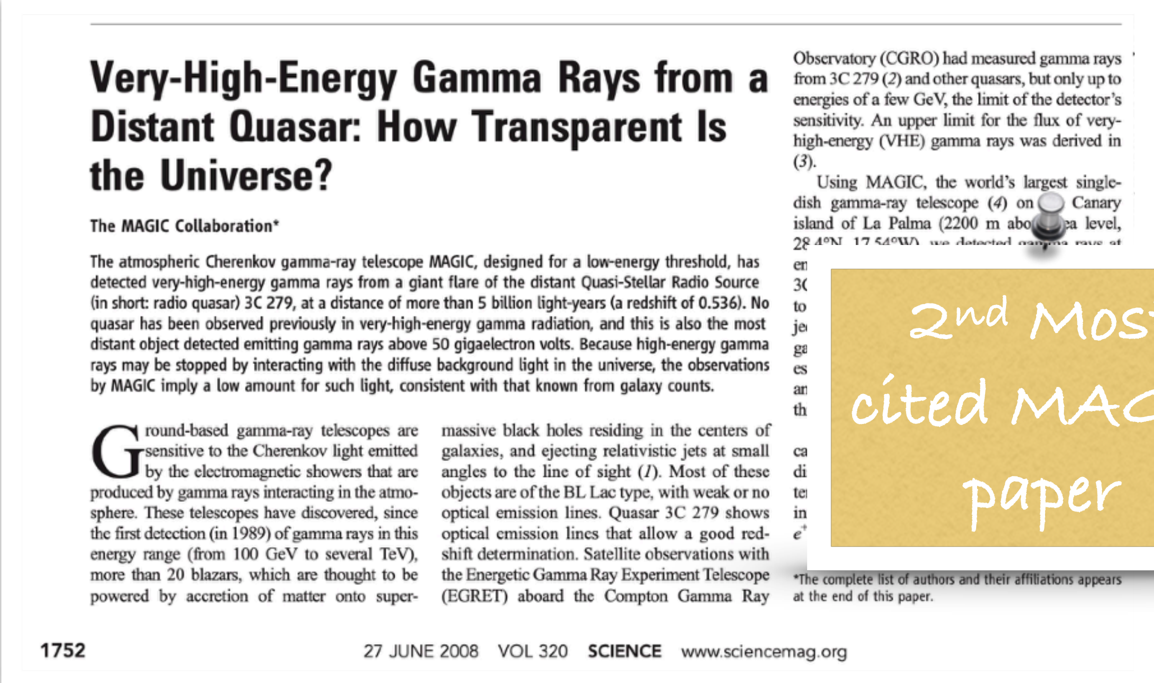
3C279: FSRQ and the gamma-ray horizon



Very-High-Energy Gamma Rays from a Distant Quasar: How Transparent Is the Universe?

The MAGIC Collaboration*

The atmospheric Cherenkov gamma-ray telescope MAGIC, designed for a low-energy threshold, has detected very-high-energy gamma rays from a giant flare of the distant Quasi-Stellar Radio Source (in short: radio quasar) 3C 279, at a distance of more than 5 billion light-years (a redshift of 0.536). No quasar has been observed previously in very-high-energy gamma radiation, and this is also the most distant object detected emitting gamma rays above 50 gigaelectron volts. Because high-energy gamma rays may be stopped by interacting with the diffuse background light in the universe, the observations by MAGIC imply a low amount for such light, consistent with that known from galaxy counts.

Ground-based gamma-ray telescopes are sensitive to the Cherenkov light emitted by the electromagnetic showers that are produced by gamma rays interacting in the atmosphere. These telescopes have discovered, since the first detection (in 1989) of gamma rays in this energy range (from 100 GeV to several TeV), more than 20 blazars, which are thought to be powered by accretion of matter onto supermassive black holes residing in the centers of galaxies, and ejecting relativistic jets at small angles to the line of sight (1). Most of these objects are of the BL Lac type, with weak or no optical emission lines. Quasar 3C 279 shows optical emission lines that allow a good redshift determination. Satellite observations with the Energetic Gamma Ray Experiment Telescope (EGRET) aboard the Compton Gamma Ray Observatory (CGRO) had measured gamma rays from 3C 279 (2) and other quasars, but only up to energies of a few GeV, the limit of the detector's sensitivity. An upper limit for the flux of very-high-energy (VHE) gamma rays was derived in (3).

Using MAGIC, the world's largest single-dish gamma-ray telescope (4) on ... Canary island of La Palma (2200 m abo... ...a level, ...

*The complete list of authors and their affiliations appears at the end of this paper.

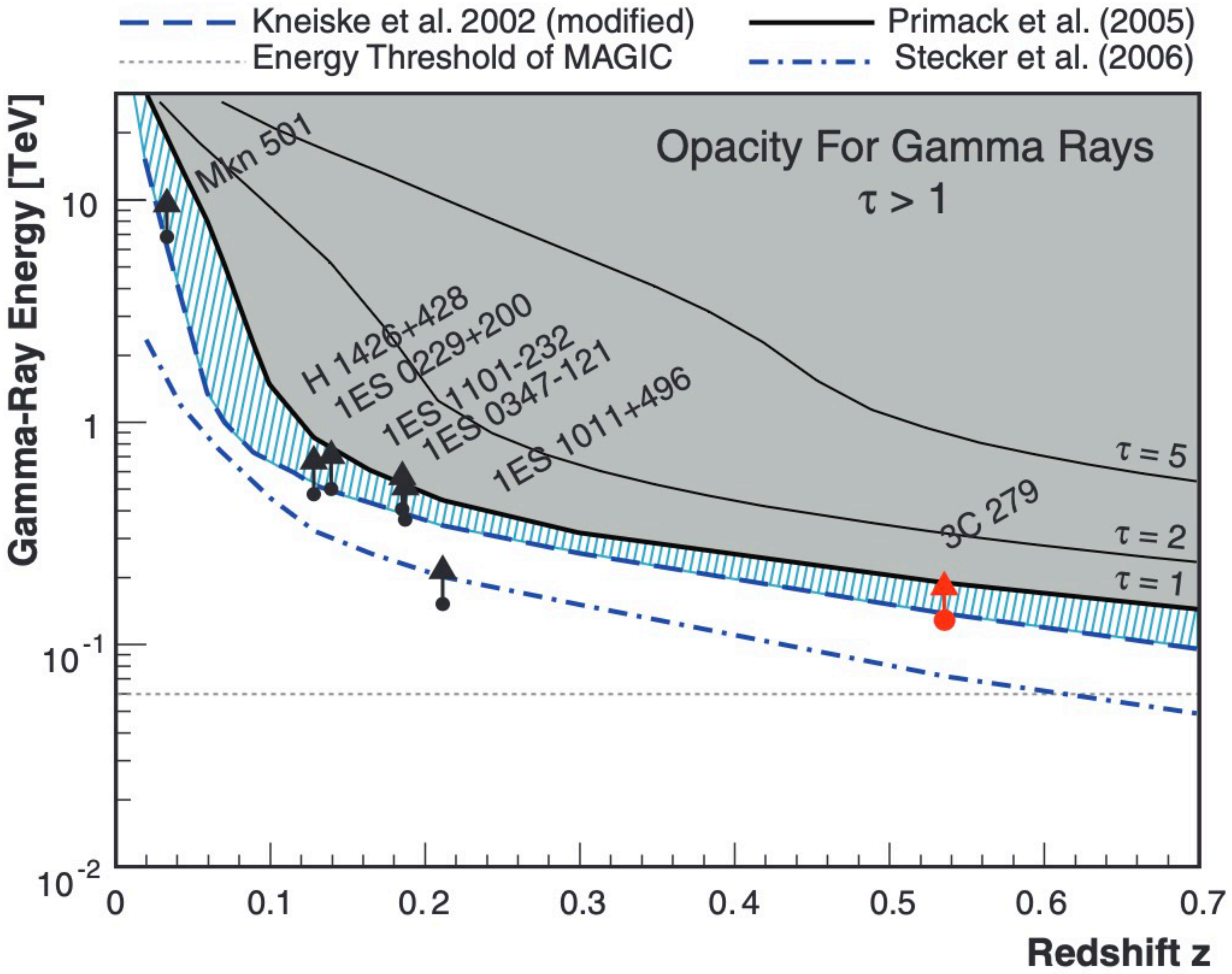
1752 27 JUNE 2008 VOL 320 SCIENCE www.sciencemag.org

2nd Most cited MAGIC paper

Impact:

- Constraining the EBL
- Study the FSRQ class
- Most distant AGN

2006-2008



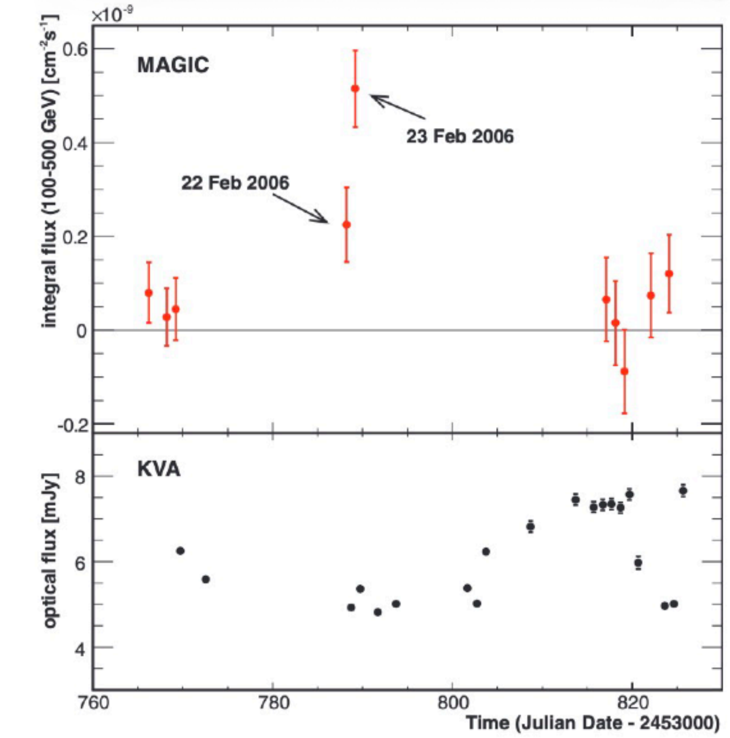


Fig. 1. Light curves. MAGIC (top) and optical R-band data (bottom) obtained for 3C 279 from February to March 2006. The long-term baseline for the optical flux is at 3 mJy.

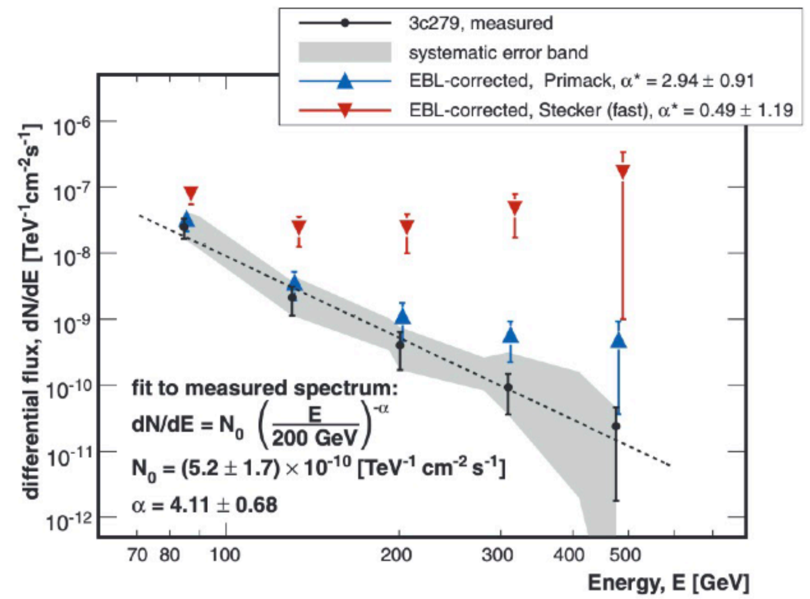
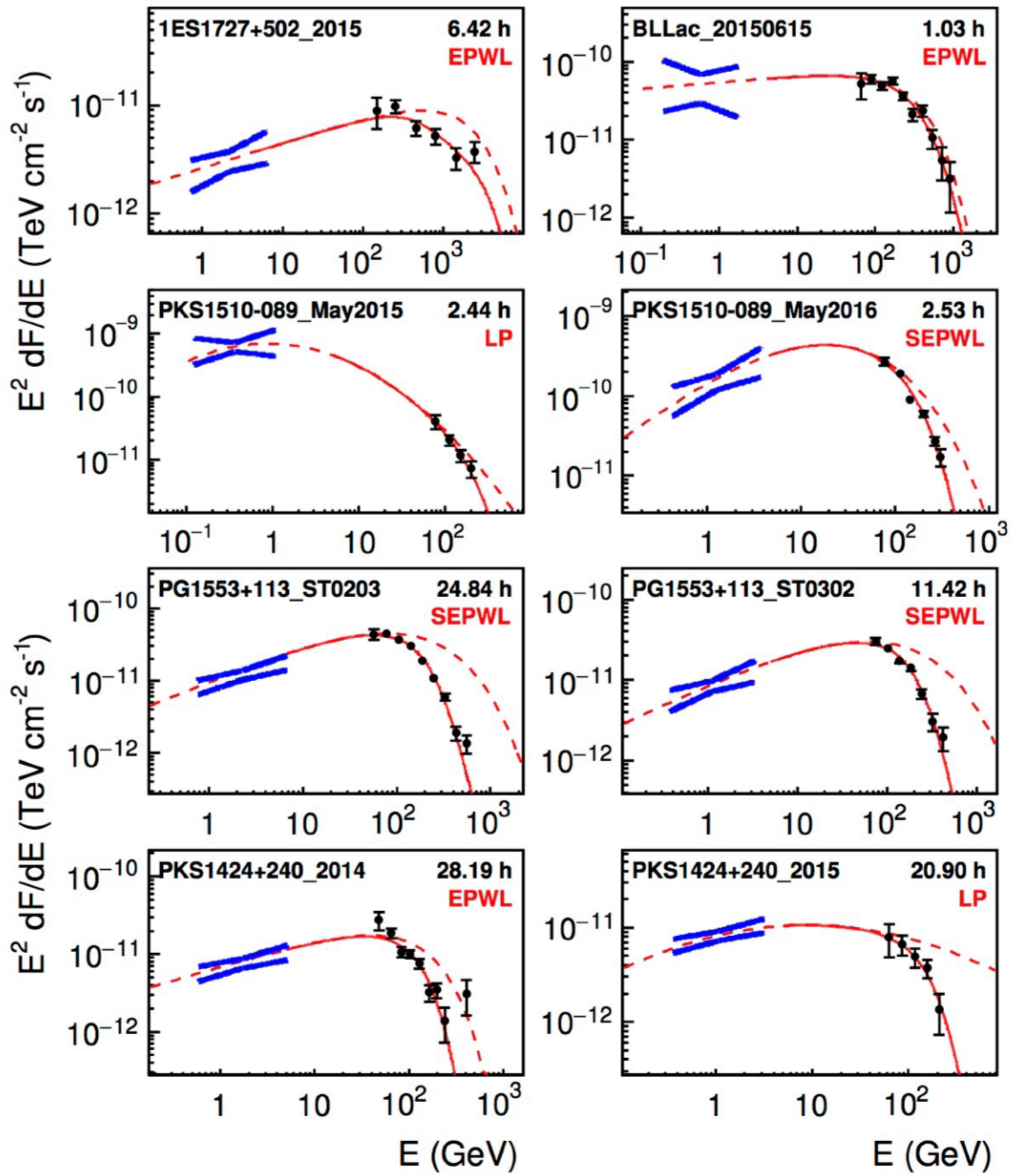


Fig. 2. Spectrum of 3C 279 measured by MAGIC. The gray area includes the combined statistical (1σ) and systematic errors, and underlines the marginal significance of detections at high energy. The dotted line shows compatibility of the measured spectrum with a power law of photon index α = 4.1. The blue and red triangles are measurements corrected on the basis of the two models for EBL density, discussed in the text.

EBL limits with the Stacking analysis on a set of blazars

2019

- 32 spectra of blazars
- Combined spectrum of Fermi/LAT and MAGIC



100 MeV — 10 TeV

➡ Wide range in the EBL spectrum

➡ Precision measurements of spectra

ref.: MAGIC coll. - 2019 - MNRAS, 486 "Measurement of the extragalactic background light using MAGIC and Fermi-LAT gamma-ray observations of blazars up to z = 1" https://dx.doi.org/10.1093/mnras/stz943

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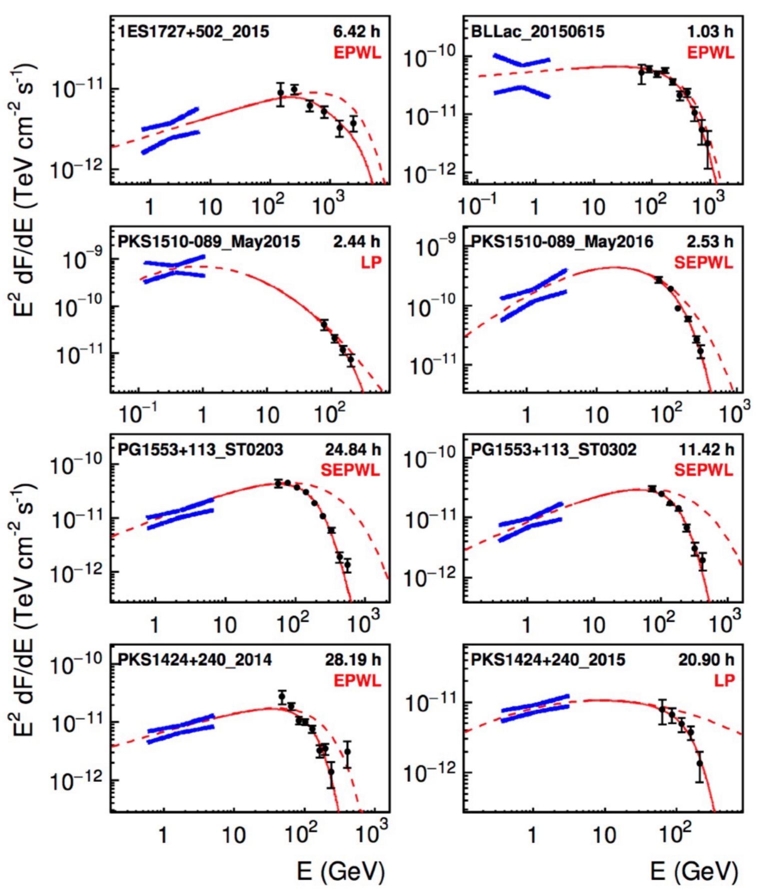
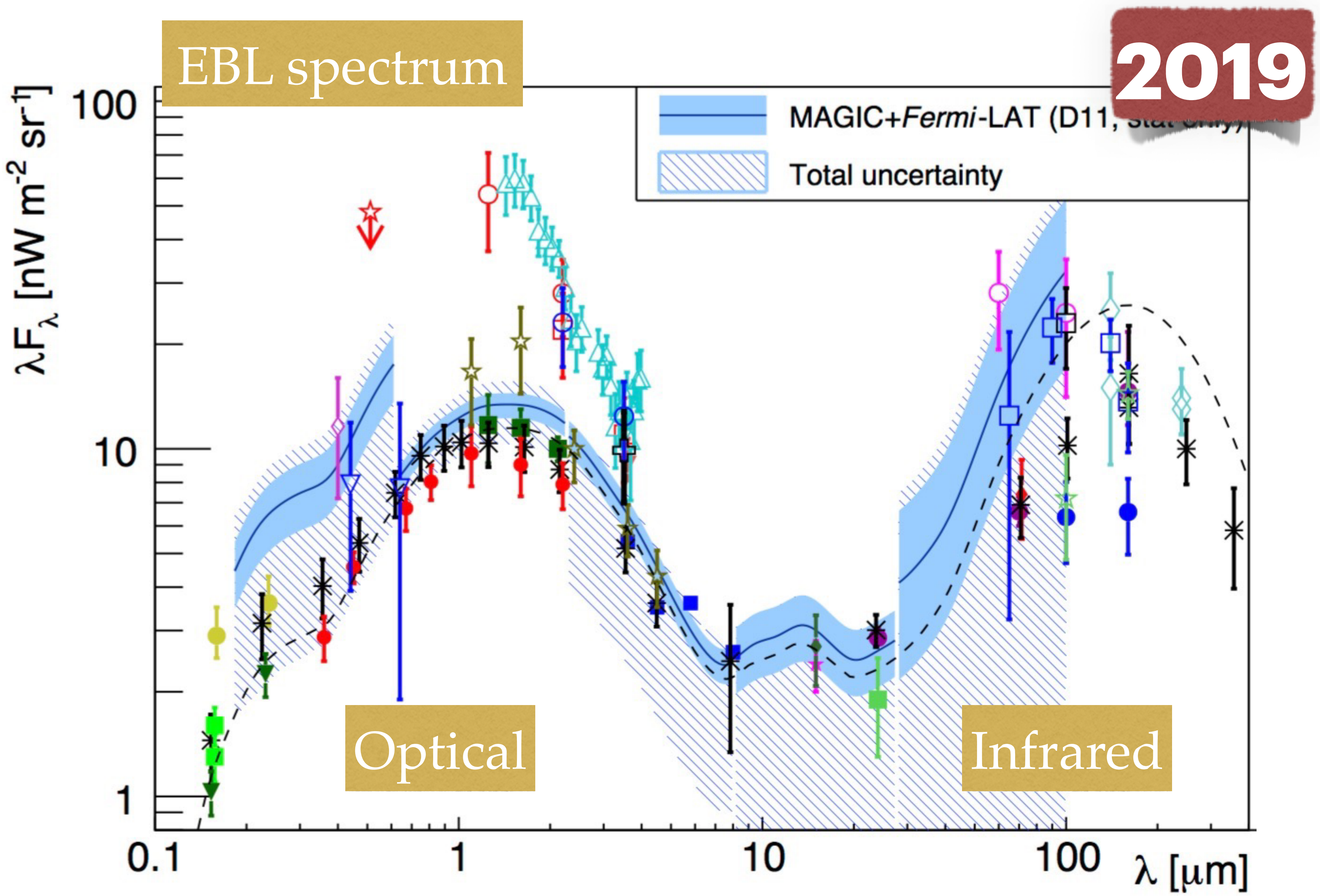


- Different intrinsic spectral models
- **Studies on systematics**
  - different EBL models
  - different intrinsic models
  - different IRF



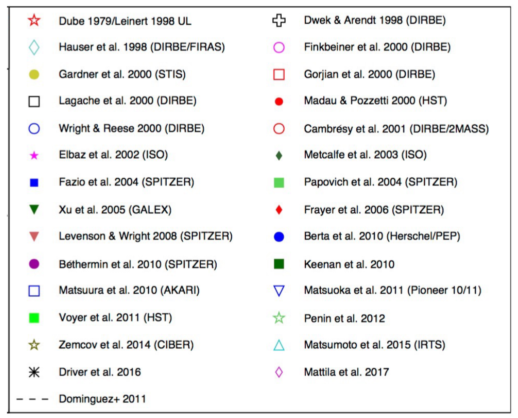


Table 5. Wavelength-resolved EBL constraints (scaling factors relative to three models) using MAGIC + *Fermi*-LAT spectra.

	EBL wavelength range (μm, @ z=0)					p-value
EBL model	0.18 - 0.62	0.62 - 2.24	2.24 - 7.94	7.94 - 28.17	28.17 - 100	
D11 (stat): (stat+sys):	2.60 (+0.56, −0.57) (+0.93, −1.72)	1.17 (+0.09, −0.10) (+0.19, −0.27)	1.10 (+0.12, −0.13) (+0.15, −0.69)	1.13 (+0.25, −0.24) (+0.25, −1.13)	1.62 (+0.99, −0.77) (+1.31, −1.62)	1.15×10^{-3}
Fi10 (stat): (stat+sys):	1.89 (+0.58, −0.33) (+0.77, −1.10)	1.04 (+0.12, −0.06) (+0.25, −0.23)	1.05 (+0.11, −0.10) (+0.17, −0.59)	0.68 (+0.18, −0.16) (+0.37, −0.68)	2.40 (+1.65, −1.32) (+4.24, −2.40)	0.91×10^{-3}
G12 (stat): (stat+sys):	1.45 (+0.35, −0.26) (+0.82, −0.97)	1.01 (+0.10, −0.07) (+0.25, −0.22)	1.03 (+0.10, −0.10) (+0.16, −0.63)	1.16 (+0.27, −0.25) (+0.30, −1.16)	2.01 (+1.13, −0.89) (+1.13, −2.01)	1.53×10^{-3}

ref.: MAGIC coll. - 2019 - MNRAS, 486 "Measurement of the extragalactic background light using MAGIC and Fermi-LAT gamma-ray observations of blazars up to z = 1" https://dx.doi.org/10.1093/mnras/stz943

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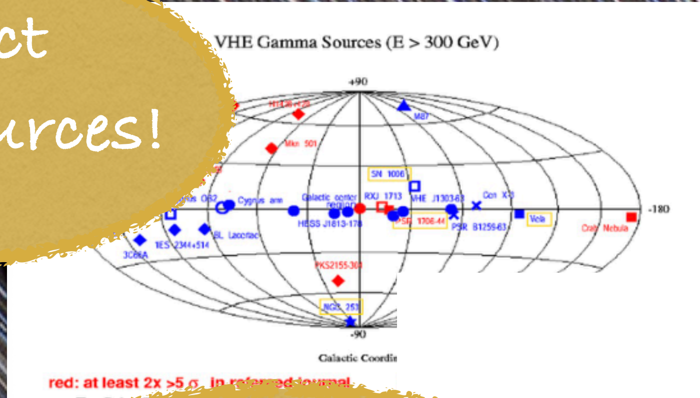

How far can we go?

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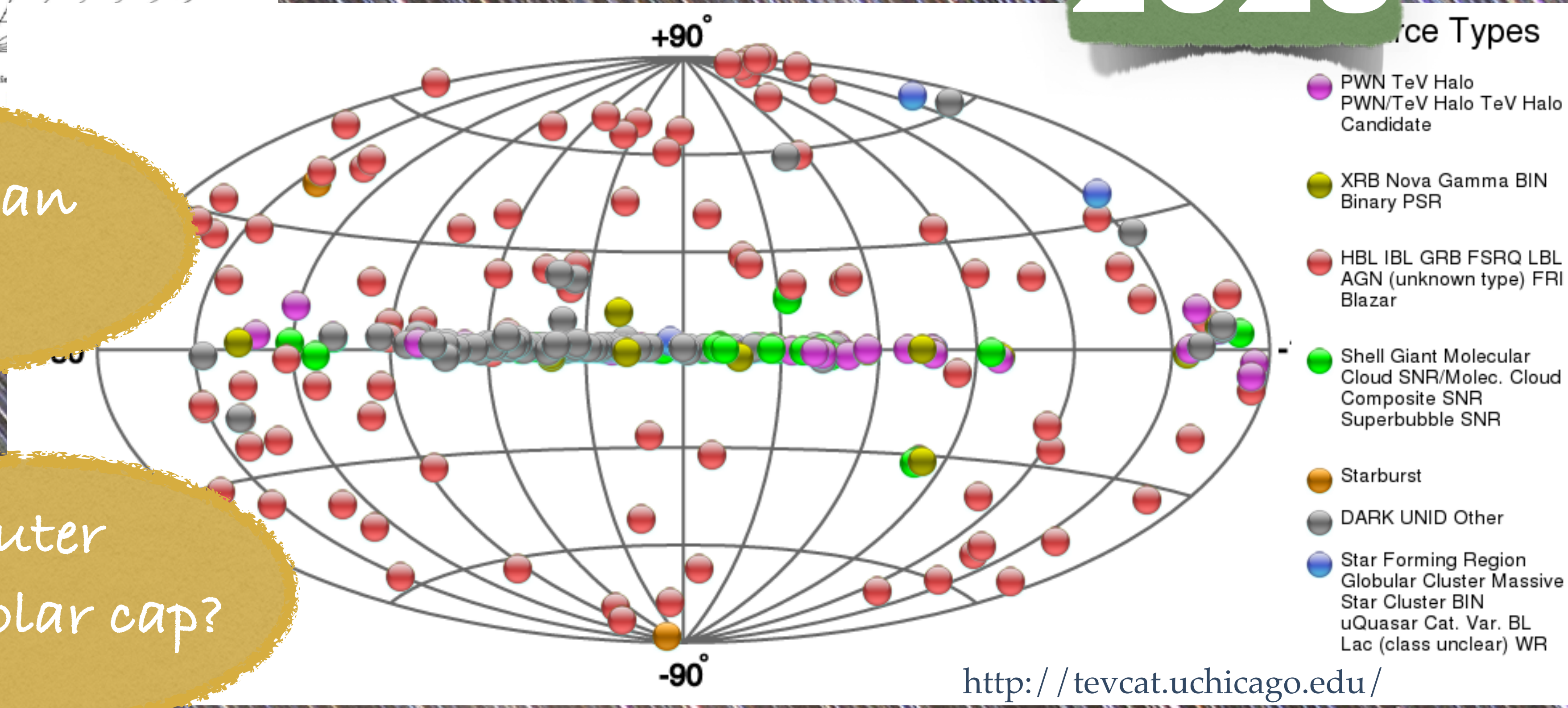
2023



http://tevcat.uchicago.edu/

Outer gap/polar cap?

5.3 Gamma-ray Pulsars

Two different models have been proposed to explain the me
observe ... models
region: near the magnetic poles (polar cap) or in the oute

Gamma-ray pulsars

- The TeV emission zone
- Inverse Compton
- Connection with the PWN

Measure the π^0 shape

5.4 The Origin of Cosmic Rays

... than 90 years after their discovery, the orig
-type supernova remnants have long been consi

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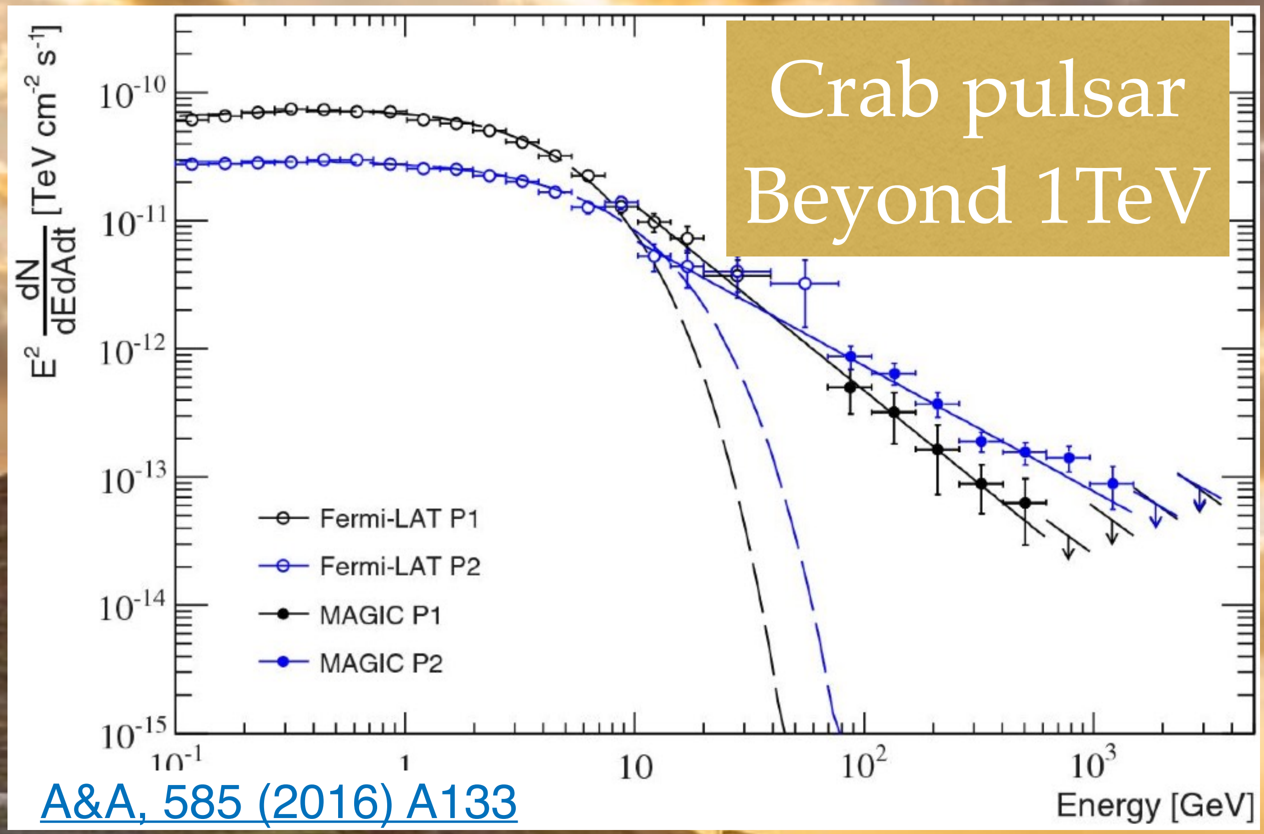
Pulsars

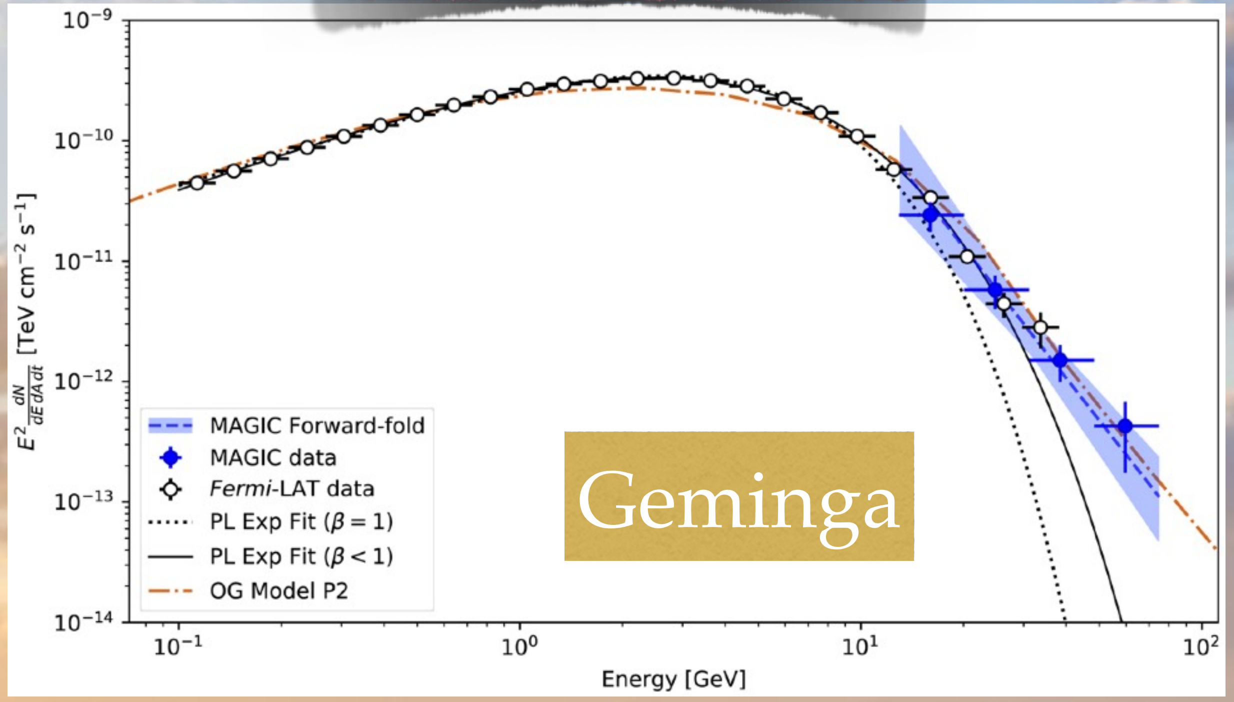
MAGIC@20

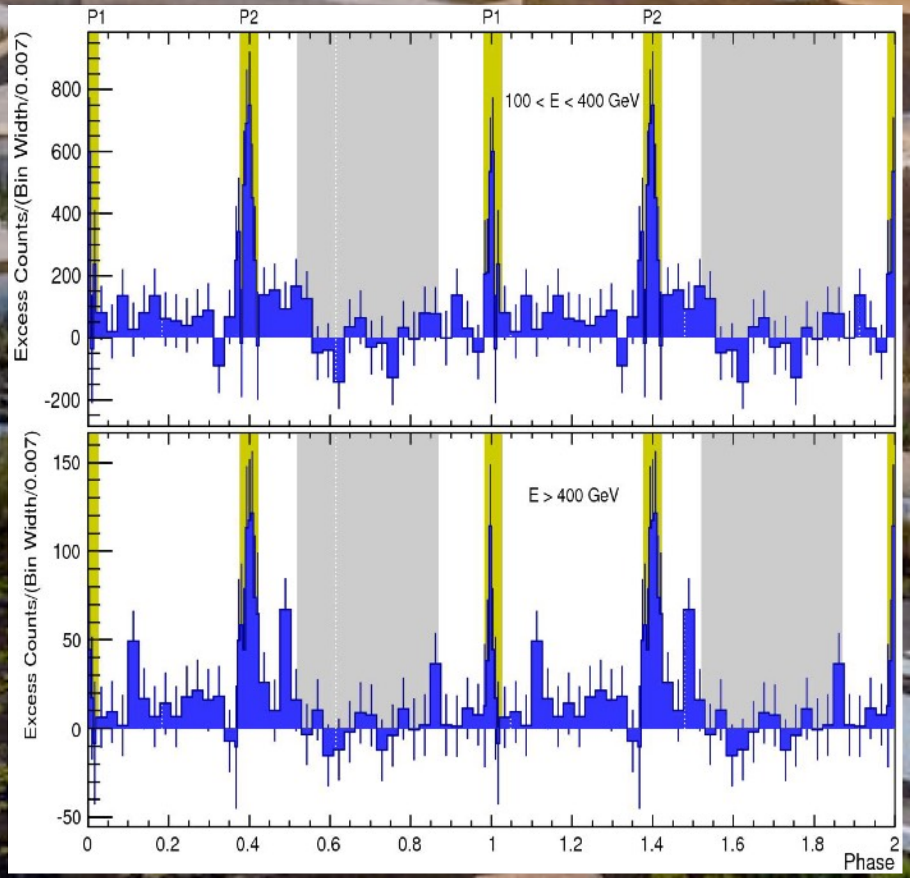
2016-2020

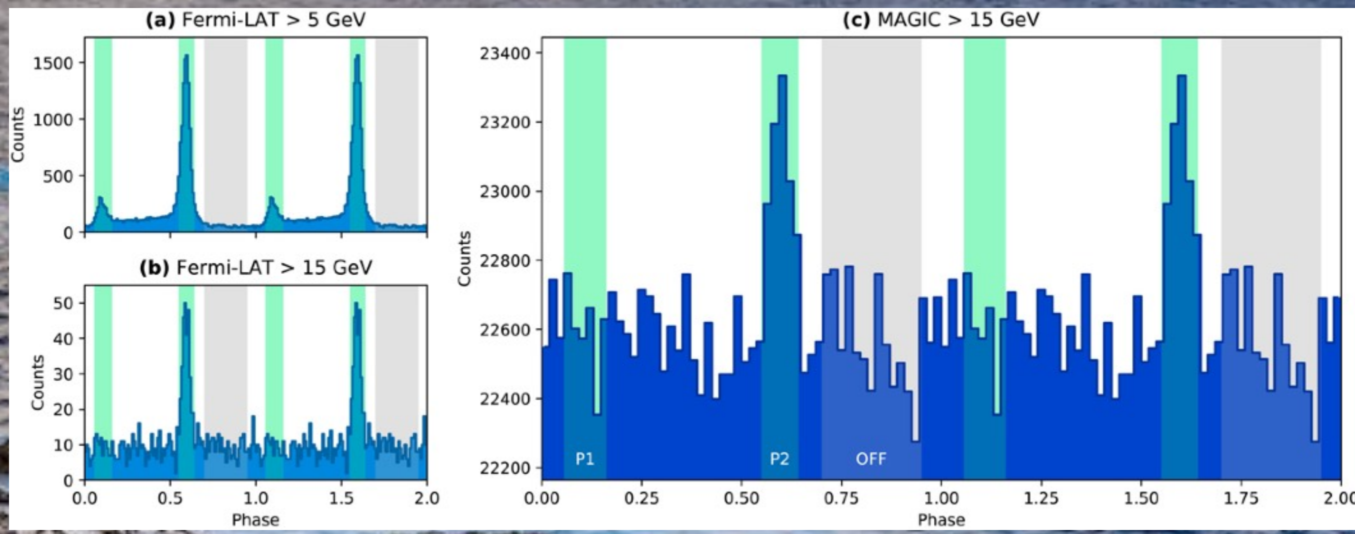


A&A, 585 (2016) A133

Inverse Compton scattering at work







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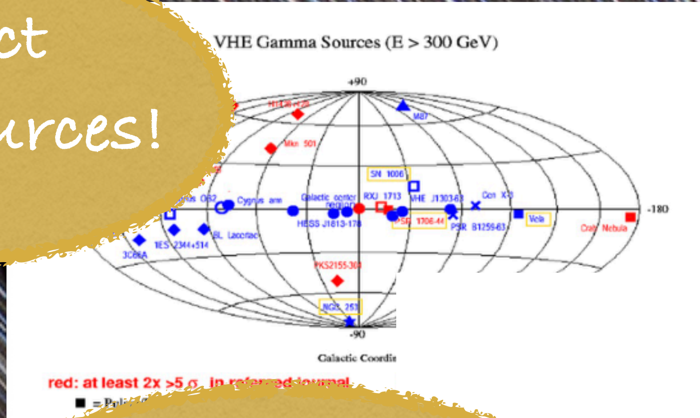
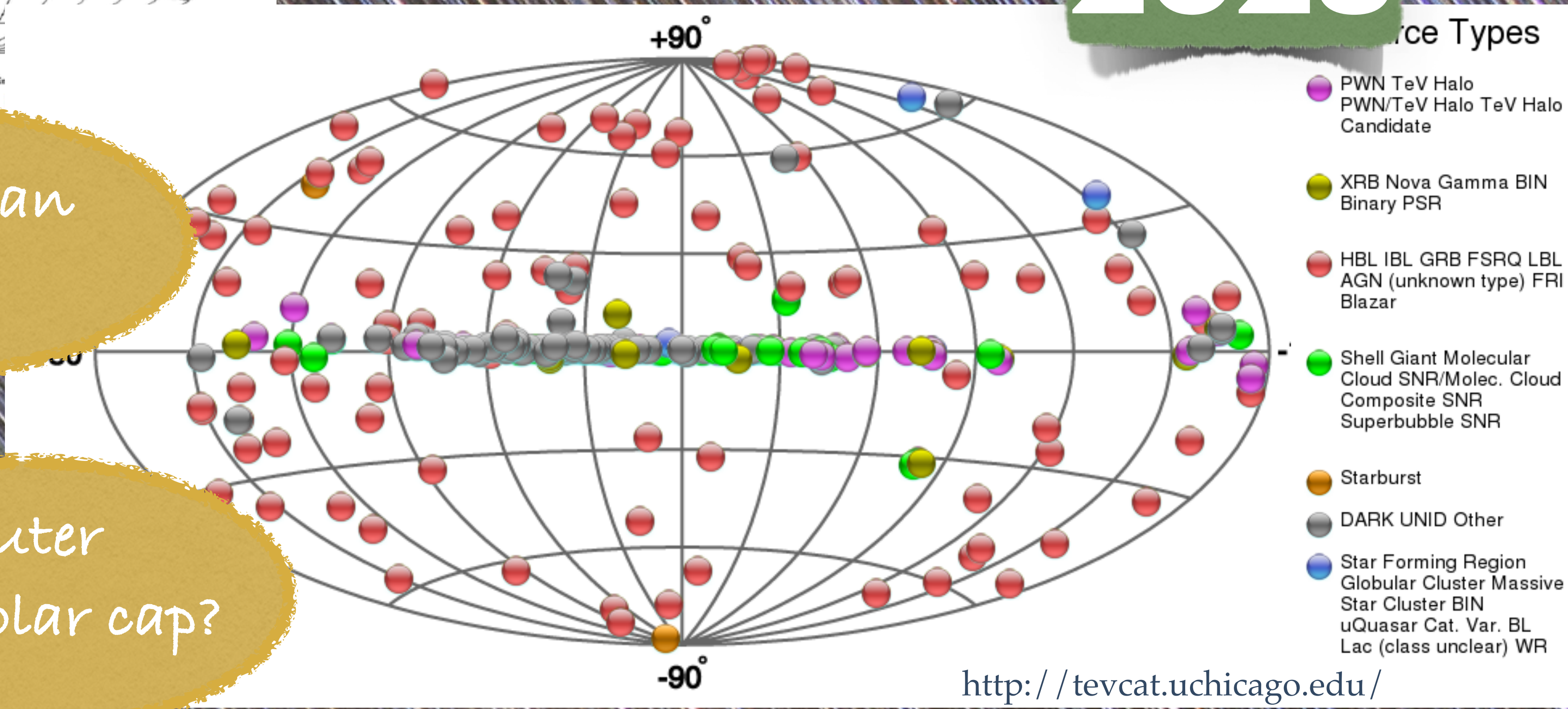


2023



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Expect the unexpected! (detect more sources...)

Cosmic ray origin

- Pevatrons
- propagation/diffusion; B-amplification
- Star clusters
- Extragalactic CR reservoir (SB, clusters)
- Connection with neutrinos

That's easy! ~1 per year expected...

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5.5 Gamma Ray Bursts

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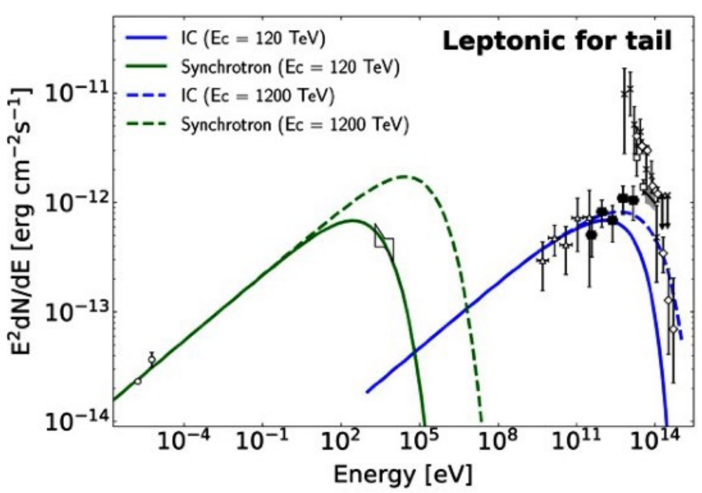
Boomerang PWN/SNR G106.3+2.7

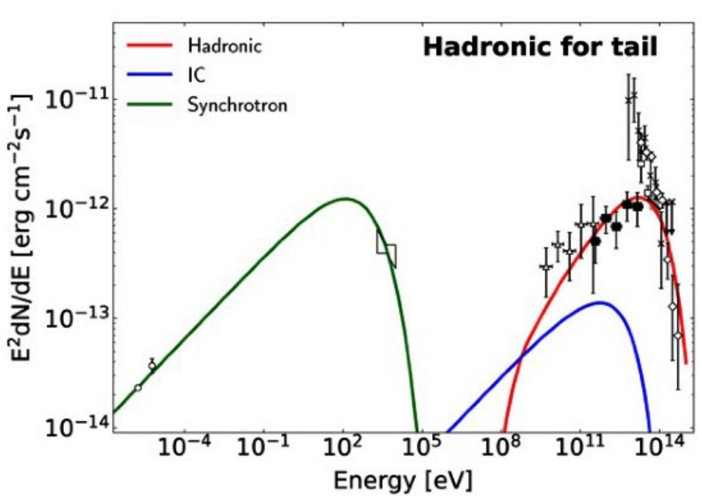
POTENTIAL PEVATRON, CANDIDATE FOR HADRONIC EMISSION

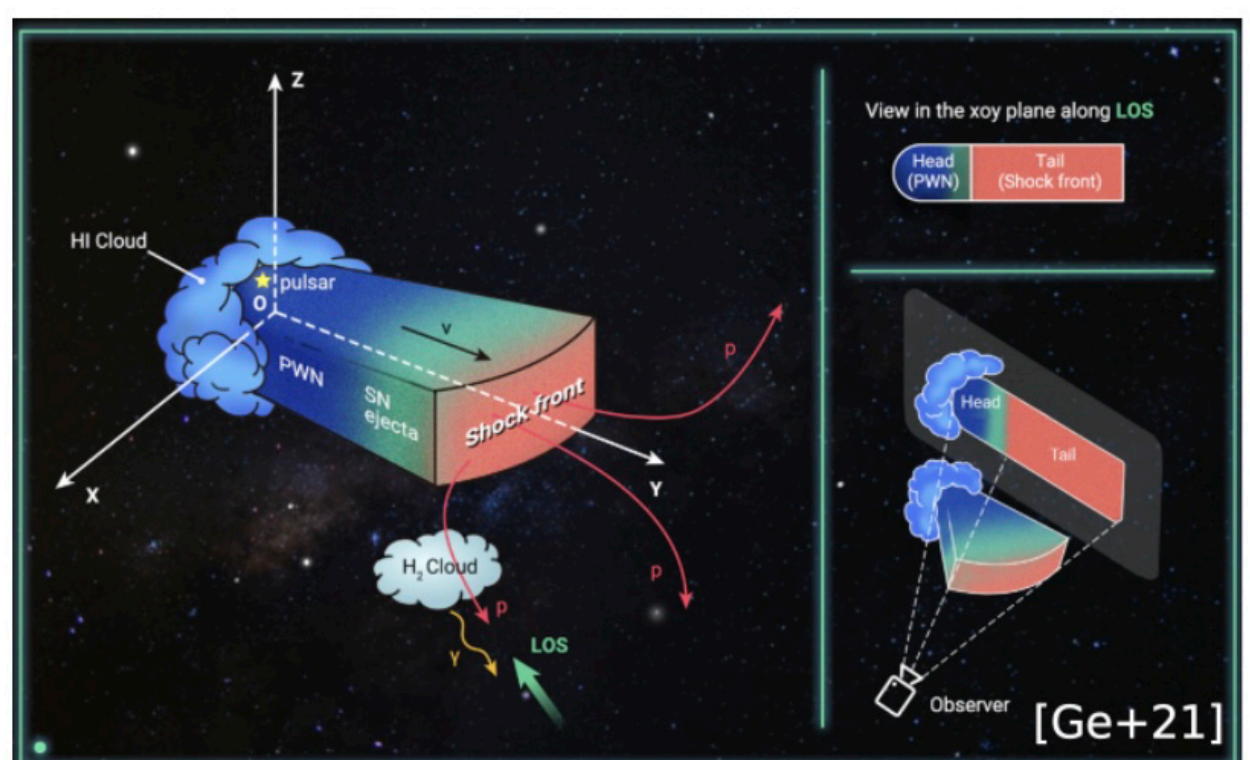
MAGIC coll., 2023, A&A, 671

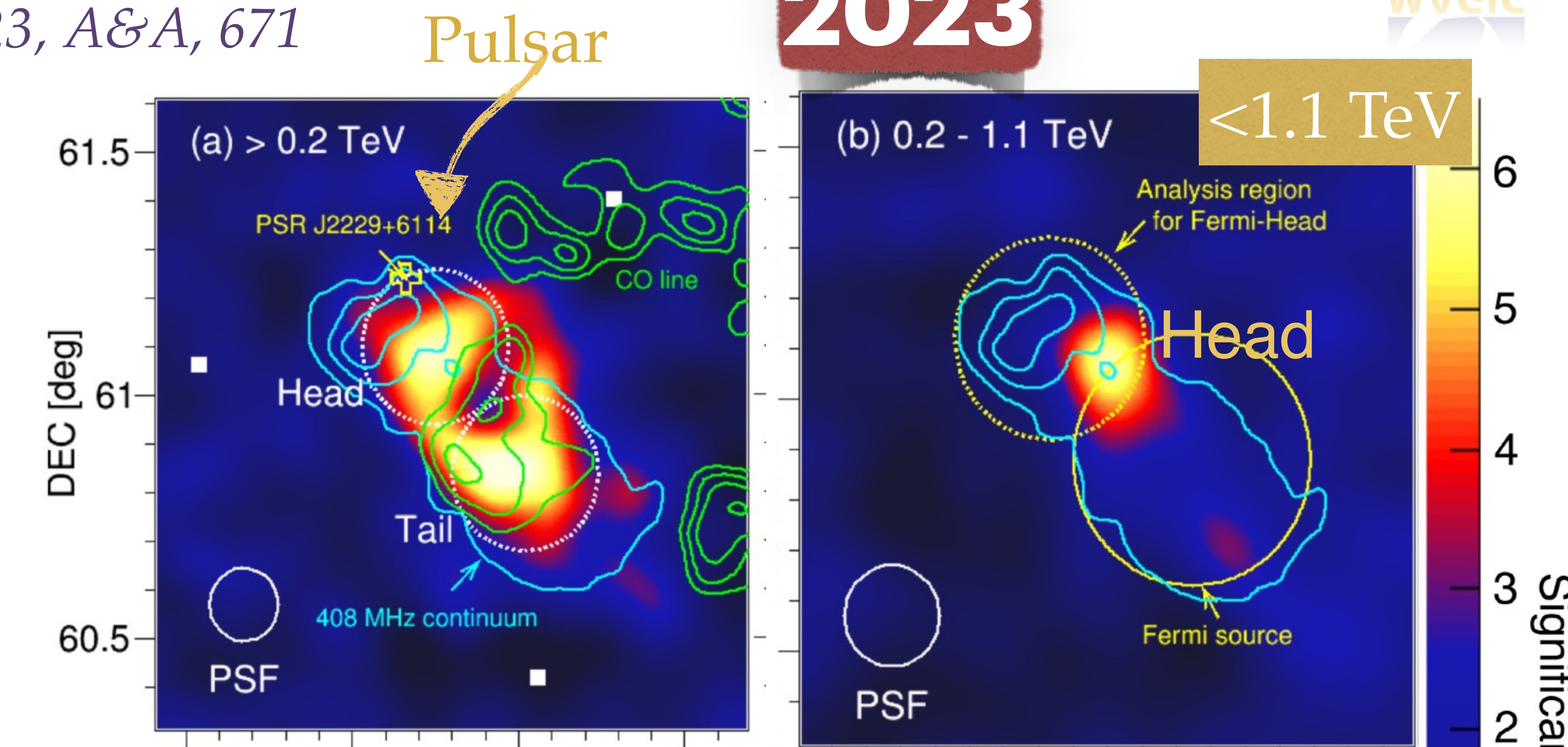
2023

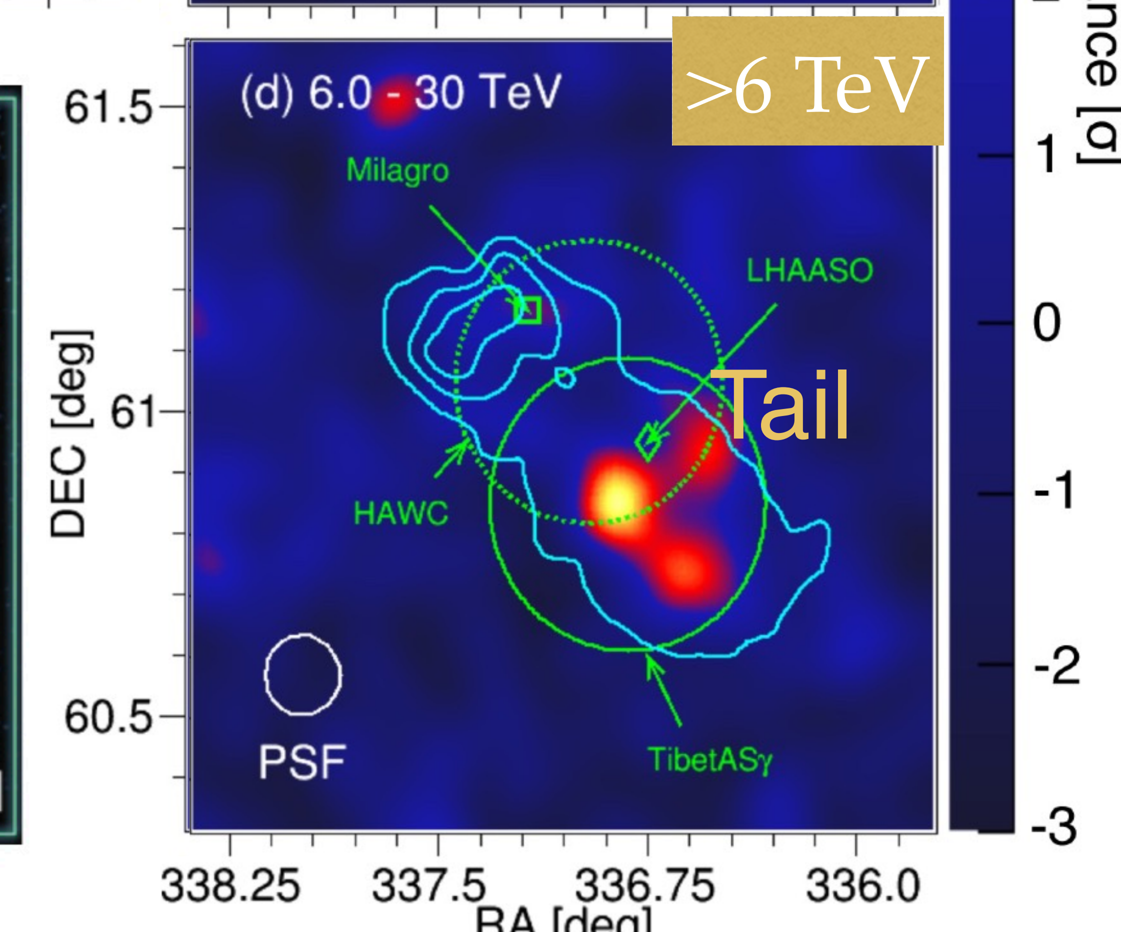
- Possible counterpart of LHAASO J2226+6057
- Two main regions: head-tail
- Tail up to ~30 TeV, compatible with hadronic emission only









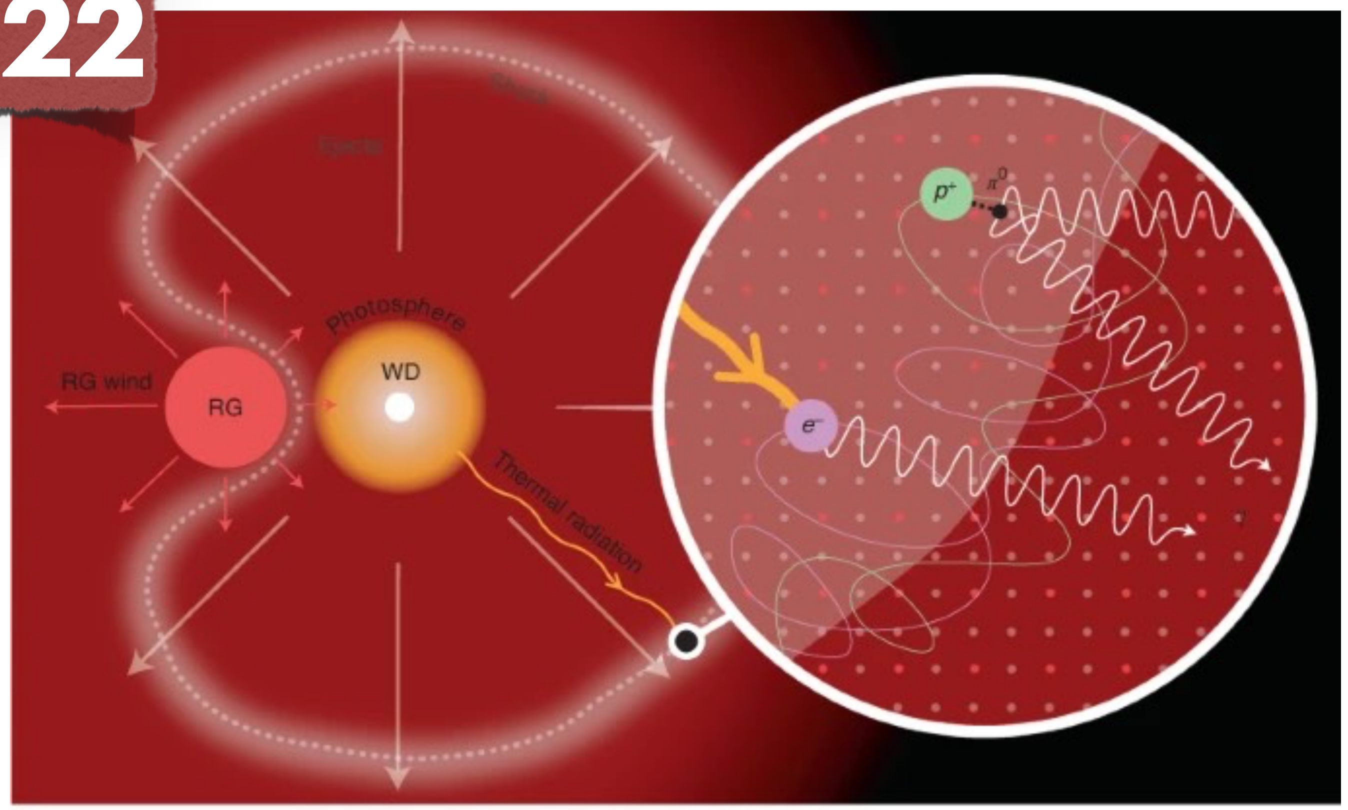


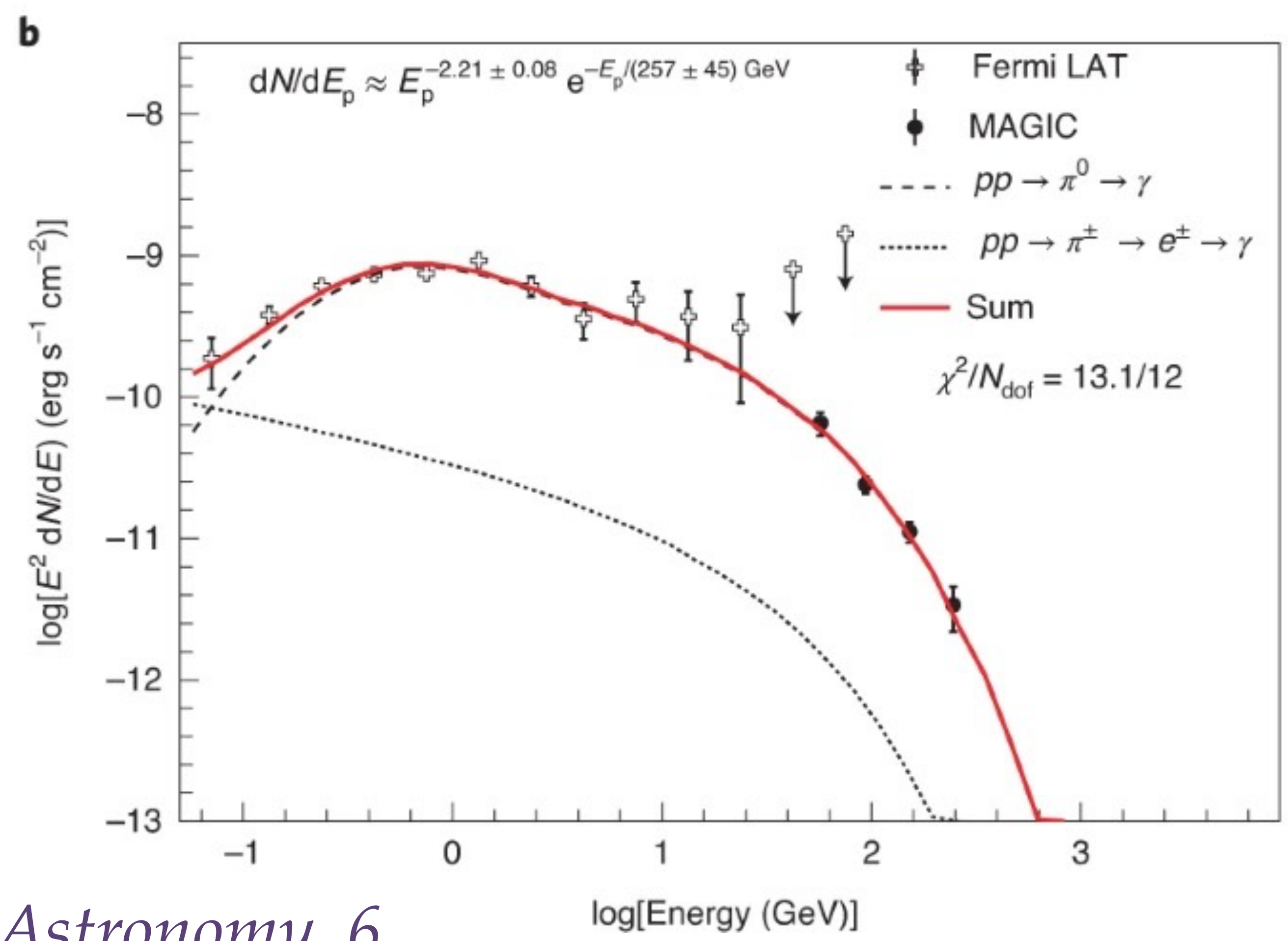
RS Ophiuchi

A new class of TeV sources with an hadronic flavour

- Recurrent nova in a symbiotic binary
  - Latest Outburst in August 2021
- MAGIC initiated a **follow up program** on novae in 2012 (MAGIC coll., 2015, A&A, 58)
- VHE (>100 GeV) data is critical to understand emission mechanisms
- Hadronic model with a natural proton slope ~2 is favoured
- Leptonic models requires ad-hoc break
- Continuing effort with MAGIC on novae

2022



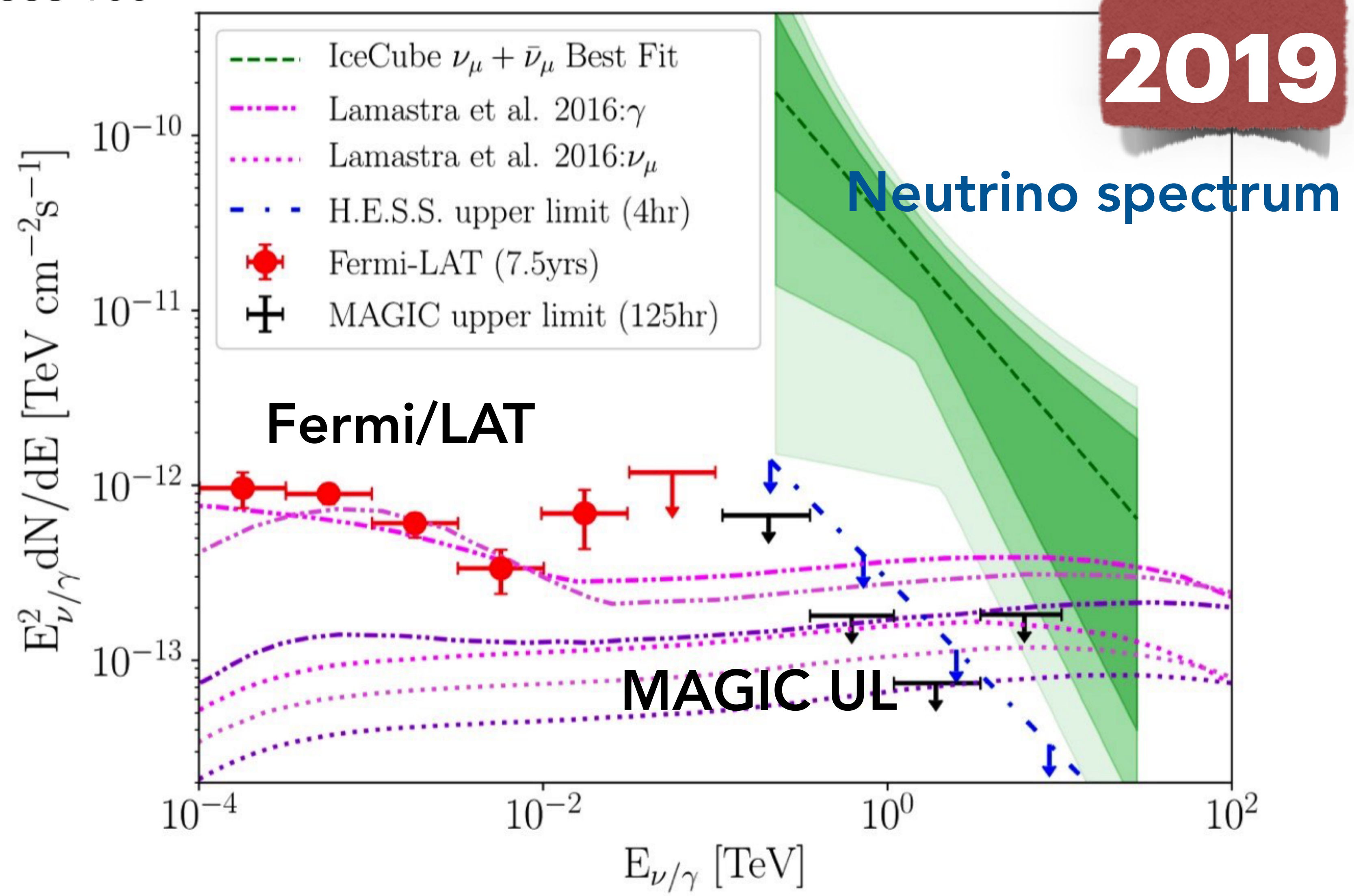


MAGIC coll., 2022, Nature Astronomy, 6

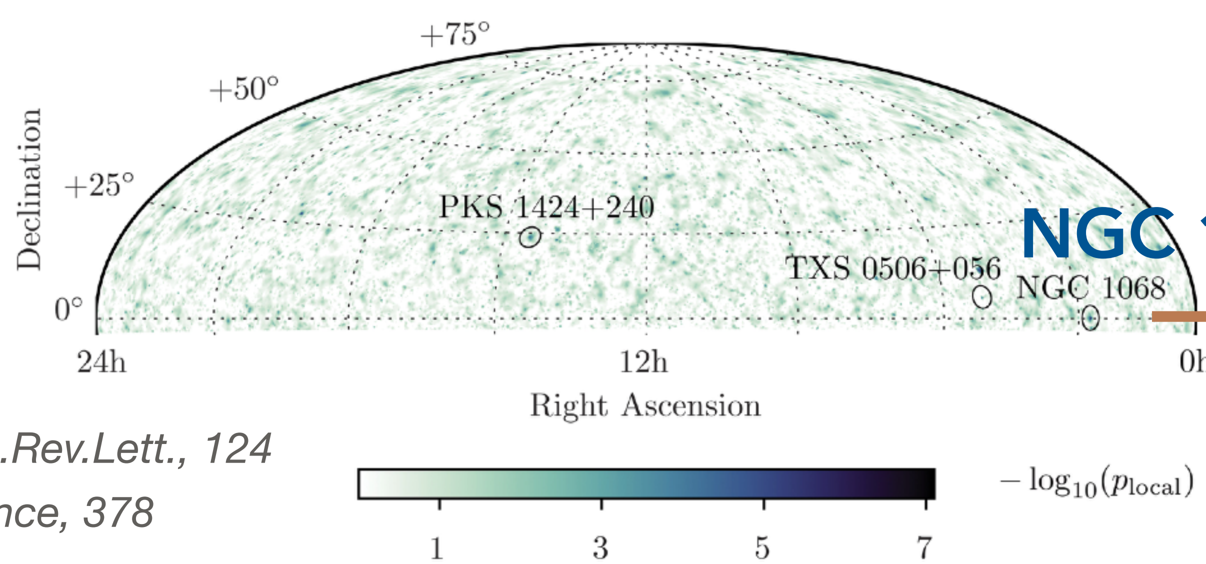
*MAGIC Coll., 2019 ApJ **883** 135*

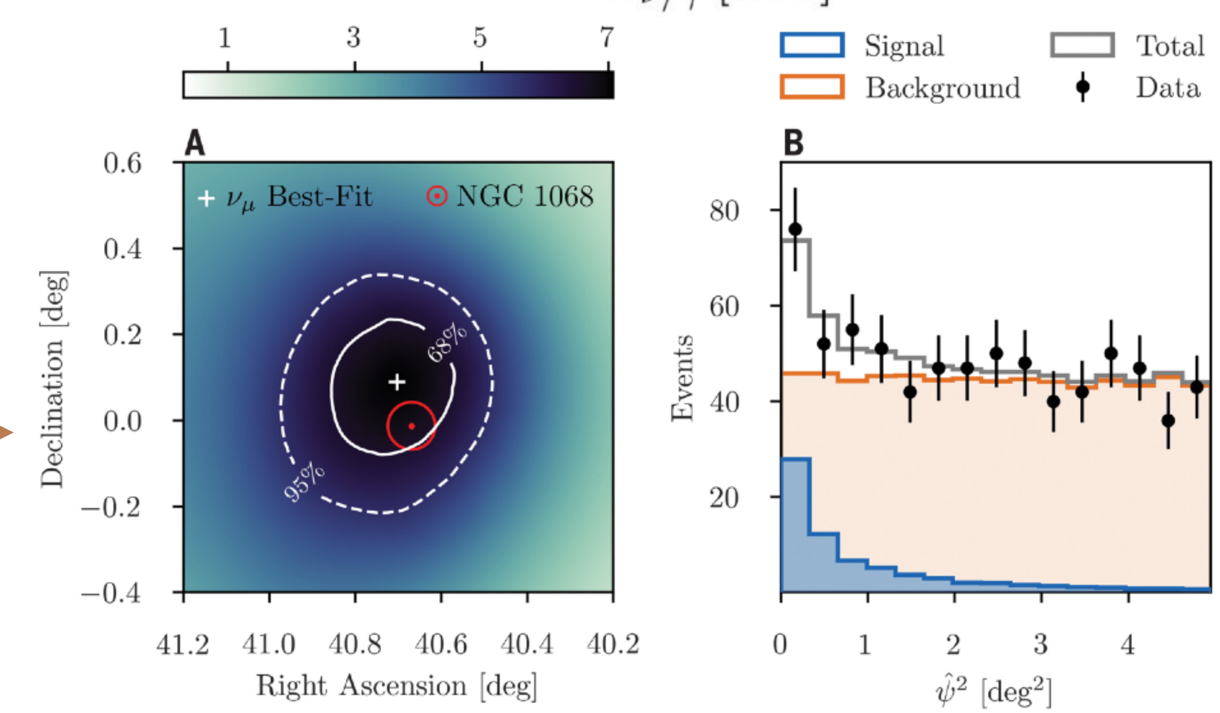
NGC 1068: Starburst galaxy, AGN driven

- 3-years of observations by MAGIC
- ➡ strong constrains on the wind models parameters and the corresponding neutrino emission (V. A. Acciari et al 2019 ApJ 883 135).
- Significant (4.2σ) hotspot in IceCube in ~8 years
- ➡ To match the estimated neutrino flux and the MAGIC UL, **gamma internal absorption is needed** (e.g. Y. Inoue+, 2020, ApJL, 891)



ICECUBE





IceCube coll., 2019, Phys.Rev.Lett., 124

IceCube coll., 2022, Science, 378

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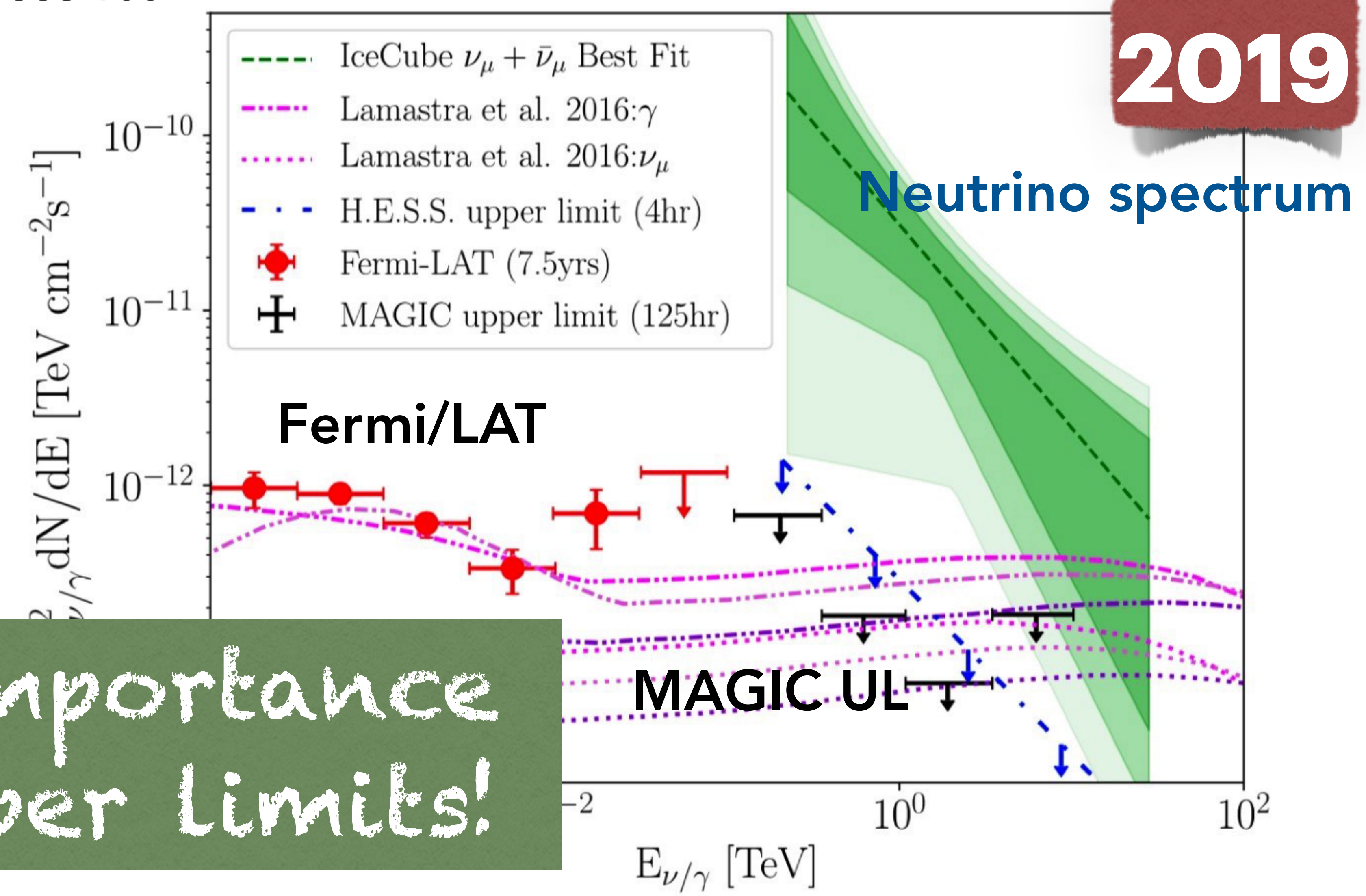

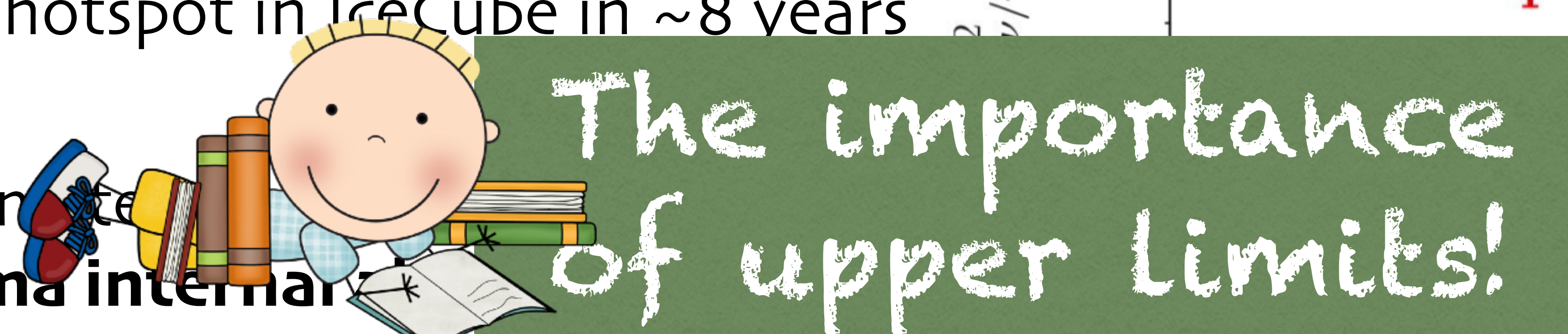

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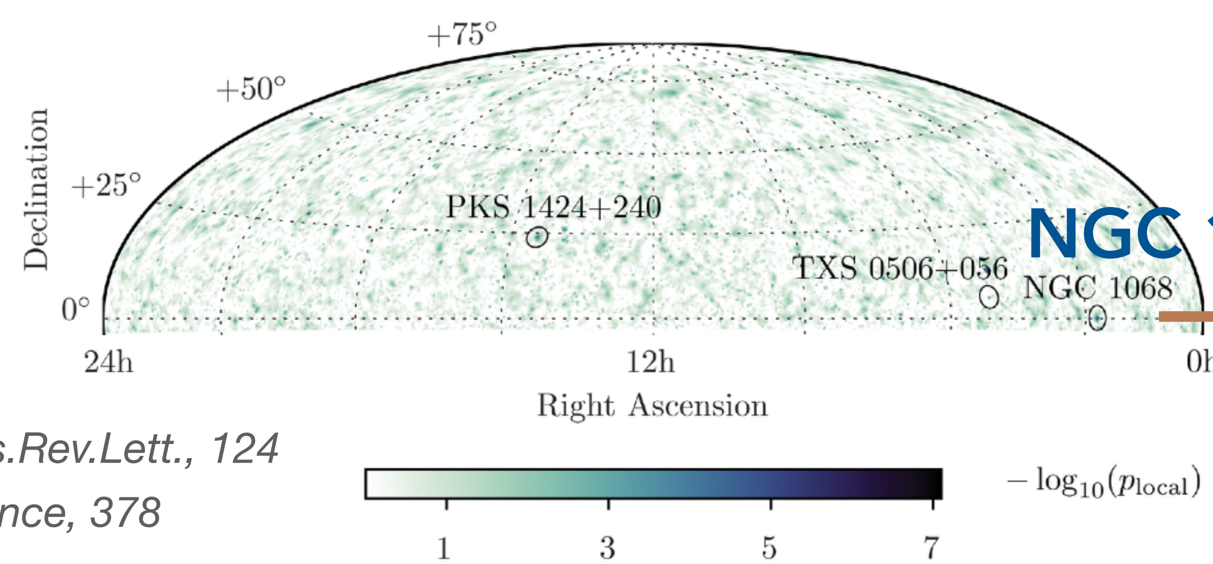
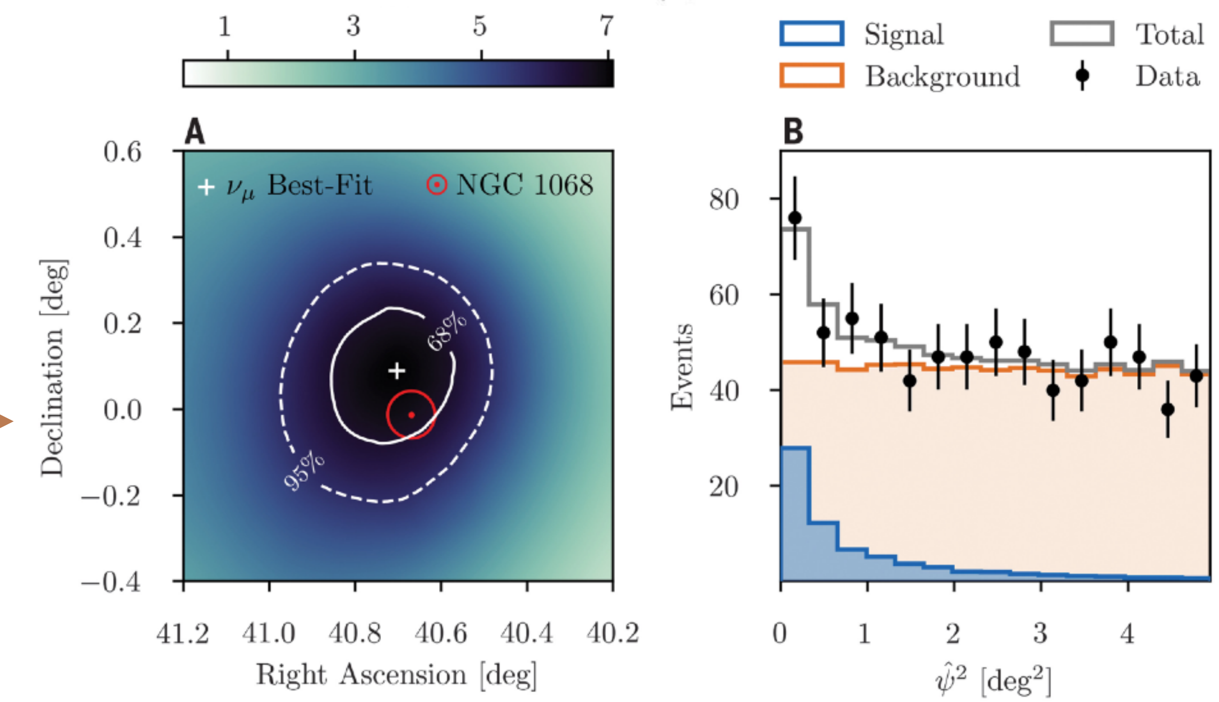


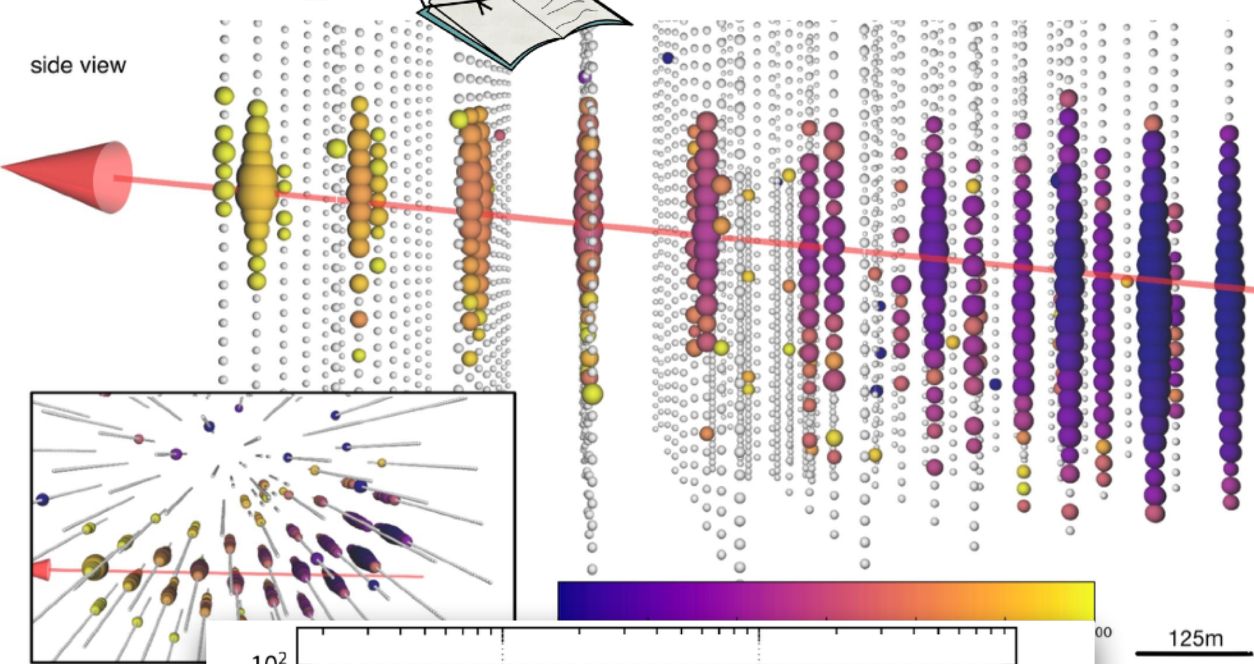
NGC 1068

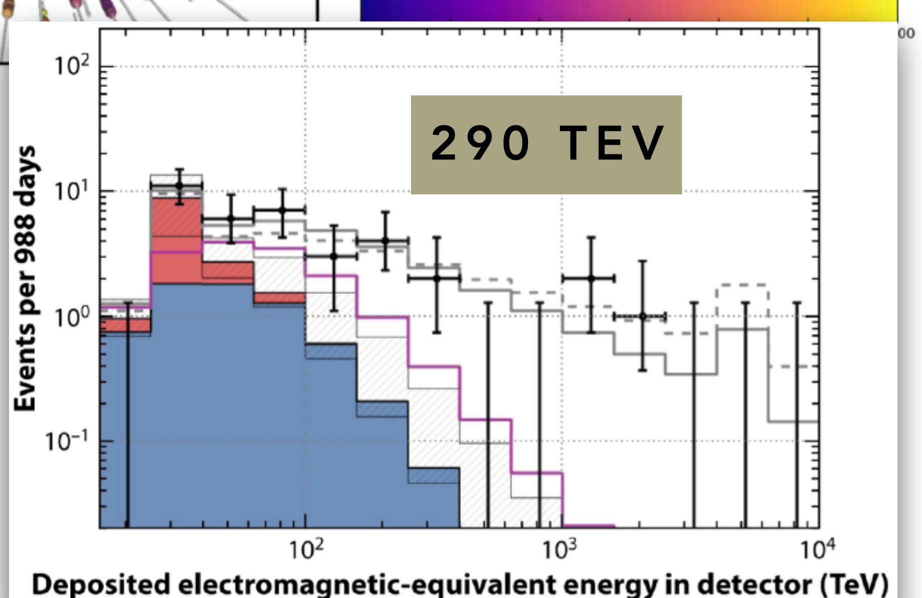


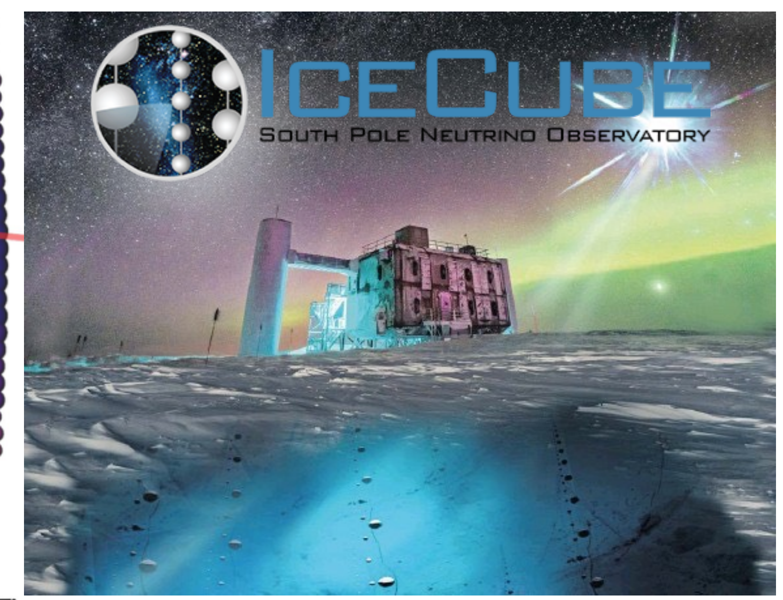
IceCube coll., 2019, Phys.Rev.Lett., 124
IceCube coll., 2022, Science, 378

- ✦ The γ-ν connection in TXS 0506+056: low/intermediate peaked blazar (z=0.3365)
- ✦ Time and physical association of (single) neutrino emission with a flare at 3.5σ

BLAZARS AS HADRONIC SOURCES?

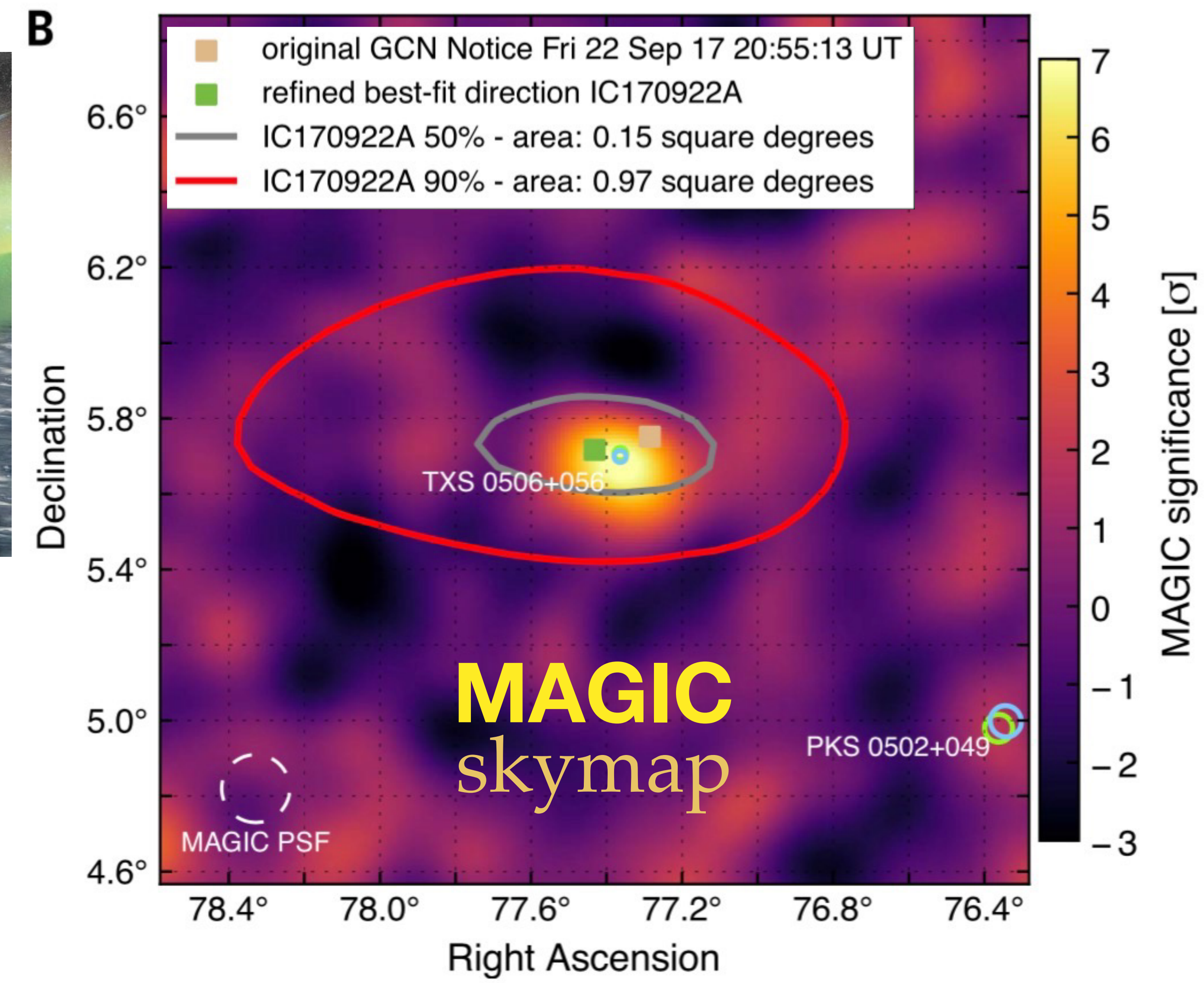




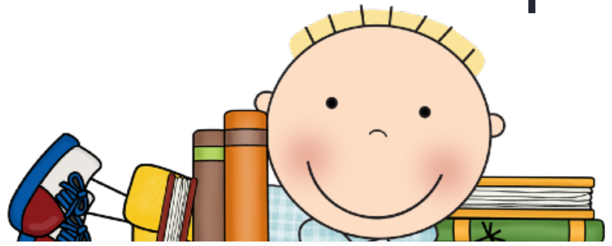


Science 361, eaat1378 (2018)

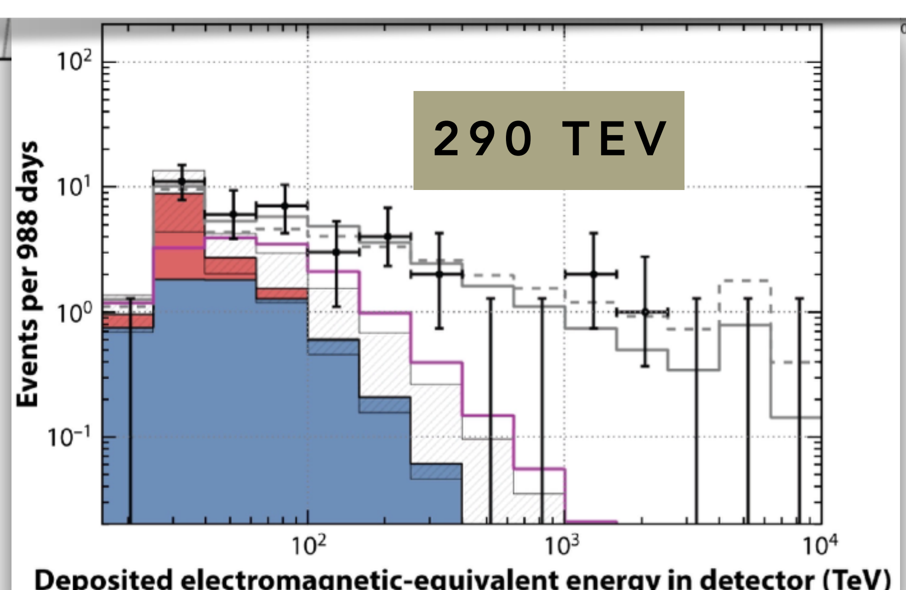
Most cited MAGIC paper with collaborations



- The γ-ν connection in TXS 0506+056: low/intermediate peaked blazar (z=0.3365)
- Time and physical association of (single) neutrino emission with a flare at 3.5σ

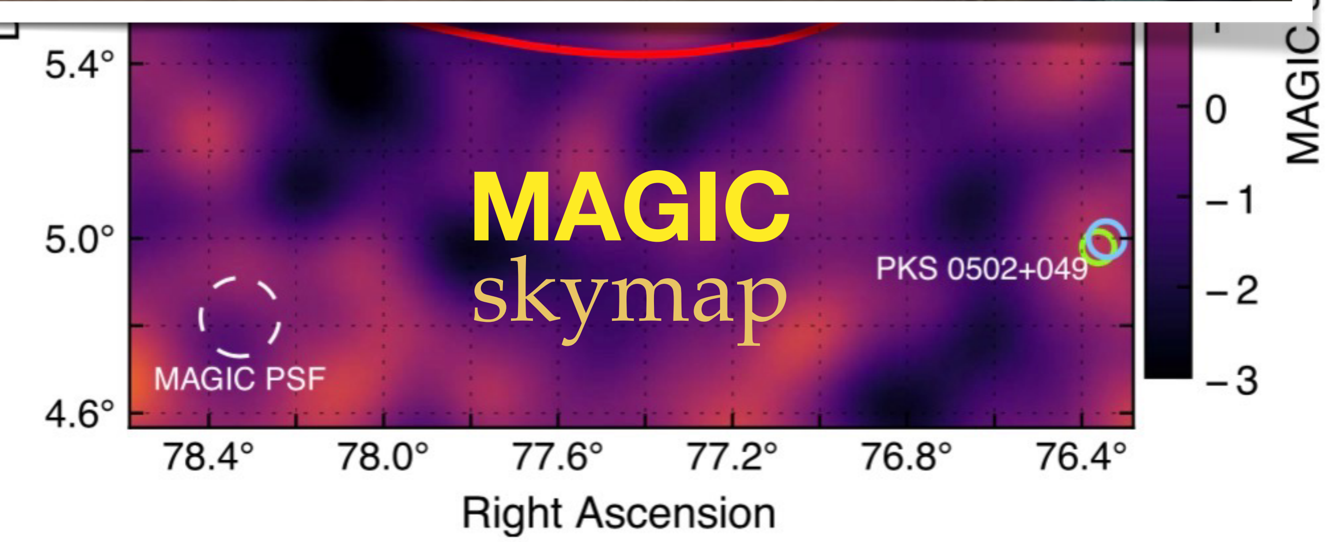


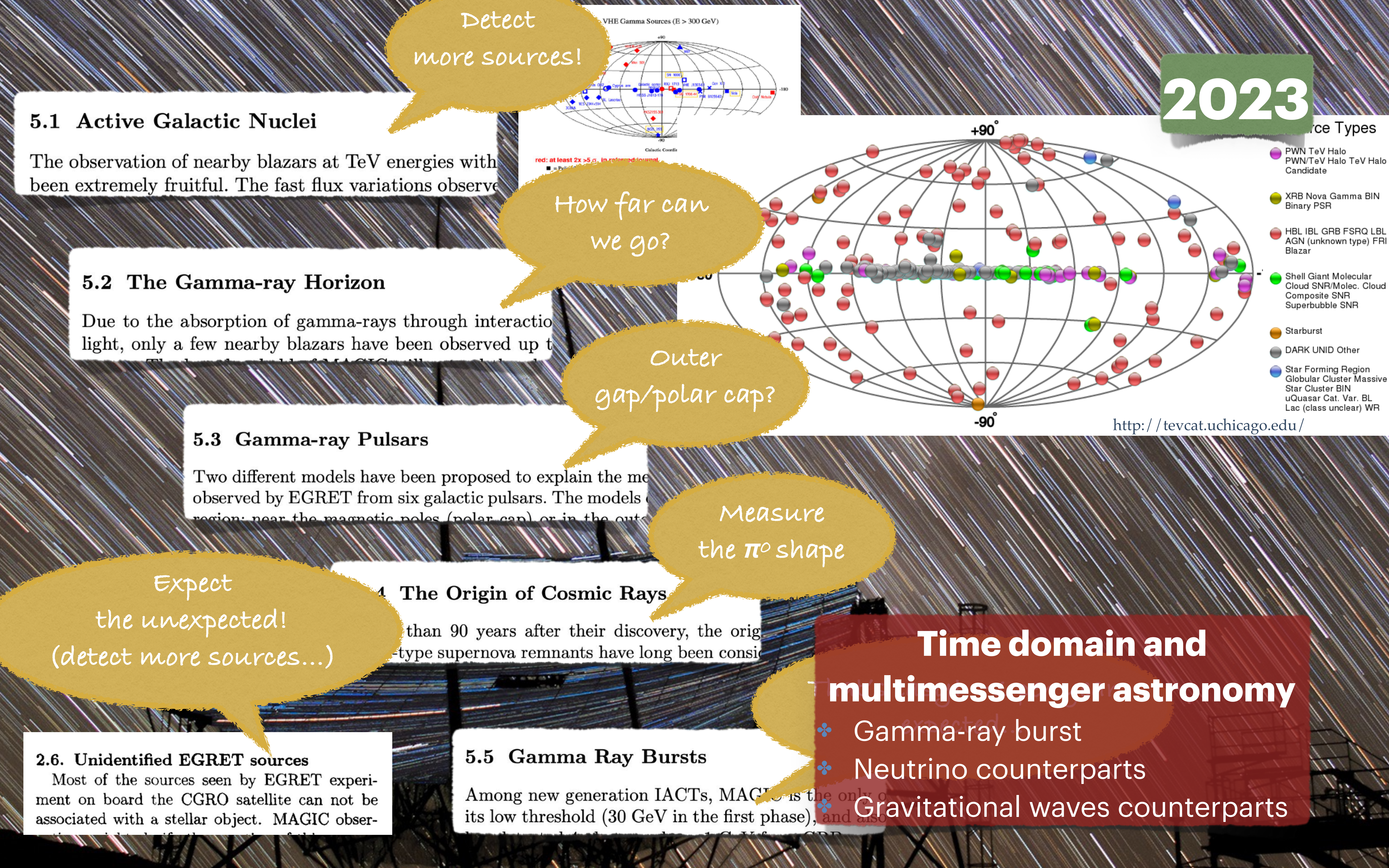
Blazars as hadronic sources?



Science 361, eaat1378 (2018)

Most cited MAGIC paper with collaborations





Detect more sources!
5.1 Active Galactic Nuclei
The observation of nearby blazars at TeV energies with
been extremely fruitful. The fast flux variations observe
VHE Gamma Sources (E > 300 GeV)
How far can we go?
5.2 The Gamma-ray Horizon
Due to the absorption of gamma-rays through interactio
light, only a few nearby blazars have been observed up t
Outer gap/polar cap?
5.3 Gamma-ray Pulsars
Two different models have been proposed to explain the me
observed by EGRET from six galactic pulsars. The models
Measure the π⁰ shape
The Origin of Cosmic Rays
than 90 years after their discovery, the orig
-type supernova remnants have long been consi
Expect the unexpected! (detect more sources…)
2.6. Unidentified EGRET sources
Most of the sources seen by EGRET experiment on board the CGRO satellite can not be associated with a stellar object. MAGIC obser-
5.5 Gamma Ray Bursts
Among new generation IACTs, MAGIC is the only o
its low threshold (30 GeV in the first phase), and also
2023
+90°
-90°
PWN TeV Halo PWN/TeV Halo TeV Halo Candidate
XRB Nova Gamma BIN Binary PSR
HBL IBL GRB FSRQ LBL AGN (unknown type) FRI Blazar
Shell Giant Molecular Cloud SNR/Molec. Cloud Composite SNR Superbubble SNR
Starburst
DARK UNID Other
Star Forming Region Globular Cluster Massive Star Cluster BIN uQuasar Cat. Var. BL Lac (class unclear) WR
http://tevcat.uchicago.edu/
Time domain and multimessenger astronomy
Gamma-ray burst
Neutrino counterparts
Gravitational waves counterparts

From: Robert Wagner <robert.wagner_at_mpp.mpg.de>
Date: Wed, 1 Apr 2009 02:53:31 +0000
Dear collaborators,

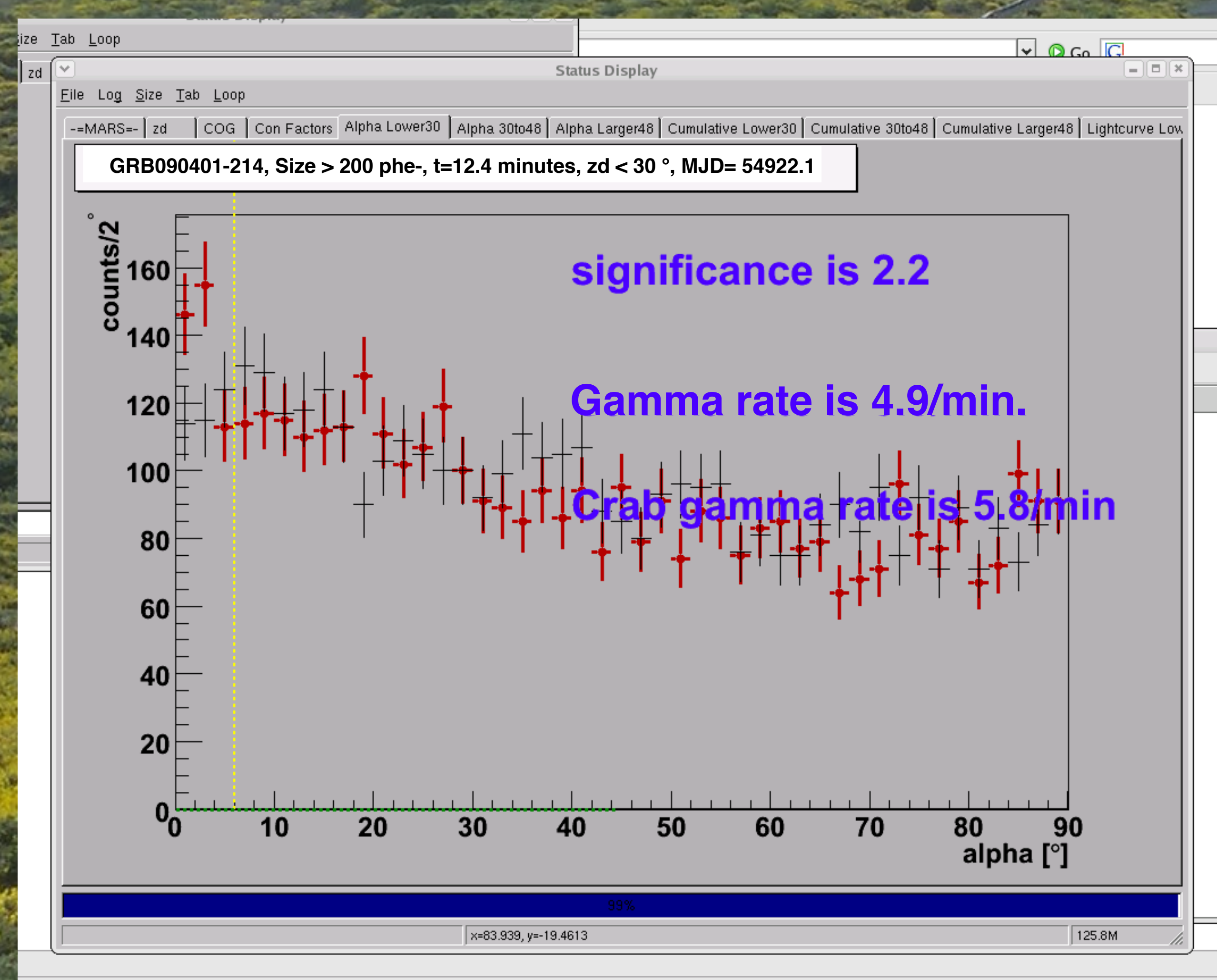
right now the whole P77 shift crew is as speechless as the current burst advocate, whom we just contacted. At 02:14 we received a GRB alert for GRB090401-214, which apparently could lift our collaboration on a whole new level. After about 15 minutes we saw a very encouraging signal from the OA, see the attached plot. We think that this 2.2 sigma from a GRB is an awful and probably never repeatable result for MAGIC.

Cheers,
the P77 shift crew.

PS. Unfortunately, however, Superarehucas stopped the observations after 15 minutes, obviosly because of the too large GBM error, and so we continued with the scheduled IPR scan.

- application/pdf attachment: Screenshot-4..pdf

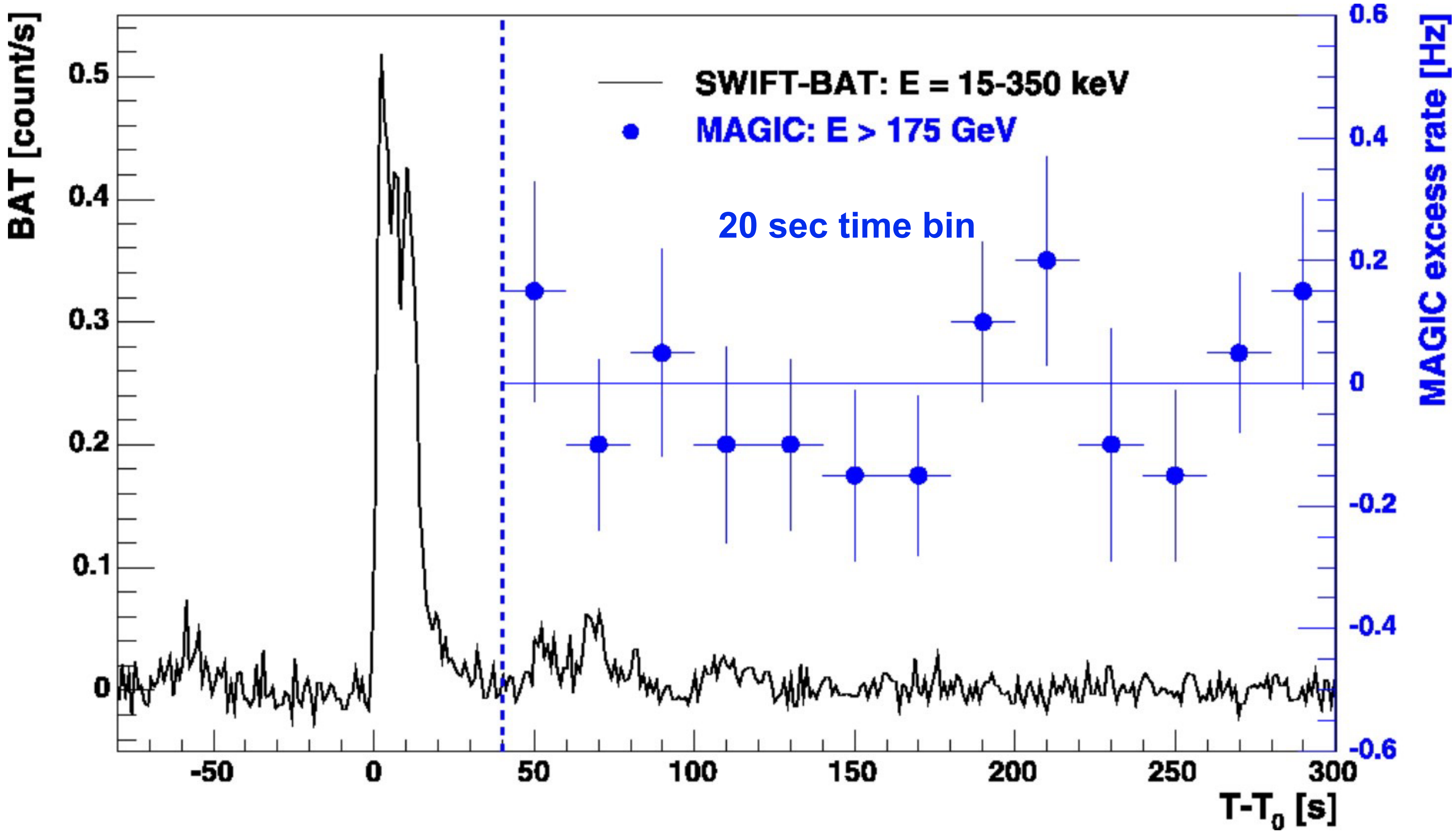
2009



GRBs with MAGIC

2005

- GRB 050713A: First GRB in the immediate afterglow phase by a IACT

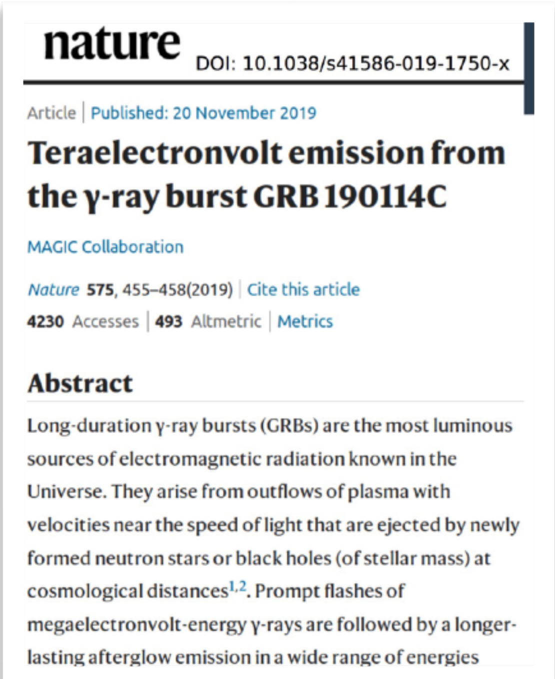


MAGIC coll. ApJL, 641, 2006

GRB190114C: a brief story of firsts

- **1st GRB detected at the teraelectronvolt (TeV) energies**
- **1st GRB observed over 20 orders of magnitude in energy**
- **1st GRB with unambiguous detection of a new energetic emission component distinct from synchrotron**
- **1st single broad-band modeling of a GRB including both components**
- **Brightest TeV source in the sky ever detected** (until GRB221009A)

GRB190114C: the high energy SEDs


nature DOI: 10.1038/s41586-019-1750-x

Article | Published: 20 November 2019

Teraelectronvolt emission from the γ-ray burst GRB 190114C

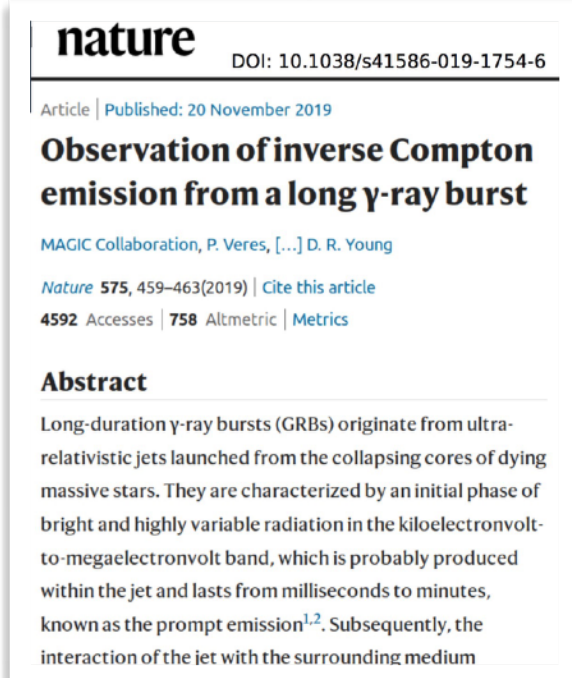
MAGIC Collaboration

Nature 575, 455–458(2019) | Cite this article

4230 Accesses | 493 Altmetric | Metrics

Abstract

Long-duration γ-ray bursts (GRBs) are the most luminous sources of electromagnetic radiation known in the Universe. They arise from outflows of plasma with velocities near the speed of light that are ejected by newly formed neutron stars or black holes (of stellar mass) at cosmological distances[1,2]. Prompt flashes of megaelectronvolt-energy γ-rays are followed by a longer-lasting afterglow emission in a wide range of energies


nature DOI: 10.1038/s41586-019-1754-6

Article | Published: 20 November 2019

Observation of inverse Compton emission from a long γ-ray burst

MAGIC Collaboration, P. Veres, [...] D. R. Young

Nature 575, 459–463(2019) | Cite this article

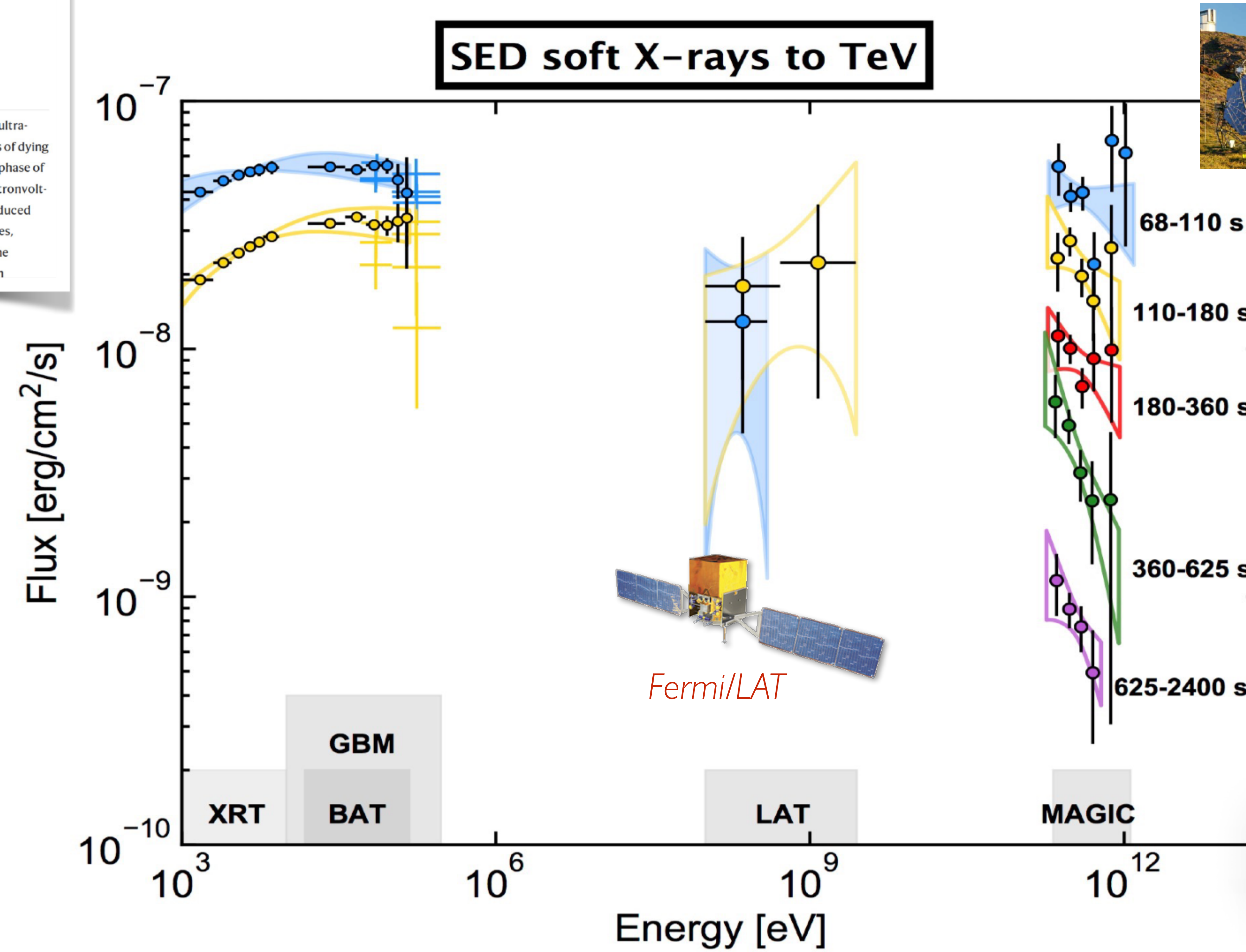
4592 Accesses | 758 Altmetric | Metrics

Abstract

Long-duration γ-ray bursts (GRBs) originate from ultra-relativistic jets launched from the collapsing cores of dying massive stars. They are characterized by an initial phase of bright and highly variable radiation in the kiloelectronvolt-to-megaelectronvolt band, which is probably produced within the jet and lasts from milliseconds to minutes, known as the prompt emission[1,2]. Subsequently, the interaction of the jet with the surrounding medium

Clear indication of a second energetic component

- Long GRB at z=0.425
  (GCN #**23695 #23708)**
- E_{iso} = 3×10^{53} erg; bright GRB, but not exceptional
- VHE photons detected by MAGIC, at >100 GeV up to ~1TeV are **well beyond the burnoff limits**

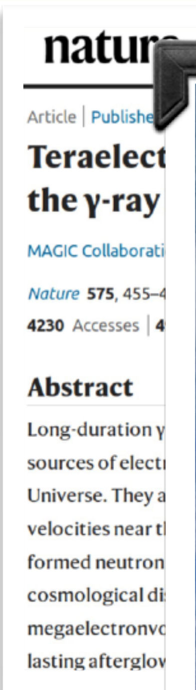


2019

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

https://www.nature.com/articles/s41586-019-1754-6

GRB190114C: the high energy SEDs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Article | Publishe

Teraelect

the γ-ray

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Nature 575, 455–4

4230 Accesses | 4

Abstract

Long-duration γ

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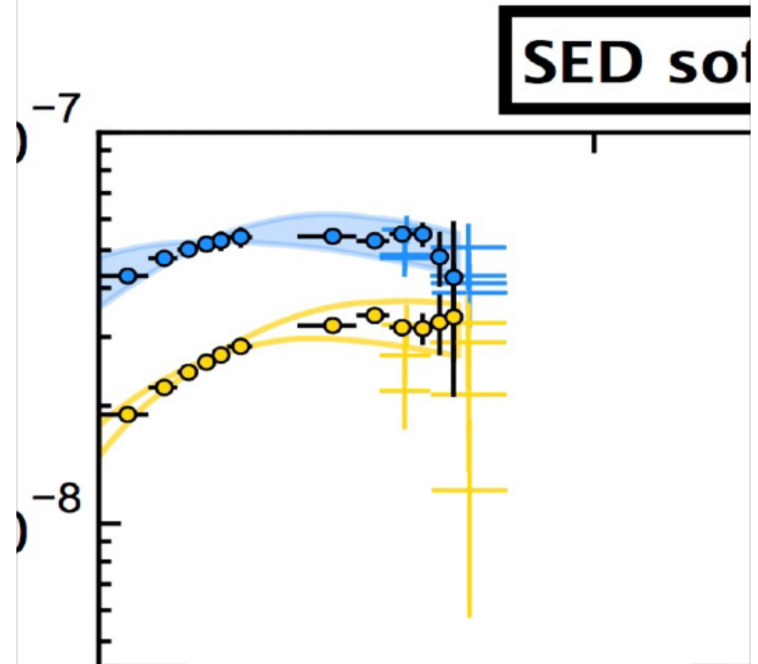
Clear indication of ... nt



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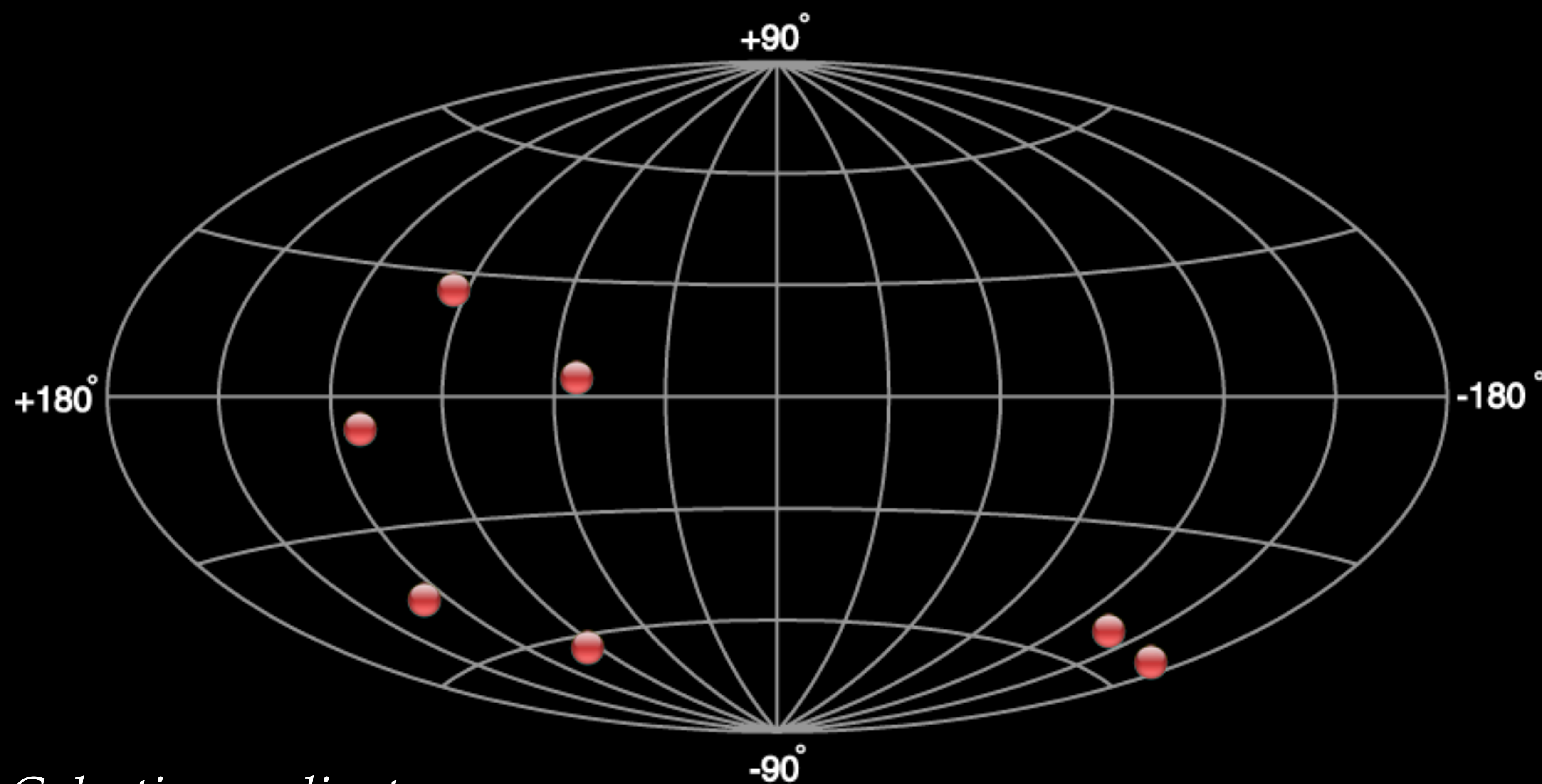
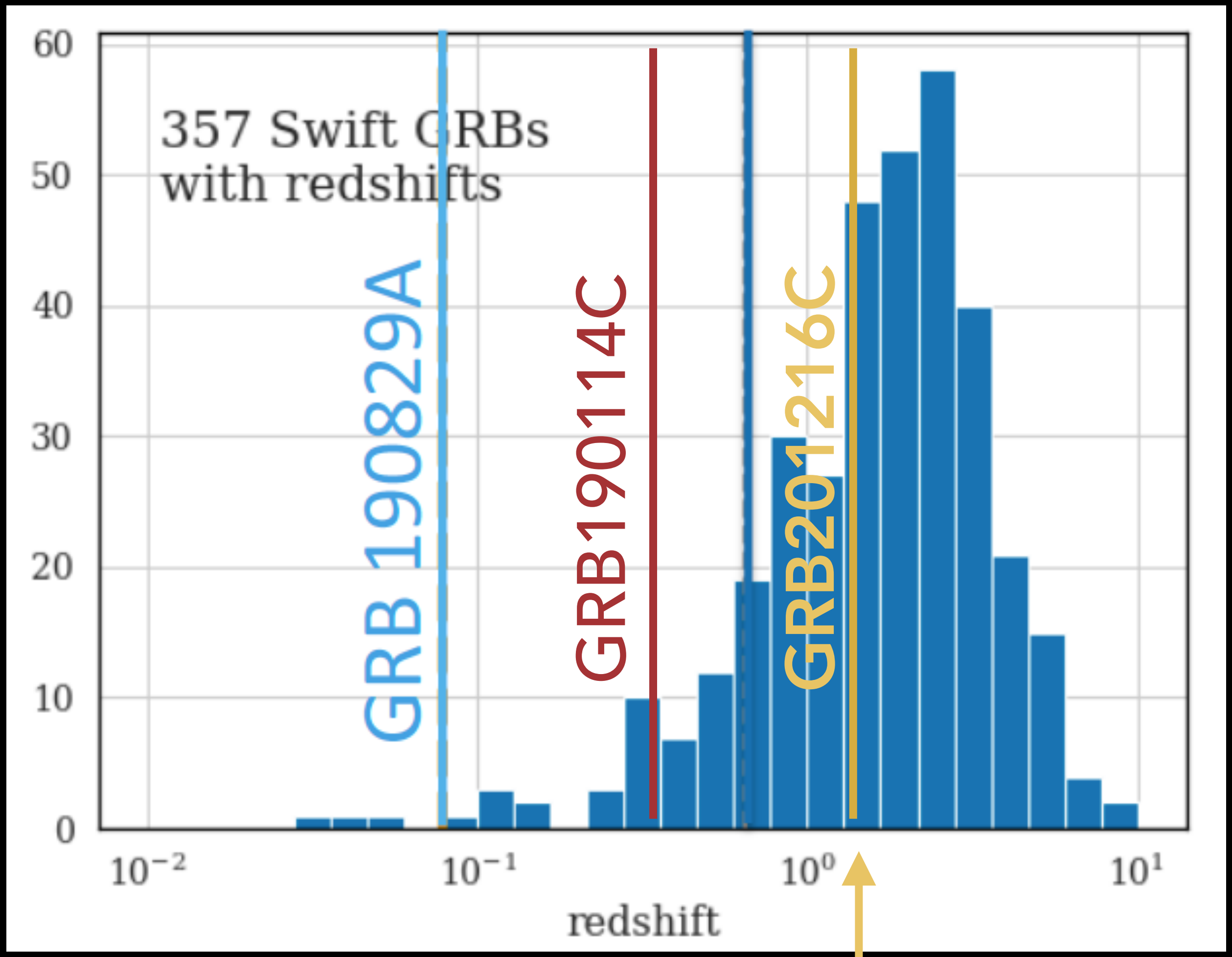
https://www.nature.com/articles/s41586-019-1754-6

TeV-GRBs: the gamma-ray horizon



Galactic coordinates



Farthest TeV source

Name	RA	Dec	Type	Discoverer	Date	Dist	Catalog
			...	...			...
GRB 180720B	00 02 07.6	-02 56 06	GRB	H.E.S.S.	2019.05	z = 0.654	Default Catalog
GRB 201216C	01 05 28.88	+16 30 58.0	GRB	MAGIC	2020.12	z = 1.1	Newly Announced
GRB 190829A	02 58 10.51	-08 57 28.1	GRB	H.E.S.S.	2019.08	z = 0.0785	Default Catalog
GRB 190114C	03 38 01.17	-26 56 46.73	GRB	MAGIC	2019.01	z = 0.4245	Default Catalog
GRB 160821B	18 39 54.71	+62 23 34	GRB	null	2016.08	z = 0.16	Source Candidates
GRB 221009A	19 13 03	+19 48 09	GRB	LHAASO	2022.10	z = 0.151	Newly Announced
GRB 201015A	23 37 16.42	+53 24 55.8	GRB	MAGIC	2020.10	z = 0.43	Source Candidates

1-7

http://tevcat.uchicago.edu/

A steady growth in performance

MAGIC@20

MAGIC

2004

MAGIC Coll. meeting
Würzburg, 2002

The MAGIC Collaboration

2002

2022

MAGIC Coll. meeting
München, June 2022

The MAGIC Science

MAGIC@20

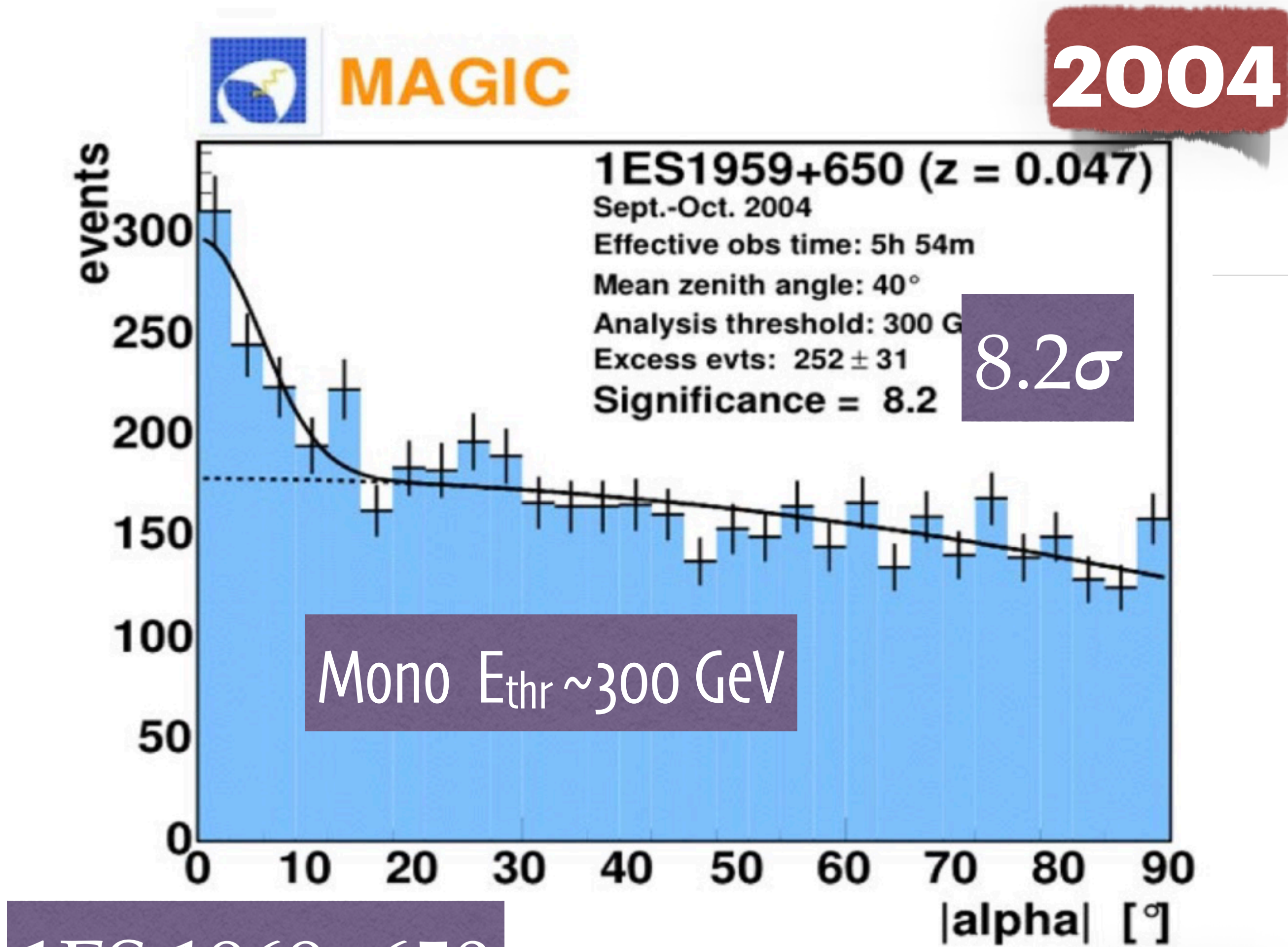
- A wealth of relevant results in the 20 years long operation of the MAGIC telescopes.
- MAGIC experiment with an observatory flavour
  - **observing time open to the external community**
- An opportunity for the **engagement of young observers** and astrophysicists willing to analyse and interpret TeV data, with important synergies with other instruments, *in preparation for the CTA*.
- An **opportunity for experts, phenomenologists - observers - theoreticians**, to develop their ideas and research, becoming MAGIC **associated scientists**.
- *A large discovery potential is still ahead of MAGIC!*

The menù:

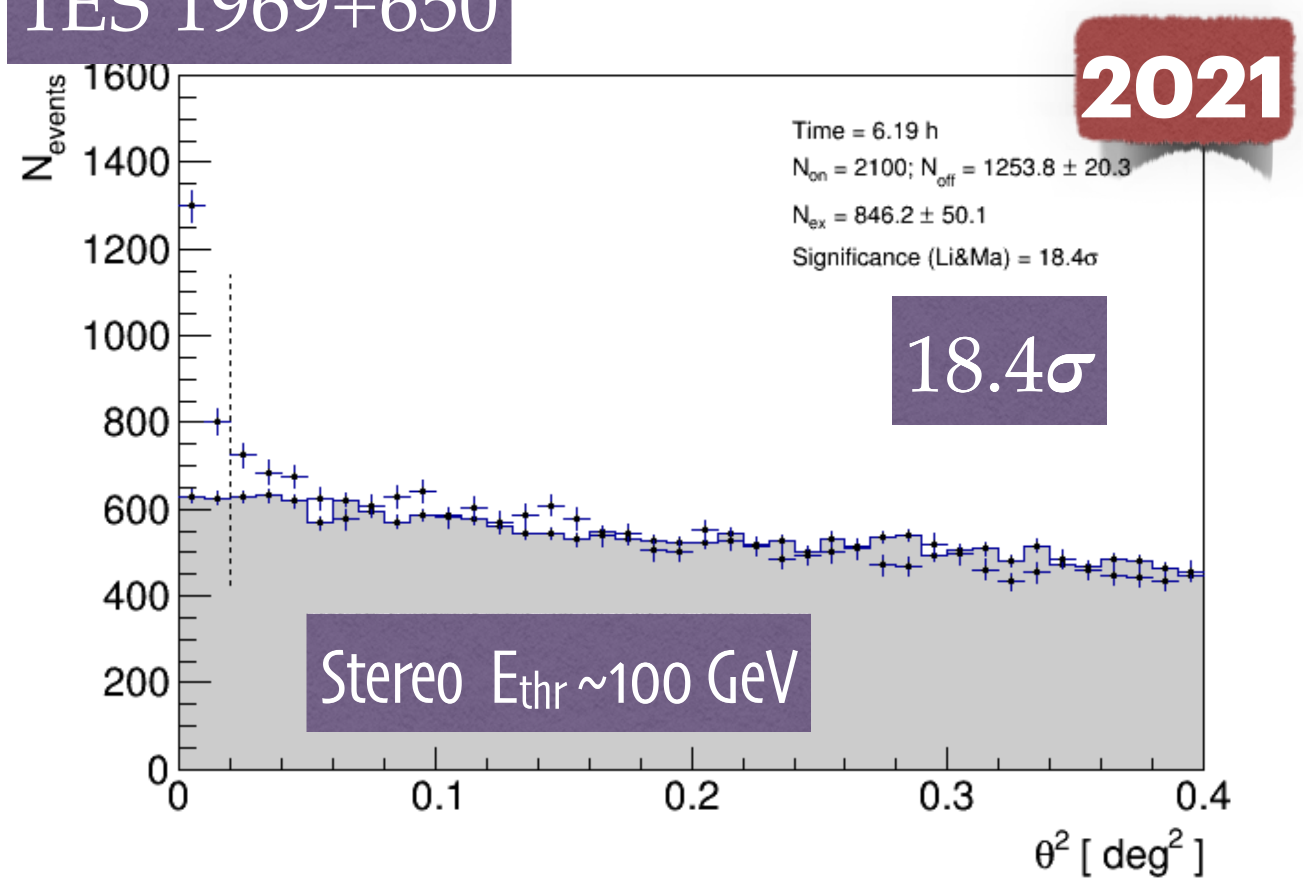
- Transients: GW search, novae
  Consolidate GRB; FRB searches
- MWL observations on AGN and Radiogalaxies (IXPE, EHT,...)
- CR cradles - SNR in MC, massive clusters, neutrino counterparts,...
- New ideas! Asteroids occultation, interferometry, ...

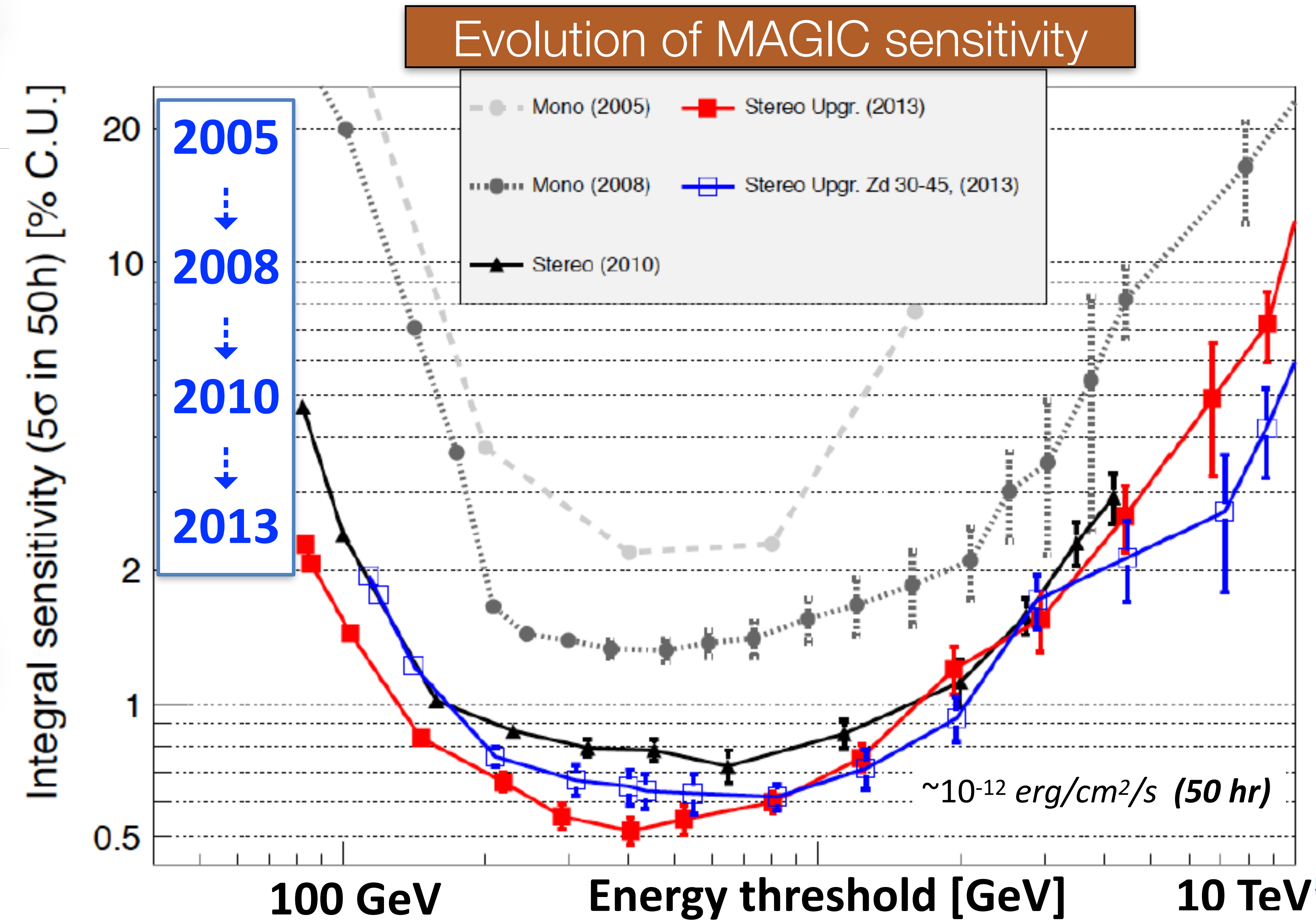
BACKUP

A steady growth in performance



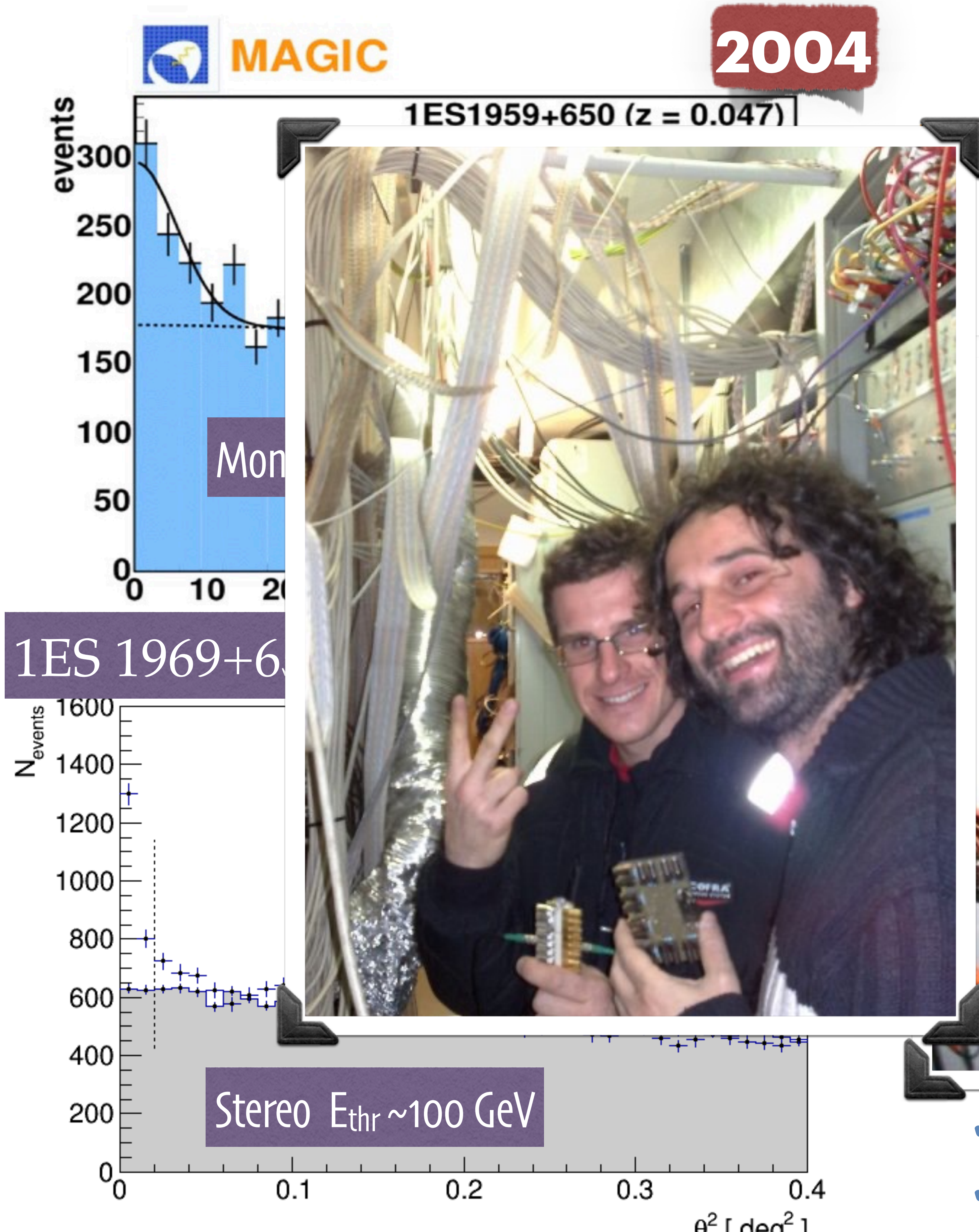
1ES 1969+650

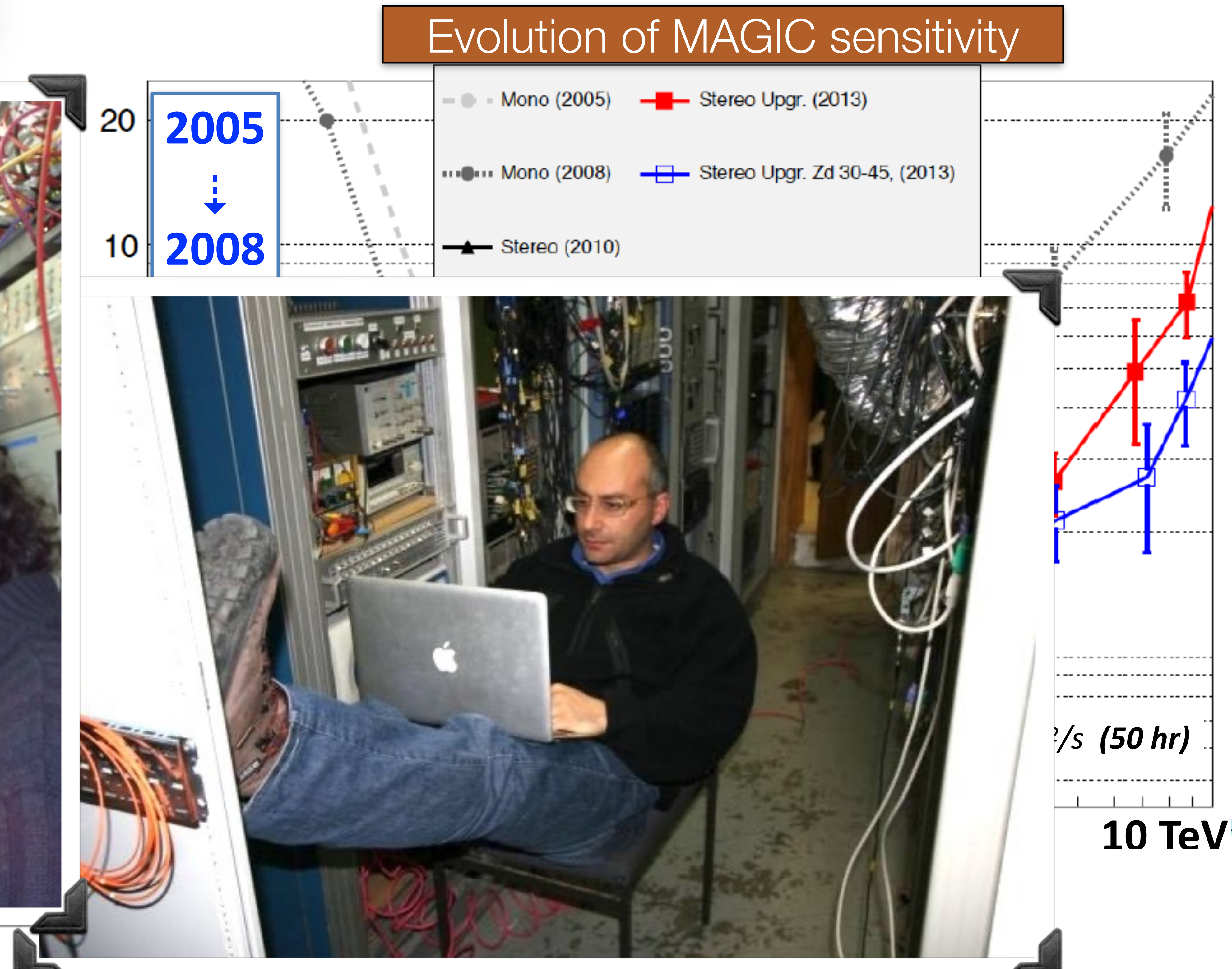




- ✓ Stereo system
- ✓ Improvements in analysis (e.g. timing information)
- ✓ Hardware upgrades

A steady growth in performance

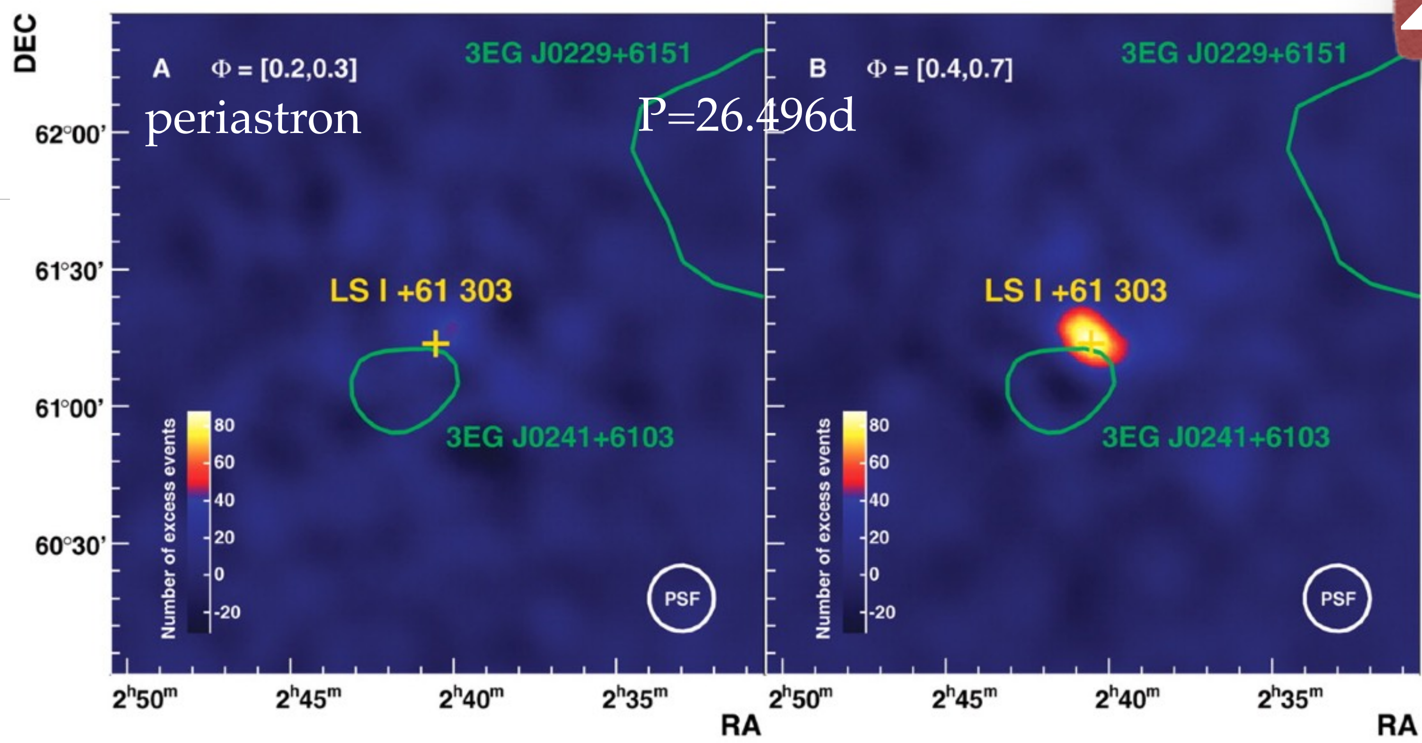




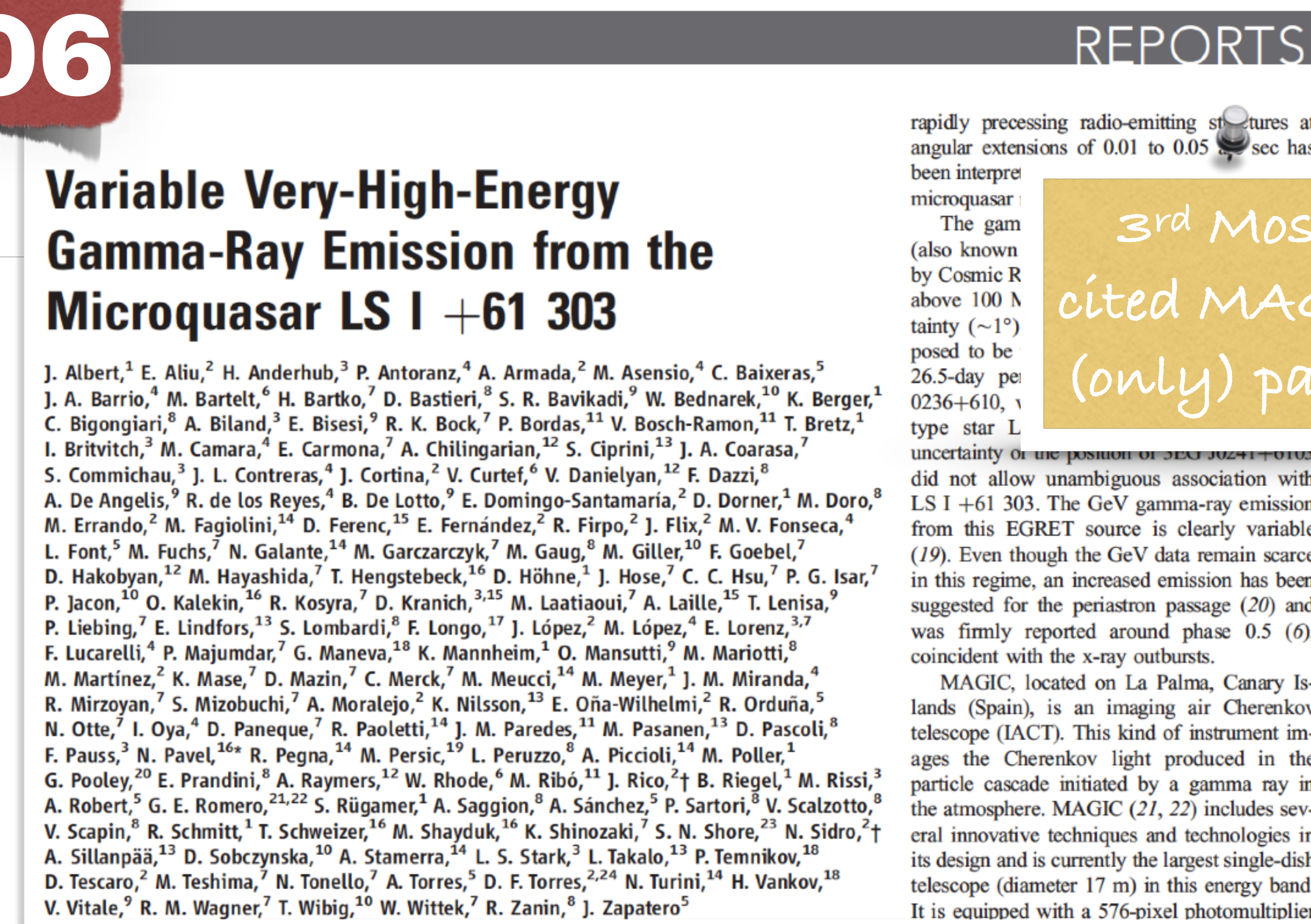
- ✓ Improvements in analysis (e.g. timing information)
- ✓ Hardware upgrades

LSI +61 303

2006



Albert et al. 2006, Sci 312, 1771



REPORTS

Variable Very-High-Energy Gamma-Ray Emission from the Microquasar LS I +61 303

J. Albert,[1] E. Aliu,[2] H. Anderhub,[3] P. Antoranz,[4] A. Armada,[2] M. Asensio,[4] C. Baixeras,[5] J. A. Barrio,[4] M. Bartelt,[6] H. Bartko,[7] D. Bastieri,[8] S. R. Bavikadi,[9] W. Bednarek,[10] K. Berger,[1] C. Bigongiari,[8] A. Biland,[3] E. Bisesi,[9] R. K. Bock,[7] P. Bordas,[11] V. Bosch-Ramon,[11] T. Bretz,[1] I. Britvitch,[3] M. Camara,[4] E. Carmona,[7] A. Chilingarian,[12] S. Ciprini,[13] J. A. Coarasa,[7] S. Commichau,[3] J. L. Contreras,[4] J. Cortina,[2] V. Curtef,[6] V. Danielyan,[12] F. Dazzi,[8] A. De Angelis,[9] R. de los Reyes,[4] B. De Lotto,[9] E. Domingo-Santamaría,[2] D. Dorner,[1] M. Doro,[8] M. Errando,[2] M. Fagiolini,[14] D. Ferenc,[15] E. Fernández,[2] R. Firpo,[2] J. Flix,[2] M. V. Fonseca,[4] L. Font,[5] M. Fuchs,[7] N. Galante,[14] M. Garczarczyk,[7] M. Gaug,[8] M. Giller,[10] F. Goebel,[7] D. Hakobyan,[12] M. Hayashida,[7] T. Hengstebeck,[16] D. Höhne,[1] J. Hose,[7] C. C. Hsu,[7] P. G. Isar,[7] P. Jacon,[10] O. Kalekin,[16] R. Kosyra,[7] D. Kranich,[3,15] M. Laatiaoui,[7] A. Laille,[15] T. Lenisa,[9] P. Liebing,[7] E. Lindfors,[13] S. Lombardi,[8] F. Longo,[17] J. López,[2] M. López,[4] E. Lorenz,[3,7] F. Lucarelli,[4] P. Majumdar,[7] G. Maneva,[18] K. Mannheim,[1] O. Mansutti,[9] M. Mariotti,[8] M. Martínez,[2] K. Mase,[7] D. Mazin,[7] C. Merck,[7] M. Meucci,[14] M. Meyer,[1] J. M. Miranda,[4] R. Mirzoyan,[7] S. Mizobuchi,[7] A. Moralejo,[2] K. Nilsson,[13] E. Oña-Wilhelmi,[2] R. Orduña,[5] N. Otte,[7] I. Oya,[4] D. Paneque,[7] R. Paoletti,[14] J. M. Paredes,[11] M. Pasanen,[13] D. Pascoli,[8] F. Pauss,[3] N. Pavel,[16*] R. Pegna,[14] M. Persic,[19] L. Peruzzo,[8] A. Piccioli,[14] M. Poller,[1] G. Pooley,[20] E. Prandini,[8] A. Raymers,[12] W. Rhode,[6] M. Ribó,[11] J. Rico,[2†] B. Riegel,[1] M. Rissi,[3] A. Robert,[5] G. E. Romero,[21,22] S. Rügamer,[1] A. Saggion,[8] A. Sánchez,[5] P. Sartori,[8] V. Scalzotto,[8] V. Scapin,[8] R. Schmitt,[1] T. Schweizer,[16] M. Shayduk,[16] K. Shinozaki,[7] S. N. Shore,[23] N. Sidro,[2†] A. Sillanpää,[13] D. Sobczynska,[10] A. Stamerra,[14] L. S. Stark,[3] L. Takalo,[13] P. Temnikov,[18] D. Tescaro,[2] M. Teshima,[7] N. Tonello,[7] A. Torres,[5] D. F. Torres,[2,24] N. Turini,[14] H. Vankov,[18] V. Vitale,[9] R. M. Wagner,[7] T. Wibig,[10] W. Wittek,[7] R. Zanin,[8] J. Zapatero[5]

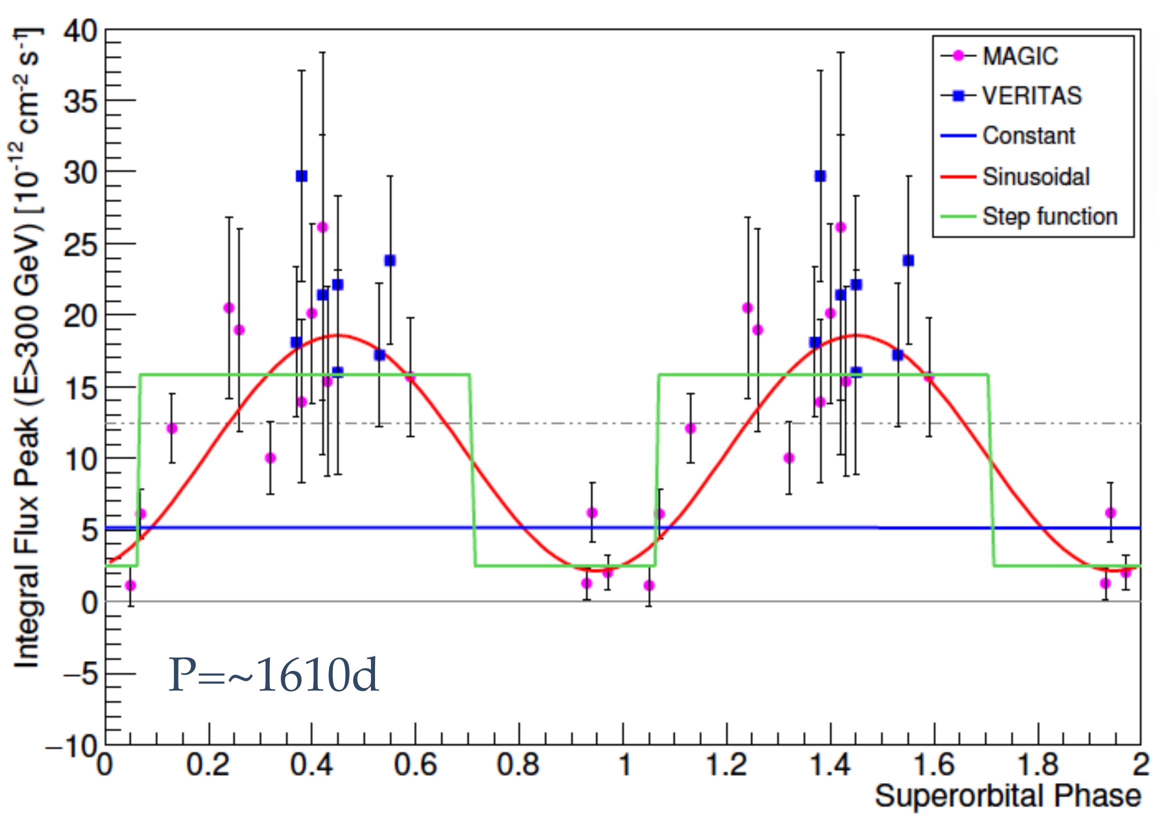
rapidly precessing radio-emitting st…tures at angular extensions of 0.01 to 0.05 …sec has been interpre… microquasar …

The gam… (also known … by Cosmic R… above 100 M… tainty (~1°) … posed to be … 26.5-day pe… 0236+610, … type star L… uncertainty of the position of 3EG J0241+6103 did not allow unambiguous association with LS I +61 303. The GeV gamma-ray emission from this EGRET source is clearly variable (*19*). Even though the GeV data remain scarce in this regime, an increased emission has been suggested for the periastron passage (*20*) and was firmly reported around phase 0.5 (*6*), coincident with the x-ray outbursts.

MAGIC, located on La Palma, Canary Islands (Spain), is an imaging air Cherenkov telescope (IACT). This kind of instrument images the Cherenkov light produced in the particle cascade initiated by a gamma ray in the atmosphere. MAGIC (*21*, *22*) includes several innovative techniques and technologies in its design and is currently the largest single-dish telescope (diameter 17 m) in this energy band. It is equipped with a 576-pixel photomultiplier

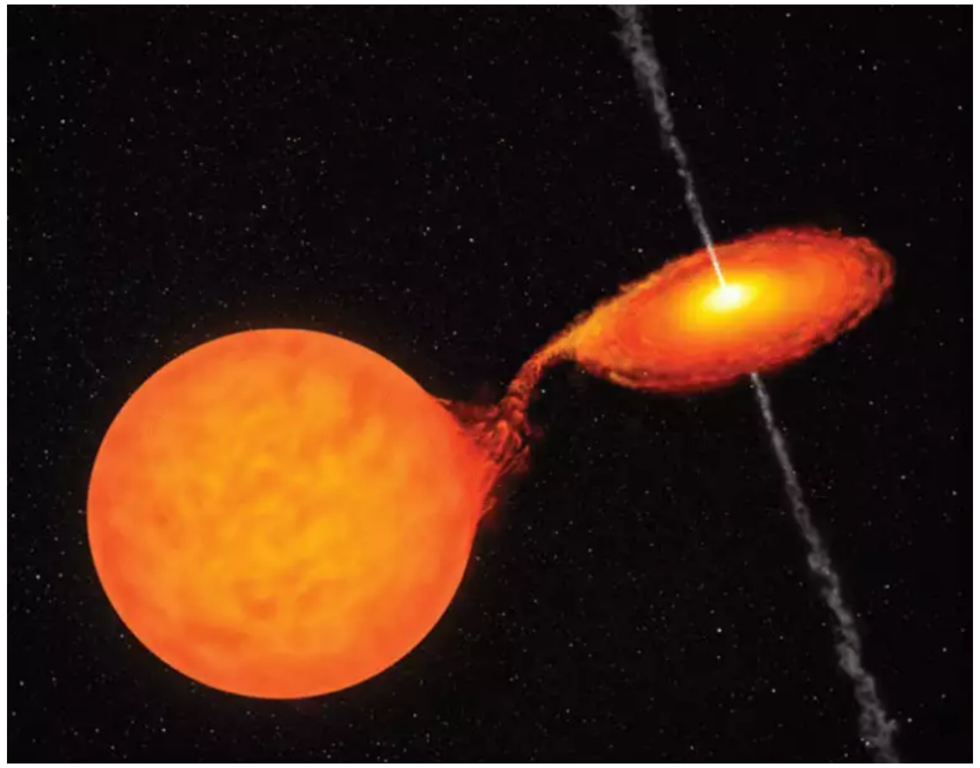
3rd Most cited MAGIC (only) paper

2016



Super-orbital variability of LS I +61 303 at TeV energies

Ahnen et al. 2016, A&A, 591, A76



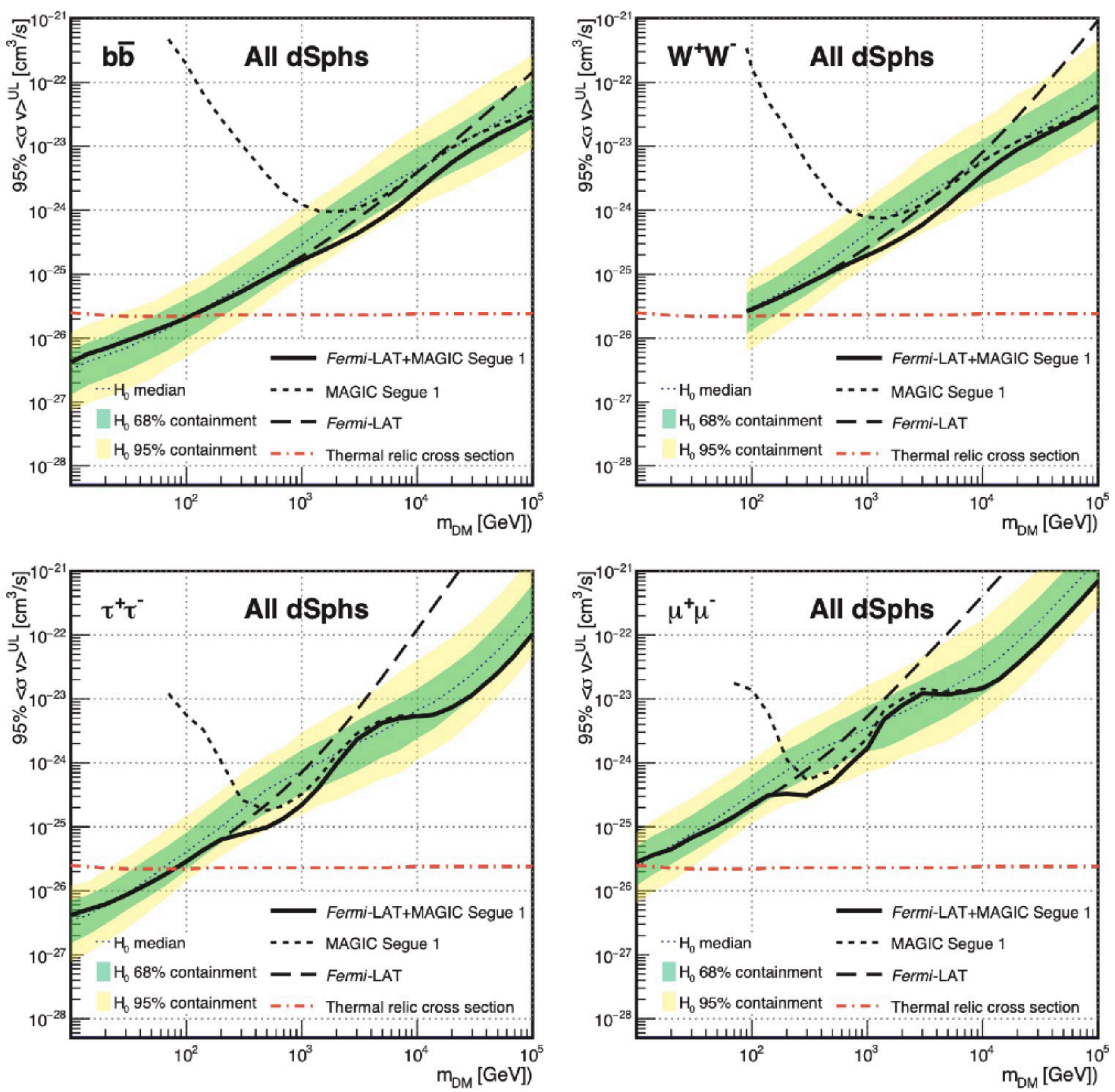
Dark matter searches and fundamental physics studies

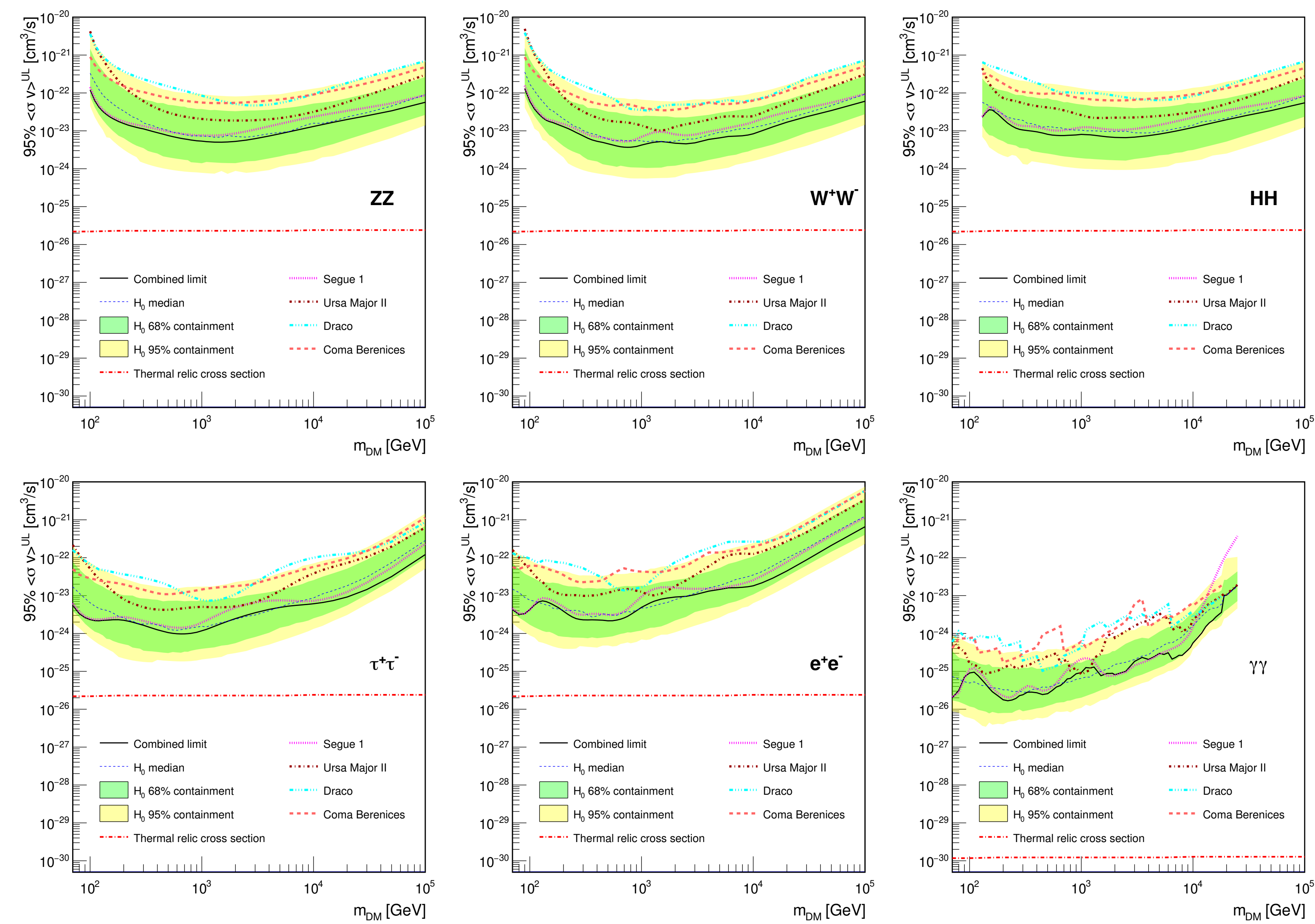
MAGIC@20

- 350 hours on four Dwarf galaxies
- Most constraining upper limits

2016-2020

MAGIC coll., 2016, ICAP, 2

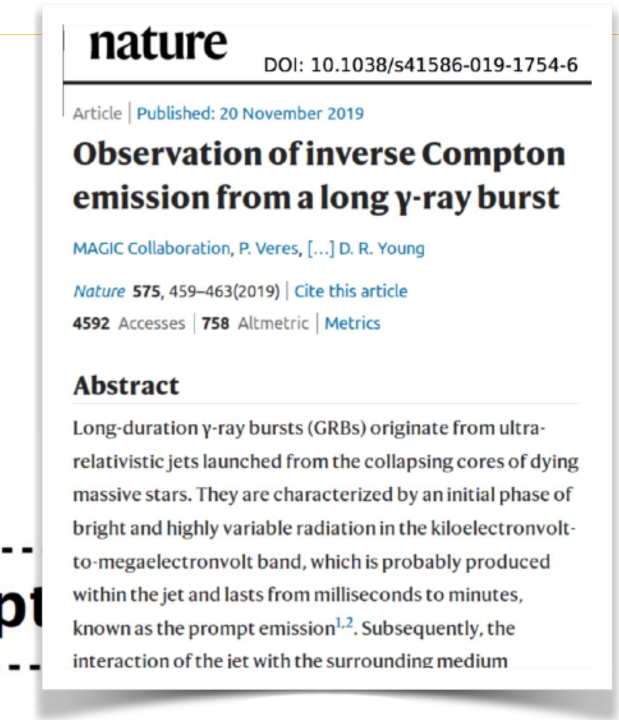




e.g. MAGIC coll., 2020, Phys.Rev. Lett., 125

GRB190114C: modeling with SSC afterglow radiation

- First modelling of broad-band and TeV emission from a GRB


nature DOI: 10.1038/s41586-019-1754-6

Article | Published: 20 November 2019

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MAGIC Collaboration, P. Veres, [...] D. R. Young

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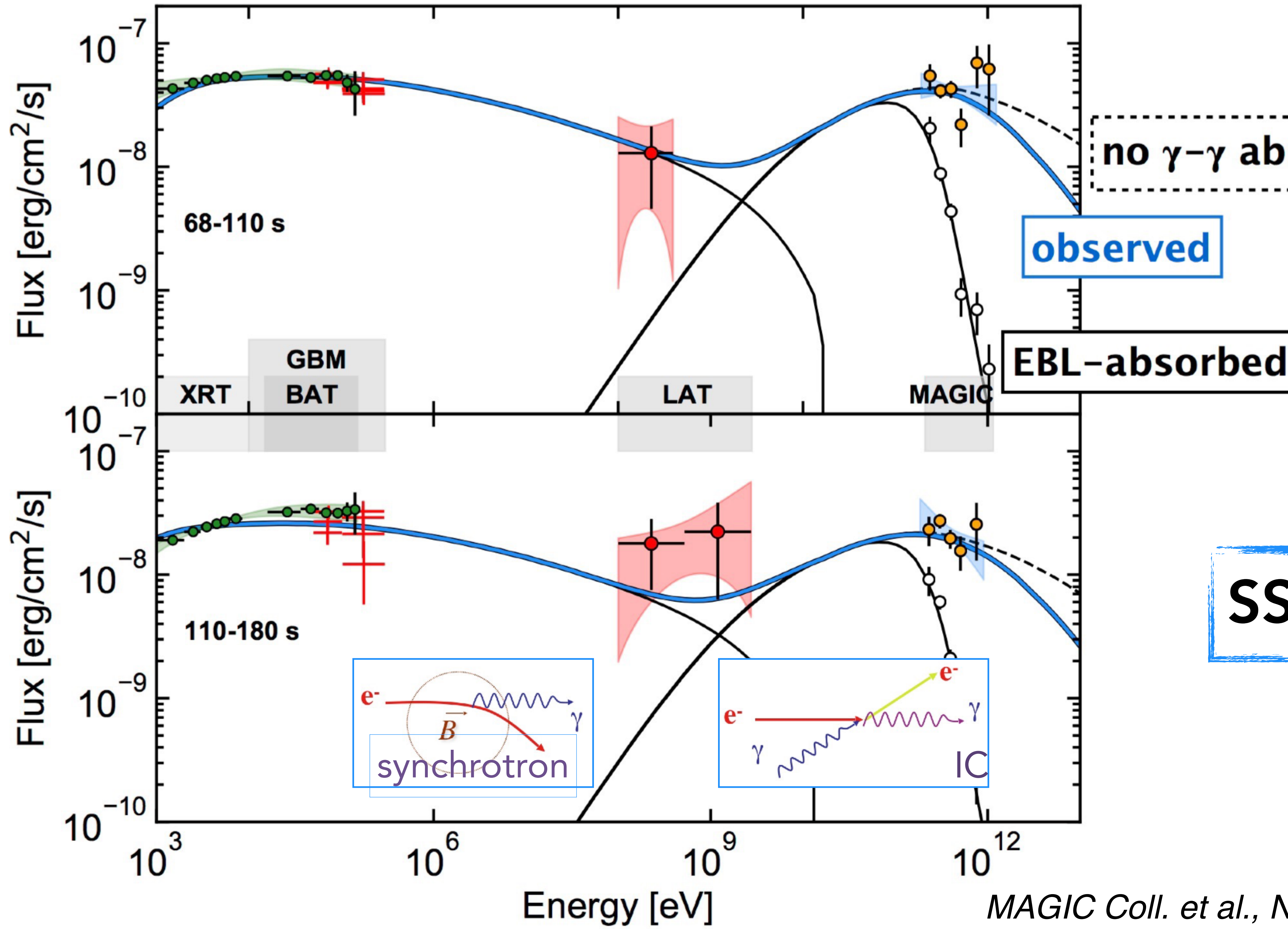
T: 68-110 s

T: 110-180 s



SSC model

2019

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

https://www.nature.com/articles/s41586-019-1754-6