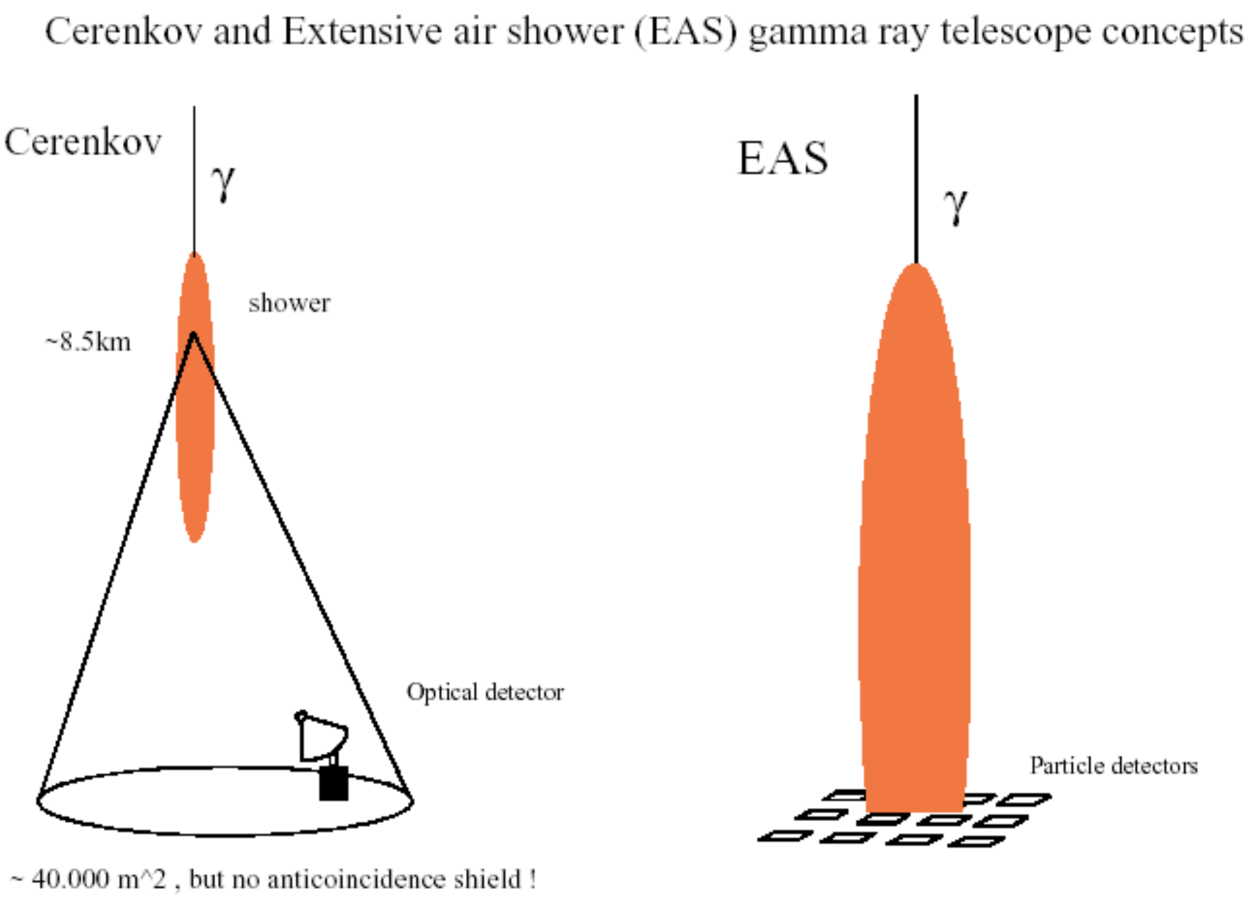
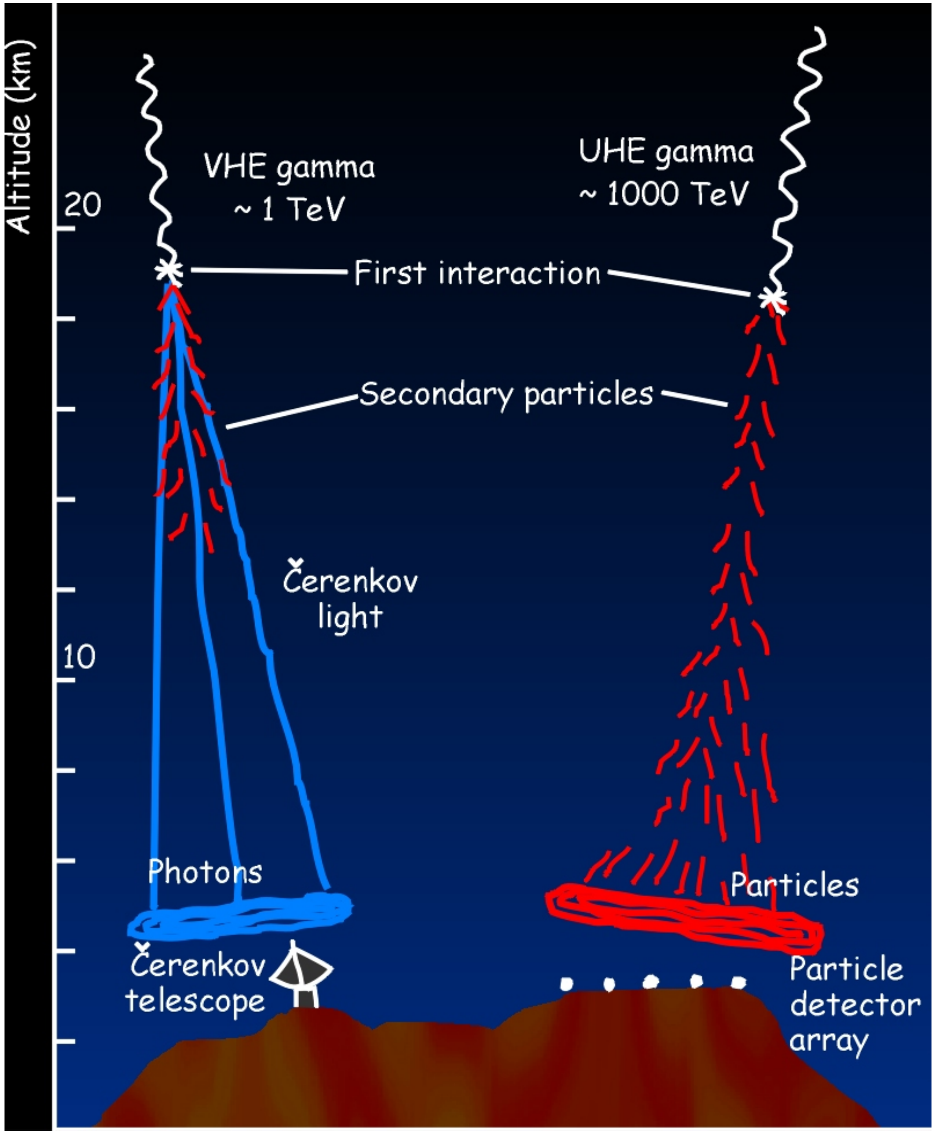
Astrofisica Nucleare e Subnucleare

TeV Astrophysics - II

TeV detectors



IACT & EAS experiments

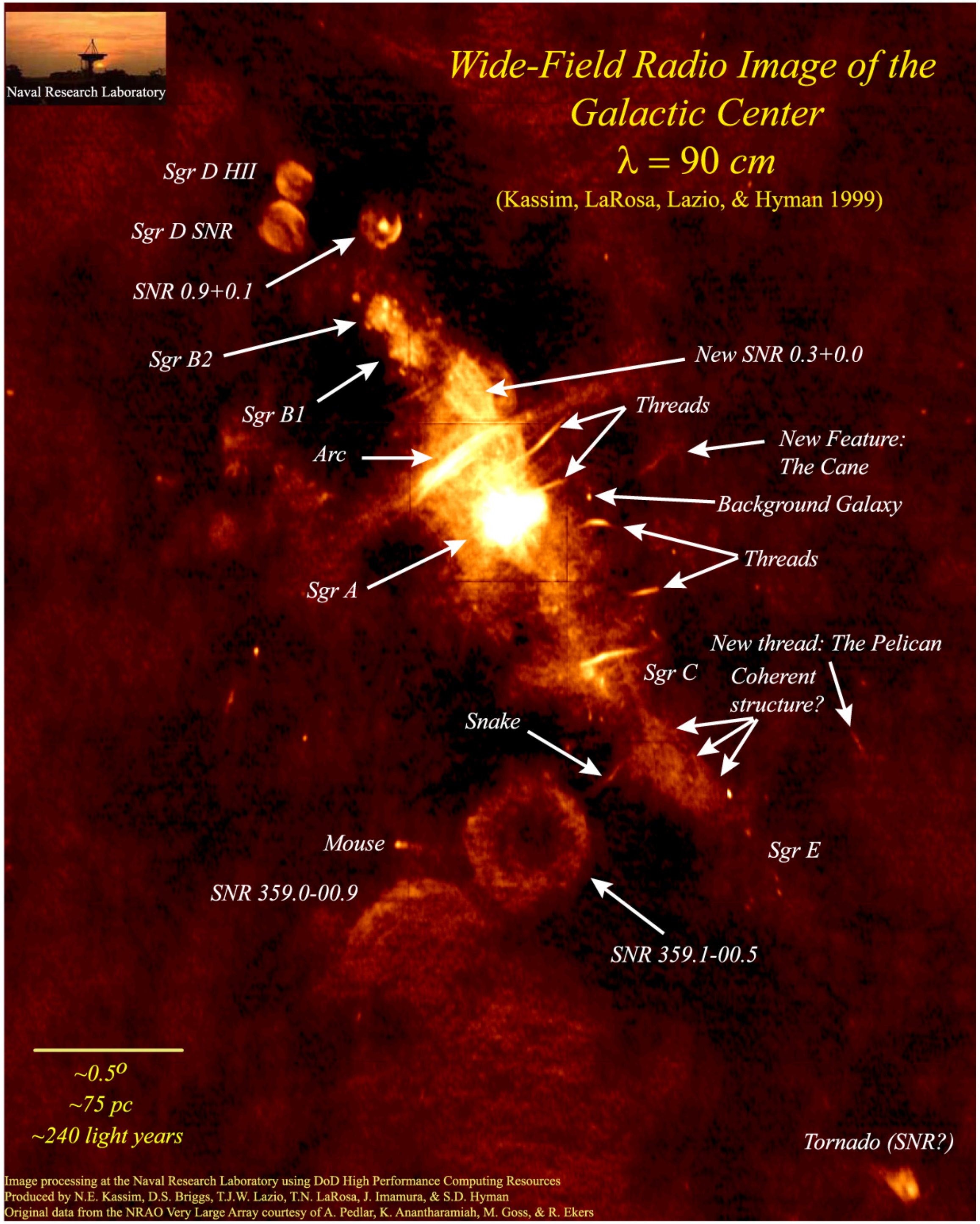


- Cherenkov experiments consist of almost-optical telescopes devoted to detect Cherenkov light.
- EAS (Extensive Air Shower) experiments are huge arrays or carpets of particle detectors.
- Cherenkov experiments have lower energy thresholds, but also a lower duty-cycle as well as a smaller field of view.

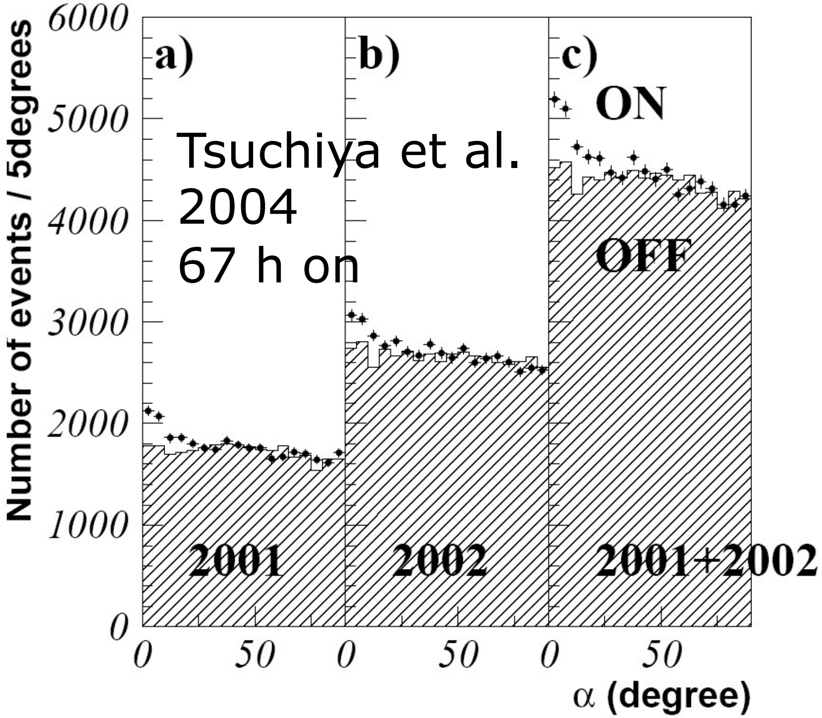
Astrofisica Nucleare e Subnucleare

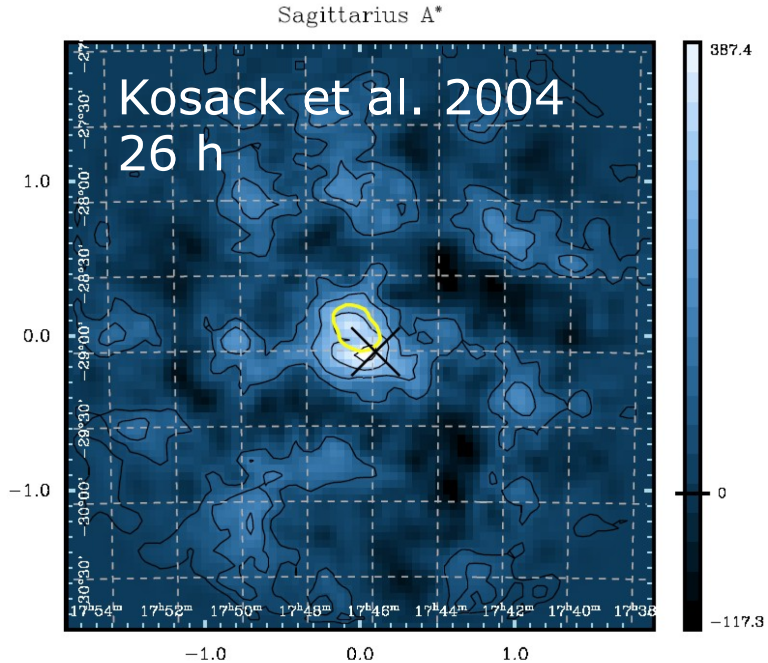
VHE Galactic Sources

The Galactic center



TeV gamma rays from GC





CANGAROO
2001/2002
> 10 σ

Whipple
1995 – 2003
3.7 σ

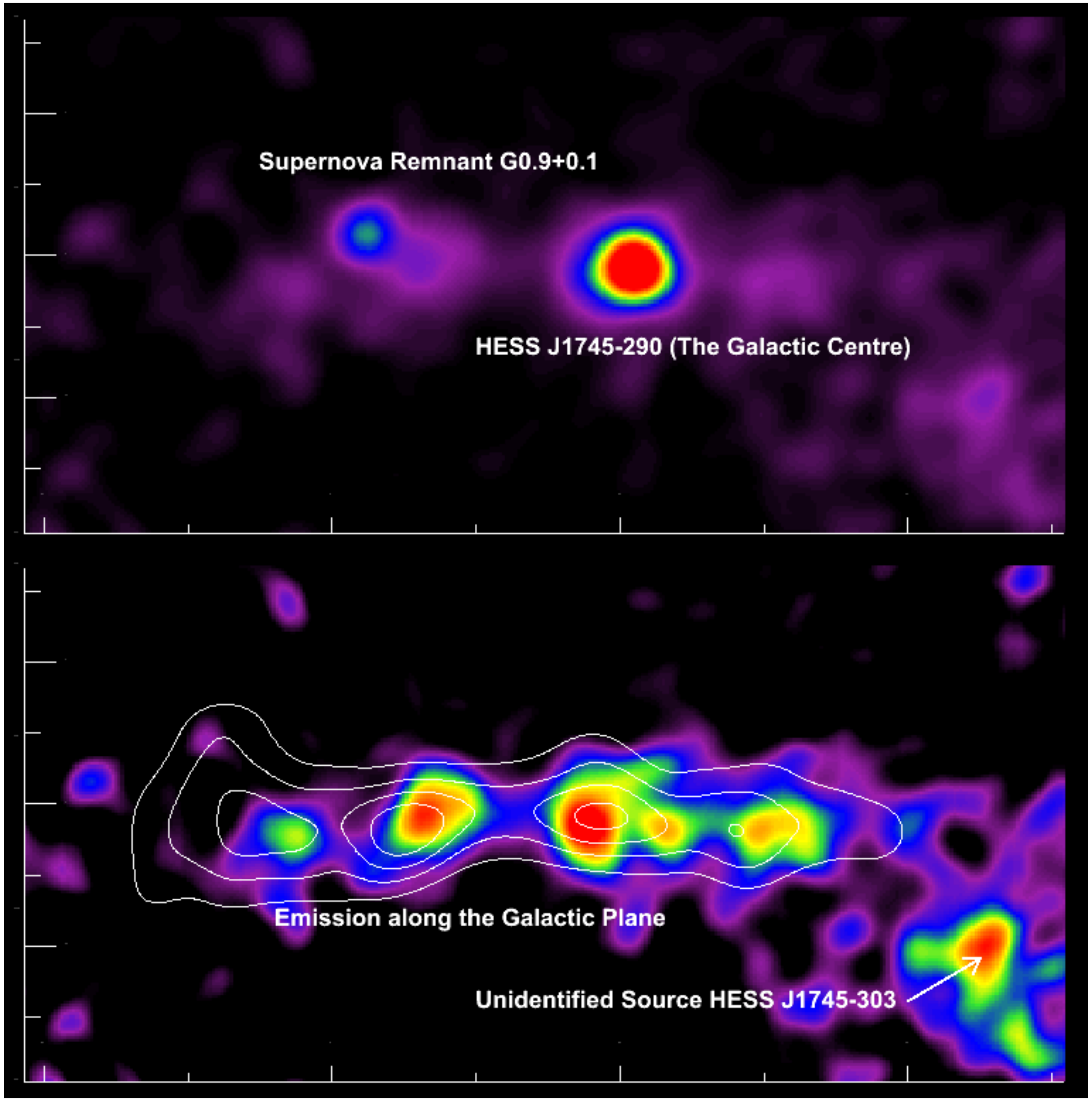
Point source (on 0.3° resolution scale)

Galactic Center

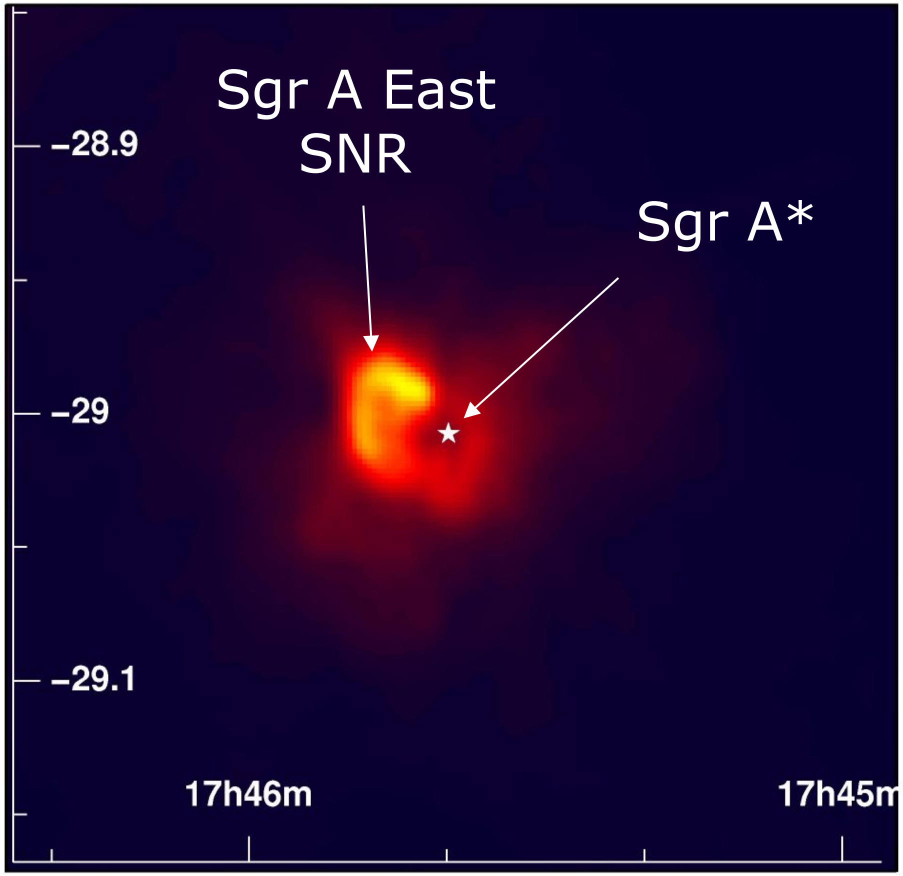
Sgr A

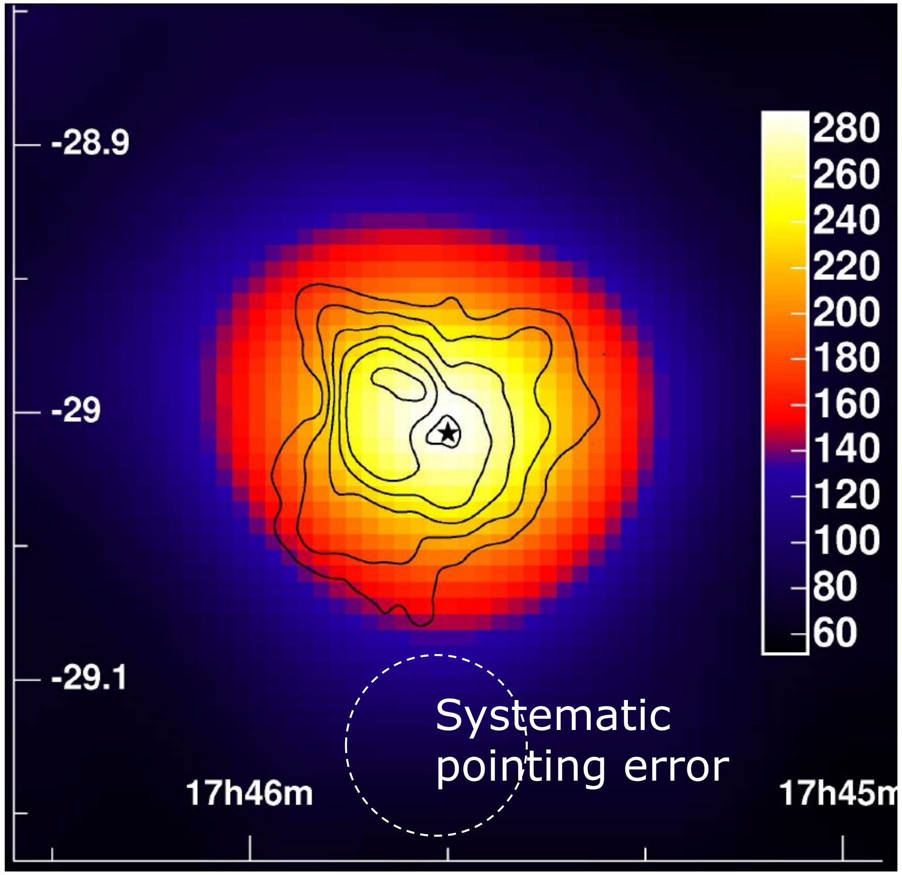
Diffuse emission

Nature, Feb. 9th 2006



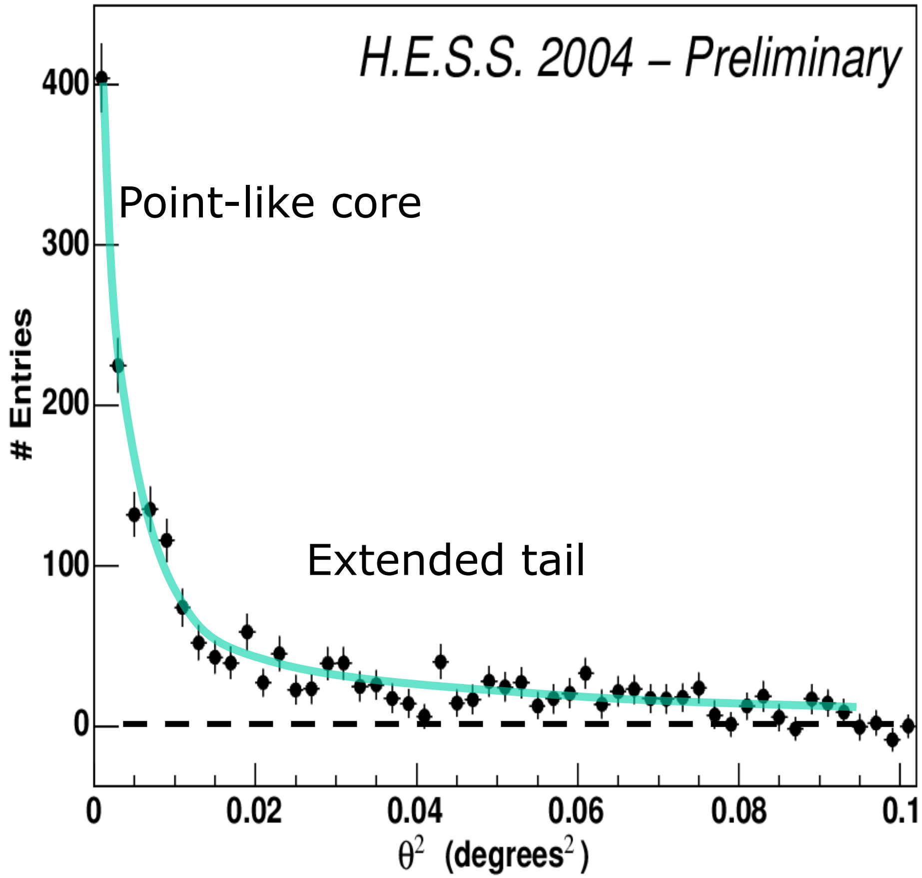
Sagittarius A

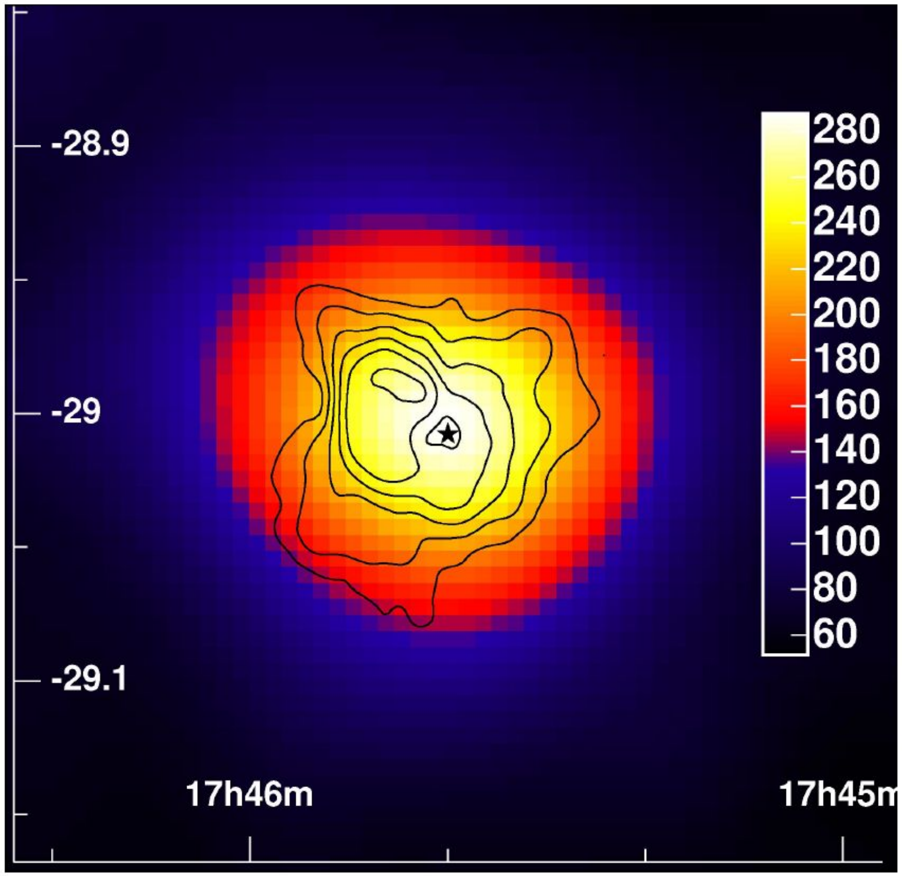




TeV H.E.S.S.

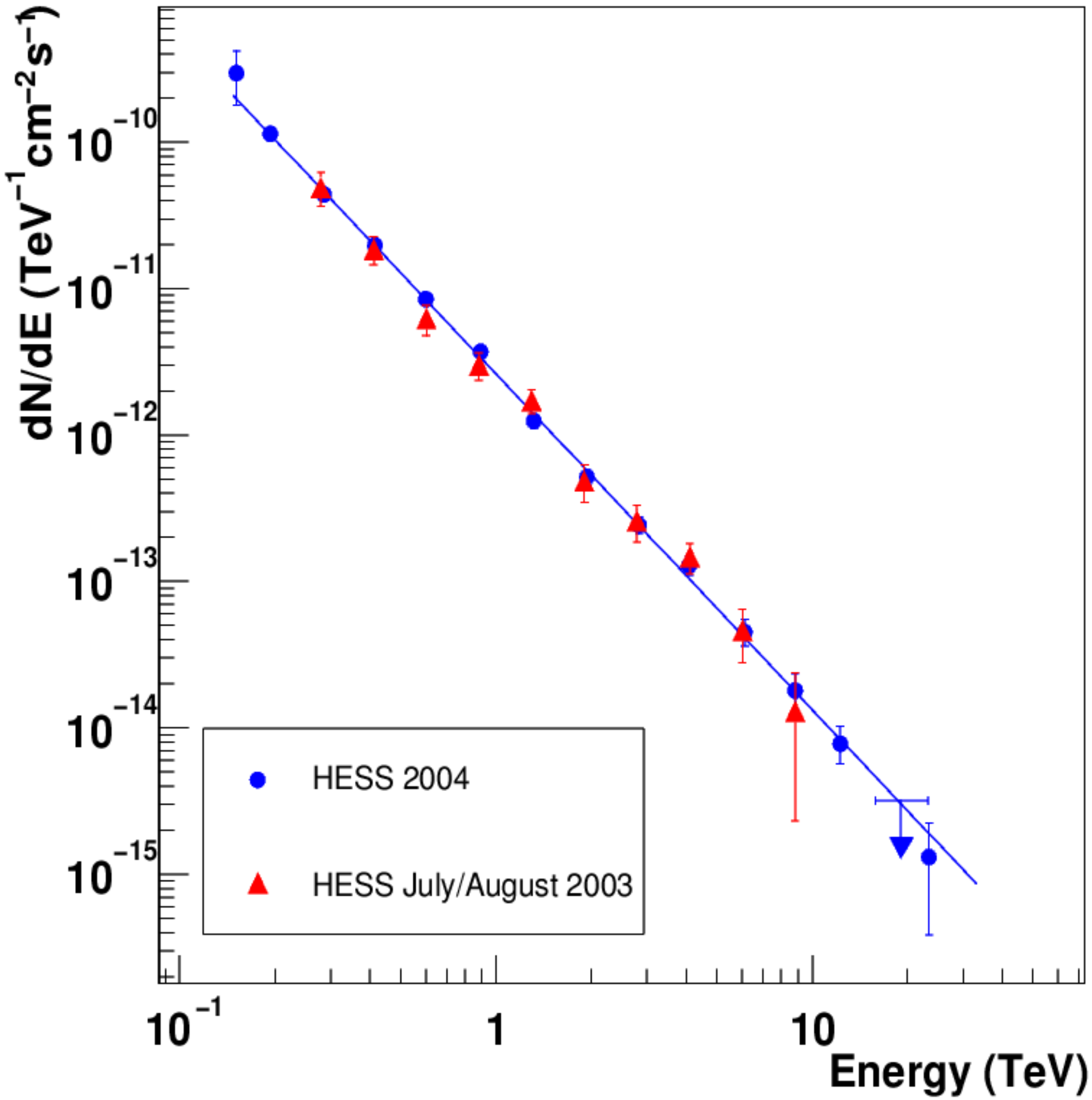
Sagittarius A





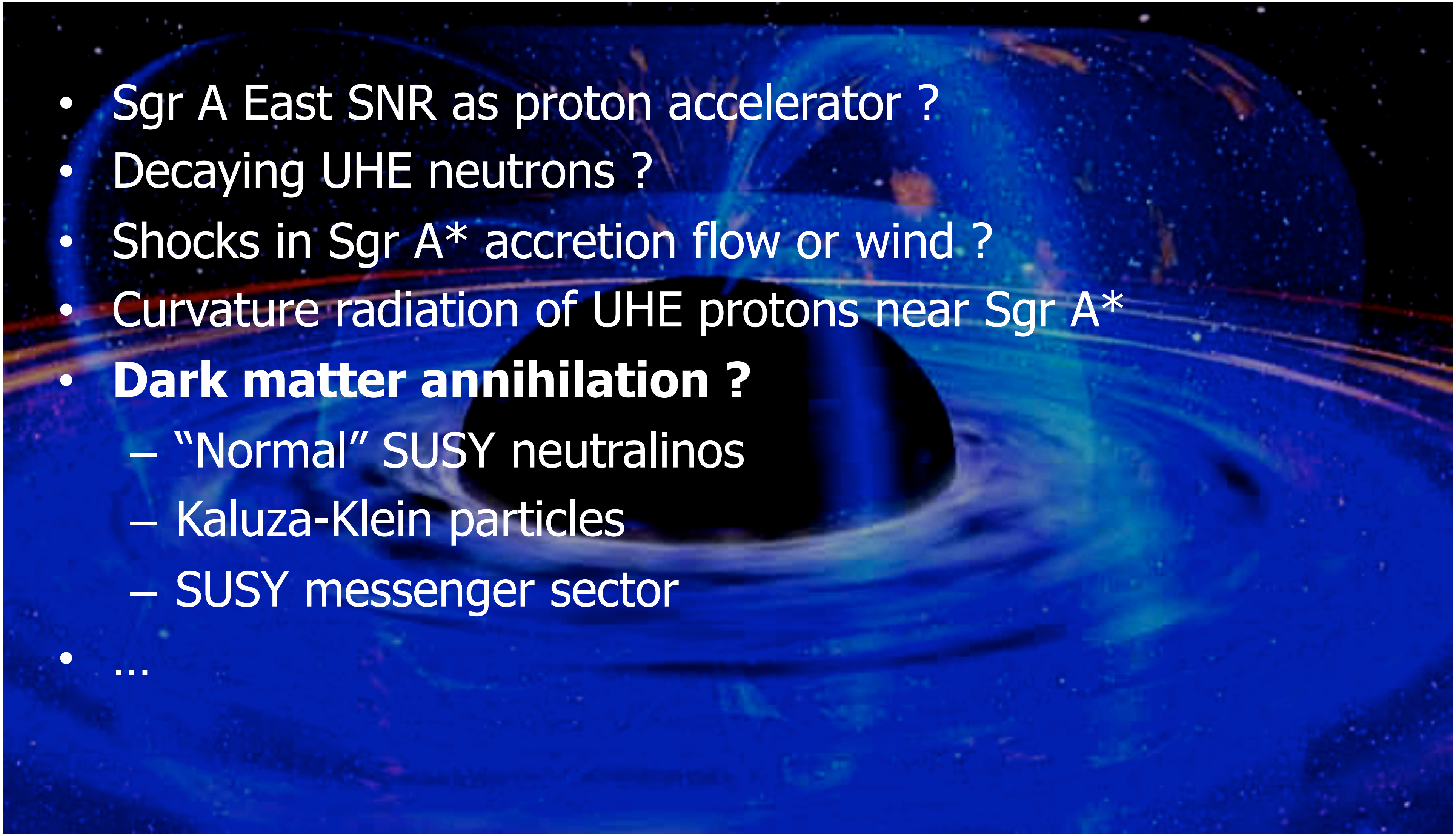
TeV H.E.S.S.

Gamma ray spectrum



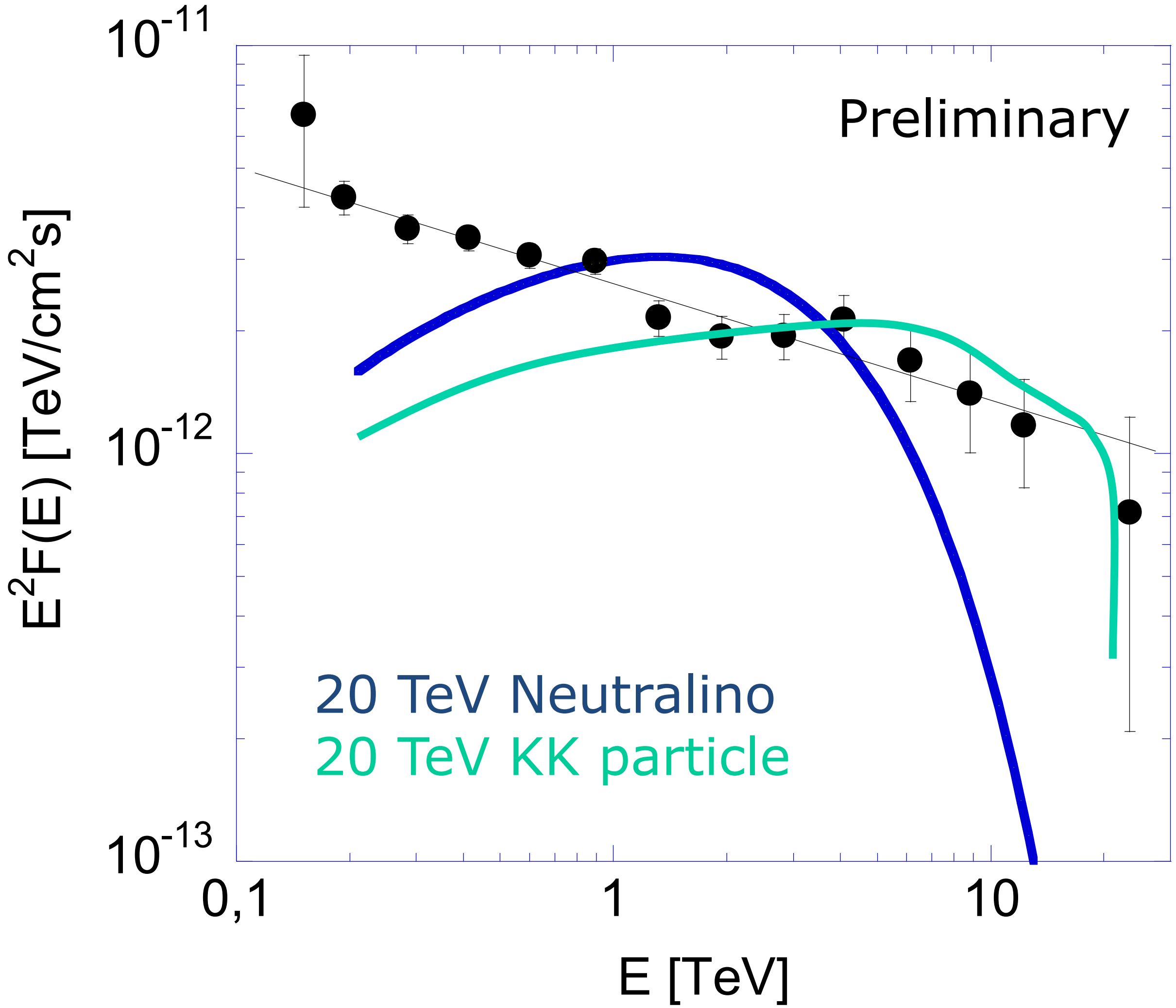
- Power law, index 2.3
- No significant variability
  - on year scale
  - on month scale
  - on day scale
  - on hour scale
  - on minute scale

Origin ?



- Sgr A East SNR as proton accelerator ?
- Decaying UHE neutrons ?
- Shocks in Sgr A* accretion flow or wind ?
- Curvature radiation of UHE protons near Sgr A*
- **Dark matter annihilation ?**
  - “Normal” SUSY neutralinos
  - Kaluza-Klein particles
  - SUSY messenger sector
- …

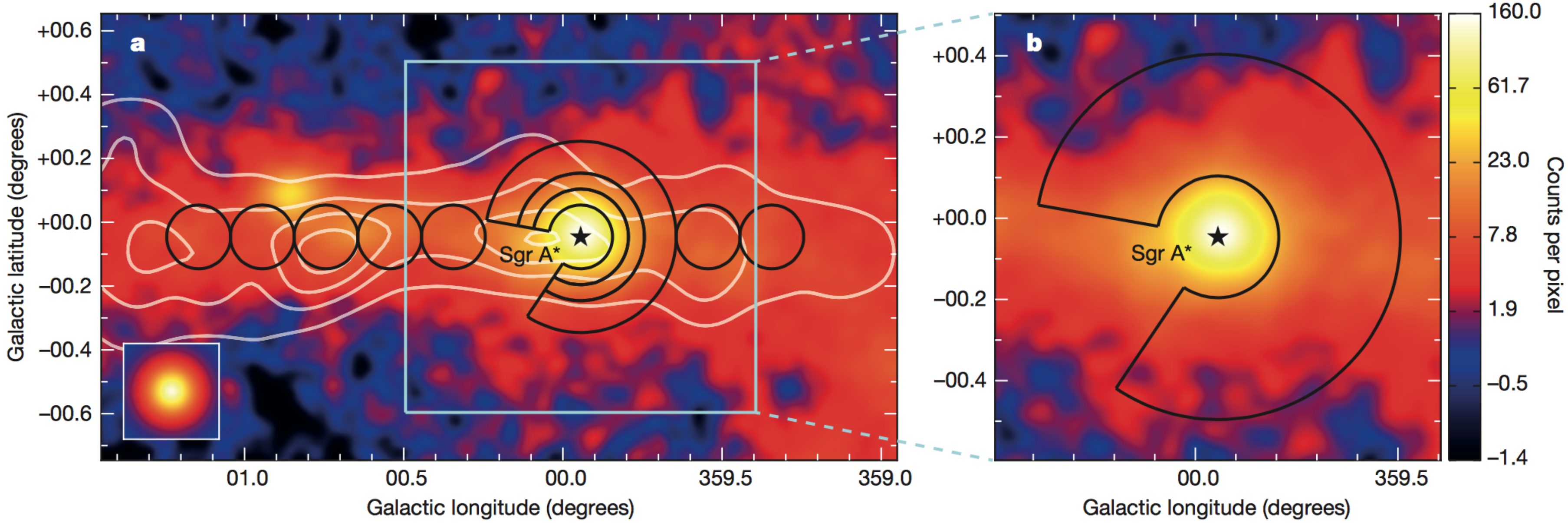
Dark matter annihilation ?



For pure DM origin

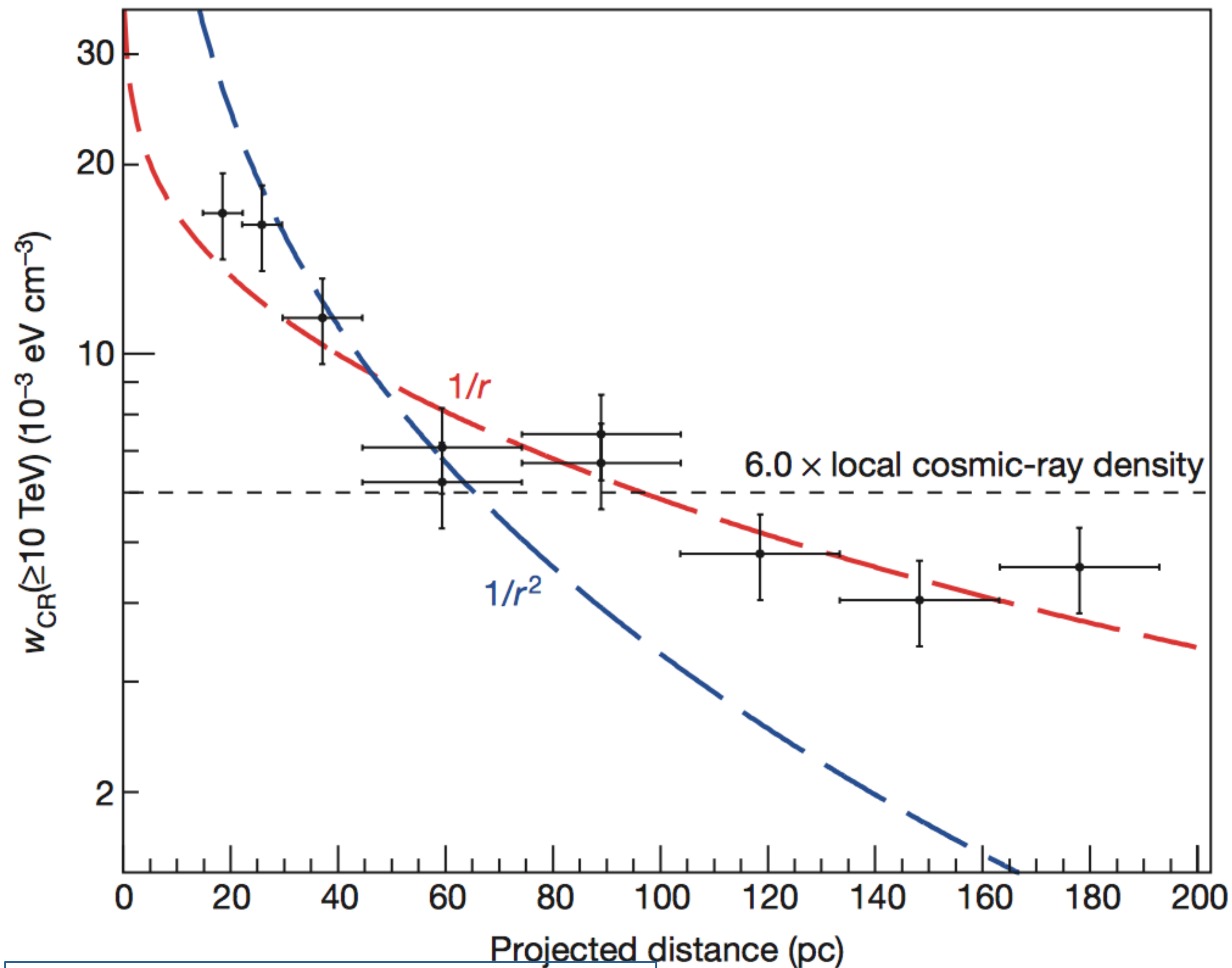
- rather large mass
- large x-section or density
- unusual spectrum or superposition of spectra

The "Pevatron"



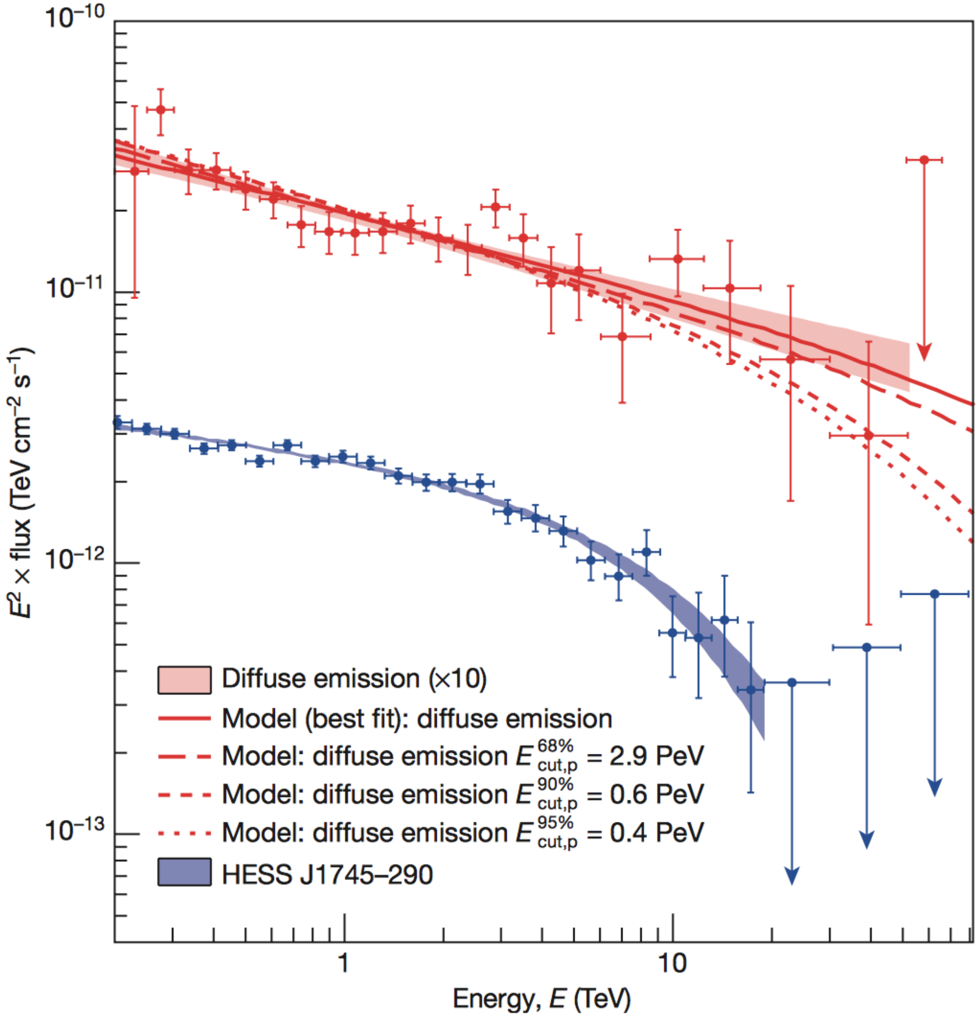
Abramovski et al. (2016)

The “Pevatron”



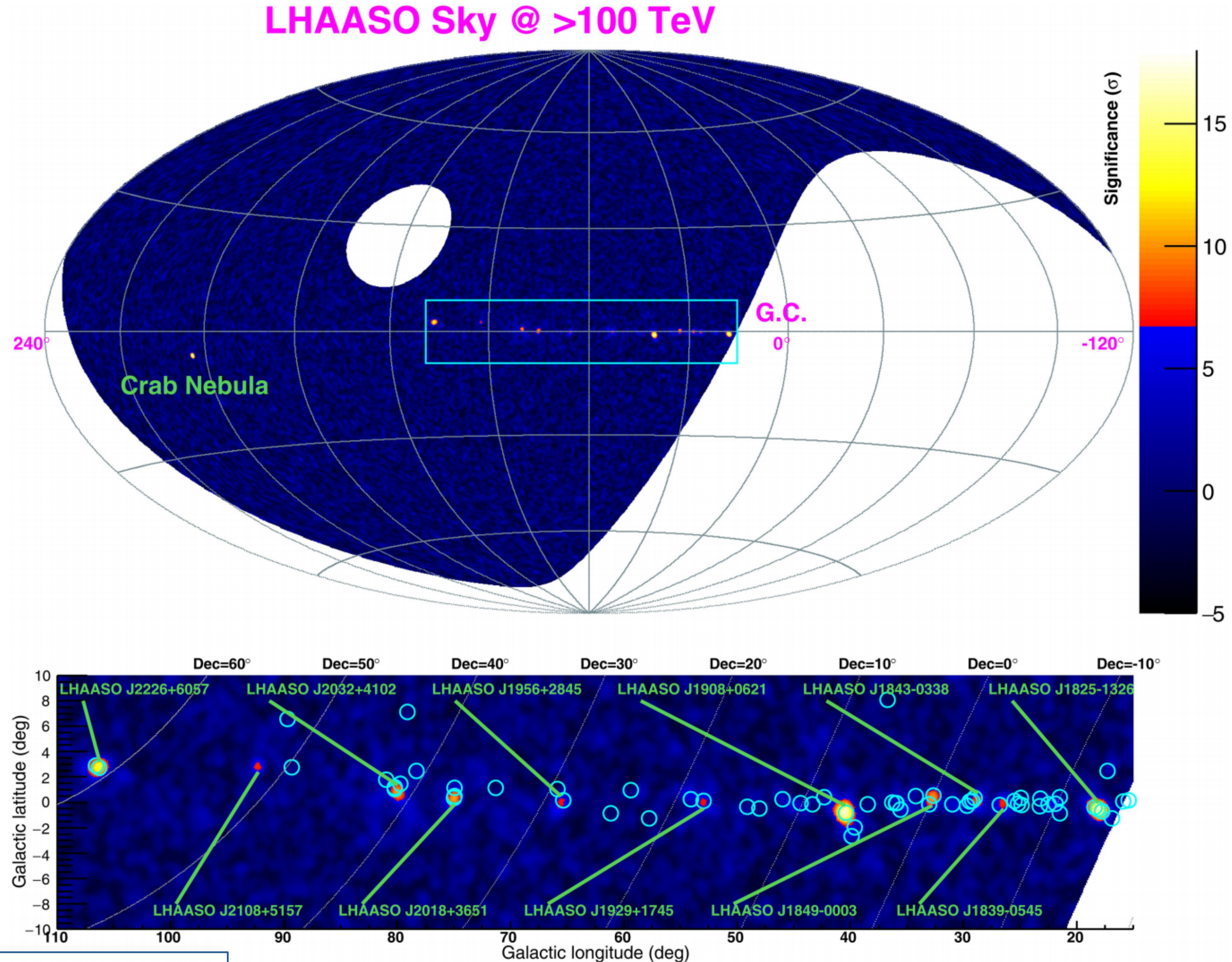
Abramovski et al. (2016)

The "Pevatron"



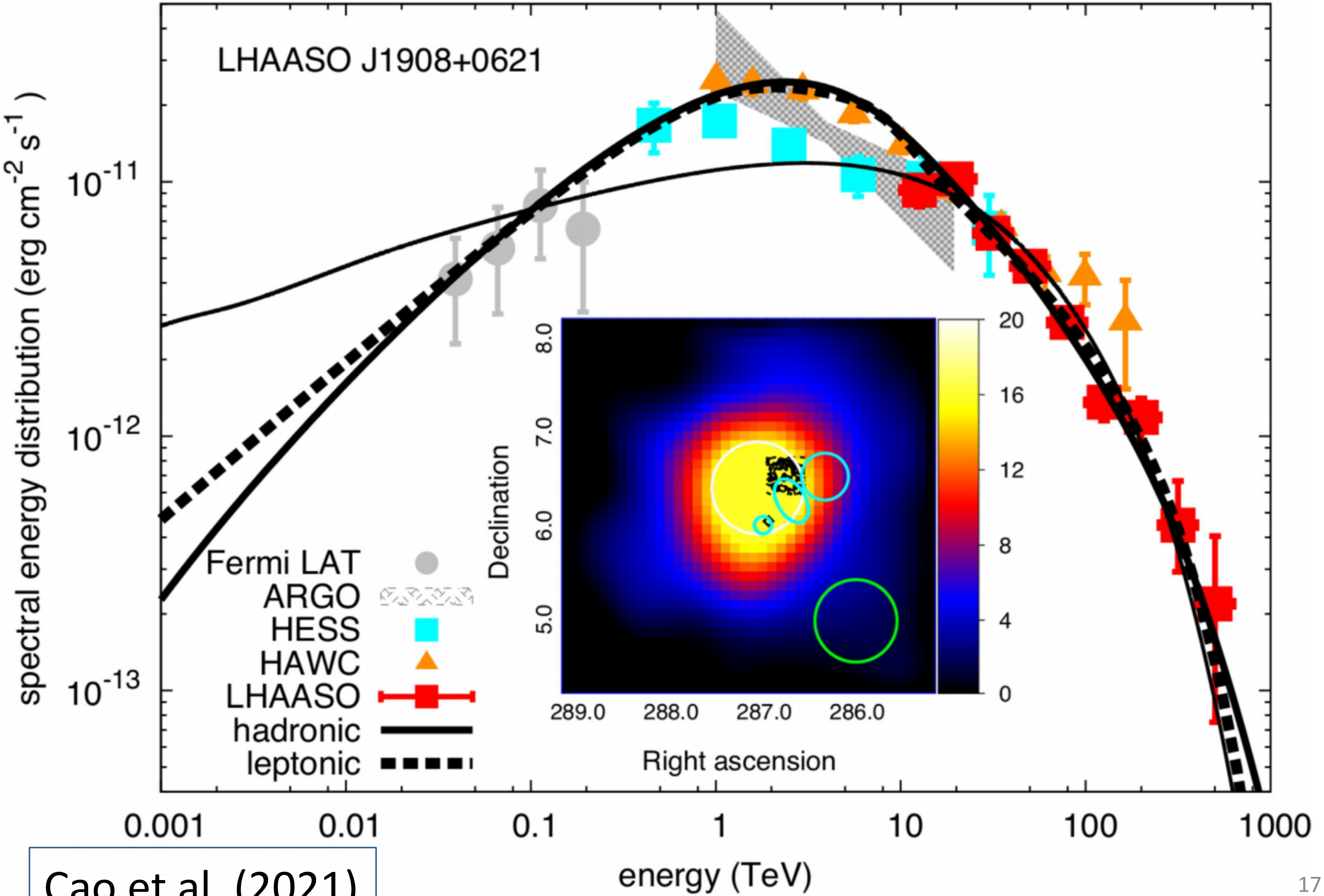
Abramovski et al. (2016)

LHAASO Pevatrons



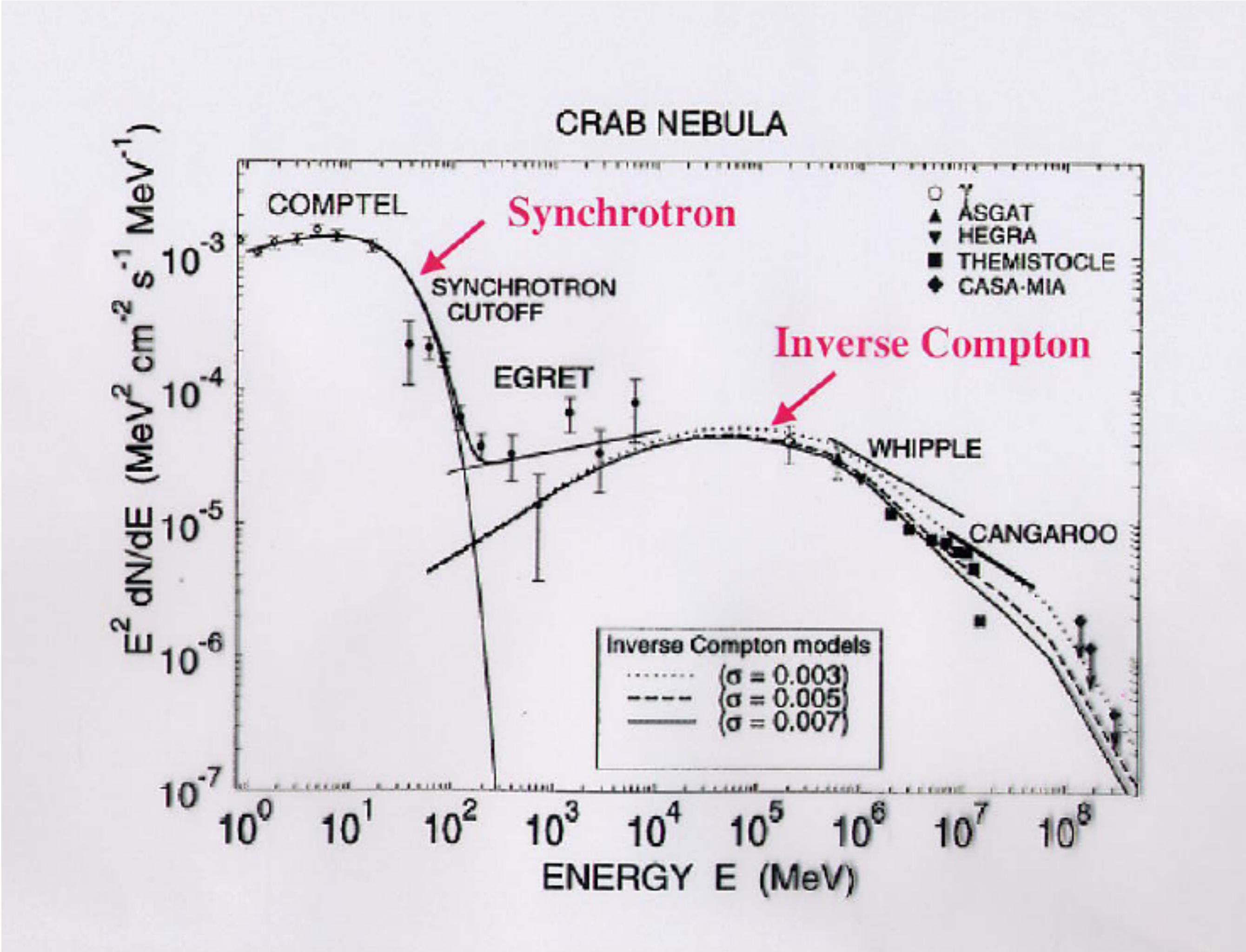
Cao et al. (2021)

LHAASO Pevatrons



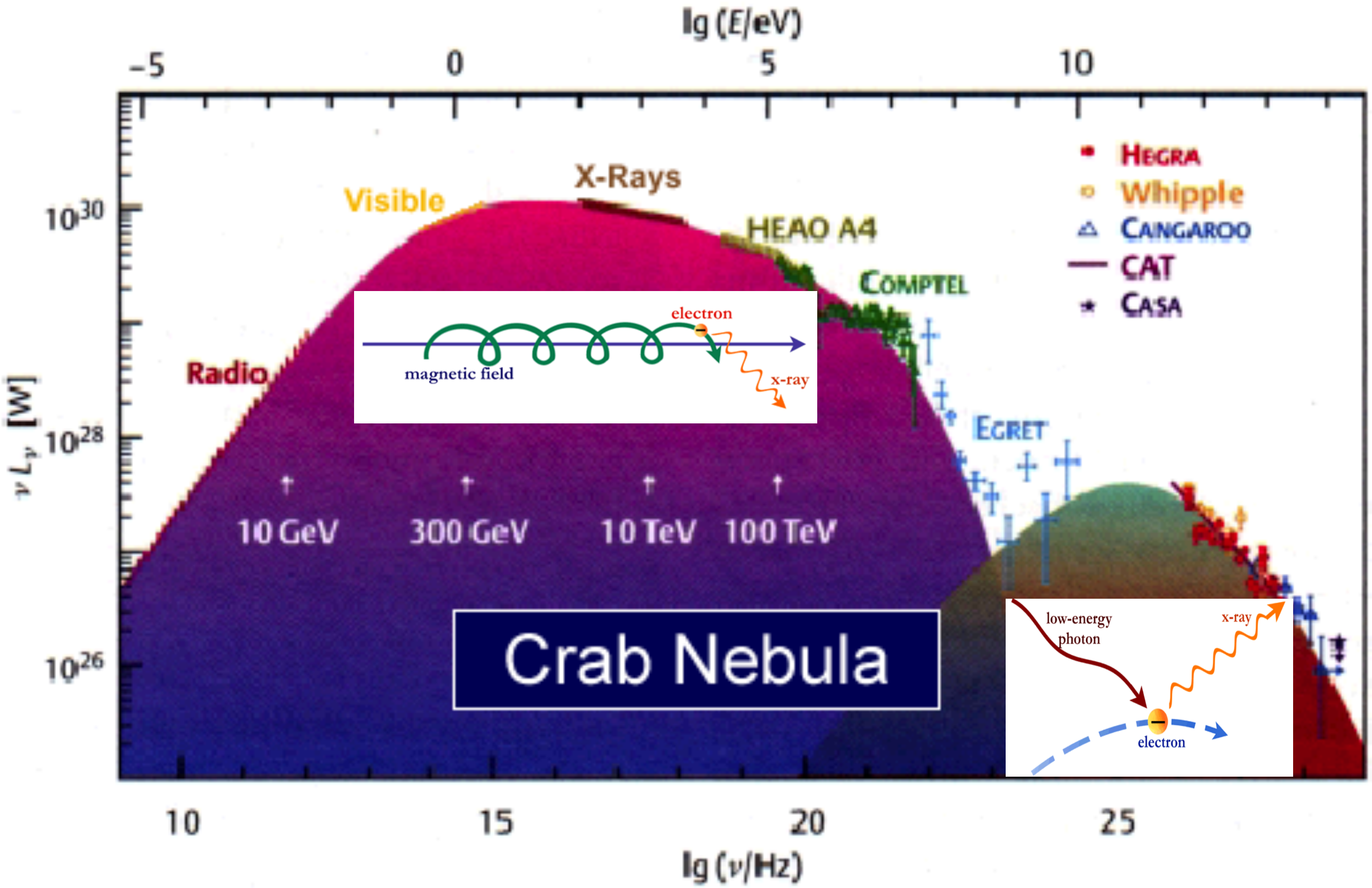
Cao et al. (2021)

Crab Nebula


CRAB NEBULA
COMPTEL
Synchrotron
SYNCHROTRON
CUTOFF
EGRET
Inverse Compton
ASGAT
HEGRA
THEMISTOCLE
CASA-MIA
WHIPPLE
CANGAROO
Inverse Compton models
(σ = 0.003)
(σ = 0.005)
(σ = 0.007)
E² dN/dE (MeV² cm⁻² s⁻¹ MeV⁻¹)
ENERGY E (MeV)

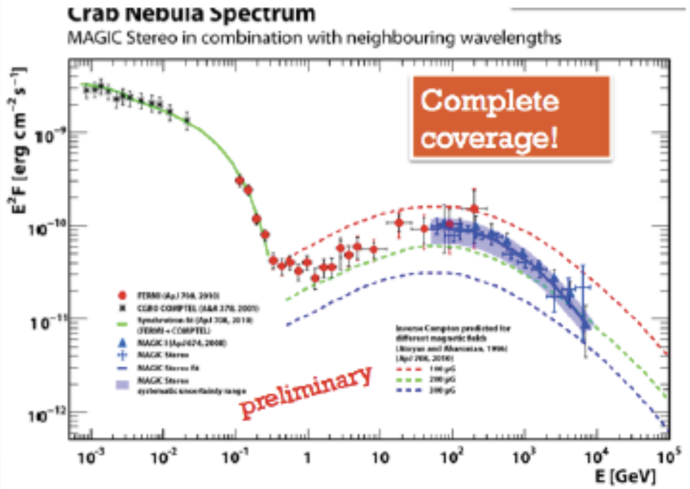
A (minimal) standard model: what do we expect?

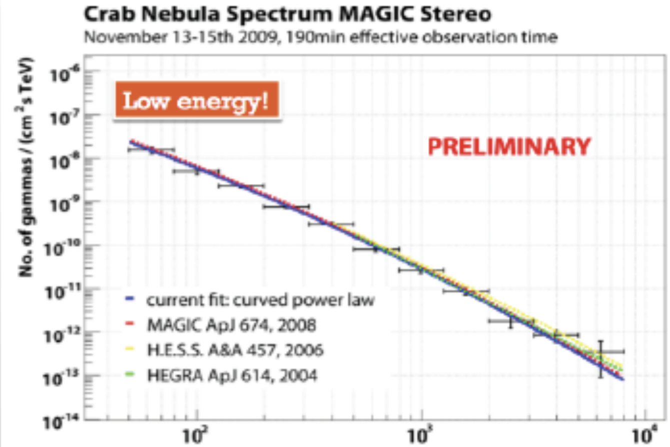
Explains most of the observations, not necessarily the most interesting…



The Crab PWN

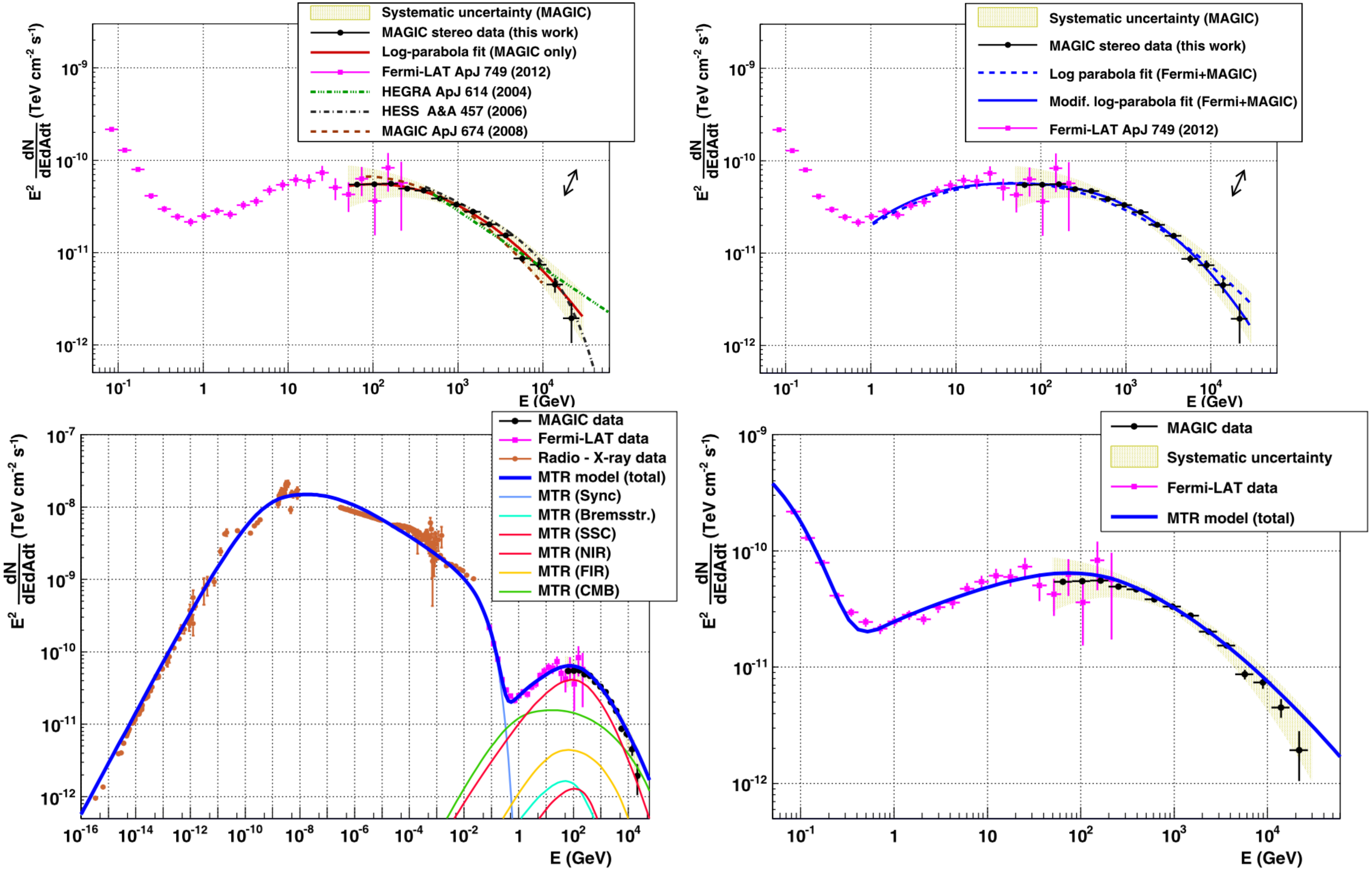
+ Crab Nebula HE-VHE coverage





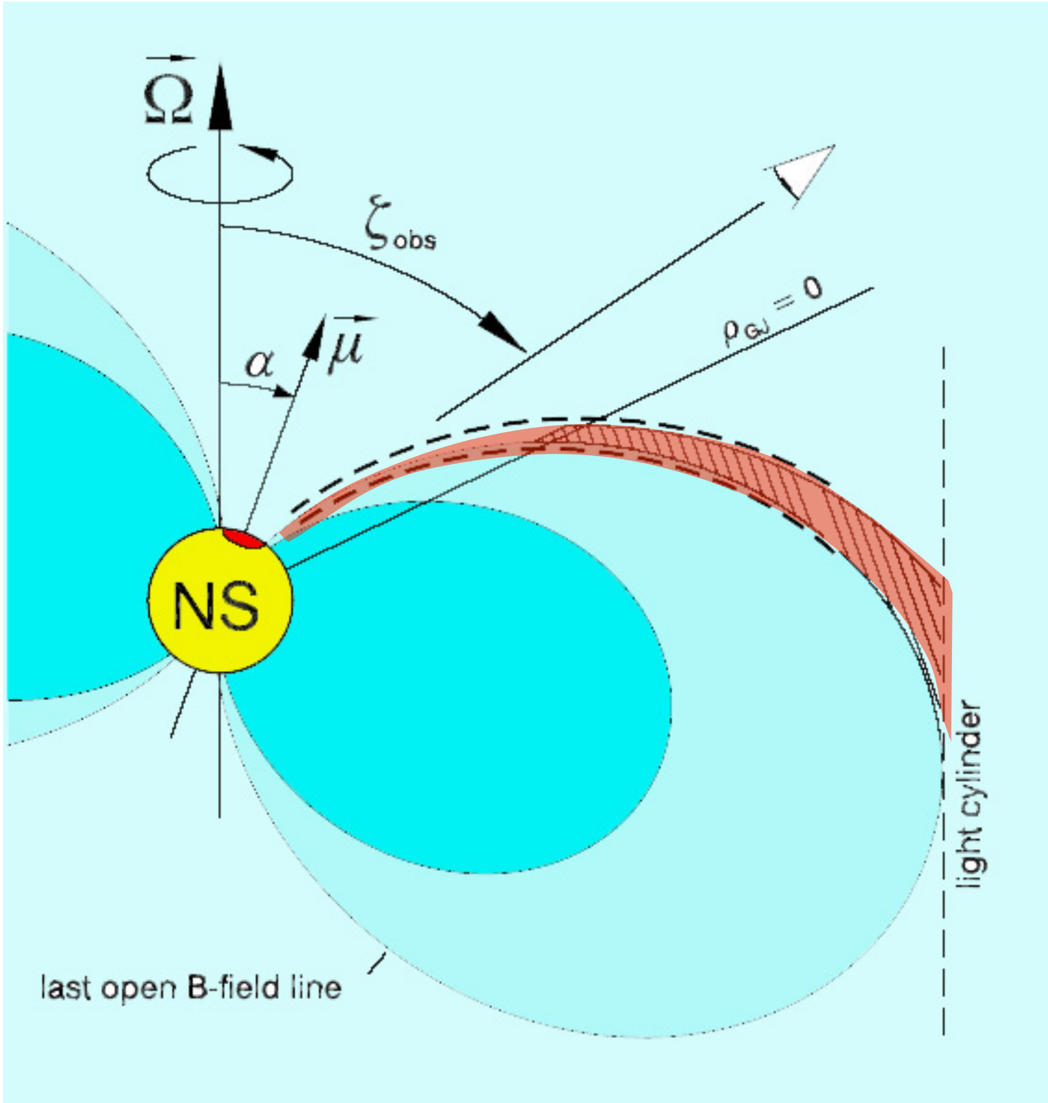
- 3.2 h of good data in Nov. 2010
- Complete overlap with Fermi
- Spectrum measured from 40-50 GeV to 30-40 TeV
- Test source for M-stereo
  - Technical Crab paper in prep.
  - Physics Crab paper in prep.
- Improved estimation of HE bump will be provided
- Regarding first HE flare (Agile, Fermi), MAGIC-stereo did not detect significant VHE flares (ATEL#2967, sep.2010)
- We monitor Fermi data for flares

The Crab Nebula



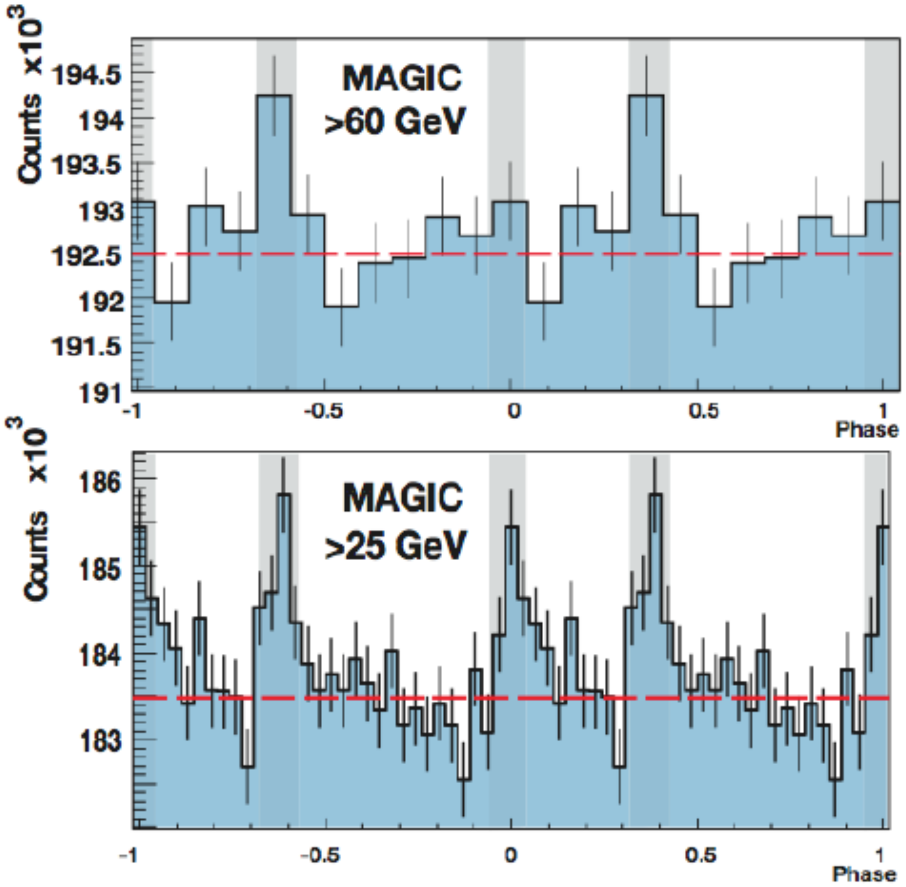
Aleksic et al. (2015)

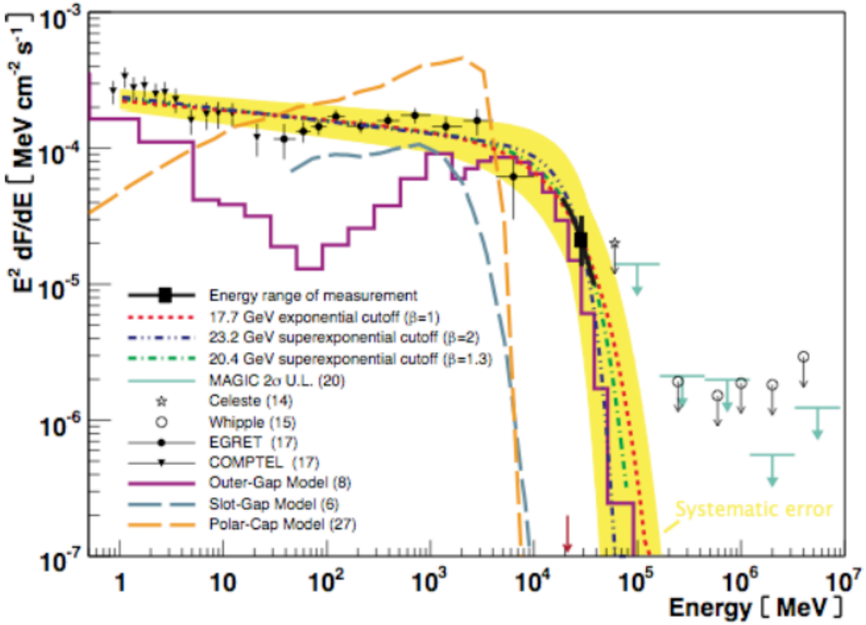
Pulsars: GR & Electrodynamics



from J. Dyks et al.

MAGIC – the Crab PSR

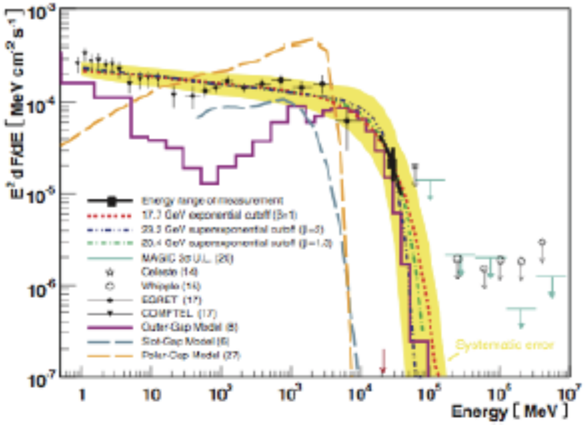


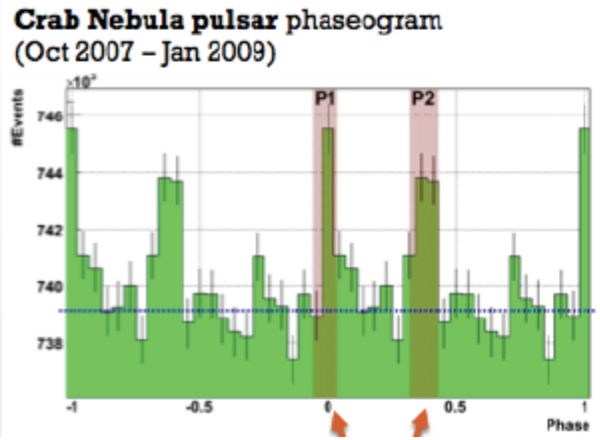


Albert et al. 2008

The Crab PSR

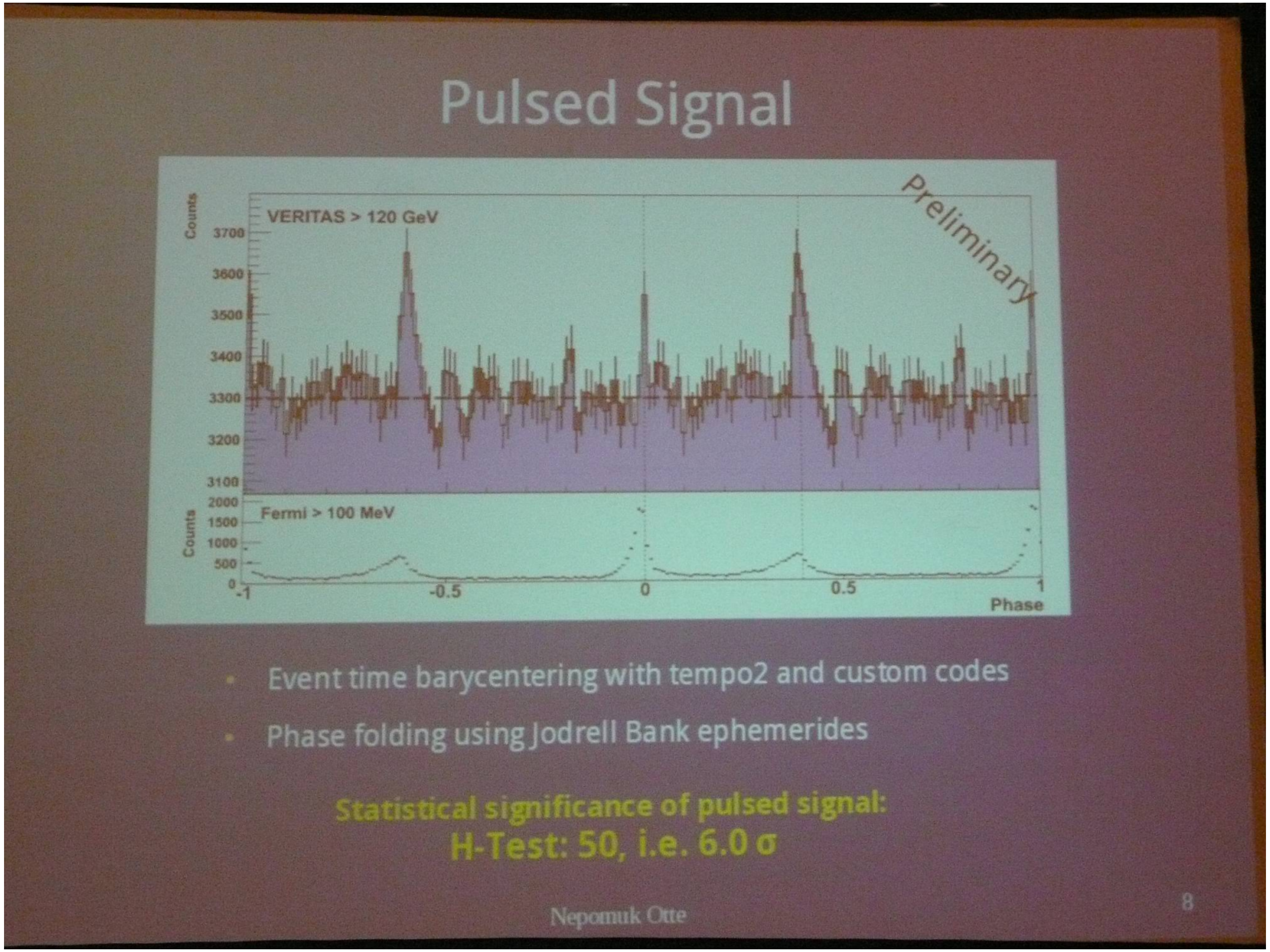
+ The Crab still beats.



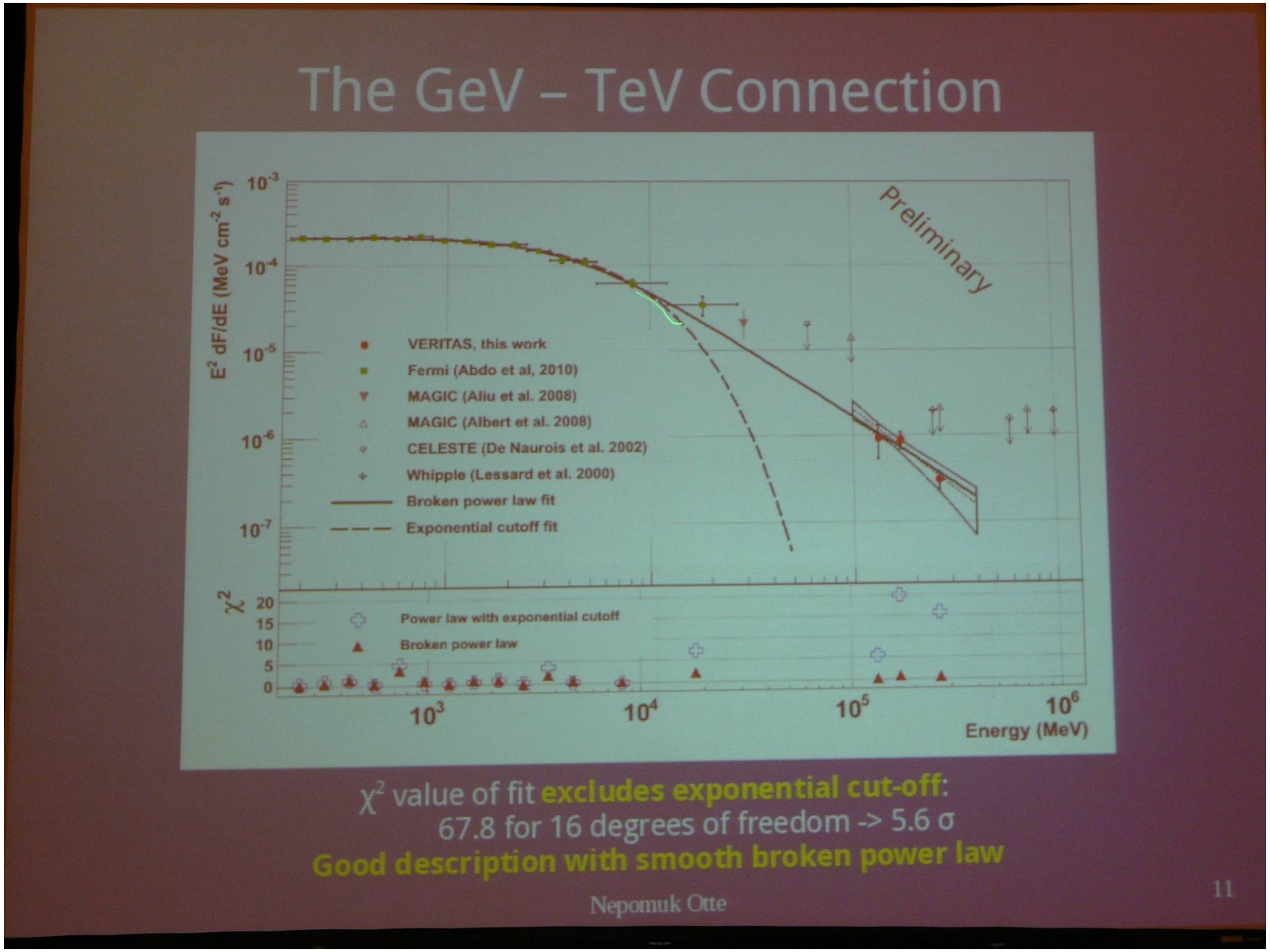


- To reach energy as low as 25 GeV special "sumtrigger" used
- In 2008, Crab pulsar detected at VHE (Science 322 (2008) 21)
- Again observed with M-stereo: publication in draft →see next ICRC
- Now used Fermi phaseogram rather than EGRET one
- Veritas showed here the detection above 100 GeV → see Ragan's talk

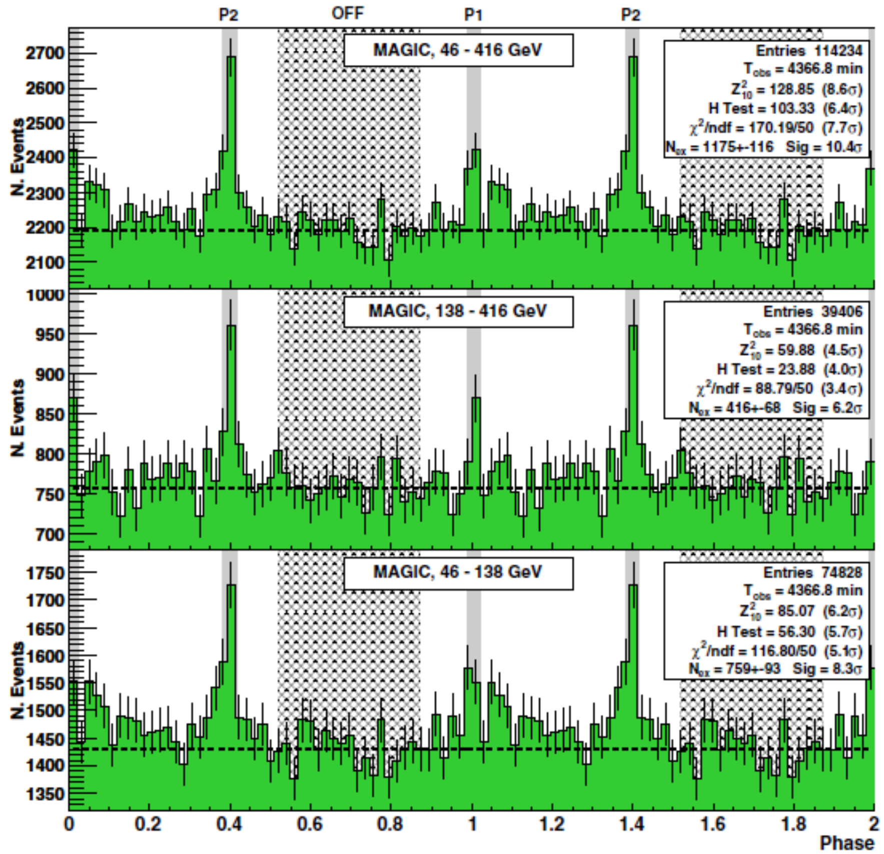
The Crab with VERITAS

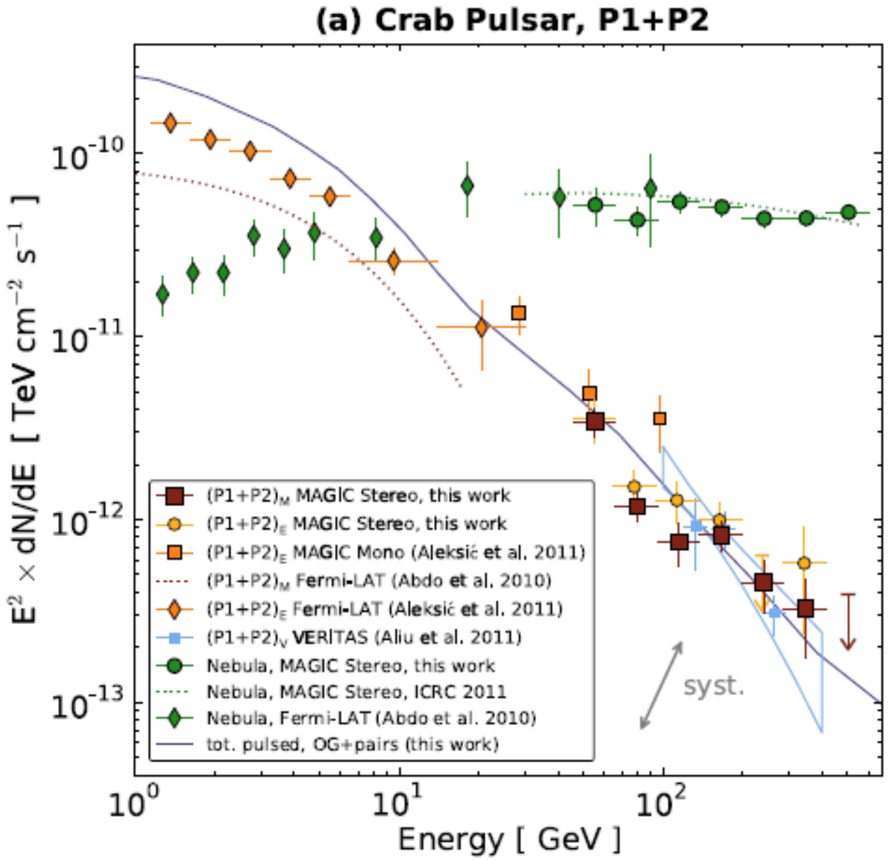


The Crab with VERITAS

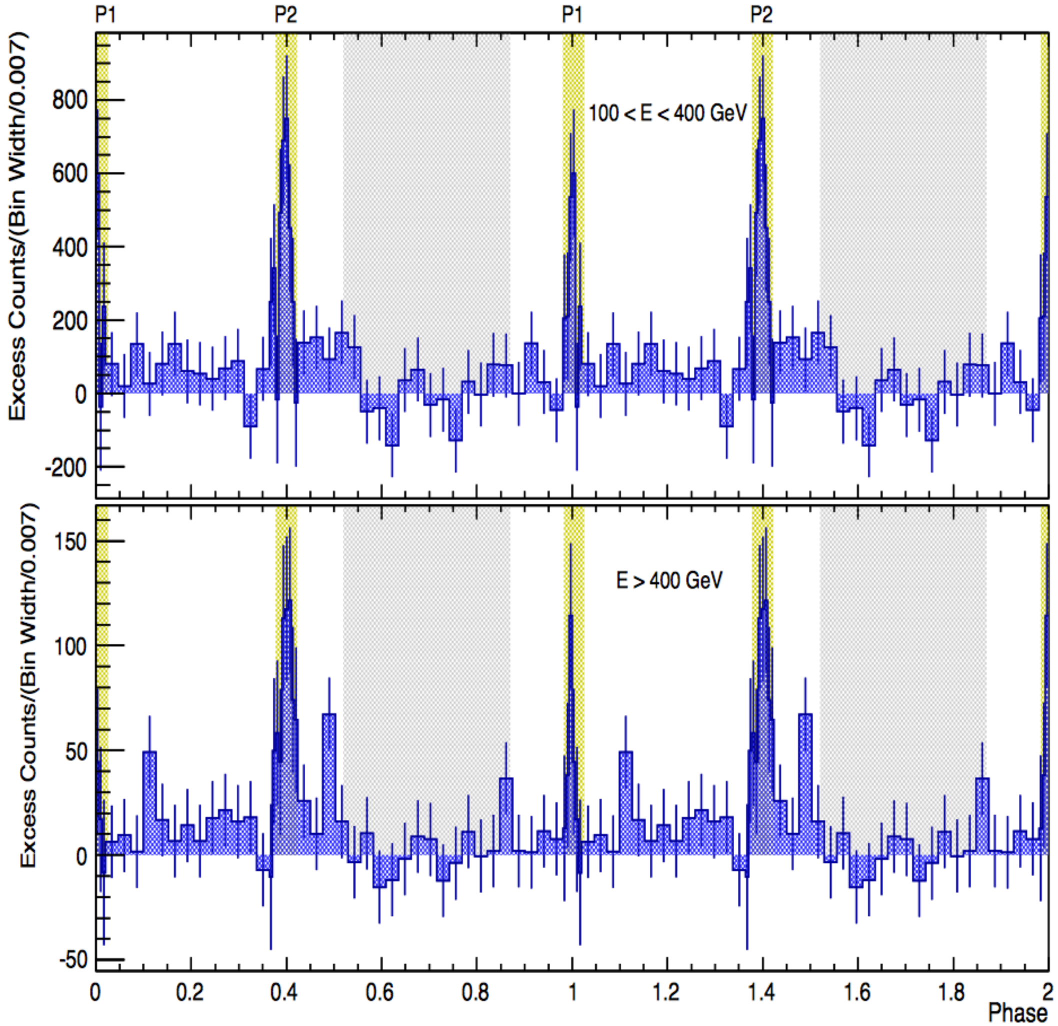


Crab PSR


P2
OFF
P1
P2
MAGIC, 46 - 416 GeV
Entries 114234
MAGIC, 138 - 416 GeV
Entries 39406
MAGIC, 46 - 138 GeV
Entries 74828
N. Events
Phase

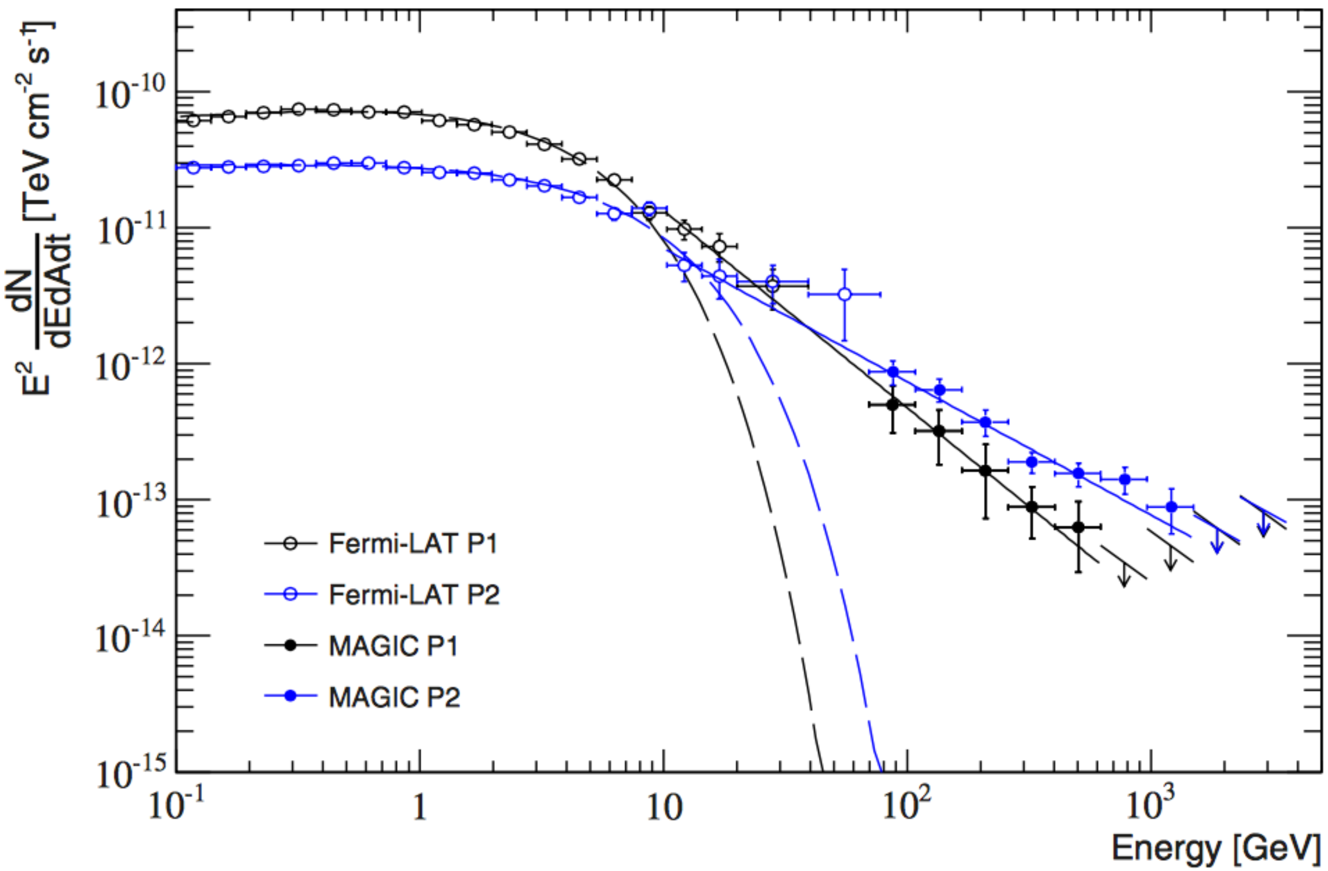

(a) Crab Pulsar, P1+P2
E² × dN/dE [TeV cm⁻² s⁻¹]
Energy [GeV]
(P1+P2)M MAGIC Stereo, this work
(P1+P2)E MAGIC Stereo, this work
(P1+P2)E MAGIC Mono (Aleksić et al. 2011)
(P1+P2)M Fermi-LAT (Abdo et al. 2010)
(P1+P2)E Fermi-LAT (Aleksić et al. 2011)
(P1+P2)V VERITAS (Aliu et al. 2011)
Nebula, MAGIC Stereo, this work
Nebula, MAGIC Stereo, ICRC 2011
Nebula, Fermi-LAT (Abdo et al. 2010)
tot. pulsed, OG+pairs (this work)
syst.

Crab PSR



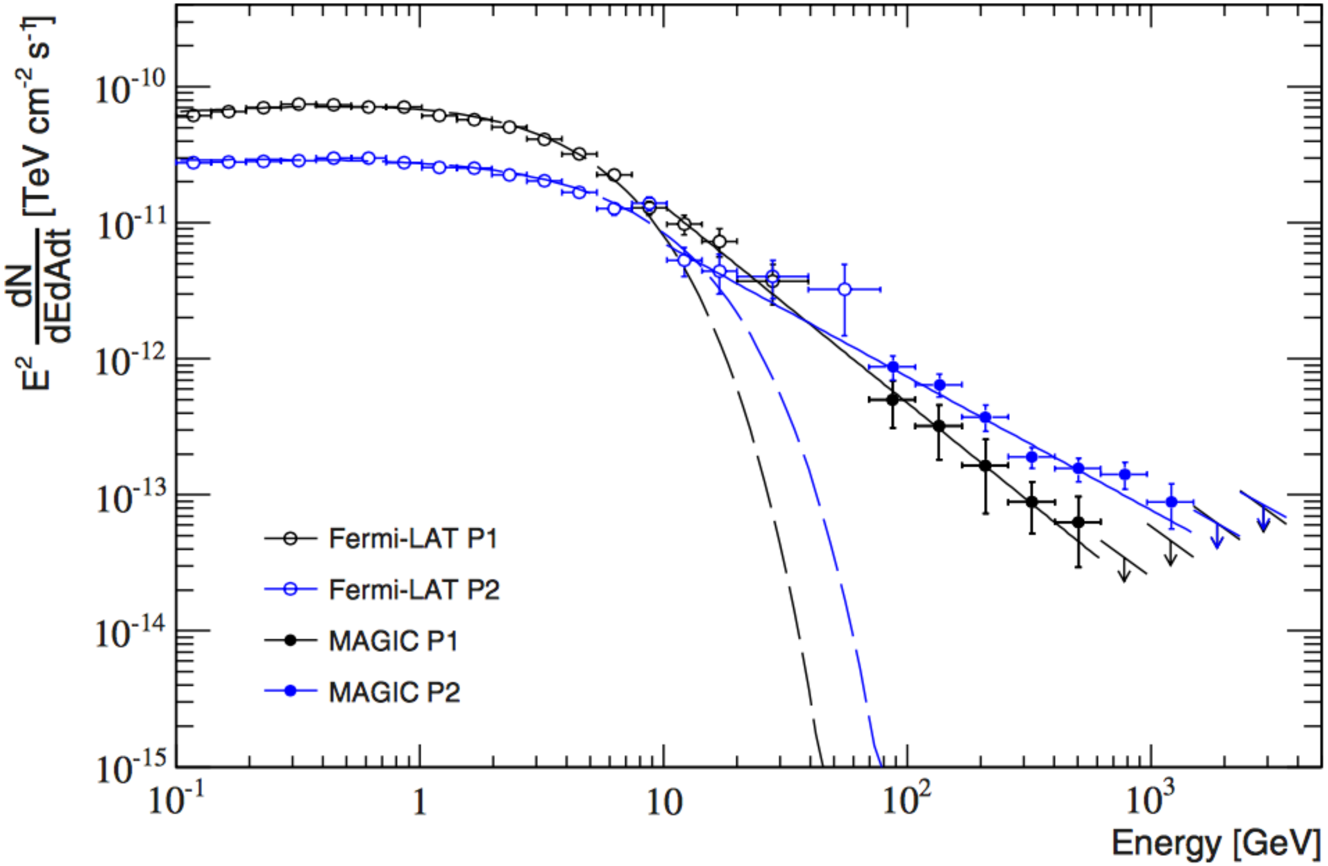
Ansoldi et al. (2016)

Crab PSR



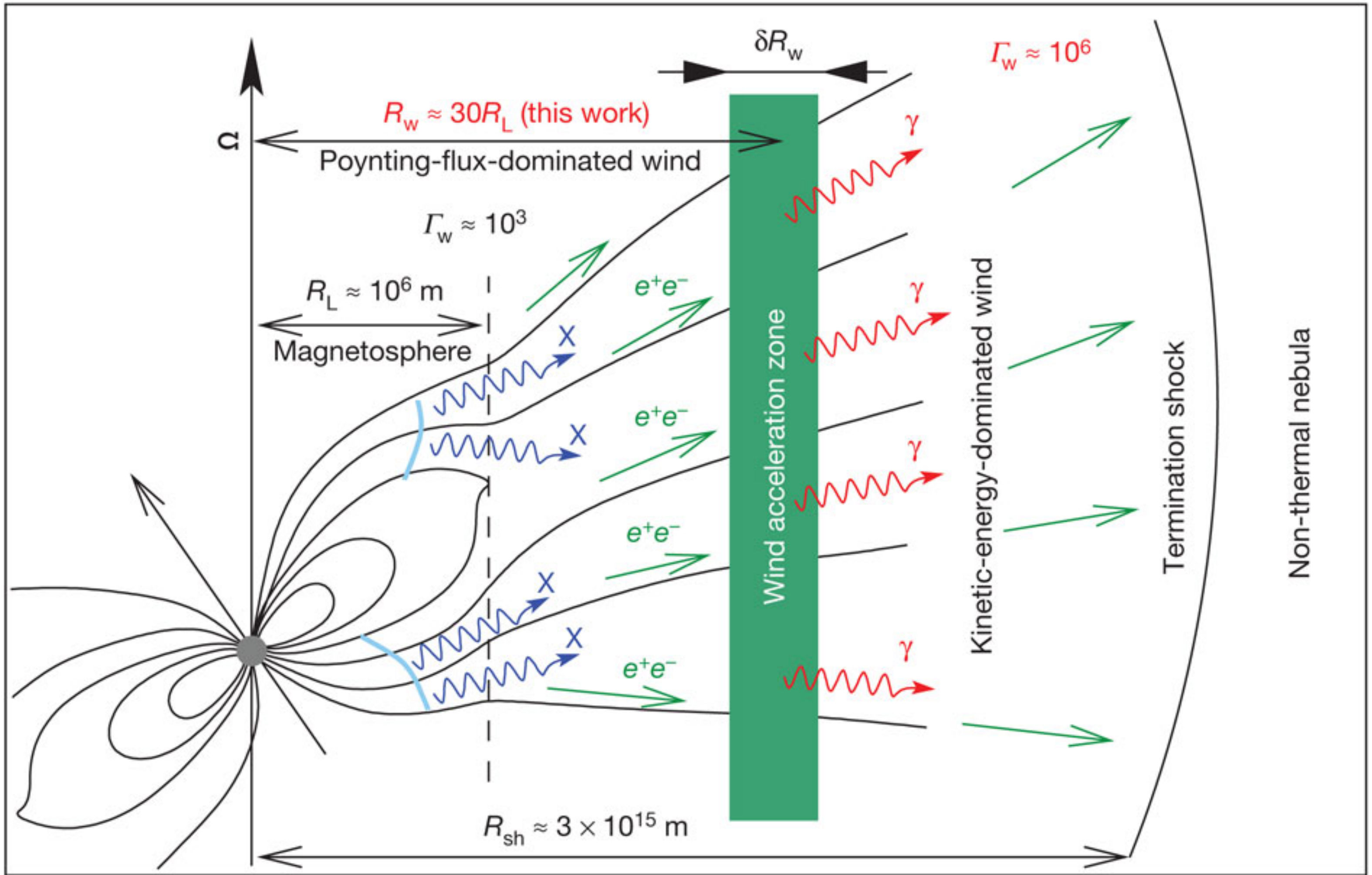
Ansoldi et al. (2016)

Crab PSR new



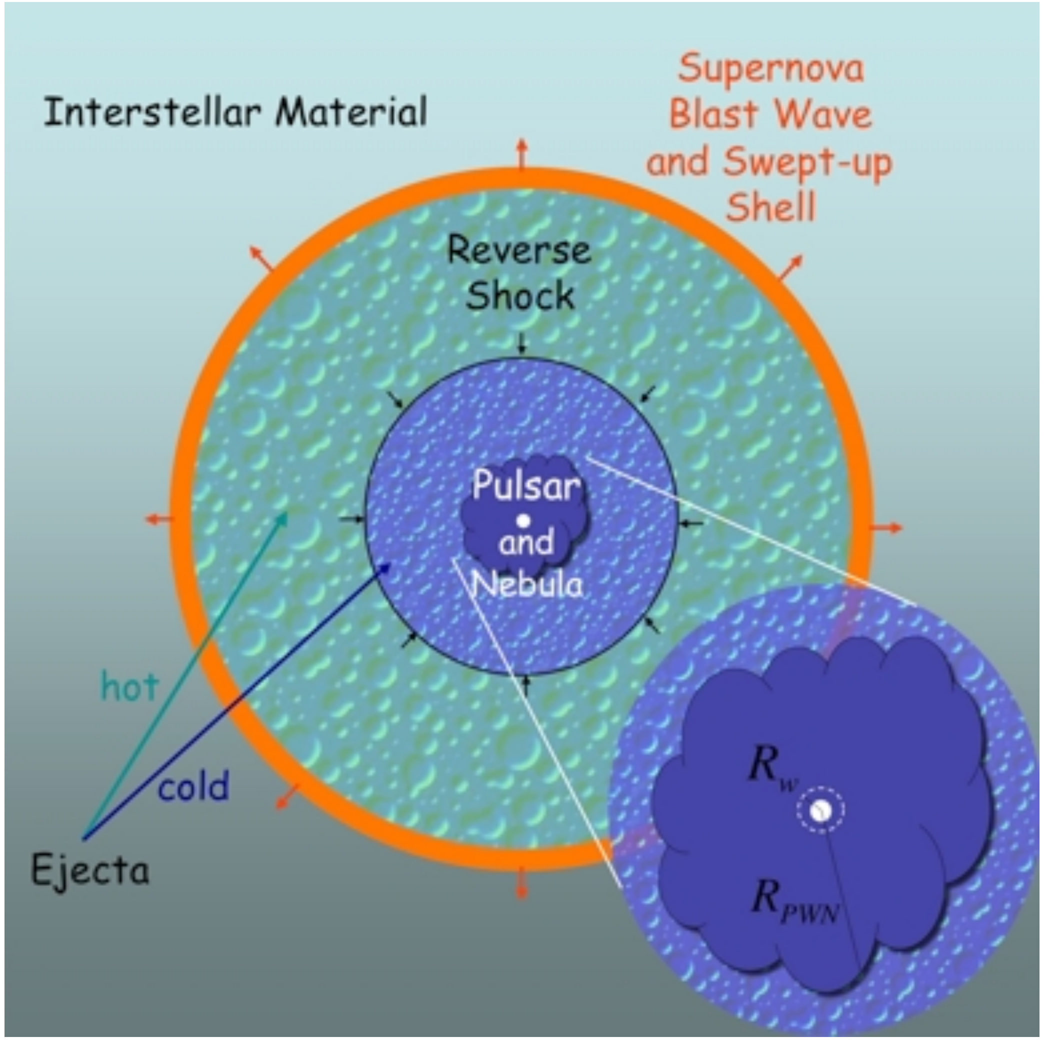
Ansoldi et al. (2016)

Crab PSR

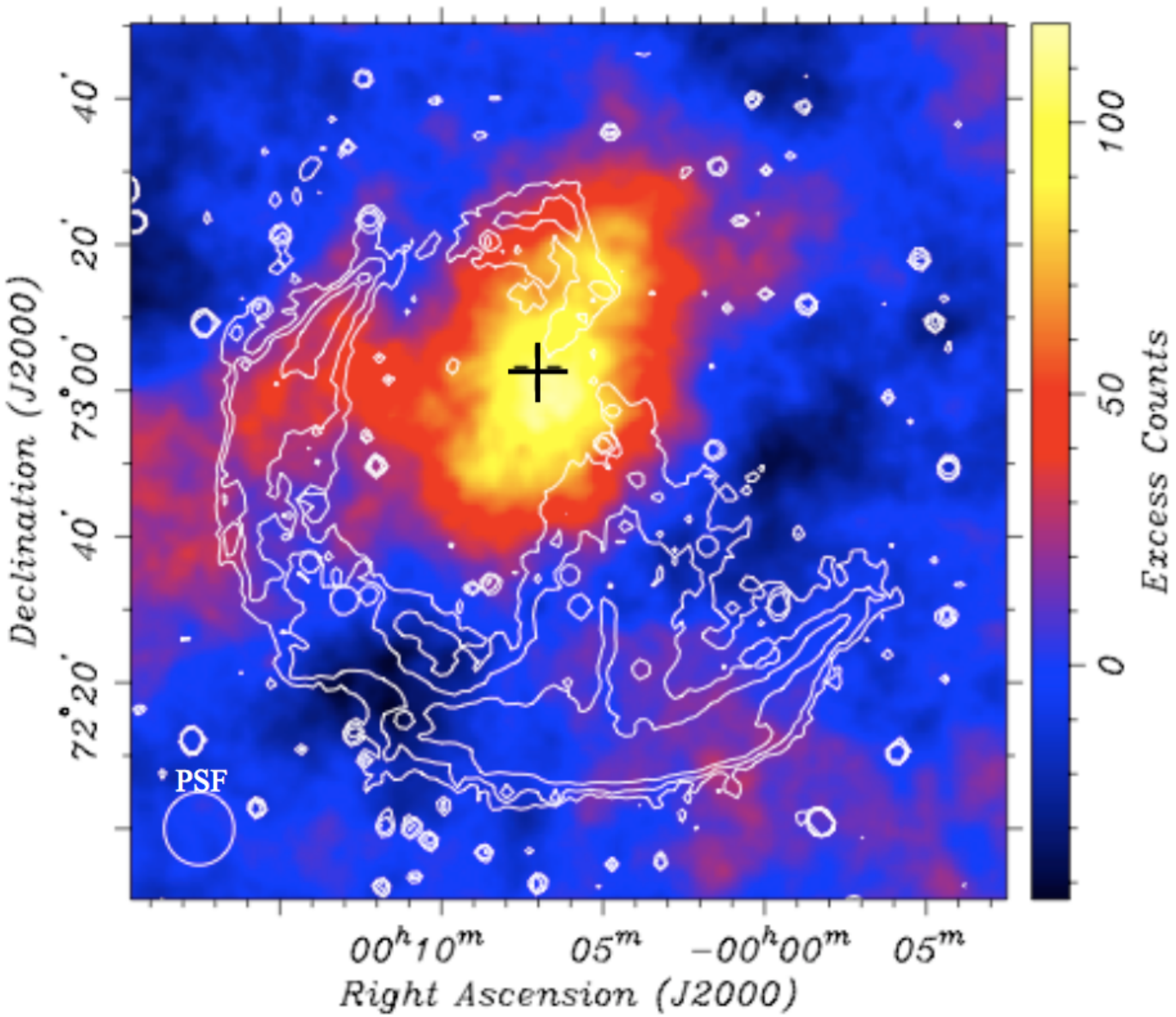


Aharonian et al. (2012)

Pulsar Wind Nebulae

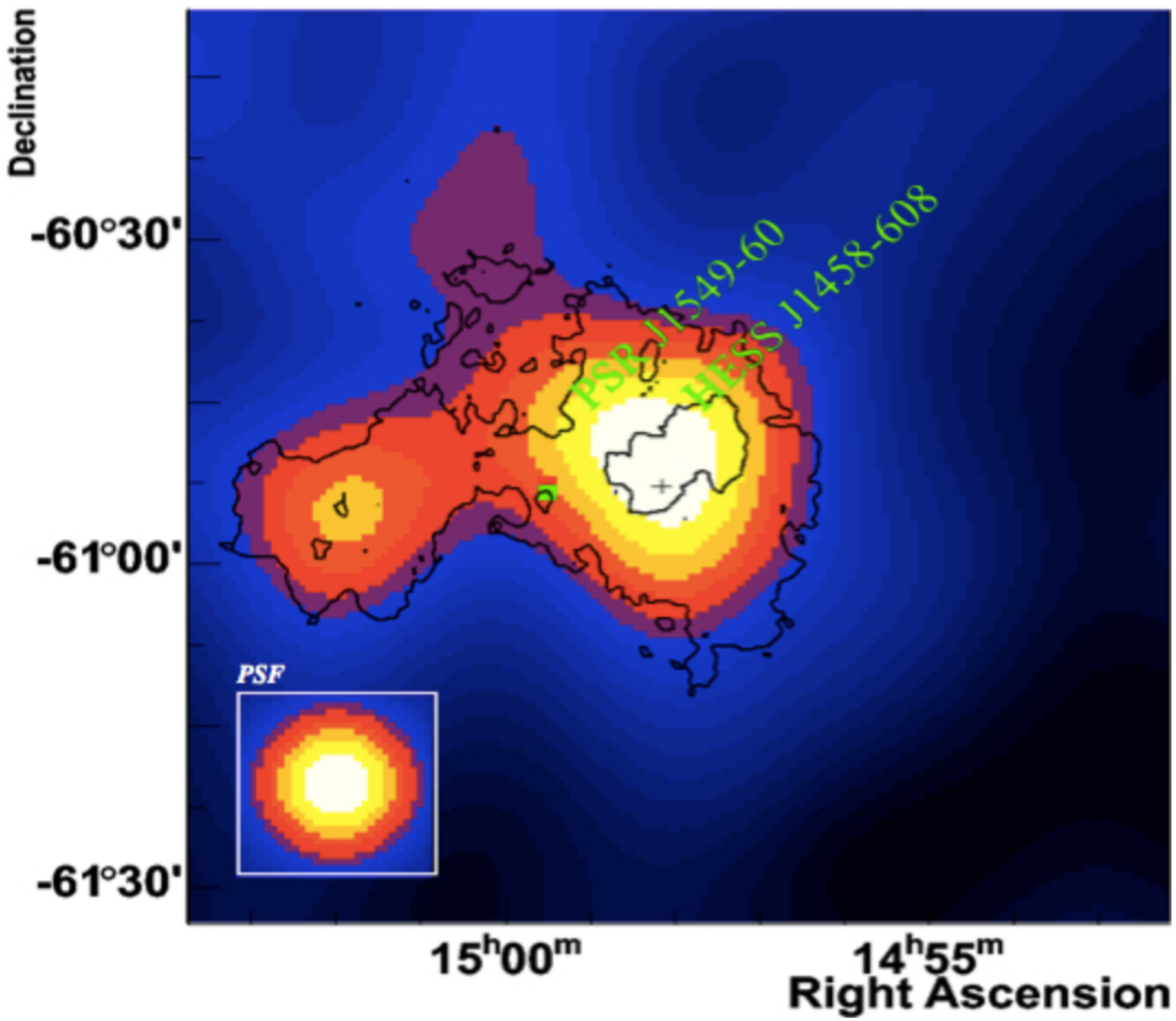


CTA1 PWN



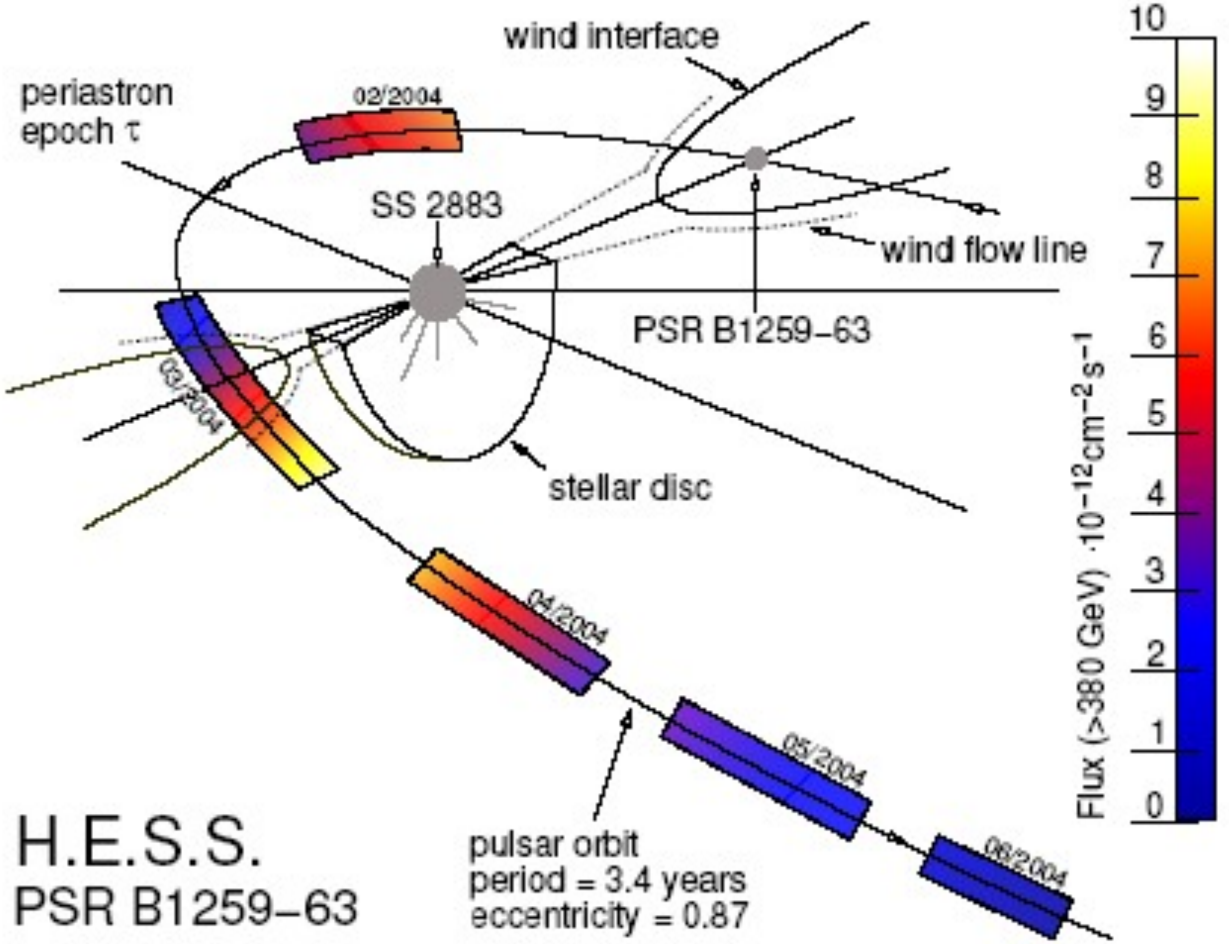
40'
20'
73°00'
40'
72°20'
Declination (J2000)
00h10m
05m
−00h00m
05m
Right Ascension (J2000)
PSF
100
50
0
Excess Counts

Pulsar Wind Nebulae

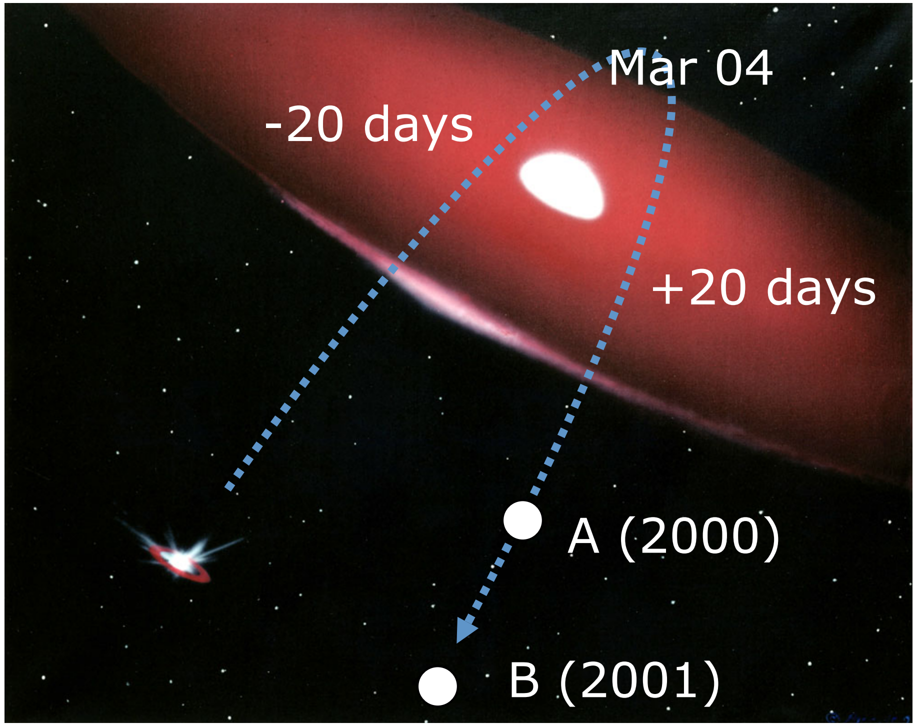


PSR B1259-63

- Binary system
- Strong stellar wind
- Shock at wind-pulsar interaction

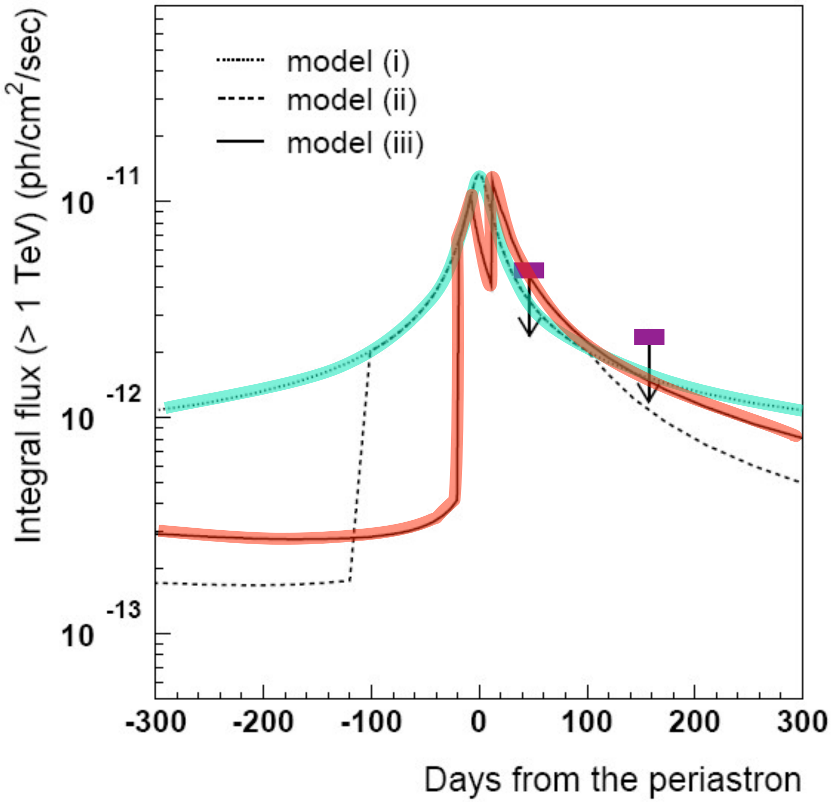


PSR B1259-63



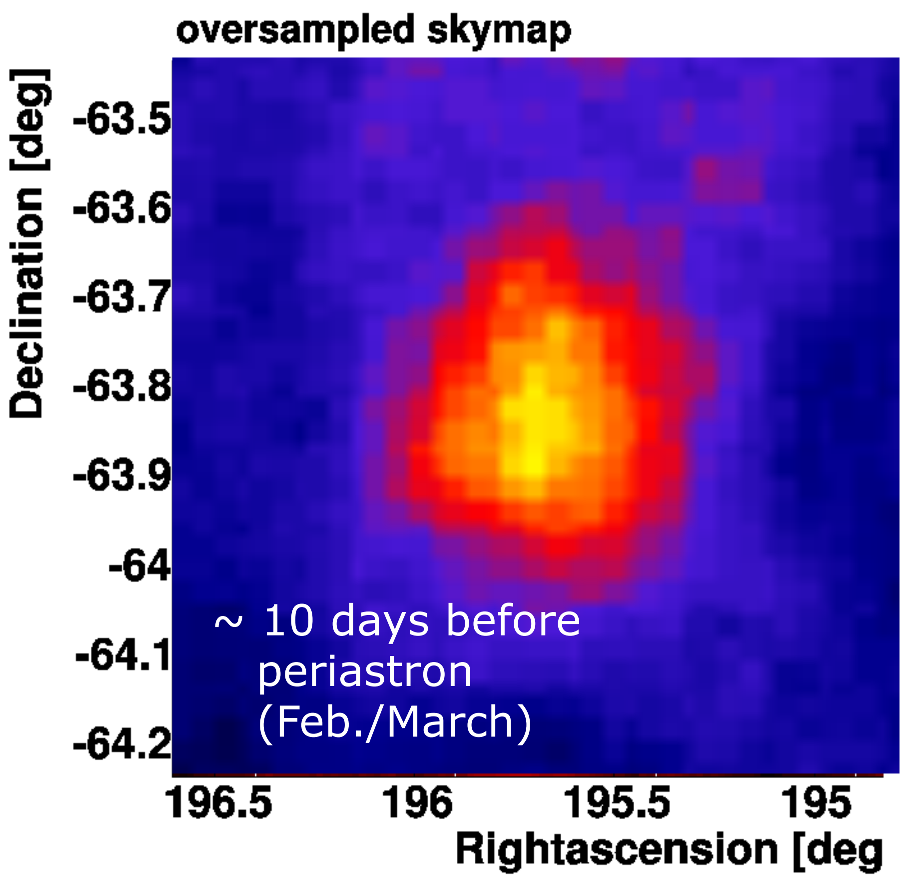
Model: Ball & Kirk 2000

CANGAROO
Kawachi et al. 2004

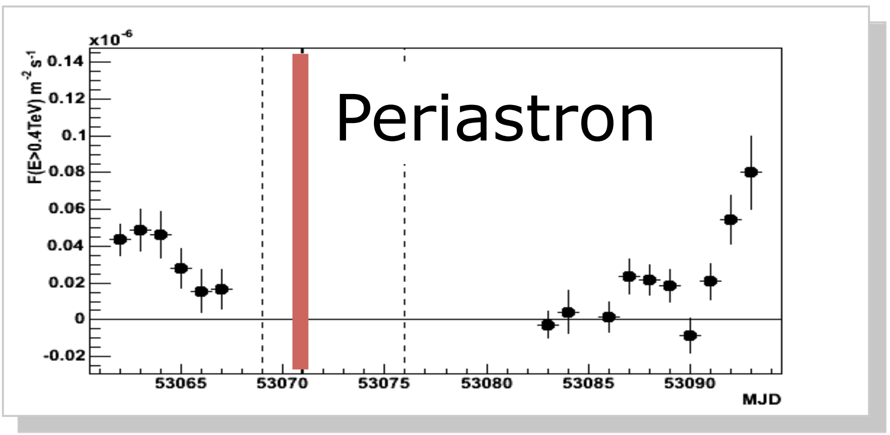


Complex structure depending on alignment of pulsar and stellar wind

PSR B1259-63

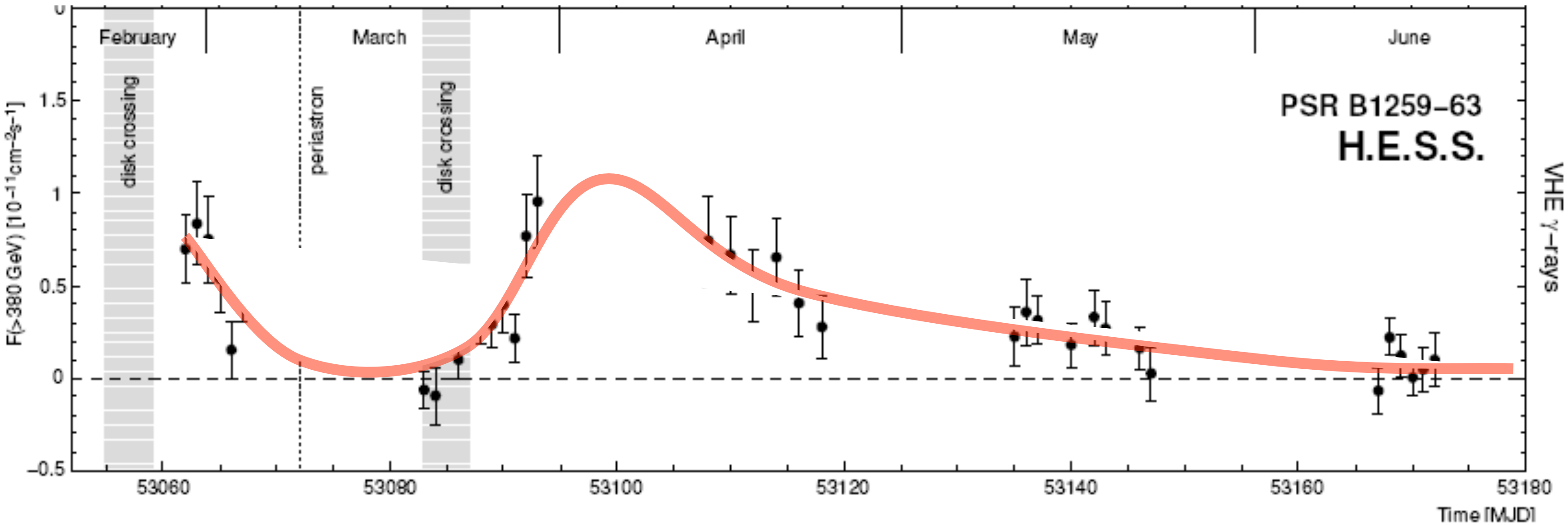


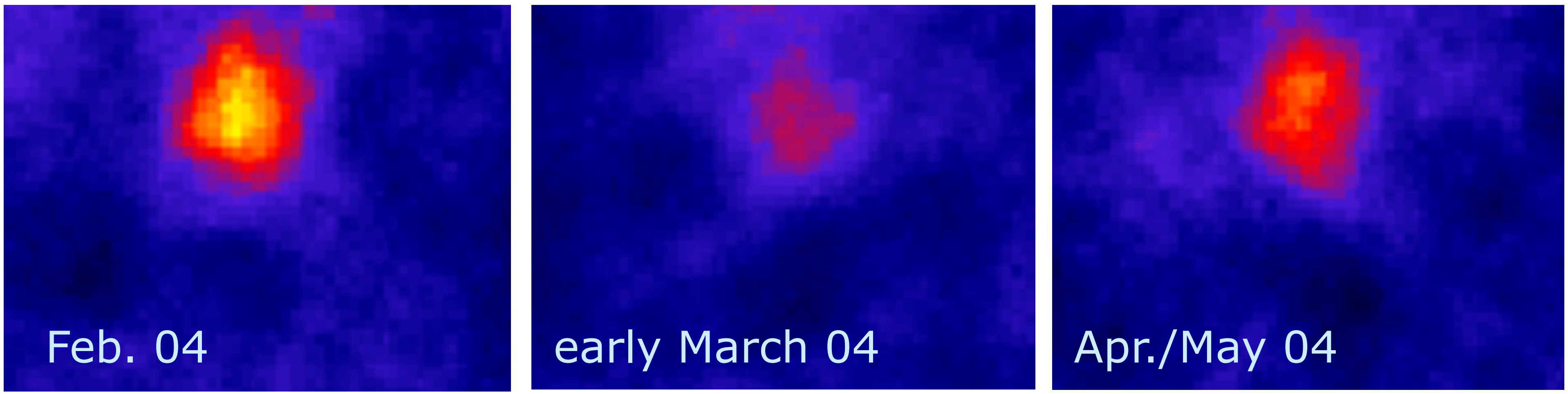
~ 9 σ pre-periastron
~ 6 σ post-periastron
Flux ~5% Crab
Index 2.8±0.3(stat)



H.E.S.S.

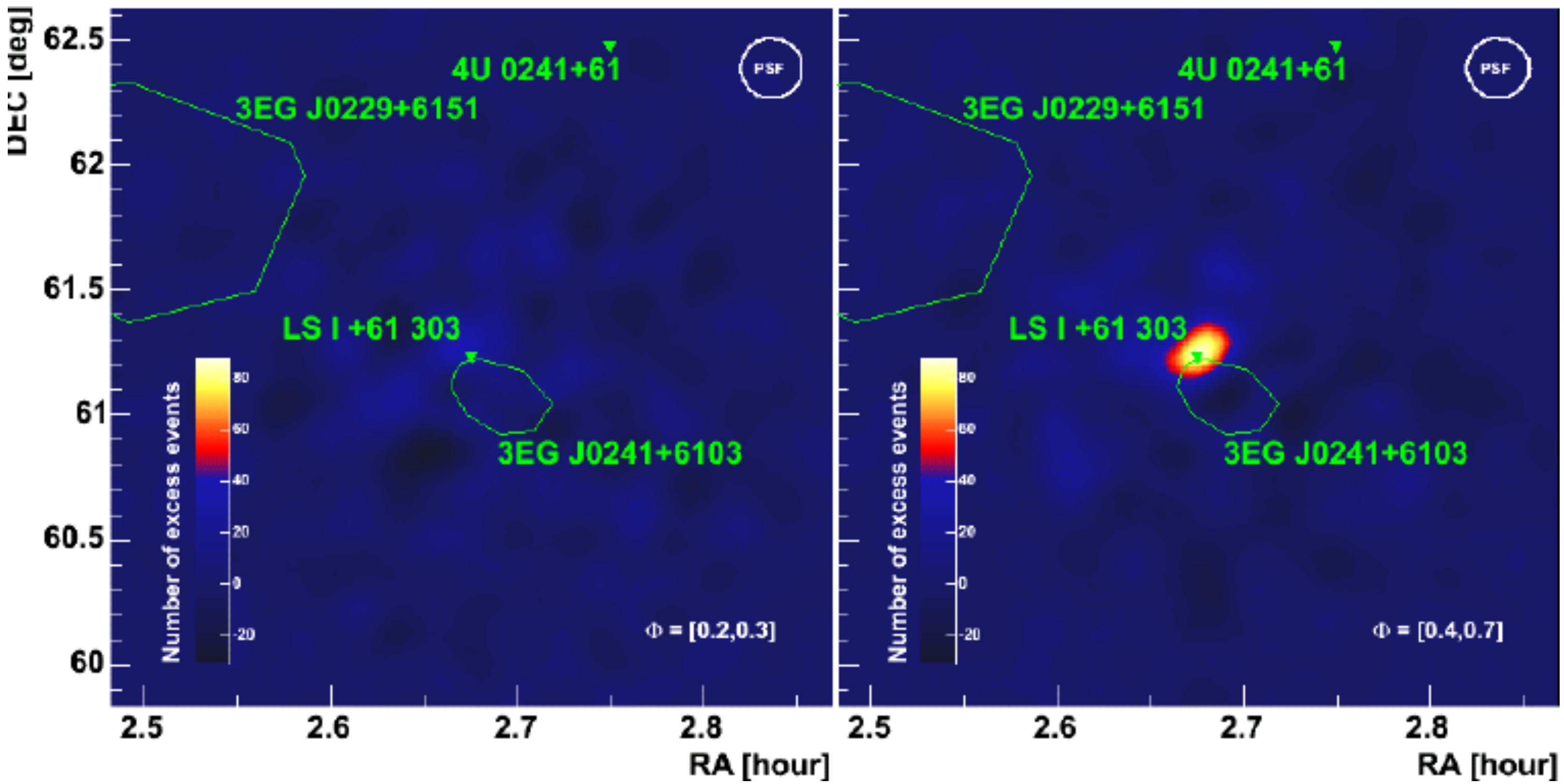
The B1259-63 field of view



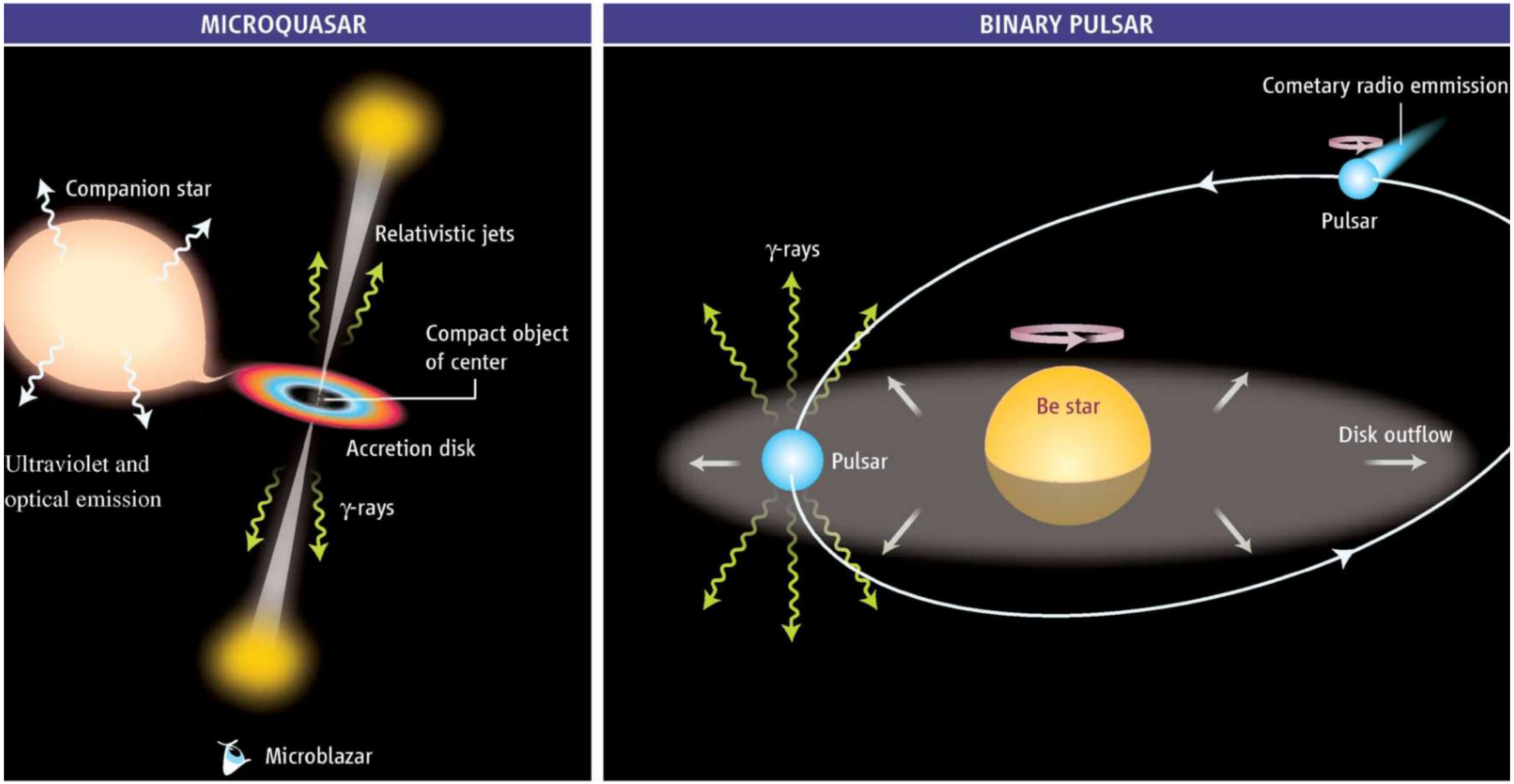


First variable galactic TeV source

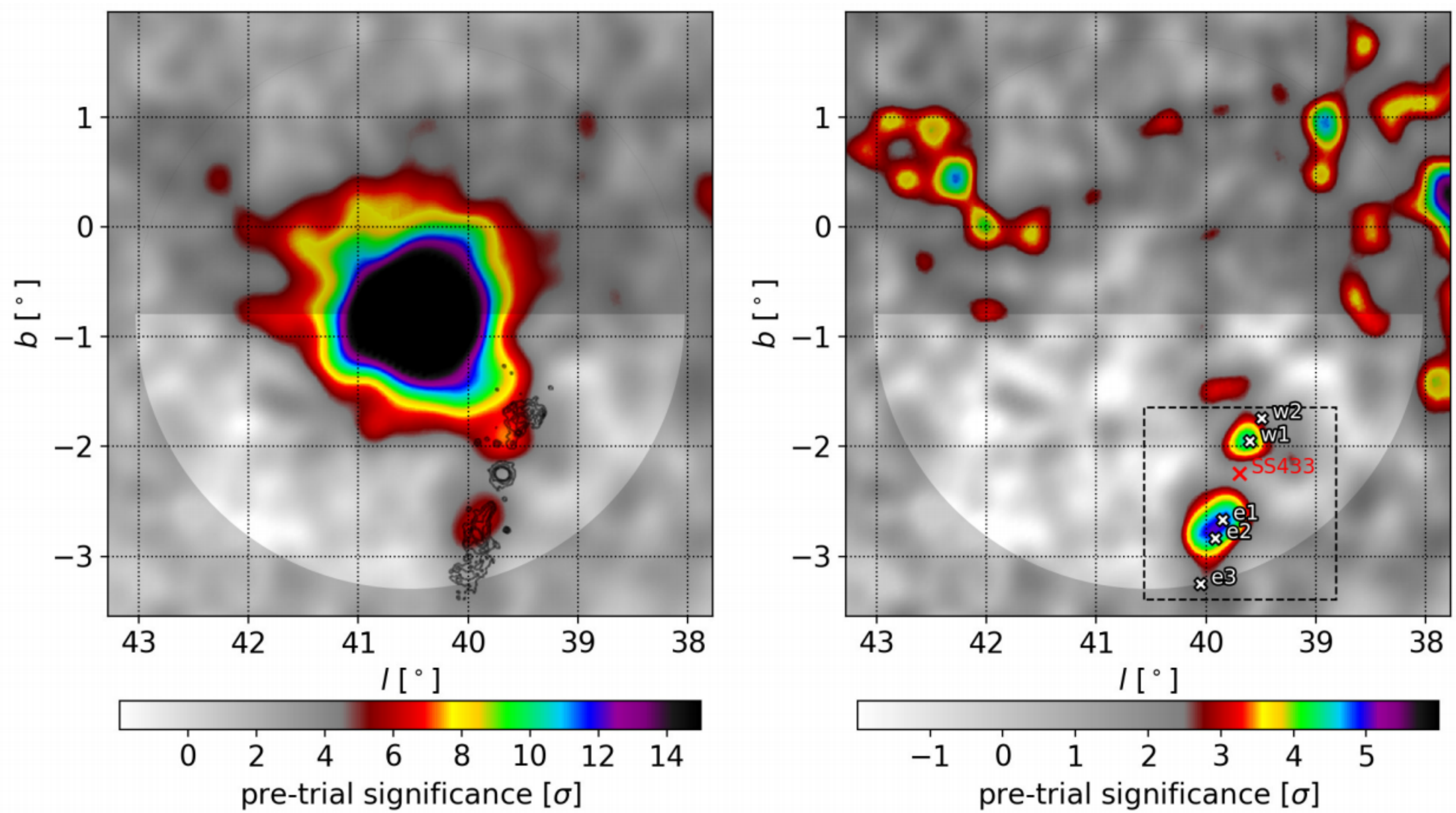
LSI 61+303 binary source



VHE Binary Sources

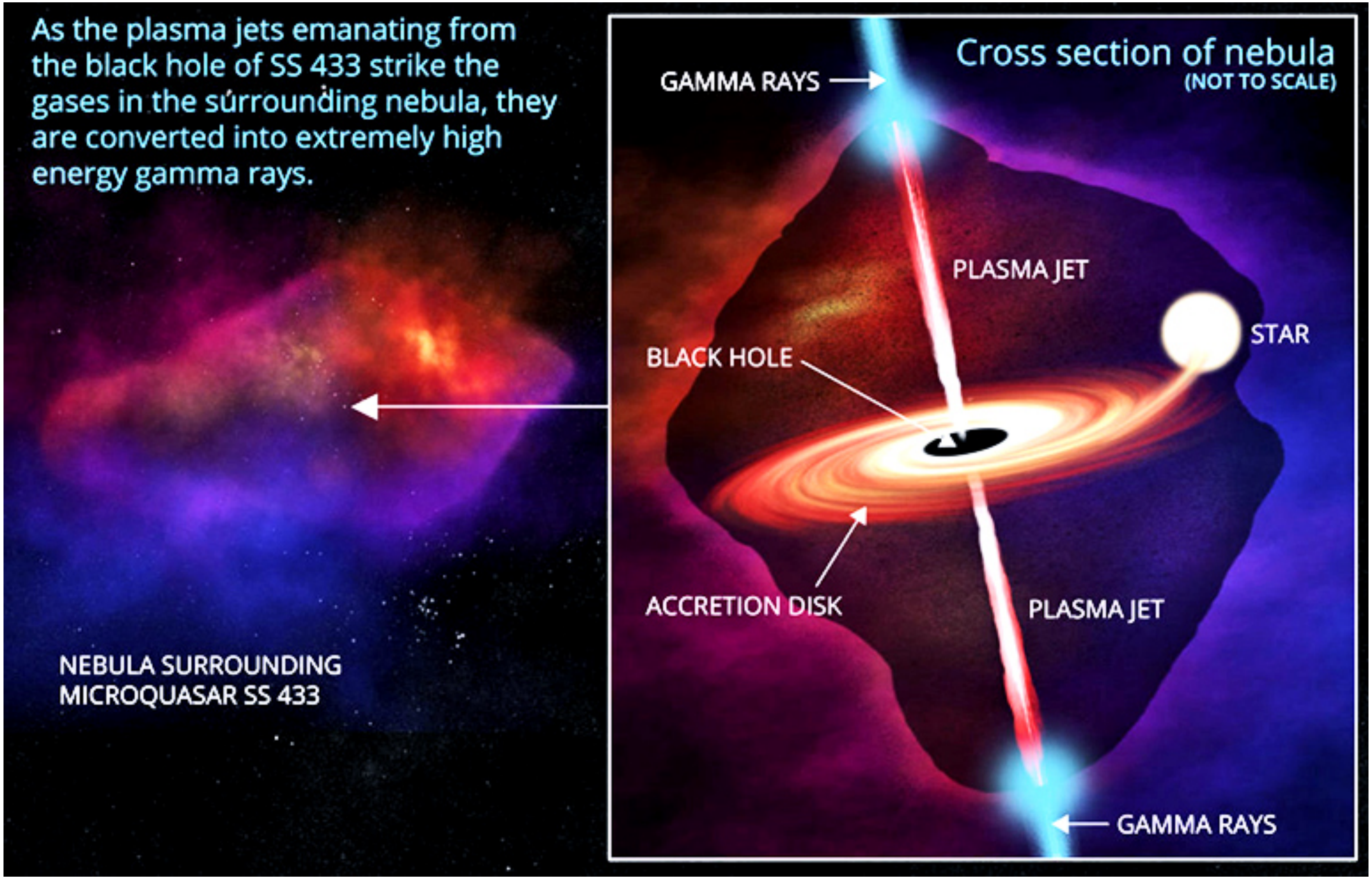


SS433 HAWC



b [°]
l [°]
pre-trial significance [σ]
w2
w1
SS433
e1
e2
e3
b [°]
l [°]
pre-trial significance [σ]

SS433 HAWC

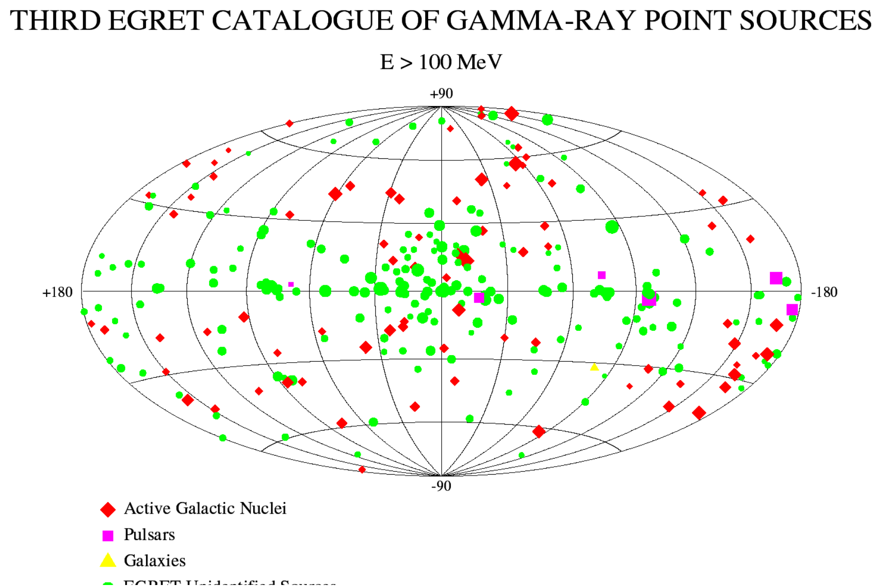

As the plasma jets emanating from the black hole of SS 433 strike the gases in the surrounding nebula, they are converted into extremely high energy gamma rays.
NEBULA SURROUNDING MICROQUASAR SS 433
Cross section of nebula
(NOT TO SCALE)
GAMMA RAYS
PLASMA JET
STAR
BLACK HOLE
ACCRETION DISK
PLASMA JET
GAMMA RAYS

Astrofisica Nucleare e Subnucleare

VHE Extra Galactic Sources

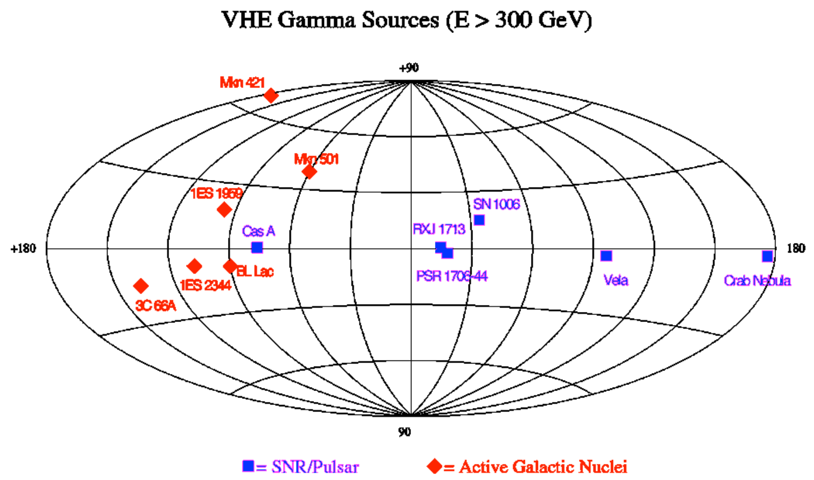
The unexplored spectrum gap

- γ-ray sources observed with EGRET satellite (E < 10 GeV)
- 271 sources (171 unidentified)



Satellite effective area < 1 m^2

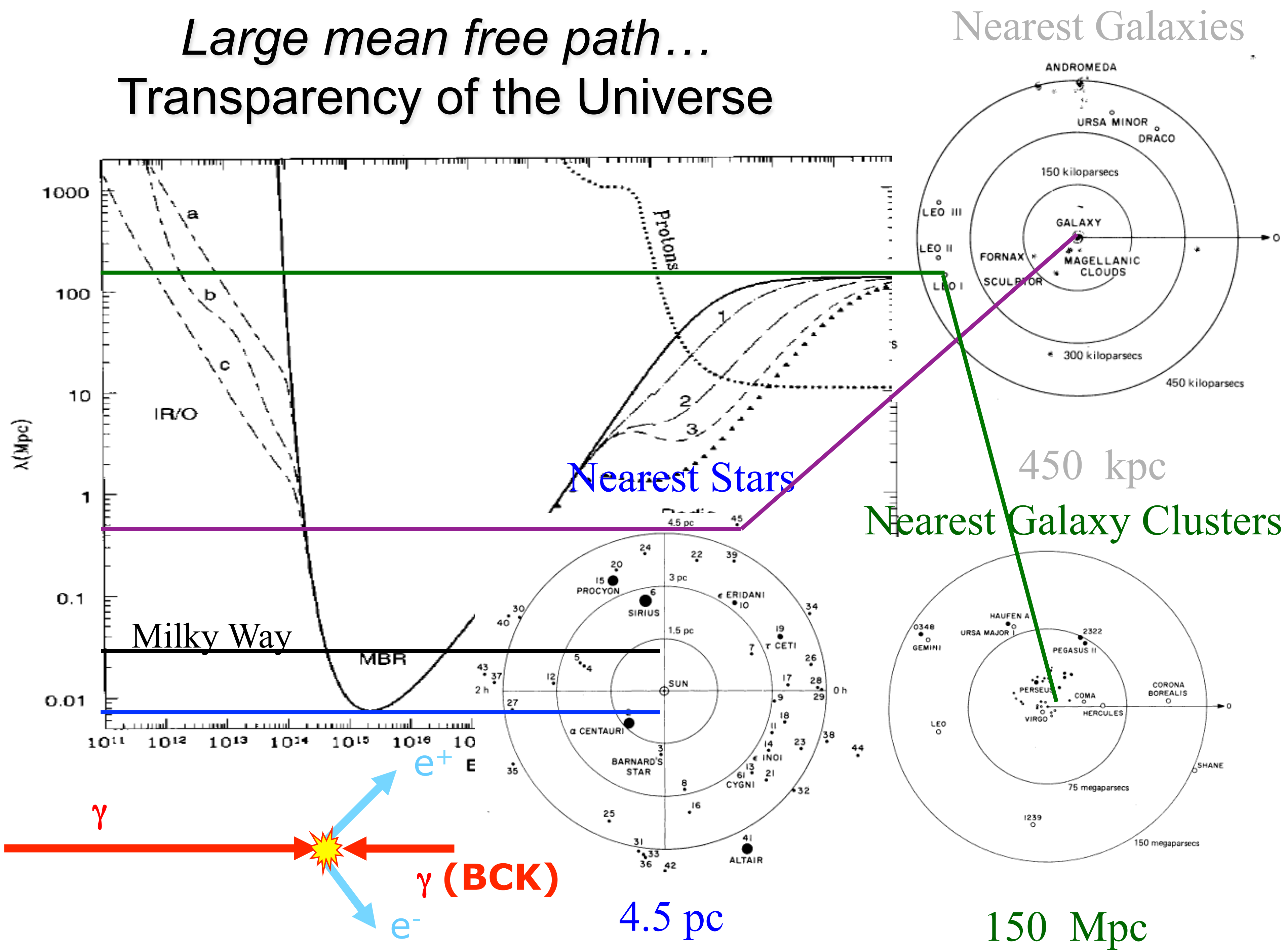
- Old generation ground-based experiments observe few sources with E > 300 GeV.



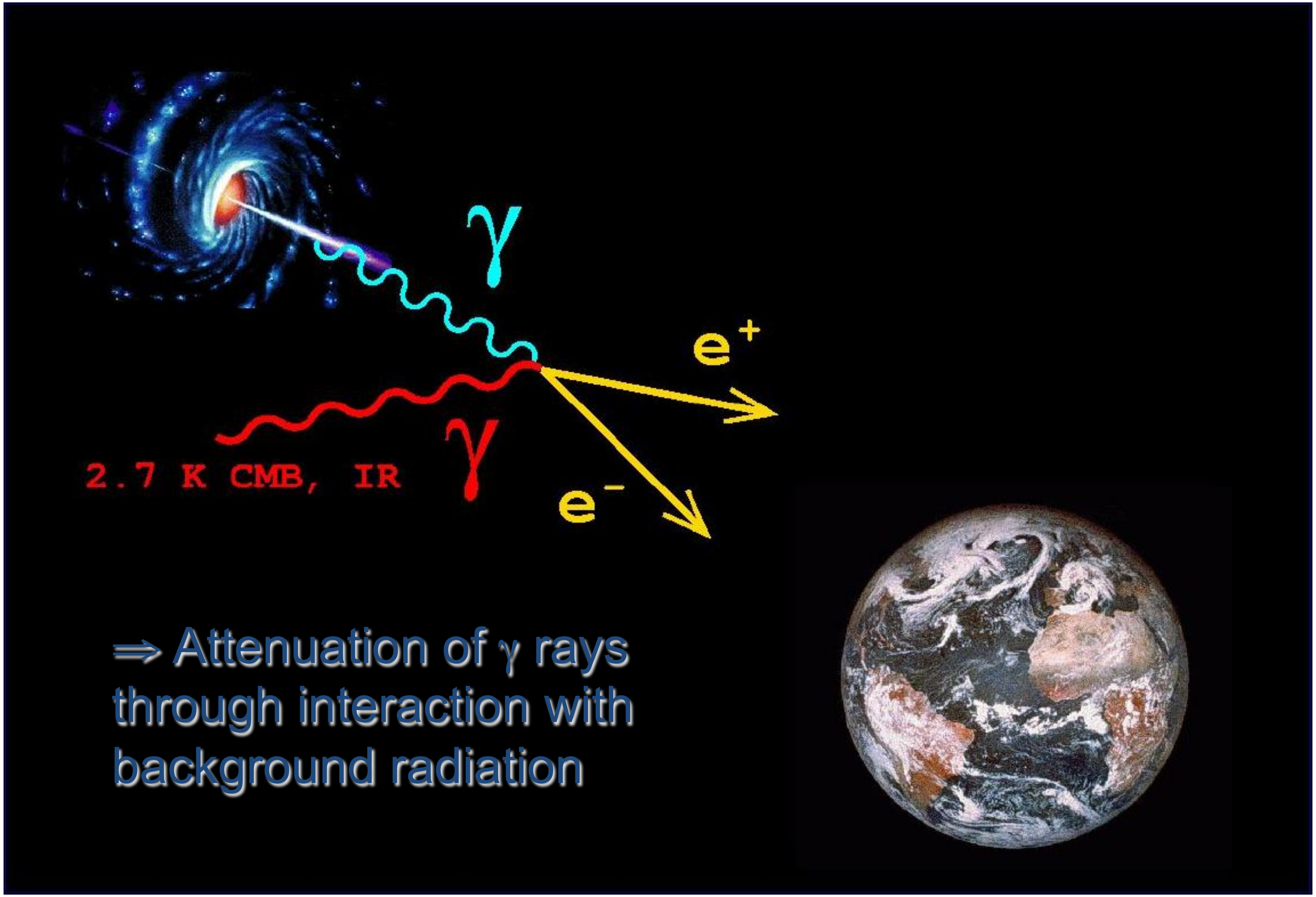
Effective area > 10^4 m^2

Strong cutoff in γ-spectrum for
30 Gev < E < 300 GeV
Explore energy gap with MAGIC

Large mean free path…
Transparency of the Universe



Photon Propagation Effects



Gamma Ray Horizon

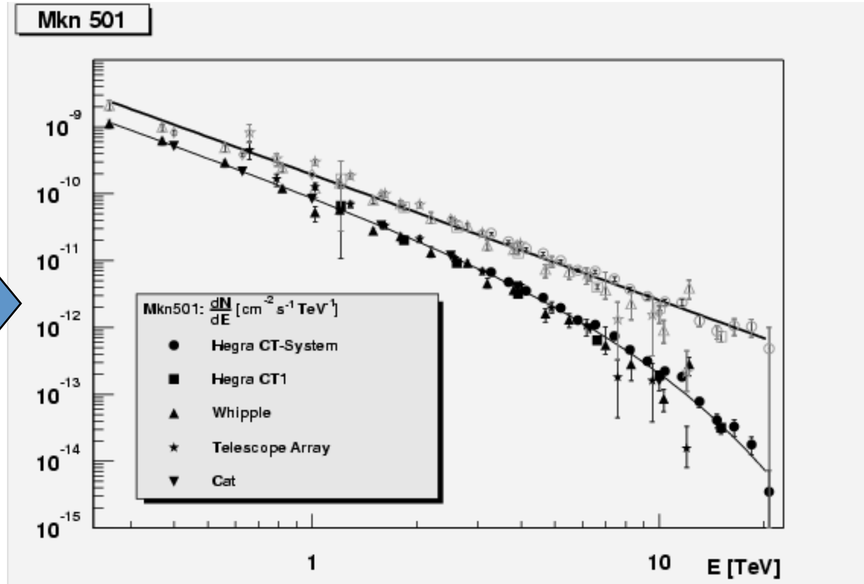
Any γ that crosses cosmological distances through the universe **interacts with the EBL**

$$\gamma_{HE}\,\gamma_{EBL} \rightarrow e^+ e^-$$

$$E\varepsilon(1-\cos\theta) > 2\left(m_e c^2\right)^2$$

The absorption effect seen on a nearby blazar

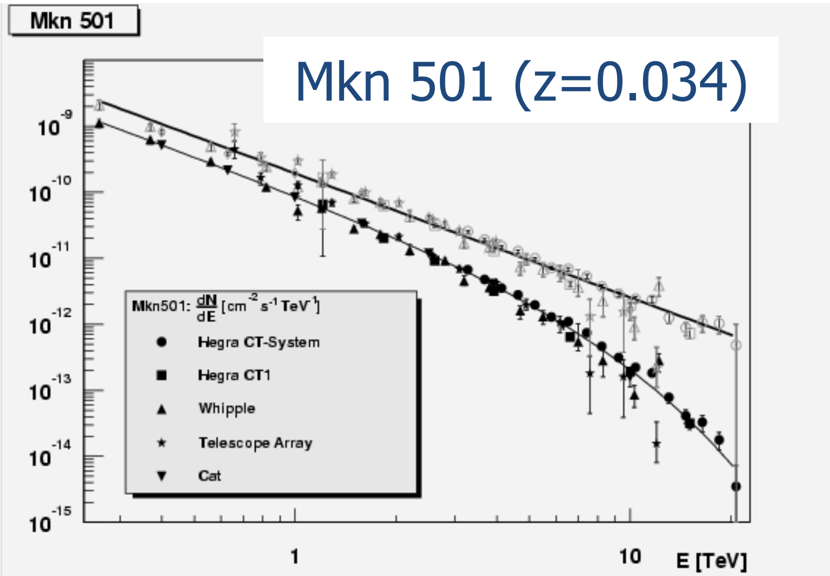
Mkn 501 (z=0.034)

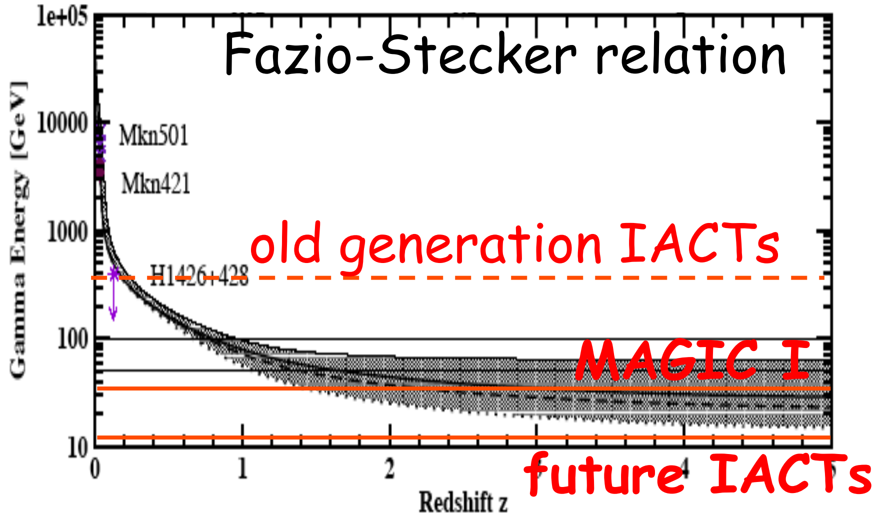


Gamma Ray Horizon

γ-rays traveling cosmological distances **interact** with **Extragalactic Background Light (EBL)**

$$\gamma_{HE}\,\gamma_{EBL} \rightarrow e^{+}\,e^{-}$$



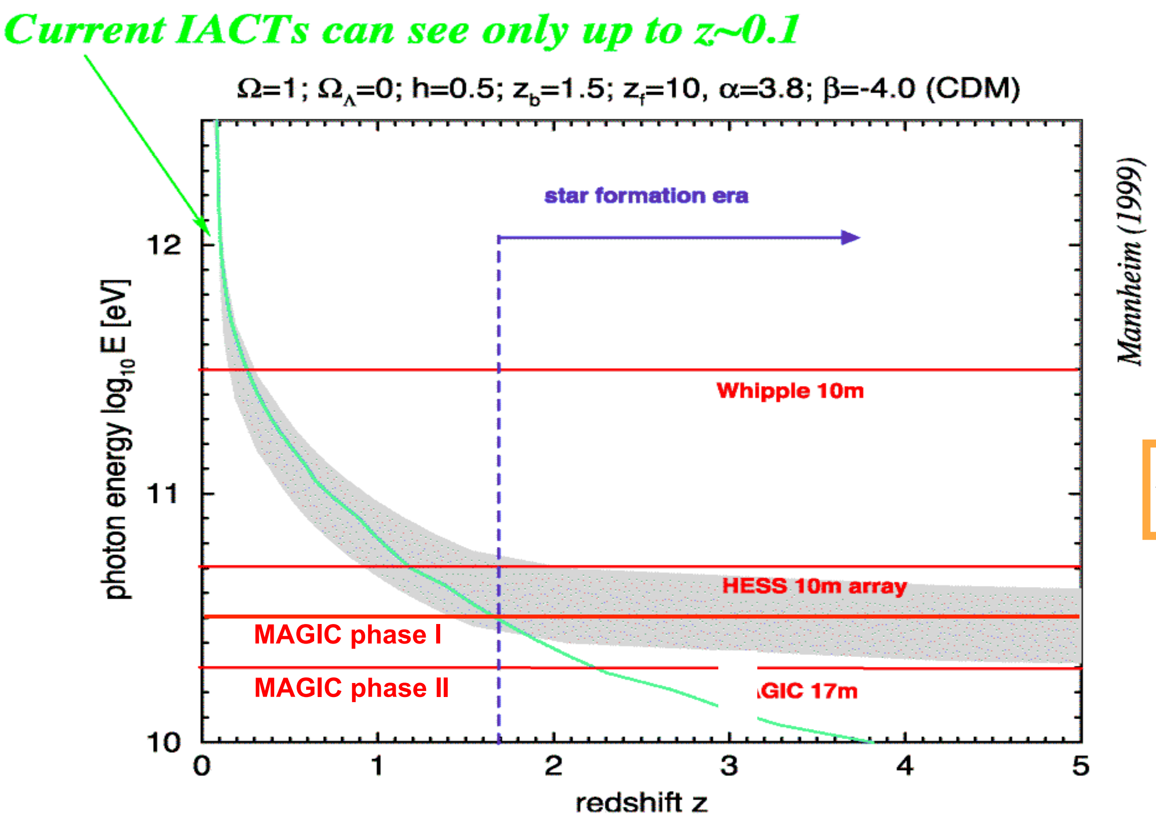


- lower energy threshold
  => observe more distant sources

- Absorption increases with energy of **γ-rays**
- Absorption leads to cutoff in AGN spectrum
- Measurement cutoff of several sources allows extraction of EBL

Gamma ray horizon (GRH)

Defined as the distance for which the optical depth for pair production process is $\tau = 1$ (i.e. a reduction 1/e of the flux of the extragalactic source).



$$\tau(E, z) = 1$$

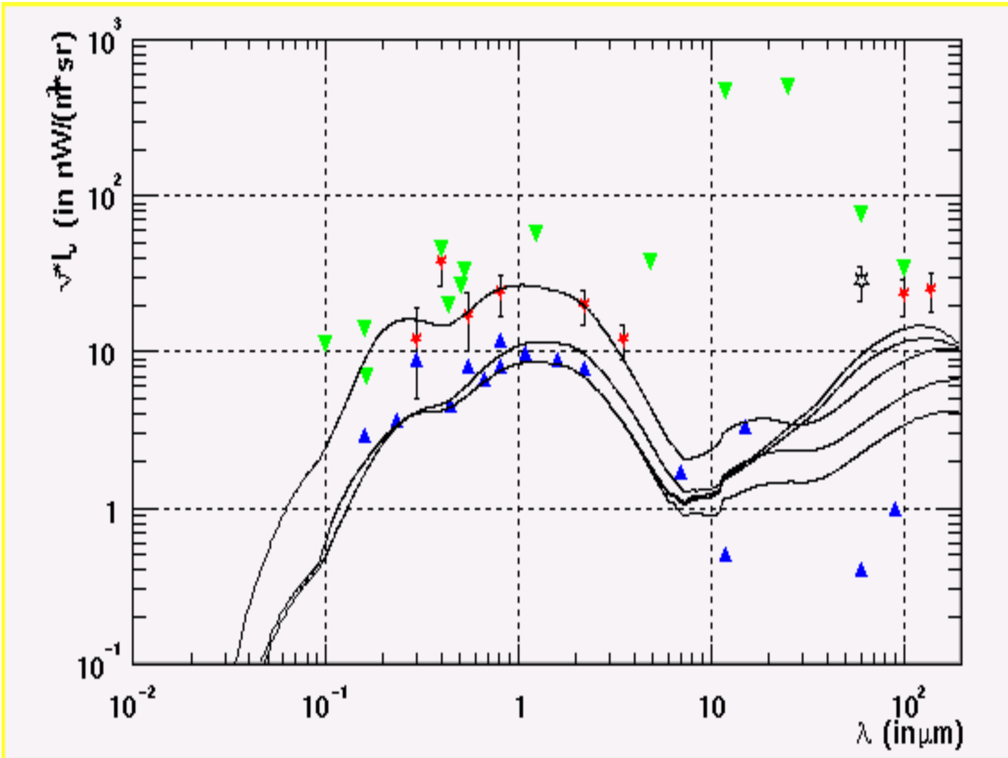
Extragalactic absorption

For the energy range of IACTs (10 GeV - 10 TeV), the interaction takes place with the **infrared** (0.01 eV - 3 eV , 100 μm - 1 μm).

Origin

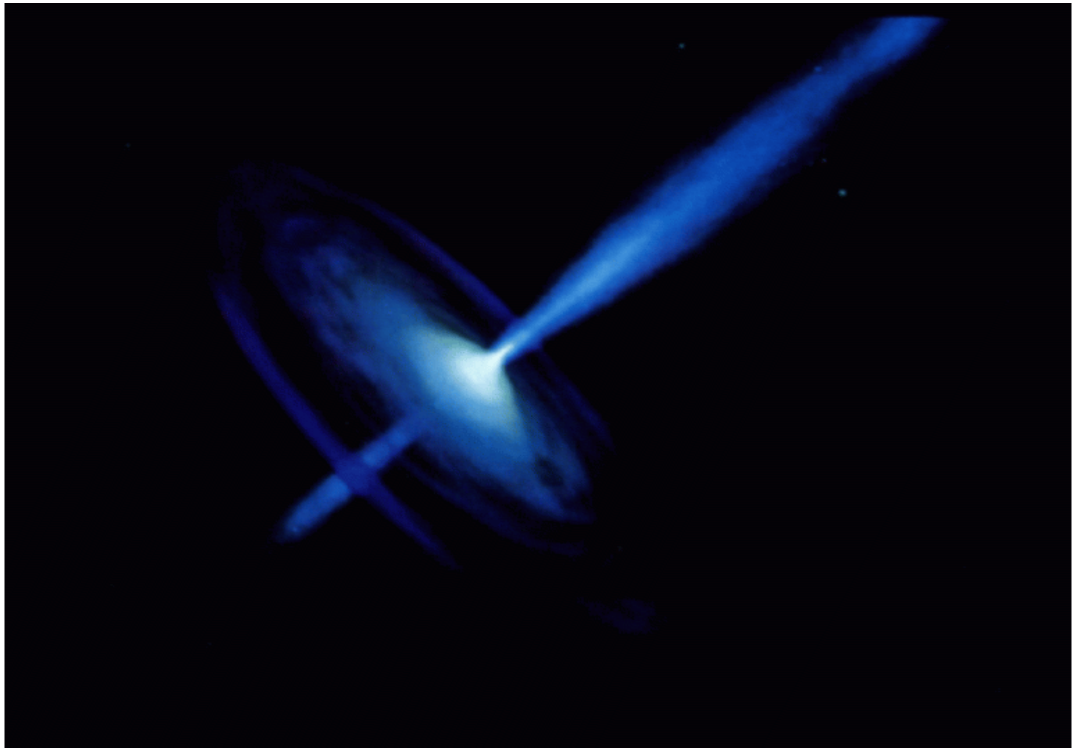
- Star formation
- Radiation of stars
- Absorption and reemission by ISM

By measuring the cutoffs in the spectra of AGNs within the, MAGIC can help in determining the IR background

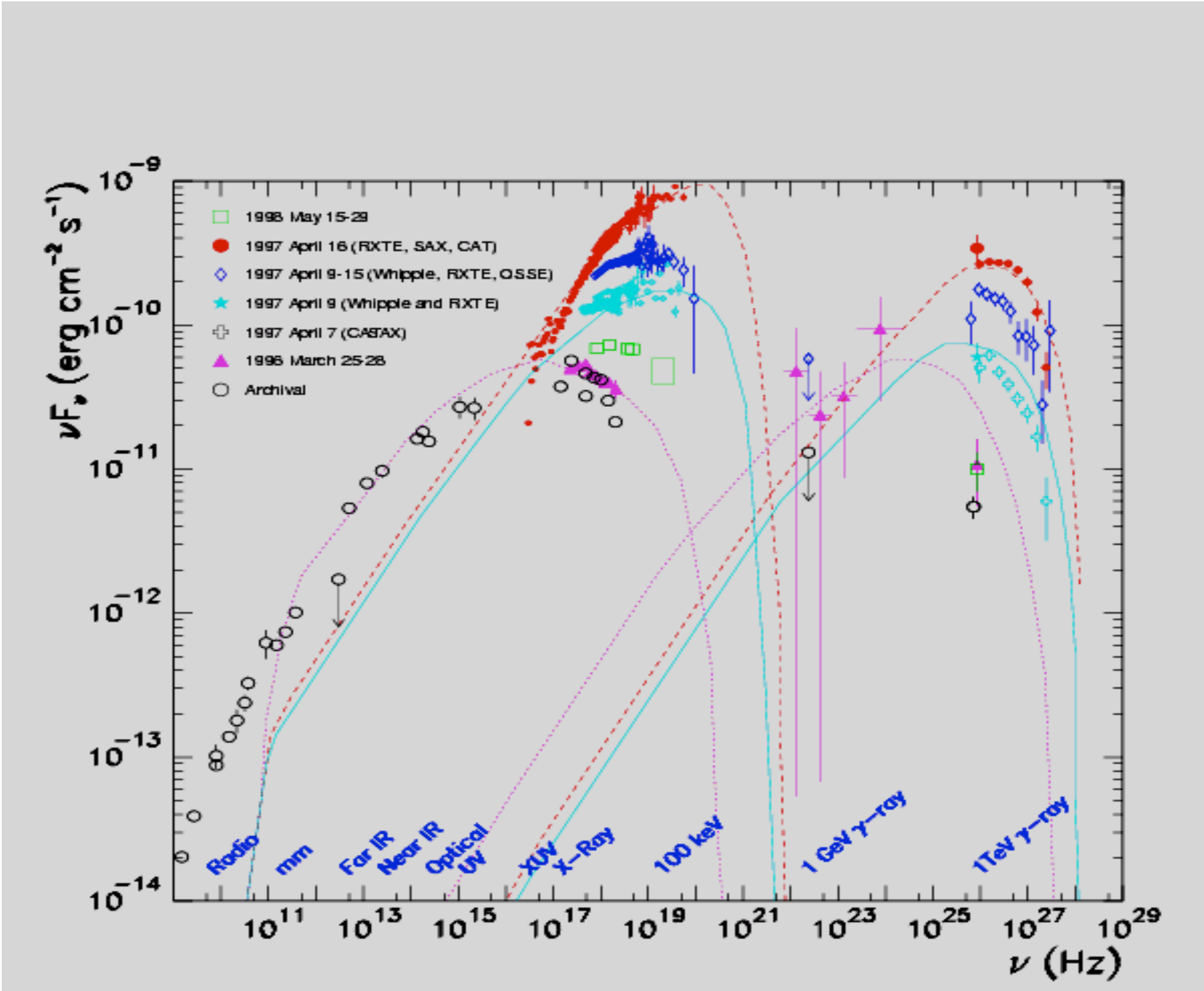


Extragalactic Sources

- Physics of AGN jets
- Cosmological extragalactic background light (EBL)

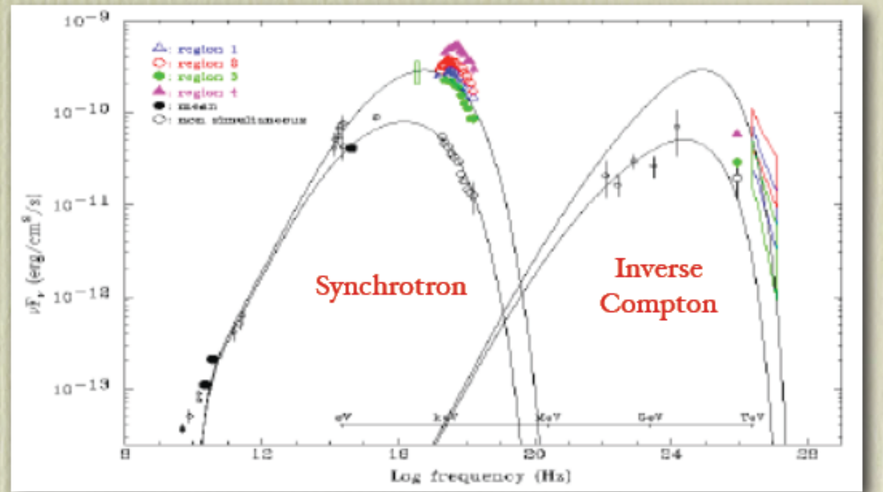


Active Galactic Nuclei



γ-ray Astronomy and Cosmic Rays

- Search for the sources of Cosmic Rays
- Investigate acceleration mechanisms
- γ-rays can be traced back to the origin



<u>Spectral Energy Distribution (SED)</u>

- characteristic two-peak structure
- competing leptonic and hadronic acceleration models.

Hadron acceleration

proton-proton interaction

p+ (TeV) + matter → π^0... → γ γ (GeV)

photo-hadron interaction

p+ (TeV) + γ (eV) → π^0... → γ γ (GeV)

Electron acceleration

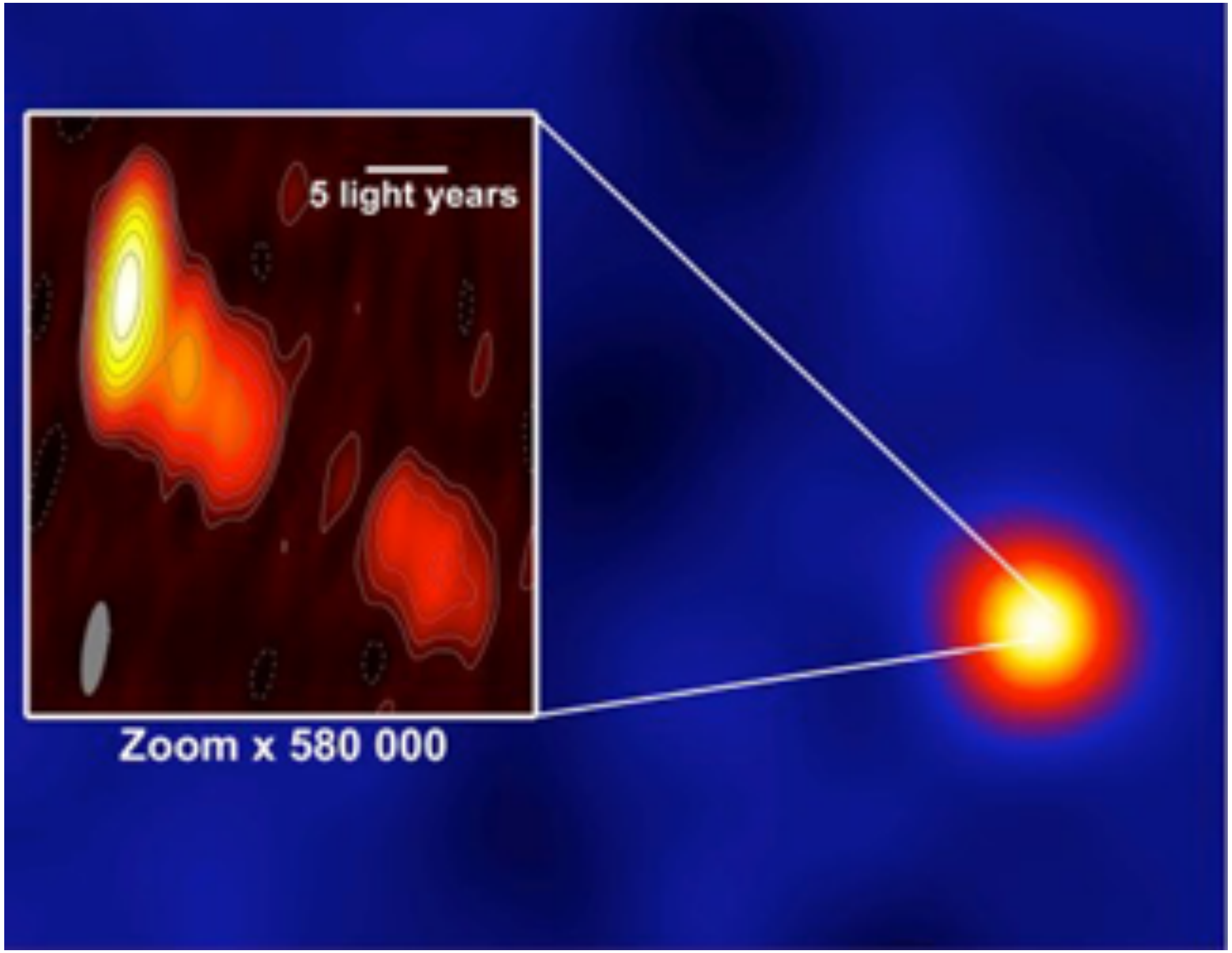
Synchrotron Radiation

e^- + B → e^- + γ (eV-keV)

Inverse Compton Scattering

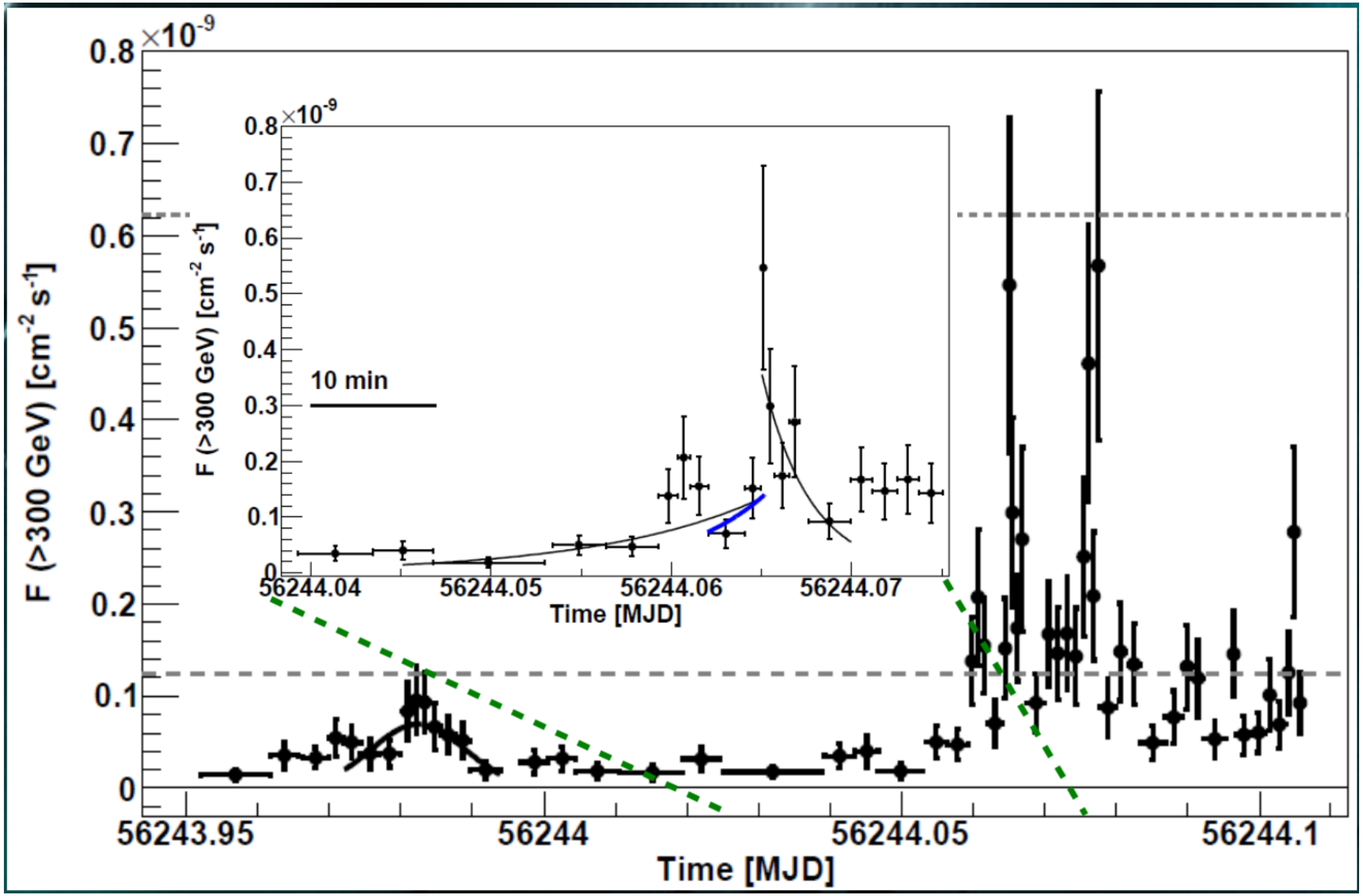
e^- (GeV) + γ (eV) → e^- + γ (GeV)

IC 310



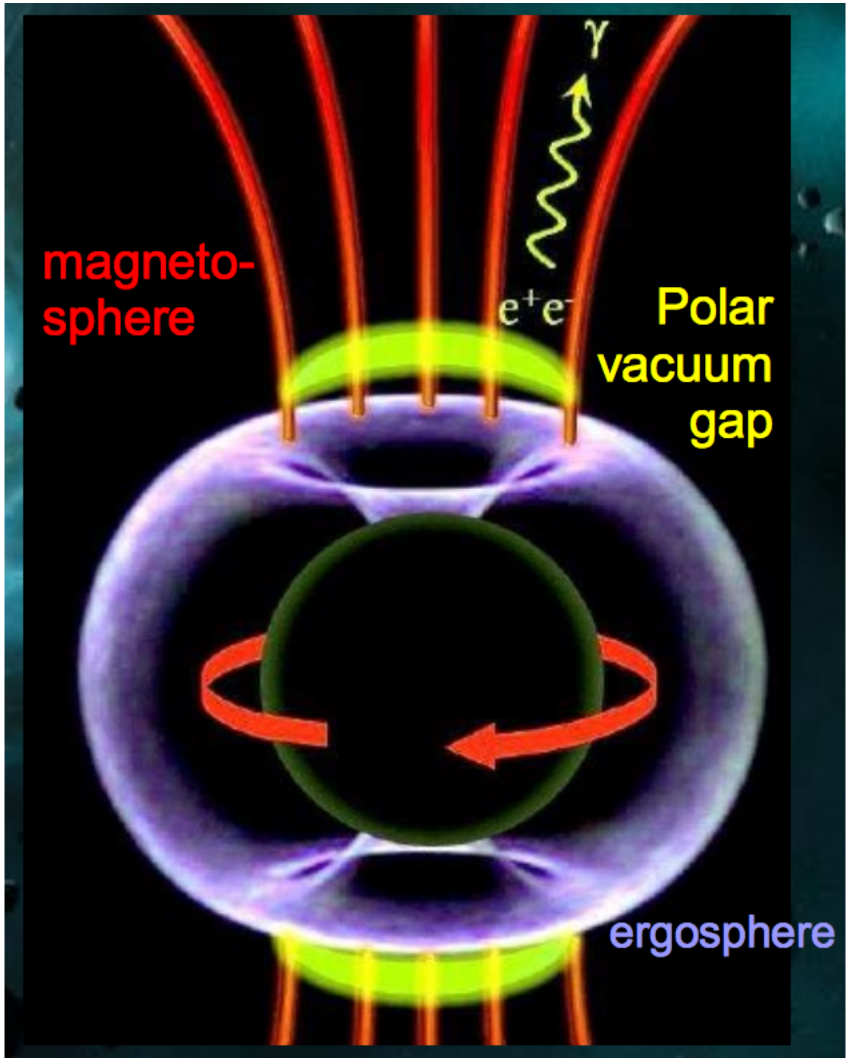
Aleksic et al 2015

IC310



Aleksic et al 2015

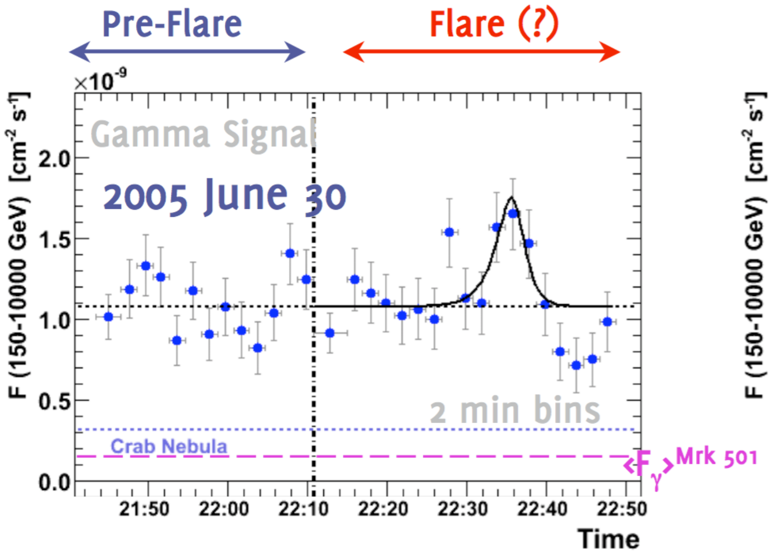
IC310



Aleksic et al 2015

Previous results

The Fastest Variability Observed So Far



Assumption: Flux variation (flare) on the top of a stable emission

b $\left(\frac{10^{-10}\ ph}{cm^2 \cdot s}\right)$	c (s)	d (s)	χ^2/NDF^{d}	P [e] (%)
13.2±4.7	81±41	50±23	20.0/15	17.3[f]
20.3±3.3	95±24	185±40	4.2/7	75.8

a: pedestal (not fit)

b: amplitude of flux variation

t_0: ~ peak position (not fit)

c, *d*: flux-doubling times

Previous results

Results of the ECF Method

MAGIC Collab. + Ellis et al.
arXiv:0708.2889, PRL subm.

$$\tau_l = (0.030 \pm 0.012) \ \mathrm{s/GeV}$$

$$\tau_q = (3.71 \pm 2.57) \times 10^{-6} \ \mathrm{s/GeV^2}$$

$$M_{QG1} = 1.398 \times 10^{16} (1 \ \mathrm{s}/\tau_l)$$

$$M_{QG2} = 1.182 \times 10^{8} (1 \ \mathrm{s}/\tau_q)^{1/2}$$

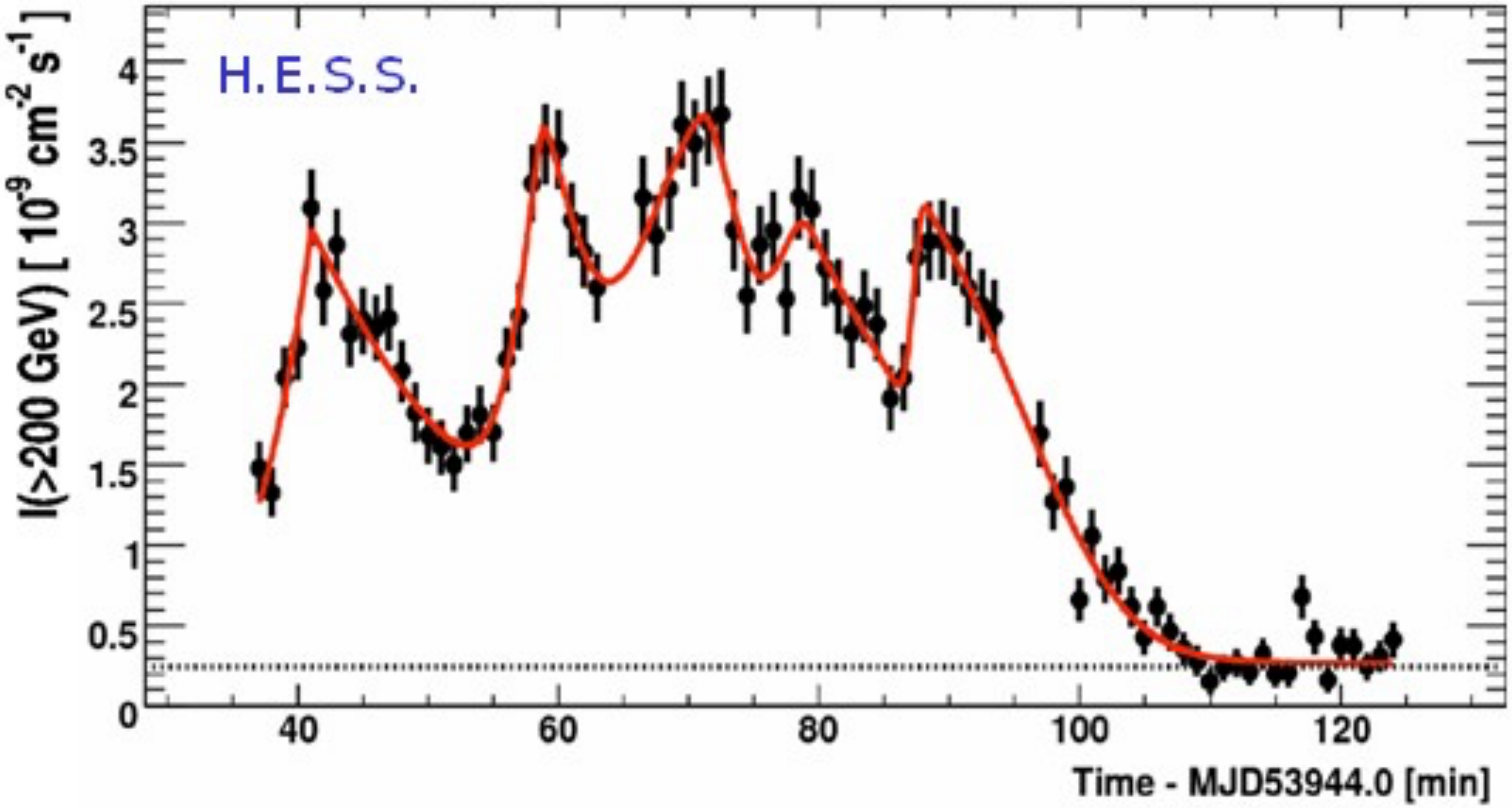
$$M_{QG1} = (0.47^{+0.31}_{-0.13}) \times 10^{18} \ \mathrm{GeV}$$

$$M_{QG2} = (0.61^{+0.49}_{-0.14}) \times 10^{11} \ \mathrm{GeV}$$

$$M_{QG1} > 0.26 \times 10^{18} \ \mathrm{GeV}$$

$$M_{QG2} > 0.27 \times 10^{11} \ \mathrm{GeV}$$

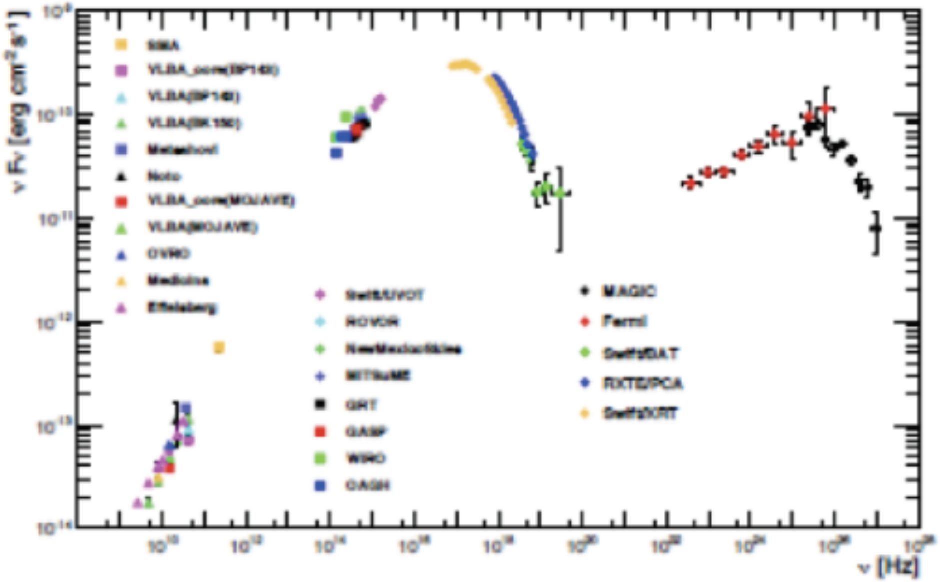
PKS 2155 -304

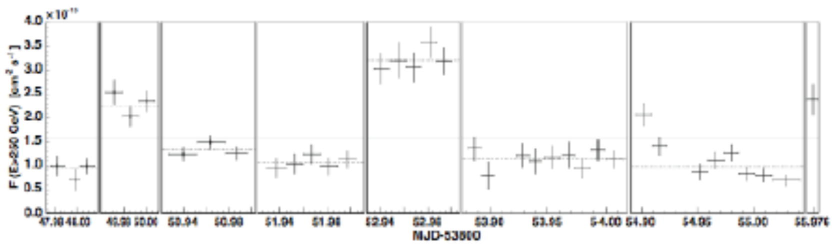


Aharonian et al 2007

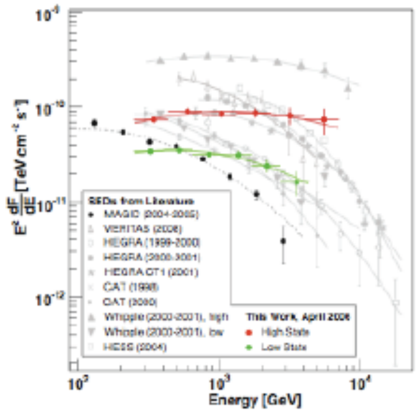
Contact with Fermi

+ Broadband radio-TeV Mrk421

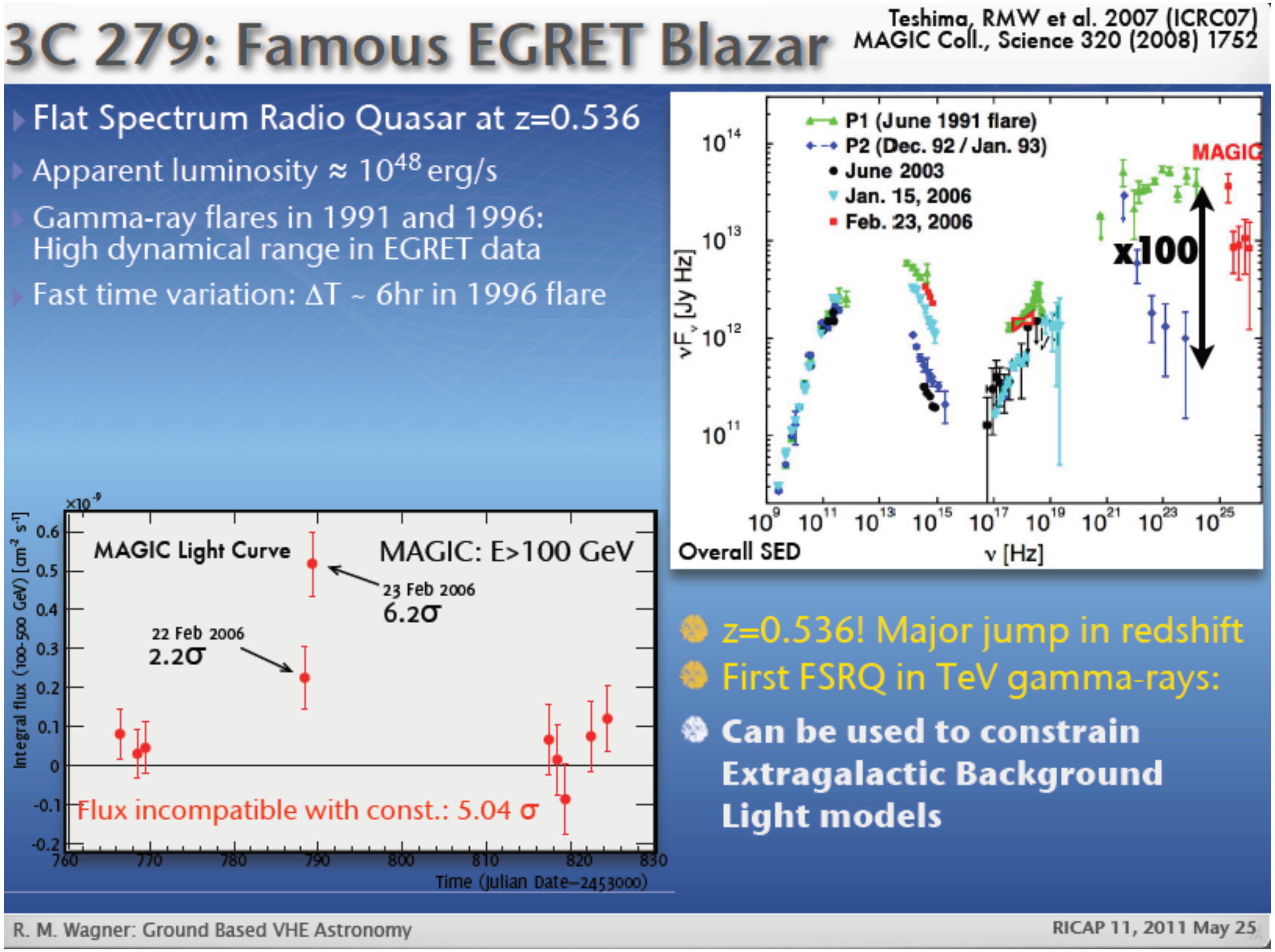




- 4.5 months campaign
- Most complete SED ever collected for Mrk421
- Total Fermi-MAGIC overlap over 5 decades in energy!
- HE-VHE connection!



3c279


3C 279: Famous EGRET Blazar
Teshima, RMW et al. 2007 (ICRC07)
MAGIC Coll., Science 320 (2008) 1752
Flat Spectrum Radio Quasar at z=0.536
Apparent luminosity ≈ 10^48 erg/s
Gamma-ray flares in 1991 and 1996: High dynamical range in EGRET data
Fast time variation: ΔT ~ 6hr in 1996 flare
P1 (June 1991 flare)
P2 (Dec. 92 / Jan. 93)
June 2003
Jan. 15, 2006
Feb. 23, 2006
MAGIC
x100
νF_ν [Jy Hz]
Overall SED
ν [Hz]
MAGIC Light Curve
MAGIC: E>100 GeV
23 Feb 2006
6.2σ
22 Feb 2006
2.2σ
Flux incompatible with const.: 5.04 σ
Integral flux (100-500 GeV) [cm^-2 s^-1]
Time (Julian Date−2453000)
z=0.536! Major jump in redshift
First FSRQ in TeV gamma-rays:
Can be used to constrain Extragalactic Background Light models
R. M. Wagner: Ground Based VHE Astronomy
RICAP 11, 2011 May 25

AGN

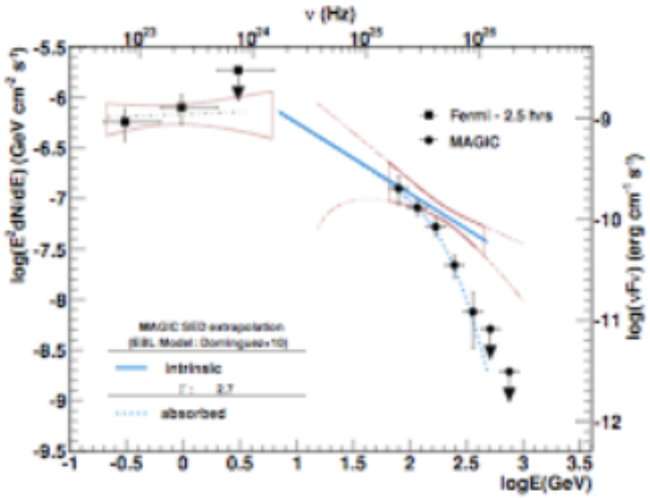
+ FSRQ PKS 1222+21 (4C21.35)

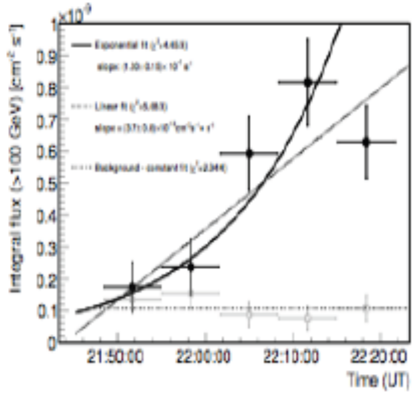
- Very good example of collaboration Fermi-IACTs (hard sources)
- Fermi Atel 2584 triggers MAGIC: 10.2 sigma detection in 0.5 h (1 Crab)
- 2nd farthest VHE source: z=0.432

- MAGIC+Fermi: can fit to single power-law -2.7(0.3) between 3 and 400 GeV
- No-sign of any cutoff
- Most rapid variation ever observed at VHE: Flux doubling-time 8.6min!

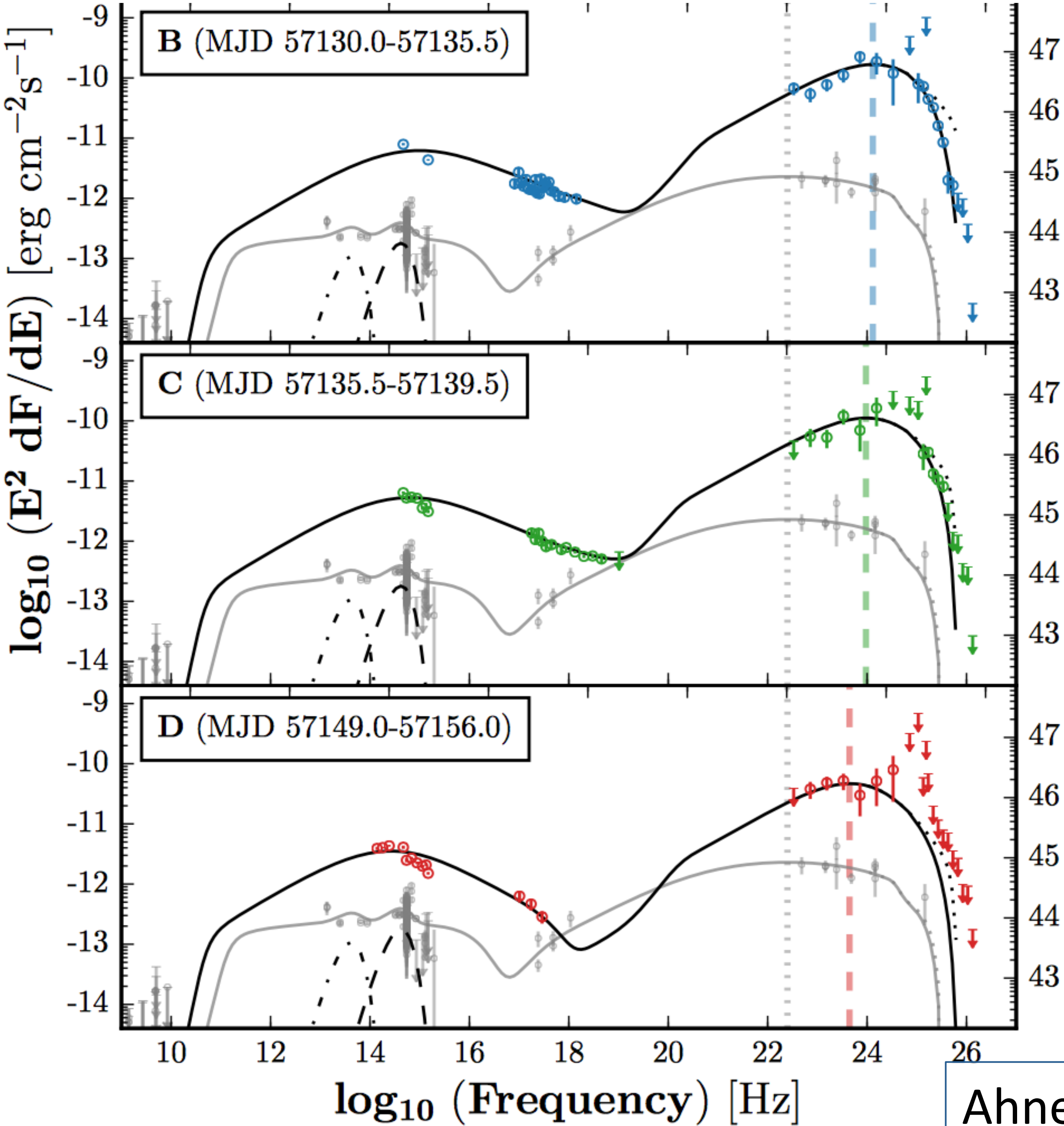
- Single spectrum → emission due to unique component
- No GeV cutoff → emission outside the BLR region, in the relativistic jet?
- Flux rapid variability→compact emission

- CHALLENGE TO EMISSION MODELS!





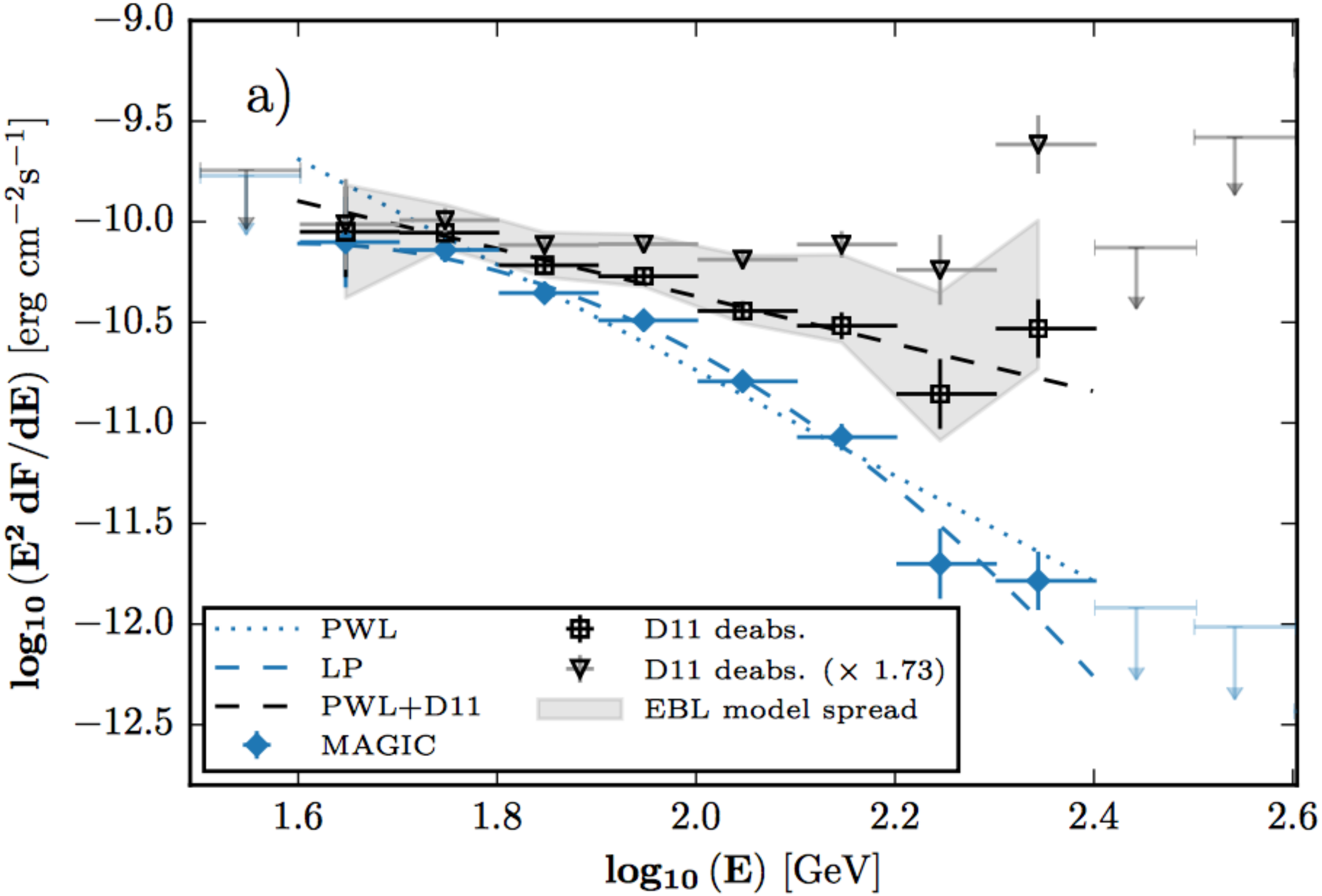
ApJL 730:L8 2011



PKS 1441+25
z=0.9397!

Ahnen et al 2016

PKS 1441+25
z=0.9397



Ahnen et al 2016

Lensed Blazar

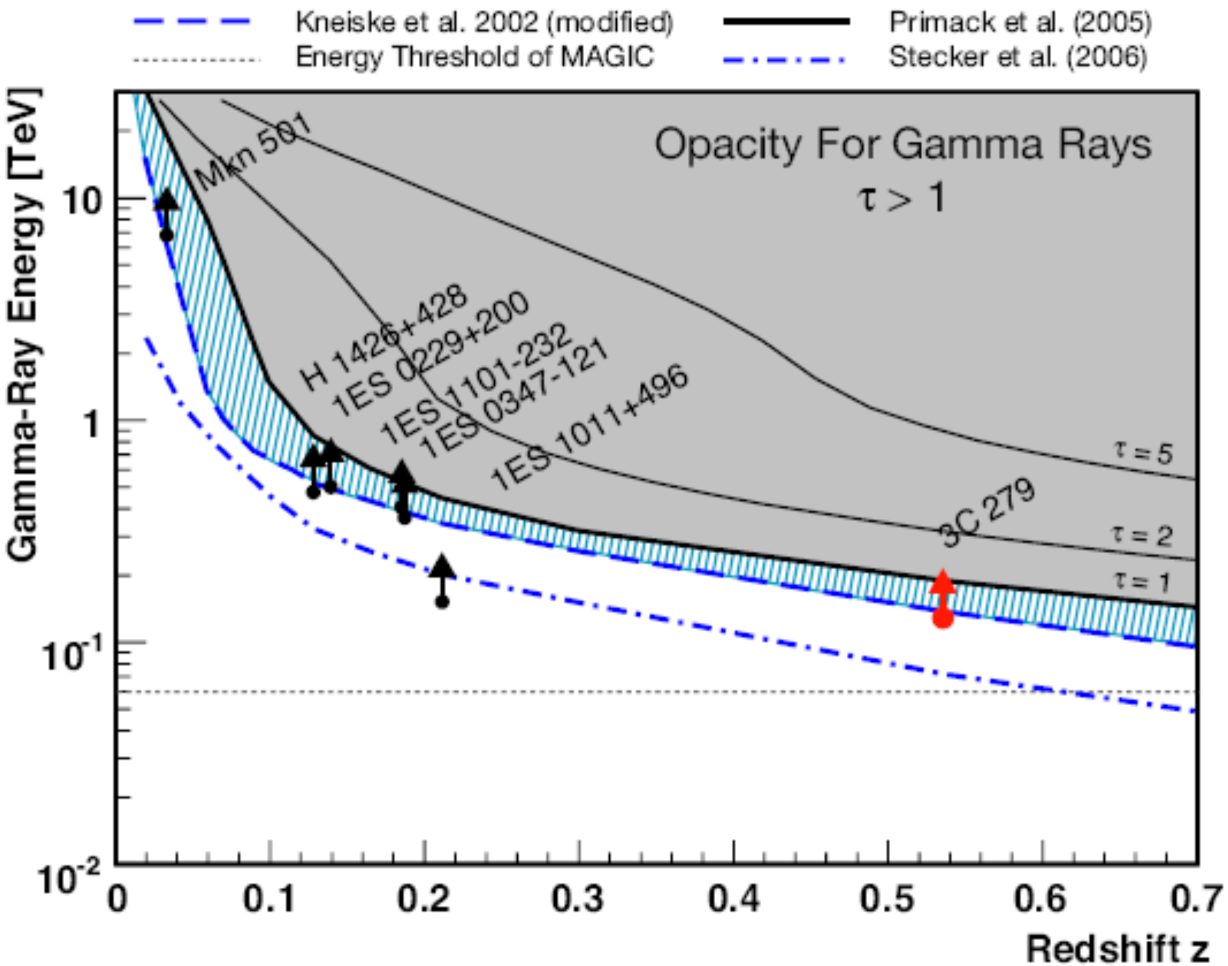
Discovery of Very High Energy Gamma-Ray Emission From Gravitationally Lensed Blazar S3 0218+357 With the MAGIC Telescopes

ATel #6349; ***Razmik Mirzoyan (Max-Planck-Institute for Physics) On Behalf of the MAGIC Collaboration***
on ***28 Jul 2014; 14:20 UT***
Credential Certification: Razmik Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de)

Subjects: Gamma Ray, >GeV, TeV, VHE, UHE, AGN, Blazar, Cosmic Rays, Microlensing Event

The MAGIC collaboration reports the discovery of very high energy (VHE; E>100 GeV) gamma-ray emission from S3 0218+357 (RA=02h21m05.5s, DEC=+35d56m14s, J2000.0). The object was observed with the MAGIC telescopes for a total of 3.5 hours from 2014/07/23 to 2014/07/26. The preliminary analysis of these data resulted in the detection of S3 0218+357 with a statistical significance of more than 5 standard deviations. From the preliminary analysis, we estimate the VHE flux of this detection to be about 15% of the flux from the Crab Nebula in the energy range 100-200 GeV. S3 0218+357 is a gravitationally lensed blazar located at the redshift of 0.944+/-0.002 (Cohen et al., 2003, ApJ, 583, 67). Fermi-LAT observations during the flaring state of S3 0218+357 in 2012 revealed a series of flares with their counterparts after 11.46+/-0.16 days delay, interpreted as due to the gravitational lensing effect (Cheung et al. 2014, ApJ, 782, L14). On 2014 July 13 and 14 Fermi-LAT detected another flaring episode (ATel #6316). Due to the full-moon time, the MAGIC telescopes were not operational and could not observe S3 0218+357 after the original alert. However, observations scheduled at the expected time of arrival of the gravitationally lensed component led to the first significant detection of a gravitationally lensed blazar and the most distant source detected at VHE with Cherenkov telescopes to date. MAGIC observations on S3 0218+357 will continue during the next days and multiwavelength observations are encouraged. The MAGIC contact persons for these observations are R. Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de) and J. Sitarek (jsitarek@ifae.es). MAGIC is a system of two 17m-diameter Imaging Atmospheric Cherenkov Telescopes located at the Canary island of La Palma, Spain, and designed to perform gamma-ray astrophysics in the energy range from 50 GeV to greater than 50 TeV.

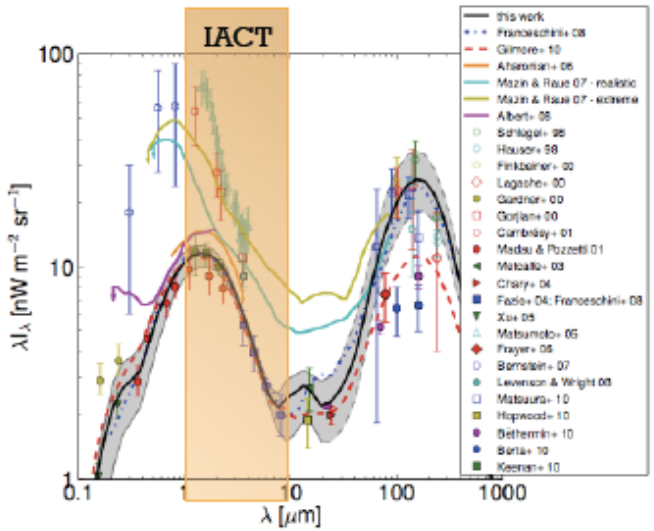
MAGIC – EBL measurements

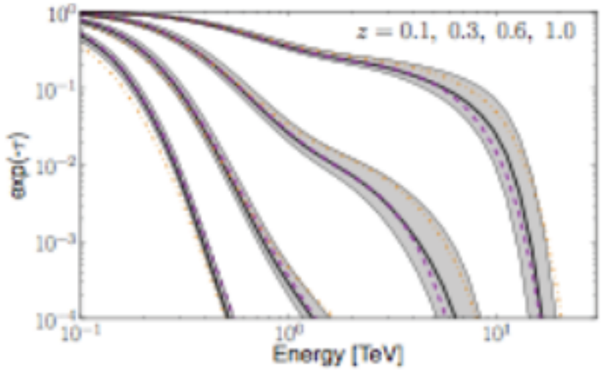


Albert et al. 2008

EBL measurements

+ Gamma-ray horizon





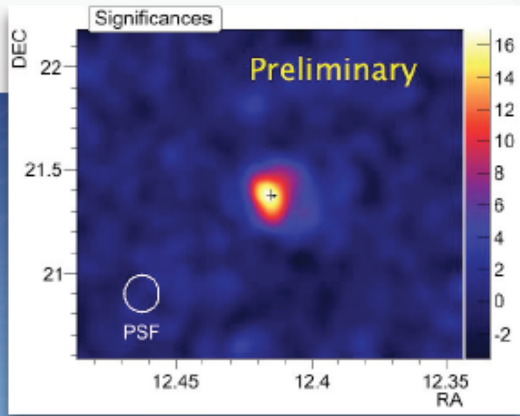
- VHE gamma-ray interacting with UV and far-IR photons, may pair produce:
  - Optical depth $\tau=\tau(E,z)$
- Distant AGNs are optimal targets (if distance is known):
  - 3C279 (z=0.536)
  - 3C66A (z=0.444?)
  - PG1553+113 (z=0.4)
  - S5 0716+714 (z=0.310?)
  - ...
- Absorption above 100 GeV makes observed spectrum:
  - Softer (steeper)
  - Difficult to observe
- IACT observation already constrained models to their minimum allowance (universe is more transparent)
- Distant AGNs are monitored by M-stereo (PG1553, 3C279)

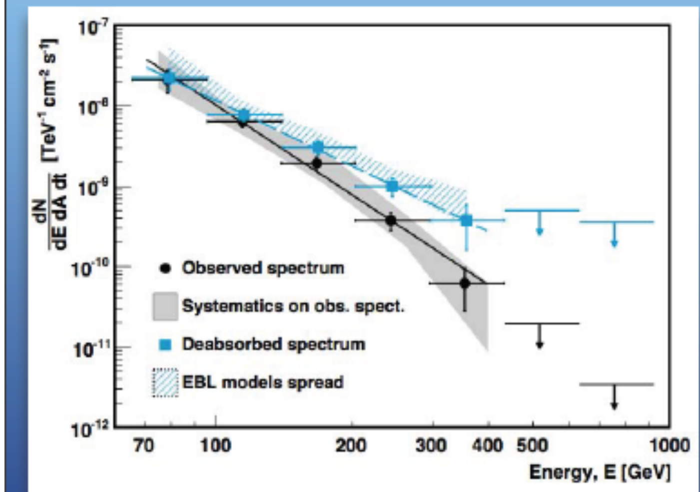
EBL measurements

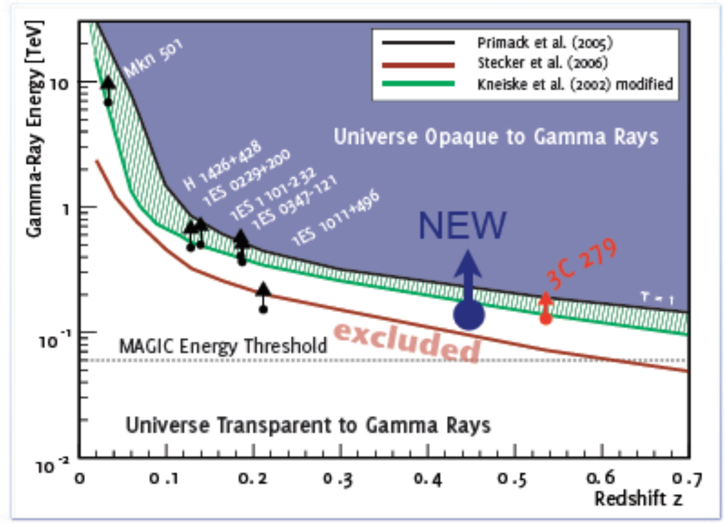
4C +21.35 aka PKS 1222+21

MAGIC Coll., A&A subm.

- 2010 June 17, flare state
- PKS 1222+21 (4C +21.35) is a high redshift (z=0.43) FSRQ
  (only 3C279, PKS1510-089 so far)
- Observations triggered by a high state reported by Fermi-LAT
- Can be used for EBL studies







Science 320 (2008) 1752

Photon – Axion Oscillation

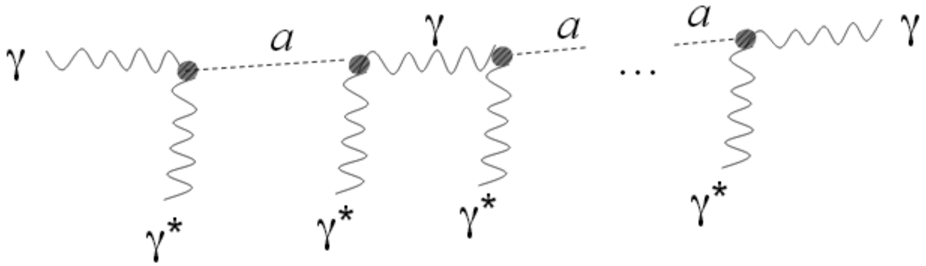
Axion Like Particle (ALP)

One intriguing possibility that have been recently proposed (DeAngelis-Mansutti-Roncadelli, 2007; DeAngelis-Mansutti-Persic-Roncadelli, 2008) is that conversion of γ's into axions into the random extragalactic magnetic fields give rise to a sort of cosmic *light-shining through wall* effect.

Axions have been introduced by Peccei & Quinn to solve the strong CP problem. Axion like particles with aγγ coupling are predicted in many extensions of the Standard Model. Pseudoscalar axions couple with the EM field through the effective Lagrangian

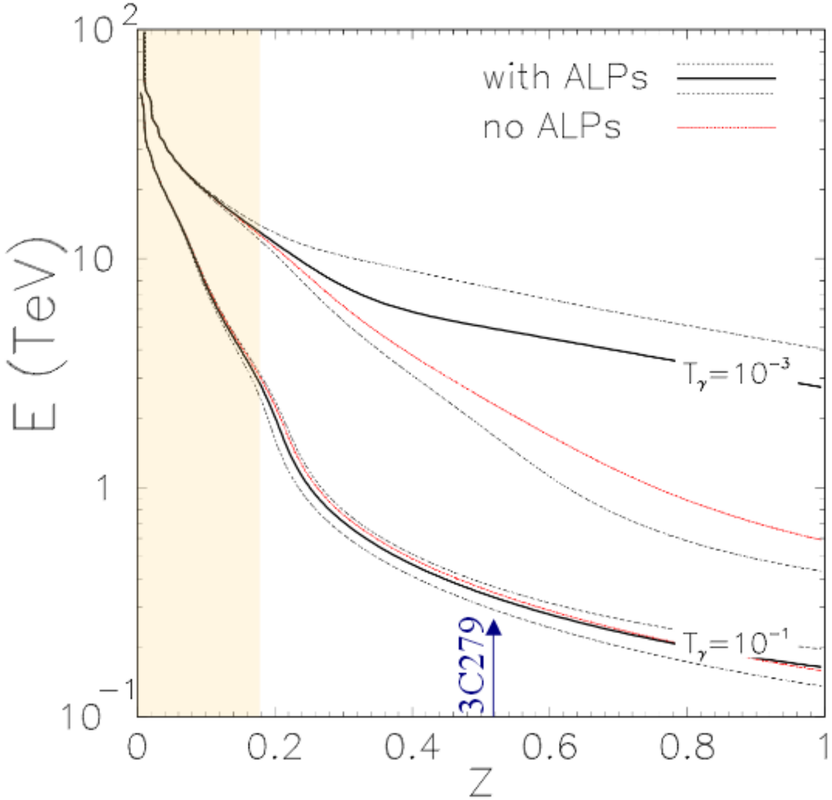
$$\mathcal{L}_{a\gamma} = -\frac{1}{4} g_{a\gamma} F_{\mu\nu} \tilde{F}^{\mu\nu} a$$

Photons propagating in an external magnetic field can undergo to photon-axion oscillations



Photon – Axion Oscillation

Realistic transfer function



For $z \leq 0.2$ the inclusion of the ALPs does not produce any significant change in the photon transfer function. Thus, it would be difficult to interpret in terms of ALP conversions the presumed transparency to gamma radiations for the sources at $z = 0.165$ and $z = 0.186$.

Conversely, ALP conversions could play a significant role for the source 3C279 at redshift $z = 0.54$

GRB repoint

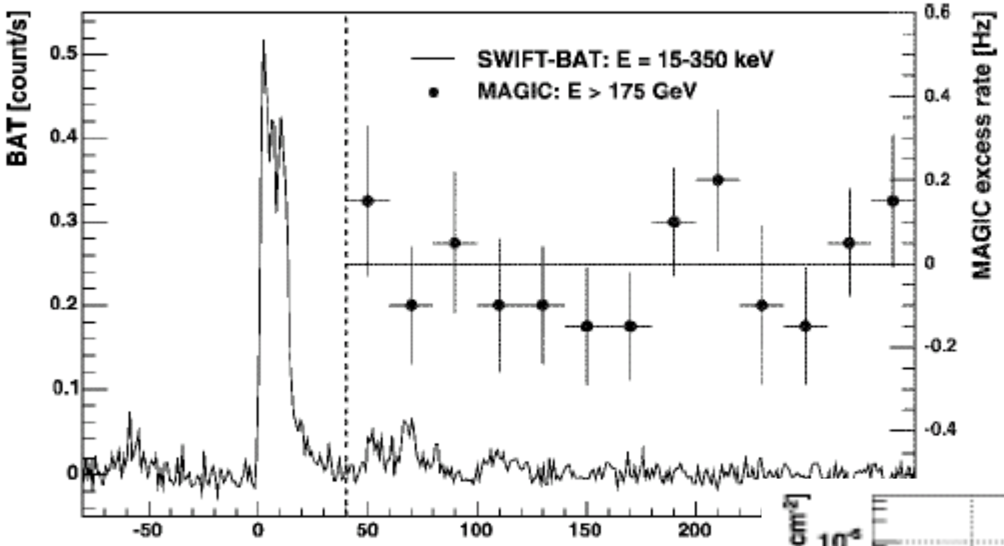
Current satellites giving alerts in short time: *FERMI, INTEGRAL, SWIFT*

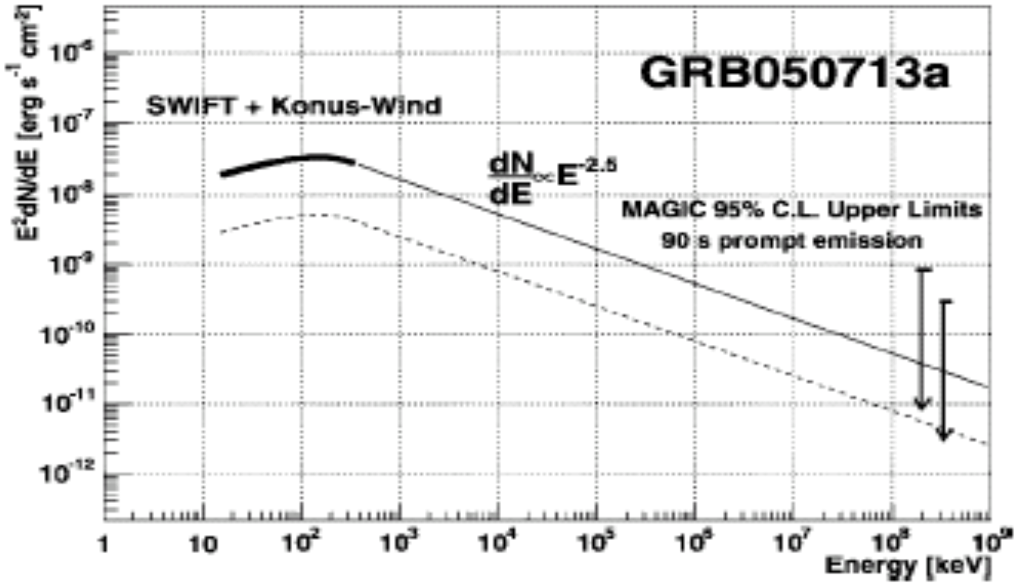
Delays of alerts from less than 10s to some minutes

Very fast repositioning capabilities are therefore requested:

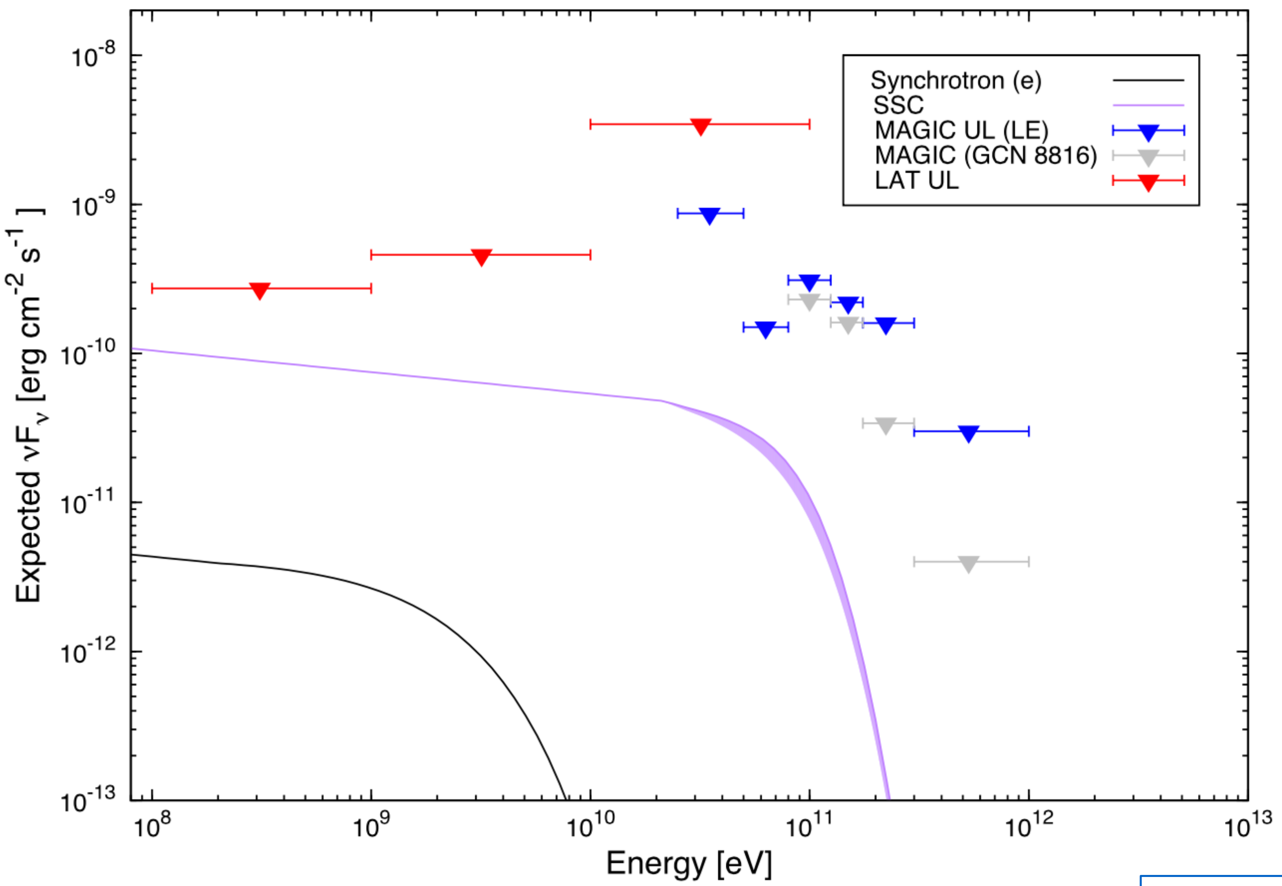
10 to 20 seconds!

GRBs


BAT [count/s]
MAGIC excess rate [Hz]
SWIFT-BAT: E = 15-350 keV
MAGIC: E > 175 GeV


GRB050713a
SWIFT + Konus-Wind
$\frac{dN}{dE} \propto E^{-2.5}$
MAGIC 95% C.L. Upper Limits
90 s prompt emission
E^2dN/dE [erg s^{-1} cm^{-2}]
Energy [keV]

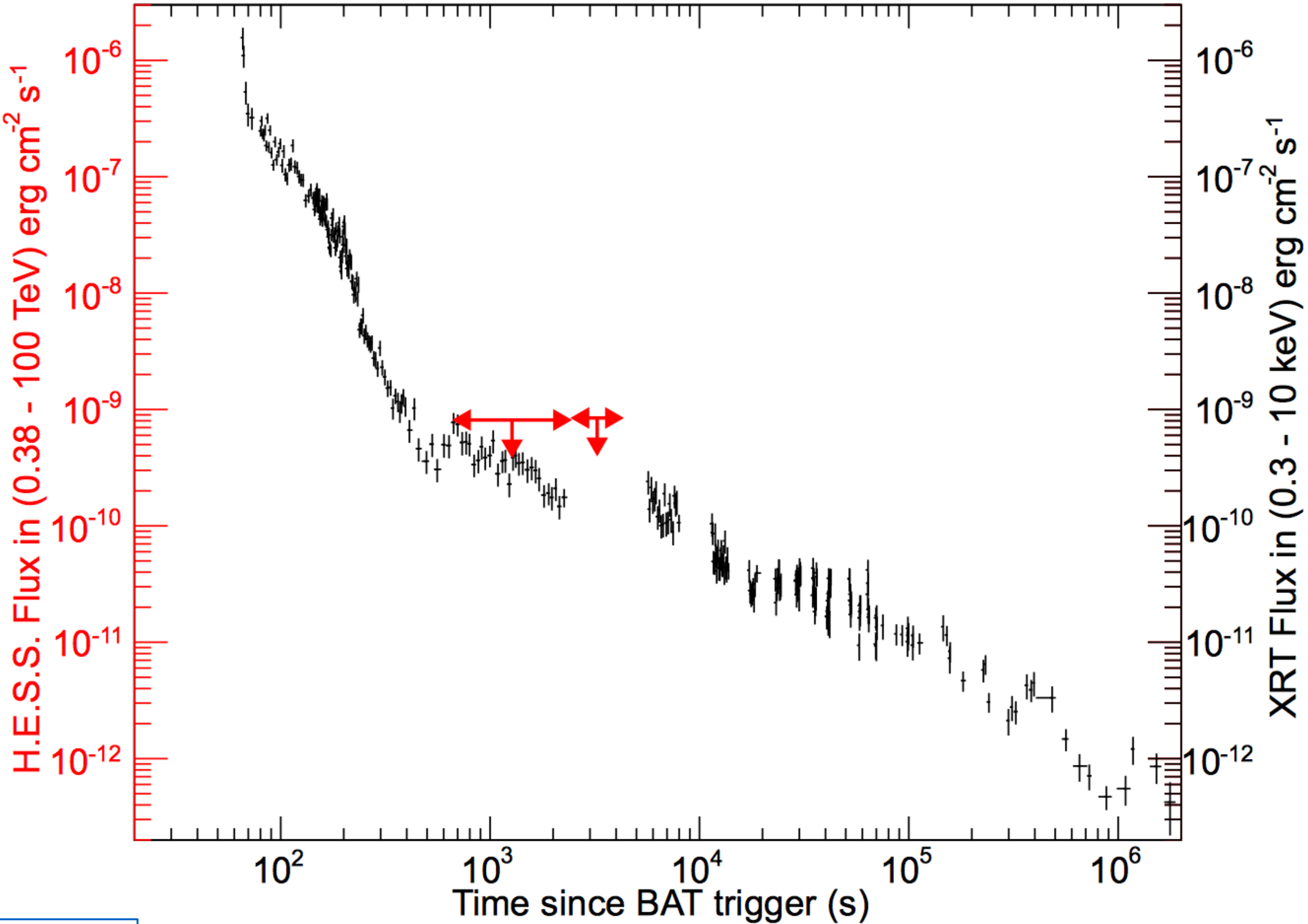
MAGIC– I upper limits



GRB 090102

J. Aleksic et al., 2014

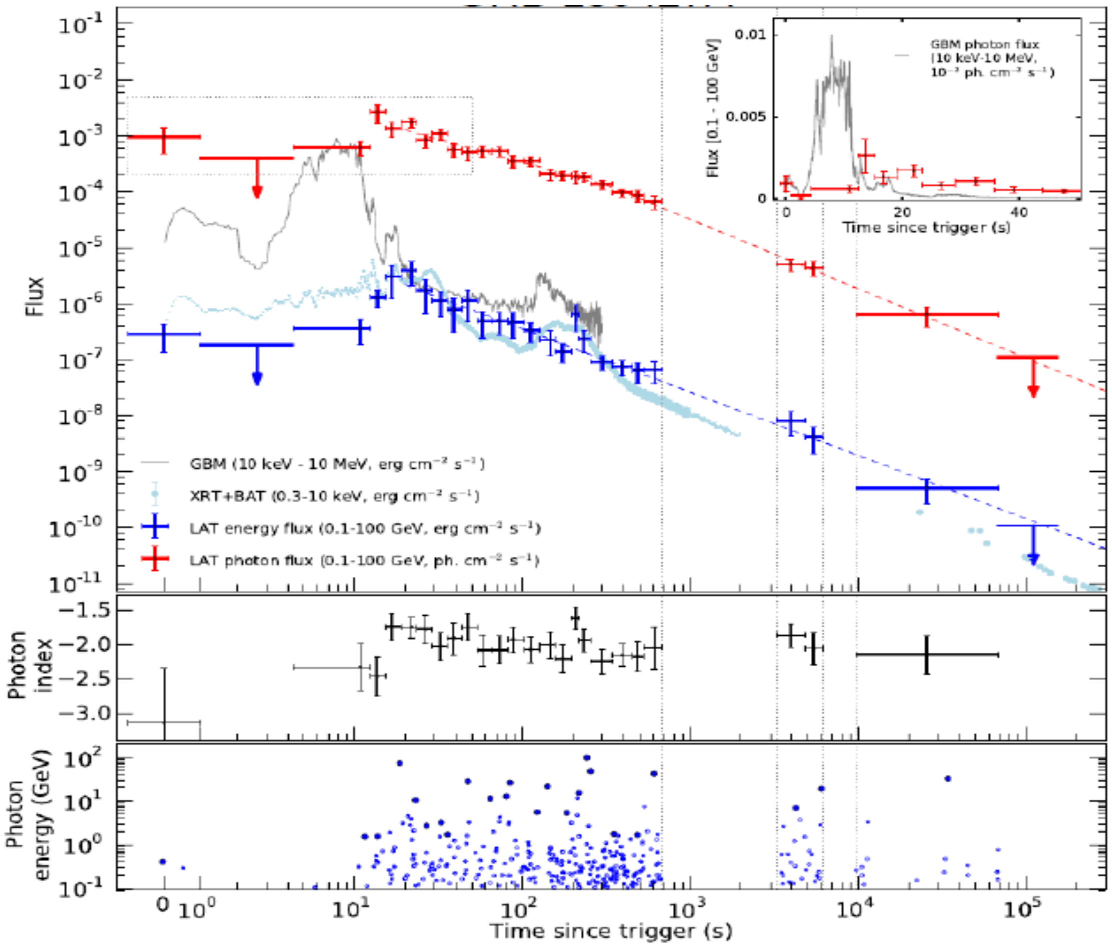
HESS - I upper limits



GRB 100621A

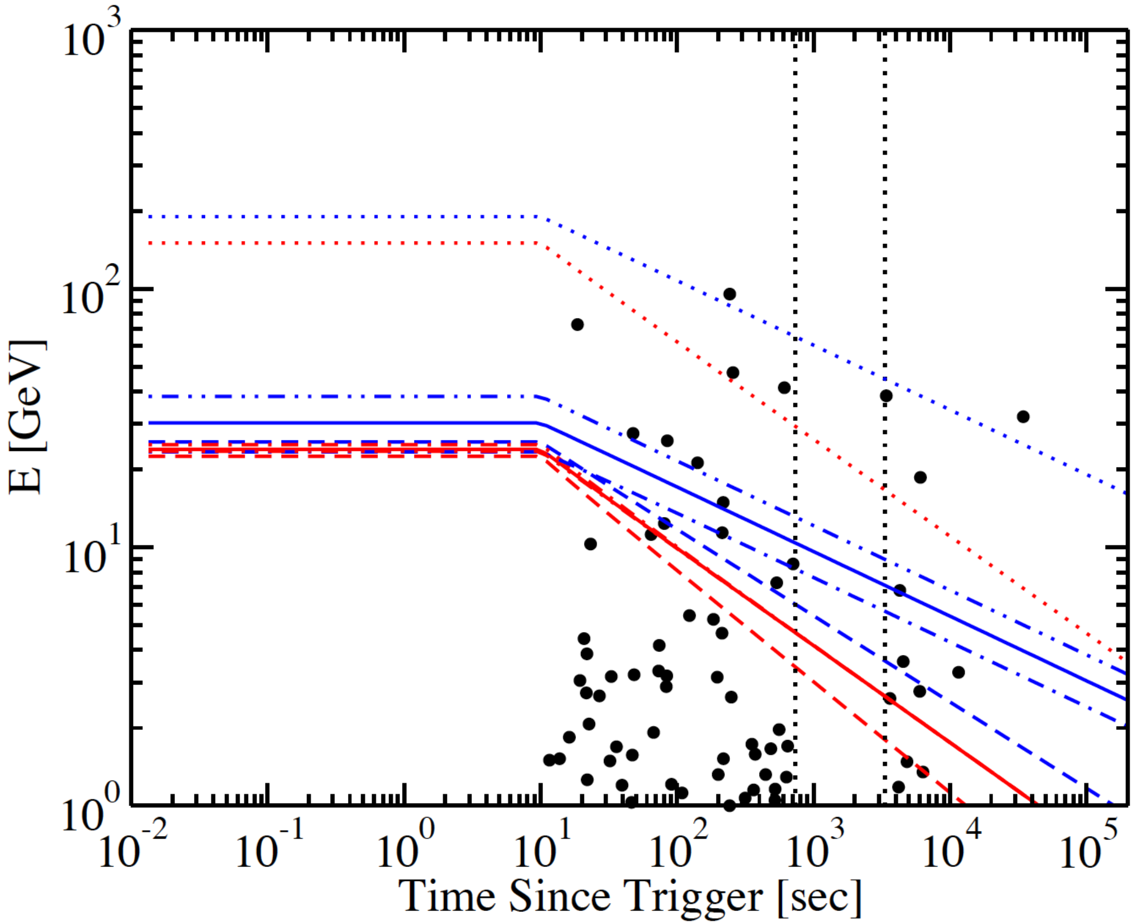
Abramowski et al. 2014

GRB 130427A



in today poster session
(Ackermann et al.,
Science, Vol. 343 no. 6166
pp. 42-47)

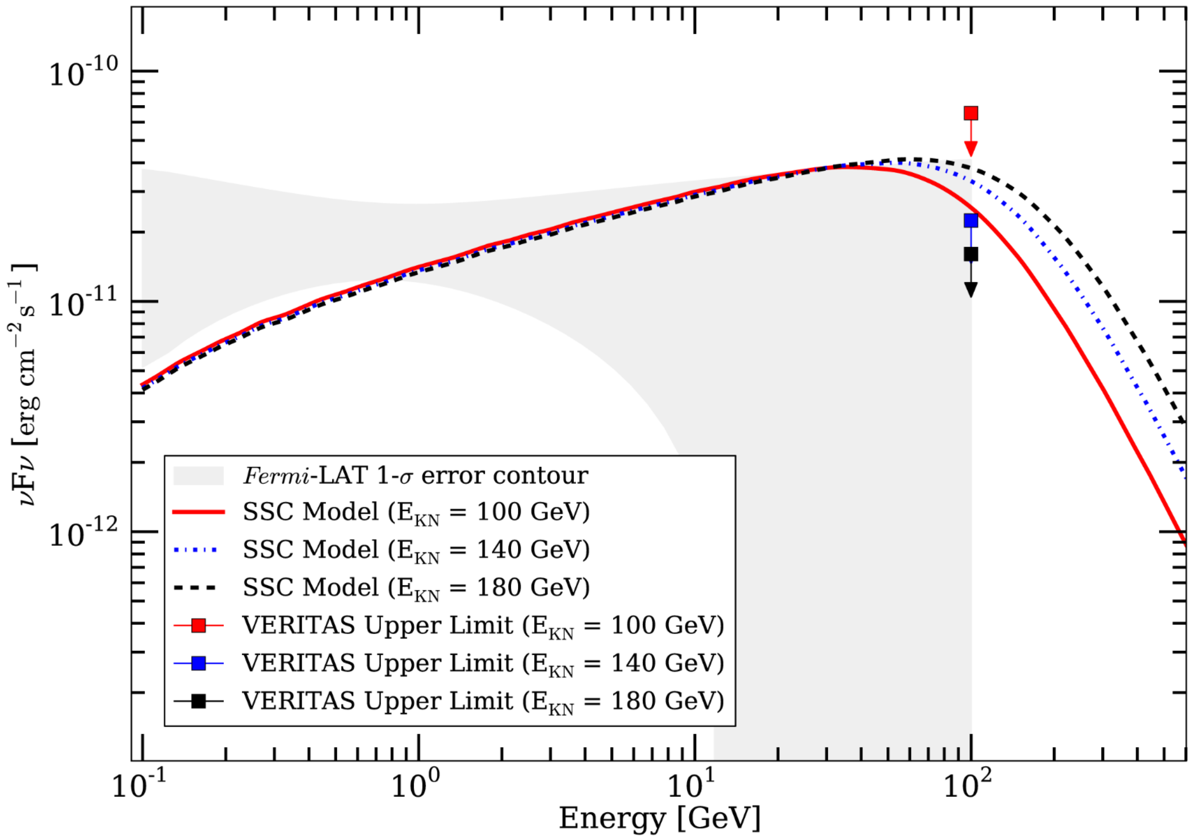
GRB VHE emission. Single photons matter



GRB 130427A

Ackermann et al. 2014

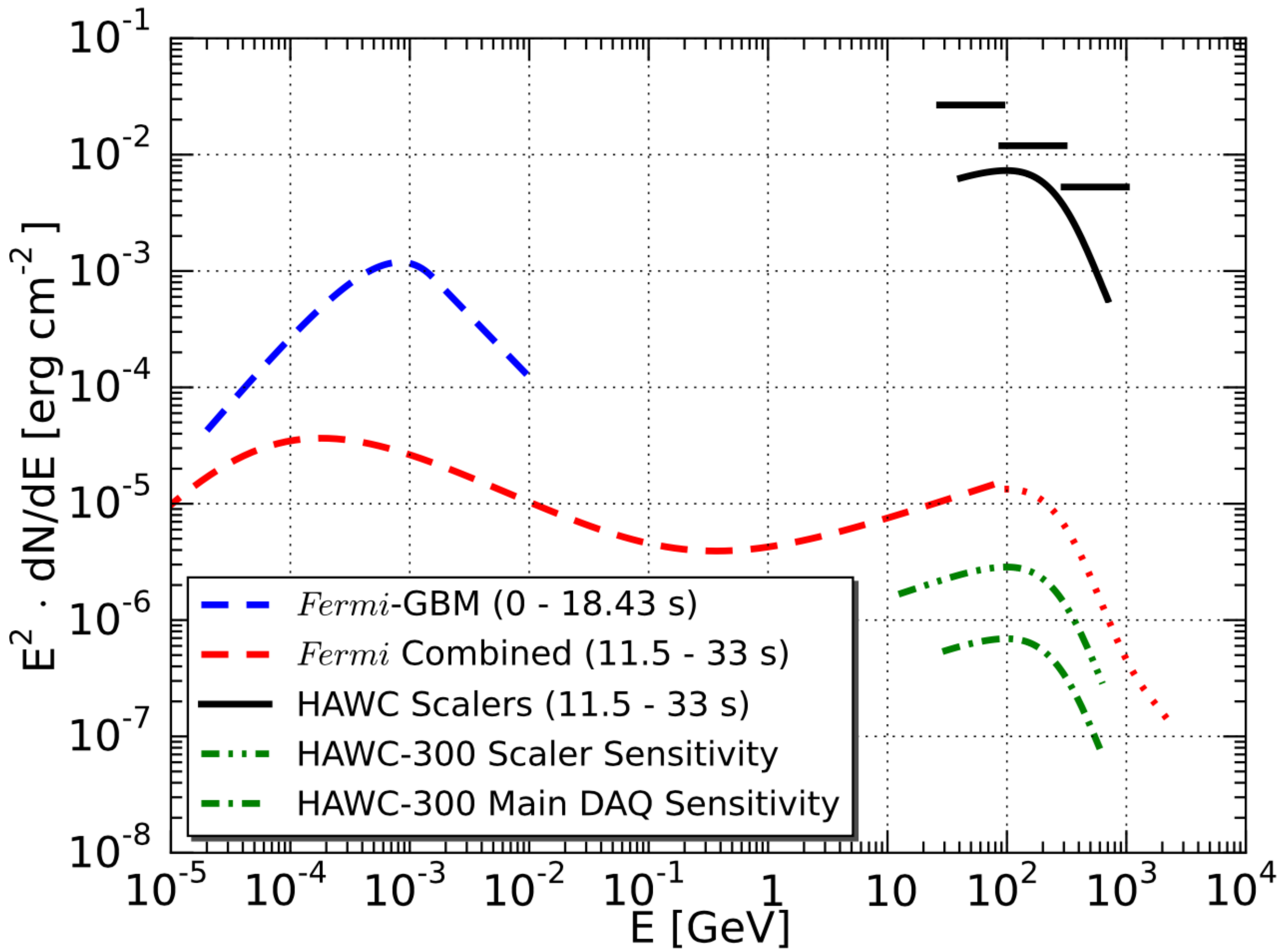
VERITAS upper limits



GRB 130427A

Aliu et al. 2014

HAWC upper limits



Abeysekara et al. 2015

GRB 130427A

MAGIC detection

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)

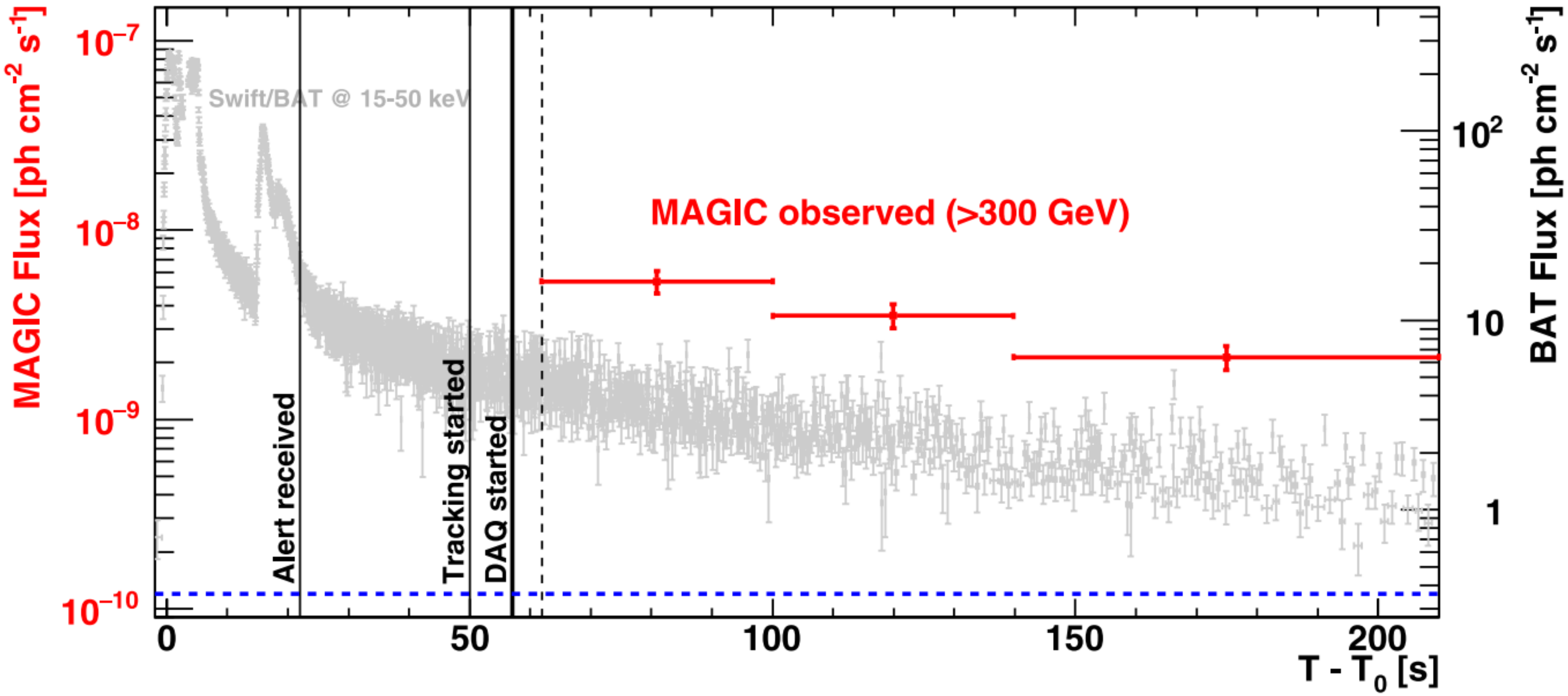
Subjects: Gamma Ray, >GeV, TeV, VHE, Request for Observations, Gamma-Ray Burst

Referred to by ATel #: 12395, 12475

Tweet

The MAGIC telescopes performed a rapid follow-up observation of GRB 190114C (Gropp et al., GCN 23688; Tyurina et al., GCN 23690, de Ugarte Postigo et al., GCN 23692, Lipunov et al. GCN 23693, Selsing et al. GCN 23695). This observation was triggered by the Swift-BAT alert; we started observing at about 50s after Swift T0: 20:57:03.19. The MAGIC real-time analysis shows a significance >20 sigma in the first 20 min of observations (starting at T0+50s) for energies >300GeV. The relatively high detection threshold is due to the large zenith angle of observations (>60 degrees) and the presence of partial Moon. Given the brightness of the event, MAGIC will continue the observation of GRB 190114C until it is observable tonight and also in the next days. We strongly encourage follow-up observations by other instruments. The MAGIC contact persons for these observations are R. Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de) and K. Noda (nodak@icrr.u-tokyo.ac.jp). MAGIC is a system of two 17m-diameter Imaging Atmospheric Cherenkov Telescopes located at the Observatory Roque de los Muchachos on the Canary island La Palma, Spain, and designed to perform gamma-ray astronomy in the energy range from 50 GeV to greater than 50 TeV.

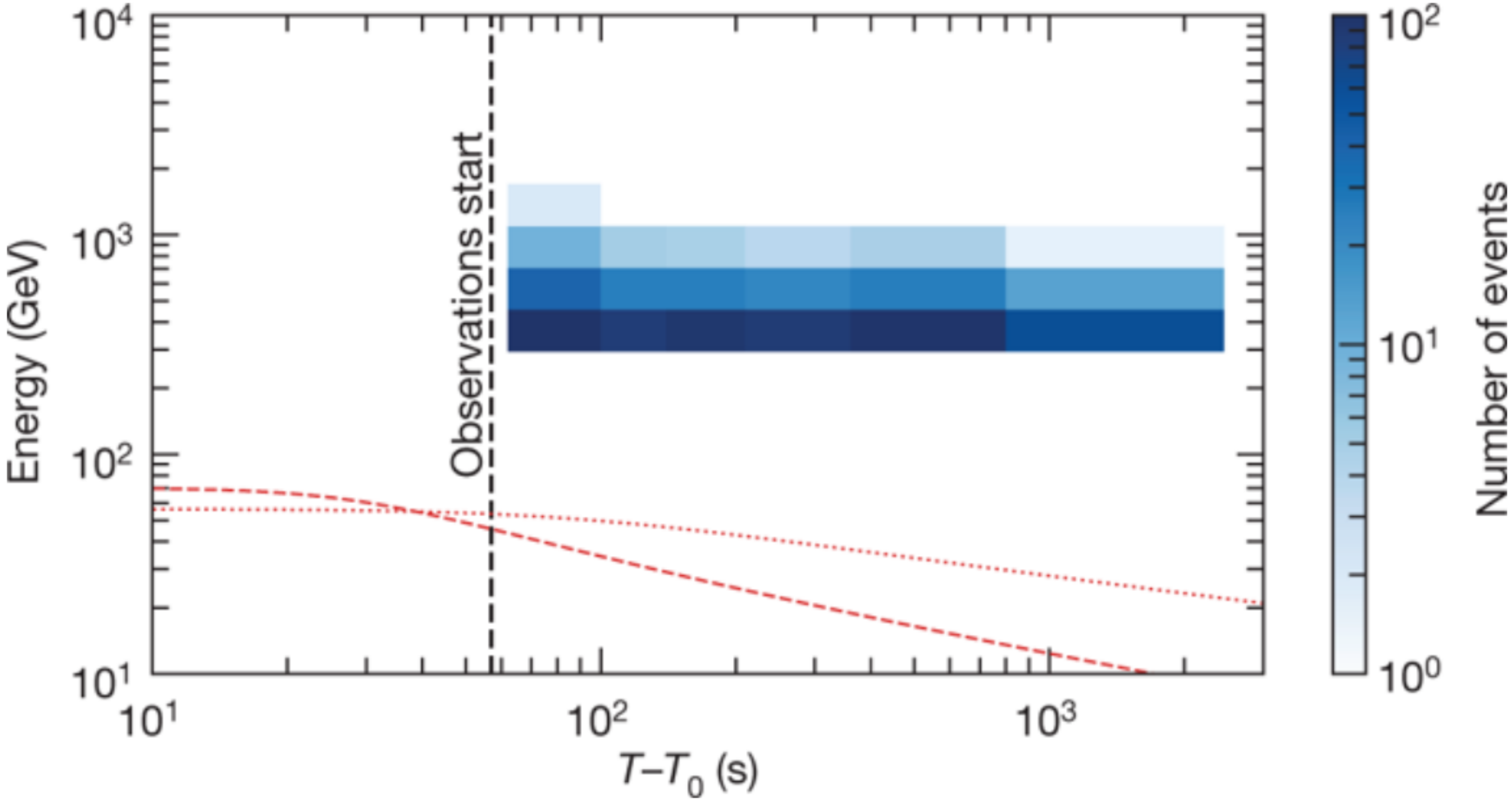
MAGIC detection



GRB 190114C

Acciari et al. 2019a

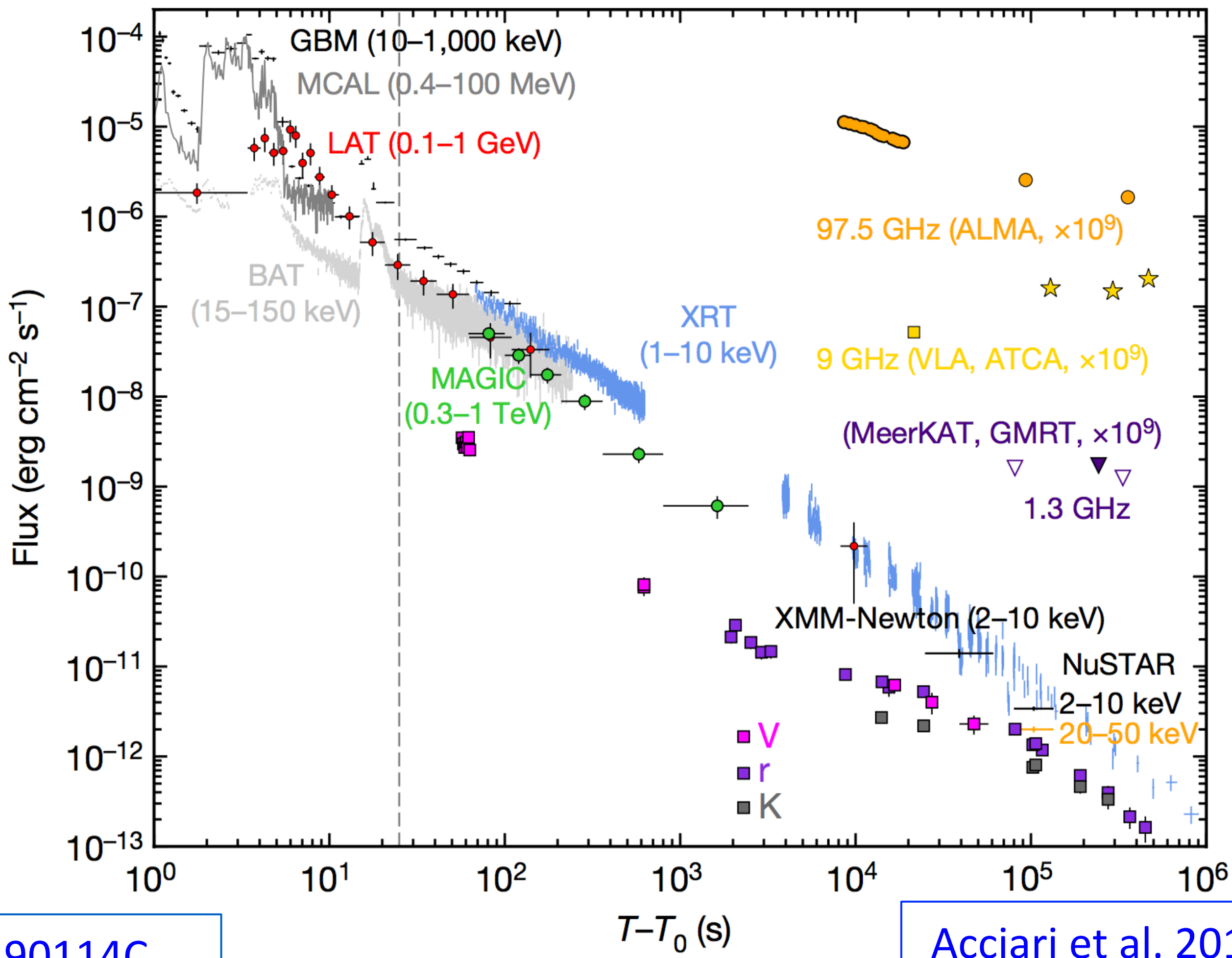
MAGIC detection



GRB 190114C

Acciari et al. 2019a

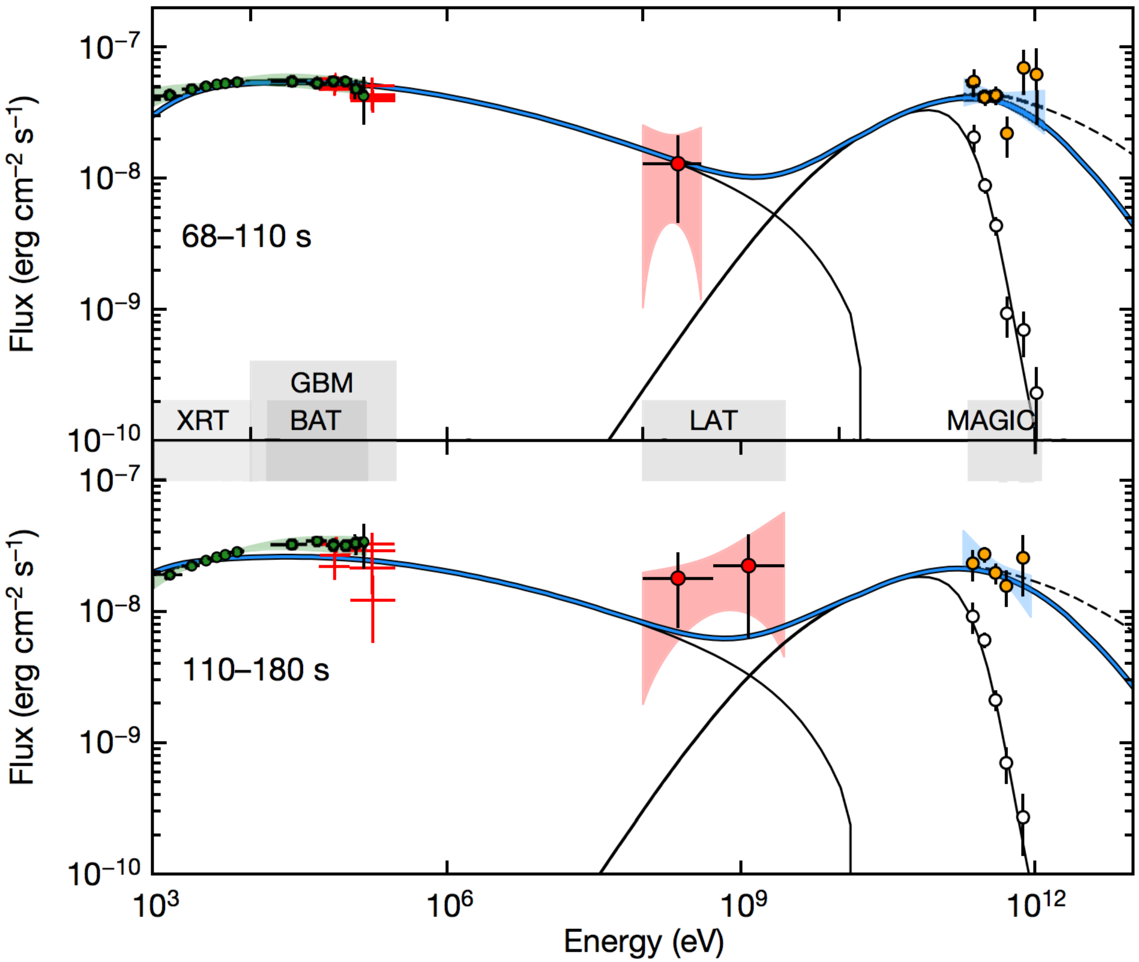
MAGIC detection



GRB 190114C

Acciari et al. 2019b

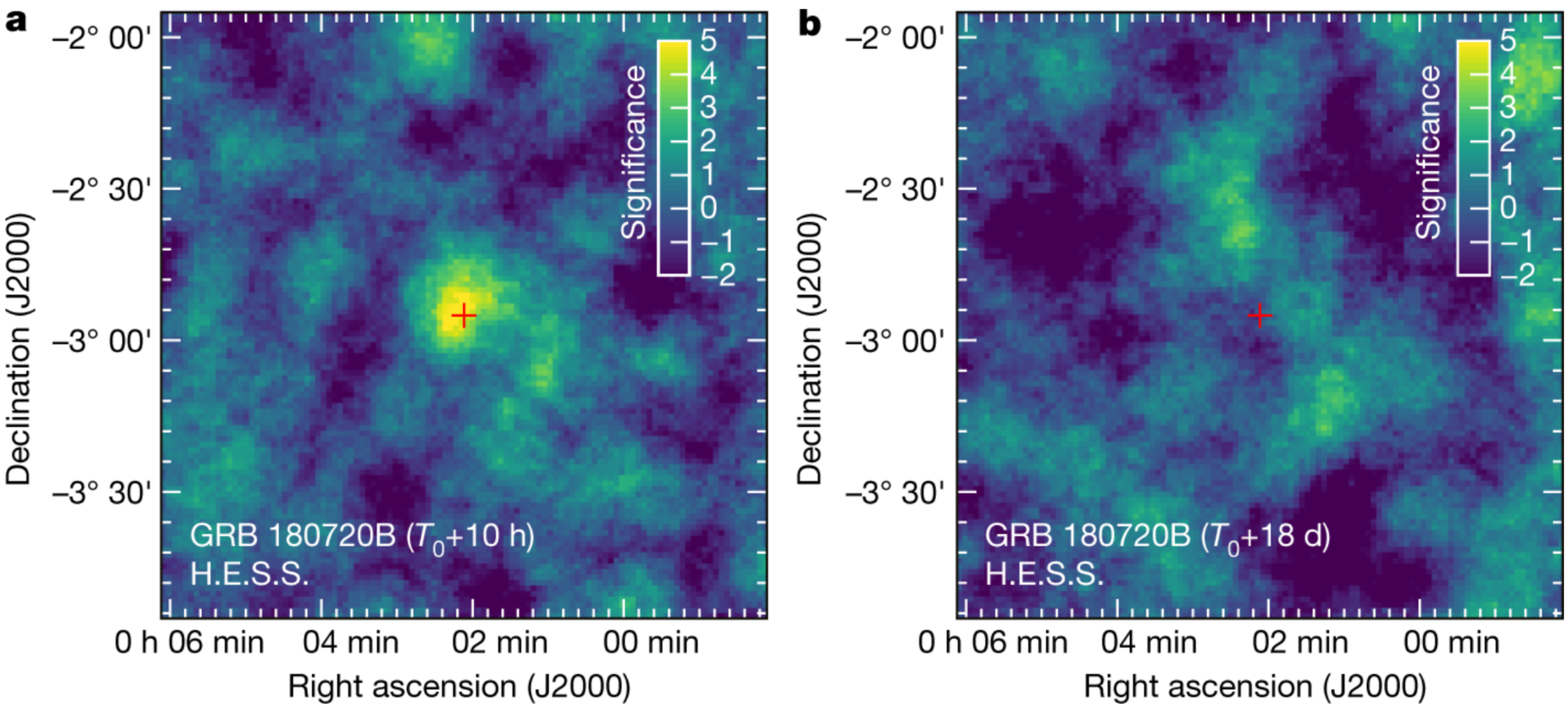
MAGIC detection



GRB 190114C

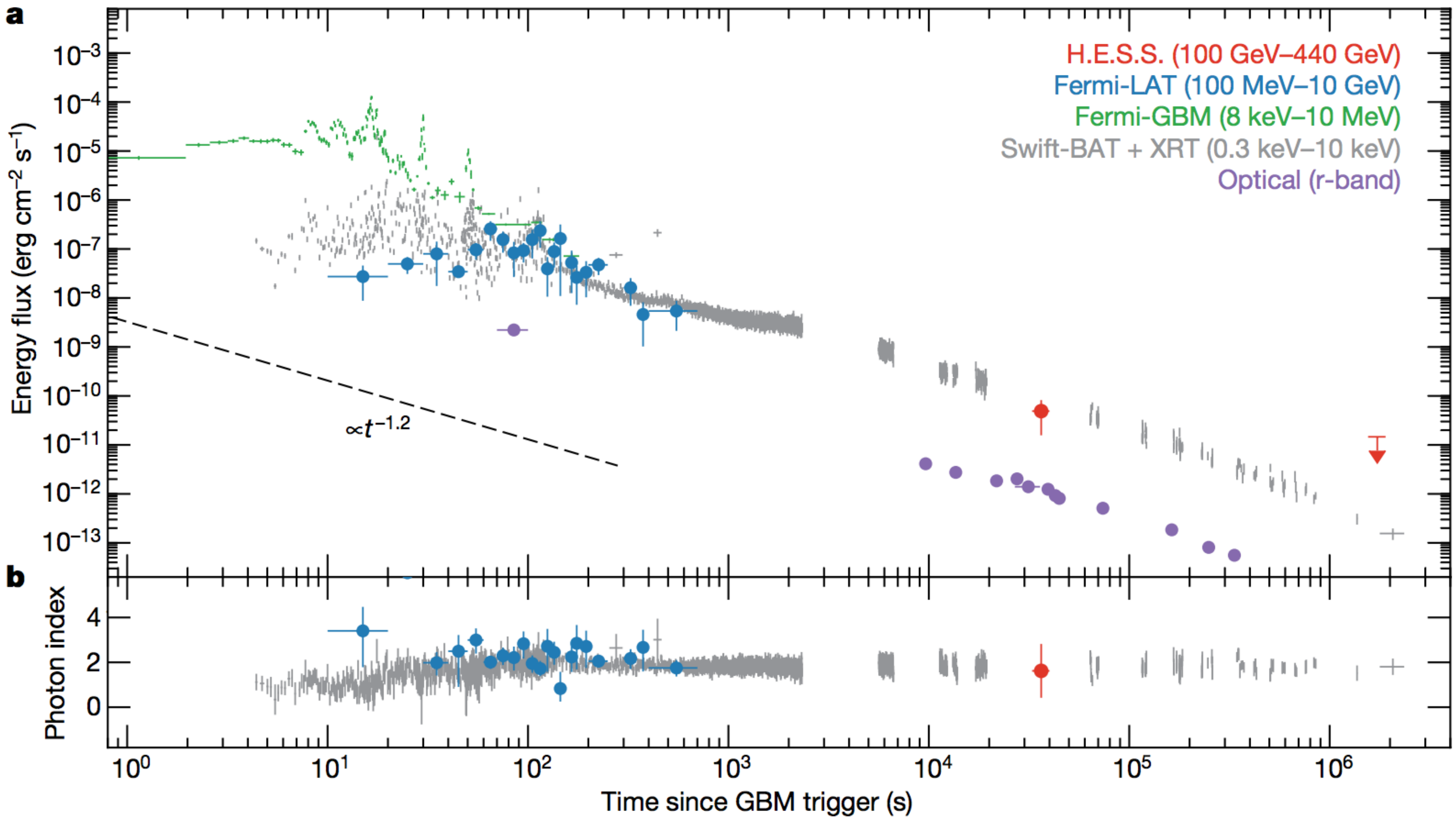
Acciari et al. 2019b

HESS detection



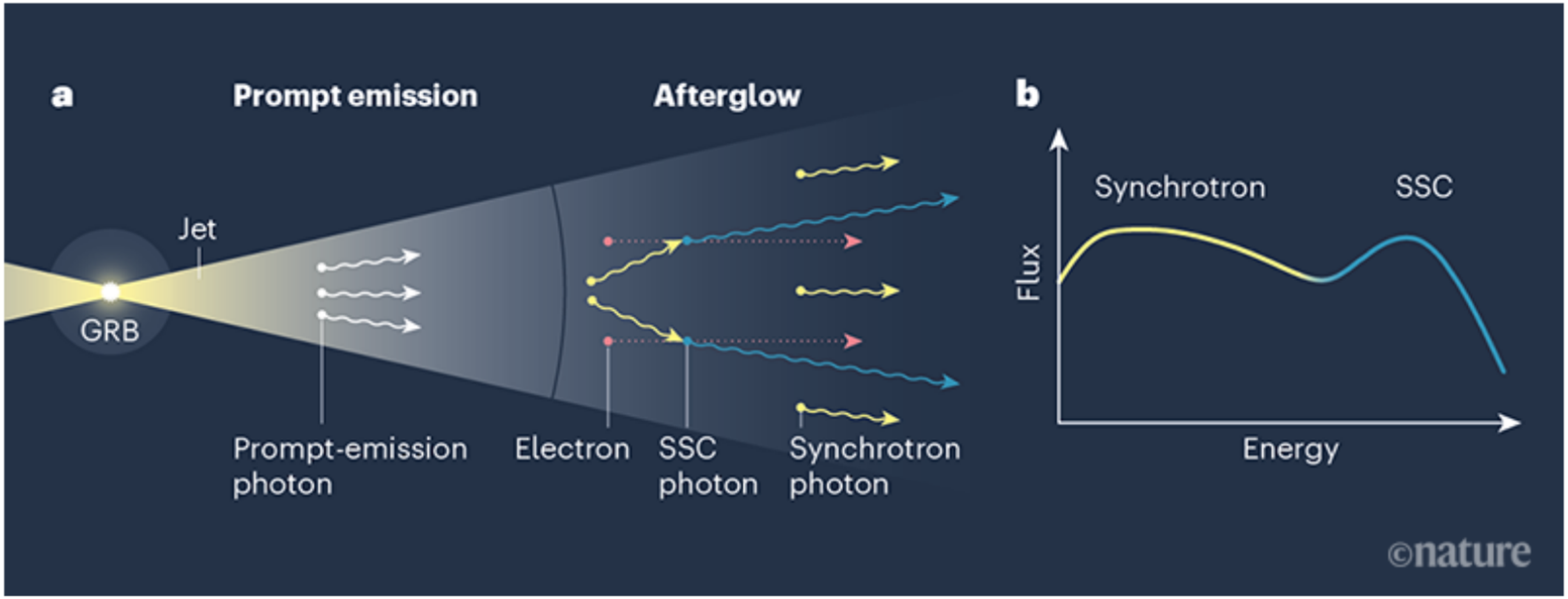
Abdalla et al 2019

HESS detection



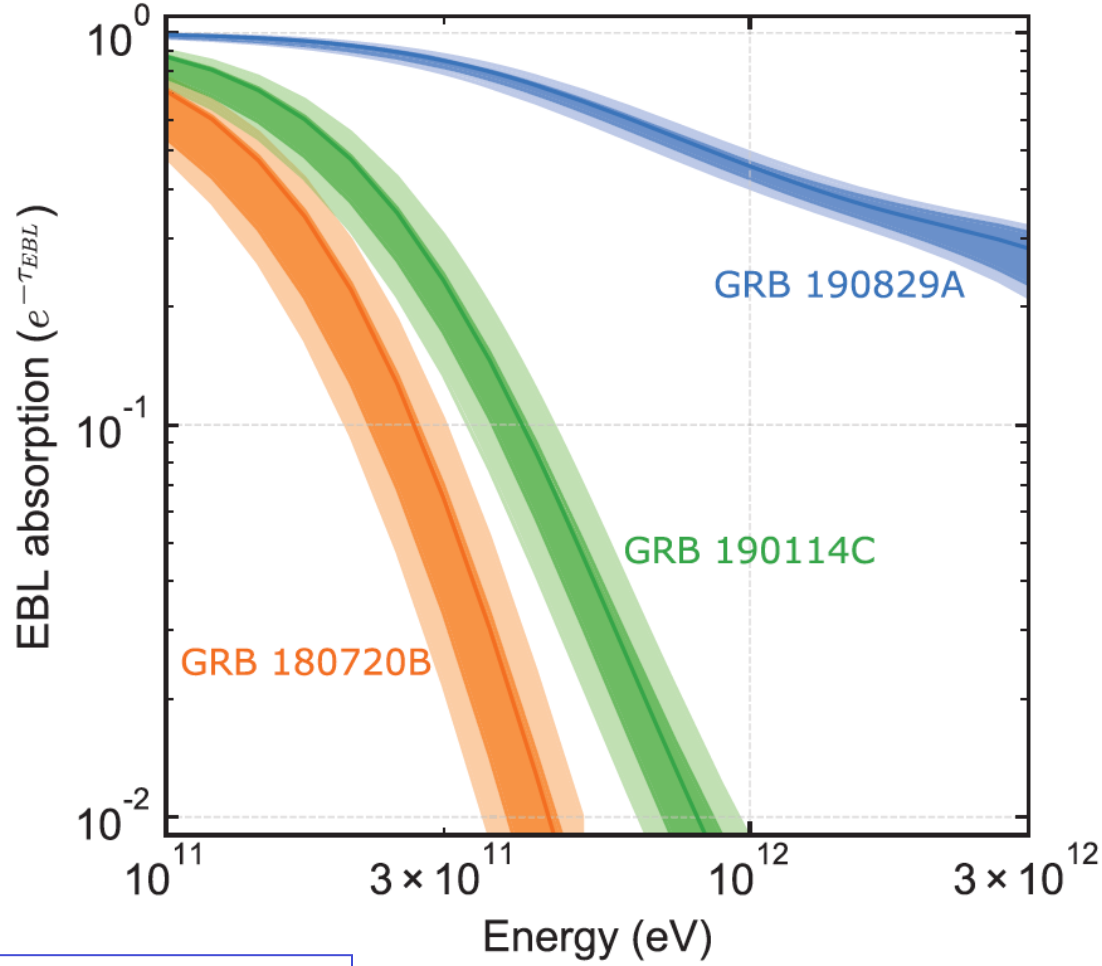
Abdalla et al 2019

MAGIC & HESS detection



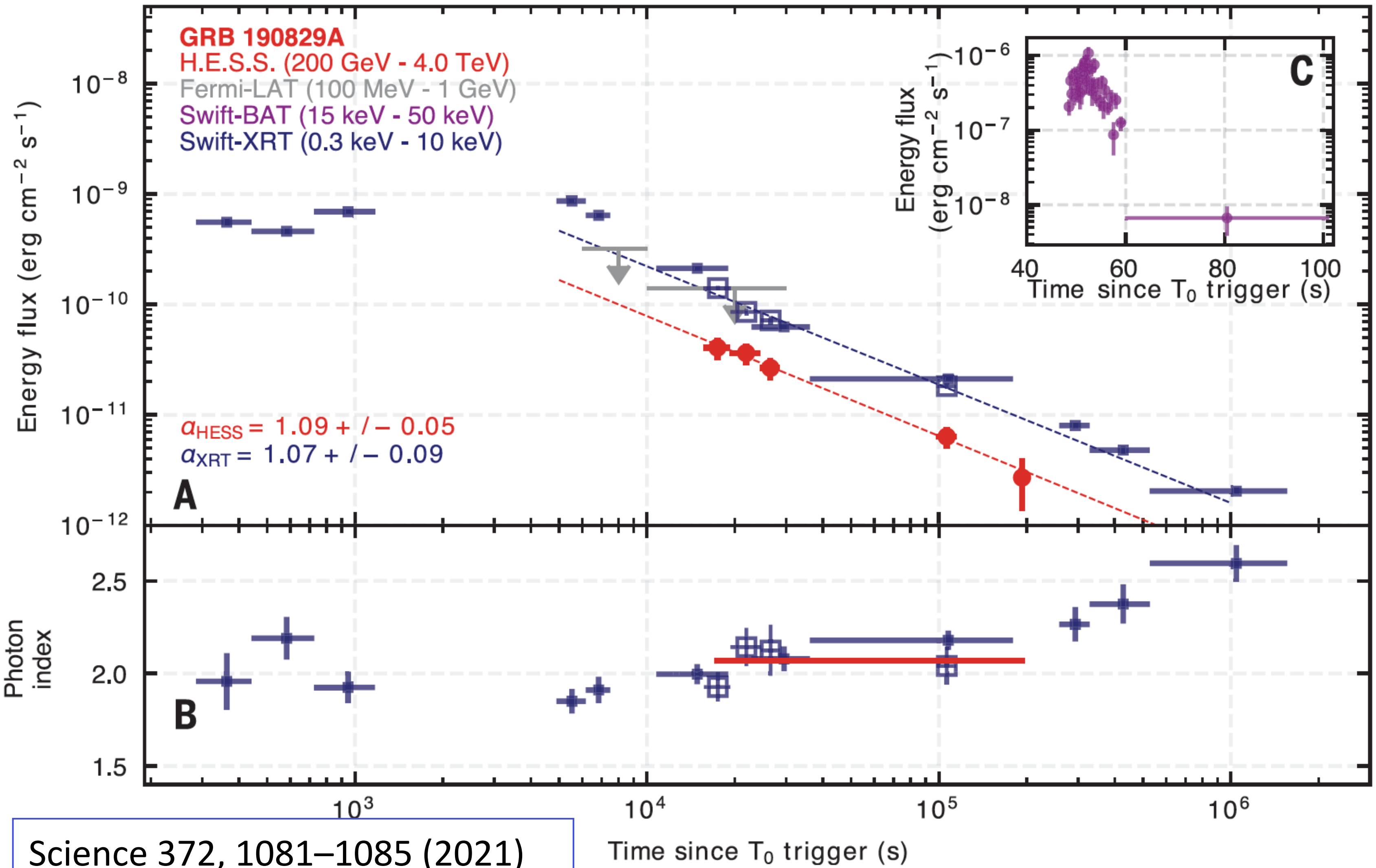
Zhang B., Nature News & Views (20/11/2019)

GRBs @ VHE ! – GRB 190829A



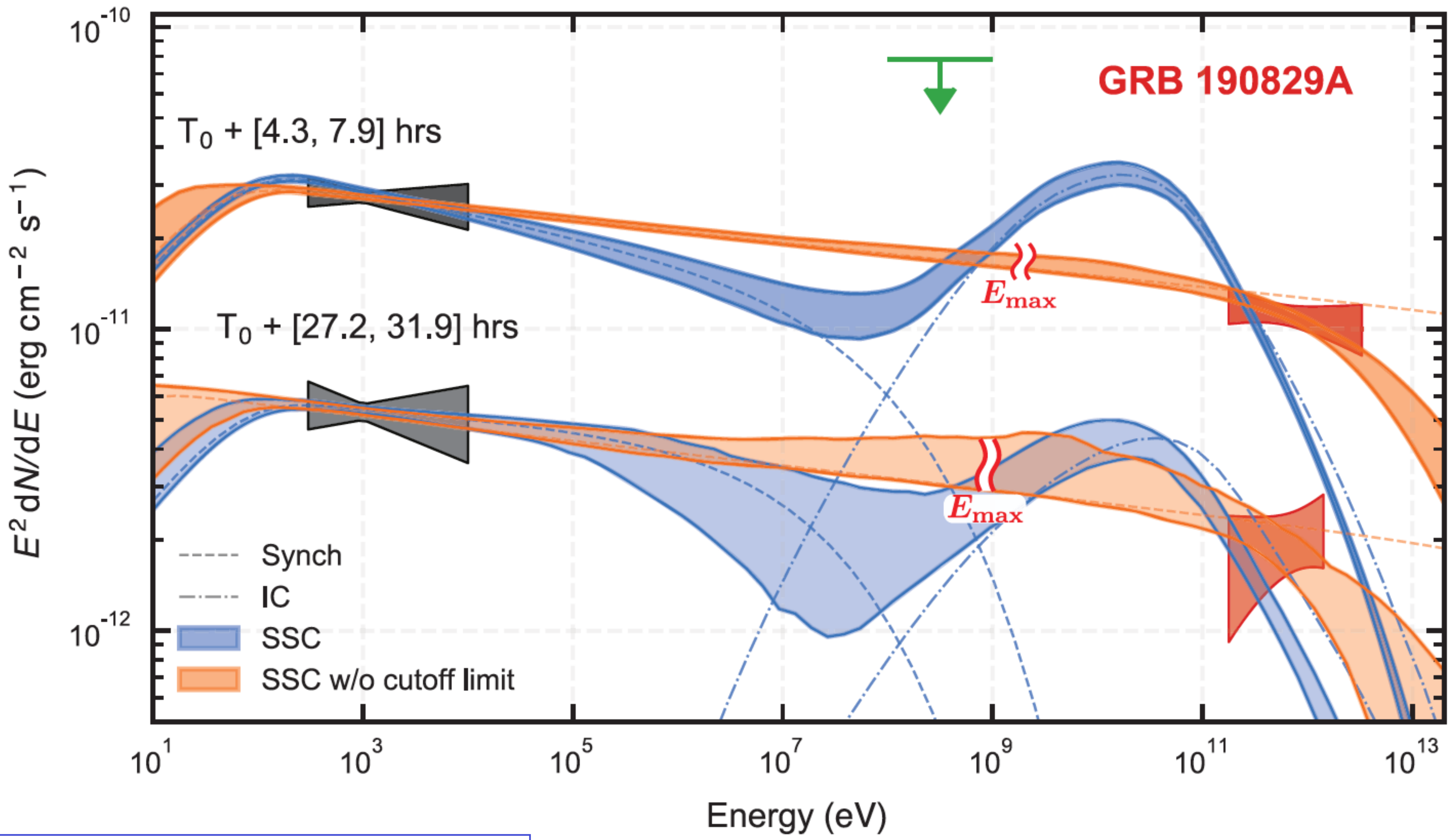
Science 372, 1081–1085 (2021)

GRBs @ VHE ! – GRB 190829A



Science 372, 1081–1085 (2021)

GRBs @ VHE ! – GRB 190829A



Science 372, 1081–1085 (2021)

Astrofisica Nucleare e Subnucleare

Future detectors

2004	2005	2006	2007	2008	2009	2010

Roadmap to the Next Generation Cherenkov Gamma Ray Telescope

H.E.S.S.

H.E.S.S. II

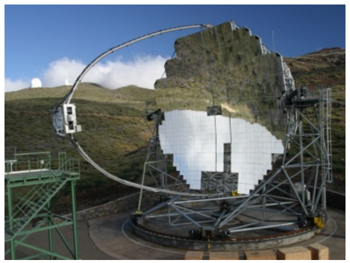
- Technology for Fully Robotic Telescope
- Experimental Study of High Altitude effect
- Design Study of Large Telescope
- Site Survey
- Characterization of Low Energy Showers
- Design Study of Wide Angle Telescope
- Advanced photon detector

Science Review

Final Conceptual Design under New collaboratio

Ultimate Ground-based Cherenkov Telescope System
Larger Dish,
High Altitude,
Advanced detector,
Wide Angle

International collaboration CANGAROO, VERITAS, etc.

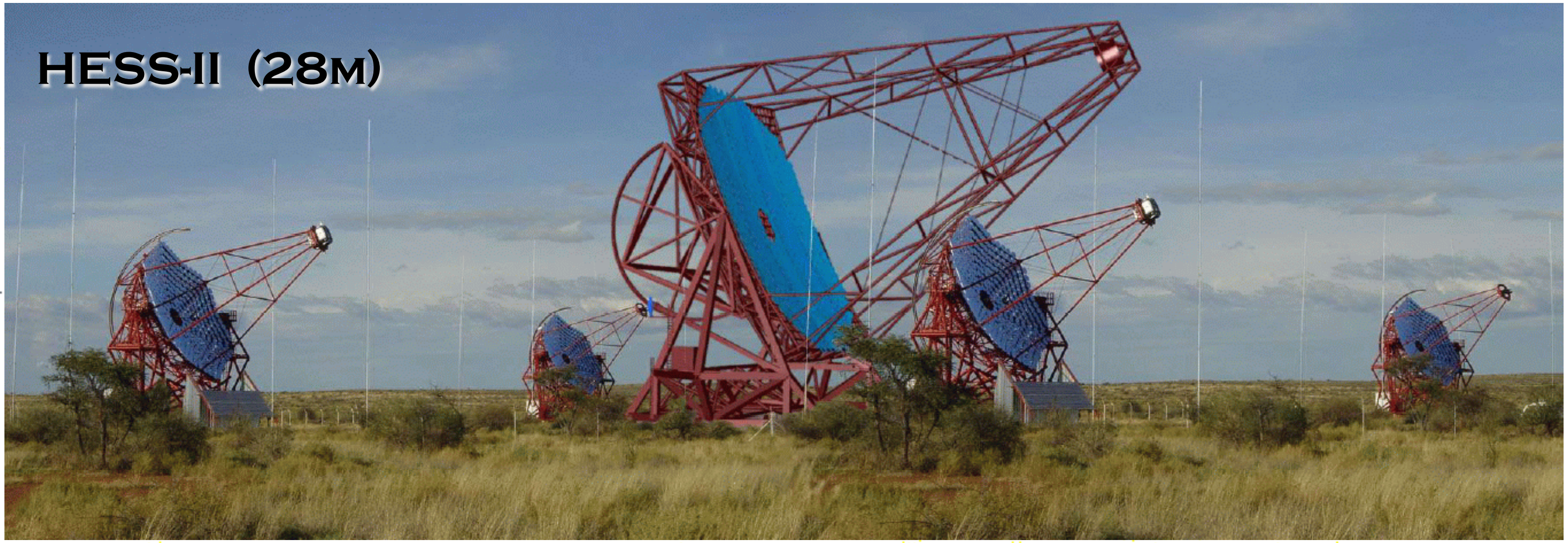


MAGIC

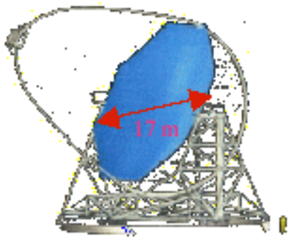
MAGIC II

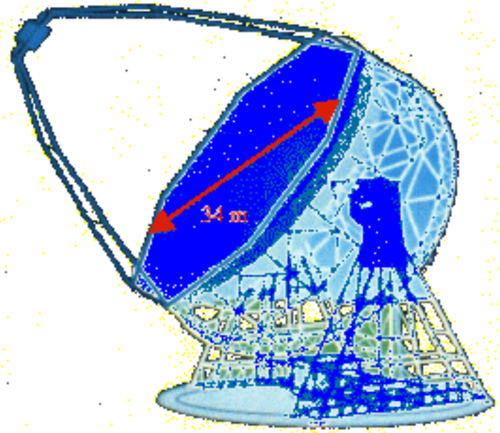
New Cherenkov telescopes

HUNT FOR LOWEST THRESHOLD: BIGGER IS BETTER !!!???

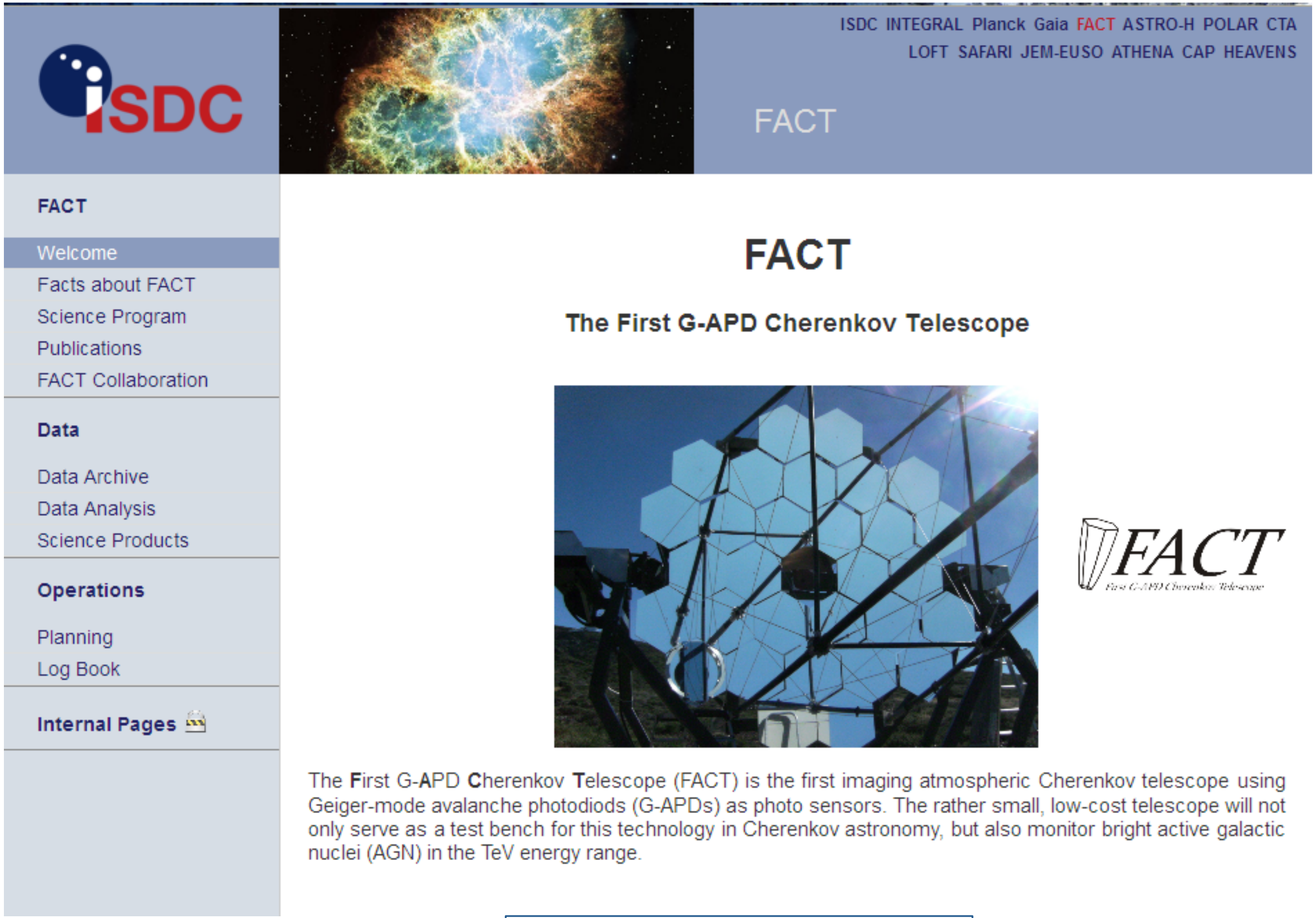


ECO-1000 ? (34m)



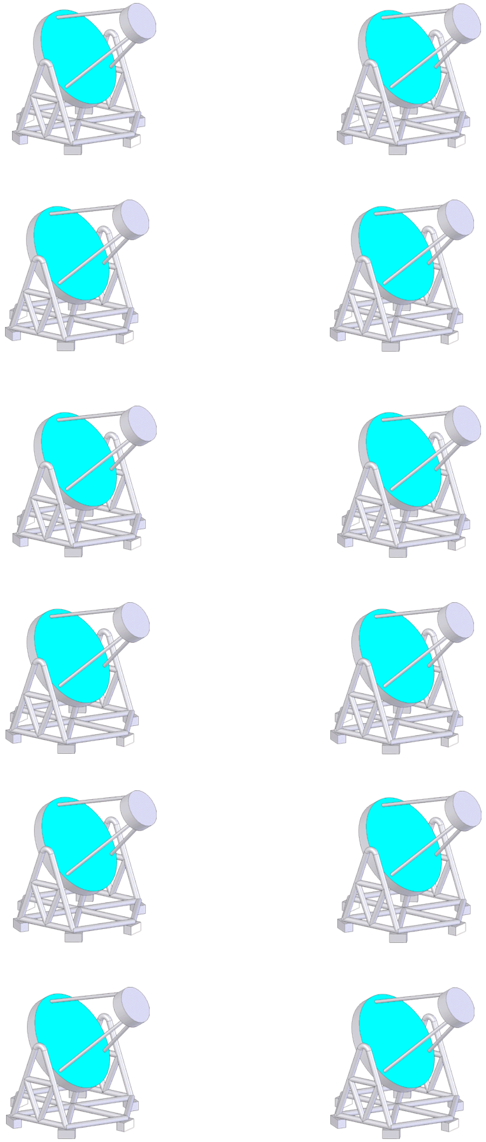


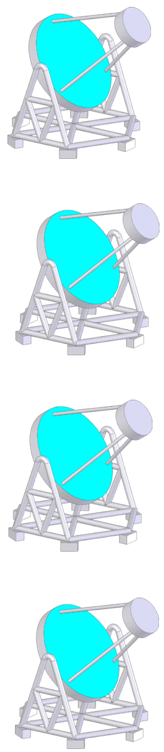
New Cherenkov telescopes



http://isdc.unige.ch/fact/

Outlook: What next ?



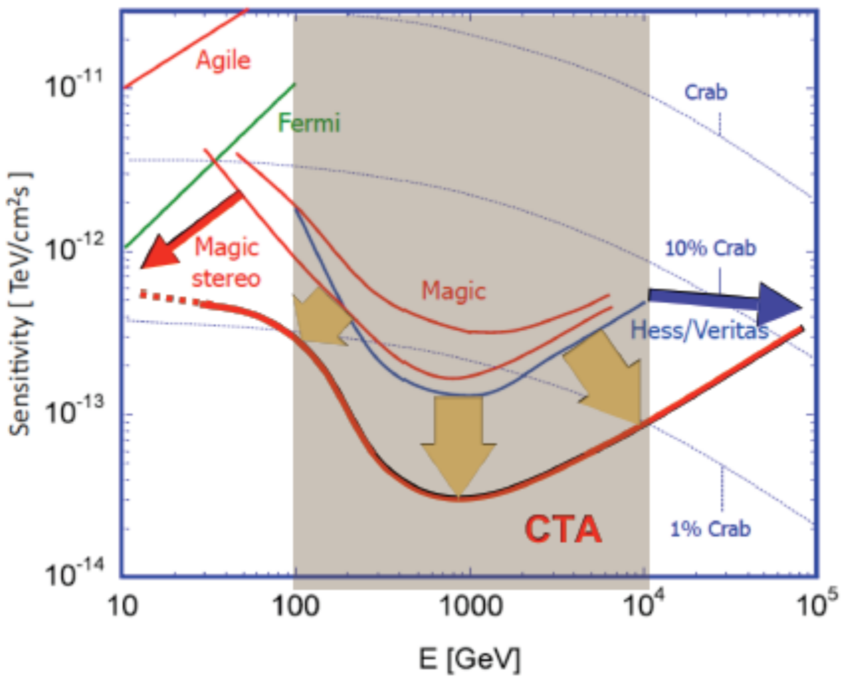


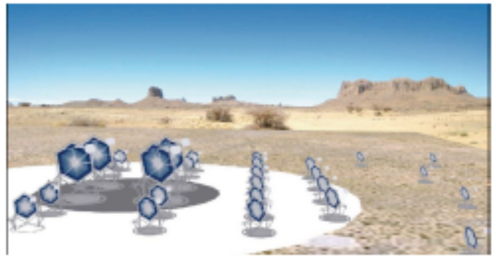
The Cherenkov Telescope Array (CTA)

- aims to explore the sky in the 10 GeV to 100 TeV energy range
- builds on demonstrated technologies
- combines guaranteed science with significant discovery potential
- is a cornerstone towards a multi-messenger exploration of the nonthermal universe

CTA

Improve sensitivity





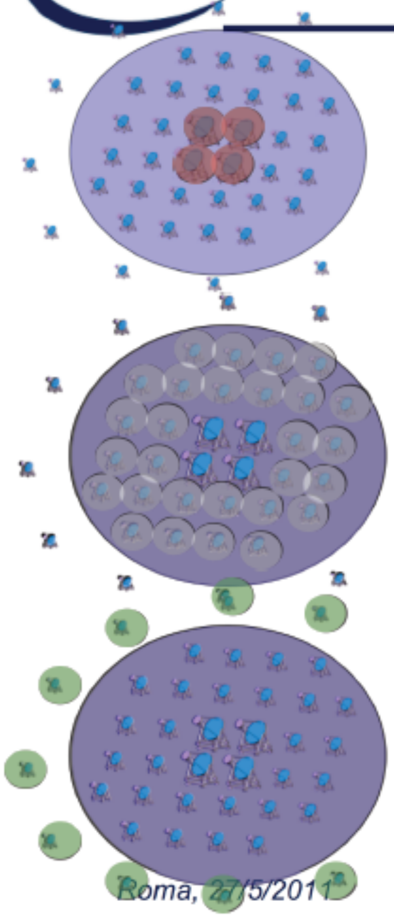
CTA will be about a factor of 10 more sensitive than any existing instrument in the 100 GeV-10 TeV energy band.

CTA will also extend the observed energy band reaching both the lower (10 GeV) and the higher (100 TeV) energies.

CTA

cherenkov telescope array

CTA concept

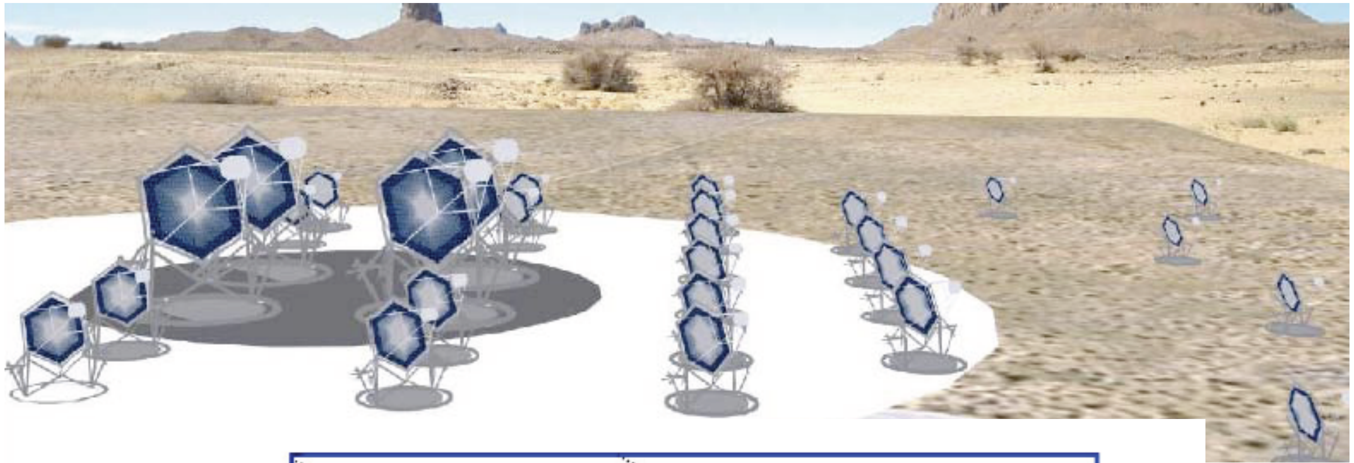


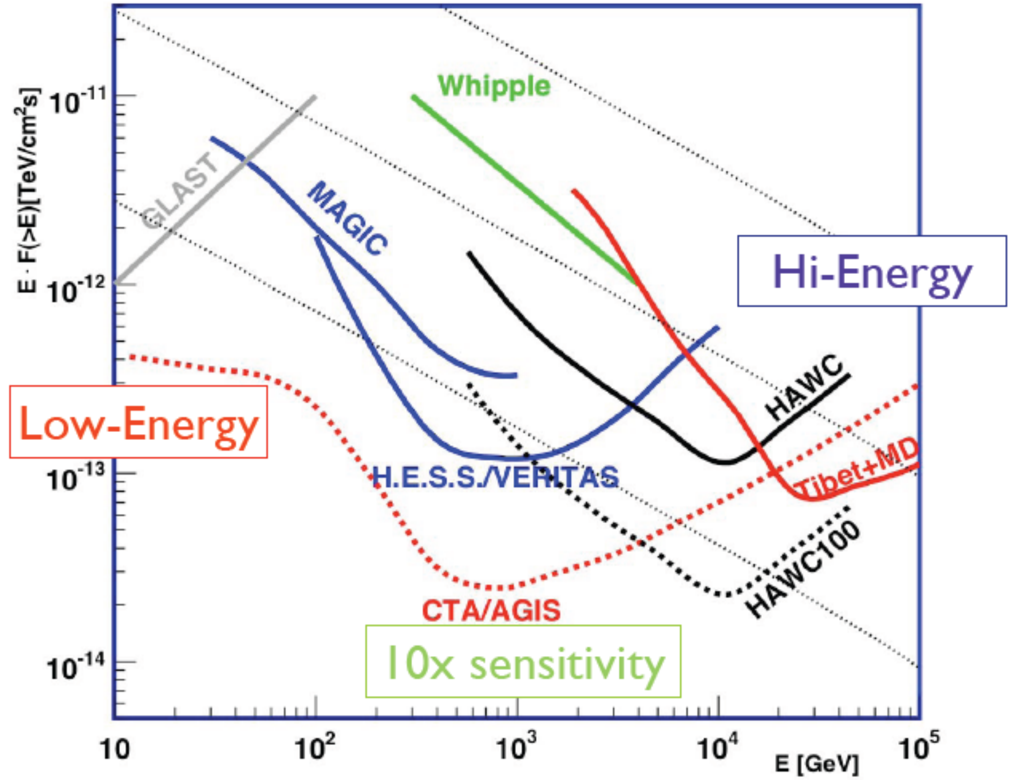
- Few Large Size Telescopes should catch the sub-100 GeV photons
  - Large reflective area
  - Parabolic profiles to maintain time-stamp
  - Contained FOV
- Several Medium Size Telescopes perform 100 GeV-50 TeV observation
- well-proven techniques (HESS, MAGIC)
- goal is to reduce costs and maintenance
- core of the array
- act as VETO for LSTs

- Several Small Size Telescopes perform ultra-50 TeV observation
- challenging design
- Large field-of-view (8°)
- New camera technology

Roma, 27/5/2011

CTA




Whipple
GLAST
MAGIC
Hi-Energy
HAWC
Low-Energy
H.E.S.S./VERITAS
Tibet+MD
HAWC100
CTA/AGIS
10x sensitivity
E · F(>E)[TeV/cm²s]
10⁻¹¹
10⁻¹²
10⁻¹³
10⁻¹⁴
10
10²
10³
10⁴
10⁵
E [GeV]

Toward the future!