MAGIC highlights. A gamma-ray and particle-physics detector.

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for the MAGIC Collaboration

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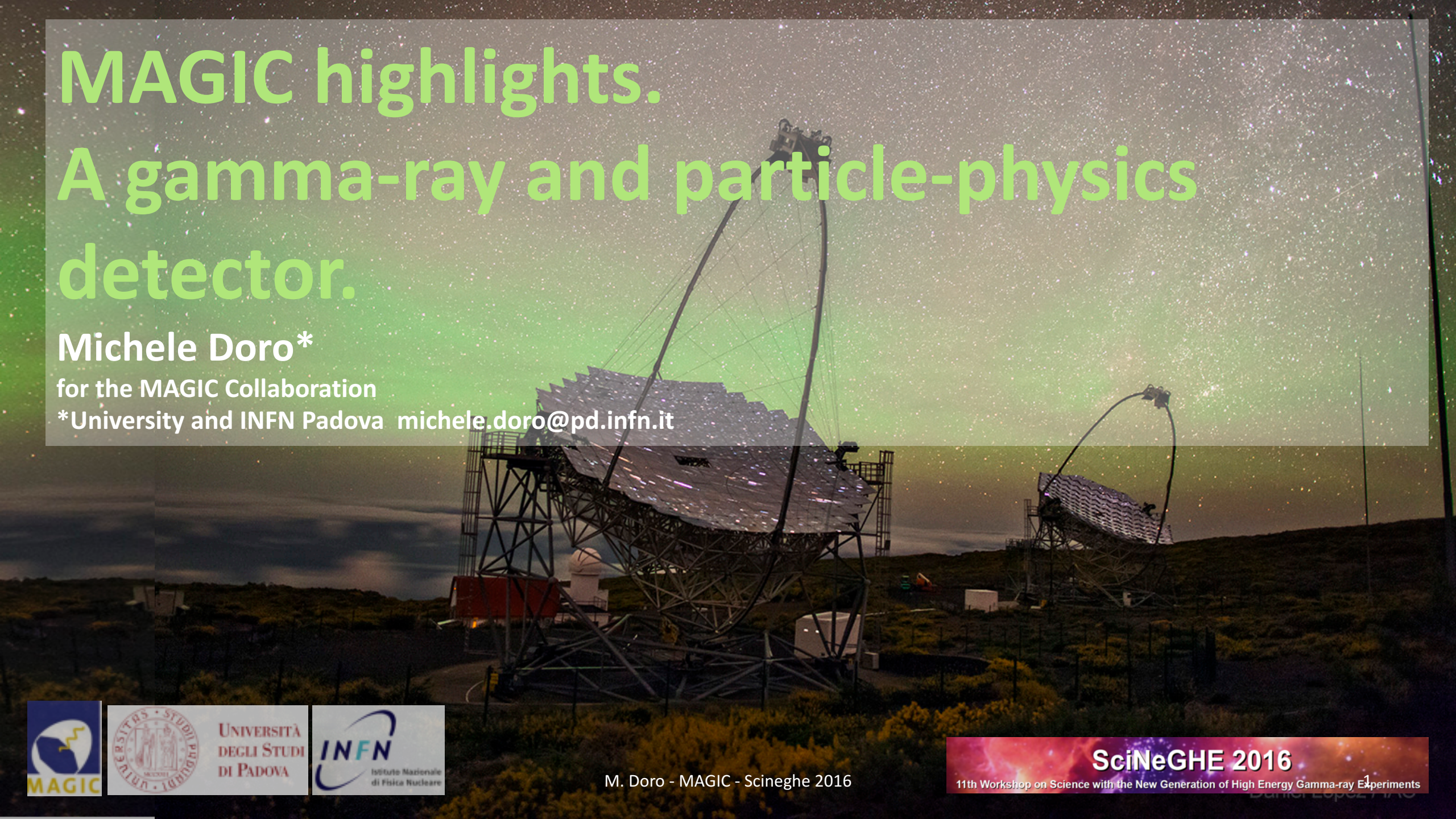


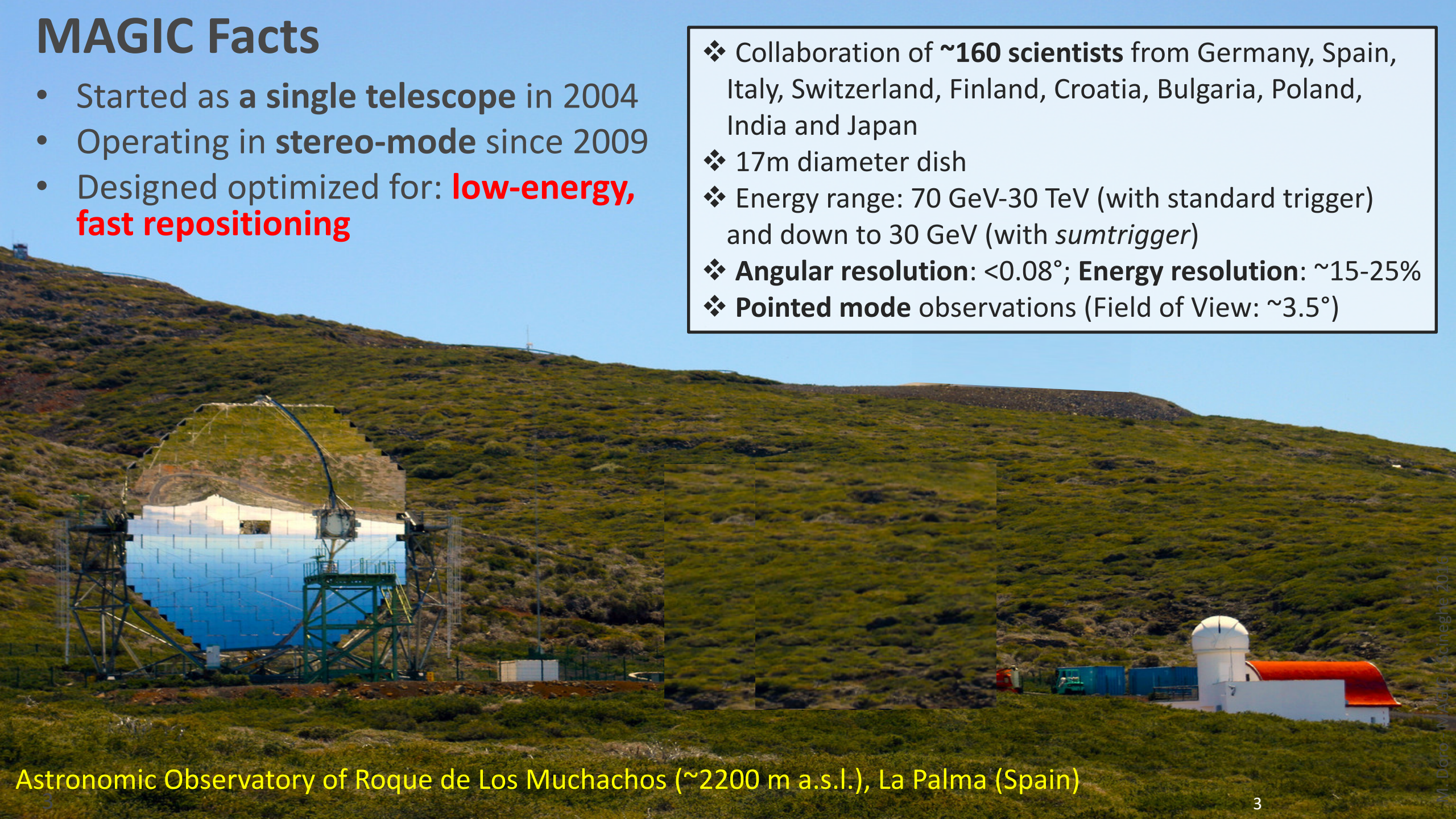
Outline

- The instrument
- Science (disclaimer: personal taste selection)
  - 0: GW-counterpart detector
  - 1: gamma-ray detector
  - 2: cosmic-ray detector
  - 3: exotic-physics detector
- Conclusions

MAGIC Facts

- Started as **a single telescope** in 2004
- Operating in **stereo-mode** since 2009
- Designed optimized for: **low-energy, fast repositioning**

- ❖ Collaboration of **~160 scientists** from Germany, Spain, Italy, Switzerland, Finland, Croatia, Bulgaria, Poland, India and Japan
- ❖ 17m diameter dish
- ❖ Energy range: 70 GeV-30 TeV (with standard trigger) and down to 30 GeV (with *sumtrigger*)
- ❖ **Angular resolution**: <0.08°; **Energy resolution**: ~15-25%
- ❖ **Pointed mode** observations (Field of View: ~3.5°)

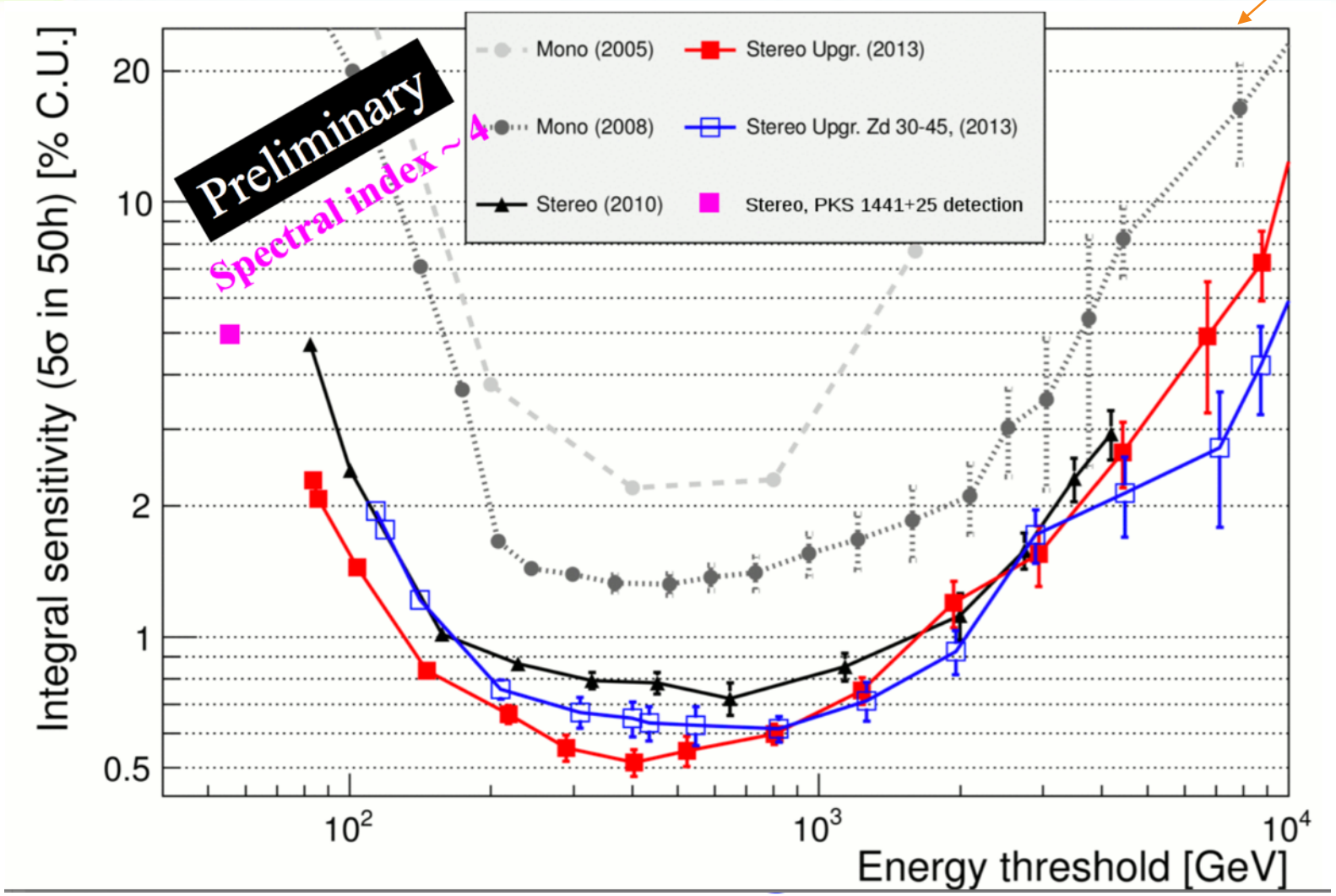


Astronomic Observatory of Roque de Los Muchachos (~2200 m a.s.l.), La Palma (Spain)

M. Doro - MAGIC Schneghe 2016

A continuous effort

See R. Coccia talk this morning



- **Mono**:
  - Light Gray circles: first installation (2005)
  - Dark gray: different readout system (2008)
- **Stereo**-phase:
  - **Black** triangles: stereo phase 1 (2010)
  - Squares: stereo after camera upgrade:
    - **zenith angle below 30◦ (red, filled),**
    - **30 – 45◦ (blue, empty)**
- **Sum-trigger** allowed <50 GeV

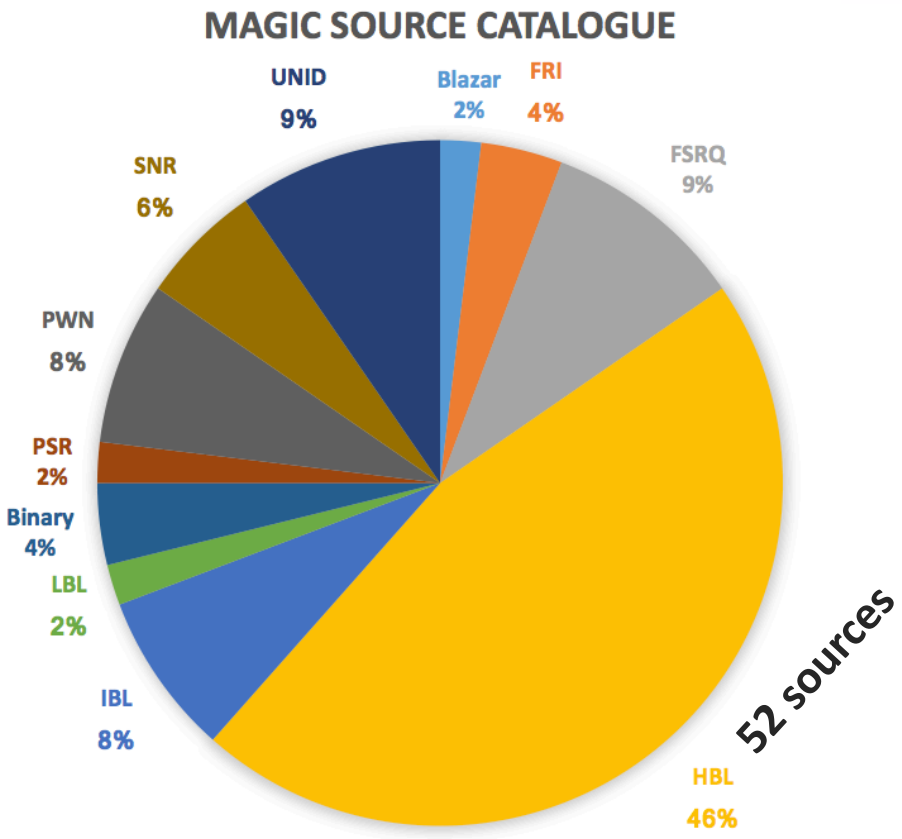
4-fold improvement in sensitivity over the last decade

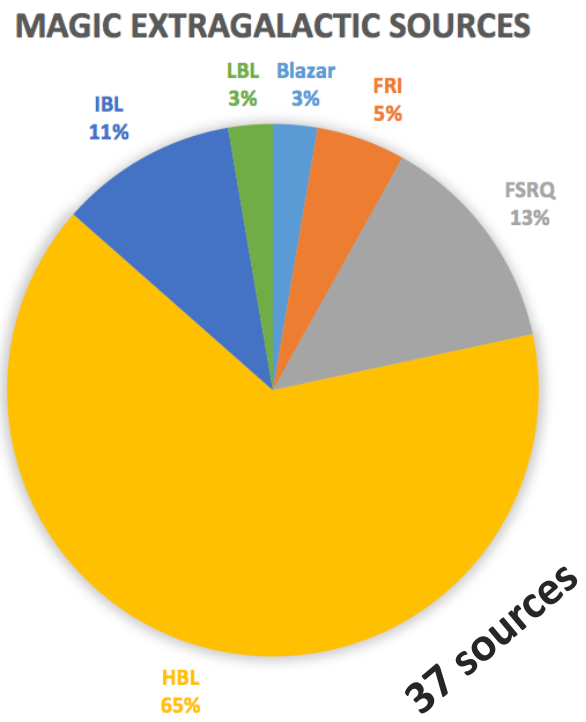
→ ~10-fold improvement at the lowest energies !!

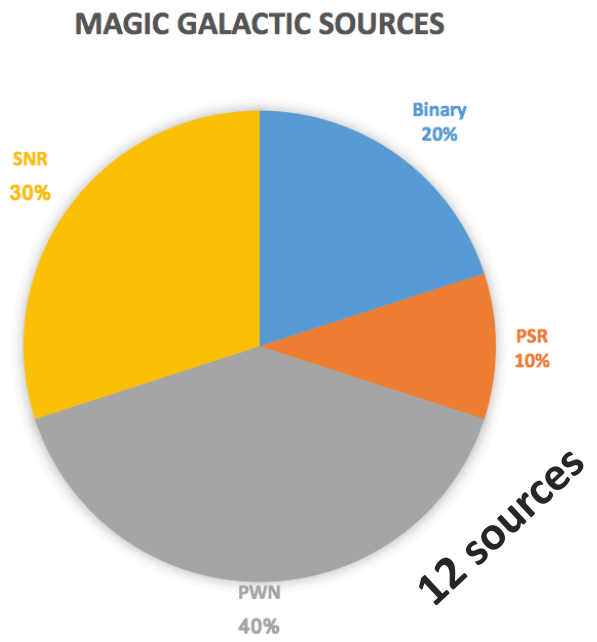
← 16 times less needed observation time!

The MAGIC "catalogues"

From TeVCat 2.0 http://tevcat2.uchicago.edu/







- MAGIC is in the N-hemisphere: optimized for extra-gal. physics
- MAGIC hunts the farthest objects due to lowest energy threshold

Dark Catalogue (many sources pointed and not detected)

PART 0
MAGIC and GW counterparts

MAGIC observed GW151226

See P.Evans talk at this conf.

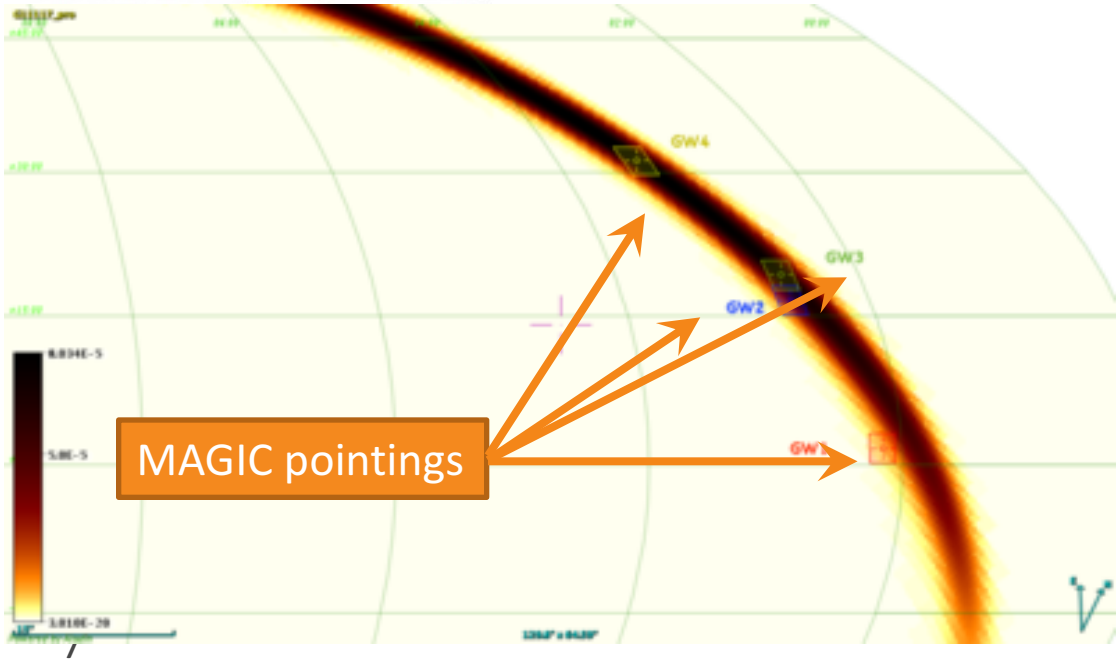
TITLE: GCN CIRCULAR
NUMBER: 18776
SUBJECT: LIGO/Virgo G211117: MAGIC very-high energy gamma-ray observations
DATE: 15/12/30 16:14:44 GMT
FROM: Antonio Stamerra at INAF-OATo/SNS-Pisa <antonio.stamerra@sns.it>

Angelo Antonelli (INAF-OaR), Alessandro Carosi (INAF-OaR), Barbara de Lotto (Univ. Udine), Razmik Mirzoyan (MPI-Müenchen) and Antonio Stamerra (INAF-OaTo and SNS-Pisa) on behalf of the MAGIC collaboration

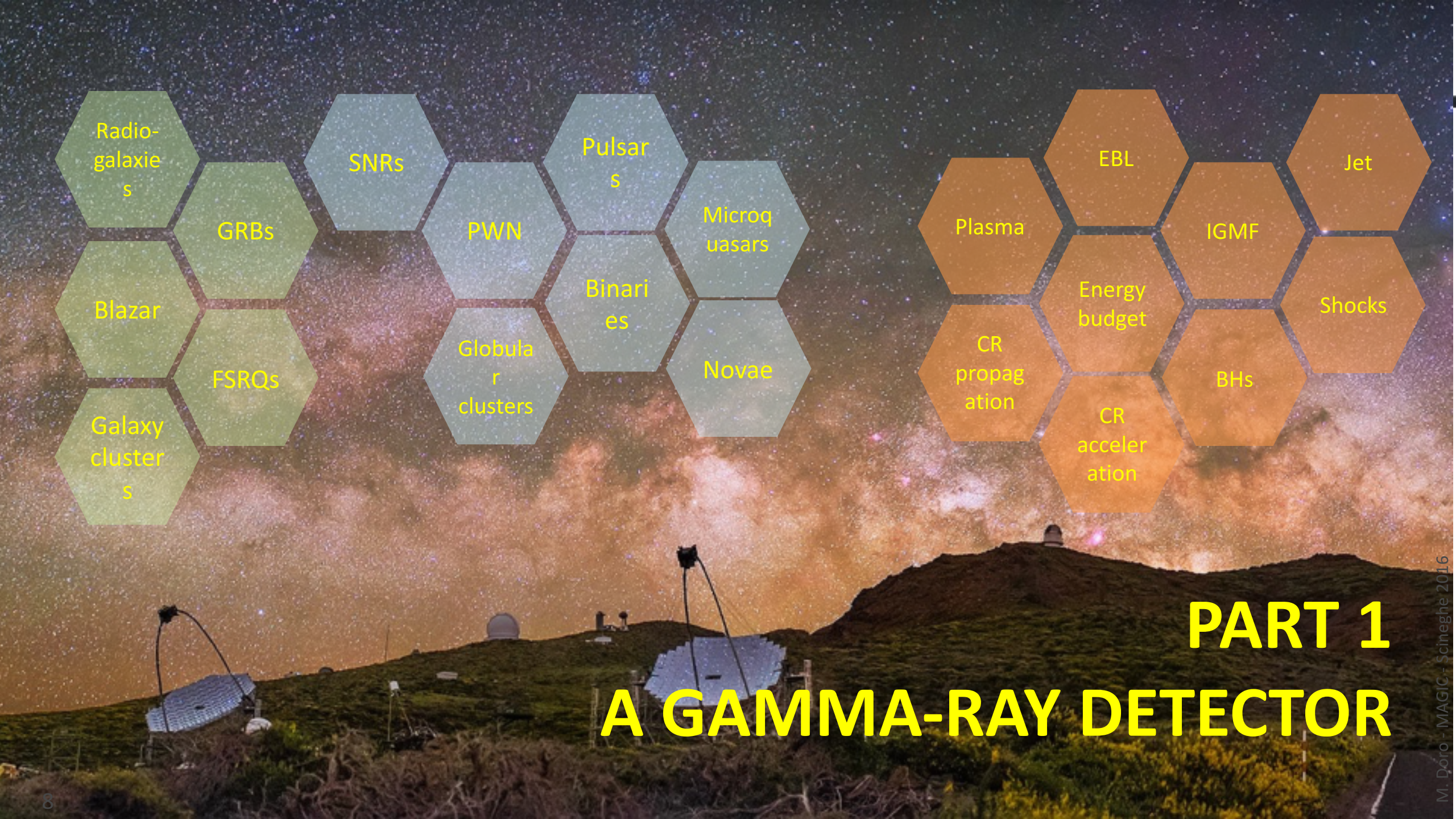
The MAGIC system of Cherenkov Telescopes, sensitive to high-energy gamma-ray above ~50 GeV, performed observations of 4 regions in the strip of the bayestar GW map for the trigger G211117.
Observations started on December 28, 21 UT. Each observation covers a region of ~2.5x2.5 deg. Analysis is on-going.
The list of targets is the following:

Target 1: PGC1200980 (OT MASTER GCN#18729)
RA,Dec (J2000): 02:09:05.8, +01:38:03.0
Duration: 42 min

Target 2: strip from GW map
RA,Dec (J2000): 02:38:38.93, +16:36:59.27
Duration: 56 min (moonlight conditions)



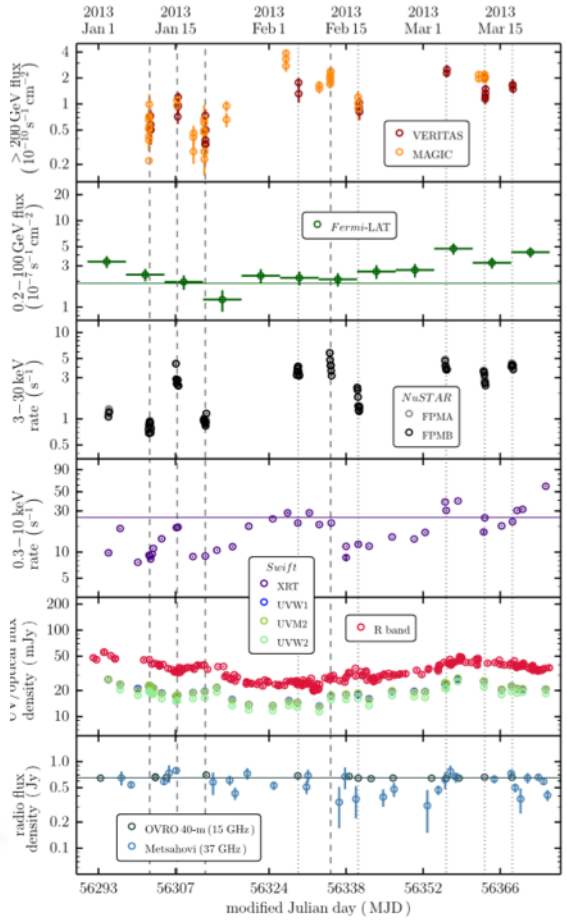
- MAGIC signed in 2014 an **MoU** with the LVC to join the **follow-up program** of GW event candidates.
- On the Dec 28th 2015, MAGIC followed-up the second GW discovery event (see our **GCN #18776**), pointing four 2.5x.2.5deg regions (2x max prob, 2x known targets). No excesses found.
  - Consider that MAGIC FOV is roughly 3x3deg
- For LVC O2 run, we are discussing **our "reaction" and "pointing" criteria**:
  - 1. immediate repositioning or later follow-up?
  - 2. Scanning mode (e.g. n positions) or association mode (closeby galaxies)?
  - 3. trigger acceptance (rate and value)
- Learning period to optimize observation modes
- The expected number of highly significant events during the O2 run is between 6 and 25.



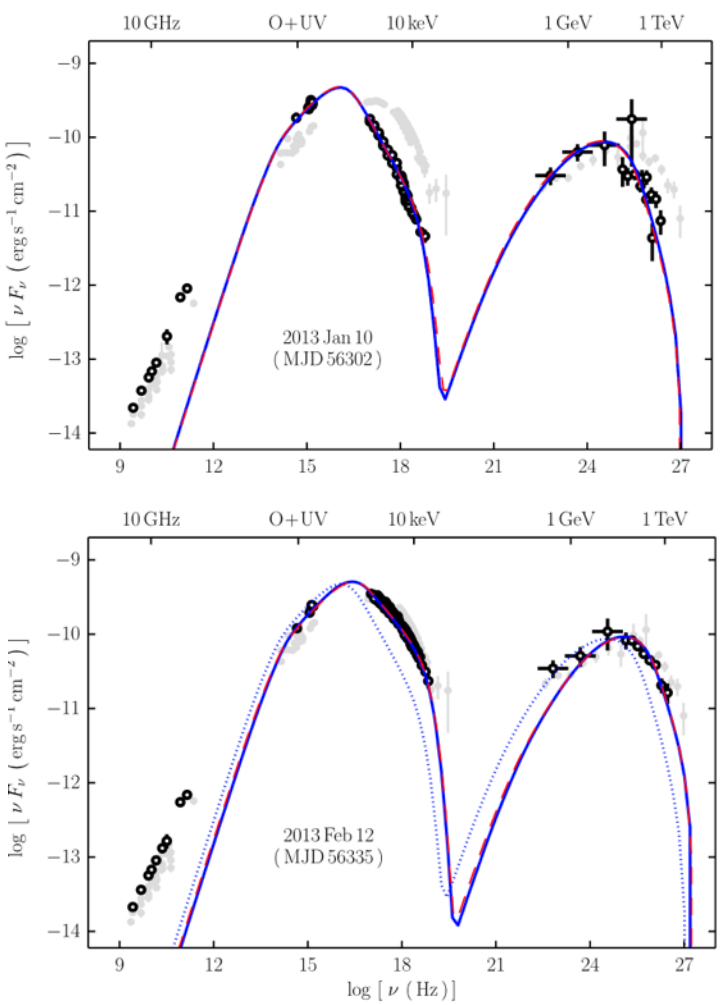
PART 1
A GAMMA-RAY DETECTOR

#1.1 Large projects: Multi-wavelength/multi-year

- The importance of multi-w campaign has become utter, MAGIC had developed several monitoring campaigns + ToO.



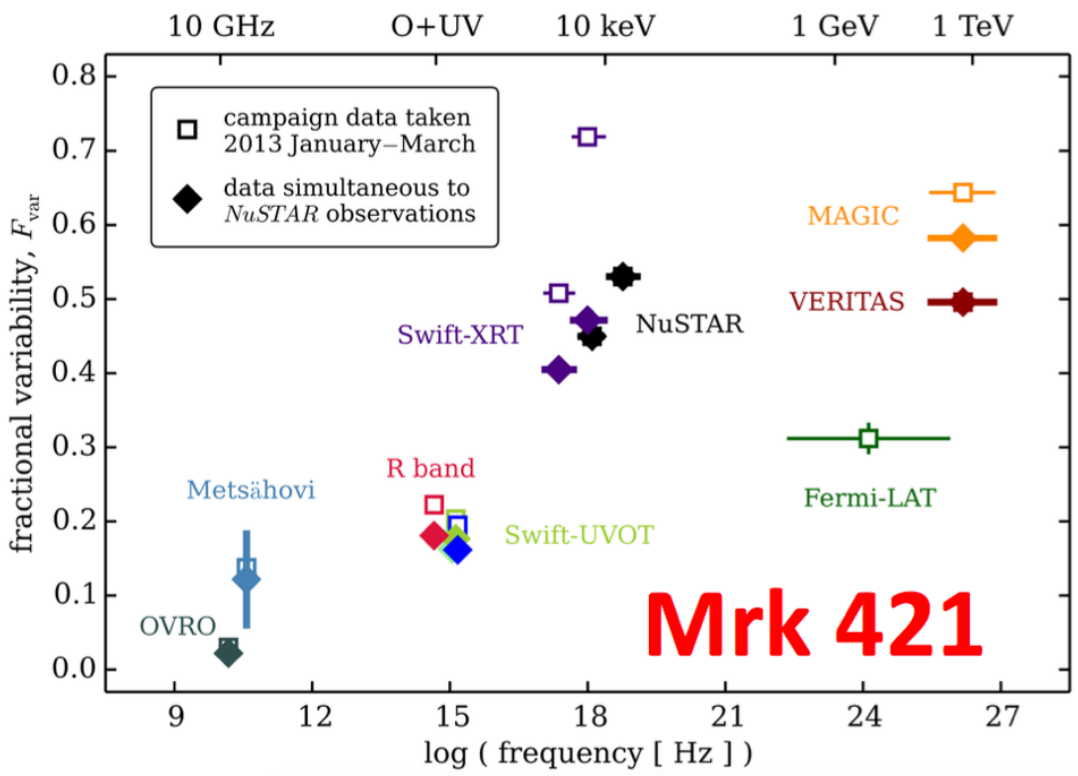
Astrophys.J. 819 (2016) 156



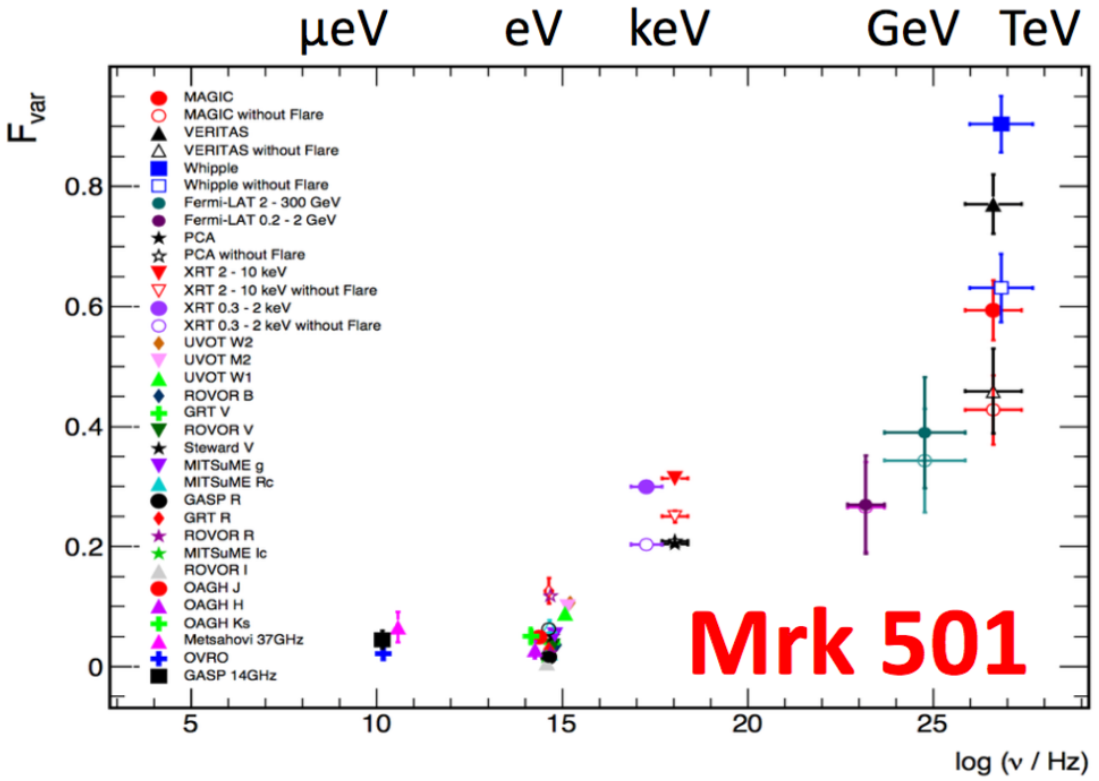
- ← Mrk421 Swift-UVOT, Swift-XRT, NuSTAR, Fermi-LAT, MAGIC, and VERITAS [MAGIC+ 2016 Apj 819]
  - Coverage issue + integration
- Flares cause not only increased flux, but also (correlated) peak-shifts. SSC mechanisms seems at work, but:
  - A different (than baseline) electron population swept-up?
  - Same population received boost?

Fractional variability: a global picture of dynamics

Balokovic et al., 2016 *ApJ* 819, 156

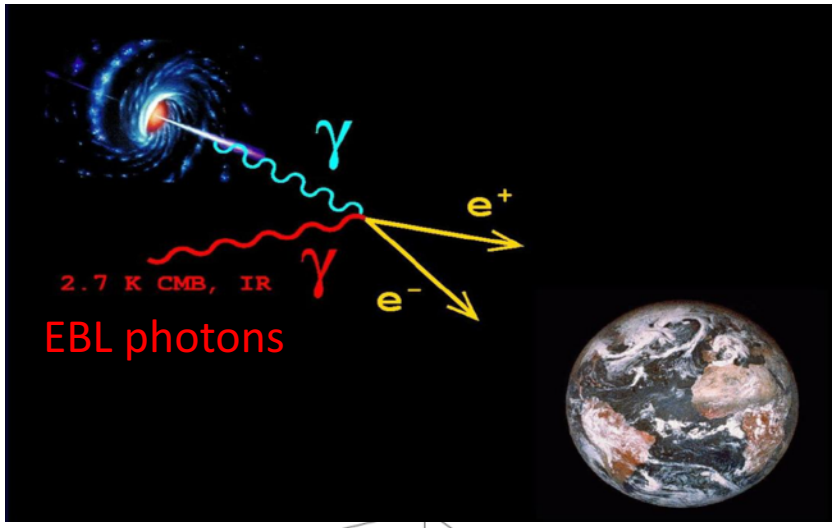


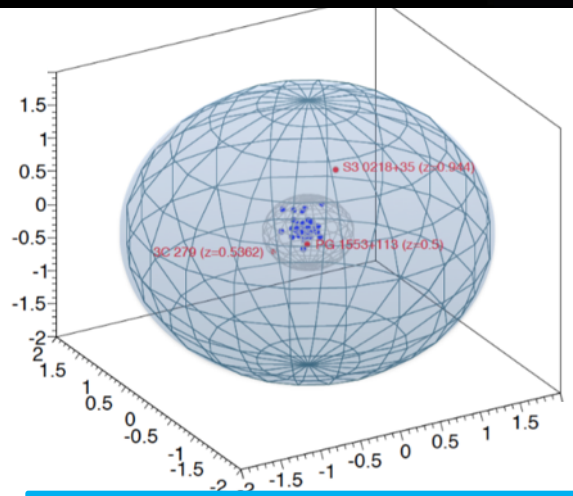
Ahnen et al. Submitted to A&A



- Fractional variability requires large coverage, but guarantees connection between two bumps:
  - Information on particle populations, acceleration efficiency…
- IACT data are now important to be made public in astronomical format in science archives..

#1.2 Expanding the TeV universe





Almost doubled the TeV universe reach in past 2 years

- Gamma-ray flux is depleted through inter-galactic space by pair-production
- Interaction with low-energy (UV-IR photons) of the Extragalactic Background Light: a proxy for modeling the evolution of Universe
- MAGIC has a design focus in the low-energies: **optimized for far-away (extragalactic) sources**

Blazar	Redshift	Discover	Year
B0218+35	**0.944**	**MAGIC**	2014
PKS 1441+25	**0.939**	**MAGIC**	2015
3C 279	0.536	**MAGIC**	2006
PKS 1222+216 (4C +21.35)	0.432	**MAGIC**	2010
S4 0954+65*	0.368	**MAGIC**	2015
PKS 1510-089	0.361	HESS	2009

Farthest objects ever observed in TeV sky!

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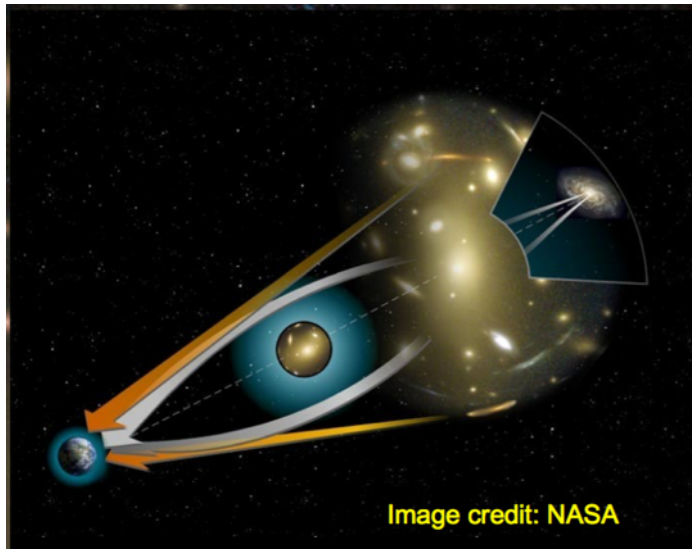
Gravitational lensed gamma-rays

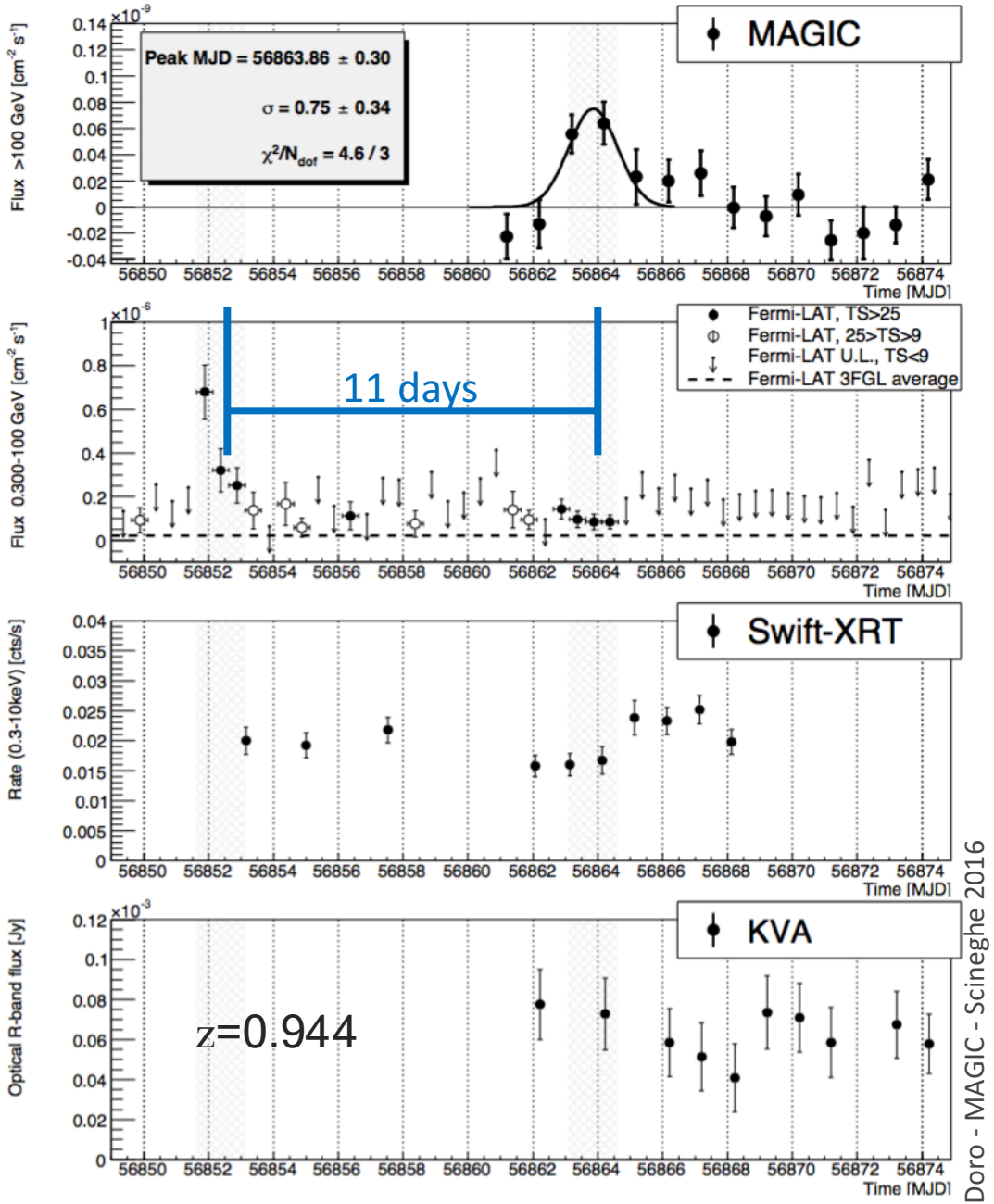


QSO B0218+357 is a gravitationally lensed blazar at redshift: 0.944 where the lens is probably a spiral galaxy B0218+357G at z=0.68

11-days is the time-delay

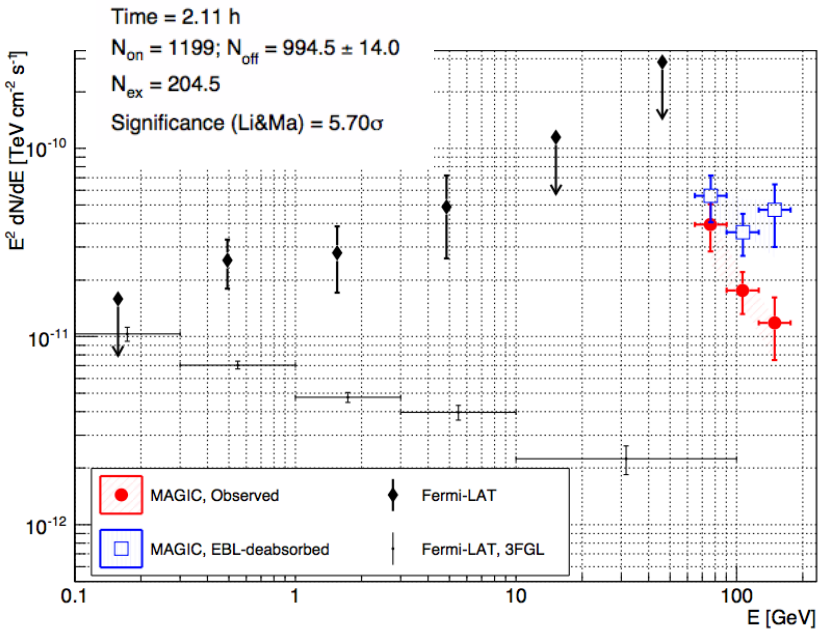
In 2014, Fermi got the first flare, and 11 days after, MAGIC detected the afterlight

- MAGIC could not observe the leading image due to the Full Moon.
- First gravitationally-lensed VHE gamma rays ever observed
- 2hours, 6 sigma significance



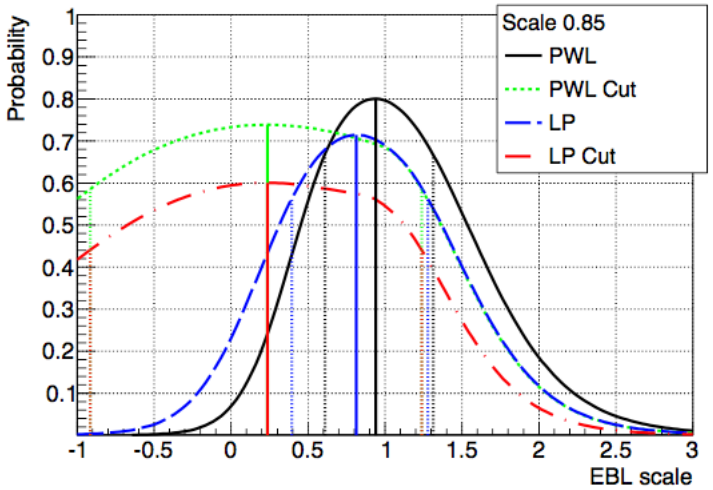
Detection of very high energy gamma-ray emission from the gravitationally-lensed blazar QSO B0218+357 with the MAGIC telescopes
MAGIC Collaboration (M.L. Ahnen *et al.*). Sep 5, 2016. 11 pp.
e-Print: arXiv:1609.01095 [astro-ph.HE] | PDF

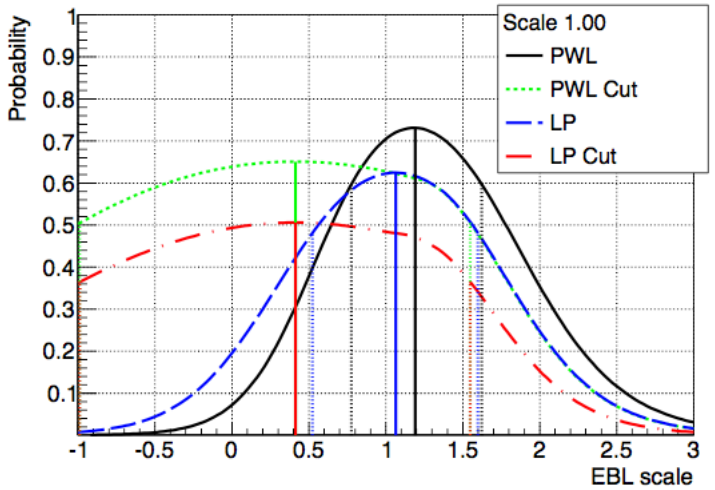
Constraints on EBL from the farthest objects

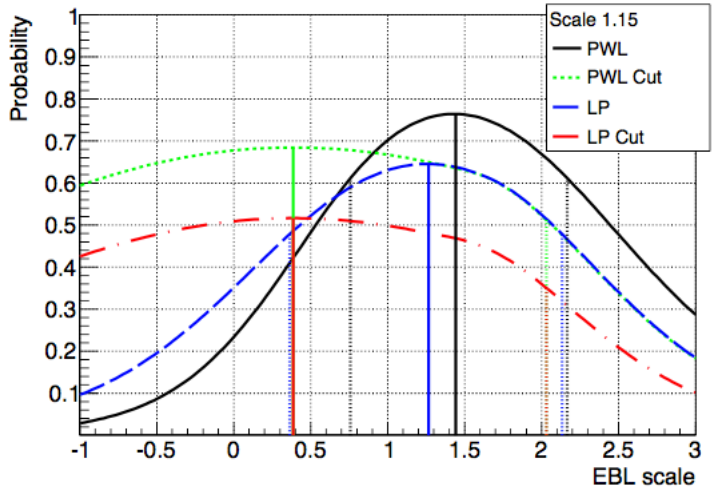


- Joint spectral fit combining *Fermi*-LAT and MAGIC points using a set of possible spectral shapes.
- Scaling parameter α of the optical depth.

Model	α (PWL)	α (all)
Franceschini et al. (2008)	$1.19 \pm 0.42_{\text{stat}} \pm 0.25_{\text{syst}}$	< 2.8
Finke et al. (2010)	$0.91 \pm 0.32_{\text{stat}} \pm 0.19_{\text{syst}}$	< 2.1
Domínguez et al. (2011)	$1.19 \pm 0.42_{\text{stat}} \pm 0.25_{\text{syst}}$	< 2.7
Gilmore et al. (2012)	$0.99 \pm 0.34_{\text{stat}}\ ^{+0.15\,\text{syst}}_{-0.18\,\text{syst}}$	< 2.1
Inoue et al. (2013)	$1.17 \pm 0.37_{\text{stat}}\ ^{+0.10\,\text{syst}}_{-0.13\,\text{syst}}$	< 2.2







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MAGIC Collaboration (M.L. Ahnen *et al.*), Sep 5, 2016. 11 pp.
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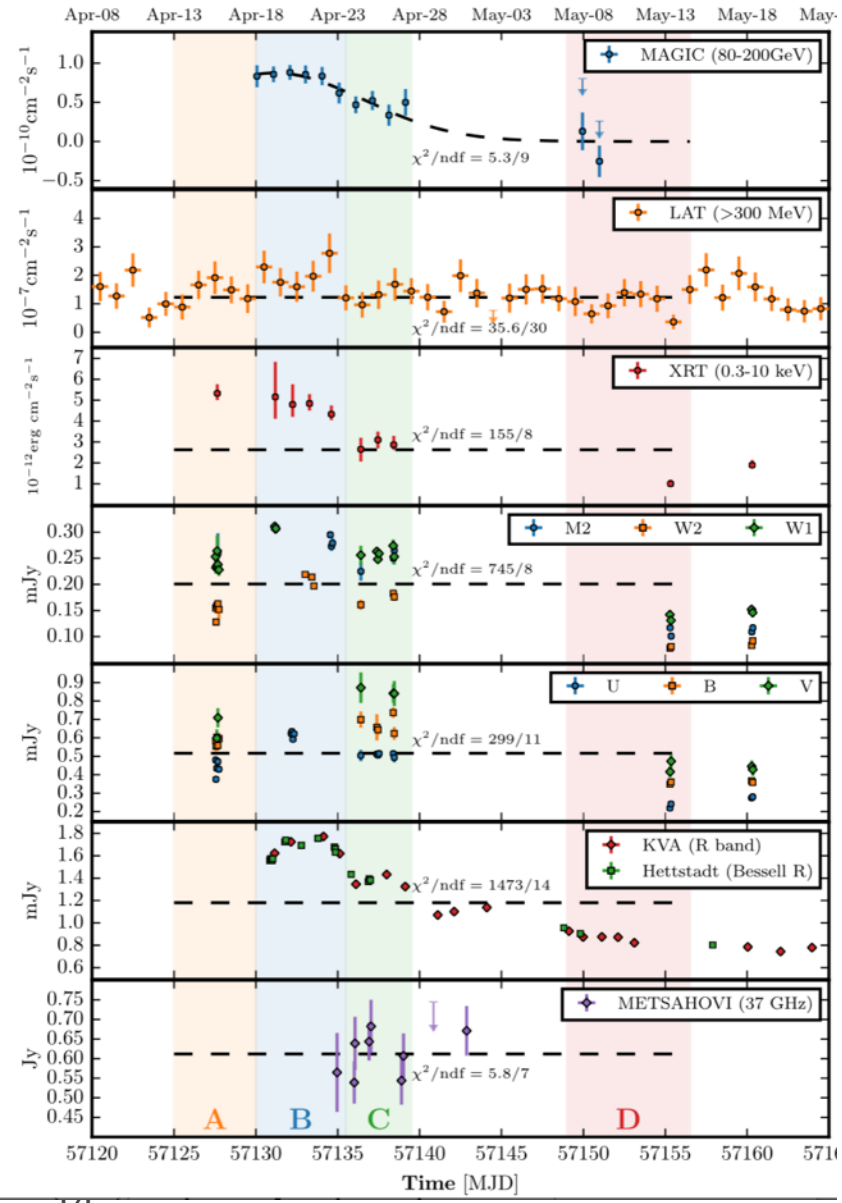
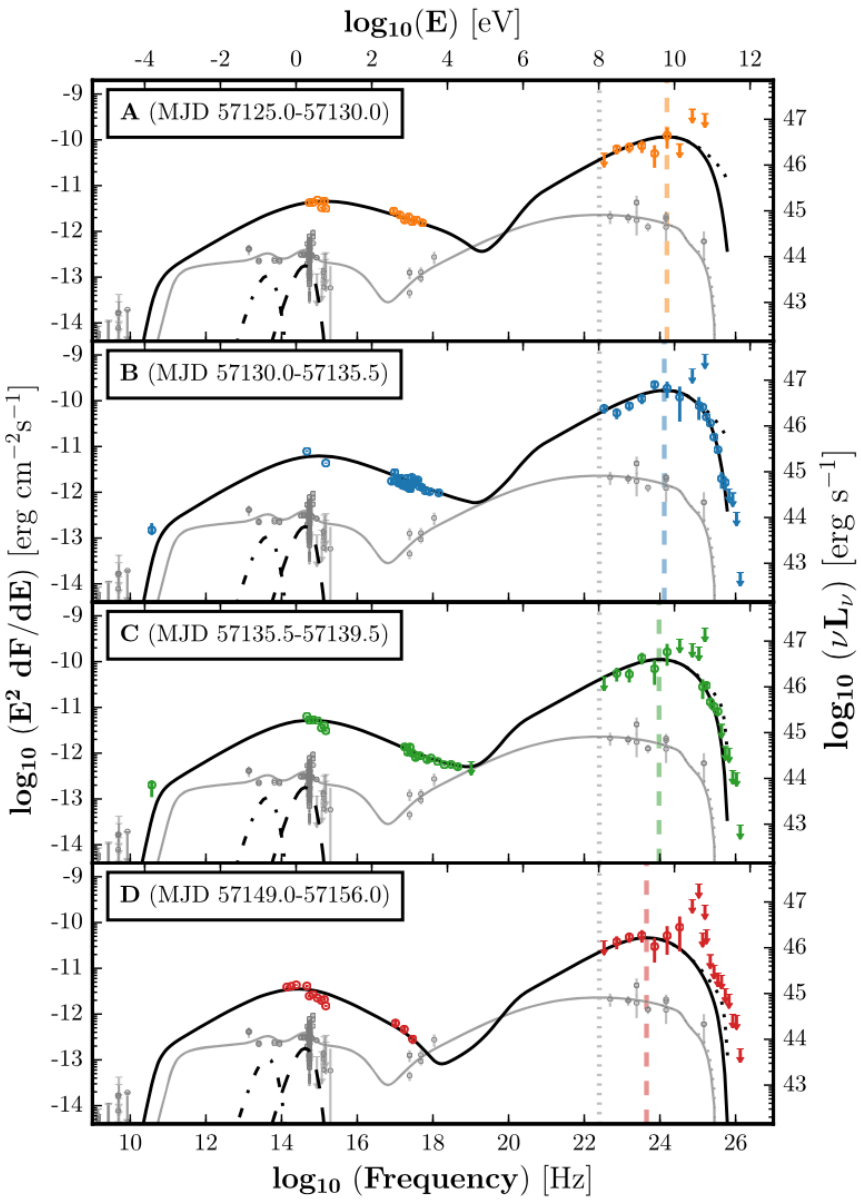
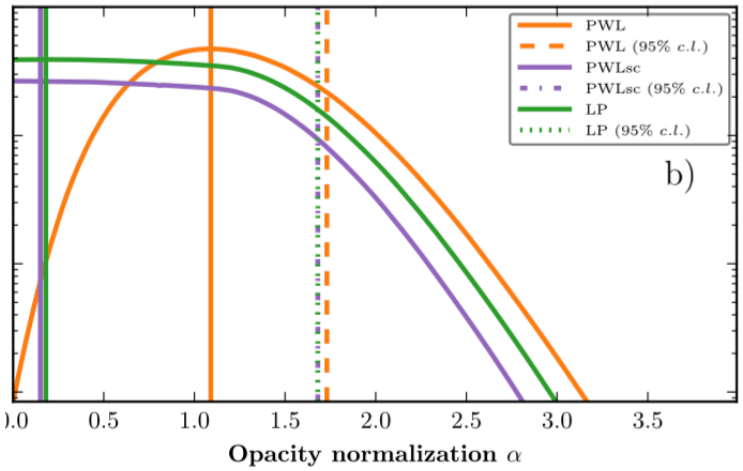
FSRQ PKS 1441+25 (z=0.94)

THE ASTROPHYSICAL JOURNAL LETTERS, 815:L23 (8pp), 2015 December 20

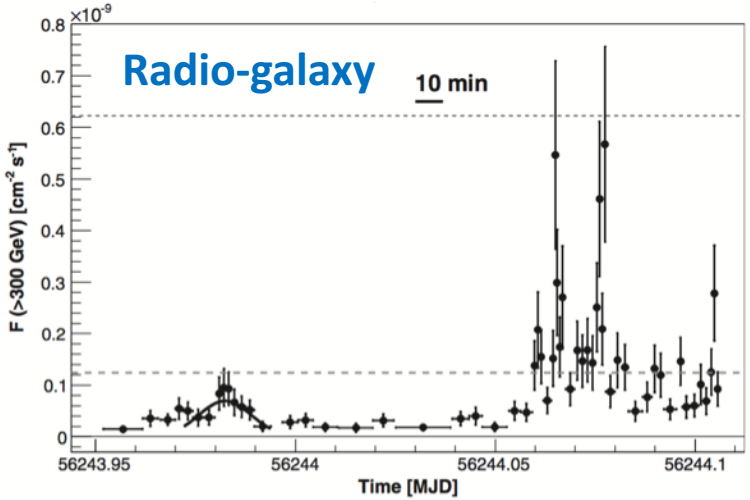




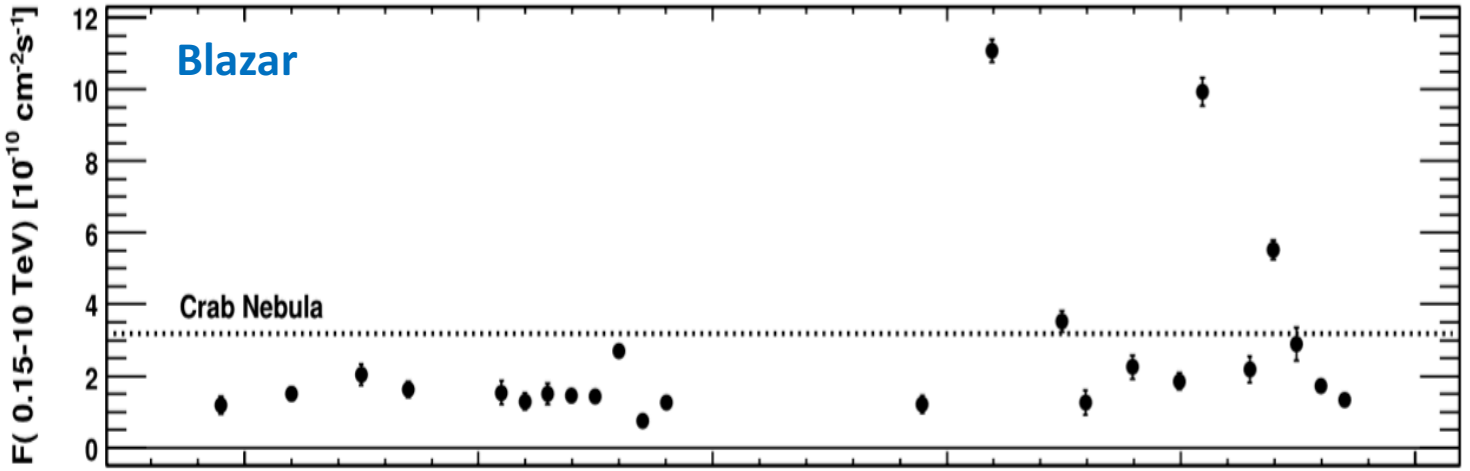
- 25.5σ from periods A,B
- Shift of both S- and IC-peaks to higher energies → emission from within BLR to outside BLR ?
- Even with more statistics, EBL constraints are not surprising



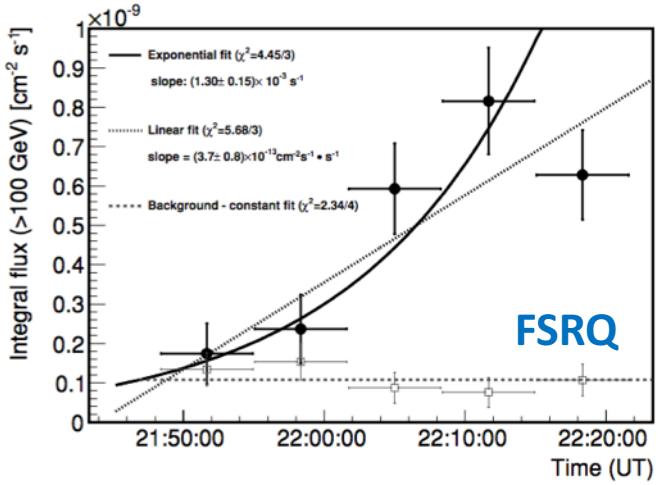
#1.3 Flares provides insight on BH or jets mechanisms



IC310. Doubling time 4.8 min



Mrk501 2005. Flux doubling time ~2min

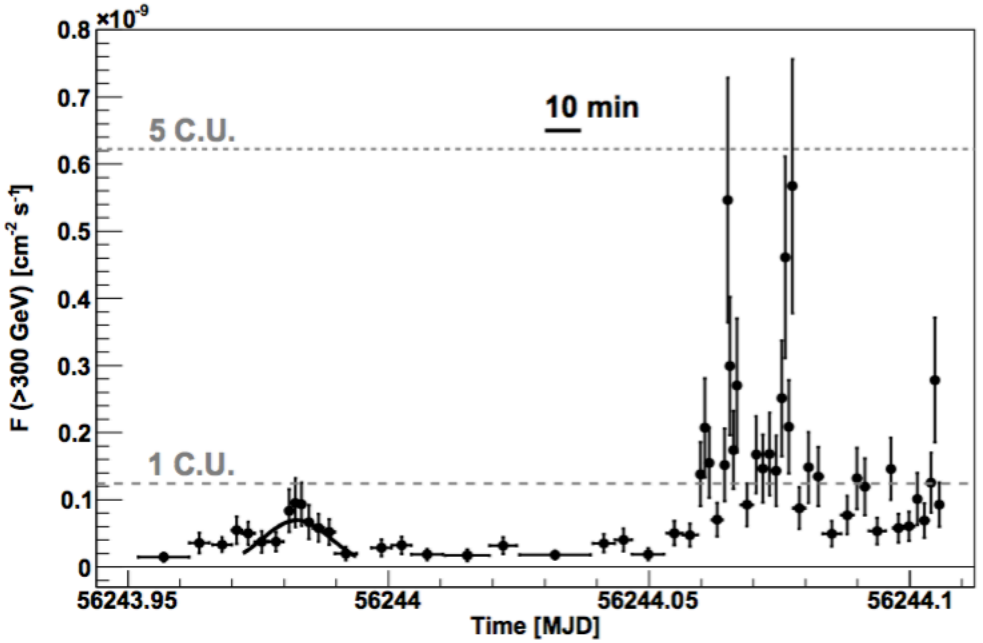


PKS1222. Doubling time 10 min

- MAGIC has detected extremely fast variability in all classes: Radio-galaxy, Blazars and FSRQ.
- Useful probe:
  - One can infer size of emission region with indirect better “angular resolution” than any other instrument
- However, still unclear whether emission scenarios is:
  - Close to the central engine
  - Far out emission region

A thunderstorm in the BH of IC310

Aleksic et al., SCIENCE (2014)



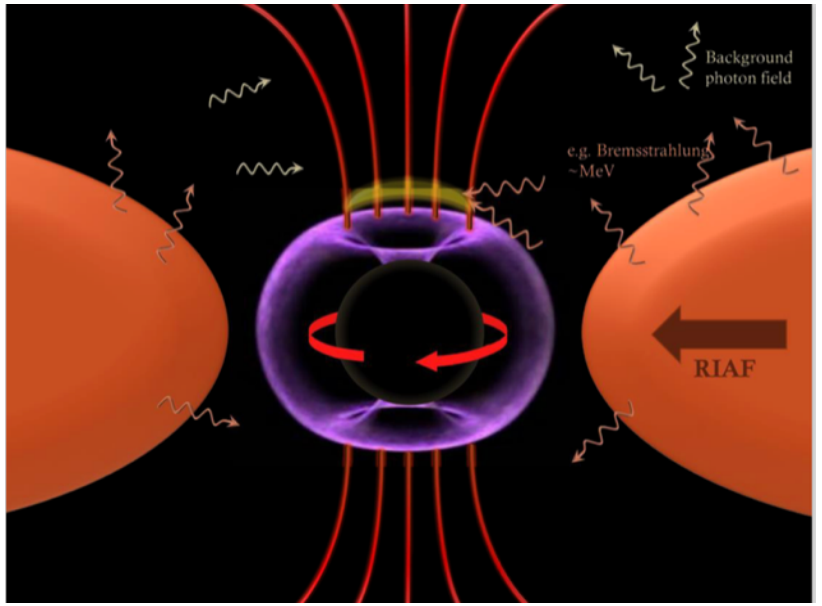
Aleksić et al. 2014, *Science*

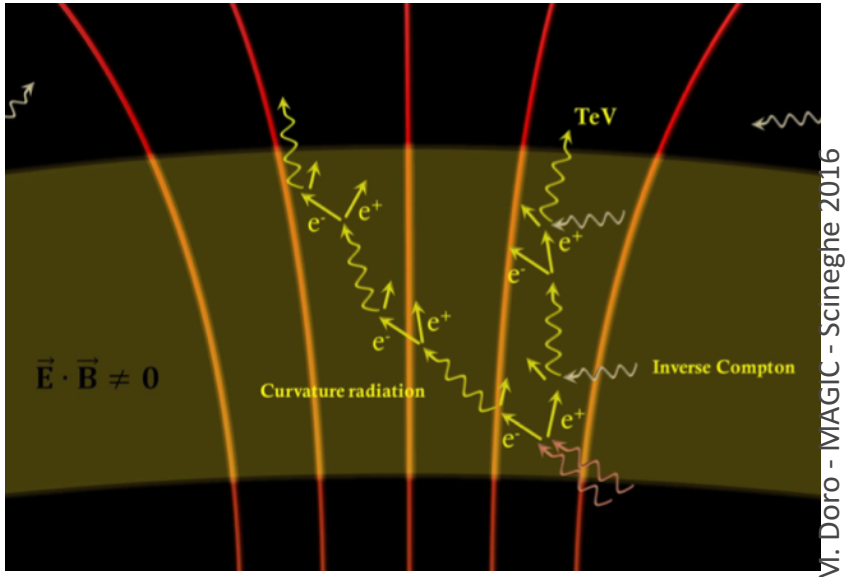
In 2014, MAGIC saw an impressive flare of the radio-galaxy **IC310**

Flux-flare was 2x in 4.8 minutes!

What mechanisms could provide such boost?

Emission region must have size smaller than the 20% of BH





Explanation (pulsar-like):
particle acceleration by the electric field across a magnetospheric gap at the base of the radio jet. Electric fields can exist in vacuum gaps when the density of charge carriers is too low to warrant their shortcut.

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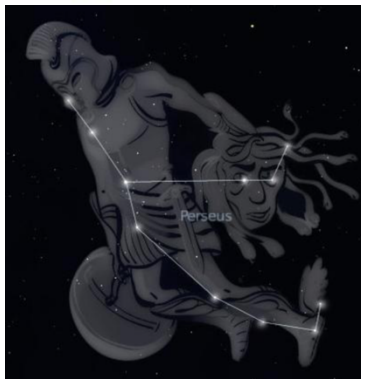
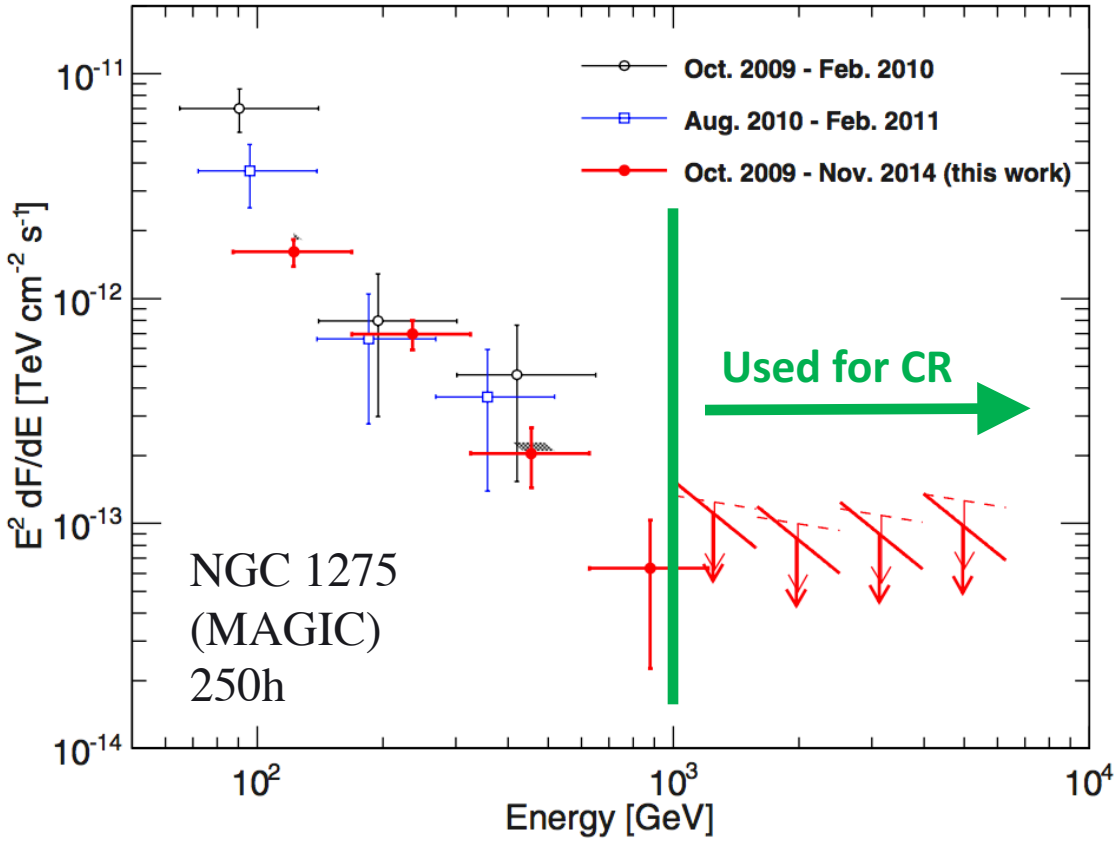
#1.4 Energy budgets in the Perseus galaxy cluster



- Galaxy clusters are expected to show a diffuse gamma-ray emission due to the interaction of accelerated CR with the ambient intracluster medium
- **Perseus** is a cool-core clusters, brightest in X-ray→optimal lab (*D*=78 Mpc, *z* = 0.018)
- MAGIC observed for 250 h (selected) in 4 years, providing several (model-dep) constraints

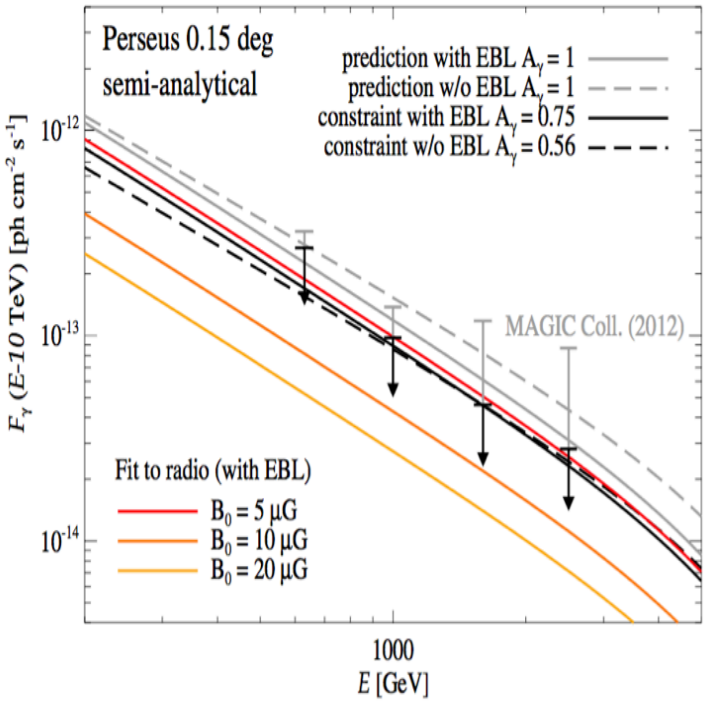
- Explanation for the origin of radio halos is more challenging → TeV gamma-ray best probe
- TeV Gamma rays expected:
  - Hadronic model: radio-emitting electrons are secondaries produced by CR protons interacting with the protons of the ICM
  - Re-acceleration model: seed population of CR electrons re-accelerated by interacting turbulent waves



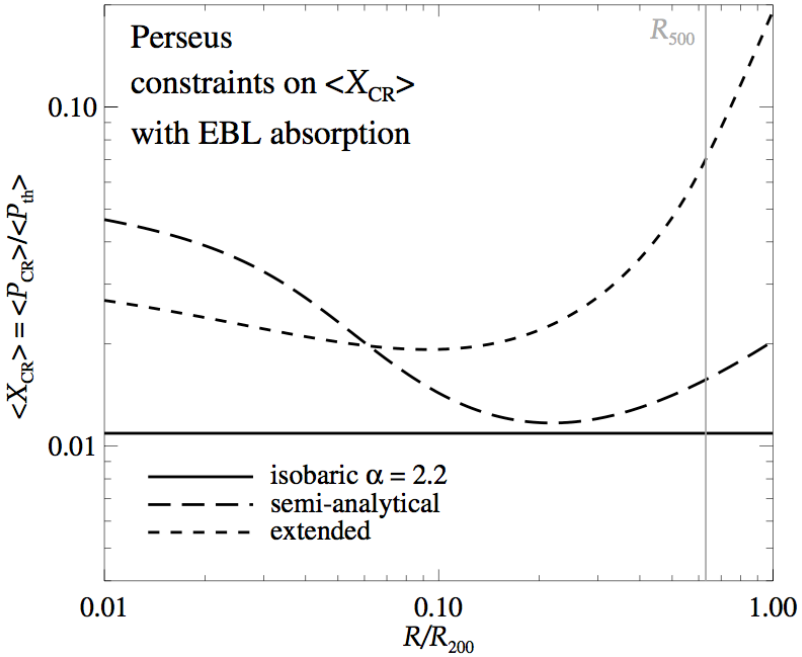
A&A 589, A33 (2016)
DOI: 10.1051/0004-6361/201527846

Constraining energy budget

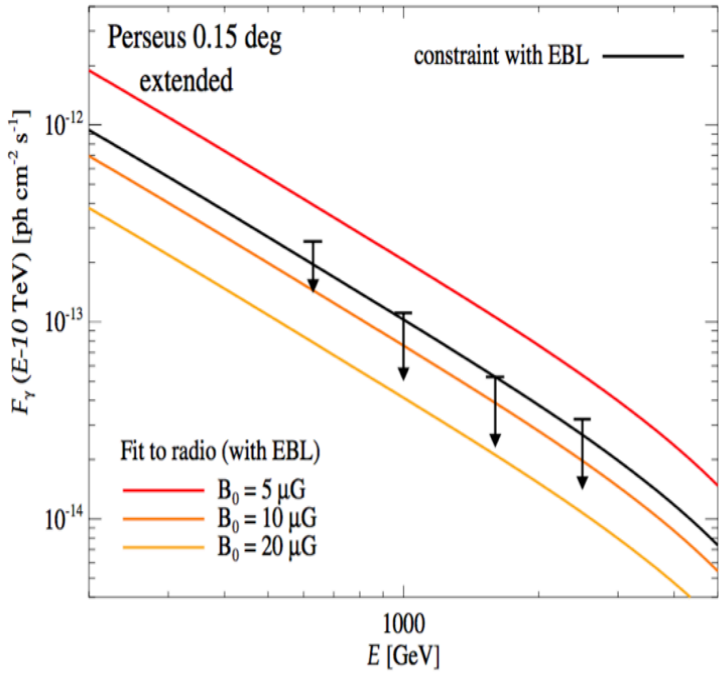
Q1: What fraction of the energy dissipated in structure formation shocks goes into particle acceleration?
Following Pinzke & Pfrommer (2010, no CR transport) model: not more than 37% of energy is converted



Q2: how is the cosmic-ray to thermal-pressure ratio?
Three models, ratio is smaller than between 2 and 20%.



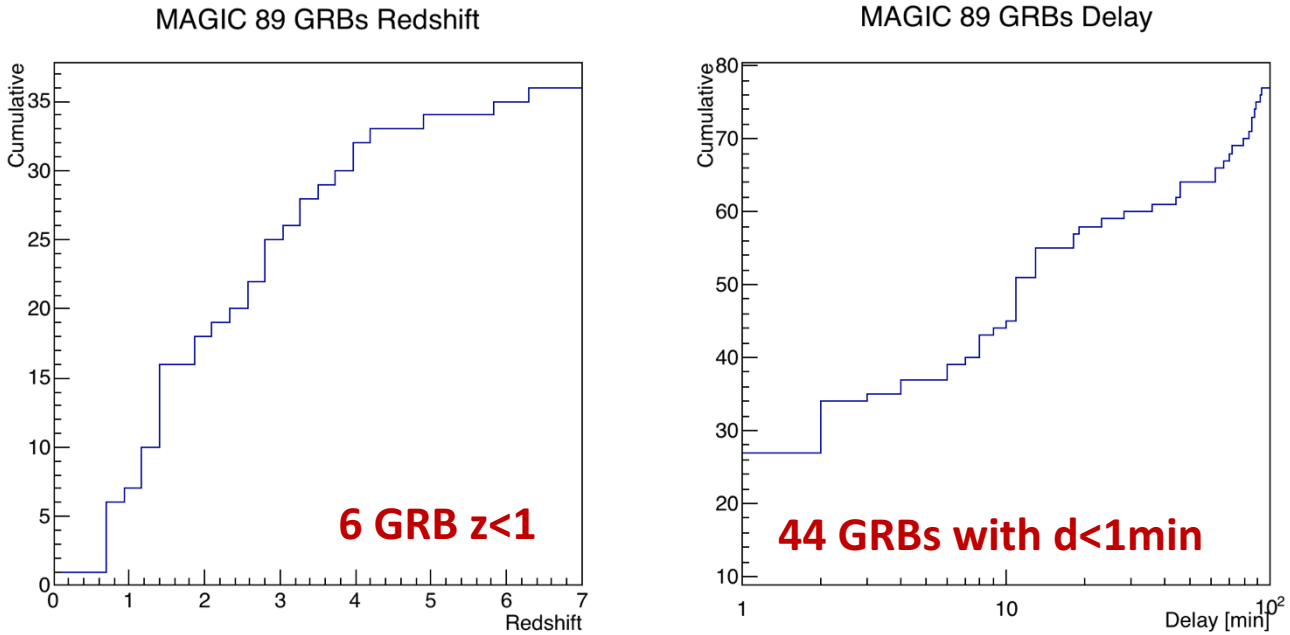
Q3: how intense is the magnetic fields that produce the observed sync-emission from secondary electrons?
Zandanel model (2015, assume CR transportaion). B is smaller than ~10 μG

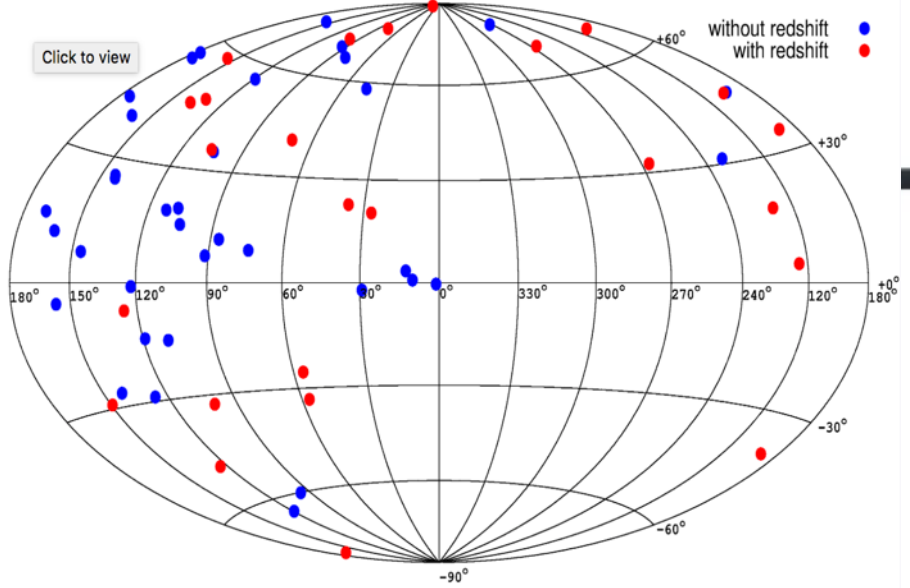


At this point…only CTA can do better

1.4 GRB program

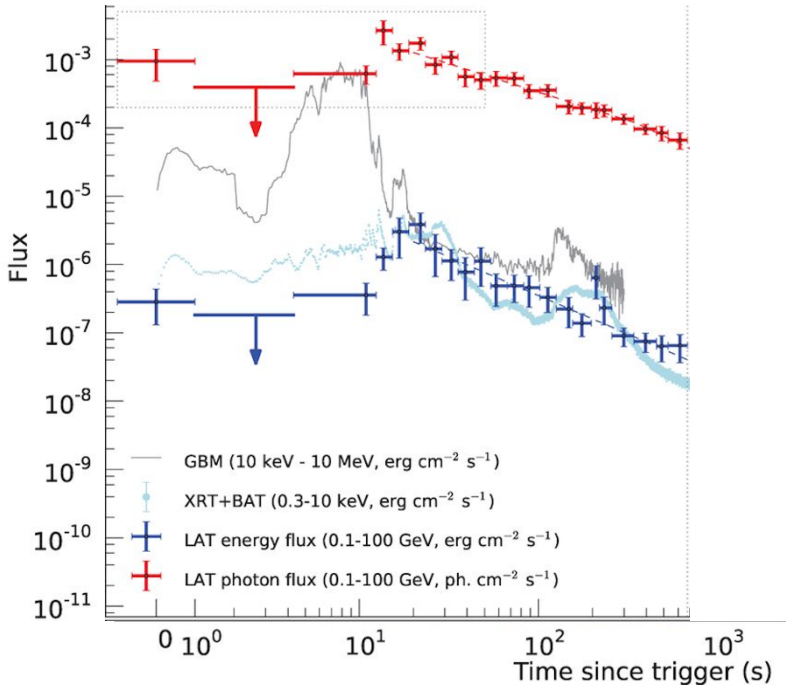
http://www.asdc.asi.it/tegrbcat/





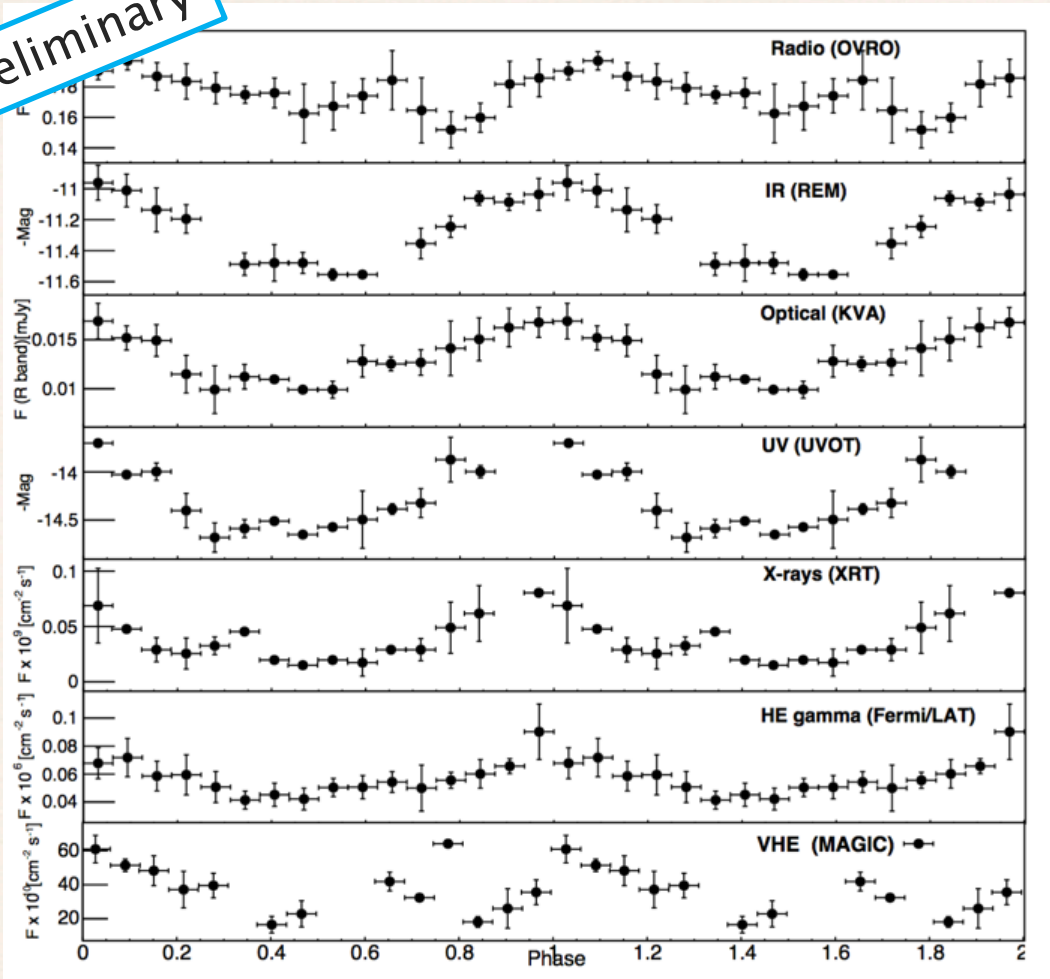
- MAGIC was built to fast-reposition to GRB alert (20sec between any pos) and to get the lowest energy threshold
  - Although late VHE signal may be expected→
- **89 GRBs** observed by MAGIC
- No significant hints at any target ☹, however, our eye is keen now

Ackermann, M. et al., 2014, Science, 343, 42



Periodicity of 1553 – very long-term monitoring

preliminary



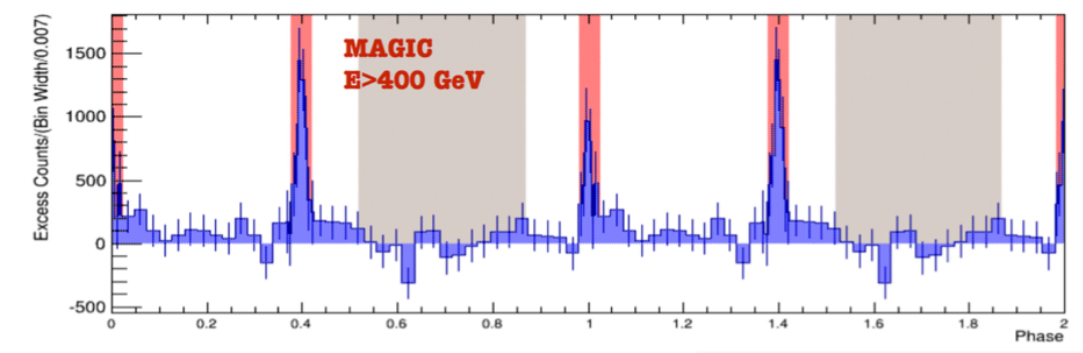
Da Vela+ Proc. Gamma2016

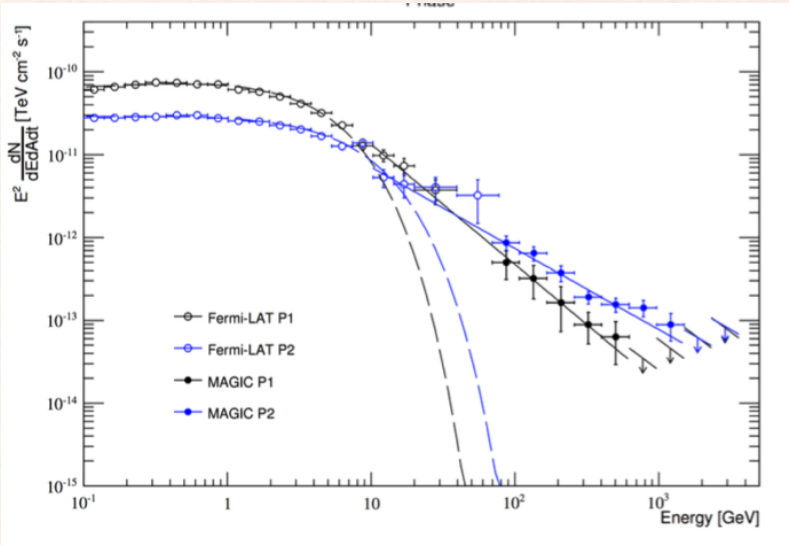
- **PG 1553+113** is the first gamma-ray blazar with a compelling evidence of **quasi-periodic modulation** (2y) in the correlated gamma-ray and optical light curves.
- Can be interpreted as **periodic changes in jet geometry or feeding processes**
  - The presence of a secondary black-hole in a sub-parsec orbit respect to the primary SMBH
  - Different mechanisms as jet precession, internal jet rotation, or helical jet motion may be invoked.
- Current MAGIC data still lack discrimination power, MAGIC will be densely monitoring the source

Pulsar hunts

Crab

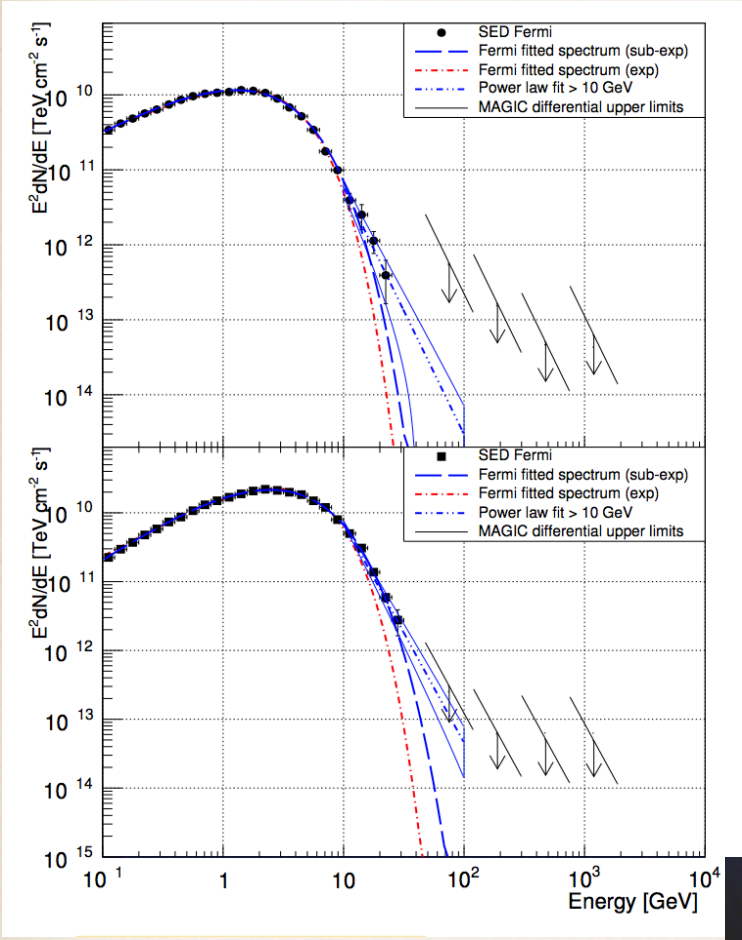
MAGIC (300h) detected pulsed emission close to 1 TeV on the Crab Pulsar





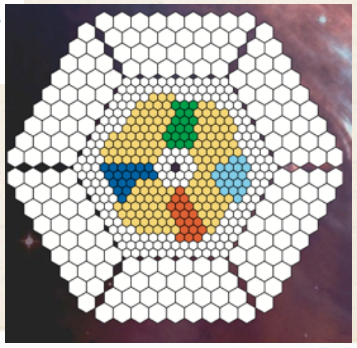
Teraelectronvolt pulsed emission from the Crab pulsar detected by MAGIC
MAGIC Collaboration (M.L. Ahnen *et al.*). Oct 23, 2015. 6 pp.
Published in **Astron.Astrophys. 585 (2016) A133**

Geminga

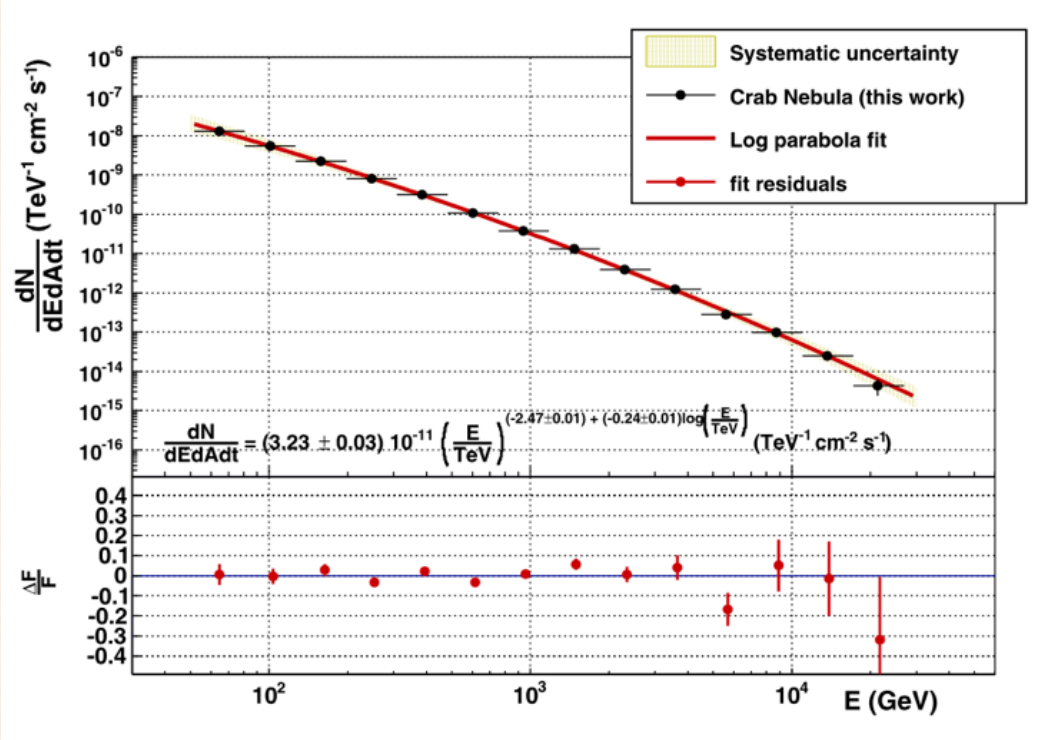


Nothing from the **Geminga pulsar** (nor Nebula) in 70h of data [MAGIC 2016]

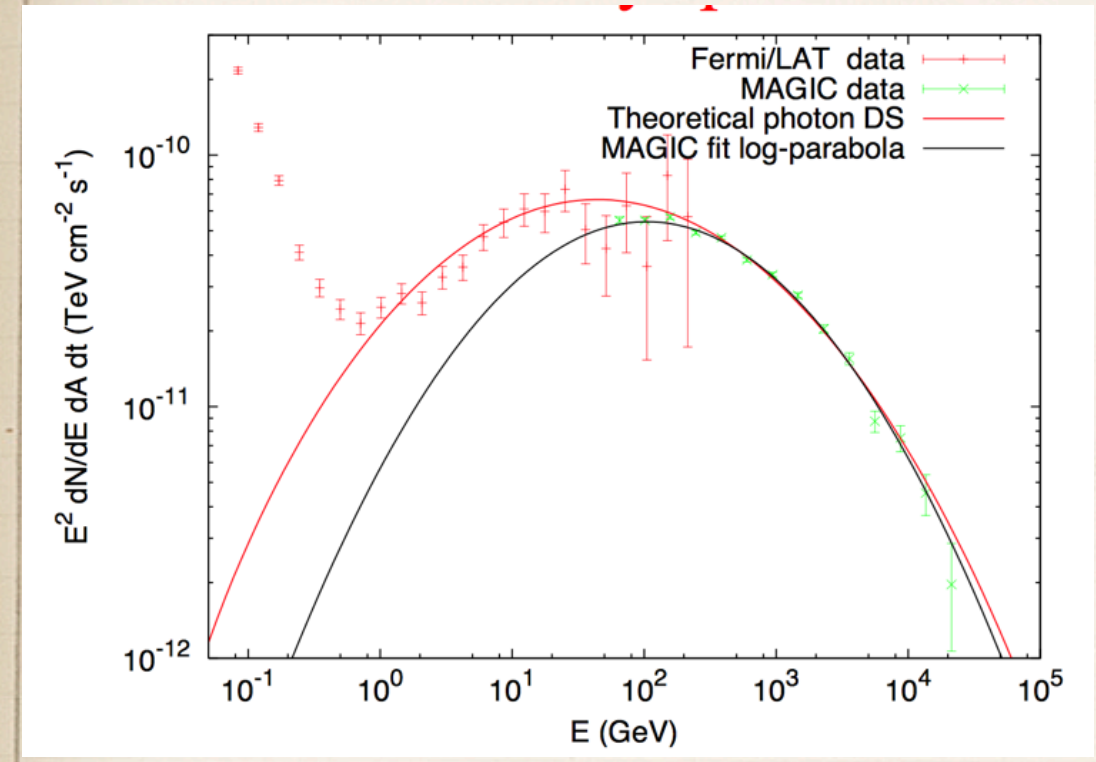
Developed a new trigger concept for low-energies ("sumtrigger")



Crab Nebula



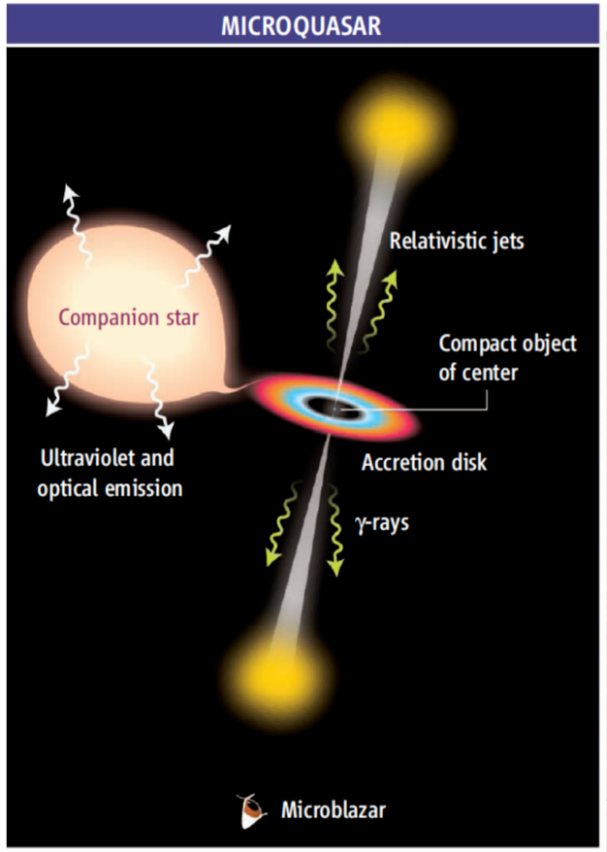
- MAGIC Crab Nebula results extend from 70 GeV to 30 TeV (higher range is in prep.) and fits well with log-parabola.
- When connected with Fermi: log-parabola is not good for both



Fraschetti+ theorized that the probability for TeV electrons of remaining in the acceleration region at mildly relativistic shock weakly decreases with energy; thus, the distribution in momentum of emitting particles is not a power-law
- However, uncertainty 10% in Fermi-MAGIC energy

Galactic jets (microquasars)

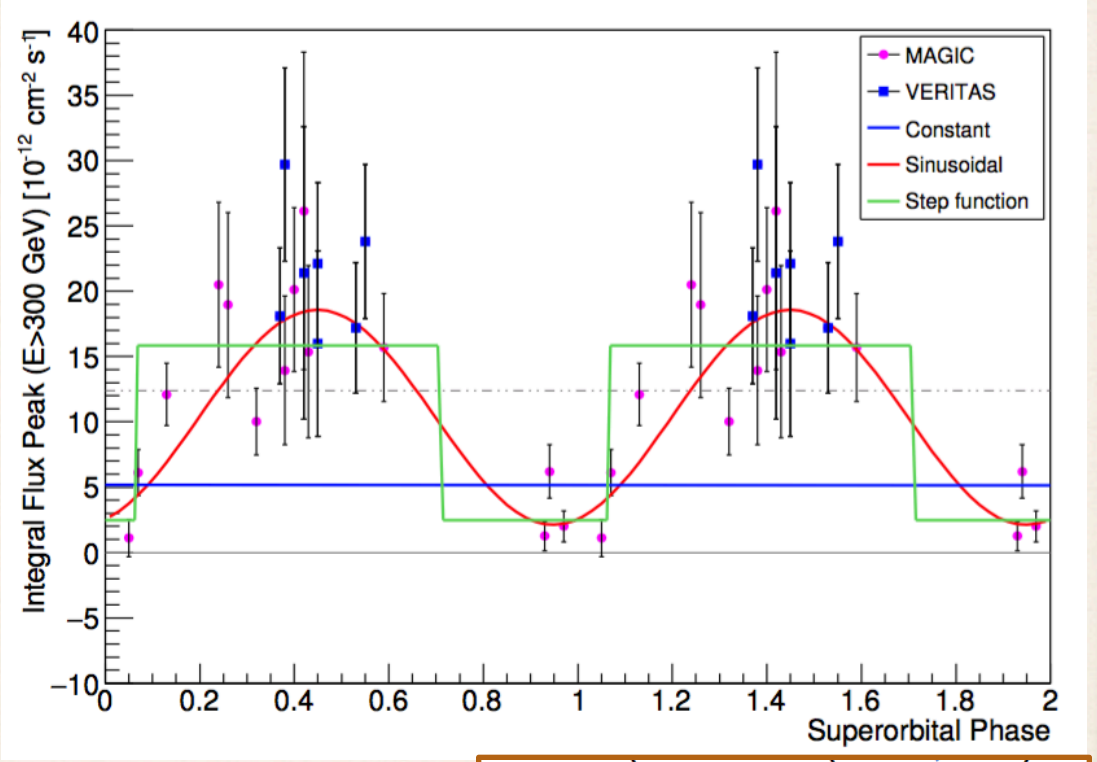
Candidates	Distance	Year	Obs. [h]	Detection	References
Cygnus X1	1.86 kpc	2006	1.3	4sigma	APJL 665
		2006-14	80	No hints	1510.03101
Cygnux X3	7kpc?	2006-09	70	No hints	APJ 721
Scorpius X1	2.8 kpc	2010	8	No hints	APJ 735
GRS1915		2005-06	14	No hints	0907.1017
V404 Cyg	2.4 kpc	2015	11	No hints	EWASS 2016



- MAGIC did not detect any VHE signal from well-established microquasars

- VHE flux is suppressed:
  - Synchrotron losses in the magnetic field present in the jets?
  - The fraction of kinetic energy transferred to plasma is low?

LSI +61 303

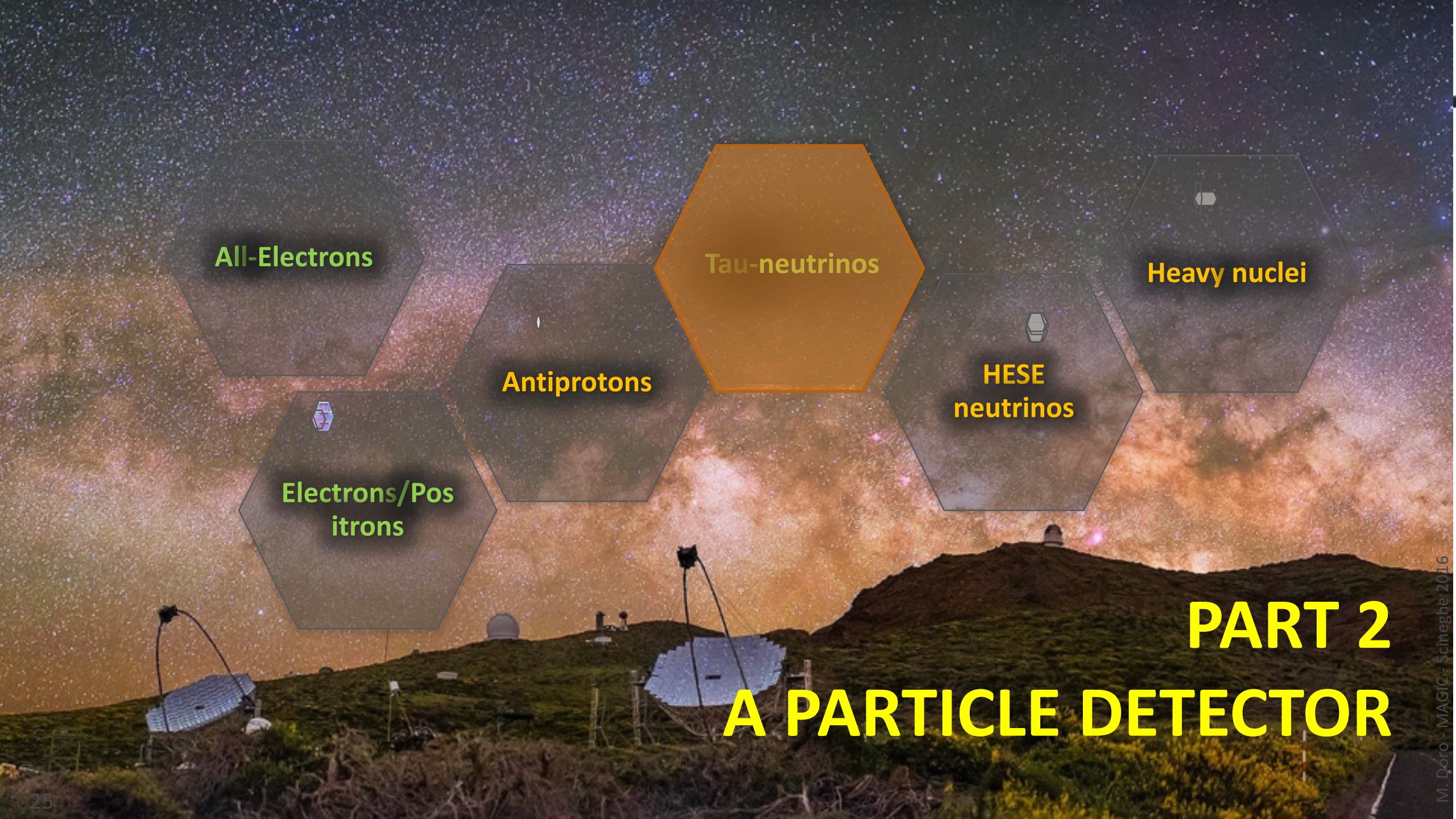


Astron.Astrophys. 591 (2016) A76

Function	Fit probability	χ^2/d.o.f.
Constant	4.5×10^{-12}	114.8/20
Step function	0.07	26.4/17
Sinusoidal	0.08	27.2/18

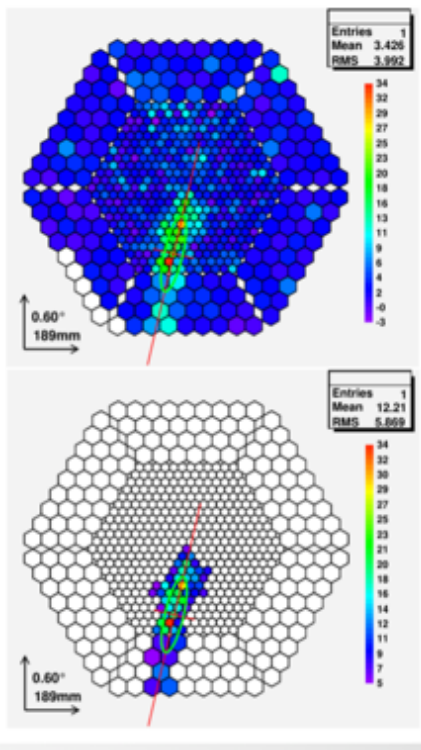
- LS I +61◦303 is a system of a Be star and a compact object of unknown nature co-rotating with a period of 26.5 days [MAGIC Science 312 (2006)] and conjuction at $\phi = 0.23$.
- LSI observed for 4 years at $\phi = 0.5–0.75$
- → **First detection of super-orbital variability** (1667 days) in the TeV regime compatible with radio data witin 8%

- The **flip-flop model** (Zamanov et al. 2001; Torres et al. 2012; Papitto et al. 2012) considers LS I +61◦303:
  - Accretion state changes from a propeller regime during periastron to an ejector regime at apastron.

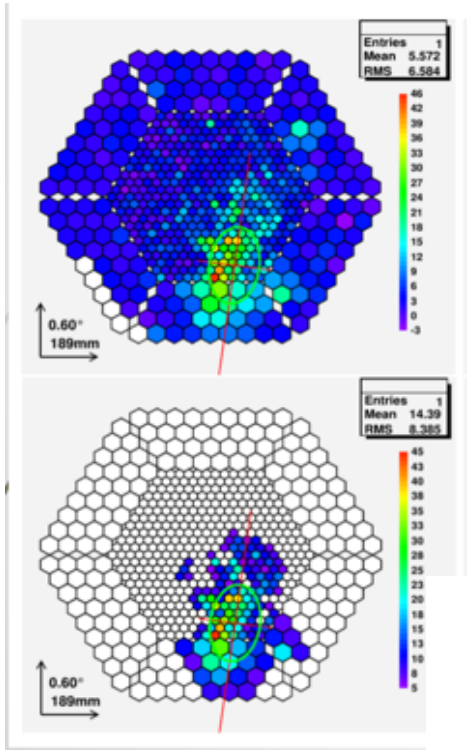


Events classification

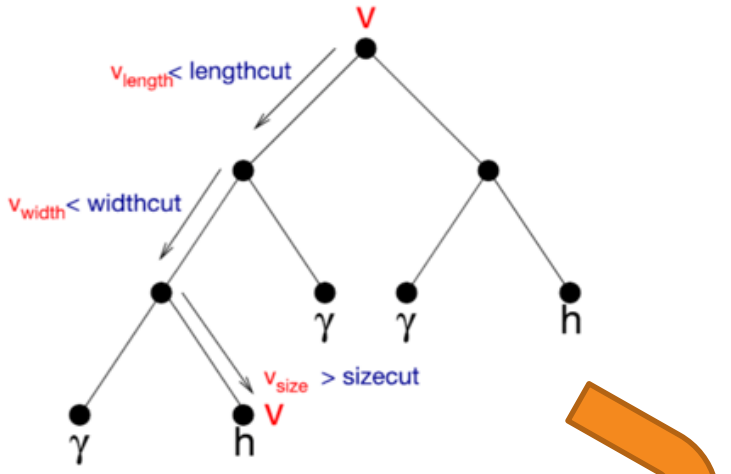
Gamma



Hadron

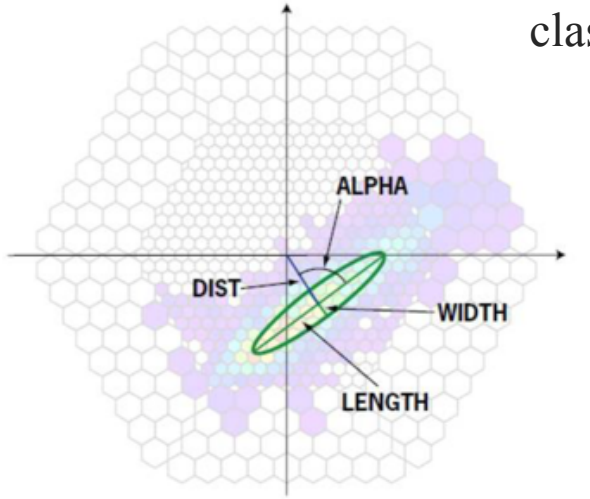


Shape and time evolution can change between event classes



1

Image parameters

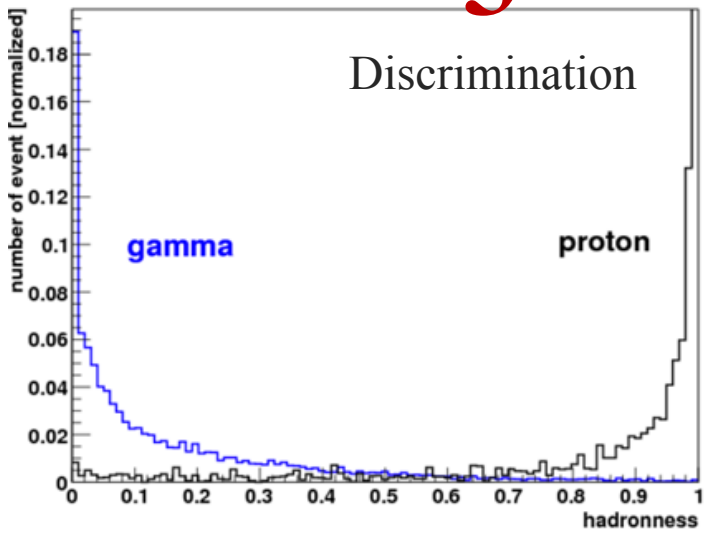


2

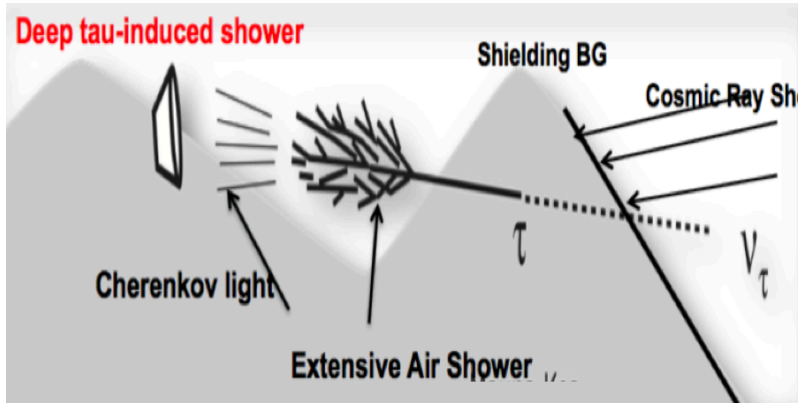
Decision trees for classification

3

Discrimination



#2.1 Neutrinos



- **Tau neutrinos may** reach Earth from space from energetic engines (AGNs, GRBs) from decay of charged pions. At Earth

$$\nu_e : \nu_\mu : \nu_\tau \sim 1 : 1 : 1$$

- If crossing the right amount of matter, nu_tau **can convert to tau-lepton in ground** and if exiting the ground again, can **generate atmospheric showers**

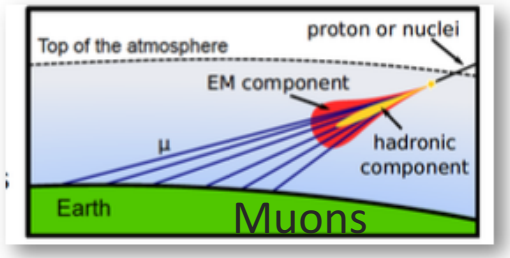
- MAGIC has a **sea window** observable (sometimes) when clouds are high in the sky and prevent cosmic observation
- **Complexity in MC simulations** (atmosphere, shower model, interactions, orography)
- All solved ☺ in Gora+ Astropart.Phys. 26 (2007) 402-413

D. Fargion, Astrophys.J. 570, 909 (2002).
X. Bertou et al., Astropart.Phys. 17, 183 (2002)
E. Zas, New J.Phys. 7, 130

Discrimination

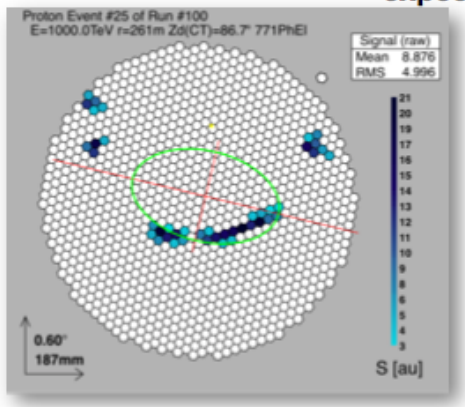
- Observations performed at 85 deg ZA
- Tau-lepton induced showers happen much closer to MAGIC: they produce a cascade or muon ring(s)

Proton injected at the top of the atmosphere
(X_{inj} < 50 g/cm^2, ~1000 km to detector for 87 deg)

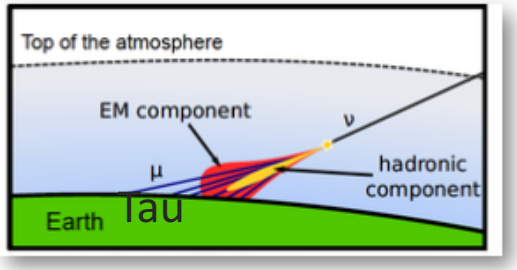


E_{muon} = 1 PeV

Background expectation

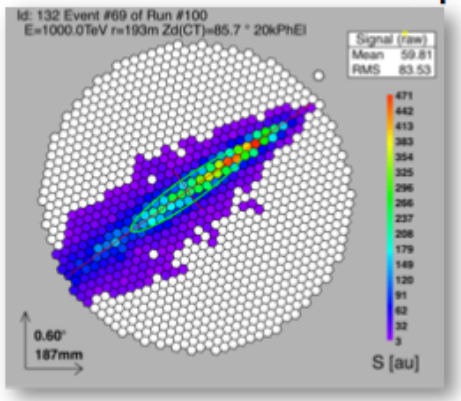


Deep tau-induced shower
(X_{inj} = 760 g/cm^2, ~50 km to the detector)



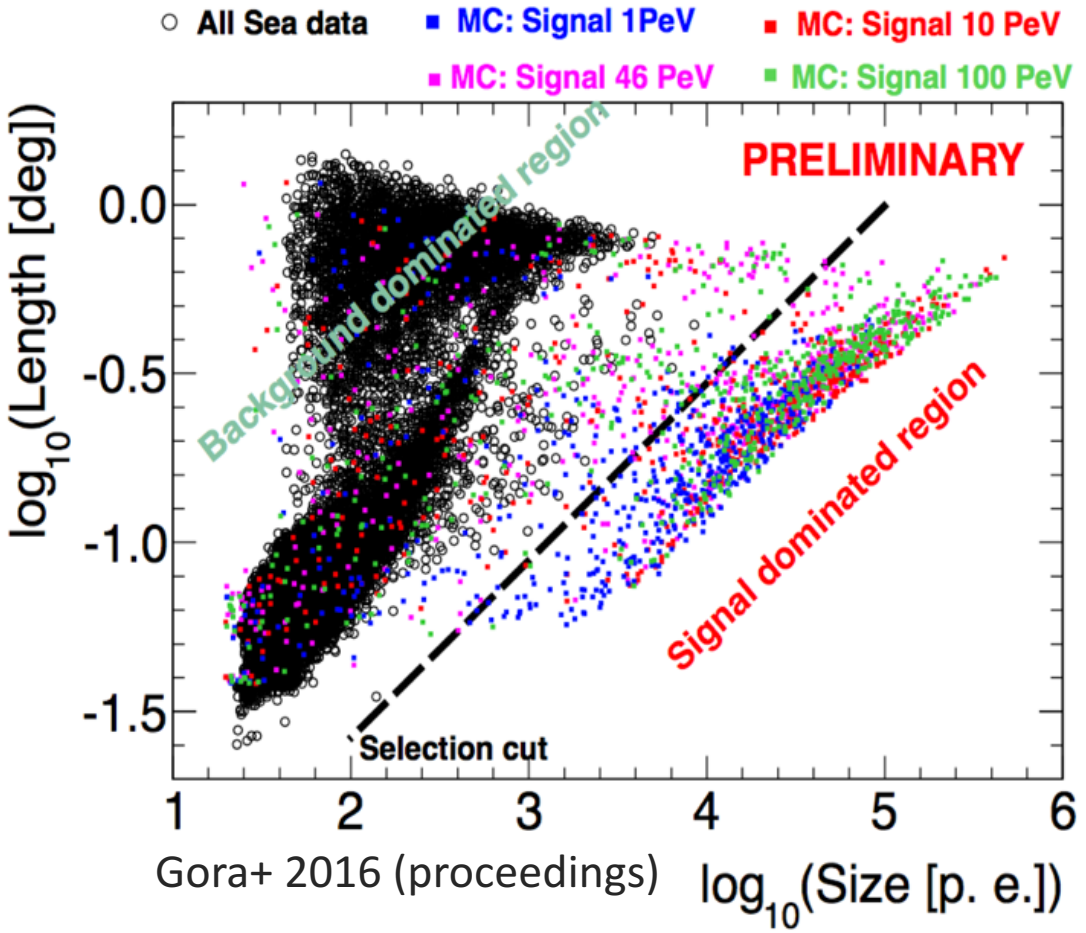
E_{tau} = 1 PeV

Signal expectatio



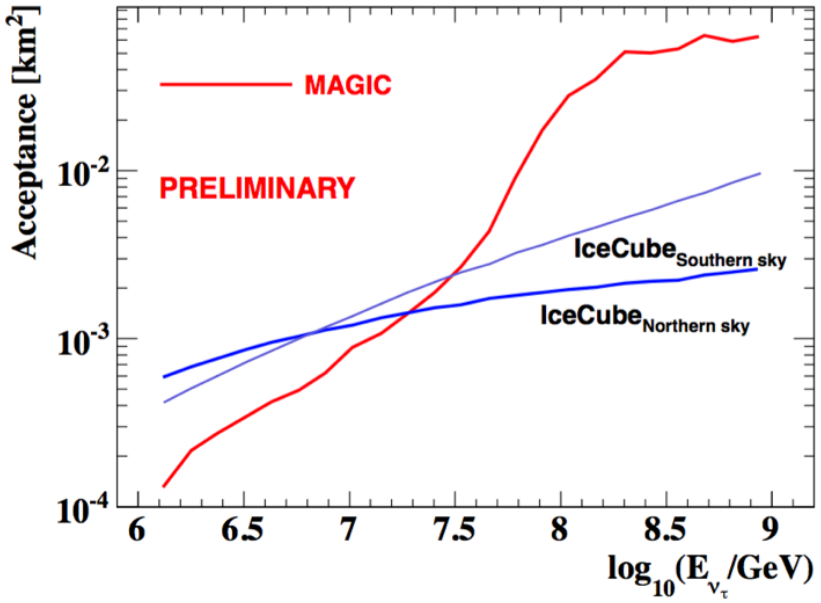
Gora+ 2016 (Gamma16 poster)

- Discriminated by (larger) Size and Length of the images



Gora+ 2016 (proceedings)

Performance and Expectations



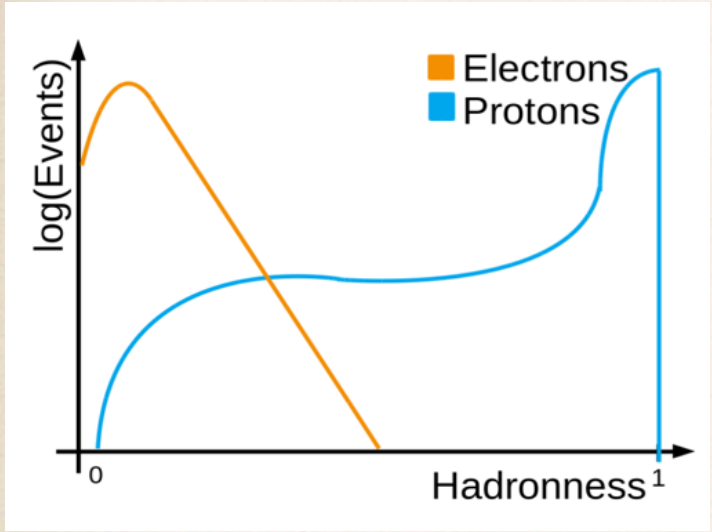
Results to be published soon

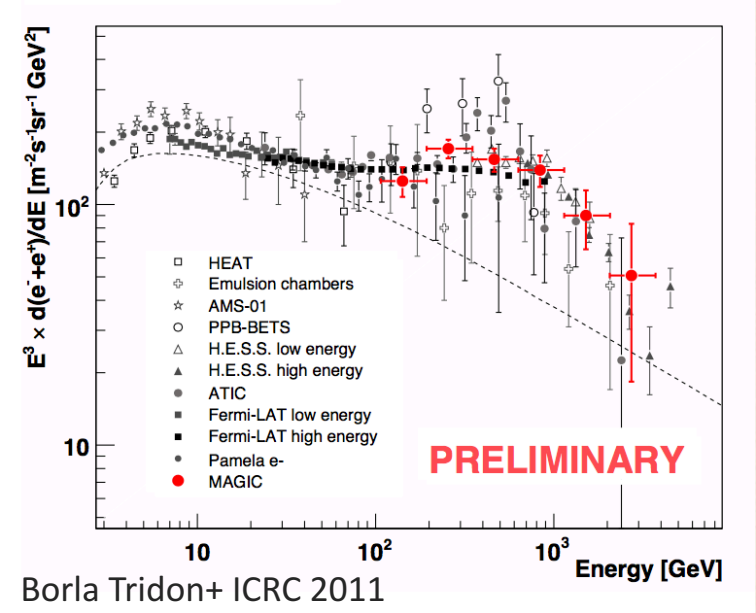
- Sensitivity above the PeV is good (due to combination of large acceptance window and large number of photons)
- However, events are very rare
  - **Diffuse neutrino** flux is low, but MAGIC constraints in the PeV could be the strongest (300h achievable)
  - **Bright flares** from can be observed when the source passes through the "sea window"
    - GRBs possible in case of late neutrino emission (Phys. Rev. D 93, 083003 (2016))
    - AGNs?
    - GW?

- Proposed also to make "muon tomography" of mountains [N. Lesparre et al. 2010, Geophys. J. Int, 183 O. Catalano et al. 2016,]

2.2 All-electrons

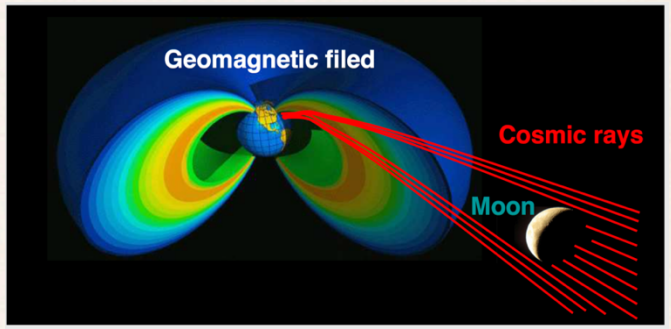
- MAGIC can measures cosmic-electron induced showers
  - totally similar to that of g-ray
  - Discrimination possible when comparing “background only” regions
- Preliminary results in 2011 (40h), took a long way to update them
  - It is hard to gain control on systematics

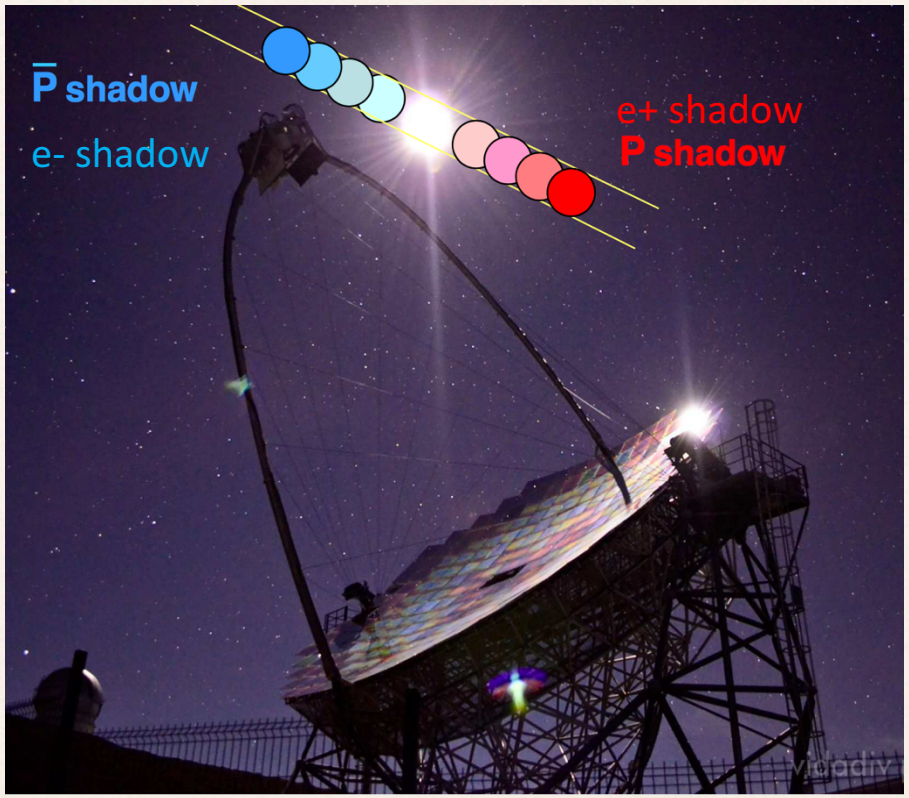




Borla Tridon+ ICRC 2011

#2.2 Electron/positrons – antiprotons





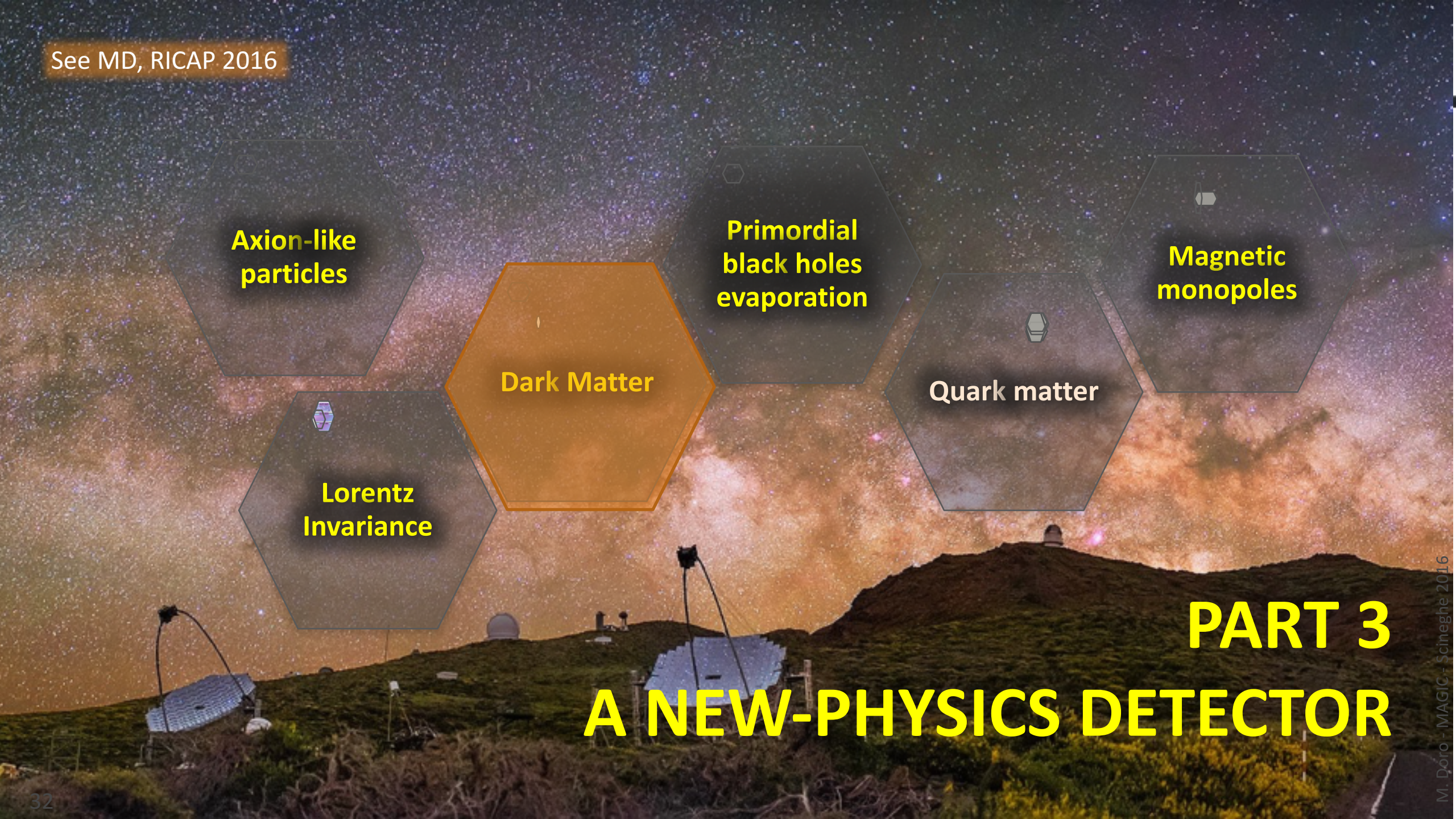
Credit: P.Colin

- Is it possible to charge-separate cosmic-rays?
- By means of the moon-shadow:
  - deficit charge-dependent at one side to the moon
  - Deficit shift in distance following particle energy
- MAGIC collected several h in few years → very bright moon analysis (not standard). Also during a lunar eclipse
- *Paper in prep*.

Colin+ ICRC 2015

Composition hypothesis	Missing flux 300-700 GeV	Detection time with MAGIC
MAGIC spectrum [5]:		
100% e-	5.4%	∼30 h
80% e-	4.3%	∼50 h
60% e-	3.3%	∼90 h
40% e+	2.2%	∼200 h
20% e+	1.1%	∼800 h
ATIC spectrum [3] :		
100% e-	7.2%	∼20 h
80% e-	5.7%	∼30 h
60% e-	4.3%	∼50 h
40% e+	2.9%	∼100 h
20% e+	1.5%	∼400 h

See MD, RICAP 2016



PART 3
A NEW-PHYSICS DETECTOR

Dark matter search at all targets

Target	Year	Time	Experiment	Ref.
Globular Clusters				
M15	2002	0.2	Whipple	[5]
	2006–2007	15.2	H.E.S.S.	[6]
M33	2002–2004	7.9	Whipple	[5]
M32	2004	6.9	Whipple	[5]
NGC 6388	2008–2009	27.2	H.E.S.S.	[6]
Dwarf Satellite Galaxies				
Draco	2003	7.4	Whipple	[5]
	2007	7.8	MAGIC	[7]
	2007	18.4	VERITAS	[8]
Ursa Minor	2003	7.9	Vhipple	[5]
	2007	18.9	VERITAS	[8]
Sagittarius	2006	11	H.E.S.S.	[9]
Canis Major	2006	9.6	H.E.S.S.	[10]
Willman 1	2007–2008	13.7	VERITAS	[8]
	2008	15.5	MAGIC	[11]
Sculptor	2008	11.8	H.E.S.S.	[12]
Carina	2008–2009	14.8	H.E.S.S.	[12]
Segue 1	2008–2009	29.4	MAGIC	[13]
	2010–2011	48	VERITAS	[14]
	2010–2013	158	MAGIC	[15]
Boötes	2009	14.3	VERITAS	[8]
Galaxy Clusters				
Abell 2029	2003–2004	6	Whipple	[16]
Perseus	2004–2005	13.5	Whipple	[16]
	2008	24.4	MAGIC	[17]
Fornax	2005	14.5	H.E.S.S.	[18]
Coma	2008	18.6	VERITAS	[19]
The Milky Way central region				
MW Center	2004	48.7	H.E.S.S.	[20]
MW Center Halo	2004–2008	112	H.E.S.S.	[21]
Other searches				
IMBH	2004–2007	400	H.E.S.S.	[22]
	2006–2007	25	MAGIC	[23]
Lines	2004–2008	112	H.E.S.S.	[24]
	2010–2013	158	MAGIC	[15]
UFOs	–	–	MAGIC	[25]
	–	–	VERITAS	[26]
All-electron	2004–2007	239	H.E.S.S.	[27,28]
	2009–2010	14	MAGIC	[29]
Moon-shadow	–	–	MAGIC	[30]

- MAGIC and IACTS searched everywhere for Dark Matter
  - Galactic Center, dSphs, Galaxy Clusters, UFOs,+

Single-telescope (MAGIC-I alone) results

- ❖ Galactic Center
  - **(17 h)** ApJ Lett. 638 (2006) L101
- ❖ Galaxy clusters
  - **Perseus (25 h)** ApJ 710 (2010) 634
- ❖ Dwarf Galaxies:
  - **Draco (8 h):** ApJ 679 (2008) 428
  - **Willman 1 (16 h):** ApJ 697 (2009) 1299
  - **Segue 1 (30 h):** JCAP 06 (2011) 035

A decade ago, we were investing few hours per source.

MAGIC has now moved to 100h+ campaigns.

AIM is detection of course, but also legacy robust results

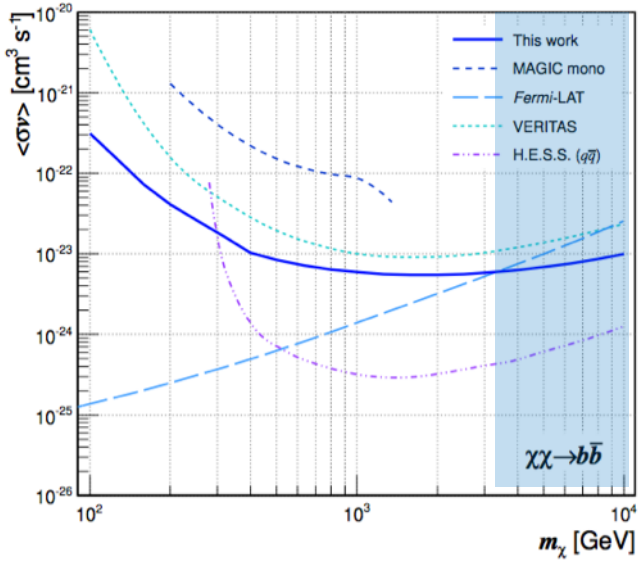
← *MD, NIM A 742 (2014)*

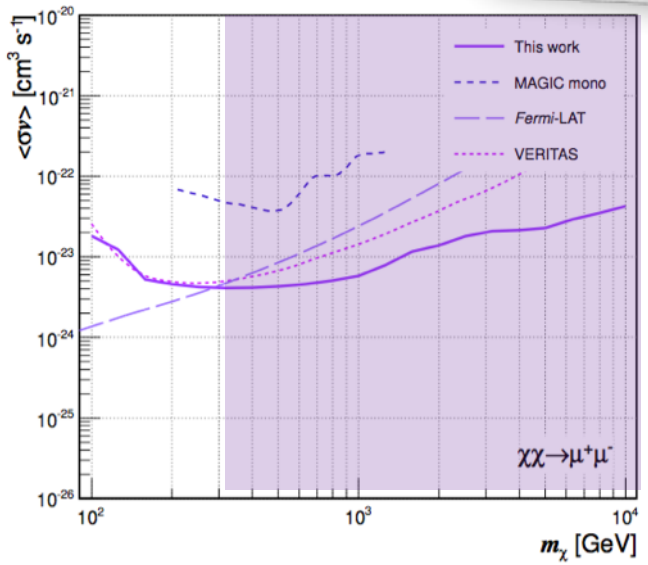
#3.1 Segue 1 Deep Scan with MAGIC stere

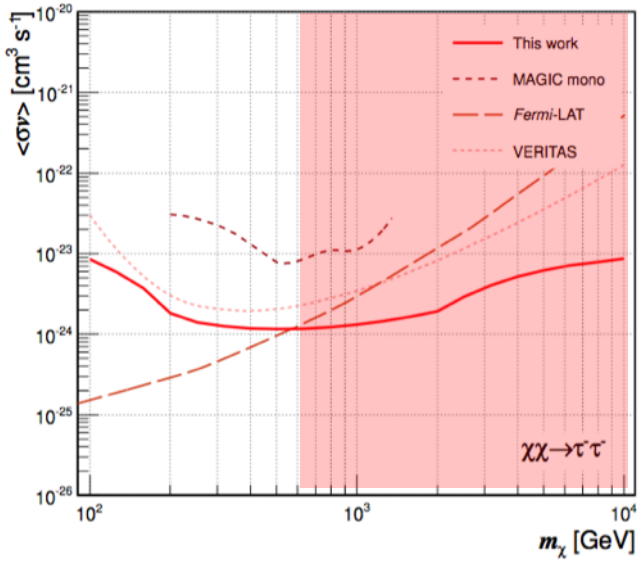
Best limits from dwarfs in high-mass range

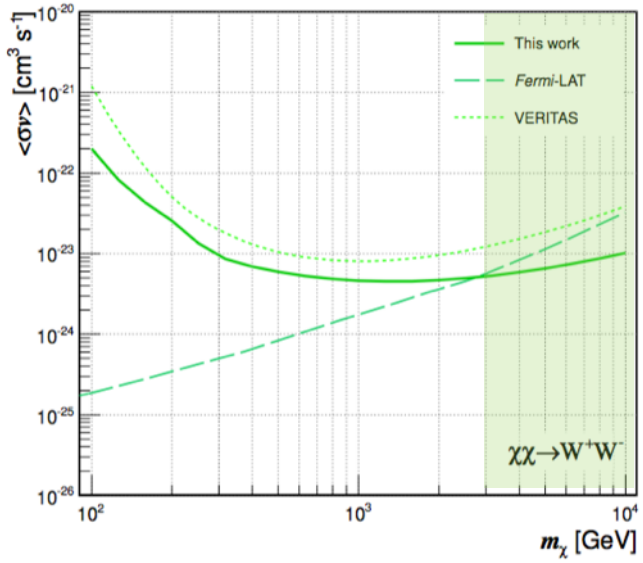
- MAGIC decided to perform the **longest exposure on a single dSph**: Segue 1
- **160 hours** of good-quality data between 2011 and 2013.
- Optimized statistical treatment allowed performance boost

See Aleksic+ **JCAP 1210 (2012) 032**

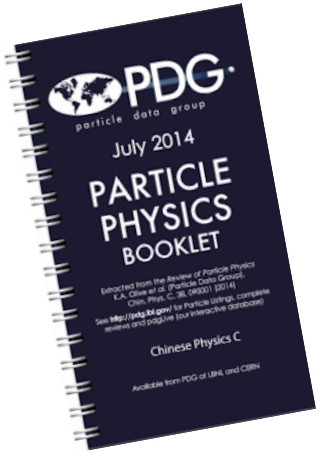








- Strongest constraints above few hundreds GeV according to channel
- Results made into the PDG

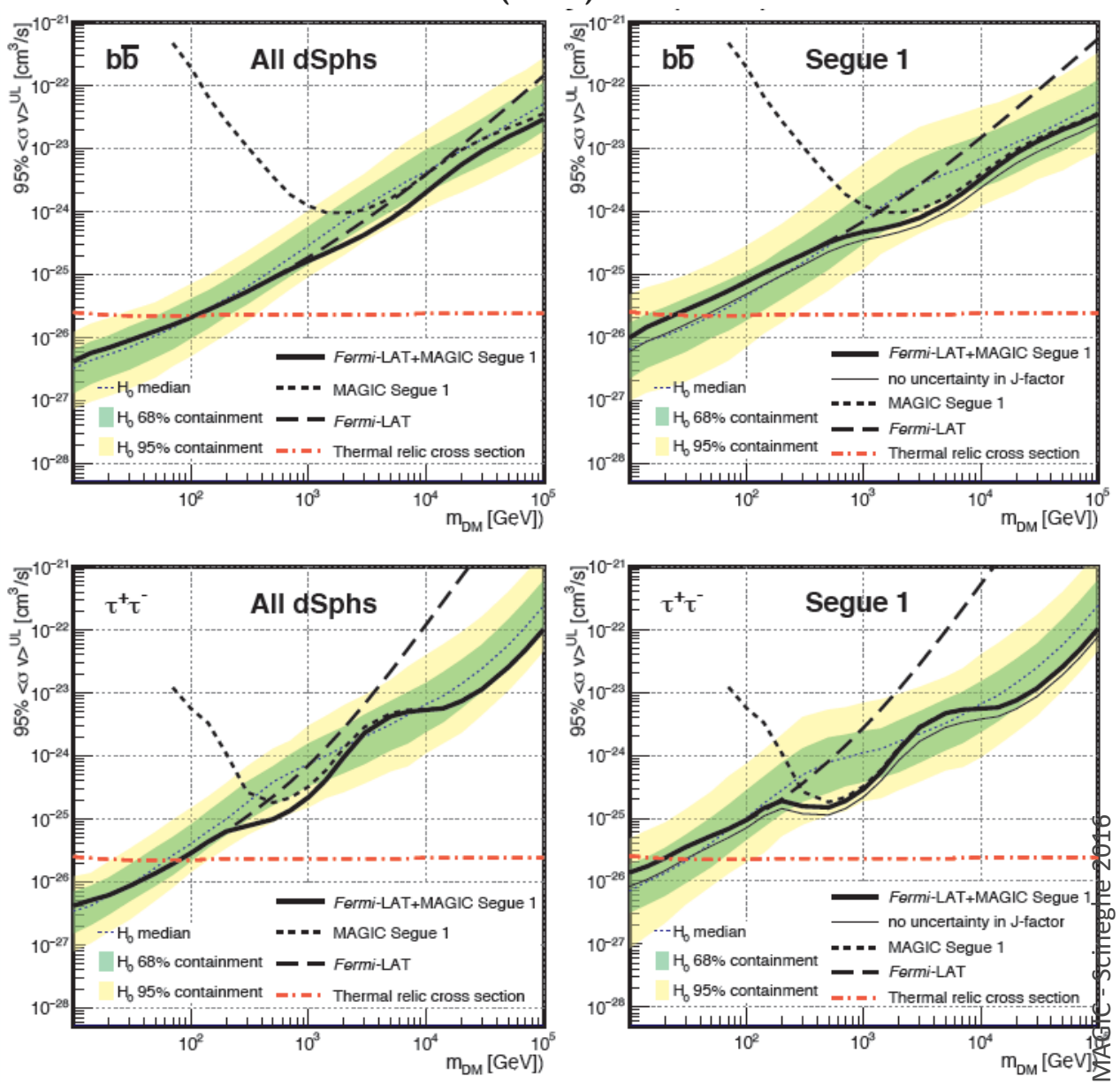


MAGIC + Fermi combined

- MAGIC: Segue 1 (158 h) and Fermi-LAT: 15 dwarfs (6 years, Pass8)

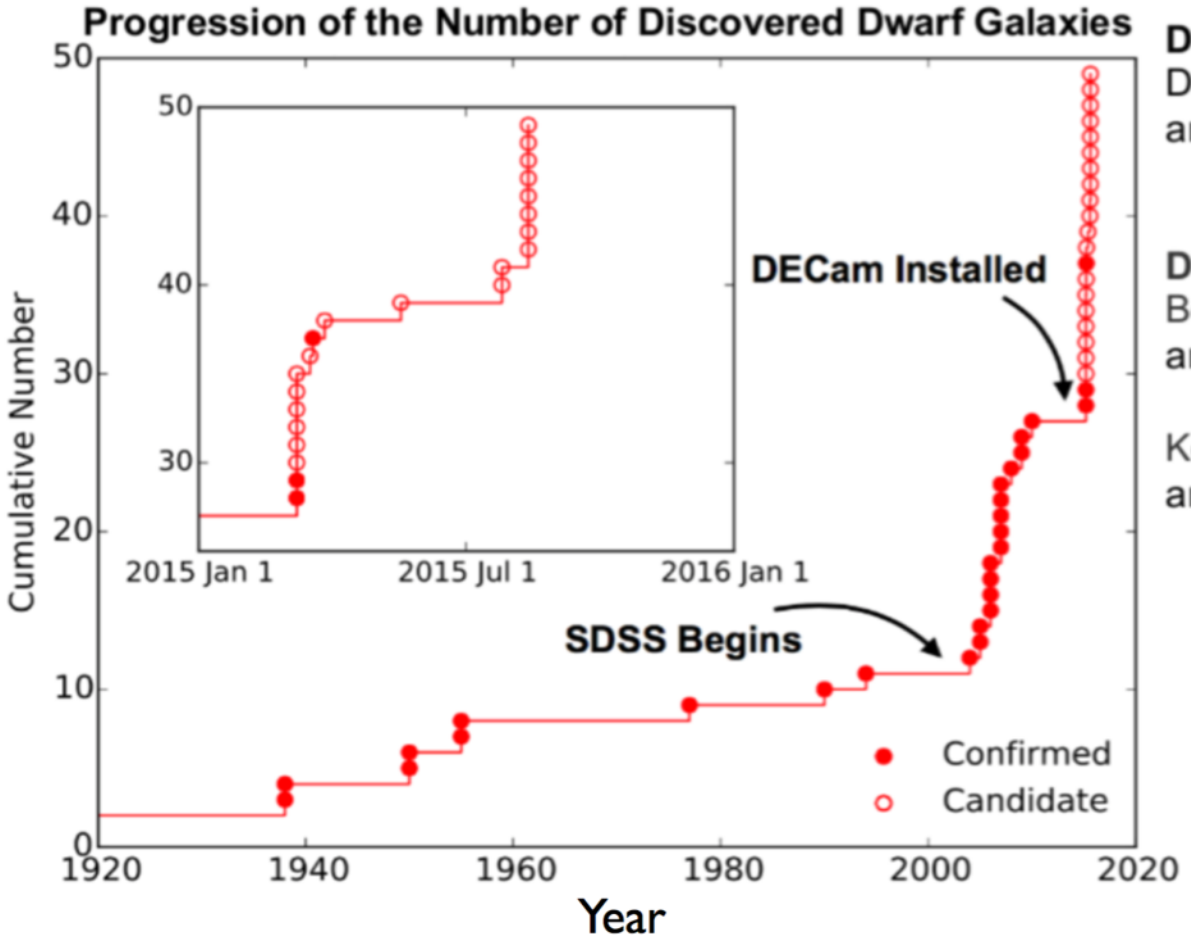
- **Coherent limits** between 10 GeV and 100 TeV (widest range so far explored)
  - Annihilation limits for DM particle masses below O(1) TeV dominated by Fermi-LAT, above O(1) TeV by MAGIC (and IACTs, in general)
- **Effective combination (2x stronger constraints) in the range 300-500 GeV**

- *Possible to add additional indirect detection instruments (a call was raised by MAGIC)*



JCAP02(2016)039

MAGIC program



DES Year 2 Data:
Drlica-Wagner+,
arXiv:1508.03622

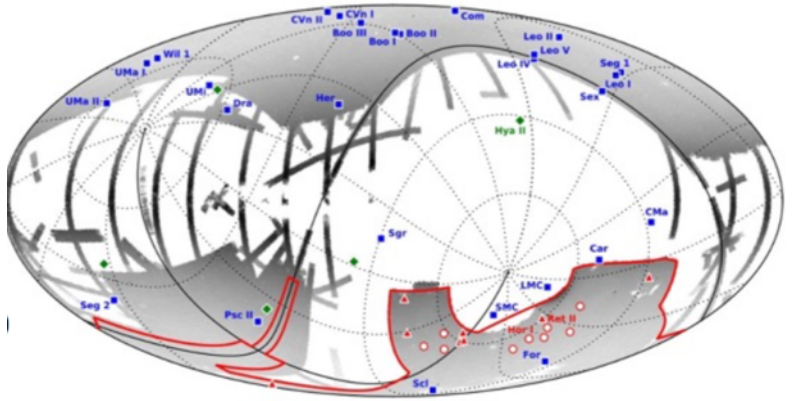
DES Year 1 Data:
Bechtol+:
arXiv:1503.02584

Koposov+:
arXiv:1503.02079

New instruments are discovering new dSphs: some very promising.

Expect results from MAGIC!

Catching up with ΛCDM predictions:
until 2004: 9 “classical”
2005: +15 (SDSS)
2015: +>20 (DES + Pan-Starrs)


Credit: Dark Energy Survey Collaboration

Decaying DM in Cluster of galaxy

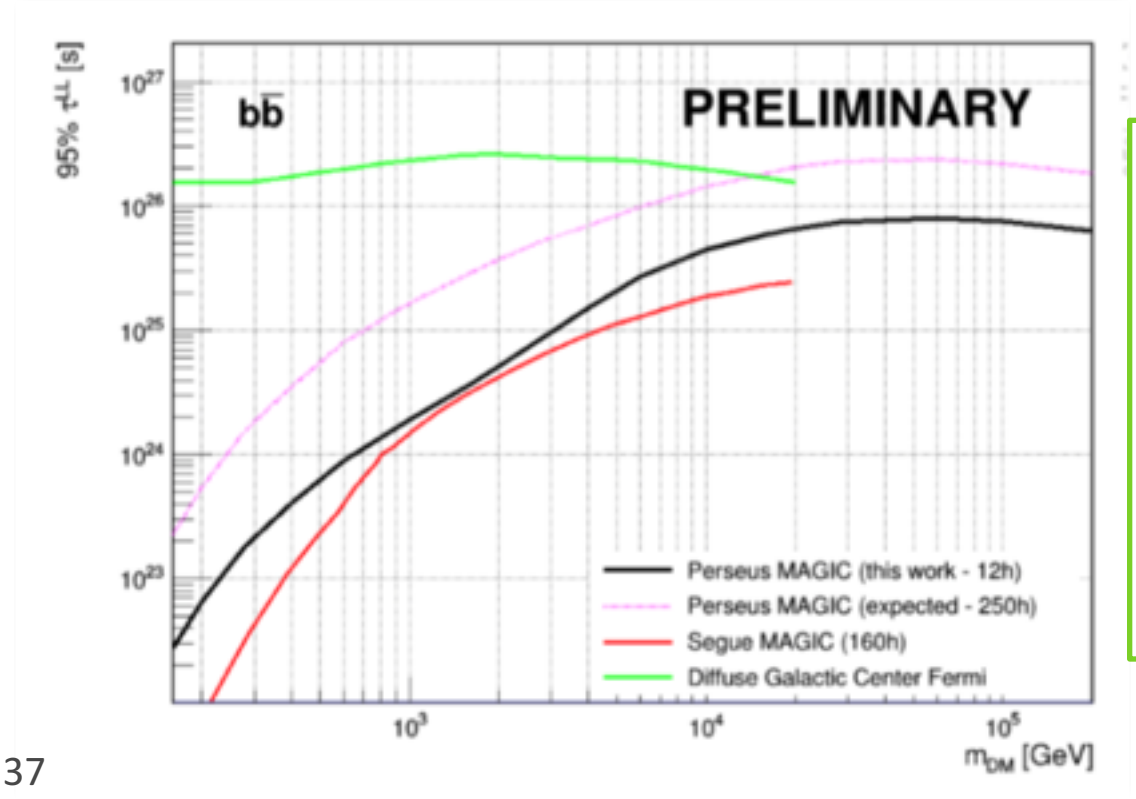
$$\frac{d\Phi_\gamma}{dE} = \frac{d\Phi_\gamma^{PP}}{dE} \times J(\Omega)$$

- **Galaxy clusters** are very far-away
  - Cannot compete (probably) with closer object in terms of annihilating DM (where DM density-square matters)
  - **Are optimum targets for decaying DM**
- We used the **large campaign** on a Perseus

Decay

$$\frac{d\Phi_\gamma^{PP}}{dE} = \frac{1}{4\pi m_\chi \tau_\chi} \frac{dN_\gamma}{dE}$$

$$J(\Omega) = \int_\Omega \int_{los} \rho(r) dr d\Omega$$

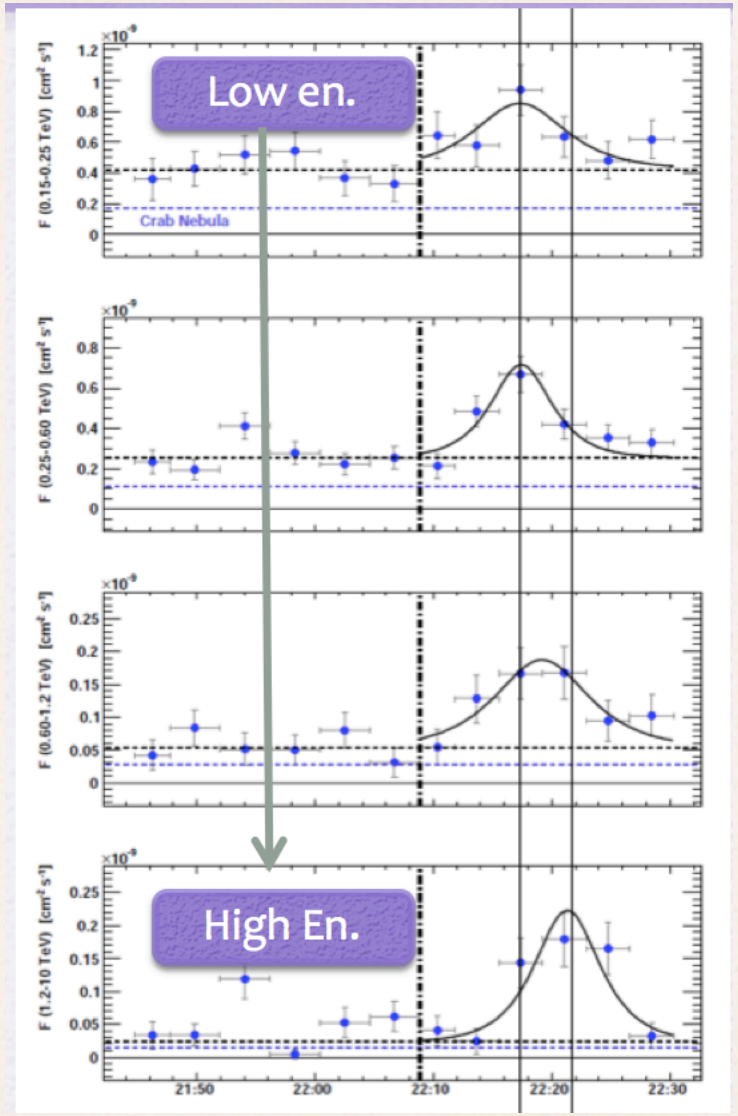


We are obtaining excellent results in the decaying DM case

Lower limits on DM particle decay lifetimes (*with ONLY 12 hours !!*) Best limits for X→Tau+Tau- for DM masses above 2 TeV

Publication soon!

LIV contraints from AGN



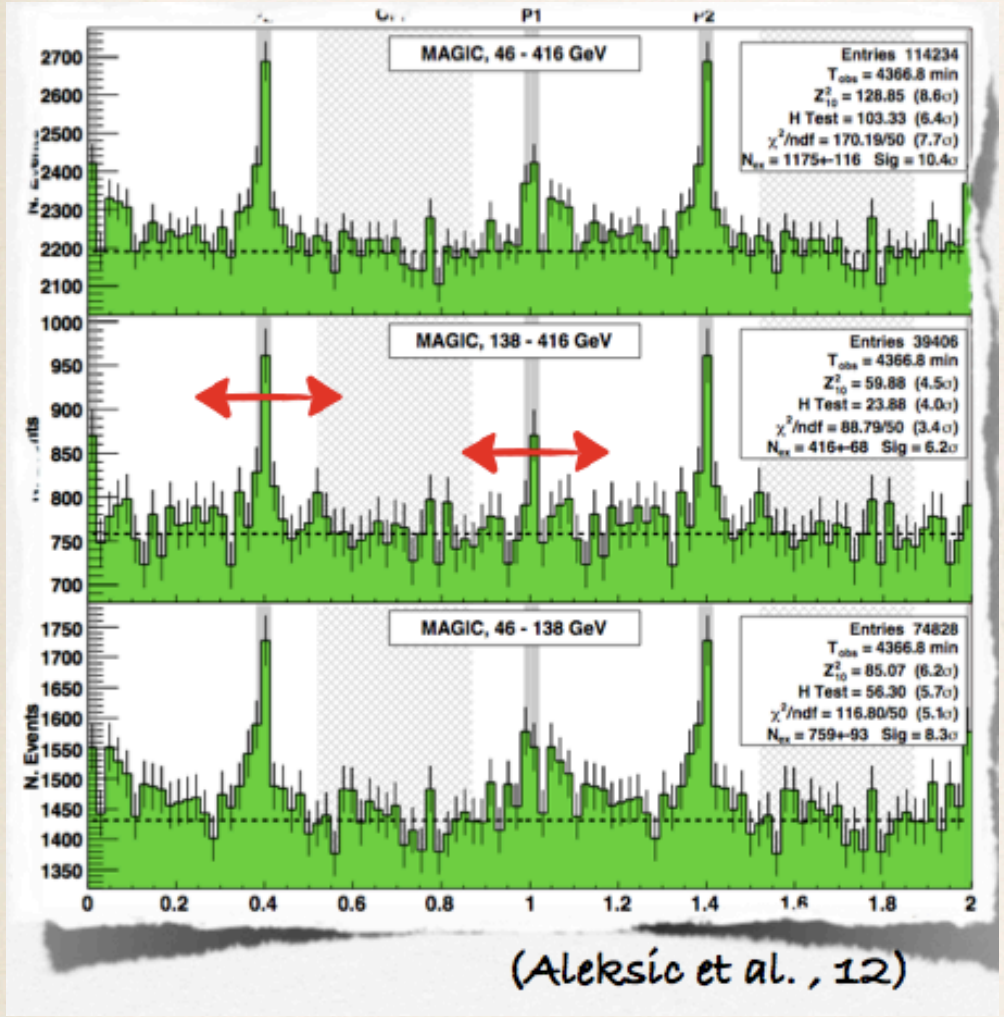
- ←In 2007, MAGIC saw a great delay of arrival times of photons at different energies....however simple **intrinsic effects** cannot be excluded
- Since then, several flares observed
- Effort now is to combine all flare into a single limit (also with other instruments in the filed)

LIV contraints from pulsars

- **Intrinsic effect can be excluded** in pulsar, where there is a first derivative of the frequency with time (need long time-lag)
- MAGIC has the Crab pulsar observed for a decade
- Paper to be published soon

Limits obtained with g-rays but things will improve soon…

Telescope	M_P/ξ [GeV]	M_P/ζ [GeV]
MAGIC	0.03×10^{19}	5.7×10^{10}
H.E.S.S.	0.21×10^{19}	6.4×10^{10}
Fermi-LAT	1.50×10^{19}	3.0×10^{10}



CONCLUSIONS

Conclusions: MAGIC science-hiking maps

Is This For You?

Find the right cross-country singletrack trail grade for your abilities

Singletrack trails

Grade	Suitable for:	Trail
Green: Easy	Gal/Egal astroph: AGN, PWN+	Take data / detect / publish
Blue: Moderate	Gal/Egal missing targets: Micro-q/GRBs	Take data / no detect / publish?
Red: Difficult	Cosmic rays/Neutrunos	Cosmic rays
Black: Severe	Exotic physics	Get many PhDs

bikes.

Gamma-ray astroph is a potentially hazardous activity carrying a significant risk.