OBSERVATIONAL GAMMA-RAY ASTRONOMY: RECENT HIGHLIGHTS AND THE PATH TOWARDS CTA

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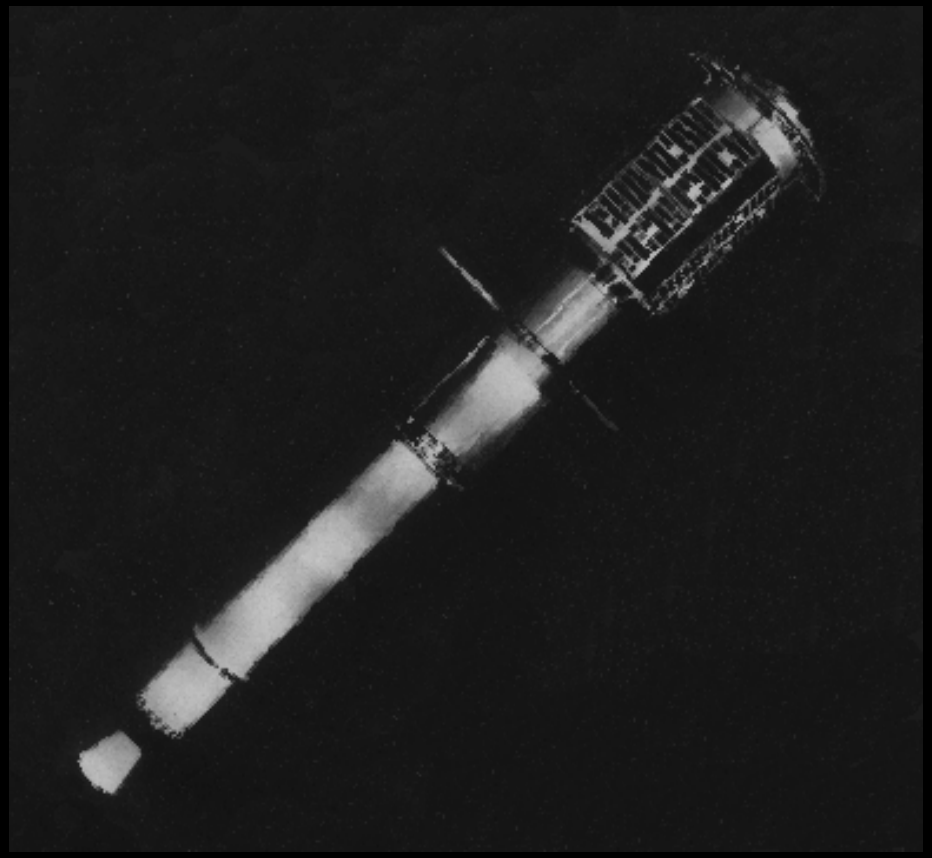
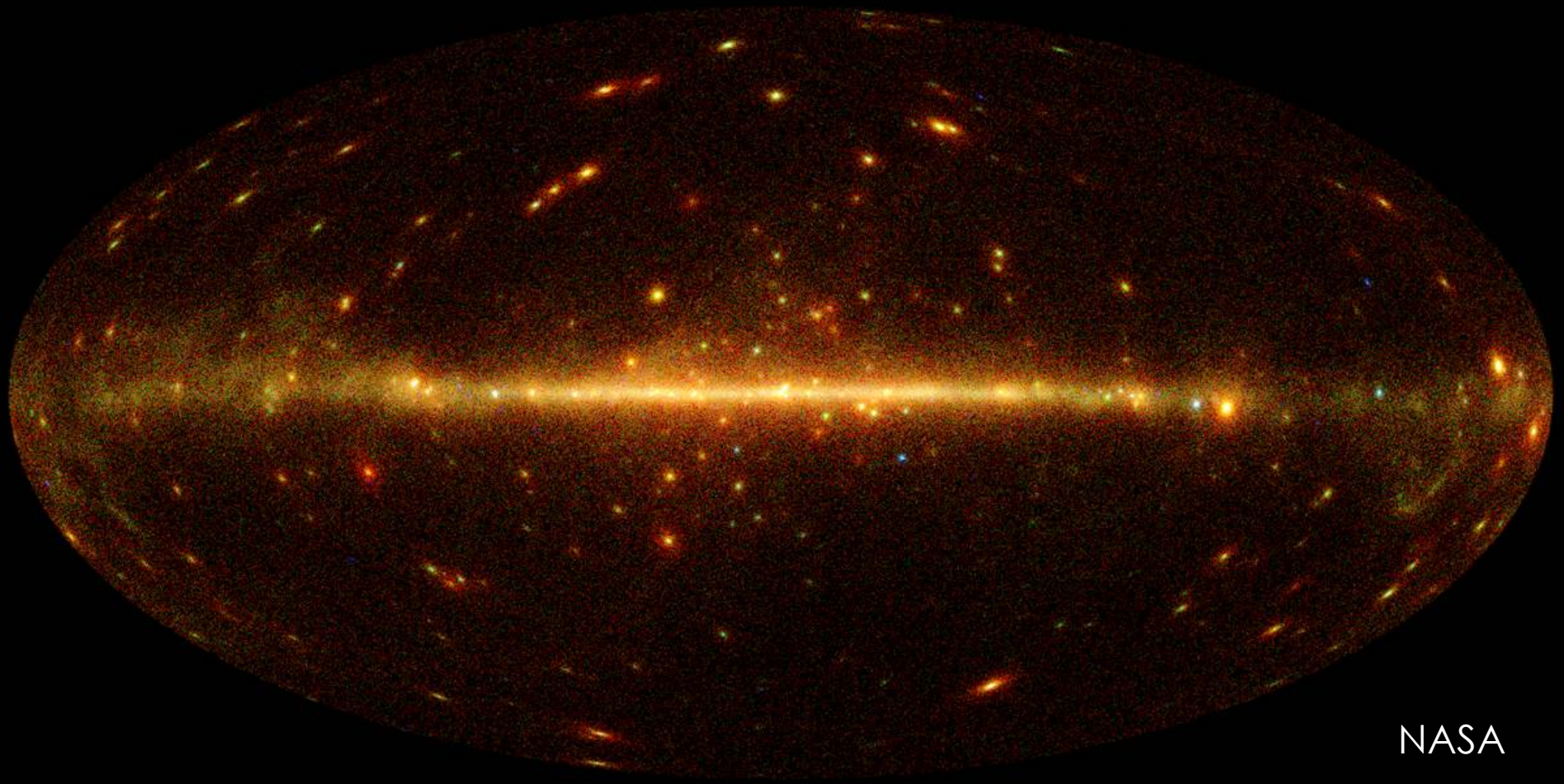
EARLY LANDMARKS



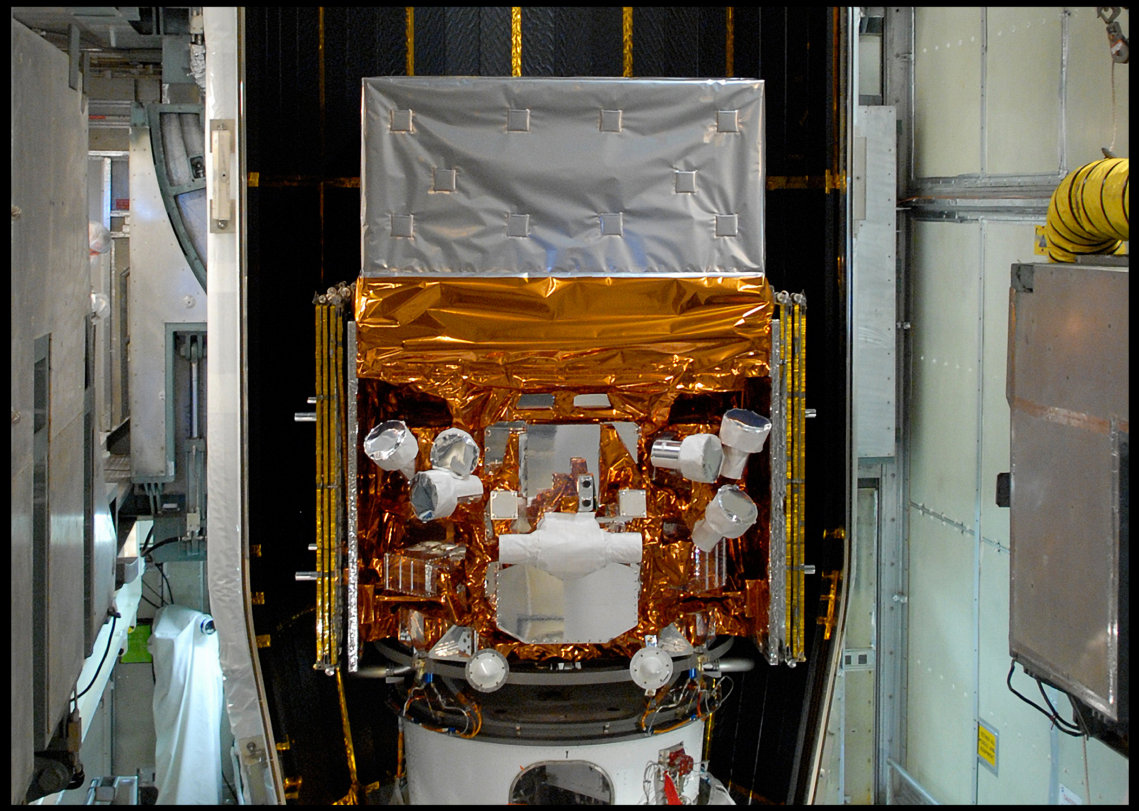
Explorer 11, 1961 (NASA)

Whipple Telescope, first VHE detection of the Crab nebula in 1989 (ISU)



NASA

FERMI



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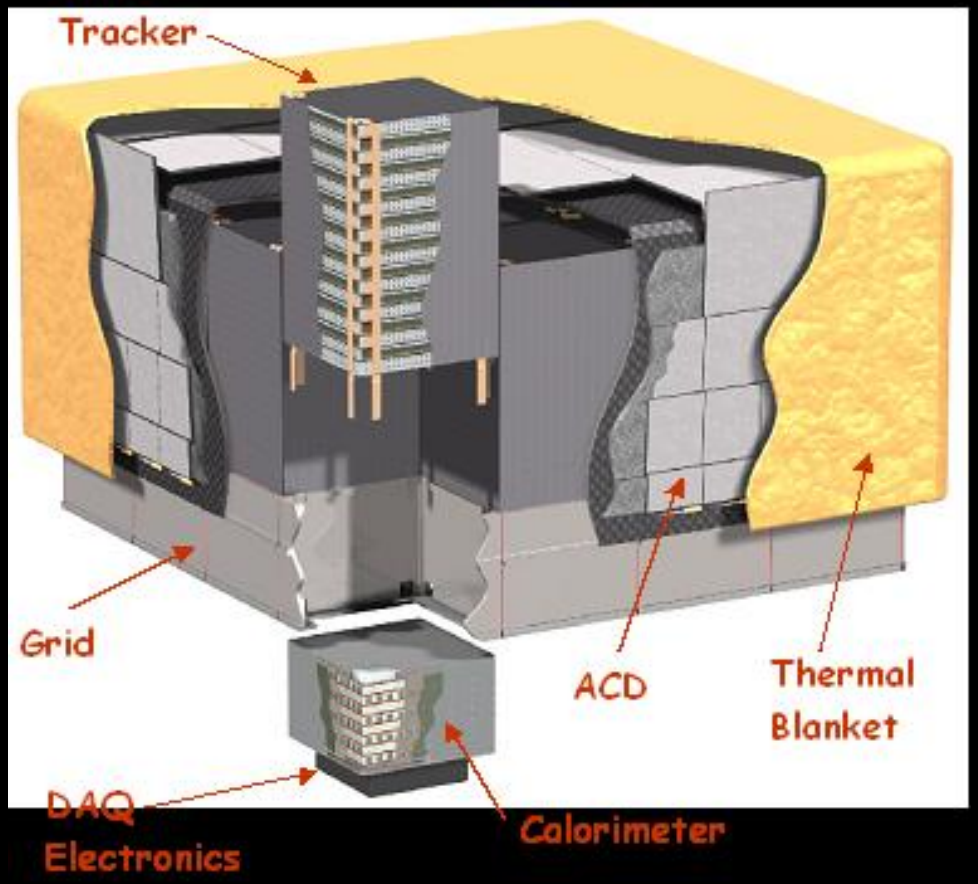
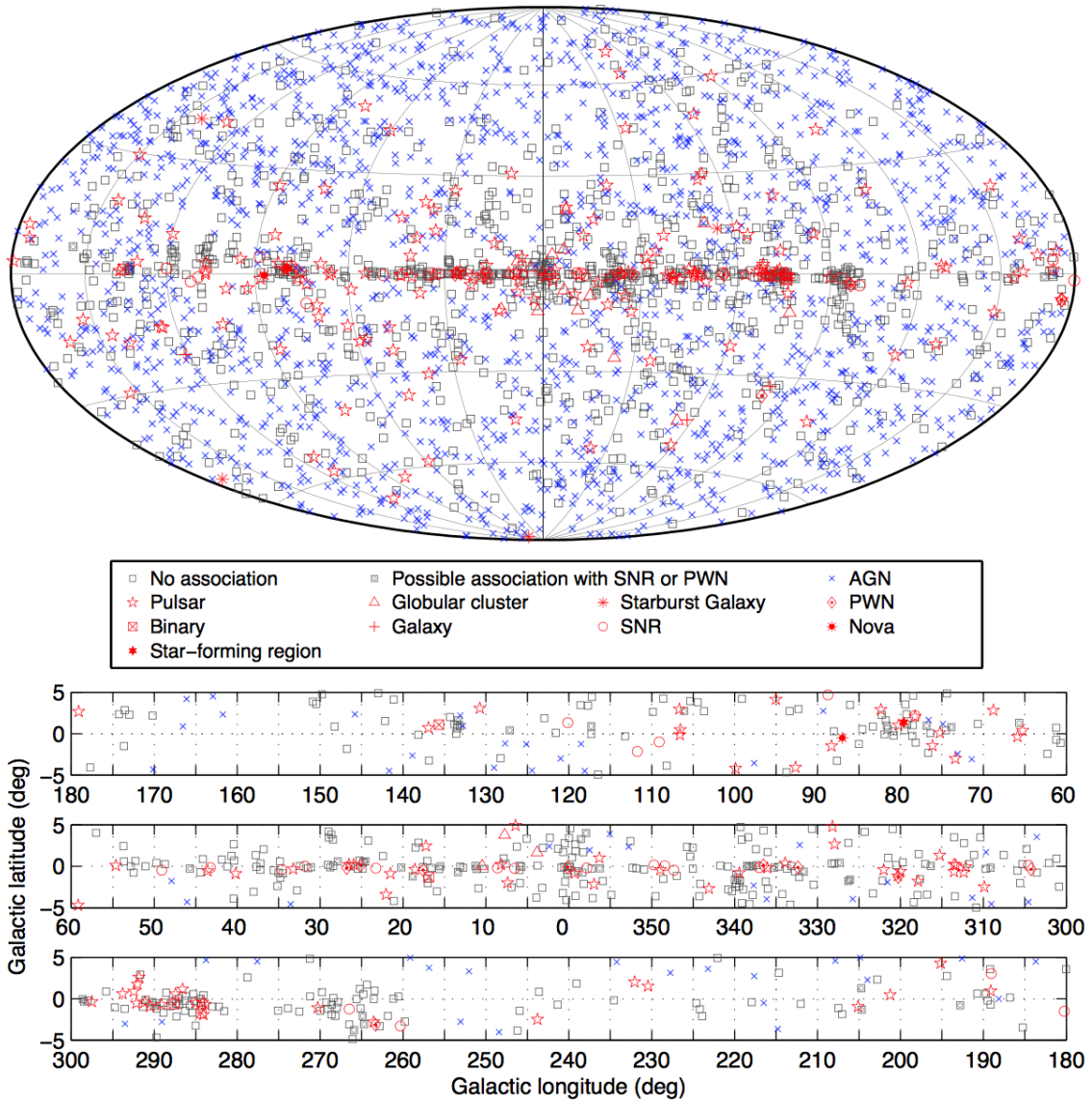


NASA

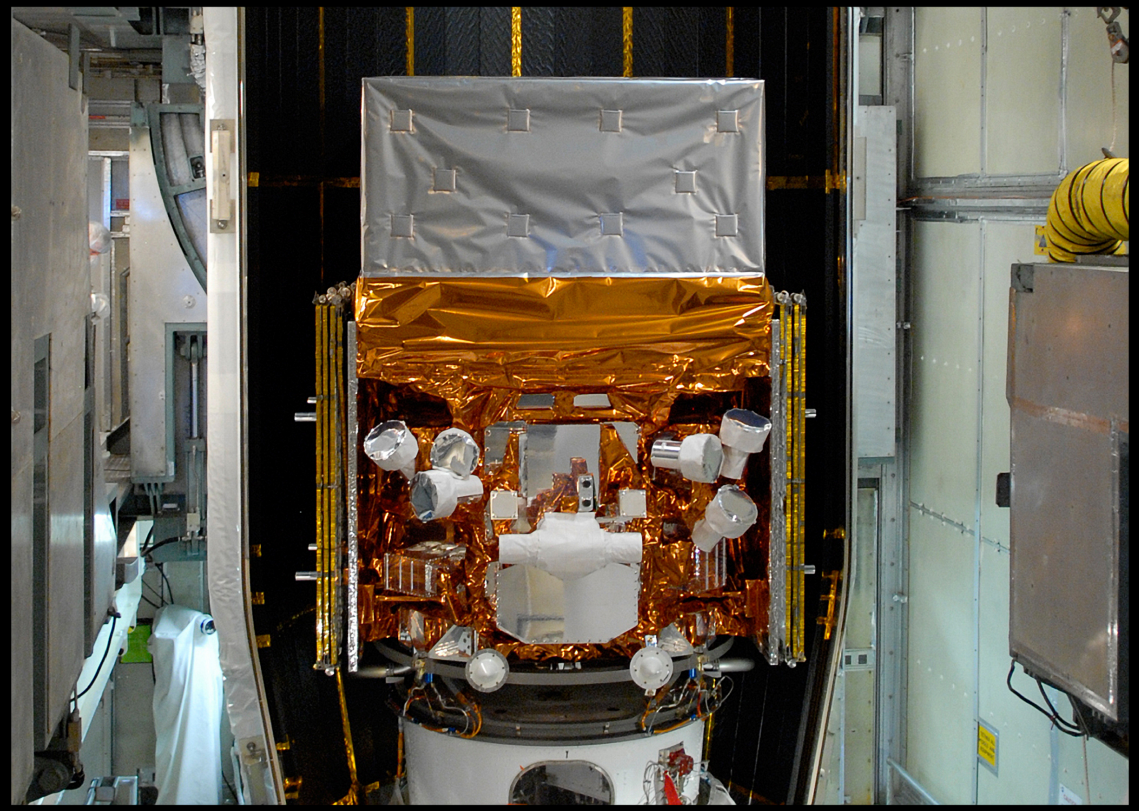
3FGL



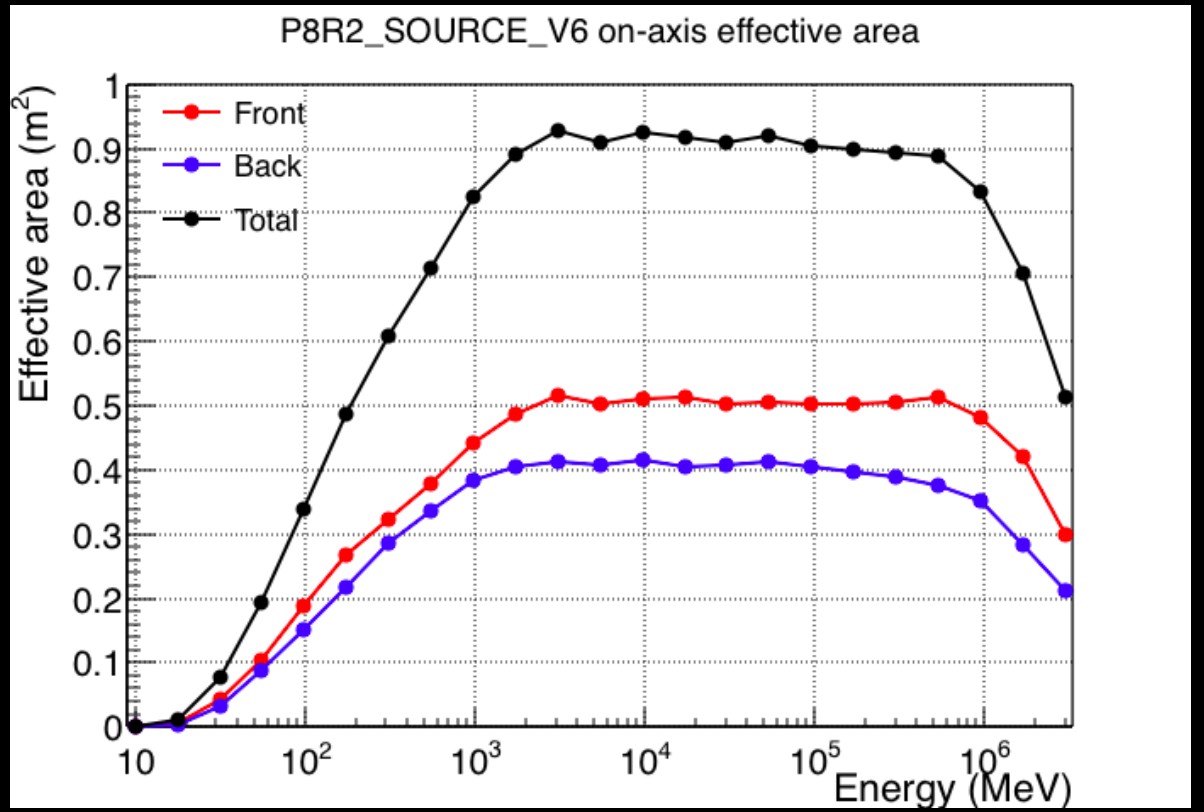
Acero et al. 2015 **ApJS**

Description	Identified		Associated	
	Designator	Number	Designator	Number
Pulsar, identified by pulsations	PSR	143	...	...
Pulsar, no pulsations seen in LAT yet	...	...	psr	24
Pulsar wind nebula	PWN	9	pwn	2
Supernova remnant	SNR	12	snr	11
Supernova remnant / Pulsar wind nebula	...	...	spp	49
Globular cluster	GLC	0	glc	15
High-mass binary	HMB	3	hmb	0
Binary	BIN	1	bin	0
Nova	NOV	1	nov	0
Star-forming region	SFR	1	sfr	0
Compact Steep Spectrum Quasar	CSS	0	css	1
BL Lac type of blazar	BLL	18	bll	642
FSRQ type of blazar	FSRQ	38	fsrq	446
Non-blazar active galaxy	AGN	0	agn	3
Radio galaxy	RDG	3	rdg	12
Seyfert galaxy	SEY	0	sey	1
Blazar candidate of uncertain type	BCU	5	bcu	568
Normal galaxy (or part)	GAL	2	gal	1
Starburst galaxy	SBG	0	sbg	4
Narrow line Seyfert 1	NLSY1	2	nlsy1	3
Soft spectrum radio quasar	SSRQ	0	ssrq	3
Total	...	238	...	1785
Unassociated	...	...	...	1010

A MISSION WHERE THERE TRULY IS A „BEFORE“ AND AN „AFTER“

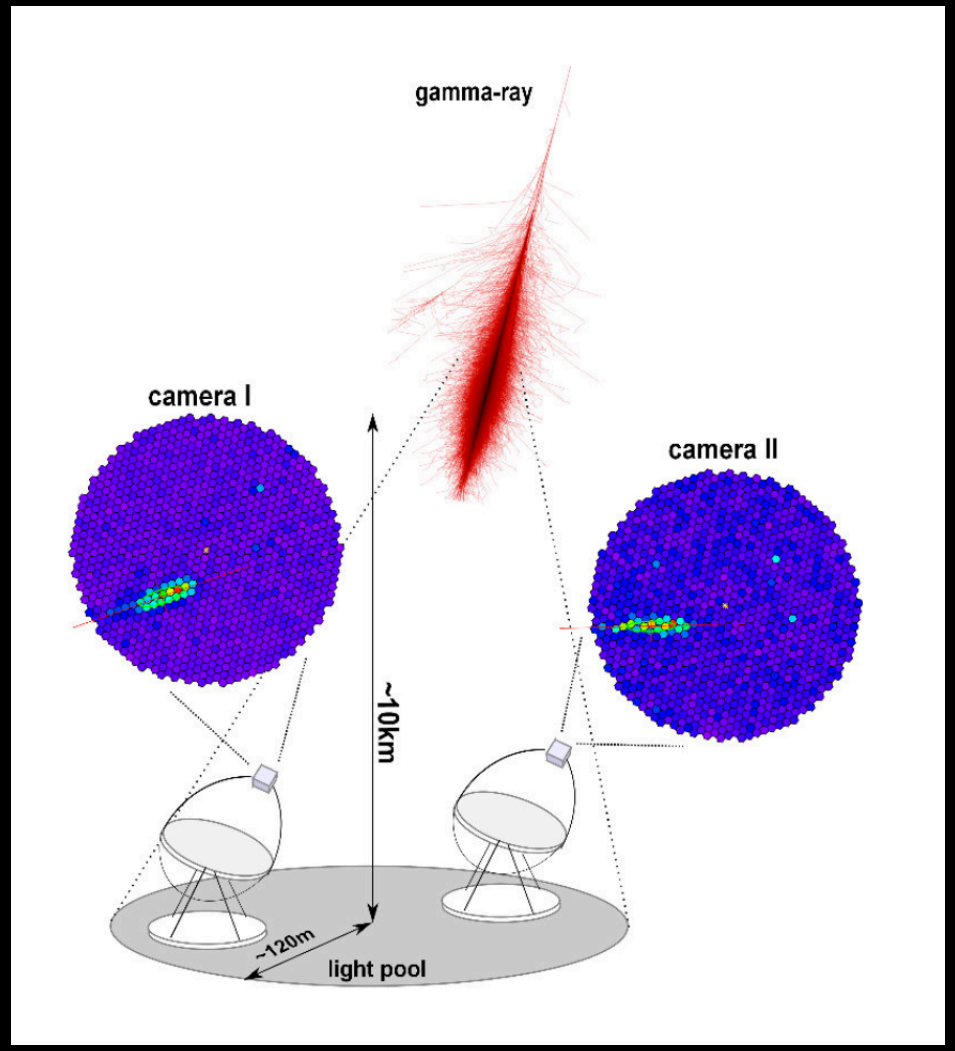


NASA



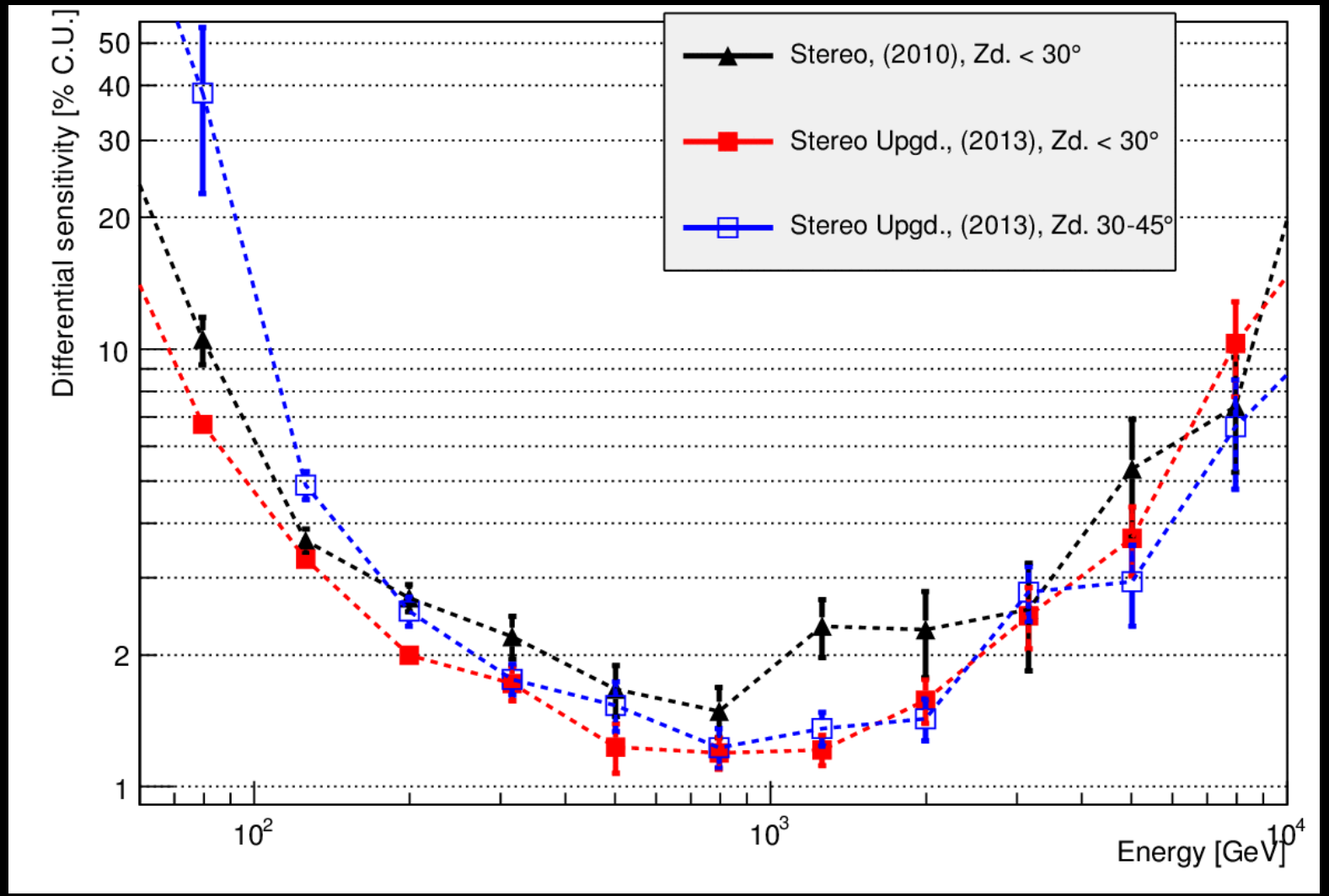
SLAC

IMAGING AIR CHERENKOV TELESCOPES

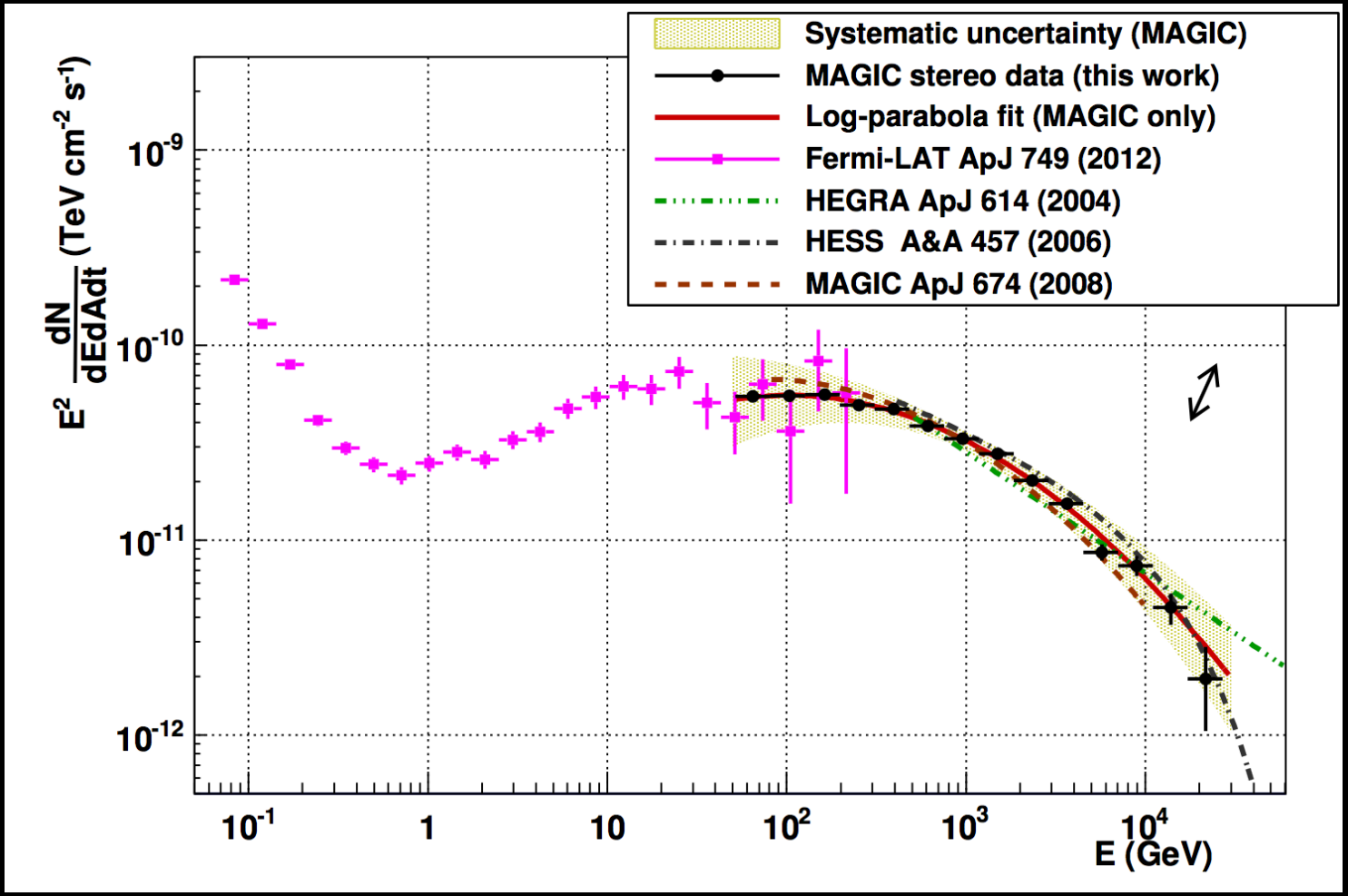


- Very large effective area
- Gains VHE sensitivity up to multi-TeVs
- Potential for high-cadence monitoring
- Comes at price of large hadronic background

EXAMPLE: MAGIC DIFFERENTIAL SENSITIVITY



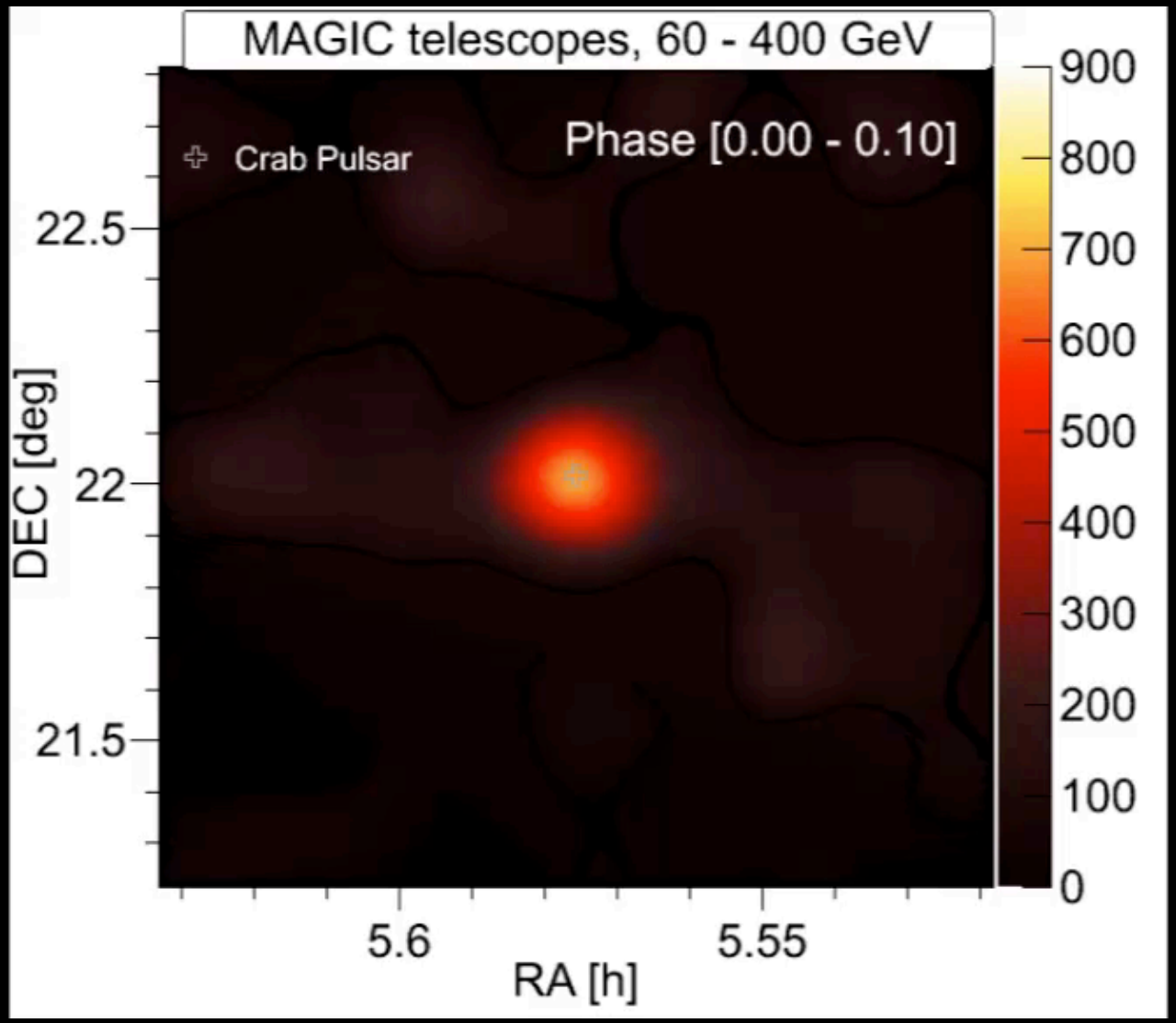
COMBINED OBSERVATIONAL POWER



MAGIC, JHEAp 5, 2015

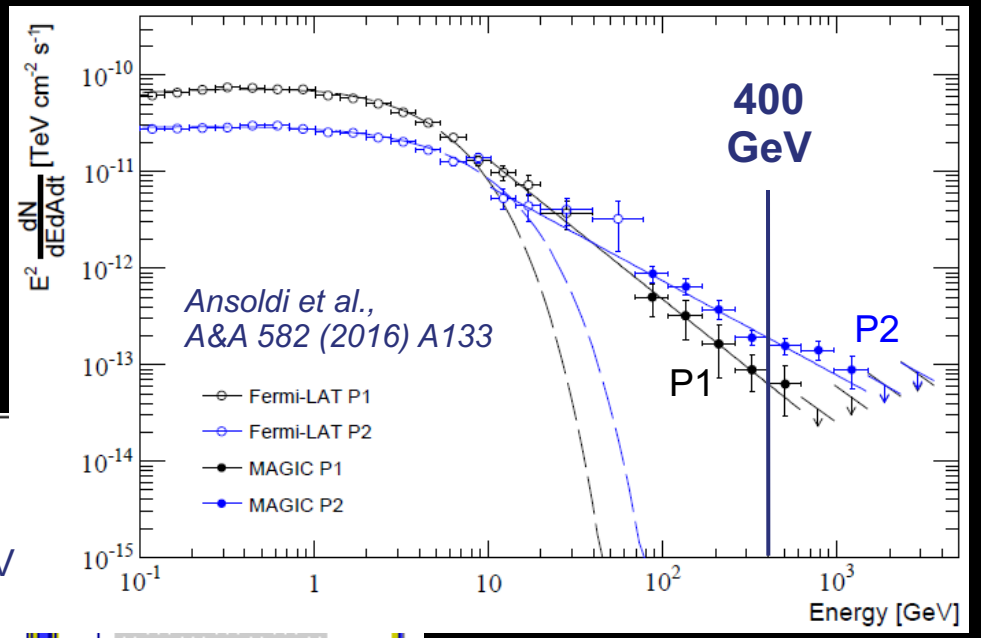
SOME KEY QUESTIONS

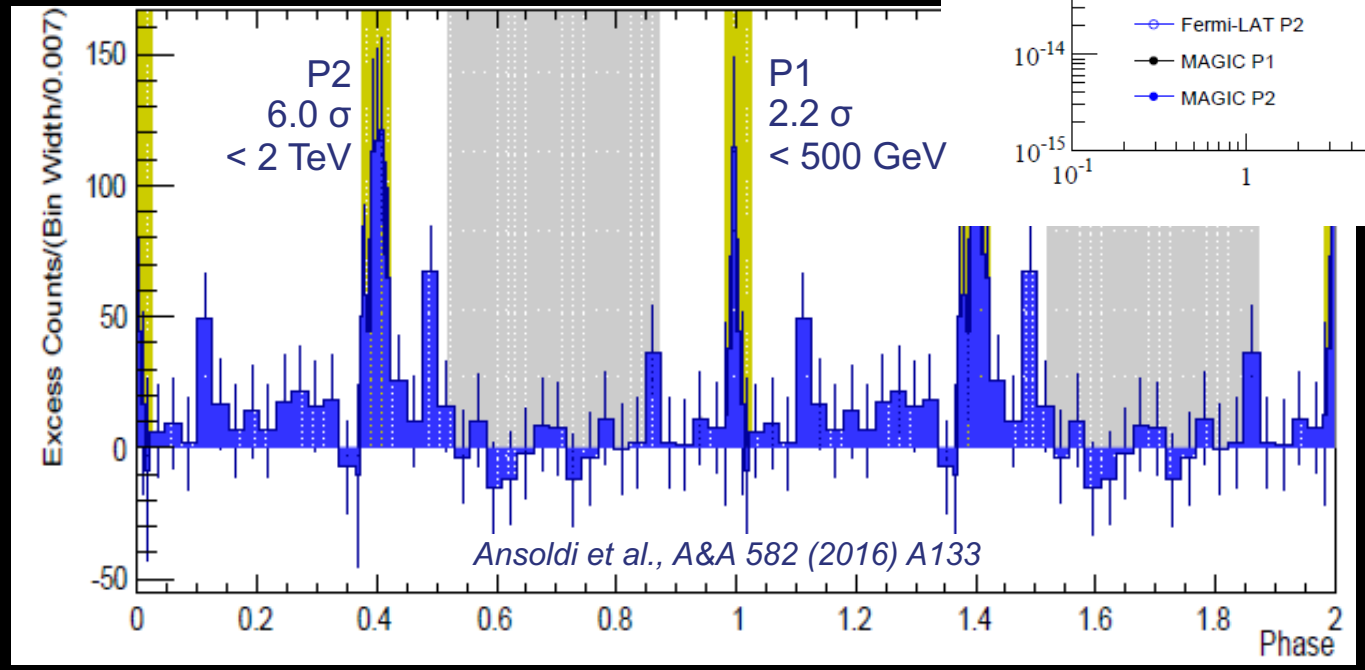
- What are the physical processes that accelerate particles in the Universe and that give rise to HE- and VHE-emission? On which timescales do they play out?
- What are the sources of the Cosmic high energy neutrinos detected by IceCube?
- Can we substantially improve existing limits on the Nature of the dark matter?


MAGIC telescopes, 60 - 400 GeV
Crab Pulsar
Phase [0.00 - 0.10]
22.5
22
21.5
DEC [deg]
5.6
5.55
RA [h]
900
800
700
600
500
400
300
200
100
0

CRAB PULSES AT TEV ENERGIES

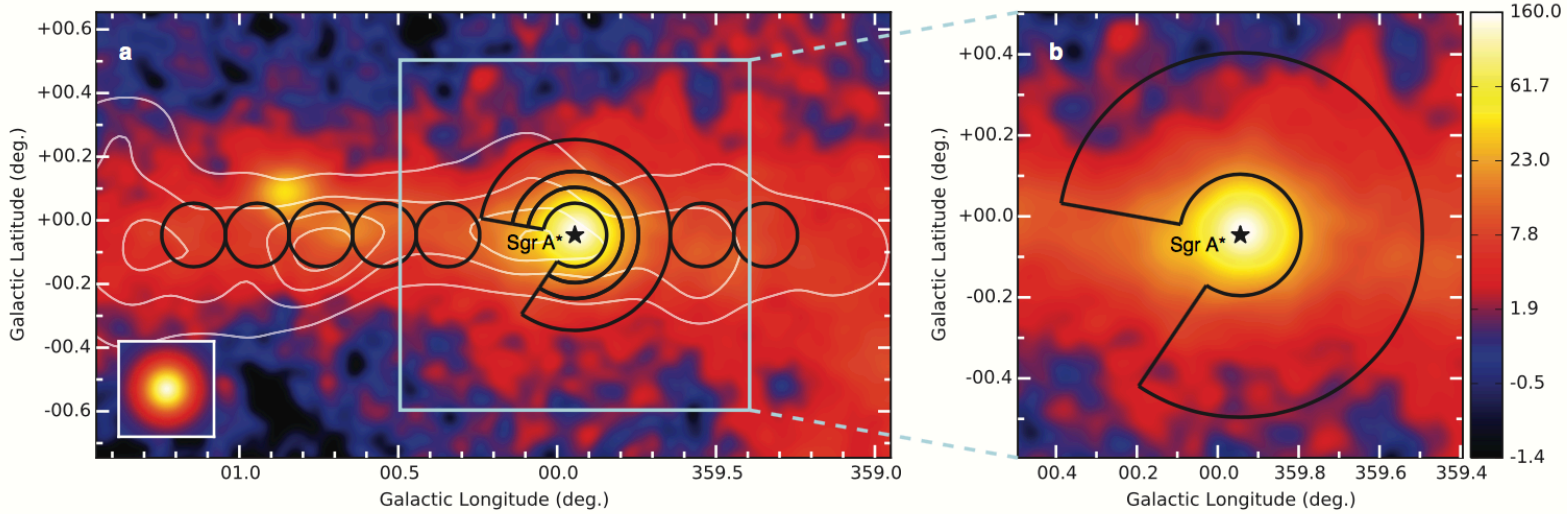
- Implications for emission
  - Inverse Compton
  - Synchrotron-curvature ruled out
  - **Challenging current models**

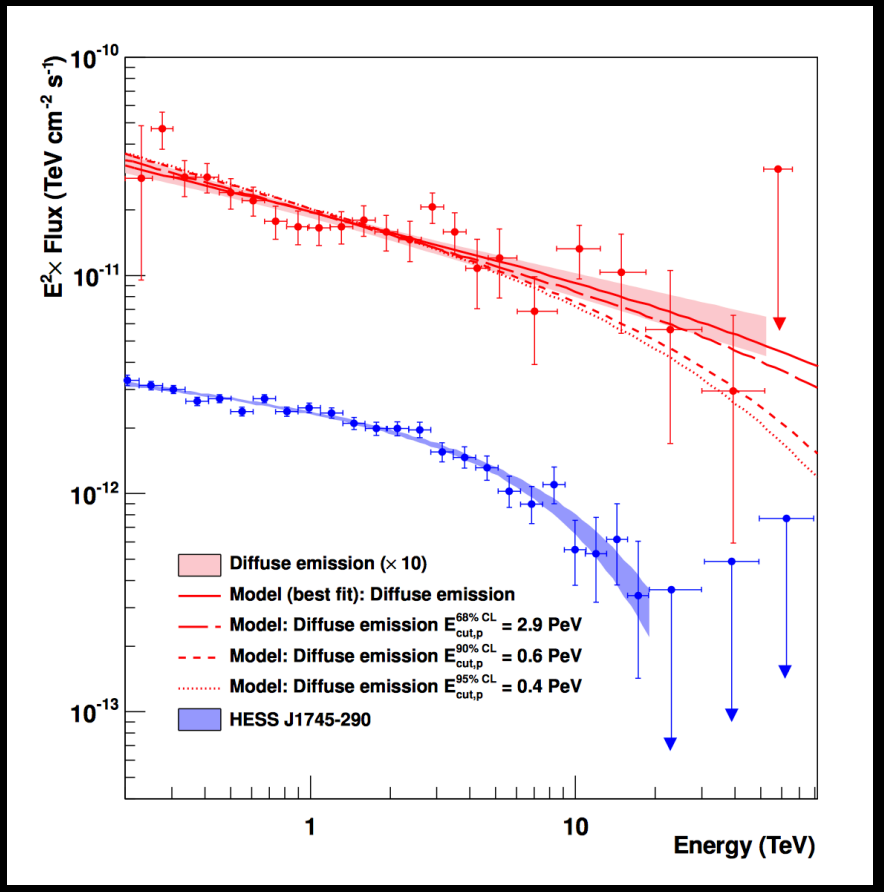




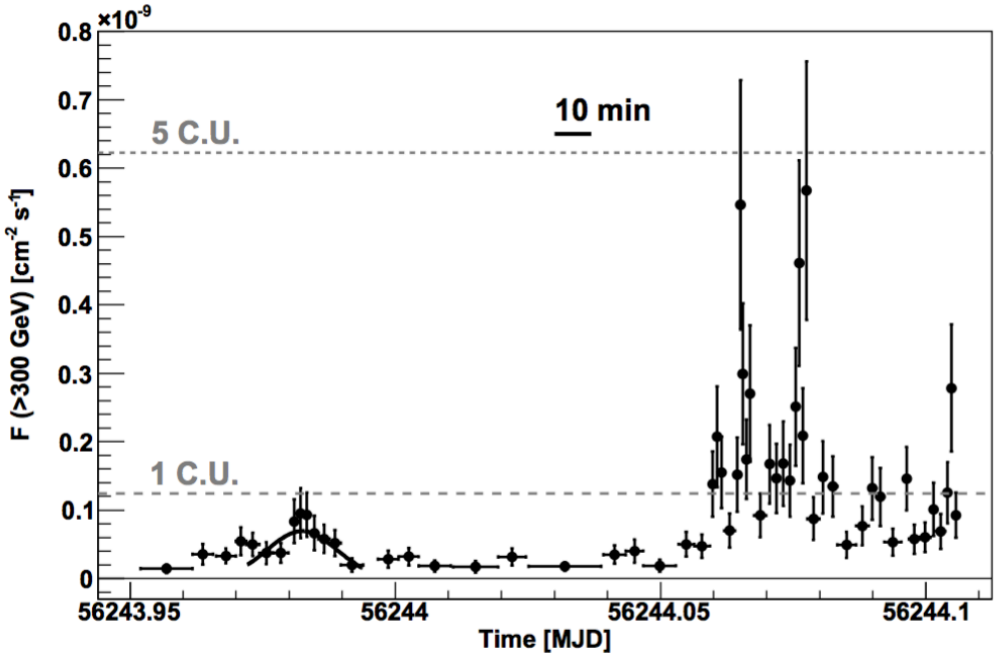
PEV PROTON ACCELERATION IN THE GC REGION

H.E.S.S., Nature 531, 476 (2016)





IC 310

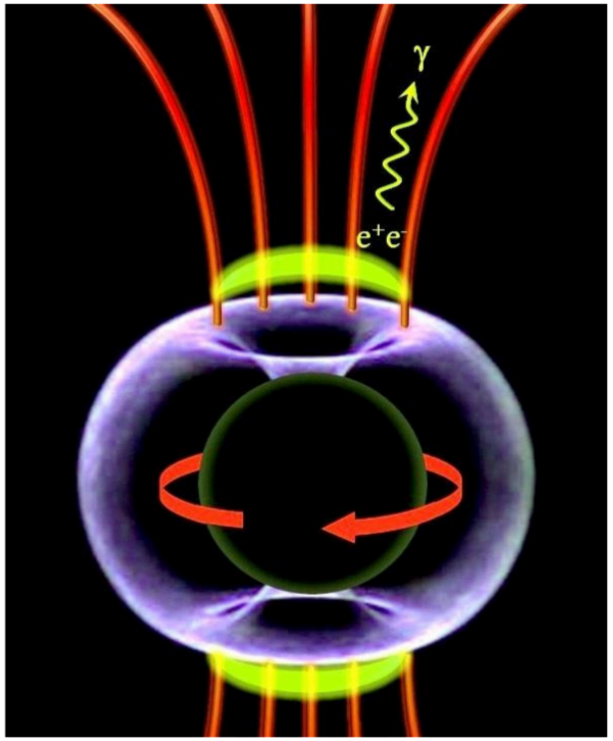


Aleksić et al. *Science* 346, 2014

- Impressive TeV flare of IC 310 → ATel #4583, #4581
- Active galaxy with inclination angle of $10° \lesssim \theta \lesssim 20°$
- Minute variability inconsistent with shock-in-jet model

IC 310

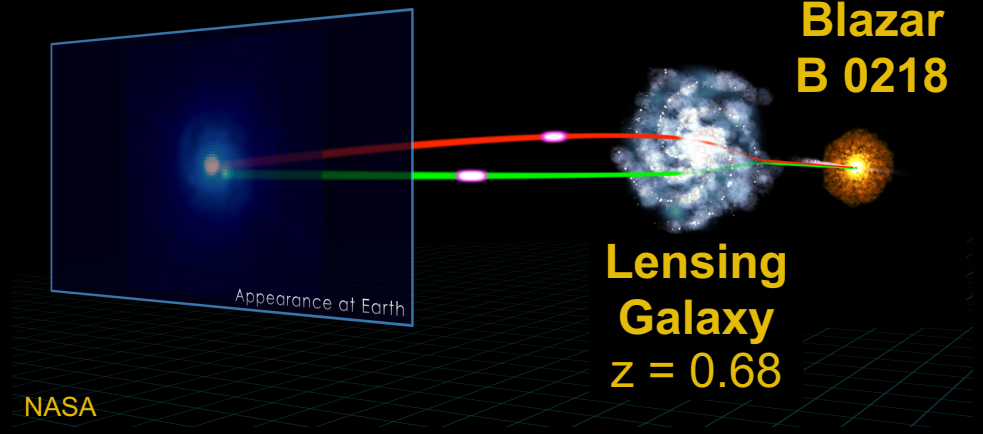
- "Magnetospheric models": by e.g. Levinson & Rieger 2011; Aleksić et al. 2014, *Science*
- Similar to "aligned magnetic rotator models" for pulsars
- **New clues on particle acceleration in AGN from ultra fast variability**

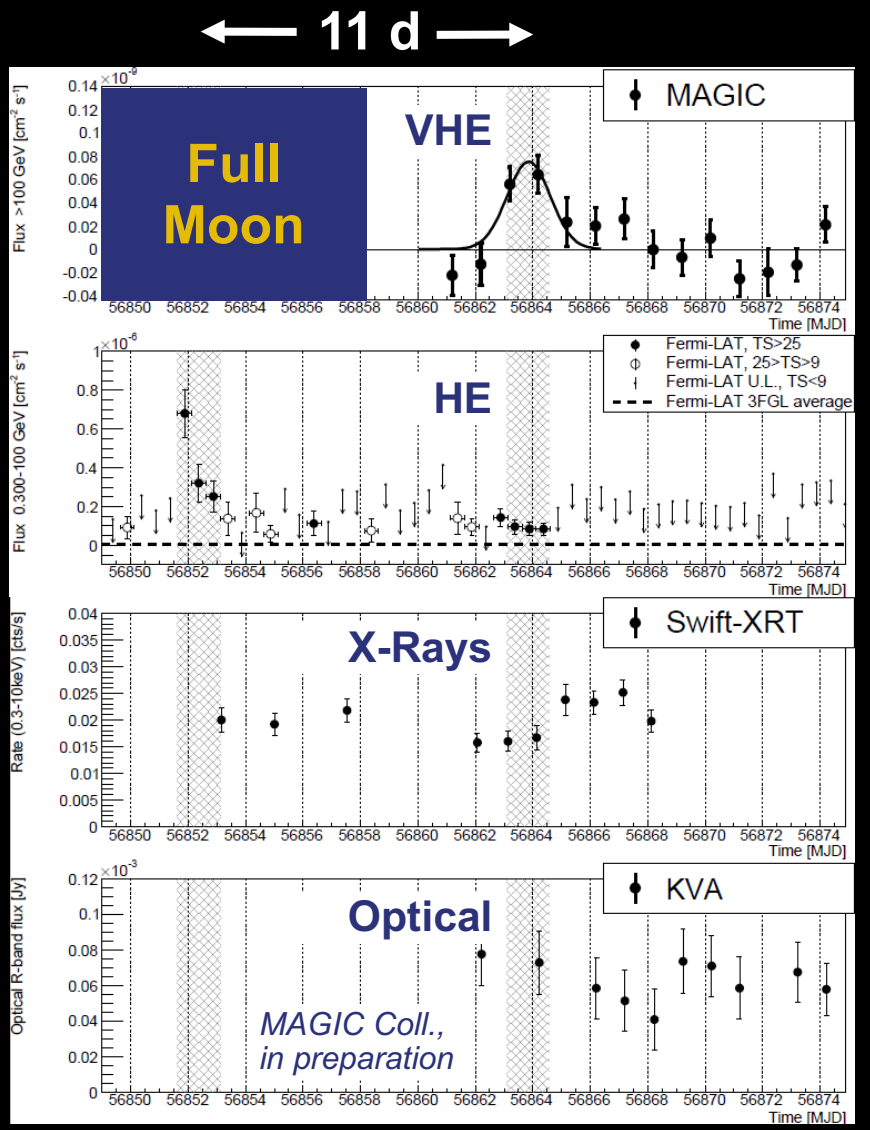


Aleksić et al. *Science* 346, 2014

B 0218+357

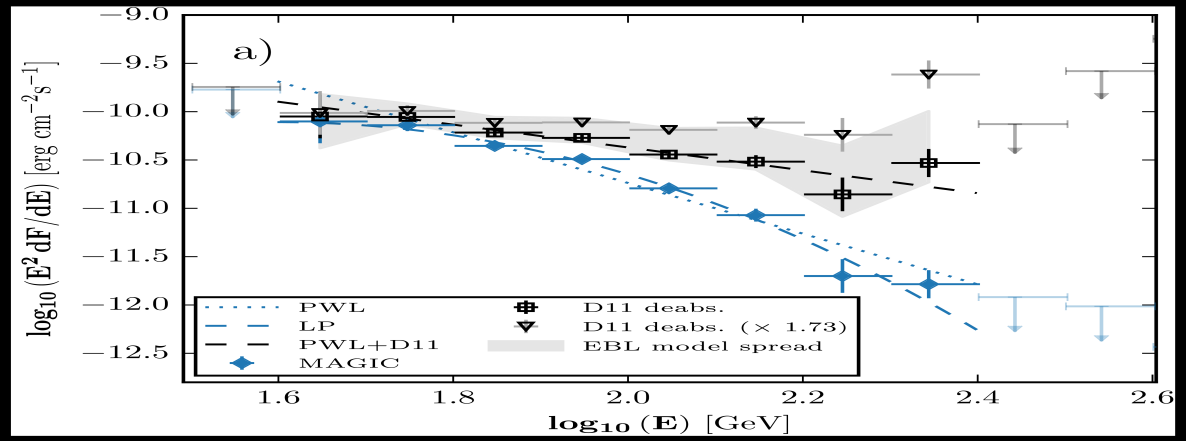
- FSRQ at z = 0.944
- Gravitationally lensed
- Flare in July 2014 → **Discovery**

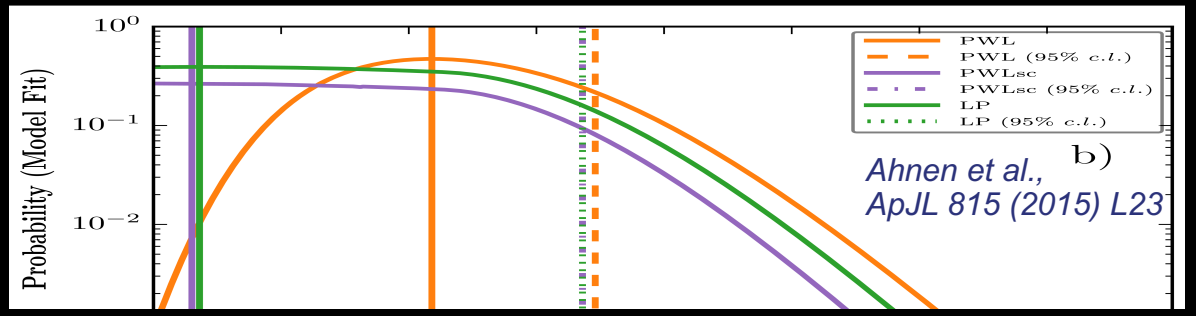


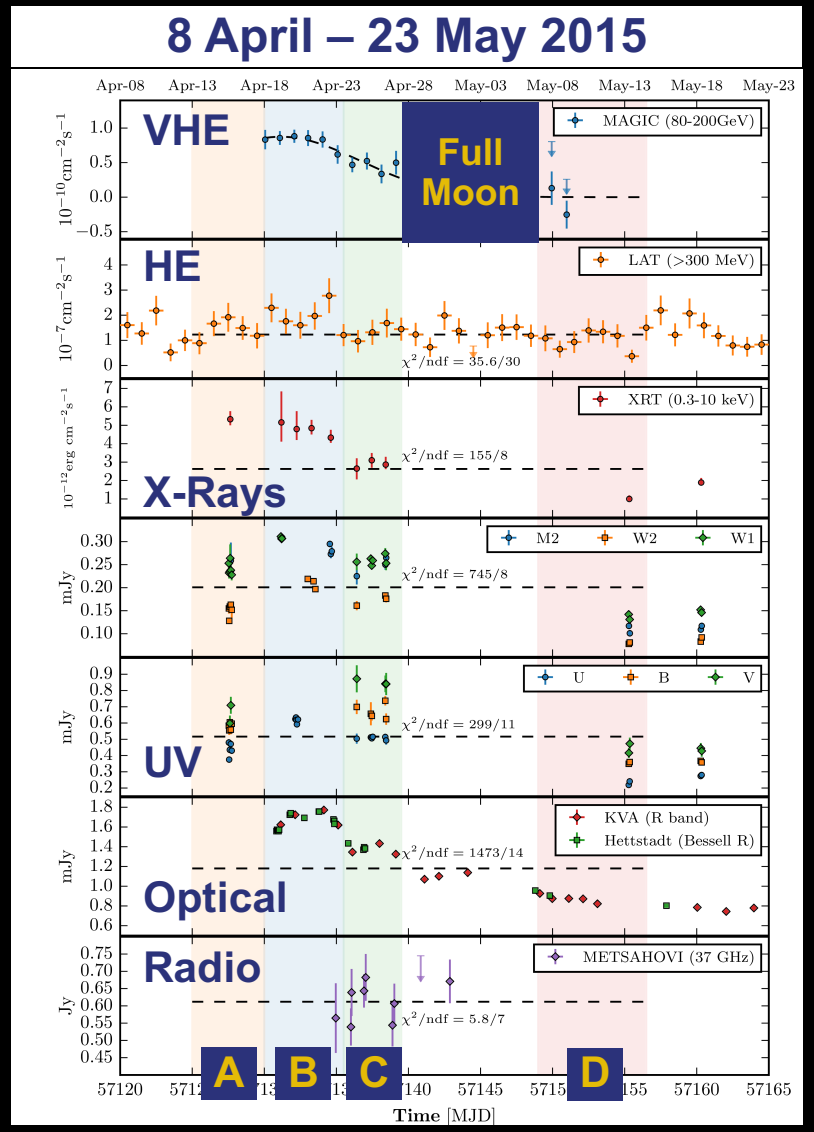


PKS 1441+25

- FSRQ at z = 0.939
- Flare in April 2015 → **Discovery**
- Spectrum fully consistent with current EBL models





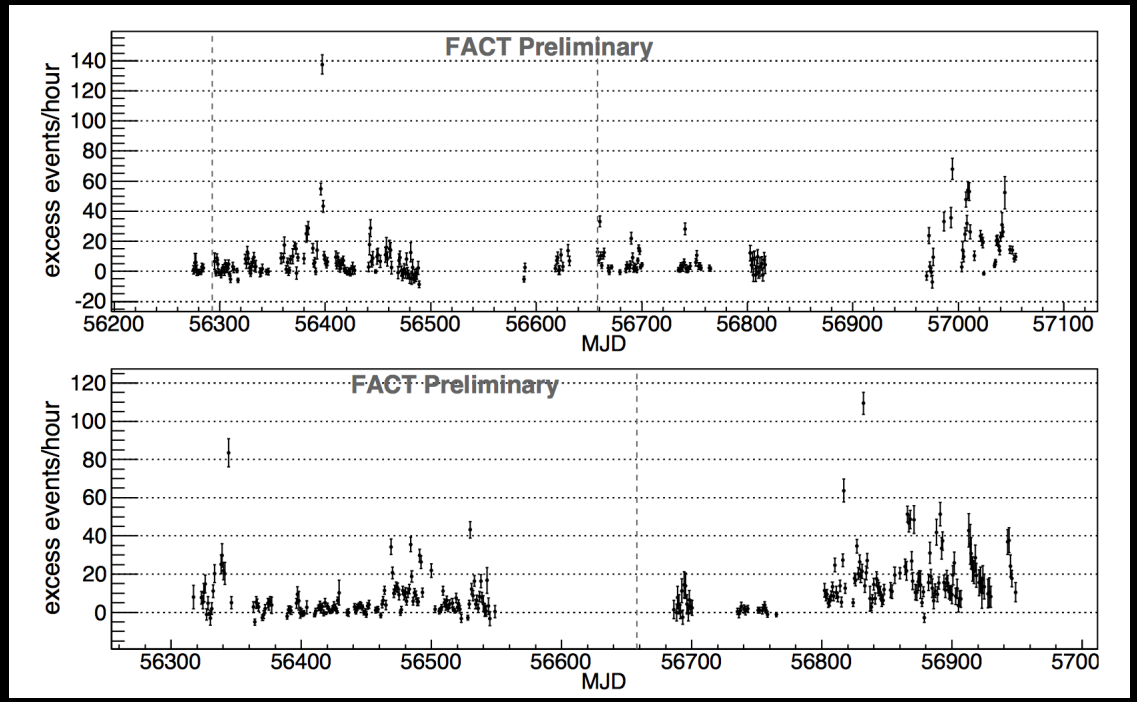


FACT

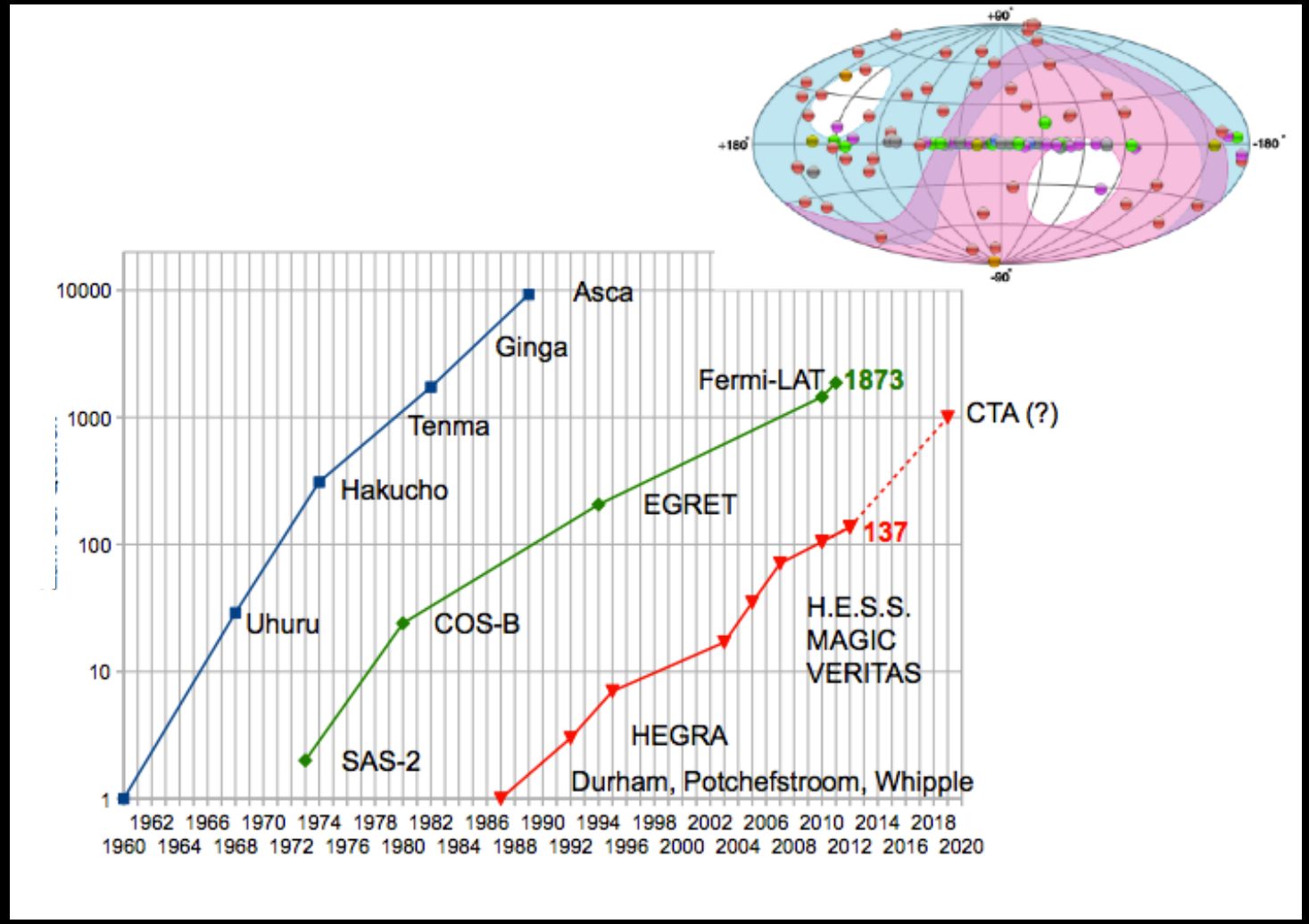
- Refurbished HEGRA mount equipped with new mirrors and G-APD camera at the MAGIC site
- Continuous monitoring of selected blazars also during moonlight
- Regular flare alerts to the community
- Prototype telescope for a possible world-wide monitoring system

FACT

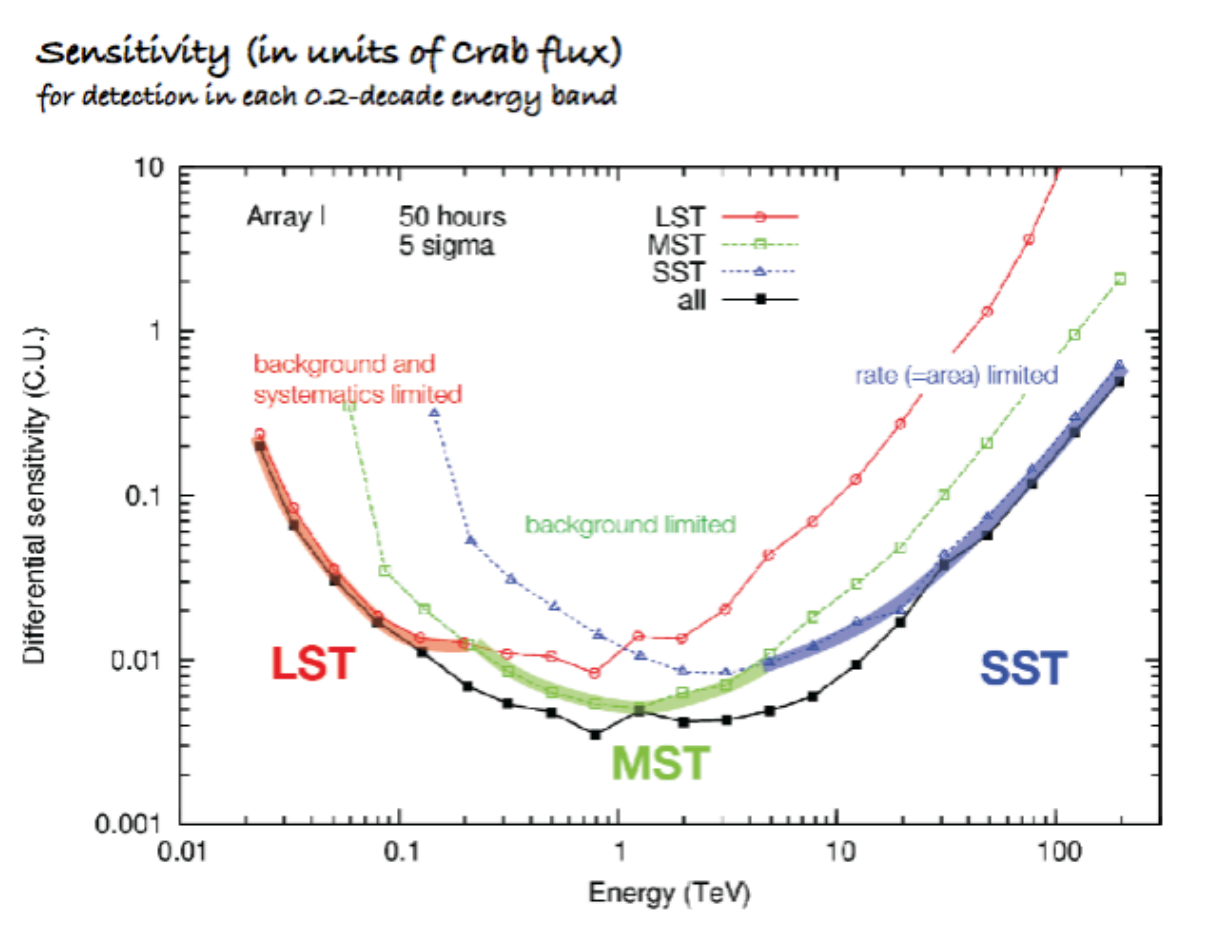
Mrk421


FACT Preliminary
excess events/hour
140
120
100
80
60
40
20
0
-20
56200
56300
56400
56500
56600
56700
56800
56900
57000
57100
MJD
FACT Preliminary
excess events/hour
120
100
80
60
40
20
0
56300
56400
56500
56600
56700
56800
56900
5700
MJD

OBSERVATIONAL PATH TO THE FUTURE

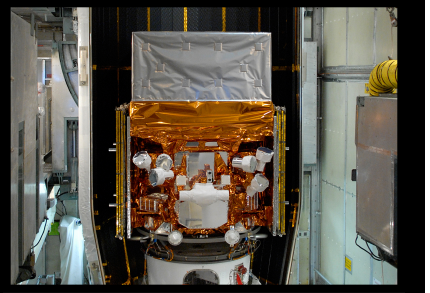


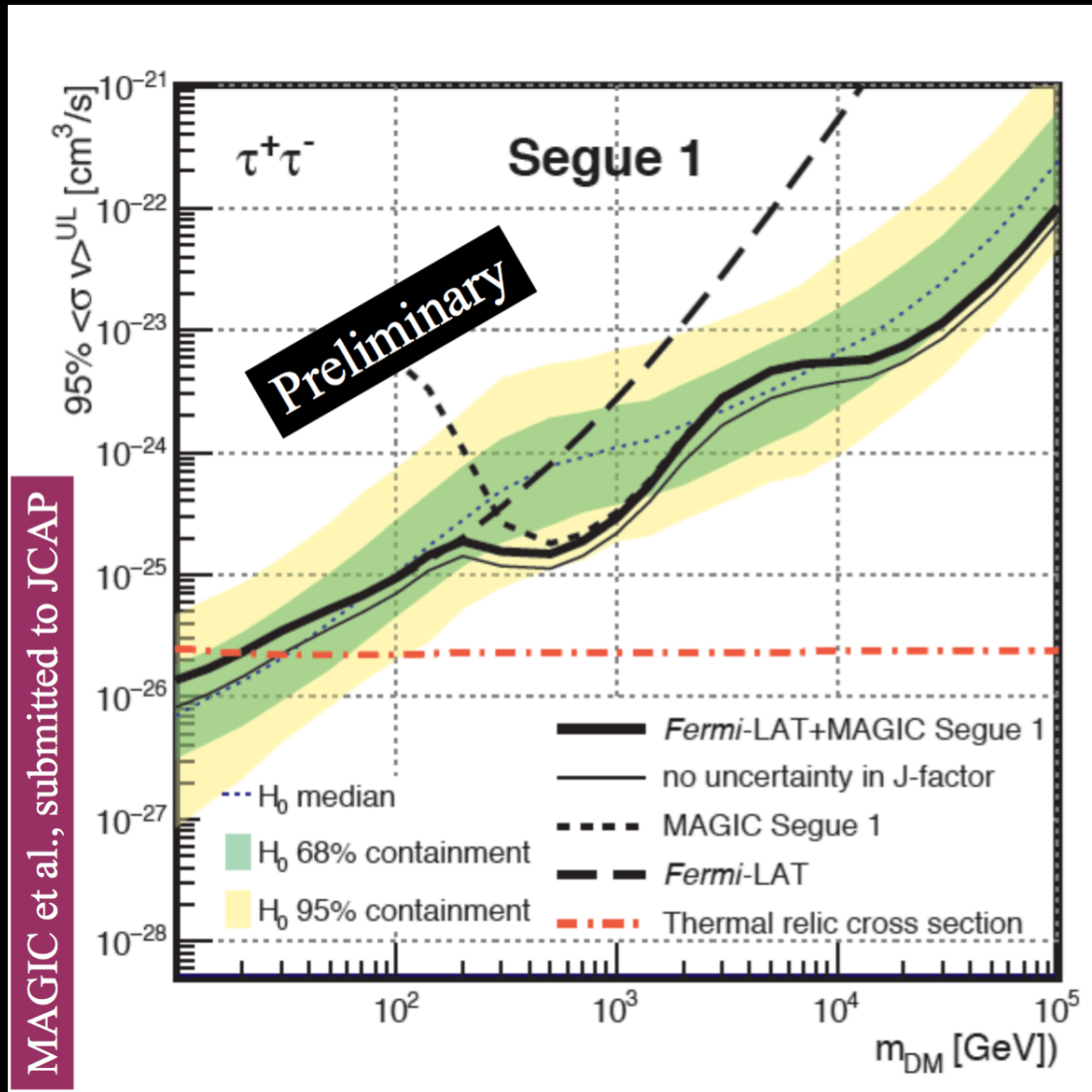
CHERENKOV TELESCOPE ARRAY



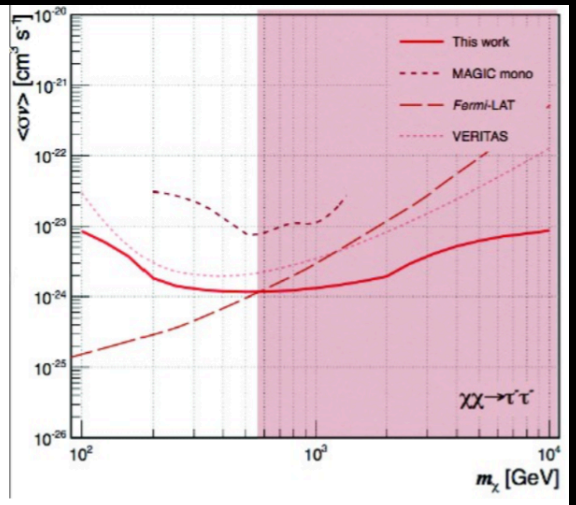
	SST "small"	MST "medium"	LST "large"	SCT "medium 2-M"
Number	**70 (S)**	**25 (S) 15 (N)**	**4 (S) 4 (N)**	**36 (S)**
Spec'd range	> few TeV	200 GeV to 10 TeV	20 GeV to 1 TeV	200 GeV to 10 TeV
Eff. mirror area	> 5 m^2	> 88 m^2	> 330 m^2	> 40 m^2
Field of view	> 8°	> 7°	> 4.4°	> 7°
Pixel size ~PSF θ_{80}	< 0.25°	< 0.18°	< 0.11°	< 0.075°
Positioning time	90 s, 60 s goal	90 s, 60 s goal	50 s, 20 s goal	90 s, 60 s goal
Availability	> 97% @ 3 h/week	>97% @ 6 h/week	>95% @ 9 h/week	>97% @ 6 h/week
Target capital cost	420 k€	1.6 M€	7.4 M€	2.0 M€

INDIRECT DARK MATTER SEARCHES





MAGIC et al., submitted to JCAP



Large exposure (158h) of Segue 1 dSph galaxy

Result acknowledged in PDG

Combining MAGIC with Fermi data to further improve the limits

New inclusive analysis approach able to combine data from other detectors

- Very substantial progress on the observational front
- Tantalizing hints to key questions
- CTA, SKA and other facilities already on the horizon
- Definitely need to actively shape the path into this future. This includes continued operation of existing facilities as precursors and also testbeds