The Galactic Transients KSP

Sandro Mereghetti
INAF - IASF Milano

Core Program = ~40% of time in first 10 yrs = 9 (+1) Key Science Projects

Theme		Question	Dark Matter Programme	Galactic Centre Survey	Galactic Plane Survey	LMC Survey	Extra-galactic Survey	Transients	Cosmic Ray PeVatrons	Star-forming Systems	Active Galactic Nuclei	Galaxy Clusters
Understanding the Origin and Role of Relativistic Cosmic Particles	1.1	What are the sites of high-energy particle acceleration in the universe?		✔	✔✔	✔✔	✔✔	✔✔	✔	✔	✔	✔✔
	1.2	What are the mechanisms for cosmic particle acceleration?		✔	✔	✔		✔✔	✔✔	✔	✔✔	✔
	1.3	What role do accelerated particles play in feedback on star formation and galaxy evolution?		✔		✔				✔✔	✔	✔
Probing Extreme Environments	2.1	What physical processes are at work close to neutron stars and black holes?		✔	✔	✔			✔✔		✔✔	
	2.2	What are the characteristics of relativistic jets, winds and explosions?		✔	✔	✔	✔	✔✔	✔✔		✔✔	
	2.3	How intense are radiation fields and magnetic fields in cosmic voids, and how do these evolve over cosmic time?					✔	✔			✔✔	
Exploring Frontiers in Physics	3.1	What is the nature of Dark Matter? How is it distributed?	✔✔	✔✔		✔						✔
	3.2	Are there quantum gravitational effects on photon propagation?						✔✔	✔		✔✔	
	3.3	Do Axion-like particles exist?					✔	✔			✔✔	

Comparison with other KSP

Extragalactic Survey	—> 1000 hr, 25% of sky, 6mCrab
Gal Plane Survey	—> 1600 hr, ~2-4 mCrab
Galactic Center Survey	—> 825 hr
LMC Survey	—> 500 hr (S)
Transients	—> 2700 hr

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LMC Survey	—> 500 hr (S),
Transients	—> 2700 hr
Pevatrons	—> 200 hr ??
Star forming systems	—> 720 hr
AGNs	—> 3300 hr
Galaxy Clusters	—> 300 hr

KSP on Transients in "Science with CTA"

A) Gamma-ray Bursts

B) Galactic Transients

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B) Galactic Transients

C) X-ray, optical and radio transients
(=external alerts)

D) High-E neutrino transients

E) GW transients

F) Serendipitous VHE transients
(=internal CTA alerts during regular observations)

G) VHE transient survey
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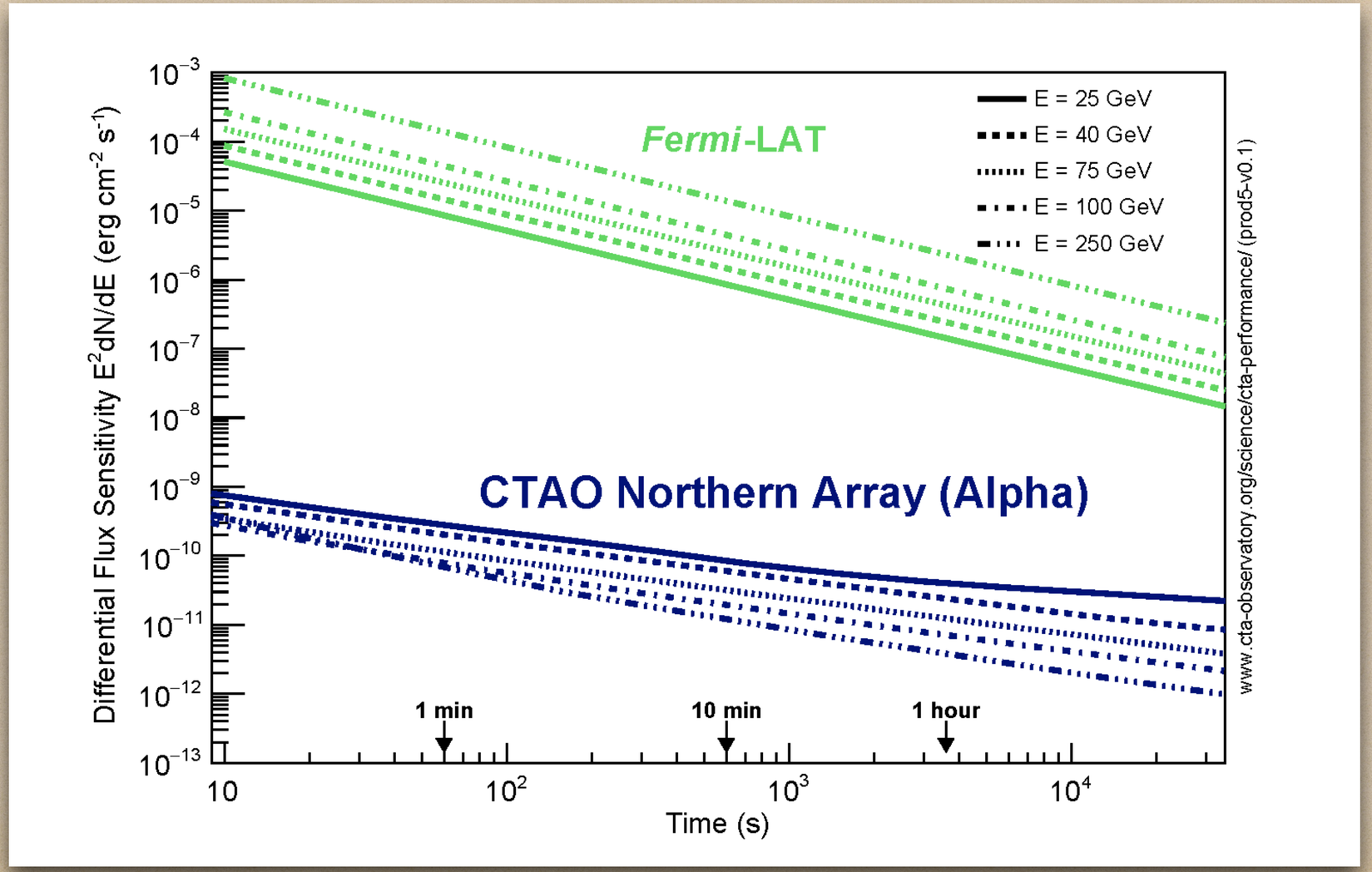
Planned observation time for transients KSP

	Hours / year / site		
	Early phase	Years 1-2	Years 2-10
GRB	50	50	50
Galactic	150	30	0 ?
X-ray, optical, radio	50	10	10
HE neutrinos	20	5	5
GW	20	5	5
Serendipitous VHE	100	25	25
TOTAL	390	125	95

Sensitivity on short timescales



OUTLINE

- Introduction
- Pulsar Wind Nebulae
- Gamma-ray Binaries
- Micro QSOs
- Novae
- Magnetars
- Remarks

Pulsar Wind Nebulae

- Gamma-ray variability discovered by AGILE and Fermi in 2011

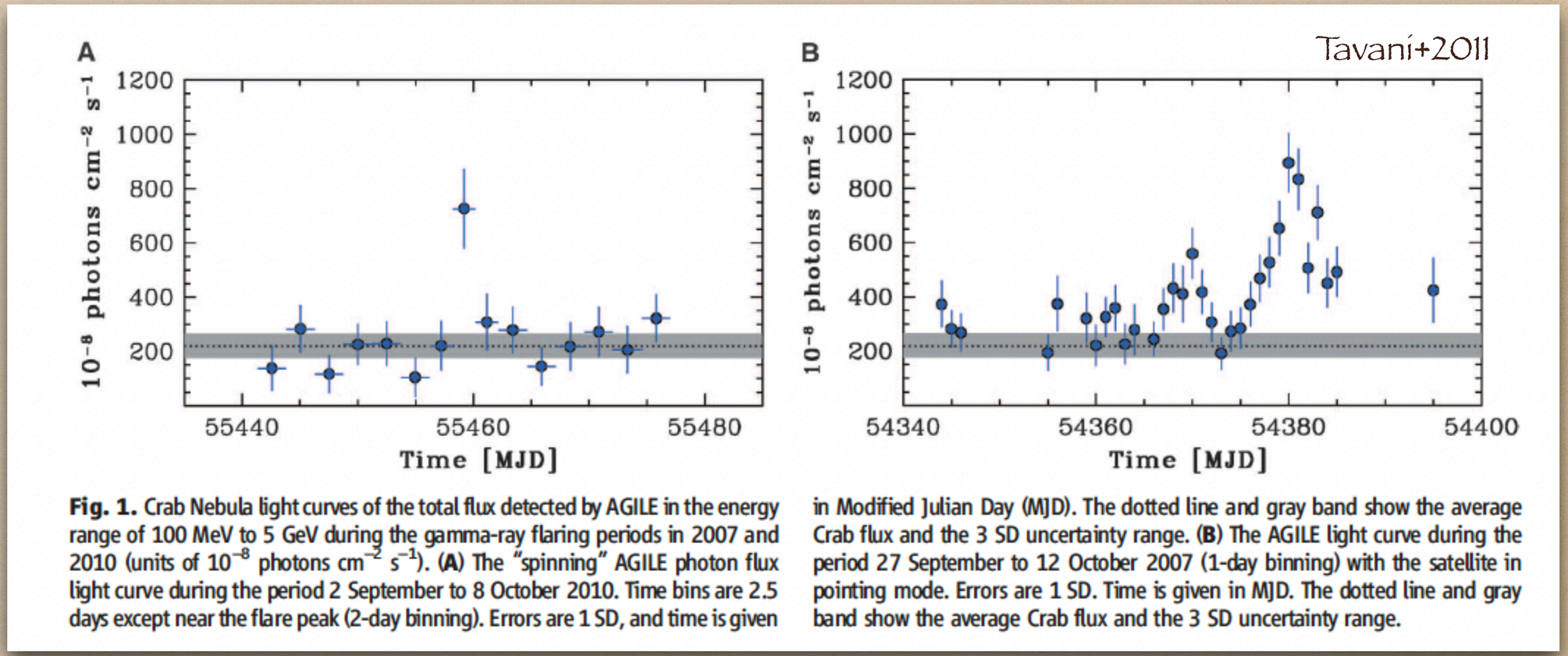


Fig. 1. Crab Nebula light curves of the total flux detected by AGILE in the energy range of 100 MeV to 5 GeV during the gamma-ray flaring periods in 2007 and 2010 (units of 10^{-8} photons cm^{-2} s^{-1}). (**A**) The "spinning" AGILE photon flux light curve during the period 2 September to 8 October 2010. Time bins are 2.5 days except near the flare peak (2-day binning). Errors are 1 SD, and time is given in Modified Julian Day (MJD). The dotted line and gray band show the average Crab flux and the 3 SD uncertainty range. (**B**) The AGILE light curve during the period 27 September to 12 October 2007 (1-day binning) with the satellite in pointing mode. Errors are 1 SD. Time is given in MJD. The dotted line and gray band show the average Crab flux and the 3 SD uncertainty range.

0.1-5 GeV 3x increase in ~day

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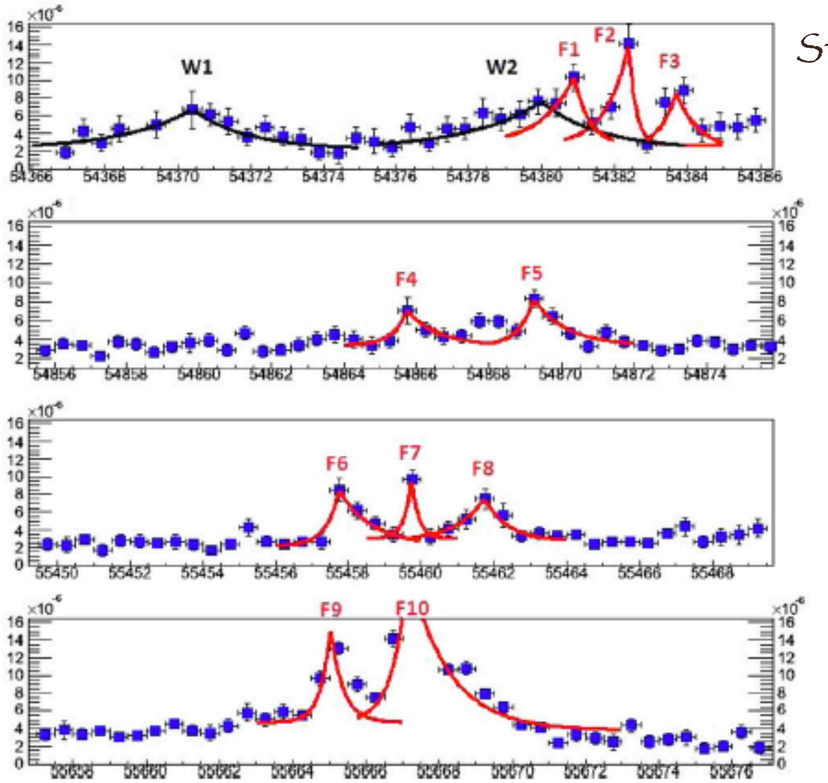

Striani+2013

Figure 1. Gamma-ray lightcurves above 100 MeV (12 hr time bins) from the Crab (pulsar plus Nebula) detected by *AGILE* and *Fermi*-LAT. From top to bottom: the 2007 September–October event (*AGILE* data), the 2009 February event (*Fermi*-LAT data), the 2010 September event (*Fermi*-LAT data), and the 2011 April event (*Fermi*-LAT data).

(A color version of this figure is available in the online journal.)

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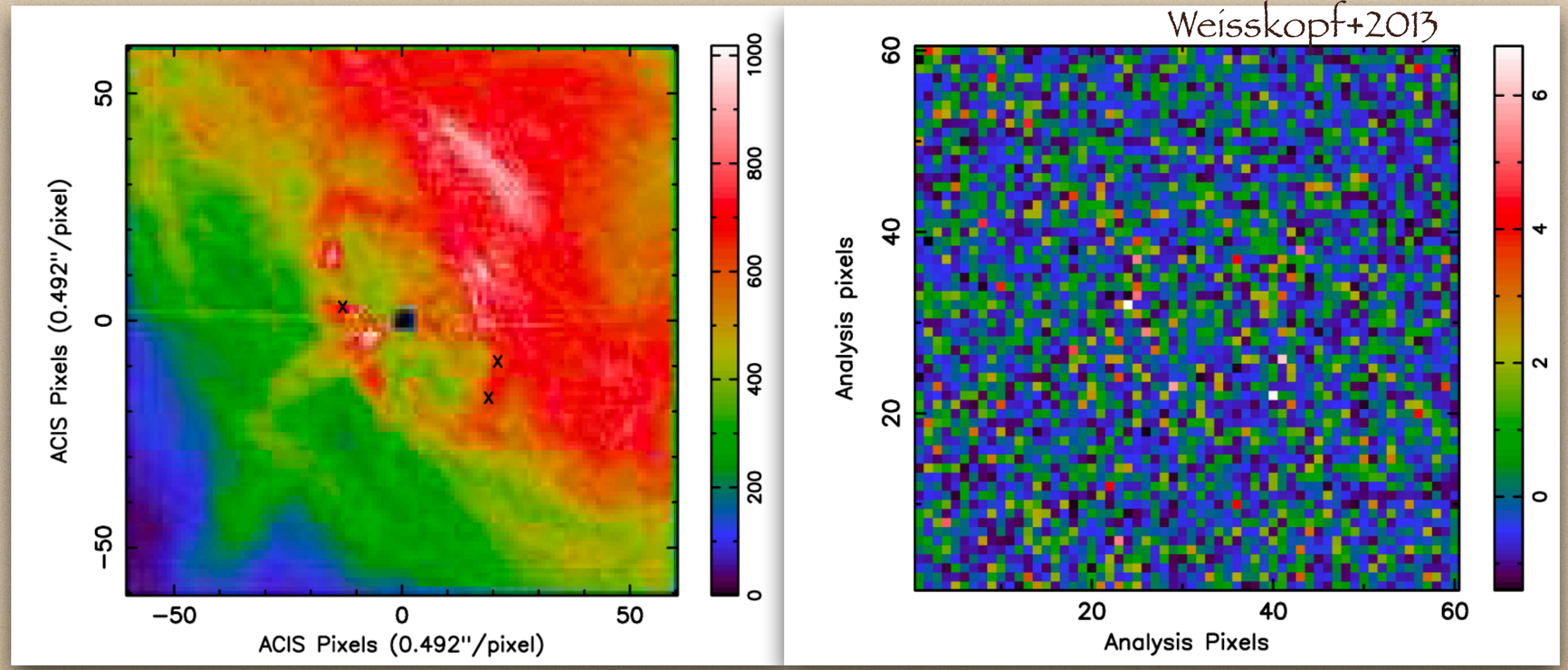

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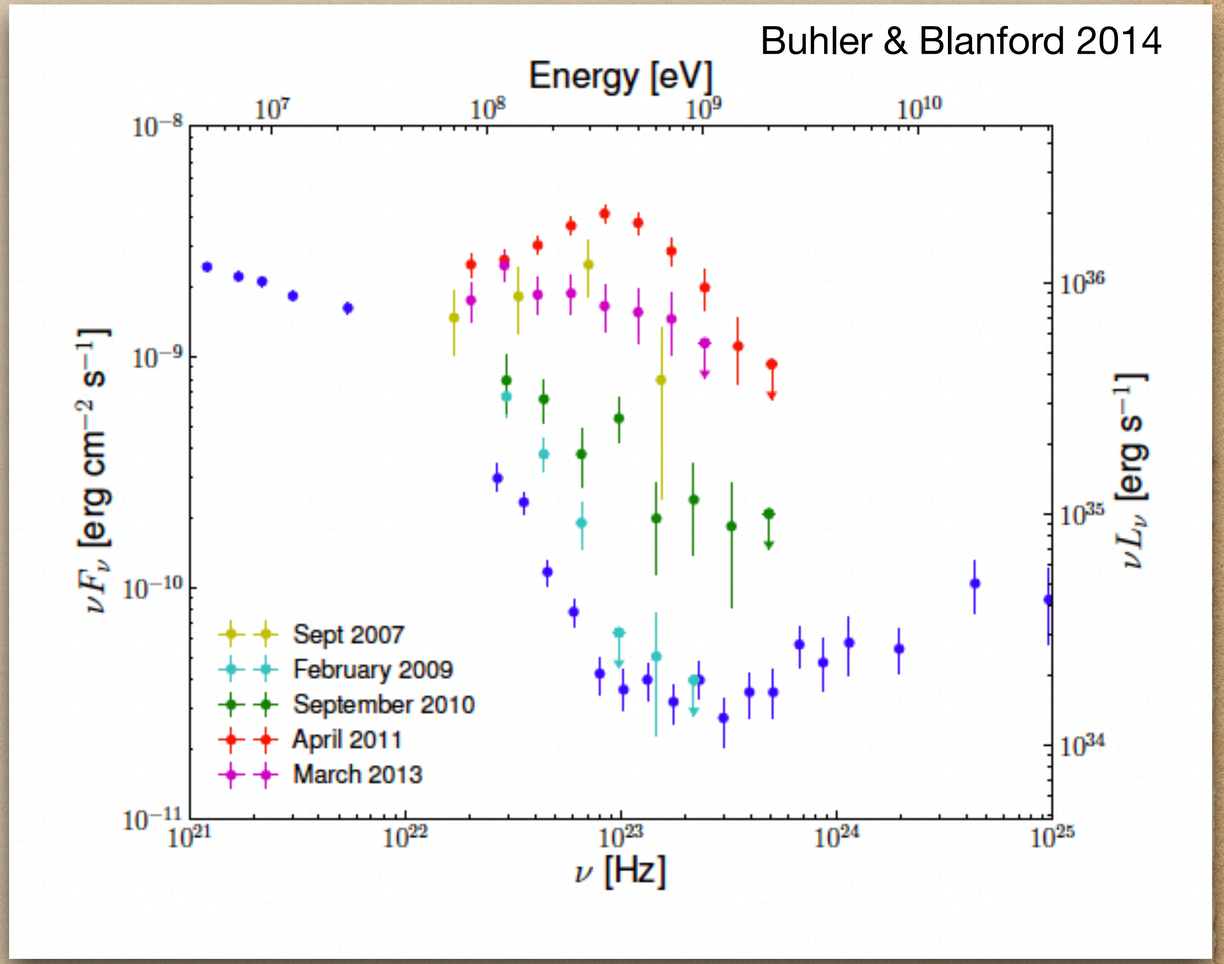
- ~0.1-1 GeV —> higher E tail of synchrotron component
- magnetic reconnection / relativistic boosting ?
- Synchrotron + IC, pair production

Buhler & Blanford 2014



Pulsar Wind Nebulae

- ~0.1-1 GeV higher part of synchrotron component
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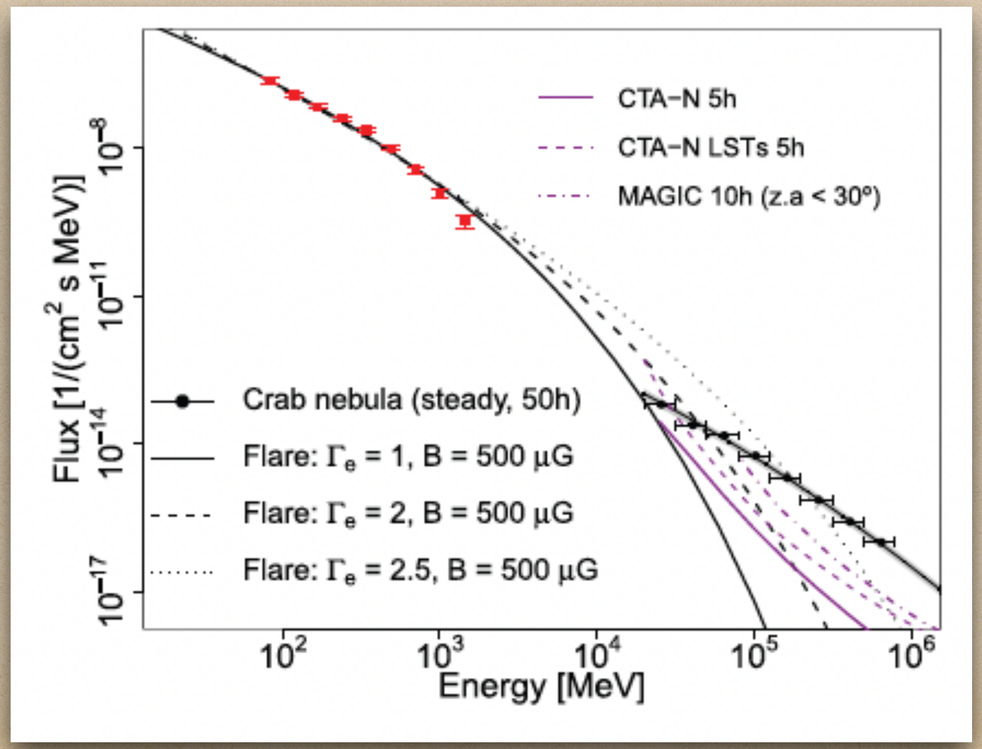

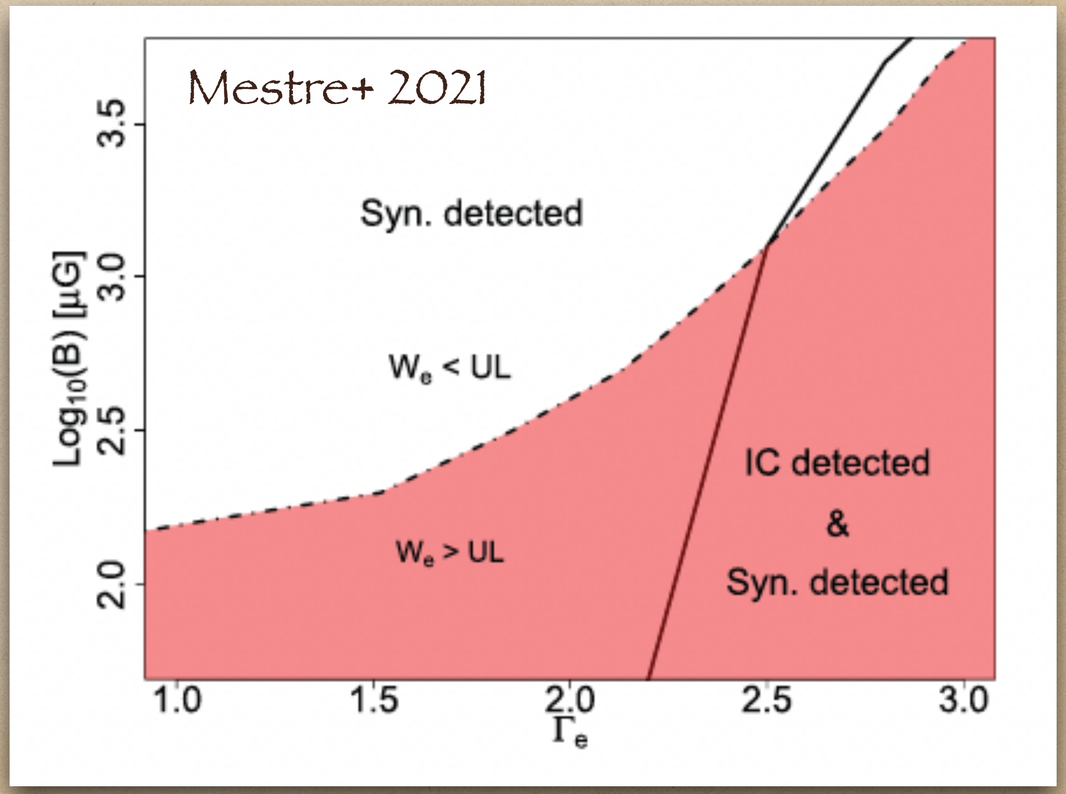

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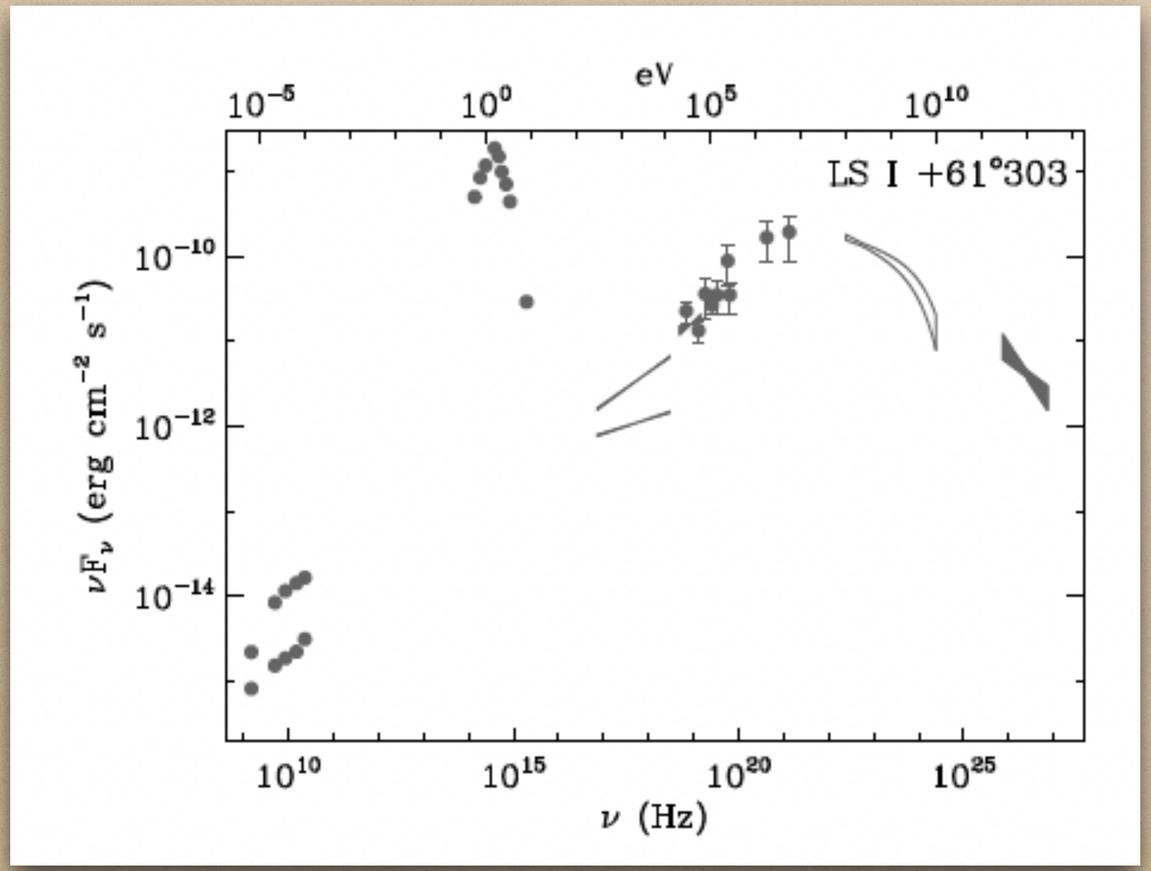

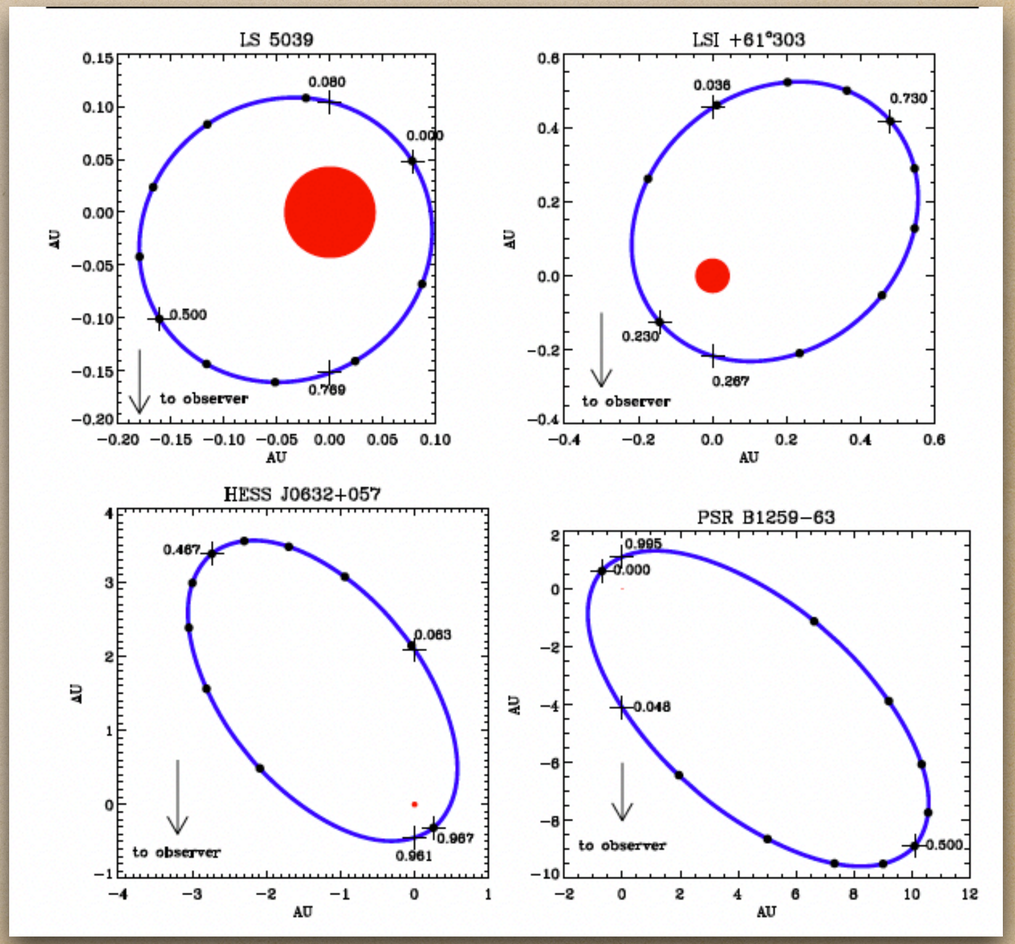

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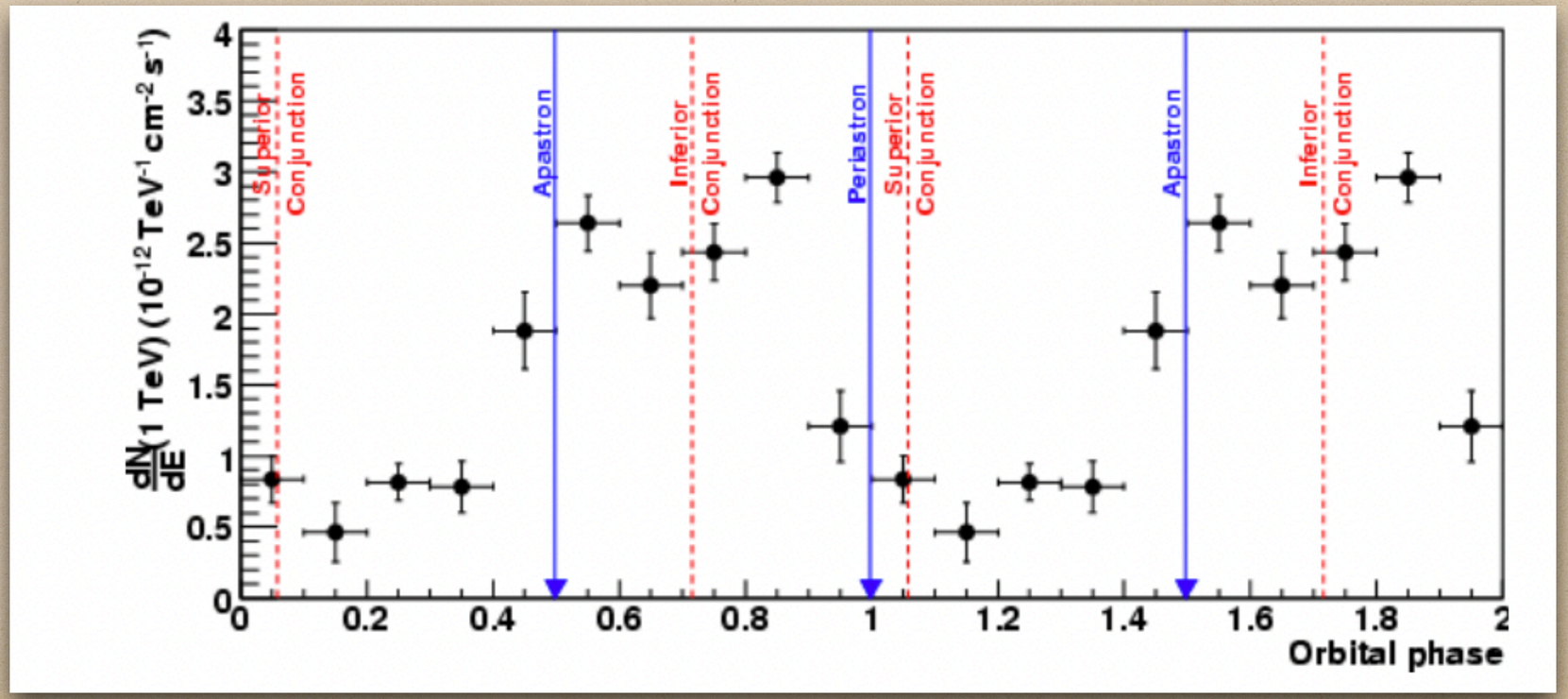
LS5039 - Aharonian+ 2006



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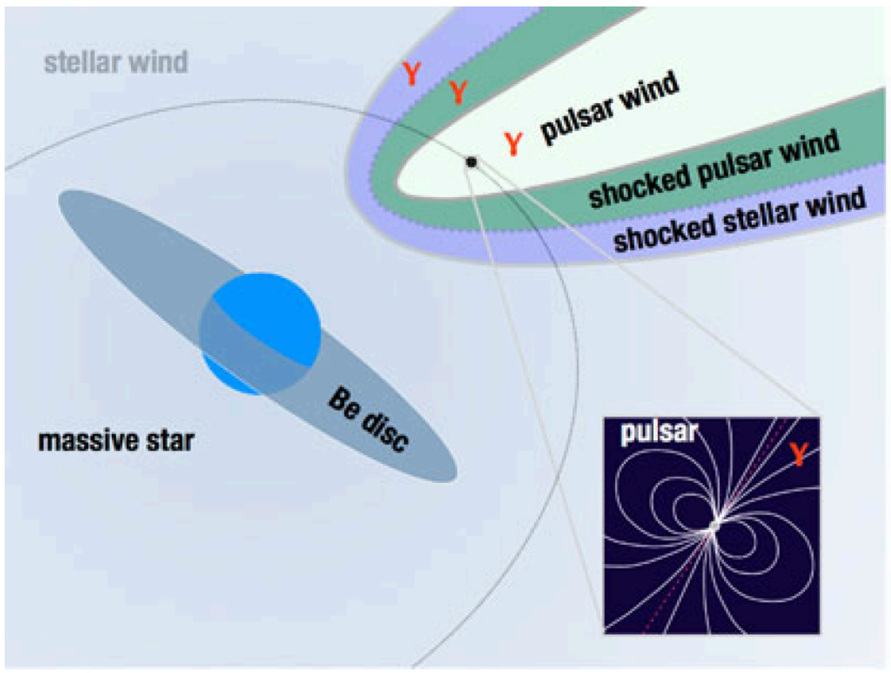

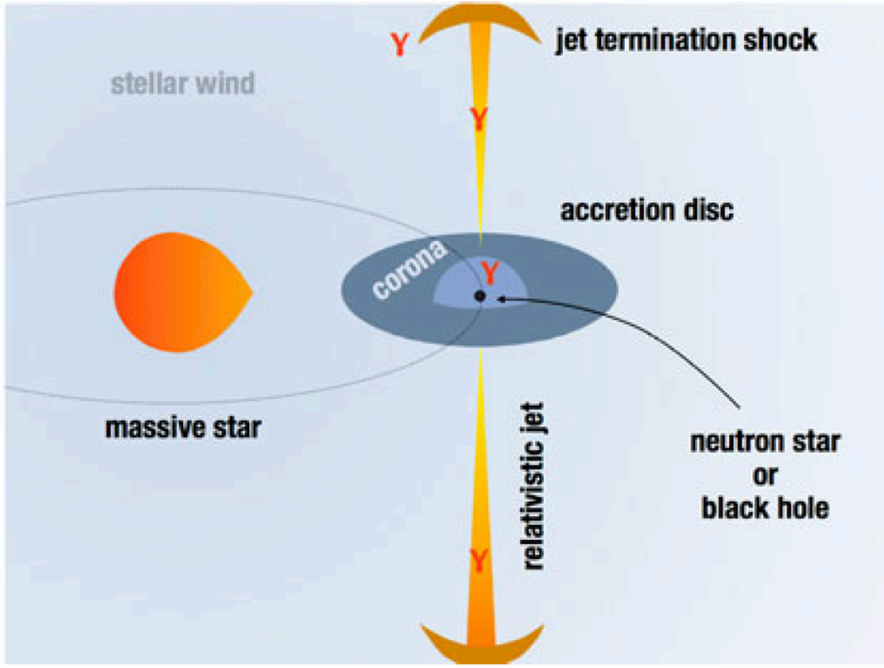

Dubus 2013

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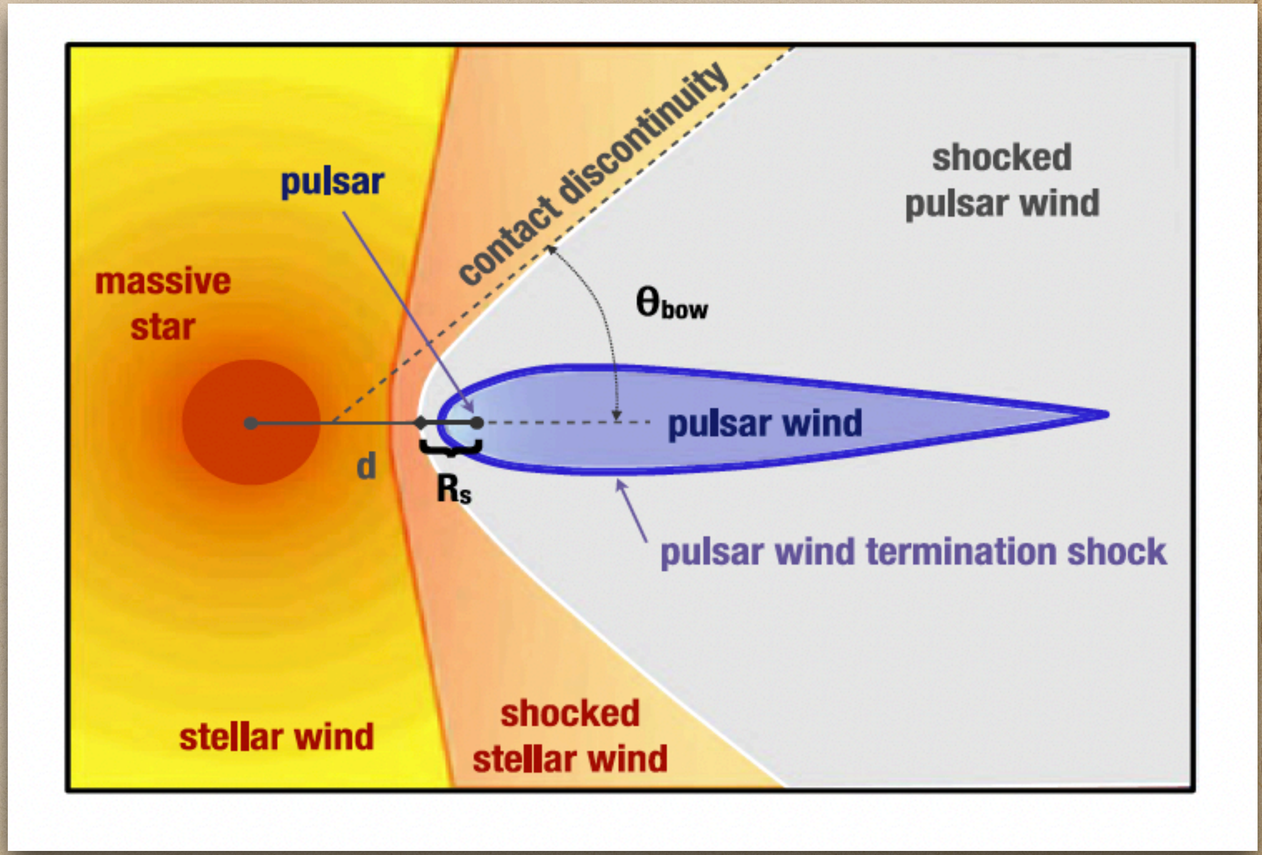

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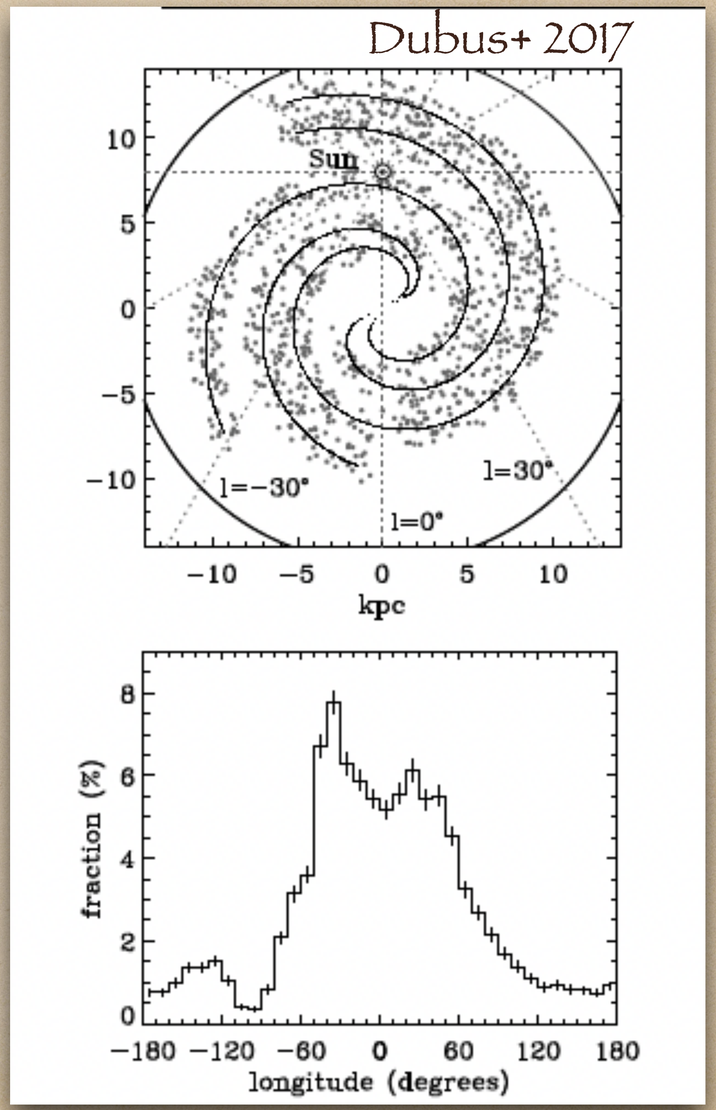

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Micro QSOs

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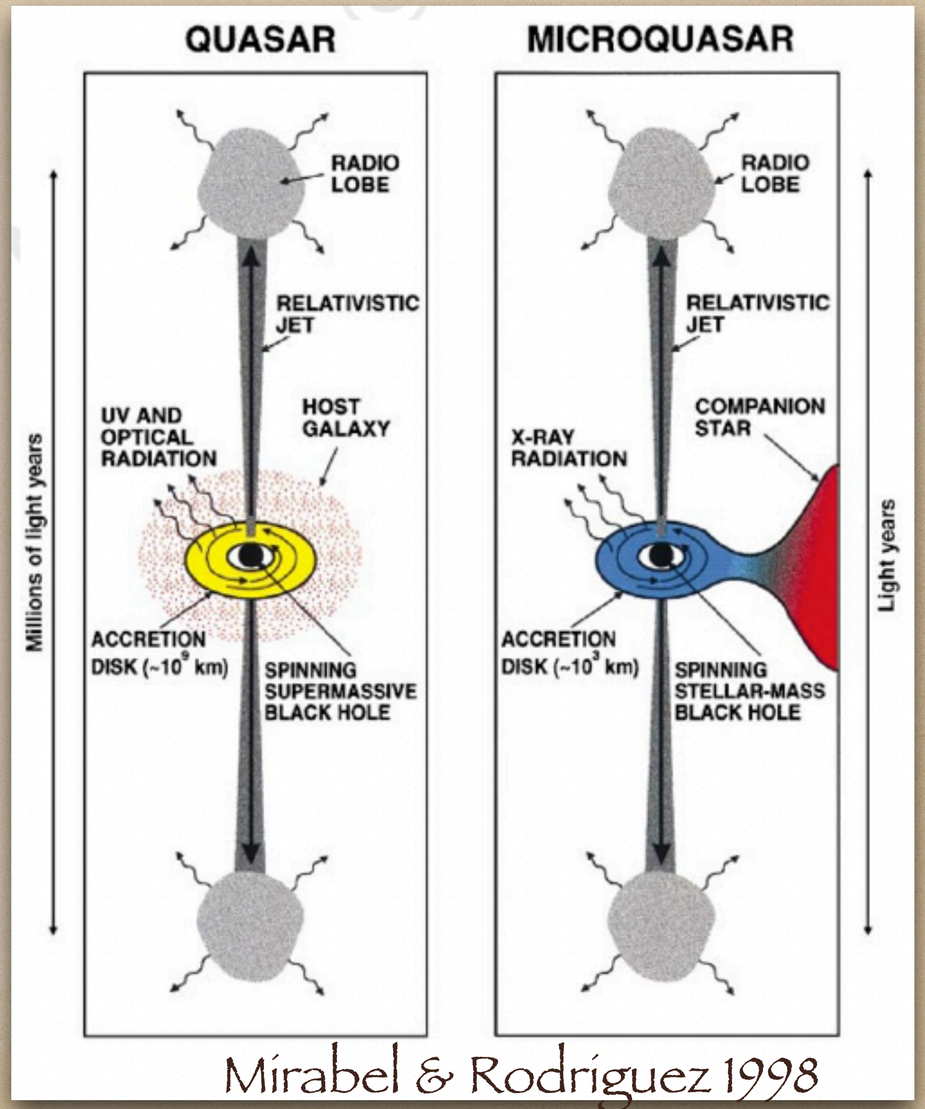

Mirabel & Rodriguez 1998

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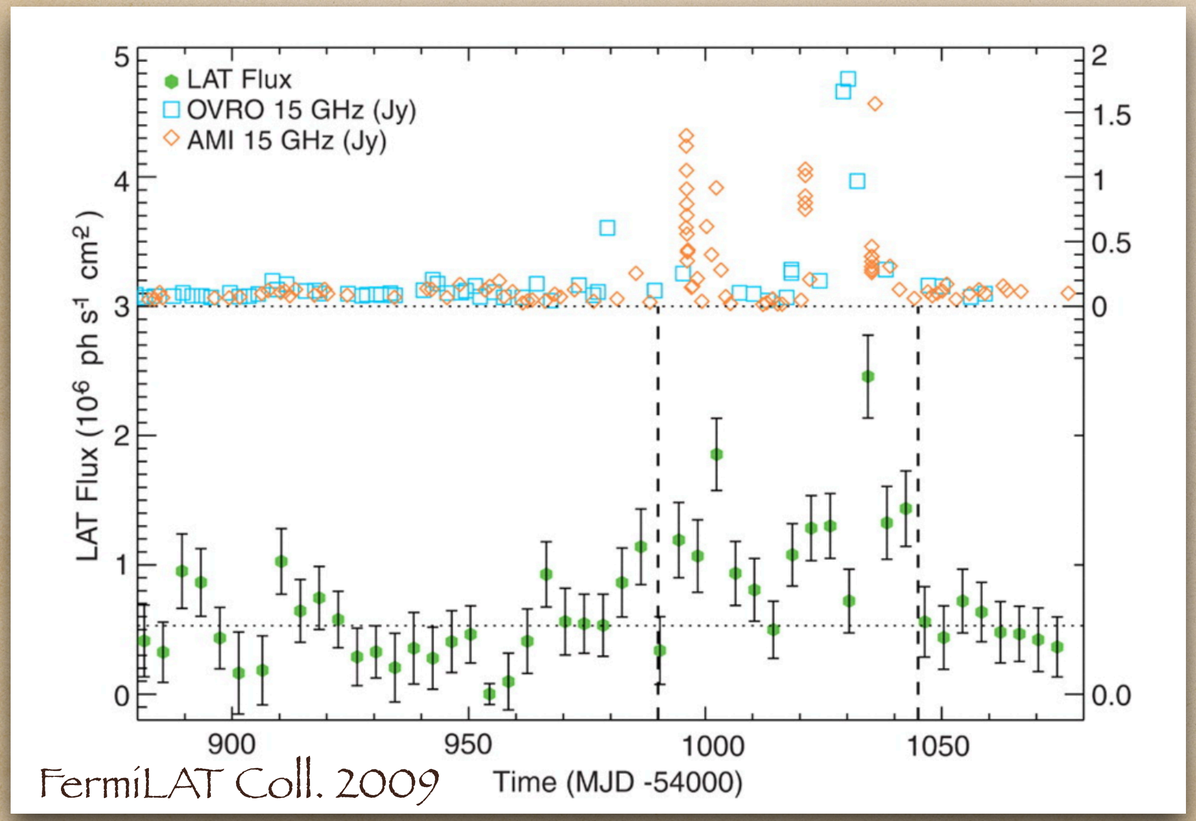
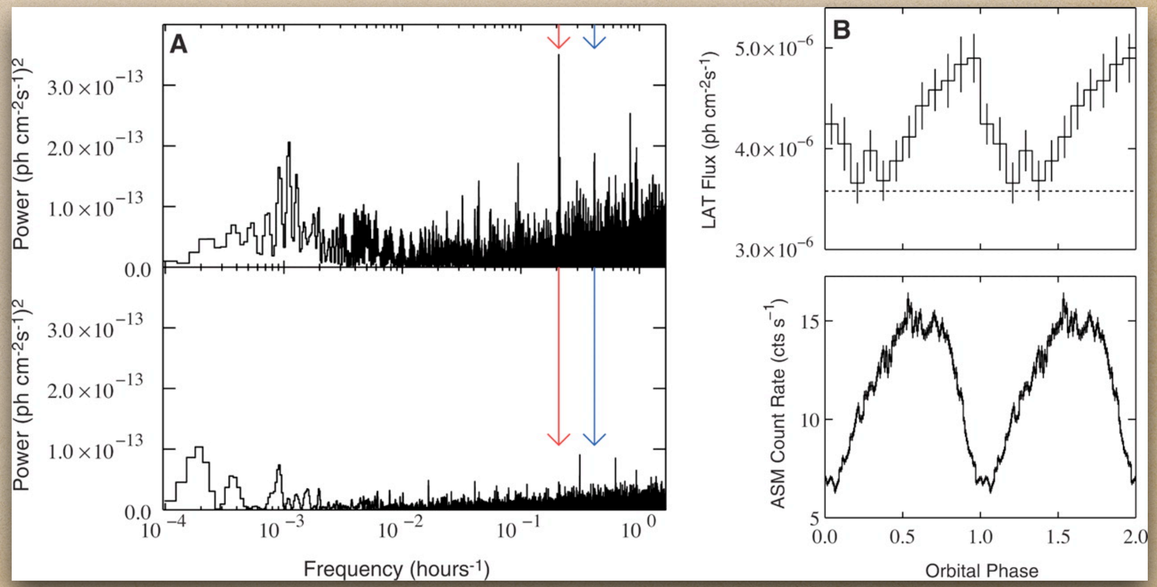


Cyg X-3



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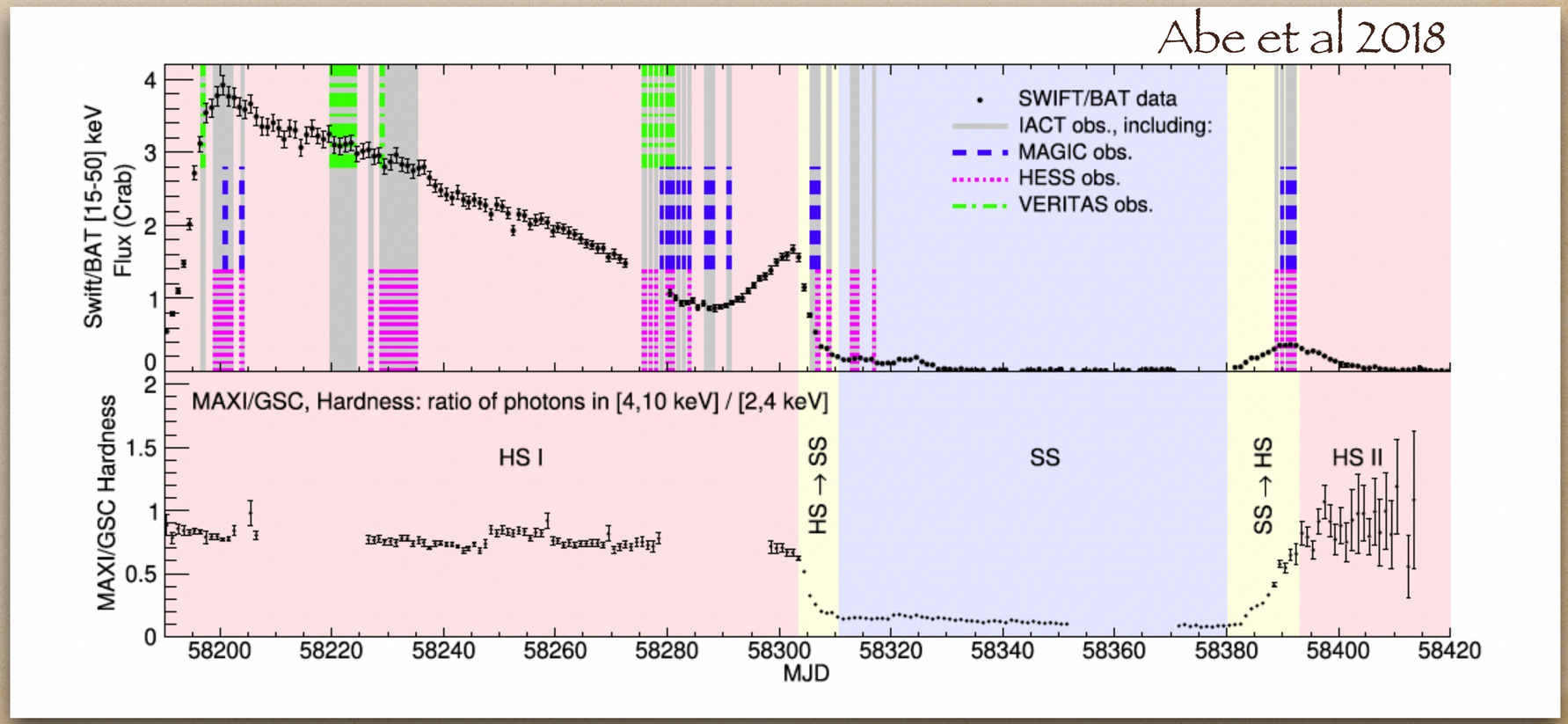
Abe et al 2018



MAXI J1820+070

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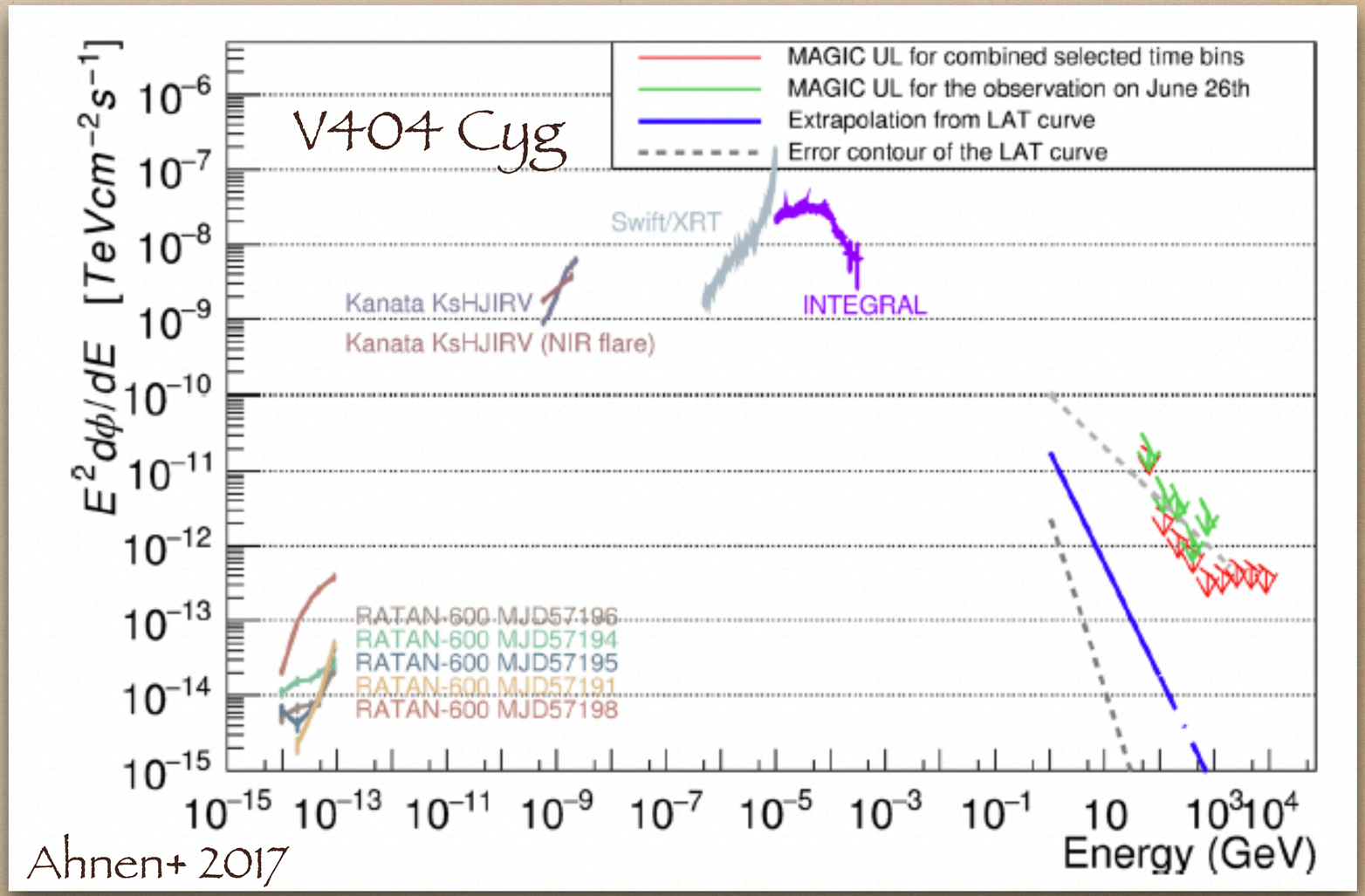

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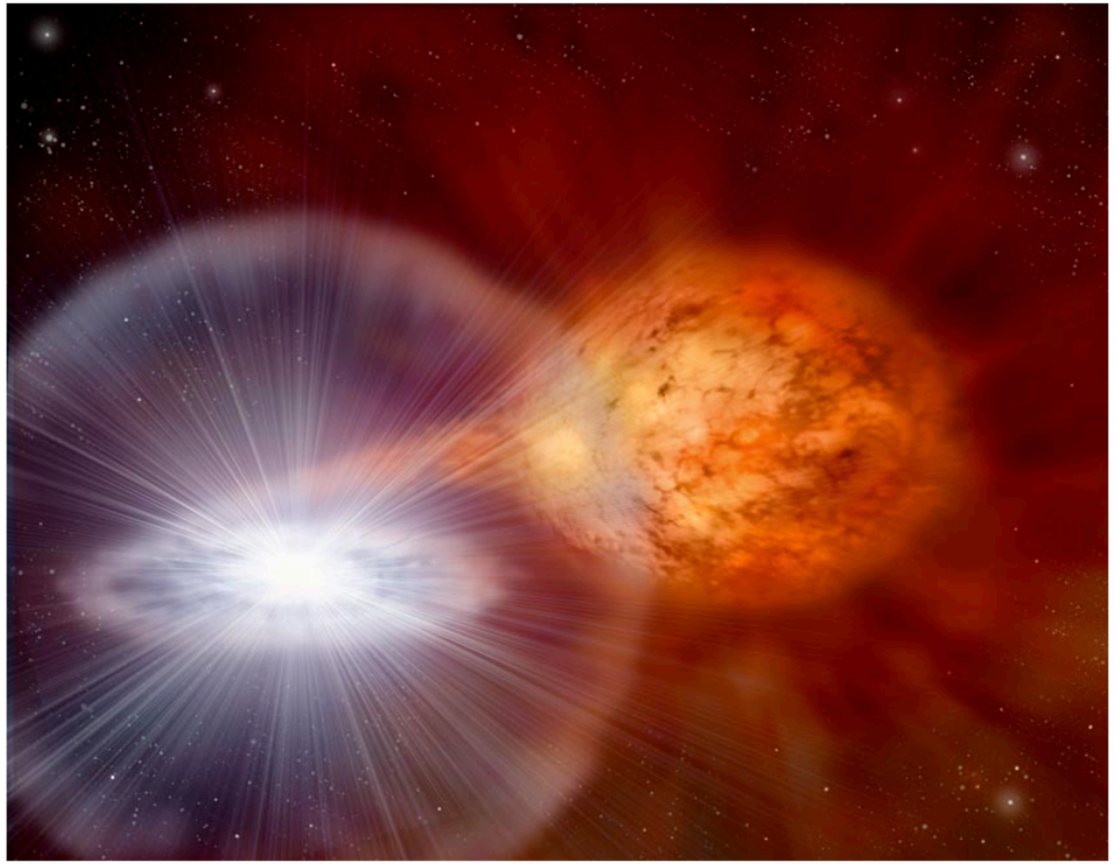
Novae

- accreting WD undergoing recurrent outbursts caused by thermonuclear runaway explosions



Credit: David A.Hardy/ www.astroart.org & PPARC.

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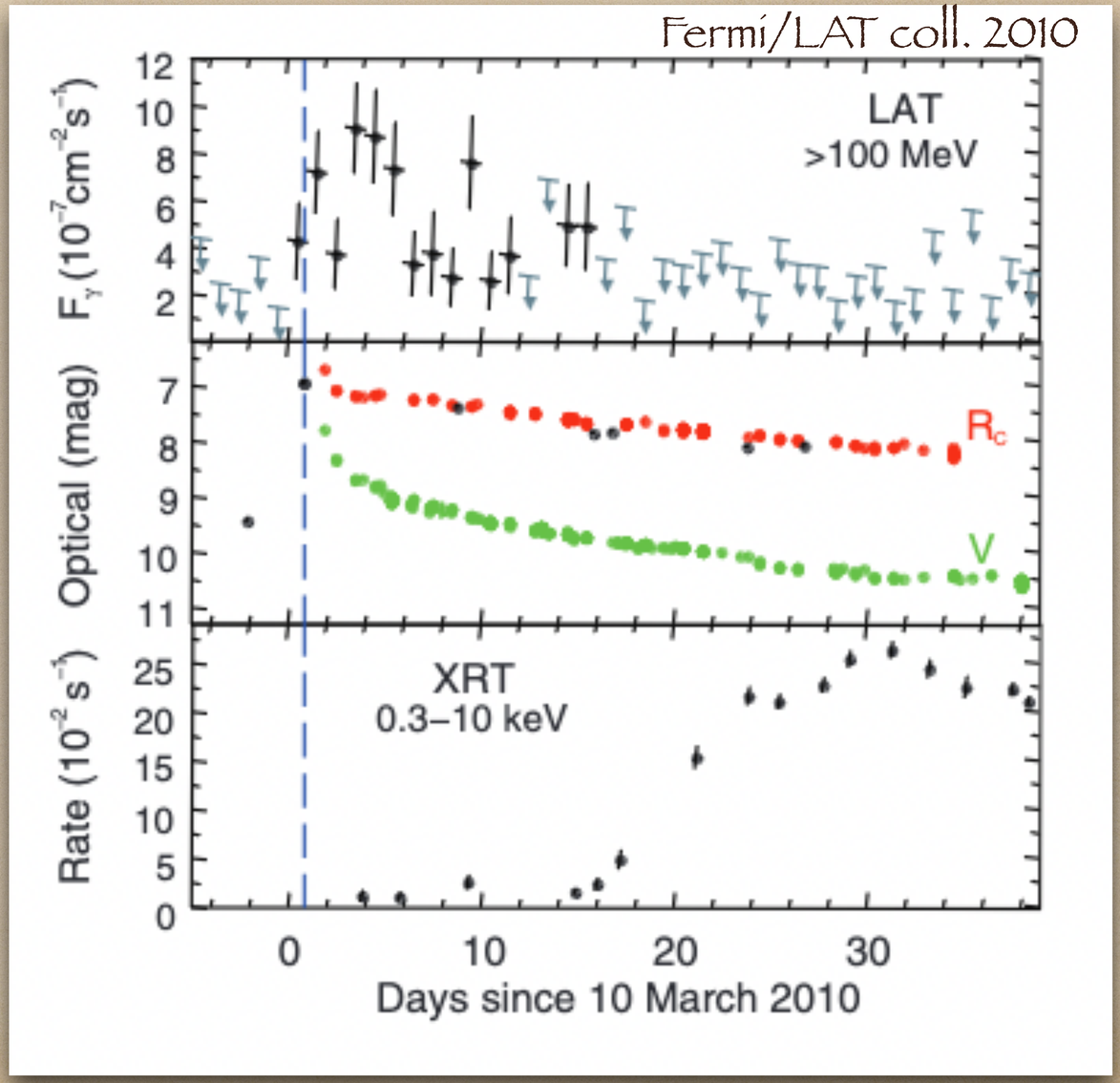
V407 Cyg



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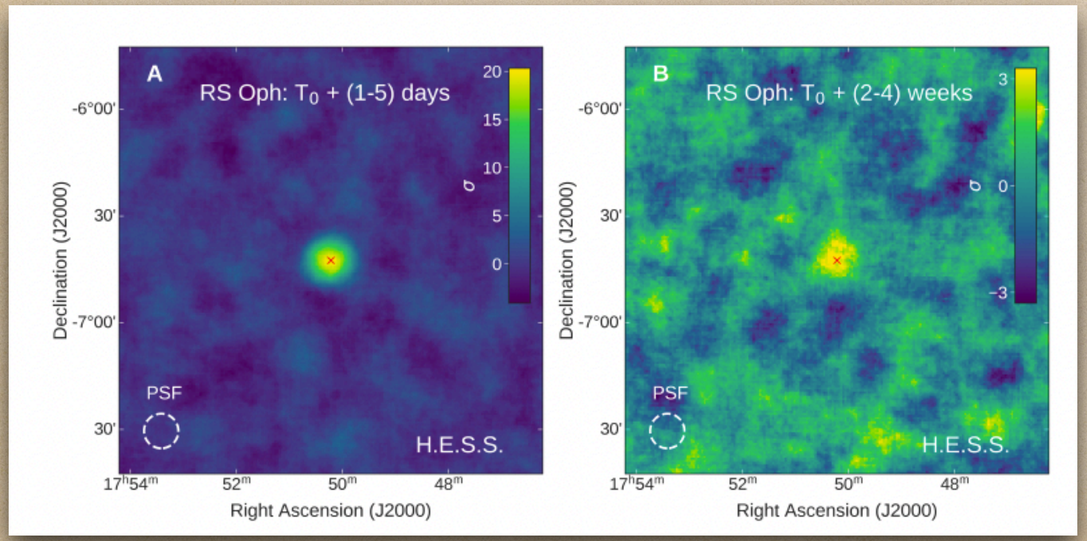

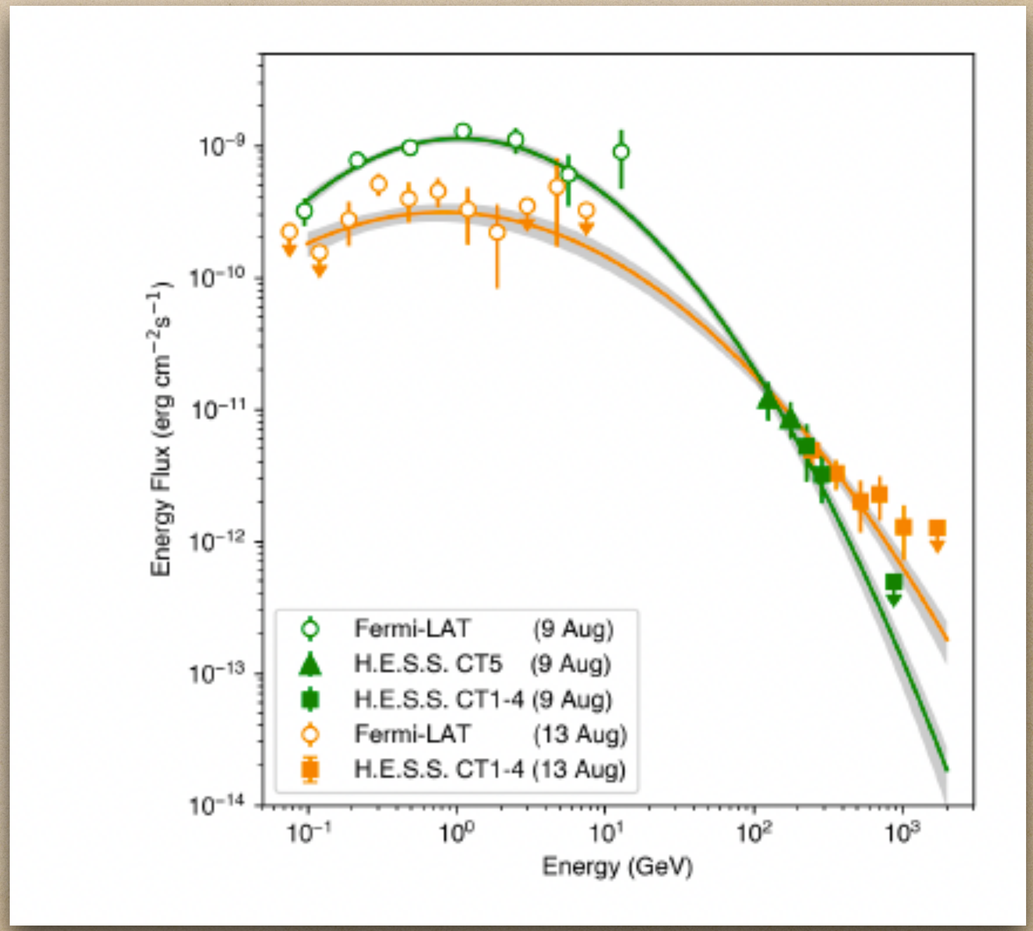

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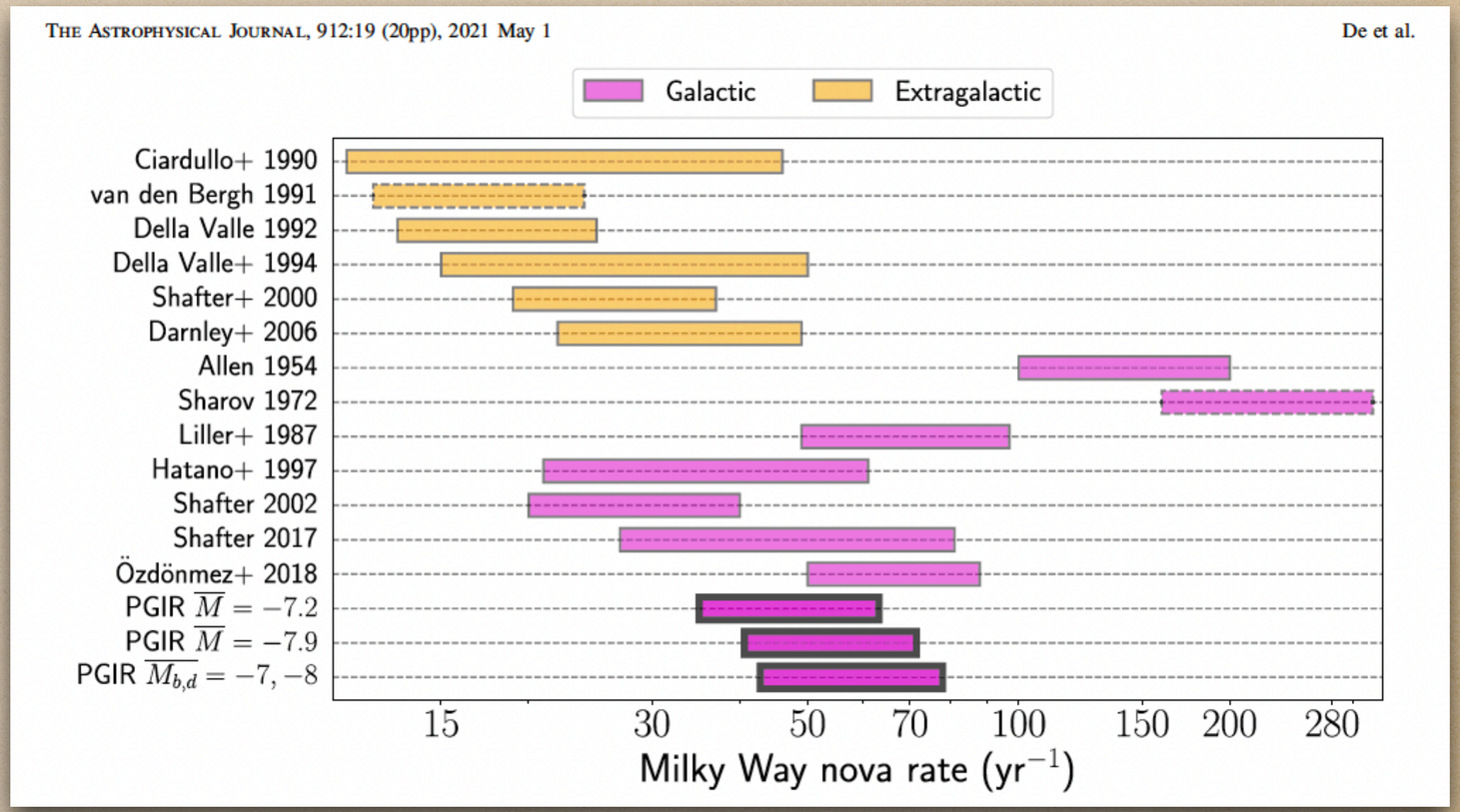

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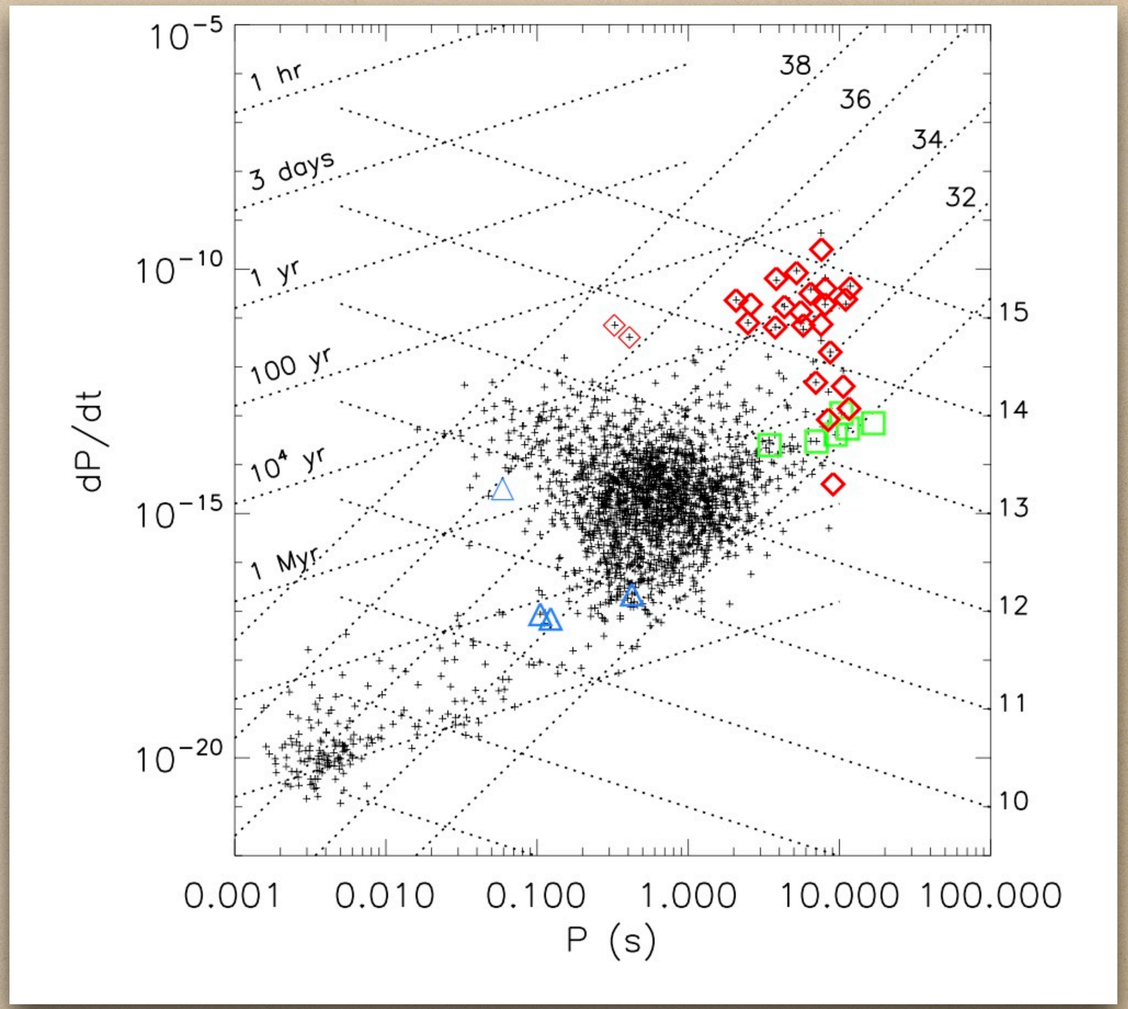

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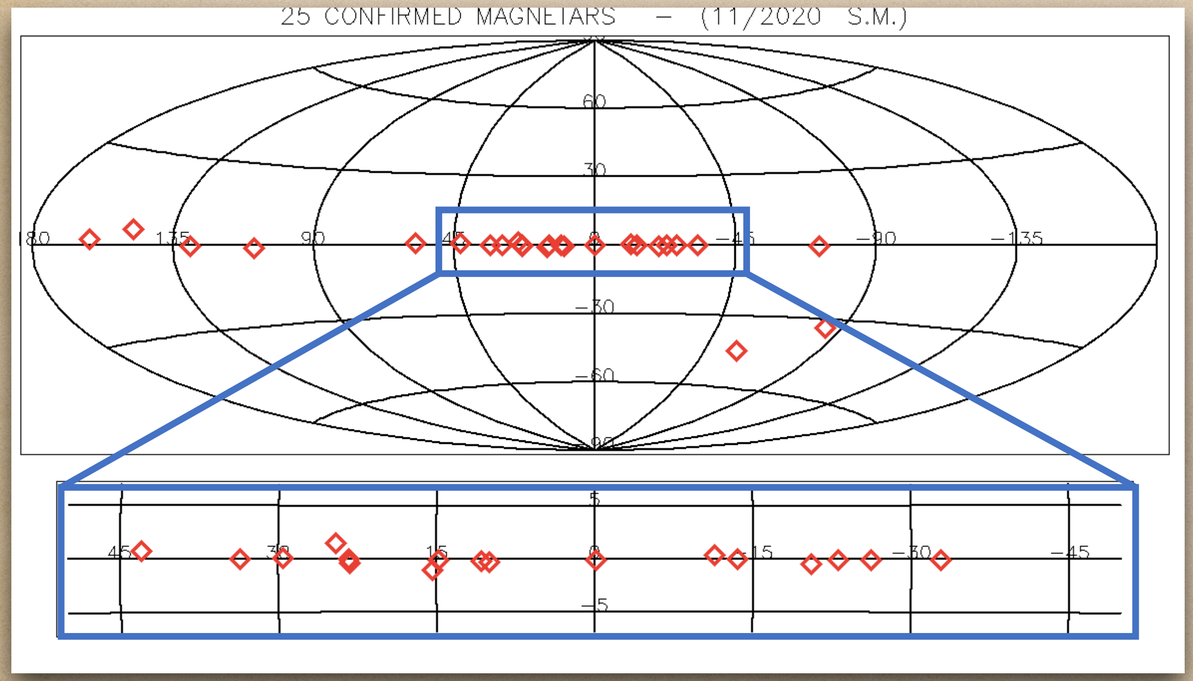

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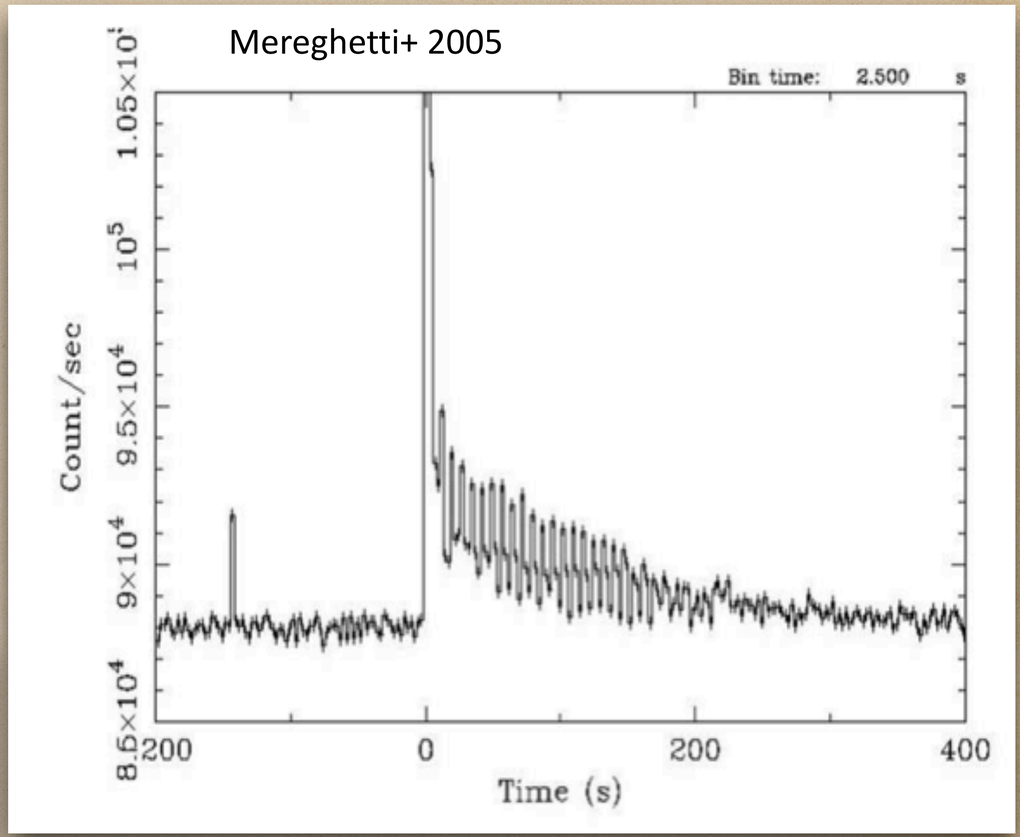

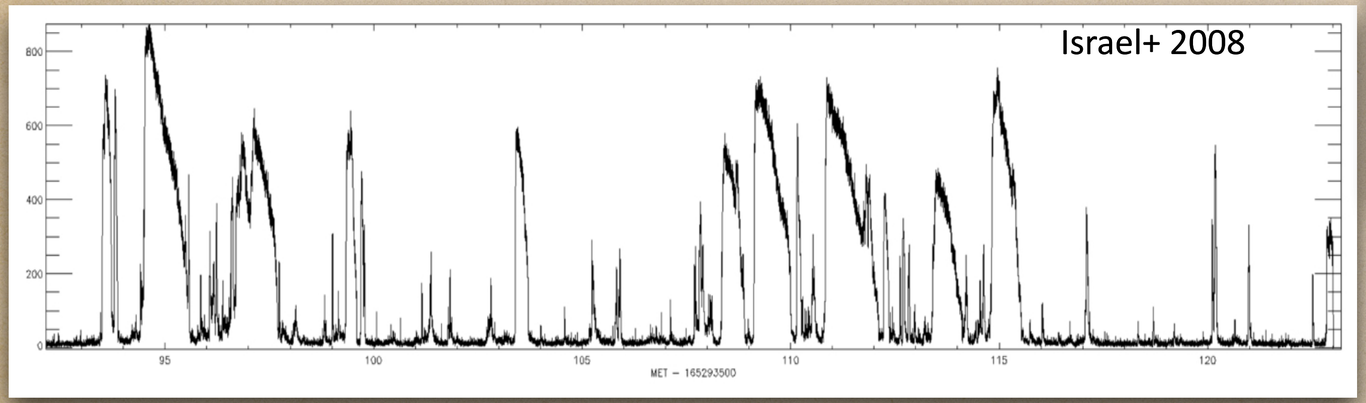

30 sec

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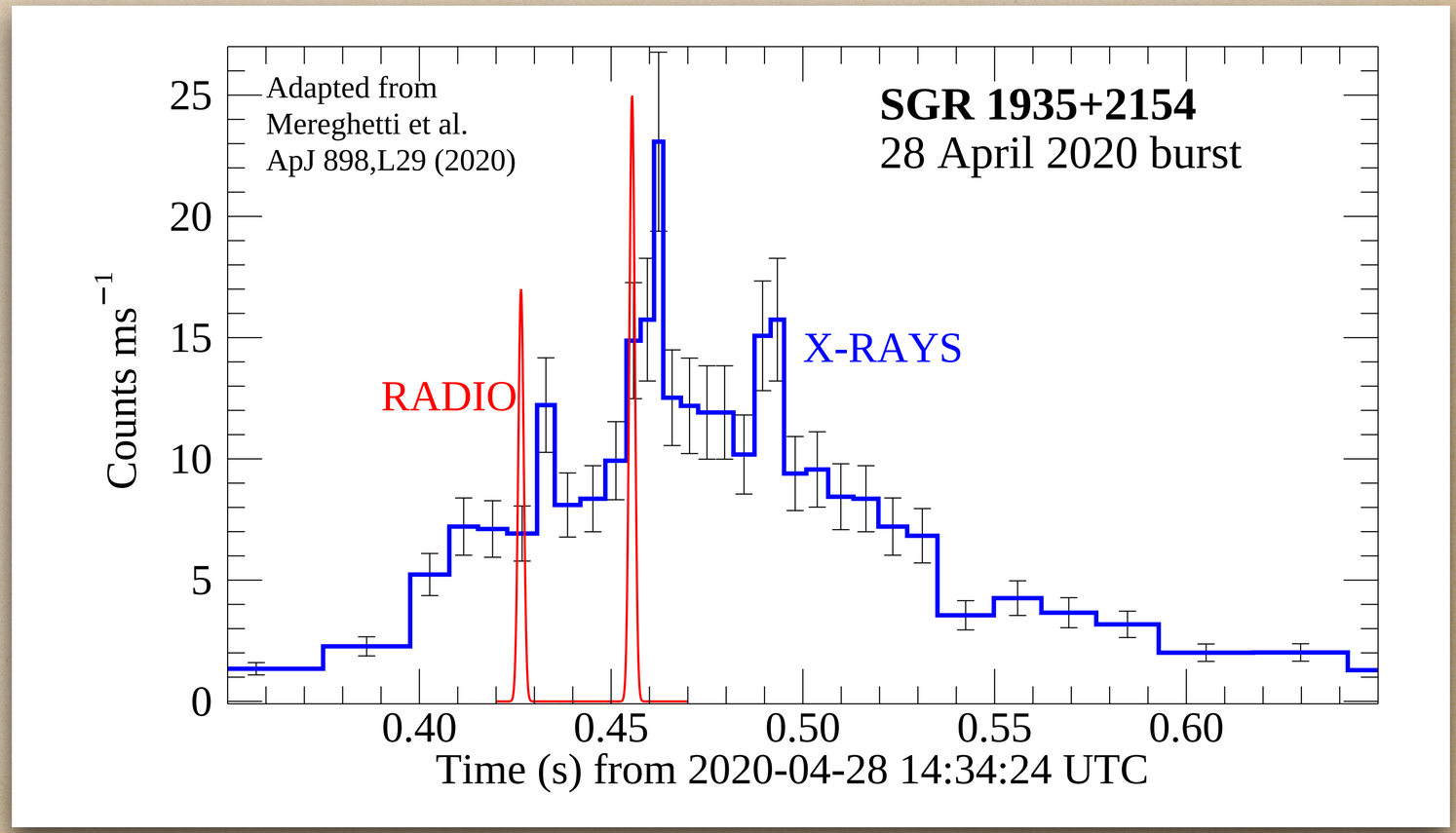

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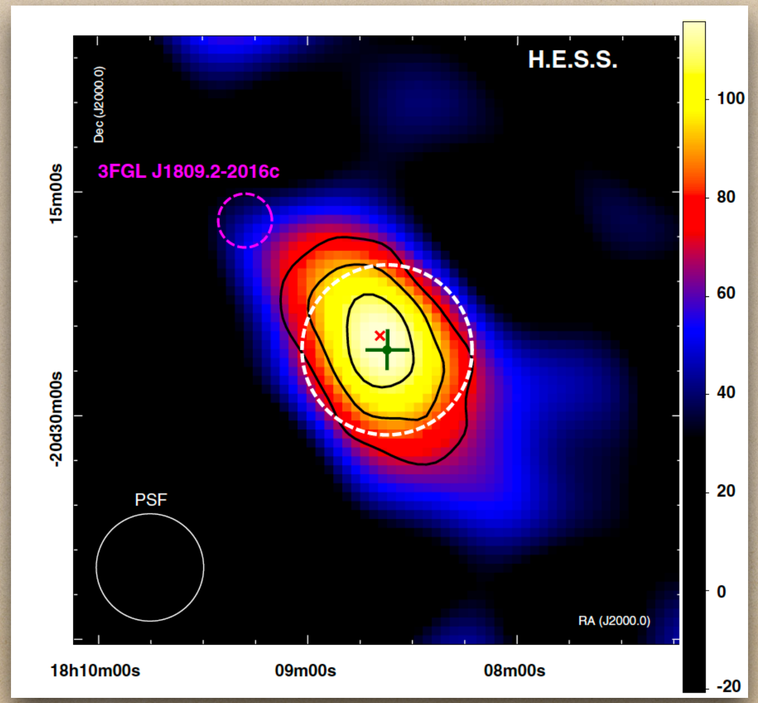
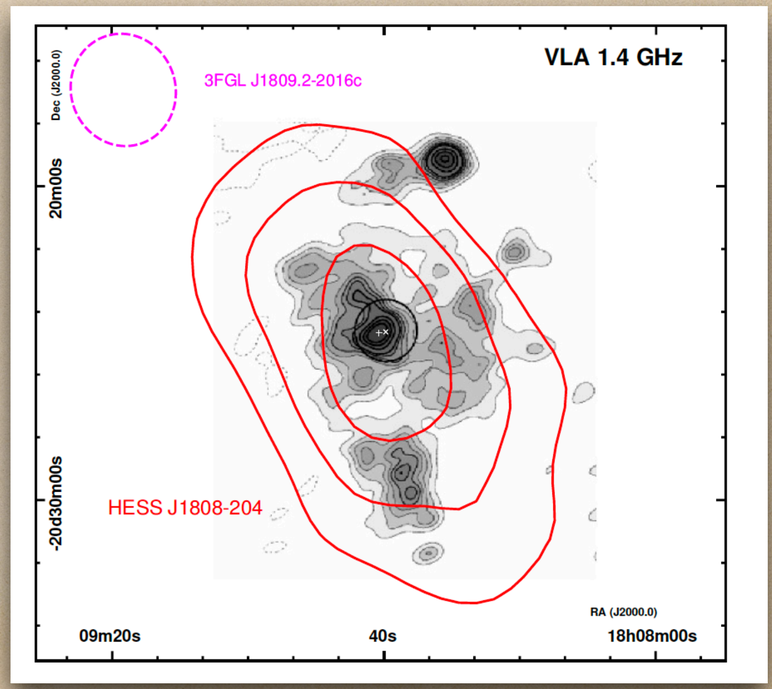
SGR 1806-20

HESS Coll. 2018





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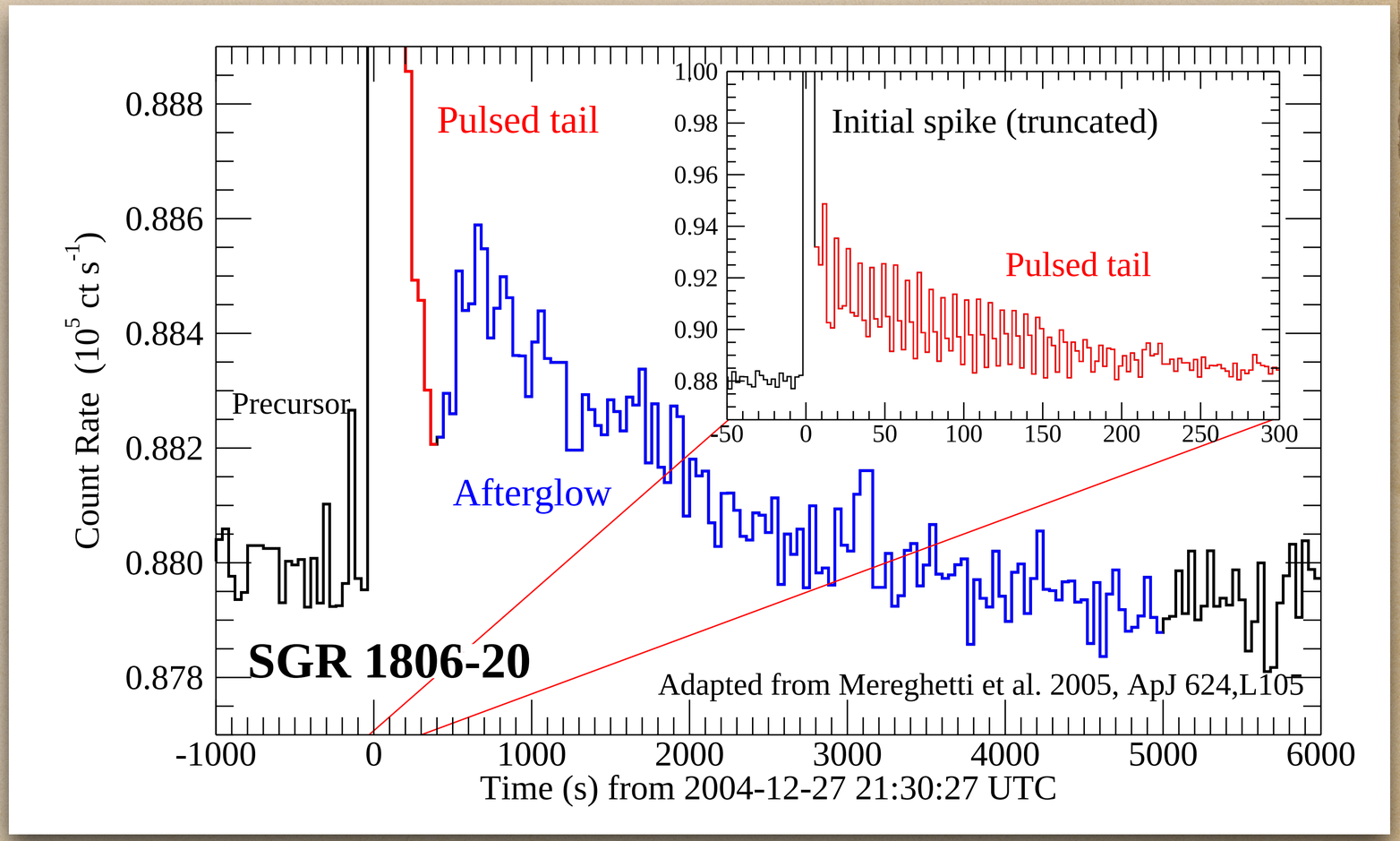

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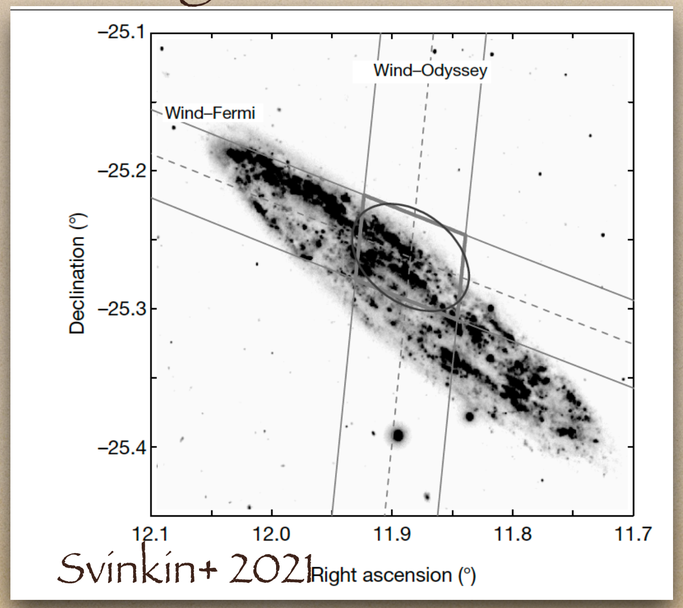
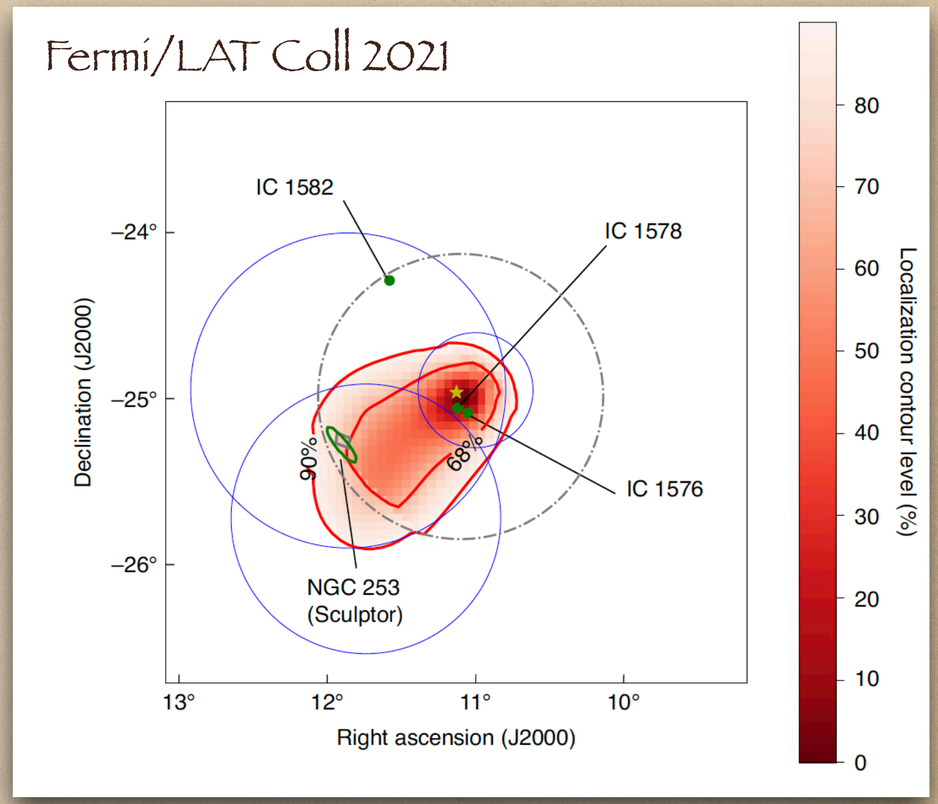


Svinkin+ 2021



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Final remarks

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EXTRA SLIDES

Galactic Center Survey

Table 5.1: Exposure summary for the Galactic Centre KSP.

	Deep exposure	Extended survey	Monitoring+multi-waveband
Time requested	525 h	300 h	(Co-ordinated with other instruments)
Priority	1	3	2
Strategy	survey	survey	Periodic + coordinated
Site	S	S	S
Sub-array	Full	Full	Full
Zenith Range	<40°	<50°	<40°
Atmosphere Quality	high	high	Medium
Targets Covered	multiple	multiple	Multiple

Galactic Plane Survey

Table 6.3: Estimated point-source sensitivity reach of the CTA Galactic Plane Survey for various regions of the Galactic plane.

	STP (years 1–2)		LTP (years 3–10)	Total (years 1–10)	
Galactic Longitude	Hours	Sensitivity	Hours	Hours	Sensitivity
SOUTH					
300°–60°, Inner region	300	**2.7 mCrab**	480	780	**1.8 mCrab**
240°–300°, Vela, Carina			180	180	**2.6 mCrab**
210°–240°			60	60	**3.1 mCrab**
				1020	
NORTH					
60°–150°, Cygnus, Perseus	180	**4.2 mCrab**	270	450	**2.7 mCrab**
150°–210°, anti-Centre, etc.			150	150	**3.8 mCrab**
				600	

Notes: These sensitivities correspond to an energy threshold of 125 GeV. For the approximate effective exposure "on-axis" for each region, see Table 6.4.

AGNs

Table 12.3: Summary of required observing times for the northern site ("N") and the southern site ("S") for the different parts of the observation programme.

Programme	Total N [h]	Total S [h]	Duration [yr]	Observation mode
Long-term monitoring	1110	390	10†	Full array
AGN flares				
Snapshots	1200	475	10*	LSTs
Snapshots	138	68	10*	MSTs (assuming 10 sub-array
Verification ext. trig.	300	150	10*	LSTs or MST sub-arrays
Follow-up of triggers	725	475	10*	Full array
High-quality spectra				
Redshift sample	195	135	3	Full array
M 87 and Cen A	100	150	3	Full array

Note: The total duration of each programme is given in the fourth column, where a "
("†") indicates a reduction of the yearly exposure time after 2 (5) years.