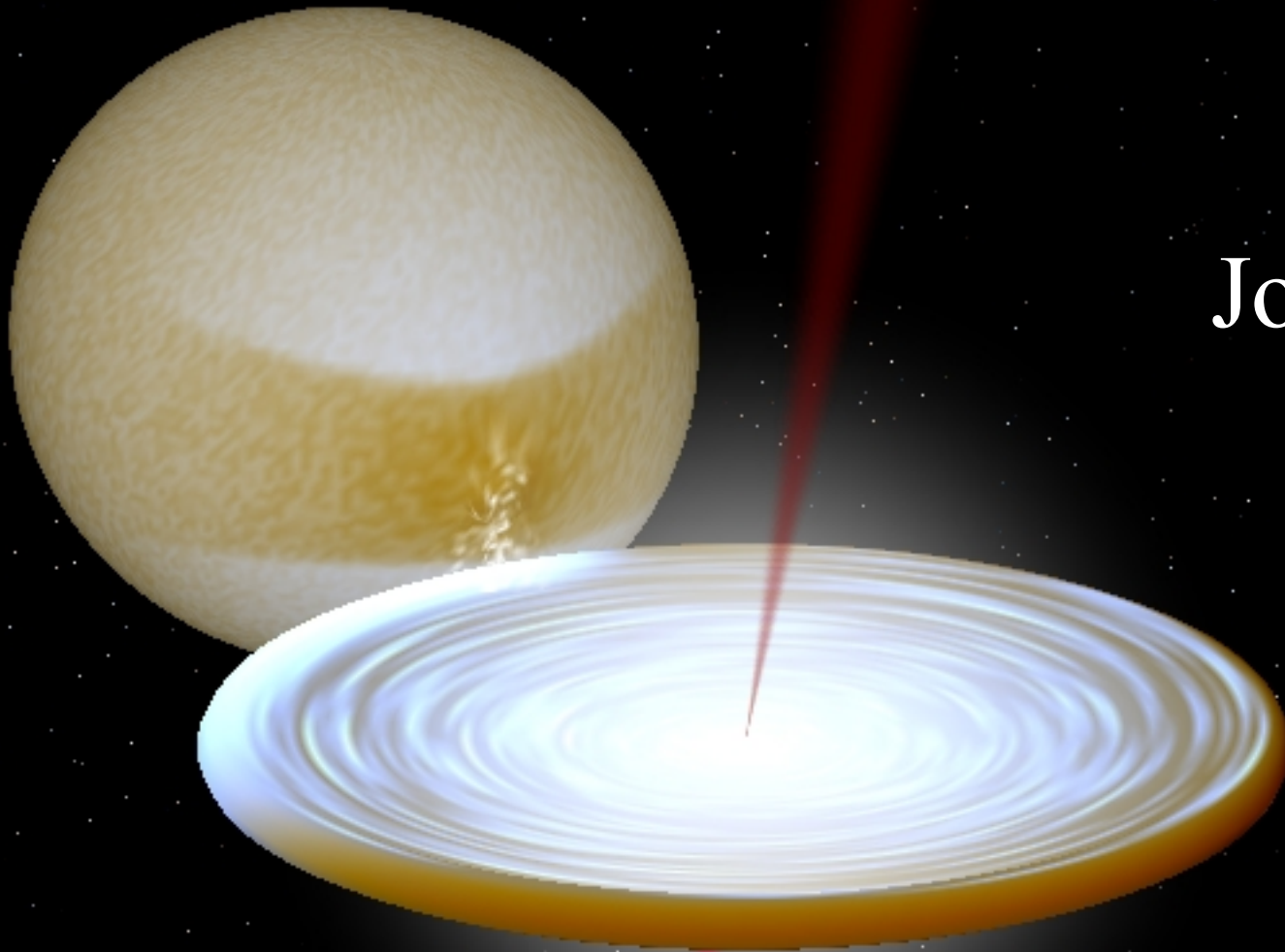


HESS J0632+057: A new gamma-ray binary?

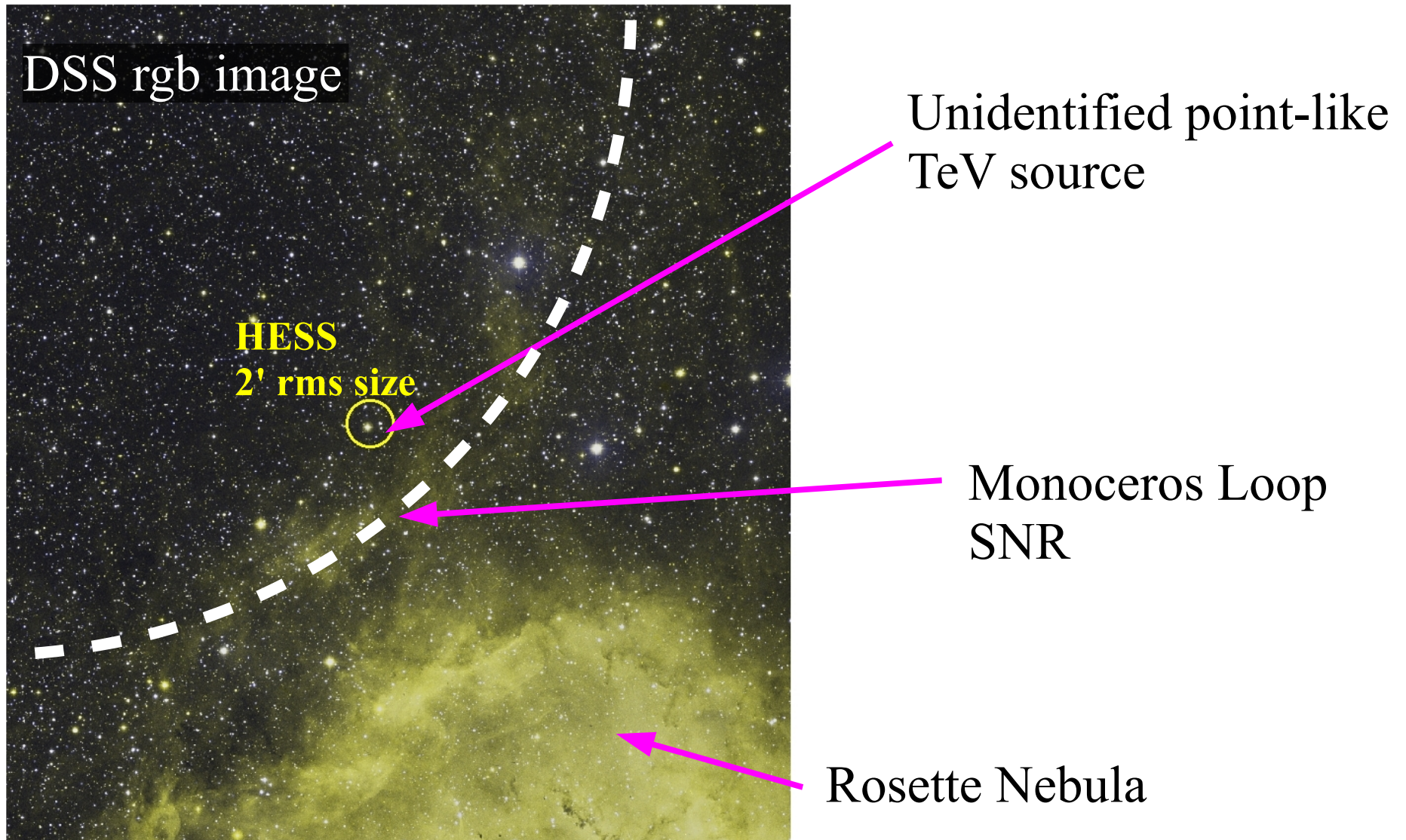


Joanna Skilton
MPIK

Jim Hinton, Julia Brucker,
M. Pommier, T. Cheung,
A. Marcowith, G. Dubus,
Y. Gallant, S. Funk,
O. Reimer, A. Fiasson,
F.A. Aharonian

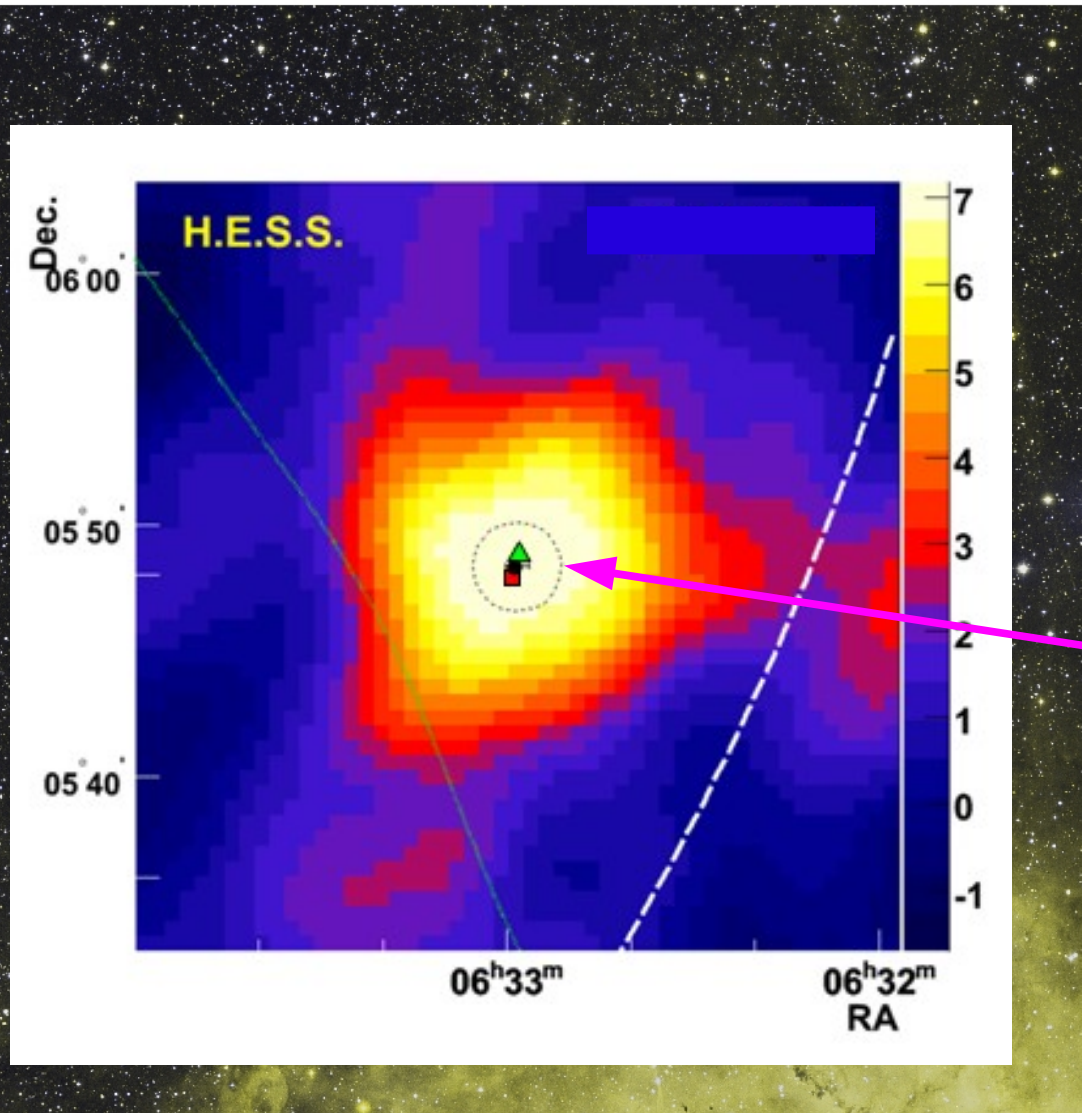
+ many more!

HESS J0632+057 – discovery



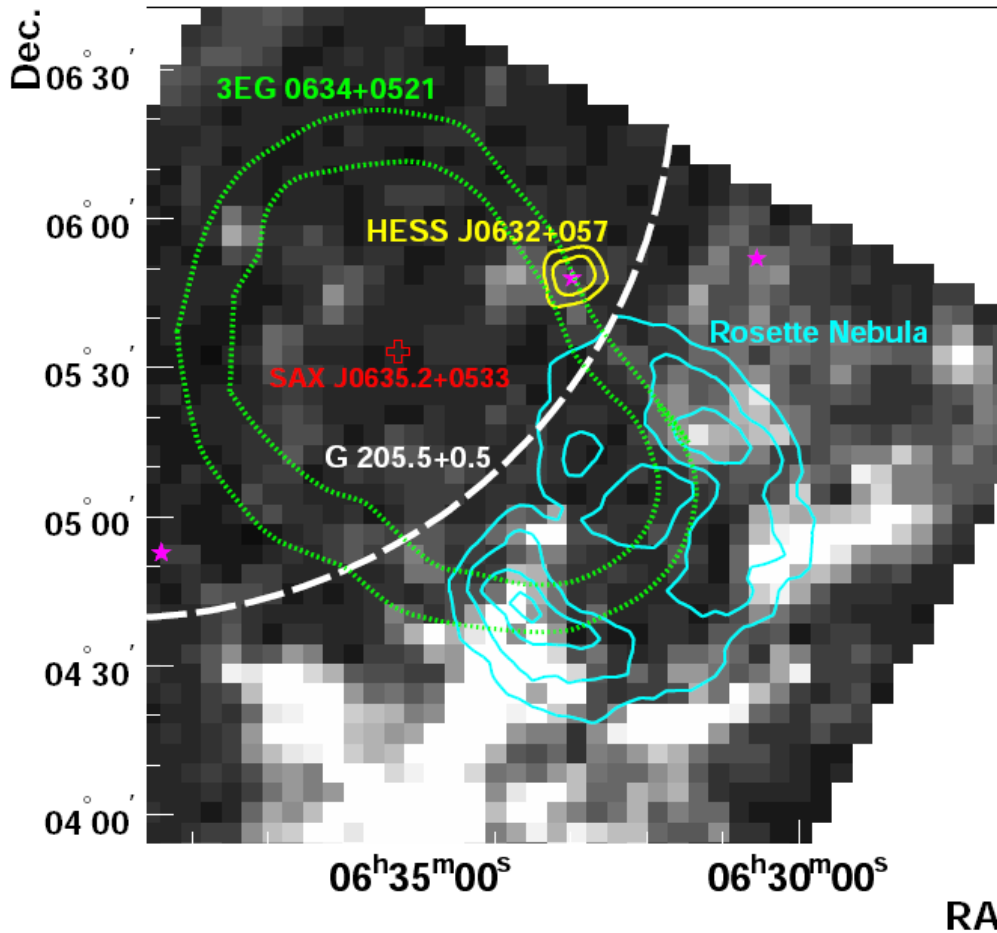
Discovery of a point-like very-high-energy γ -ray source in Monoceros
HESS Collaboration 2007, A&A, 469, L1

HESS J0632+057 – discovery



2' Upper limit on source size

HESS J0632+057 – counterparts

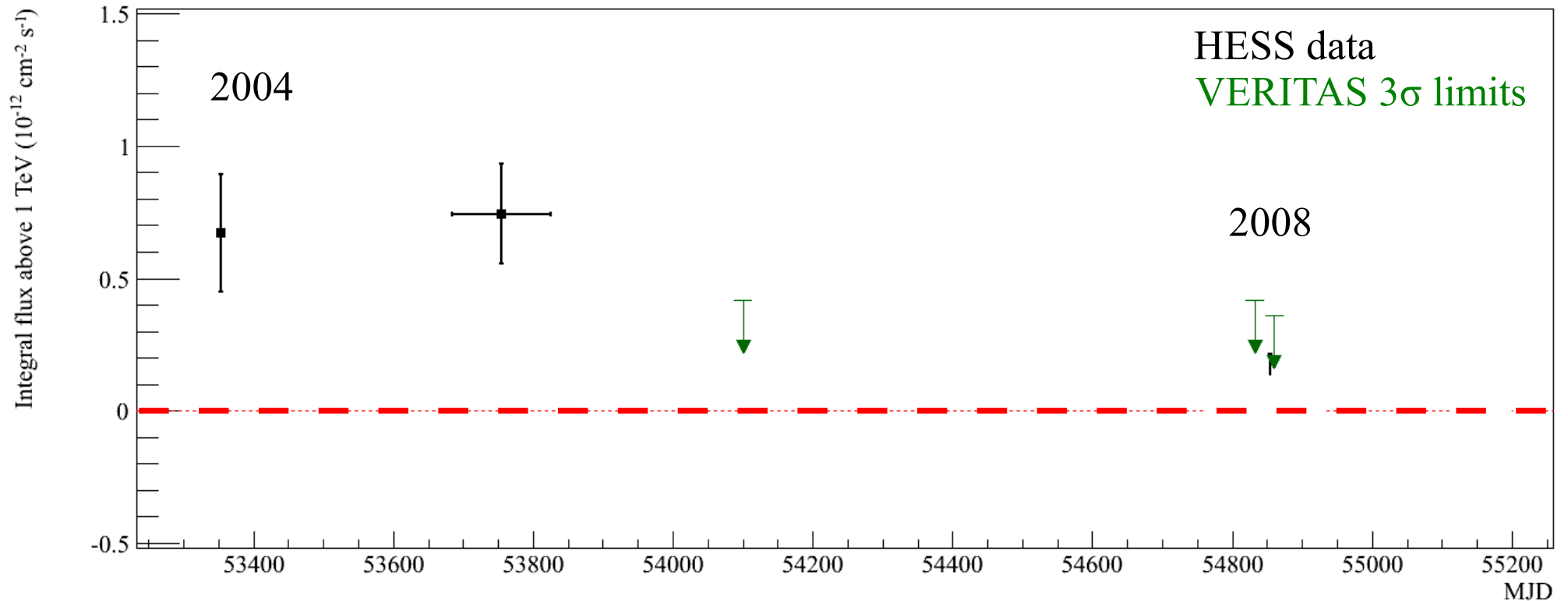


Possible counterparts

- Massive B0pe star HD 259440/
MWC 148
- EGRET 3EG 0634+0521
- ROSAT 1RXS
J063258.3+054857

→ Gamma-ray binary?

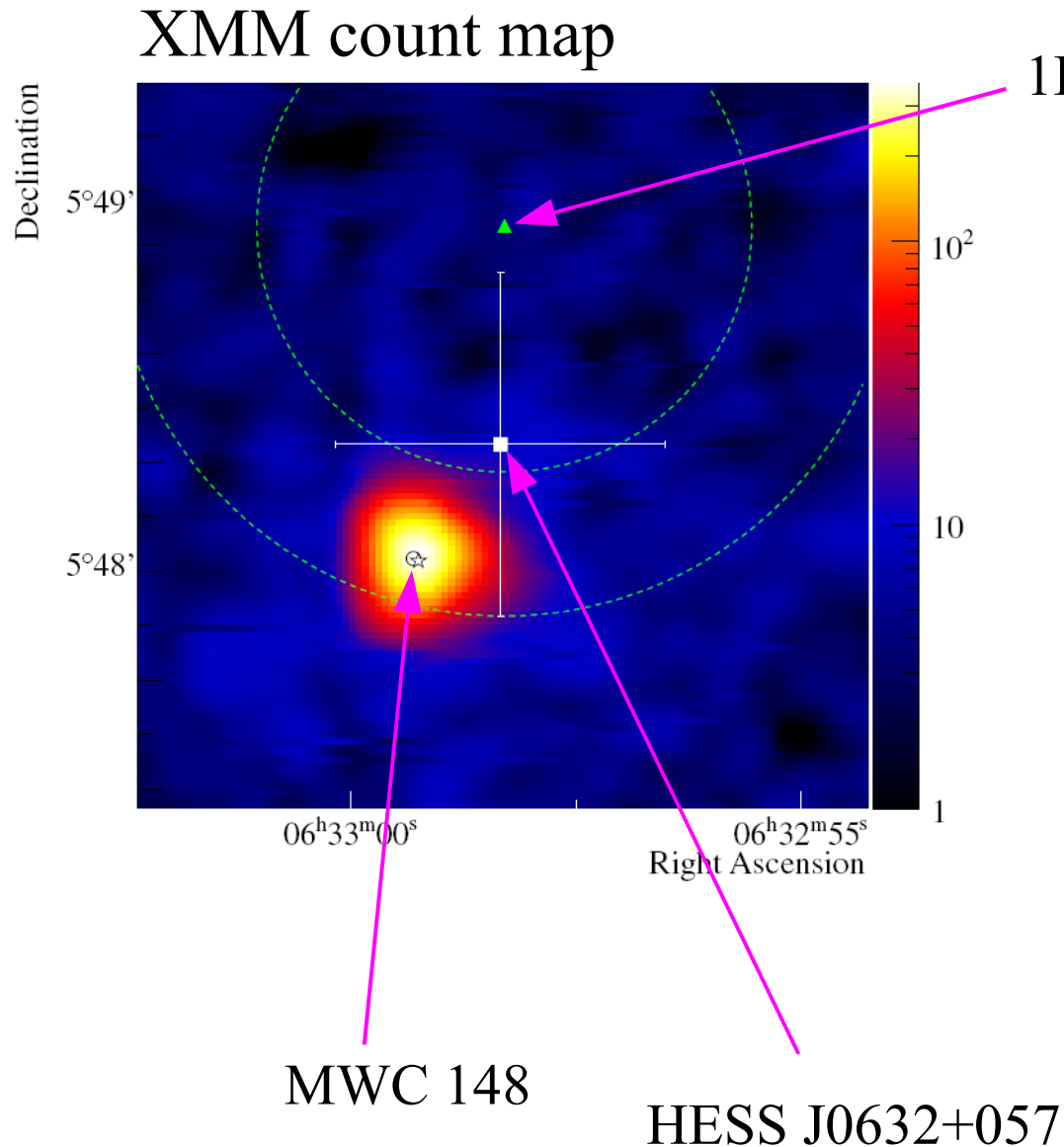
Combined HESS/VERITAS Lightcurve



Variability at 4 sigma level (VERITAS)

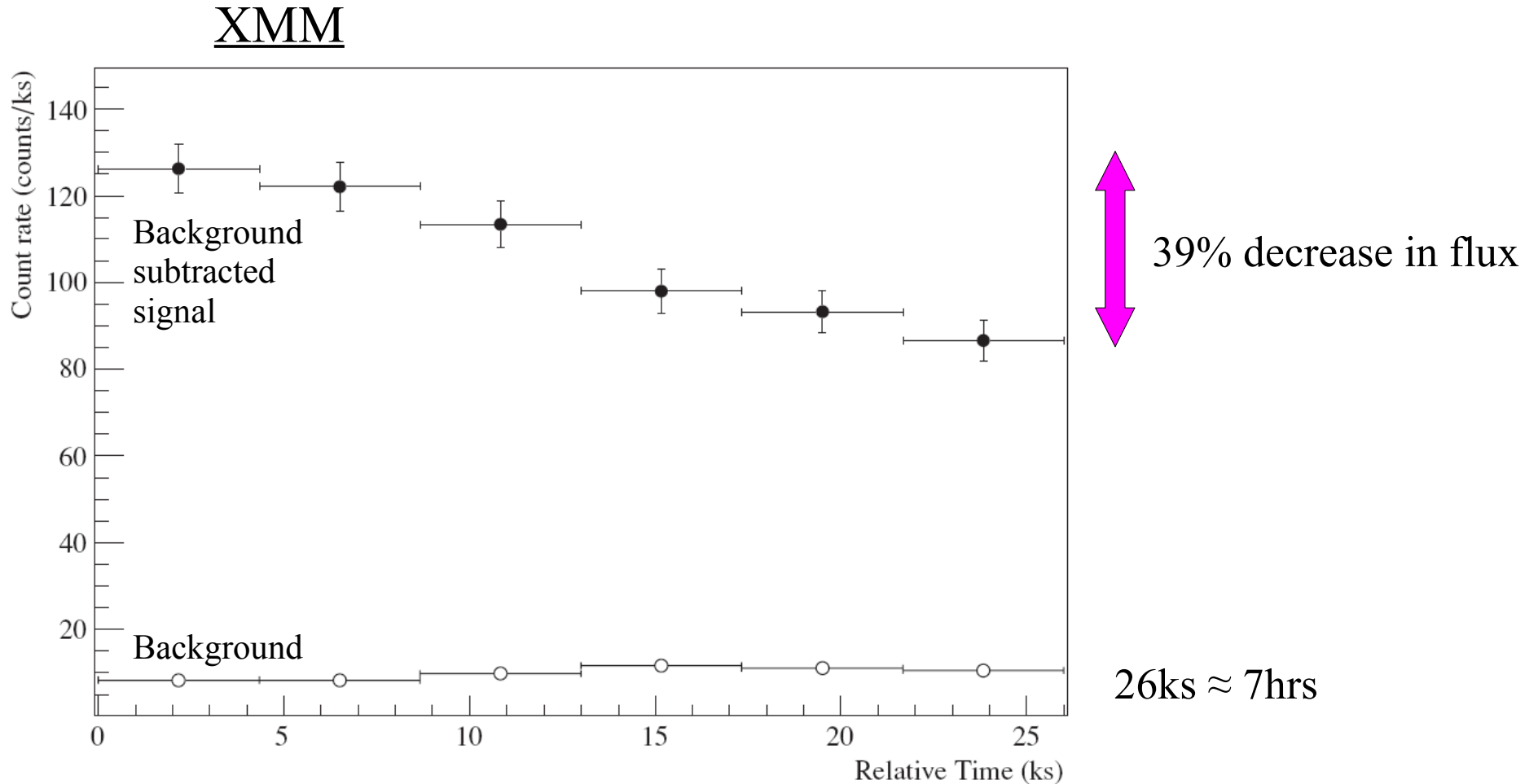
- HESS Collaboration 2007, A&A, 469, L1
- VERITAS Collaboration, 2009, ApJ, 698L, 94
- HESS and VERITAS Collaborations, 2010, in prep

X-ray Observations



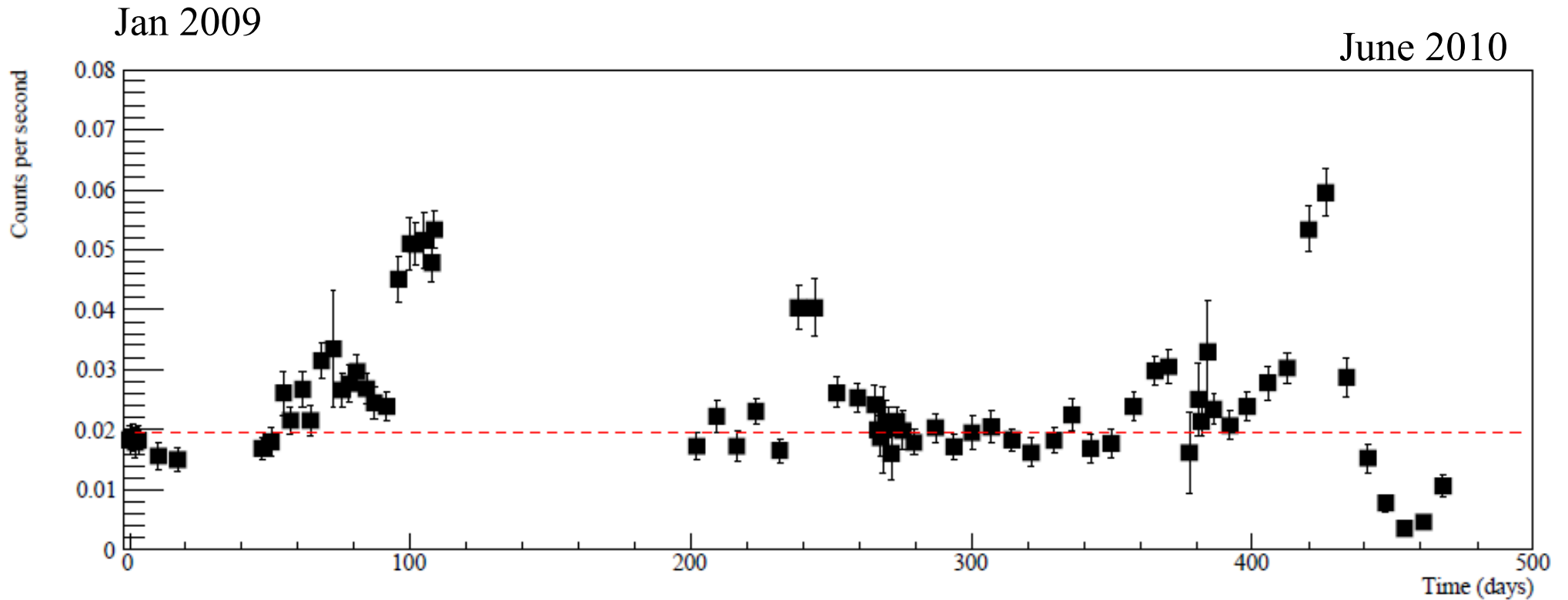
- 26 ks data with XMM-Newton in September 2007
 - [Hinton 2009](#)
- ~150 ks with Suzaku April 2008 and April 2009
 - [Skilton 2011 \(in prep\)](#)
- >250 ks with Swift Jan 2009 – June 2010
 - [Falcone 2010](#), [Skilton 2011 \(in prep\)](#), [Falcone 2011 \(in prep\)](#)

X-ray Lightcurve



Variability on \sim **day** timescales

X-ray Lightcurve – Swift



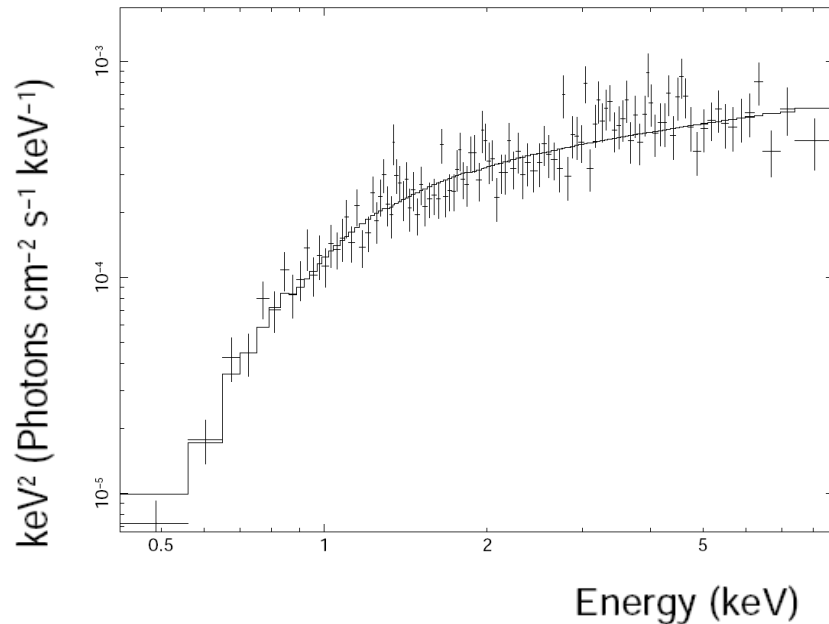
Variability on **~few day – month** timescales

No significant periodicity

X-ray Spectrum

Best fit with absorbed power law model

Instrument	Date(s)	Spectral index	$N_{\text{H}} 10^{21} \text{ cm}^{-2}$
XMM	Sept 07	1.26 ± 0.04	3.1 ± 0.3
Suzaku	April 08	1.55 ± 0.05	3.1 ± 0.4
Suzaku	April 09	1.38 ± 0.03	2.6 ± 0.3
Swift	Jan 09 – June 10	1.66 ± 0.05	3.6 ± 0.3



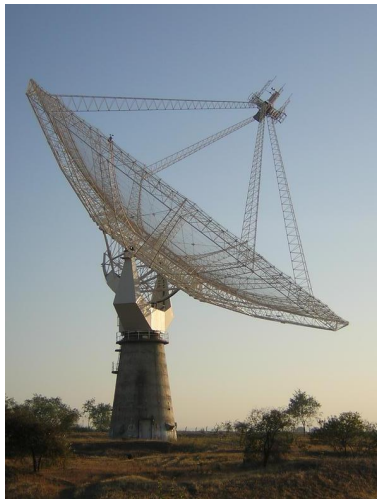
Evidence for variation
in spectral index

Radio Observations



VLA

- ~50 hours with VLA
 - Mostly 5 GHz
 - Also some 1.4 and 8 GHz
 - June 2008 – August 2009
-

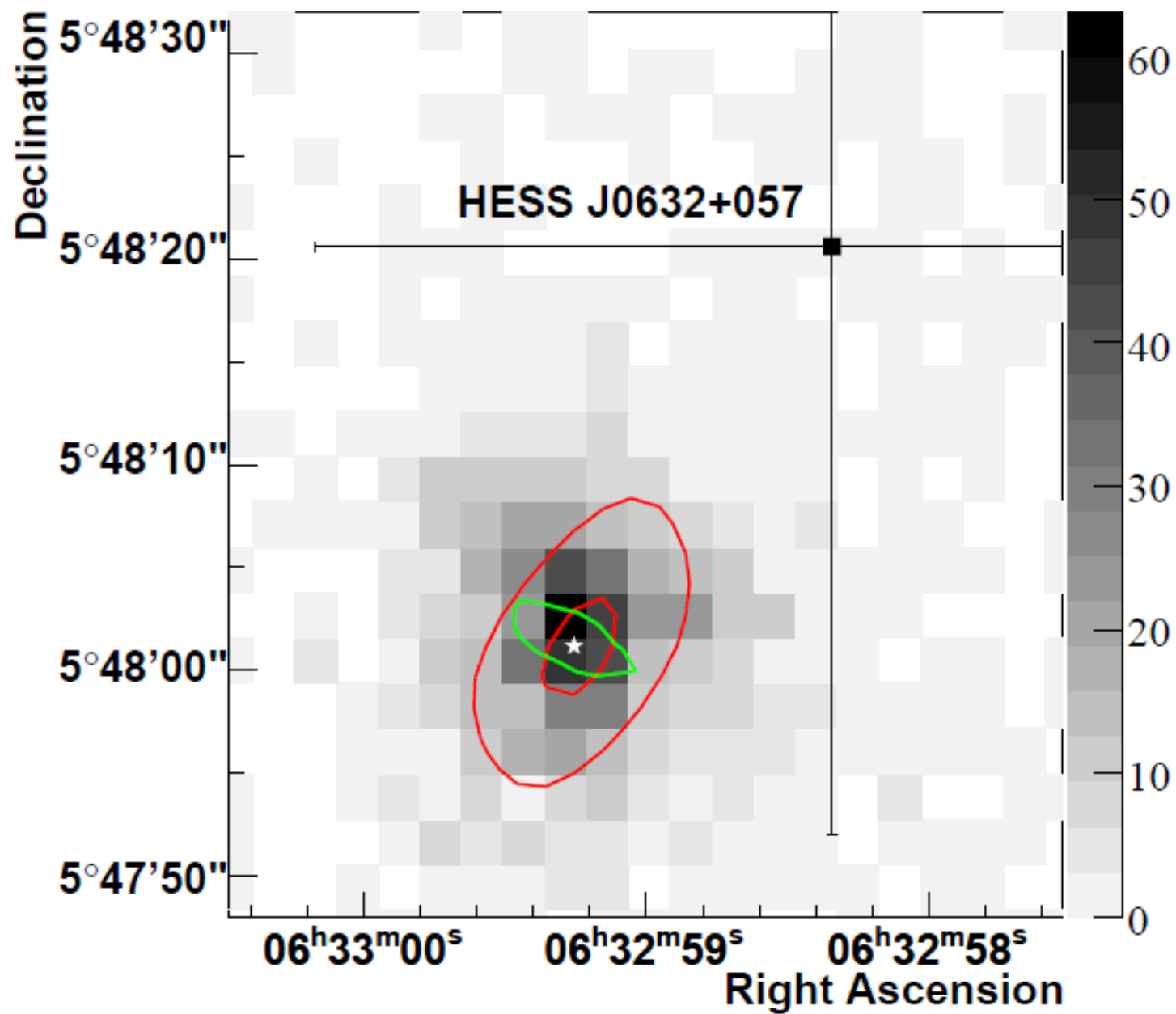


GMRT

- ~50 hours with GMRT
- Mostly 1.28 GHz
- June 2008 – May 2009

Skilton 2009, Skilton 2011 (in prep)

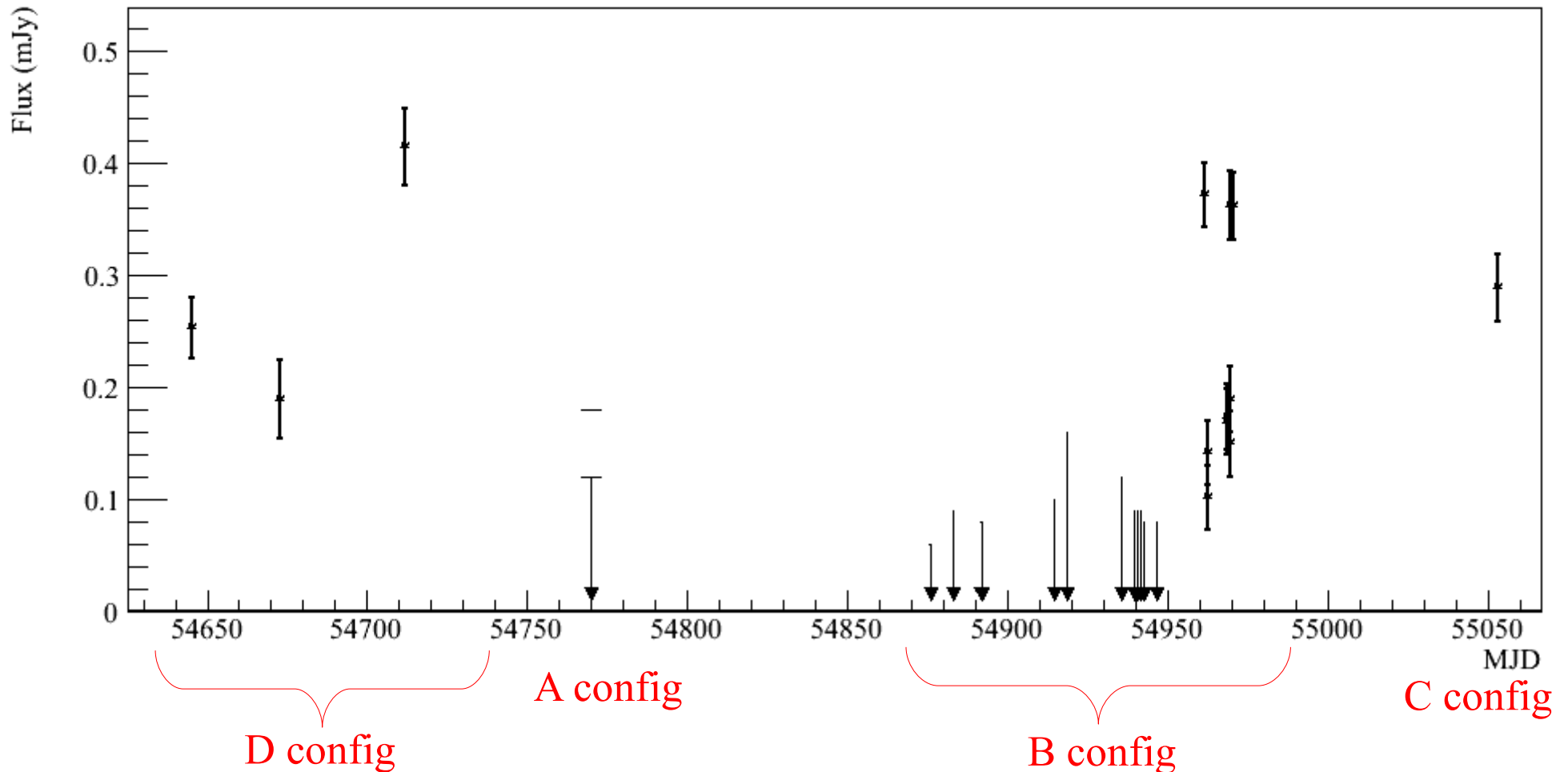
Radio position



VLA 5 GHz Lightcurve

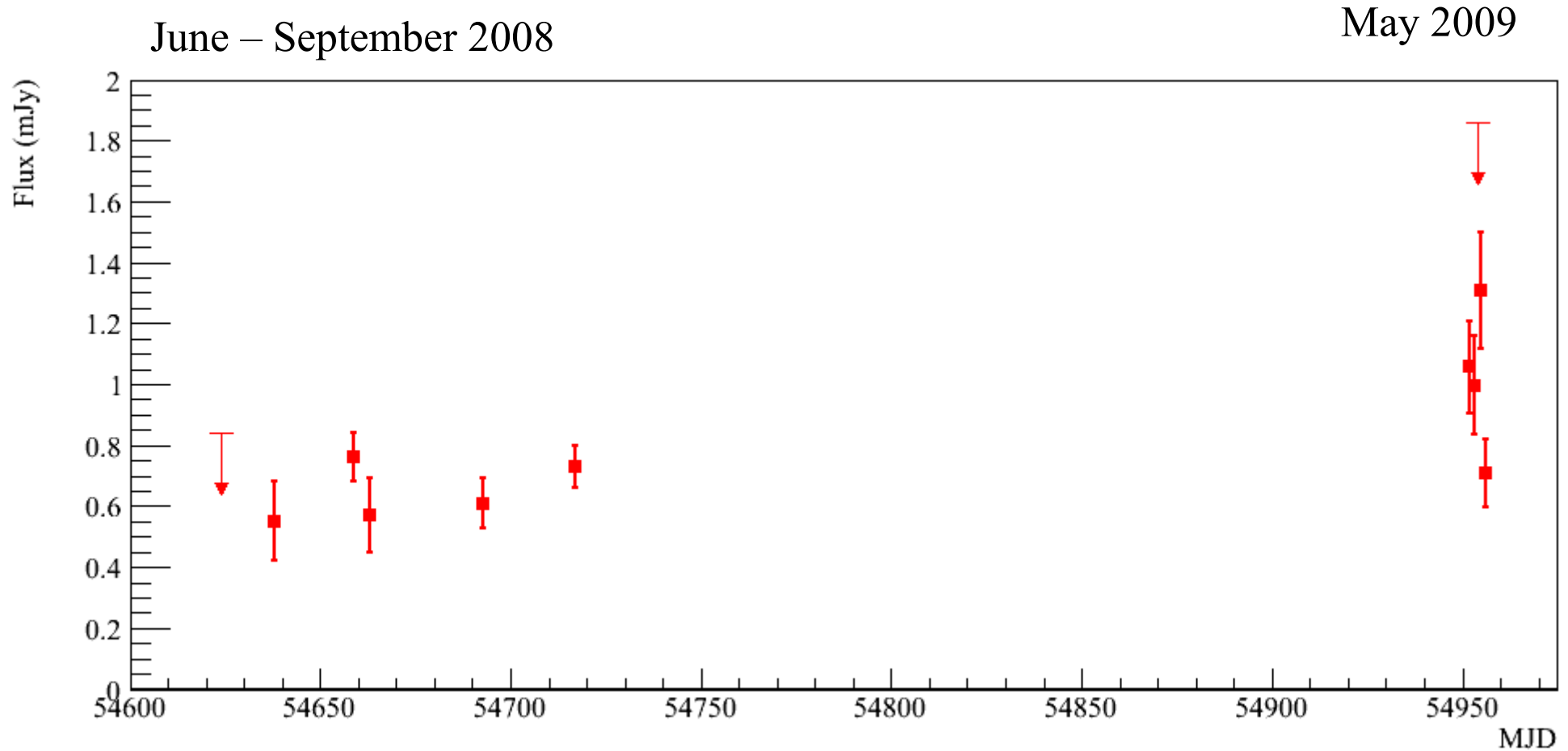
June 2008

August 2009



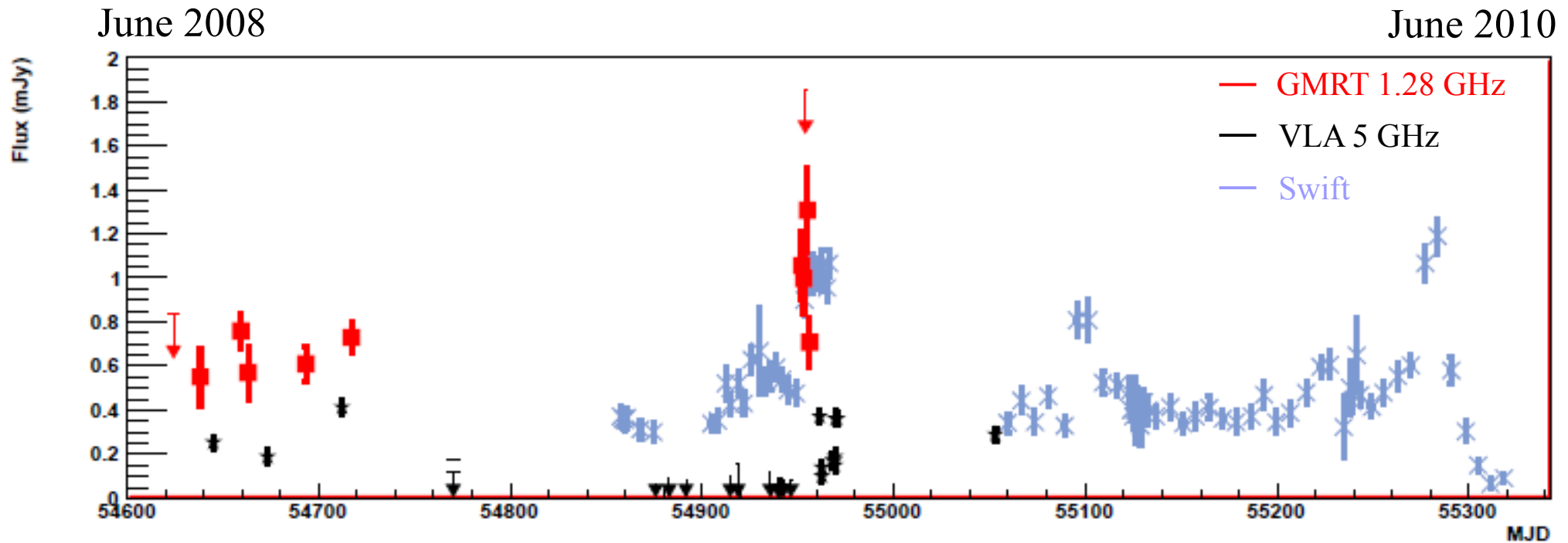
Long term variability (~month timescales)

GMRT 1.28 GHz Lightcurve



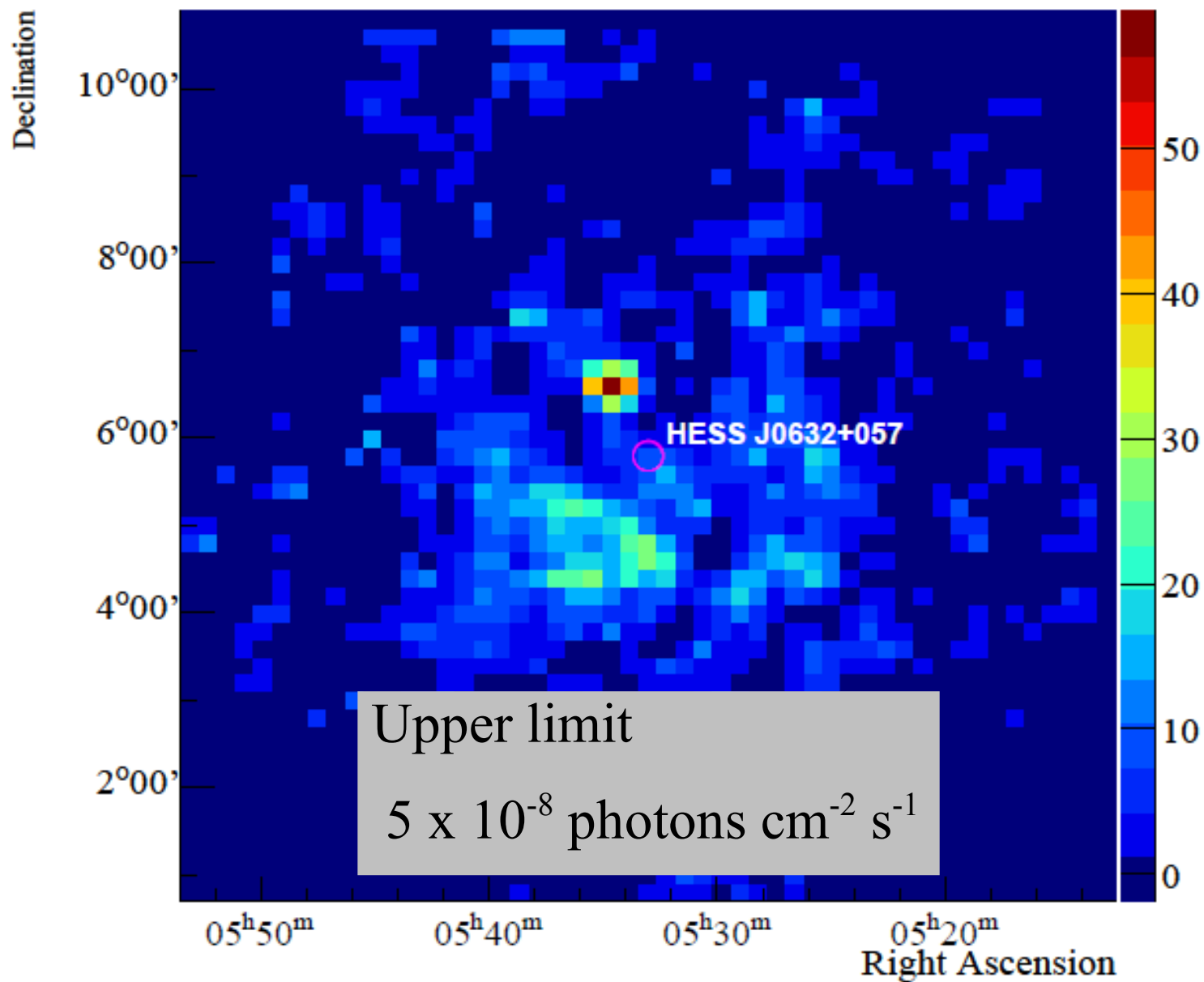
Long term variability (\sim month timescales)

Radio and X-ray Lightcurve

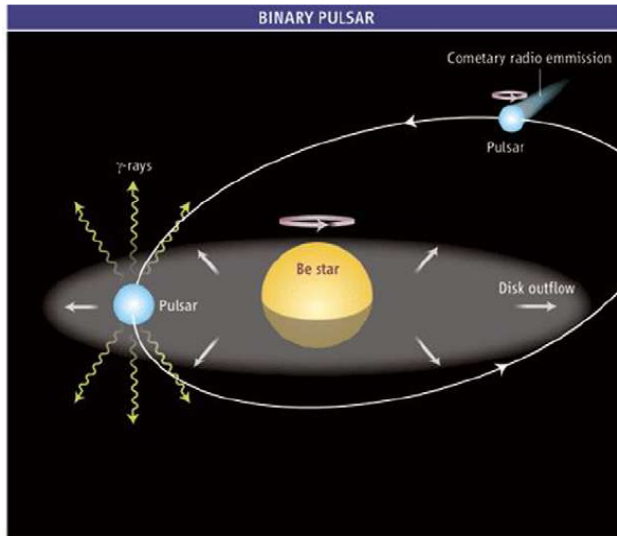


- Simultaneous high radio/X-ray state?

Fermi LAT observations



GBT observations



- Search for radio pulsations with GBT – (D. Torres and co.)
- No periodic signals or individual dispersed bursts
- If the system does contain a pulsar, it must be either
 - Very dim
 - Very distant
 - Significantly obscured by the wind from its companion star.

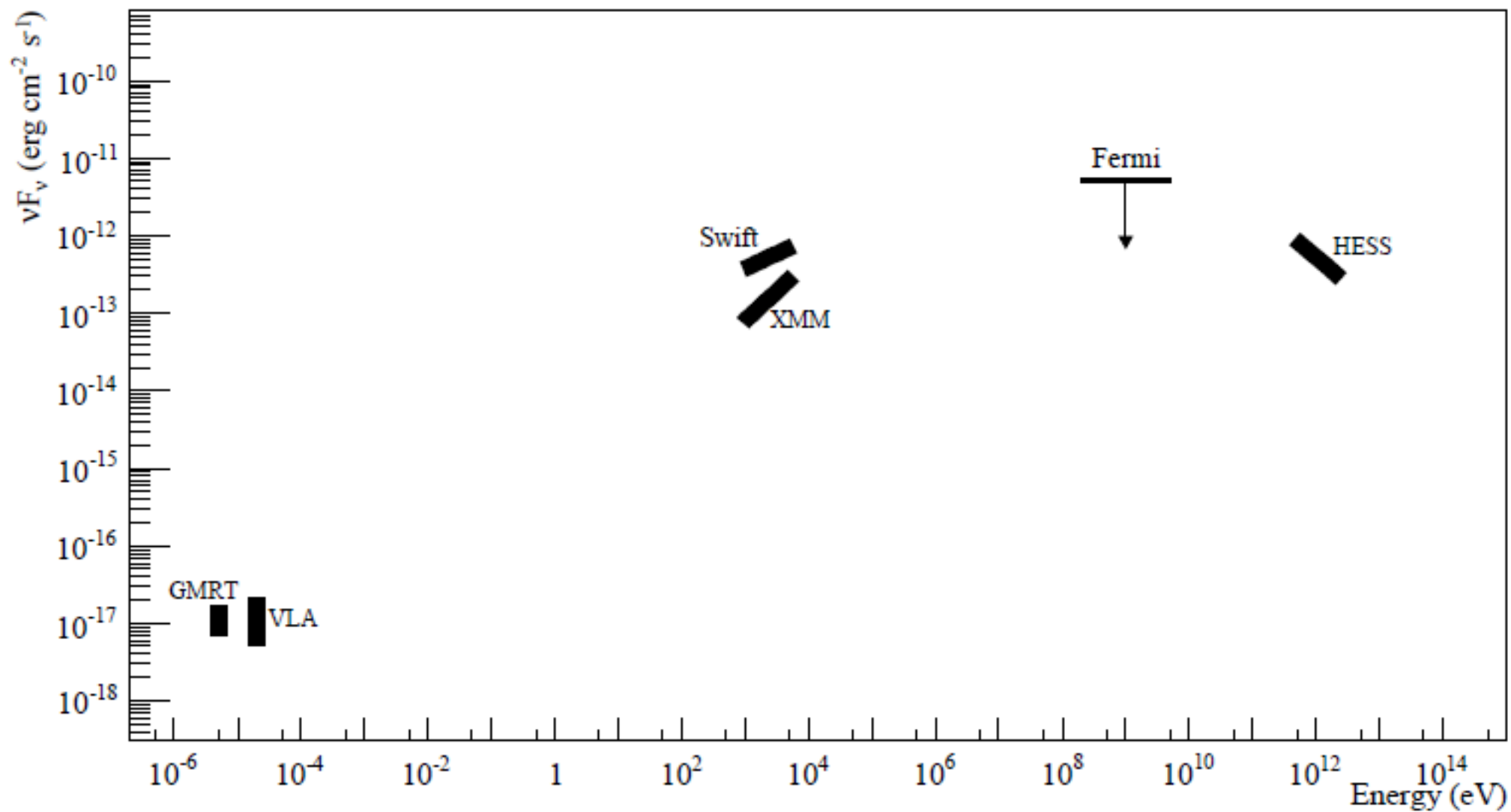


Optical Emission

- Dedicated observations of MWC 148 *Aragona 2010*
- Confirm B0e spectral type
- Provide new estimates of
 - Stellar temp 30,000 K
 - Mass 16 M_{sol}
 - Radius 6.6 R_{sol}
- Very broad lines
- No obvious radial velocity variations at a level of 10 km s^{-1}
- No evidence for periodicity.
- Favours long period binary (>100 days)



Spectral Energy Distribution



Comparison to known binaries

Name	D (kpc)	L_r	L_X	L^a_{GeV}	L_{TeV}	α_r	α_X	α_γ
LS 5039	2.5	1.3	5–50	70	4–11	0.46^b	$0.45\text{--}0.6^c$	$0.9\text{--}1.5^d$
LSI+61 303	2.0	1–17	3–9	60	8	$-0.6\text{--}0.45^e$	0.53^f	1.6 ± 0.2^g
PSR B1259–63	1.5	0.02–0.3	0.3–6	\dots^h	2.3	$-2.2\text{--}0.3^i$	0.78^j	1.7 ± 0.2^k
Cygnus X-1	2.2	0.3	10^4	\dots^h	12	0.1^l	0.8^m	2.2 ± 0.6
HESS J0632+057	1.5	0.003	0.13^n	<9	0.9^o	0.6	0.26-0.61	1.5 ± 0.3^o

- Luminosities in units of 10^{33} erg/s
(radio 10^{31} erg/s)
- L_r : 0.1 – 100 GHz
- L_X : 1 – 10 keV
- L_{GeV} : 1 – 10 GeV
- L_{TeV} : 0.2 – 10 TeV

- $dN/dE \propto E^{-(1+\alpha)}$
- $F(\nu) \propto \nu^{-\alpha}$

Overview

- 3 years ago
 - Unidentified HESS source
- Now
 - Over 100 hours dedicated radio observations
 - Over 400 ks dedicated X-ray observations
 - >60 hours observations with HESS/VERITAS
 - Dedicated search for radio pulsations
 - Dedicated observations with optical telescopes
 - ~2 years Fermi observations

Overview

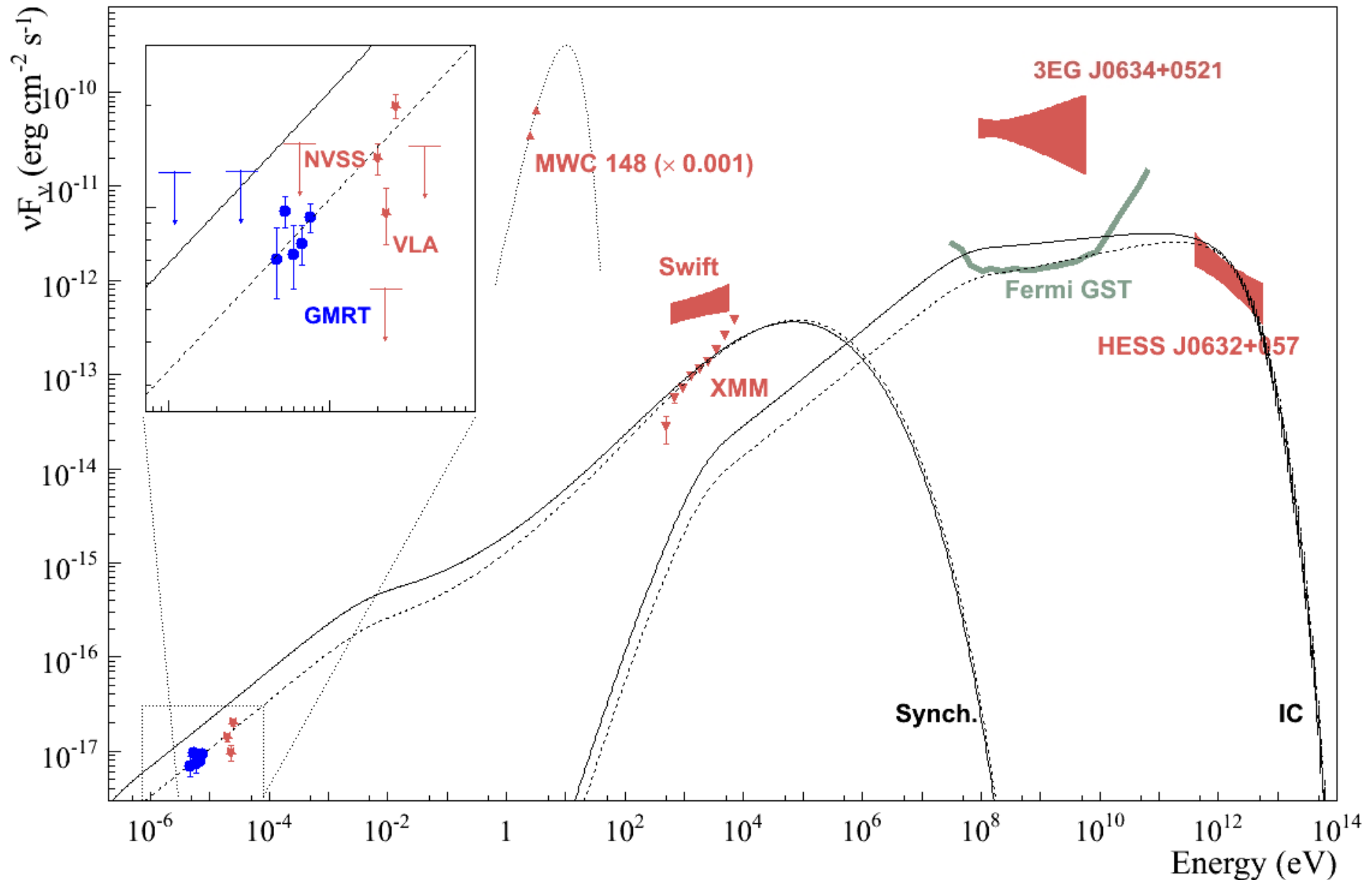
- 3 years ago
 - Unidentified HESS source
- Now
 - X-ray and radio counterparts discovered
 - Variability seen in TeV gamma-ray, X-ray and radio
 - Hints for periodicity

Overview

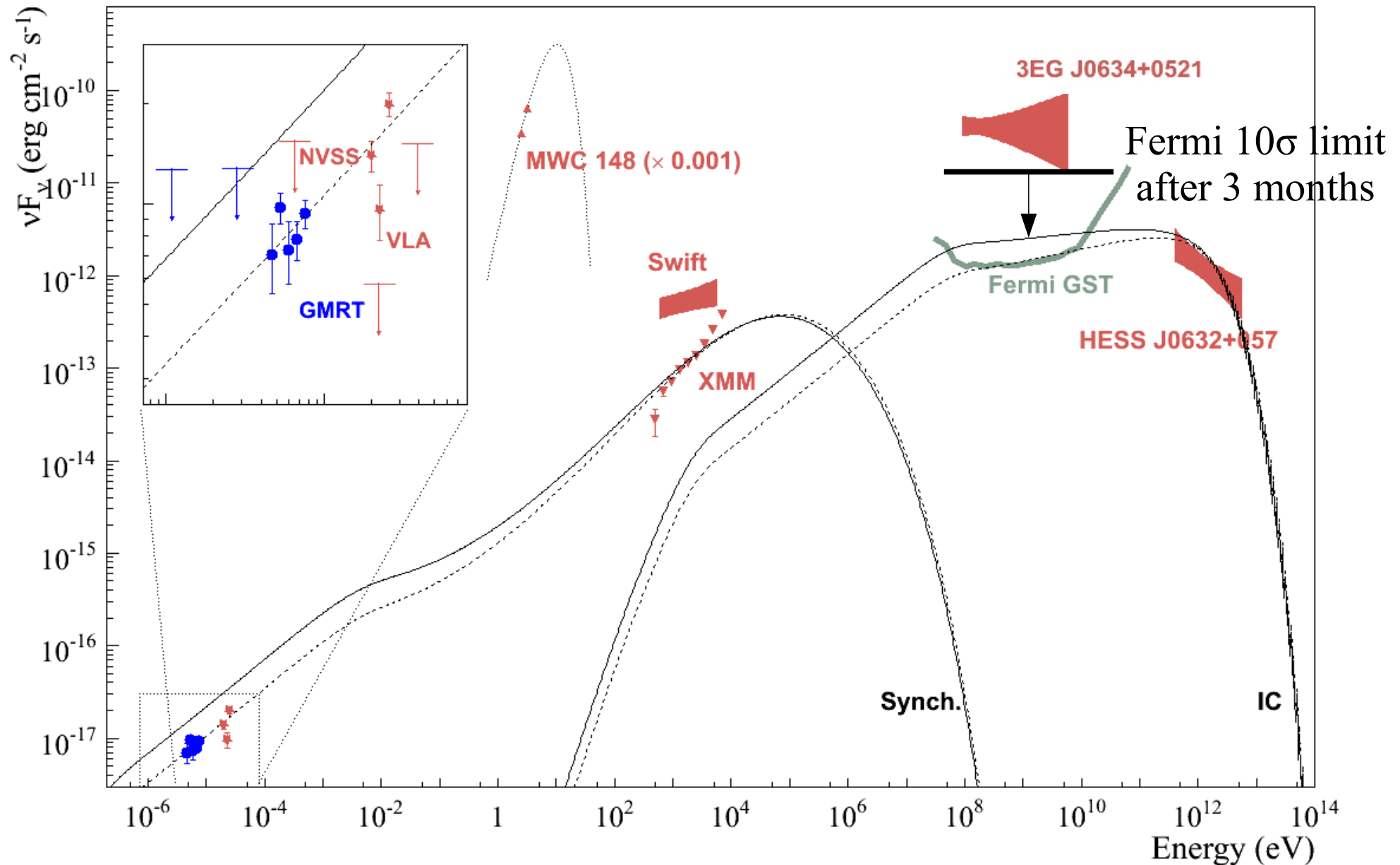
- 3 years ago
 - Unidentified HESS source
- Now
 - Strong candidate for gamma-ray binary
- The future
 - More observations needed to confirm binary nature
 - Watch this space!

Backup

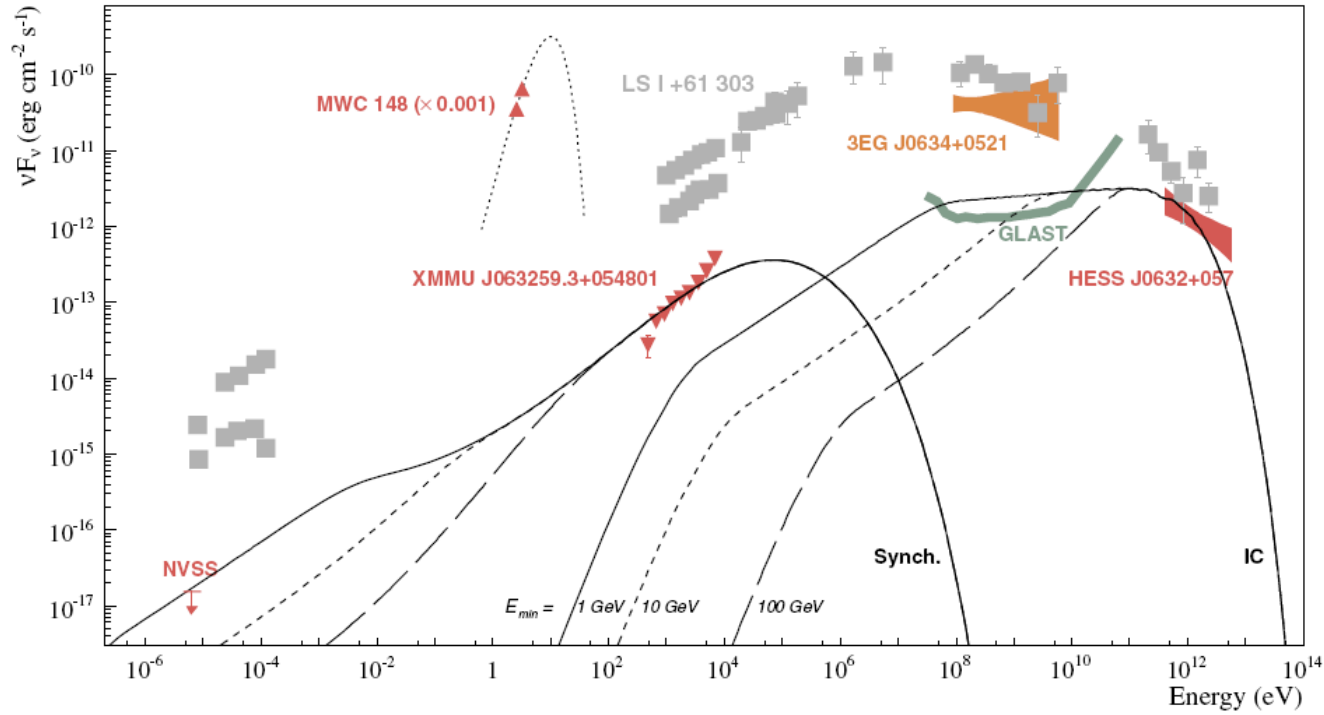
Spectral Energy Distribution



Spectral Energy Distribution

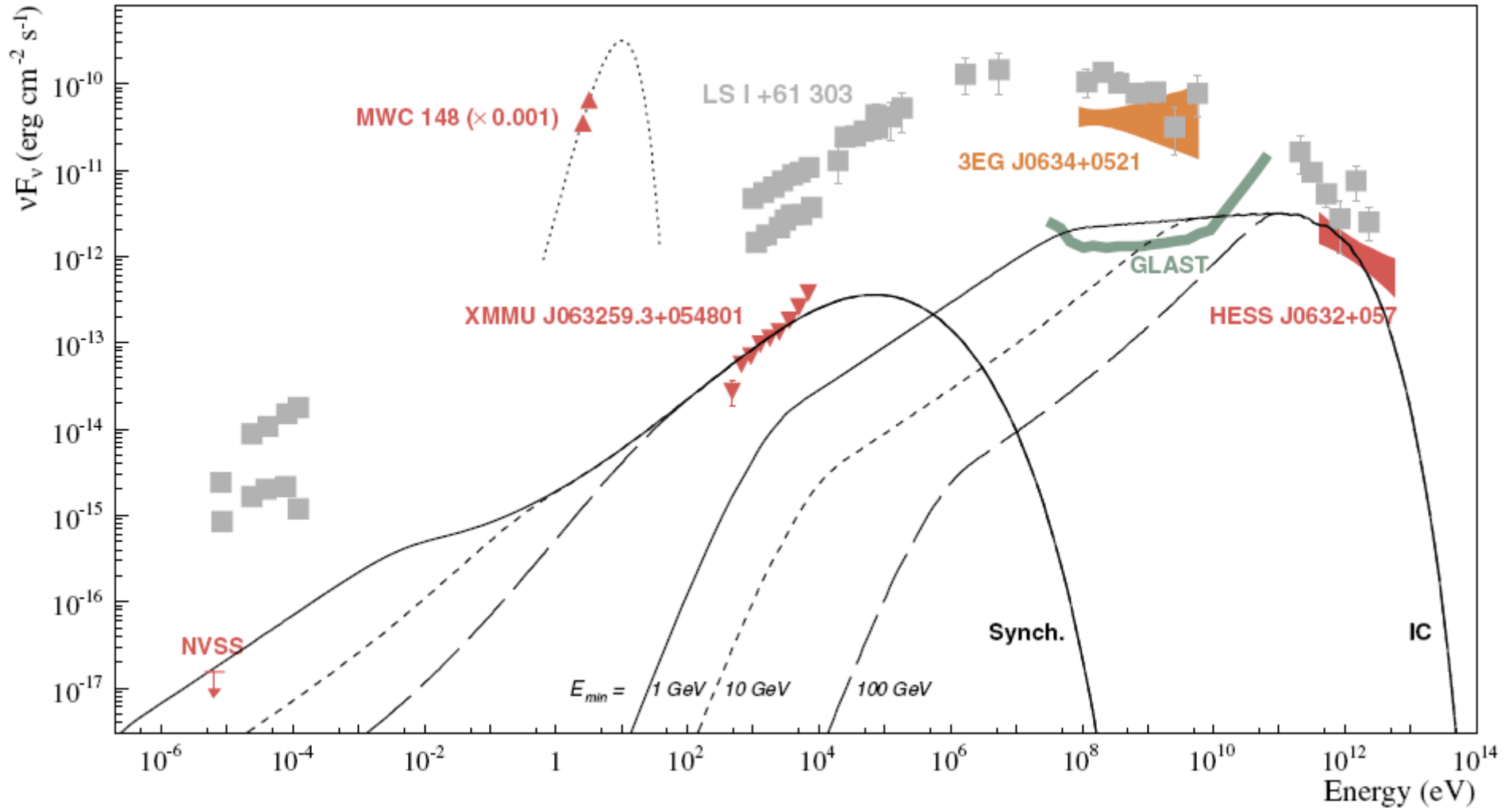


The Model



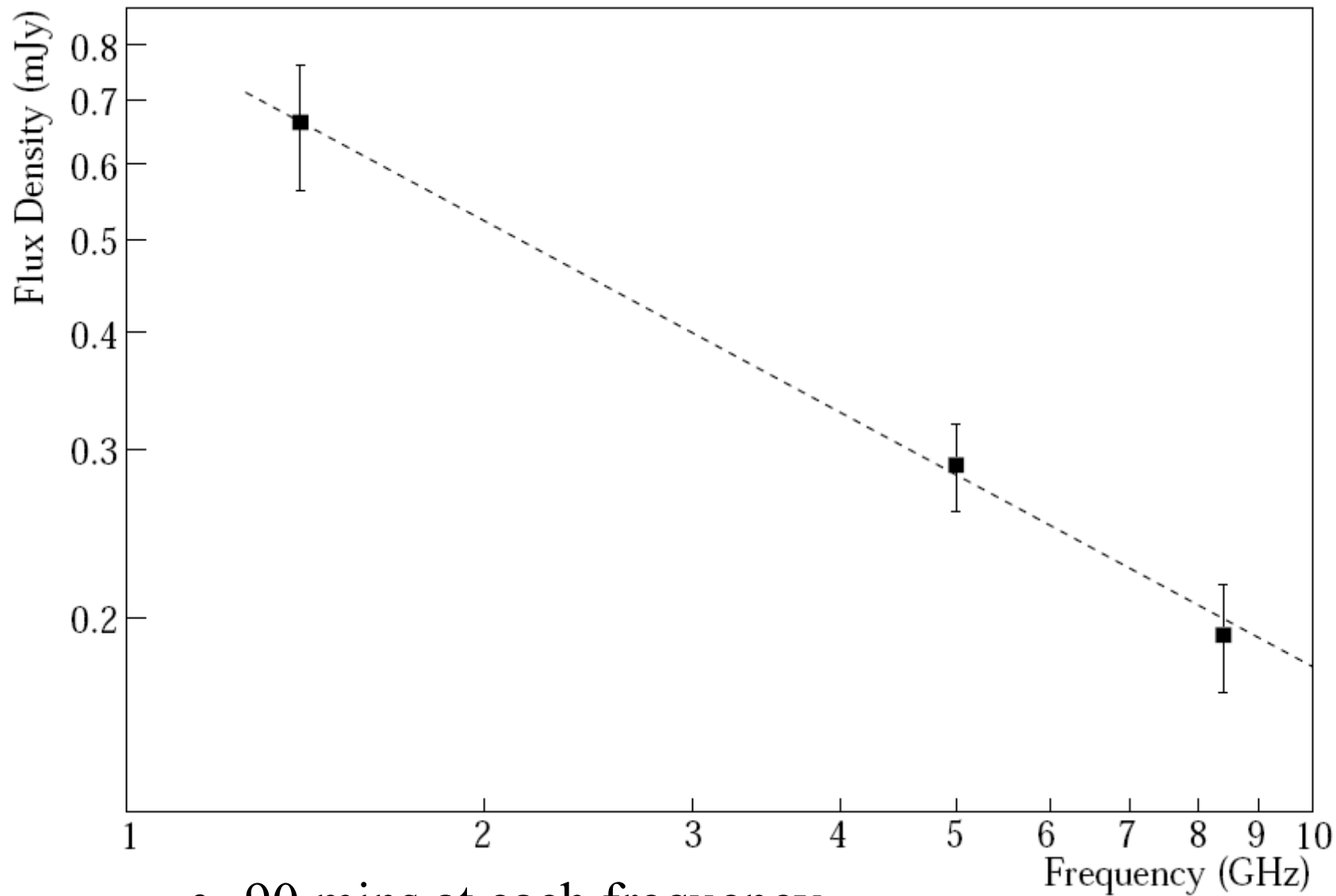
- Distance $\sim 1.5 \text{ kpc}$
- One-zone model
- $dN/dE \sim E^{-\alpha} \exp(-E/E_{\max})$
 - $\alpha = 2$
 - $E_{\max} = 10 \text{ TeV}$
- $U_{\text{rad}} = 1 \text{ erg cm}^{-3}$
- Emission region $\sim \text{few AU}$ from star
- $B = 70 \text{ mG}$
- Power required = $10^{34} \text{ erg s}^{-1}$

Spectral Energy Distribution



Hinton et al. 2009

Radio spectrum



- 90 mins at each frequency
- Index 0.7 ± 0.2