



Fermi

Gamma-ray Space Telescope



Exploring the nature of a possible Galactic neutrino source MGRO J1908+06

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On behalf of the Fermi/LAT collaboration

In collaboration with E. de Oña Wilhelmi,
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Outline

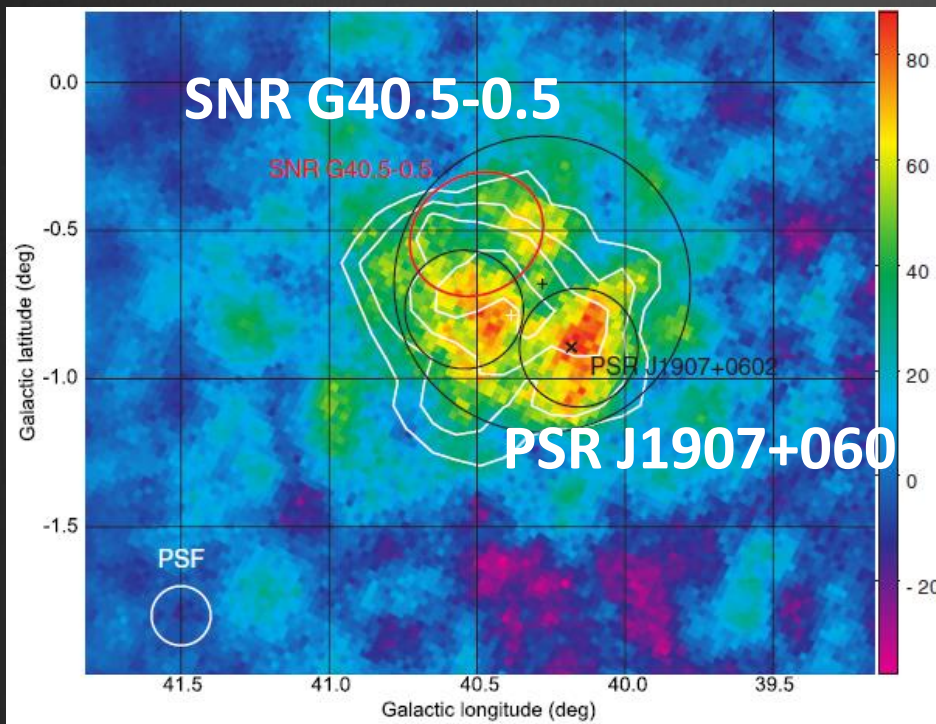
- 1. Introduction
- 2. Fermi/LAT observations on MGRO J1908+06
- 3. Multi-wavelength counterparts for MGRO J1908+06
- 4. Summary

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Introduction

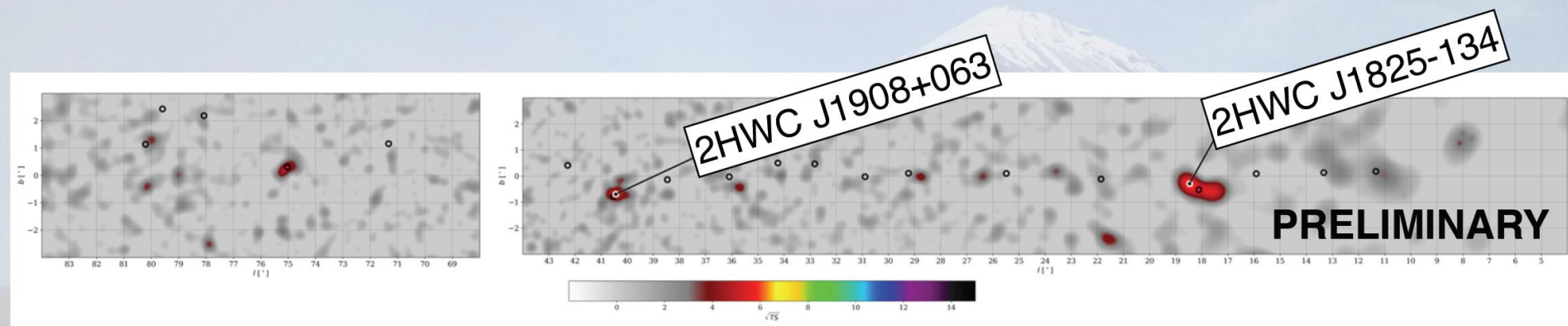
- MGRO J1908+06 one of the brightest TeV sources in the sky.
- It was discovered by Milagro (Abdo et al. 2007) and subsequently detected in TeV range by all the main instruments (H.E.S.S., Aharonian et al. 2009; VERITAS, Ward 2008; ARGO-YBJ, Bartoli et al. 2012; HAWC, Abeysekara et al. 2017).



MGRO J1908+06 is an unidentified source but proposed to be a PWN powered by PSR J1907+0602 (Abdo et al. 2010; Acero et al. 2013)

MGRO J1908+06 is detected by HAWC above 100 TeV
(PeVatron candidate?)

The Galactic plane above 100 TeV in reconstructed energy



Kelly Malone's talk on TeVPA 2018

MGRO J1908+06 was recently proposed to be a possible neutrino emitting source

Type	Source	α 1°	δ 1°	p -value	n_S	γ
radio quasar	PKS 1622-297	246.53	-29.86	0.11	3.8	2.3
	QSO 1730-130	263.26	-13.08	...	0.0	...
	PKS 1406-076	212.24	-7.87	0.053 ^c	7.3	2.6
	QSO 2022-077	306.42	-7.64	...	0.0	...
	3C 279	194.05	-5.79	0.42	0.5	2.0
	3C 273	187.28	2.05	0.25	7.7	3.2
	PKS 1502+106	226.10	10.49	0.38	3.1	2.7
	PKS 0528+134	82.73	13.53	0.44	2.7	4.0
	3C 454.3	343.49	16.15	0.12	4.1	2.0
	4C 38.41	248.81	38.13	0.12	6.3	2.4
Galactic center	Sgr A*	266.42	-29.01	...	0.0	...
Not identified	MGRO J1908+06	286.98	6.27	0.025	4.5	2.0
Pulsar wind	Geminga	98.48	17.77	...	0.0	...
nebula	Crab Nebula	83.63	22.01	0.34	6.1	3.8
	MGRO J2019+37	305.22	36.83	0.23	7.8	4.0
Star formation region	Cyg OB2	308.30	41.32	0.26	5.9	4.0
Supernova remnant	IC443	94.21	22.50	0.22	8.1	4.0

All-sky Search for Time-integrated Neutrino Emission from Astrophysical Sources with 7 yr of IceCube Data (Aartsen et al. 2017)

Interesting Sources



Table 1: Results of the pre-defined source list.

Source	Type	α [deg]	δ [deg]	p-Value	TS	n_s	Φ_0 [TeV cm ⁻² s ⁻¹]
MGRO J1908+06	NI	286.99	6.27	0.0032	6.284	3.28	$1.13 \cdot 10^{-12}$
Cyg A	SRG	299.87	40.73	0.0049	6.335	4.30	$1.78 \cdot 10^{-12}$
4C 38.41	FSRQ	248.81	38.13	0.0055	5.686	6.62	$1.72 \cdot 10^{-12}$
3C454.3	FSRQ	343.50	16.15	0.0072	5.503	5.98	$1.26 \cdot 10^{-12}$
Crab Nebula	PWN	83.63	22.01	0.1188	0.709	4.32	$8.65 \cdot 10^{-13}$
Cas A	SNR	350.85	58.81	0.2069	0.033	0.88	$1.05 \cdot 10^{-12}$
1ES 1959+650	BL Lac	300.00	65.15	0.2069	0.124	1.69	$1.17 \cdot 10^{-12}$
PKS 1502+106	FSRQ	226.10	10.52	0.2322	-0.000	0.00	$5.98 \cdot 10^{-13}$
Mrk 421	BL Lac	166.11	38.21	0.2433	0.029	0.48	$8.68 \cdot 10^{-13}$

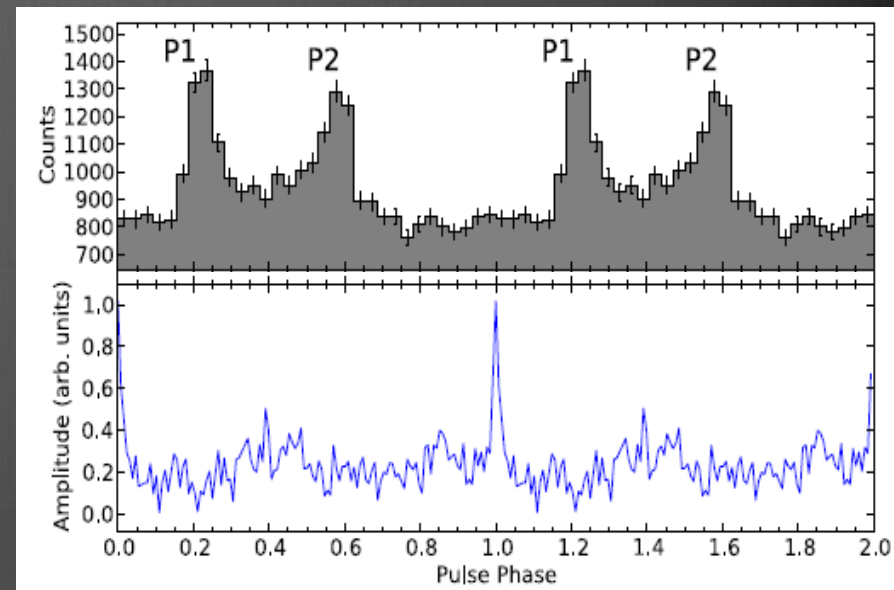
However, the number of source-like event is still consistent with the background.

Further 6-15 years of observation is needed to confirm the detection at 3 sigma level (Halzen et al. 2017)

Though shining brightly in TeV range, MGRO J1908+06 was not detected in any other wavelength.

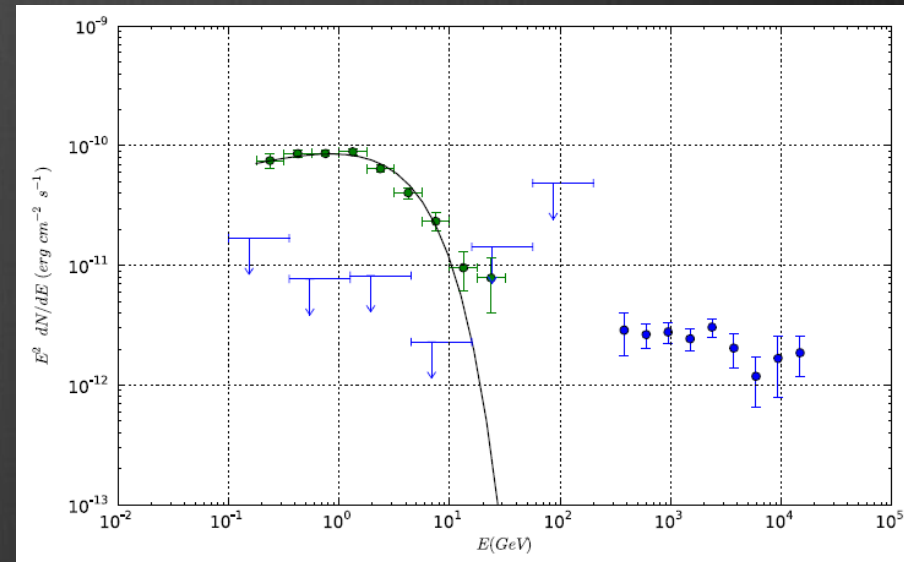
For instance, GeV...

PSR J1907+0602 is a 106.6 ms radio faint gamma-ray pulsar located within MGRO J1908+06 , possible powering it as a PWN.



Up: Gamma-ray (dark)/radio pulse profile (blue) of J1907+0602 (Abdo et al. 2010).

However, MGRO J1908+06 is not detected during the off-peak phase of PSR J1907+0602 (Abdo et al. 2010)



Phase averaged (green points) and off-peak SED of PSR J1907+0602 (blue upper limits), HESS SED for MGRO J1908+06 (blue points)

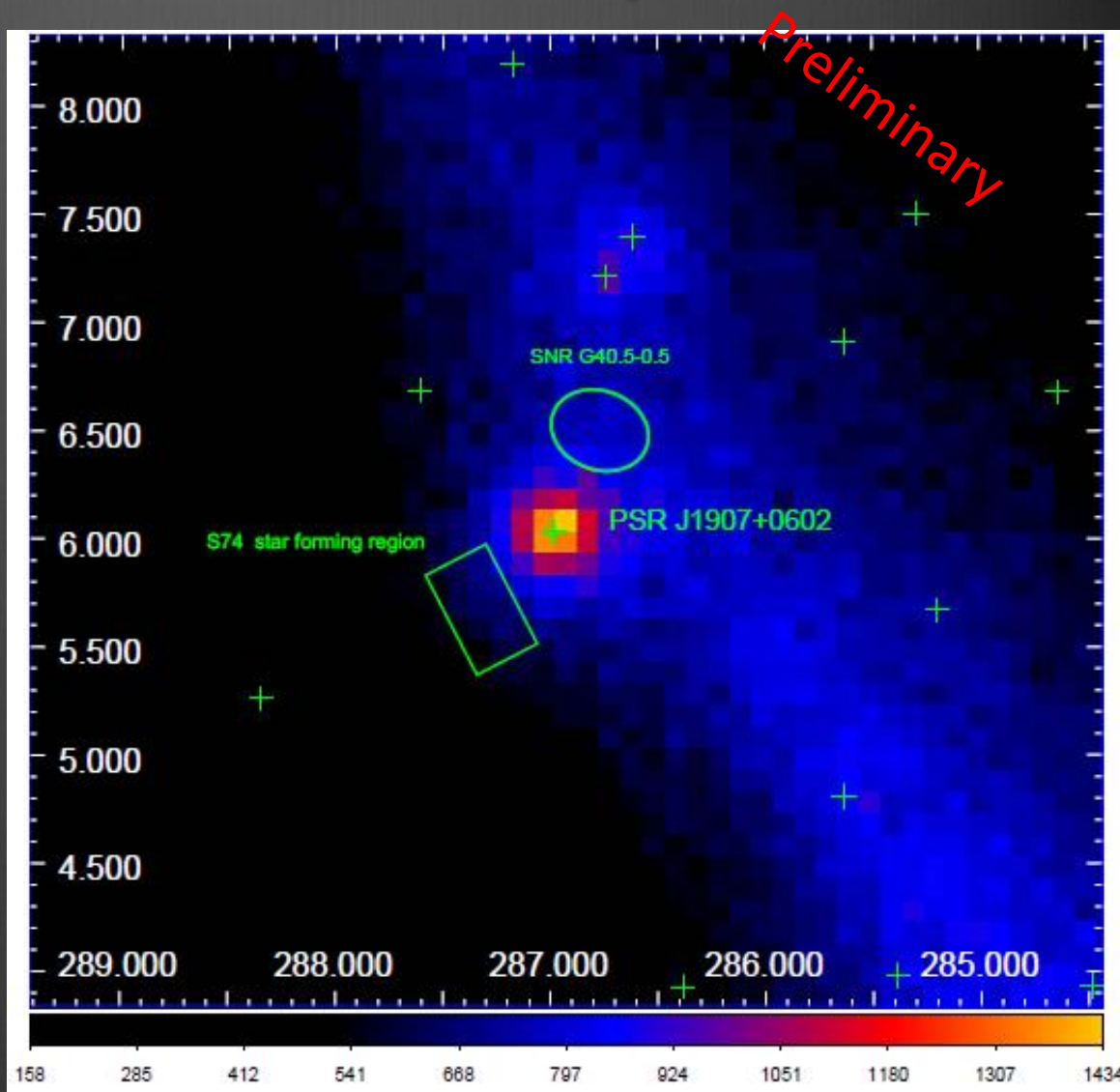
To understand the nature of MGRO J1908+06 and its feasibility as a neutrino emitting source, we searched for its GeV counterpart as well as counterparts in other wavelengths

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Fermi/LAT data analysis

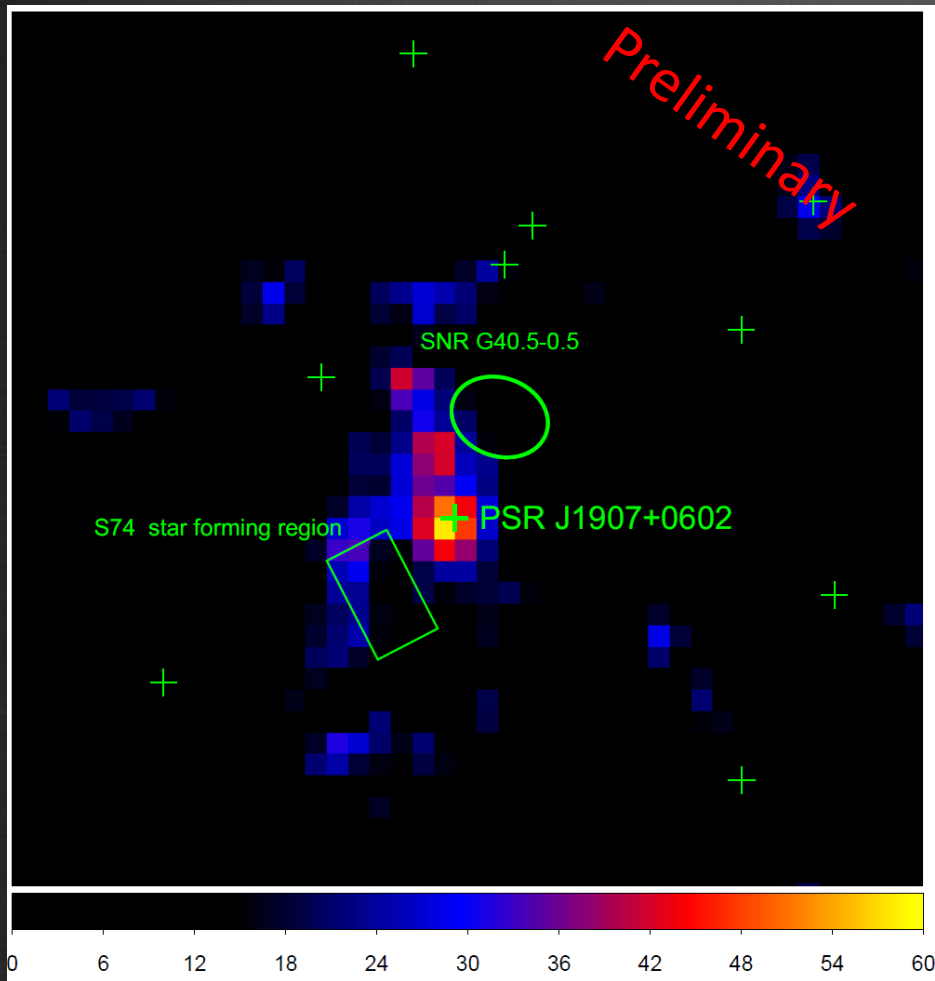
- ~10 years Pass 8 data, 2008-08-04---2018-03-17
- data radius of 15 degree,
- 100 MeV-300 GeV
- Catalog: FL8Y, free model radius: 5 degree



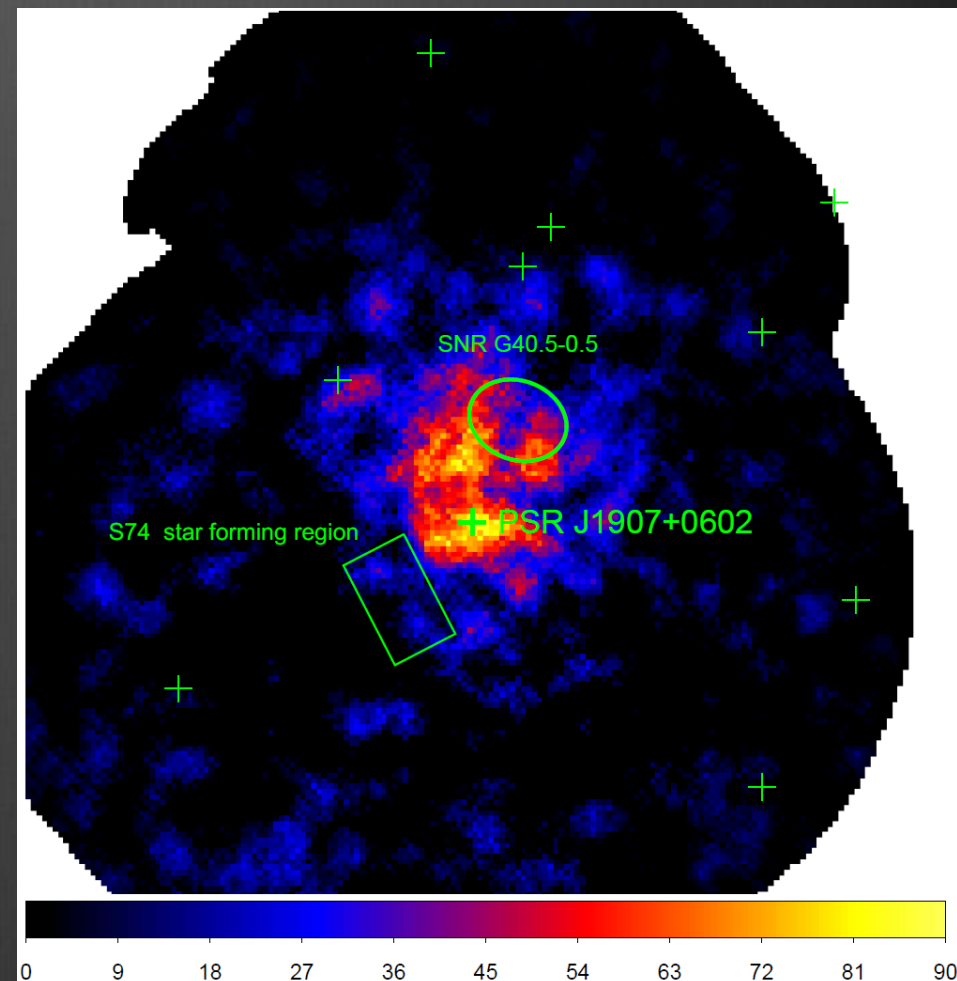
Counts map in 100 MeV-300 GeV

During the off-peak phase, diffuse gamma-ray emission is detected and analog to the TeV morphology of MGRO J1908+06.

Off-peak TS map in 0.1-300 GeV

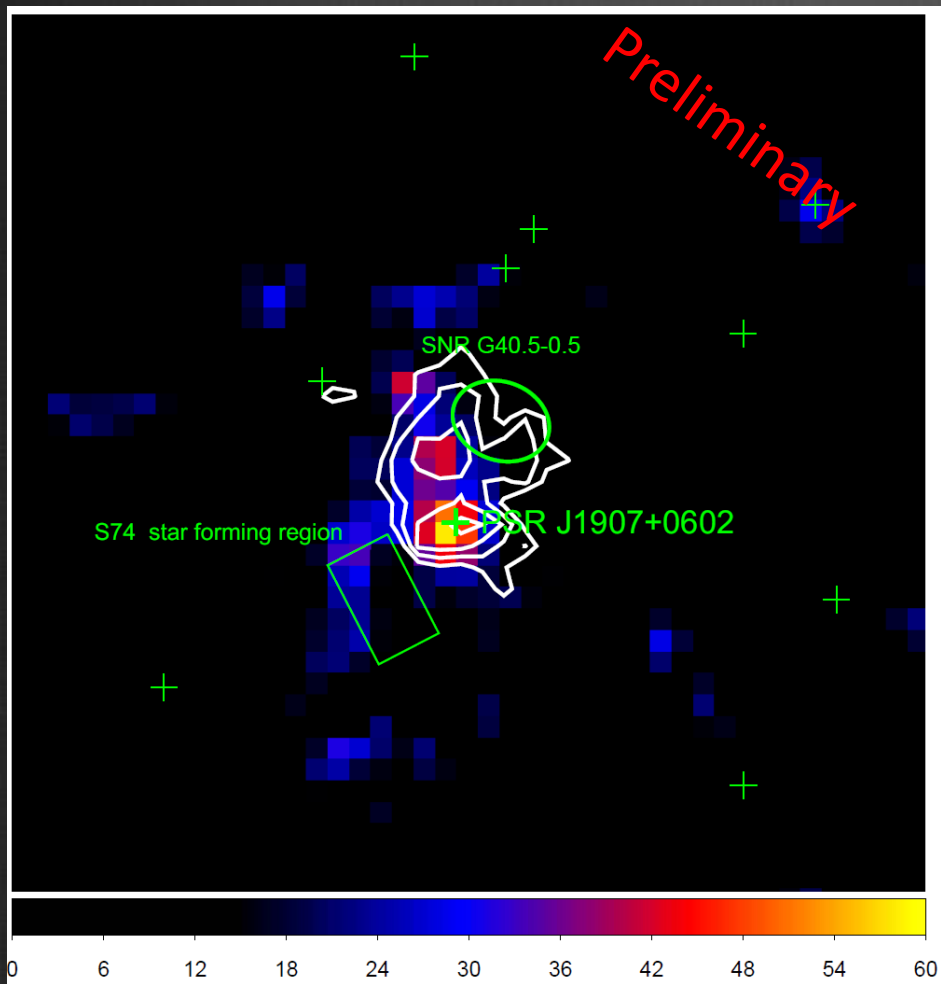


VERITAS excess map

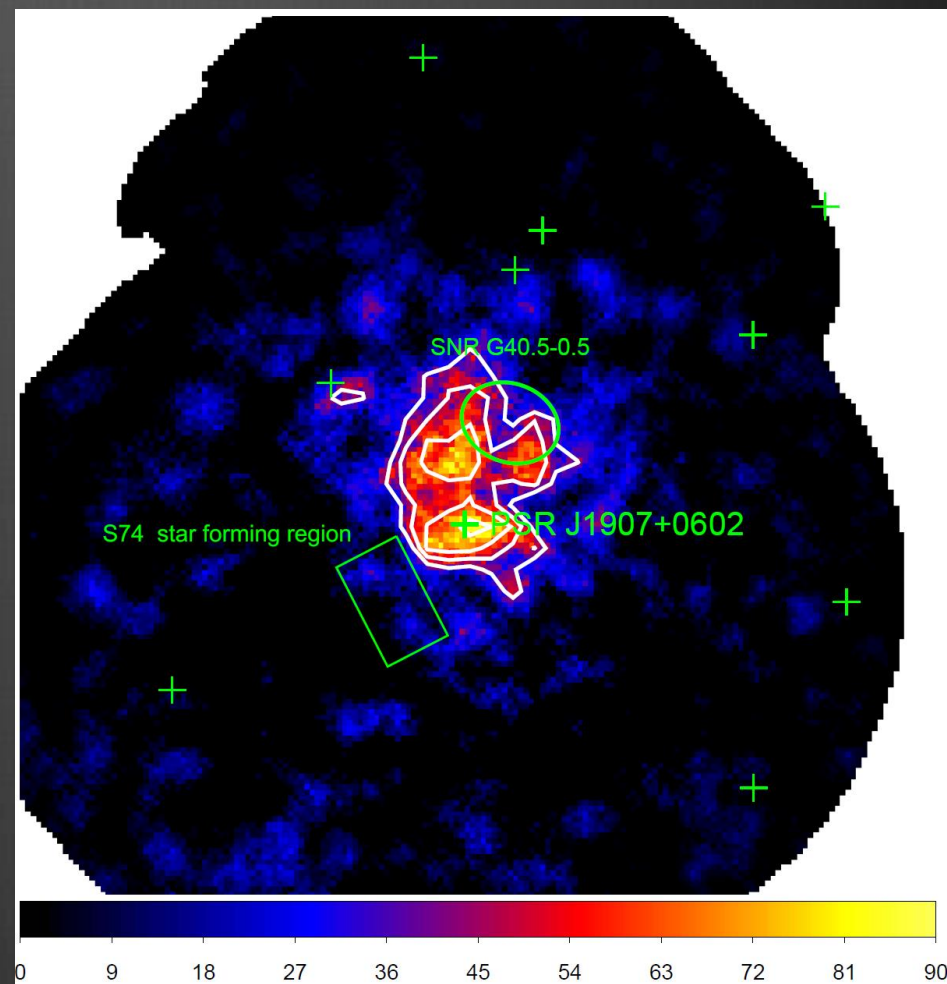


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Off-peak TS map in 0.1-300 GeV

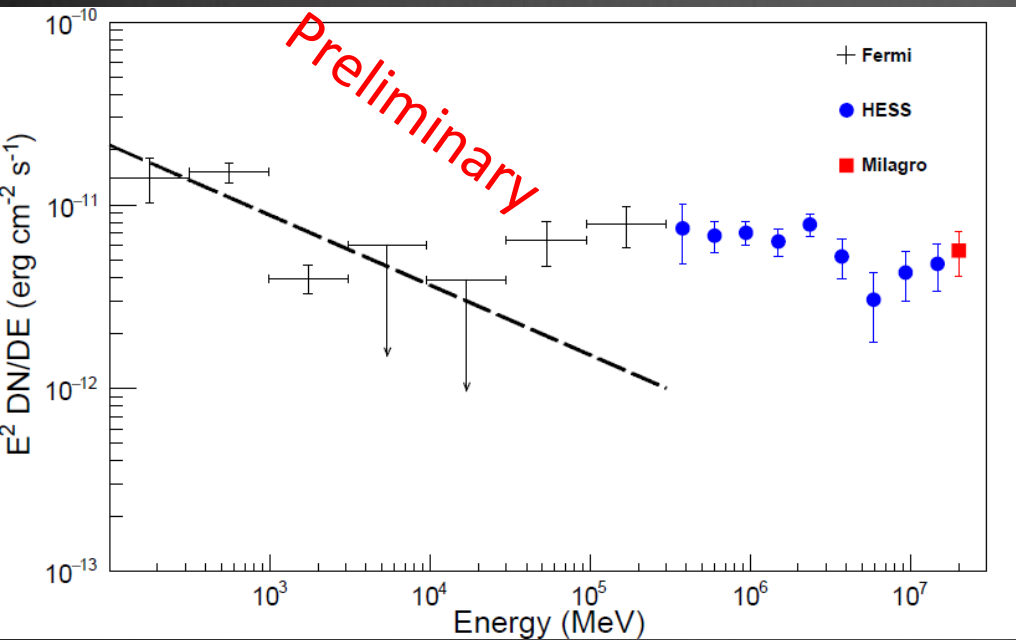


VERITAS excess map

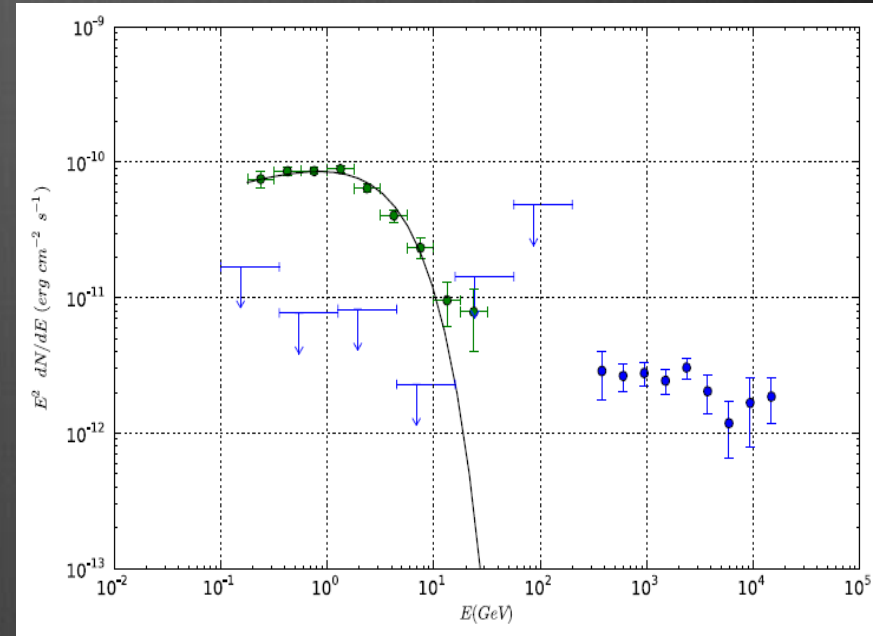


white contours are from VERITAS data.

GeV and TeV SEDs of MGRO J1908+06



SED of this study



SED from Abdo et al. (2010).

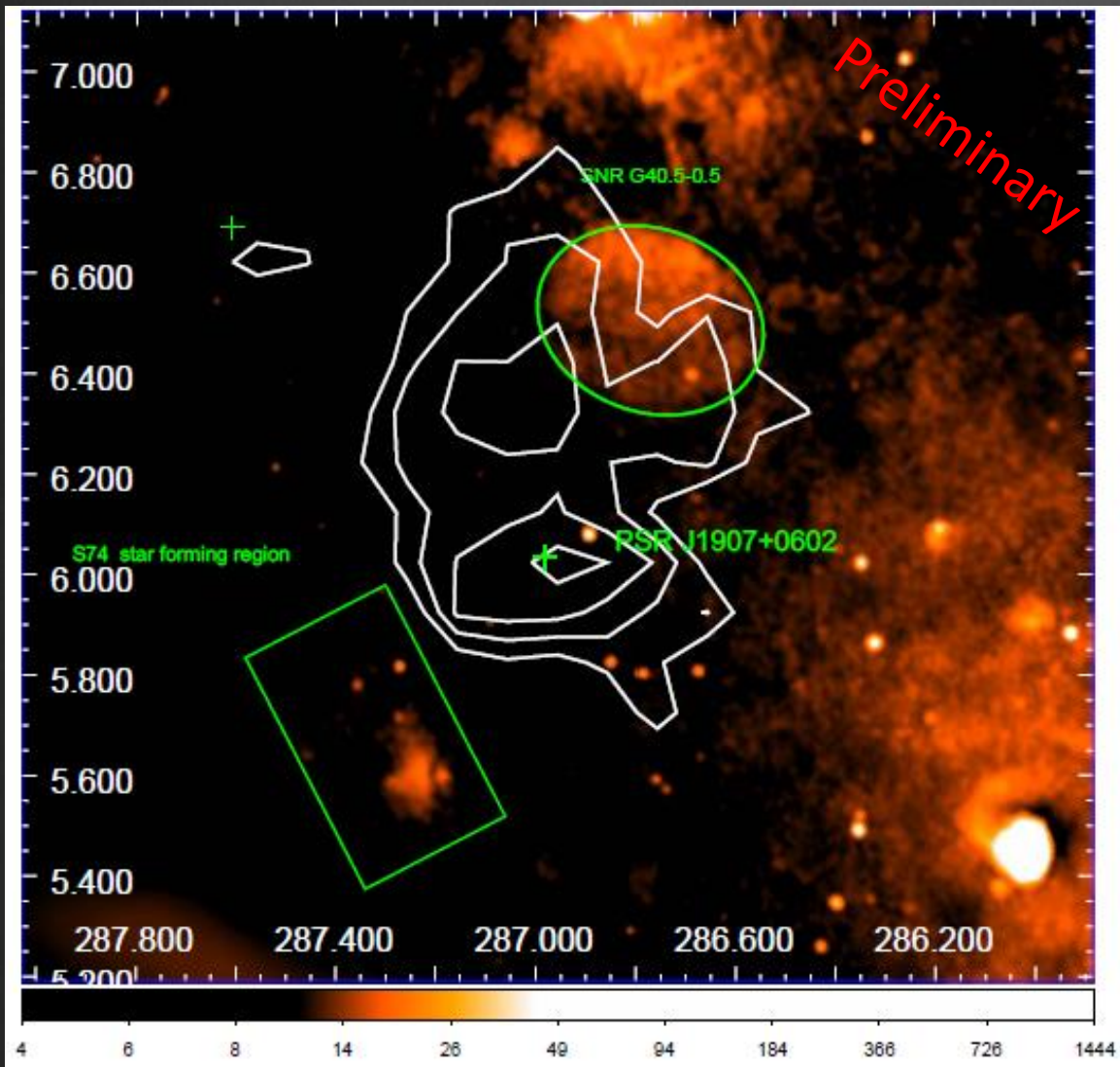
There is a spectral turnover around 10 GeV, which is consistent with Abdo et al. (2010).

We have discovered the GeV counterpart of MGRO J1908+06 with Fermi/LAT

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- MGRO J1908+06 was proposed to be a PWN powered by PSR J1907+0602 (Aliu et al. 2014; Abdo et al. 2010).
- We studied radio (VGPS, 1420 MHz) data of this region

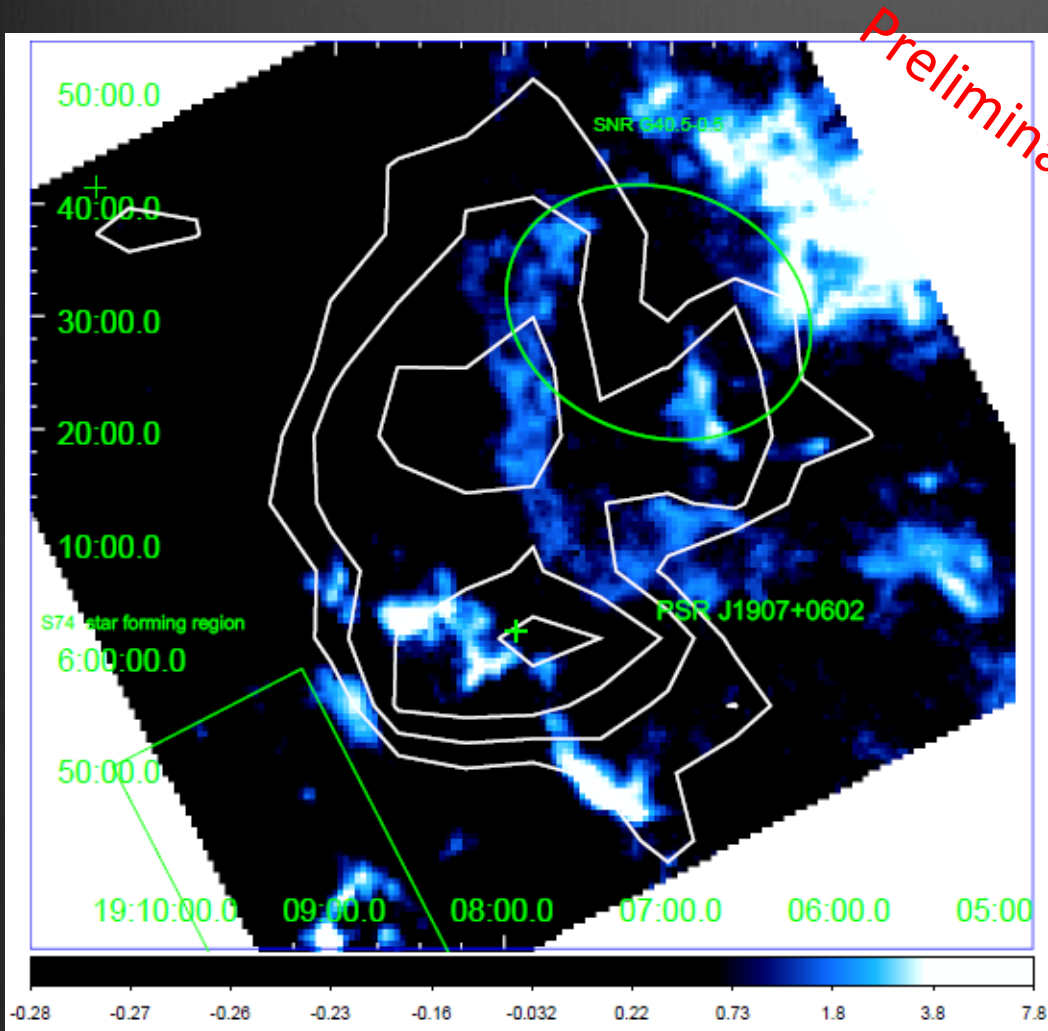


The shell of SNR G40.5-0.5 is clearly visible.

No radio PWN is associated with PSR J1907+0602

No radio structure is associated with TeV morphology.

^{12}CO map in 48-54km/s, corresponding to a distance consistent with PSR J1907+0602 and SNR G40.5-0.5 (3.2 kpc)
(data from Purple Mountain Observatory)



Preliminary

There is molecular cloud surrounding PSR J1907+0602.

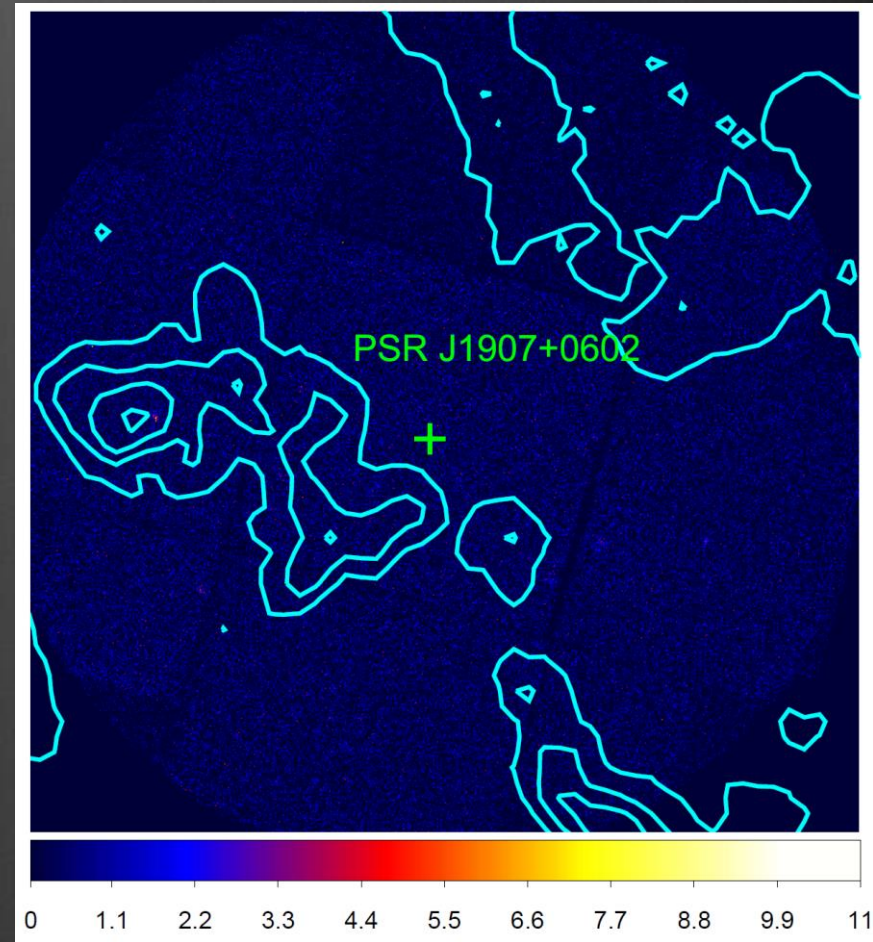
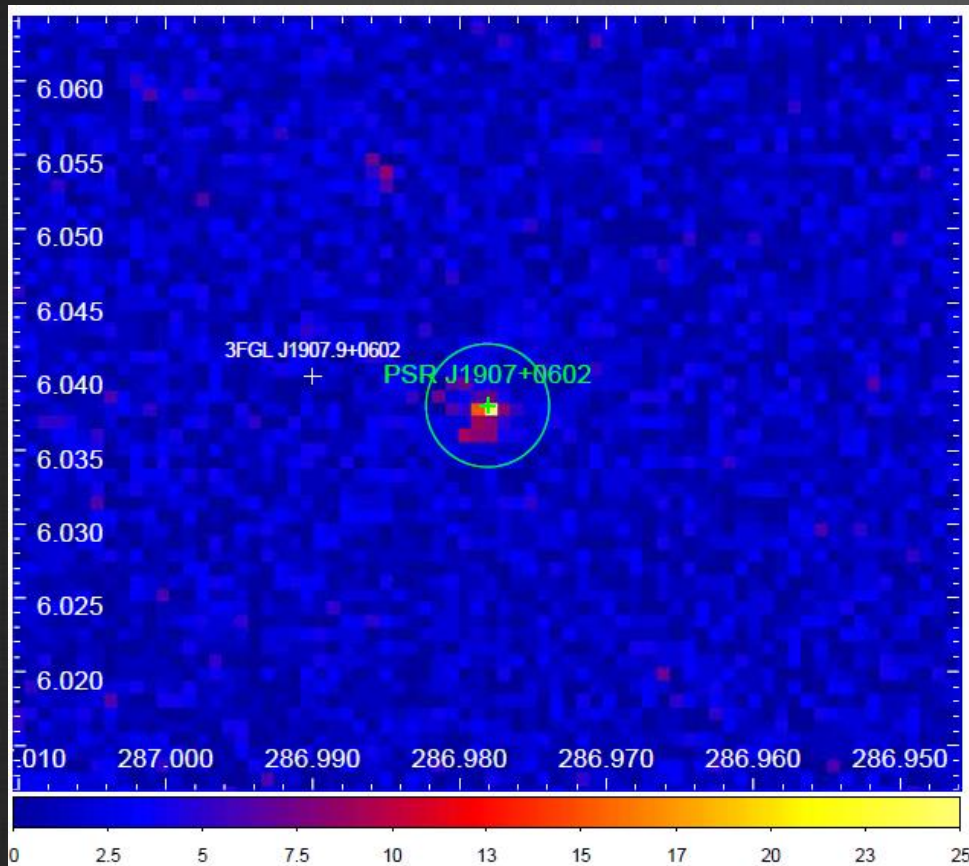
A shell like structure near SNR G40.5-0.5 but not consistent with radio morphology.

Part of the molecular cloud overlaps with GeV and TeV peak.

We didn't find evidence of interactions

XMM has covered this region with 52 ks exposure (obs. ID 0605700201). PSR J1907+0602 is detected but no PWN could be identified.

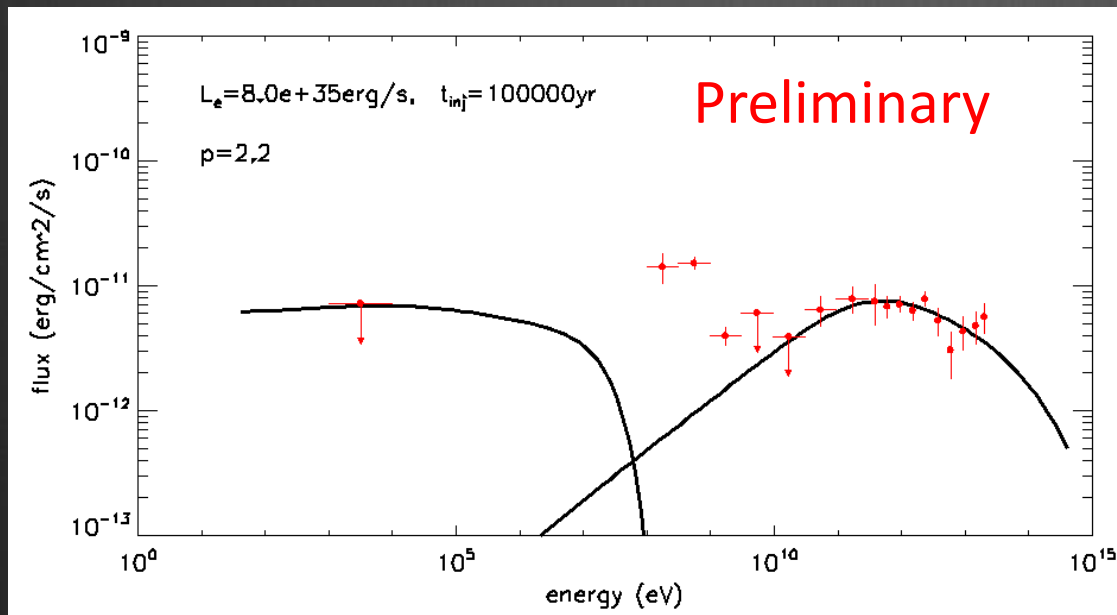
We searched for diffuse X-ray emission associated with MGRO J1908+06 but no detection could be reached.



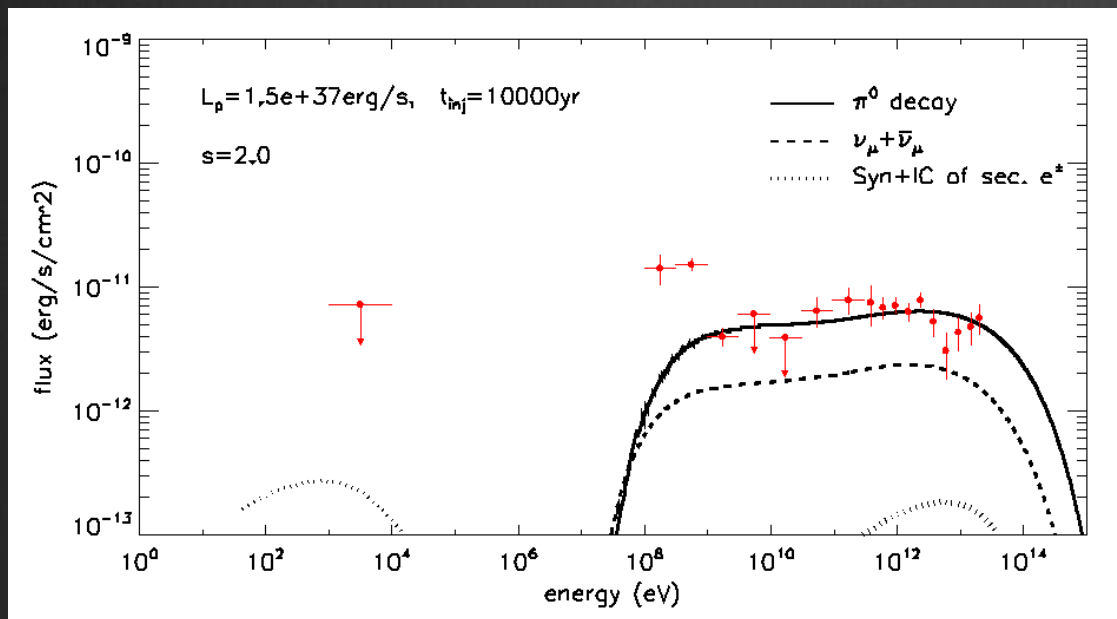
MOS 1 & 2 combined image.

The cyan contour indicates the distribution of molecular clouds traced by ^{12}CO

Models of MGRO J1908+06

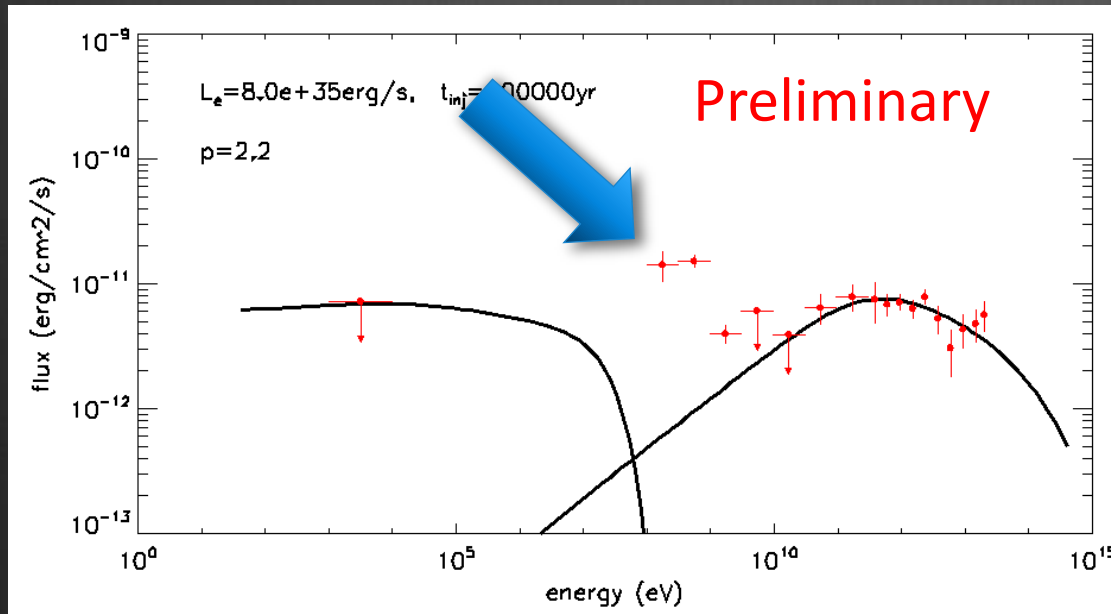


Leptonic

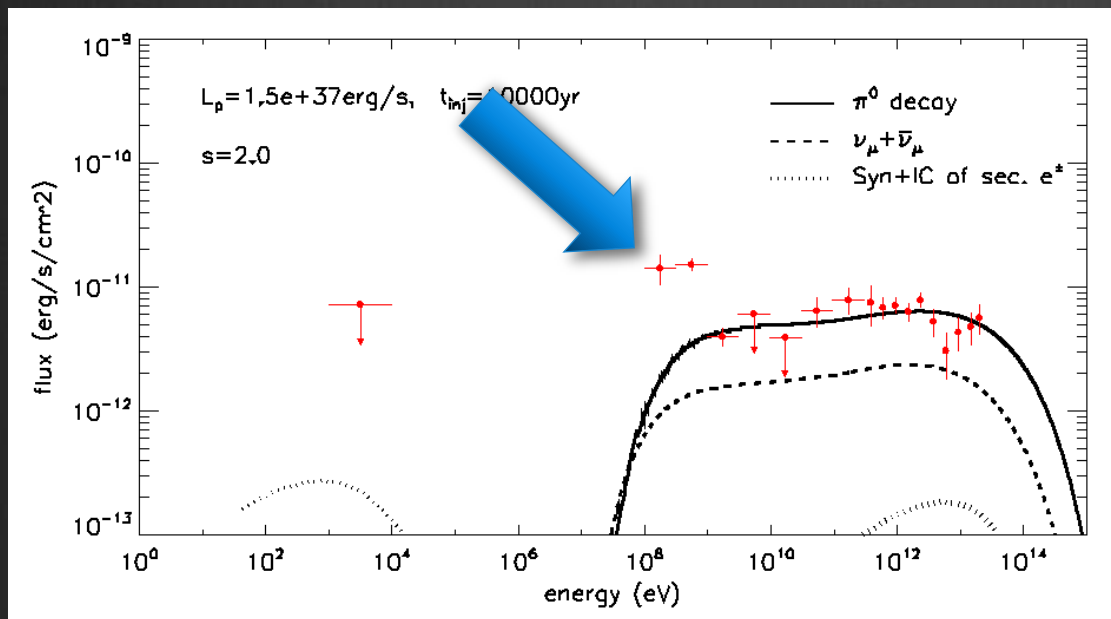


Hadronic

Models of MGRO J1908+06



Leptonic



Hadronic

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Information to take away

1. GeV counter part of MGRO J1908+06 is discovered for the first time.
2. Molecular clouds are identified to be associated with MGRO J1908+06 but no counterpart detected in radio or X-ray.
3. We provide preliminary leptonic/hadronic model fitting to the observed SED data. Neutrino emission is possible.

Thank you!

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