

THE SECOND AGILE CATALOG OF GAMMA-RAY SOURCES: FINAL REVIEW

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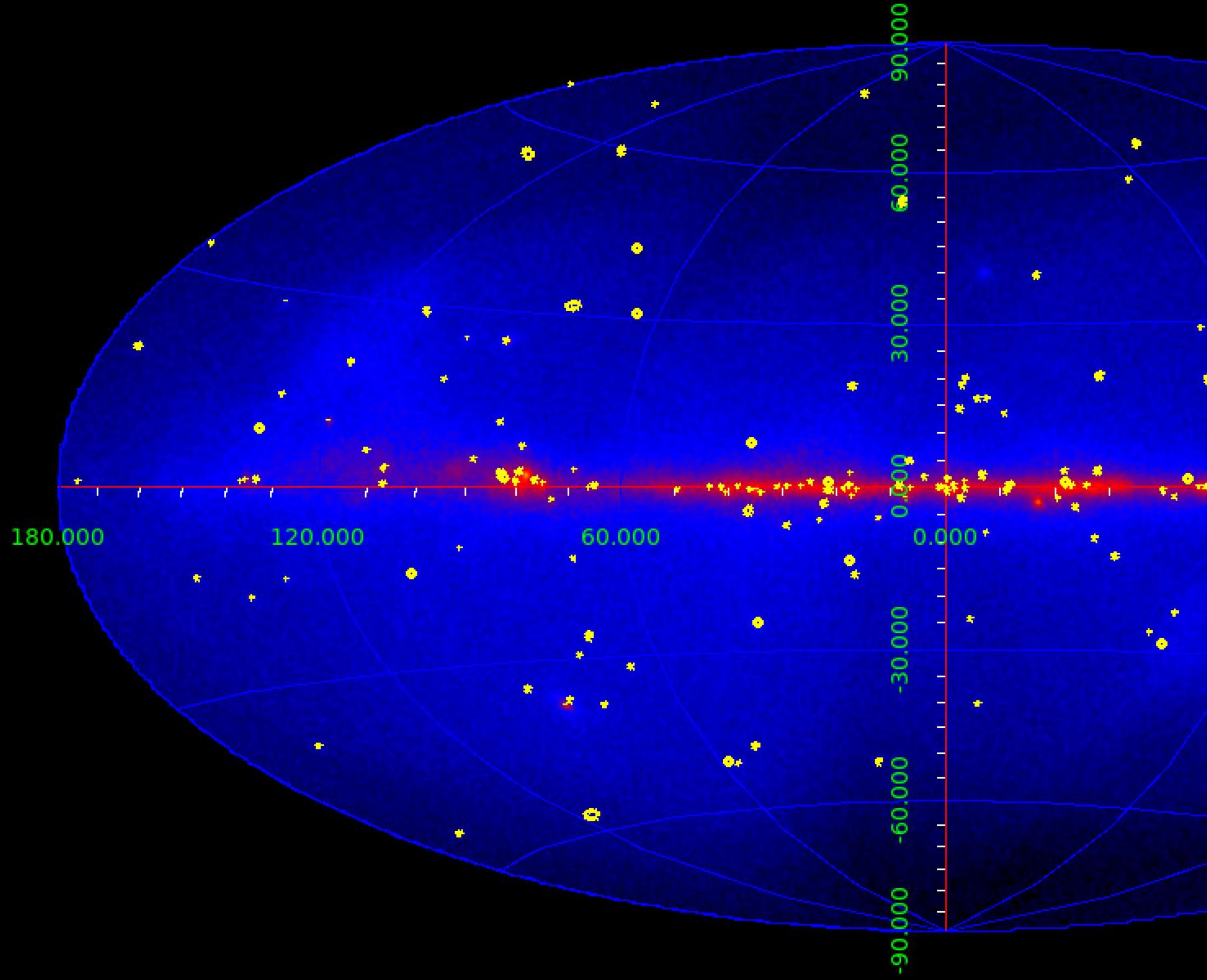
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OUTLINE

- Updates
- Method
- Results
- Products
- Some regions:
 - Galactic Center region
 - Carina region
 - Cygnus region



- The 2th AGILE Catalog of gamma-ray sources: final review
- AGILE/GRID observations covering the time period July 4, 2007, to October 15, 2009 (the AGILE POINTING MODE).
- The analysis is based on data in the
 - 100 MeV to 50 GeV energy range
 - A check in the "*low*" energy range 30 MeV - 100 MeV has been performed for the most significant sources
- Source detection is based on the integrated data set, i.e., sources are detected according to their average fluxes over about 27 months.

Region Name	OB Number	Starting RA, Dec J2000 (deg)	Starting LII, BII (deg)	Start Observation (UTC)	End Observation(UTC)
SA Crab (8,24)	OB5510	108.283 , 28.625	188.9607 , 16.9953	2008-04-05 12:00	2008-04-07 12:00
SA Crab (15,26)	OB5520	111.762 , 35.688	183.0072 , 22.2023	2008-04-07 12:00	2008-04-08 12:00
Anti-Center 2	OB5530	110.404 , 20.758	197.2962 , 15.7167	2008-04-08 12:00	2008-04-10 12:00
Vulpecula Field	OB5600	286.259 , 20.819	53.0394 , 6.4733	2008-04-10 12:00	2008-04-30 12:00
North Gal Pole	OB5700	250.075 , 72.497	104.8522 , 35.4379	2008-04-30 12:00	2008-05-10 12:00
Cygnus Field 2	OB5800	304.286 , 35.974	74.0497 , 0.2720	2008-05-10 12:00	2008-06-09 18:00
ToO WComae ON+231	OB5810	182.285 , 29.614	195.5016 , 80.3738	2008-06-09 18:00	2008-06-15 12:00
Cygnus Repointing	OB5820	323.248 , 50.079	93.6645 , -1.1664	2008-06-15 12:00	2008-06-30 12:00
Antlia Field	OB5900	161.83 , -47.73	282.31 , 10.11	2008-06-30 12:00	2008-07-25 18:00
TOO 3C 454.3	OB5910	19.37 , 38.09	128.56 , -24.49	2008-07-25 18:00	2008-07-31 12:00
Estensione TOO	OB5920	25.09 , 40.12	330.46 , 28.98	2008-07-31 12:00	2008-08-15 12:00
3C454.3	-	-	-	-	-
Musca Field 2	OB6010	175.31 , -74.13	298.10 , -11.92	2008-08-15 12:00	2008-08-31 12:00
ToO SGR 0501+4516	OB6110	61.87 , 44.06	333.90 , 27.26	2008-08-31 12:00	2008-09-10 12:00
Gal. Center 3	OB6200	256.55 , -28.53	355.51 , 7.40	2008-09-10 12:00	2008-10-10 12:00
ToO PKS 0537-441	OB6210	98.80 , -46.77	255.44 , -22.05	2008-10-10 12:00	2008-10-17 12:00
Aquila Field	OB6310	290.97 , 10.10	45.62 , -2.51	2008-10-17 12:00	2008-10-31 12:00
Cygnus Field 3	OB6400	295.52 , 35.64	70.03 , 6.15	2008-10-31 12:00	2008-11-30 12:00
Cygnus Field 4	OB6500	320.40 , 35.50	81.95 , -10.17	2008-11-30 12:00	2008-12-20 12:00
Cygnus Field 5	OB6600	334.10 , 44.05	95.70 , -10.47	2008-12-20 12:00	2009-01-12 18:00
ToO Carina Field	OB6610	161.67 , -59.86	287.86 , -0.69	2009-01-12 18:00	2009-01-19 18:00
Cygnus Field 6	OB6710	325.75 , 68.11	106.75 , 11.37	2009-01-19 18:00	2009-02-28 12:00
Gal.Center 4	OB6800	247.20 , -29.03	349.85 , 13.43	2009-02-28 12:00	2009-03-25 12:00
Gal.Center Prolonged	OB6810	275.73 , -30.50	2.59 , -7.83	2009-03-25 12:00	2009-03-31 12:00
Crab Field	OB6910	102.70 , 31.71	184.07 , 13.75	2009-03-31 12:00	2009-04-07 12:00
Aquila Field 1	OB7010	288.88 , -19.31	18.06 , -13.82	2009-04-07 12:00	2009-04-15 12:00
Aquila Field 2	OB7100	290.88 , 16.16	50.92 , 0.44	2009-04-15 12:00	2009-04-30 12:00

UPDATES

- A long path... Updates from last Workshop:

- The catalog adopts now different spectral shapes

$$\frac{dN}{dE} = N_0 \left(\frac{E}{E_0} \right)^\gamma$$

$$\frac{dN}{dE} = N_0 \left(\frac{E}{E_0} \right)^{\gamma_1} \exp \left(- \left(\frac{E}{E_c} \right) \right)$$

$$\frac{dN}{dE} = N_0 \left(\frac{E}{E_0} \right)^{\gamma_1} \exp \left(- \left(\frac{E}{E_c} \right)^{\gamma_2} \right)$$

$$\frac{dN}{dE} = N_0 \left(\frac{E}{E_b} \right)^{-(\alpha + \beta \log(E/E_b))}$$

- Simple Power Law
- Power Law with exponential cutoff
- Power Law with super exponential cutoff
- Log Parabola
- The NEW BUILD25 (AGILE/GRID Science Tools) has been used, that include also the energy dispersion correction factor (EDP)
- New Instrument Response Functions: H0025 -> energy range 100-300, 300-1000, 1000-3000, 3000-10000, 10000-50000 MeV

NEW BUILD25: SPECTRAL ANALYSIS

3C454.3

30 MeV - 50 GeV

ph cm⁻² s⁻¹

10⁻⁸

$$\frac{dN}{dE} = N_0 \left(\frac{E}{E_0} \right)^\gamma$$

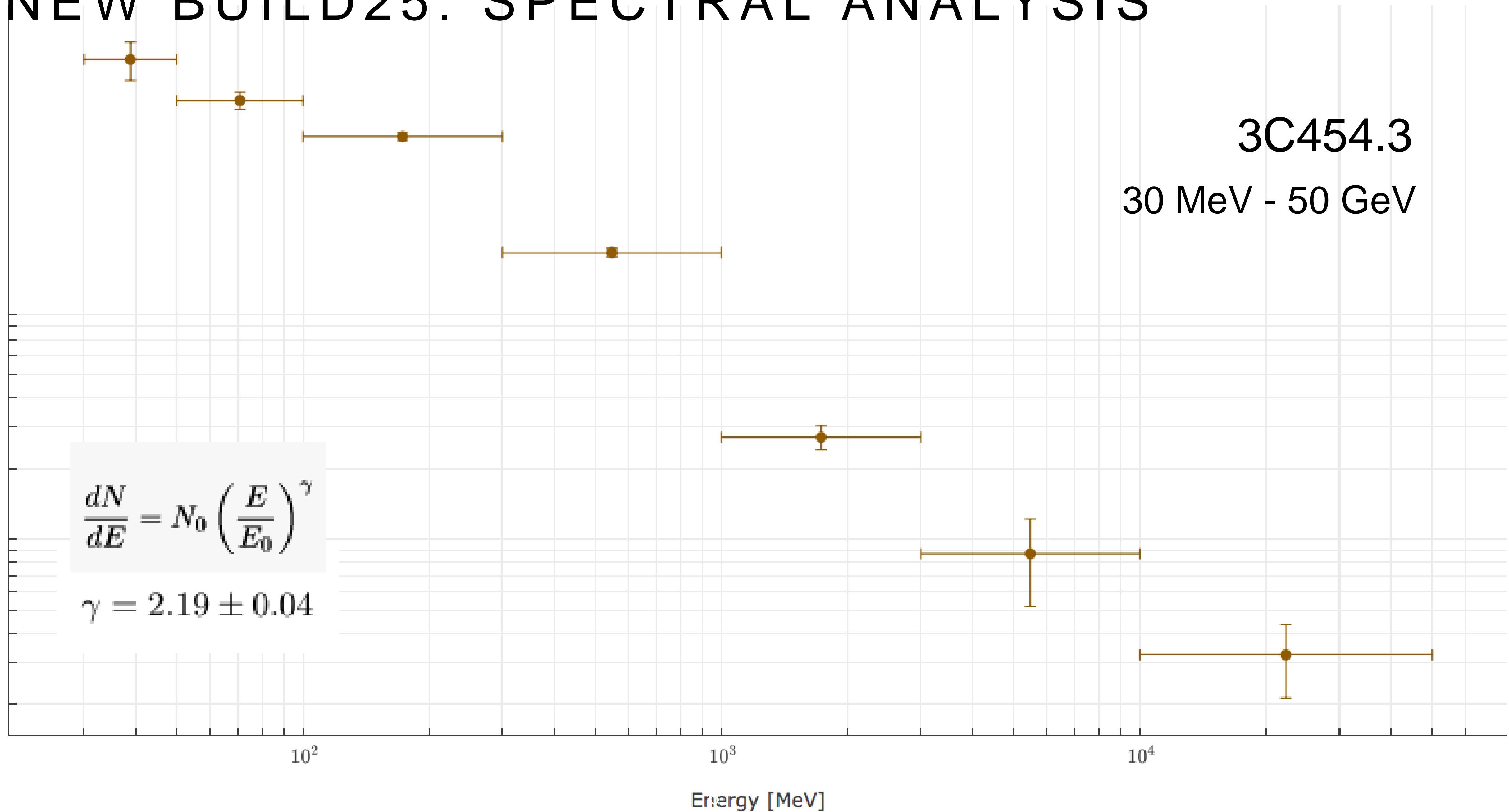
$$\gamma = 2.19 \pm 0.04$$

10²

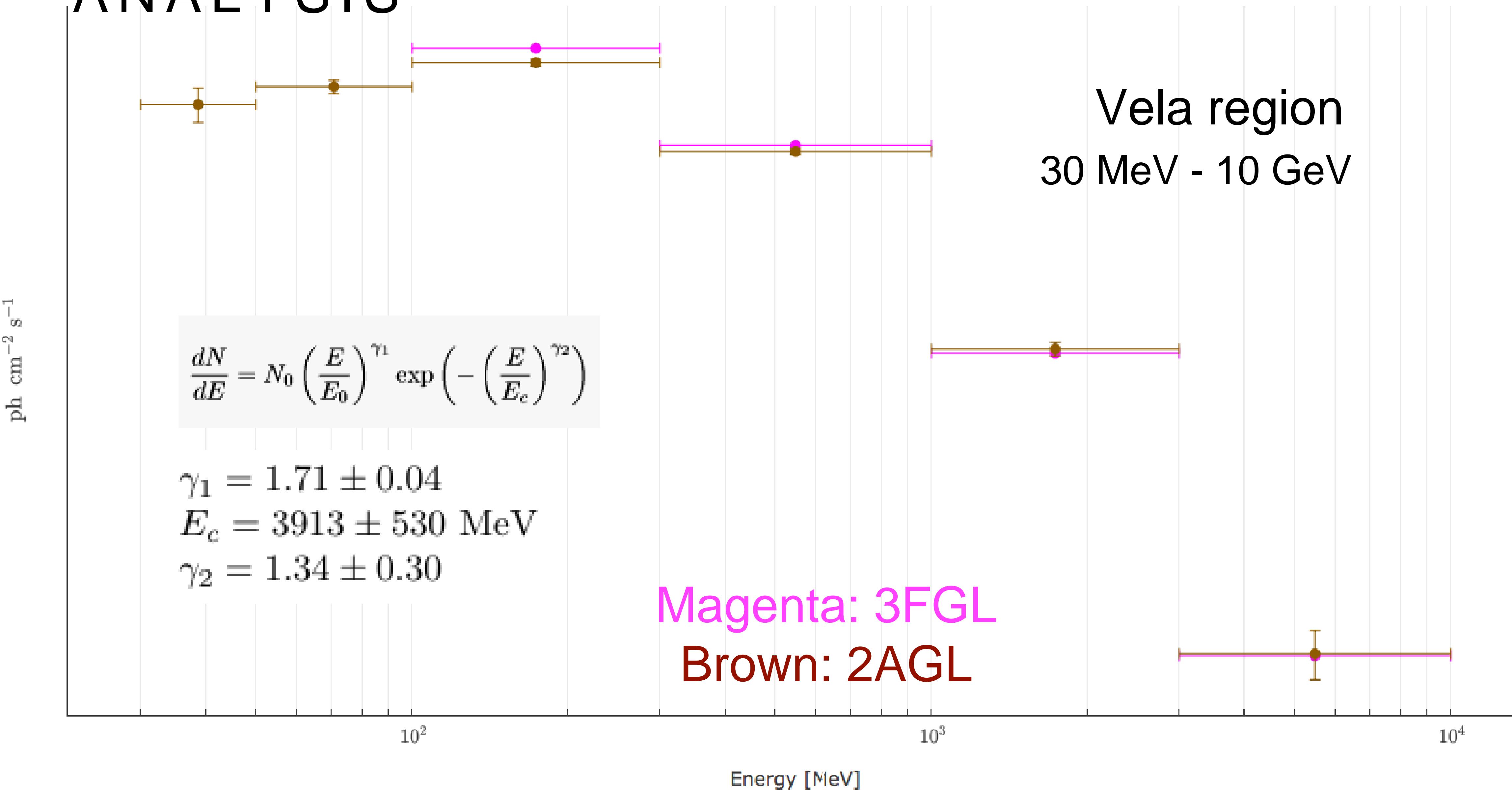
10³

10⁴

Energy [MeV]



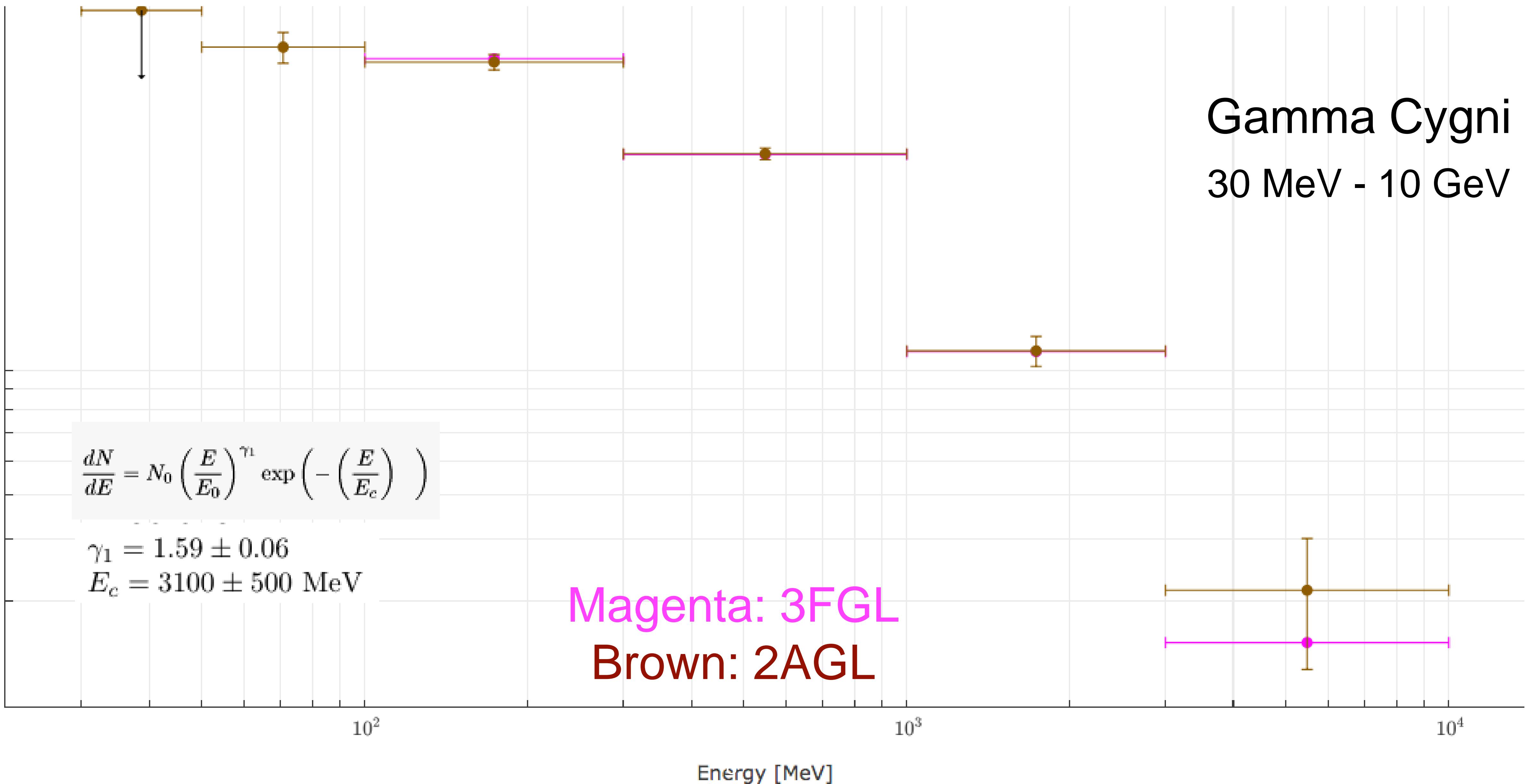
NEW BUILD25: CURVED SPECTRAL ANALYSIS



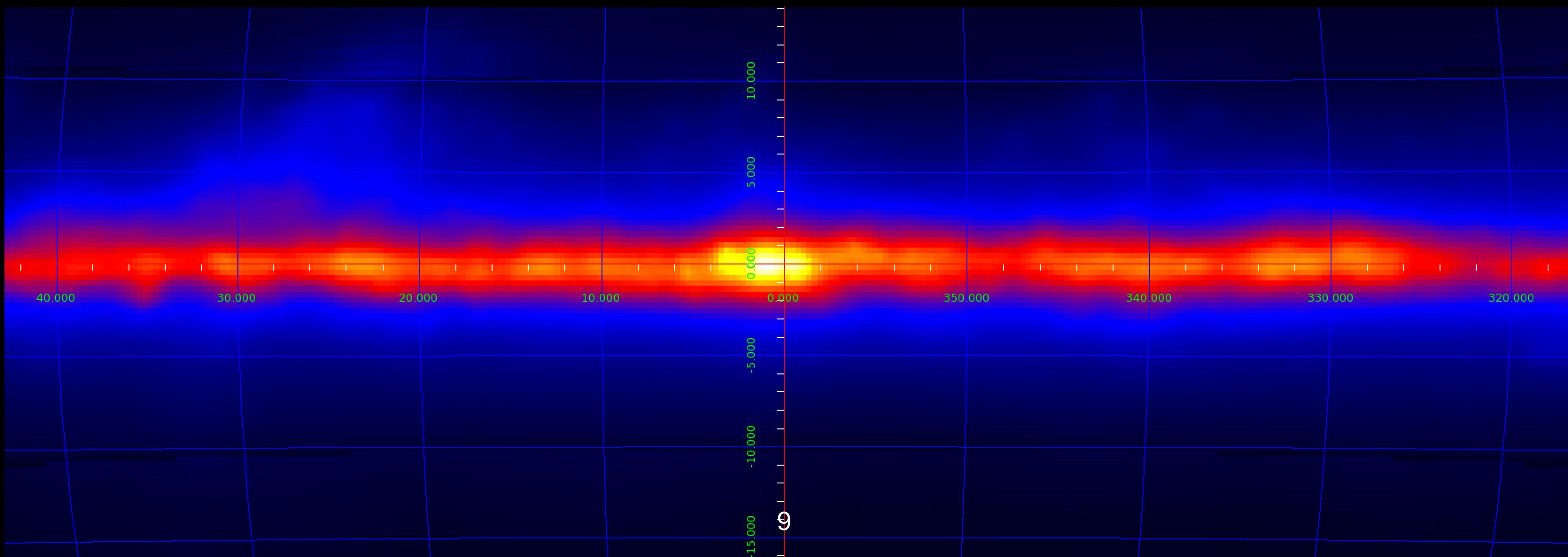
Gamma Cygni

30 MeV - 10 GeV

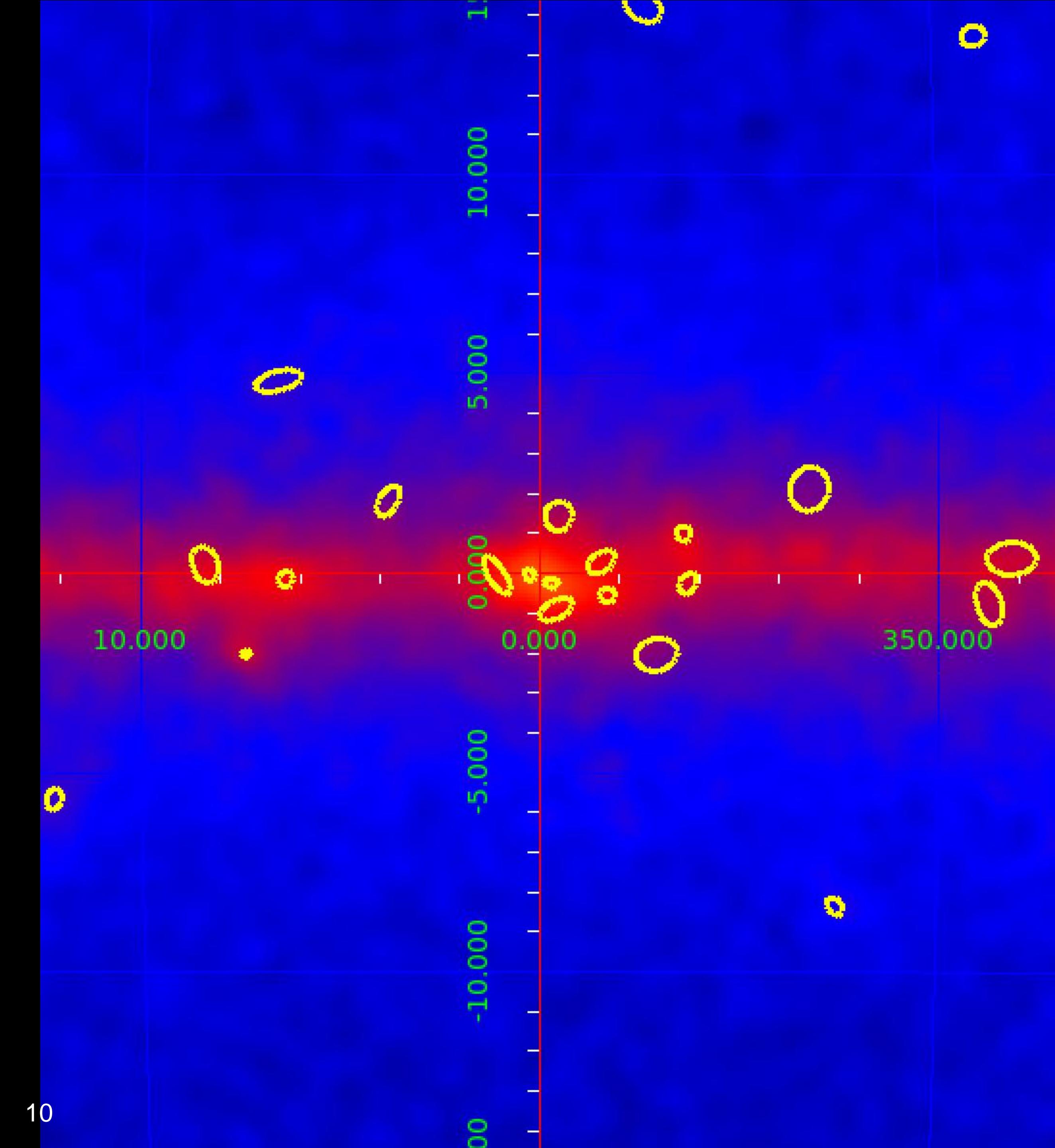
ph cm⁻² s⁻¹

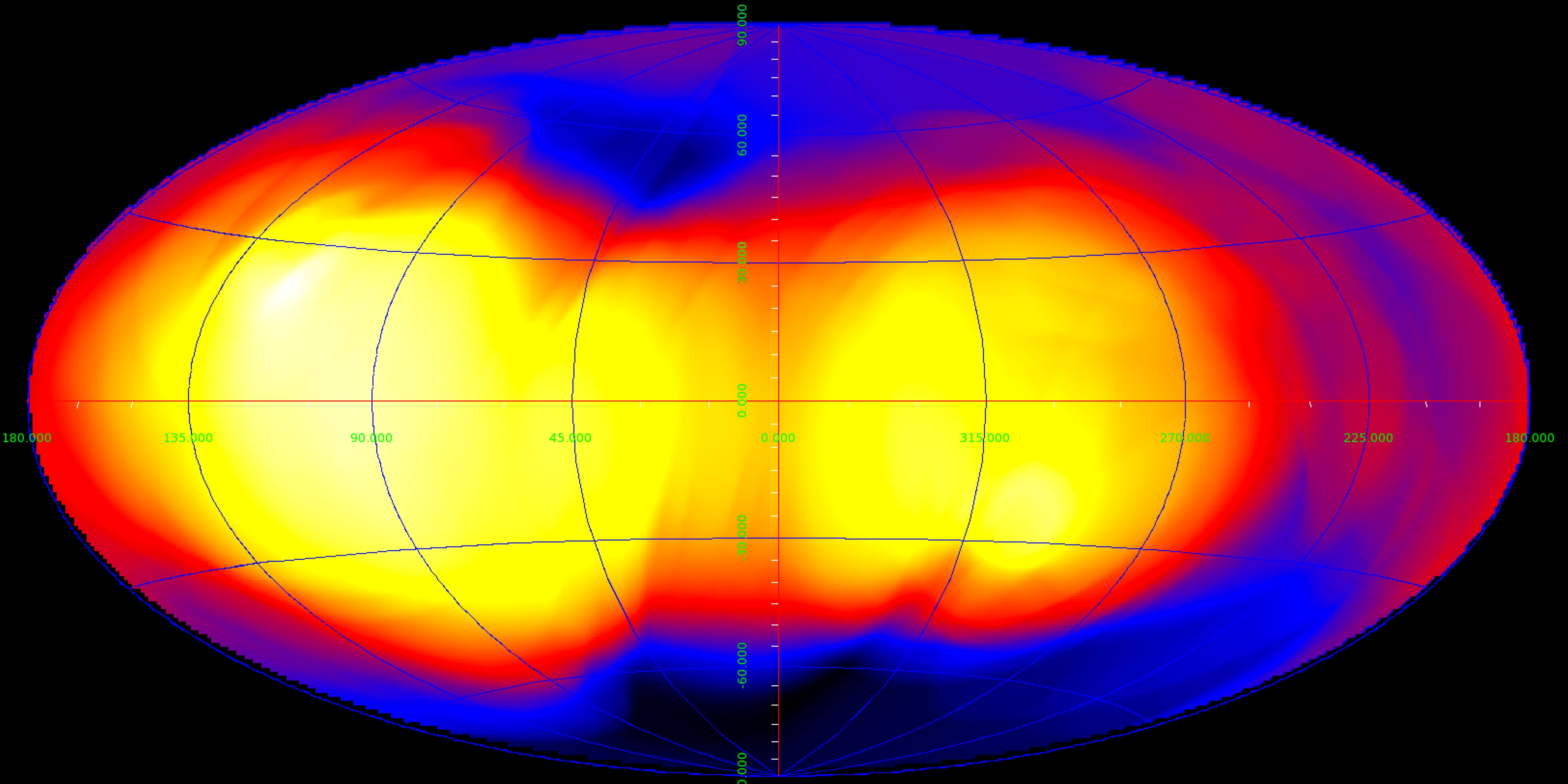


- Cross check with previous BUILD22@SSDC: only confirmed detections are included in the catalog
- The gamma-ray diffuse model used in the analysis has been improved. The diffuse model is particularly important for sources from low to mid Galactic latitudes.



METHOD

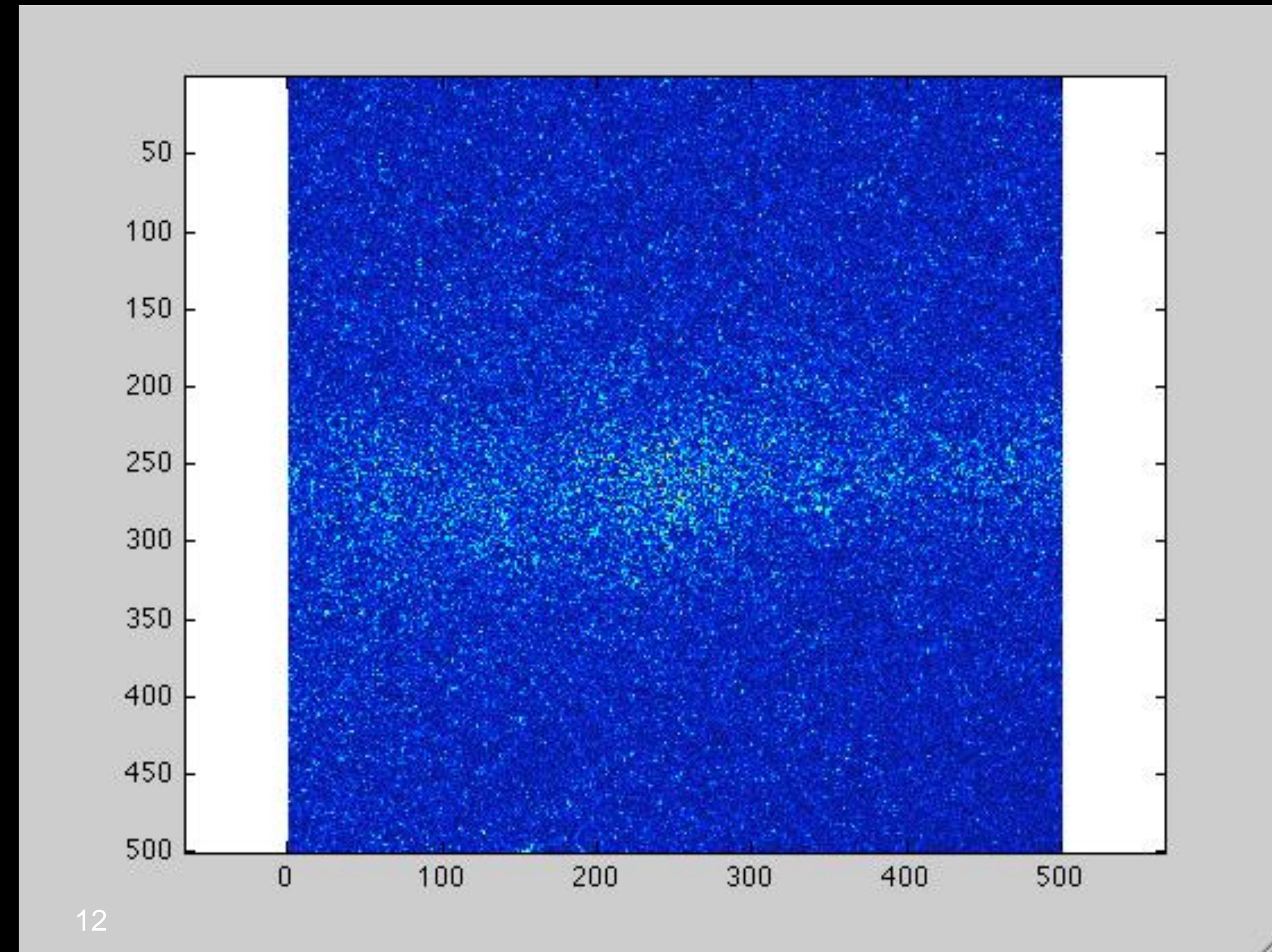
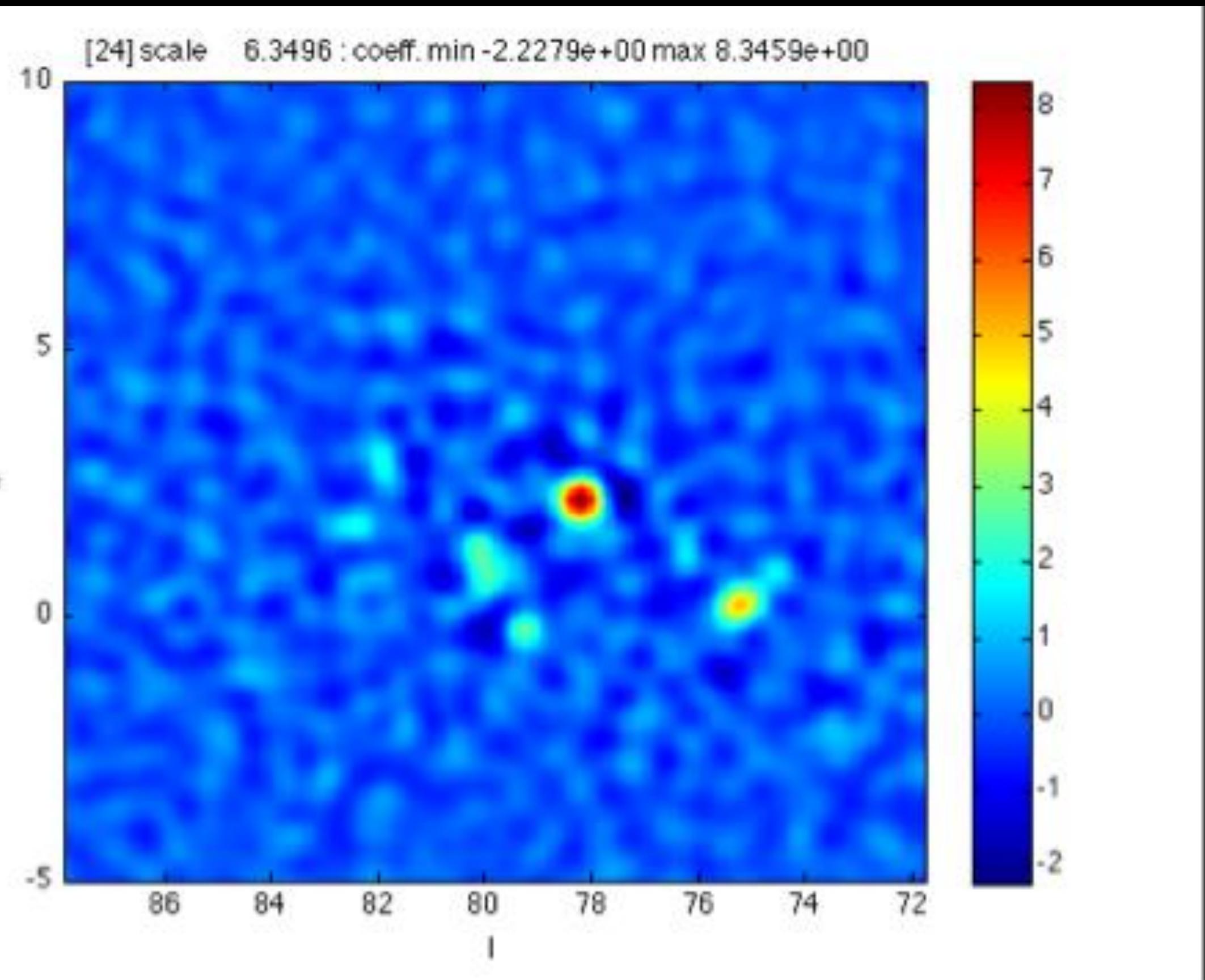




Exposure map ($\text{cm}^2 / \text{s sr}$) in pointing mode
The exposure is not uniform

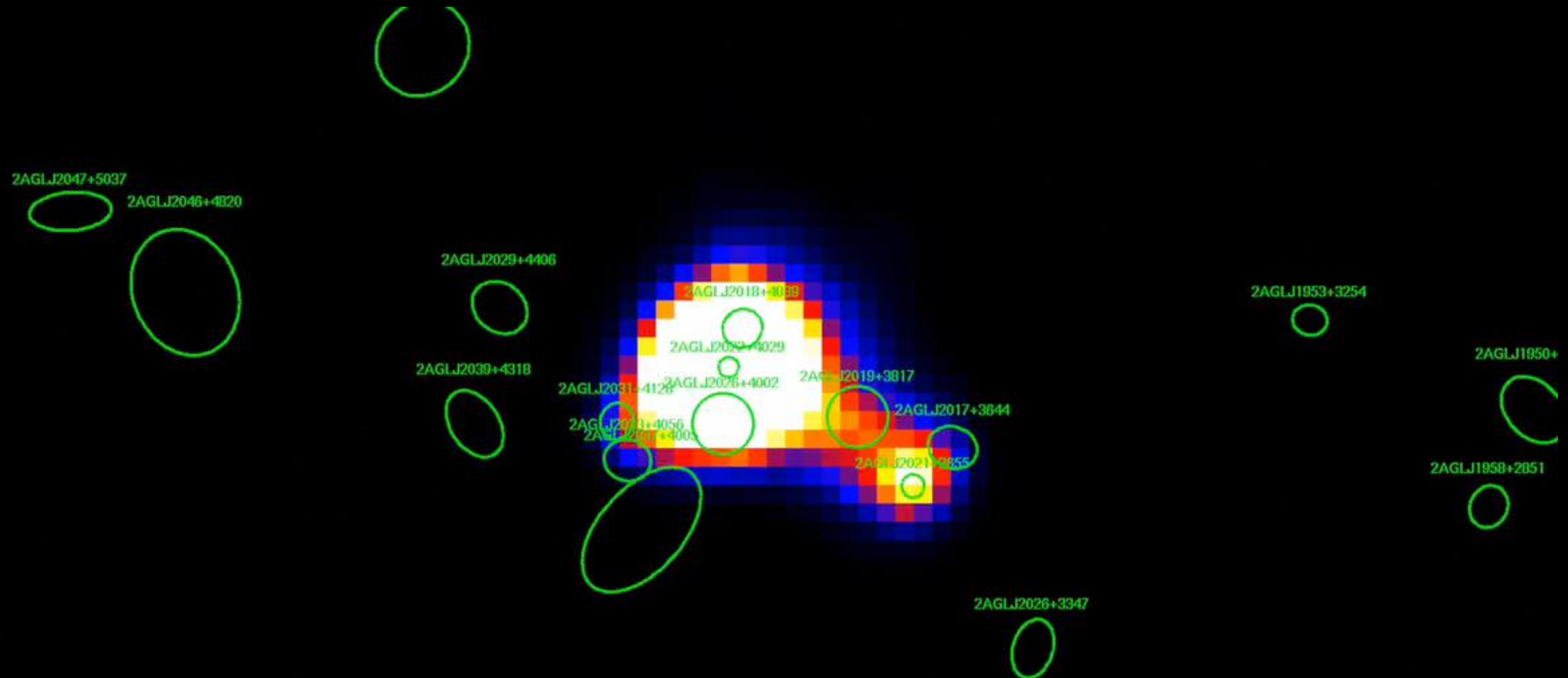
First step: the seeds

WAVELET ALGORITHM (THE SEED METHOD N° 1)



First step: the seeds

SIGNIFICANCE MAP (THE SEED METHOD N° 2)



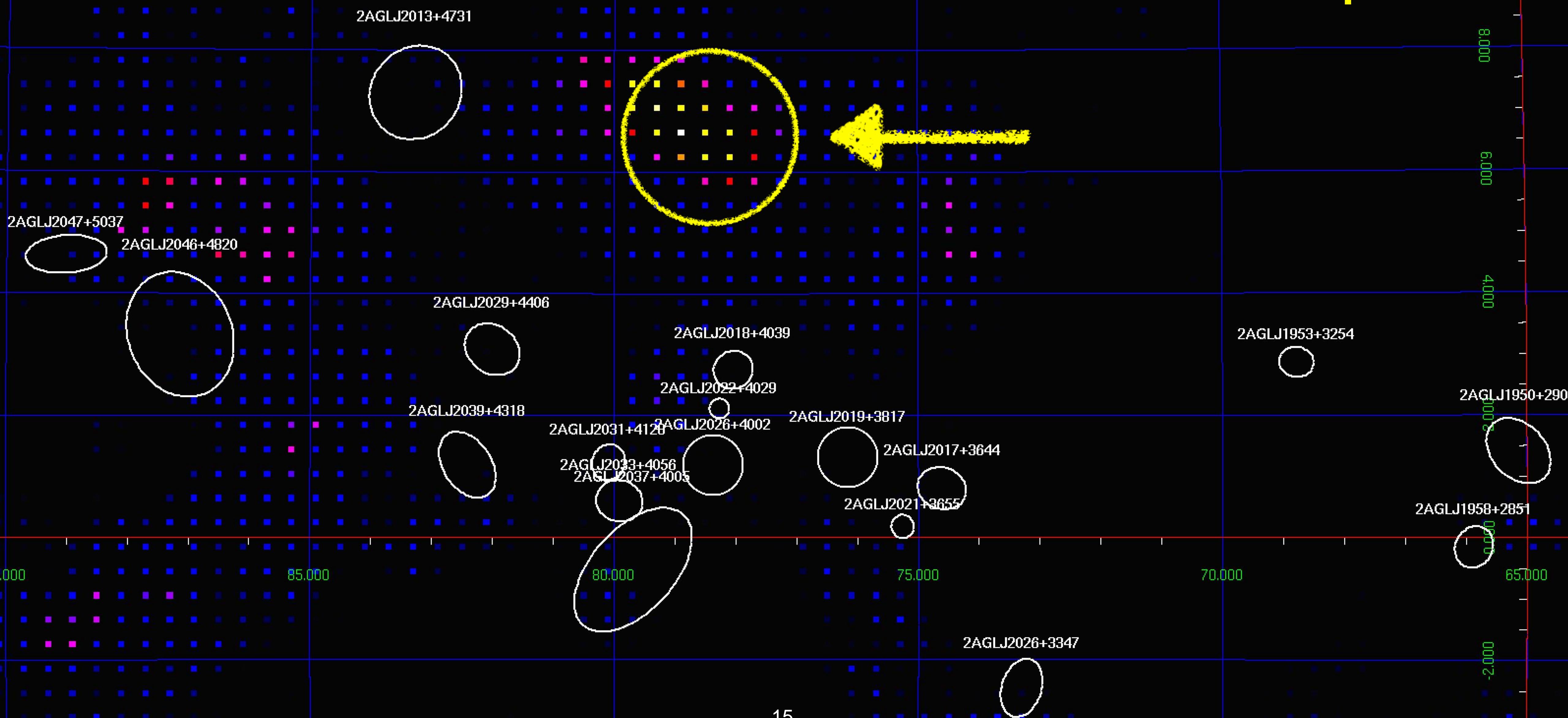
Second step

MANUAL ANALYSIS

- From the list of seeds using both methods...
 - Manual analysis
 - Final determination of position and flux

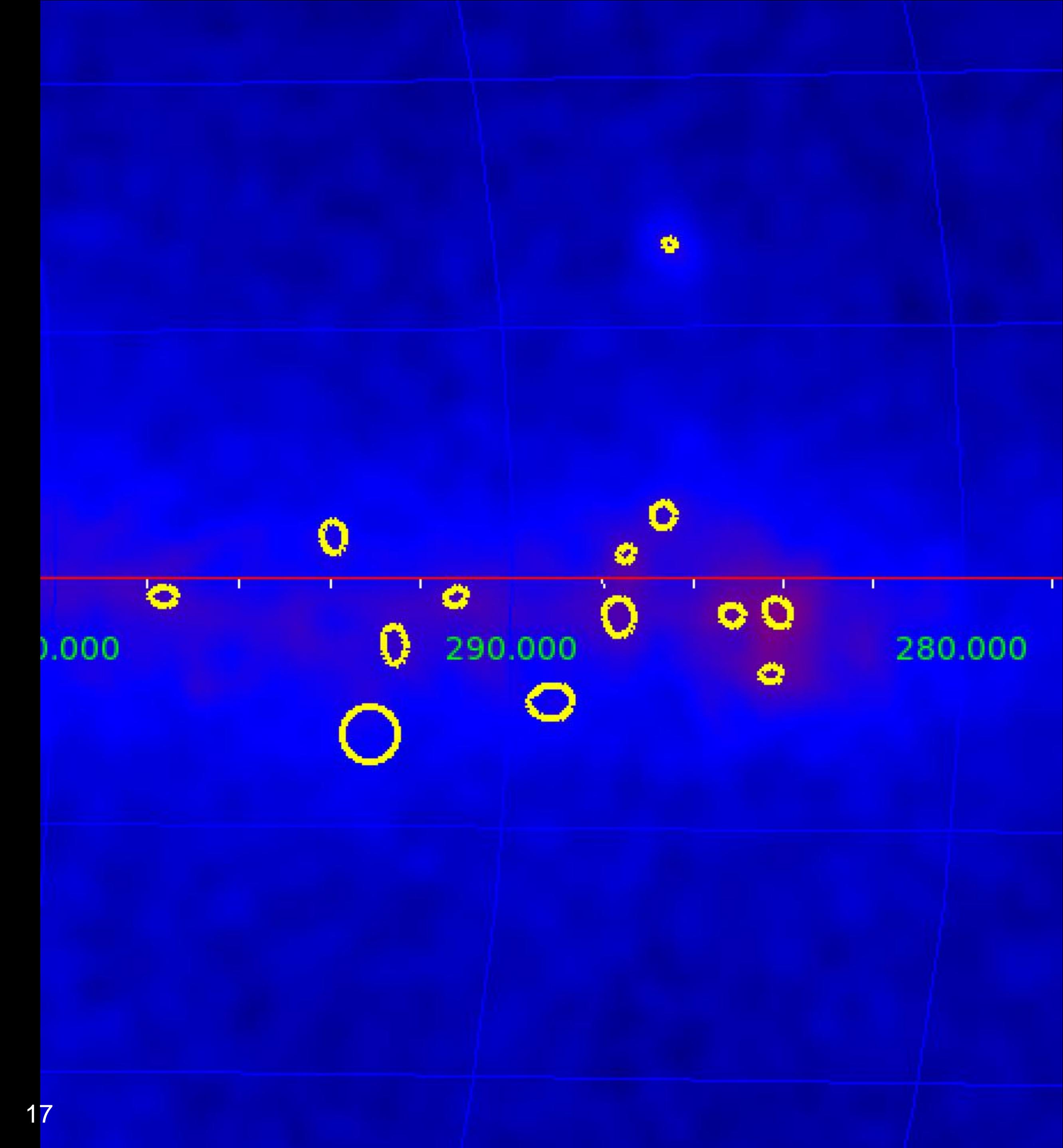
THE RESIDUAL TS MAP

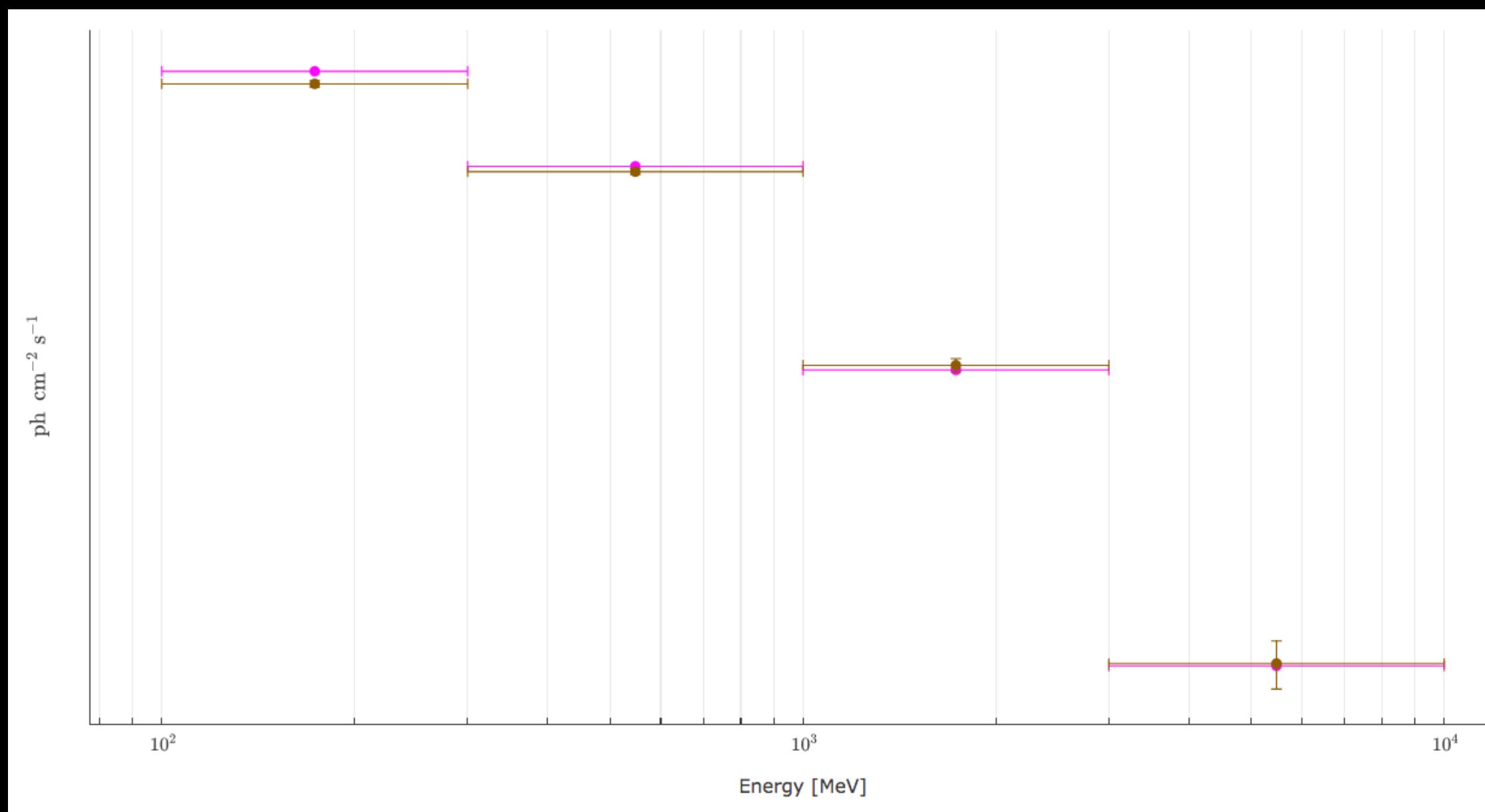
Third step



- After computing the maximum likelihood, the threshold for inclusion in the 2AGL Catalog is the likelihood Test Statistic $TS > 16$.

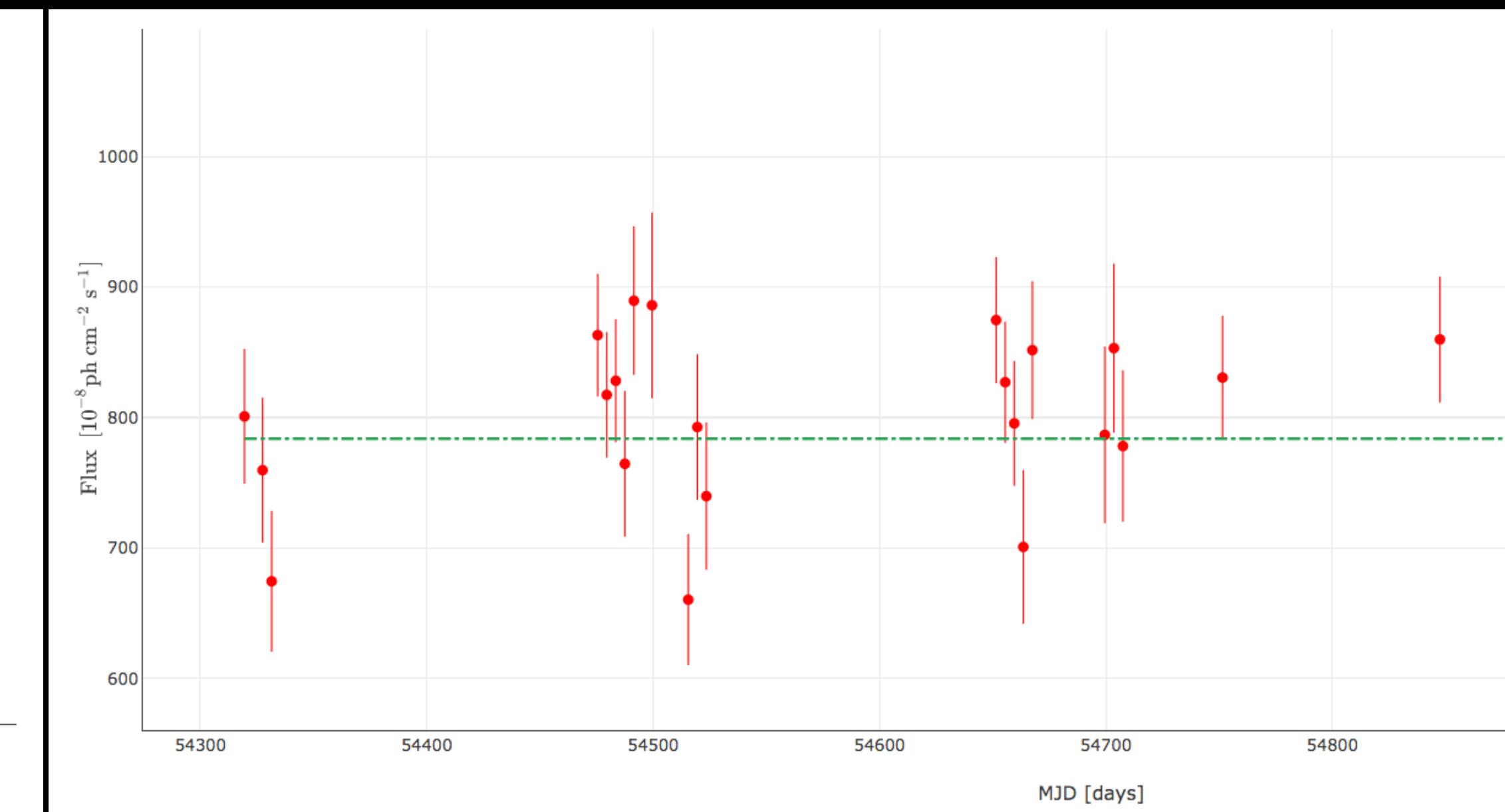
PRODUCTS





Spectra (100-10000 MeV)

$$TS_{curve} = 2(\log L(CurvedSpectra) - \log L(PL))$$



Light curves (4 days)

Lets TS_0 the value of TS evaluating all the time bins at the same time but considering a constant flux, TS_1^i the value of TS optimizing the flux in each period of time i .

The variability index is

$$TS_{var} = \sum_{i=1}^N TS_1^i - TS_0$$

If the null hypothesis is correct TS_{var} is distributed as χ^2 with N degrees of freedom, and a value of $TS_{var} > h(N)$ is used to identify variable sources at a 99% confidence level.

It is possible to introduce a corrective factor (similar to (Nolan 2012)):

$$TS_i^{corr} = F_{sigma_i}^2 / (F_{sigma_i}^2 + f^2 * F_0^2)$$

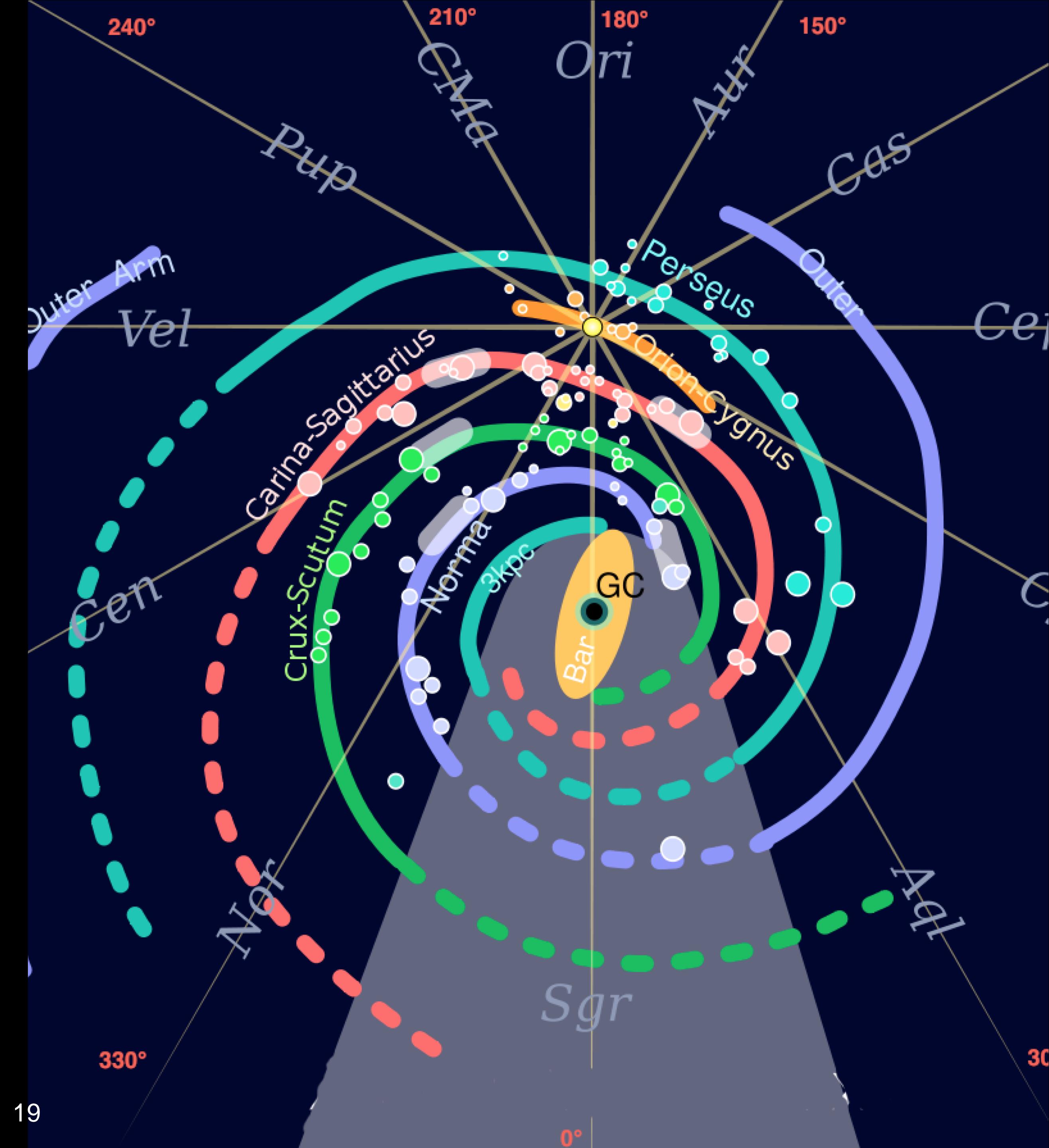
We consider $f = 0.01$ in our analysis. The variability index is

$$TS_{var}^* = \sum_{i=1}^N (TS_i^{corr} * TS_1^i) - TS_0$$

Curvature Index

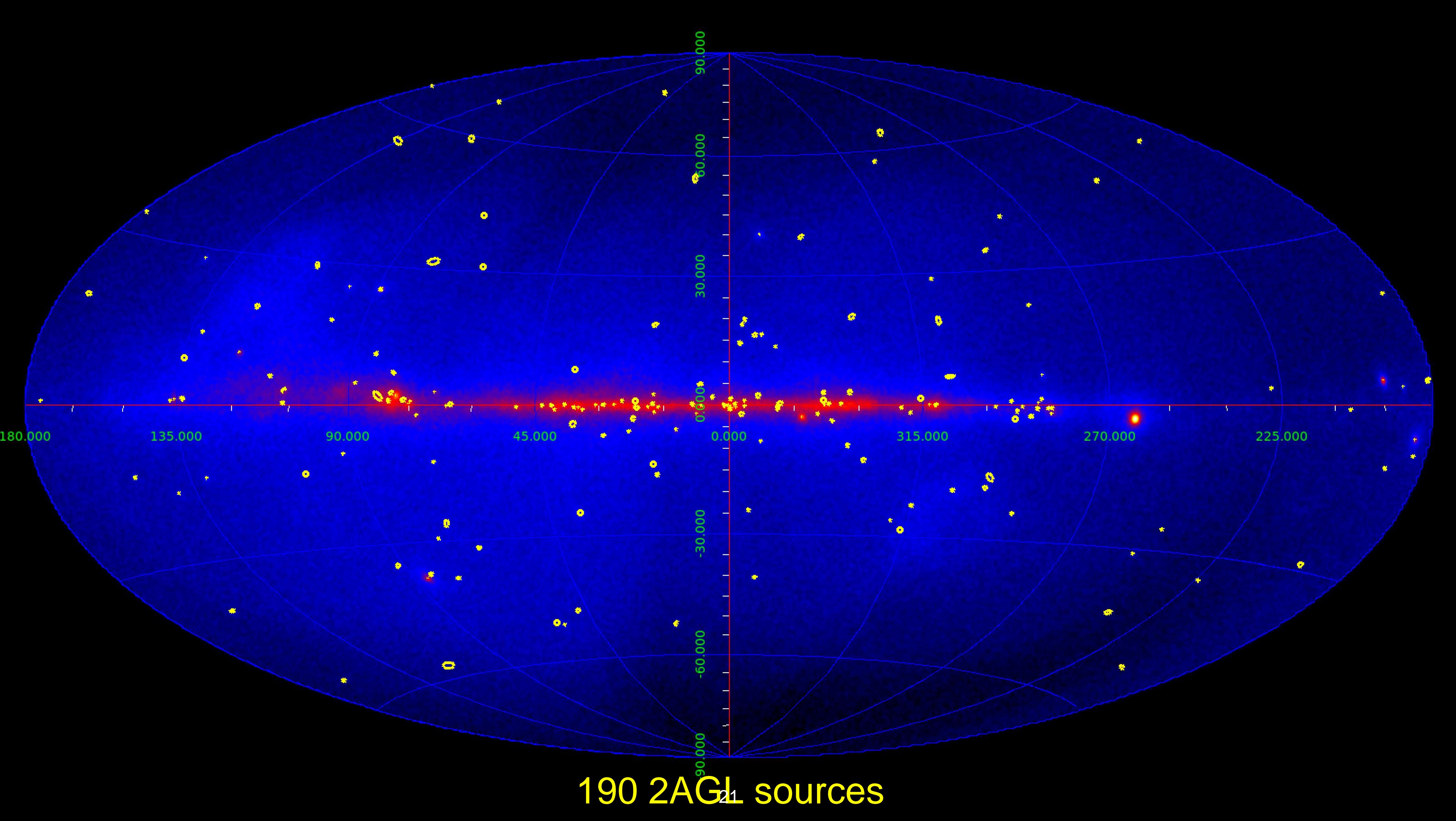
Variability Index

RESULTS

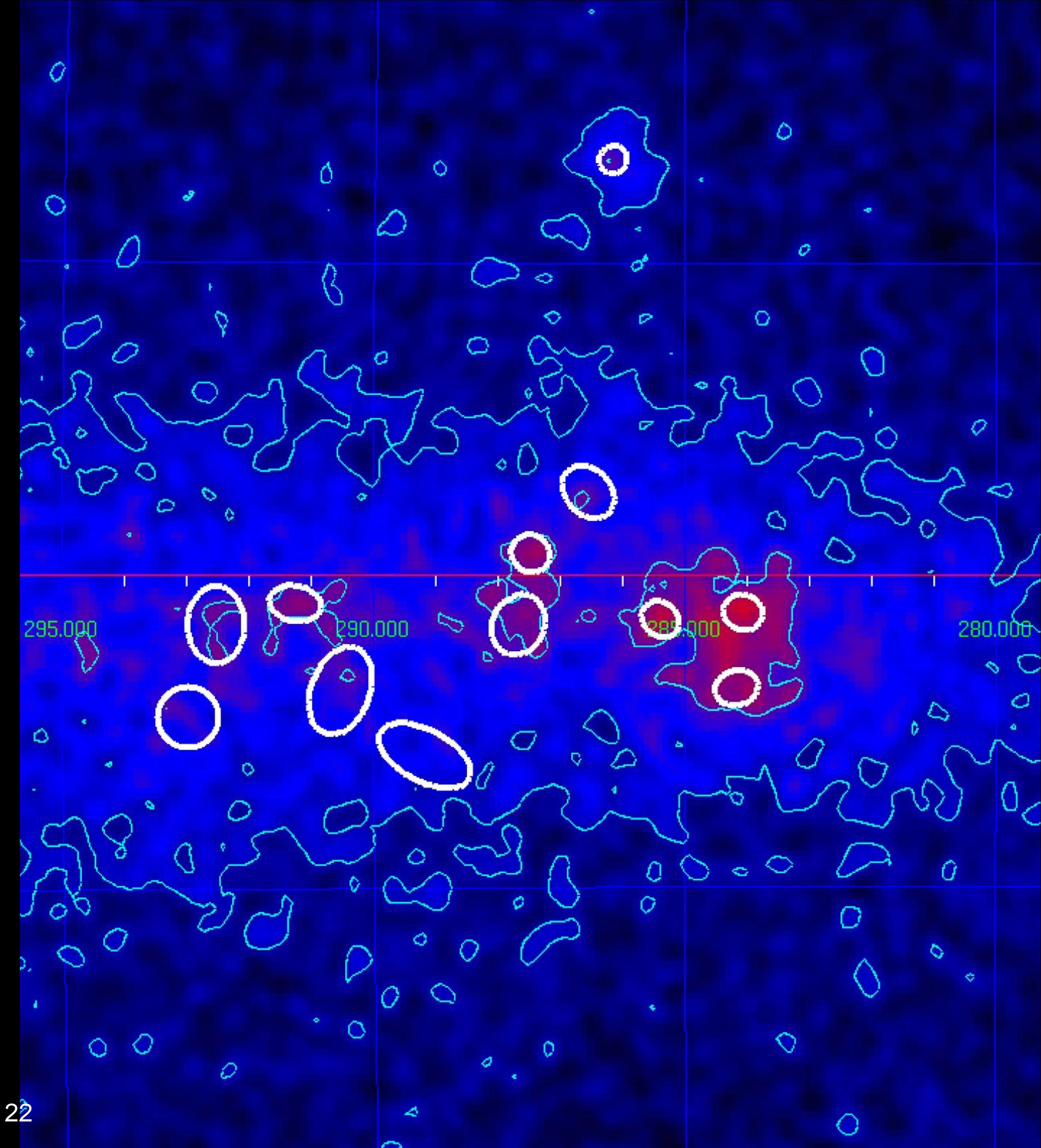


RESULTS

- Results
 - AGILE only sources
 - Associations
 - WARNING: AGILE 0.1-50 GeV, Fermi 0.1-100 GeV
-



ASSOCIATIONS



PRELIMINARY ASSOCIATIONS

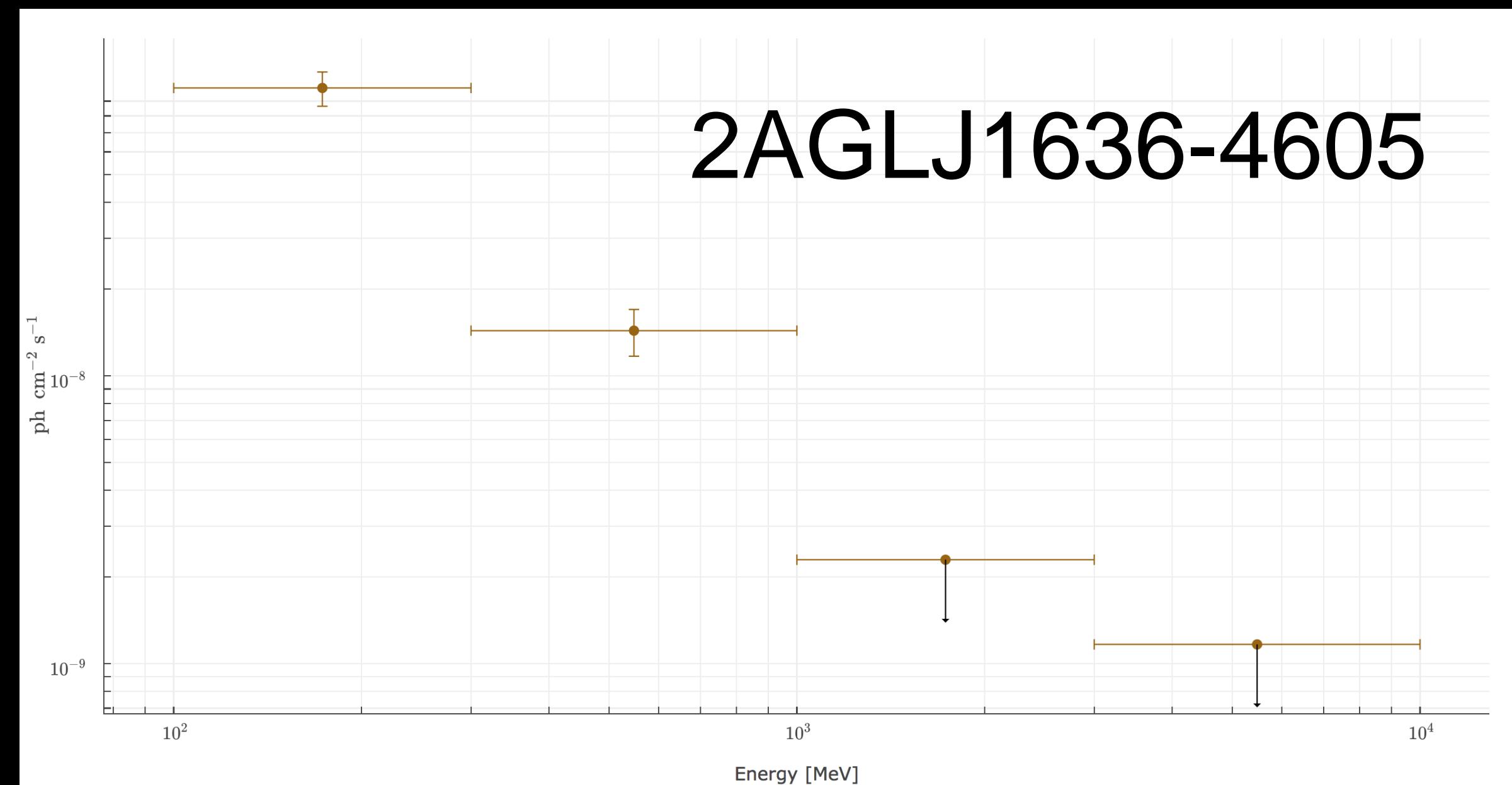
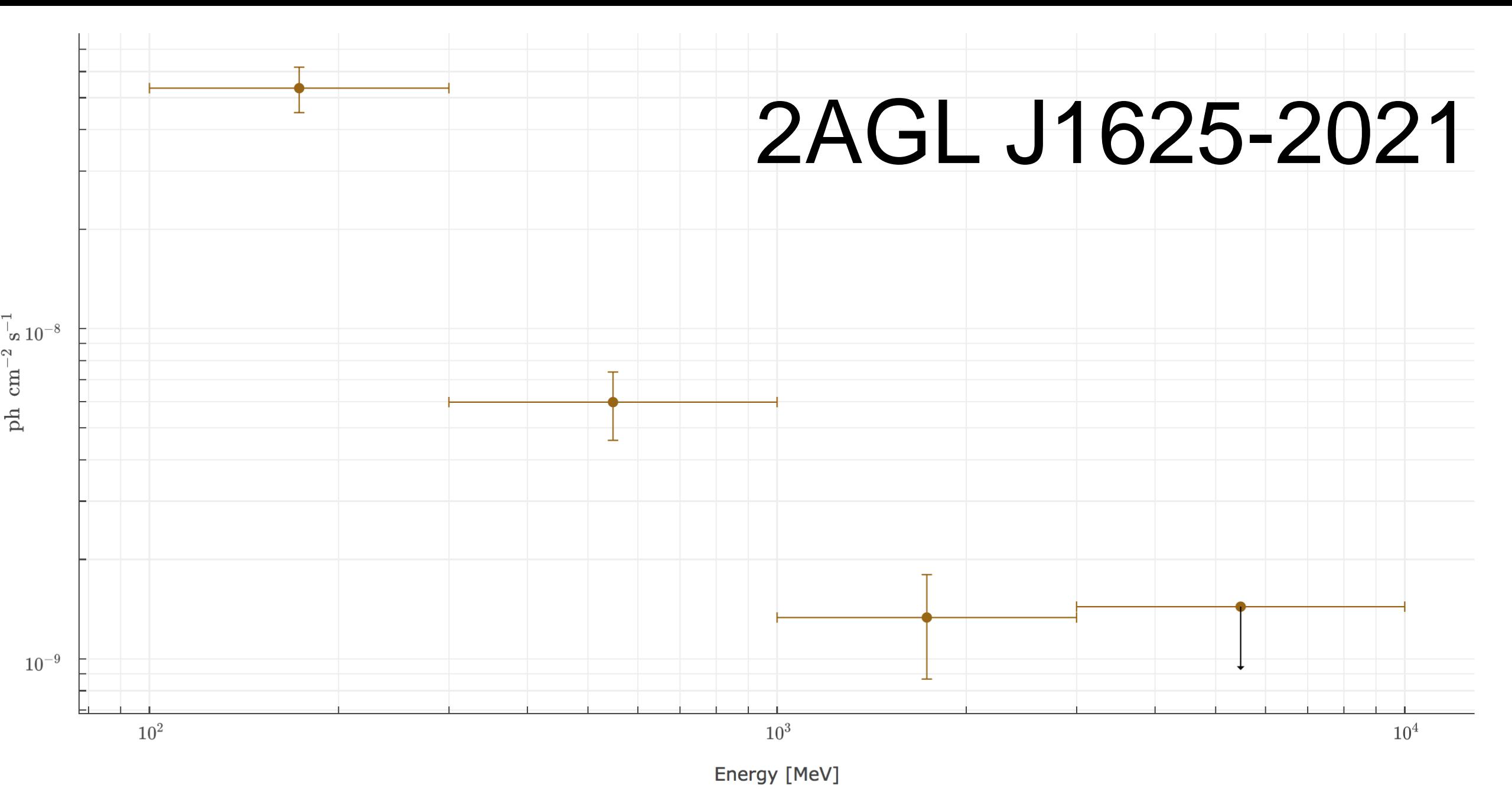
- Positional coincidence only
- These associations are not in general to be taken as firm identifications: a physical relationship is not established between gamma-ray sources and sources in other wavelengths.
- 20 AGILE-only (no 3FGL) sources

AGN

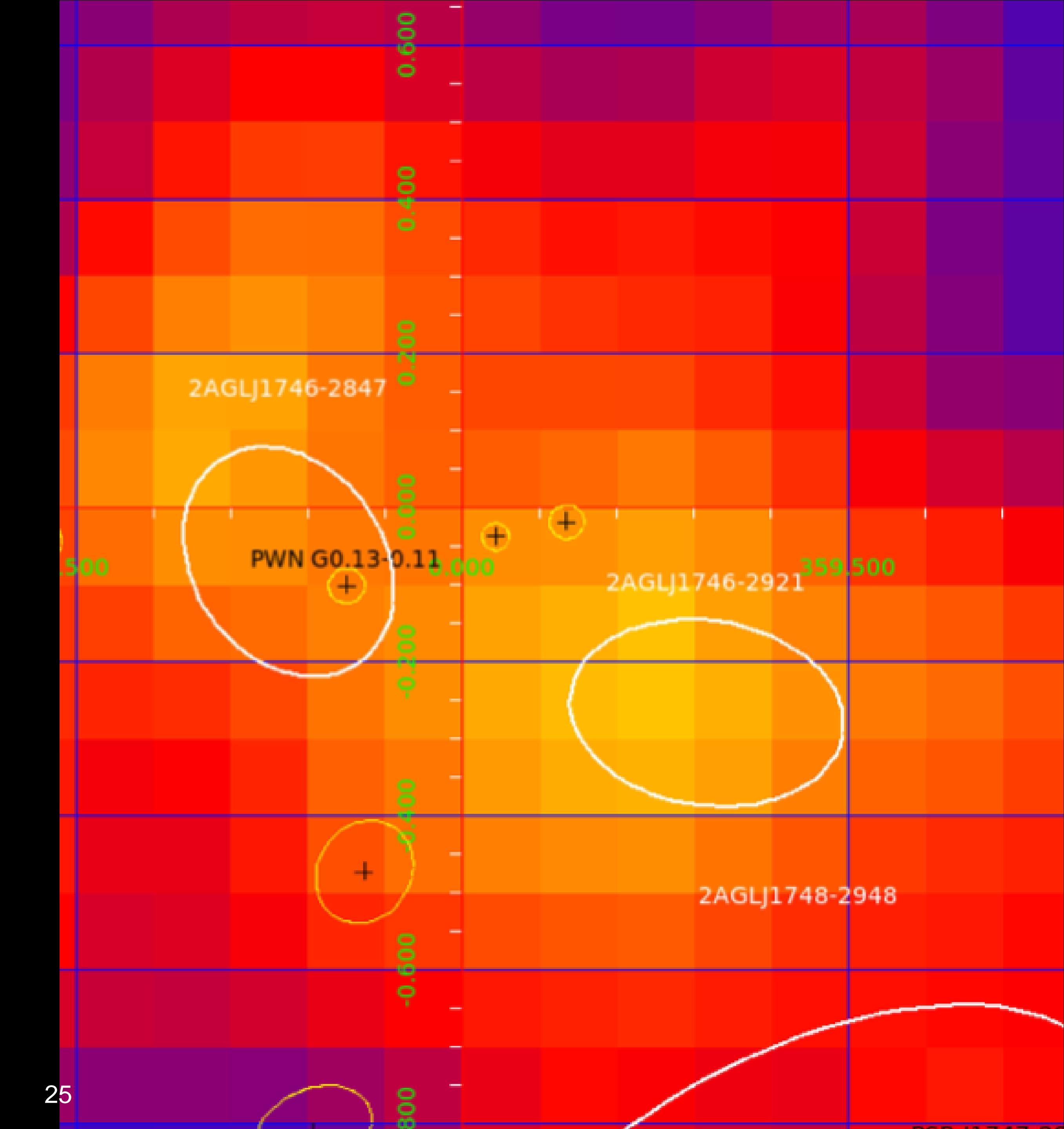
Description	number
BCU (Blazar candidate of uncertain type)	10
BLL (BL Lac type of blazar)	17
FSRQ (FSRQ type of blazar)	31
RDG (Radio galaxy)	2 (CenA, NGC1275)
BIN (Binary)	1 (Eta Carinae)
GLC (Globular cluster)	1 (Terzan 5)
HMB (High-mass binary)	3
PSR (positional only)	50
PWN	3
SNR	9
SPP	7
	134

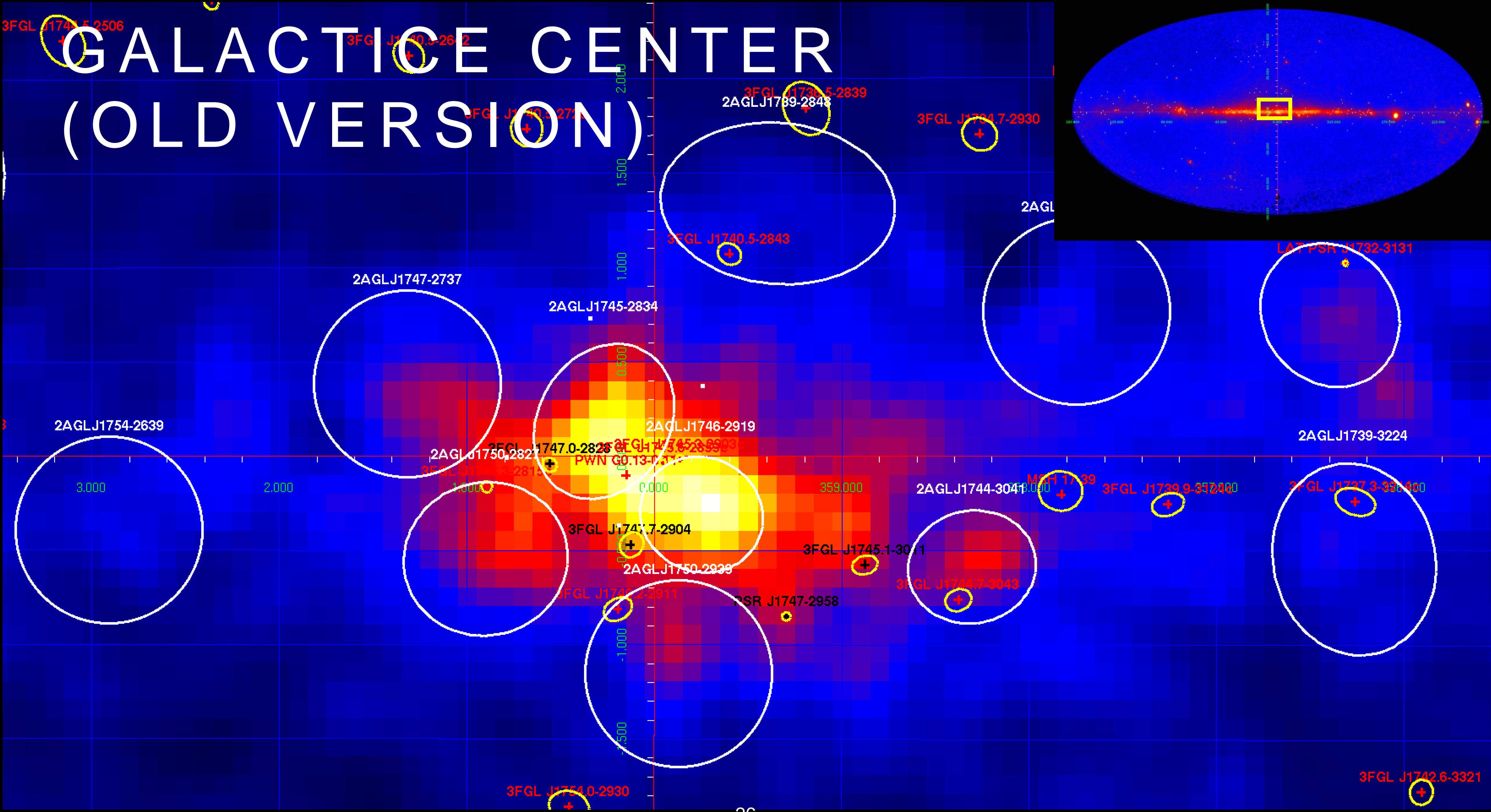
HMB (High-mass binary)	LSI+61 303, 1FGLJ1018.6-5856, Cygnus X-3
SNR	IC443, CTB37A, W28, W30, W44, W49B, W51, GammaCygni, HB21
PWN	Crab Nebula, HESSJ1632-478, PWNG0.13-0.11)

AGILE ONLY SPECTRA



THE GALACTIC CENTER





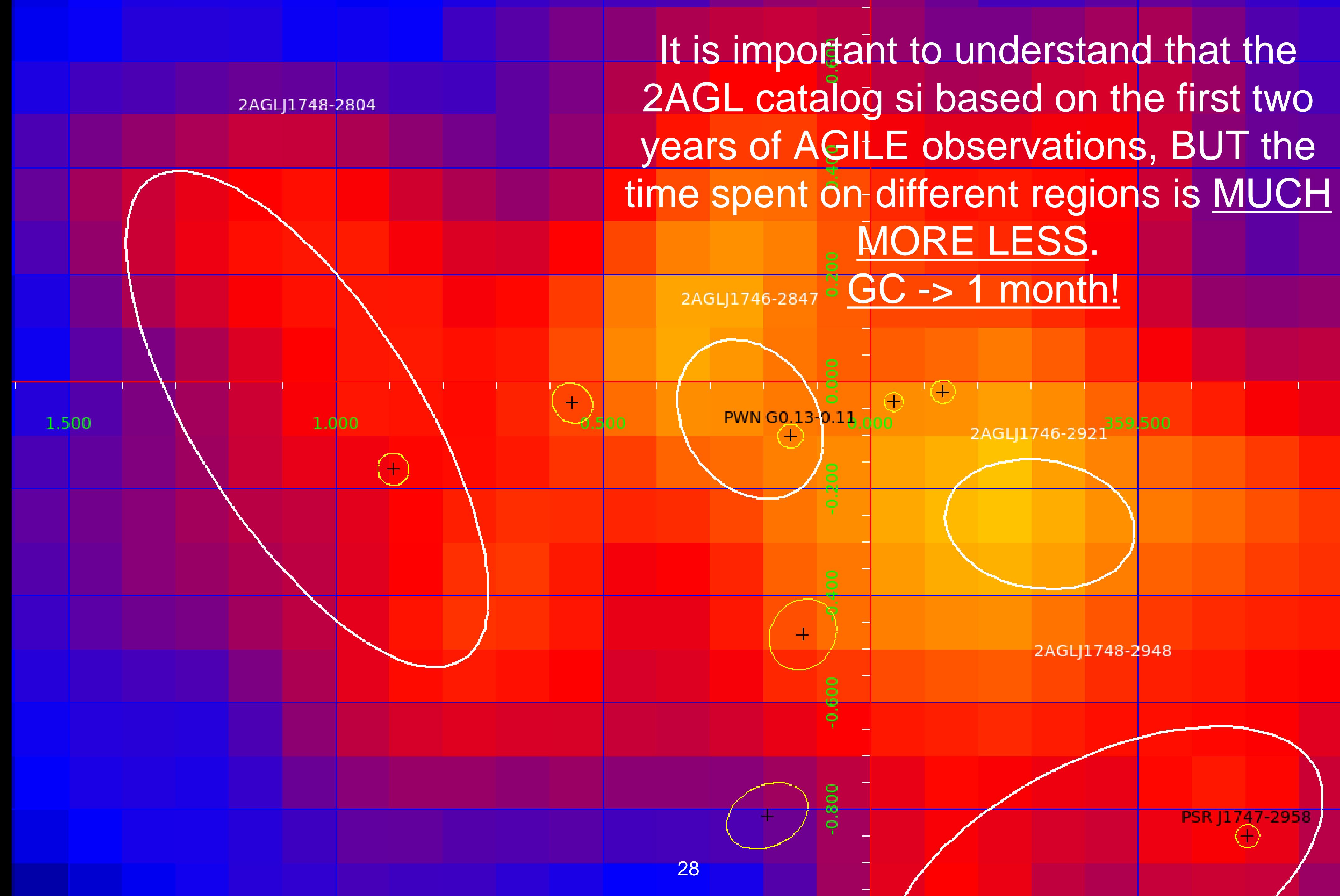
GALACTIC CENTER (FINAL VERSION)

New Science Tools

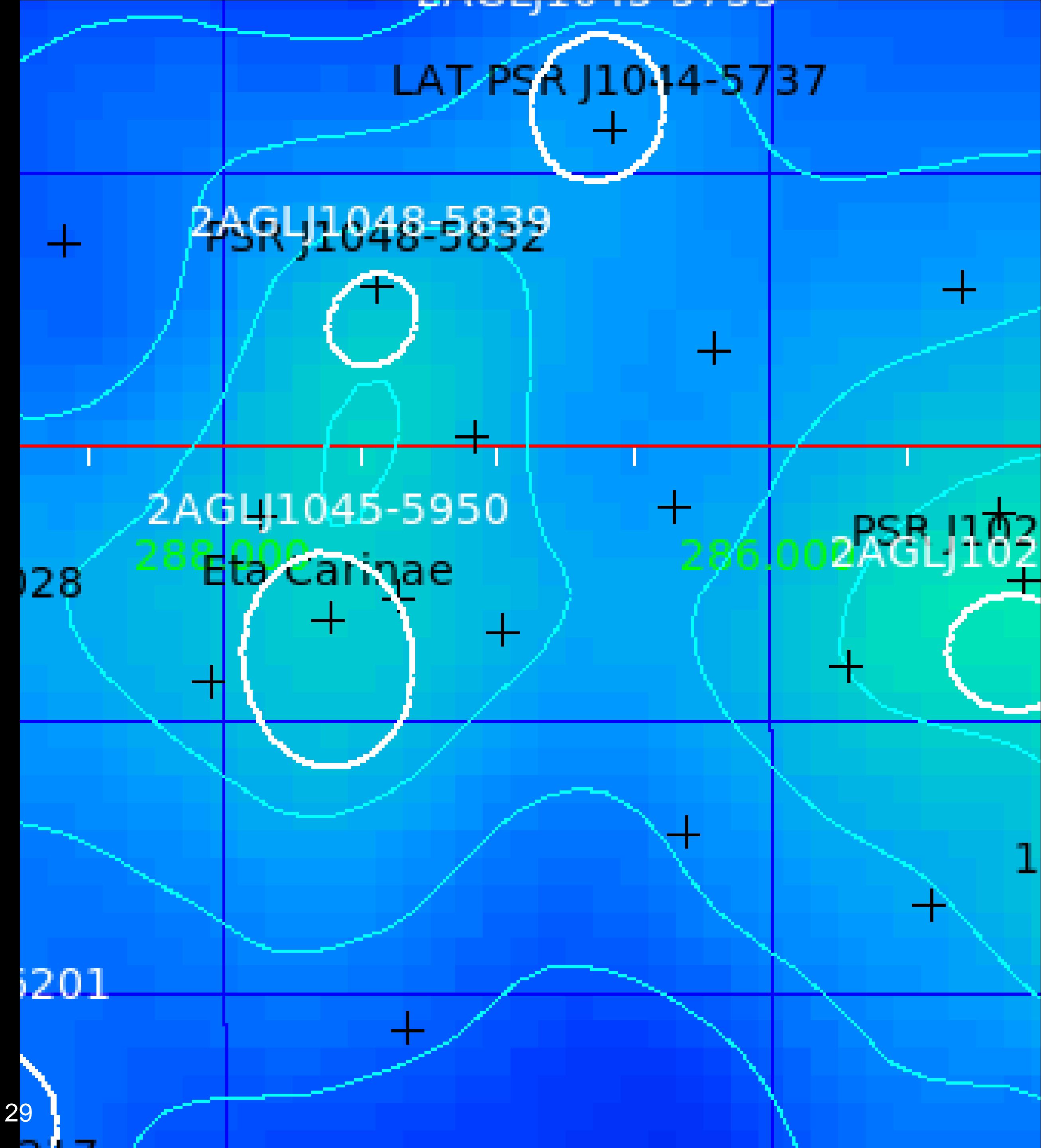
New IRF

New diffuse emission model

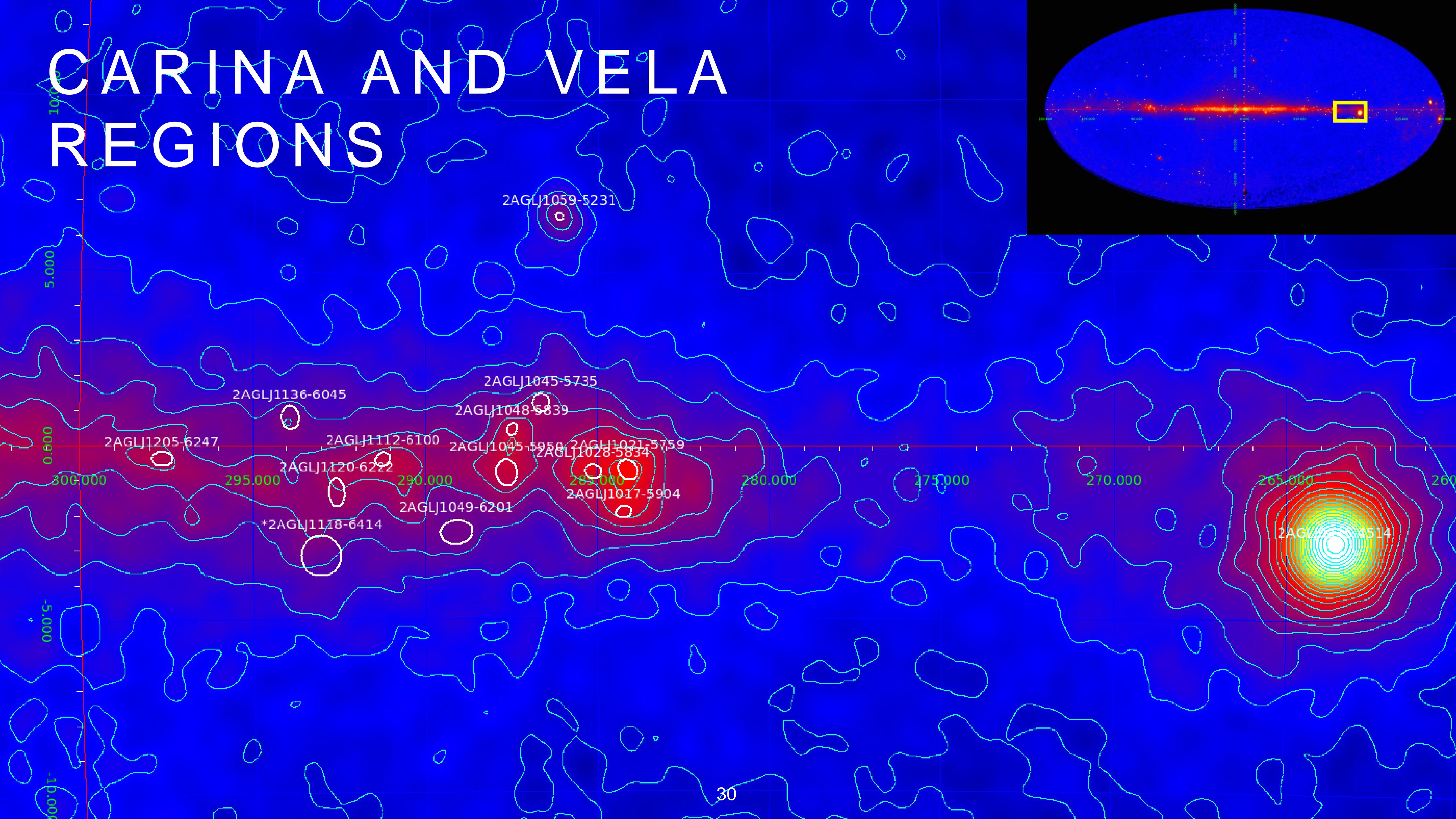
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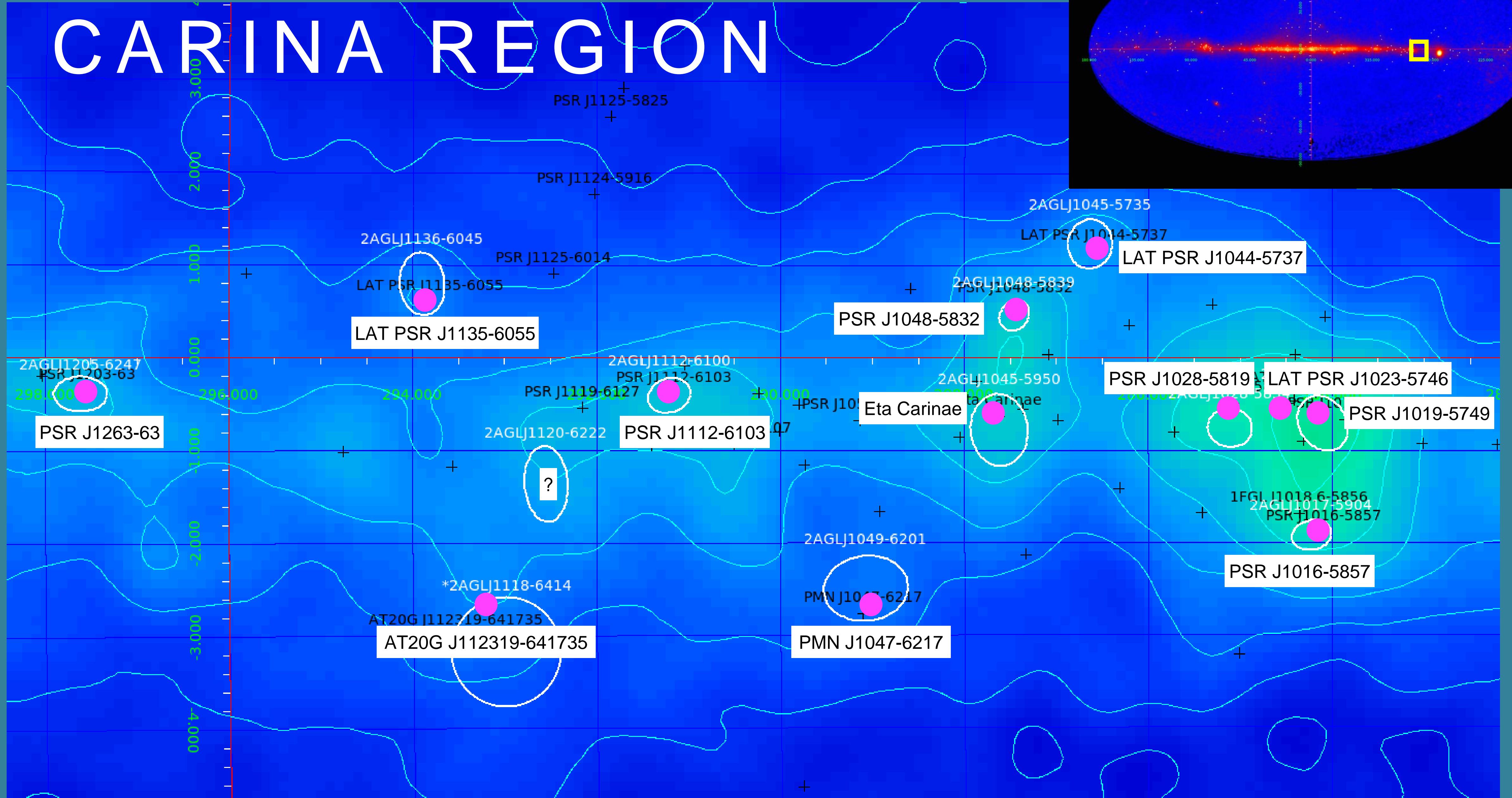
THE CARINA REGION



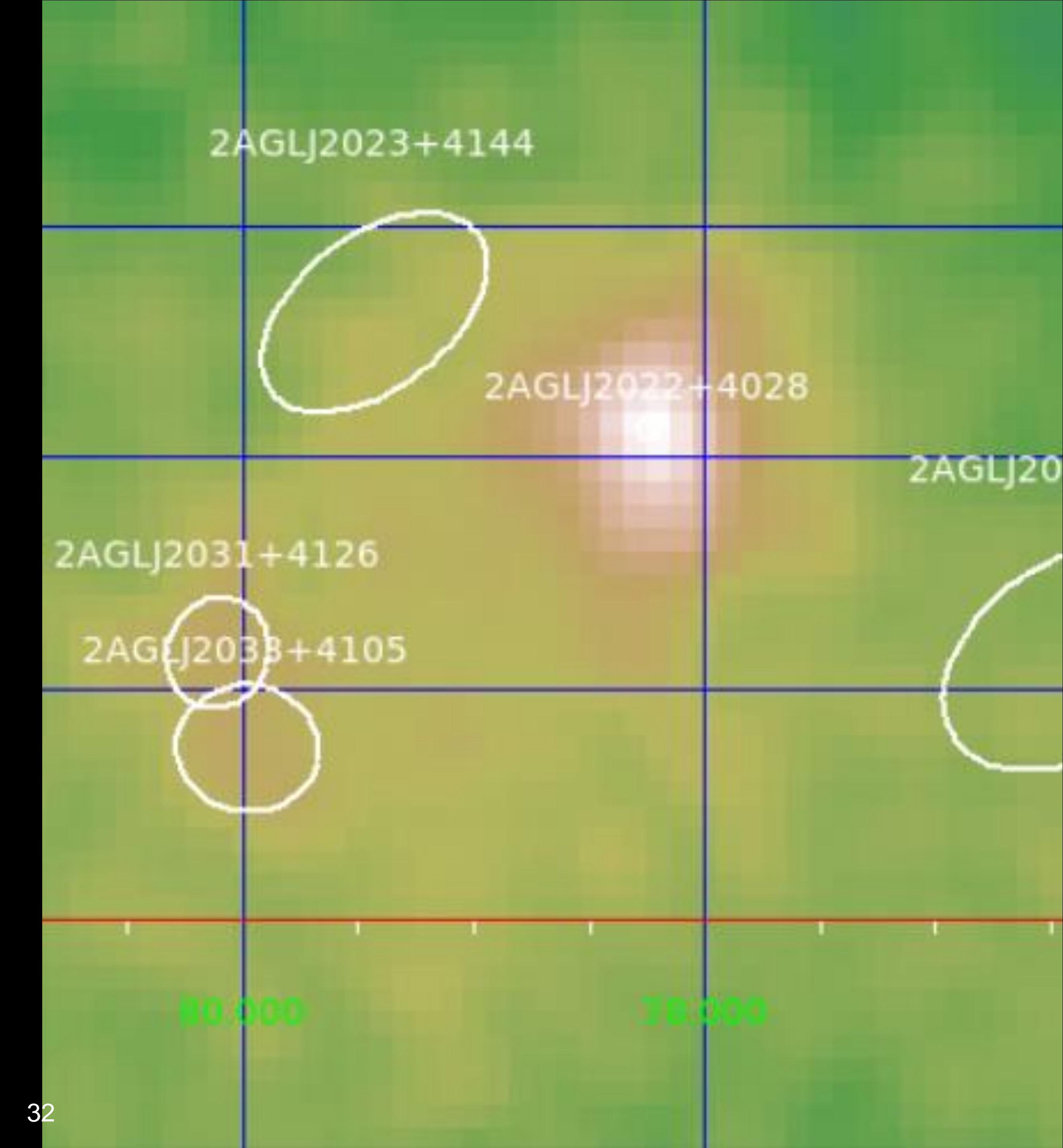
CARINA AND VELA REGIONS



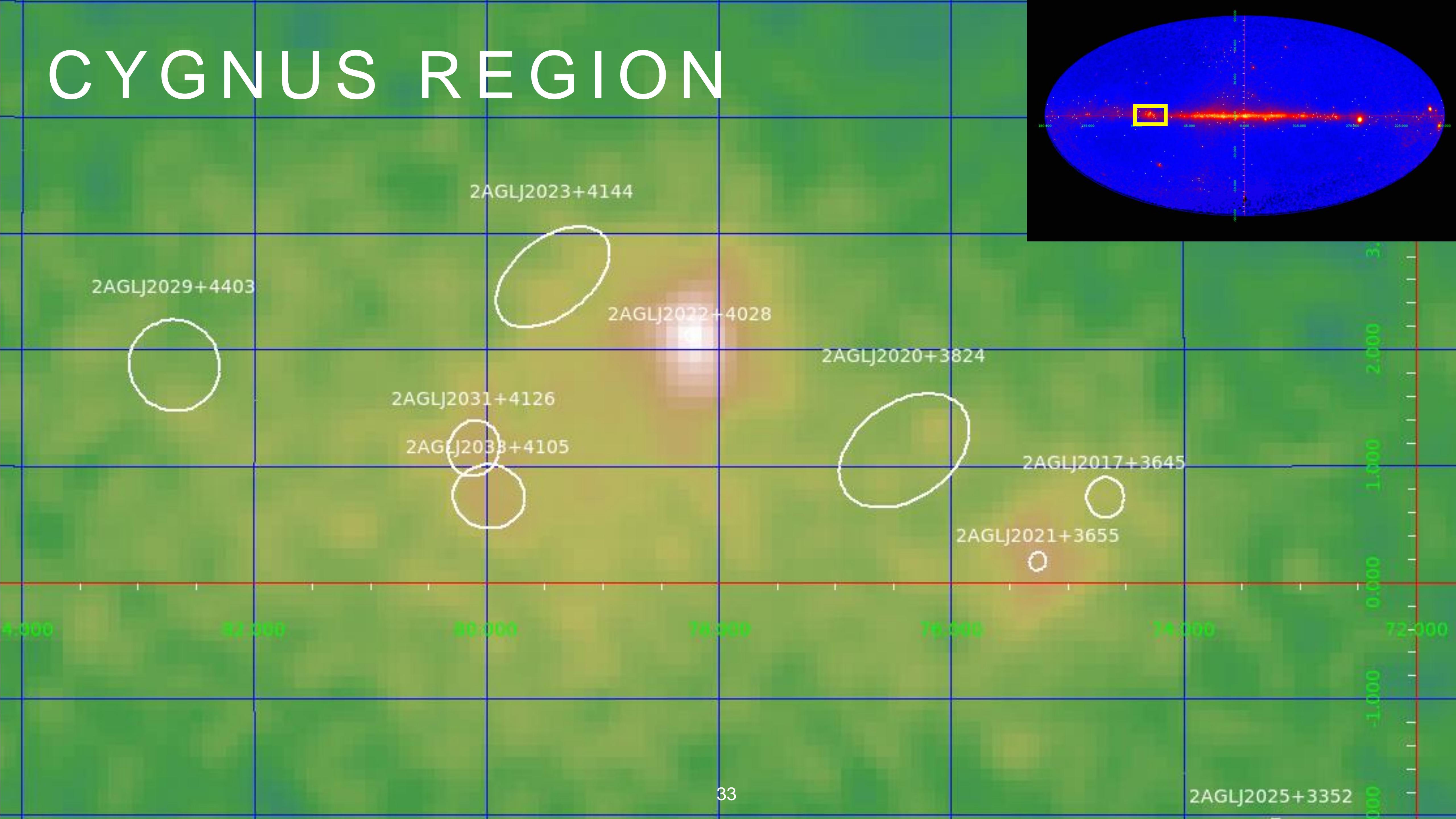
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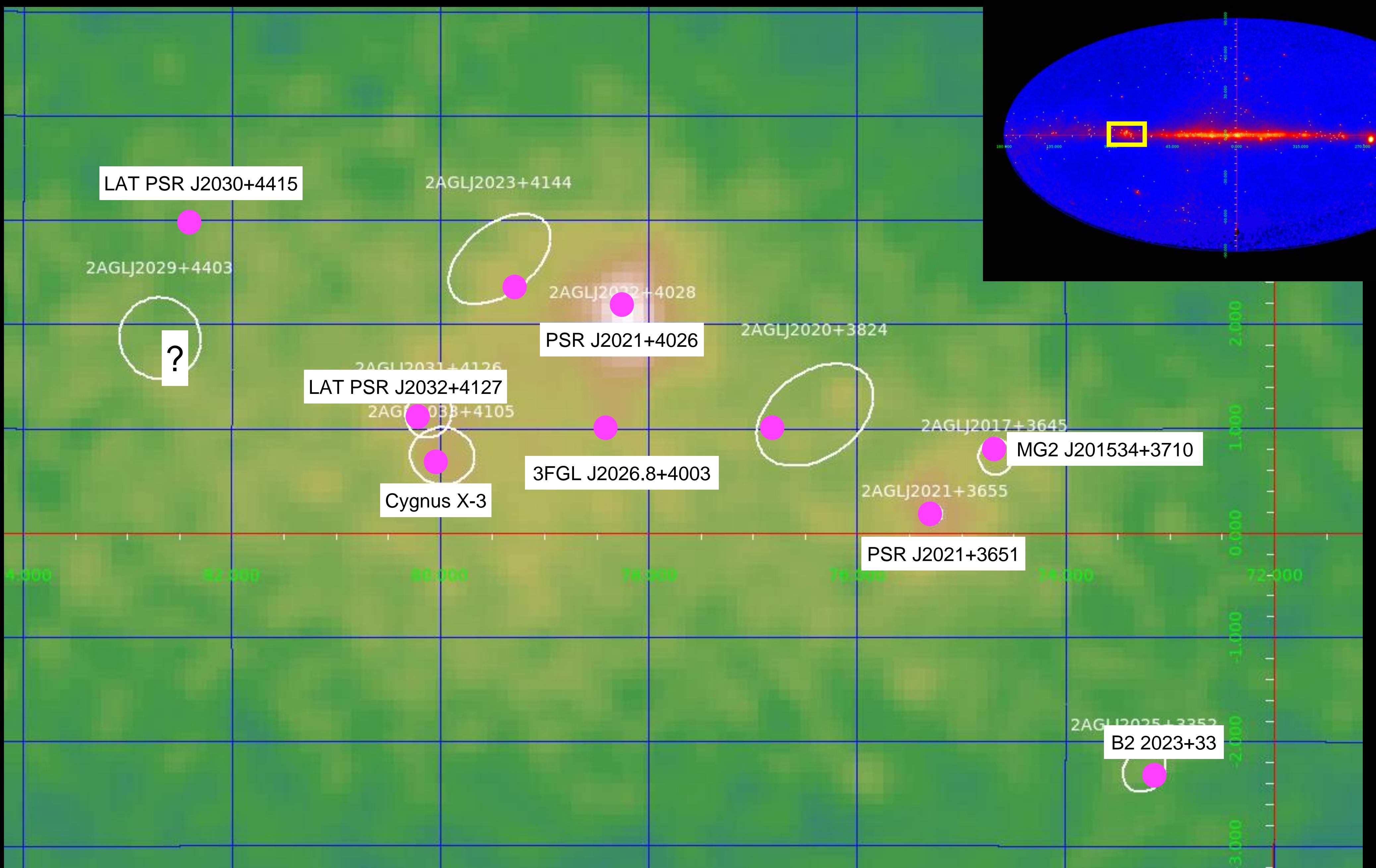


THE CYGNUS REGION



CYGNUS REGION

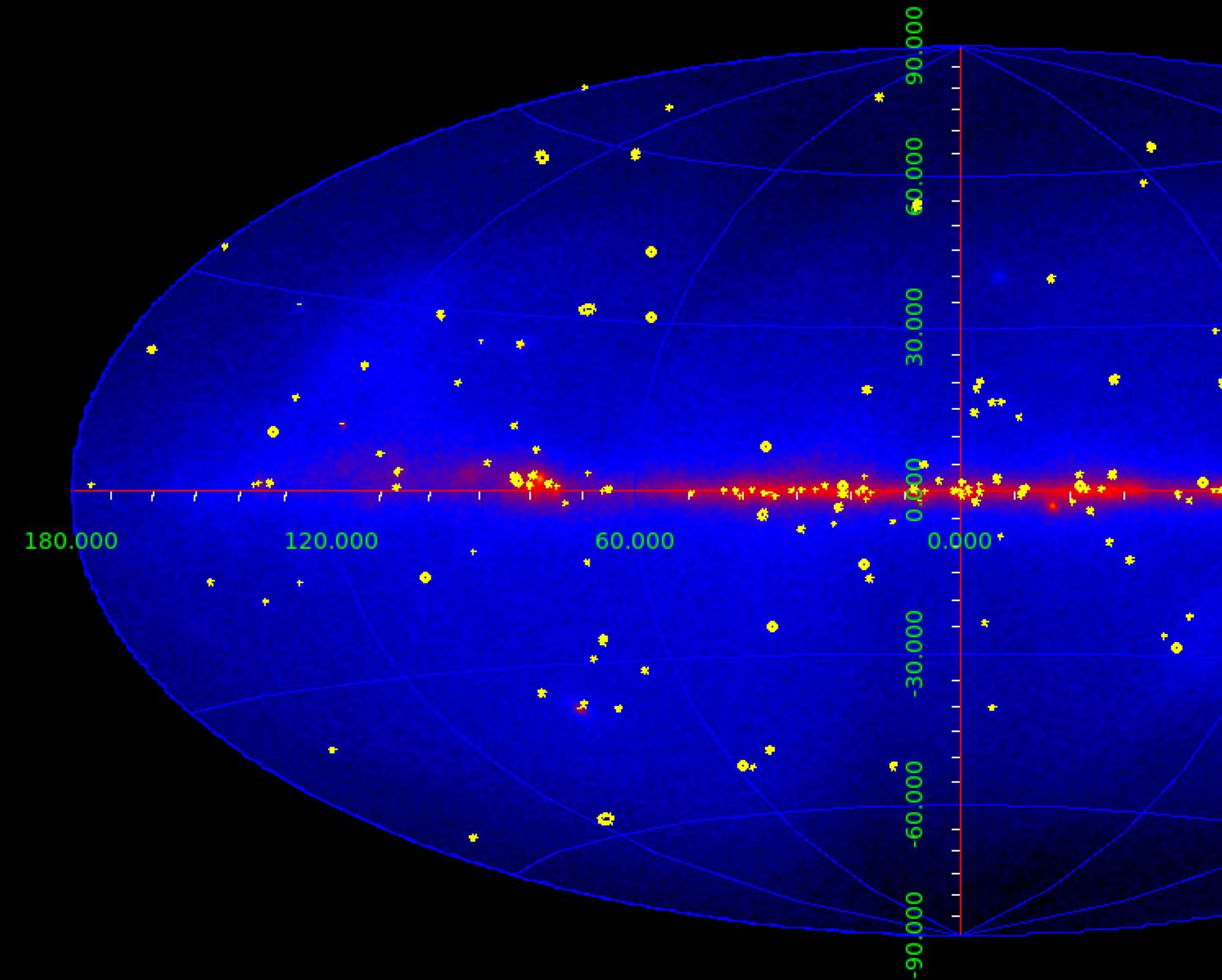




Name	2AGL 1 (deg)	b (deg)	^a Pos. Error (95%) (deg)	\sqrt{TS}	$\Gamma \pm error$	^c Mean Flux & Error ($\times 10^{-8}$ ph cm $^{-2}$ s $^{-1}$)	γ -ray assoc.	Confirmed Counterp.	Classification
2AGLJ1746-2847	0.22	-0.07	0.14	9.4	2.14 ± 0.06	78.4 ± 9.2	1FGL J1746.4-2849c 2FGL J1746.6-2851c 3FGL J1746.3-2851c 3EG J1746-2851	PWN G0.13-0.11 PWN G0.13-0.11 2EG J1746-2852	PWN PWN 9999
2AGLJ1748-2804	1.05	-0.07	0.34	8.5	2.14 ± 0.08	42.9 ± 5.5	TeV J1747-2809 3FGL J1748.3-2815c	SNR G0.9+0.1 -	PWN -
2AGLJ1748-2448	3.76	1.78	0.31	9.1	2.43 ± 0.1	38.9 ± 5.7	TeV J1747-2448 TeV J1747-248 1FGL J1747.9-2448 2FGL J1748.0-2447 3FGL J1748.0-2447	Terzan 5 Terzan 5 Terzan 5 Terzan 5 Terzan 5	GC - GLC GLC GLC
2AGLJ1801-2334	6.34	-0.18	0.19	13.3	2.19 ± 0.06	56.6 ± 5.9	2FHL J1801.3-2326e 1AGL J1803-2258 0FGL J1801.6-2327 2FGL J1801.3-2326e 3FGL J1801.3-2326e 3EG J1800-2338	W28 - UNDEFINED SNR G006.4-00.1 W28 2EG J1801-2312	SNR SNR SNR/PWN SEE PAPER SNR SNR 9999
2AGLJ1810-2337	7.33	-2.06	0.1	14.2	1.74 ± 0.09	41.1 ± 5.5	1AGL J1809-2332 1AGLR J1809-2333 0FGL J1809.5-2331 1FGL J1809.8-2332 2FGL J1809.8-2332 3FGL J1809.8-2332 3EG J1809-2328	- - LAT PSR J1809-2332 LAT PSR J1809-2332 LAT PSR J1809-2332 PSR J1809-2332 2EG J1811-2339	- - PULSAR PSR PSR PSR 9999
2AGLJ1804-2138	8.36	0.19	0.39	8.1	2.47 ± 0.13	42.8 ± 6.5	TeV J1804-2143 TeV J1804-216 1AGL J1805-2143 1AGLR J1805-2149 0FGL J1805.3-2138 1FGL J1803.1-2147c 1FGL J1805.2-2137c 2FGL J1803.3-2148 3FGL J1803.1-2147	HESS J1804-216 HESS J1804-216 - - UNDEFINED -	- - EXTENDED - - UNIDENTIFIED - SPP - PSR
								LAT PSR J1803-2149	

CONCLUSIONS

- The 2th AGILE catalog has been finalized
- 190 2AGL gamma-ray sources: (134 with positional association). 20 AGILE only sources (under investigation)



“Thank you.”

-ANDREA