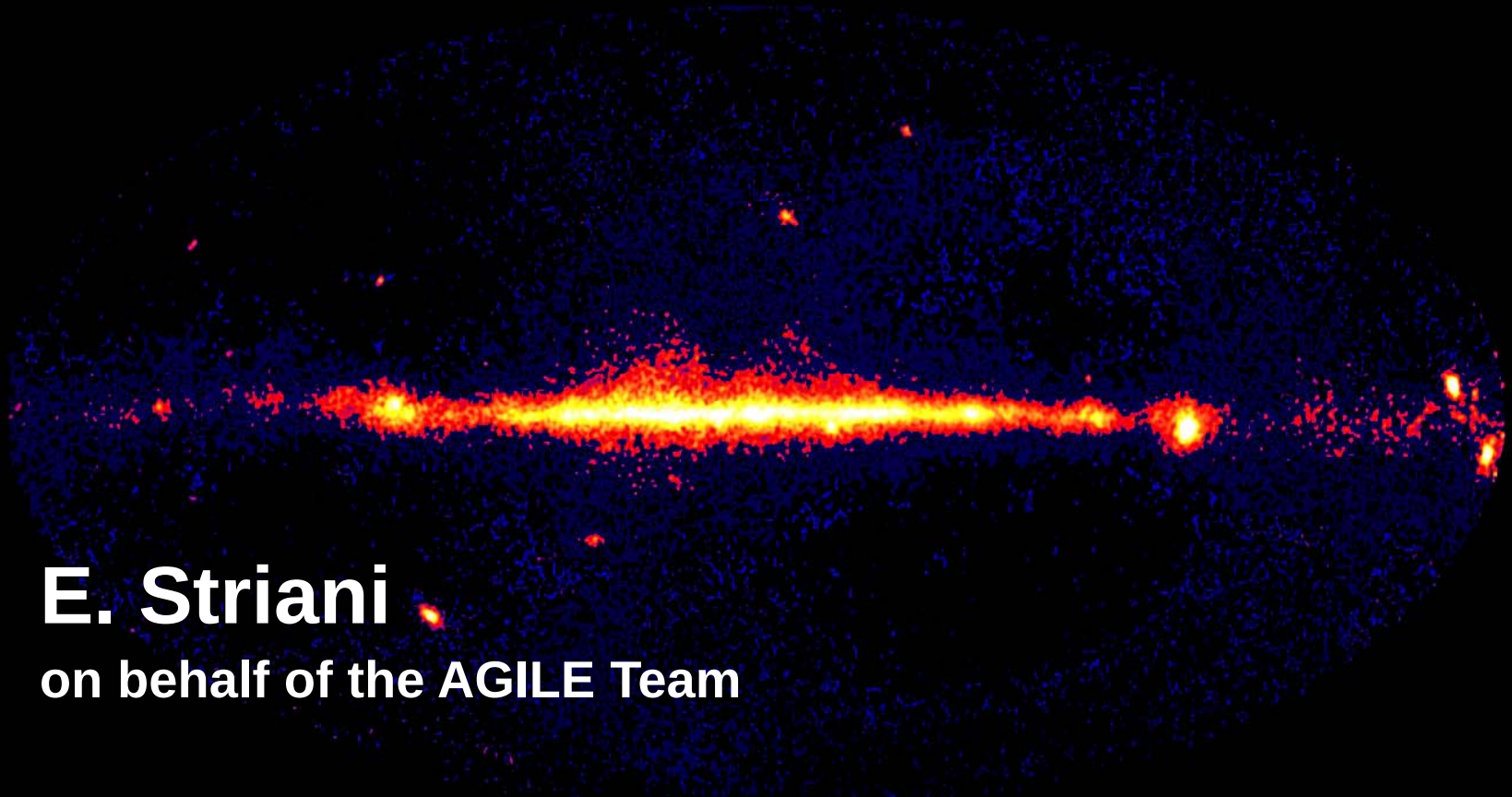
The AGILE gamma-ray sky



E. Striani

on behalf of the AGILE Team

SCINEGHE 09, Oct. 7, 2009

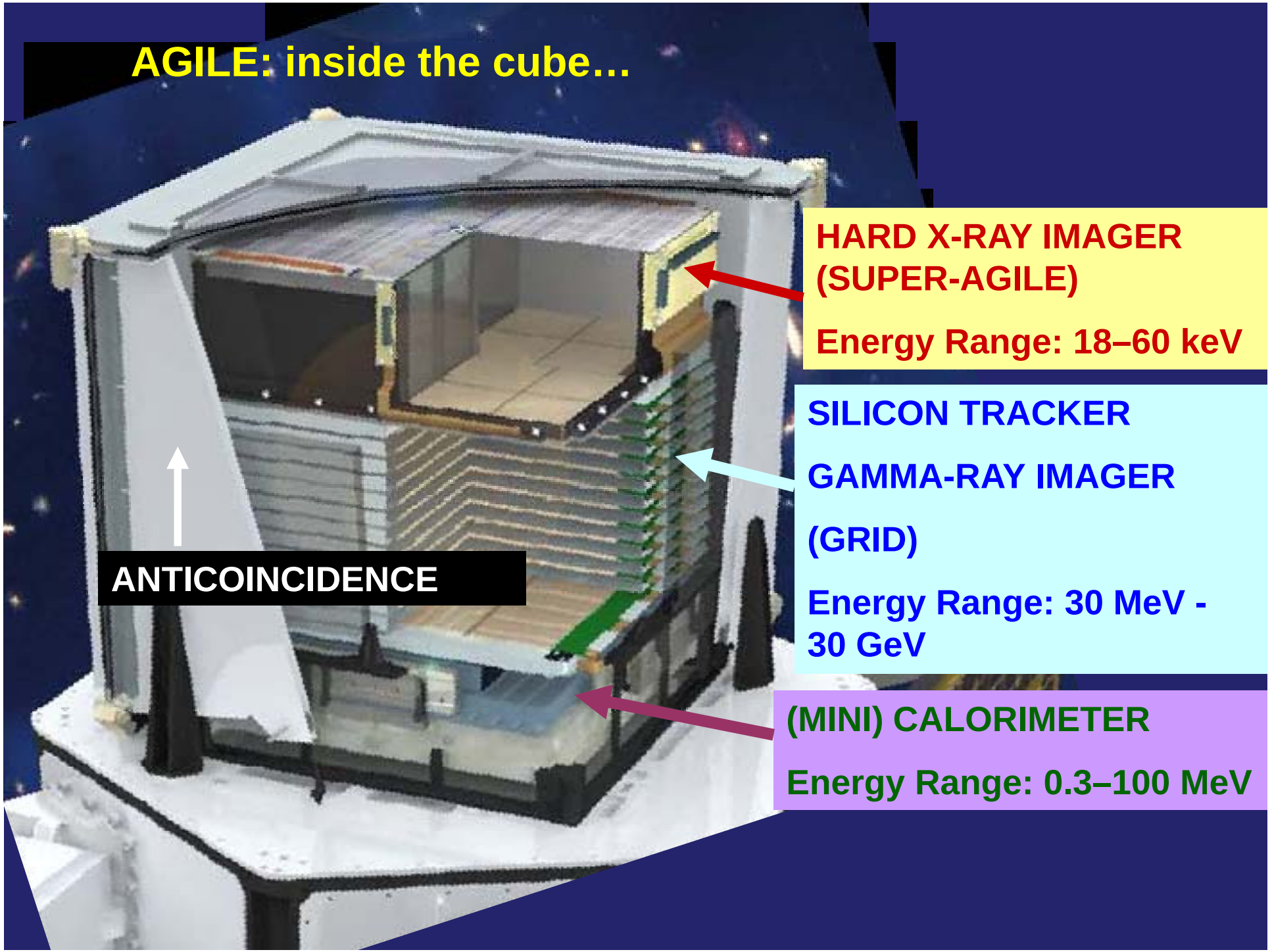
The AGILE Payload: the most compact instrument for high-energy astrophysics

It combines for the first time a gamma-ray imager (30 MeV- 30 GeV) with a hard X-ray imager (18-60 keV) with large FOVs (1-2.5 sr) and optimal angular resolution

Gamma-ray astrophysics missions (above 30 MeV)

SAS-2	NASA	Nov. 1972 – July 1973
COS–B	ESA	Aug. 1975 – Apr. 1982
CGRO	NASA	Apr. 1991 – Jun. 2000
AGILE	ASI	April 23, 2007
FERMI	NASA	June 11, 2008

AGILE: inside the cube…



HARD X-RAY IMAGER
(SUPER-AGILE)

Energy Range: 18–60 keV

SILICON TRACKER

GAMMA-RAY IMAGER

(GRID)

Energy Range: 30 MeV - 30 GeV

(MINI) CALORIMETER

Energy Range: 0.3–100 MeV

ANTICOINCIDENCE

AGILE: 2 and 1/2 years in orbit…

- ~ 12.600 orbits, October 7, 2009.
- very good scientific performance
- Cycle-1: Dec. 2007- Nov. 2008
- Cycle-2: Dec. 2008- Nov. 2009
- approved funding: 2010-2011

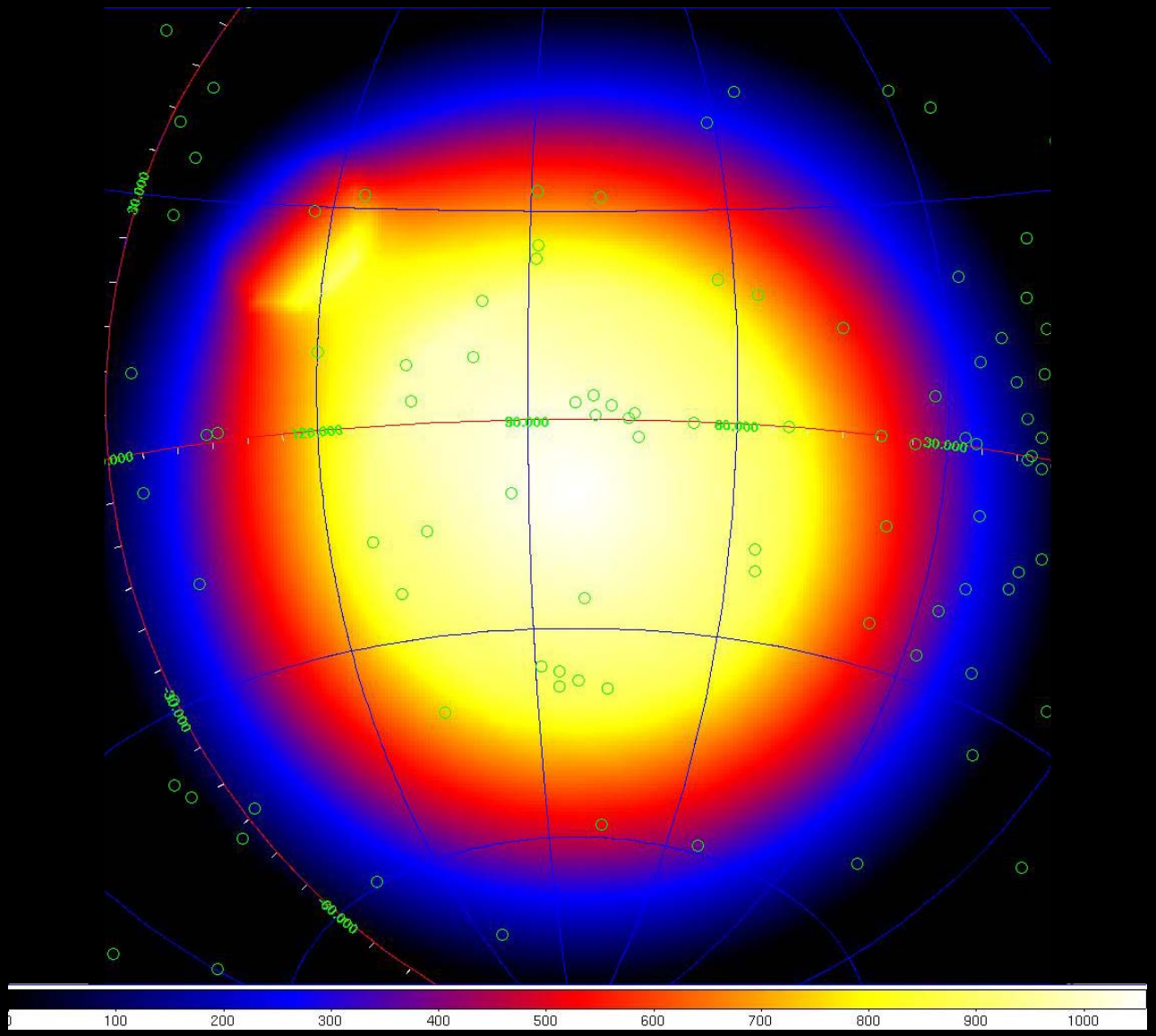
A quick comparison

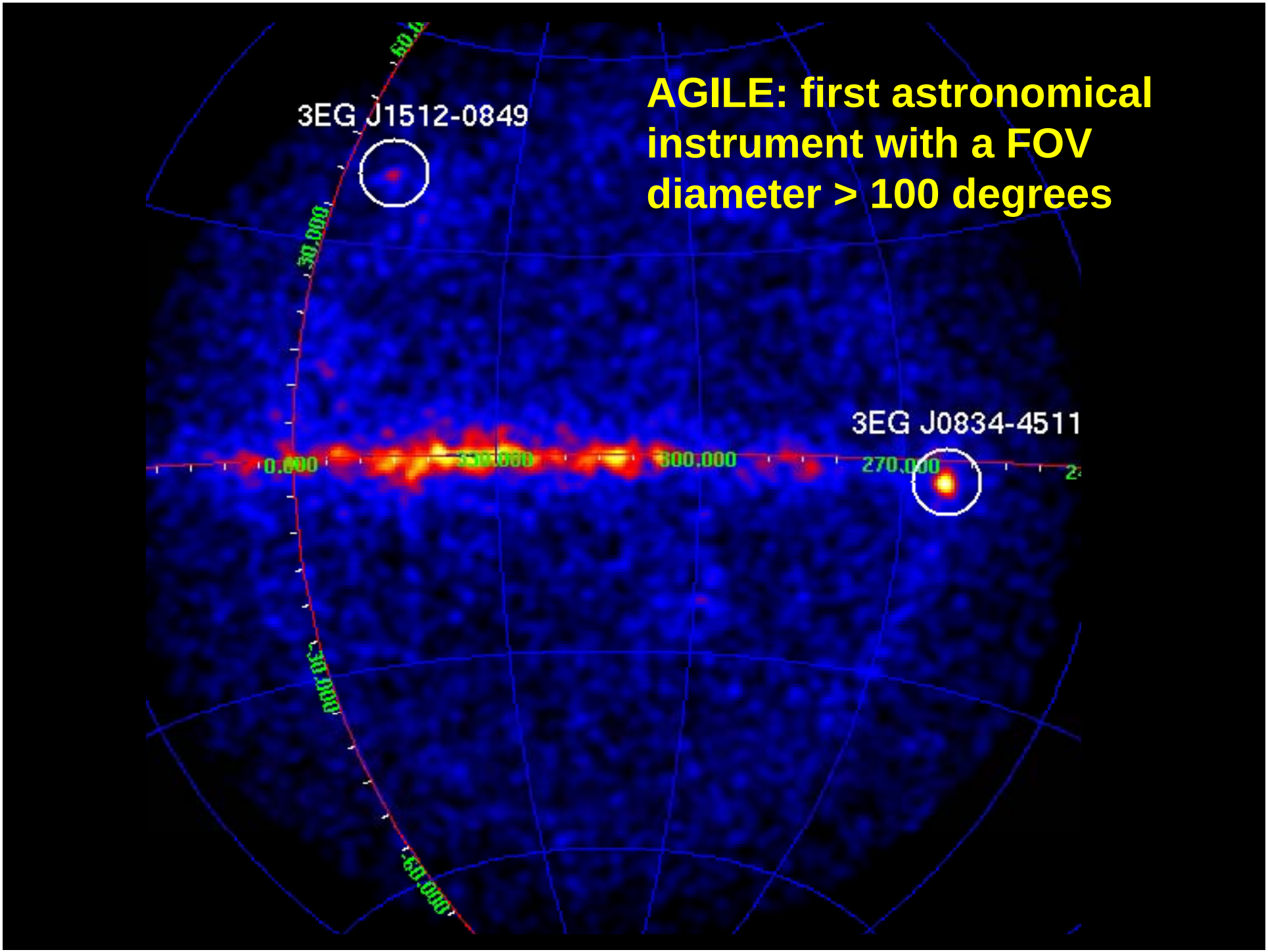
	AGILE	FERMI/LAT
A_{eff} (100 MeV) (cm^2)	~400	~ 1000-2000
A_{eff} (1 GeV) (cm^2)	500	~ 8000-10000
FOV (sr)	2.5	2.5
sky coverage	1/5	whole sky
Energy resolution (~ 400 MeV)	50 %	10 %
PSF (68 % cont. radius) 100 MeV 1 GeV	 3º - 4º < 1º	 4º - 5º < 1º

a comparison: 1-day exposure

	AGILE (GRID)	FERMI (LAT)
FOV (sr)	2.5	2.5
sky coverage	1/5	whole sky
Source livetime fraction	~ 0.5	~ 0.16
1-day exposure (30 degree off-axis, at 100 MeV)	~ 10^7 cm^2 sec	~ 10^7 cm^2 sec
Attitude	fixed	variable

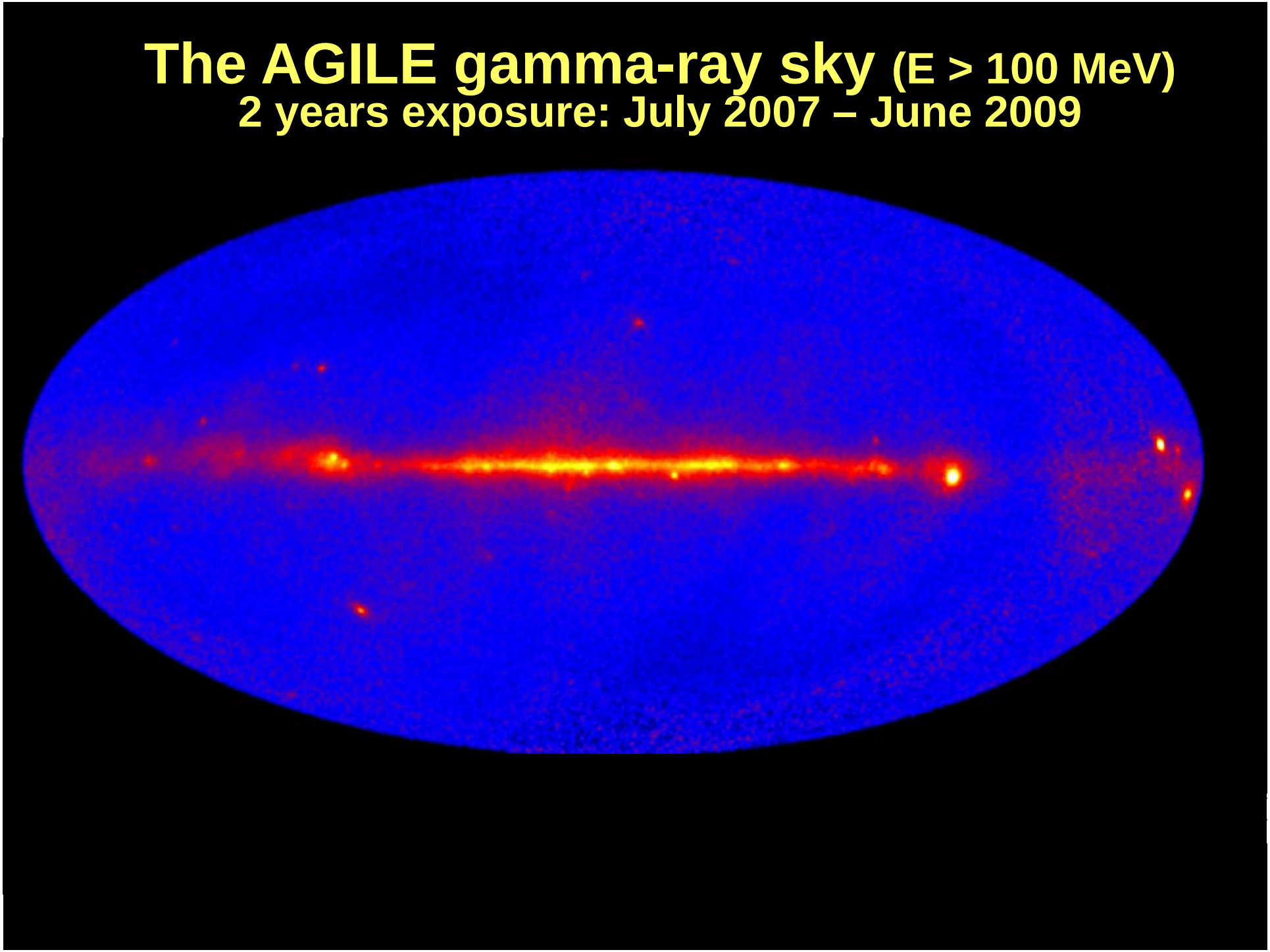
The AGILE 1-day exposure (E > 100 MeV) (30 Nov. 2008)



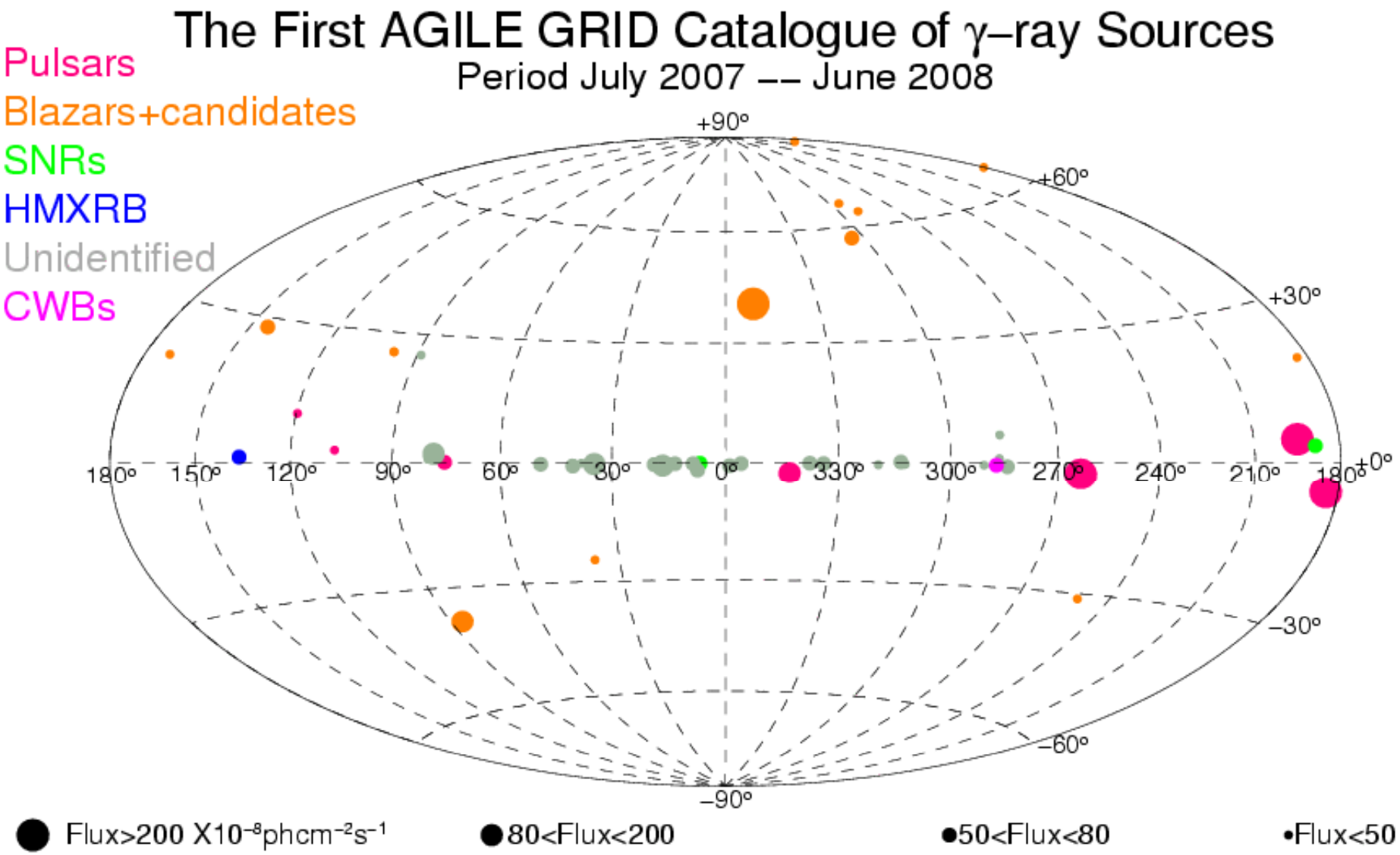

3EG J1512-0849
3EG J0834-4511
AGILE: first astronomical instrument with a FOV diameter > 100 degrees
0.000
300.000
270.000

The AGILE gamma-ray sky (E > 100 MeV)

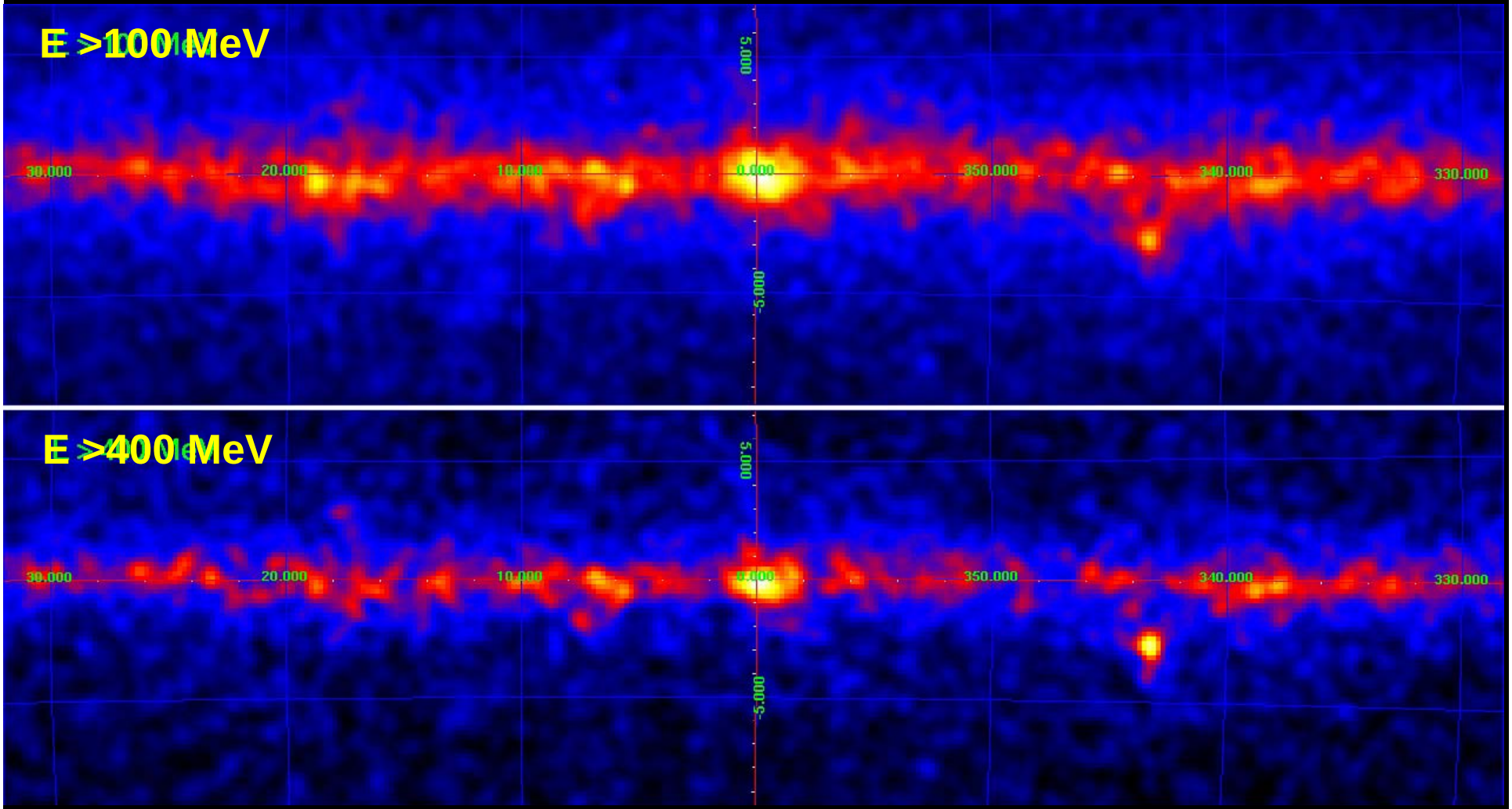
2 years exposure: July 2007 – June 2009

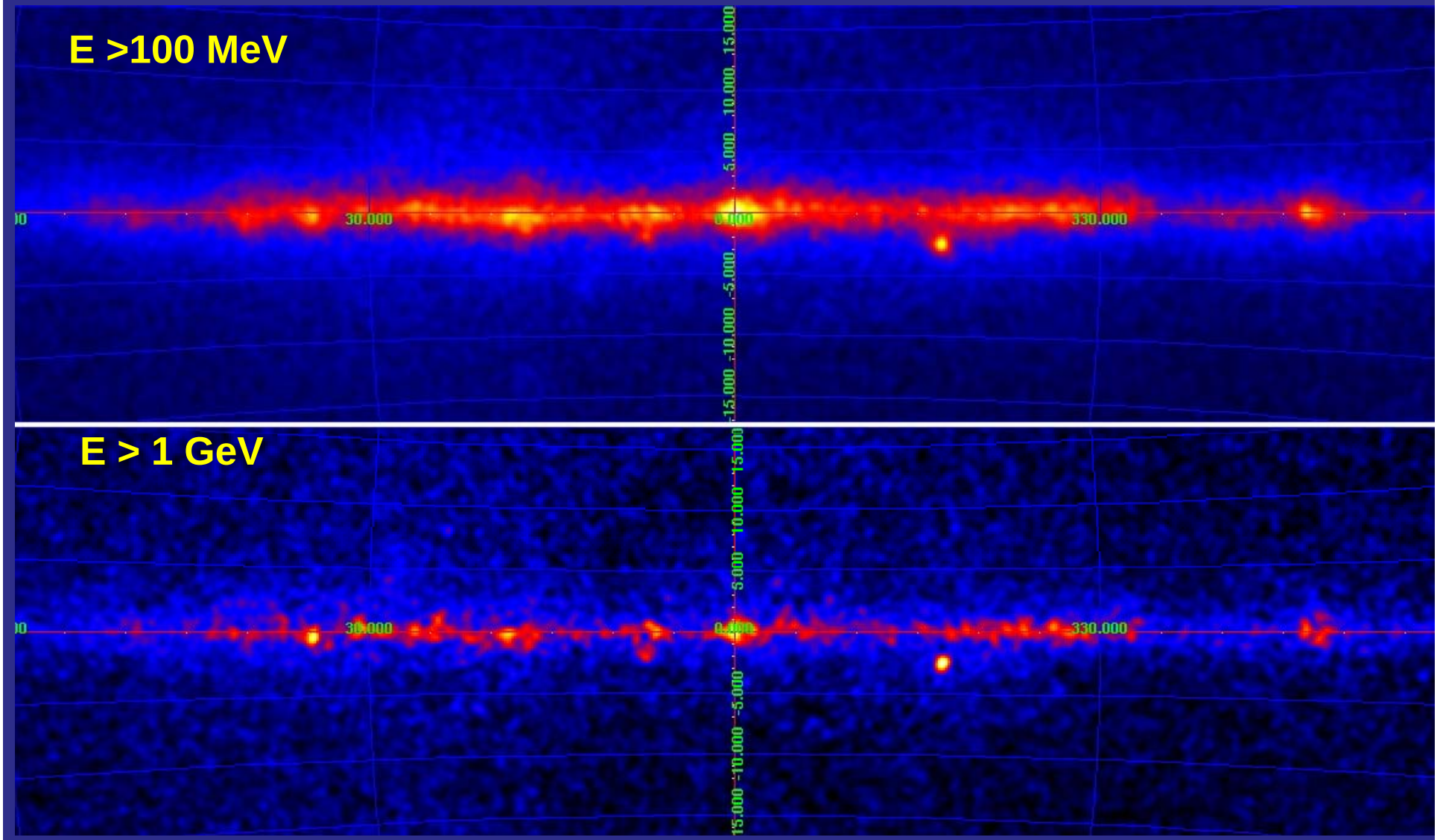


High-significance AGILE gamma-ray sources (ASDC)

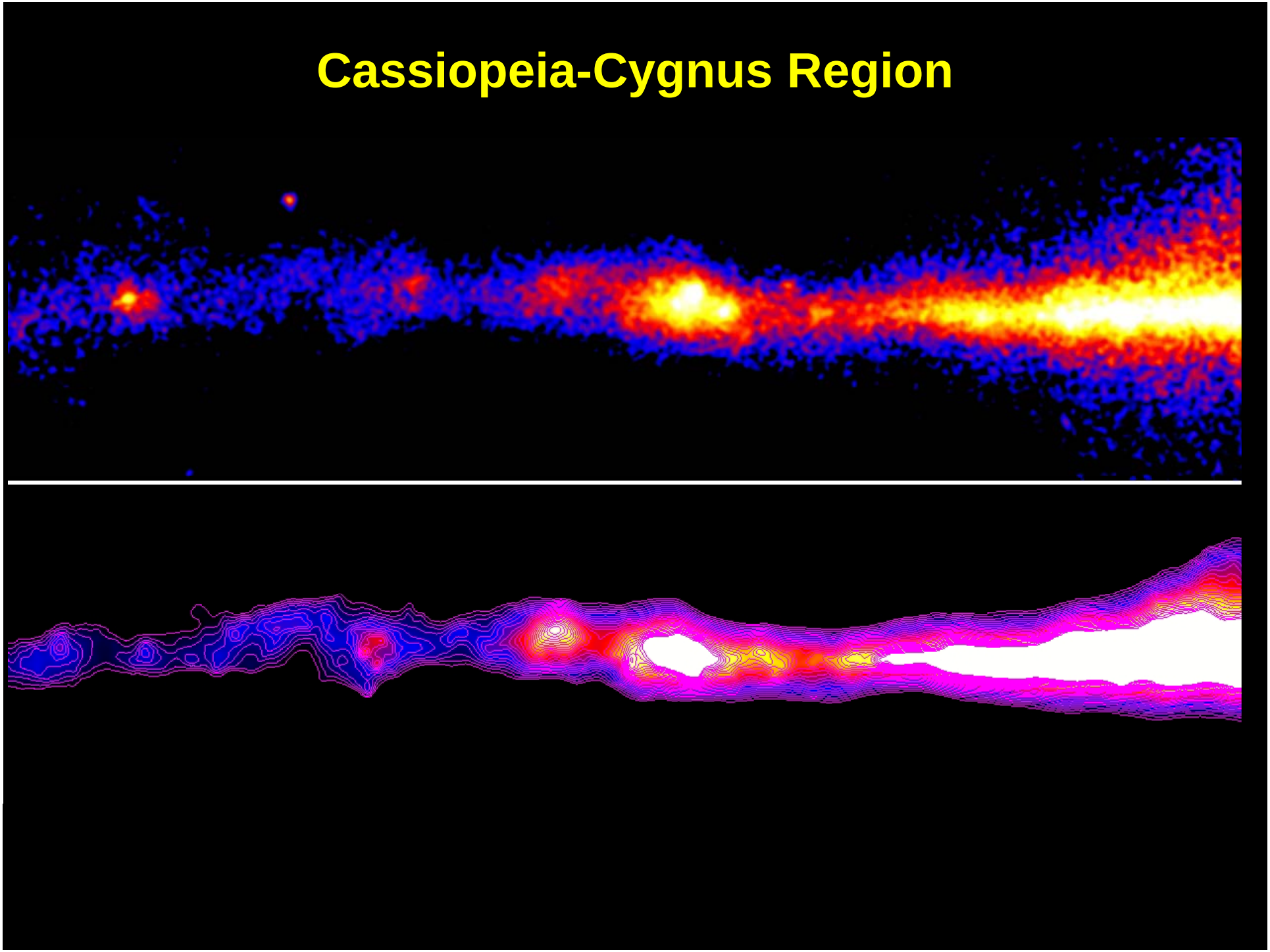


AGILE, Galactic Center Region at 100 and 400 MeV

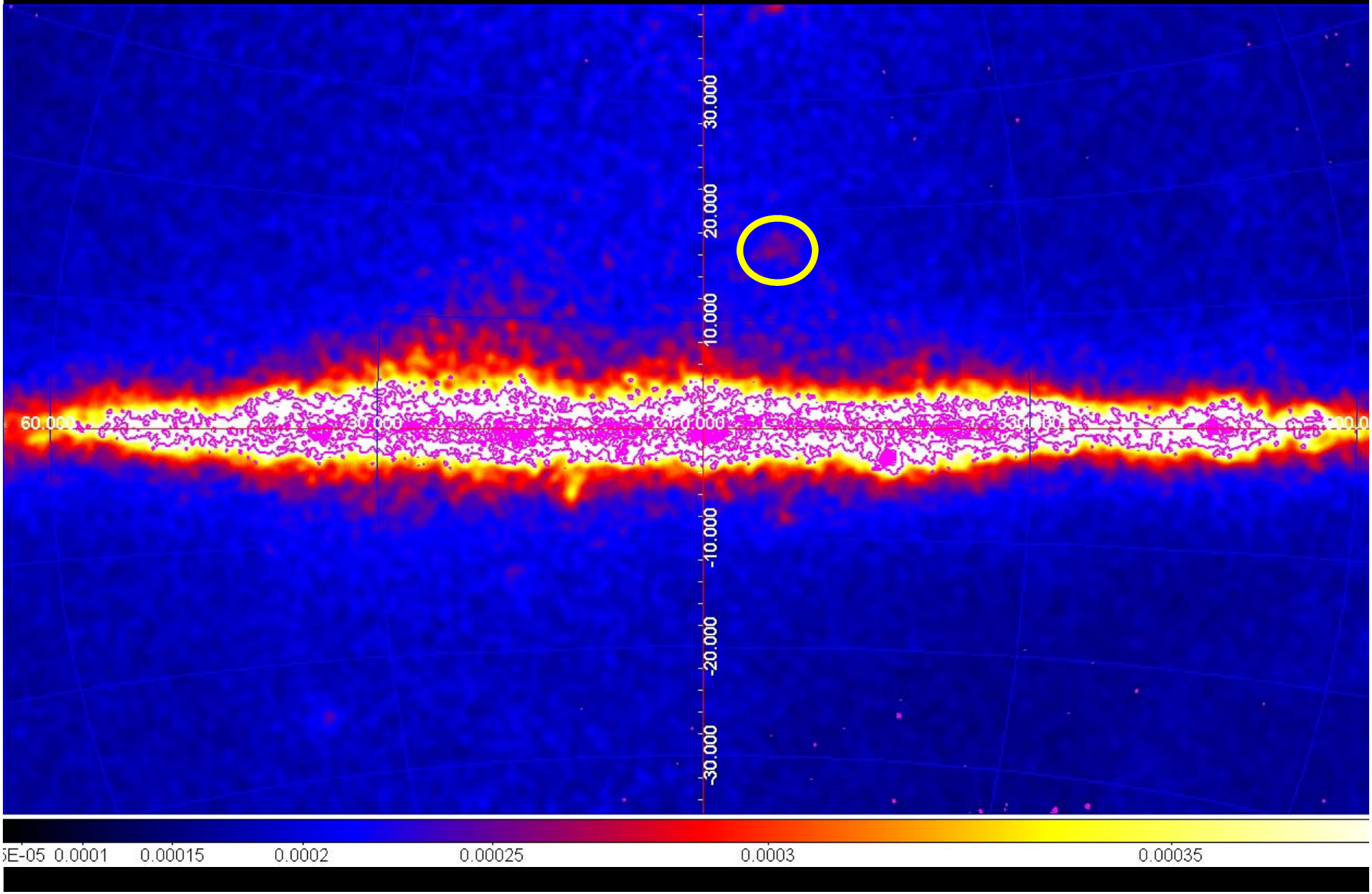



E >100 MeV
30.000
330.000
15.000
10.000
5.000
-5.000
-10.000
-15.000
E > 1 GeV
30.000
330.000
15.000
10.000
5.000
-5.000
-10.000
-15.000

Cassiopeia-Cygnus Region



Molecular cloud studies: example of the GC



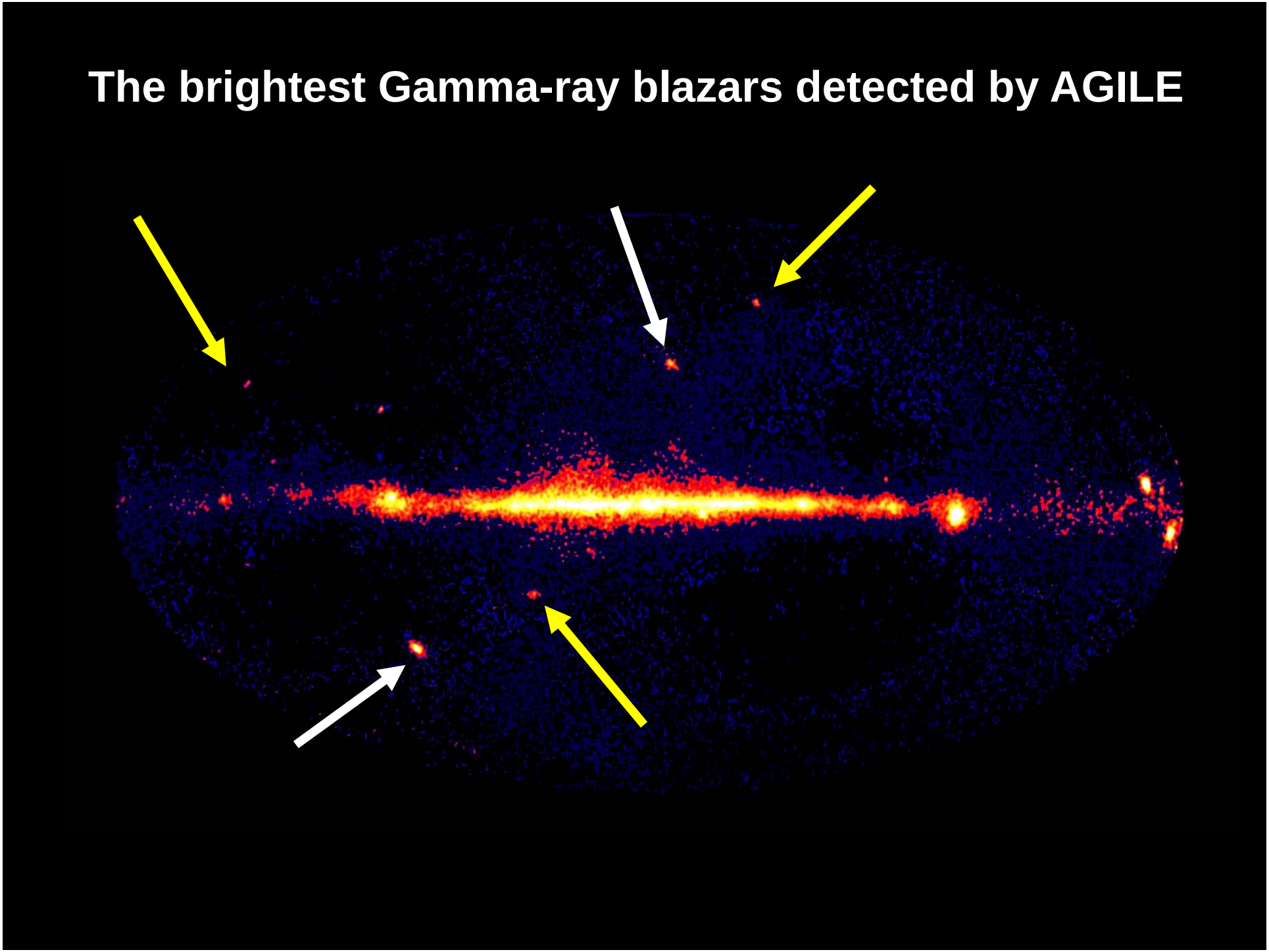
Main science topics

- Bright blazars (3C 454.3, PKS 1510-089, TX 0716+714)
- 10 new Pulsars
- Discovery gamma-ray transients in the Galaxy
- Microquasar studies, Gamma-ray emission from Gal. compact objects
- SNRs and origin of cosmic rays
- Gamma-Ray Bursts, Millisecond triggers, Terrestrial Flashes

Multifrequency science

- AGILE, FERMI
- Radio Telescopes (VLA, Mojave, Michigan)
- Optical Obs. Networks (GASP, REM, …)
- SWIFT, Suzaku, XMM
- INTEGRAL
- TeV (MAGIC, HESS, VERITAS)

The brightest Gamma-ray blazars detected by AGILE



The brightest gamma-ray blazars are very well studied by AGILE

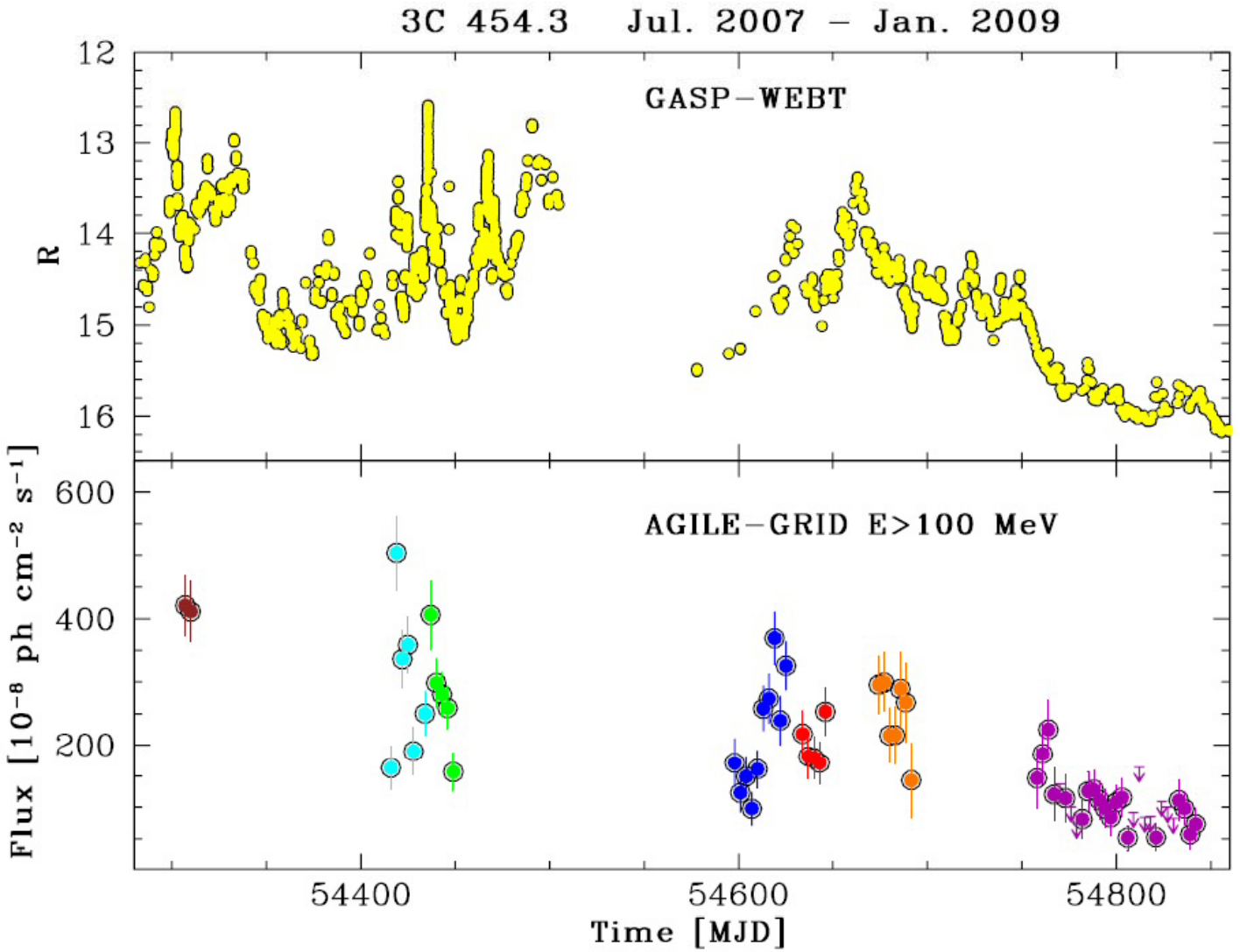
- 3C 454.3
- HB 1510-089
- TXS 0716+714
- 3C 279
- 3C 273
- Mrk 421
- PKS 0537-441

3C 454.3: the crazy diamond

- the blazar which showed the most variable activity in the gamma-ray sky in the last 2 years
- intensive monitoring of 3C454.3 with AGILE together with Spitzer,WEBT, REM,MITSuME, Swift, RXTE, Suzaku and INTEGRAL observatories
- longest multiwavelength coverage of this gamma-ray quasar so far.

3C 454.3: the Crazy Diamond of 2007-2008

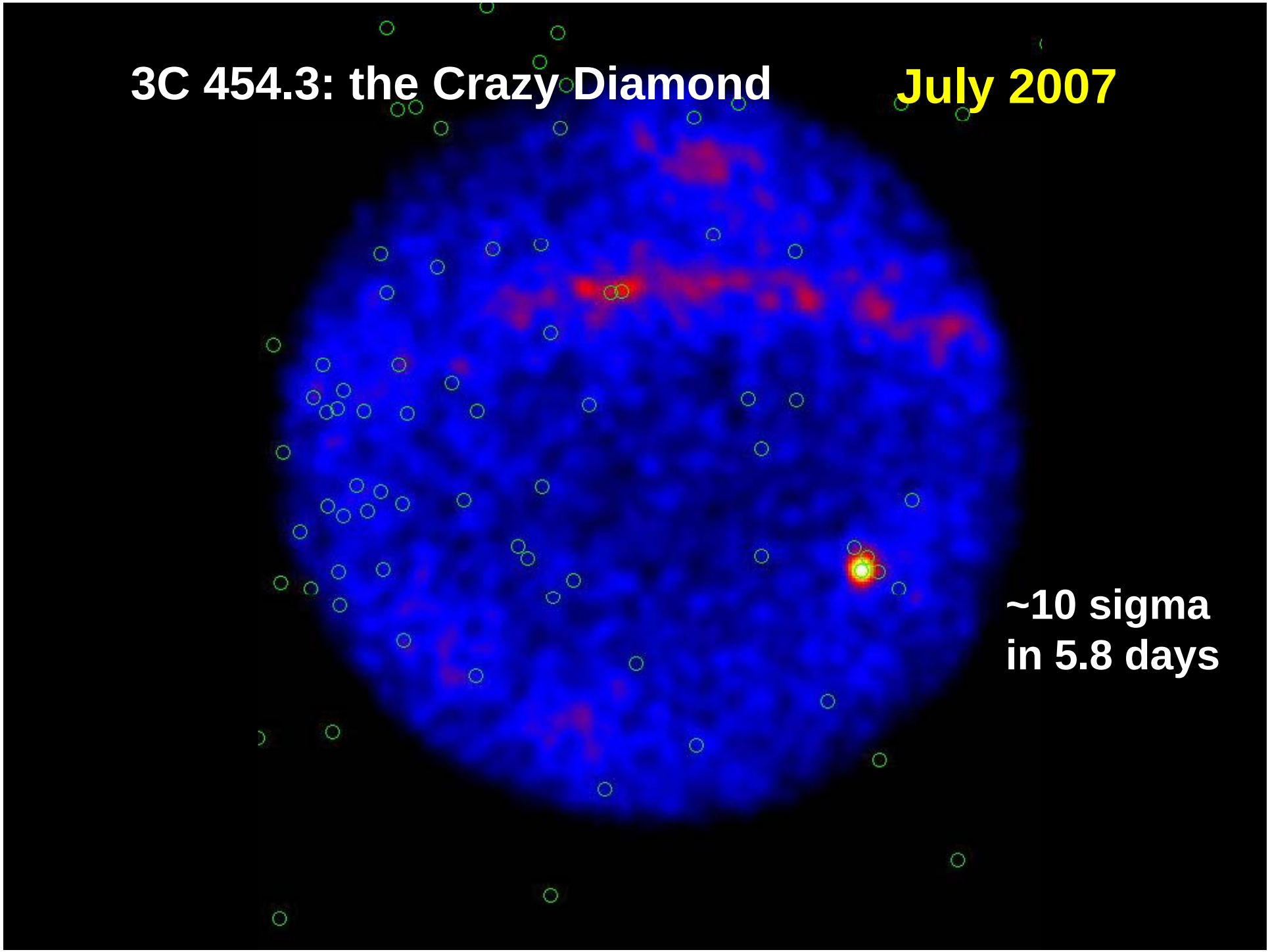
(Vercellone et al. 2007-2008-2009, Donnarumma et al. 2009)

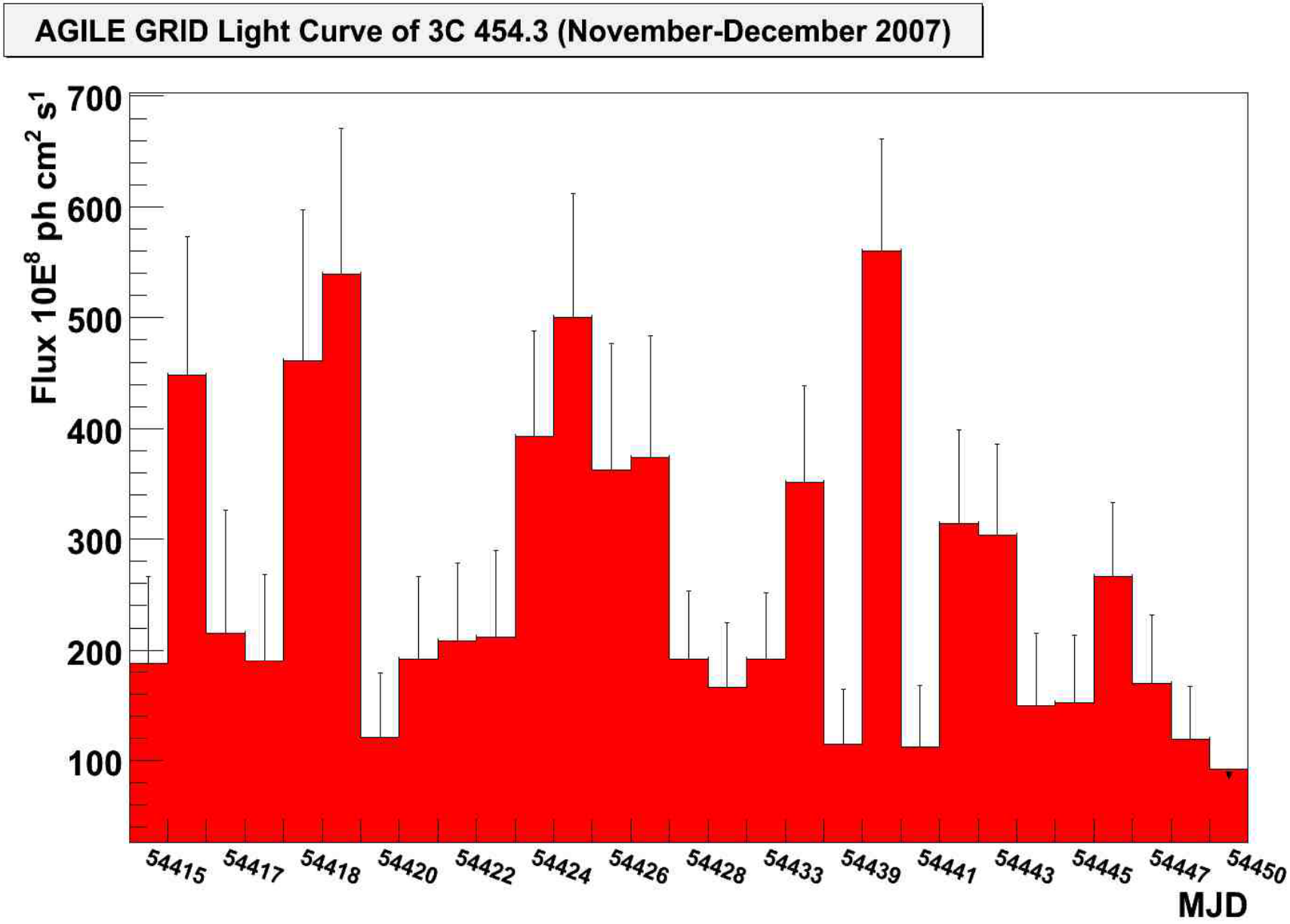


optical

gamma

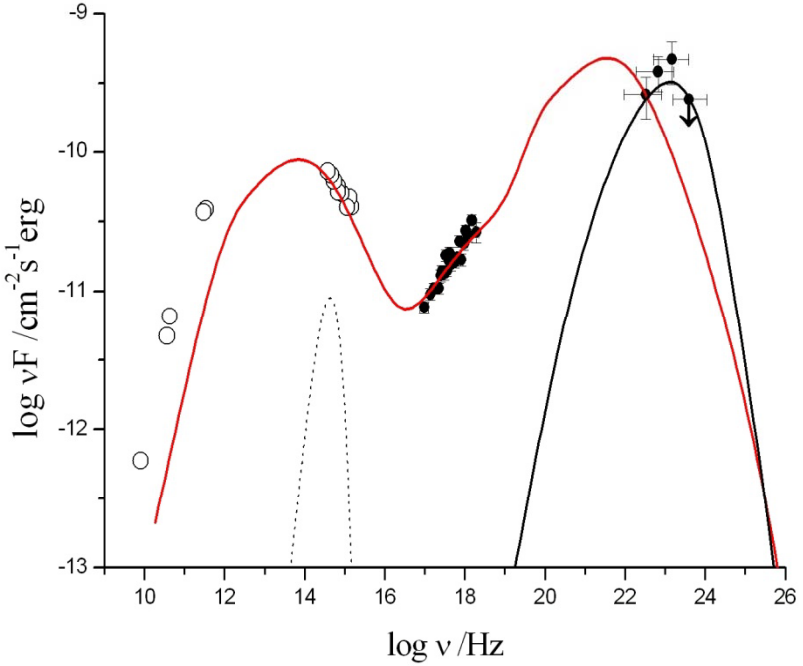
Emission in the optical and gamma-ray bands appears to be well correlated


3C 454.3: the Crazy Diamond
July 2007
~10 sigma
in 5.8 days

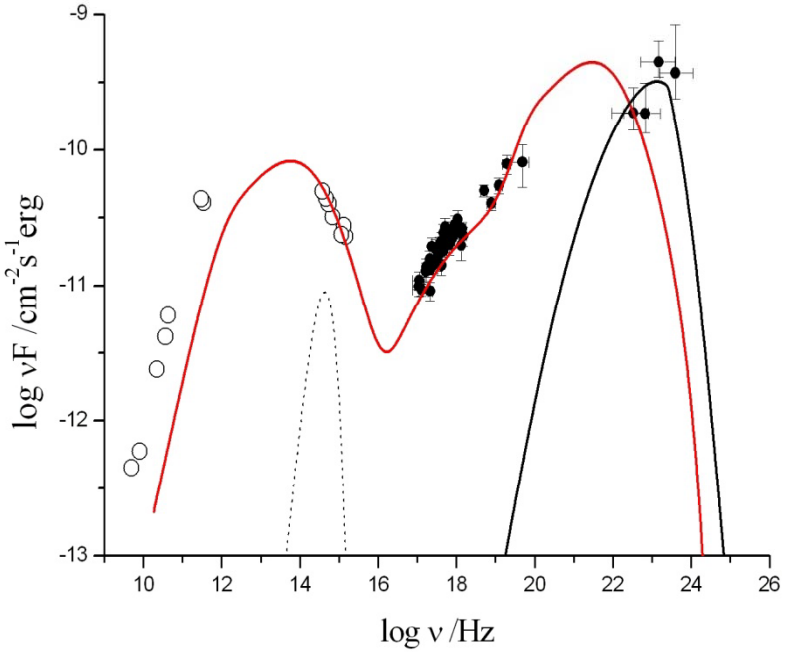

AGILE GRID Light Curve of 3C 454.3 (November-December 2007)
Flux 10E8 ph cm2 s1
700
600
500
400
300
200
100
54415
54417
54418
54420
54422
54424
54426
54428
54433
54439
54441
54443
54445
54447
54450
MJD

3C454 nov07

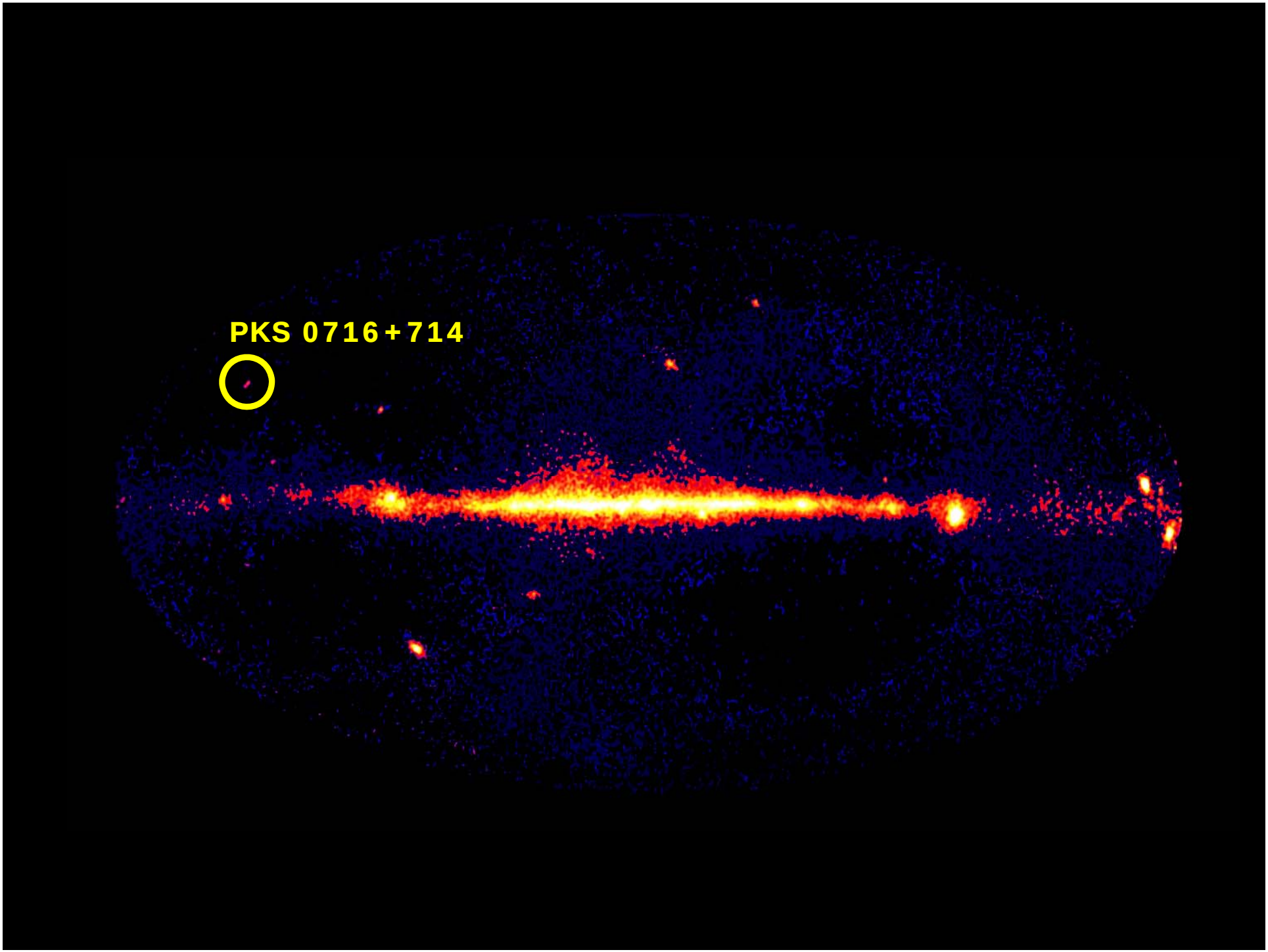
High-state



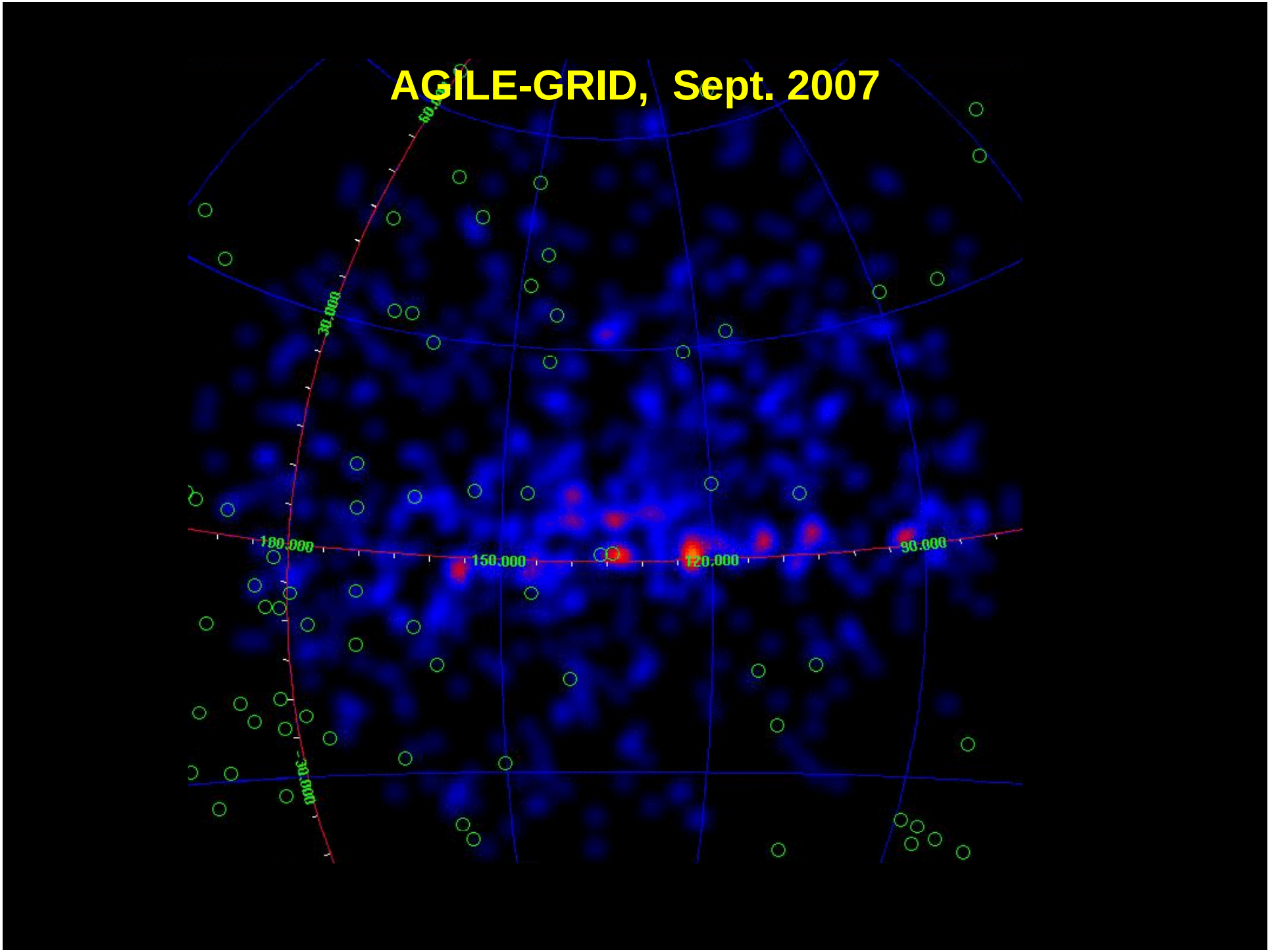
Low-state

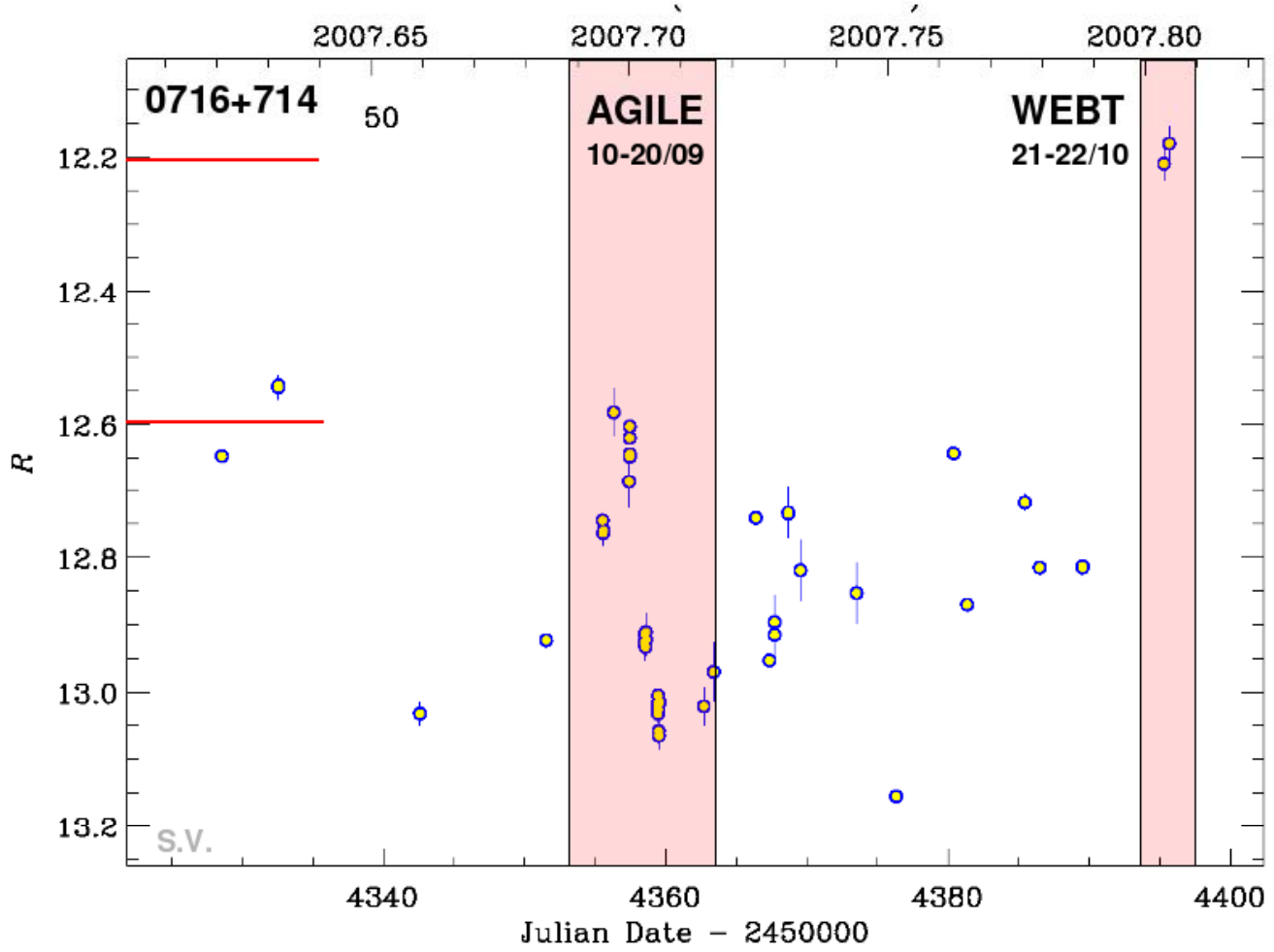


evidence for an additional component of external photons, compatible with a Broad Line Region IC component.


PKS 0716+714

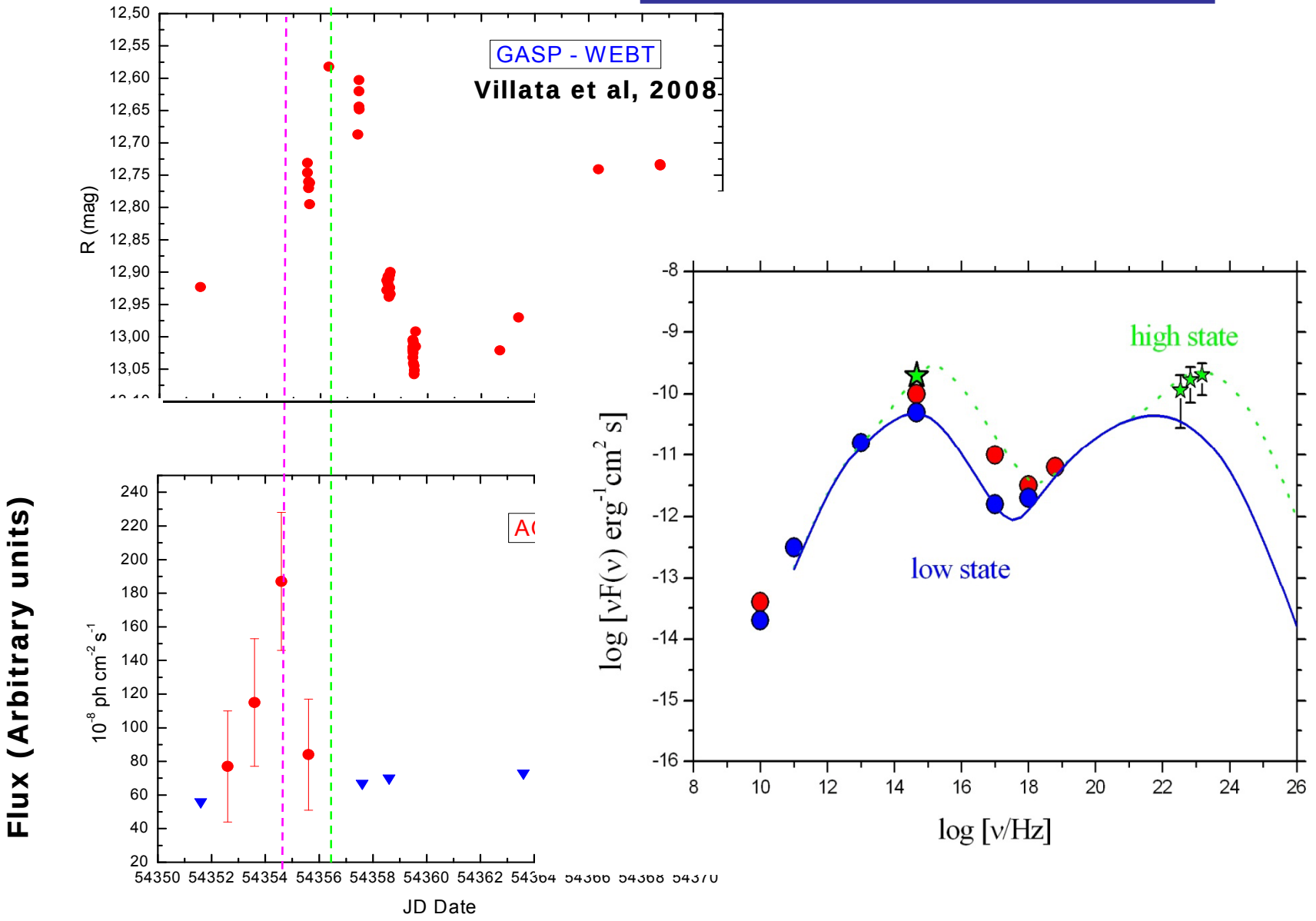
AGILE-GRID, Sept. 2007

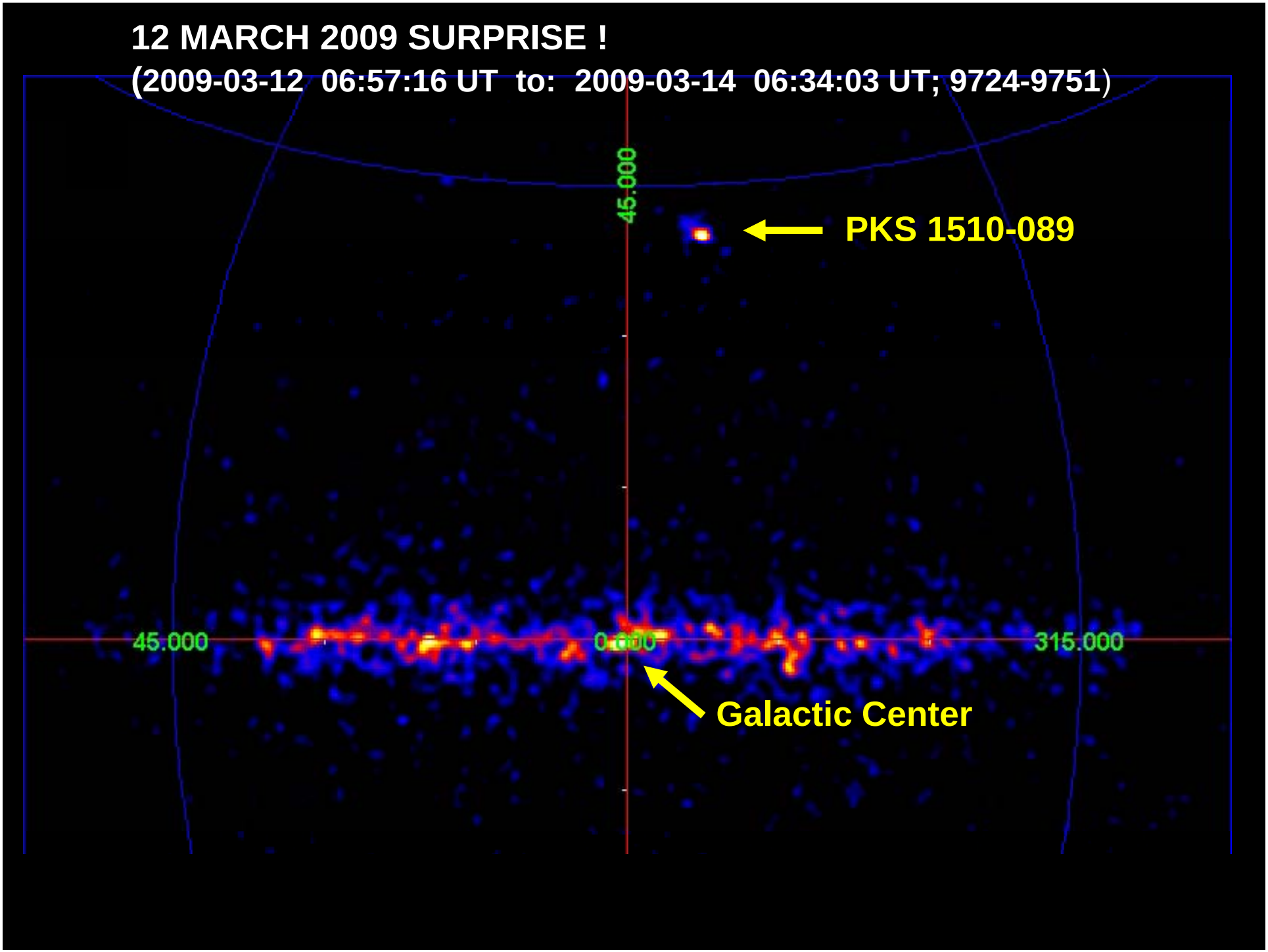




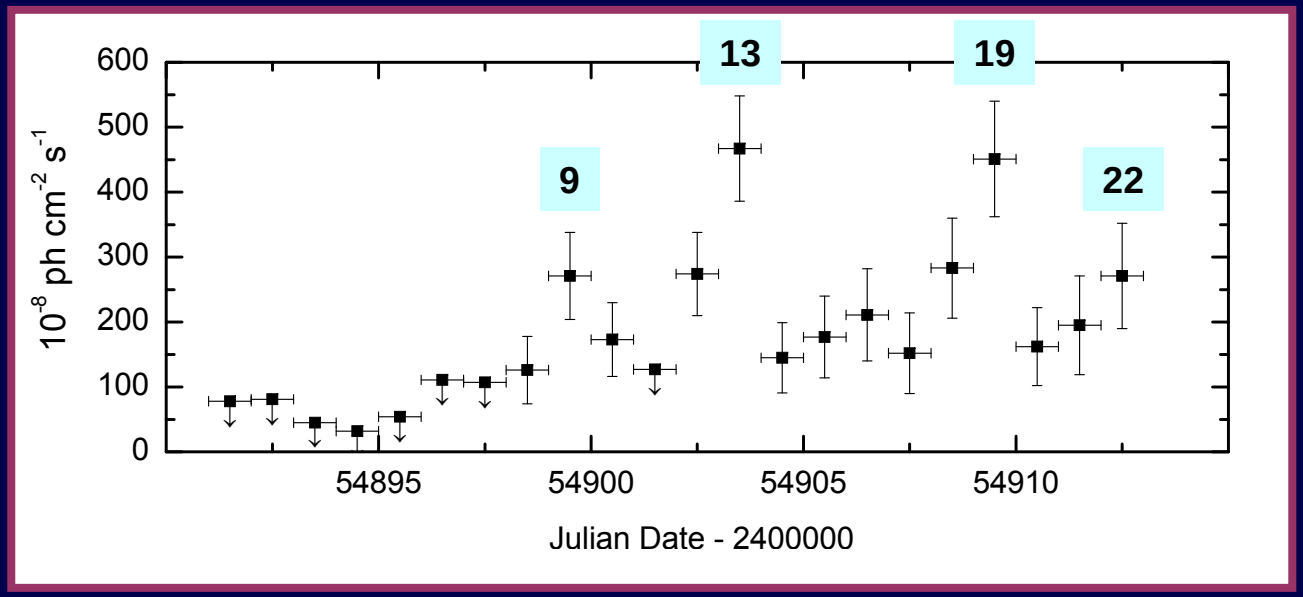
almost simultaneous GASP-WEBT optical campaign started after the AGILE detection

PKS 0716+714 Sep. '07 (Chen et al, 2008)




12 MARCH 2009 SURPRISE !
(2009-03-12 06:57:16 UT to: 2009-03-14 06:34:03 UT; 9724-9751)
45.000
PKS 1510-089
45.000
0.000
315.000
Galactic Center

PKS 1510-089: Marzo 2009



AGILE detection of the flaring gamma-ray blazar PKS 1510-089

ATel #1957; *F. D'Ammando (Univ. Tor Vergata and INAF-IAS (INAF-IASF Palermo), M. Tavani, G. Pucella (INAF-IASF Ro (INAF-IASF Milano), A. Bulgarelli (INAF-IASF Bologna), G. Pi M. Feroci, I. Donnarumma, L. Pacciani, E. Del Monte, F. La Evangelista, I. Lapshov, M. Rapisarda, A. Argan, A. Trois, G. De M. Marisaldi, F. Gianotti, M. Trifoglio, G. Di Cocco, C. Labant (INAF-IASF Bologna), P. Caraveo, S. Mereghetti, F. Perotti, M. I IASF Milano), A. Pellizzoni, M. Pilia (INAF-OACagliari), G. B Moretti, E. Vallazza (INFN Trieste), P. Picozza, A. Morselli, S. Sa Prest (Universita` dell'Insubria), P. Lipari, D. Zanello (INFN Ro Pavia), C. Pittori, F. Verrecchia, P. Santolamazza, S. Colafrances Salotti (ASI)*
on 10 Mar 2009; 12:14 UT

AGILE detection of a persistent and very intense gamma-ray flaring state of the blazar PKS 15

ATel #1968; *G. Pucella, F. D'Ammando, M. Tavani, E. Del Mont Marisaldi, F. Gianotti, M. Trifoglio, A. Bulgarelli (INAF-IASF Verrecchia (ASDC), S. Vercellone (INAF-IASF Palermo), A. Che Milano), G. Piano, V. Vittorini, E. Costa, M. Feroci, I. Donnar Lazzarotto, P. Soffitta, Y. Evangelista, I. Lapshov, M. Rapisarda, Paris (INAF-IASF Roma), G. Di Cocco, C. Labanti, F. Fuschin Bologna), P. Caraveo, S. Mereghetti, F. Perotti, M. Fiorini, A. Zan A. Pellizzoni, M. Pilia (INAF-OACagliari), G. Barbiellini, F. Long (INFN Trieste), P. Picozza, A. Morselli, S. Sabatini (INFN Roma dell'Insubria), P. Lipari, D. Zanello (INFN Roma-1), P. Catt Santolamazza, S. Colafrancesco, P. Giommi (ASDC),*
on 13 Mar 2009; 13:00 UT

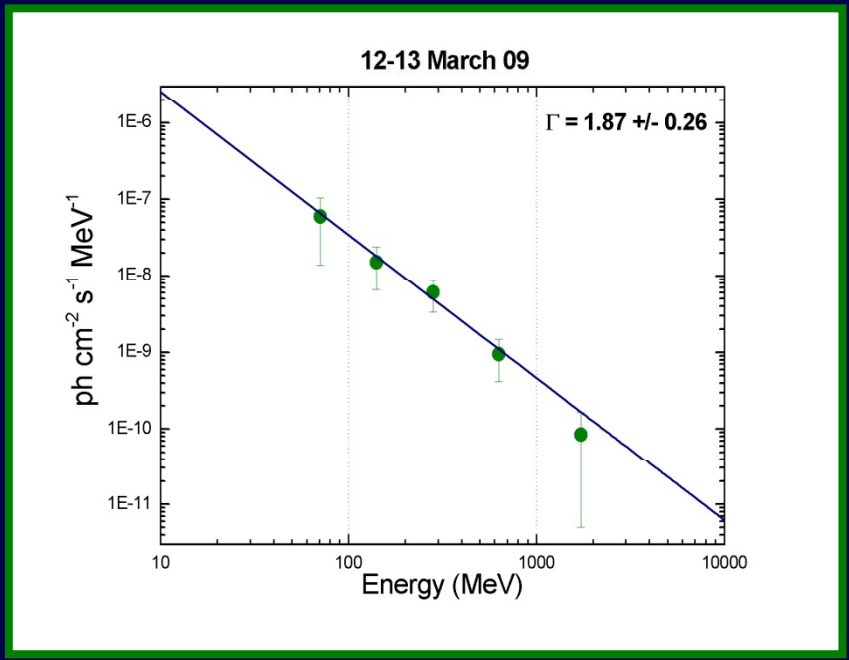
AGILE detection of a gamma-ray re-brightening of the blazar PKS 1510-089

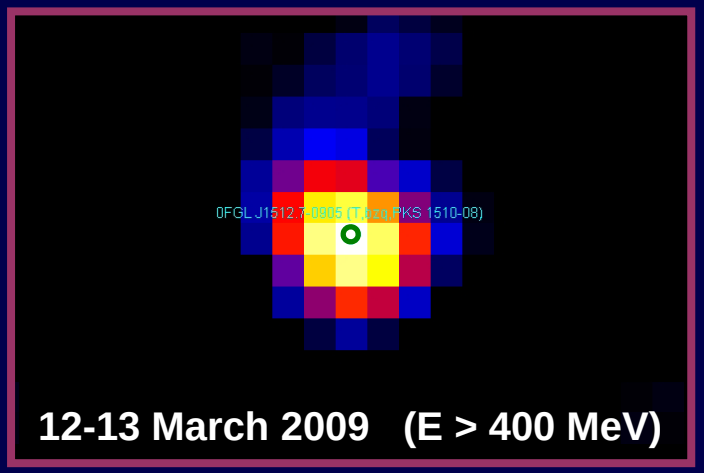
ATel #1976; *S. Vercellone (INAF-IASF Palermo), F. D'Ammando, G. Pucella, M. Tavani, I. Donnarumma, L. Pacciani (INAF-IASF Roma), A. Bulgarelli, M. Marisaldi, F. Gianotti, M. Trifoglio (INAF-IASF Bologna), C. Pittori, F. Verrecchia (ASDC), A. Chen, A. Giuliani (INAF-IASF Milano), G. Piano, V. Vittorini, E. Costa, M. Feroci, E. Del Monte, F. Lazzarotto, P. Soffitta, Y. Evangelista, I. Lapshov, M. Rapisarda, A. Argan, A. Trois, G. De Paris (INAF-IASF Roma), G. Di Cocco, C. Labanti, F. Fuschino, M. Galli (INAF-IASF Bologna), P. Caraveo, S. Mereghetti, F. Perotti, M. Fiorini, A. Zambra (INAF-IASF Milano), A. Pellizzoni, M. Pilia (INAF-OA Cagliari), G. Barbiellini, F. Longo, E. Moretti, E. Vallazza (INFN Trieste), P. Picozza, A. Morselli, S. Sabatini (INFN Roma-2), M. Prest (Universita' dell'Insubria), P. Lipari, D. Zanello (INFN Roma-1), P.W. Cattaneo, A. Rappoldi (INFN Pavia), P. Santolamazza, S. Colafrancesco, P. Giommi (ASDC), L. Salotti (ASI).*
on 19 Mar 2009; 12:07 UT

PKS 1510-089

- Agile detection
- Several flares
- Continuous monitoring in the radio-to-optical bands by the GLAST-AGILE Support Program (GASP) of the Whole Earth Blazar Telescope (WEBT)
- Detailed study of the multifrequency time evolution and spectral energy distribution

PKS 1510-089: March 2009



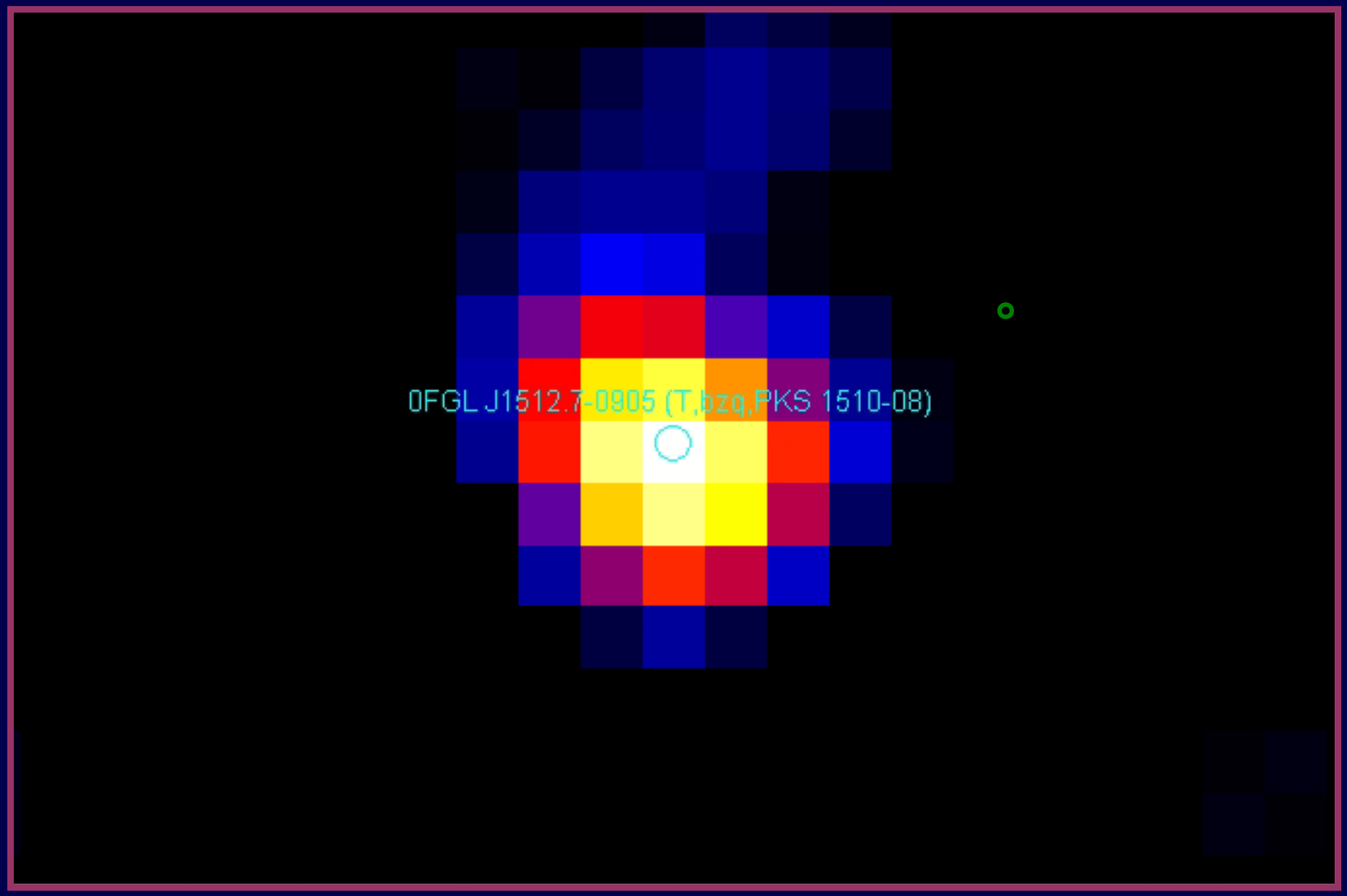


Hard gamma-ray spectrum during flares: $\Gamma = 1.87 \pm 0.26$

Source positioning at 400 MeV in very good agreement with FERMI/LAT 0FGL Catalog

PKS 1510-089: March 2009

12-13 March 2009 (E > 400 MeV)



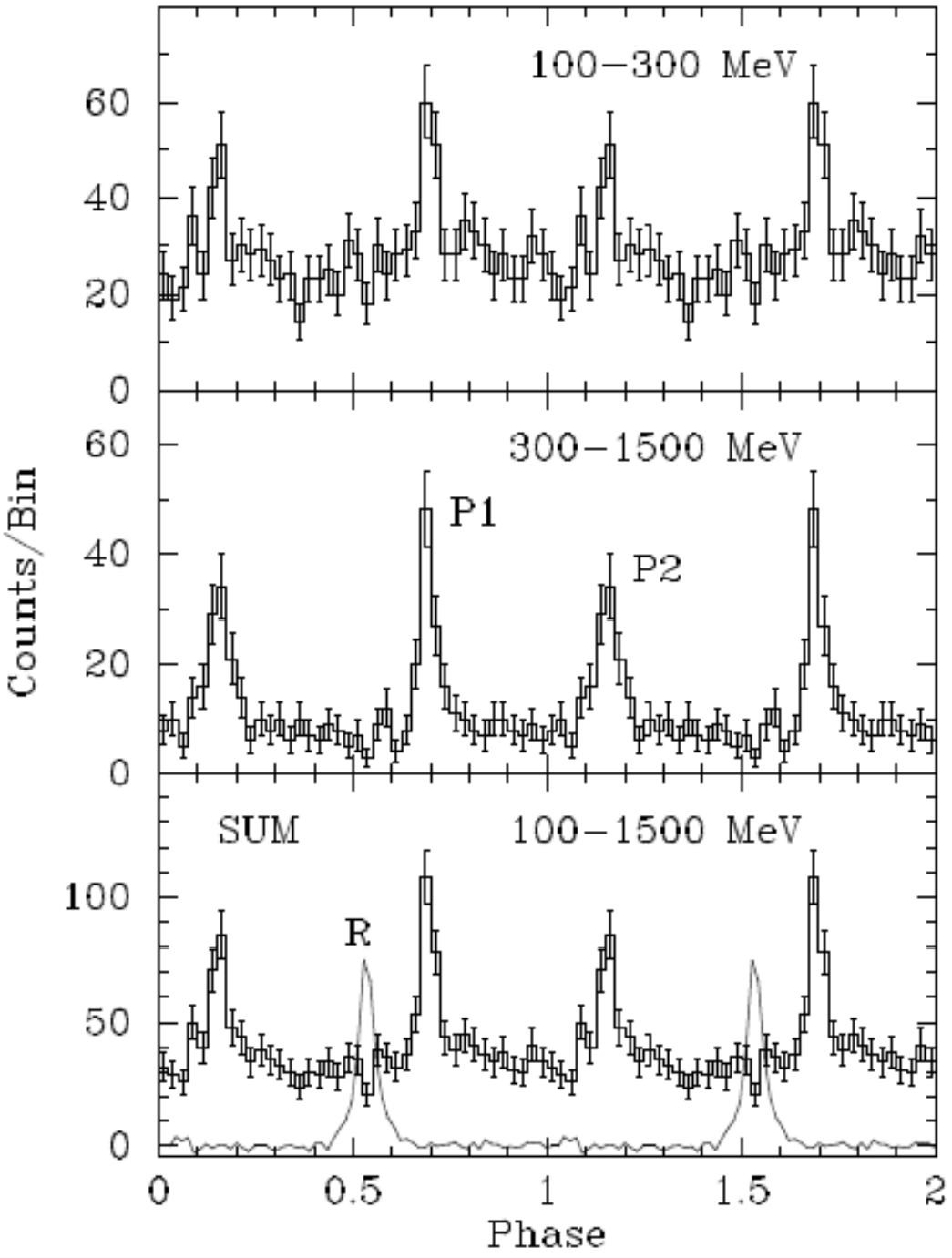
Source positioning at 400 MeV in very good agreement with FERMI/LAT 0FGL Catalog

Galactic sources: main topics and discoveries

- 10 new Pulsars
- Discovery of new gamma-ray sources and gamma-ray transients in the Galaxy
- Microquasar studies, Gamma-ray emission from Gal. compact objects
- Colliding wind systems
- SNRs and origin of cosmic rays

AGILE new gamma-ray PSR (Halpern et al. 2008)

PSR J2021-3651



New Gamma-Ray Pulsars

J2229+6114, J2021+3651, …: Vela-like

J1513-5908: High B pulsar

J1824-2452: ms PSR in Globular Cluster

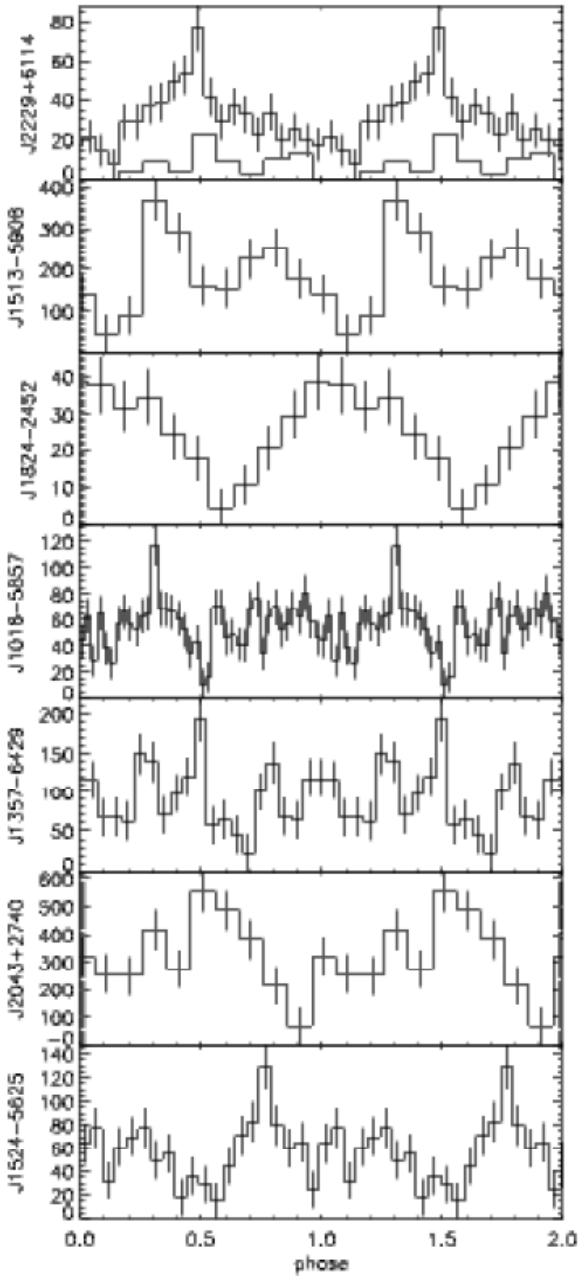
J1016-5857: possibly 3EG source

J1357-6429

J2043+2740: oldest gamma-ray pulsar

J1524-5625

Pellizzoni et al., 2009

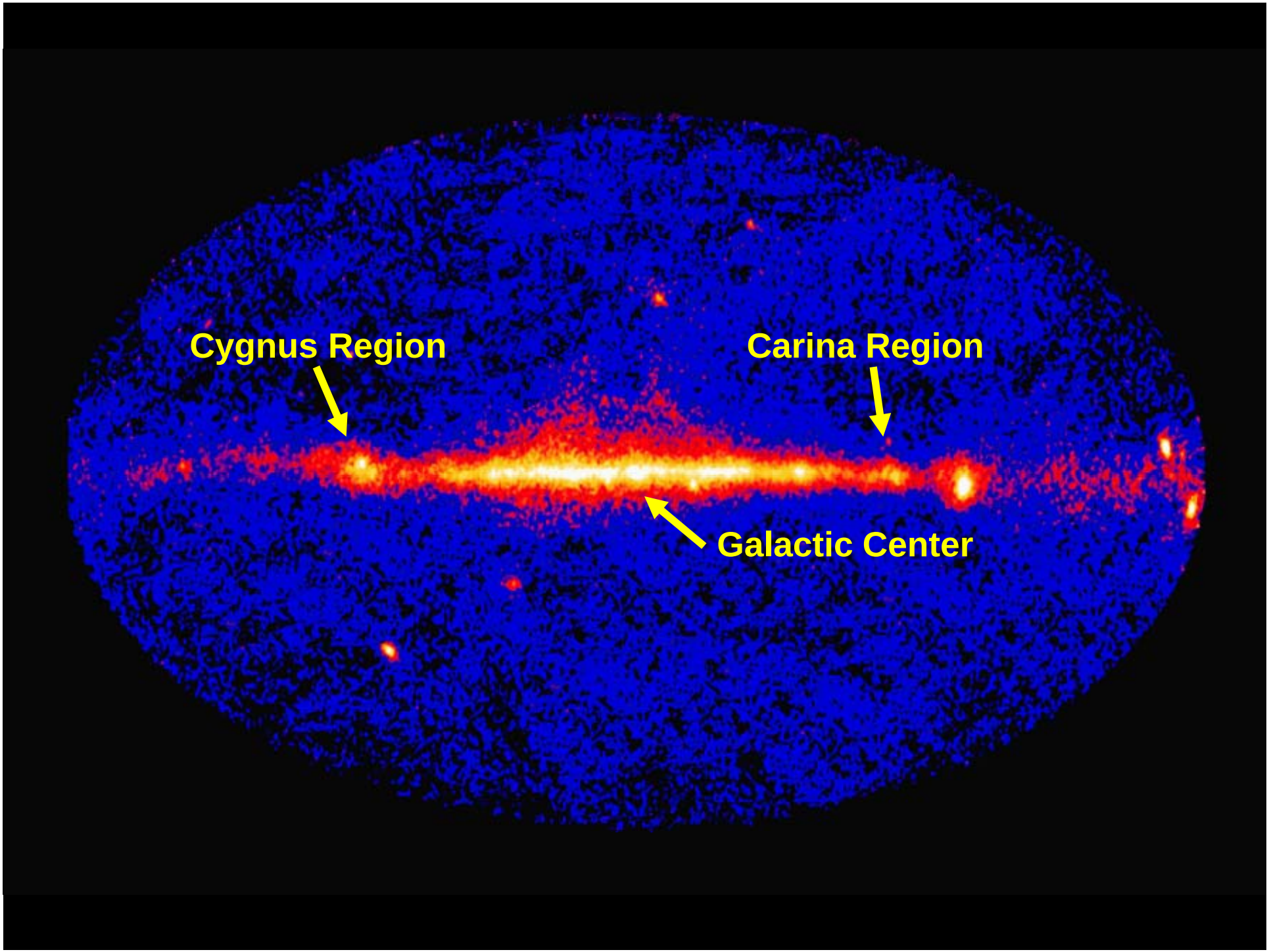


AGILE-GRID
transient candidates

Galactic gamma-ray transients: an AGILE discovery

- **Cygnus region**
- **Carina region**
- **Galactic Center region**

- **AGILE observes variability and detects new transients on time scales of 1 day at flux levels of 10^{-6} $cm^{-2}s^{-1}$, even in crowded, high diffuse emission Galactic plane regions.**
- **NO detectable simultaneous hard X-ray emission (F < 20-30 mCrab, 18-60 keV, 1-day integration)**

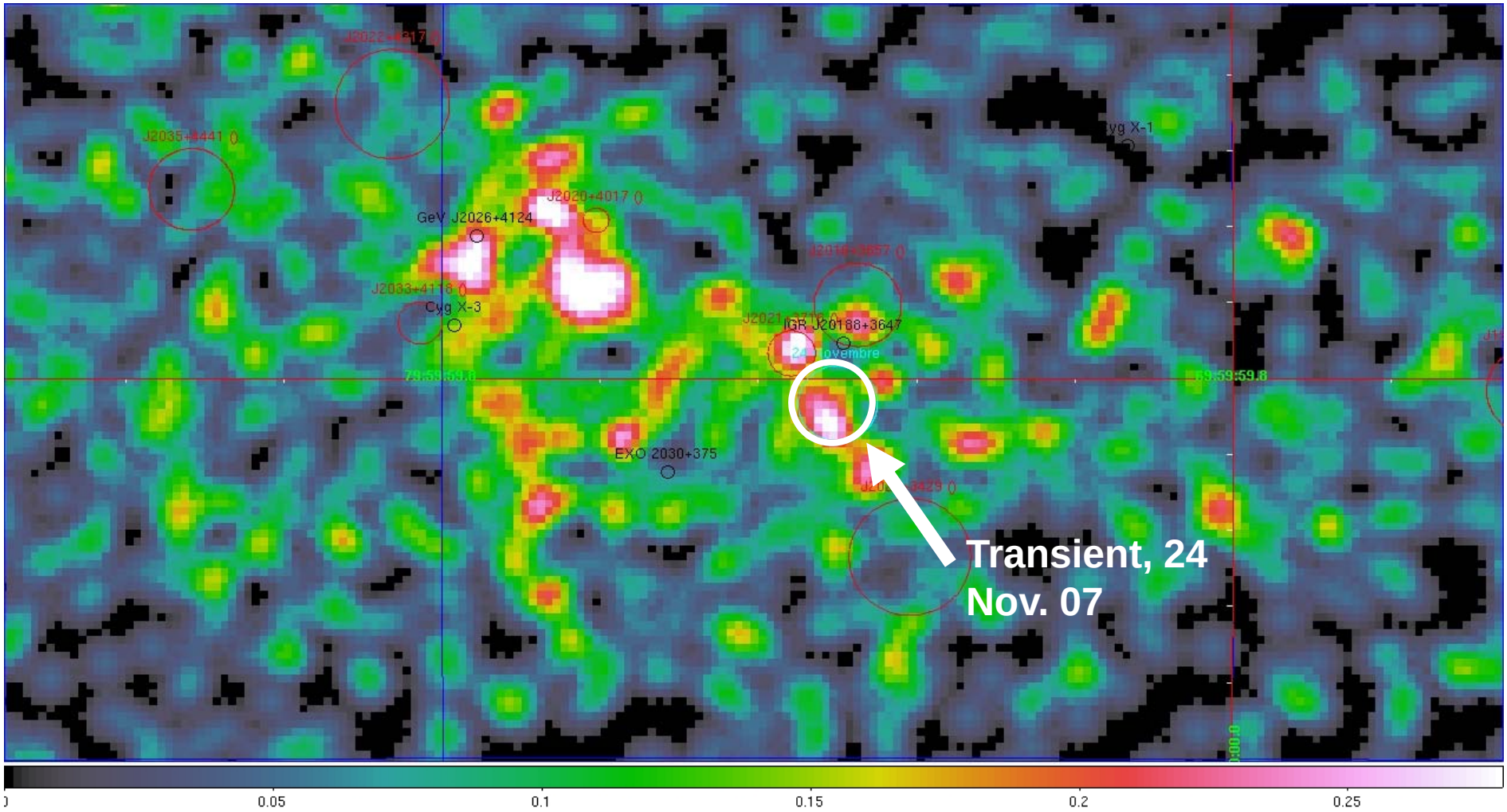

Cygnus Region
Carina Region
Galactic Center

Gamma-Ray Galactic Transients

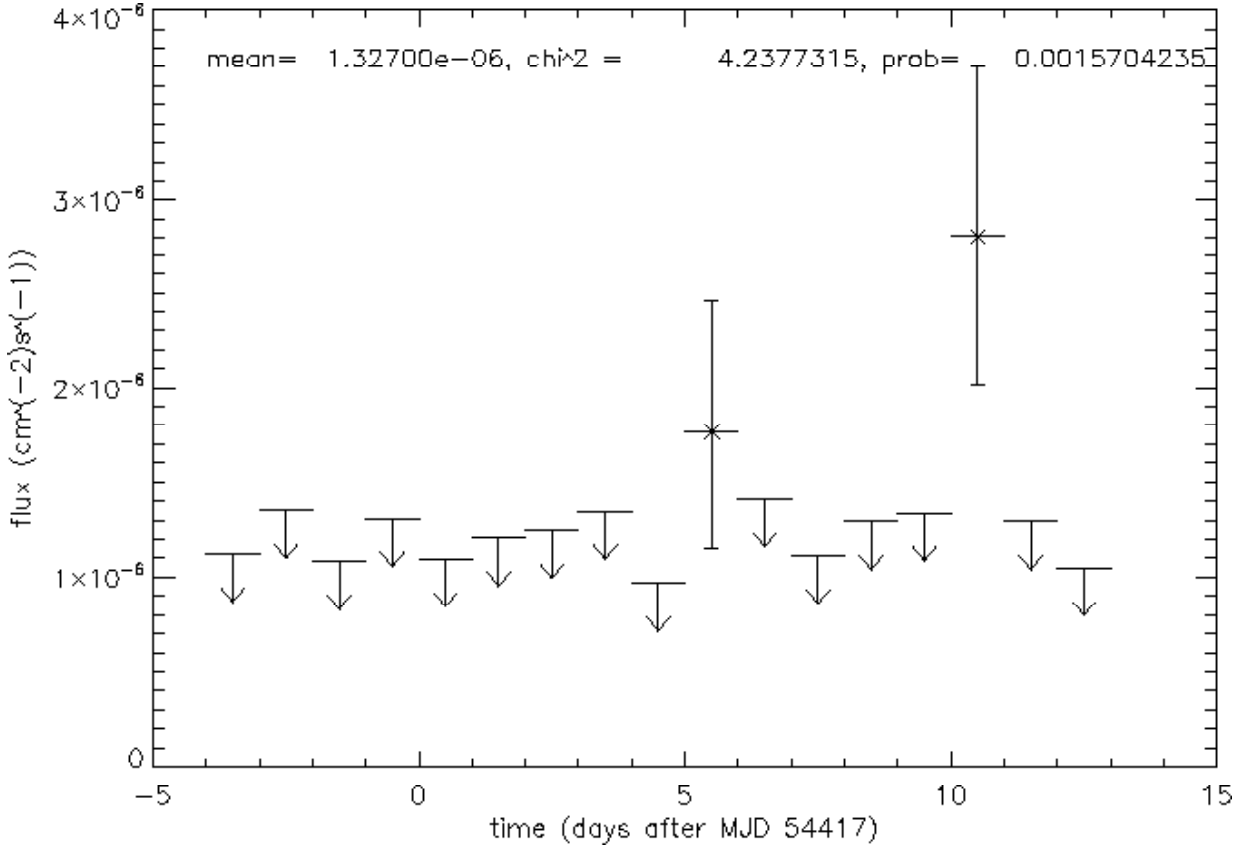
- **Big issue with EGRET, some detection/hints**
  - **example: GRO J1838-04 (Tavani et al. 1997)**
  - **anti-example: IAU-Circulars on transients then retracted e.g., (Kanbach et al…)**

- **AGILE detection of many tens of candidates (usually low-energy)**
  - **Examples:**
    - **24 Nov. 2007**
    - **Crux Region transients**
    - **Carina Region transients**
    - **Eta-Car**
    - **Galactic Center transients (March 09)**
    - **L= 17**
    - **L = 8 (Easter-09 transient)**
    - **Cygnus transients**

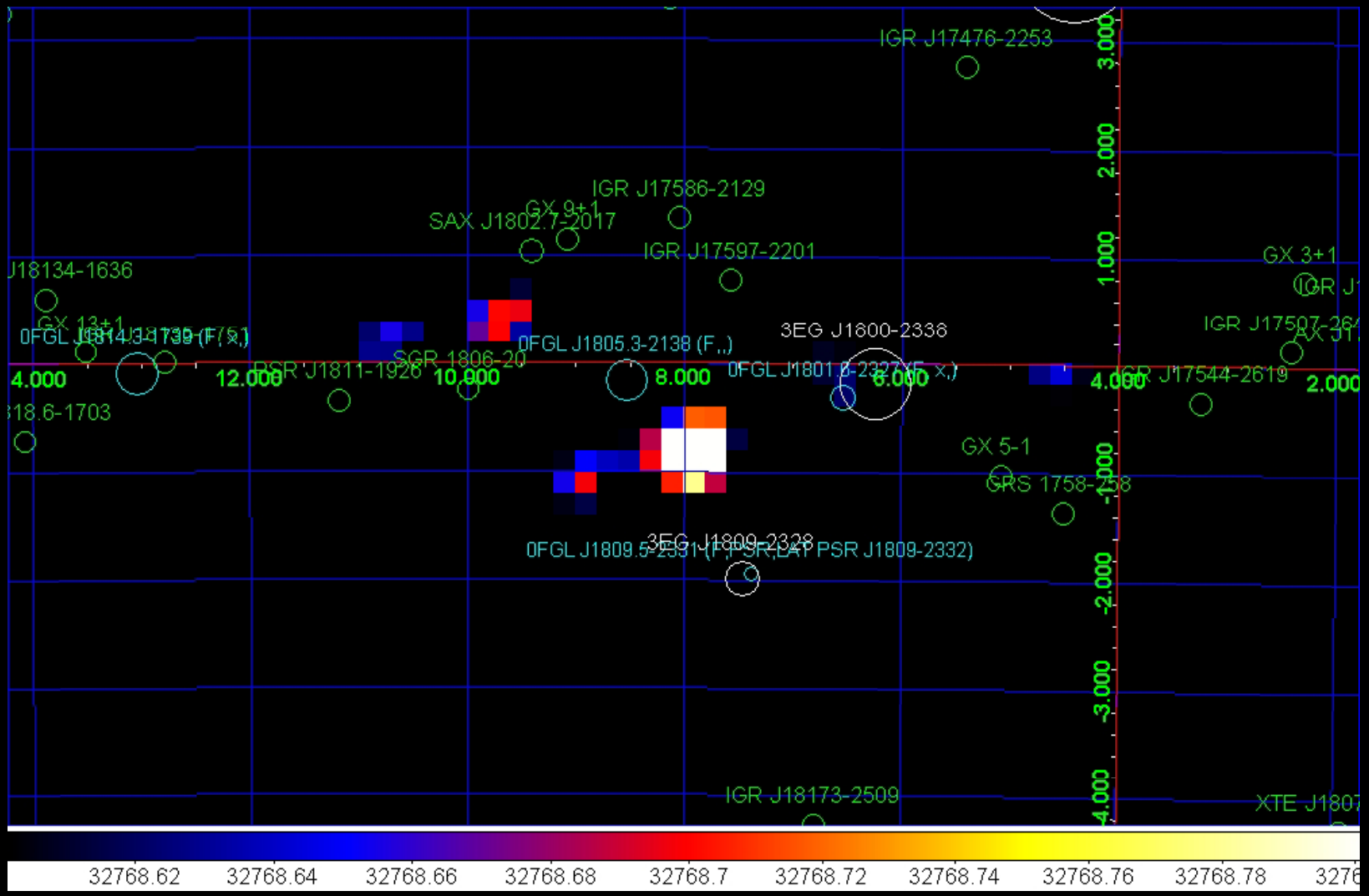
Transient in the Cygnus Region
Nov 18-28, 2007



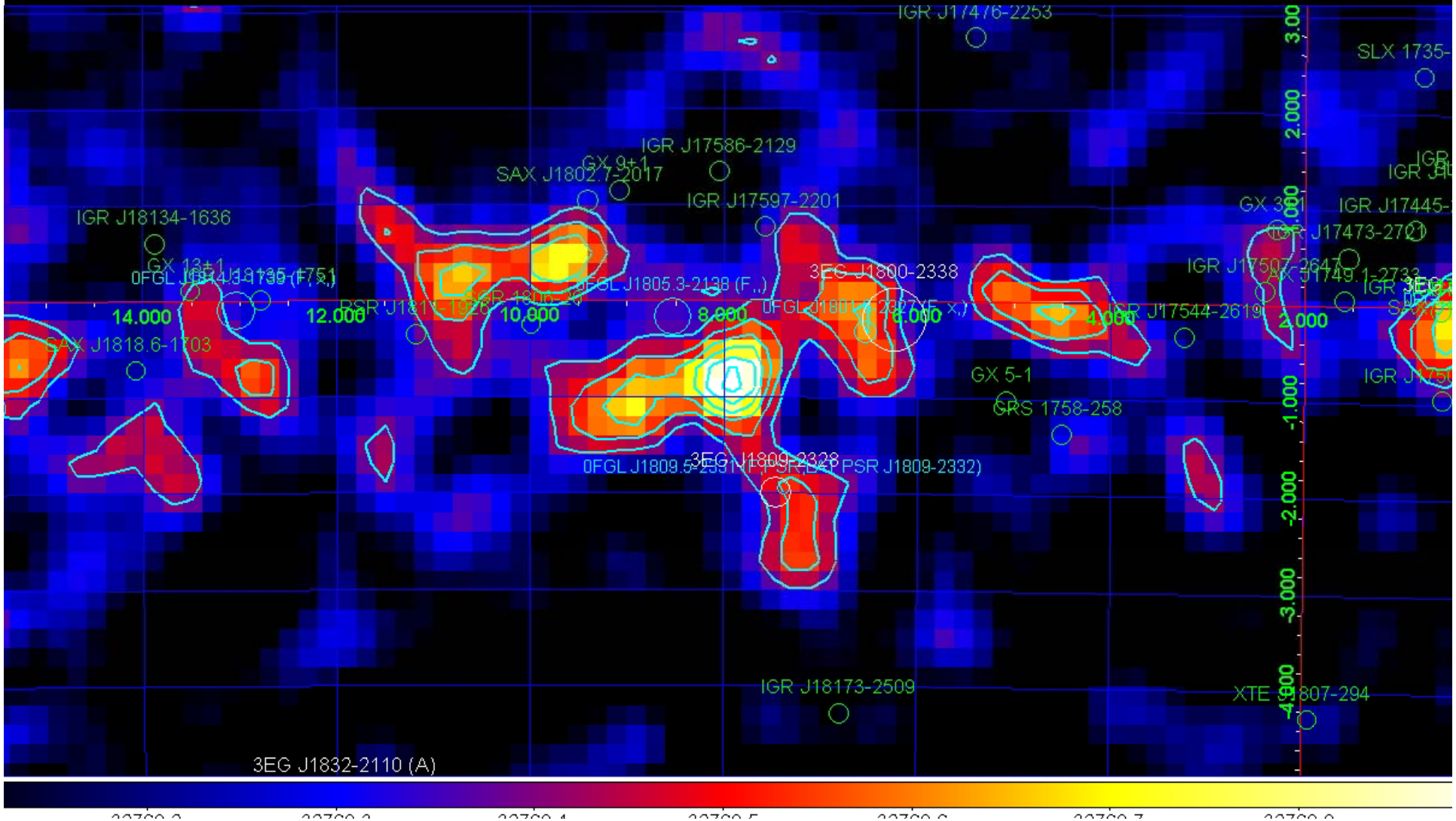
AGLJ2022+3622 -- Light Curve



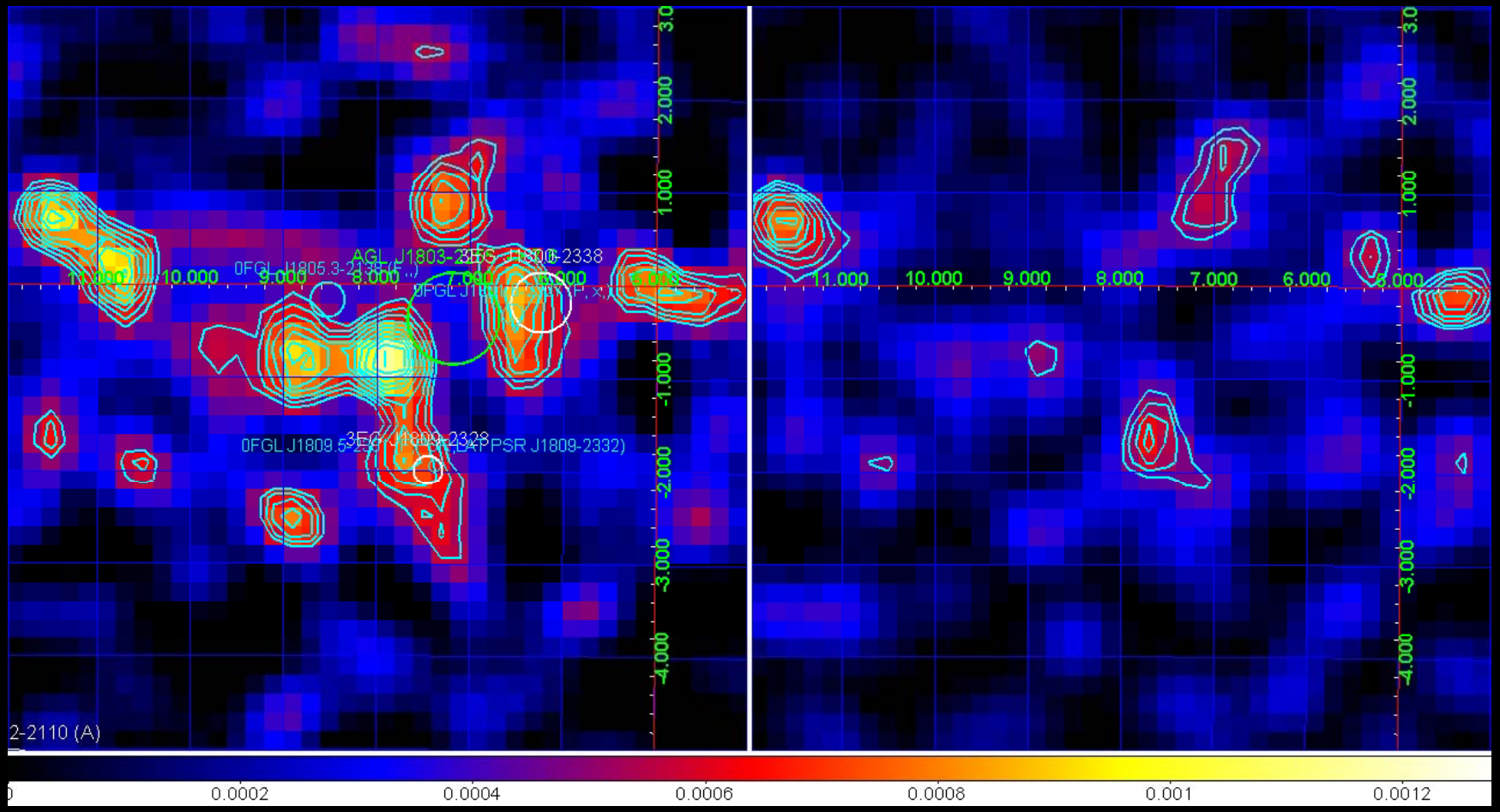
Easter transient: 10-13 April 2009, 10143-10180, bin =0.2, B16, FM, E>100 MeV



Easter transient: 10-13 April 2009, 10143-10180, bin =0.2, B16, FM, E>100 MeV



Easter transient: 10-13 April 2009, 10143-10180, bin =0.2, B17b, FT



E > 100 MeV

E > 400 MeV

AGILE surprises

- **NO simultaneous strong HARD X-RAY emission (no accreting micro-qso's in strong outburst) !!!**
- **in general, no obvious X-ray source or INTEGRAL sources**
- **some SWIFT follow-ups: no detection, except one.**

It could be a NEW CLASS of (non-accreting or low X-ray) sources !!!

some candidates...

	A-LIKE	A-FDR	Integration
PKS 1510	~9	$5x10^{-6}$	1-day
Cyg X-3 cand.	~4	0.05	1-day
		0.01	1-day
GX 5-1 cand		0.05	1-day
		0.05	2-days
Easter trans. l~8	5.3	0.05	1-day
		0.01	2.5-days
l~17		0.01	1-day
		10^{-3}	2-days
		10^{-5}	10-days
Eta Car flare	~5	~0.01	2-days
PSR J1709		10^{-3}	10-days
Gal Centre	3.6	10^{-5}	2-days

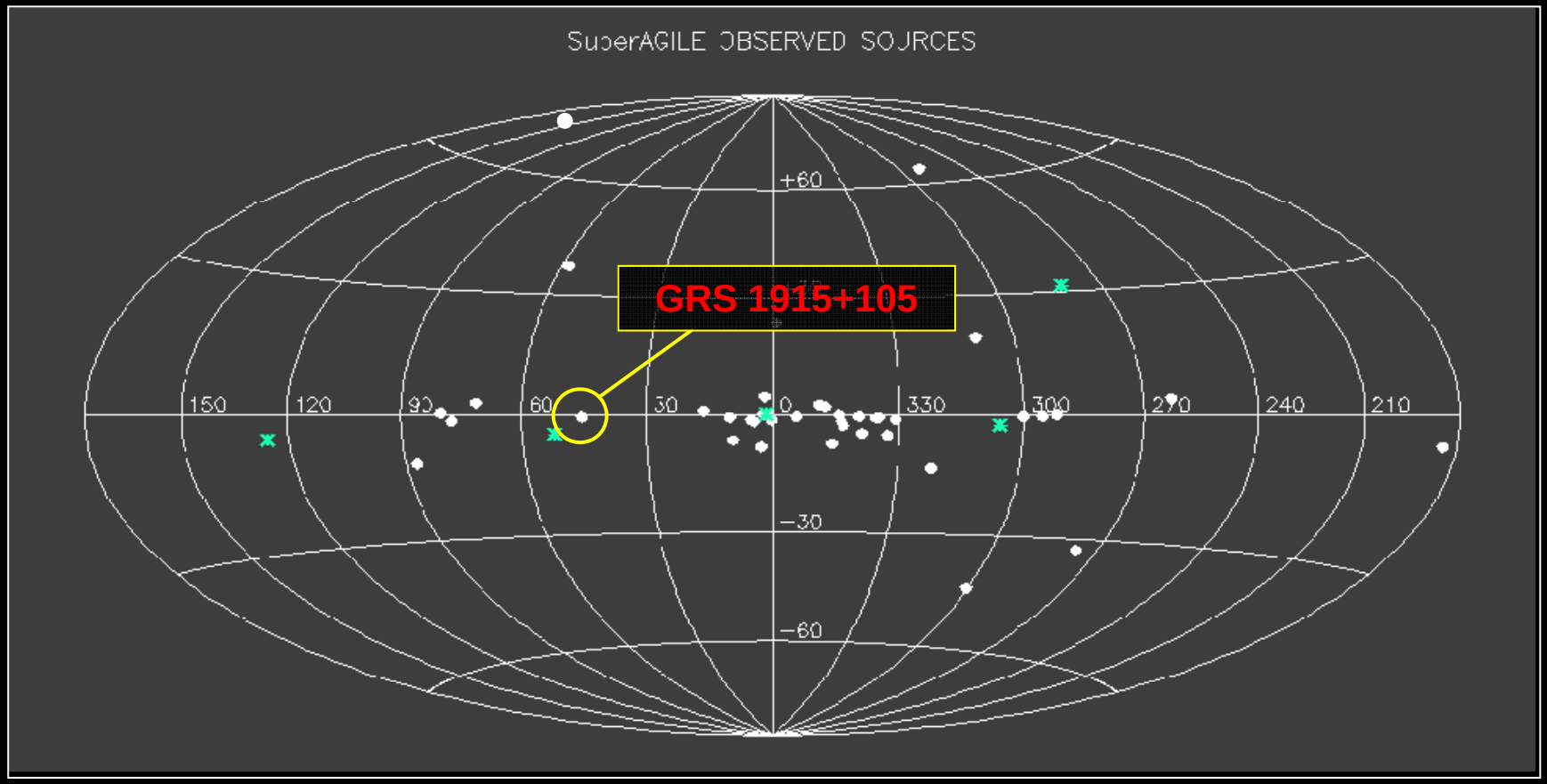
Some sources...

Table 5: Summary of the analyses carried out in this document

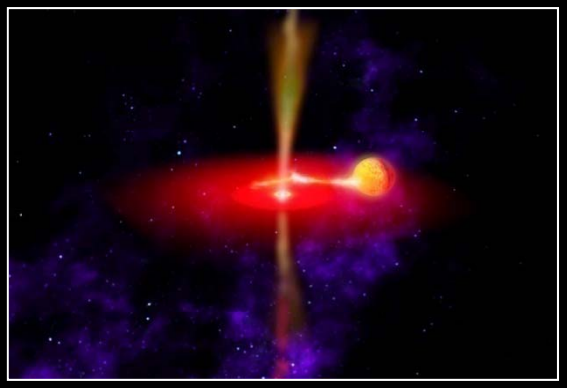
Region	l	b	Orbits	Exposure	FDR-CL	Counts	Theta
PKS1510	351.3	40.11	9723-9736	1-day	$< 10^{-3}$	11	36.8
Cygnus	80.25	0.85	7897-7910	1-day	0.05	9	6.6
Carina	287.75	-1.25	7577-7604	2-days	0.05	11	37.8
GX5-1 candidate	5.75	-1.75	9723-9736	1-day	0.05	10	9.9
	5.75	-1.75	9710-9736	2-days	0.05	15	9.9
l$\sim$ 17	16.25	-0.25	9723-9736	1-day	0.01	13	19.2
	16.25	-0.25	9710-9736	2-days	10^{-3}	21	19.2
	17.25	-0.73	9710-9850	10-days	10^{-5}	86	20.2
	17.25	-0.73	9850-9990	10-days	10^{-5}	81	20.2
l$\sim$ 8	7.75	-0.75	9693-9714	1.5-days	0.05	14	12.8
	7.75	-0.75	9835-9848	1-day	0.05	10	6.8
	7.75	-0.75	10143-10180	2.6-days	0.01	21	20.4
GRS1915+105	45.87	-0.1	10316-10339	1.7-days	~ 0.05	10	9.2
PSR1709	-	-	9723-9736	1-day	-	-	-
	-	-	9710-9736	2-days	-	-	-
	343.25	-2.21	9710-9850	10-days	0.05	65	15.4
	343.25	-2.71	9850-9990	10-days	10^{-3}	67	15.4

Micro-QSO studies

- Cyg X-1
- Cyg X-3
- GRS 1915+105
- SS 433
- ….


SuperAGILE OBSERVED SOURCES
GRS 1915+105
+60
−30
−60
150
120
90
60
30
0
330
300
270
240
210

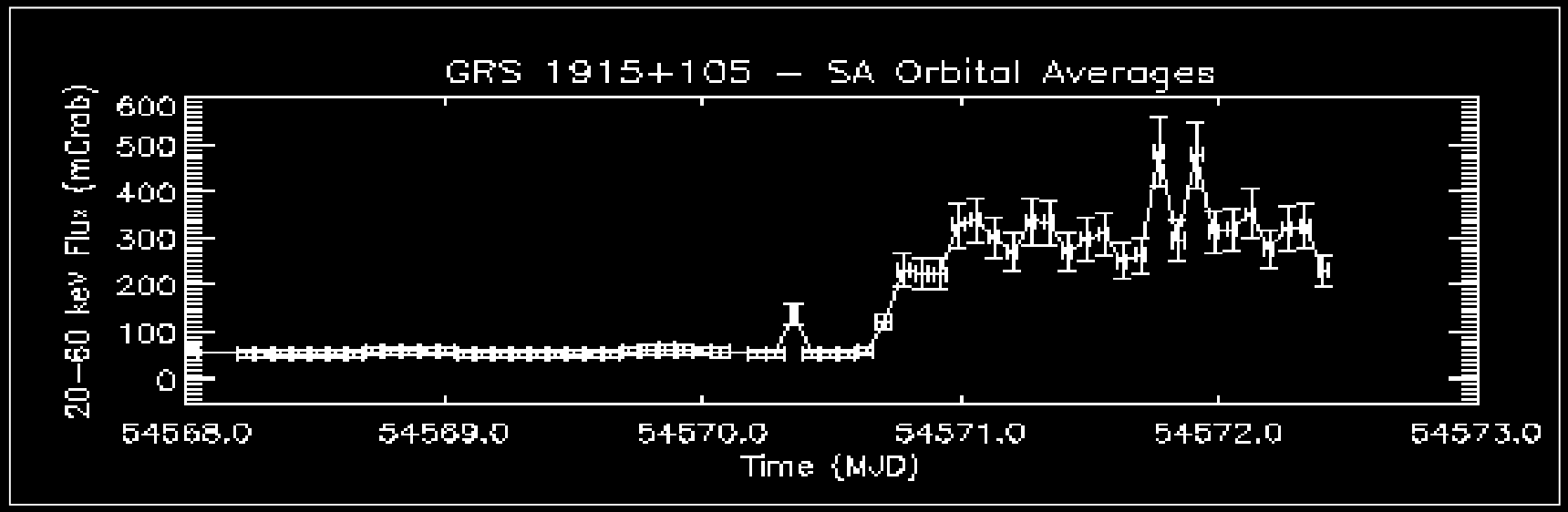
GRS 1915+105



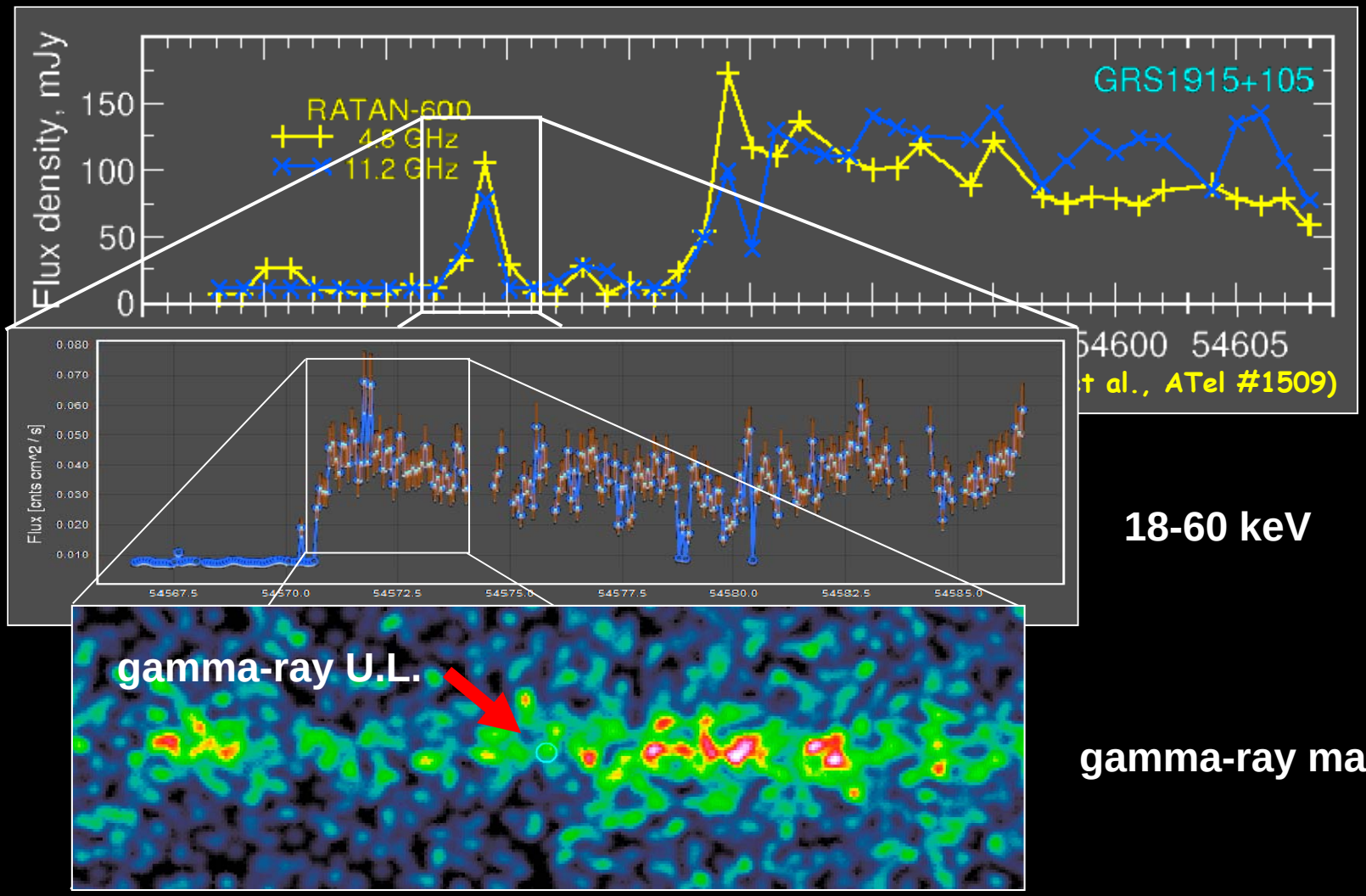
15 April 2008

Riattivazione del microquasar

GRS 1915+105



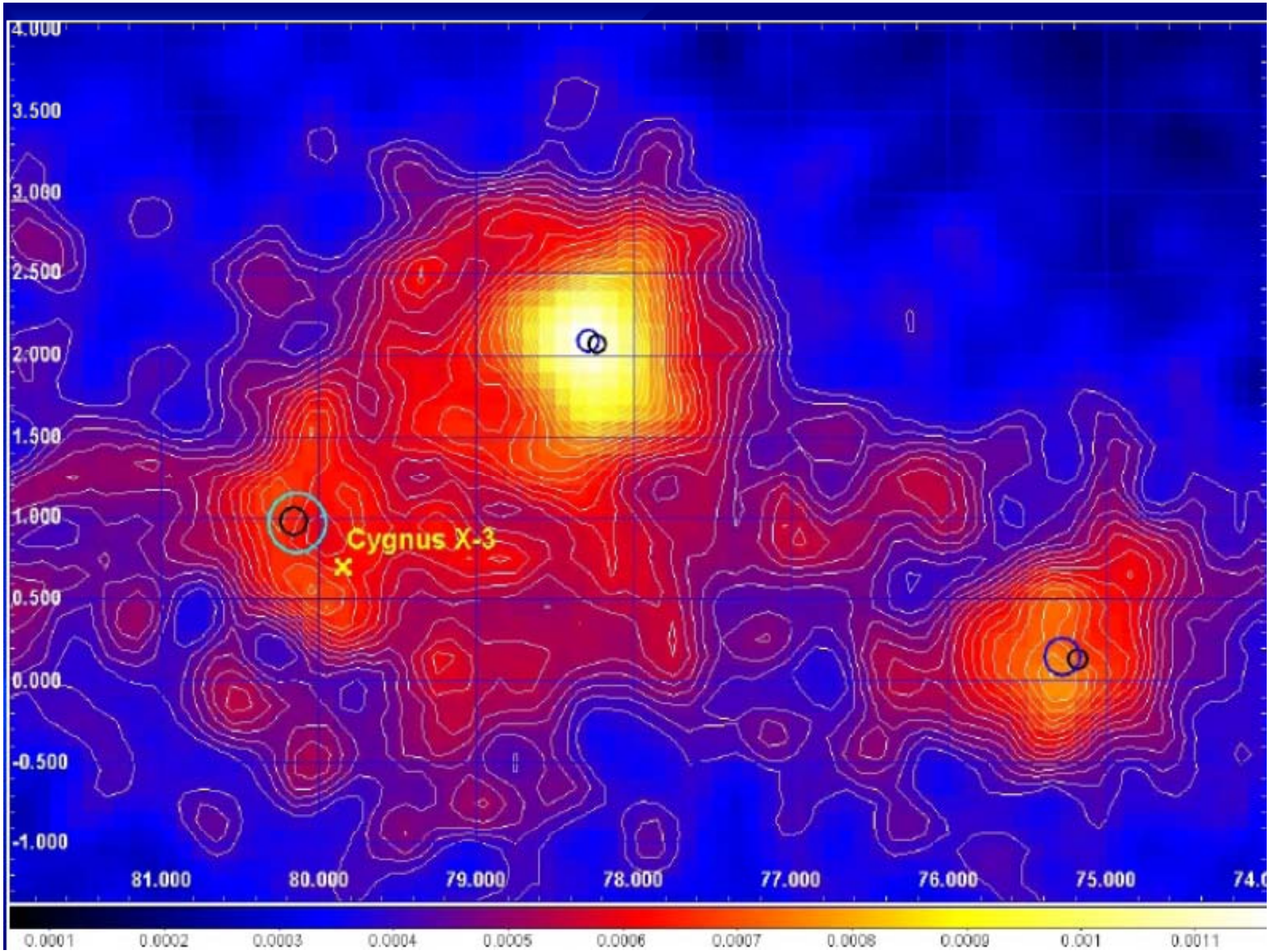
GRS 1915+105

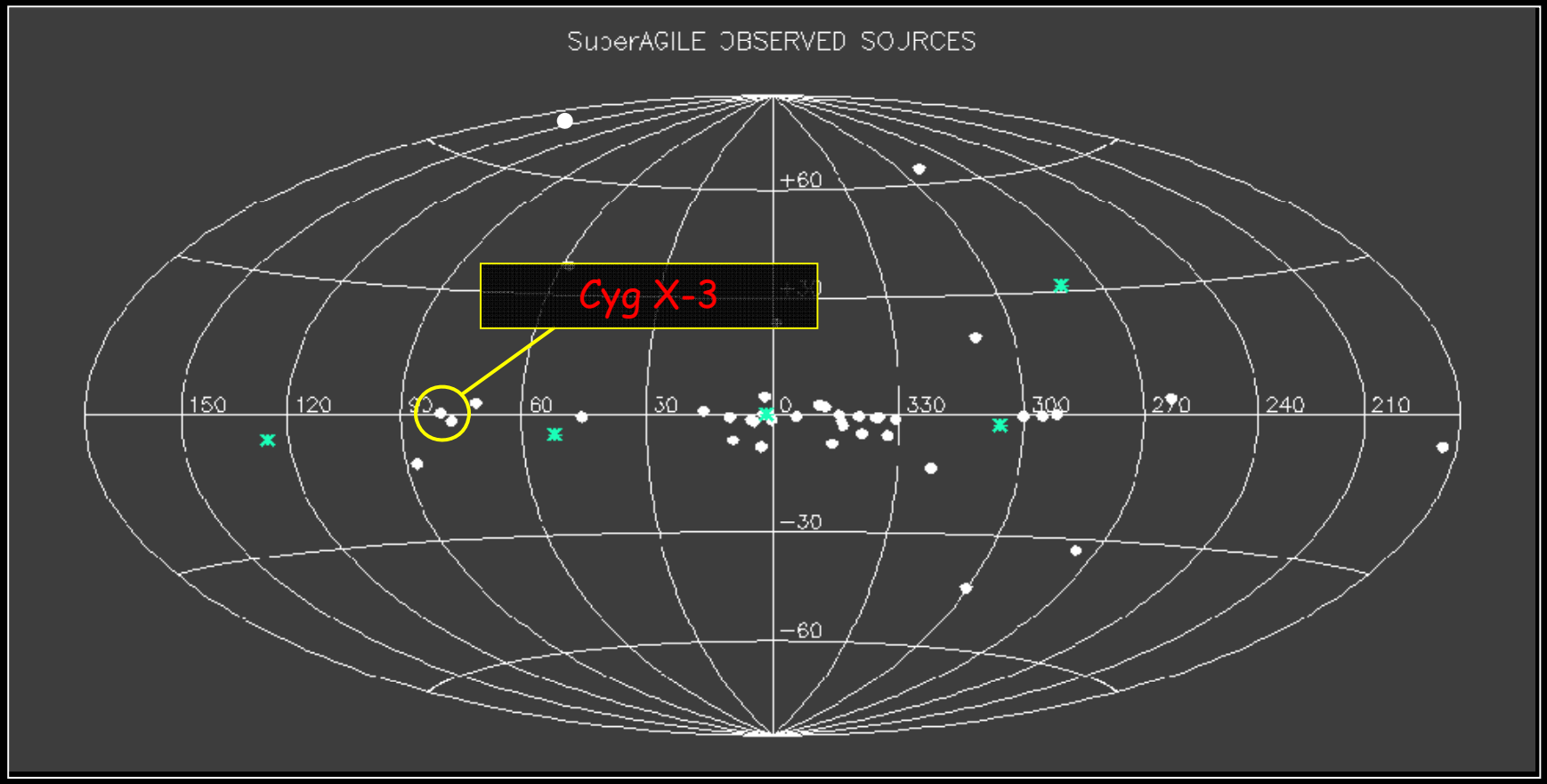


18-60 keV

gamma-ray map

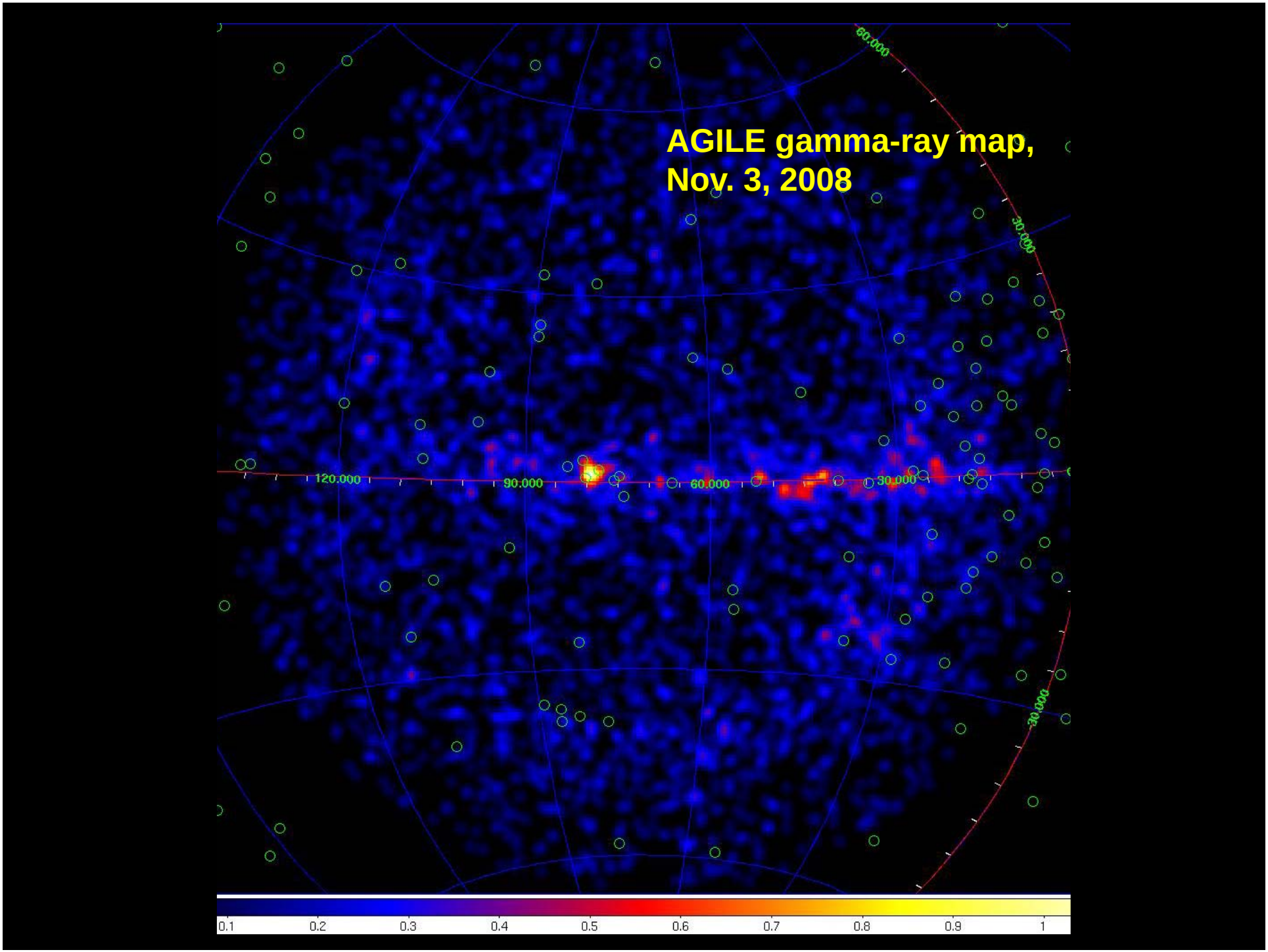
Cygnus region


4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
-0.500
-1.000
81.000
80.000
79.000
78.000
77.000
76.000
75.000
Cygnus X-3
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0.0007
0.0008
0.0009
0.001
0.0011


SuperAGILE OBSERVED SOURCES
Cyg X-3
+60
−30
−60
150
120
90
60
30
0
330
300
270
240
210

AGILE and Cygnus X-3

- **AGILE detects several gamma-ray flares from Cygnus X-3, and also weak persistent emission above 100 MeV**
- **very interesting correlations with radio and X-ray states**
- **gamma-ray flares usually *before* radio flares**


AGILE gamma-ray map,
Nov. 3, 2008
120.000
90.000
60.000
30.000
60.000
30.000
30.000
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Cygnus X-3

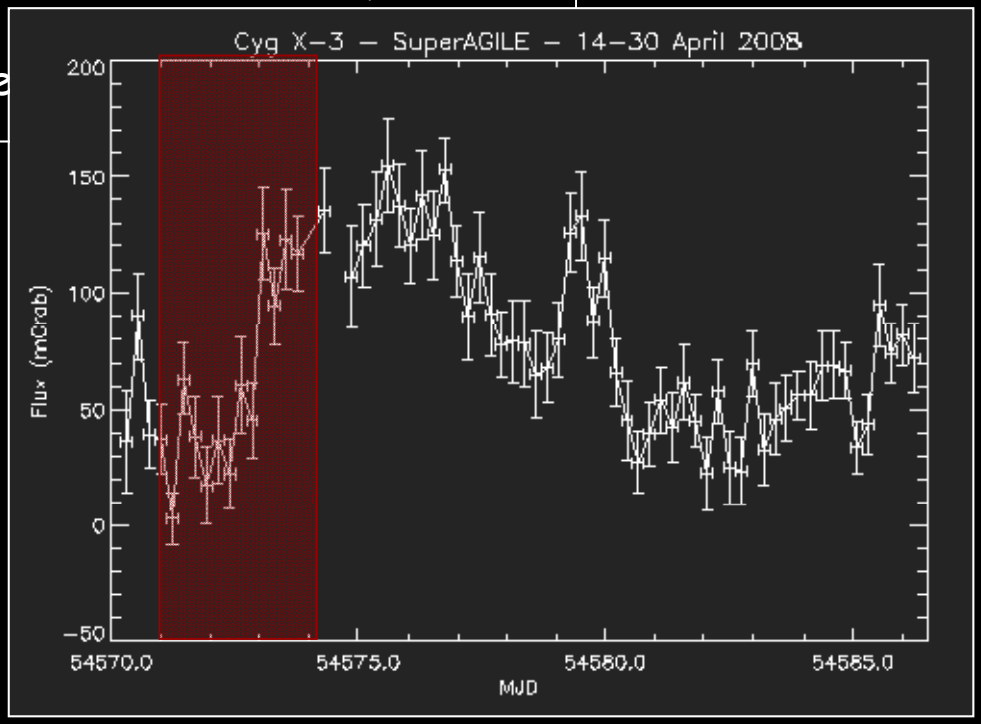
15 - 18 April 2008

Giant radio flare of Cygnus X-3 detected by RATAN-600 radio telescope

Radio flux increasing of a factor ~10^3, from ~10 mJy to ~10 Jy

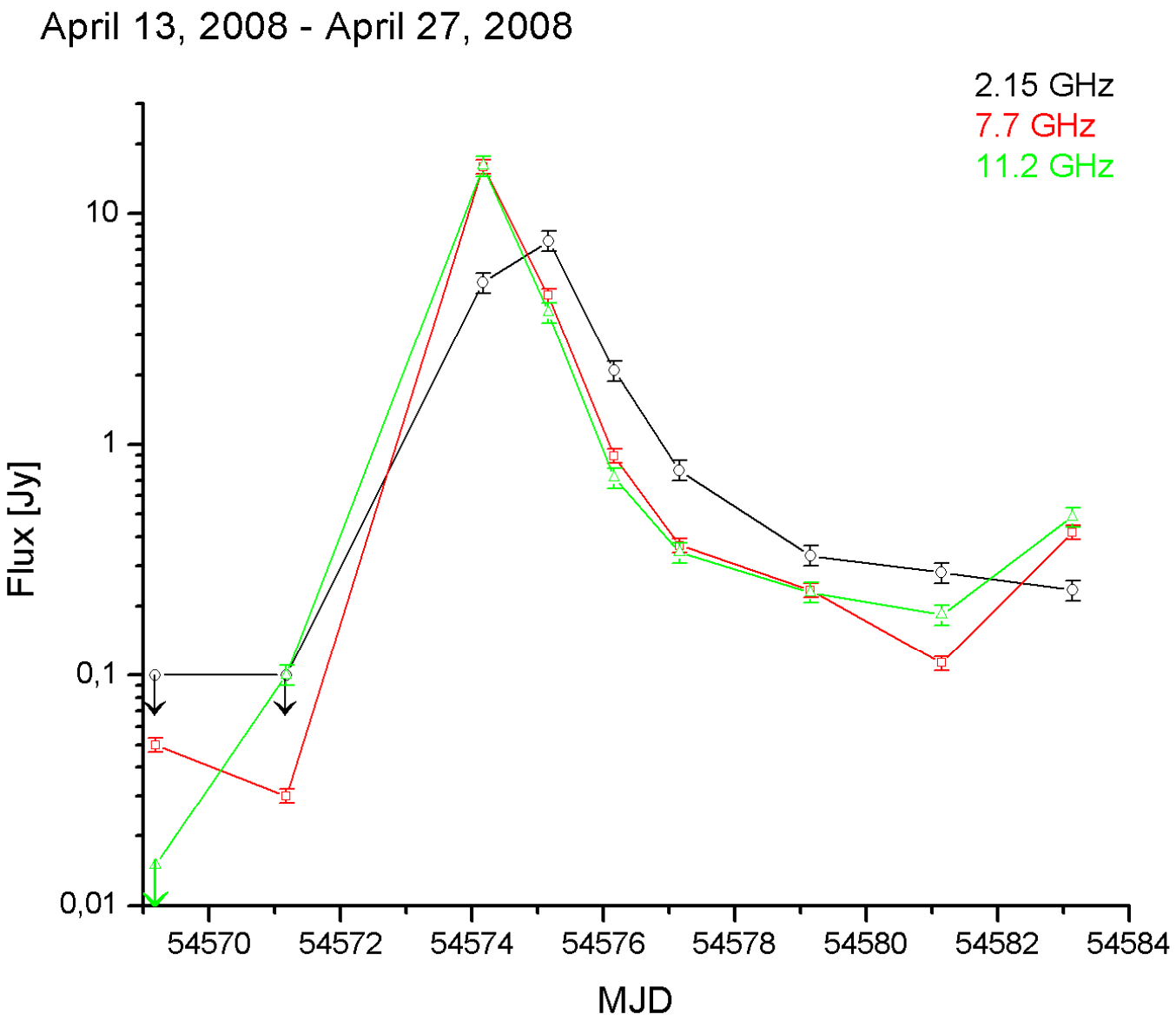
S.A.Trushkin et al., ATel #1483

10 Jy is typical flux for plasmoids e



In the same period SuperAGILE revealed an X-ray flare

RATAN Obs. (S. Truskhin et al.) Apr. 13 – Apr. 27, 2008



very strong radio flare, presumably with jet ejection

(RATAN-600)

strong gamma-ray flare

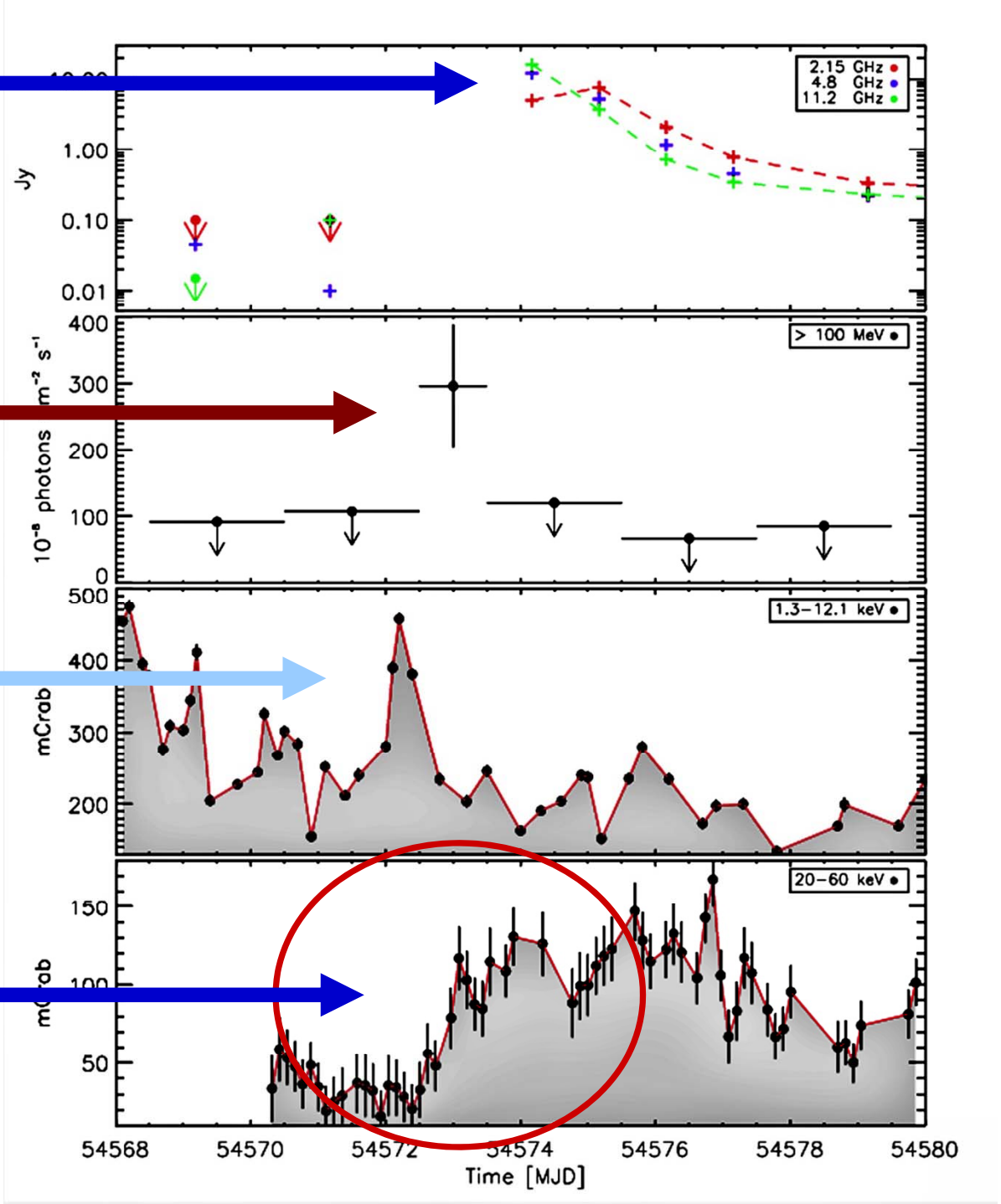
(AGILE-GRID)

X-ray (1-10 keV) flare

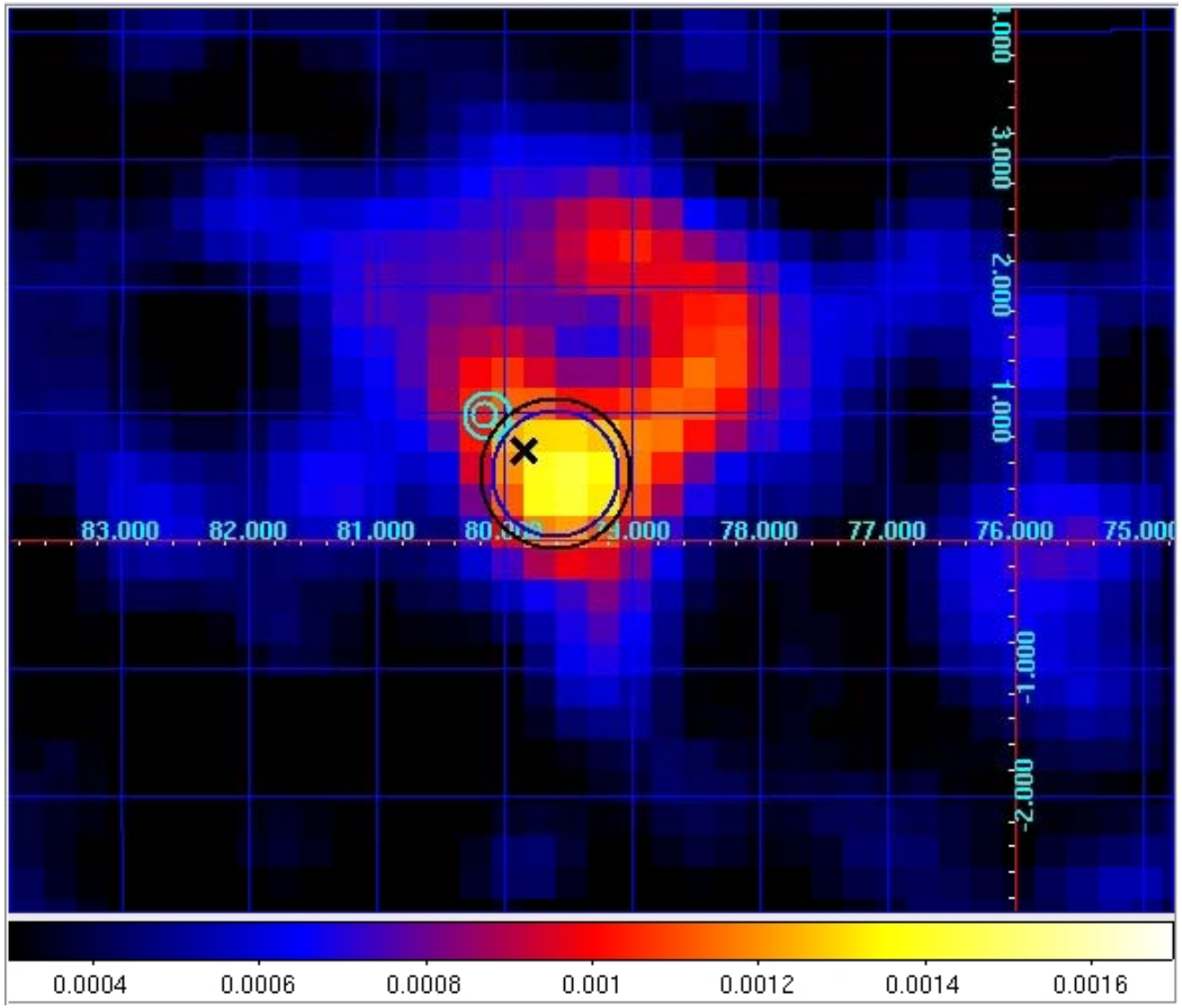
(ASM of XTE)

Hard X-ray flux state change

(SuperAGILE)

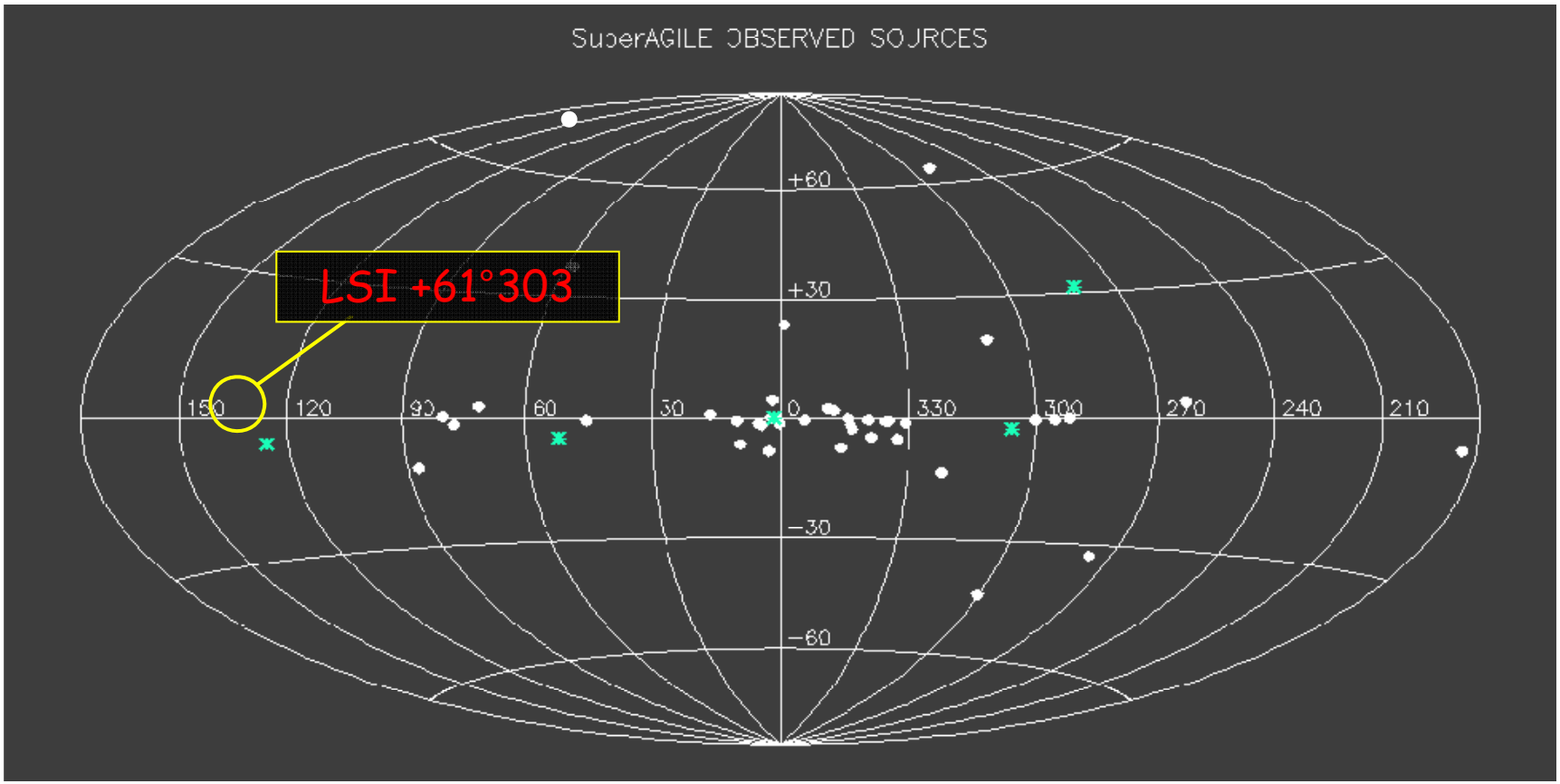


By integrating all flaring data, we find that a gamma-ray source is detected at 5.5 σ level with an average flaring flux F = (190 ± 40) x 10e-8 photons cm-2 s-1 above 100 MeV



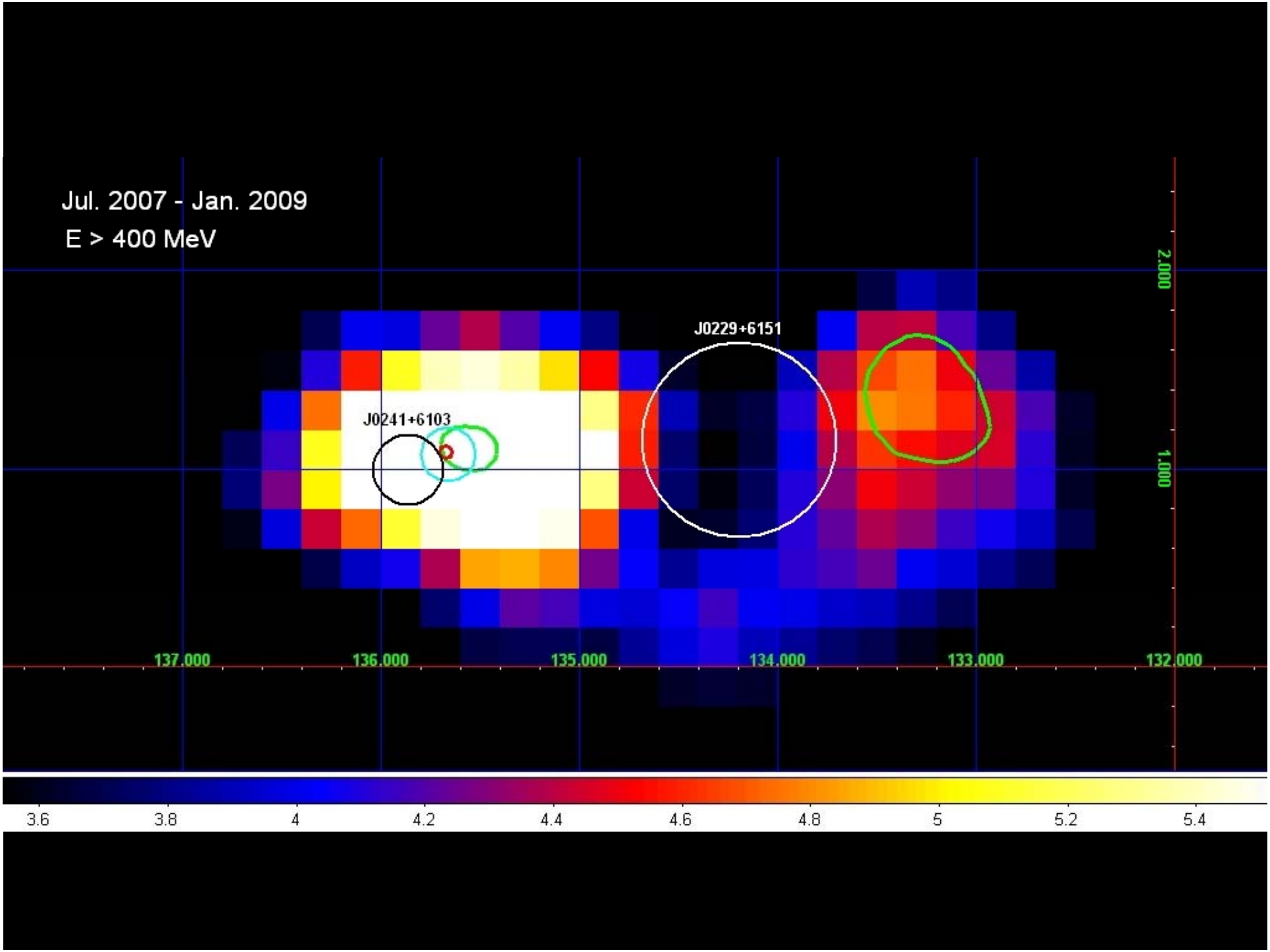
Cygnus X-3 and other micro-qso's

- long timescale monitoring of micro-qso's at hard X-ray and gamma-ray energies is crucial
- remarkable detection of Cygnus X-3
- encouraging prospect to detect other gamma-ray flares from microquasars
- need of multifrequency (especially radio, X-ray) data !

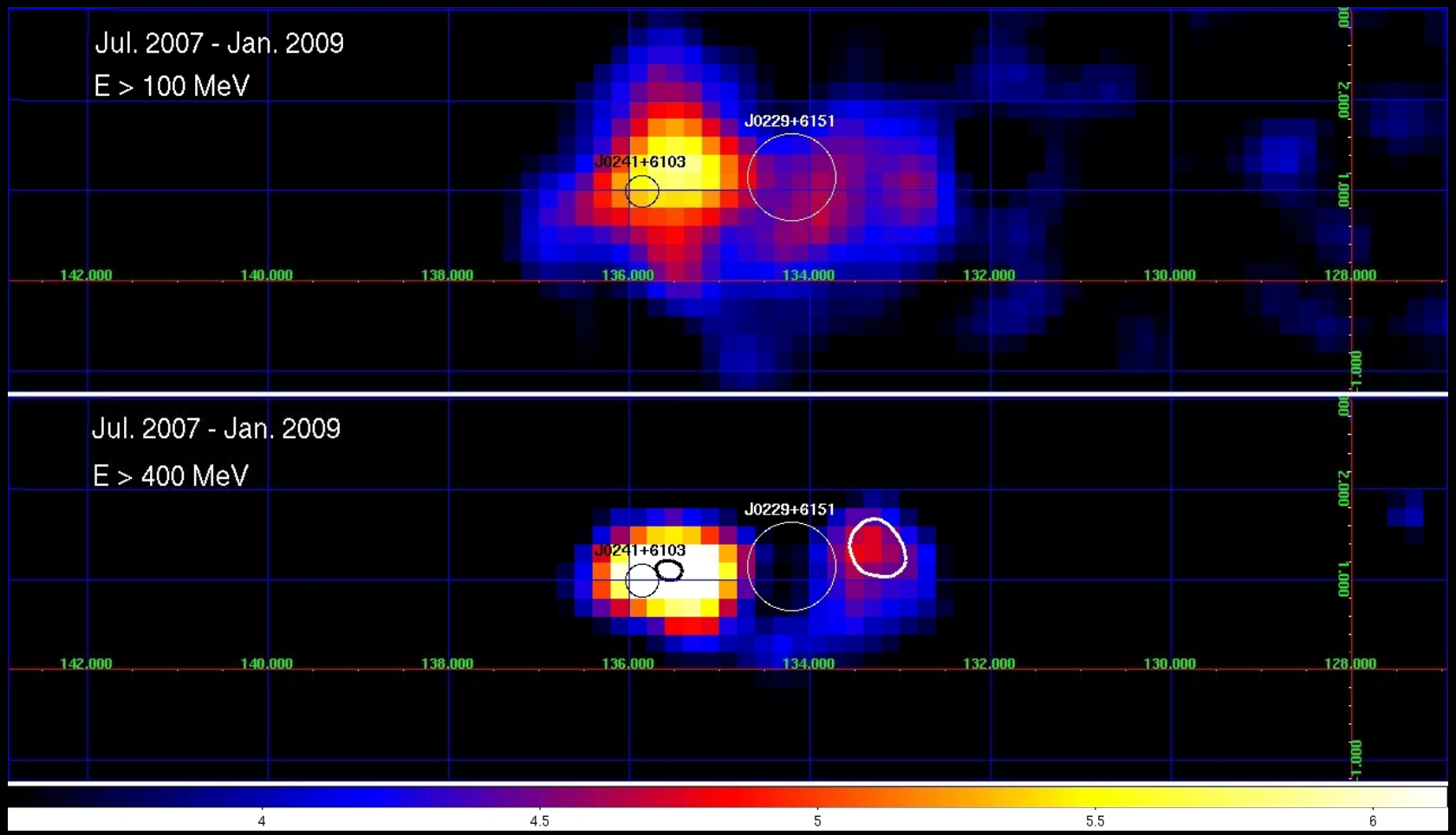

SuperAGILE OBSERVED SOURCES
LSI +61°303
+60
+30
−30
−60
120
90
60
30
0
330
300
270
240
210

LSI +61°303

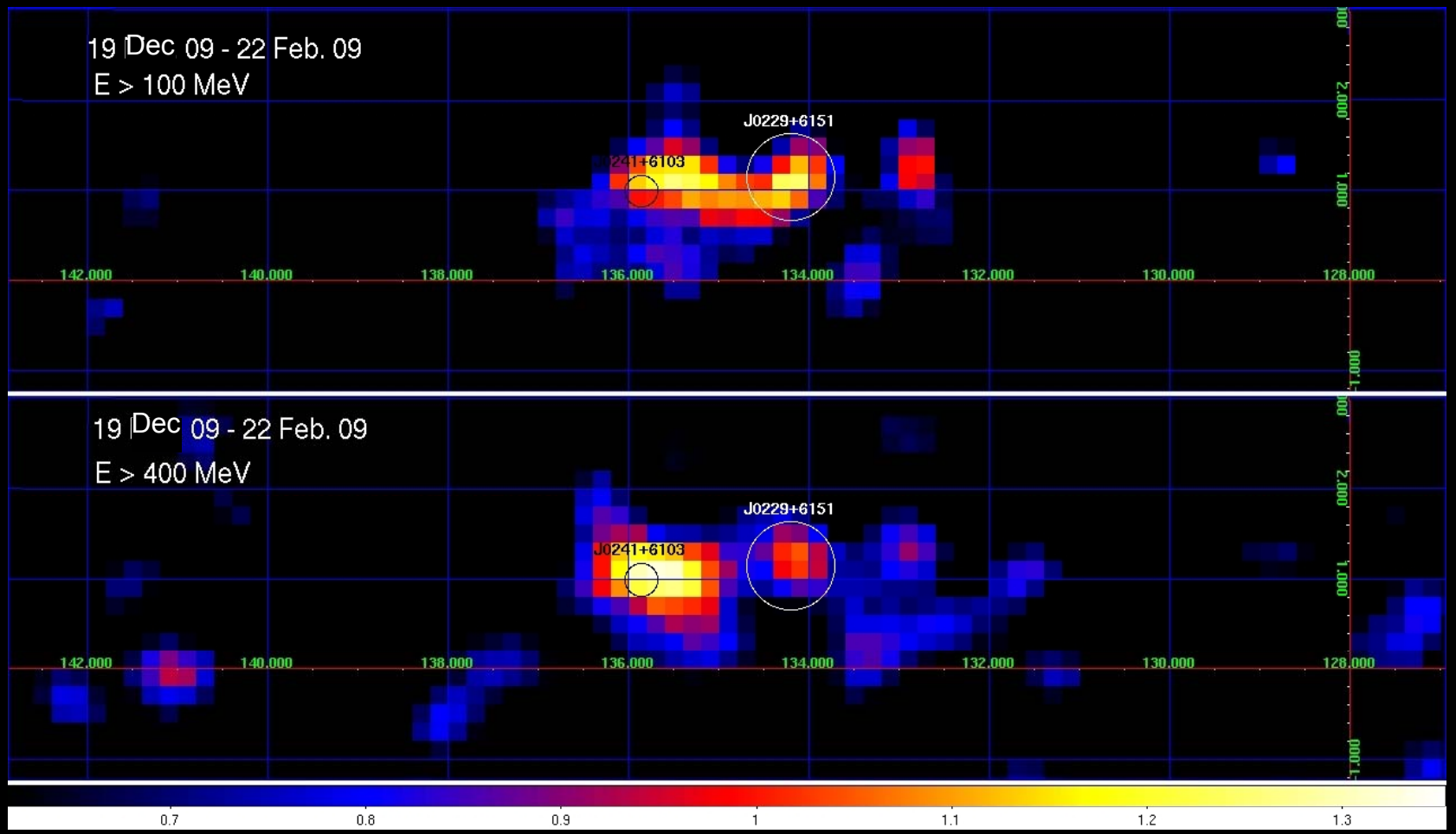
GRID Galactic anticenter observation

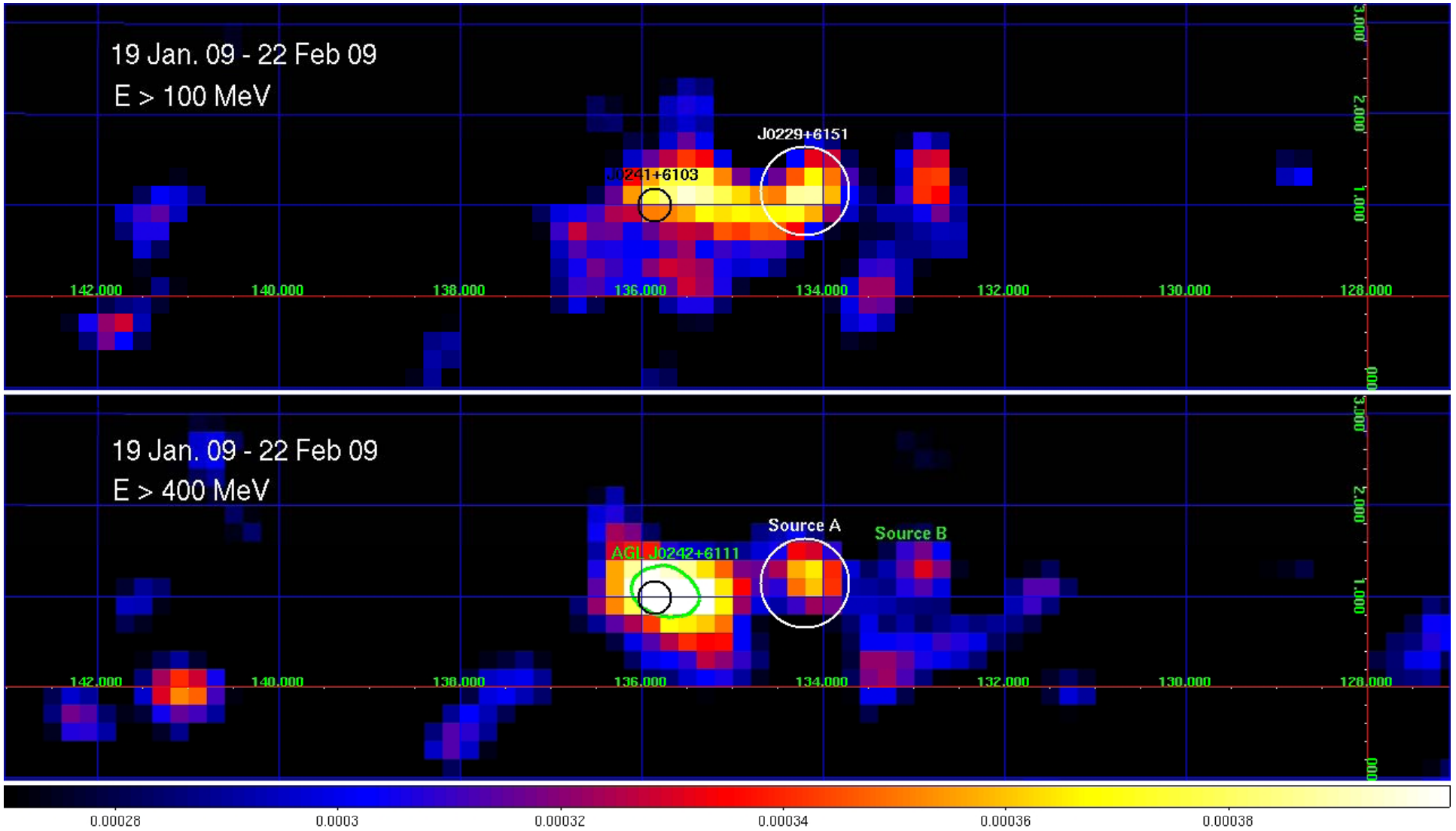

Jul. 2007 - Jan. 2009
E > 400 MeV
J0229+6151
J0241+6103
2.000
1.000
137.000
136.000
135.000
134.000
133.000
132.000
3.6
3.8
4
4.2
4.4
4.6
4.8
5
5.2
5.4

LSI 61 303 field (all data)



LSI 61 303 field (Dec. 08 – Feb. 09)



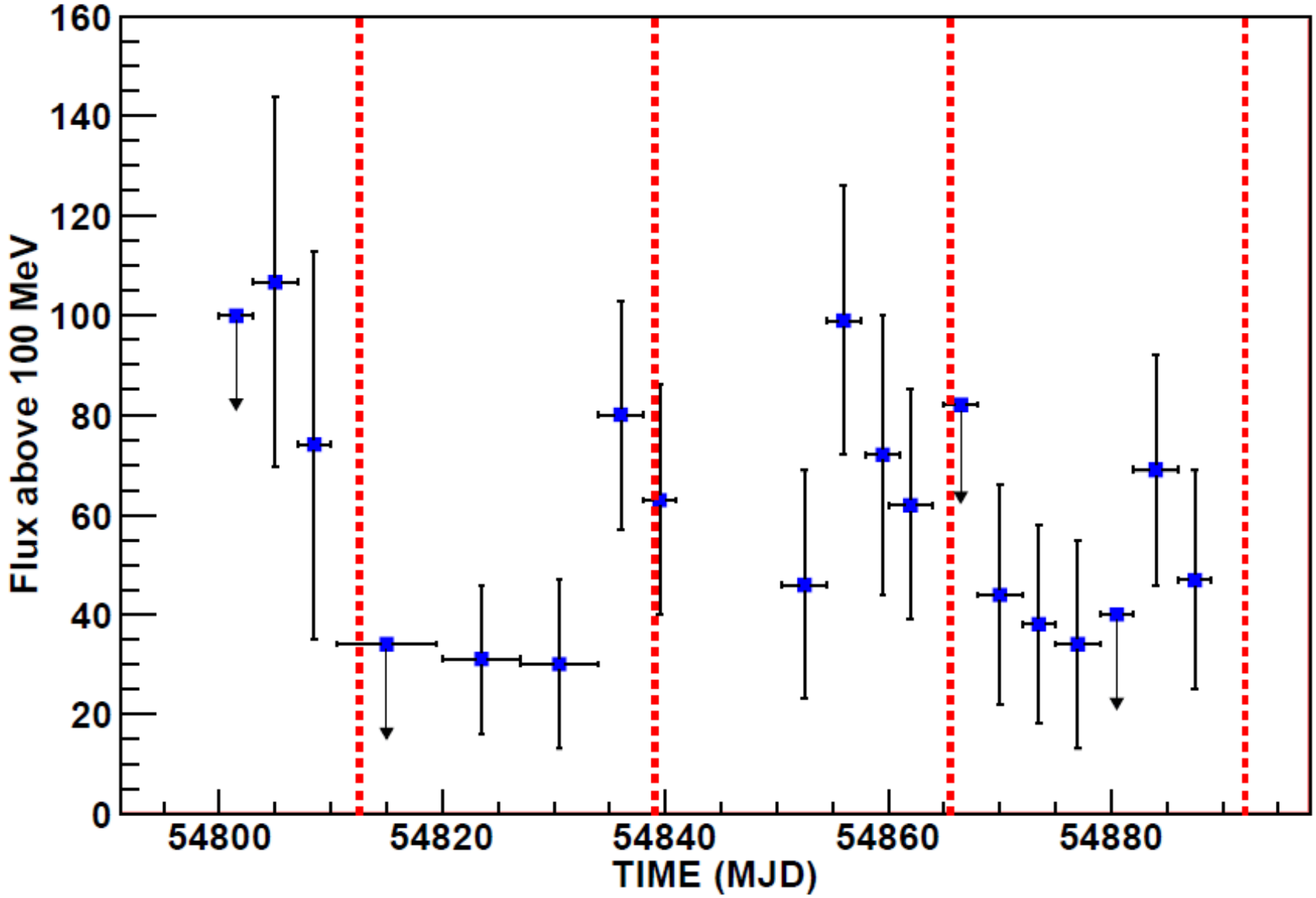


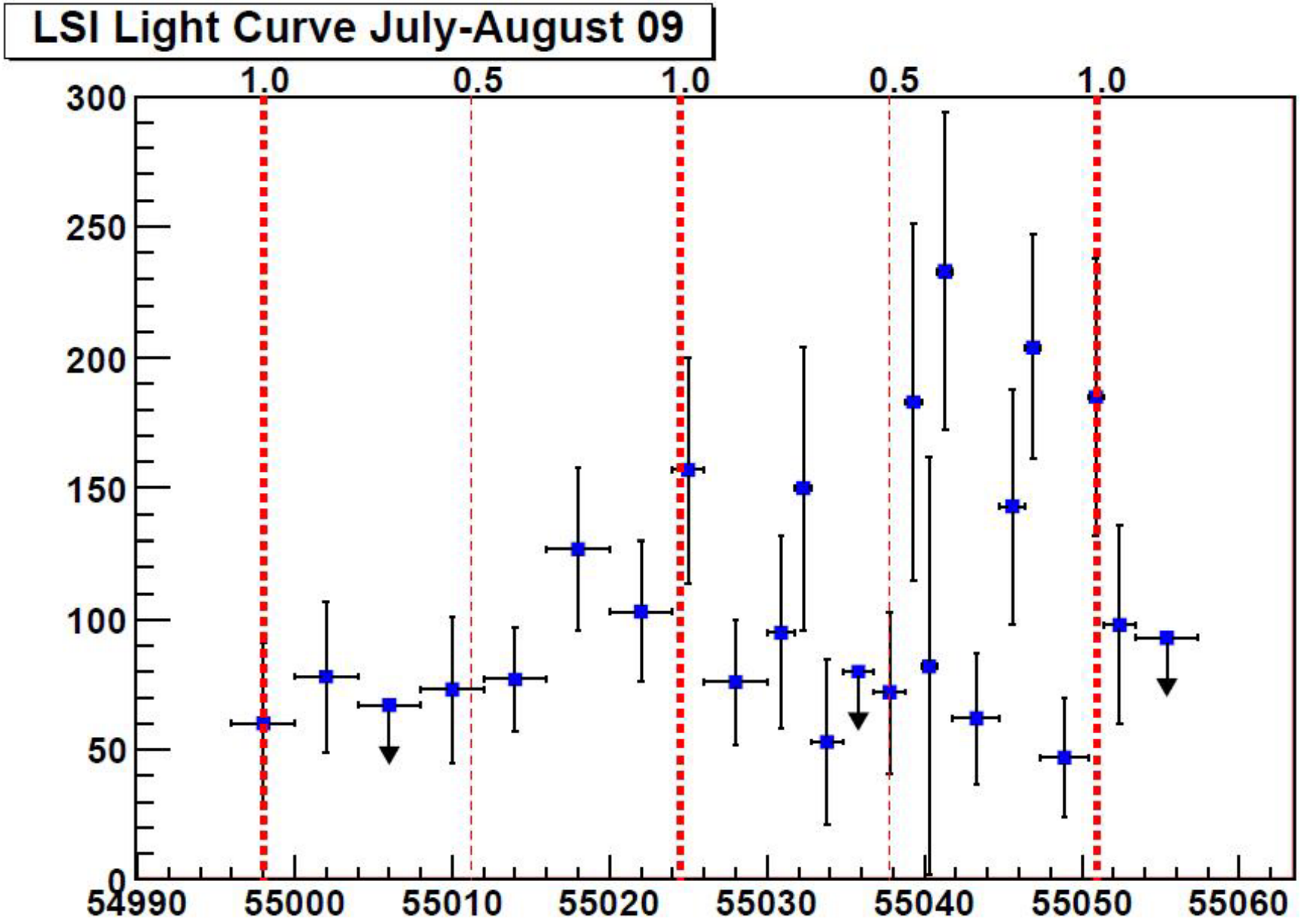
GAMMA-RAY SOURCES NEAR LS I +61 303

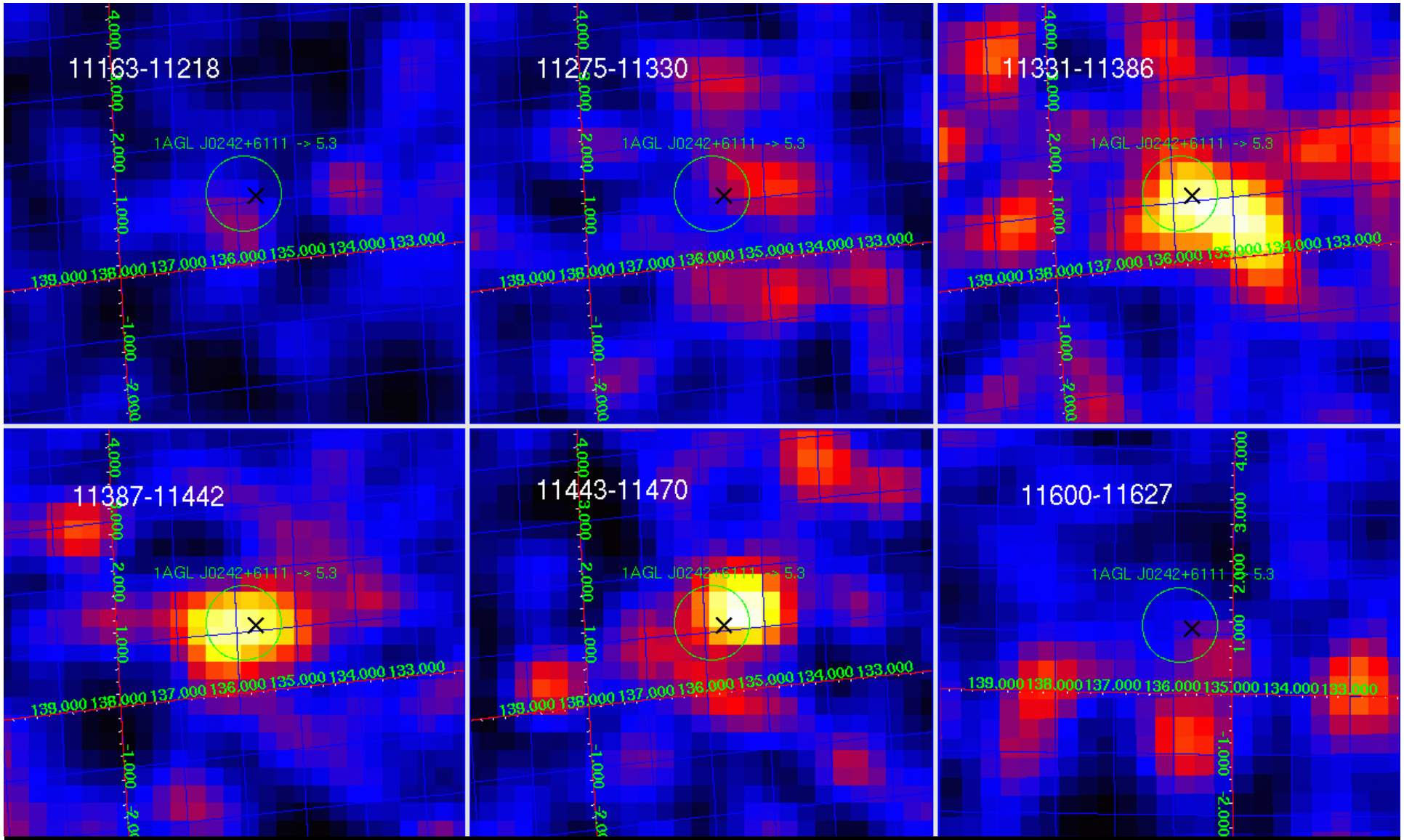
Source	AGILE contacts	l	b	error box radius	Average flux above 100 MeV (10^{-8} phcm^{-2} s^{-1})
LS I +61 303 (AGL J0242+6111)	1200-9994	135.54	1.1	0.1	41.7 ± 2.8
Source B (3EG J0229+6151)	1200-9994	133.3	1.4	0.3	14.6 ± 2.5
Source A	8996-9472	134.2	1.2	0.3	13.8 ± 3.5

Light Curve LSI 54800-54890

(Dec. 08 – Feb. 09)



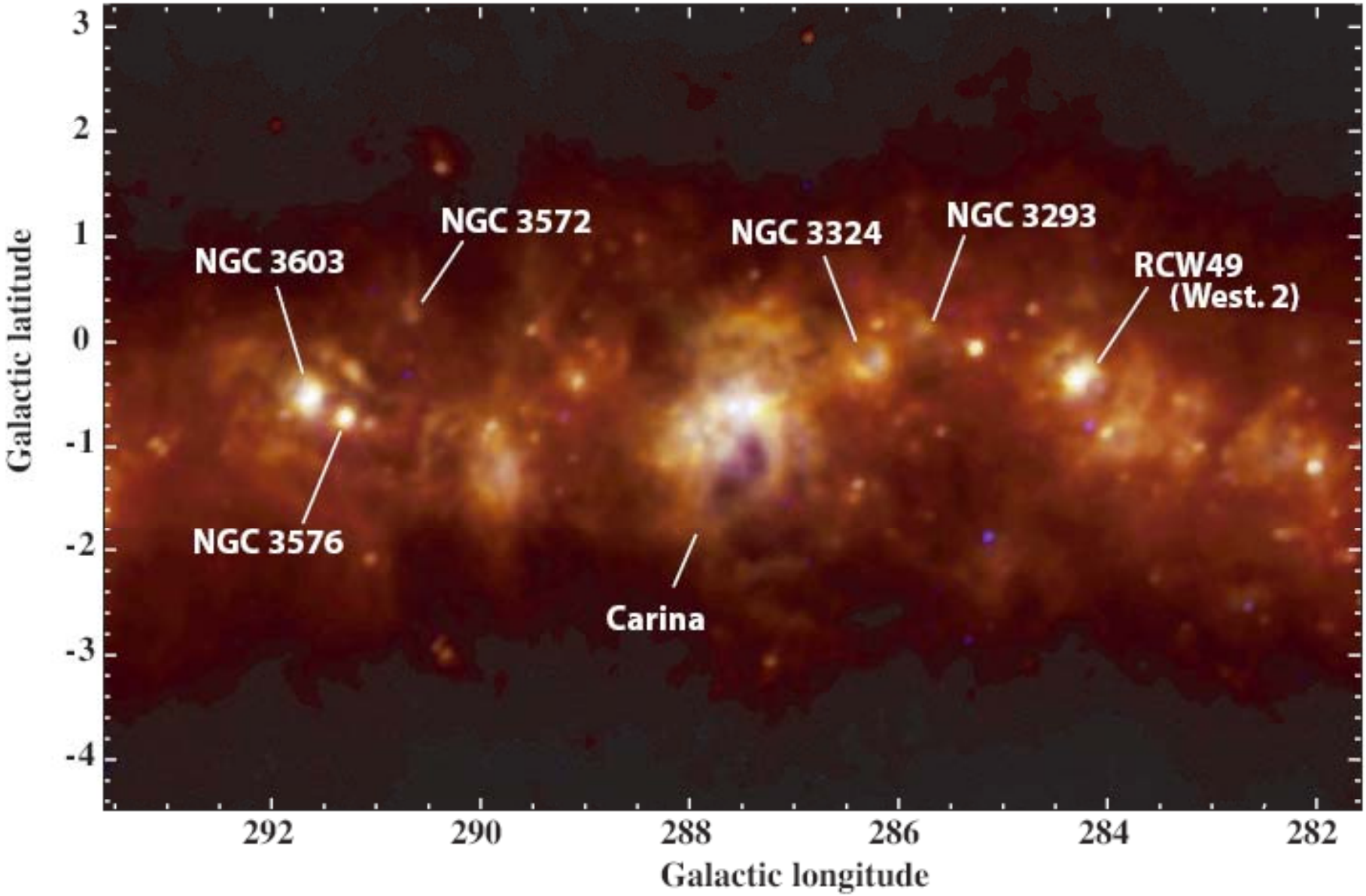

LSI Light Curve July-August 09
1.0
0.5
1.0
0.5
1.0
300
250
200
150
100
50
0
54990
55000
55010
55020
55030
55040
55050
55060



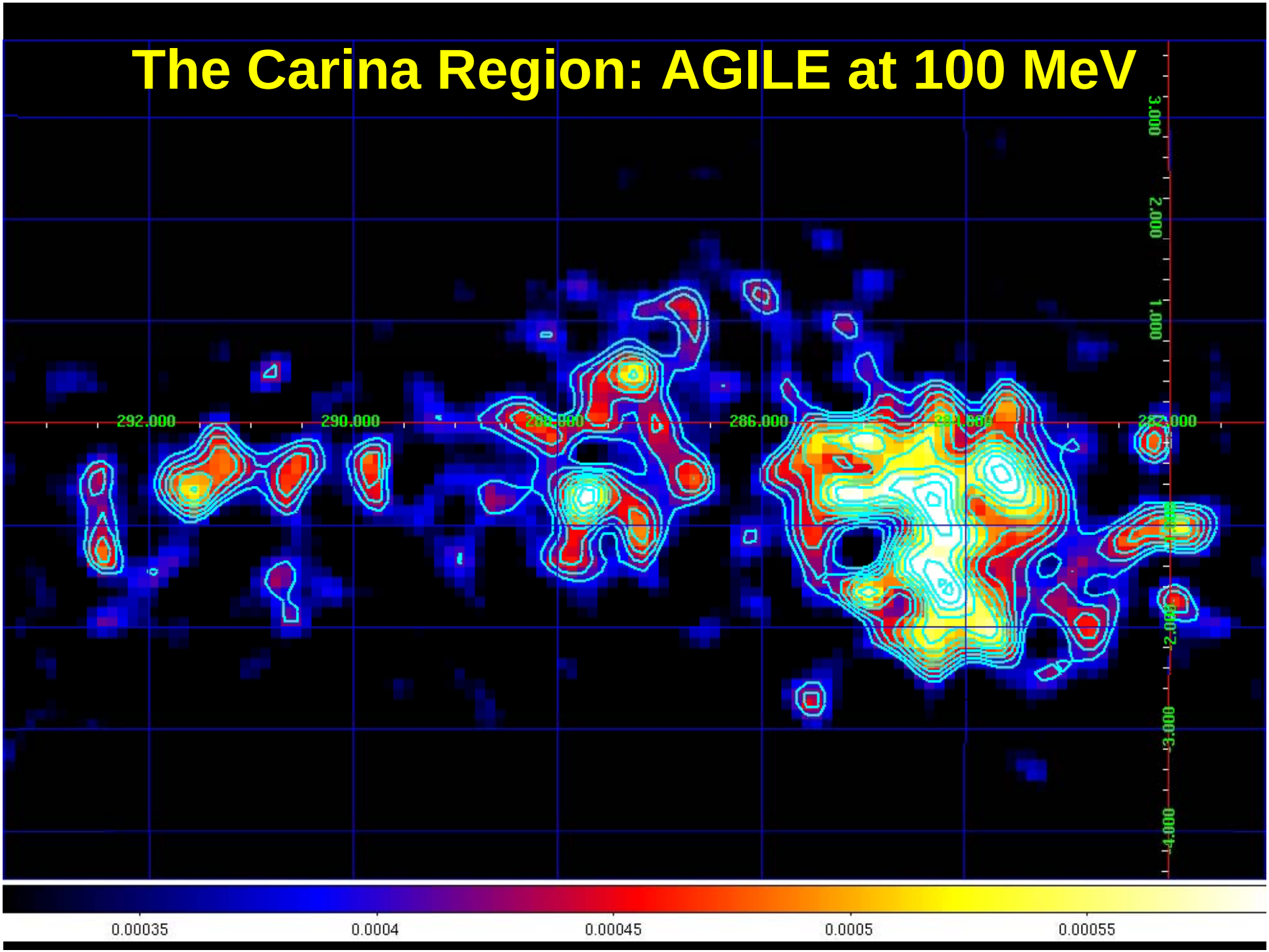
July 09 flares

AGILE and the Carina Region

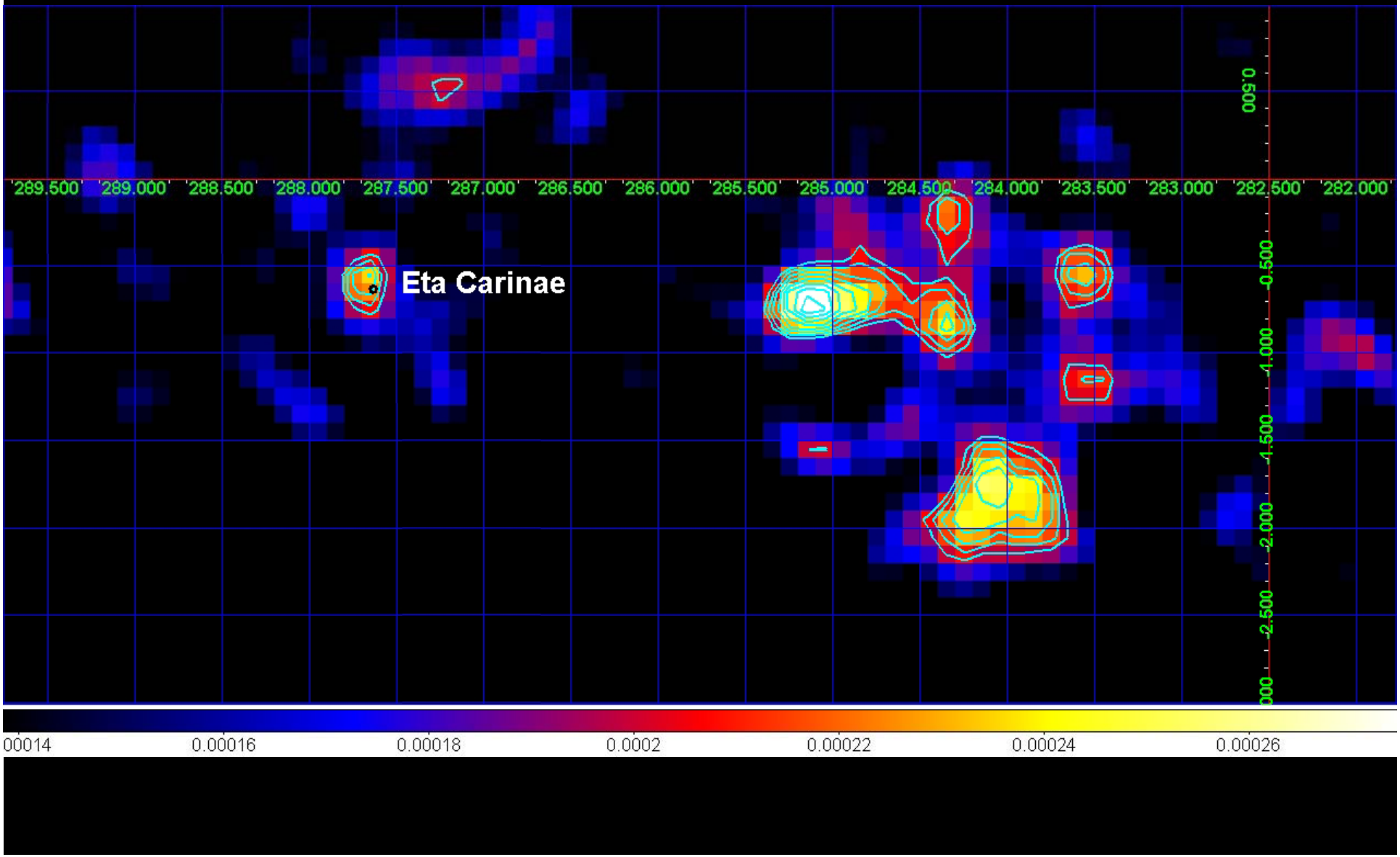
The Carina Region, IR



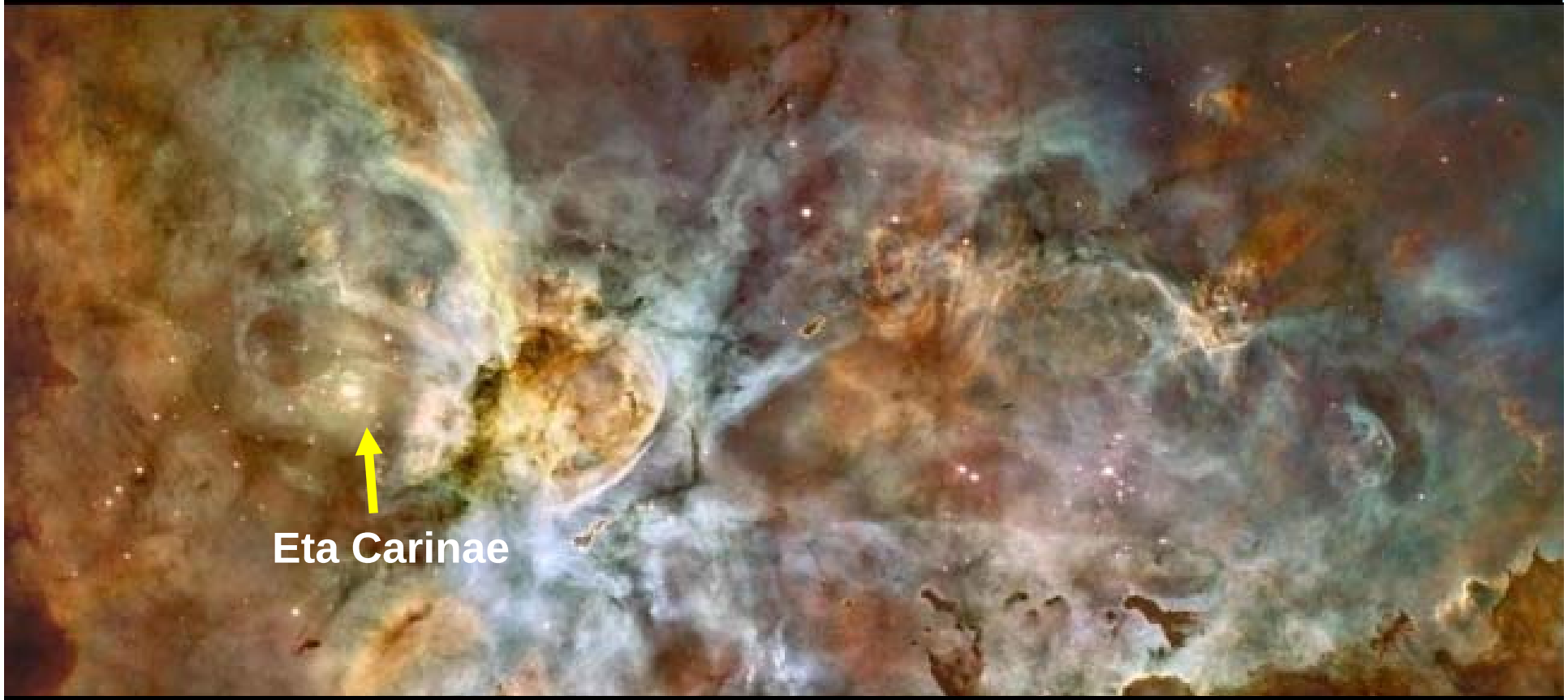
The Carina Region: AGILE at 100 MeV



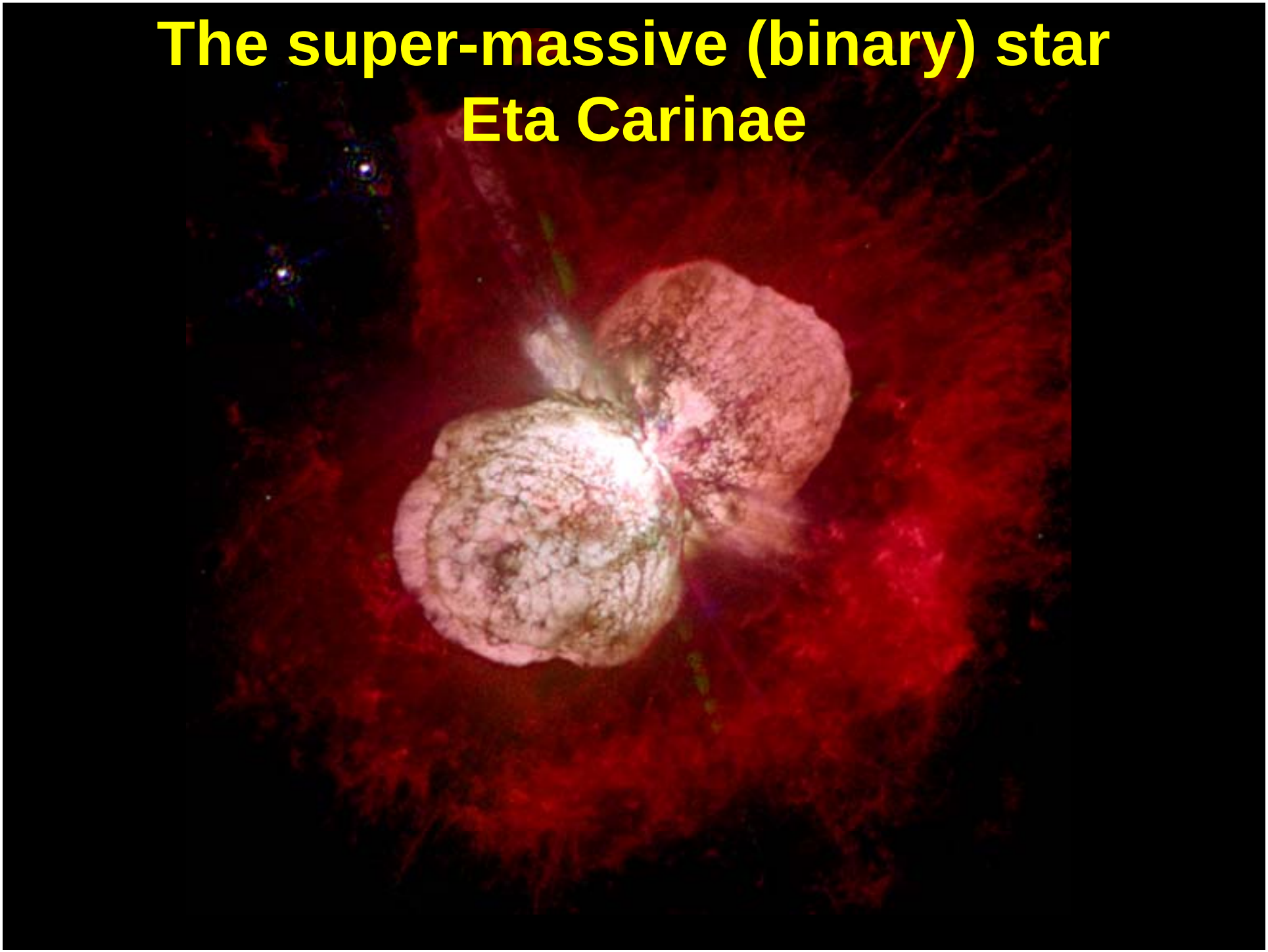
AGILE –Carina Region at 400 MeV



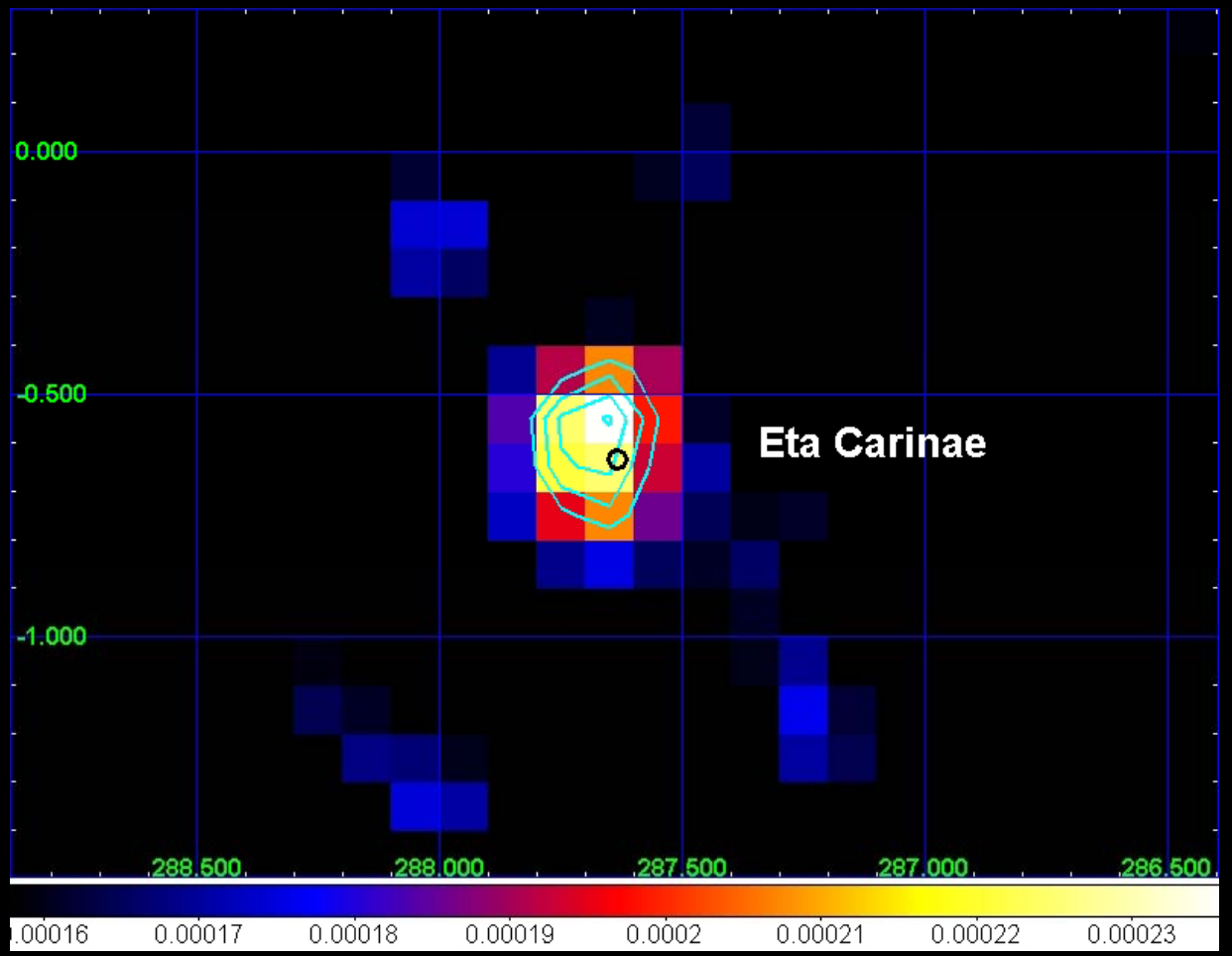
Star formation in the Carina Nebula



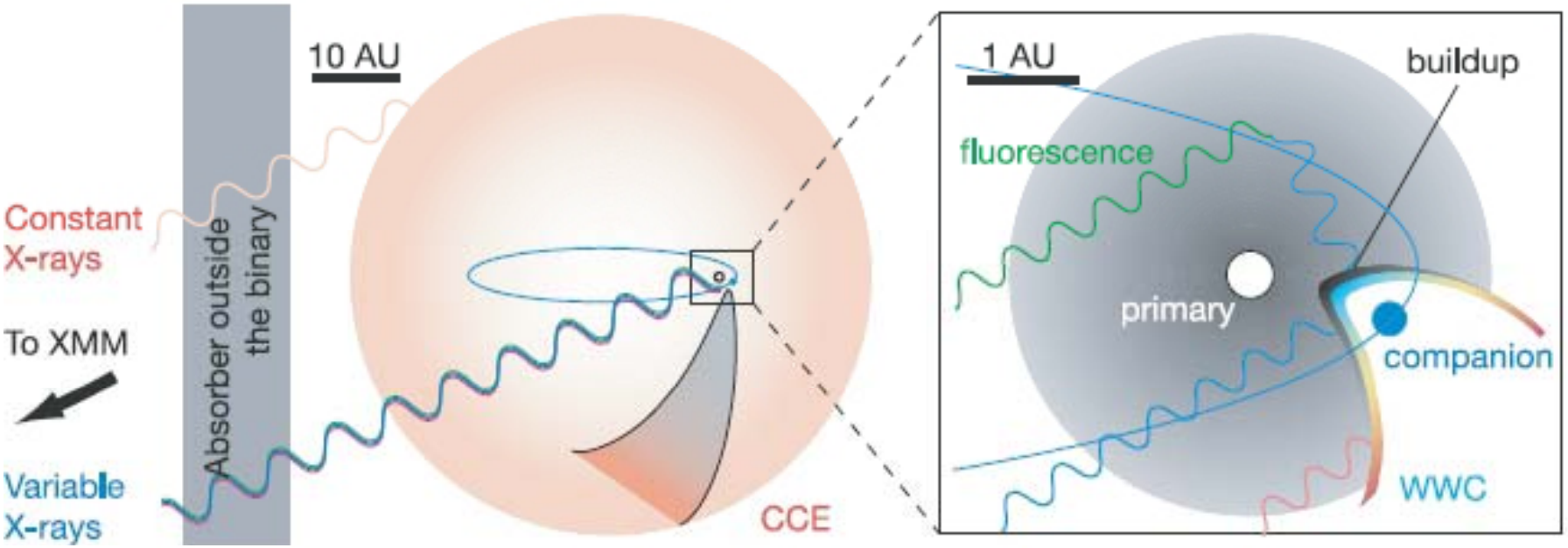
The super-massive (binary) star Eta Carinae



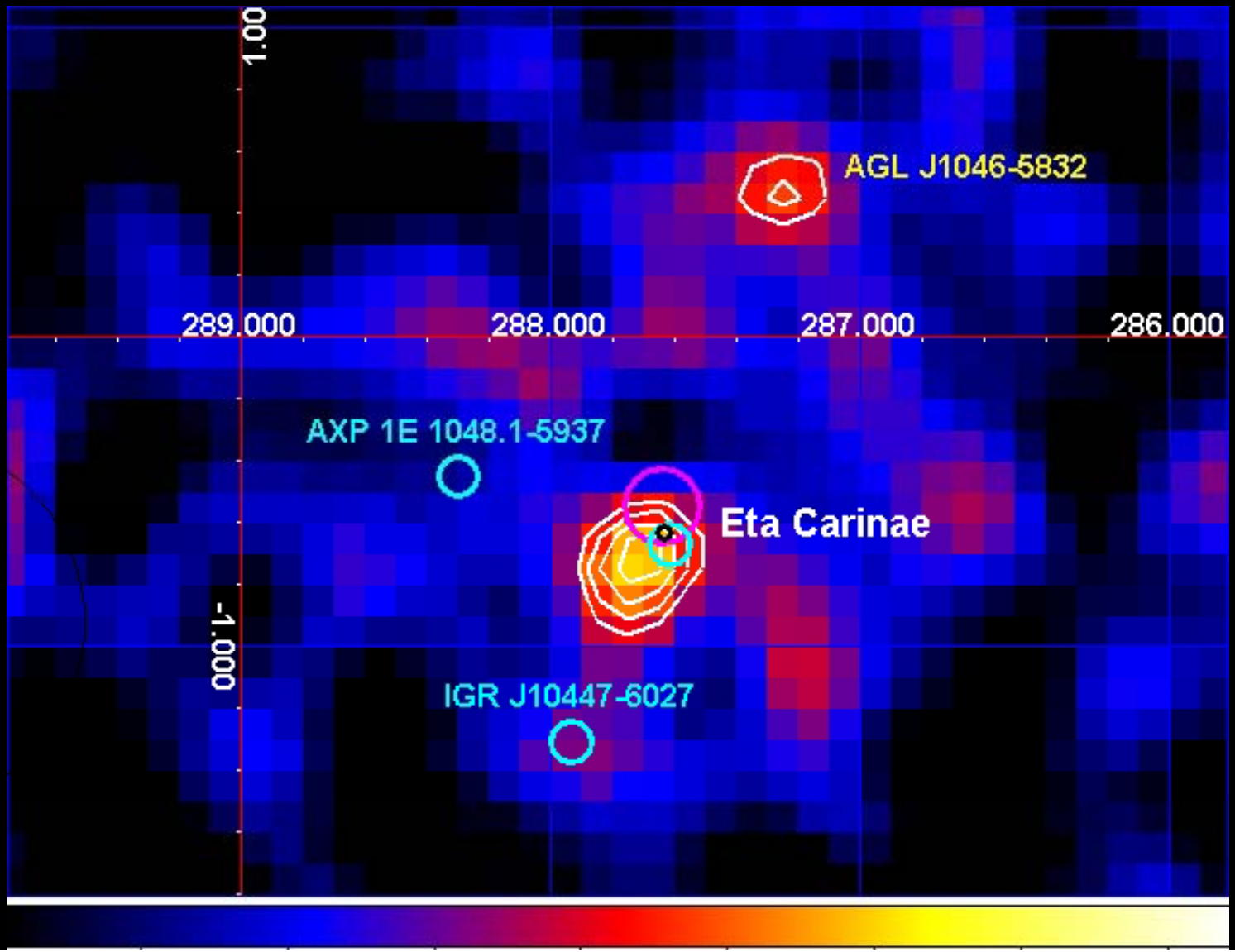
AGILE-GRID, Eta Carinae at 400 MeV



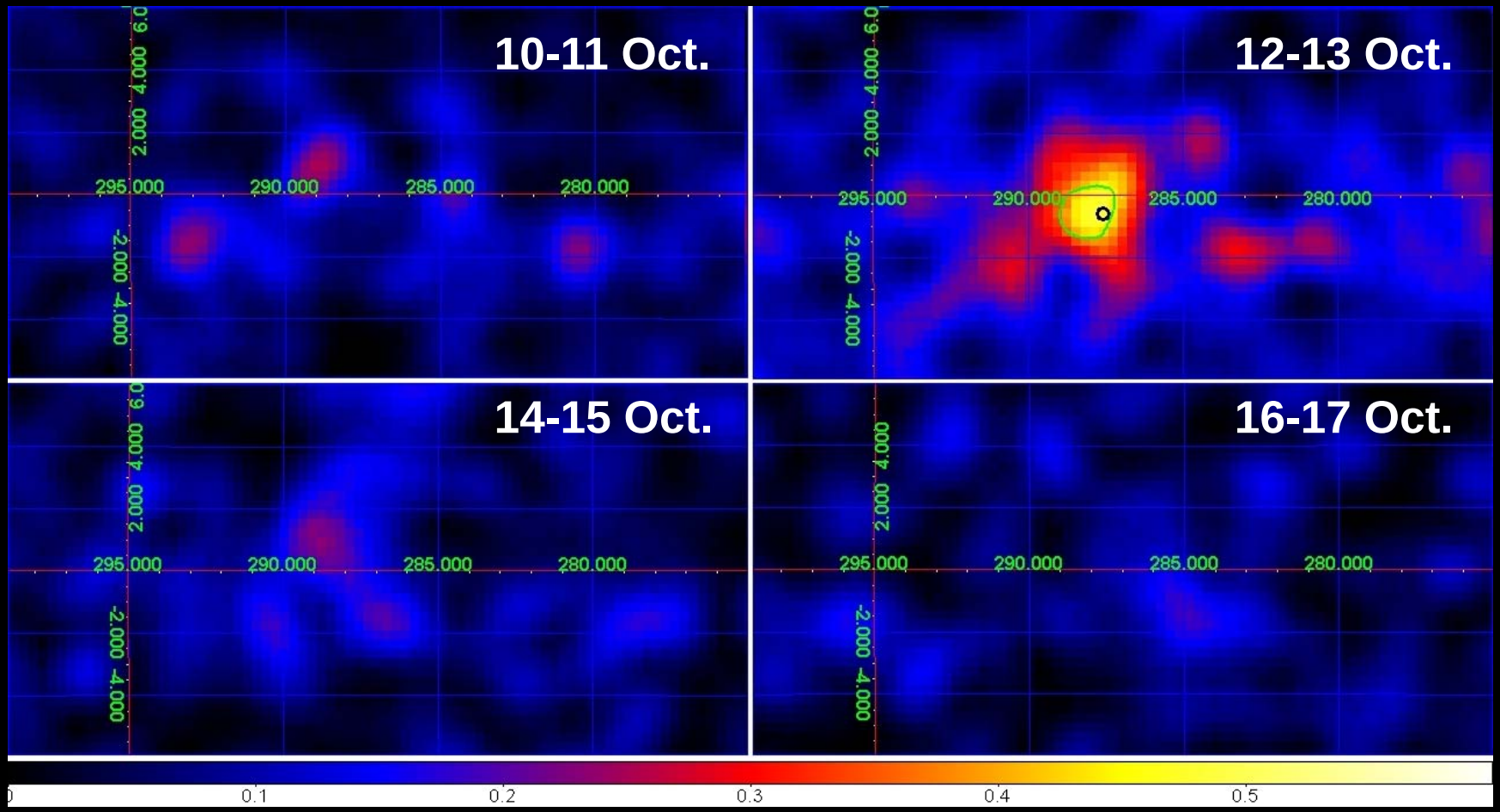
The Eta Carinae system: a colliding wind binary



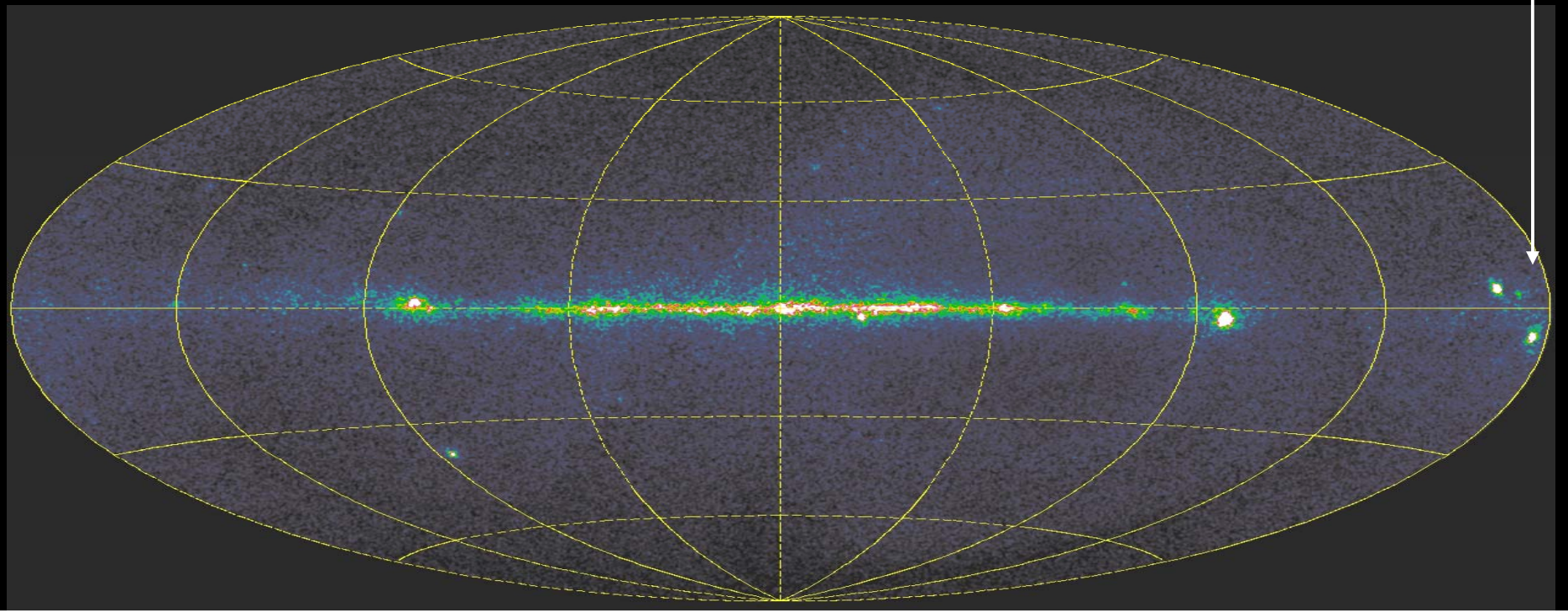
AGILE discovery of gamma-ray emission from the Eta Carinae region: first observation of colliding wind binary in gamma-ray



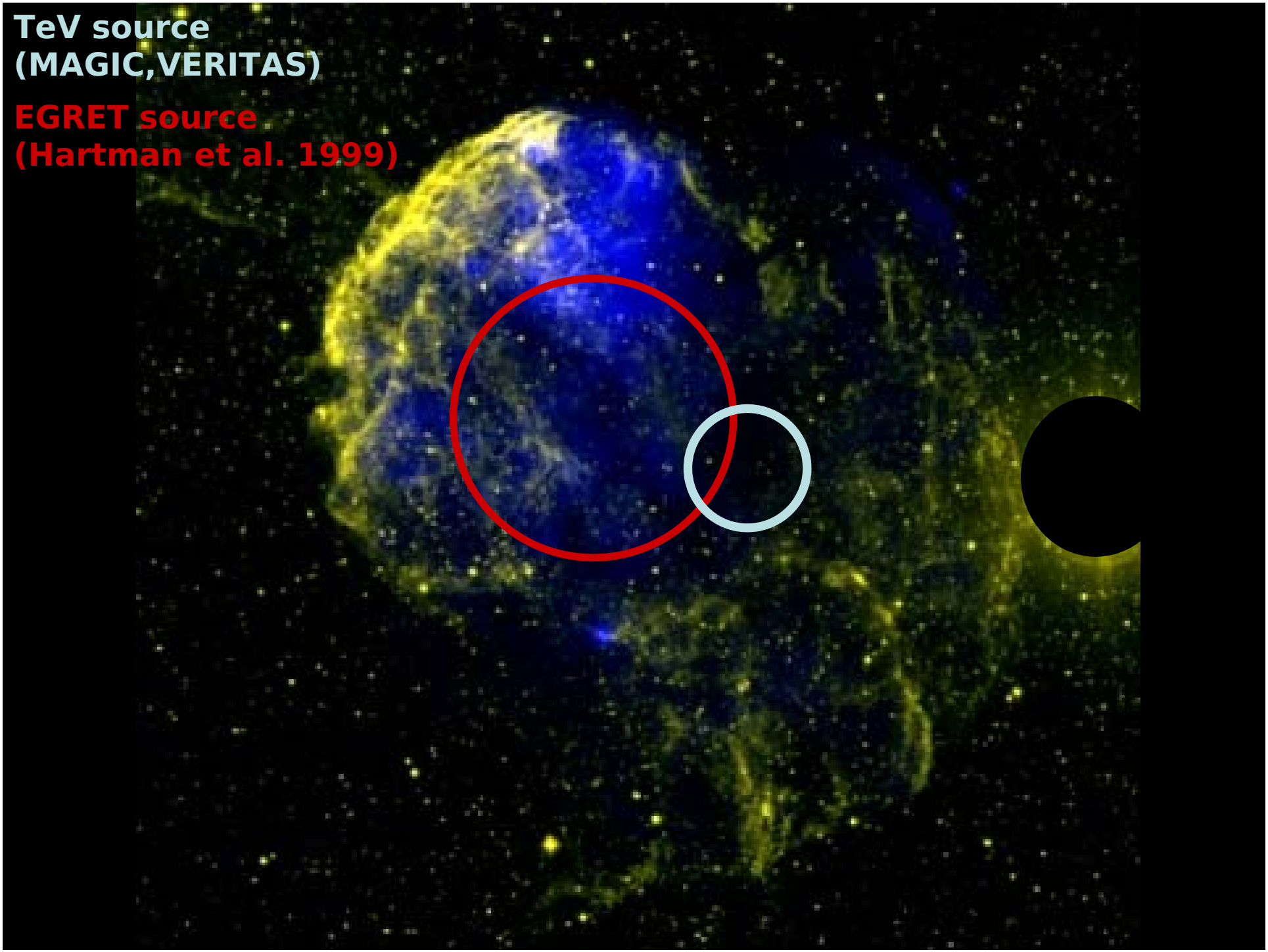
Transient gamma-ray emission from Eta Carinae (12-13 Oct., 2008)



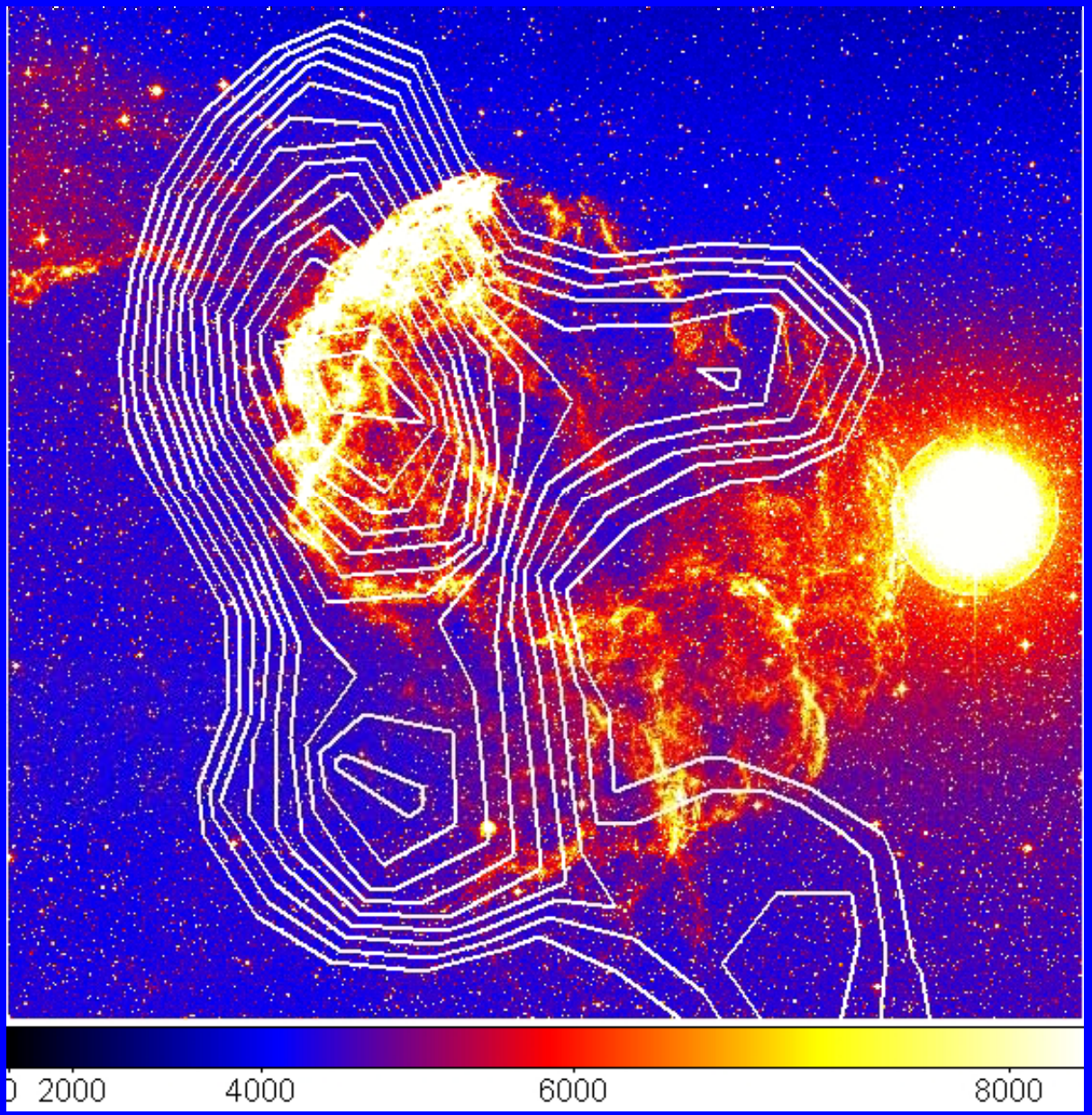
AGILE's SNRs

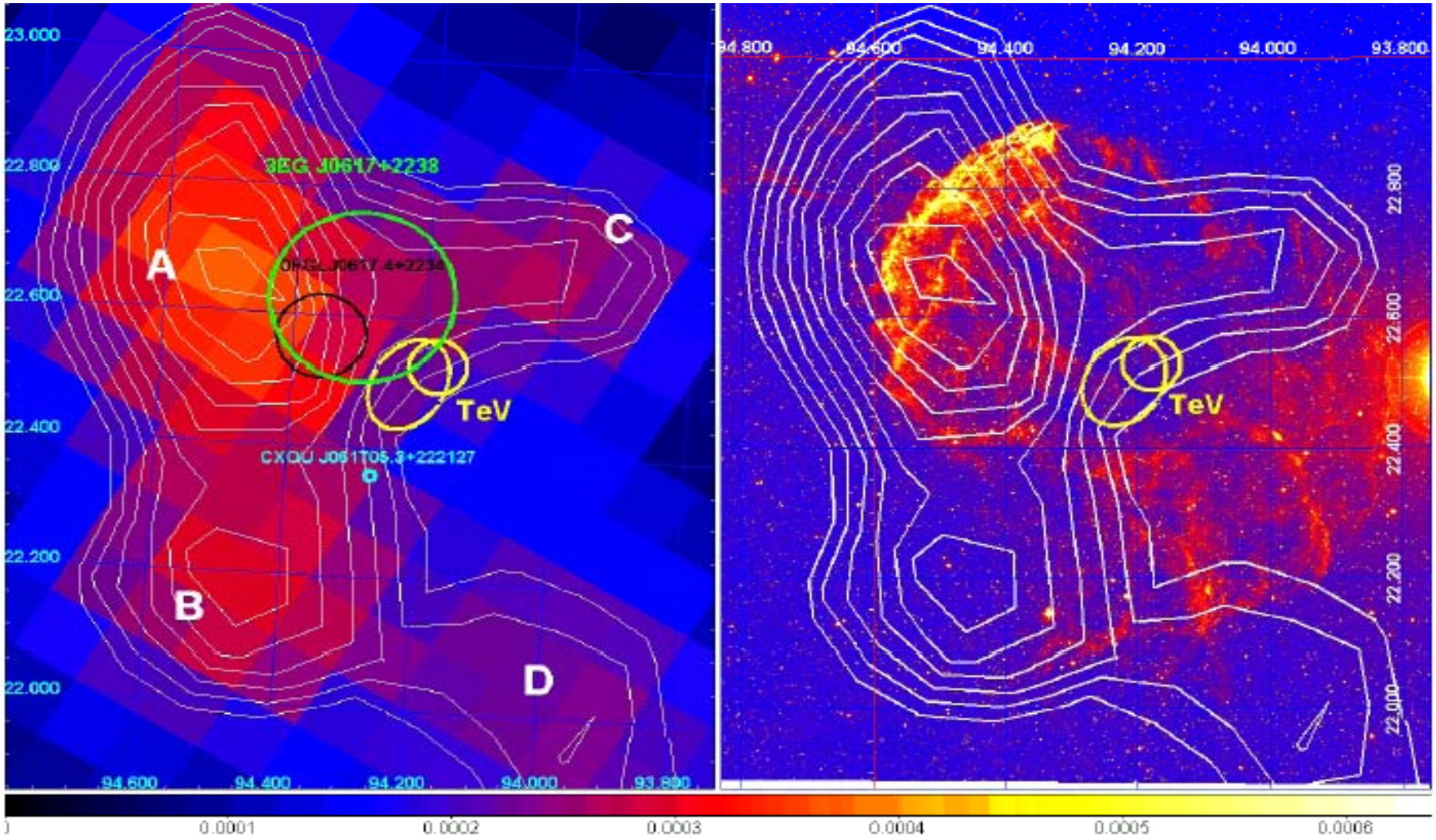


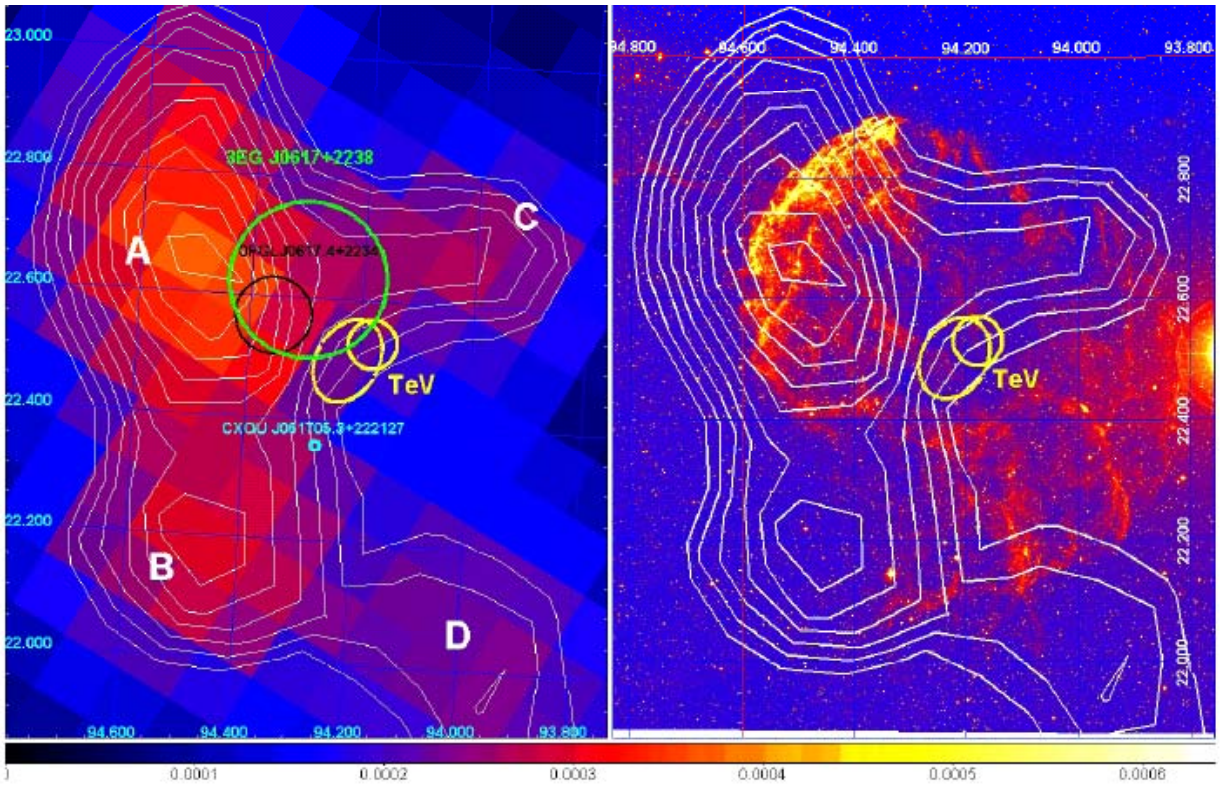

IC 443


TeV source
(MAGIC,VERITAS)
EGRET source
(Hartman et al. 1999)

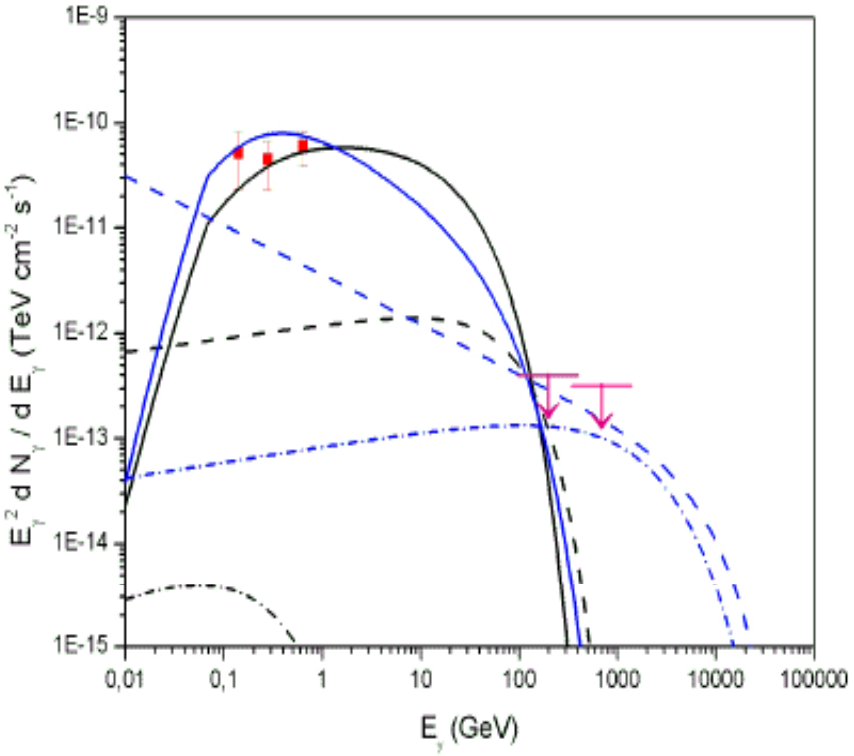
AGILE: gamma-ray imaging (E> 400 MeV) of IC 443




23.000
22.800
22.600
22.400
22.200
22.000
94.600
94.400
94.200
94.000
93.800
3EG J0617+2238
A
B
C
D
TeV
CXOU J061705.3+222127
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006



Gev Source
≠
TeV Source



- **Model 1**
  - **Electron/proton ratio: 3 x 10^{-2}**
  - **α = 2.7**
  - **n_cloud = 10^3 cm^{-3}**
  - **E_electron_cutoff = 10 TeV**
  - **E_proton_cutoff = 200 GeV**
- **Model 2**
  - **Electron/proton ratio: 10^{-2}**
  - **α = 2.1**
  - **n_cloud = 10^3 cm^{-3}**
  - **E_electron_cutoff = 100 GeV**
  - **E_proton_cutoff = 100 GeV**

Spectral characteristics, and location of the most prominent gamma-ray emission together with the overall absence of co-spatial detectable TeV emission are consistent only with a hadronic model of cosmic-ray acceleration in the SNR

Direct evidence for hadronic cosmic ray acceleration in SNR.

- High-spatial resolution gamma-ray imaging of IC 443 leads to the discovery of disjoint gamma-ray and TeV emission in the SNR.
- The inferred total number of accelerated protons is consistent with a CR energy near 1-10% of the total SN kinetic energy
- From the implausibility of the electron model of emission, we conclude to have provided the first long-sought **direct evidence** for hadronic cosmic ray acceleration in SNR.

Conclusions

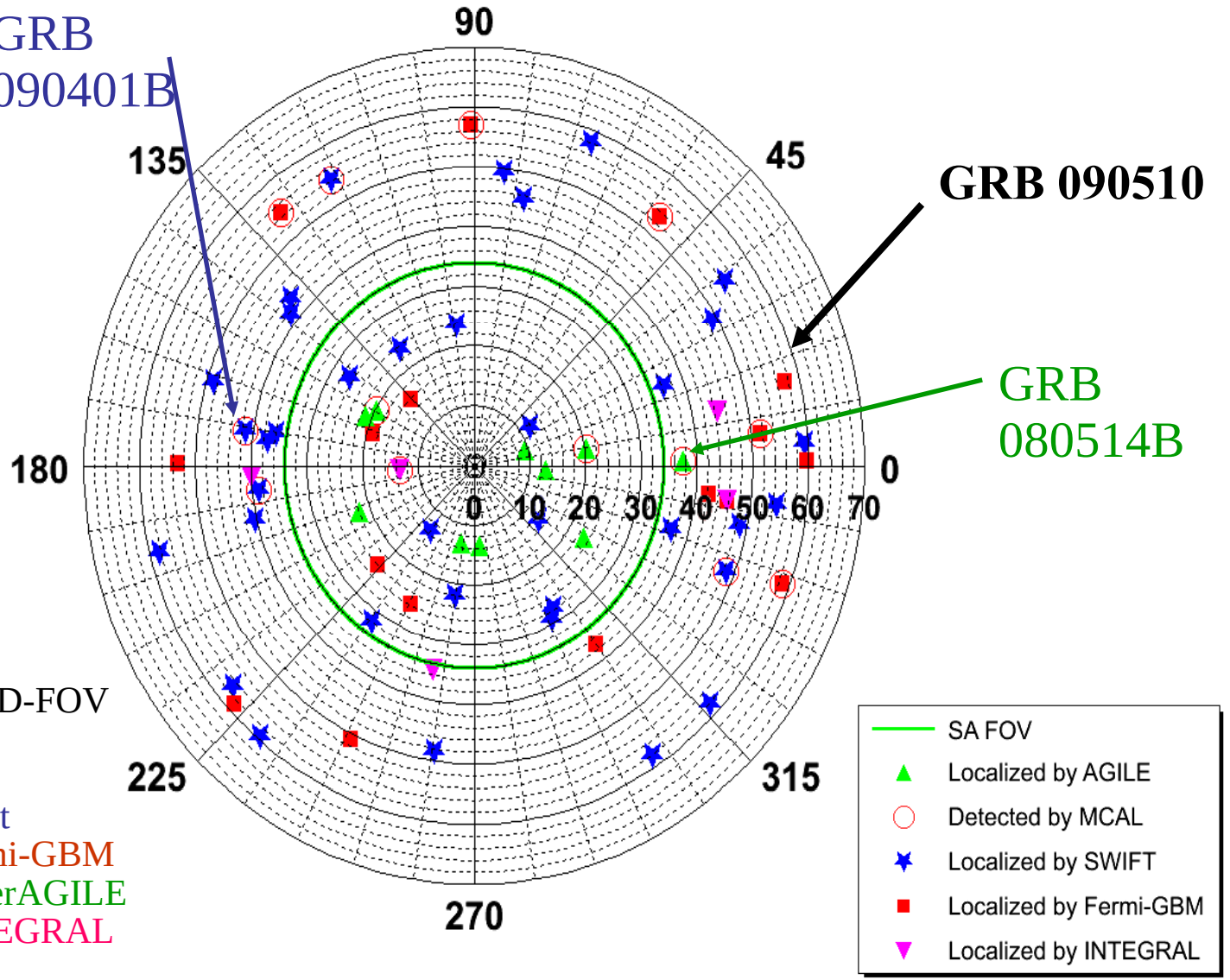
- **Very exciting time for gamma-ray and VHE astrophysics**
- **AGILE and FERMI will provide a wealth of data on a variety of sources**
- **First detections by AGILE of Galactic transients**
  - **no hard X-ray outbursts**
- **Special attention to Galactic microquasars and CWB during the AGILE Cycle-3**
- **Require FAST alerts and follow-up multi-freq. observations!**

THANK YOU!

GRBs and Flashes

- only 4 GRBs detected so far above 100 MeV
- very good timing capability, millisecond trigger
- Terrestrial Gamma-Ray Flashes (TGFs)

The AGILE GRB dataset (detections and upper limits)



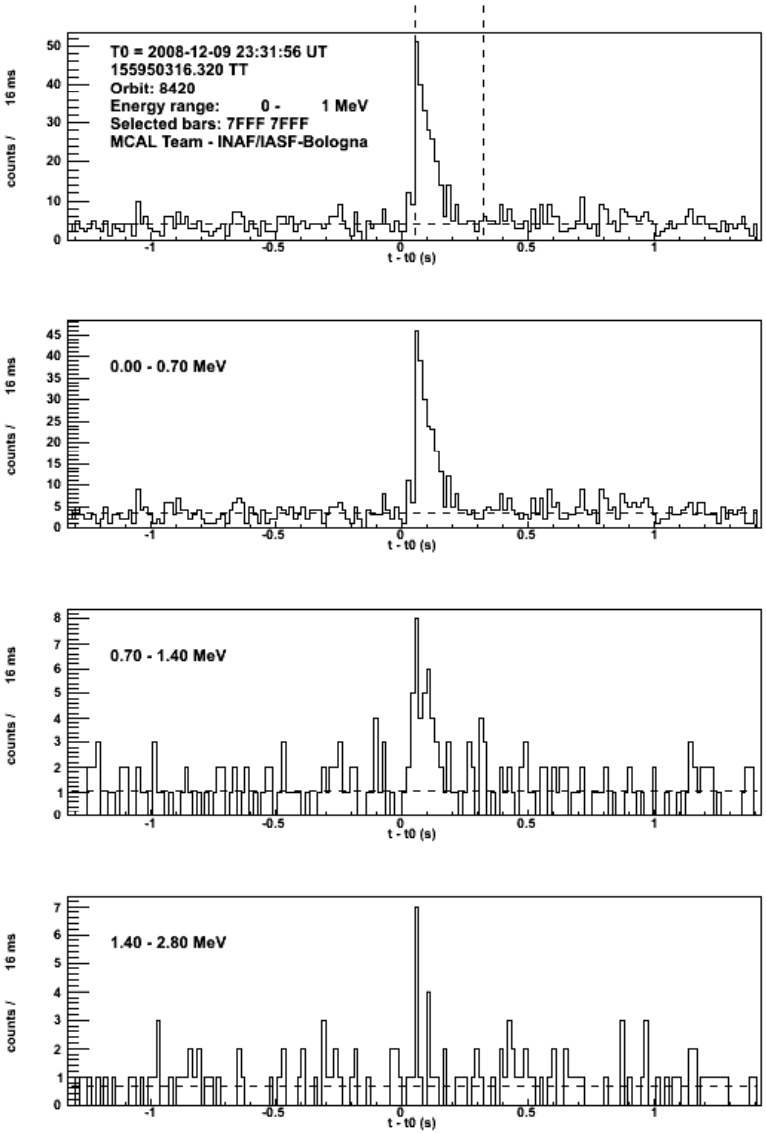
68 GRBs in the GRID-FOV
until 17 April 2009:

36 localized by Swift
17 localized by Fermi-GBM
10 localized by SuperAGILE
5 localized by INTEGRAL

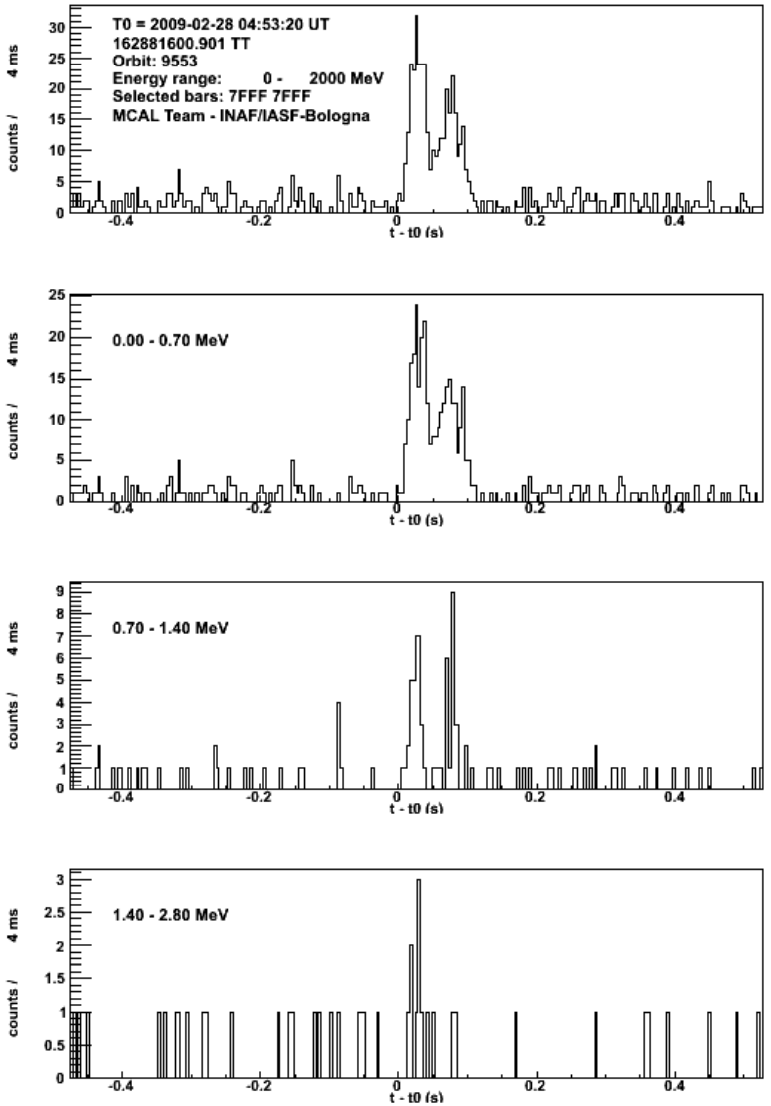
13 also detected by MCAL

cosmic short/hard GRBs

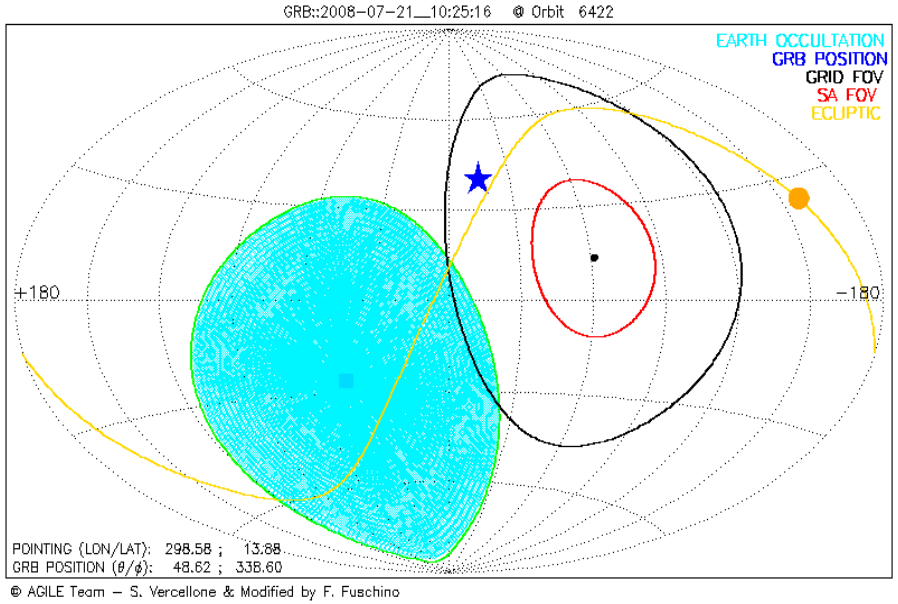
GRB 081209

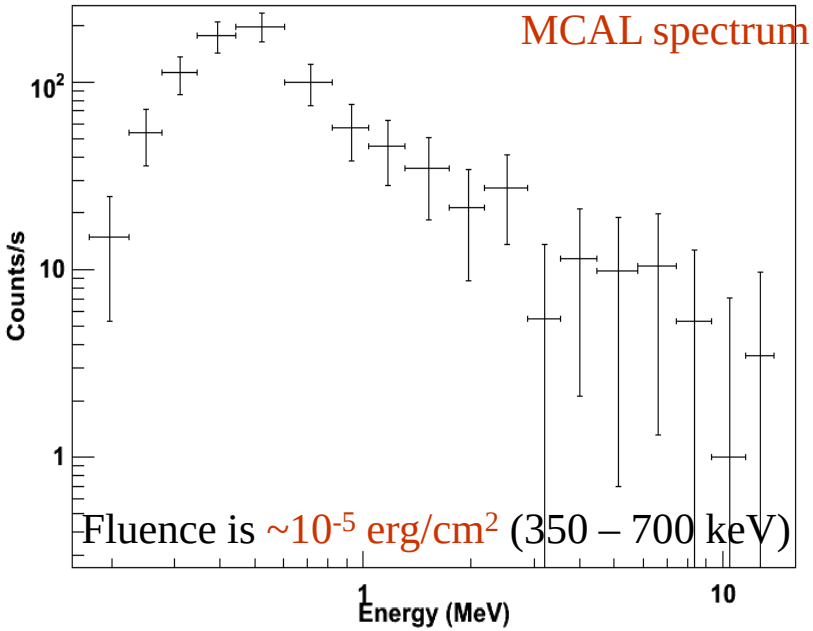


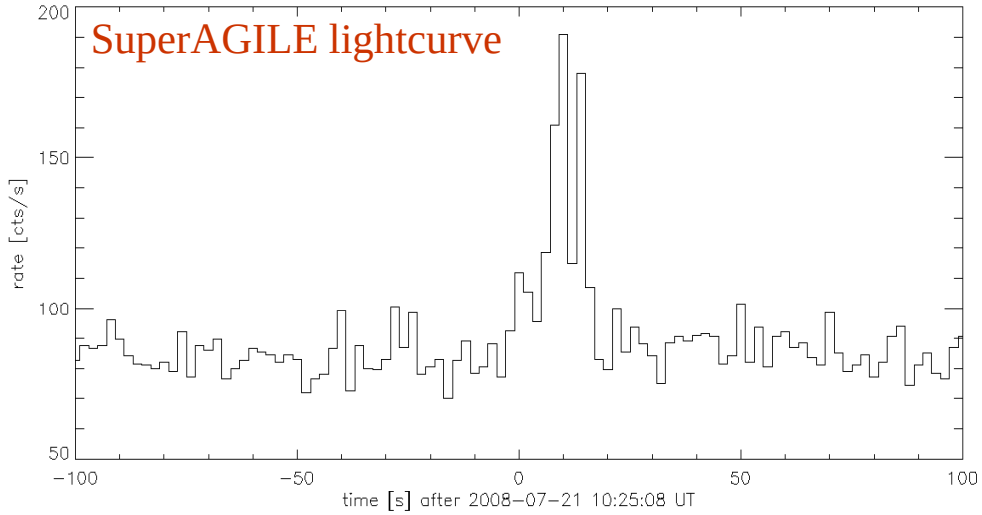
GRB 090228



GRB 080721







Off-axis ~49°

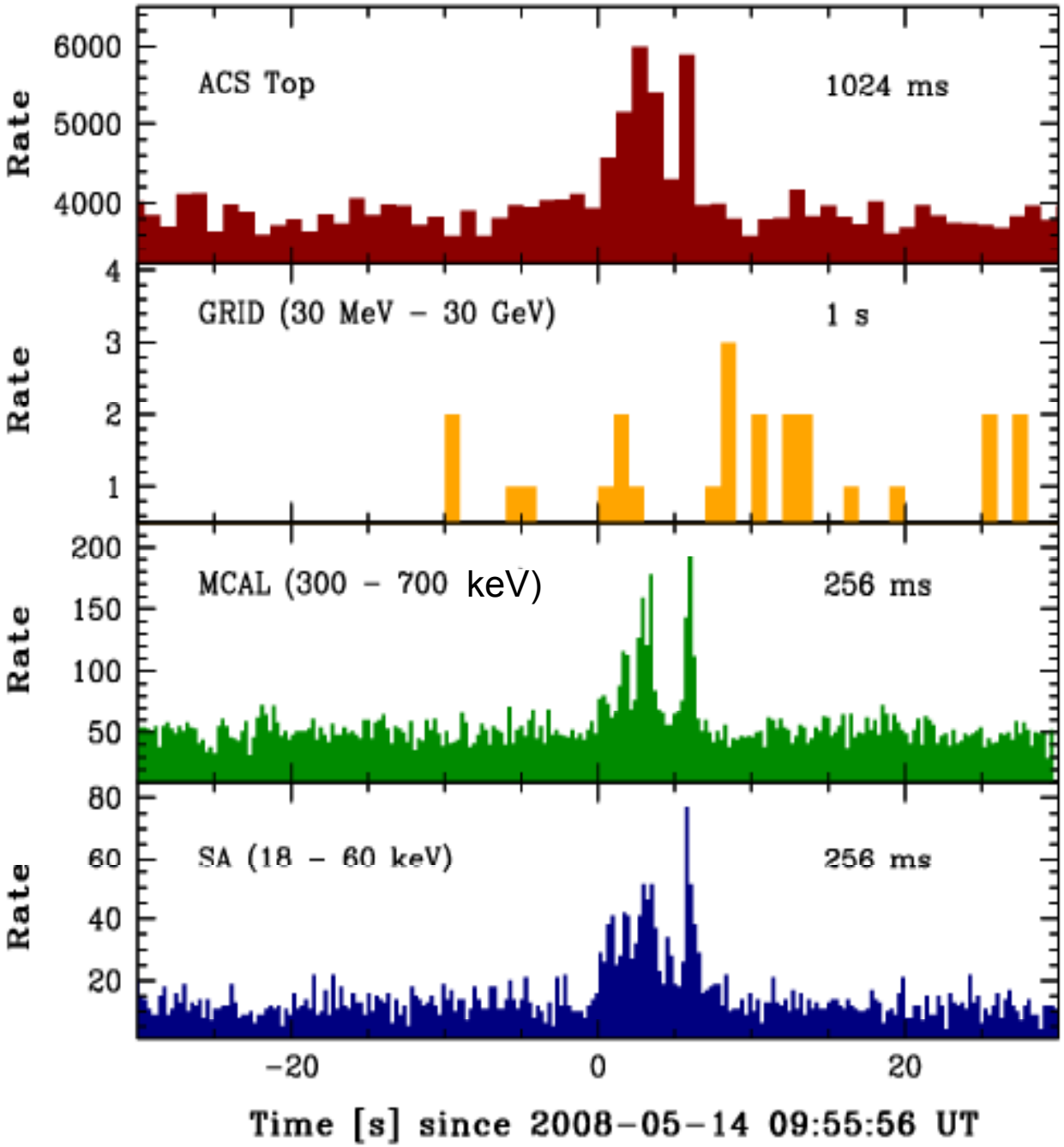
fluence 8×10^{-5} erg/cm^2 (20 keV – 5 MeV);

E_{peak} 485 keV (Konus-Wind, GCN 7995);

redshift 2.6 (GCN 7997);

Events 4 (F4)

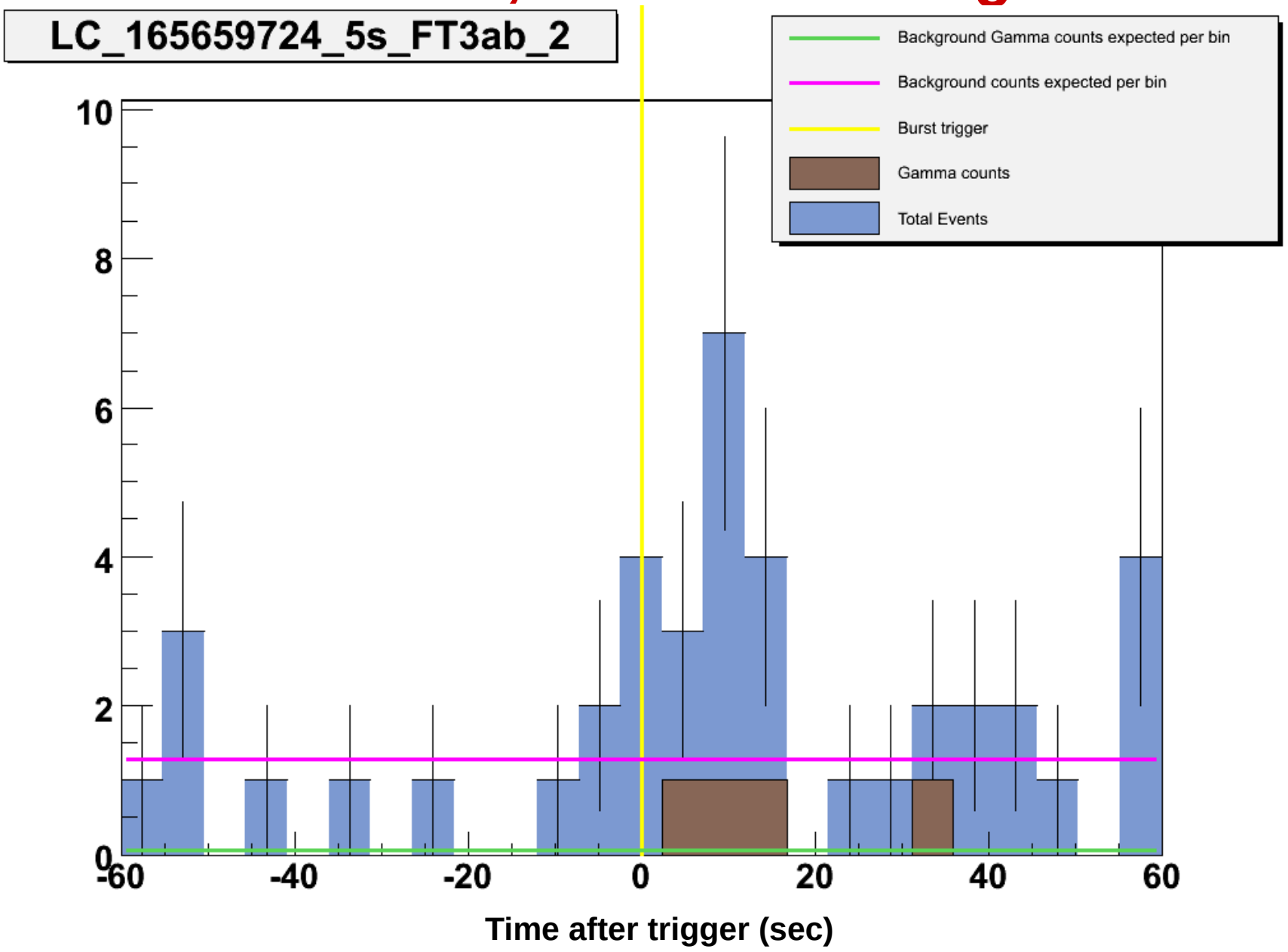
Prob. 3.35σ (TBC)



GRB 080514B

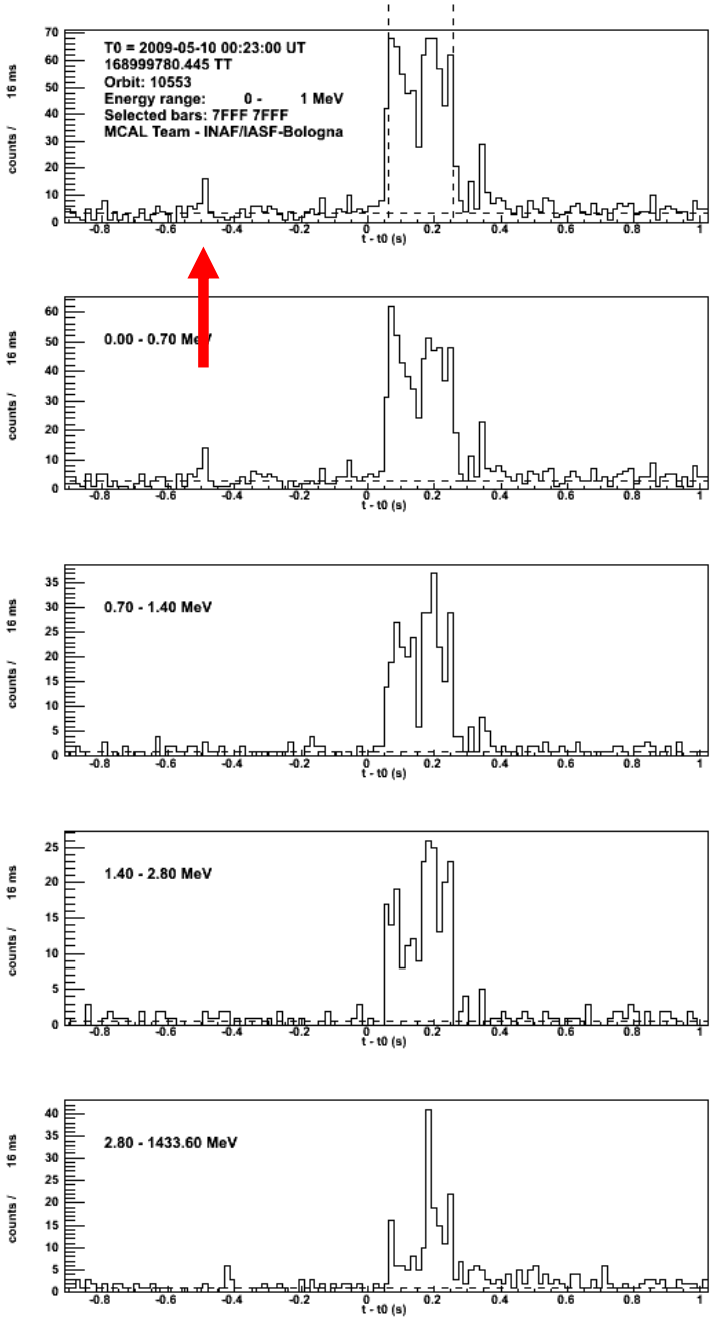
(Giuliani et al. 2008 arXiv:0809.1230)

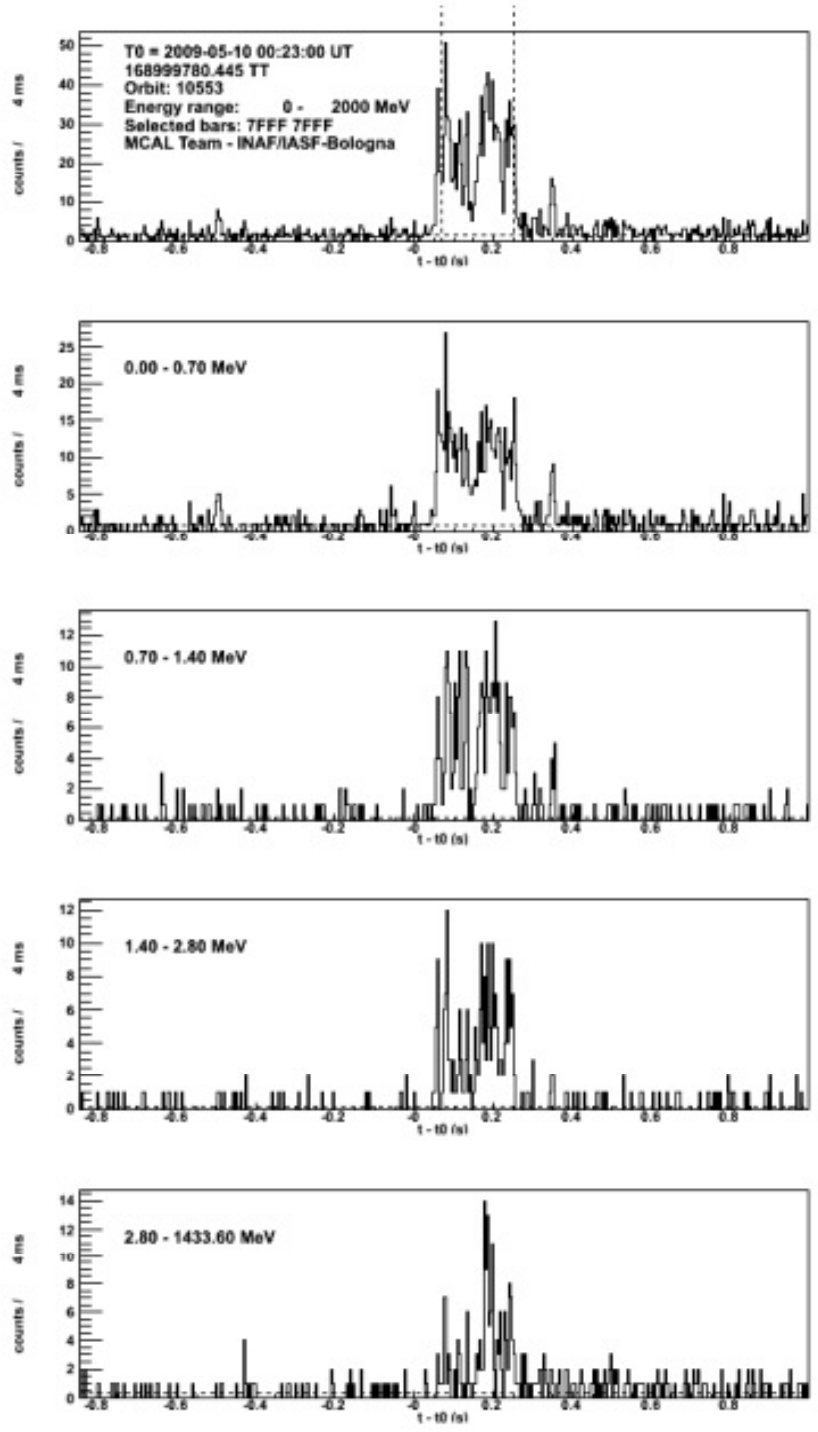
GRB 090401B, AGILE-GRID lightcurve



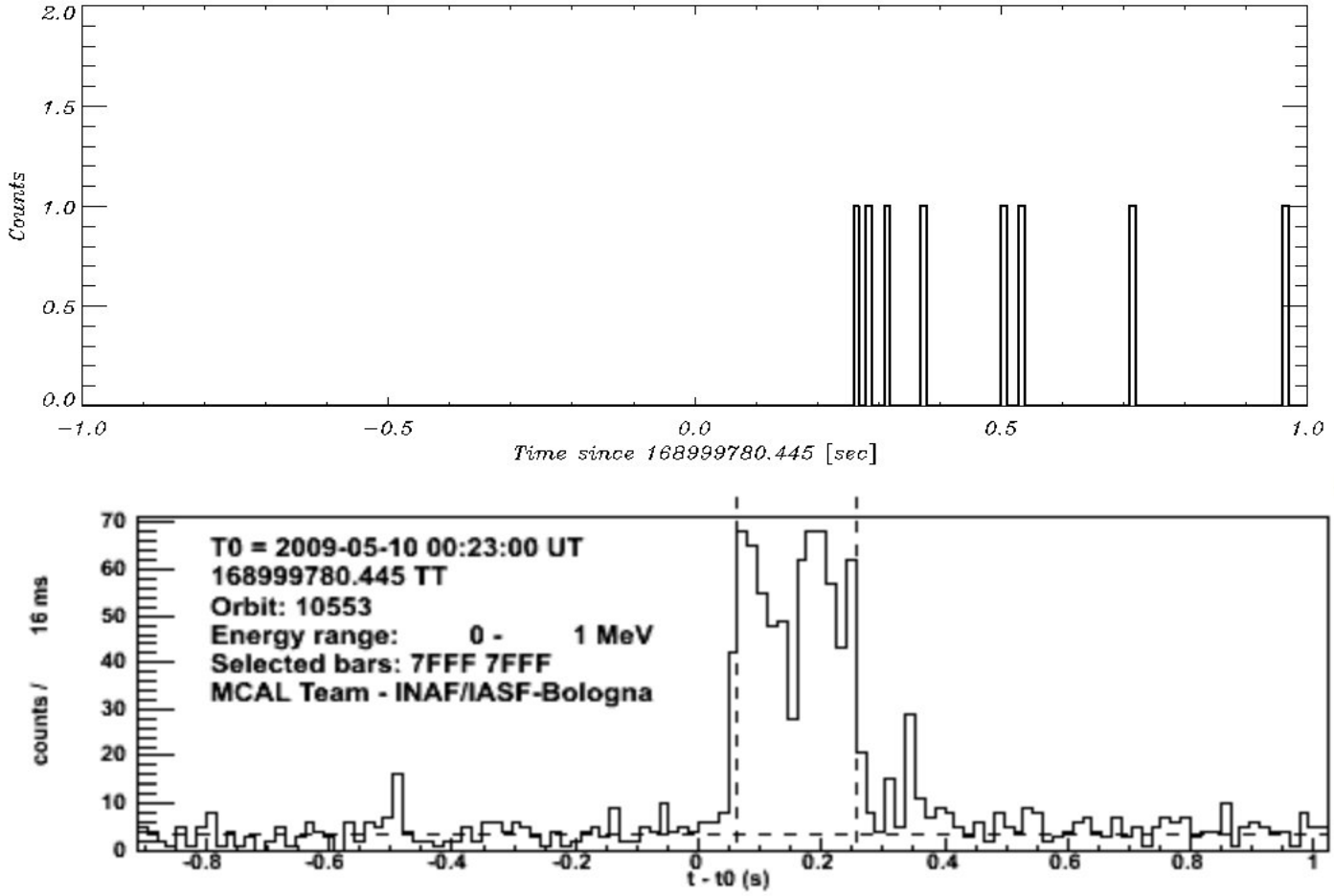
AGILE
and
the “short”
GRB 090510

z = 0.9

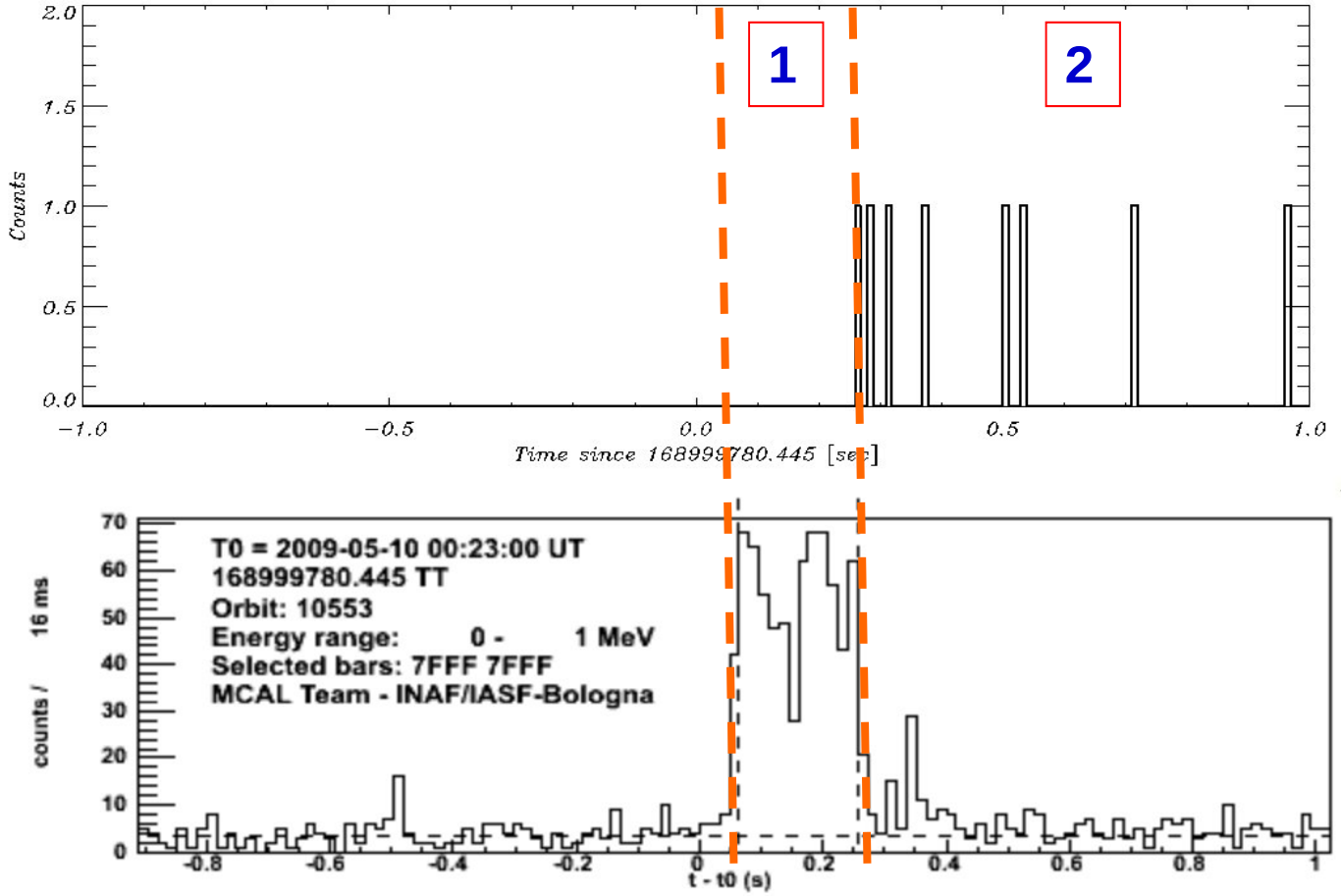

T0 = 2009-05-10 00:23:00 UT
168999780.445 TT
Orbit: 10553
Energy range: 0 - 1 MeV
Selected bars: 7FFF 7FFF
MCAL Team - INAF/IASF-Bologna
0.00 - 0.70 MeV
0.70 - 1.40 MeV
1.40 - 2.80 MeV
2.80 - 1433.60 MeV
counts / 16 ms
t - t0 (s)


T0 = 2009-05-10 00:23:00 UT
168999780.445 TT
Orbit: 10553
Energy range: 0 - 2000 MeV
Selected bars: 7FFF 7FFF
MCAL Team - INAF/IASF-Bologna
0.00 - 0.70 MeV
0.70 - 1.40 MeV
1.40 - 2.80 MeV
2.80 - 1433.60 MeV
counts / 4 ms
t - t0 (s)

The short GRB 090510 (61 degree off-axis)

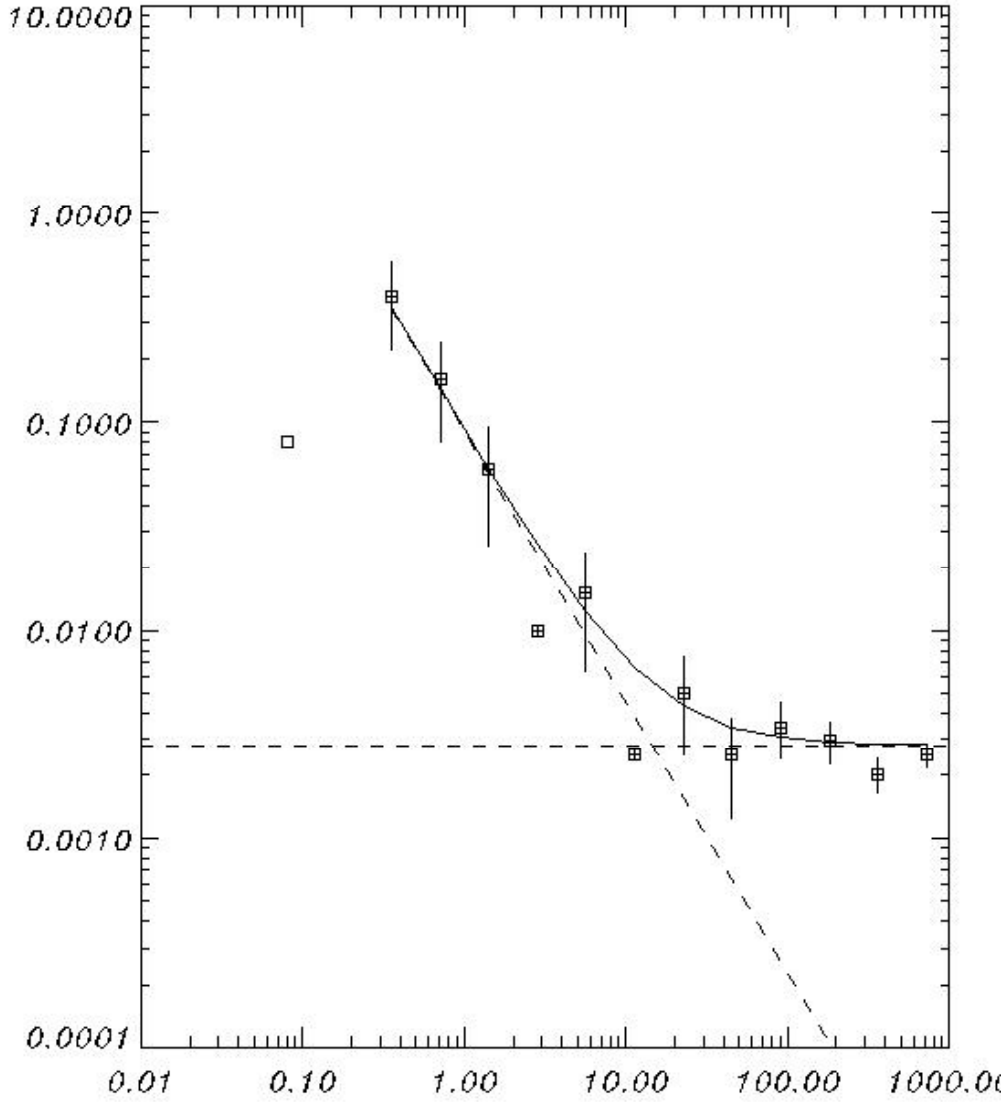


AGILE: GRB 090510

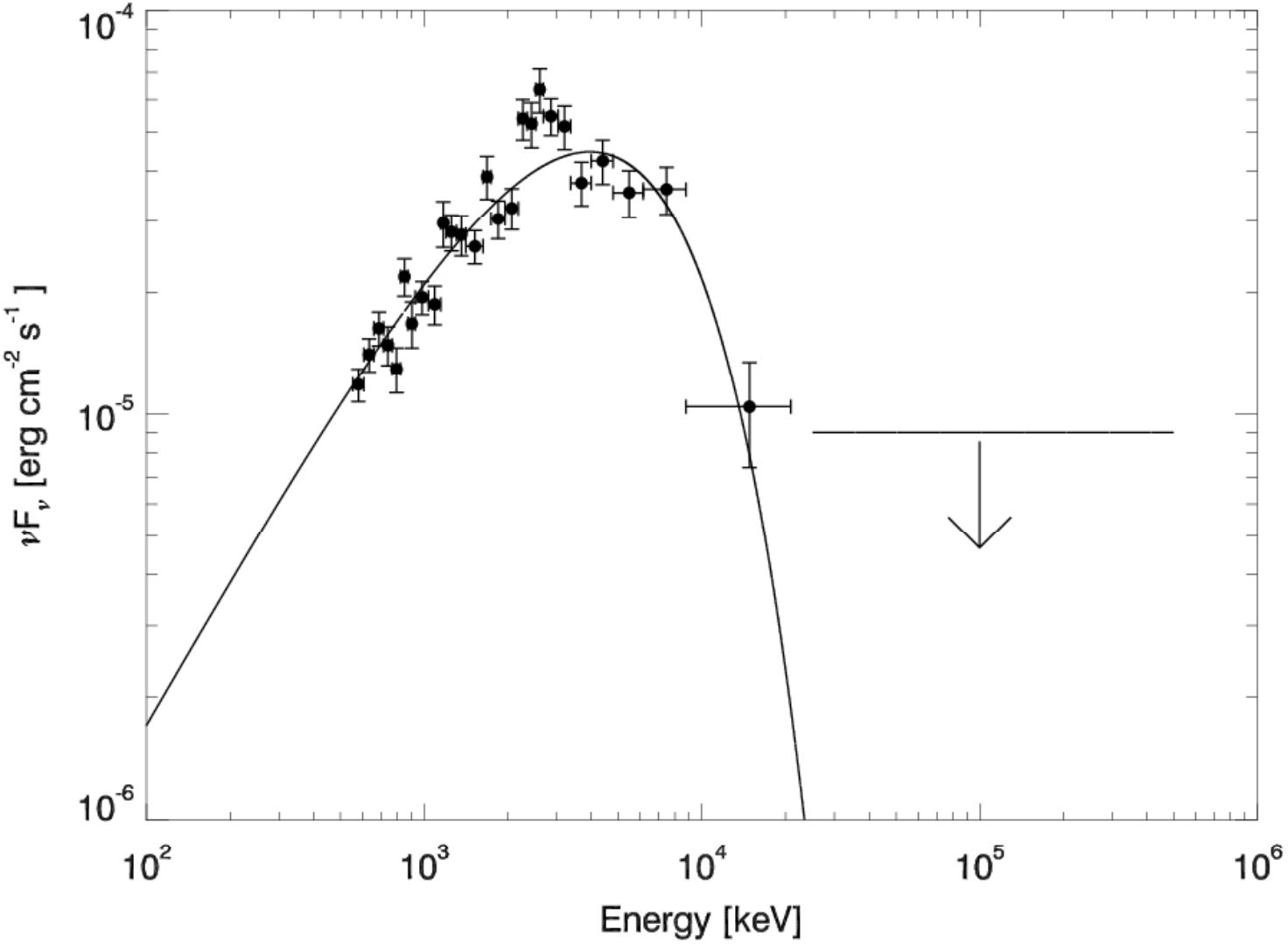


Gamma-ray tail (delayed emission)

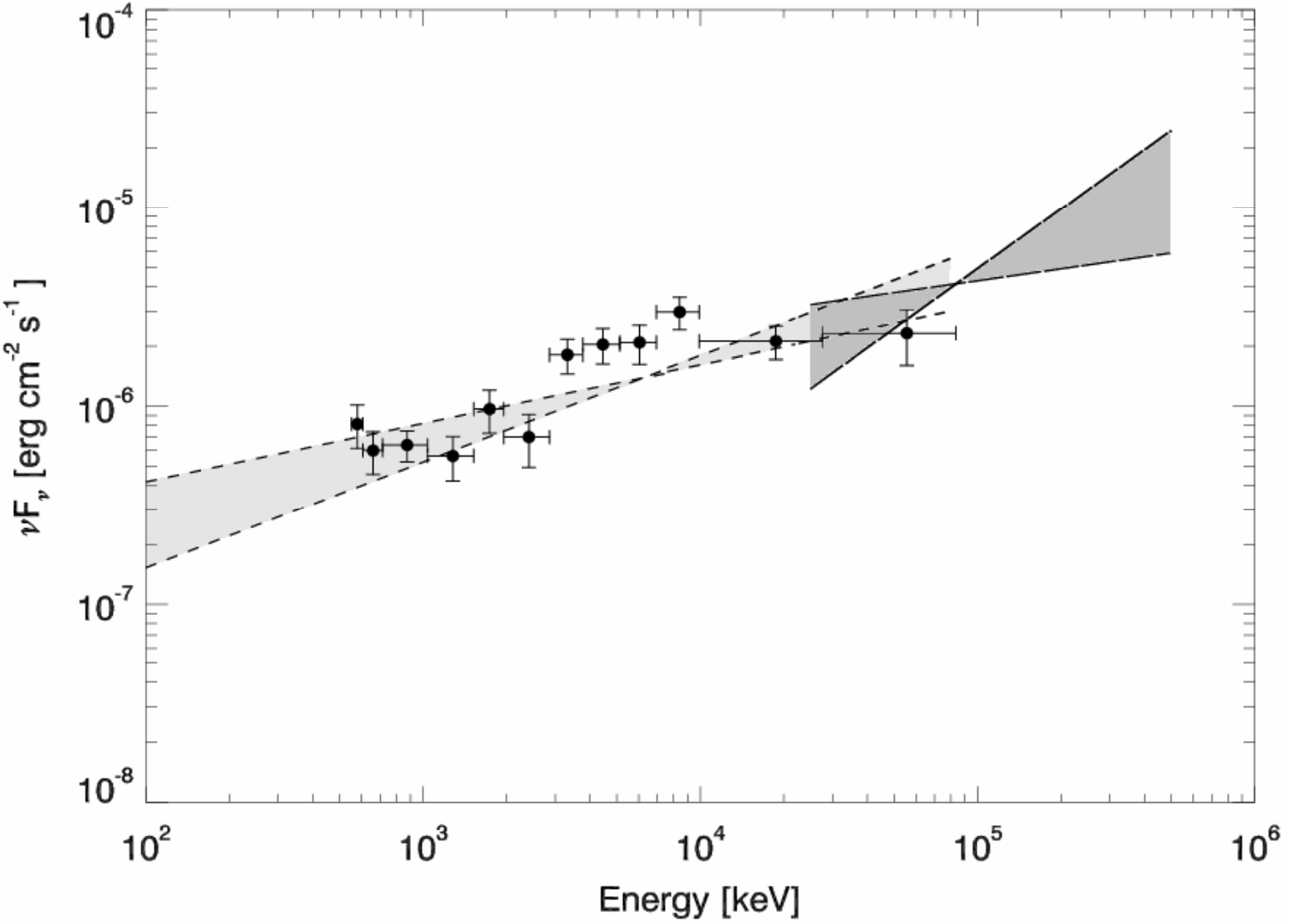
$F = t^{-1.32}$



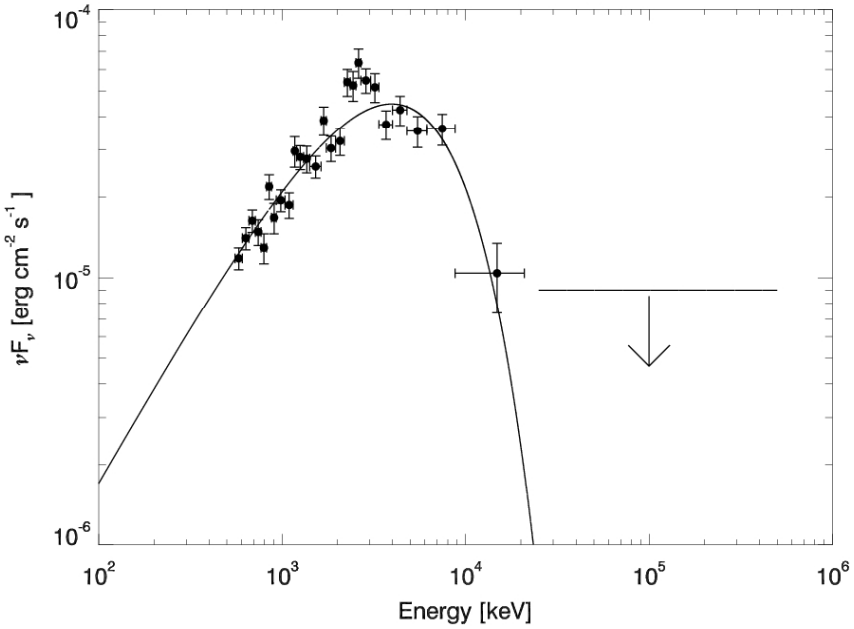
AGILE – GRB 090510: interval: 1



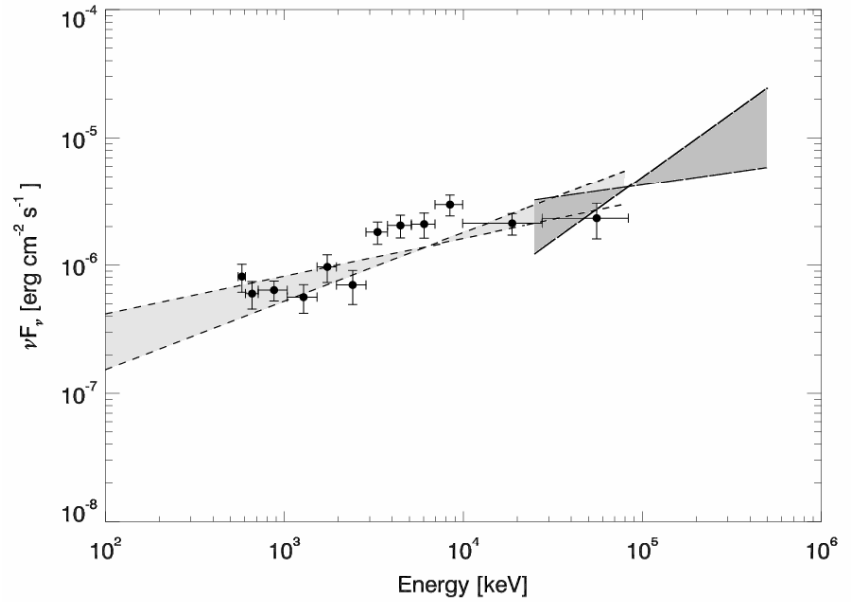
AGILE – GRB 090510: interval: 2



Interval 1



Interval 2

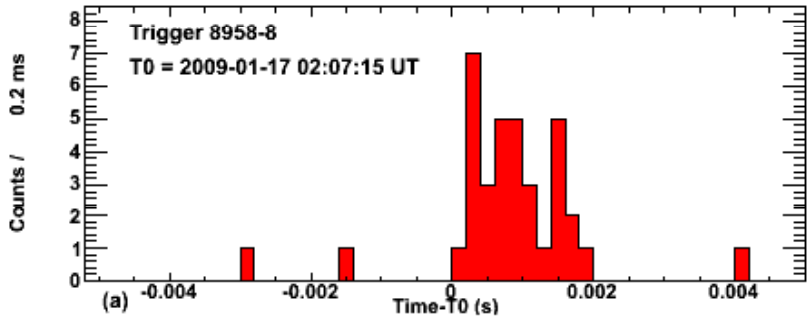


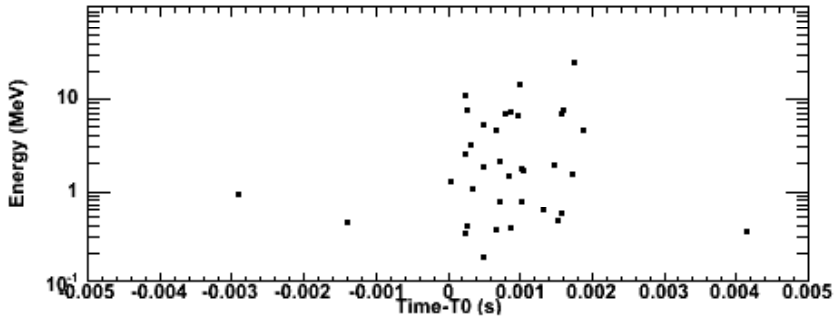
on the “short” GRB 090510…

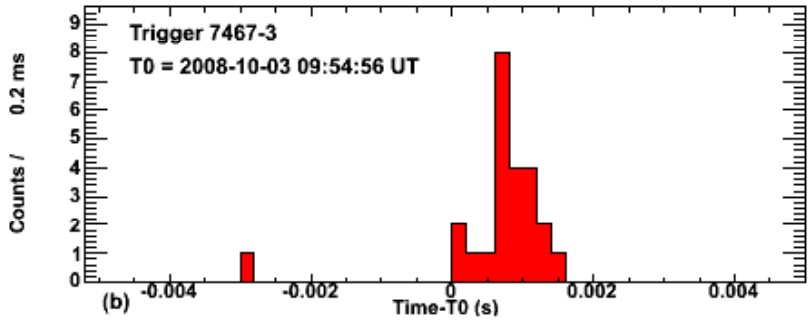
- one of the shortest events with remarkable high-energy emission
- For a z~0.9, E(iso) = 10^{52} ergs
- MeV and gamma-ray emission above 100 MeV
  - Interval 1: E(peak) ~ 3 MeV
  - Interval 2: E(peak) > 50 MeV
    - » $F = t^{-1.3}$

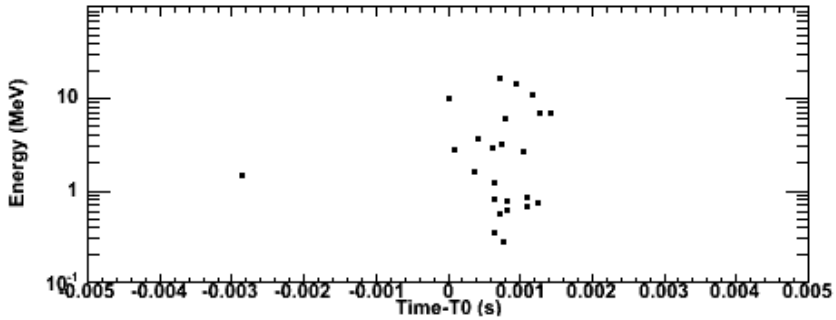
MCAL TGF light curves

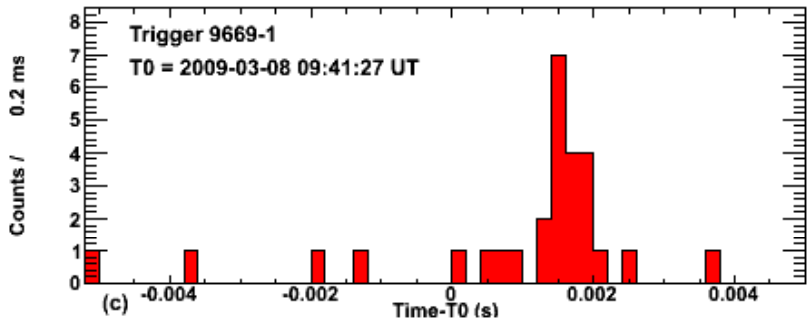
The three brightest events

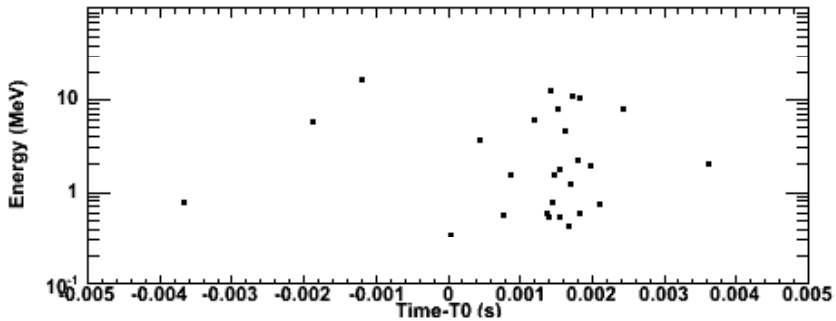






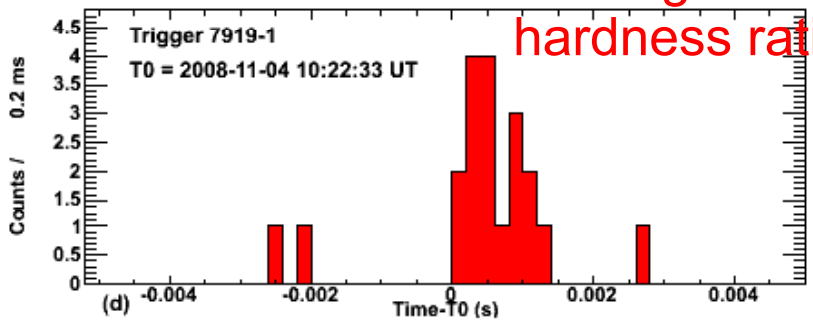


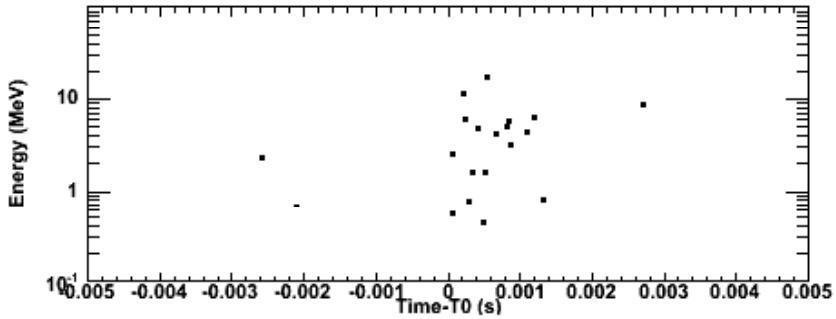




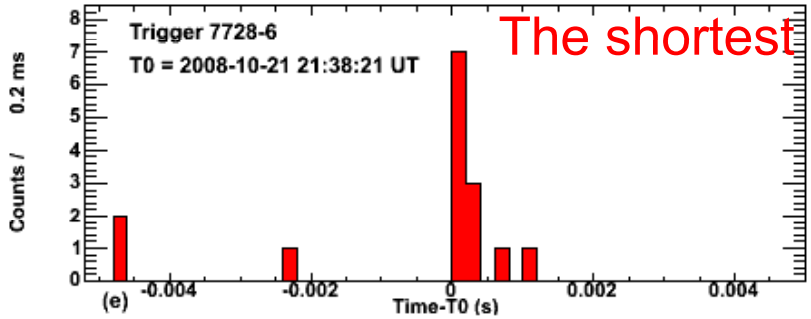
MCAL TGF light curves

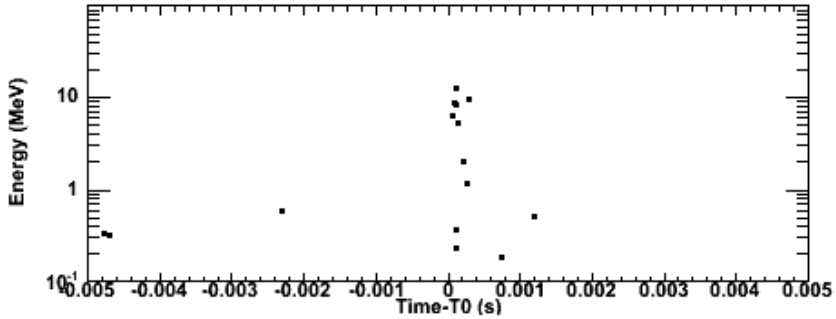
The highest hardness ratio



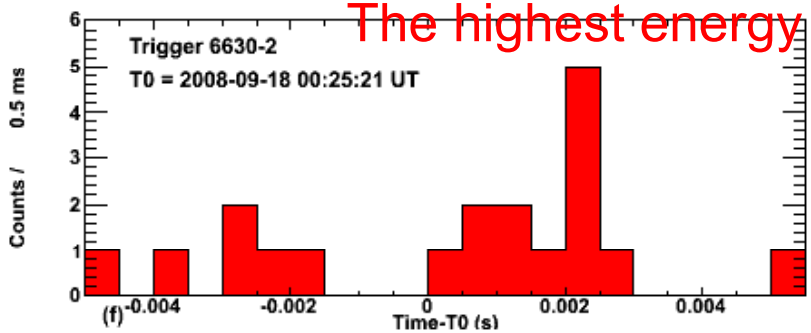


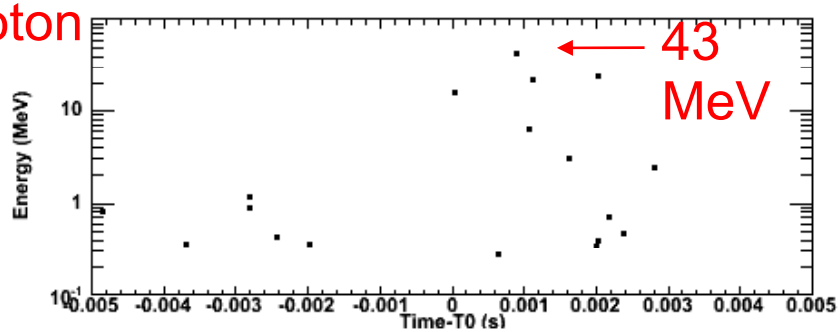
The shortest





The highest energy photon

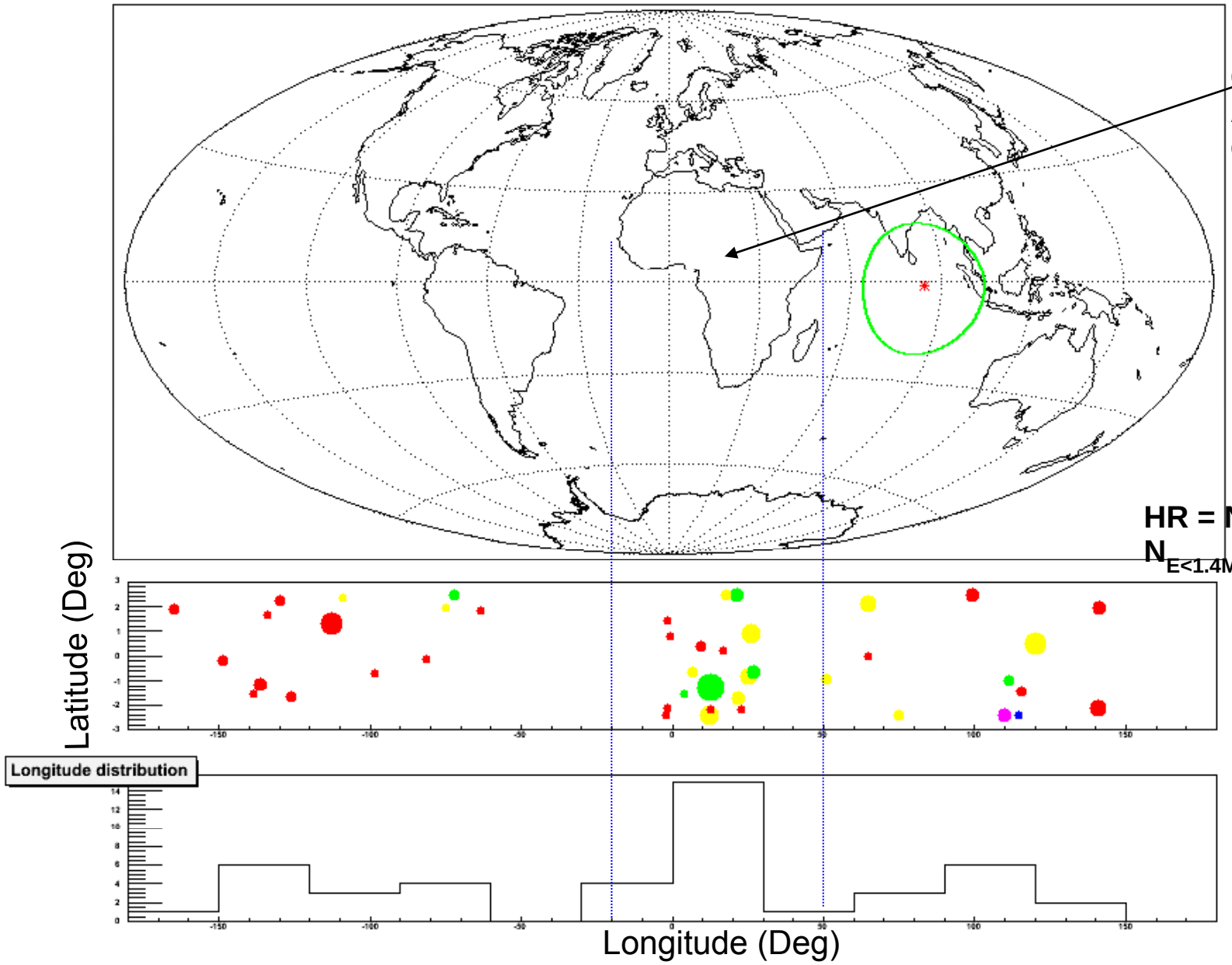




43 MeV

TGF candidates distribution

Selection criteria: HR>0.2 AND fluence > 7 counts: 44 candidates / 8 months



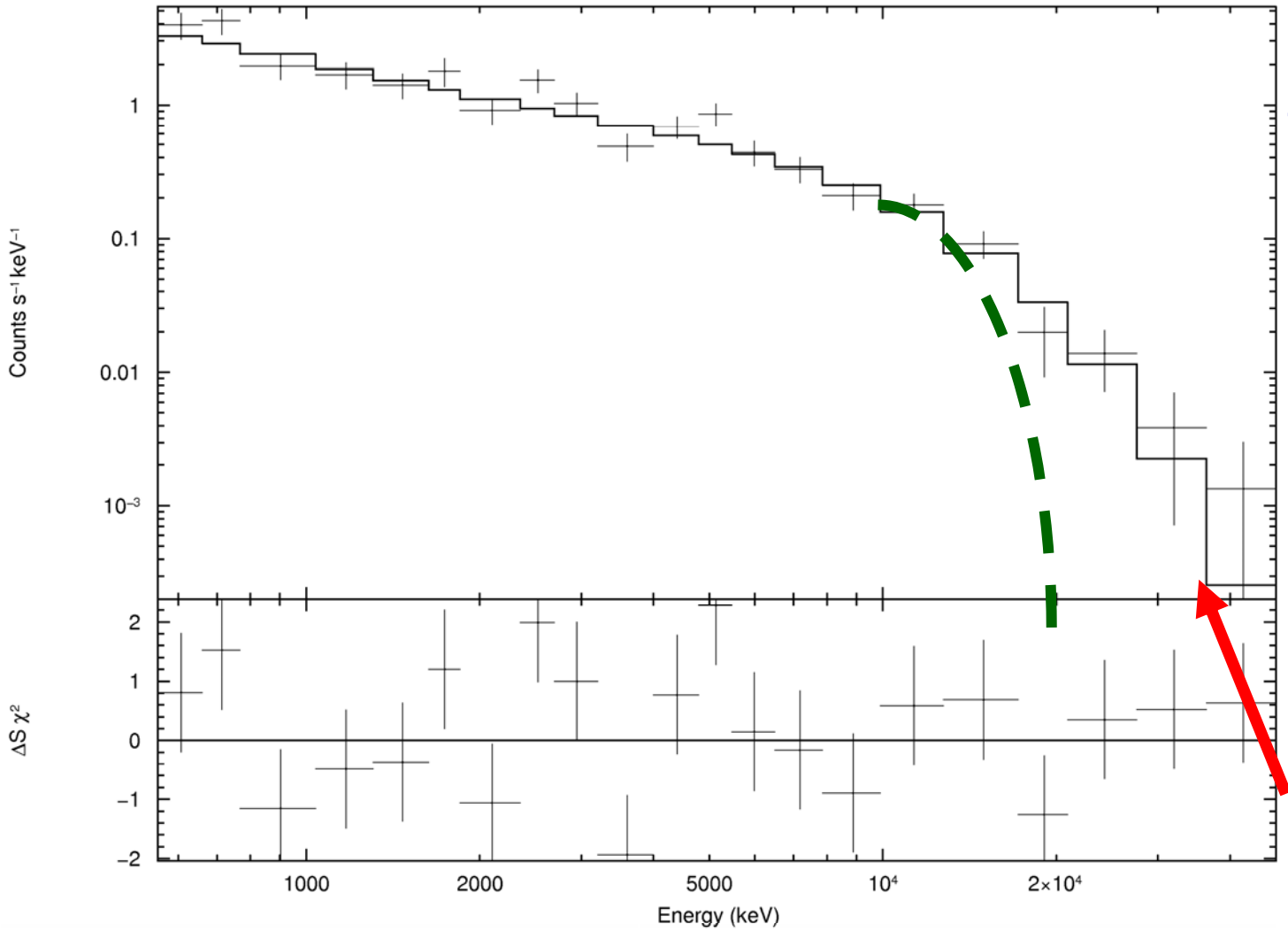
Clustering over Africa as expected from RHESSI results

HR = $N_{E>1.4\ MeV}$ / $N_{E<1.4MeV}$

0 <= HR < 1
1 <= HR < 2
2 <= HR < 3
3 <= HR < 4
4 <= HR

Spot radius propotional to fluence (7-24 counts)

MCAL TGF cumulative spectrum



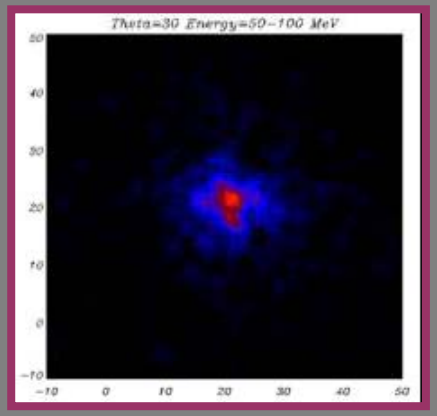
cutoff PL model
fitting with XSPEC

$F(E) \sim E^{-\alpha} e^{-E/E0}$

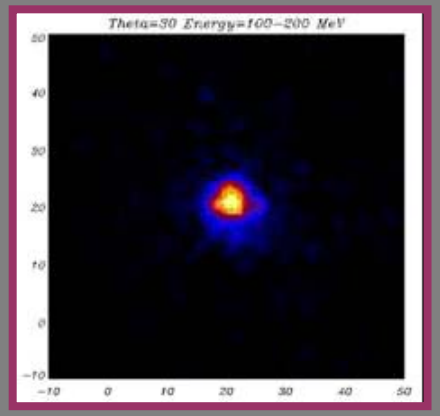
α = 0.4 +/- 0.3
E_0 = 8.5 +/- 1.6 MeV
red. chi^2 = 1.4
(18 d.o.f.)

AGILE-MCAL crucial spectral contribution

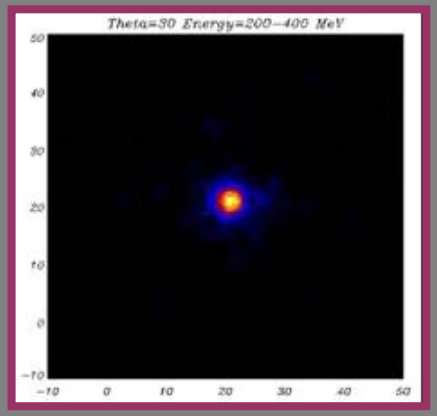
Effective Area (LNF-BTF calibration data)



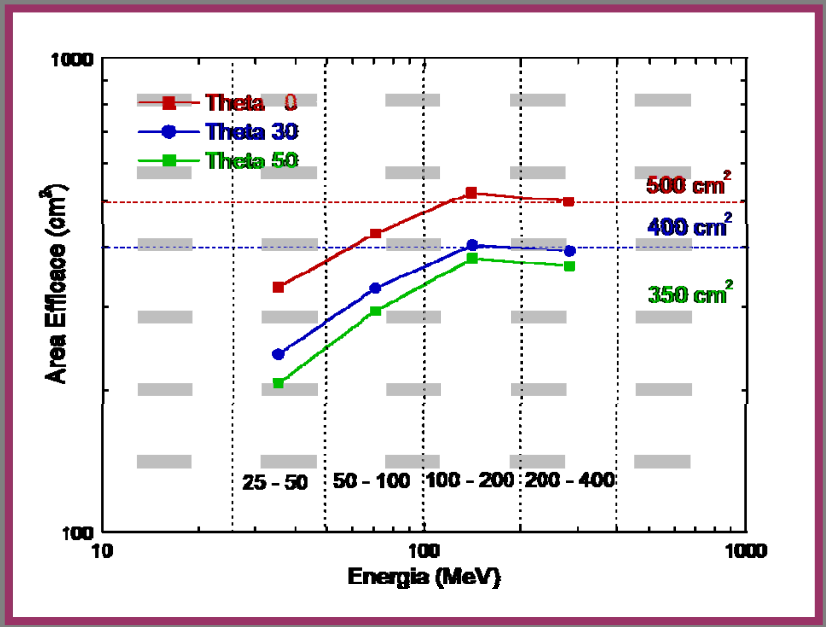
Energy: 50 – 100 MeV

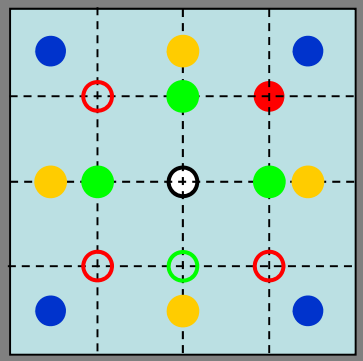


Energy: 100 – 200 MeV



Energy: 200 – 400 MeV

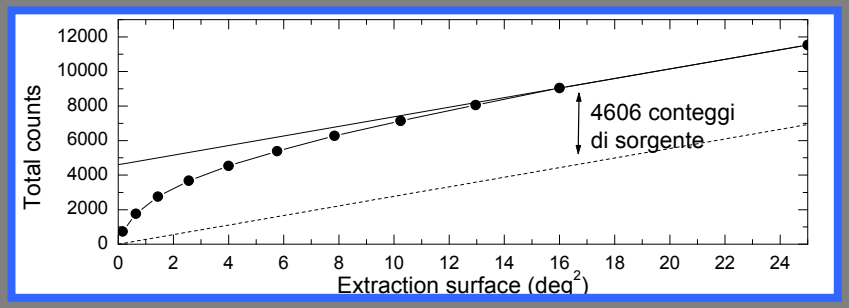


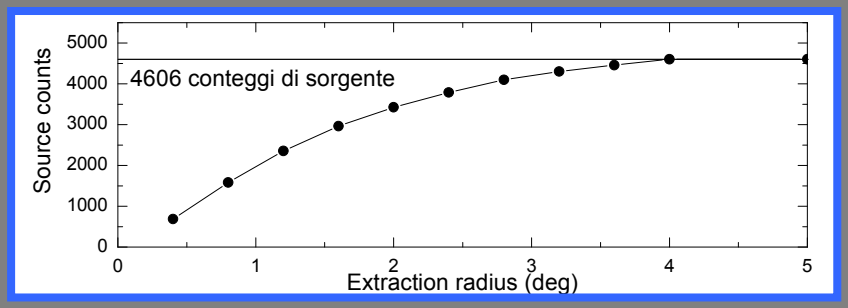


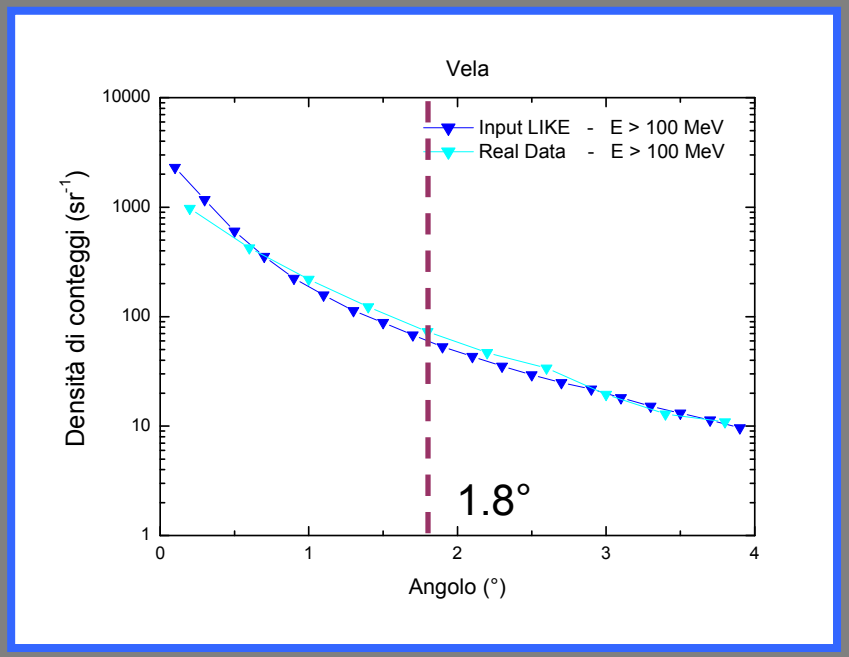
Point Spread Function

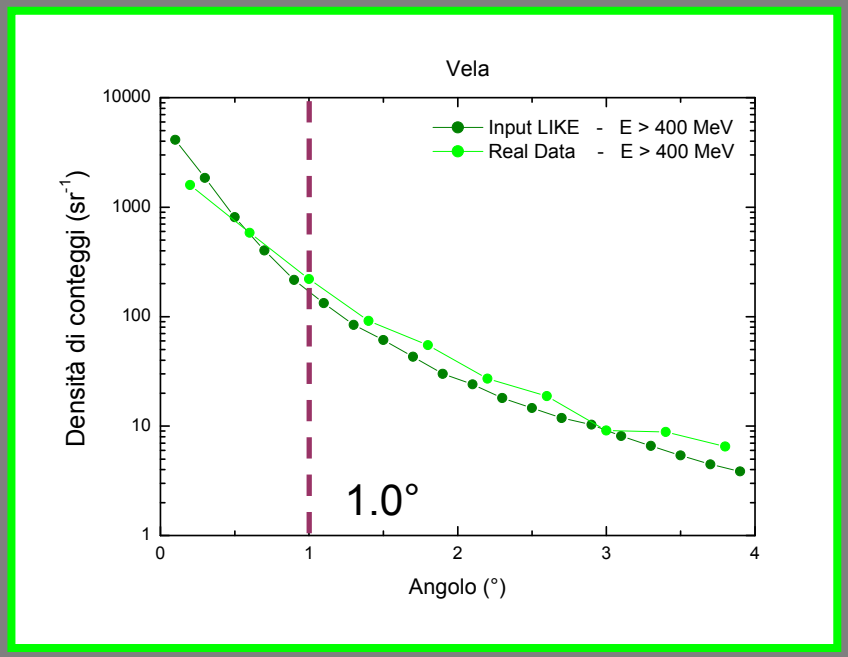
Energia	PSF 0°		PSF 30°		PSF 50°	
	Best PSF	Best Aeff	Best PSF	Best Aeff	Best PSF	Best Aeff
25 ÷ 50	7.1	13.7	6.9	14.7	10.7	19.1
50 ÷ 100	4.7	9.0	4.9	9.8	4.1	10.5
100 ÷ 200	2.8	4.9	3.0	7.0	3.6	7.3
200 ÷ 400	1.9	3.1	1.7	3.9	1.7	5.7

PSF: real data vs. simulations (G.Pucella, A.Giuliani, A.Chen)









E > 100 MeV

E > 400 MeV

a spectral comparison with Fermi-LAT