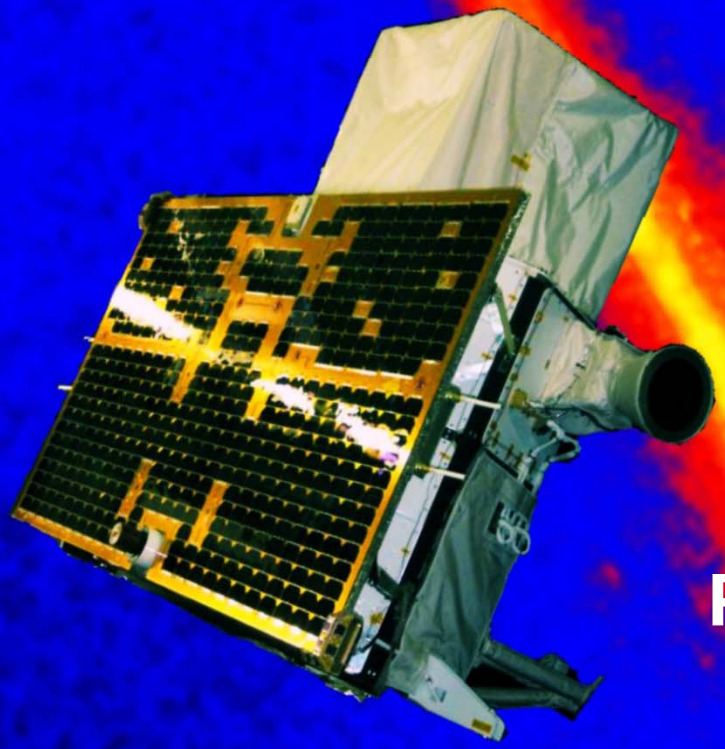
AGILE Observations of Variable and Transient Gamma-Ray Sources in the Galactic Plane

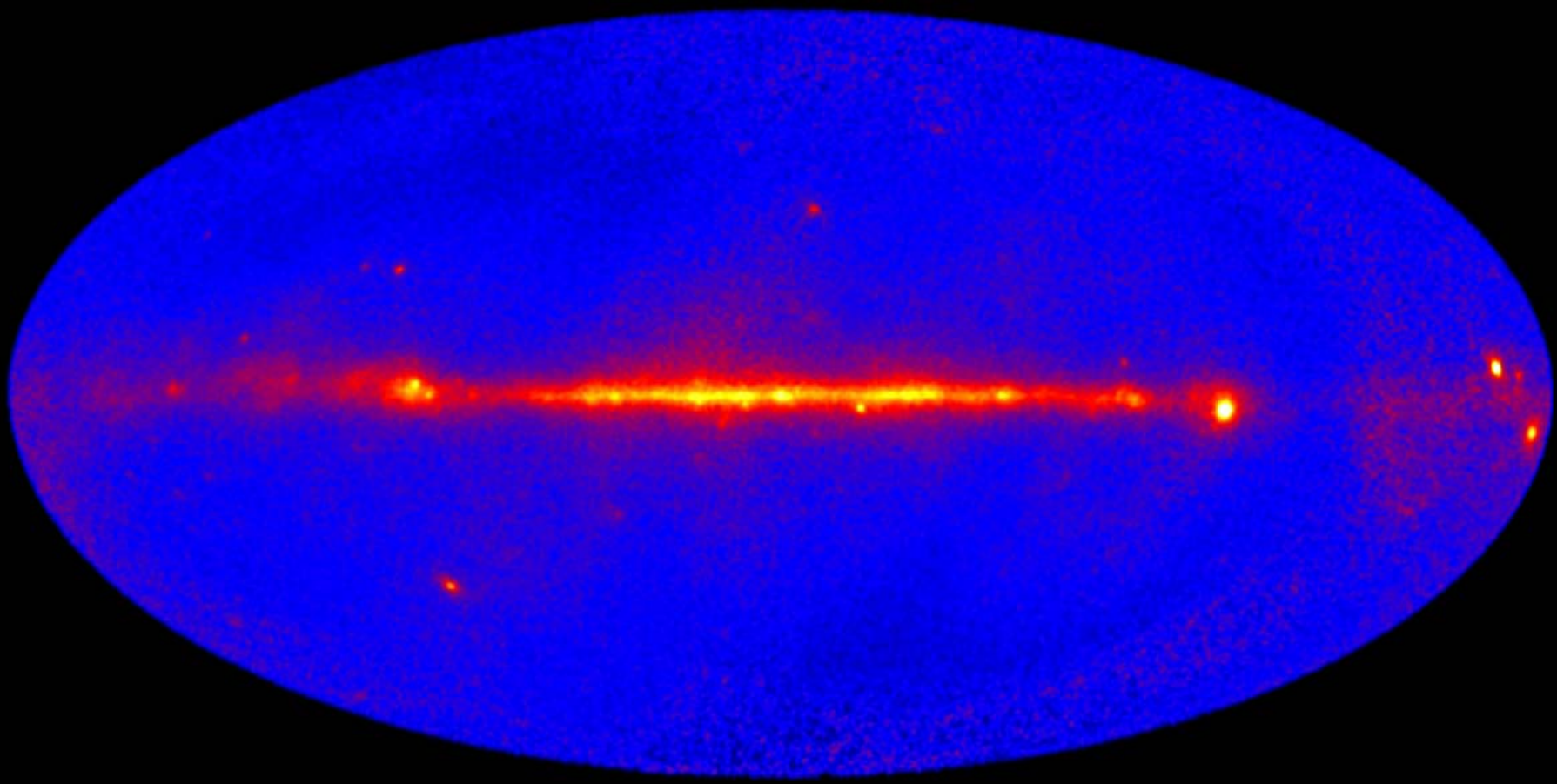


F.Longo (INFN Trieste)

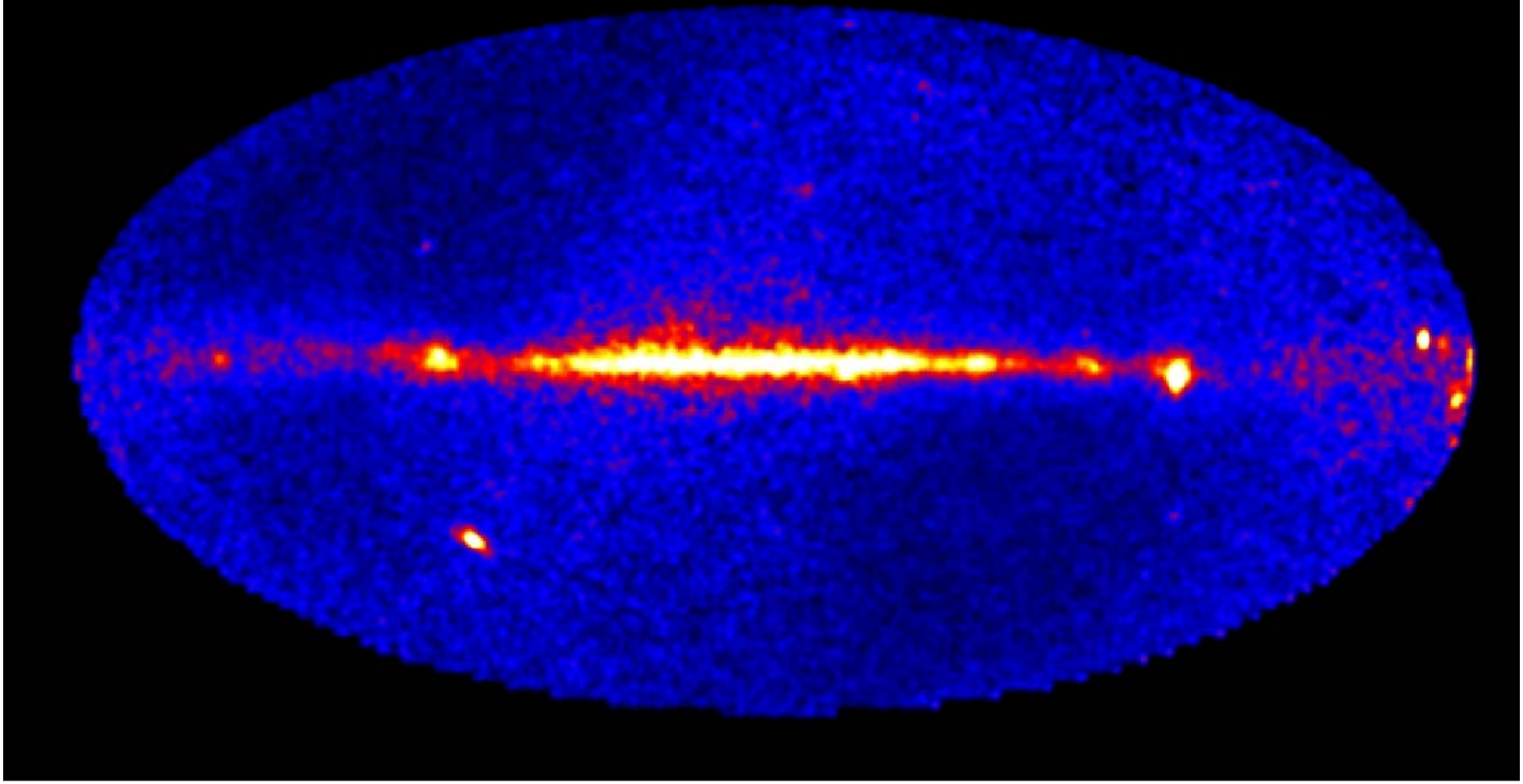
SciNeGHE 2010

Trieste September 9, 2010

The AGILE gamma-ray sky (E > 100 MeV)
2 year exposure: July 2007 – June 2009



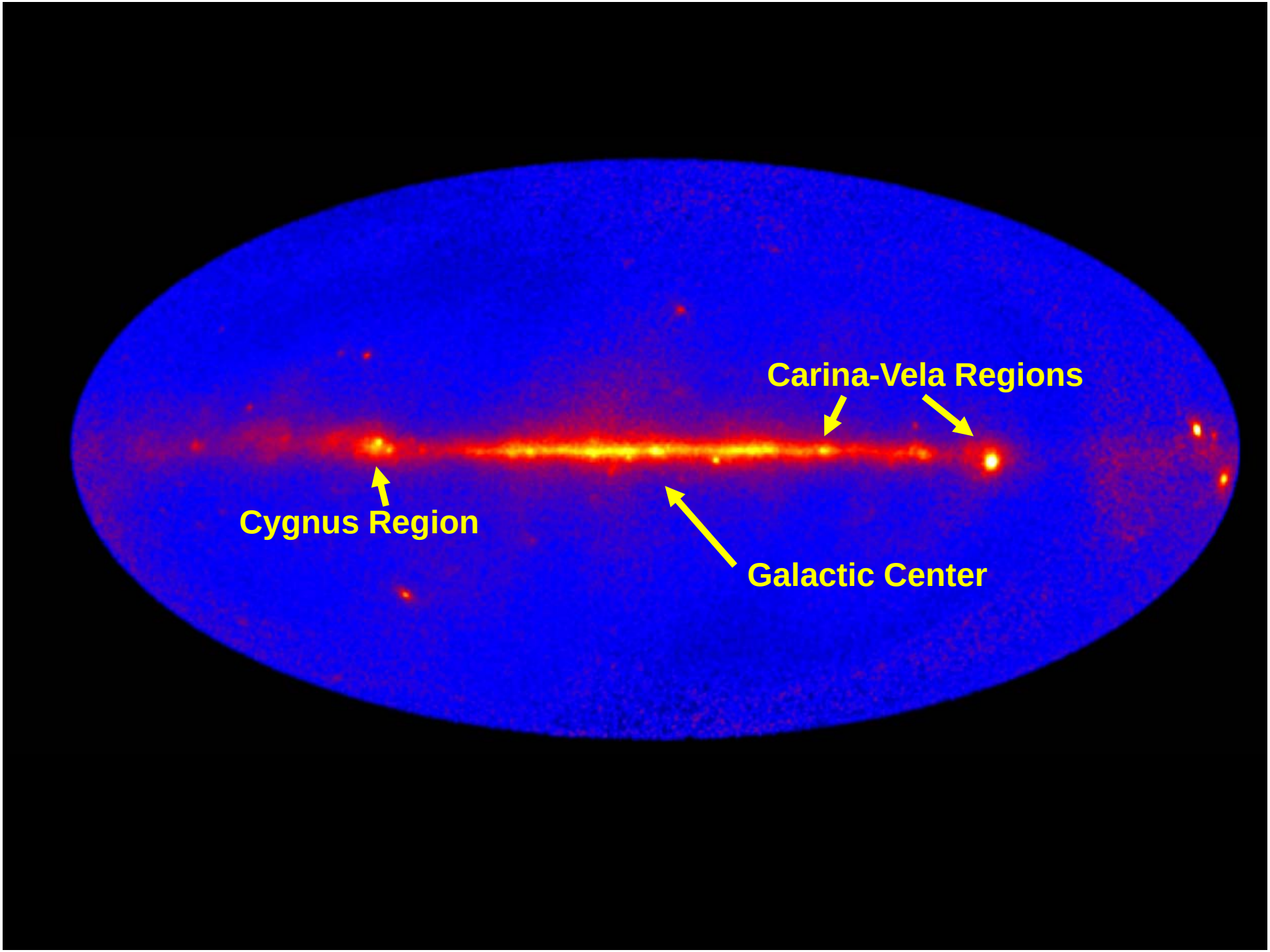
AGILE-2: 5-month intensity map (E > 100 MeV)
(Nov. 2009 – Mar. 2010)



Galactic (Variable) Sources

AGILE “Galactic” Science Topics

- **New (soft) gamma-ray Pulsars**
- **PWNe**
- **Microquasar studies, Gamma-ray emission from Gal. compact objects**
- **“New” gamma-ray transient candidates**
- **SNRs and origin of cosmic rays**
- **Molecular clouds, CR propagation**
- **Hard X-ray monitoring with Superagile**
- **Galactic Center**


Carina-Vela Regions
Cygnus Region
Galactic Center

Variable and Transient sources

- **Plasma physics under extreme conditions**
  - **PARTICLE ACCELERATION**
  - **ACCRETION “STATES”, INSTABILITIES, JETS**

- **Black hole astrophysics**
  - **microquasar reproducible patterns, extreme particle acceleration (not Comptonized !)**
  - **massive black hole jet ejections, particle acceleration**

- **New Galactic transients**
  - **Identification strategies**
  - **Search for new source classes**

Micro-QSOs

Microquasar studies at gamma-ray energies

- **Mechanisms of extreme particle acceleration and strongly non-thermal (or Comptonized) emission above 100 MeV**
- **Jet geometry can play a crucial role in detection (see the case of Cyg X-3)**
- **transient acceleration & gamma-ray emission on hour-day timescales**
- **Gamma-ray emission in “special states” (Cyg X-3)**
- **Bright future for understanding BHs**

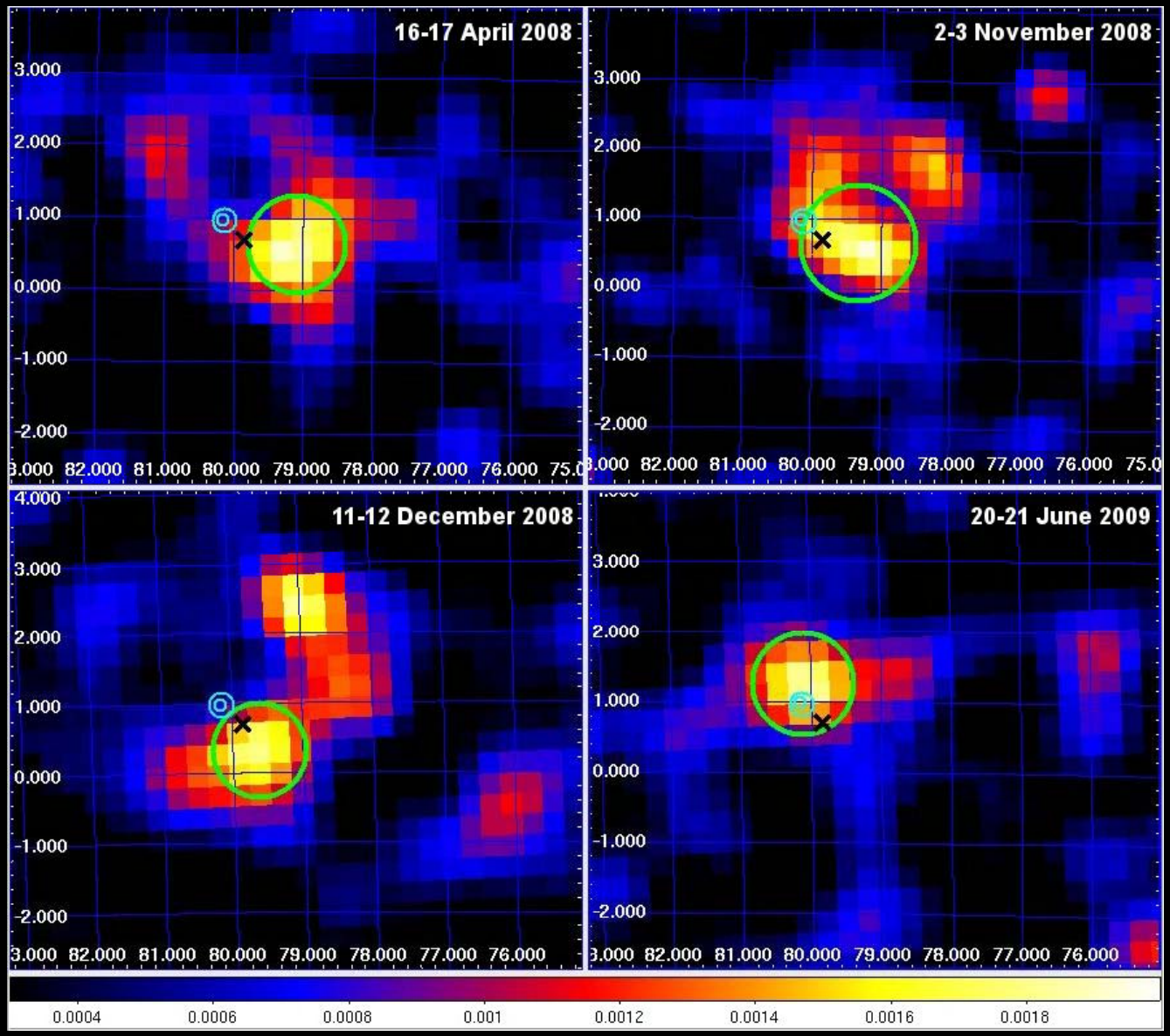
AGILE and Cygnus X-3 (*Nature,* Nov. 22, 2009)

see also FERMI detection of Cyg X-3, Abdo et al. *Science* Nov. 26, 2009)

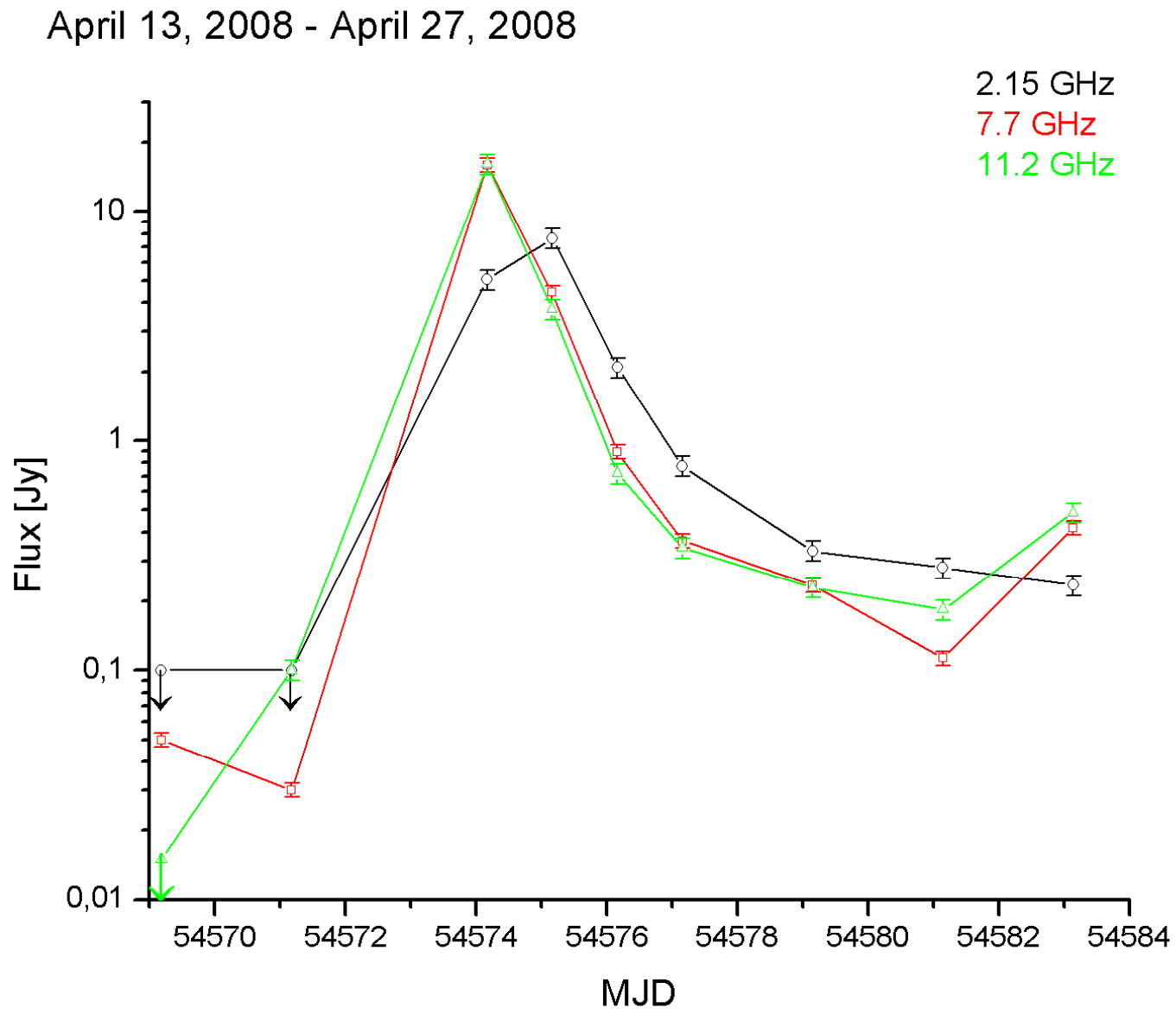
- **AGILE detects several gamma-ray flares from Cygnus X-3, and also weak persistent emission above 100 MeV**

- **very interesting correlations with radio and X-ray spectral state changes**

- **gamma-ray flares usually *before* radio flares**


16-17 April 2008
2-3 November 2008
11-12 December 2008
20-21 June 2009
3.000
2.000
1.000
0.000
-1.000
-2.000
4.000
82.000 81.000 80.000 79.000 78.000 77.000 76.000
0.0004 0.0006 0.0008 0.001 0.0012 0.0014 0.0016 0.0018

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

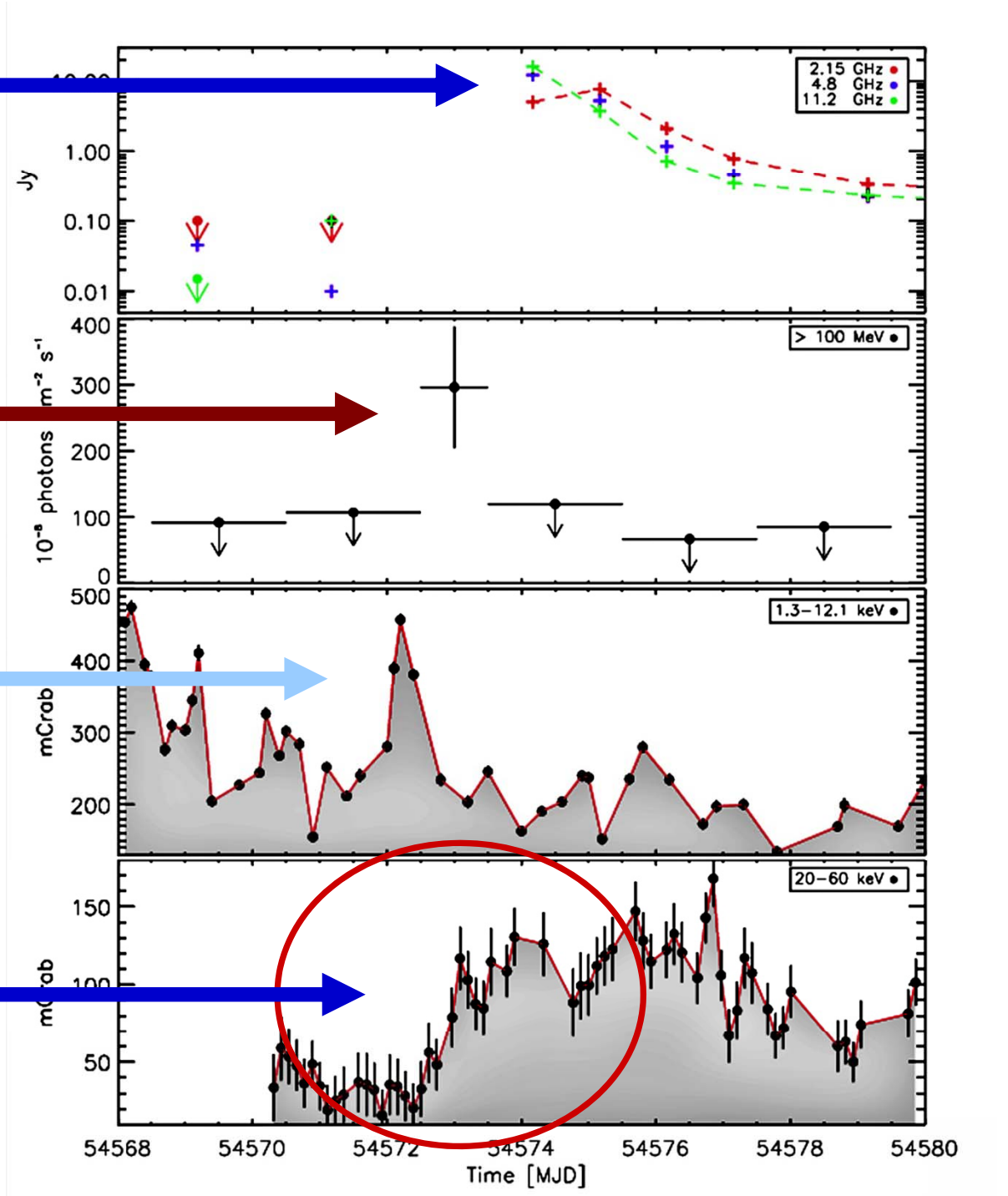


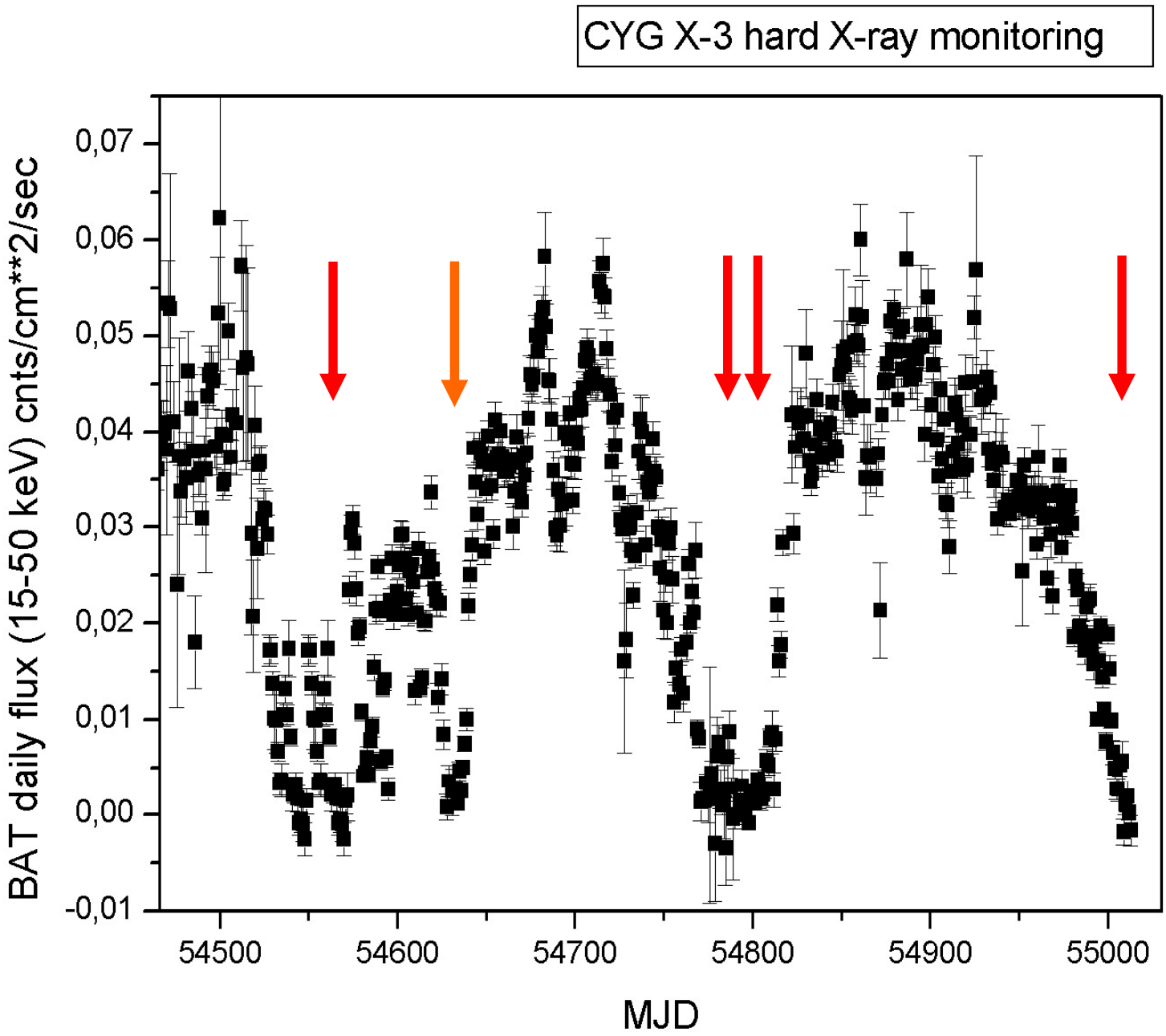
very strong radio flare, presumably with jet ejection

strong gamma-ray flare

X-ray (1-10 keV) flare

Hard X-ray flux state change (Super-A monitoring)




CYG X-3 hard X-ray monitoring
BAT daily flux (15-50 keV) cnts/cm**2/sec
0,07
0,06
0,05
0,04
0,03
0,02
0,01
0,00
-0,01
54500
54600
54700
54800
54900
55000
MJD

Major gamma-ray flares in special transitional states in preparation of radio flares !

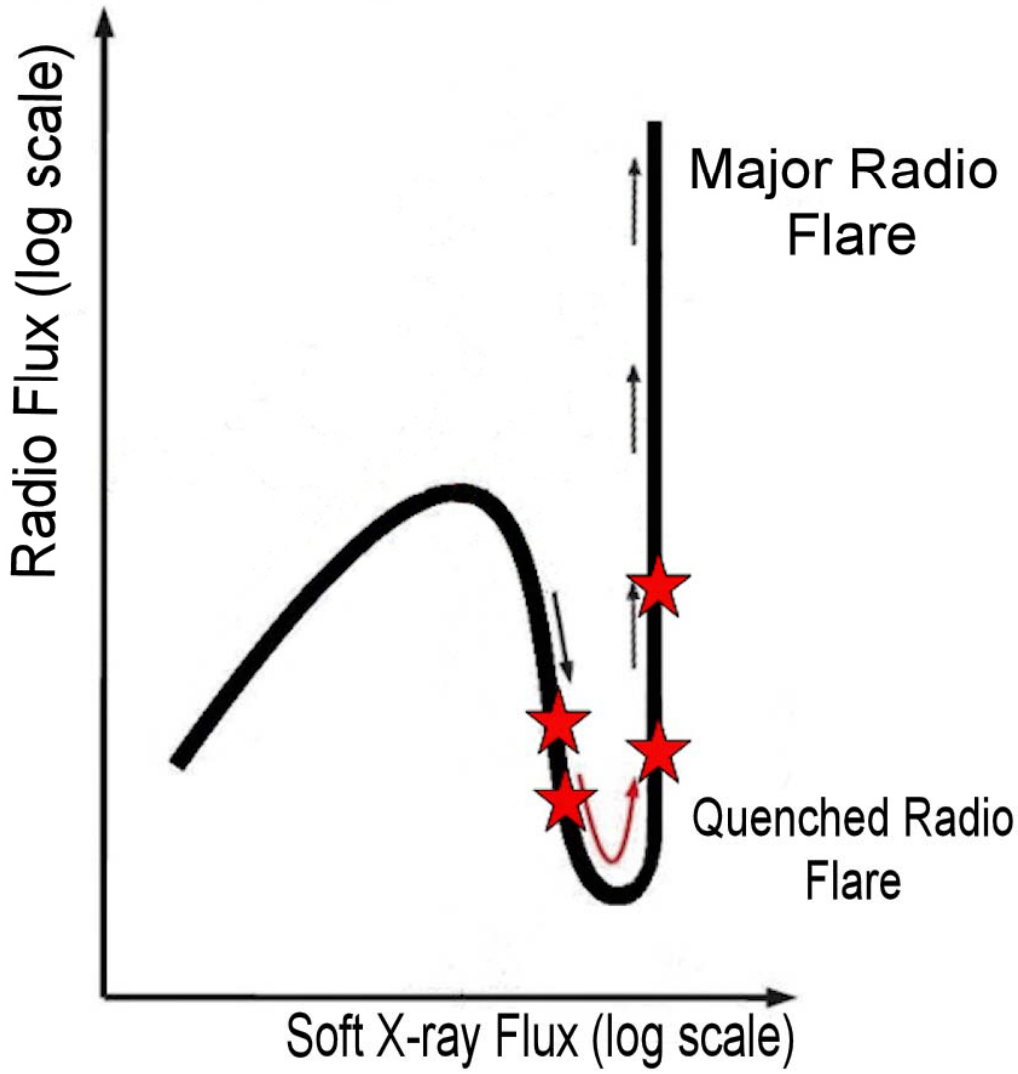
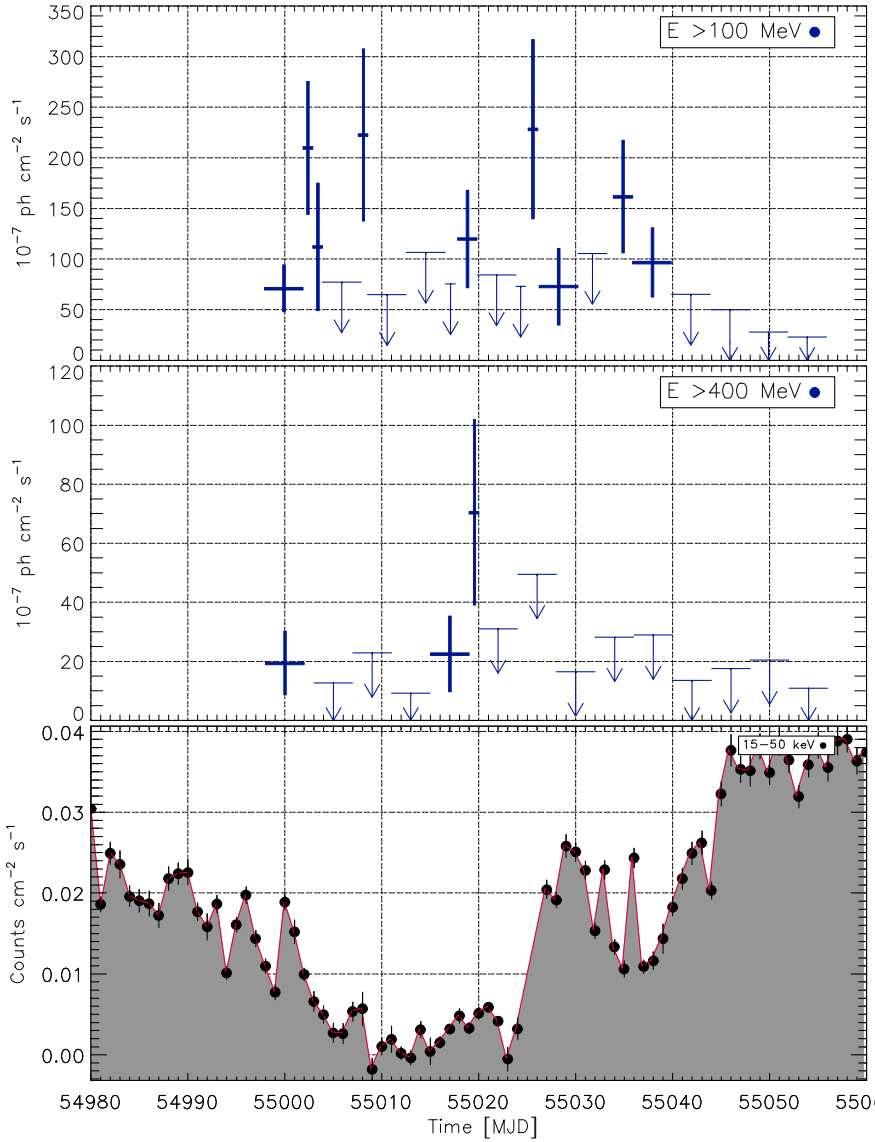


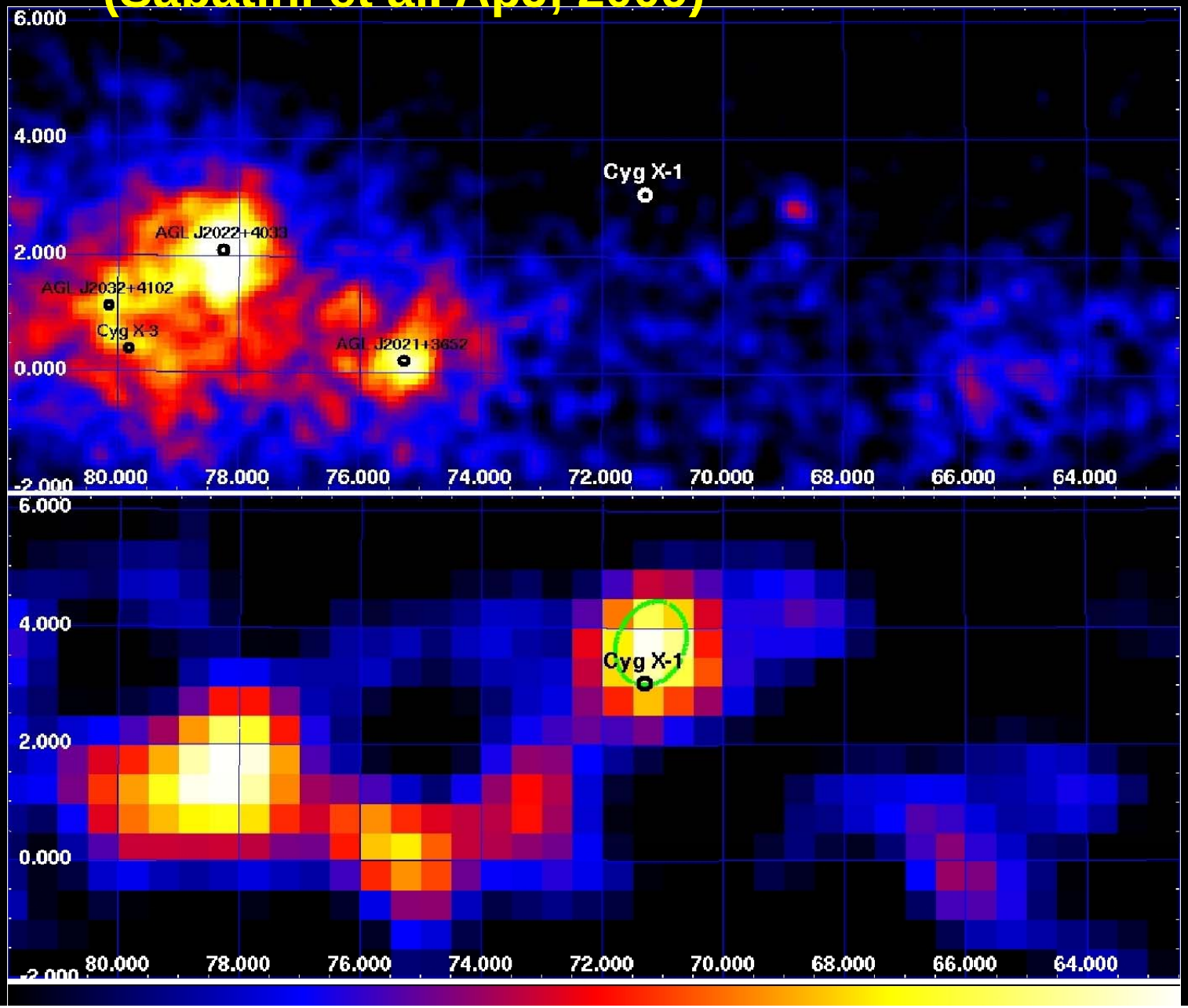
figure adapted from Szostek Zdziarski & McCollough (2008)

AGILE/GRID and Swift/BAT data of Cygnus X-3 during Jun-Jul 2009



EPISODIC TRANSIENT GAMMA-RAY EMISSION FROM CYG X-1

AGILE gamma-ray detection of Cygnus X-1 (Sabatini et al. ApJ, 2009)

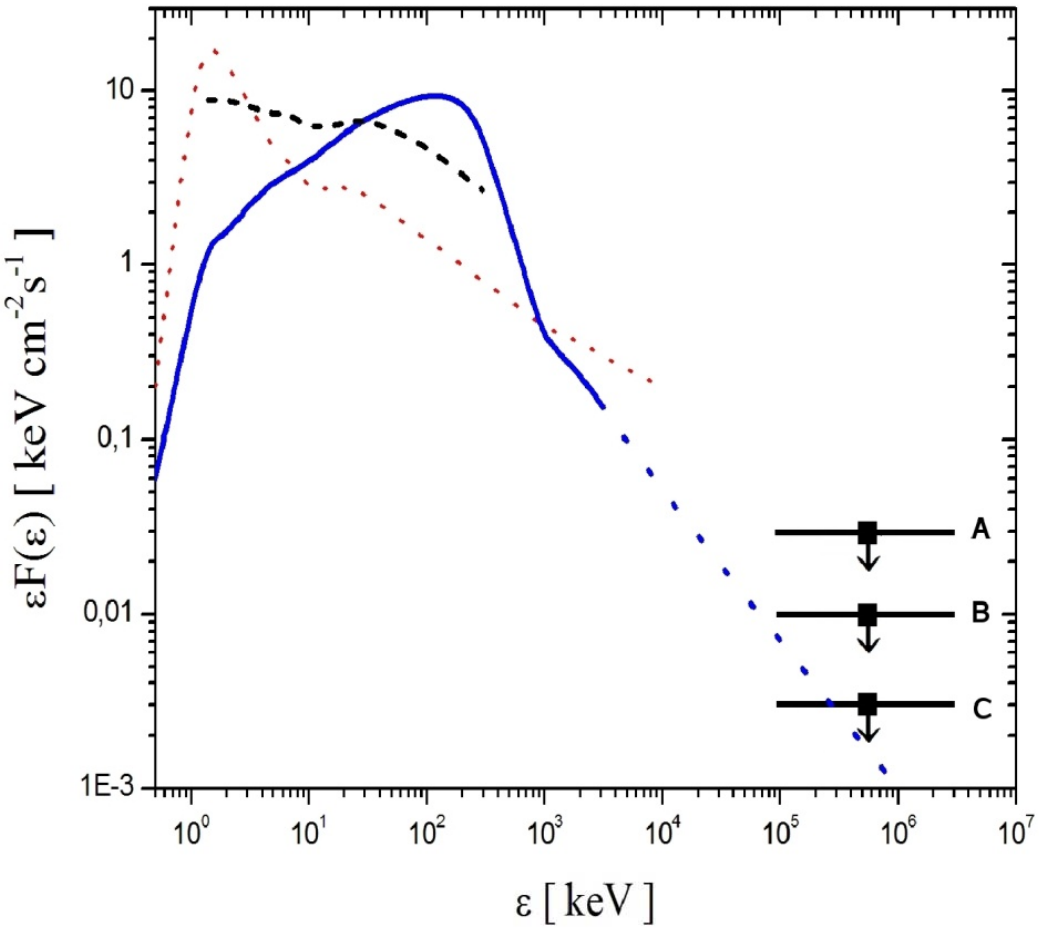


CygX-1 Spectral Energy Distribution - persistent
(Sabatini et al., 2010, ApJL)

Spectral energy distribution in typical states for Cyg X-1

Agile 2-sigma upper limits above 100 MeV for
A)2 weeks
B)4 weeks
C)315 days (first slide "deep integration")

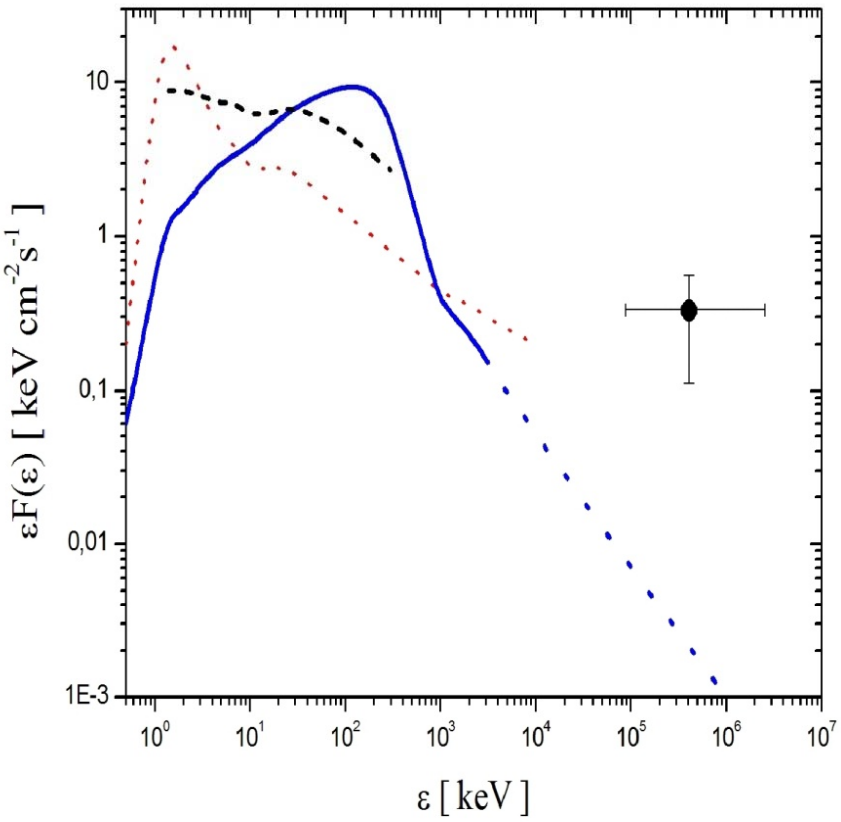
->average gamma-ray spectra in hard-state: a spectral cut-off



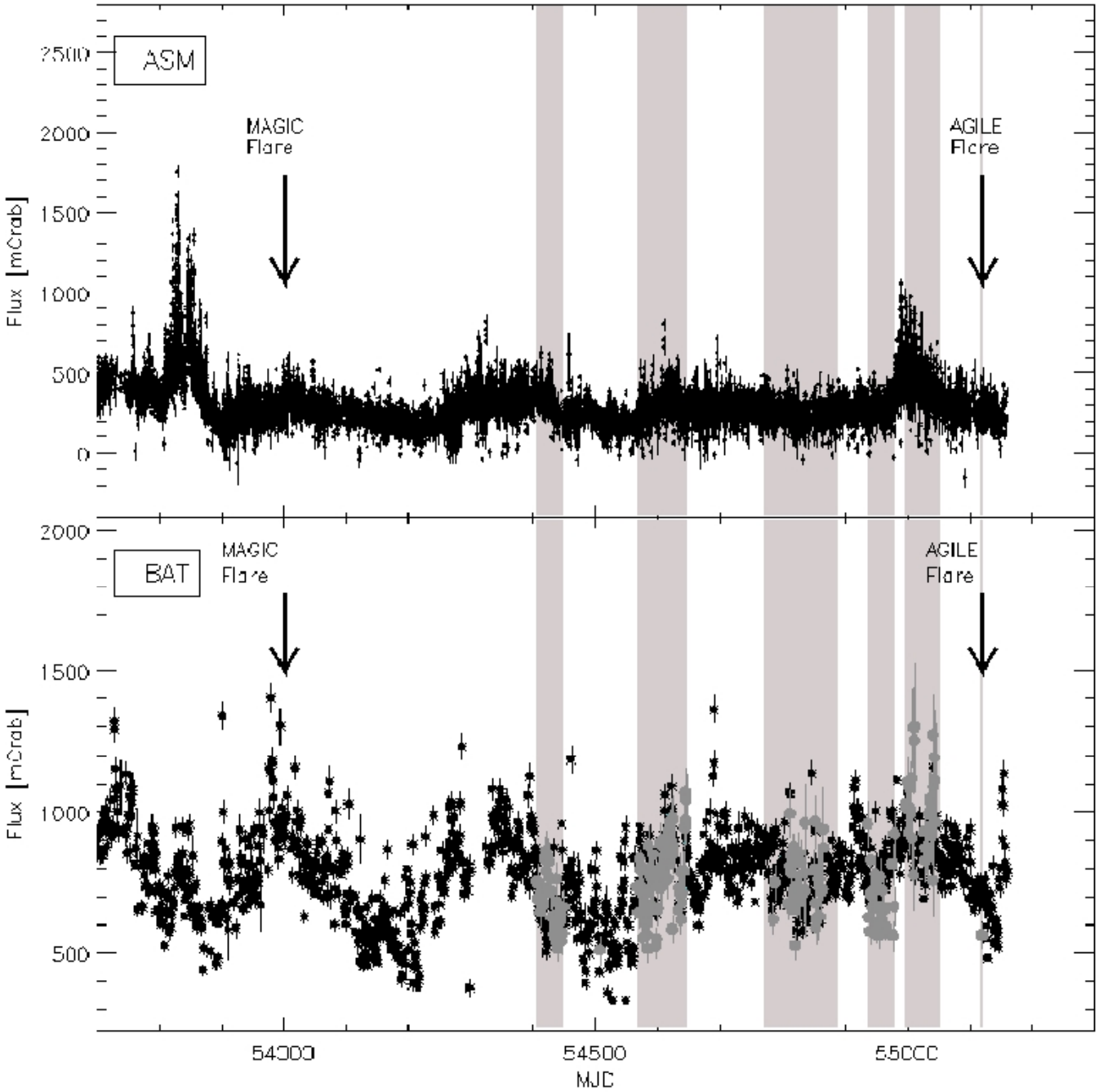
CygX-1 Spectral Energy Distribution - Flare

Spectral energy distribution for Cyg X-1 and AGILE data above 100 MeV for the flaring episode (15 October 09)

->First reported 1-day gamma-ray flare (0.1-3 GeV) in hard state!



(for a 1 year monitoring with AGILE: Del Monte et al., 2010, accepted by *A&A*)

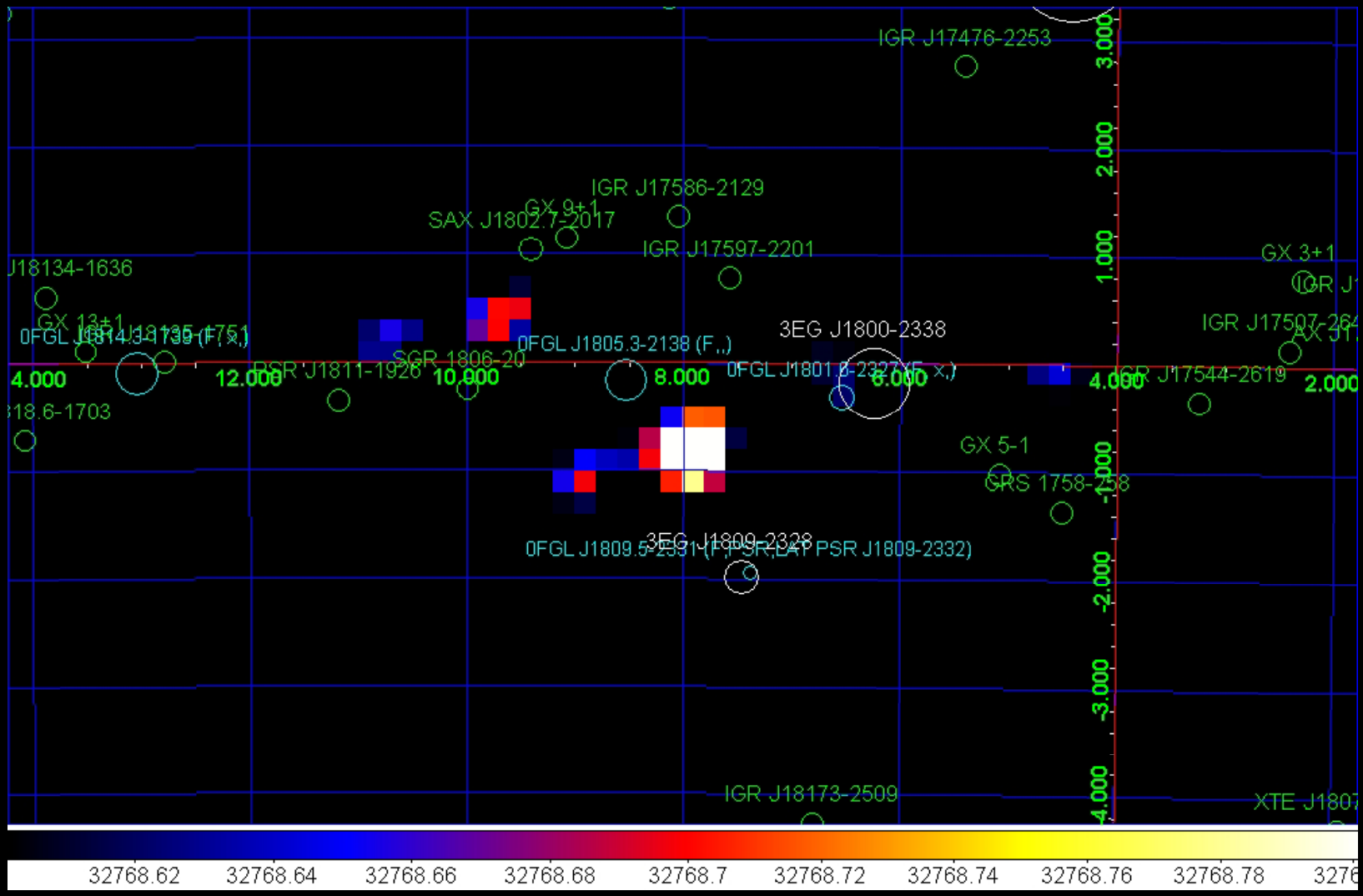

ASM
MAGIC
Flare
AGILE
Flare
Flux [mCrab]
2500
2000
1500
1000
500
0
BAT
MAGIC
Flare
AGILE
Flare
Flux [mCrab]
2000
1500
1000
500
54000
54500
55000
MJD

Gamma-Ray Galactic Transients

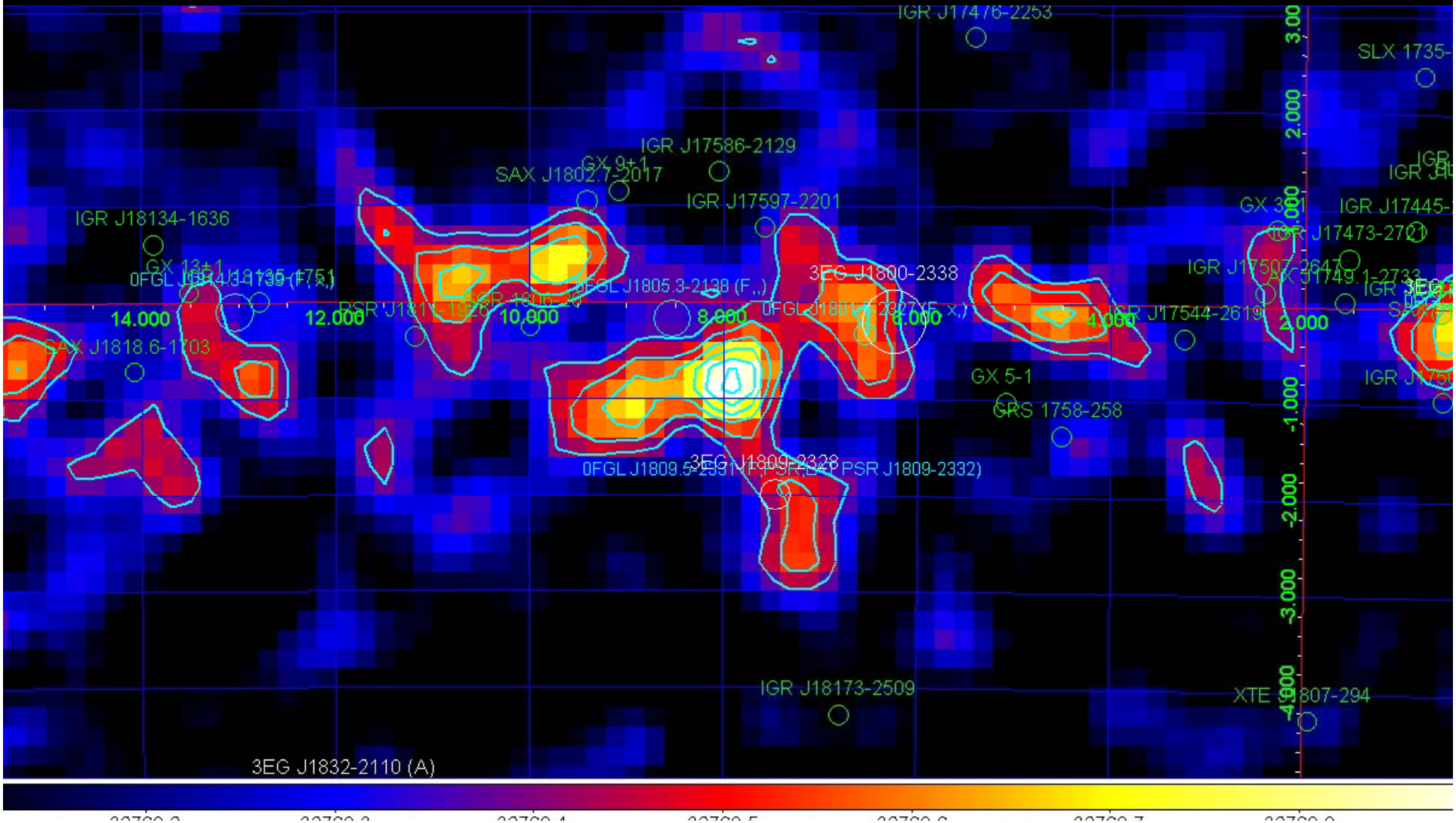
- **Some detection/hints from EGRET**
  - **example: GRO J1838-04 (Tavani et al. 1997)**

- **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**

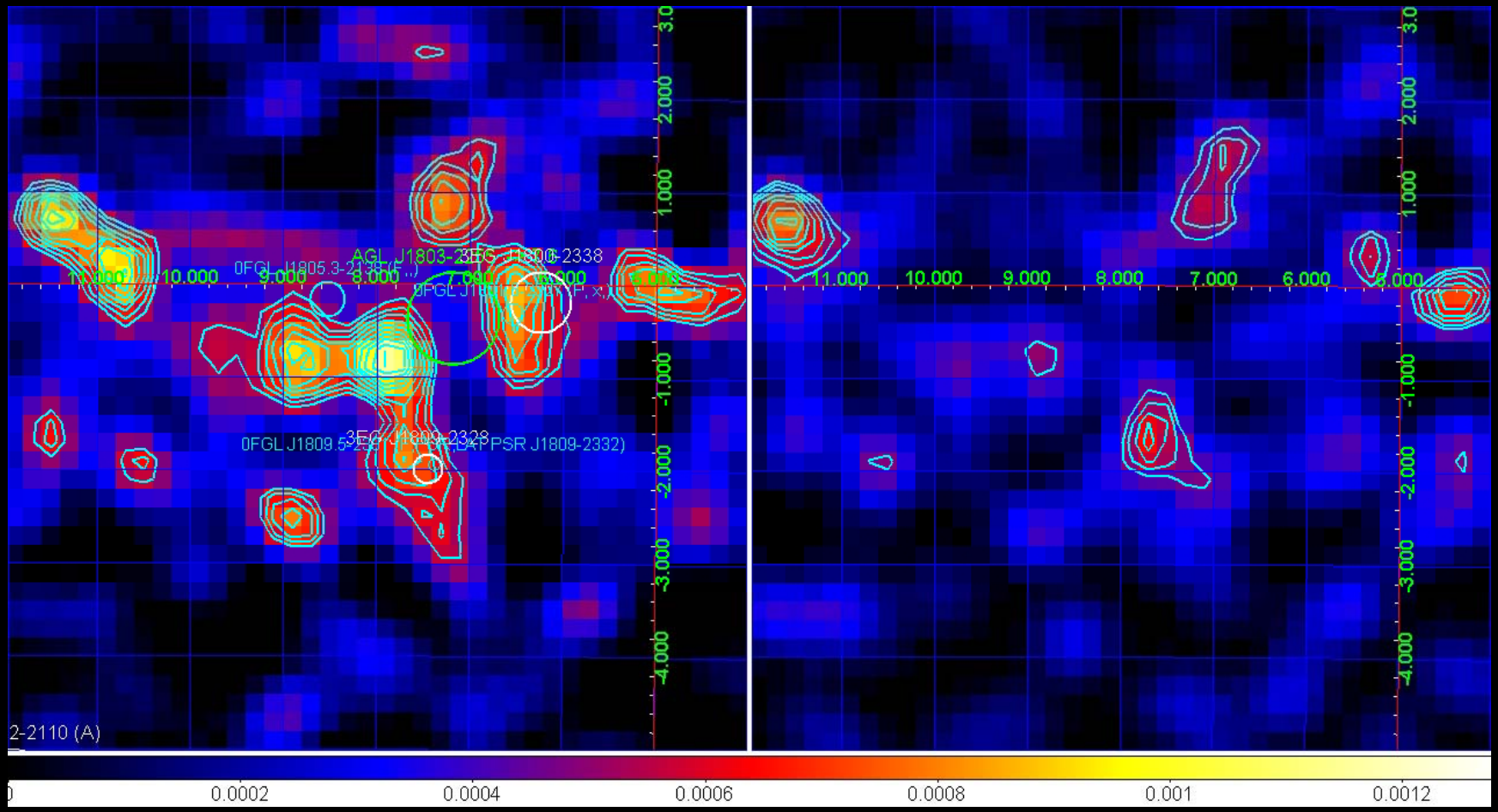
Easter transient: 10-13 April 2009, 10143-10180, bin =0.2, B16, FM, E>100 MeV



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

Galactic gamma-ray transient candidates:

- GC region
- Cygnus region
- Carina region
- Crux 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)

AGILE facts and surprises

- in general, no obvious X-ray or hard X-ray strong source (above 10 mCrab)
- some SWIFT follow-ups: no detections, (except one…)
- but…Eta-Car and Cygnus X-3 examples

Energetics…

- **Gamma-ray luminosity above 100 MeV**

$$L = (\text{a few}) \times 10^{34}\ d^2_{kpc}\ \text{erg/s}$$

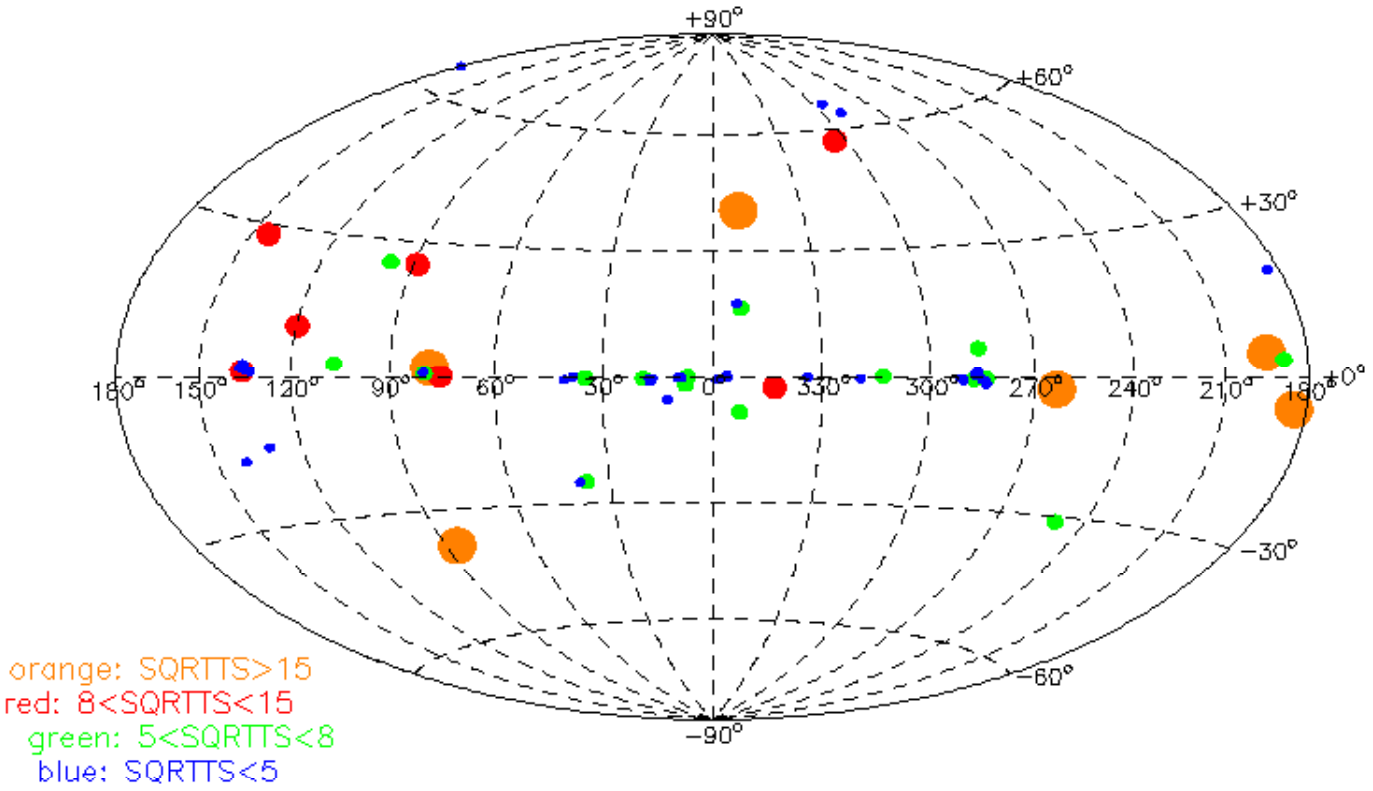
- **Compatible with WR/CWB expectations**
  - **It could be a class of WR/CWB or flaring stars**

- **But also it could be a NEW CLASS of (non-accreting or low X-ray) sources**

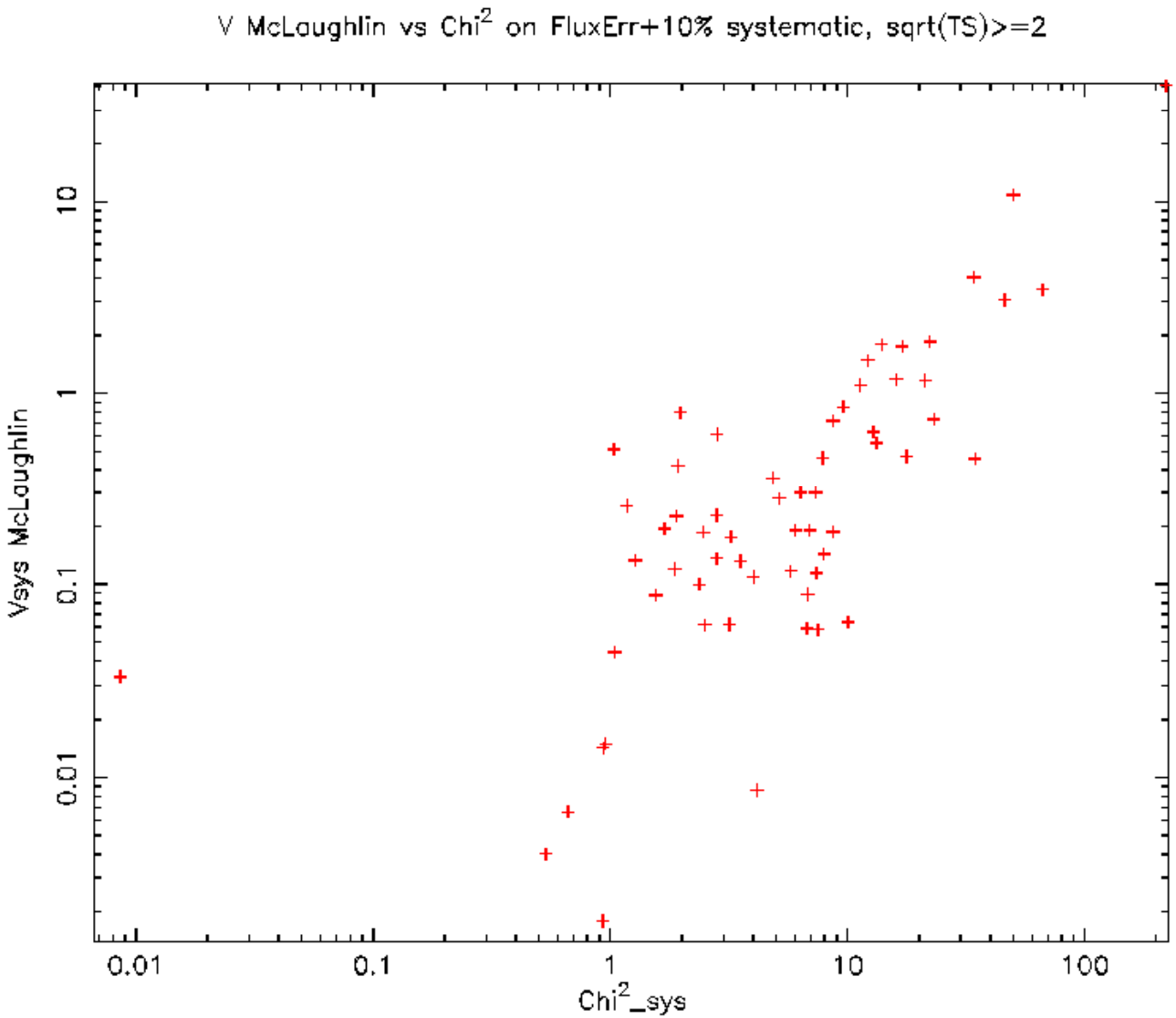
Some Galactic source variability may be due to transient source superposition

- One possible example: 1AGL J2022+4032
  - Coincident with 1FGL J2021.5+4026 which has been identified as a gamma-ray pulsar
  - Nearby sources 1FGL J2020.0+4049, associated with VER J2019+407
- Using data from November 2007 to August 2009, AGILE sees some evidence of variability on a ~6 day time scale
  - Variable X-ray source in FOV, from Chandra data
- Corresponding error circle has radius ~1°
- Variable component of flux may be due to unidentified, steep spectrum source within 6 day error circle

AGILE Catalog of Variable and Transient Sources in preparation



AGILE Catalog of Variable and Transient Sources in preparation



AGILE vs. Fermi: different results

- **AGILE-GRID is optimized near 100 MeV, Fermi-LAT at E > 1 GeV**
  - **Fermi extrapolates from E > 200 MeV to determine flux E > 100 MeV**
  - **Due to AGILE energy resolution, E > 100 MeV flux contains large contribution from sub-100 MeV photons**

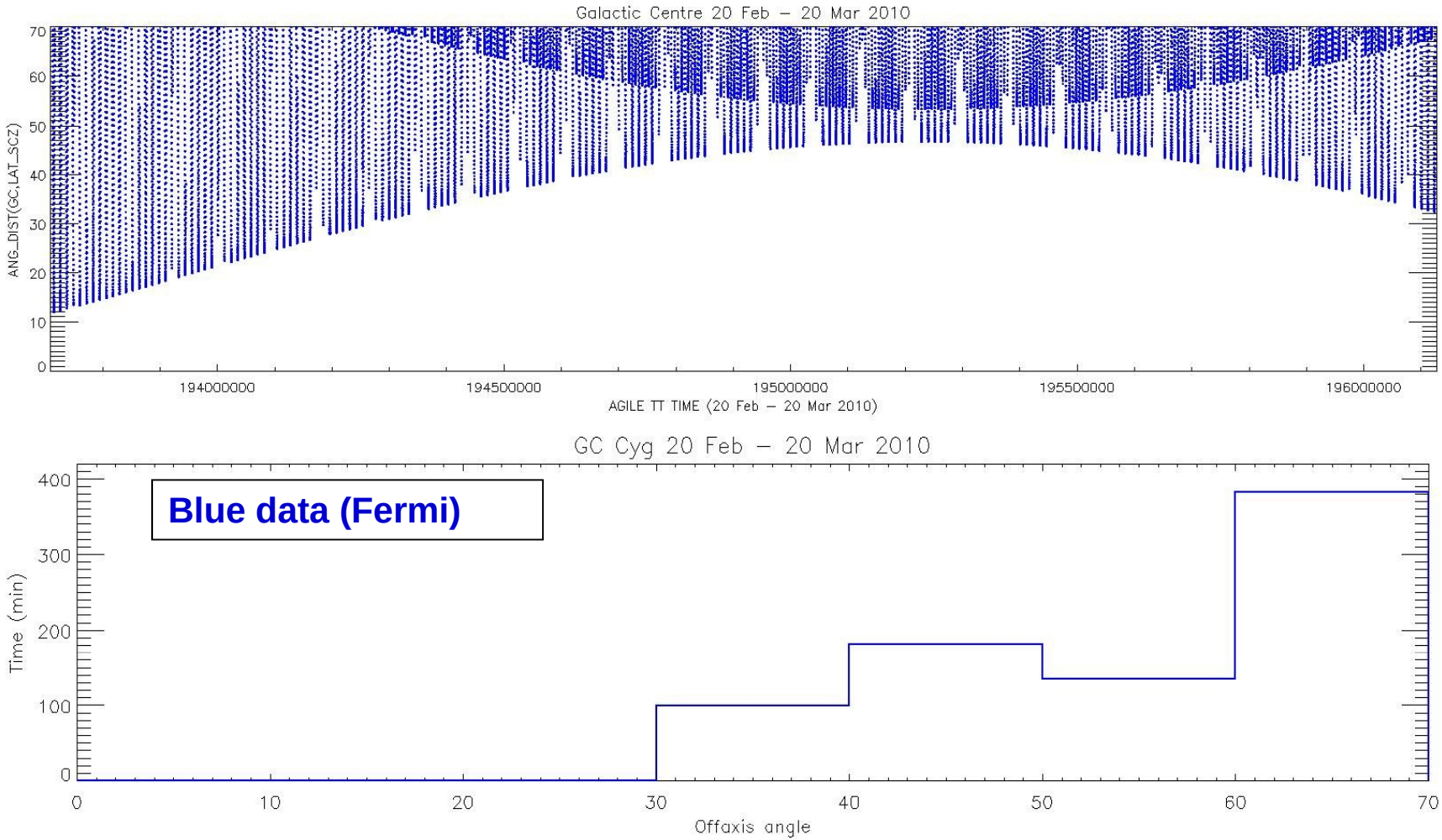
AGILE vs. Fermi: different results

- **depending on the season and source position, AGILE and Fermi can have quite different exposure below 1 GeV**
  - **exposure and off-axis distribution**
  - **different livetime sequence, different time windows**

a comparison: 1-day exposure

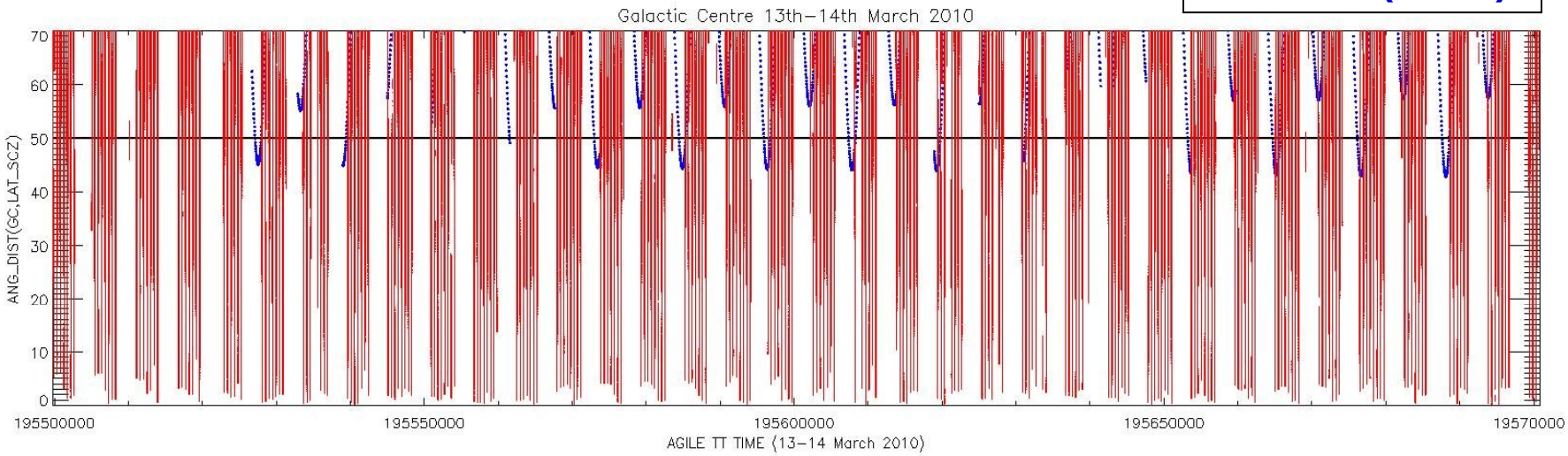
	p-AGILE (GRID)	sp-AGILE (GRID)	FERMI (LAT front)
FOV (sr)	2.5	2.5	2.5
Attitude	fixed	variable (spinning)	variable
sky coverage	1/5	~ 70%	whole sky
Source livetime fraction	~ 0.5	~ 0.2	~ 0.16
1-day exposure (30 degree off-axis, 100 MeV)	~ $2\ 10^7$ (cm^2 sec)	(0.5-1) 10^7 (cm^2 sec)	~(1-2) 10^7 (cm^2 sec)

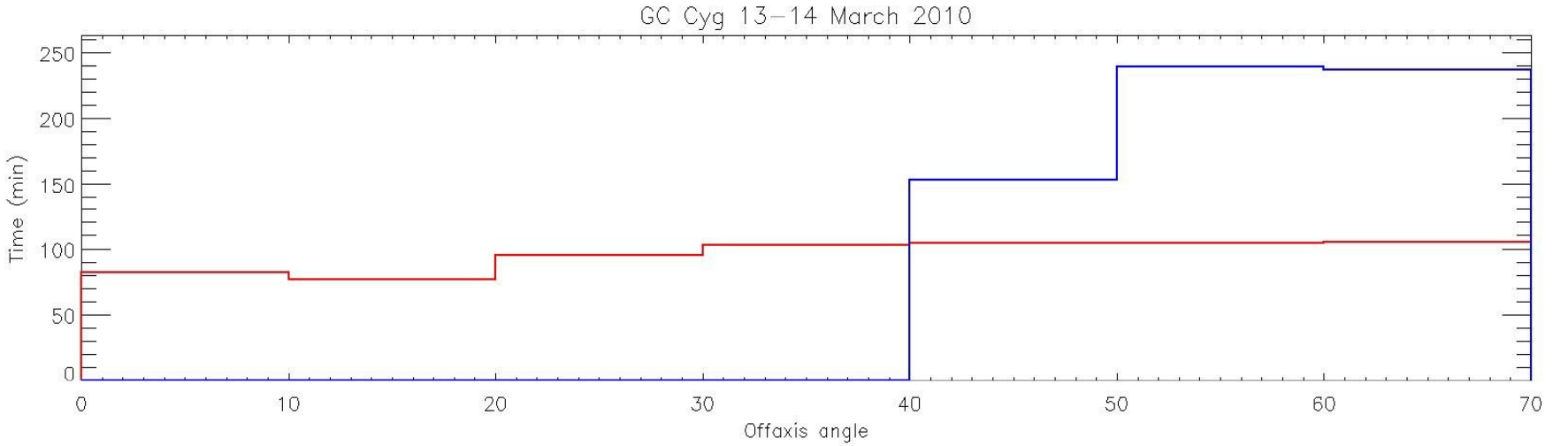
Example: Fermi Galactic Centre 1-month integration (20 Feb-20 Mar 2010) off-axis angle vs. time and cumulative histogram (Sabatini etal. 2010)



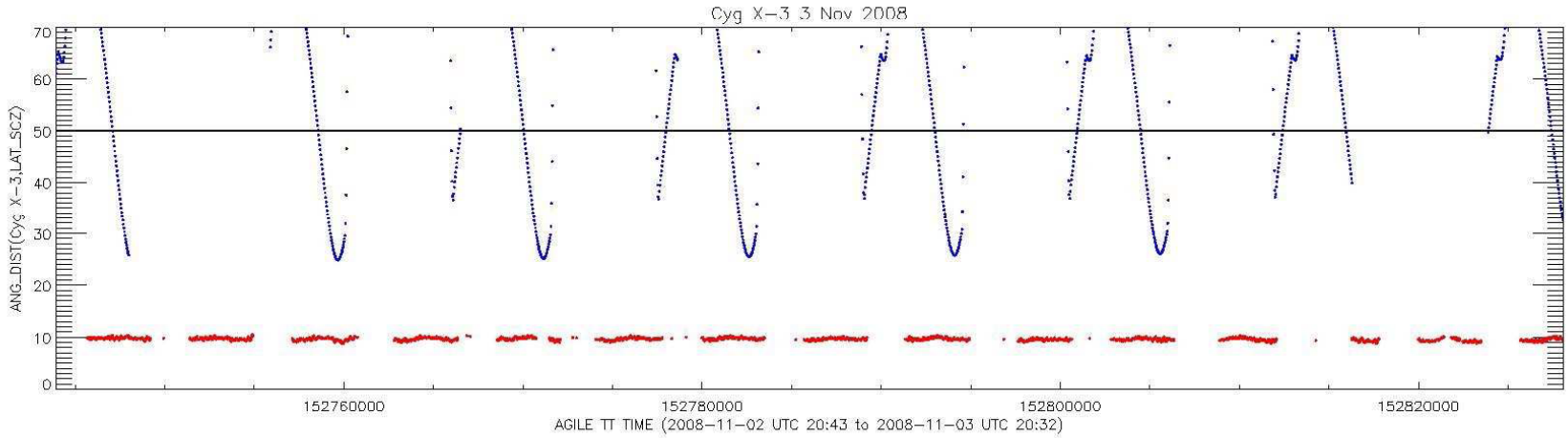
Example: Galactic Centre 2-days integration (13-14 Mar 2010)
AGILE spinning mode vs. Fermi (Sabatini et al. 2010)

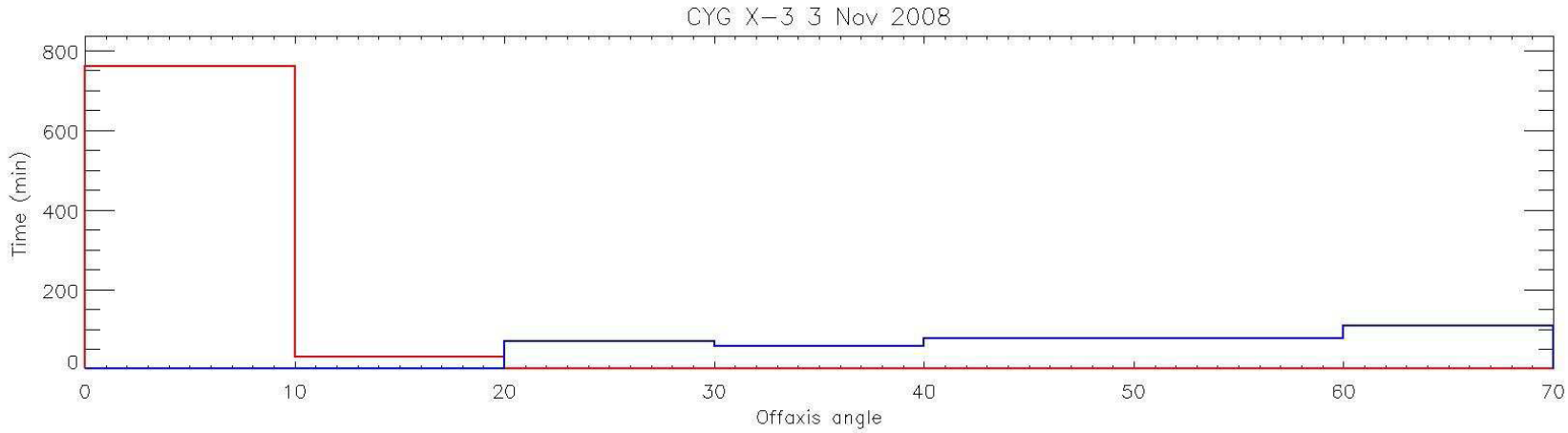
Red data (AGILE)
Blue data (Fermi)



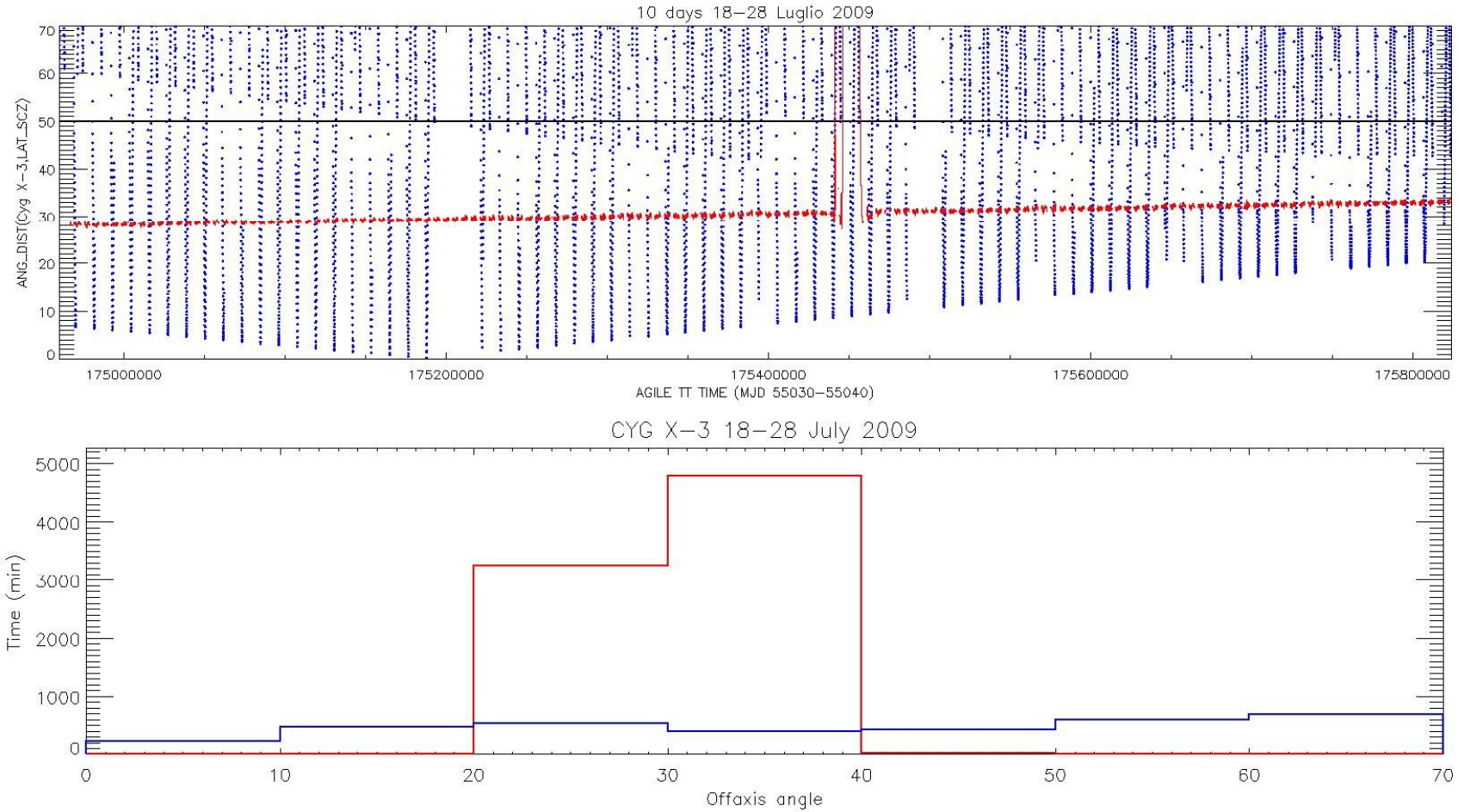


Cyg X-3: AGILE and Fermi time coverage and off-axis angle





AGILE and Fermi off-axis angle
(18-28 July 2009)



PSR B1259-63

[Previous | Next]

AGILE detection of transient gamma-ray emission from the PSR B1259-63 region

ATel #2772; *M. Tavani (INAF-IASF-Rm and Univ. Tor Vergata), F. Lucarelli, C. Pittori, F. Verrecchia (ASDC), A. Bulgarelli, F. Gianotti, M. Trifoglio (INAF/IASF Bologna), E. Striani (Univ. Tor Vergata), S. Sabatini, G. Piano (INAF/IASF Roma), A. Argan, A. Trois, G. De Paris, V. Vittorini, E. Costa, I.Donnarumma, M. Feroci, L. Pacciani, E. Del Monte, F. Lazzarotto, P. Soffitta, Y. Evangelista, I. Lapshov (INAF-IASF-Rm), A. Chen, A. Giuliani (INAF-IASF-Milano), M. Marisaldi, G. Di Cocco, C. Labanti, F. Fuschino, M. Galli (INAF/IASF Bologna), P. Caraveo, S. Mereghetti, F. Perotti (INAF/IASF Milano), G. Pucella, M. Rapisarda (ENEA-Roma), A. Pellizzoni, M. Pilia (INAF/OA-Cagliari), G. Barbiellini, F. Longo (INFN Trieste), P. Picozza, A. Morselli (INFN and Univ. Tor Vergata), M. Prest (Universita` dell'Insubria), P. Lipari, D. Zanello (INFN Roma-1), S. Vercellone, F.D'Ammando (INAF/IASF-Palermo), P.W. Cattaneo, A. Rappoldi (INFN Pavia), P. Giommi, P. Santolamazza (ASDC), S. Colafrancesco and L. Salotti (ASI)*

on ***5 Aug 2010; 13:04 UT***

Distributed as an Instant Email Notice (Request for Observations)

Password Certification: Carlotta Pittori (carlotta.pittori@asdc.asi.it)

Subjects: Gamma Ray, >GeV, Request for Observations, Binaries, Pulsars, Transients

Referred to by ATel #: 2780, 2782

AGILE is detecting transient gamma-ray emission above 100 MeV from a source near the Galactic plane and positionally consistent with the binary pulsar PSR B1259-63 (J2000 coordinates: RA: 13 02 47.66, Dec: -63 50 08.6; l = 304.1836, b = -0.9916).

Related

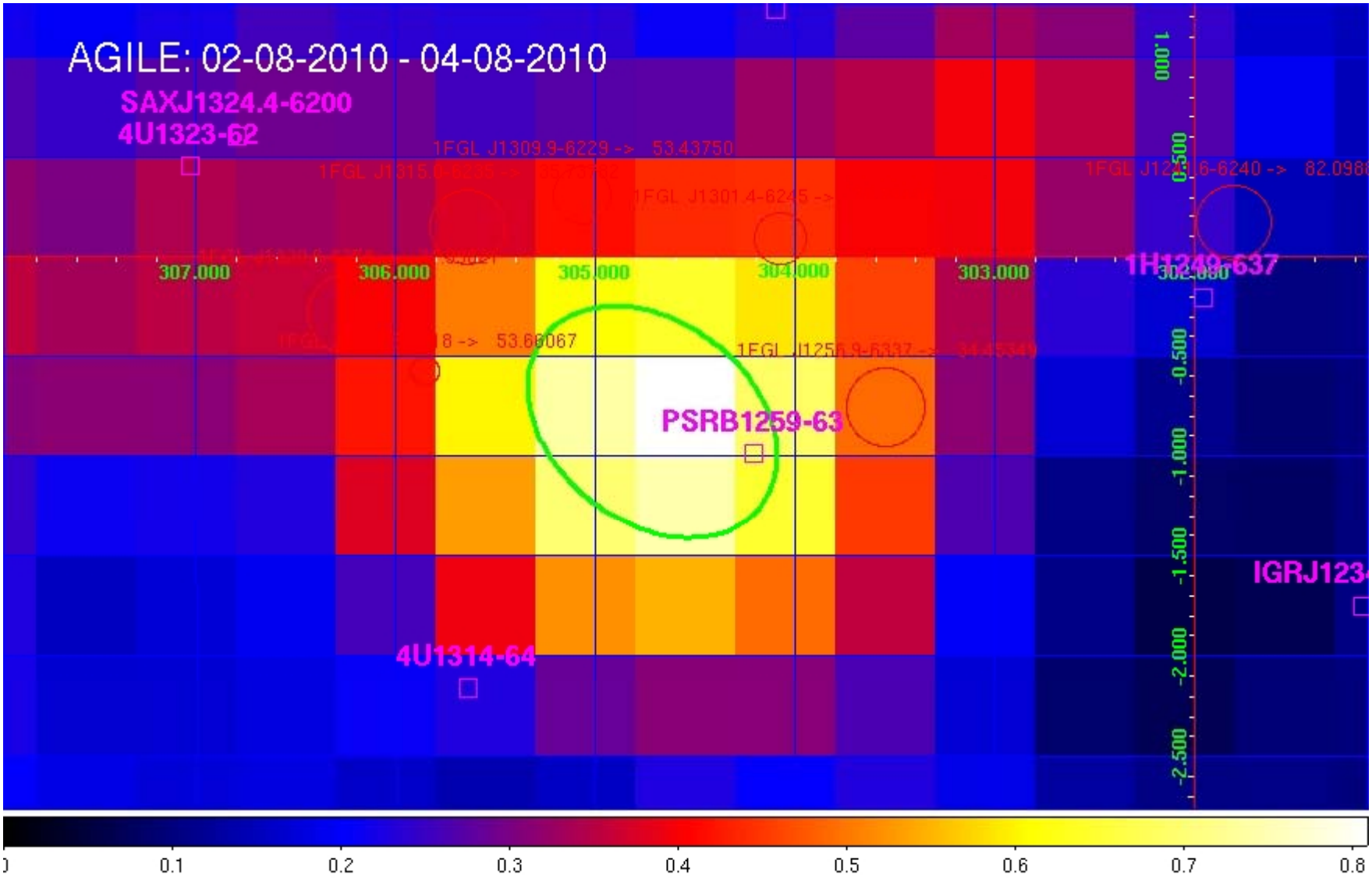
2782 Swift/XRT observations of the region near PSR B1259-63

2780 Fermi LAT observations of the PSR B1259-63 region

2772 AGILE detection of transient gamma-ray emission from the PSR B1259-63 region

250 Planned Observation Schedule on PSR 1259-63 by the H.E.S.S. experiment in March, 2004

249 Discovery of PSR 1259-63 in VHE Gamma-Rays with H.E.S.S.


AGILE: 02-08-2010 - 04-08-2010
SAXJ1324.4-6200
4U1323-62
1FGL J1309.9-6229 -> 53.43750
1FGL J1301.4-6245 ->
307.000
306.000
305.000
304.000
303.000
1H1249-637
PSRB1259-63
4U1314-64
IGRJ123
1.000
0.500
-0.500
-1.000
-1.500
-2.000
-2.500
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

Conclusions

- **Microquasar gamma-ray flares coincide with radio/X state transitions**
  - **hard X-ray emission suppressed**
  - **may be related to changes in disk structure**
  - **limits on Comptonized models**
- **Many Galactic transients observed**
  - **Some source variability may be due to hidden transients**
  - **Catalog in preparation**
- **AGILE and Fermi complementary in energy sensitivity and exposure**