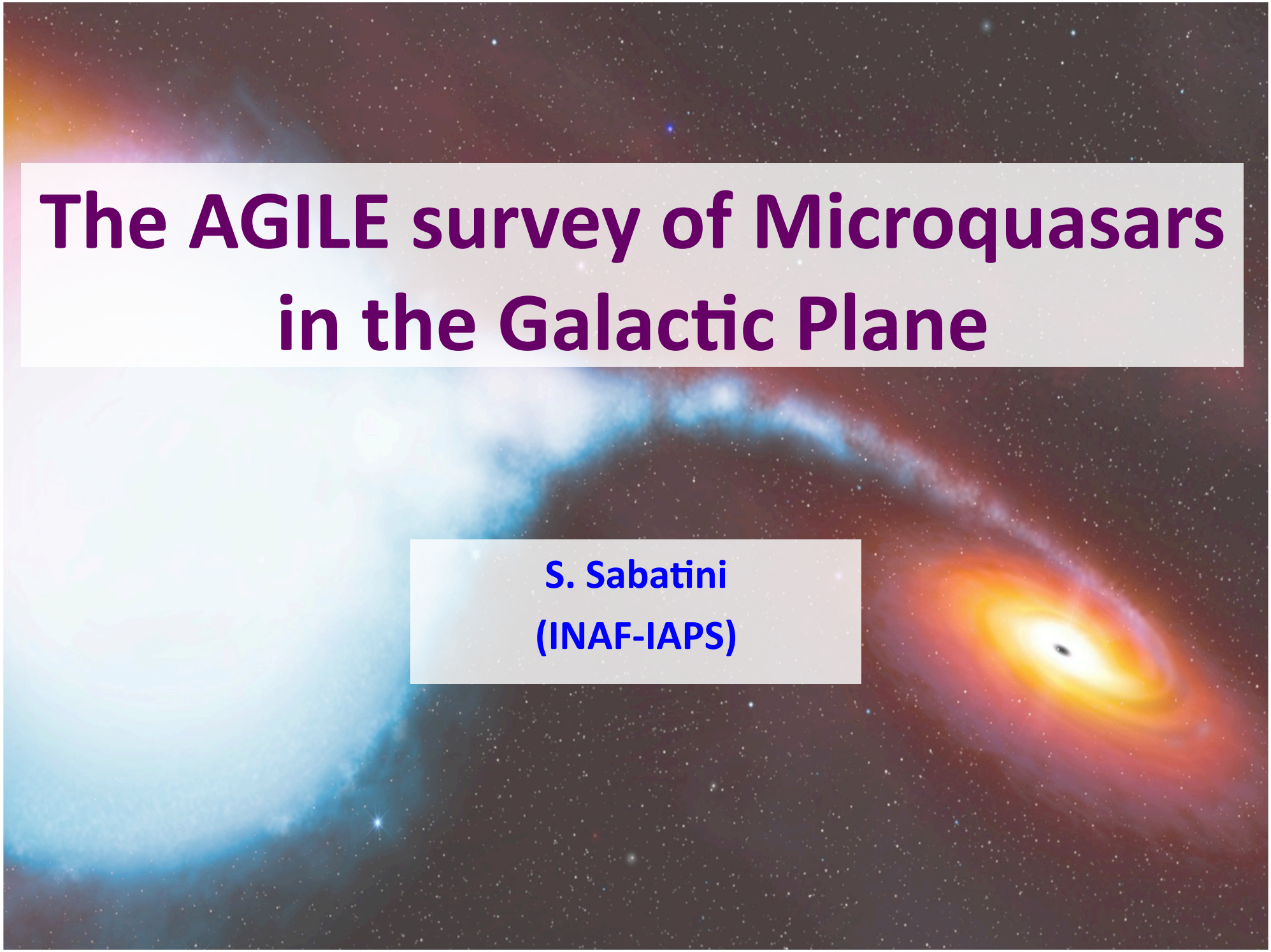
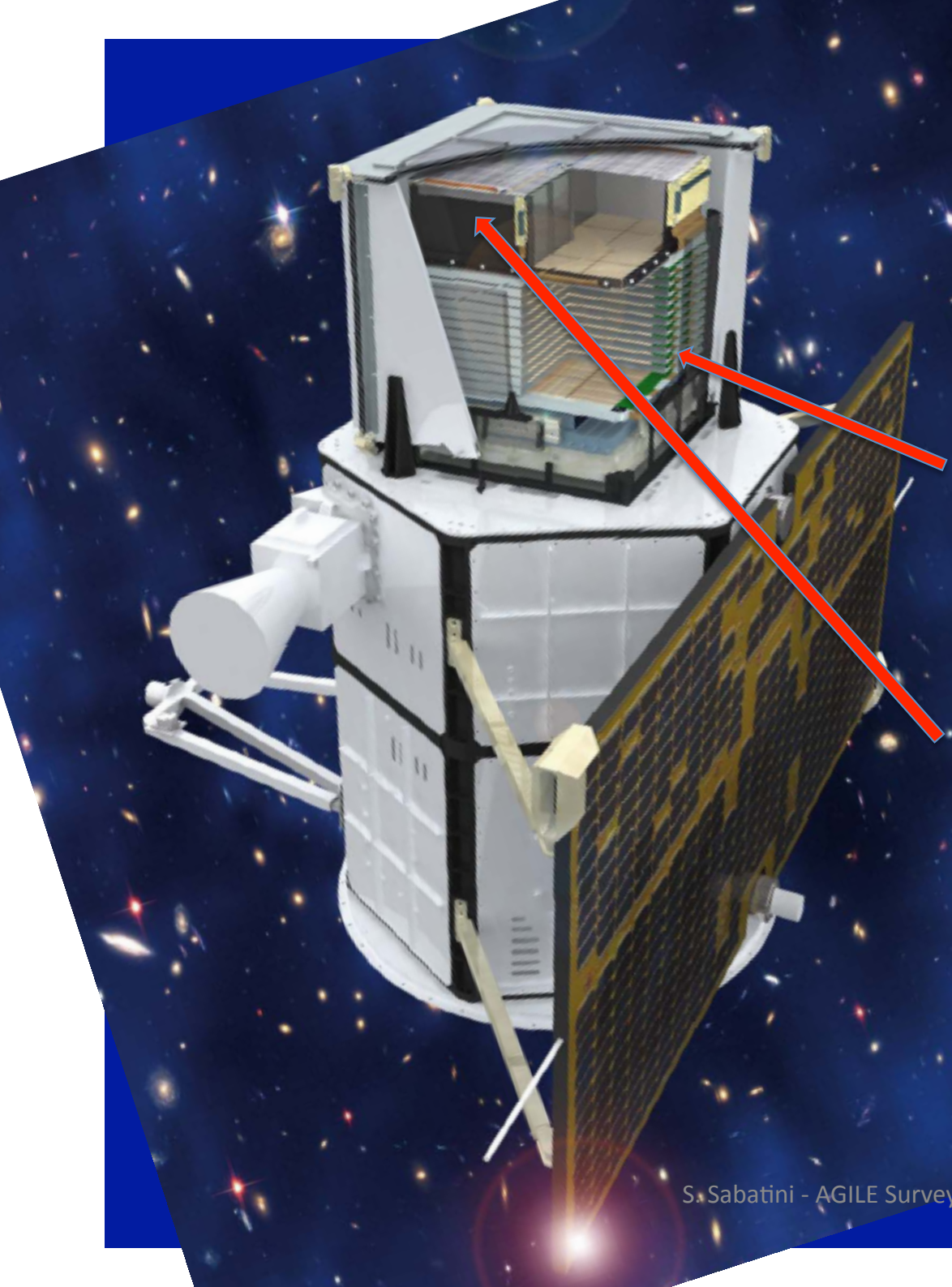


# The AGILE survey of Microquasars in the Galactic Plane

S. Sabatini
(INAF-IAPS)

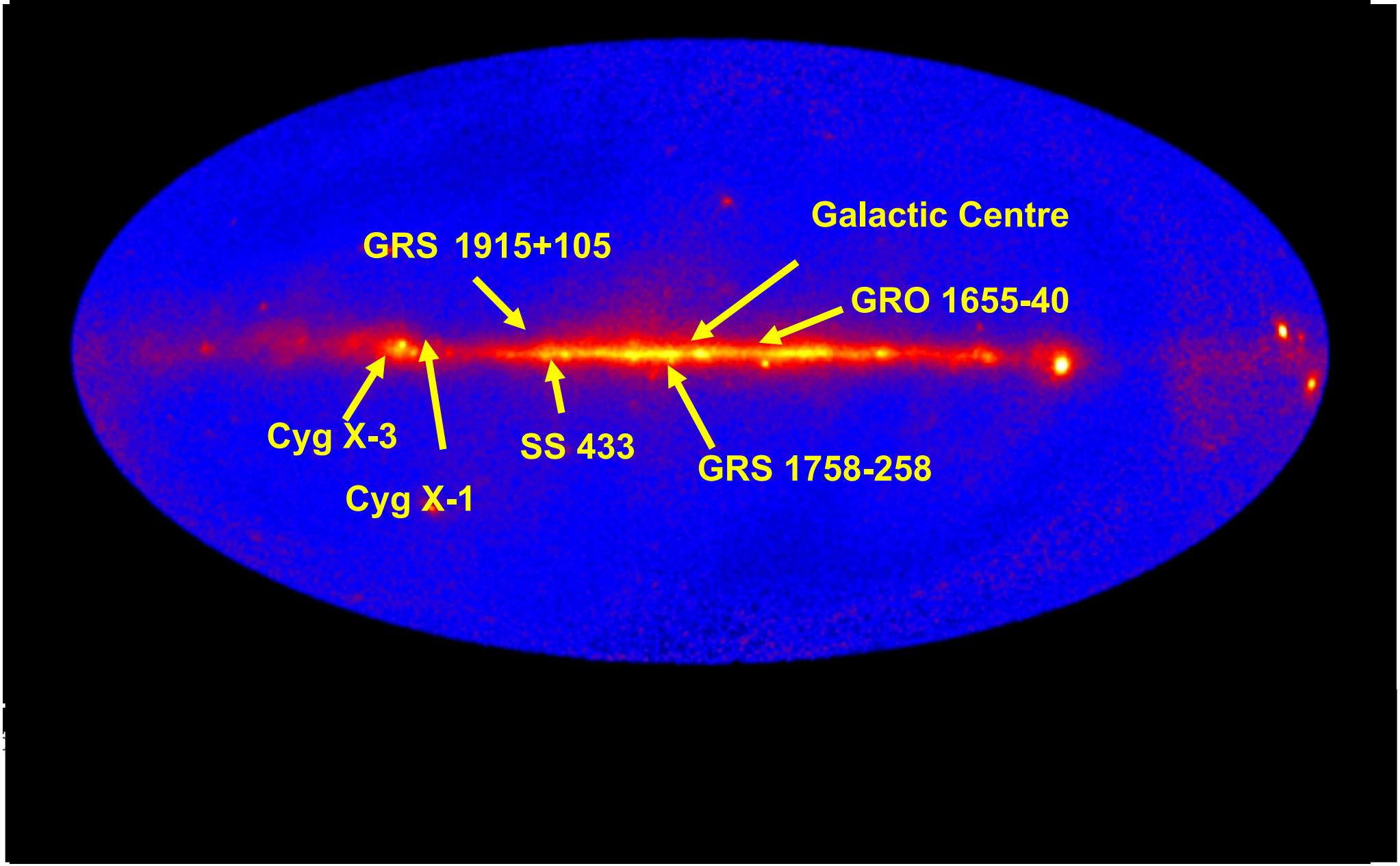


# The AGILE Payload: the most compact instrument for high-energy astrophysics

- gamma-ray imager (30 MeV- 30 GeV)
- hard X-ray imager (18-60 keV)

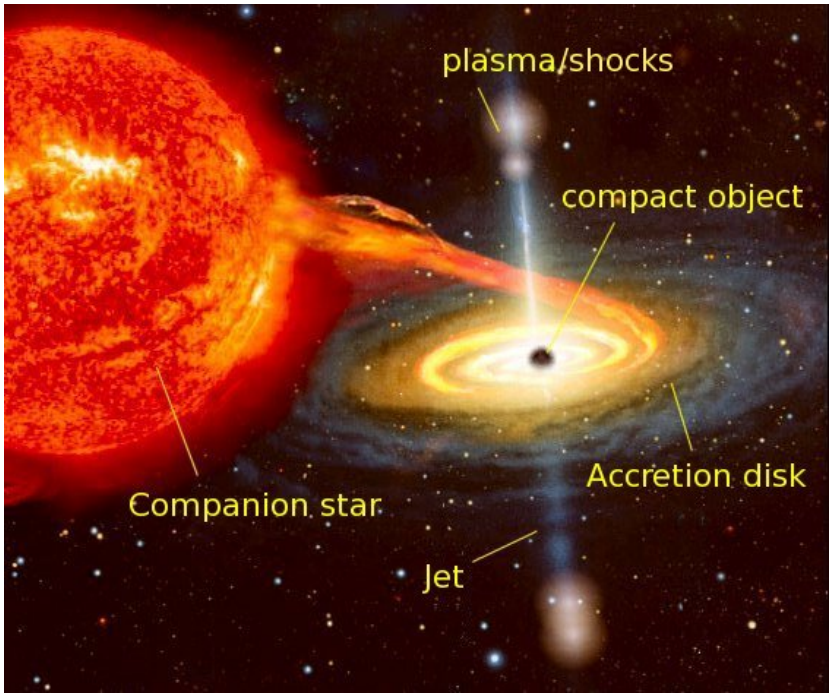
large FOVs (1-2.5 sr) and optimal angular resolution

# AGILE 2-years exposure $\gamma$-ray sky (E > 100 MeV)
# 2007, July – 2009 June



# Surprises from microquasars…

- Gamma-ray emission in general is rare or not detectable (e.g., GRS 1915+10).



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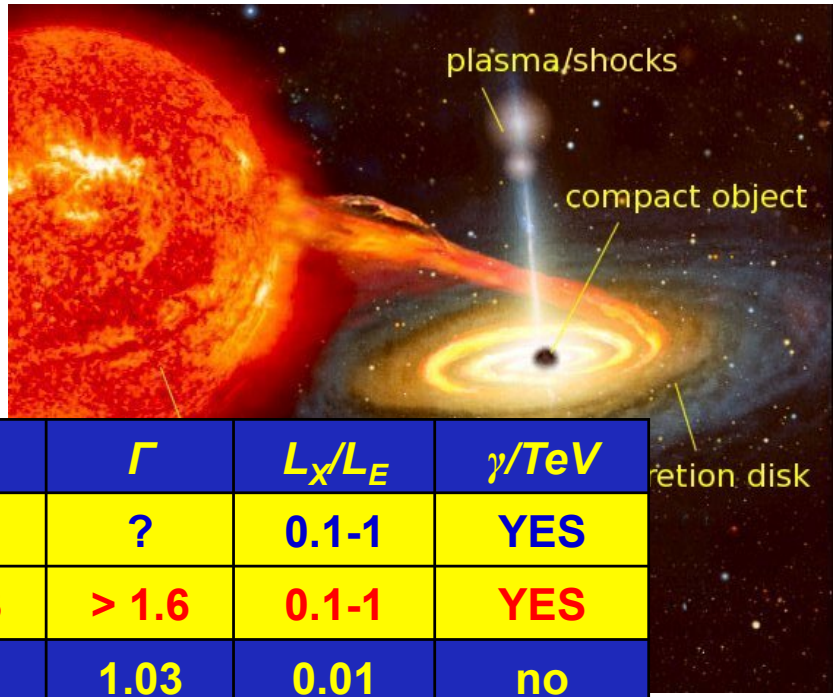


| | $\Theta$ (degrees) | $\beta$ | $\Gamma$ | $L_X/L_E$ | $\gamma$/TeV |
|---|---|---|---|---|---|
| Cyg X-1 | 30? | ? | ? | 0.1-1 | YES |
| Cyg X-3 | < 14 | > 0.8 | > 1.6 | 0.1-1 | YES |
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| GRS 1915+105 | 70 | 0.92 | 2.5 | 0.1-1 | no |
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| LS I 61 303 | ? | ? | ? | $10^{-4}$ | yes |
| LS 5039 | < 80 | > 0.2 | ? | $10^{-4}$ | yes |

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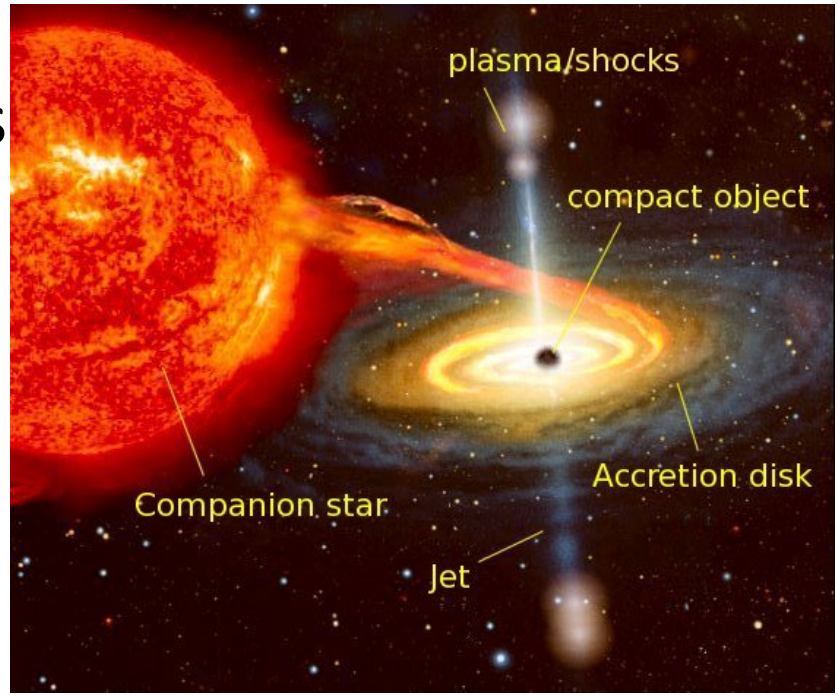

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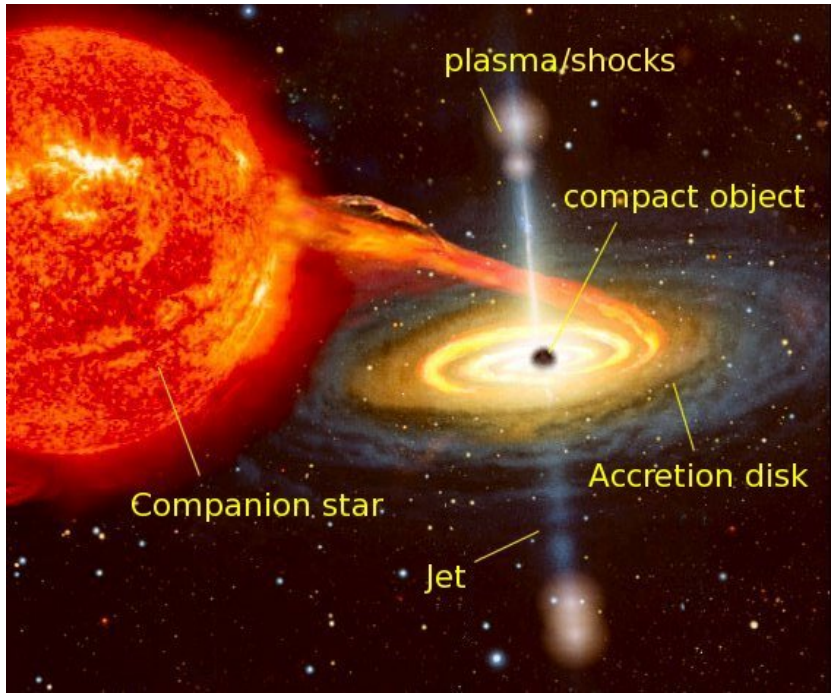
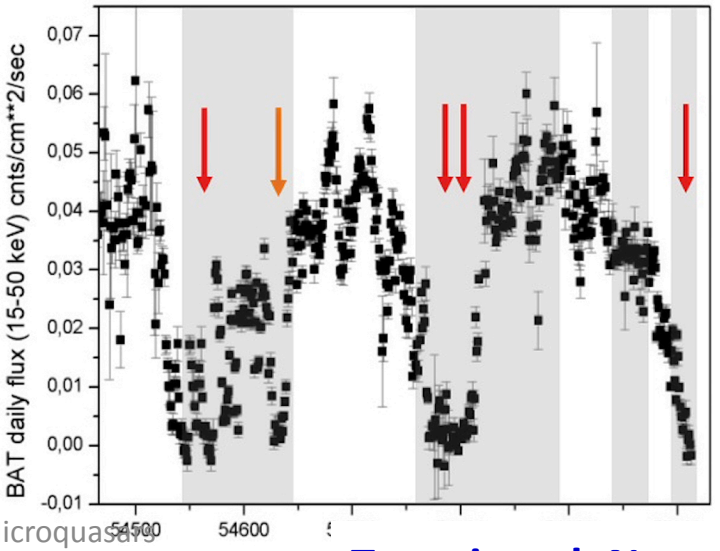
- **in Cygnus X-3 clear evidence of gamma-ray emission at major spectral transitions (soft-to-hard and hard-to-soft)**




Tavani et al. Nature 2009

# Galactic "Micro-QSOs" (radio "jet" sources)

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| **Cyg X-3** | **G. PIANO (next talk)** | | | | |
| SS 433 | 80 | 0.26 | 1.03 | 0.01 | no |
| GRS 1915+105 | 70 | 0.92 | 2.5 | 0.1-1 | no |
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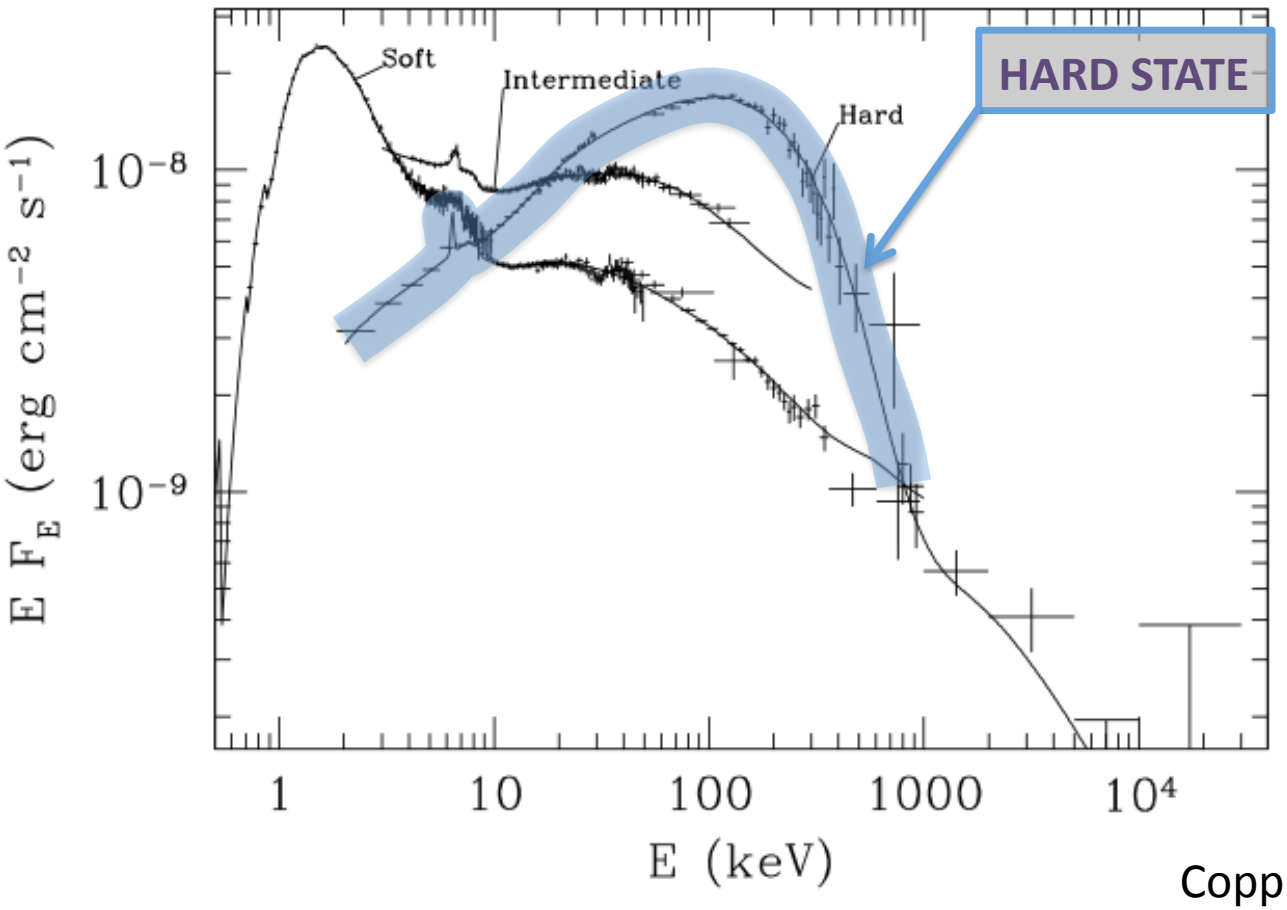
# Cygnus X-1

- **It is the archetypal black hole binary system in our Galaxy**
- **O9.7 Iab supergiant star orbiting around a compact star (mass lower limit 6-13 $M_{\odot}$)**
- **Extensively monitored in radio, IR, UV and X-rays.**
- **One of the most X-ray prominent. Highly variable on all timescales (months to seconds)**

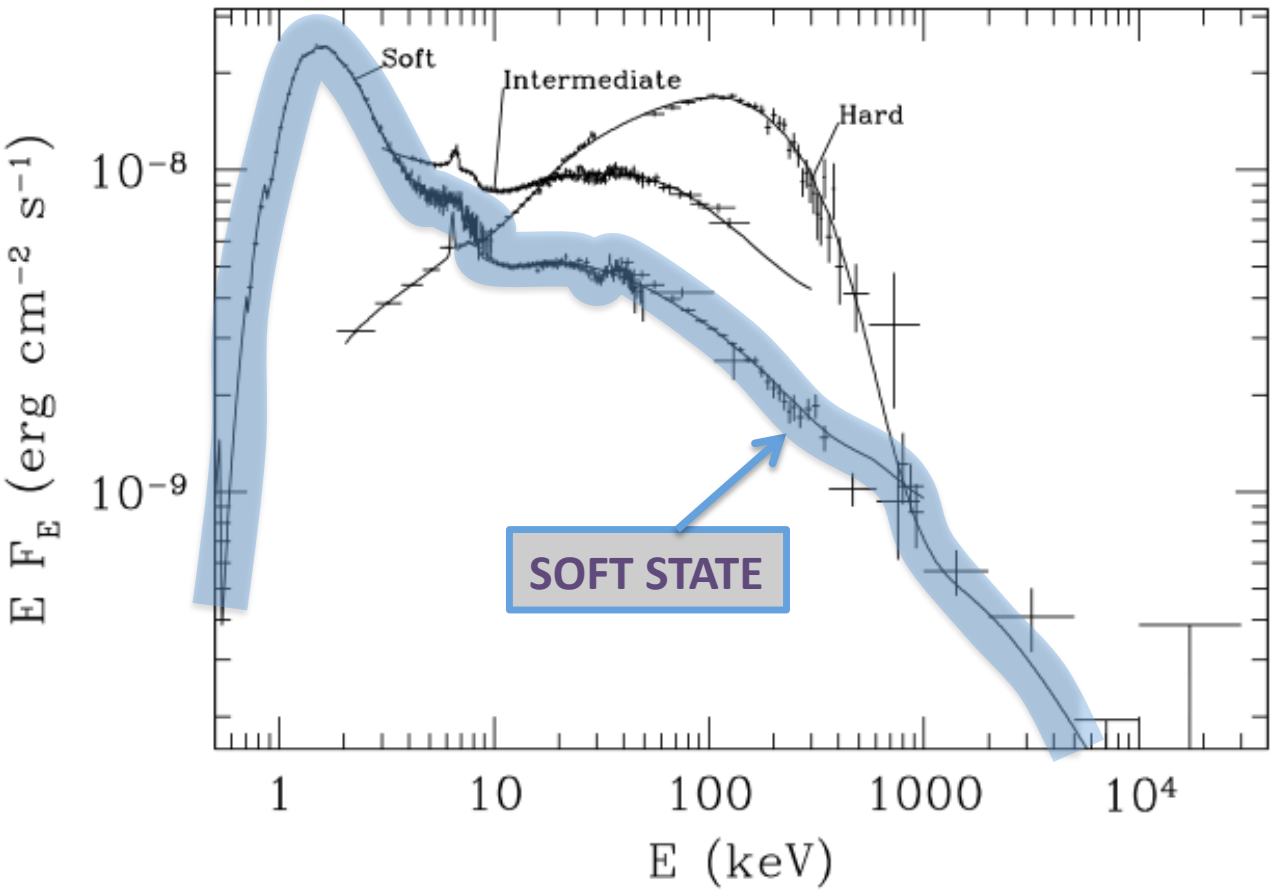
# Cyg X-1 TYPICAL SPECTRAL STATES




Coppi 1999

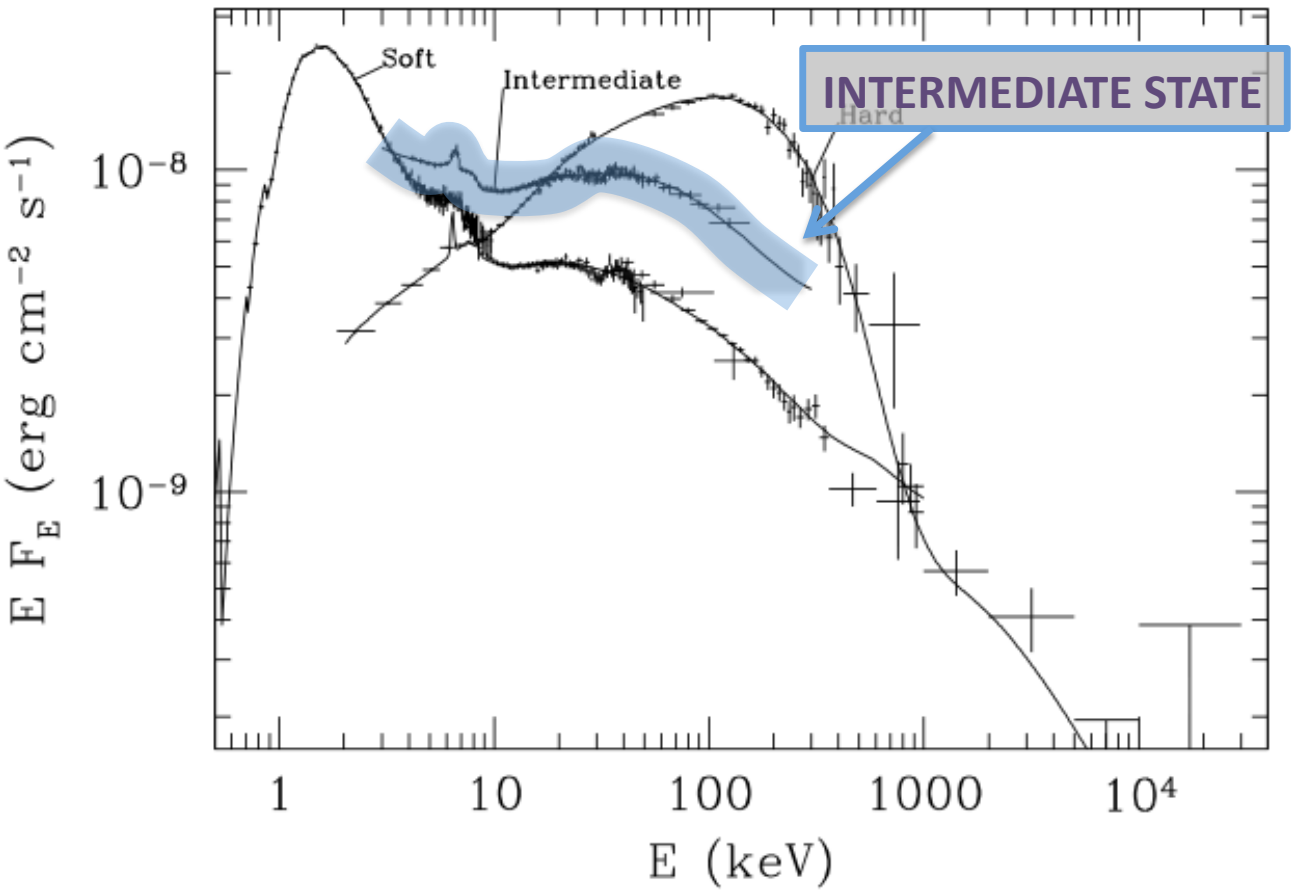
- **Power law ($E^{-\Gamma}$) with $\Gamma$ ~-1.7**
- **High-energy cut-off @ ~150 keV**

# Cyg X-1 TYPICAL SPECTRAL STATES



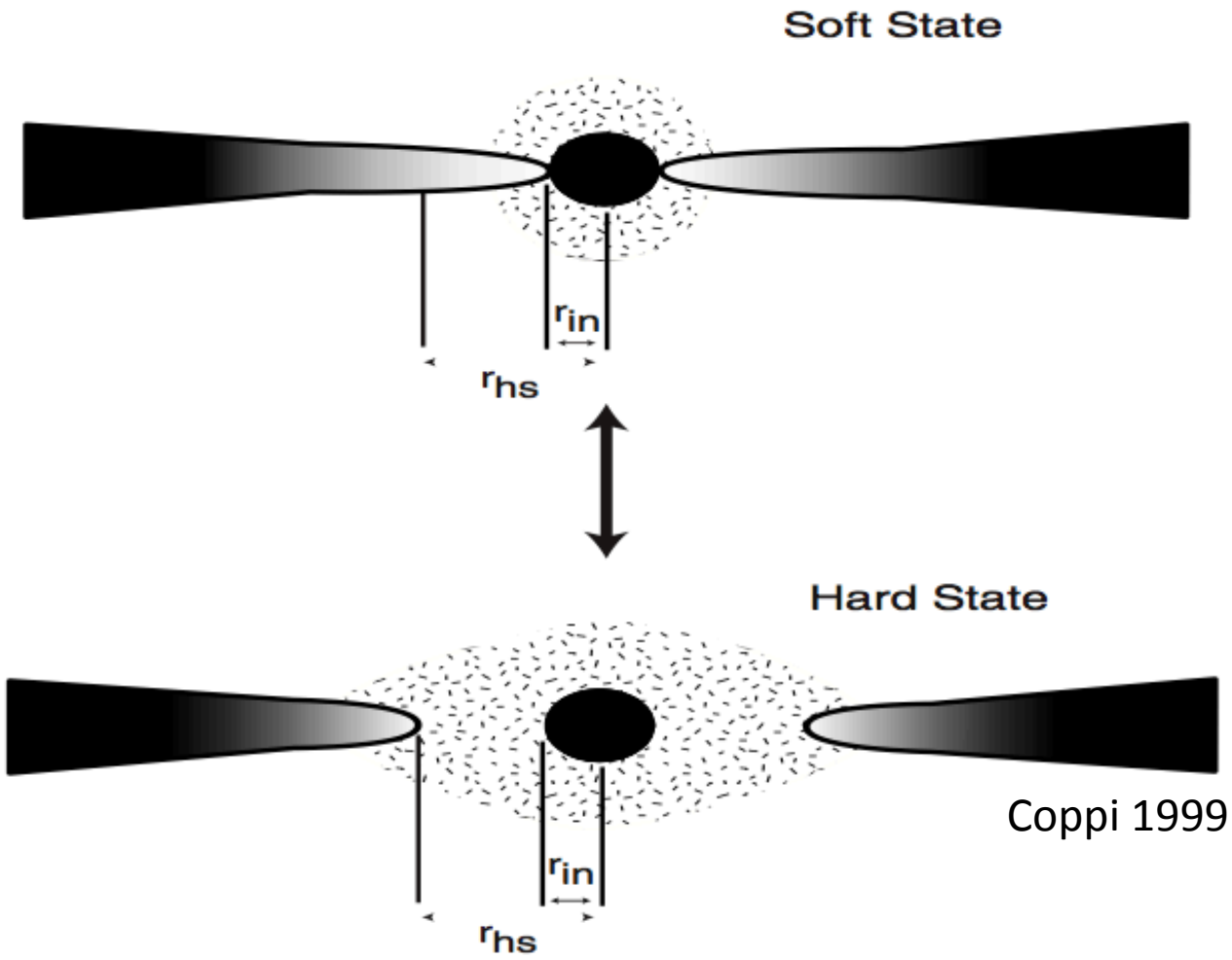

- **Blackbody component with kT ~ 0.5 keV**
- **Power law tail with $\Gamma$ ~2-3**

# Cyg X-1 TYPICAL SPECTRAL STATES




**Transitional states**

# Comptonization Models




Coppi 1999

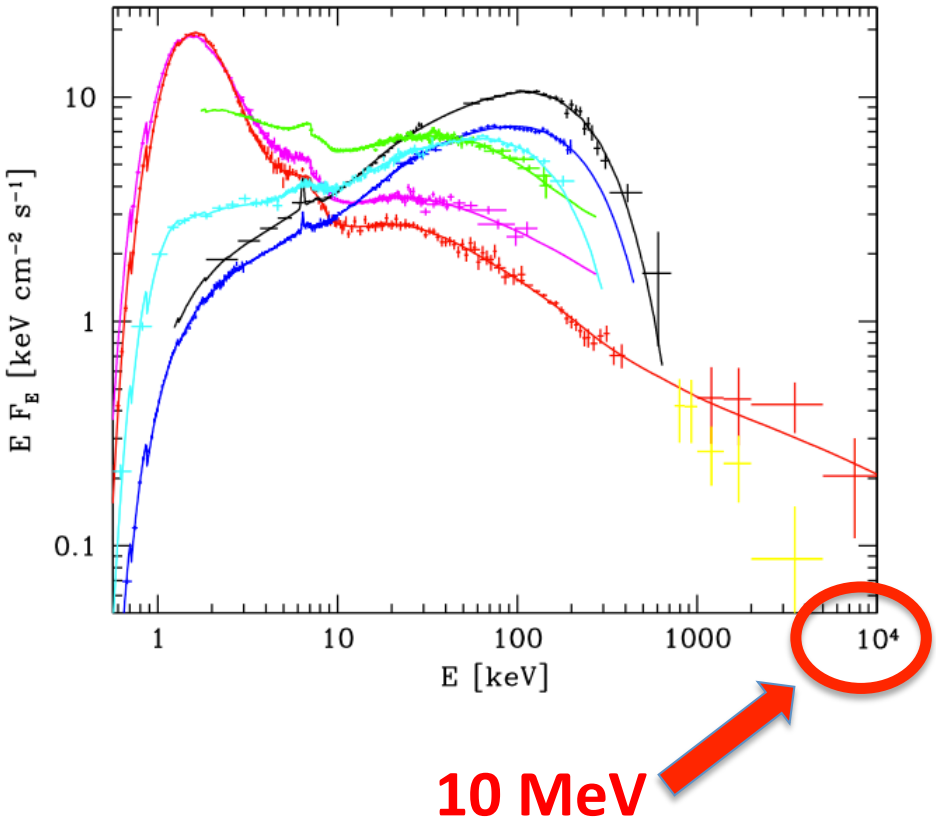
the cool disk moves inwards,and penetrates into the inner coronal region. Only the non-thermal accelerator continues to make a significant contribution to the corona's power.

disk puffs up and acts as a hot, Comptonizing corona

# PRE-AGILE γ-RAY OBSERVATIONS

**COMPTEL (2-10 MeV): hard/soft state**

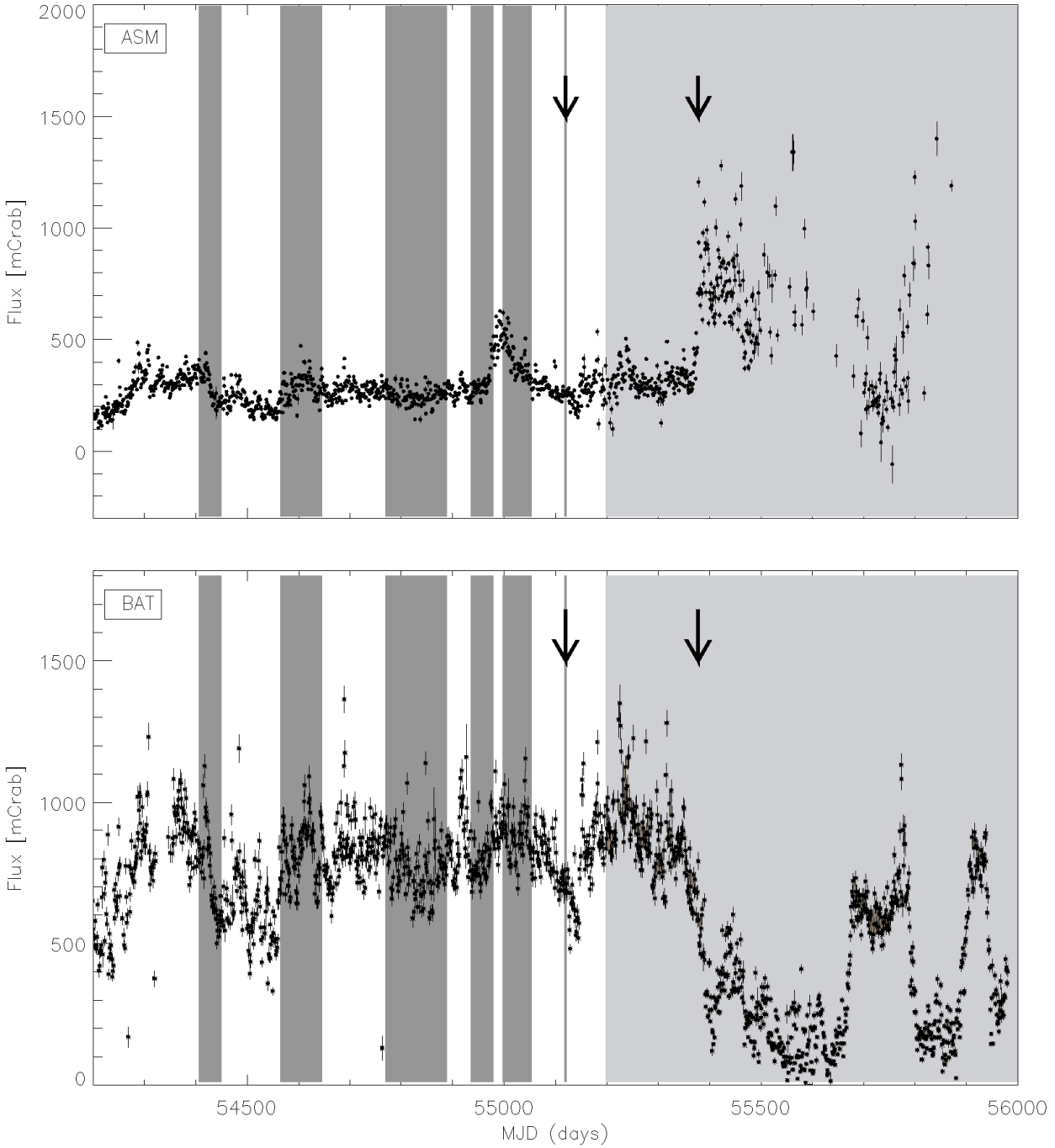
**EGRET (> 100 MeV ): upper limit hard state**



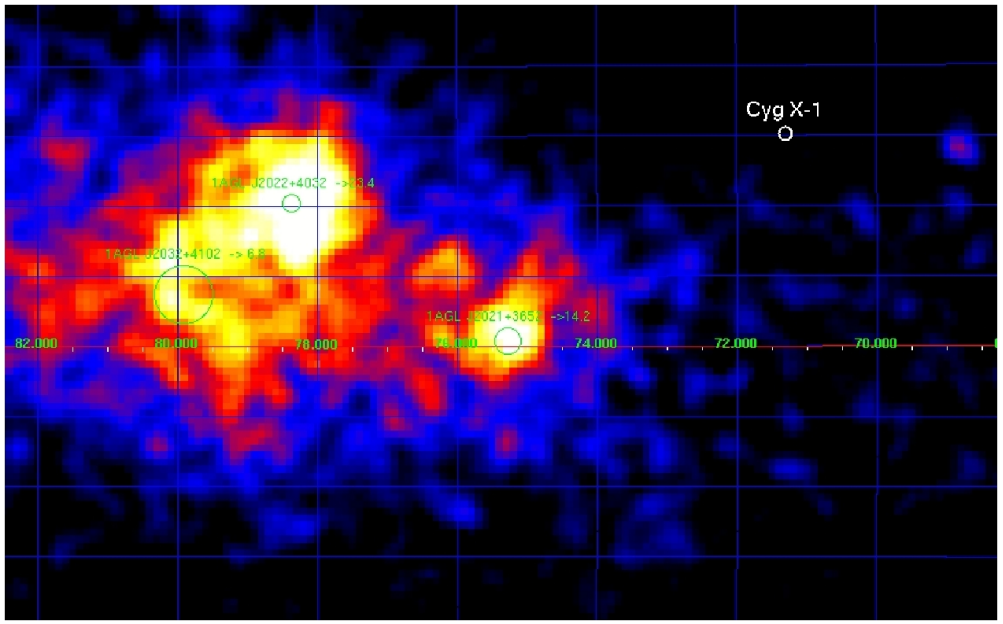

**After EGRET, AGILE was the first satellite sensitive to γ-rays (E > 100MeV)**

# SEARCH FOR PERSISTENT EMISSION from Cyg X-1 in GAMMA-RAYS

# CYG X-1 AGILE GAMMA-RAY MONITORING



# AGILE DEEP INTEGRATIONS




Sabatini et al 2010

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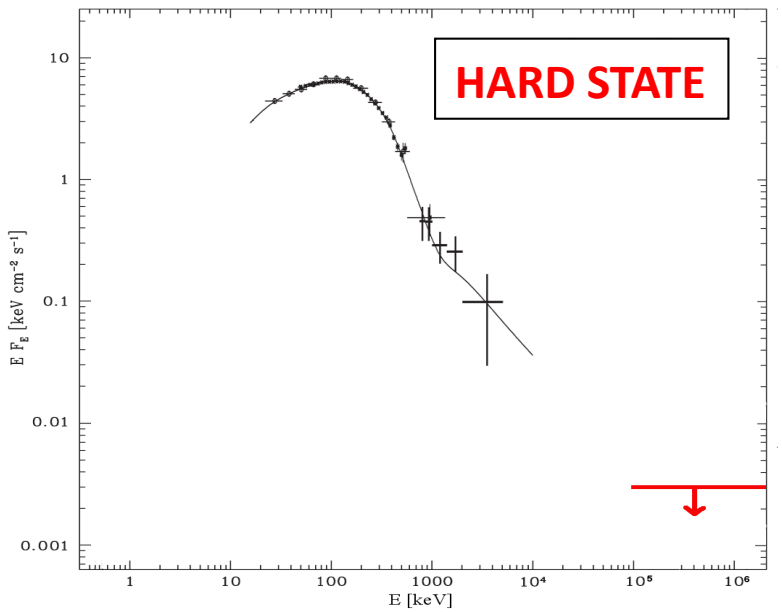


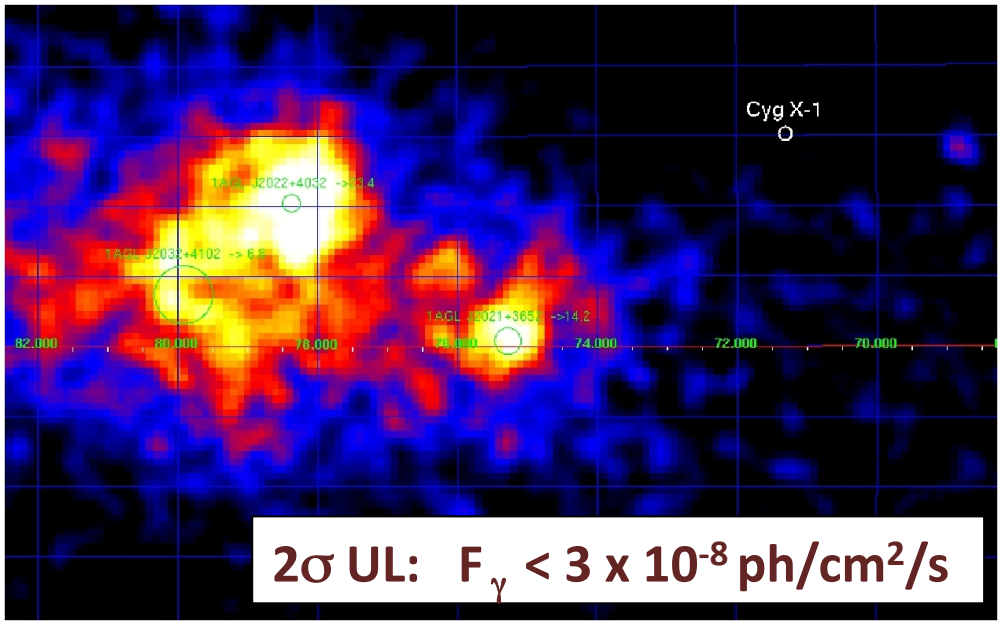


Sabatini et al 2010

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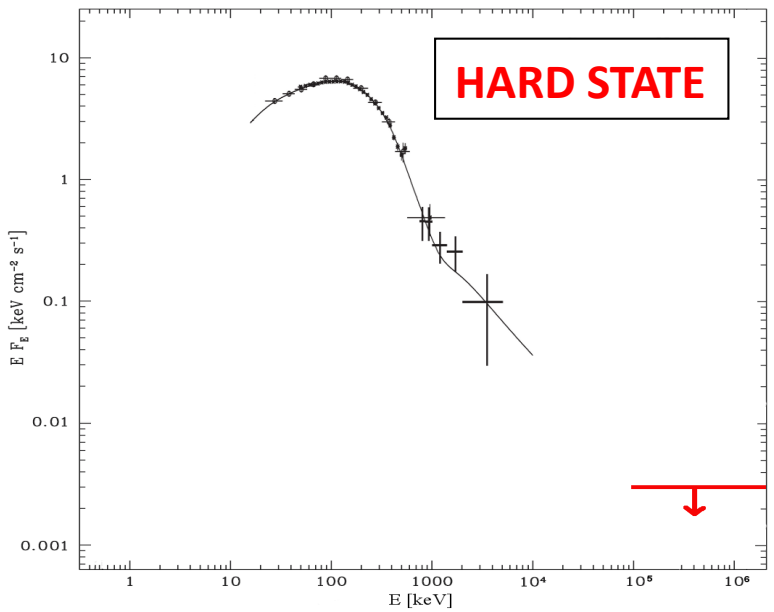
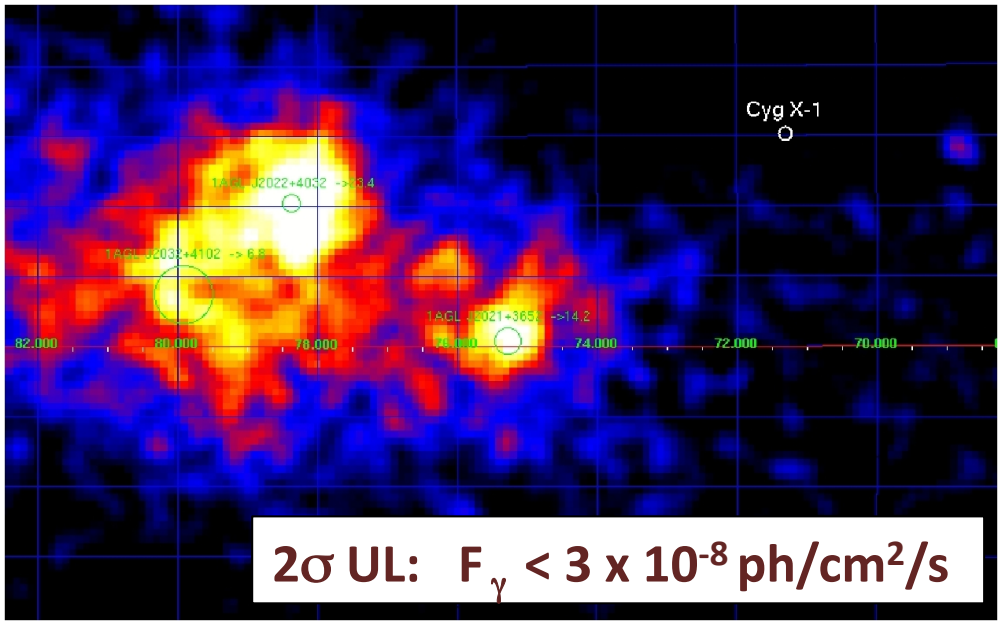
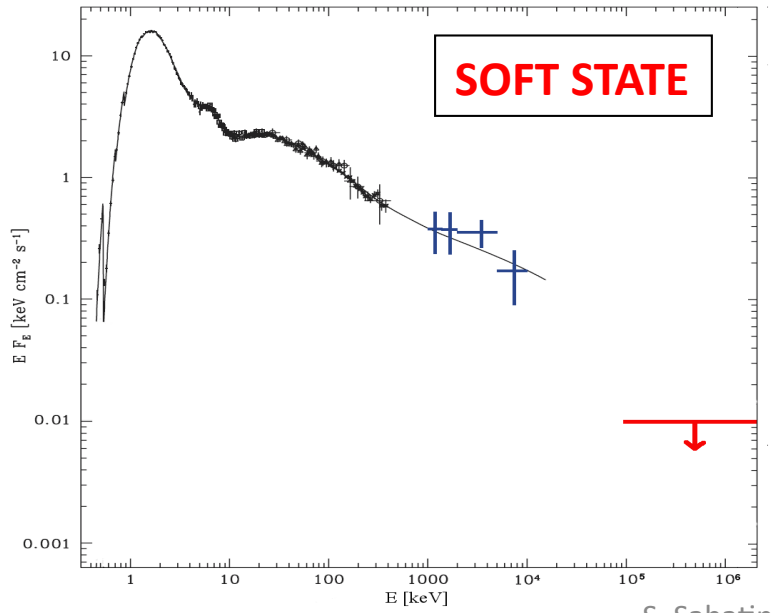
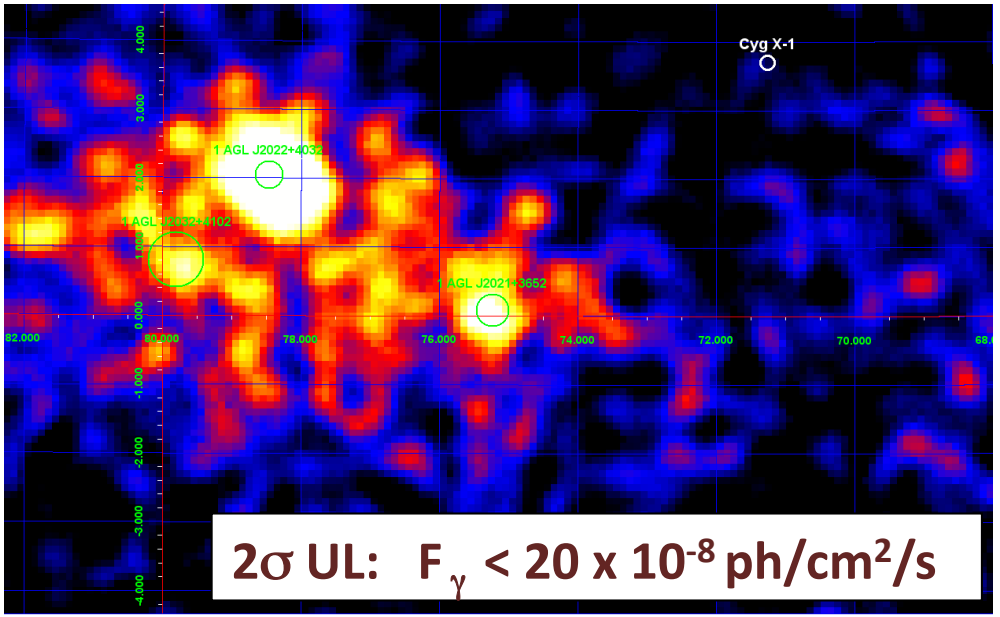


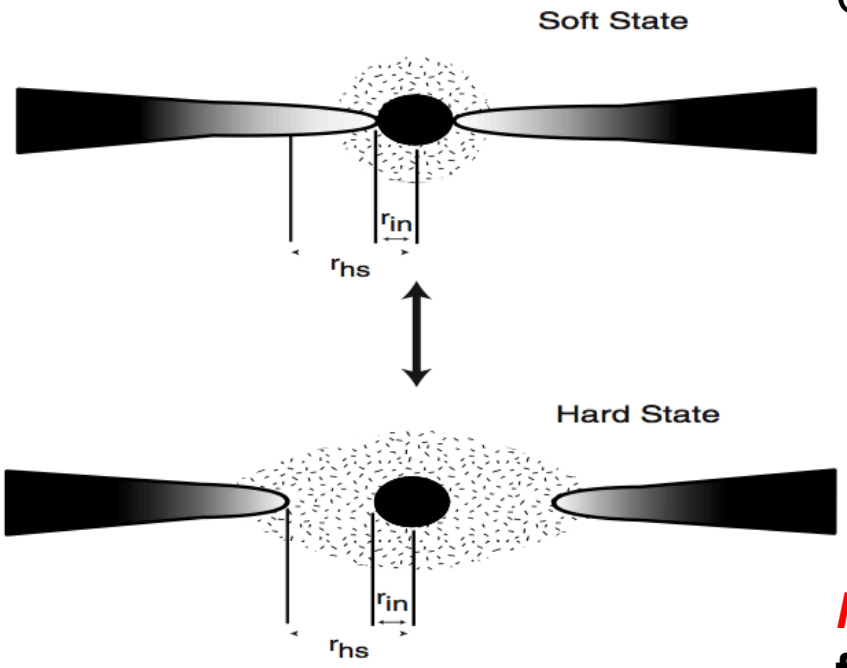






Sabatini et al, in prep

# Comptonization Models




Compactness Parameter:

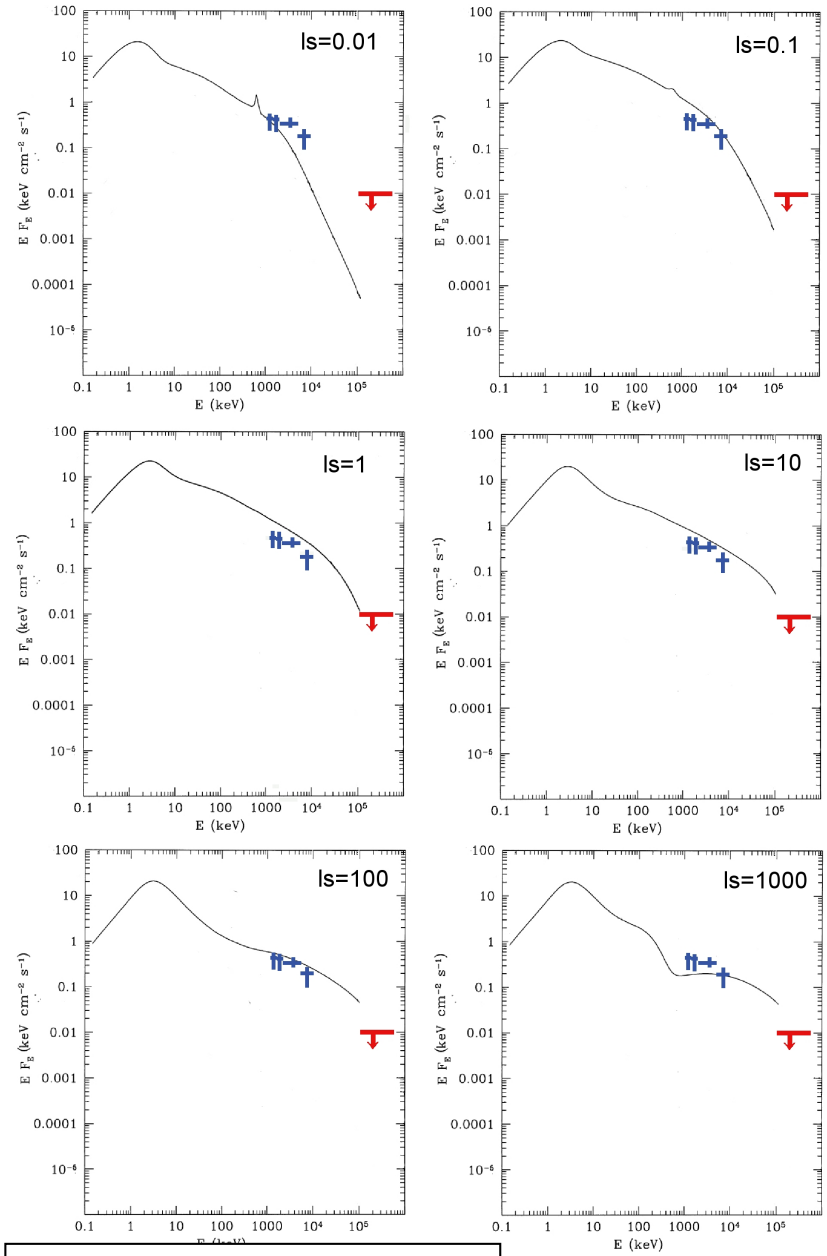
$$l = L\sigma_T / R m_e c^3$$

***ls*** **soft photons from the disk**

***lh*** **hard tail components (thermal+non thermal)**

Coppi 1999

# Model predictions for Cyg X-1




Gierlinski et al 2002:

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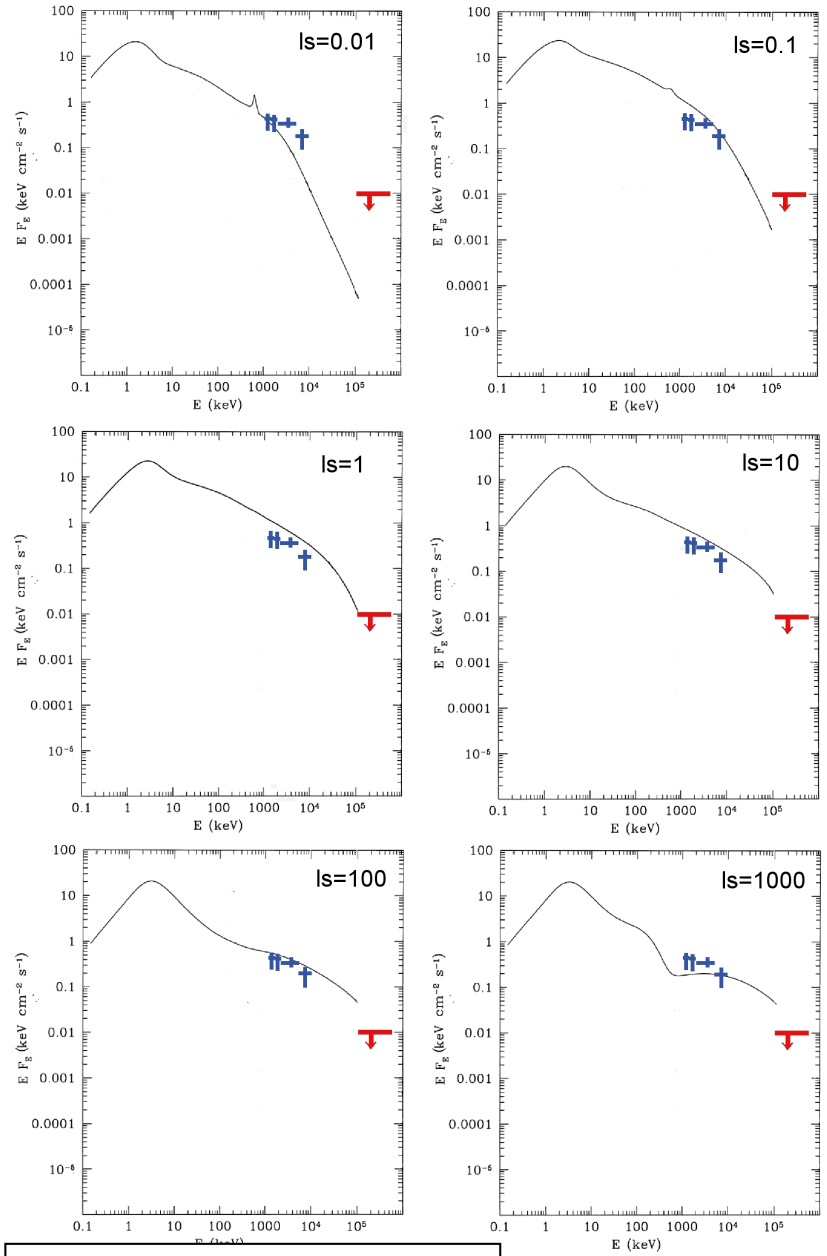


Gierlinski et al 2002:

Compactness Parameters:

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AGILE data seem to favour
The following range:

$$l_s \leq 1$$

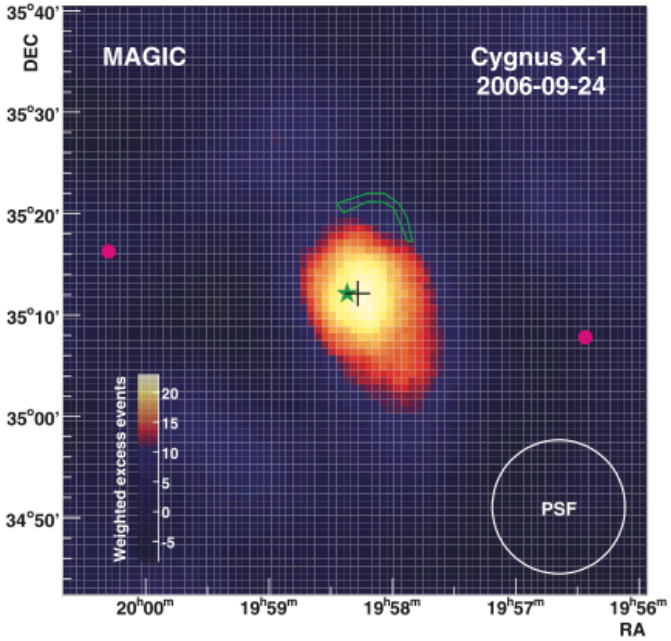
which for lh/ls = 0.36 gives

$$l_h \leq 0.3$$

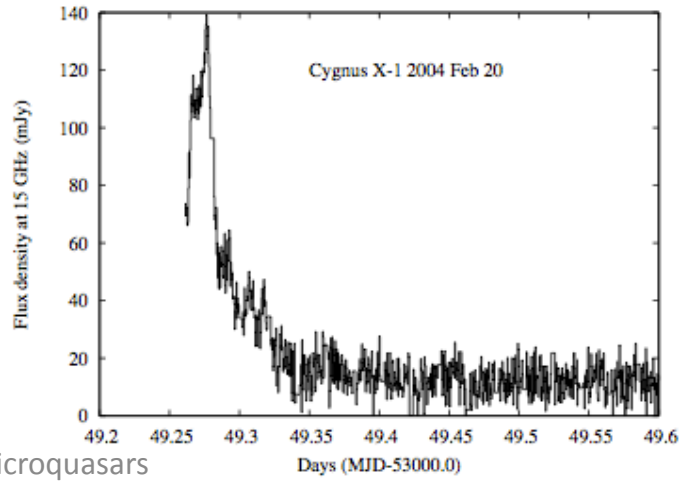
# Cyg X- 1 TRANSIENT ACTIVITY in GAMMA-RAYS

# FAST FLARING ACTIVITY

- **VHE (>100GeV) flare lasting ~1hr (MAGIC; Albert 2007)**
  - **An intense peak in hard X-rays followed it (INTEGRAL; Malzac 2008)**




- **Transient relativistic RADIO jet ~20min (MERLIN; Fender 2006)**



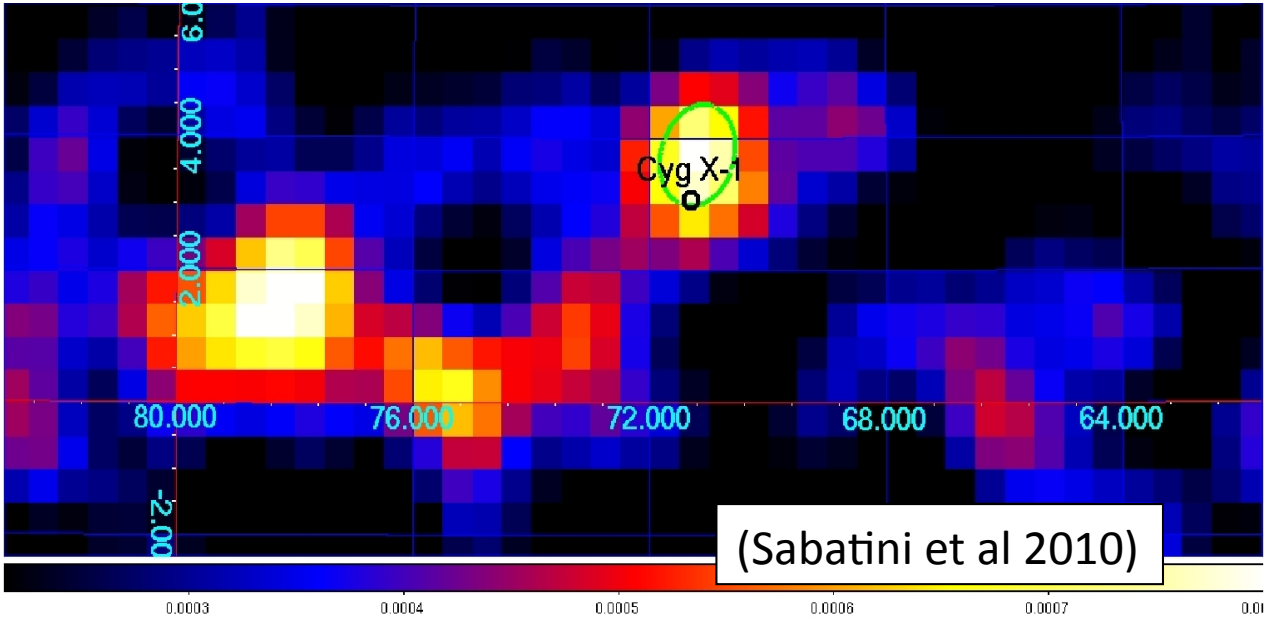
# GAMMA-RAY FLARING EPISODES

**HARD STATE**

**1-day duration (or less)**

**SIGNIFICANCE: 5.3σ**

**$F_\gamma = 232 \pm 66 \times 10^{-8}$ ph/cm²/s**



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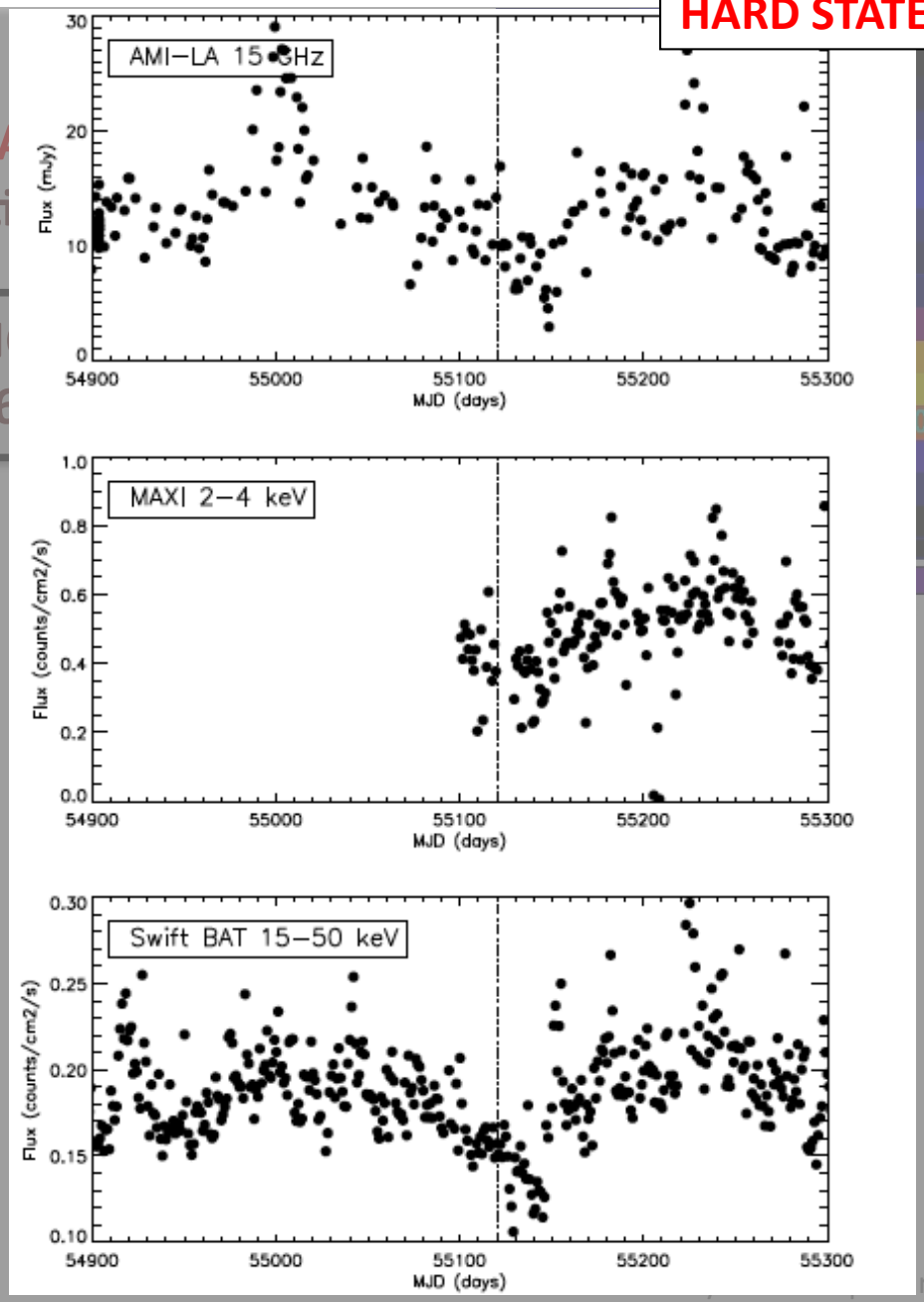


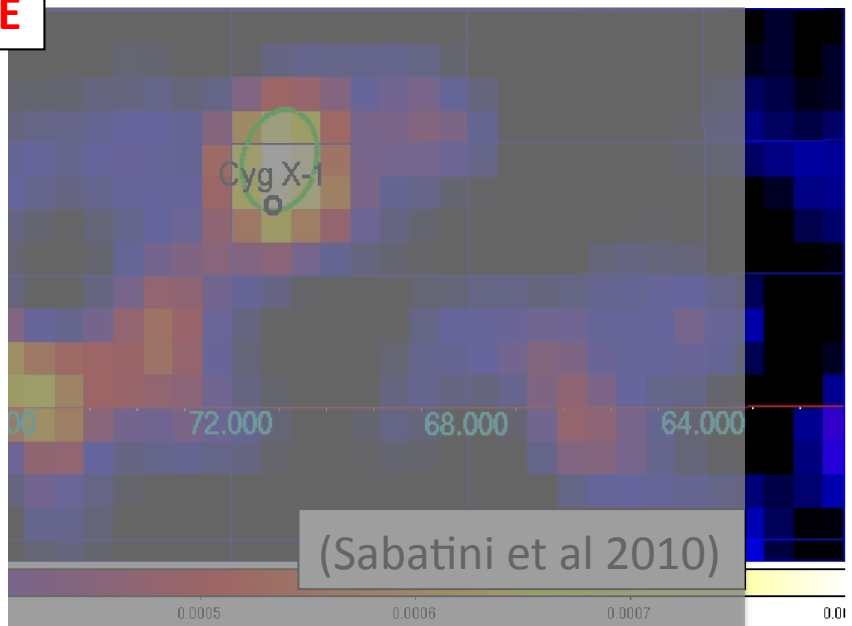


(Sabatini et al 2010)

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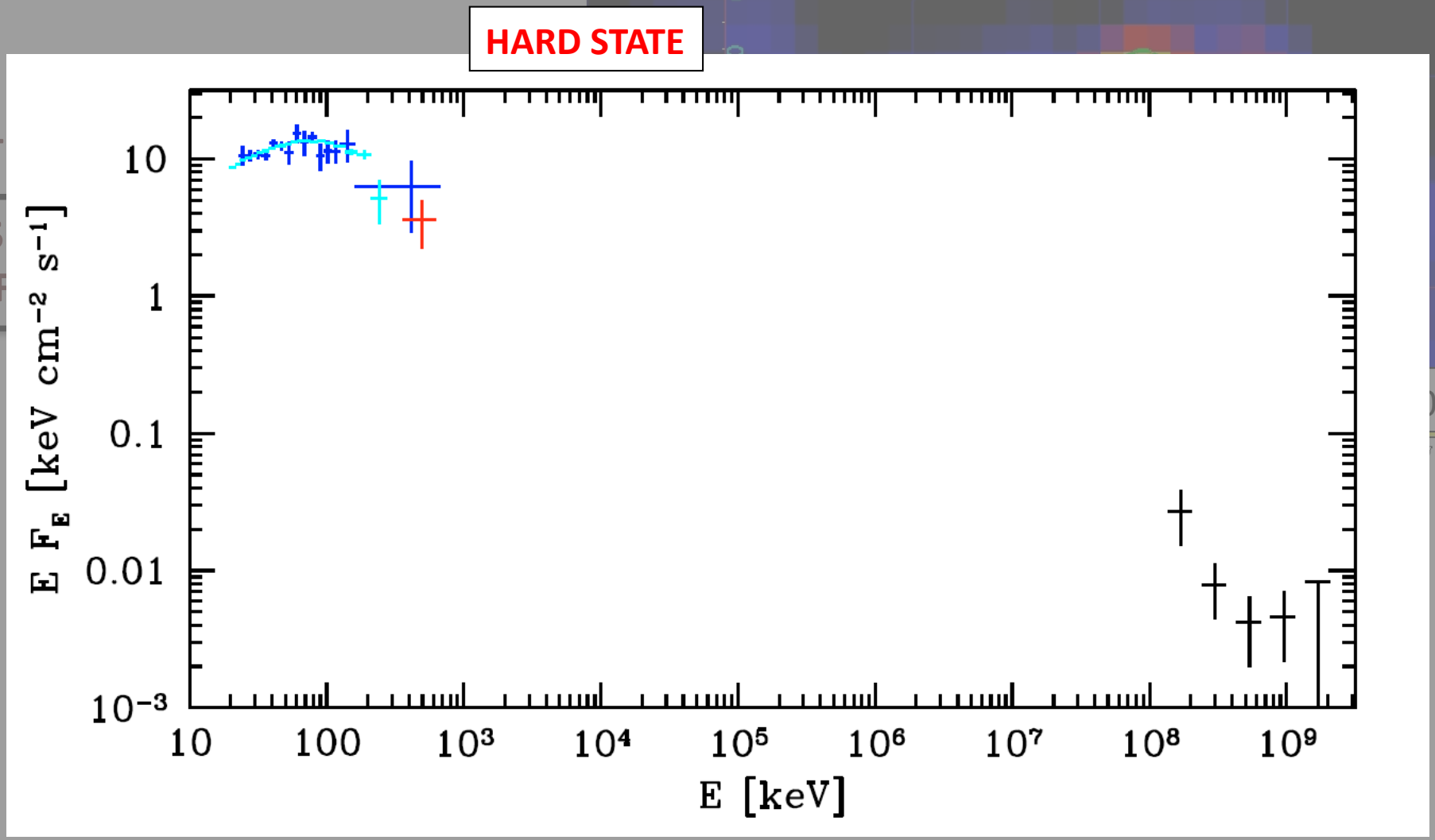

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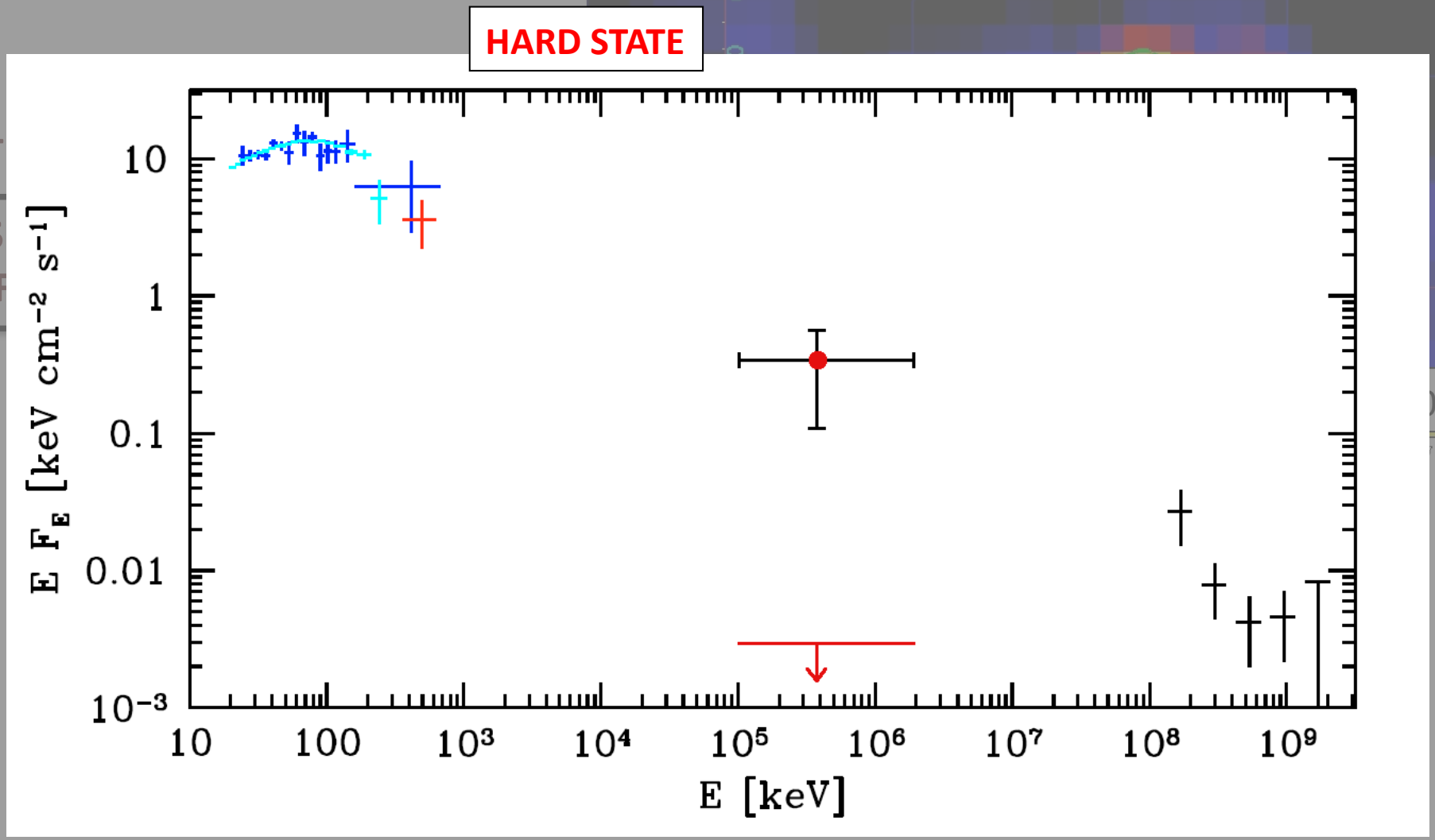

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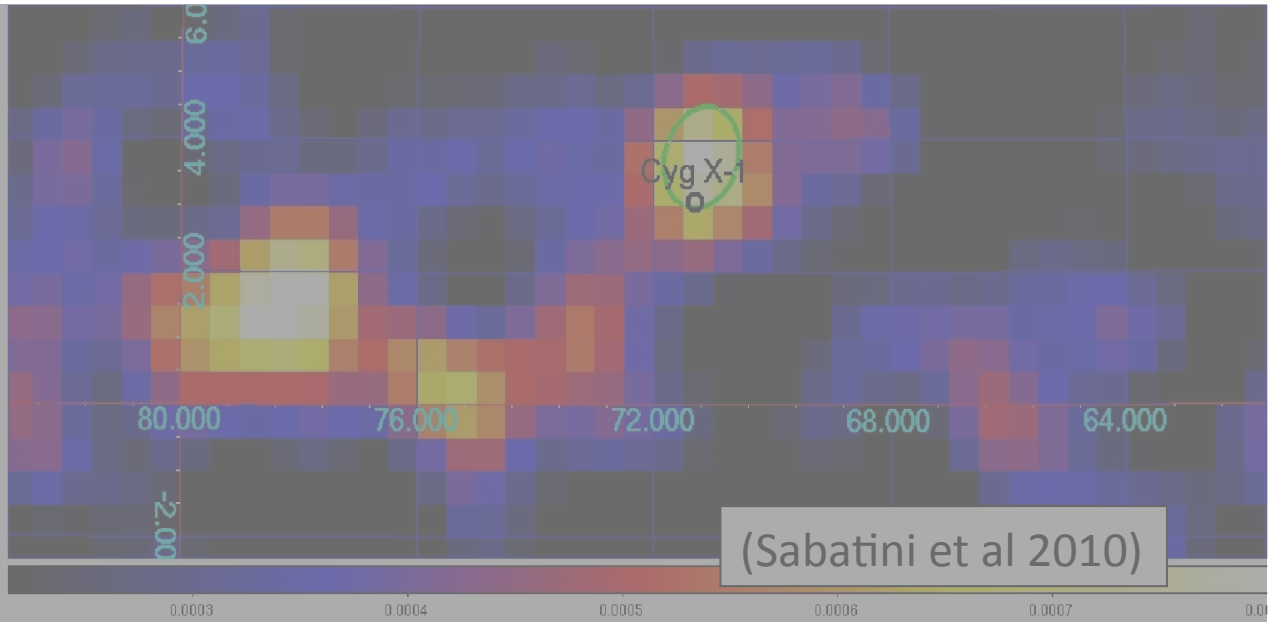
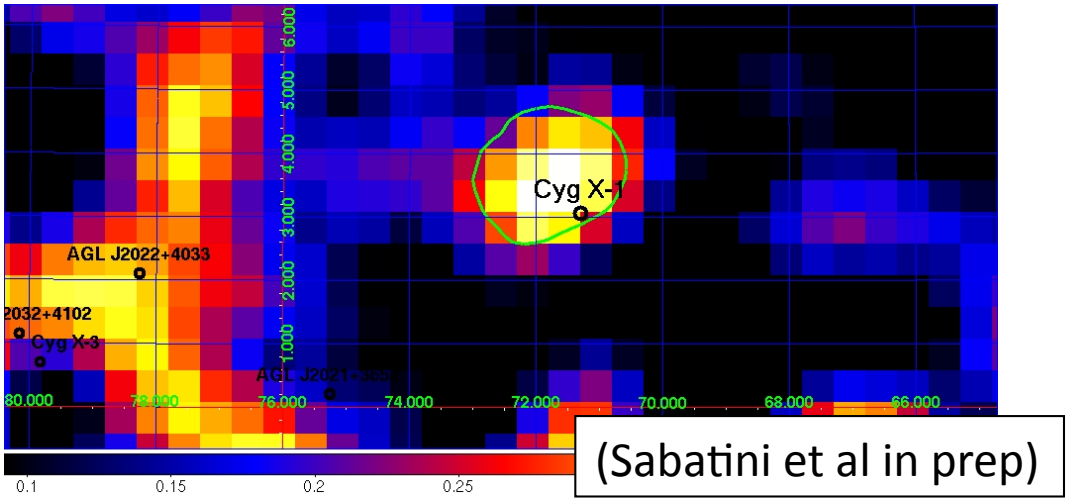



**INTERMEDIATE STATE**

**3-days duration (or less)**

**SIGNIFICANCE: 3σ**

$F_\gamma = 145 \pm 78 \times 10^{-8}$ ph/cm²/s



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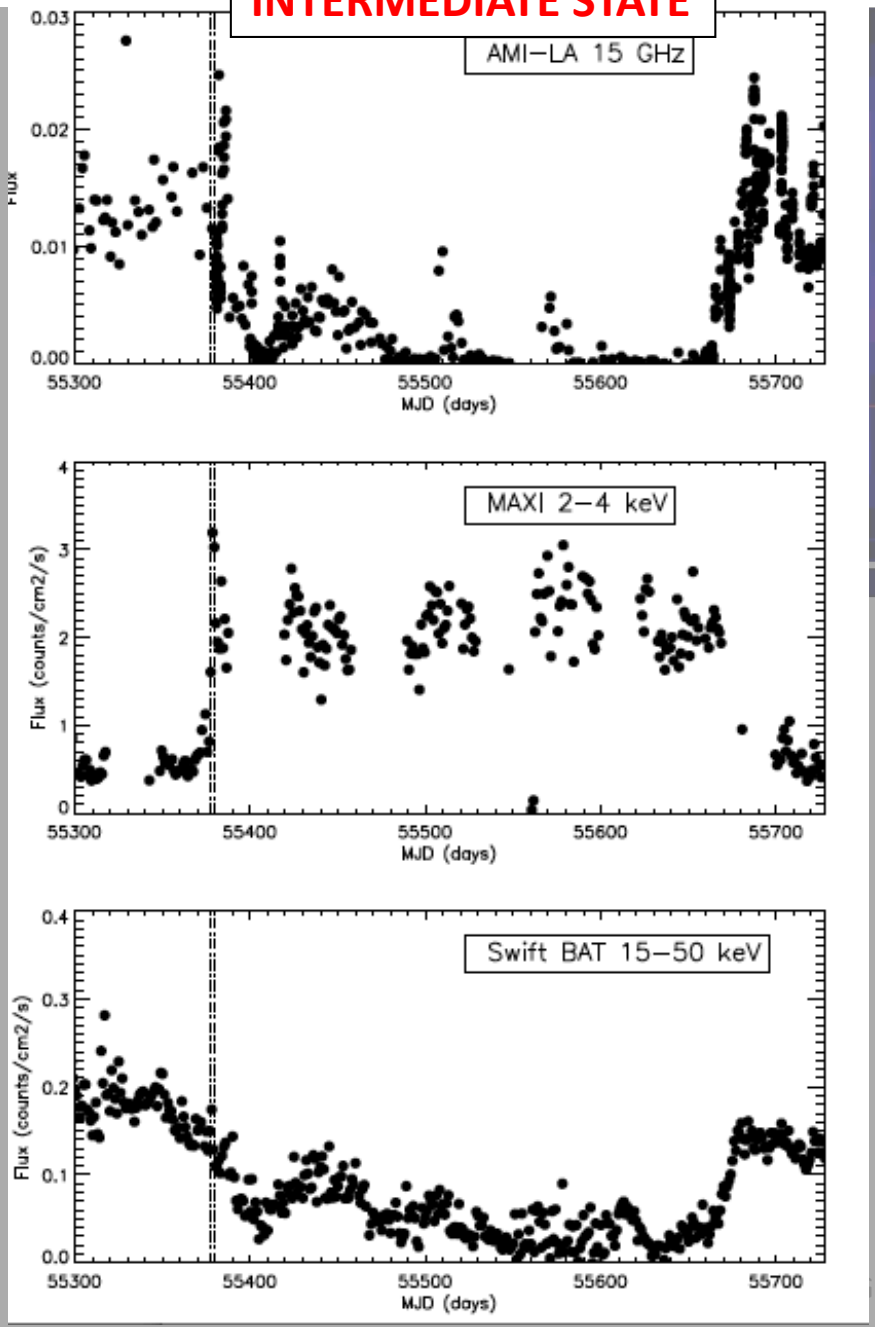
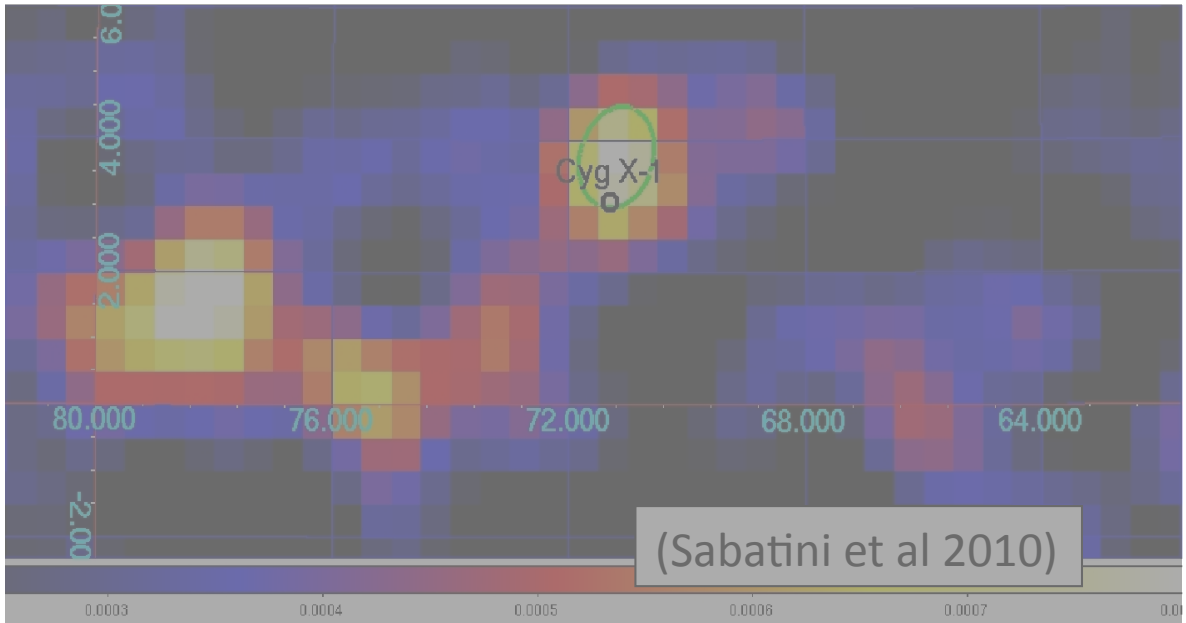
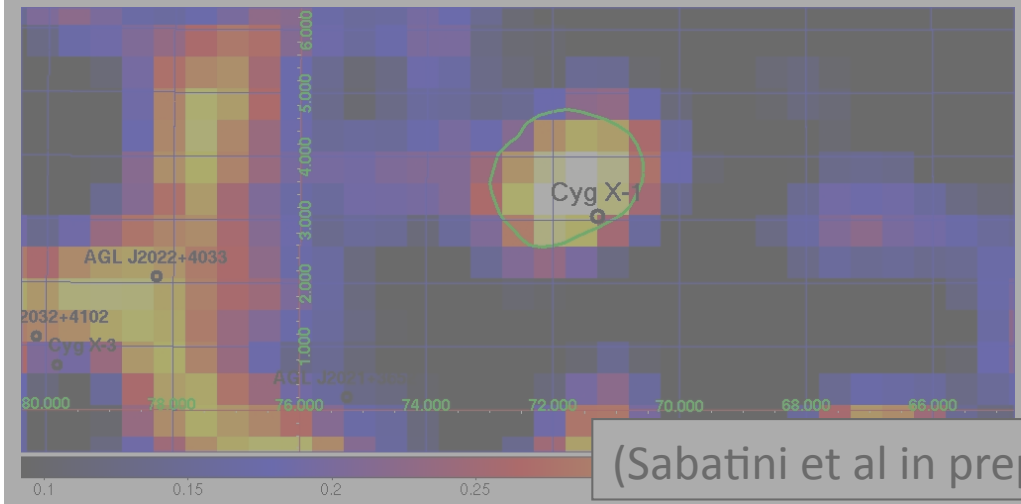



(Sabatini et al 2010)




(Sabatini et al in prep)

ILE Survey of Microquasars

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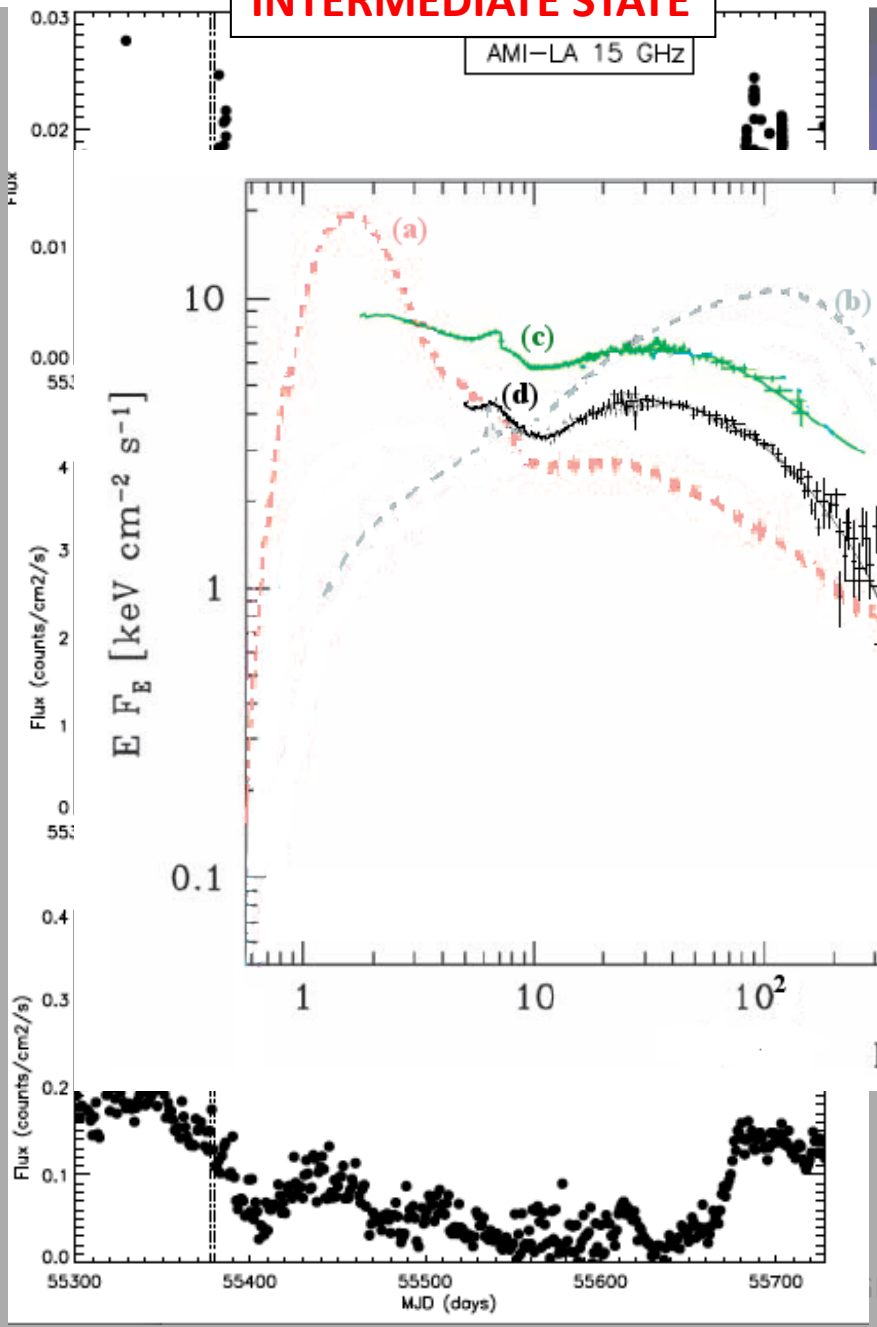








al 2010)

(Sabatini et al in prep)

ILE Survey of Microquasars

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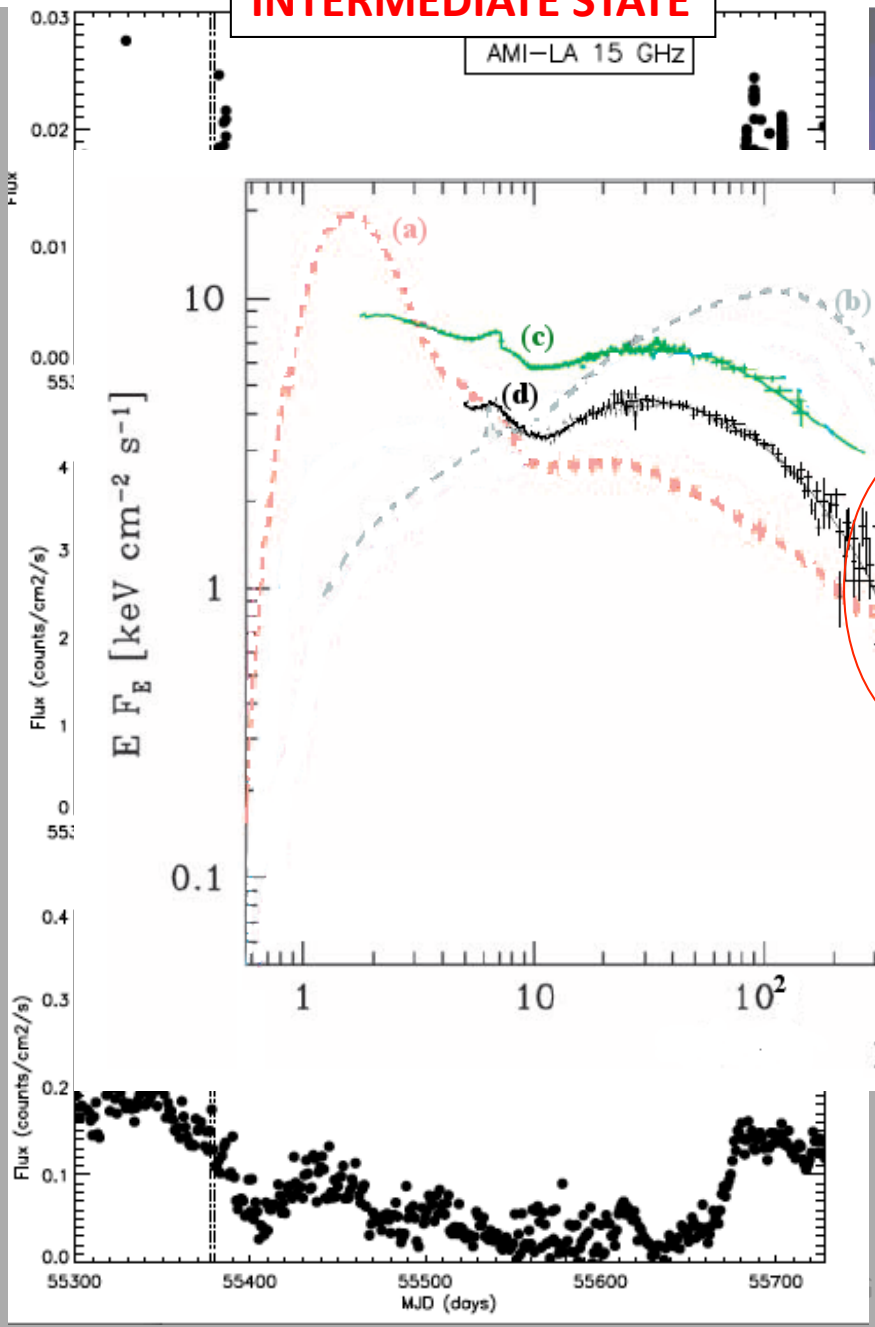








al 2010)

(Sabatini et al in prep)

ILE Survey of Microquasars

# CONCLUSIONS

- **Gamma-ray emission is rare or undetectable in microquasars**

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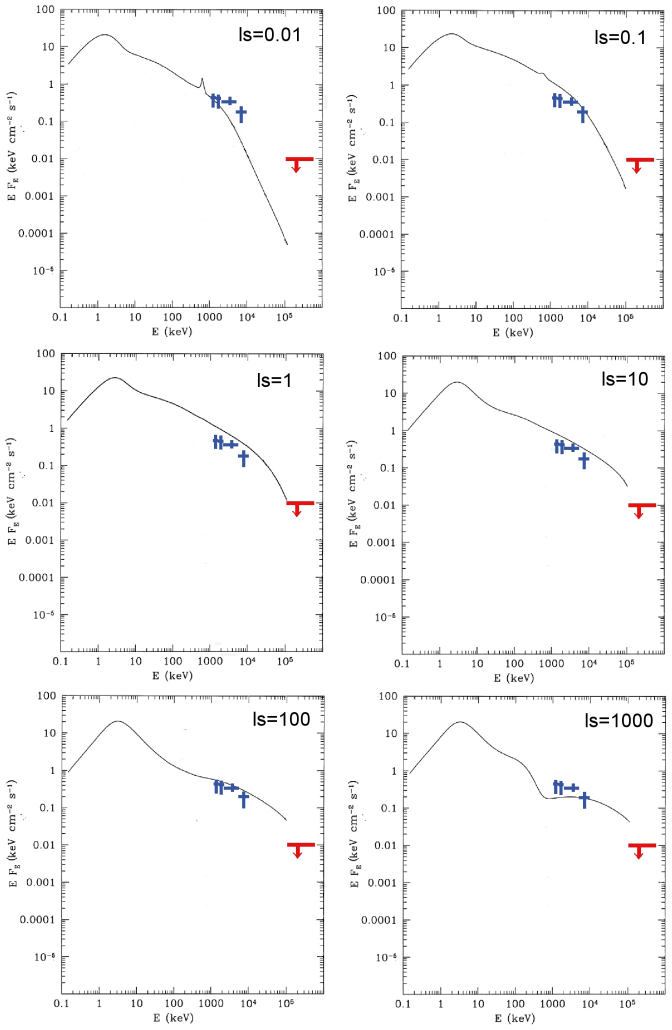
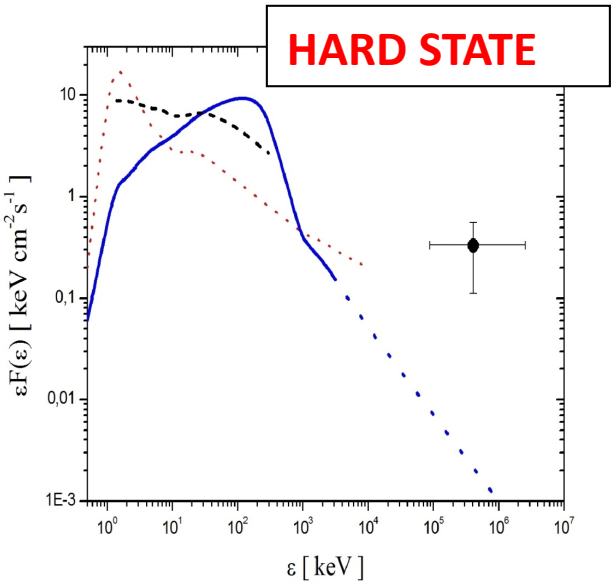
# CONCLUSIONS

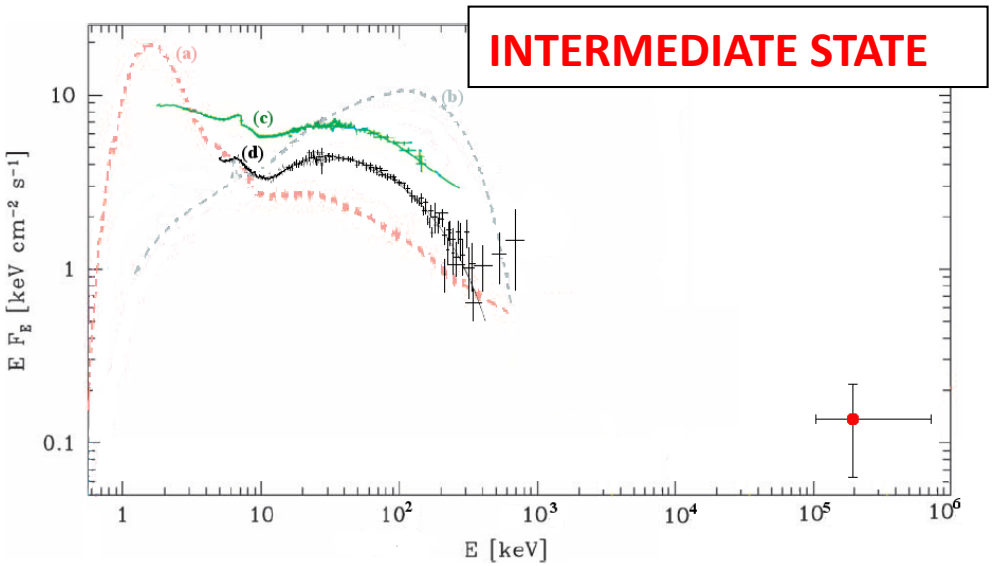
- Gamma-ray emission is rare or undetectable in microquasars
- **Cyg X-1 UL puts important constraints to Comptonization models (confirmed at large)**



# CONCLUSIONS

- Gamma-ray emission is rare or undetectable in microquasars
- Cyg X-1 UL puts important constraints to Comptonization models (confirmed at large)
- **However, possible violations of model predictions arise during gamma-ray flares**



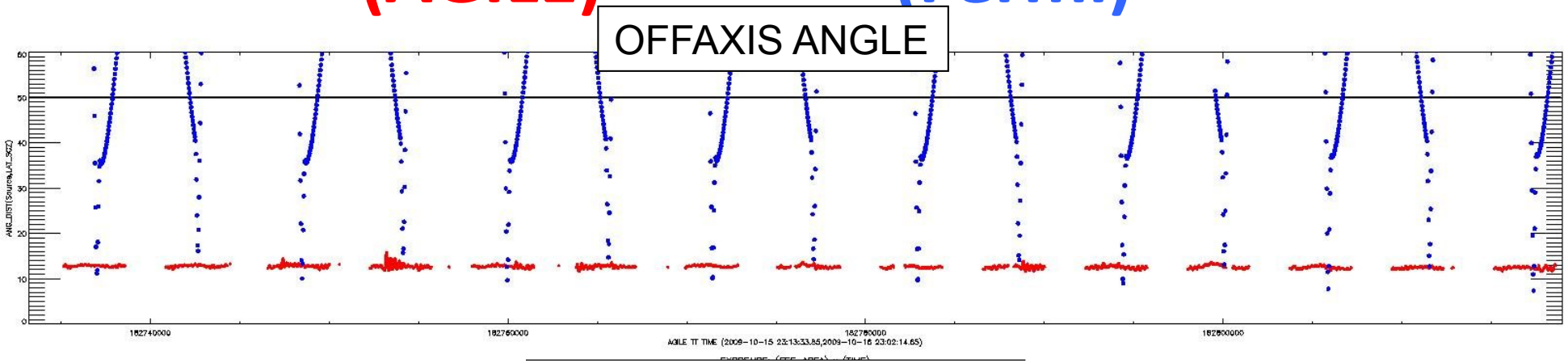
# CONCLUSIONS #2

- AGILE DATA in POINTING are ideal to study transient events: we have a list of unidentified flaring sources

- They could be  related to new gamma-ray binaries (see e.g. 1FGL 1018.6-5856) or other less understood sources (see e.g. SFXT).

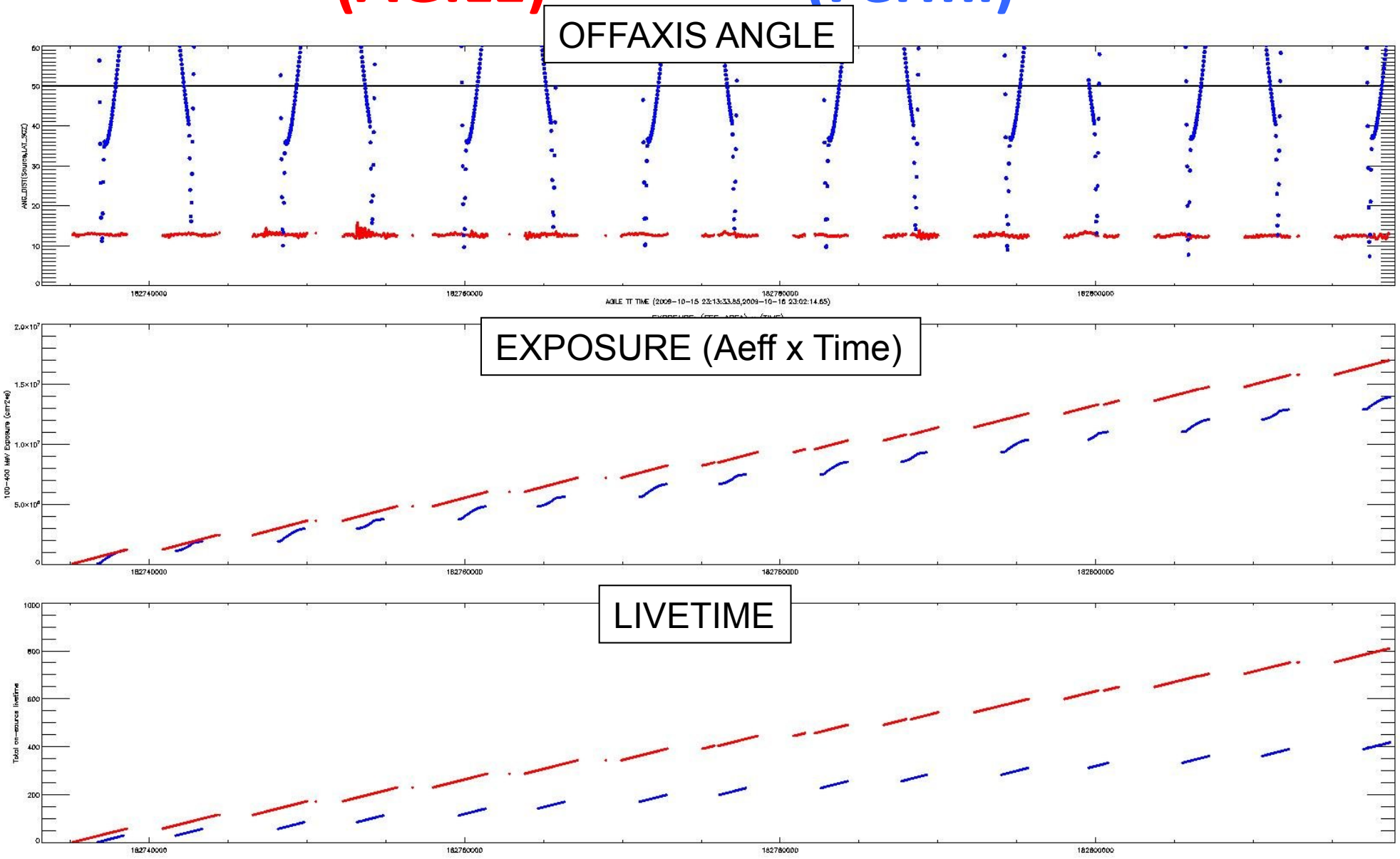
# POINTING vs SCANNING

## (AGILE) (Fermi)



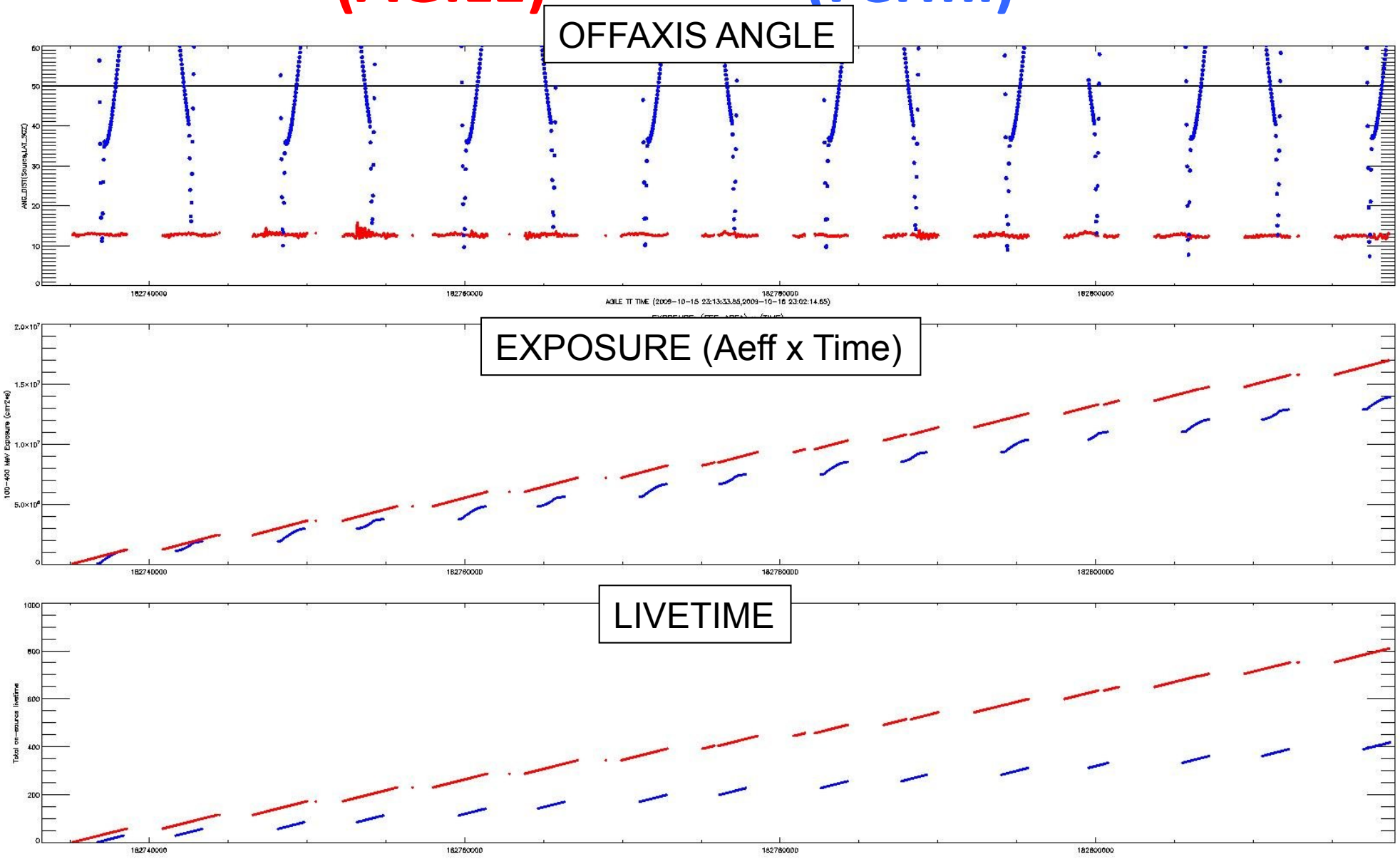
# POINTING vs SCANNING

## (AGILE) (Fermi)



# POINTING vs SCANNING

## (AGILE) (Fermi)



# POINTING vs SCANNING

## (AGILE) (Fermi)