# Gamma-ray Observations of the Microquasars Cygnus X-1, Cygnus X-3, GRS 1915+105, and GX 339–4 with Fermi-LAT


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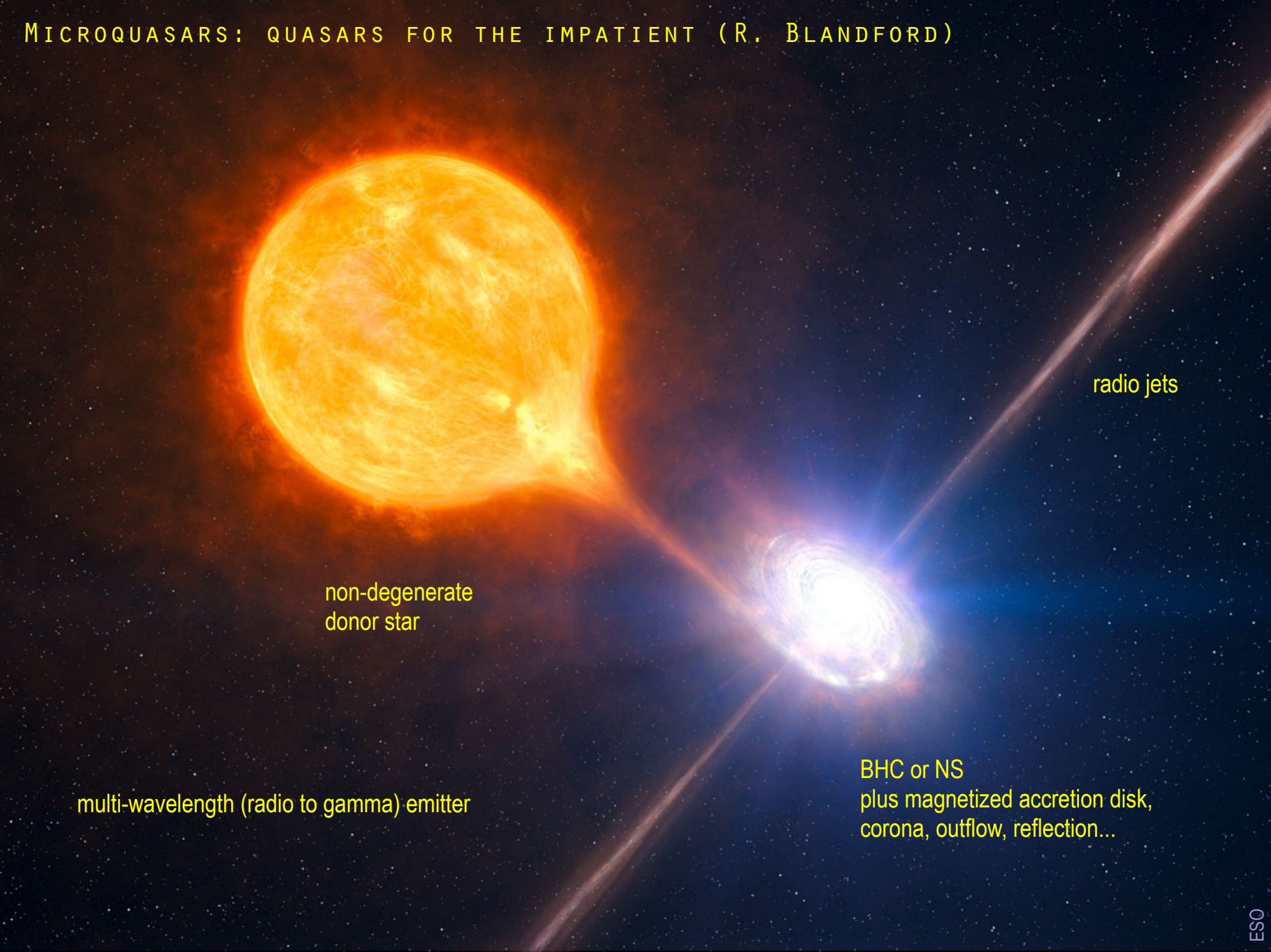
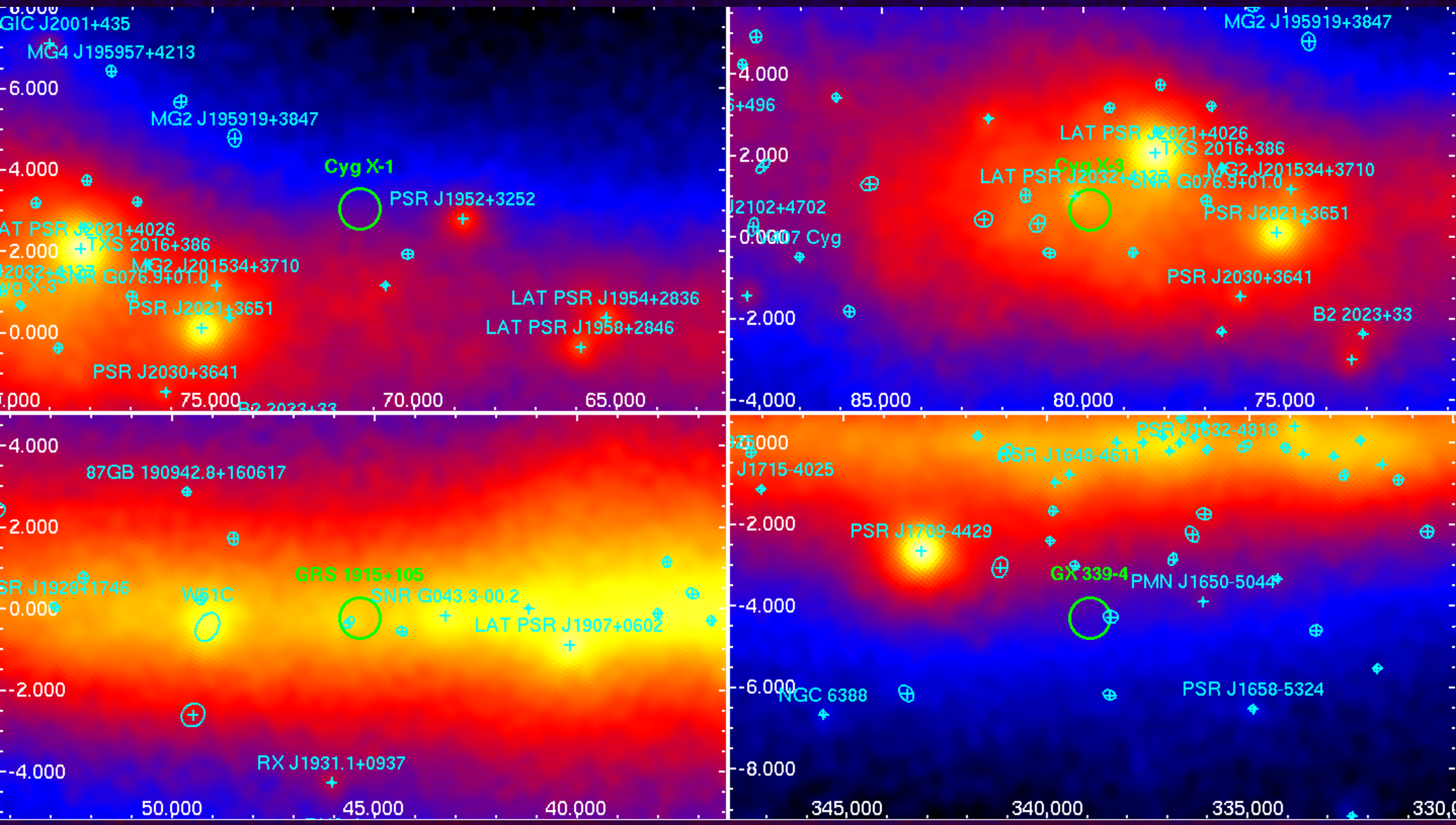
# Microquasars: quasars for the impatient (R. Blandford)



# Microquasars: quasars for the impatient (R. Blandford) and masochistic (A. Bodaghee)

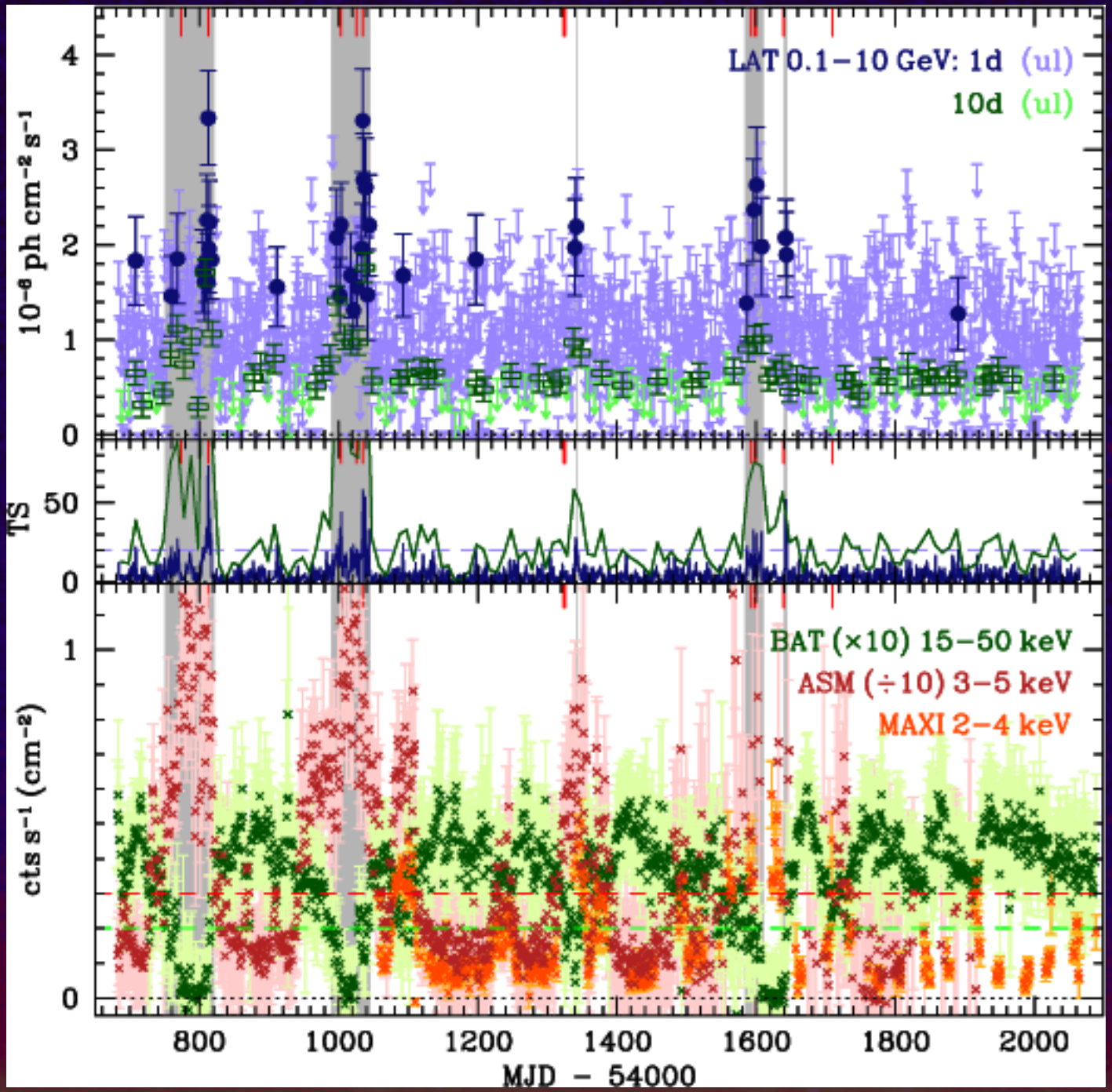



extremely low source counts
extremely high diffuse background
emission < 10 GeV where Fermi PSF ~ 2 degs ⇒ source confusion

# Cyg X-3: gamma-ray light curve

blue points: TS ≥ 20 in 1d bin
green points: TS ≥ 20 in 10d bin

gray bands: known LAT detections
red marks: known AGILE detections



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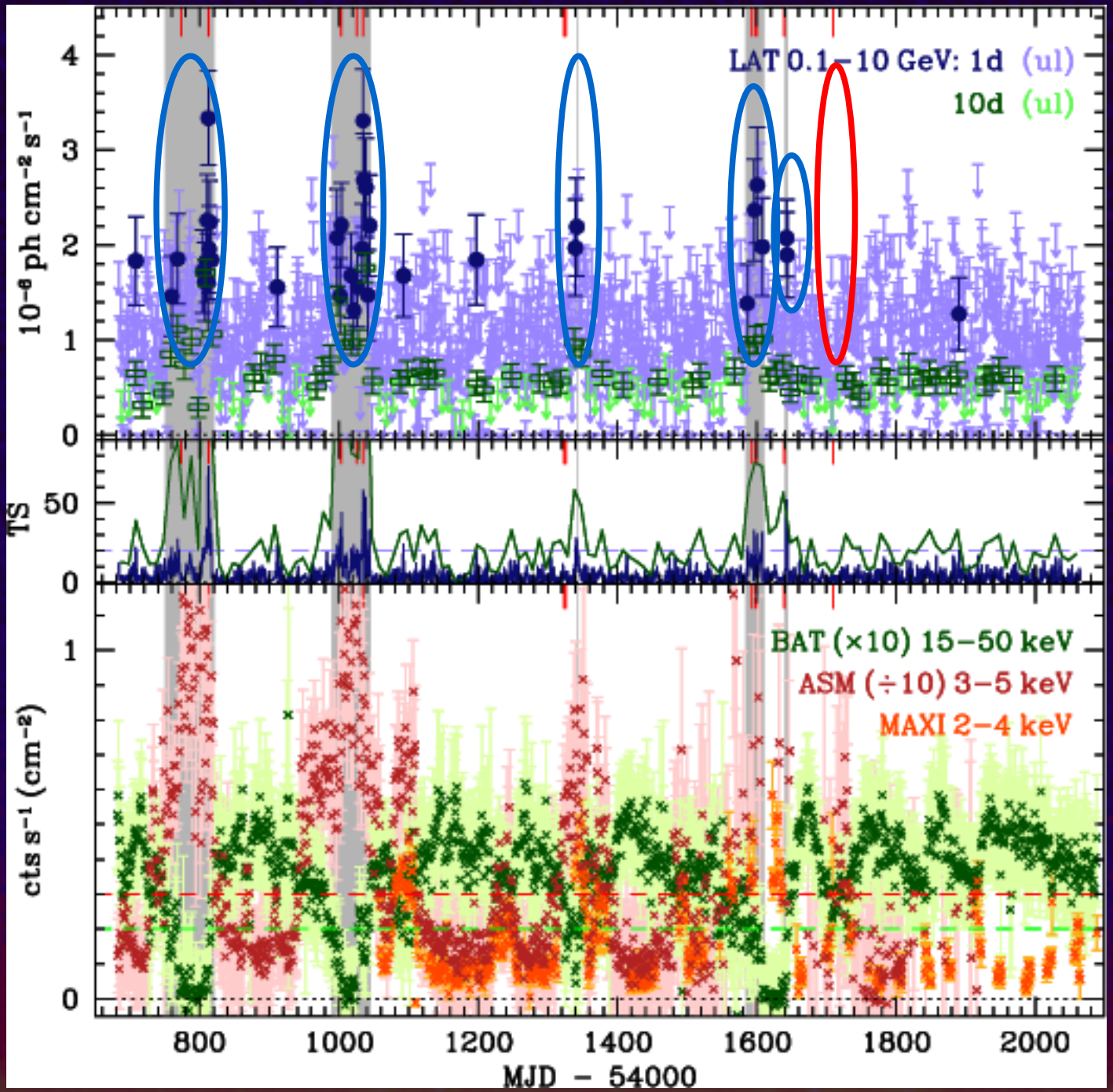
previous gamma-ray detections
by LAT or AGILE are reproduced
(except the last one)

c.f. Abdo et al. (2009)
Bulgarelli et al. (2010)
Bulgarelli et al. (2011a)
Bulgarelli et al. (2011b)
Corbel & Hays (2010)
Corbel et al. (2011)
Corbel et al. (2012)
Piano et al. (2012)
Tavani et al. (2009)
Williams et al. (2011)



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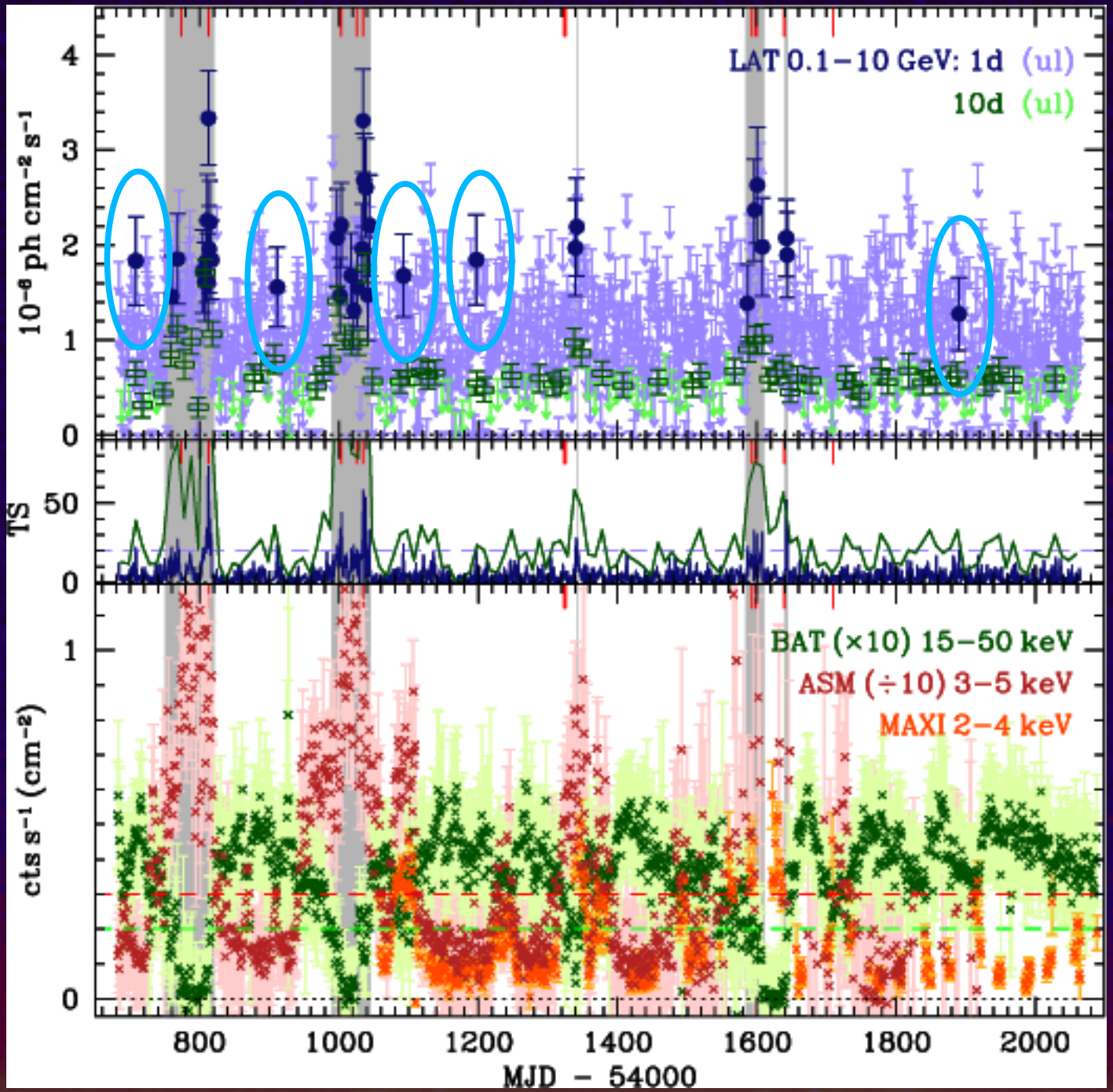
there are 5 new daily detections (TS ~ 20—25; backed up by 10d)



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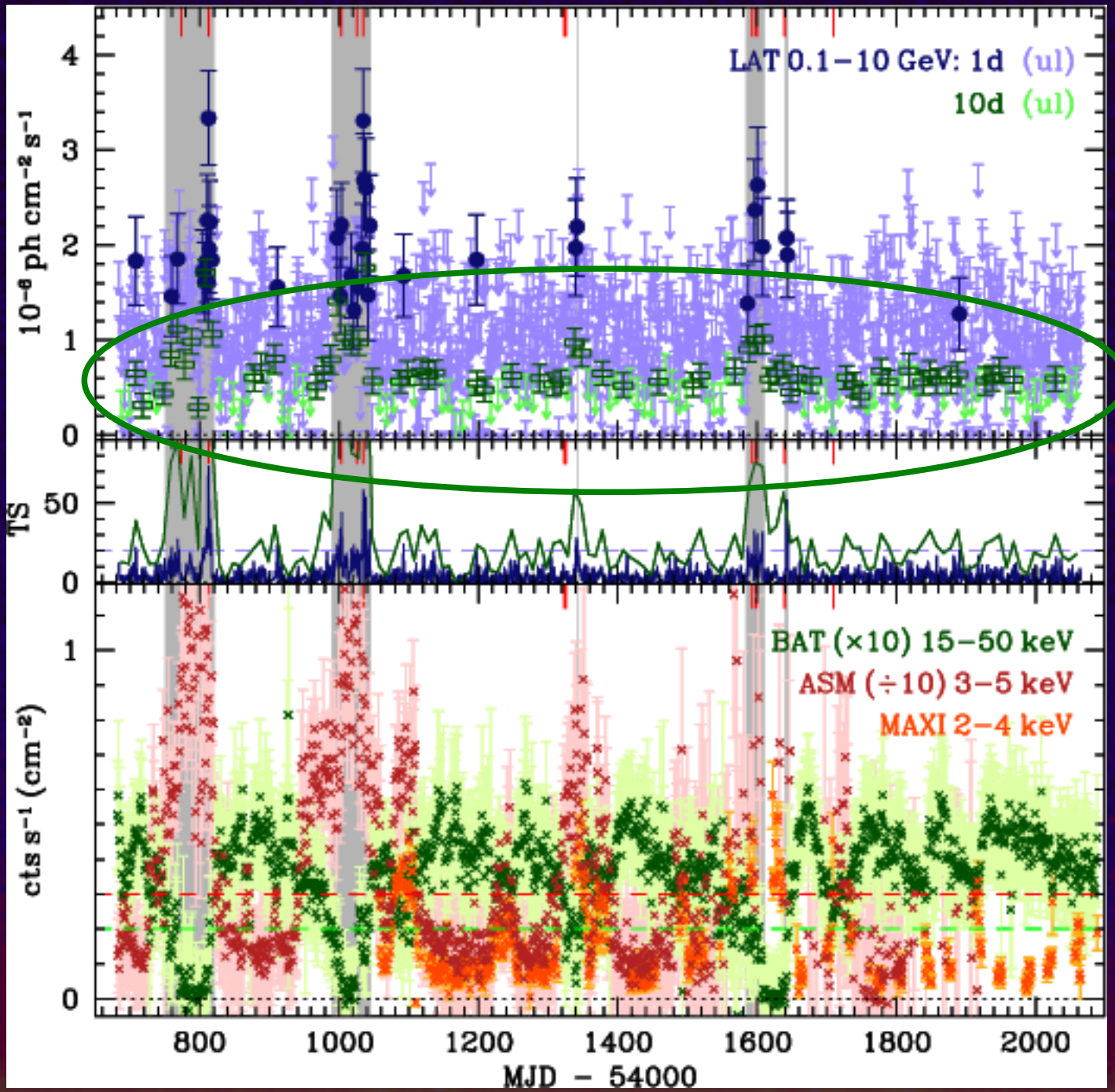
numerous 10d detections
in and out of flaring epochs:
persistent gamma-ray emission



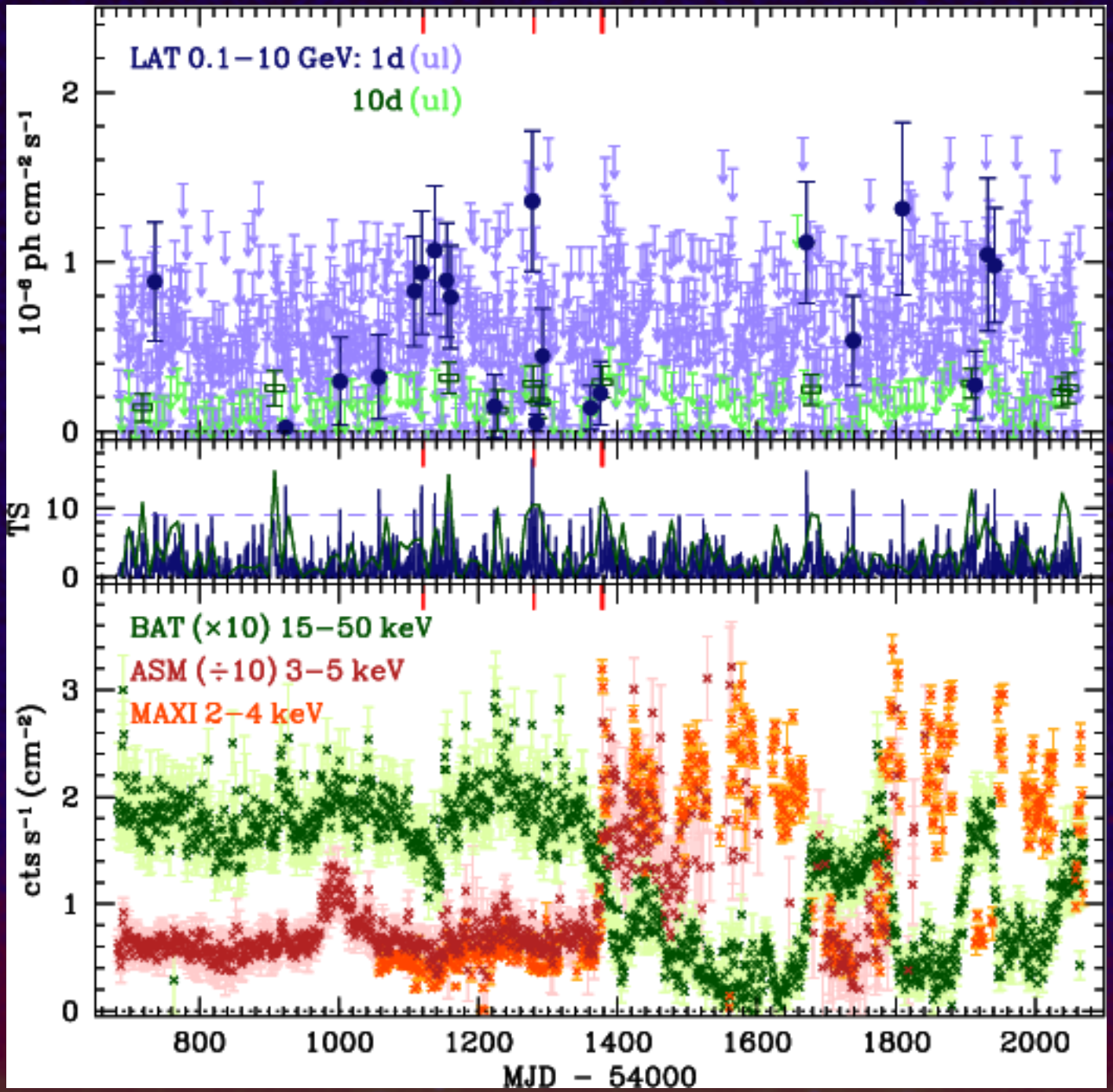
# Cyg X-1: gamma-ray light curve

blue points: TS ≥ 9 in 1d bin
green points: TS ≥ 9 in 10d bin

red marks: known AGILE detections

3 previous gamma-ray detections by AGILE are reproduced for the first time with LAT

c.f. Bulgarelli et al. (2010a)
Sabatini et al. (2010a)
Sabatini et al. (2010b)



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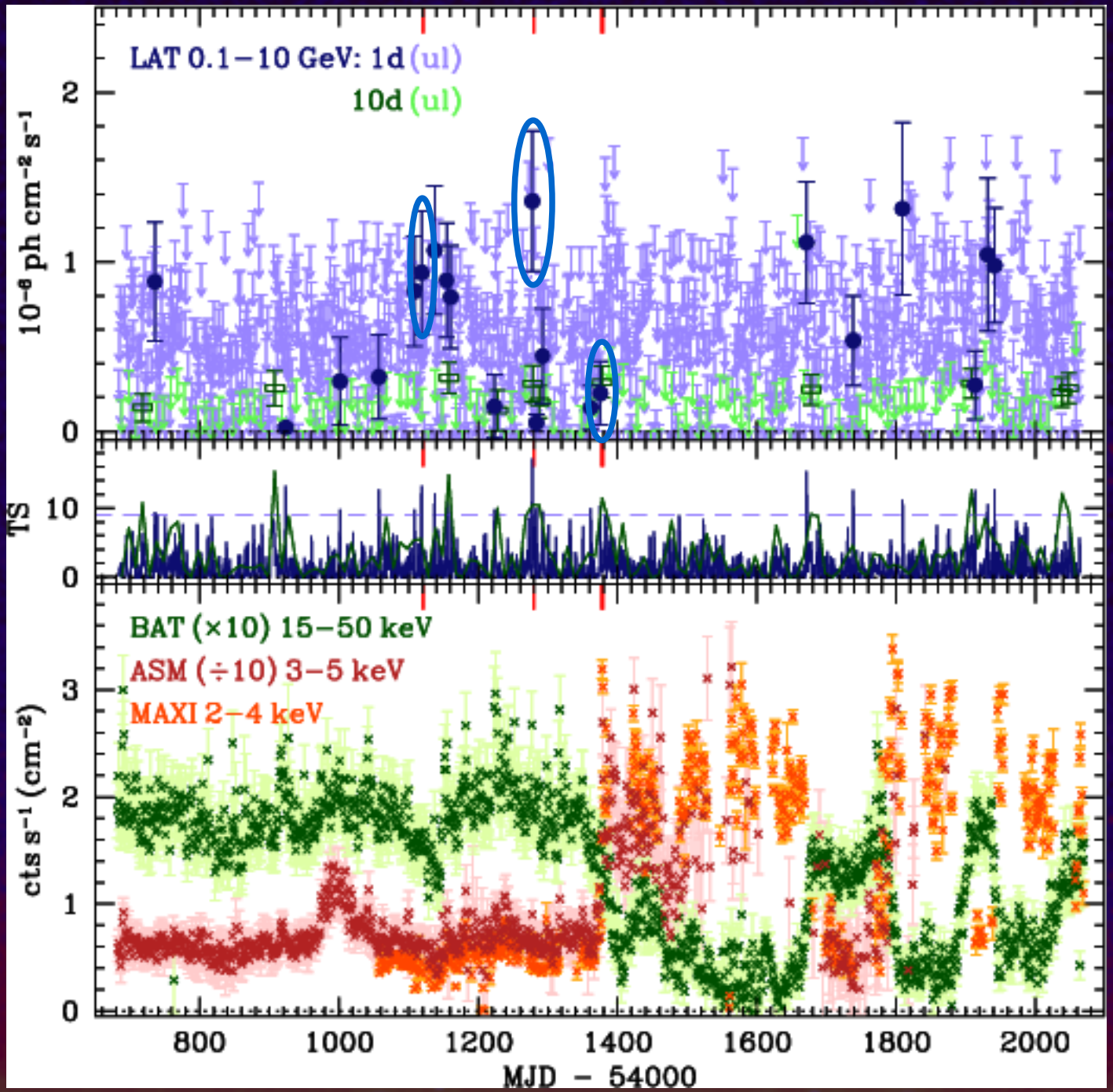

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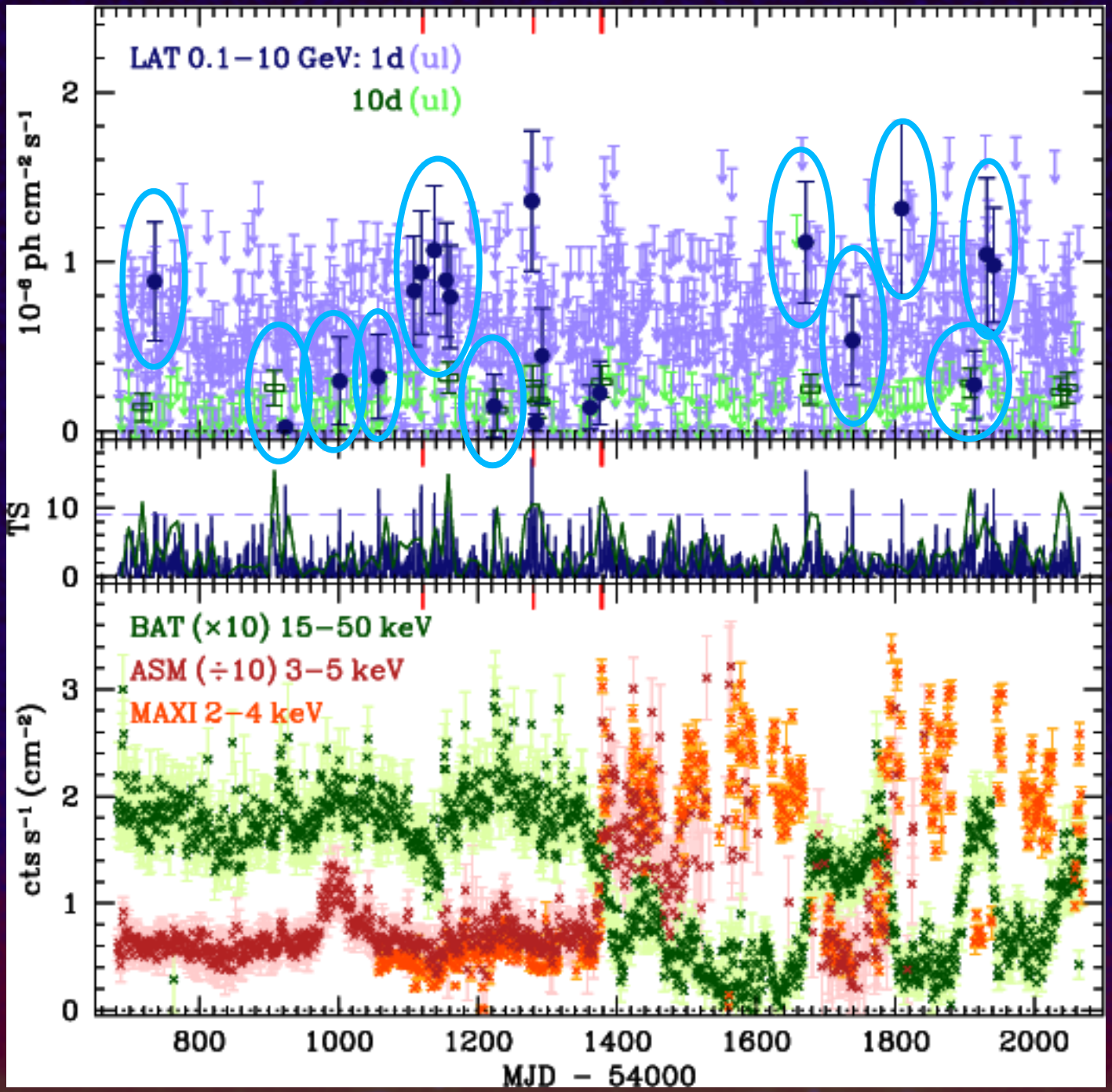
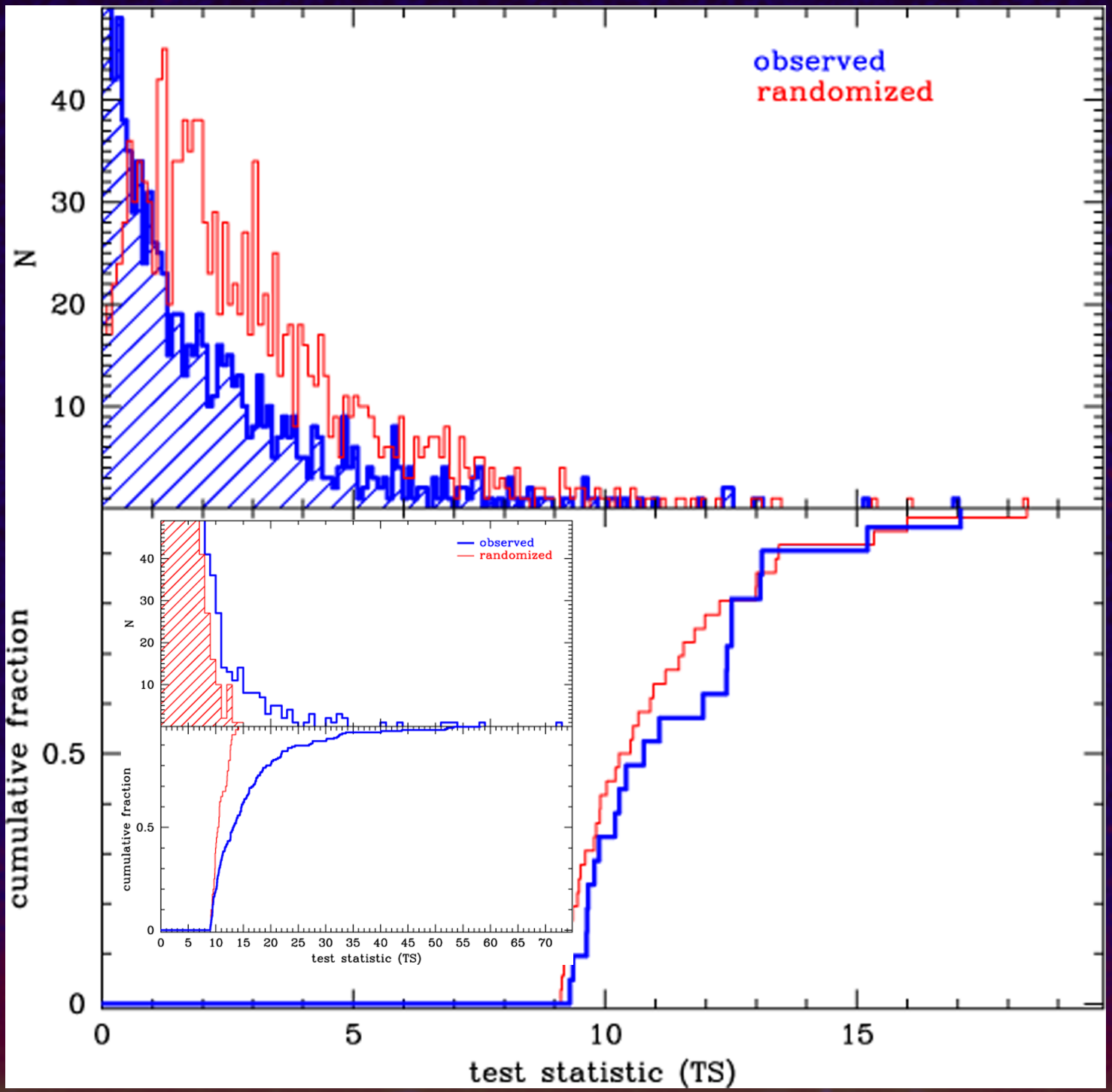
21 days with TS ~ 9—16
some are backed by 10d



# Cyg X-1: gamma-ray light curve

comparison with TS distribution of spurious source yields 55% KS-test prob. of match

candidate LAT detections not contemporaneous with AGILE are probably spurious



GRS 1915+105

GX 339–4

no prior gamma-ray detections by AGILE or LAT

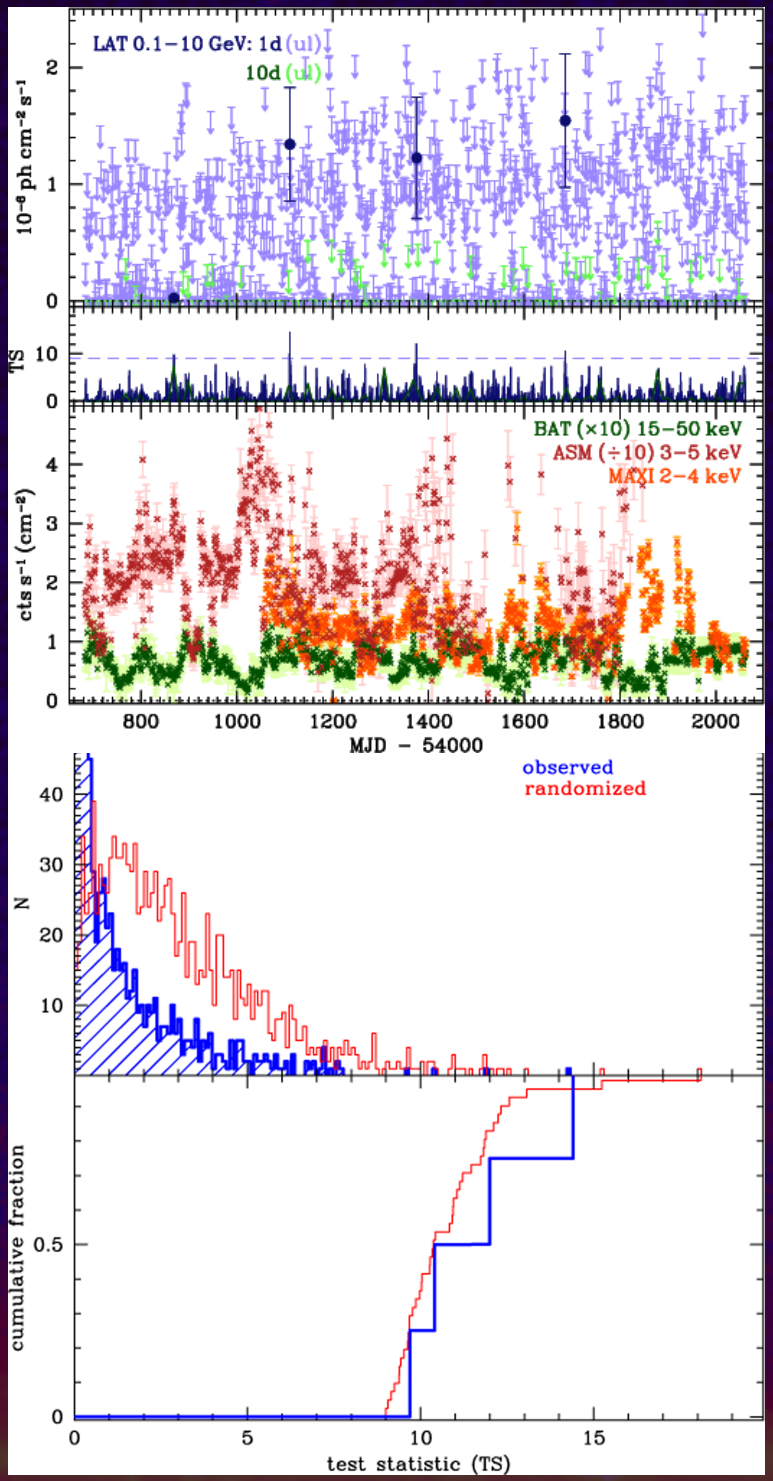
comparison with TS distribution of spurious source yields >70% KS-test prob. of match

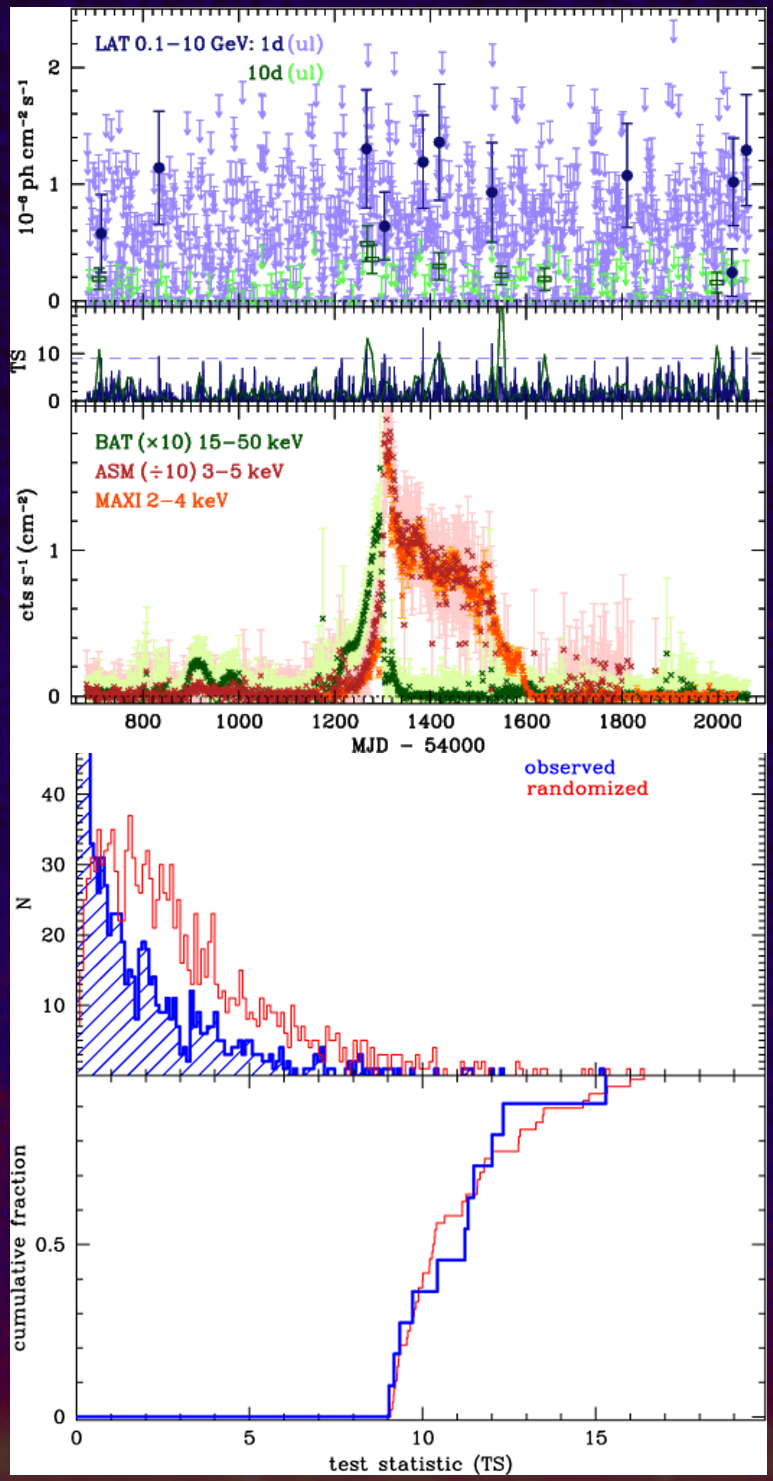
the few candidate detections we have are likely spurious

3σ upper limits on persistent flux in 0.1—10 GeV:

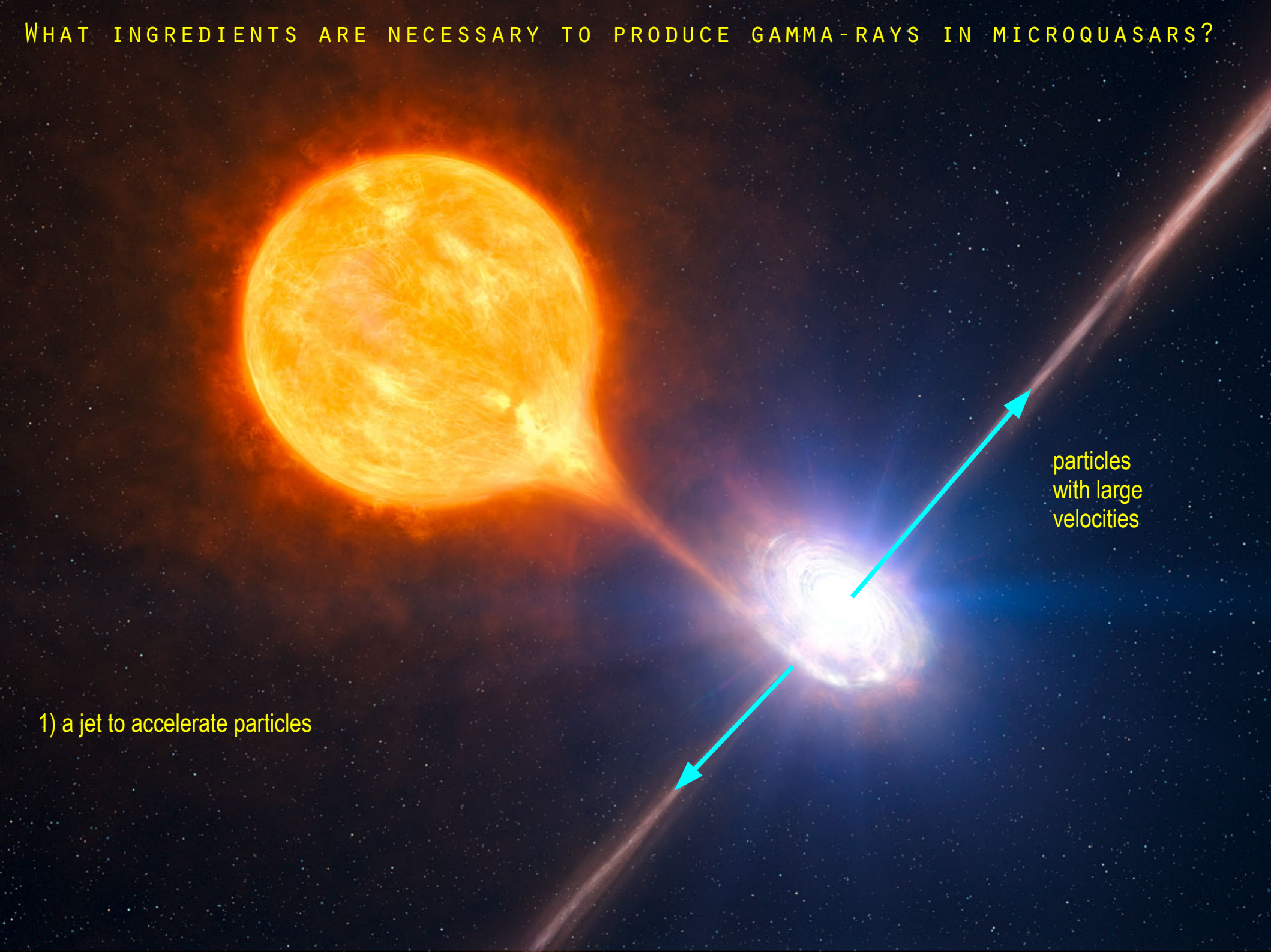
GRS1915+105: $2.3\times10^{-8}$ ph/cm$^2$/s

GX 339–4: $1.6\times10^{-8}$ ph/cm$^2$/s



# What ingredients are necessary to produce gamma-rays in microquasars?



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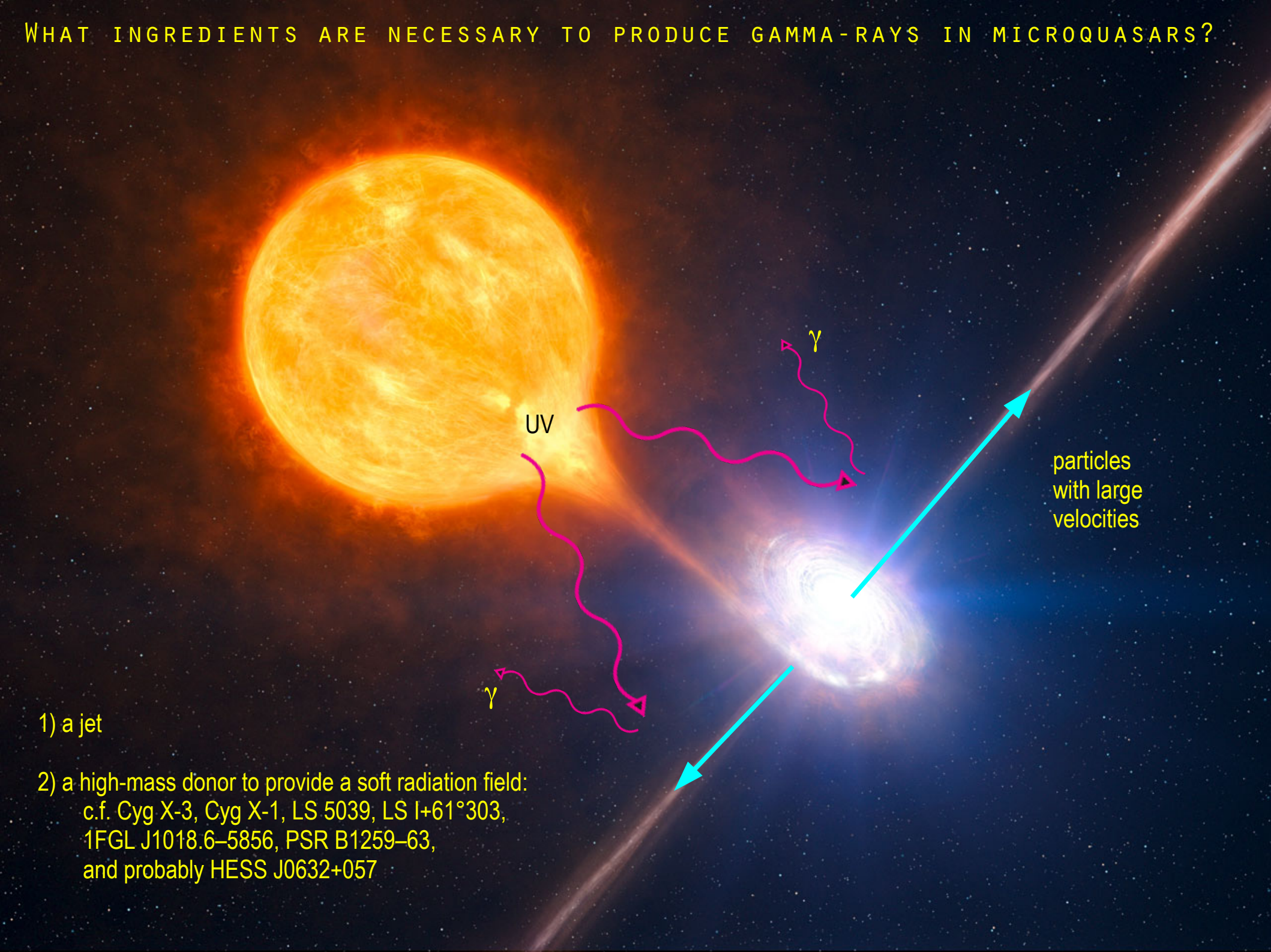



1) a jet

2) a high-mass donor to provide a soft radiation field:
c.f. Cyg X-3, Cyg X-1, LS 5039, LS I+61°303,
1FGL J1018.6–5856, PSR B1259–63,
and probably HESS J0632+057

# What ingredients are necessary to produce gamma-rays in microquasars?




1) a jet

2) a high-mass donor

3) superior conjunction to maximize area of soft photon target (?)
   Cyg X-3: orbital period shows peaks at SC
   Cyg X-1: MAGIC detection and 2 of 3 LAT-AGILE detections at SC

# What ingredients are necessary to produce gamma-rays in microquasars?




1) a jet

2) a high-mass donor

3) superior conjunction (?)

4) others: jet angle, magnetic field, etc. (?)

# Summary & Conclusions

Cyg X-3:

- confirmed all but one previously-reported gamma-ray detections
- found five additional unreported gamma-ray flares
- uncovered evidence of persistent emission

Cyg X-1:

- LAT confirmed all previous gamma-ray detections by AGILE
- other candidate gamma-ray detections likely spurious

GRS 1915+105 and GX 339–4:

- candidate gamma-ray detections likely spurious

recipe for producing gamma-rays from microquasars:

- jet
- high-mass donor star
- superior conjunction (?)
- other factors (?)

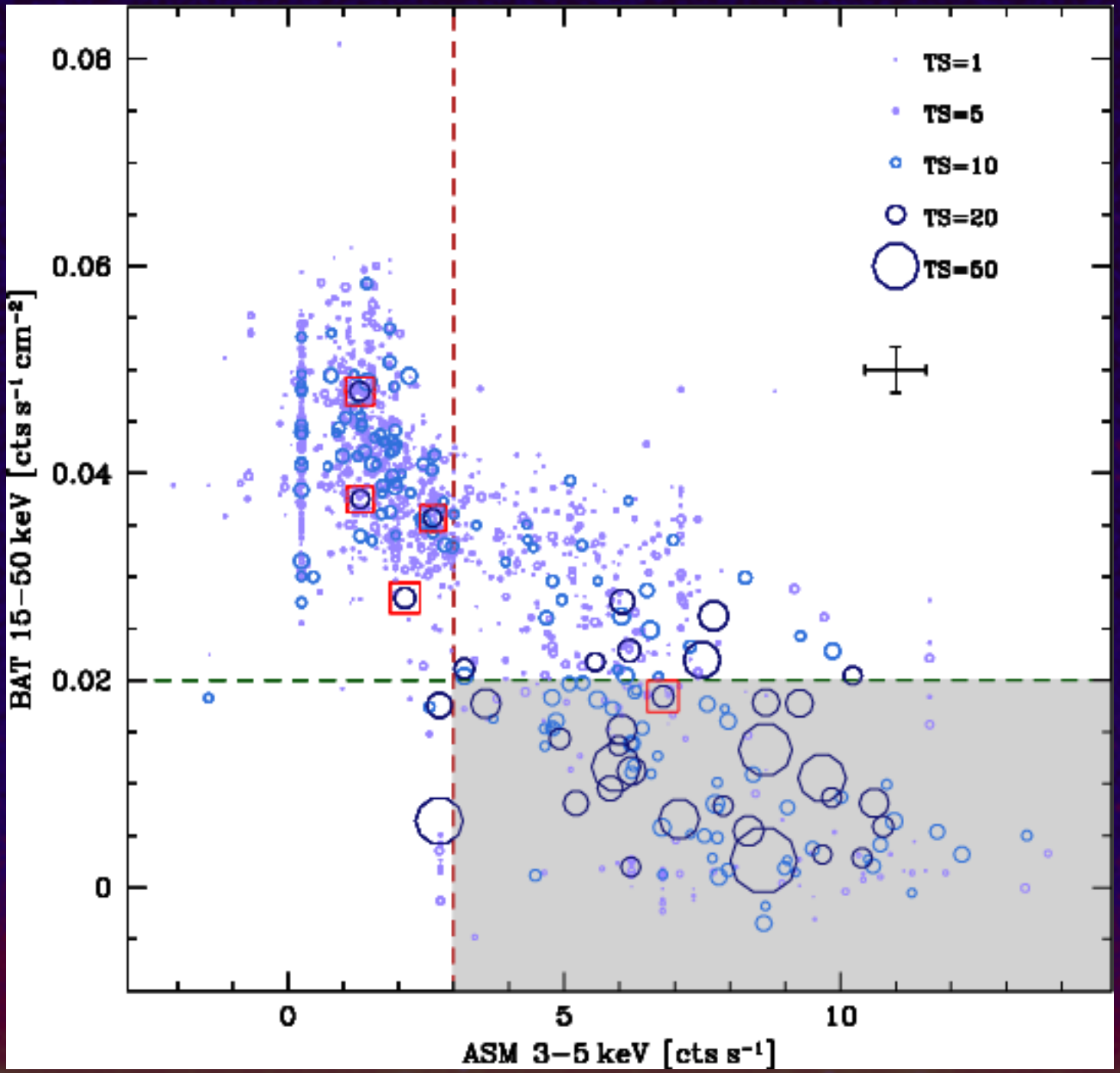
*Fermi observations of microquasars can shed light on the role of relativistic jets in producing gamma-ray emission around accreting compact objects.*

Bodaghee et al. 2013 submitted to ApJ

thank you

# Cyg X-3: predicting the next gamma-ray flare

criteria of Corbel et al. (2012) are good predictors of gamma flaring



# Cyg X-1: predicting the next gamma-ray flare

use X-ray state definitions of Grinberg et al. (2013)