Giant radio flares of microquasar Cyg X-3: association with X-Ray and Gamma-Ray activity

Sergei Trushkin (SAO RAS, Kazan U.)

M. McCollough (CfA, Harvard), K. Koljonen (FINCA),

M.Gurwell (SMA), E. Ergon (INAF), D. Green & G. Pooley (MRAO),

R. Corbet (Fermi) , M. Tavani & G. Piano (INAF) ,

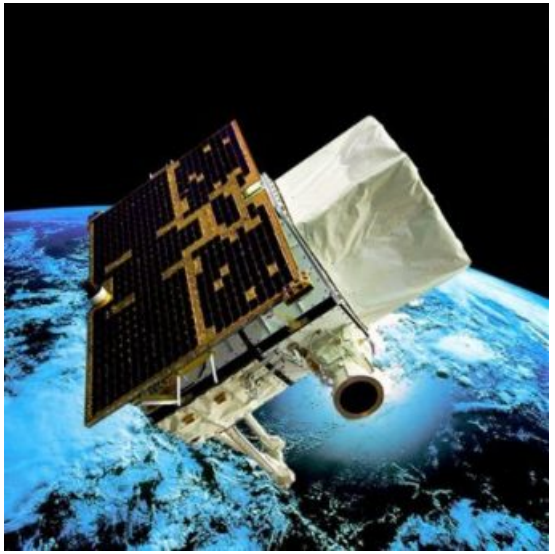
M. Corcoran (GSFC), T. Kalman & Z. Arzoumanajn (NACA,NICER),

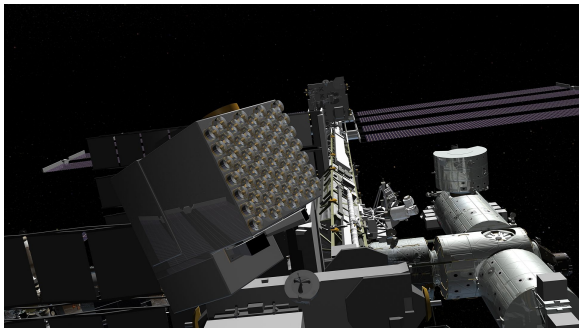
N. Bursov, N. Nizhelskij, P. Tsybulev, A. Shevchenko (SAO RAS)

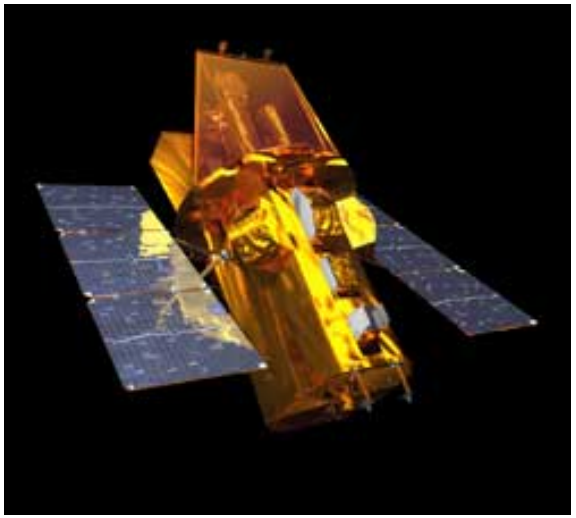
Workshop "Variable Galactic Gamma-Ray Sources"

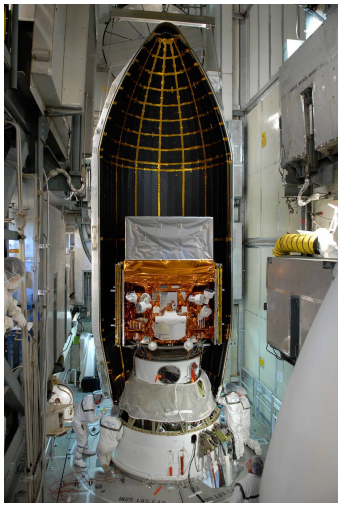
Barcelona University, 5 September 2019

RATAN+SMA+ AMI-LA+AGILE+NICER+Swift+Fermi



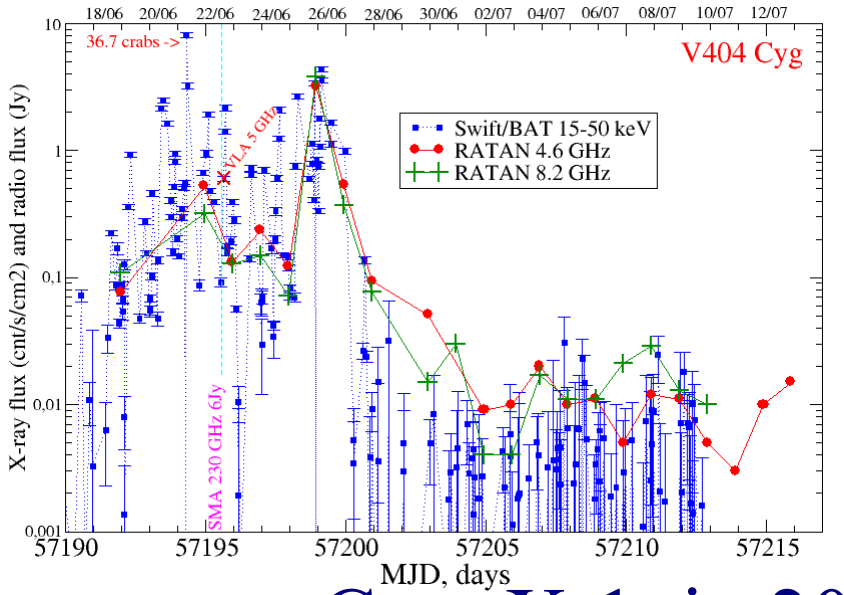


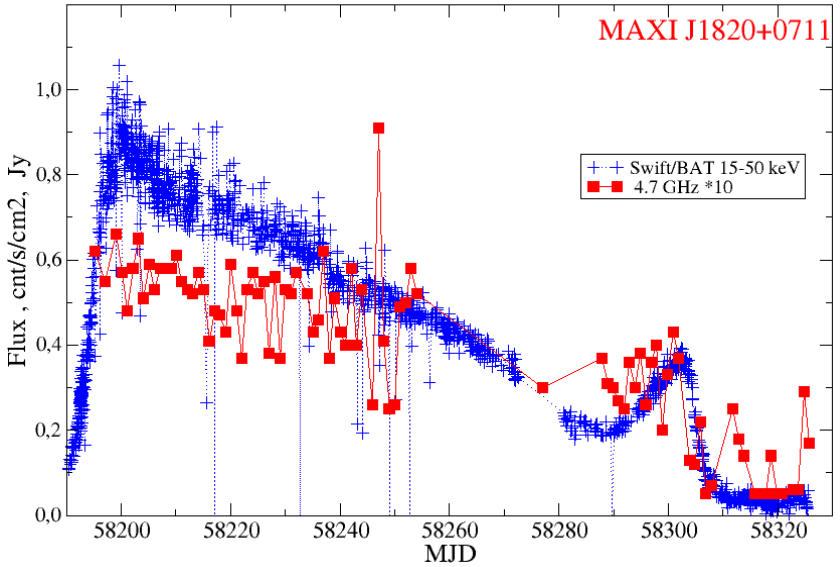




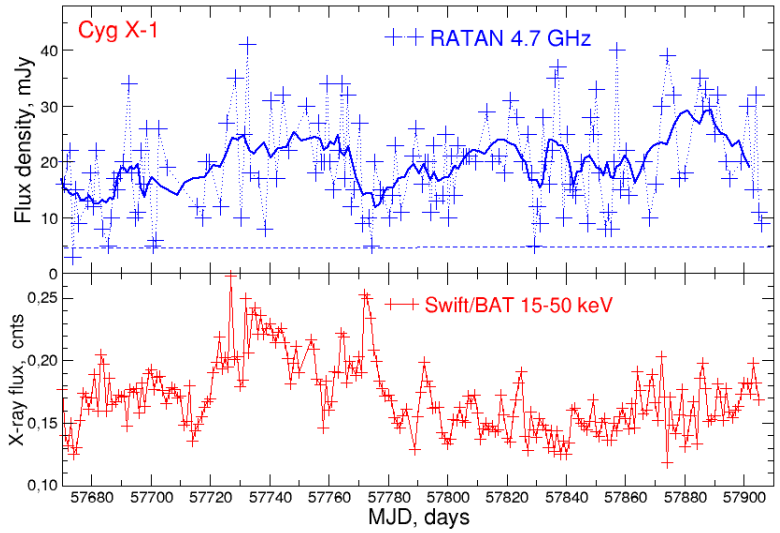
RATAN achievements

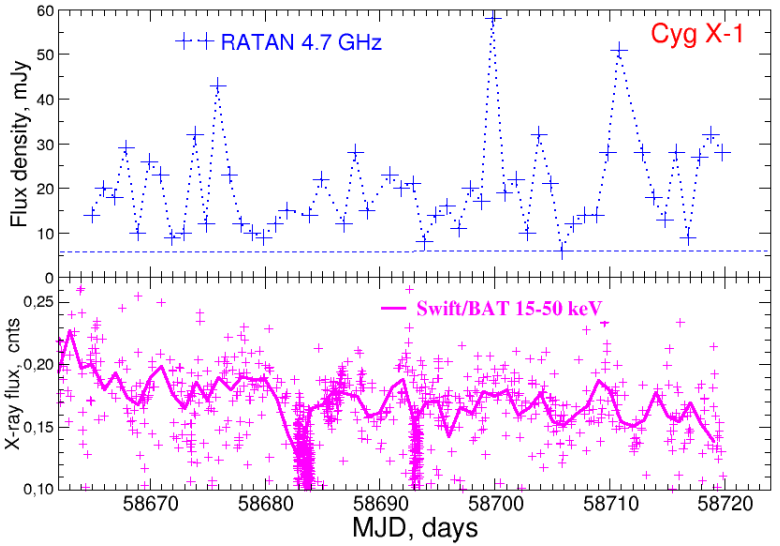
V404 Cyg in June 2015 & MAXI1820+0711 in 2018

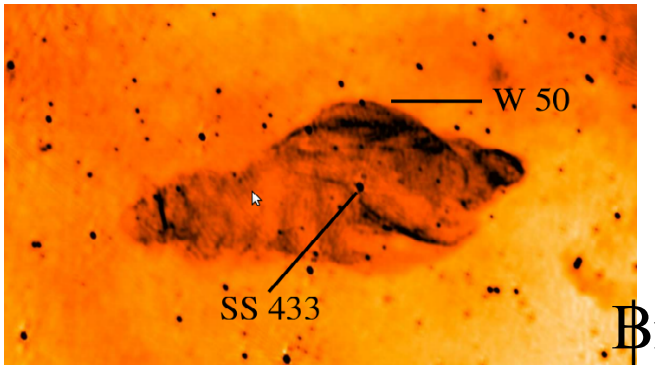




Cyg X-1 in 2016-17 and in 2019

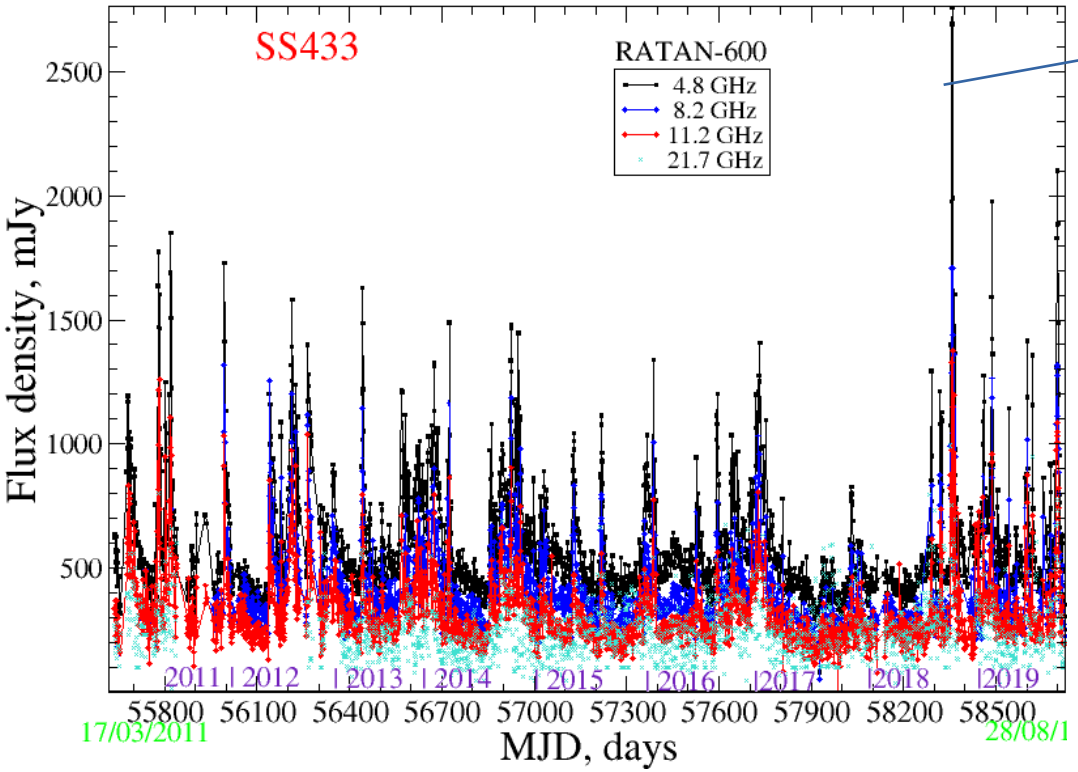


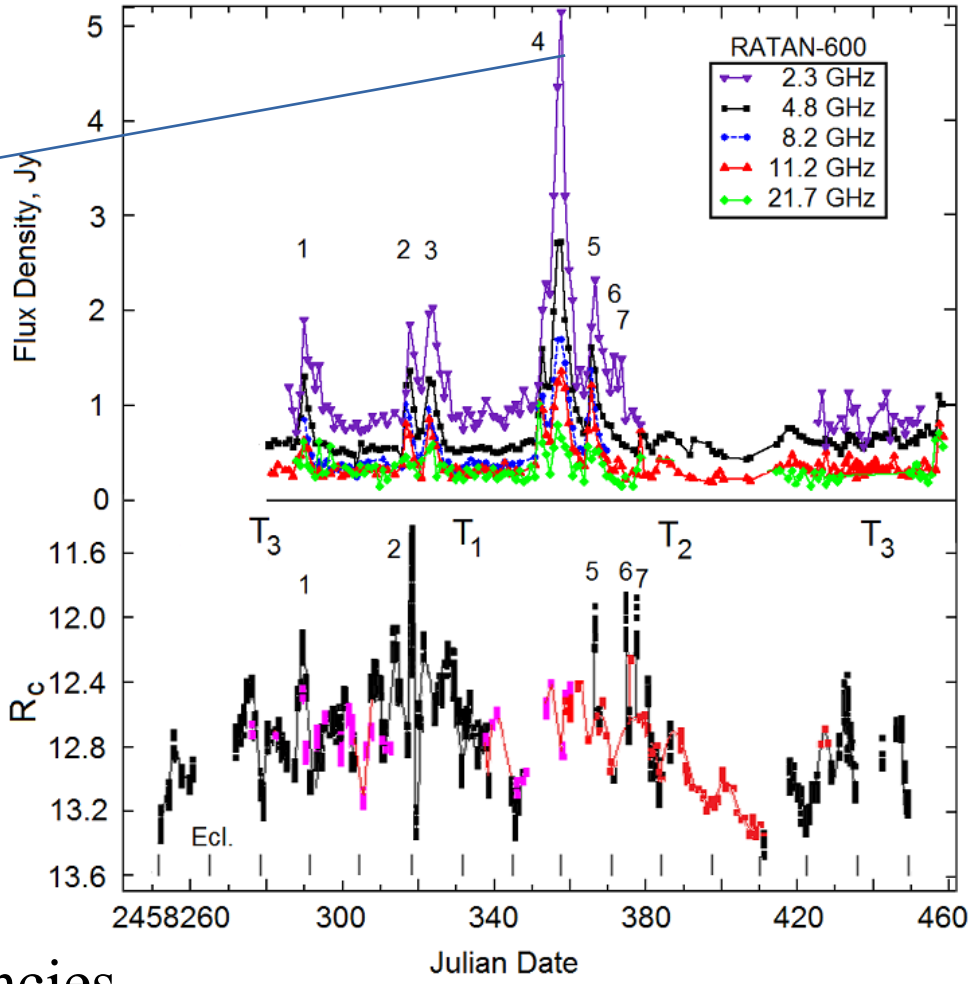




SS433 in 2011-2019

Broderick et al





2750 days of monitoring at 4-5 frequencies

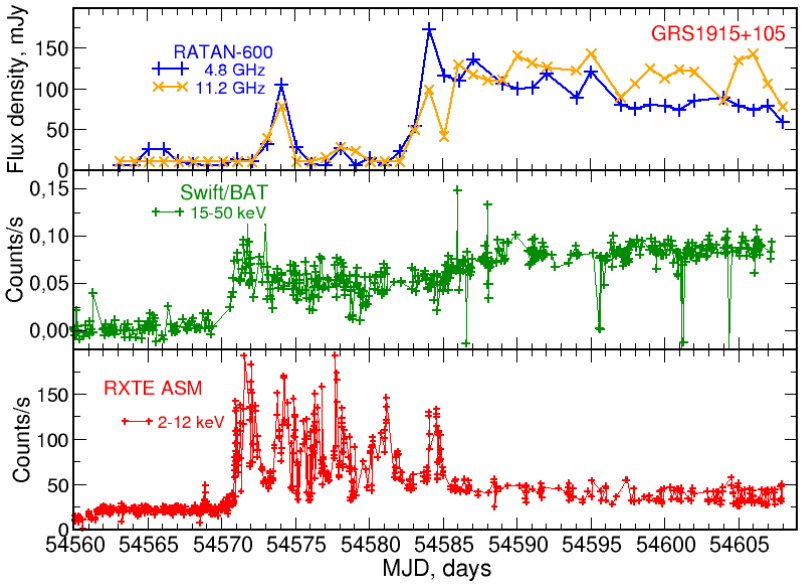
a lot of flares, in July 2018 the most bright!

Radio 2-22GHz +

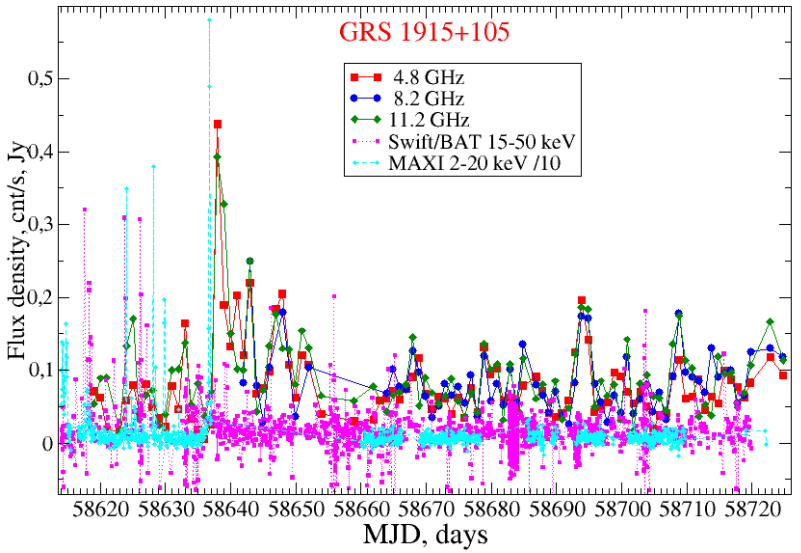
optics Rc (Goranskij)

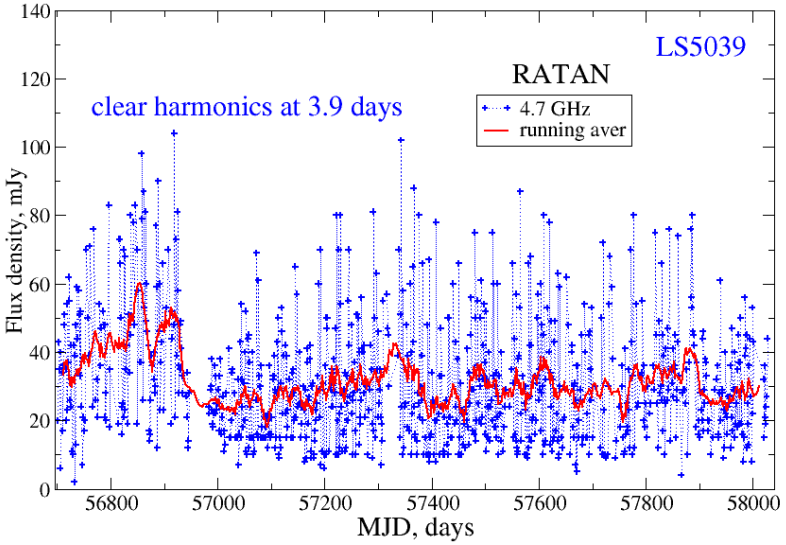
GRS 1915+105 & LS5039

April-June 2008

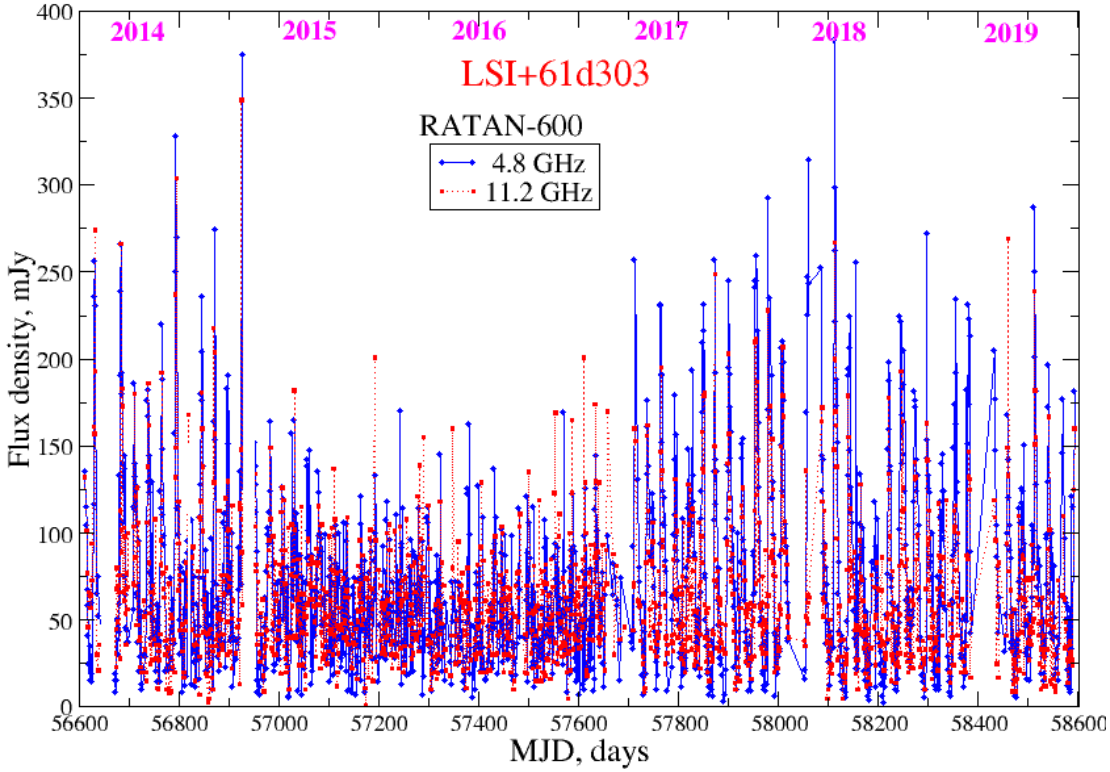


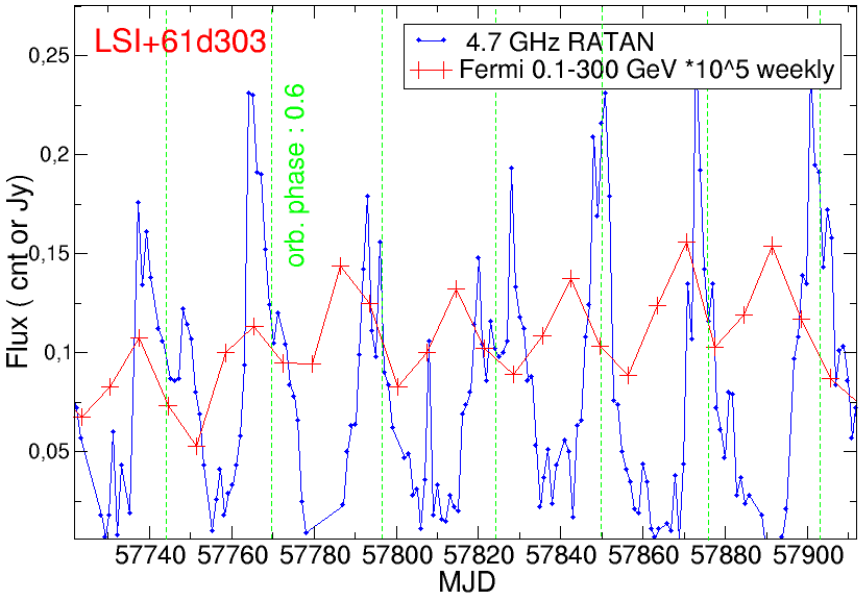
May-Sep 2019





LSI+61d303: 77 orbits (2030d) in 2013-2019





Fermi/LAT +RATAN

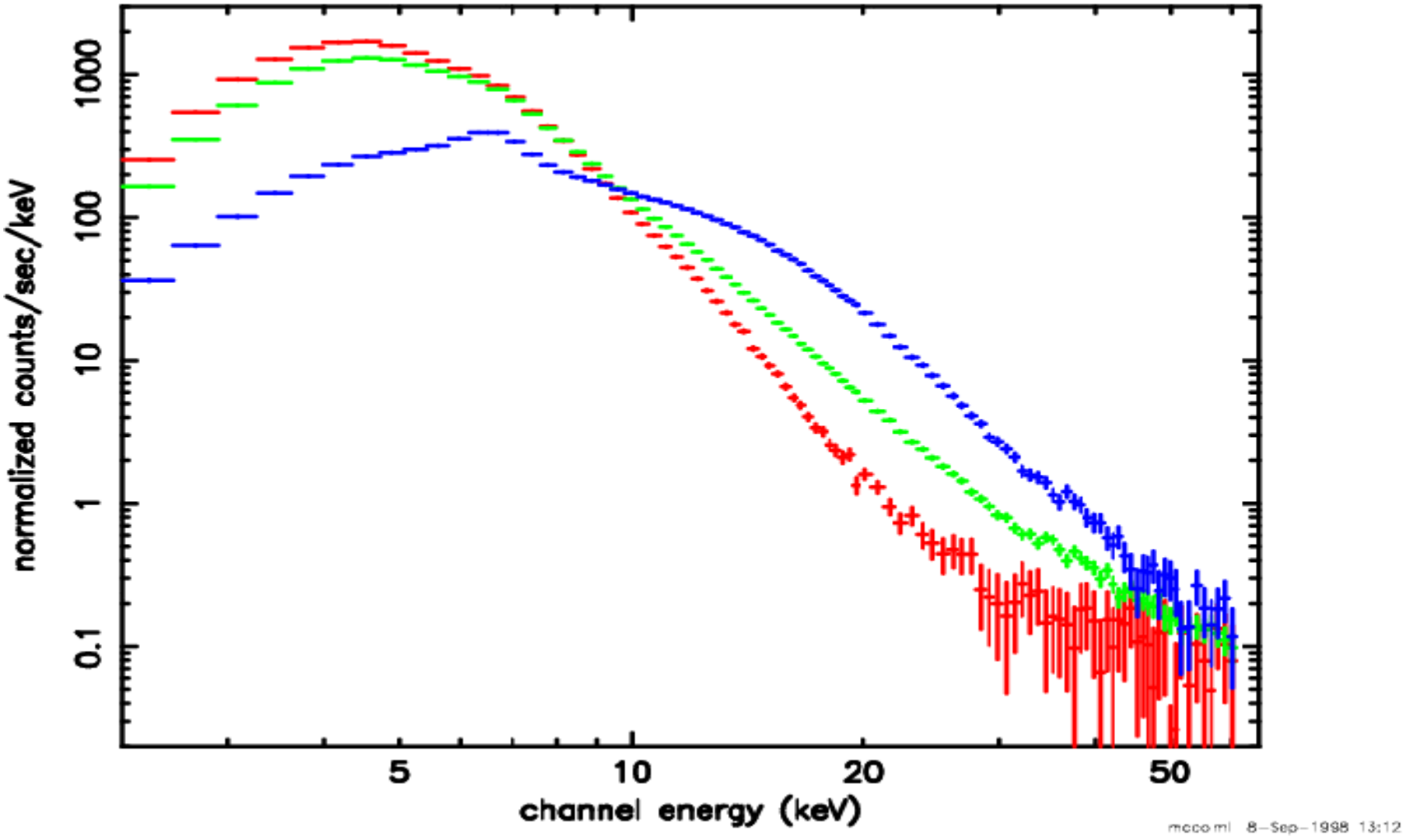
We see the superorbital period =1667d:

sawtooth or sinusoidal profile ?

Cyg X-3 (WR-star + BH?)

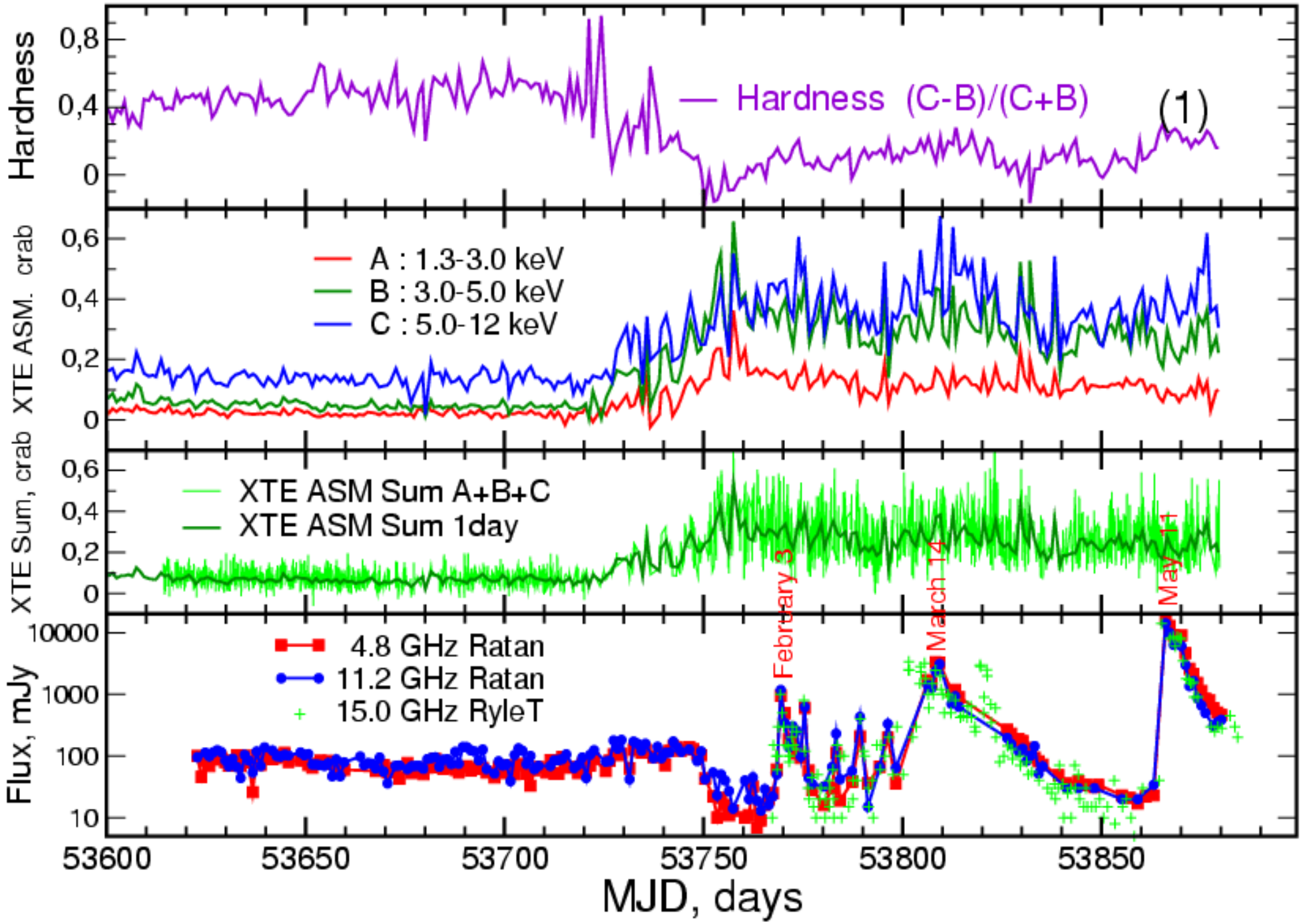
- First flaring Galactic source (Nature, 1972) – during 47 yr ~30 giant flares >3Jy (2011-16: 0!, 2016-19:4)
- P_orb = 4.8h (IR/Xray) P/Pdot~10^6 years
- Variable velocity of jets: 0.1-0.9c
- Close to «classical» synchrotron radio flares.
- Periods of the activity ~100 days, but in 2011-2016 (2000 days!) there are no any flares.
- Enigma: radio flux droped down before strong flares during: ~1-8 weeks. See Koljonen et al. (2010)+

X-ray spectra of the Cyg X-3 states

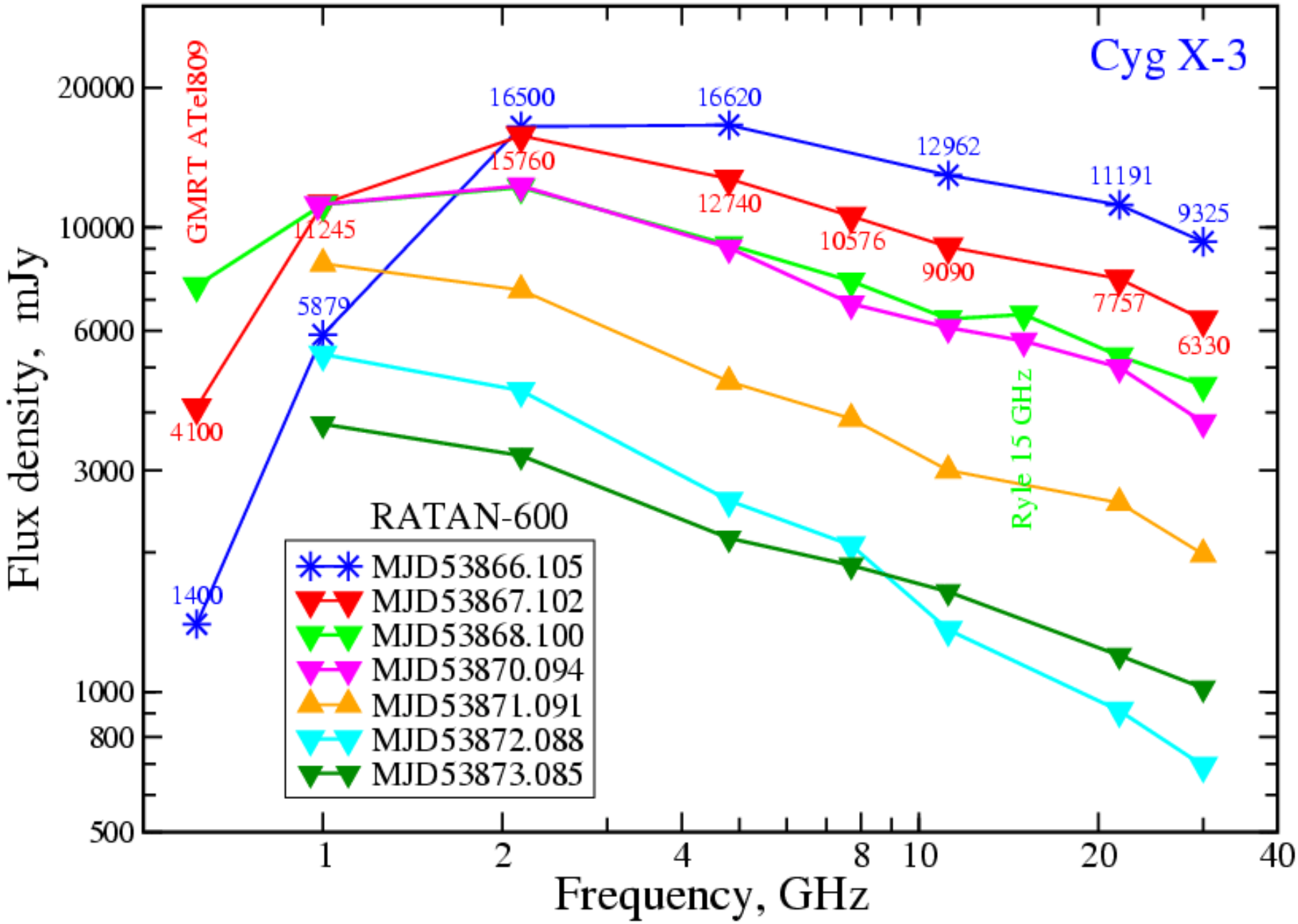


- Blue – quite state; red -- pre-flare; green – flare!

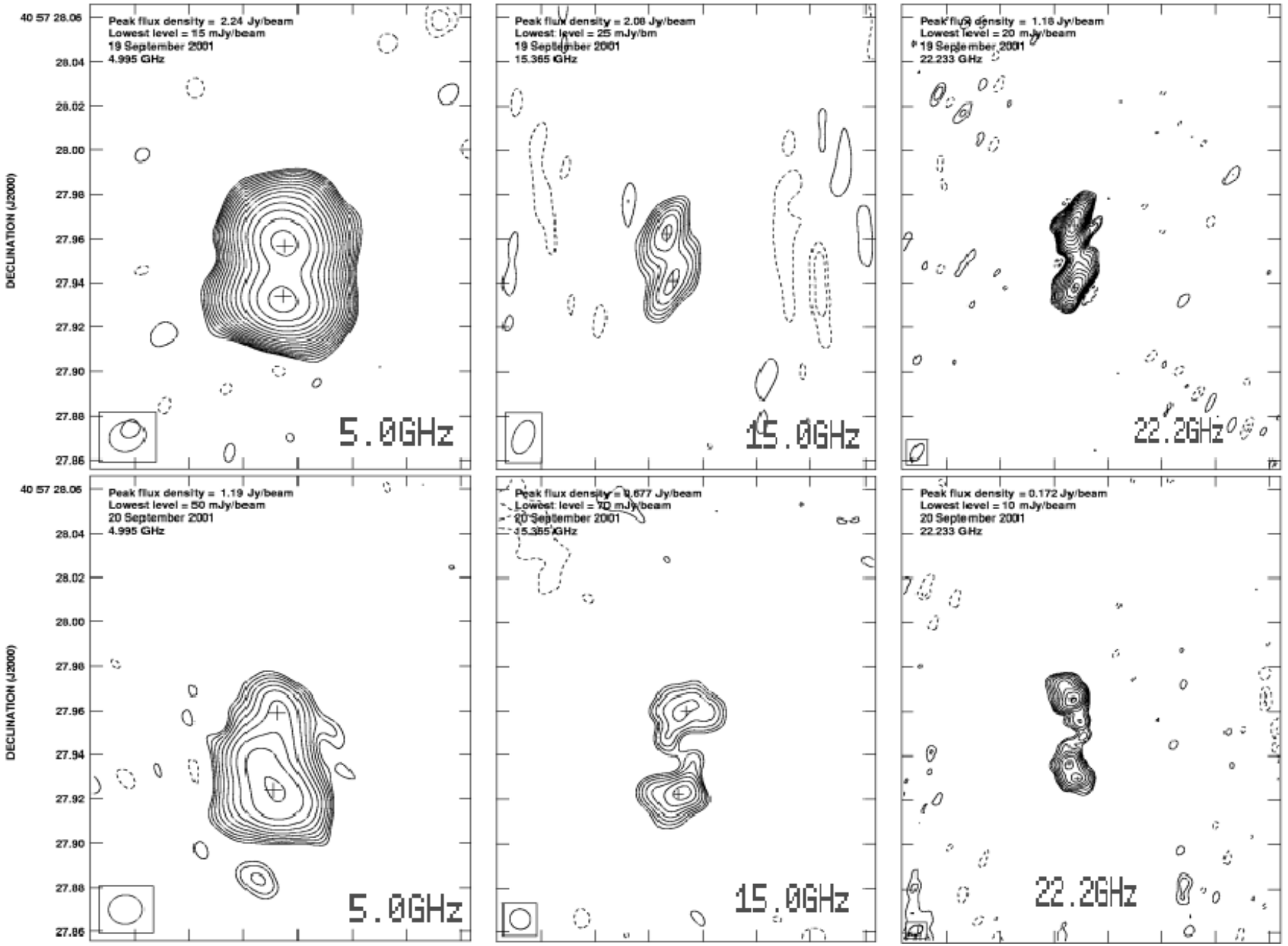
Cyg X-3 light curves in 2005-2006



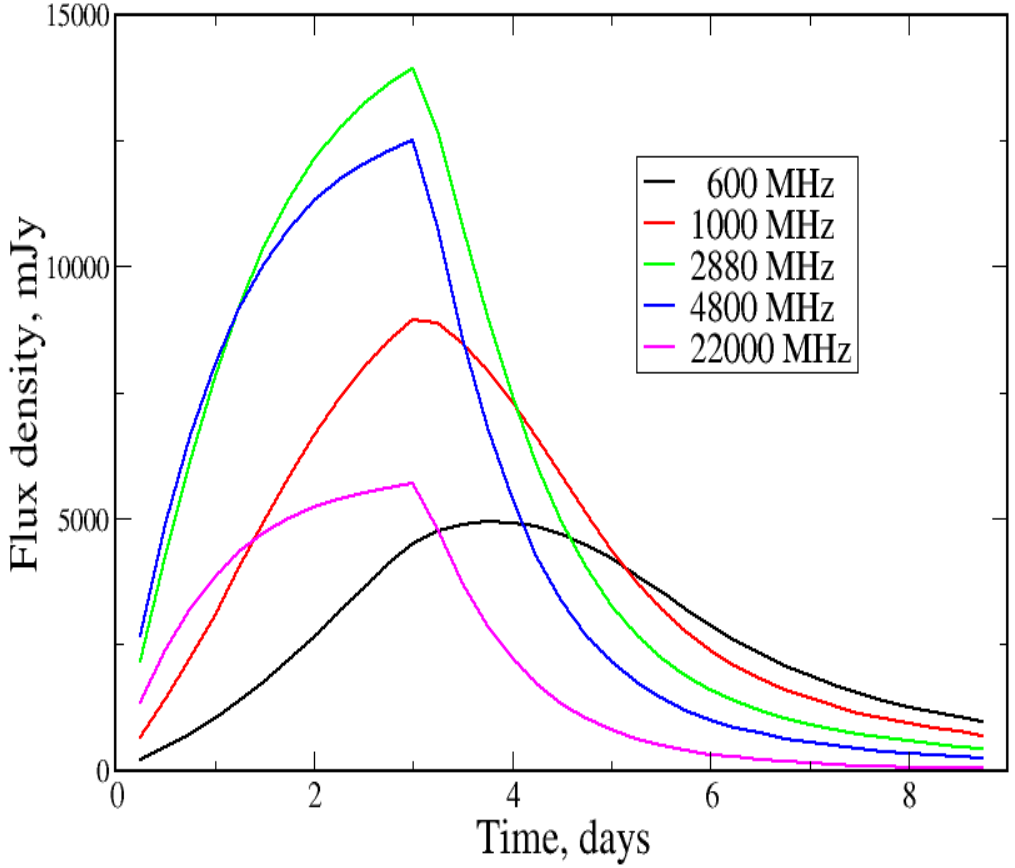
Spectra of the 2006 May flare



Cyg X-3 VLBA maps in September 2001 from Miller-Jones+ (2004)

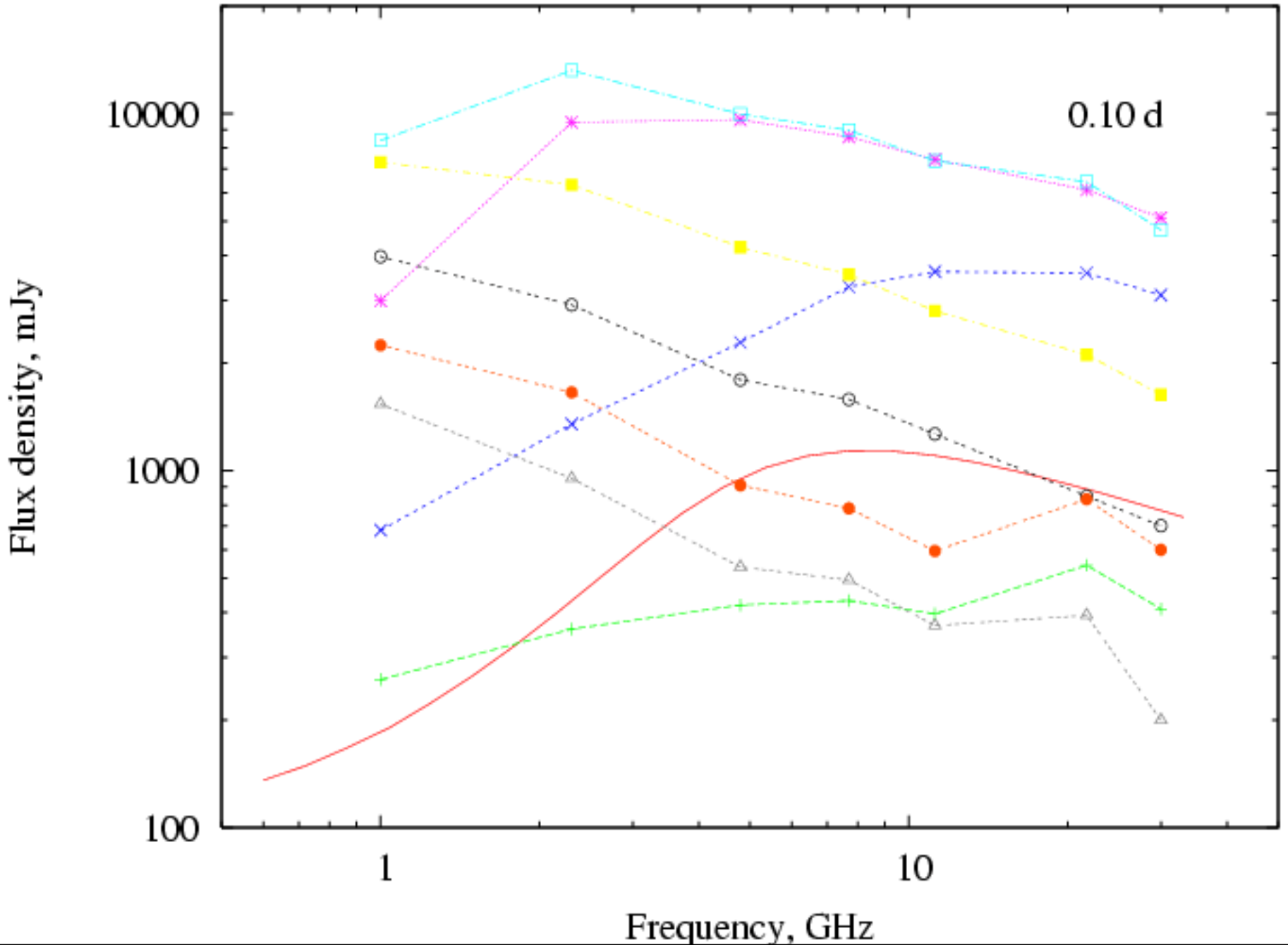


Model light curve of the July flare, Marti et al., 1992

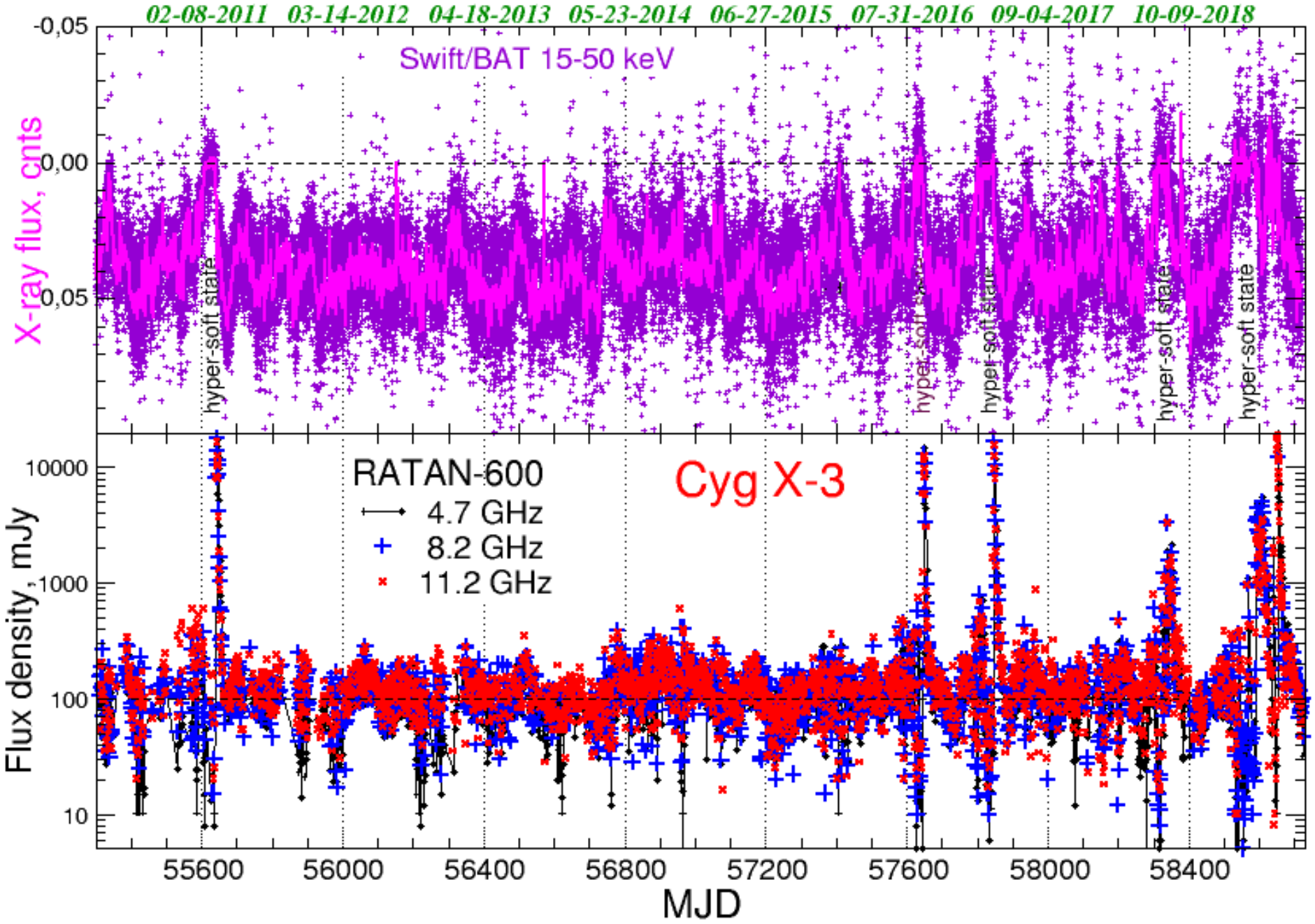


- t_i ~ 3-12 days
- t_exp_expansion = ~2-12d
- n_the =2*10^5 cm^-3
- Mdot_rel = 5 10^-13 Msun/y
- v_jet =0.74, 0.43, 0.74c
- B0 = 0.02-0.04 Gs
- N(E) ~ N*E^-1.85+-0.1
- T_e =10^4 K

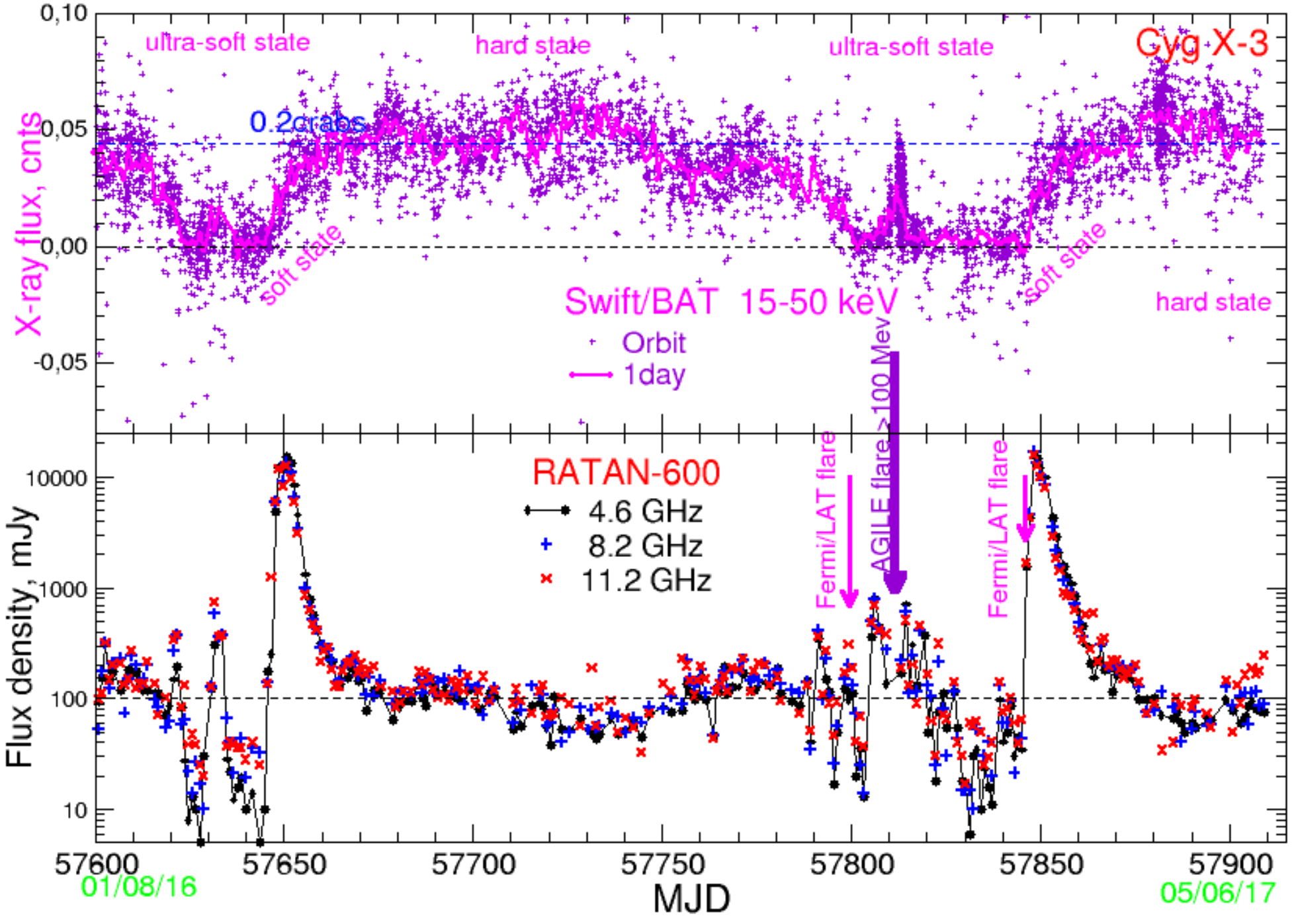
Modelling of the flare



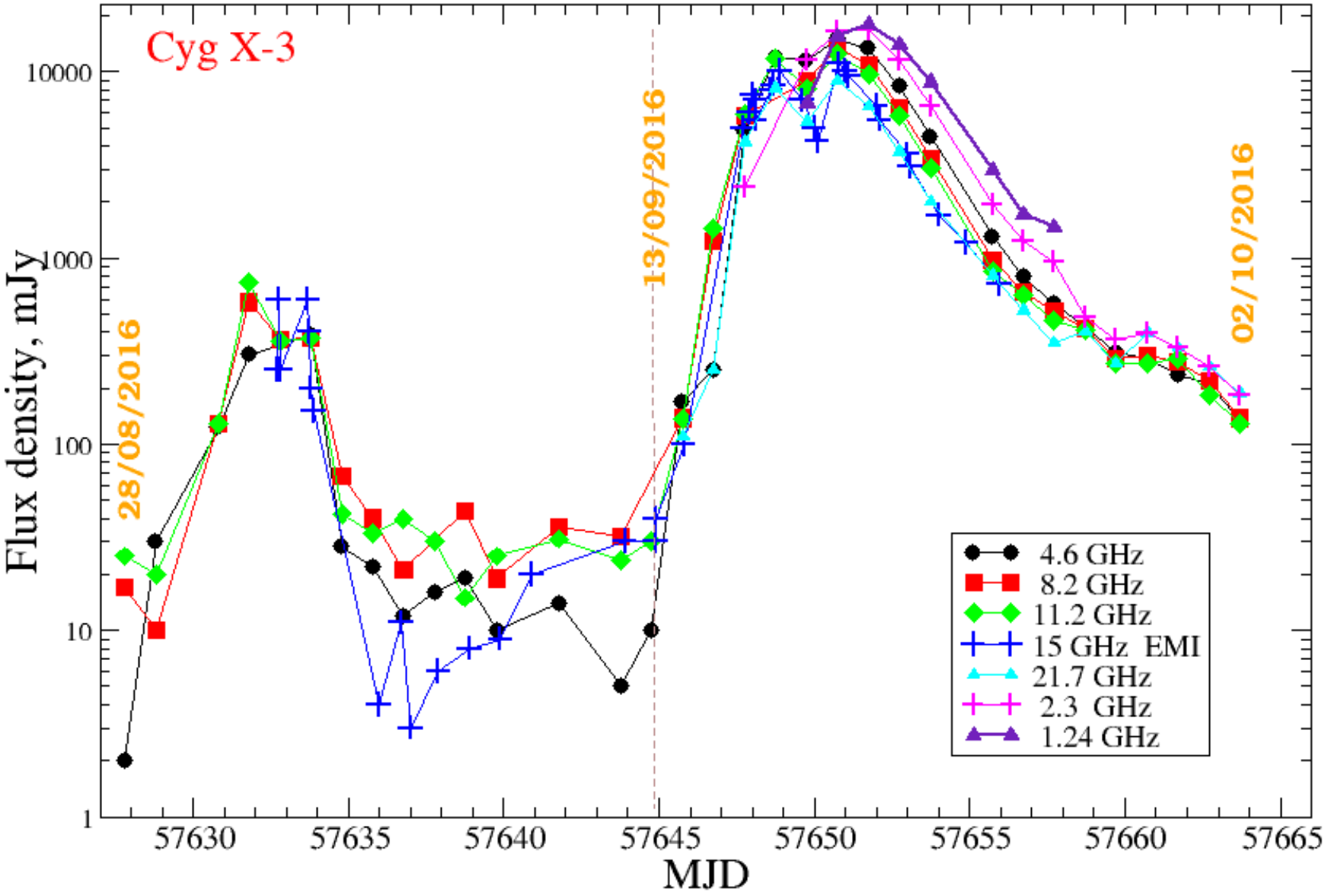
Cyg X-3 during from Nov 2010 to Aug 2019



Cyg X-3 with RATAN and Swift/BAT in 2016-17

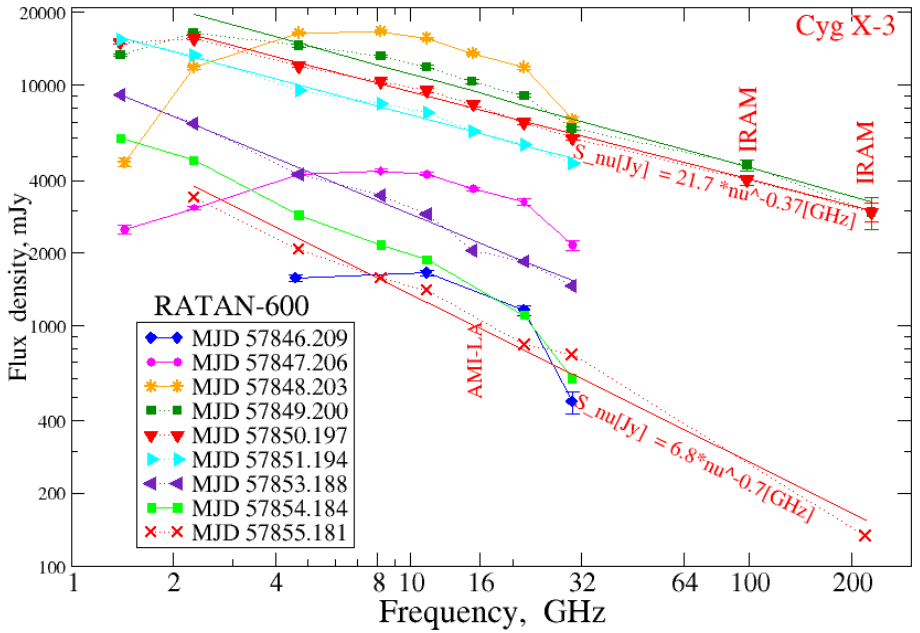


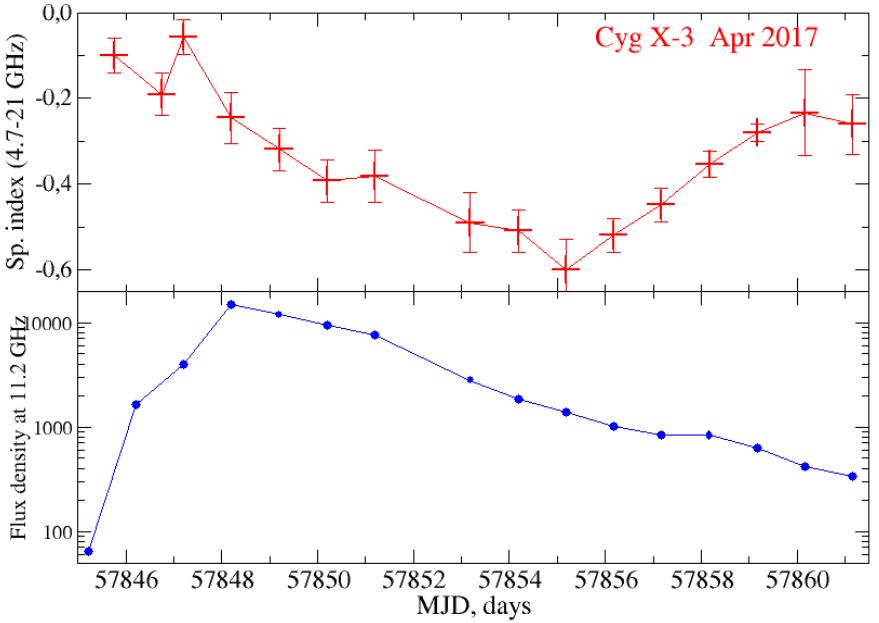
Cyg X-3: the flare in 2016

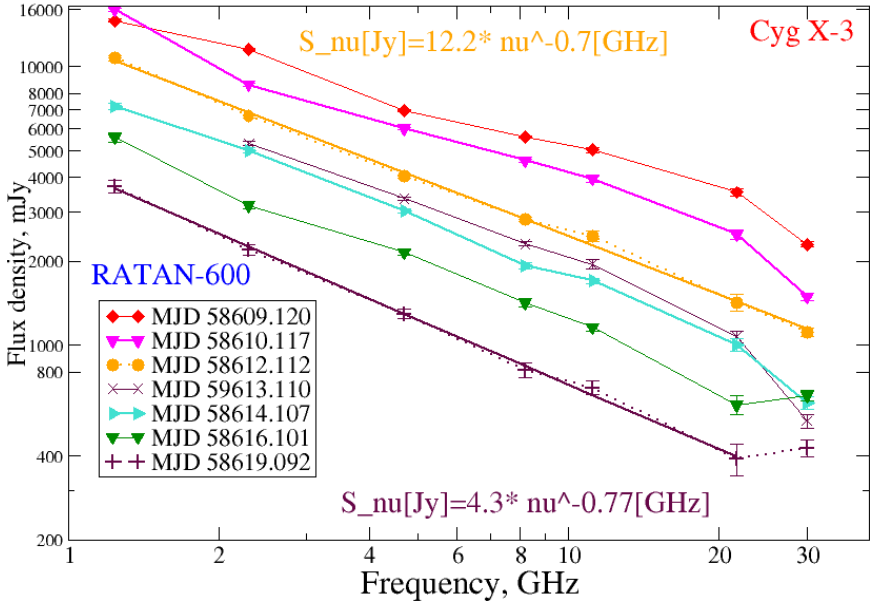


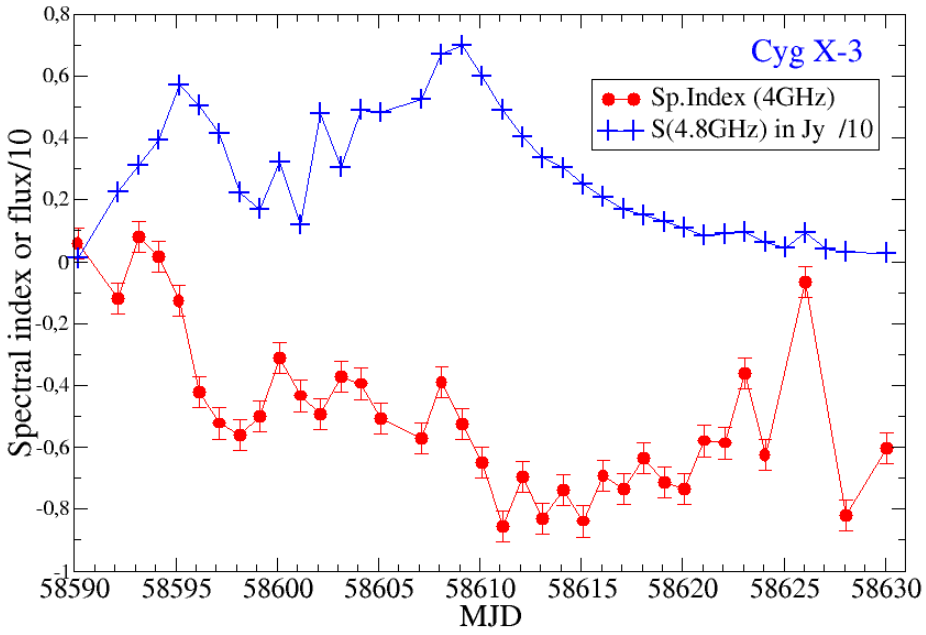
SMA+Metsahovi+EMERLIN+ eEVN+Veritas+AGILIE+Sardinia

Spectra and Sp.I. evolution in the flare in Apr 2017 & Apr 2019

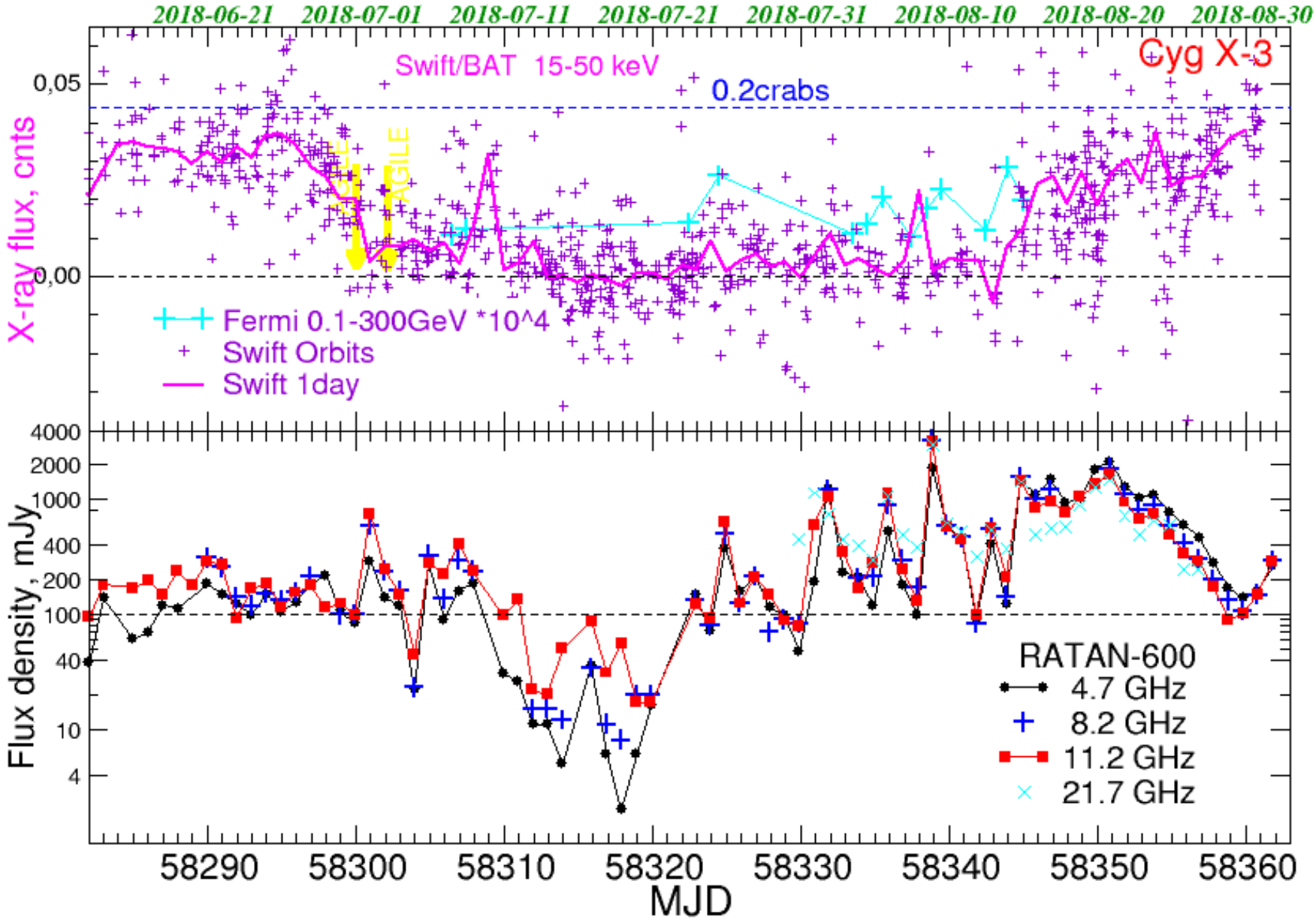




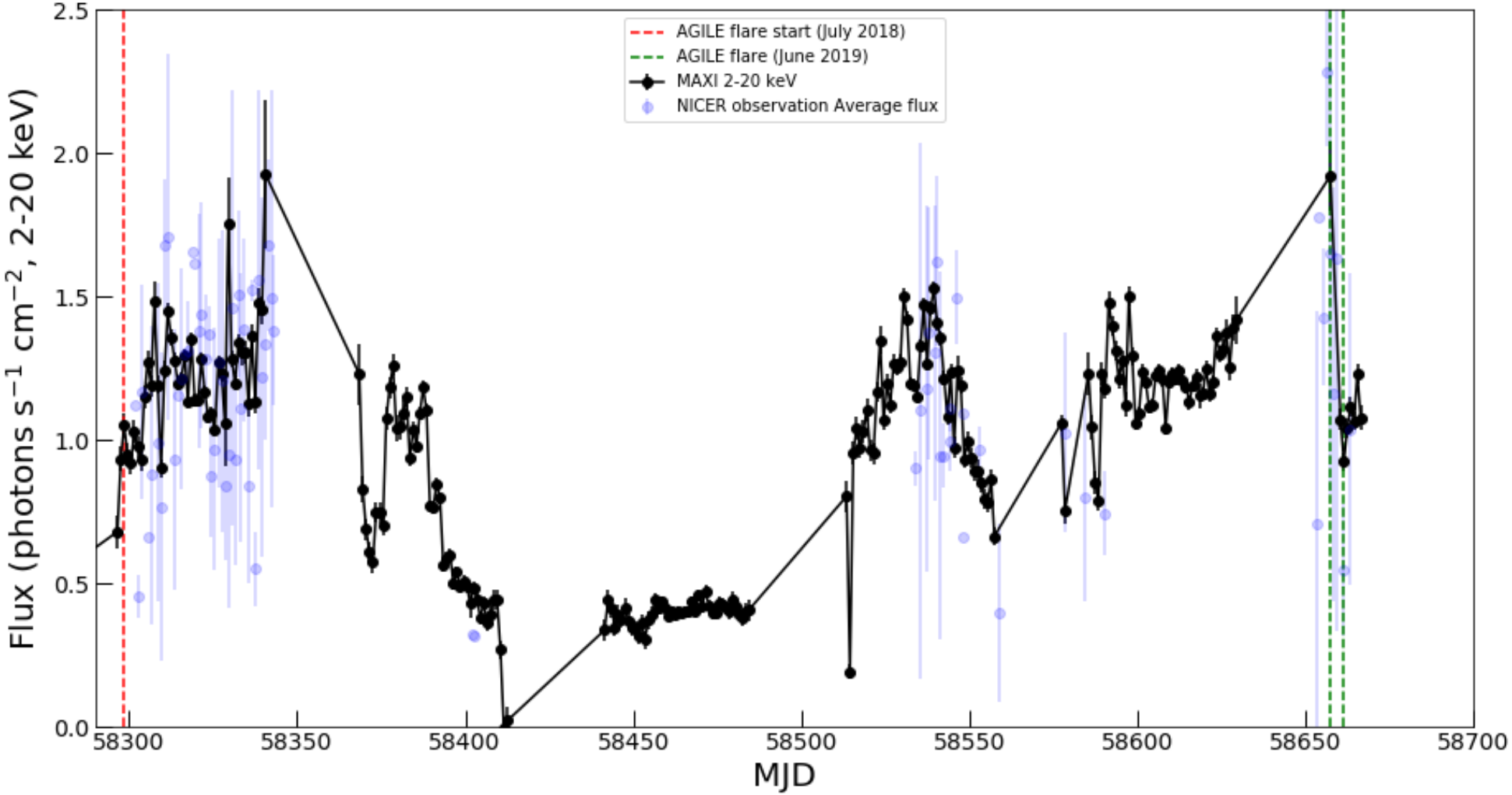




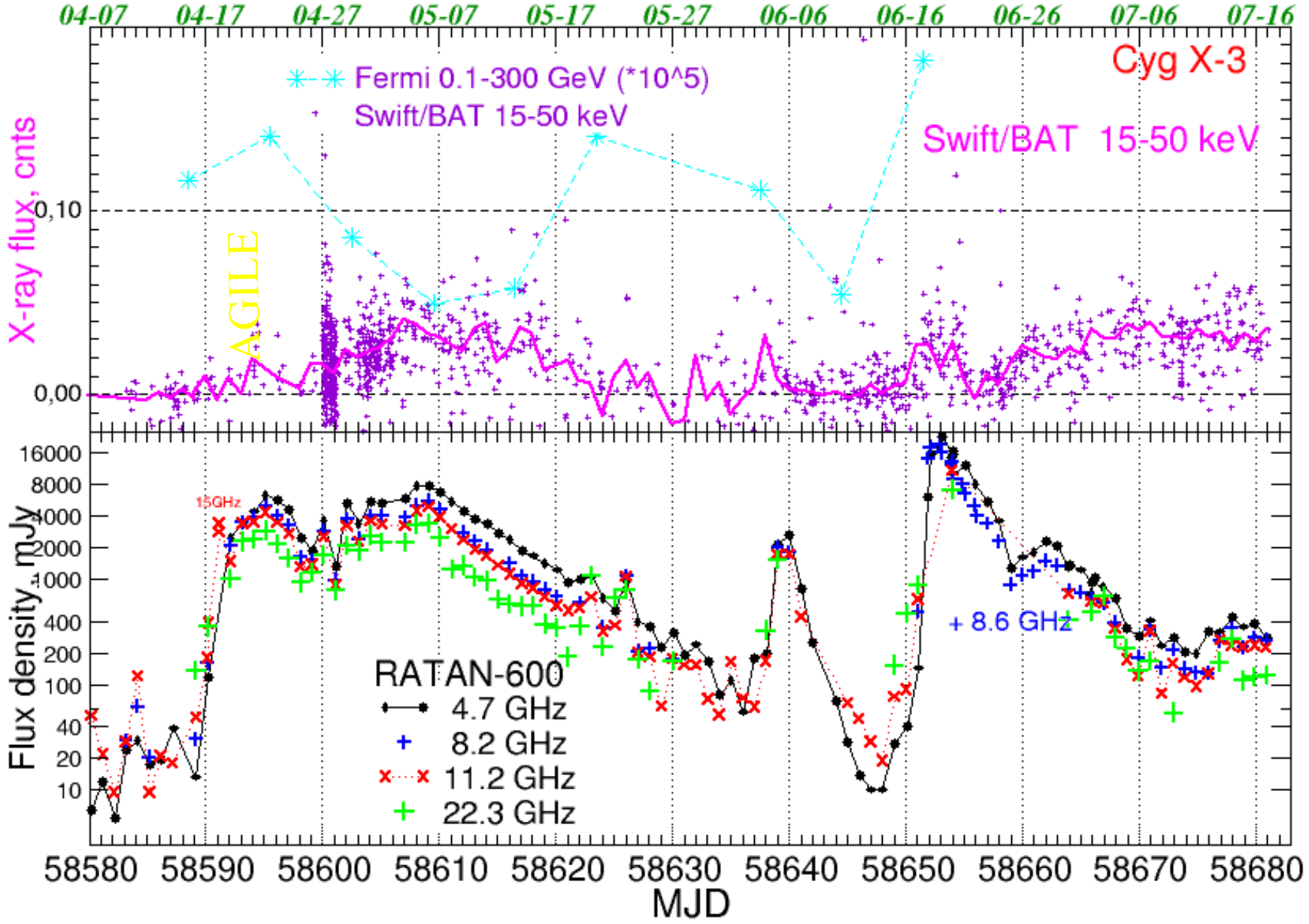
The new ultra-soft state of Cyg X-3 in summer of 2018



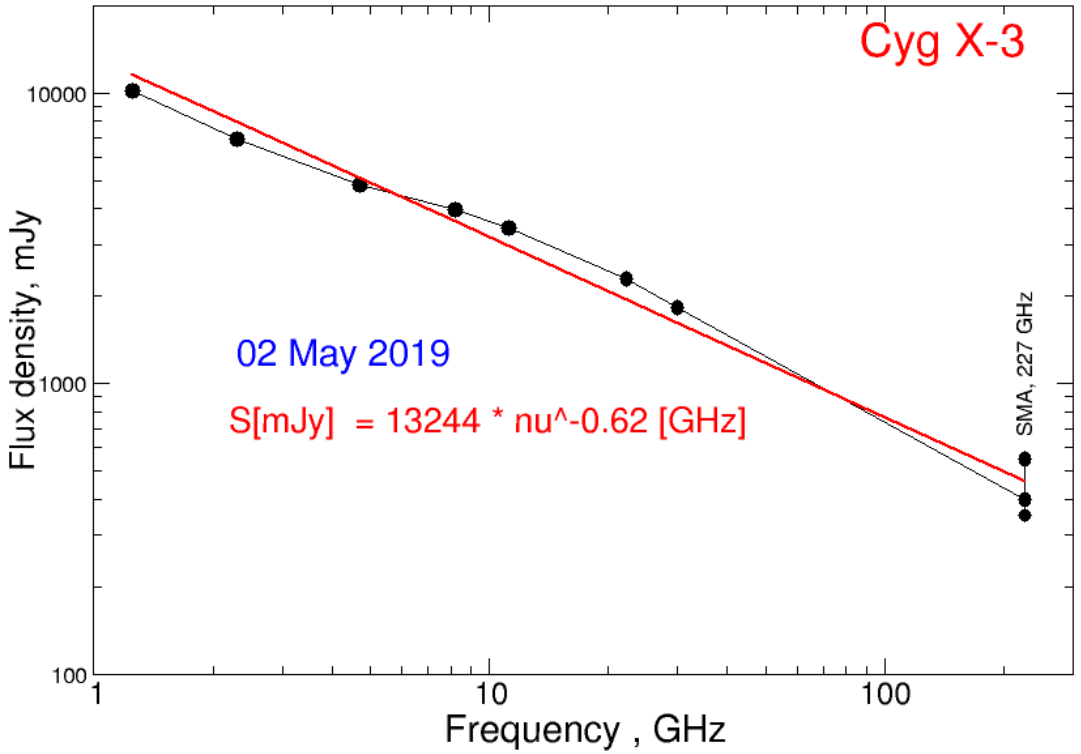
Cyg X-3: AGILE+MAXI+NICER in 2018-2019

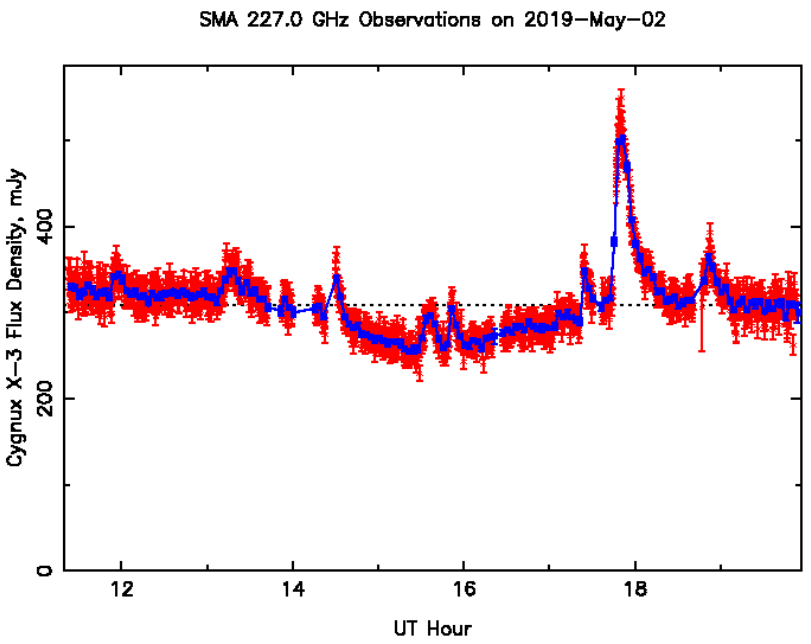


The new ultra-soft state of Cyg X-3 in April-June 2019

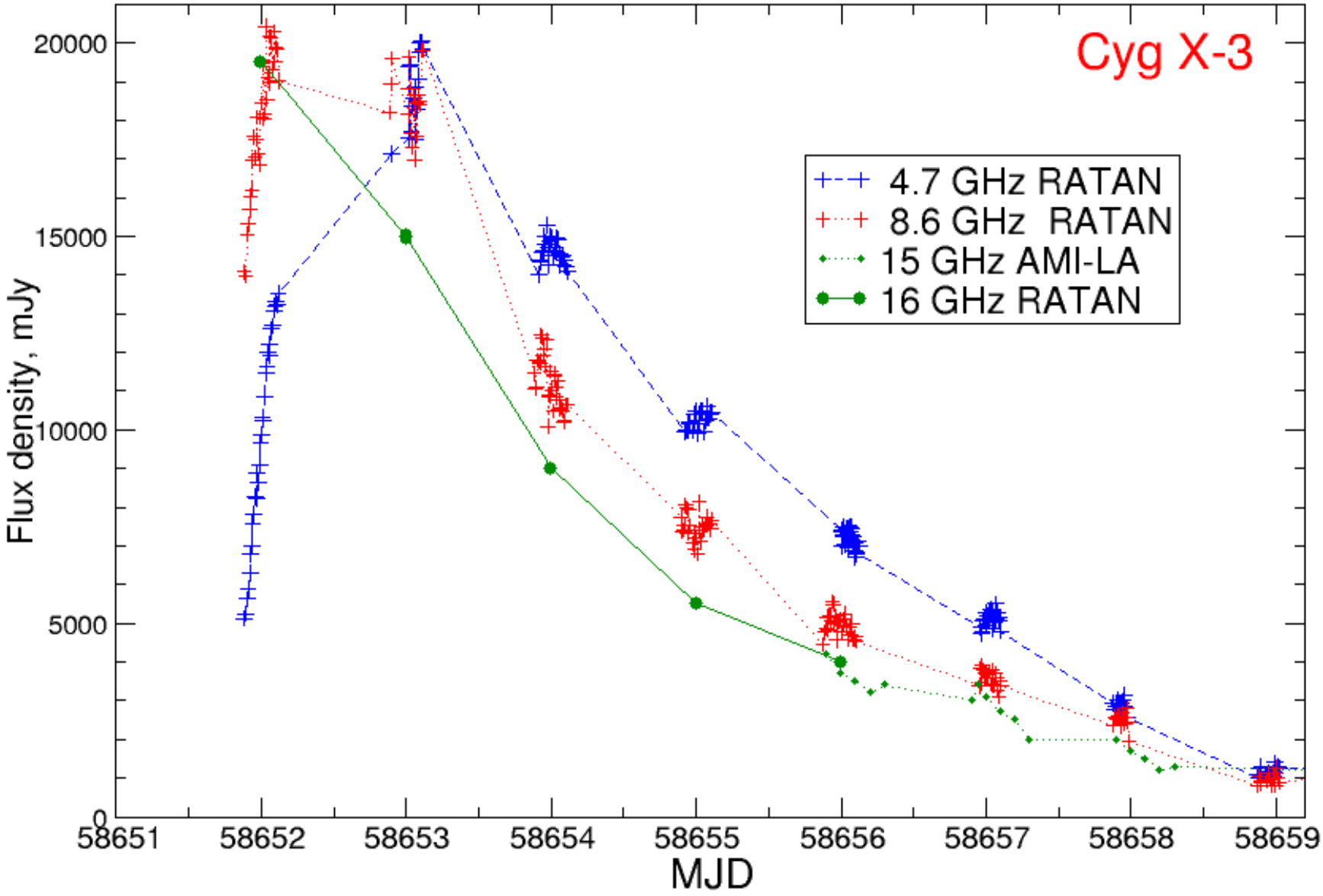


Cyg X-3 with SMA at 227 GHz on 2 May 2019

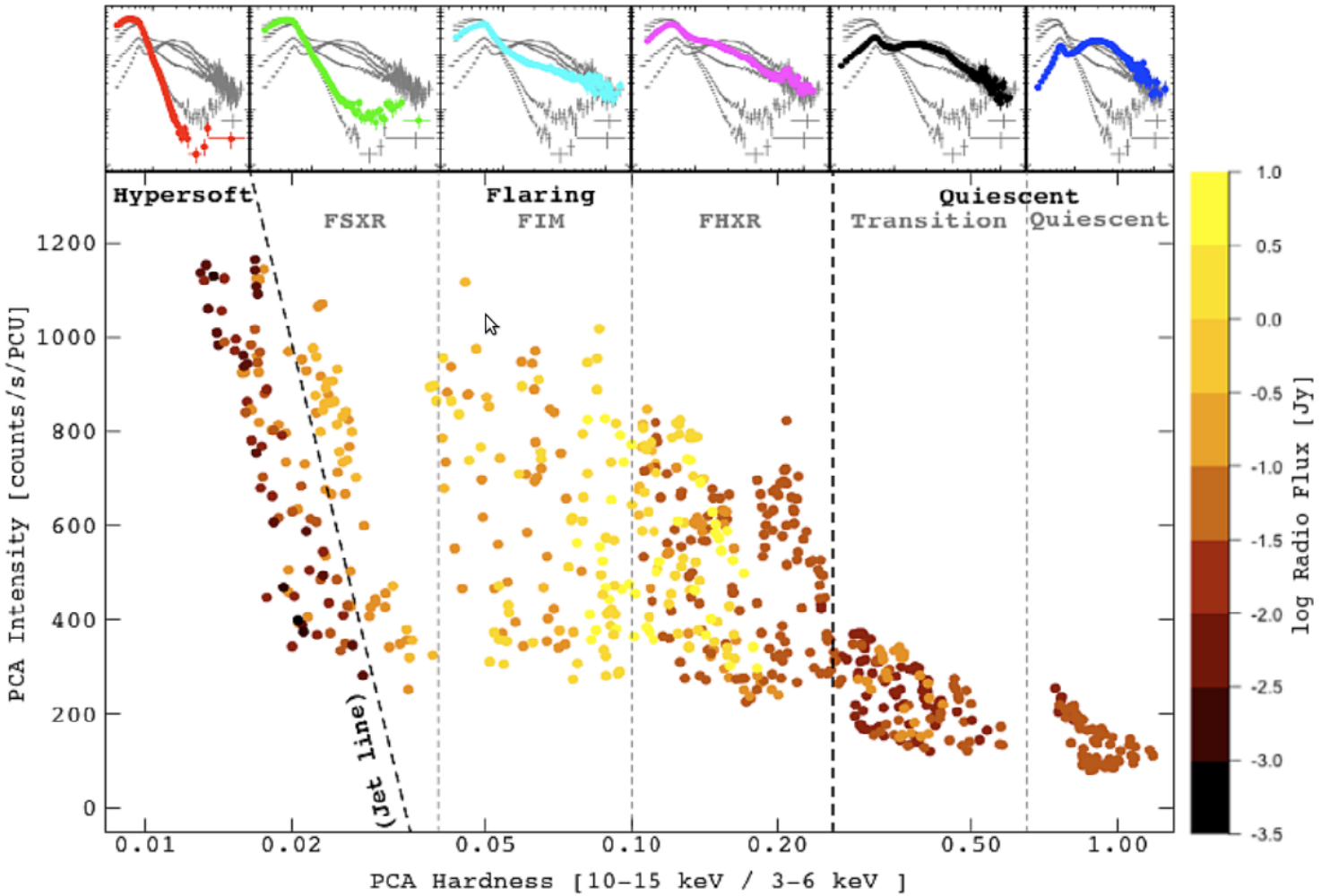




Intra-day variability with RATAN multi-azimuthal observations



Hardness-Intensity Diagram for Cyg X-3



Koljonen et al., 2010

Jet-Wind interaction (Koljonen et al 2018)

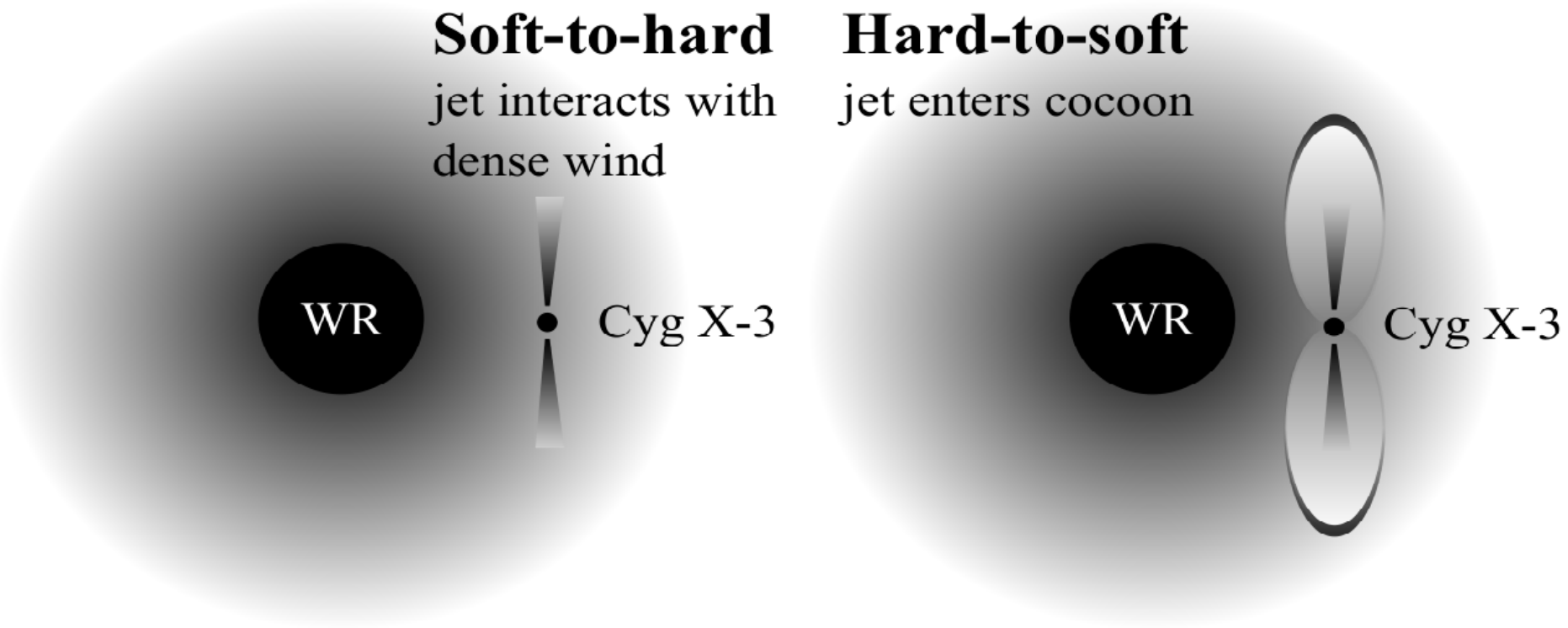


Fig. 13: The cartoon of the jet-wind interaction for Cyg X-3.

Monitoring of Cyg X-3:

- Radio flaring light curves – tracers of the the jet activity.
- Very close relation between the X-ray states and radio (dm-mm) emission (internal shocks?).
- Obviously Gamma-Ray flares related this jet activity (radio flares)
- Multifrequency data show us the spectral evolution in optically thick & thin regions – evidence of initial acceleration of electrons.
- Total radio monitoring *is extremely* valuable for AGILE, Swift, Fermi and VHE gamma-telescopes.
- Good chance to compare qso and mqso evolution