# Hot accretion flow in X-ray binaries: spectral and timing evidence

Alexandra Veledina
Juri Poutanen
Indrek Vurm

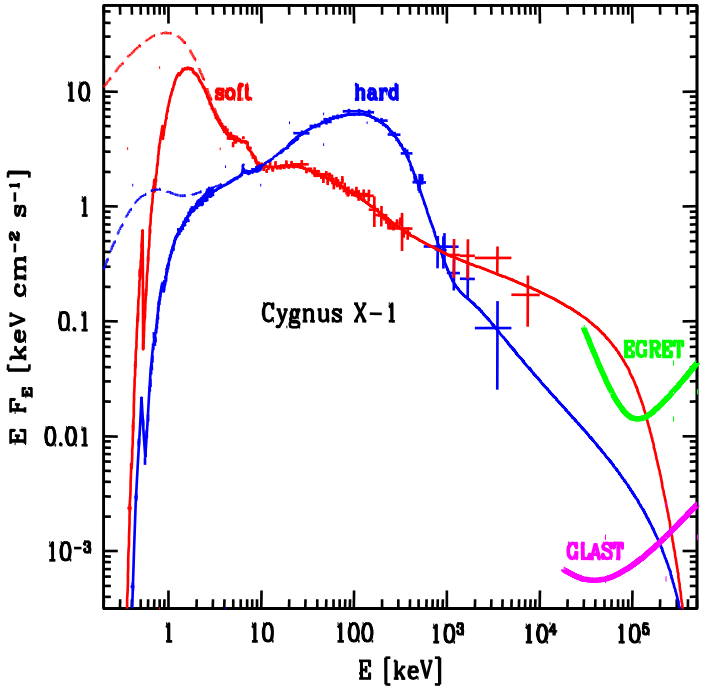
University of Oulu

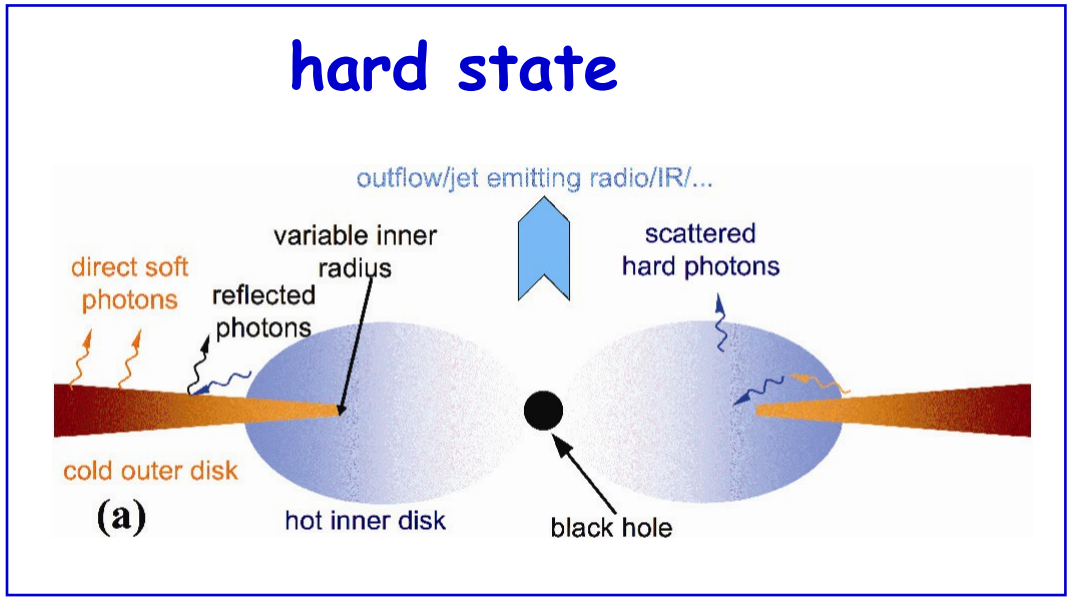
# Outline

- Black hole spectra: radio to X-rays
- Optical/X-ray variability
- Spectral and timing modelling

# OBSERVATIONS

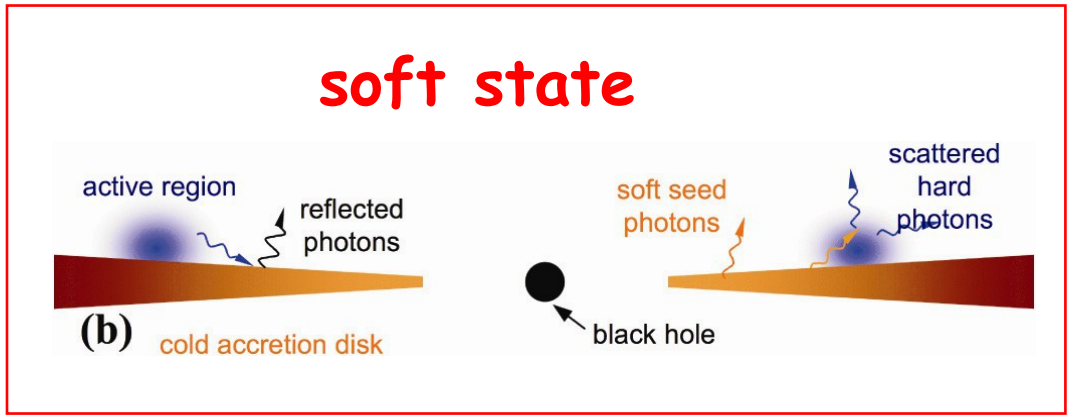
# X-ray spectra and geometry



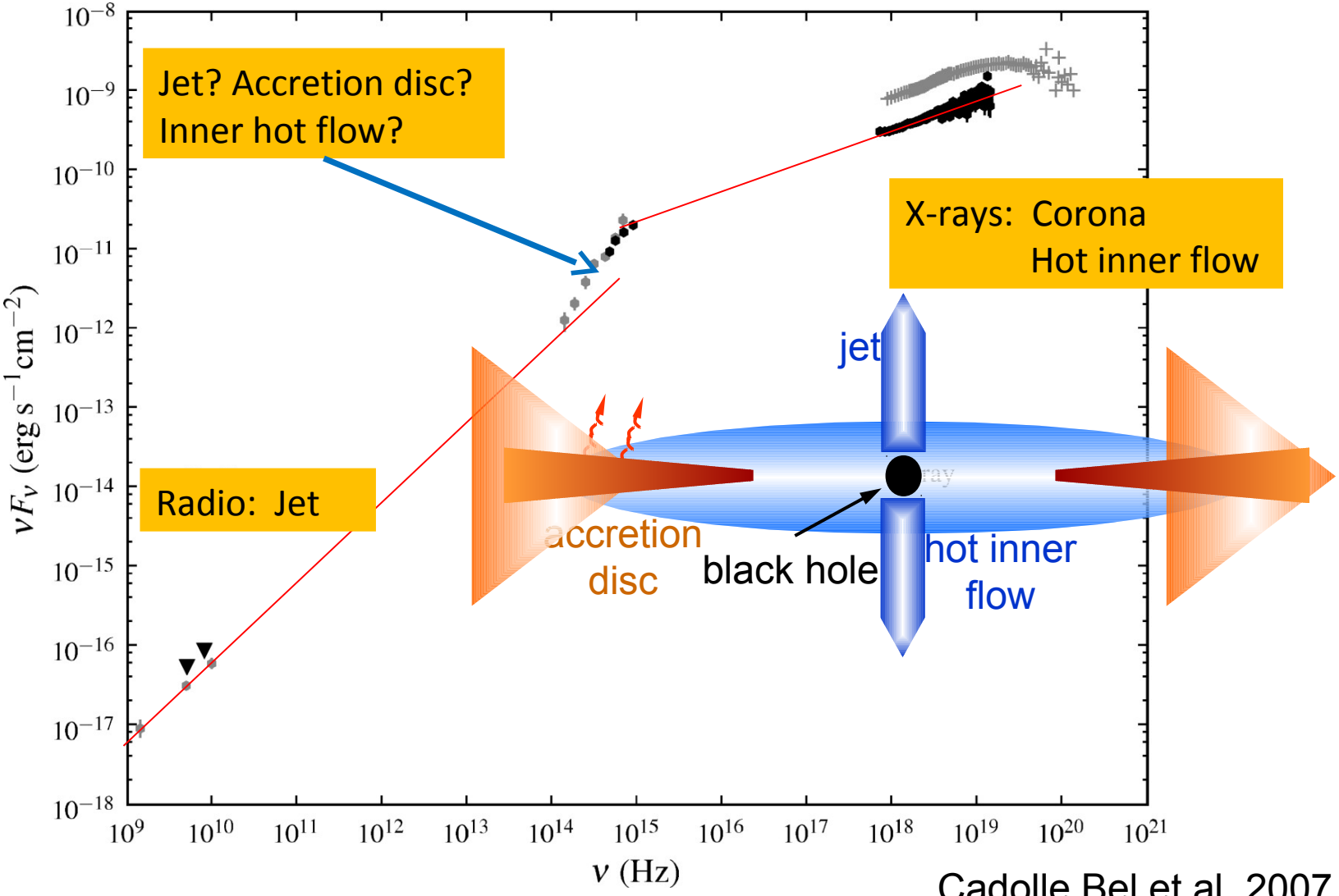

Hard state - standard cold outer disk + hot inner flow?

Soft state - standard accretion $\alpha$ -disk, plus corona?




Zdziarski & Gierlinski, 2004

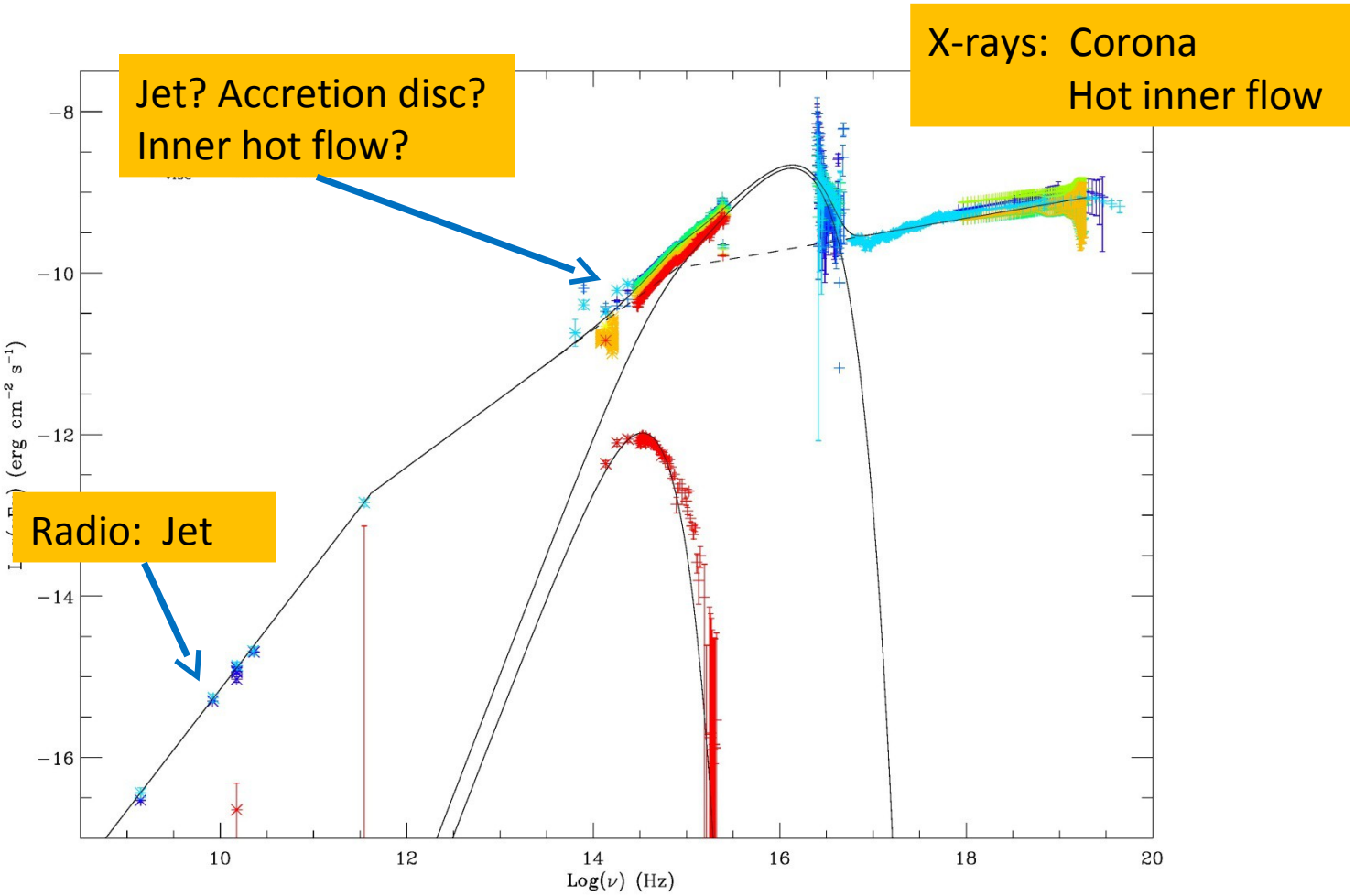
# Broadband spectra of LMXBs




Swift J1753.5-0127

Cadolle Bel et al. 2007,
Durant et al. 2009

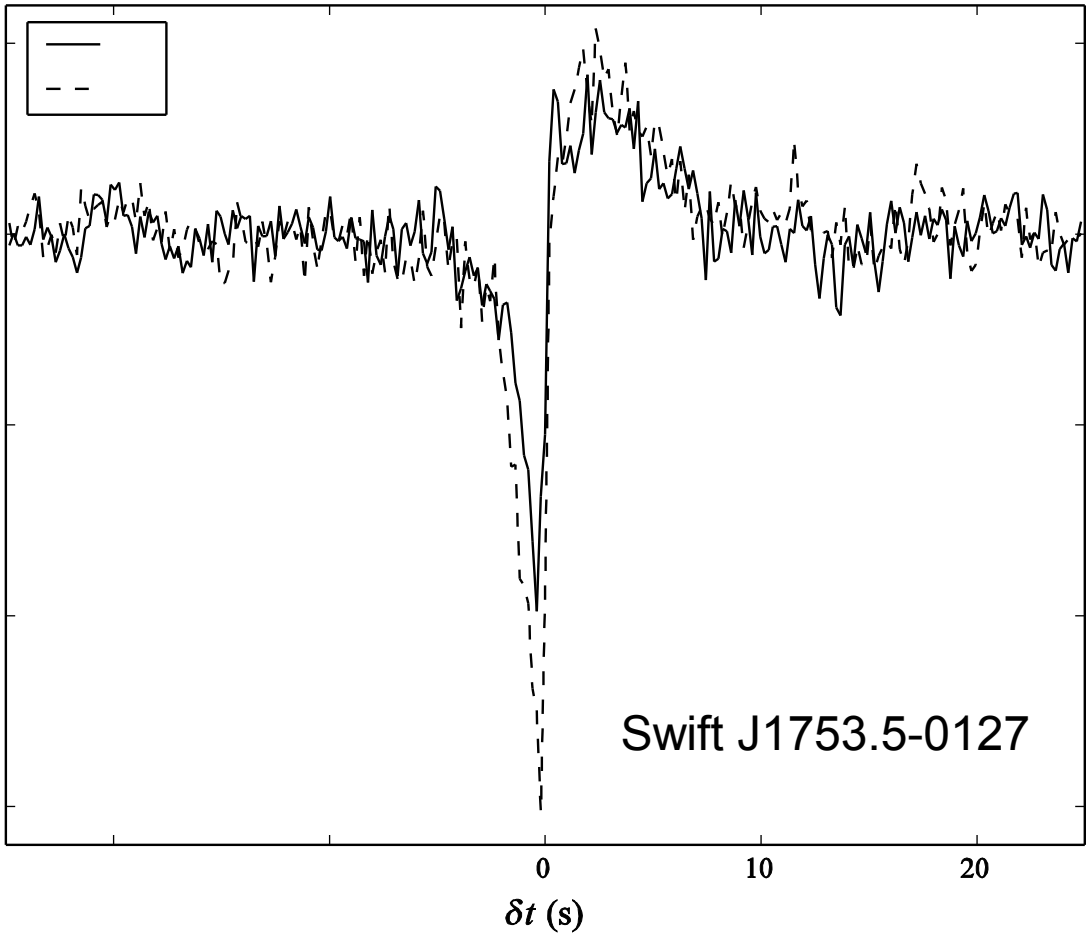
# Broadband spectra of LMXBs




XTE J1118+480

Chaty et al. 2003

# Optical/X-ray cross-correlation




Durant et al. 2010

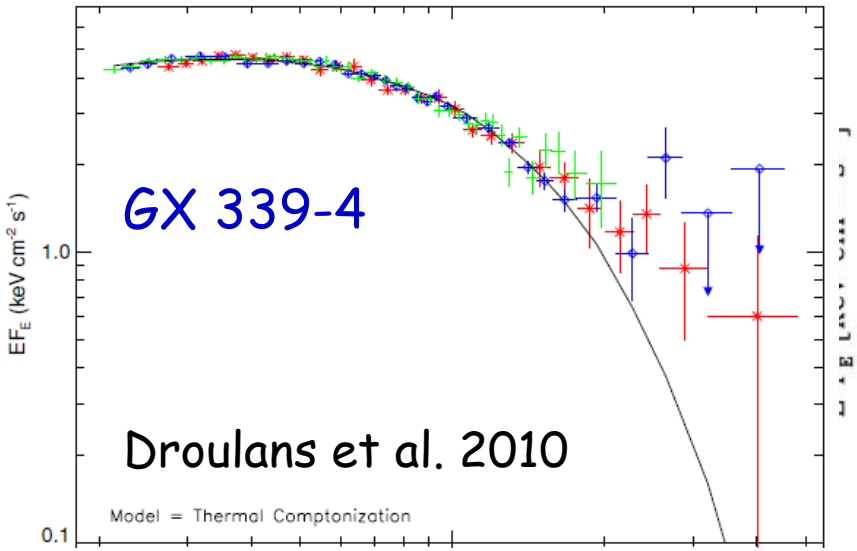
# Observational aspects

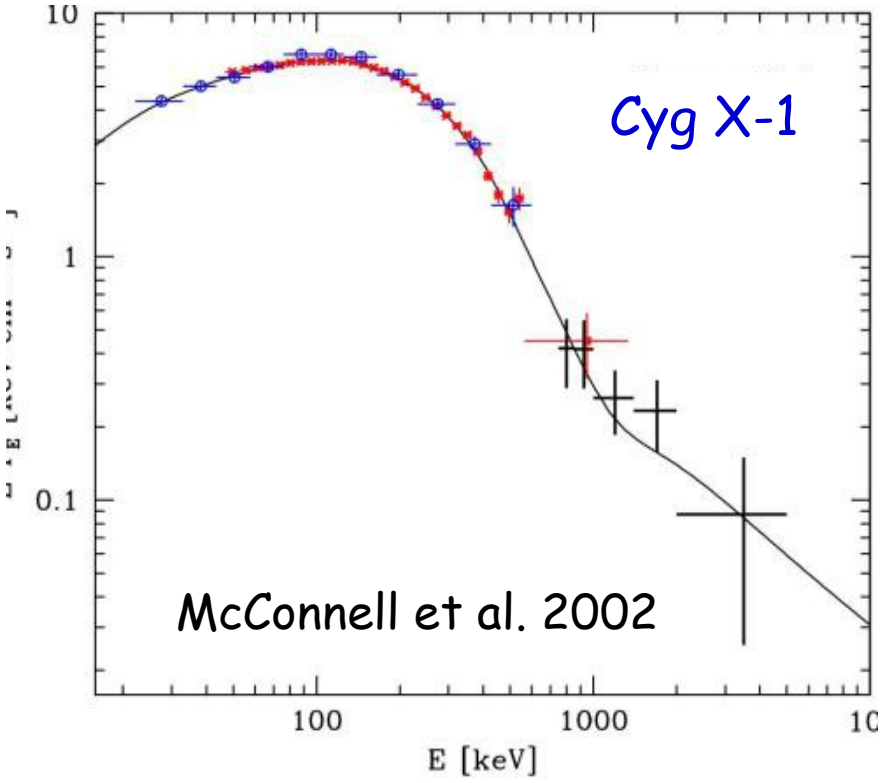
- Spectrum: optical/infrared spectrum is inconsistent with being produced by standard accretion disc or the jet

- Timing: mysterious shape of the cross-correlation function

# MODELING

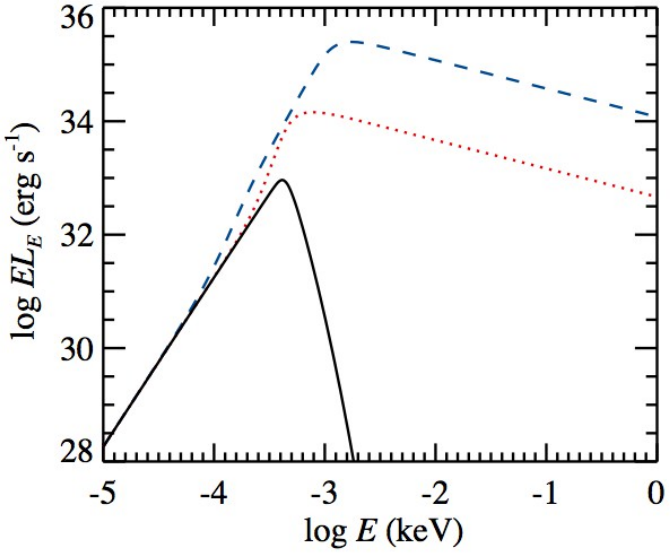
# Thermal Comptonization in the hard state




A weak non-thermal tail is present

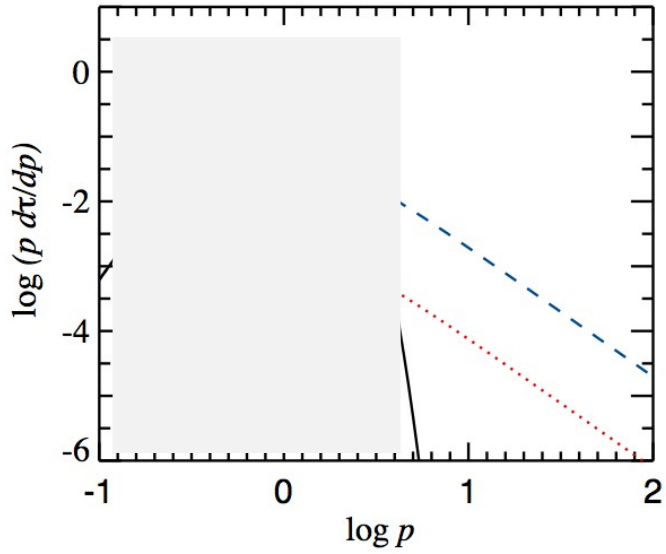
# Synchrotron in hybrid plasma




Hybrid electrons, 1% energy
in the non-thermal component

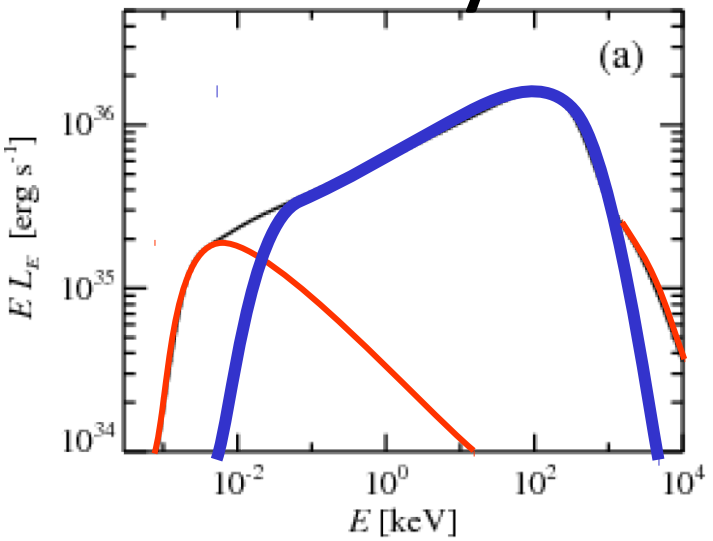
Hybrid electrons, 0.01% energy
in the non-thermal component

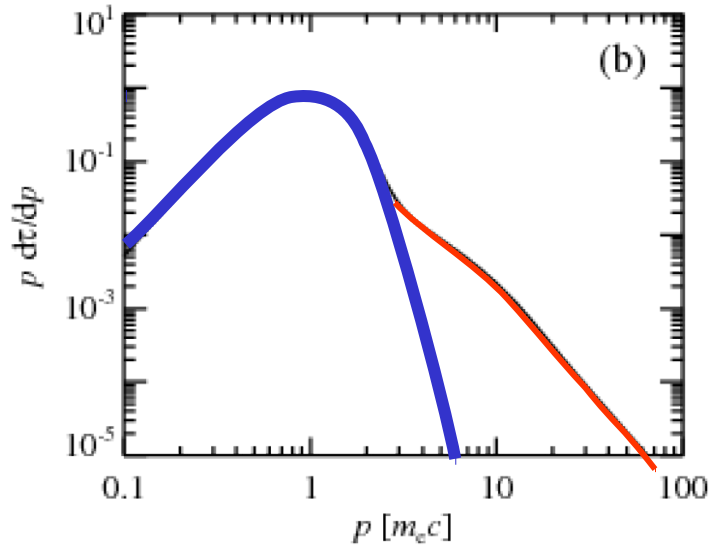
Thermal electrons, 100 keV




Synchrotron can be the main source of
seed photons for Comptonization

# Synchrotron Self-Compton (SSC) mechanism in hybrid plasma



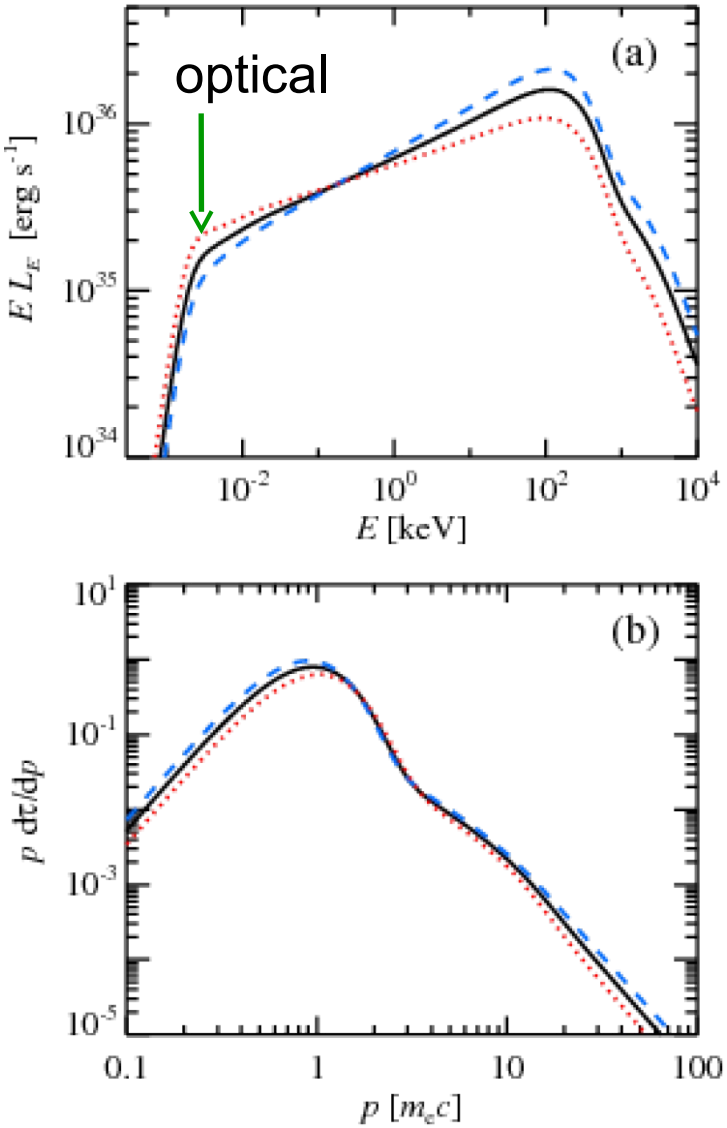




$R = 9 \times 10^{7}\,cm$

$\tau = 1.0$

$B = 3 \times 10^{5}\,G$

# Synchrotron Self-Compton mechanism in hybrid plasma




$$R \propto \dot{m}^{-4/3}$$ (Rozanska & Czerny 2000)

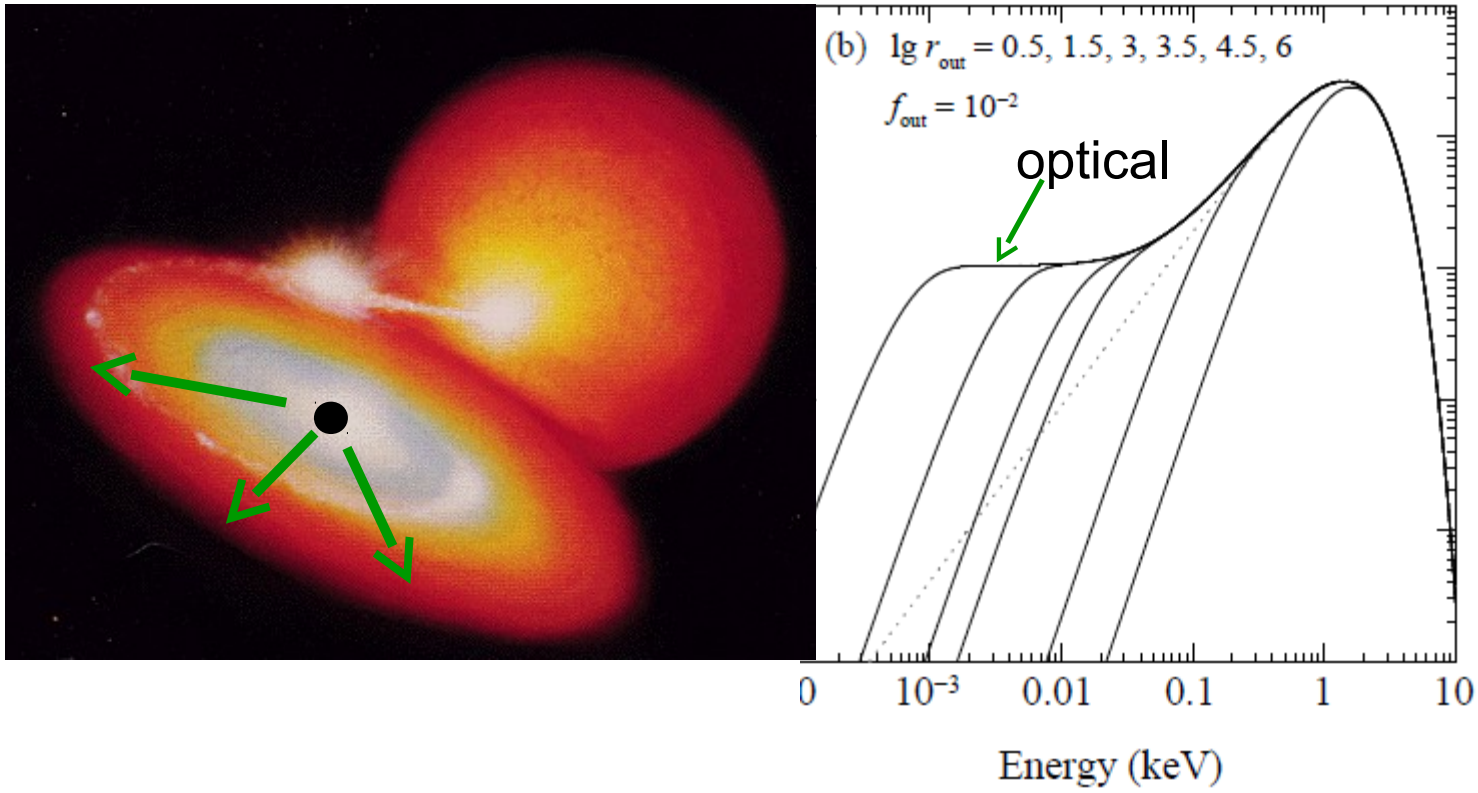
$$L \propto \dot{m}$$

$$\tau \propto \dot{m}$$

$$B = const$$

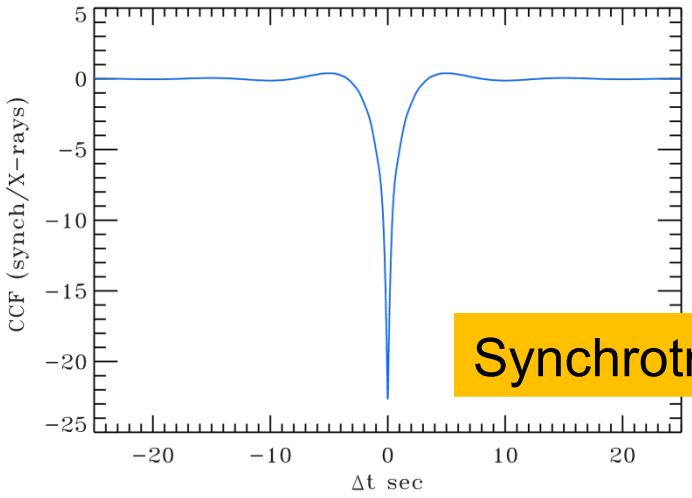
The optical and the X-rays are anticorrelated

# Irradiated discs



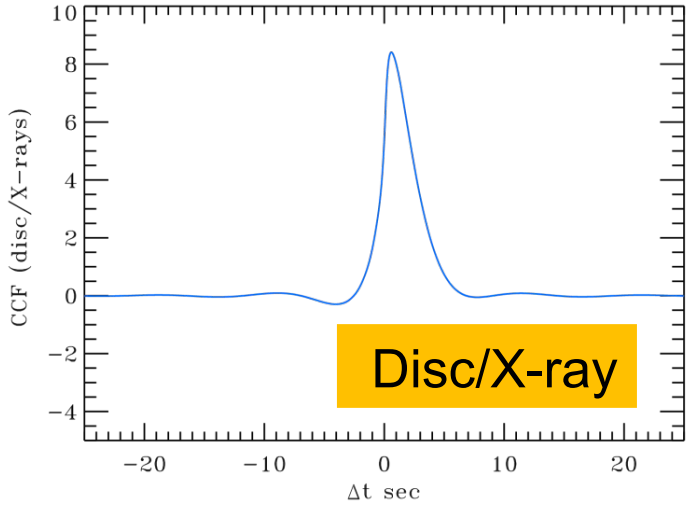

Gierlinski et al. 2009

# Optical/X-ray cross-correlation



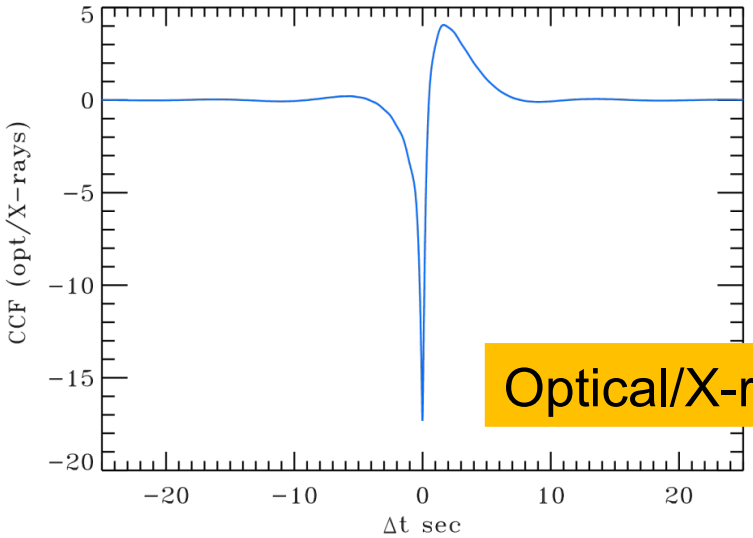

Synchrotron/X-ray

+



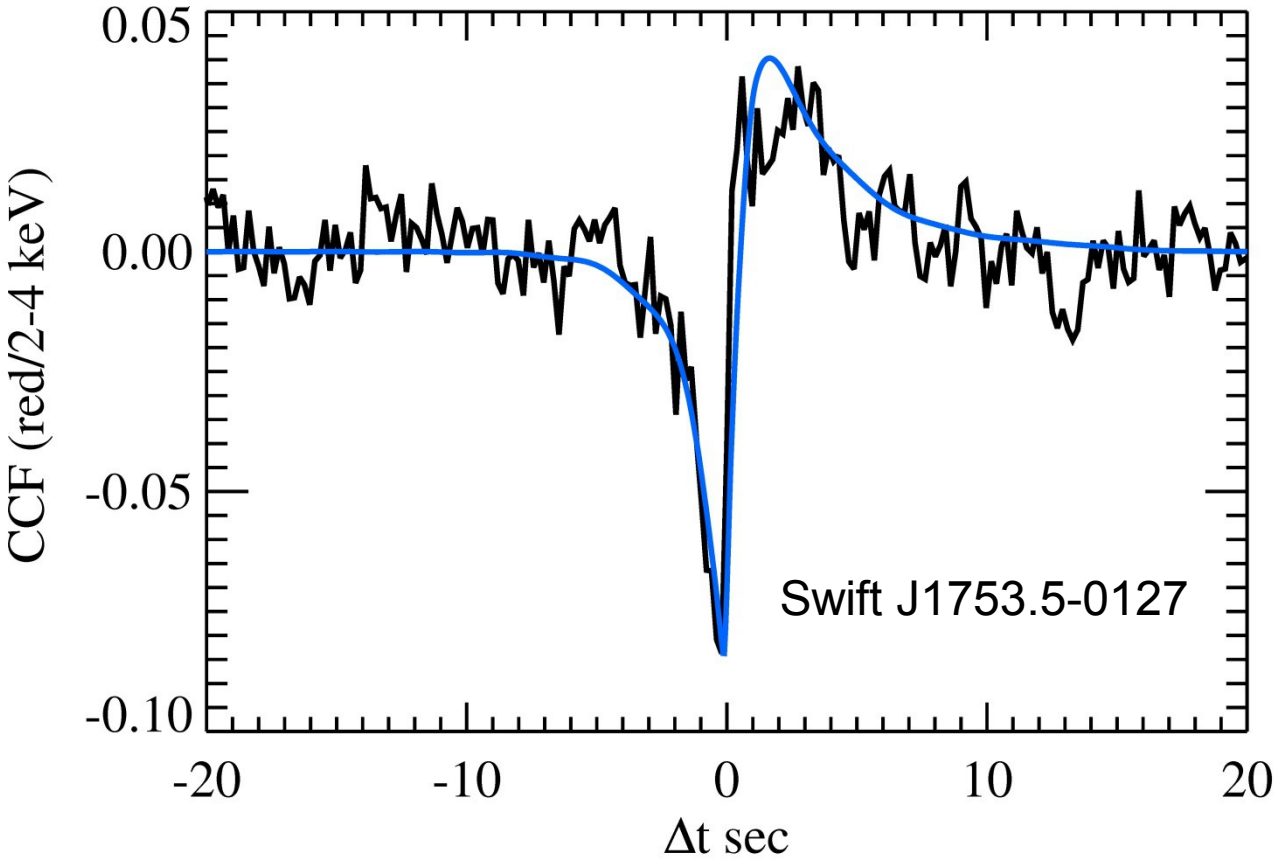

Disc/X-ray

=



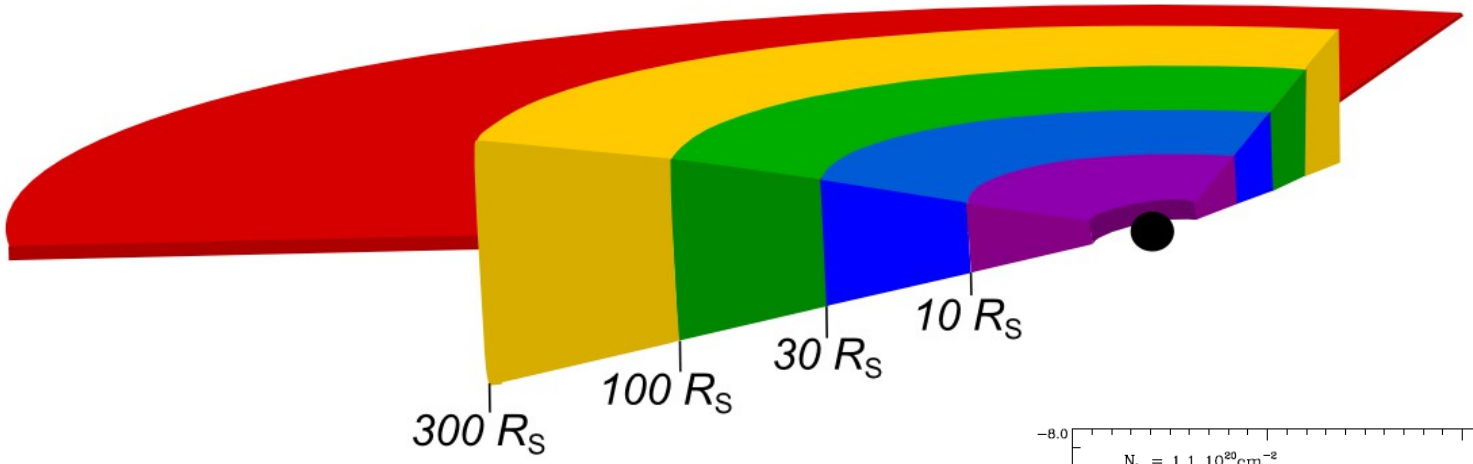

Optical/X-ray

# Comparison with the data



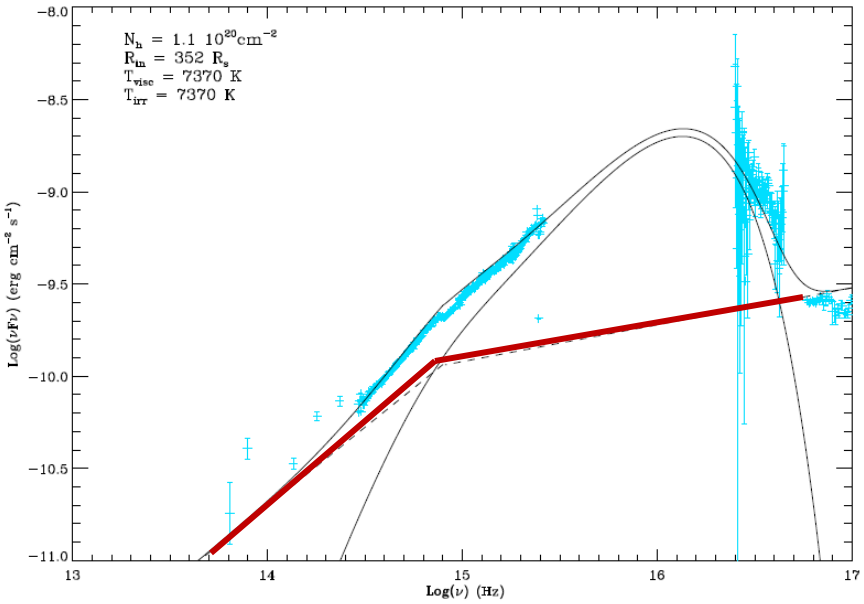

Data from Durant et al. 2010

# Multi-zone hot accretion flow

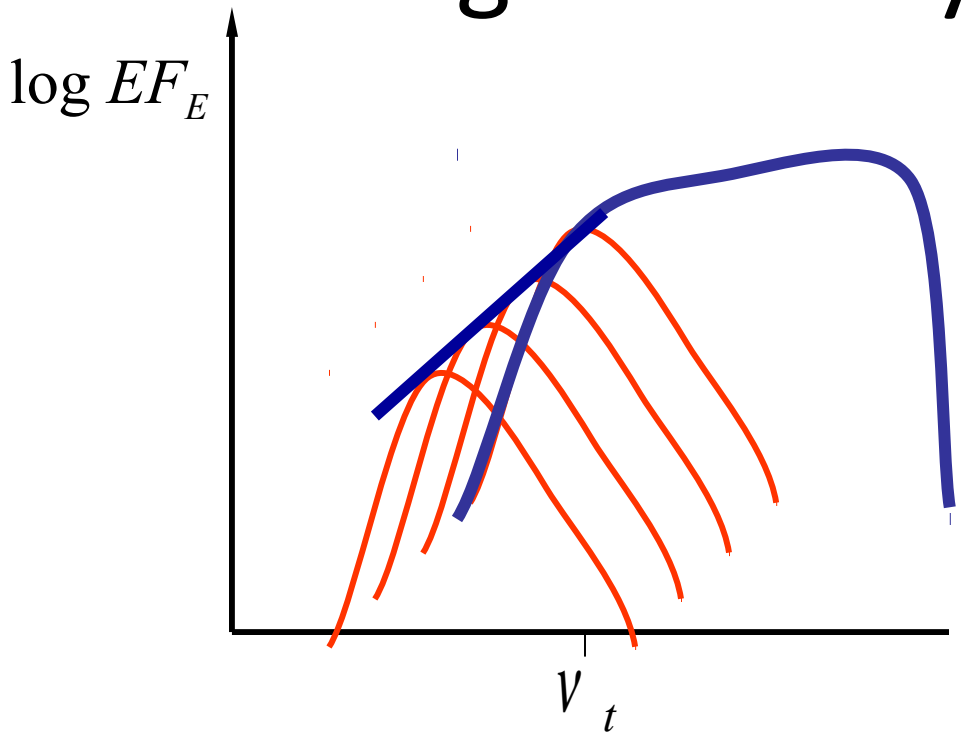



<u>Hot inner flow</u> can be divided into a number of zones. More compact zones have higher self-absorption frequency. The resulting OIR spectrum is flat

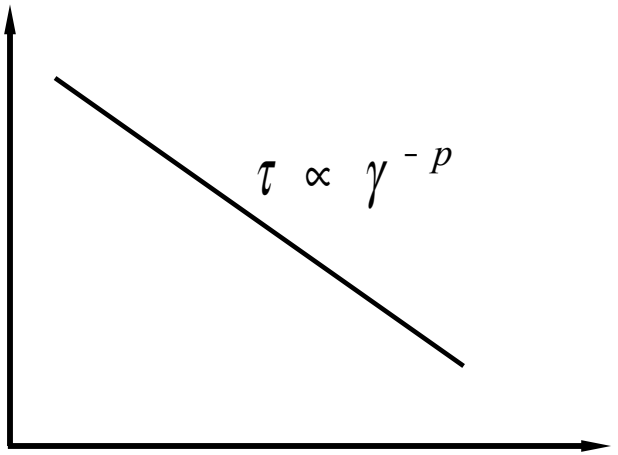
$$F_\nu \propto \nu^0$$

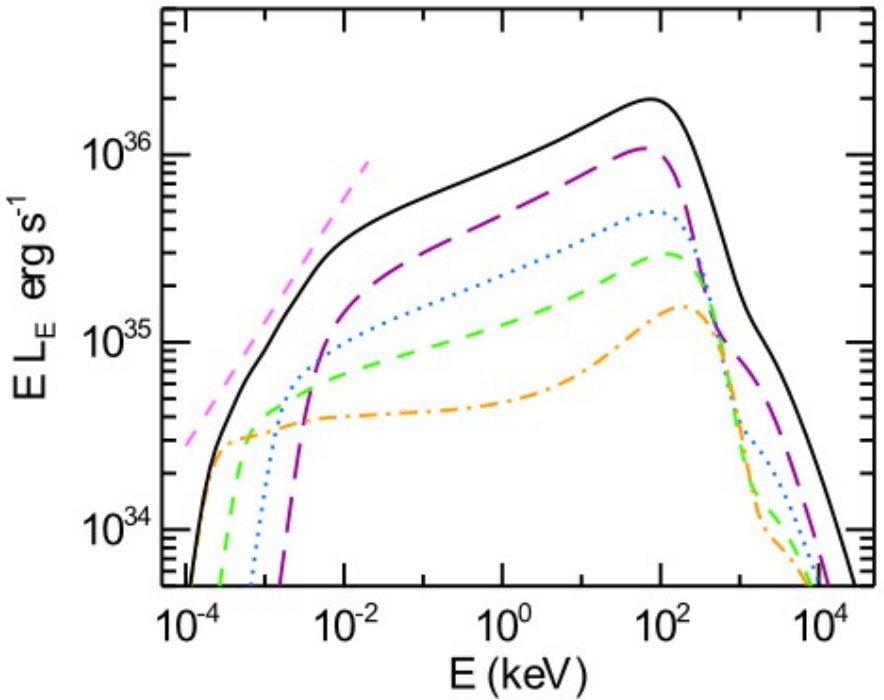


# Inhomogeneous synchrotron source

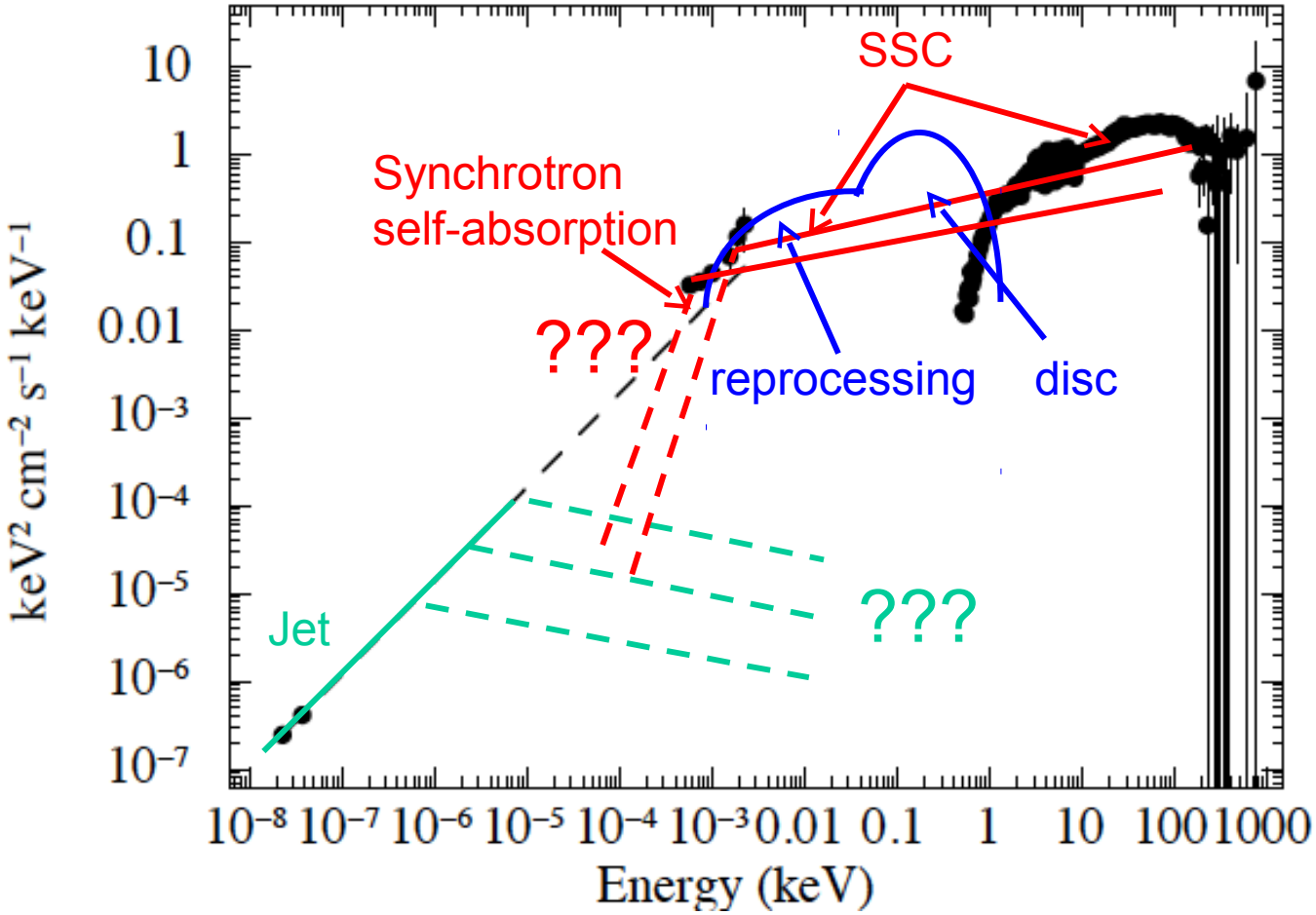



$$\nu_t \propto B^{(p+2)/(p+4)} \tau^{2/(p+4)}$$



# Broadband spectrum and multi-zone hot accretion flow




GX 339-4

Cadolle Bel et al. 2011

# Conclusions

- The mysterious shape of the optical/X-ray CCF is explained by joint contribution of the synchrotron + irradiated disc emission
- Flat optical/infrared spectra can be explained in terms of inhomogeneous SSC model

- Question regarding the importance of the jet at these wavelengths remains to be studied