X/γ-ray studies of the central engine

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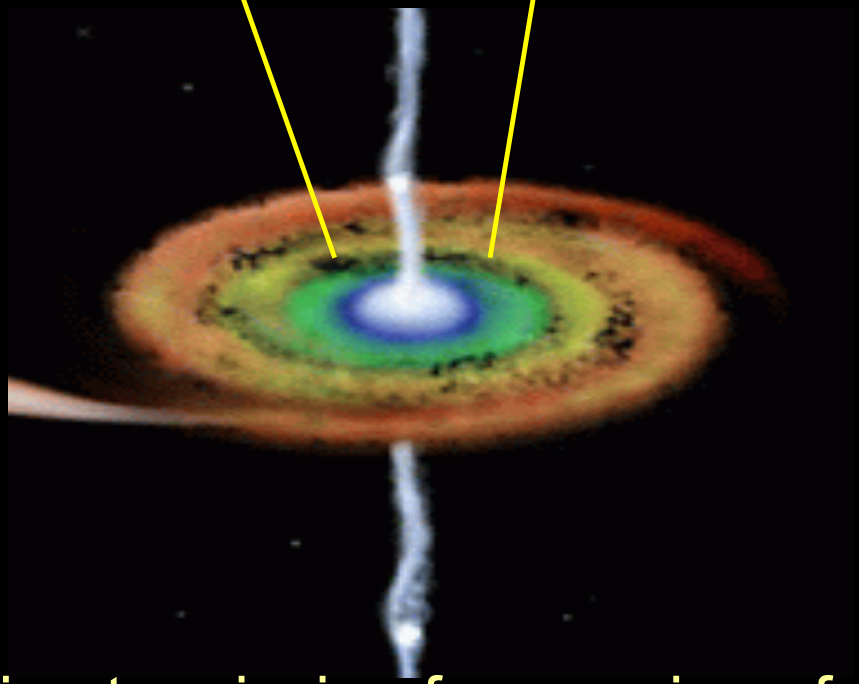
Accretion onto black holes (WG2 and WG4)

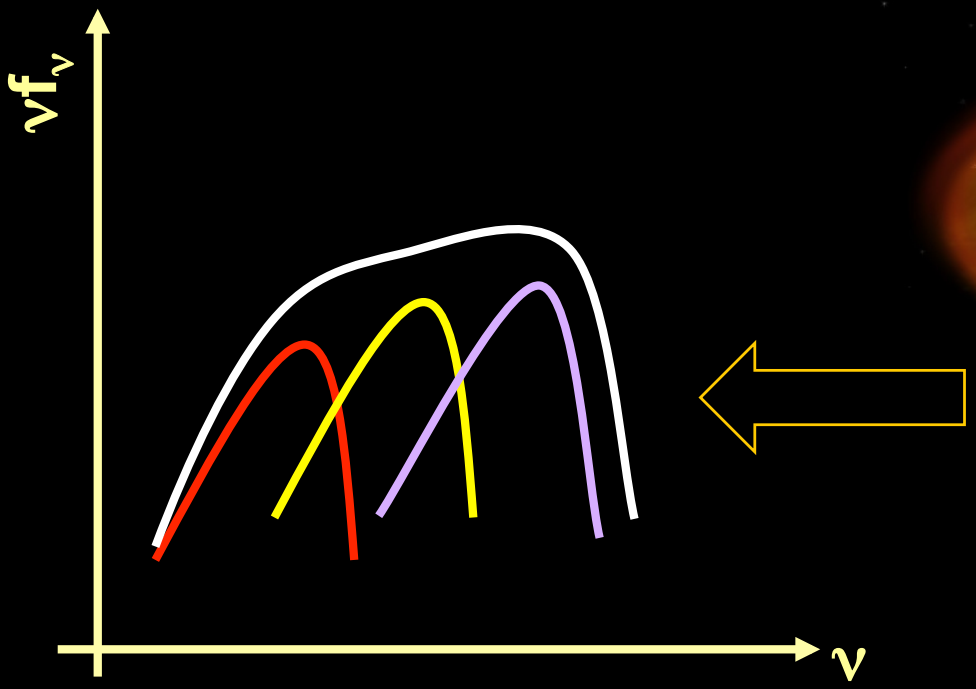
The gravitational potential energy released mostly within 100 R_g

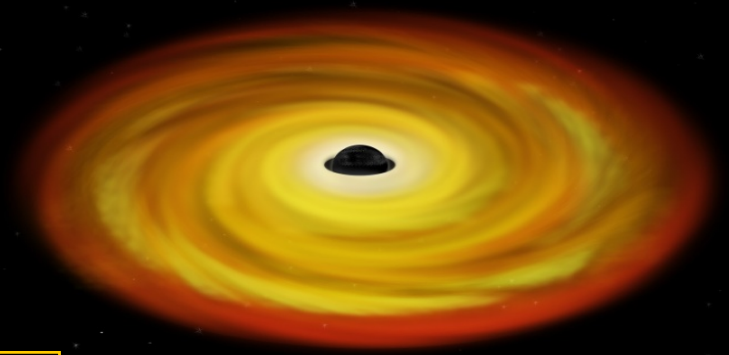


$$R_g = \frac{GM}{c^2}$$ *gravitational radius*

Direct emission from region of strong space-time curvature: if we understand accretion physics, we will be able to put observational constraints on strong gravity

The simplest form of an accretion flow: Keplerian, optically thick disc (Shakura, Sunyaev 1973; Novikov, Thorne 1974)



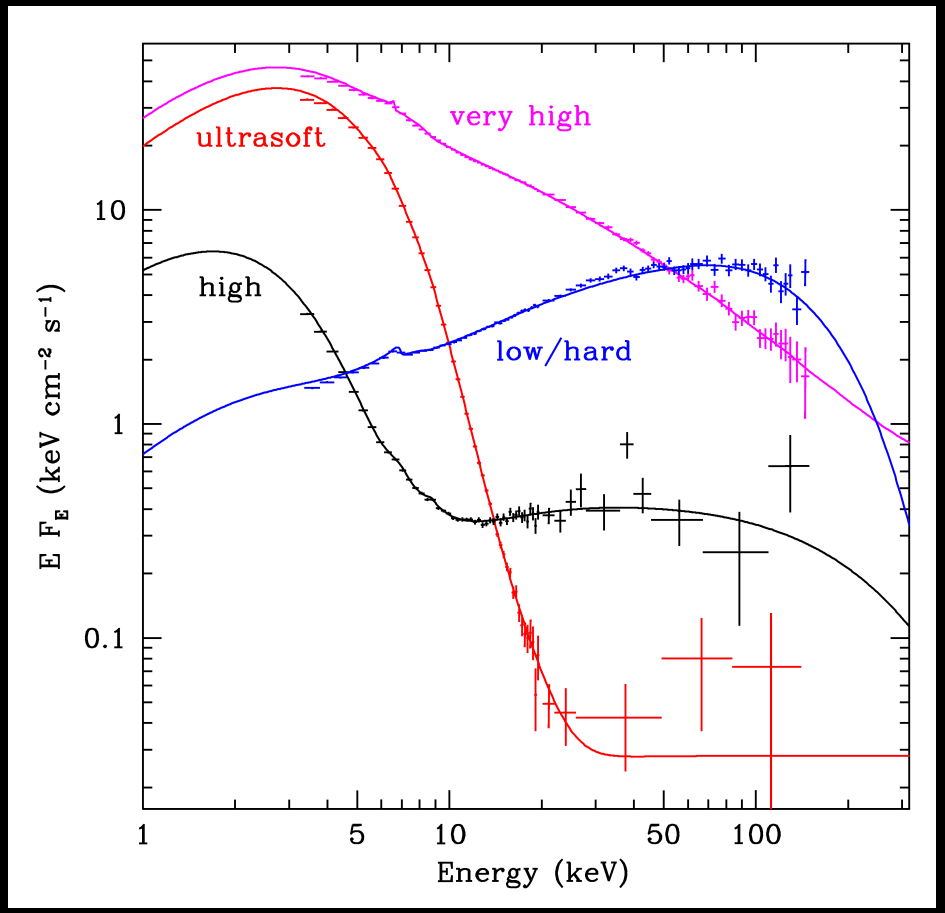


Thermal emission in UV (AGNs) and soft X-rays (BH binaries)

In addition, huge (often dominating) hard X-ray/soft gamma-ray lumiosity → the flow structure is more complex

Models of accretion flows more extensively studied in the context of X-ray binaries, where the wealth of data enables putting stronger constraints on geometry than in the case of AGN

spectral states of BH binaries: the same object, different days



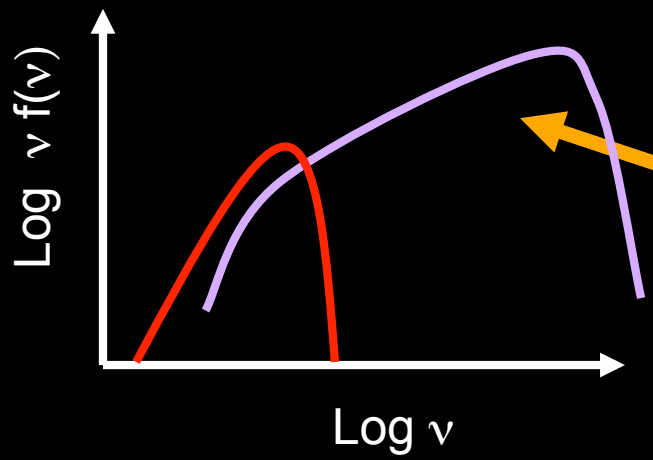
Gierlinski & Done 2003

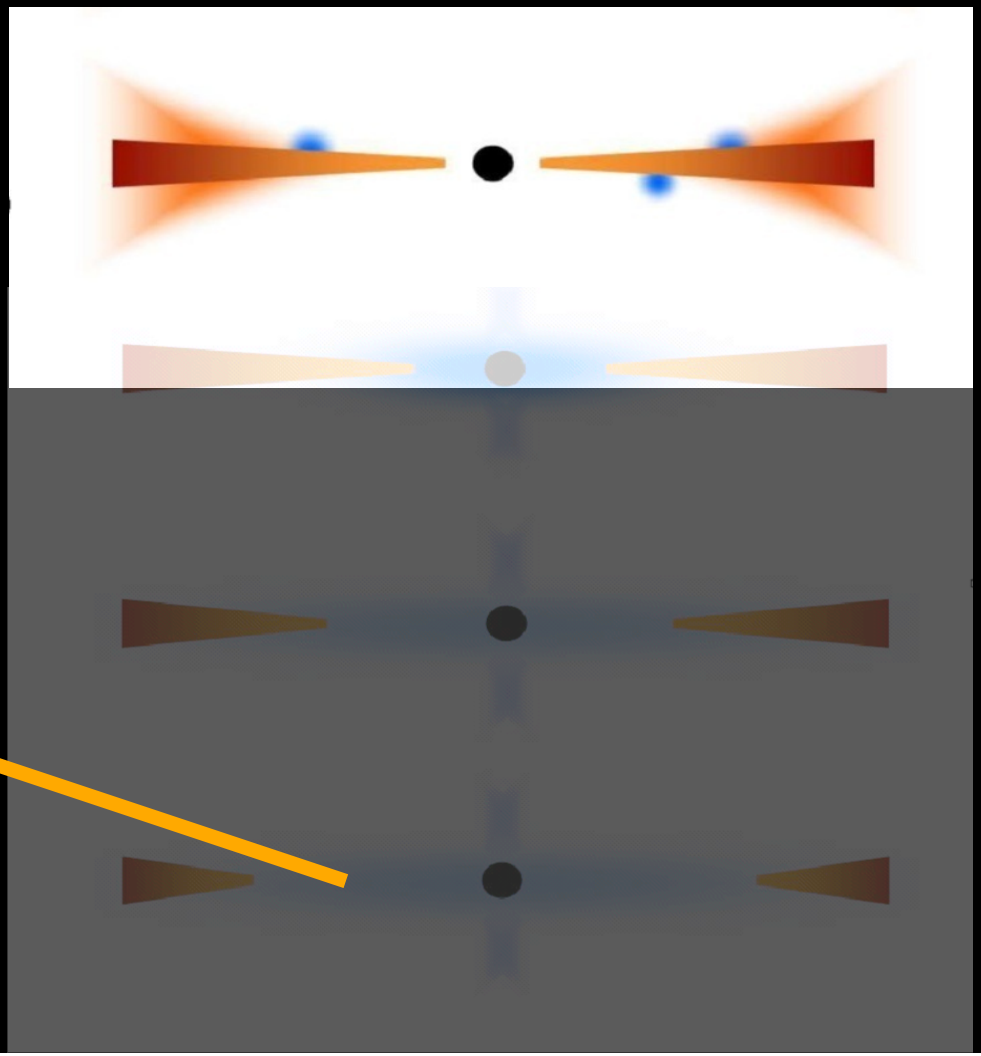
Correlated changes e.g. in jet activity!

Hot inner flow at lower accretion rates

Done et al. 07

Hot, optically thin, geometrically thick flow replacing the inner disc (Shapiro et al. 1976; Narayan & Yi 1995). Hot electrons Compton upscatter photons from outer cool disc





AGN ???

Normal Seyfert galaxies – similar to hard spectral states? With a hot inner flow?

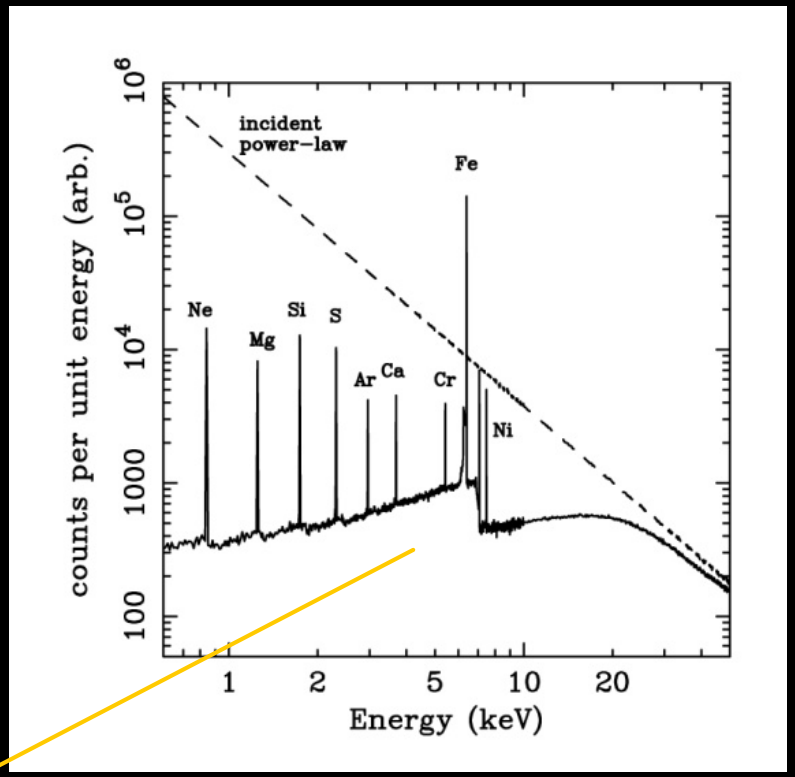
Higher accretion rate objects (NLSy1): similar to soft (very high) states?

The most powerful diagnostic of the flow structure: X-ray reflection spectrum ….

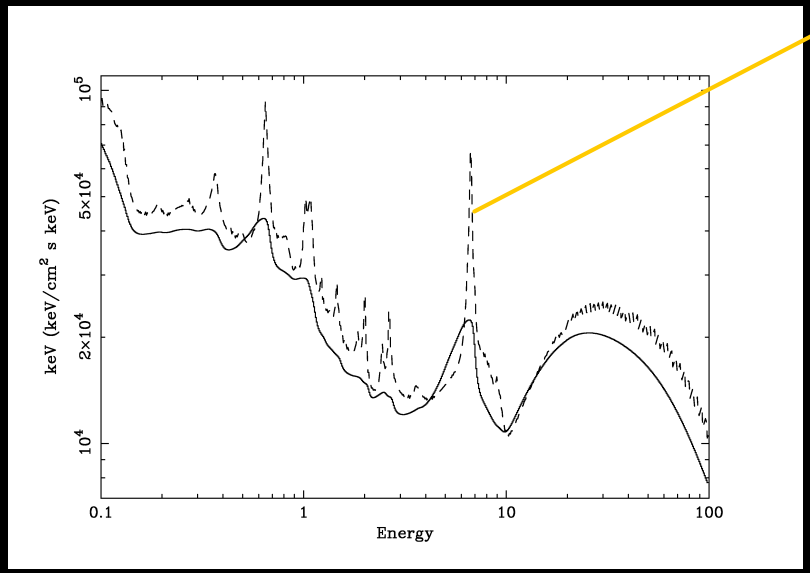
Irradiation of the dense disc material by hard X-rays gives rise to a reflection spectrum which is the result of Compton scattering and photoelectric absorption followed by fluorescent line emission.

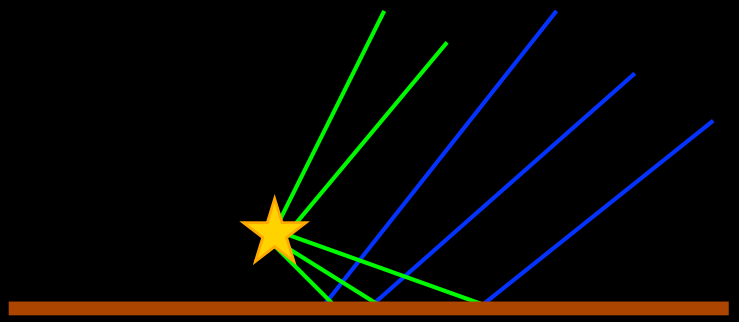
Fe Kα line at **6.4 keV** is the most prominent fluorescent line in the X-ray reflection spectrum (large cosmic abundance + high fluorescent yield).

Reflection spectrum in the disc **rest frame**

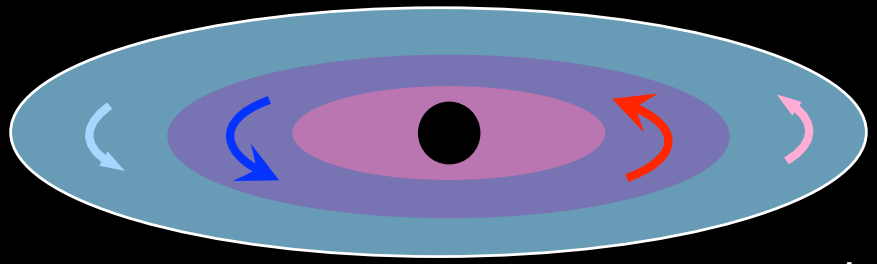


Observed (relativistically blurred)





The line shape is distorted by special and general relativistic effects.



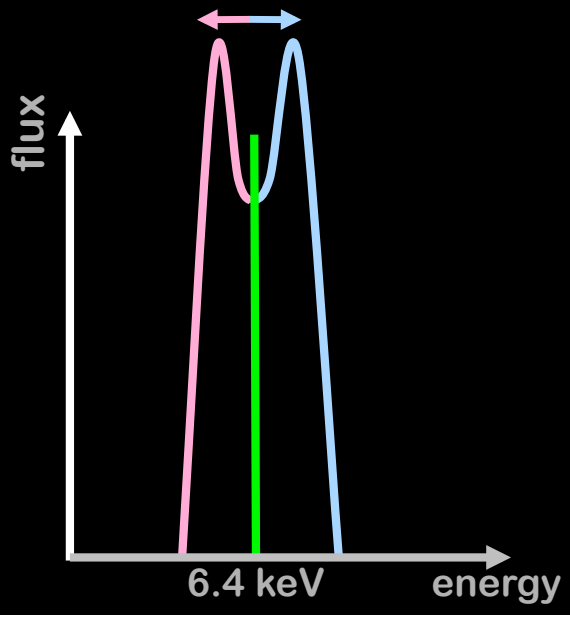
each radius on the disc produces a symmetric double-peaked line profile with the peaks corresponding to emission from the approaching and receding sides of the disc

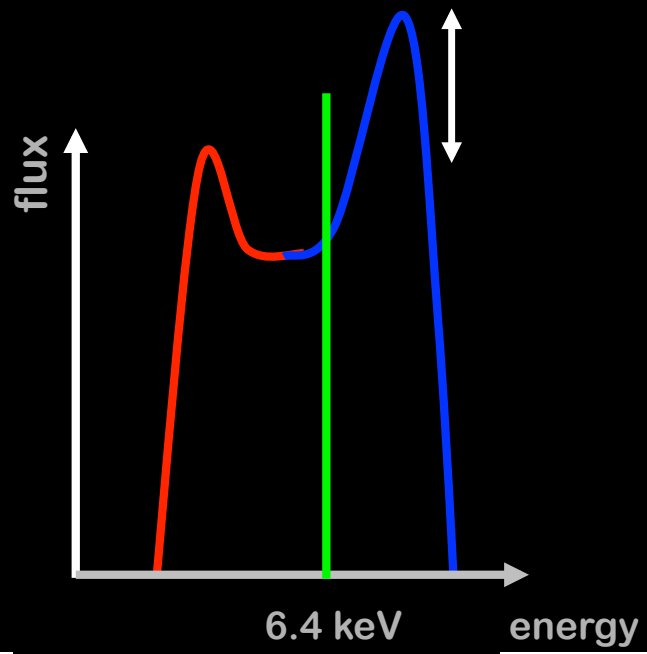
relativistic beaming enhances the blue peak with respect to the red one

transverse Doppler effect: $1/\gamma$

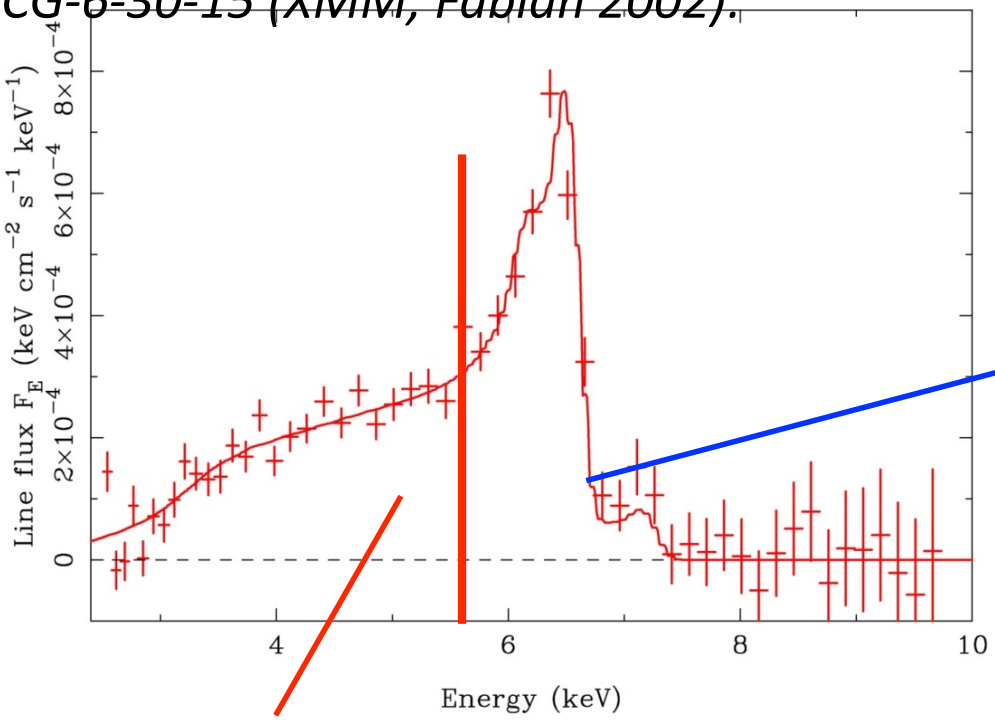
gravitational redshift

classical Doppler effect:





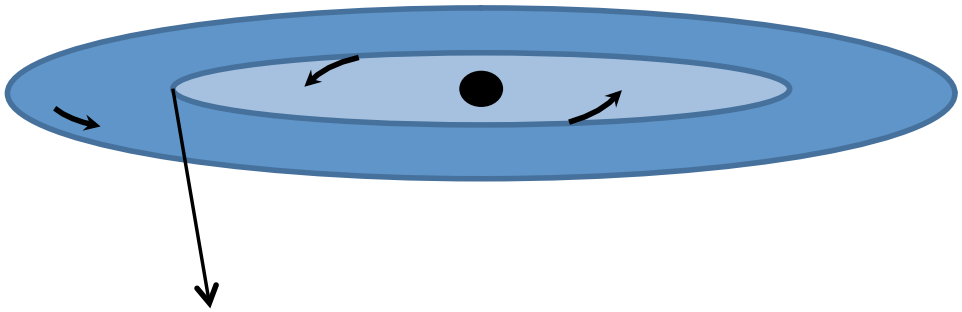
MCG-6-30-15 (XMM; Fabian 2002):



$R > 6R_g$

$2R_g < R < 6R_g$

a = 0.989
(Brenneman 2006)



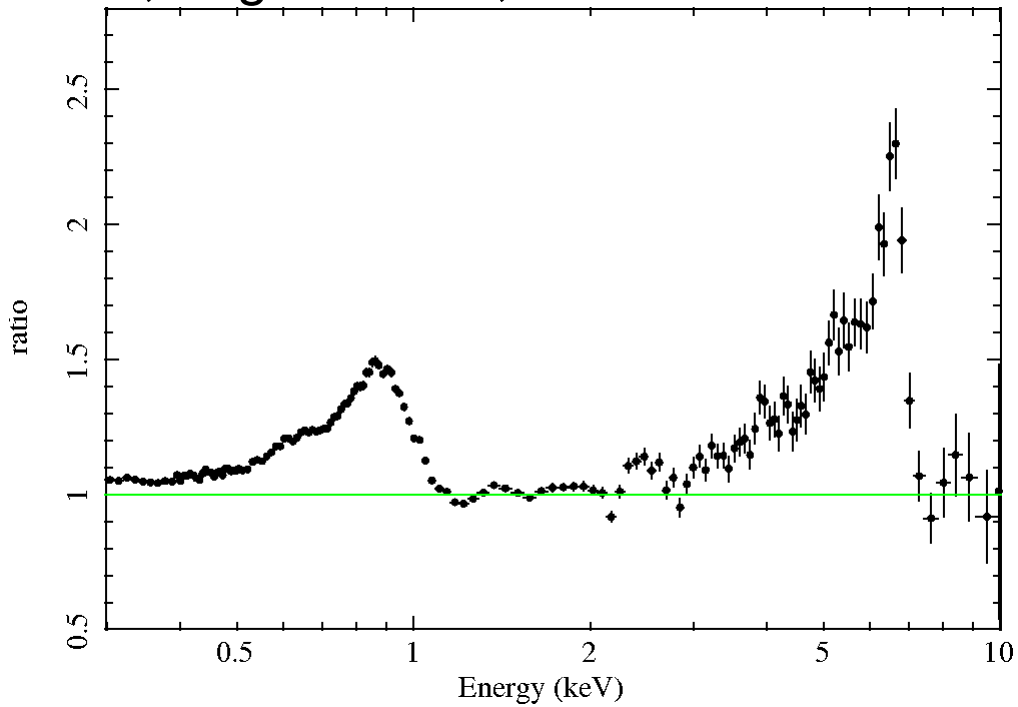
a=0.998: ≈1.2R_g
a=0: 6R_g

$$a = \frac{J}{cMR_g}$$

J – BH angular momentum

$J_{max} \rightarrow a$=0.998

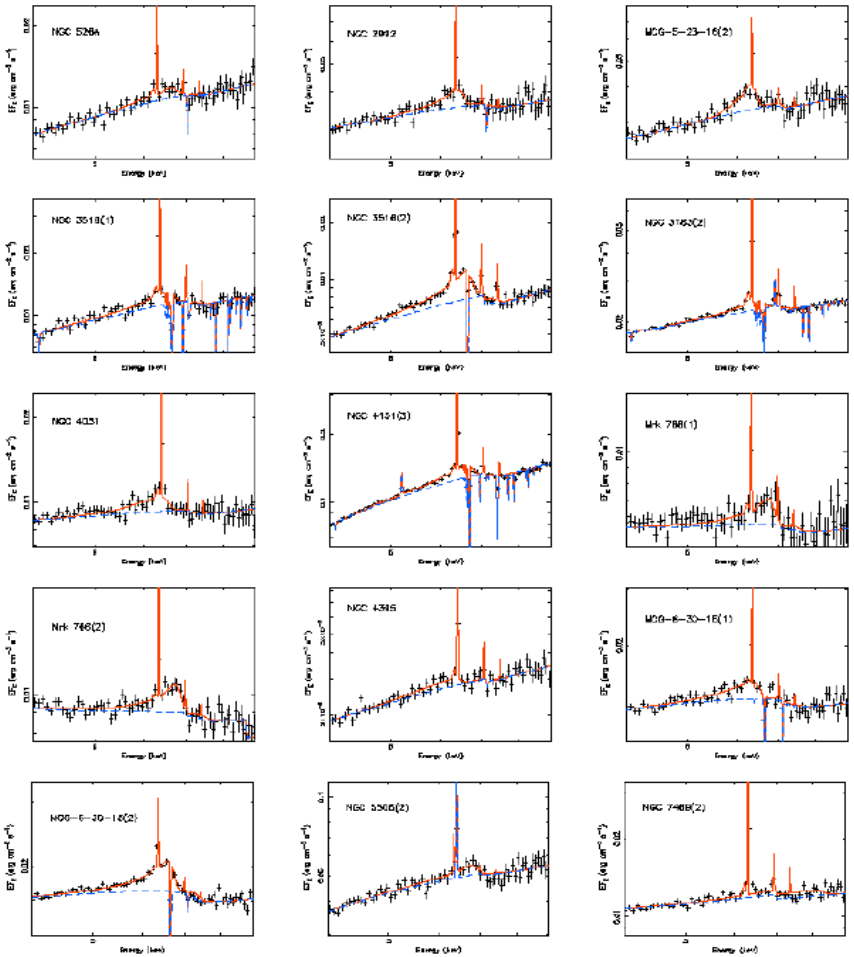
XMM, Zoghbi 2009 ; 1H0707-495

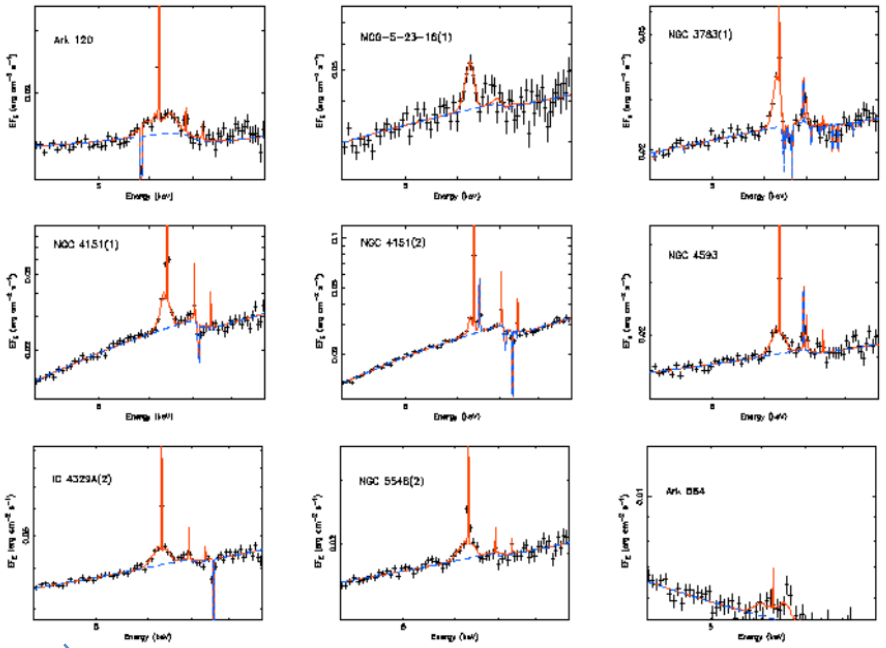


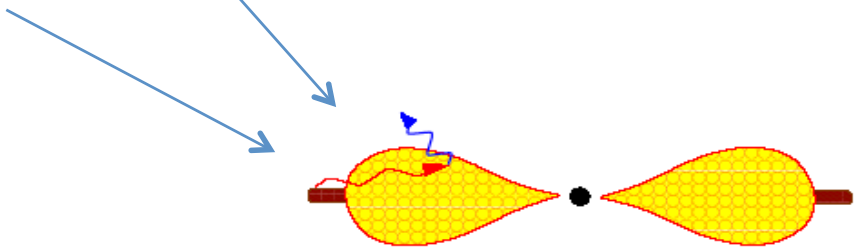
Soltan-type studies: mean accretion efficiency higher than 0,1 in AGN → a > 0.5 → most observed accretion energy released within innermost few R_g

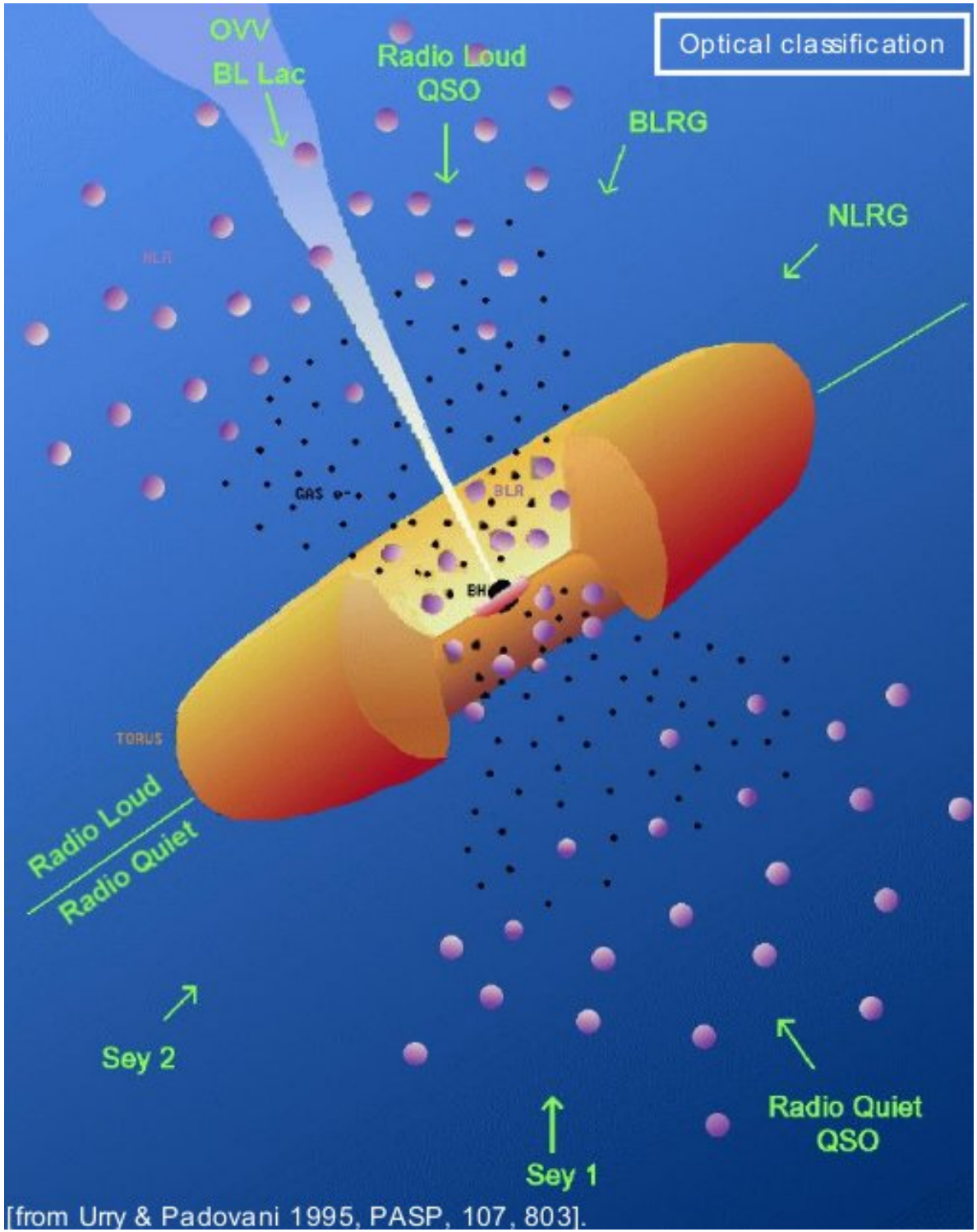
Nandra et al (2007):

In most objects $R > 10R_g$ *in many* $R > 50R_g$

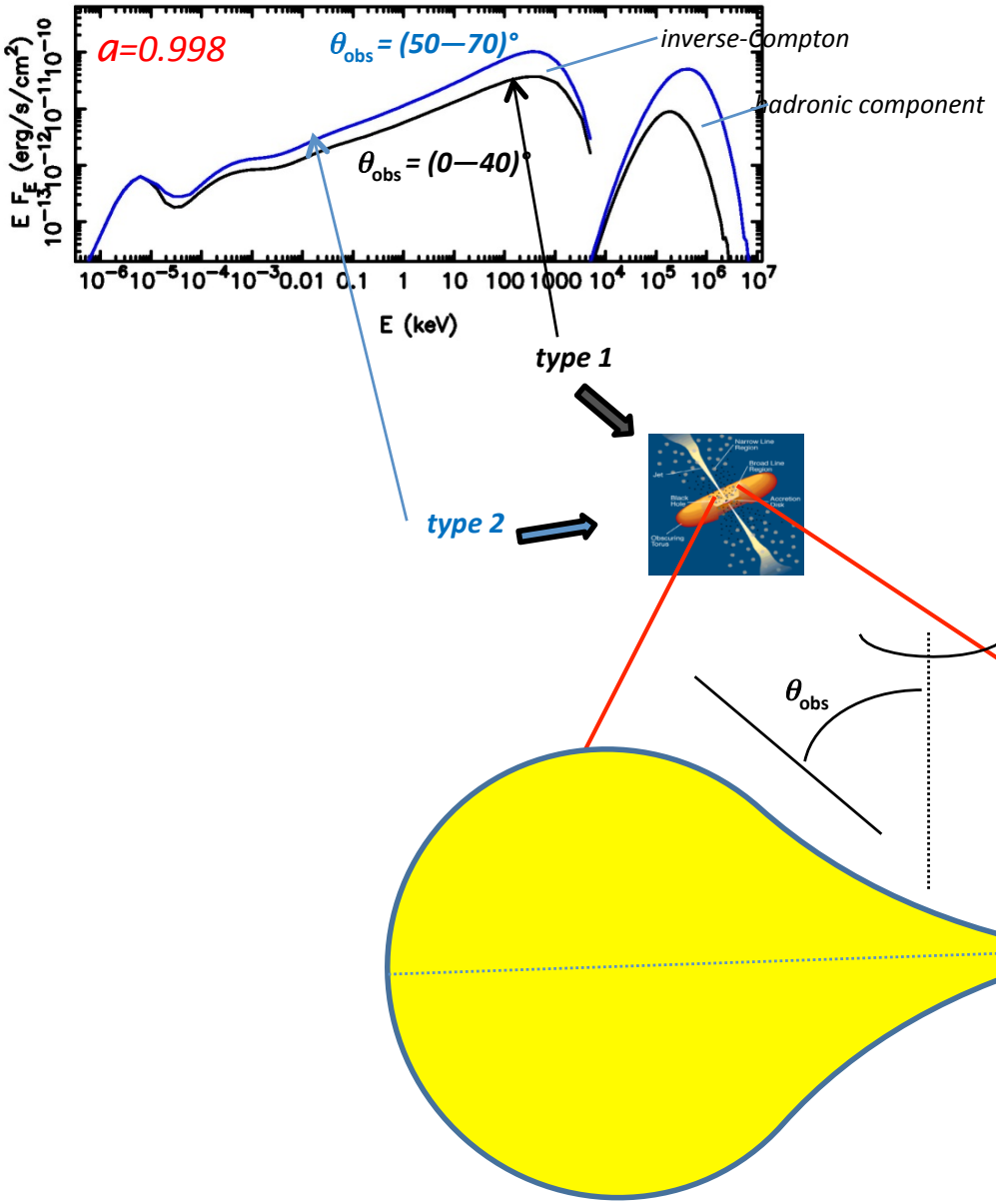








[from Urry & Padovani 1995, PASP, 107, 803].

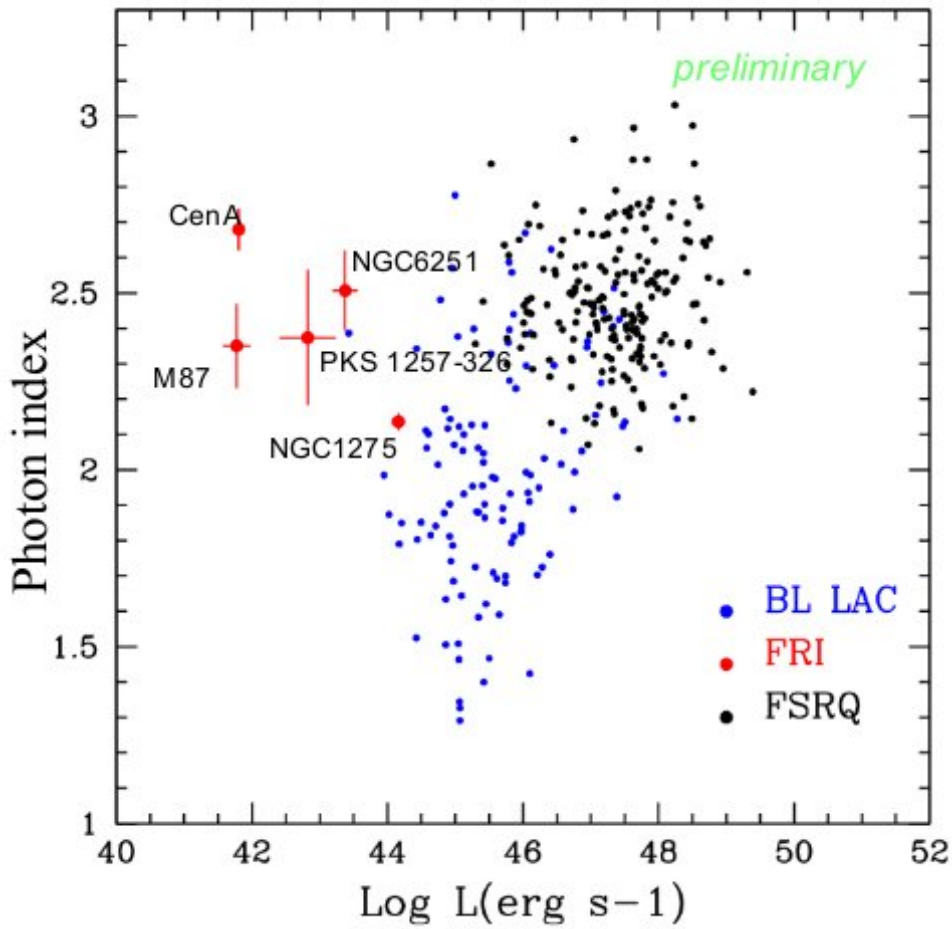


type 1 – type 2 hard x-ray dychotomy

Radiation produced close to a rapidly rotating black hole is gravitationally focused toward the equatorial plane → contribution from that region is stronger for observers with larger θ_{obs}

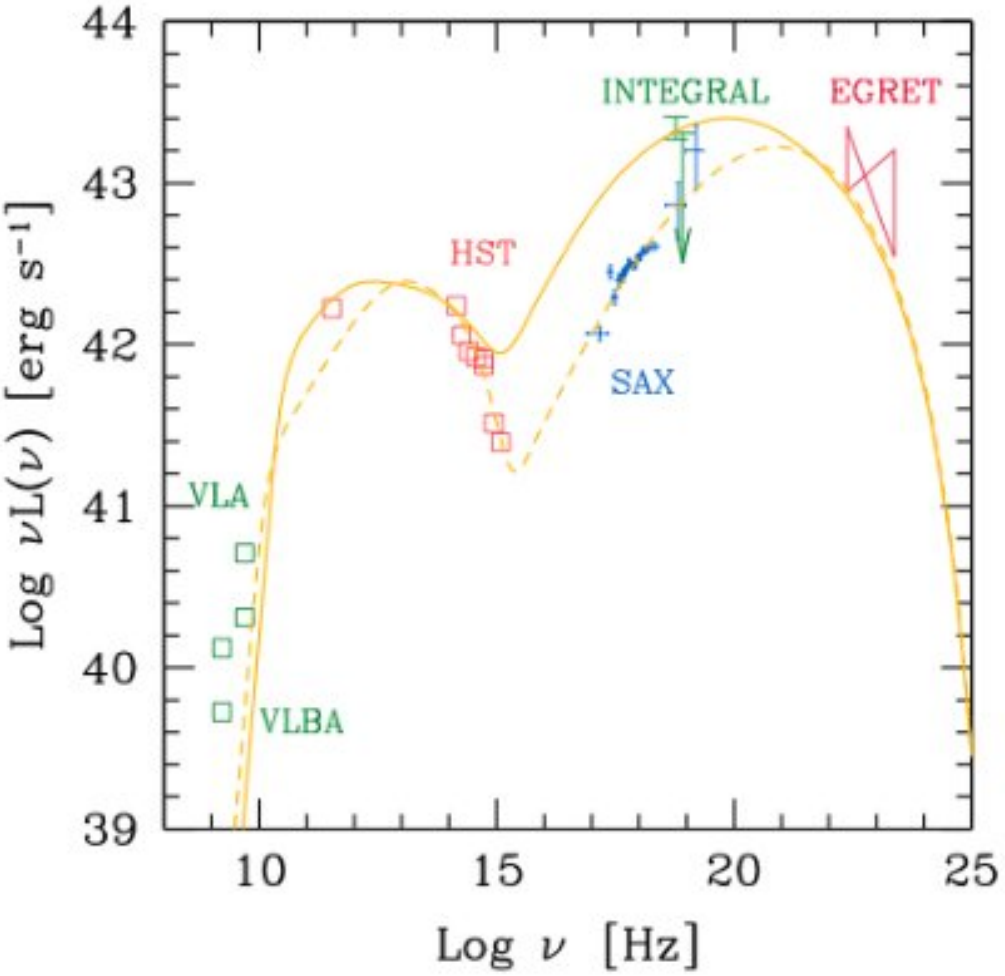
Several radio galaxies detected by *Fermi*

Cavazzuti 2009



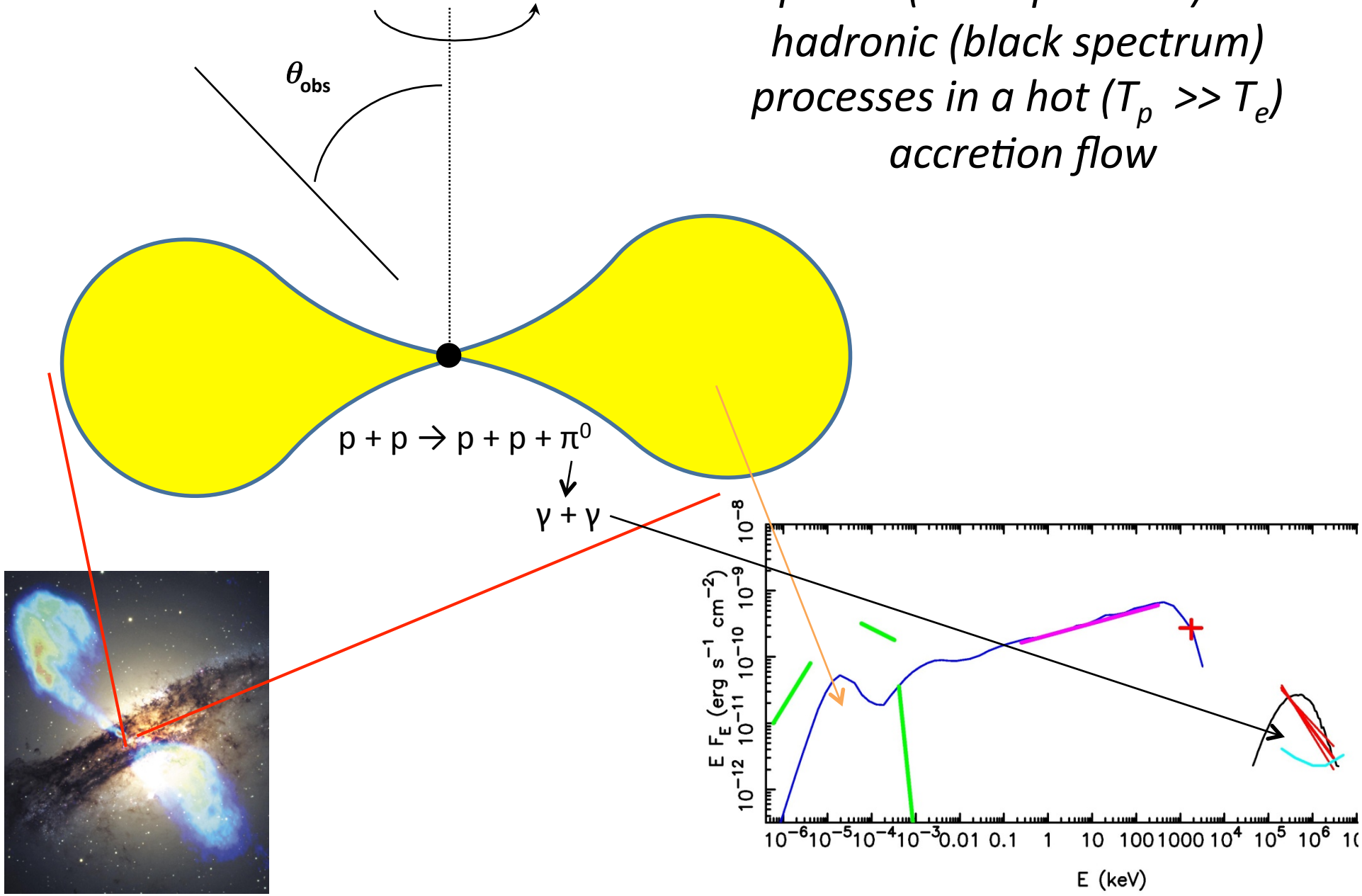
Interpretation of the gamma-ray emission process - uncertain

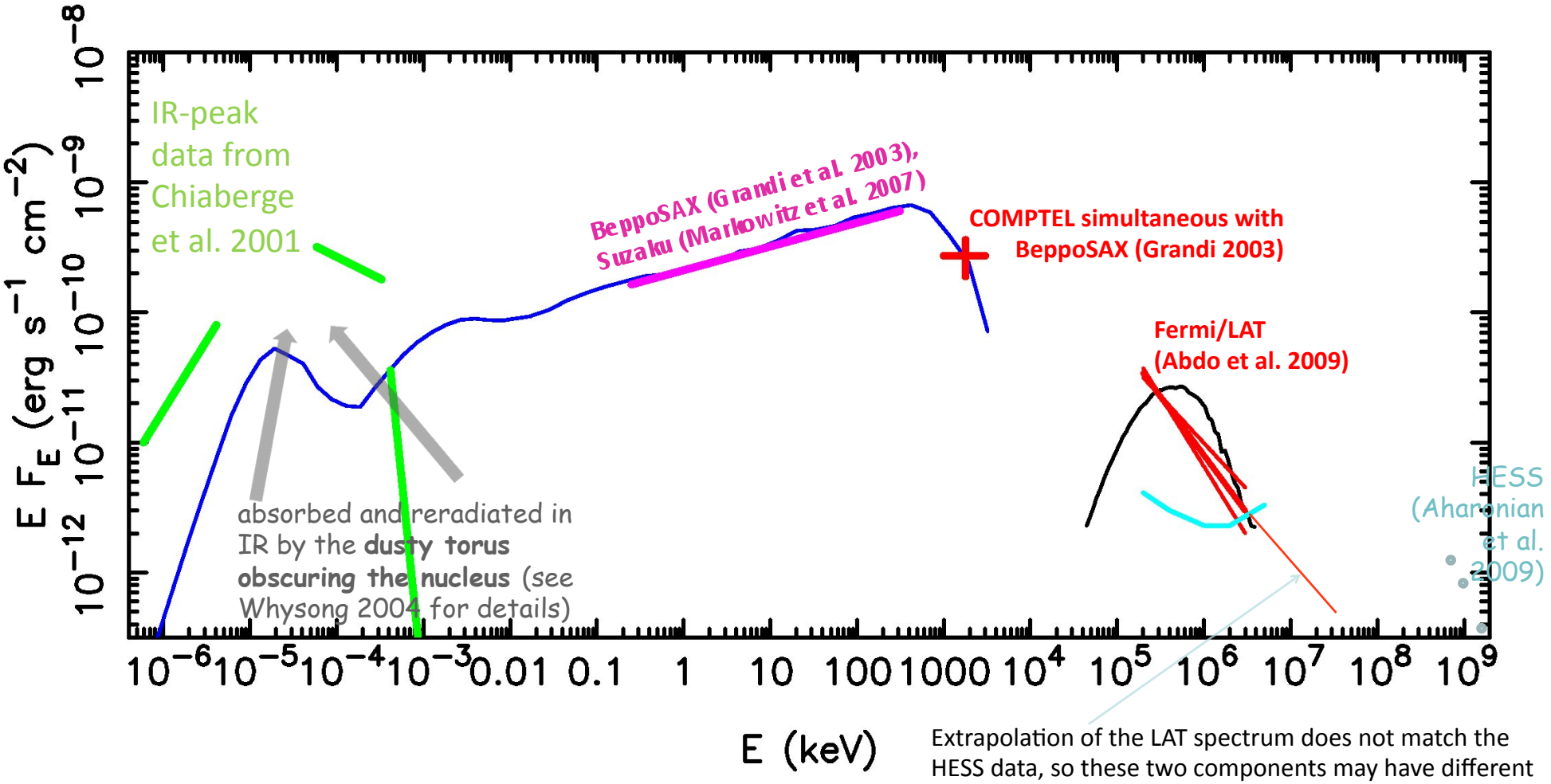
Foschini et al A&A 433, 515, 518 (2005)



most popular: SSC

Spectral components formed by leptonic (blue spectrum) and hadronic (black spectrum) processes in a hot (T_p >> T_e) accretion flow





Extrapolation of the LAT spectrum does not match the HESS data, so these two components may have different origin.