Blazars and cosmic bkgs.

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Introduction: AGNs, blazars

Blazars: phenomenology

Blazars: emission models

Absorption of gamma-rays:
backgrounds
and the intergalactic B-field

INTRODUCTION

Almost all galaxies contain a massive black hole

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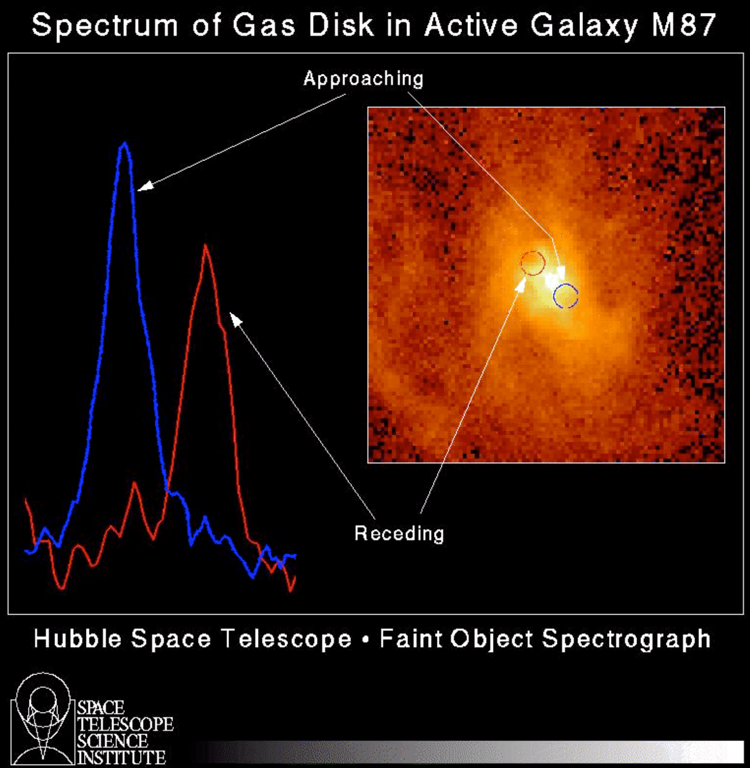
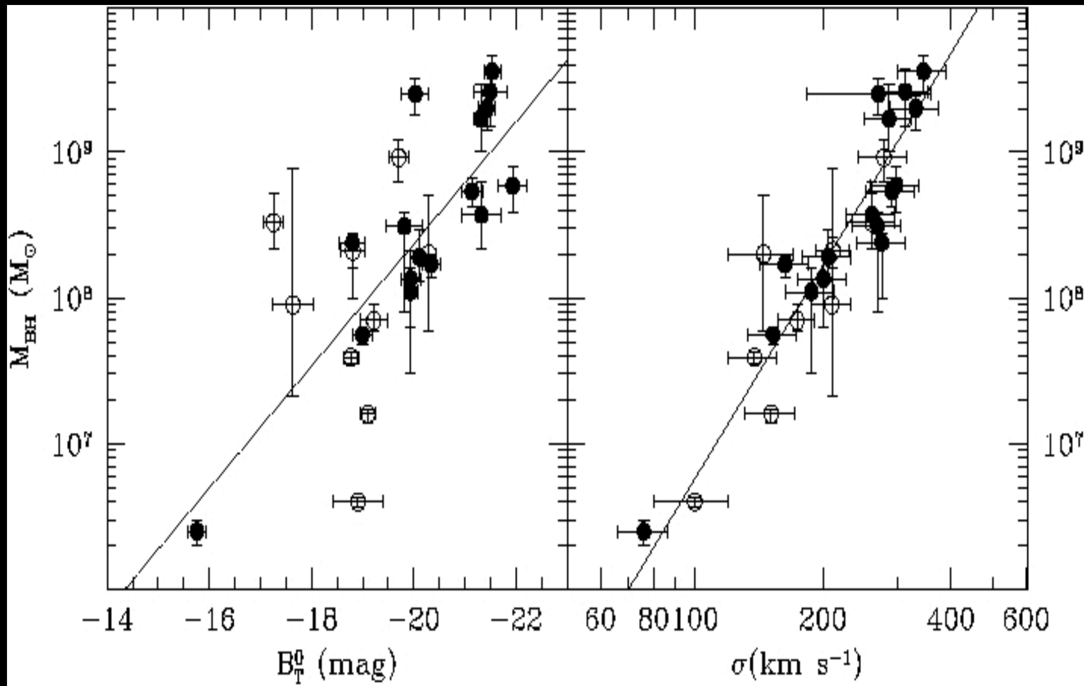




Ferrarese & Ford 2004

Almost all galaxies contain a massive black hole

99% of them is (almost) silent (e.g. our Galaxy)

Almost all galaxies contain a massive black hole

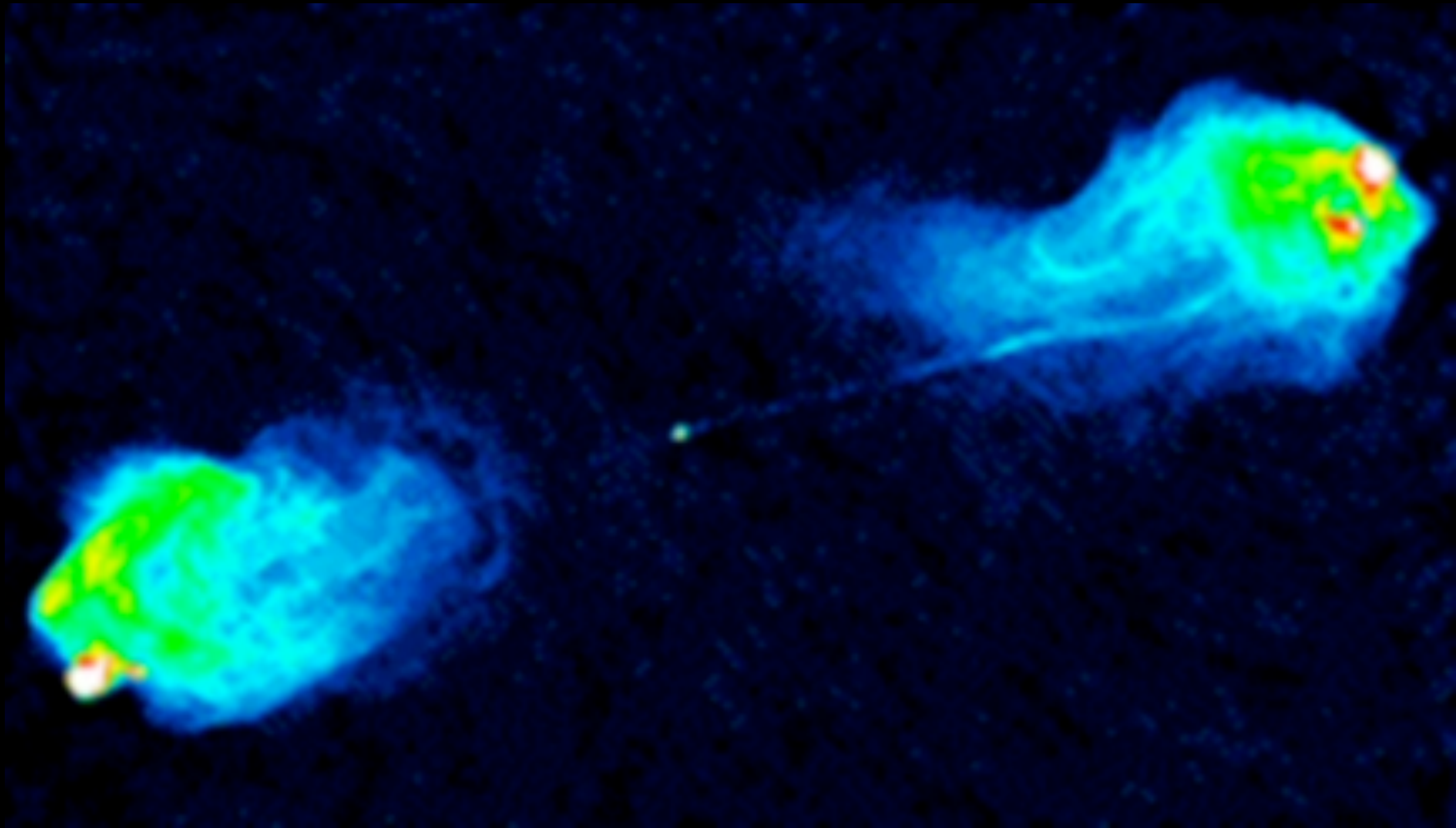
99% of them is (almost) silent (e.g. our Galaxy)

1% per cent is active (mostly radio-quiet AGNs):

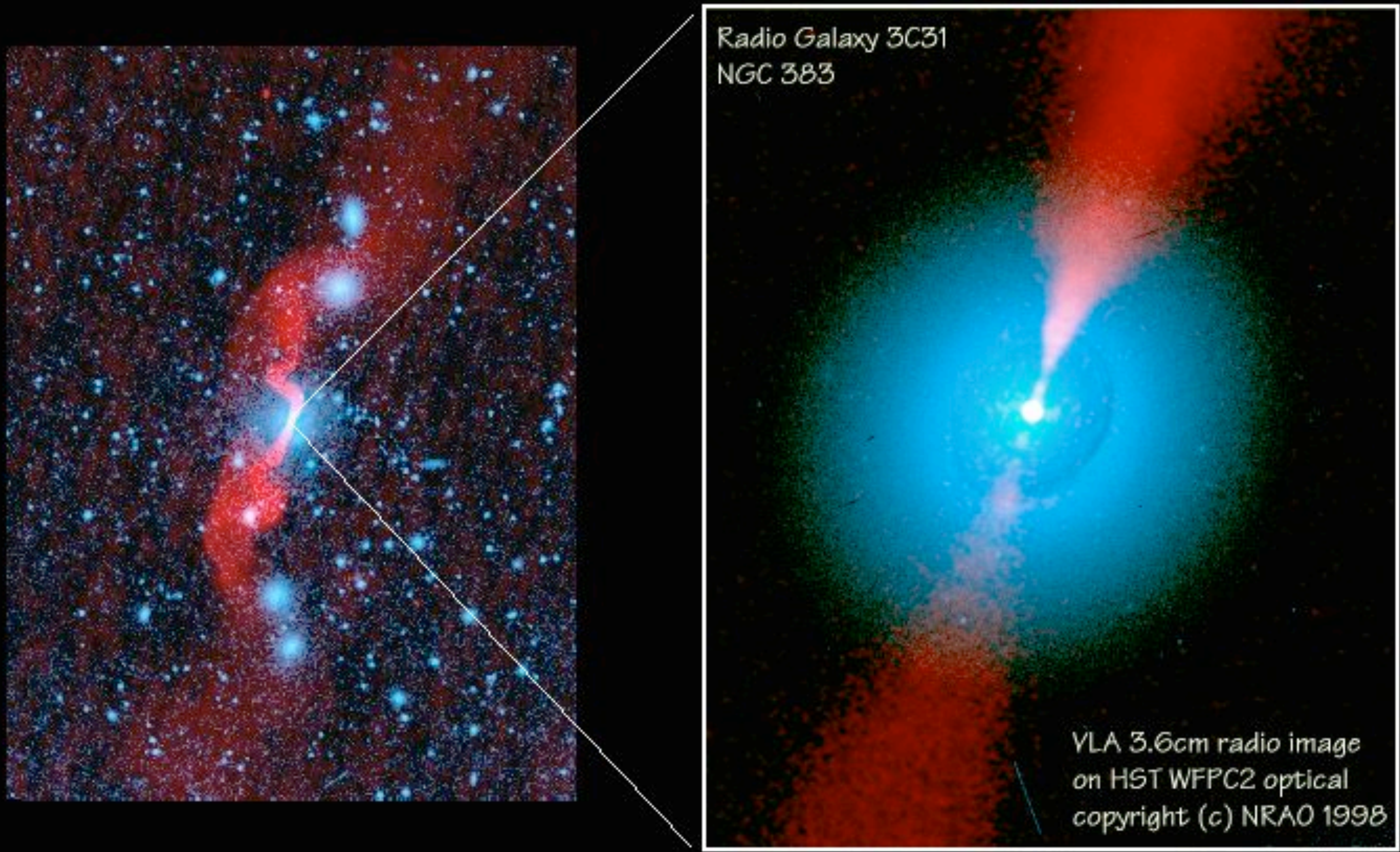
BH+accretion flow (disk): most of the emission in the UV-X-ray band

0.1% is radio loud: jets mostly visible in radio

Powerful (FRII) Radiogalaxy: Cygnus A



Weak (FRI) radiogalaxy: 3C31



The radio-loud zoo is large and complex

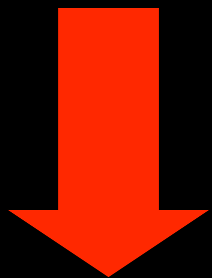
Messy classification! FRI, FRII, NLRG, BLRG, FSRQ, OVV, HPQ, BL Lac objects …

Idea:

Jet emission is anisotropic (beaming): viewing angle

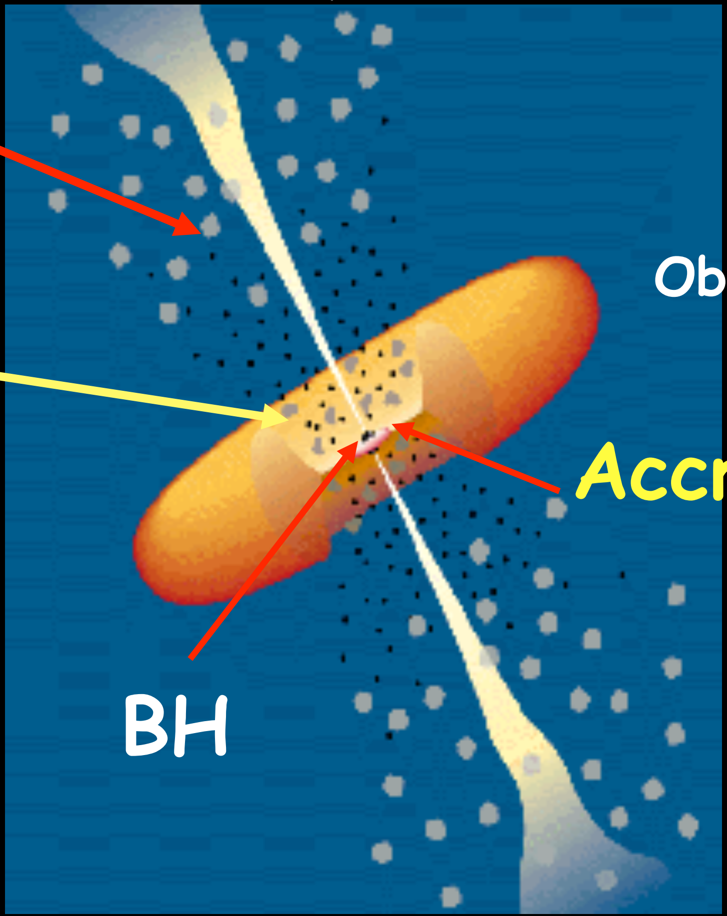
+

intrinsic jet (and AGN) power



"Unification scheme"

Urry & Padovani 1995



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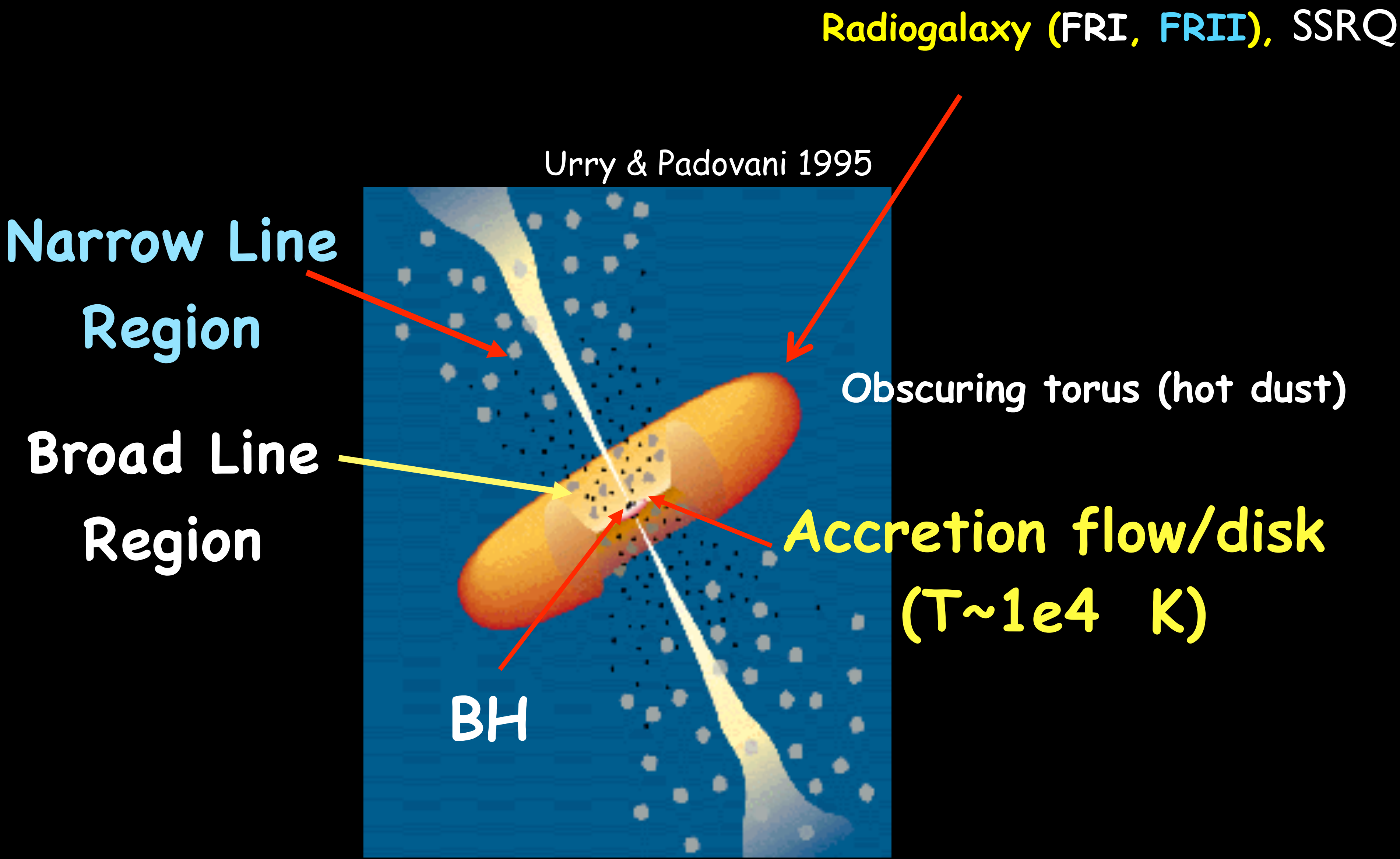
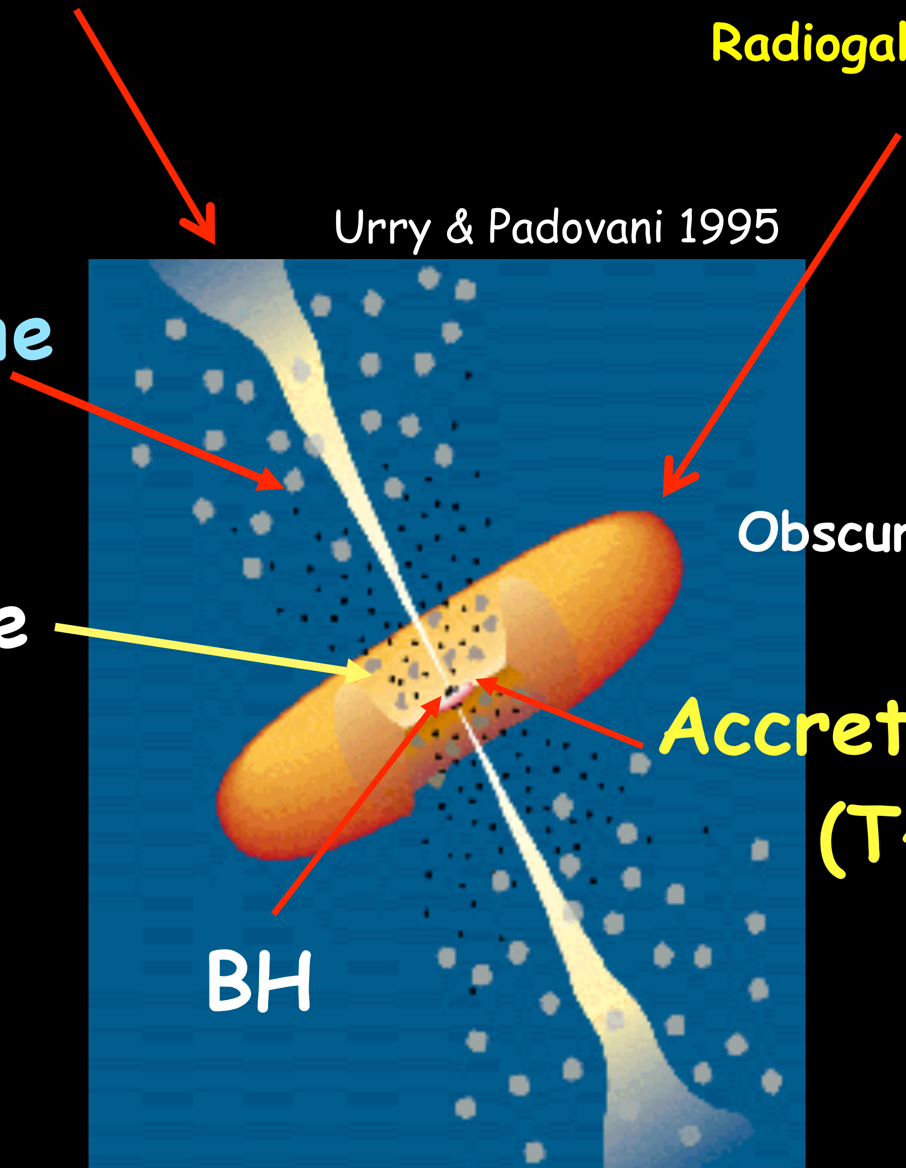


“Unification scheme”

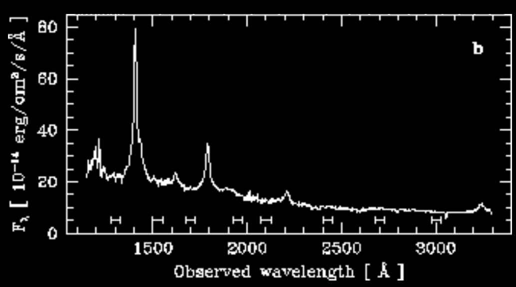


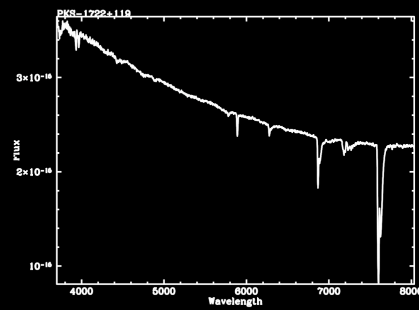
Blazar characteristics:

- Compact radio core, flat or inverted spectrum
- Extreme variability (amplitude and t) at all frequencies
High optical and radio polarization

FSRQs: bright broad (1000-10000 km/s) emission lines
often evidences for the "blue bump" (acc. disc)

BL Lacertae: weak (EW<5 Å) emission lines
no signatures of accretion





Evidences for relativistic beaming

Superluminal motions

Level of Compton emission

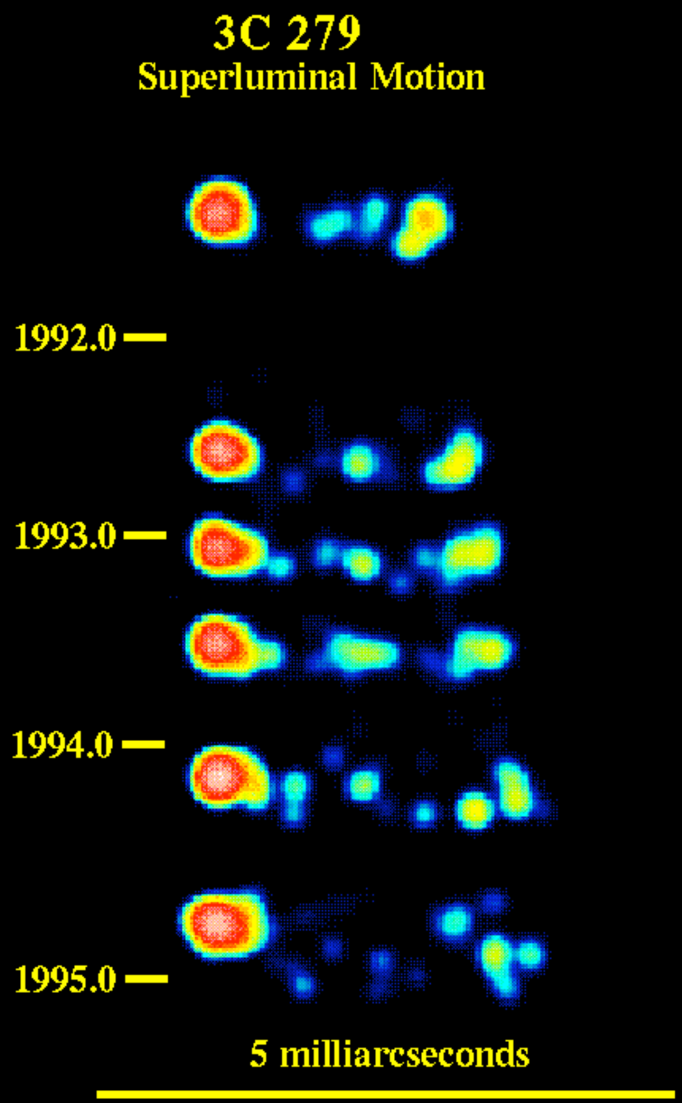
High brightness temperatures

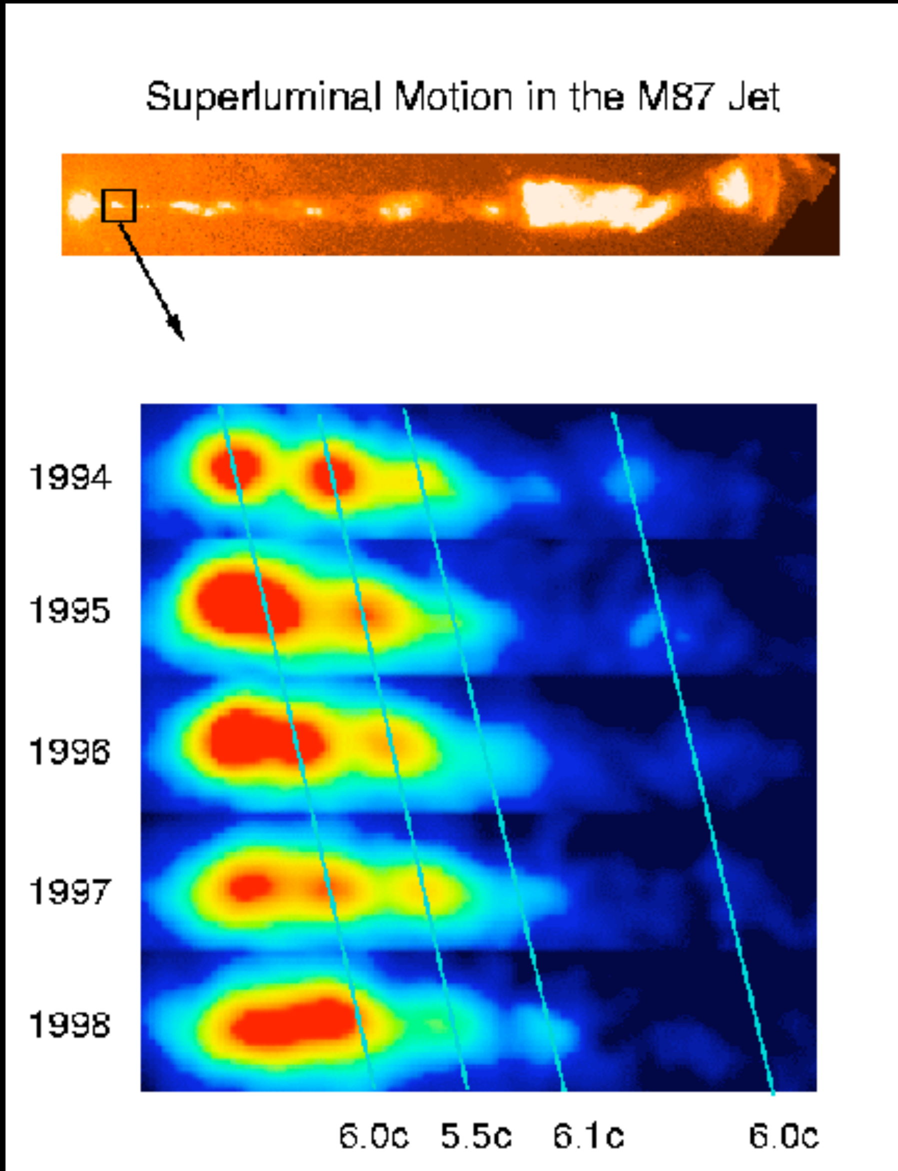
Gamma-ray emission/absorption

Superluminal motion

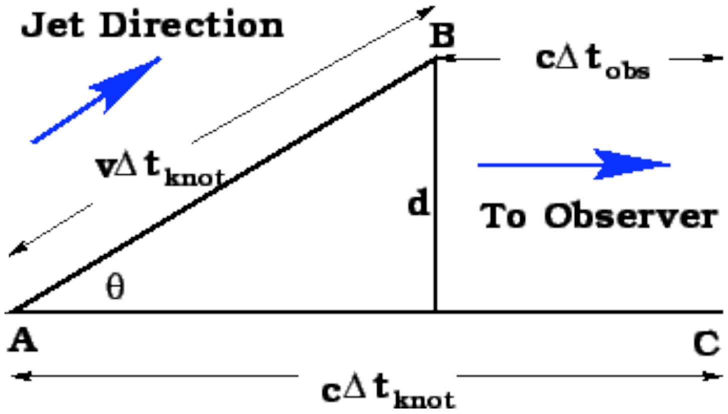
Radio VLBI

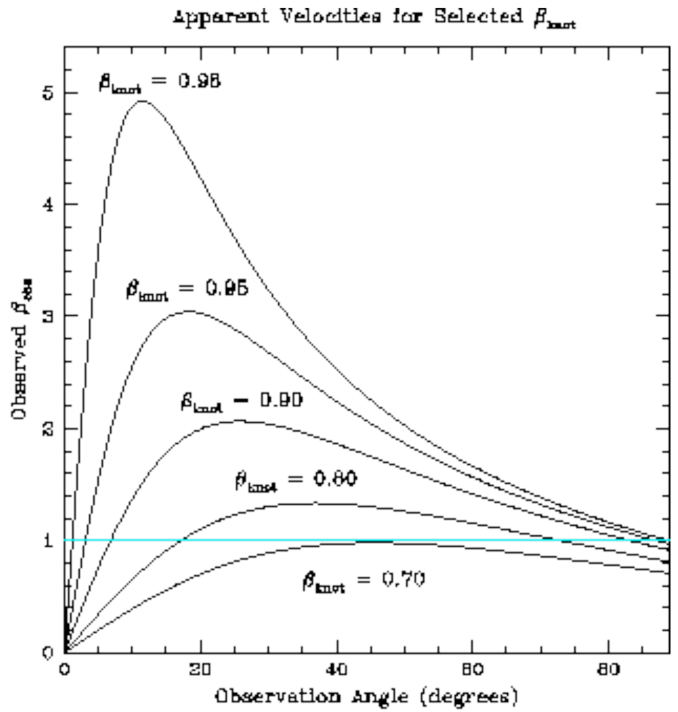
Optical HST





Superluminal motion

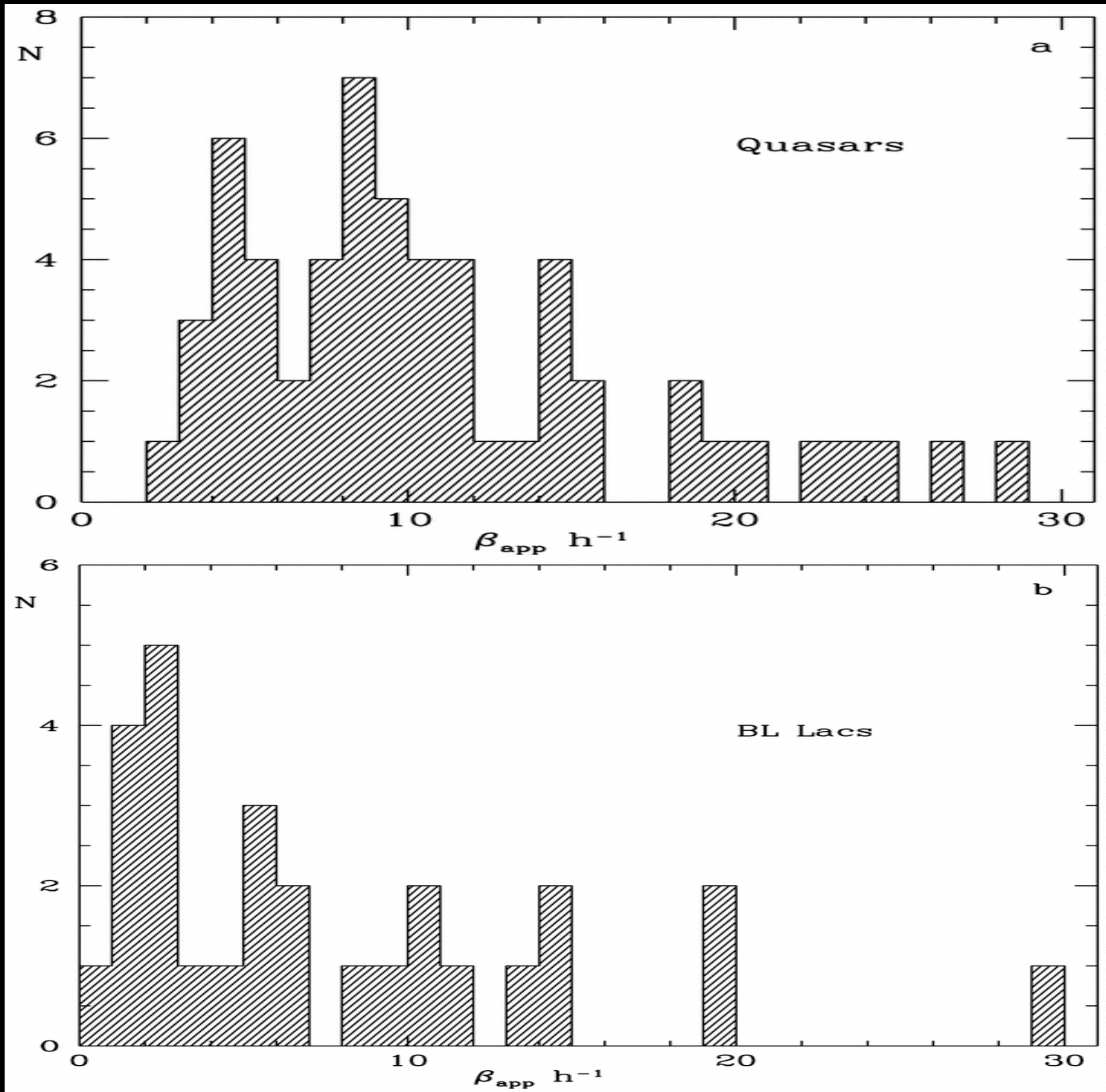




$$v_{obs} = \frac{d}{\Delta t_{obs}} = \frac{v \Delta t_{knot} \sin\theta}{\Delta t_{obs}}.$$

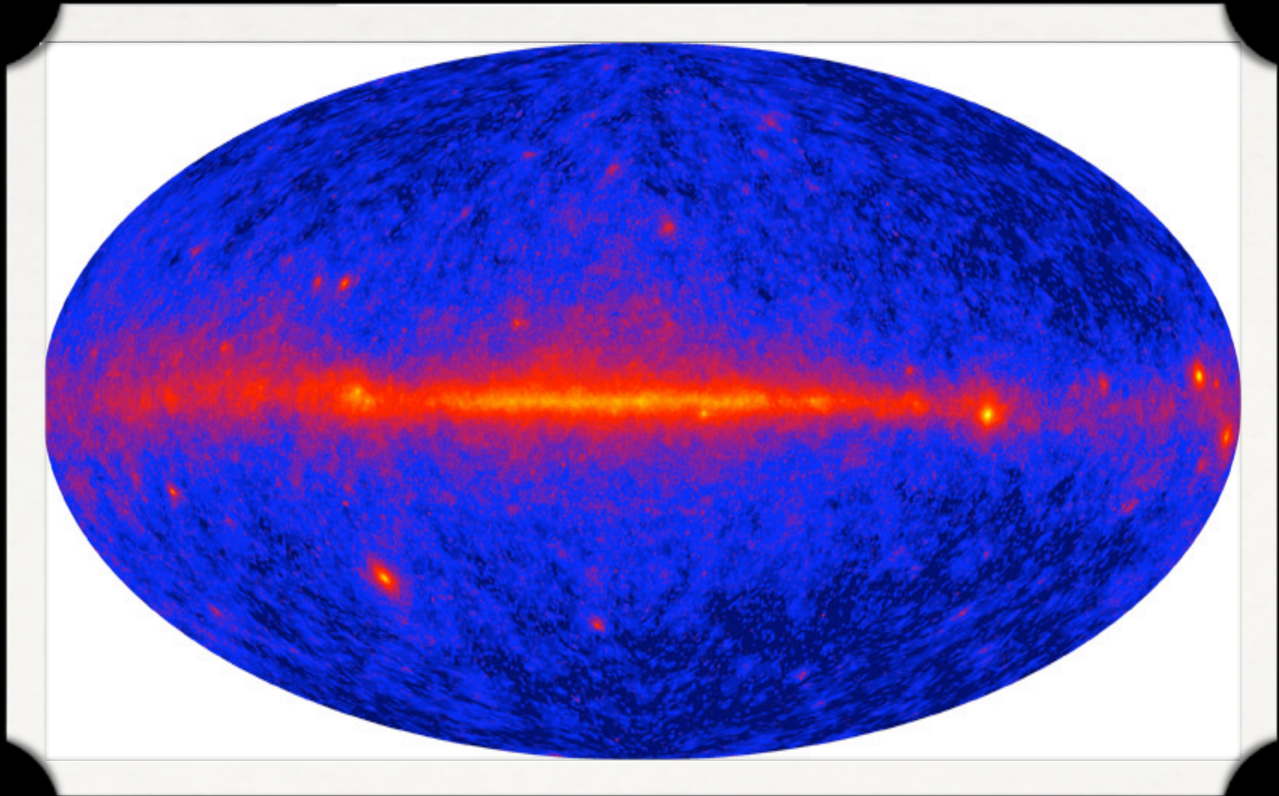
$$\beta_{obs} = \frac{\beta_{knot} \sin\theta}{1 - \beta_{knot} \cos\theta}.$$

Jorstad et al. 2001



Blazars: phenomenology

The Fermi/LAT (0.1-100 GeV) sky



2LAC: (2 years)

395 BL Lac

310 FSRQ

5 radiogalaxy

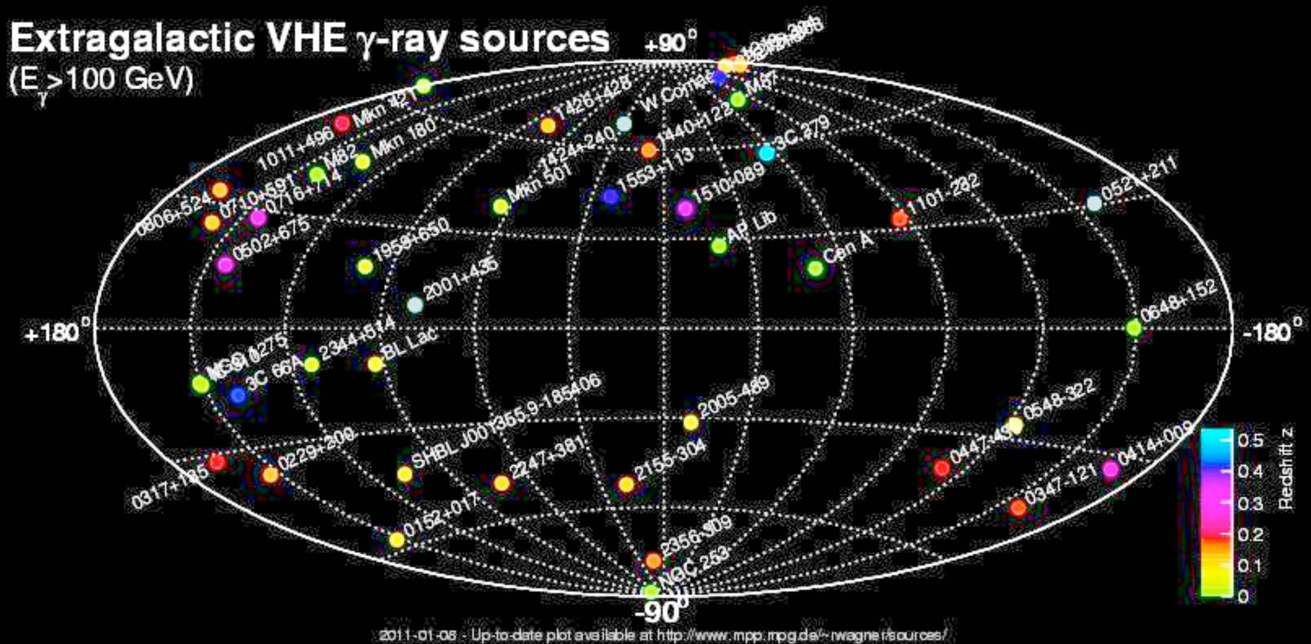
2 SSRQ

The VHE extragalactic gamma-ray sky

38 BL Lacertae

5 radiogalaxies

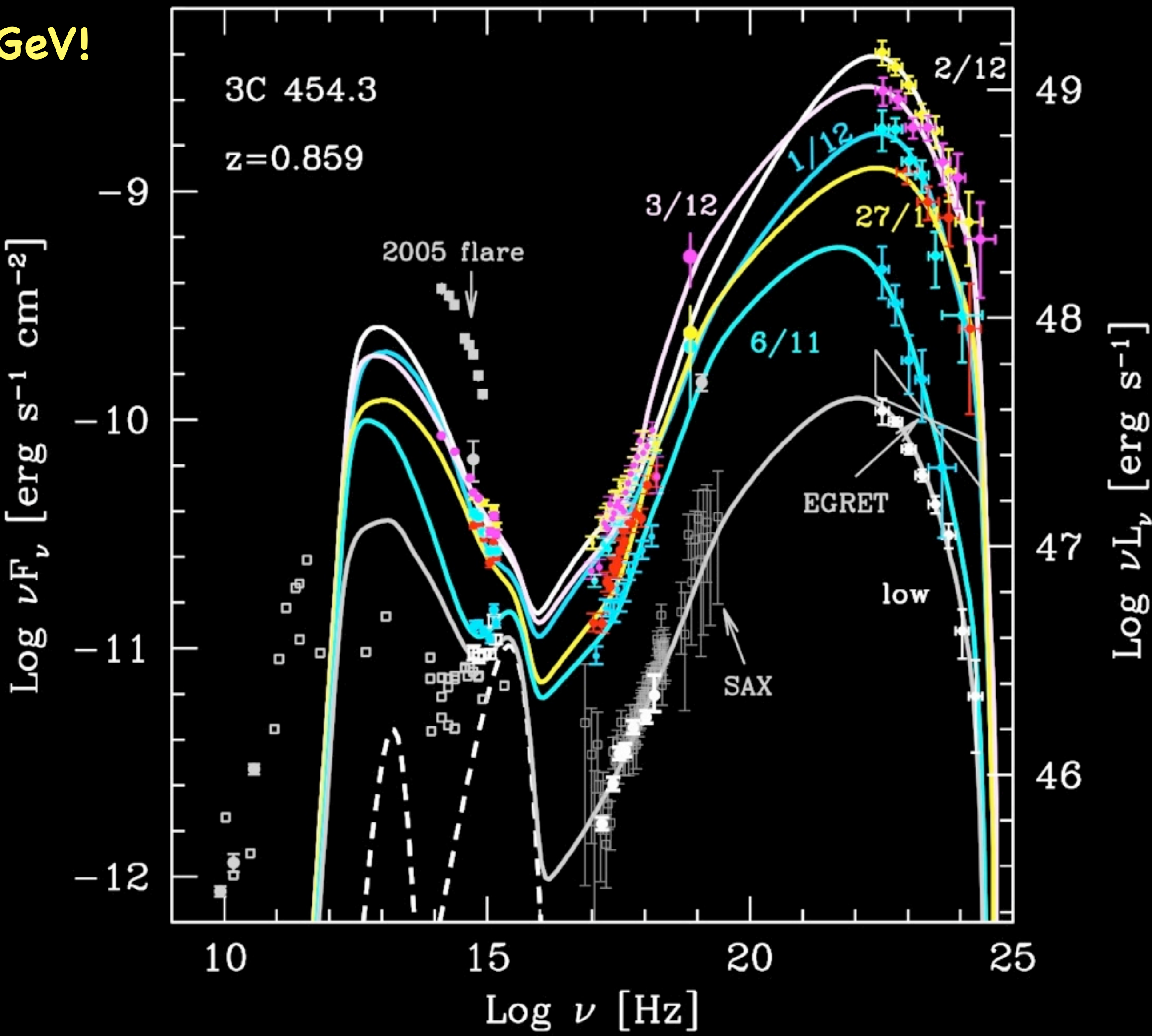
3 FSRQ (3C279, z=0.536)



The bumpy spectral energy distribution

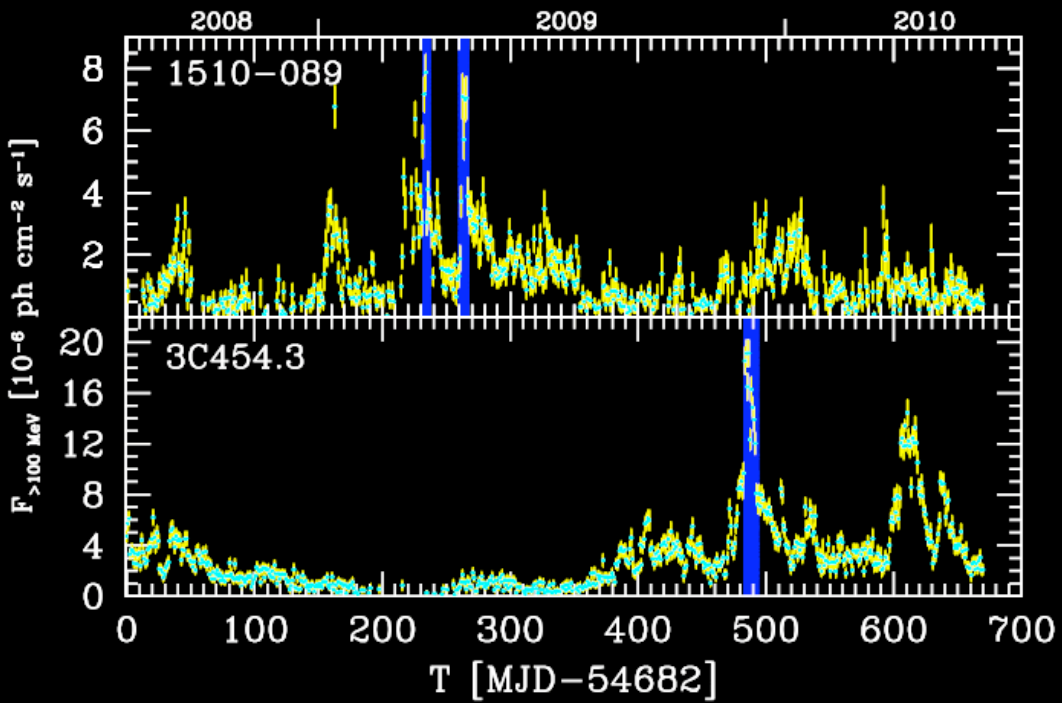
The brightest source in GeV!

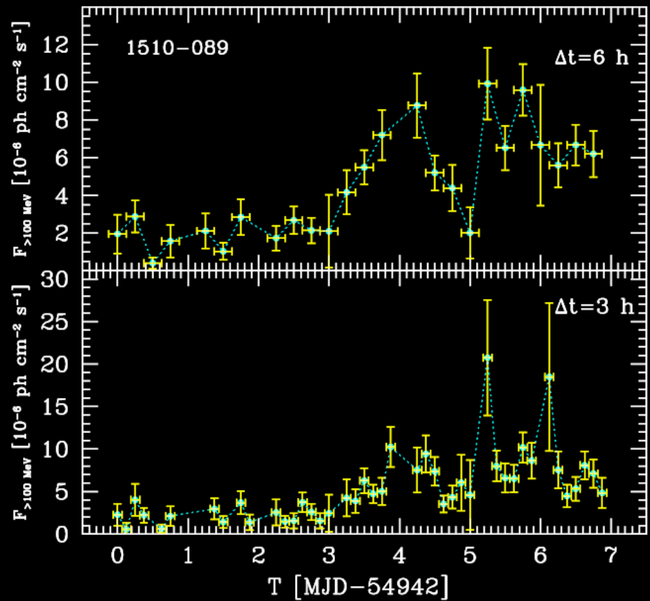
Bonnoli et al. 2010

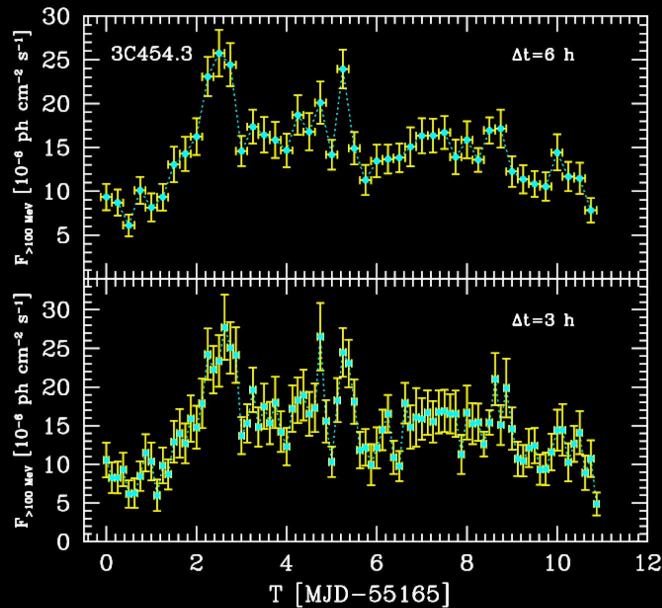


The erratic light-curve

LAT lightcurve







FT et al. 2010

See also Foschini et al. 2010

Abdo et al. 2010, arXiv:1007.0483 for 3C454.3

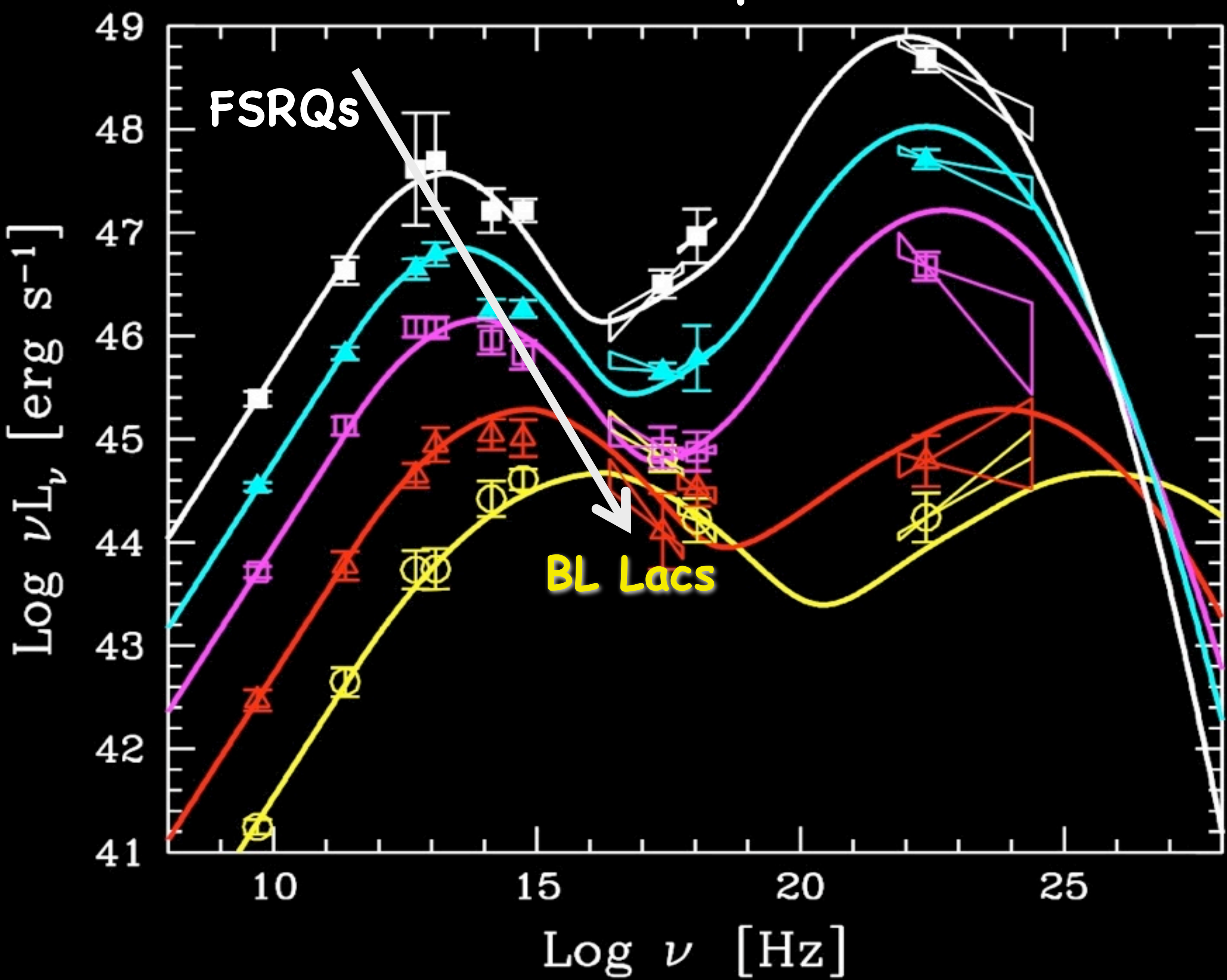
Rapid variability implies compact regions!

$$R < ct_{\rm var}\frac{\delta}{1+z} \simeq \frac{6.5\times10^{15}}{1+z}\left(\frac{t_{\rm var}}{6\,{\rm h}}\right)\left(\frac{\delta}{10}\right)\ {\rm cm}$$

IF $d \simeq \frac{R}{\theta_{\rm j}}$ **Conical geometry**

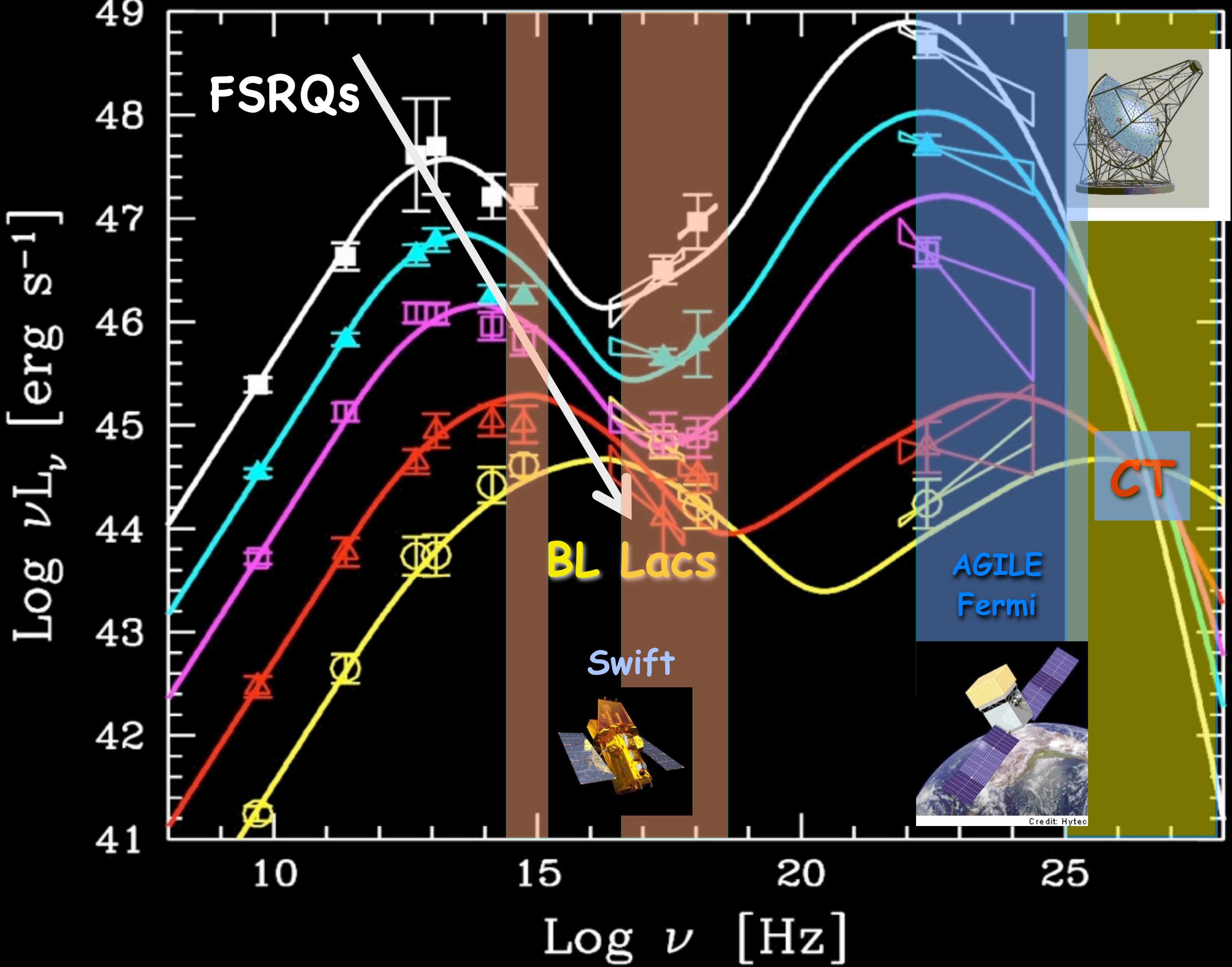
$$d < ct_{\rm var}\frac{\delta}{1+z}\theta_{\rm j}^{-1} \simeq \frac{6.5\times10^{16}}{1+z}\left(\frac{t_{\rm var}}{6\,{\rm h}}\right)\left(\frac{\delta}{10}\right)\left(\frac{\theta_{\rm j}}{0.1}\right)^{-1}\ {\rm cm}$$

The "blazar sequence"



Fossati et al. 1998; Donato et al. 2001

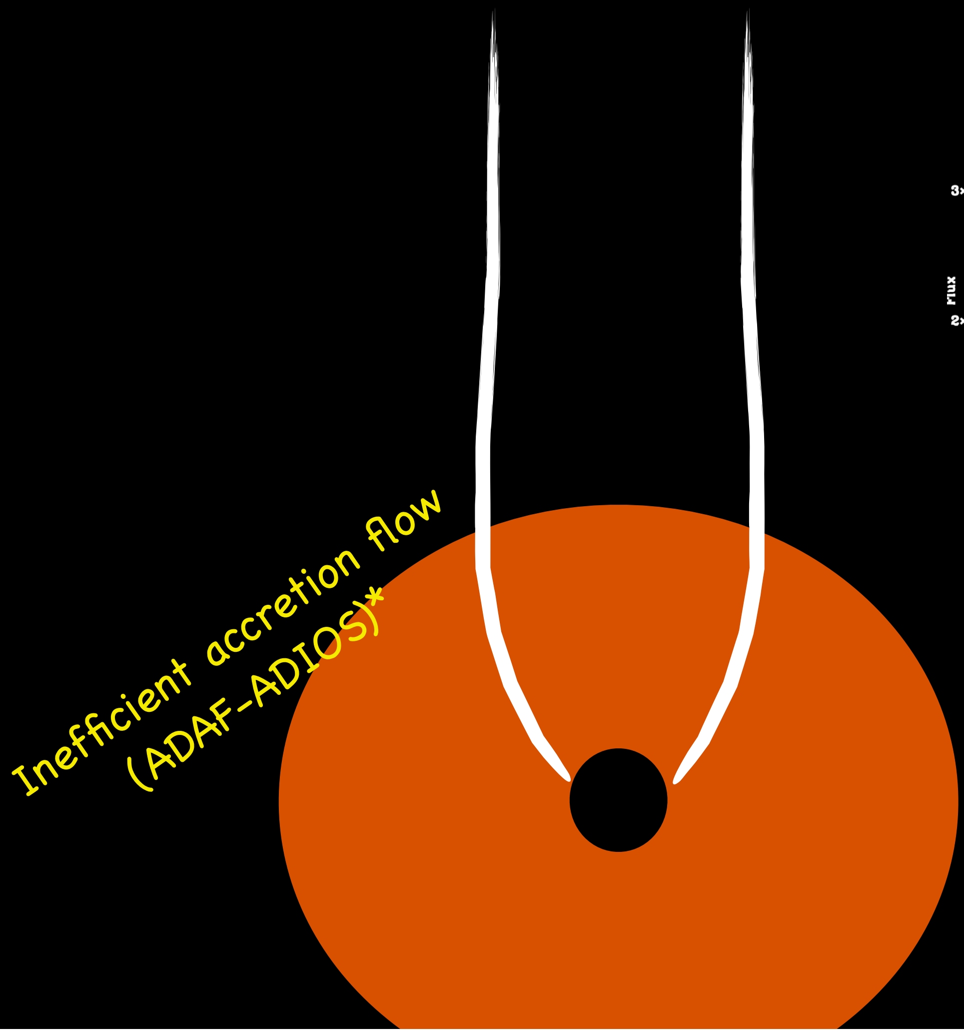
The "blazar sequence"

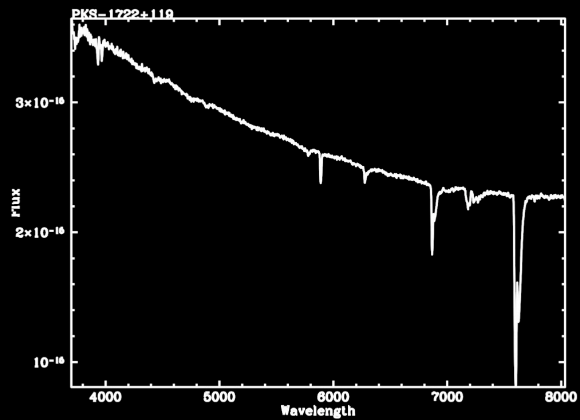


Fossati et al. 1998; Donato et al. 2001

Blazars: emission models

BL Lacs: “clean” jets





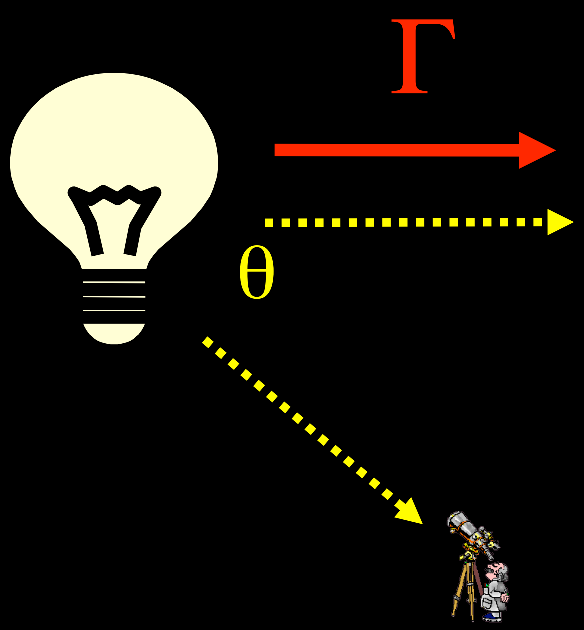
*but see Raiteri et al. 2009
Capetti et al. 2010 for BL Lac itself

Emission Models

Simplest scenario: SSC model (HBL)

Other : external radiation (LBL, FSRQs, HBL?)

The relativistic Doppler factor

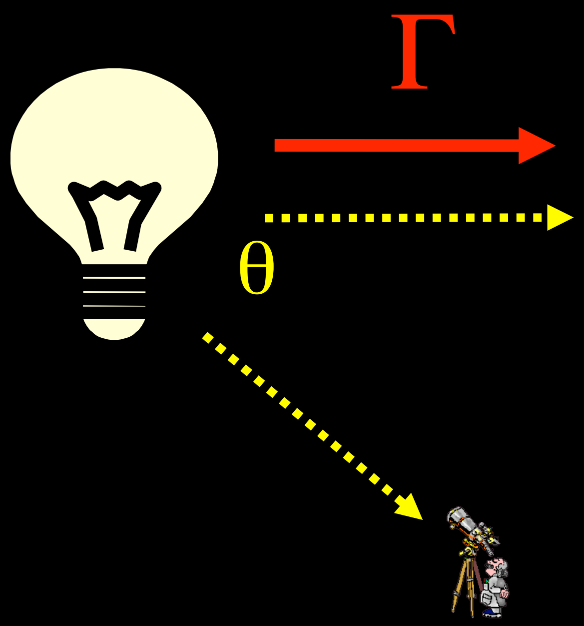


Special relat.

$$\delta = \frac{1}{\Gamma\,(1-\beta\cos\theta)}$$

Photon "compression"

The relativistic Doppler factor



Special relat.

$$\delta = \frac{1}{\Gamma\,(1-\beta\cos\theta)}$$

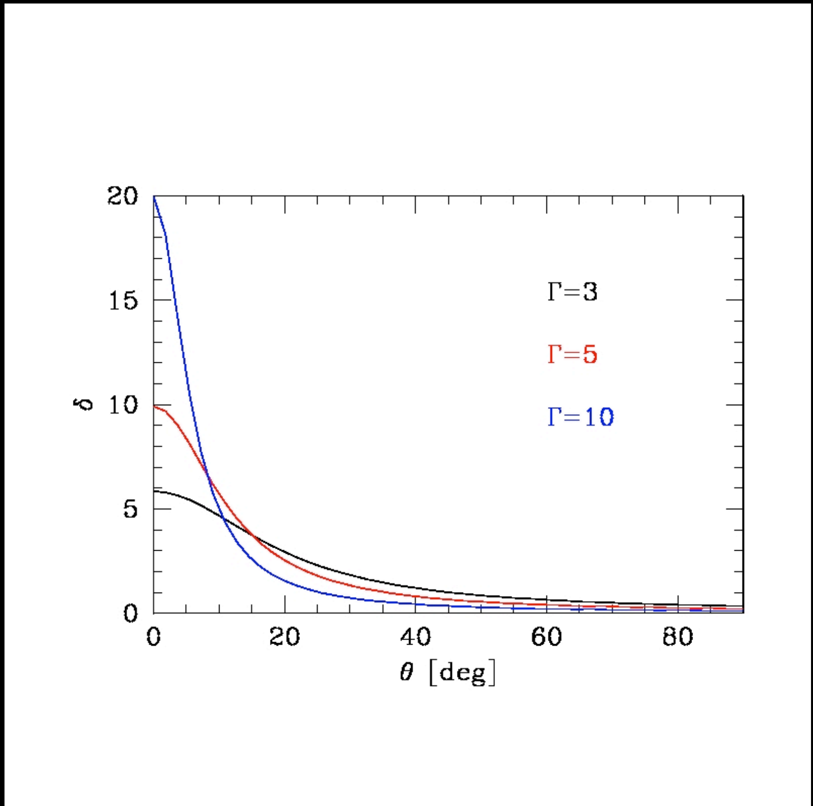
Photon "compression"

$L = L'\delta^4$

$\nu = \nu'\,\delta$

$\Delta t = \Delta t'/\delta$

The relativistic Doppler factor



Special relat.

$$\delta = \frac{1}{\Gamma\,(1-\beta\cos\theta)}$$

Photon "compression"

$L = L'\delta^4$

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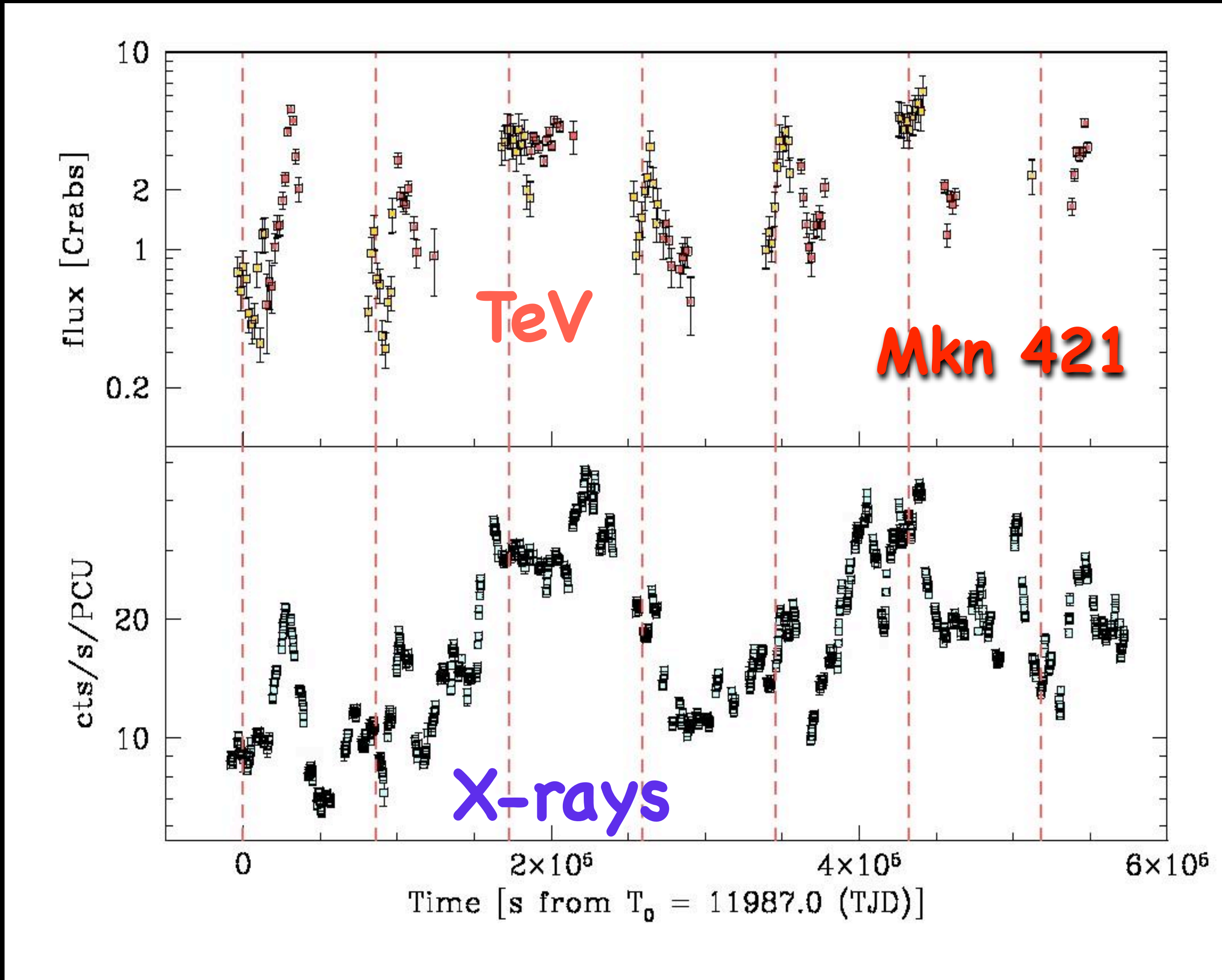
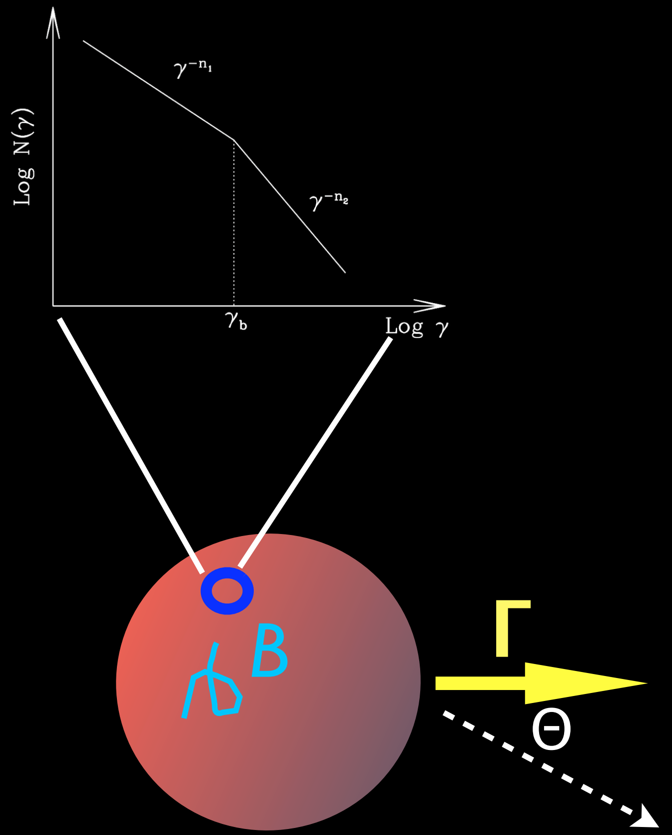
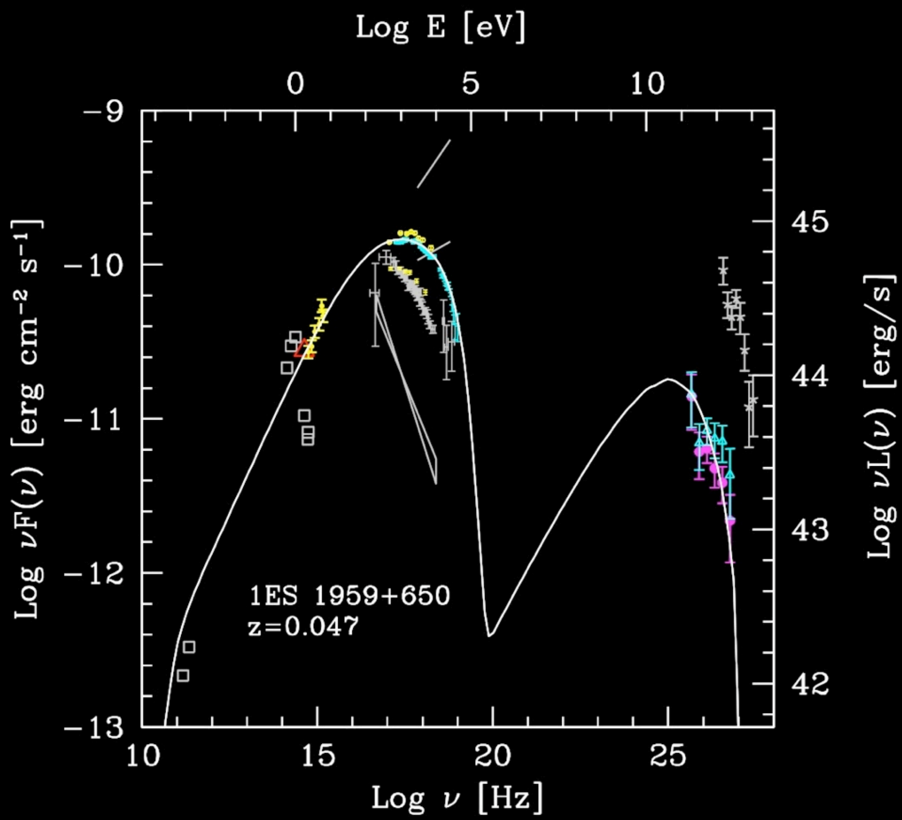
$\Delta t = \Delta t'/\delta$

Coordinated variability at different ν



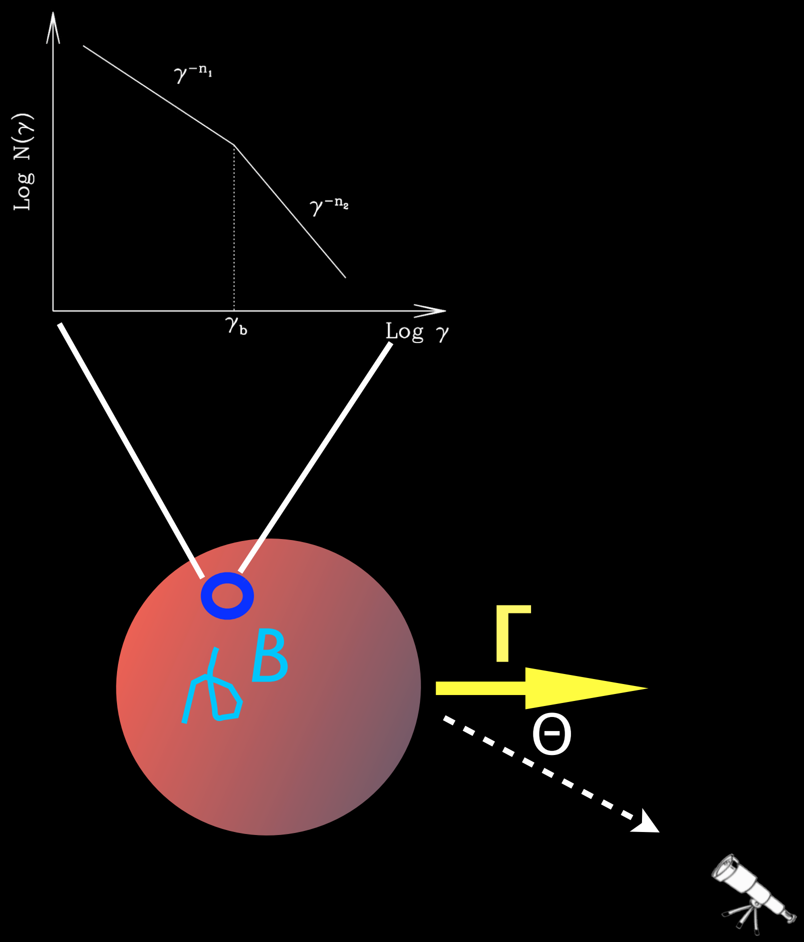
One-zone Synch. Self-Compton models

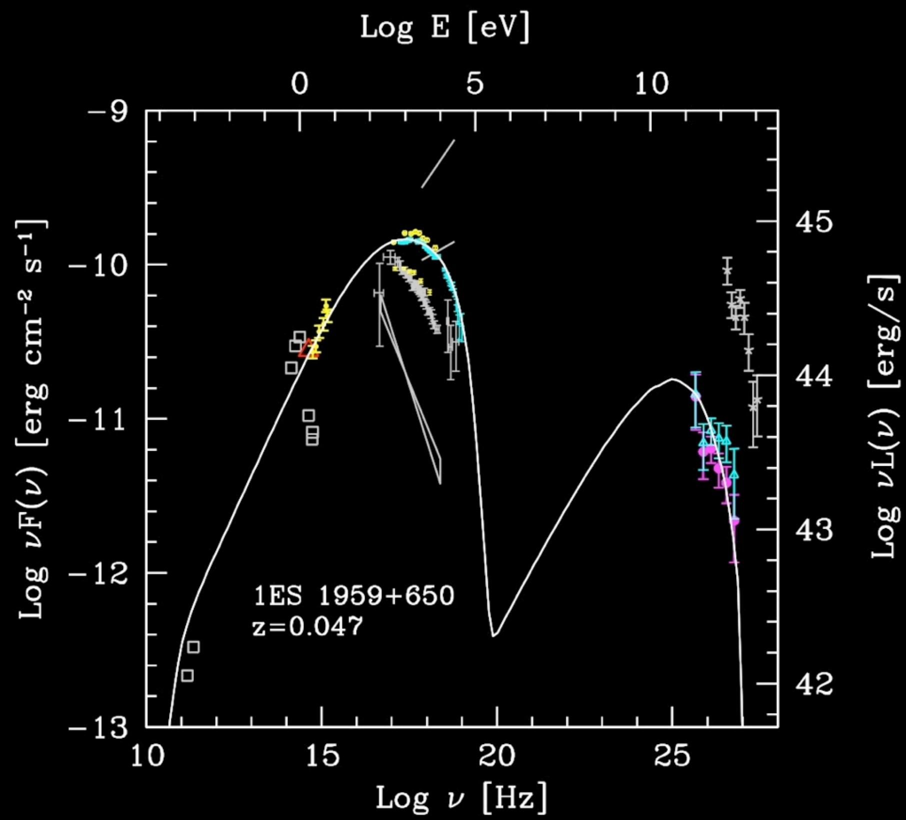




Tagliaferri et al. + MAGIC Coll. 2008

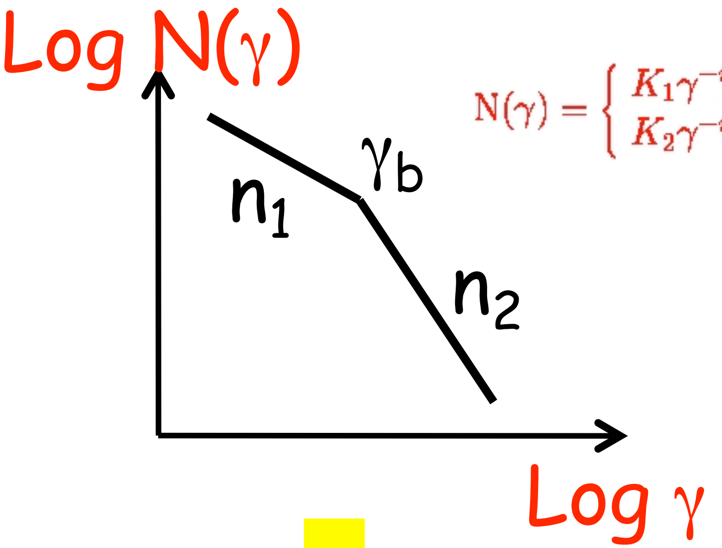
One-zone Synch. Self-Compton models



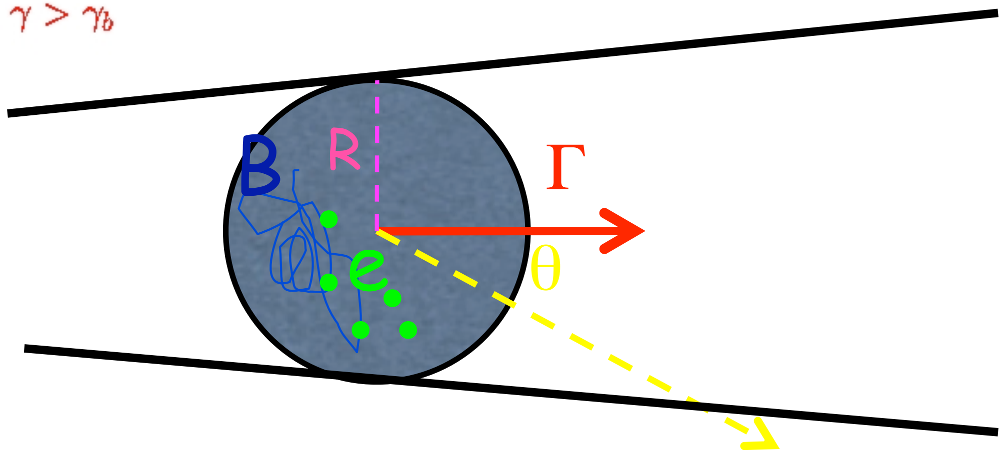


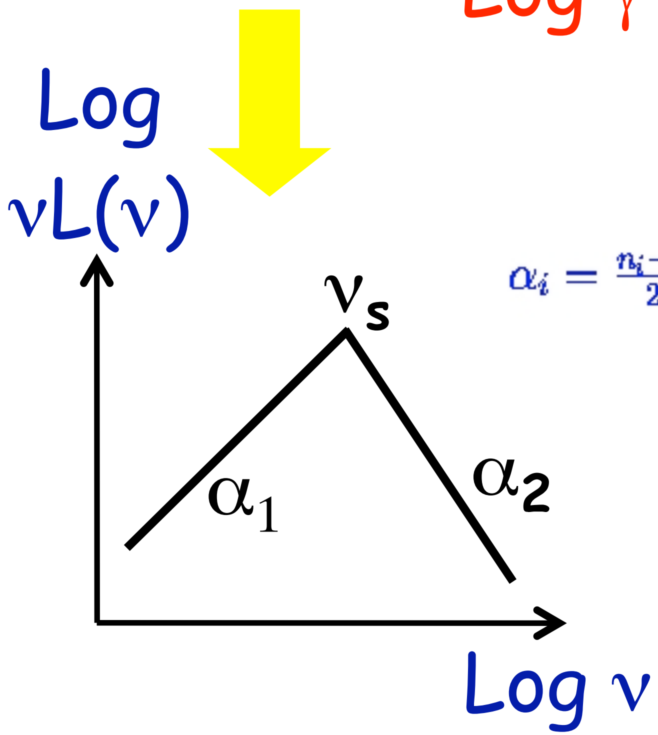
Tagliaferri et al. + MAGIC Coll. 2008

The simplest model - 1

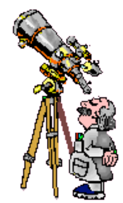


$$N(\gamma) = \begin{cases} K_1\gamma^{-n_1} & \gamma < \gamma_b \\ K_2\gamma^{-n_2} & \gamma > \gamma_b \end{cases}$$





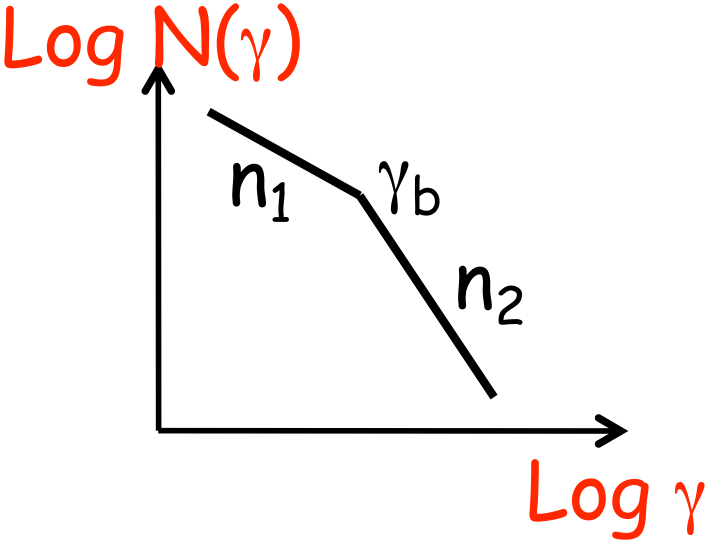
$$\alpha_i = \frac{n_i - 1}{2}$$



$$\nu_s = 3 \times 10^6 B \gamma_b^2 \delta$$

$$\nu_s L(\nu_s) \propto \sigma_T c B^2 N(\gamma_b) \gamma_b \gamma_b^2 V \delta^4$$

The simplest model - 2a



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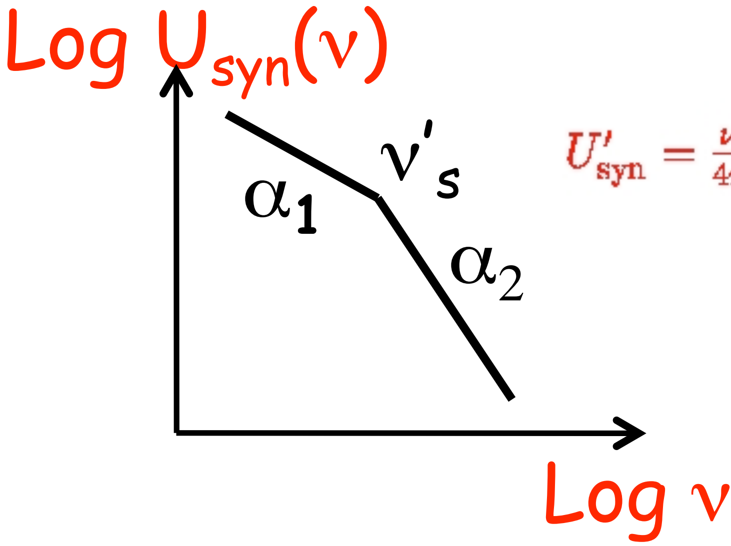
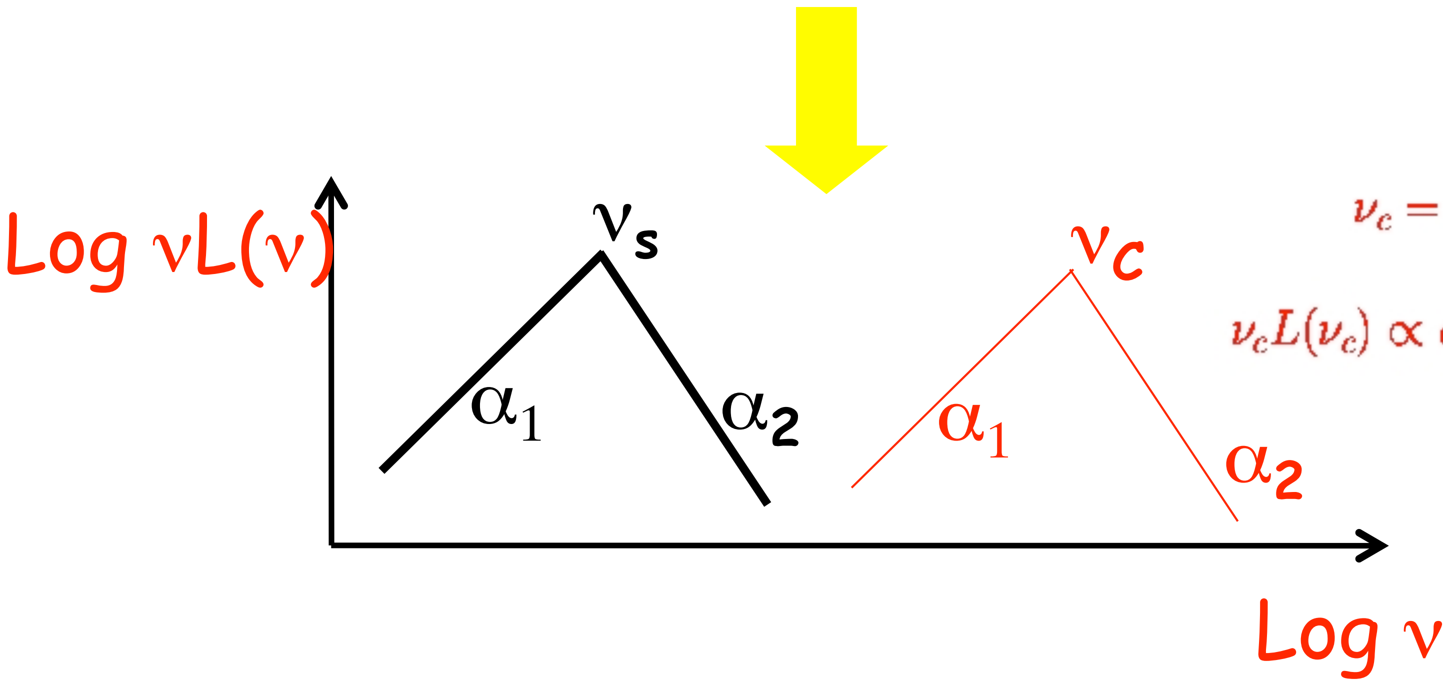


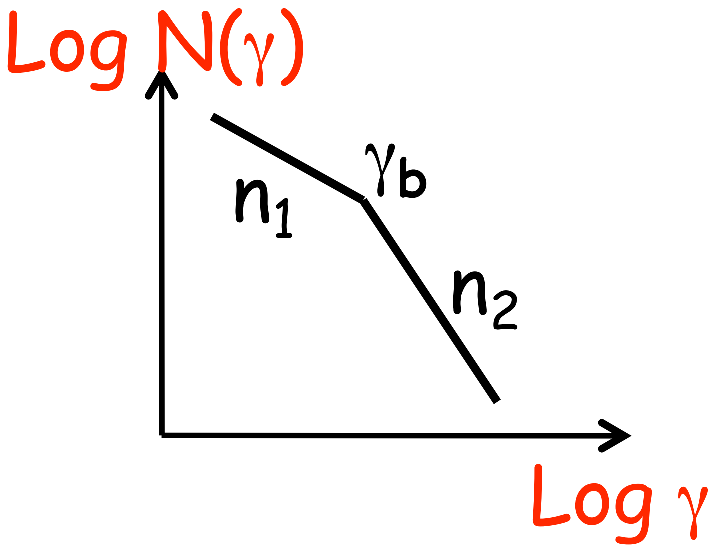
$$U'_{\rm syn} = \frac{\nu_s L(\nu_s)}{4\pi R^2 c\delta^4}$$



$$\nu_c = \nu_s' \gamma_b^2 \delta \quad \nu_s' = \nu_s/\delta$$

$$\nu_c L(\nu_c) \propto \sigma_T c U'_{\rm syn} N(\gamma_b) \gamma_b \gamma_b^2 V \delta^4$$

The simplest model - 2b



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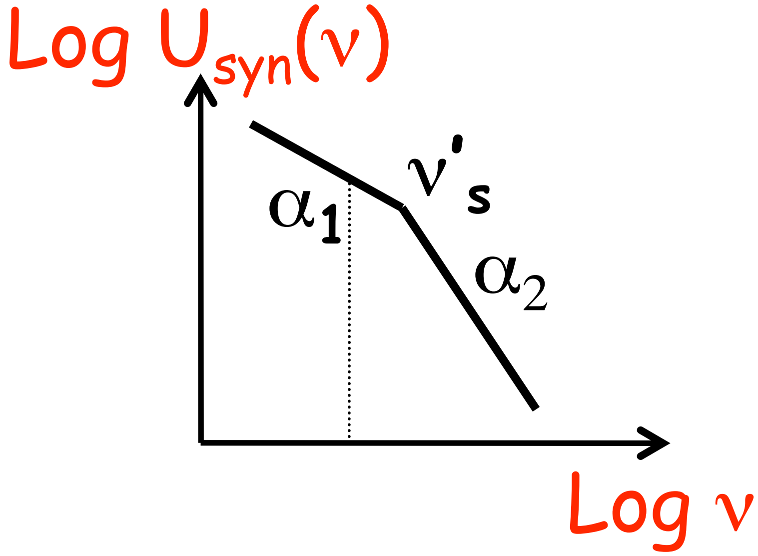
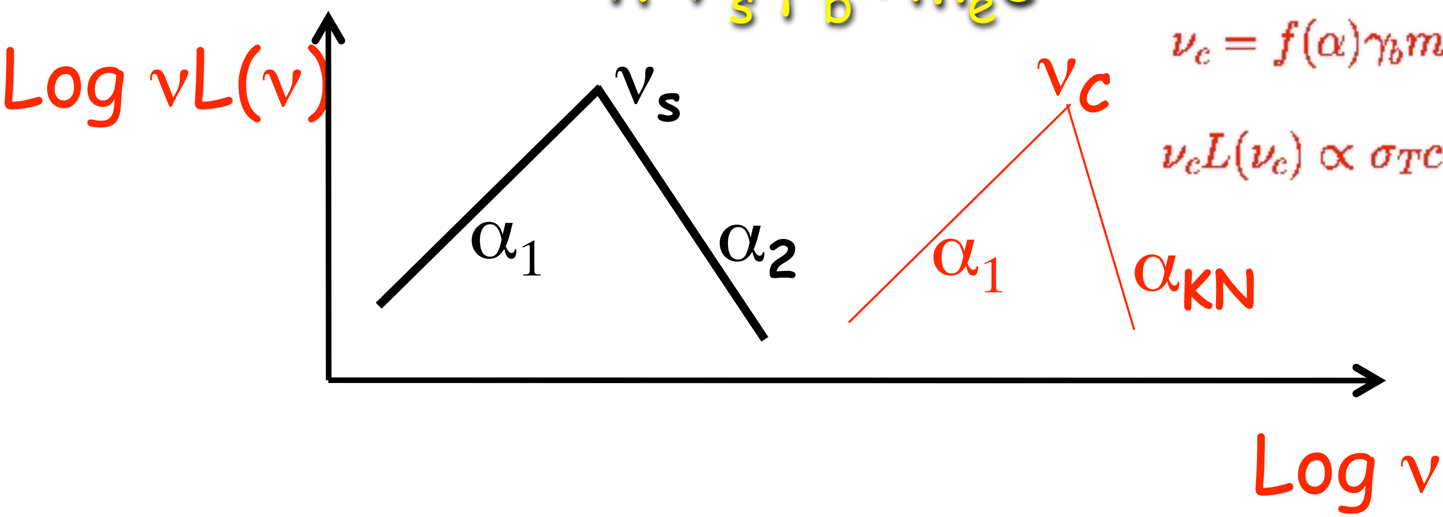


"Klein-Nishina regime"

$h\,\nu'_s\,\gamma_b > m_e c^2$

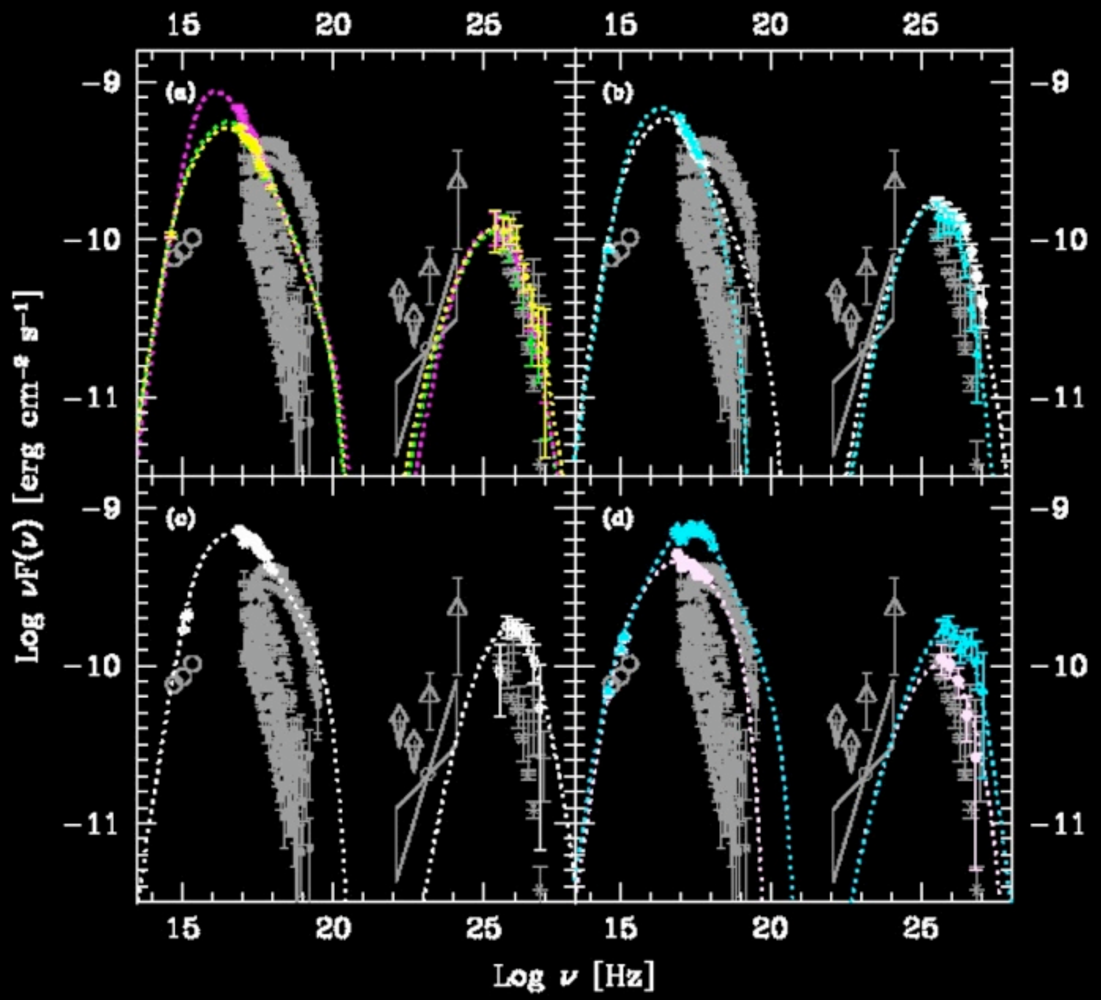


$$\nu_c = f(\alpha)\gamma_b m c^2 \delta \quad f(\alpha) \simeq 0.1 - 0.2$$

$$\nu_c L(\nu_c) \propto \sigma_T c U'_{\rm syn,avail} N(\gamma_b)\gamma_b \gamma_b^2 V \delta^4$$

The simplest model - 4

"Pure" SSC → Mkn 421: a BL Lac



In principle, in the simplest version of the SSC model, all the parameters can be constrained by quantities available from observations:

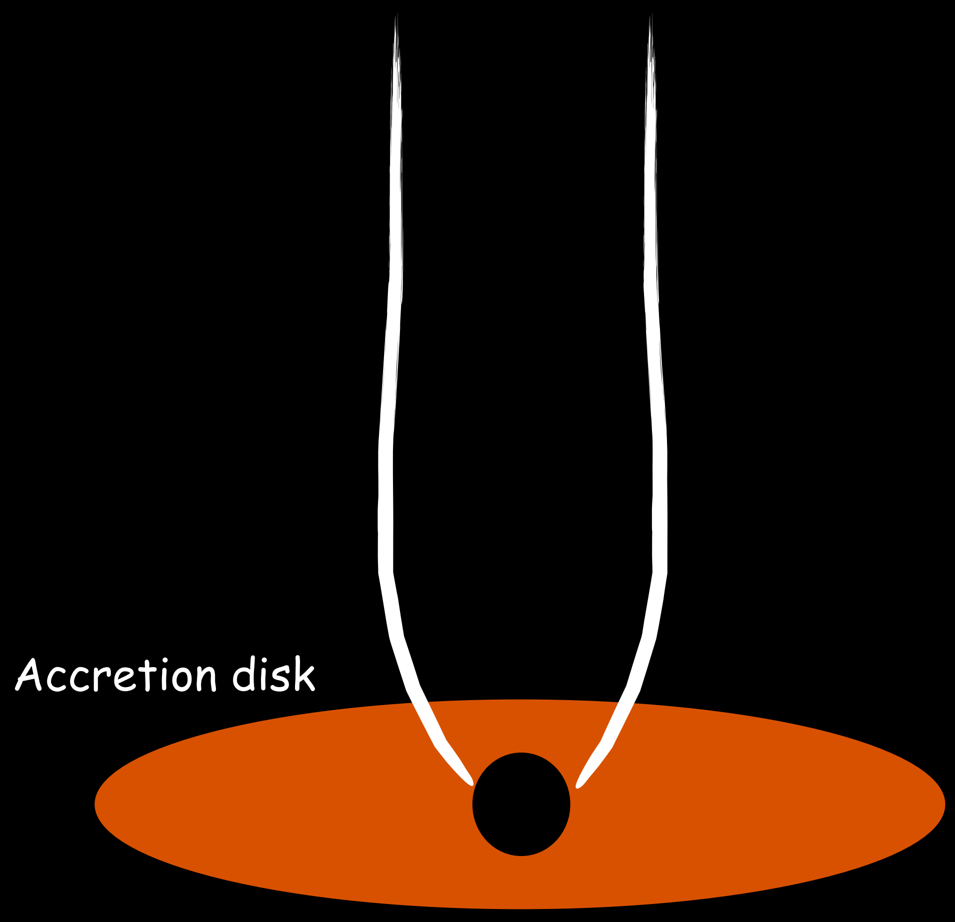
7 free parameters

Model parameters: R B N_o γ_b n_1 n_2 δ

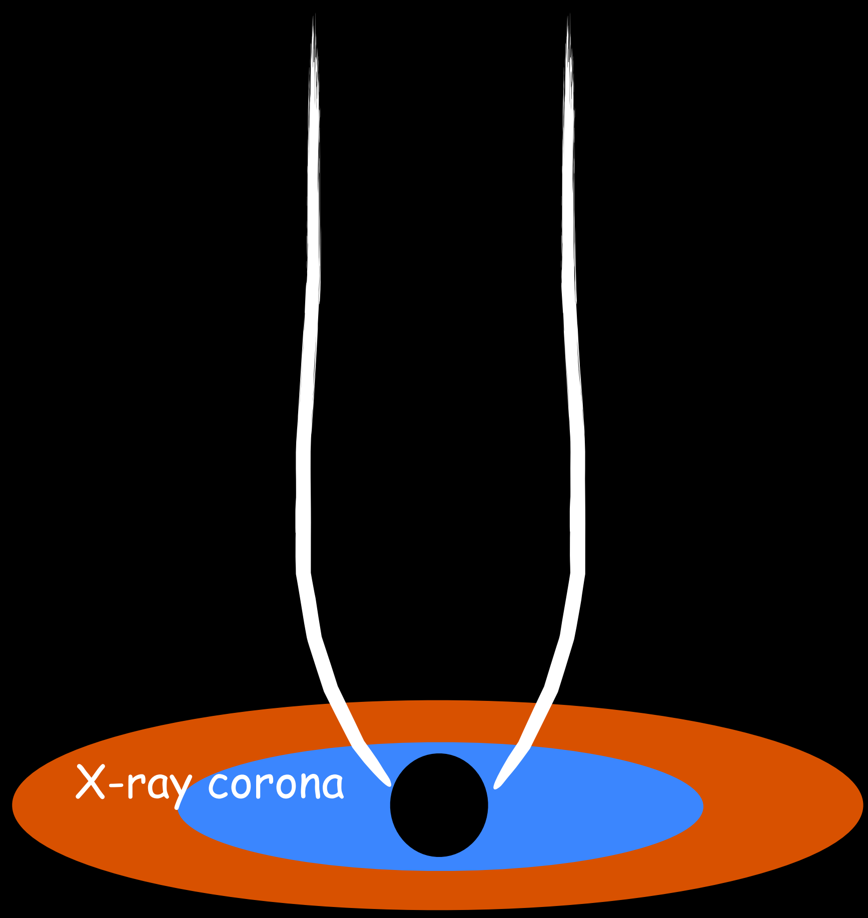
Observational parameters: ν_s L_s ν_C L_C t_{var} α_1 α_2

7 observational quantities

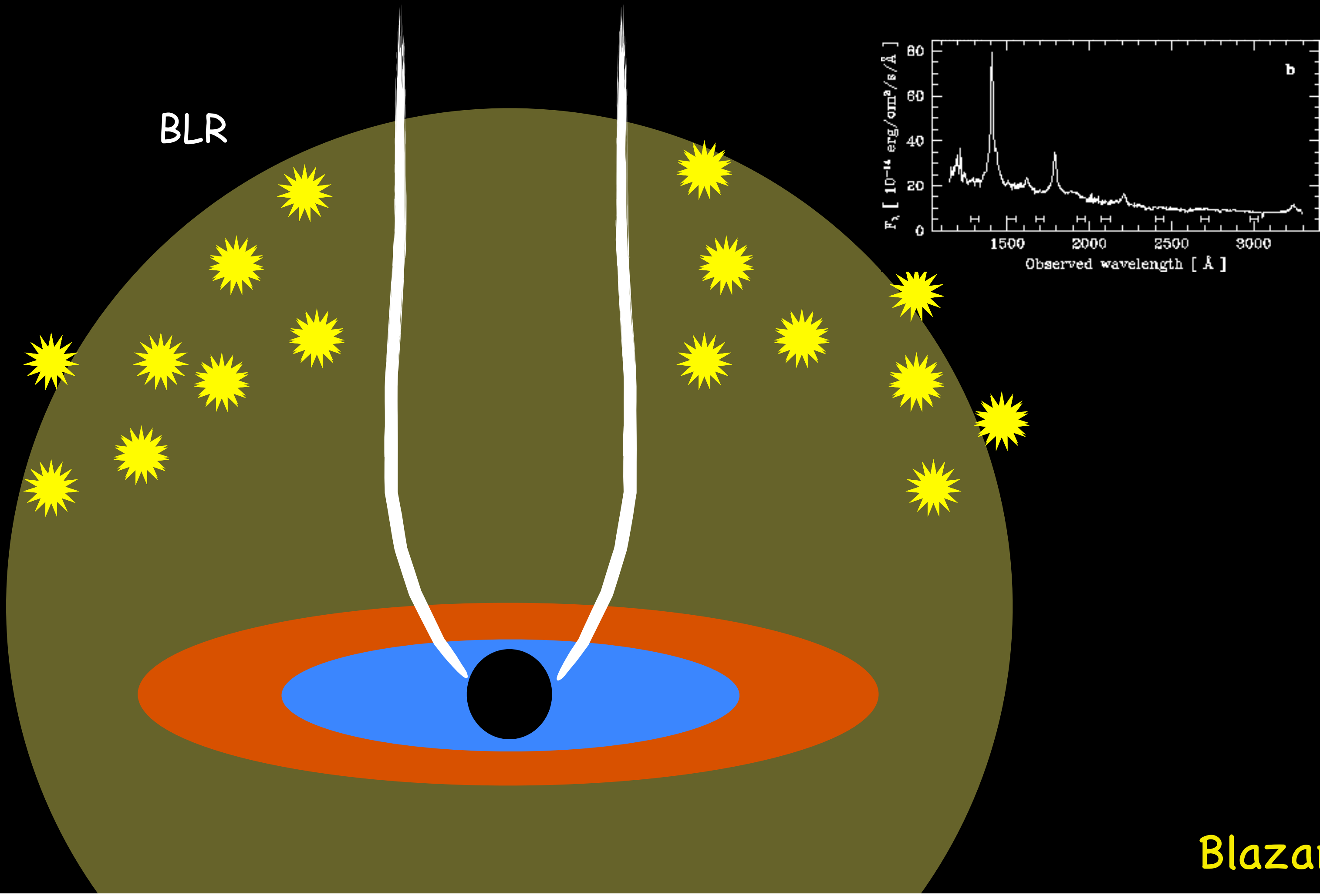
FSRQs: the general scenario



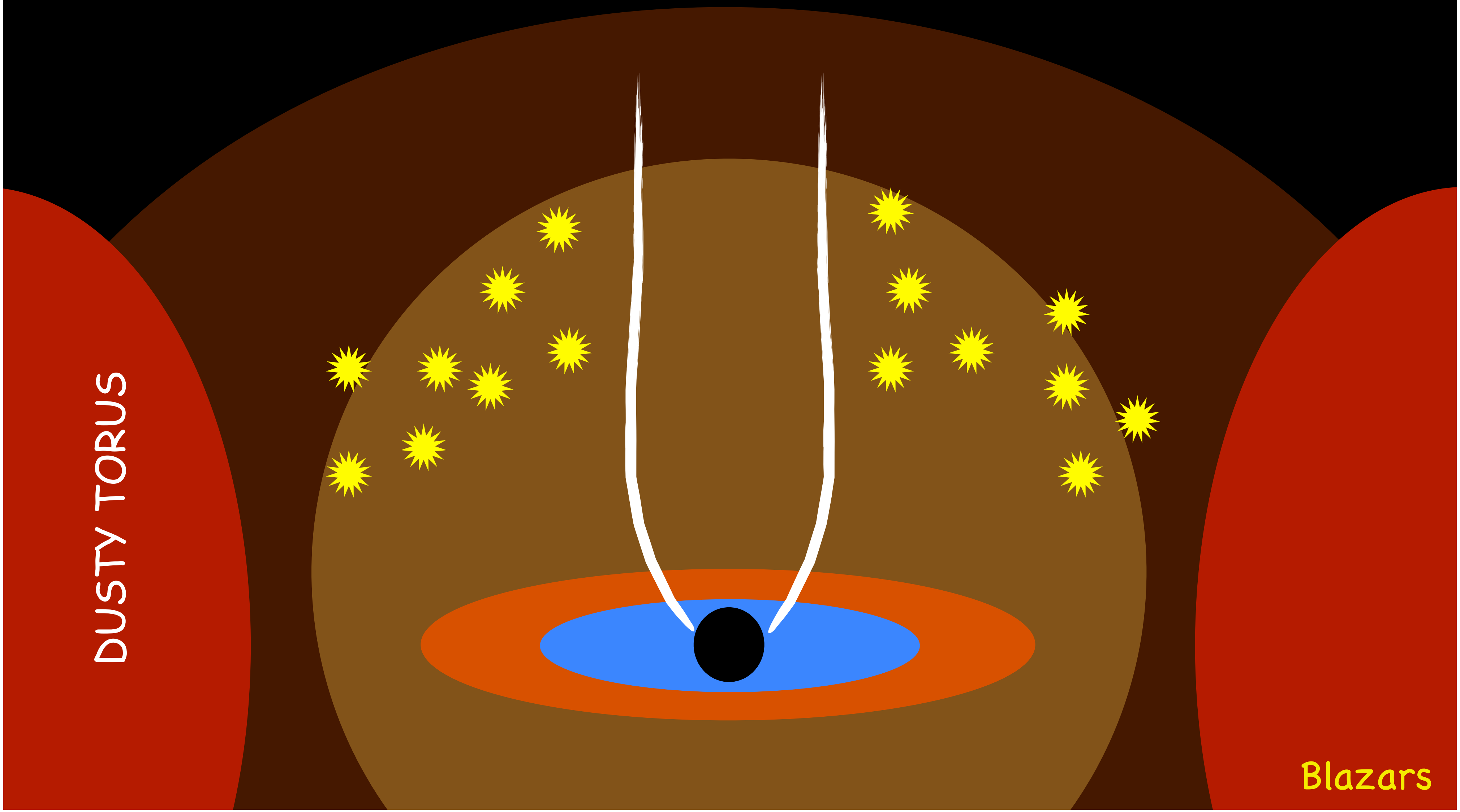
FSRQs: the general scenario



FSRQs: the general scenario

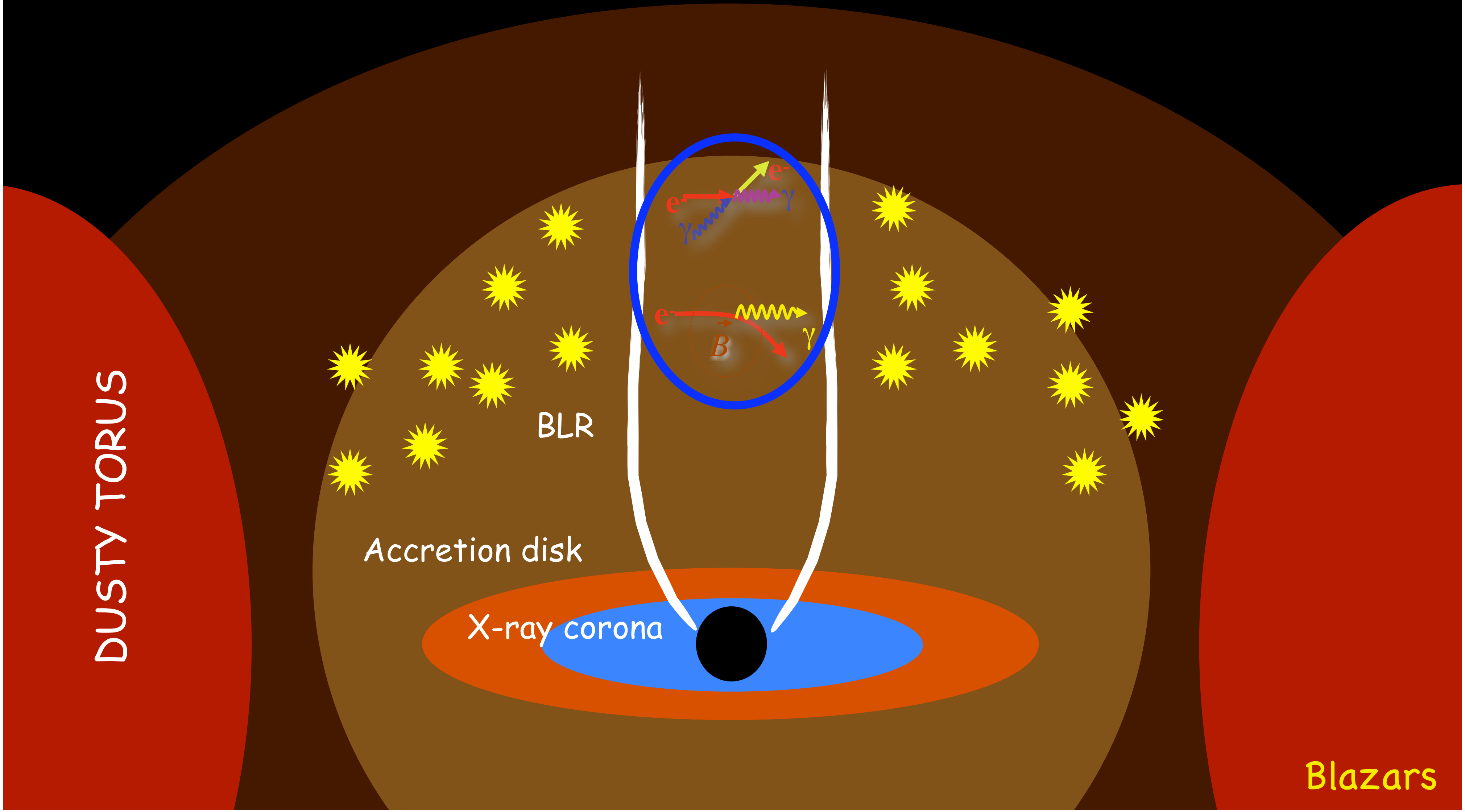


FSRQs: the general scenario

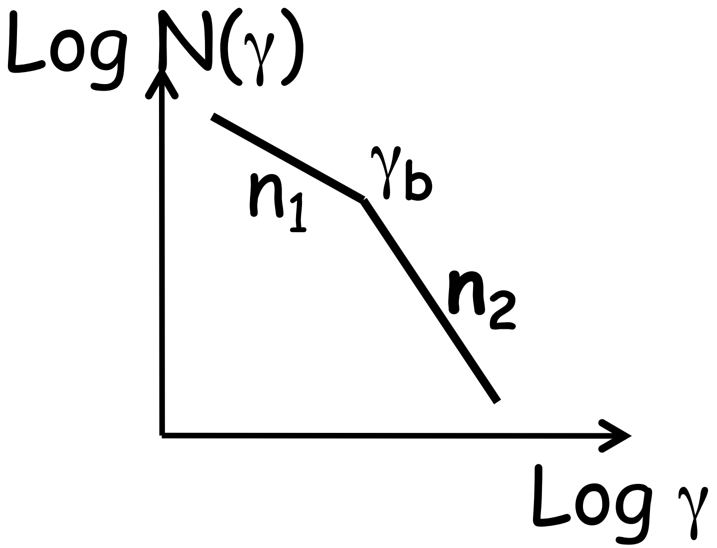


FSRQs: the "canonical" scenario

Dermer et al. 2009
Ghisellini, FT 2009
Sikora et al. 2009



The simplest model - 5



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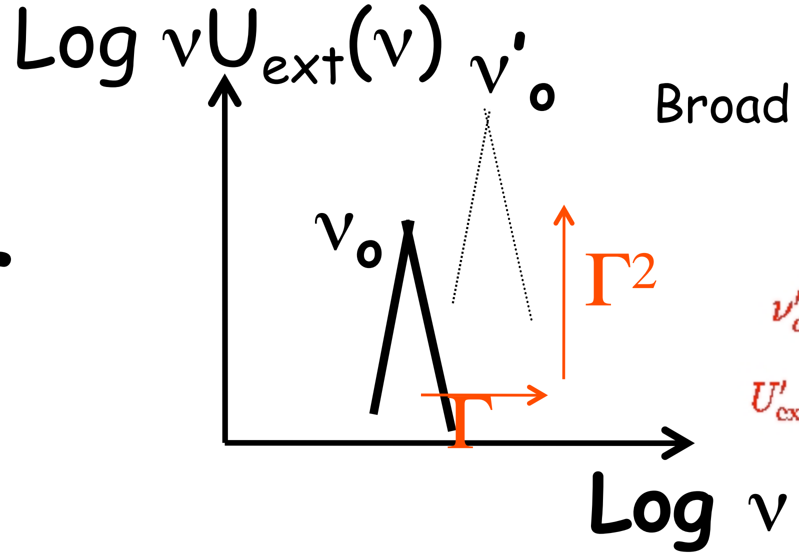
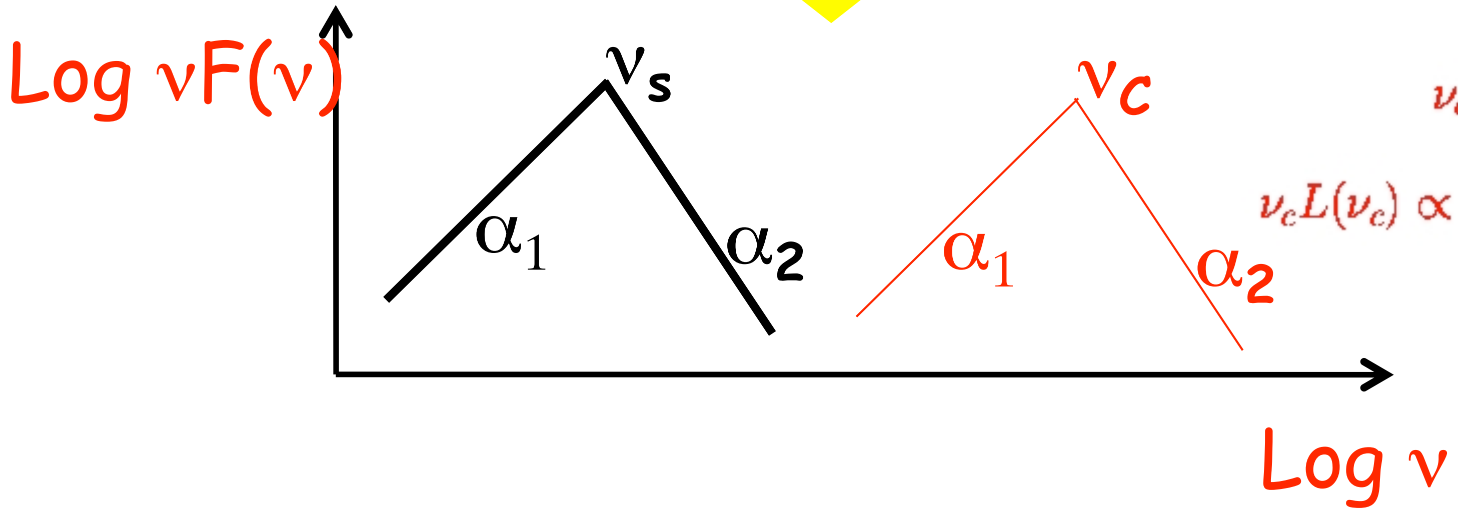


Broad line region,
Disk

$$\nu'_o = \Gamma \nu_o$$

$$U'_{\rm ext} = \Gamma^2 U_{\rm ext}$$

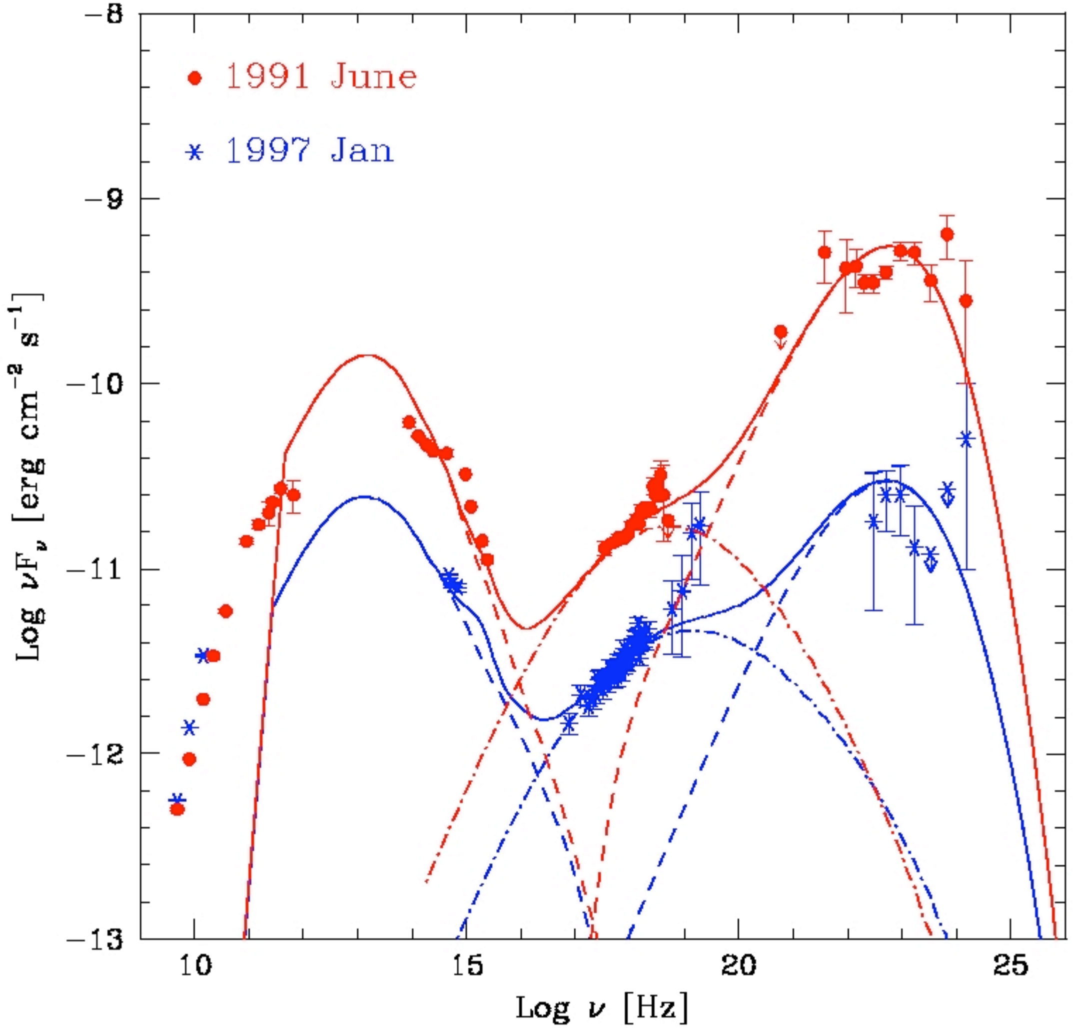


$$\nu_c = \nu'_o \gamma_b^2 \delta = \nu_o \gamma_b^2 \Gamma \delta$$

$$\nu_c L(\nu_c) \propto \sigma_T c U'_{\rm ext} N(\gamma_b) \gamma_b \gamma_b^2 V \delta^4$$

The simplest model - 6

EC + SSC → 3C 279



$B = 0.6$ - $\delta = 17.8$ - $\gamma_b = 550$ -

Ballo et al. 2002