AGN open questions and GLAST

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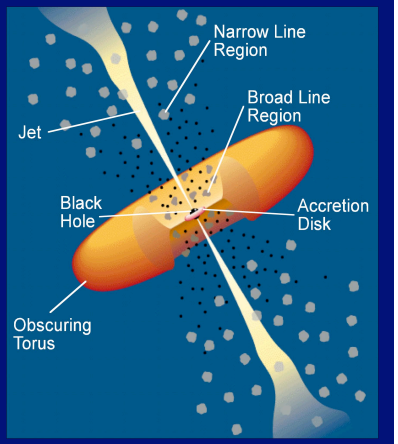
- Open questions jetted AGN
- Aspects GLAST can help tackling
- Maybe more than blazars ?
- GLAST capabilities which are involved

Active Galactic Nuclei



- Inflow: energy from accretion onto SMBH
  accretion rate and mode ?

- Outflows: jets/winds
  total and relative energetics ?
  relativistic jets – 10 % AGN are `jetted'

+ Orientation effects: obscuration and/or
  Doppler beaming

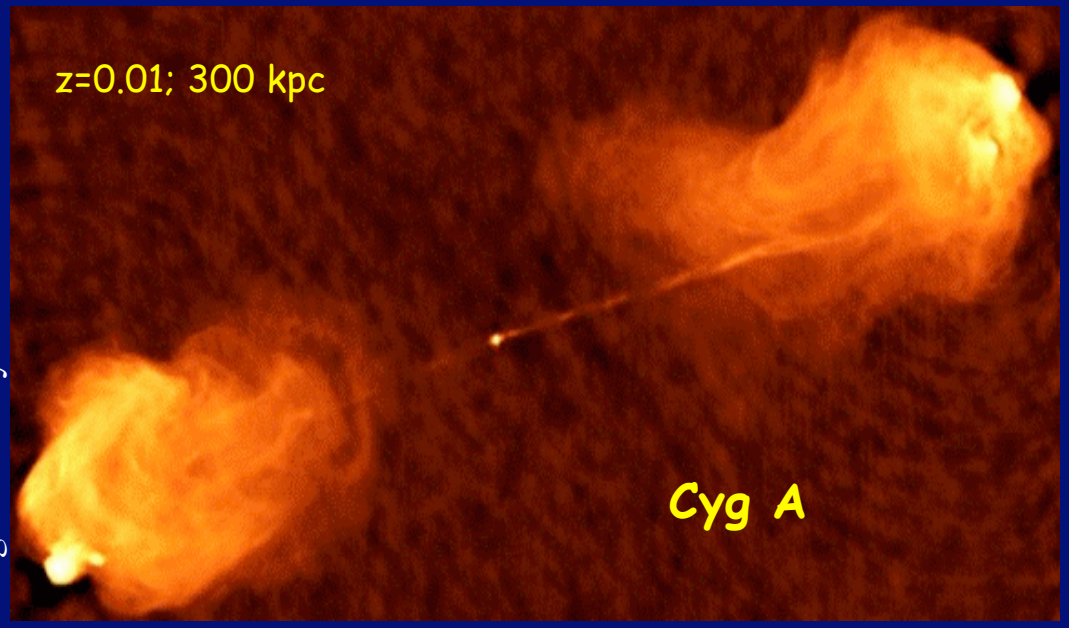
Blazars are the chief targets for GLAST

`Big' questions on jetted AGN

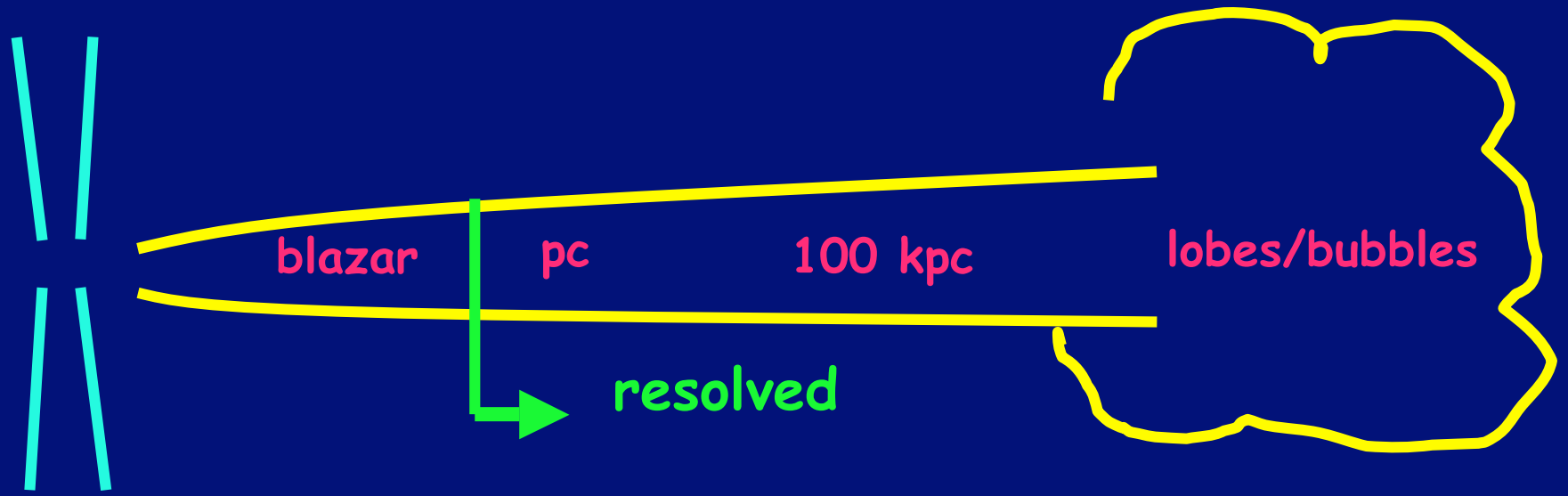
- How do jets form ?
  - Magnetic processes ?
  - Powered by disk or BH spin?
- What are they made of ?
  - Baryonic vs pair vs el.m. plasma?
- Efficiency of energy transport ?
  - Power: bulk Lorenz factor vs mass loading
  - Dissipation: internal, recollimation shocks vs. reconnection?
  - Particle acceleration
- How do they propagate and interact with environ ?
  - Gas: entrainment, boundary layers
  - Radiation: ambient photon fields

Some issues on which GLAST can help

- Emission processes
- Jet power and content
- Connection accretion properties and jets
- Dissipation site and mechanism
- Mapping the ambient
- Jet structure
- Cosmic evolution
- Jet formation
- Population studies and unification models
- γ- ray background
- Optical-UV background
- …

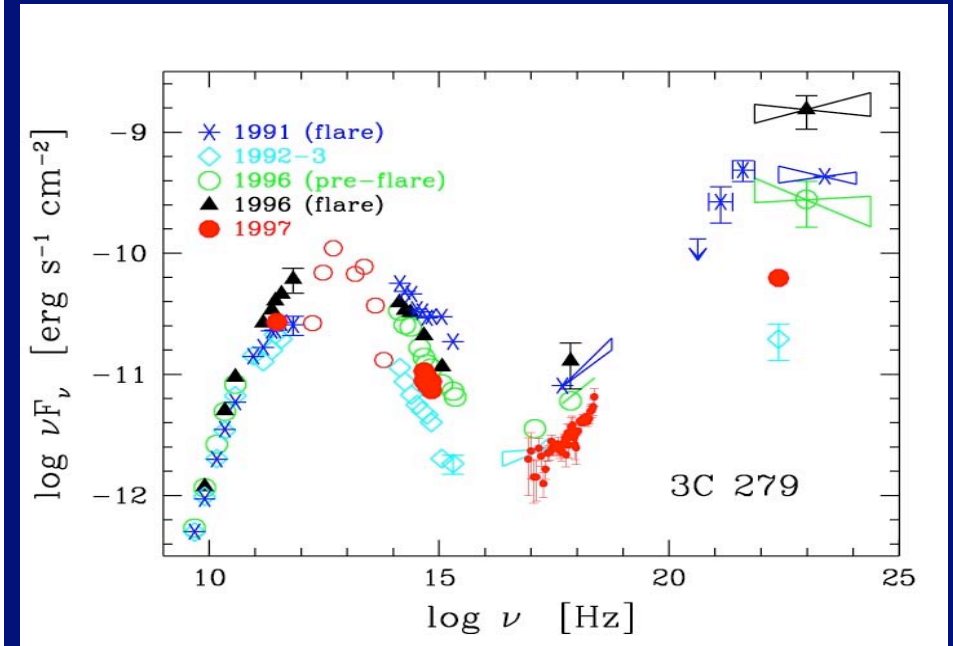


Images courtesy of NRAOAUI

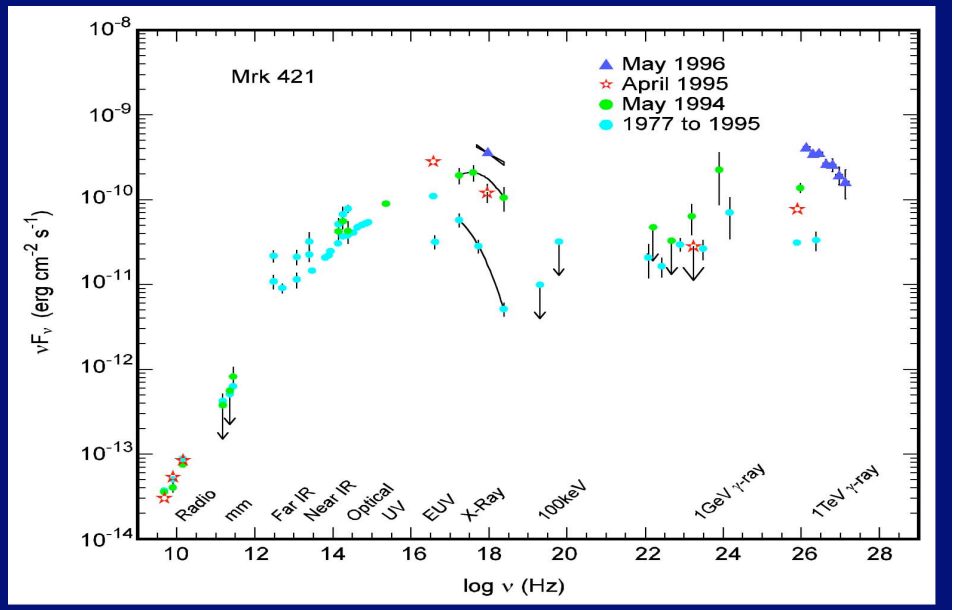


Emission processes

Broadband spectra: two components



(Wehrle et al. 1998)

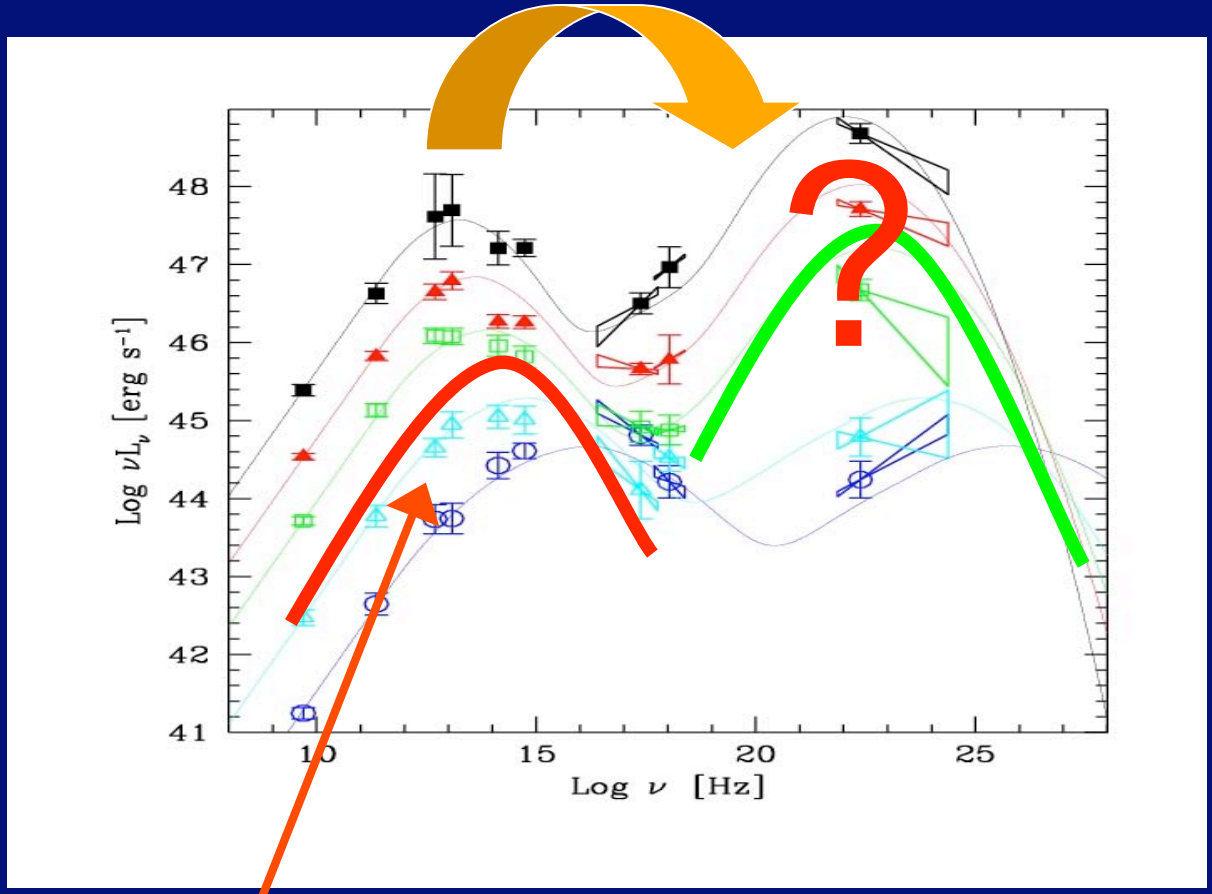


(Macomb et al. 1995)

Simplest model: same electrons produce both peaks

IR-X

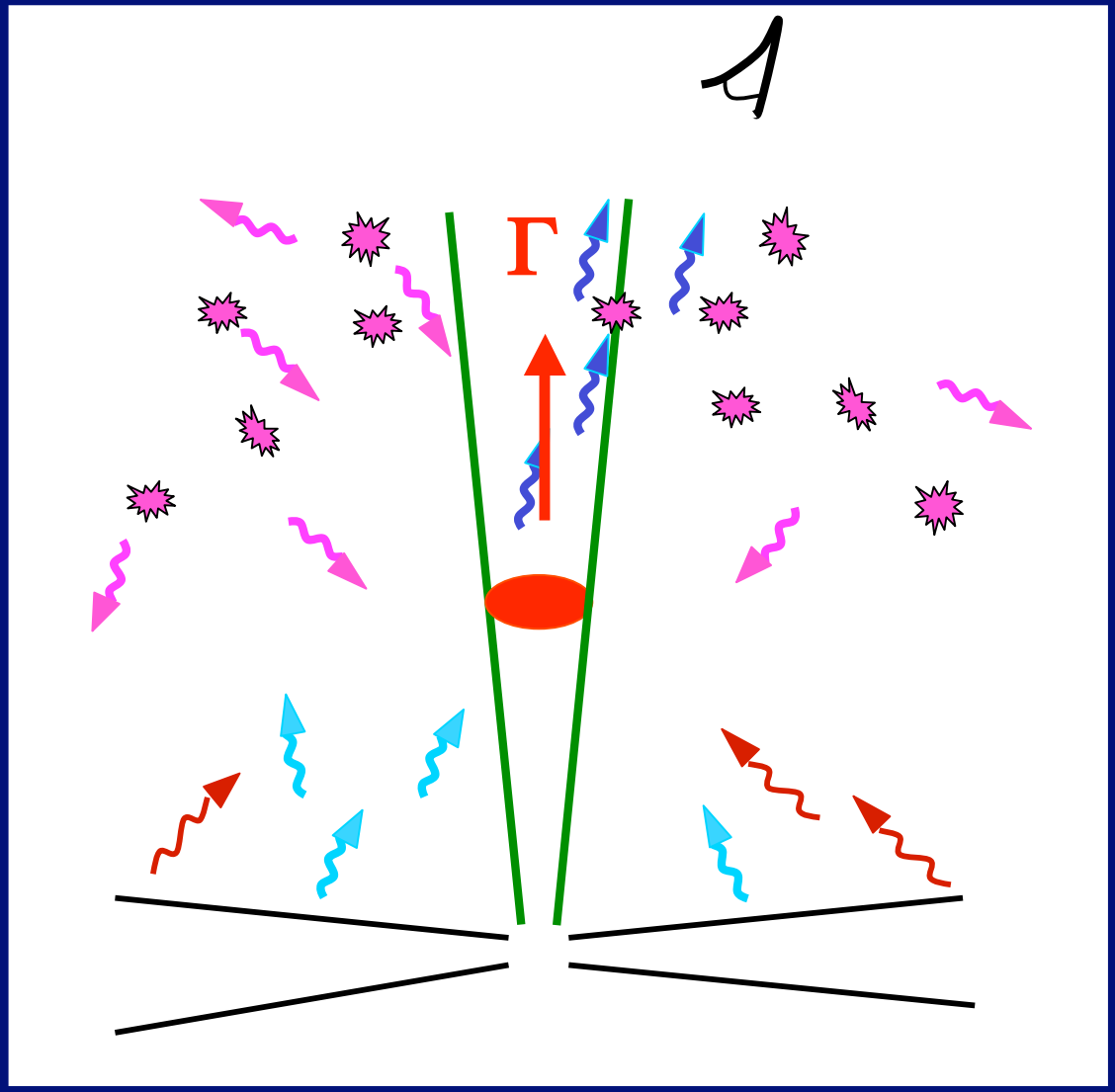
GeV-TeV

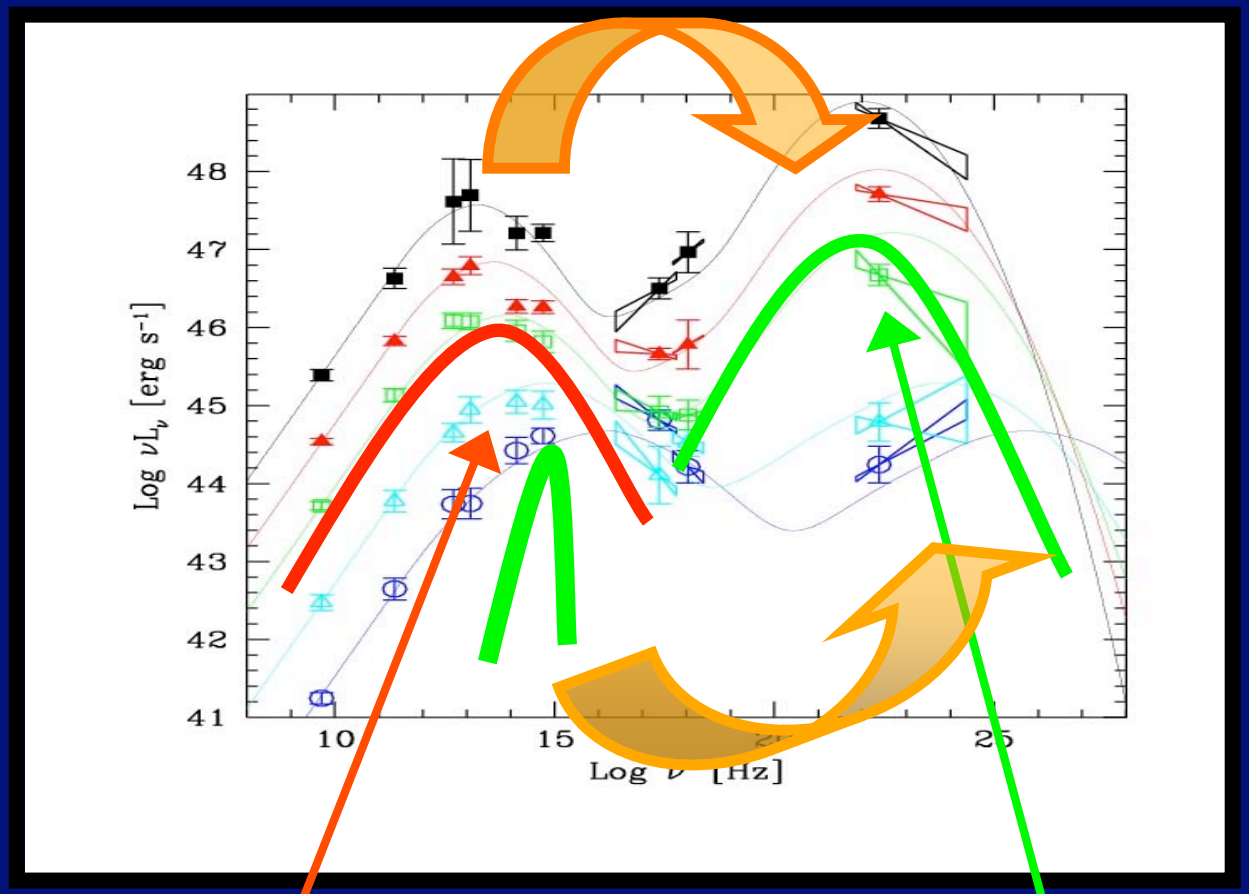


Fossati et al. 98

Synchrotron

External Compton





Synchrotron

Synchrotron self-Compton +
External Compton on BLR, disc, torus,…

Hadronic models [p+p, p+B, p+γ..] some difficulties, but not ruled out

SSC vs EC vs more complex models: How to distinguish?

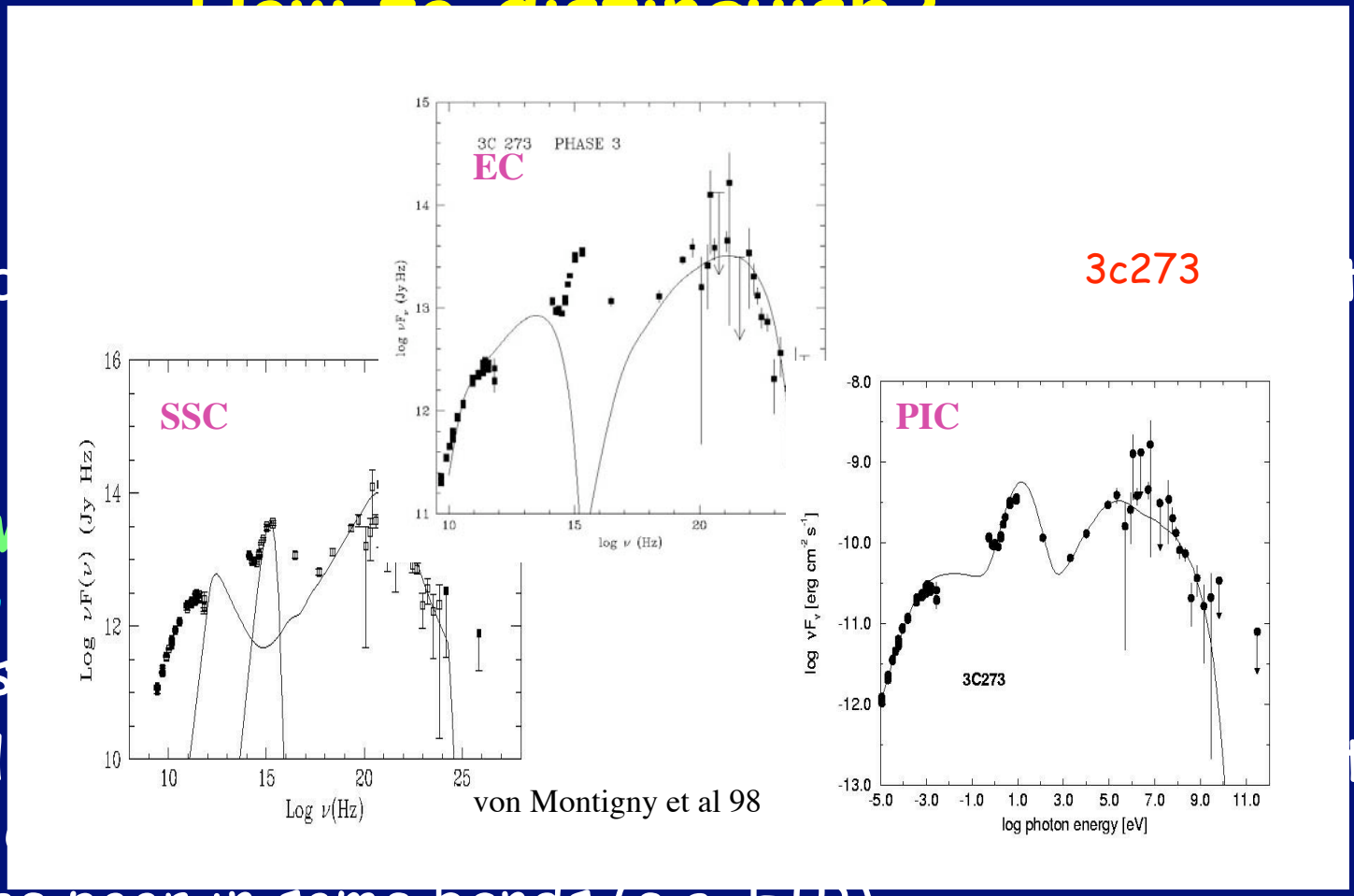
Broad

Coulc ty

Multiv

strong

- Seen es
- Limited ter timescal
- Coverage poor in some bands (e.g. FIR)
- Light curve correlations (radio/γ-ray): mapping the dissipation



Connection accretion – jet ?

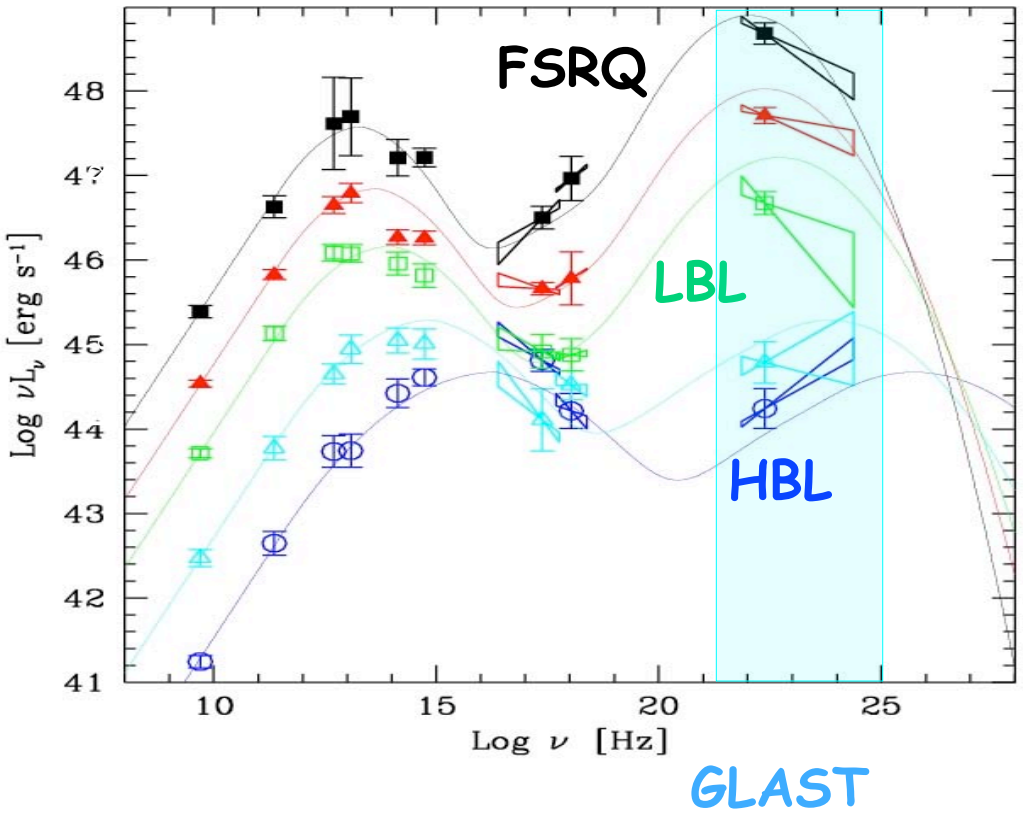
IF

Quasars - Strong ambient radiation = EC

BL Lac - Weak ambient radiation = SSC

A blazar sequence defines a connection

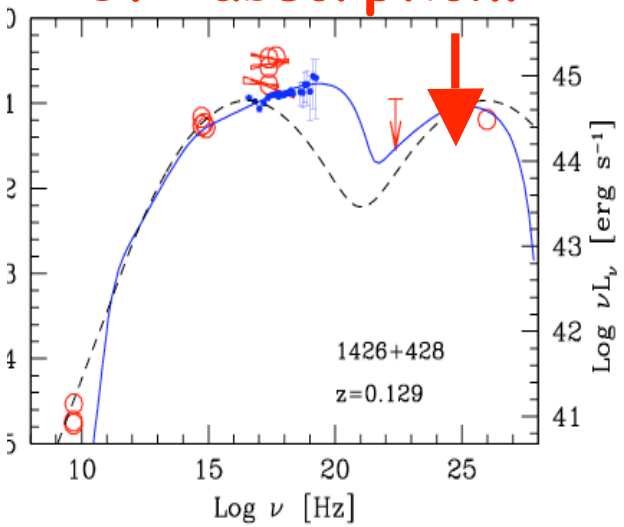
Fossati et al. 98



GLAST

Outliers?

TeV absorption?



Dynamics, transport of energy

Variability + γ-ray luminosity imply γ–γ absorption of γ-ray. Ascribed to Doppler beaming.

Set lower limits to Γ (~ 10)

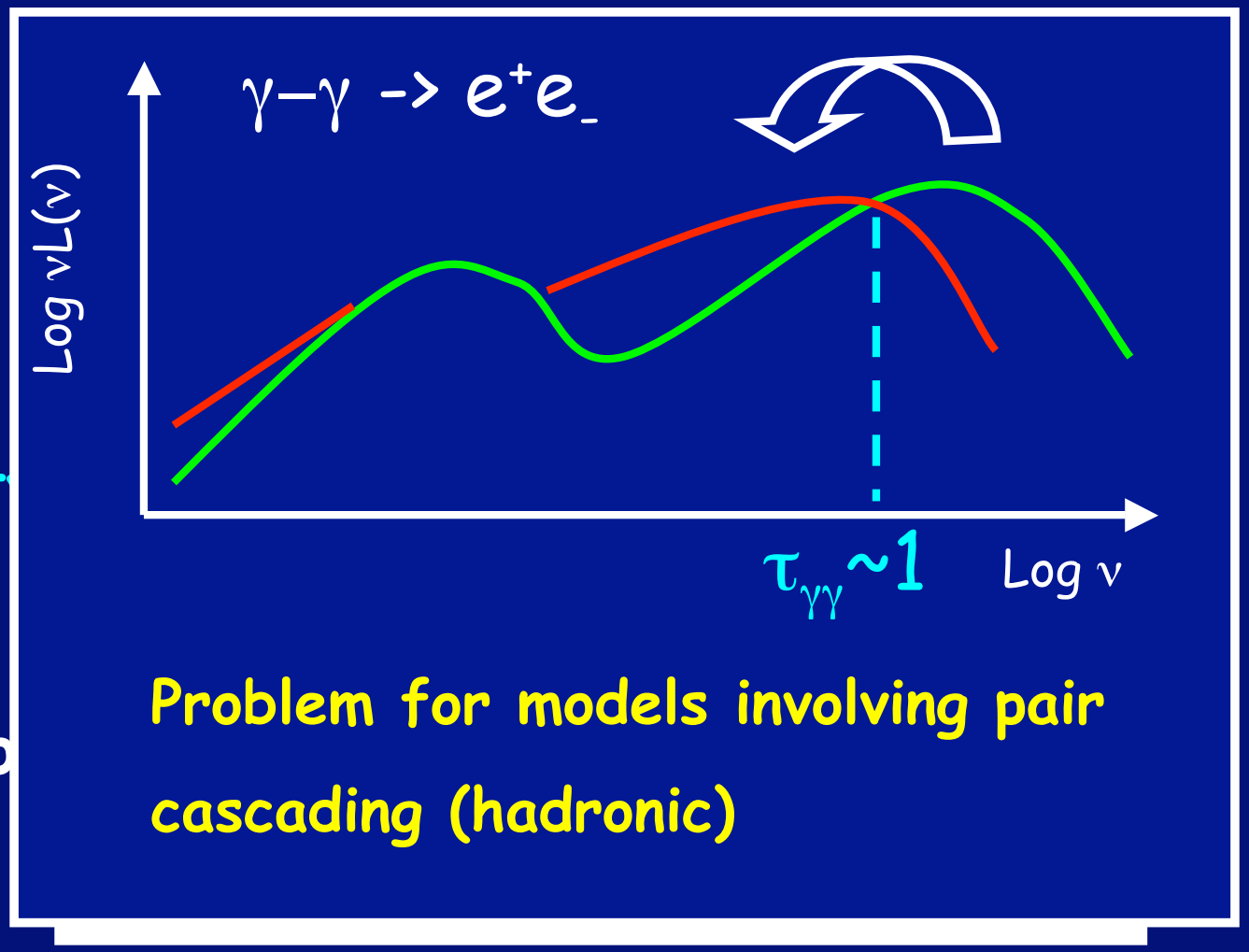
- Comparison with IDV limits?
- Shorter timescale variations in TeV

Dissipation

Variability

Pair opacit

Internal sho



Problem for models involving pair cascading (hadronic)

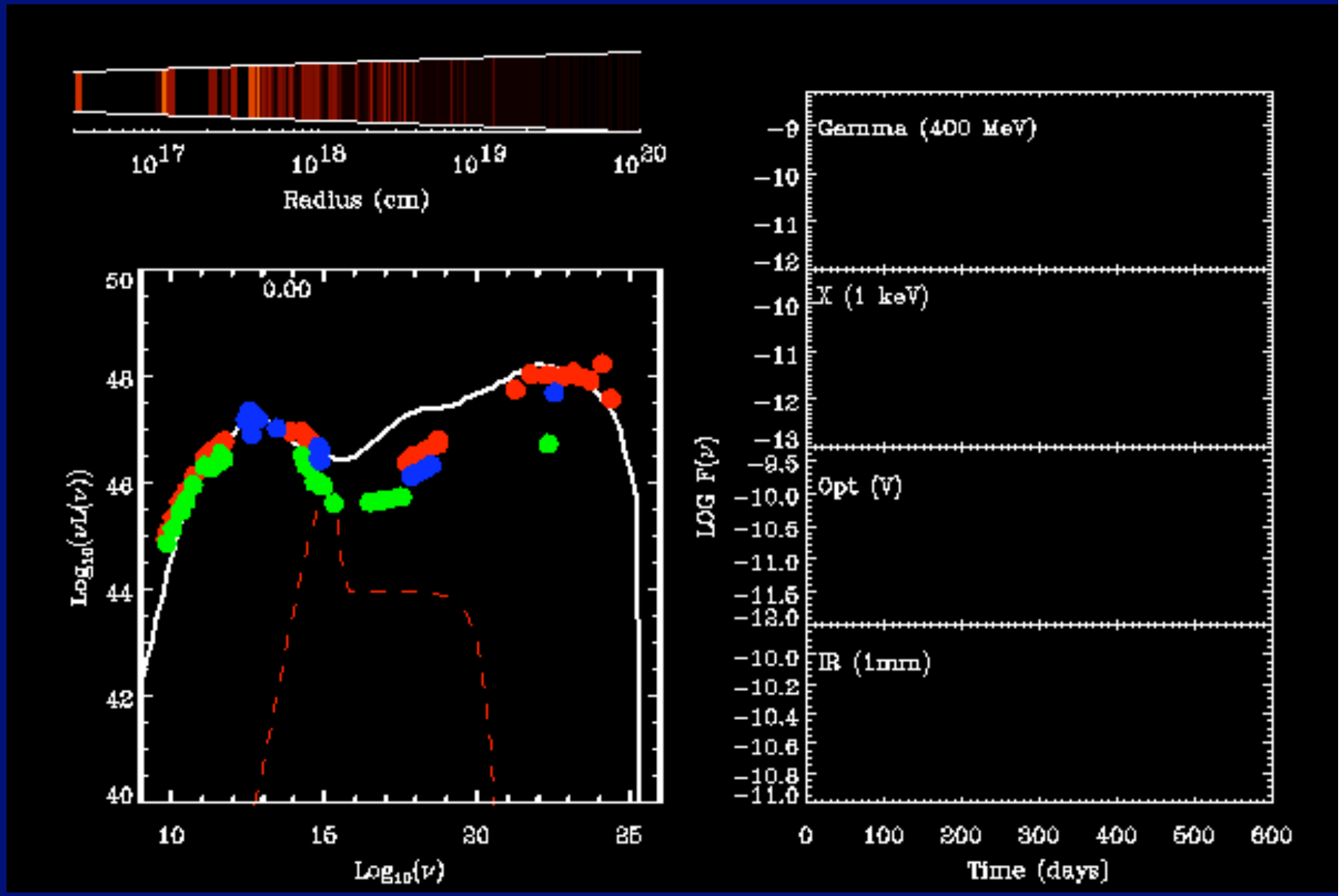
Characteristic variability timescale ? PDS

Internal shocks

Unsteady velocity 'injection'

- Typical distance for dissipation ~ $R_0\ \Gamma^2$ ~100 R_s, but highly variable
- Low radiative efficiency
- $L_{kin} > L_{el.m}$ in contrast with el.m. model

Numerical simulations for 3C 279



Spada et al 2001

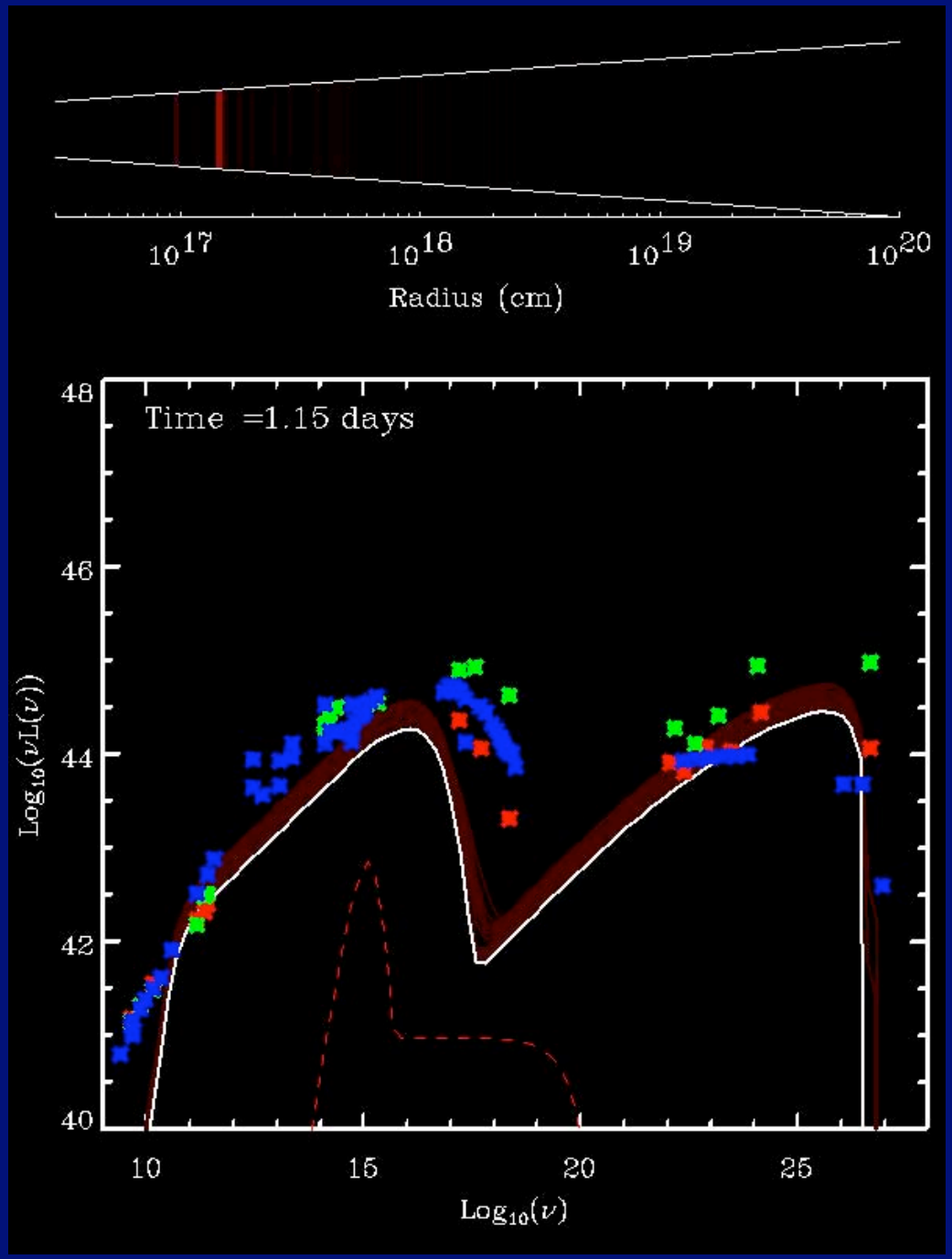
and Mkn 421

Overall spectrum depends on $\langle L_{jet} \rangle$

Large L_{jet} ~ FSRQ

Low L_{jet} ~ HBL

Variability indicators

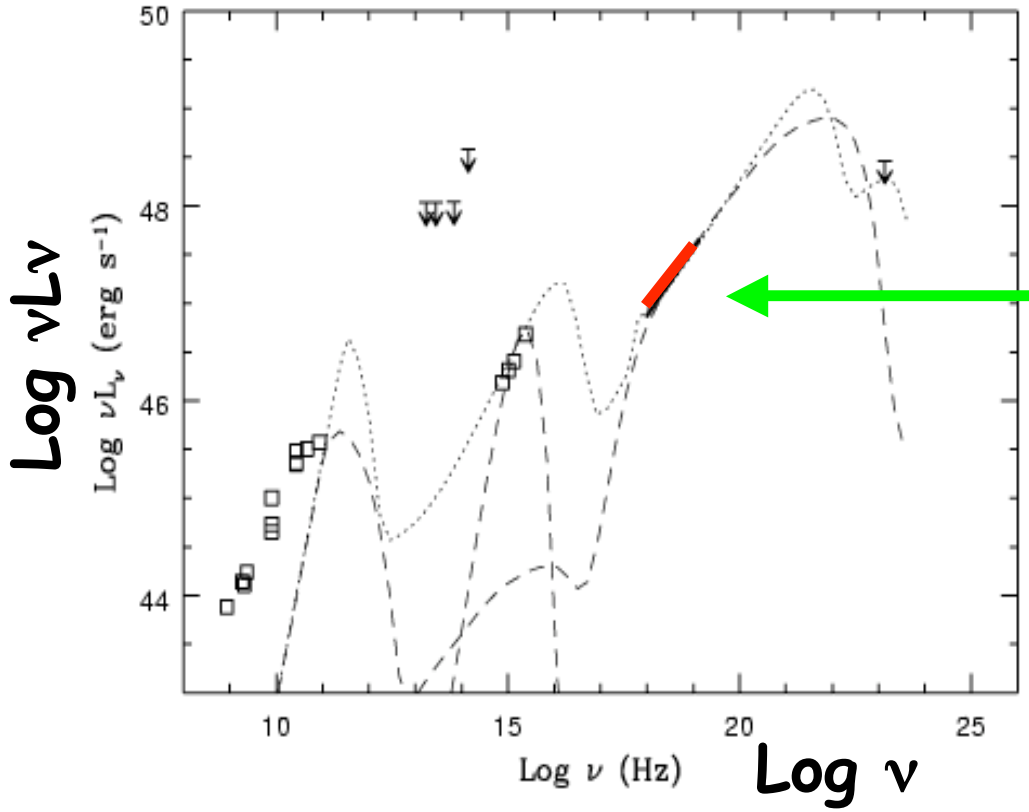


Guetta et al 2004

Jet power and content

But need duty cycles

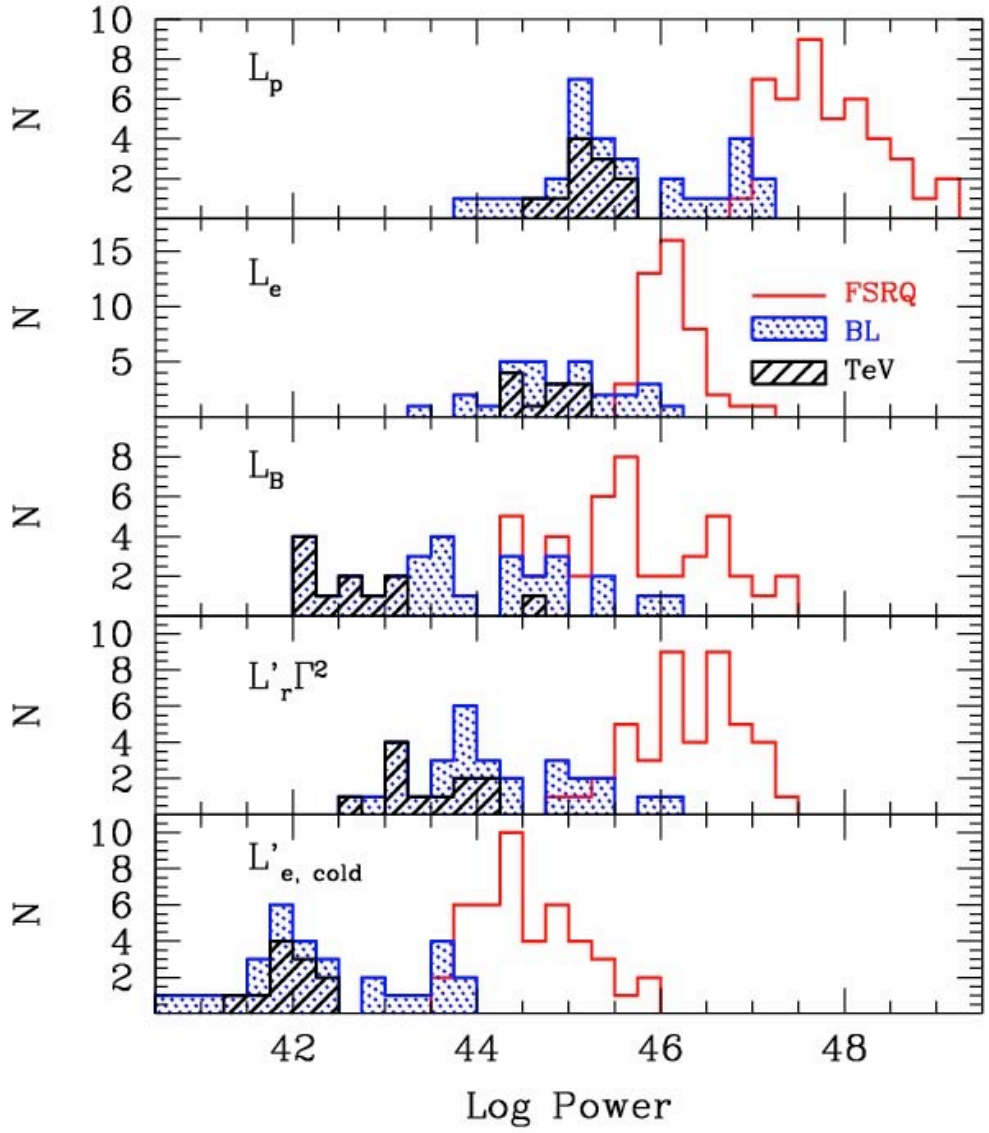
$L_{jet} > L_{obs} / \Gamma^2$



$L_{jet} > 10^{47}$ erg/s

Fabian et al. 1998

Via spectral modeling (Γ,B,n,..)



Protons (one p per emitting e-)

Relat. Electrons

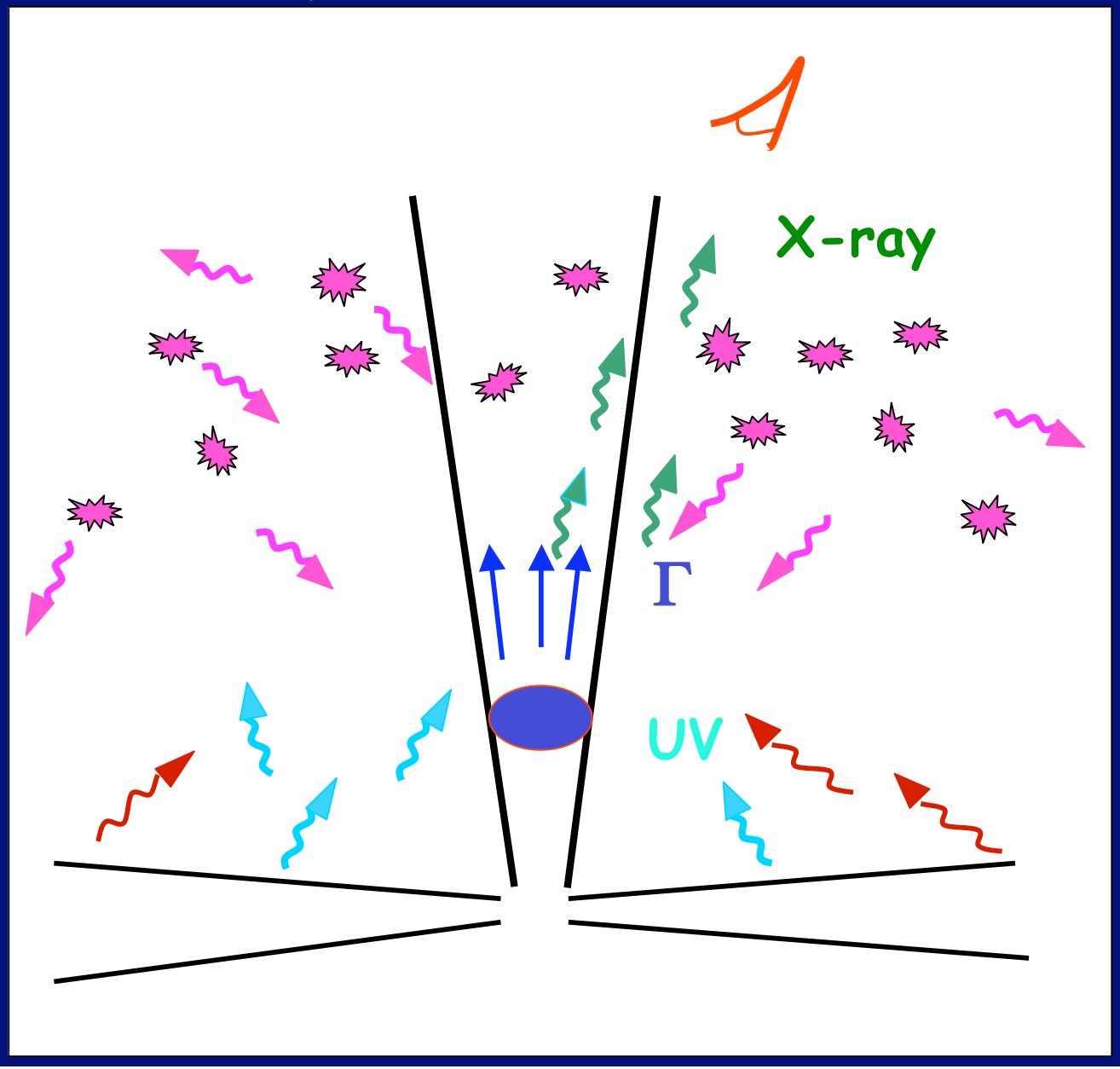
B-field

Radiation

Cold elecrons

[Begelman & Sikora 1987]

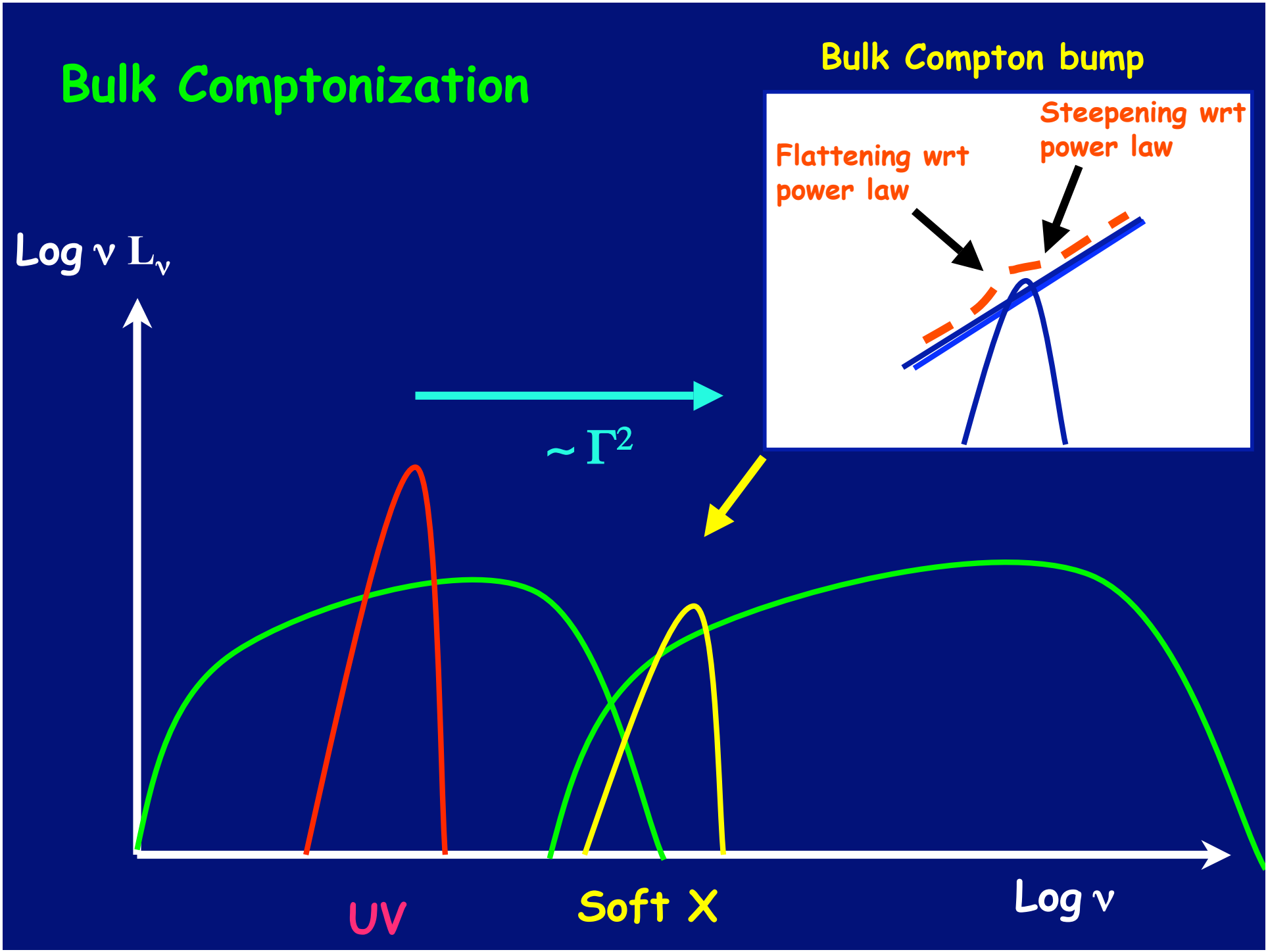
Bulk Comptonization



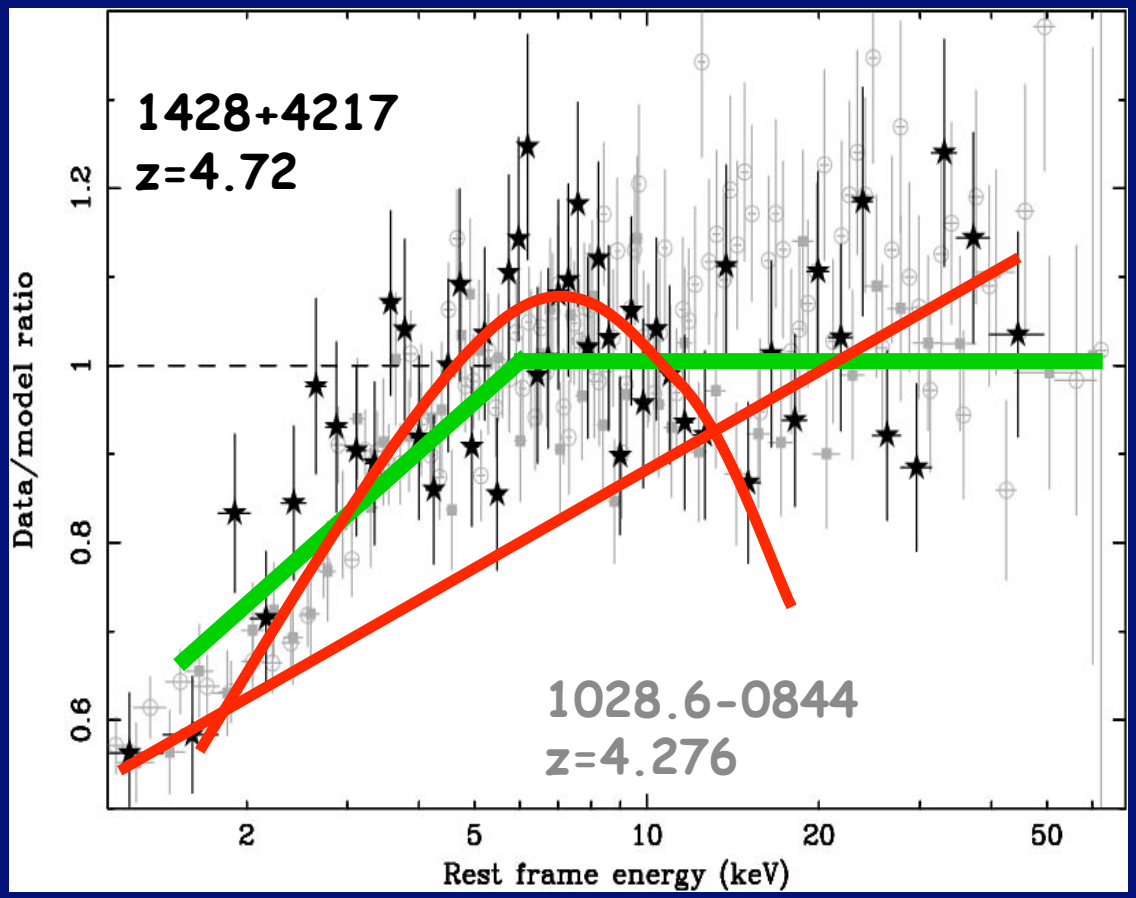
`cold' leptons

$< \gamma > \sim 1$

Bulk Comptonization



If detected get info on: # `cold' particles, Γ

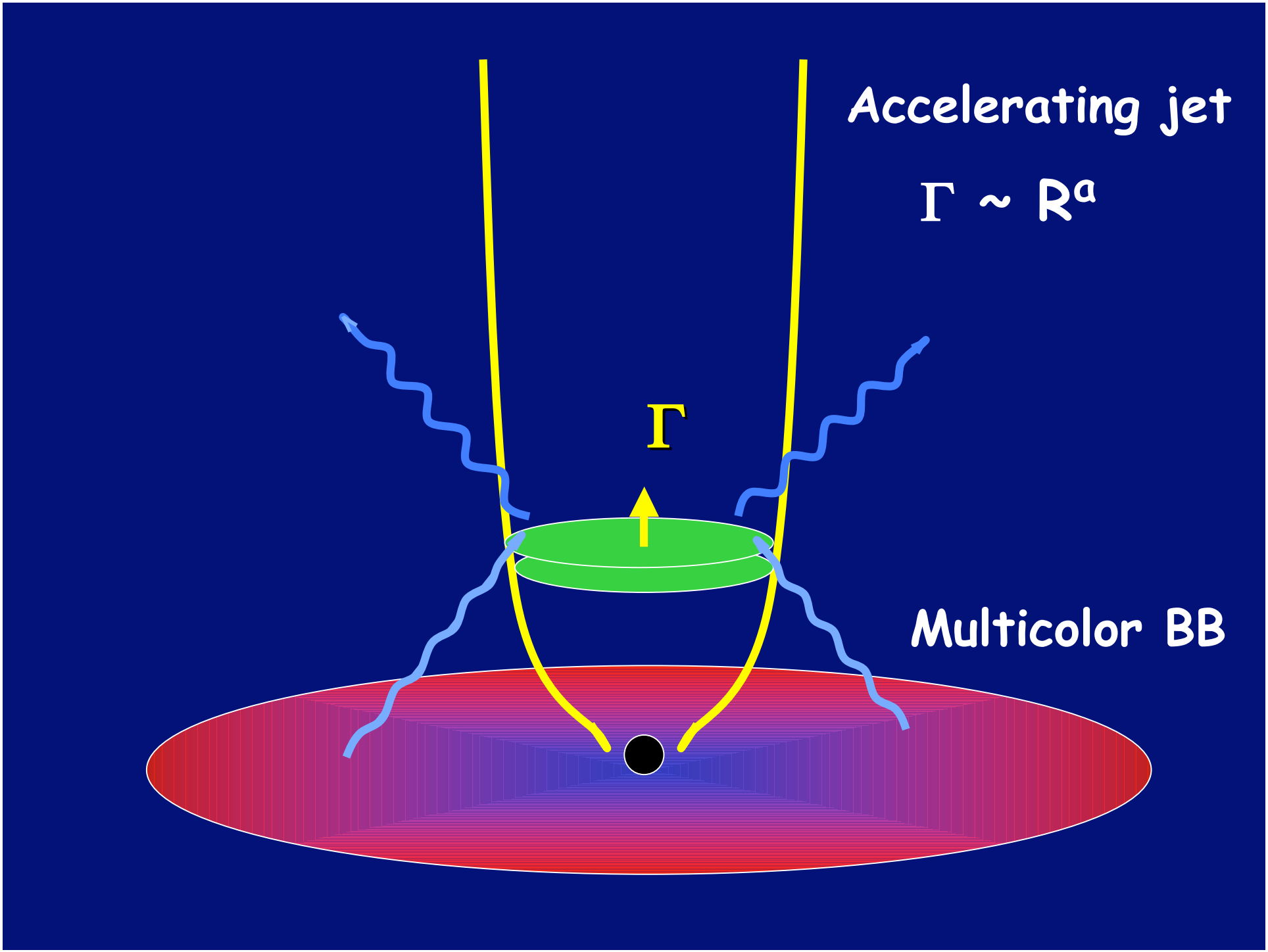


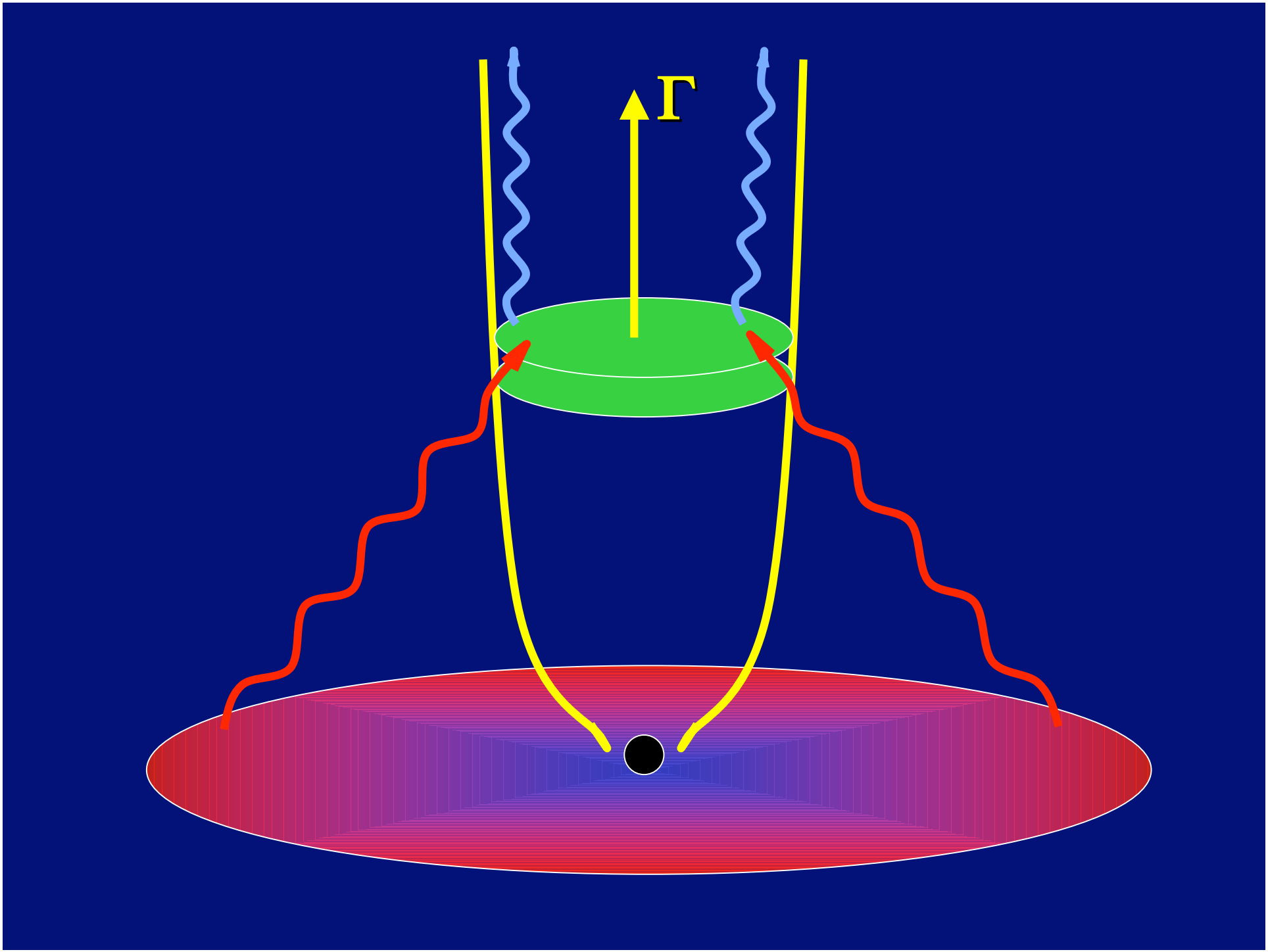
Tozzi et al. 2005

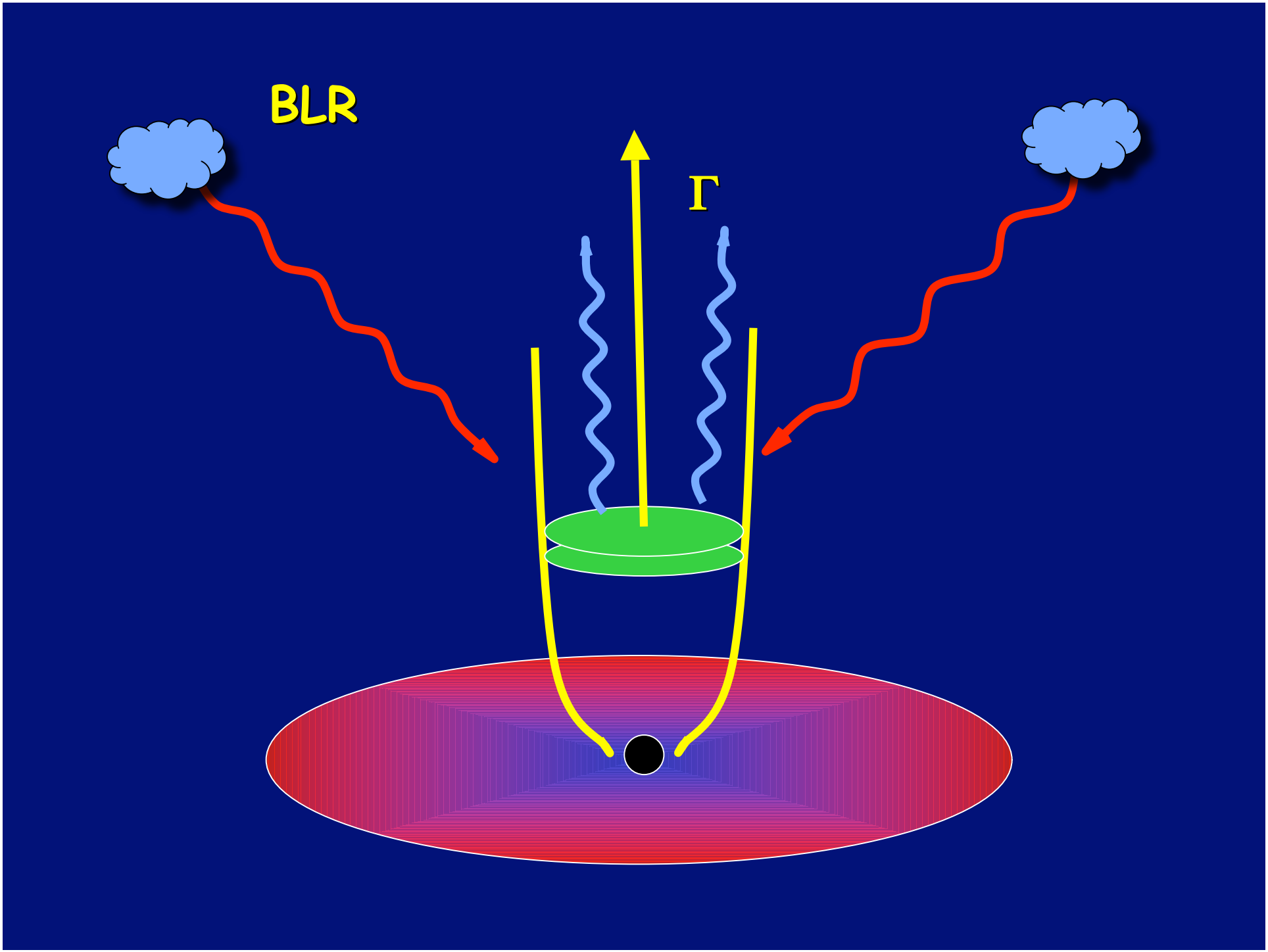
Soft X-ray flattening due to absorption…

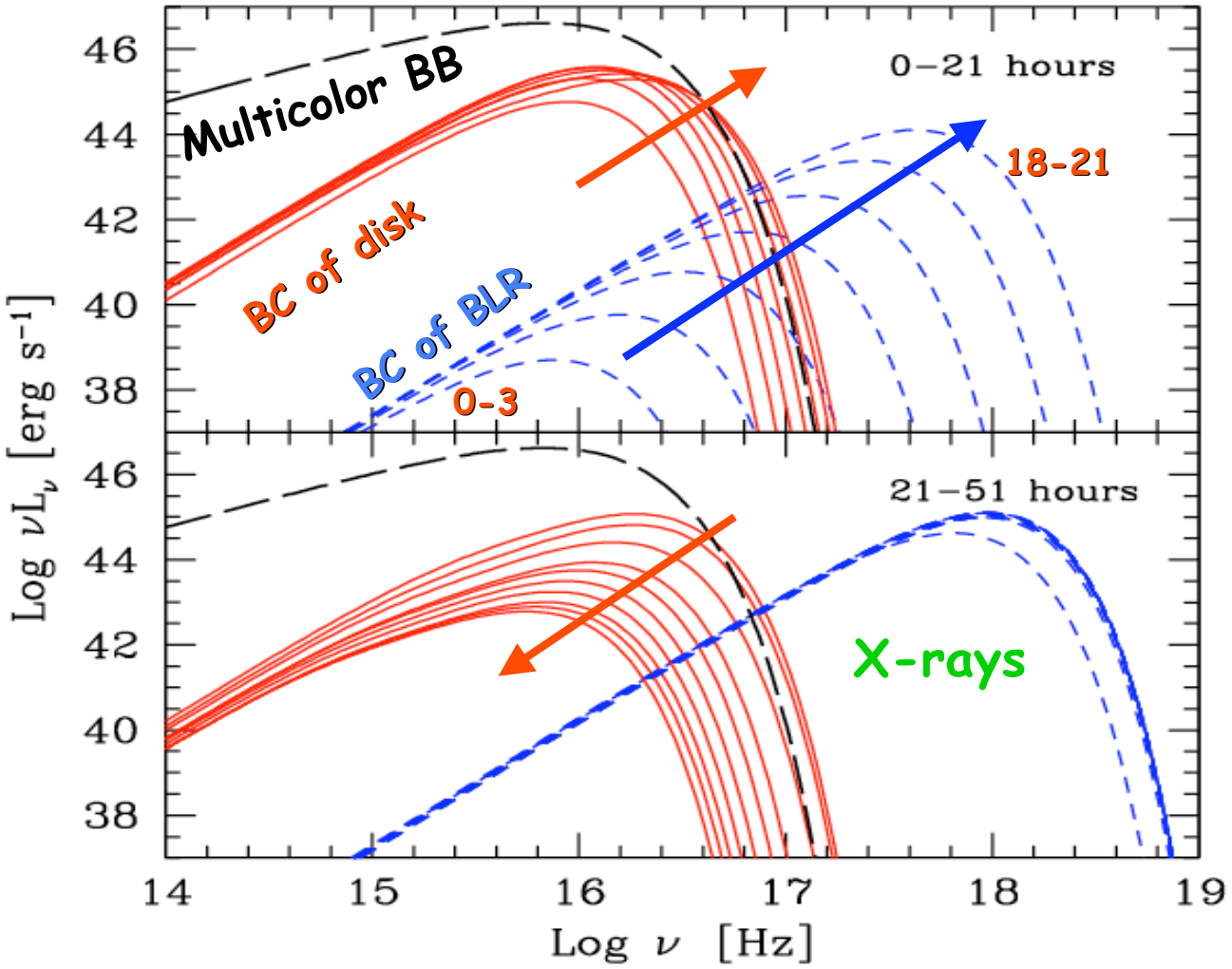
..or a bump ?

Statistically equally consistent


Accelerating jet
Γ ~ R^a
Γ
Multicolor BB

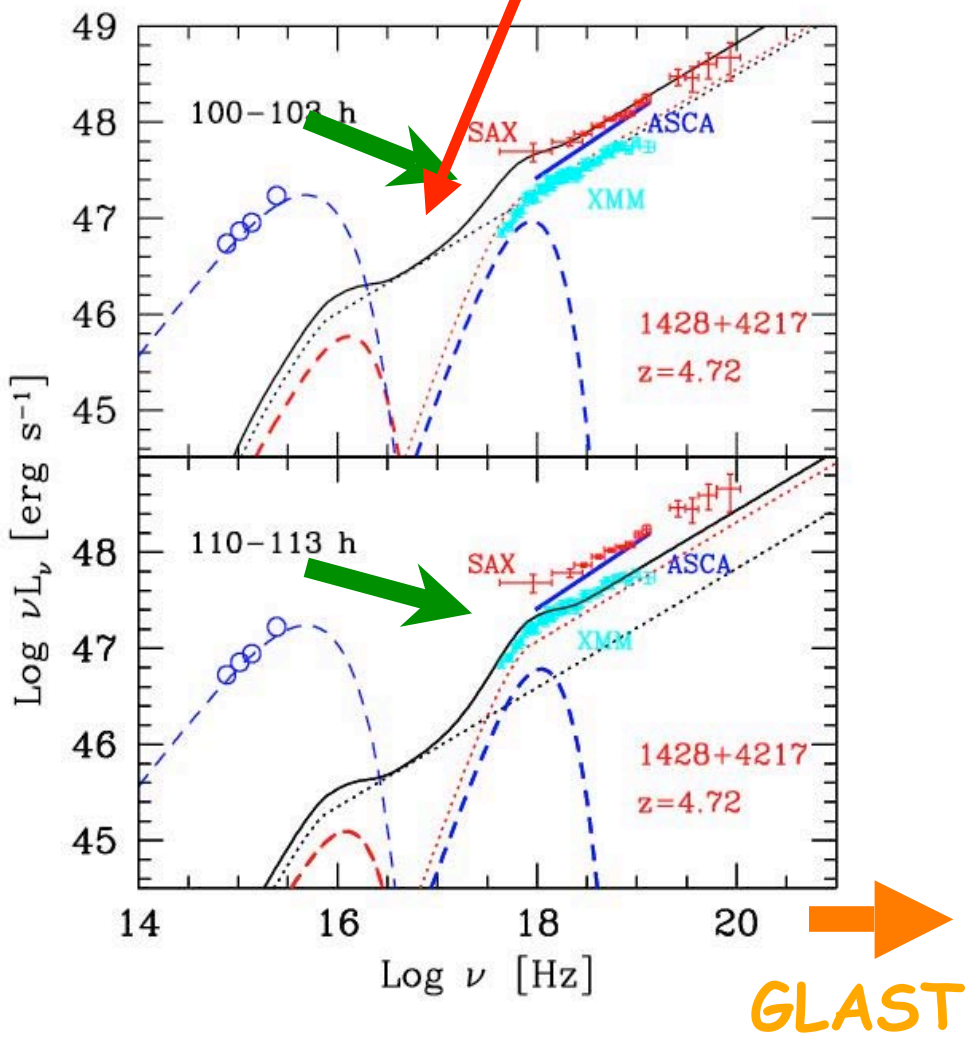

Γ


BLR
Γ



- Transient feature
- Difficult to observe (low SSC)
- Powerful (i.e. high z) blazars favoured

Disc contribution can be important



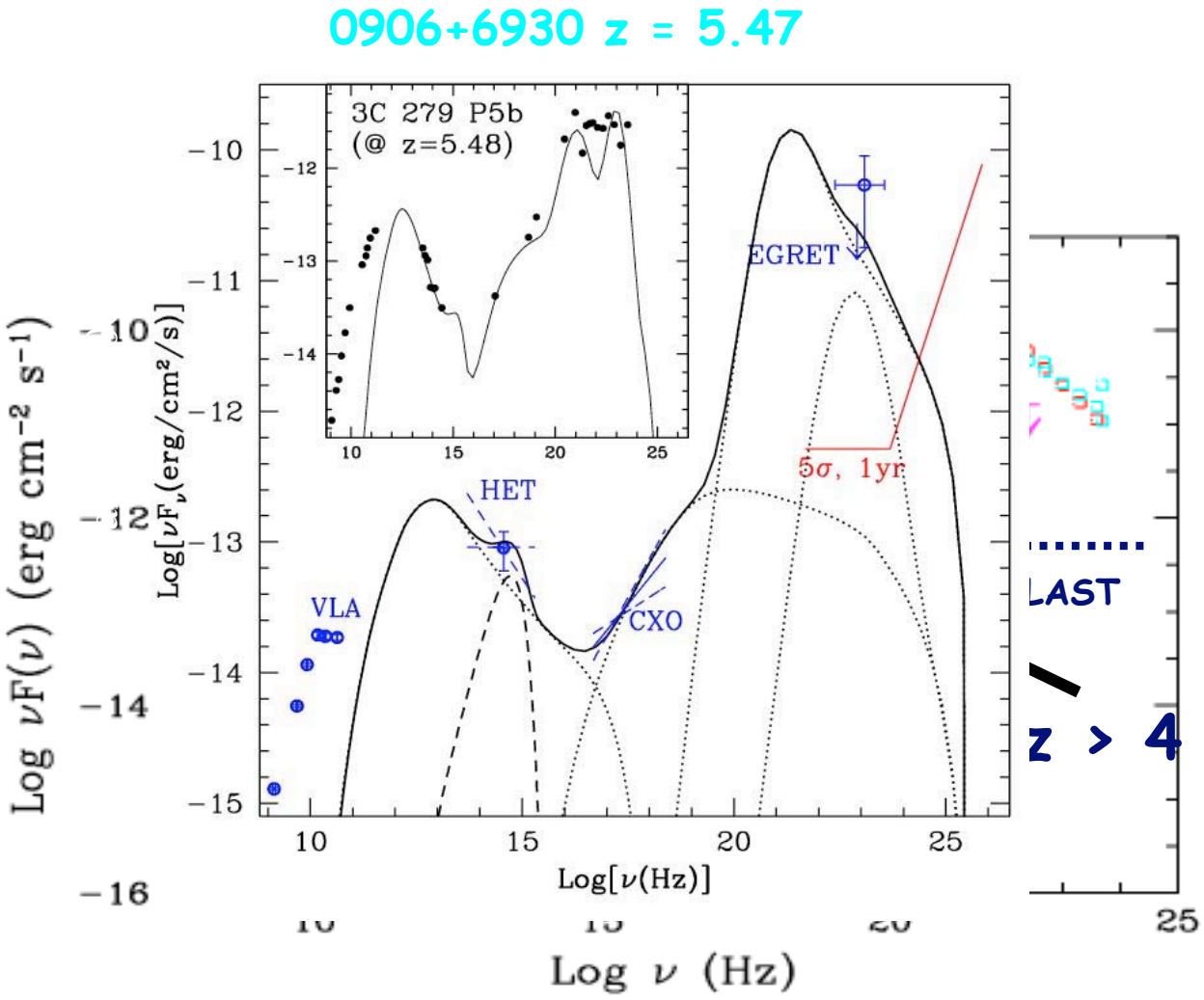
Why GLAST?

Relative norm relativistic and 'cold' leptons requires high energy component

Delays: mapping the dissipation vs acceleration ?

Evolution

High z blazars



How many ?

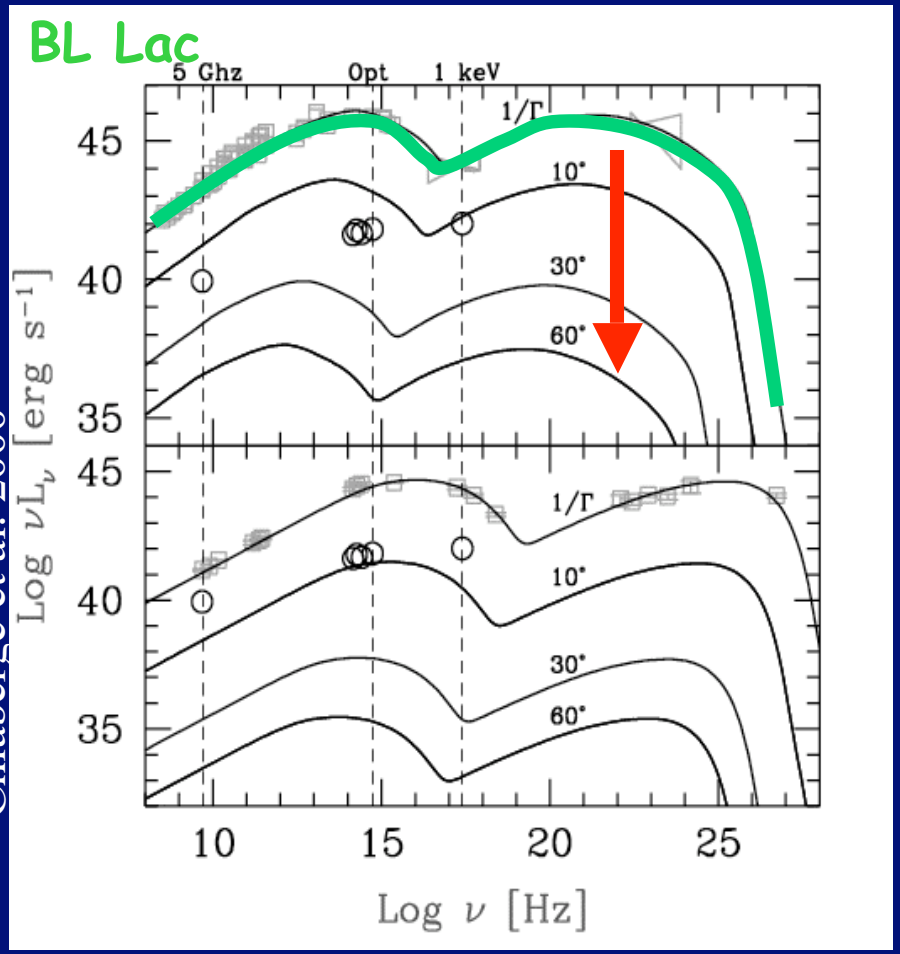
Evolution in environment ?

(nuclear, host,...

$t_{var}/(1+z)$

But EBL...

Jet structure



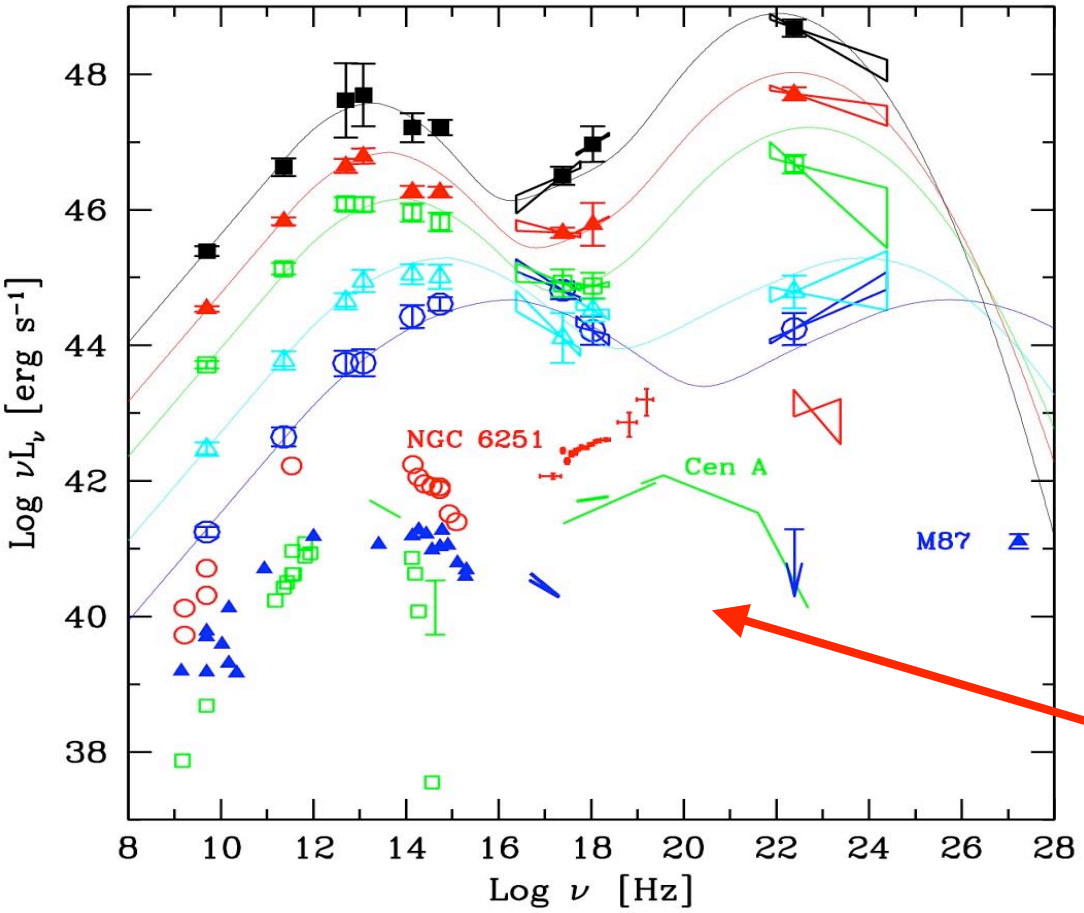
Chiaberge et al. 2000

Radio galaxies

Emission higher than expected from simple de-beaming in FRI

Mildly beamed component at larger angles?

Structured jets due to L_{jet} (θ) or interaction with environment ?



Radiogalaxies
so far only FRI

- HESS: rapid TeV variability in M87 ?
- Non variable reprocessed extended component

And a part from flaring blazars ?

Blazars

- Flaring activity
- Steady emission ?
- Dissipation on scales < 100 R_s

And a part from flaring blazars ?

Blazars

Flaring activity

Steady emission ?

Dissipation on scales < 100 R_s

-Faint

-`Steady' physical process and/or large scale emission

And a part from flaring blazars ?

Blazars

Flaring activity

Steady emission ?

Dissipation on scales < 100 R_s

- Collimation/acceleration region?
- Need low opacity for pair production – radiatively inefficient accretion systems?

And a part from flaring blazars ?

Blazars

Flaring activity

Steady emission ?

Dissipation on scales < 100 R_s

Non blazars jetted AGN

Radio galaxies: - Debeamed radiation

- Large scale emission

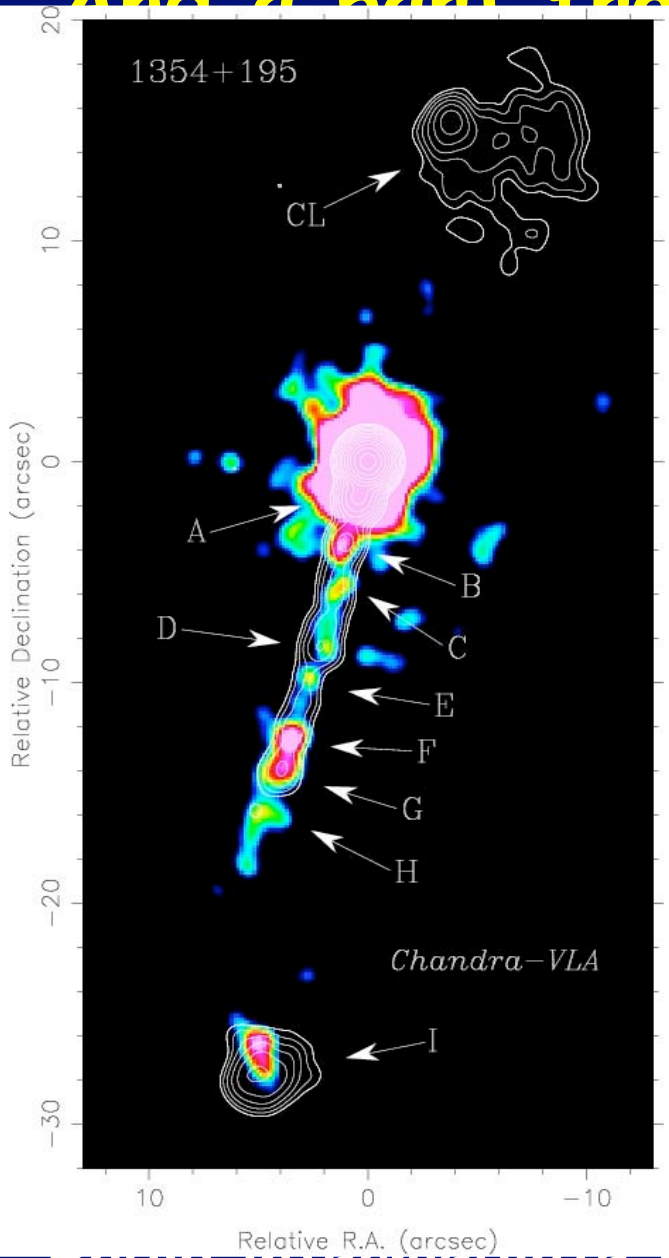
- Young radio galaxies

Radio intermediate quasars: `low speed' outflows?

And a part from flaring blazars ?

Blaz

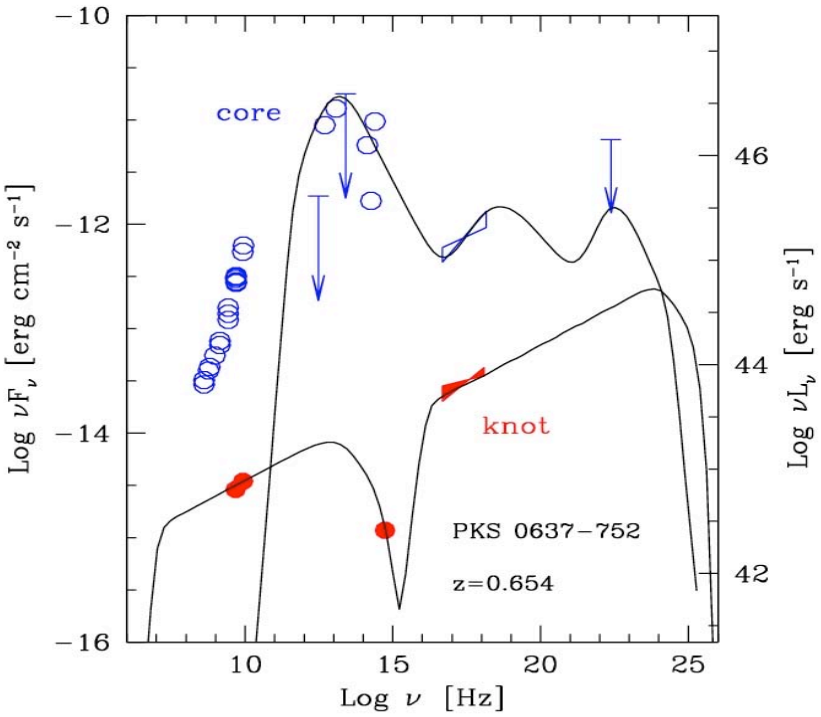
Nor



Model debated

Possible tests in γ-rays

(for non-blazars)



Radio intermediate quasars? "low speed" outflows?

And a part from flaring blazars ?

Blazars

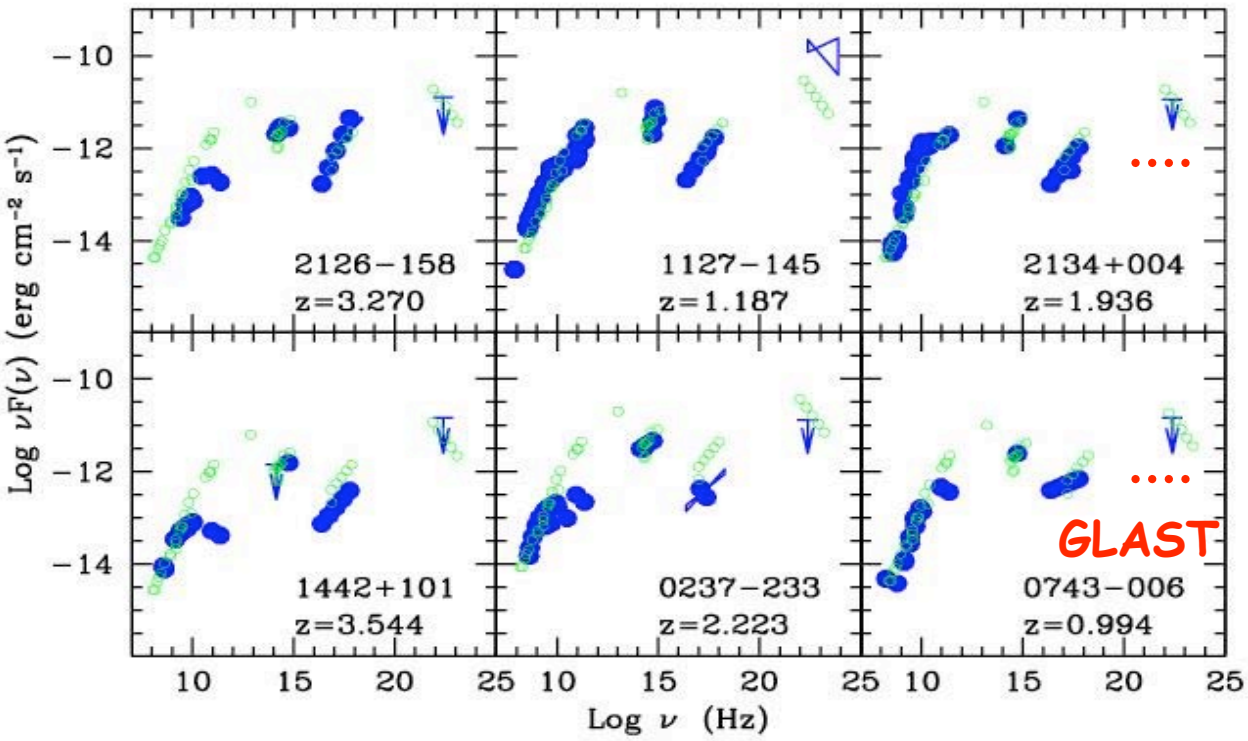
Flari

Stea

Dissi

Non blaz

Radi



From GPS sample

Very large blazar contamination?

Or blazars do not grow old?

Radio intermediate quasars: `low speed' outflows?

Ar

Blazars

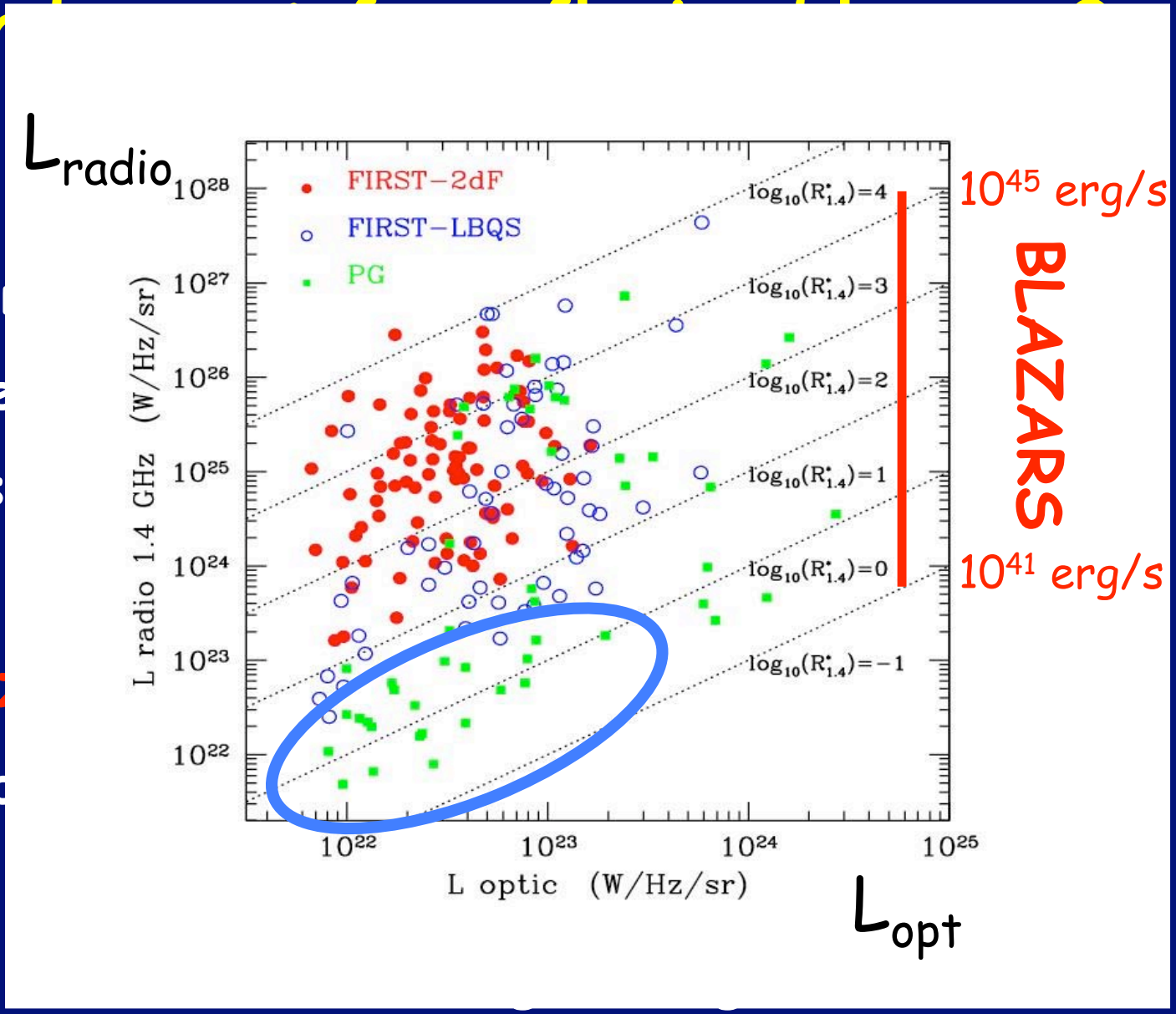
Fla

Ste

Dis

Non bla

Rad



Radio intermediate quasars: `low speed' jets?

Potential of GLAST

- **Effective area:**
  - # sources
  - fainter emitting components
  - new classes of sources
  - variability time resolution (flares < 1 day)

- **Spectral resolution:**
  - spectral quality on brightest sources

- **Wide energy range:**
  - very broad band spectra, overlap with Cherenkov (e.g. Klein-Nishina effects)

- **FOV + monitoring all sky almost continuos**:
  - # sources
  - # 'multi-frequency flares
  - monitoring on large range timescales
  - duty cycle

- **Effort on multi-frequency coordinated observations by LAT team**

Conclusions

GLAST holds great promises to get insights into the physics of relativistic jets (and more) in AGN.

Exciting perspectives independently of the final value of the parameter R

$$R = \frac{\#\ \text{answers}}{\#\ \text{new questions}}$$