Unified scheme for active galactic nuclei

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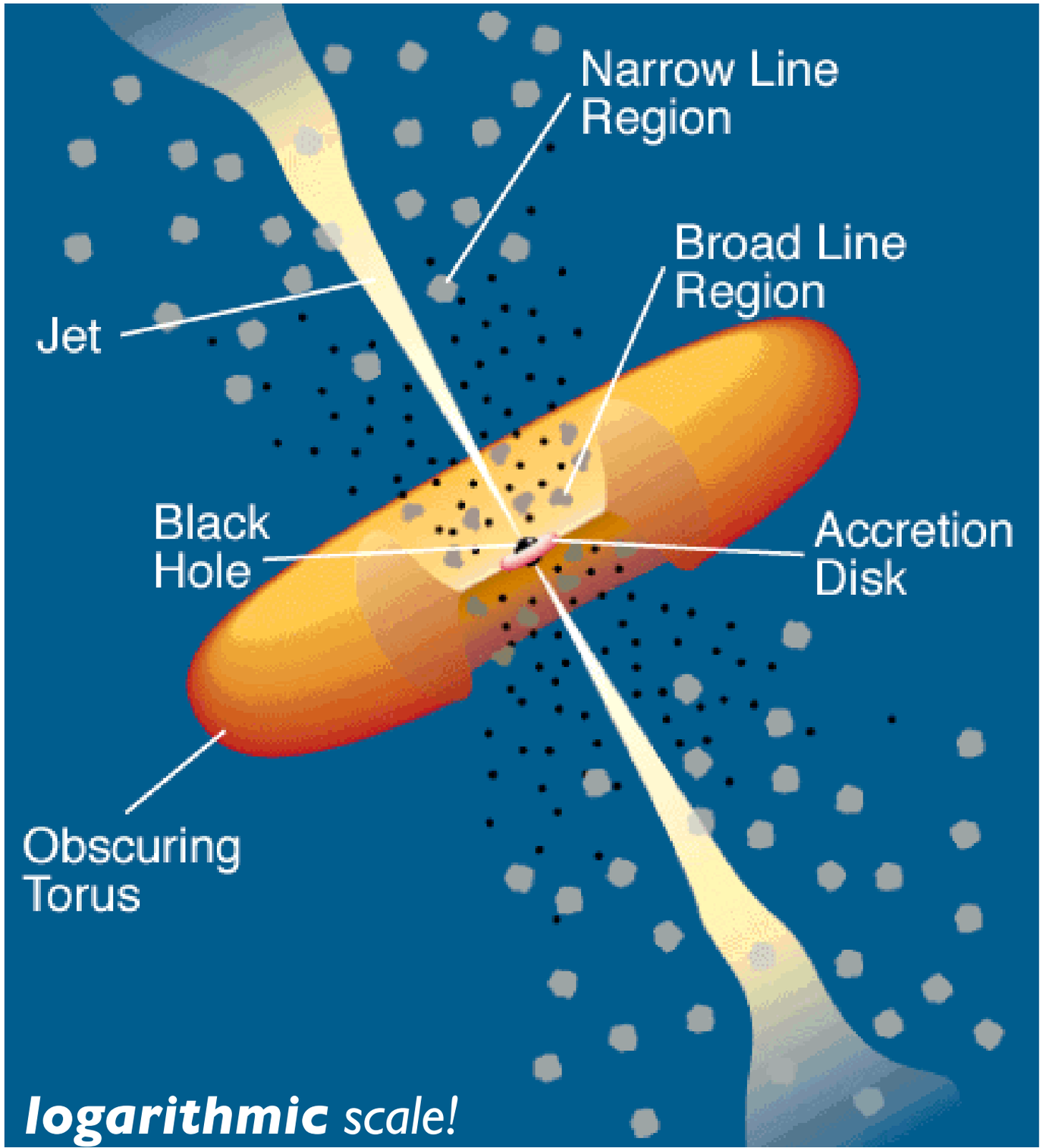
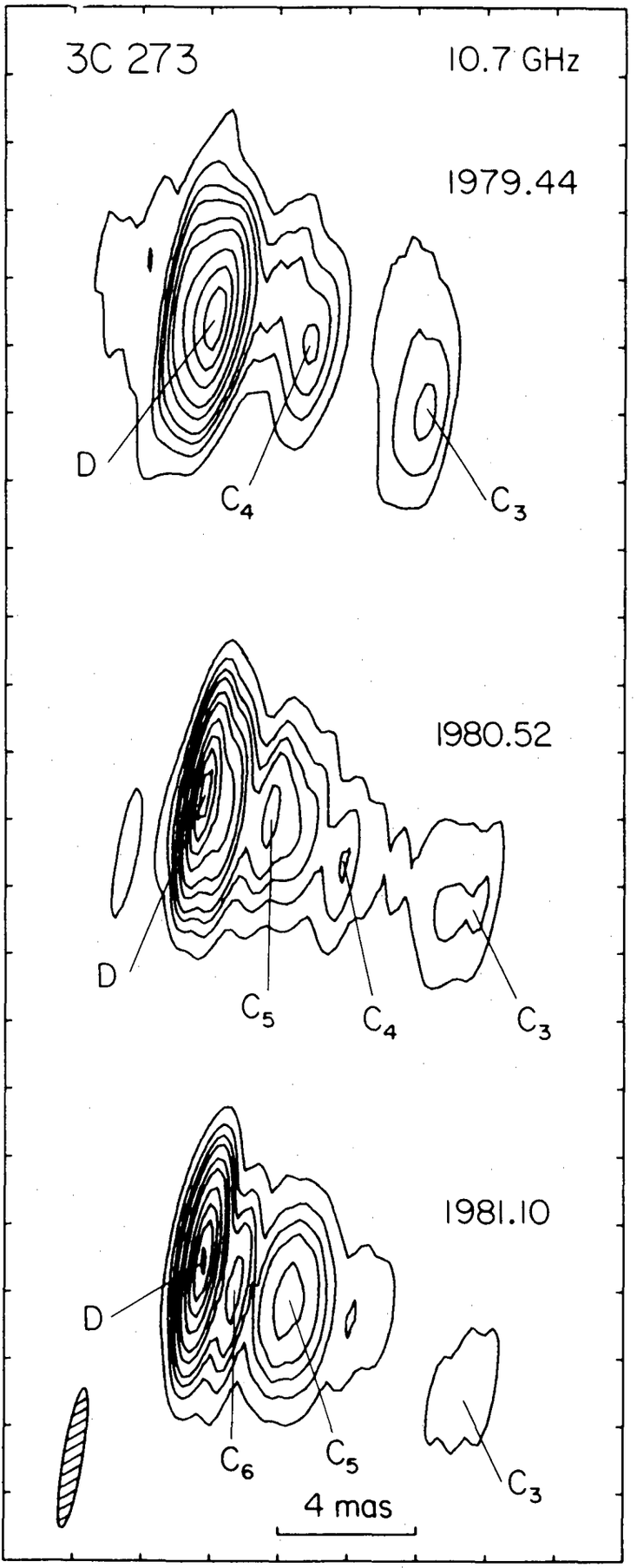
Active Galactic Nuclei (AGN)

- Nuclei of a large number of galaxies are much brighter than average galaxy of same Hubble type
- Radio quiet Seyferts in S galaxies, radio loud in E
- Brightness variability (all wavelengths) from minutes to years → active region < $c \cdot \Delta t \approx 0{,}001$ pc << galactic radius (15 kpc)
- Properties span several orders of magnitude, e.g. luminosity: 10^{42} erg/s (LINER) ... 10^{49} erg/s (QSO) (galaxy: 10^{44} erg/s)

AGN paradigm



Urry, Padovani 1995

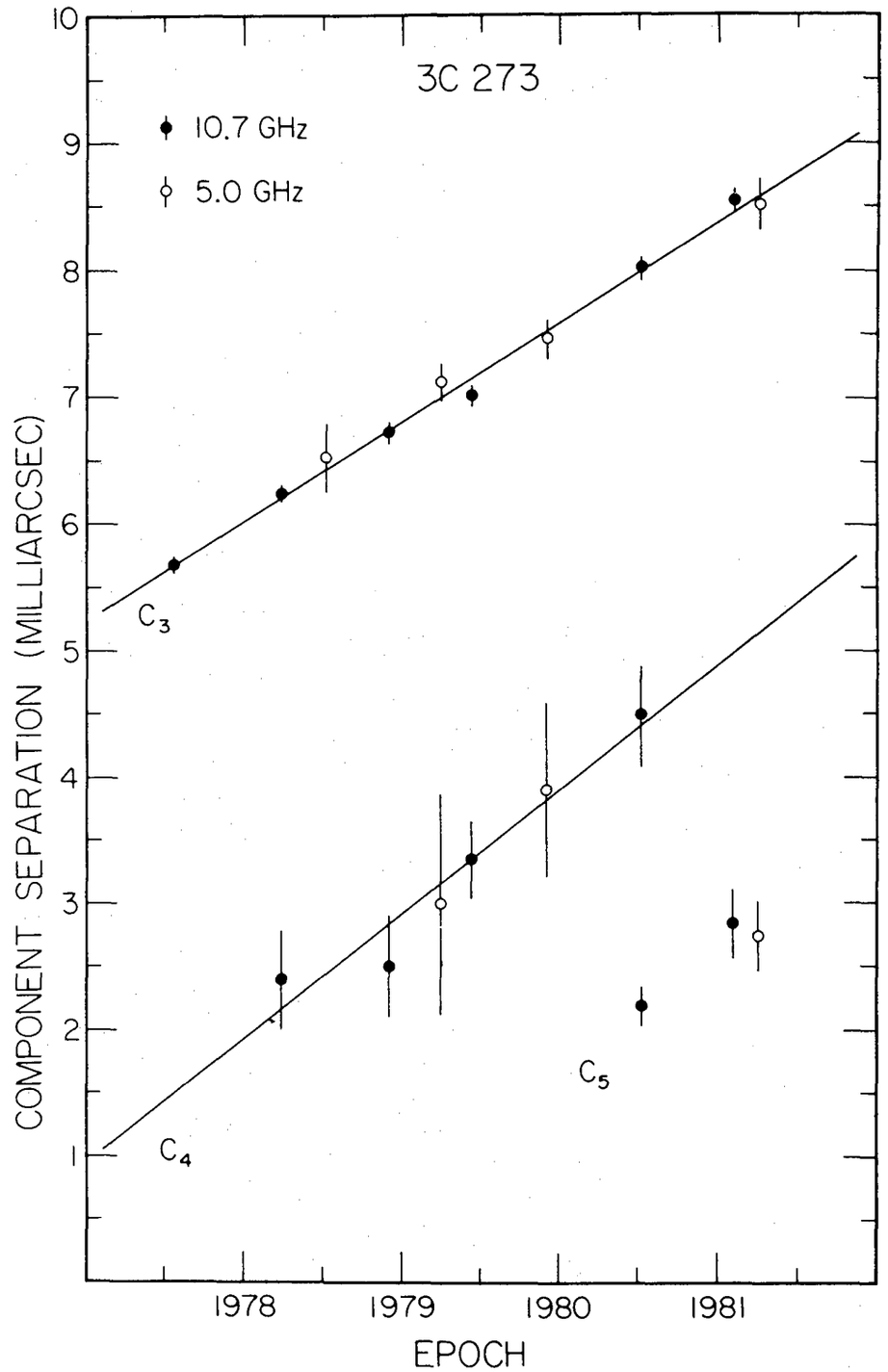


AGN Ingredients

Superluminal Motion

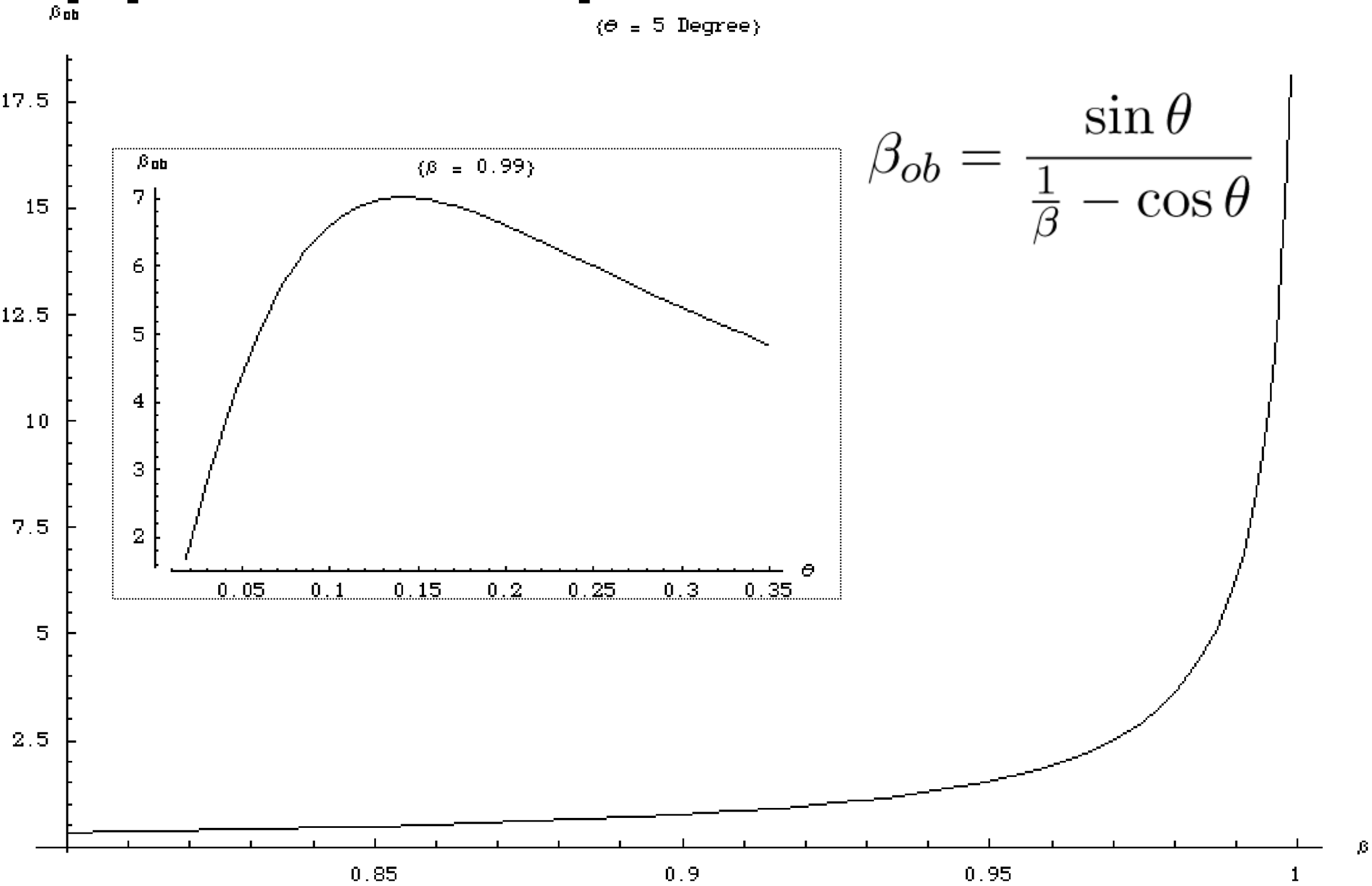
- Identify components of 3C 273 at several epochs
- apparent superluminal motion with v/c ~ 6

(Unwin et al., 1985)



AGN Ingredients

Apparent superluminal motion



$$\beta_{ob} = \frac{\sin\theta}{\frac{1}{\beta} - \cos\theta}$$

AGN Ingredients

Relativistic beaming

- Consider relativistic electrons in jet with Doppler factor

$$\mathscr{D} = [\gamma\,(1 - \beta\cos\theta)]^{-1}$$

- Lorentz factor

$$\gamma = (1 - \beta^2)^{-\frac{1}{2}}$$

- So

$$\cos\theta \approx \beta \rightarrow \mathscr{D} \approx \gamma$$

AGN Ingredients

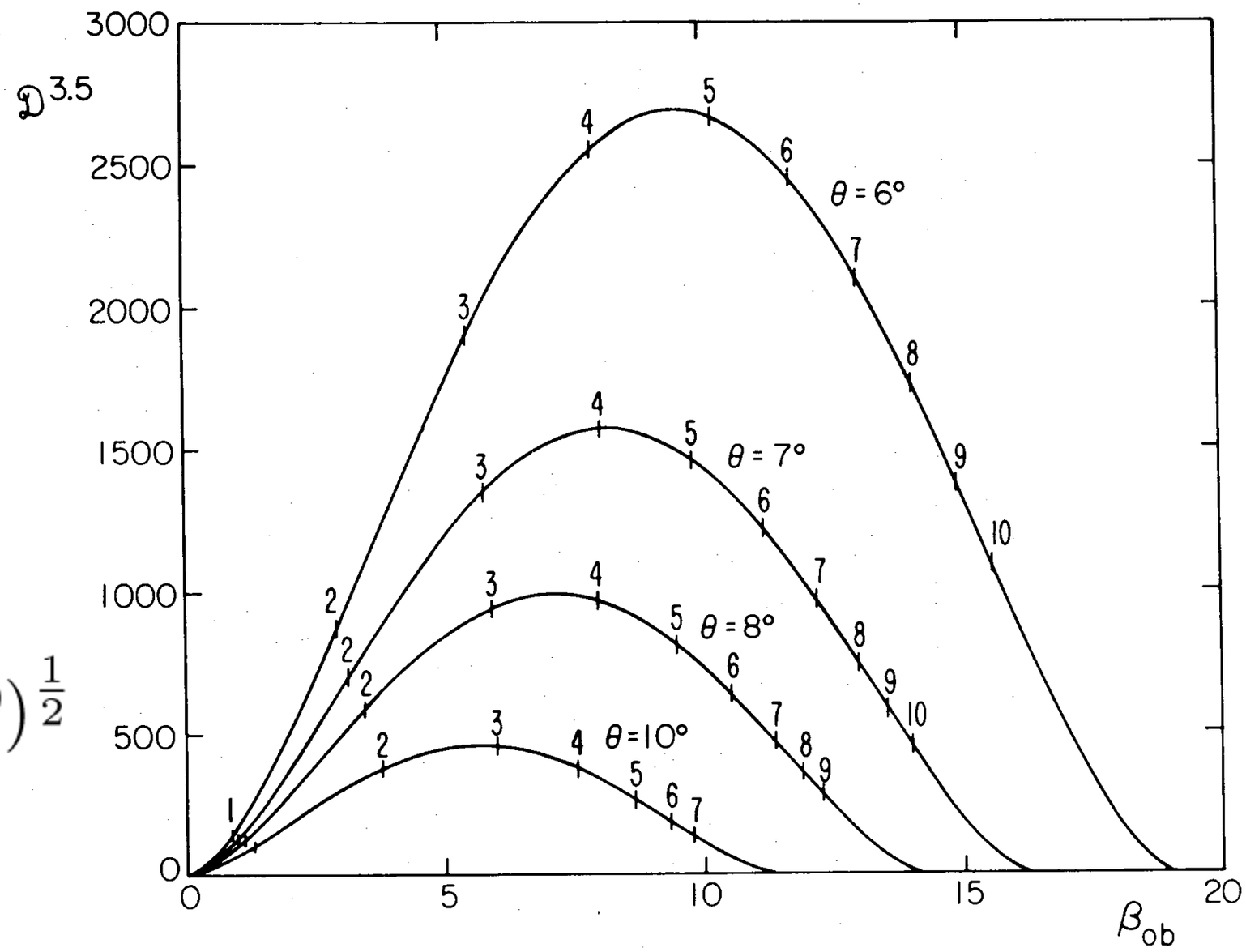
Relativistic beaming

Power law spectrum:

$$\alpha = -\frac{\mathrm{d}\ln S}{\mathrm{d}\ln \nu}$$

$$S_{ob}(\nu) = S(\nu)\mathscr{D}^{3+\alpha}$$

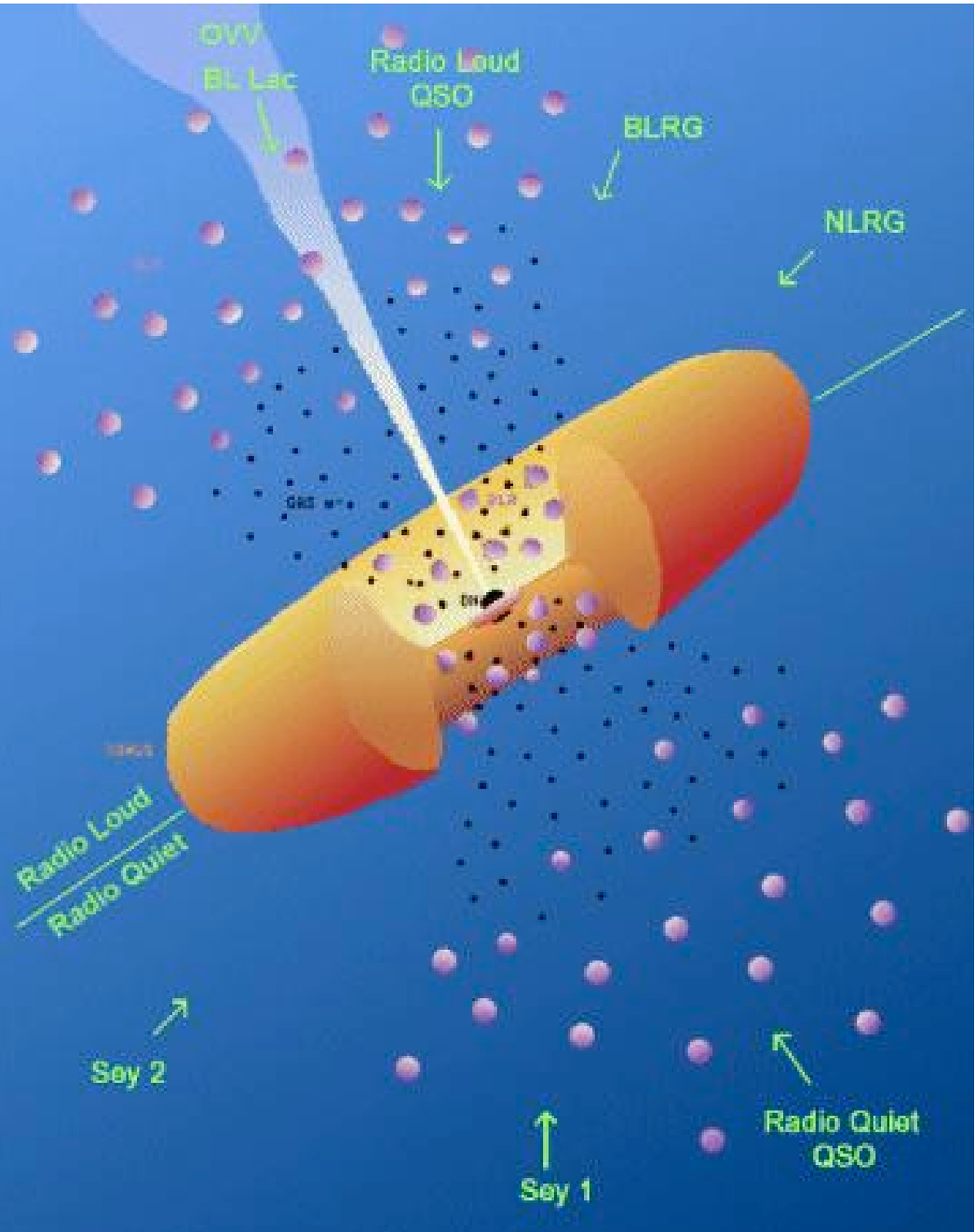
$$\mathscr{D} = (1 - \beta_{ob}^2 + 2\beta_{ob}\cot\theta)^{\frac{1}{2}}$$



$$\theta = 6^\circ, \beta_{ob} = \beta_{max} = 9.5 \rightarrow \mathscr{D}^{3.5} = 2700$$

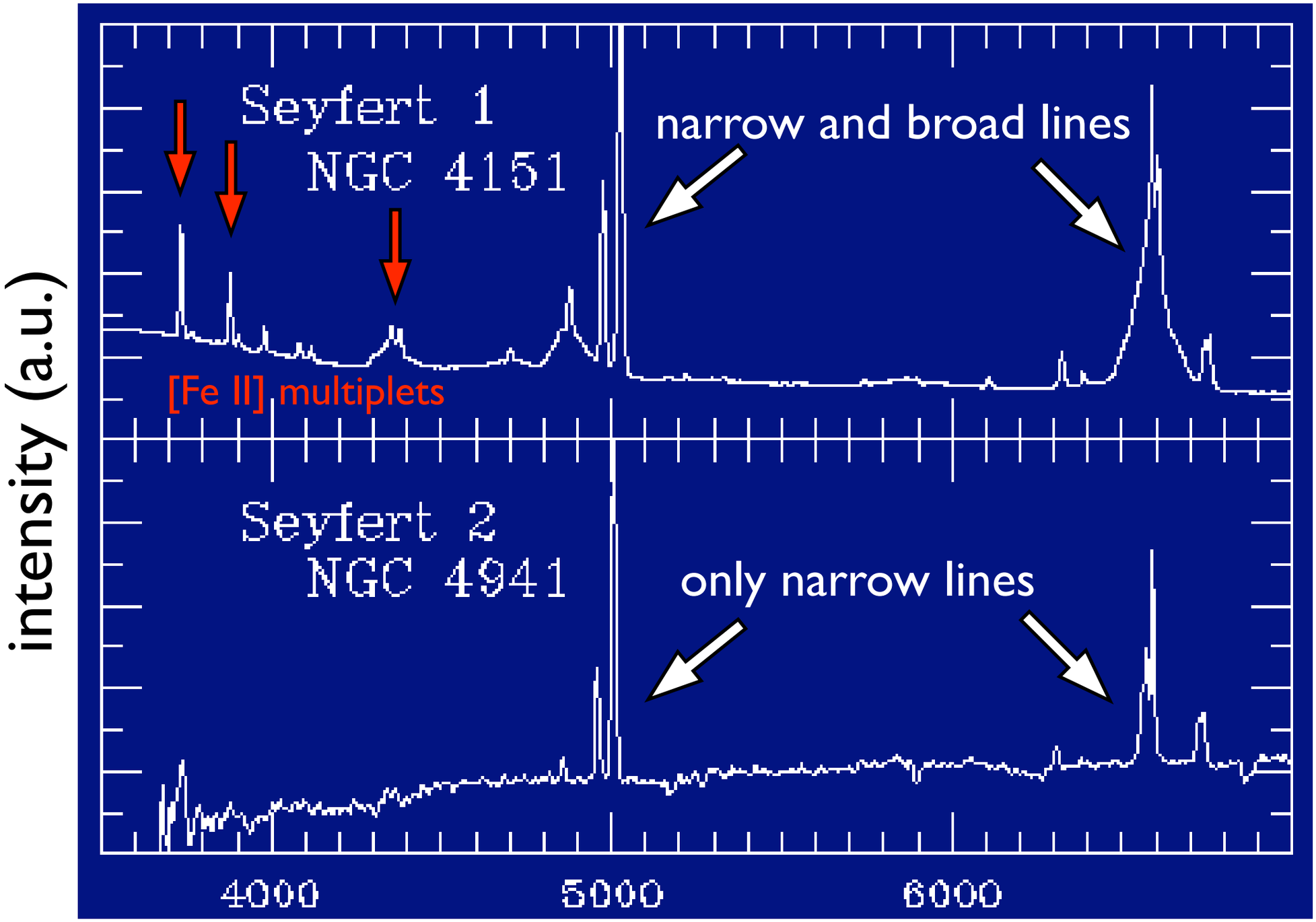
Blandford, Königl 1979

Unified Model



- Thermal emission components (accretion disk: V/UV/soft X; dust reprocessing: FIR-NIR) depend strongly on orientation due to dust obscuration
- Nonthermal emission component (relativistic jets: radio - gamma) with even stronger orientation effect due to relativistic beaming
- Main parameters: accretion rate, BH spin (Blandford & Znajek, 1977)

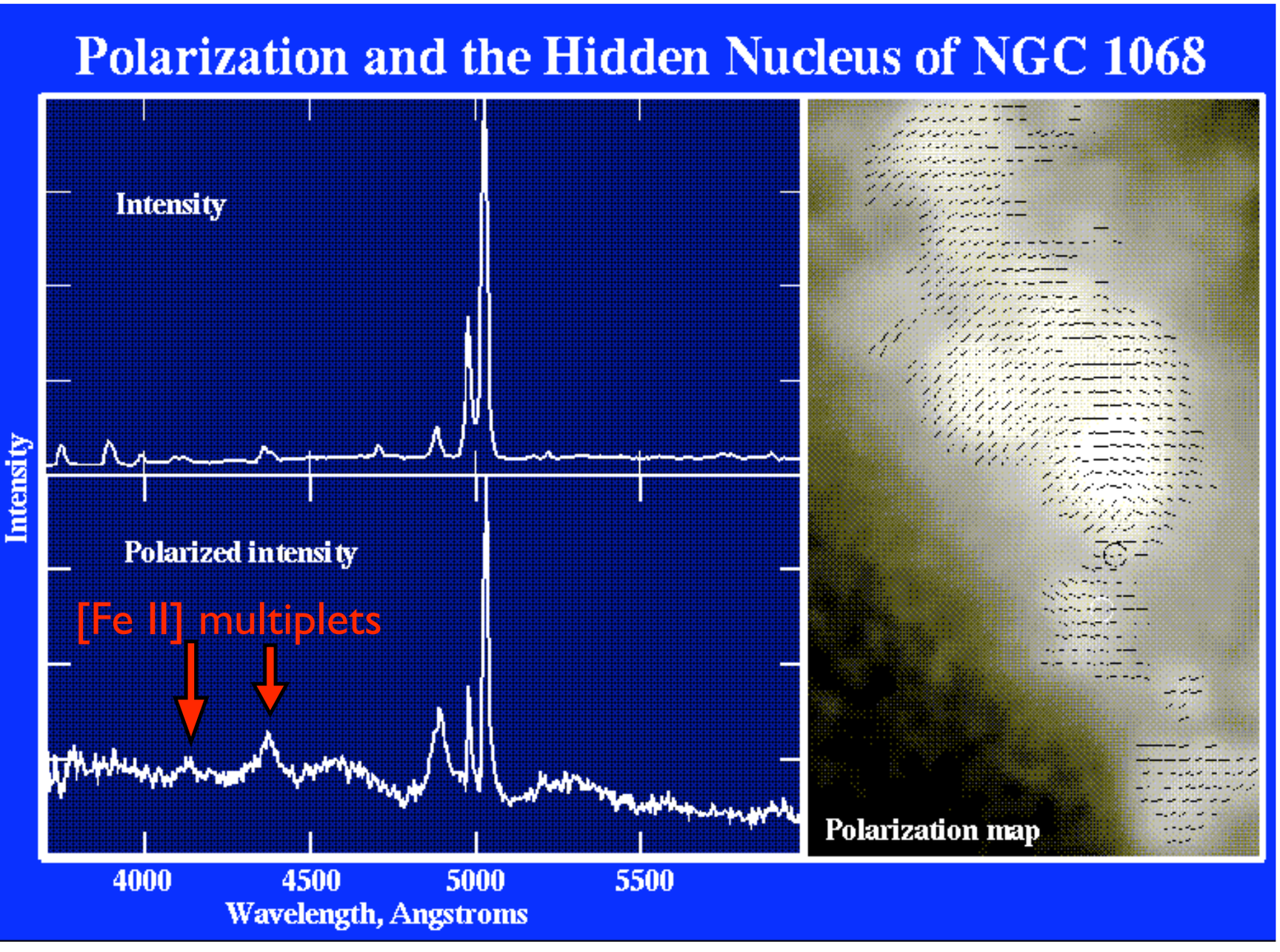
Seyfert Galaxies



Bill Keel's web page
http://www.astr.ua.edu/keel/

Evidence for Unification

Polarized light in Seyfert 2 galaxy

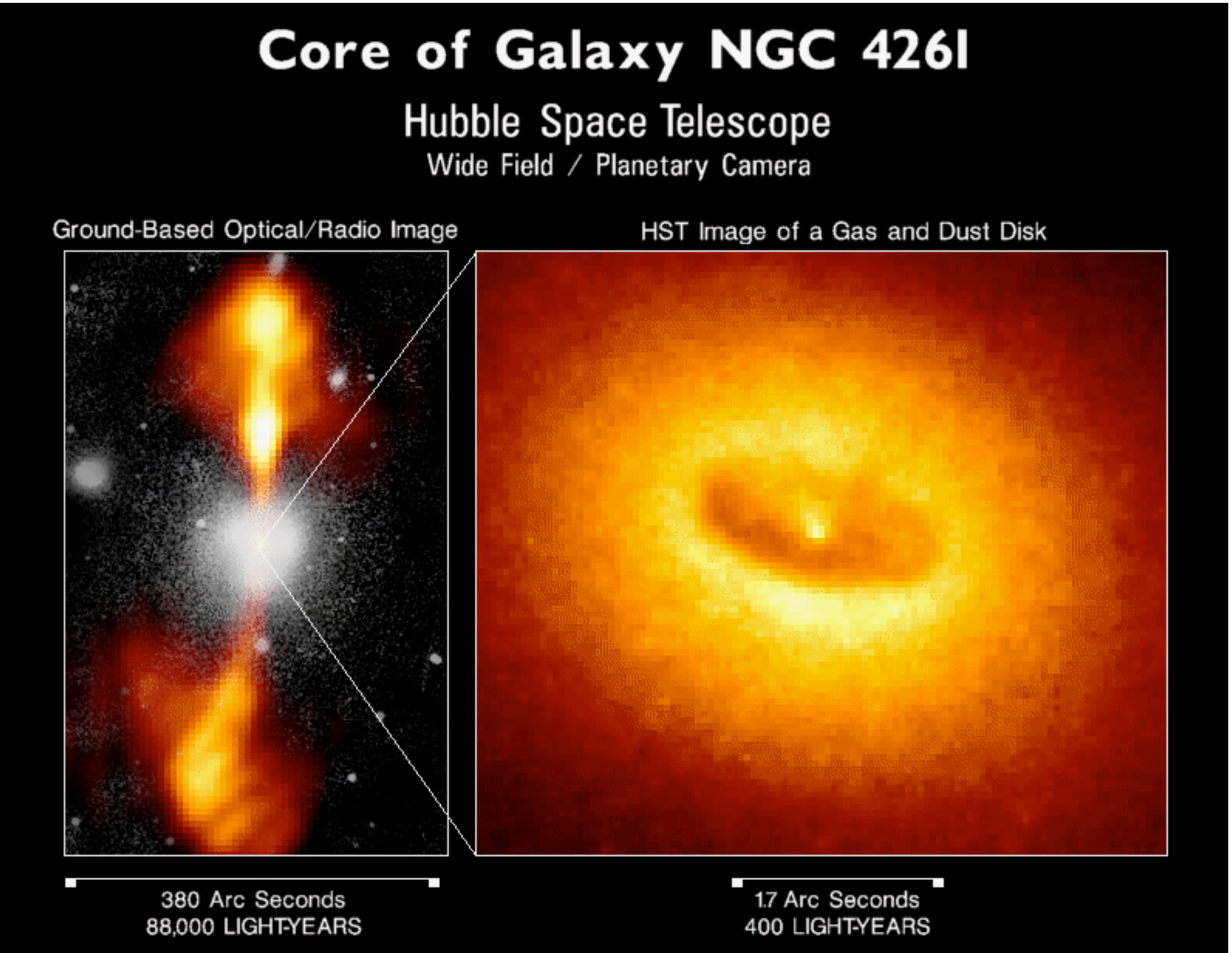


- Polarized light reveals Sy 1 lines in Sy 2 galaxies
- Polarized light is light from BLR scattered on NLR clouds
- Centre of Polarisation is origin of radio jets!

Bill Keel's web page, http://www.astr.ua.edu/keel/
Miller, Goodrich, Matthews 1991; Capetti et al. 1995

Evidence for Unification

Accretion disks



HST sees 20 pc thin disk of obscuration, 125 pc wide

Jaffe et al. 1996

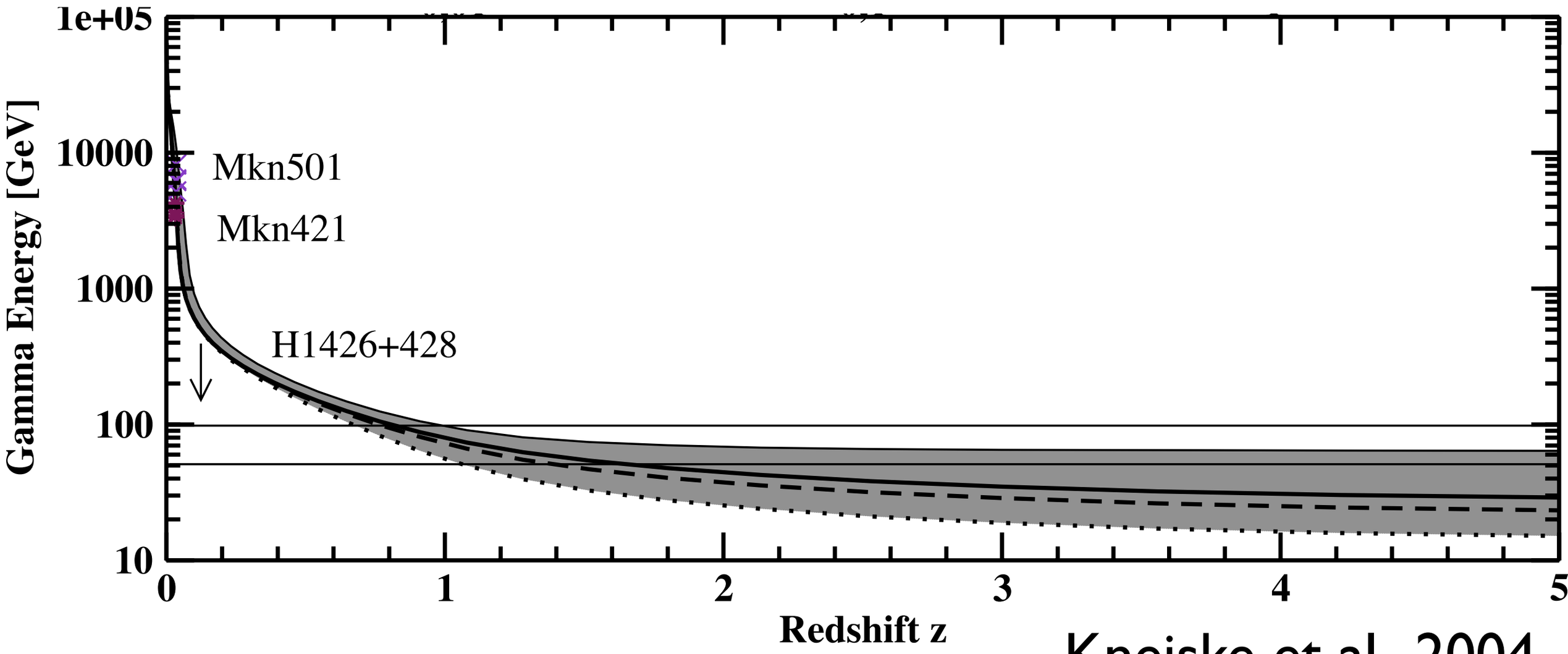
Evidence for Unification

TeV-γ from Blazars

- 80 blazars seen by EGRET (up to 10 GeV) with maximum of spectral energy distribution (SED) in gamma rays
- Also visible at TeV? Problem: TeV Gammas are absorbed by pair production with EBL; mean free path length (TeV) ~ MPc (Fazio & Stecker; Kneiske et al., 2004)
- Therefore only nearby blazars are potential candidates
- MAGIC has so far detected 4 blazars at ~200 GeV; one source at z = 0.182 for the first time

proceedings of the 29th ICRC 2005, Pune

Fazio-Stecker relation



Kneiske et al., 2004

TeV Gammas are absorbed by pair production with EBL; mean free path length (TeV) ~ MPc

Further reading

- Bradley M Peterson: *Introduction to Active Galactic Nuclei*, Cambridge University Press
- T C Weekes: *Very High Energy Astronomy*, IoP Publishing

Thanks for your attention!