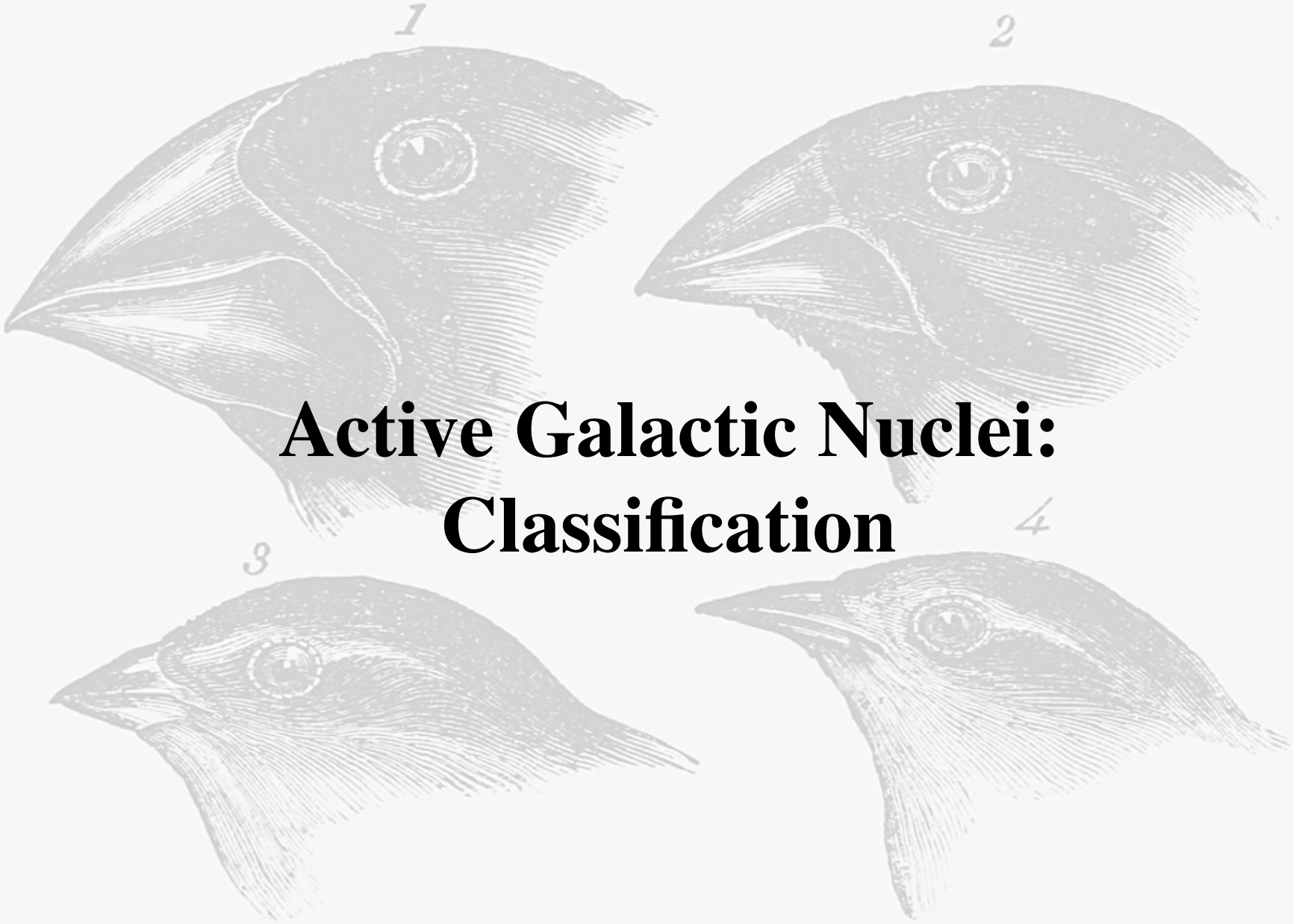
Active Galactic Nuclei: Classification



1. Geospiza magnirostris.
2. Geospiza fortis.
3. Geospiza parvula.
4. Certhidea olivasea.

AGN Classification

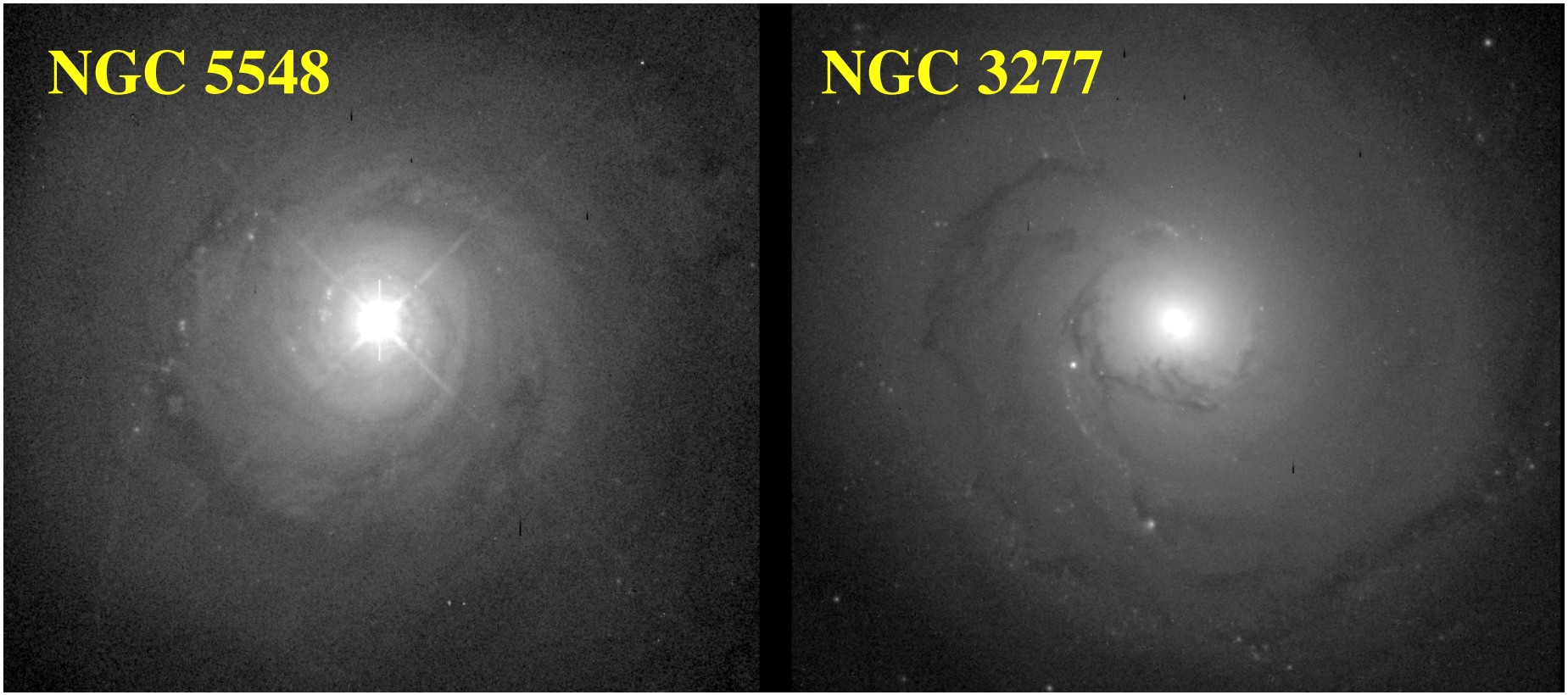
- According to radio emission:
  - Radio loud: radio galaxies (RGs) and quasars; F-R types I and II
  - Radio quiet (but perhaps not entirely radio silent)
- According to optical spectrum:
  - Narrow-line RGs, Seyfert 2's; Liners
  - Broad line RGs, Seyfert 1's, quasars
- According to optical luminosity:
  - Seyfert to quasar sequence, range of radio powers, etc.
- Special types:
  - Blazars (aka BL Lac's) and optically violently variable (OVV) objects
- These classifications are largely parallel
- Some distinction may reflect real, internal physical differences, and some may be simply orientation effects
  - This is the central thesis of the AGN unification models

Active Galactic Nuclei: Seyferts

- Seyferts are the low luminosity counterparts of quasars
- First noted by Fath at Lick Observatory in 1908 (!), who was taking spectra of the nuclei of "spiral nebulae" and noted that NGC 1068 had strong emission lines
- Slipher obtained a higher quality spectrum at Lowell in 1917, noted the lines were similar to planetary nebulae
- In 1926, Hubble noted 3 galaxies with strong emission lines: NGC 1068, NGC 4051, NGC 4151
- In 1943 (~30 years later!), Carl Seyfert recognized that there was a class of galaxies (now known as Seyfert galaxies), with strong, broad high-ionization emission lines and bright nuclei
  - Why this was not remembered when the first spectra of quasars were taken in 1960's, is a mystery …

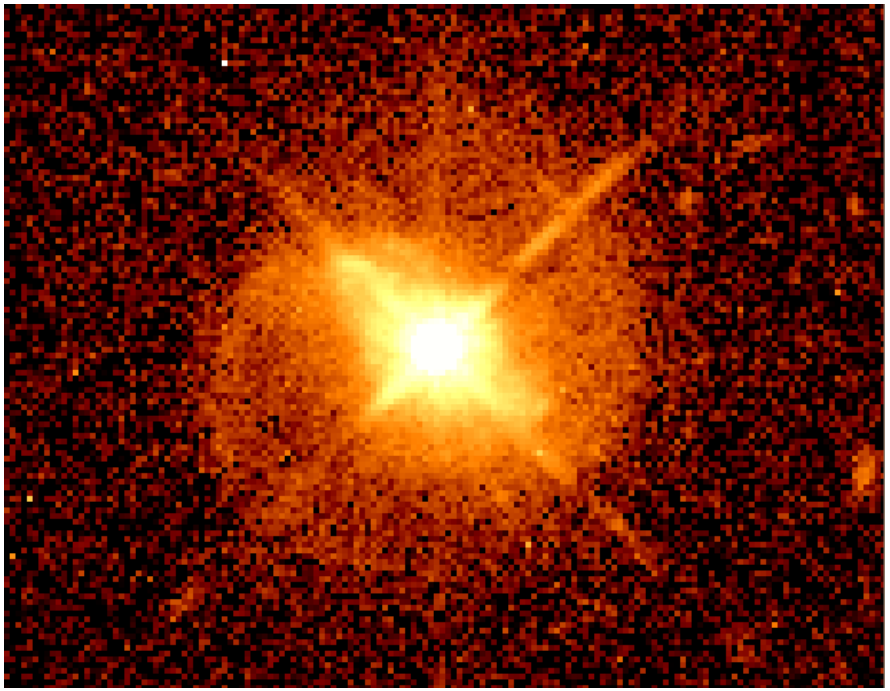
Active Galactic Nuclei: Seyferts

- Seyfert nuclei are found in spiral galaxies; up to ~10% of Sa and Sb's are Seyferts; but at a lower level of activity, there are more
- Seyferts have only moderate radio emission (~10^{40} erg/s) but strong x-ray emission (> 10^{42} erg/s)

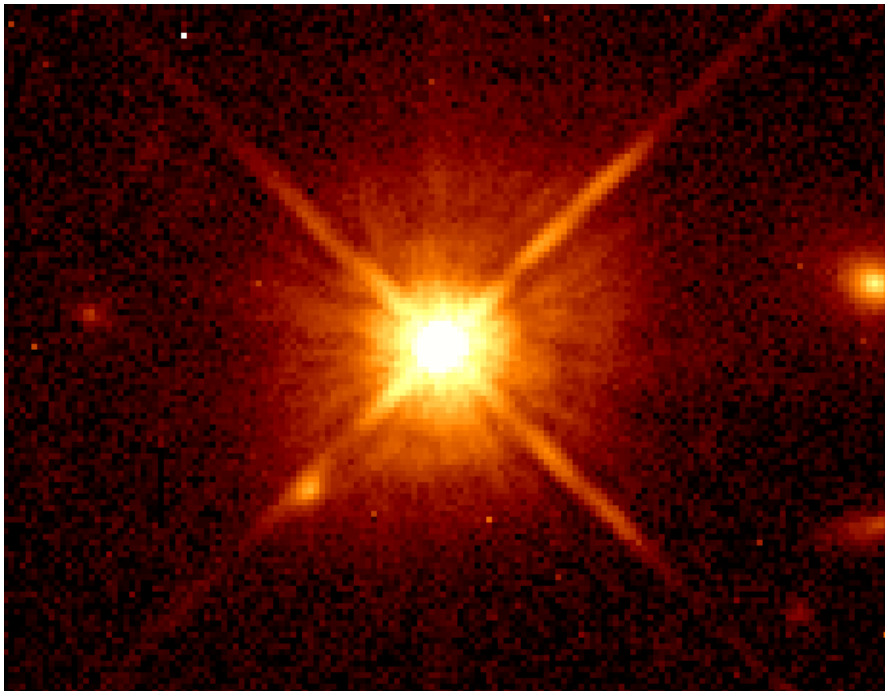


Quasar Images

Even with HST imaging, difficult to detect the light of the host galaxy due to the high luminosity of the nucleus



Spiral host - somewhat unusual



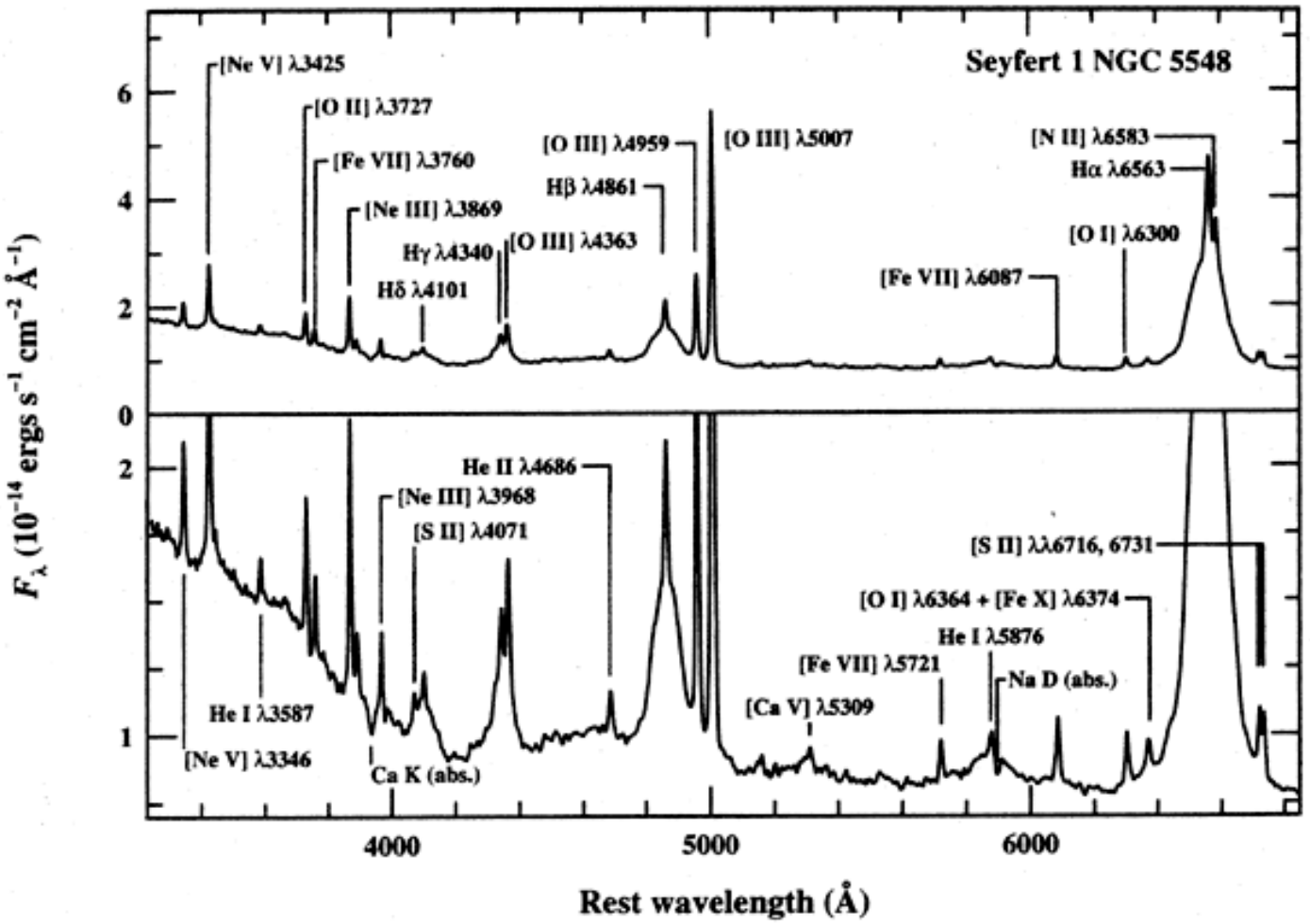
Elliptical host - more common

In general, QSO hosts tend to show signs of tidal interactions or mergers - suggesting a triggering / fueling mechanism

Types of Seyfert Galaxies

Type 1 Seyfert galaxies have in their spectra:

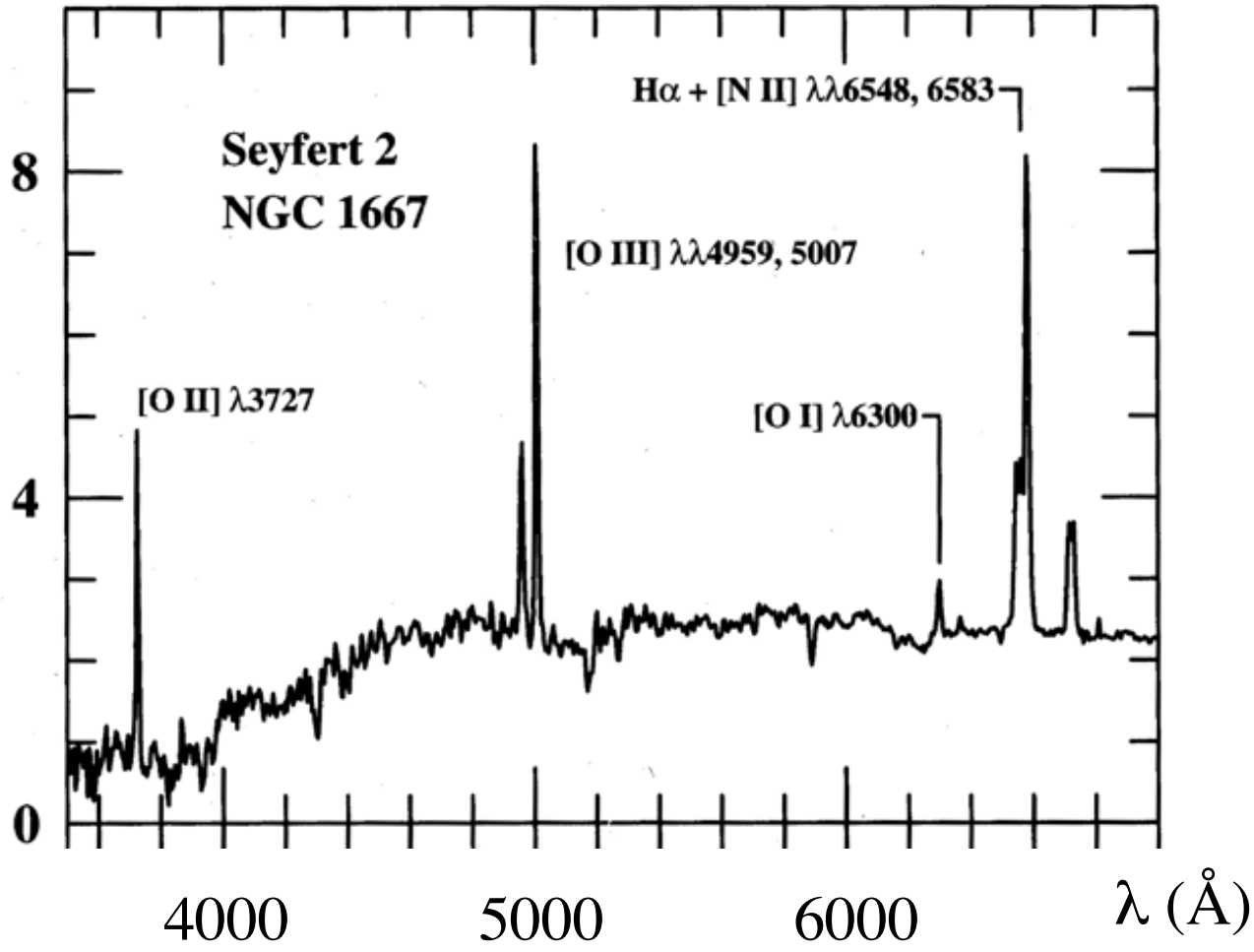
- **Narrow emission lines**, with a width of several hundred km/s
- **Broad emission lines**, with widths up to 10^4 km/s



They also have brighter and bluer nuclei

Types of Seyfert Galaxies

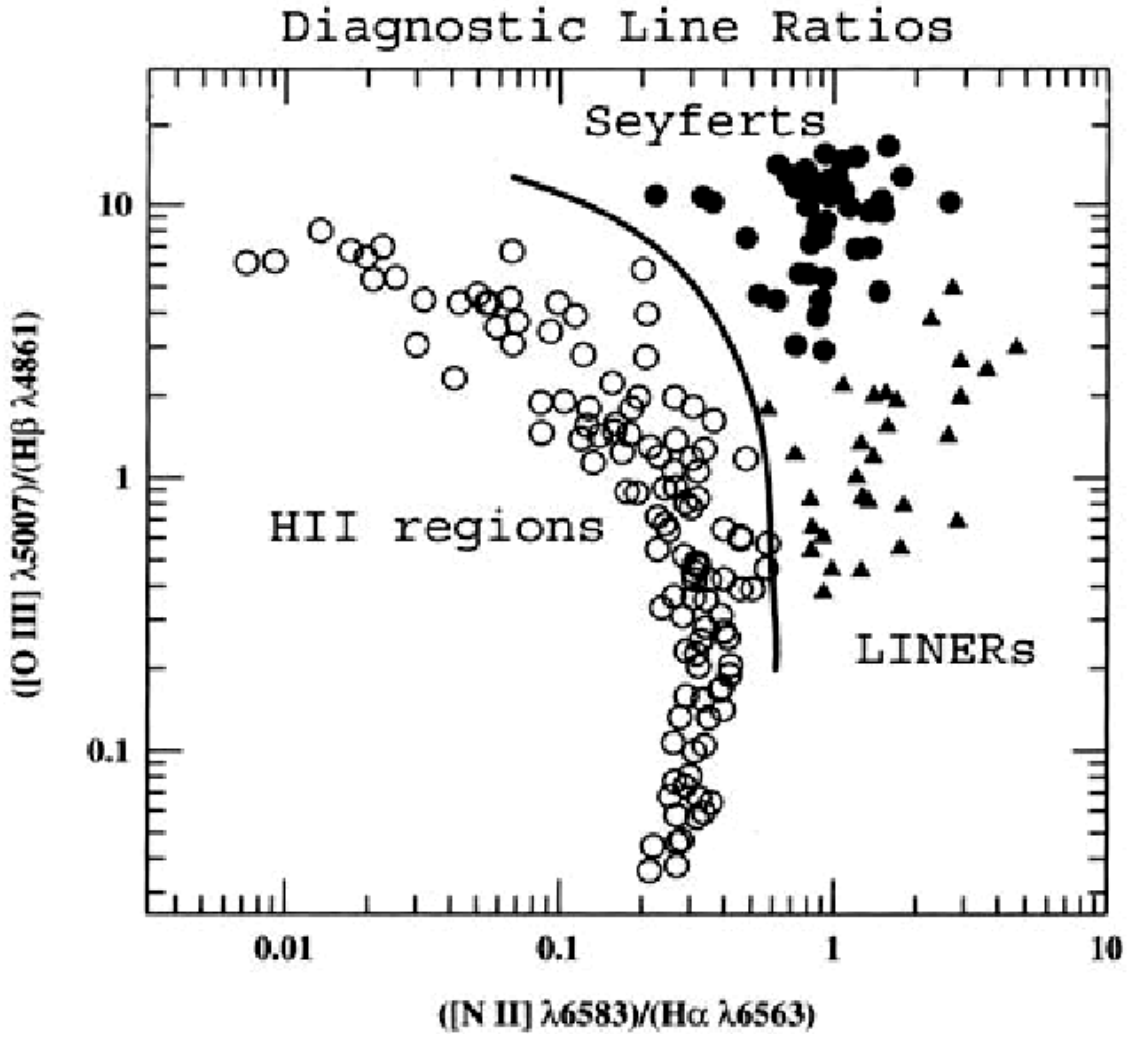
Type 2 Seyfert galaxies have only the narrow line component:



Both types have high ionization, forbidden lines
(= transitions not easily observed in the lab)

Spectroscopic Diagnostics

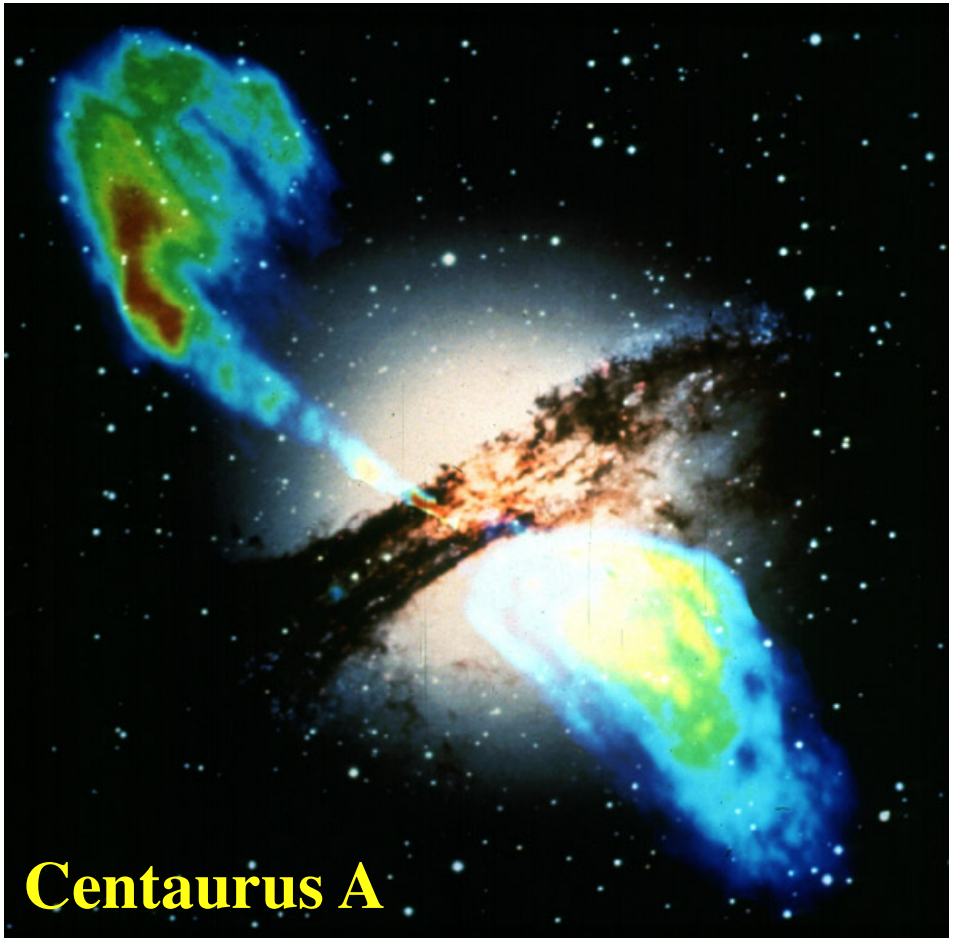
Intensity ratios of various emission lines depend on the spectrum of the ionizing continuum radiation: to get lines from high energy levels (e.g., ionizing potentials of tens of eV), one needs "hard" spectra with lots of high energy (UV / soft X-ray) photons.

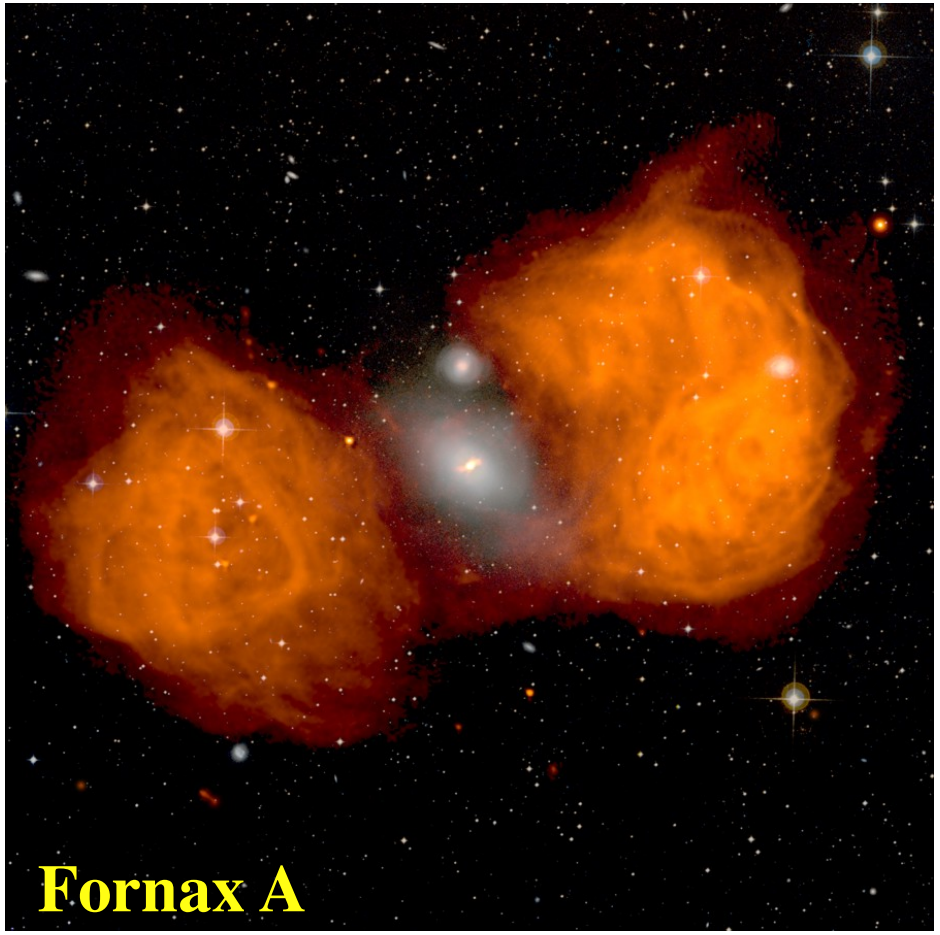


Accretion disks can provide those in AGN, while objects powered by star formation have much "softer" spectra

Radio Galaxies: Typical Examples

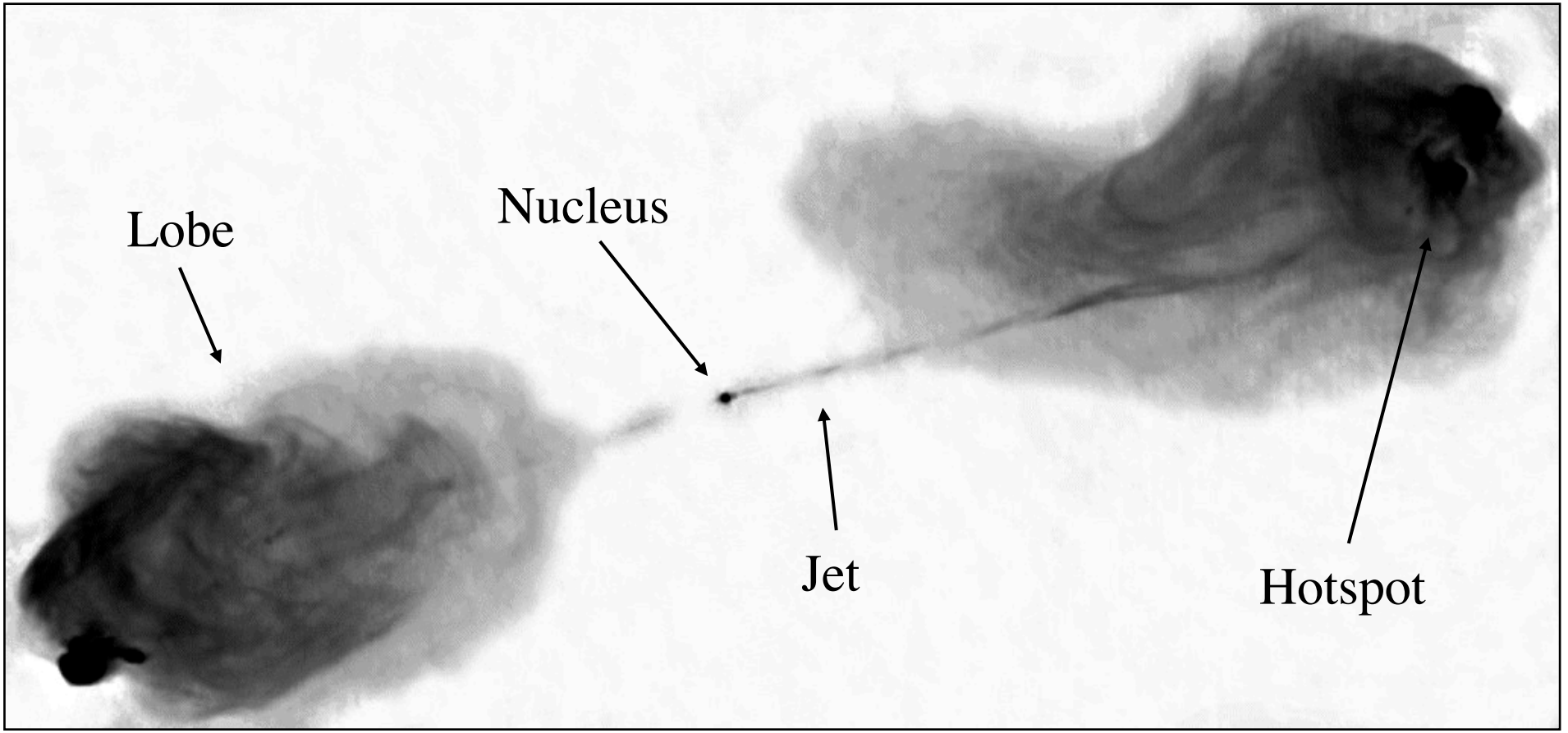
Radio overlayed on optical images





Energy stored in radio lobes can reach ~ 10^{60} - 10^{61} erg. If jet lifetime is ~ 10^{8} yrs, the implied mechanical luminosities are ~ 10^{12} - 10^{13} $L_{\odot}$

Cygnus A: A Modern VLA Radio Map



For more good radio images, see the VLA image gallery at
http://www.nrao.edu/imagegallery/php/level1.php

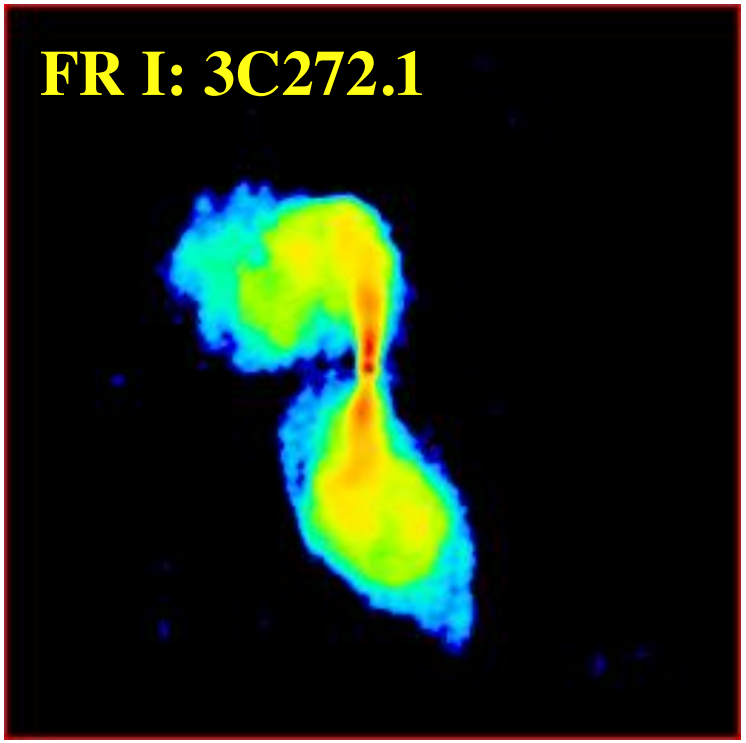
Radio Source Classification

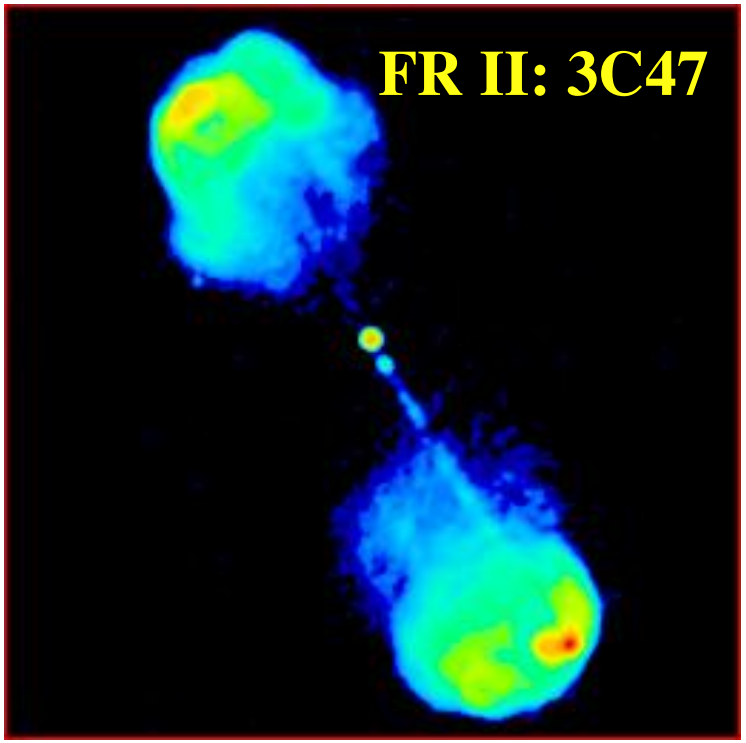
Fanaroff-Riley Type I (FR I): Separation between the points of peak intensity in the lobes < 1/2 the largest size of the source

Edge darkened radio jets, slower jet speeds, lower radio power

Fanaroff-Riley Type II (FR II): Separation between the points of peak intensity in the lobes > 1/2 the largest size of the source

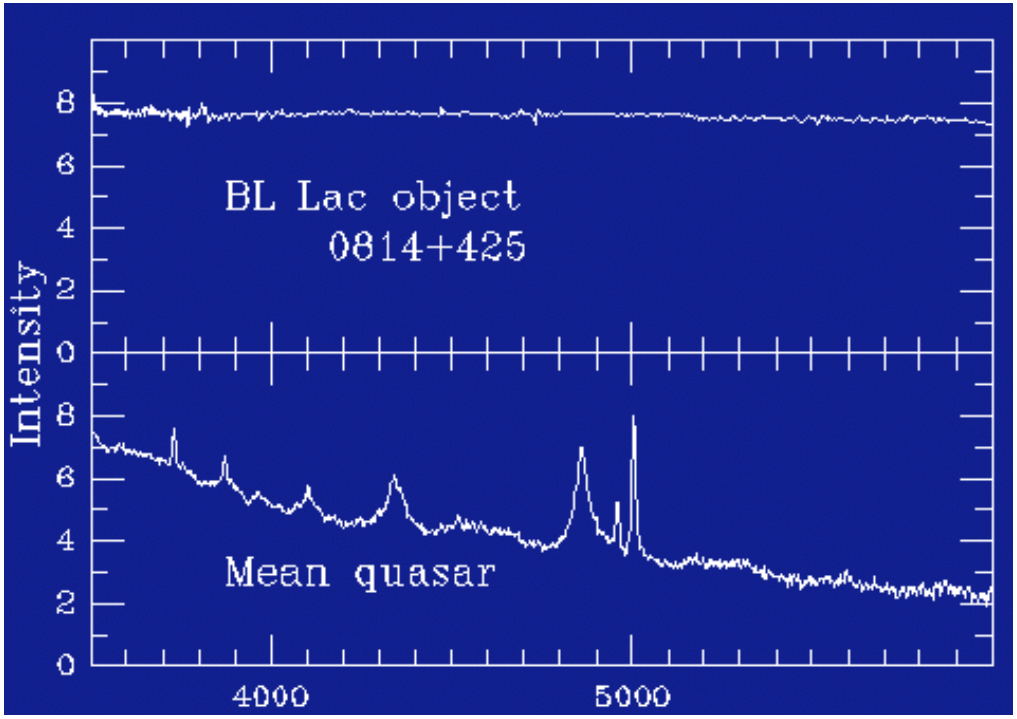
Edge brightened radio jets, speeds ~0.1c, higher radio power

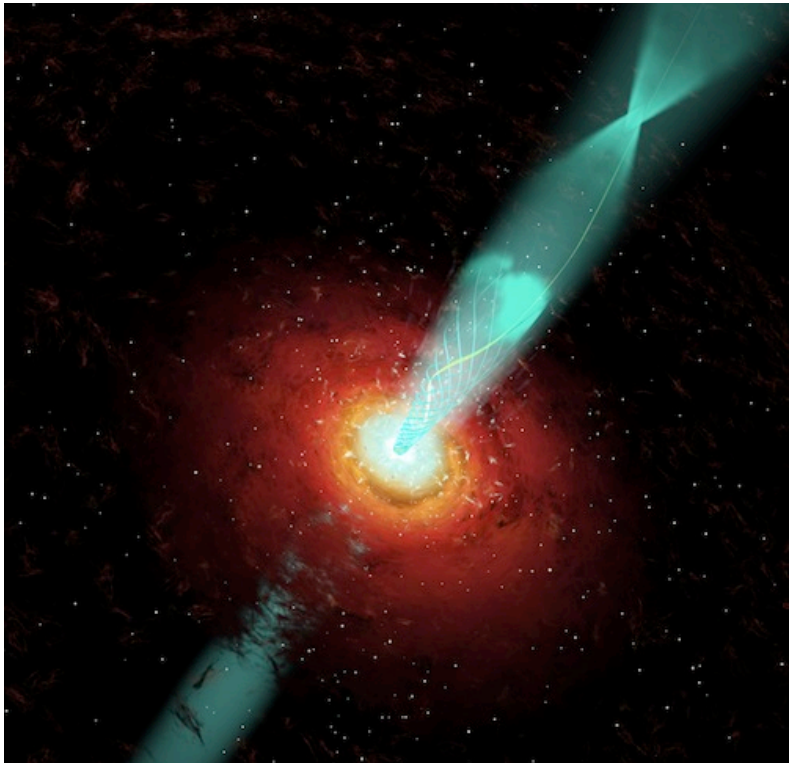




BL Lacs (Blazars)

Named after the prototype BL Lacertae. They have strong, blue, variable continua, and lack strong emission *or* absorption lines in their spectra:





They are radio-loud quasars, viewed along the relativistic jet

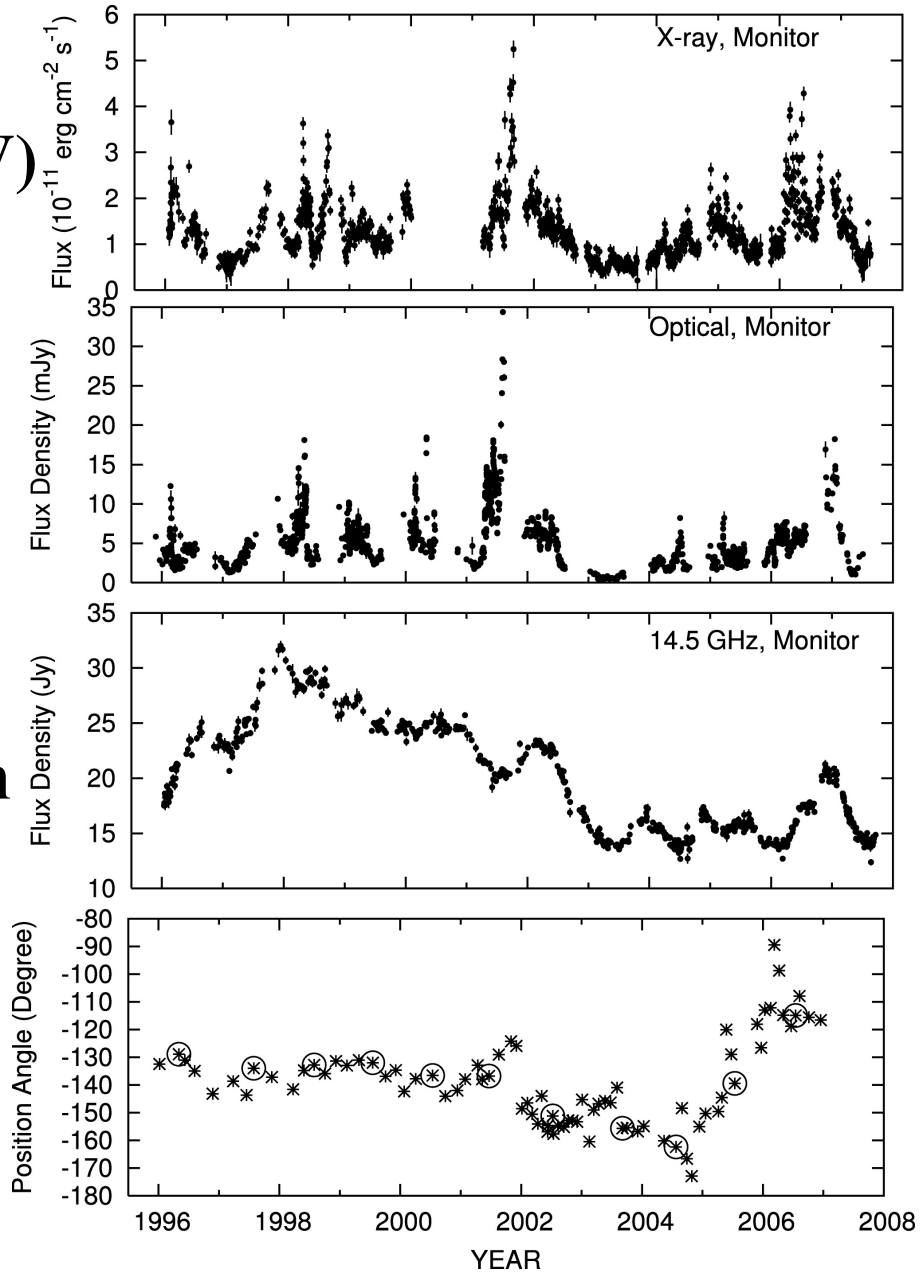
Relativistic beaming amplifies any variations in intensity

Optically Violent Variables (OVVs)

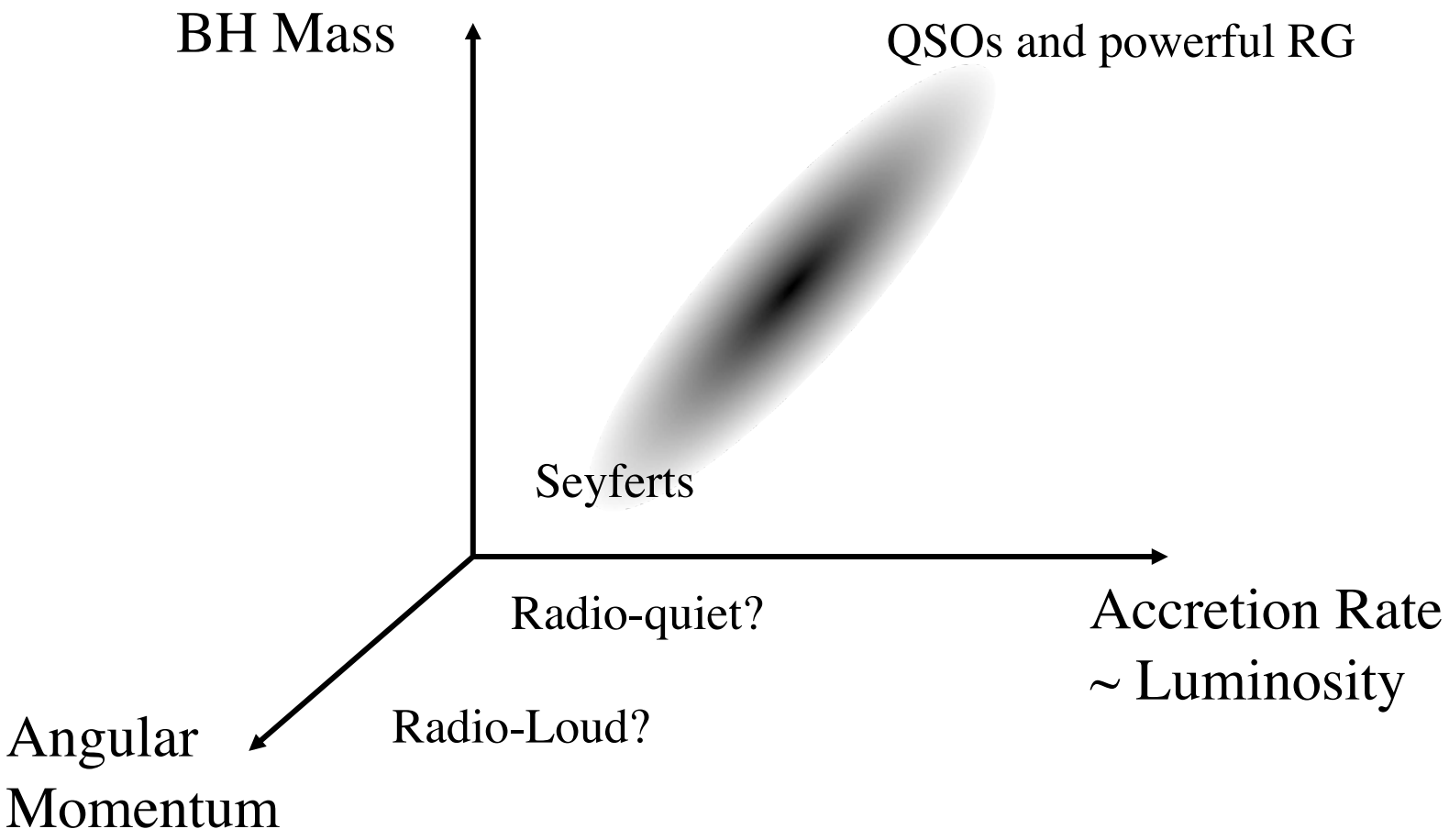
Related class to blazars are **optically violent variables (OVV)**

All AGN are variable, but OVVs show large variations (> 0.1 mag) in optical flux on short timescales (< day), and much stronger at longer time scales

Variability can be due to accretion to the central engine (black hole), or the instabilities in the jet.
It may or may not be correlated between different wavelengths.



AGN: A Physical Classification



… but in addition, there will be some dependence on the viewing orientation

Next:

AGN Unification Models