Classification of AGN

Luminous AGN are classified as:

- Seyfert galaxies (Type I and II)
- Quasars
- BL Lacs or Optically Violent Variables
- Radio galaxies (in `Broad line' and `Narrow line' variants)

All powered by accretion onto supermassive black holes.
But why so many classes - are these all physically distinct objects?

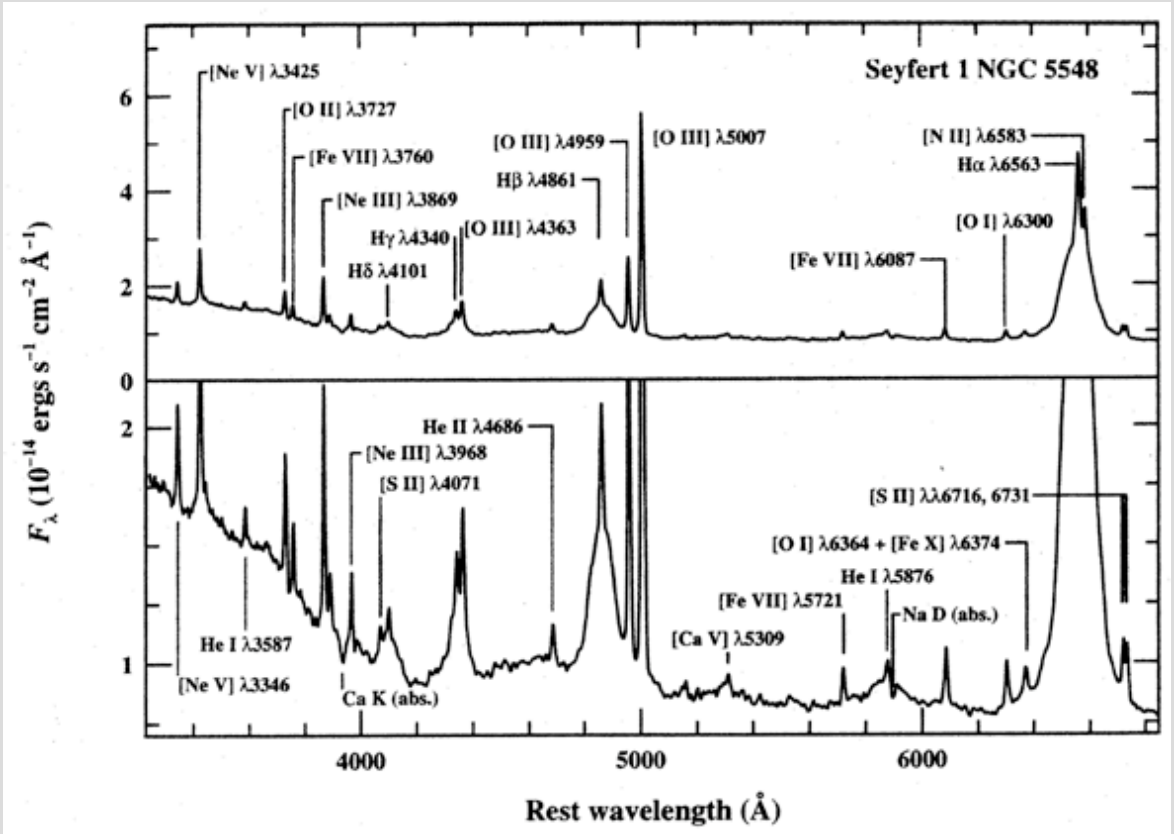
Another class of galaxies are LINERs (low-ionization nuclear emission-line region galaxies). These are much more common than the other classes, but have very low luminosities.

Seyfert galaxies

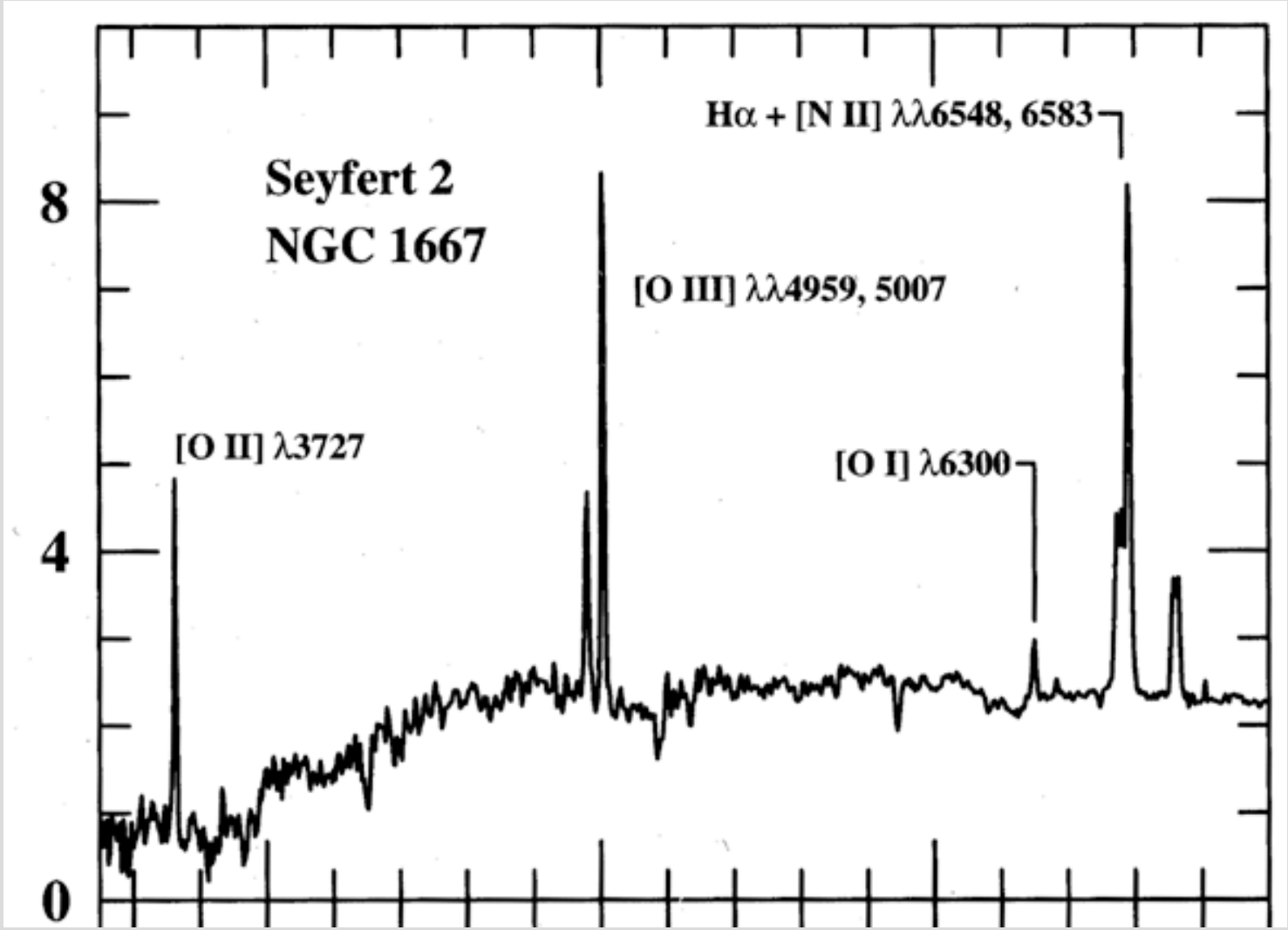
Lower-luminosity AGN, normally found in spiral galaxies.

Two subclasses: ***Type 1 Seyfert*** galaxies have two sets of emission lines in their spectra:

- **Narrow lines**, with a width (measured in velocity units) of several hundred km/s
- **Broad lines**, with widths up to 10^4 km/s

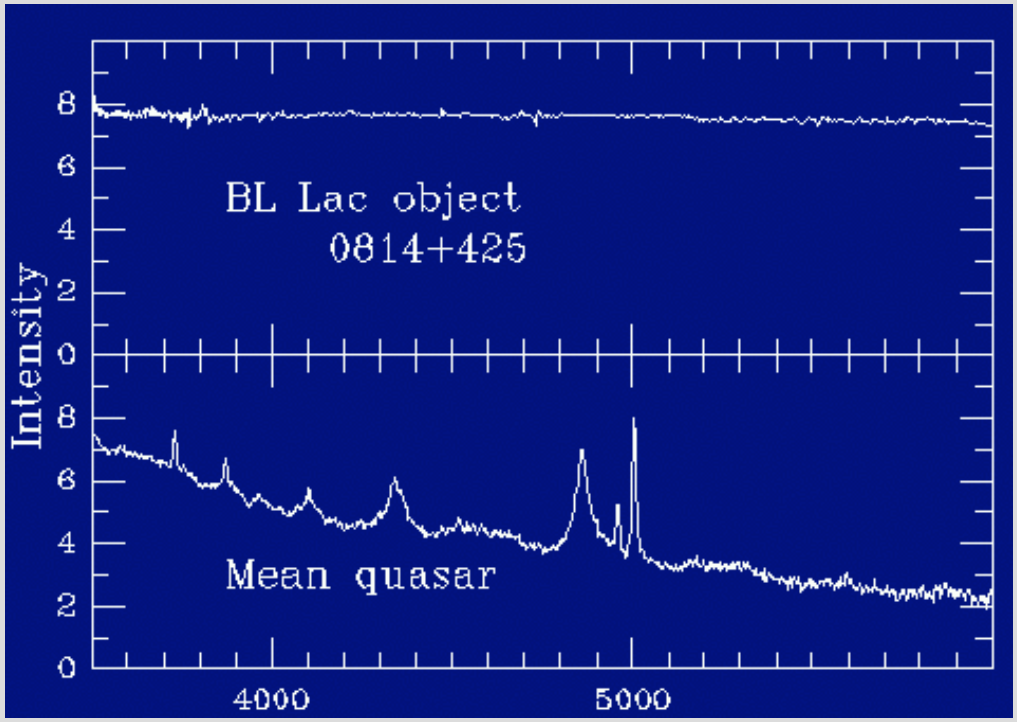


Type 2 Seyfert galaxies: As Type 1, but with only the narrow line component



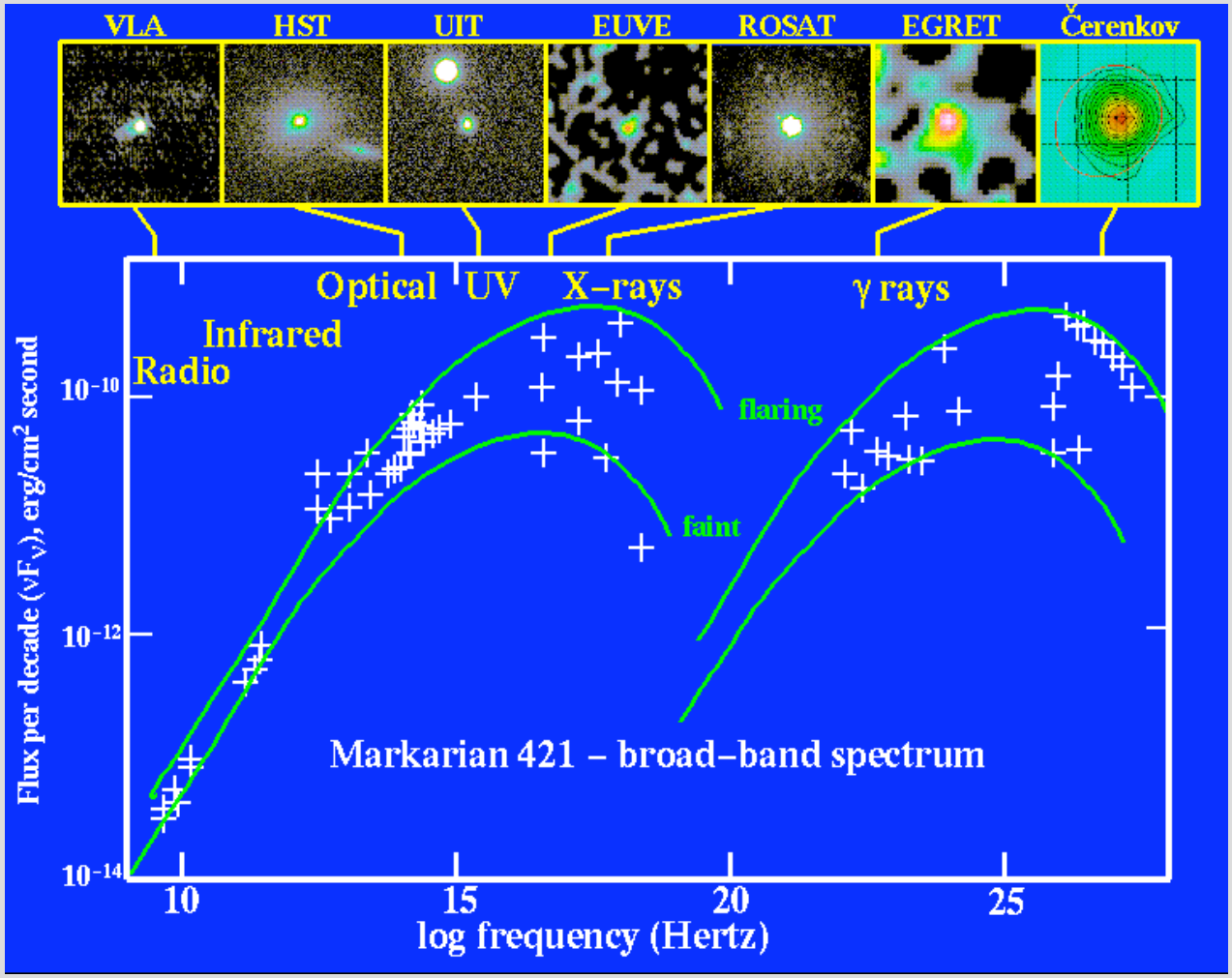
BL Lacs

BL Lacs are named after the prototype BL Lacertae
Distinguished by lack of strong emission *or* absorption lines in their spectra:



Related class of objects are **optically violent variables**. Many AGN are variable, but OVVs show larger variations (> 0.1 mag) in optical flux on short timescales (e.g. a day).

Collectively, OVVs and BL Lacs are called **blazars**



Can be observed across entire EM spectrum

All known blazars are radio sources…

Quasars

Most luminous subclass of AGN.

Small fraction (5-10%) are the strong radio sources which originally defined the quasar class.

Nuclear emission normally dominates host galaxy light.

Spectra very similar to Seyfert galaxies, except that:

- Stellar absorption lines are very weak, if detectable at all
- Objects called quasars are all `Type 1' in Seyfert jargon - i.e can see the broad lines

Radio galaxies

Strong radio sources typically associated with giant elliptical galaxies. Two types of radio galaxies have optical spectra that show AGN activity:

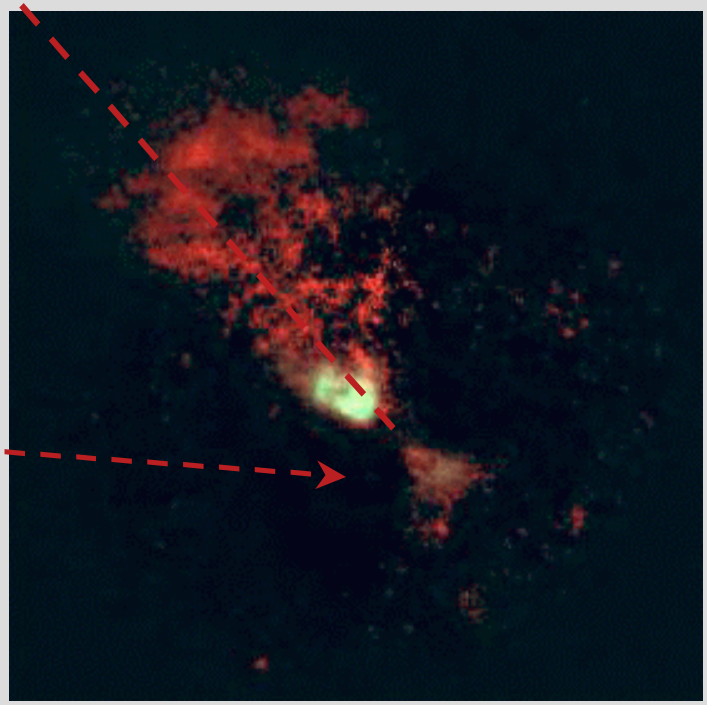
- Broad-line radio galaxies — like Type 1 Seyferts
- Narrow-line radio galaxies — like Type 2 Seyferts

Basically these look like radio loud Seyferts, **but** they seem to occur in ellipticals rather than spirals…

Unified models

Some order can be imposed on this zoo of AGN subclasses. Crucial observational realization is that emission from nuclear regions is not spherically symmetric. On observable scales (~pc in the nearest AGN), nucleus often has axial symmetry:

Radiation is escaping in a conical region



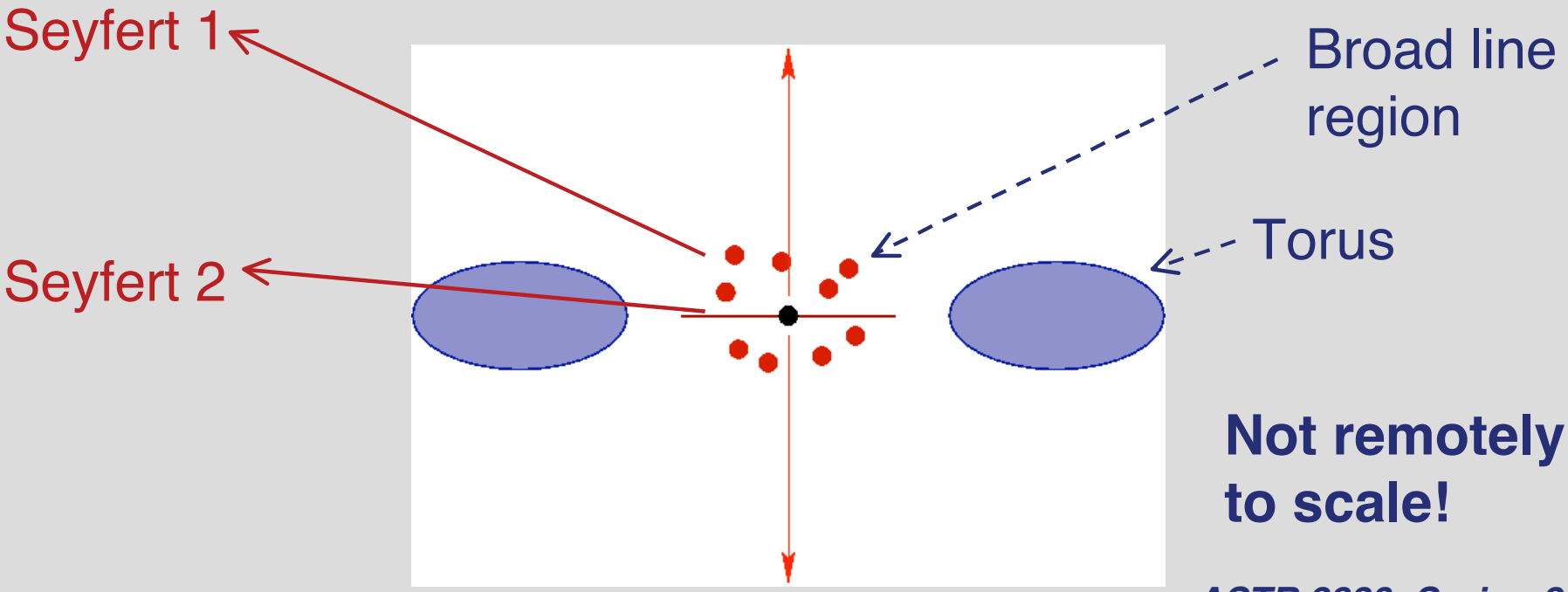
NGC 5728

Something blocking the way here?

Unified models seek to explain different classes of AGN as being due to different orientations of intrinsically similar systems to the observer's line of sight.

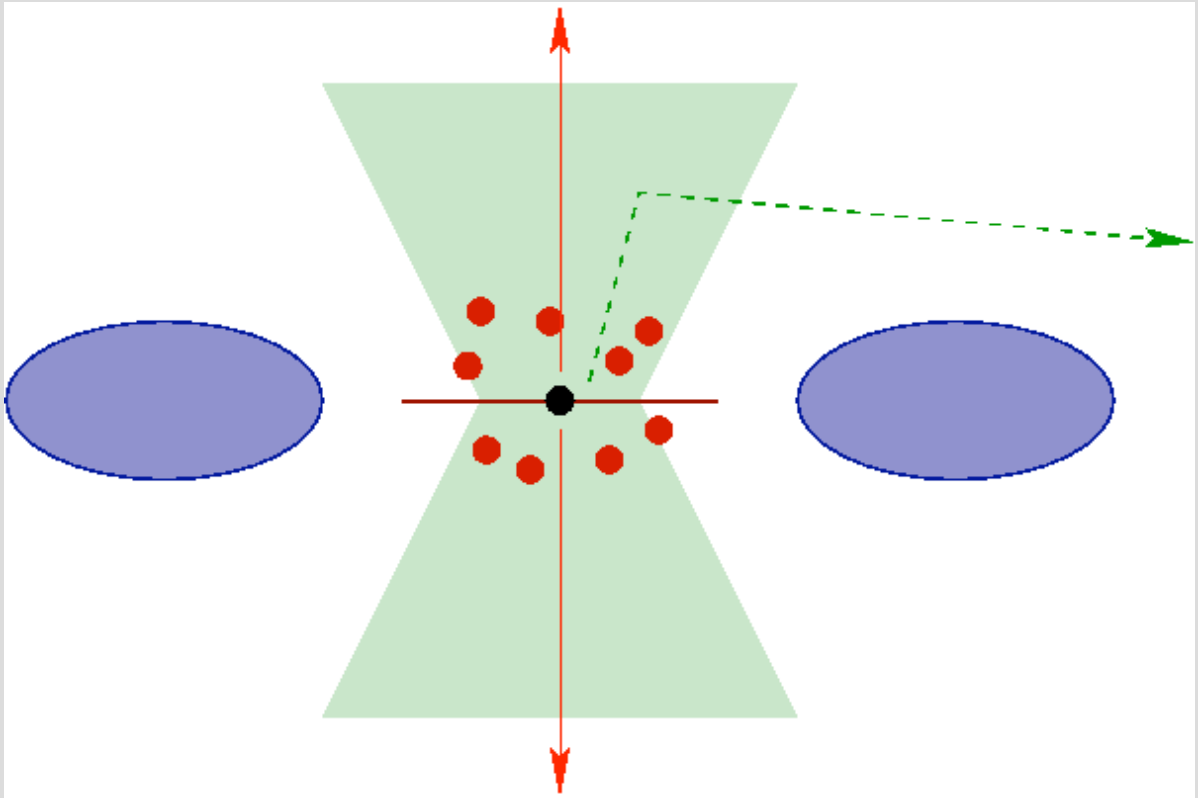
Seyfert 1 and Seyfert 2 galaxies

Most secure unification. Basic idea: an obscuring **torus** prevents us seeing the broad line region in Seyfert 2's.



Not remotely to scale!

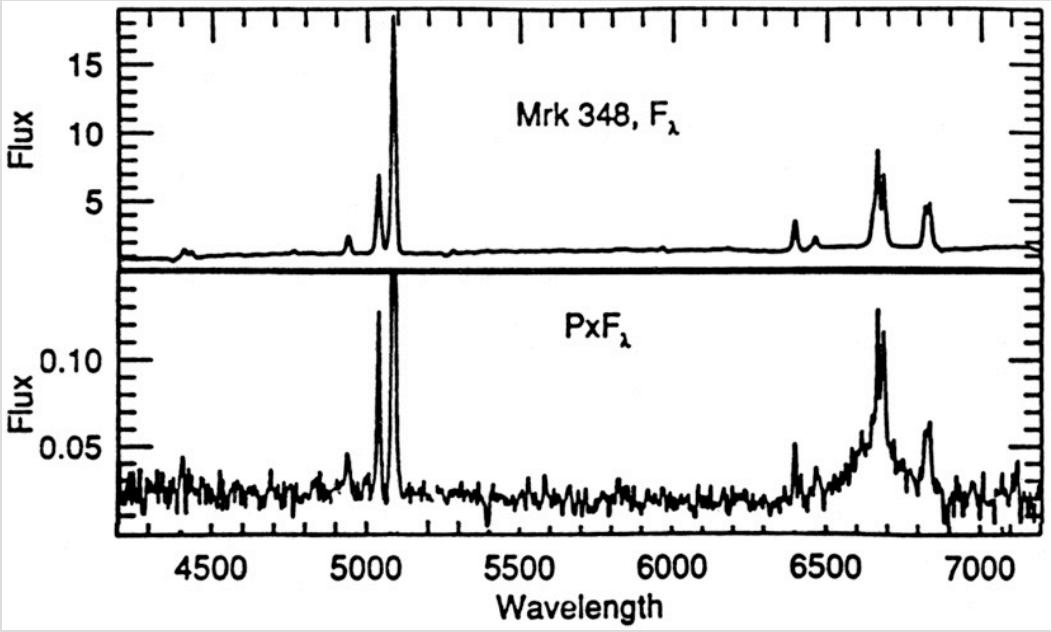
Why do we still see the continuum in Seyfert 2 galaxies?



Continuum radiation comes from the disk at smaller radii than the broad lines - why doesn't the torus block that too?

Assume that a scattering medium (e.g. free electrons) scatters some of this radiation into our line of sight…

Support for this picture: in some Seyfert 2 galaxies the polarized emission shows broad lines!



Consistent with the unified model, since scattering produces polarization. Conclude:

- At least some Seyfert 2 galaxies are intrinsically similar to Seyfert 1's
- If this applies to all Seyferts, statistics mean that the torus must block about 3/4 of the sky as seen from the nucleus

Reasonably secure to also fit quasars and blazars into this unified scheme:

Type 2 quasars aren't seen in the optical, but highly obscured luminous AGN are needed to make up the X-ray background. Giant elliptical galaxies have higher mass black holes, so reasonable to expect quasars to favor these galaxies.

Radio loud vs radio quiet

More ambitious unification schemes aim to explain why some AGN are radio loud, others radio quiet. *Possible* physical difference - spin of the hole:

Radio loud	Radio quiet
High spin holes a ~ 1	Low spin holes a << 1
Produce jets, which are origin of radio emission (cf blazars are radio loud)	No jets
Jets powered by spin energy extracted from black hole	Spectrum produced by accretion disk (blackbody plus nonthermal coronal emission)