

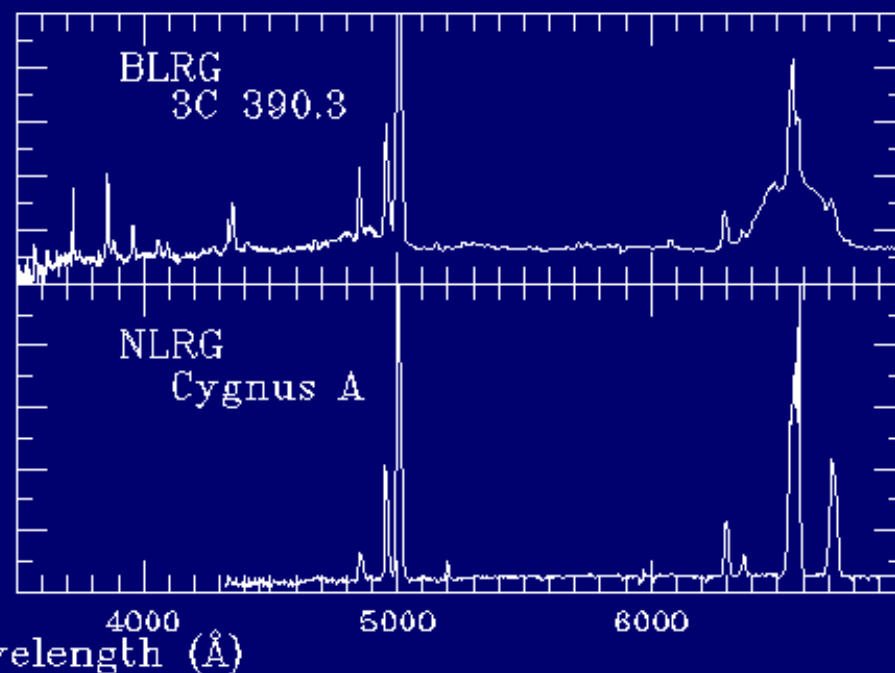
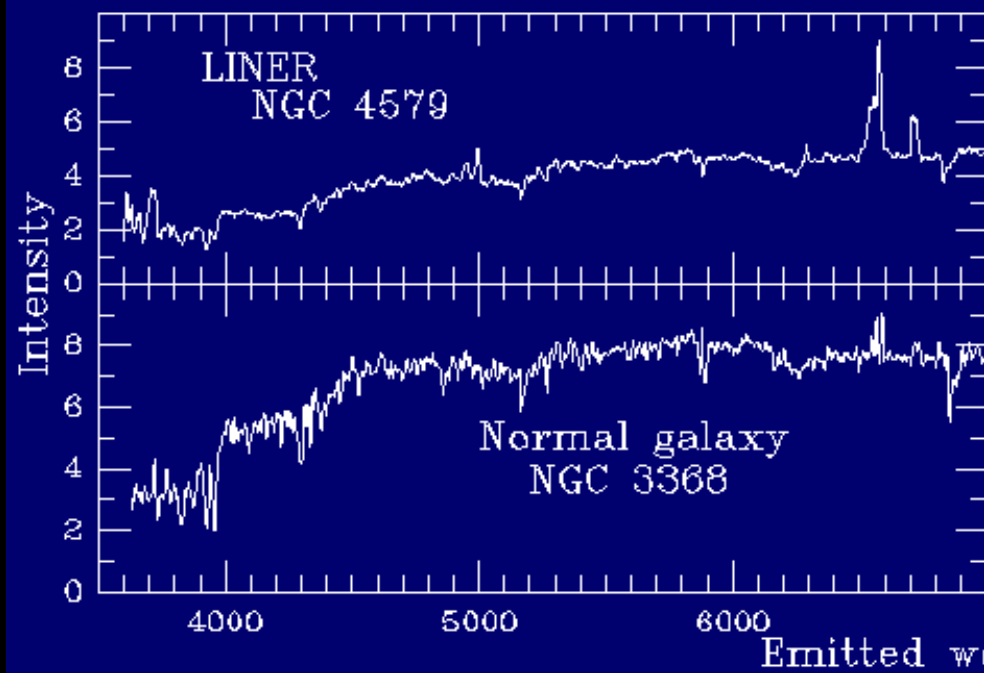
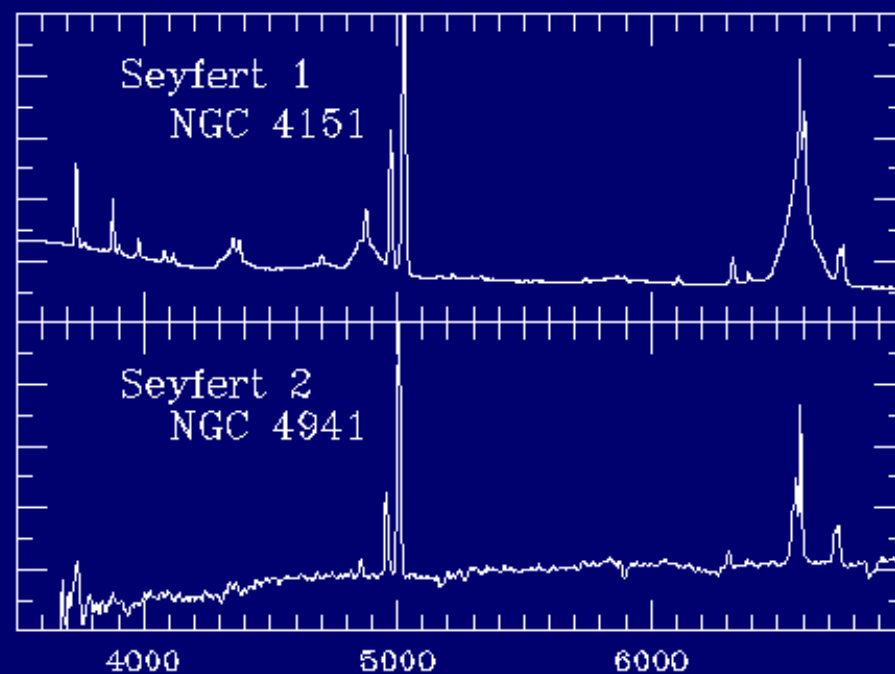
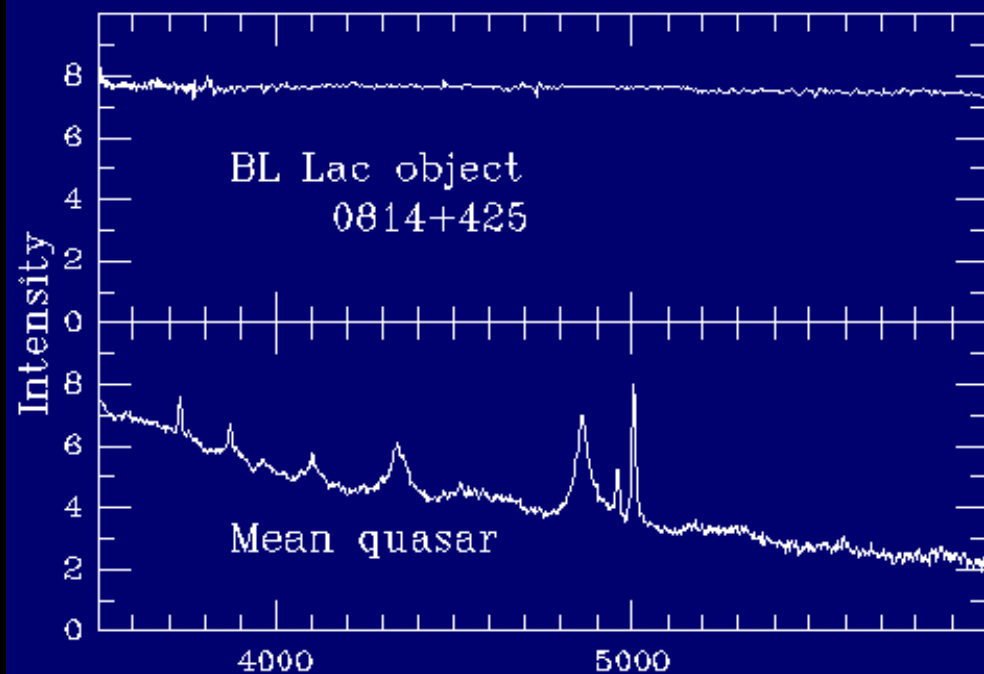
Aktív galaxisok



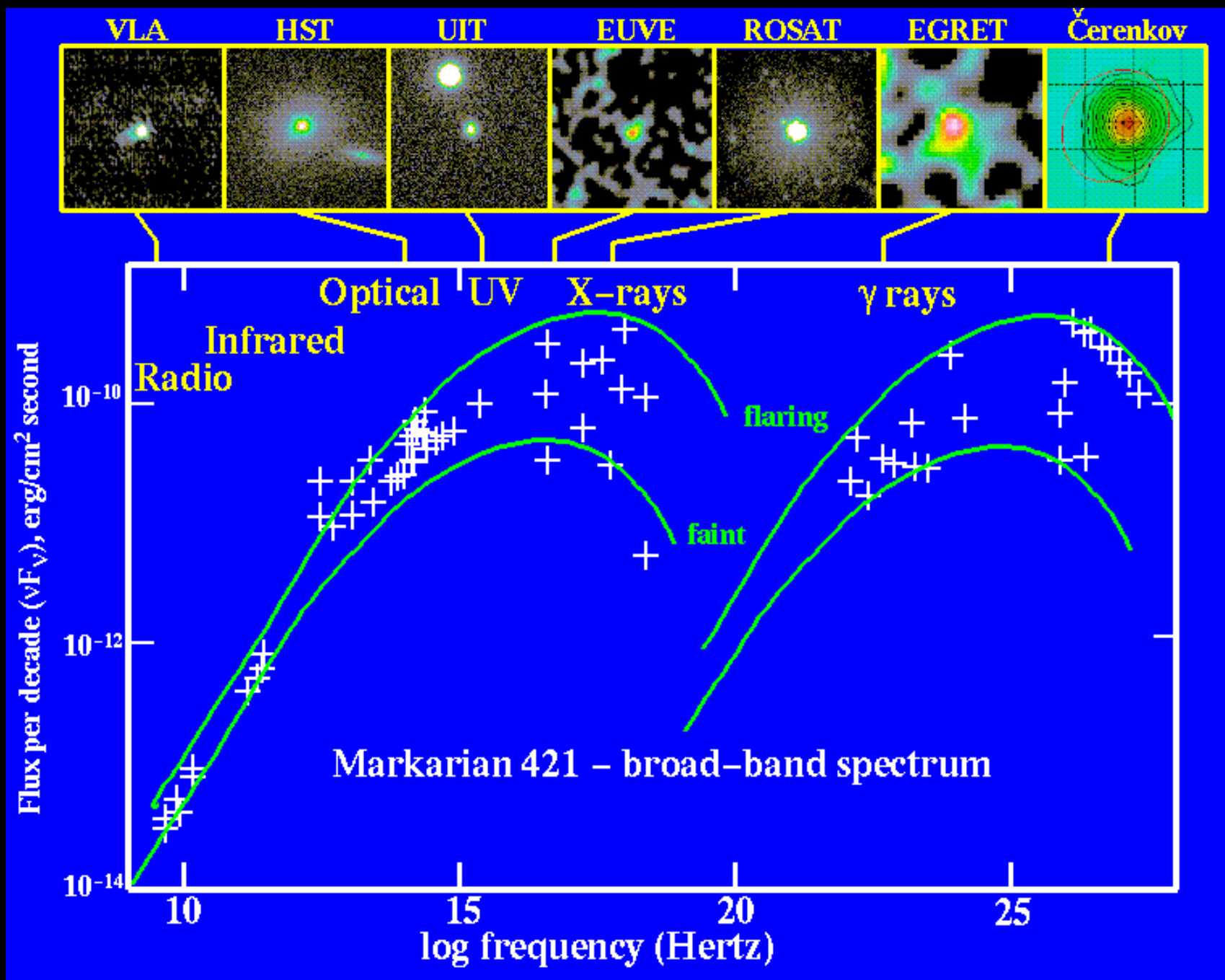
Aktív galaxisok típusai

- Seyfert-galaxisok
- BL Lac-objektumok
- kvazárok
- LINER-ek
- rádió-galaxisok

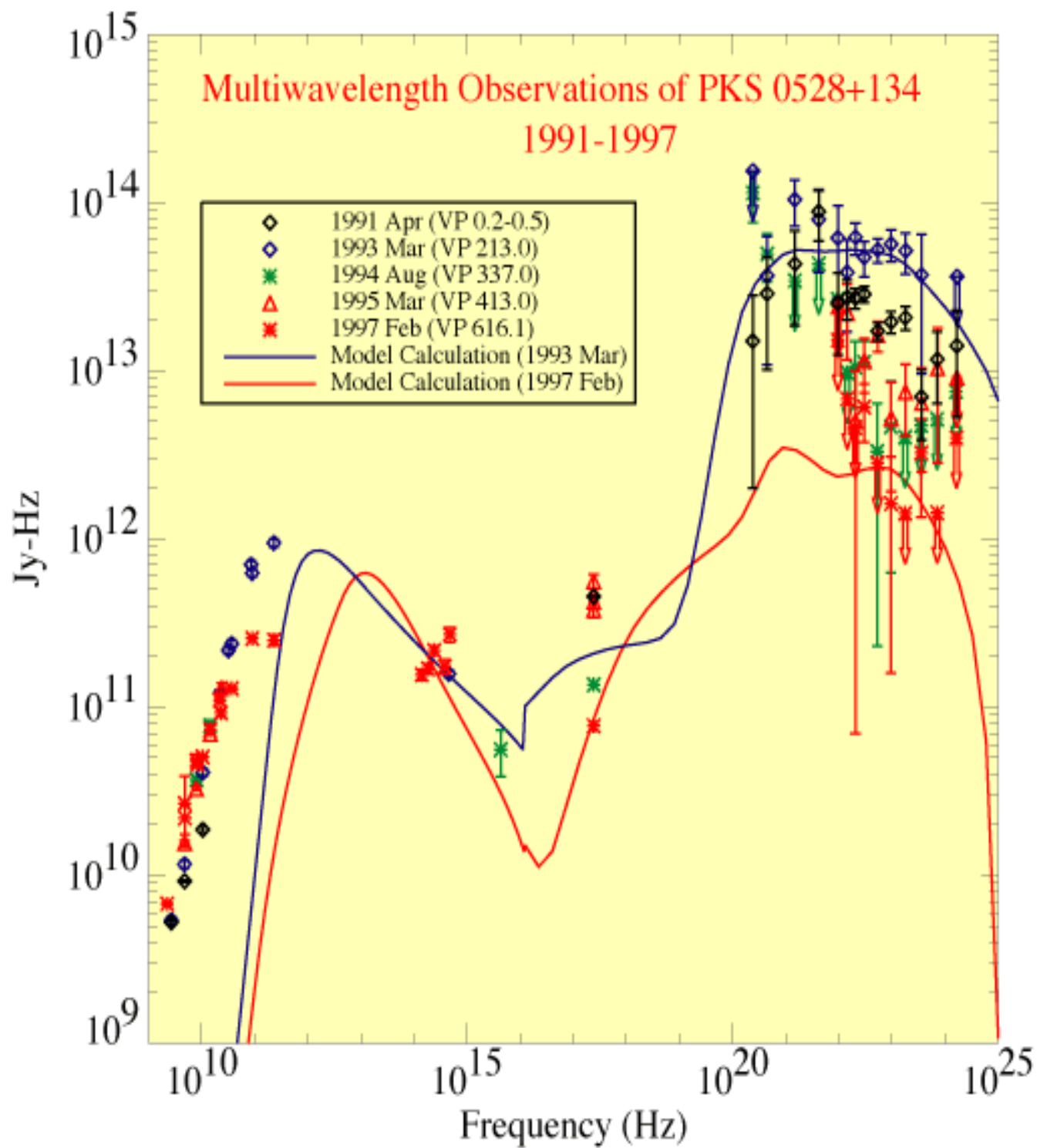
Spektroszkópiai jellemzők: optikai spektrumok



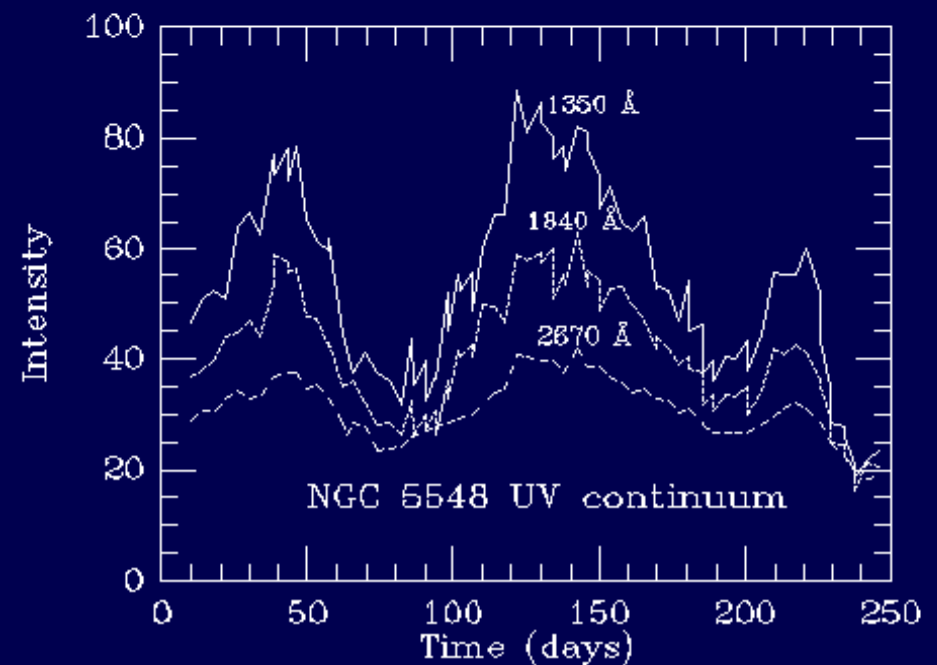
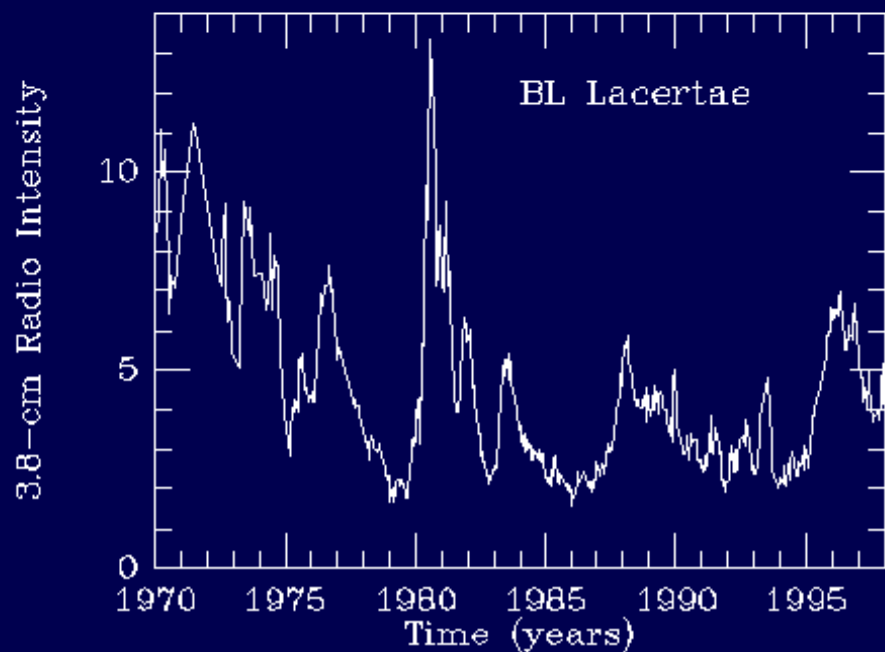
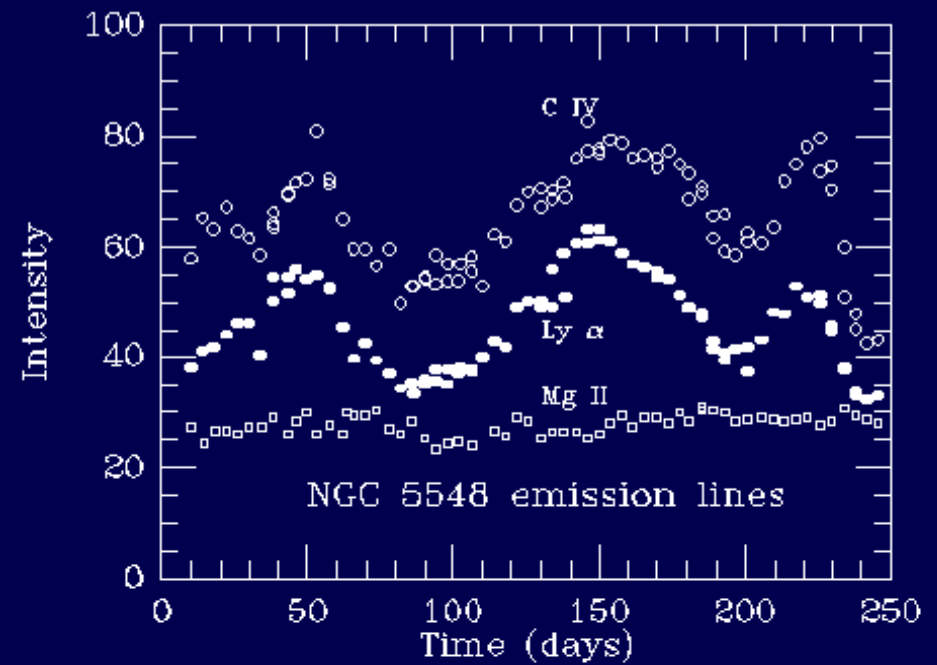
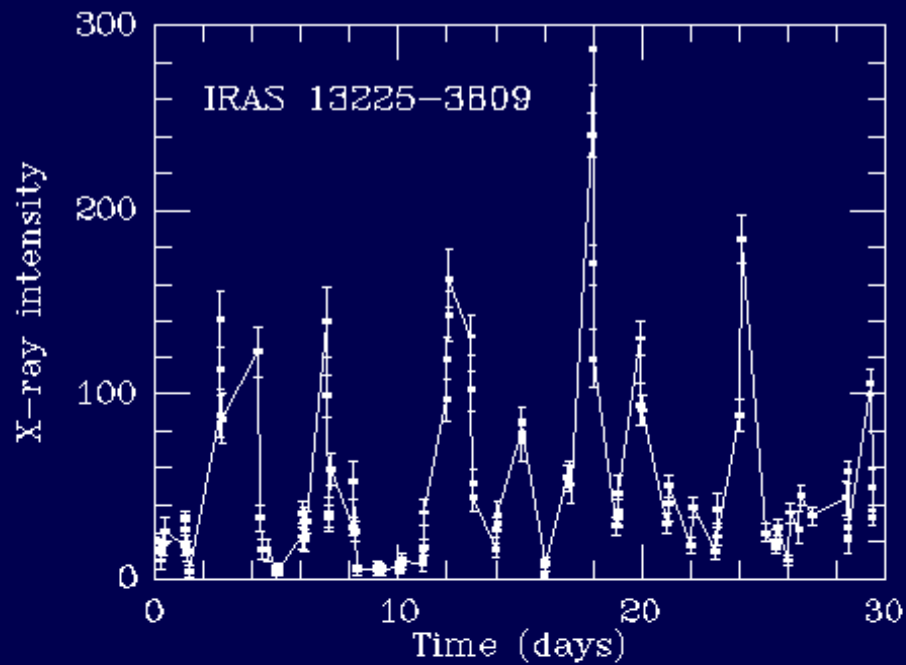
Spektroszkópiai jellemzők: teljes spektráltartomány



Multiwavelength Observations of PKS 0528+134 1991-1997



Rádió-, UV-, röntgenfluxus időbeli változása



Seyfert-galaxisok

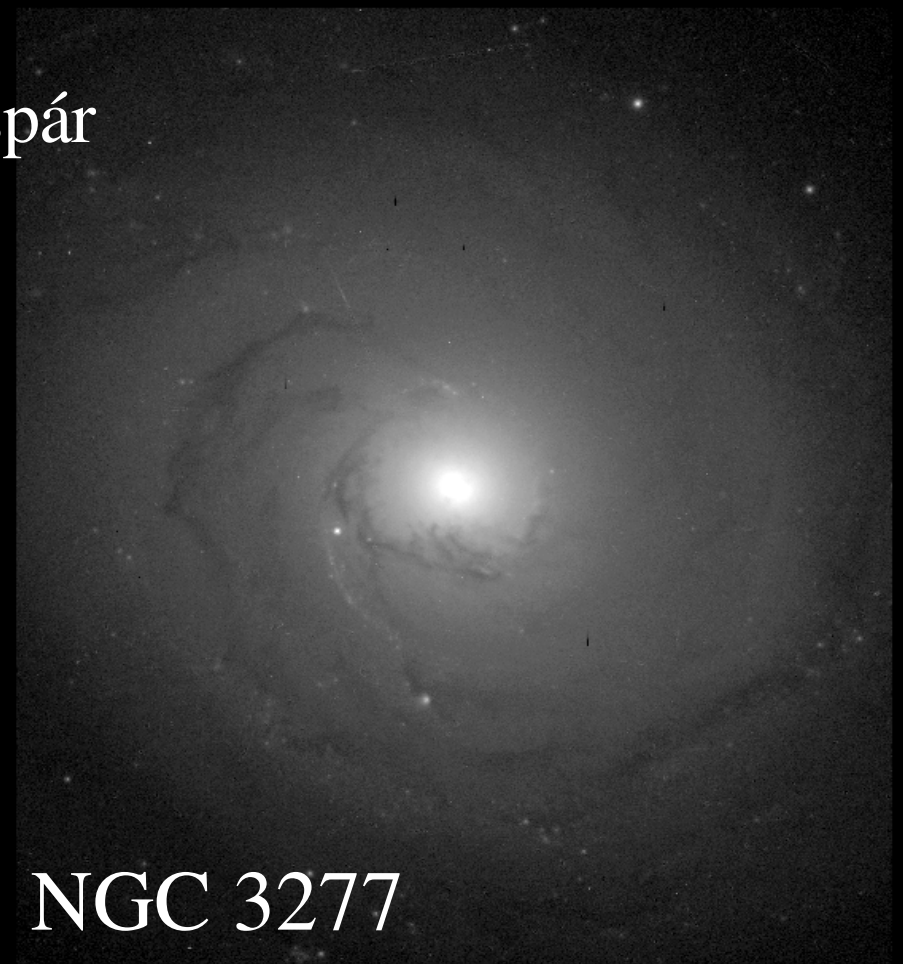
Carl K. Seyfert (1943)

csillagszerű mag

emissziós színekép

90 %-uk Sb, vagy SBb

gyakori a kölcsönható galaxispár

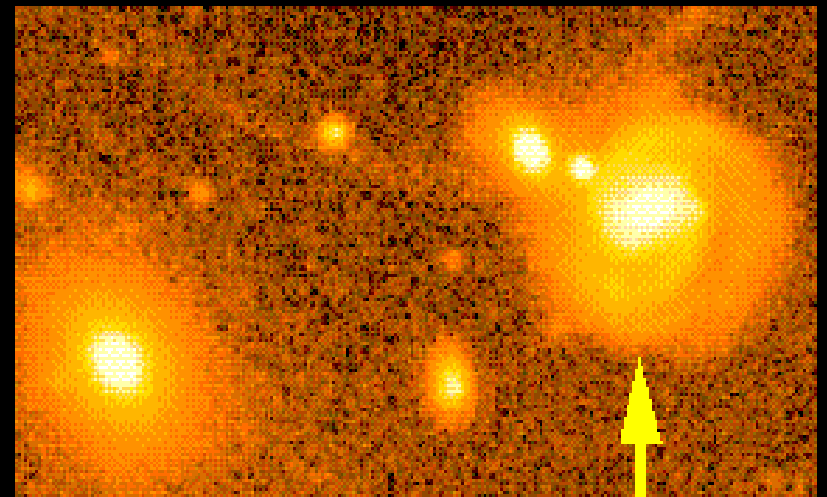
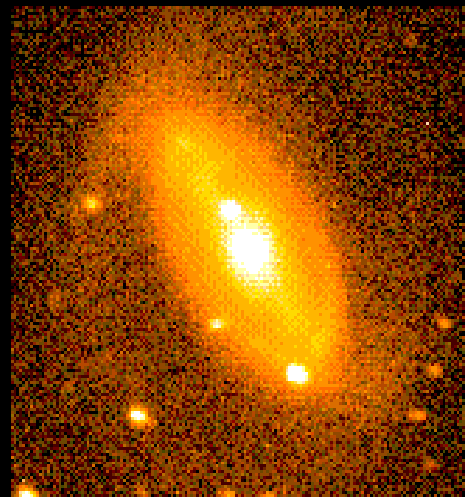
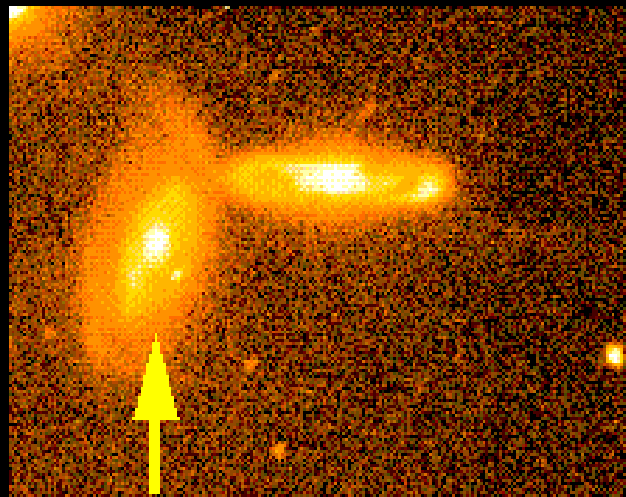
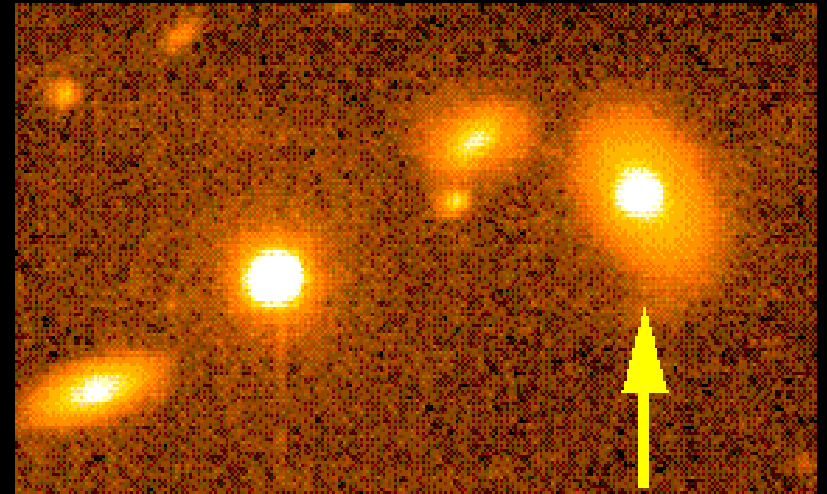
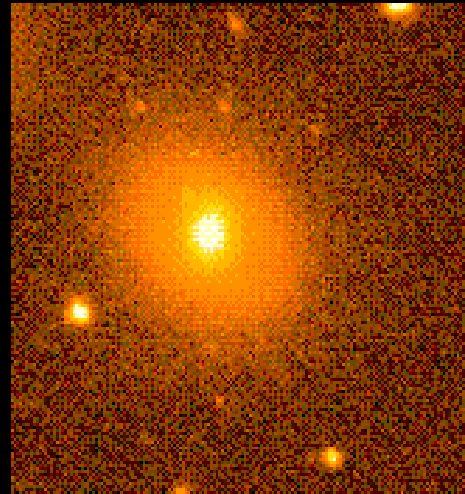
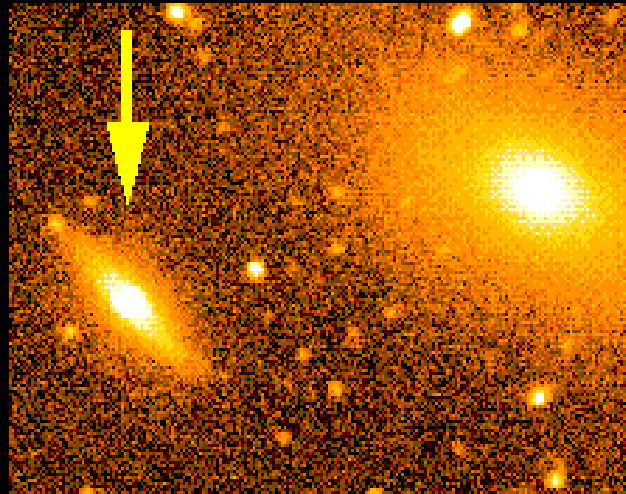


Seyfert Galaxies

IC 4329A

NGC 3516

Markarian 279



NGC 3786

NGC 5728

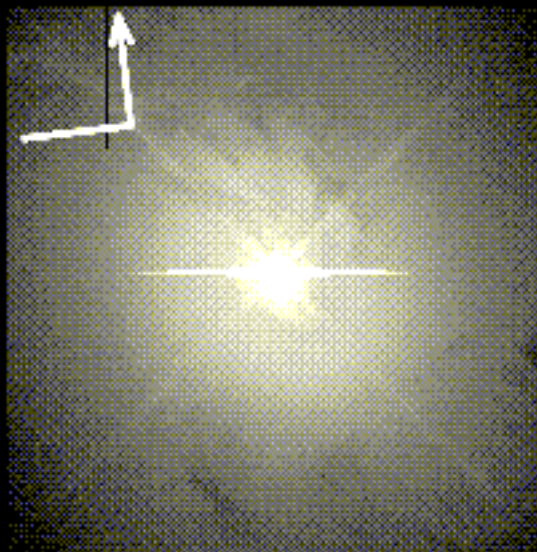
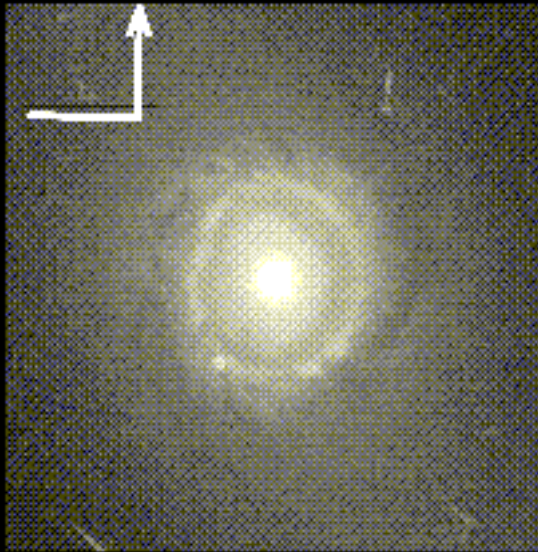
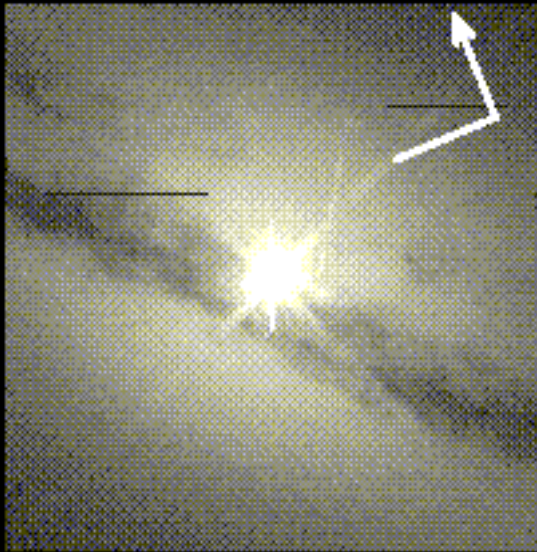
NGC 7674

Seyfert Nuclei – HST Planetary Camera

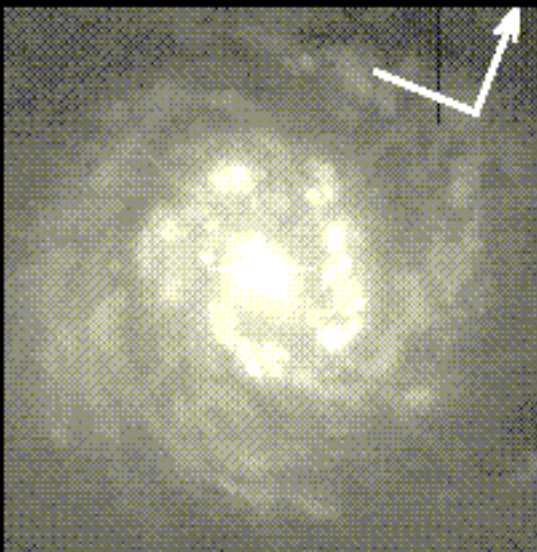
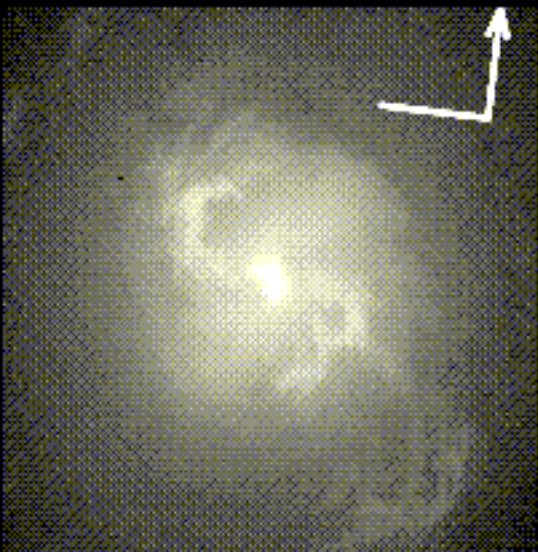
IC 4329A

NGC 1019

NGC 3516



1"



Mkn 1376

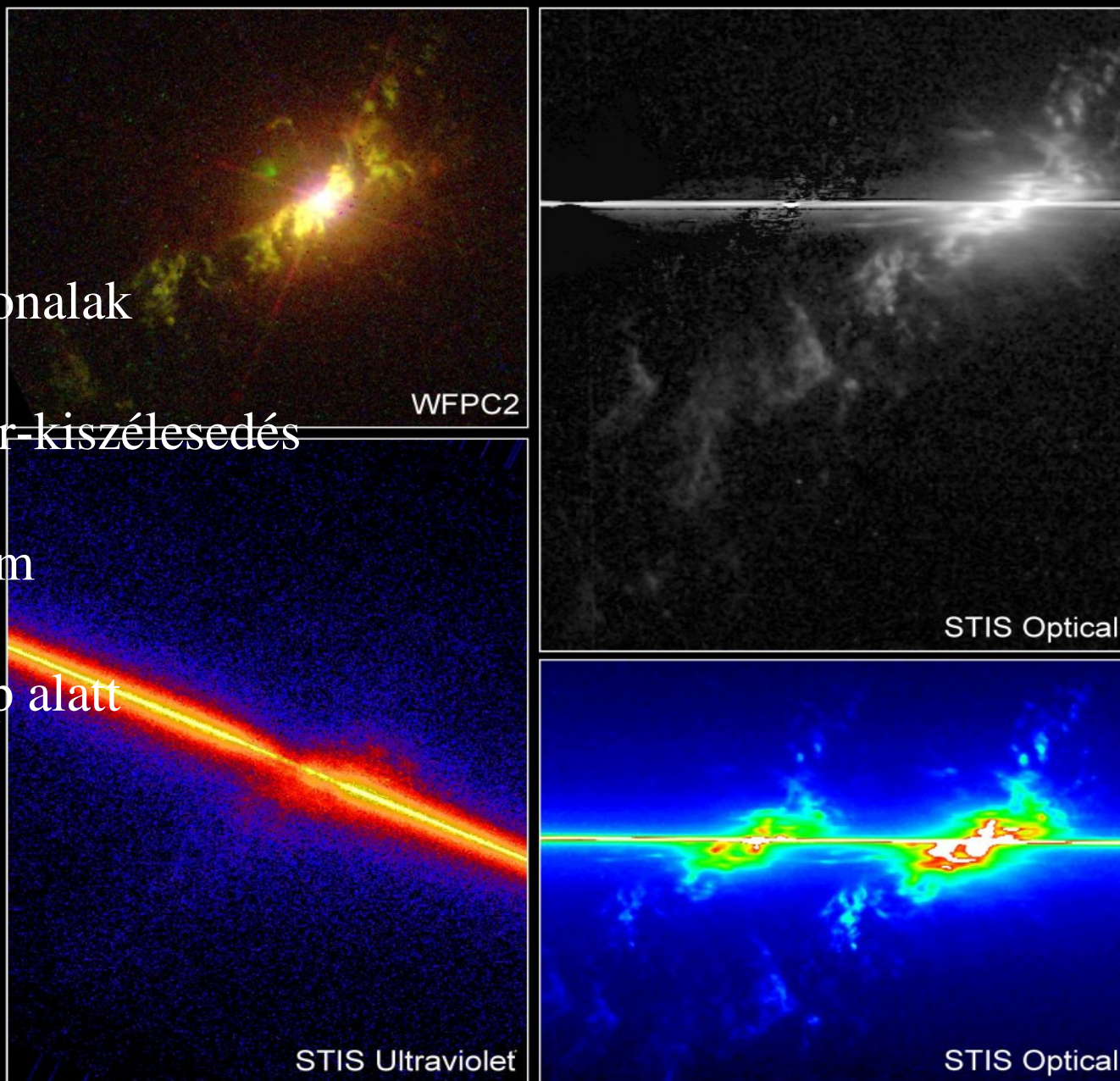
NGC 3393

NGC 7469

Seyfert-1

széles H I, He I, He II vonalak
keskeny tiltott vonalak
1000-5000 km/s Doppler-kiszélesedés

nagyon fényes kontinuum
röntgen-emisszió:
erős változás néhány nap alatt

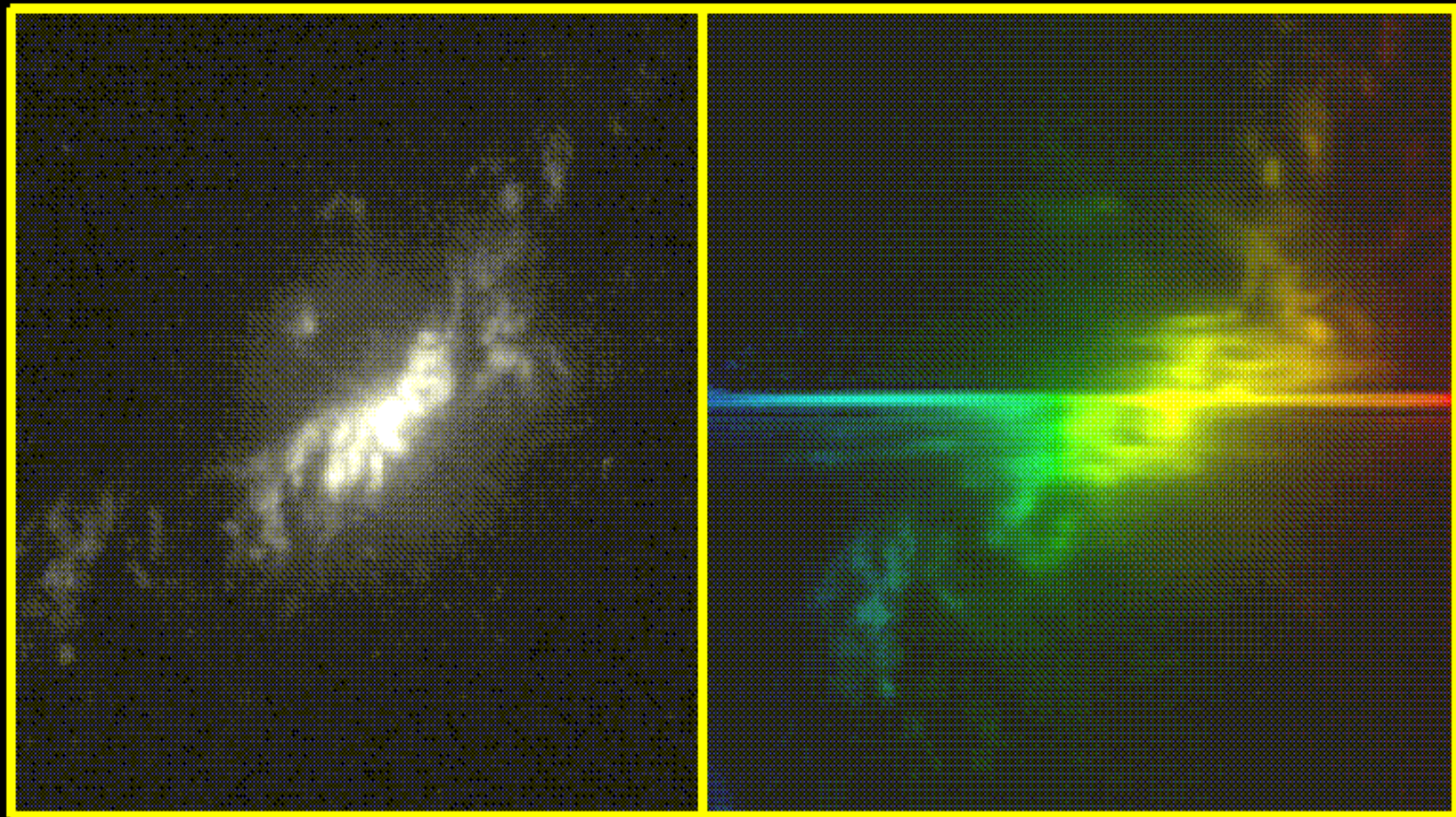


Seyfert Galaxy NGC 4151
Hubble Space Telescope • STIS • WFPC2



NGC 4151 – [O III] structure

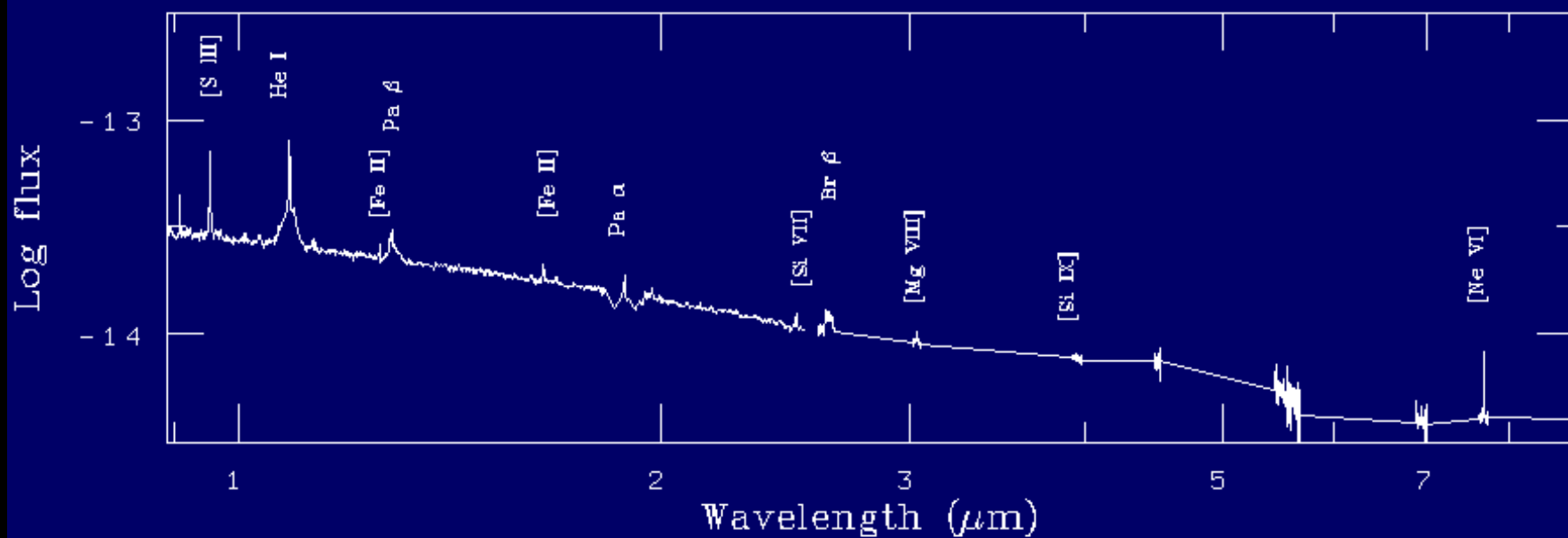
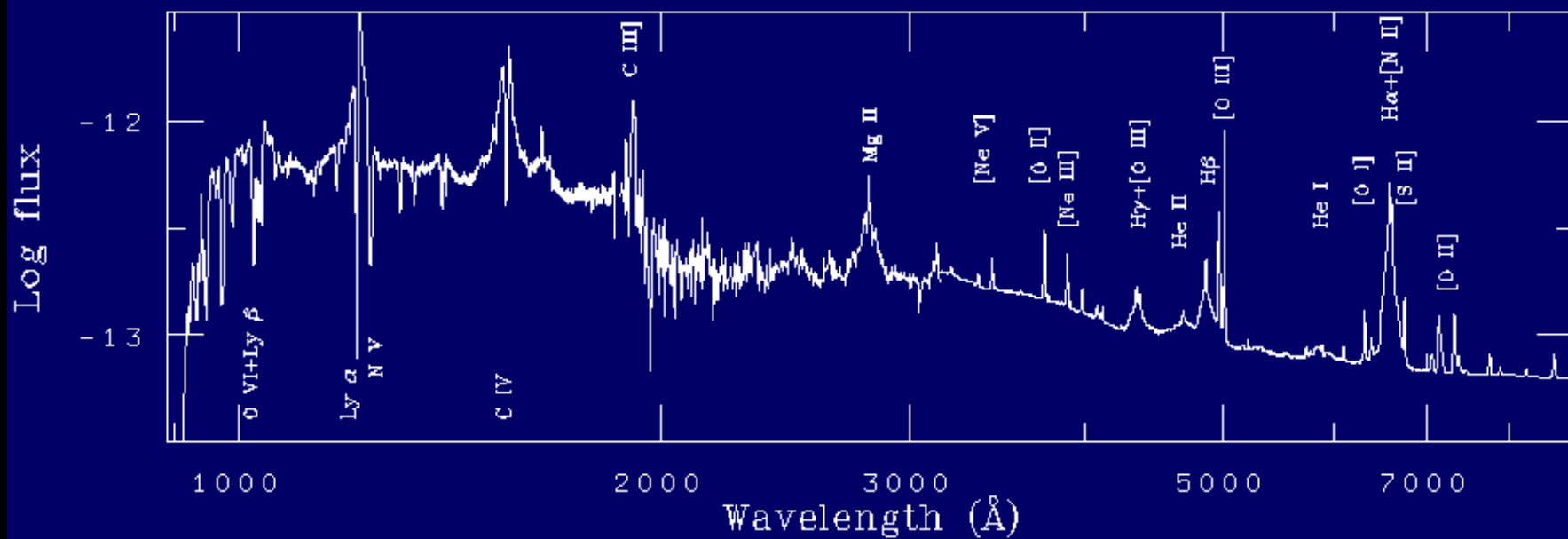
STIS/HST



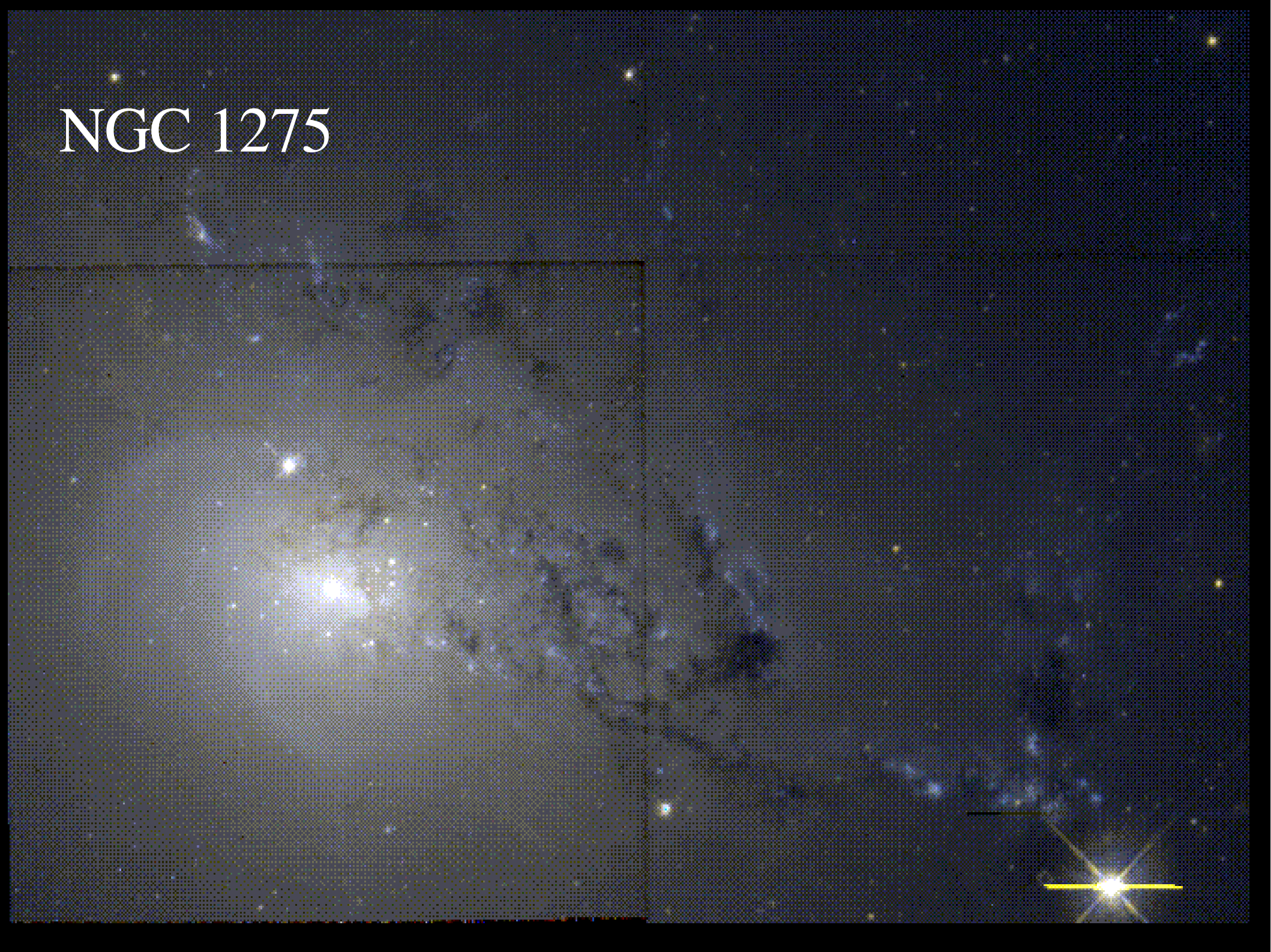
Direct image, $\lambda 5007$

Slitless spectrum

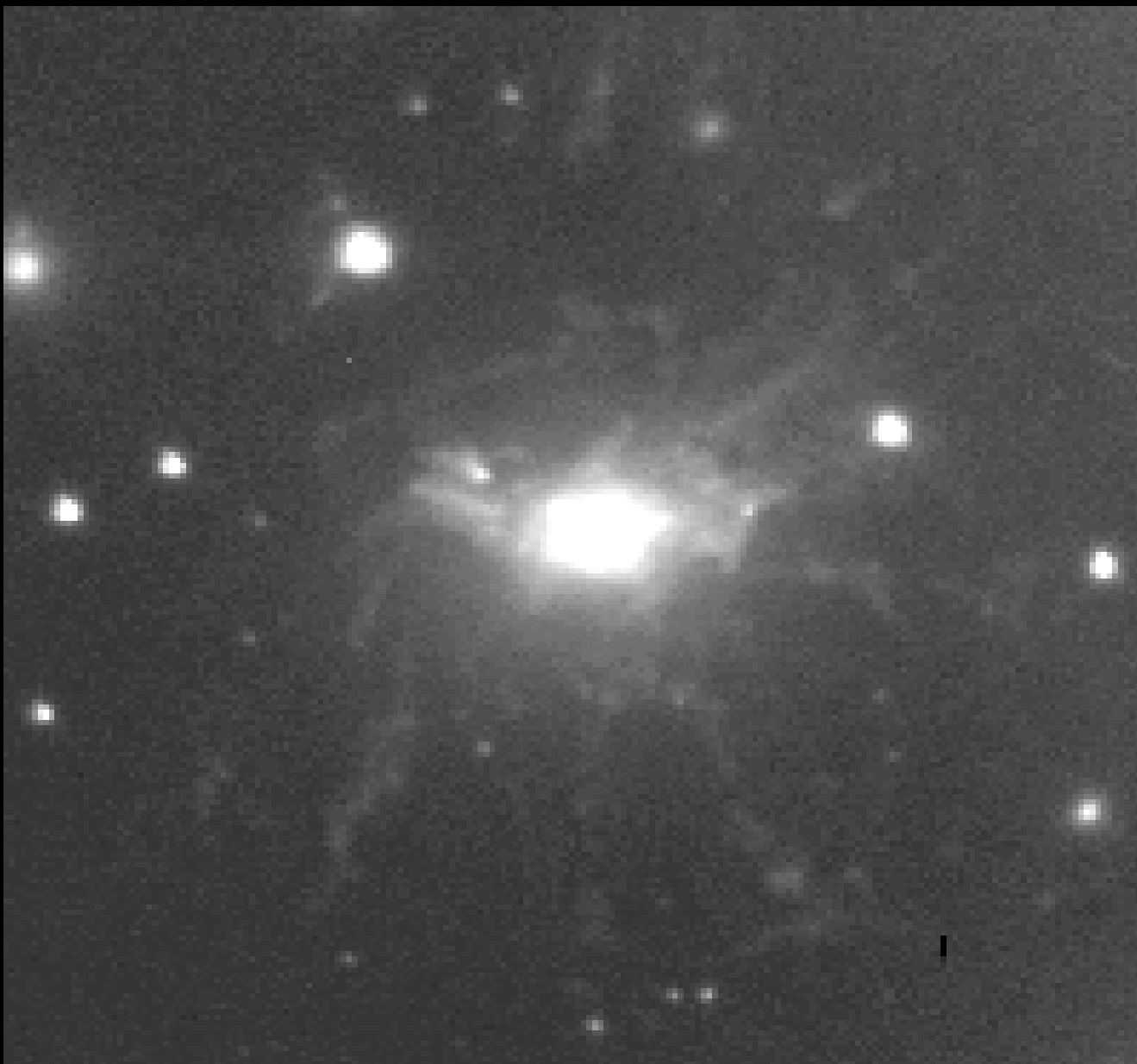
NGC 4151 (Seyfert-1) spektruma



NGC 1275



NGC 1275 -- H emisszió



Seyfert-2

csak keskeny vonalak

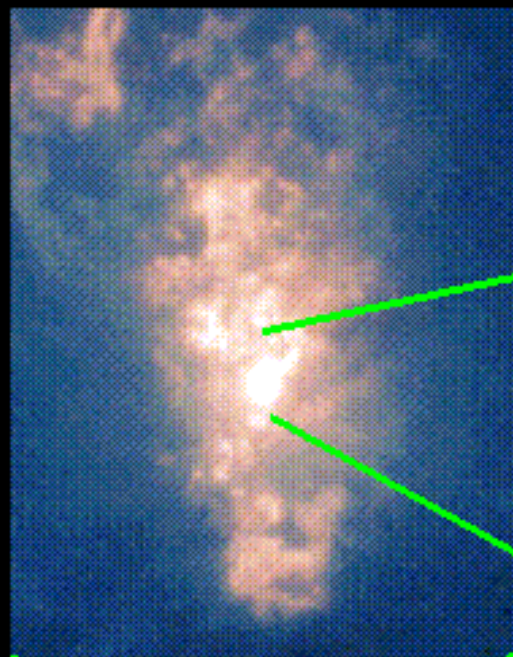
500 km/s Doppler-kiszélesedés

kevésbé fényes kontinuum

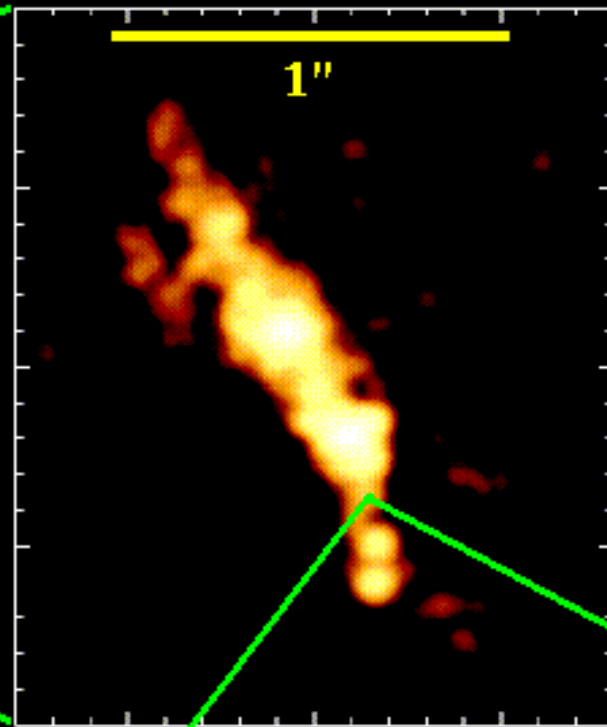


NGC 1068 (Seyfert 2)

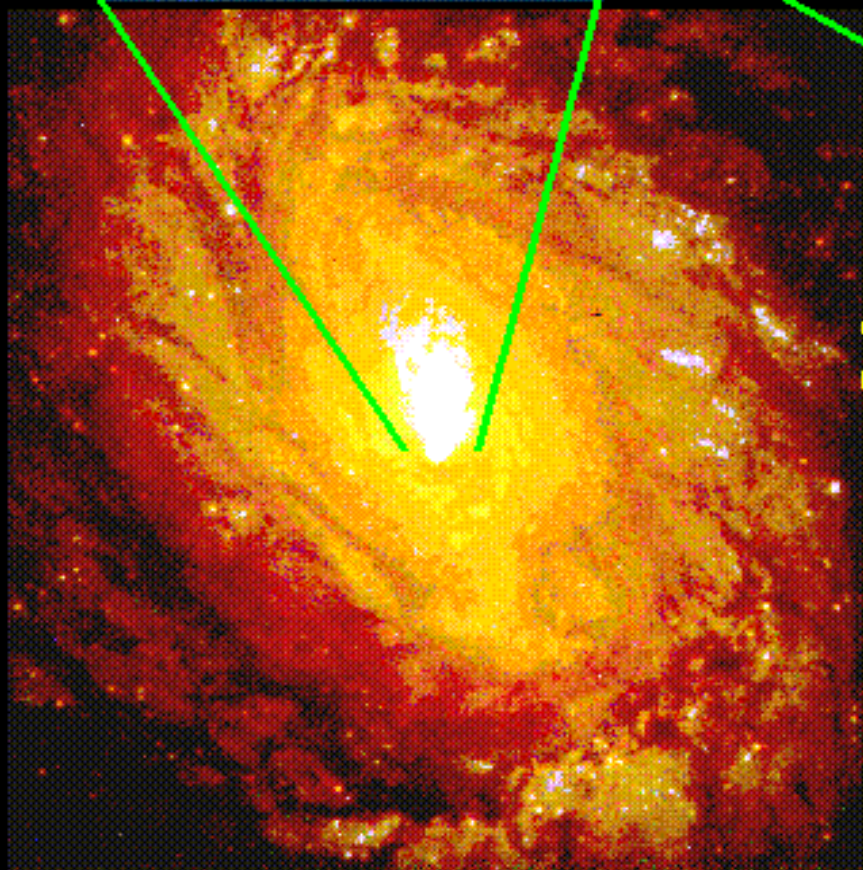
NGC 1068



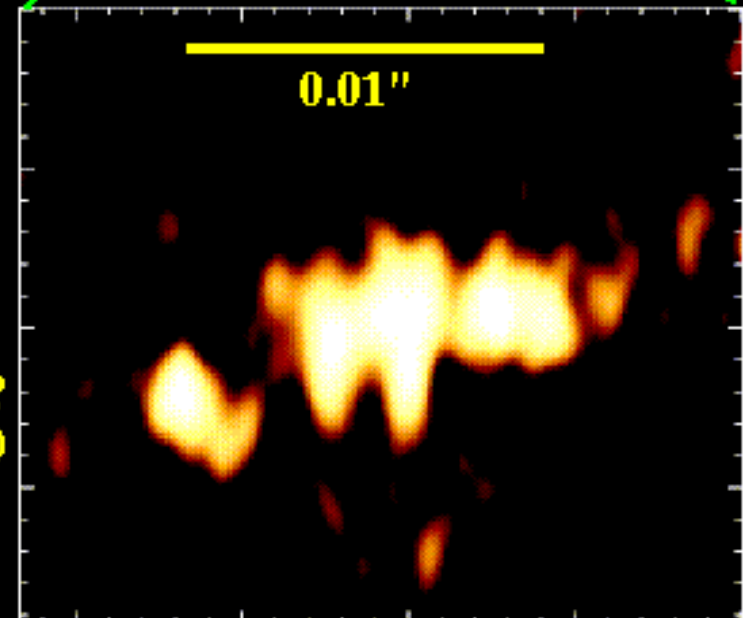
Nuclear reflection
cone (HST/FOC)



Radio jet
(MERLIN)

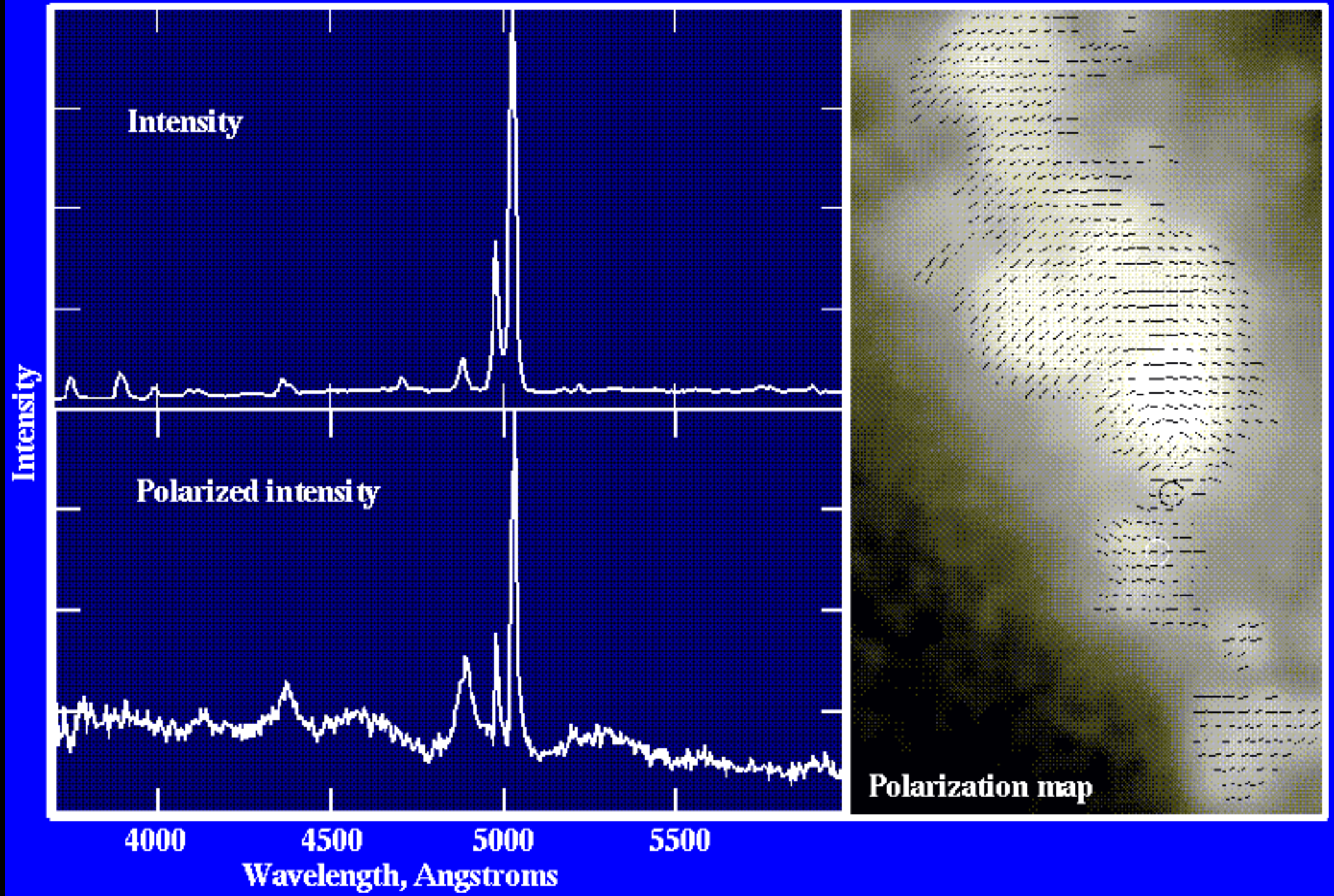


Optical galaxy
(HST)

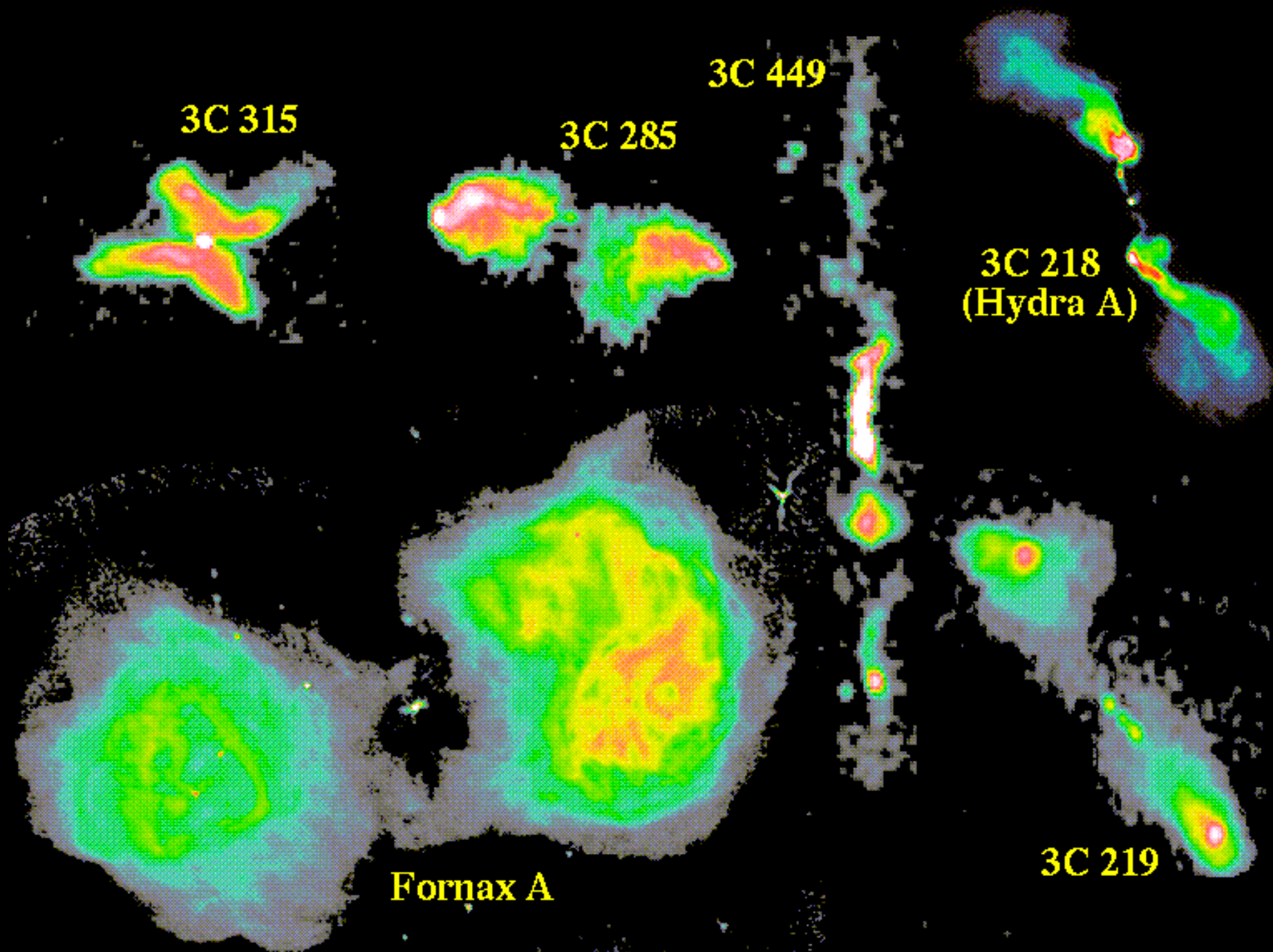


Obscuring torus ?
(VLBA)

Polarization and the Hidden Nucleus of NGC 1068



Rádió galaxisok



Rádió galaxisok

extrém erős rádiósugárzás

prototípus: Cygnus A

spektrum: $F_\nu \sim \nu^{-\alpha}$ $\alpha \approx 1$

A teljes rádióluminozitás: $L_r = 4\pi D^2 \int_{\nu_1}^{\nu_2} F_\nu d\nu$

$D = 200$ Mpc ($z = 0.057$ alapján)

$\alpha = 0.8$

$\nu_1 = 10^7$ Hz, $\nu_2 = 3 \cdot 10^7$ Hz

$\implies L_r = 10^{44}$ erg/s = 10^{11} L_\odot

2 altípus:

széles vonalú (broad-line) RG

keskeny vonalú (narrow-line) RG

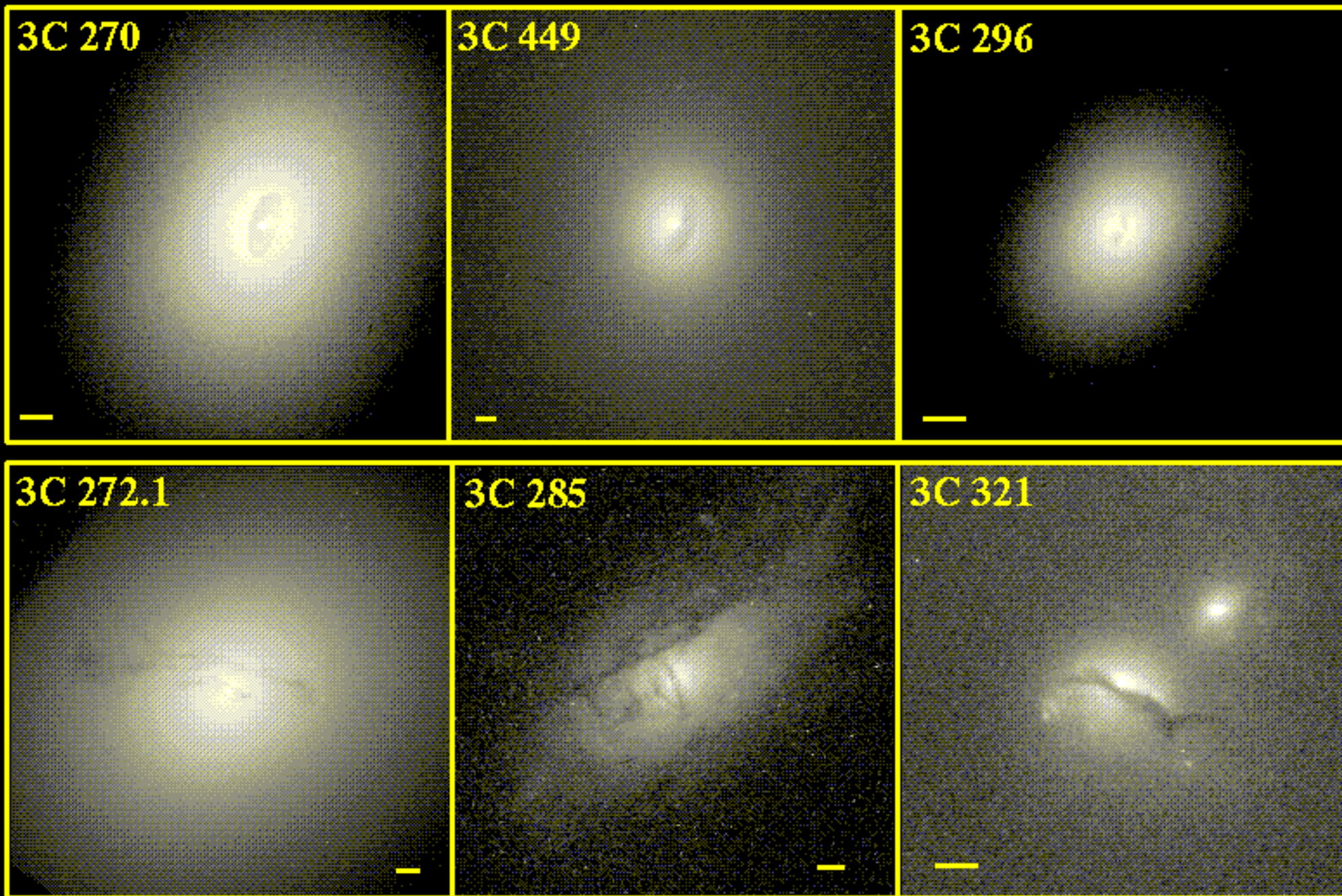
szinte mindegyik cD galaxis

rádiósugárzó lebenyek (radio lobes)

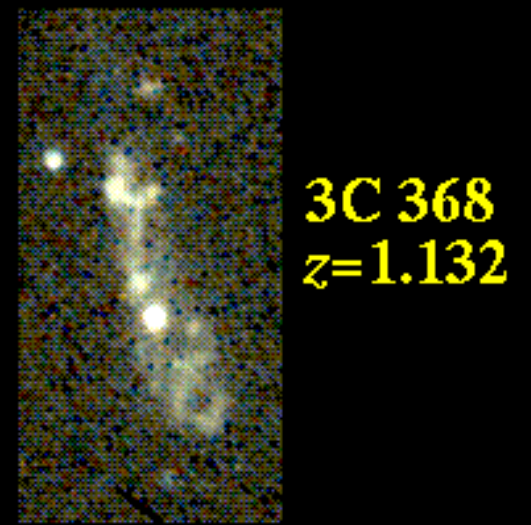
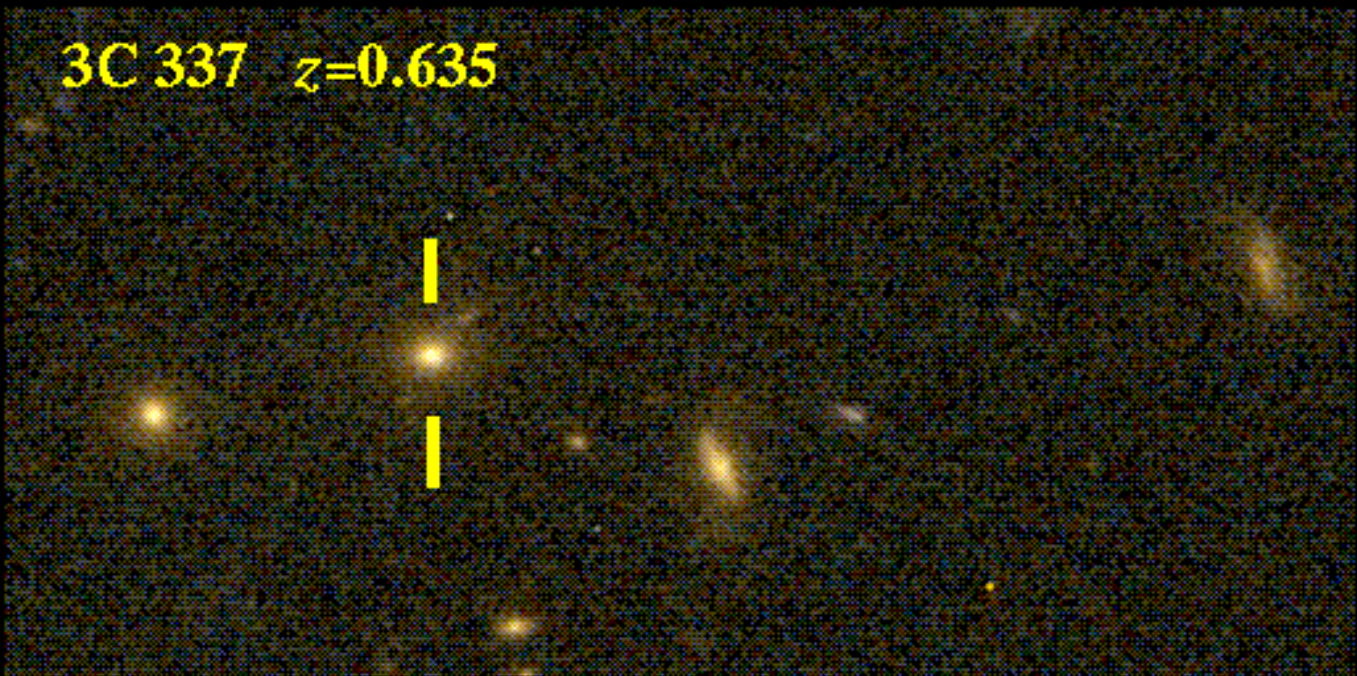
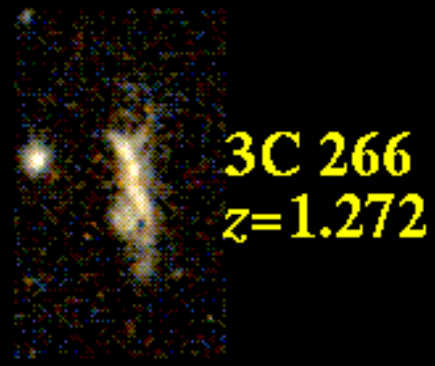
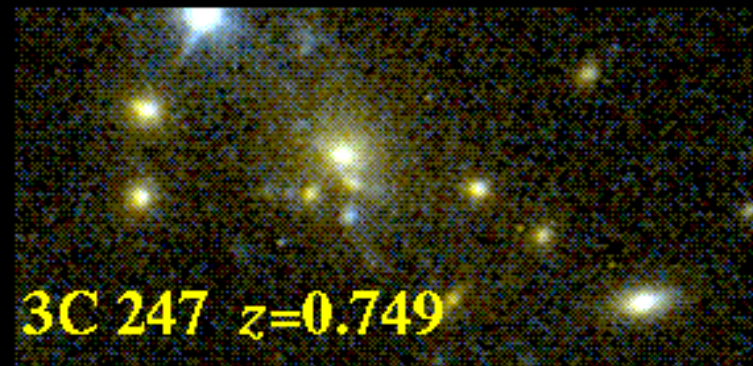
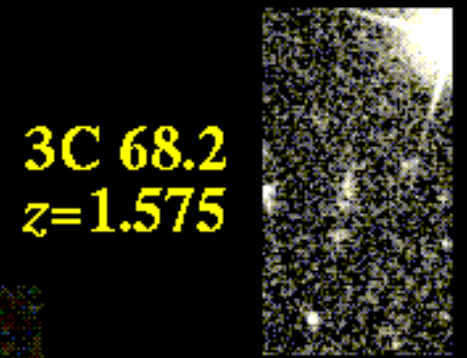
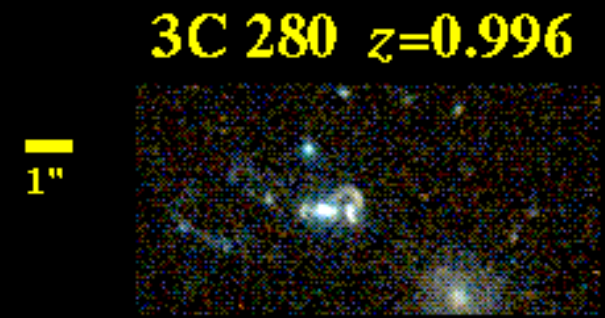
óriási kifújások (jet-ek)

nagy vöröseltolódásoknál gyakoribbak

Rádió galaxisok optikai képe



HIGH-REDSHIFT RADIO GALAXIES



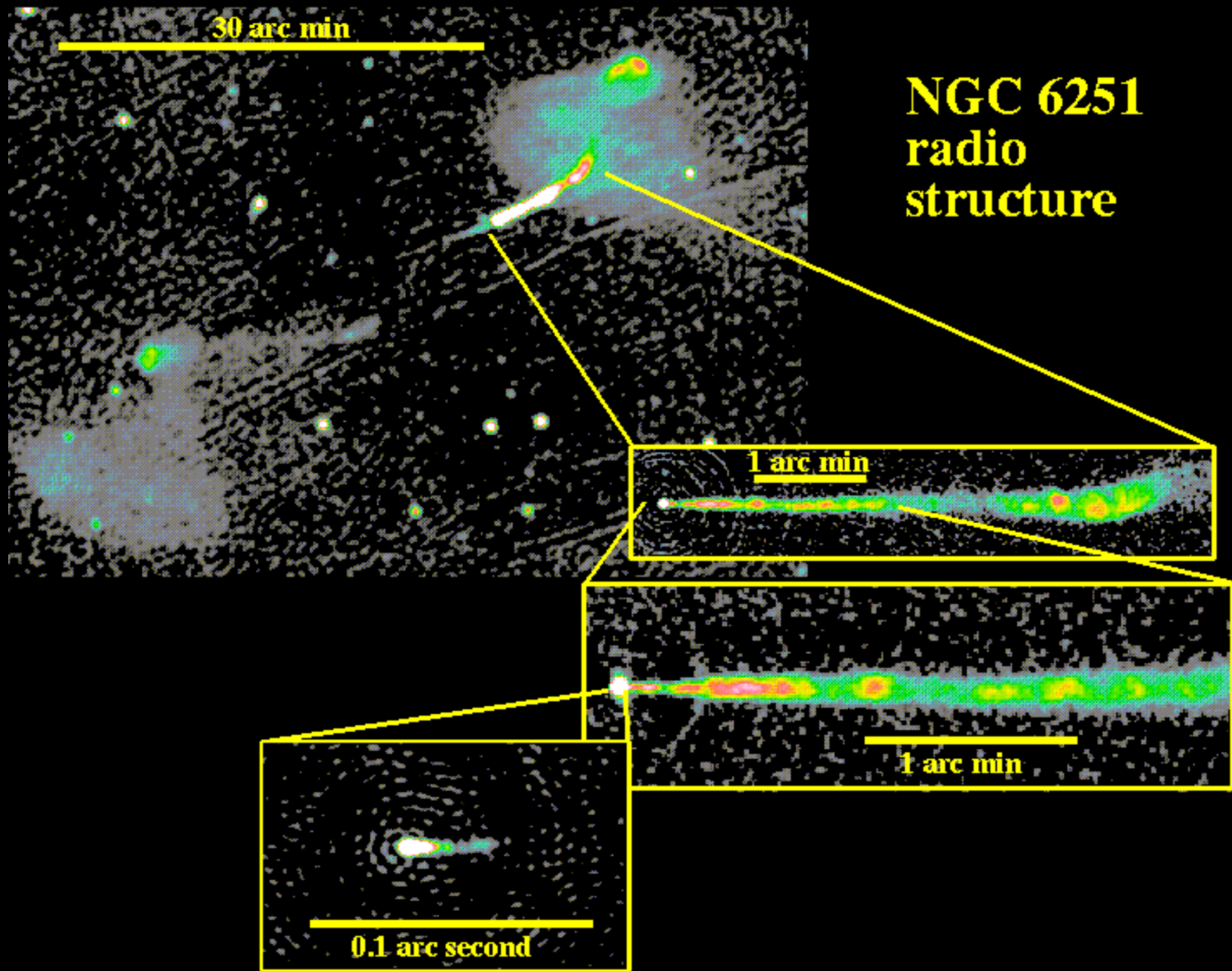
30 arc min

NGC 6251
radio
structure

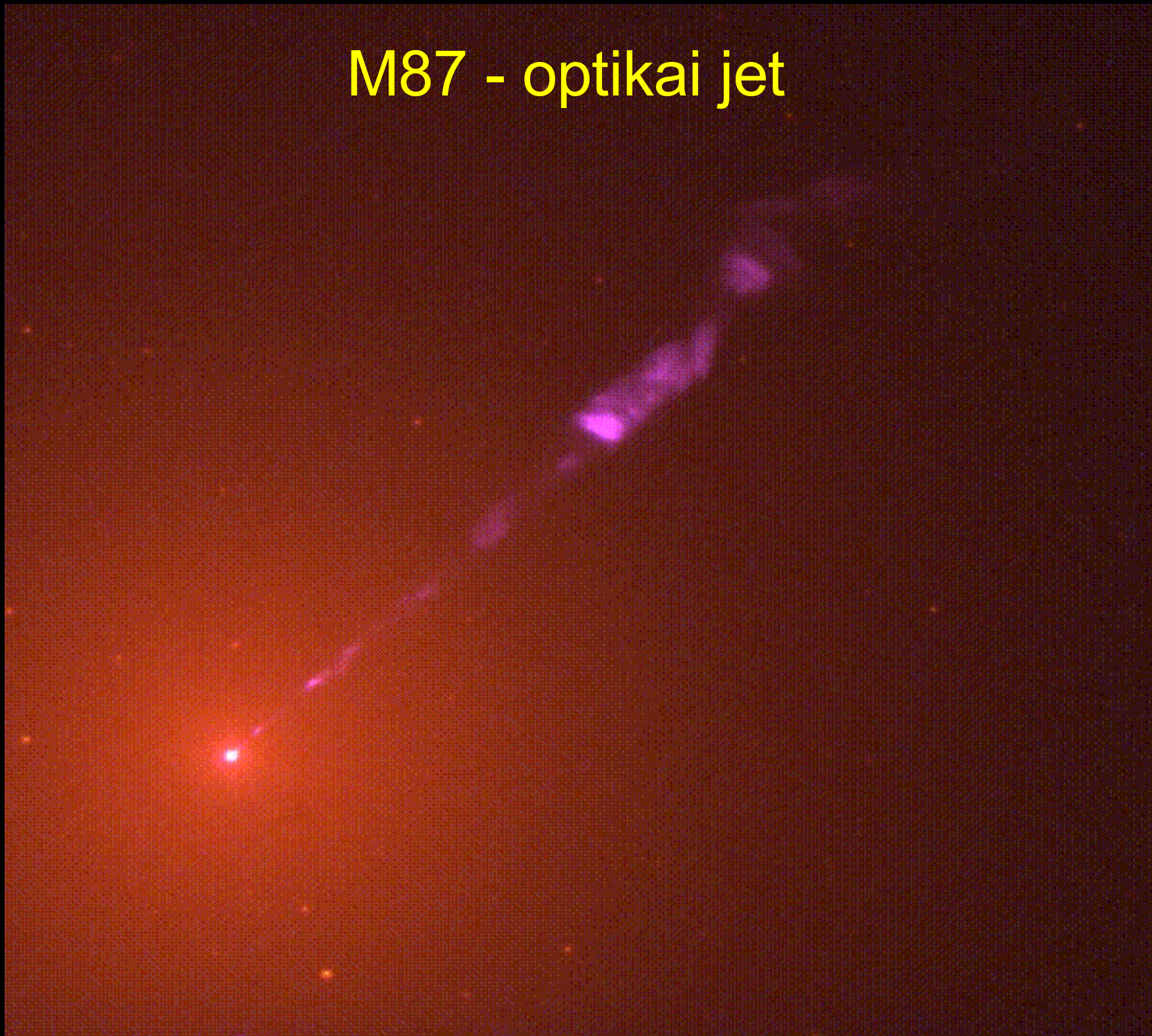
1 arc min

1 arc min

0.1 arc second

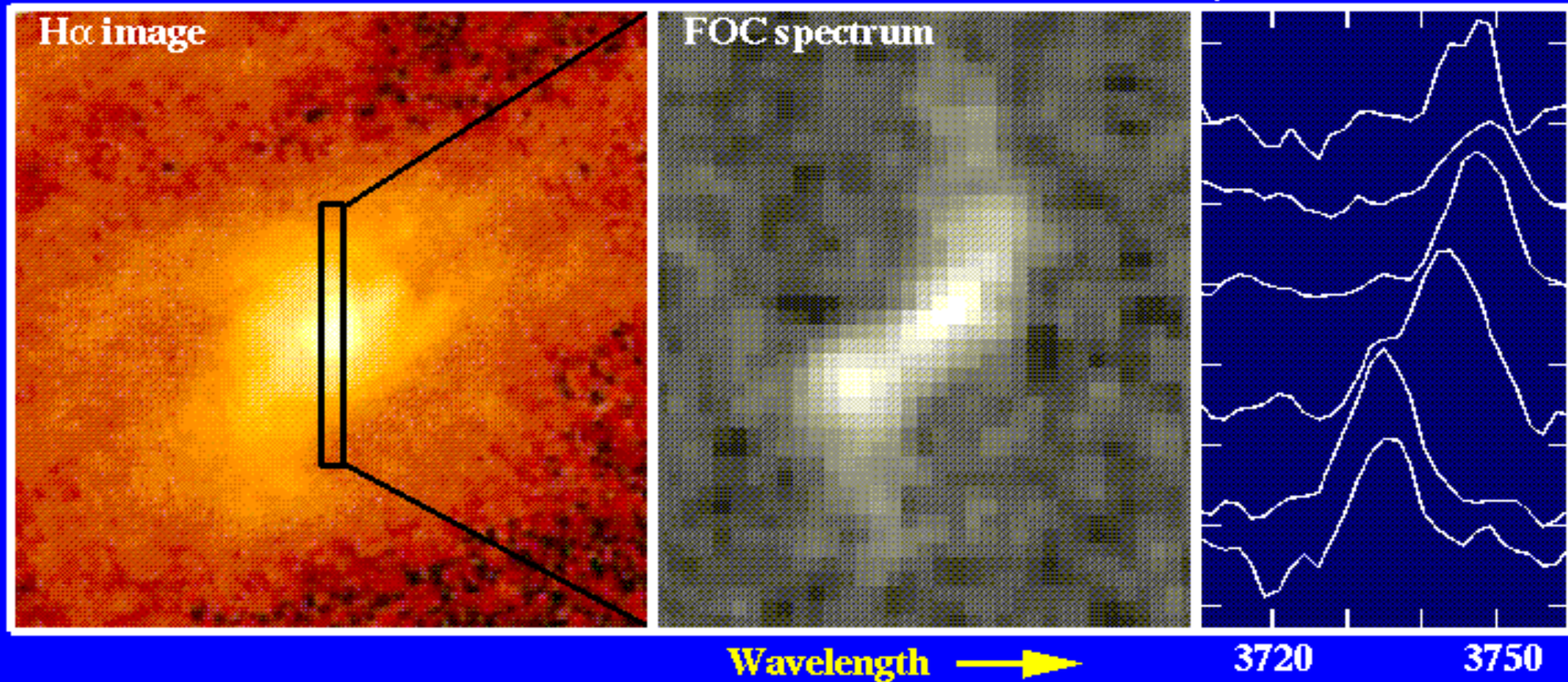
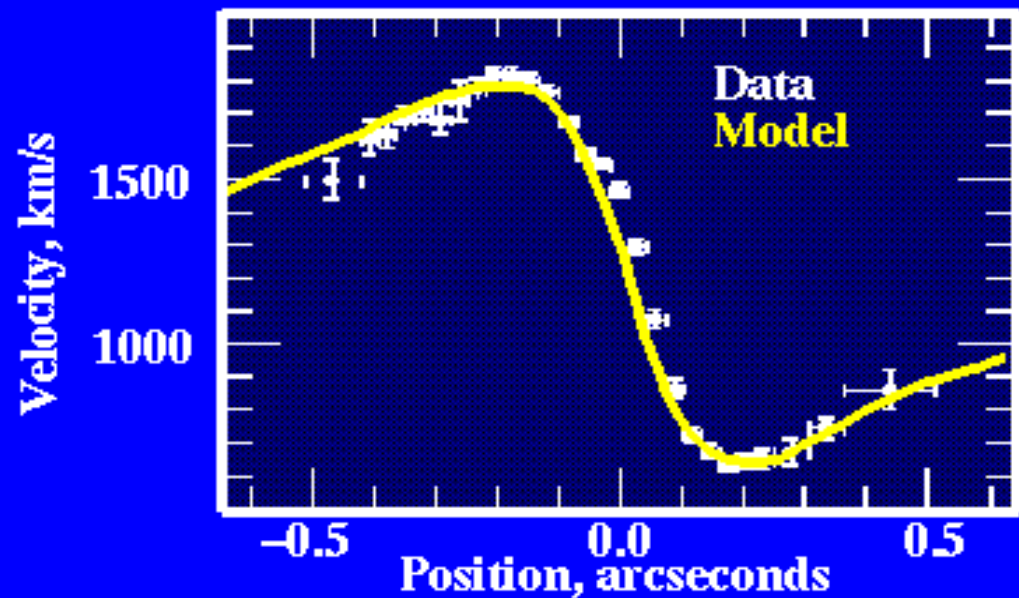


M87 - optikai jet

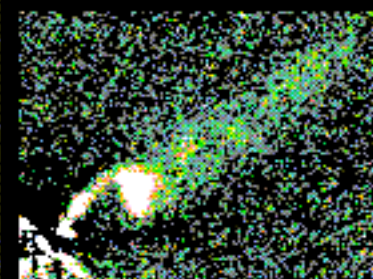
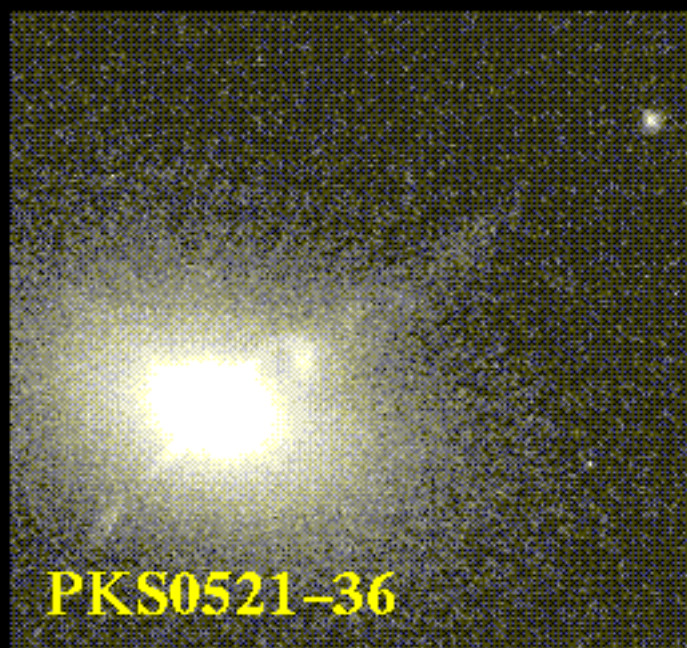
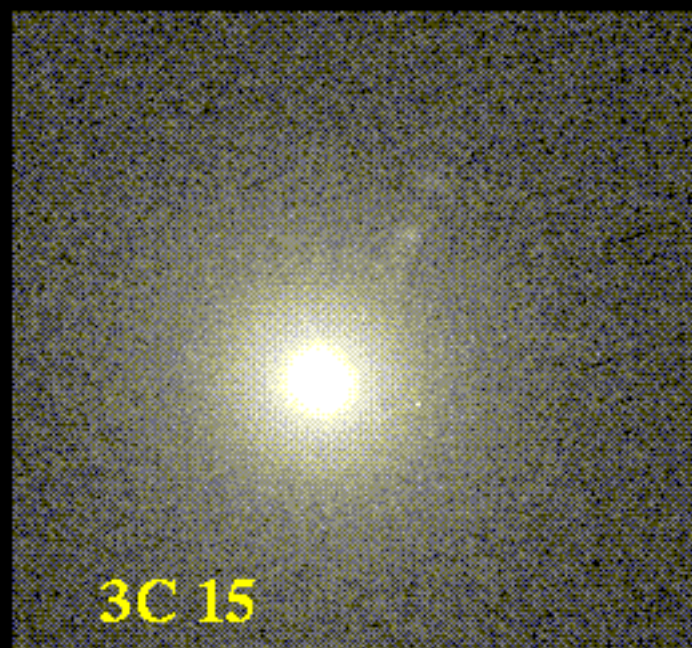
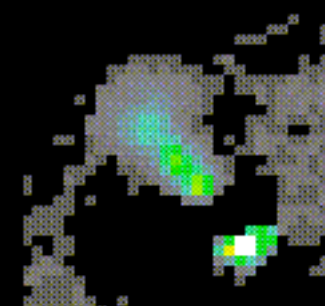
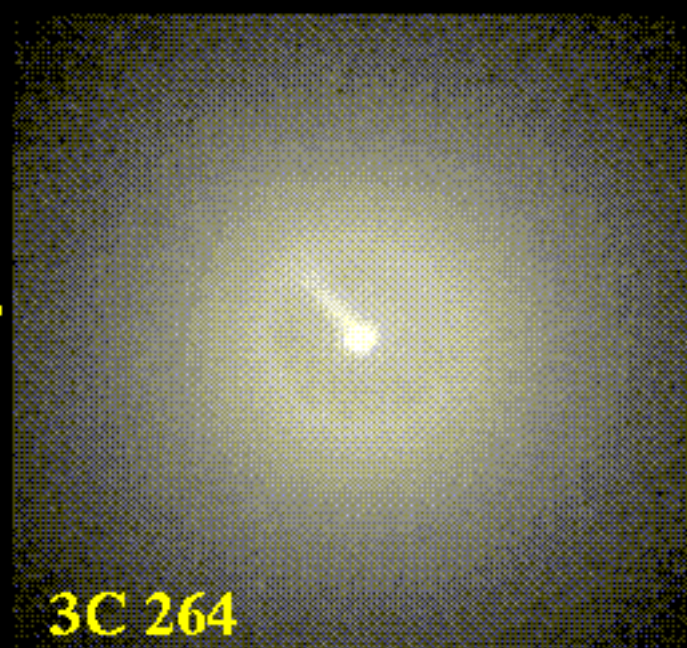


Velocity Profiles in the M87 Core

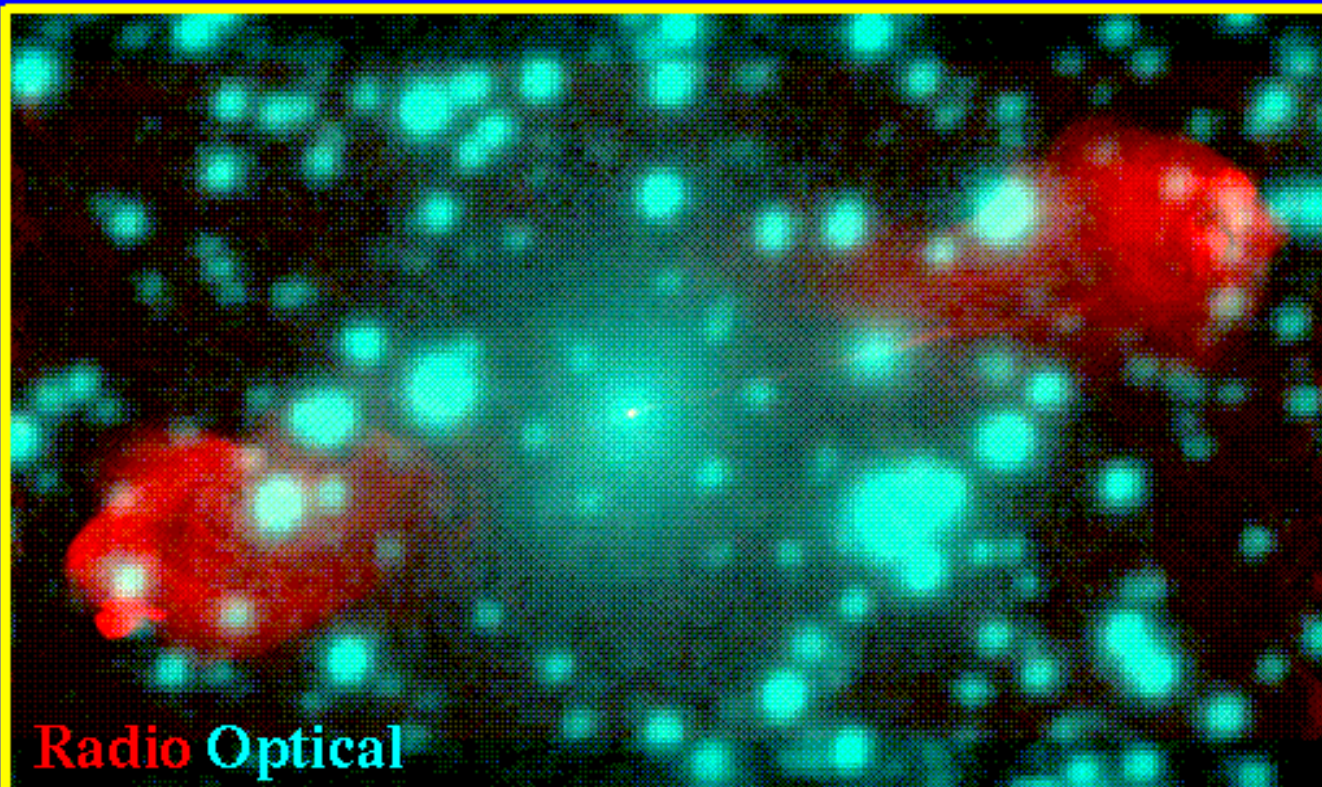
Model: central mass 3.2×10^9 solar masses



OPTICAL JETS IN RADIO GALAXIES

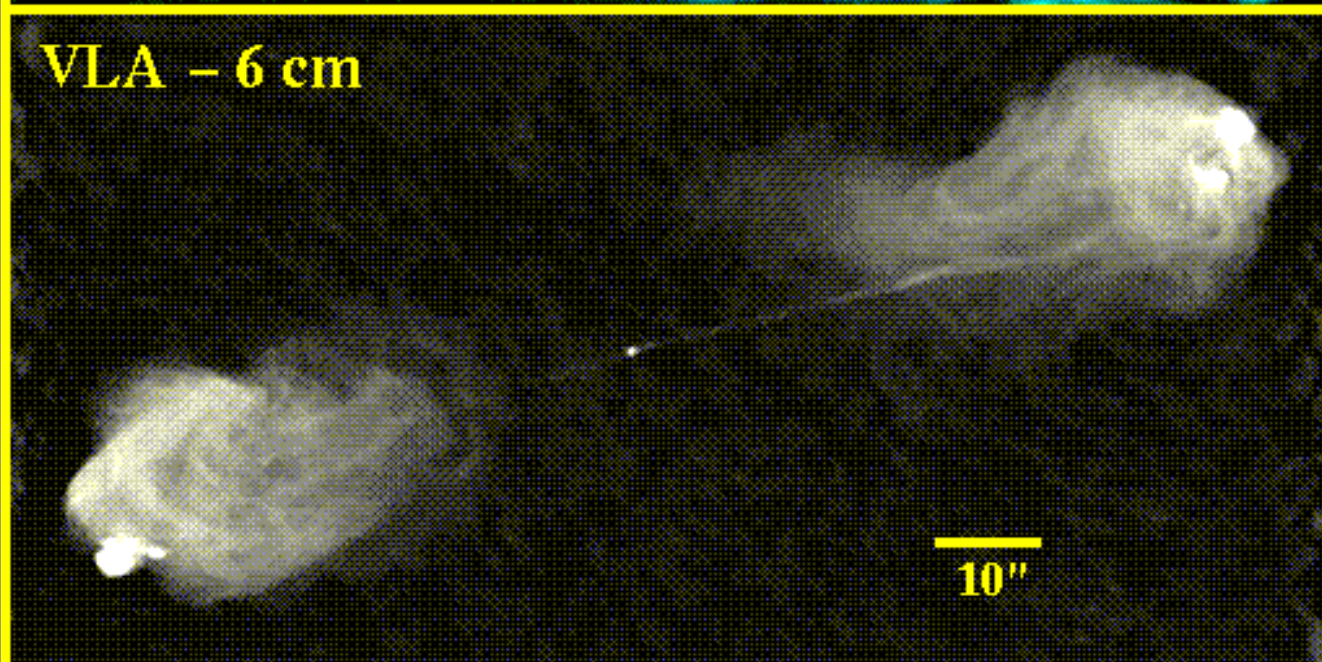


Cygnus A (3C 405)

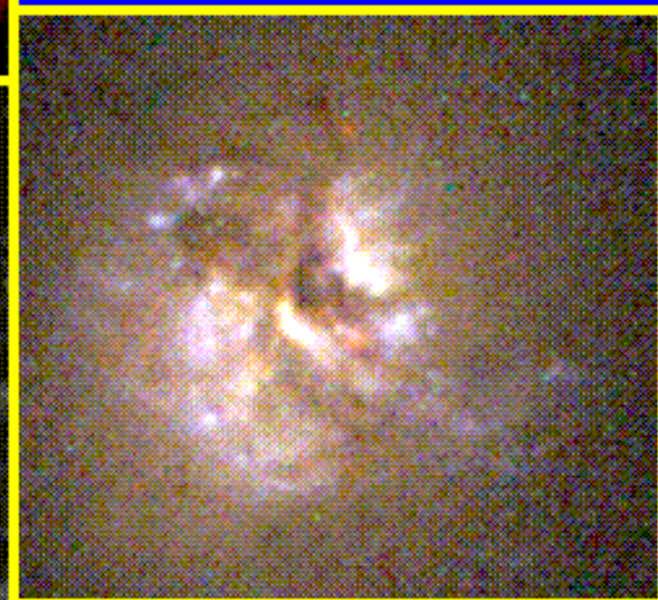


Radio Optical

VLA - 6 cm

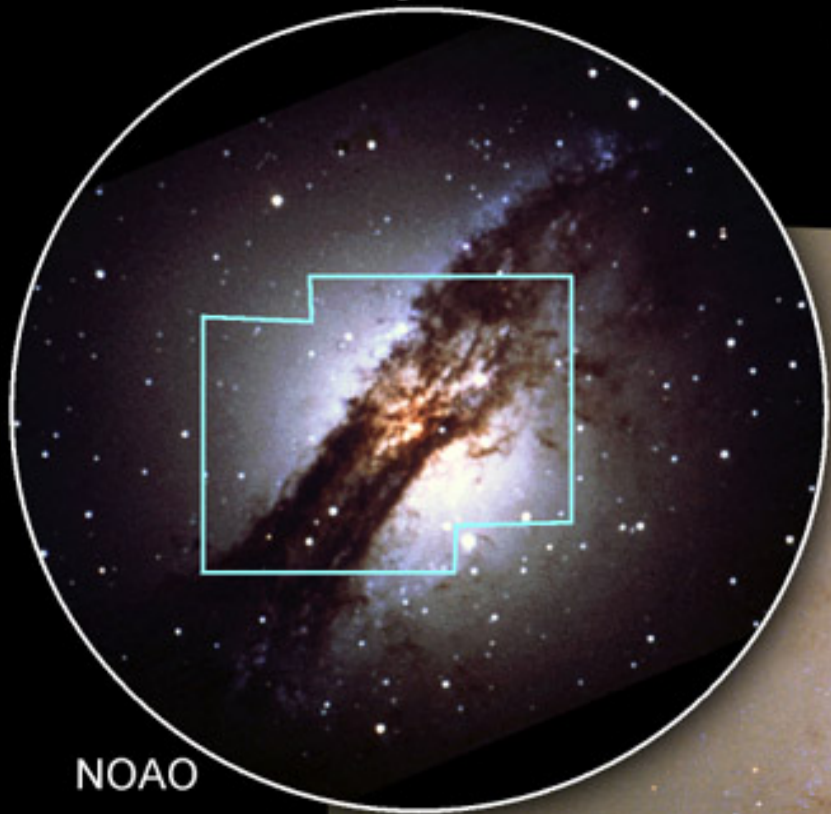


10"

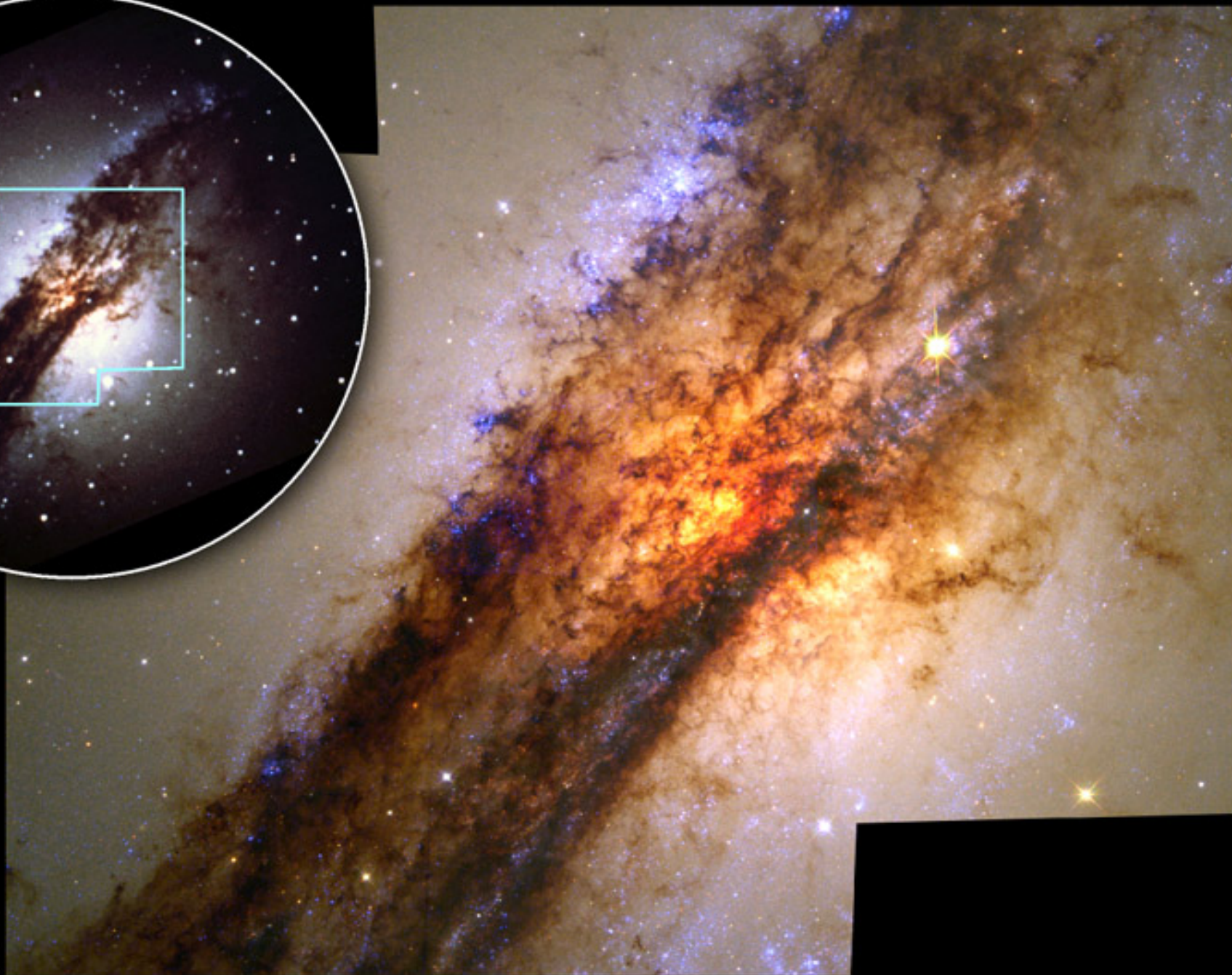


5"

Active Galaxy Centaurus A

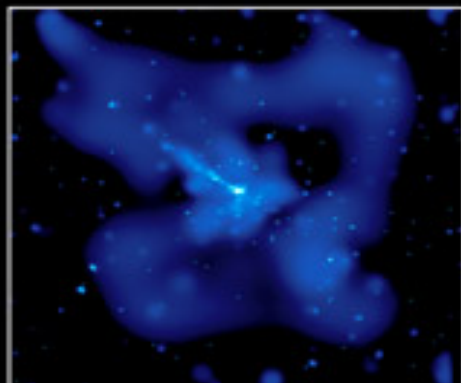
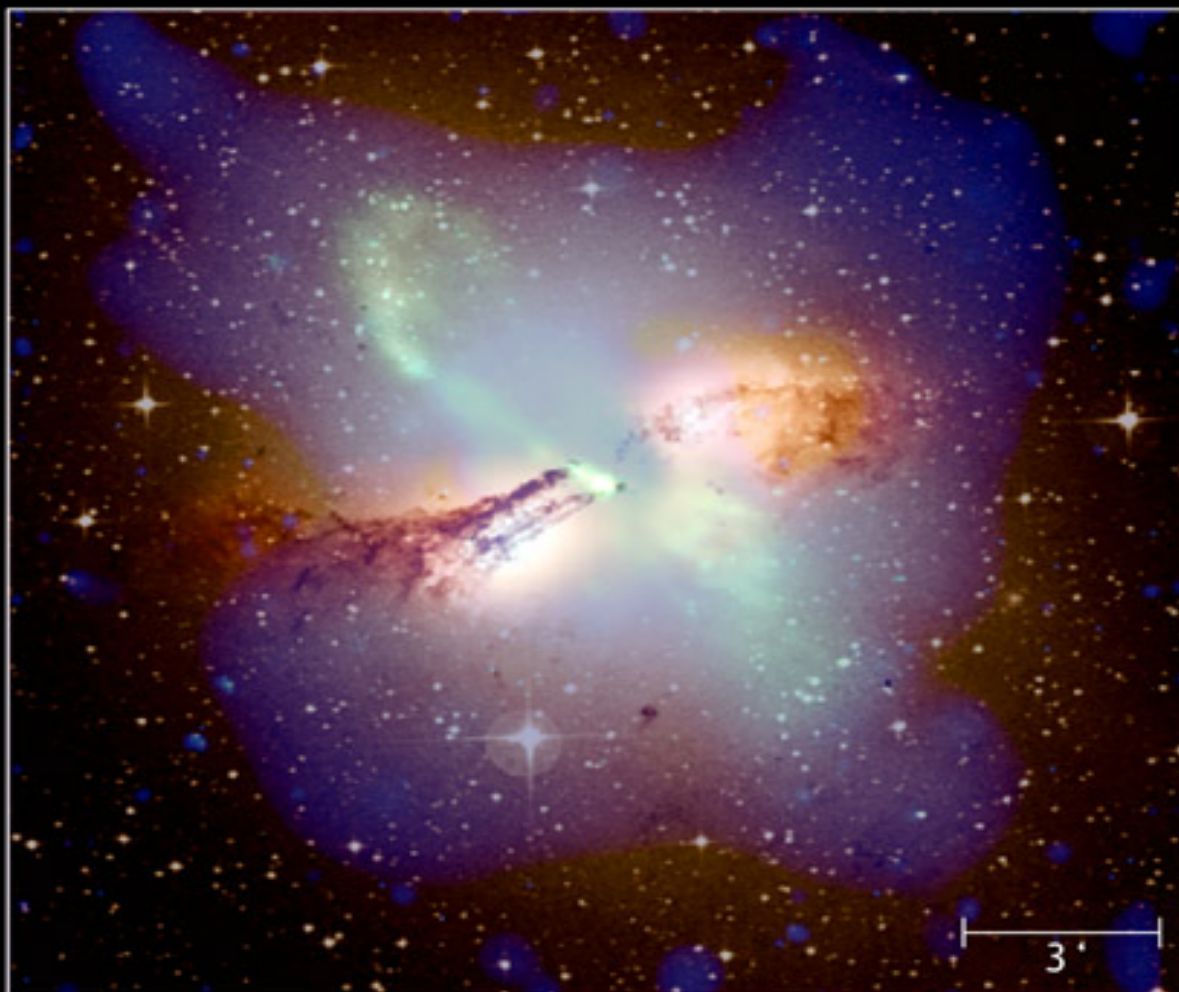


NOAO

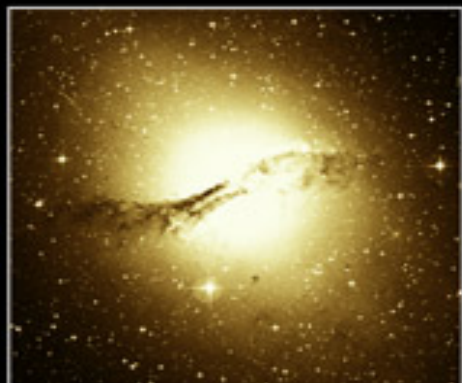


HST
WFPC2

PRC98-14a • ST ScI OPO • May 14, 1998 • E. Schreier (ST ScI) and NASA



CHANDRA X-RAY



DSS OPTICAL



NRAO RADIO
CONTINUUM



NRAO RADIO
(21-CM)

Kvazárok

első felfedezés: 3C273 (Sandage & Smith, 1969)

fényes csillagszerű mag

nagyon nagy vöröseltolódás

$L \sim 10^{45} - 10^{48} \text{ erg/s}$

(kb. $10^5 L_{\text{Tejútrsz}}$)

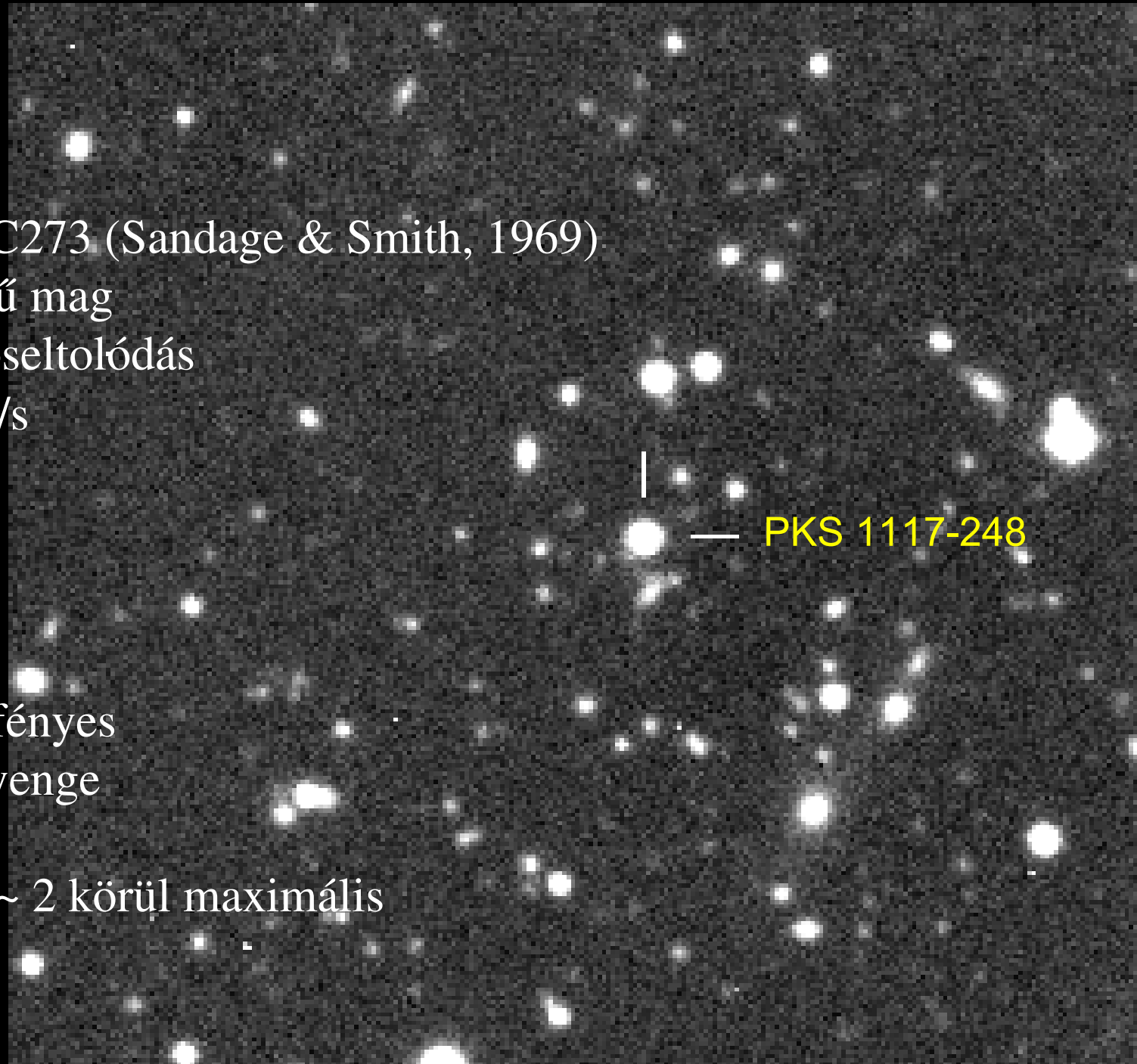
erős UV-többség

2 altípus:

quasar: rádió-fényes

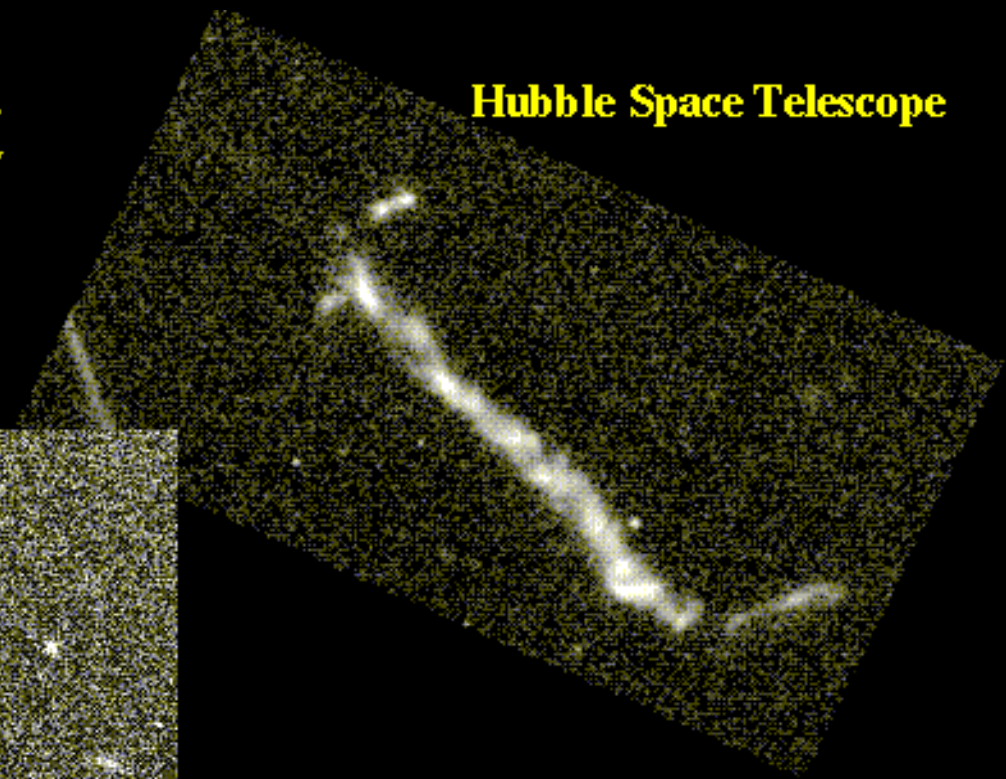
QSO: rádió-gyenge

térbeli sűrűség: $z \sim 2$ körül maximális

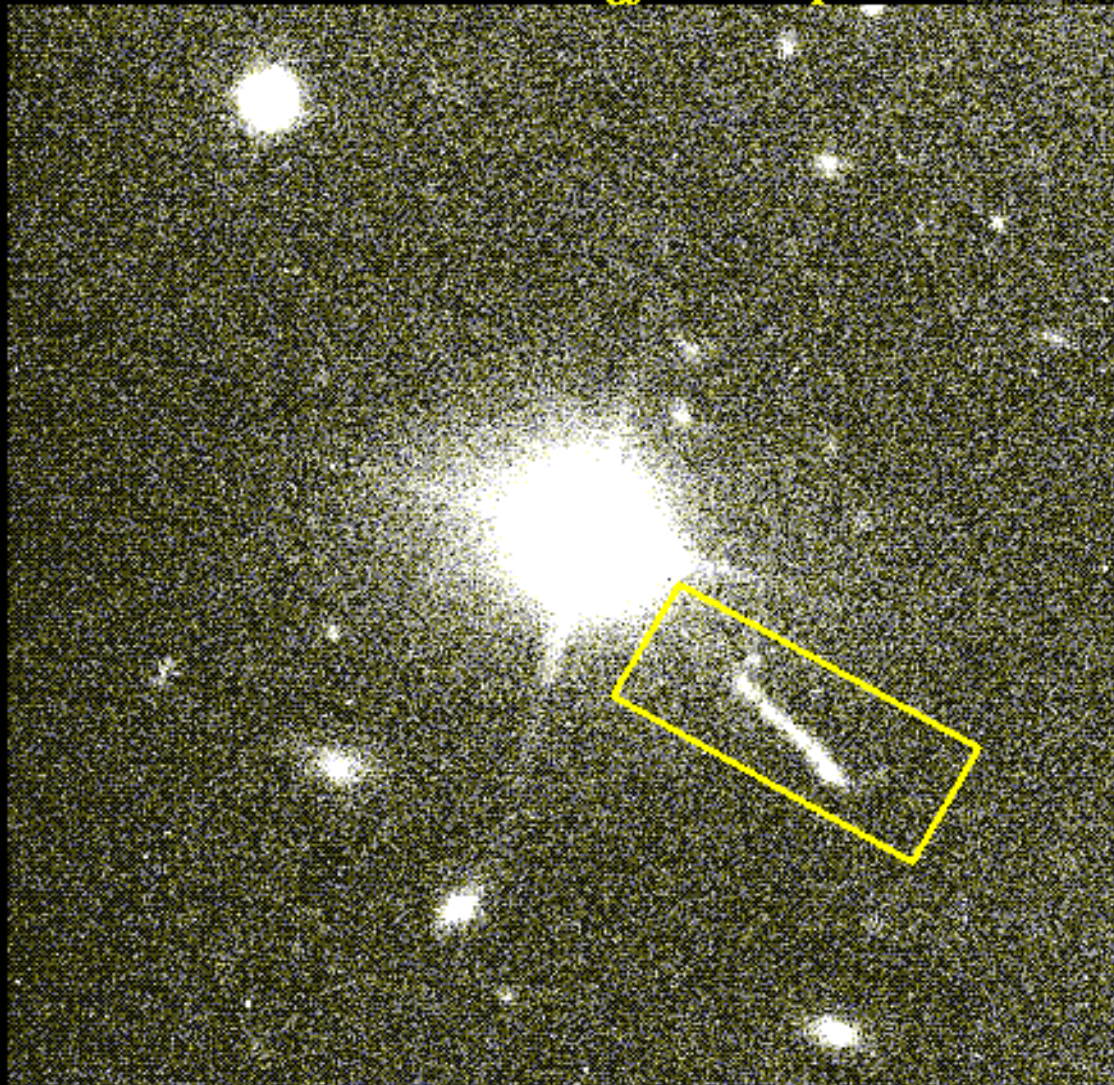


3C 273 and its Jet

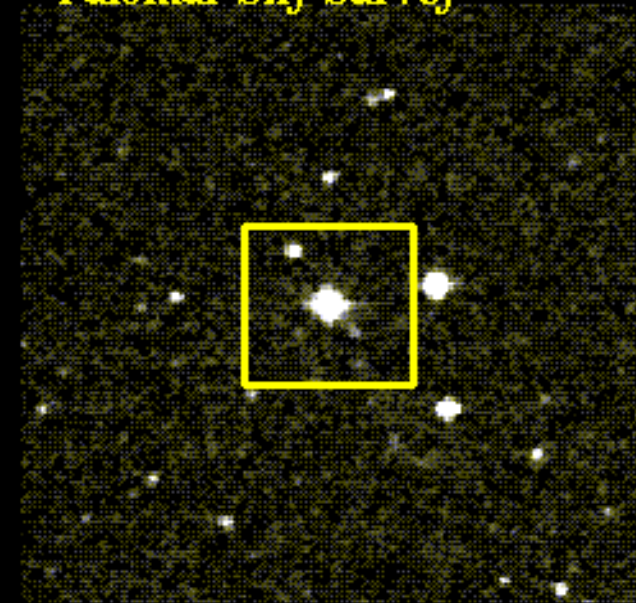
Hubble Space Telescope



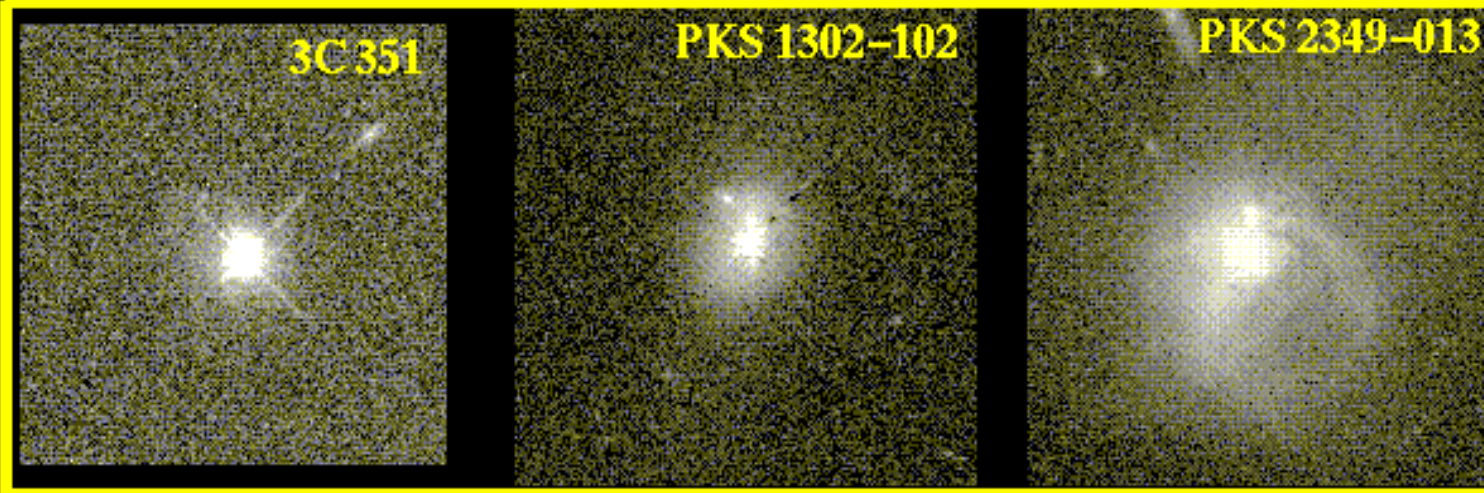
ESO New Technology Telescope



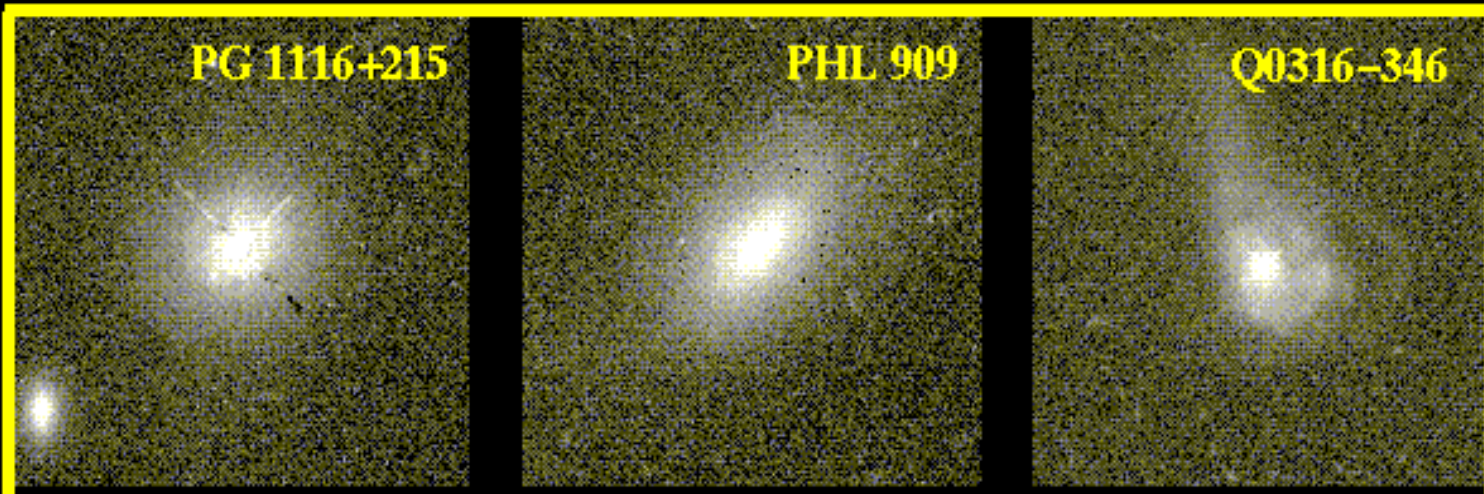
Palomar Sky Survey



Radio-loud



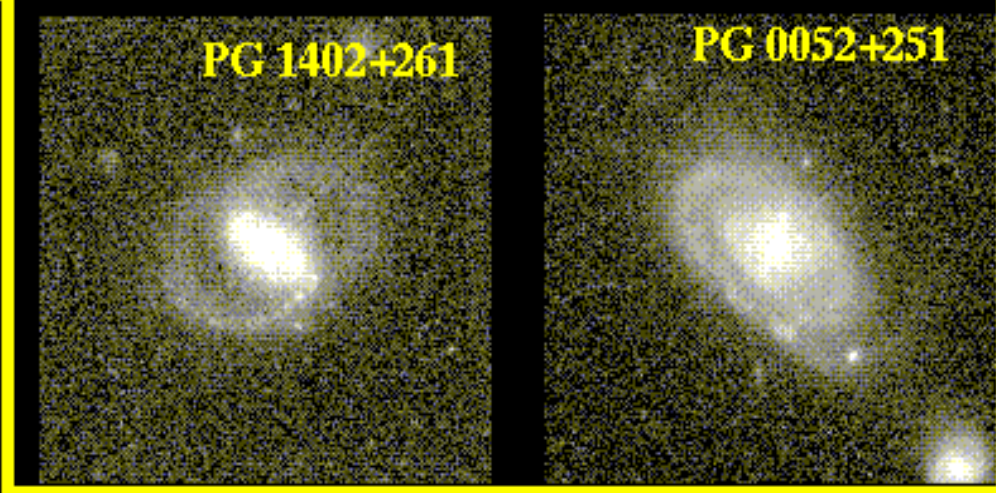
Radio-quiet



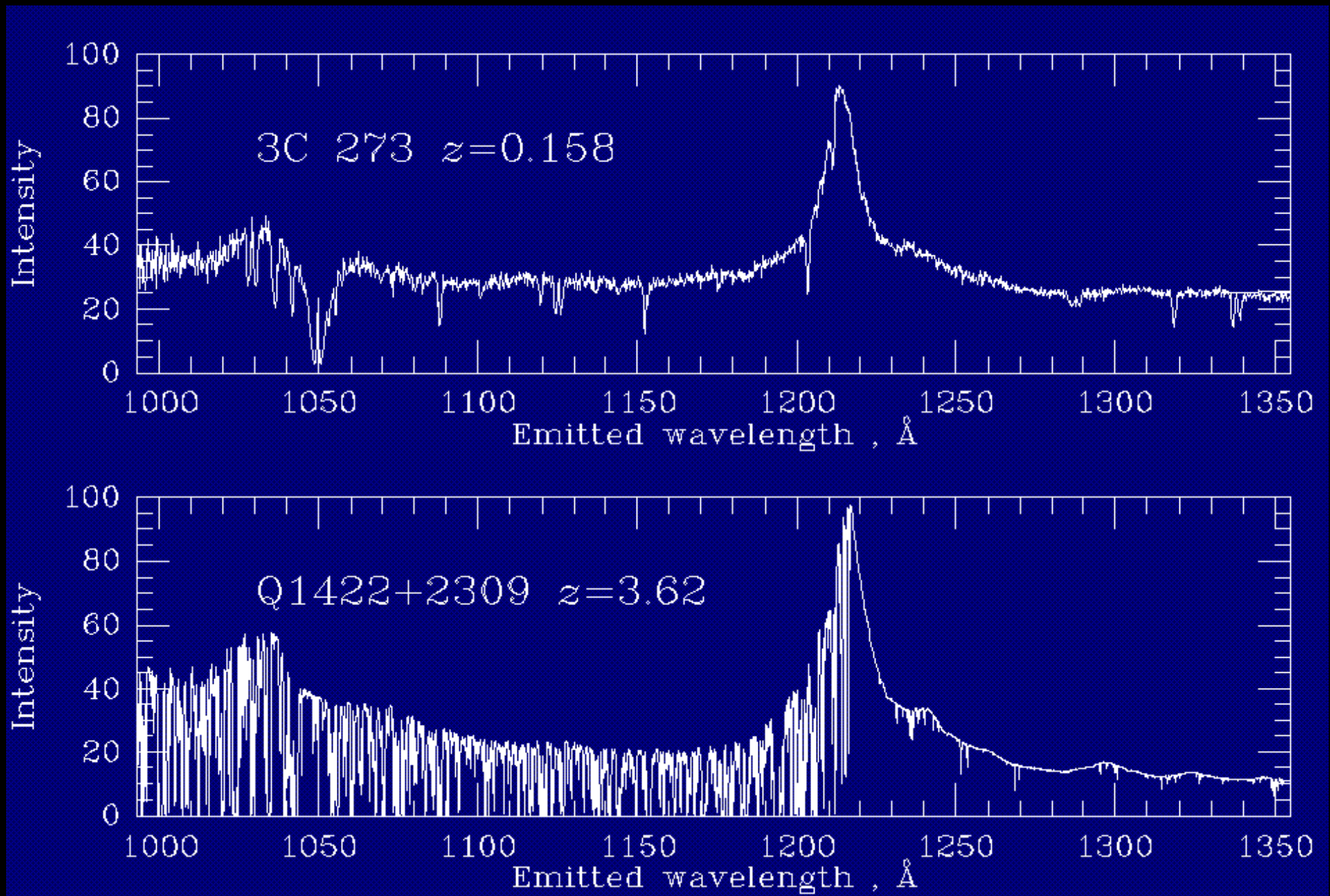
QSO Host Galaxies

HST images

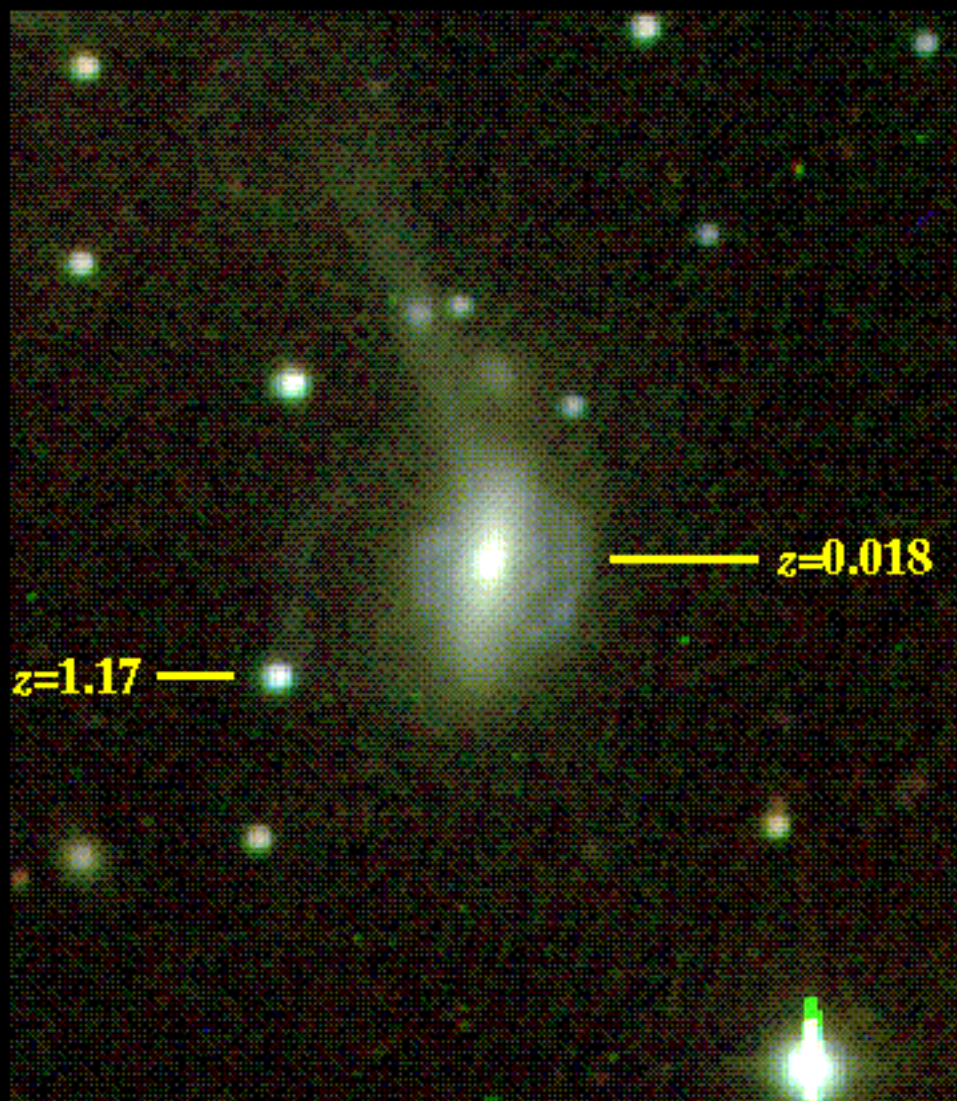
10"



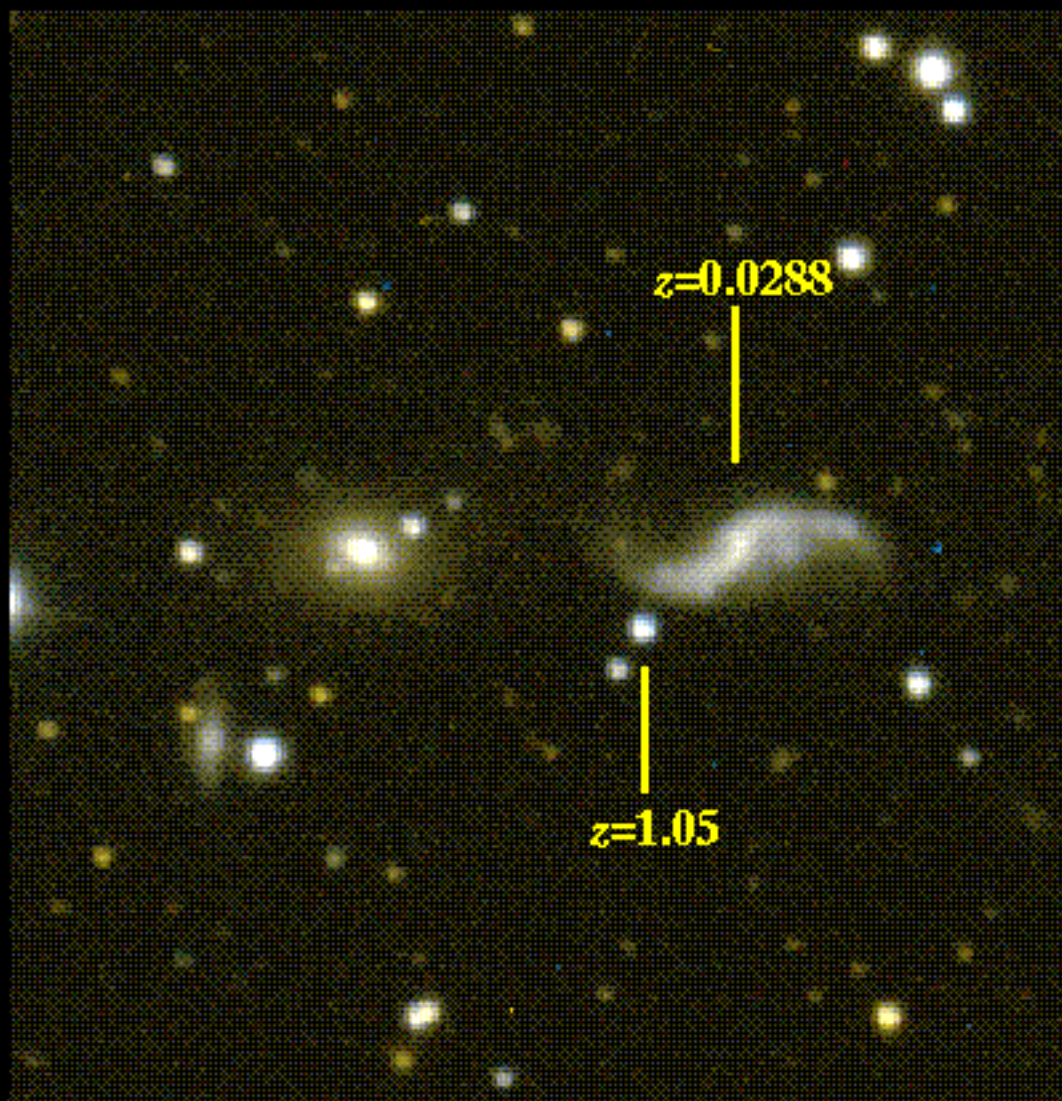
Lyman-alfa erdő



ANOMALOUS QUASAR-GALAXY ASSOCIATIONS

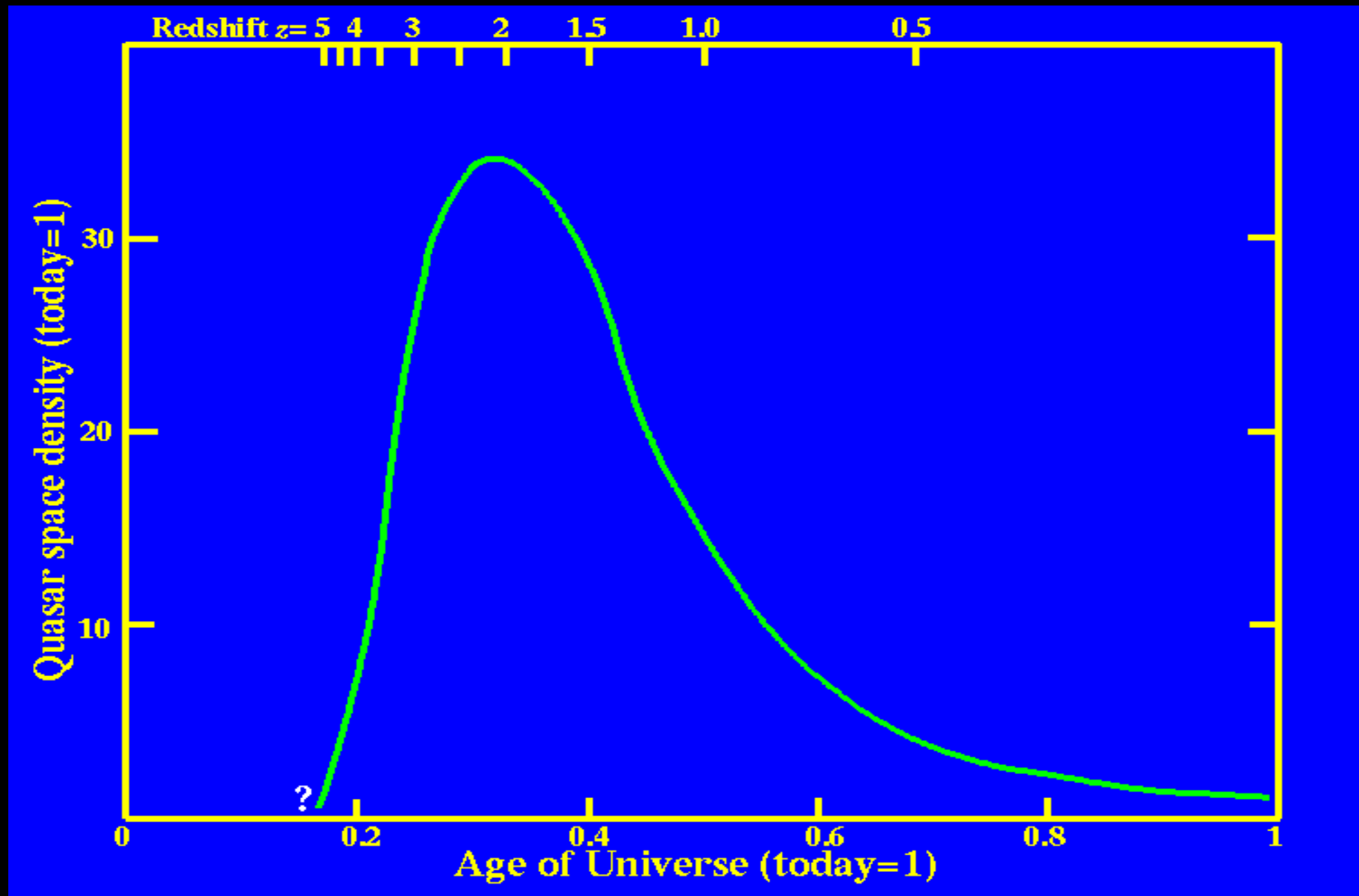


ESO 1327-206/PKS1327-206



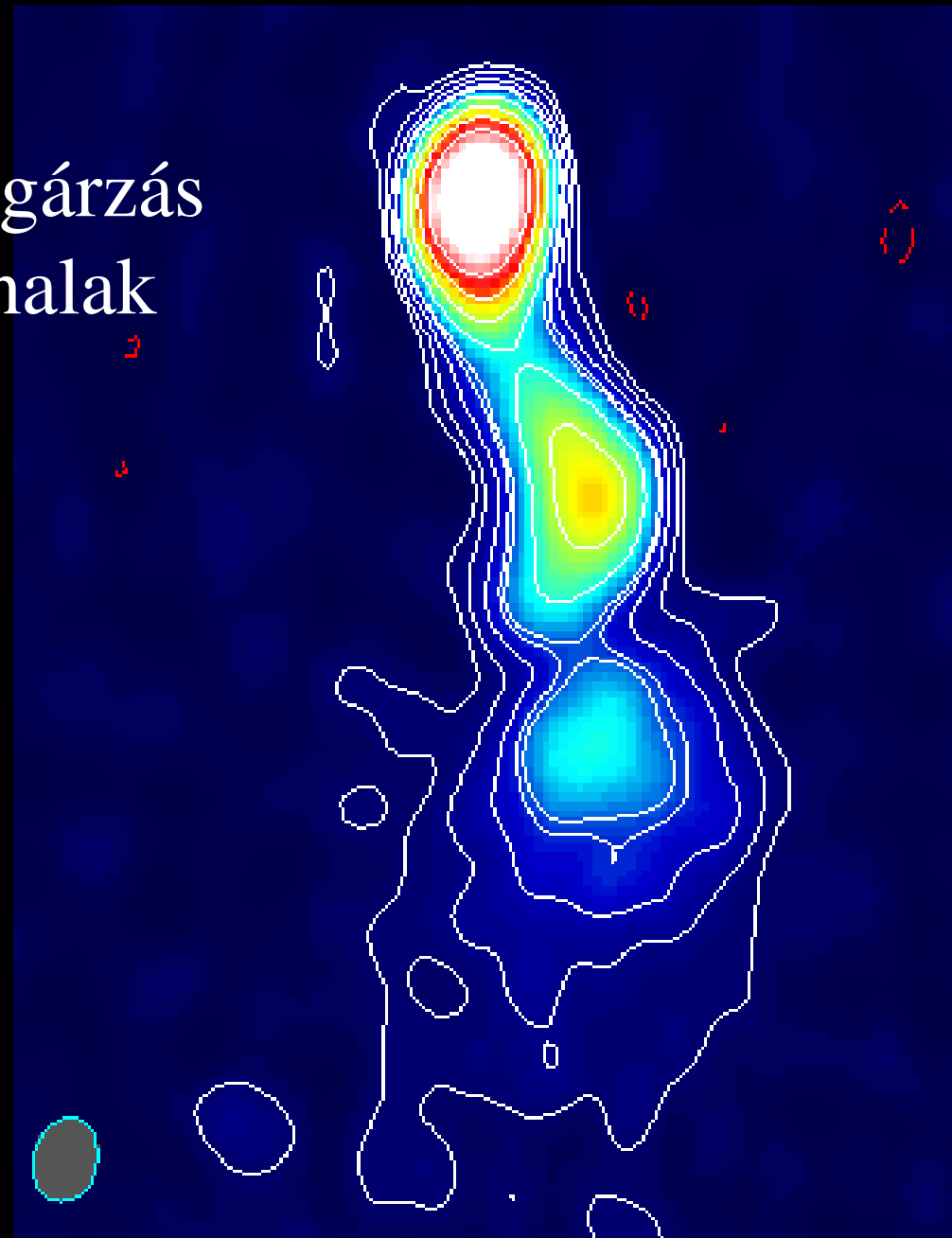
Klemola 31AB/PKS 2020-370

Kvazárok evolúciója



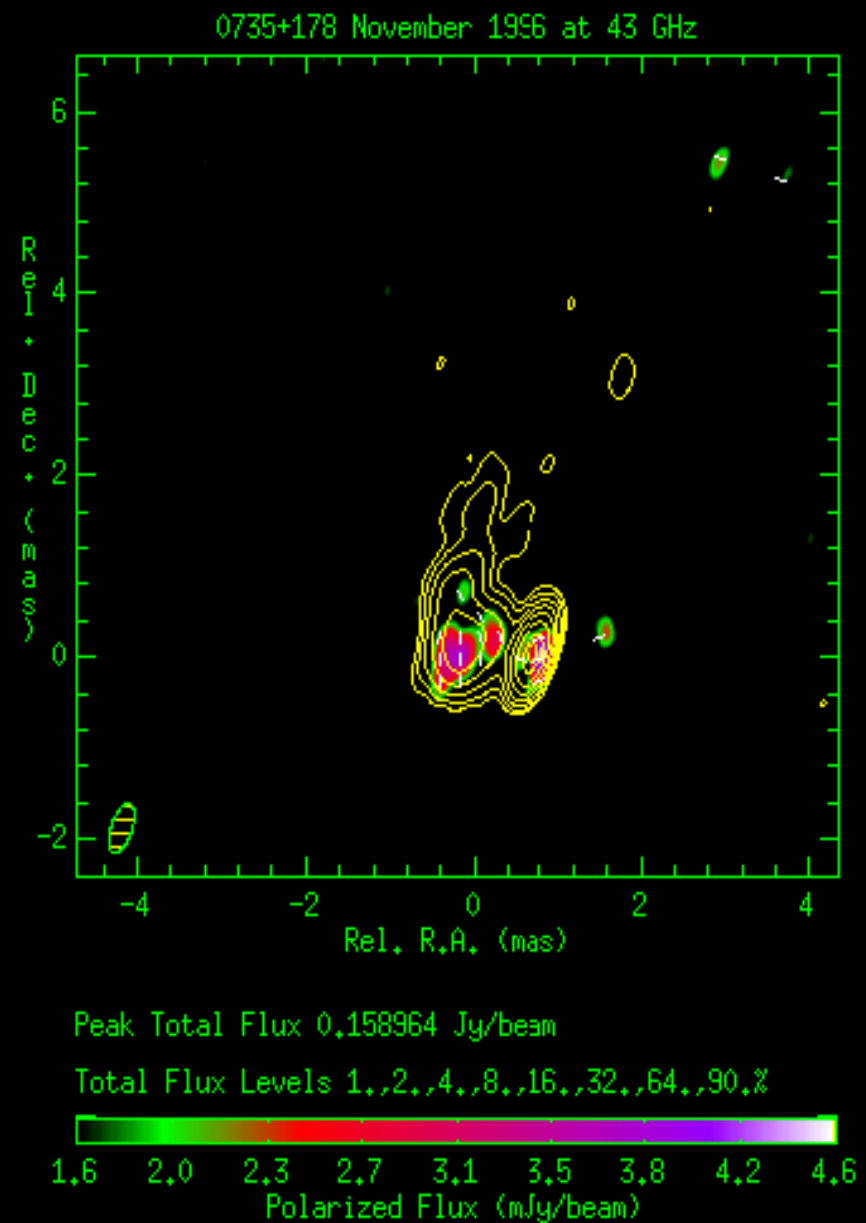
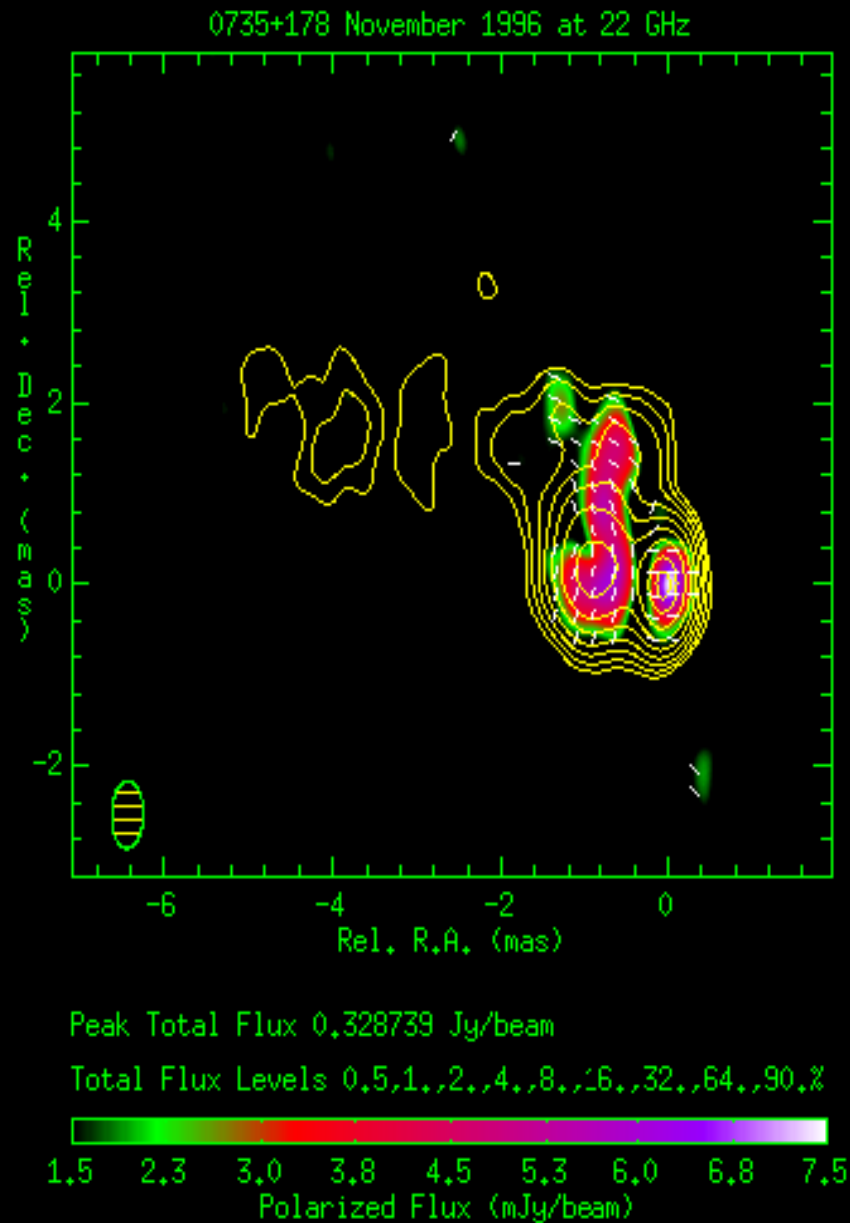
Blazárok (BL Lac-objektumok)

erősen változó, polarizált sugárzás
csak kontinuum, gyenge vonalak
90 %-uk elliptikus gx mag



BL Lac VLBI-rádiótérképe

Blazárok (BL Lac-objektumok)



Időbeli változás

AGN méretére ad becslést

A megfigyelt változás időskálája Δt , az idődilatáció miatt a valódi változás időskálája:

$$\Delta \tau = \Delta t \sqrt{1 - v^2/c^2} = \Delta t \sqrt{1 - z^2}$$

Ebből az objektum kauzális mérete:

$$R = c \Delta \tau = c \Delta t \sqrt{1 - z^2}$$

Példa: $\Delta t = 1$ óra $\implies R = 7$ AU

Luminozitás: a minimális tömeget lehet becsülni

$$L < L_E = 1.5 \cdot 10^{38} M/M_o \quad \text{kell, hogy legyen!}$$

Példa: $L \sim 5 \cdot 10^{46}$ erg/s $\implies M > 3 \cdot 10^8 M_o$
tehát egy AGN biztosan fekete lyuk!!

Egy 7 AU méretű fekete lyuk tömege:

$$M = \frac{c^2}{2G} R \approx 4 \cdot 10^8 M_o$$

Akkréciós korong

a sugárzás forrása: akkr.korong a szupermasszív
fekete lyuk körül

akkréciós luminozitás: a felszabaduló grav.energia

$$L_a = \frac{1}{2} \frac{G M \dot{M}}{R}$$

$$R = \frac{2 G M}{c^2} \rightarrow L_a = \frac{1}{4} \dot{M} c^2 = \eta \dot{M} c^2$$

Forgó BH : $\eta \sim 0.5$ lehet $\implies R = G M / c^2$
(Kerr-lyuk)

Akkreció korong hőmérséklete

$$dL_a = \frac{dE}{dt} = \frac{dE}{dr} \frac{dr}{dt} = \frac{d}{dr} \left(\frac{-GMm}{2r} \right) \frac{dr}{dt} = \frac{GM\dot{M}}{2r^2} dr$$

$$dL_a = A\sigma T^4 = \frac{GM\dot{M}}{2r^2} dr$$

$$2(2\pi r dr)\sigma T^4 = \frac{GM\dot{M}}{2r^2} dr$$

Ebből:

$$T = \left(\frac{GM\dot{M}}{8\pi\sigma r^3} \right)^{1/4}$$

Az eseményhorizontnál:

$$T_{max} = \left(\frac{c^6 \dot{M}}{8\pi\sigma G^2 M^2} \right)^{1/4}$$

Ha $L =$ Eddington-fényesség, akkor:

$$L = \eta \dot{M} c^2 = L_E = \frac{4\pi G c}{\kappa} M$$

Ebből:

$$\dot{M} = \frac{4\pi G M}{\kappa c} \frac{1}{\eta} \rightarrow T_{max} = \left(\frac{c^5}{2\kappa\sigma G M \eta} \right)^{1/4} \sim M^{-1/4}$$

AGN-ek egyesített modellje

Seyfert-2 →

↗
Seyfert-1

jet

keskeny vonalak

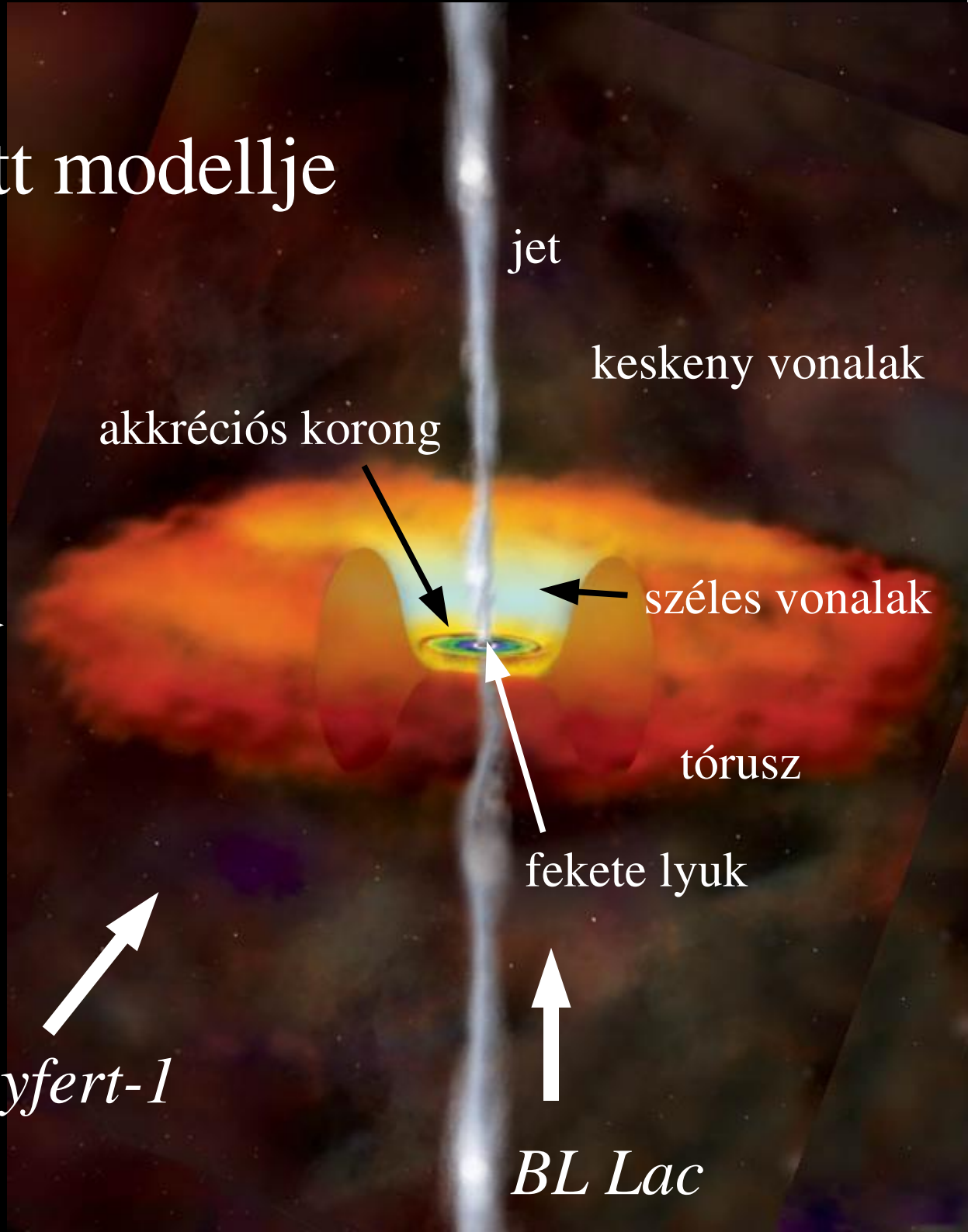
akkréciós korong

← széles vonalak

tórusz

↑ fekete lyuk

↑
BL Lac



Széles vonal tartomány

$$\Delta t = 1 \text{ hónap} \implies R \sim 10^{17} \text{ cm}$$

$$T \sim 10^4 \text{ K} \implies n \sim 10^9 - 10^{10} \text{ cm}^{-3}$$

itt csak megengedett átmenetek lehetnek

$$\text{FWHM} = 5000 \text{ km/s}$$

$$\text{ebből: } M = v^2 R / G \sim 2 \cdot 10^8 \text{ Mo}$$

konzisztens az előző becslésekkel

Keskeny vonal tartomány

$$n \sim 10^4 \text{ cm}^{-3}, T \sim 10^4 \text{ K} : \text{ tipikus H II, PN}$$

itt tiltott átmenetek is létrejöhetnek