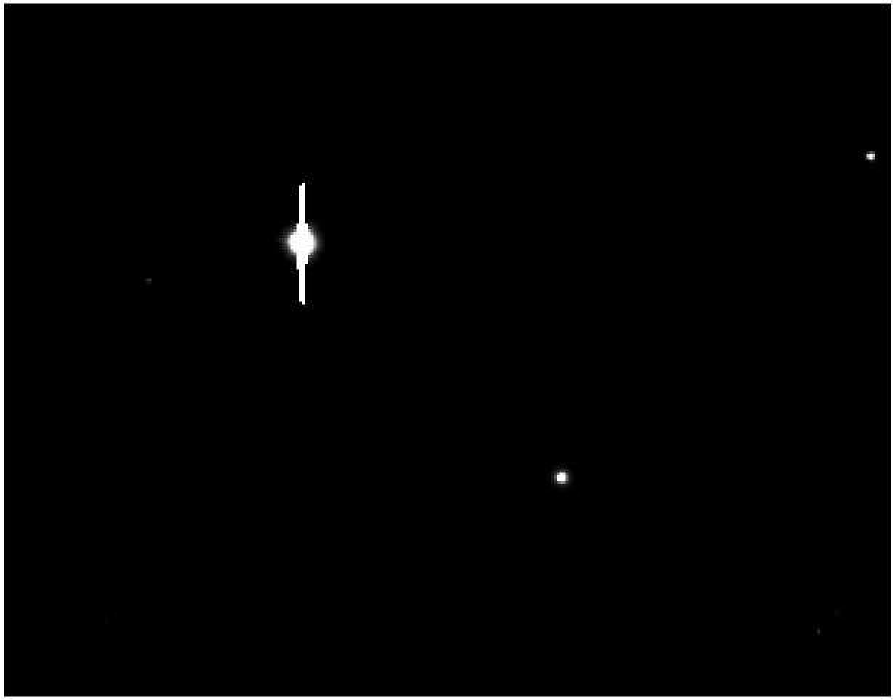
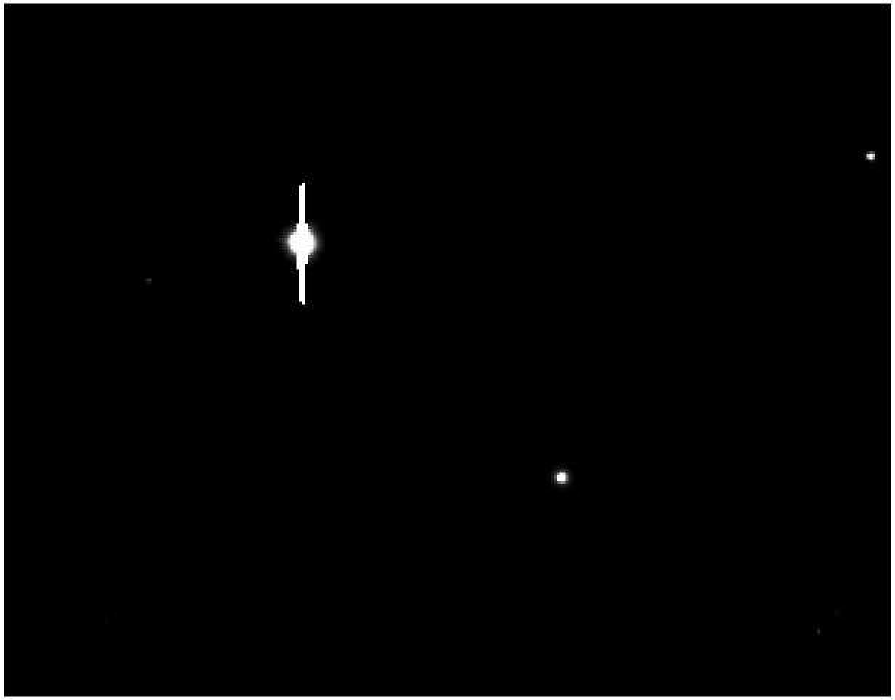
Broad-Band Spectra

Active Galaxies, I

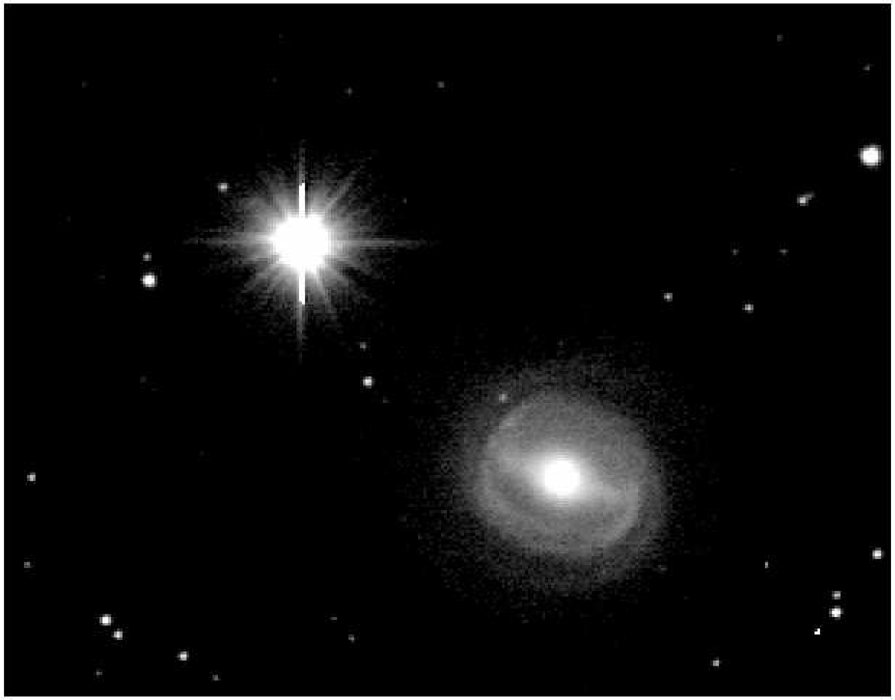


NGC 3783: *linear* intensity scale

Active Galaxies, II

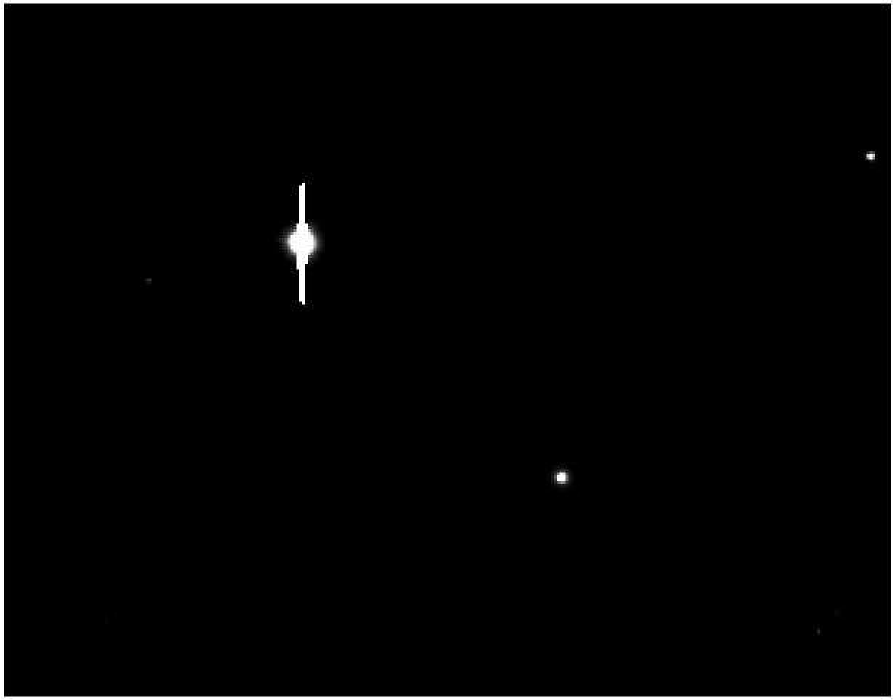


NGC 3783: *linear* intensity scale

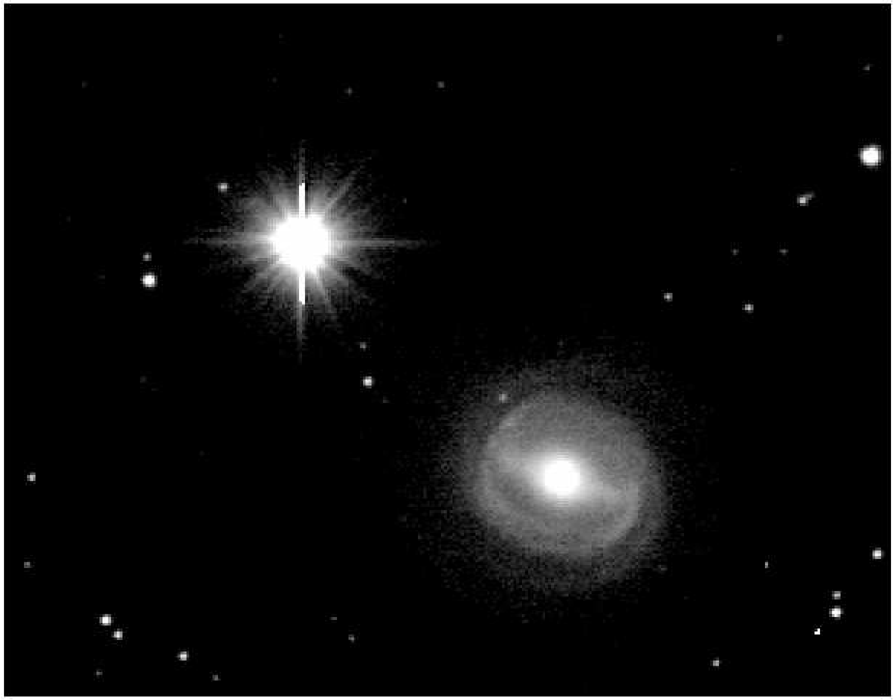


logarithmic intensity scale

Active Galaxies, III



NGC 3783: *linear* intensity scale

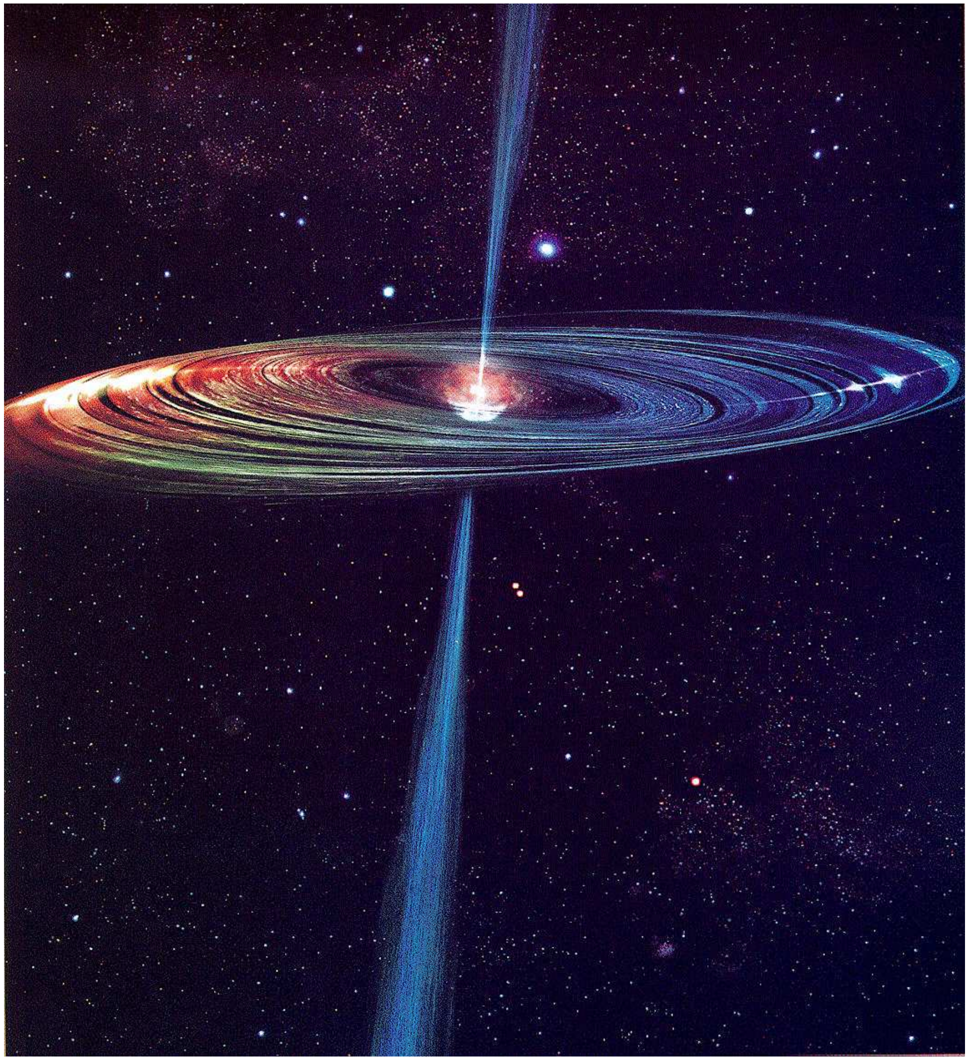


logarithmic intensity scale

Active Galactic Nuclei (AGN): supermassive black holes ($M \sim 10^{6...8}\,M_\odot$), accreting $1\ldots2\,M_\odot/\mathrm{year}$

$\Longrightarrow$ Luminosity $\sim 10^{10}\,L_\odot$ (comparable to galaxy luminosity)

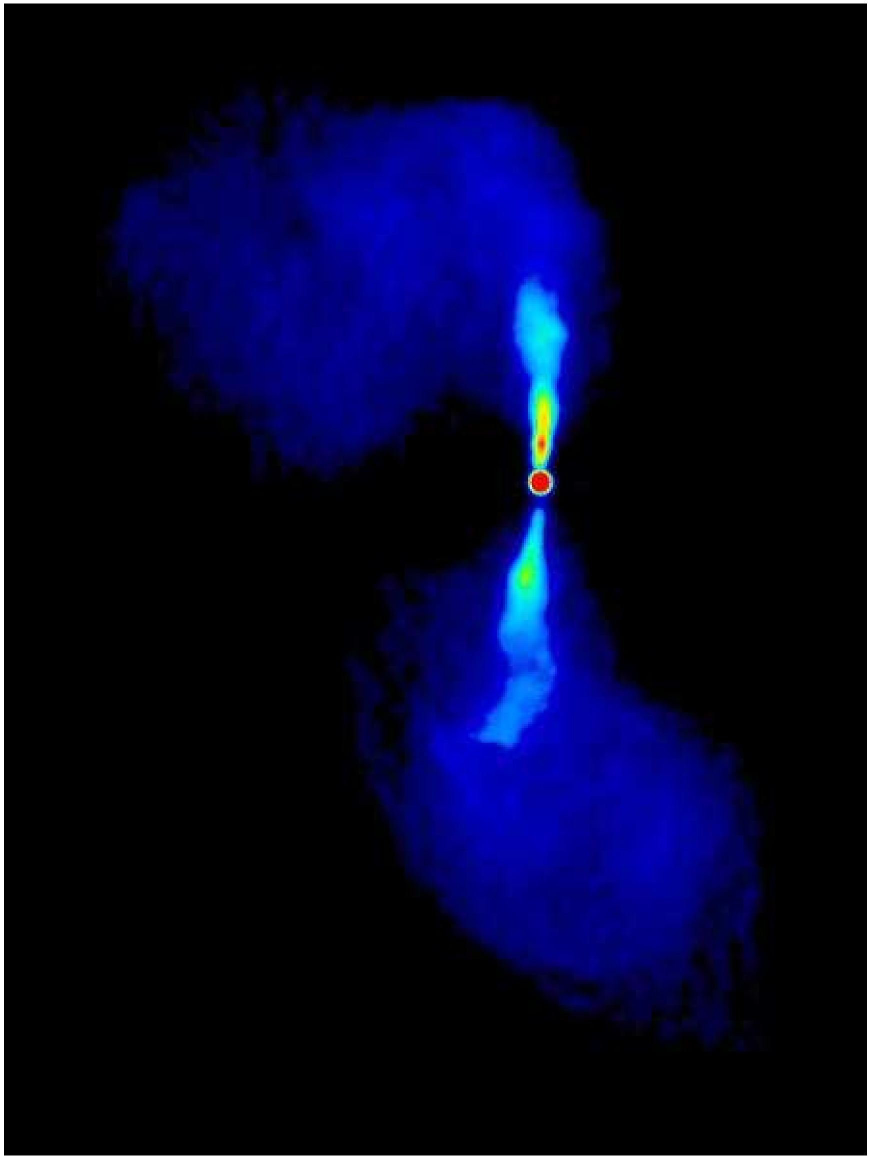
Active Galaxies, IV



Structure of Active Galactic Nuclei (AGN):

- supermassive black hole ($10^7\,M_\odot$)
- accretion disk ($\dot{M} \sim 1 \ldots 2\,M_\odot\,\mathrm{yr}^{-1}$)
- large luminosity ($L \sim 10^{10}\,L_\odot$)
- Schwarzschild radius $2GM/c^2 \sim 1$ AU

Active Galaxies, V



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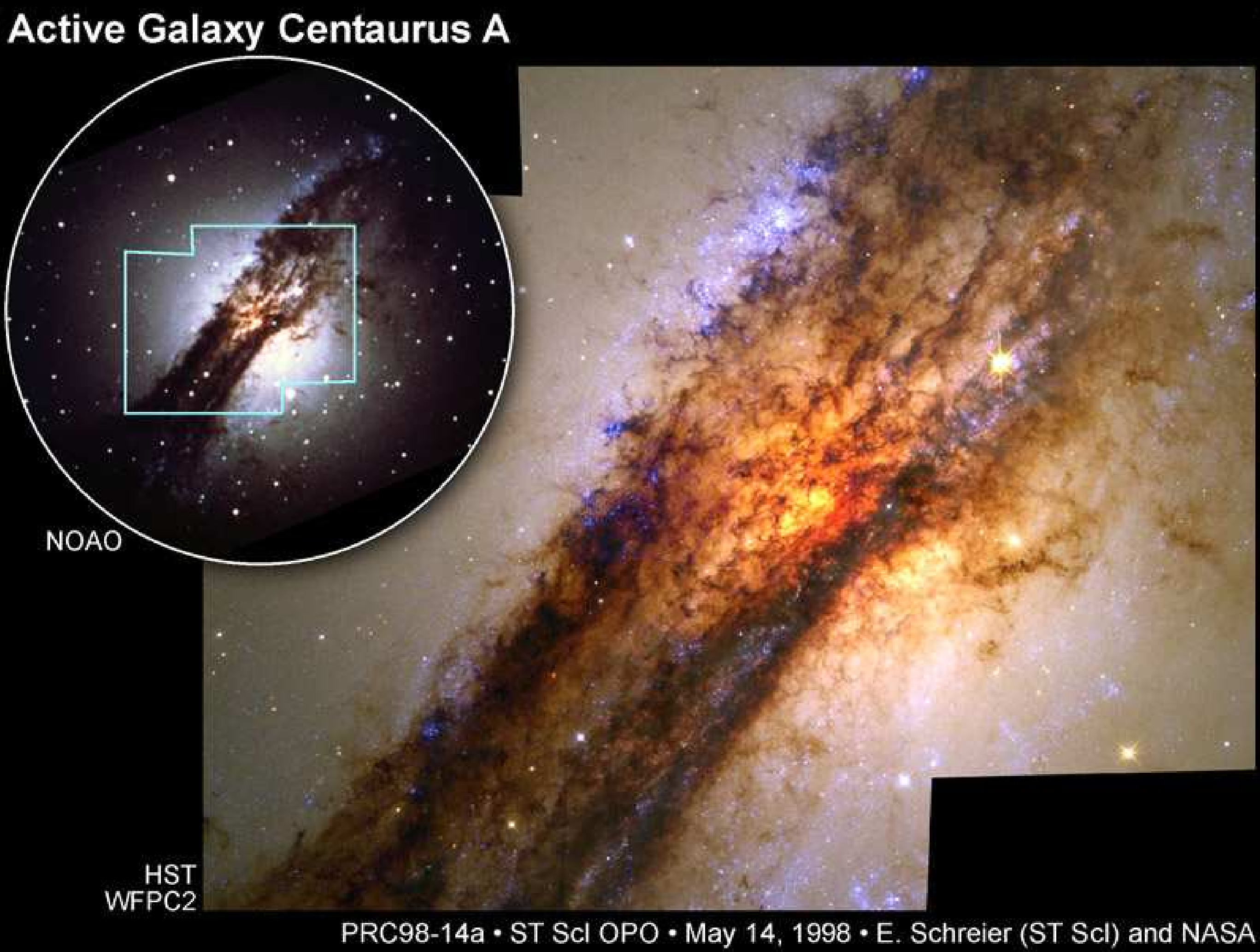
- Schwarzschild radius $2GM/c^2 \sim 1$ AU
- often relativistic jets, where material is accelerated to the speed of light

AGN *with* jets: quasars, blazars...

AGN *without* jets: Seyfert galaxies

Placeholder for accretion writeup



In the following as an example:

Centaurus A (NGC 5128)

- one of the brightest radio sources in the sky
- distance: 11 million light years
- giant elliptical galaxy (more properly: S0), merged with spiral galaxy about 100 million years ago, remnant of the spiral seen as dust lane.

AGN are exceptionally good examples for the importance of multi-wavelength astronomy.

Centaurus A

Cen A: VLT Kueyen+FORS2, courtesy ESO

Optical:

Thermal emission from stars and gas, i.e., bremsstrahlung (free-free radiation), line emission, dust scattering,. . .)

Centaurus A

2MASS, courtesy IPAC, Univ. Massachusetts

Near Infrared:

Thermal emission, mainly from stars, similar to optical, but dust less apparent

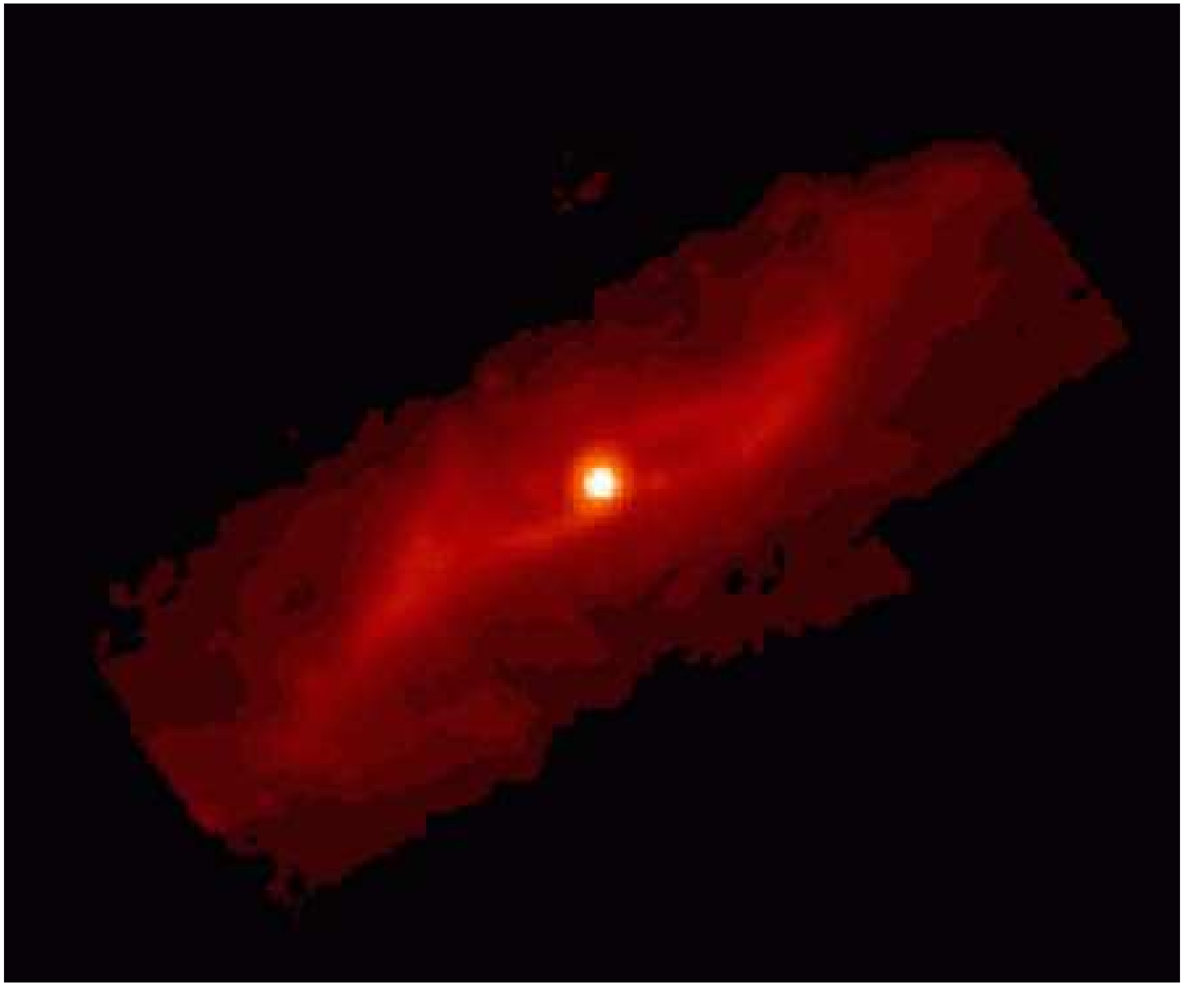
$\Longrightarrow$ *Opacity* of dust in IR is smaller.

Centaurus A

Spitzer Space Telescope, courtesy Caltech/NASA

Mid Infrared (3.6–8 μm): Thermal emission from dust starts to dominate, contribution of thermal emission from stars still significant.

Centaurus A



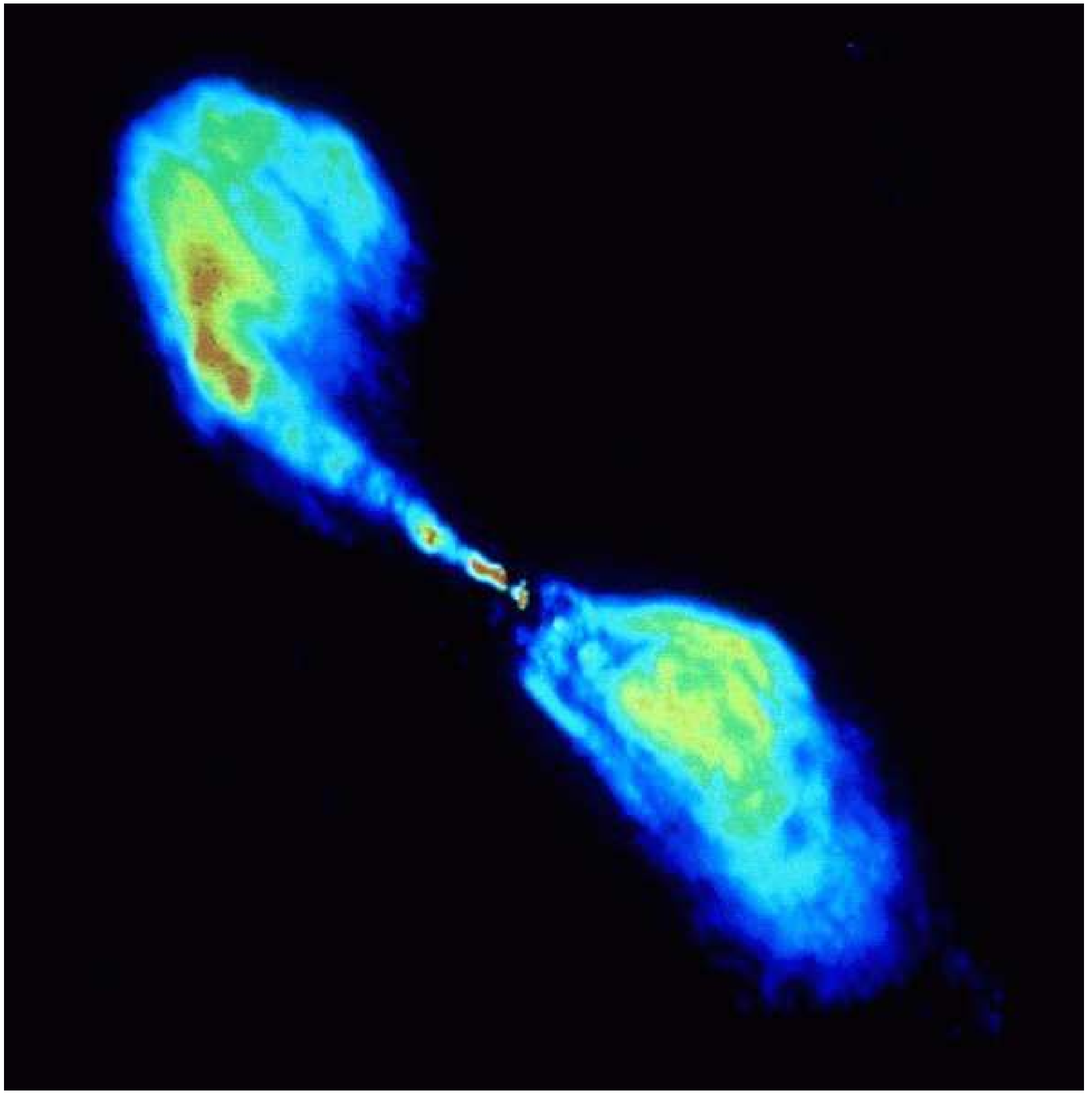
ISO, courtesy ESA-ESTEC

Far Infrared (7 μm):

Thermal emission from dust

Resolution of this image is worse than the previous Spitzer telescope image.

Centaurus A

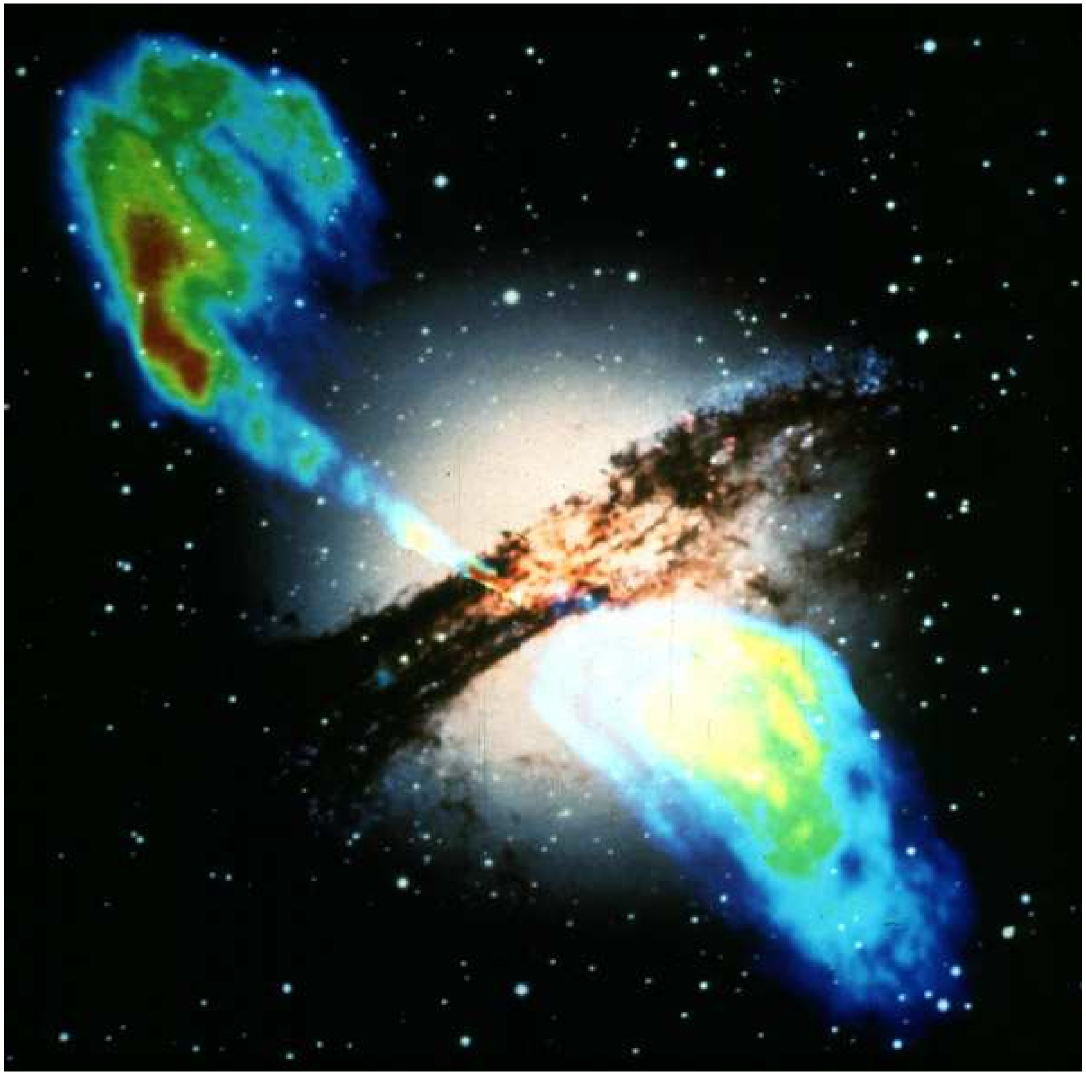


VLA, courtesy NRAO

Radio (6 cm):

Synchrotron radiation from jets and black hole.

Centaurus A



VLA/optical, courtesy STScI

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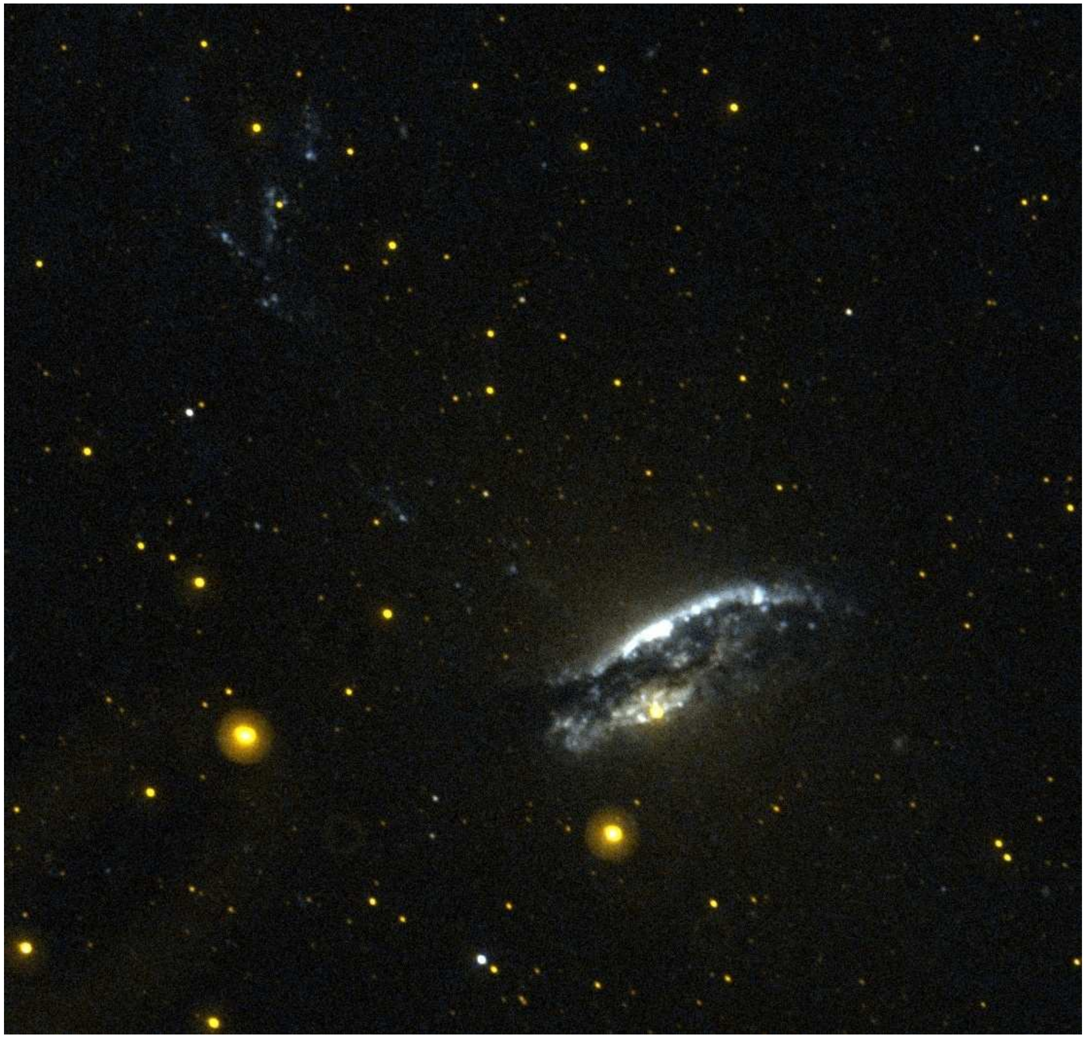
Centaurus A



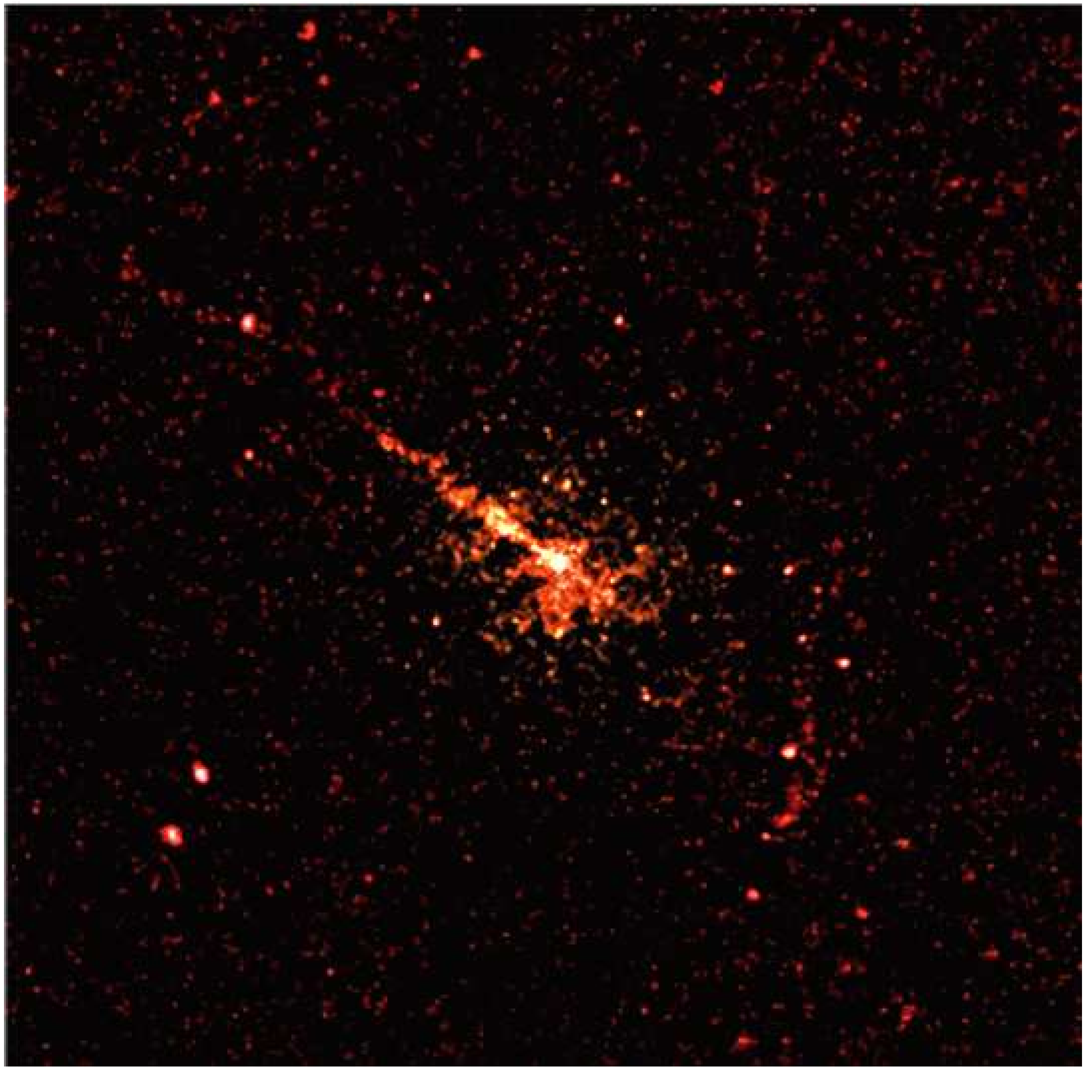
GALEX, courtesy NASA/Caltech

UV (30–300 nm):

Thermal UV emission from young stars (in NE corner)

Photoabsorption and absorption by dust by dust lane

Centaurus A

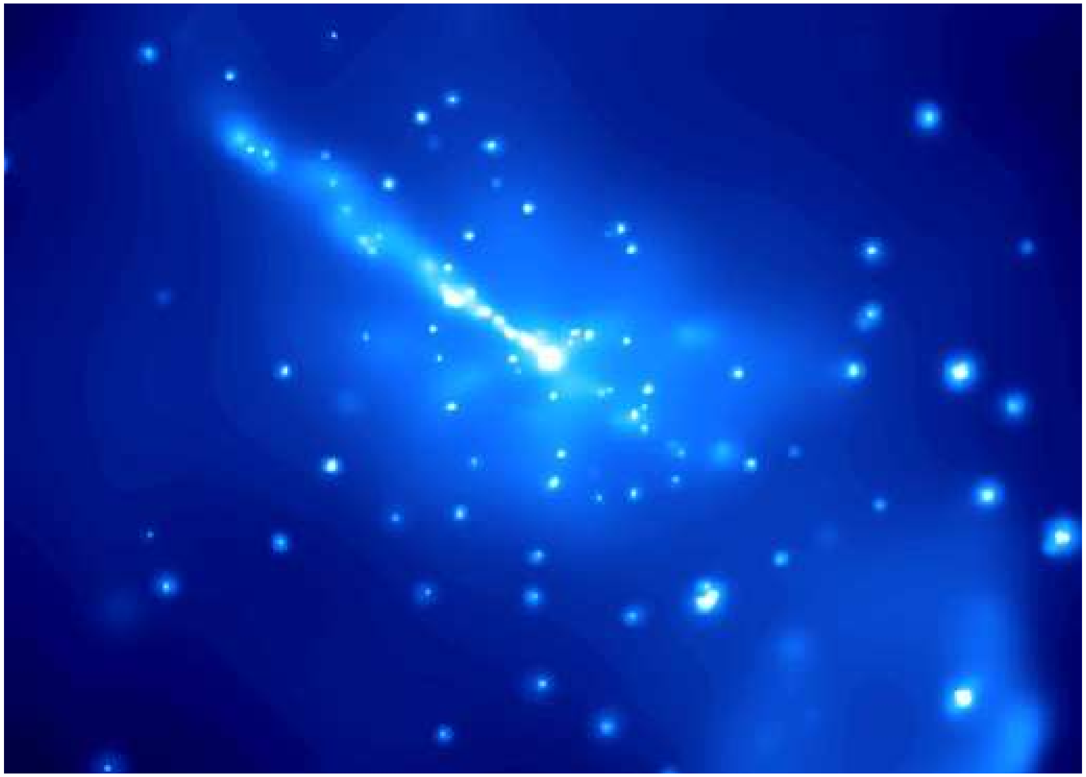


Chandra, courtesy CXC

X-rays (2–10 keV):

- Synchrotron radiation from jet,
- Comptonized photons from black hole,
- other emission from X-ray binaries and background AGN

Centaurus A



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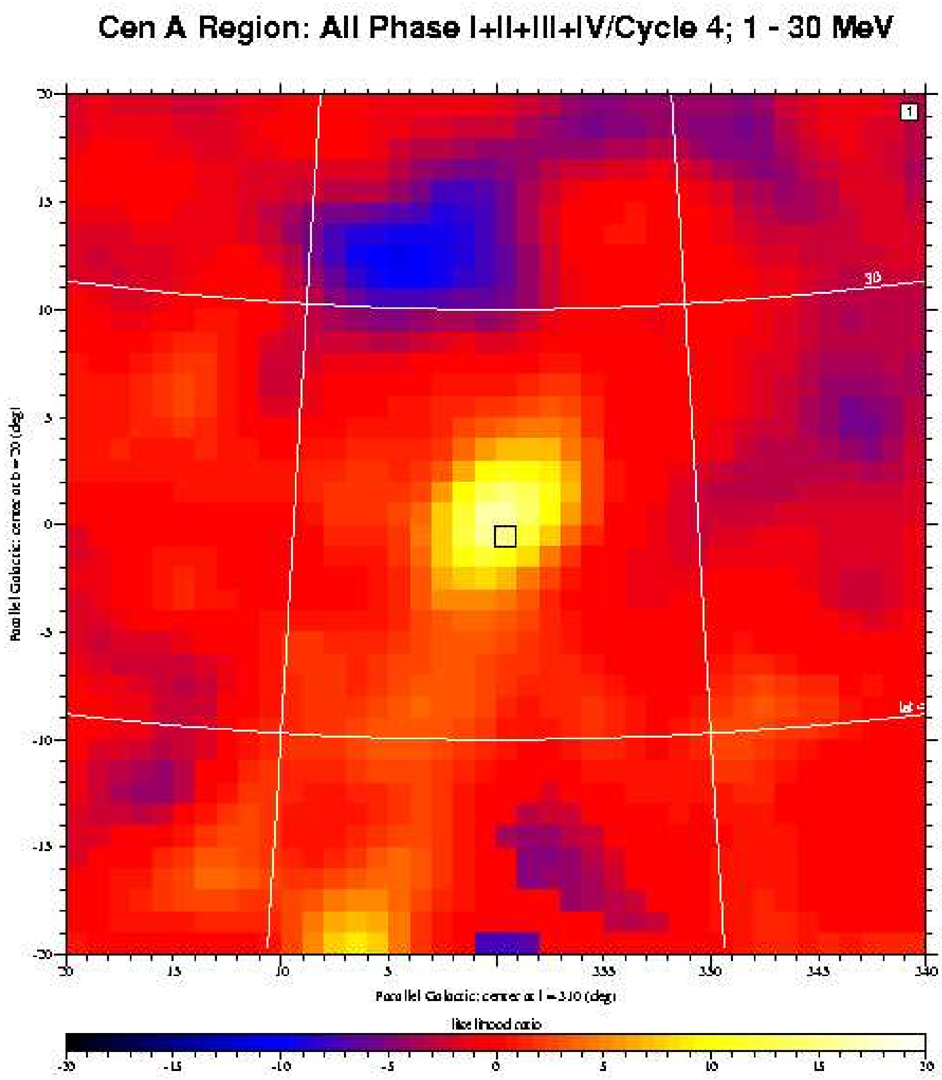
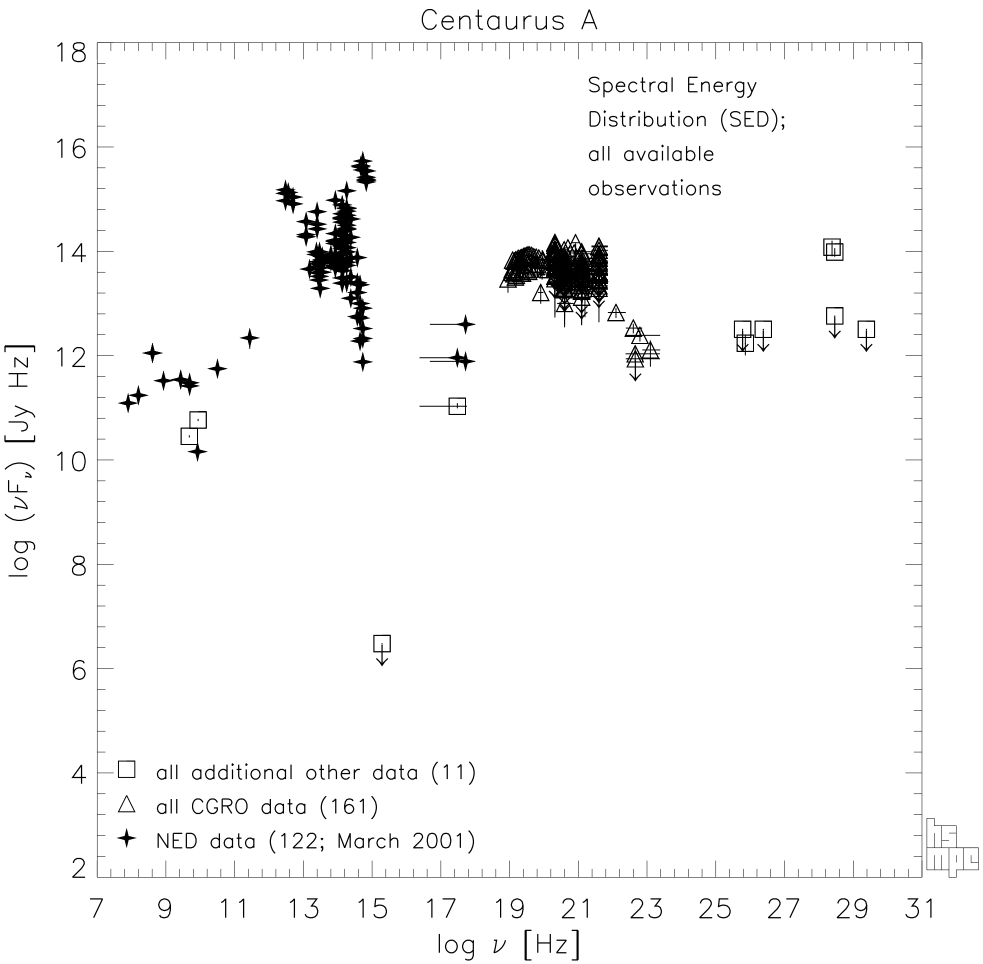


CGRO-COMPTEL, courtesy MPE/H. Steinle

γ-rays (1–30 MeV):
Comptonized synchrotron radiation
from jet and/or black hole.

Centaurus A



Steinle (AIP Conf. Proc. 587, 353–357, 2001)

Broad-band spectrum of Cen A:

Spectral Energy Distribution (SED)

νf_ν is flat

$\Longrightarrow$ similar energy output at all wavebands!

Shown is a νf_ν plot, where ν: frequency, f_ν: flux density at frequency ν (units of f_ν are $\mathrm{J\,s^{-1}\,cm^{-2}\,Hz^{-1}}$). Since

$$\int_{\nu_1}^{\nu_2} \nu f_\nu d\nu = \int_{\ln \nu_1}^{\ln \nu_2} f_\nu d \ln \nu$$

$\Longrightarrow$ plotting νf_ν in a log-log plot gives measure of energy emitted per frequency decade