

Centaurus A: Neutral hydrogen close to the nucleus

Workshop: The Central Kiloparsec: AGN and Their Hosts
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Ierapetra - Crete

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universität
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faculty of mathematics and
 natural sciences

astronomy

Outline

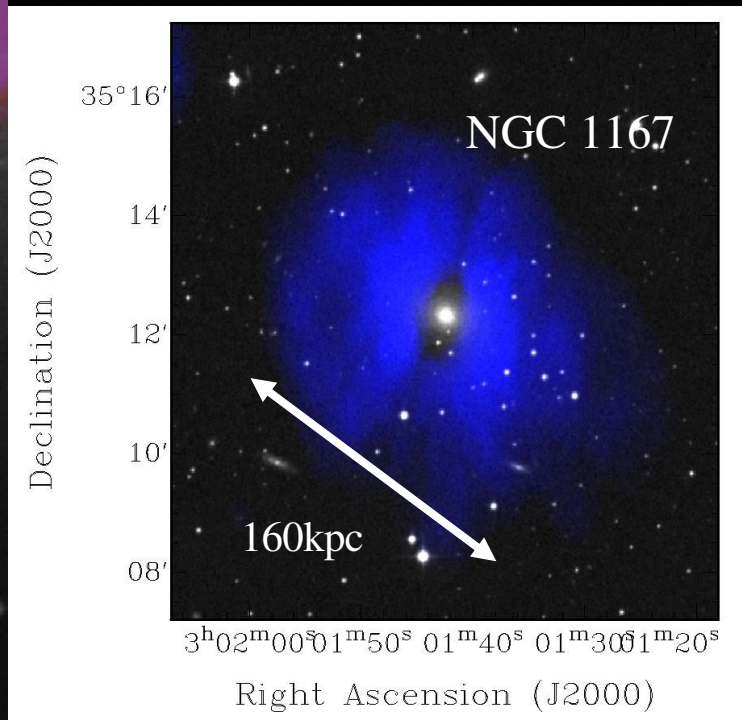
- Introduction
- An HI disk in the centre of Centaurus A
- The case of NGC 1167
- Summary and Outlook

Introduction

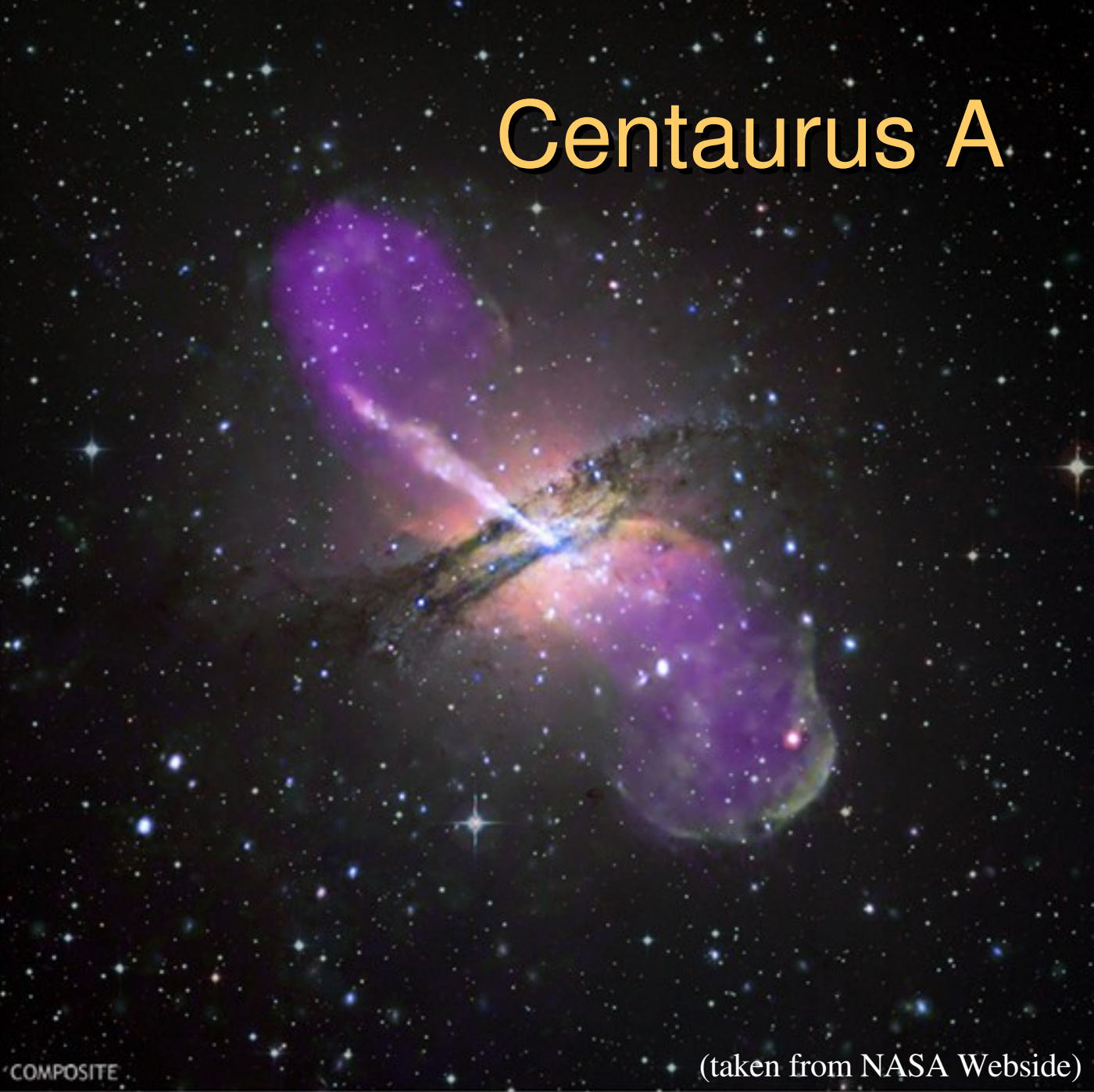
The project:

“HI structures around **radio-loud** early-type galaxies as relics of their formation“

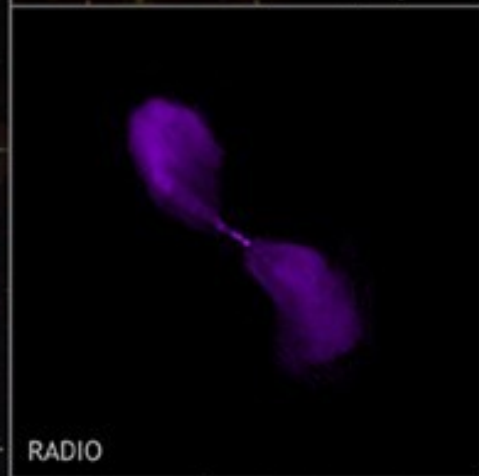
- Role of AGN in the process of galaxy formation
- Triggering/fuelling the AGN
- AGN are predominantly hosted by early-type galaxies
- Radio galaxies are often (perceived to be) gas poor
- HI is a good tracer of galaxy interactions, minor mergers and small accretions



Centaurus A



X-RAY



RADIO



OPTICAL

COMPOSITE

(taken from NASA Website)

Centaurus A

- Prototype of an elliptical galaxy
- Nearest elliptical galaxy ($D=3.5$ Mpc)
- Double-lobed radio source perpendicular to the (warped) dust lane
- Product of a merger of a small gas rich spiral galaxy with a large elliptical galaxy (Baade & Minkowski 1954)
- Recent merging event, about 200 million yr ago (Quillen et al. 1993)
- Observed in all frequency bands at (almost) all resolutions
-



BUT: Structure and kinematics of the (gaseous) warped disk is still not fully understood neither the AGN fuelling/activity

Centaurus A

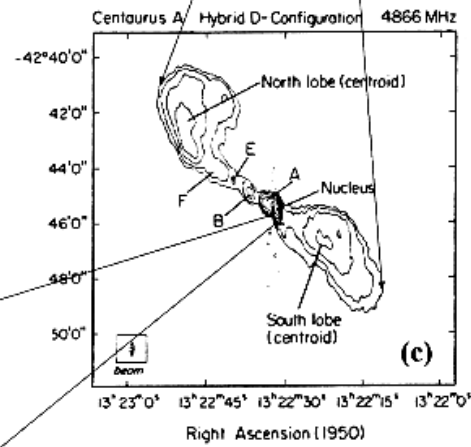
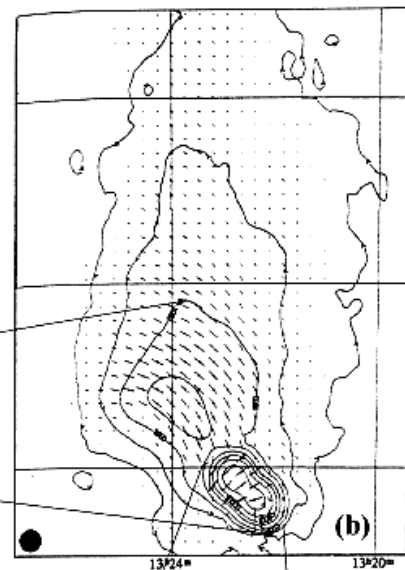
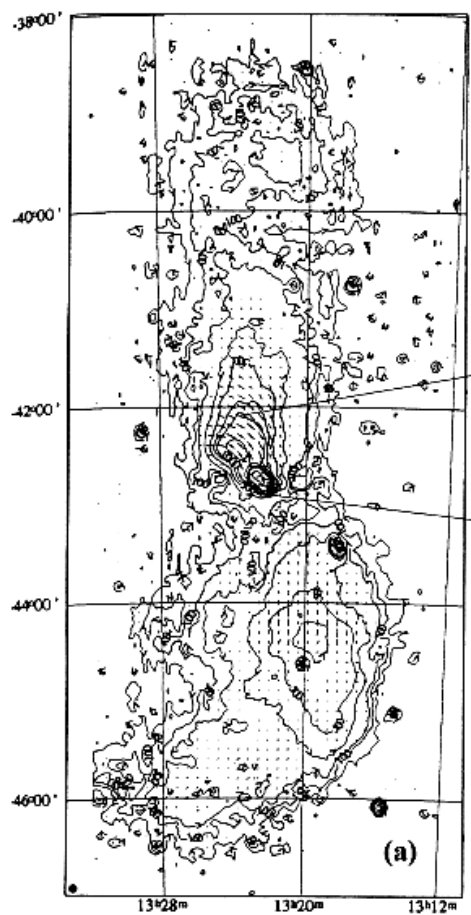
- Prototype of an elliptical galaxy
- Nearest elliptical galaxy ($D=3.5$ Mpc)
- Double-lobed radio source
- the (warped) dust lane
- Product of a merger of a
- spiral galaxy and a dwarf
- (Baade & Minkowski 1968)
- Recent merger
- ago (Quillen et al. 2009)
- Observed in all
- all resolutions
-

**Our ATCA HI Data:
Observations have better
sensitivity and spatial resolution
than previous investigations**

BUT: Structure and kinematics of the
(gaseous) warped disk is still not
fully understood neither the AGN
fuelling/activity

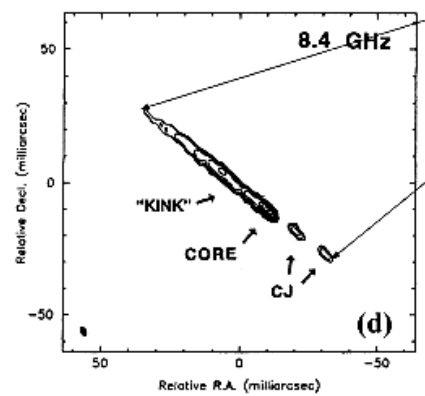
Cen A

500 kpc



10 kpc

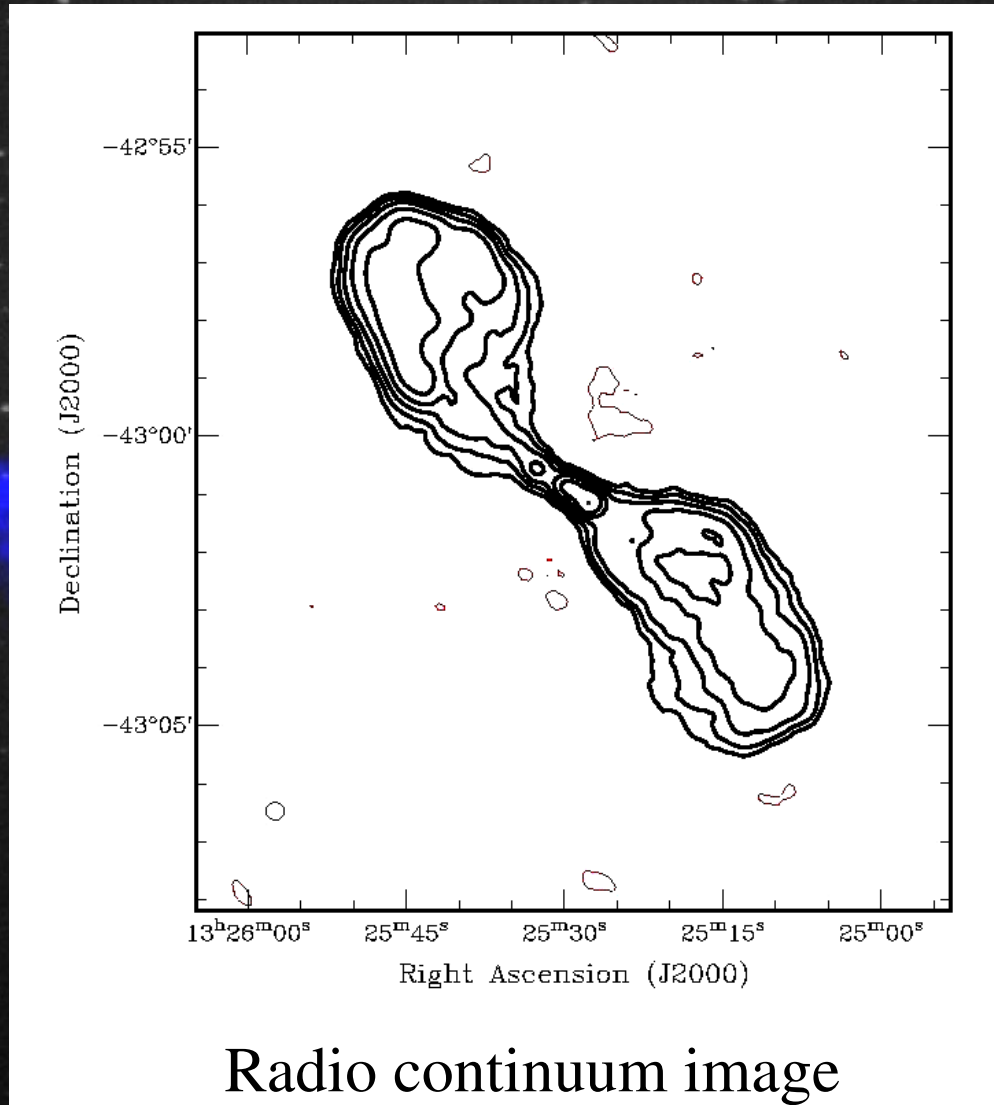
0.1 kpc



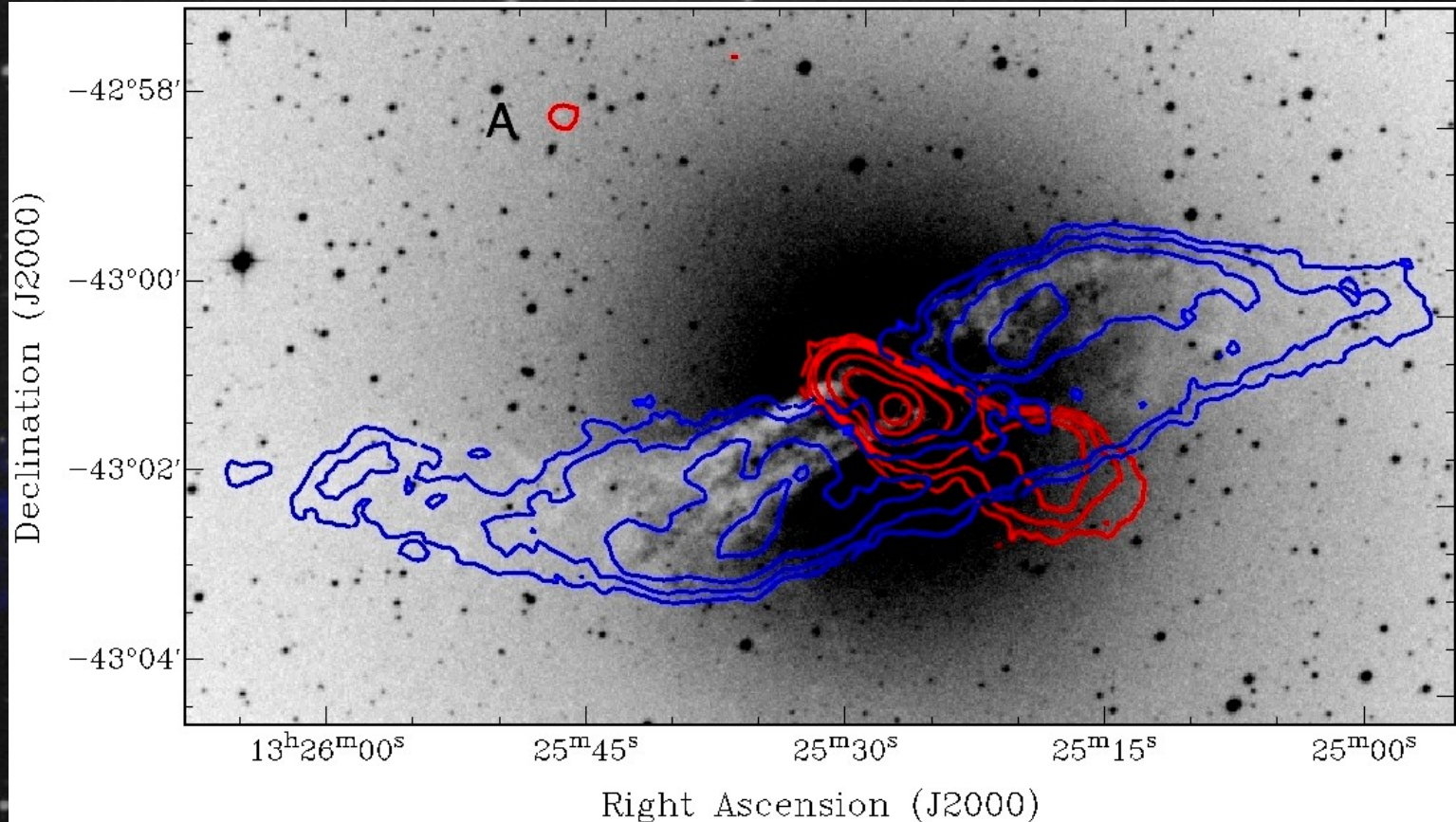
(taken from Morganti et al. 1999)

Space VLBI observations:
0.01 pc / beam

Centaurus A

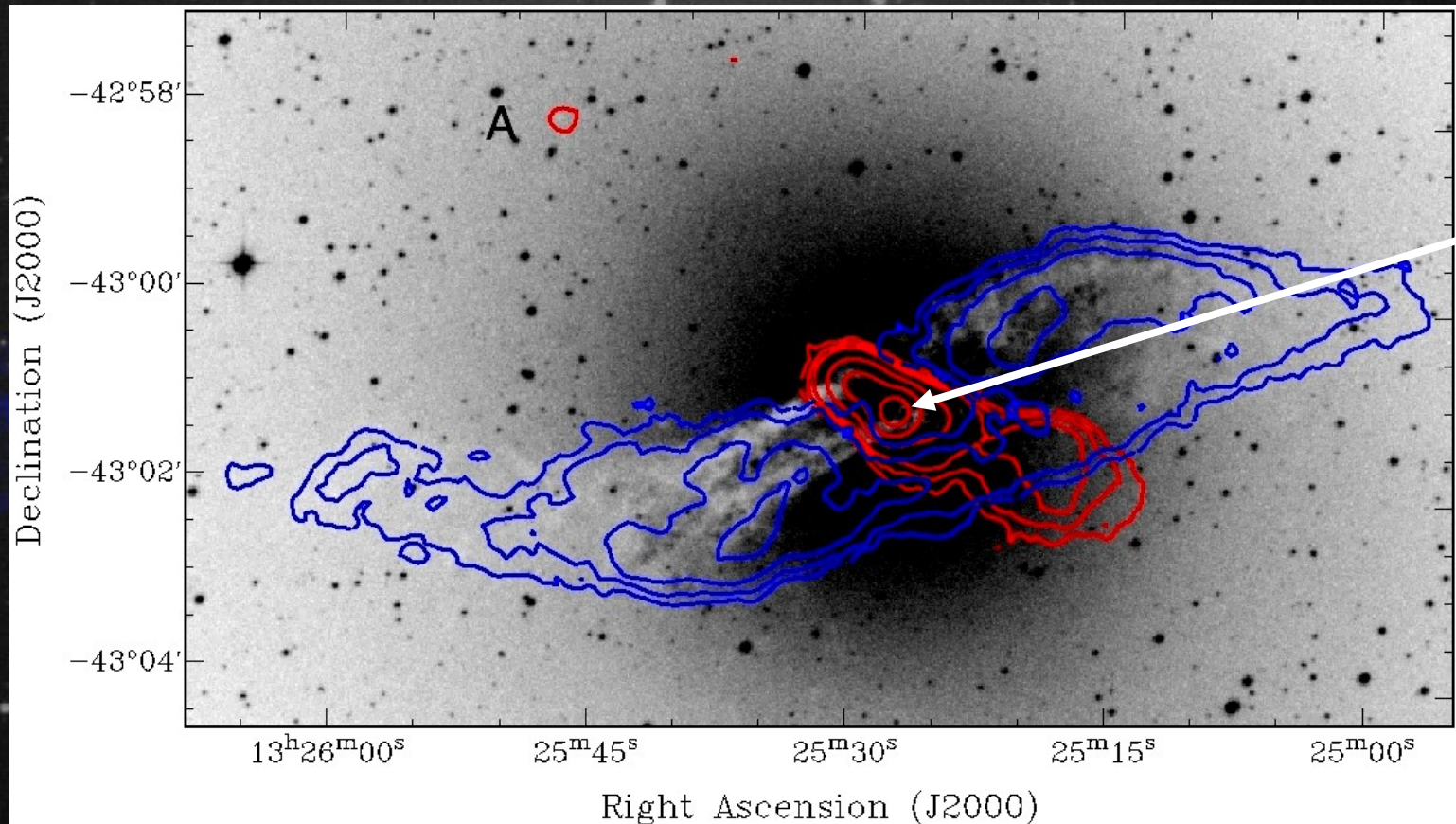


Total intensity map

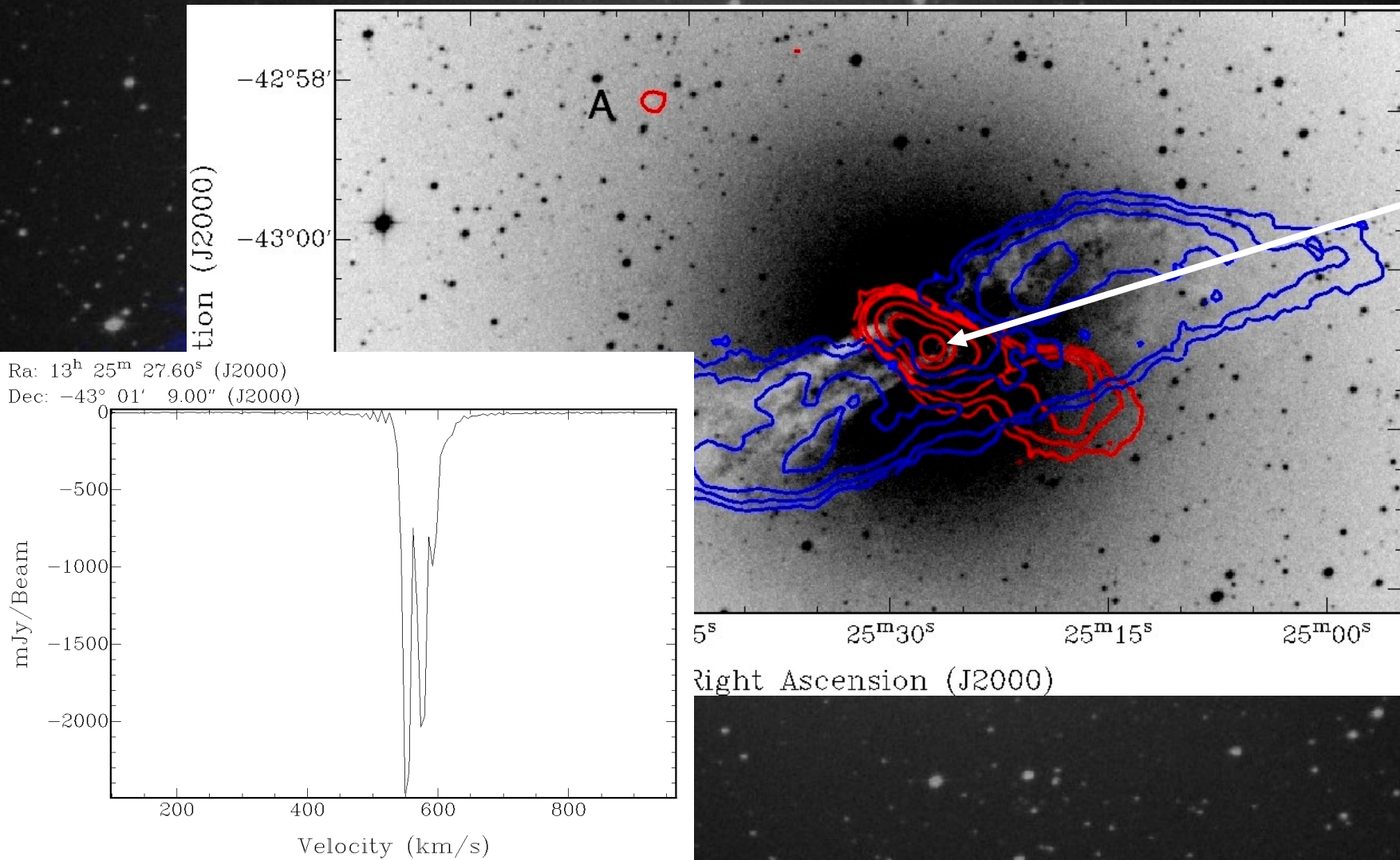


- Absorption against unresolved nucleus, northern jet and southern radio lobe
- Warped large-scale disk
- Dominated by rotation

Total intensity map

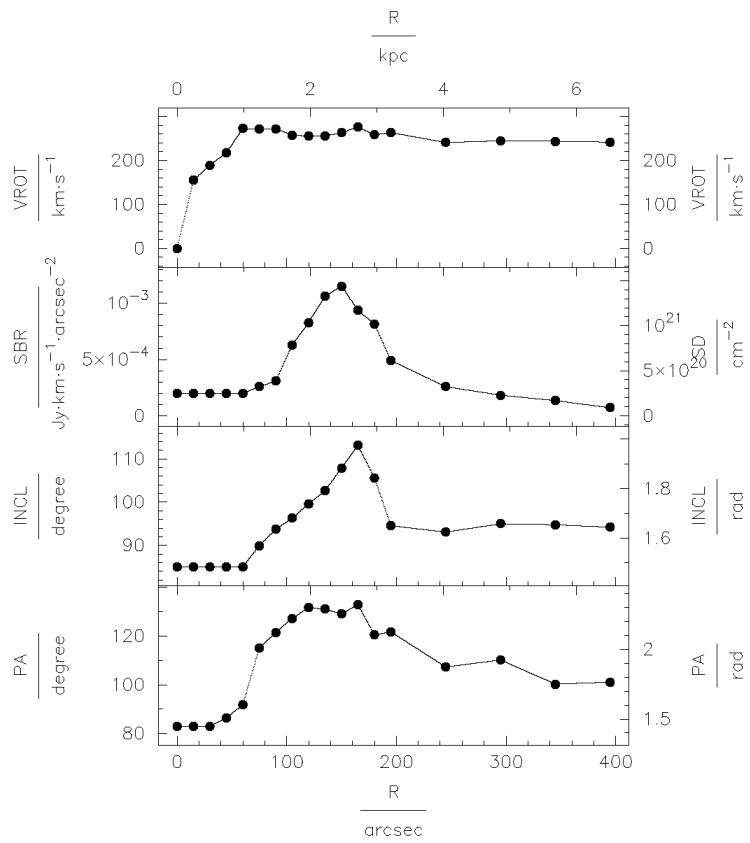


Total intensity map

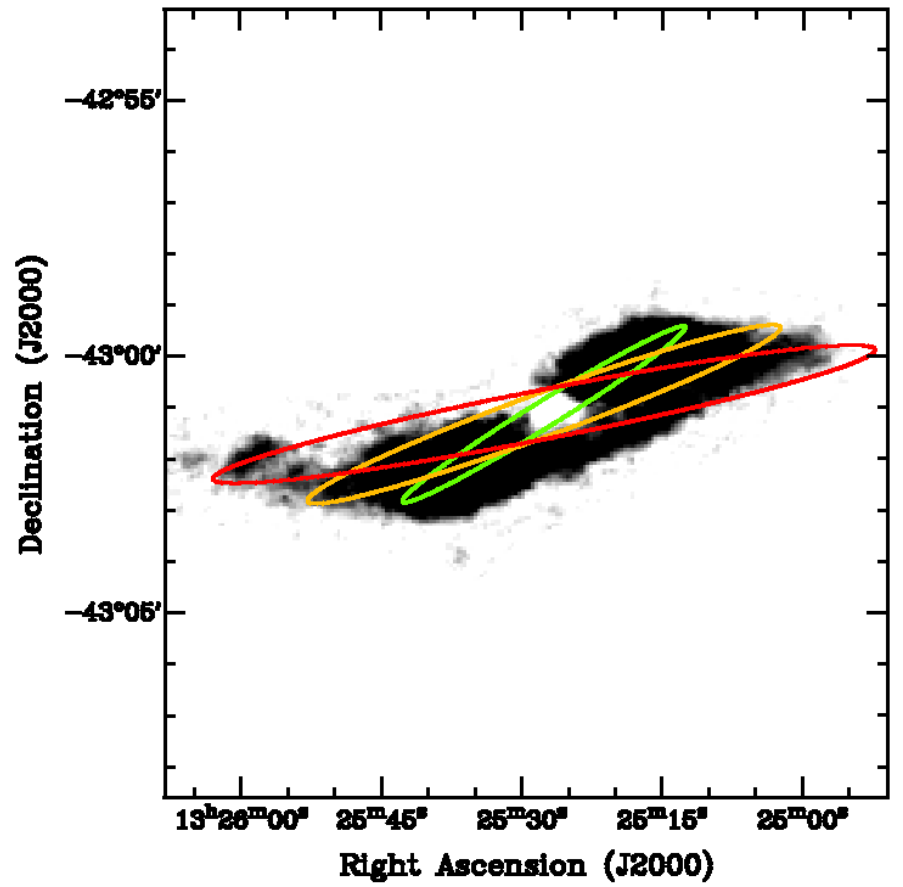


Kinematic modelling of disks

Tilted-ring model results



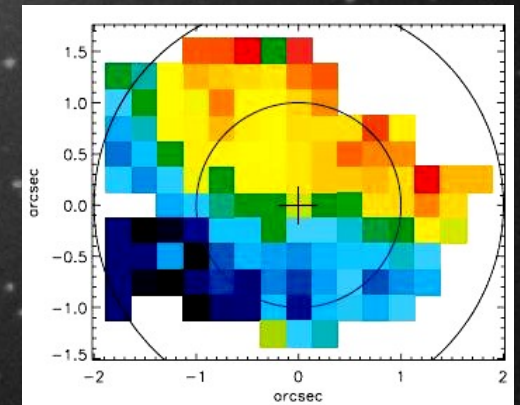
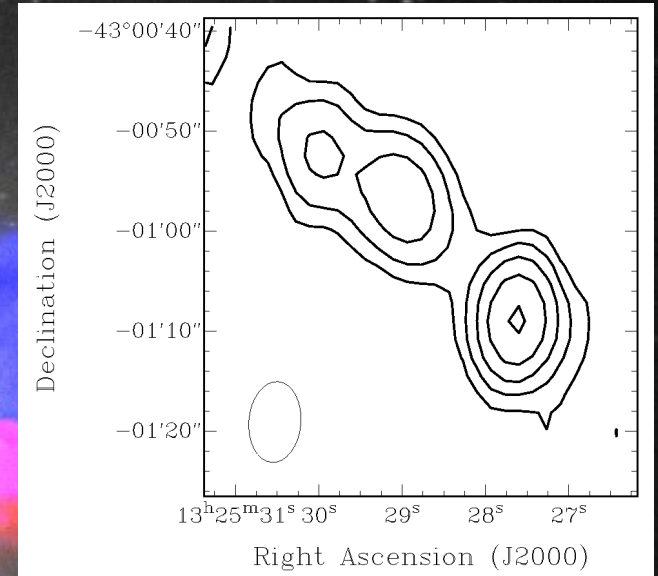
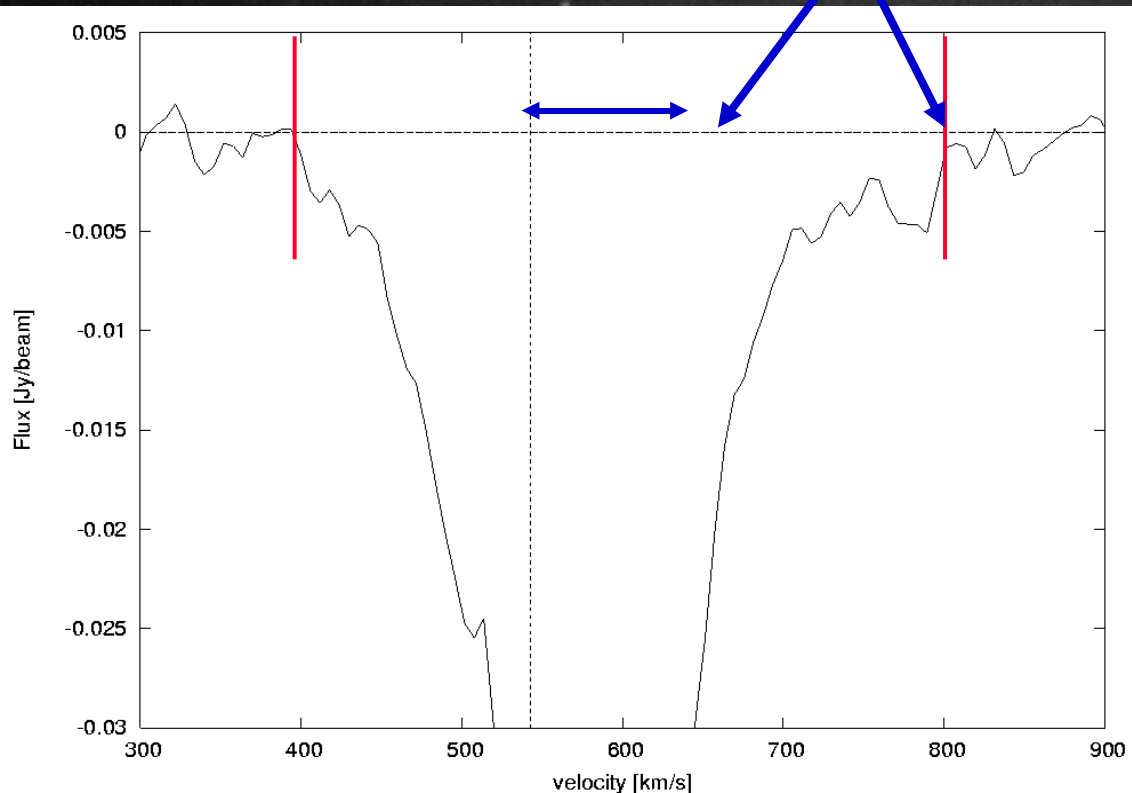
R: Radius
 VROT: Rotation velocity
 SBR: Surface brightness
 INCL: Inclination
 PA: Position angle



Inclinogram

Parametrisation of the HI model

The central ~ 100 pc



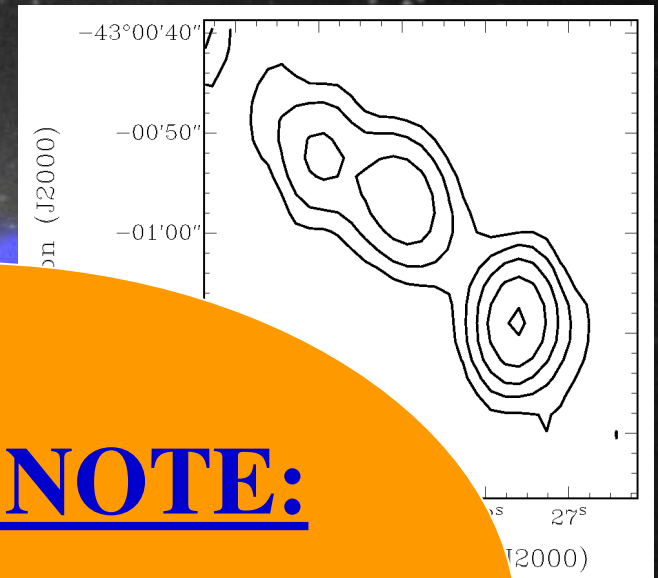
Krajnovic et al. 2007

- Red- and bluishifted absorption, challenges old

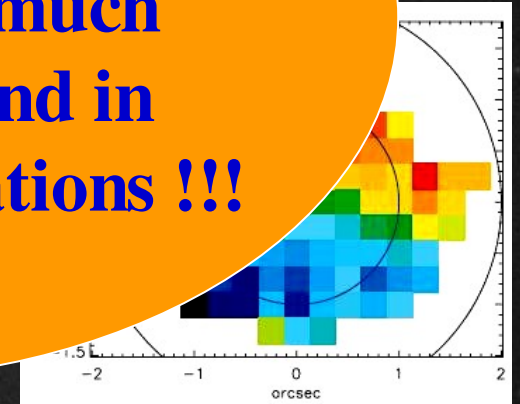
- picture
A circumnuclear disk?

- Not that simple !!!

The central ~ 100 pc



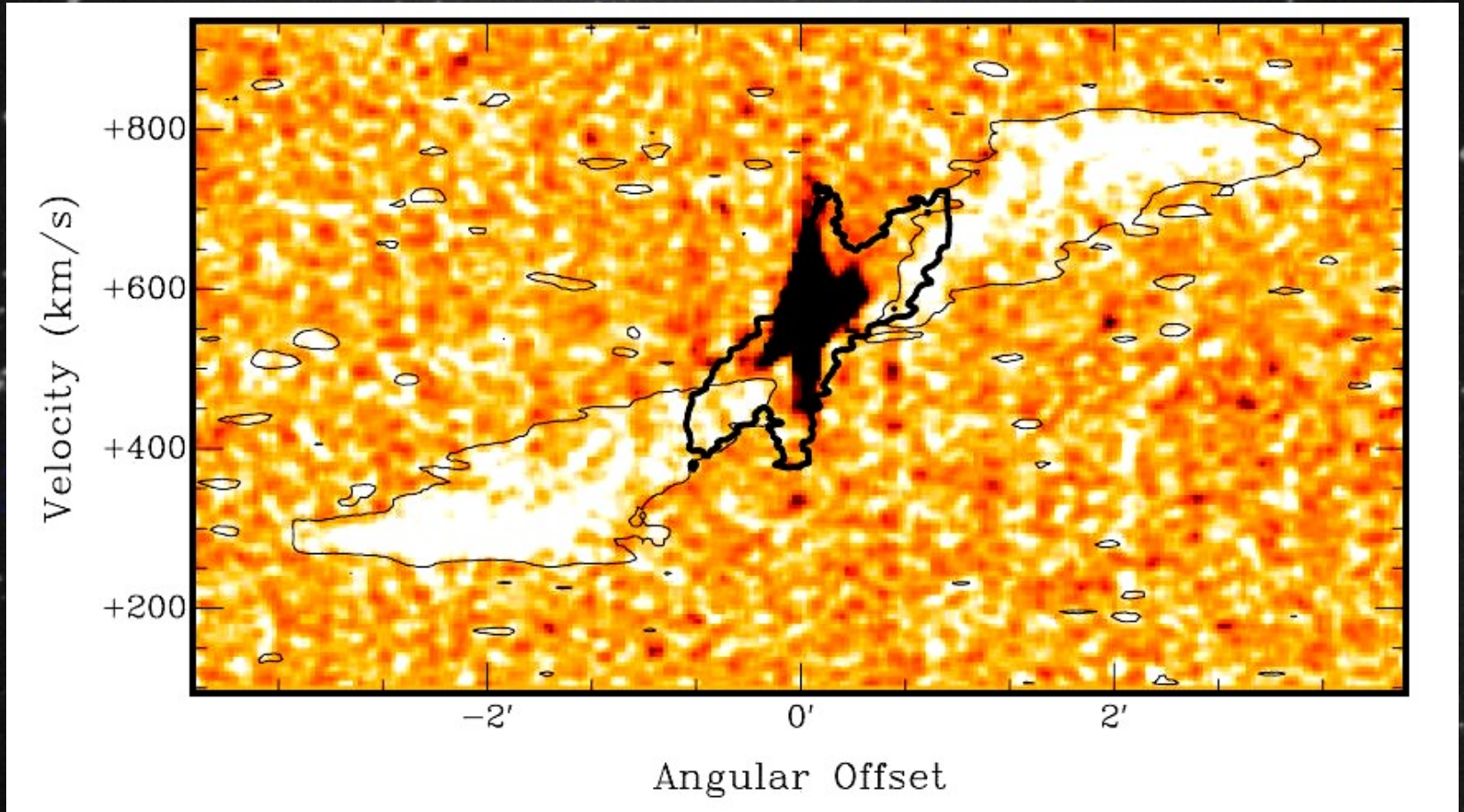
PLEASE NOTE:
Velocity width much larger than found in molecular observations !!!



- Red- and blueshifted absorption
- picture
- A circumnuclear disk?
- Not that simple !!!

The central ~ 100 pc

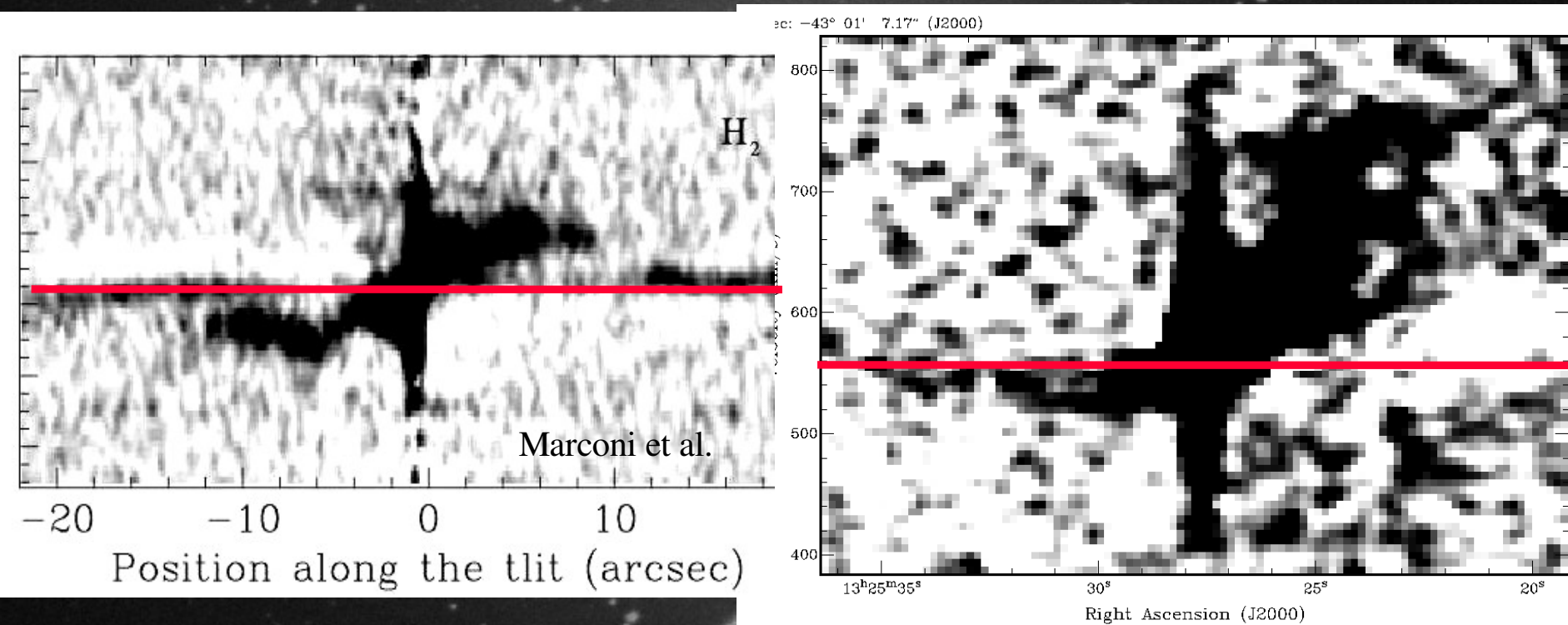
Position-velocity diagram:



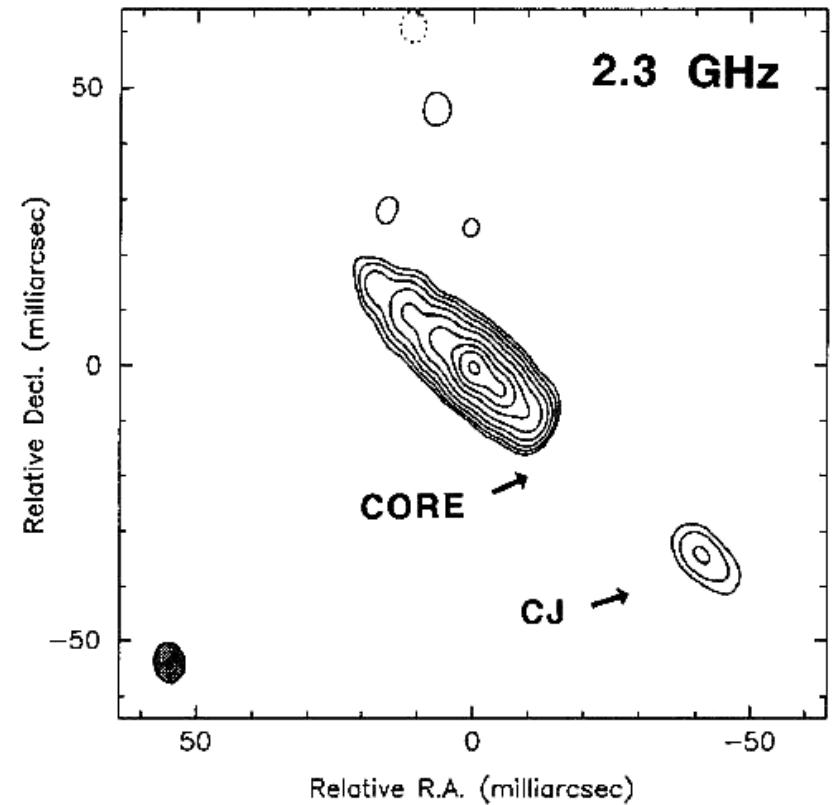
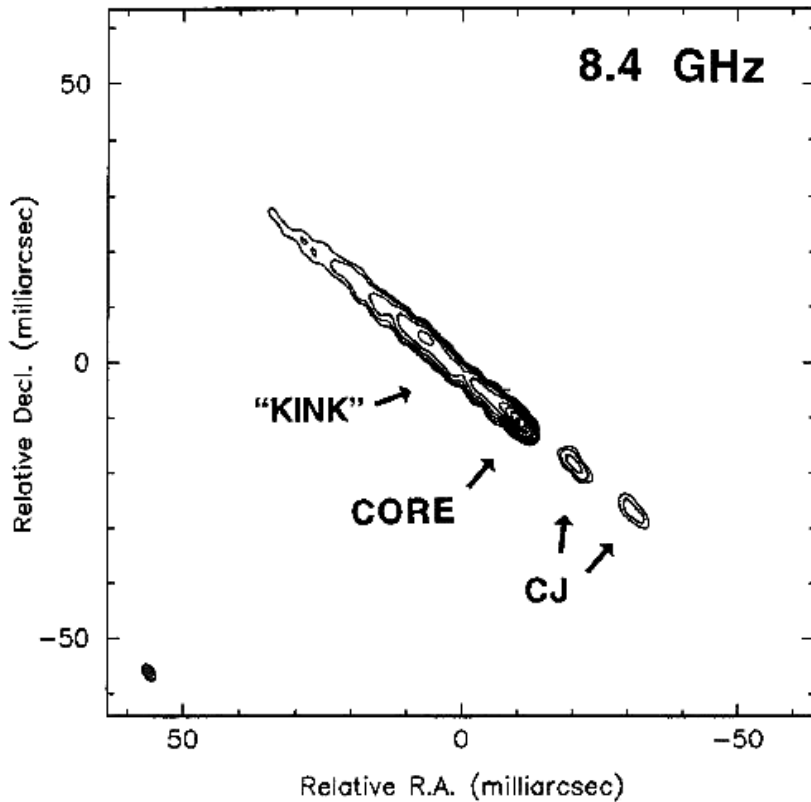
CO data cube kindly provided by H. Liszt

The central ~ 100 pc

Position-velocity diagram:



The central ~ 100 pc



Jones et al. 1996

Core is obscured at 1.4GHz !!!(?)

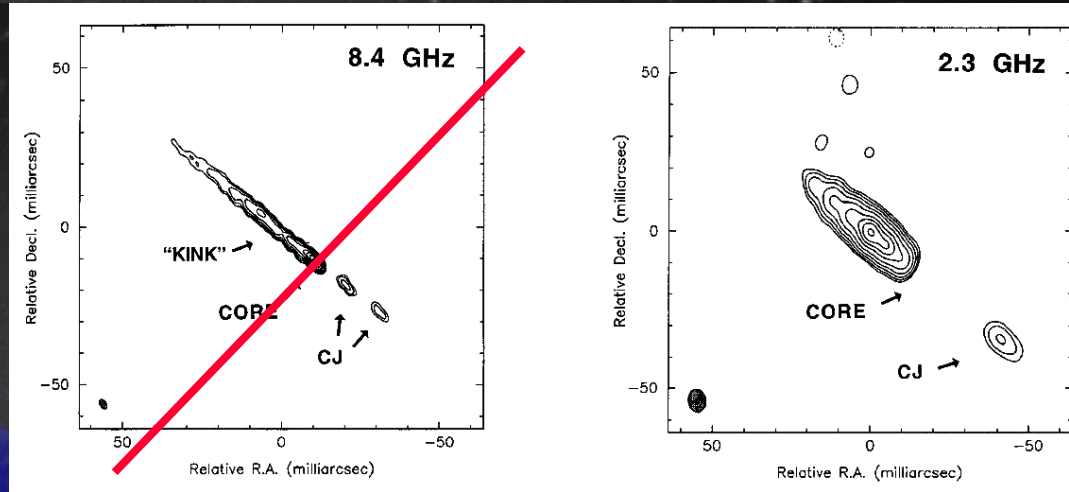
The central ~ 100 pc

Absorption:

- Against the (northern) jet
 - Against the (southern) counterjet
 - Diffuse component???
- extra flux in the VLBI observations

Tingay & Murphy 2001

→ Circumnuclear disk tori with high column density

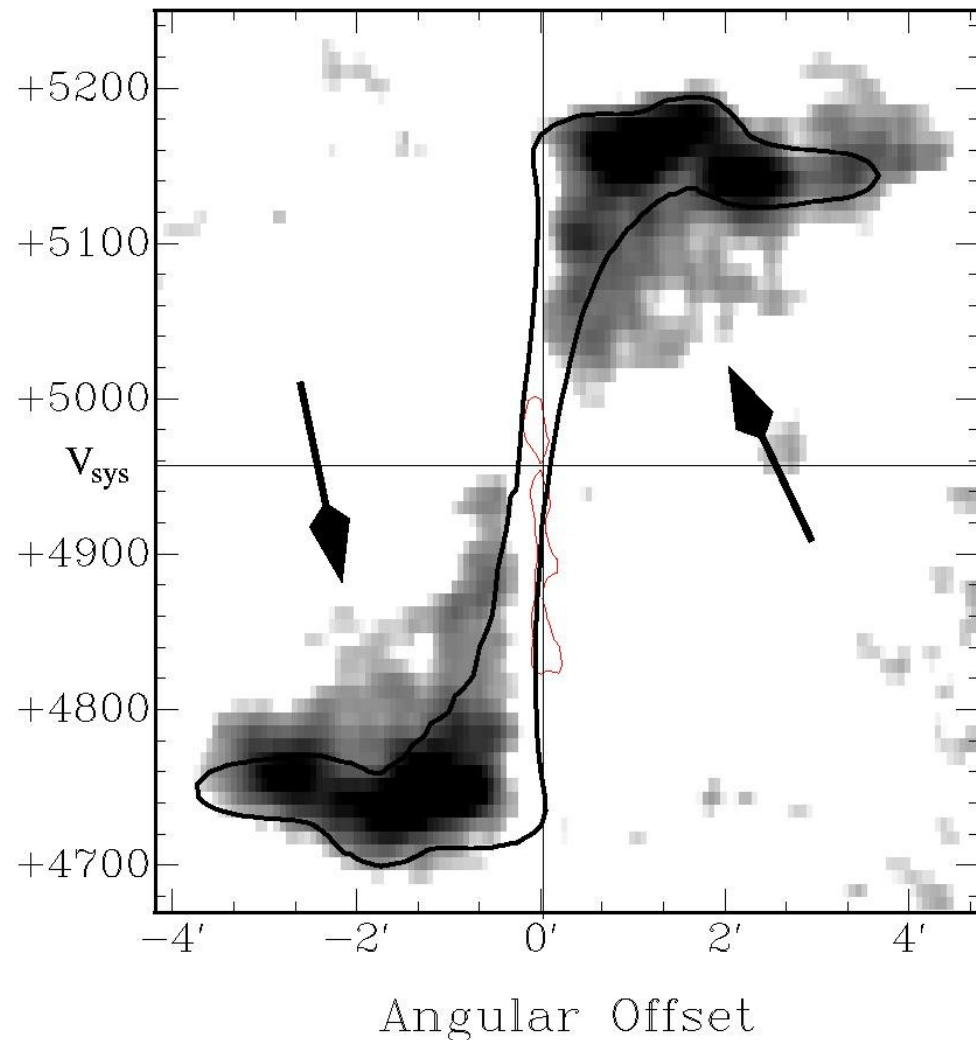
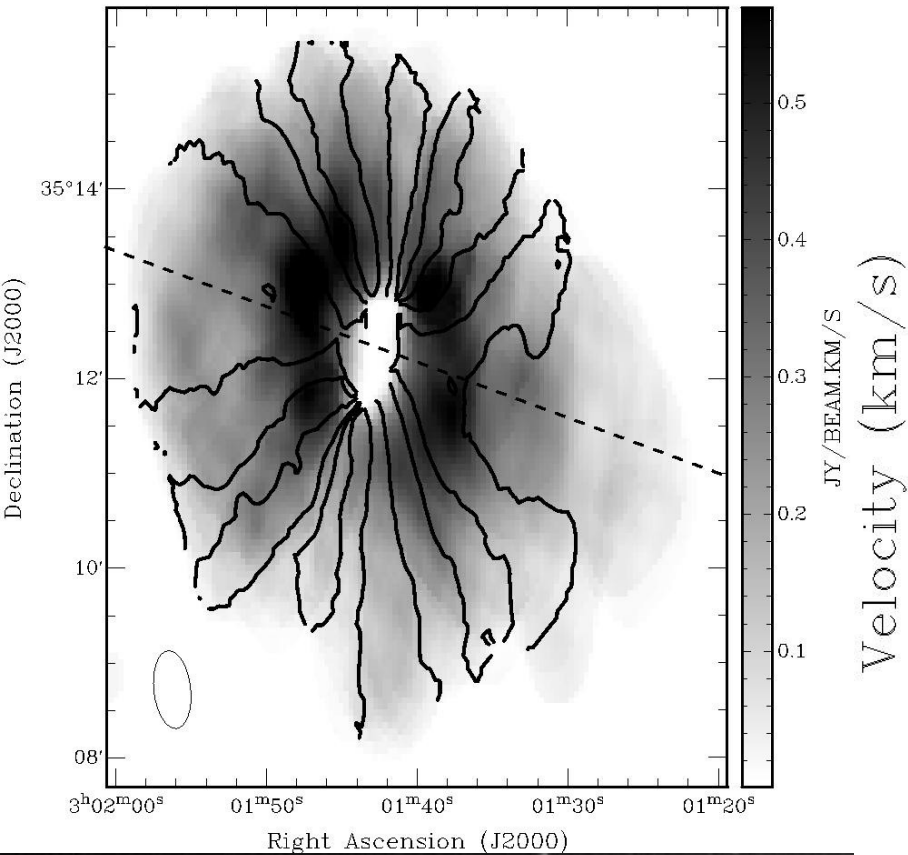


Similar case: Cygnus A (Conway 1999)

Why is the existence of a circumnuclear HI disk interesting?

- How does the gas get close to the black-hole of an active galaxy?
- Mergers are important for powerful radio galaxies
- But accretion from ISM/IGM important as well
- Redshifted absorption often seen as evidence for infall
- Blueshifted absorption occurs as often as redshifted (outflow)
- Theory predicts existence of circumnuclear disks
- Observations indicate presence of circumnuclear disks (Cygnus A, Cen A, NGC 1167)

NGC 1167



160 kpc in size

Lots of halo gas, but no recent merger!

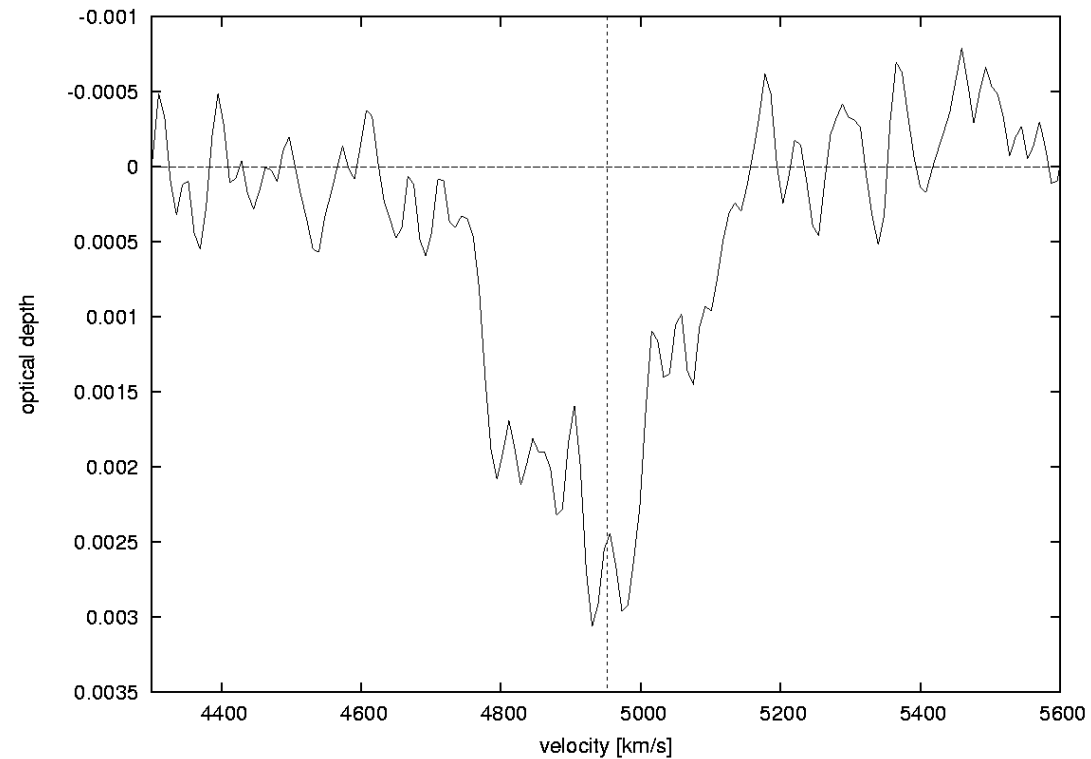
NGC 1167

- Background is unresolved with WB, but extended on arcsec scale

- Absorption profile symmetric w.r.t. v_{sys}

- Velocities fit rotation amplitude of large-scale disk

- Circumnuclear disk ???



Summary and Outlook

- Old picture: Redshifted absorption clouds (infall) deliver the fuel for active galaxies
- BUT: Blueshifted absorption (outflow) occurs as often as redshifted
- Circumnuclear disks expected and observed (?)
- Cen A ATCA observations reveal **red- and blueshifted absorption**, much broader than previously known
- HI structure similar to CO → **circumnuclear disk/torus ?**
- WB data suggests also a **circumnuclear HI disk in NGC 1167**
- Maybe part of absorption was also missed in other radio galaxy observations (due to insufficient band width)?
- Need **Cen A VLBI** and **NGC 1167 VLA-A observations** to see the origin of the absorption