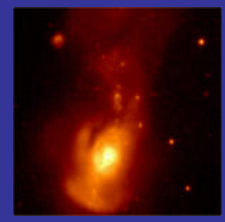
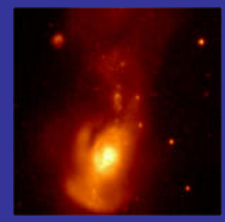
Sub-arcsecond imaging of the radio continuum and H1 absorption in the Medusa merger



Rob Beswick, Susanne Aalto, Alan Pedlar & Susanne Huttemeister

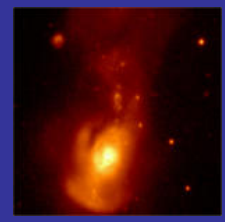
- The global picture of the Medusa
- Radio continuum at the heart of the starburst
- The building blocks of the activity:-
    - The neutral gas

The Medusa Merger

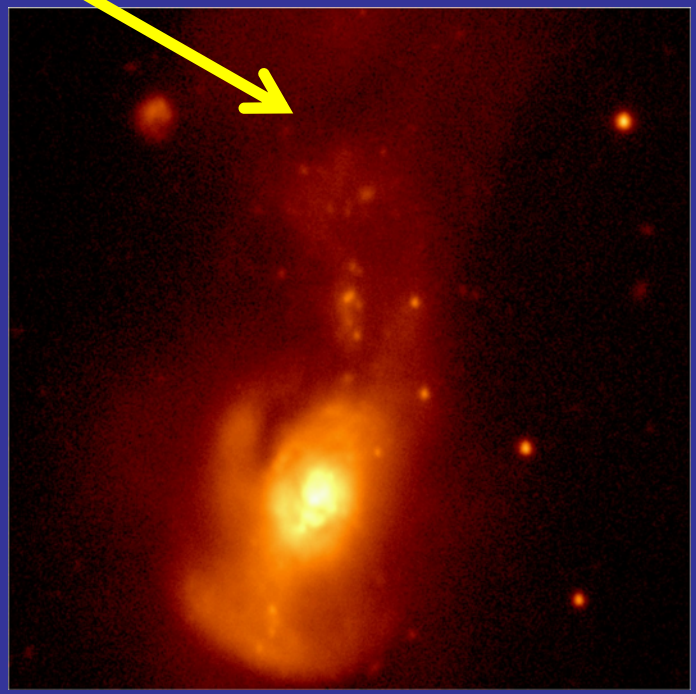


- Nearby ‘starburst’ galaxy/merger.
- D=39Mpc implying 1”=189pc
- Intermediate luminosity IR star-forming merger.
  - i.e. Lots of gas, lots of dust, and a bit of star-formation.

The Medusa on intermediate scales -- The Optical:



Hair!

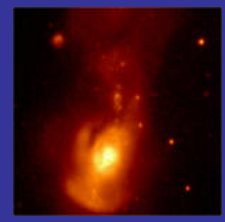


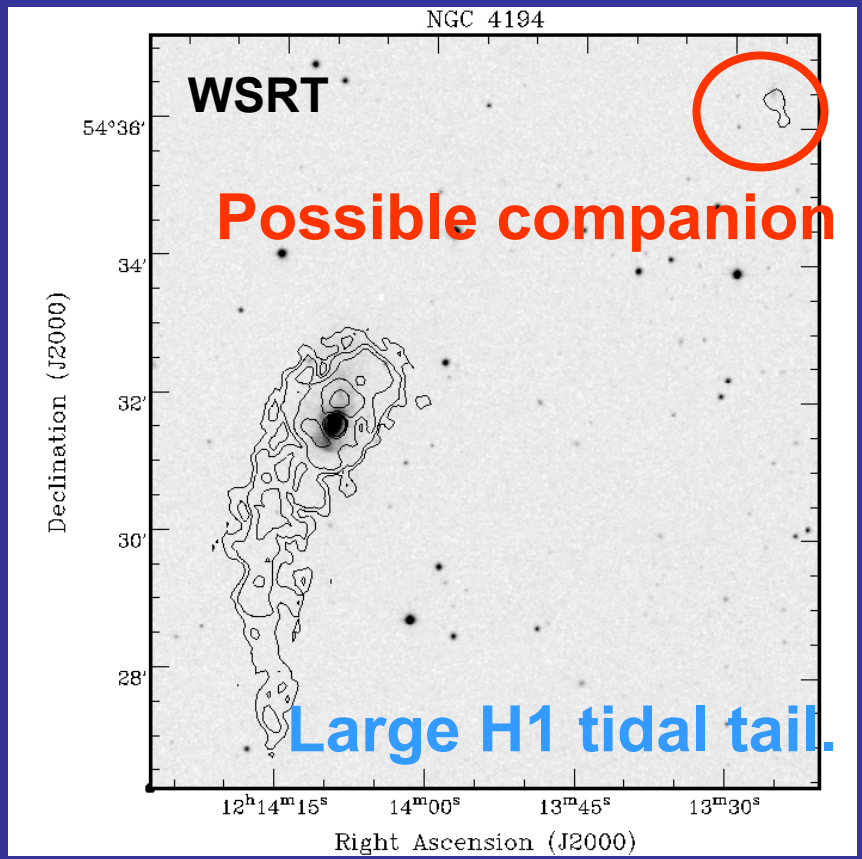
R-band image (see conf. website!)

(Mazzarella & Boroson 1993)

SDSS colour composite image

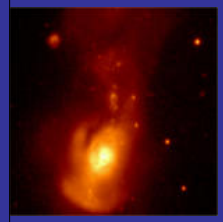
The Medusa on large scales
The H1:

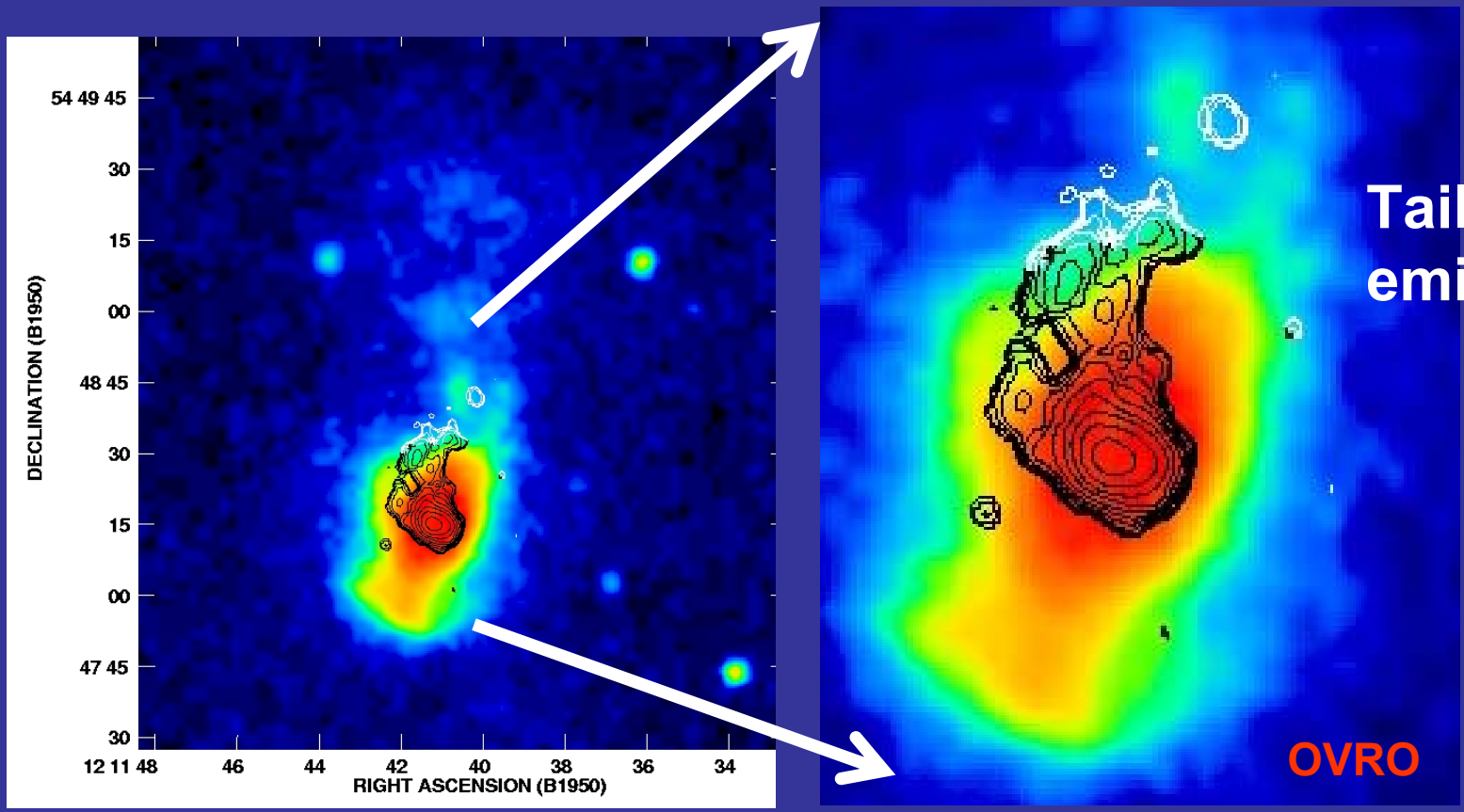




- Large scale H1 emission.
  - Long (5 arcmin) tidal tail of H1 sretching south of the galaxy
  - Possible H1 companion.
- Further evidence for an interaction.

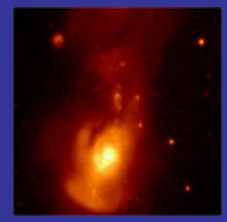
The Medusa on large scales CO (over DSS):

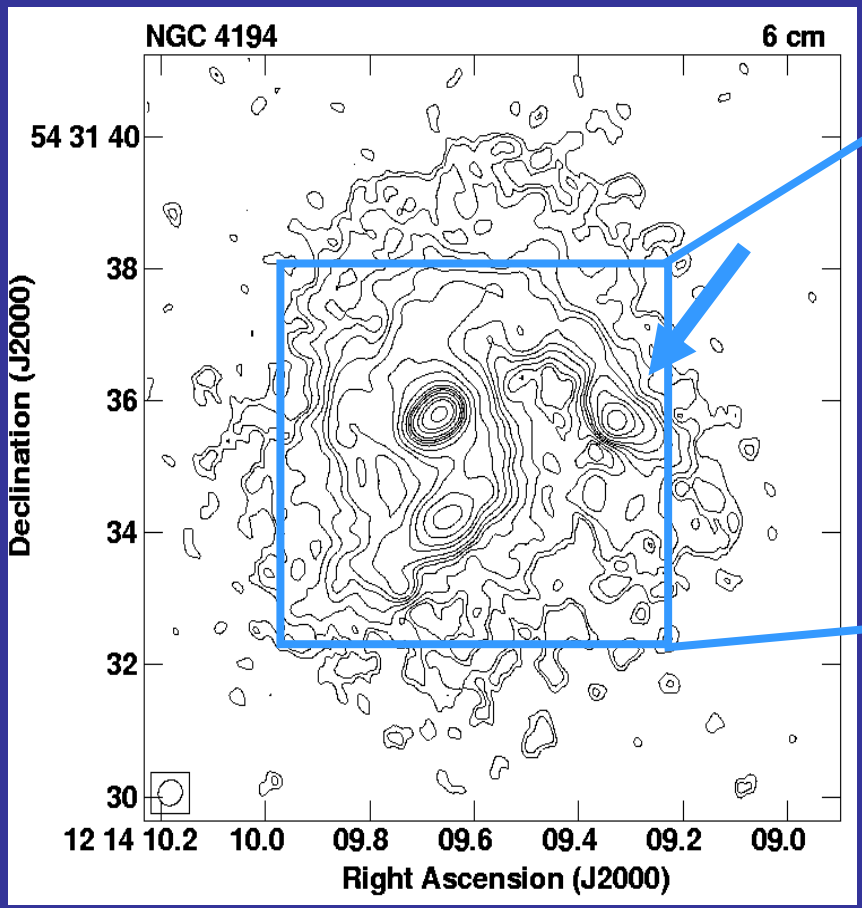


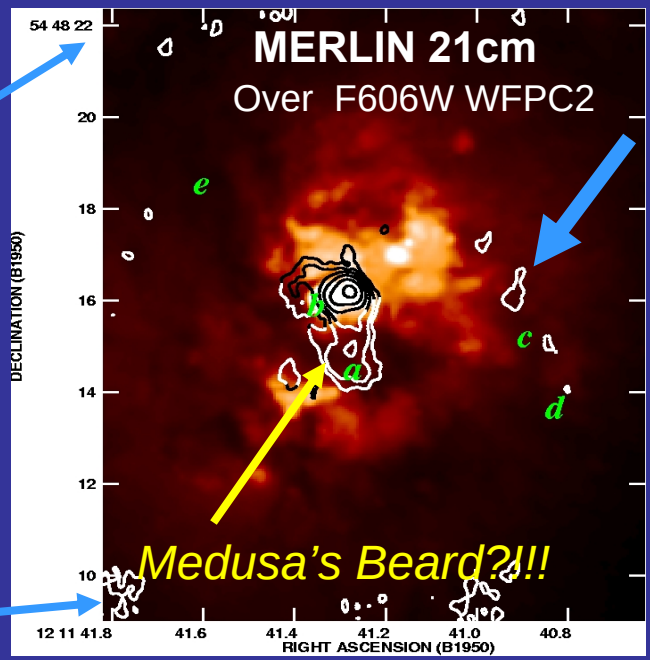


(From Aalto & Huttemeister 2000)

The Medusa on large to small scales -- The Radio continuum:



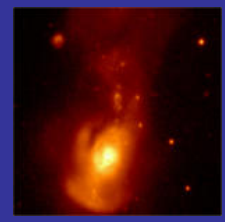


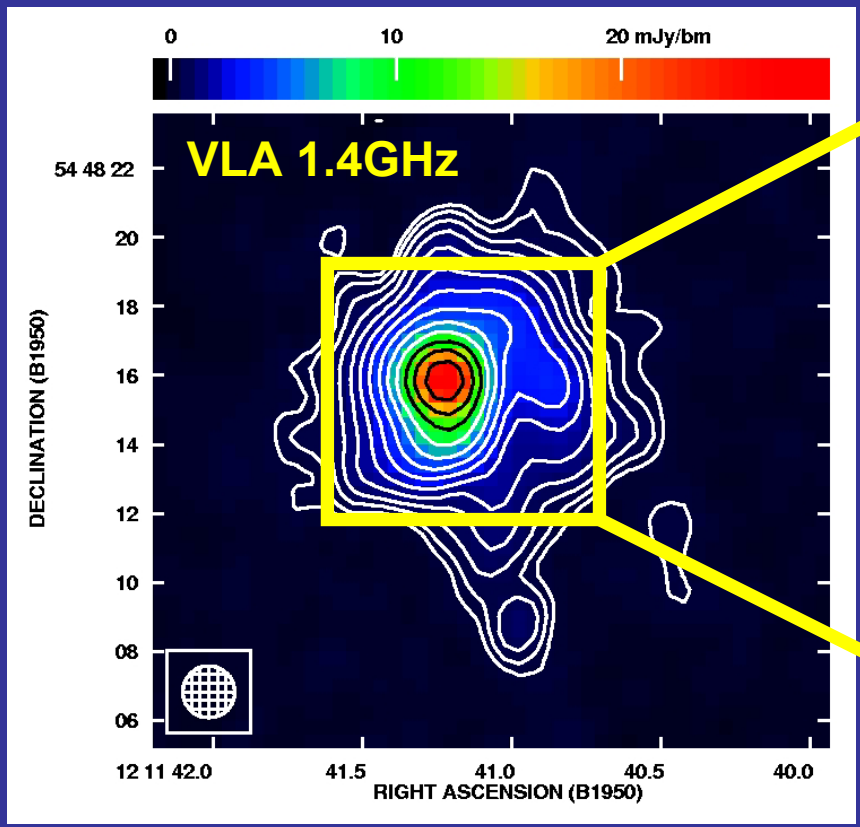


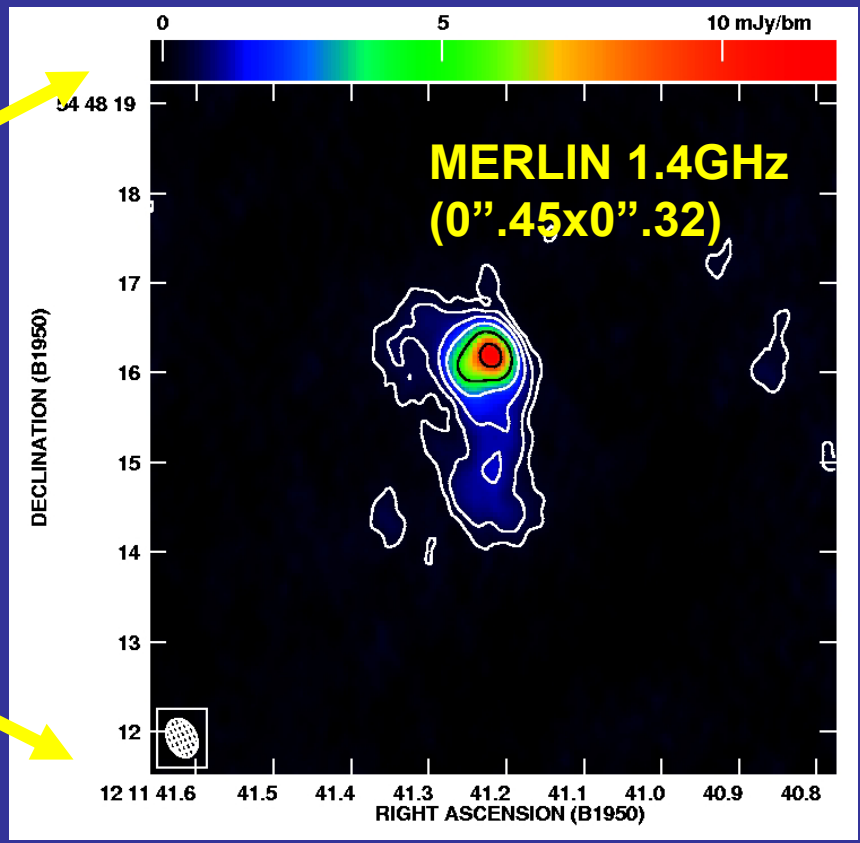
VLA 6cm map (courtesy of S. Neff)

- **Extensive radio emission from the core region.**
- **Star-formation related radio emission. RSNe & HII regions.**

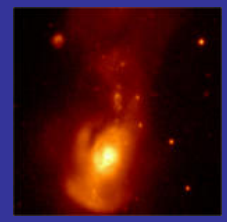
The 21 cm radio continuum

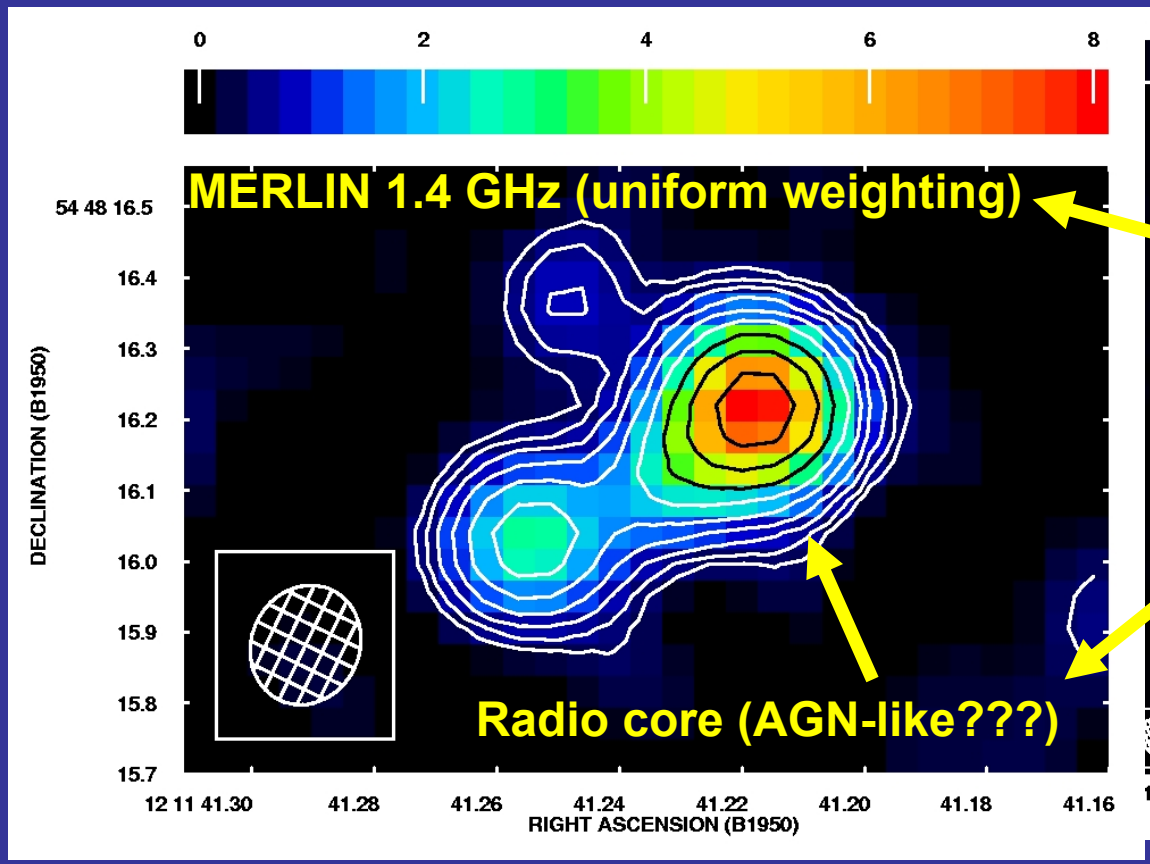


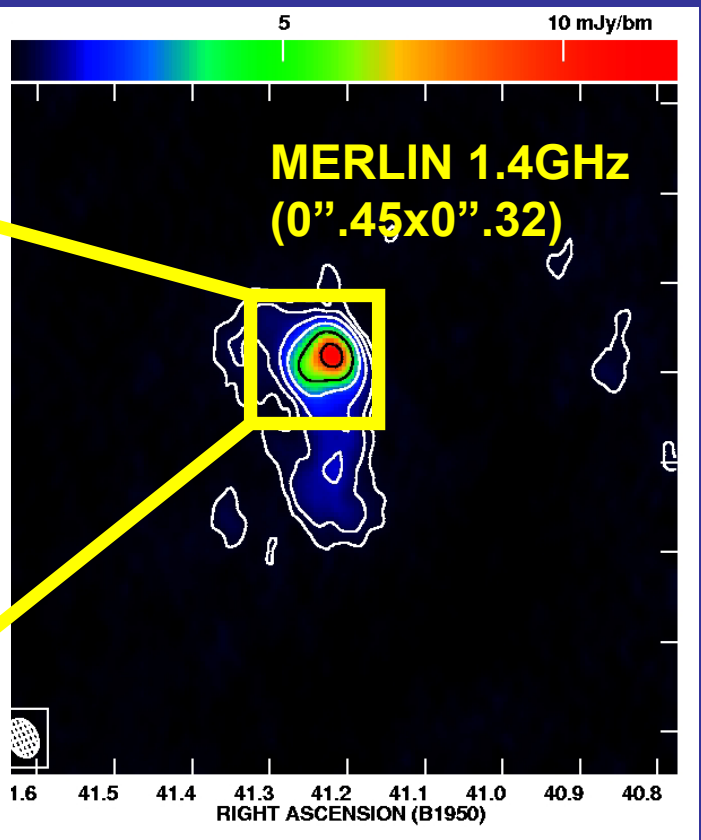




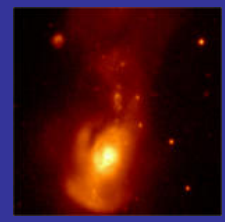
The 21 cm radio continuum: A close up.

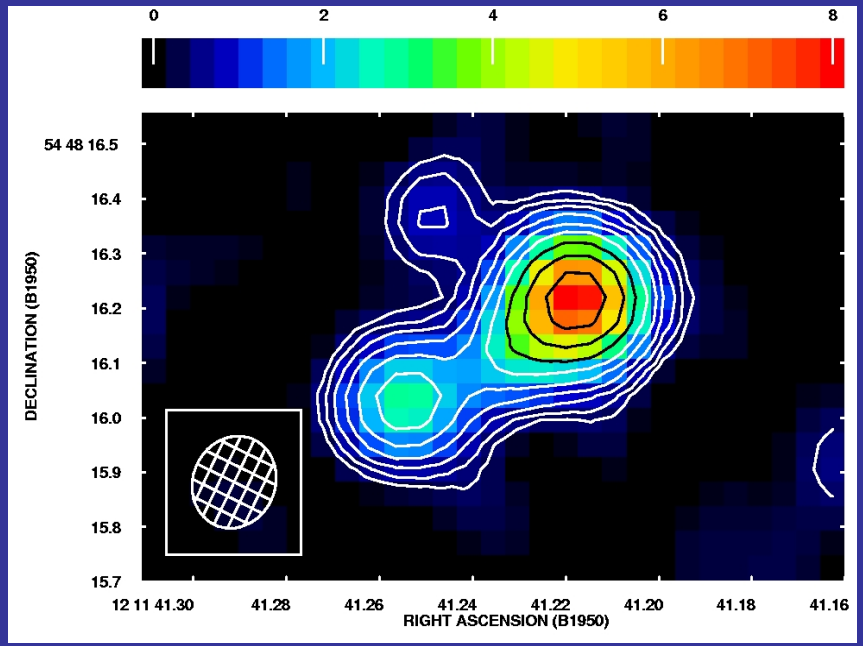






The compact core-like components.

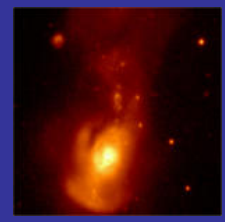




Beam = 0”.17×0”.15

- Two unresolved compact radio components.
  - separation 65 parsecs
  - component sizes <25pc
- Could be a weak AGN like feature!
- But more likely compact radio emission associated with RSNe or clusters of RSNe.

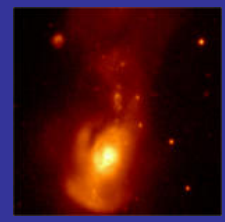
The Neutral gas: Why via absoprtion??

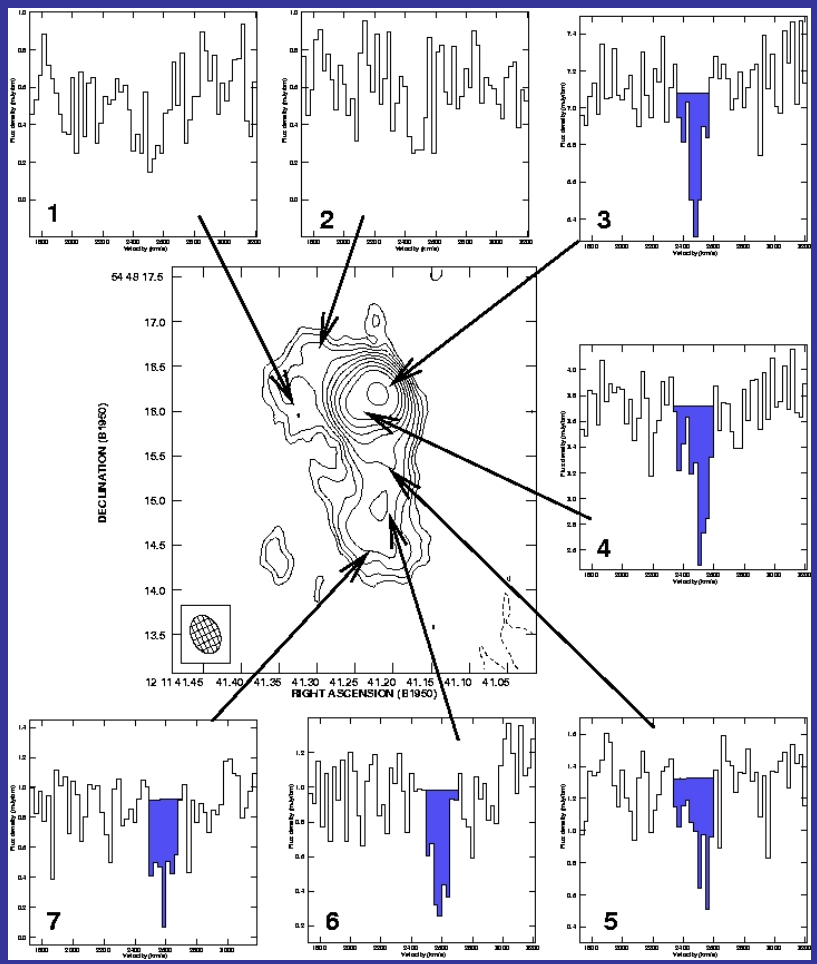


- The highest angular resolution studies of H1 emission currently possible have angular resolutions of few arcseconds.
- Whereas H1 absorption observations are only limited by the detection of the background 21cm continuum source.

i.e. Sub-arcsecond angular resolutions (see previous talk)

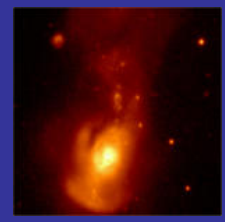
H1 absorption against the Medusa.

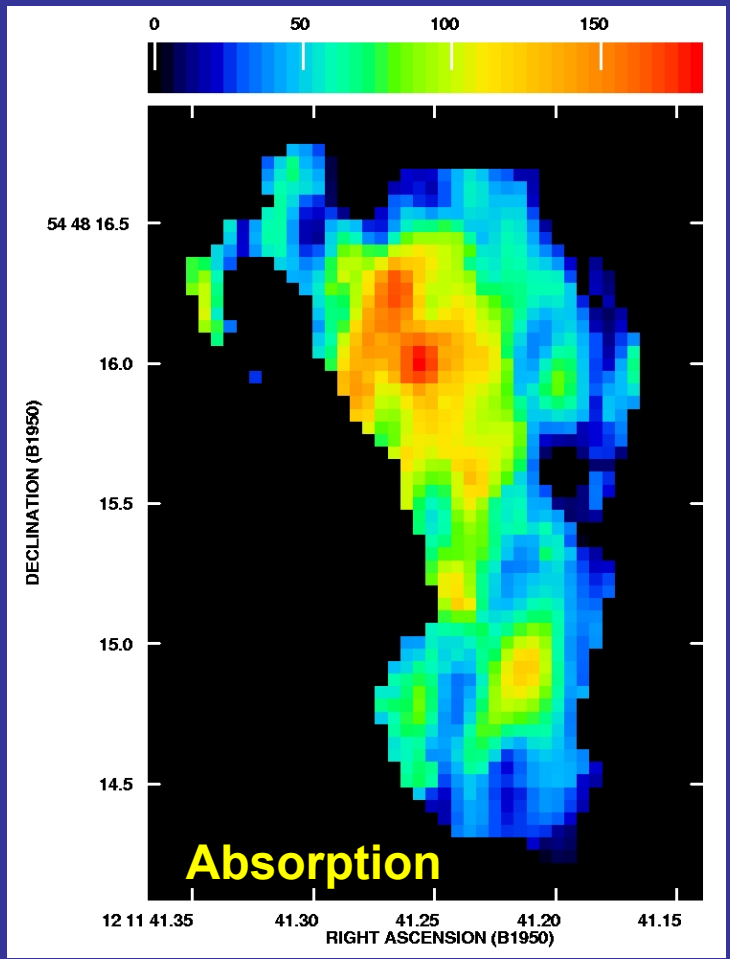




- Deep, high opacity H1 absorption detected.
- Detectable H1 covering most of the nuclear radio continuum.

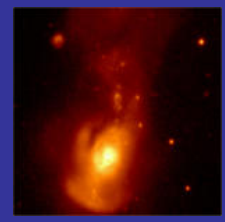
H1 absorption distribution

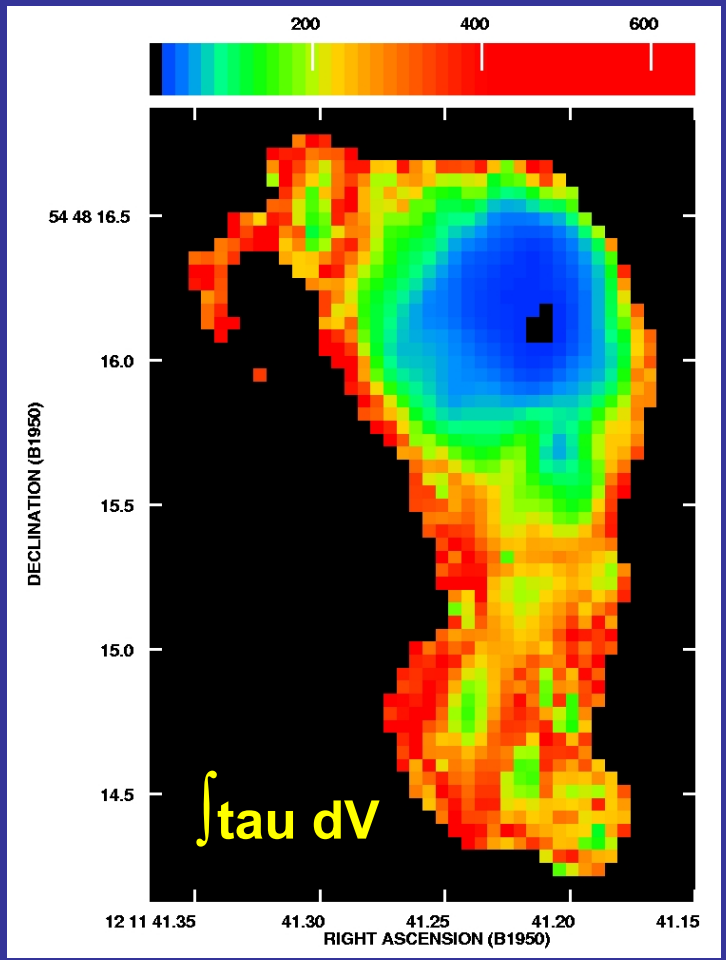




- Large range in the depths of the measured absorption line across the source.
  - Note dependence on size of background radio flux.

H1 gas distribution



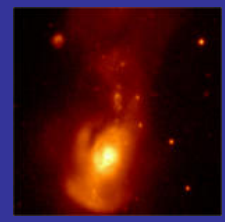


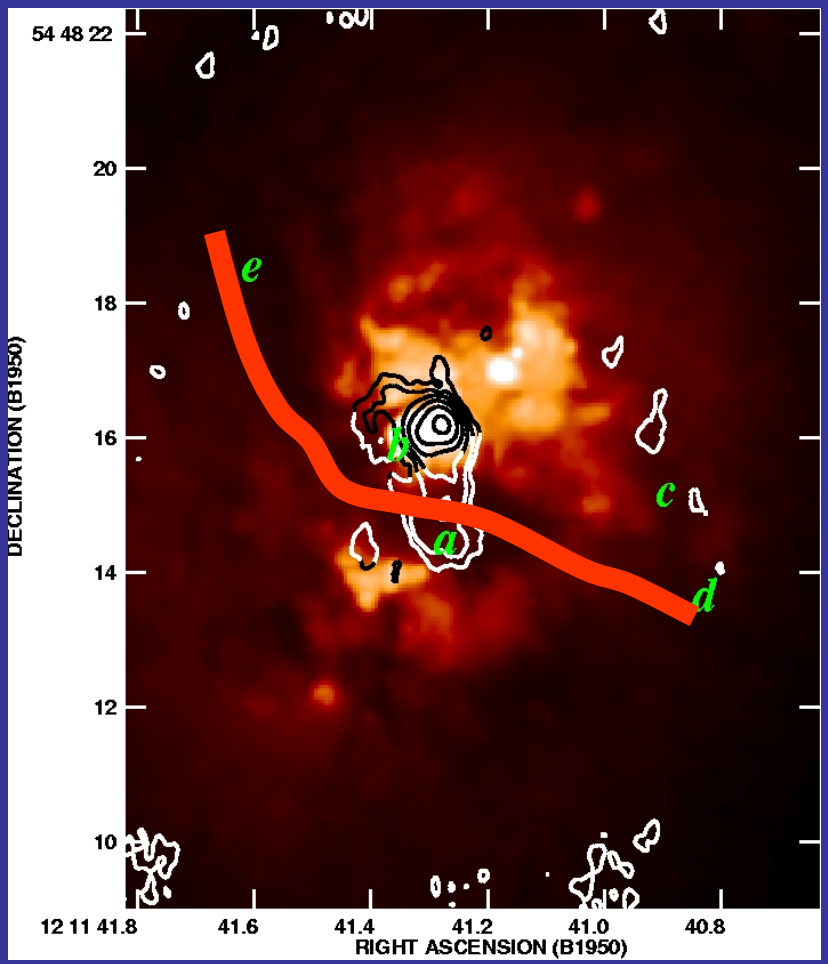
- The distribution of optical depth also displays variability.
  - General tendency to higher tau toward the south.
  - Toward South

    Tau>1
  - Toward core

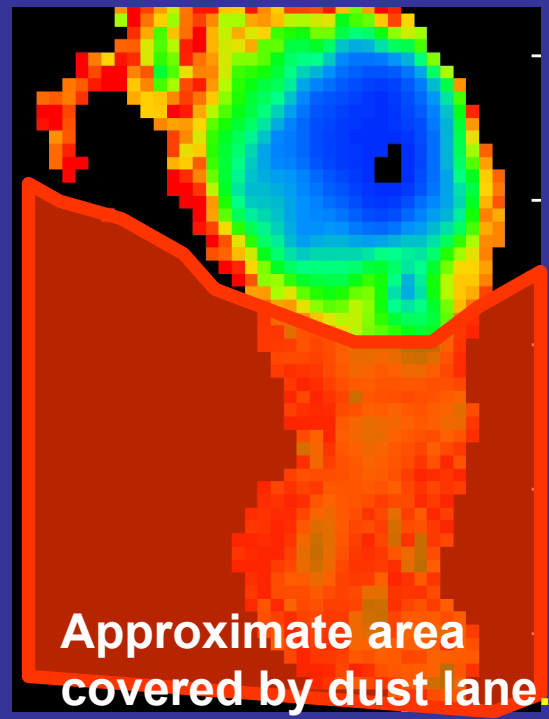
    Tau~0.1→ 0.5

Relative to the dust lane



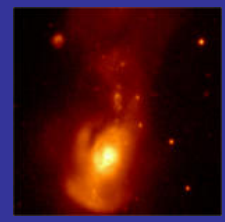


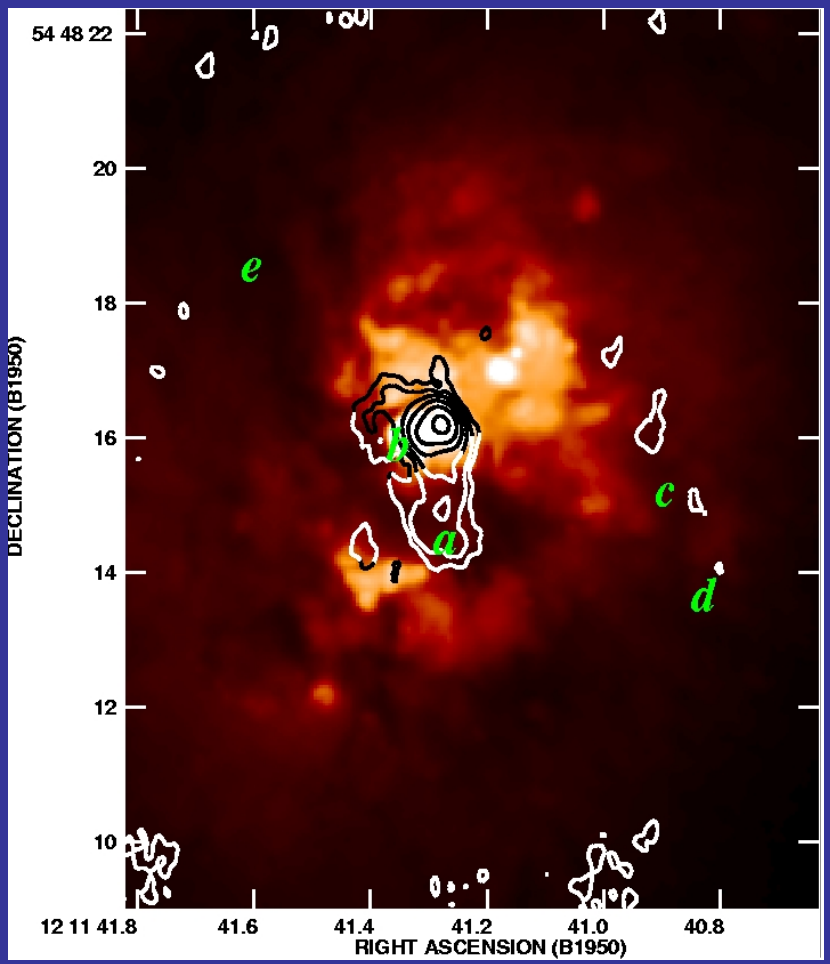
Dust lane tracks across southern part of the nuclear radio continuum.



H1 absorption columns imply an extinction of A_B~4 to 5 in the dust lane.

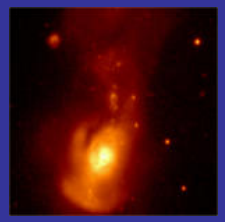
Dust Lane in CO & H1

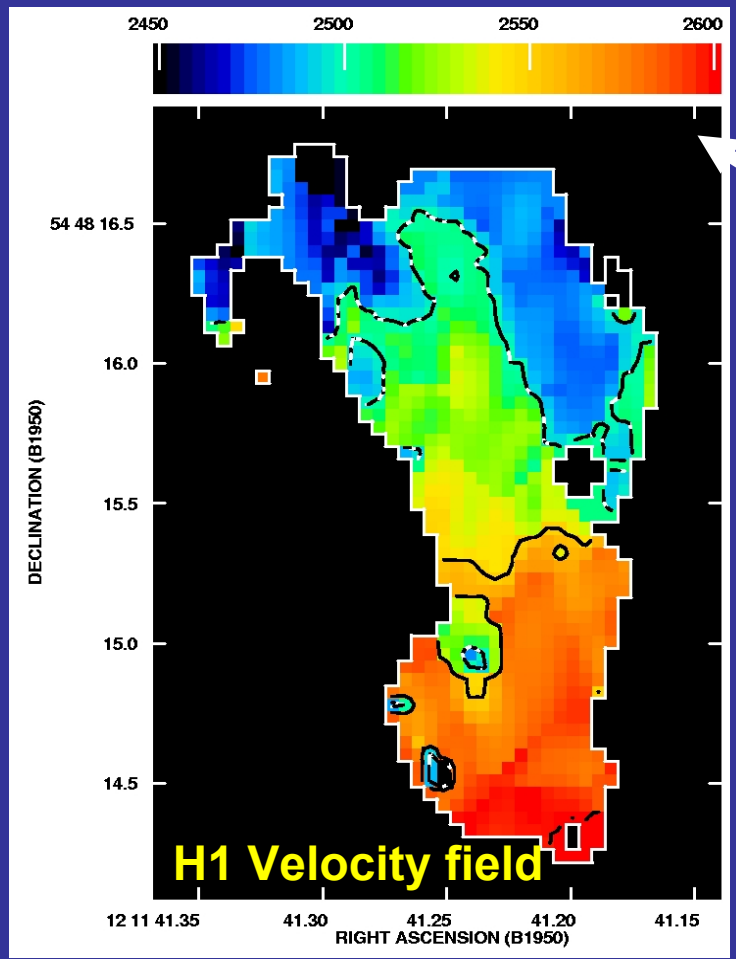




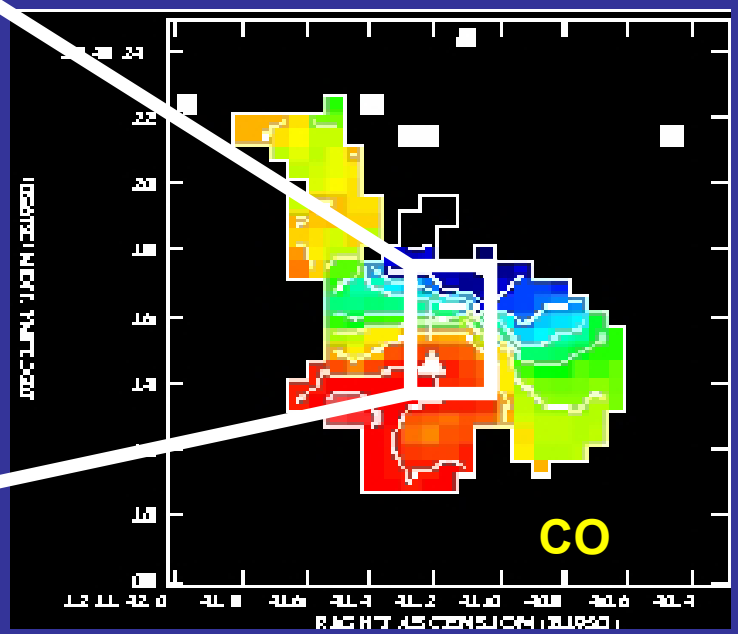
- Note also that the dust lane is co-spatial with the CO emission (AH)
- Implies probable association of dust lane, CO, and H1.
- And all are probably in front of the radio cont.

Velocity fields

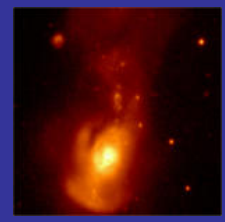


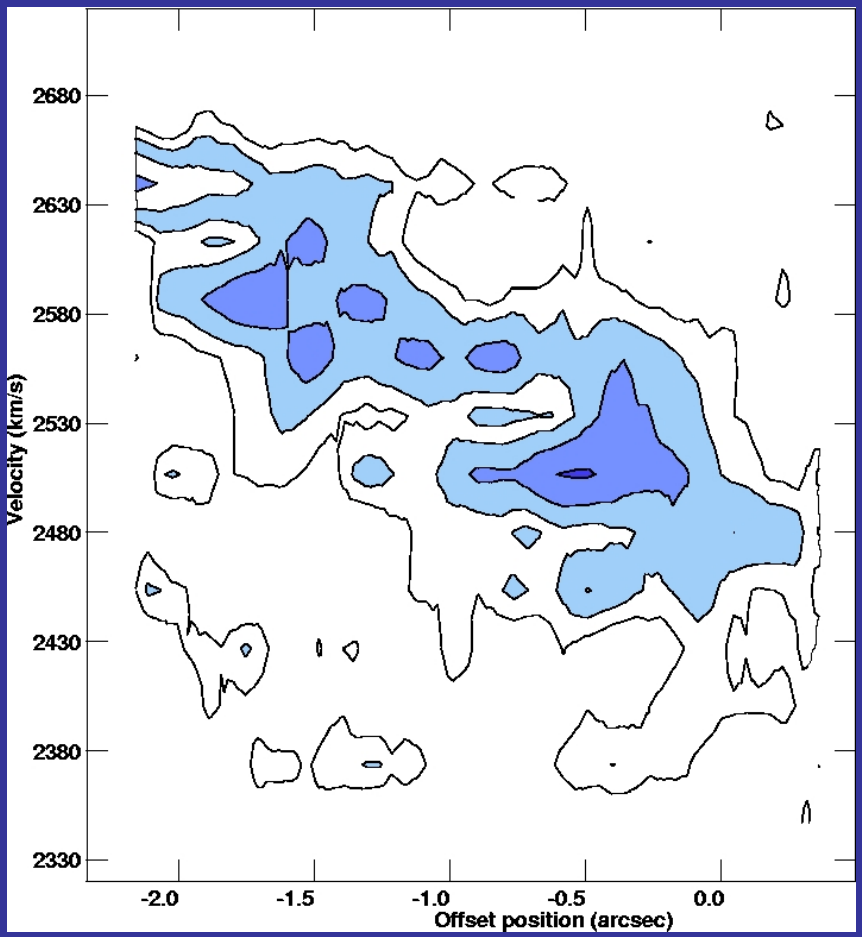


- Sub arcseond H1 velocity field
  - ~ north-south vel. grad.
  - Some twisting and detail now visible in the H1 velocity field.



N-S Position-velocity

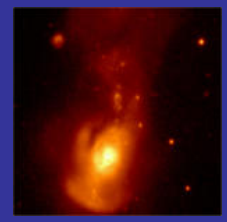


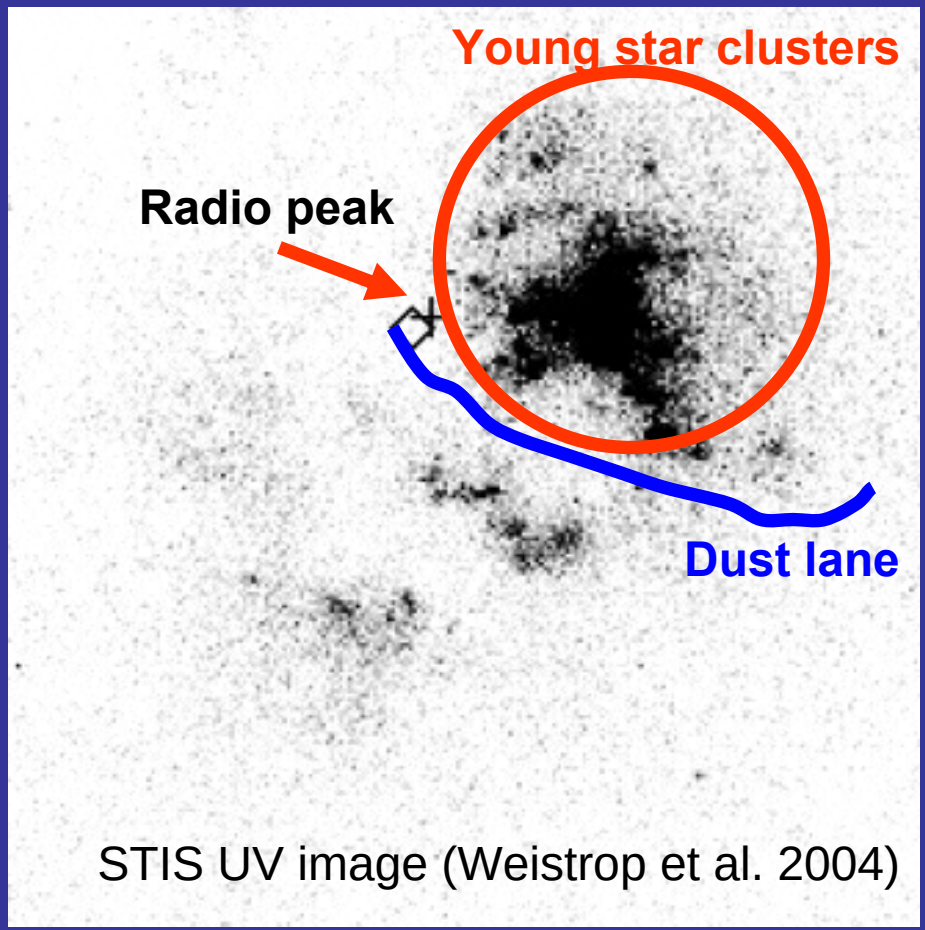


- Velocity gradient
  - ~320km/s/pc

  over ½kpc extent of nuclear region.
  - implies an enclosed mass of $<10^6$ solar masses

Young star clusters

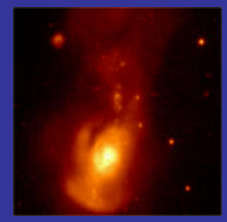


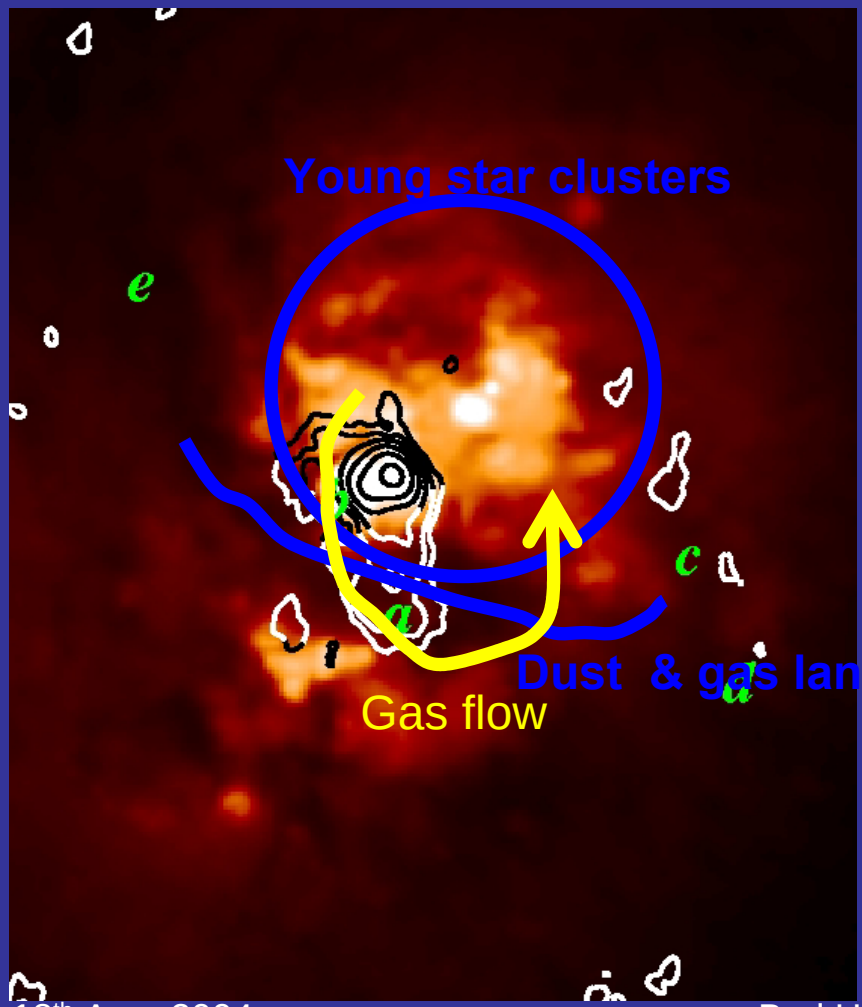


STIS UV image (Weistrop et al. 2004)

- UV STIS observations of young star clusters imply that the majority of the ongoing star-formation is occurring toward the North & West of the radio peaks.

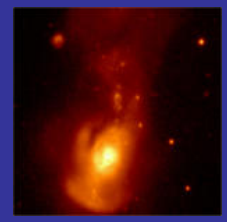
Fuelling of the Starburst?





- Most of the gas & dust resides toward south of the source.
- Whereas the majority of the star formation is to the N & NW.
- Gas circulation from the dust lane to the SF regions.
- & Lowest H1 absorption columns toward north of radio source.
  - Gas & dust in reservoir in dust lane region.
  - Less gas in front of the northern radio source.
- i.e. gas being circulated with some being converted to stars.

Summary



- Using MERLIN radio continuum and sub-arcsecond H1 absorption observations.
  - Radio continuum:-
    - Compact radio components (size < 25pc) detected.
    - AGN-like radio components but relatively weak.
    - Extensive, weak, diffuse 1.4GHz radio emission south of the brightest compact components. -- The radio emission most probably related to the starburst activity and traces the recent star formation.
  - The H1 absorption:-
    - V. deep, high opacity H1 absorption is detected against the majority of the radio continuum.
    - Strong variations in the column density of H1 detected.
      - Largest H1 columns detect toward the south of the source and spatially coincident with the nuclear dust lane, and peaks in the CO emission.
    - Shallow approximately north-south velocity gradient, consistent with lower resolution CO observations. → apparent rotation about the central region.
      - If solid-body rotation is assumed results in an enclosed mass estimate of $10^6 M_{sun}$
    - Is the dust lane the fuel reservoir for the young star-formation.