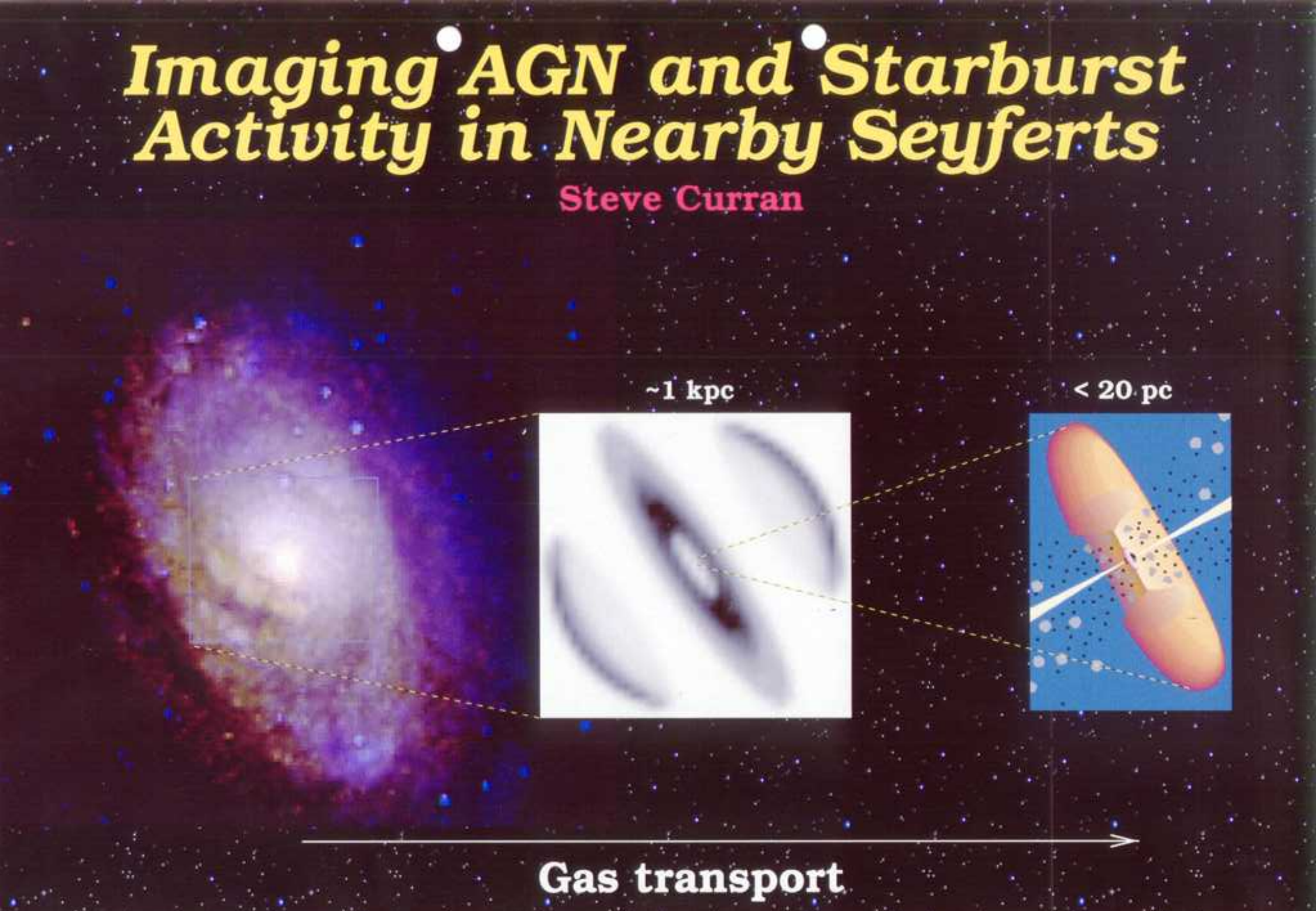
Imaging AGN and Starburst Activity in Nearby Seyferts

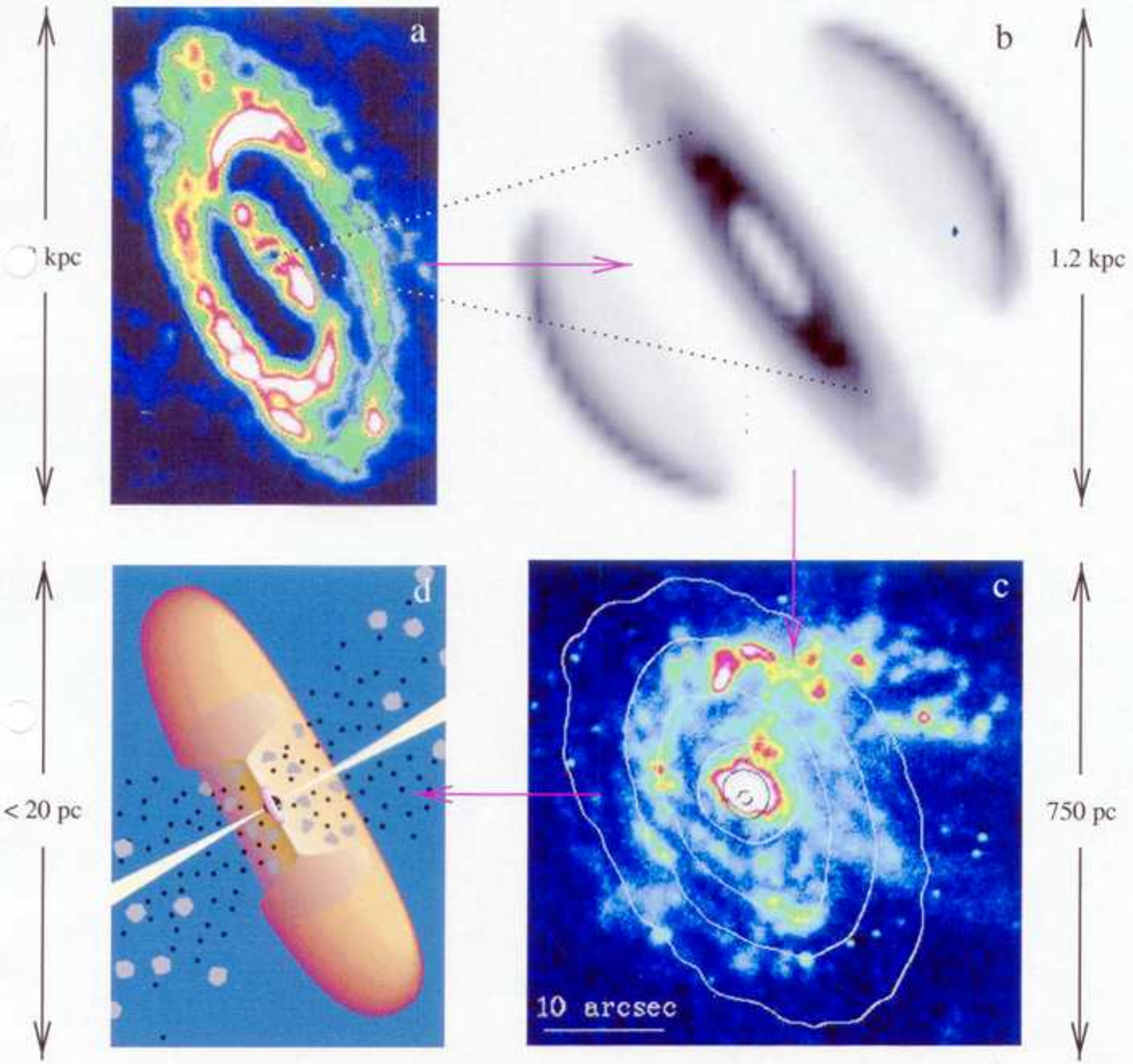
Steve Curran



Rings of Gas in Circinus

a. HI by ATCA (Jones et al., 1999, MNRAS 302, 649)

b. Model of the molecular ring as traced by CO



c. Ionised gas as traced by Hα+[NII]

d. Schematic of the dense nuclear obscuration

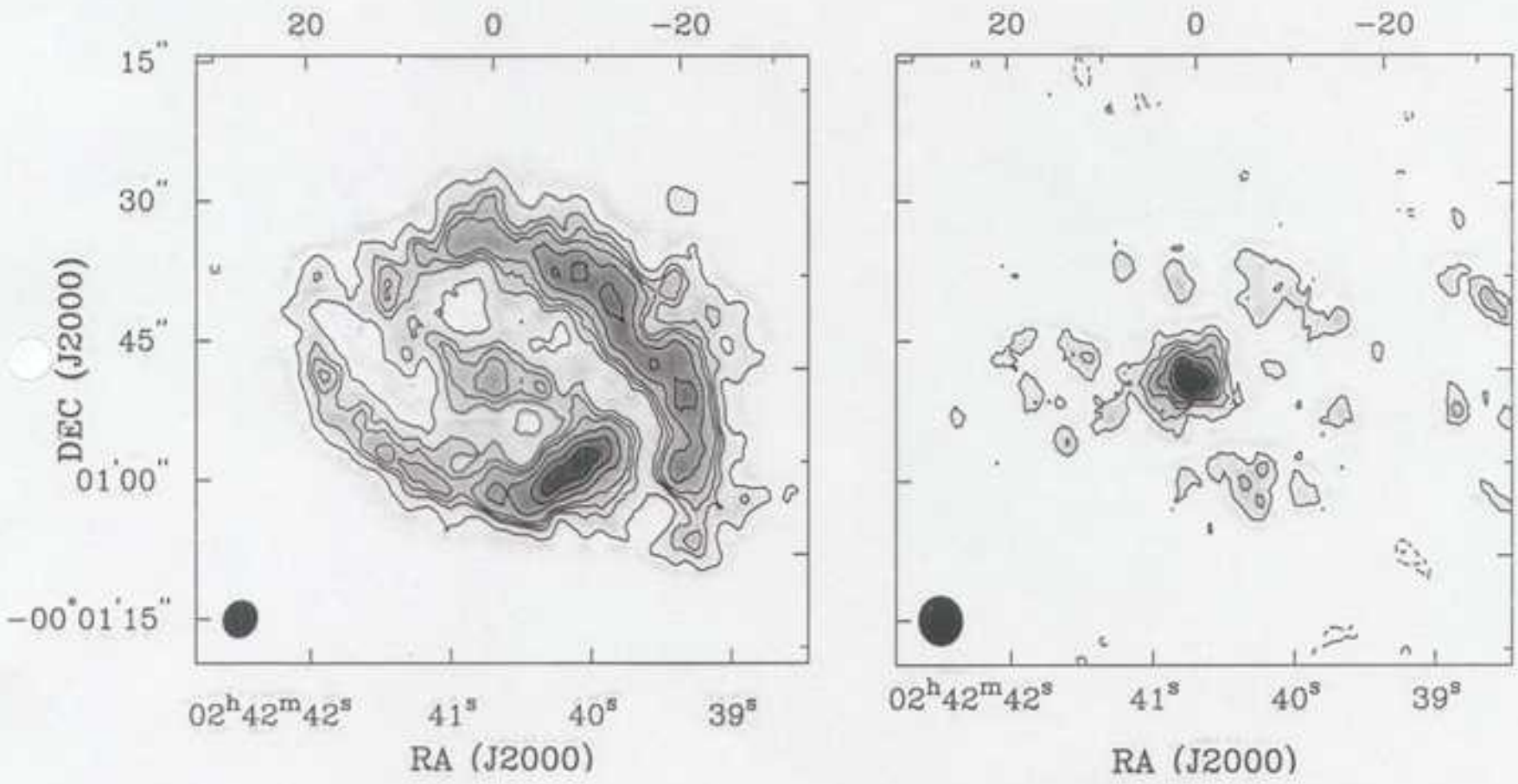
These are general features of Seyfert galaxies

Also in Seyferts & Starbursts (ULIRGS)

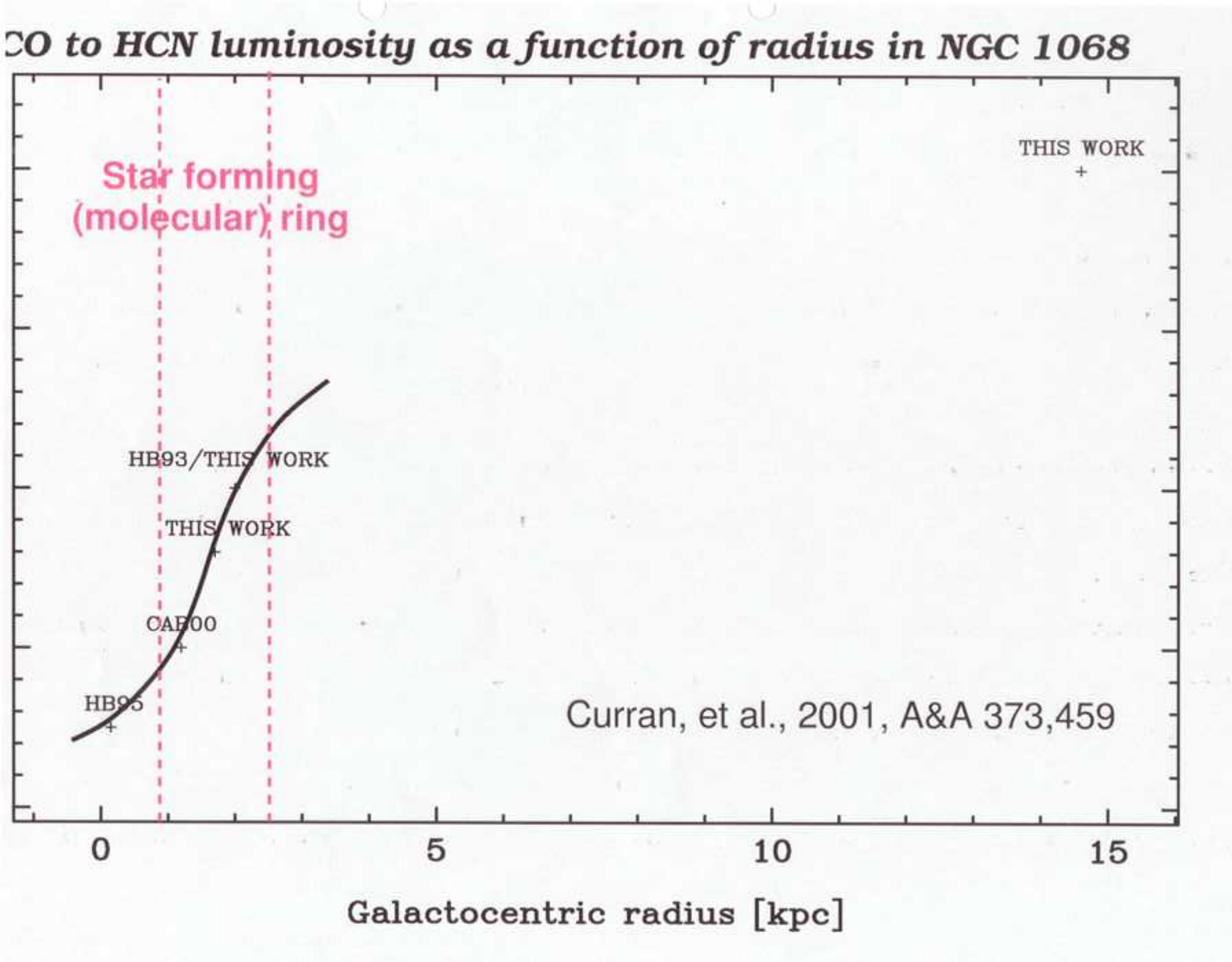
Star formation occurs in the ~100 pc–scale molecular ring (as traced by CO).

It is traditionally believed that the dense gas (as traced by HCN) is located in sites of star formation.

BUT, the bulk HCN is not necessarily located in the CO ring. For example, NGC 1068...



CO and HCN in NGC 1068, from Helfer & Blitz, 1995, ApJ 450, 90. At 15 Mpc this is one of the closest Seyferts in the northern sky and the 4" beam corres–ponds to a resolution of ~300 pc at this distance.


CO to HCN luminosity as a function of radius in NGC 1068
Star forming
(molecular) ring
THIS WORK
HB93/THIS WORK
THIS WORK
CAB00
HB93
Curran, et al., 2001, A&A 373,459
0
5
10
15
Galactocentric radius [kpc]

Back to NGC 4945 and Circinus...

From multi-transitional studies of several molecules, Curran et al, 2001, A&A 367, 457

found $n_{H_2} \sim 10^4$ cm^{-3} in NGC 4945

and $n_{H_2} \sim 10^5$ cm^{-3} in Circinus

Although $\frac{L_{HCN}}{L_{CO}}$ (NGC 4945) ~ $2\frac{L_{HCN}}{L_{CO}}$ (Circinus)

(The molecular rings share the same dynamical masses)

Also $\frac{L_{HCN}}{L_{FIR}}$ (NGC 4945) ~ $2\frac{L_{HCN}}{L_{FIR}}$ (Circinus)

That is, excess HCN in NGC 4945 c.f. the bulk molecular gas and FIR radiation, although this is in a less dense phase than in Circinus.

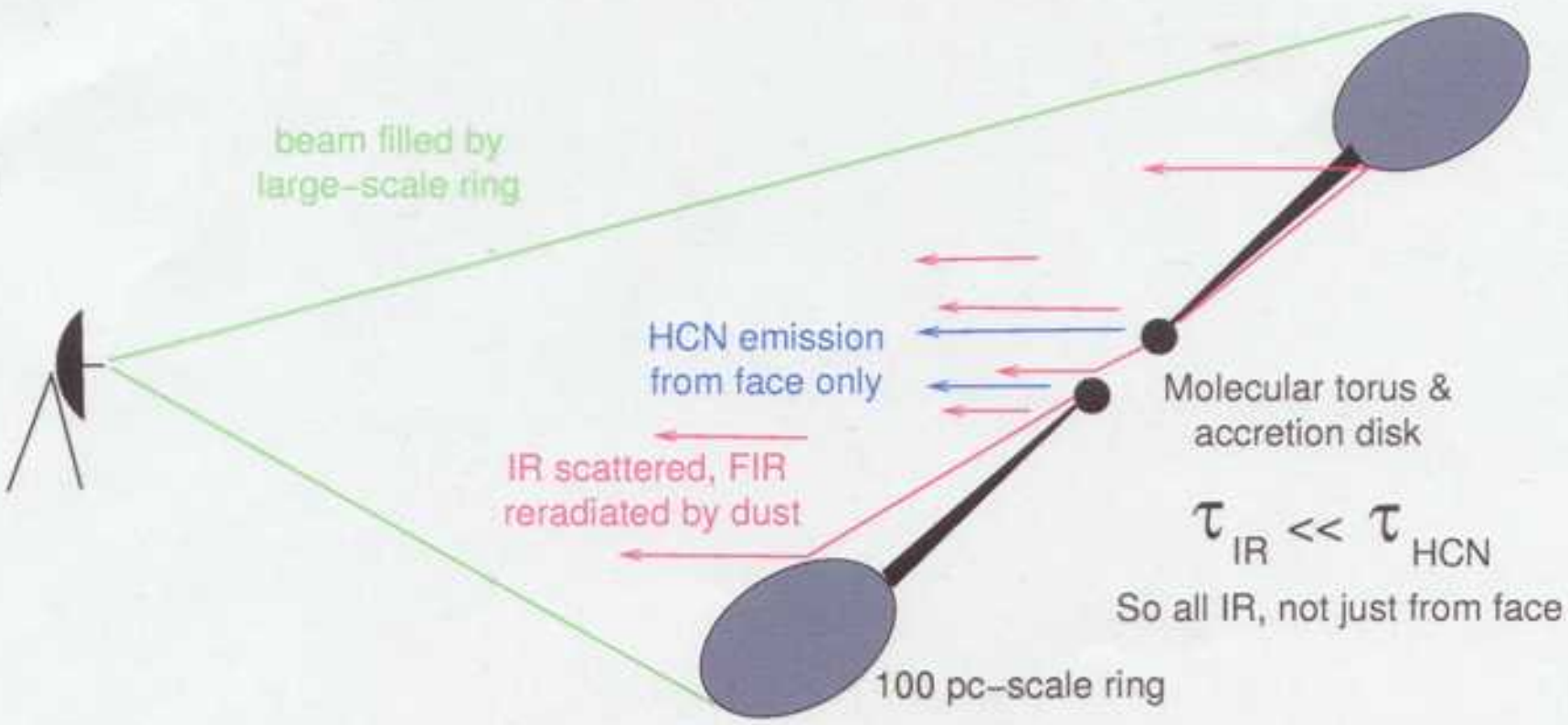
So some of the HCN is associated with the obsuration as in NGC 1068.

From a sample of nearby Seyferts

Curran et al, 2001, A&A 373, 459 find that, in general, the HCN/CO ratio increases towards the nucleus in beyond the region of powerful star formation.

Also in the sample (including NGC 4945 & Circinus), some FIR also associated with the nucleus – cannot be attributed purely to star formation, which is usually the case.

But L_{FIR} / L_{HCN} is found to increase with L_{FIR} (more luminous and distant galaxies), so is there a beam filling effect?



CONCLUSION: Further statistics of little value with high resolution observations being the key.

The mm-equipped ATCA

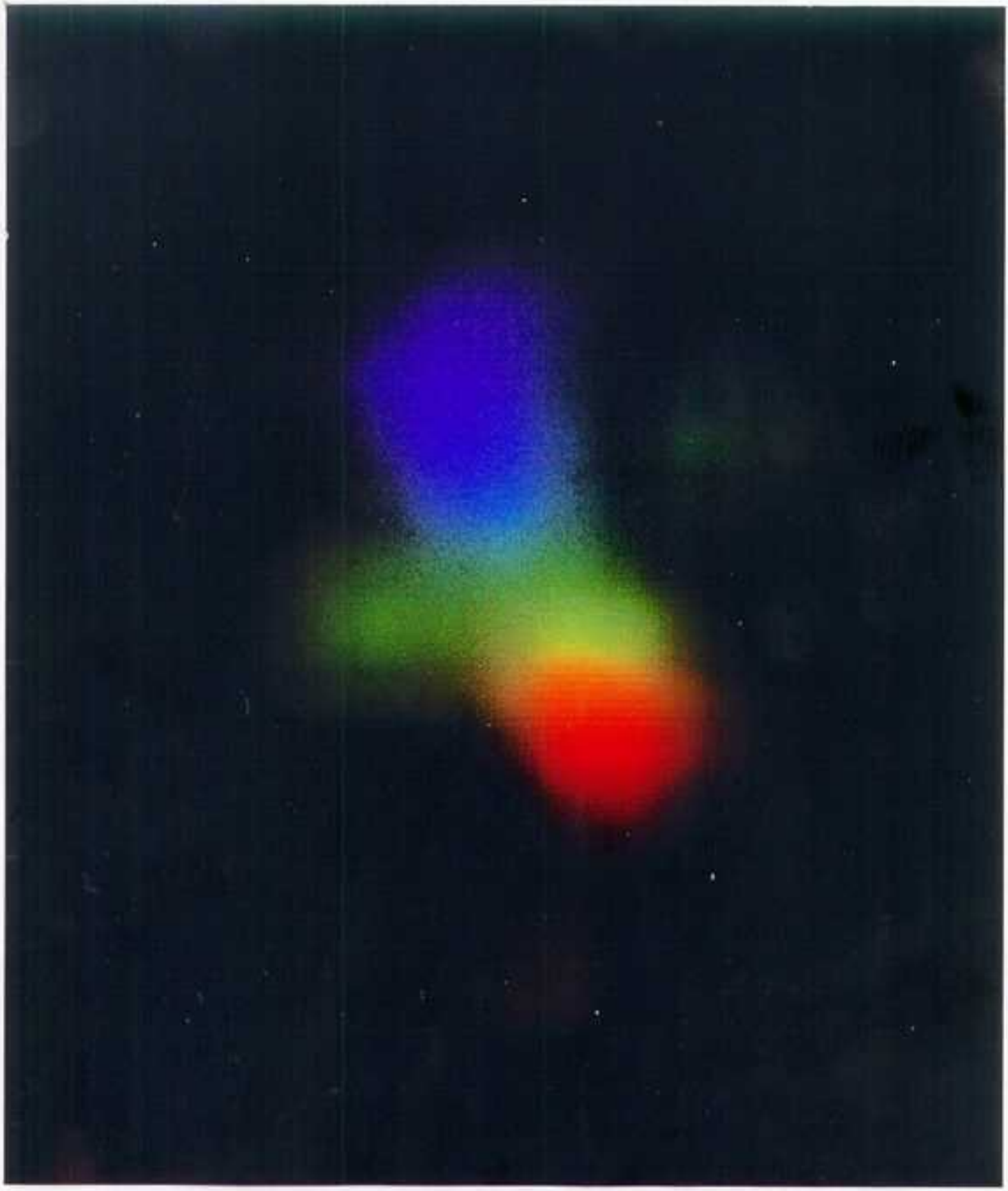
Only interferometer capable of observing molecular gas in the closest examples of Seyfert nuclei; NGC 4945, Circinus as well as Centaurus A.

At 4 Mpc (and $\delta \approx -60°$) the EW352 & 375 arrays will give a resolution of ≈100 pc (5") and the 1.5D array could give a res–olution as high as ≈ 10 pc (0.5").

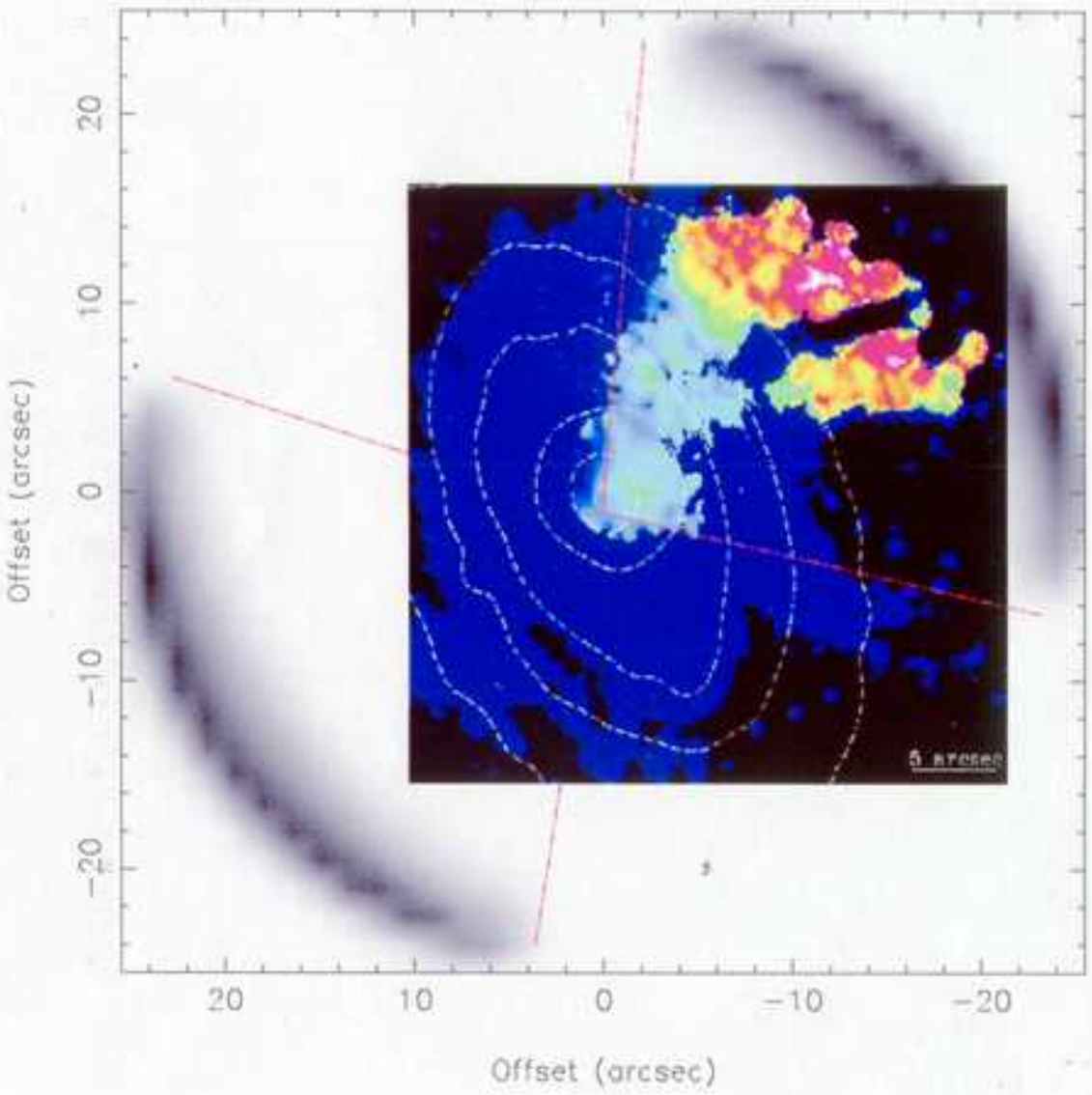
So in these (and perhaps other southern Seyferts) we could image the HCN dist–ribution and compare this with that in Circinus (as well as a sample of starburst galaxies) to see if the molecular gas is indeed less centrally concentrated.

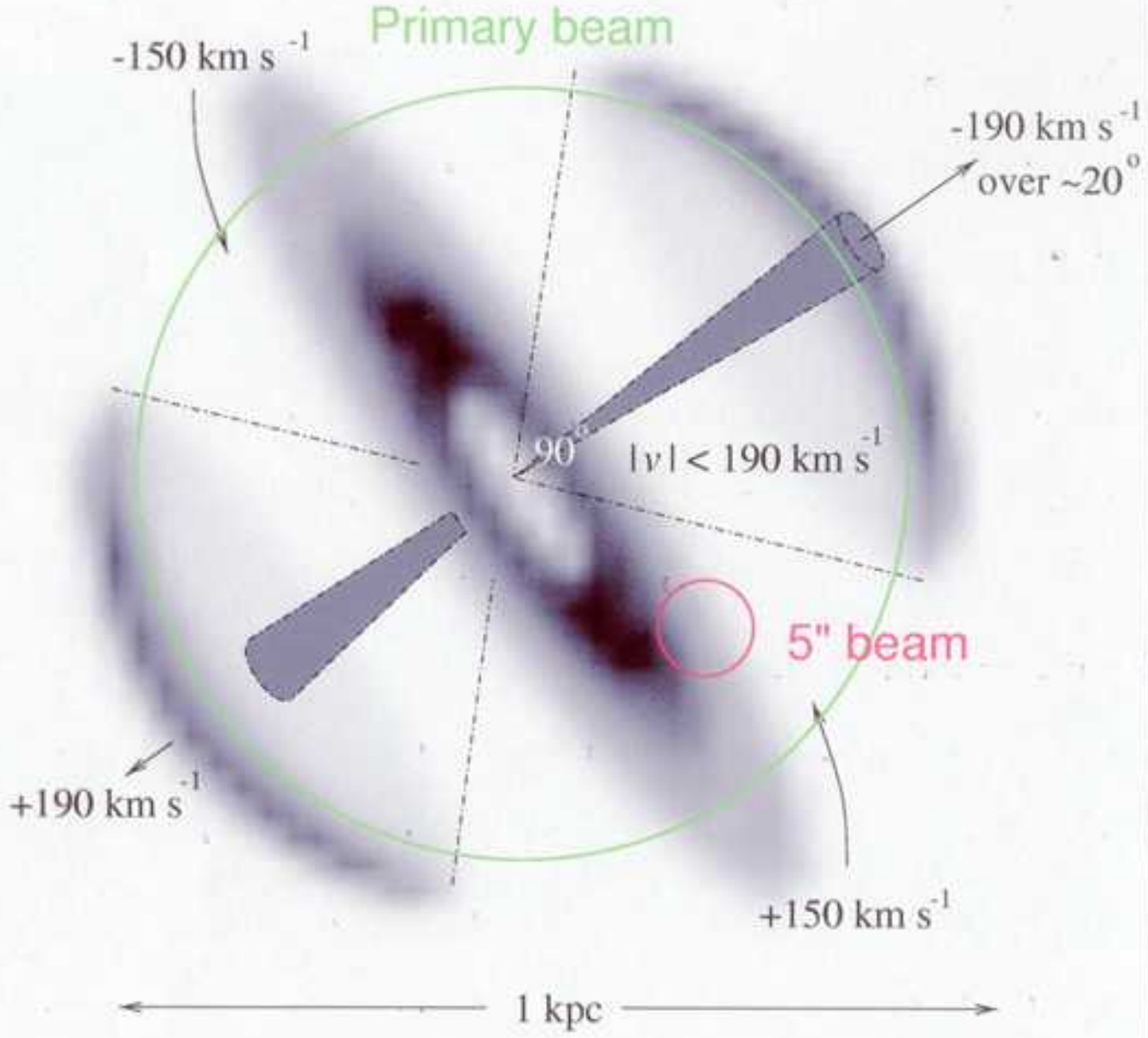
How is the dense gas distributed between the nucleus and star forming ring?

Also, molecular outflows in Seyferts...



The molecular ring and outflow in Circinus shown in relation to the ionisation cone





Curran, 2001, A&A, 376, 402

Summary

High resolution observations of the molecular gas in NGC 4945 and Circinus can determine:

1) The different gas distributions and how these relate to the observed line ratios.

2) The presence of any molecular outflows expected but so far only possibly obse–rved in 3 cases (NGC 3079, Circinus & Cen A, see Curran, 2001, A&A 376, 402).

BUT, each line is ≈400 km/s wide and the bandwidth is only ≈700 km/s (0.2 GHz).
AND, for a 6 σ image expect (25" source)

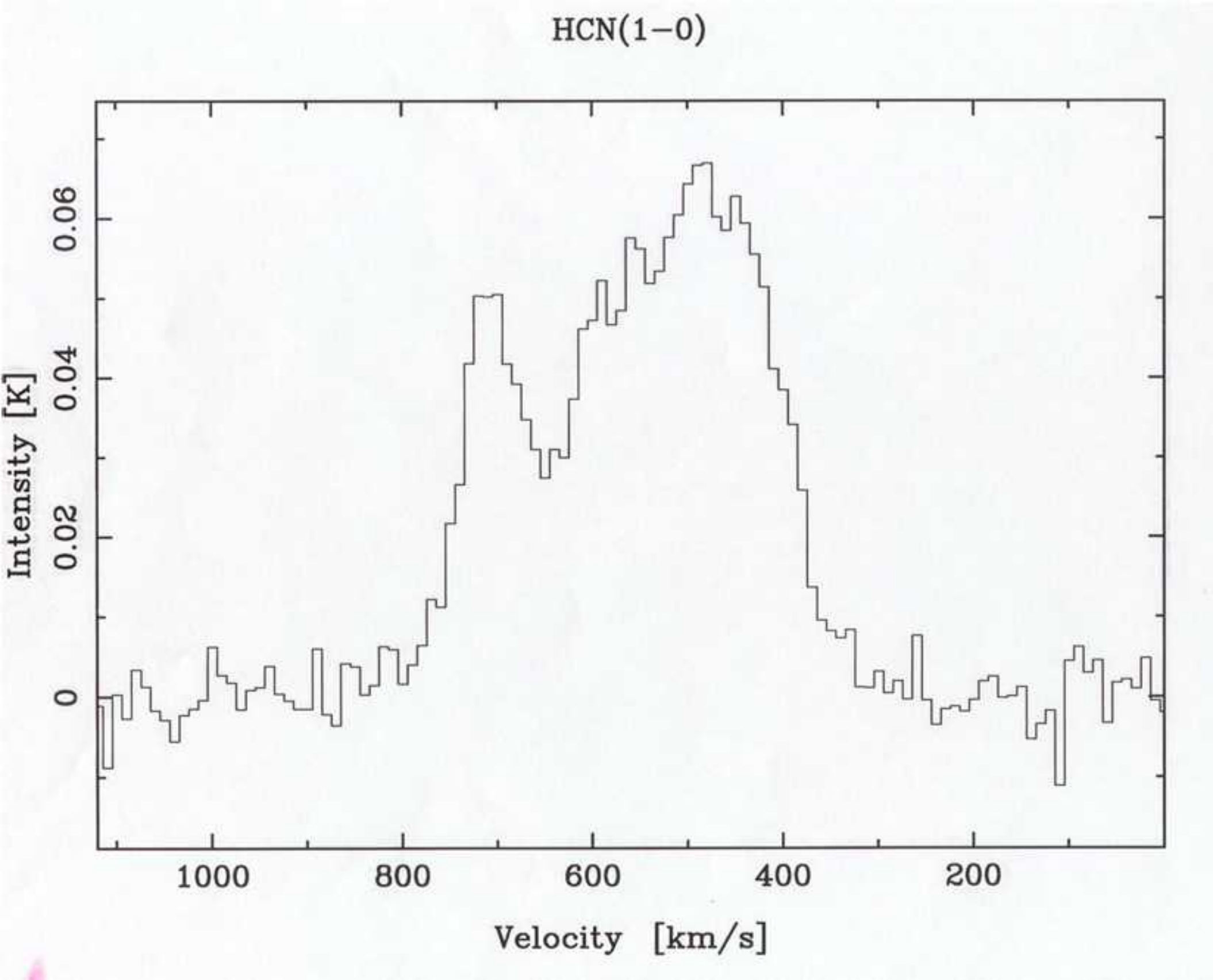
~5 hrs for resolution of 5"

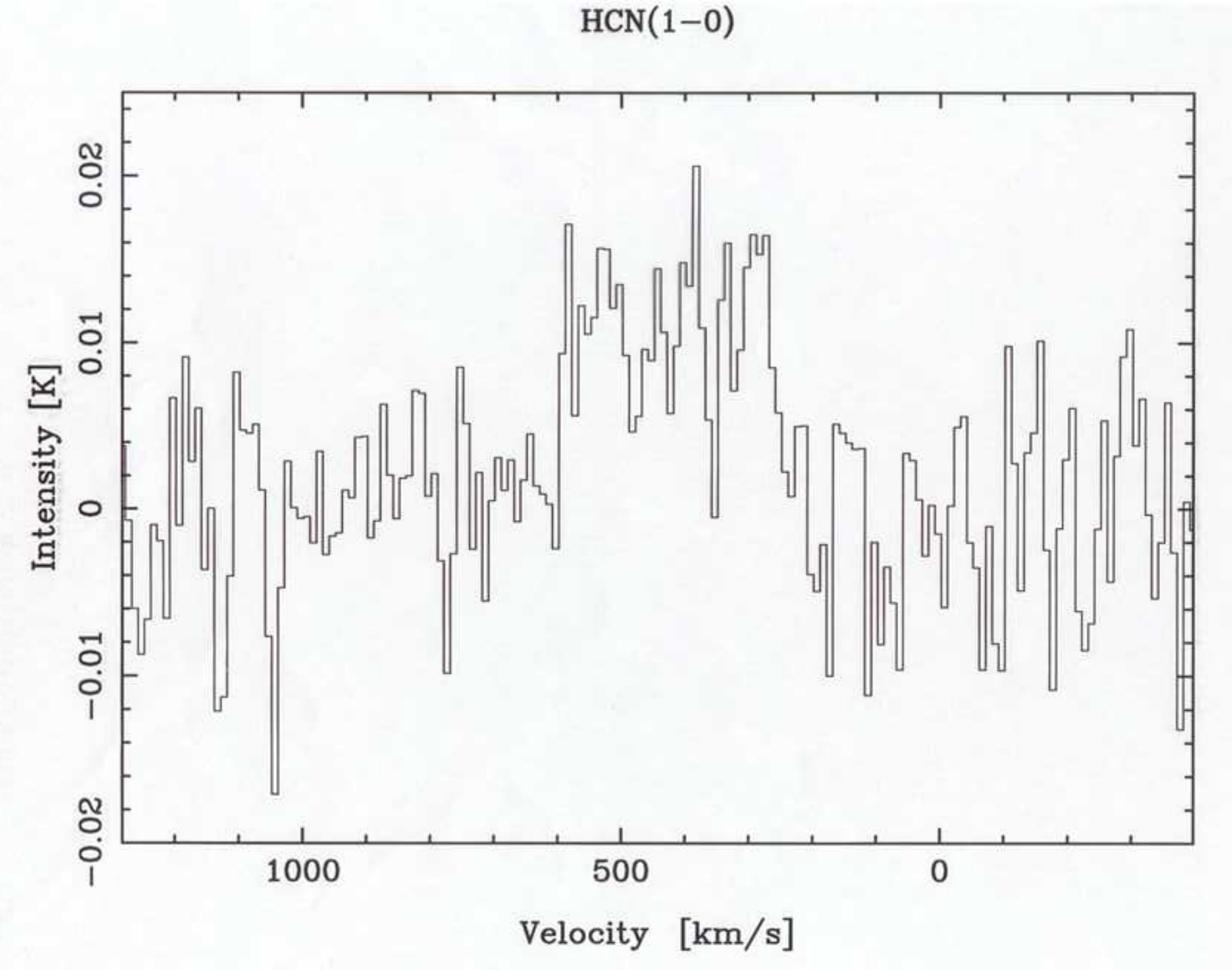
~200 hrs for resolution of 2"

in NGC 4945, ~10 times these in Circinus.

If these two problems could be overcome – using all 5 antennae each equipped with 2 correlators:

ATCA could be the first mm–array to pro–duce such images in Seyferts at < 10 Mpc giving unparalleled detail.


HCN(1−0)
Intensity [K]
0
0.02
0.04
0.06
1000
800
600
400
200
Velocity [km/s]


HCN(1−0)
Intensity [K]
0.02
0.01
0
−0.01
−0.02
1000
500
0
Velocity [km/s]