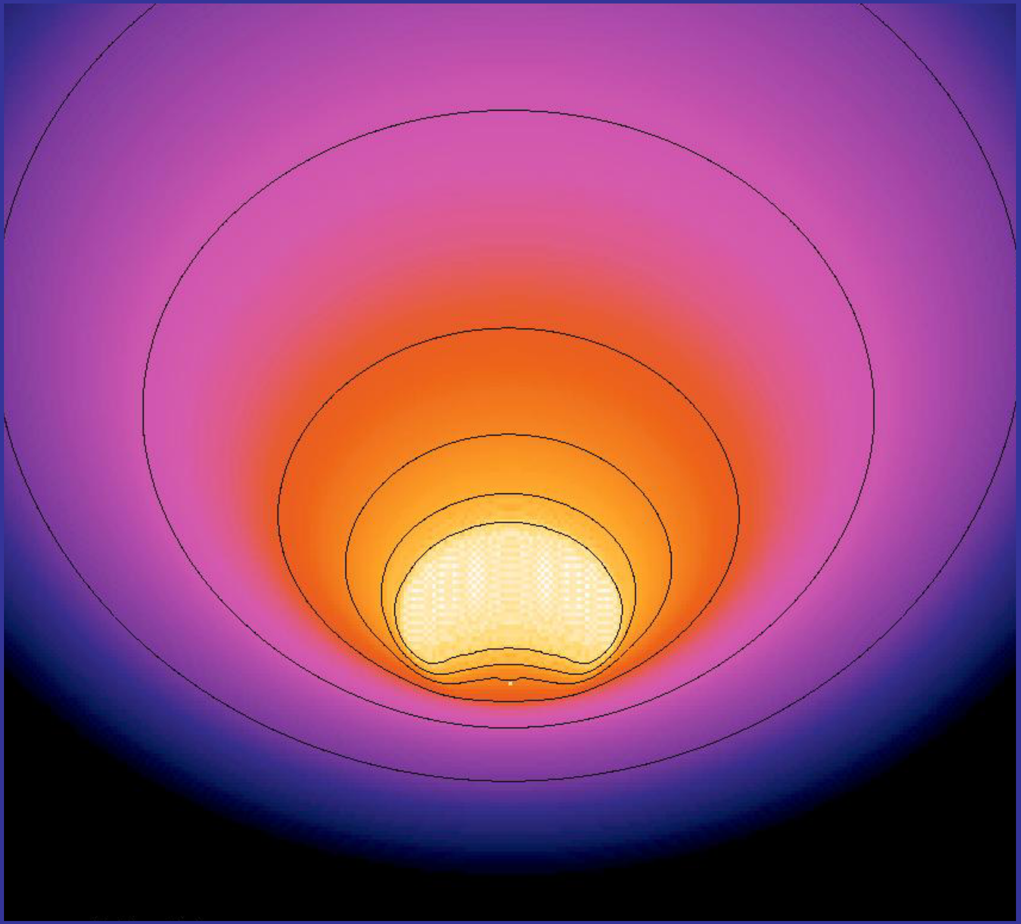
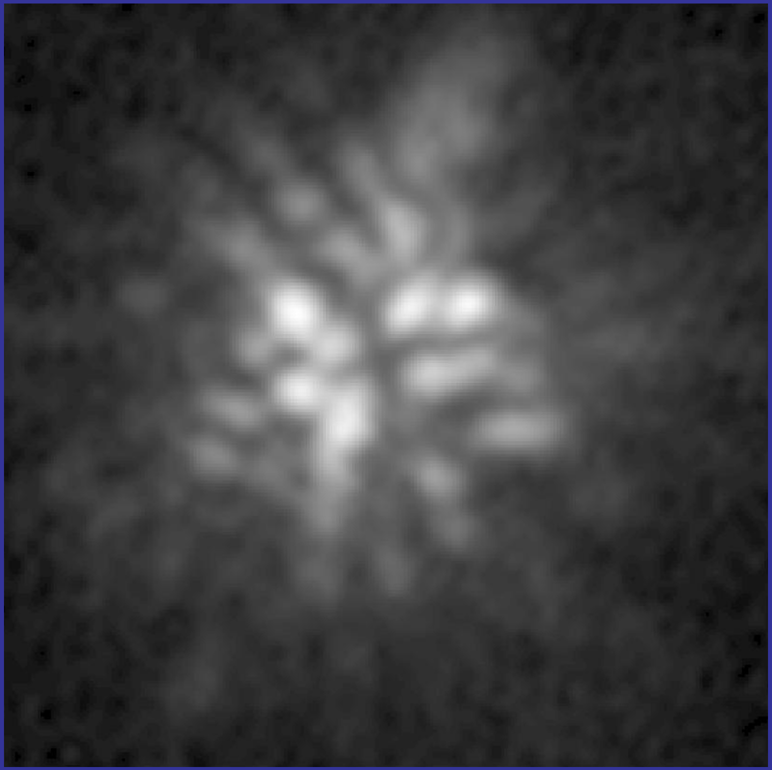
Bispectrum speckle interferometry of NGC 1068



G. Weigelt, M. Wittkowski, Y. Balega, T. Beckert, K.-H. Hofmann, S. Menshchikov



1.8''

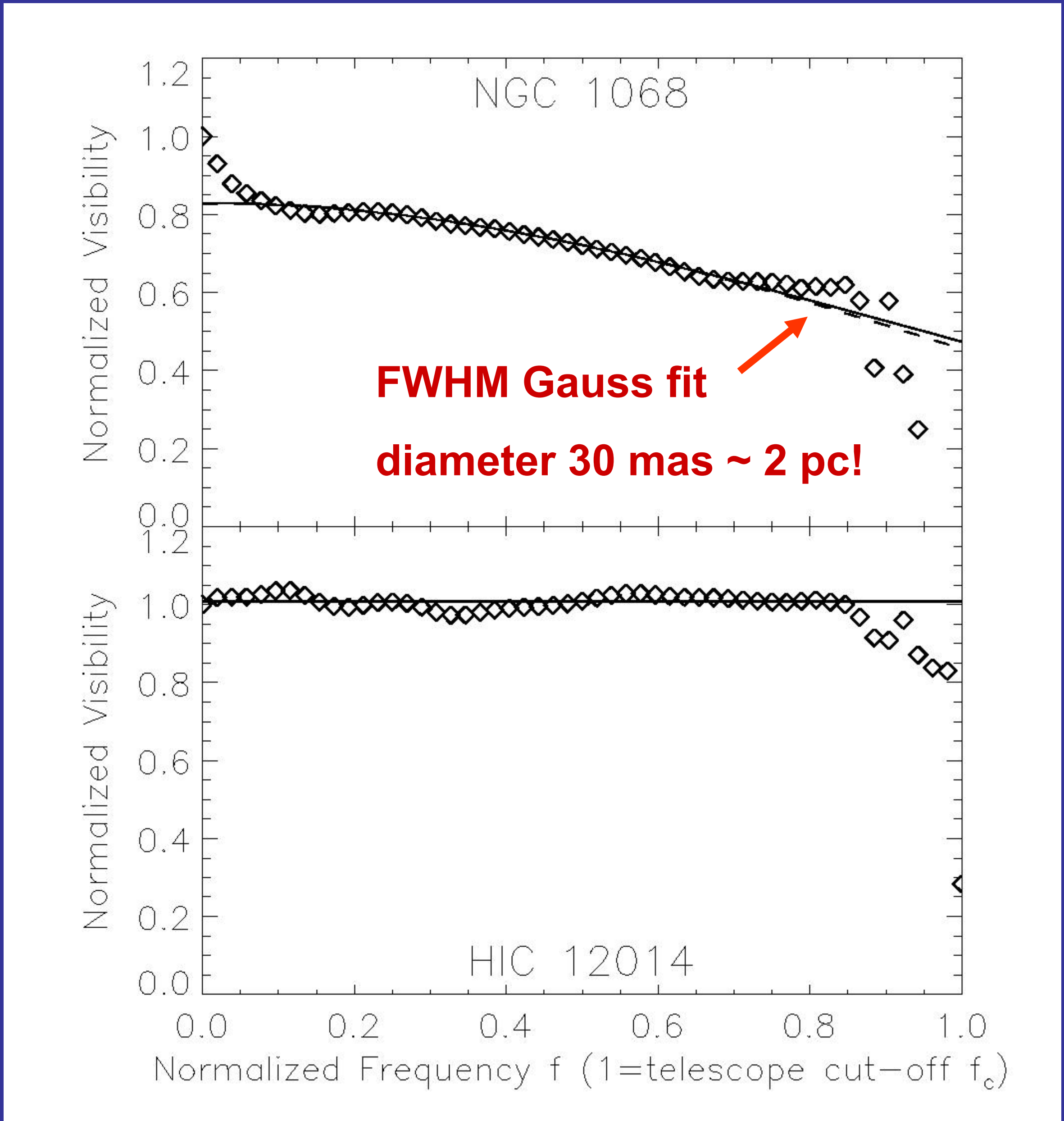
K-band speckle interferogram
of NGC 1068:

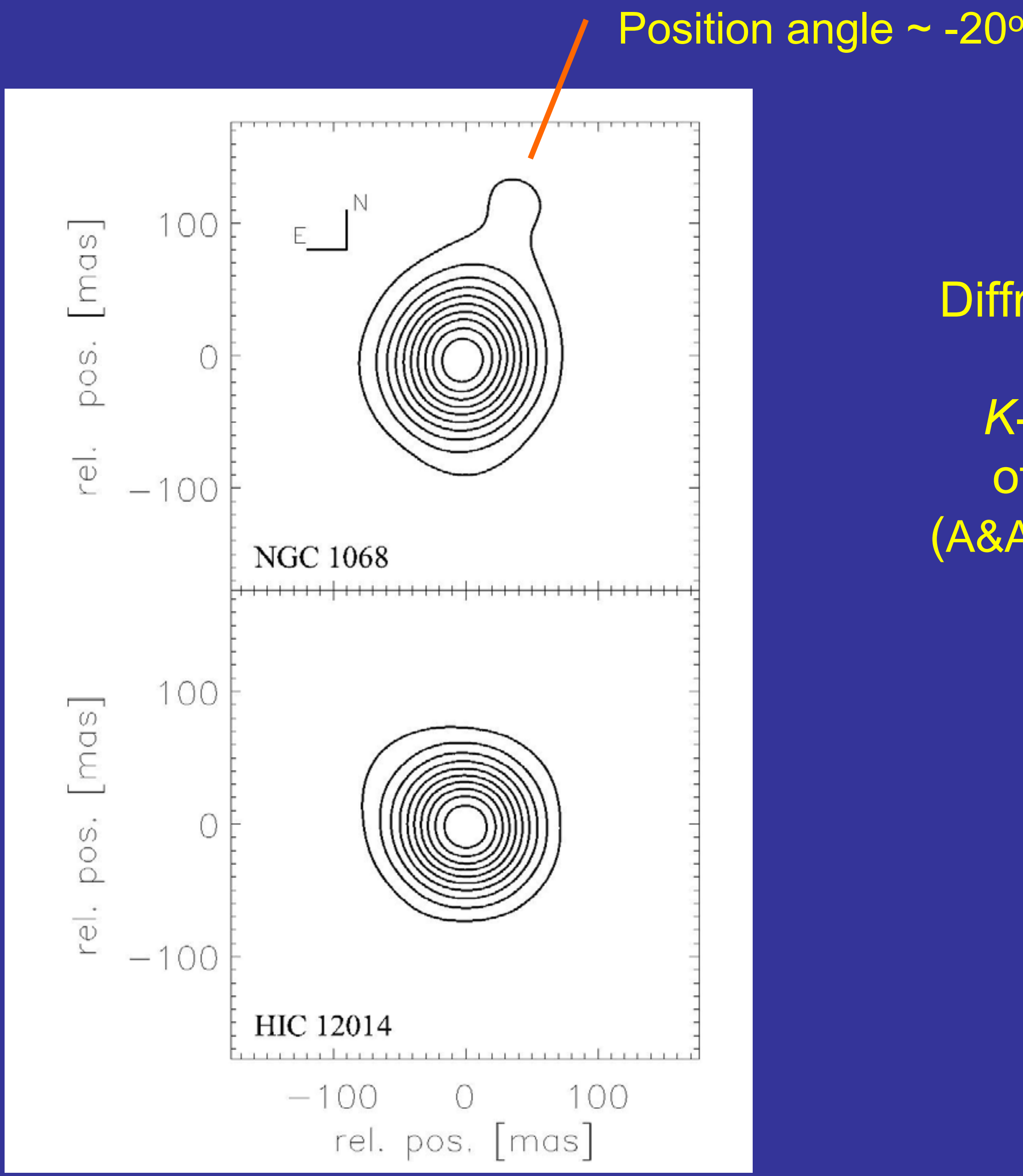
6 m SAO telescope,
exposure time 200 ms,
FOV 1.8 x1.8 ''

Azimuthally averaged visibility of NGC 1068 (top) and an unresolved reference star (bottom)

Wittkowski et al.
A&A 329, L45, 1998

1999: Weinberger et al. confirmed this result (AJ 117, 2748)



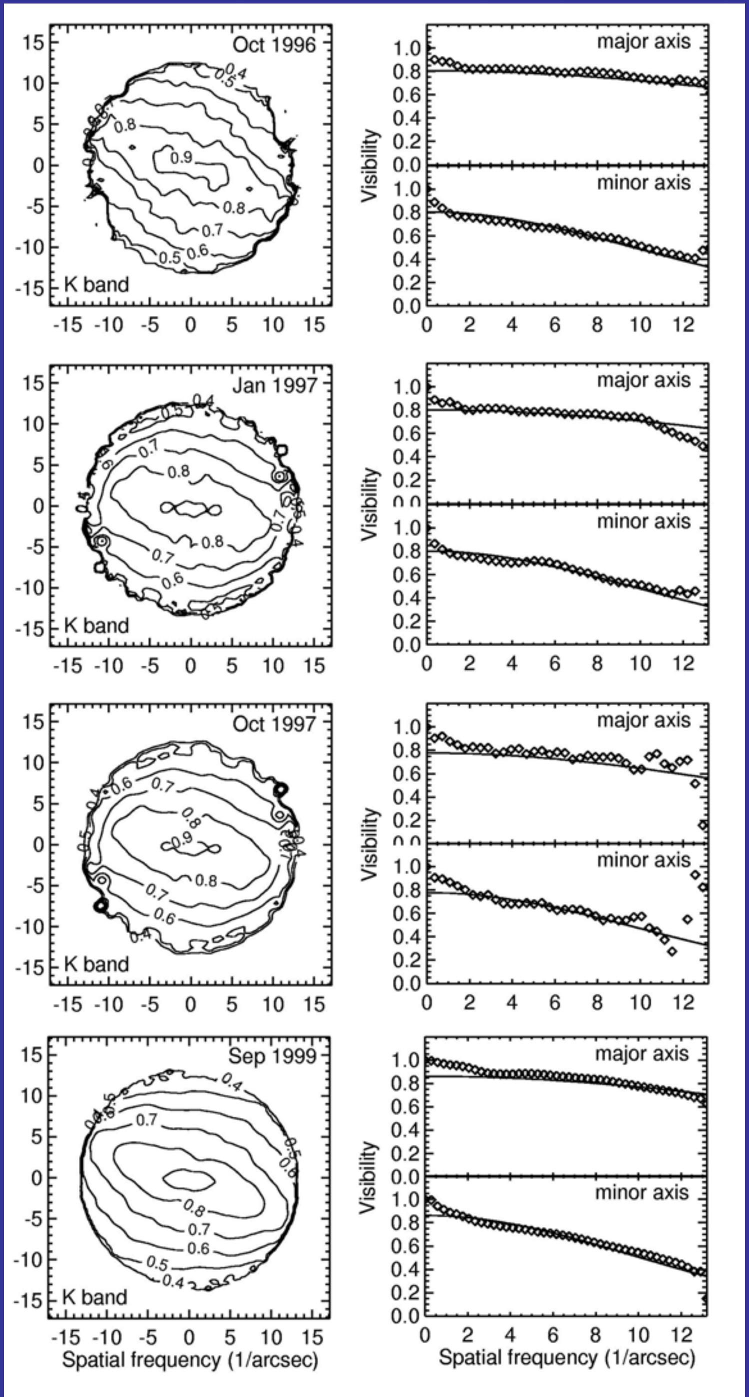


Diffraction-limited,
elongated
K-band image
of NGC 1068
(A&A 329, L45, 1998)

NGC 1068:

visibility functions derived from 4 different data sets

Weigelt et al., A&A 425, 77 (2004)



major axis

19 x 40 mas

minor axis

20 x 40 mas

24 x 40 mas, 600 frames, 2'' seeing

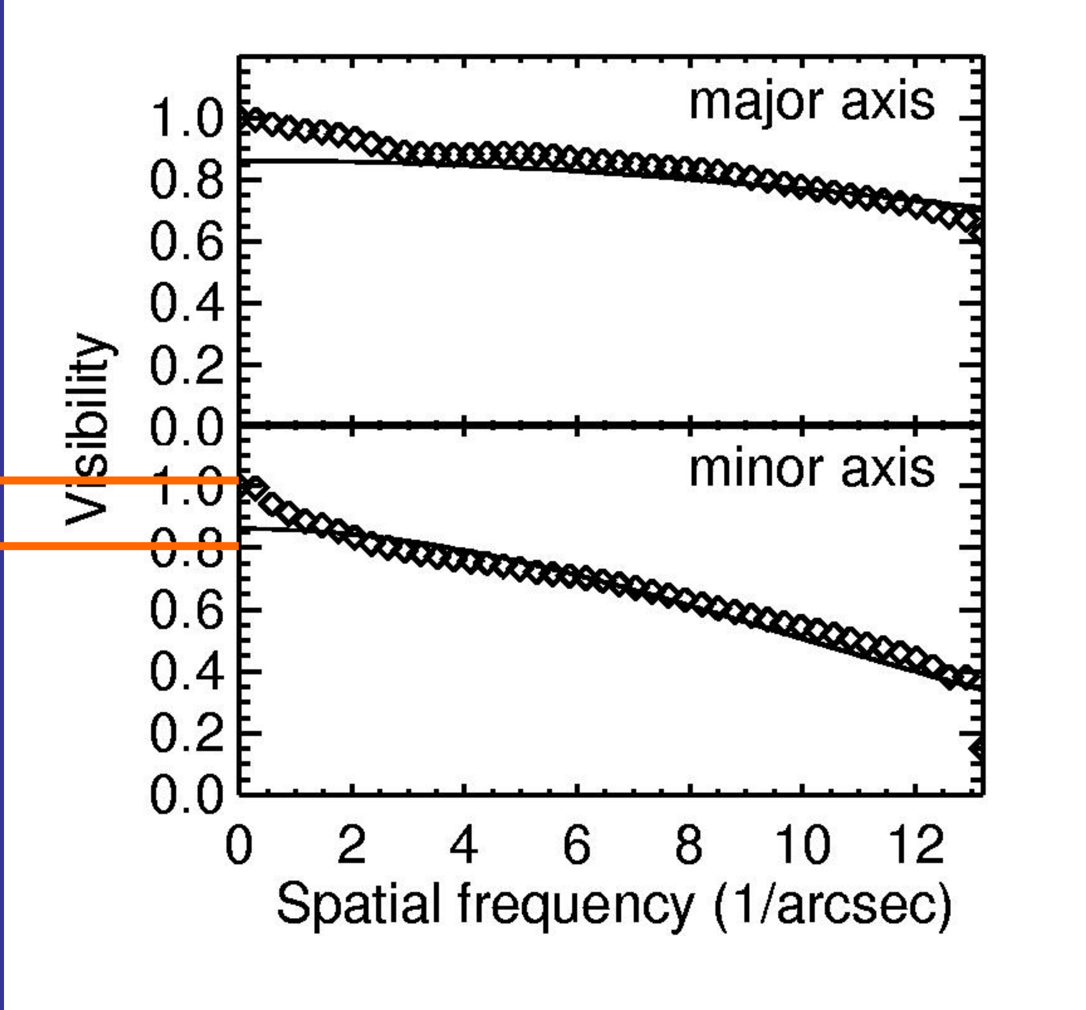
18 x 38 mas ~ **1.5 x 3 pc**

error +/- 3 mas

11 000 frames,

1.2'' seeing

K-band flux of the 20 x 40 mas object



~18-20 %

Photometric K-band results

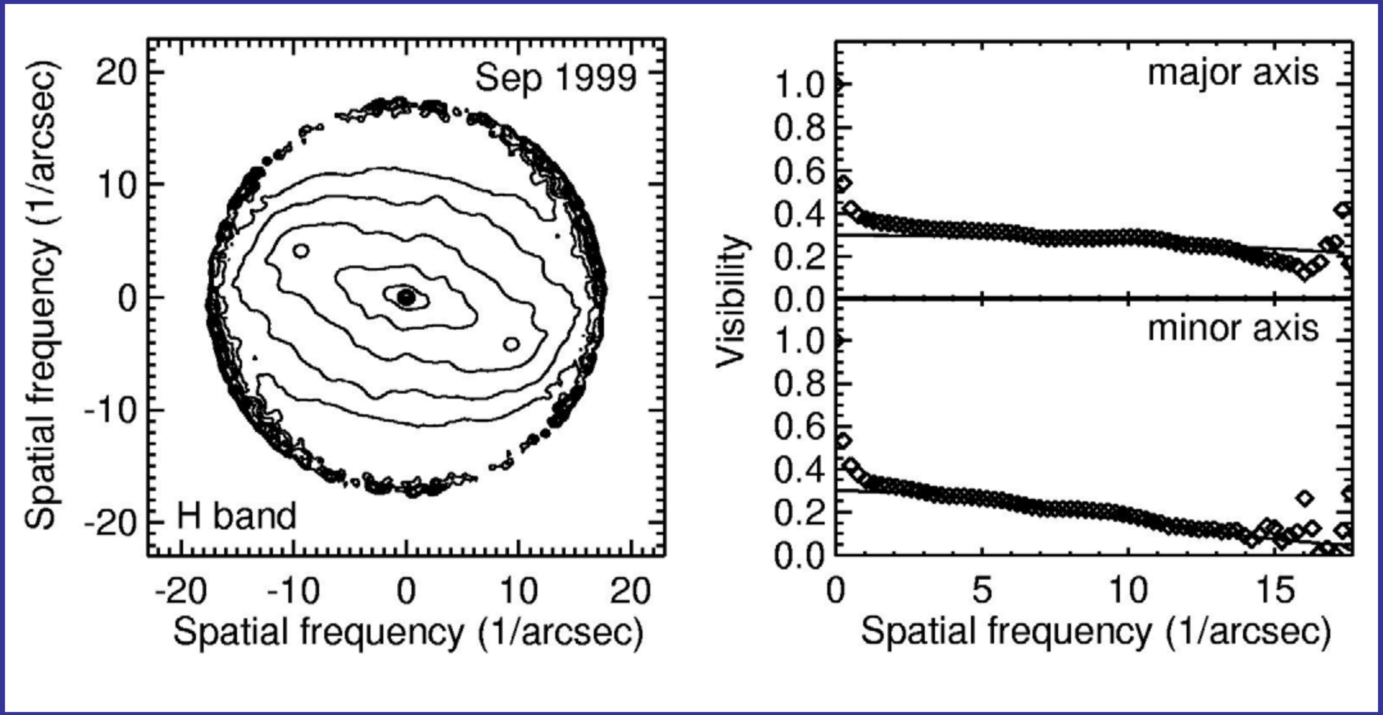
Flux in ratio in 2.5'' FOV:

Total flux: phot. calibrators

20 x 40 mas: 80% = 350 **mJy**

Extended components: 70 mJy

H-band visibility of NGC 1068

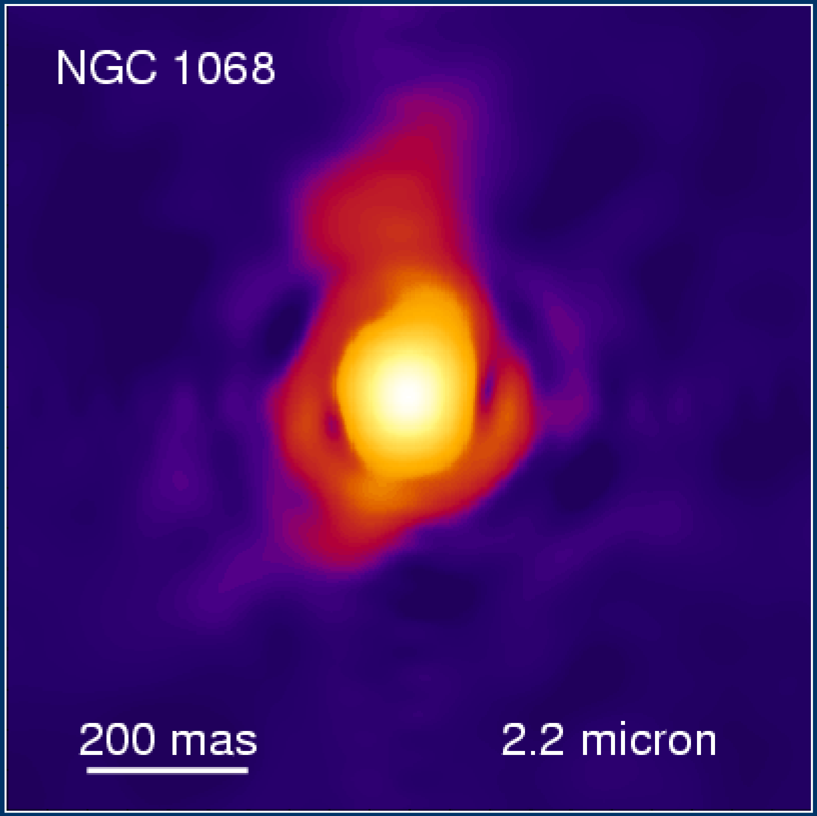


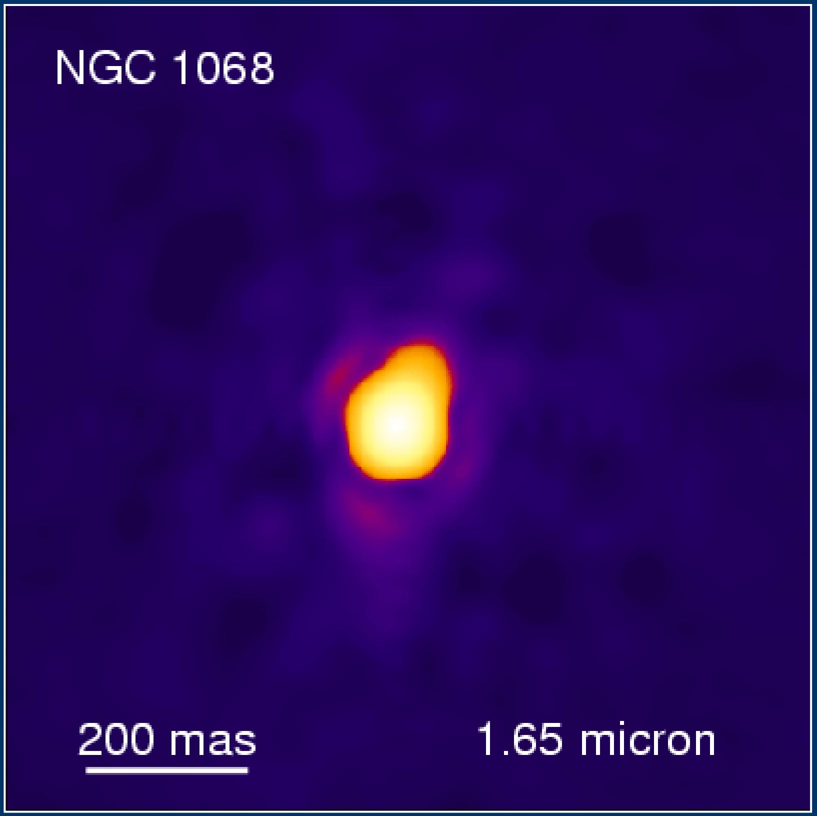
FWHM Gauss fit diameter: 18 x 45 mas (+/- 3 mas)

Bispectrum speckle interferometry

Real-time Movie

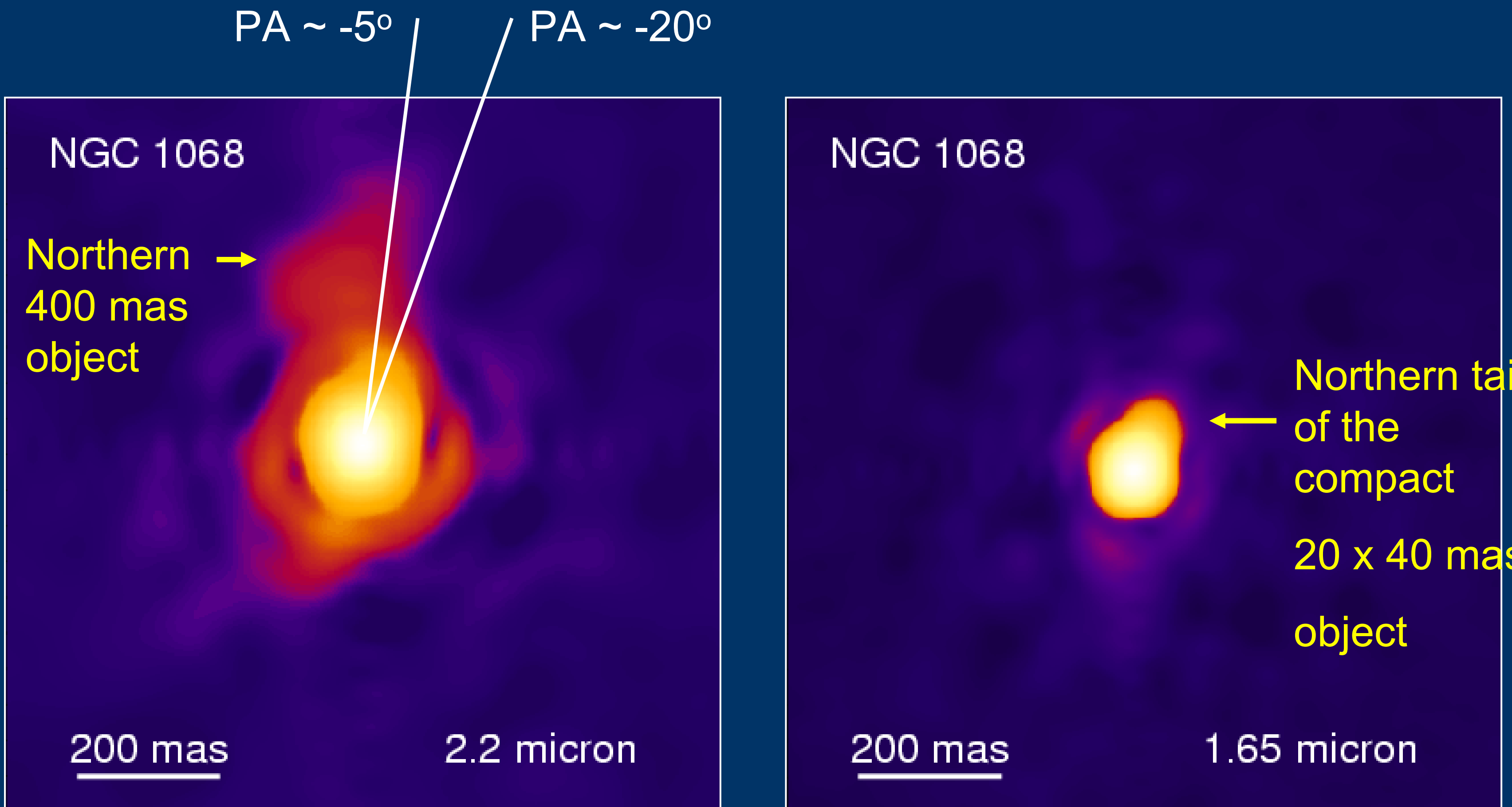
Diffraction-limited K- and H-band images of NGC 1068 reconstructed by **bispectrum speckle interferometry**





Weigelt et al., A&A 425, 77 (2004)

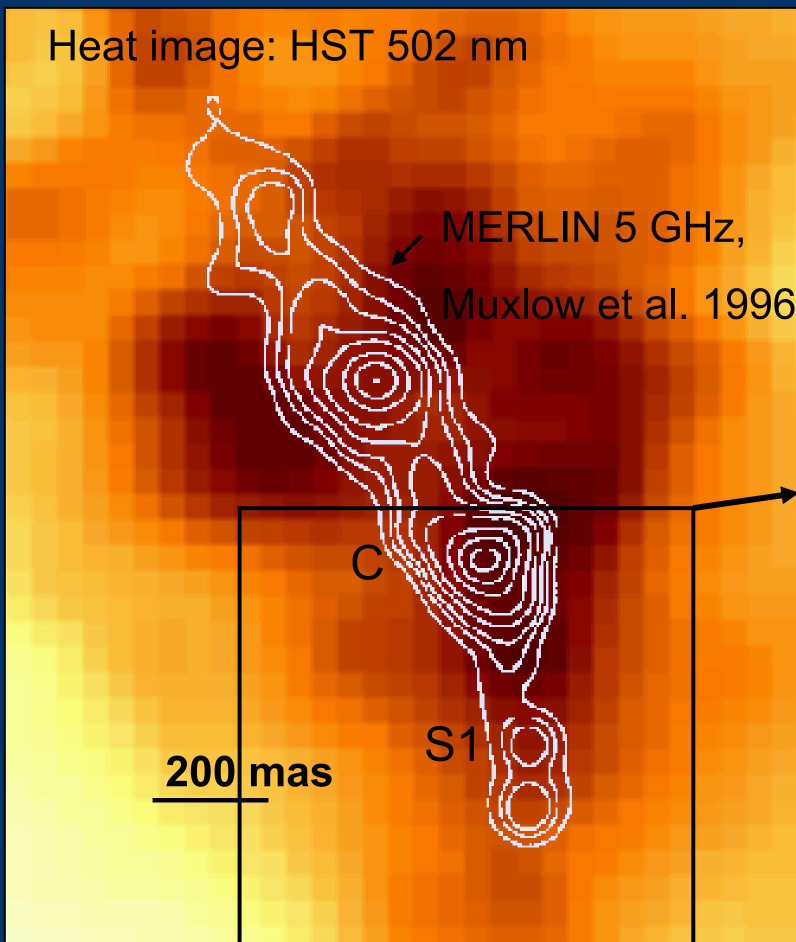
Diffraction-limited K- and H-band images of NGC 1068

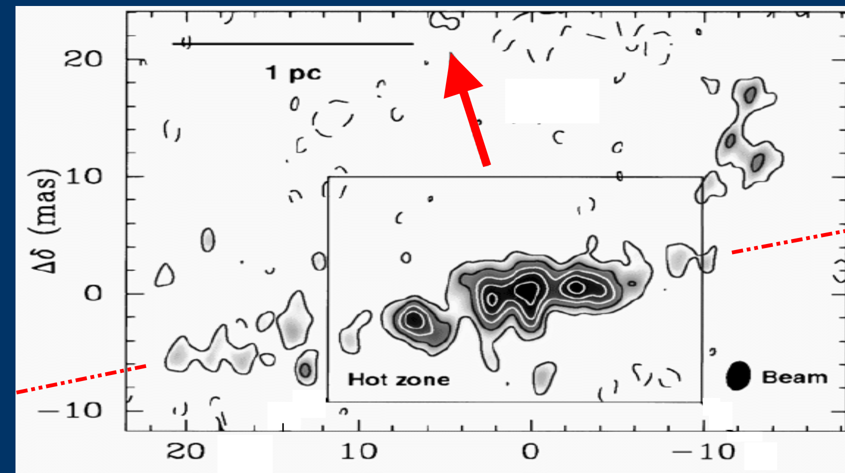


Compact component: 20 x 40 mas ~ 1.5 x 3 pc

Northern component: 400 mas

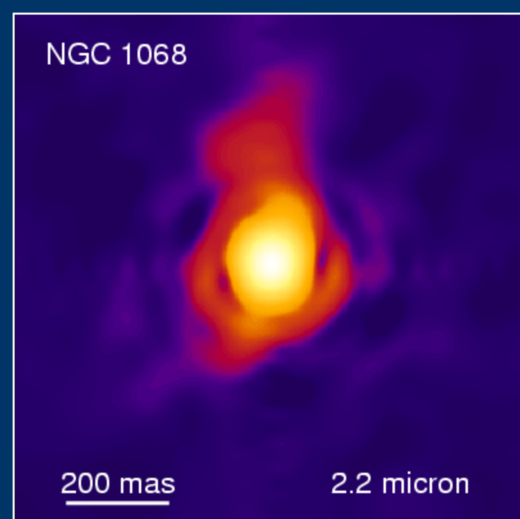
Comparison with HST, Merlin, and VLBA images

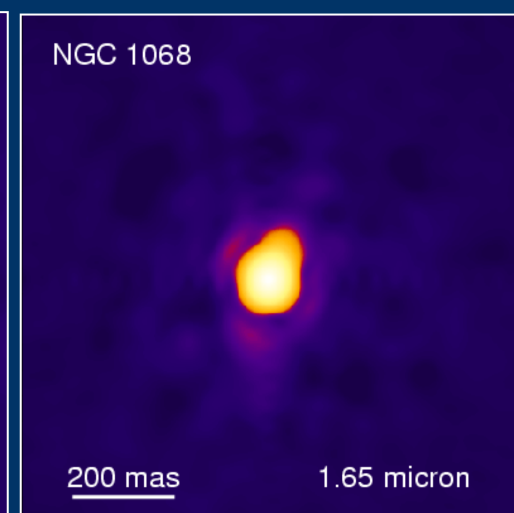




100 mas

VLBA 8.4 GHz radio continuum;
Gallimore et al. 1997: ~ 5 x 20 mas





Hot optically thin dust emission?

Emission in the *K* band may be interpreted quite naturally as thermal radiation of hot dust near its sublimation temperatur (~ 1500 K), located at the inner edge of the dusty torus or in the polar cone between BLR and NLR.

Dust sublimation radius of NGC 1068 (e.g., Puget et al. 1985, Dopita et al. 1998, Cameron et al. 1993): 0.5 – 3 pc.

Radiation from an optically thick torus?

A number of models have been published for NGC 1068 (e.g., Pier & Krolik 1992, 1993; Granato & Danese 1994; Efstathiou et al. 1995; Granato et al. 1997). The observed MIR fluxes can be fitted by a variety of models, but the *observed* *K*-band flux of the central component of 350 mJy is too high to be explained by most of the dusty torus models.

In order to resolve this problem Efstathiou & Rowan-Robinson (1995) introduced an additional dust component located within the outflow **cone** between BLR and NLR and obtained a *K*-band flux of 400 mJy.

It was noted early on by Krolik & Begelmann (1988) that **clumpiness** might be the key to understand the broadband IR spectrum. Nenkova (2002) investigated this in more detail and developed a statistical treatment of the radiative transfer for in a clumpy environment. The broadband nature of the IR spectrum of AGN is here a consequence of dusty clouds being effectively heated both near and far from the central source due to clumpiness
(talk by Moshe Elitzur ...).

Discussion

One possible explanation of the compact northern **20 x 40 mas ~ 1.5 x 3 pc object** is that dust is located between the BLR and NLR. This dust can emit and scatter *K*-band radiation. Efstathiou et al. 1995 have shown that thermal emission and scattering at such a dust component can explain a *K*-band flux of 400 mJy.

Another possibility is that a large fraction of the observed flux of the compact core is direct thermal radiation from the inner edge of the torus or non-thermal direct radiation from the central continuum source.

The **northern 400 mas *K*-band emission** appears to be aligned with both the western wall of the ionization cone and the jet. This suggests that the extended 400 mas component is radiation scattered by electrons and dust grains in the western cone wall or radiation of dust heated by dynamical interaction with the radio jet.