LBT AO observations of AGN

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Summary

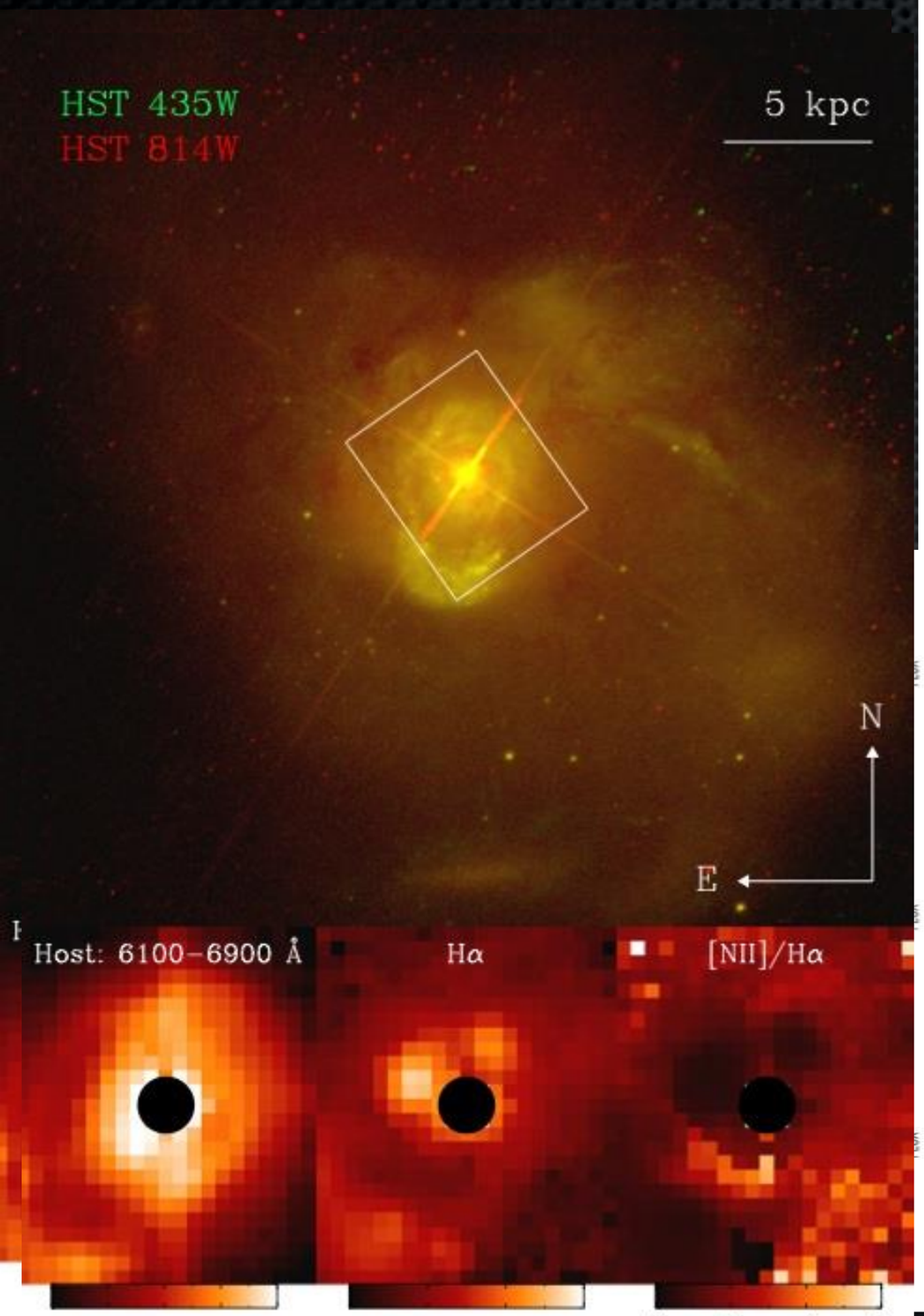
- Host galaxies of nearby AGN: the case of Markarian 231

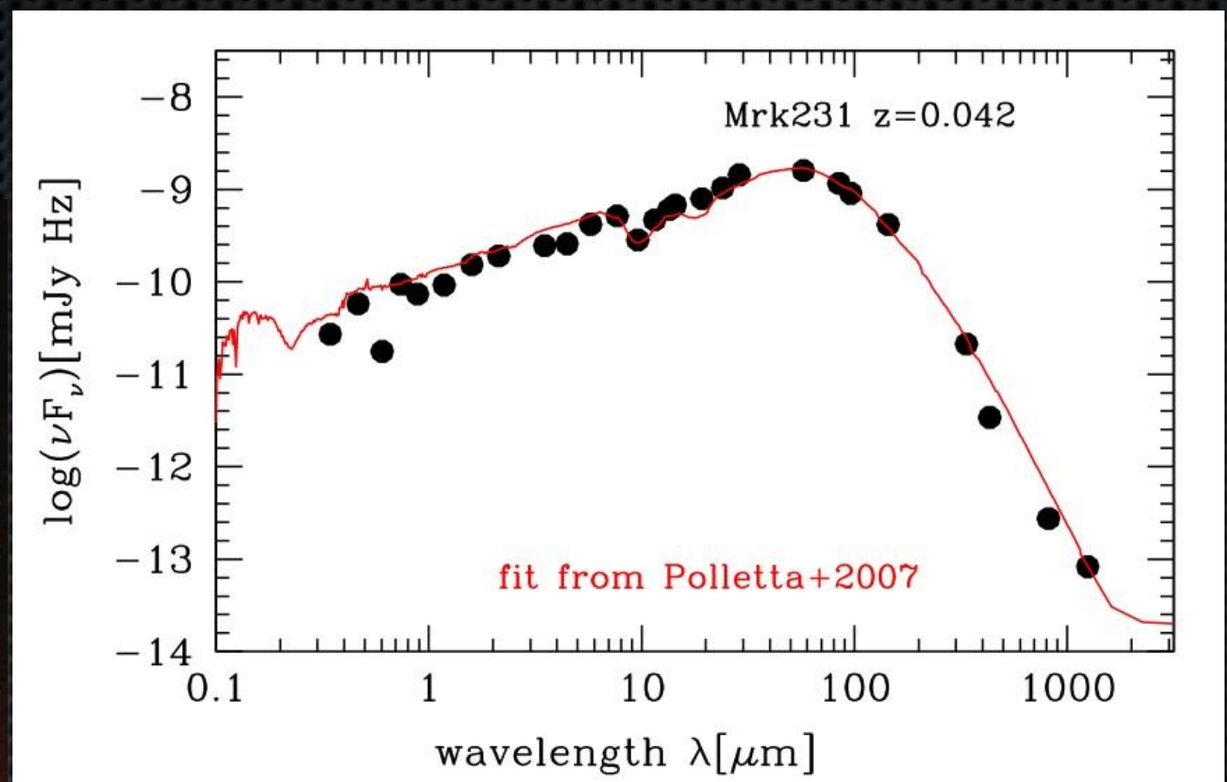
Or..

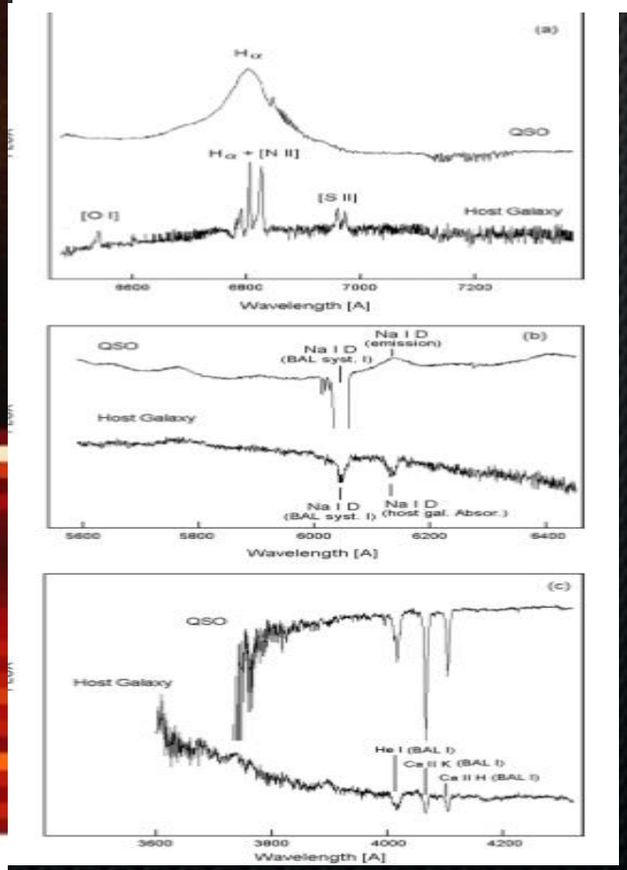
Where is the dust in a dust enshrouded star-forming galaxy?

- High-z QSO: probes of fundamental physics

The case of Markarian 231





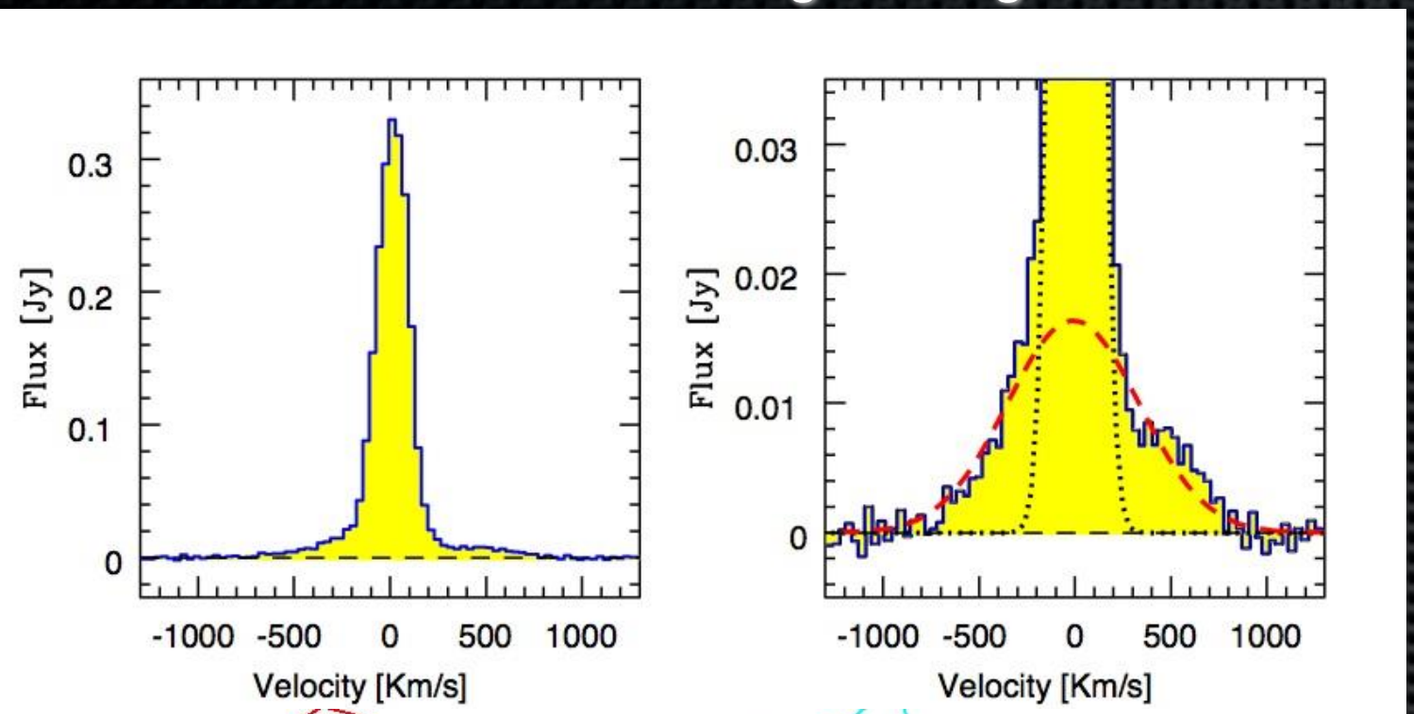


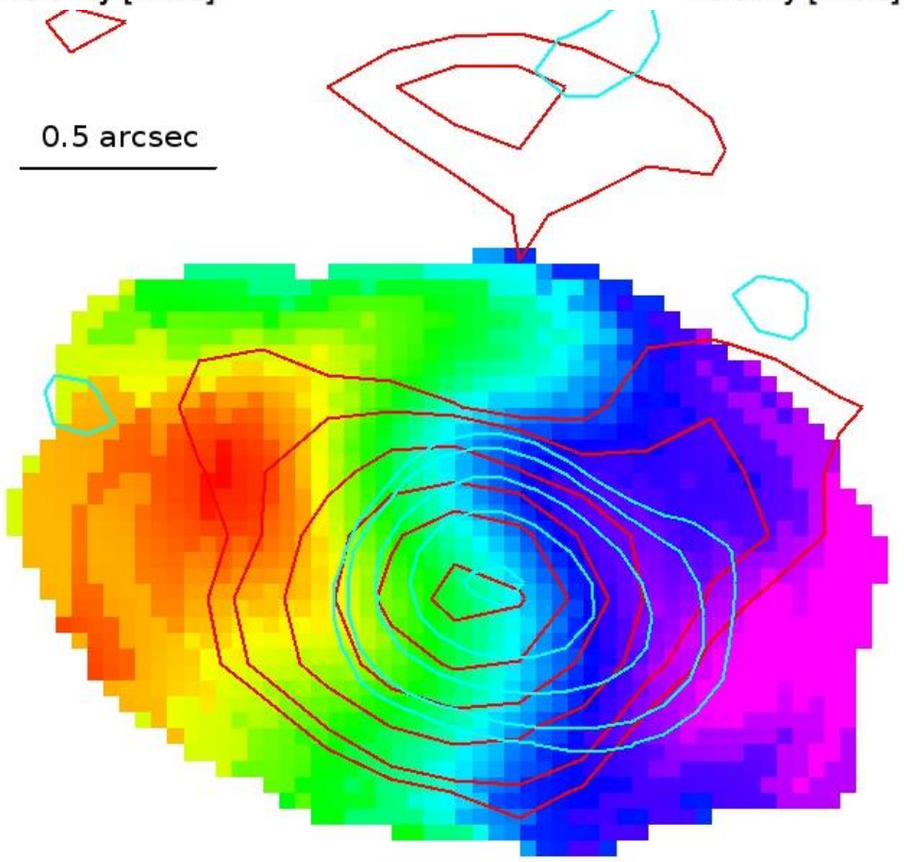
- Nearby z=0.042, 187Mpc
- Merger system
- High luminosity (L_{bol}~10^{46} erg/s), highly obscured (N_H~10^{24} cm^{-2}) BALQSO.
- SFR=200 M_{Sun}/yr
- ERO, R-K=6

Dust enshrouded AGN/star-forming

Mark 231 molecular outflow

Mark231 broad CO line wings Feruglio+2010





L_{bol}~5×10^{45} ergs/s

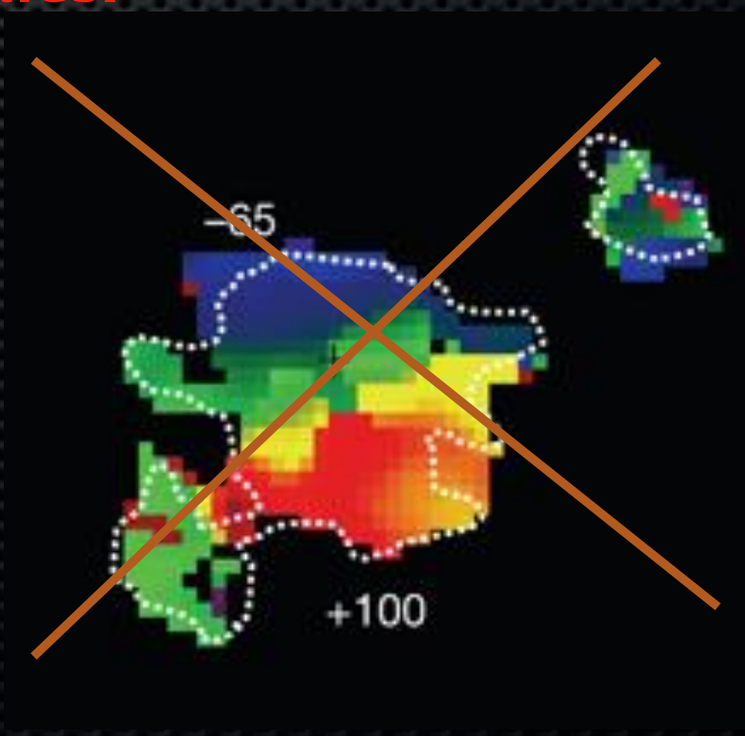
M_{H2}~7×10^{7} M_{sun}

(uncertain conversion L'CO to M_{H2})

M_{out}~700 M_{Sun}/yr, SFR~200M_{sun}/yr:

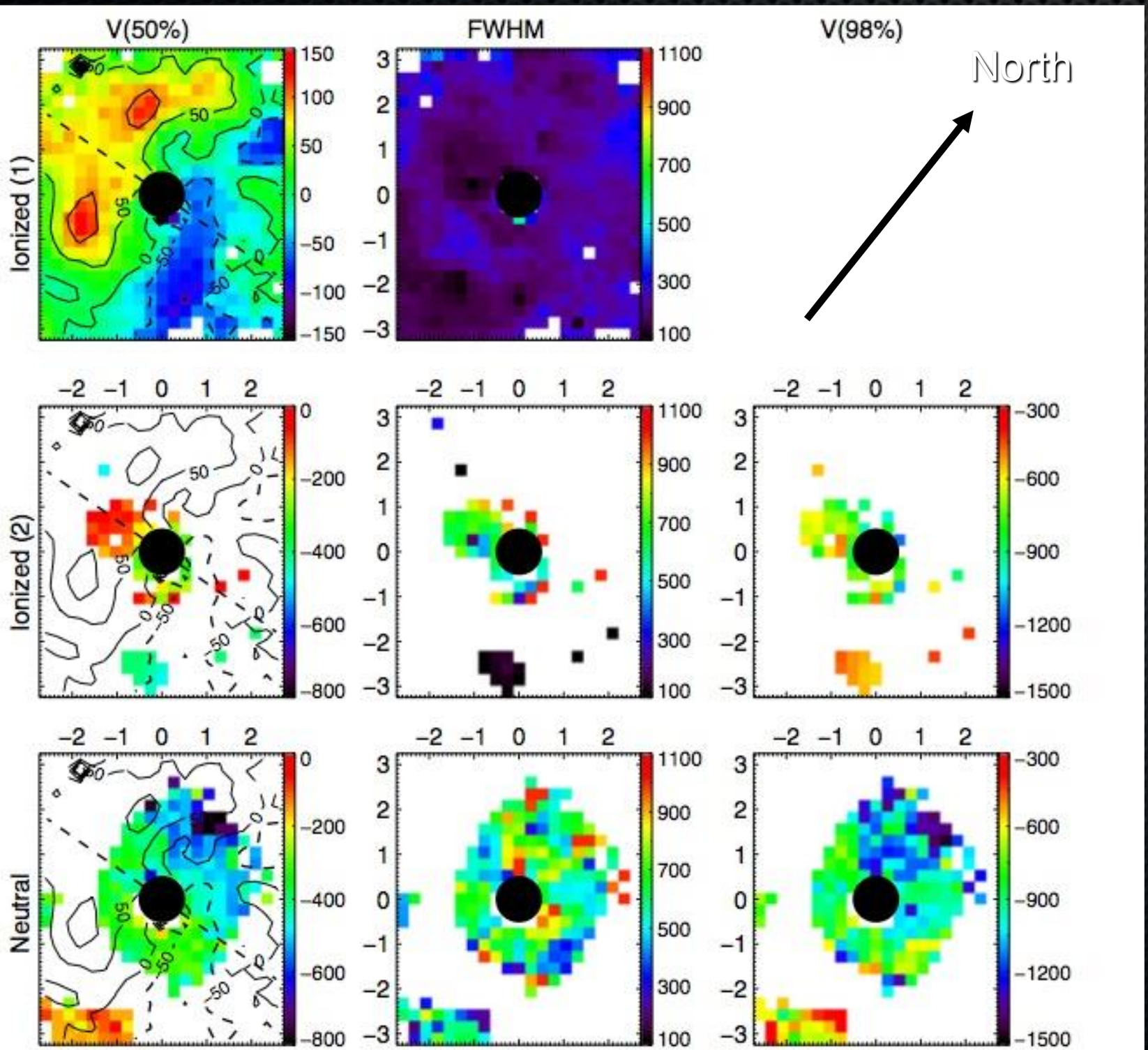
L_{bol}/M_{out}~7×10^{42} erg/s / M_{Sun}/yr

Wings are spatially resolved and extended on **1.2 kpc scales.**



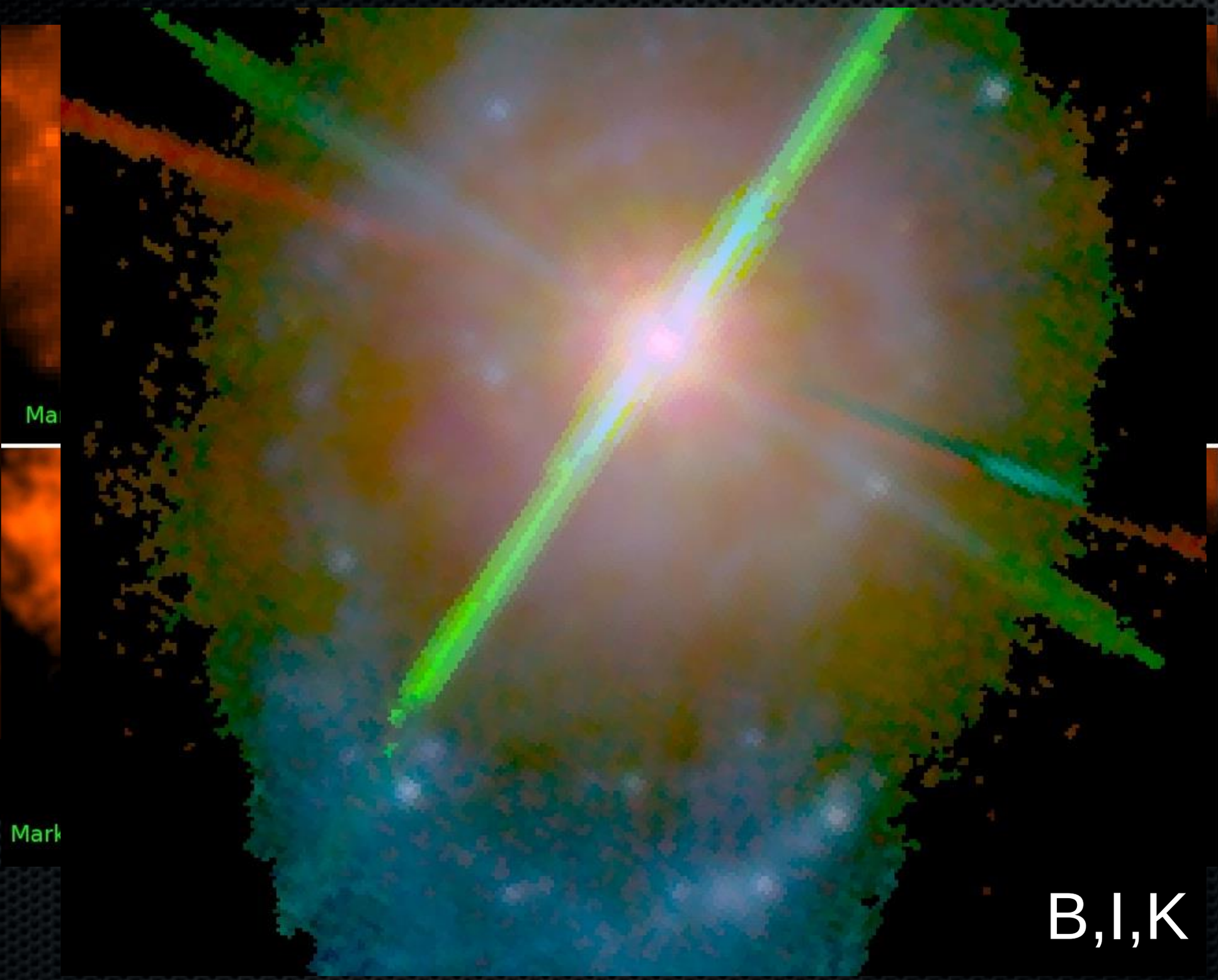
OUTFLOW!!!

Mark 231 neutral gas outflow



- Narrow ionized lines=disk
- Broad ionized lines=outflow
- Neutral gas, NaI absorption = outflow
- Rupke&Veilleaux 2011,2013

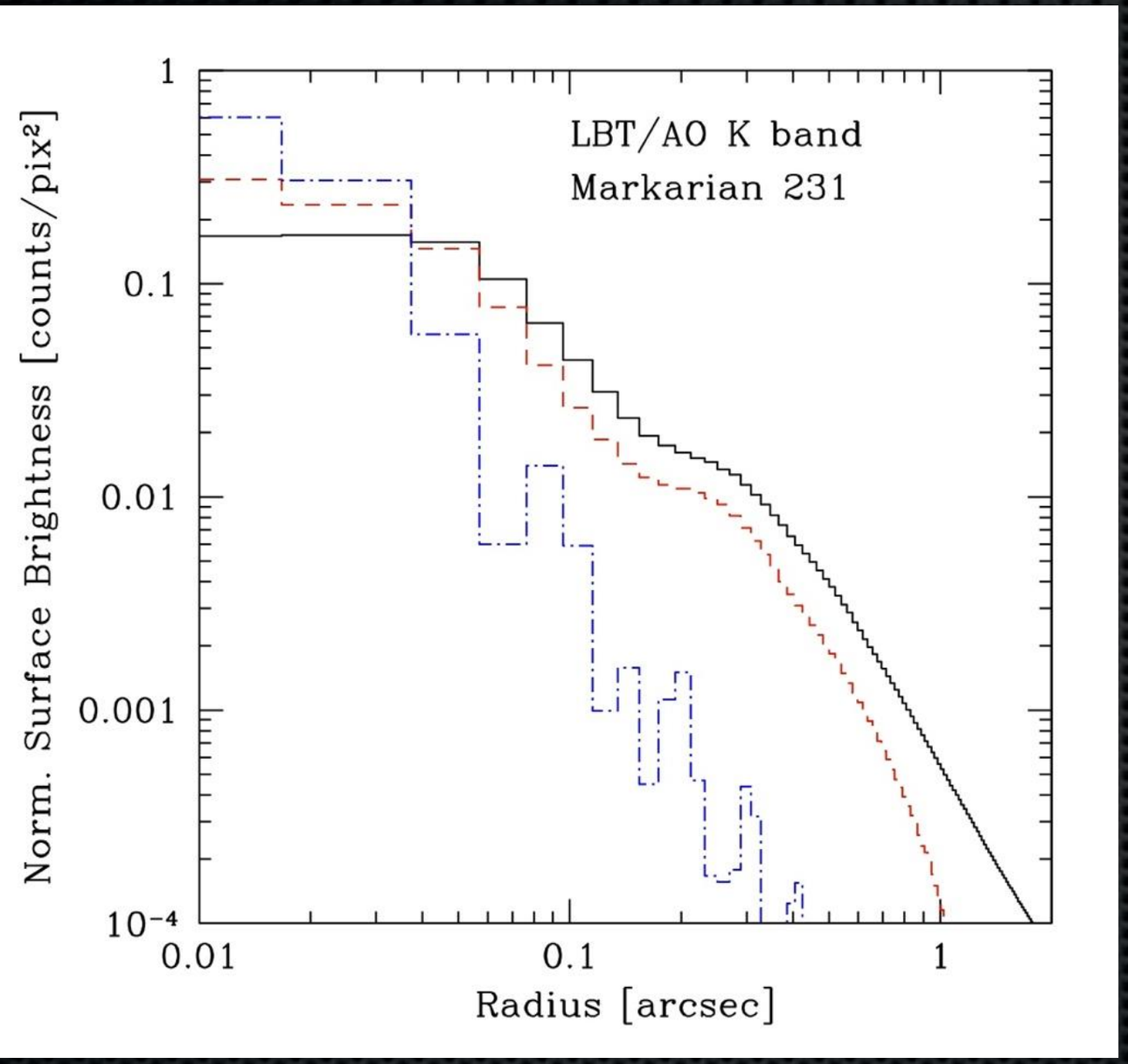
LBT AO J,K observations

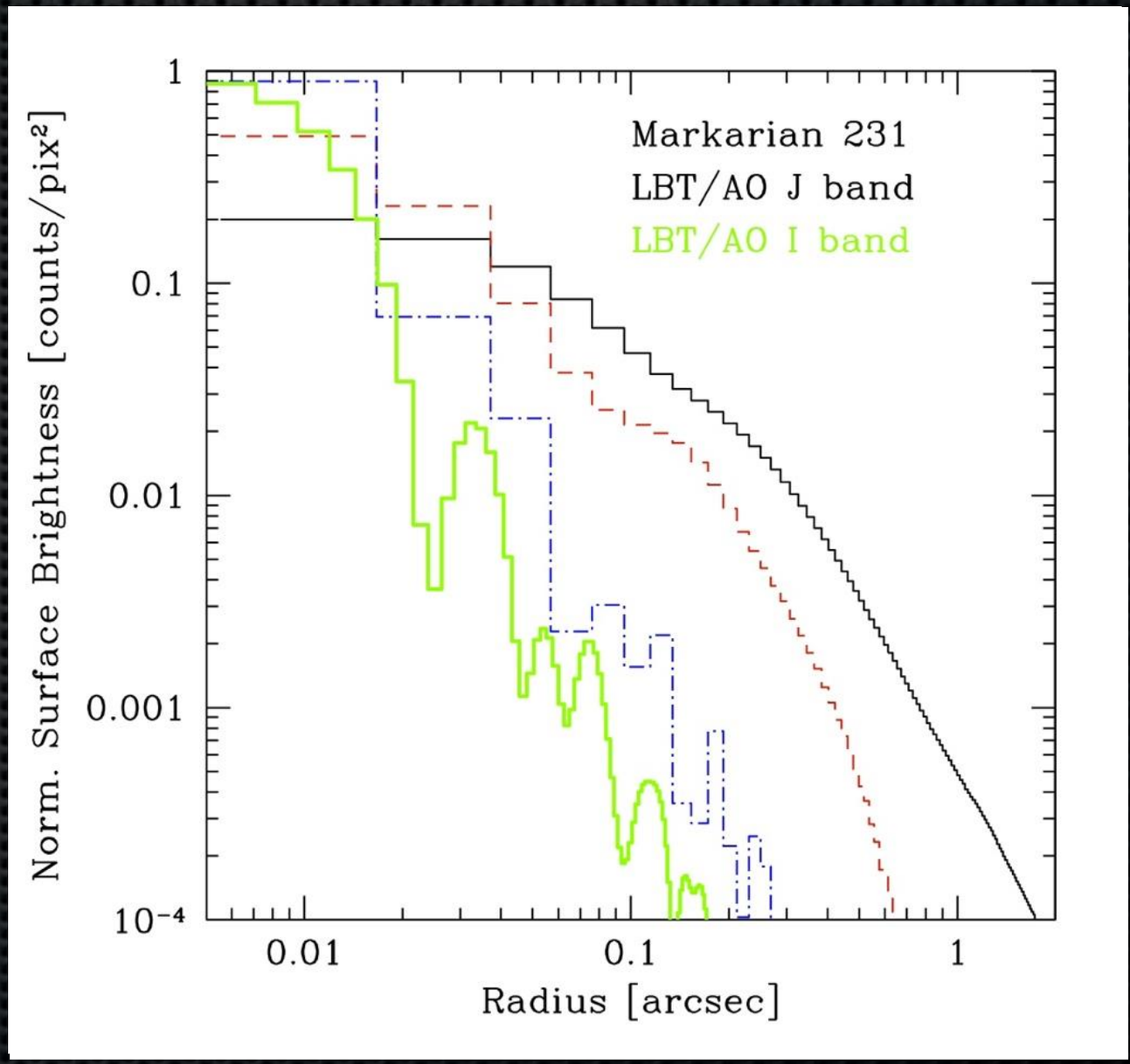


- AGN guided AO observation. R, I=13.7, 12.9
- Average seeing: 1.1 arcsec
- Strehl ratio: ~30% (dominated by host galaxy detection)
- PSF calibrated through simulations
- SR~50% in K,
- SR~40% in J

Bongiorno, FF et al. 2014

LBT AO J,K observations





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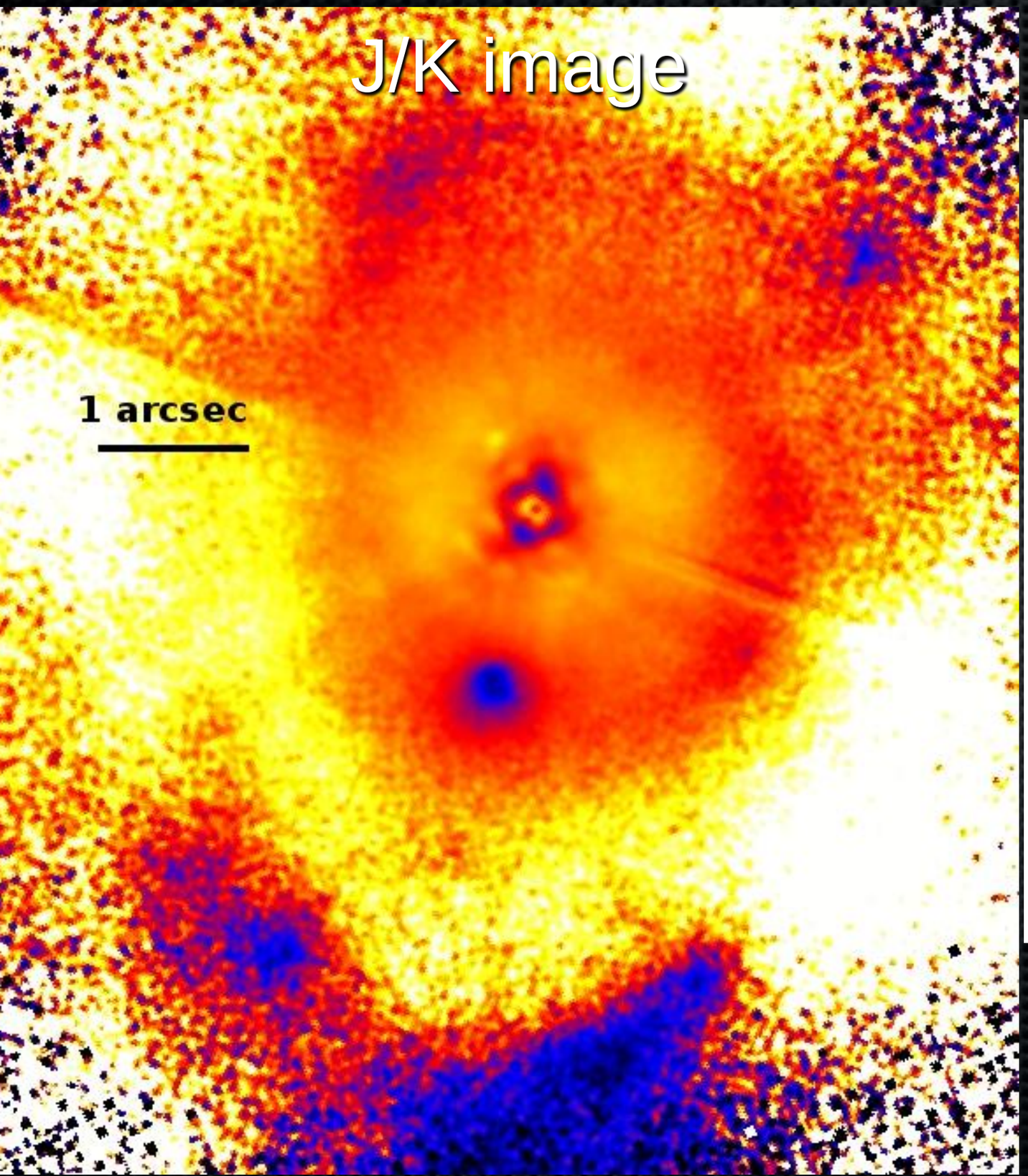

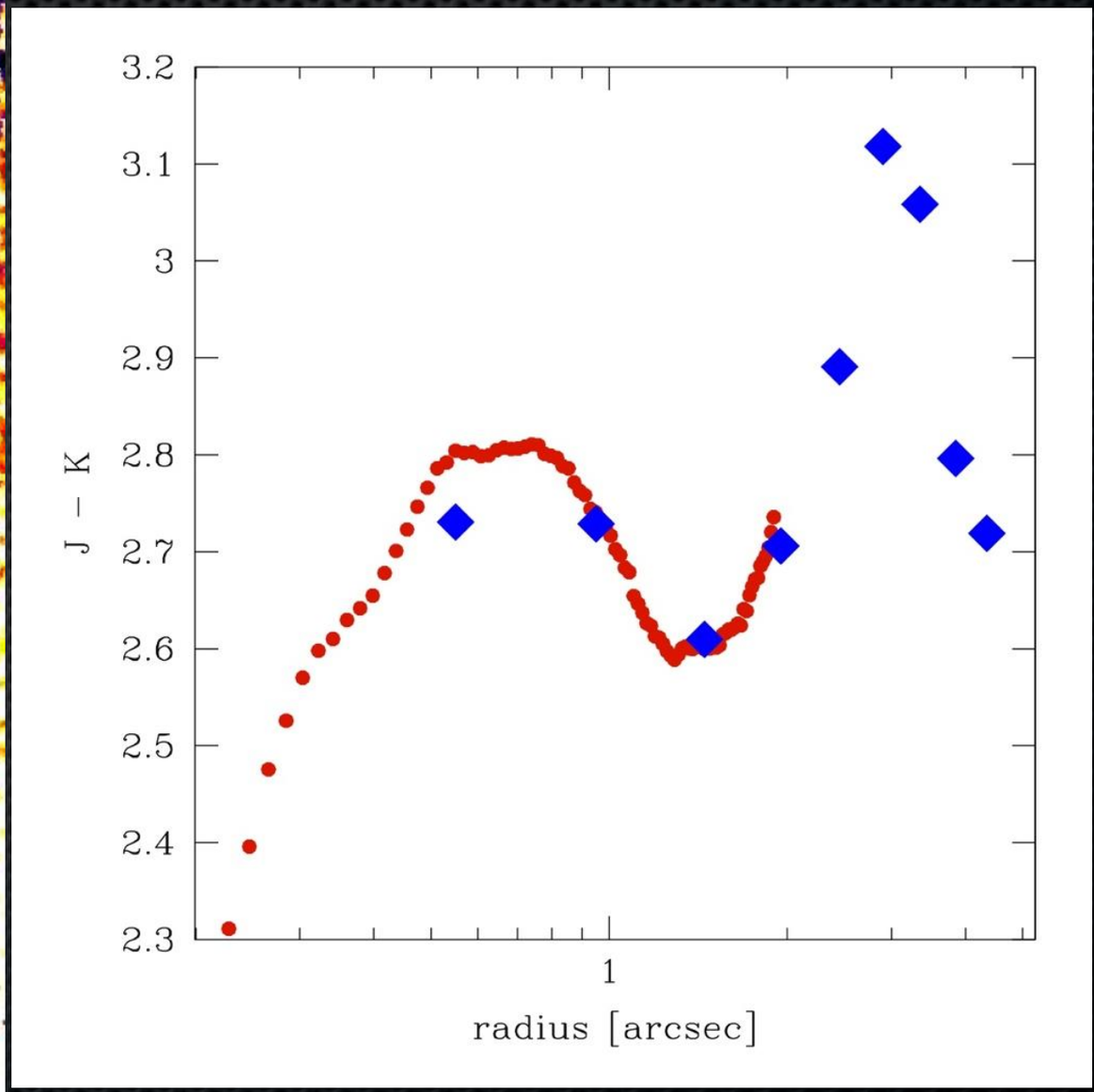

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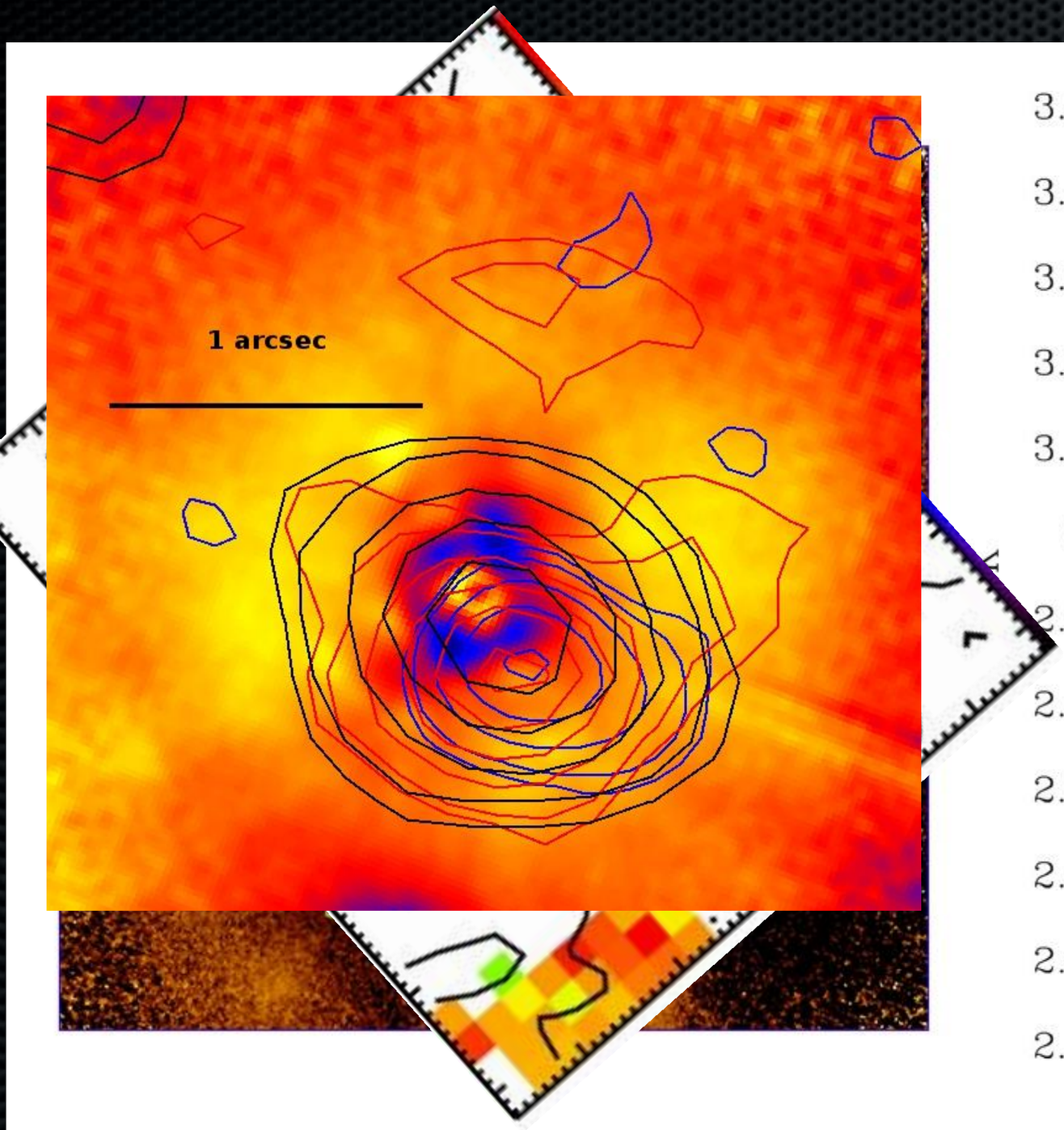

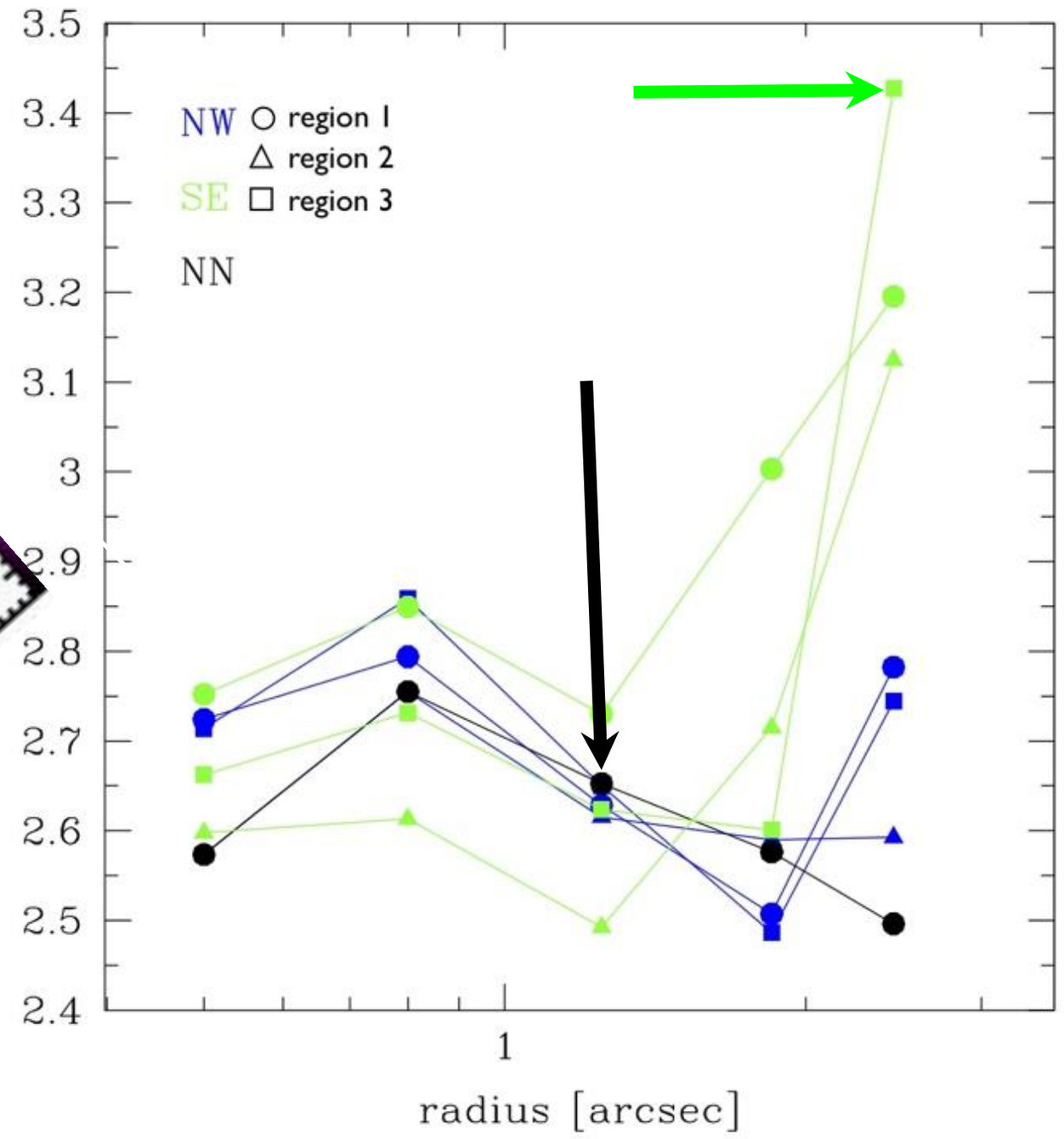

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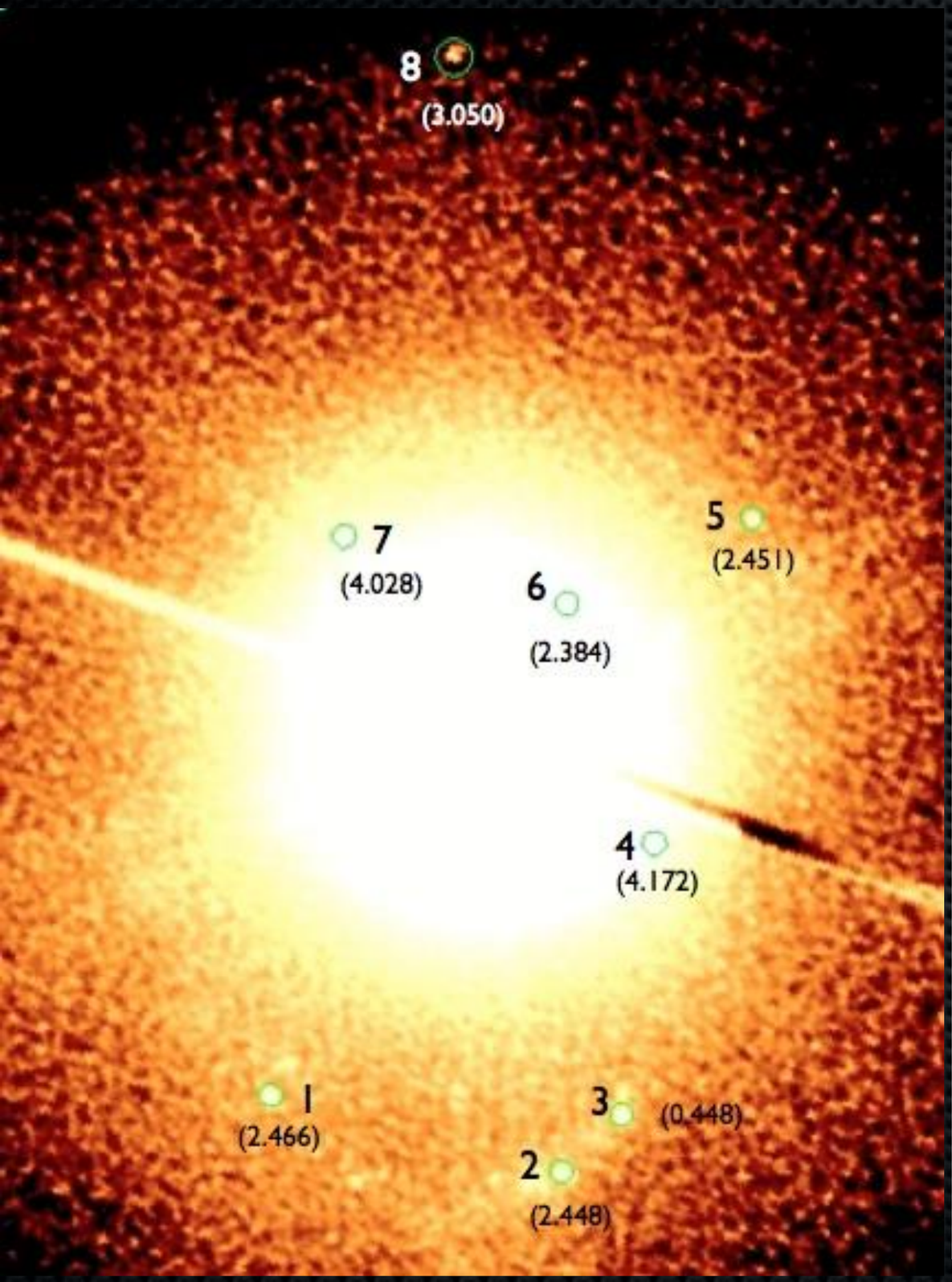
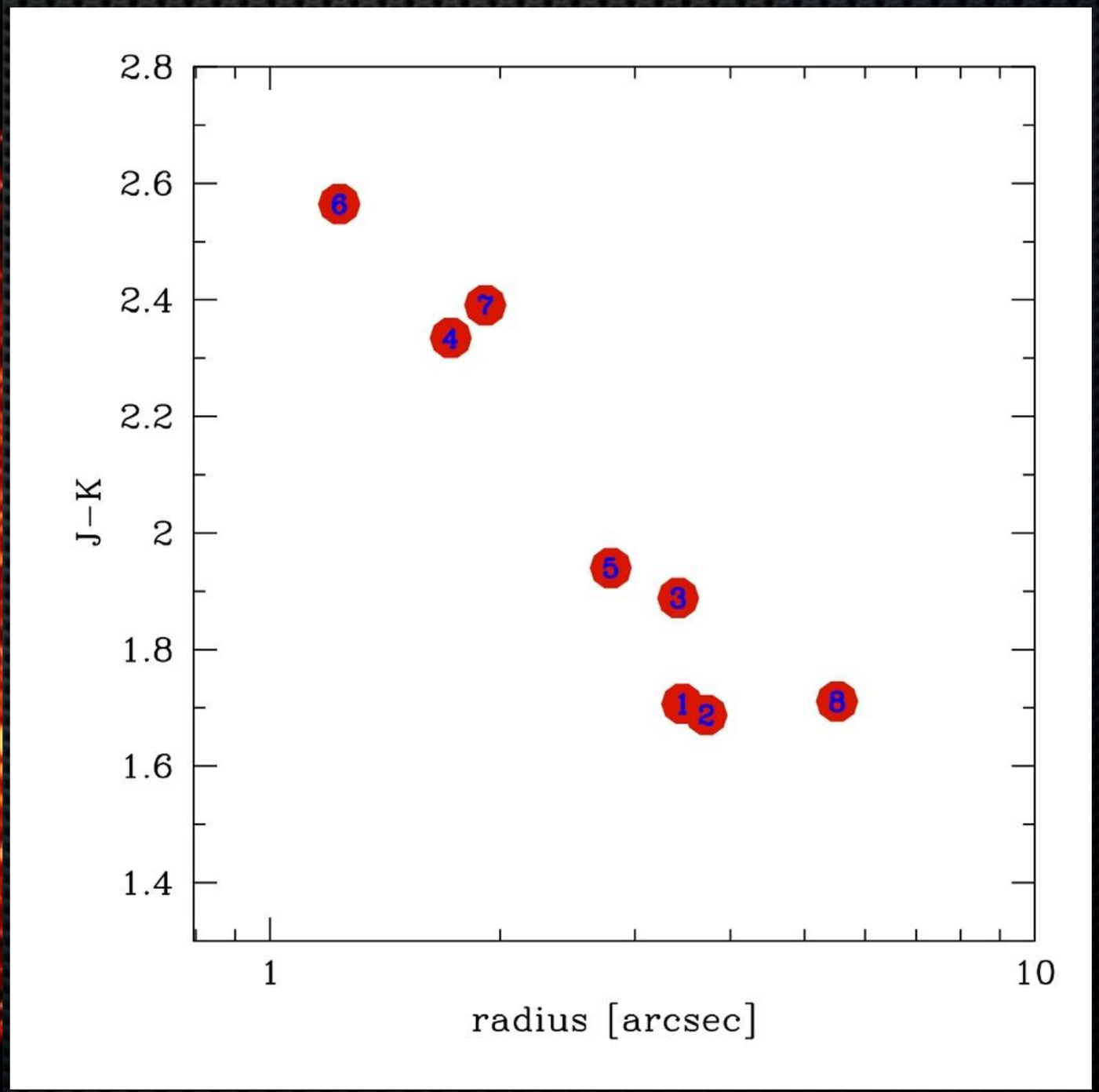
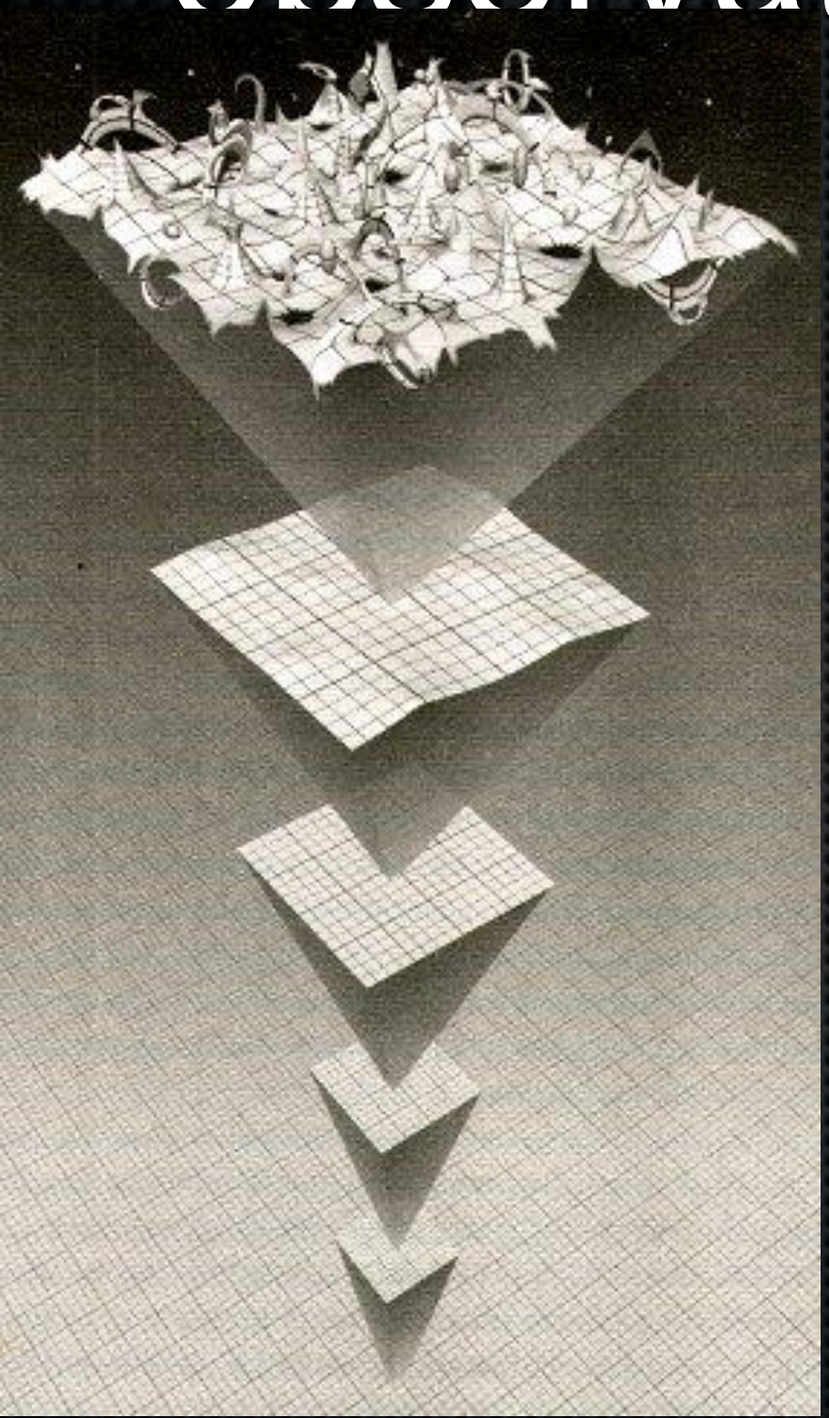




Science goals for future (and present) instrumentation

- Map ionized and neutral outflows with an AO assisted IFU on scales down to a few pc in the closest AGN and hundred pc in ULIRGs at z<0.1.
- Map dust lanes on scales down to hundred pc, and investigate whether ouflows are dusty or rather the AGN feedback has already swept the ISM.
- Measure the color and the spectra of star-formation region in the galaxy nucleus and disk thus constraining the star-formation rate, the age, and the metallicity. Study whether the AGN outflow affected (or not) the local formation of stars.
- Search for newly exploded Supernovae (assuming a SN yield of ~ 0.005 one would expect just 1 SN/yr in local ULIRGs).

Constraining fundamental physics with AO observations



- Quantum space-time scenarios predict a degradation of the diffraction images of distant sources (Amelino-Camelia+ 1999, Ragazzoni+ 2003, Tamburini+ 2011
- The best limits on this fuzziness have been obtained so far by HST in the optical band.

QST with QSOs

$$\frac{\Delta L}{L} < a_0 \left(\frac{l_P}{\lambda}\right)^{\alpha}$$

Impossibility of measuring a distance L with precision ΔL using light of wavelength λ

Ragazzoni+2003

$$\Delta\theta \approx \frac{\Delta L}{D}$$

A variation ΔL of the wave-front will translate in an apparent angular shift Δθ

$$\Delta\theta = a_0 \frac{L}{D} \left(\frac{l_P}{\lambda}\right)^{\alpha}$$

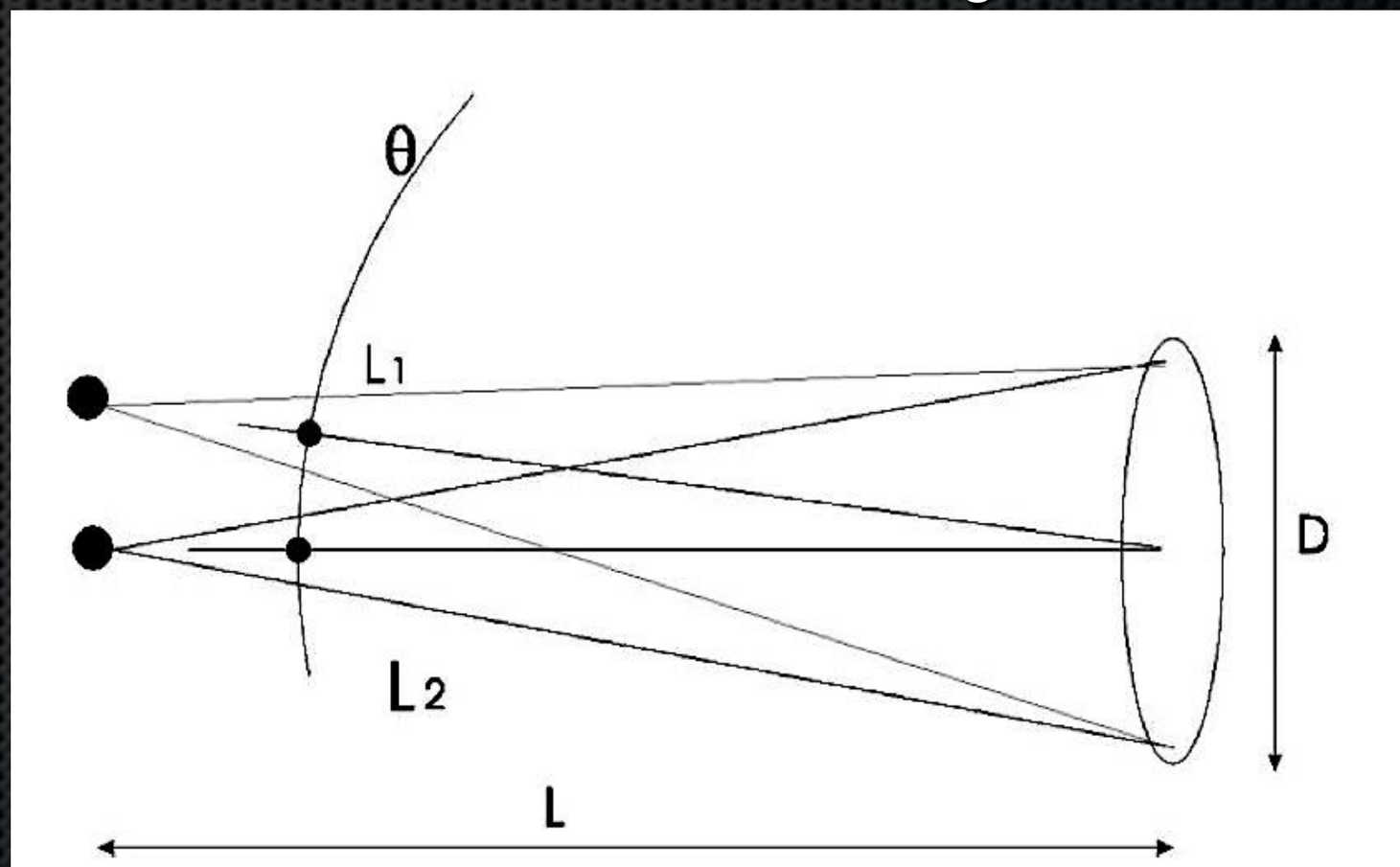
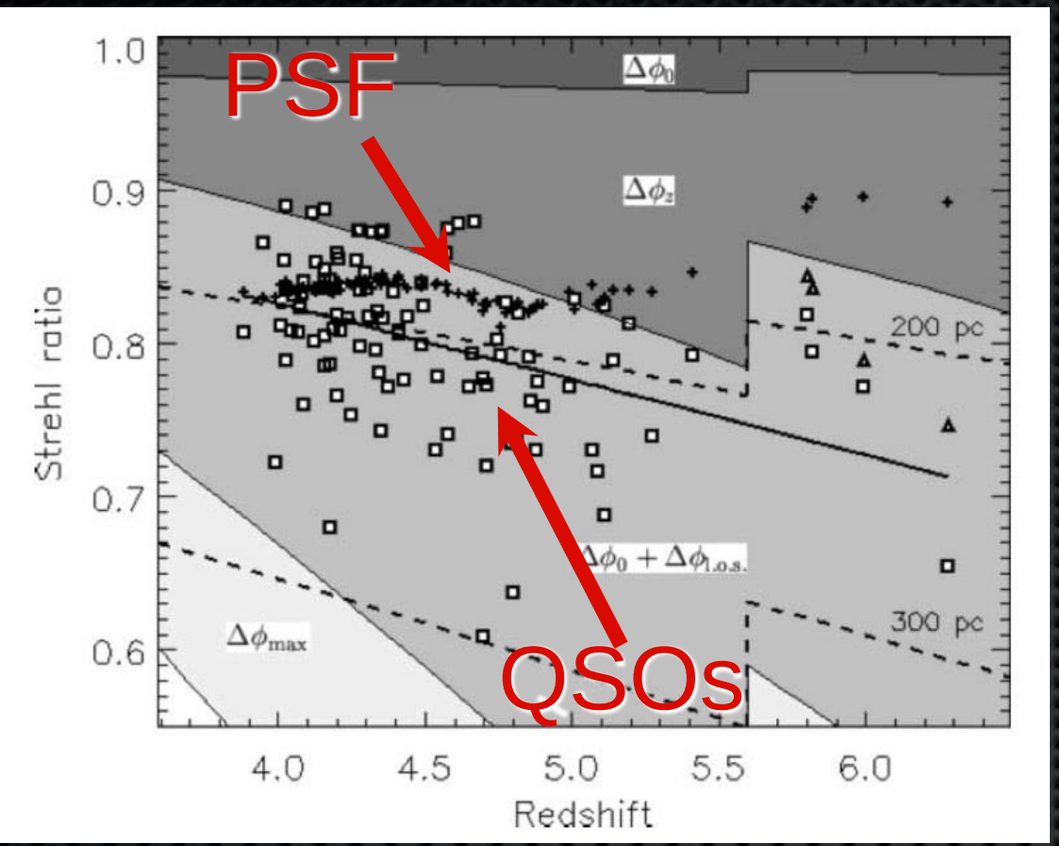
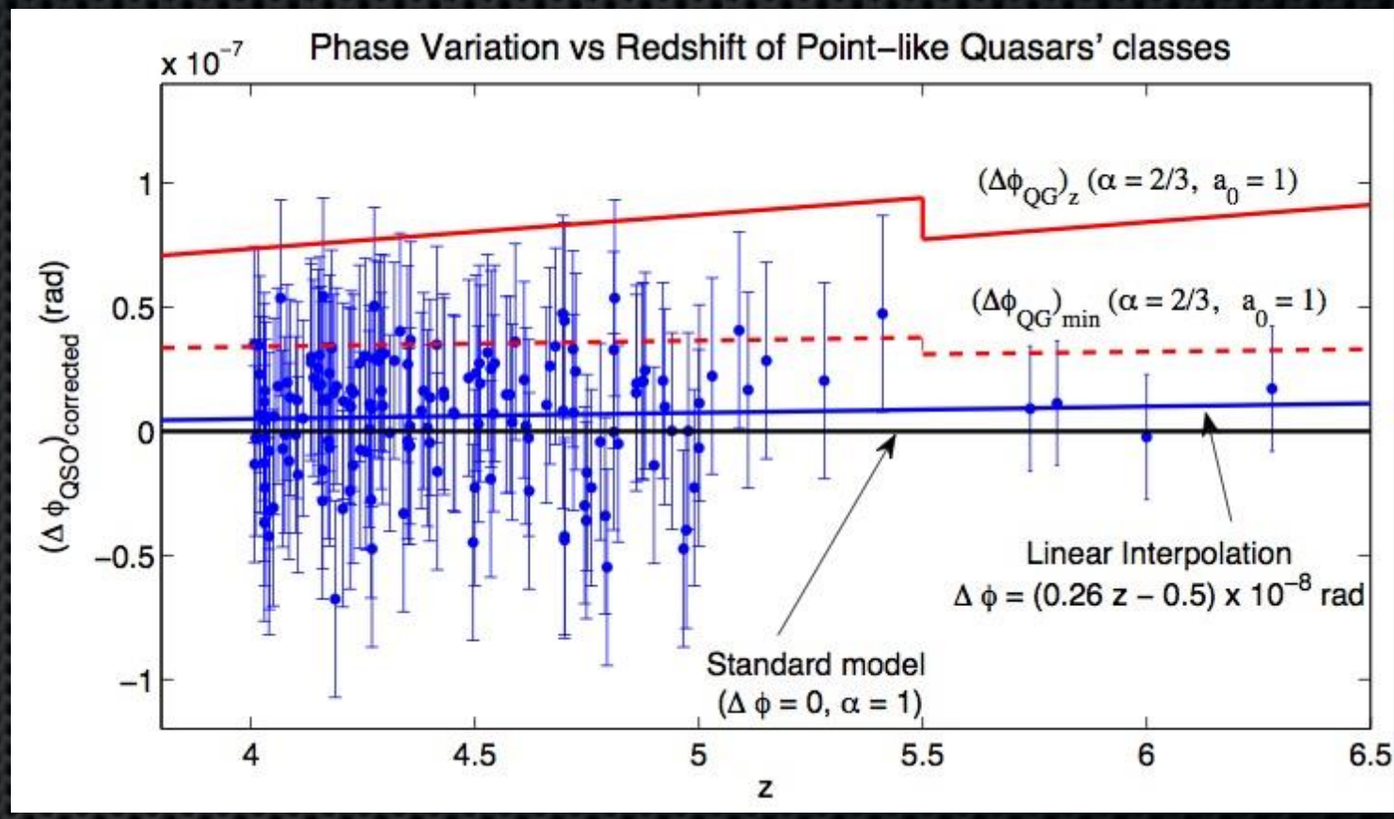


FIG. 1.—Observation of a light source at a distance L from the center of the telescope aperture. The distances between the source and two extremity positions on the aperture are denoted by L_1 and L_2. A variation in L_1 and L_2 will result in an apparent displacement $\Delta\theta$ in the location of the source .

QST with QSOs



Steinbring 2007



Tamburini+ 2011

$$\Delta\phi \approx \frac{\lambda}{D}\sqrt{-ln(S)}$$

$$\Delta\phi(z)_{QSO} = \Delta\phi_{ab} + \Delta\phi(z)_{size} + \Delta\phi(z)_{QG} + \Delta\phi(z)_{lens}$$

QST with QSOs

$$p^2 = E^2[1 \pm a_0(E/E_P)^\alpha].$$

Planck-scale in-vacuo dispersion

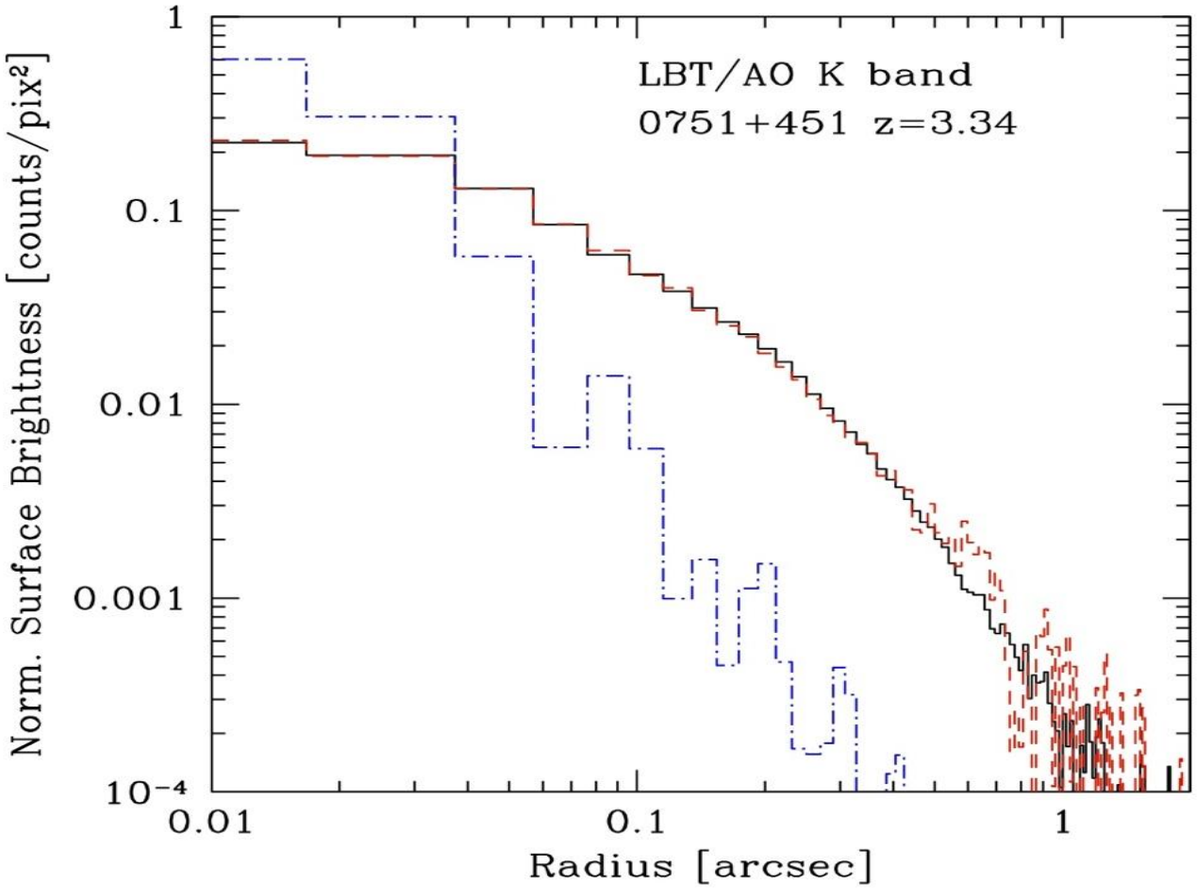
= ???

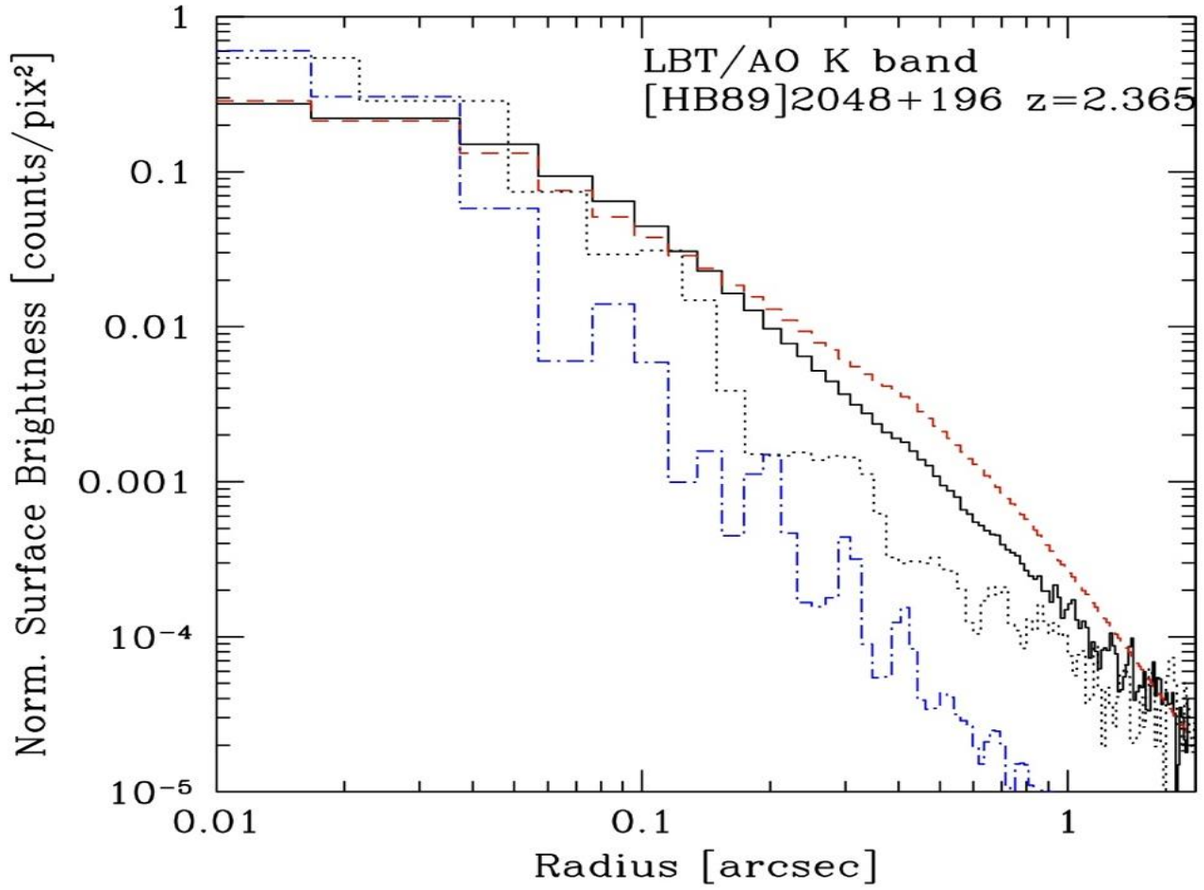
$$(\Delta\phi_{QG})_{min} \sim 2\pi a_0 \frac{l_p^\alpha L^{1-\alpha}}{\lambda}$$

$$\sim 2\pi \frac{L}{\lambda}\left[1 \pm \sqrt{2}\alpha\left(\frac{hc}{\lambda E_P}\right)^\alpha\right]$$

Phase variation accumulated by a wave traveling a distance L

QST with QSOs





SDSS J075155.09+451619.7 z=3.340
AO star R=15.2 @ 11.6”, Seeing 0.6-0.9”

[HB89]2048+196 z=2.365, radio loud
AO star R=12.8 @ 21”, Seeing 0.5-0.8”

$$\otimes(\lambda, D, S) = \lambda \Delta \ln(S)$$

$\otimes(0.75, 2.4, 0.83) = 1.5 \times 10^{-7}$ rad (HST I band)

$\otimes(2.2, 8.2, 0.6) = 1.9 \times 10^{-7}$ rad (LBT K)

$\otimes(1.2, 8.2, 0.5) = 1.2 \times 10^{-7}$ rad (LBT J)

$$\otimes(0.75, 8.2, 0.4) = 8 \times 10^{-8} \text{ rad (LBT I)}$$

Conclusions

- Observations of Markarian231 (and NGC2273, see Eleonora Sani talk) demonstrate the feasibility of AGN guided AO observations.
- Host galaxy clearly detected. Structures studied down to 0.1” scale. Gradients in colors.
- AO observations of high-z QSOs look promising to search for new physics on scales not accessible to HST (or most other ground based systems).