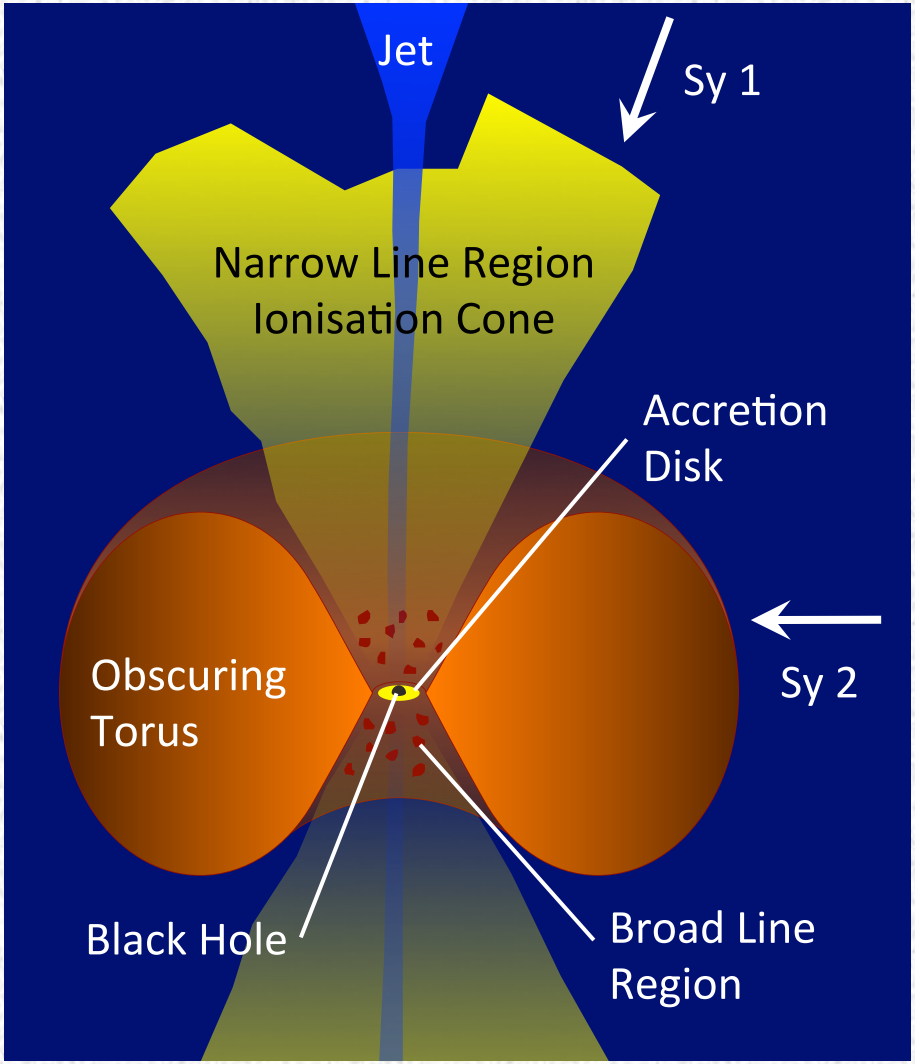
Extragalactic astronomy at high-precision

Optical Interferometry of Active Galactic Nuclei

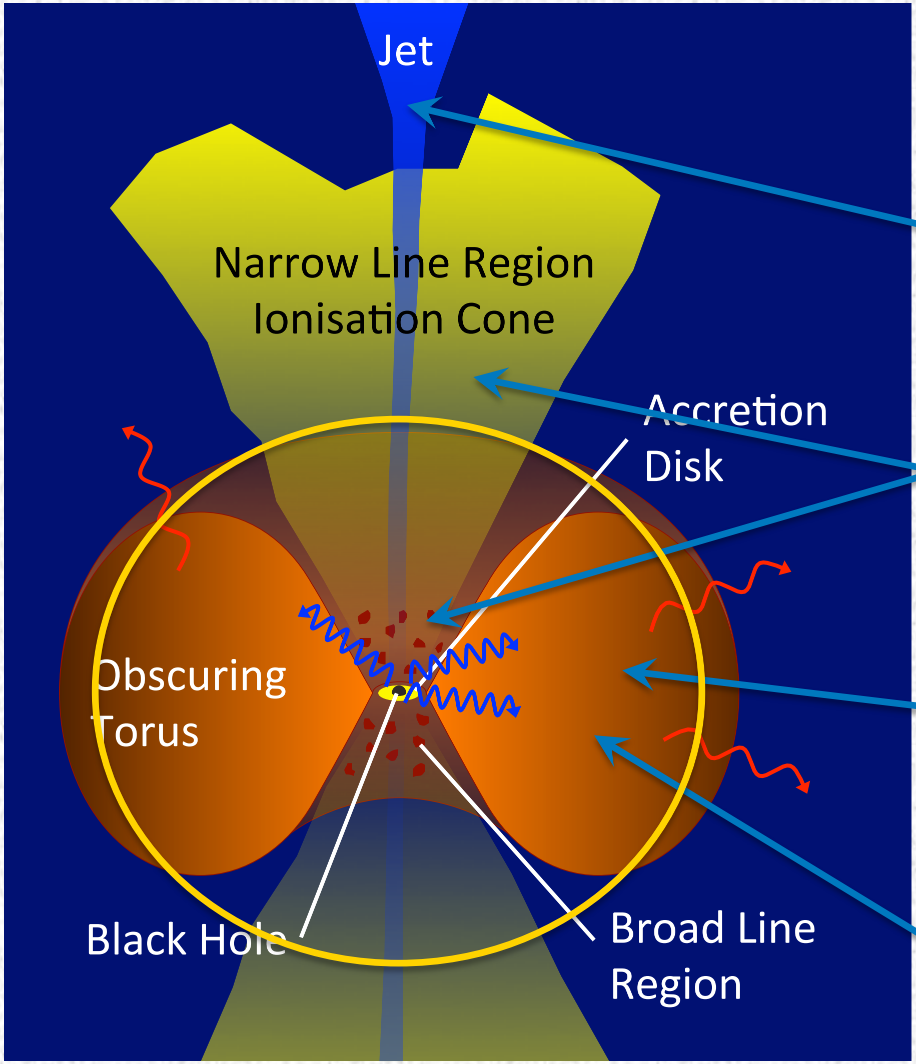
Konrad R. W. Tristram

EUROPEAN SOUTHERN OBSERVATORY

Introduction: the torus emission



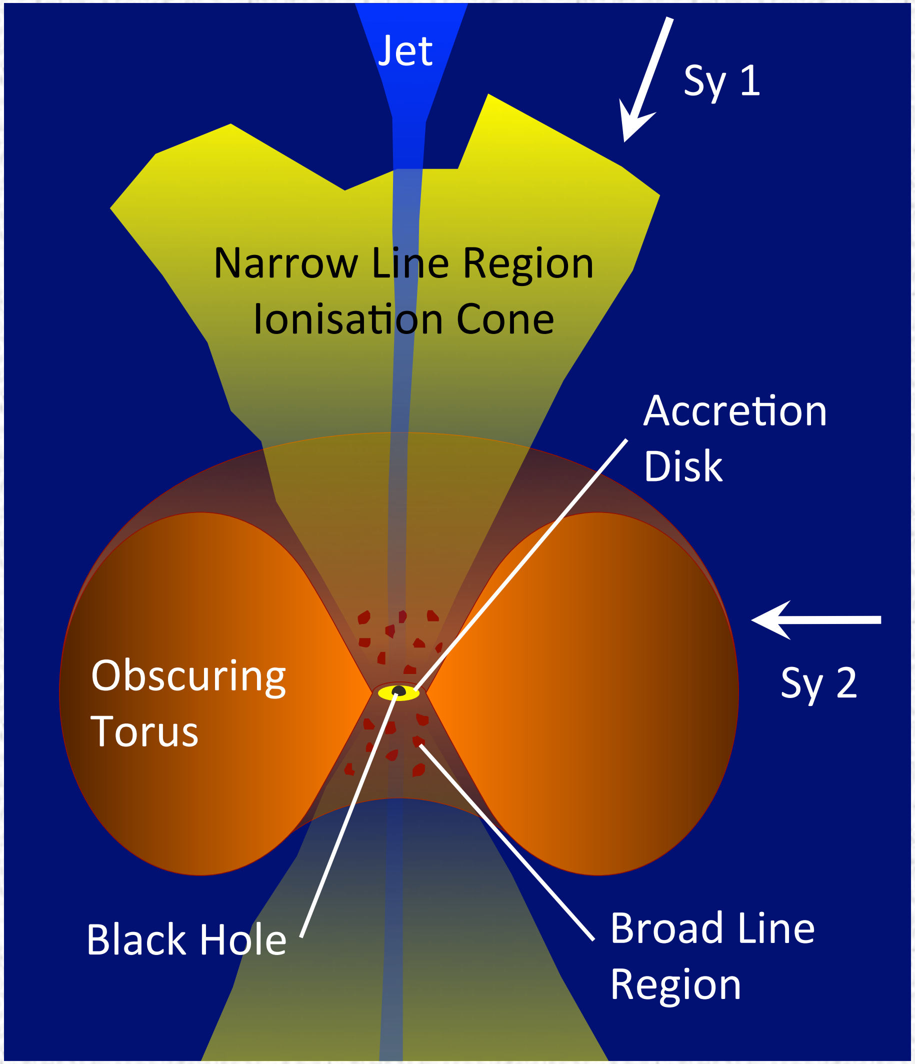
Introduction: the torus emission



Emission mechanisms:

- non-thermal emission (jet)
- emission lines (BLR / NLR gas)
- molecular emission (warm gas)
- thermal emission (dust)

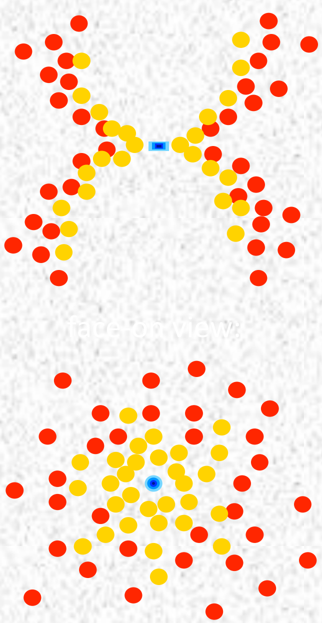
Active Galactic Nuclei & OIR Interferometry

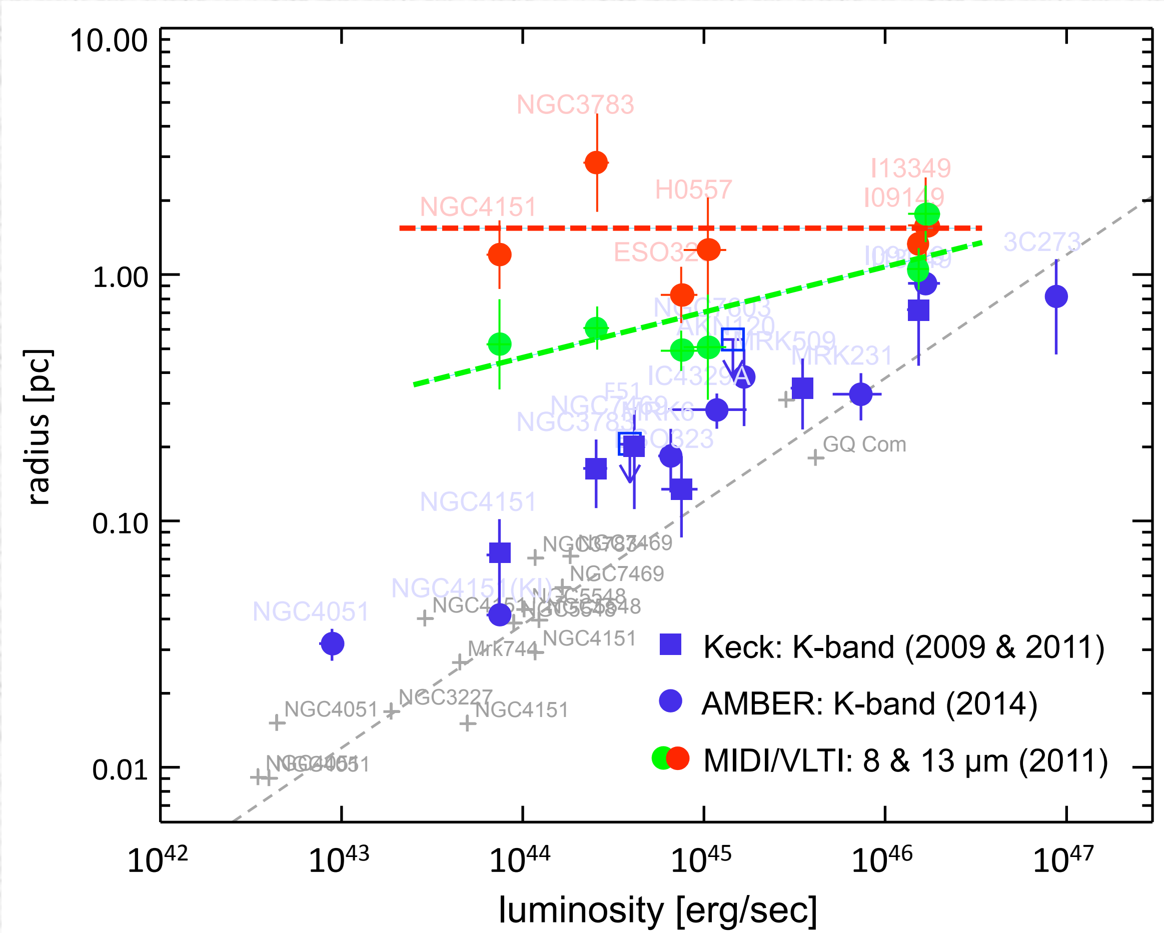


Three main subjects for OIR interferometry:

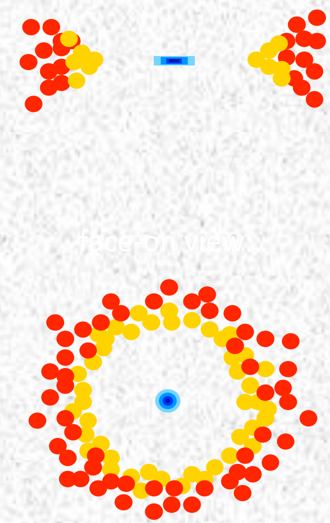
1. dust emission (thermal)
2. dust parallaxes (thermal)
3. BLR characterisation (emission lines: Brγ, Paα)

1. Thermal dust: size-luminosity relation (B)



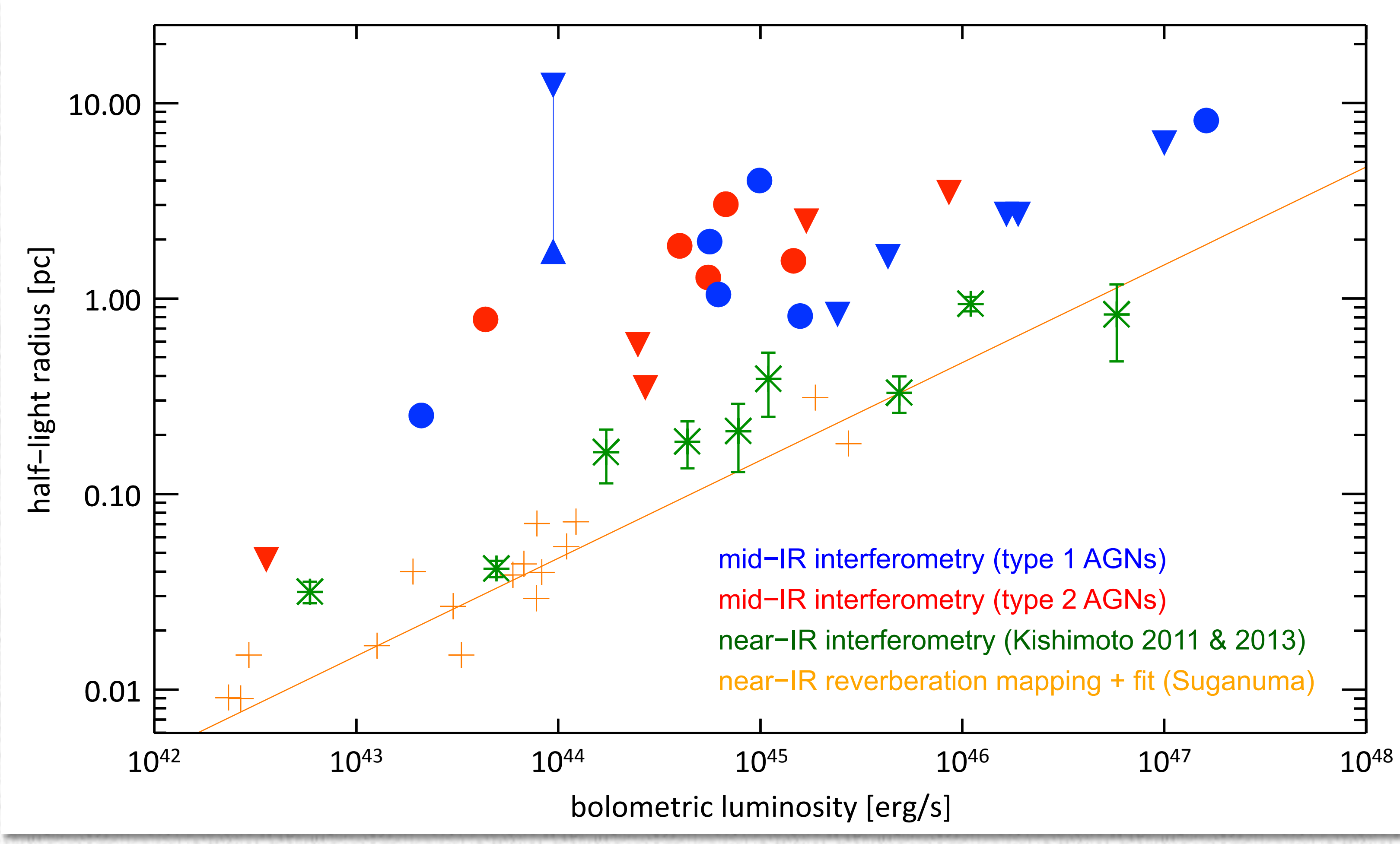


Kishimoto et al. 2011, 2013



↳ flatter dependency, change in radial dust distribution

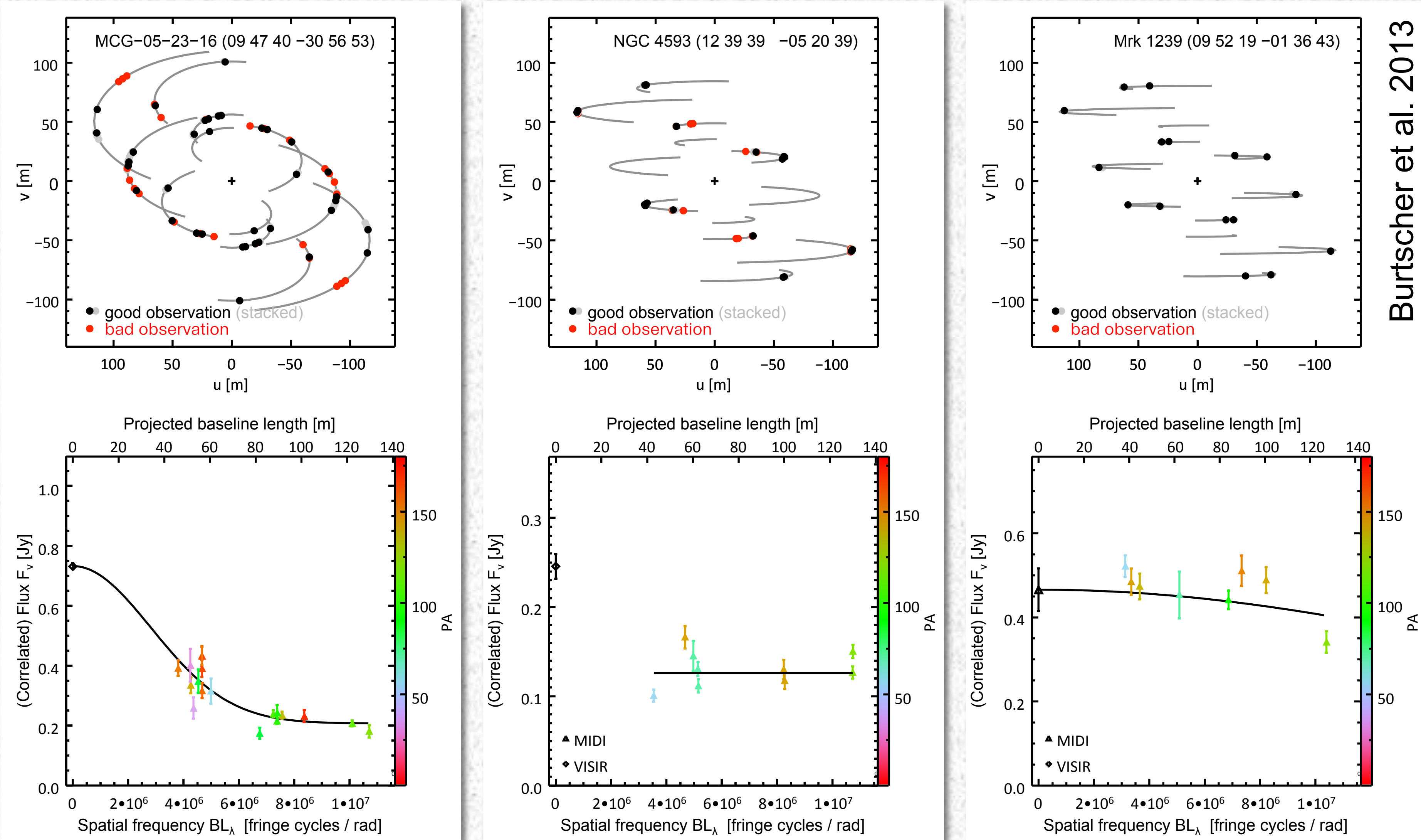
1. Thermal dust: size-luminosity relation (C)



Burtscher et al. 2013

↳ size dependency confirmed, but large scatter

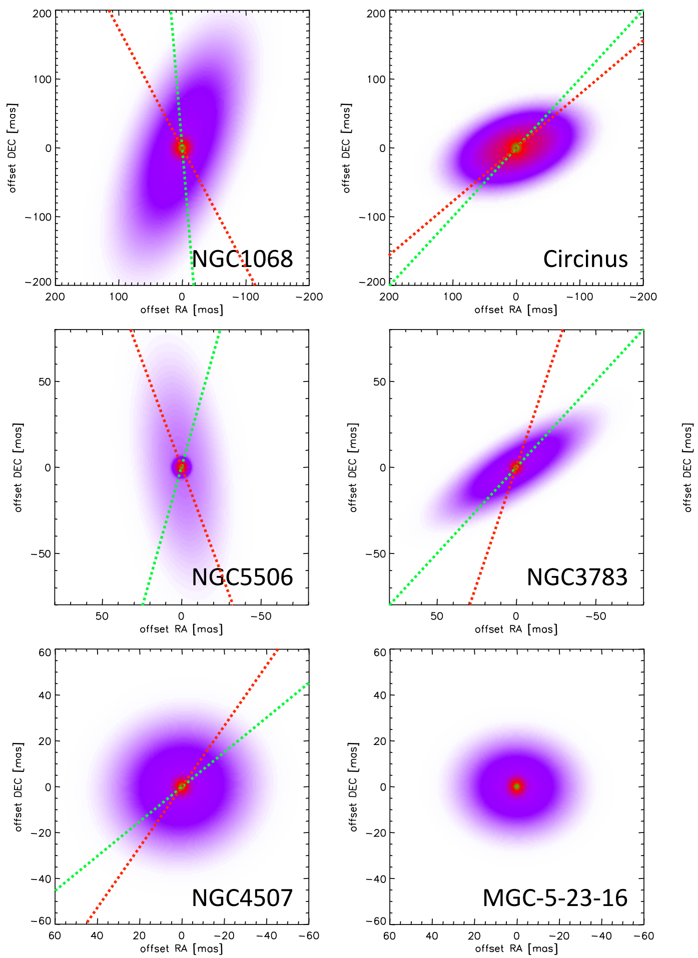
1. Thermal dust: radial structures



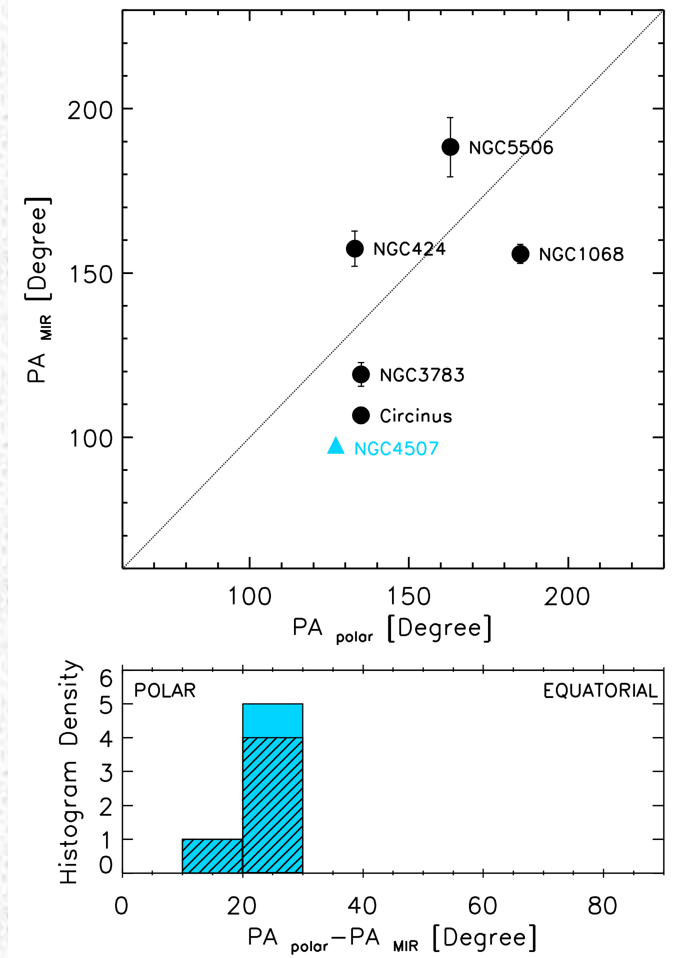
Burtscher et al. 2013

1. Thermal dust: polar dust structures

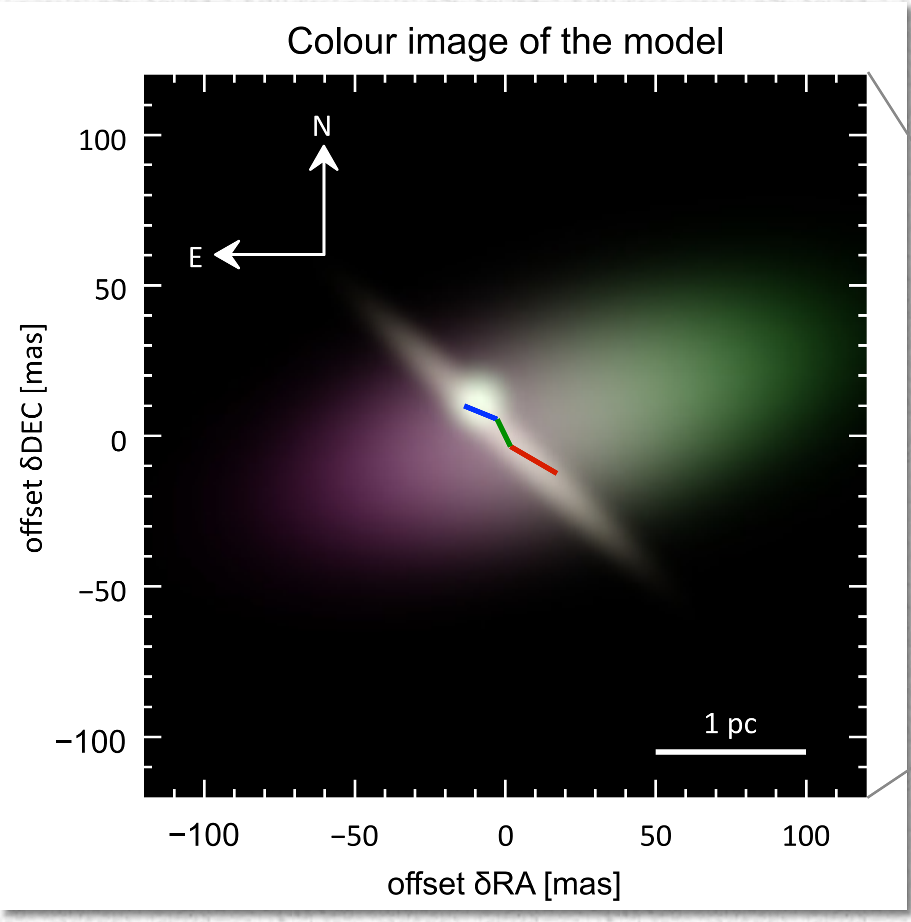
Result: 5 out of 7 sources elongated in polar direction



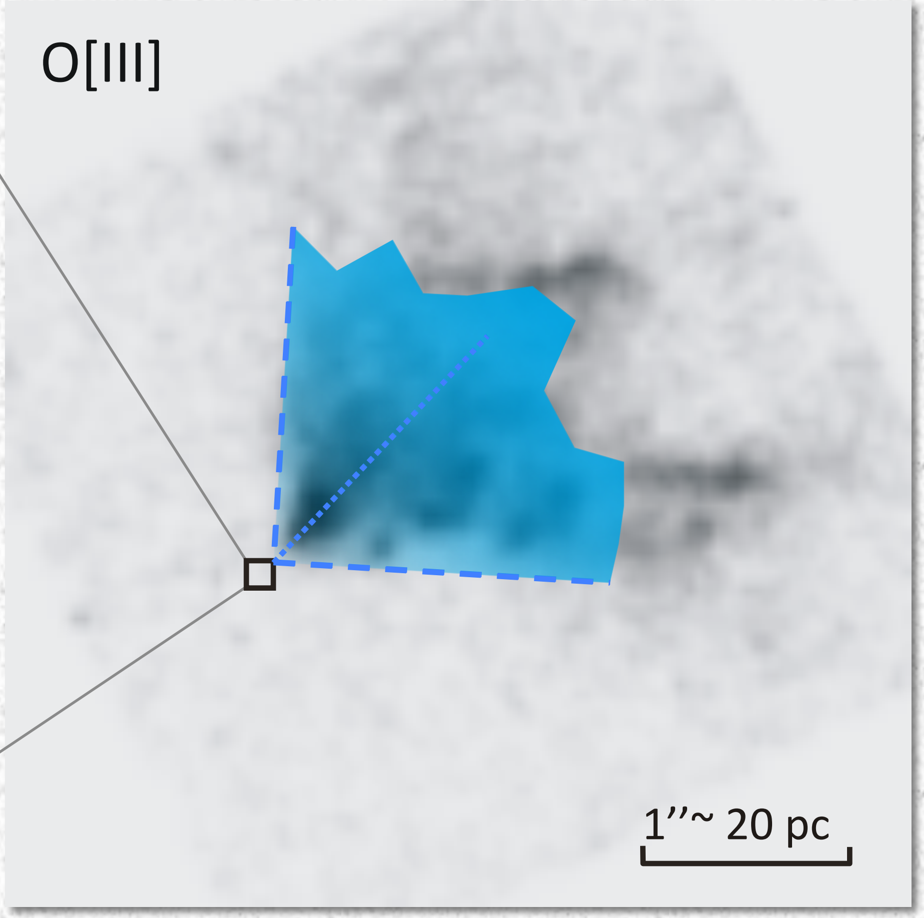
López Gonzaga
et al. 2016



1. Thermal dust: Circinus – geometry

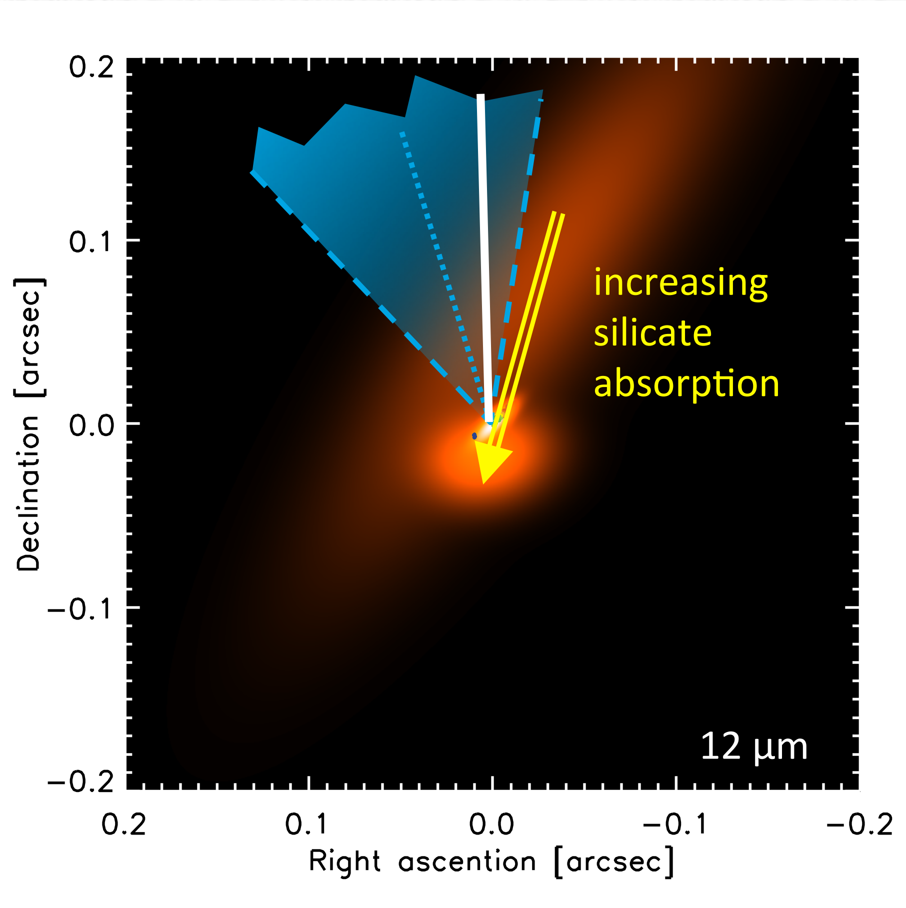


Tristram et al. 2014



Wilson et al. 2000

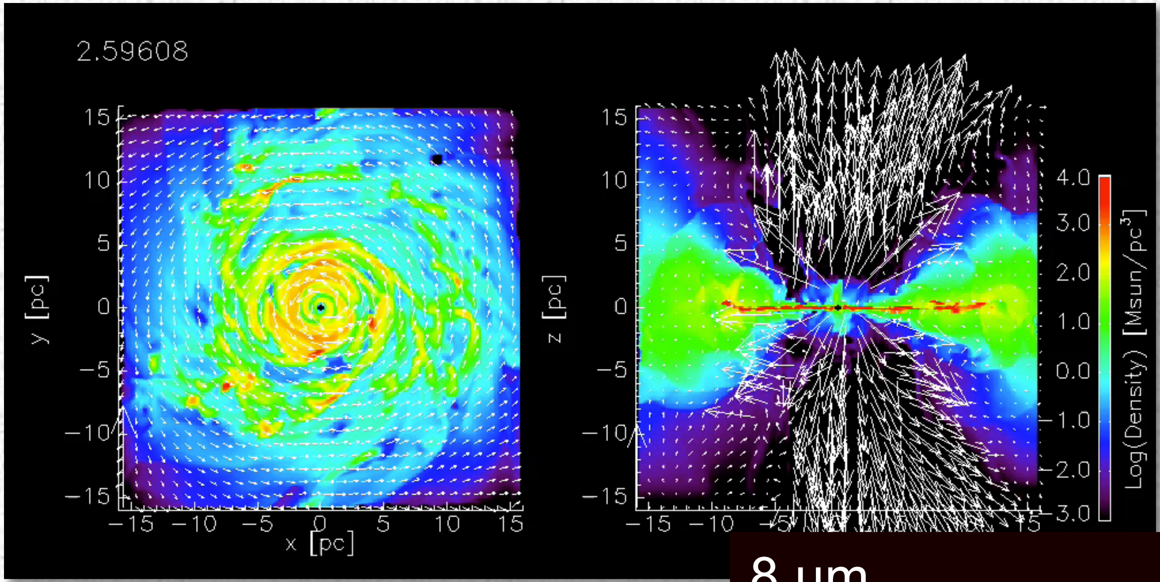
1. Thermal dust: NGC 1068 – geometry



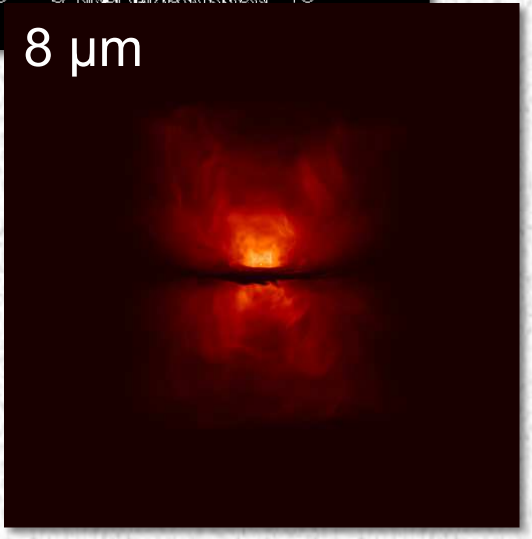
López Gonzaga et al. 2014

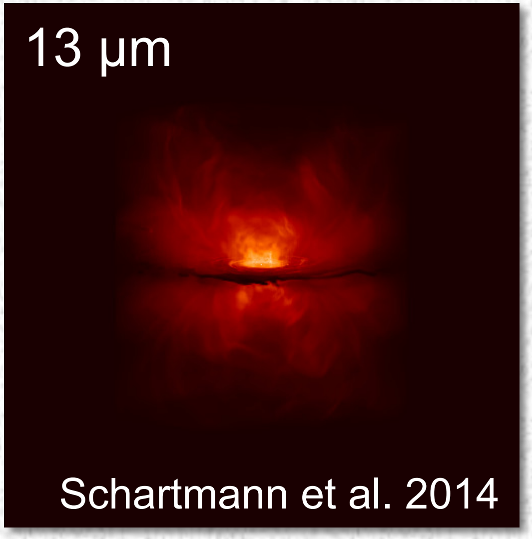
- three blackbody Gaussians with offsets
- fit to 30 correlated fluxes and phases (ATs and UTs)
- interpretation as inner wall of a dusty cone

1. Thermal dust: modelling



Wada 2012



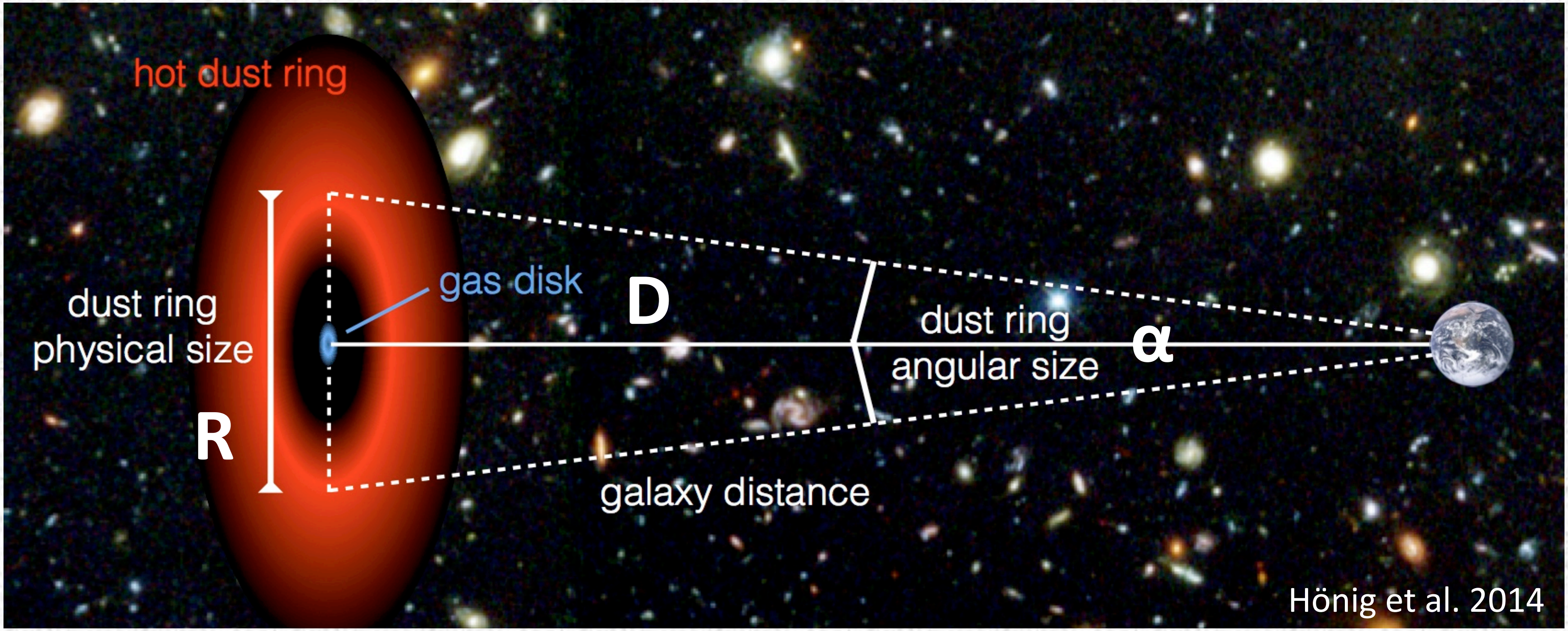


Schartmann et al. 2014

2. Dust parallaxes: technique

- Reverberation: $R = c \cdot \tau$, where τ is the delay
- Interferometry: α – angular size, $\sin(\alpha) = R / D$

↳ angular diameter distance: $D = c \cdot \tau / \alpha$



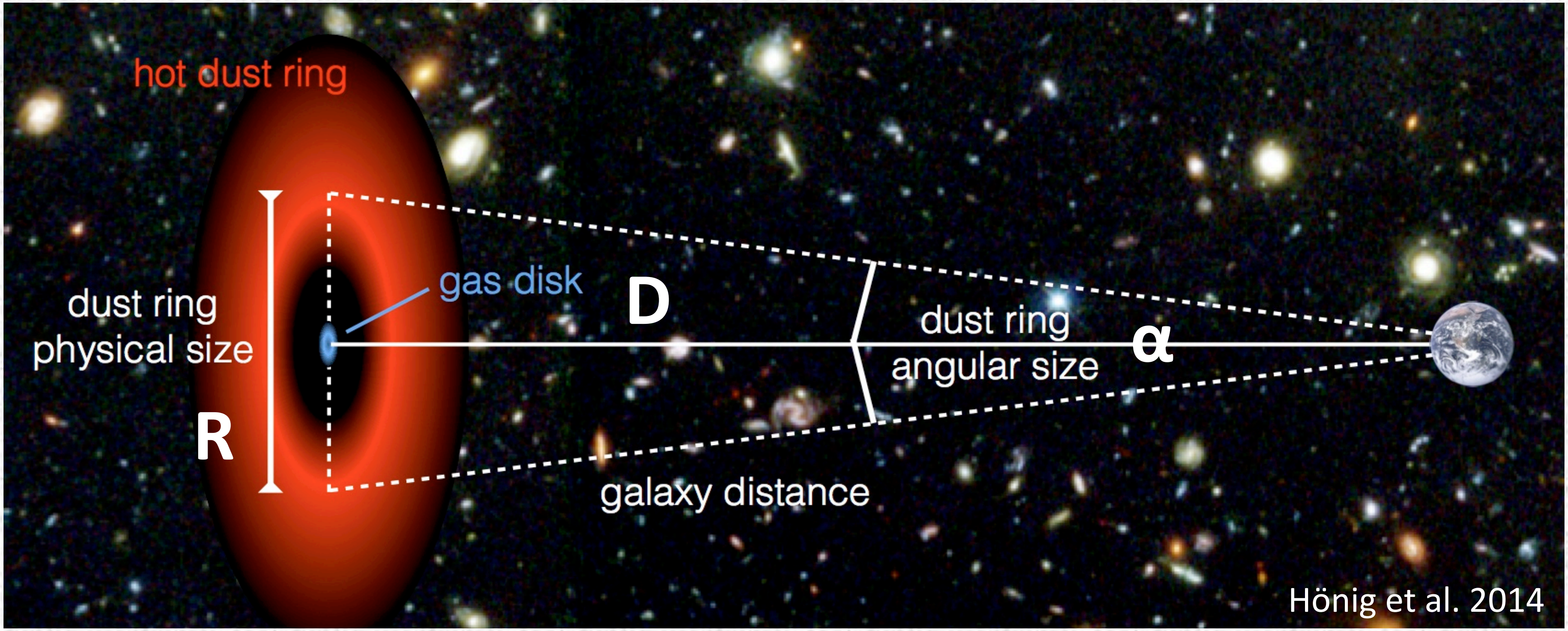
Hönig et al. 2014

2. Dust parallaxes: technique

Independently determine the Hubble constant

⇒ Preferably hotter dust: H-, K-bands (less smeared)

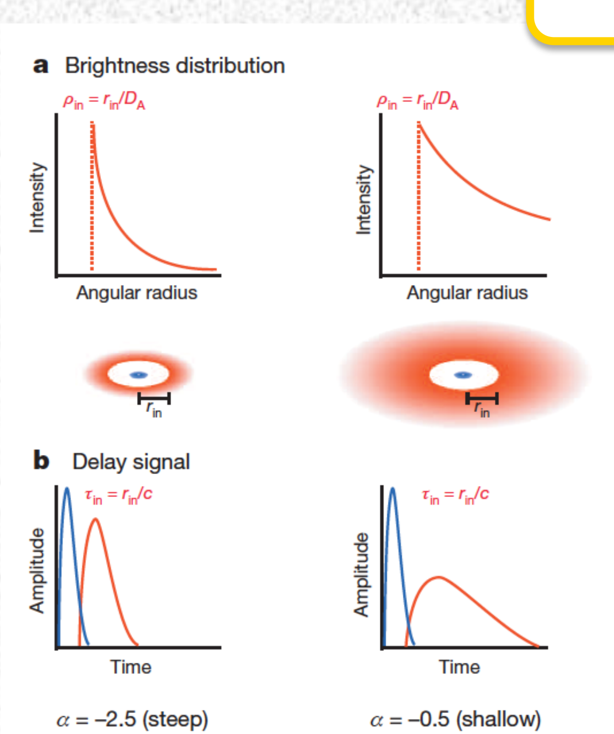
⇒ Accurate radii: accurate visibilities (because V ~ 1)



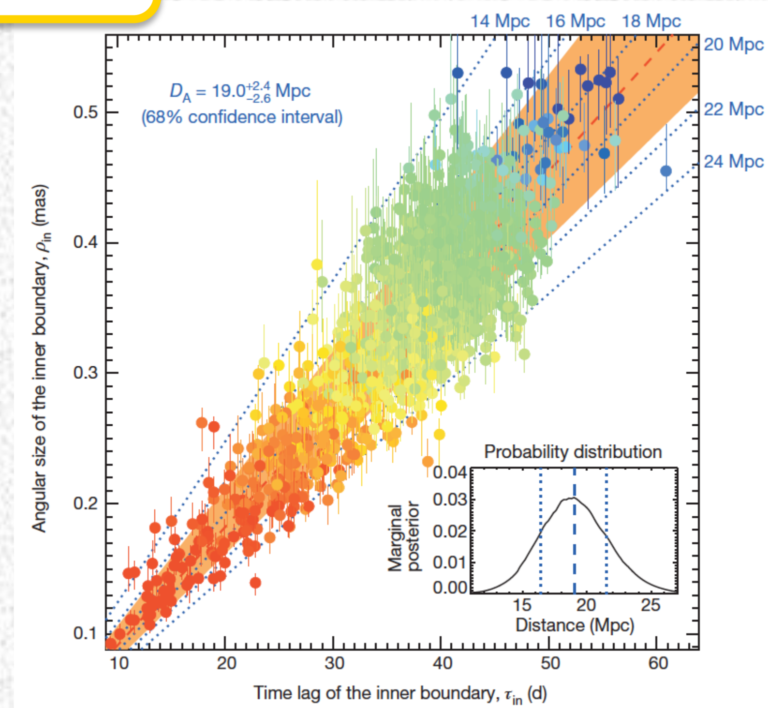
2. Dust parallaxes: distance to NGC4151

- Model dependence on brightness distribution.
- Monte Carlo modelling of the measurements.

D = 19.0 ± 2.6 pc

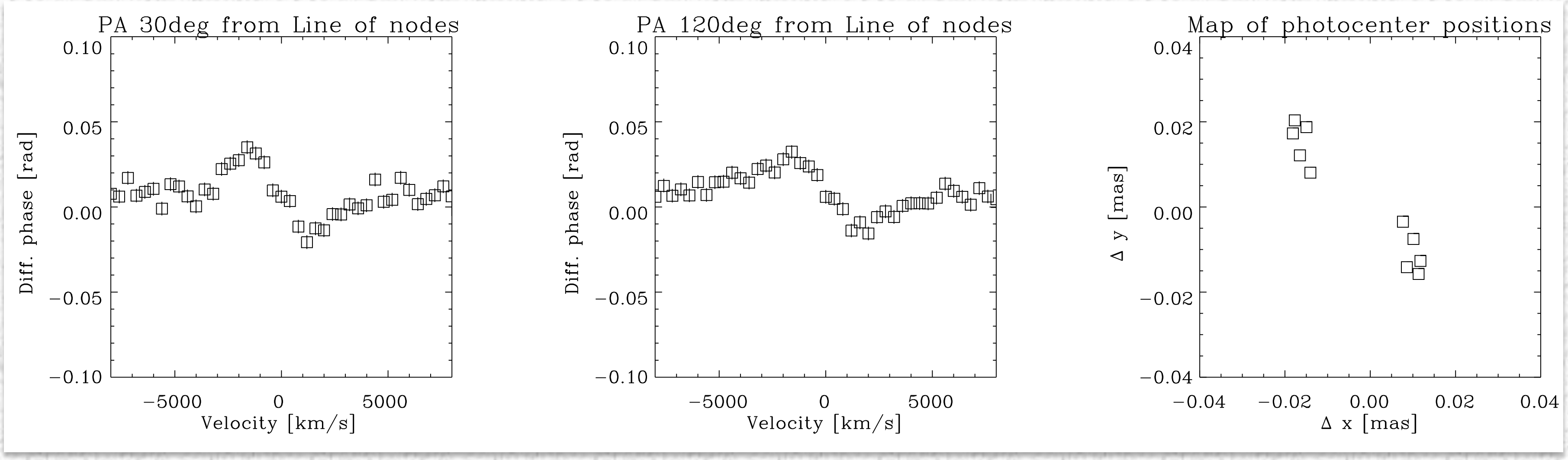


Hönig et al. 2014



3. BLR characterisation: motivation

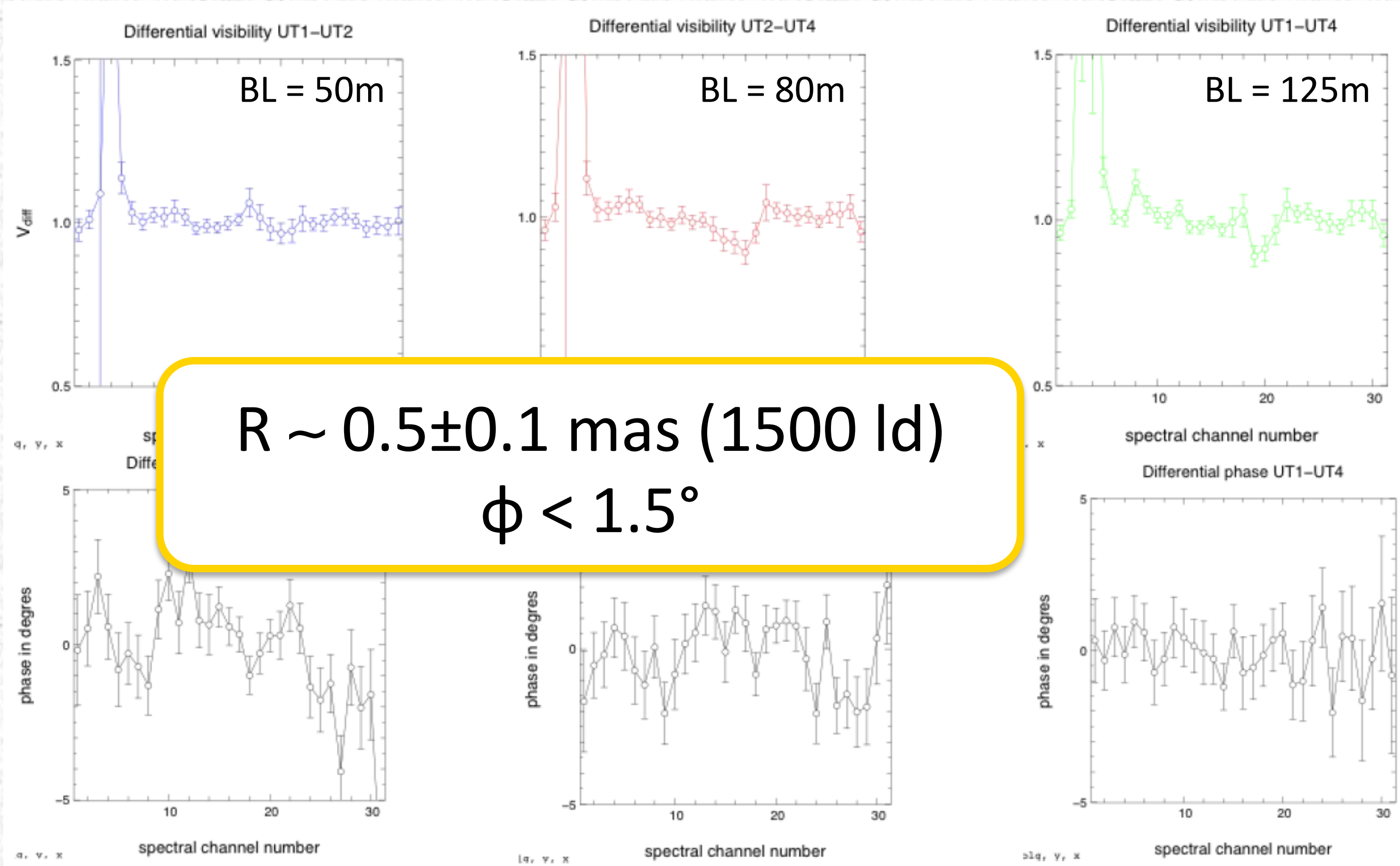
- Getting a hold of black hole – galaxy coevolution requires accurate knowledge of black hole masses.
- resolve velocity gradients in the Broad Line Regions (BLR) of several nearby AGN.



Petrov et al. 2012

3. BLR characterisation: 3C273 with AMBER

Petrov et al. 2012



R ~ 0.5±0.1 mas (1500 ld)

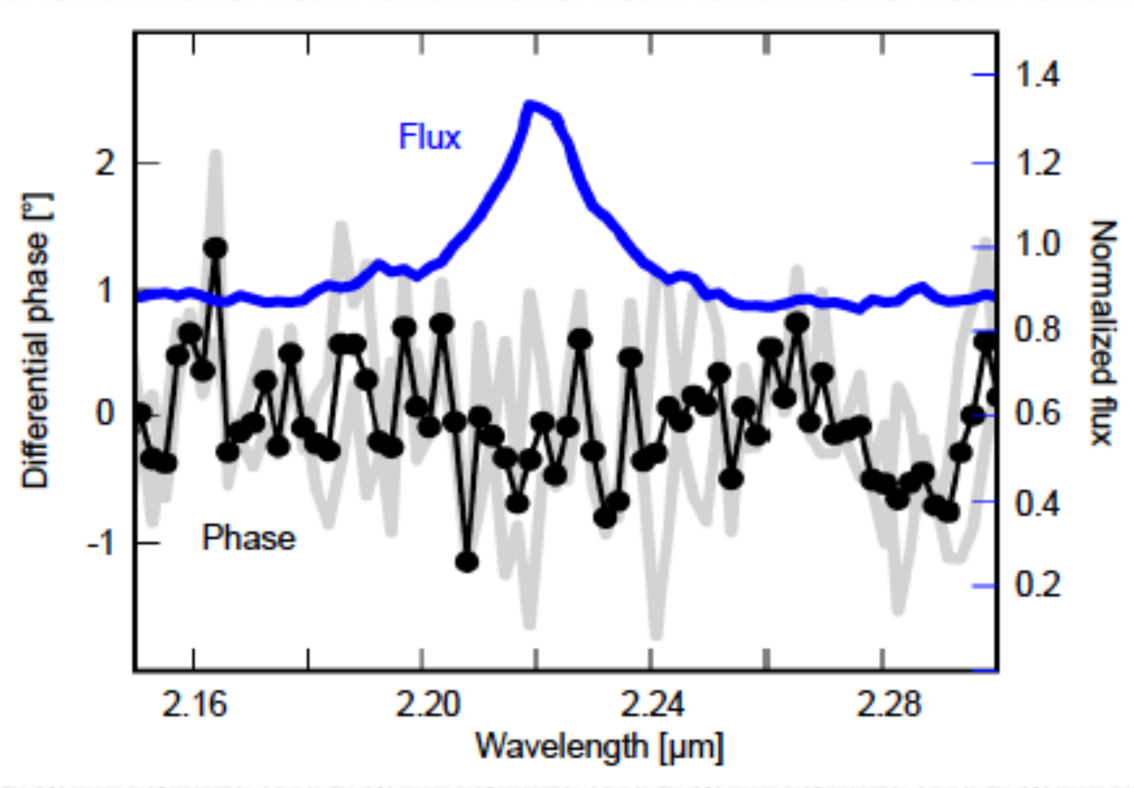
ϕ < 1.5°

↳ V_{line}/V_{cont} decreasing with BL, BLR larger than R_{in}

3. BLR characterisation: PDS 456 / GRAVITY

- Focus on Pa α redshifted into the K band:

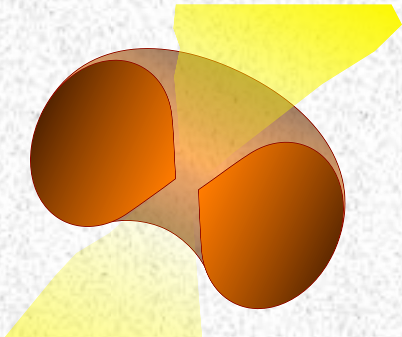
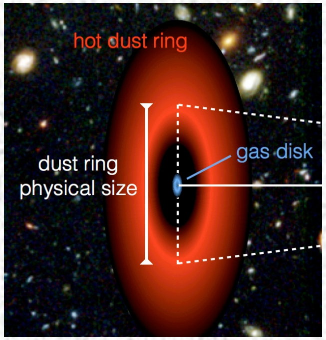
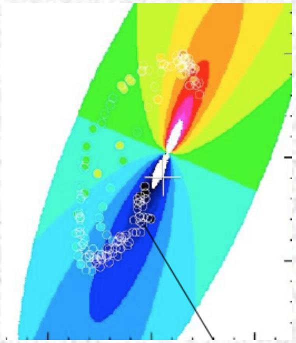
  ⇒ PDS 456: K = 9.9 mag, z = 0.184



FWHM < 0.6 mas
ϕ < 1.0°
⇒ offset ≤ 10 µas

GRAVITY Collaboration et al. 2017

Conclusion

	dust morphology	dust parallax	emission lines
			
wavelengths	long: M, N, Q	short: H, K, L	short: K, L
measurables	absolute V & ϕ	absolute V & ϕ	differential δV & $\delta\phi$
sensitivity & accuracy	sensitivity: N << 1 Jy imaging $\Rightarrow$ ATs	sensitivity: K >> 10^m $V \neq 1$ accuracy	$\delta V < 1\%$ $\delta\phi \ll 1°$
spectral capabilities	low	low	high
VLTI competition	MATISSE	GRAVITY (AMBER)	GRAVITY MATISSE