On the importance of polar dust in AGN

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with

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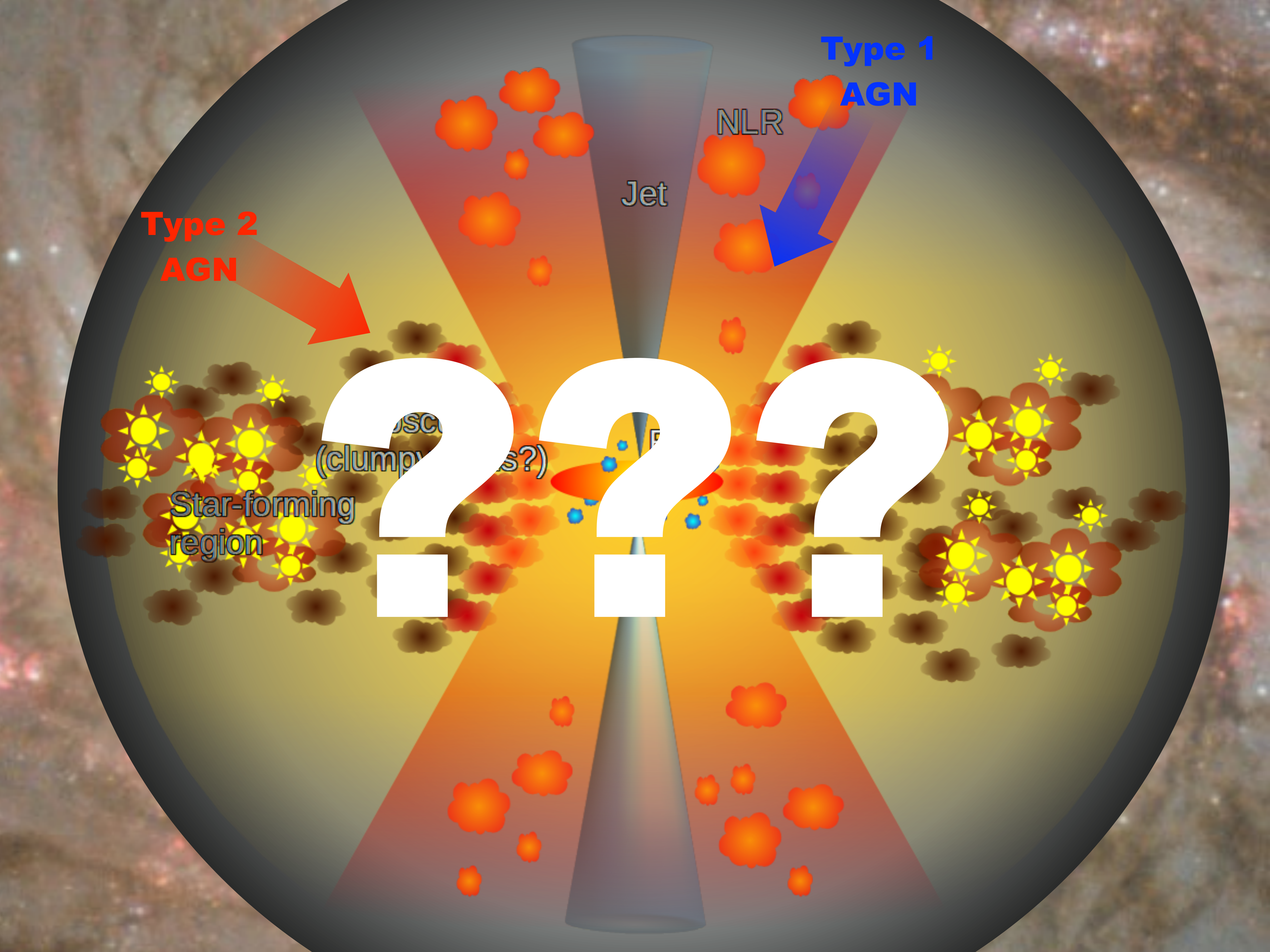
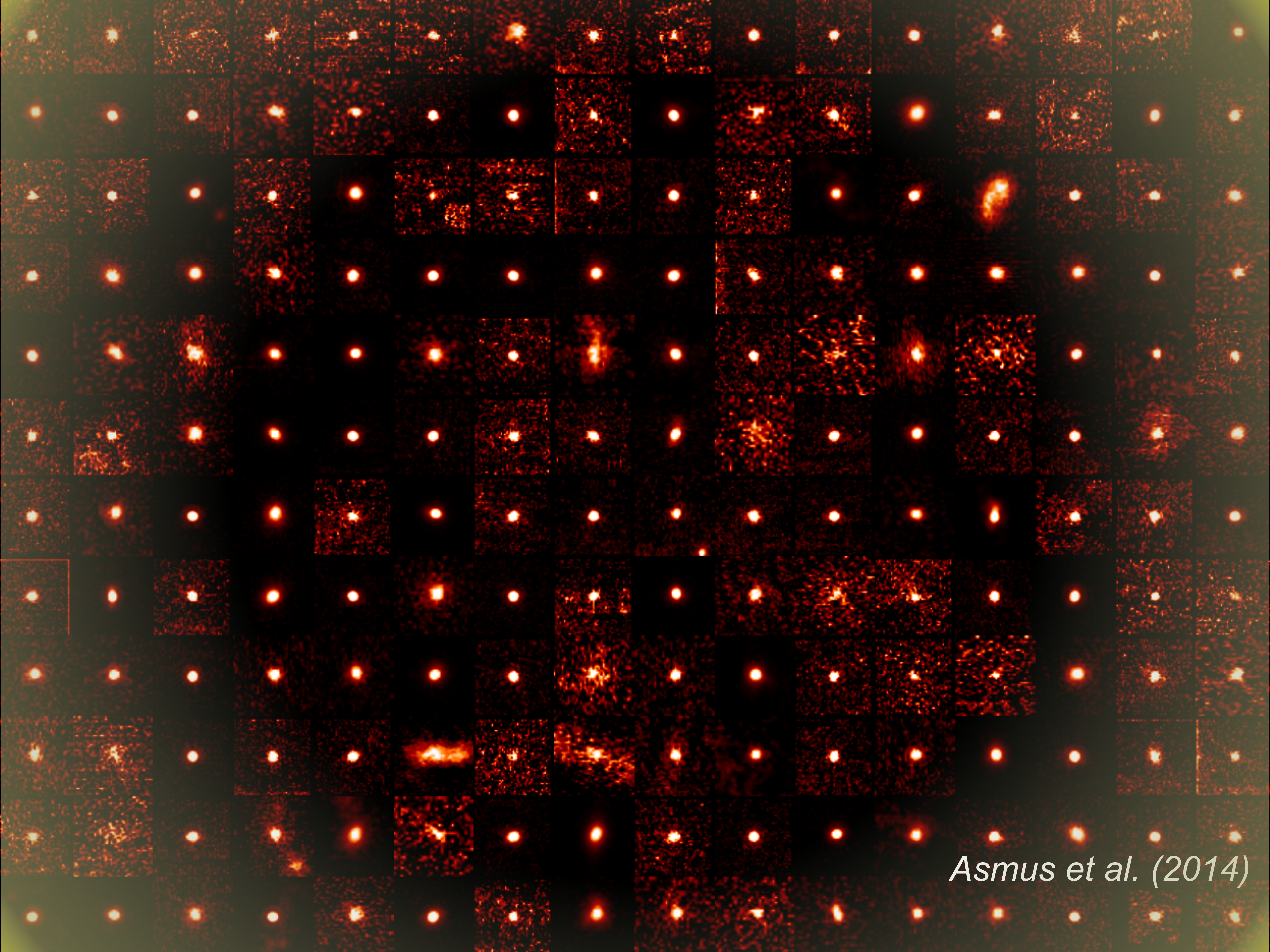
MARIE CURIE ACTIONS

UNIVERSITY OF Southampton

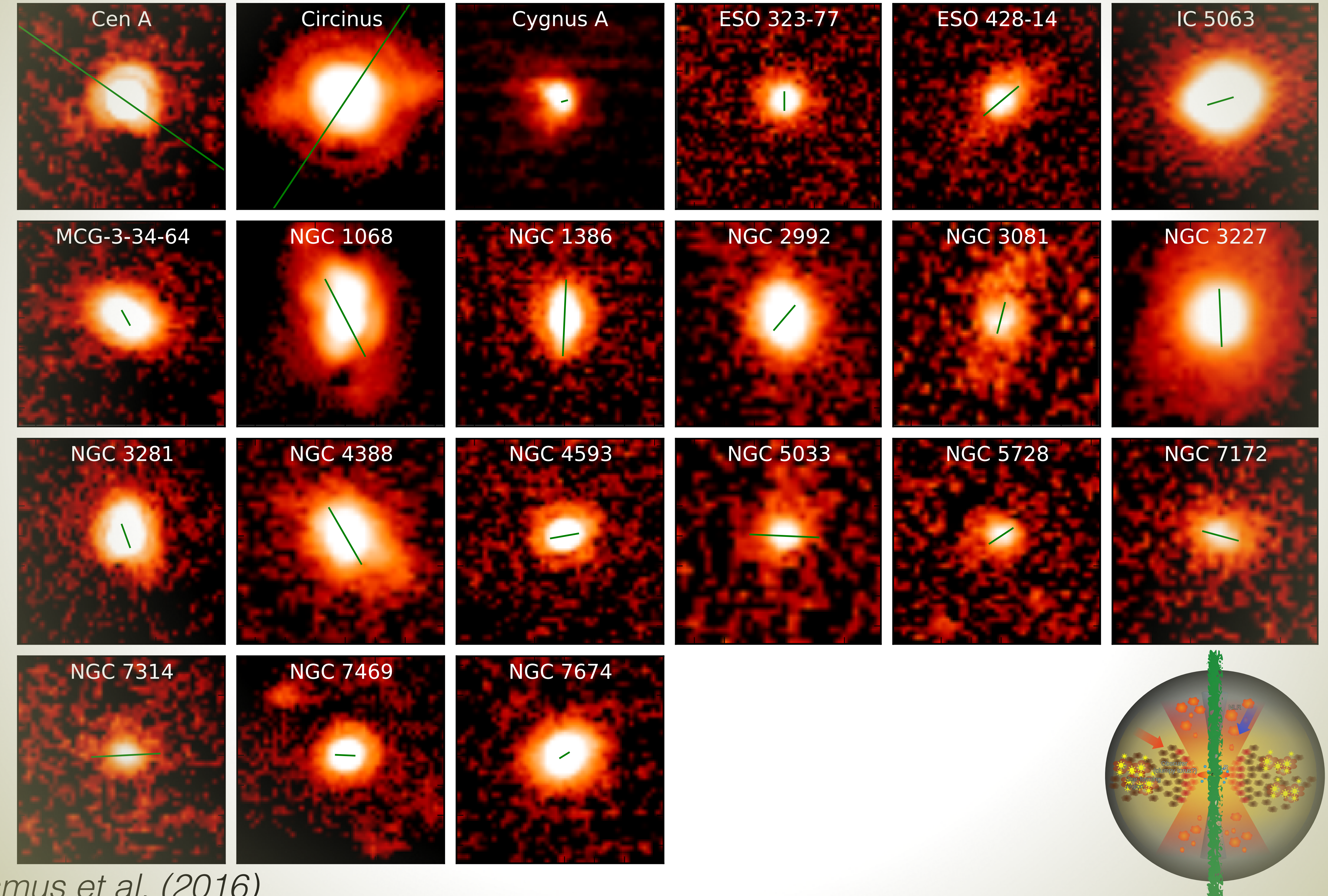


Type 1
AGN
NLR
Jet
Type 2
AGN
(clump
s?)
Star-forming
region
???



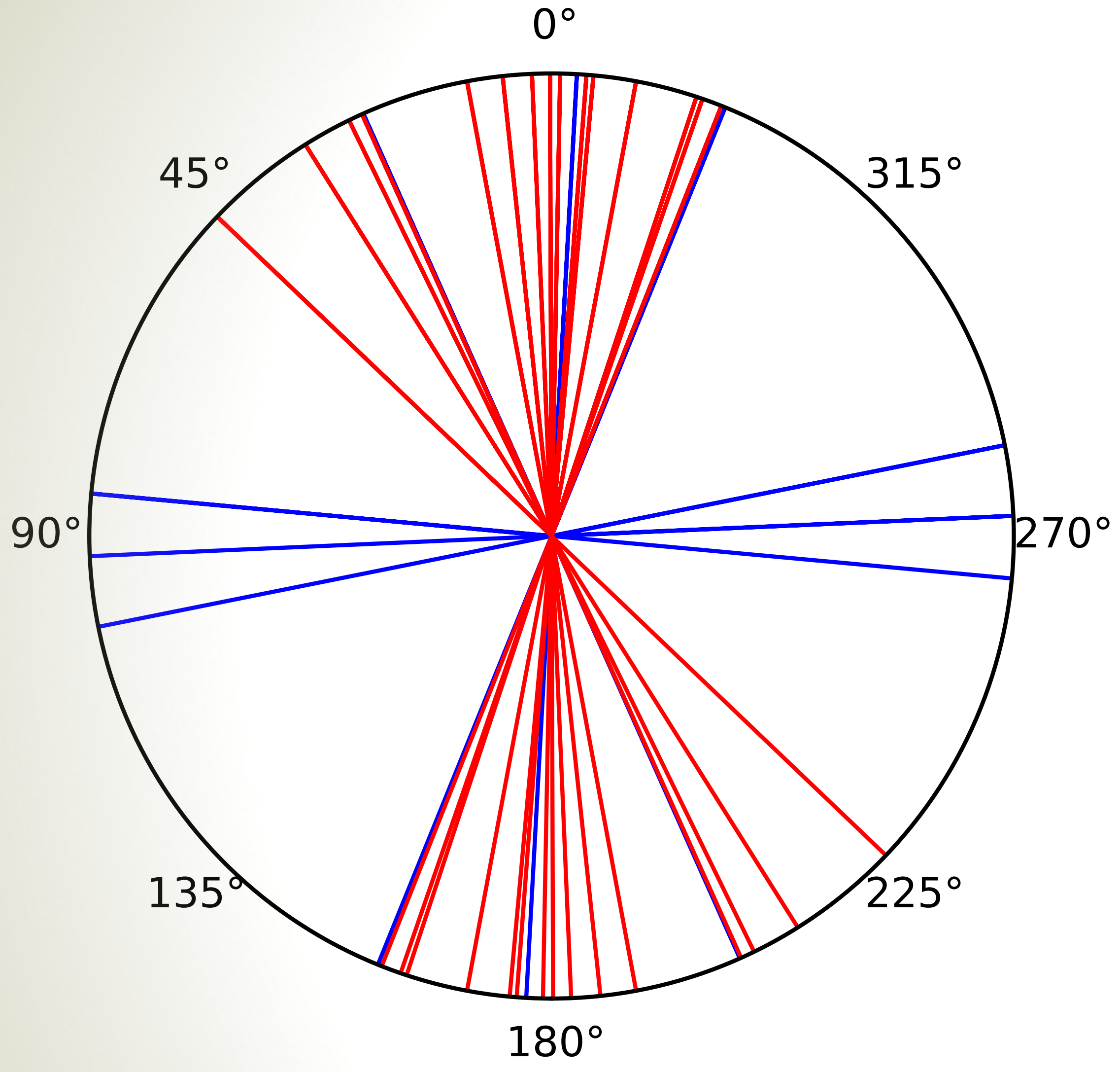
Asmus et al. (2014)

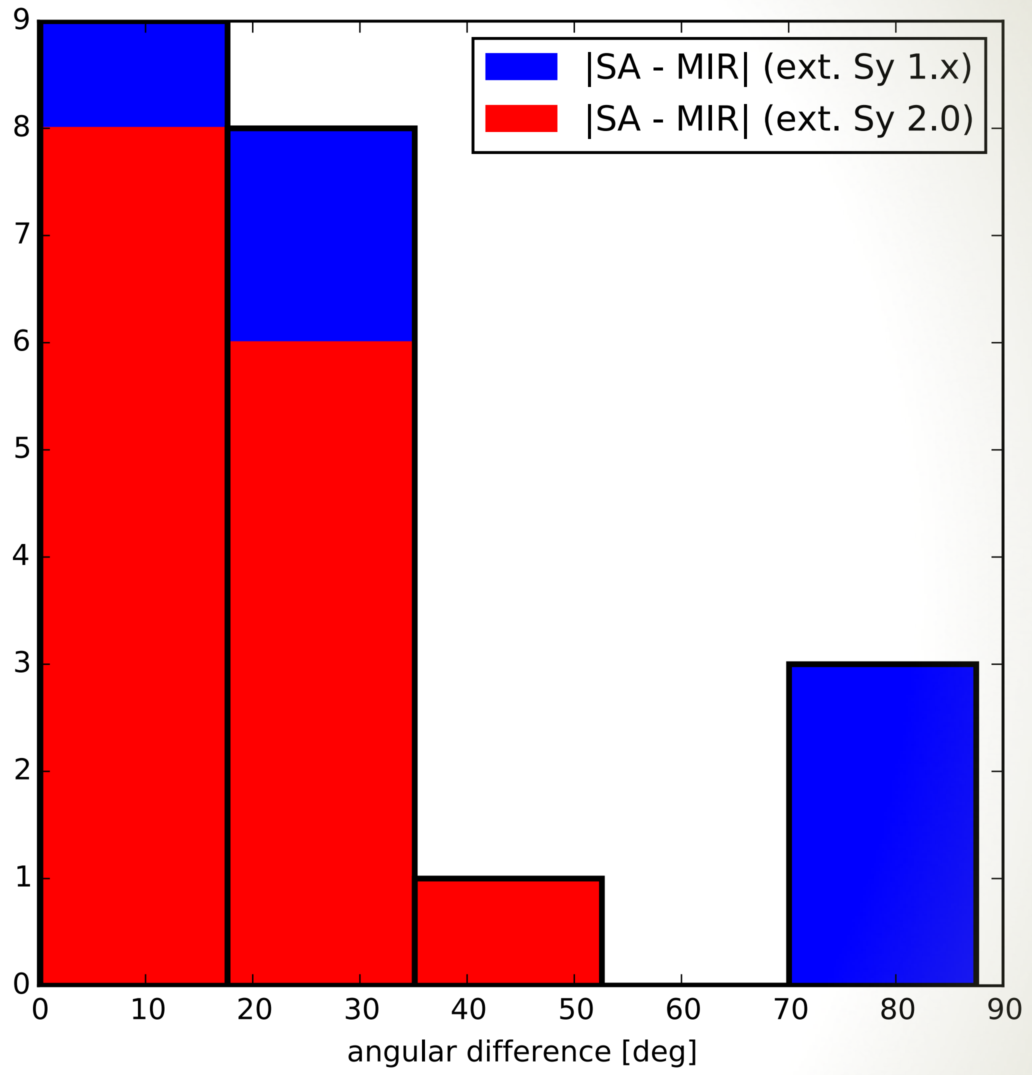
Out of ~150 nearby AGN without strong nuclear star formation, 21 show extended nuclear mid-infrared emission



Asmus et al. (2016)

The resolved emission is coming from the polar axis of the AGN systems!



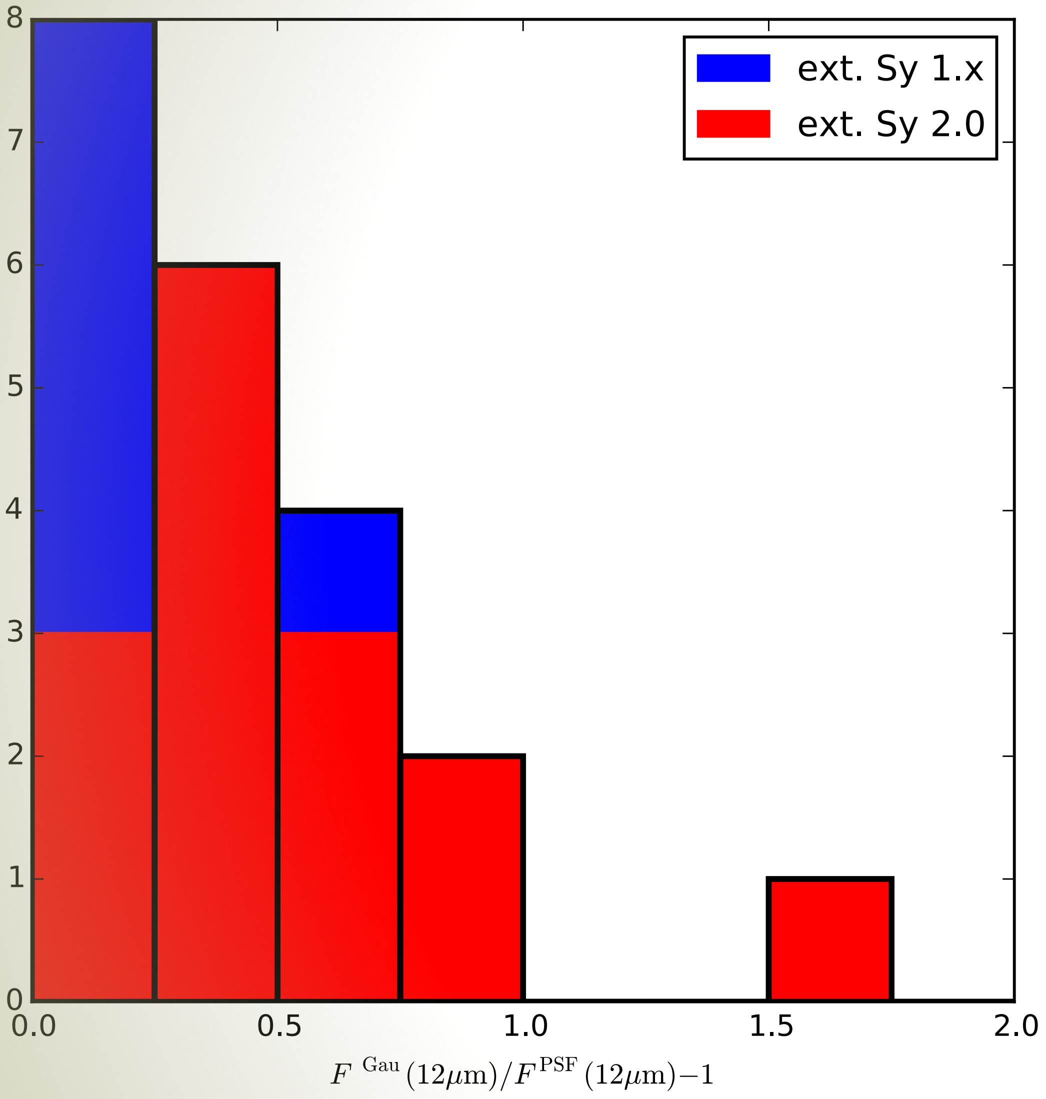


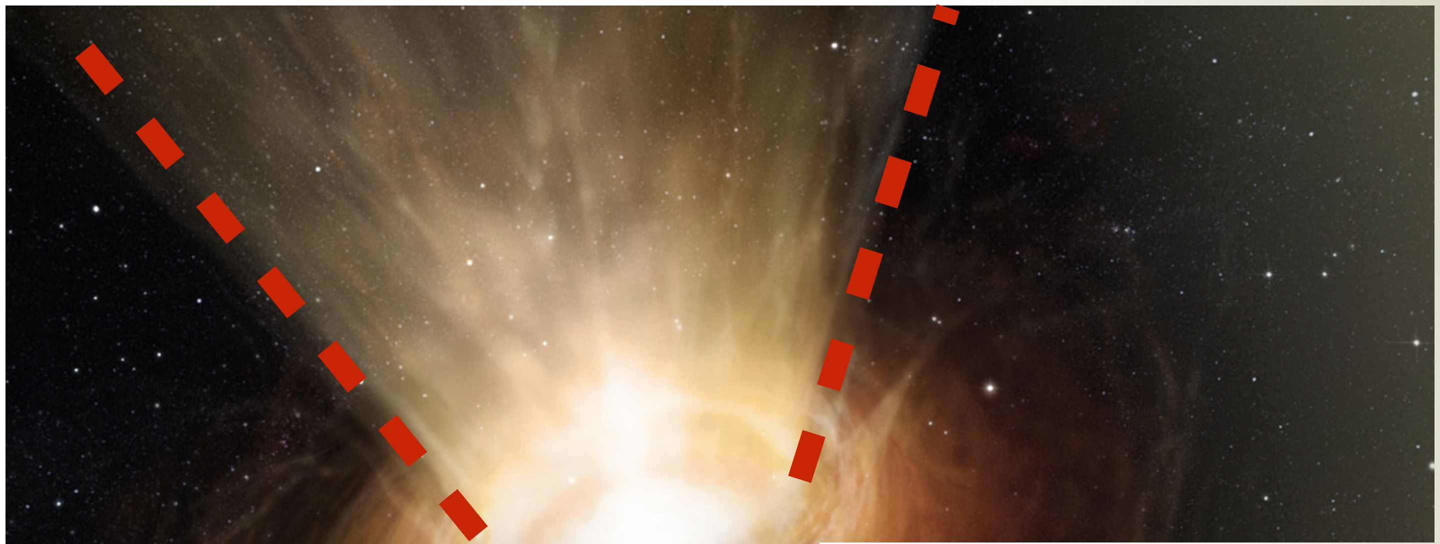
Angular difference (System Axis - MIR extension)

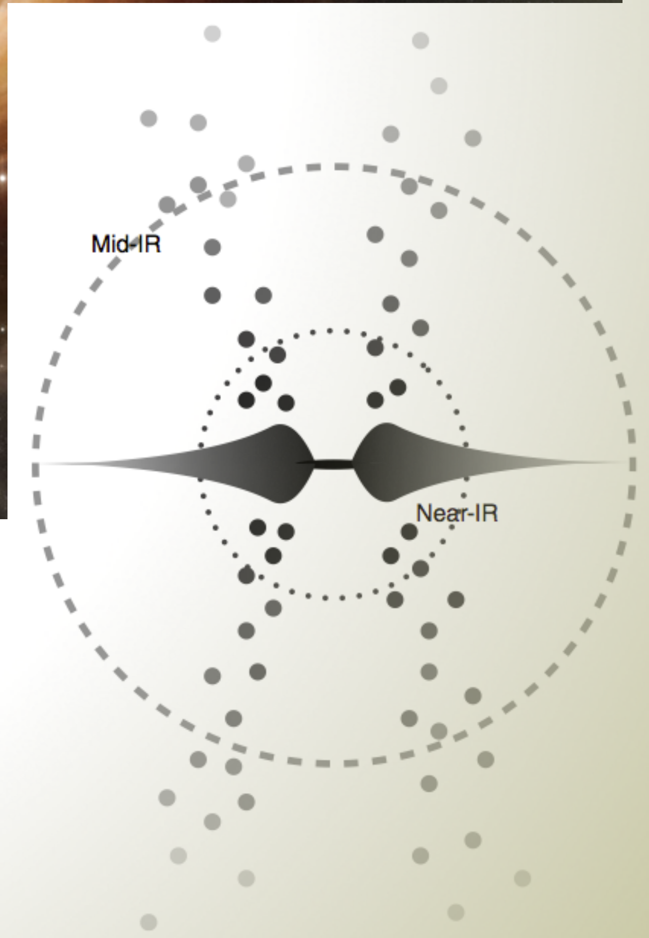
Asmus et al. 2016 (see also Braatz et al. 1993; Cameron et al. 1993; Bock et al. 2000; Radomski et al. 2002, 2003; Whysong & Antonucci 2004; Packham et al. 2005; Reunanen, Prieto & Siebenmorgen 2010; Hönig et al. 2010)

Is the mid-infrared emission of AGN dominated by dust in/along the ionisation cone instead of the obscuring torus?

Minimum relative amount of resolved emission



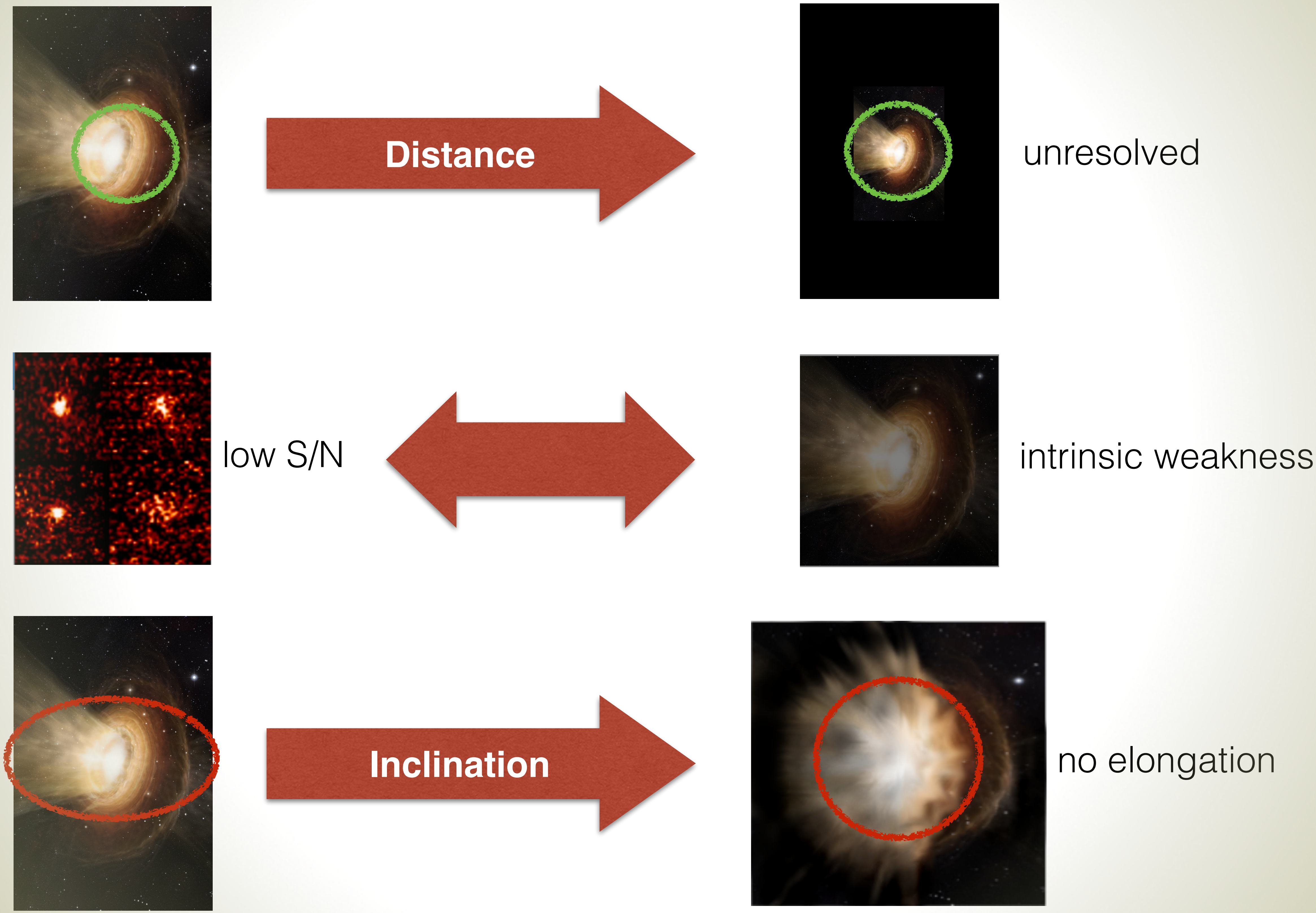




Asmus et al. (2016)

Hönig et al. (2012)

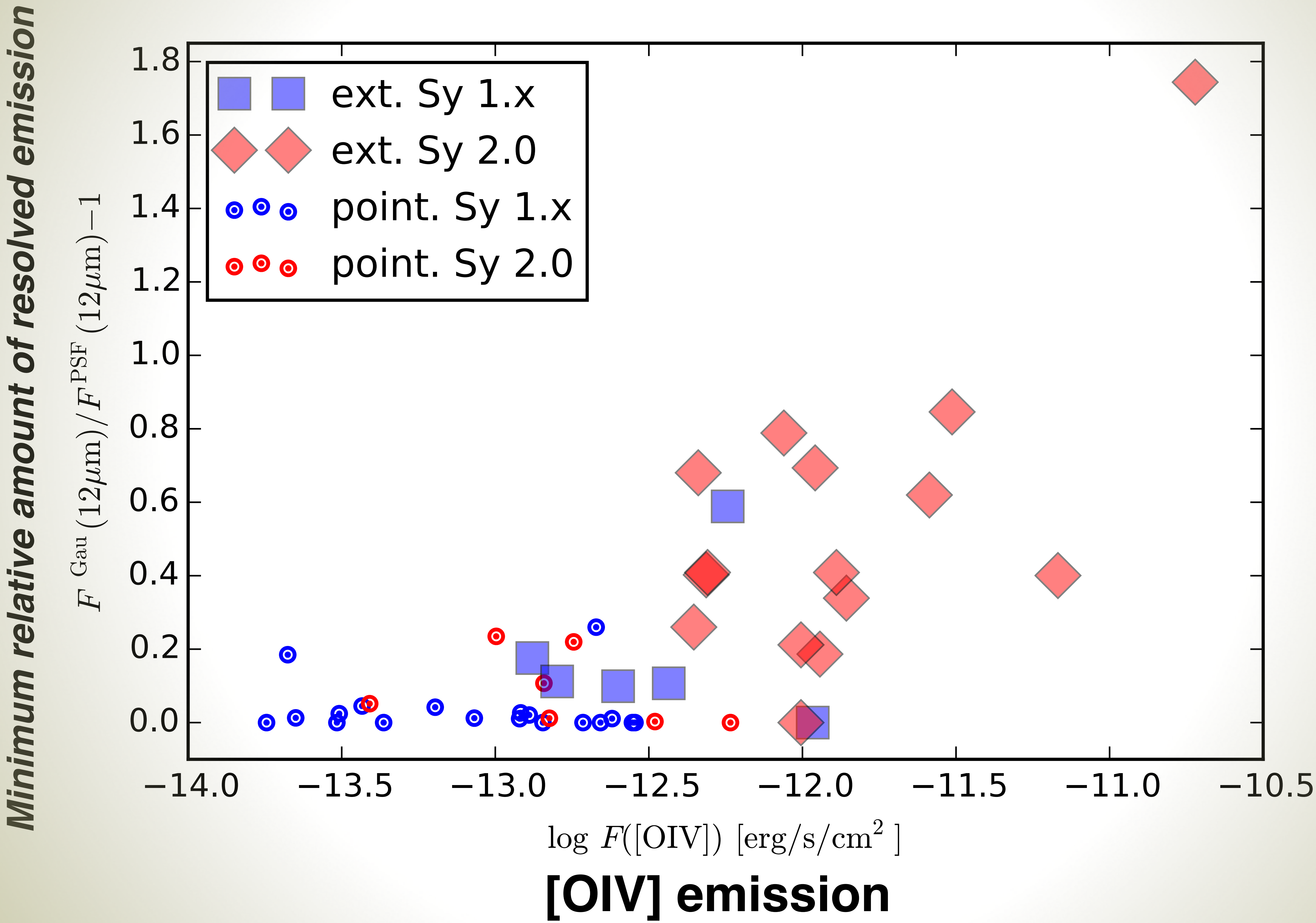
The reasons for the low detection rates



Asmus et al. 2016

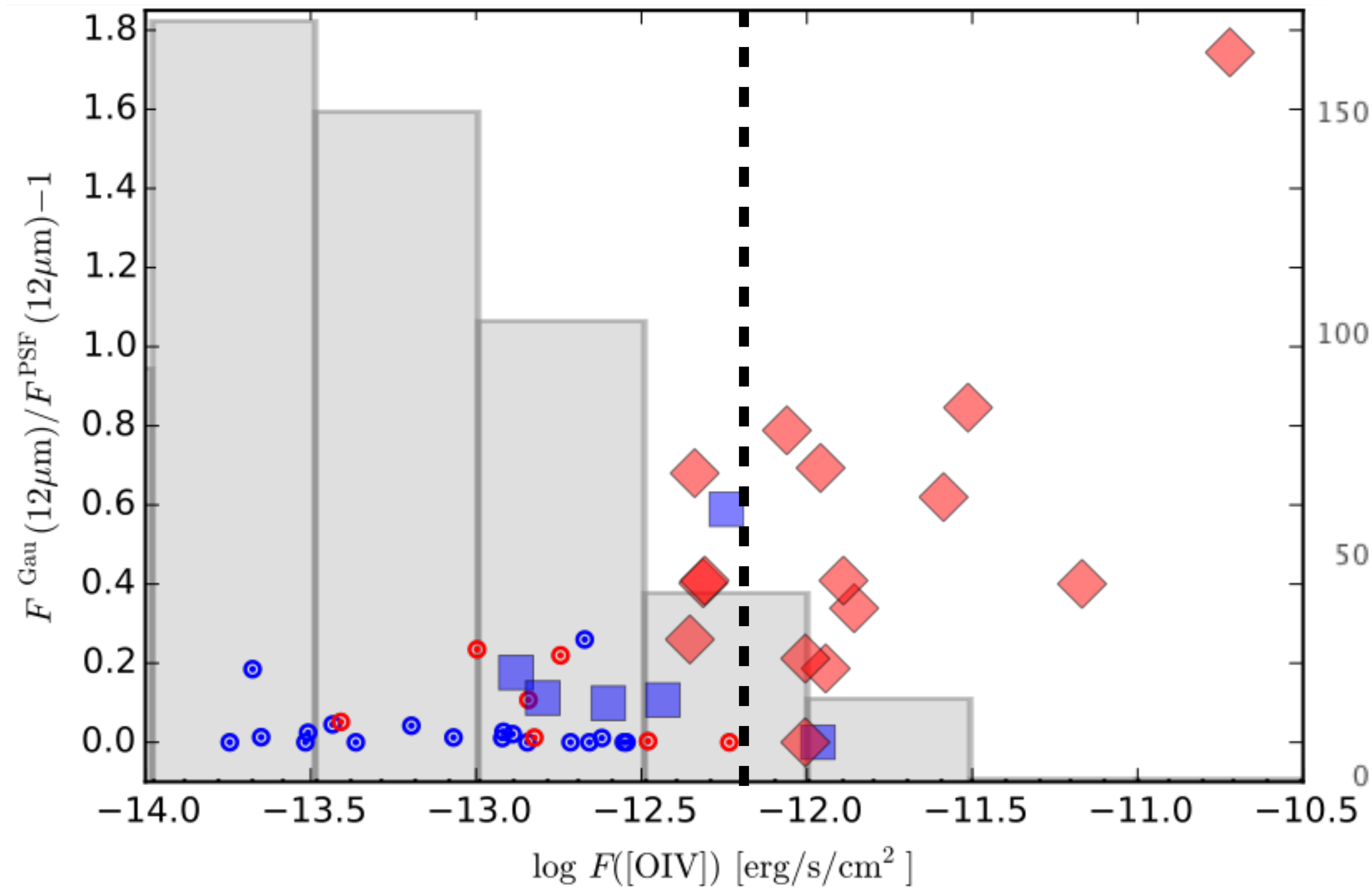

Is polar dust ubiquitous in AGN?

The resolved emission strongly correlates with the [OIV] emission produced in the ionisation cone



Asmus et al. 2016

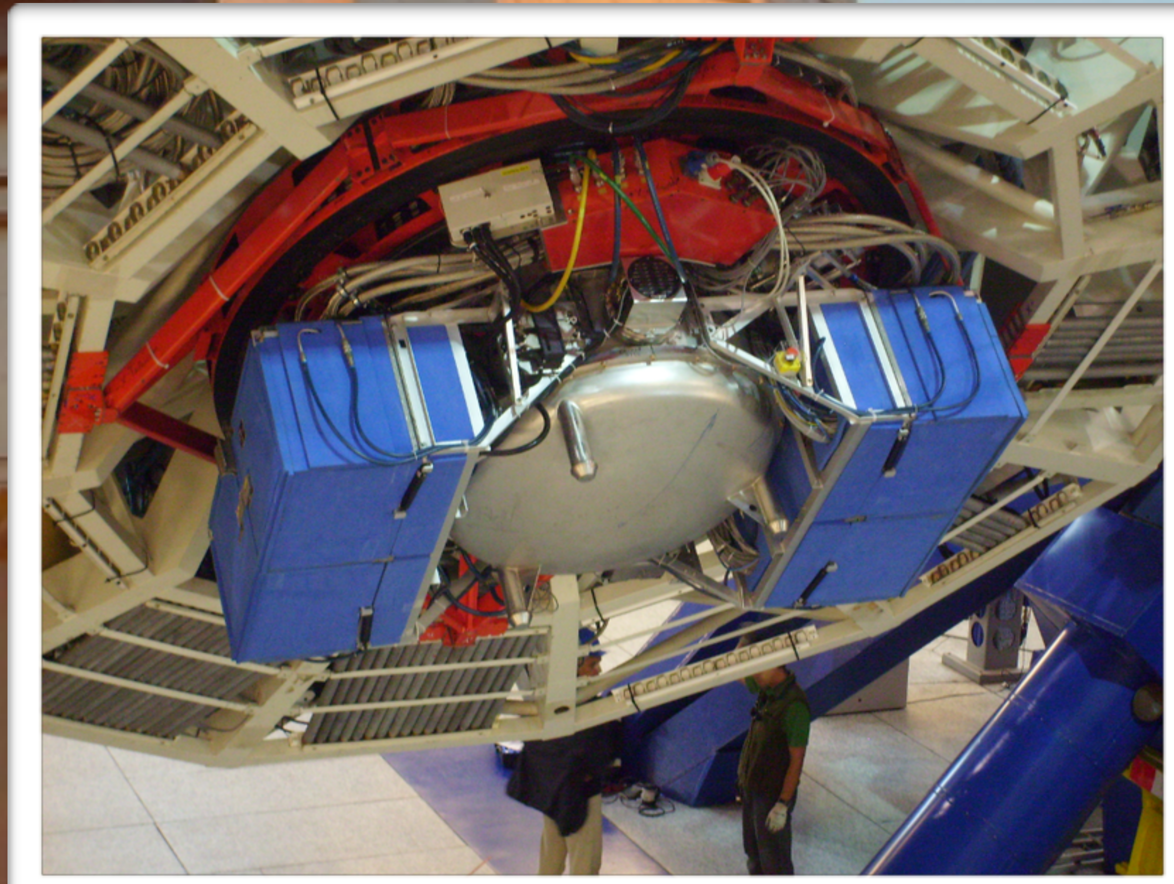
The resolved emission strongly correlates with the [OIV] emission produced in the ionisation cone

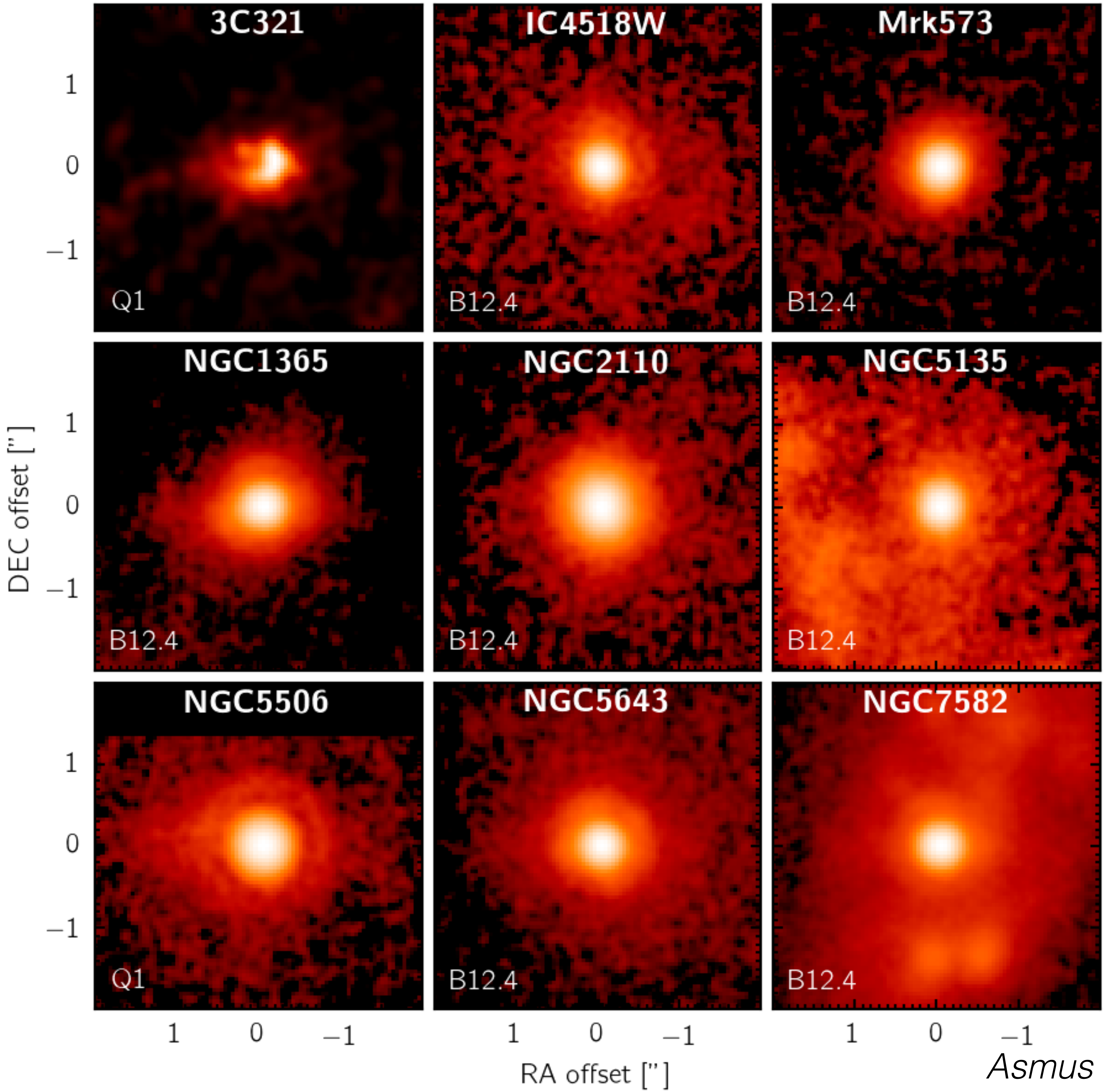


[OIV] emission

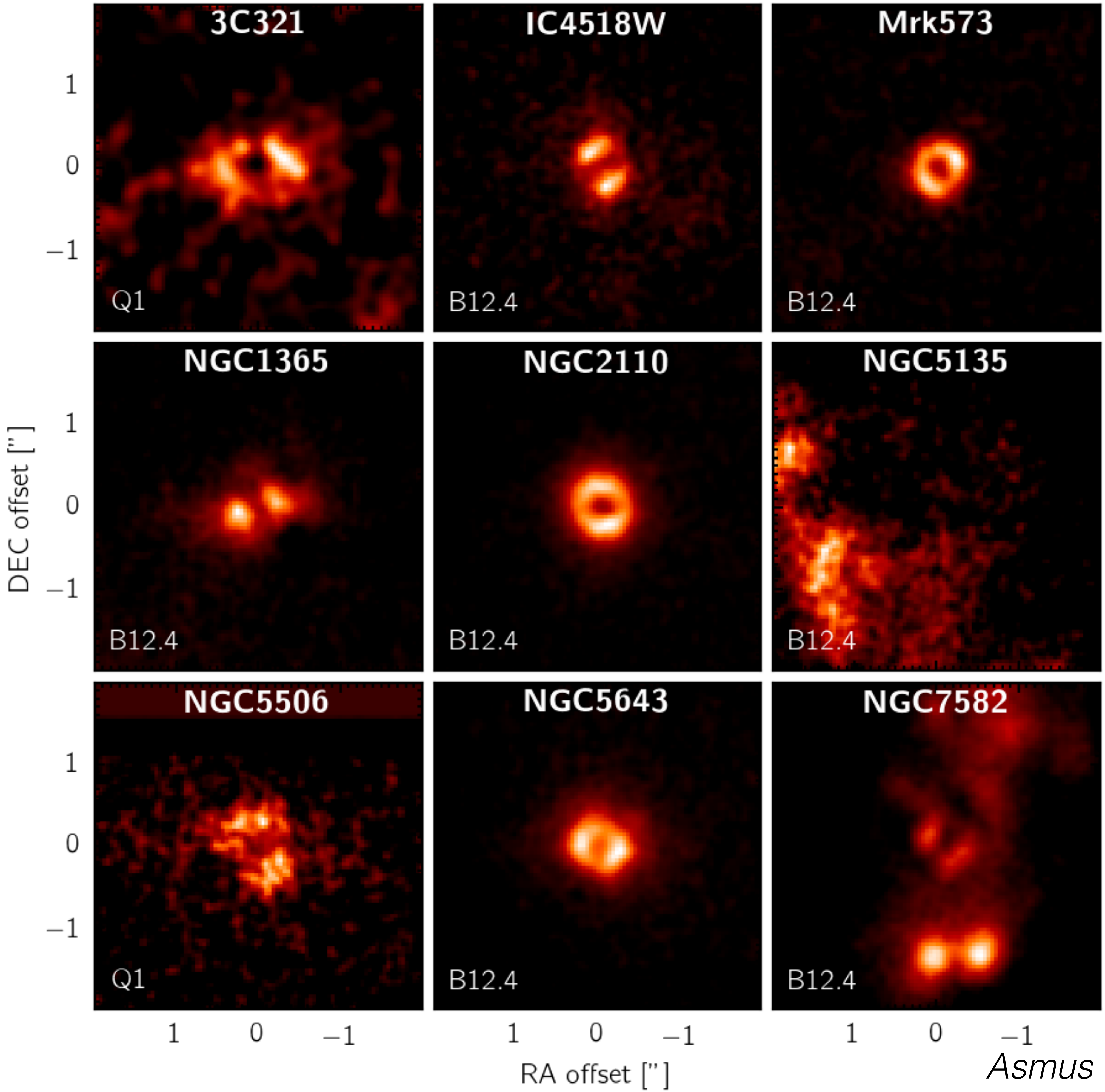
Asmus et al. 2016

20 hours of A-ranked time for 12 & 18μm deep imaging with the upgraded VLT/VISIR of 9 objects with PSF reference

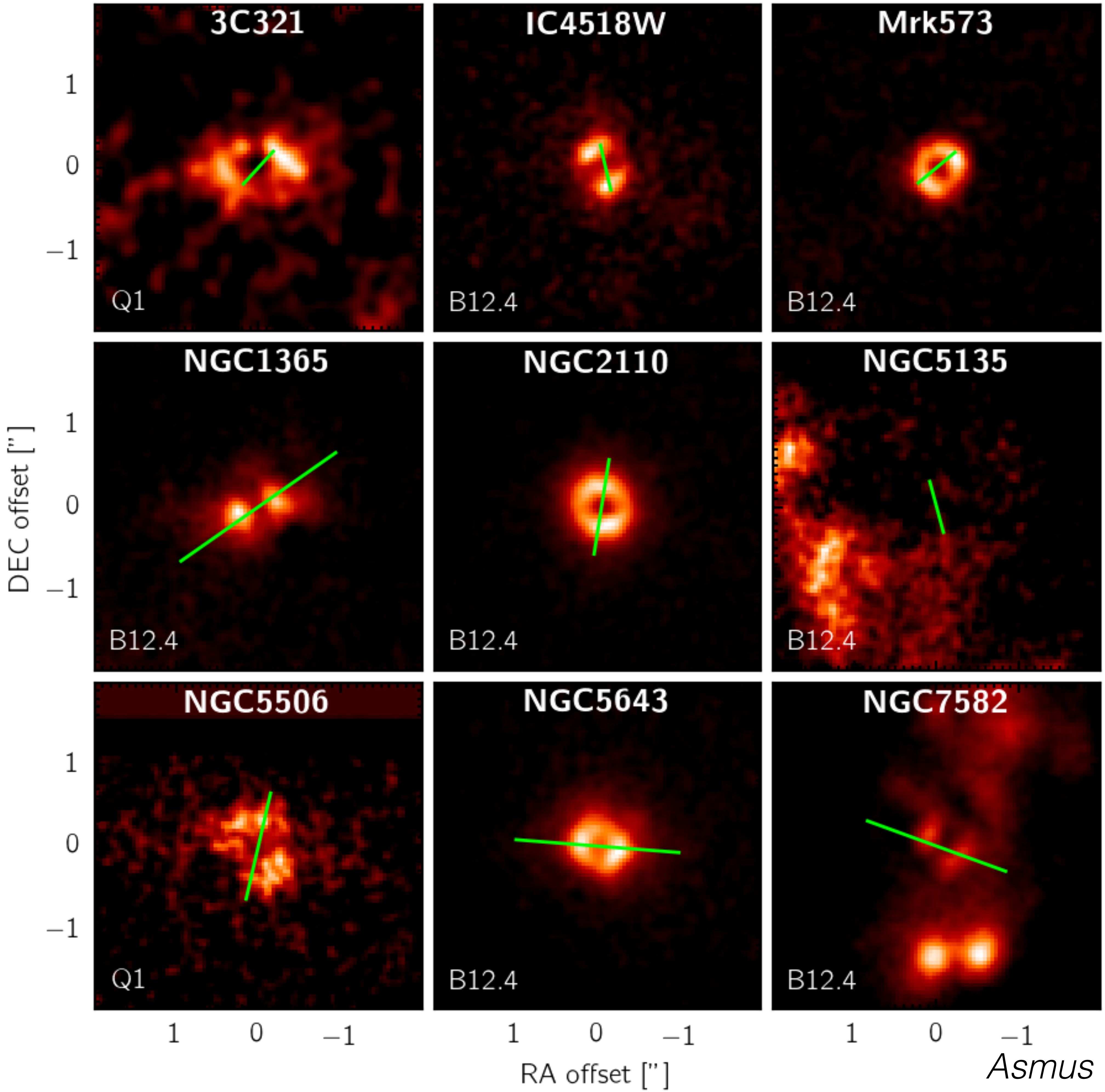




Asmus et al. (in prep.)

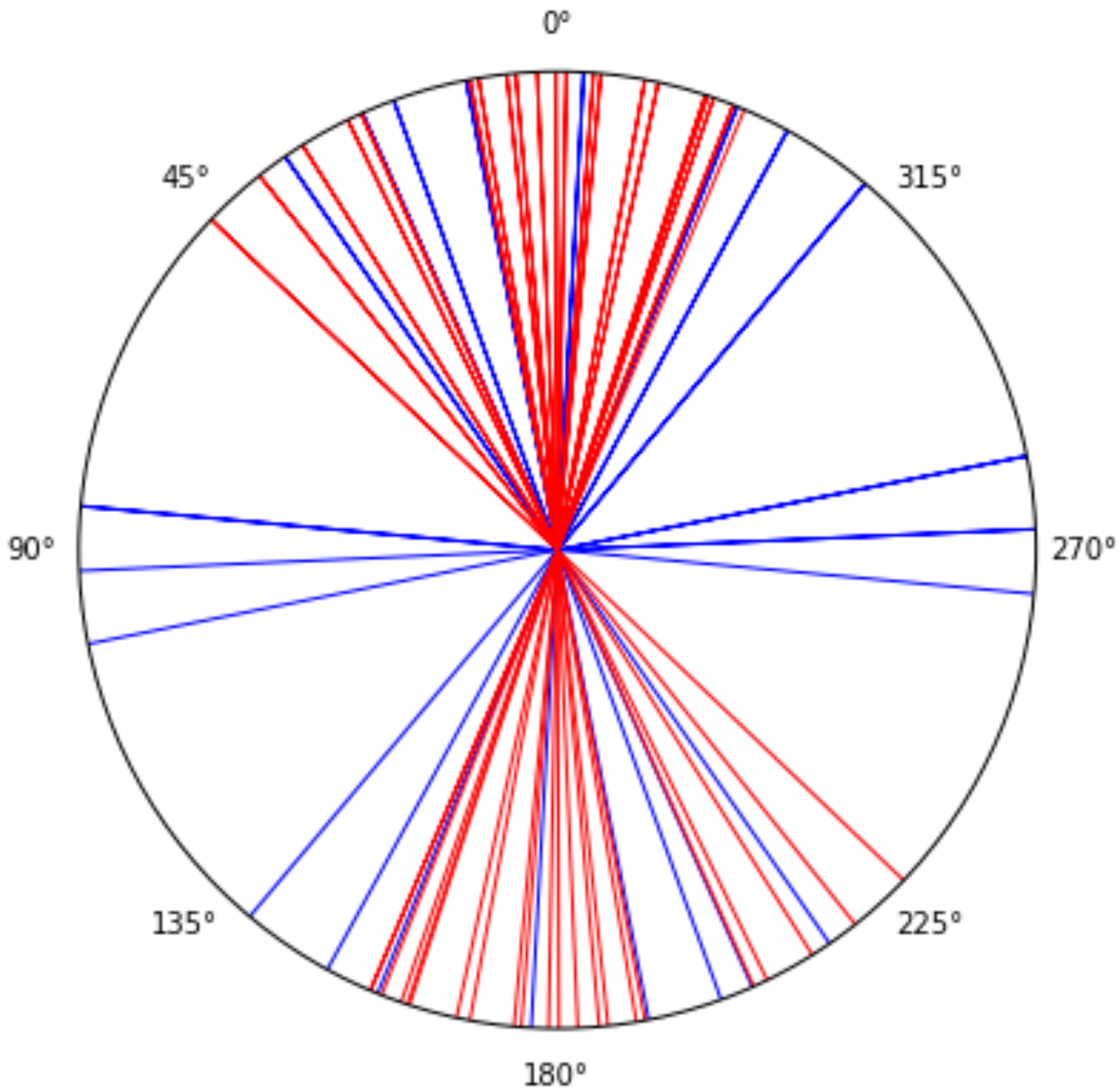


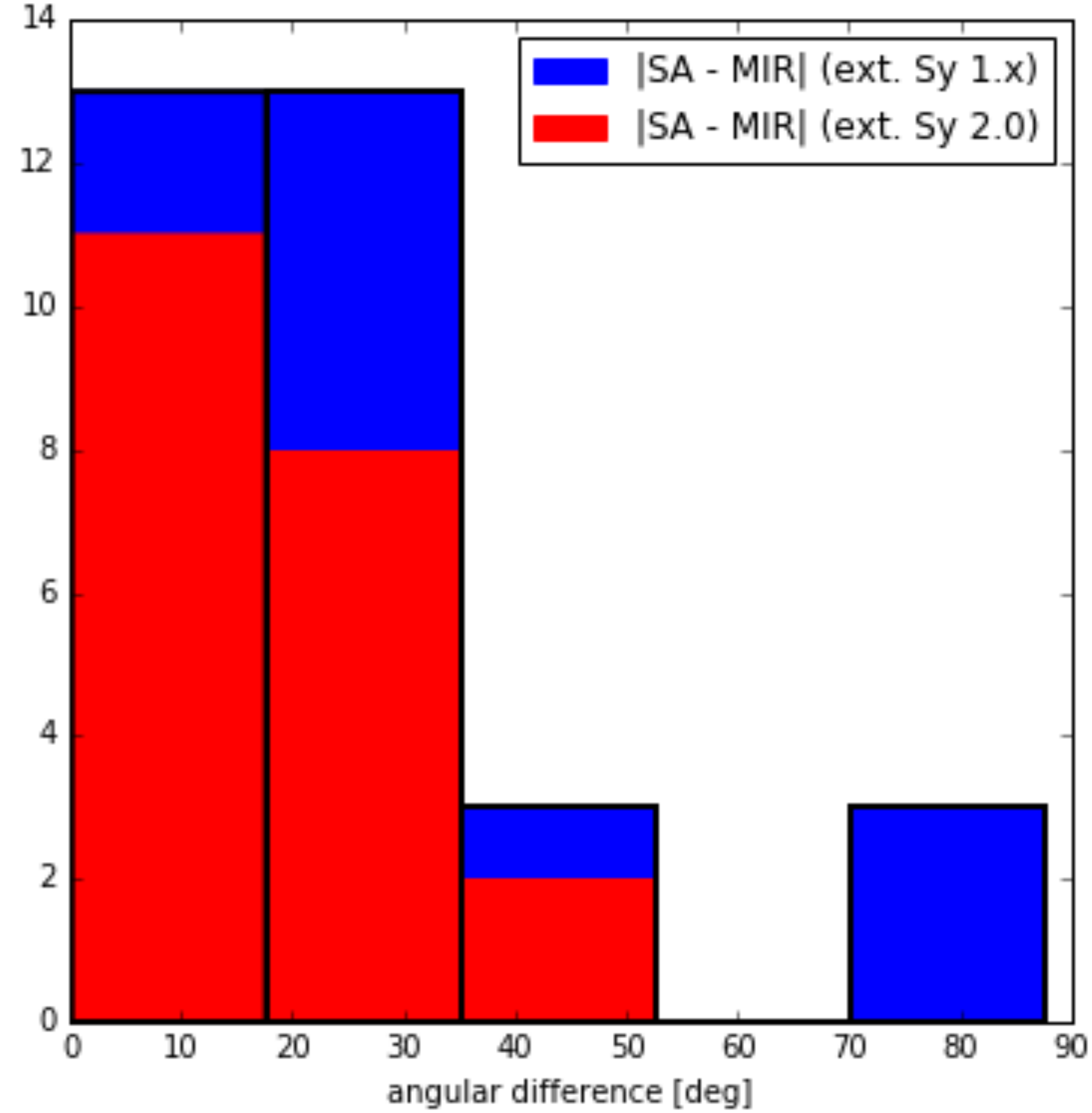
Asmus et al. (in prep.)



Asmus et al. (in prep.)

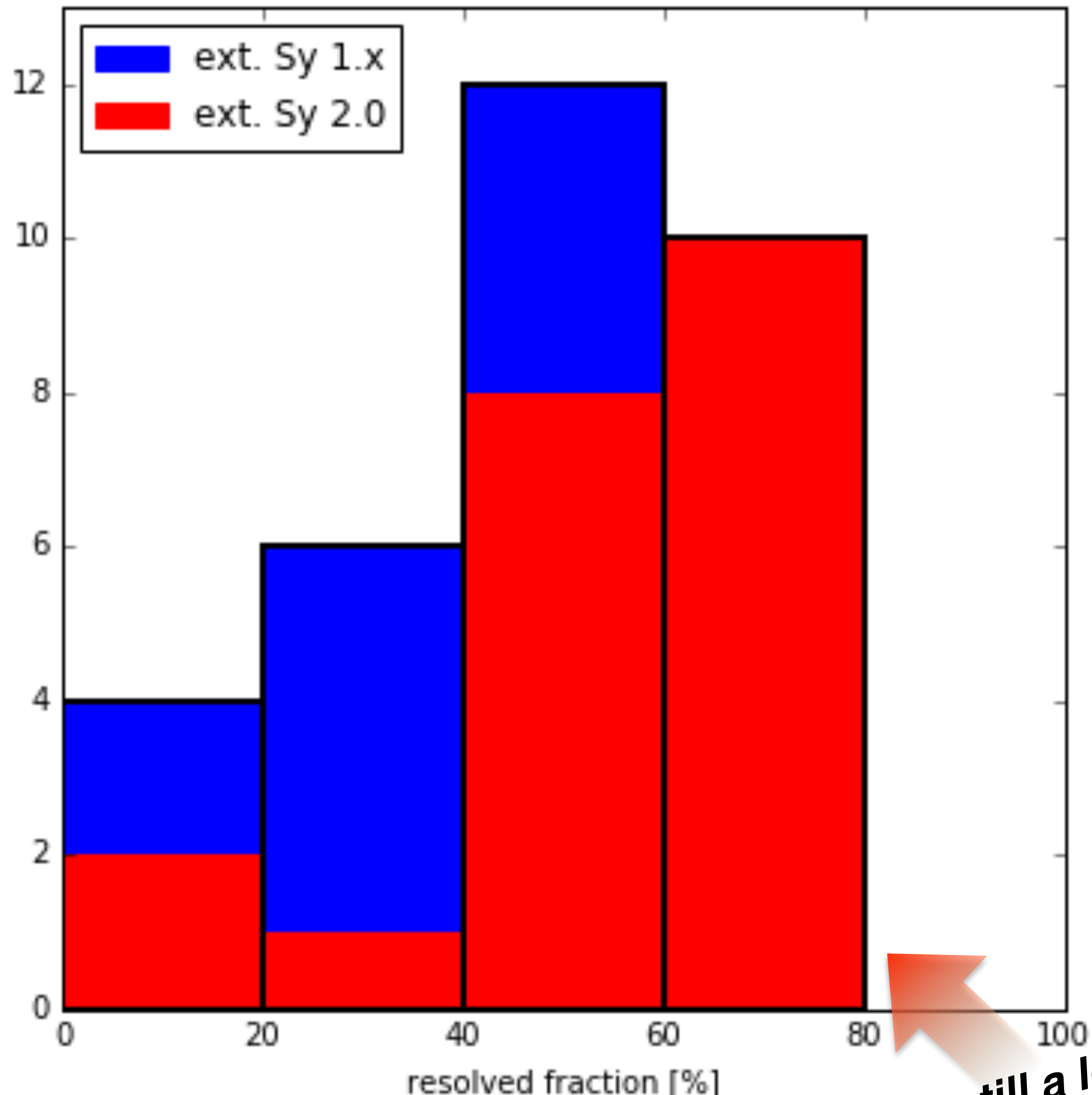
Extended MIR emission has clear preference for polar direction —> origin: polar dusty wind (?)





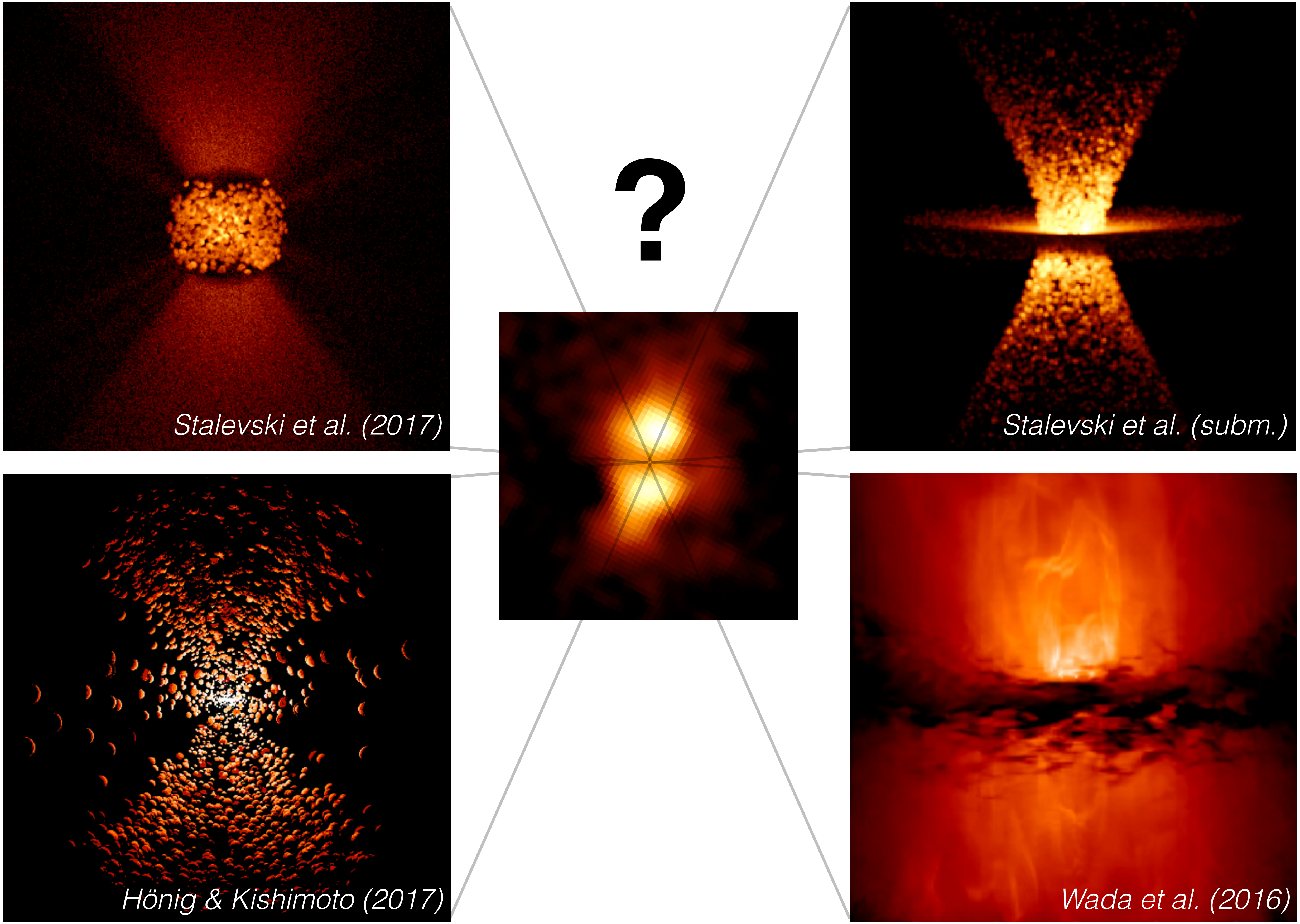
Asmus et al. (in prep.)

The polar dust is probably dominating the total mid-infrared emission of the AGN

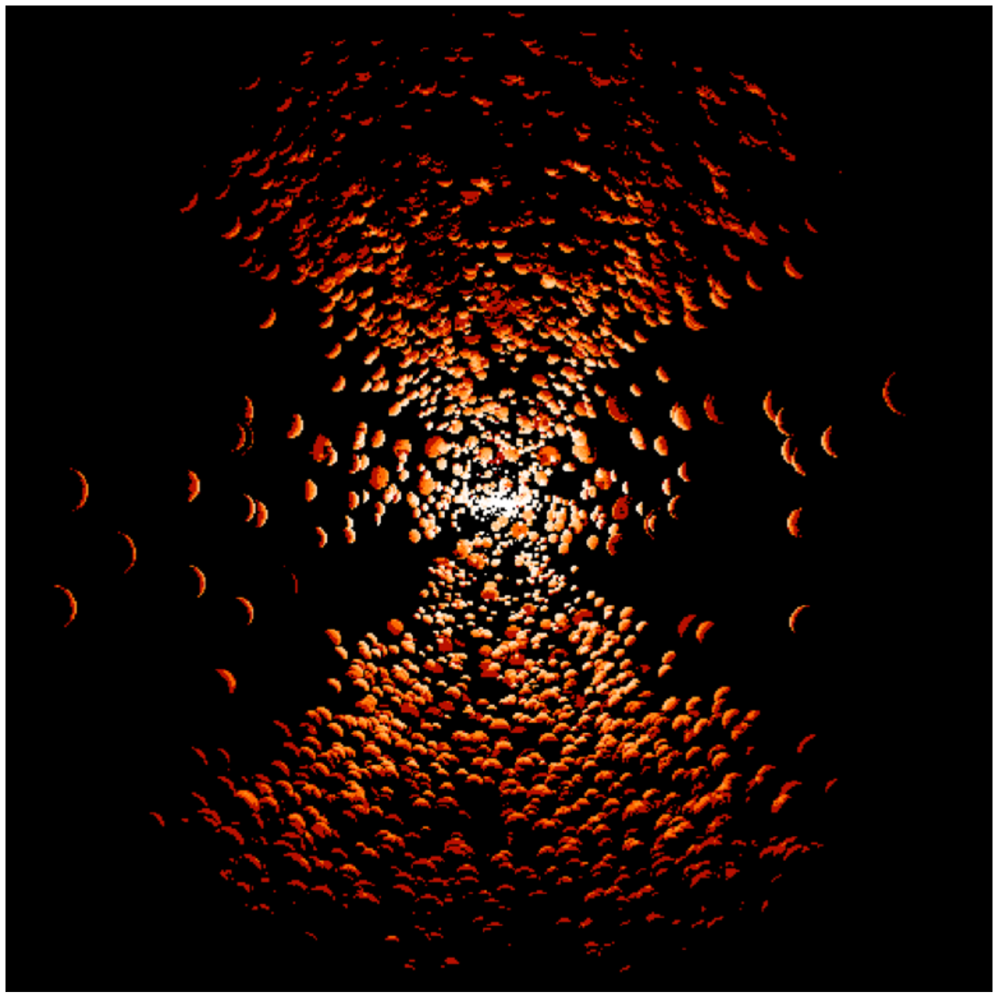


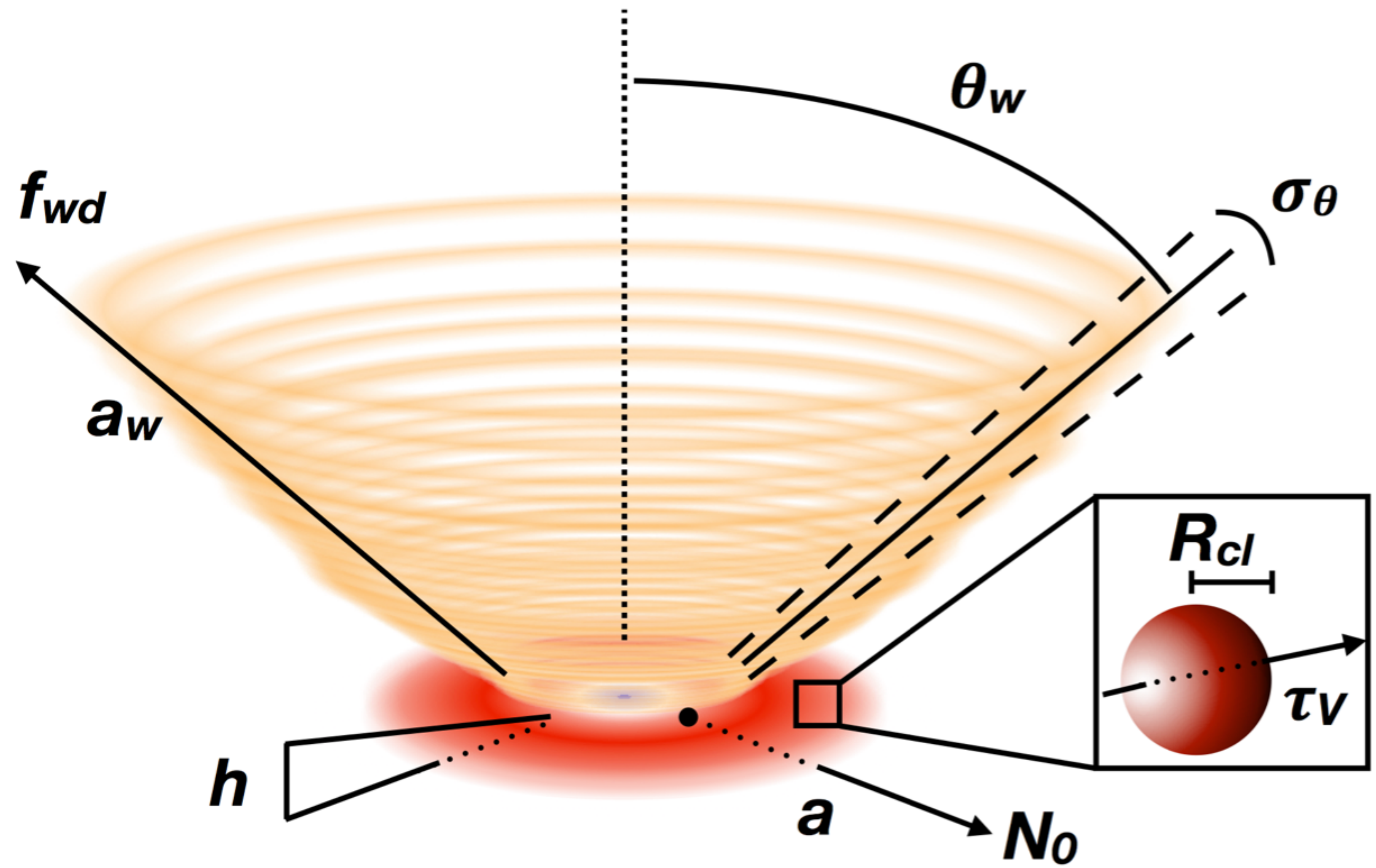
still a lower limit to the actual polar emission!

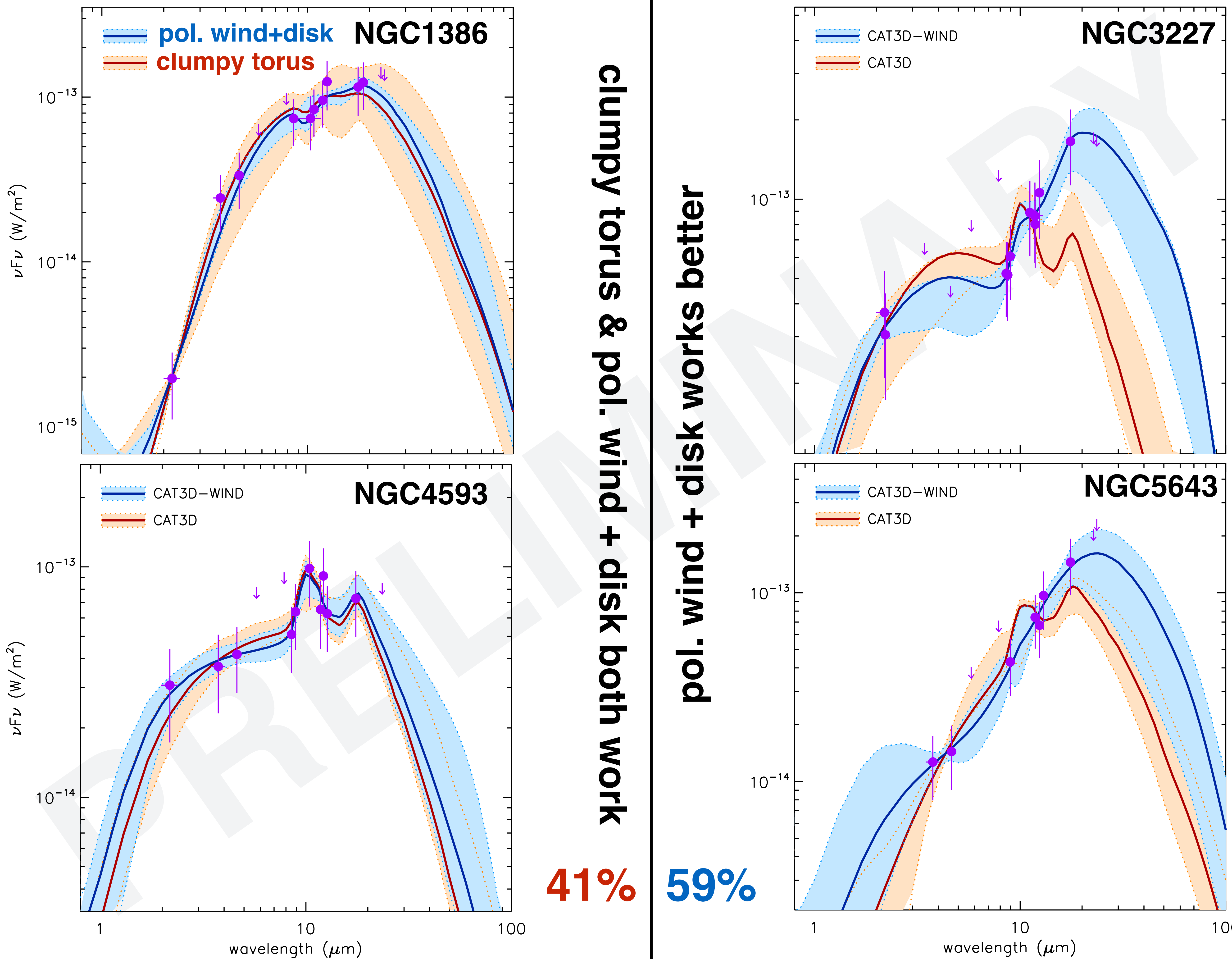
So what is it: torus+ambient, torus+cone, disk+cone/wind, or all/none of the above?



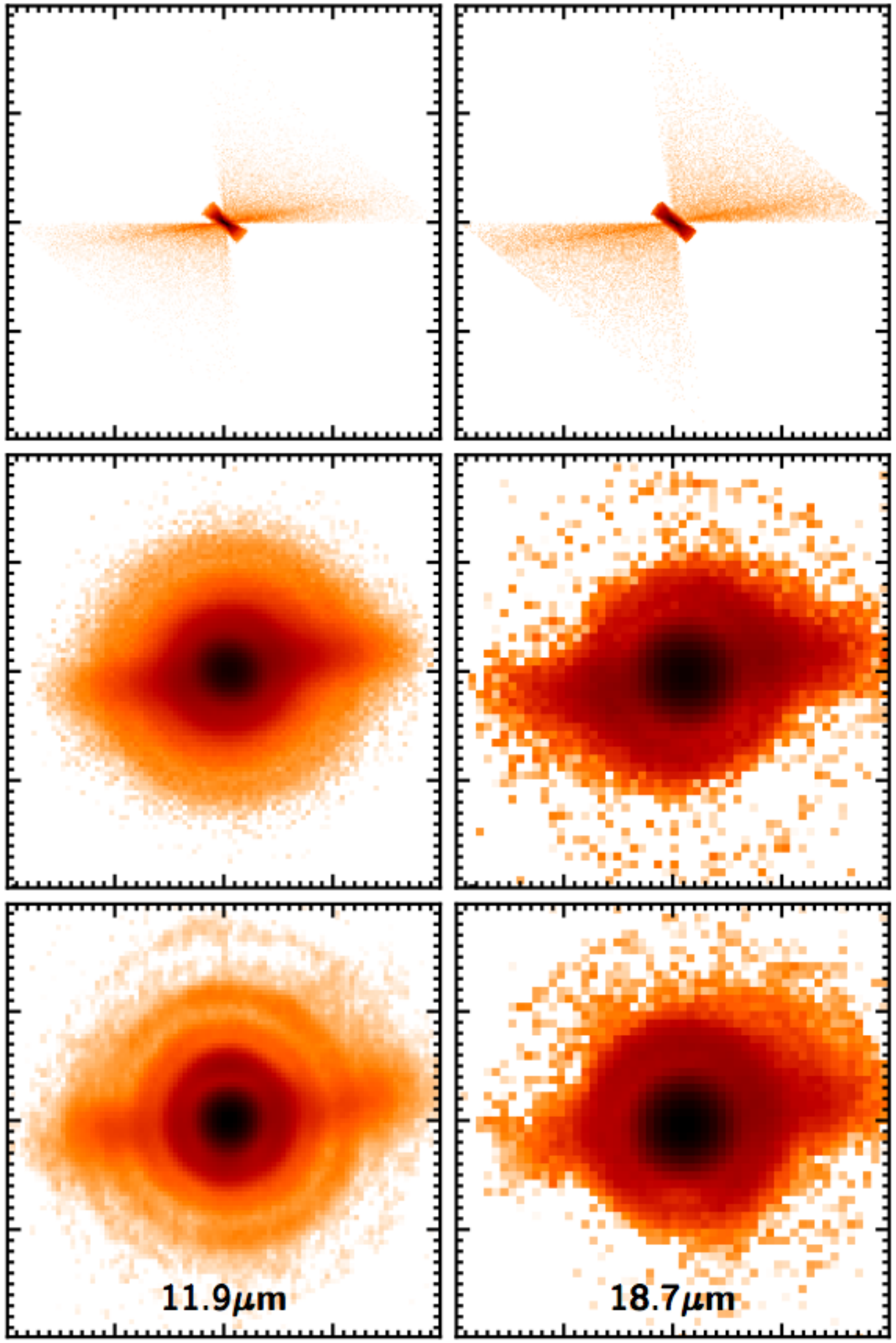
CAT3D-WIND (Hönig & Kishimoto 2017)



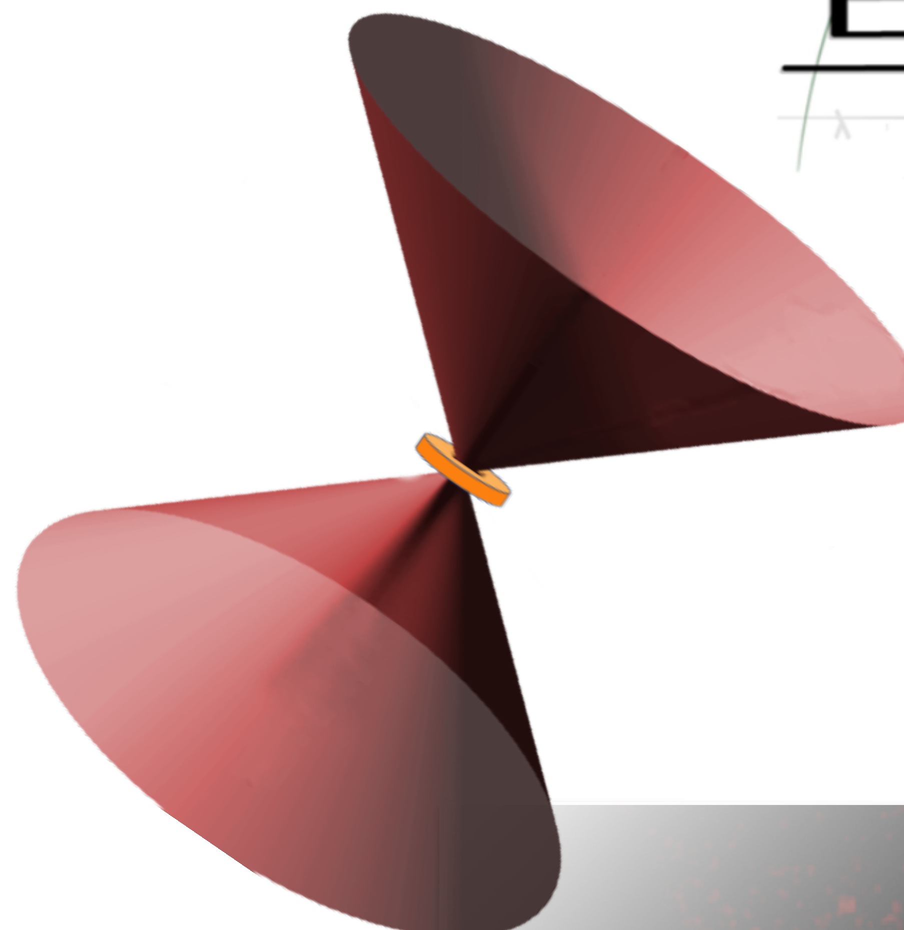



pol. wind+disk
clumpy torus
NGC1386
CAT3D−WIND
CAT3D
NGC3227
NGC4593
NGC5643
νFν (W/m²)
wavelength (μm)
1
10
100
10⁻¹³
10⁻¹⁴
10⁻¹⁵
clumpy torus & pol. wind + disk both work
pol. wind + disk works better
41%
59%
PRELIMINARY

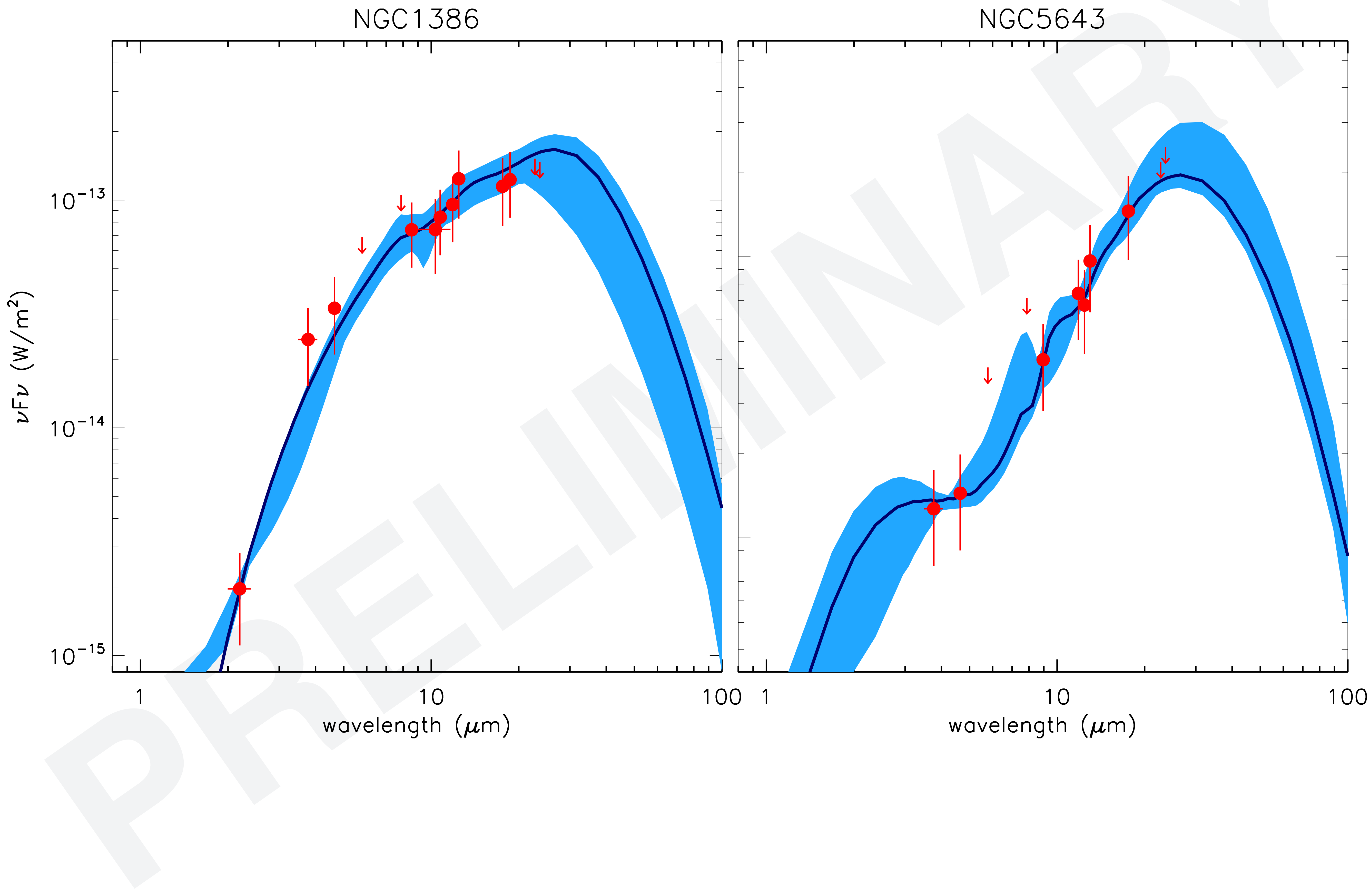
Polar dust structure models by Stalevski et al.



Stalevski et al. (2017)

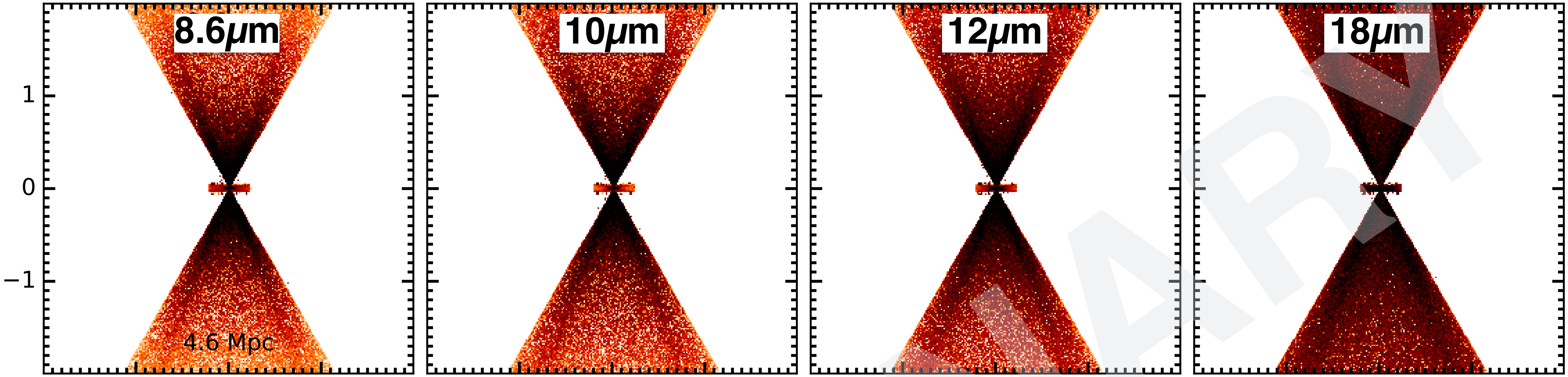


see M. Stalevski's talk on Tuesday!



NGC1386
NGC5643
$\nu F \nu$ (W/m^2)
10^{-13}
10^{-14}
10^{-15}
1
10
100
wavelength (μm)
PRELIMINARY

NGC1386

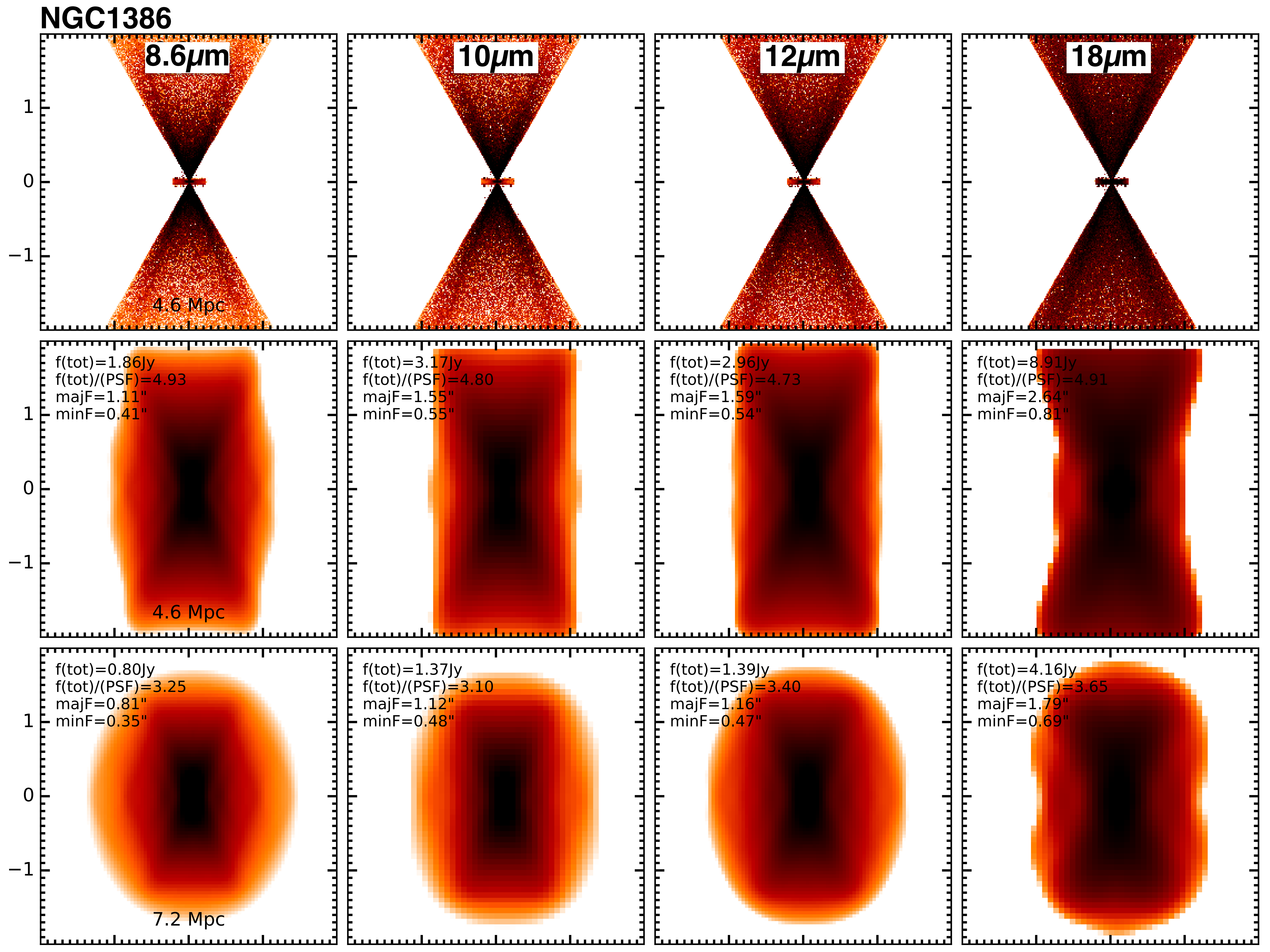


disk:

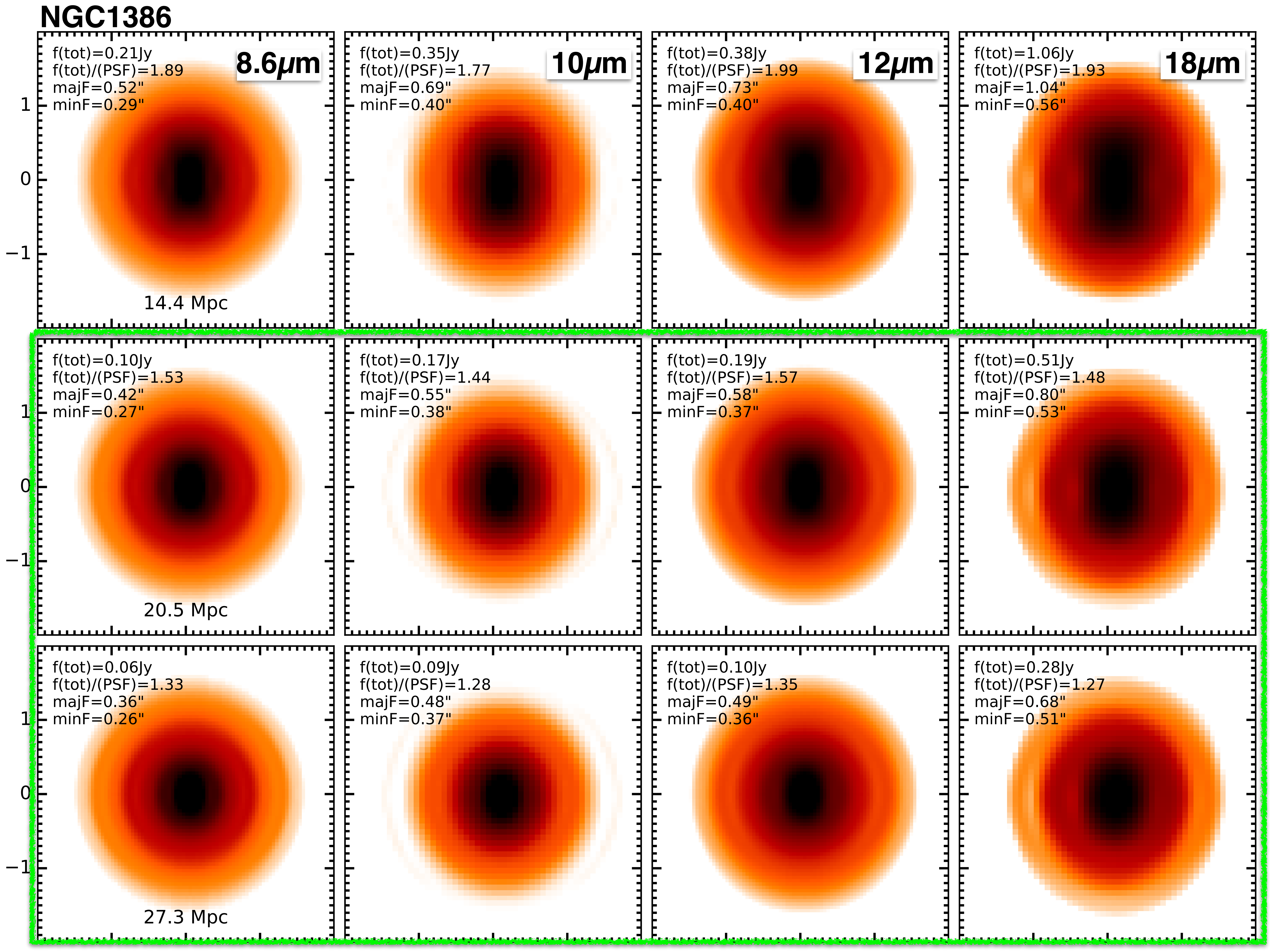
- half opening angle: 10°
- $\tau_{9.7\mu m}$ in the plane = 6
- outer radius = 5pc
- flat & smooth density

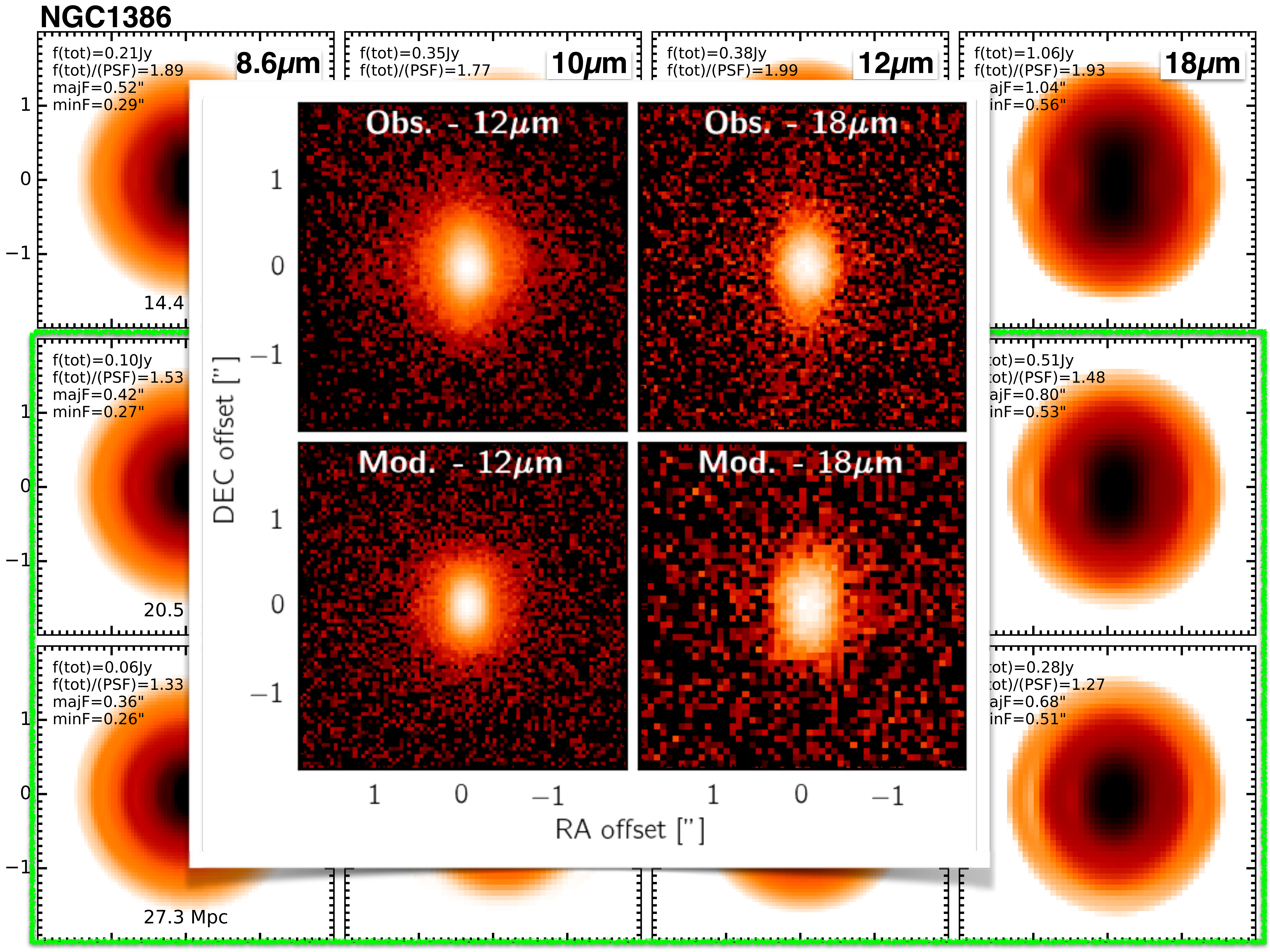
polar wind:

- half opening angle: 20°
- τ_V along the cone wall = 1
- outer radius = 50pc
- flat & smooth density



NGC1386
8.6μm
10μm
12μm
18μm
4.6 Mpc
f(tot)=1.86Jy
f(tot)/(PSF)=4.93
majF=1.11"
minF=0.41"
4.6 Mpc
f(tot)=3.17Jy
f(tot)/(PSF)=4.80
majF=1.55"
minF=0.55"
f(tot)=2.96Jy
f(tot)/(PSF)=4.73
majF=1.59"
minF=0.54"
f(tot)=8.91Jy
f(tot)/(PSF)=4.91
majF=2.64"
minF=0.81"
f(tot)=0.80Jy
f(tot)/(PSF)=3.25
majF=0.81"
minF=0.35"
7.2 Mpc
f(tot)=1.37Jy
f(tot)/(PSF)=3.10
majF=1.12"
minF=0.48"
f(tot)=1.39Jy
f(tot)/(PSF)=3.40
majF=1.16"
minF=0.47"
f(tot)=4.16Jy
f(tot)/(PSF)=3.65
majF=1.79"
minF=0.69"


NGC1386
8.6μm
10μm
12μm
18μm
f(tot)=0.21Jy
f(tot)/(PSF)=1.89
majF=0.52"
minF=0.29"
14.4 Mpc
f(tot)=0.35Jy
f(tot)/(PSF)=1.77
majF=0.69"
minF=0.40"
f(tot)=0.38Jy
f(tot)/(PSF)=1.99
majF=0.73"
minF=0.40"
f(tot)=1.06Jy
f(tot)/(PSF)=1.93
majF=1.04"
minF=0.56"
f(tot)=0.10Jy
f(tot)/(PSF)=1.53
majF=0.42"
minF=0.27"
20.5 Mpc
f(tot)=0.17Jy
f(tot)/(PSF)=1.44
majF=0.55"
minF=0.38"
f(tot)=0.19Jy
f(tot)/(PSF)=1.57
majF=0.58"
minF=0.37"
f(tot)=0.51Jy
f(tot)/(PSF)=1.48
majF=0.80"
minF=0.53"
f(tot)=0.06Jy
f(tot)/(PSF)=1.33
majF=0.36"
minF=0.26"
27.3 Mpc
f(tot)=0.09Jy
f(tot)/(PSF)=1.28
majF=0.48"
minF=0.37"
f(tot)=0.10Jy
f(tot)/(PSF)=1.35
majF=0.49"
minF=0.36"
f(tot)=0.28Jy
f(tot)/(PSF)=1.27
majF=0.68"
minF=0.51"


NGC1386
8.6μm
10μm
12μm
18μm
f(tot)=0.21Jy
f(tot)/(PSF)=1.89
majF=0.52"
minF=0.29"
14.4
f(tot)=0.35Jy
f(tot)/(PSF)=1.77
f(tot)=0.38Jy
f(tot)/(PSF)=1.99
f(tot)=1.06Jy
f(tot)/(PSF)=1.93
f(tot)=0.10Jy
f(tot)/(PSF)=1.53
majF=0.42"
minF=0.27"
20.5
f(tot)=0.06Jy
f(tot)/(PSF)=1.33
majF=0.36"
minF=0.26"
27.3 Mpc
Obs. - 12μm
Obs. - 18μm
Mod. - 12μm
Mod. - 18μm
DEC offset ["]
RA offset ["]

Conclusions

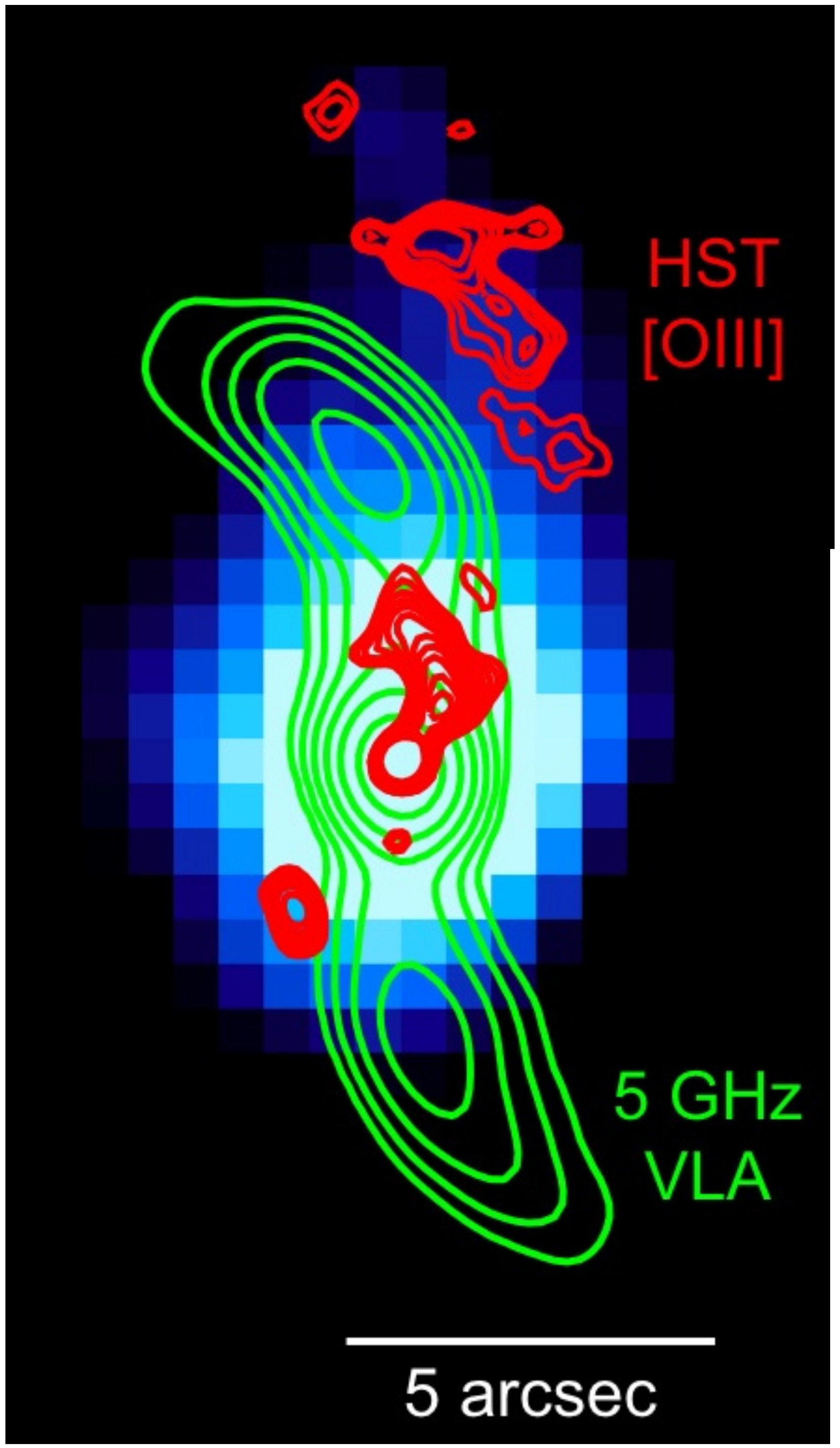
- Polar dust emission might be ubiquitous in AGN
- Polar dust emission appears to dominate the total mid-infrared emission of the AGN
- Disk + polar wind models fit the observed data better than “classical” clumpy torus models AND can reproduce morphology!
- The generation of instruments will allow to test the above

Dave Williamson’s talk on Thursday!

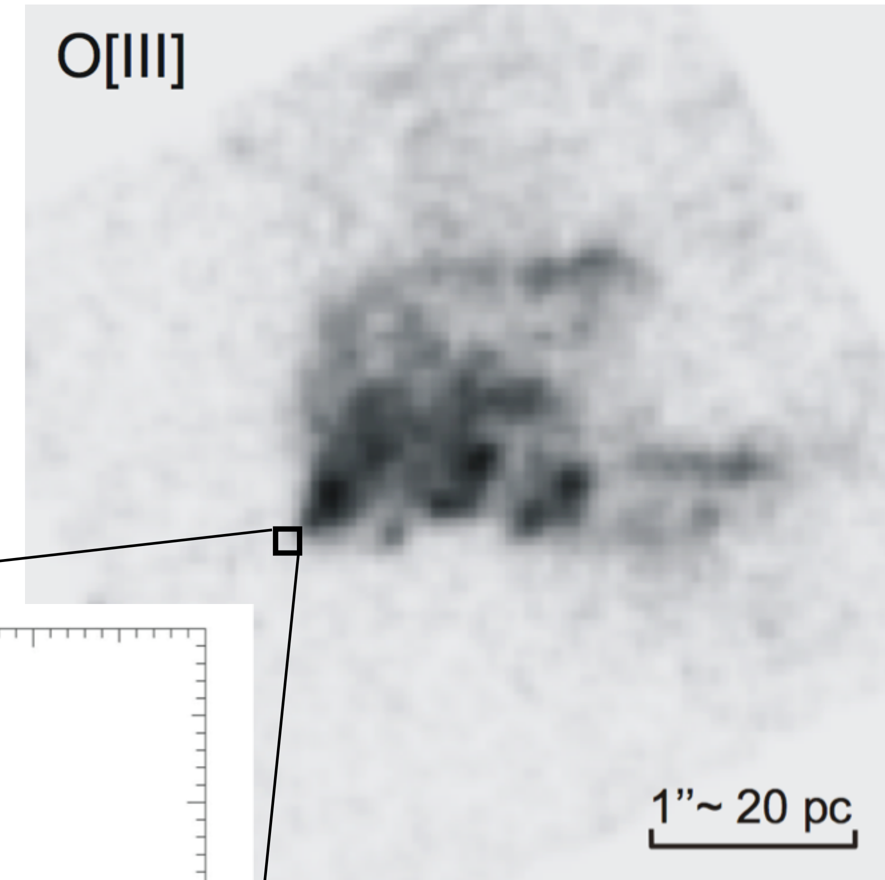
see also poster by Marta Venanzi

Back-up Slides…

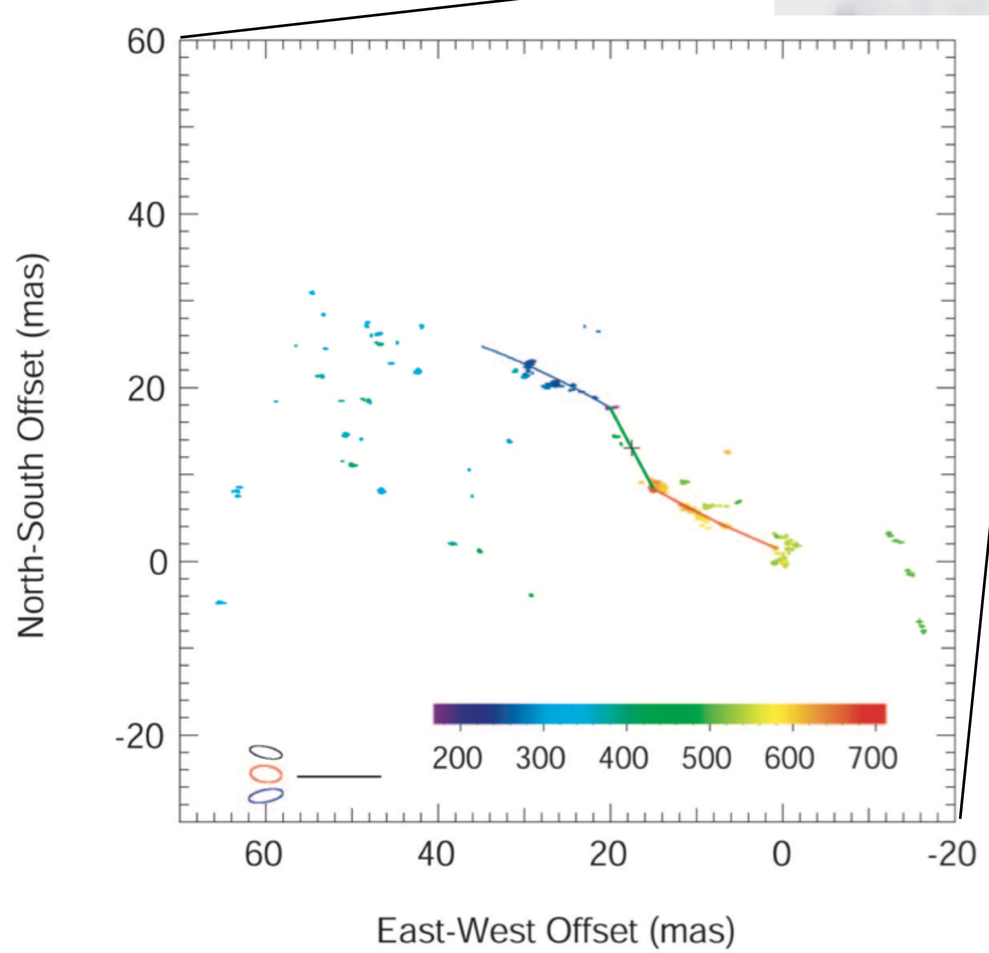
Establishing a system axis from ionisation cones [OIII], radio jets, maser disks, and polarized emission.



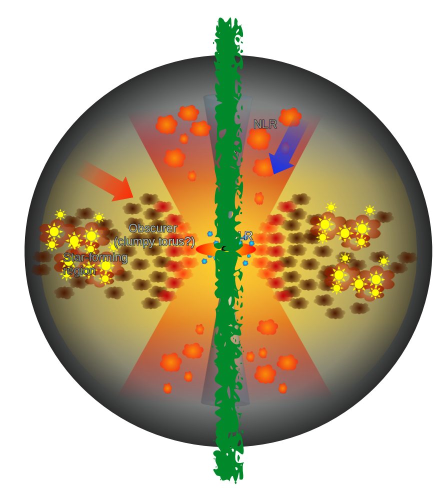
NGC 2110; *credit: D. Evans*



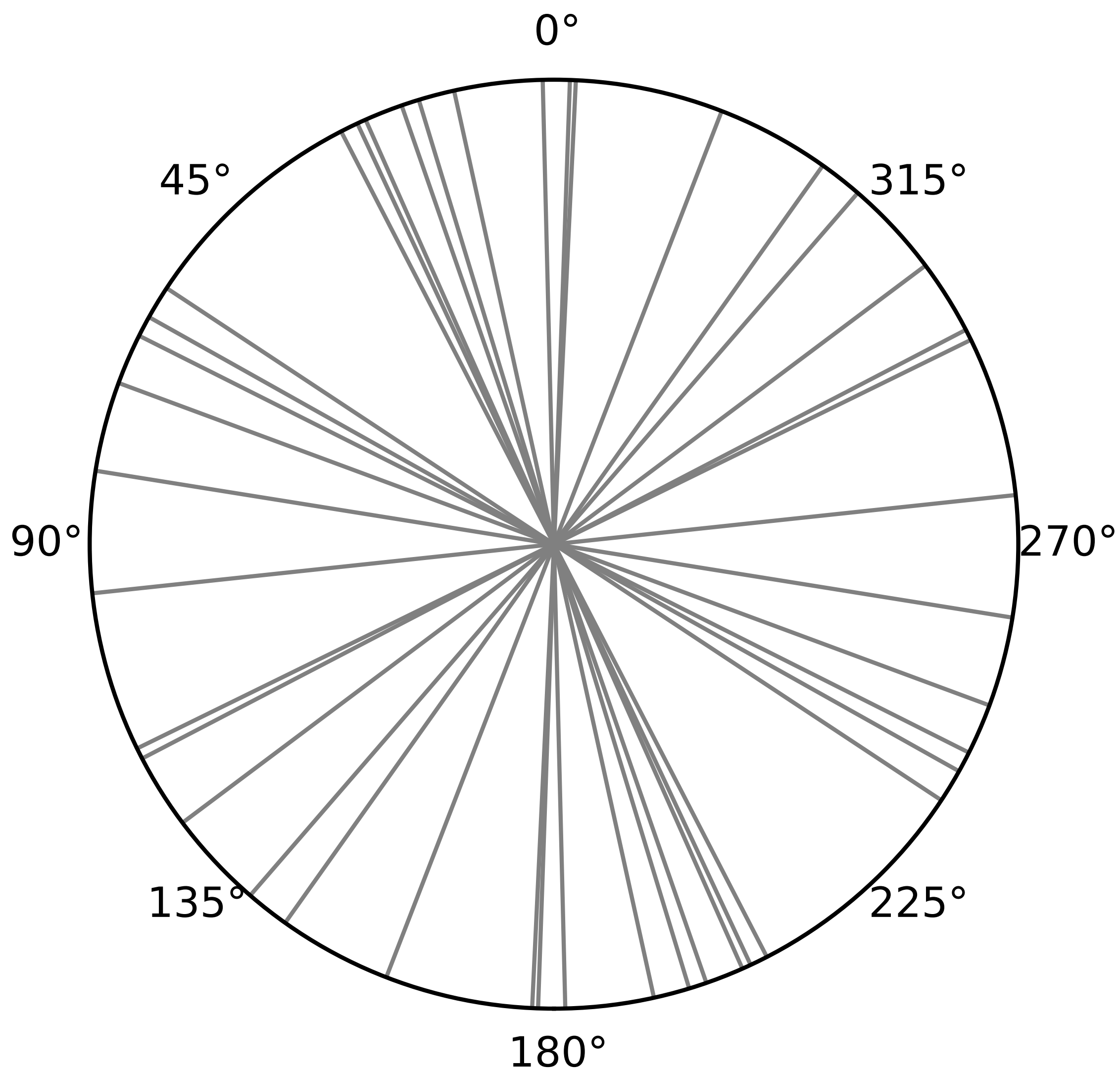
Circinus;
Wilson et. al. 2000

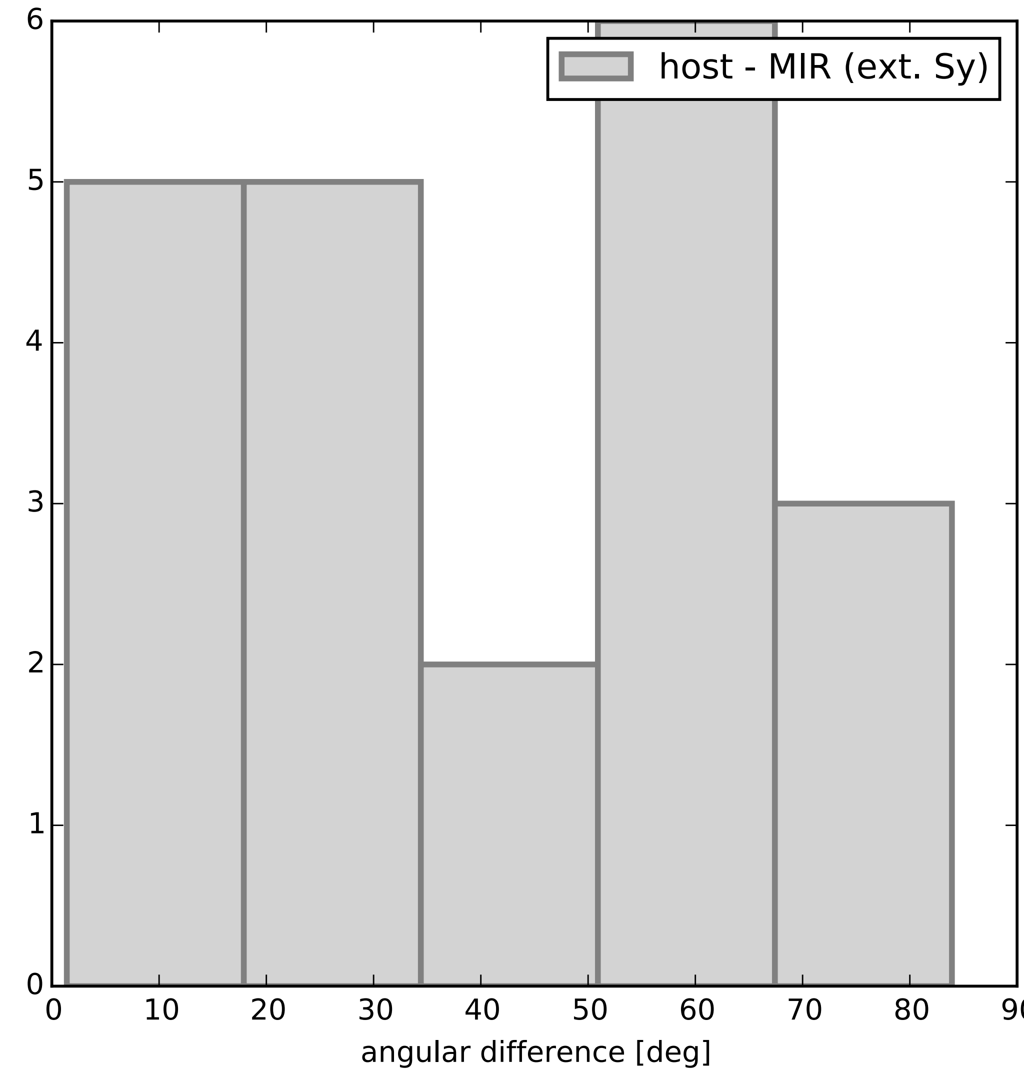


Circinus; *Greenhill et al. 2003*



The resolved emission is not correlated to the host orientation.

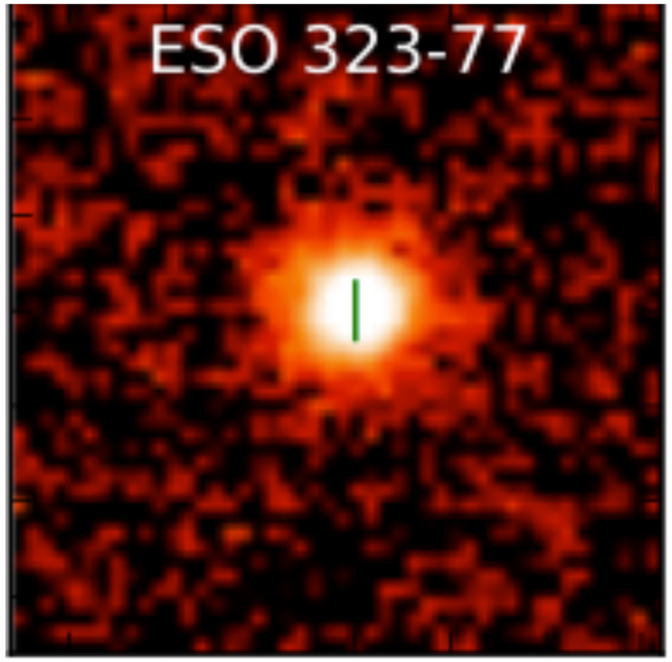




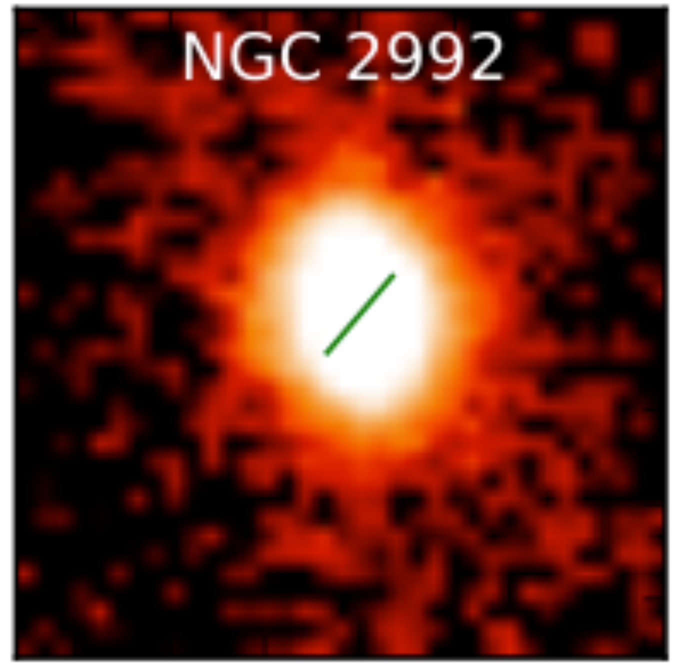
Angular difference (System Axis - MIR extension)

Asmus et al. 2016

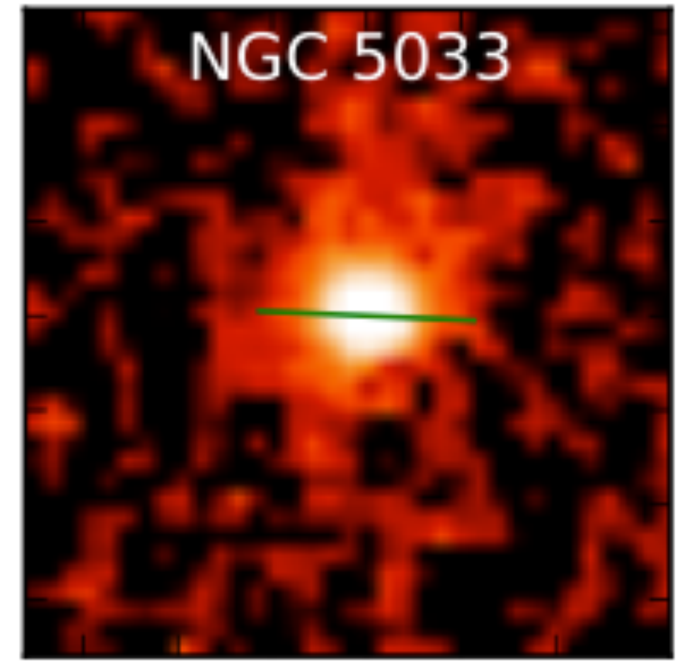
The outliers



- Seyfert 1.2
- [OIII] pointlike
- marginally resolved
- PA error 27°

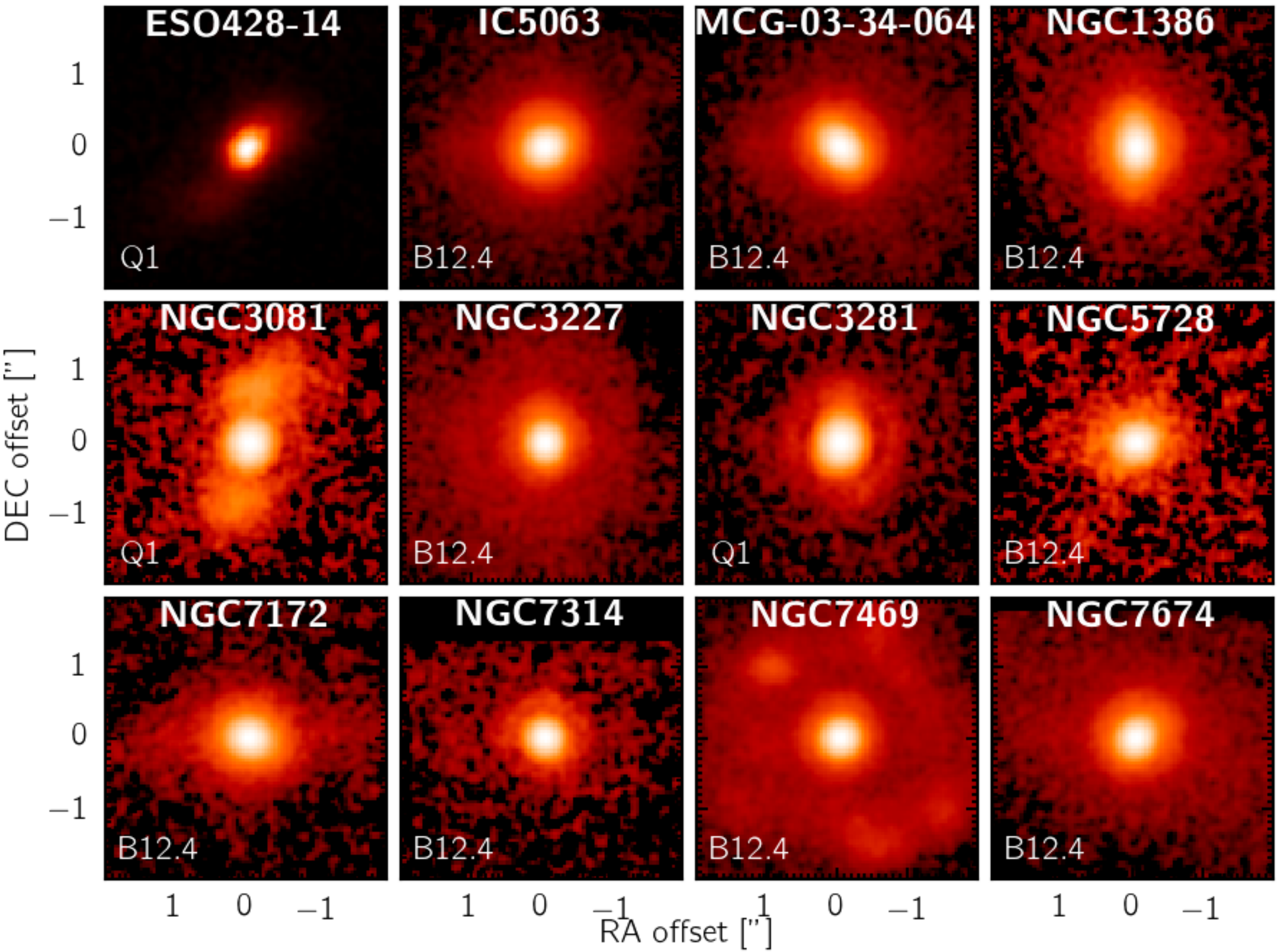


- Seyfert 1.5/2
- wide opening ionisation cones
- edge-on spiral
- emission traces host dust lane

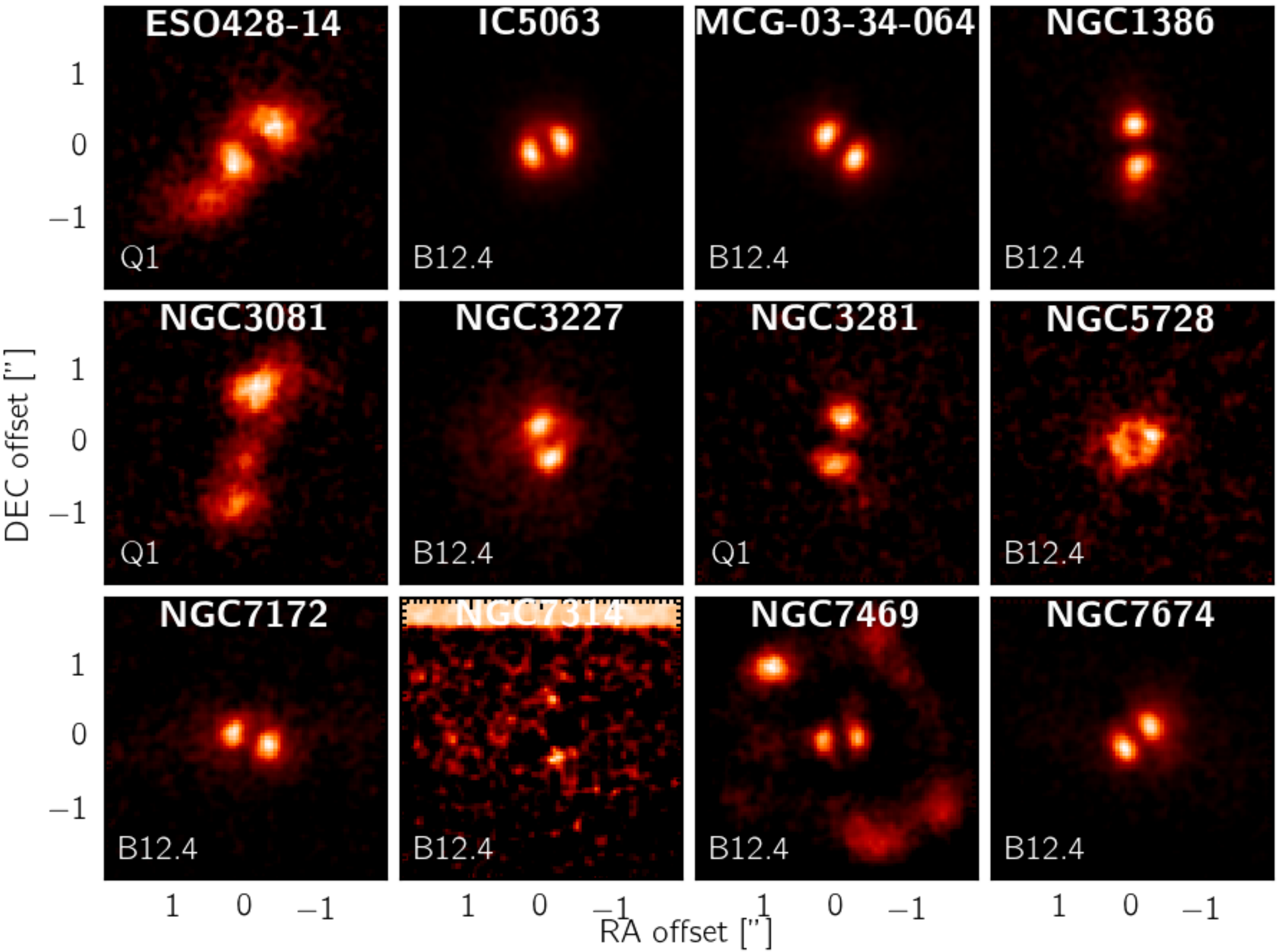


- Seyfert 1.2
- wide opening ionisation cones
- weakest AGN in the sample
- low S/N

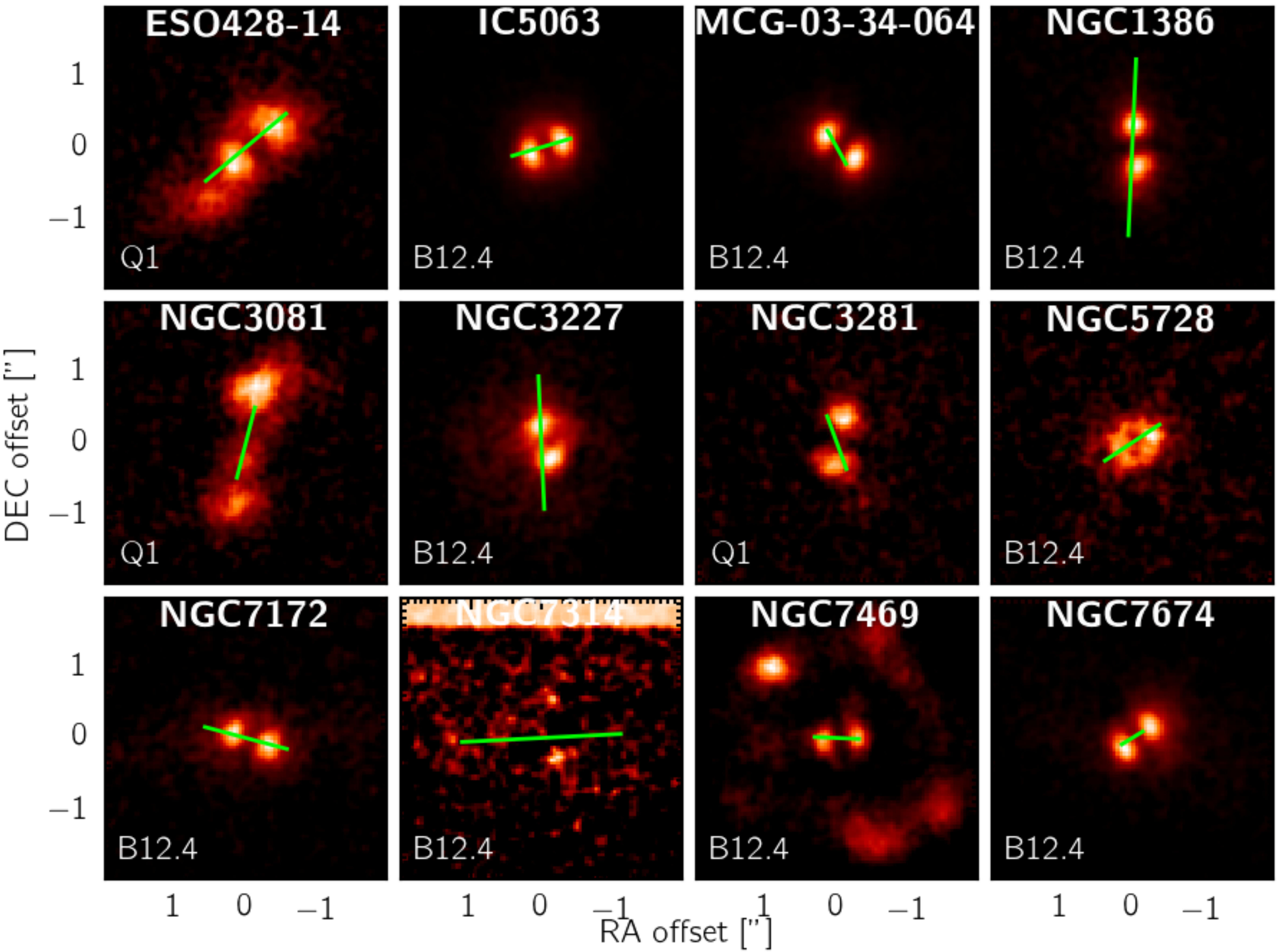
see poster by James Leftley



ESO428-14
IC5063
MCG-03-34-064
NGC1386
NGC3081
NGC3227
NGC3281
NGC5728
NGC7172
NGC7314
NGC7469
NGC7674
Q1
B12.4
B12.4
B12.4
Q1
B12.4
Q1
B12.4
B12.4
B12.4
B12.4
B12.4
DEC offset ["]
RA offset ["]
1
0
−1

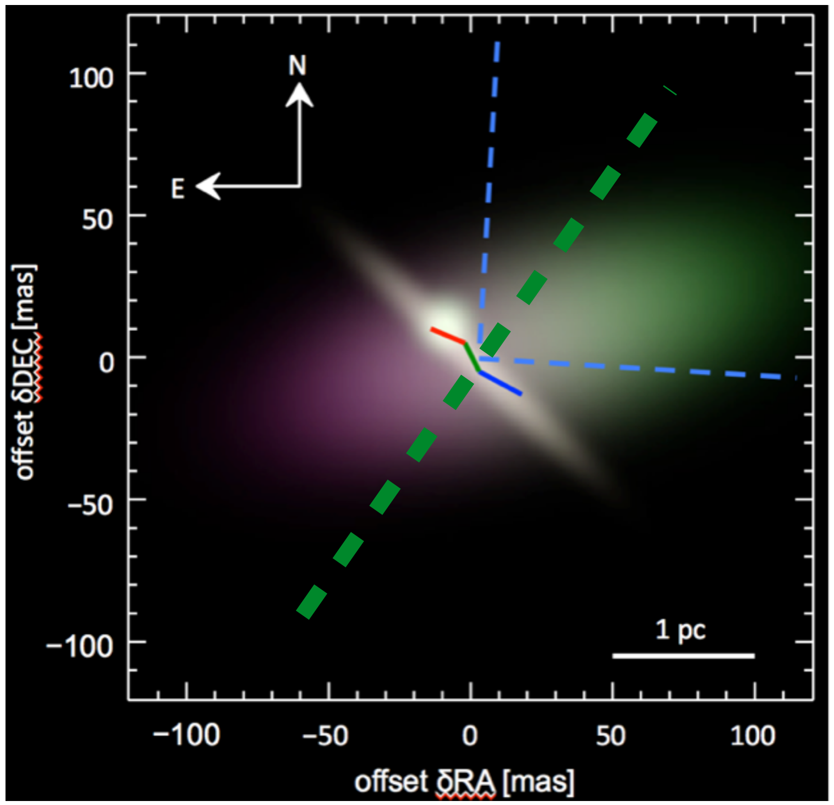


ESO428-14
IC5063
MCG-03-34-064
NGC1386
NGC3081
NGC3227
NGC3281
NGC5728
NGC7172
NGC7314
NGC7469
NGC7674
Q1
B12.4
DEC offset ['']
RA offset ['']
1
0
−1

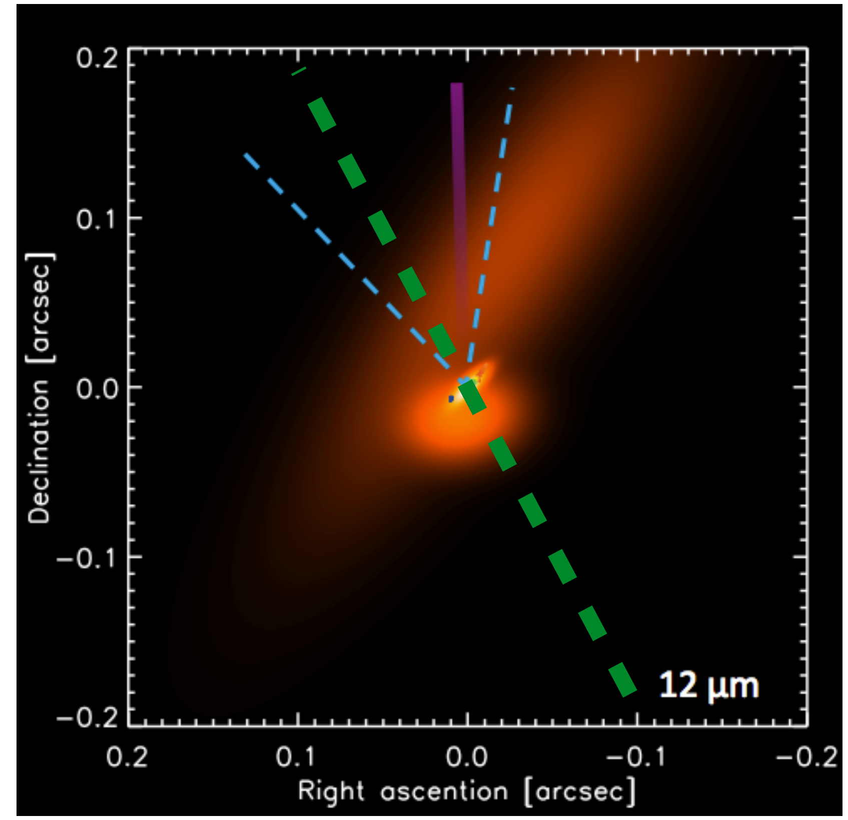


ESO428-14
IC5063
MCG-03-34-064
NGC1386
NGC3081
NGC3227
NGC3281
NGC5728
NGC7172
NGC7314
NGC7469
NGC7674
Q1
B12.4
DEC offset ["]
RA offset ["]

Polar elongation is dominant also on parsec scale as found with MIDI interferometry (Lopez-Gonzaga et al. 2016)

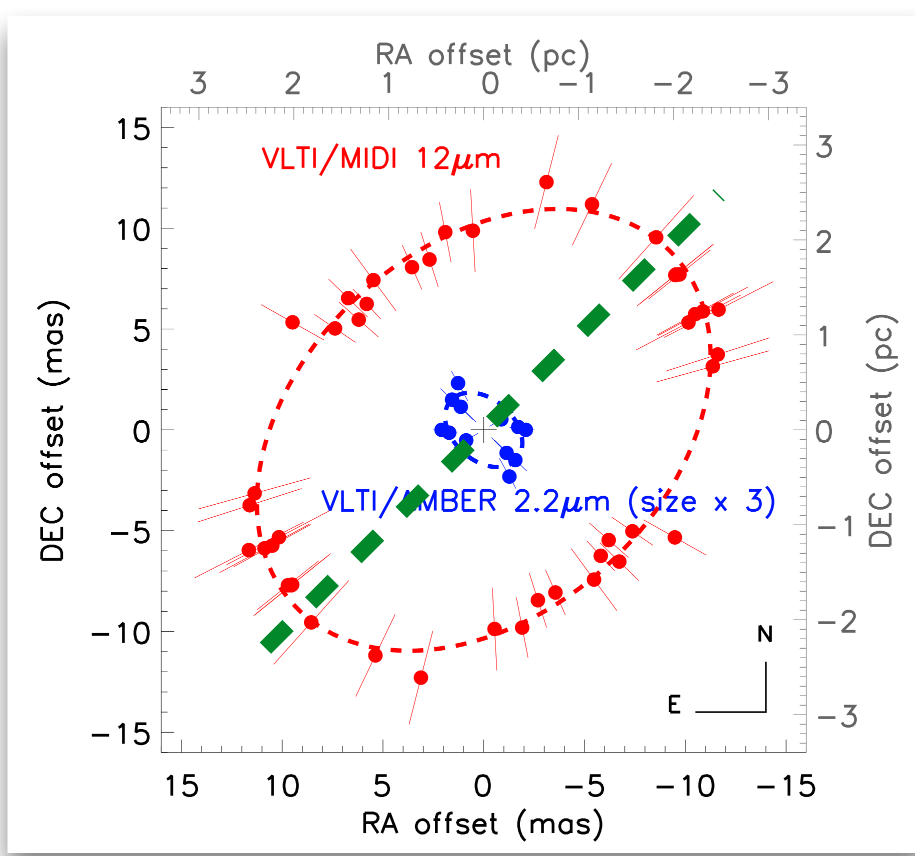


Circinus; Tristram et al. (2014)

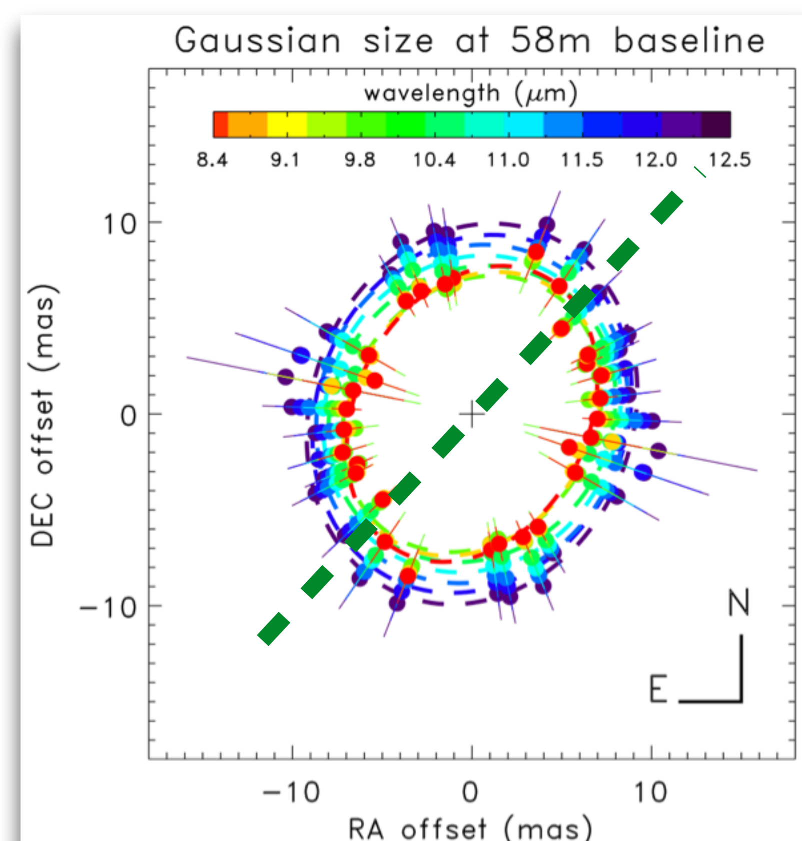


NGC1068; López-Gonzaga et al. (2014)

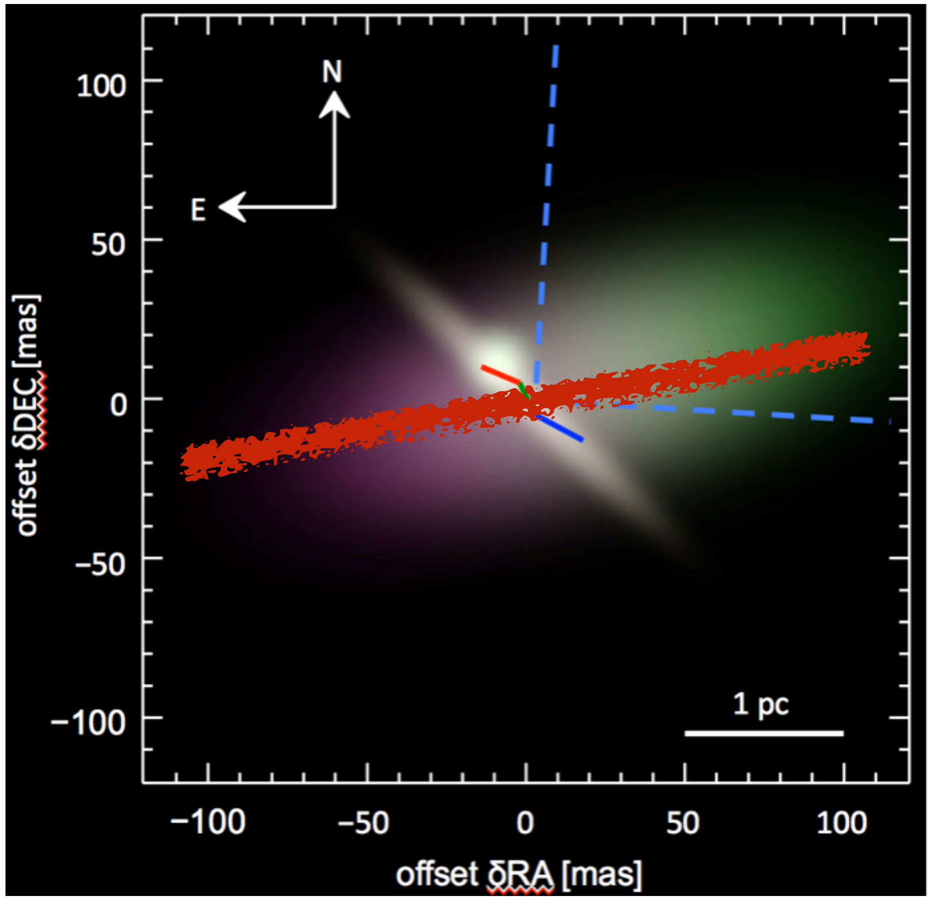
NGC3783; Hönig et al. (2013)

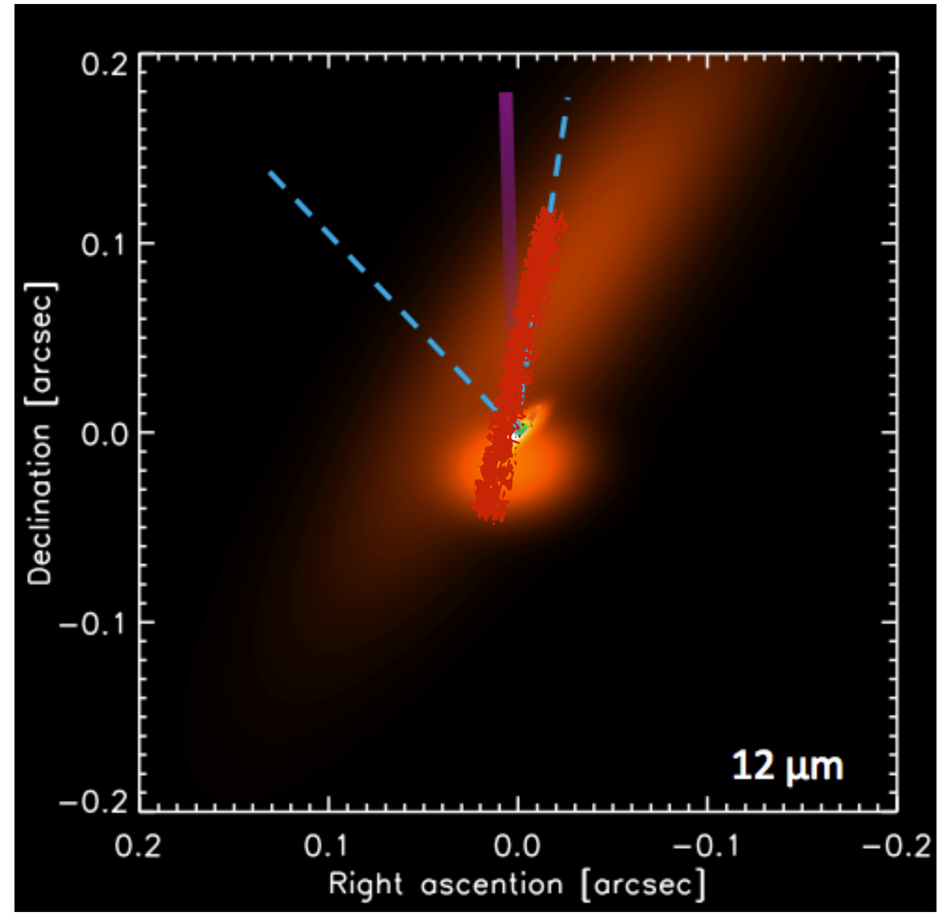


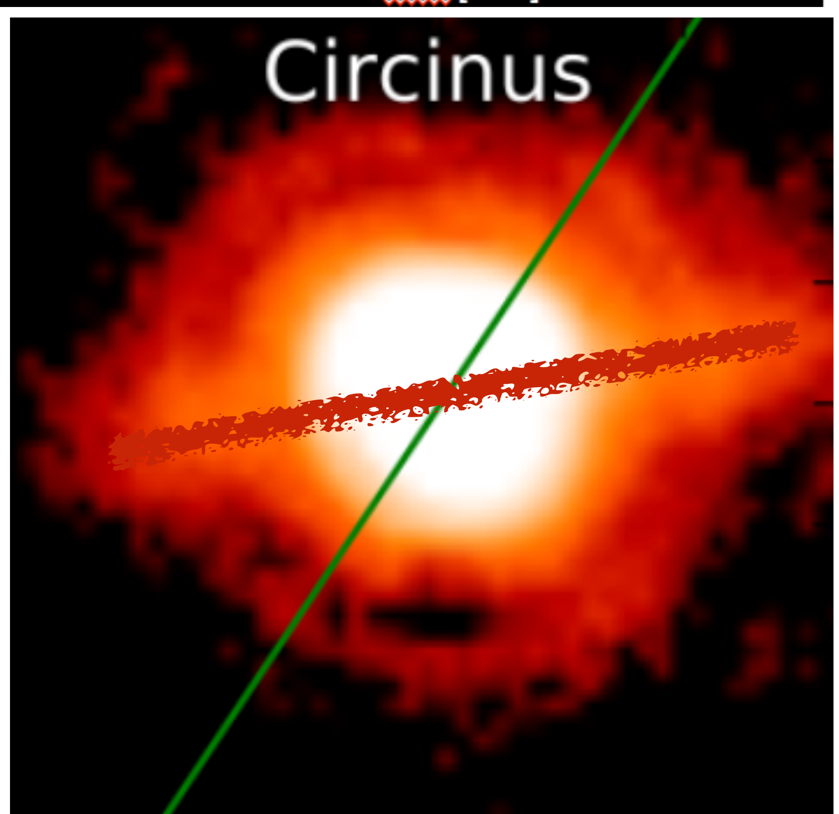
NGC424; Hönig et al. (2012)

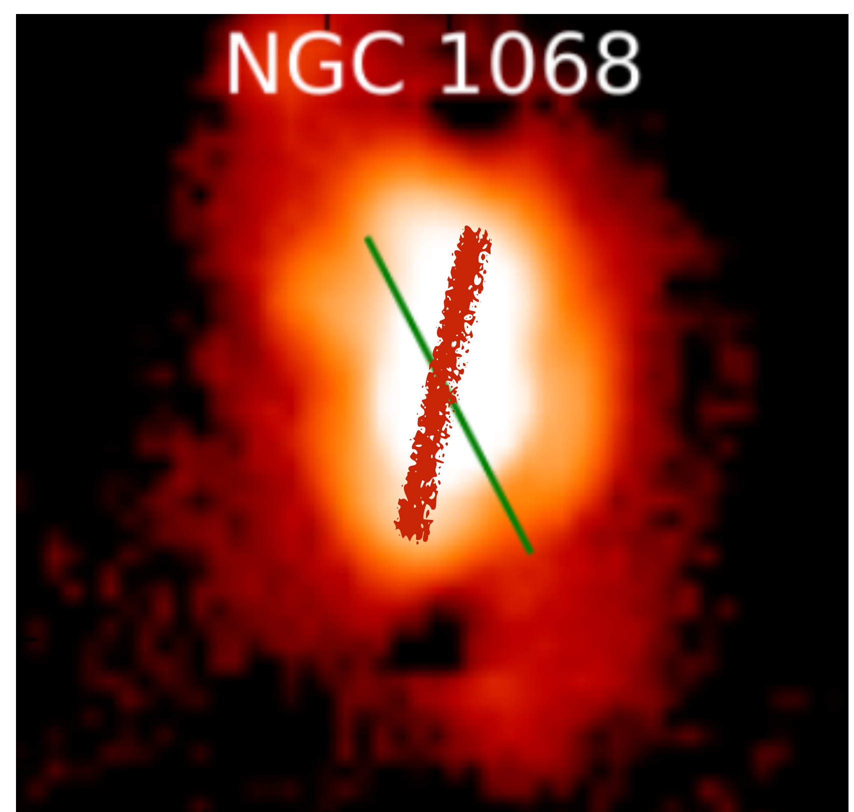


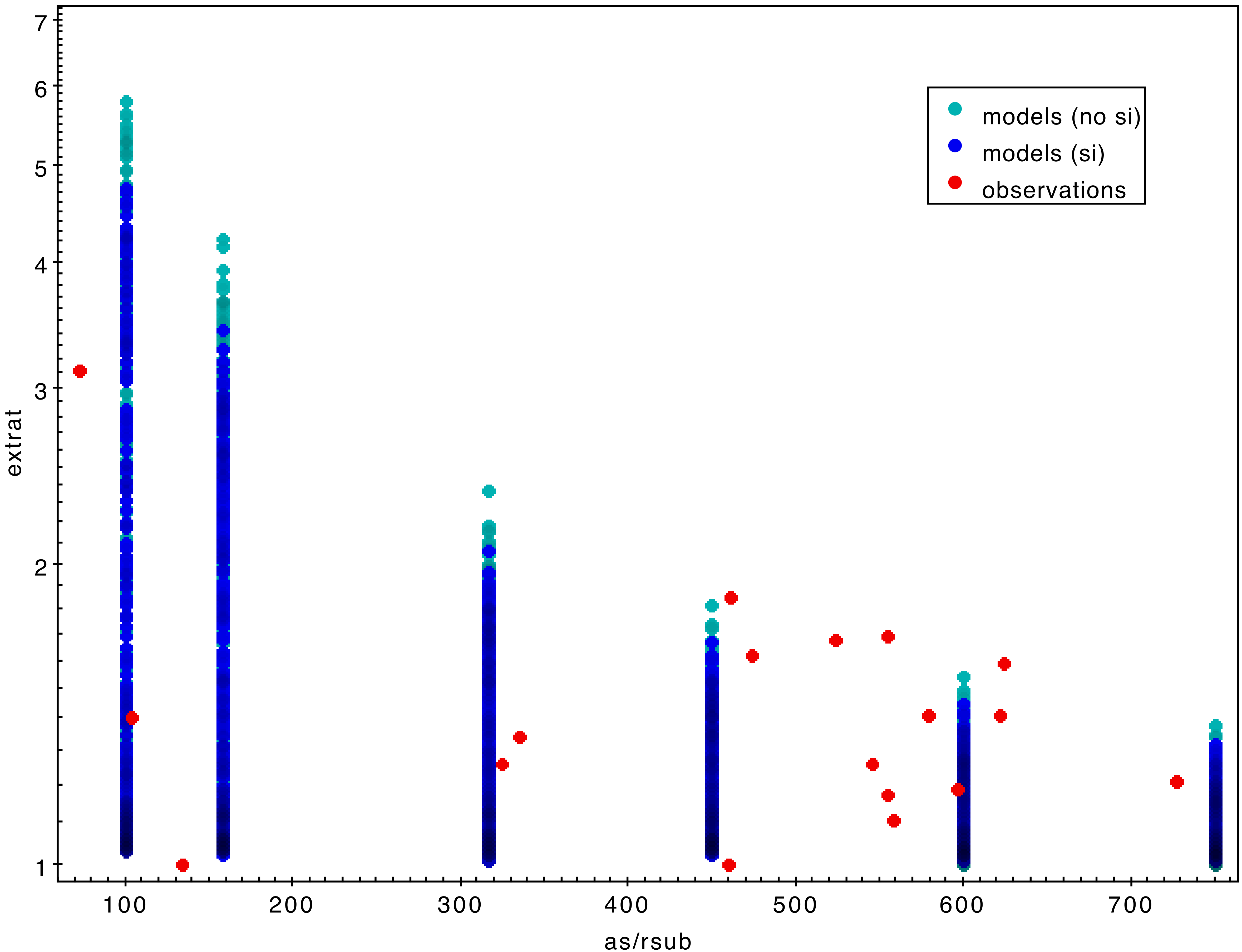
The small and large scale elongation are aligned and seem to trace the edge of the ionisation cone.



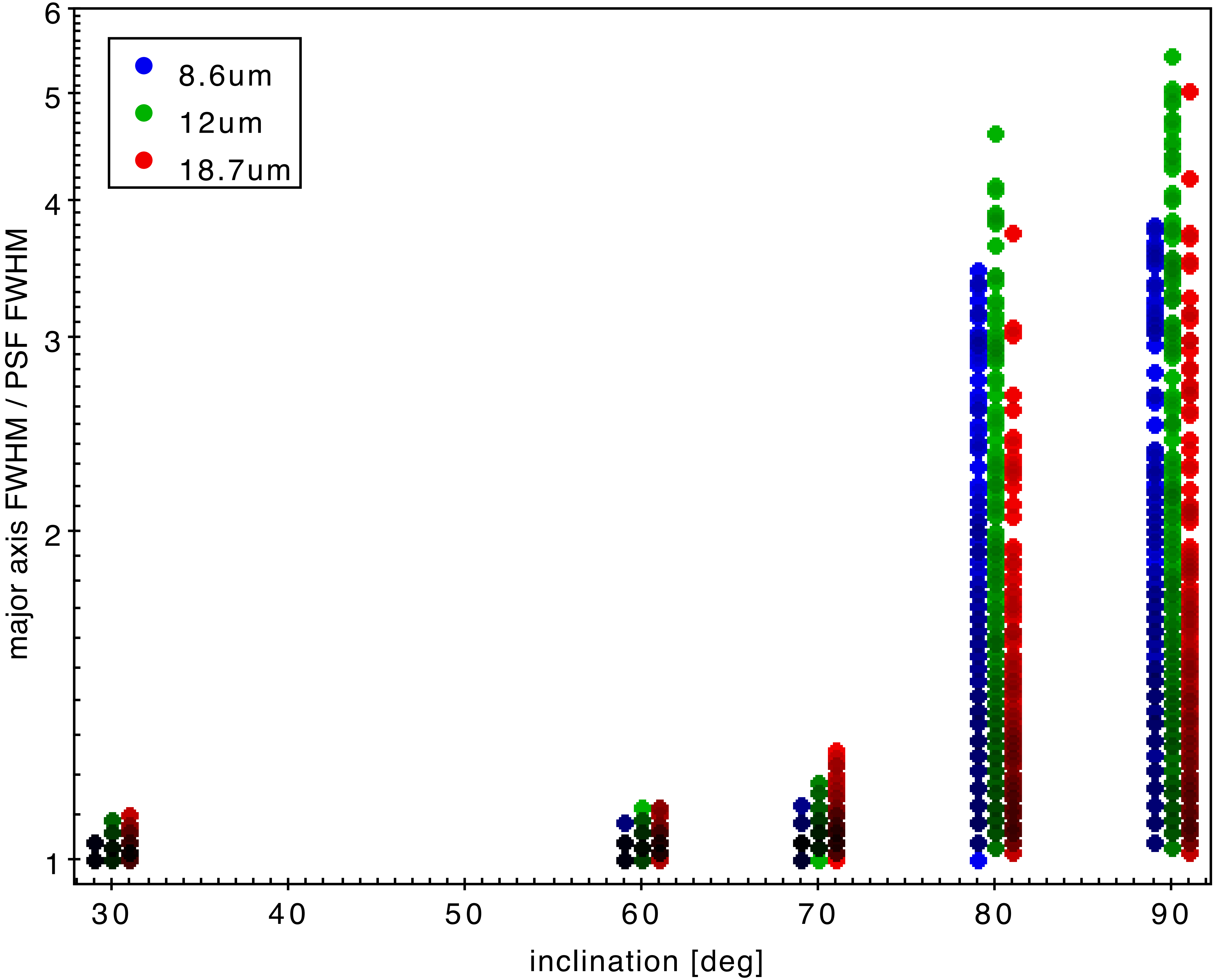






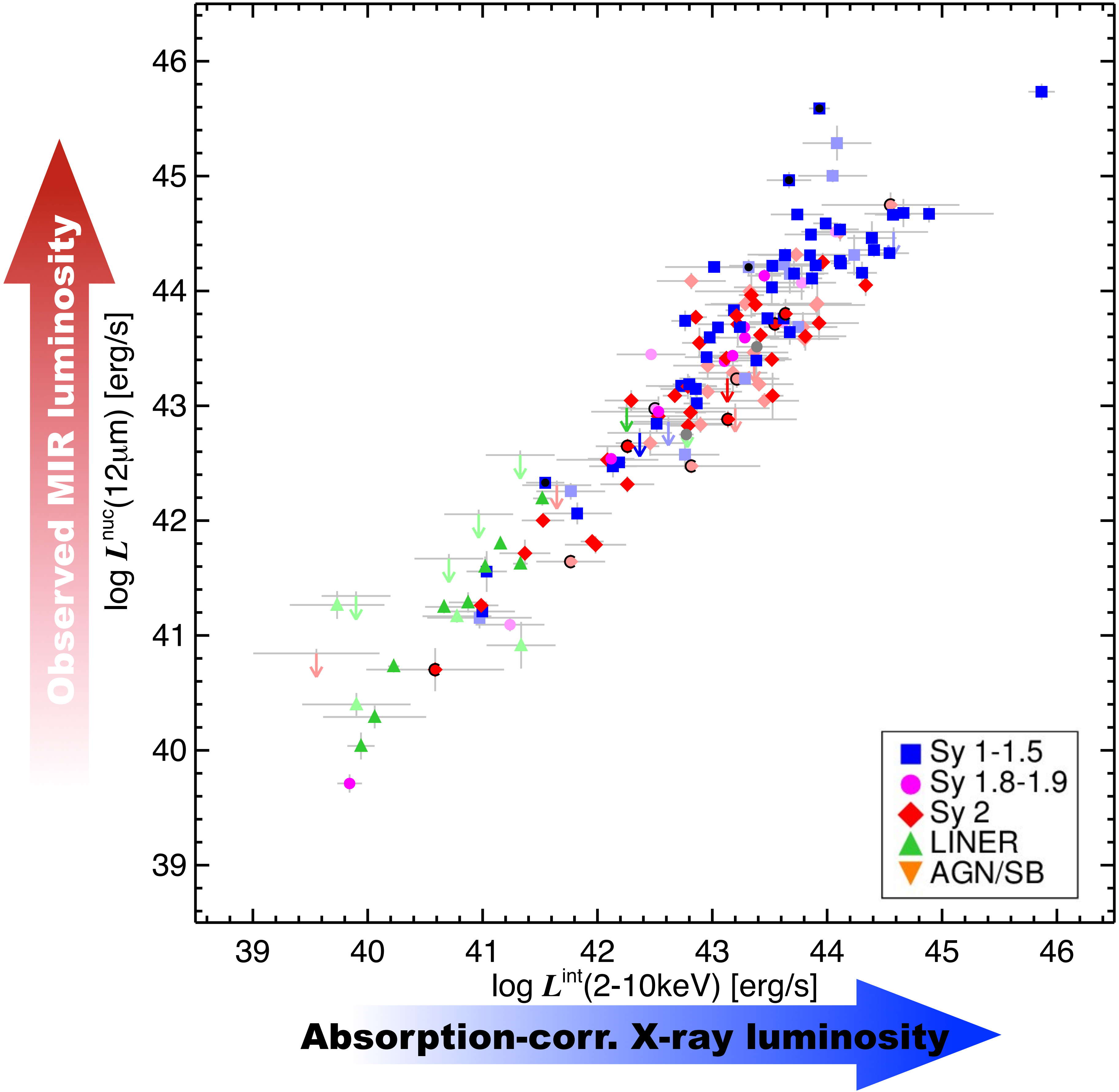


models (no si)
models (si)
observations
extrat
as/rsub
1
2
3
4
5
6
7
100
200
300
400
500
600
700



8.6um
12um
18.7um
major axis FWHM / PSF FWHM
inclination [deg]
1
2
3
4
5
6
30
40
50
60
70
80
90

The mid-infrared—X-ray correlation for all types of AGN is driven by dust in the ionisation cones rather than the torus



Asmus et al. 2015

(see also:
Glass et al. 1982;
Krabbe et al. 2001;
Lutz et al. 2004;
Horst et al. 2006;
Ramos Almeida et al. 2007;
Horst et al. 2008;
Gandhi et al. 2009;
Levenson et al. 2009;
Fiore et al. 2009;
Hardcastle et al. 2009;
Hoenig et al. 2010;
Asmus et al. 2011;
Mullaney et al. 2011;
Mason et al. 2012;
Matsuta et al. 2012;
Ichikawa et al. 2012;
Sazonov et al. 2012;
Mateos et al. 2015;
Stern 2015;
Chen et al. 2017)

Difference between type I and II is smaller than expected