

Towards a new paradigm of dust structure in AGN: Circinus galaxy and beyond



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UNIVERSITY OF
Southampton



Towards a new paradigm of dust structure in AGN: Dissecting the mid-IR emission of Circinus galaxy

– What's so special about it ?

Monthly Notices

of the

ROYAL ASTRONOMICAL SOCIETY



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Dissecting the active galactic nucleus in Circinus – I. Peculiar mid-IR morphology explained by a dusty hollow cone

Marko Stalevski,^{1,2,3★} Daniel Asmus⁴ and Konrad R. W. Tristram⁴

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Dissecting the active galactic nucleus in Circinus – II. A thin dusty disc and a polar outflow on parsec scales

Marko Stalevski ,^{1,2★} Konrad R. W. Tristram³ and Daniel Asmus⁴

Towards a new paradigm of dust structure in AGN: Dissecting the mid-IR emission of Circinus galaxy

– What's so special about it ?

<http://www.torus2018.org>

TORUS 2018

The many faces of the AGN obscuration

Puerto Varas, Chile

10-14 December 2018

| | | | |
|-------------|--------|--------------|-------------------------------------------------------------------------------------------------------------------------|
| 09:00 | 25 min | B. Vollmer | Models of thick turbulent gas disks with magnetocentrifugal winds in AGN and their application to Circinus and NGC 1068 |
| 09:25 | 25 min | M. Stalevski | Towards a new paradigm of dust structure in AGN: Dissecting the mid-IR emission of Circinus galaxy |
| 09:50 | 20 min | C. Andonie | The first IR/X-ray model of the circumnuclear environment of the Circinus Galaxy |
| 14:30 | 20 min | T. Izumi | Circumnuclear Multi-phase Gas in the Circinus Galaxy Revealed with ALMA |
| 14:50 | 20 min | K. Tristram | The compact molecular torus in the Circinus galaxy constrained by ALMA |
| A. Tanimoto | | | X-Ray Spectral Model from Clumpy Torus and Its Application to Circinus Galaxy |

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Circumnuclear Multi-phase Gas in the Circinus Galaxy Revealed with ALMA

The compact molecular torus in the Circinus galaxy constrained by ALMA

X-Ray Spectral Model from Clumpy Torus and Its Application to Circinus Galaxy

The many 'faces' of the molecular torus of NGC 1068

The counter rotating molecular torus in NGC 1068

ALMA reveals a rotating dense molecular torus in NGC 1068

NUclei of GALaxies (NUGA) resolved by ALMA

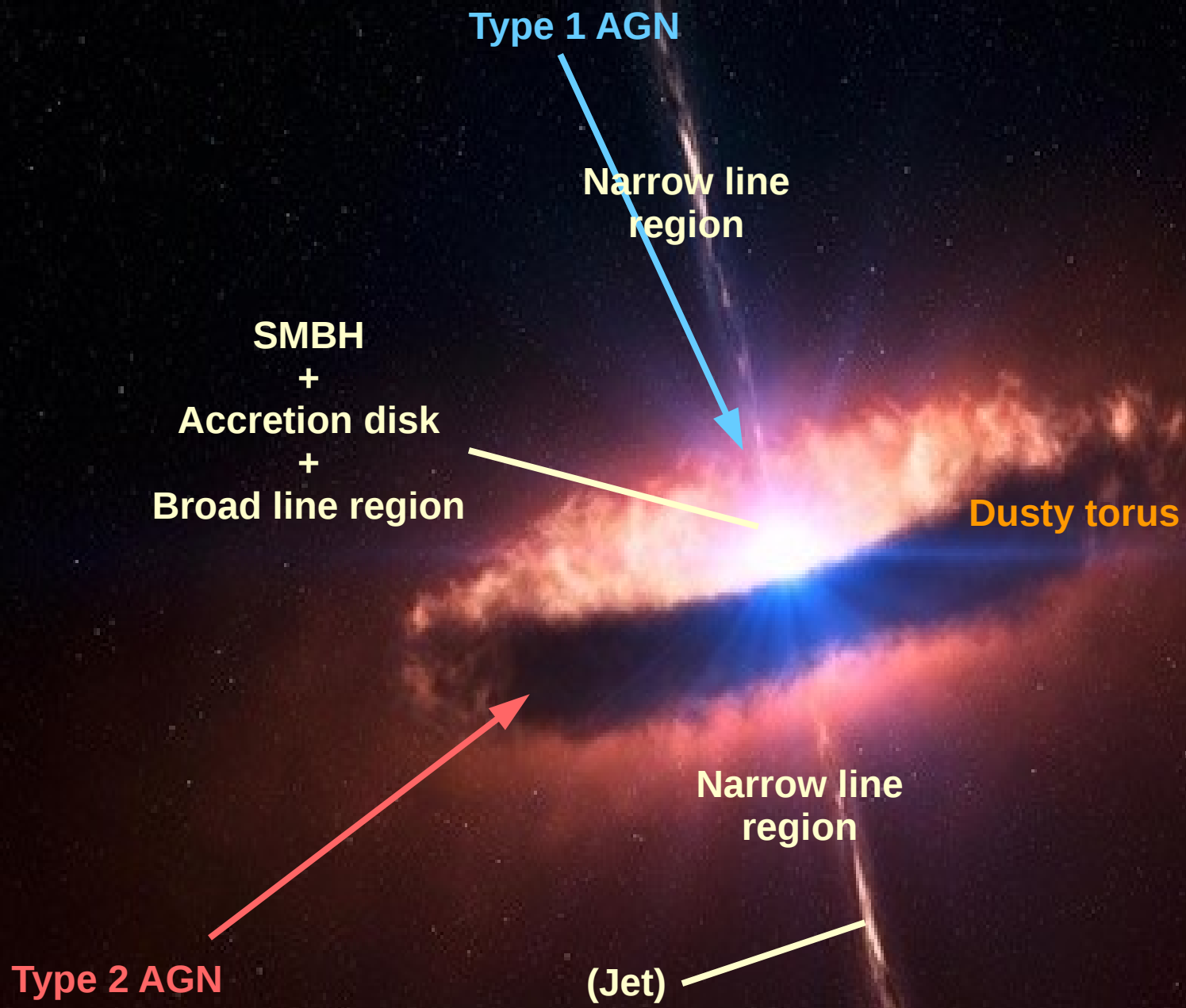
First successful MATISSE observations of NGC 1068

The dust and cloud distribution of the torus of NGC 1068

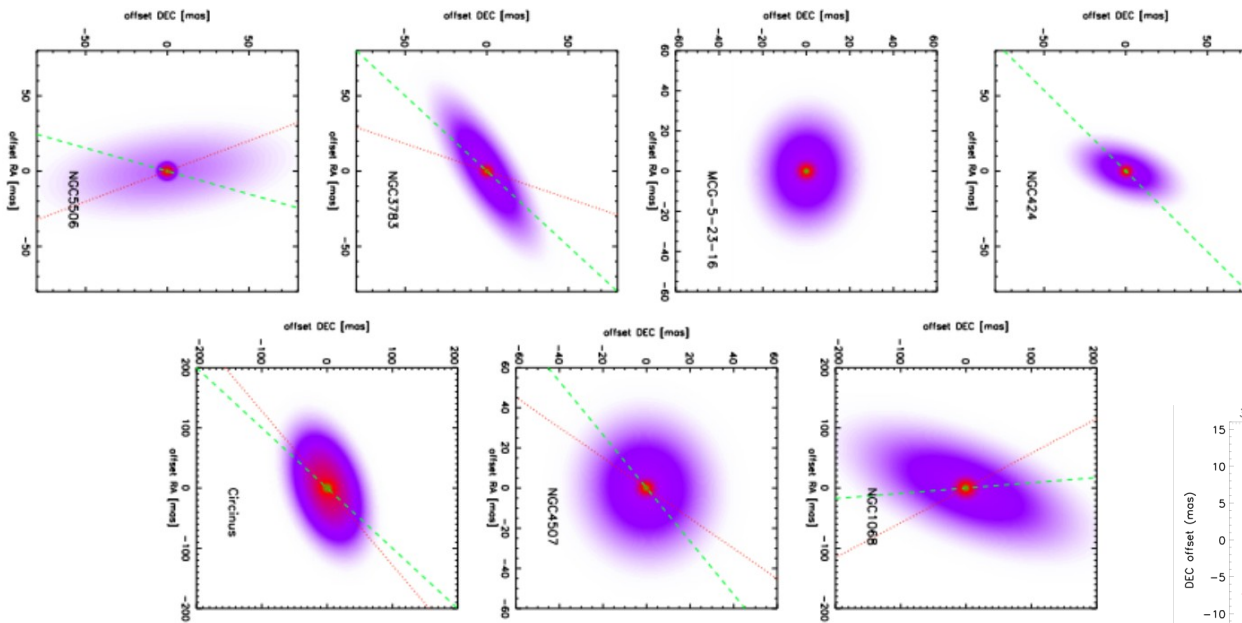
Investigating the nature and geometry of NGC 1068 through NuSTAR observations and future X-ray polarimetry

Models of thick turbulent gas disks with magnetocentrifugal winds in AGN and their application to Circinus and NGC 1068

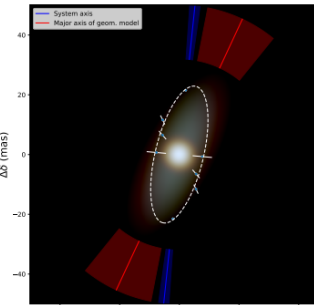
ACTIVE GALACTIC NUCLEI



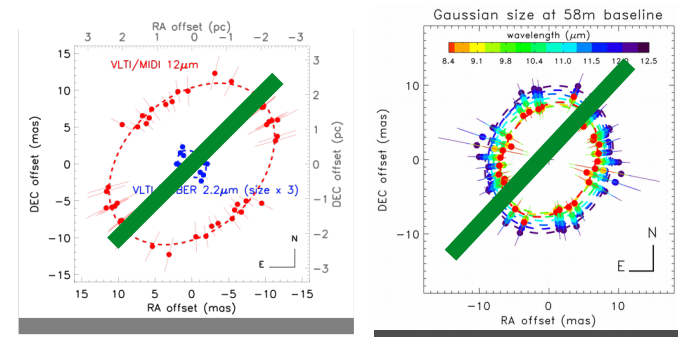
VLT/MIDI: polar elongation on pc-scale



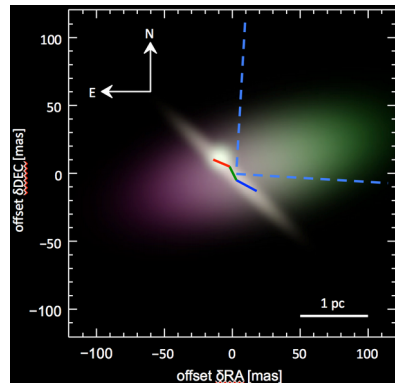
López Gonzaga et al. (2014)



Leftley et al. (2018)



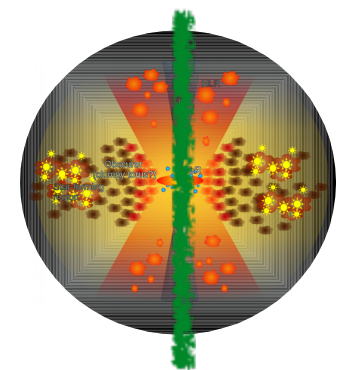
Hönig et al. (2013) Hönig et al. (2012)



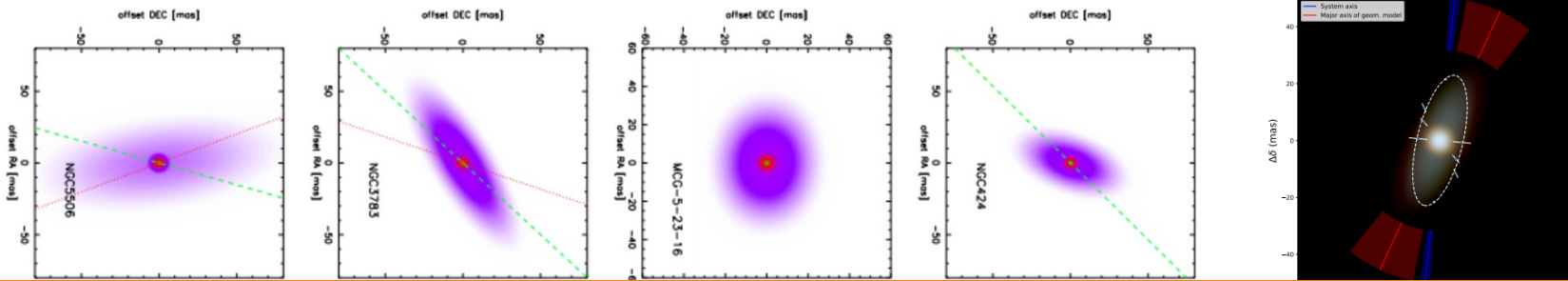
Cirinus; Tristram et al. (2014)

NGC 1068;

López Gonzaga et al. (2014)



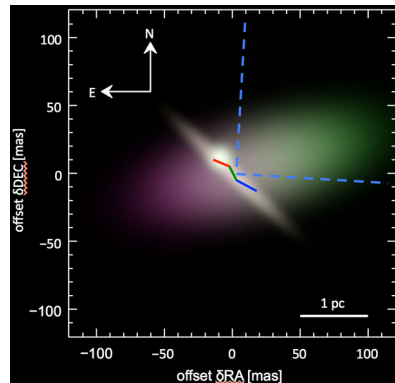
VLT/MIDI: polar elongation on pc-scale



López Gonzaga+14:

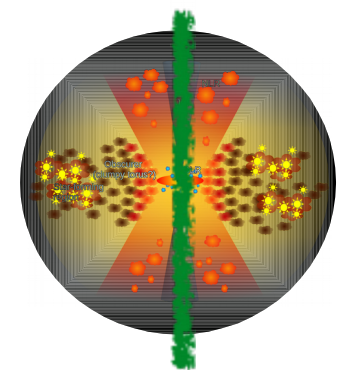
23 sources: 7 with good uv coverage & S/N;
5 of those 7 with polar elongation !

Leftley+18: **+1**



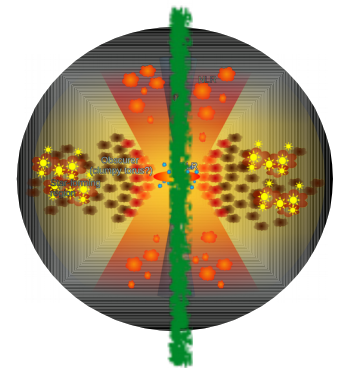
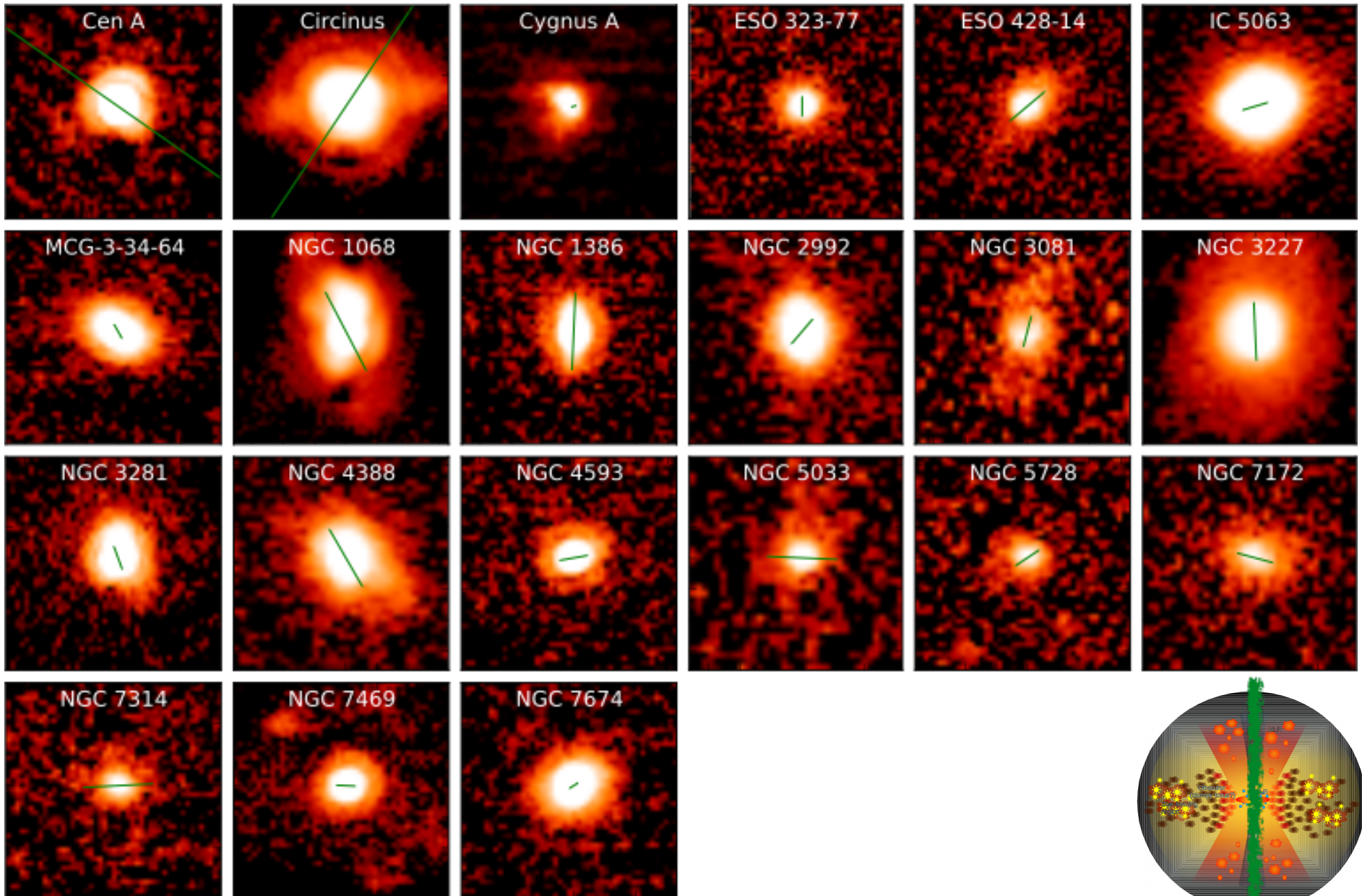
Circinus;
Tristram et al. (2014)

NGC 1068;
López Gonzaga et al. (2014)



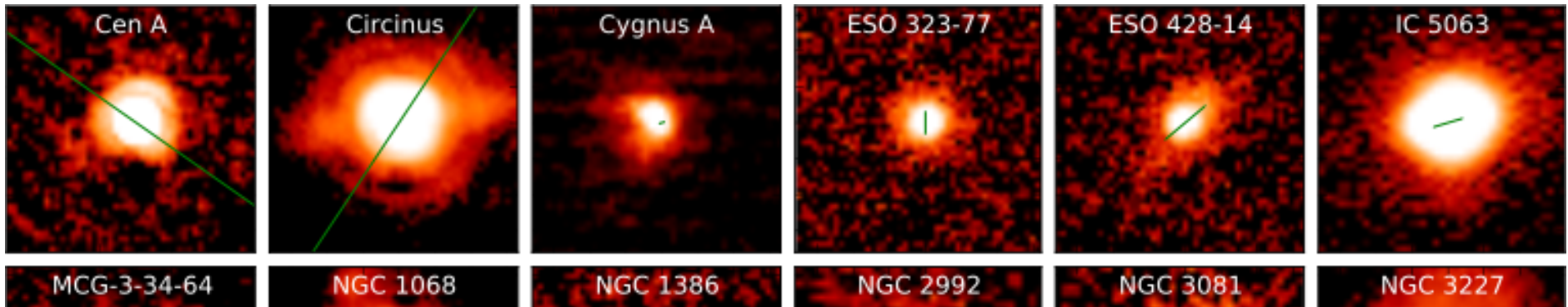
MIR polar elongation on 10s-100s pc scale

Asmus, Honig, Gandhi (2016)

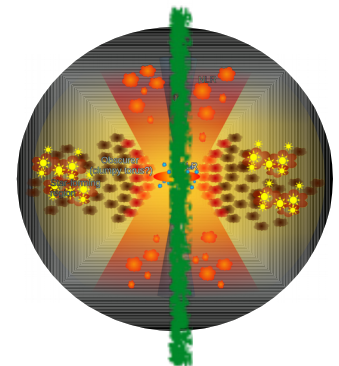
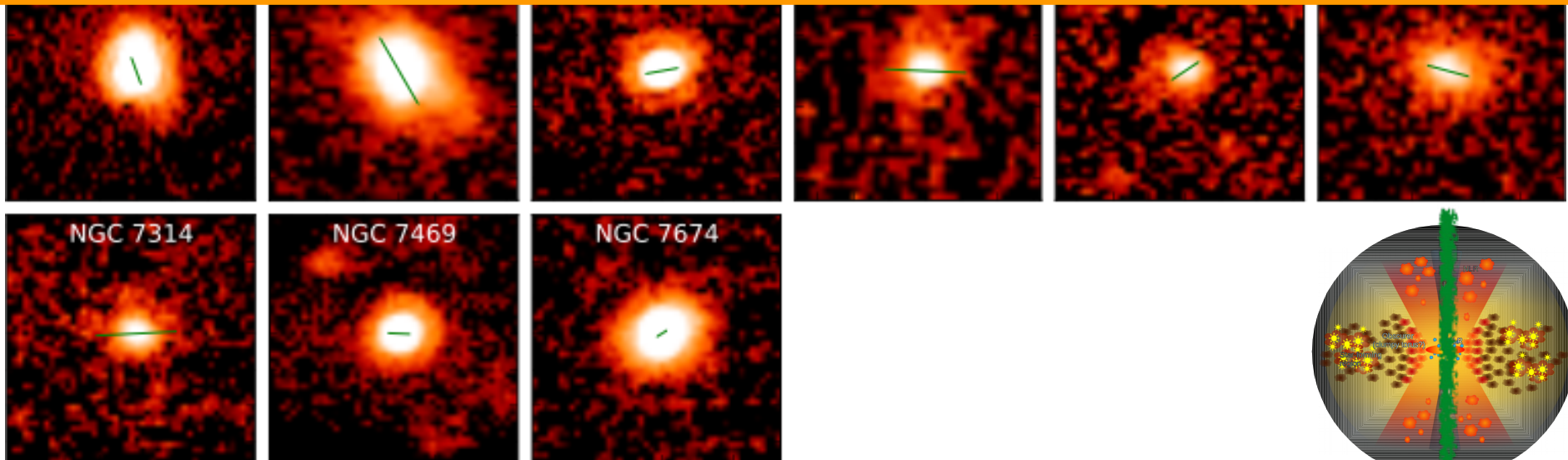


MIR polar elongation on 10s-100s pc scale

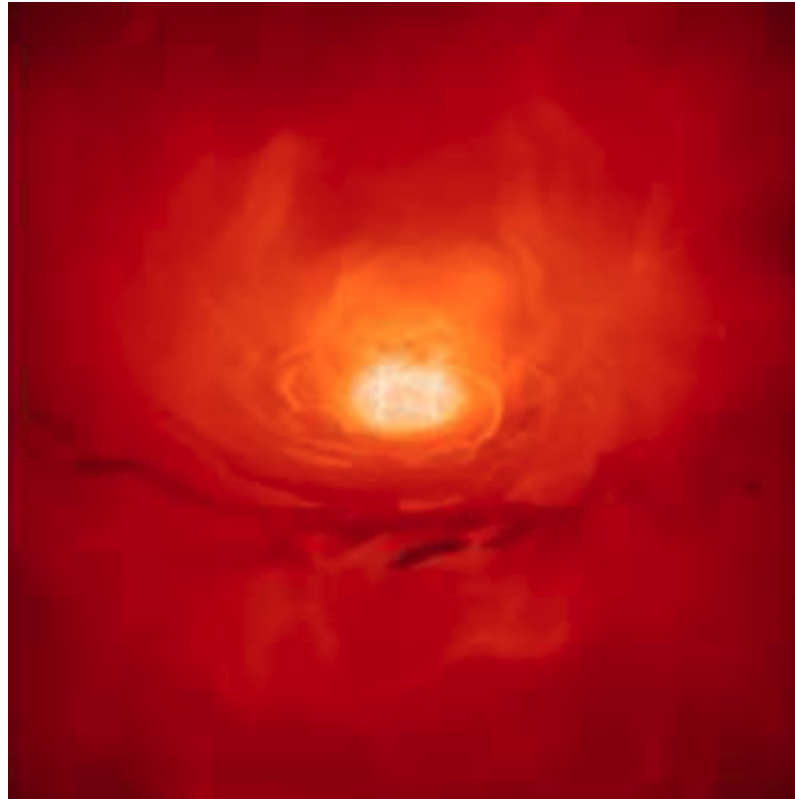
Asmus, Honig, Gandhi (2016)



18 out of 21 with polar elongation !

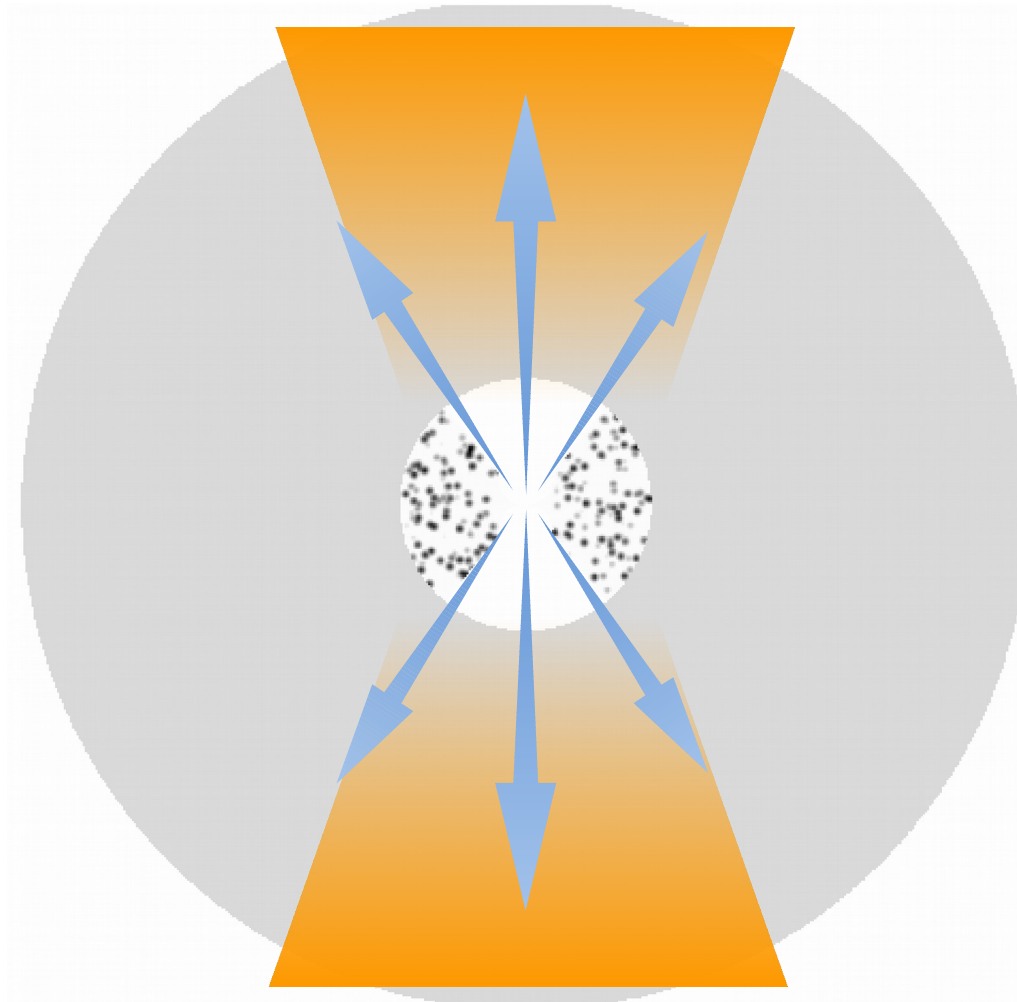


Polar elongation – inclined torus ?

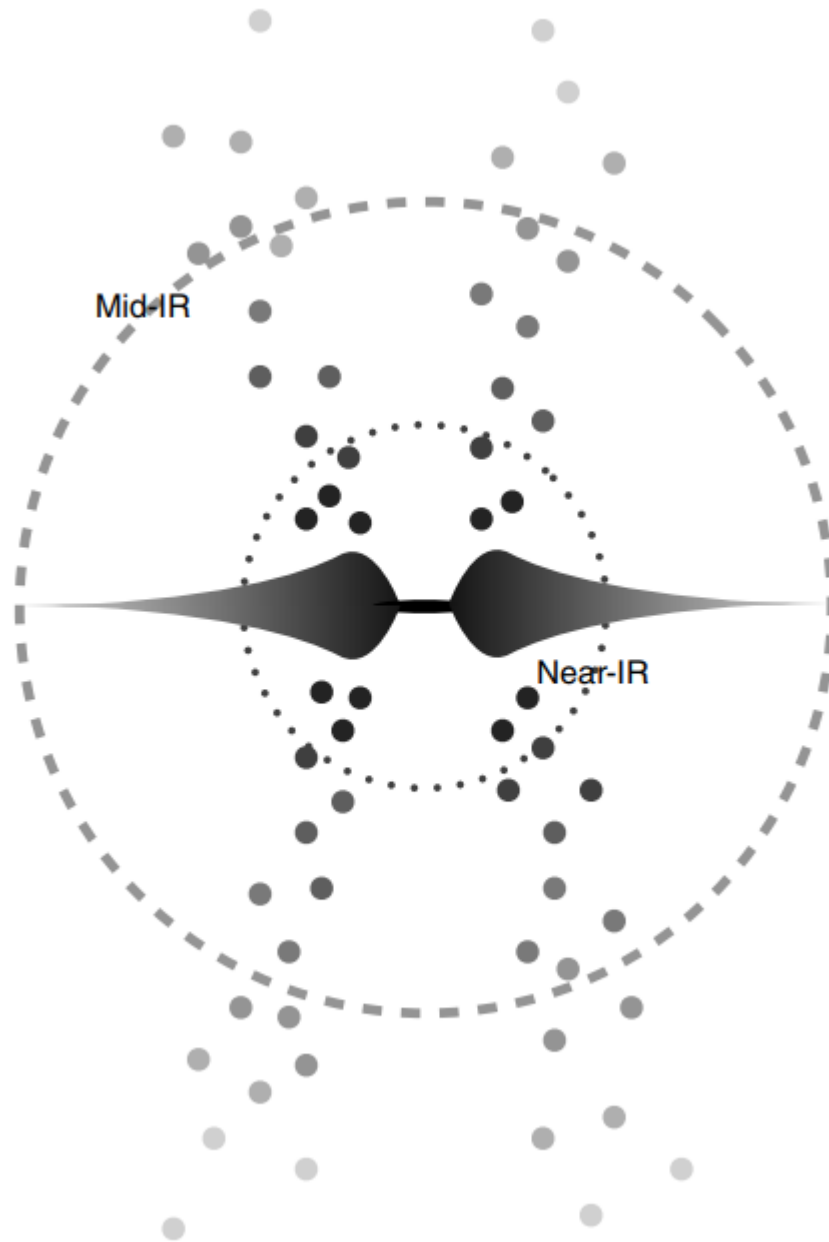


Schartmann et al. (2014)

Polar elongation – host galaxy dust ?



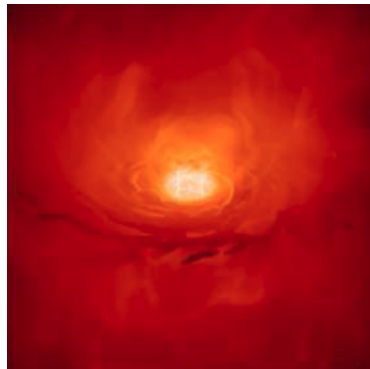
Polar elongation – dusty wind ?



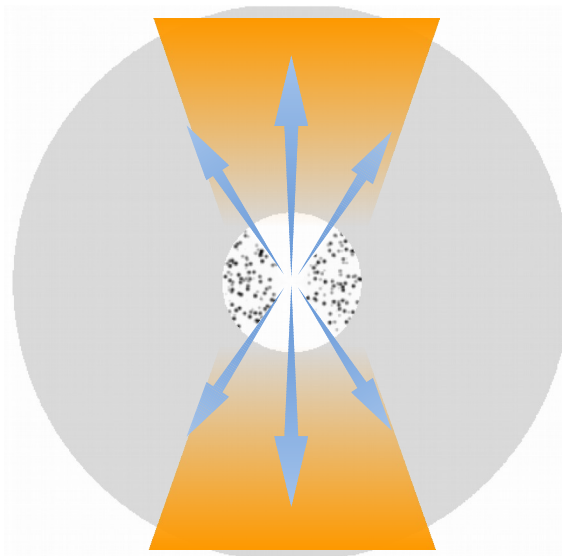
Honig et al. (2012)

Polar elongation –

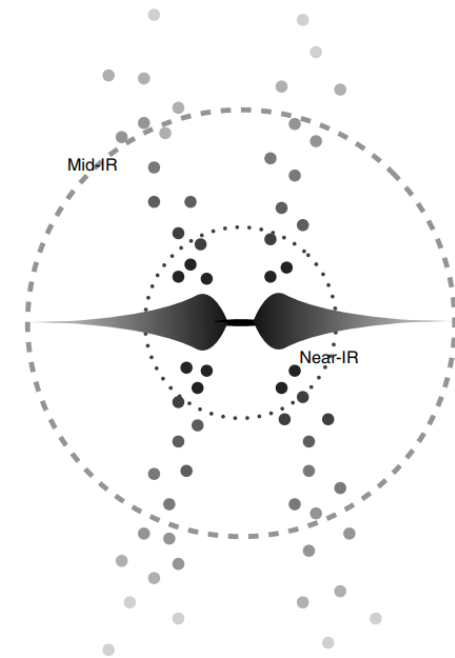
inclined torus?



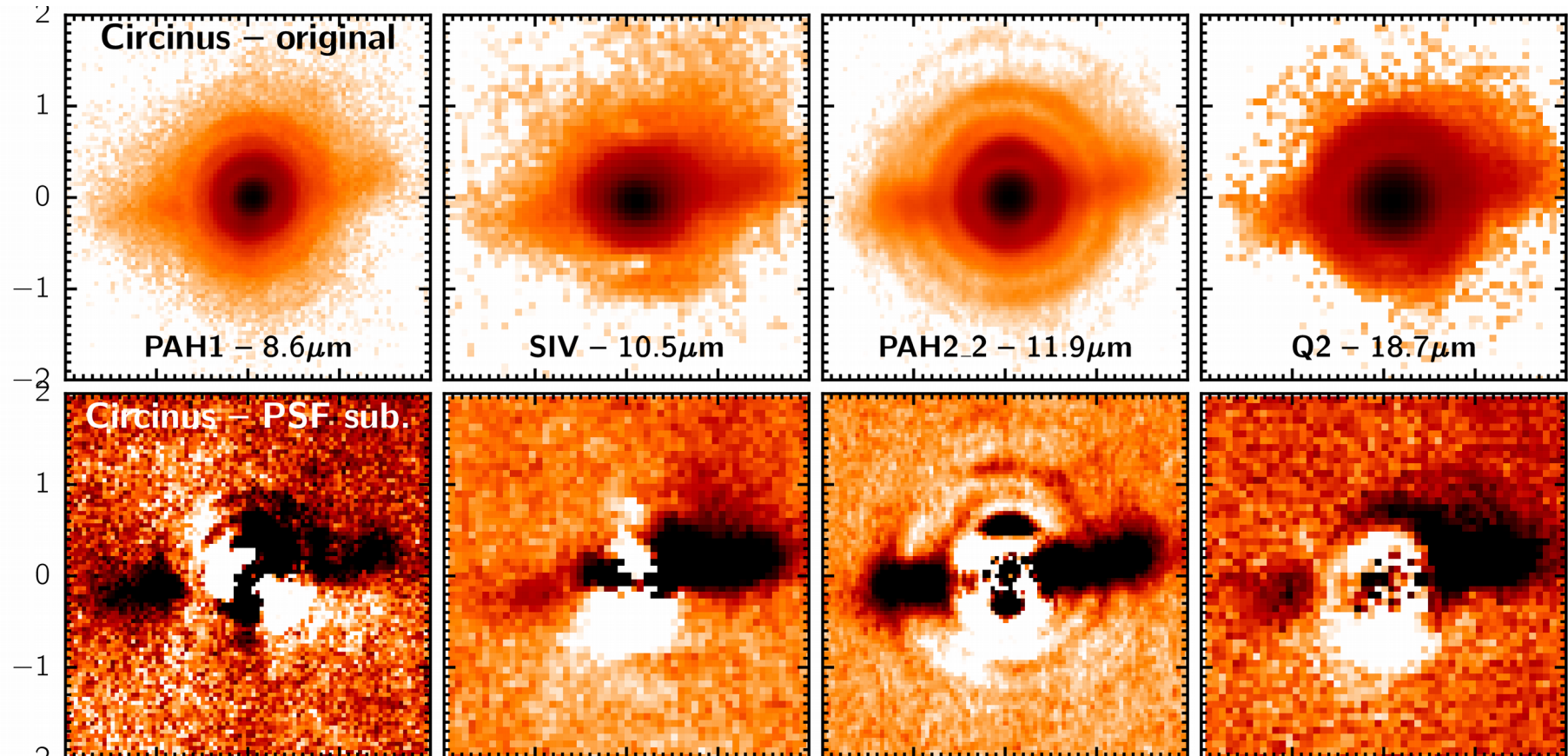
host galaxy dust?



dusty wind?

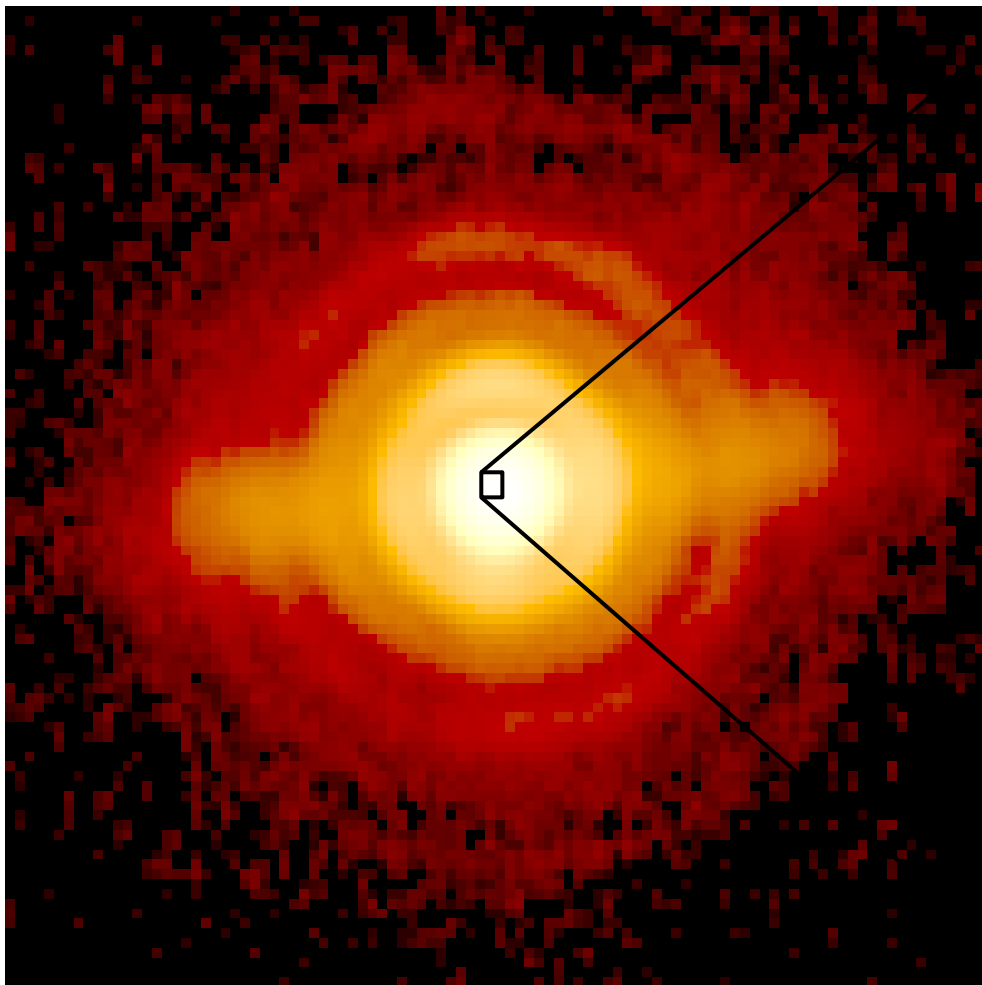


Circinus with VLT/VISIR

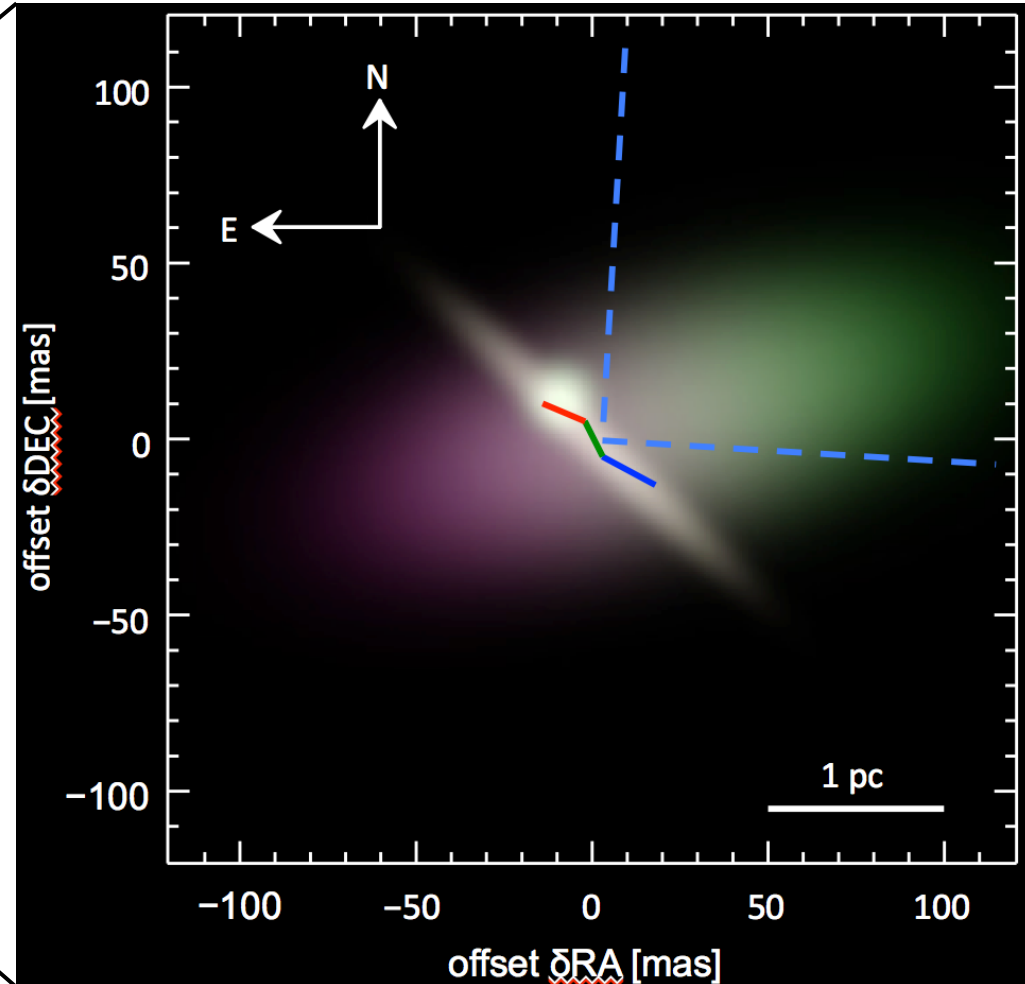


Stalevski, Asmus & Tristram (2017)

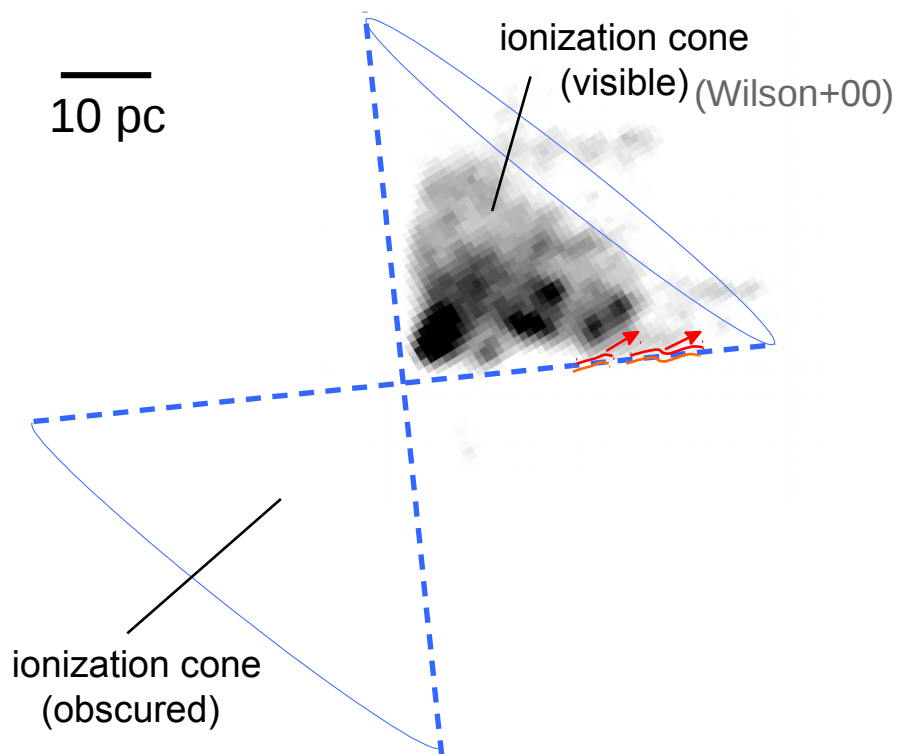
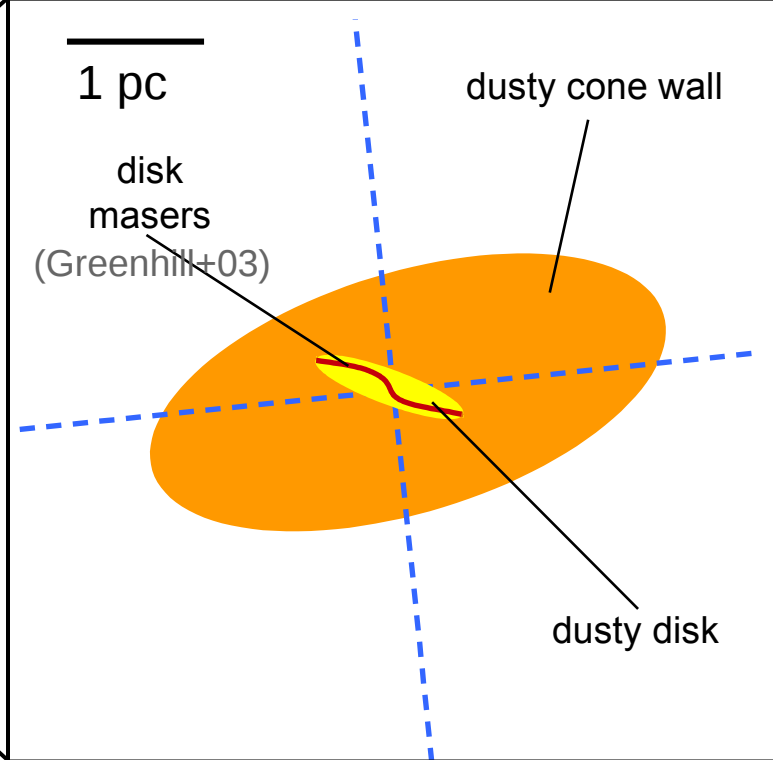
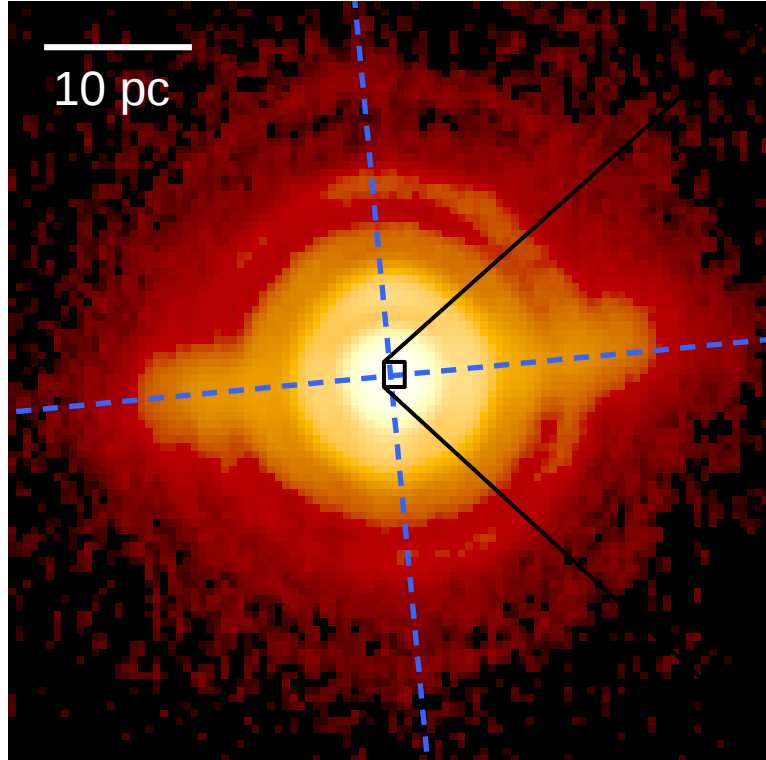
Circinus with VLT/MIDI

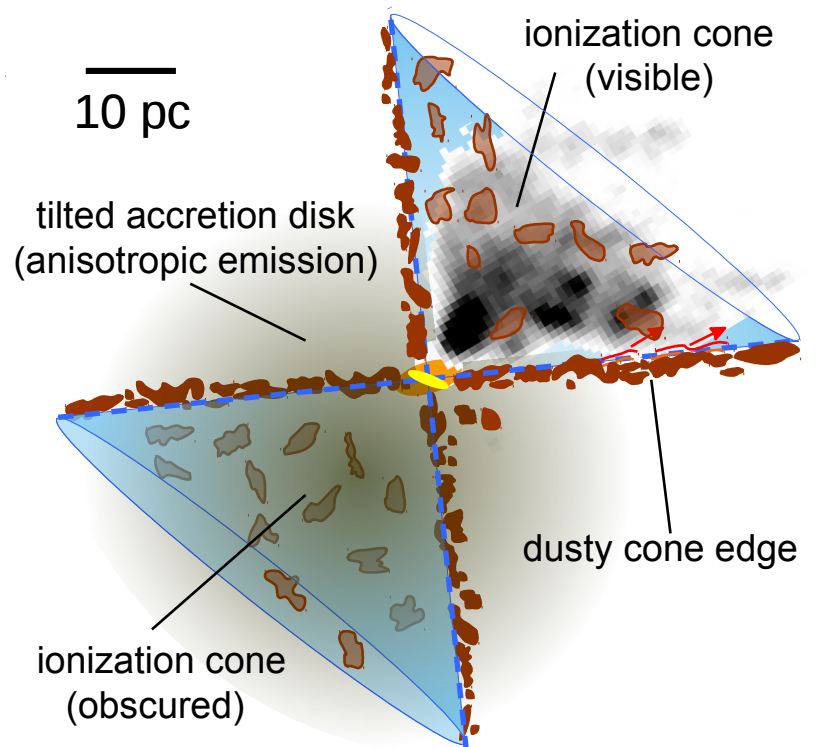
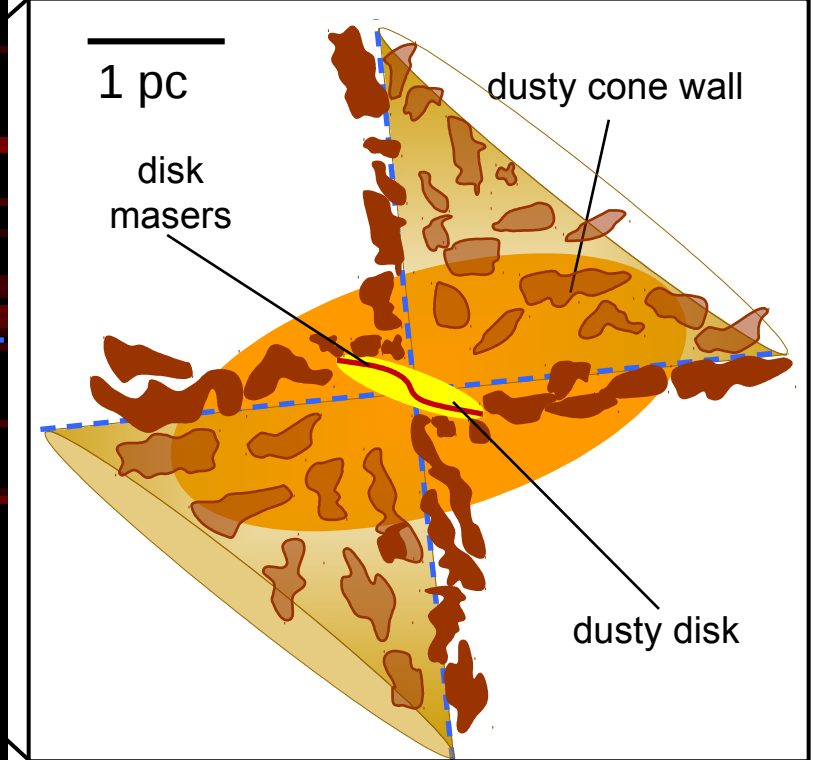
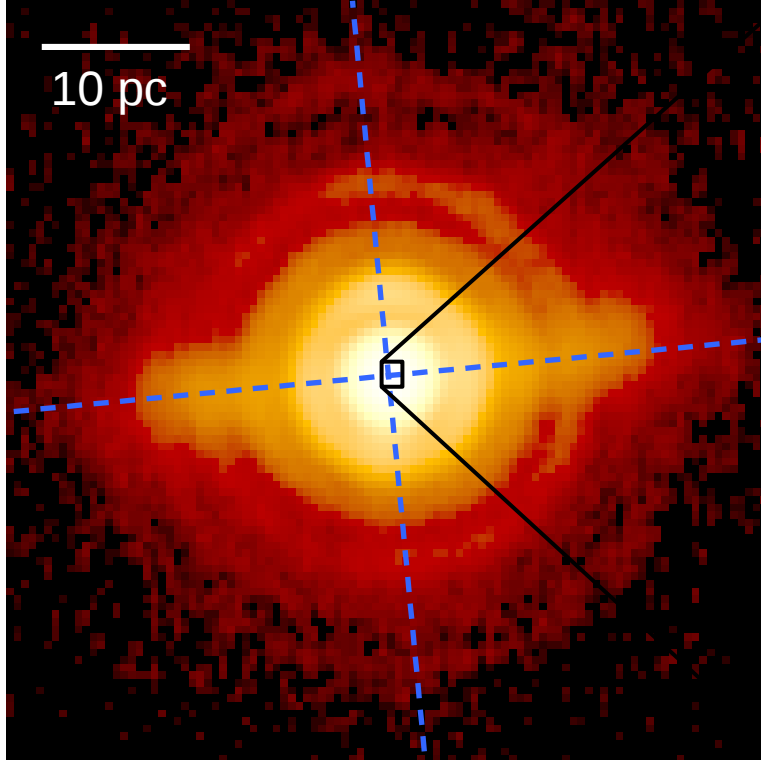


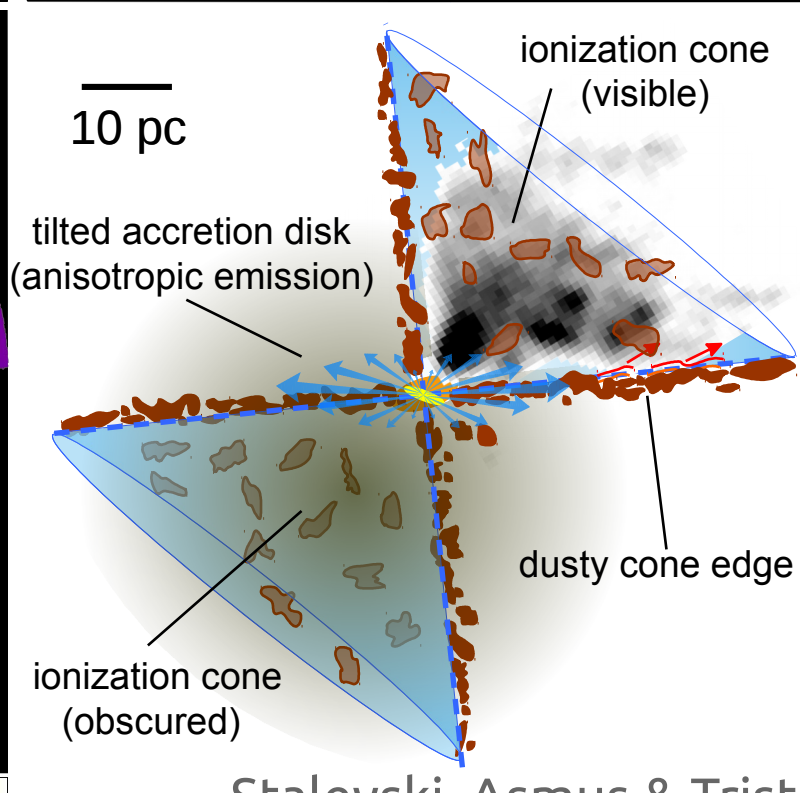
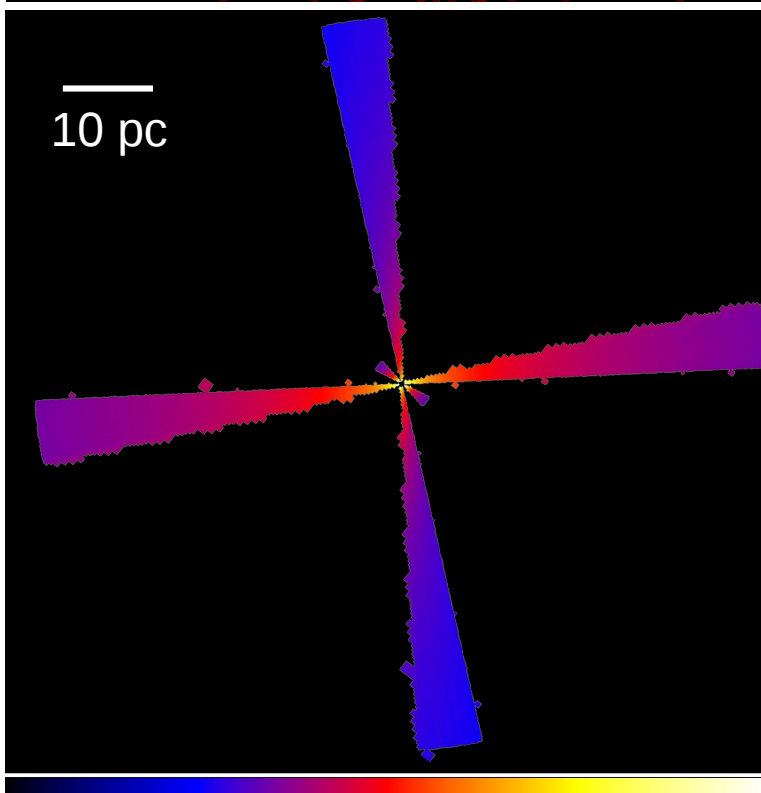
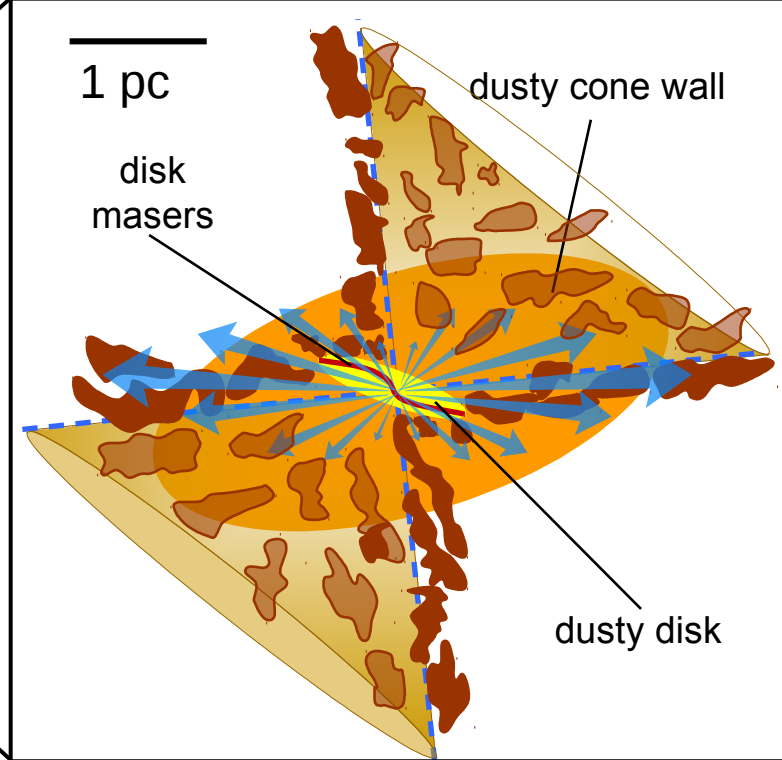
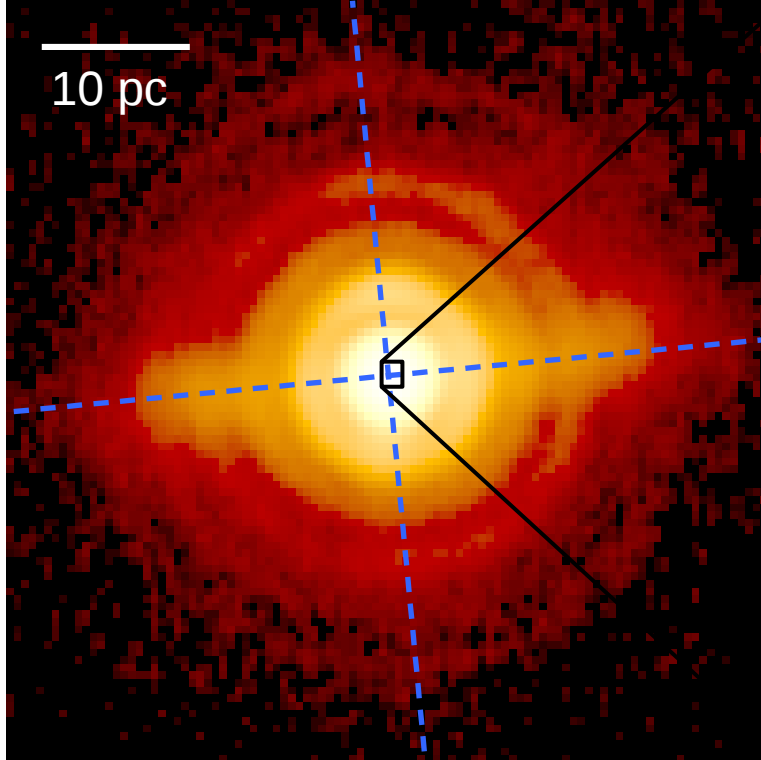
Stalevski, Asmus & Tristram (2017)



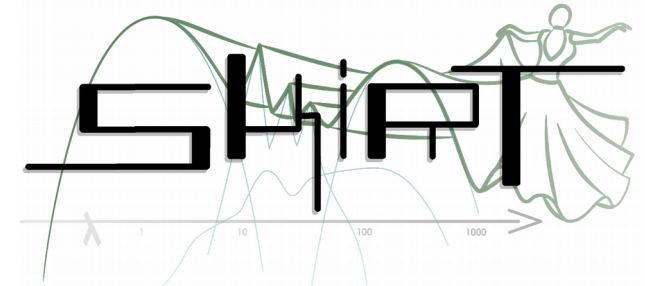
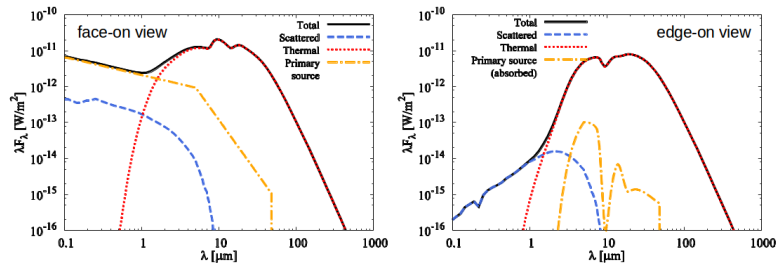
Tristram et al. (2014)







Monte Carlo radiative transfer



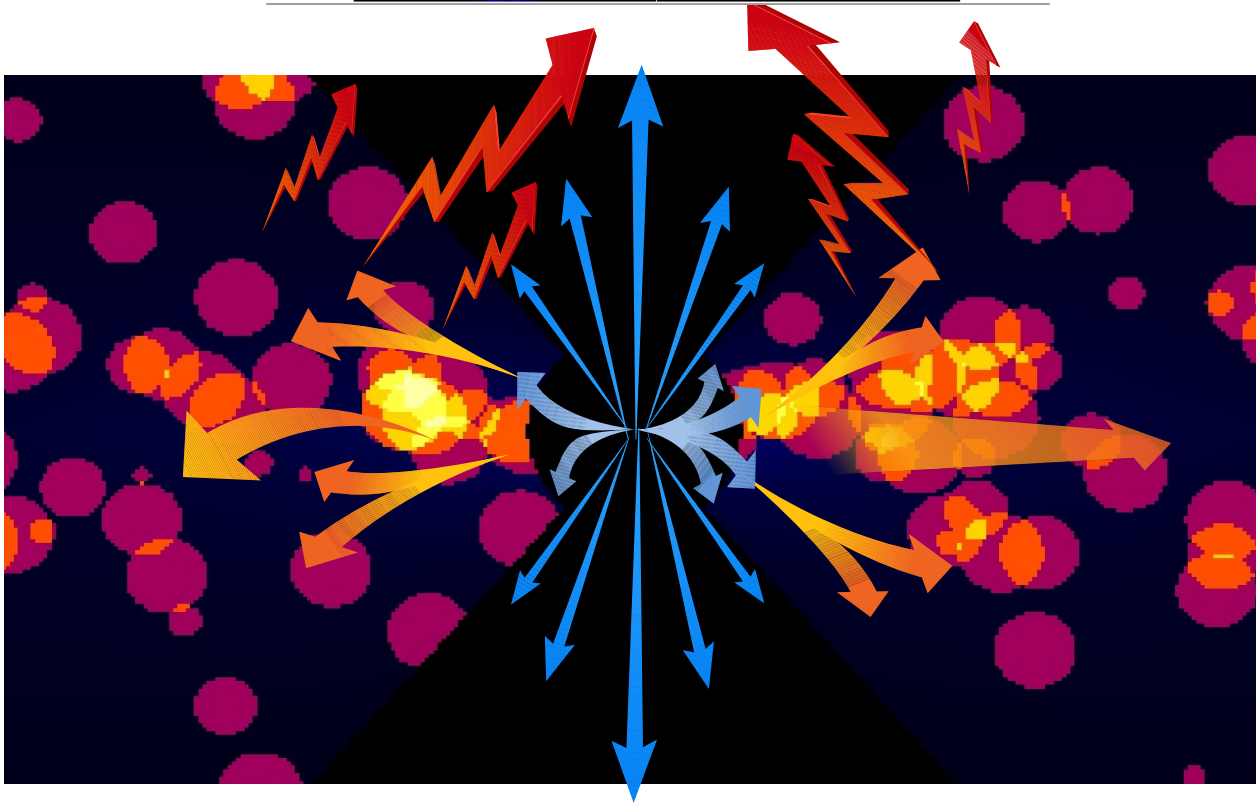
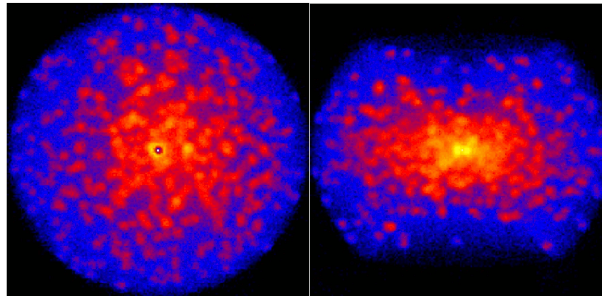
<http://www.skirt.ugent.be>

Baes+ 2011

Baes & Camps 2015

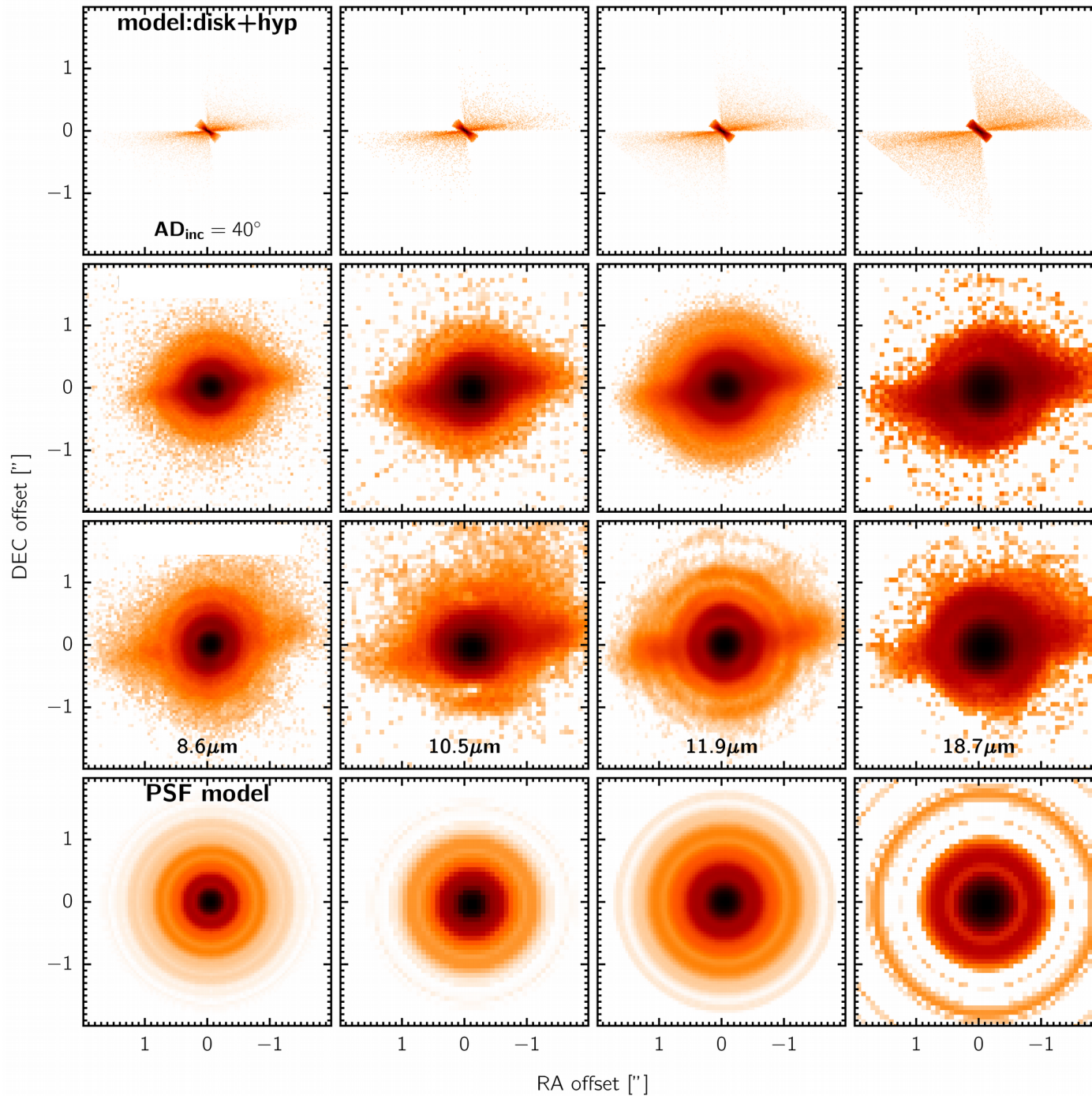
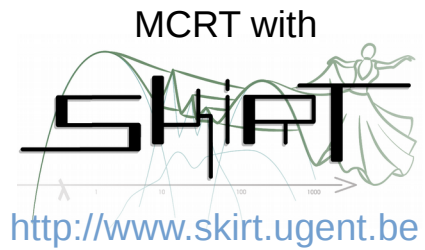
Camps & Baes 2015

Stalevski+ 2012, 2016



Good match with the MIR morphology

Stalevski, Asmus & Tristram (2017)

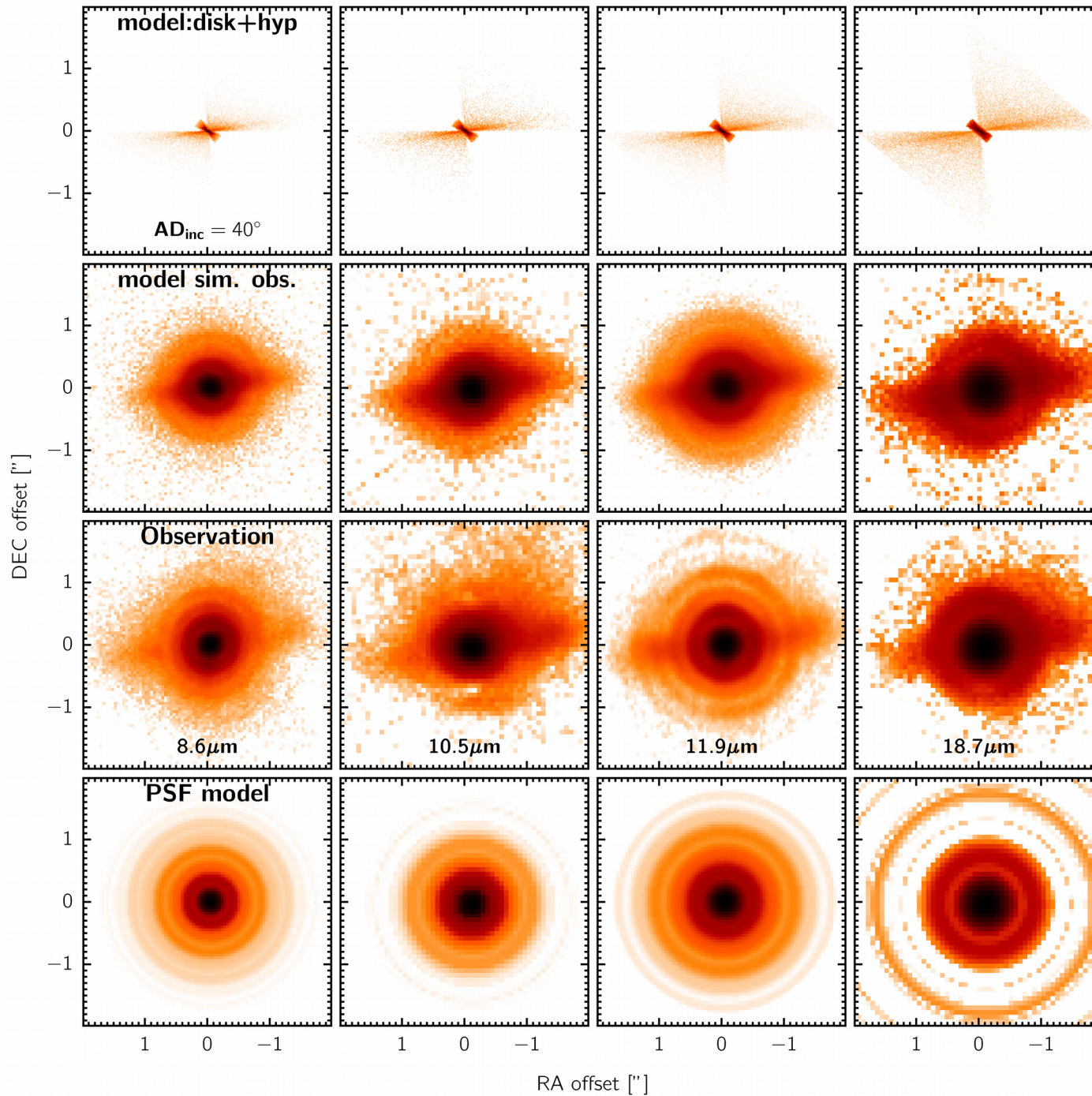
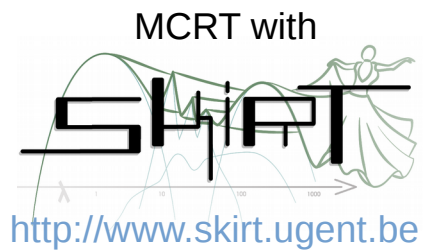


Model RT
image

PSF model

Good match with the MIR morphology

Stalevski, Asmus & Tristram (2017)



Model RT
image

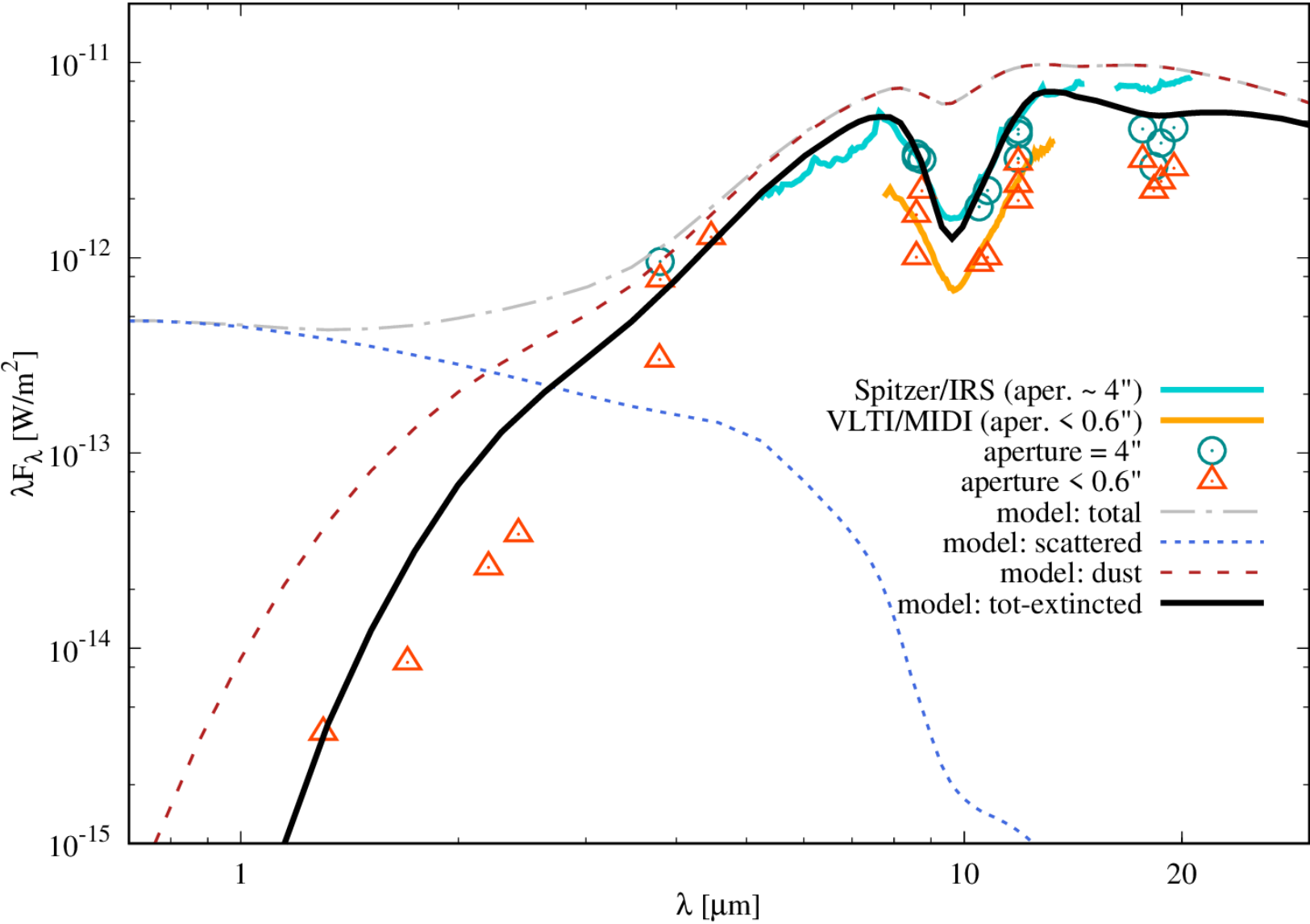
Synthetic obs.
of the model

Observed
images

PSF model

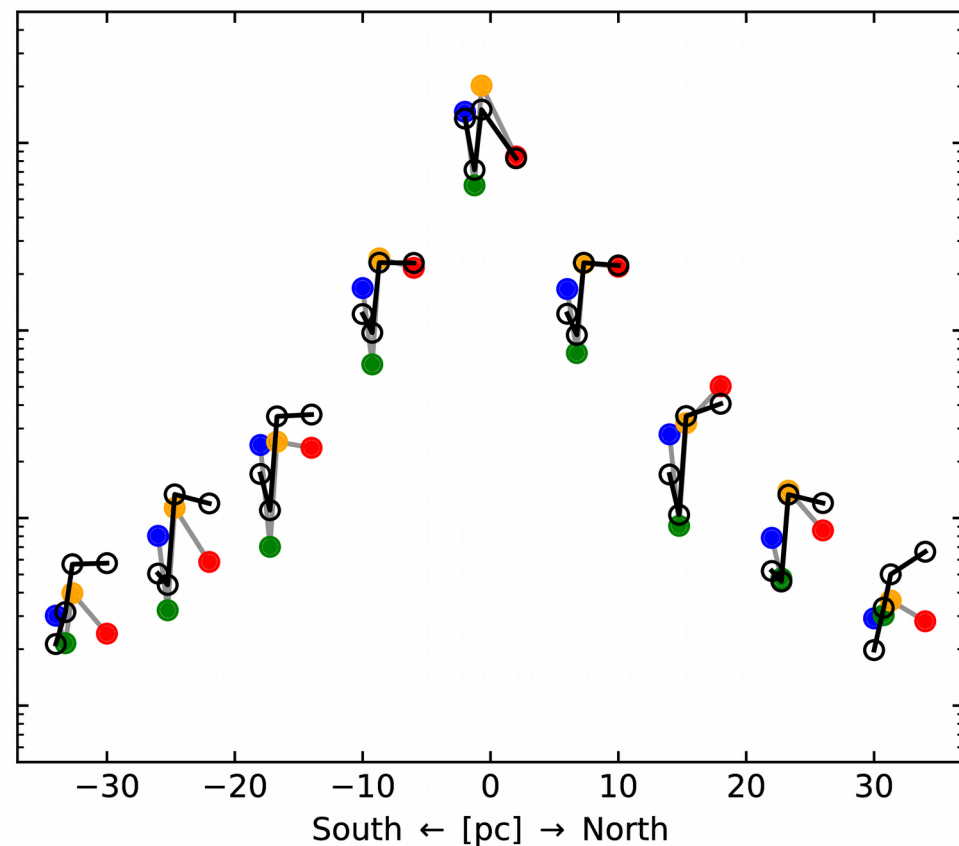
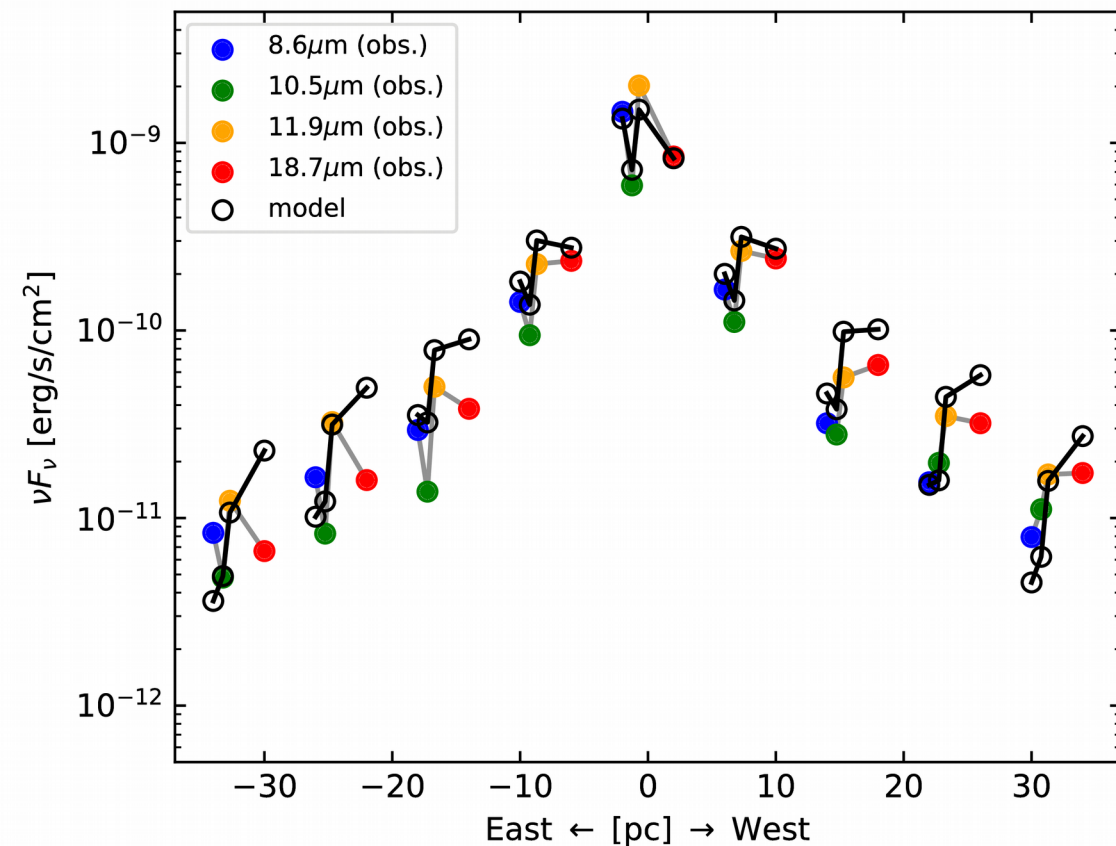
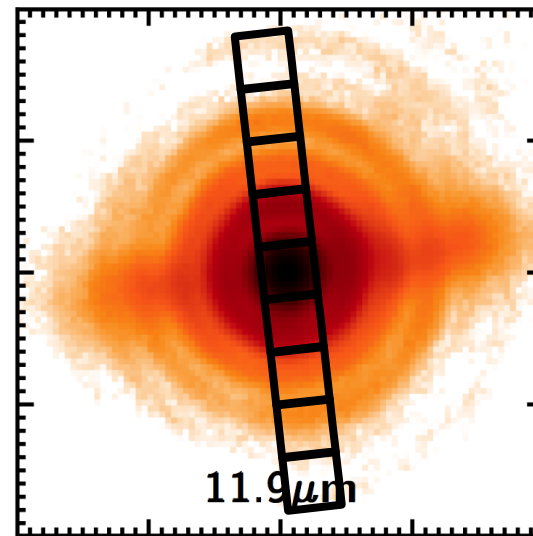
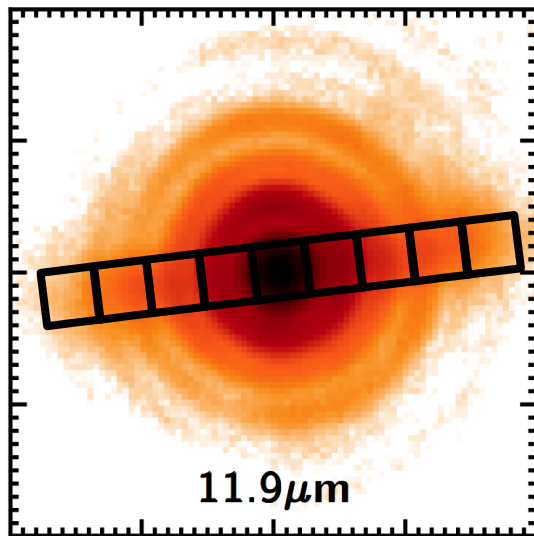
Good match with the SED

Stalevski, Asmus & Tristram (2017)

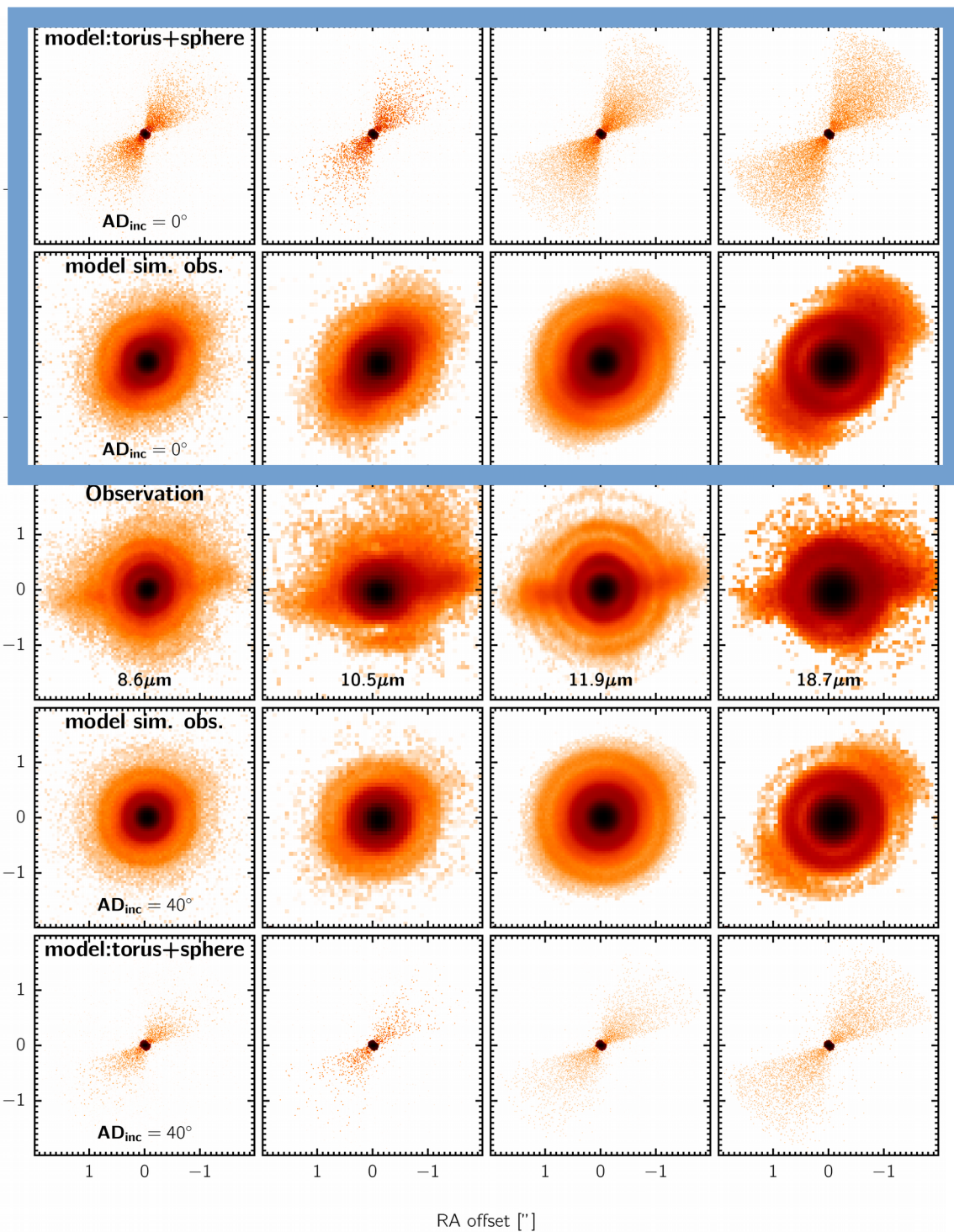


Good match with the resolved photometry

Stalevski, Asmus & Tristram (2017)



torus+sphere shell: does not work



Model RT image

Aligned AD

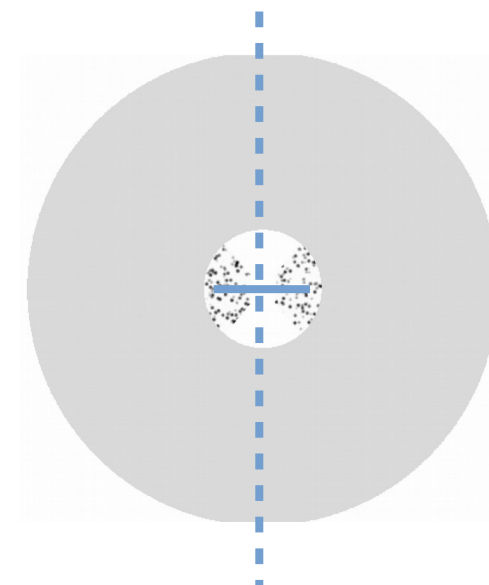
Synthetic obs. of the model

Observed images

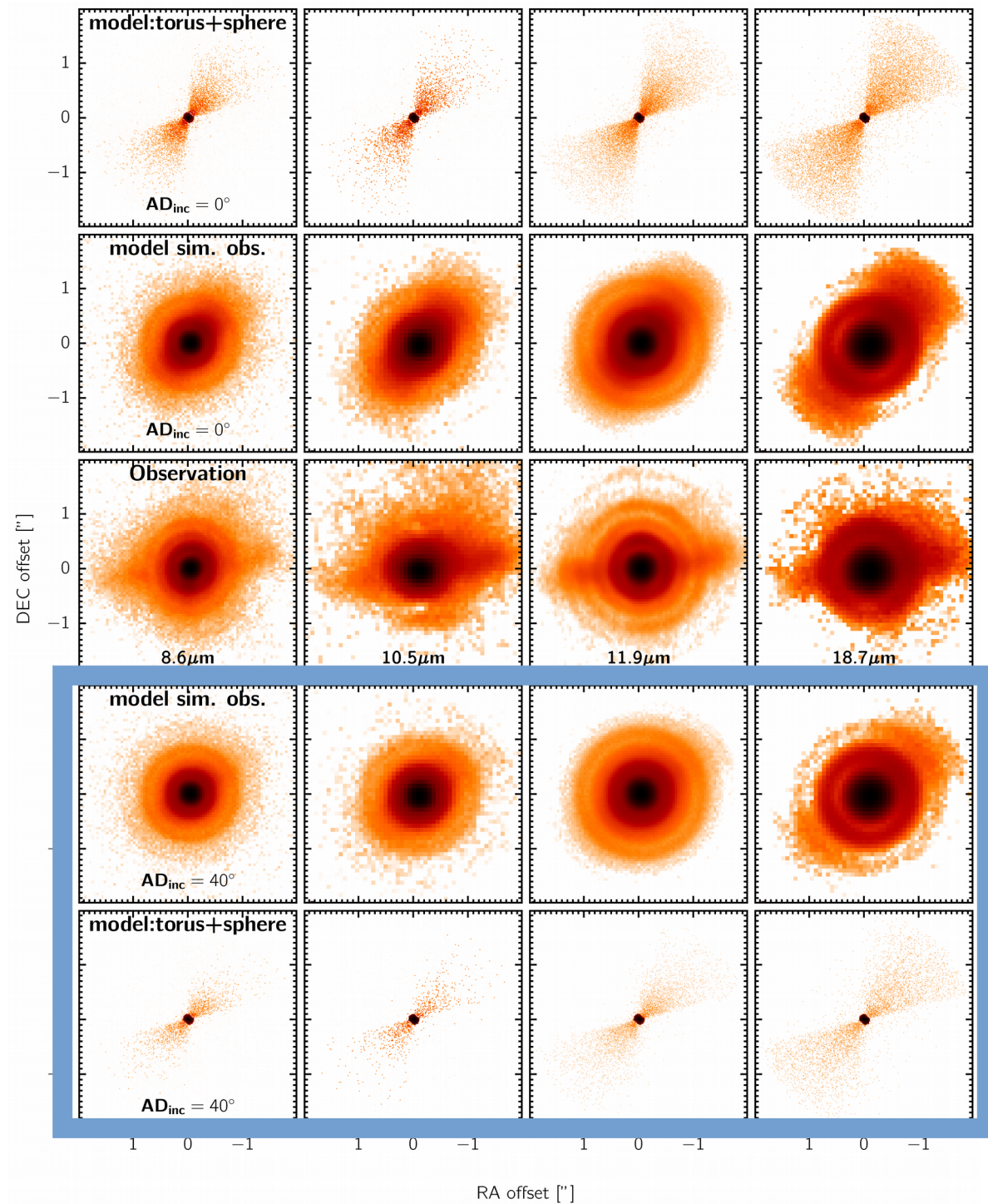
Synthetic obs. of the model

Tilted AD

Model RT image



torus+sphere shell: does not work



Model RT image

Aligned AD

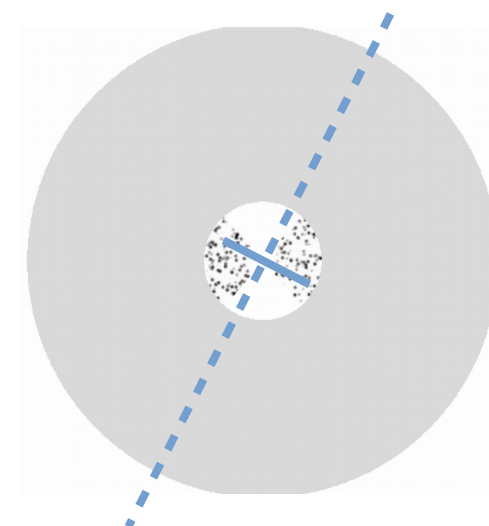
Synthetic obs. of the model

Observed images

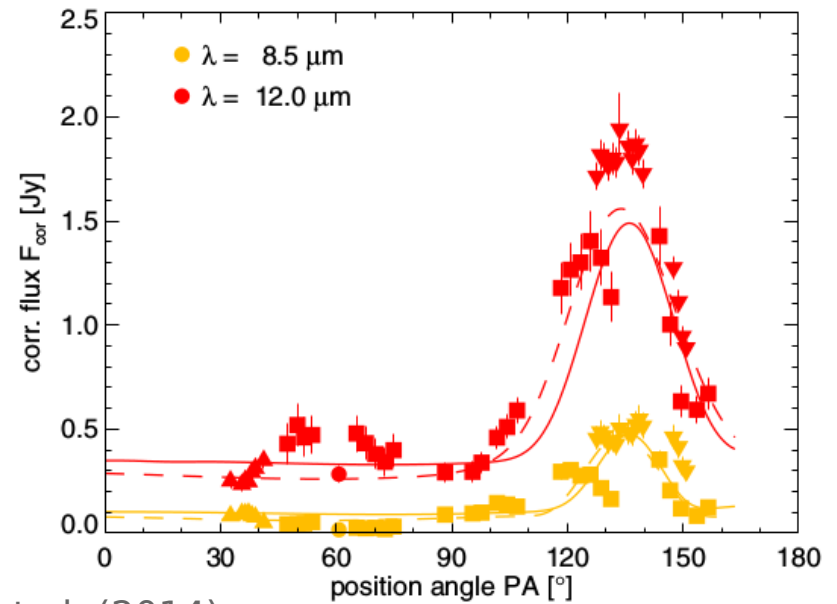
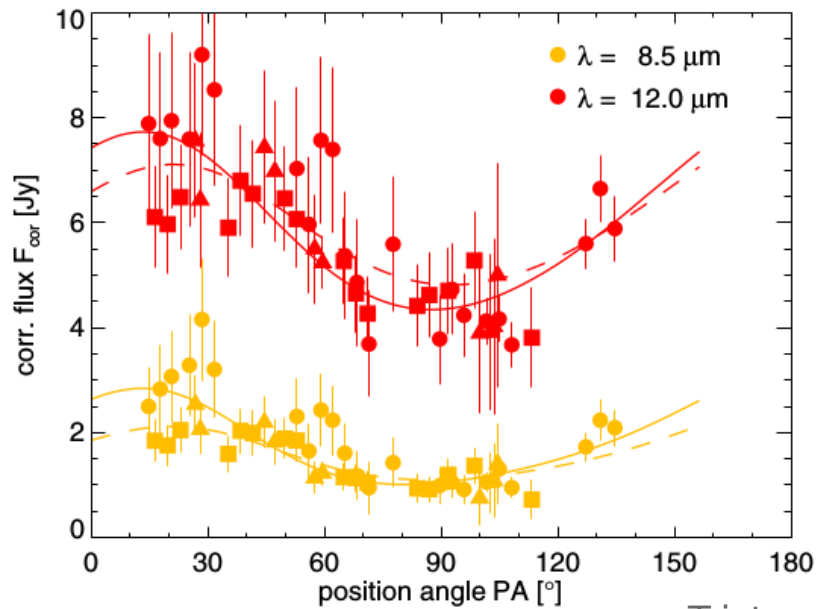
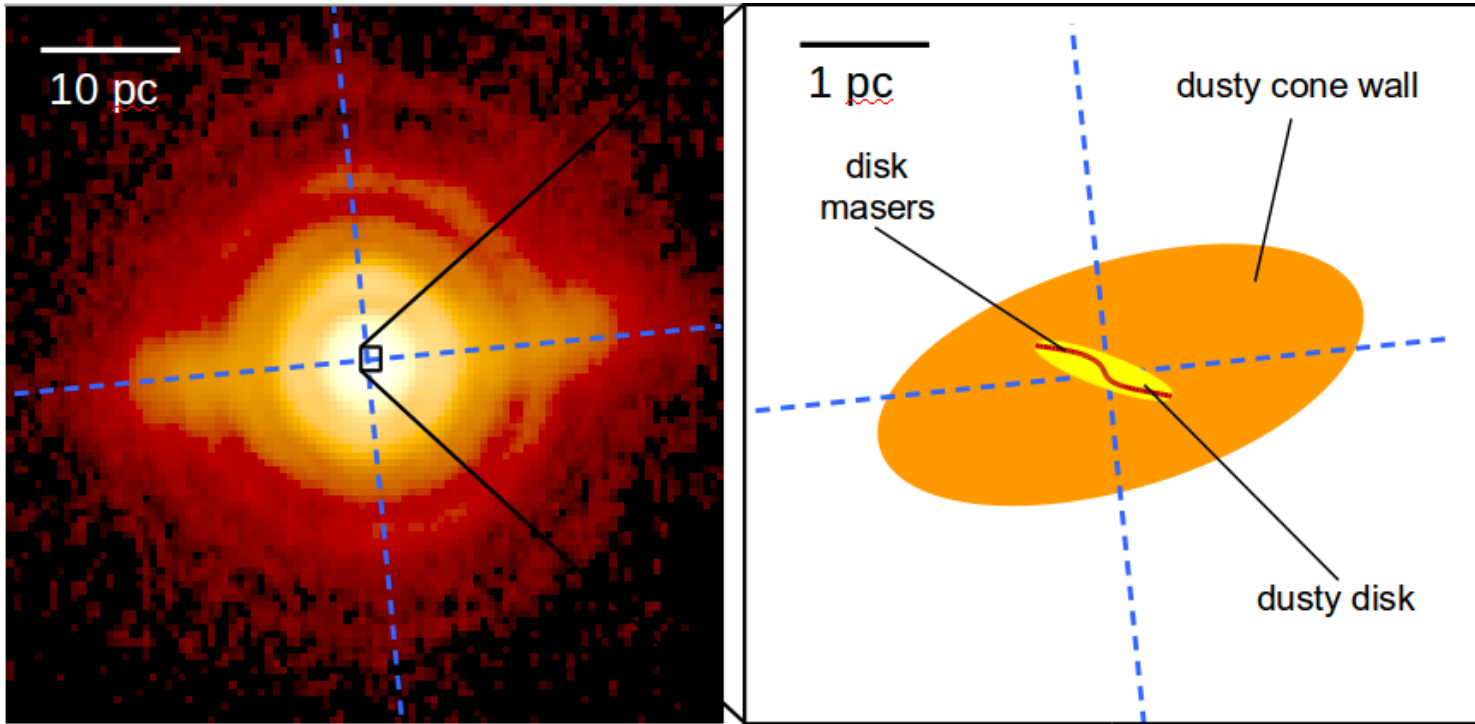
Synthetic obs. of the model

Tilted AD

Model RT image

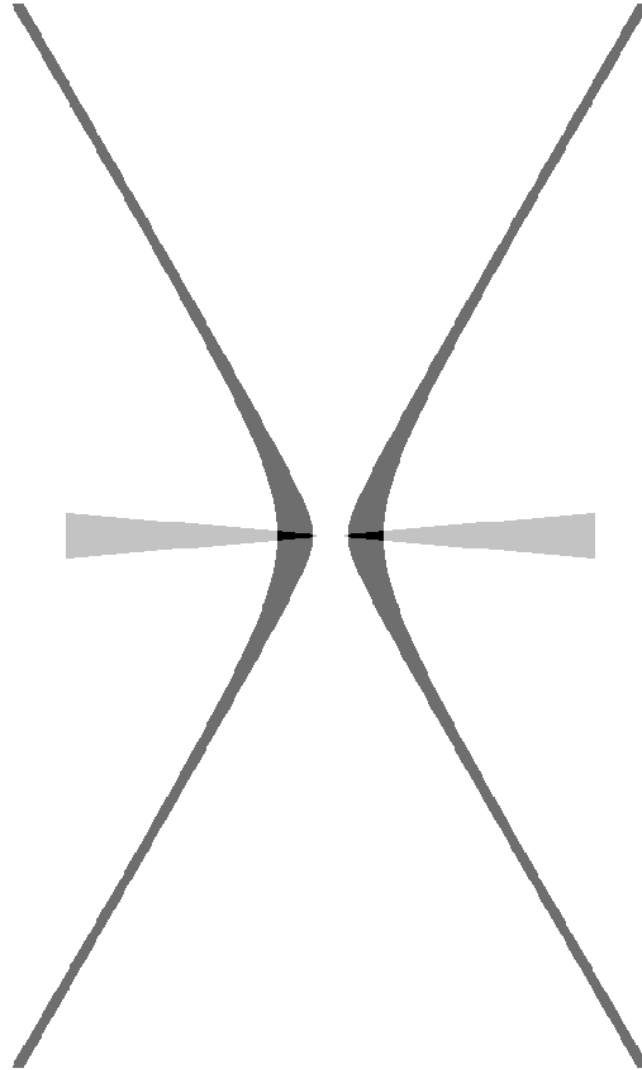


Zooming in with VLT/MIDI



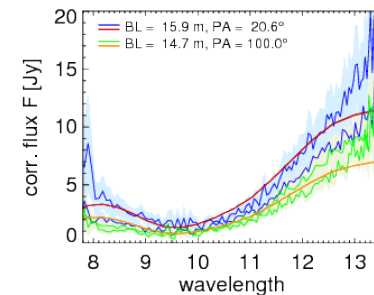
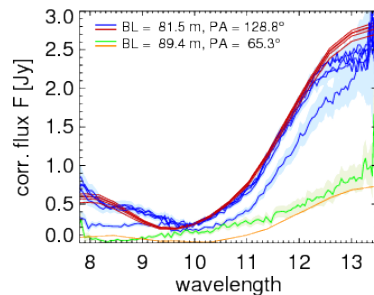
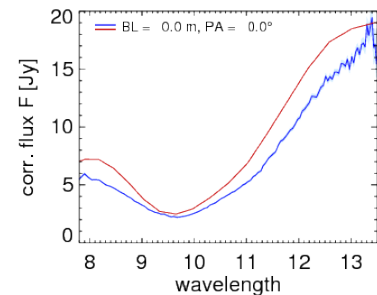
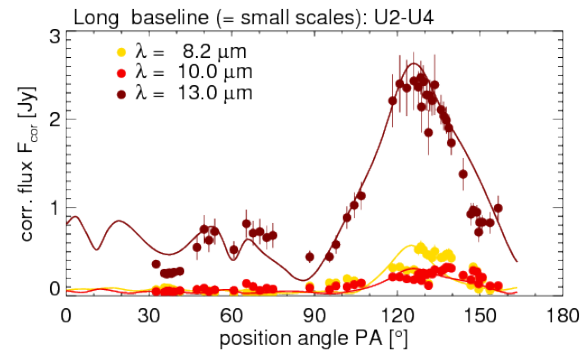
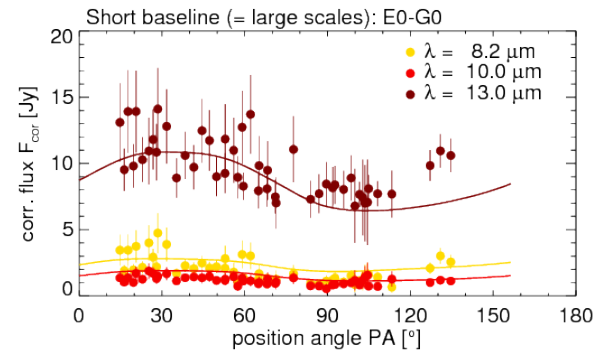
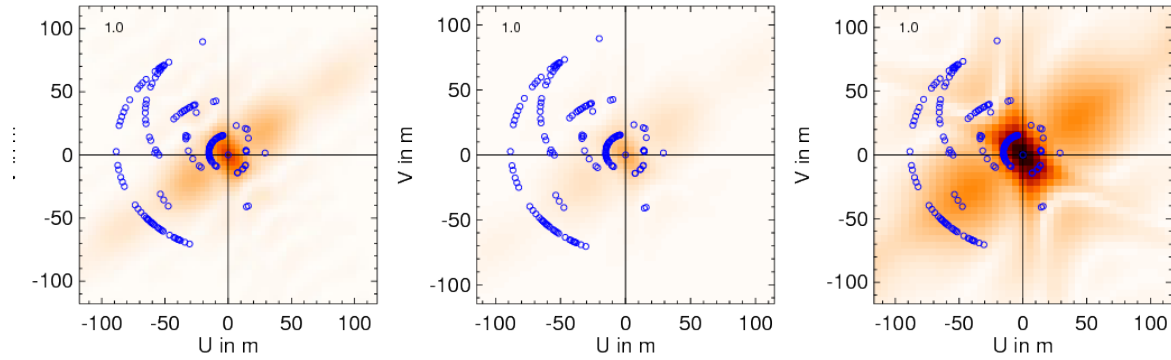
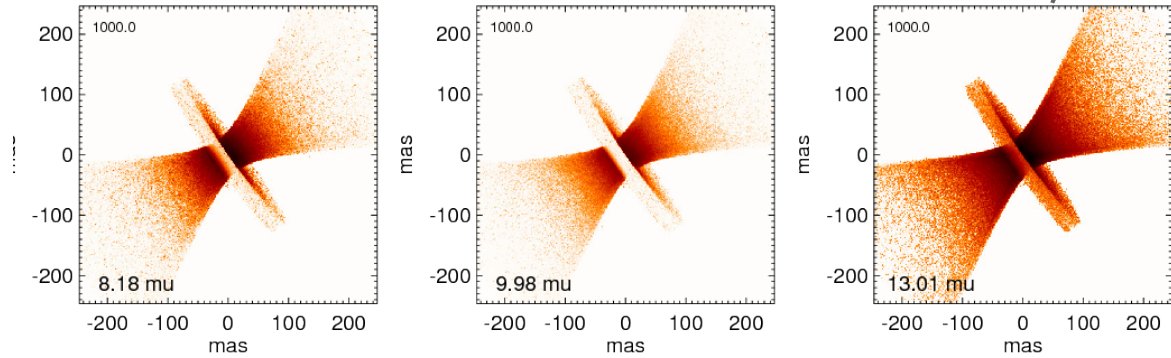
disk + hyperboloid polar wind

Stalevski, Tristram & Asmus (2019)



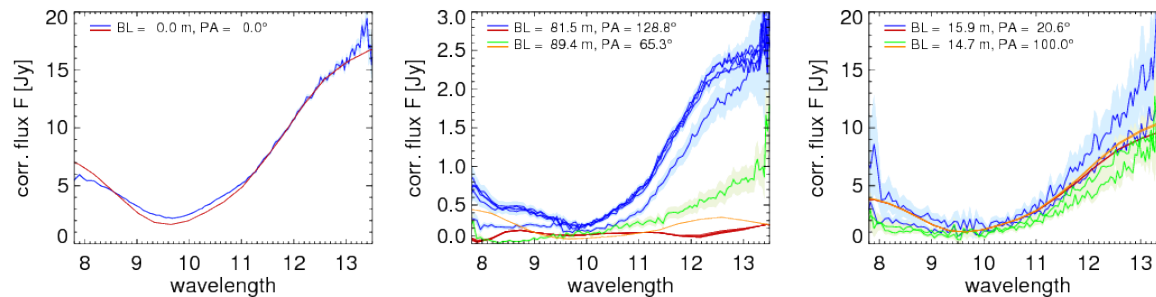
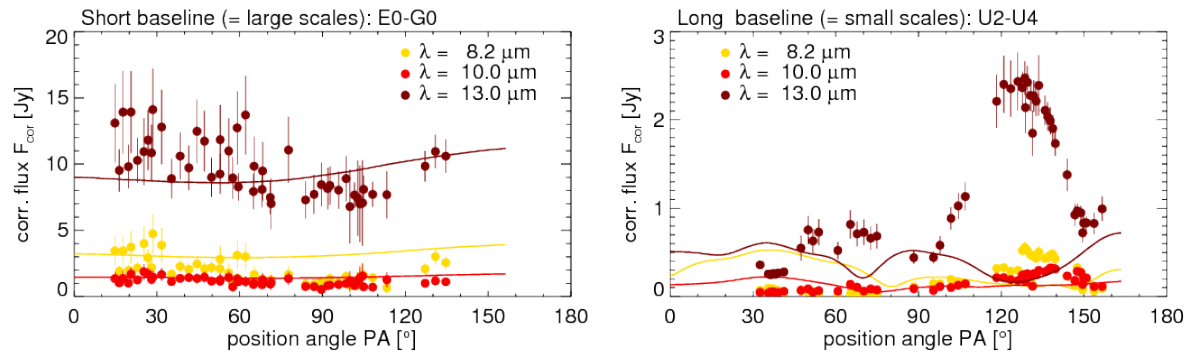
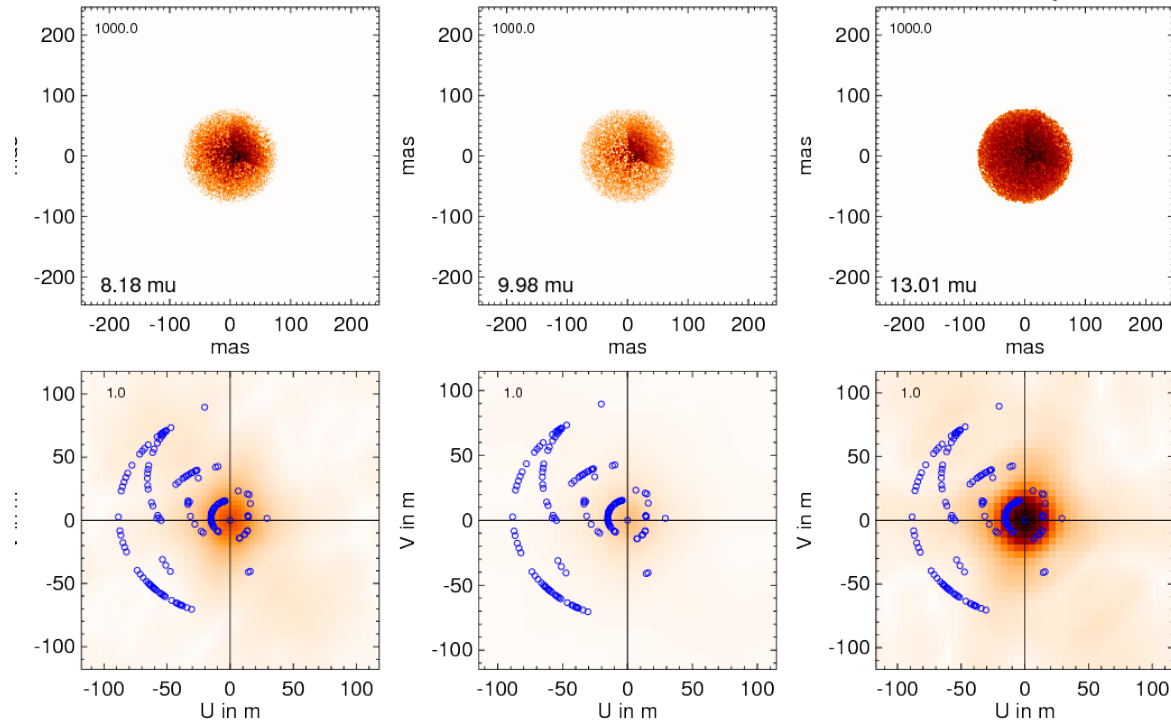
disk+hyp wind: good match with VLTI/MIDI

Stalevski, Tristram & Asmus (2019)



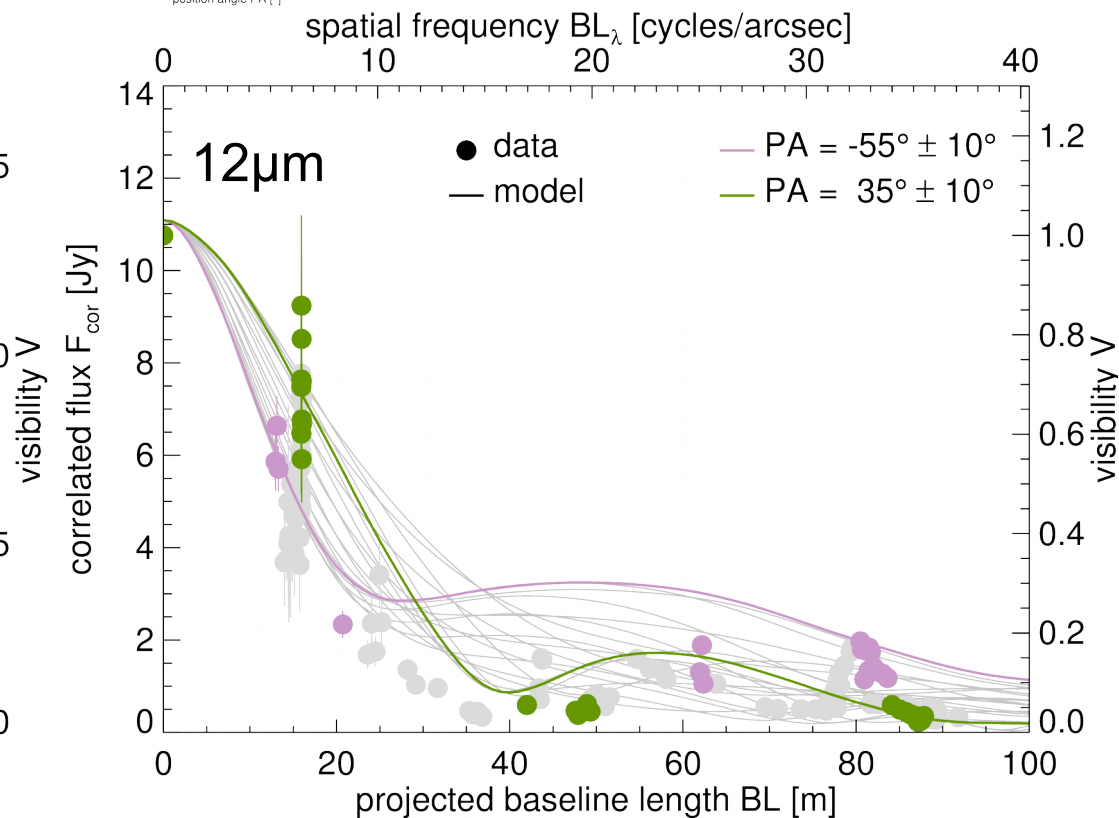
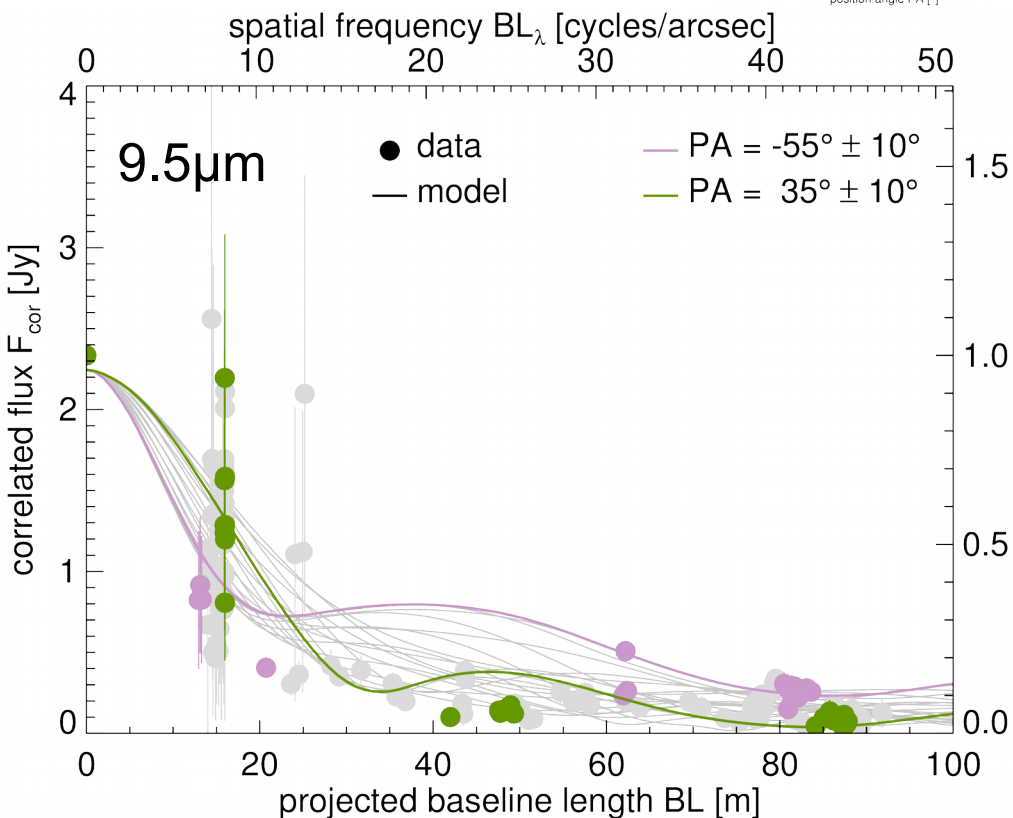
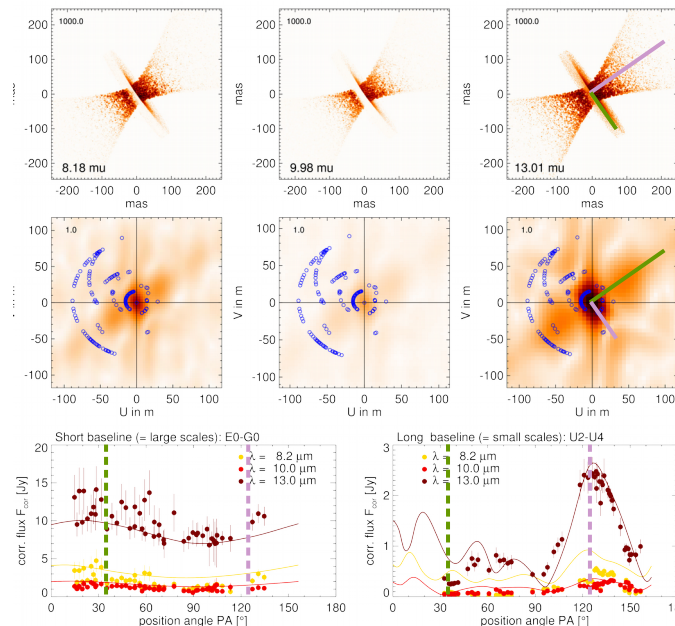
clumpy torus: doesn't work with VLTI/MIDI

Stalevski, Tristram & Asmus (2019)



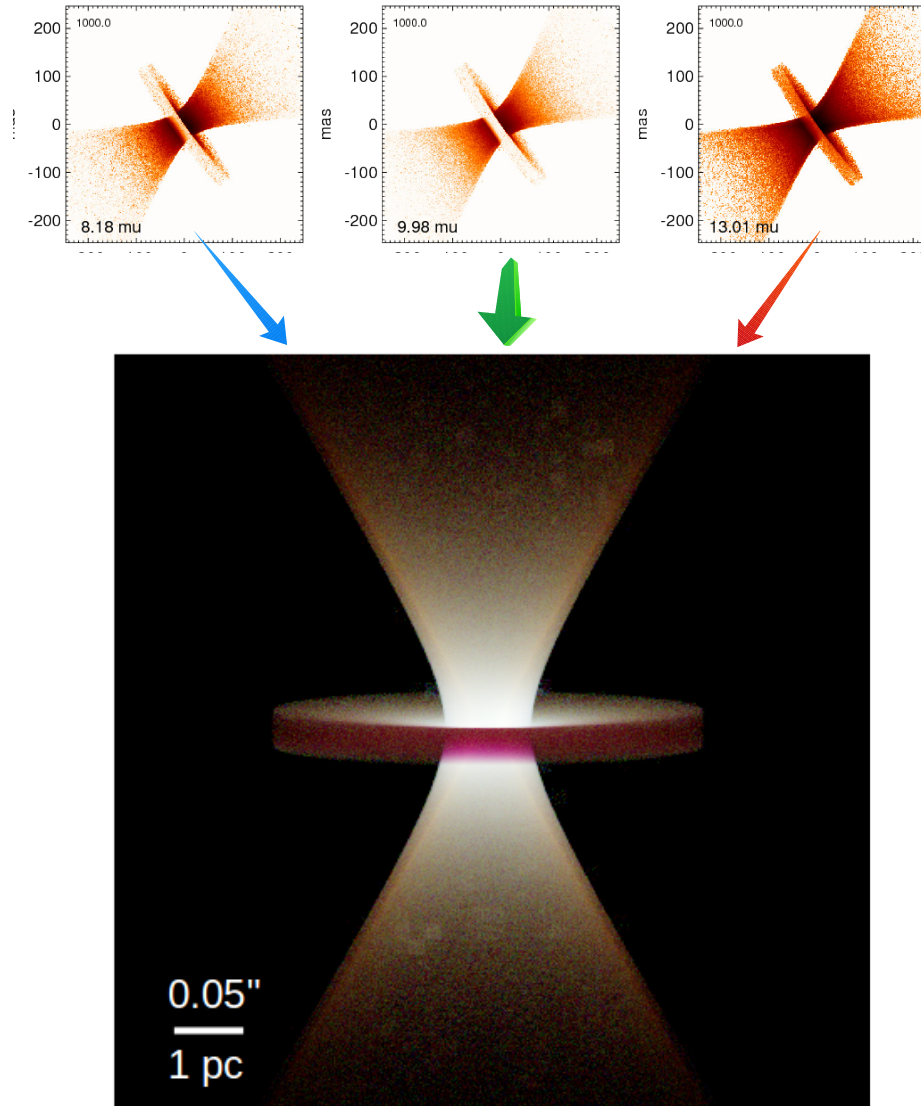
disk+ (clumpy) wind: good match with VLTI/MIDI

Stalevski, Tristram & Asmus (2019)



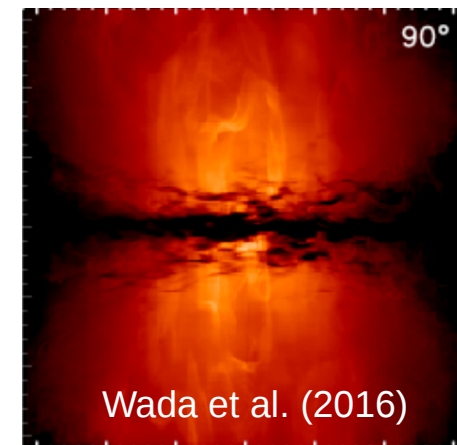
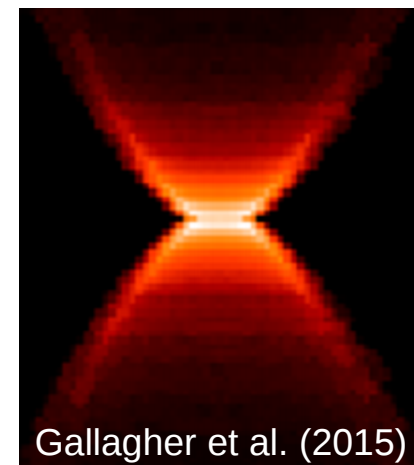
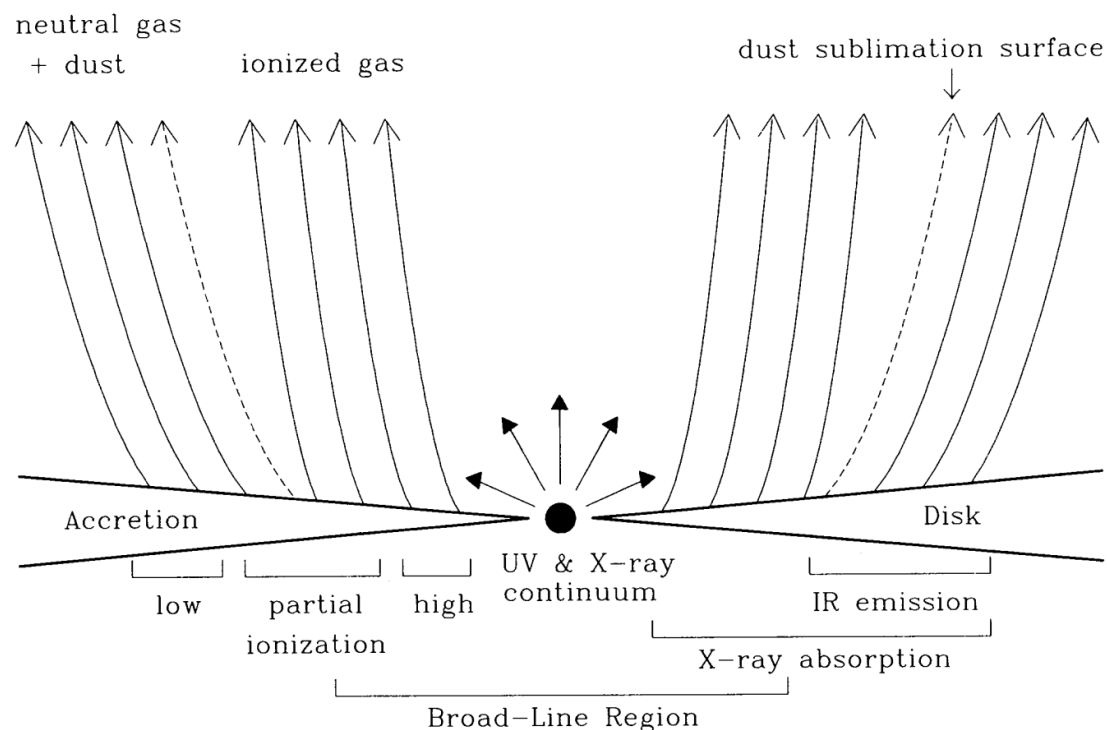
AGN in Circinus: dusty disk + hyperboloid wind

Stalevski, Tristram & Asmus (2019)



Radiation pressure driven dusty winds

Radiation pressure drives away the gas and dust from the accretion disk to the polar regions, leaving behind what may constitute the obscuring dusty disk/torus



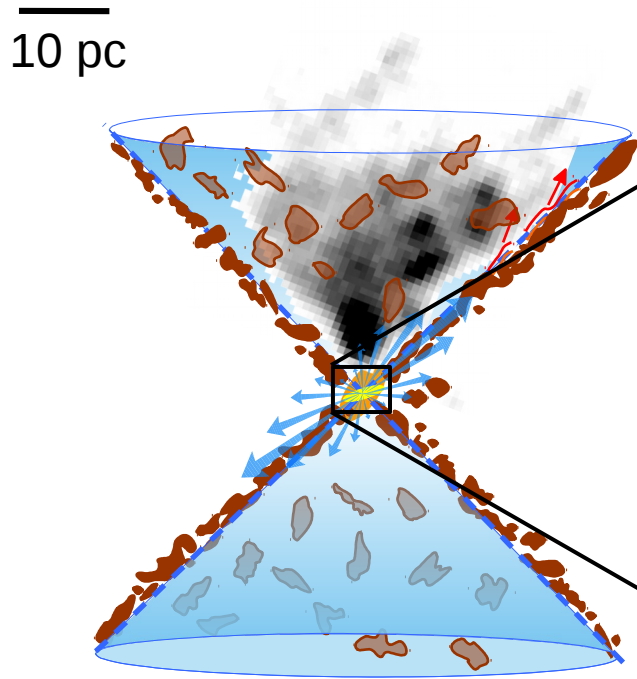
[Konigl & Kartje (1994); Keating+ (2012); Roth et al. (2012); Gallagher+ (2015)]

[Dorodnitsyn+ (2011, 2012); Dorodnitsyn & Kallman (2012); Dorodnitsyn+ (2016)]

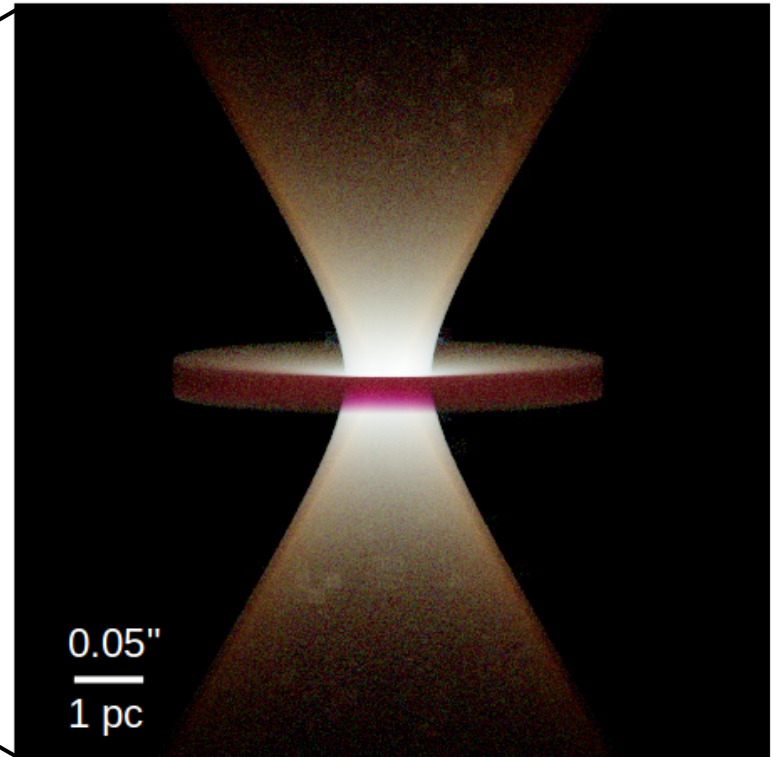
[Wada (2012), Wada+ (2016), Chan & Krolik (2016, 2017), Vollmer et al. (2018)]

Conclusions

Stalevski, Asmus & Tristram (2017)



Stalevski, Tristram & Asmus (2019)

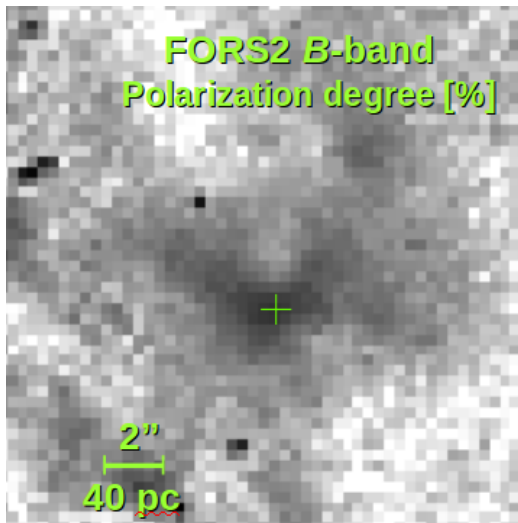


AGN in Circinus: a prototype for polar dust AGN population
+
Call for caution when using torus models

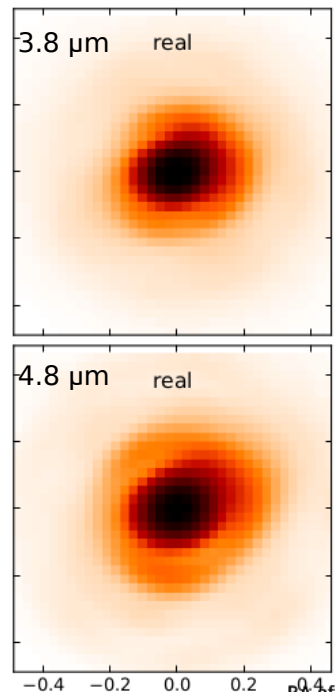
Appendix

Keeping an eye on Circinus with VLT...

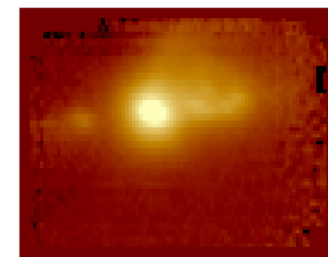
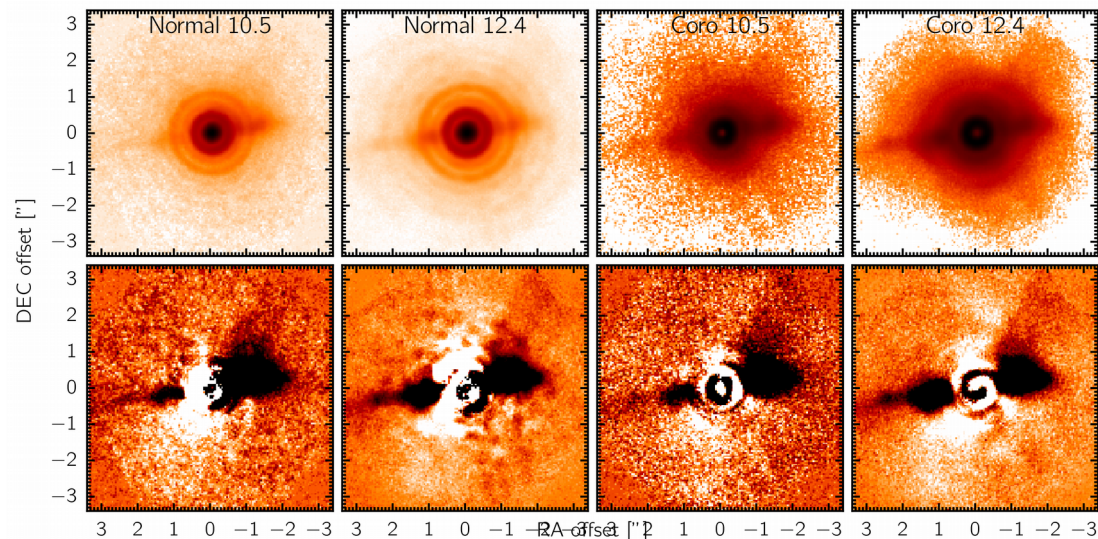
FORS2 (B, V)



NACO



VISIR coronagraphy (+SAM)

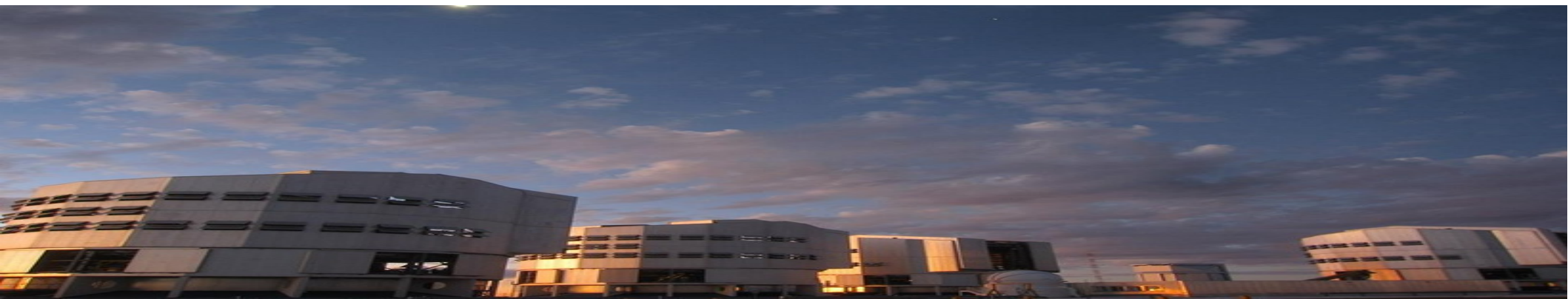
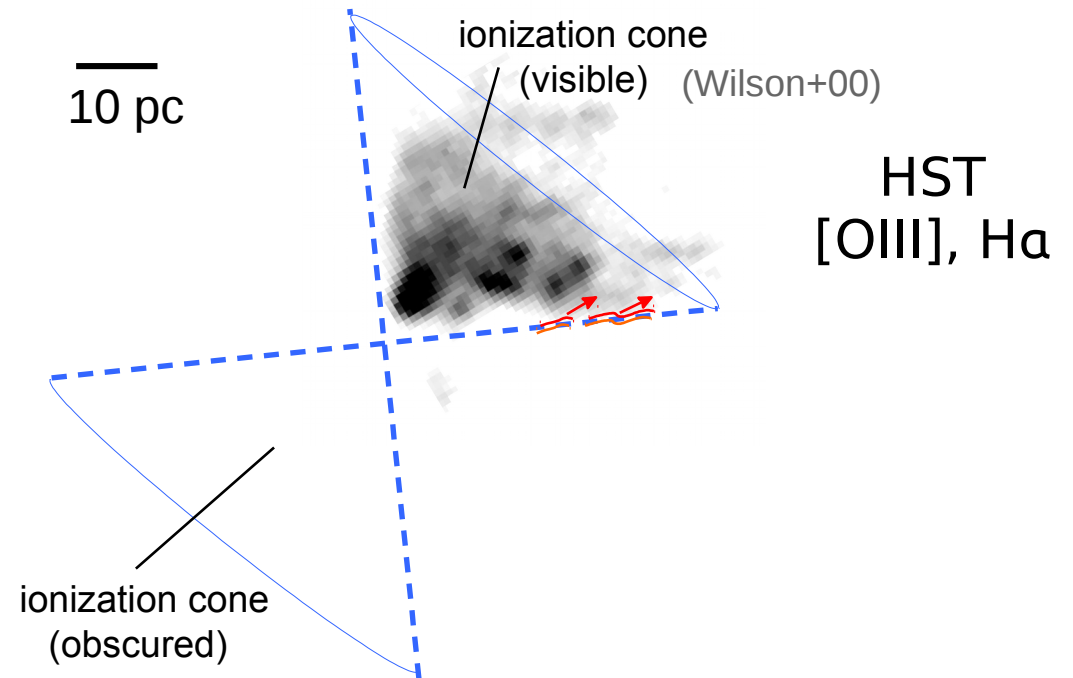
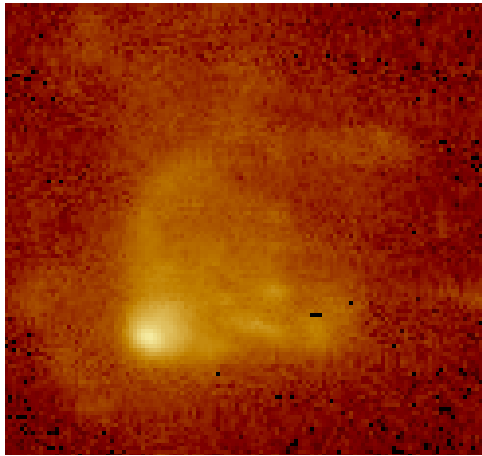


Coming up:

- SPHERE
- SINFONI
- MUSE
- FORS2 (R, I)

Keeping an eye on Circinus with VLT...

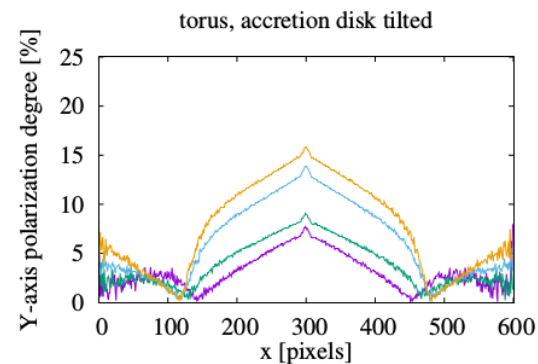
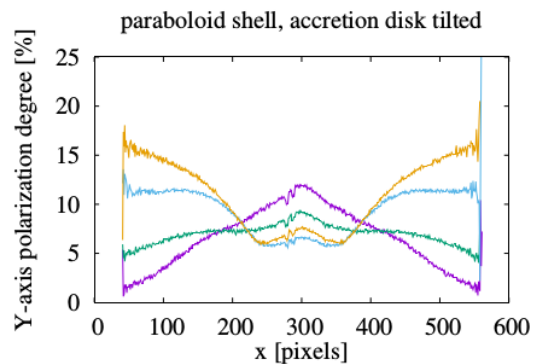
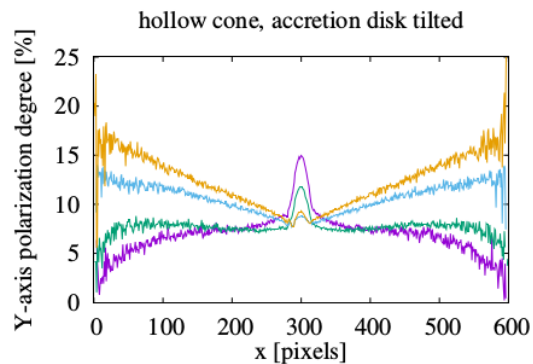
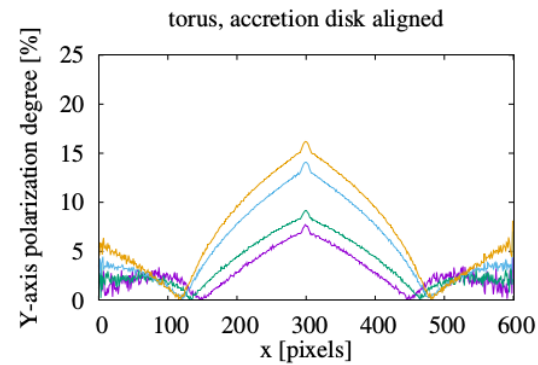
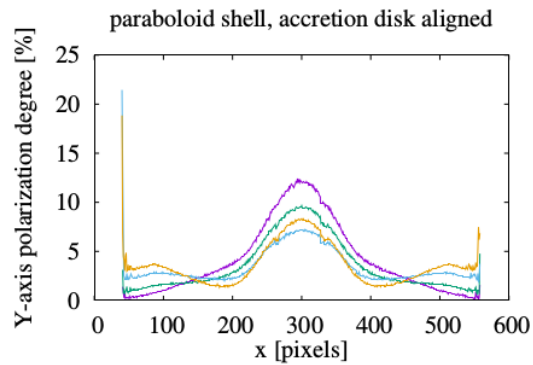
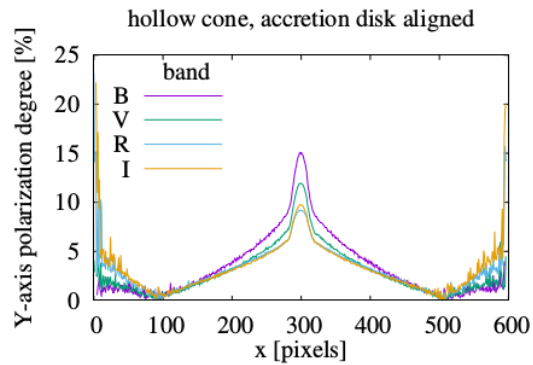
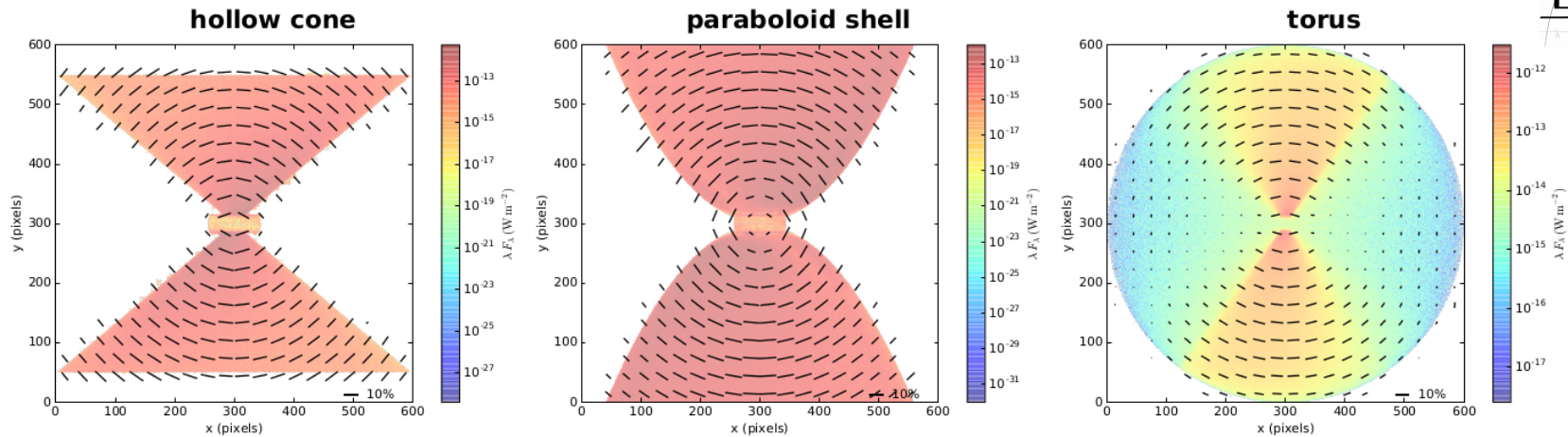
VLT/MUSE NFM
[SIII]



Keeping an eye on Circinus with VLT...

Polarization as an independent test for the hollow dusty cone scenario in the Circinus AGN

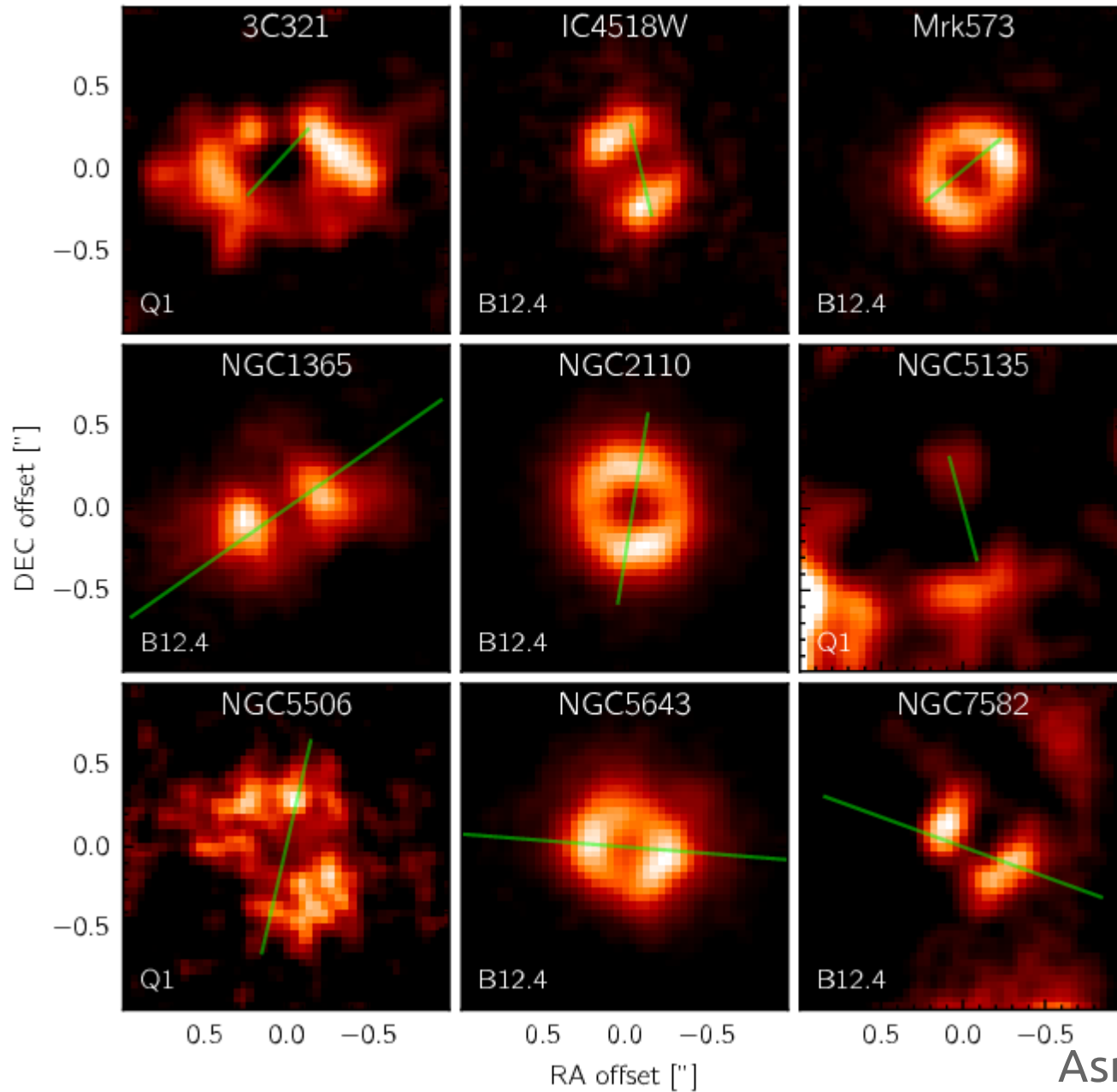
(PI: Marko Stalevski) (FORS2 polarization imaging of Circinus)



Are powerful polar dusty winds ubiquitous in AGN?

(VISIR deep imaging of 9 nearby type 2 AGN)

(PI: Daniel Asmus)

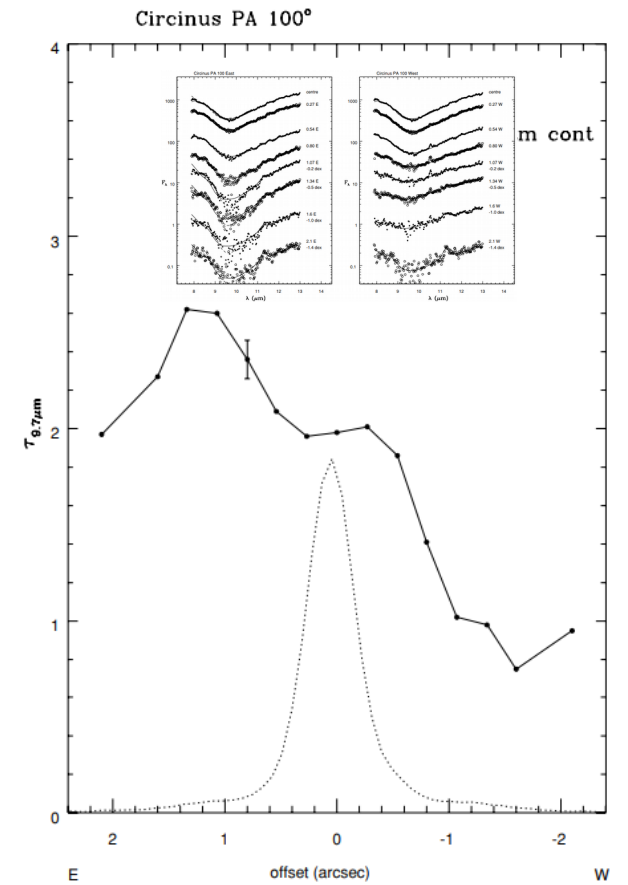
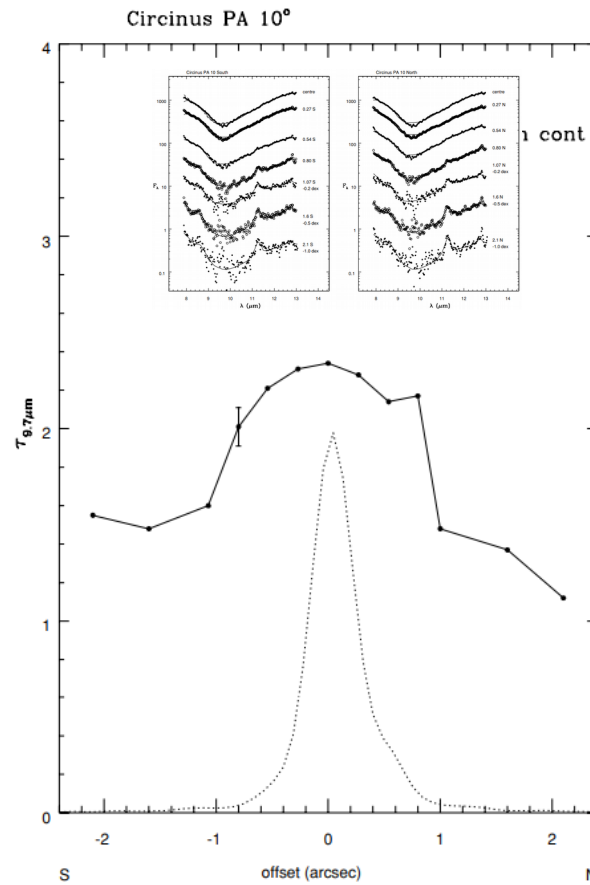
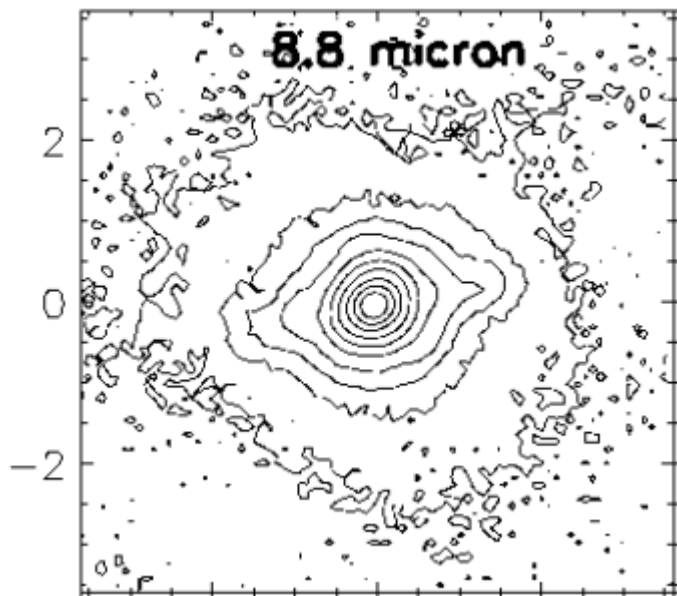


Asmus, et al. (in prep)

Circinus extended emission and host galaxy extinction

Roche et al. 2006

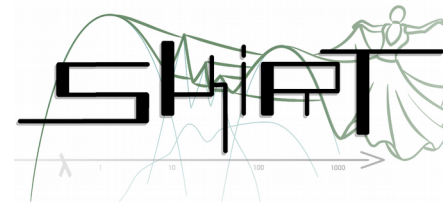
Packham et al. 2005



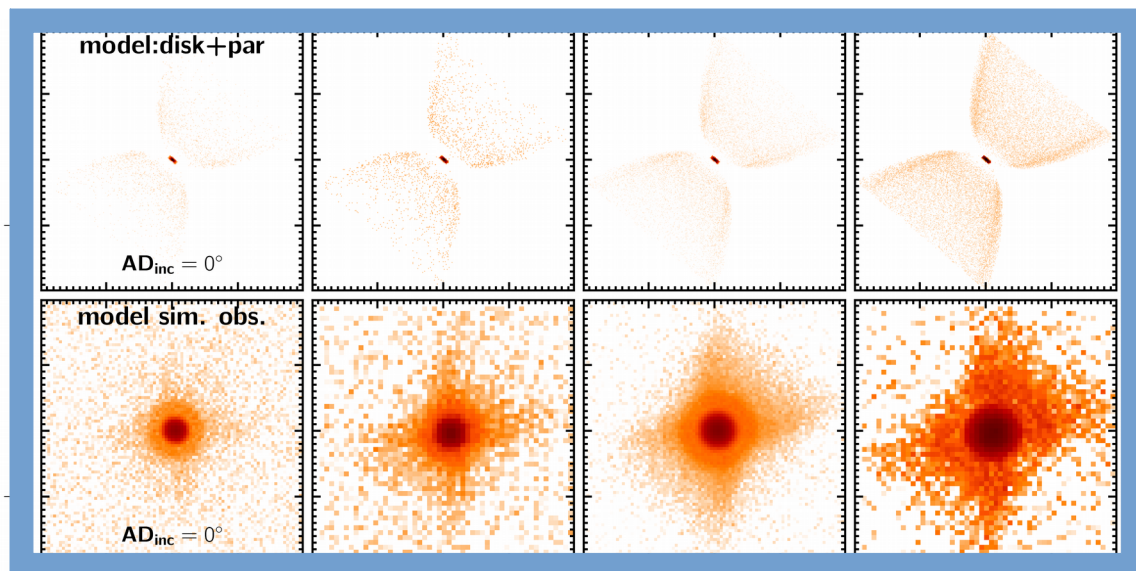
(Gemini South / T-Recs)

disk+paraboloid: does not work

Monte Carlo radiative transfer with



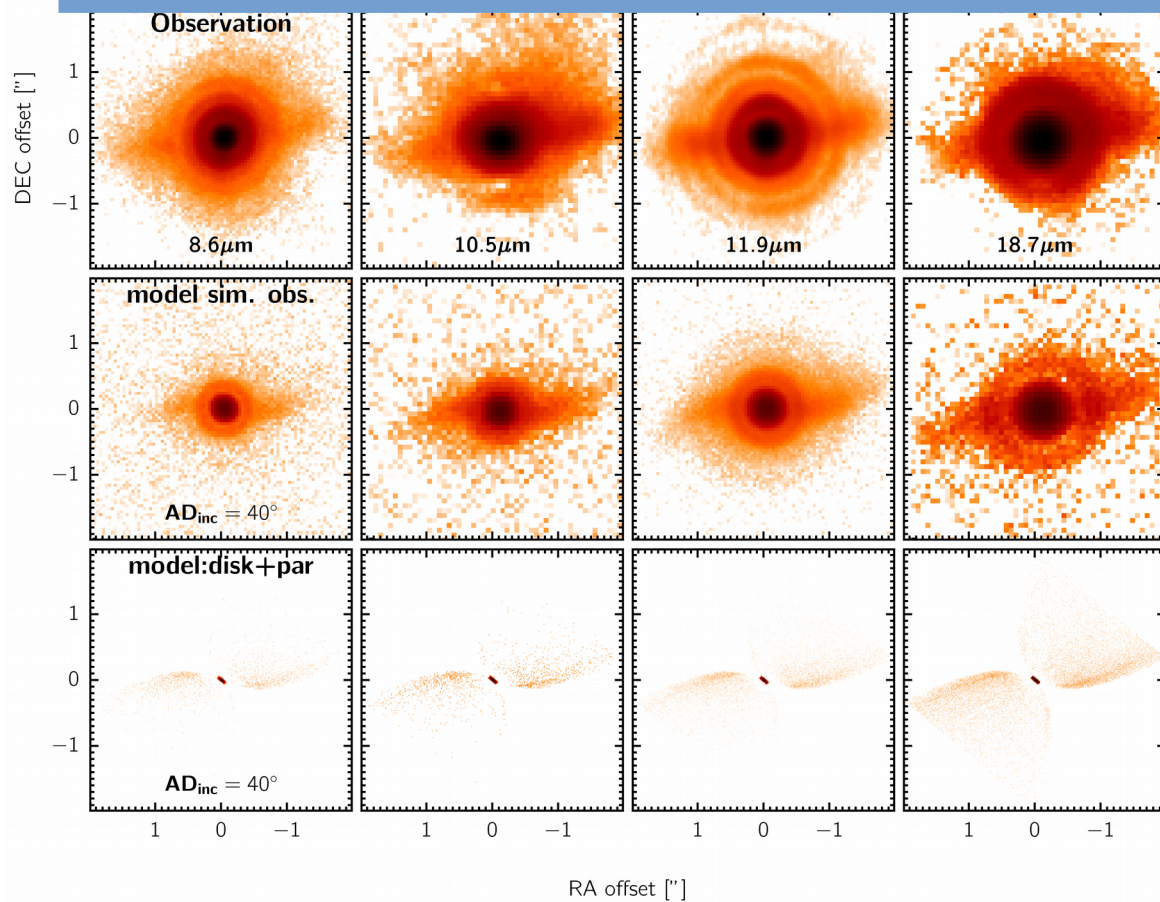
<http://www.skirt.ugent.be>



Model RT image

Aligned AD

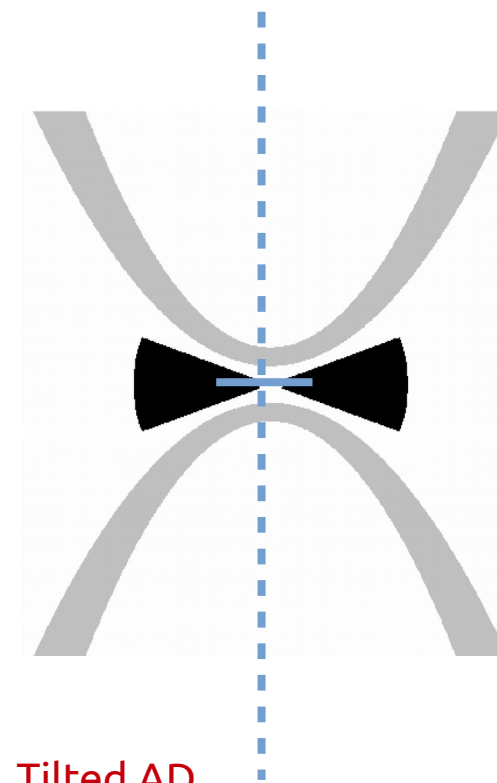
Synthetic obs. of the model



Observed images

Synthetic obs. of the model

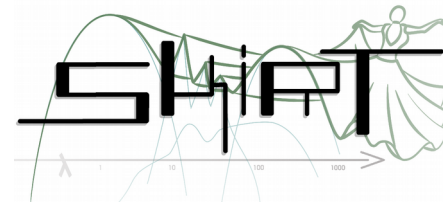
Model RT image



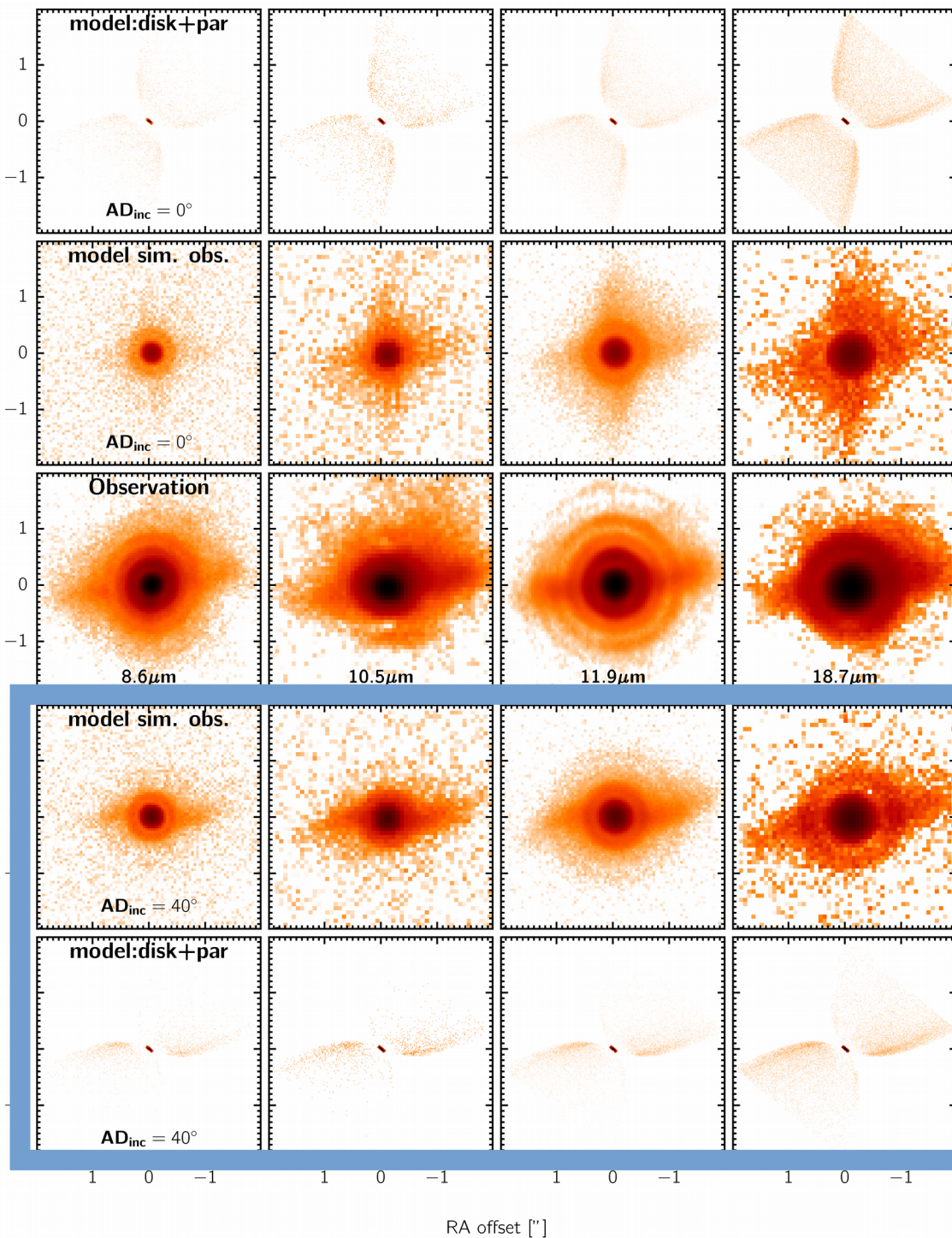
Tilted AD

disk+paraboloid: does not work

Monte Carlo radiative transfer with



<http://www.skirt.ugent.be>



Model RT image

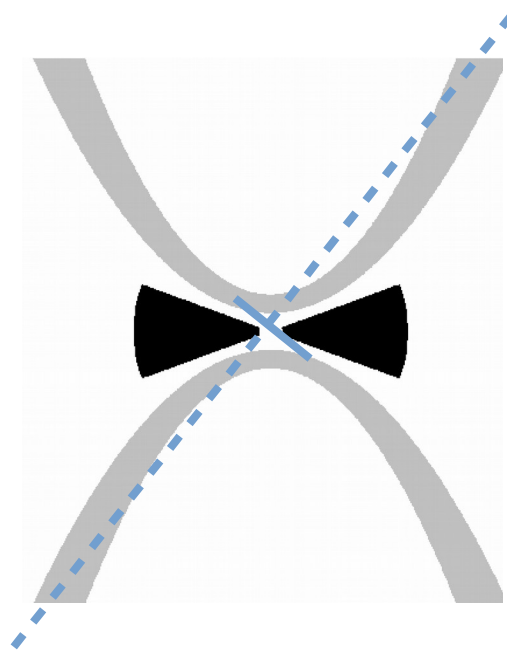
Synthetic obs. of the model

Observed images

Synthetic obs. of the model

Model RT image

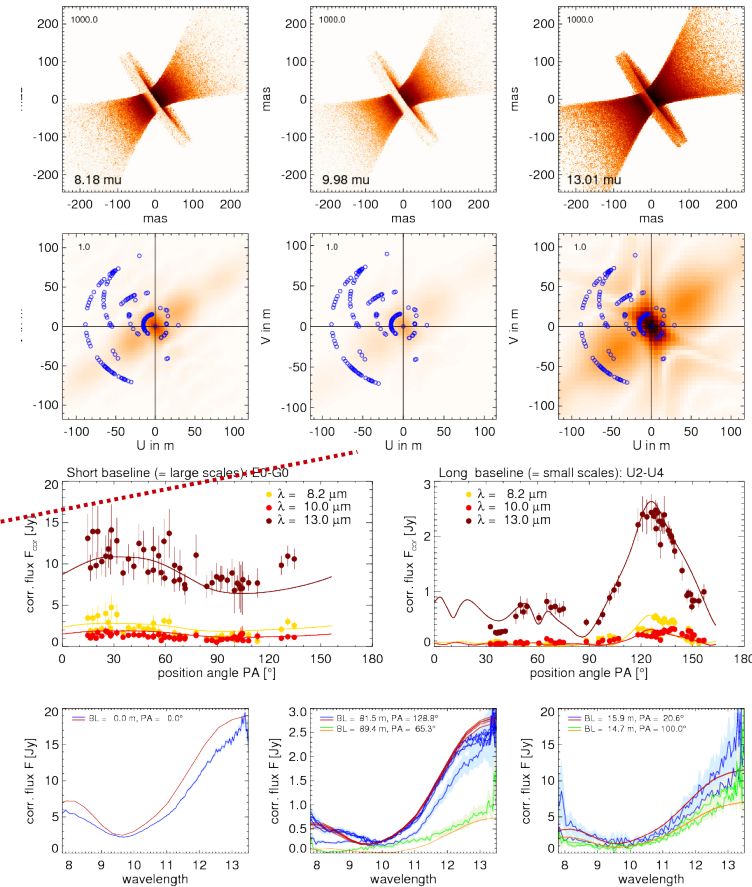
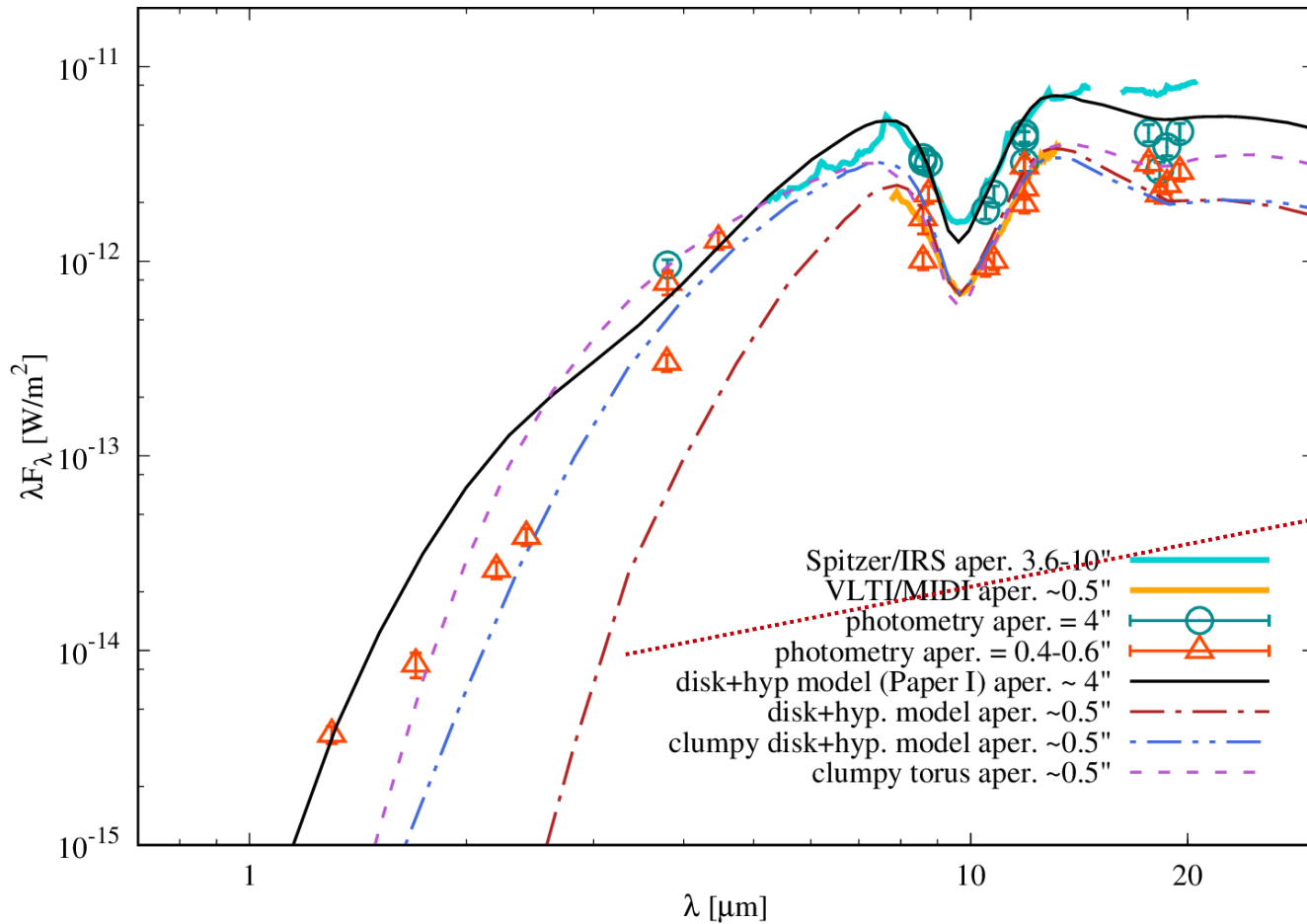
Aligned AD



Tilted AD

disk+wind

Stalevski, Tristram & Asmus (2019)



MIR good, NIR missing

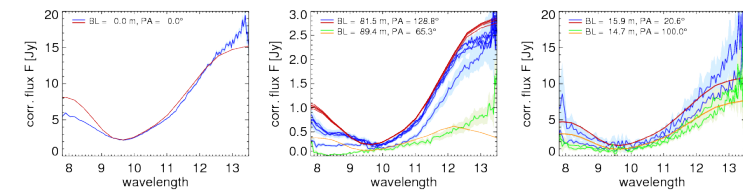
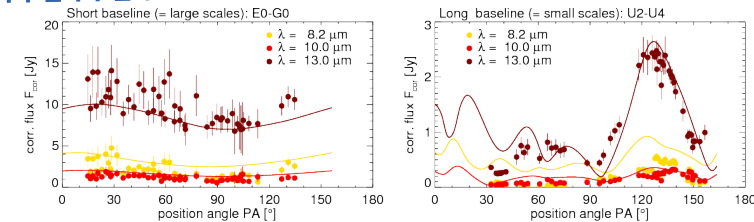
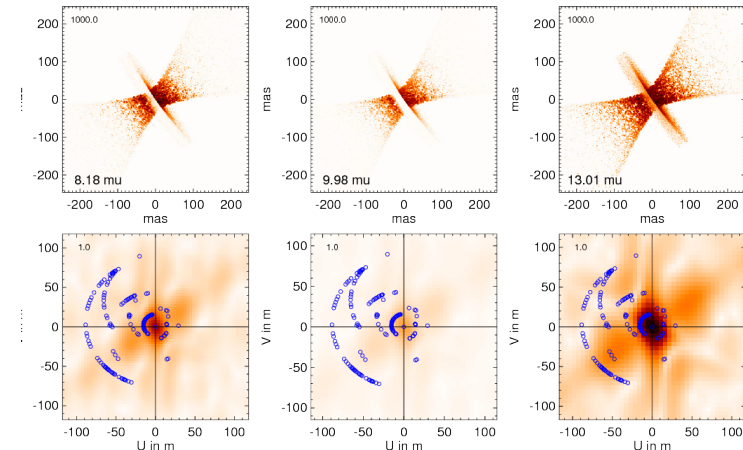
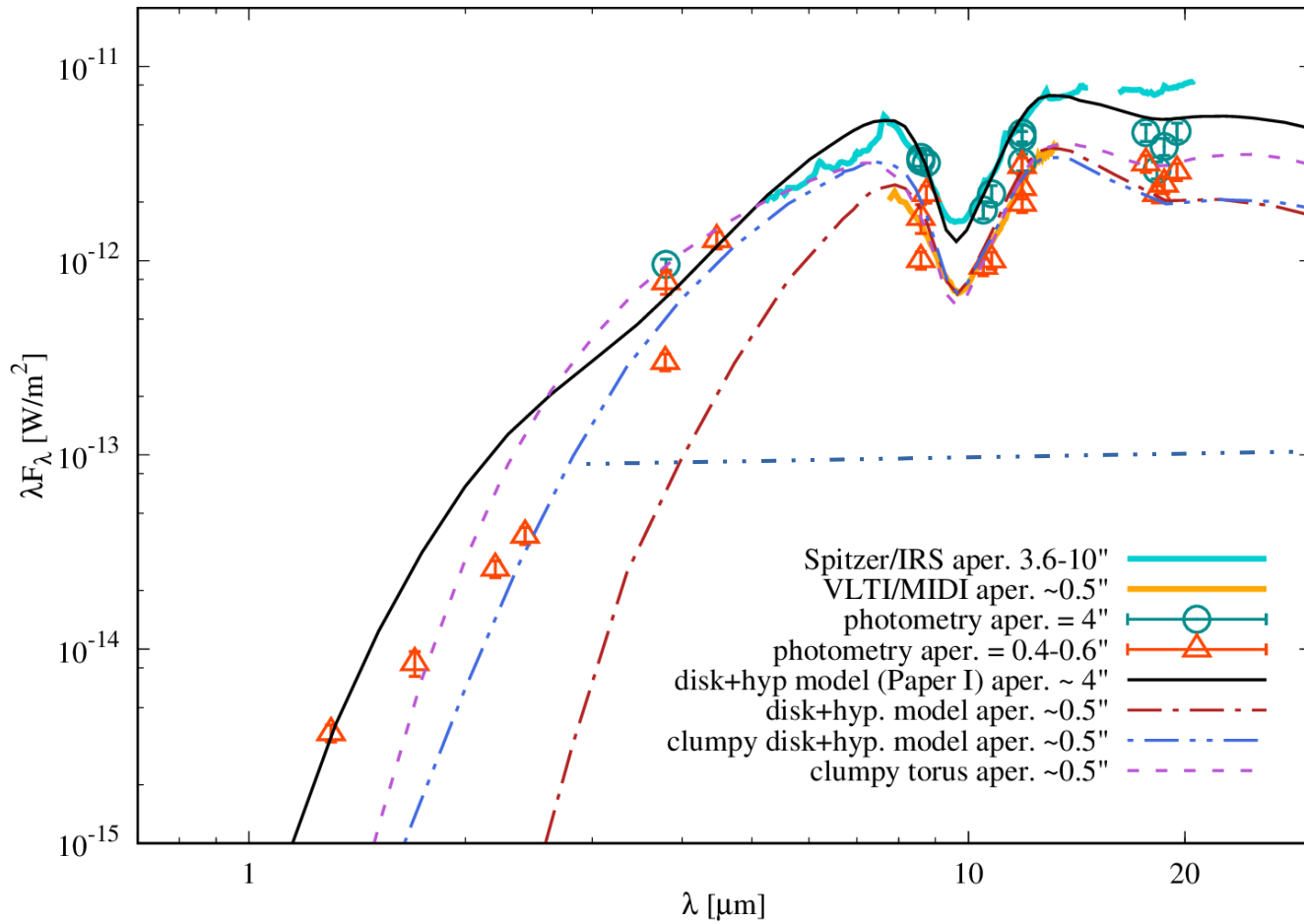


VLTI/MIDI: good



disk+clumpy wind

Stalevski, Tristram & Asmus (2019)



MIR good, NIR good

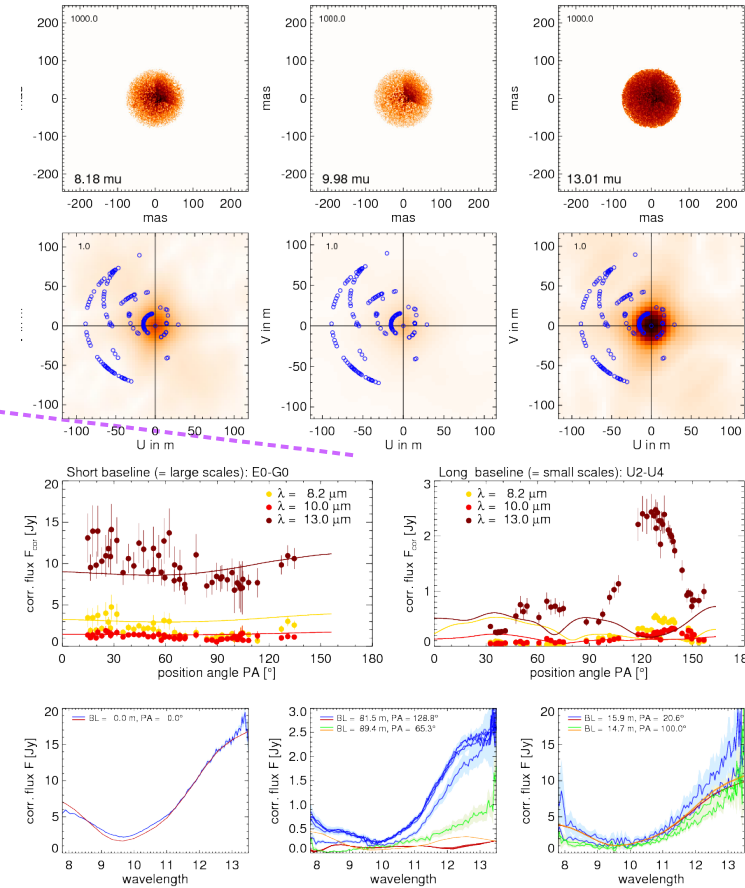
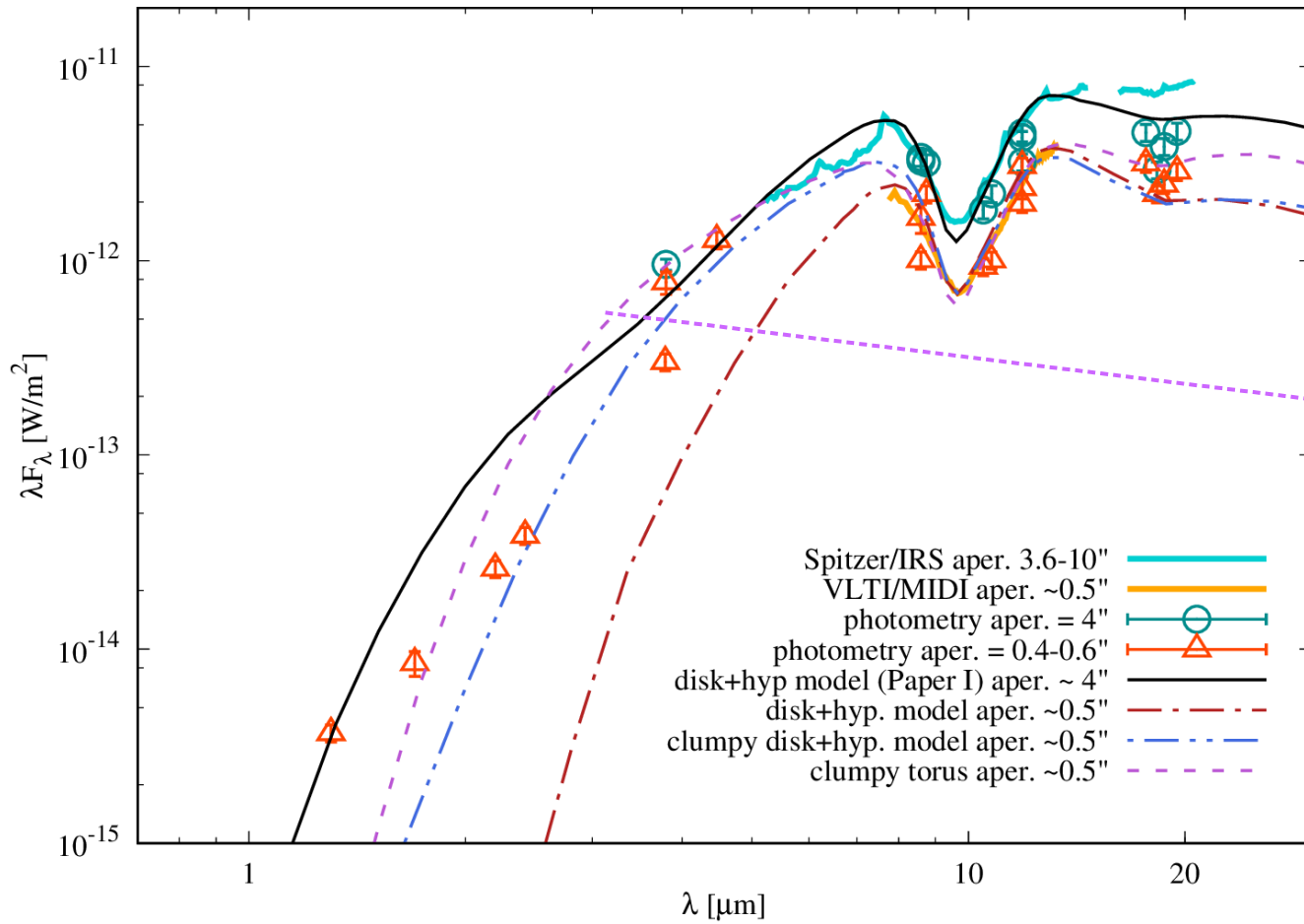


VLT/MIDI: good



clumpy torus

Stalevski, Tristram & Asmus (2019)



MIR good, NIR good



VLT/MIDI: ugly

