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

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with

Daniel Asmus & Konrad Tristram

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

– What's so special about it ?

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

Marko Stalevski,[1,2,3]* Daniel Asmus[4] and Konrad R. W. Tristram[4]

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

Marko Stalevski [iD],[1,2]* Konrad R. W. Tristram[3] and Daniel Asmus[4]

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

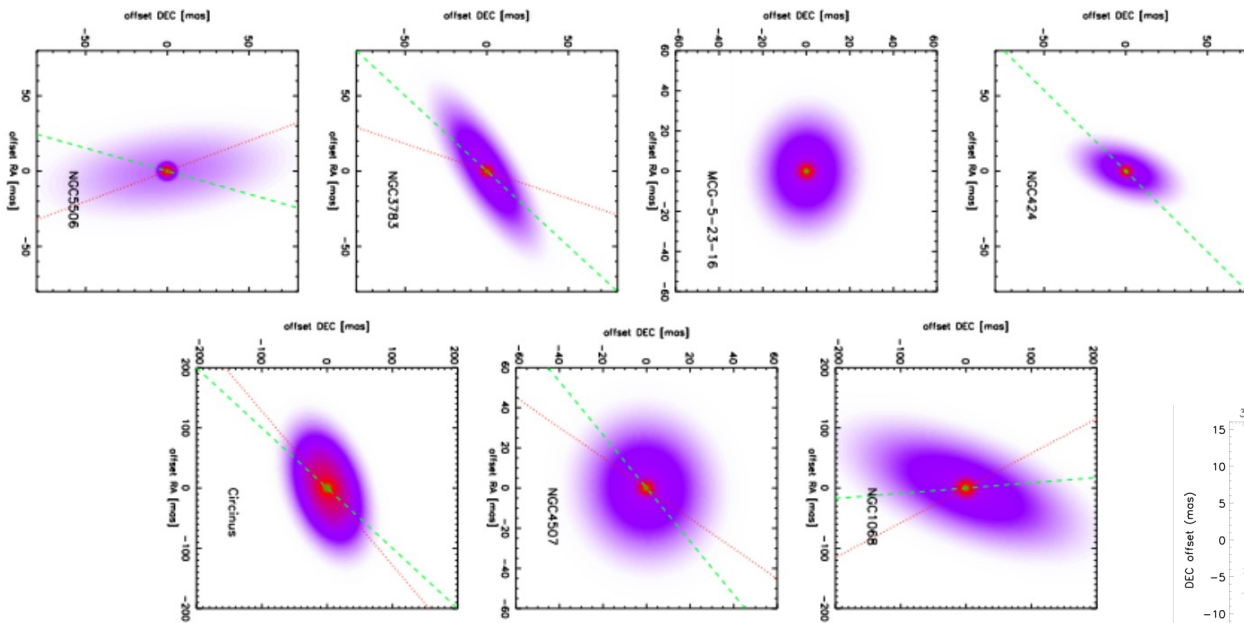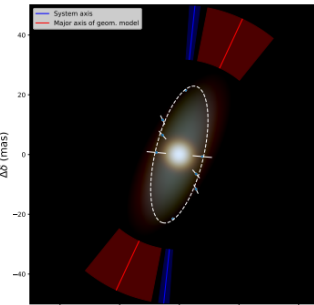|			
09:00	25 min	B. Vollmer	Models of thick turbulent gas disks with magnetocentrifugal winds in AGN and their application to Circinus and NGC 1068
09:25	25 min	M. Stalevski	Towards a new paradigm of dust structure in AGN: Dissecting the mid-IR emission of Circinus galaxy
09:50	20 min	C. Andonie	The 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

Towards a new paradigm of dust structure in AGN: Dissecting the mid-IR emission of Circinus galaxy
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TORUS 2018

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Models of thick turbulent gas disks with magnetocentrifugal winds in AGN and their application to Circinus and NGC 1068
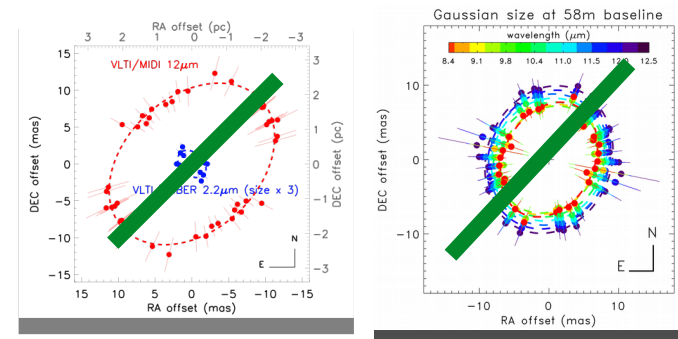
Towards a new paradigm of dust structure in AGN: Dissecting the mid-IR emission of Circinus galaxy

The first IR/X-ray model of the circumnuclear environment of the Circinus Galaxy

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 NGC1068

The counter rotating molecular torus in NGC1068

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

Type 1 AGN

Narrow line region

SMBH
+
Accretion disk
+
Broad line region

Dusty torus

Narrow line region

Type 2 AGN

(Jet)

Credit: ESO

VLTI/MIDI: polar elongation on pc-scale

Leftley et al. (2018)

López Gonzaga et al. (2014)
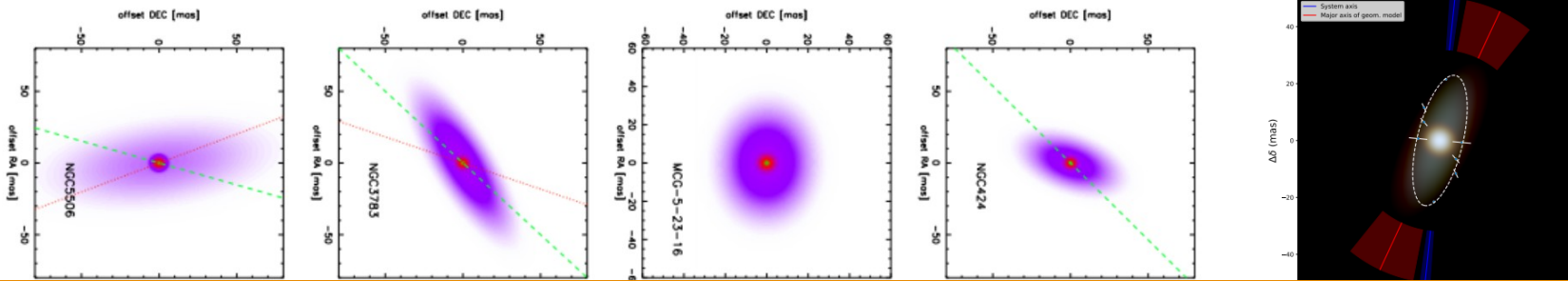

Hönig et al. (2013) Hönig et al. (2012)
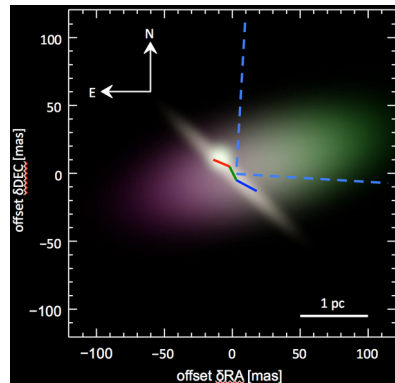
Circinus;
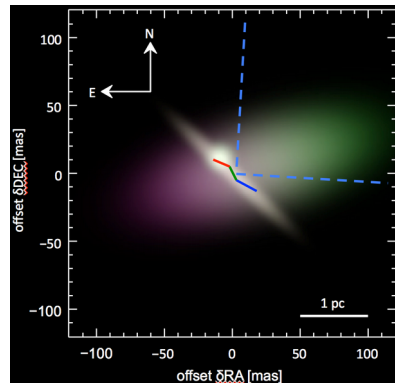Tristram et al. (2014) NGC 1068;
López Gonzaga et al. (2014)
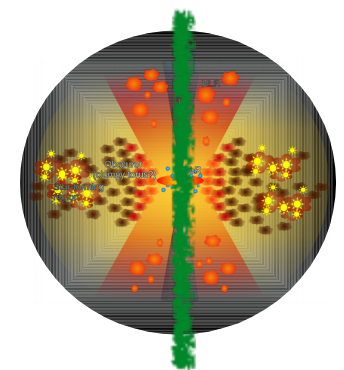
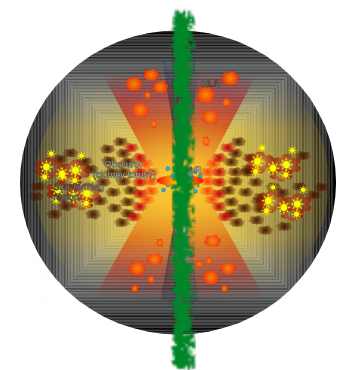# VLTI/MIDI: polar elongation on pc-scale

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)
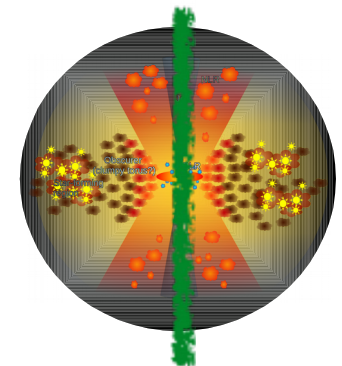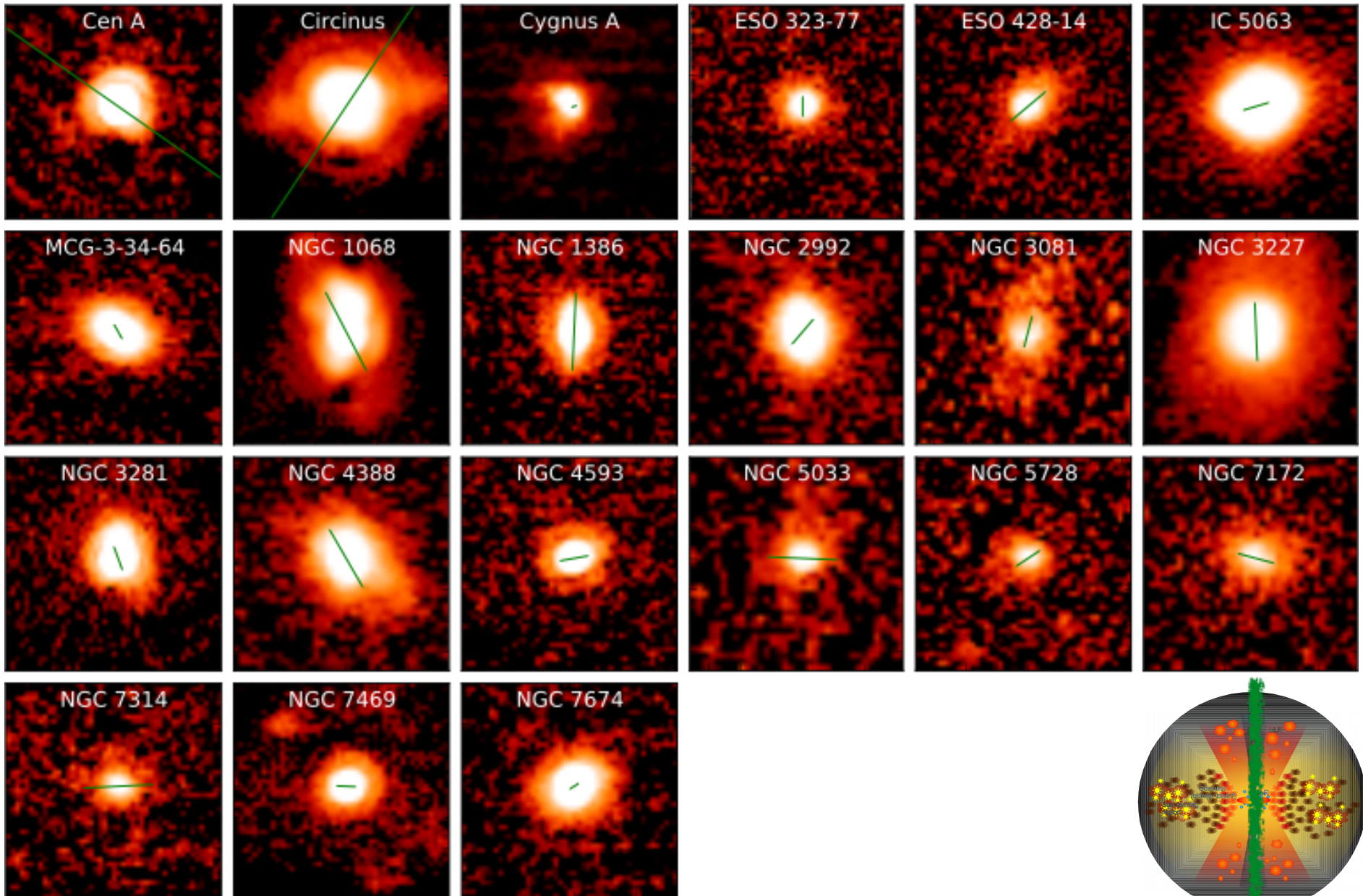
MIR polar elongation on 10s-100s pc scale

Asmus, Honig, Gandhi (2016)
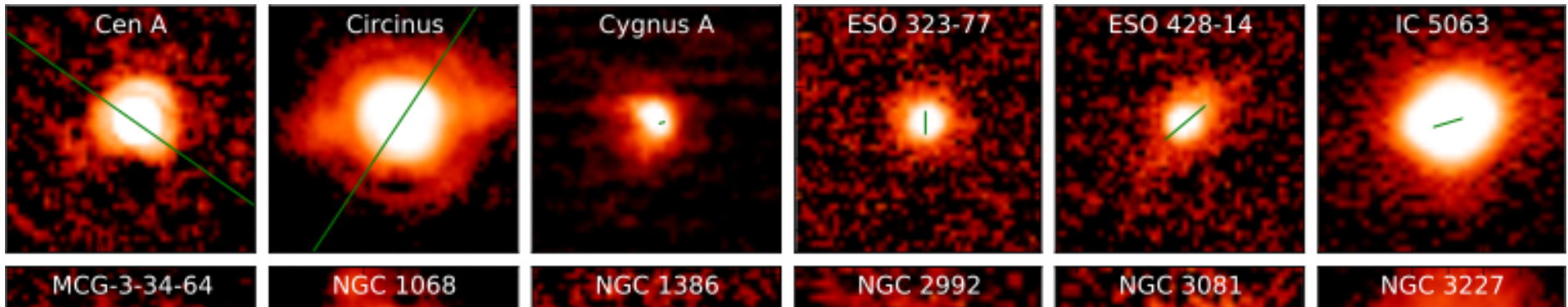
18 out of 21 with polar elongation !
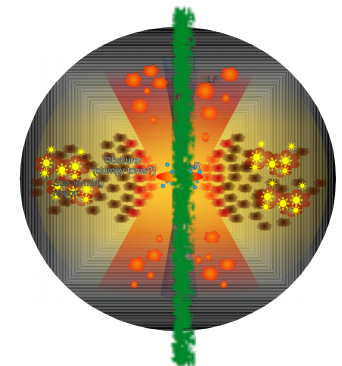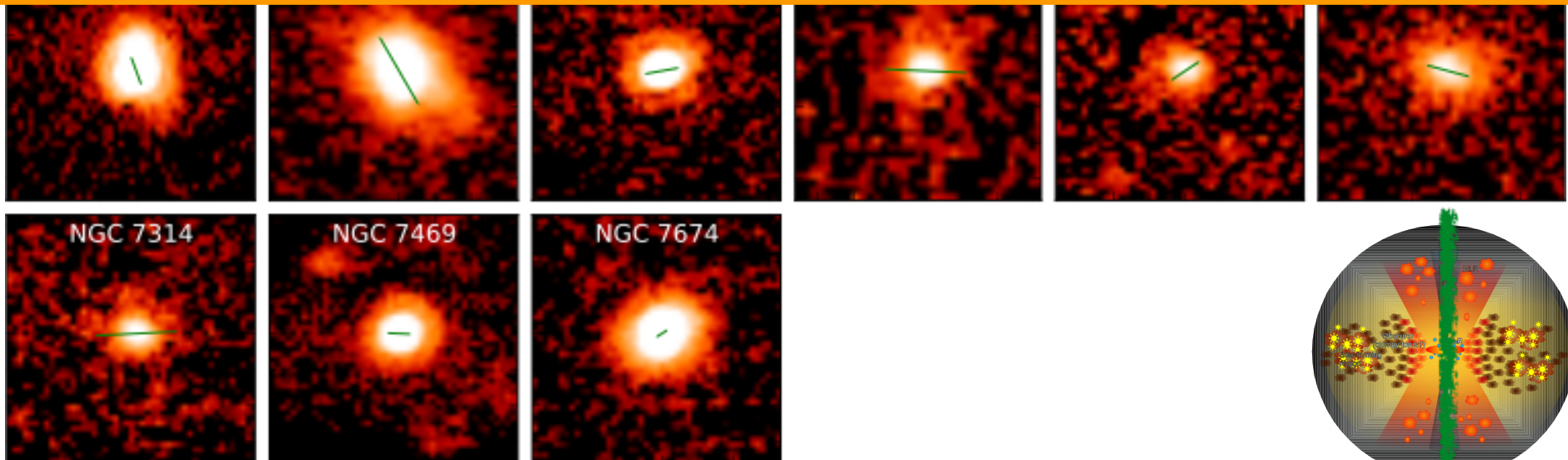
Polar elongation – inclined torus ?
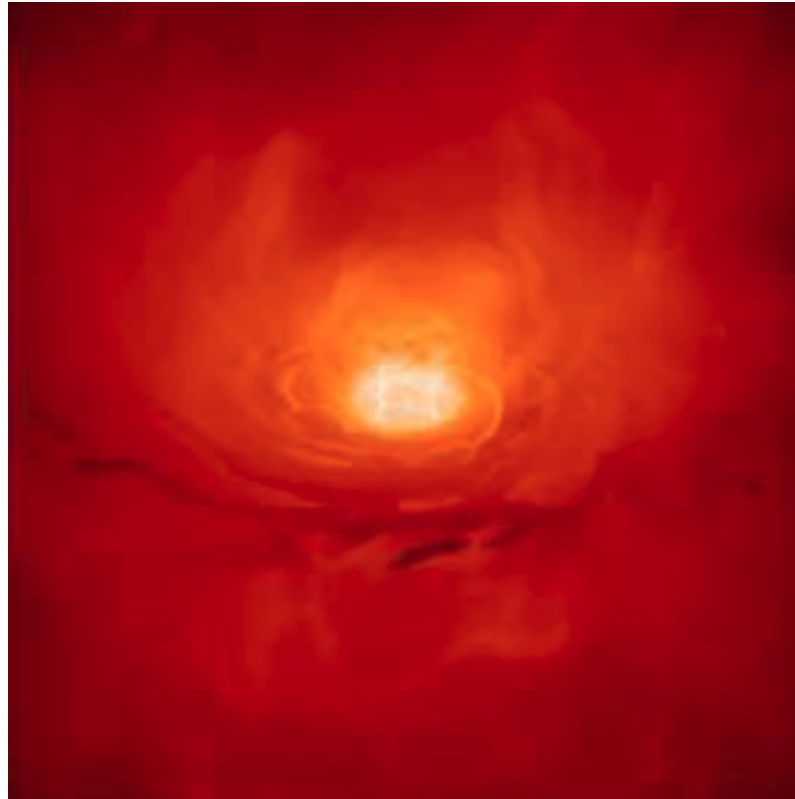
Schartmann et al. (2014)

Polar elongation – host galaxy dust ?
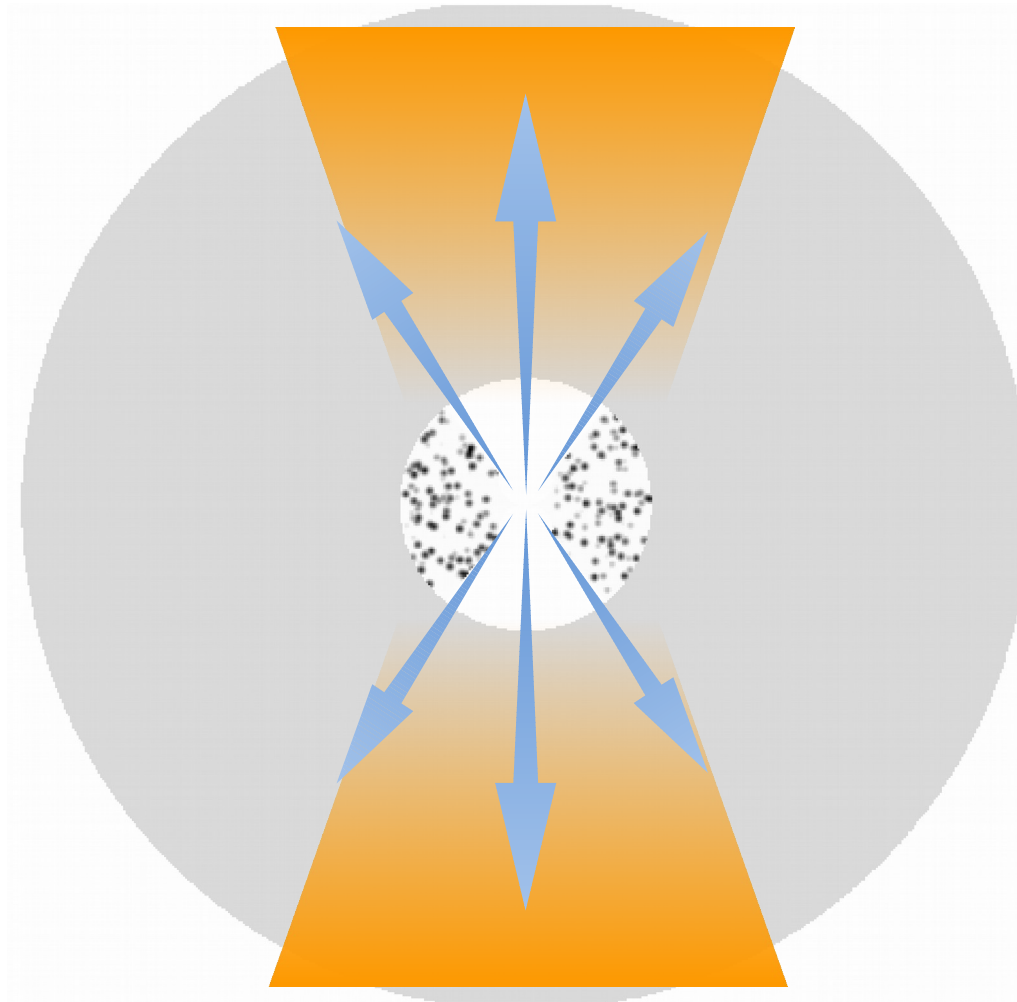
Polar elongation – dusty wind ?

Mid-IR

Near-IR
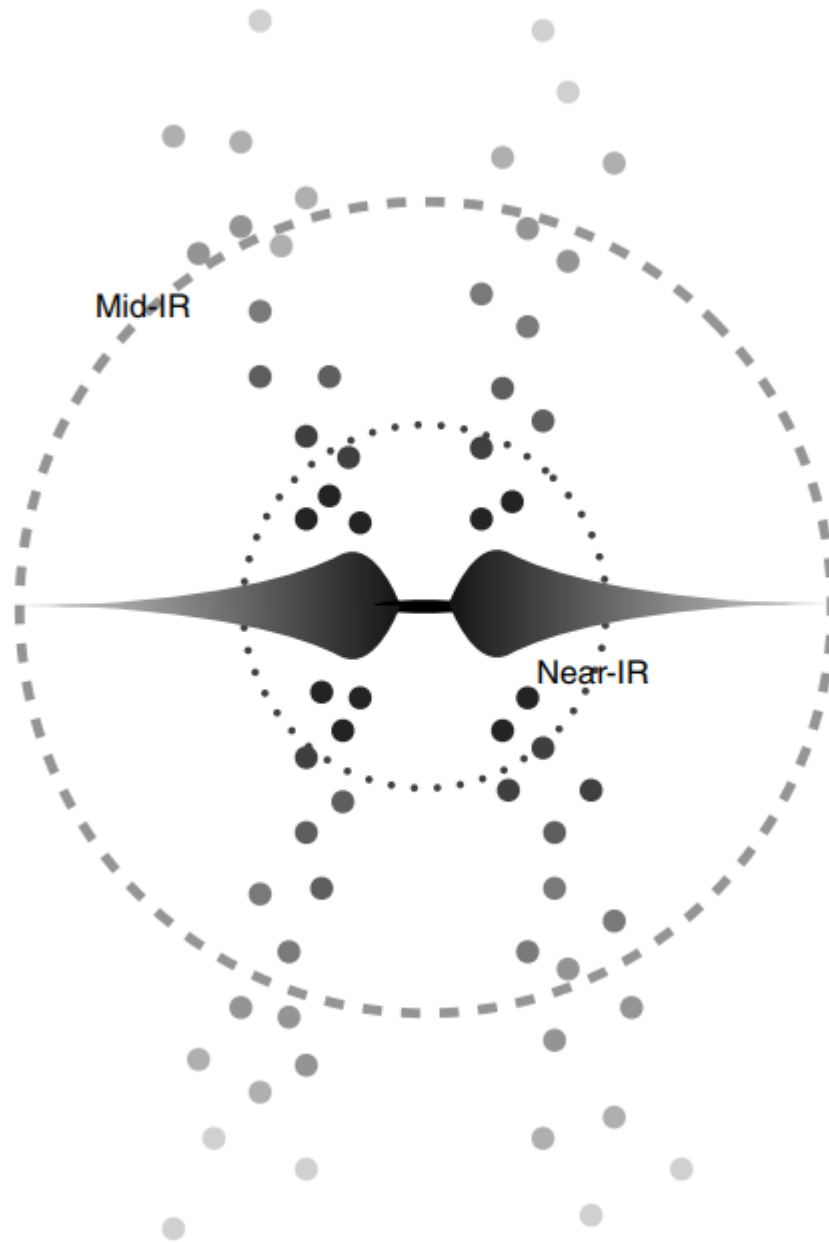
Honig et al. (2012)

Polar elongation –

inclined torus?
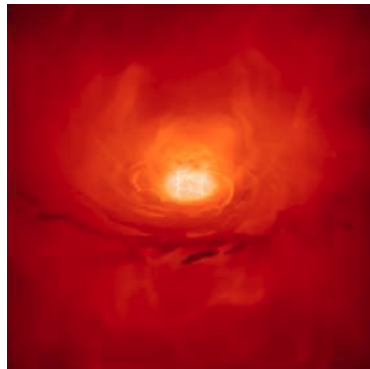
host galaxy dust?
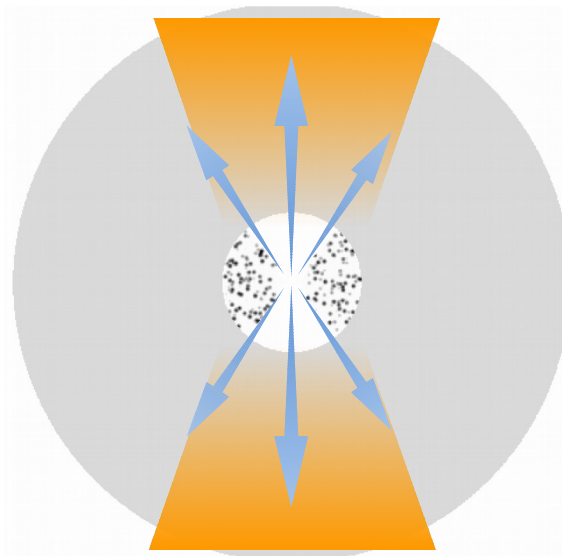
dusty wind?
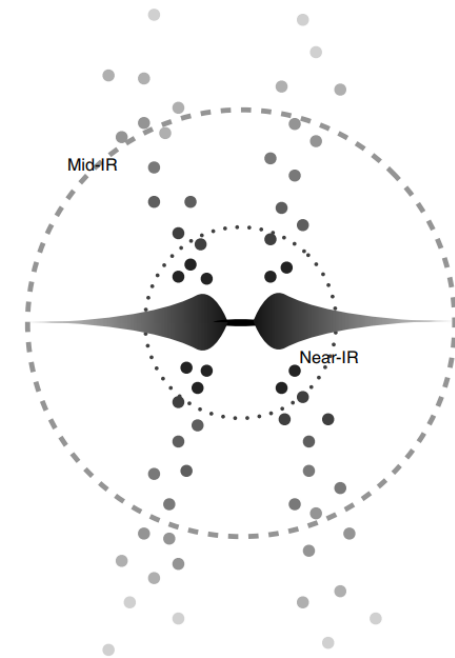
Circinus with VLT/VISIR
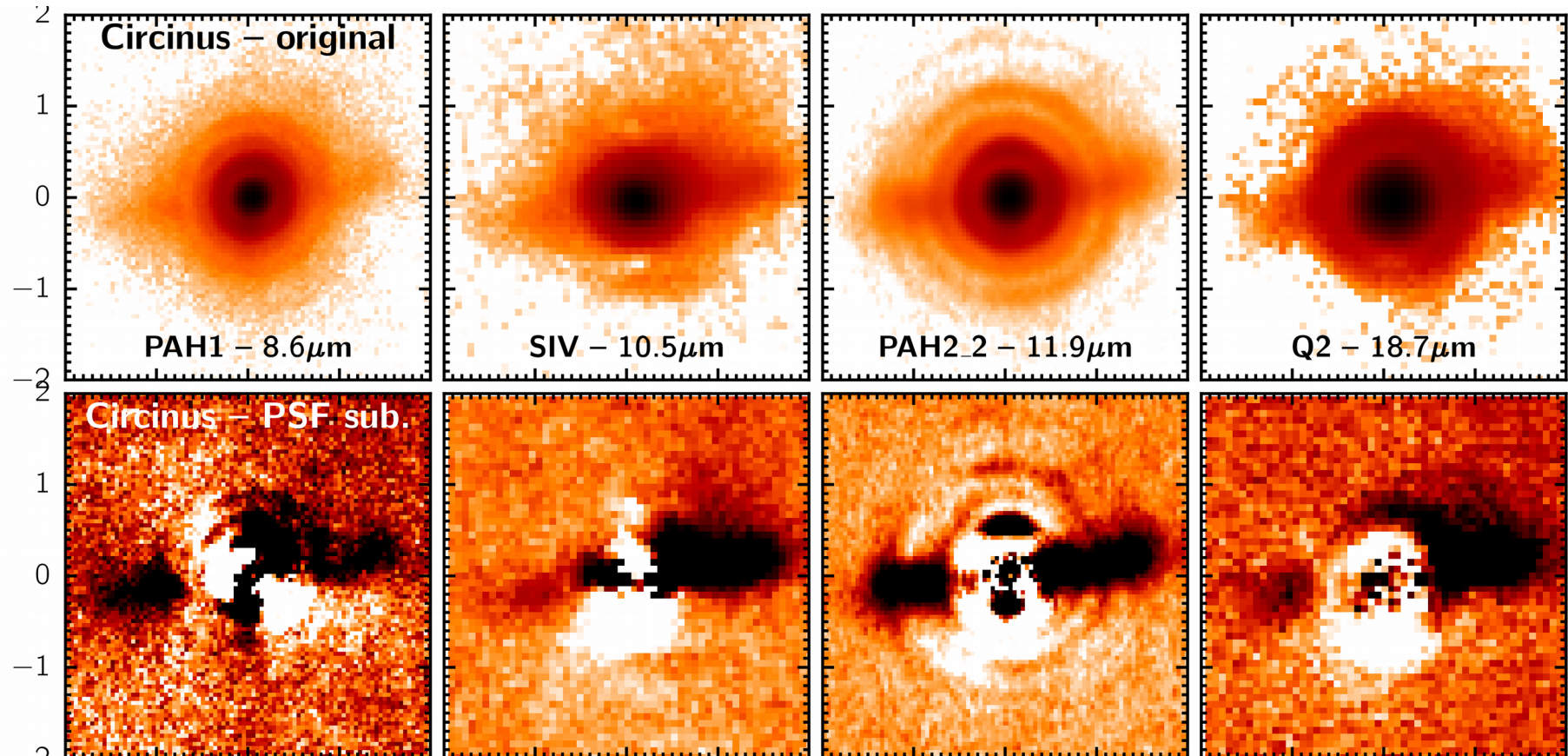
Stalevski, Asmus & Tristram (2017)

Circinus with VLTI/MIDI
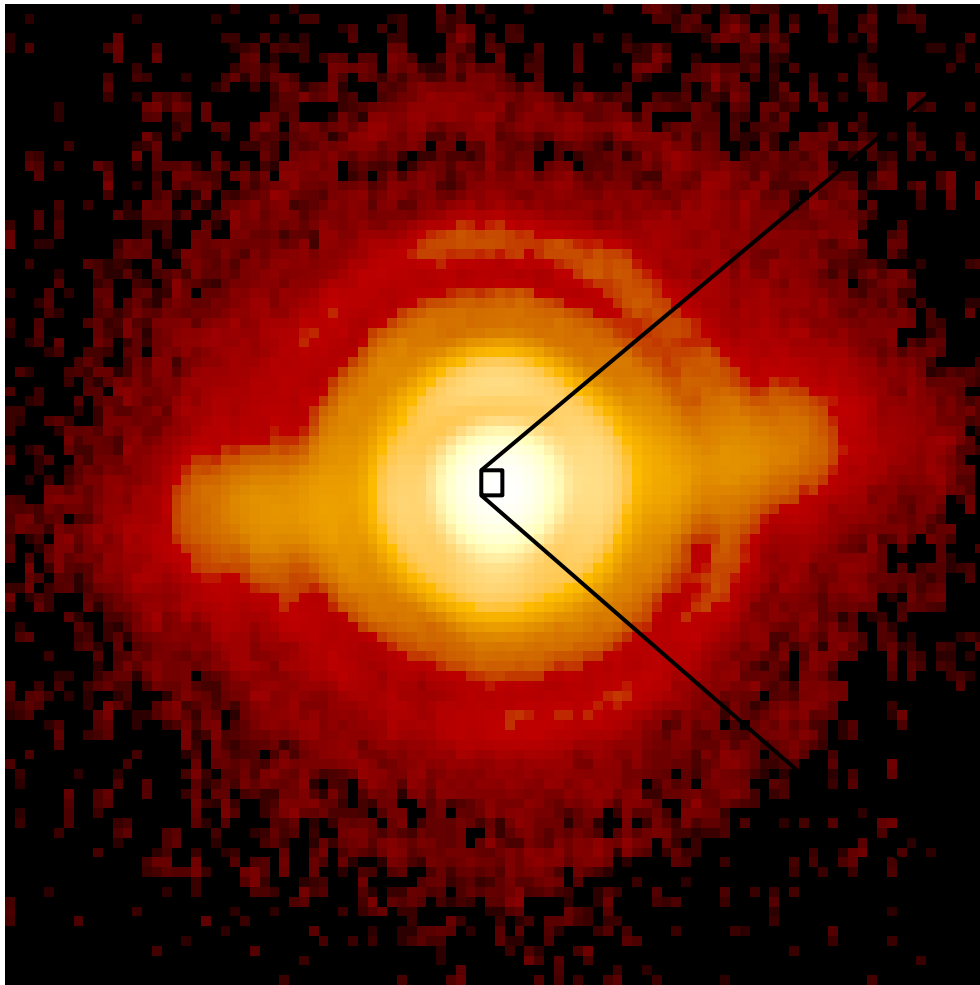
Stalevski, Asmus & Tristram (2017)

Tristram et al. (2014)

10 pc

1 pc

dusty cone wall

disk
masers
(Greenhill+03)

dusty disk

ionization cone
(visible) (Wilson+00)

10 pc

ionization cone
(obscured)

10 pc

1 pc

dusty cone wall

disk masers

dusty disk

10 pc

ionization cone (visible)

tilted accretion disk (anisotropic emission)

dusty cone edge

ionization cone (obscured)

Stalevski, Asmus & Tristram (2017)

10 pc

1 pc

disk masers

dusty cone wall

dusty disk

10 pc

10 pc

tilted accretion disk (anisotropic emission)

ionization cone (visible)

ionization cone (obscured)

dusty cone edge

9 35 79 141 221 317 432 565 714

Stalevski, Asmus & Tristram (2017)

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)

MCRT with

http://www.skirt.ugent.be
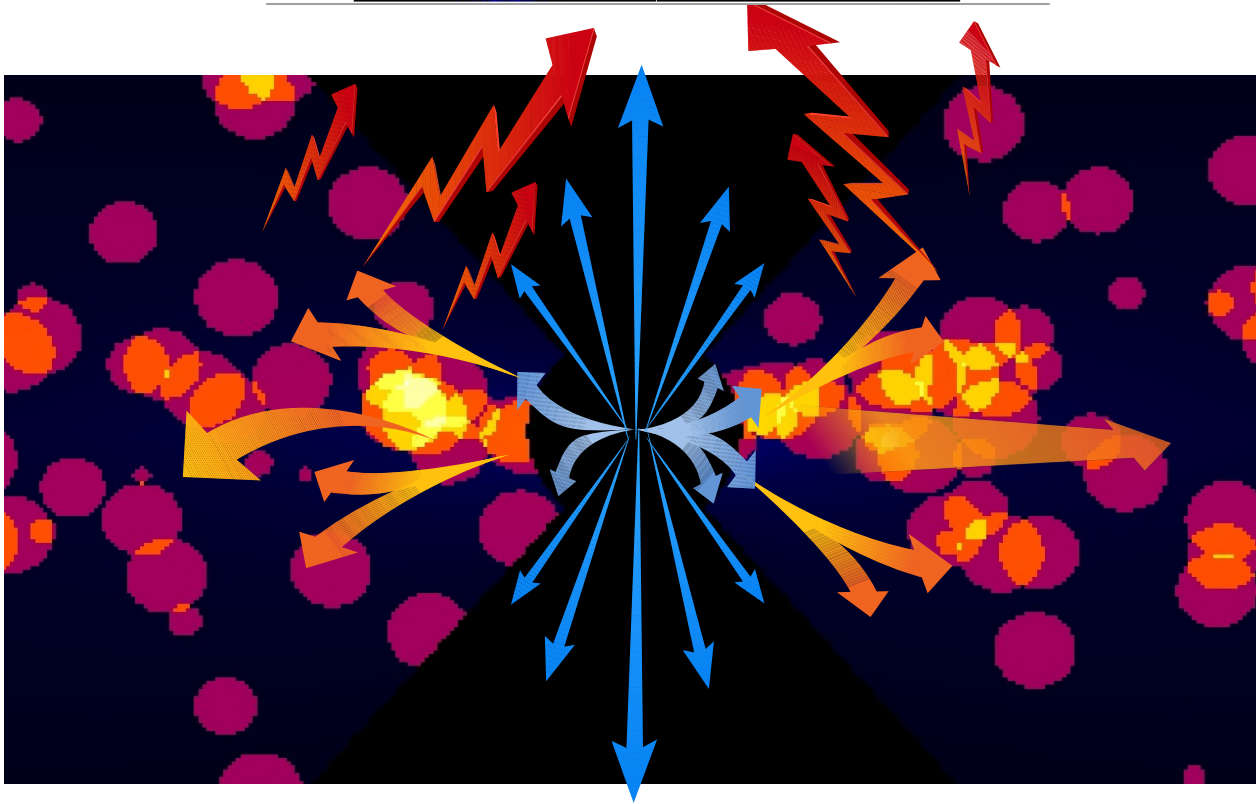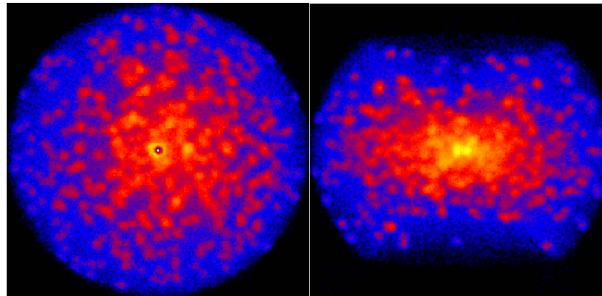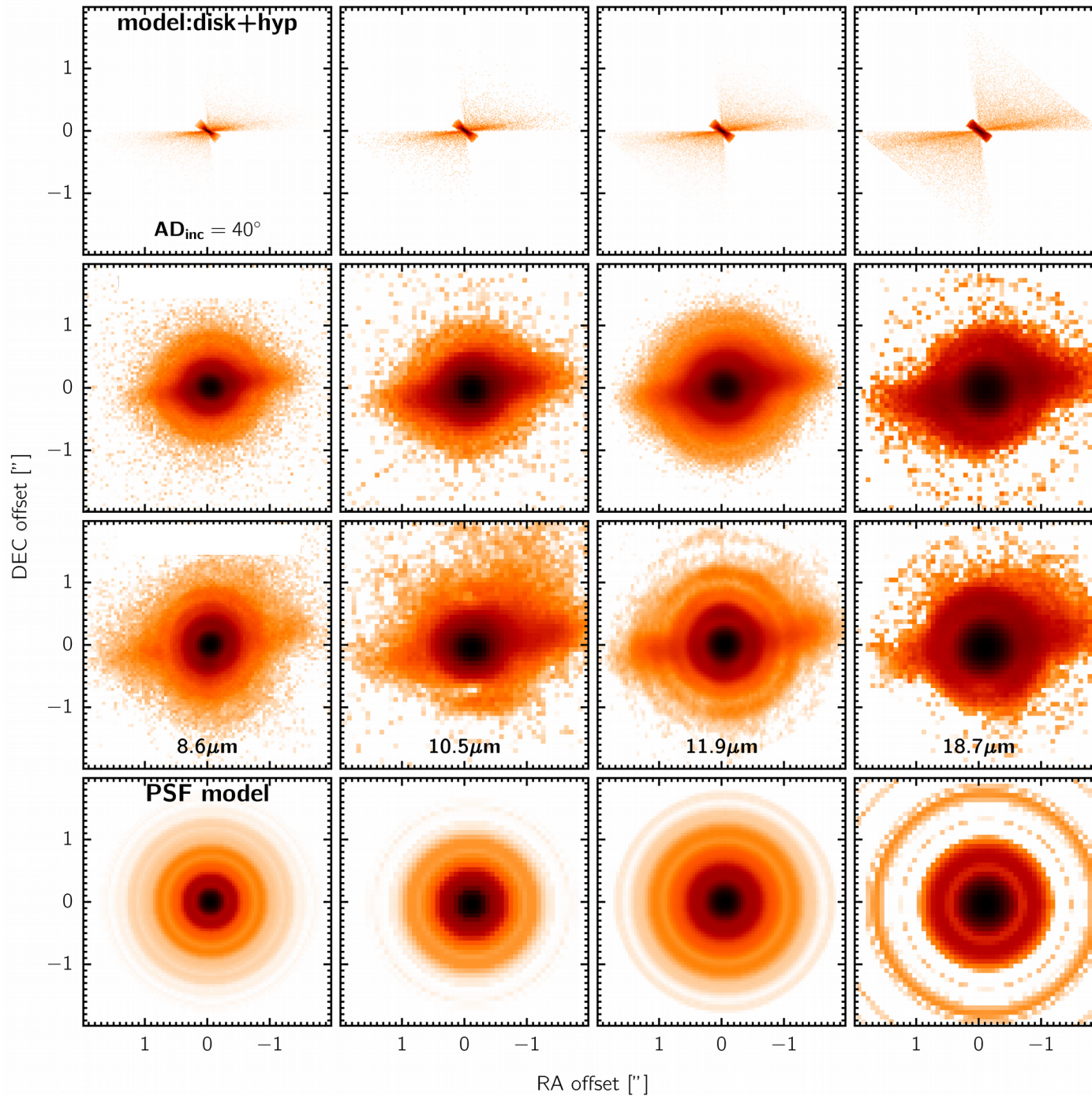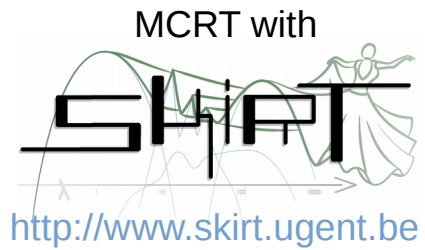
Model RT image

PSF model

Good match with the MIR morphology

Stalevski, Asmus & Tristram (2017)

MCRT with

http://www.skirt.ugent.be

model:disk+hyp

$AD_{inc} = 40°$

model sim. obs.

Observation

8.6μm   10.5μm   11.9μm   18.7μm

PSF model

DEC offset ["]

RA offset ["]
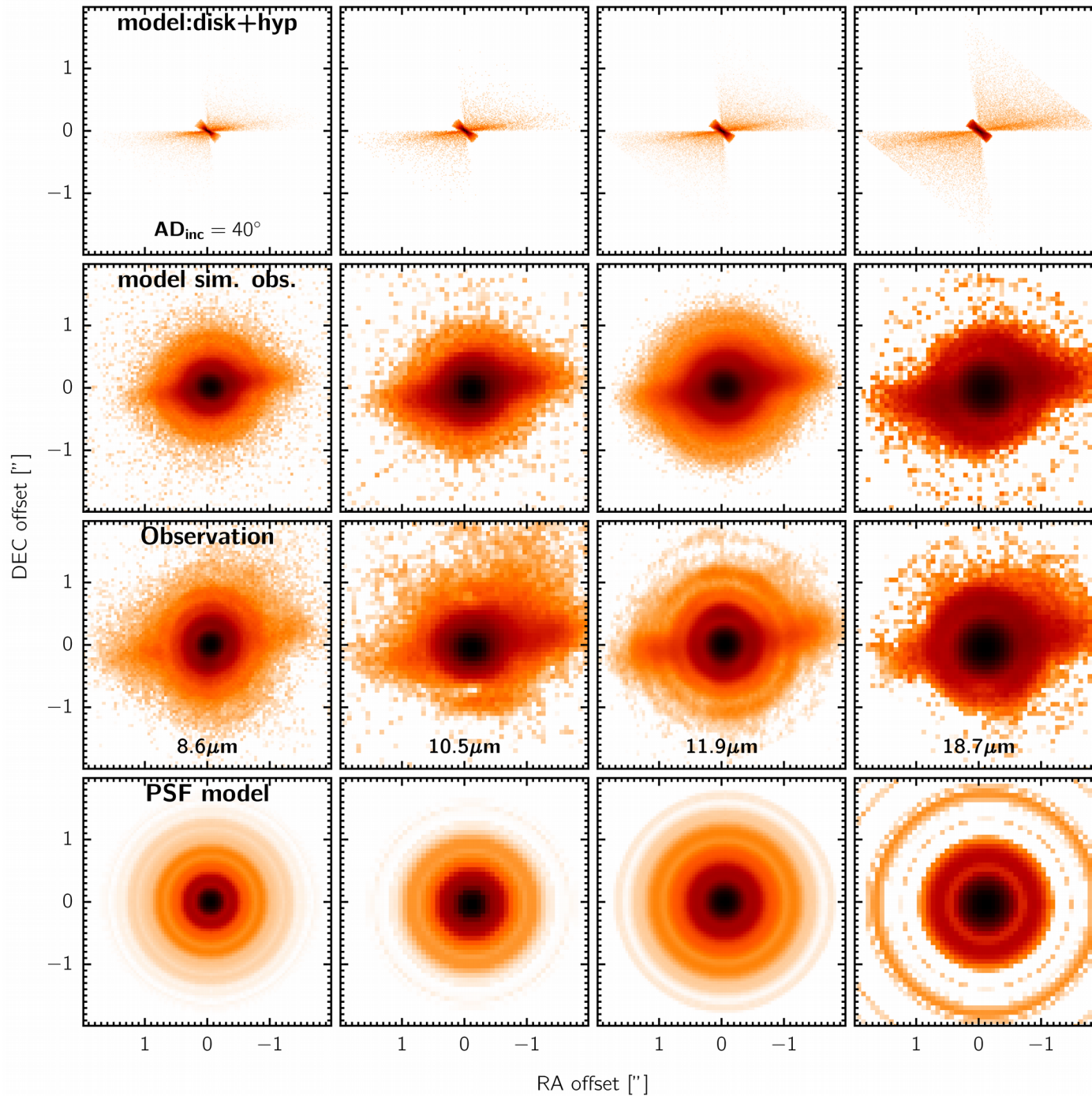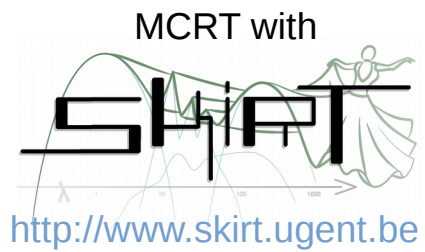
Model RT image

Synthetic obs. of the model

Observed images

PSF model

Good match with the SED

Stalevski, Asmus & Tristram (2017)
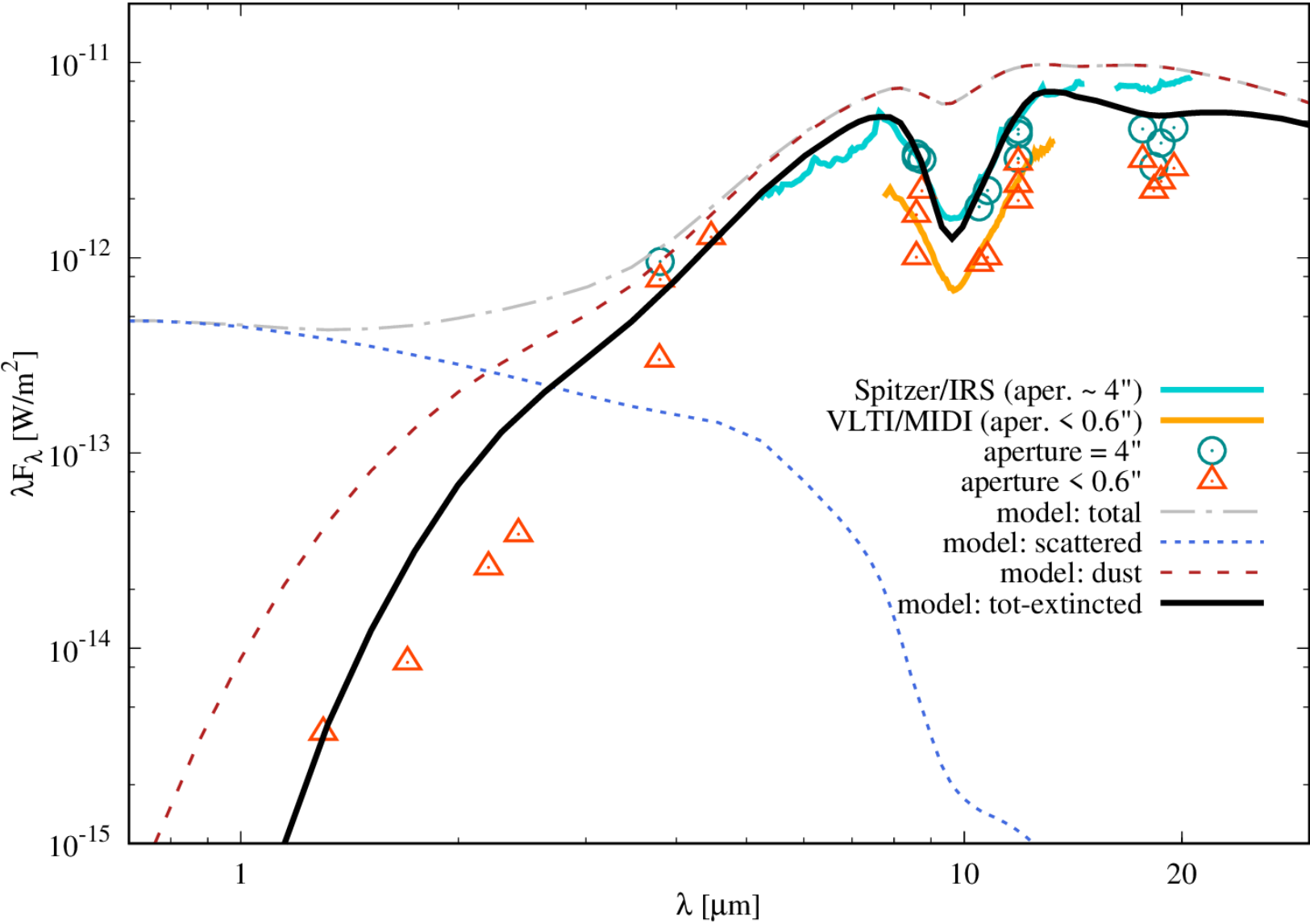
Good match with the resolved photometry
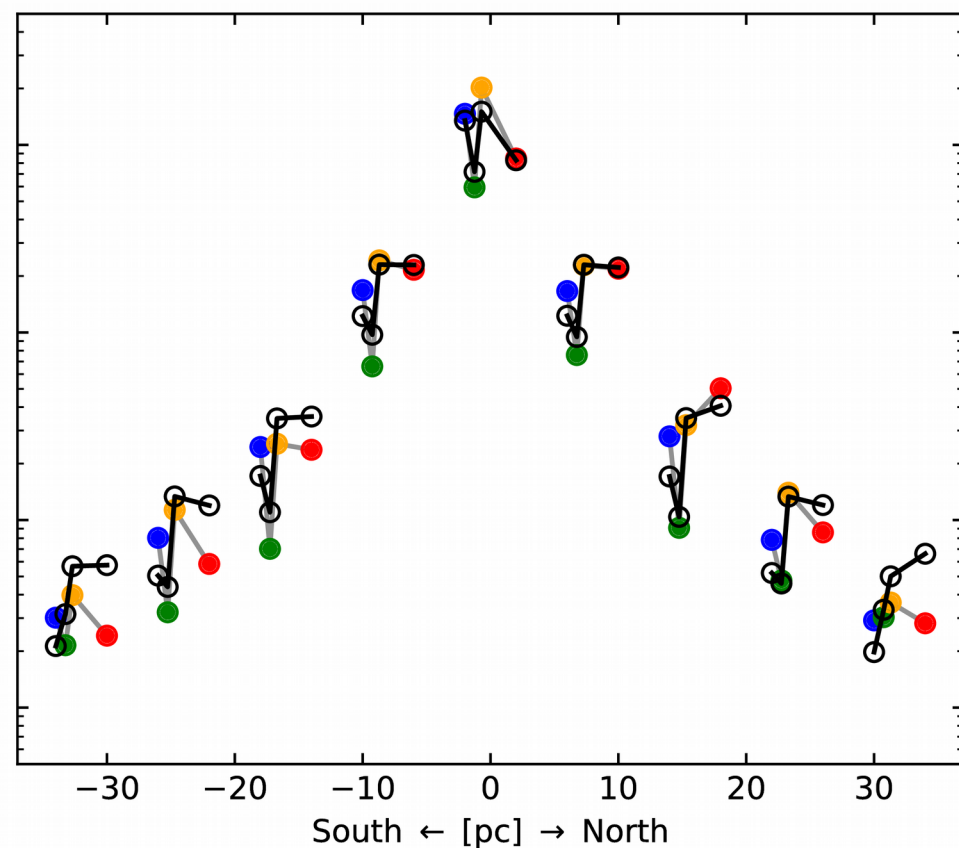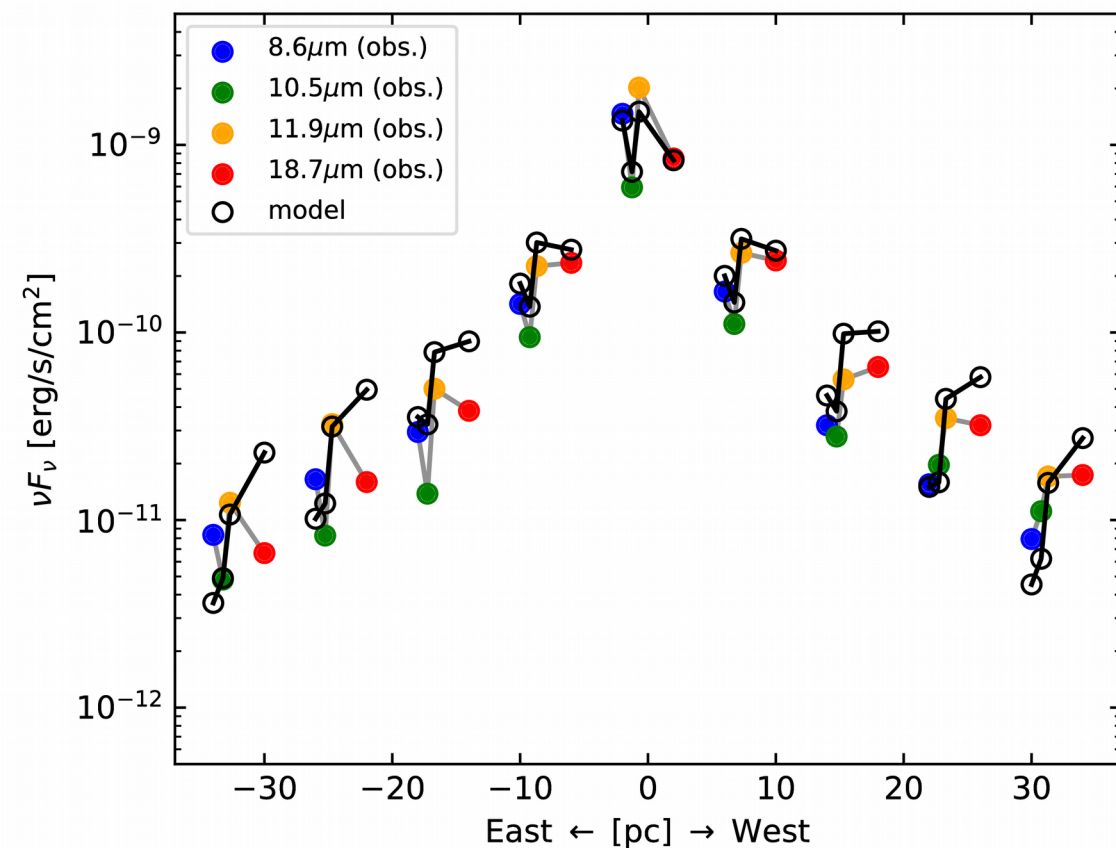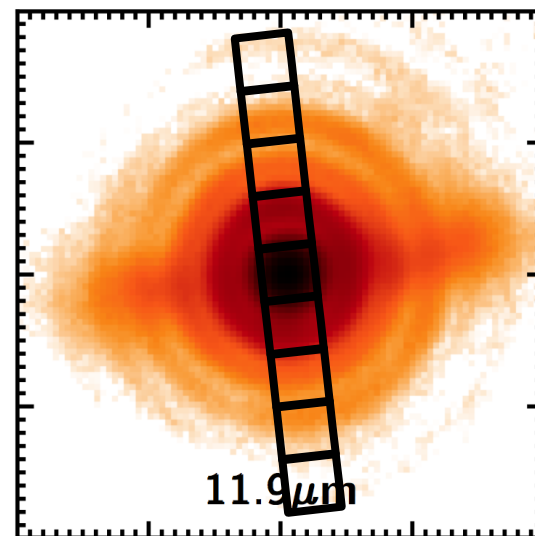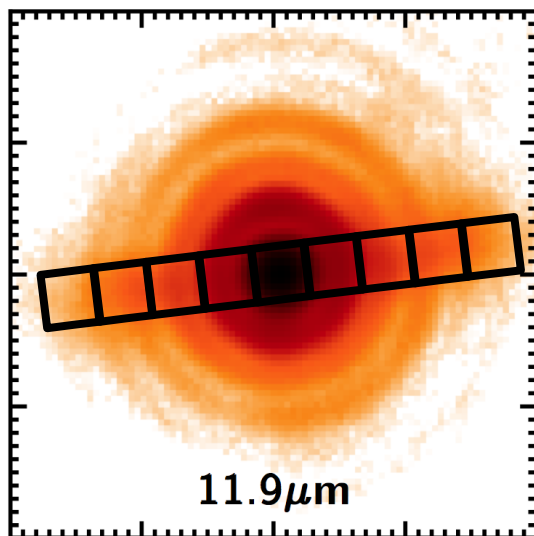
# torus+sphere shell: does not work

Model RT image

Synthetic obs. of the model

Aligned AD

Observed images

Synthetic obs. of the model

Tilted AD

Model RT image

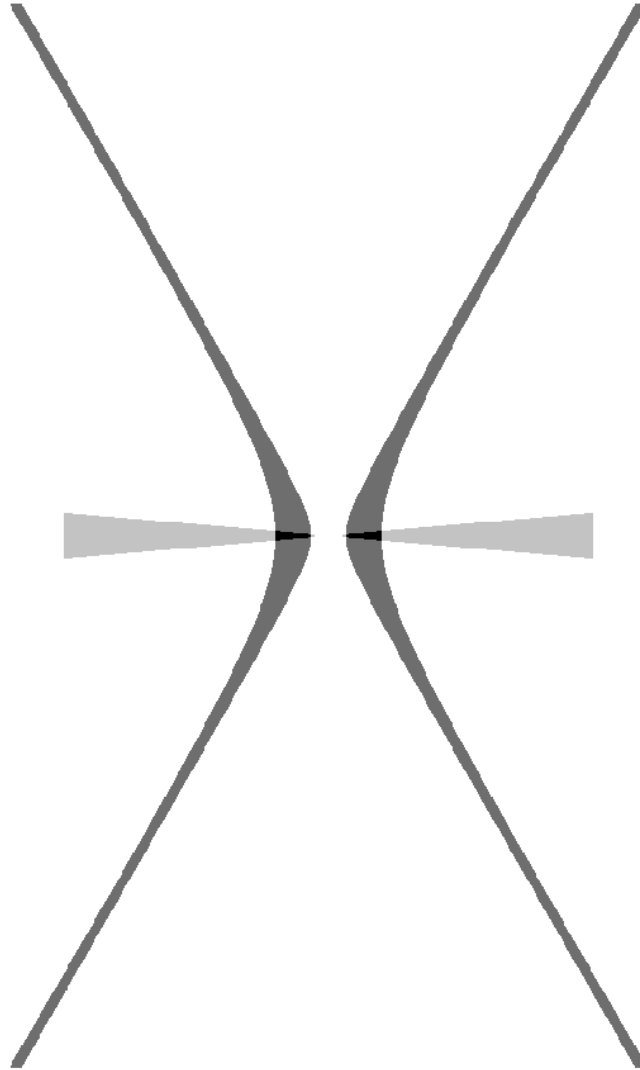Stalevski, Asmus & Tristram (2017)

torus+sphere shell: does not work
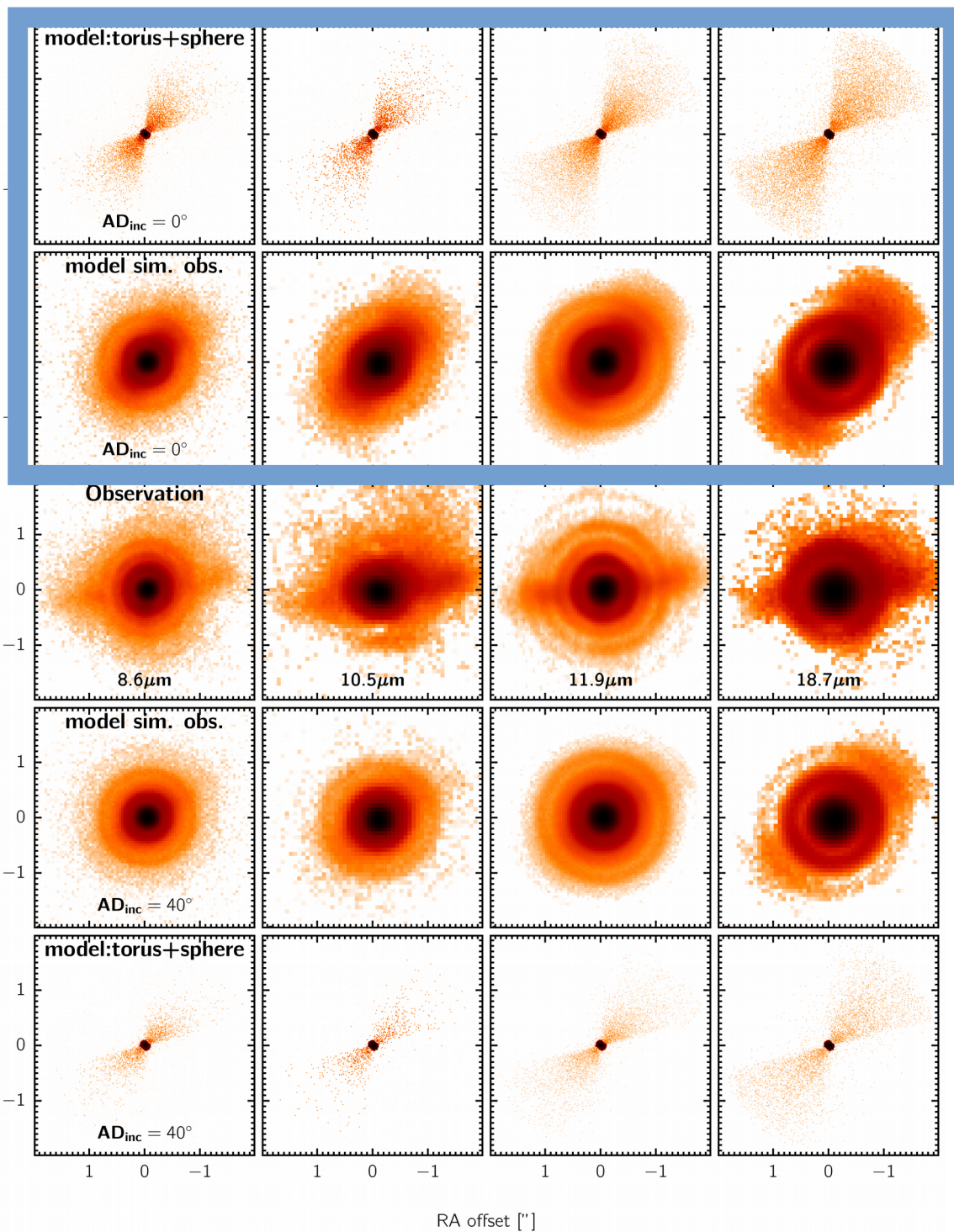
Model RT image

Synthetic obs. of the model

Aligned AD

Observed images

Synthetic obs. of the model

Tilted AD

Model RT image

Stalevski, Asmus & Tristram (2017)
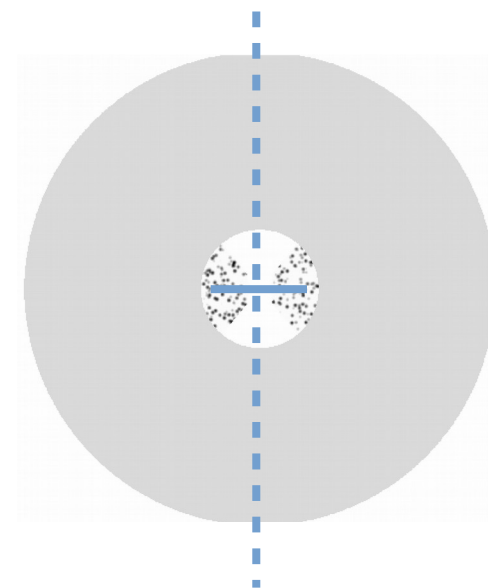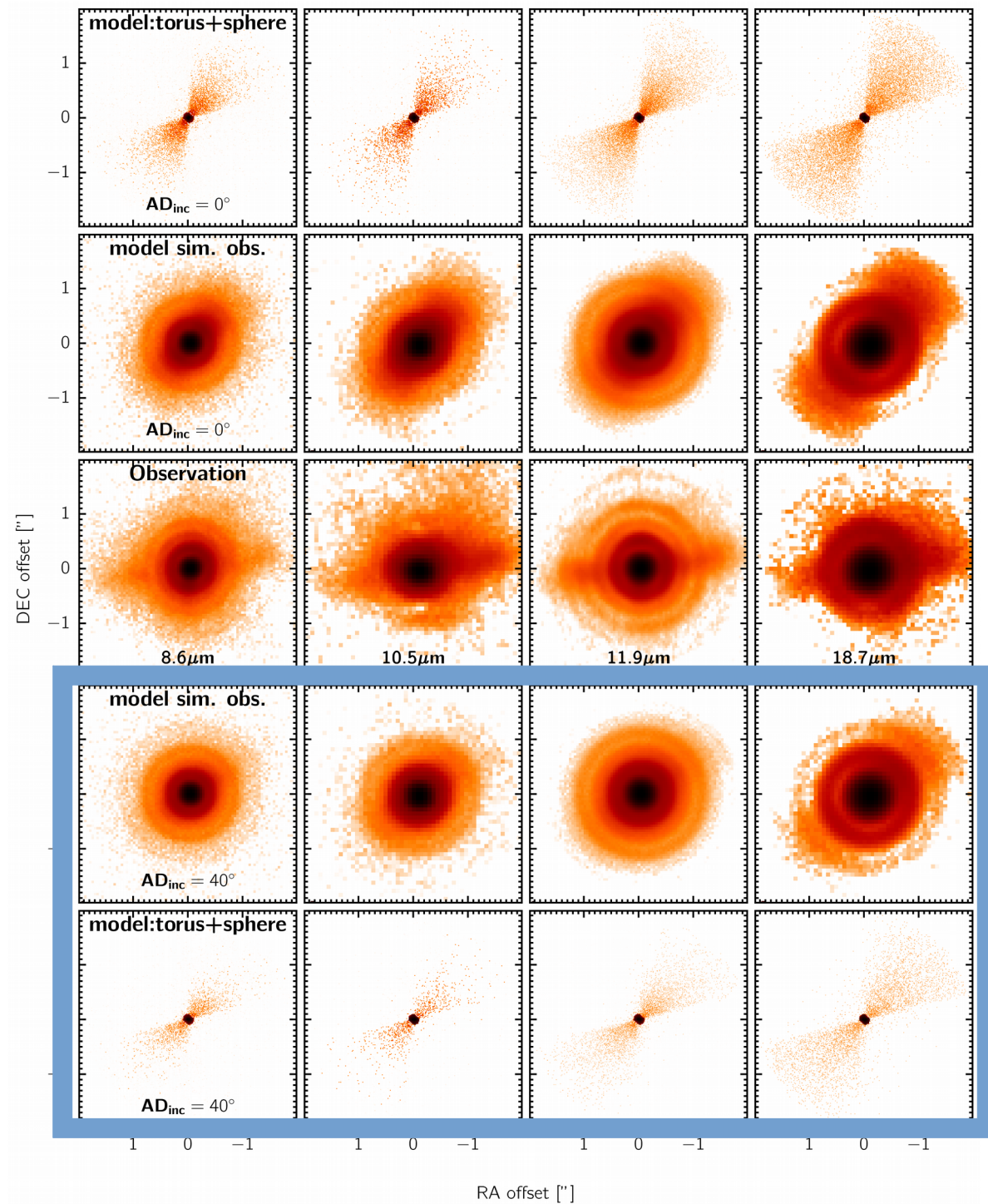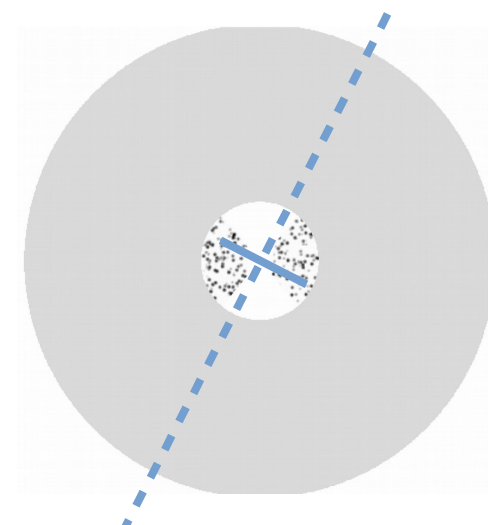
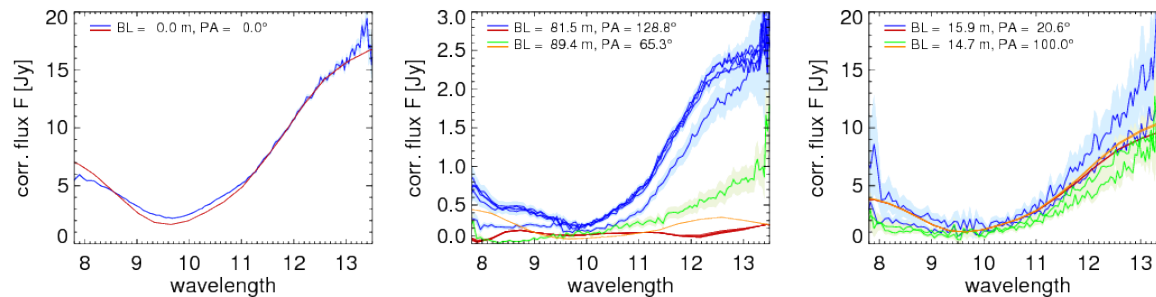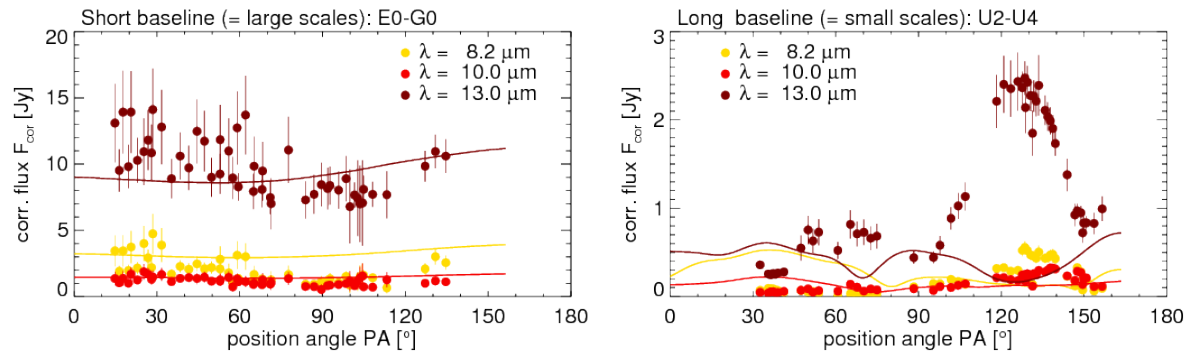# Zooming in with VLTI/MIDI

Tristram et al. (2014)
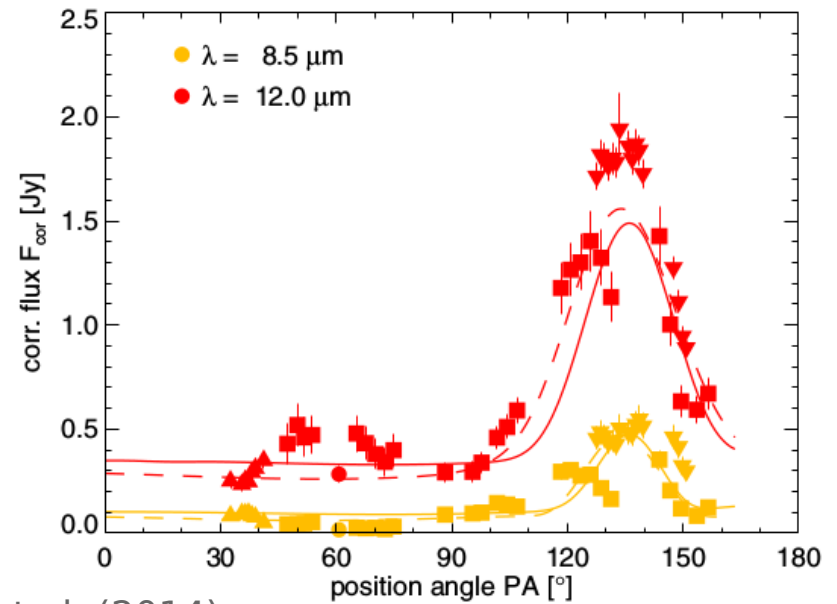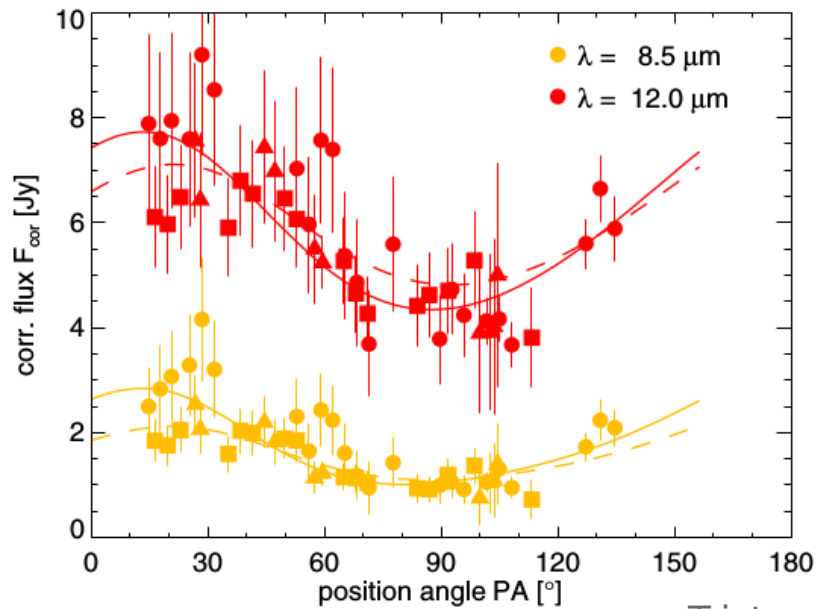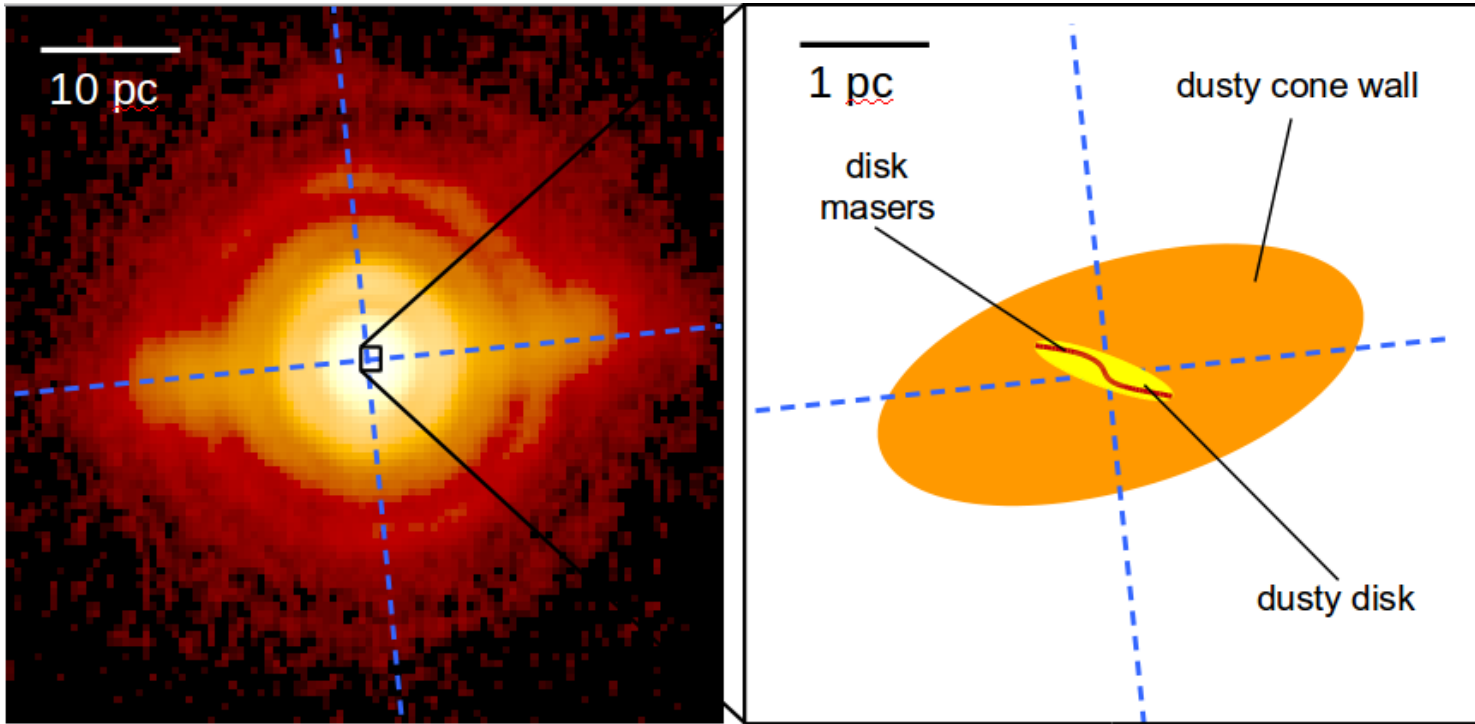
disk + hyperboloid polar wind

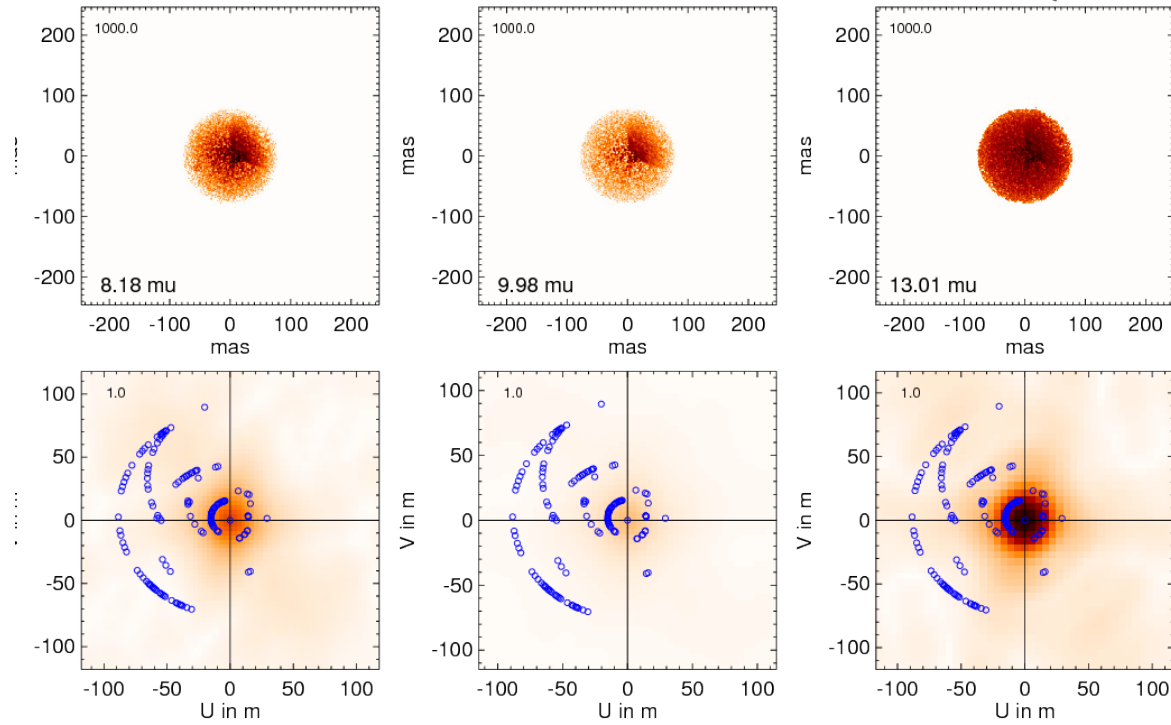Stalevski, Tristram & Asmus (2019)

disk+hyp wind: good match with VLTI/MIDI

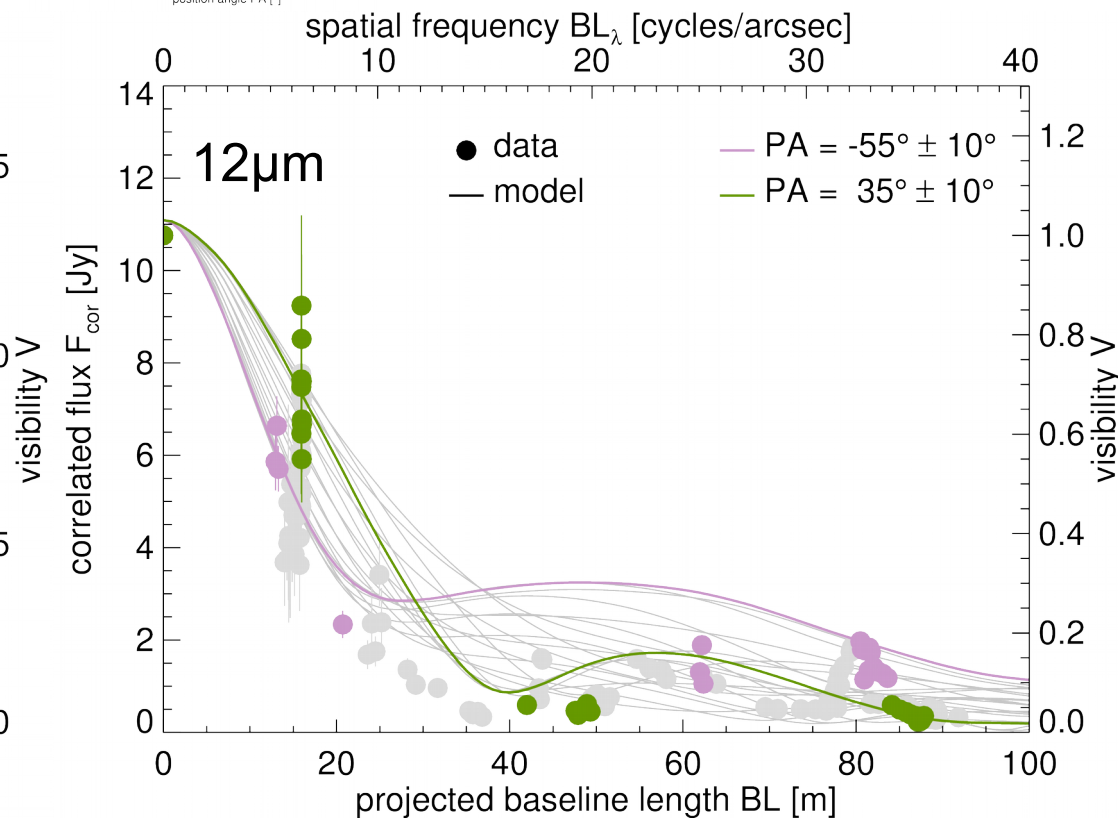Stalevski, Tristram & Asmus (2019)
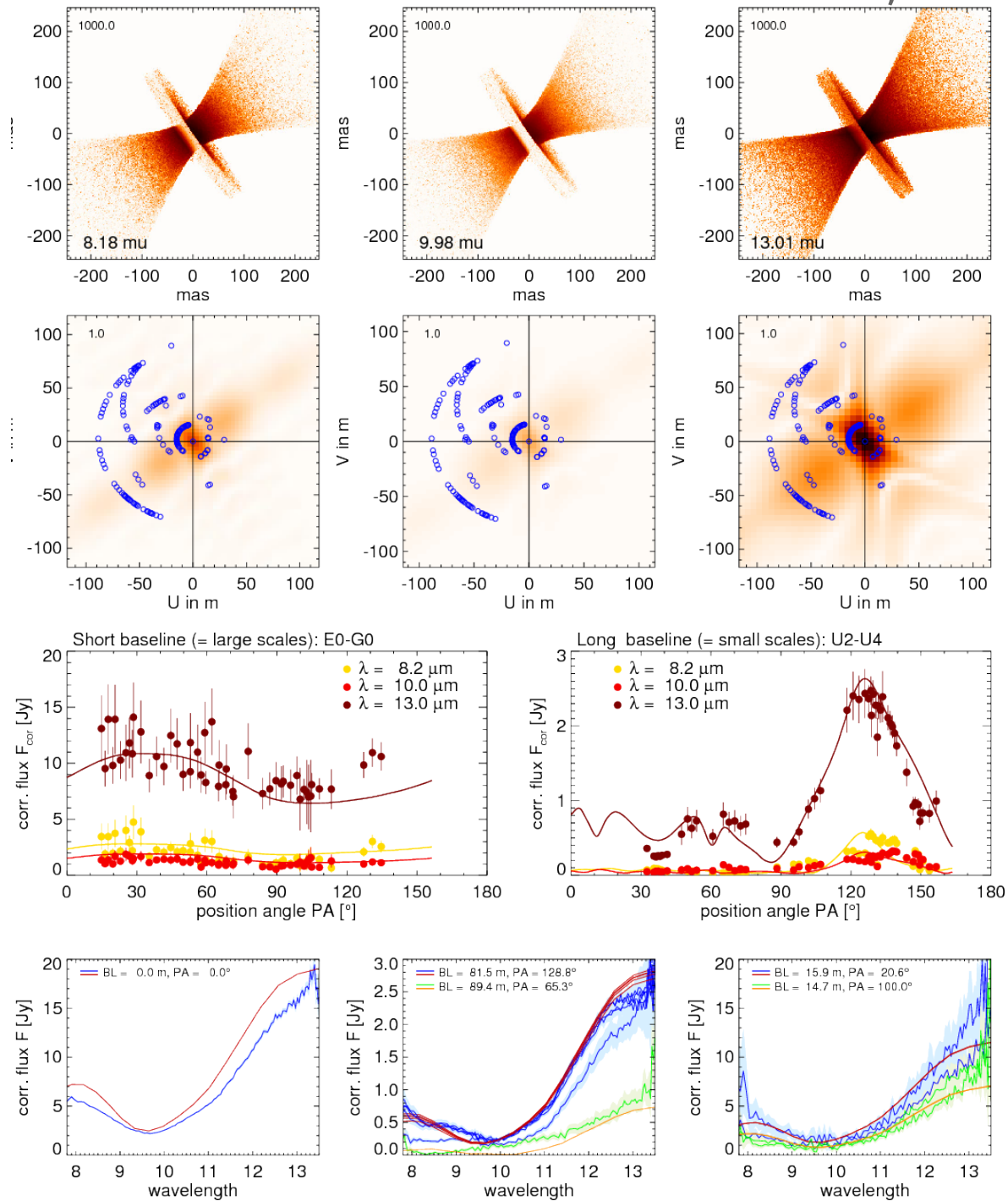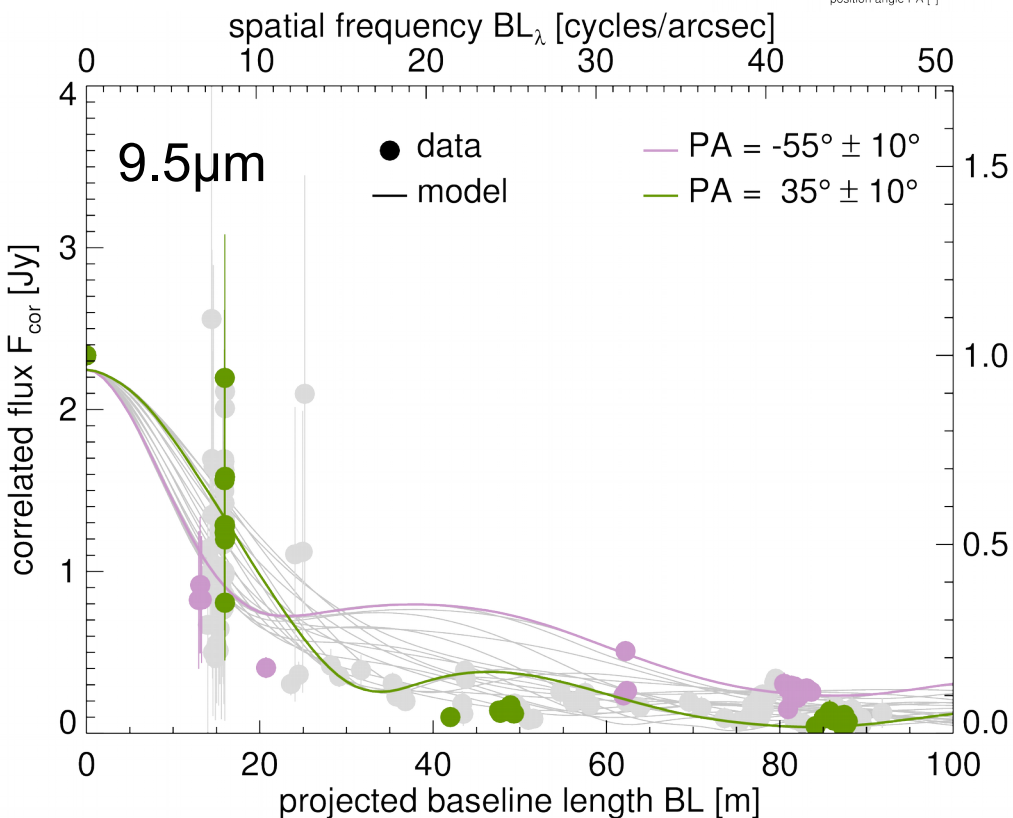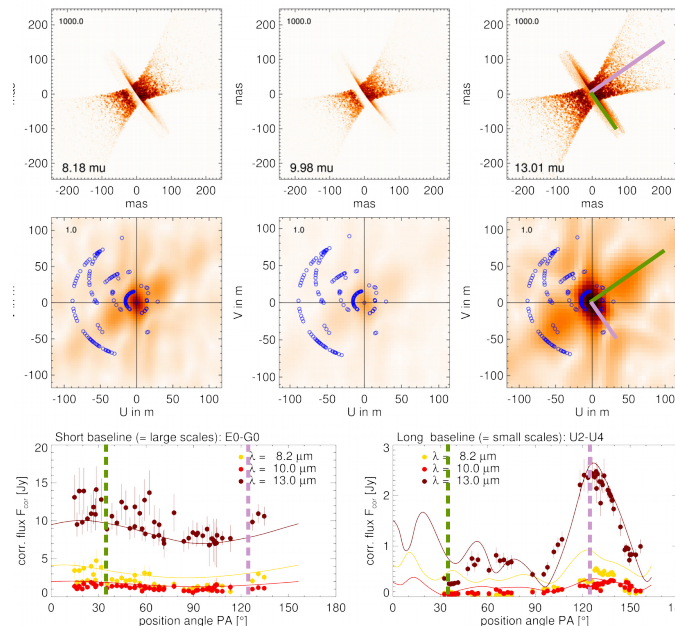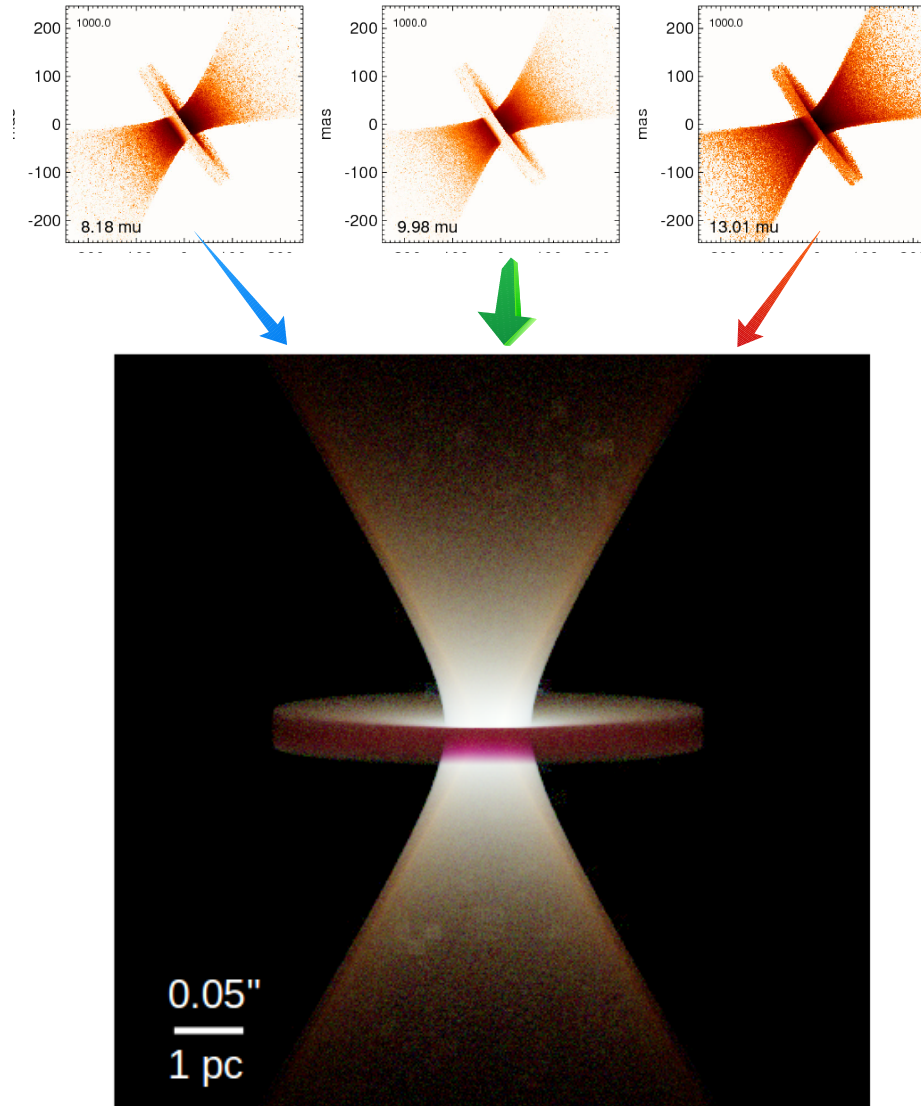
clumpy torus: doesn't work with VLTI/MIDI

disk+ (clumpy) wind: good match with VLTI/MIDI
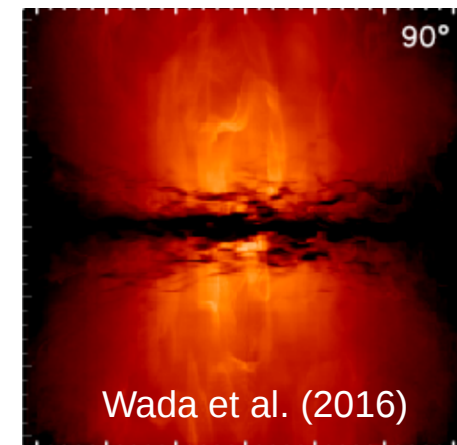
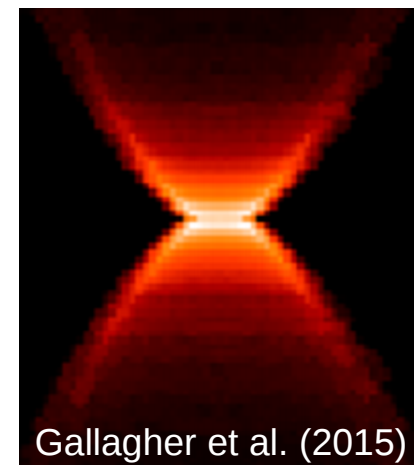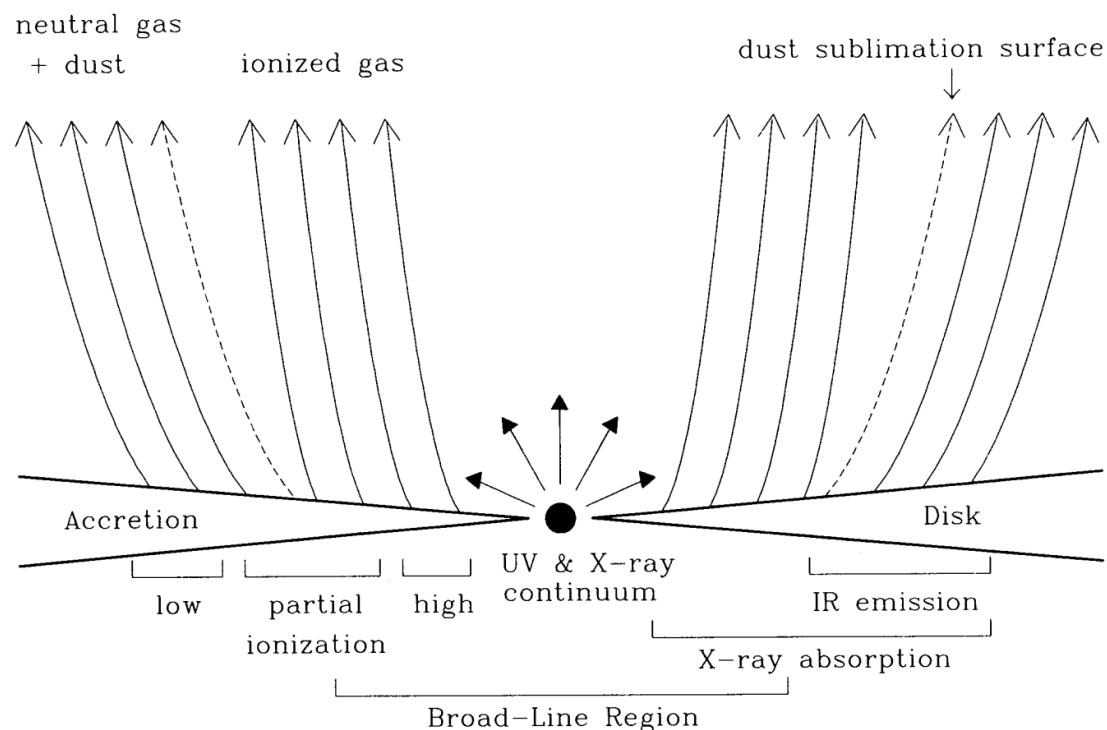Stalevski, Tristram & Asmus (2019)

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

Gallagher et al. (2015)

Wada et al. (2016)

neutral gas + dust ionized gas dust sublimation surface

Accretion Disk

UV & X-ray continuum

low partial ionization high
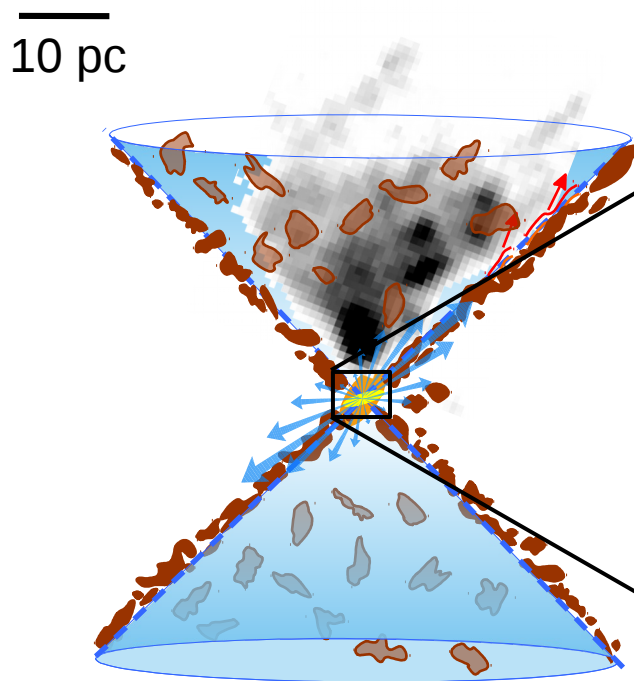
IR emission

X-ray absorption

Broad-Line Region

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

[Dorodnitsyn+ (2011, 2012); Dorodnitsyn & Kallman (2012); Dorodnitsyn+ (2016)]
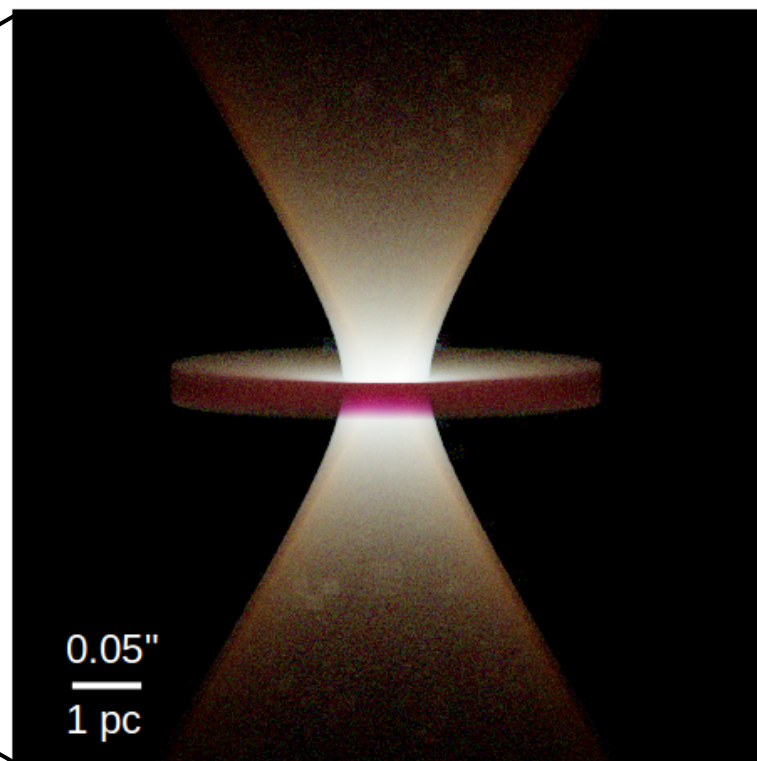
[Wada (2012), Wada+ (2016), Chan & Krolik (2016, 2017), Vollmer et al. (2018)]

Conclusions

Stalevski, Asmus & Tristram (2017)

Stalevski, Tristram & Asmus (2019)

10 pc

0.05"
1 pc
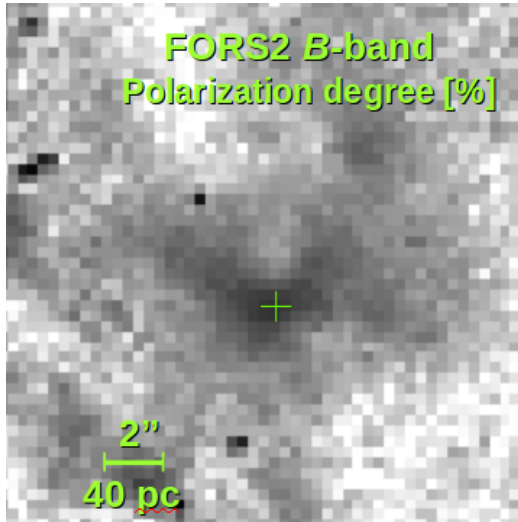
AGN in Circinus: a prototype for polar dust AGN population
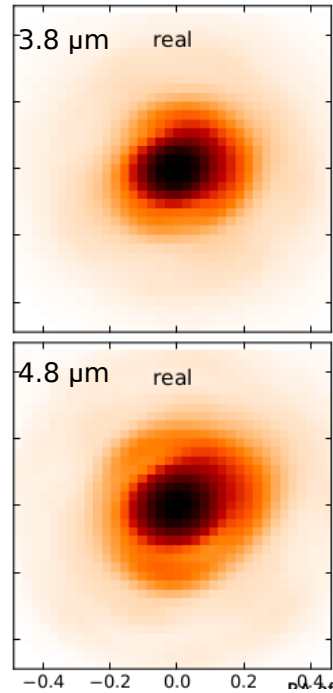+
Call for caution when using torus models

Appendix
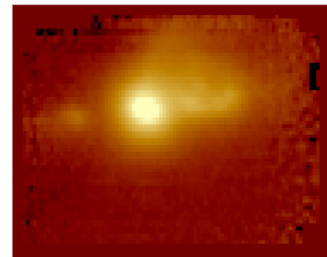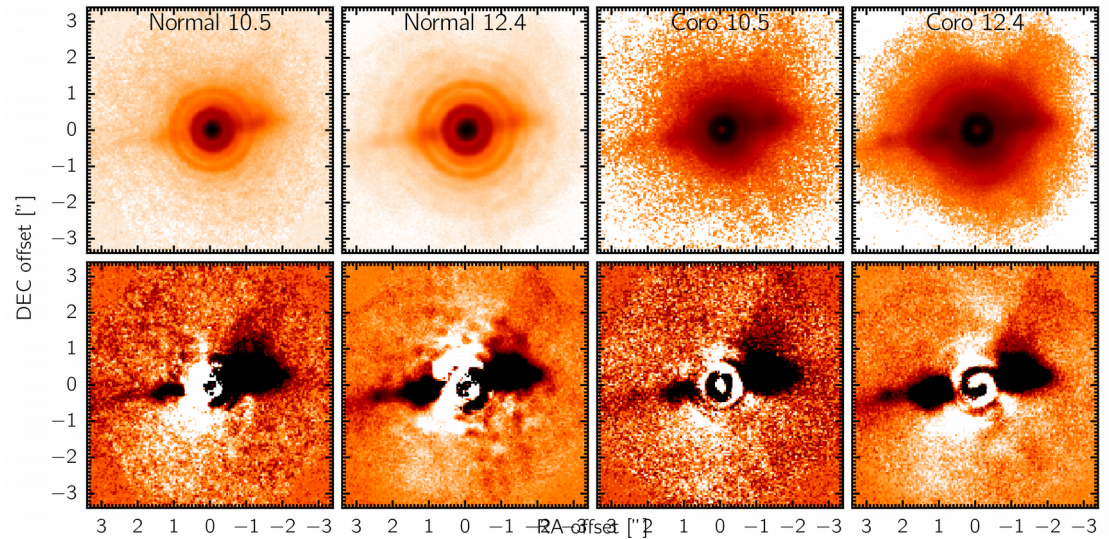
Keeping an eye on Circinus with VLT...

FORS2 (B, V)

FORS2 *B*-band
Polarization degree [%]

2"
40 pc

NACO

3.8 μm   real

4.8 μm   real

-0.4   -0.2   0.0   0.2   0.4

VISIR coronagraphy (+SAM)

Normal 10.5   Normal 12.4   Coro 10.5   Coro 12.4

DEC offset ["]

3 2 1 0 -1 -2 -3   3 2 1 0 -1 -2 -3   3 2 1 0 -1 -2 -3   3 2 1 0 -1 -2 -3

RA offset ["]

Coming up:
- SPHERE
- SINFONI
- MUSE
- FORS2 (R, I)

Keeping an eye on Circinus with VLT...

VLT/MUSE NFM
[SIII]

ionization cone
(visible) (Wilson+00)
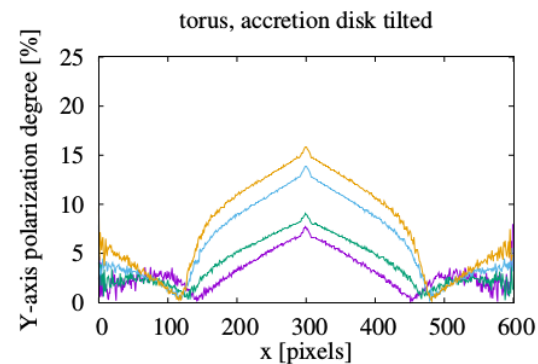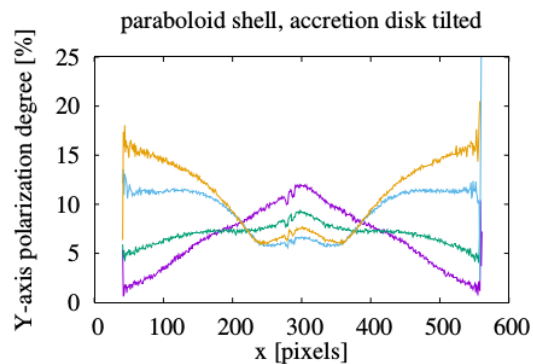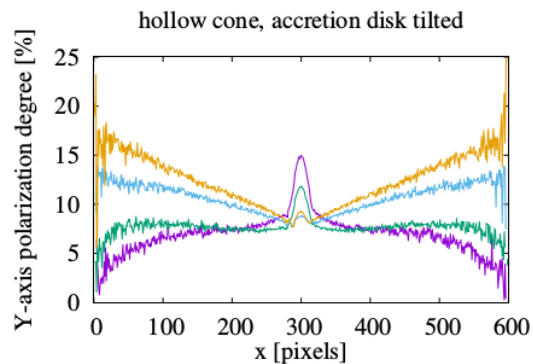
10 pc

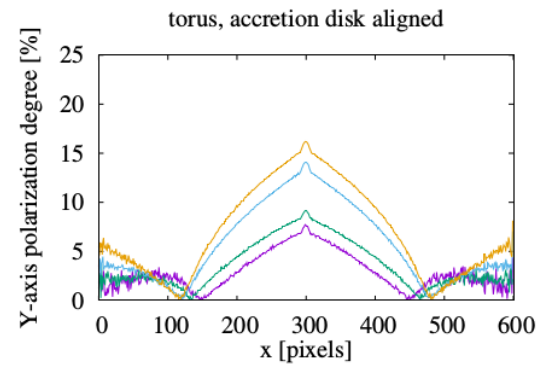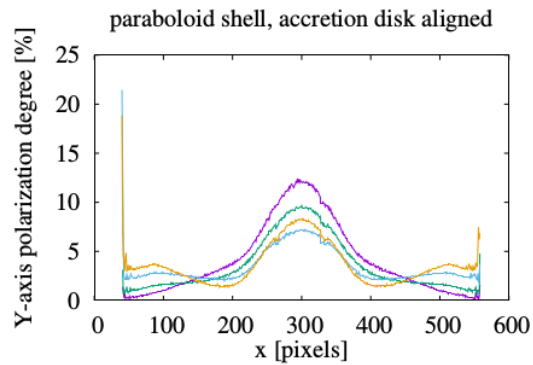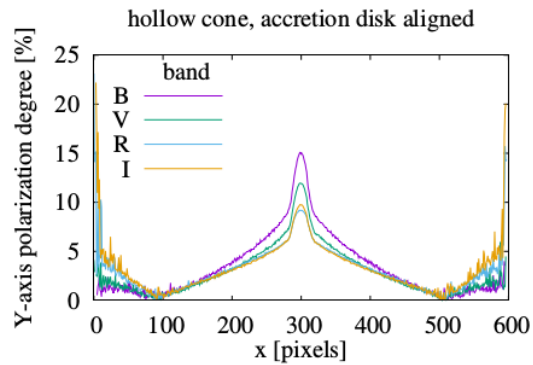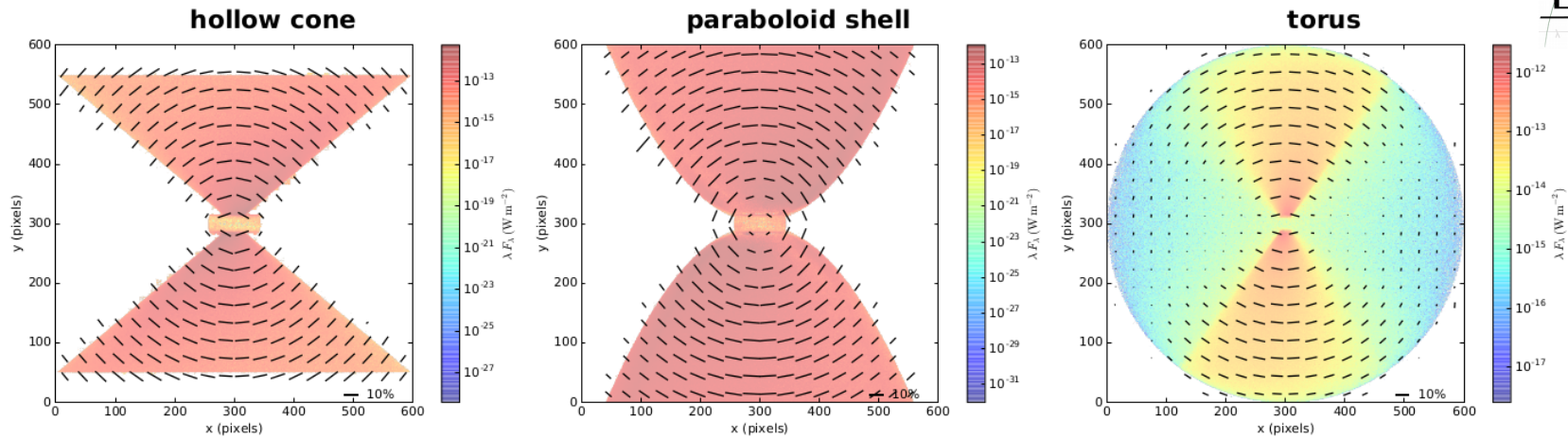HST
[OIII], Hα

ionization cone
(obscured)
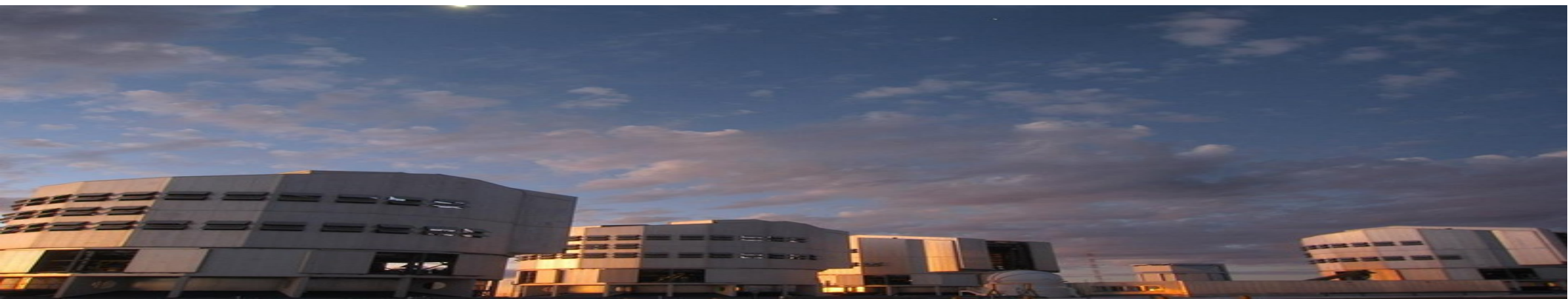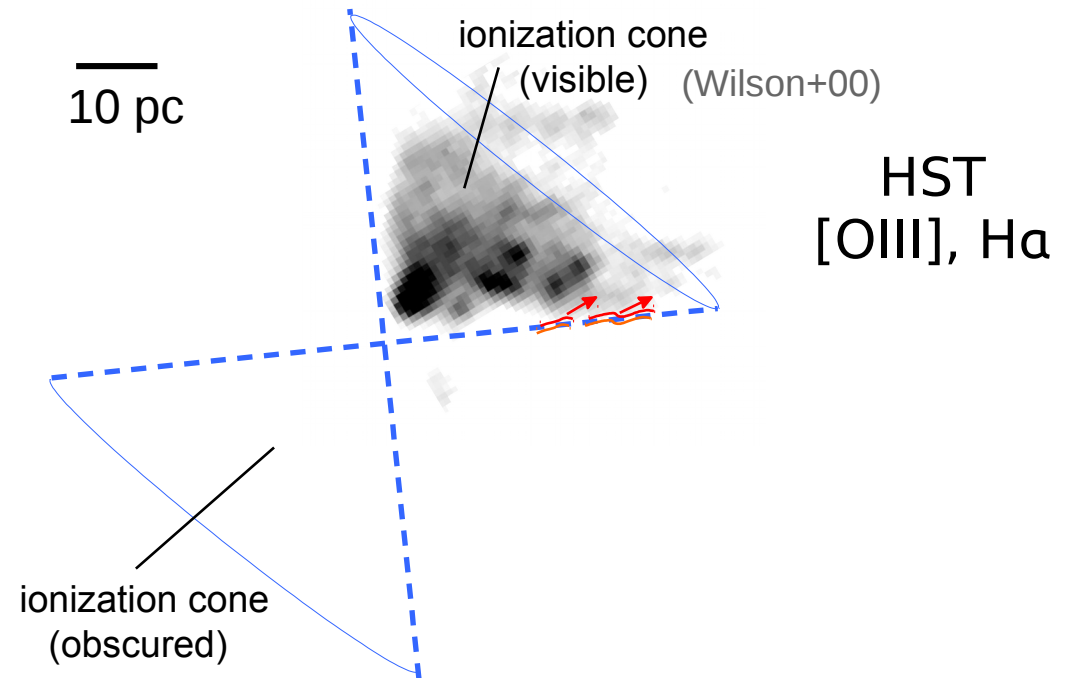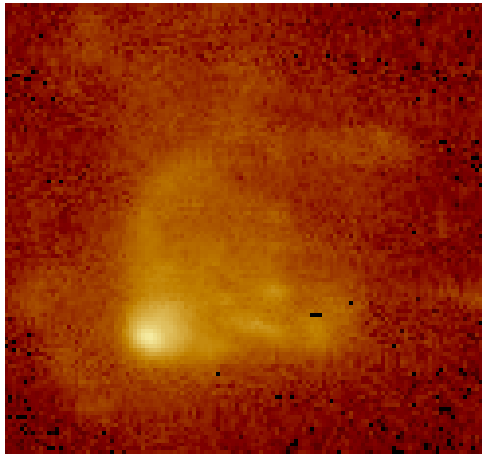
Keeping an eye on Circinus with VLT...

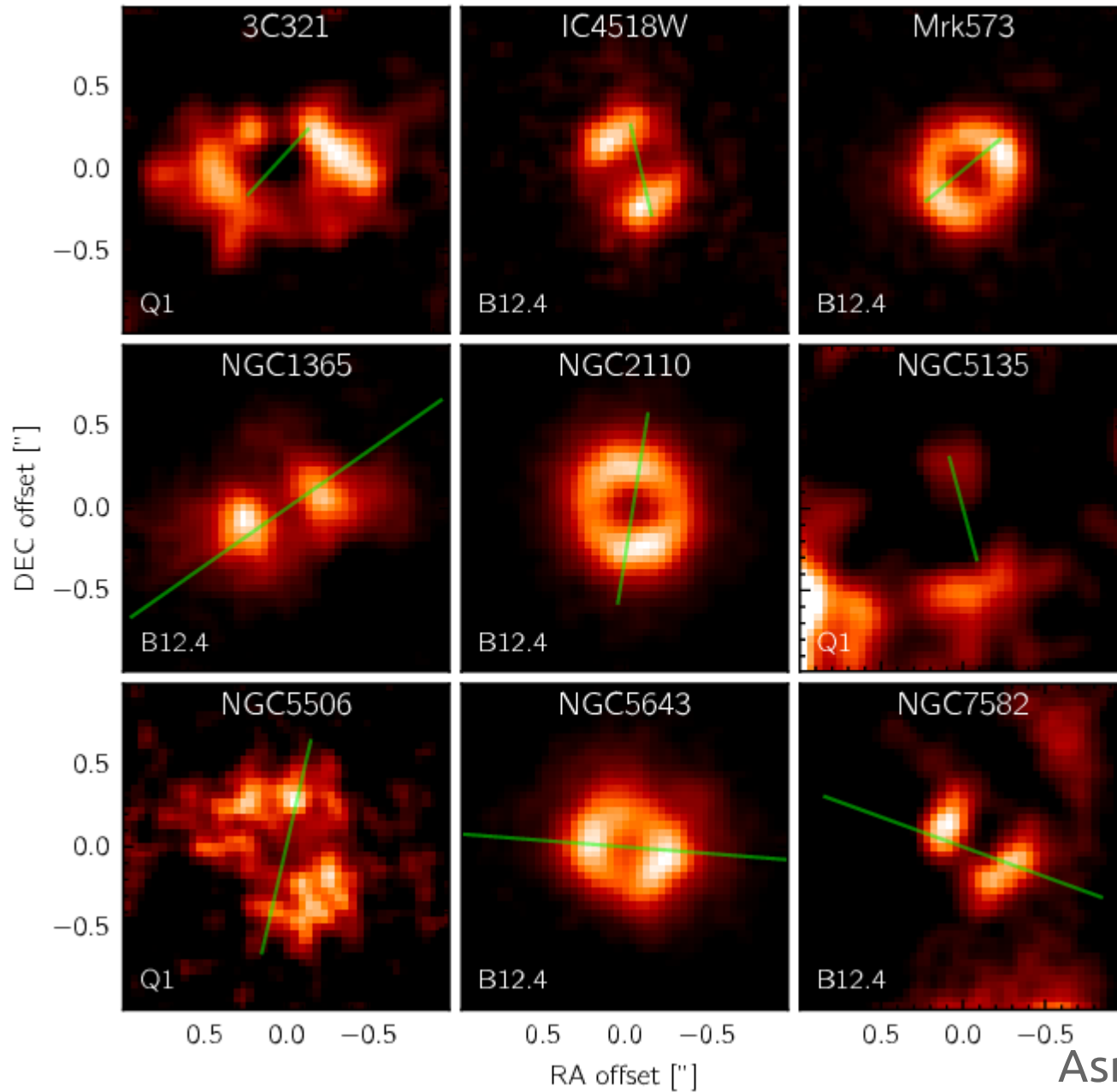Polarization as an independent test for the hollow dusty cone scenario in the Circinus AGN

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

Stalevski, et al. (in prep)

Are powerful polar dusty winds ubiquitous in AGN?

(VISIR deep imaging of 9 nearby type 2 AGN)

(PI: Daniel Asmus)

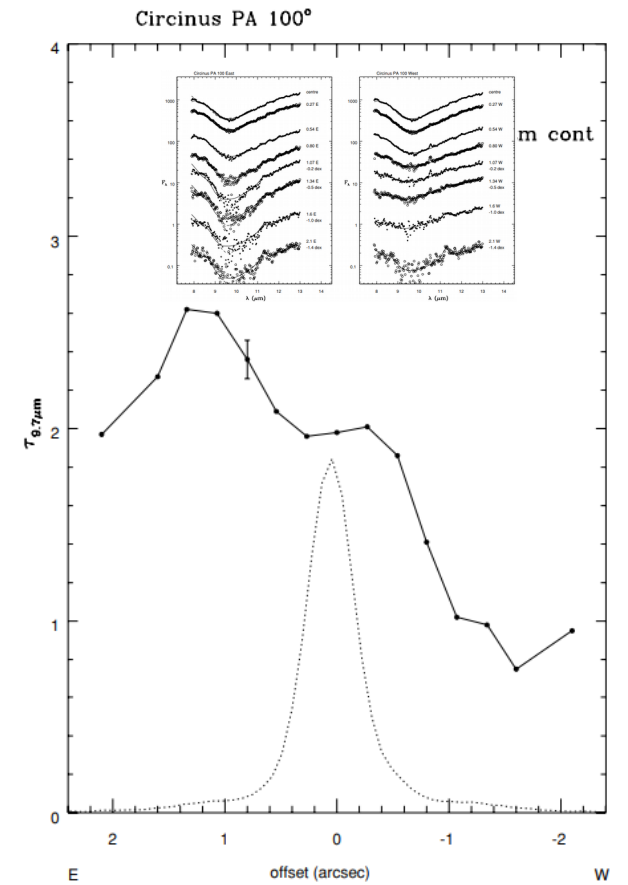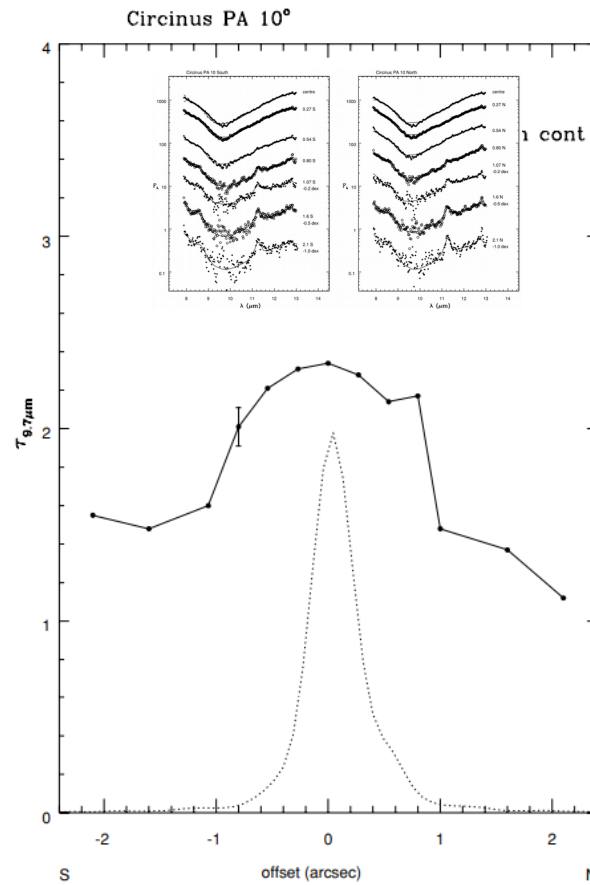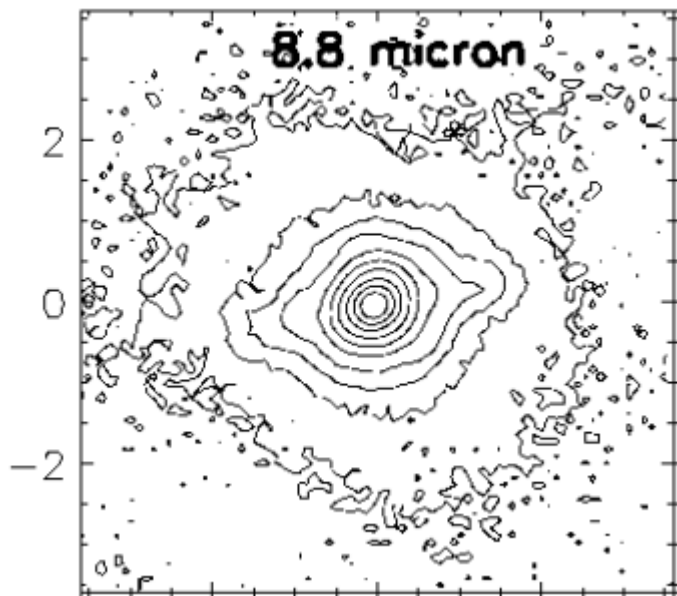
Asmus, et al. (in prep)

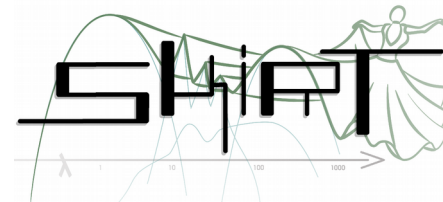# Circinus extended emission and host galaxy extinction

Roche et al. 2006

Packham et al. 2005

(Gemini South / T-Recs)
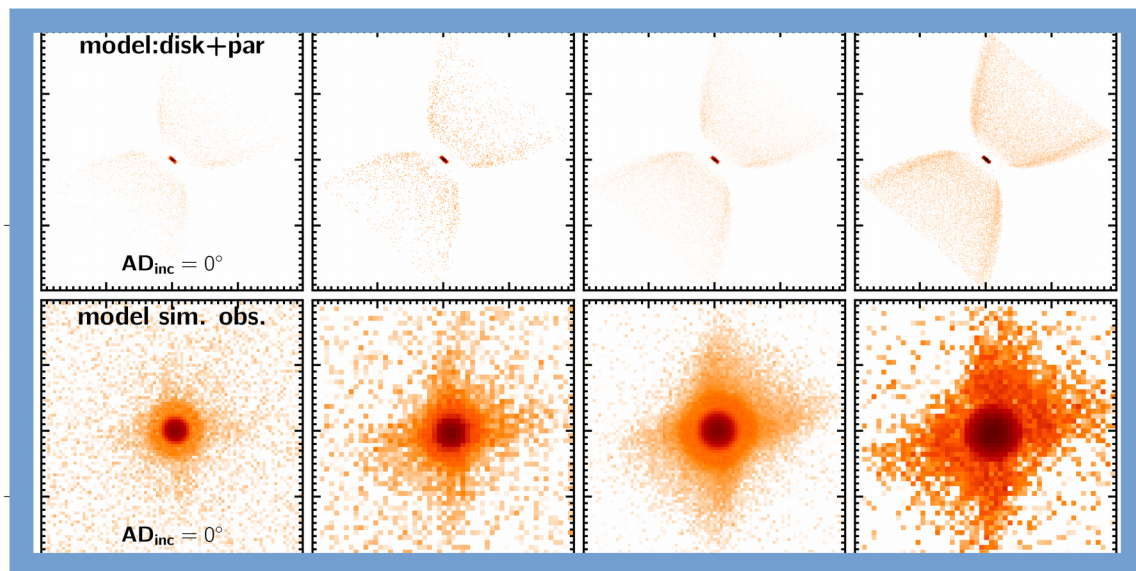
disk+paraboloid: does not work
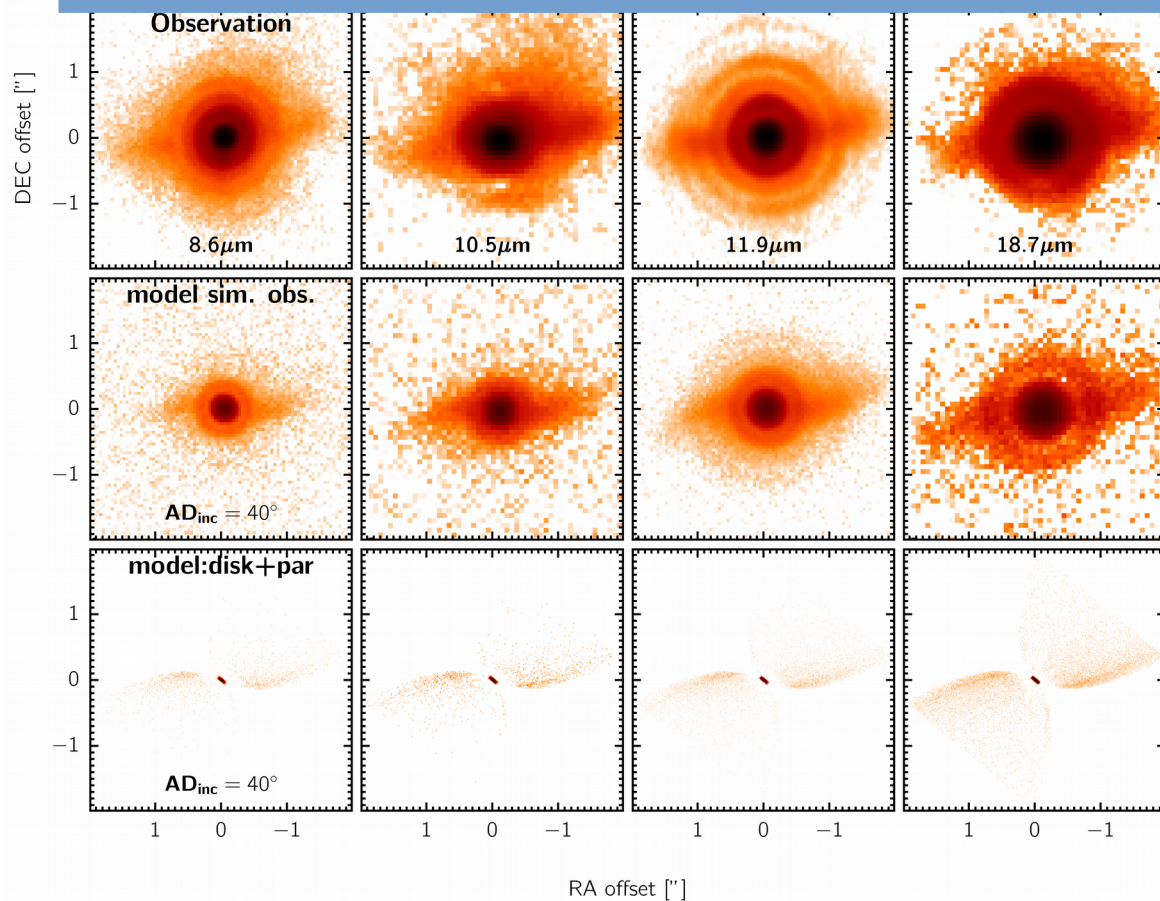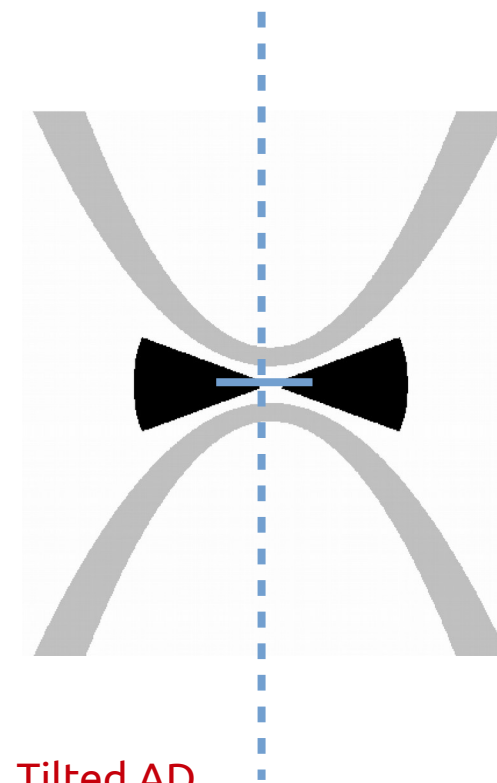

Monte Carlo radiative transfer with

SKIRT

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

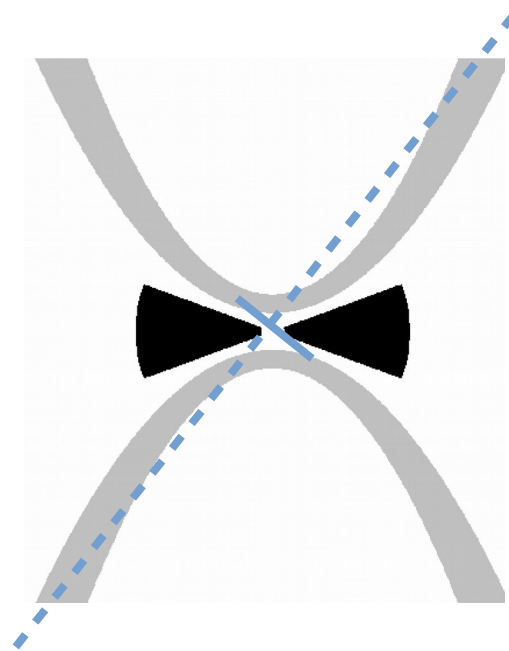Stalevski, Asmus & Tristram (2017)

disk+paraboloid: does not work

Monte Carlo radiative transfer with

SKIRT

http://www.skirt.ugent.be

Model RT image

Synthetic obs. of the model

Aligned AD

Observed images

Synthetic obs. of the model

Tilted AD

Model RT image

Stalevski, Asmus & Tristram (2017)

disk+wind

Stalevski, Tristram & Asmus (2019)
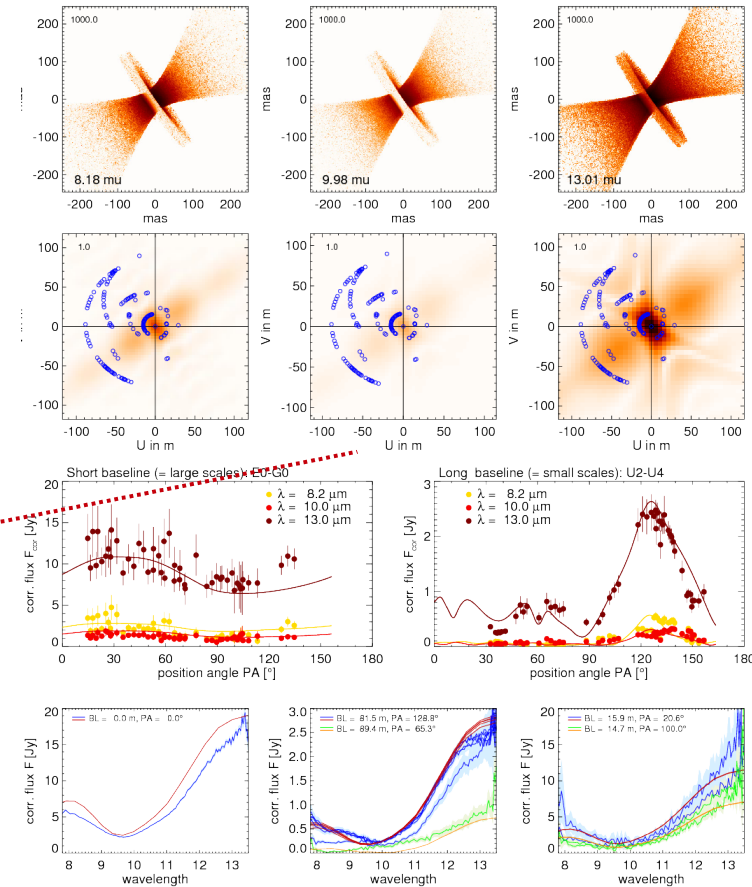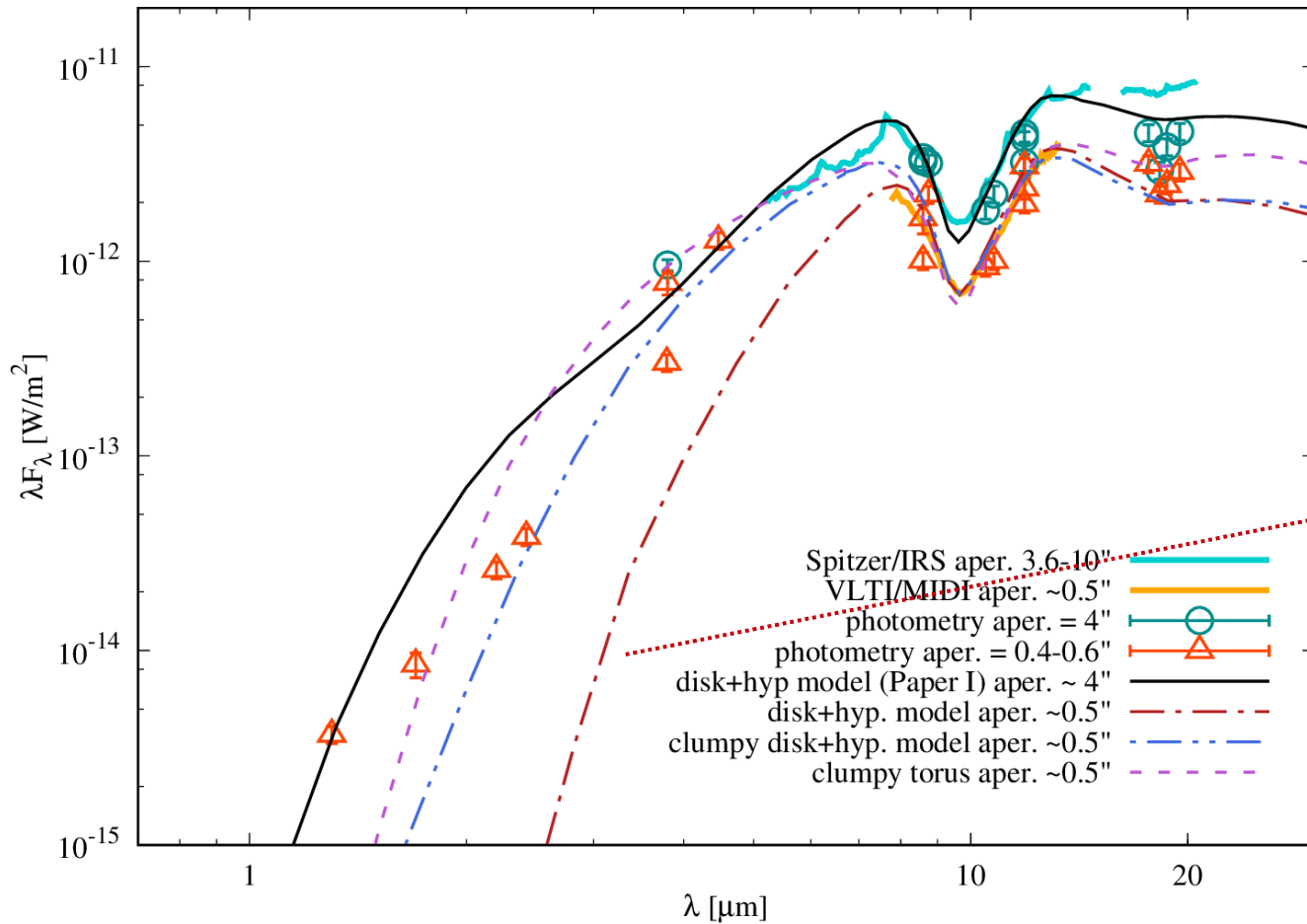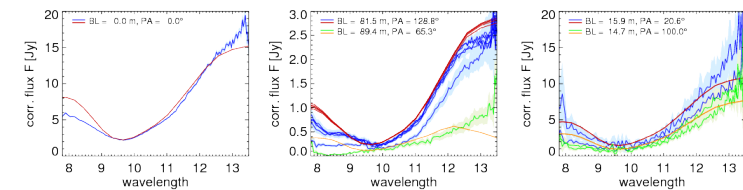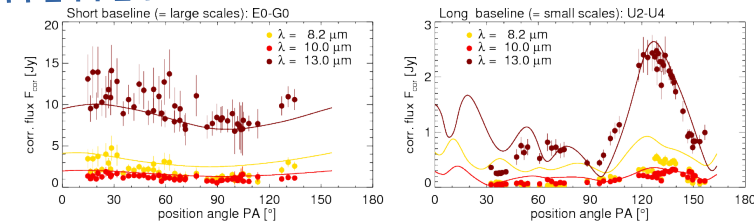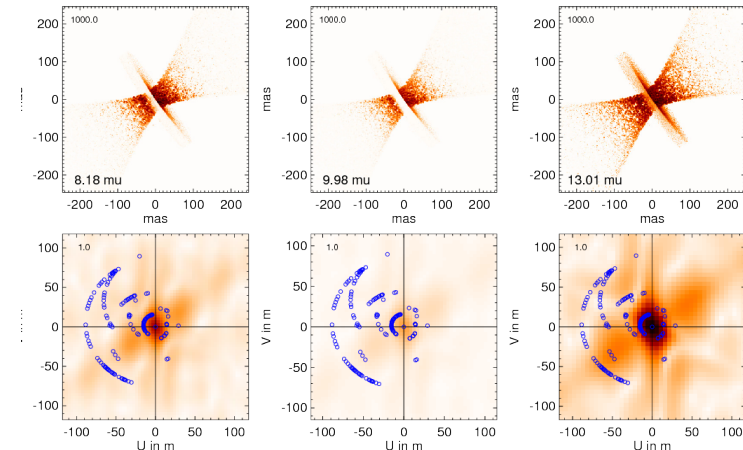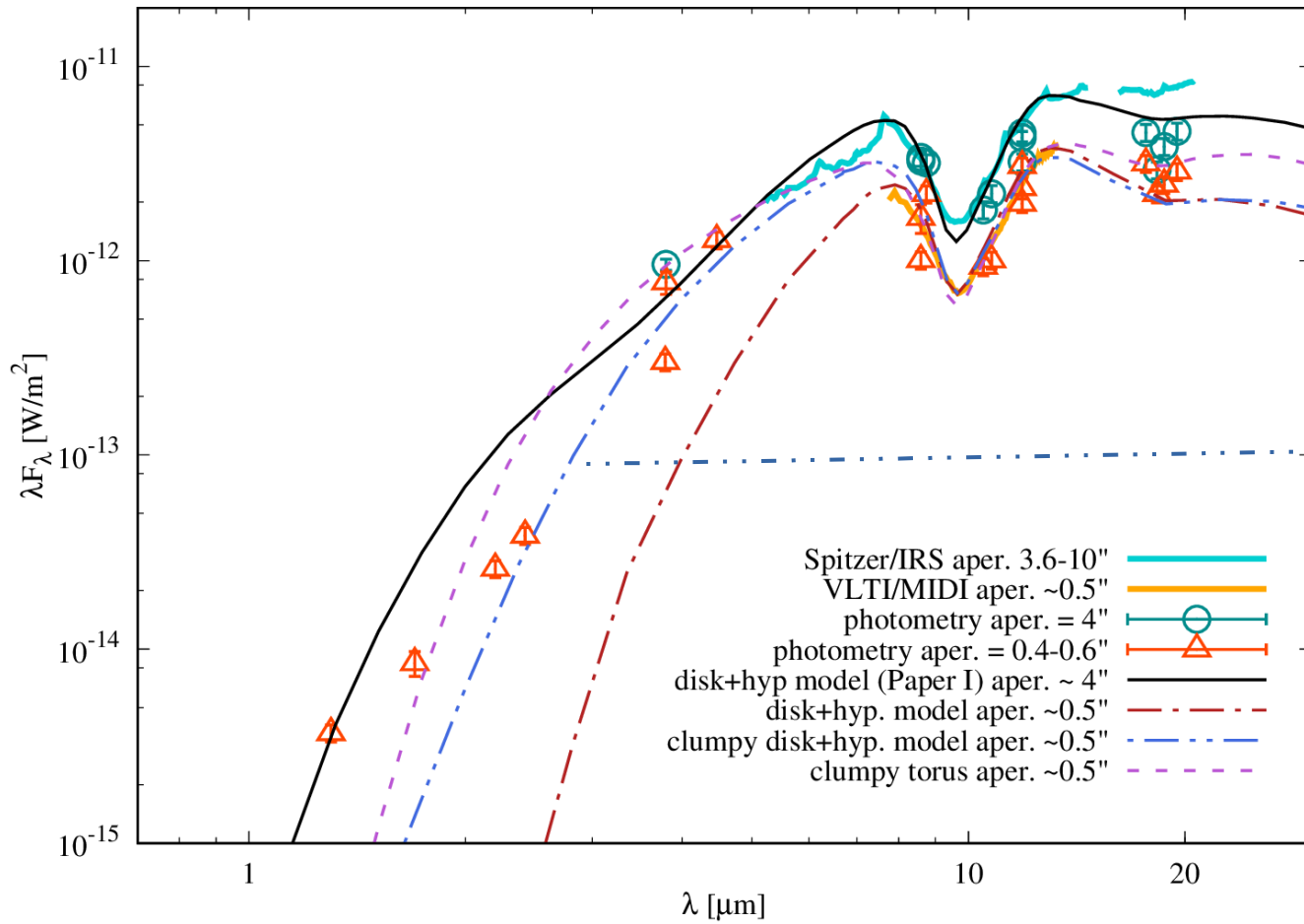

MIR good, NIR missing ✓ ✗   VLTI/MIDI: good ✓

disk+clumpy wind
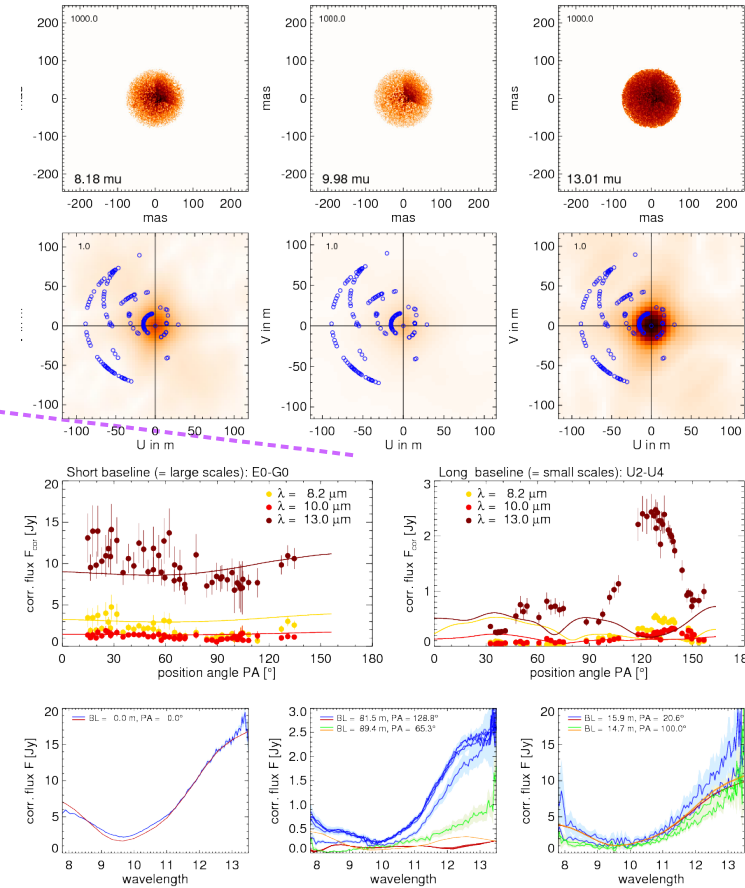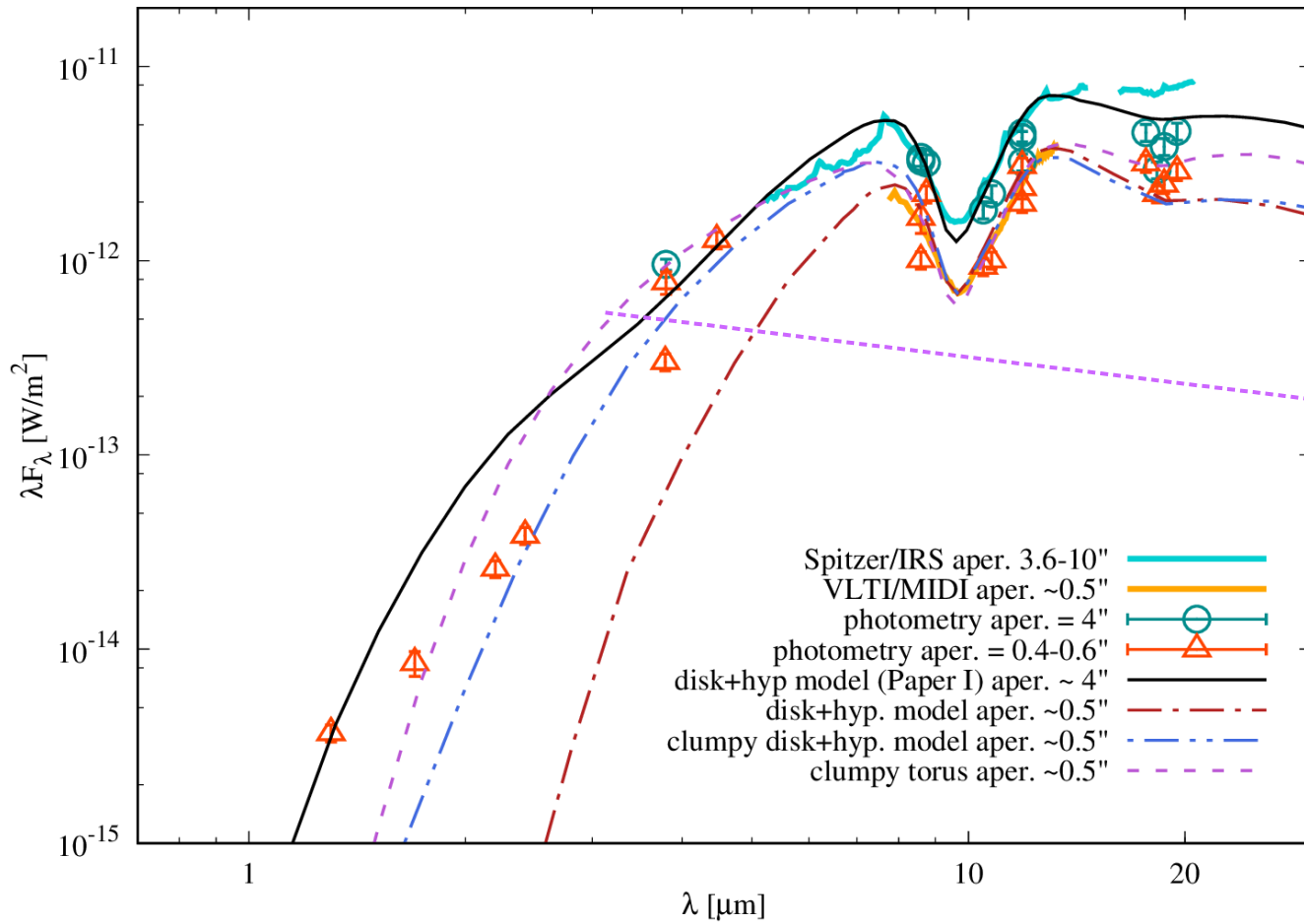
Stalevski, Tristram & Asmus (2019)

MIR good, NIR good

VLTI/MIDI: good

clumpy torus

Legend (SED plot):
- Spitzer/IRS aper. 3.6-10"
- VLTI/MIDI aper. ~0.5"
- photometry aper. = 4"
- photometry aper. = 0.4-0.6"
- disk+hyp model (Paper I) aper. ~ 4"
- disk+hyp. model aper. ~0.5"
- clumpy disk+hyp. model aper. ~0.5"
- clumpy torus aper. ~0.5"

Axes: λF_λ [W/m^2] vs λ [µm]

MIR good, NIR good

VLTI/MIDI: ugly