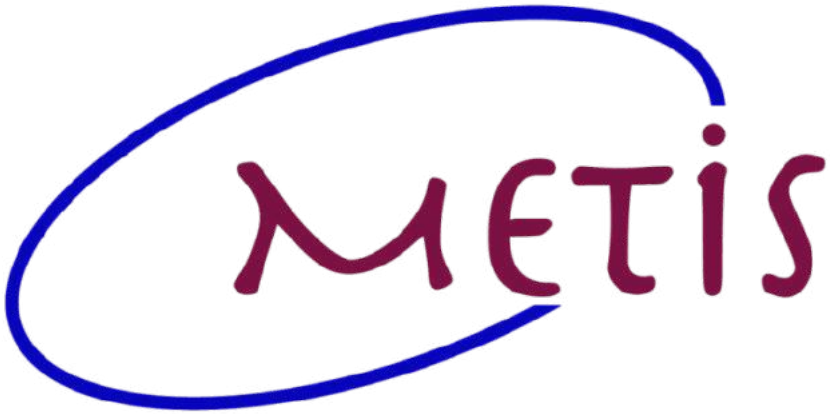
ELT/METIS and the AGN torus

Burtscher, L.H.; Baes, M.; Brandl, B.R.; Le Floc'h, E.; Orban de Xivry, G.; Zeilinger, W.



ELT/METIS and the AGN torus

Leo Burtscher

for the METIS collaboration

https://metis.strw.leidenuniv.nl

IR2022

@ELT_METIS

centra
center for astrophysics and gravitation

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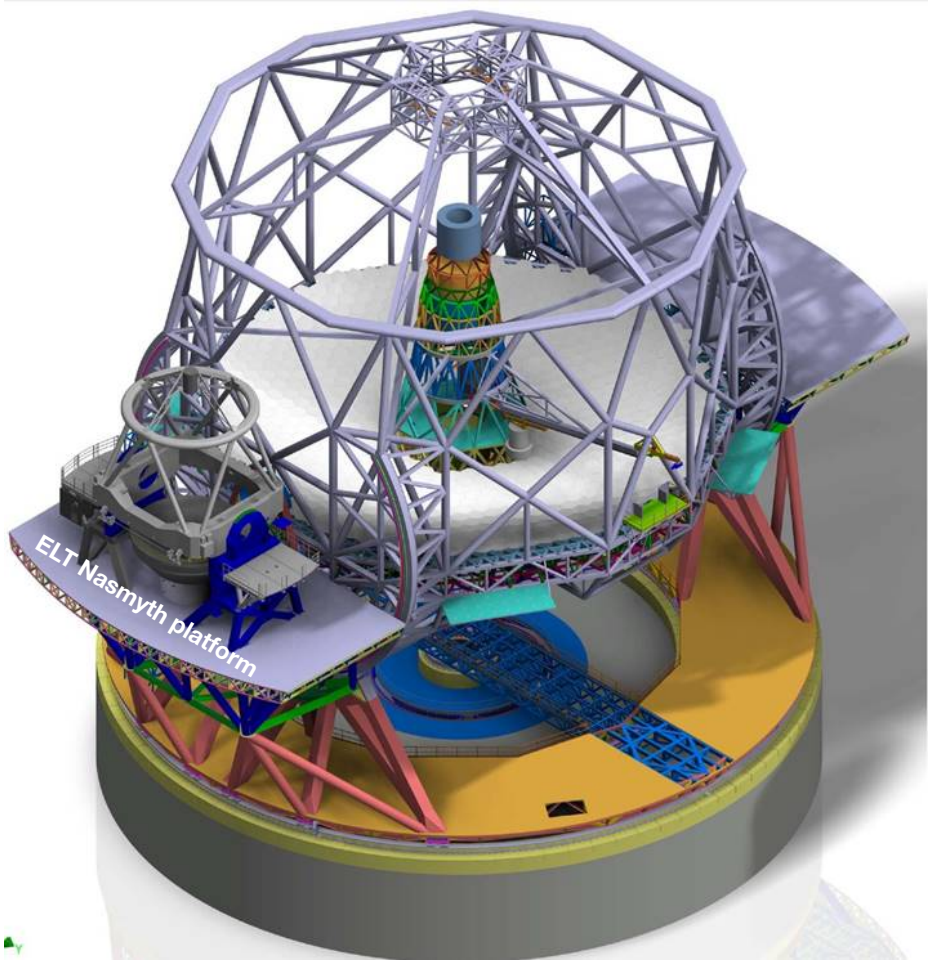
KU LEUVEN

ETH zürich

To put it in perspective…

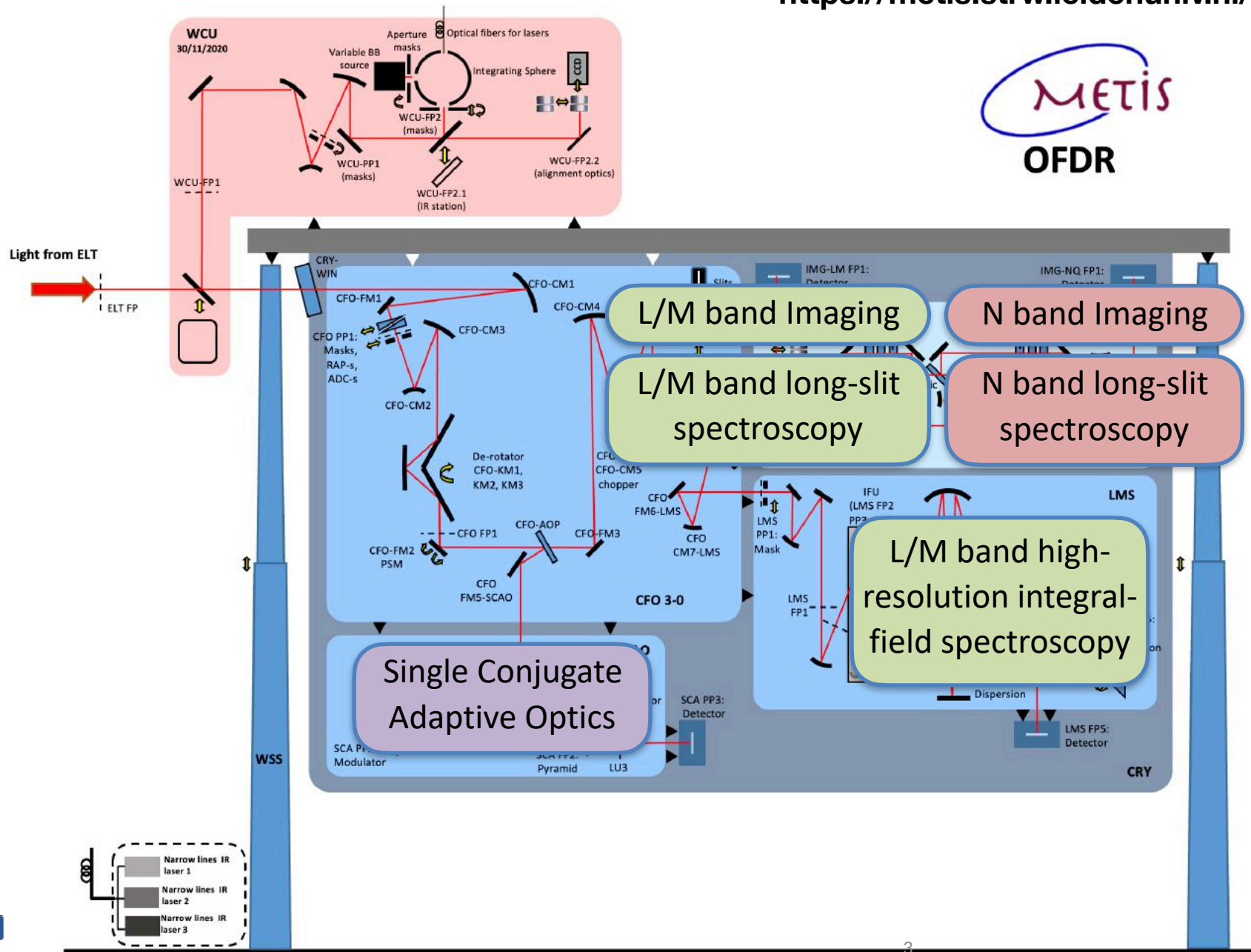


Mid Infrared ELT Imager and Spectrograph

https://metis.strw.leidenuniv.nl/

METIS

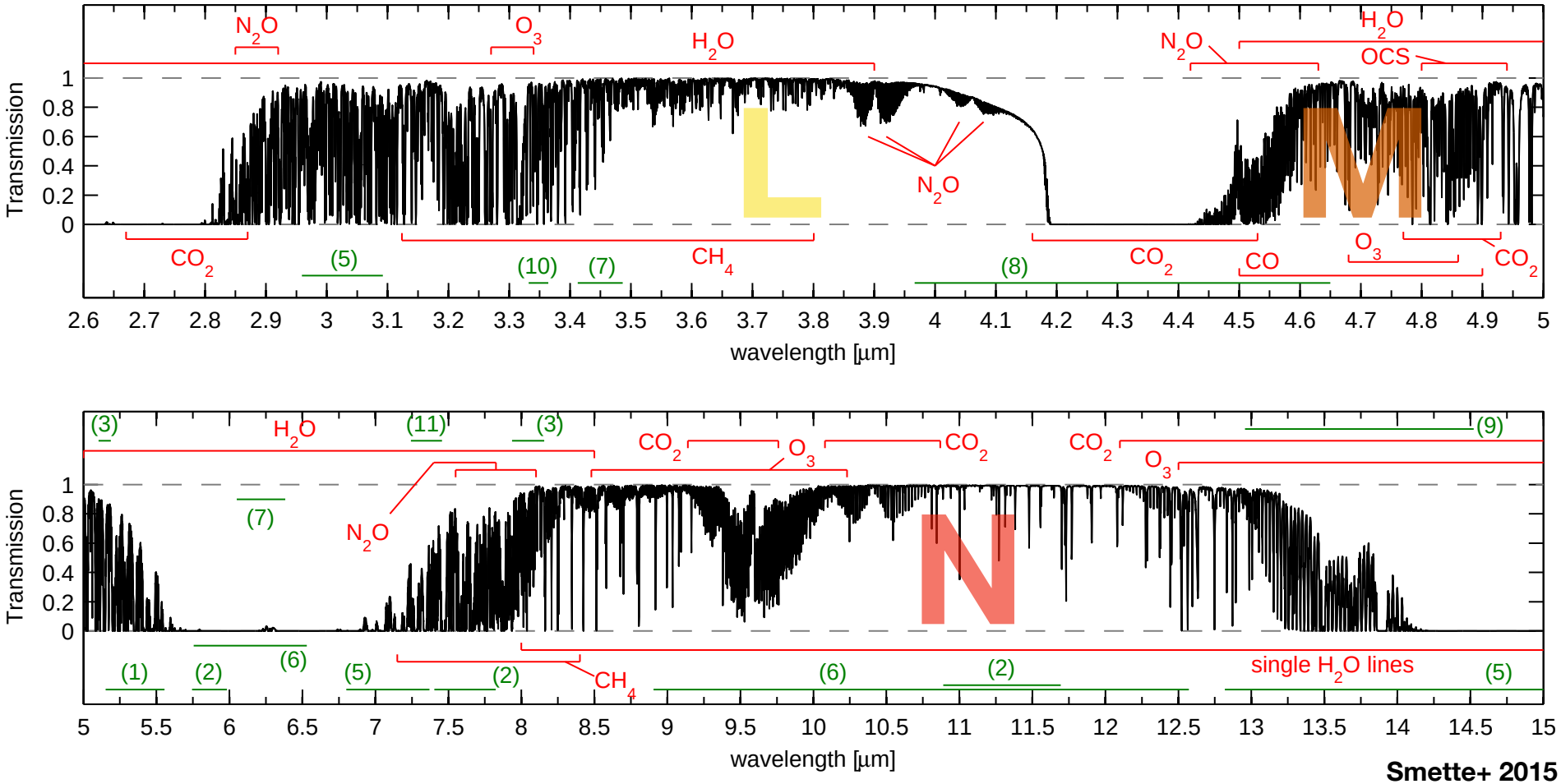
OFDR



Nasmyth platform

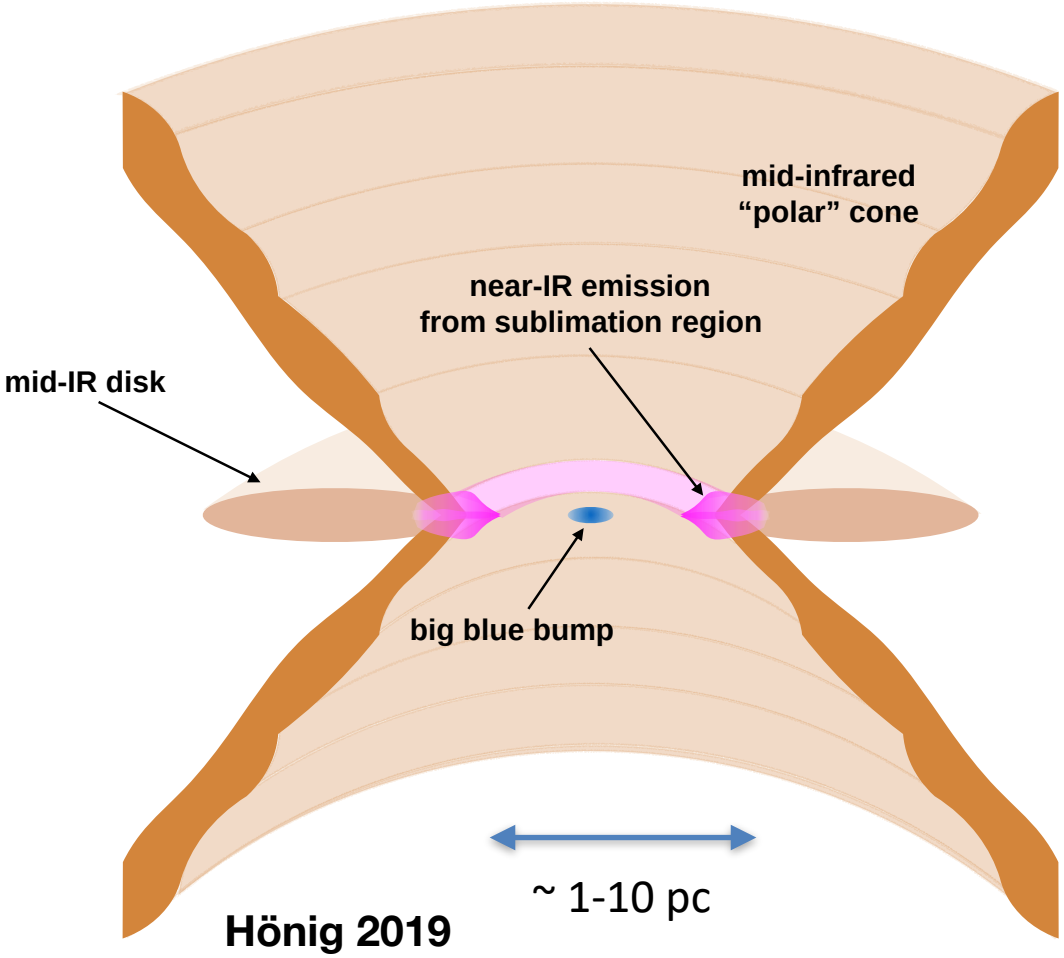
METIS in a nutshell

Diffraction-limited imaging and spectroscopy in L,M,N (Q) bands
High spectral resolution IFU (R ~ 100,000) in L and M bands
Angular resolution: 23 mas (3.5 μm) / 65 mas (10 μm)



Smette+ 2015

The AGN torus region – mission accomplished?



Hönig 2019

Why are some galactic nuclei active, and others not?

How is energy fed back from the AGN to the host galaxy?

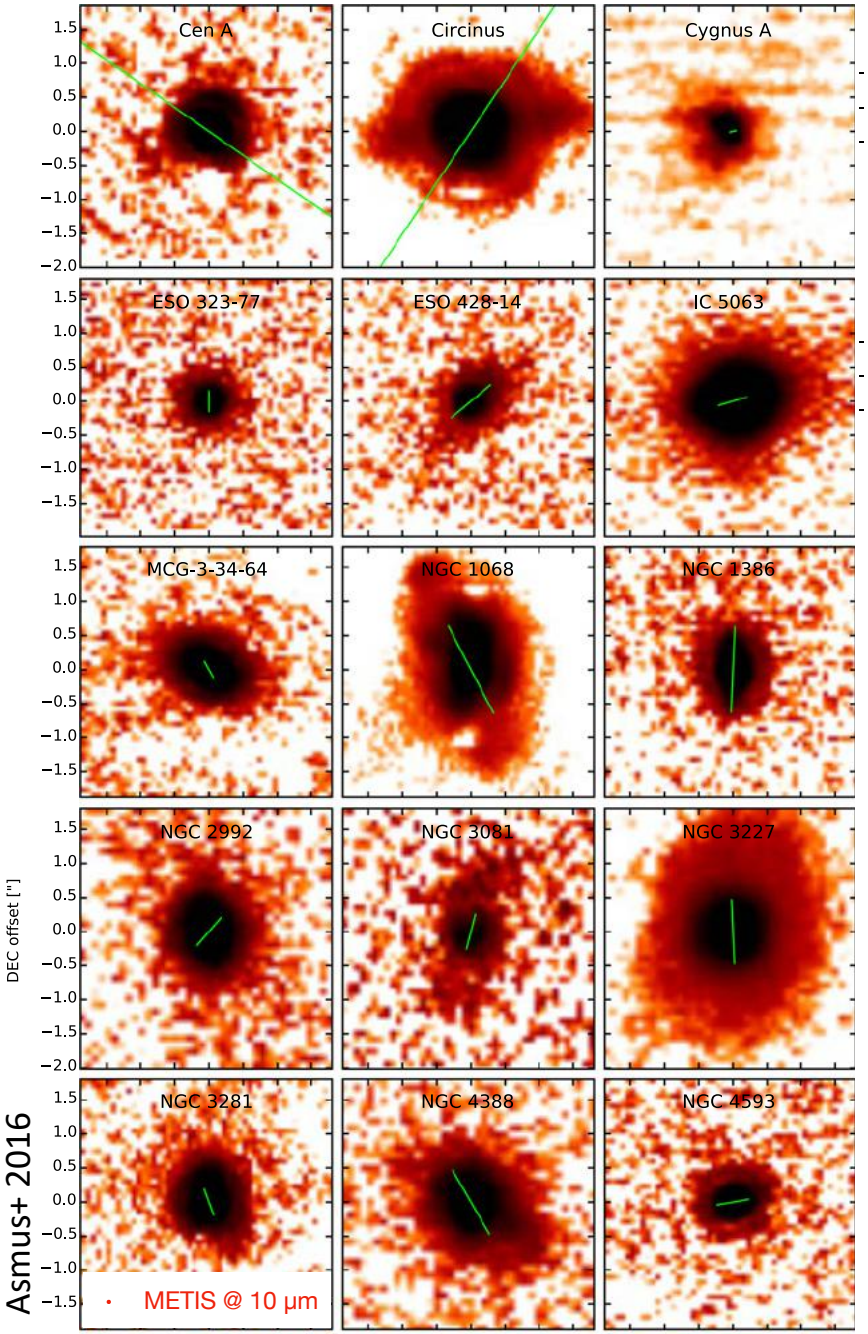
Is the „polar dust“ part of the outflow or just illuminated dust? Has it been re-processed?

What is the physical size and structure of the AGN-heated dust?

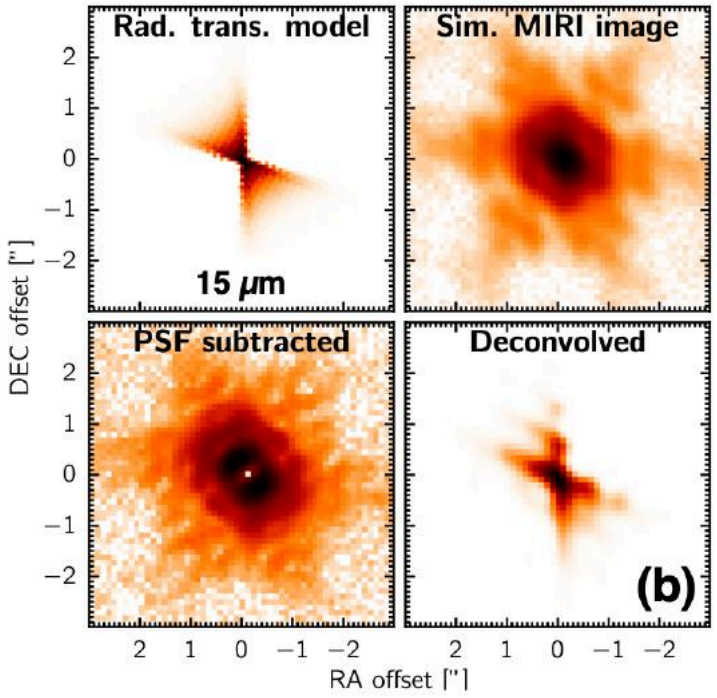
What is the kinematics of the ionised (and molecular?) gas in the nuclei of active galaxies?

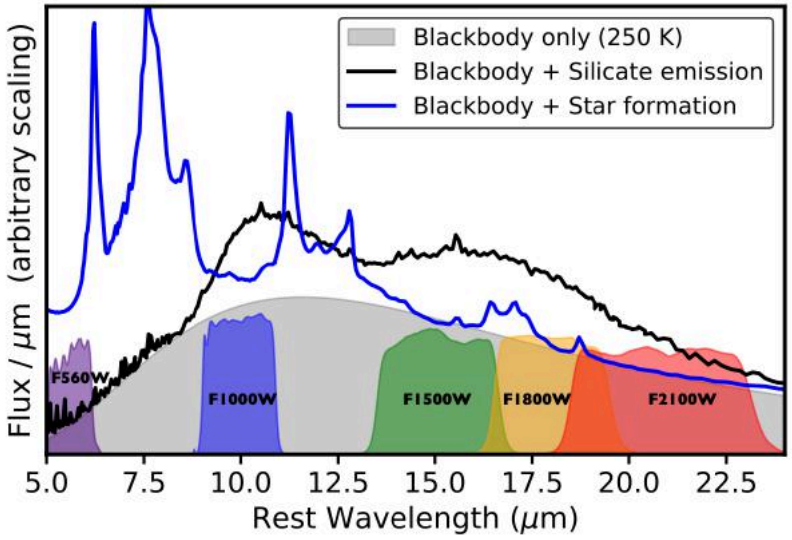
Mid Infrared ELT Imager and Spectrograph

VLT/VISIR



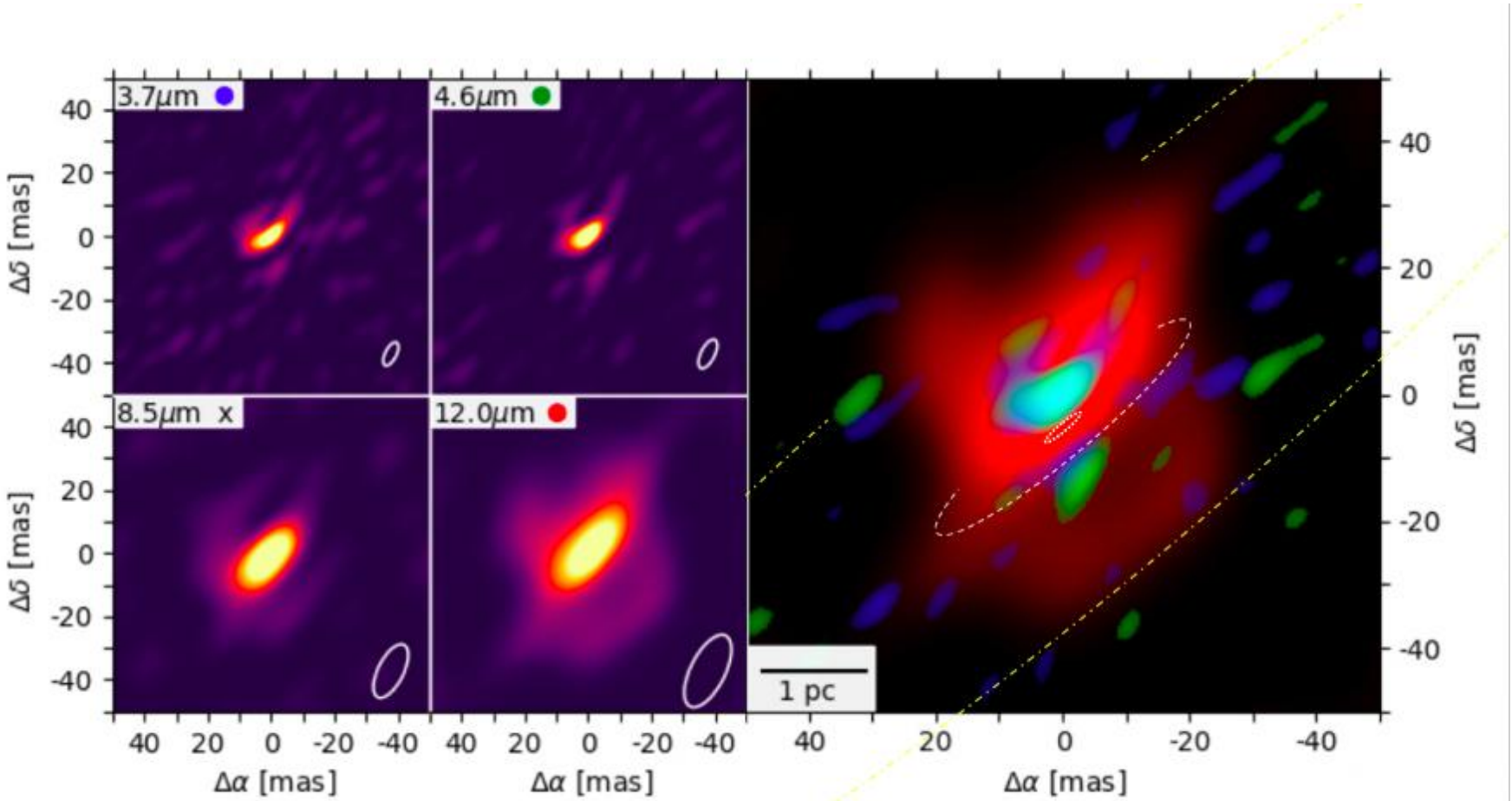
JWST/MIRI





JWST Cycle 1 programme: Rosario, Burtscher, Hönig et al.

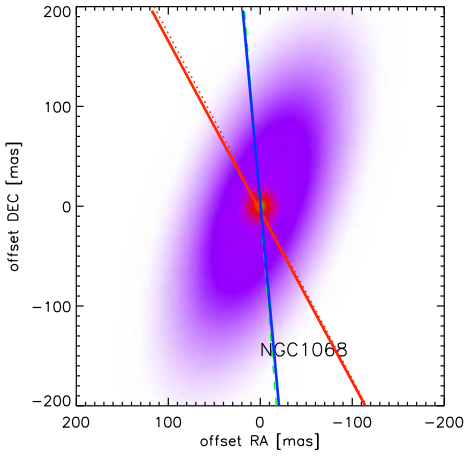
The pc-scale dusty torus: a VLTI target

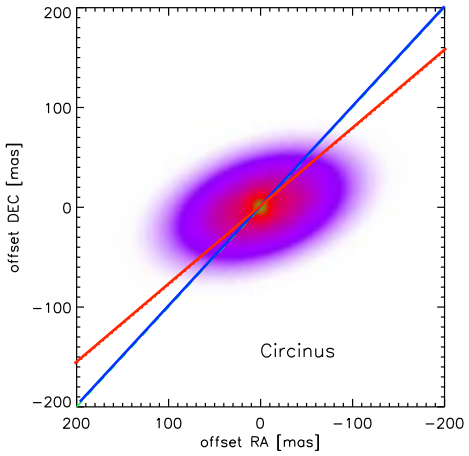


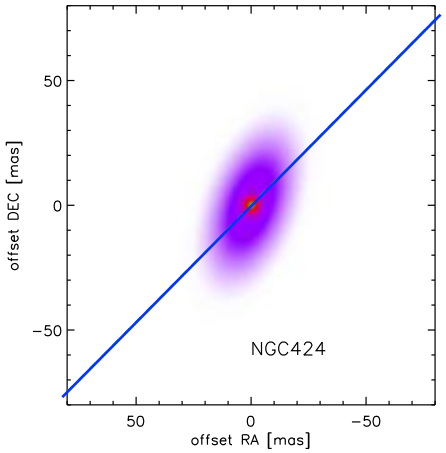
VLTI/MATISSE image of NGC 1068: Gámez Rosas et al. 2021 (Nature — published yesterday!)

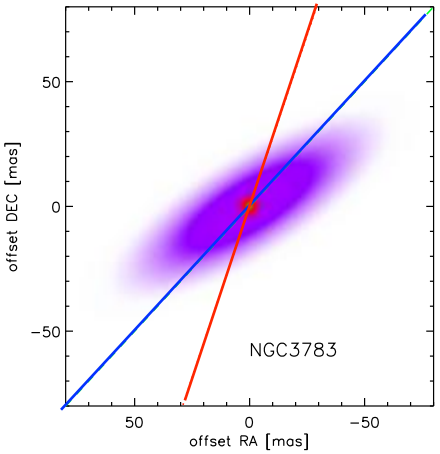
Mid Infrared ELT Imager and Spectrograph

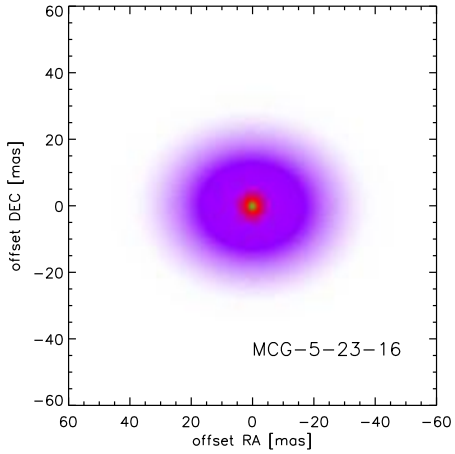
Most AGN „tori“ are oriented along the polar axis

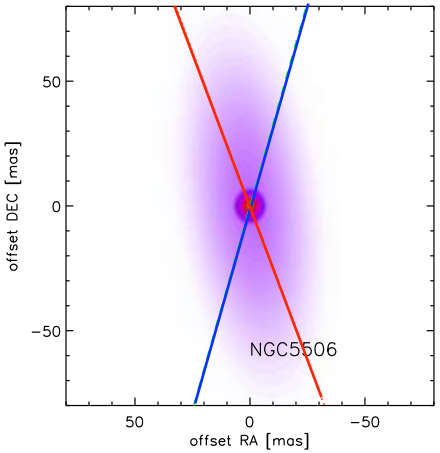


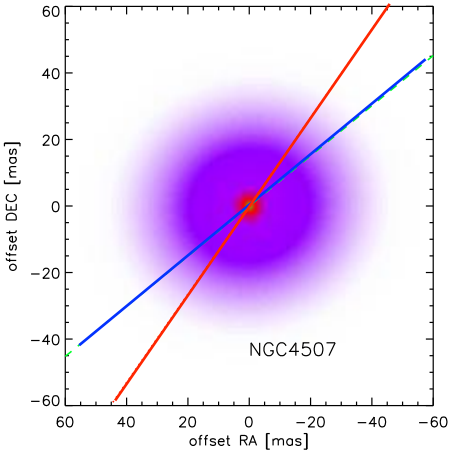












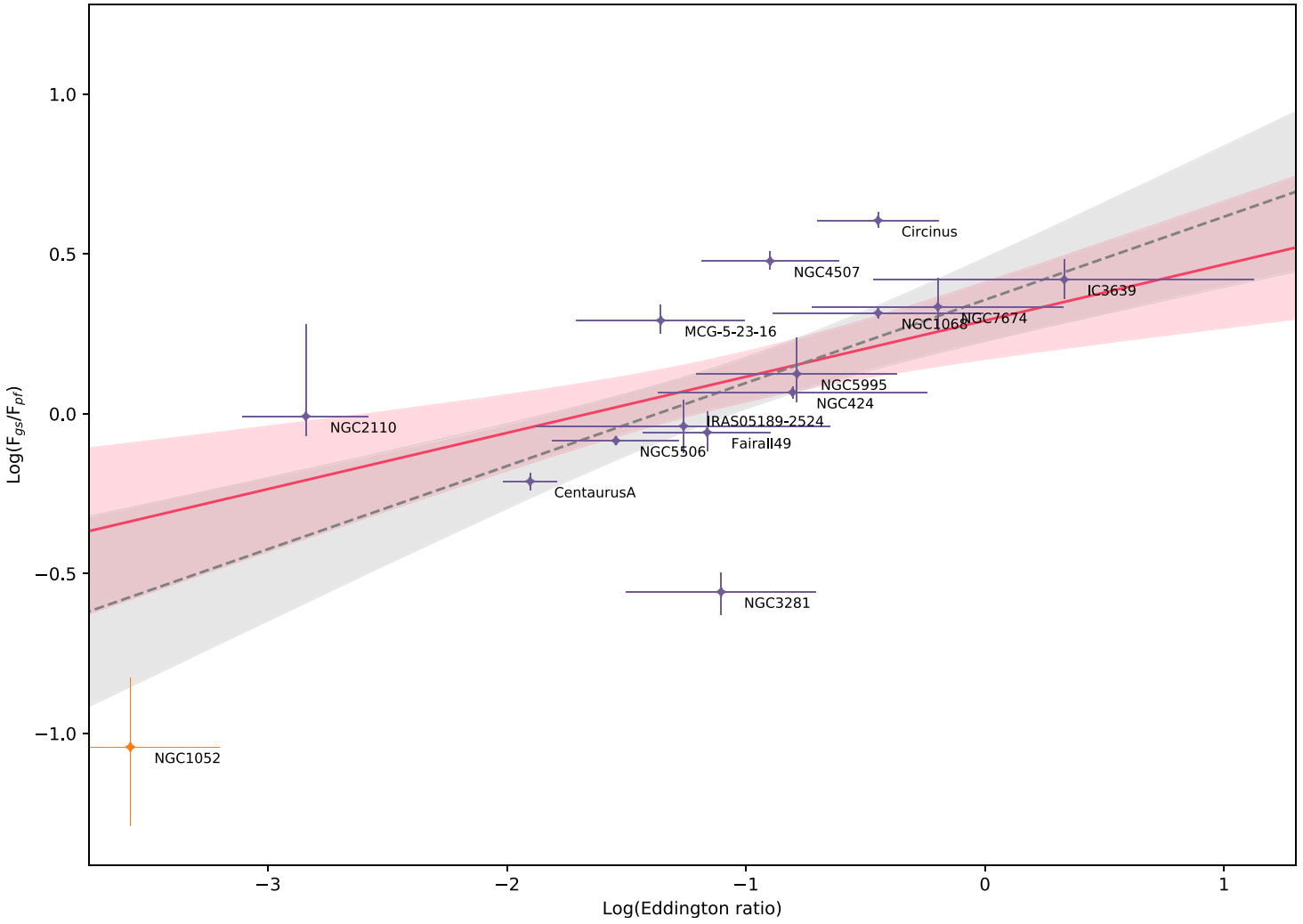
optical polarization

ionization cone

Lopez-Gonzaga et al. 2016; see also Hönig+ 2012, 2013, Tristram+ 2014, Lopez-Gonzaga+ 2014, Leftley+ 2018

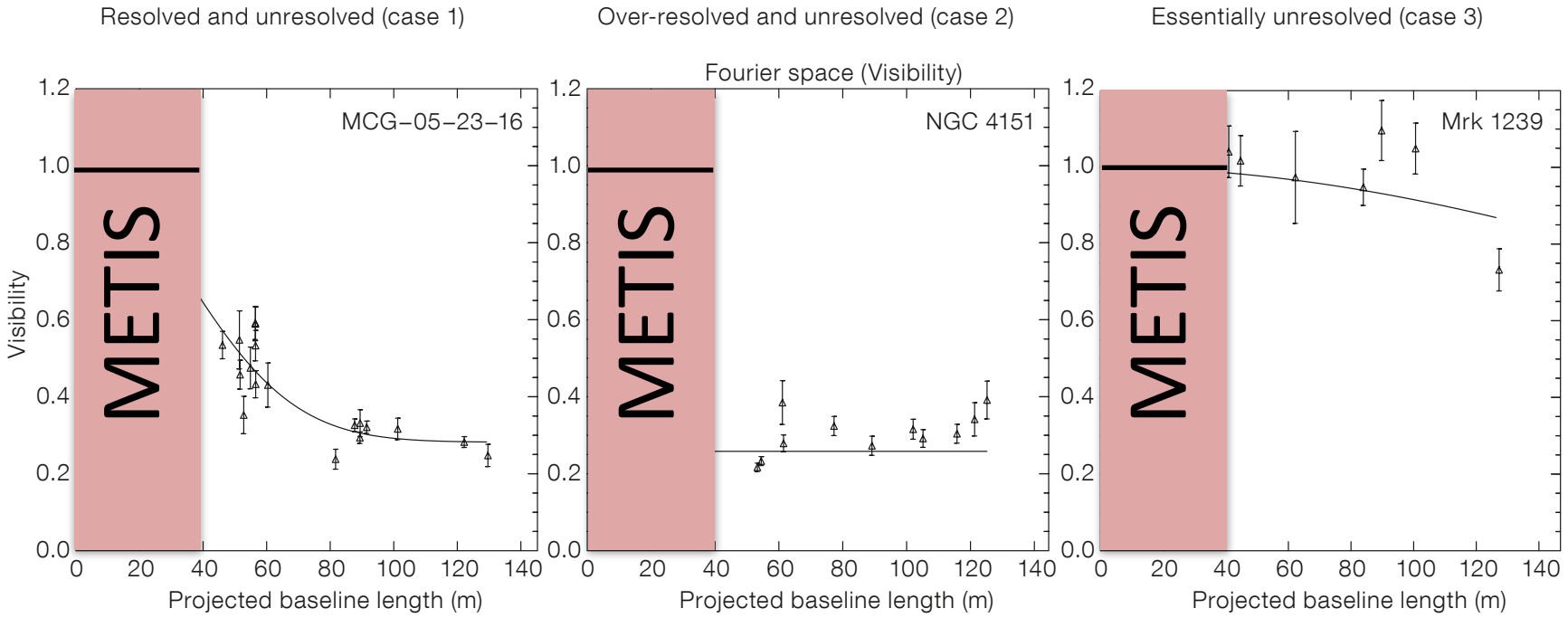
N band Imaging

A correlation between extended extended flux and Eddington ratio?



Leftley+ 2019

VLTI observations of nearby AGNs



Burtscher+ 2013

Mid Infrared ELT Imager and Spectrograph

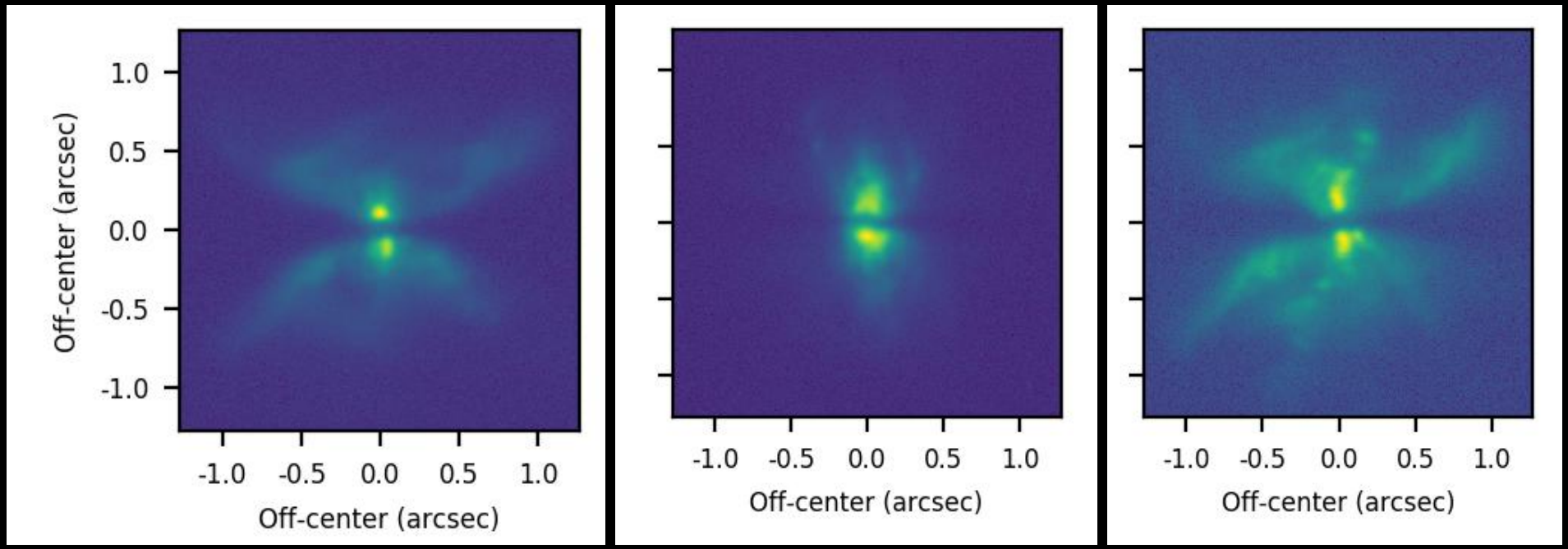
N band Imaging | L/M band Imaging

SimMETIS simulations

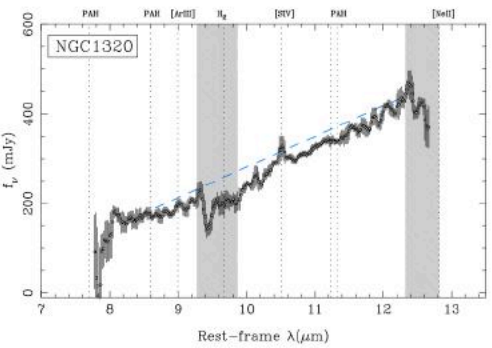
Radiation driven AGN feedback as seen by METIS

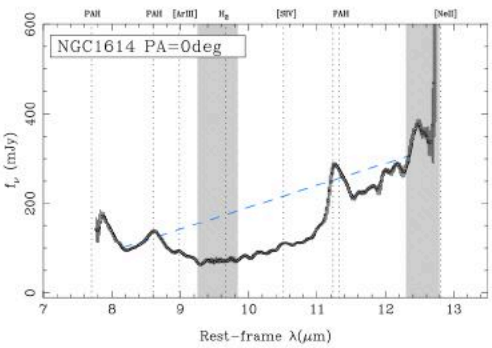
Eddington ratio

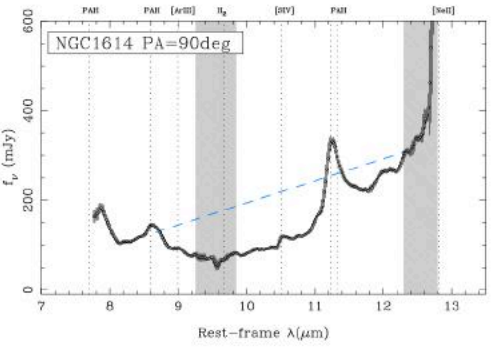
λ = 1% | **λ = 10%** | **λ = 20%**

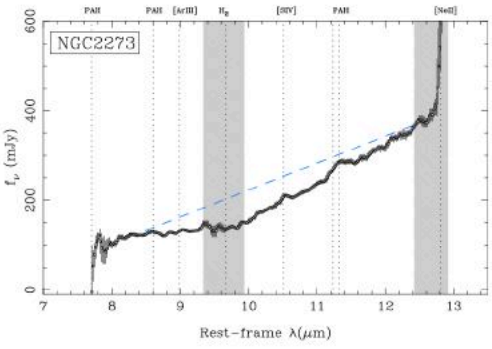


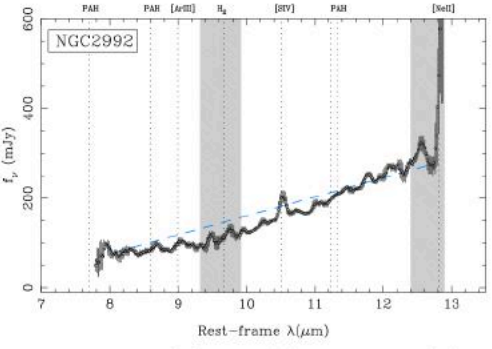
hydrodynamical model: Schartmann + 2014
SimMETIS simulation by Violeta Gamez-Rosas

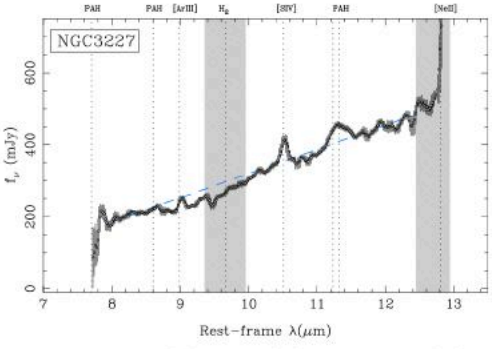


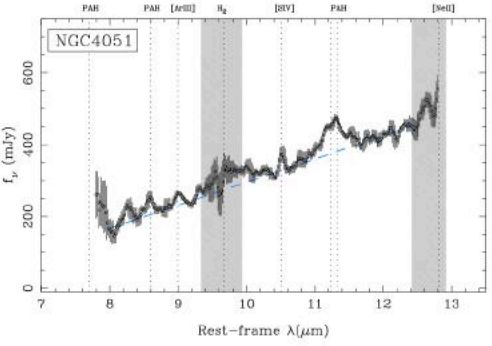


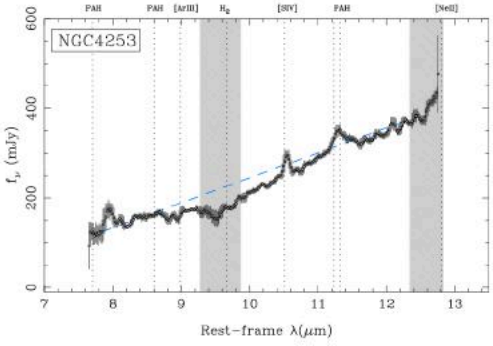












Alonso Herrero+ 2016

The mid-IR spectroscopic menu

recombination lines: Br α 4.05 μm, Pf β 4.65 μm

coronal lines [Ar VI] 3.67 μm, [Si IX] 3.94 μm, [Ca VII] 4.09 μm, [Ca V] 4.16 μm

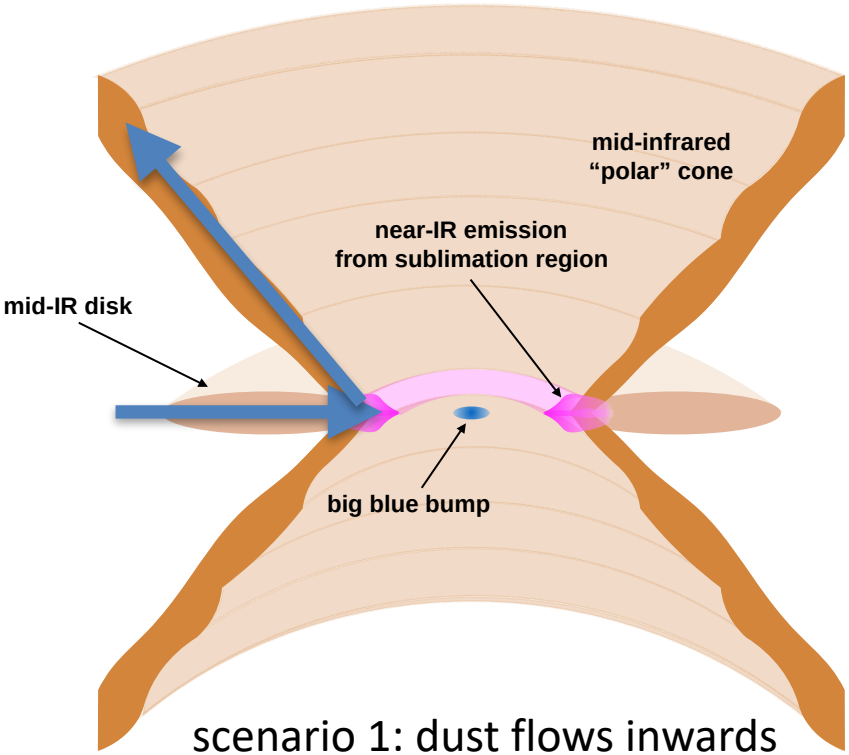
molecular transitions: hydrocarbons, CO fundamental ro-vibrational band (+isotopes?) 4.6 - 5 μm, warm H_2, PAHs: 3.3, 8.6, 11.3 μm

more NLR lines: [Ne II] 12.8 μm, [S IV] 10.5 μm,]Ar III] 8.99 μm

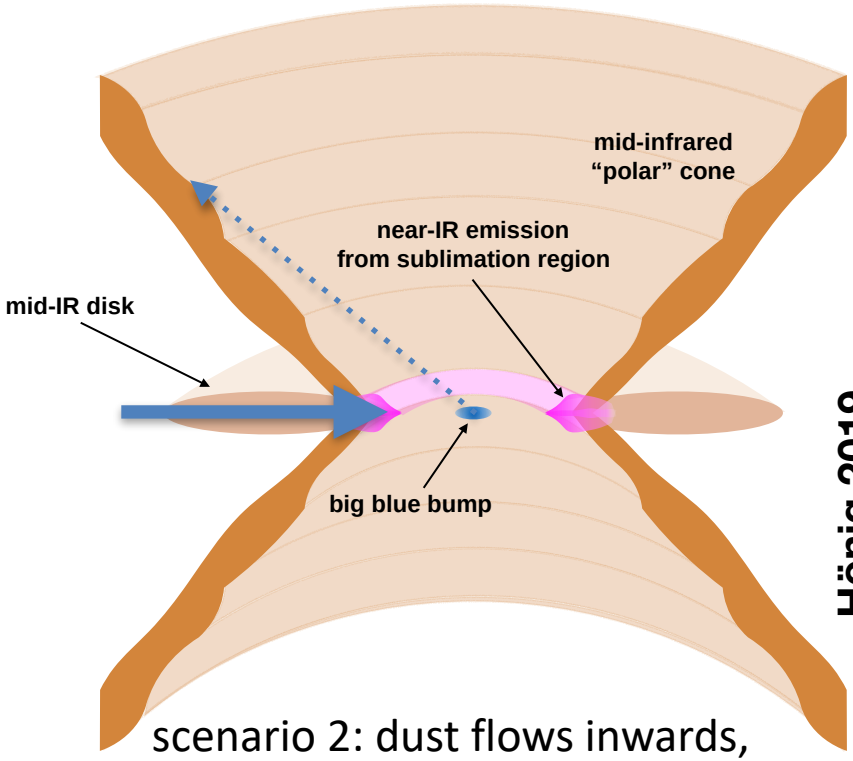
Silicate absorption feature (+ more dust species): 9.7 μm

What is the nature of the polar dust?

N band long-slit spectroscopy



scenario 1: dust flows inwards until the sublimation zone, gets lifted off the midplane by IR radiation pressure



scenario 2: dust flows inwards, gets destroyed, UV radiation illuminates host galaxy dust

Hönig 2019

Mid Infrared ELT Imager and Spectrograph

Hidden broad-line regions

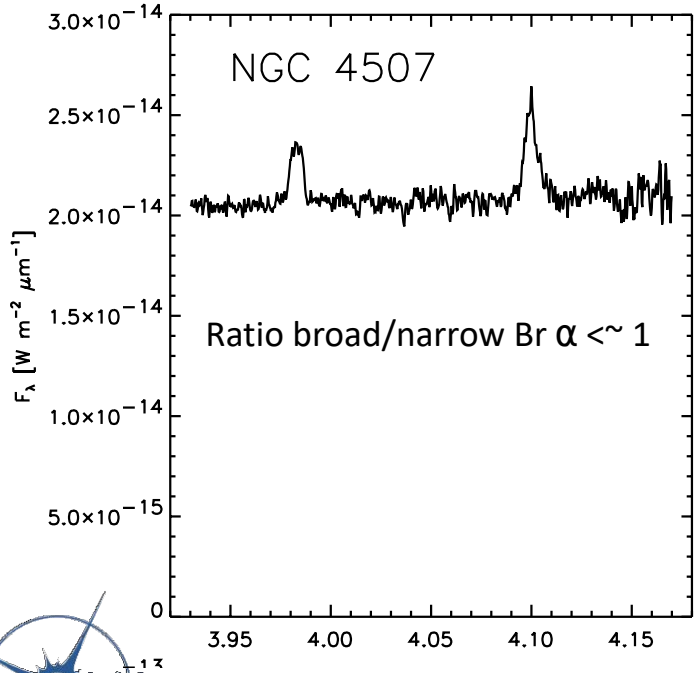
Br α (4.05 μm) **vs. Br ɣ** (2.166 μm): Sensitivity (for unresolved lines) ~ 30x better in HARMONI than METIS, but α ~ 3x brighter than ɣ and extinction ~ 2-3x lower

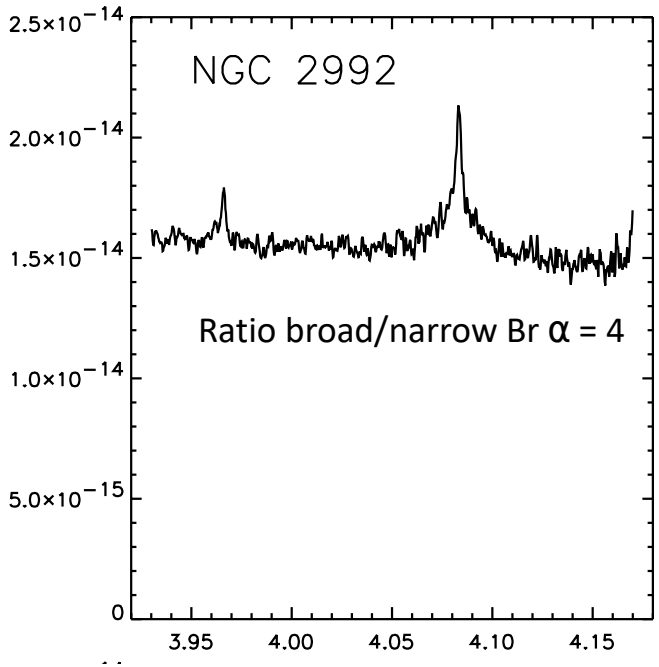
Combine METIS + HARMONI for better **extinction + excitation** measurements (as in e.g. Schnorr-Müller+ 2016)

Use METIS LMS for **spectro-astrometry** of obscured BLRs?

L/M band long-slit spectroscopy

L/M band high-resolution integral-field spectroscopy



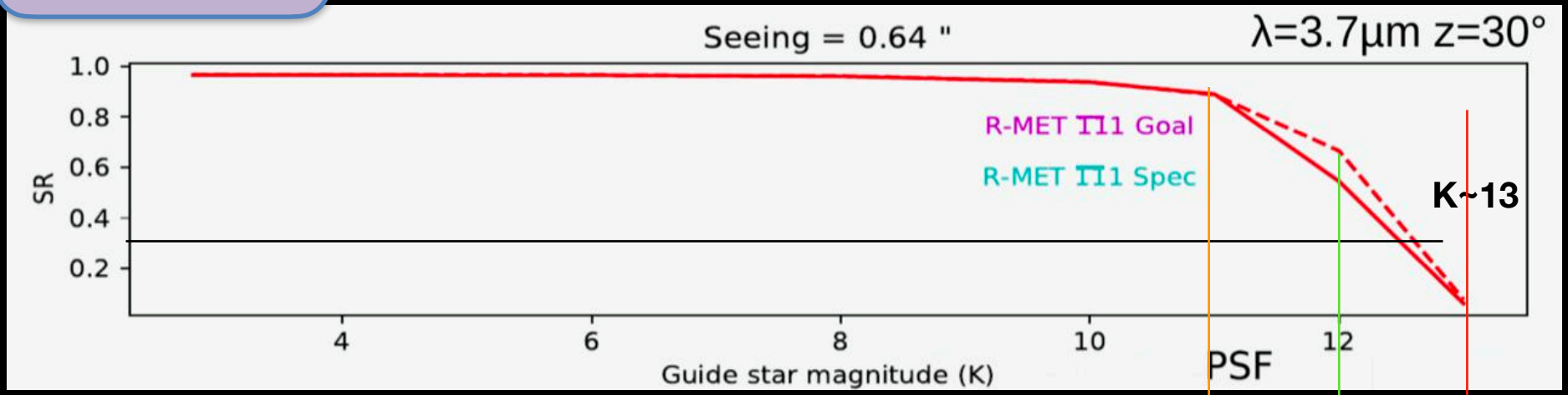


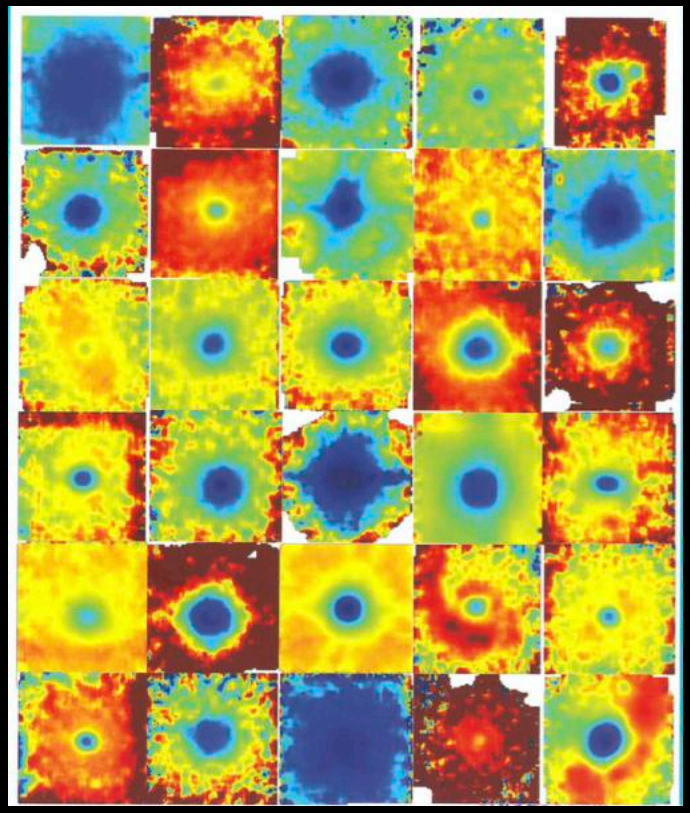
Lutz+ 2002

Mid Infrared ELT Imager and Spectrograph

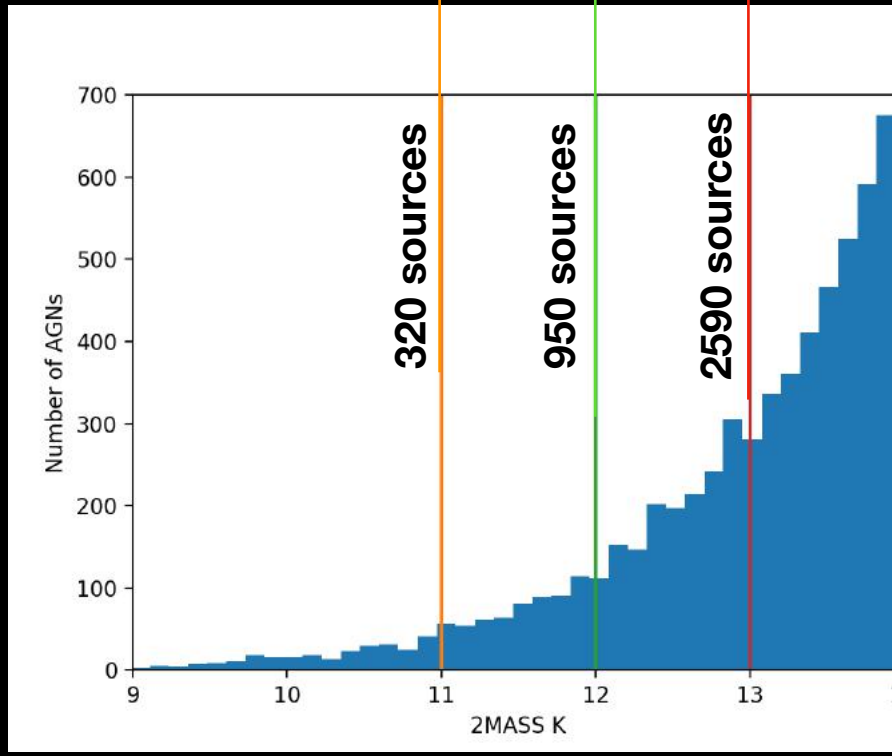
Single Conjugate Adaptive Optics

Number of observable sources





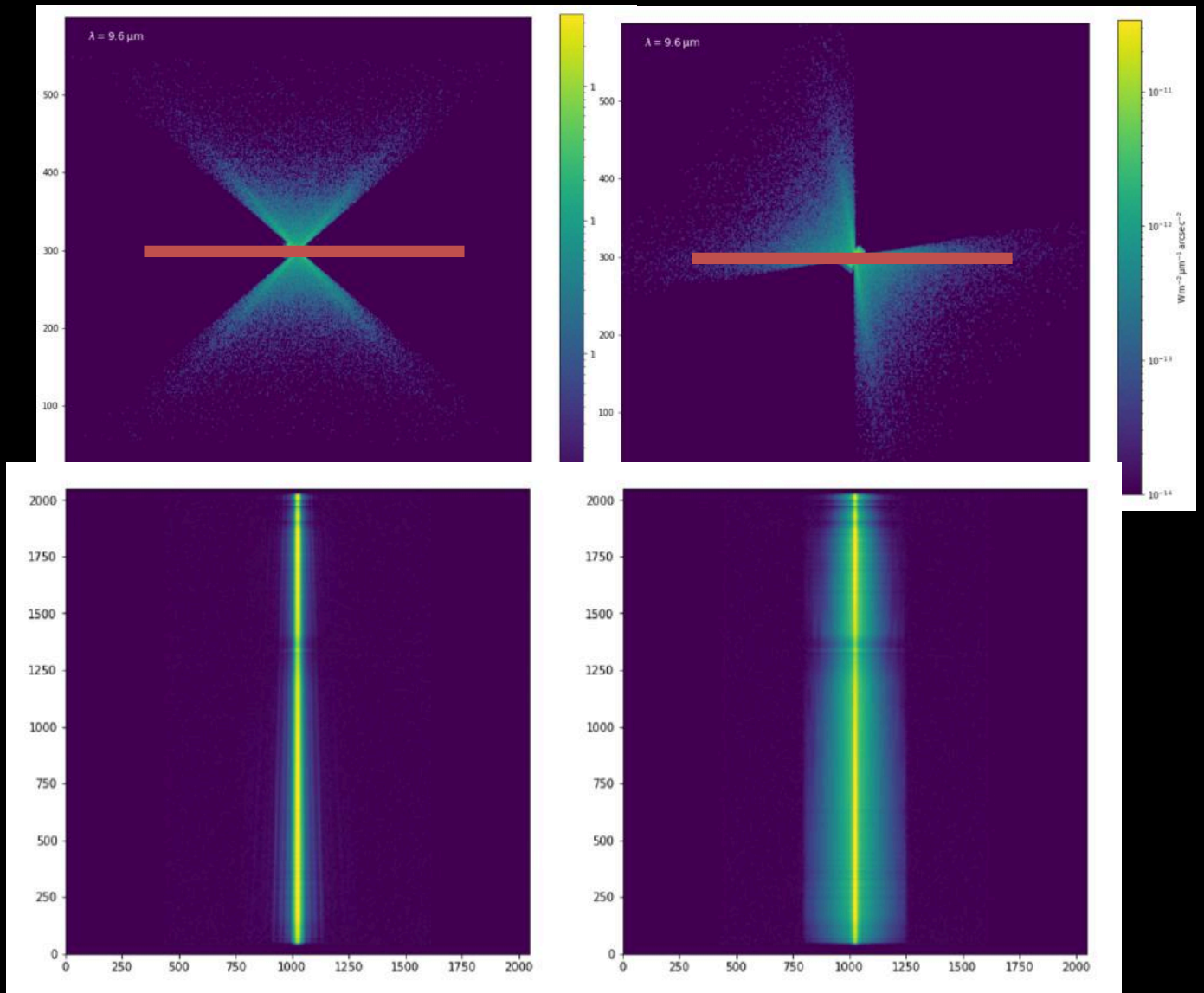
Burtscher+ 2015



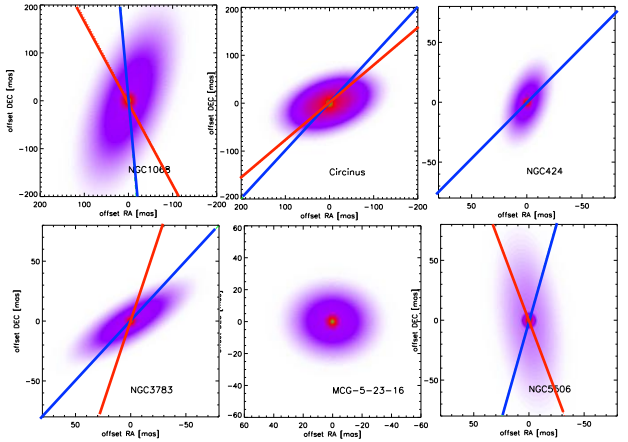
https://metis.strw.leidenuniv.nl/simmetis/

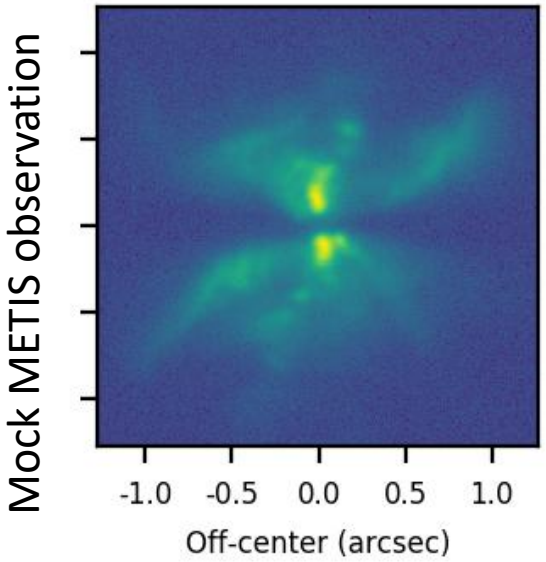
—> new version coming next week! <—

The METIS simulator



radiative transfer model: Stalevski + 2017
SimMETIS simulation by Oliver Czoske





Summary

METIS and the AGN torus

- Using **mid-IR interferometry + imaging** we have resolved the nuclear dust structures in ~ 30 nearby AGNs. On the parsec-scale, the AGN heated dust is mostly elongated along the **polar direction**.
- With **ELT/METIS** we will be able to image the base of the dusty AGN outflow in 100s of local AGNs and relate the torus phenomenology to physical parameters of the AGN.
- METIS FDR: 2022; first light: ~ 2028