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ELT/METIS and the AGN torus

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METIS

IR 2022

ELT/METIS and the AGN torus

Leo Burtscher

for the METIS collaboration

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

IR2022



@ELT_METIS



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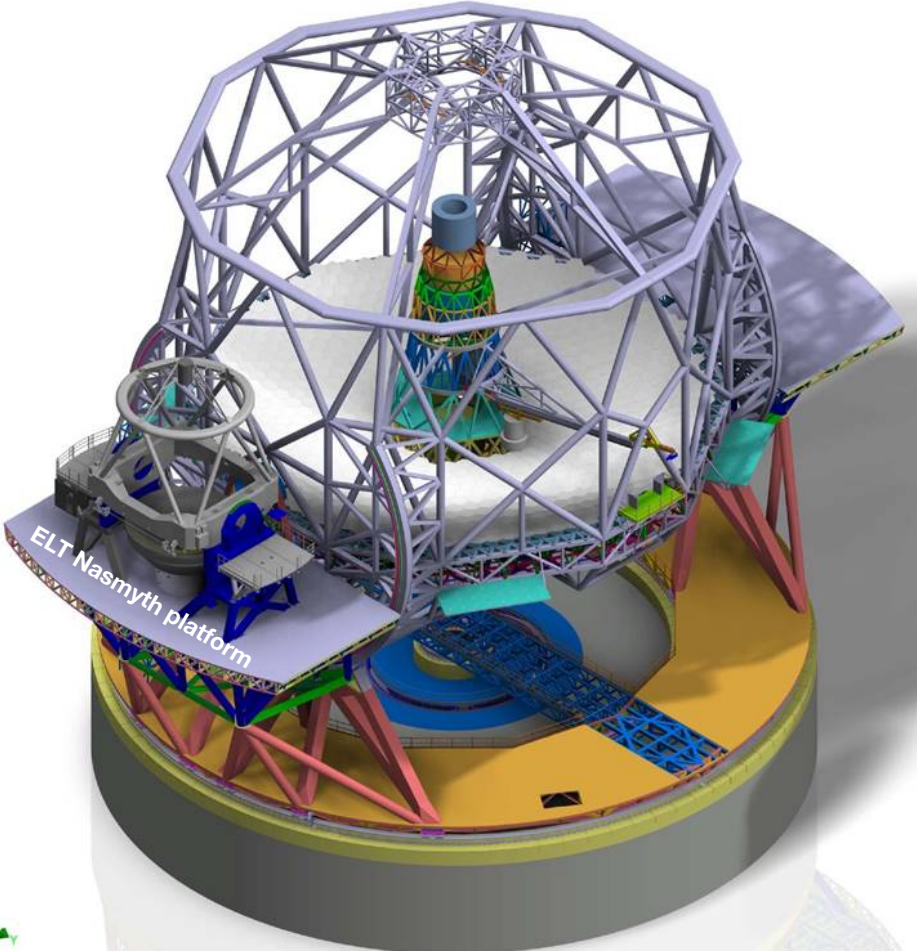
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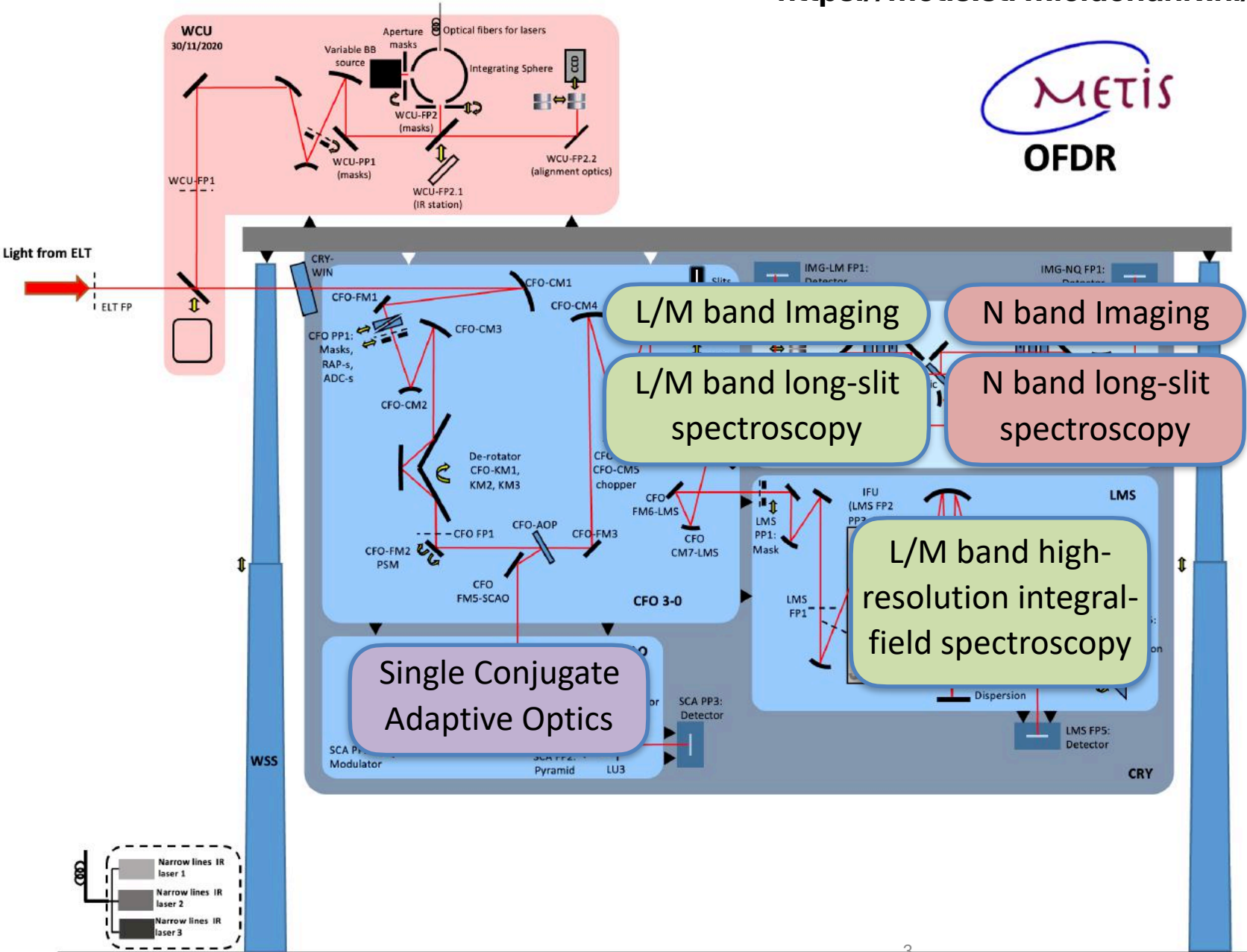


To put it in perspective...



Mid Infrared ELT Imager and Spectrograph



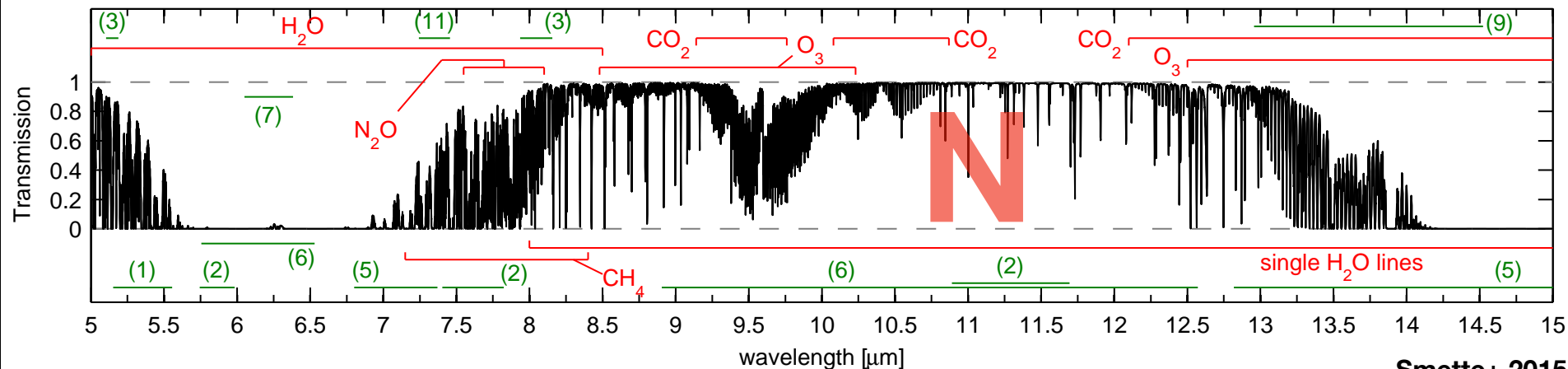
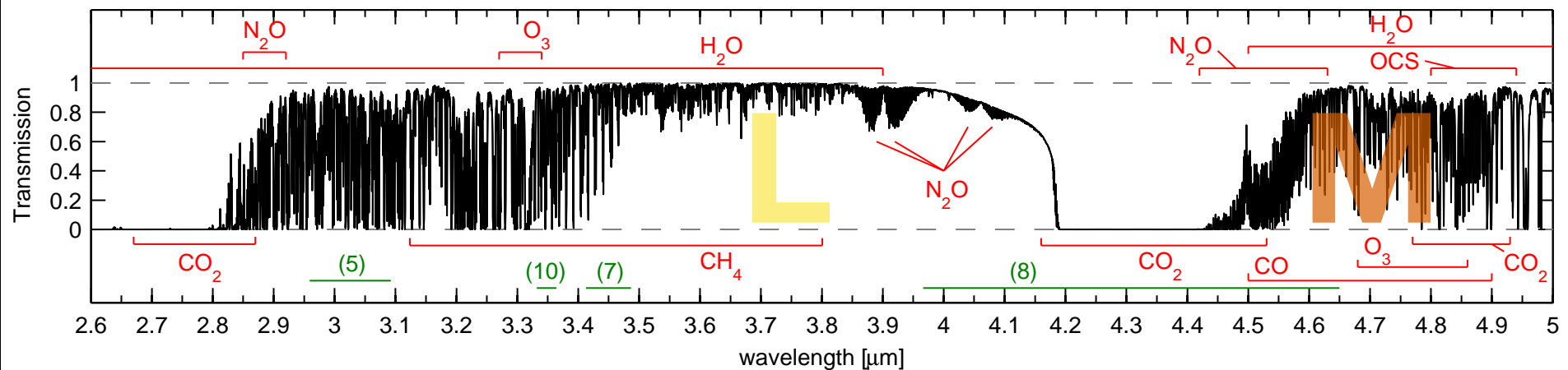


METIS in a nutshell

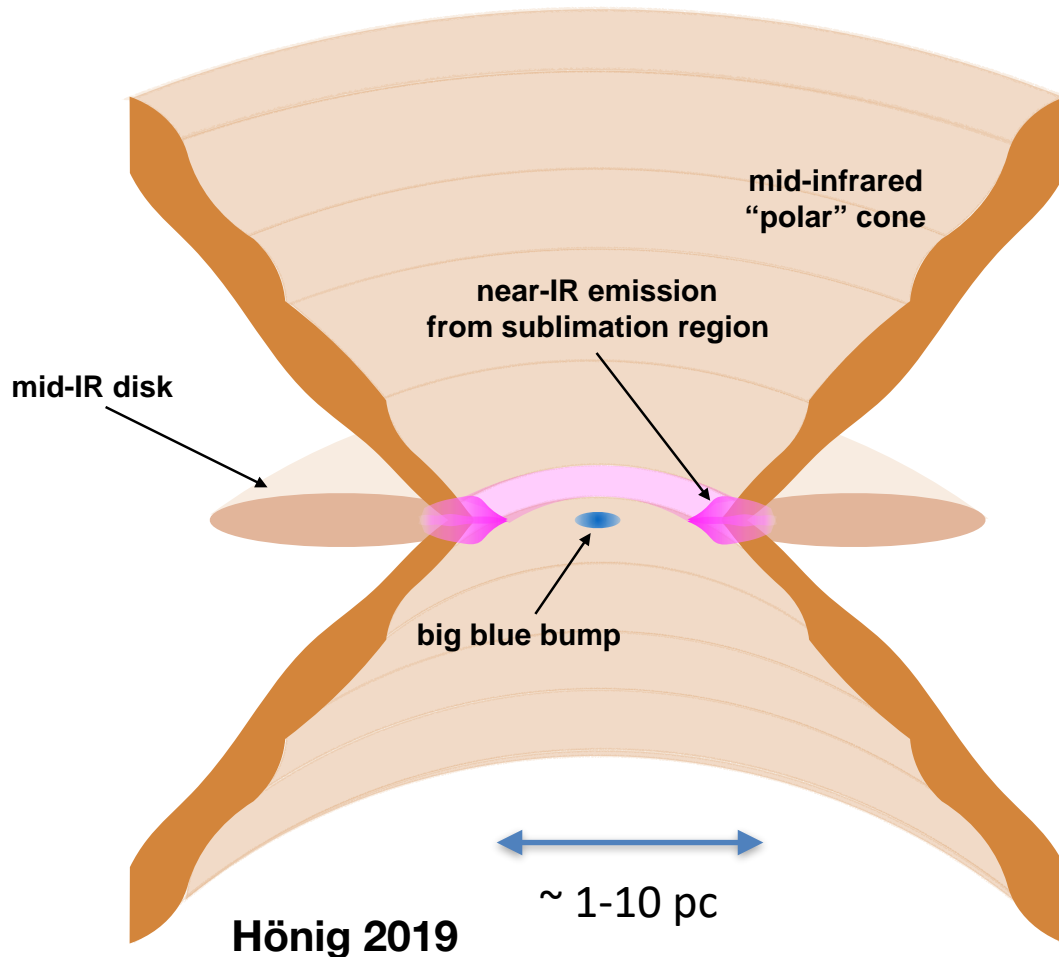
Diffraction-limited imaging and spectroscopy in L,M,N (Q) bands

High spectral resolution IFU ($R \sim 100,000$) in L and M bands

Angular resolution: 23 mas ($3.5 \mu\text{m}$) / 65 mas ($10 \mu\text{m}$)



The AGN torus region – mission accomplished?



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?**

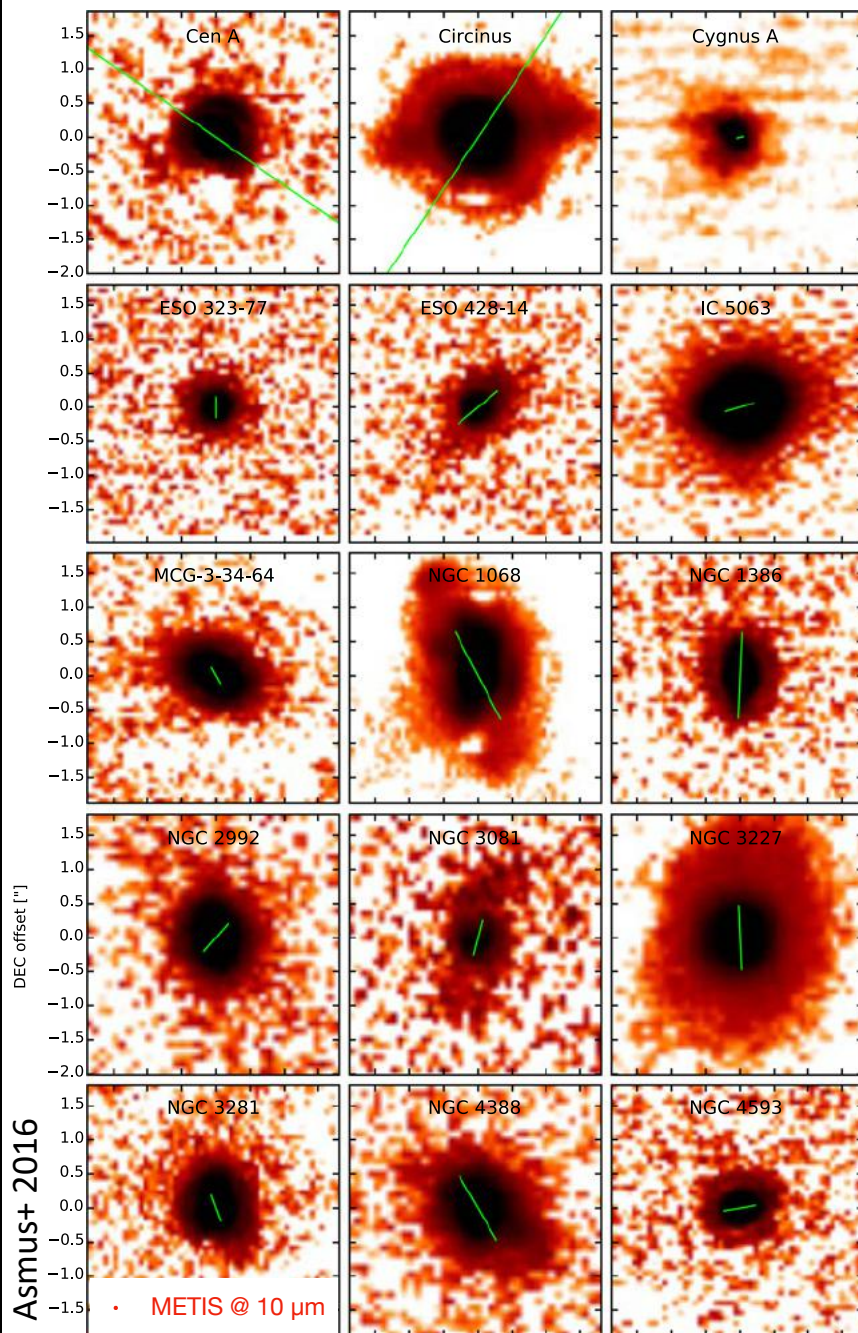
What is the physical size and structure of the AGN-heated dust?

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

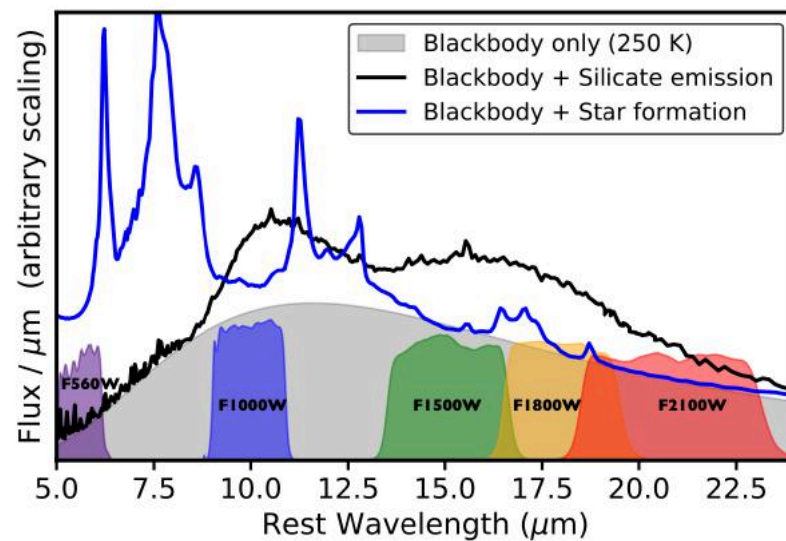
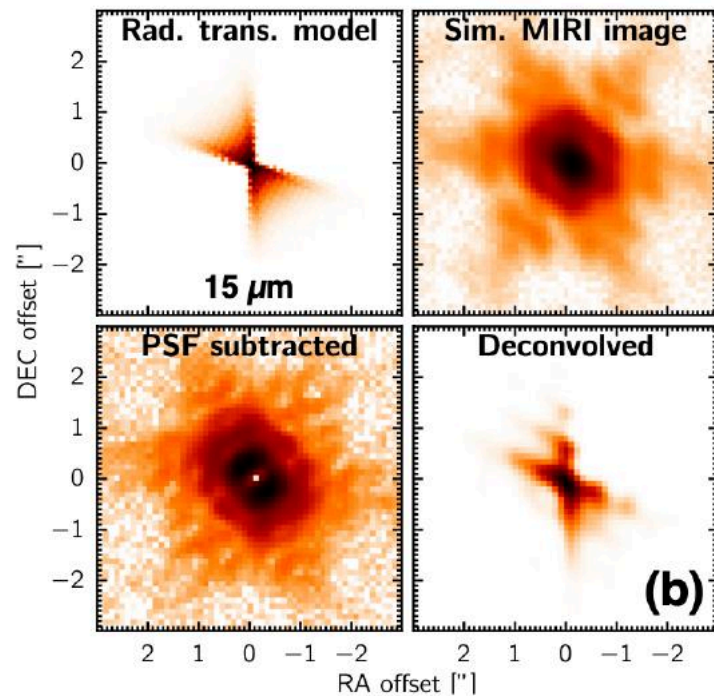
Mid Infrared ELT Imager and Spectrograph



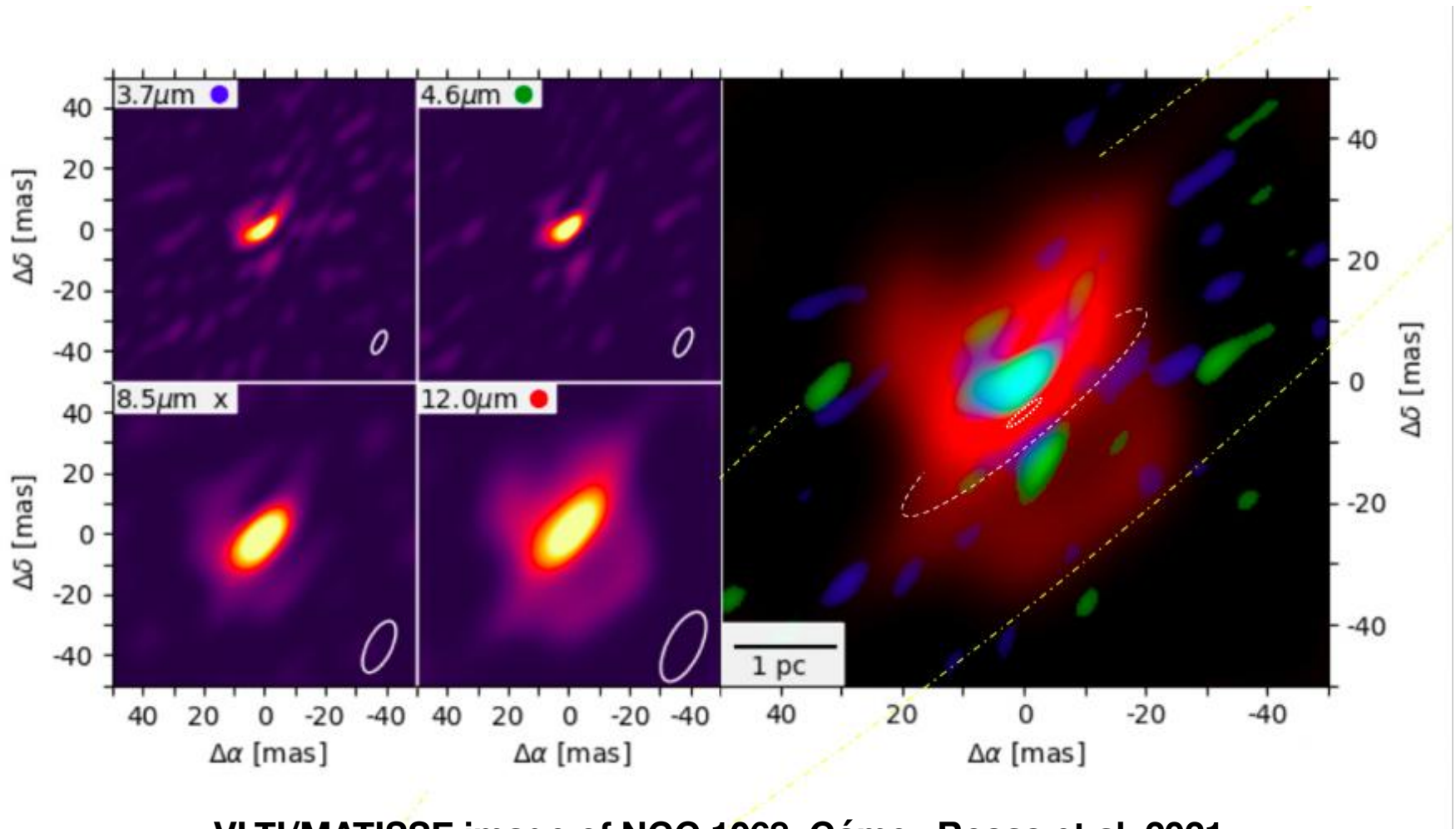
VLT/VISIR



JWST/MIRI



The pc-scale dusty torus: a VLTI target

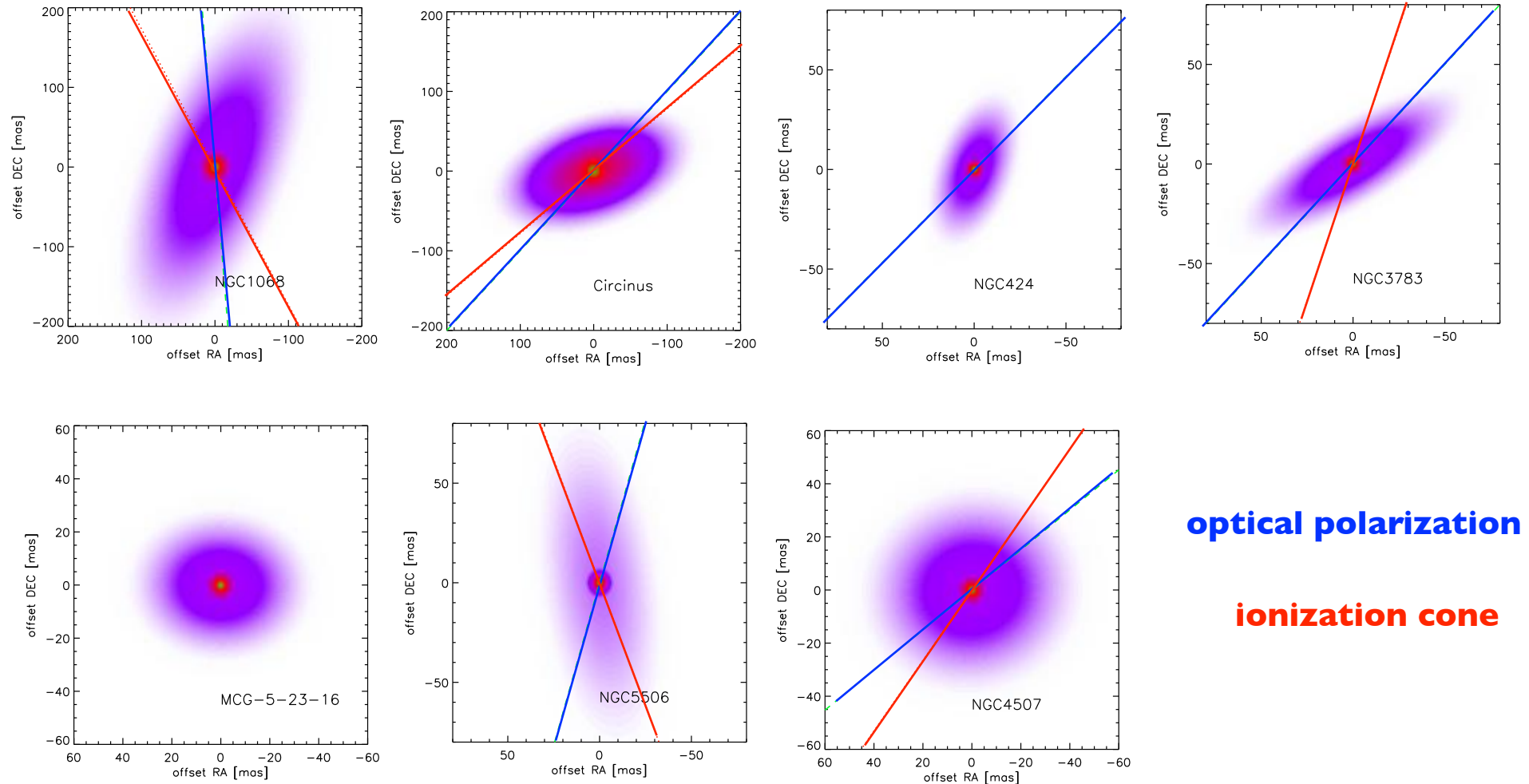


**VLTI/MATISSE image of NGC 1068: Gámez Rosas et al. 2021
(Nature — published yesterday!)**

Mid Infrared ELT Imager and Spectrograph

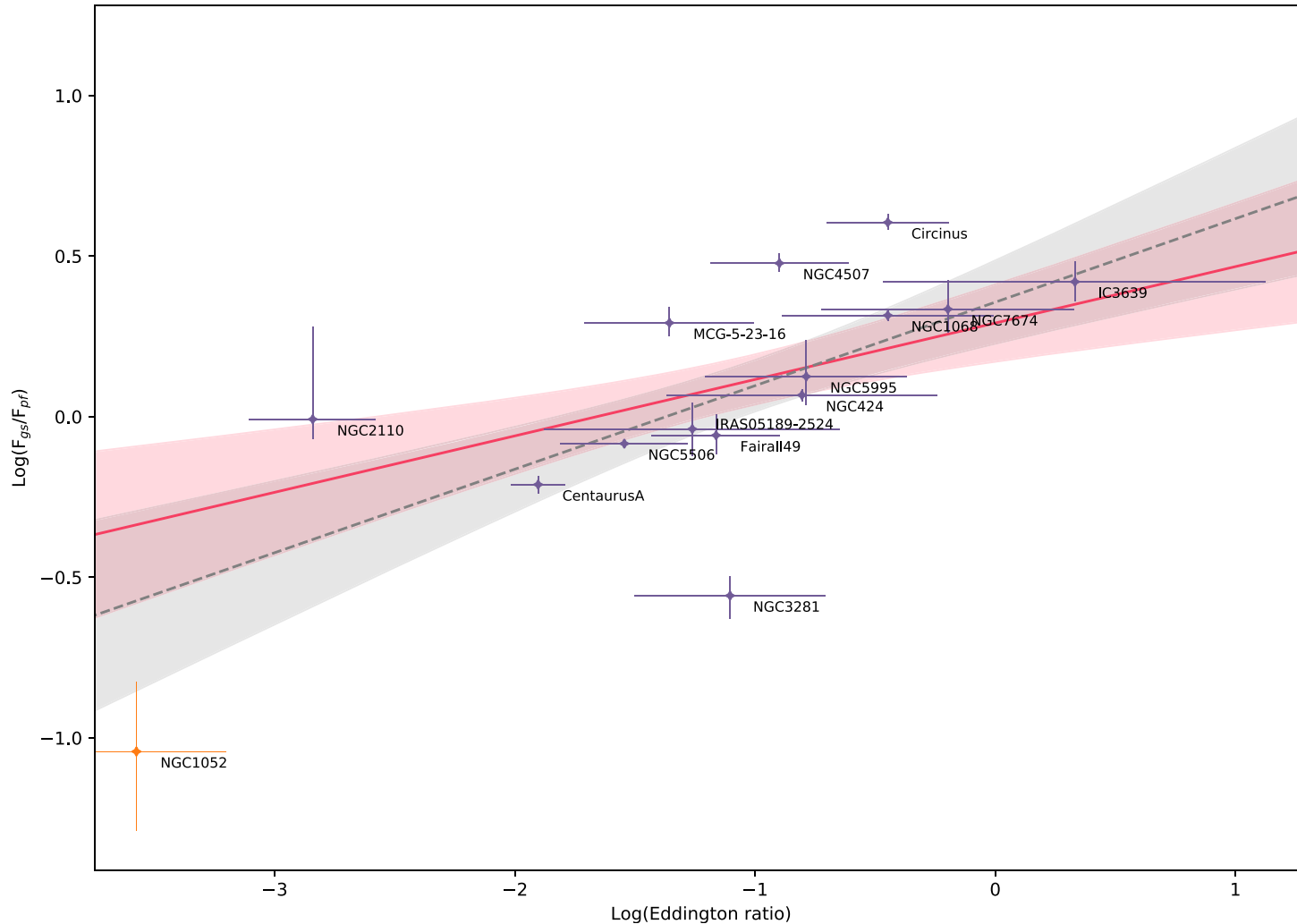


Most AGN „tori“ are oriented along the polar axis

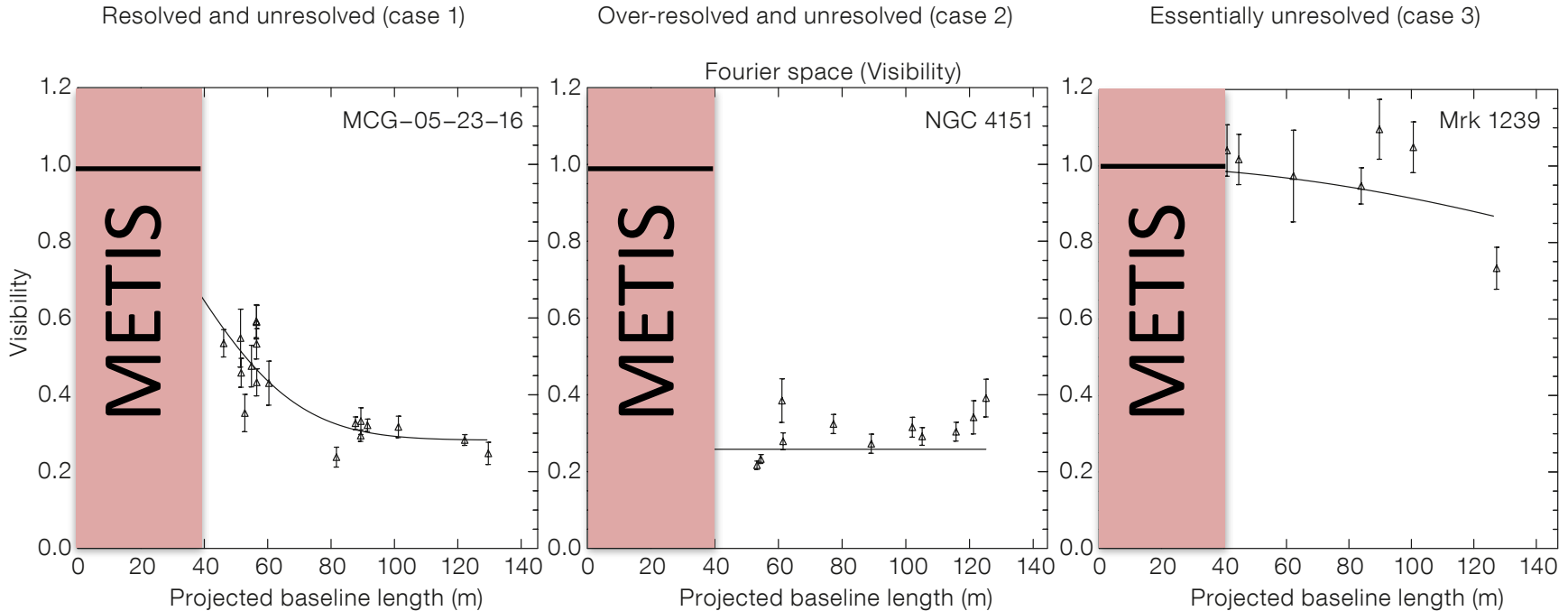


Lopez-Gonzaga et al. 2016; see also Hönic+ 2012, 2013, Tristram+ 2014, Lopez-Gonzaga+ 2014, Leftley+ 2018

A correlation between extended extended flux and Eddington ratio?



VLT/IRTI observations of nearby AGNs



Burtscher+ 2013

Mid Infrared ELT Imager and Spectrograph



N band Imaging

L/M band Imaging

SimMETIS simulations

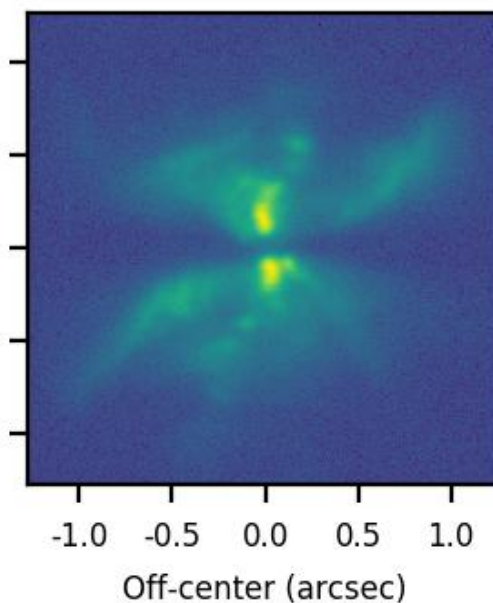
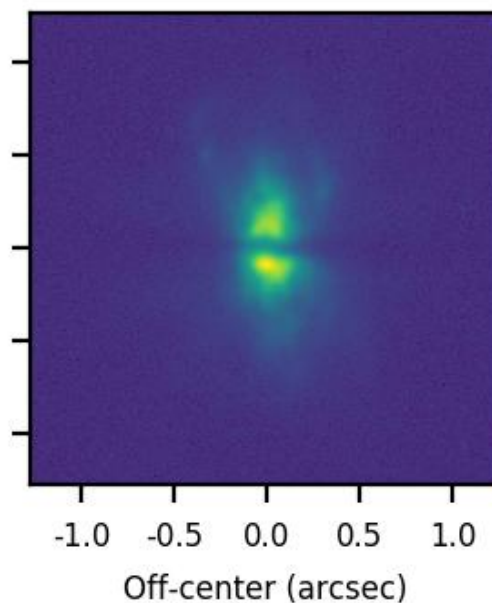
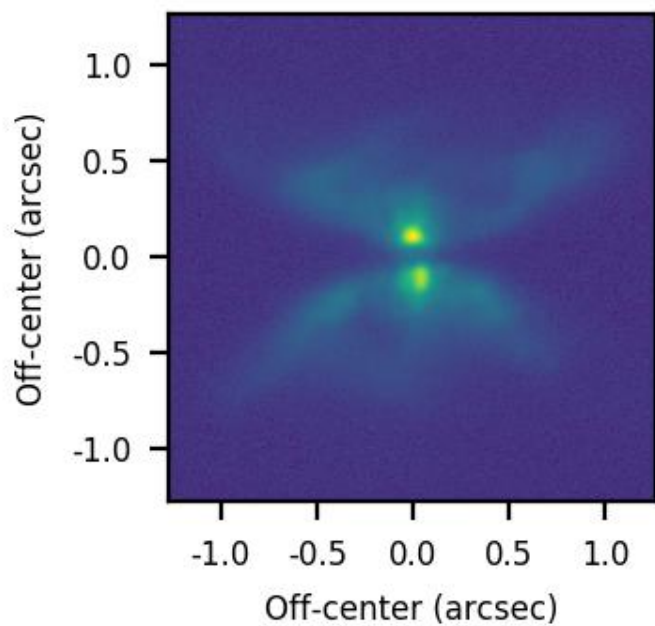
Radiation driven AGN feedback as seen by METIS

Eddington ratio

$\lambda = 1\%$

$\lambda = 10\%$

$\lambda = 20\%$



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

The mid-IR spectroscopic menu

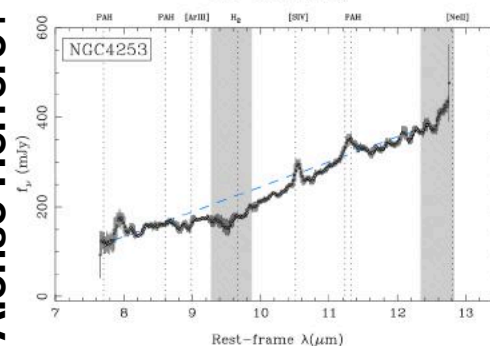
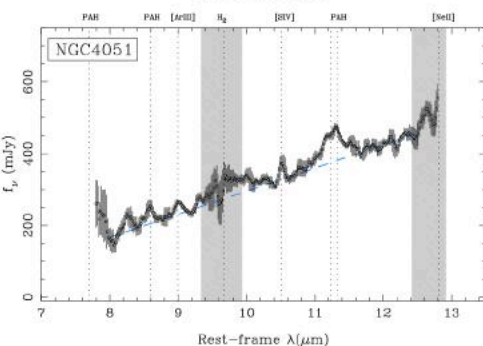
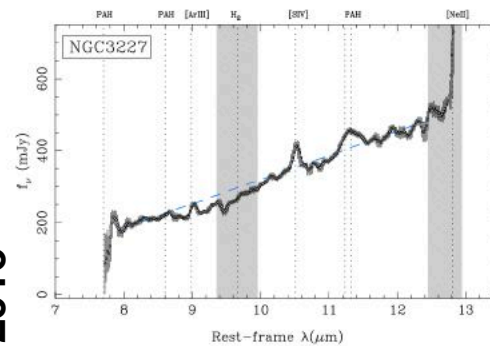
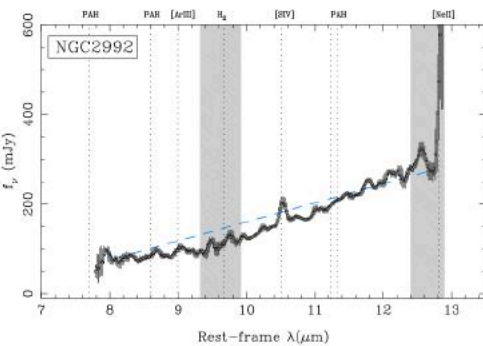
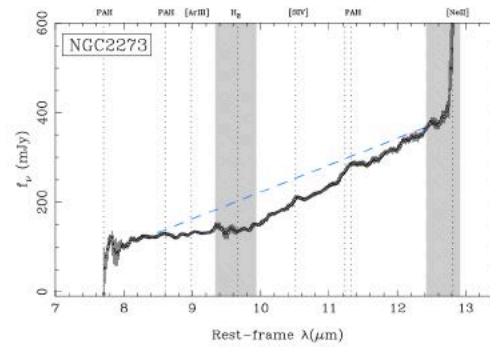
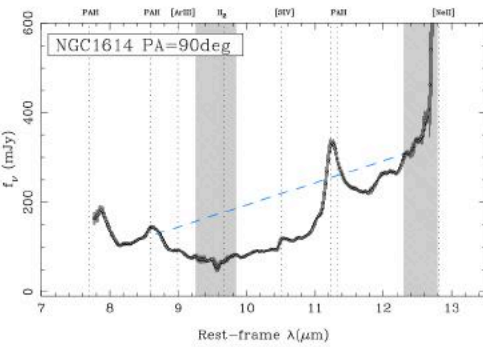
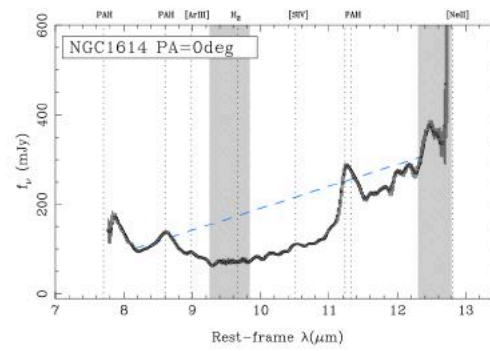
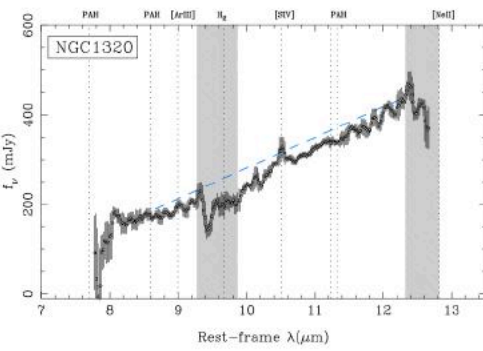
recombination lines: Br α 4.05 μm , Pf β 4.65 μm

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 H₂, 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

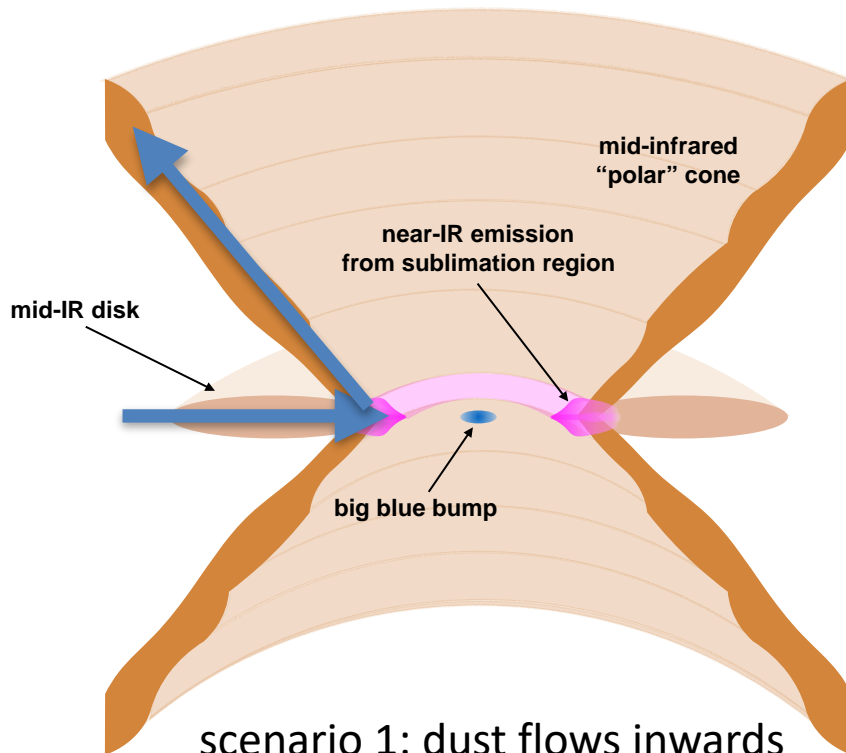
Silicate absorption feature (+ more dust species): 9.7 μm



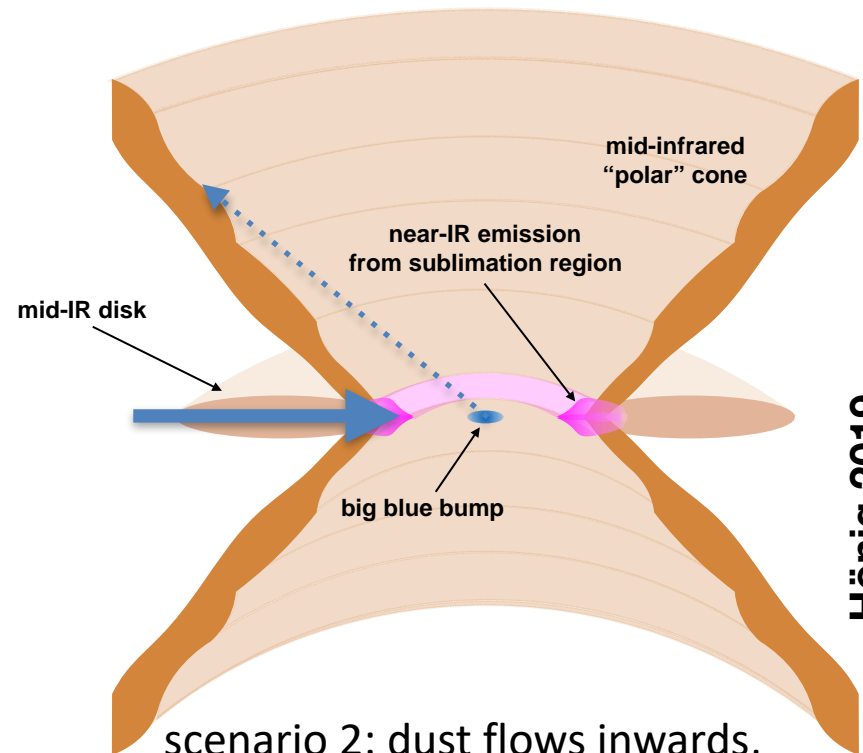
Alonso Herrero+ 2016

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

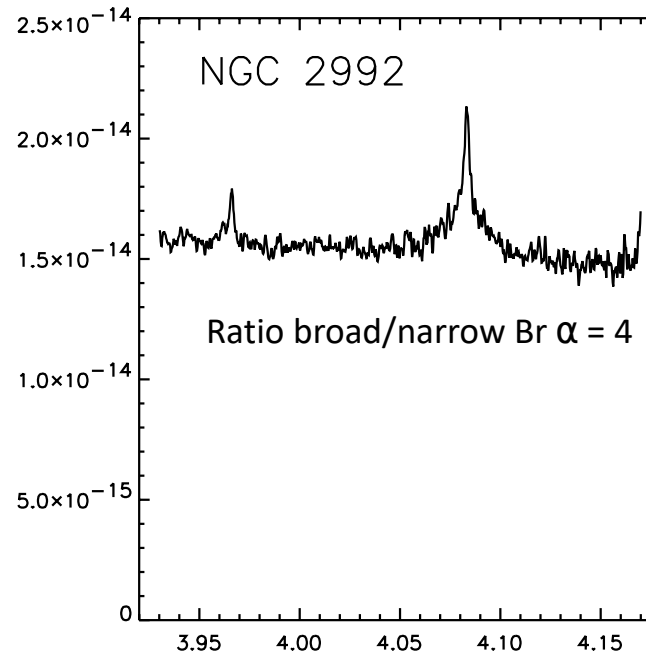
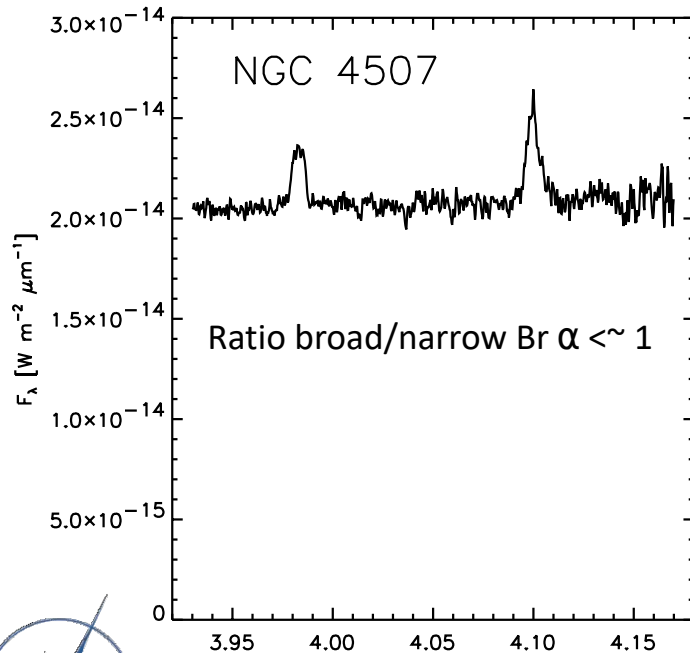
Br α (4.05 μm) vs. **Br γ** (2.166 μm): Sensitivity (for unresolved lines) \sim 30x better in HARMONI than METIS, but $\alpha \sim$ 3x brighter than γ and extinction \sim 2-3x lower

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

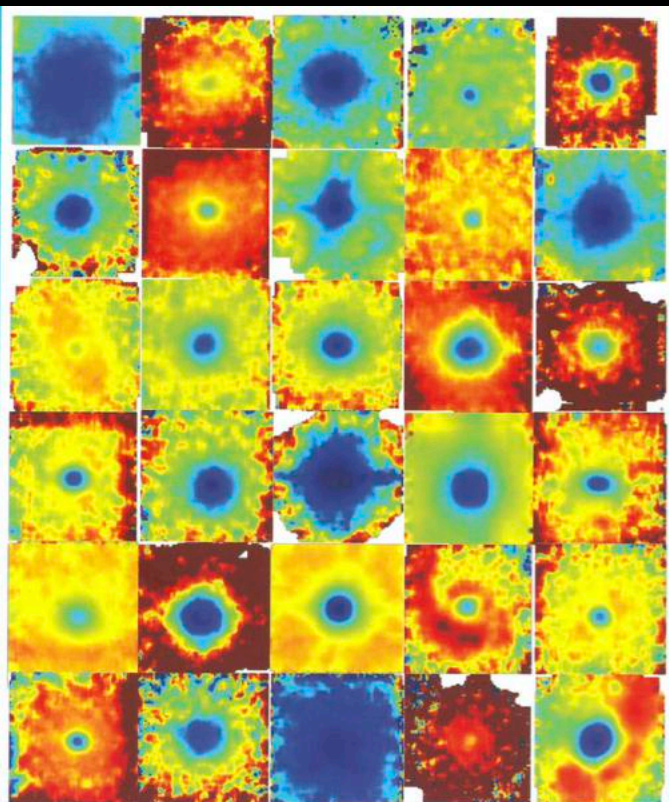
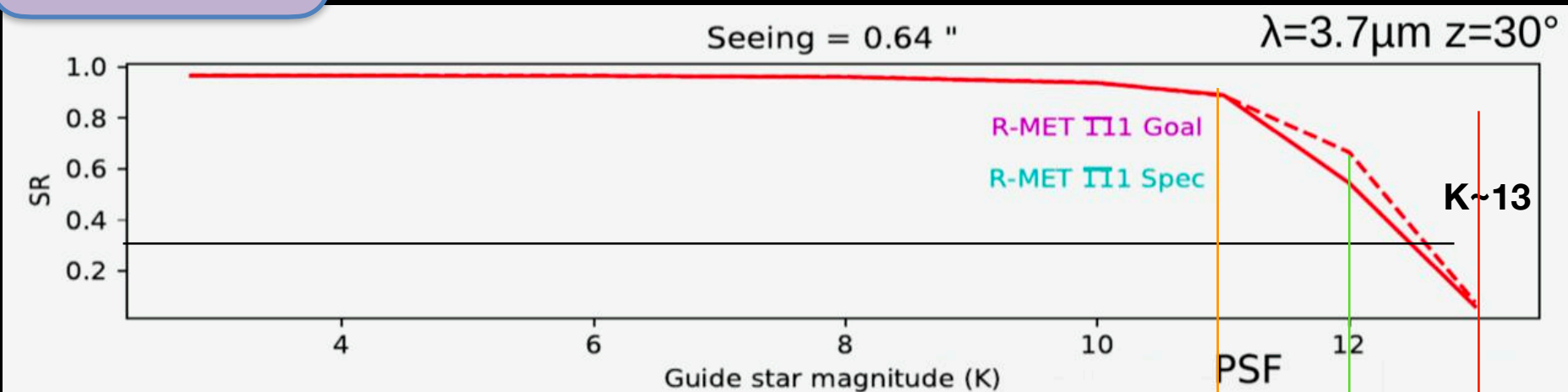
Use METIS LMS for **spectro-astrometry** of obscured BLRs?

L/M band long-slit spectroscopy

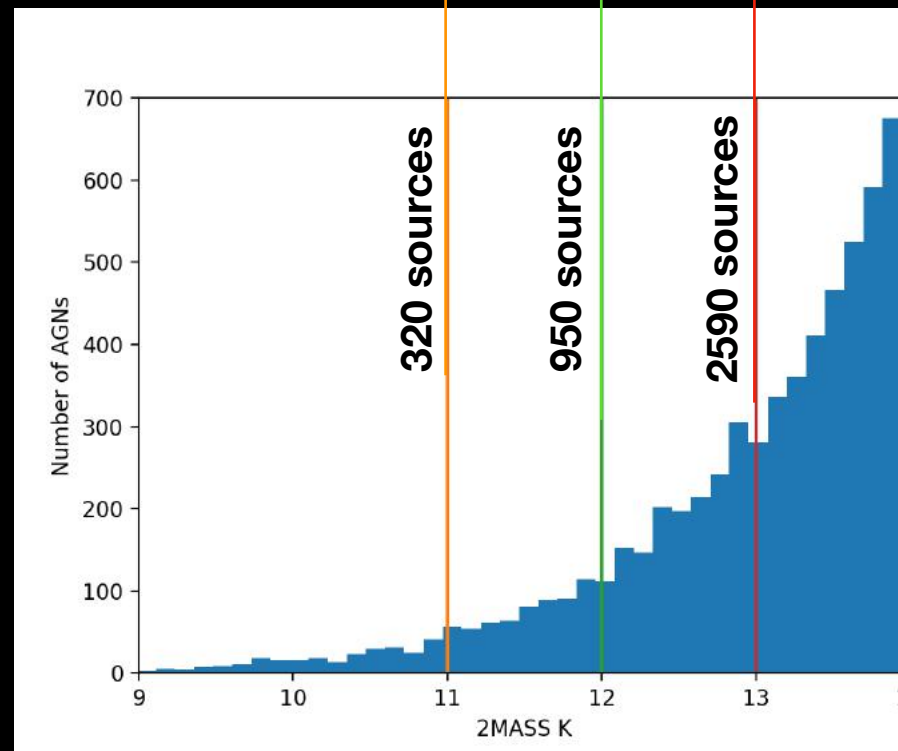
L/M band high-resolution integral-field spectroscopy



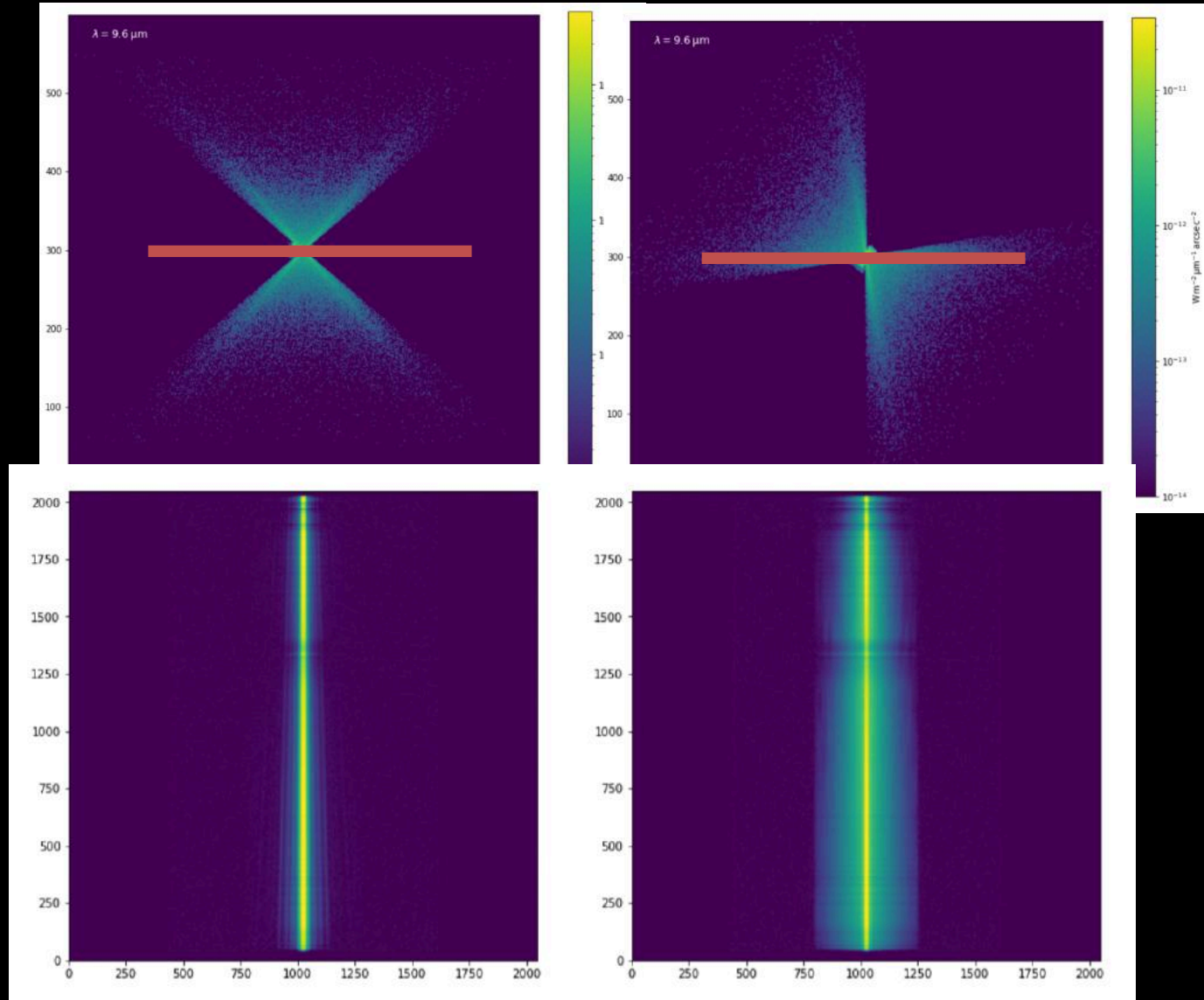
Number of observable sources



Burtscher+ 2015



The METIS simulator

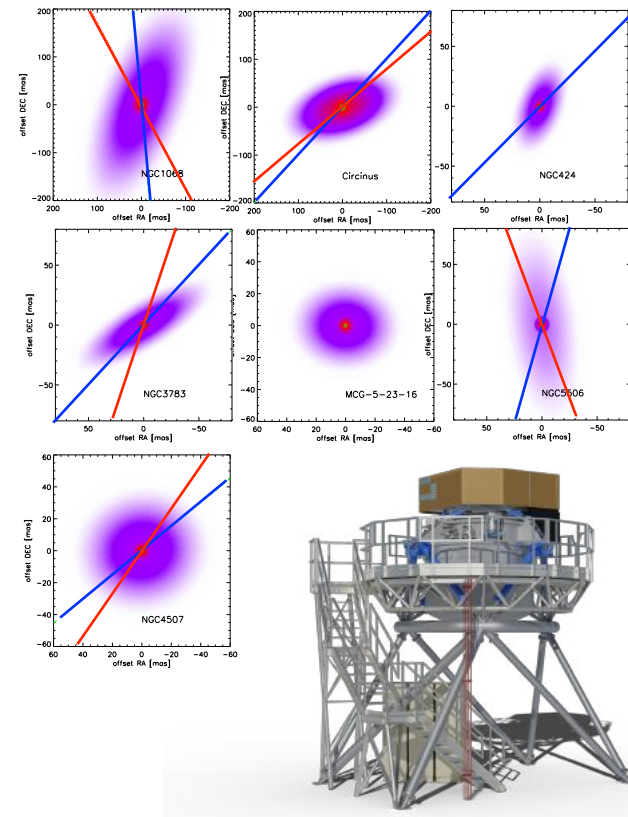


radiative transfer model: Stalevski + 2017
SimMETIS simulation by Oliver Czoske

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



Mock METIS observation

