

METIS

IR 2022

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



Science and
Technology
Facilities Council

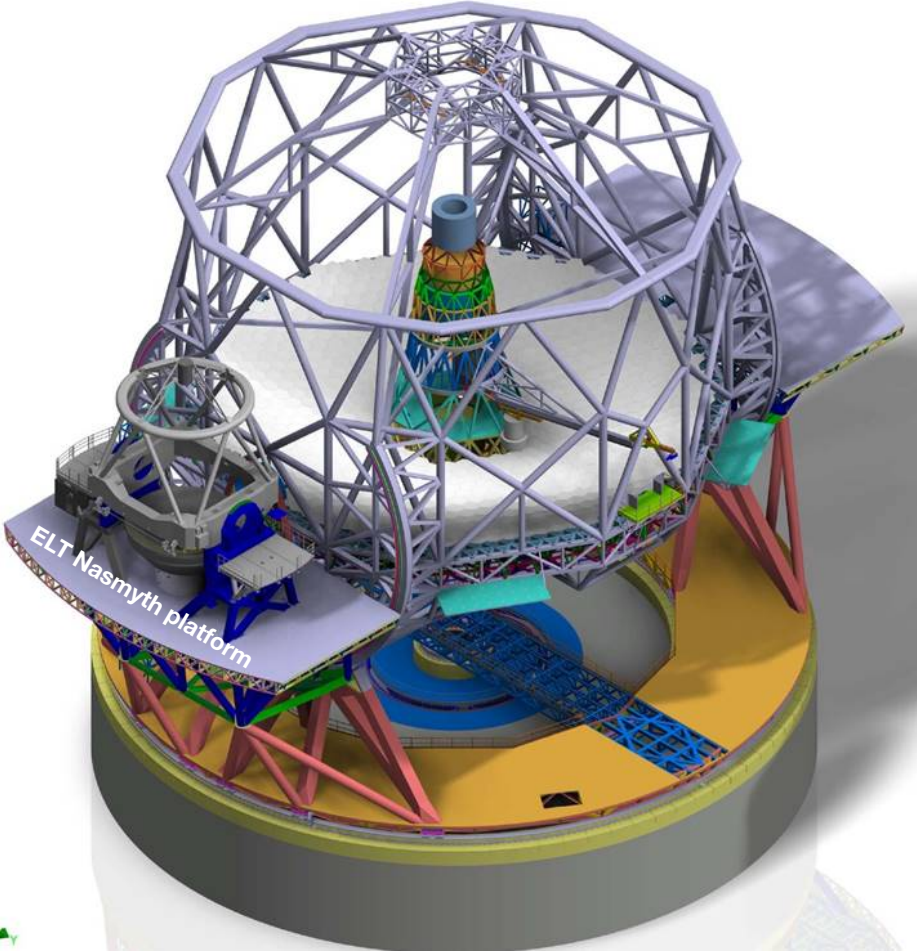
UK Astronomy
Technology Centre

KU LEUVEN

ETH zürich

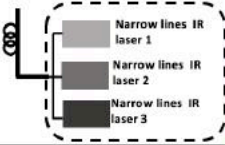
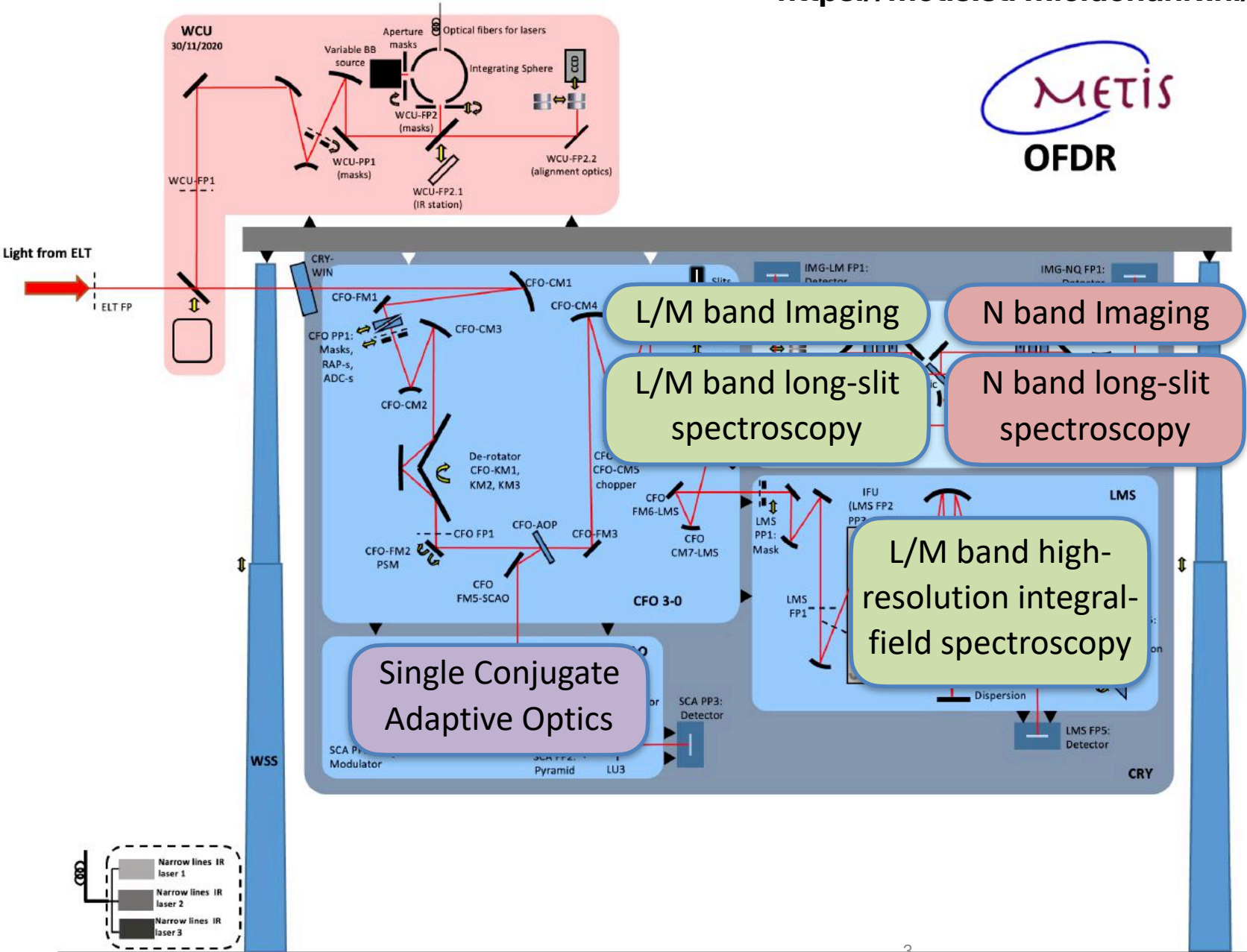


To put it in perspective...



Mid Infrared ELT Imager and Spectrograph



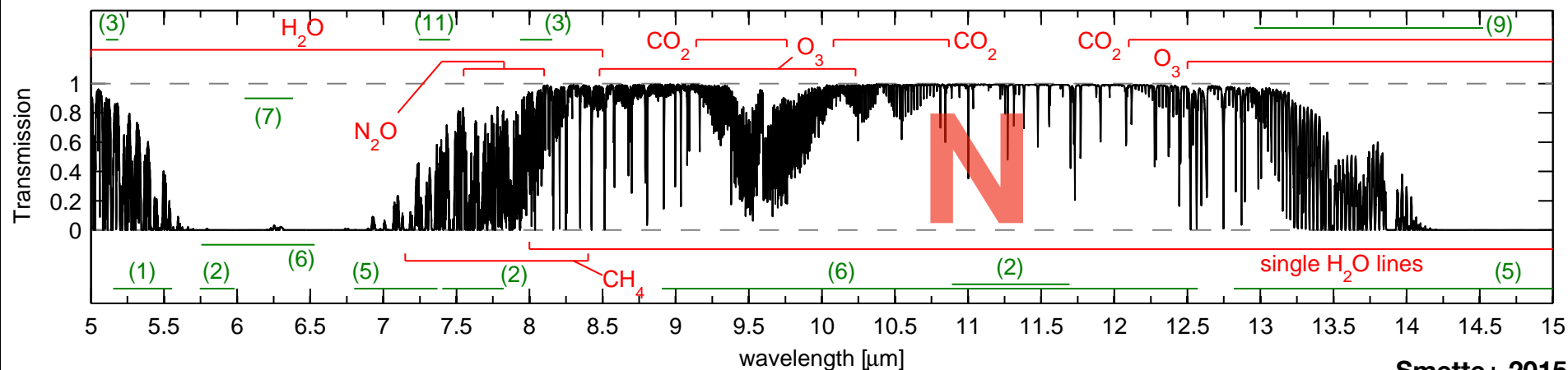
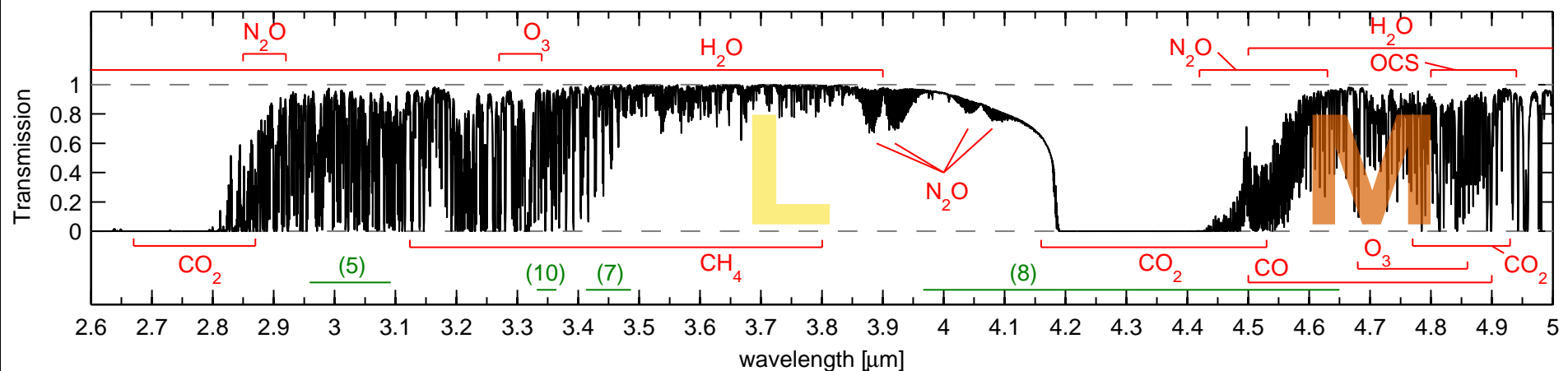


METIS in a nutshell

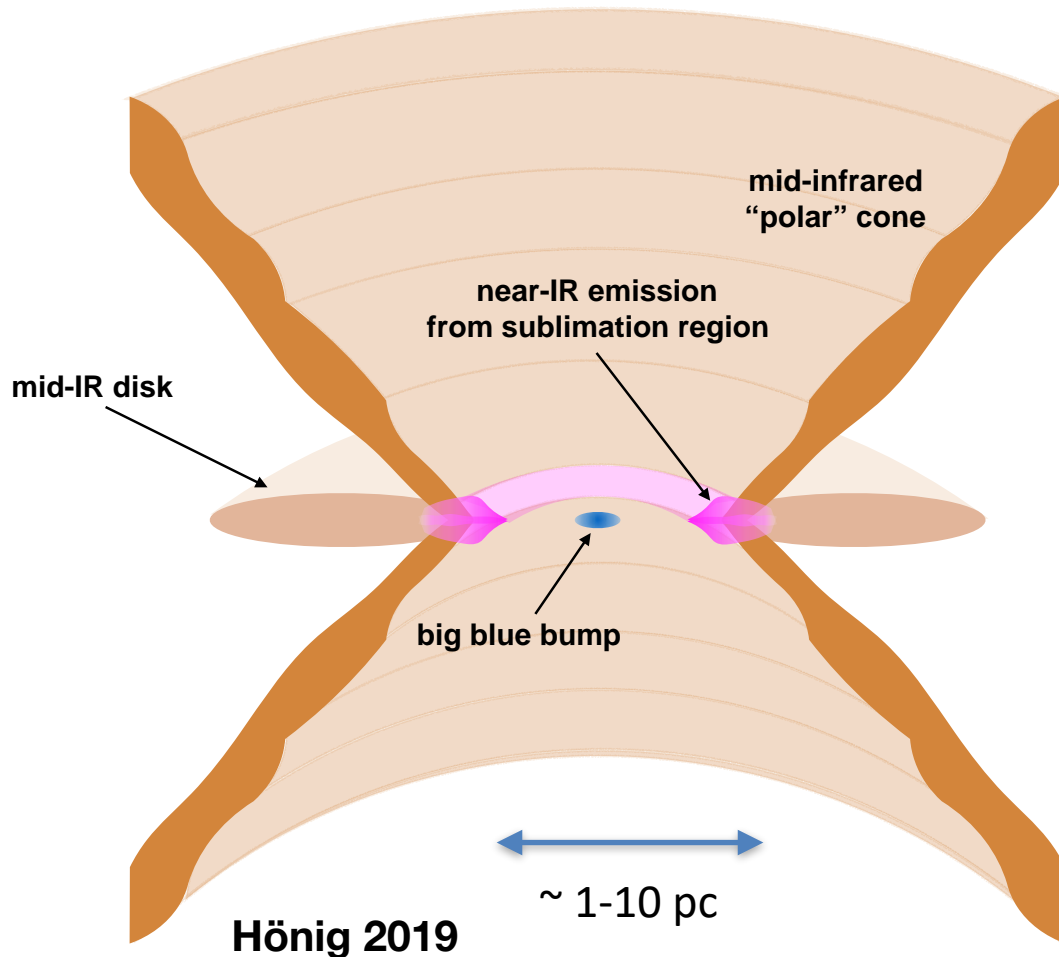
Diffraction-limited imaging and spectroscopy in L,M,N (Q) bands

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?

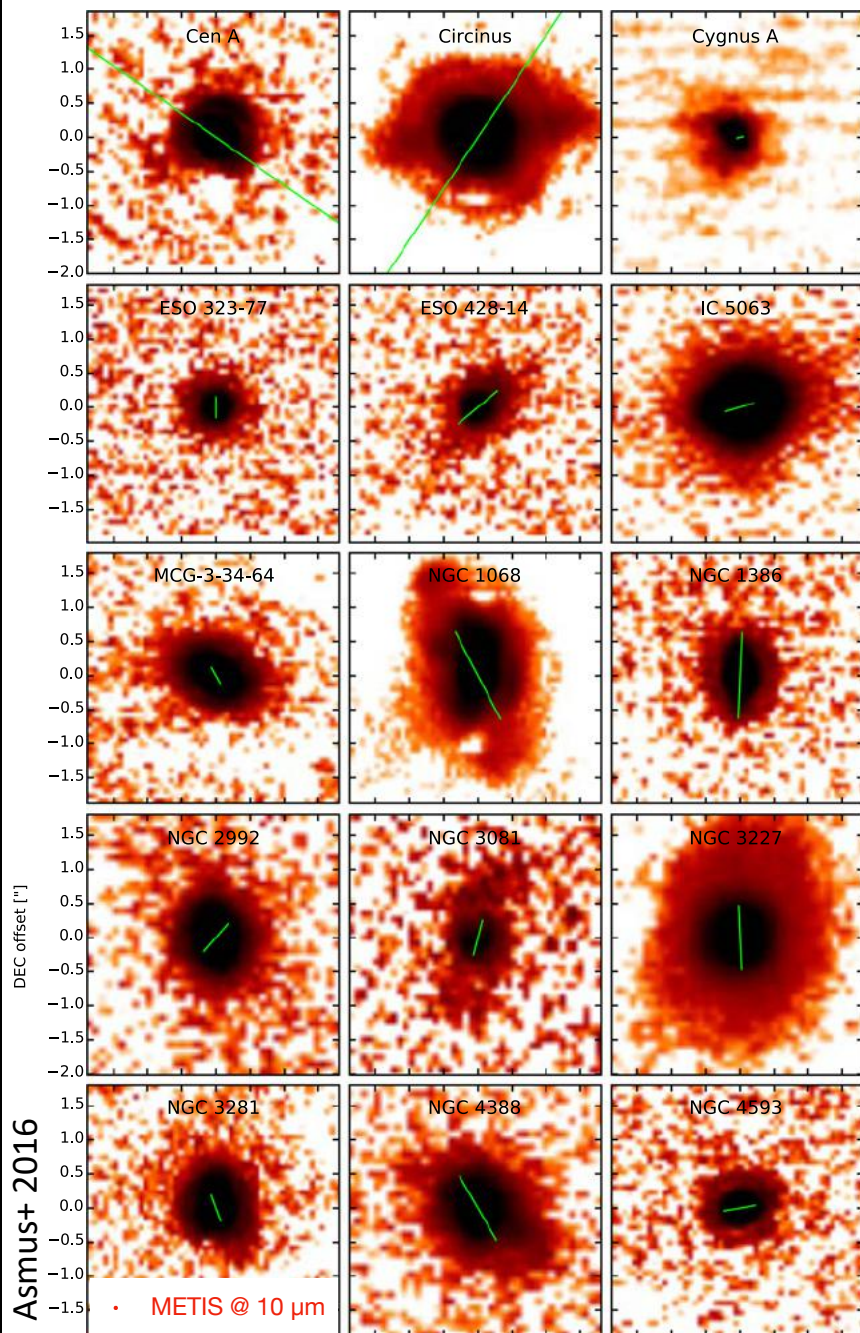
What is the kinematics of the ionised (and molecular?) gas in the nuclei of active galaxies?

Mid Infrared ELT Imager and Spectrograph

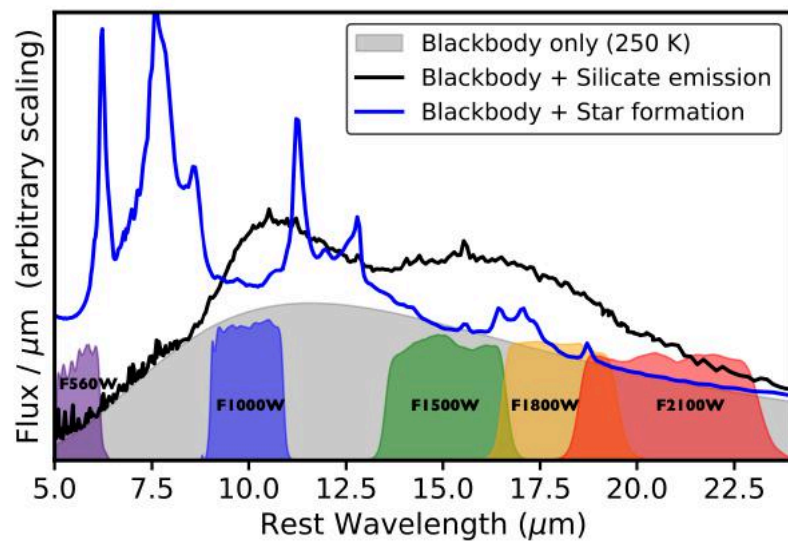
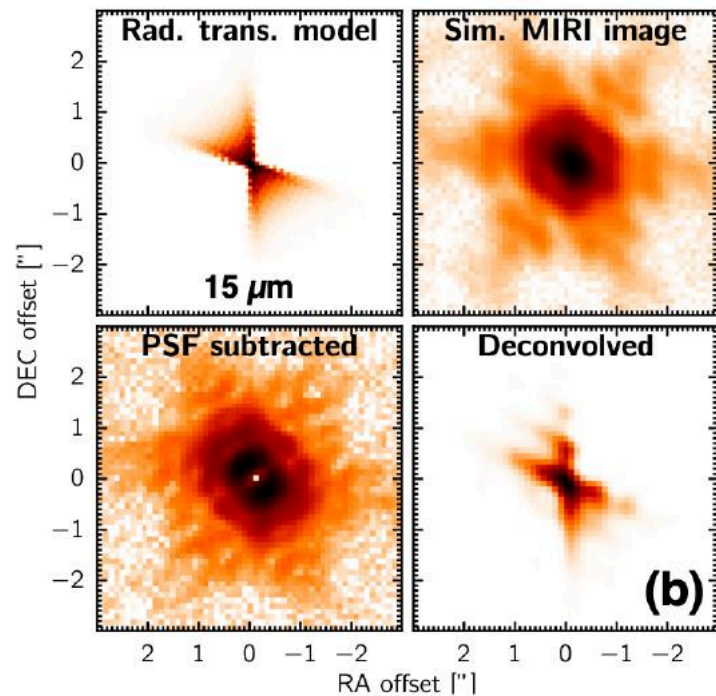
Hönig 2019



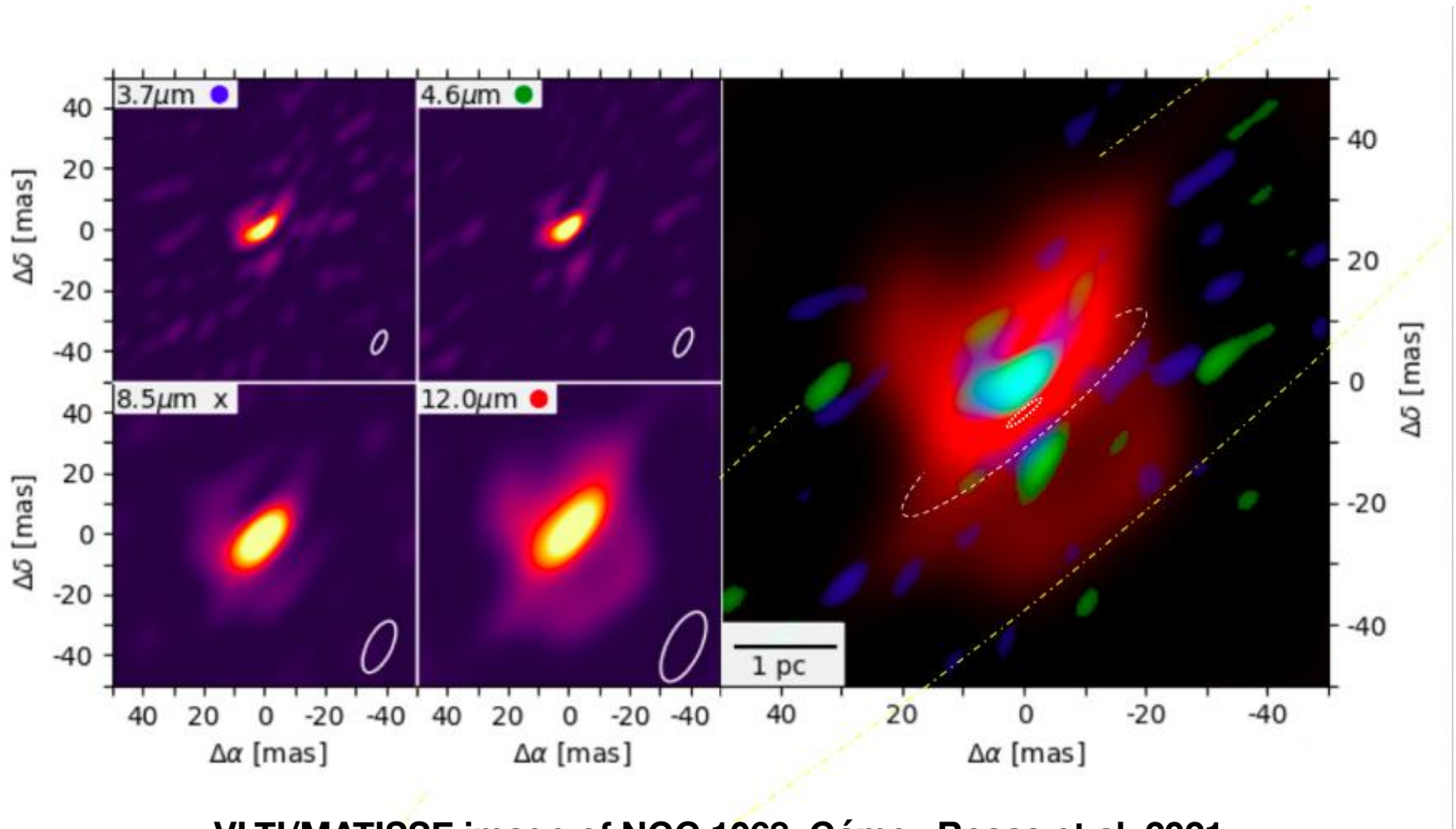
VLT/VISIR



JWST/MIRI



The pc-scale dusty torus: a VLTI target

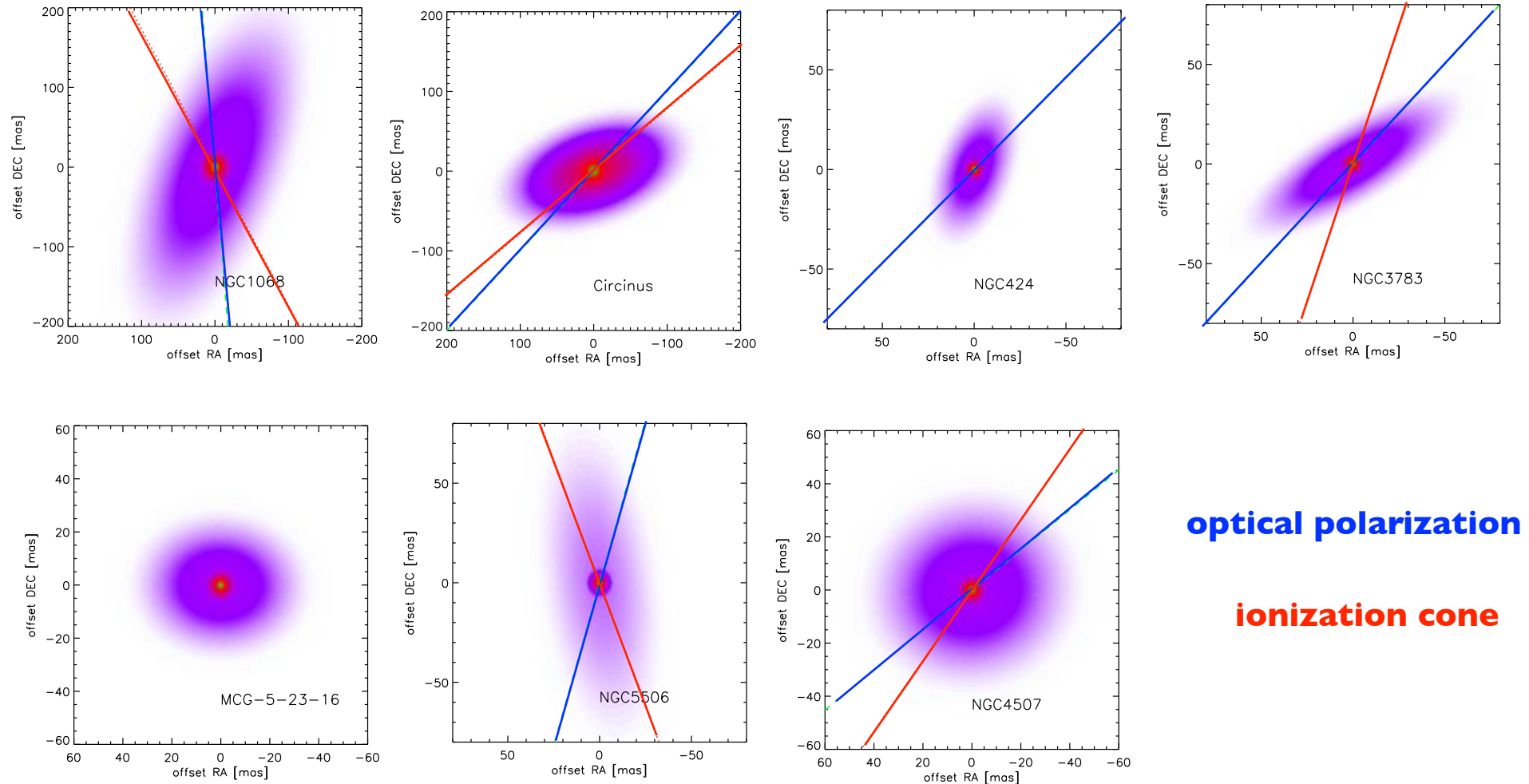


**VLTI/MATISSE image of NGC 1068: G3mez Rosas et al. 2021
(Nature — published yesterday!)**

Mid Infrared ELT Imager and Spectrograph

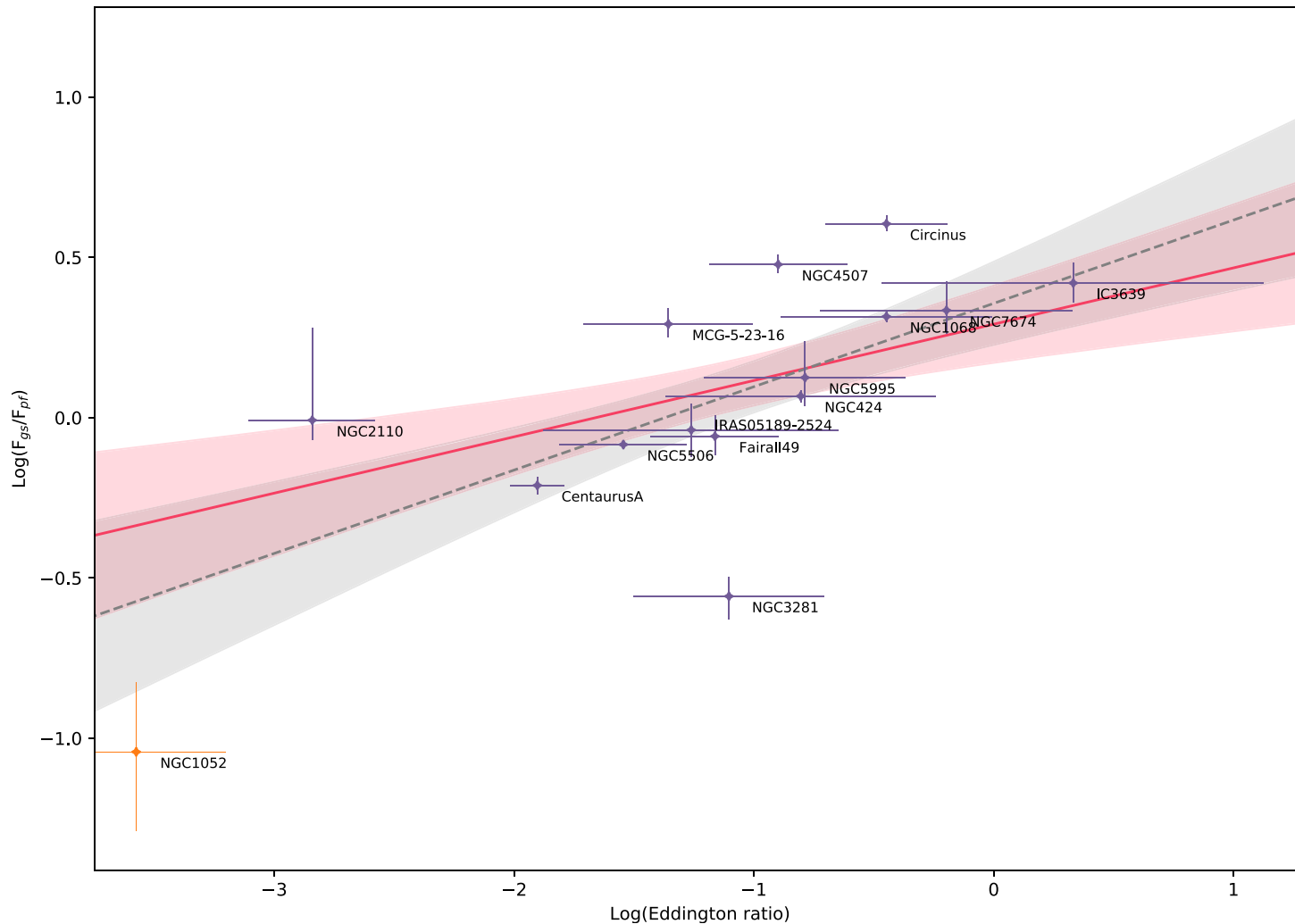


Most AGN „tori“ are oriented along the polar axis

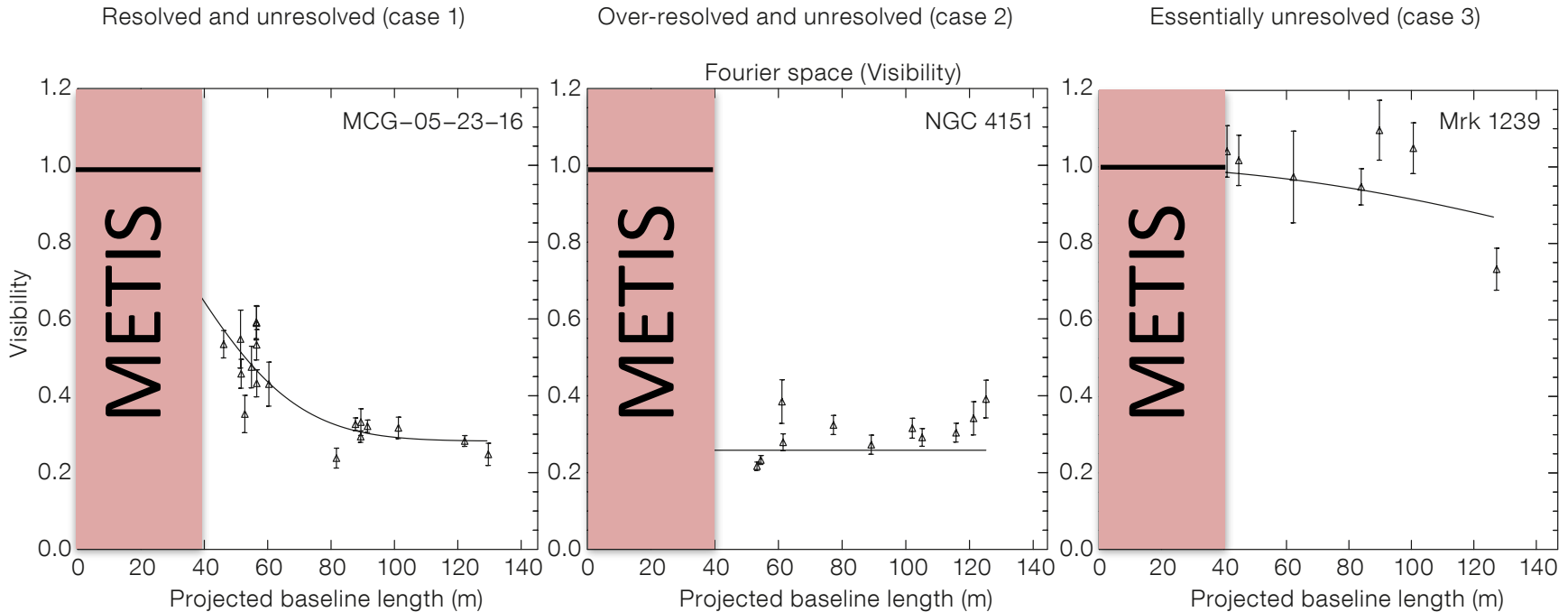


Lopez-Gonzaga et al. 2016; see also Hönic+ 2012, 2013, Tristram+ 2014, Lopez-Gonzaga+ 2014, Leftley+ 2018

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

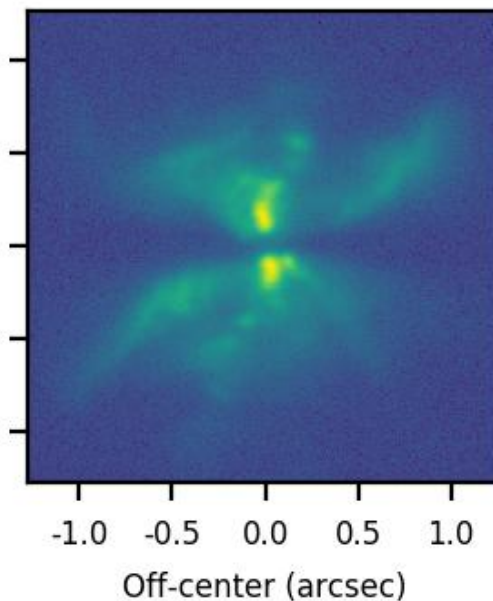
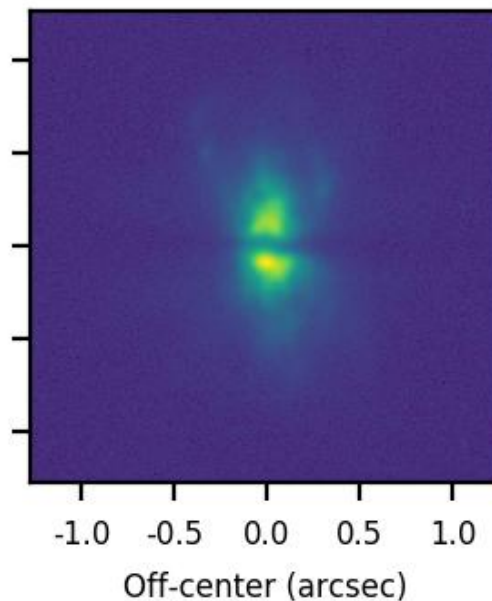
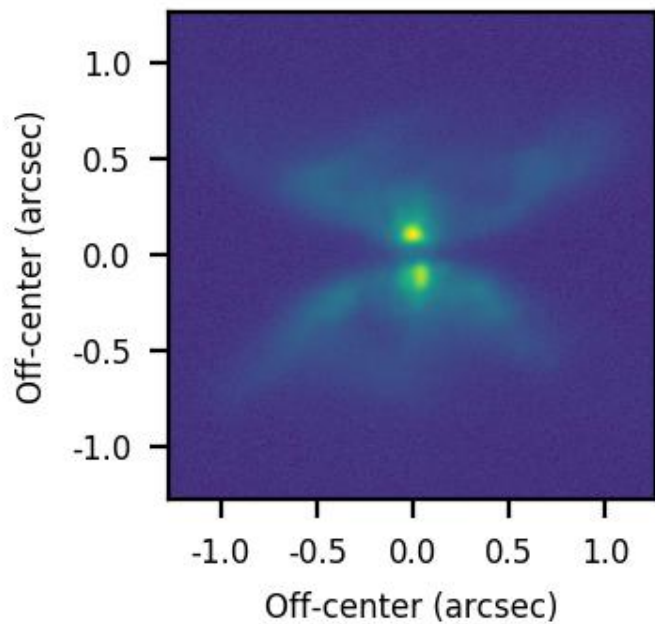
Radiation driven AGN feedback as seen by METIS

Eddington ratio

$\lambda = 1\%$

$\lambda = 10\%$

$\lambda = 20\%$



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

The mid-IR spectroscopic menu

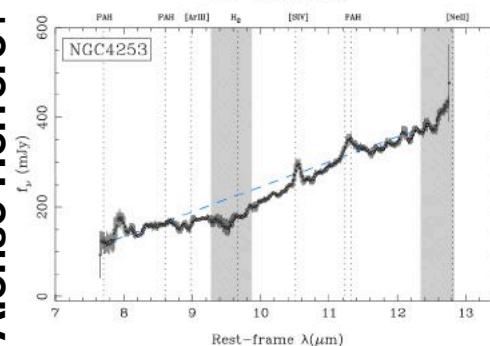
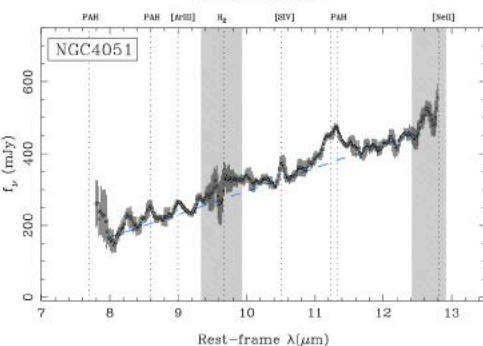
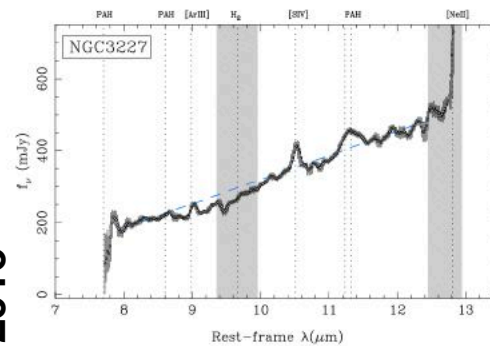
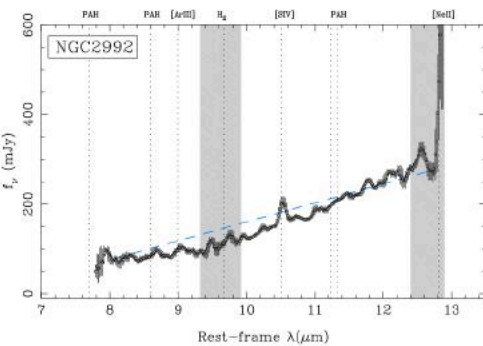
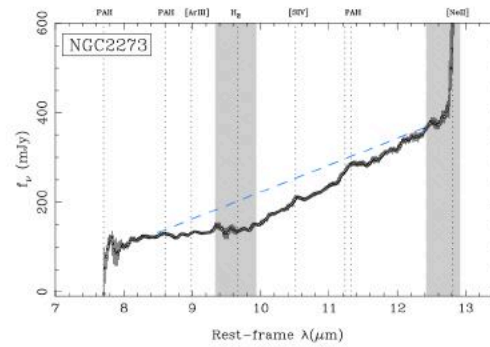
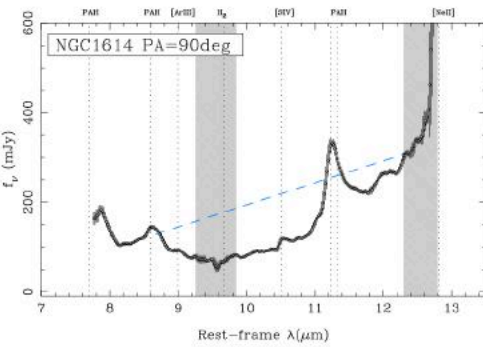
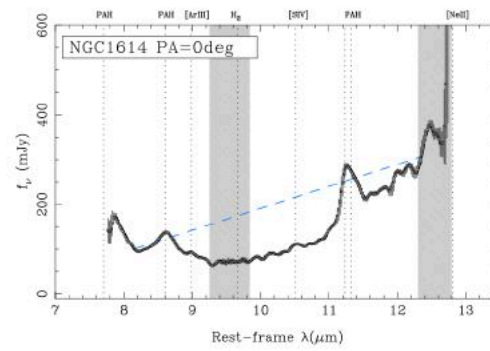
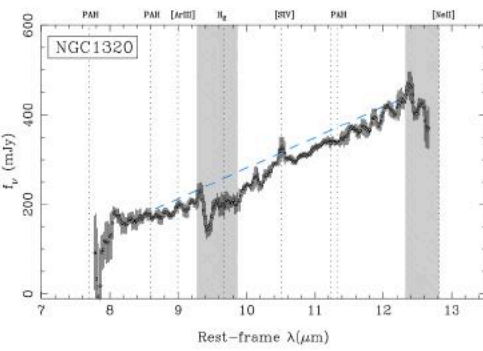
recombination lines: Br α 4.05 μm ,
Pf β 4.65 μm

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

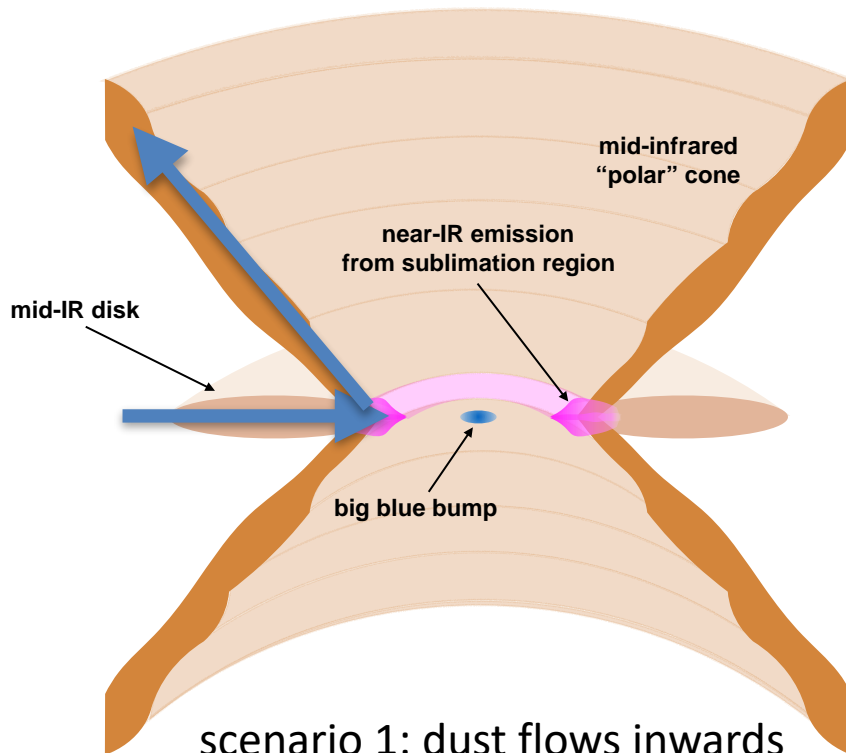
Silicate absorption feature (+ more
dust species): 9.7 μm



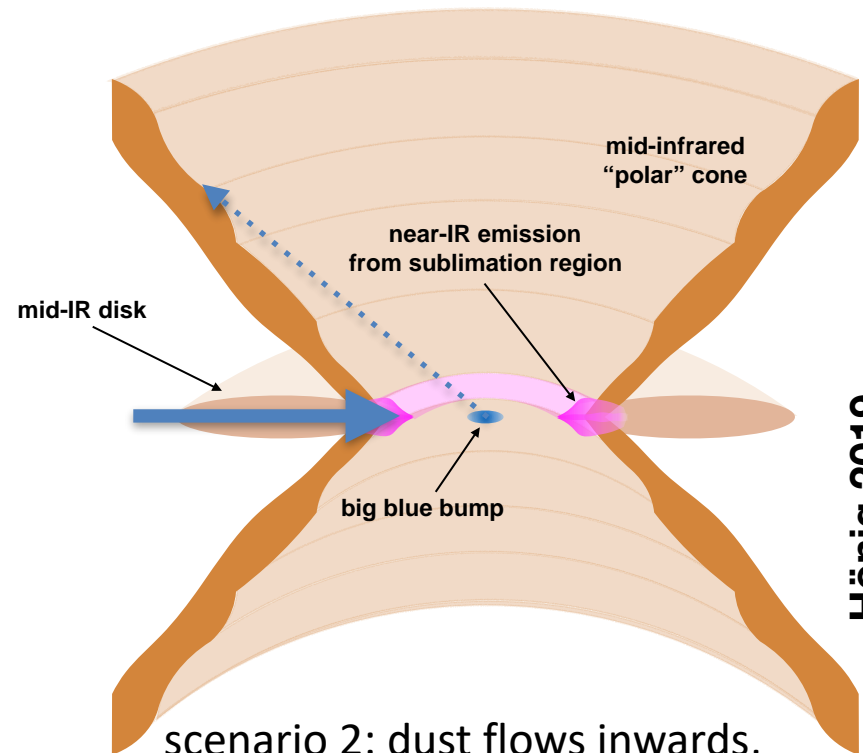
Alonso Herrero+ 2016

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

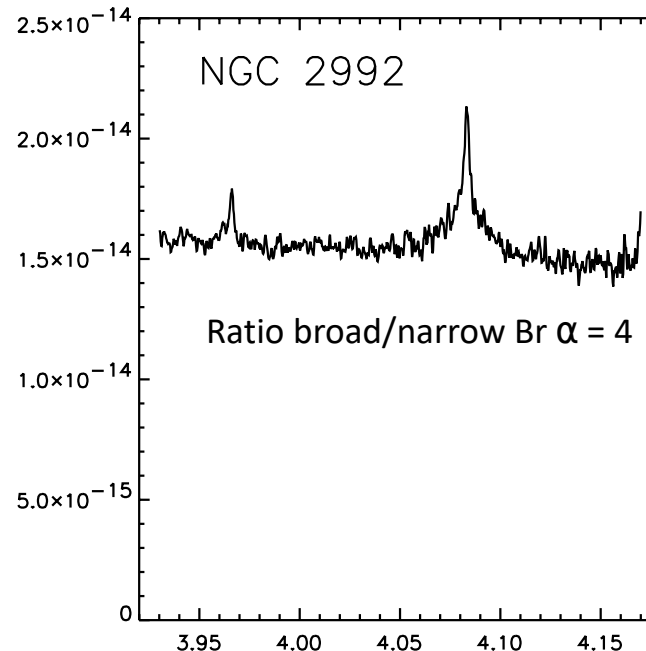
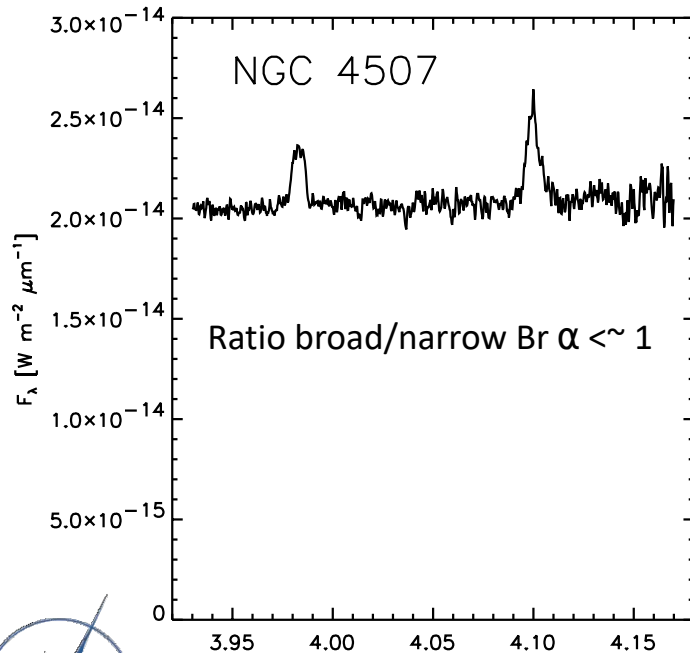
Br α (4.05 μm) vs. **Br γ** (2.166 μm): Sensitivity (for unresolved lines) \sim 30x better in HARMONI than METIS, but $\alpha \sim$ 3x brighter than γ and extinction \sim 2-3x lower

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

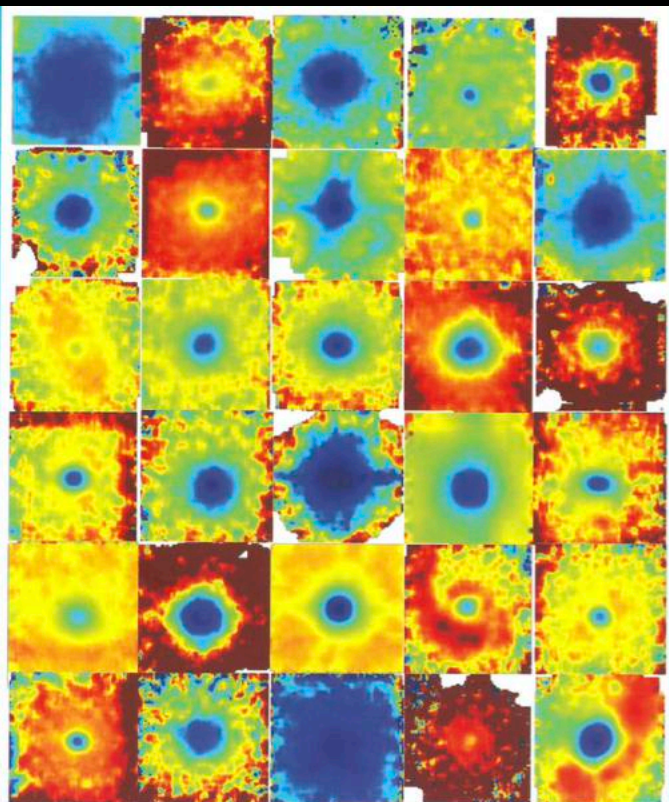
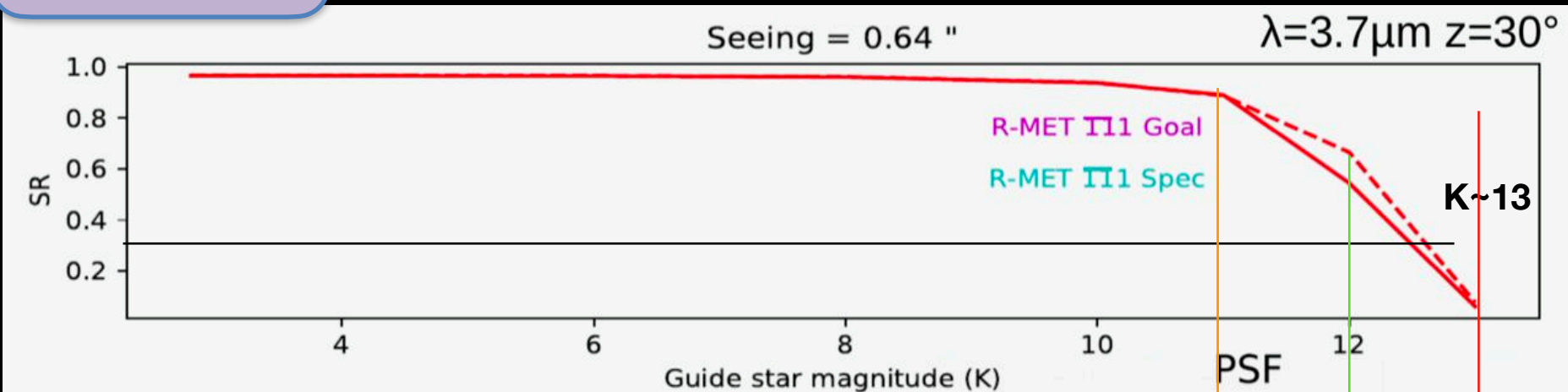
Use METIS LMS for **spectro-astrometry** of obscured BLRs?

L/M band long-slit spectroscopy

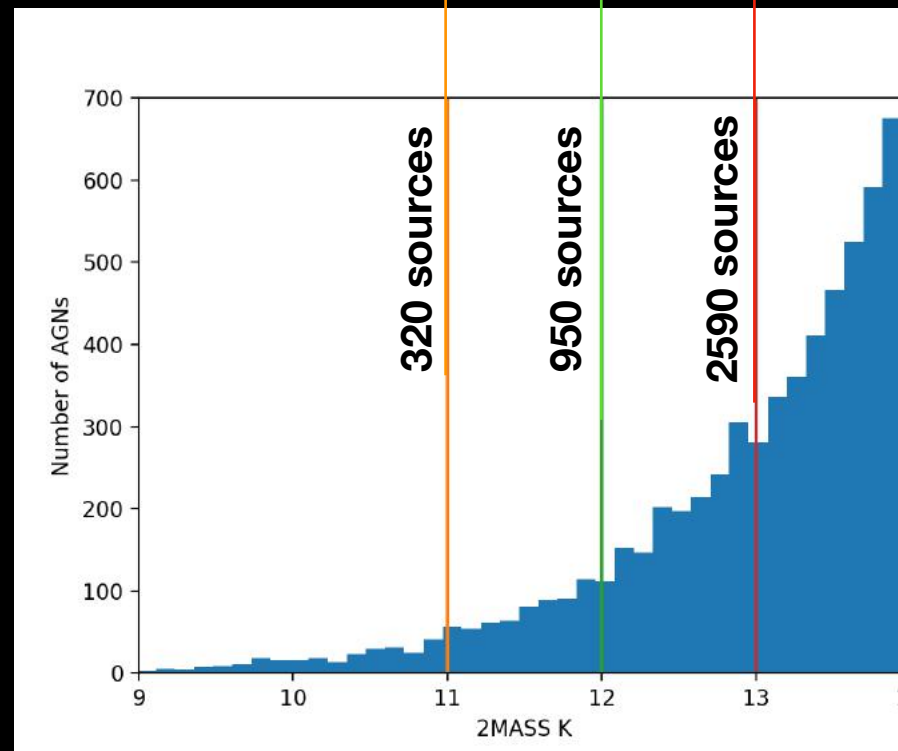
L/M band high-resolution integral-field spectroscopy



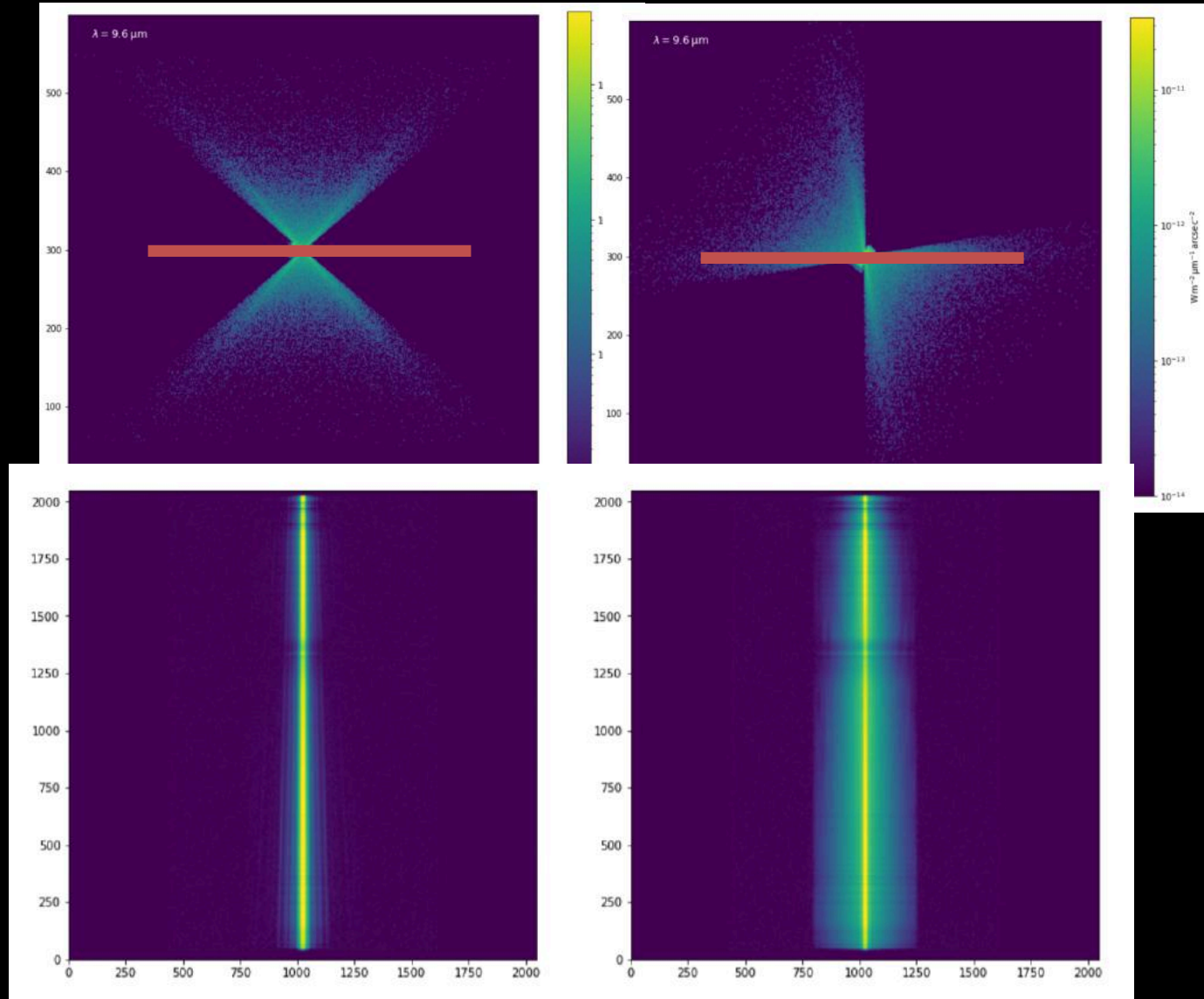
Number of observable sources



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

