Black Hole Science with Non-Redundant Masking on AFTA

Anand Sivaramakrishnan

Space Telescope Science Institute

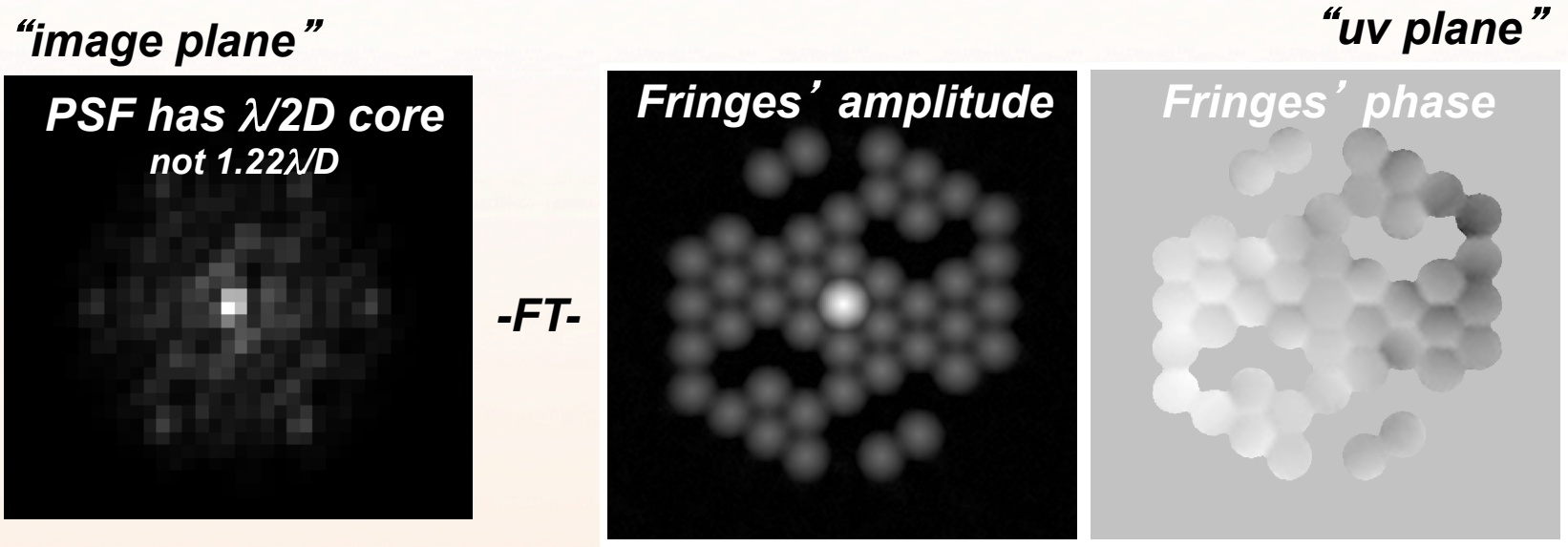
Laurent Pueyo André Martel Peter Tuthill

Saavik Ford Barry McKernan Aaron Evans

University of Sydney, City University of New York, University of Virginia & NRAO

NASA APRA support for NRM on Future Space Telescopes

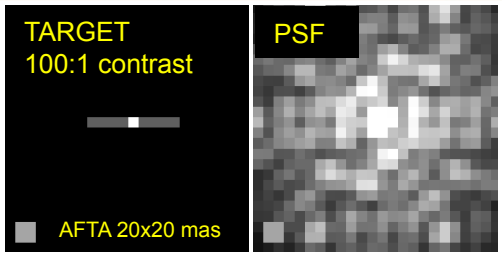
Traditional NRM data analysis



- "Fringes" from point source calibrator & science target captured by straight imaging with NRM on 2-D detector
- Fourier Transform calibrator and target image data
- Align each to subpixel accuracy (de-slope phases)
- Extract Amplitude & Phase at various (u,v) locations
- Analyze with radio-like software (eg MIRIAD)

Alternative: 'deconvolve' in image plane

Imaging with NRM



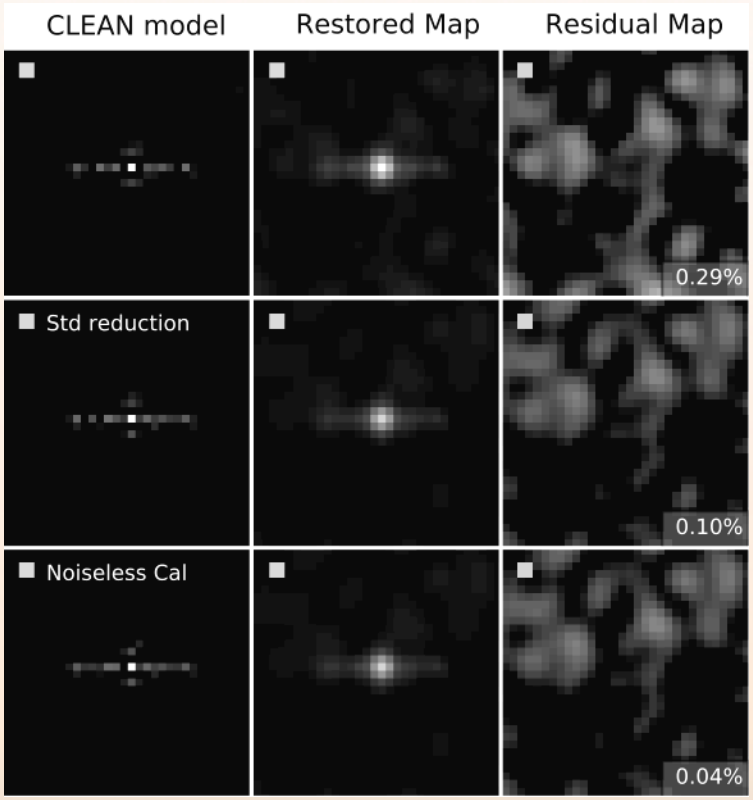
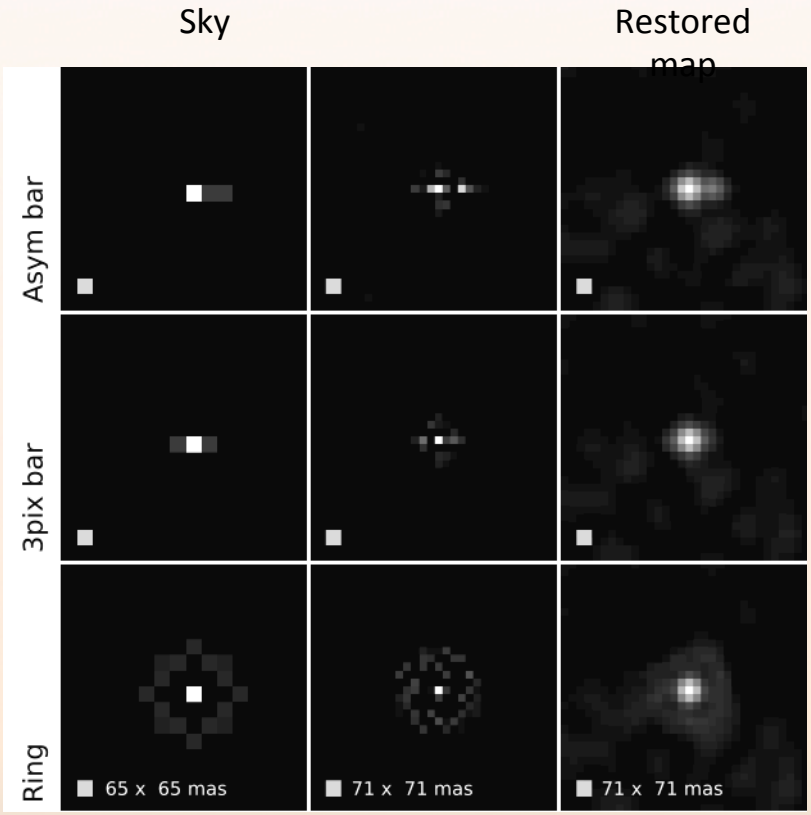


IMAGE RECOVERY WITHOUT PRIOR MODEL

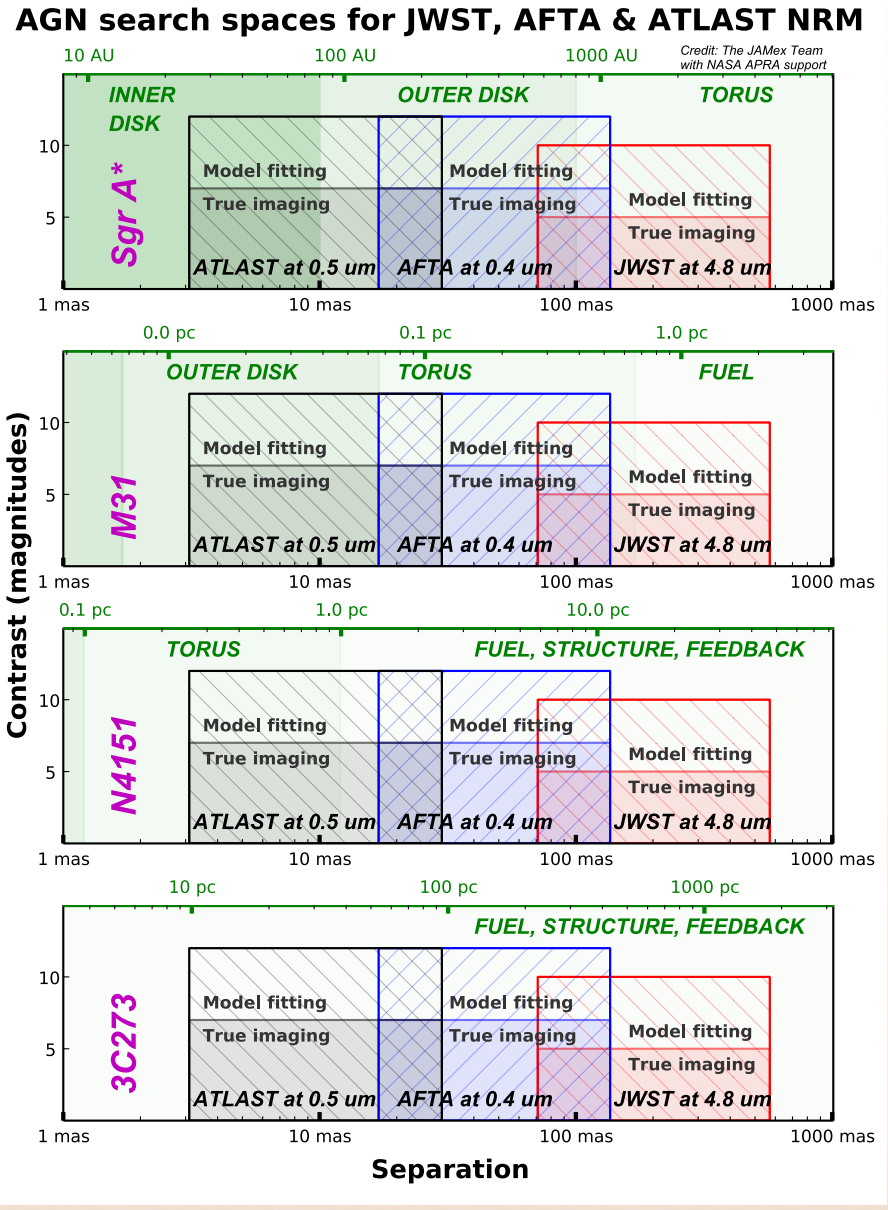
JWST NIRISS NRM, HgCdTe, noisy simulations

Ford et el. 2014 ApJ



JWST NIRISS 65 mas translates to AFTA 17 mas

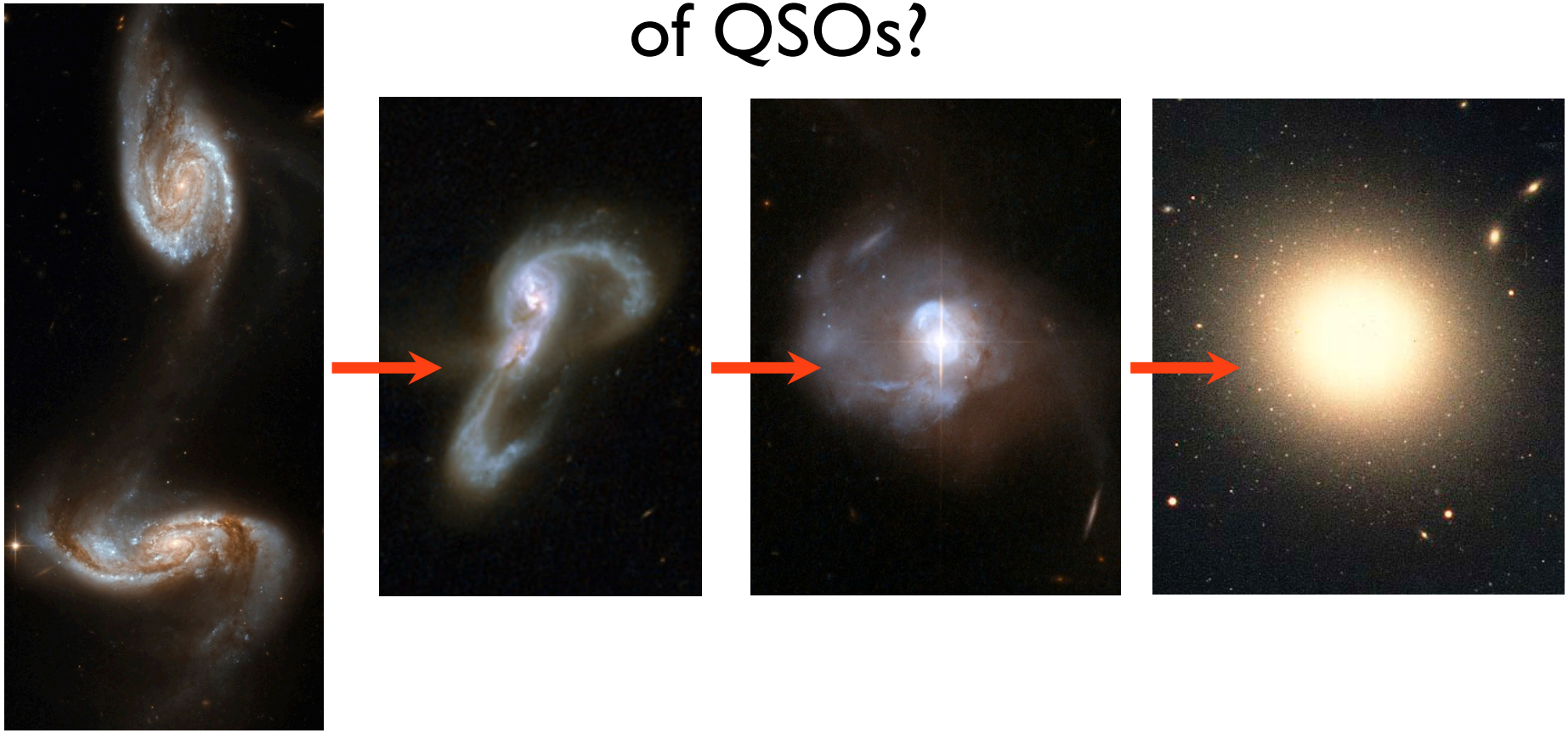
Ford et al. 2014 ApJ



~2 mag contrast improvement with CCDs (AFTA COR) compared to HgCdTe (JWST-NIRISS)?

Ford et al. 2014 ApJ

Ultraluminous IR Galaxies & the evolution of QSOs?



Gas-rich Progenitors

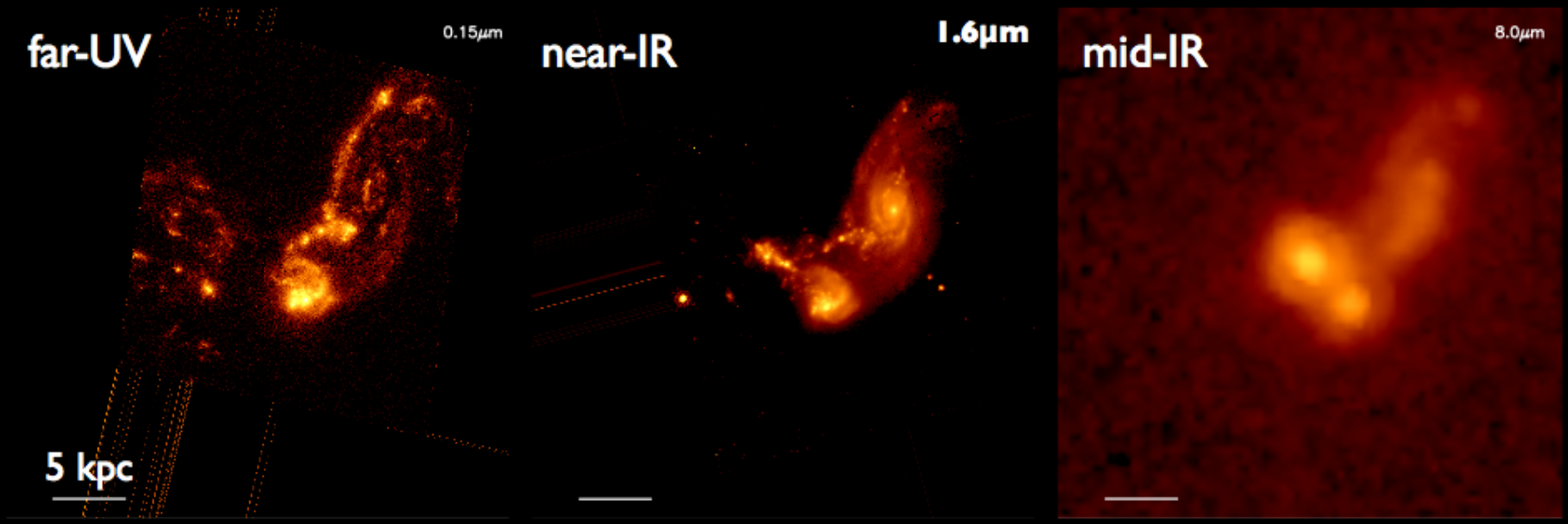
Starburst/AGN; Dust-enshrouded phase; cool IR colors

Dust-clearing; AGN-dominant phase; warm IR colors

Elliptical Byproduct

(Sanders et al. 1988; Hopkins et al. 2006)

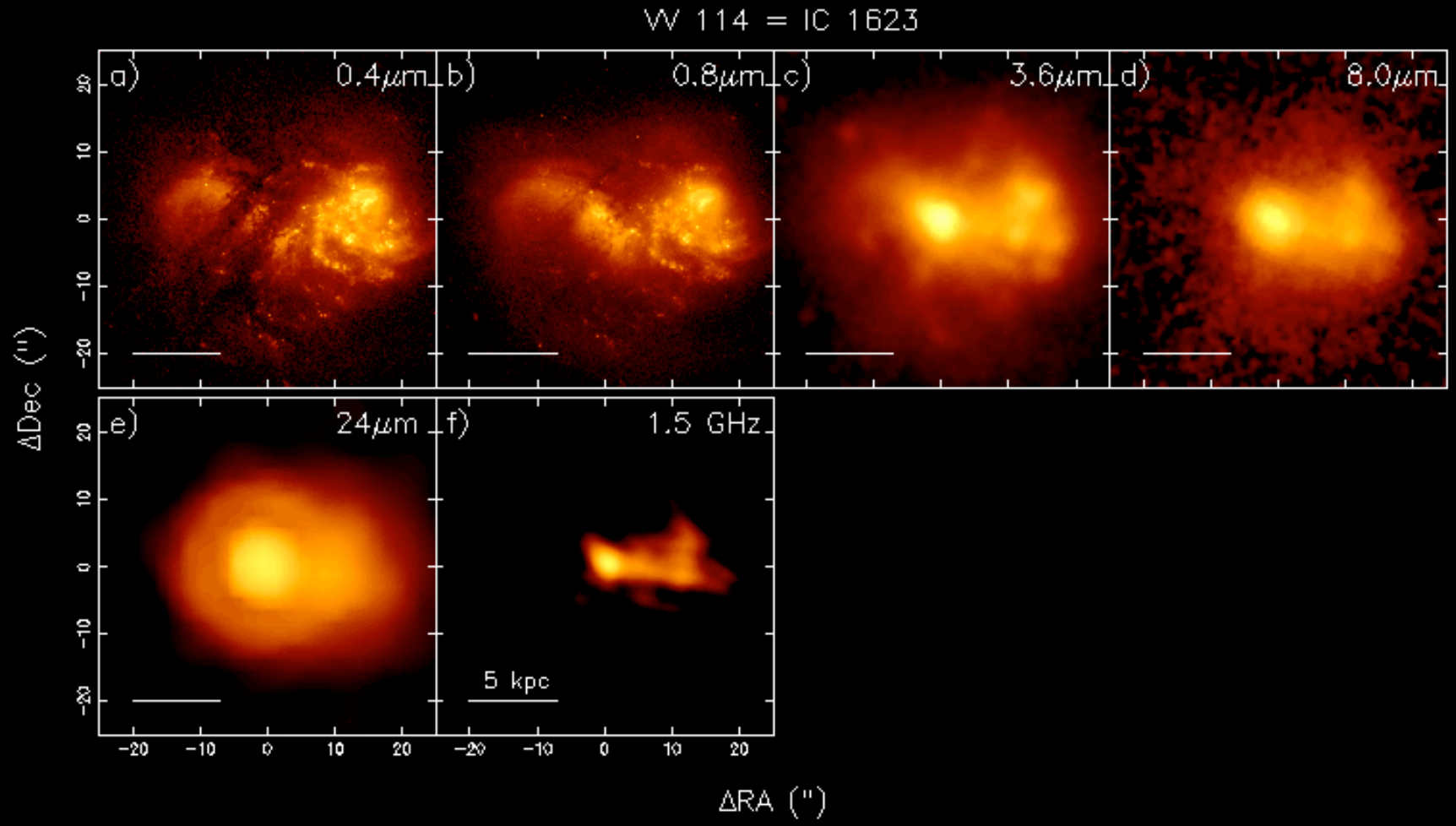
The Luminous Infrared Galaxy IIZw096



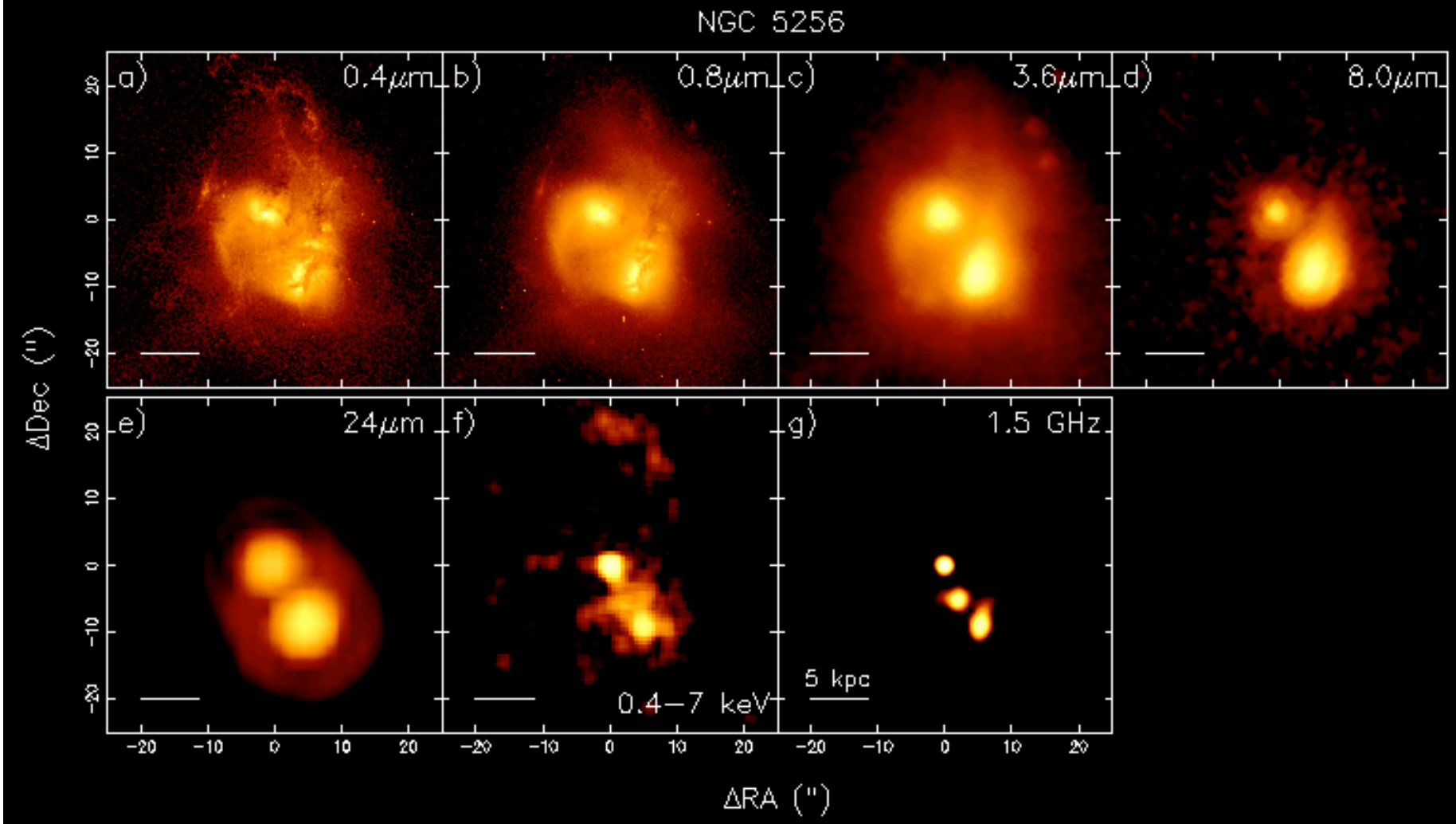
- The primary energy source, which contains 95% of bolometric luminosity, is optically obscured.
- The Spitzer observations (~ 2” resolution) do not resolve this mid-IR energy source

(Inami et al. 2010)

VV114: The region containing the primary bolometry energy source is hidden at optical wavelengths

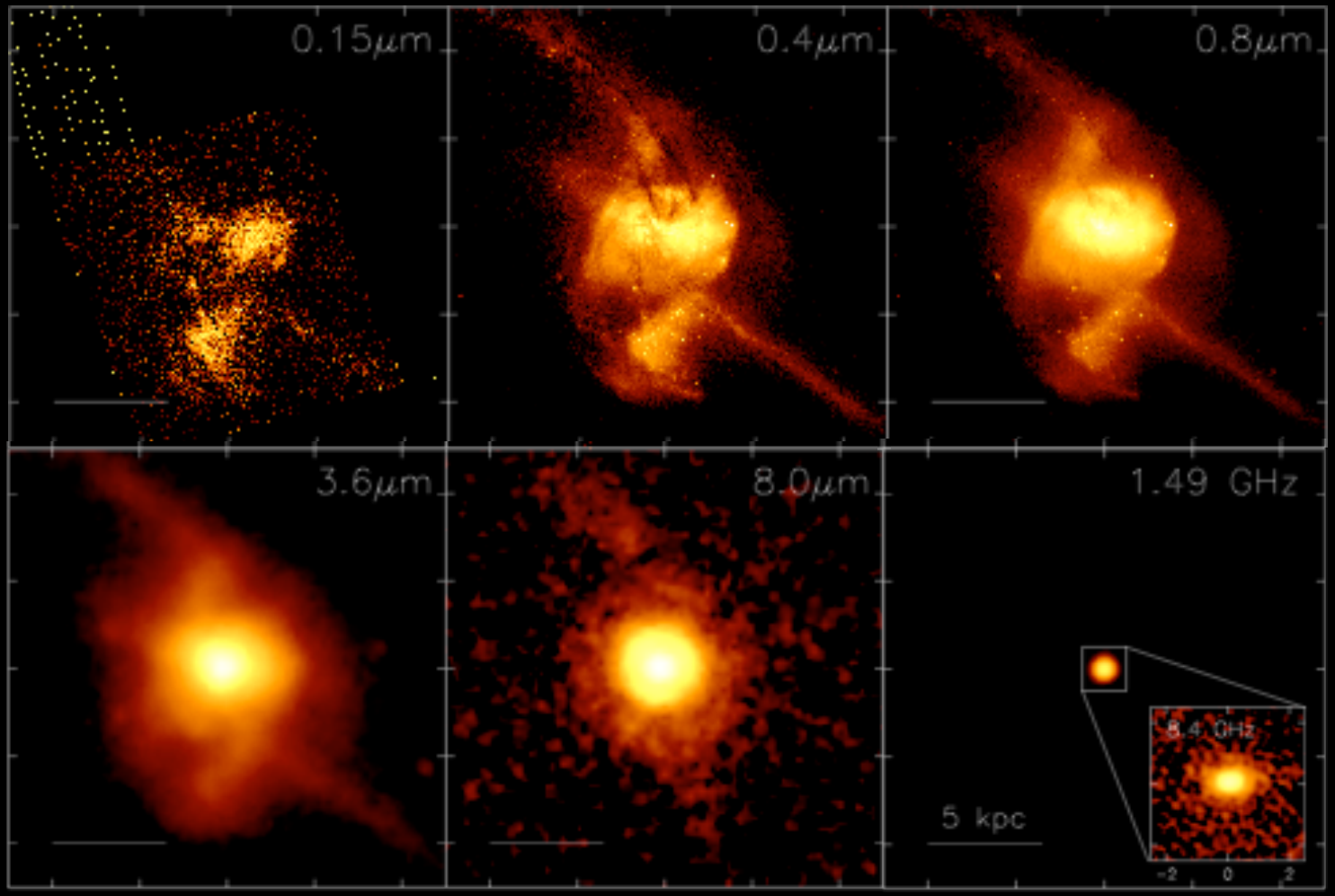


Mrk 463: mid-stage merger; double AGN + outflow



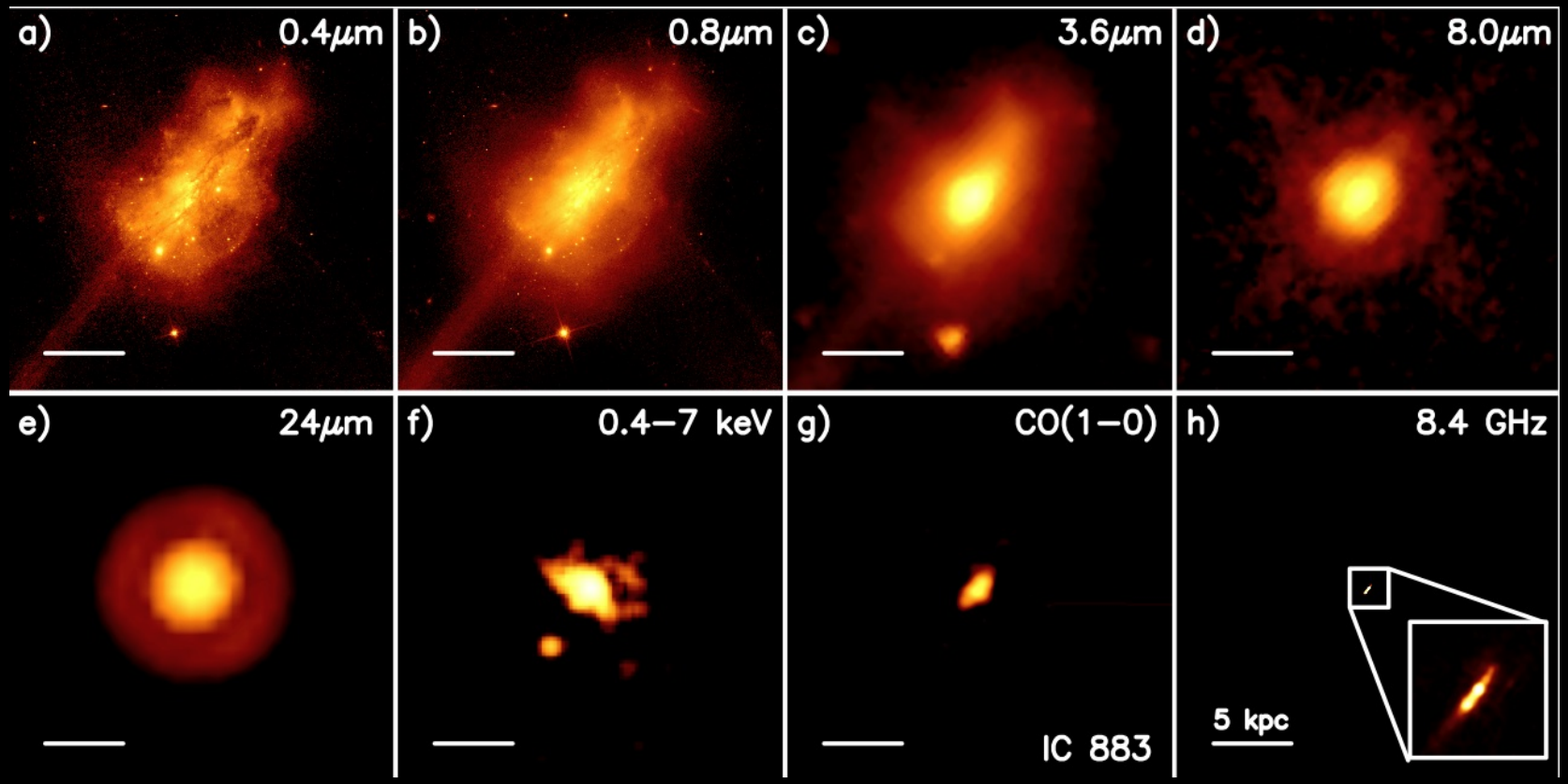
(Mazzarella et al. 2012)

NGC 2623: late-stage merger; single nucleus, weak AGN



(Evans et al. 2008)

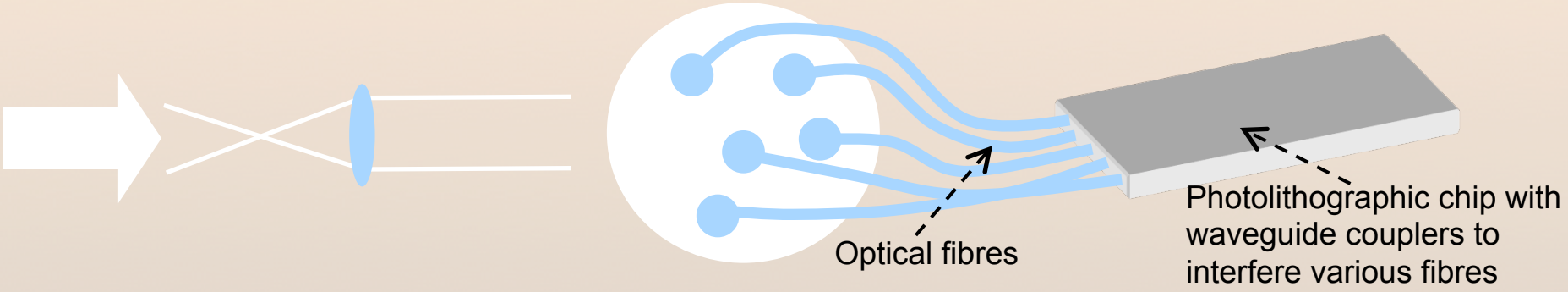
IC 883: late-stage merger containing an optically-obscured AGN

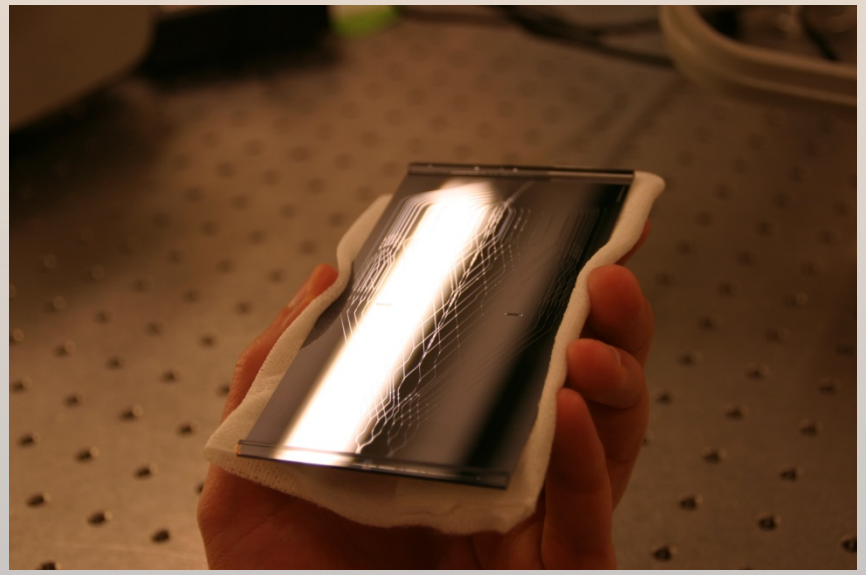


(Modica et al. 2012)

Use 100% of pupil on AFTA NRM?

Generation 2: Fiber optic + 2D optics pupil re-mapper





1. <u>High sensitivity</u>, use all the light
2. <u>High precision</u> - single mode fiber filtering
3. <u>High stability</u> - integrated beam combiner
4. Higher contrast?
5. Dual polarization at λλ 0.4um-0.8um?
6. IFU on AFTA COR

JWST & AFTA NRM + VLA + ALMA

=

Multi-wavelength understanding of AGNs, ULIRGs, environs of Supermassive Black Holes

1. **AFTA -** 20-40 mas resolution at 0.4 - 0.8 um + polarization + IFU to look at physics of outer disk, dusty torus at moderate extended object contrast, good binary nucleus contrast
2. **JWST -** Dust obscuration in the optical: high resolution mid-IR NIRISS NRM observations allow us to see embedded nuclear structures which may be funneling fuel to the nuclear AGN or starburst. Identify nuclear starbursts and AGN which may be obscured in the optical
3. **VLA -** Window on feedback
4. **ALMA -** looks at star forming gas, feedback

AFTA NRM Wishlist

- *Good pupil*
- *Good guiding (local control?)*
- *Well-calibrated flat field*
- *At least Nyquist pixels*
- *Image plane deconvolution advances*
- *Photonic 'combining' for efficiency?*
- *Calibratable instrument polarization*
- *IFU or other hyperspectral imaging*
- *Stability, repeatability between target & point source calibrator*