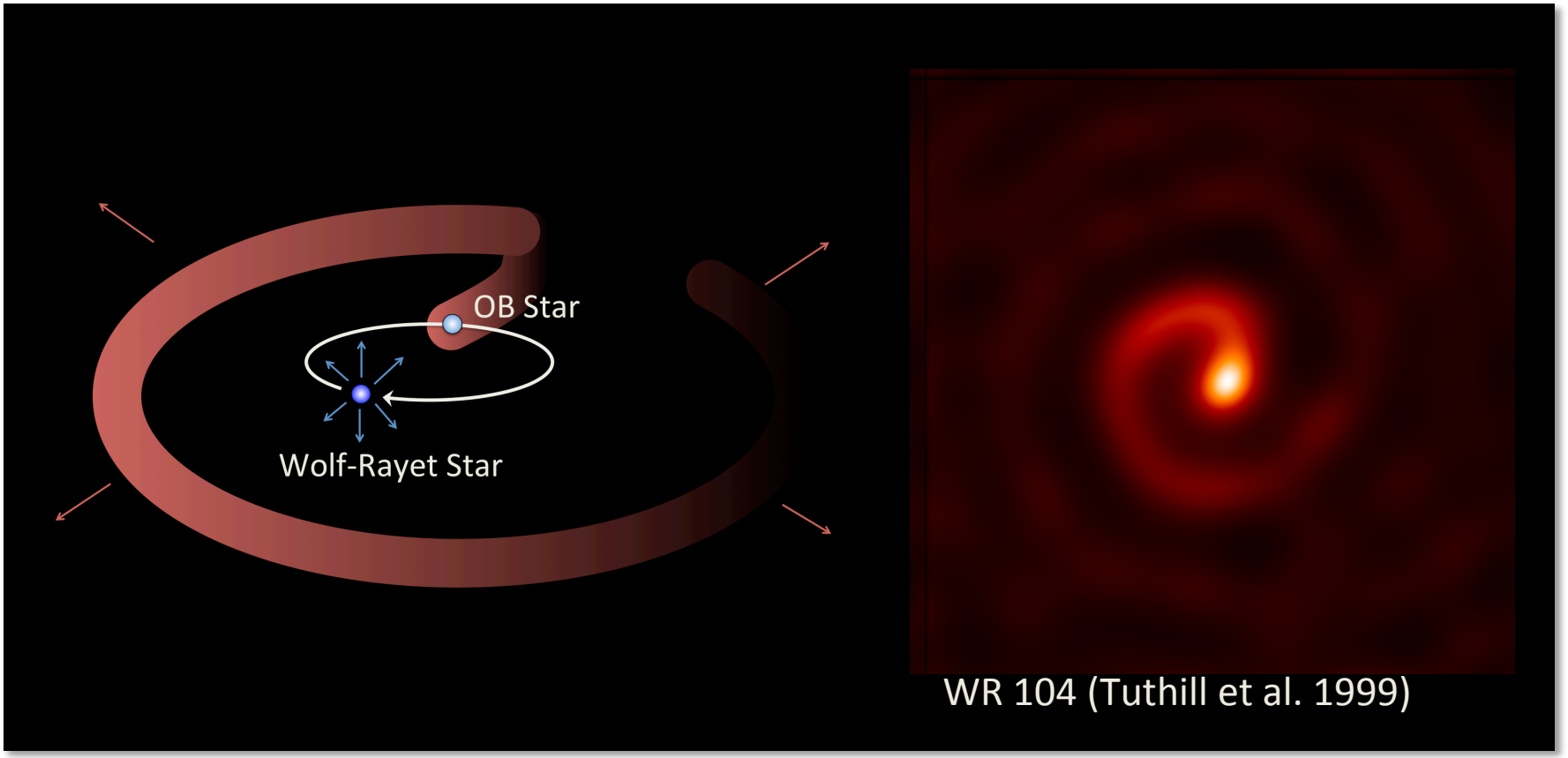
Unraveling the Nature of Dust Production from Wolf-Rayet Binaries



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TMT Science Forum
Kyoto, Japan
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Forming Dust in WR Binaries

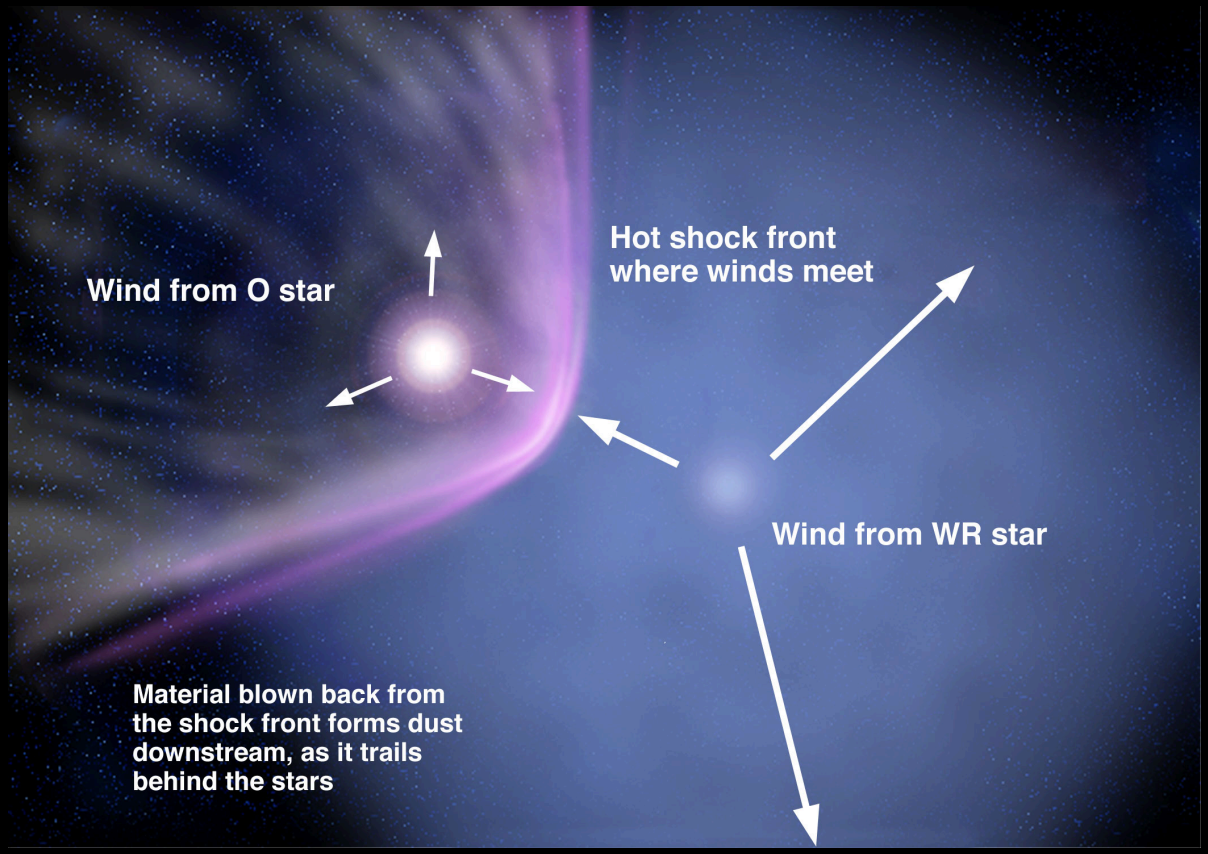


Image by Gemini Observatory

Dusty Outflow & Orbital Motion Forms a "Pinwheel"

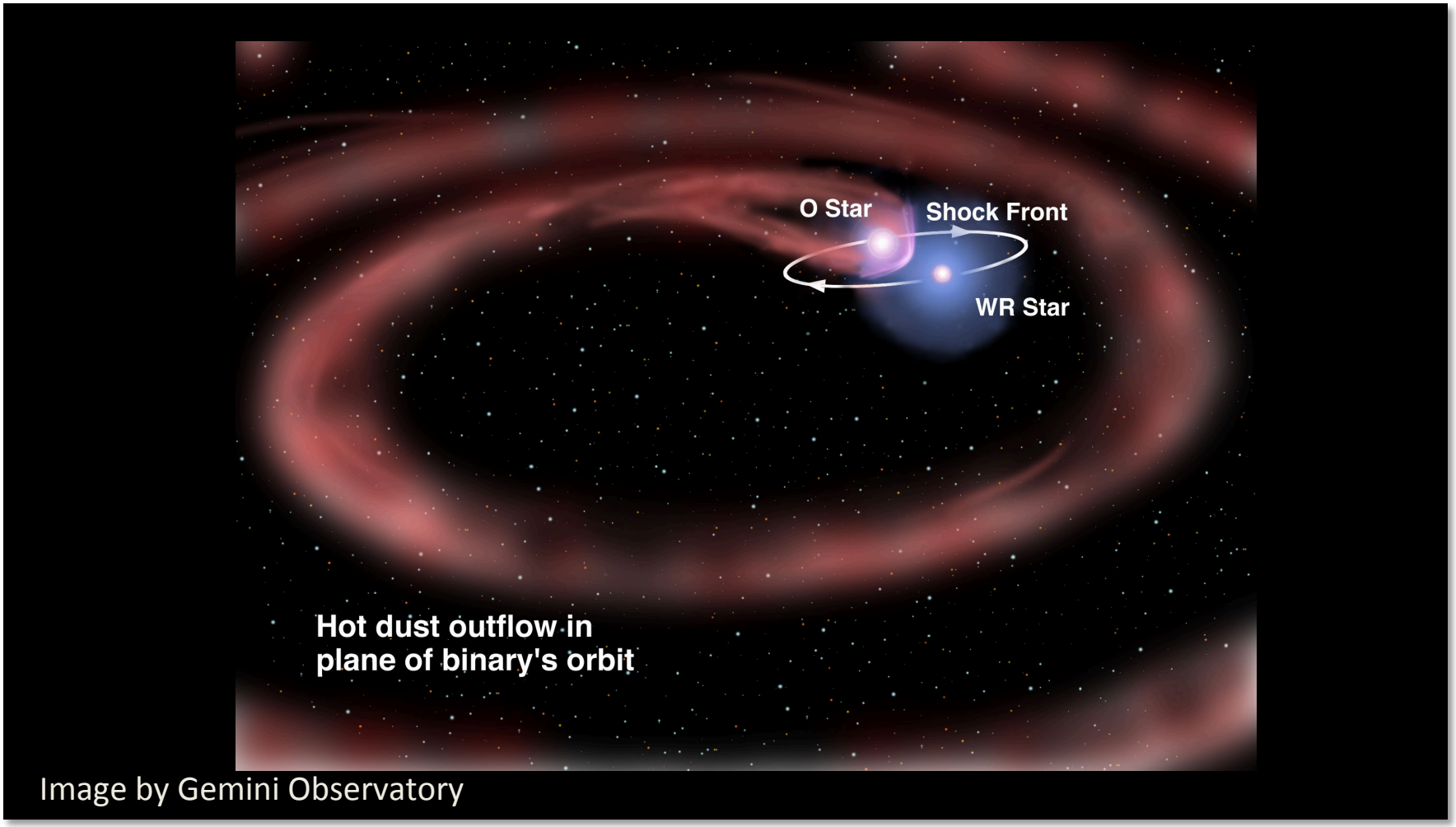
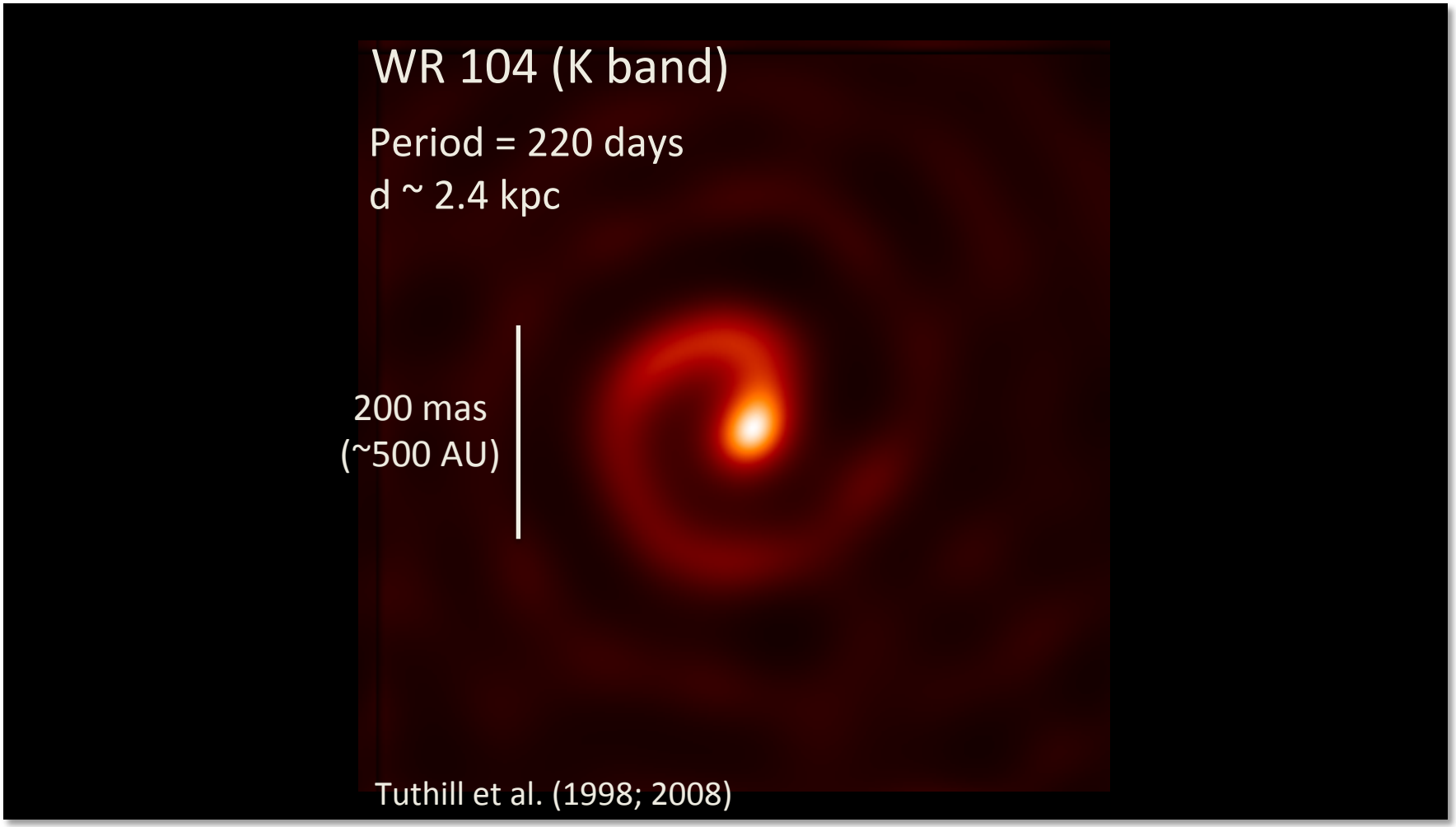


Image by Gemini Observatory

Dusty WR "Pinwheel" Nebulae!



Revisiting an important question–
What is the WR Binary Contribution to Galactic Dust Budget?

According to dust production studies in 1998…

(Dwek 1998)

DUST PRODUCTION RATES IN THE SOLAR NEIGHBORHOOD AT $t = t_G$[a]

STELLAR SOURCE	THIS WORK		JONES & TIELENS 1994	
	Carbon	Silicate	Carbon	Silicate
Quiescent mass loss				
C-rich stars	2.8	…	2.1	…
O-rich stars	…	3.7	…	3.2
Wolf-Rayet stars	0.02	…	0.06	…
Explosive mass loss				
Novae	3×10^{-3}	$<3 \times 10^{-3}$	0.3	0.03
Type II SNe	1.5	7.0	2	12
Type Ia SNe	0.09	3.5	0.3	2

Dust contribution from WR stars thought be insignificant… almost ~100x less than SNe

However, there are two important things to point out...

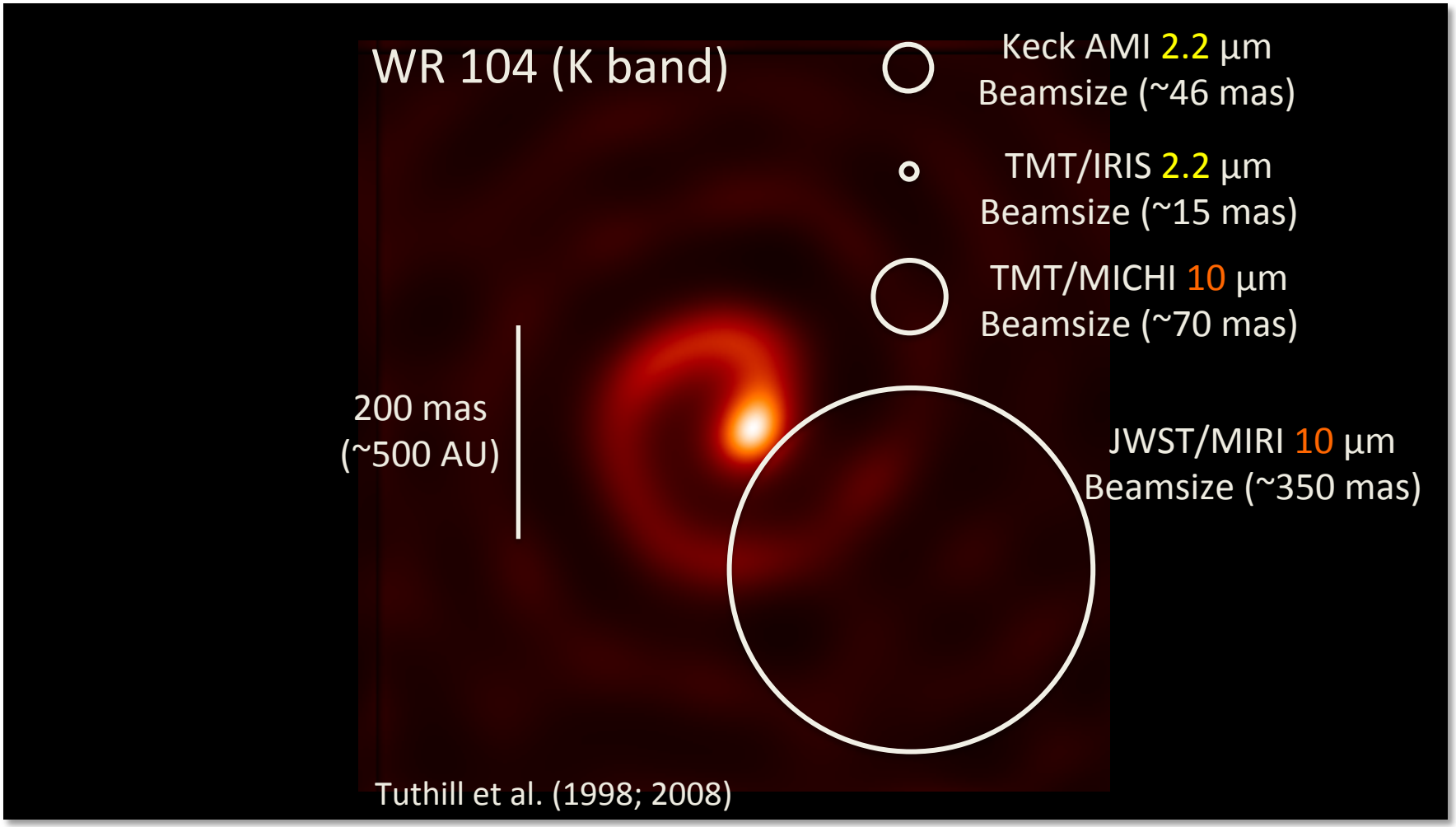
1. *There are only ~40 known galactic dusty WR system* (Rosslowe & Crowther 2015)
   - Dust formation/survival properties highly uncertain

2. *Recent observational studies revealed that >70% of massive stars exist in close binaries* (Sana et al. 2012)
   - Implies that a majority of massive stars may evolve through a dust-producing WR phase

Unraveling the nature of dust formation/survival with the TMT

- Multi-epoch, resolved near to mid-IR imaging from IRIS and MICHI will reveal…
  - Detailed morphology of the dust formation regions
    - How far "downstream" from the wind collision region does dust condense?
  - Dust temperature and density profile along the "pinwheel"
  - Mass loss history and evolution of cooler (mid-IR emitting) dust mass

WR104 from different observatories

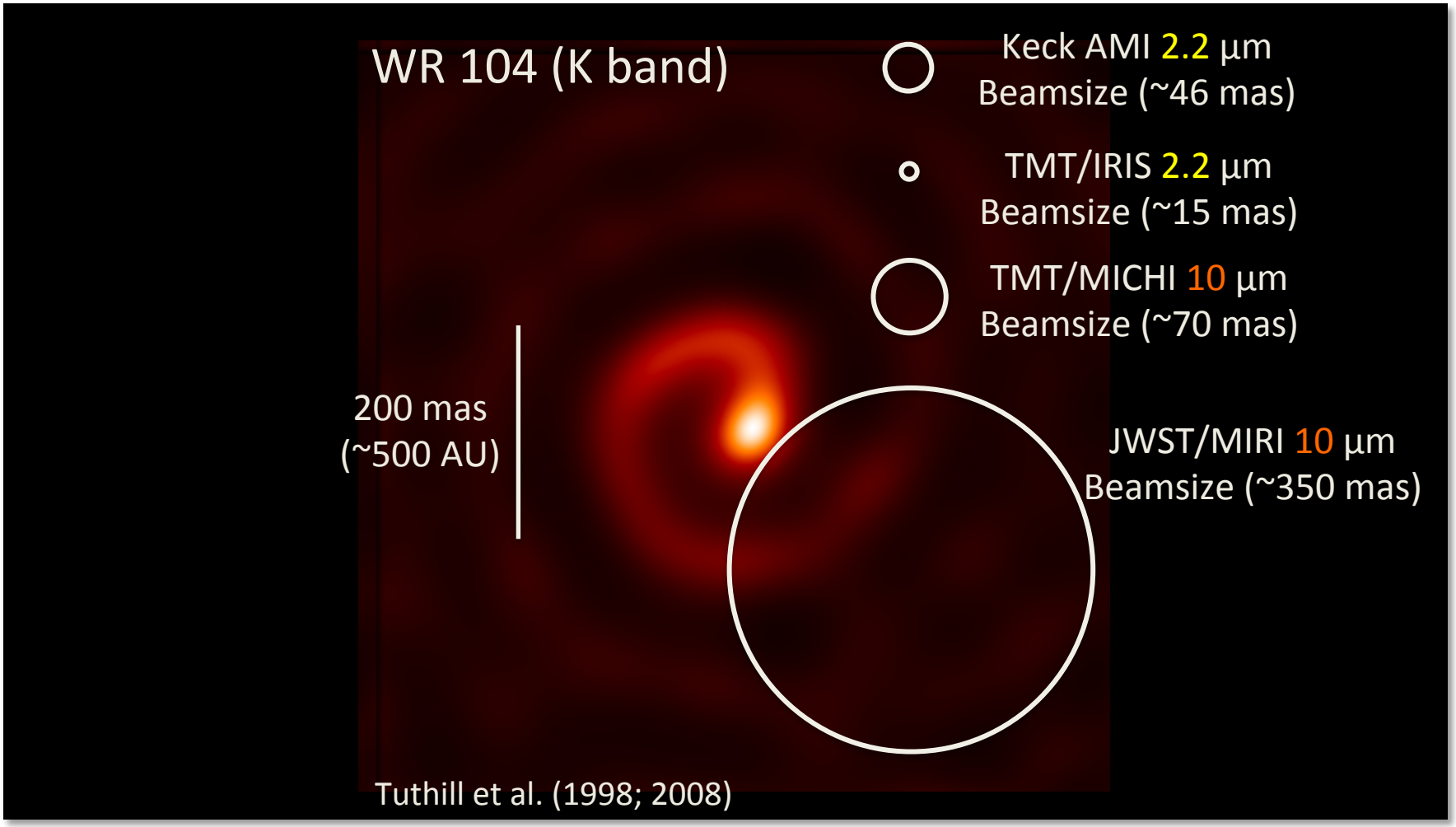


Current and Future Work

- SOFIA Mid to Far-IR photometry of dusty WR stars in the Galactic center (Hankins et al., Submitted)
  - *A lot more mass in dust than other known dusty WR systems (by factor of ~10)!*

- Near Future: JWST/MIRI mid-IR IFU observations of extended dusty WR systems
  - Chemistry and dust processing from ISM interaction

Thanks!


WR 104 (K band)
Keck AMI 2.2 µm
Beamsize (~46 mas)
TMT/IRIS 2.2 µm
Beamsize (~15 mas)
TMT/MICHI 10 µm
Beamsize (~70 mas)
200 mas
(~500 AU)
JWST/MIRI 10 µm
Beamsize (~350 mas)
Tuthill et al. (1998; 2008)