Star Formation Studies with SOFIA and its Synergy with TMT

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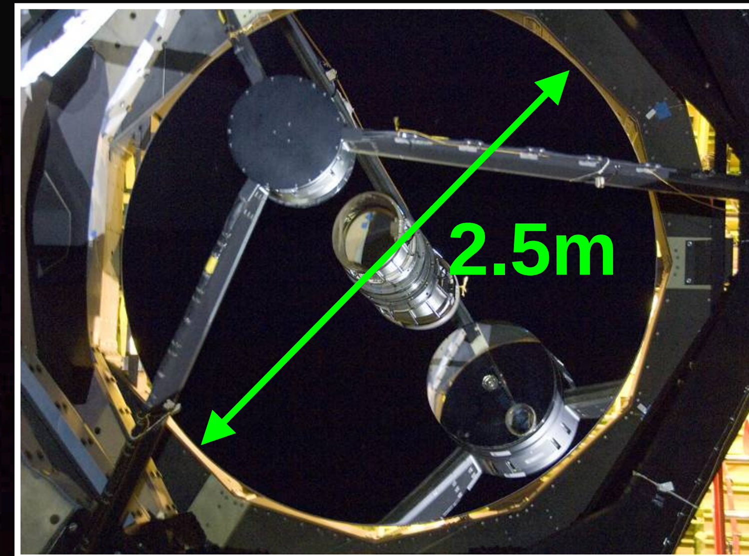
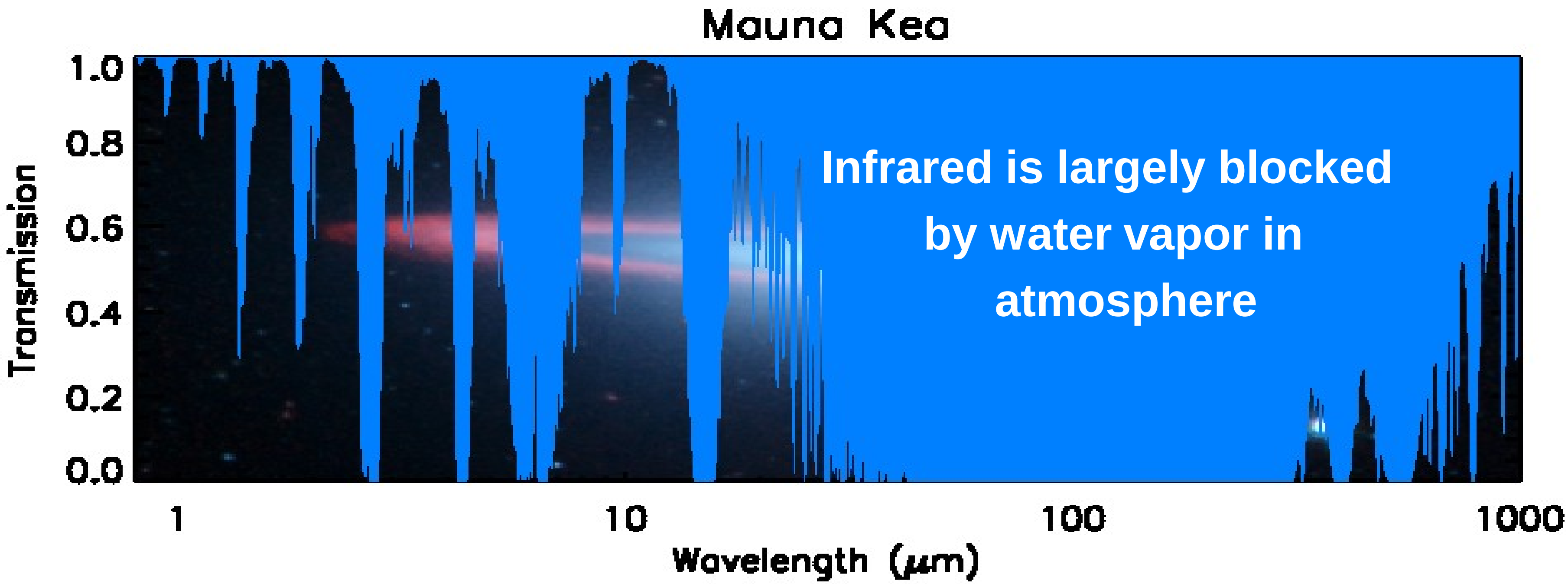
SOFIA Instrument Scientist

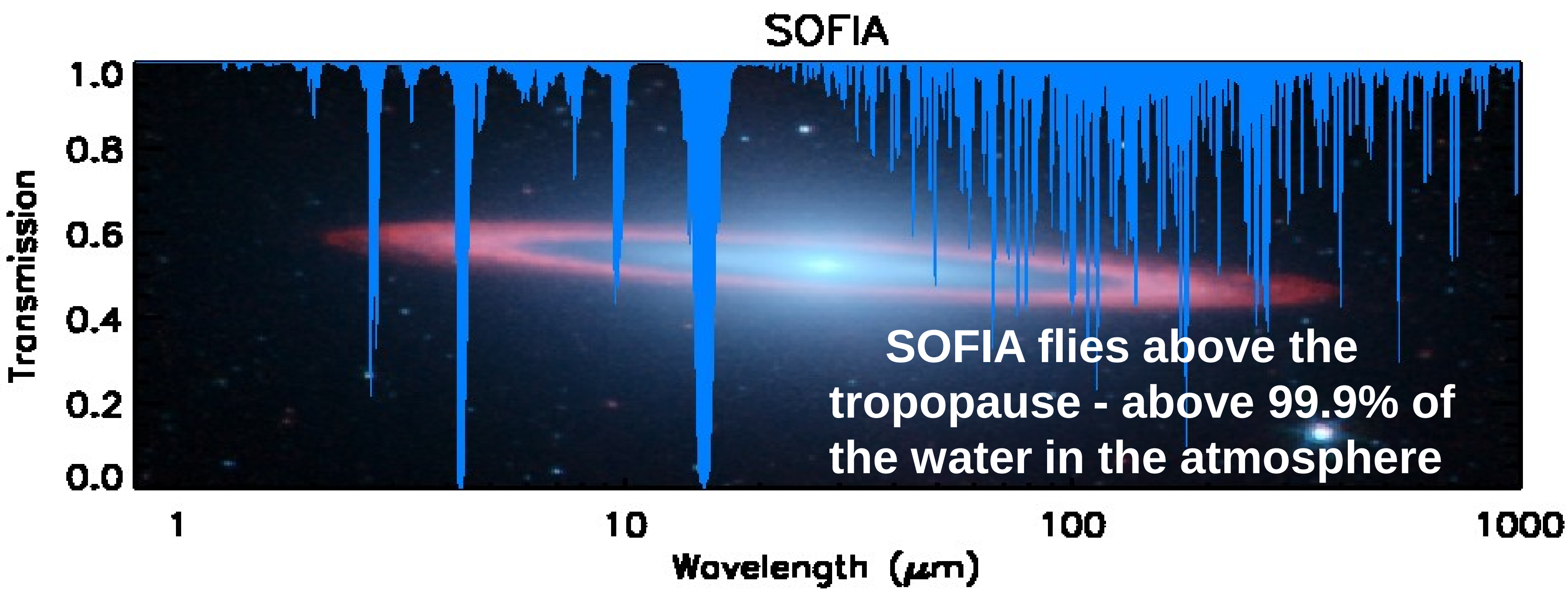

Heavily modified 747-SP aircraft
More than 40 investigator teams/y
8-10 hour flight times
SOFIA
NASA
DLR
Operational elevation between 37,000 and 45,000 ft
Partnership with Germany
NASA
450 science hours in Cycle 3 (calendar year 2015)
800 h/y in Cycle 4 ramping to 960 h/y in Cycle 6+
Reached FOC in April of this year

Telescope Details:

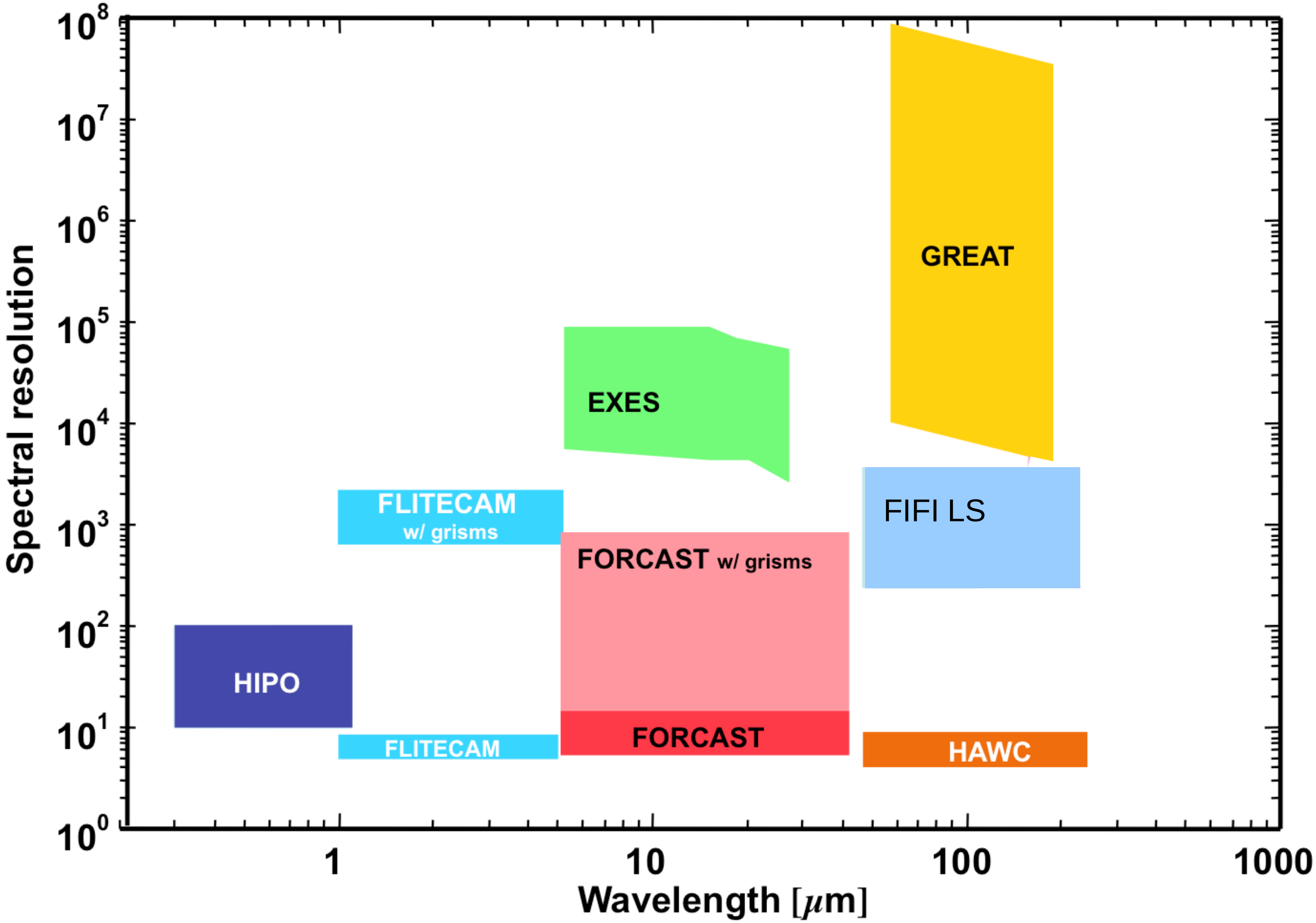
- Effective aperture: 2.5 meters
- Telescope elevation range: 20 – 60^{o}
- Wavelength range: 0.3 to 1600 um
- Diffraction-limited beyond 15 um
- 2” at 25um, 4” at 50um, 8” at 100um, 20” at 250um, 40” at 500um
- FoV up to 8 arcmin



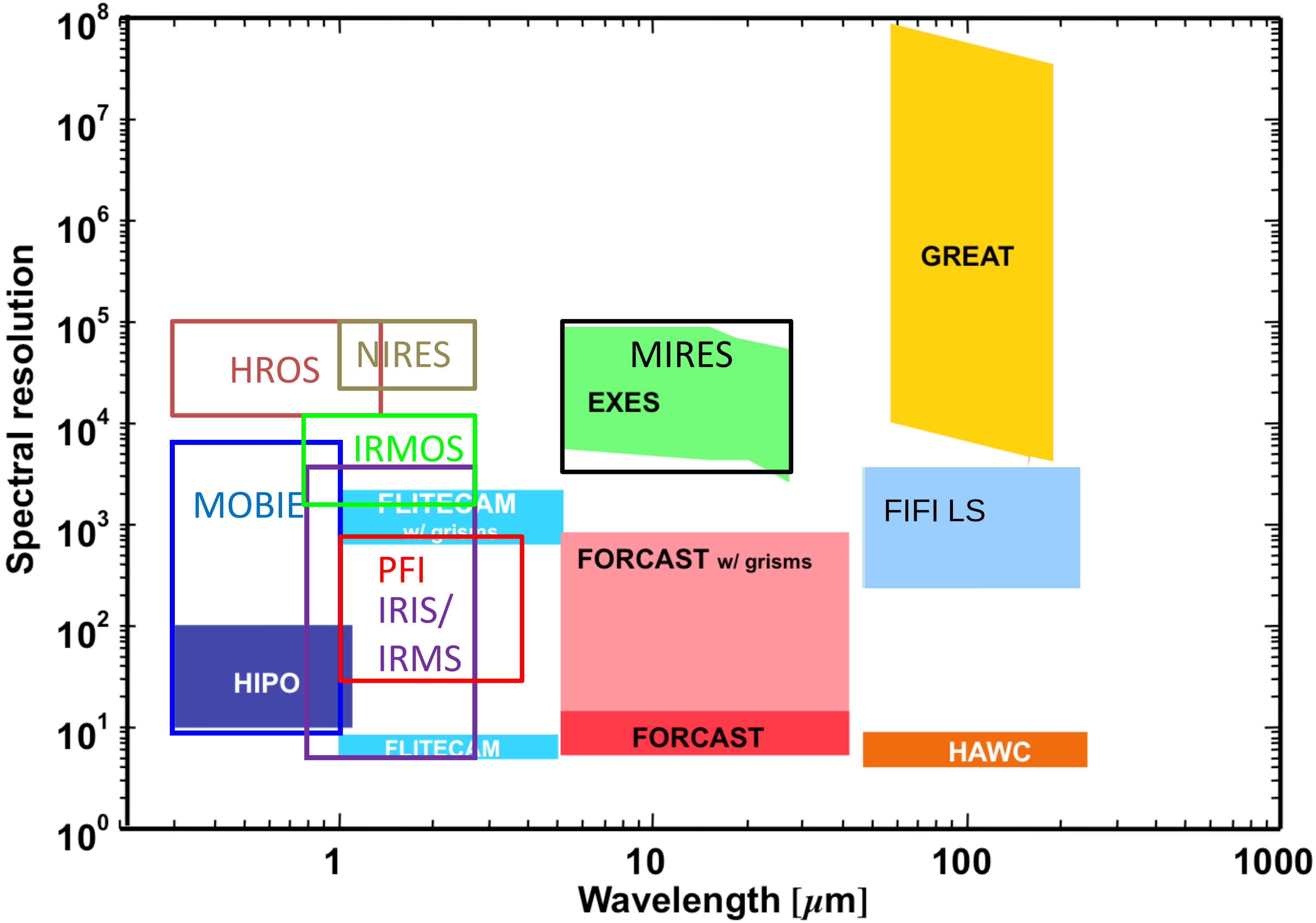

Mauna Kea
Transmission
1.0
0.8
0.6
0.4
0.2
0.0
1
10
100
1000
Wavelength (μm)
Infrared is largely blocked
by water vapor in
atmosphere


SOFIA
Transmission
1.0
0.8
0.6
0.4
0.2
0.0
1
10
100
1000
Wavelength (μm)
SOFIA flies above the
tropopause - above 99.9% of
the water in the atmosphere

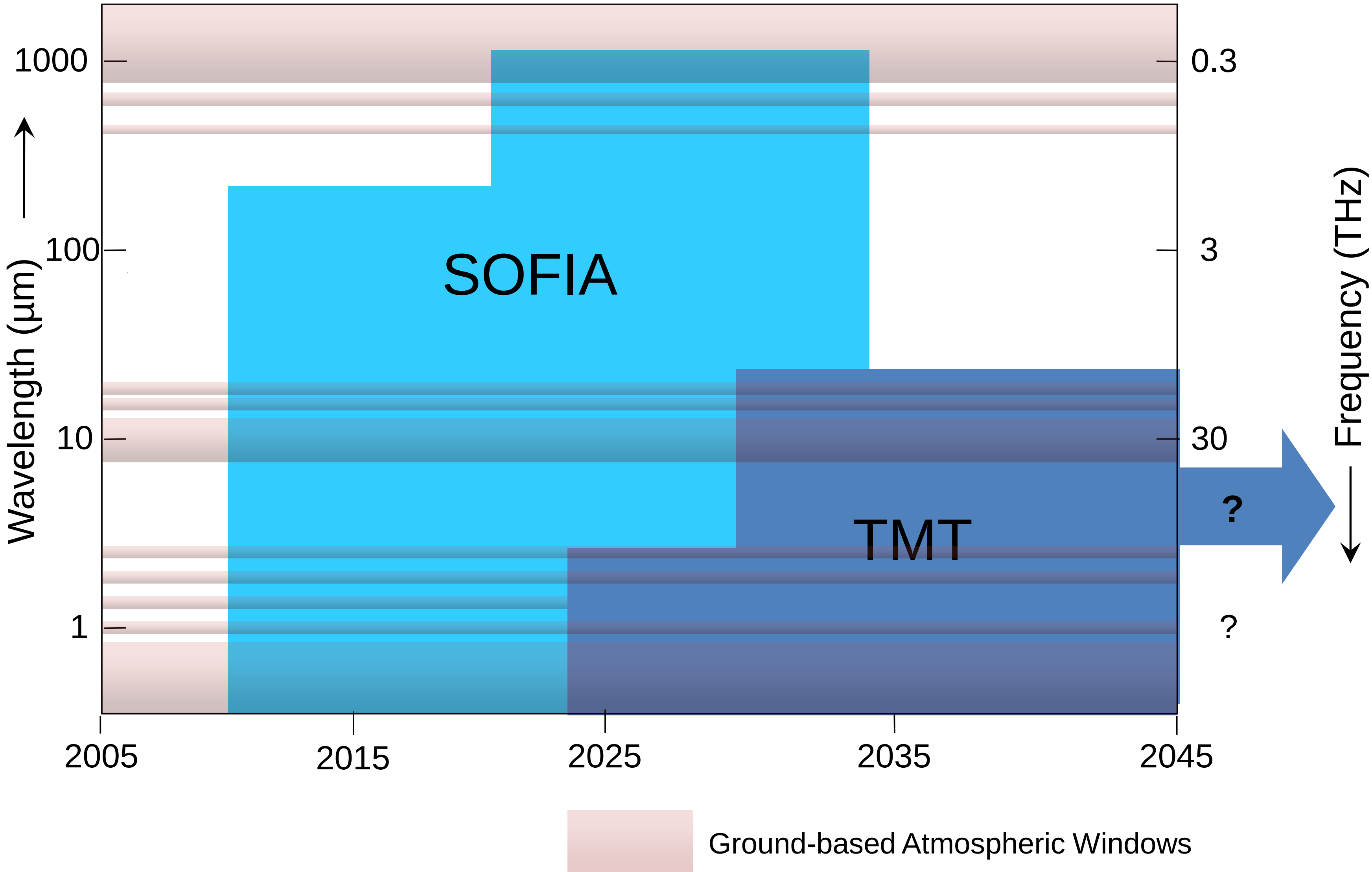
SOFIA and TMT instruments have complementary spectral coverages



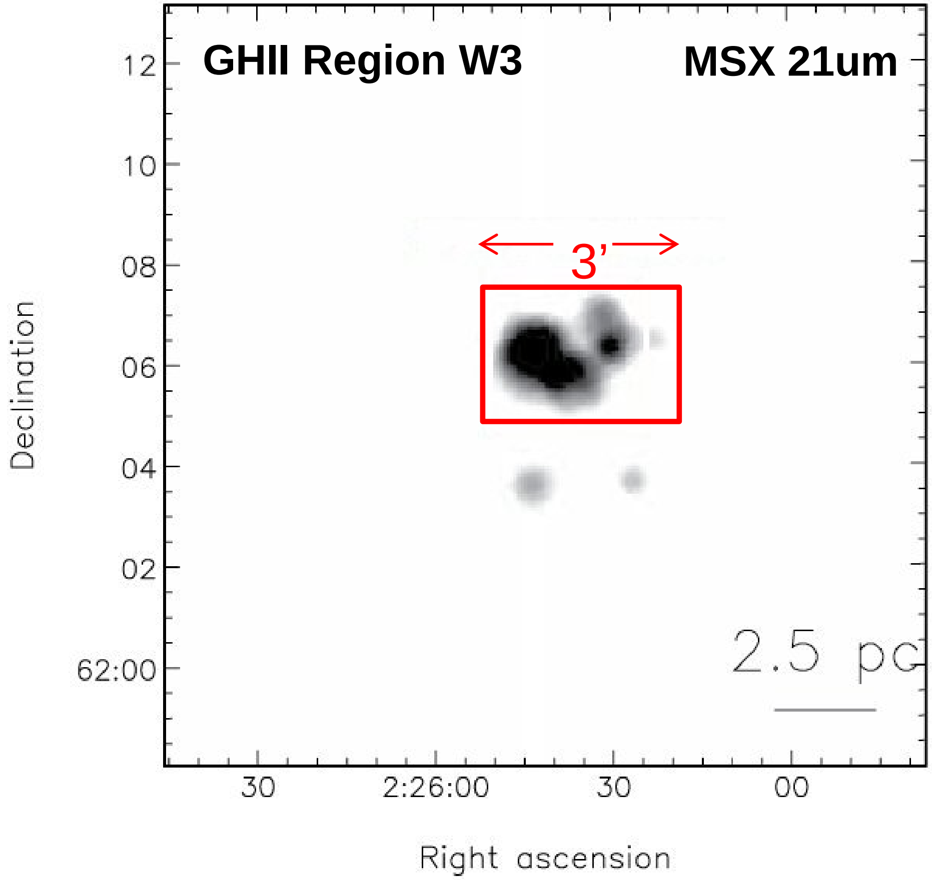
SOFIA and TMT instruments have complementary spectral coverages



SOFIA and TMT projects will be contemporaneous for at least a decade



SOFIA and TMT will allow multi-wavelength bolometric studies of star formation



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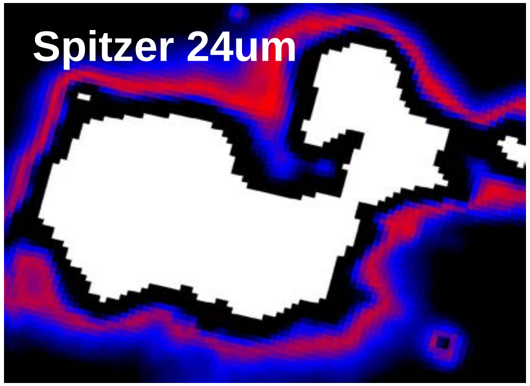
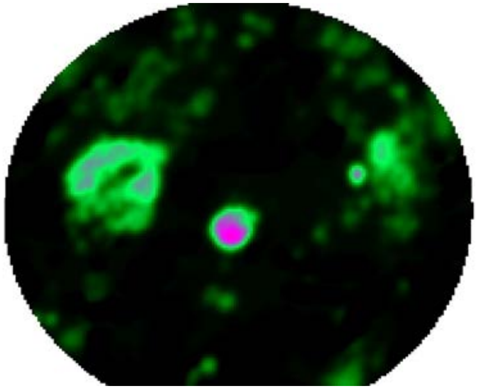
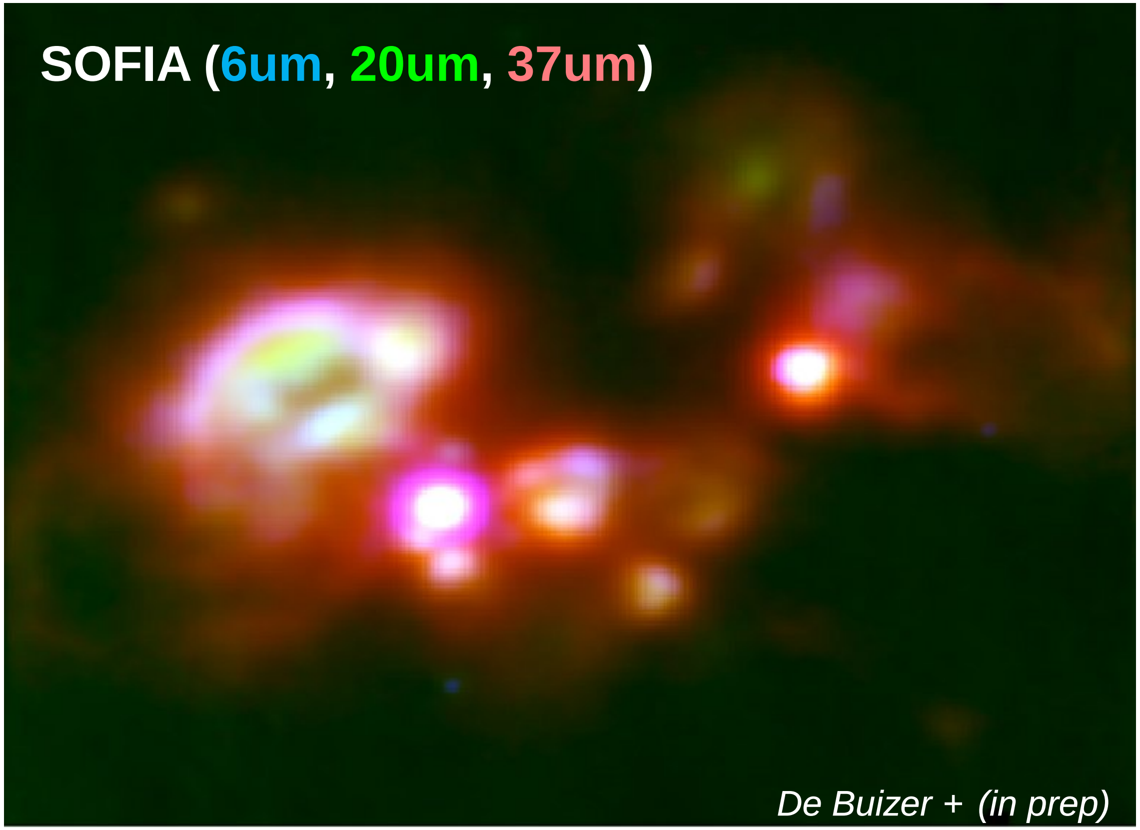


VLA 4.6 GHz

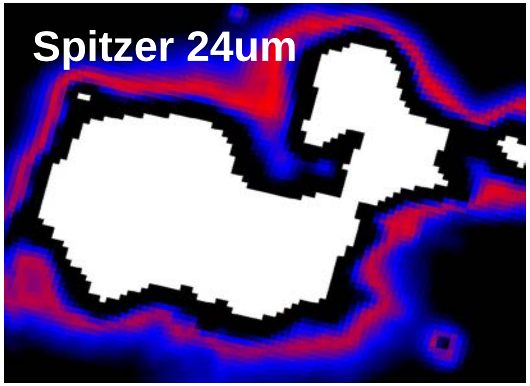




SOFIA: Longer wavelengths uncover the embedded population of very young YSOs and maps large-scale cold dust structures

TMT: Resolve out and target individual less-embedded YSOs for study

SOFIA and TMT will allow multi-wavelength bolometric studies of star formation



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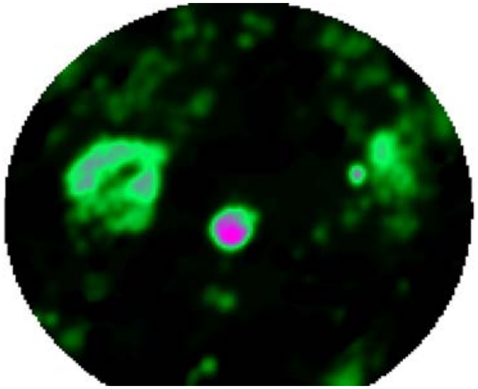
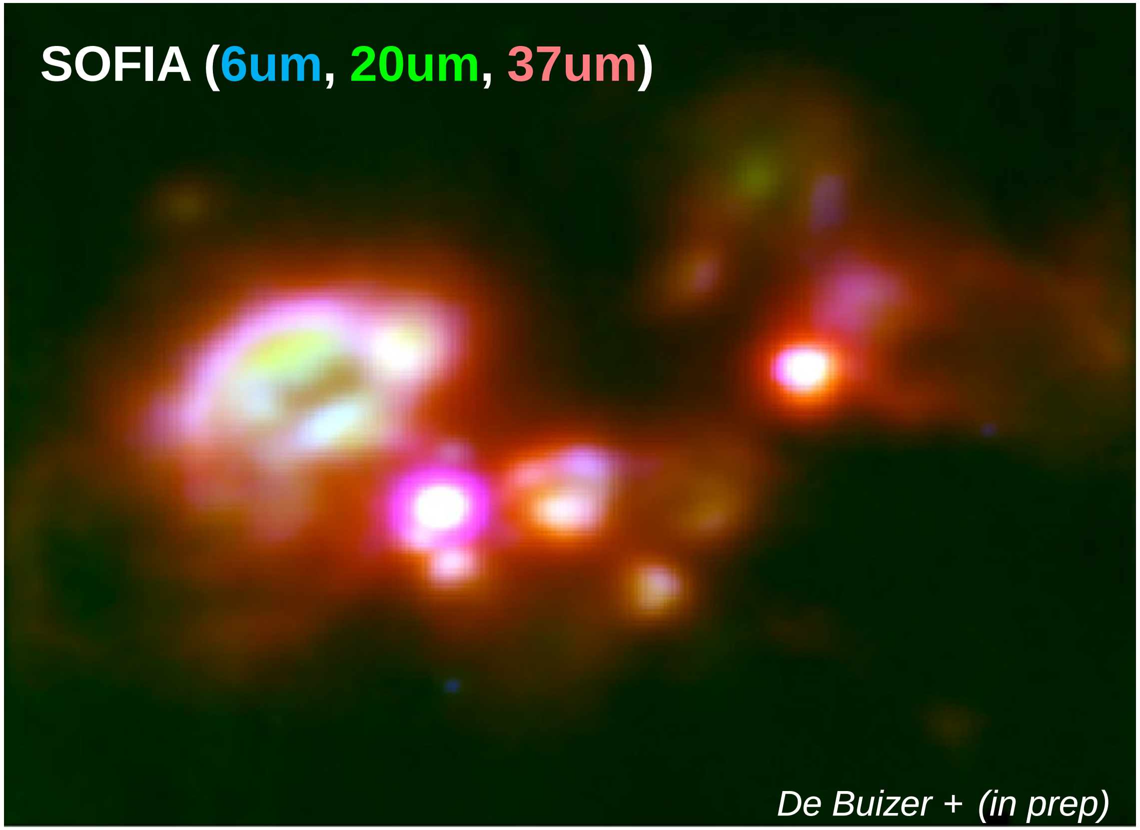
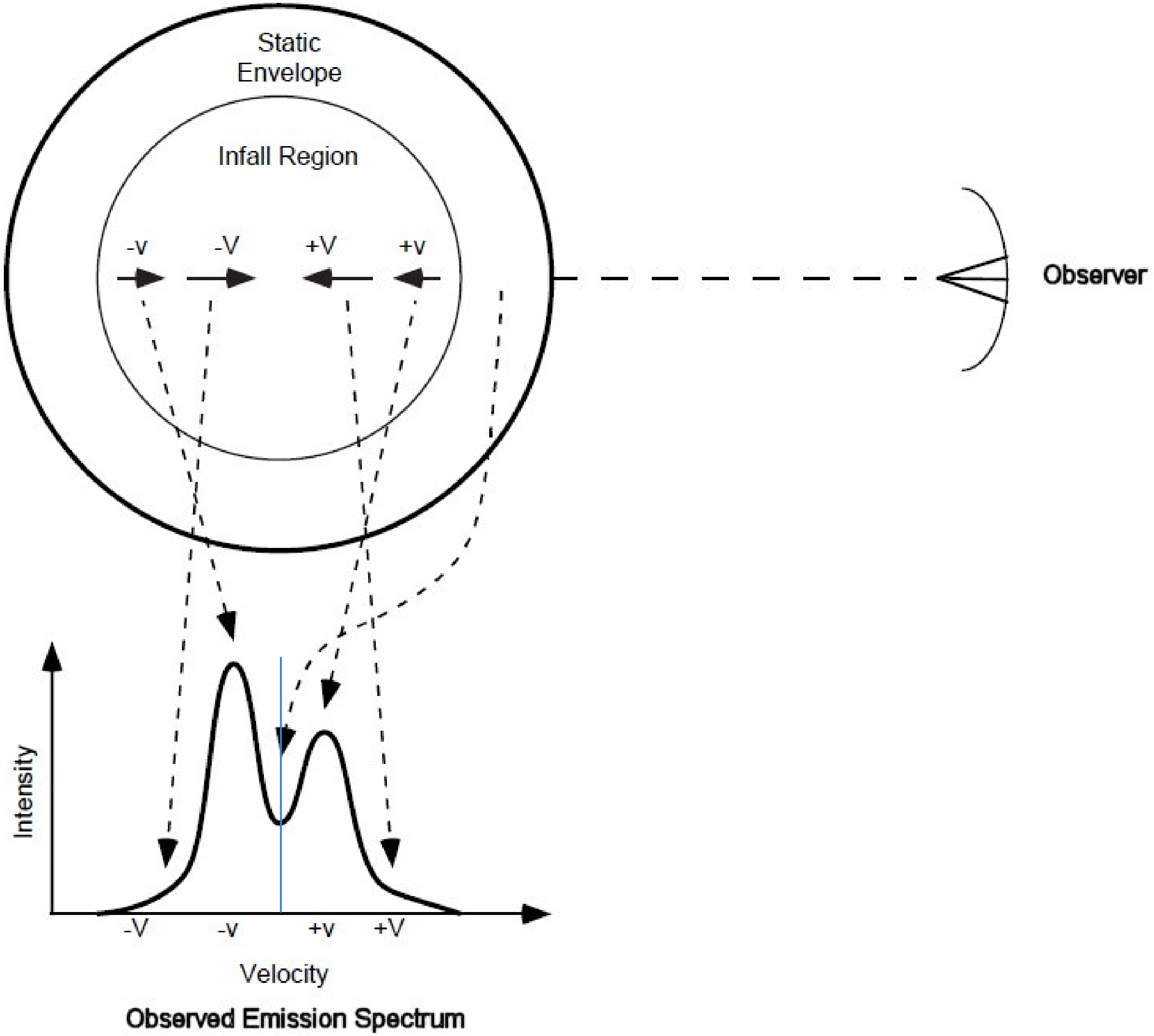




Together one can study the physical properties and the detailed energy balance inside GHII regions as a function of location

SOFIA with TMT can study how a star acquires its final mass through observations of infall and accretion



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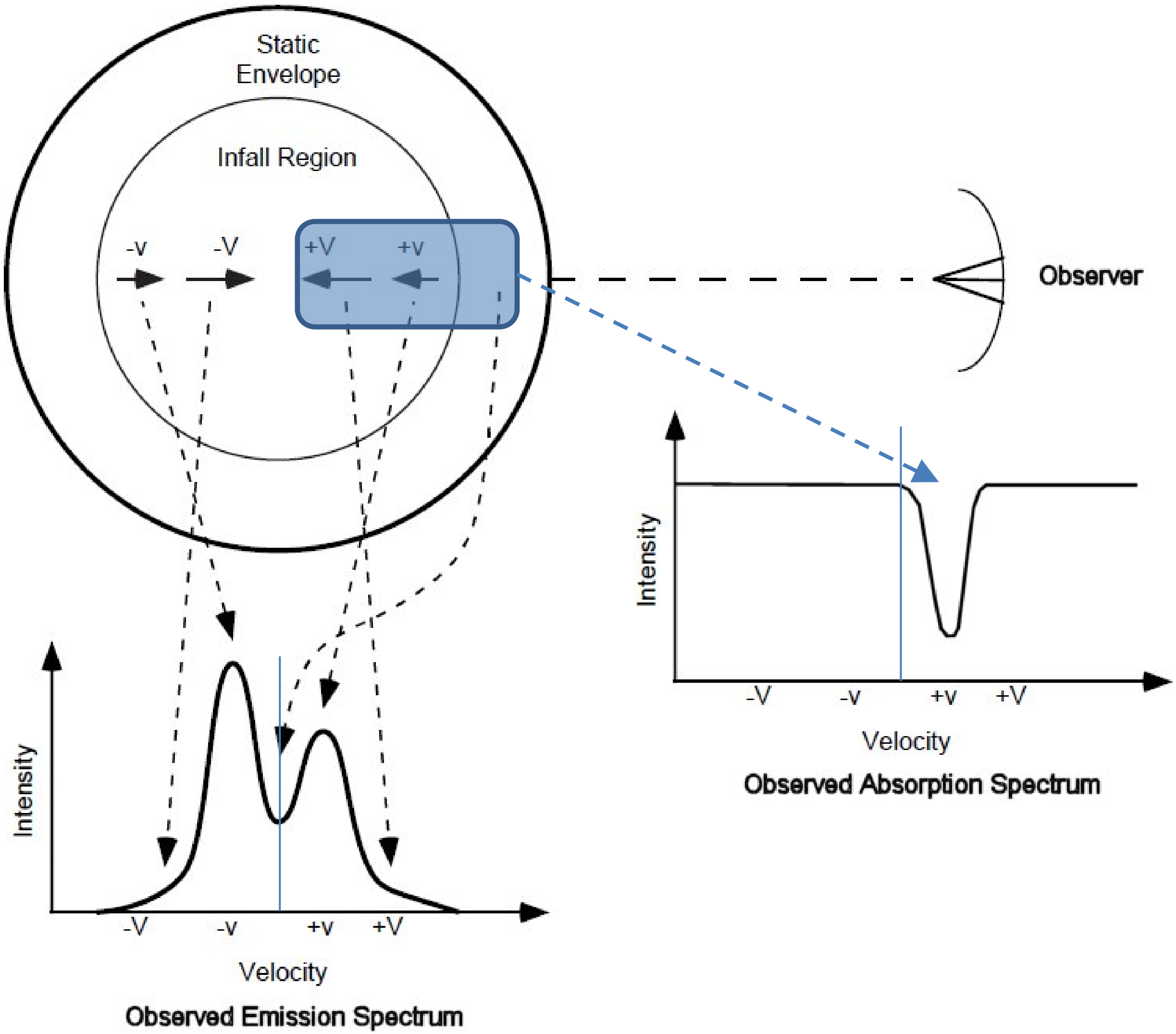
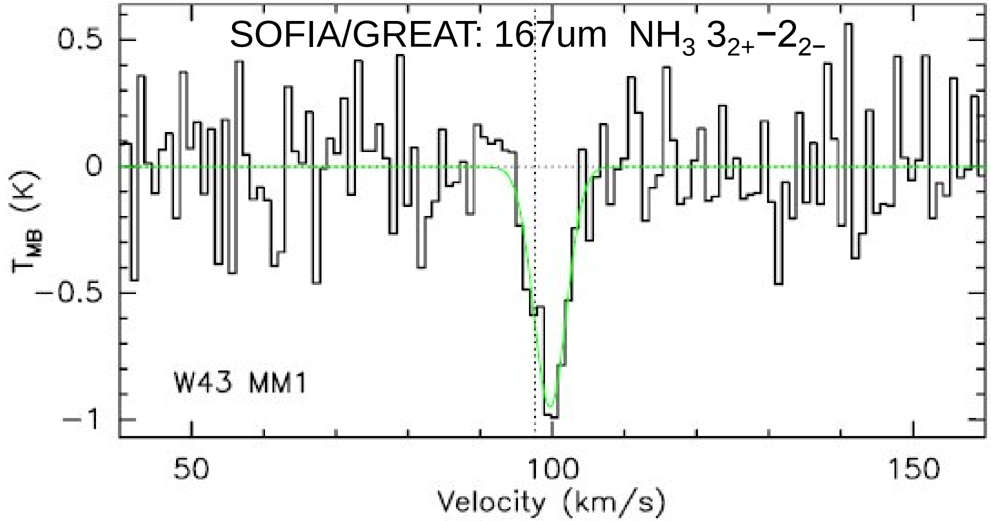


SOFIA with TMT can study how a star acquires its final mass through observations of infall and accretion

- Radio p-Cygni profiles show infall of envelope onto accretion disk but require projection against a radio continuum source



- FIR blue absorption profiles using SOFIA/GREAT only require projection against FIR dust continuum, which is ubiquitous
- Completing the picture, TMT high-spectral-resolution NIR/MIR observation can trace accretion signatures from disk onto star

Together one can trace how the accumulation of material goes from clump into forming YSOs

There are interesting synergies between SOFIA and TMT to exploit when studying star formation

Complementary wavelengths:

TMT = optical to MIR

SOFIA = MIR to sub-mm

Complementary spectral coverage at high spectral resolutions:

TMT = NIR to MIR with $R=10^{5-6}$

SOFIA = MIR to sub-mm with $R=10^{5-8}$

Contrasting and complementary studies in star formation:

TMT

- Structure, chemistry, and dynamics of individual YSOs
- Inner hotter circumstellar disk regions (dynamics and chemistry)
- Less embedded, lower mass, and more evolved states of stellar formation

SOFIA

- Structure, chemistry, and dynamics of cores and clumps
- Outer colder disk regions of isolated YSOs (bridges TMT & ALMA)
- More embedded, higher mass, younger stages of stellar formation