FORCAST Instrument Capabilities and Cycle 2 Science Highlights

Andrew Helton (SOFIA Staff Scientist, USRA)

AAS 225th Meeting

Seattle, WA

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Instrument Overview

- FORCAST - **F**aint **O**bject infra**R**ed **CA**mera for the **S**OFIA **T**elescope
- Facility Instrument
- Imaging - P.I. Terry Herter (Cornell)
  - Dual Channel, mid-IR (5-40 μm) camera
    - Short Wave Camera (SWC) – Si:As BiB Array – $\lambda < 25$ μm
    - Long Wave Camera (LWC) – Si:Sb BiB Array – $\lambda > 25$ μm
    - 3.4’ x 3.2’ FOV with 0.768’’ square pixels
- Spectroscopy – P.I. Luke Keller (Ithaca College)
  - Grism Spectroscopy
    - Low Resolution from 5-40 μm at R ~ 200
    - High Resolution from 5-14 μm at R ~ 800-1200

Star Formation: MWC 297

Disks Around Early B Stars – GIs: Vacca & Sandell

MWC 297

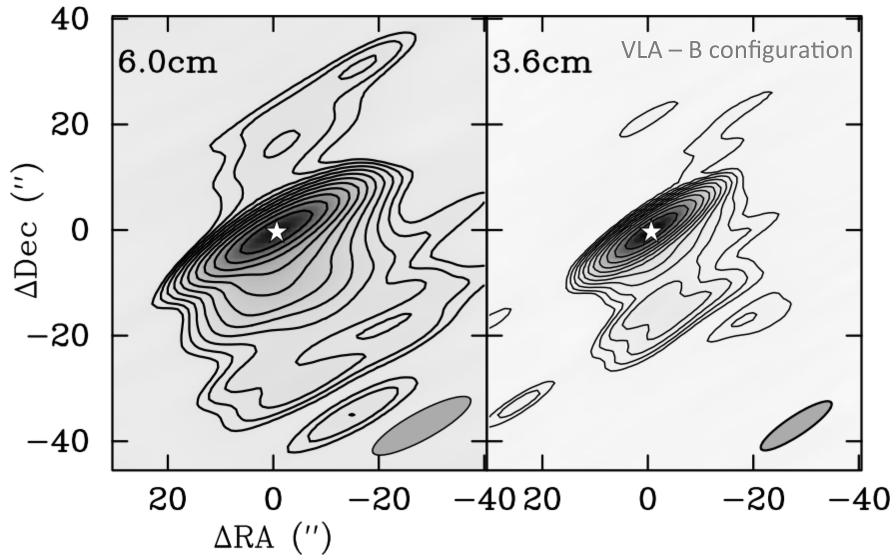
Early type B star – B1.5 Ve

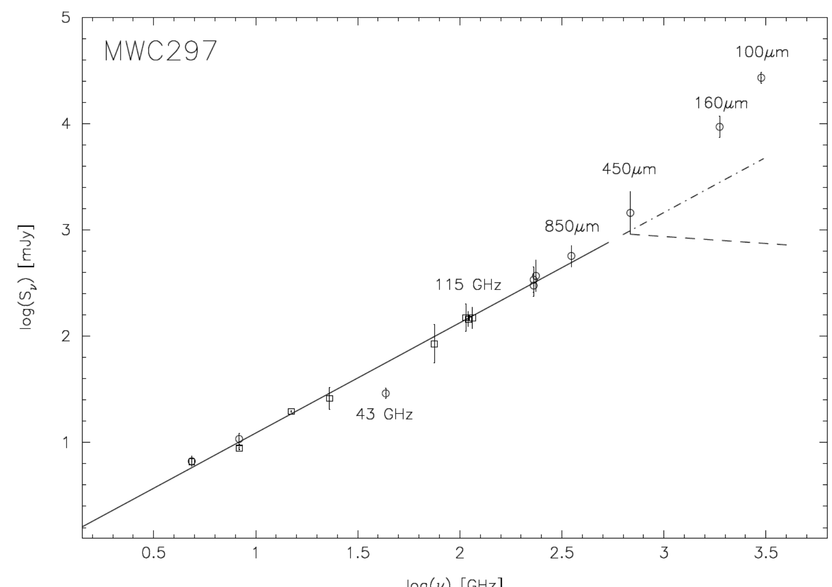
Very close – d = 250 pc

Highly reddened – A_V ~ 8 mag

Previous Studies Suggested a Disk that was:

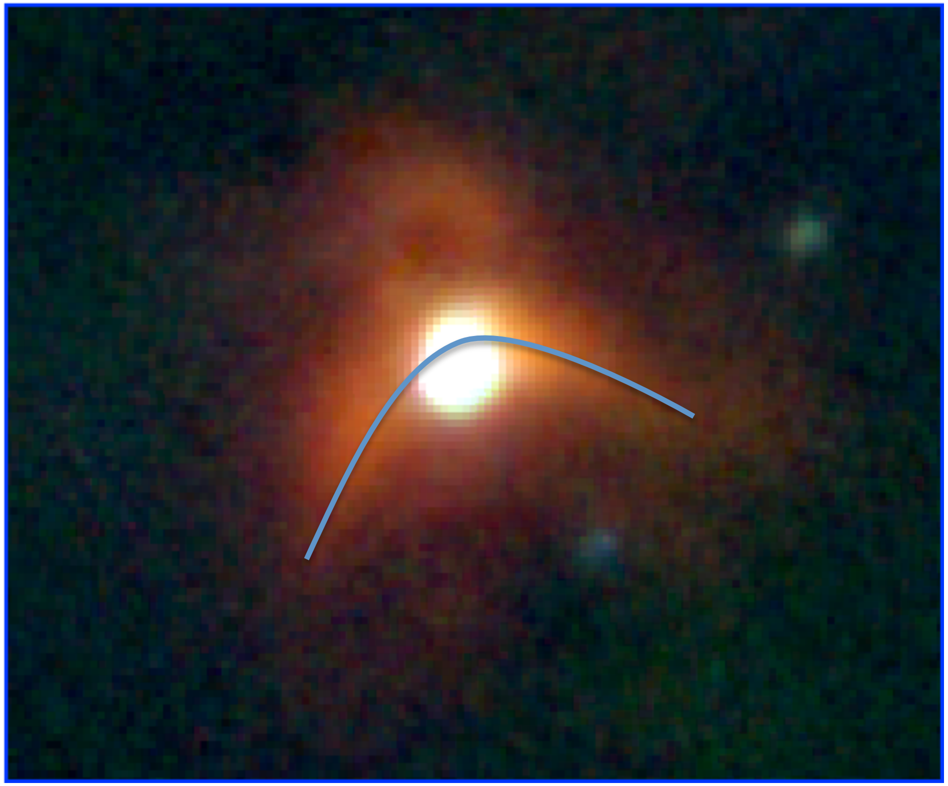
- Nearly face-on (i ~ 20˚)
- Composed primarily of:
  - Cool Dust
  - Large grains



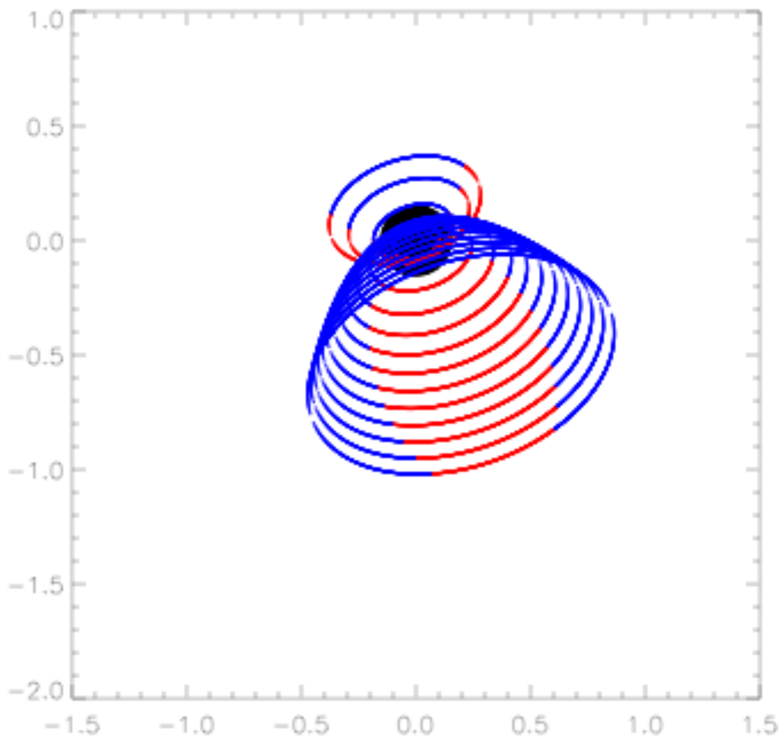


VLA, BIMA, & Herschel
Sandell et al., 2011 + Vacca et al., in prep

Star Formation: MWC 297



FORCAST 3-color image – 11.1, 19.7, 37.1 μm



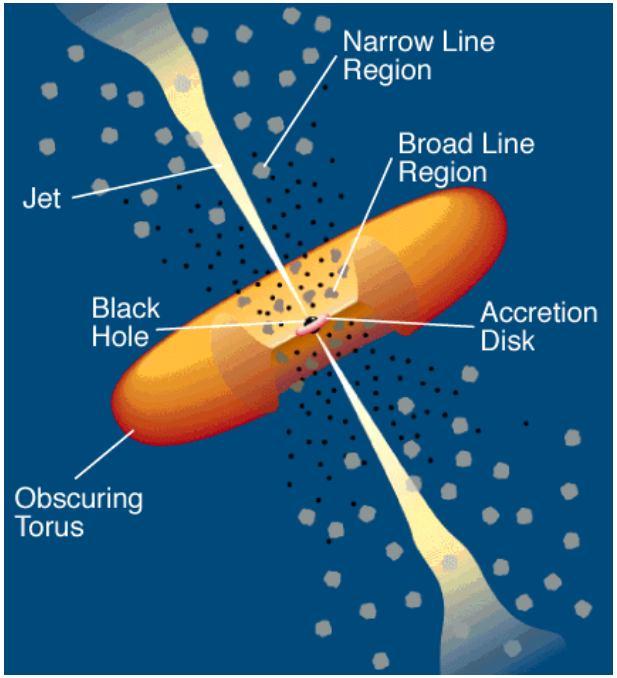
Open cavity in the south & dense cloud in the north

FORCAST images show **hot** dust surrounding the free-free outflow

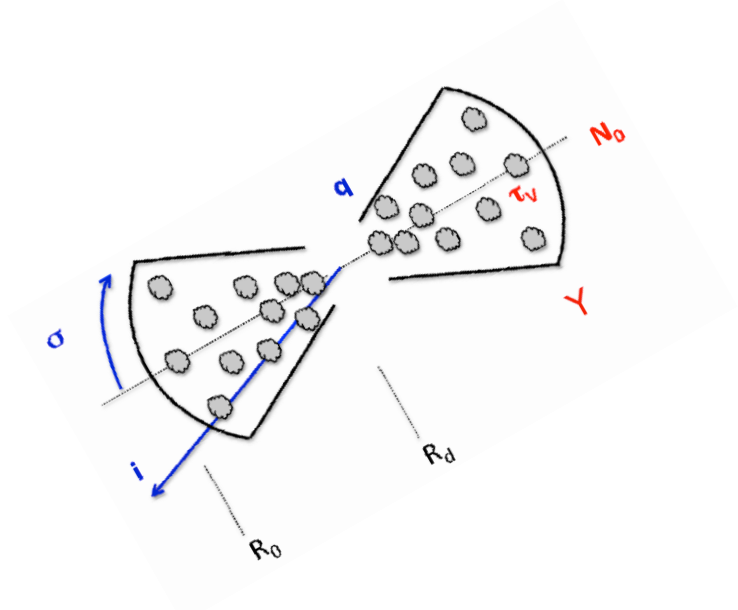
Models show a highly inclined (i > 50˚) disk demonstrating that the disk is **not** face-on

Active Galactic Nuclei

Characterization of the Torus in AGN Using 31.5 μm Imaging FORCAST Observations – P.I. Lopez-Rodriguez



Canonical AGN Model



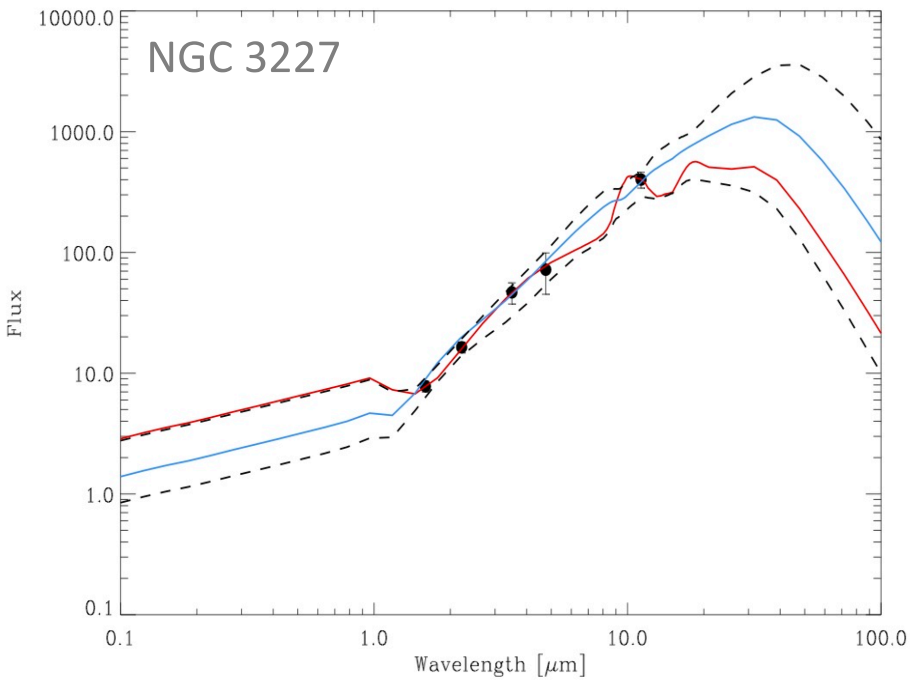
Clumpy Torus Model – Almeida et al., 2011

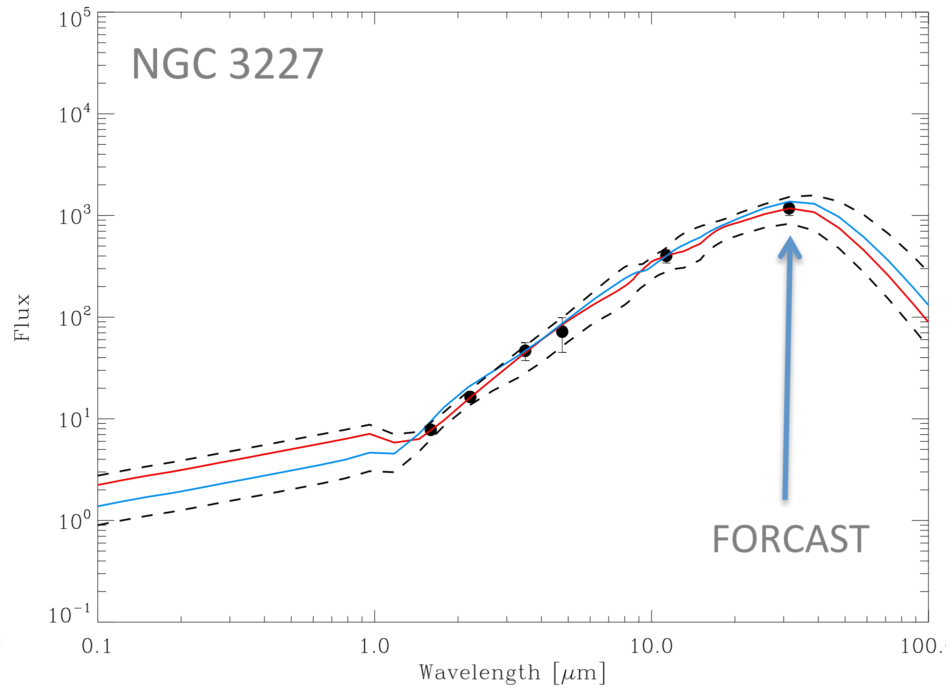
Canonical Model: All AGN have roughly the same morphology, but the different observational classes are due to viewing angle.

Clumpy Torus Model: Differences between Seyfert Type 1 & 2 nuclei may be due to intrinsic properties of the torus.

Active Galactic Nuclei: NGC 3227

Program Goal: Model the MIR SED of AGN to characterize the properties of the clumpy torus



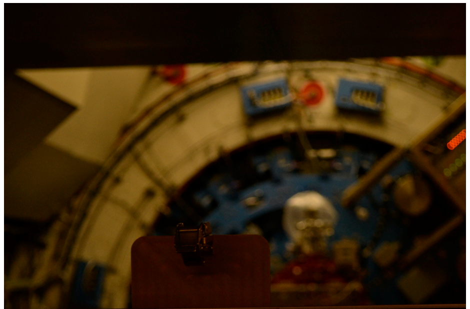


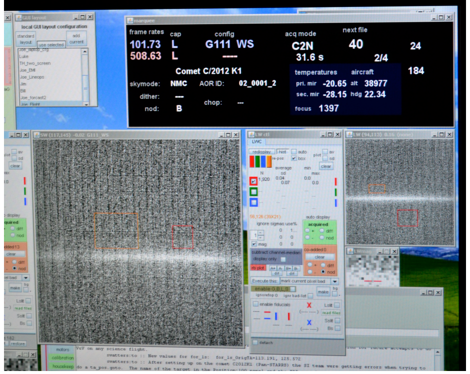
SOFIA/FORCAST MIR observations provide high angular resolution needed to isolate the torus from the surrounding galaxy and star forming regions

Modeling MIR data constrains physical parameters of the torus:

- torus radial extent
- torus width
- number and optical depth of clouds

Science Target – C/2012 K1 (PanStarrs)





Target:

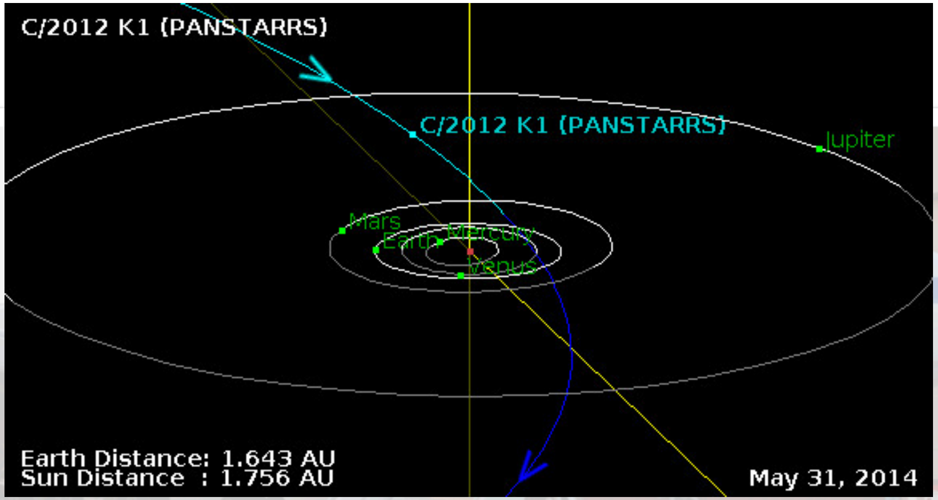
Dynamically new ($1/a_{orig} < 50e\text{-}6$) Oort Cloud comet (hyperbolic)
Perihelion date 2014-August-27.65
Perihelion distance 1.055 AU

Observations:

Spectroscopy – G111, G227 Imaging – FOR_11.1, FOR_19.7
FORCAST on 3 Flights Spanning 06 through 13 June 2014

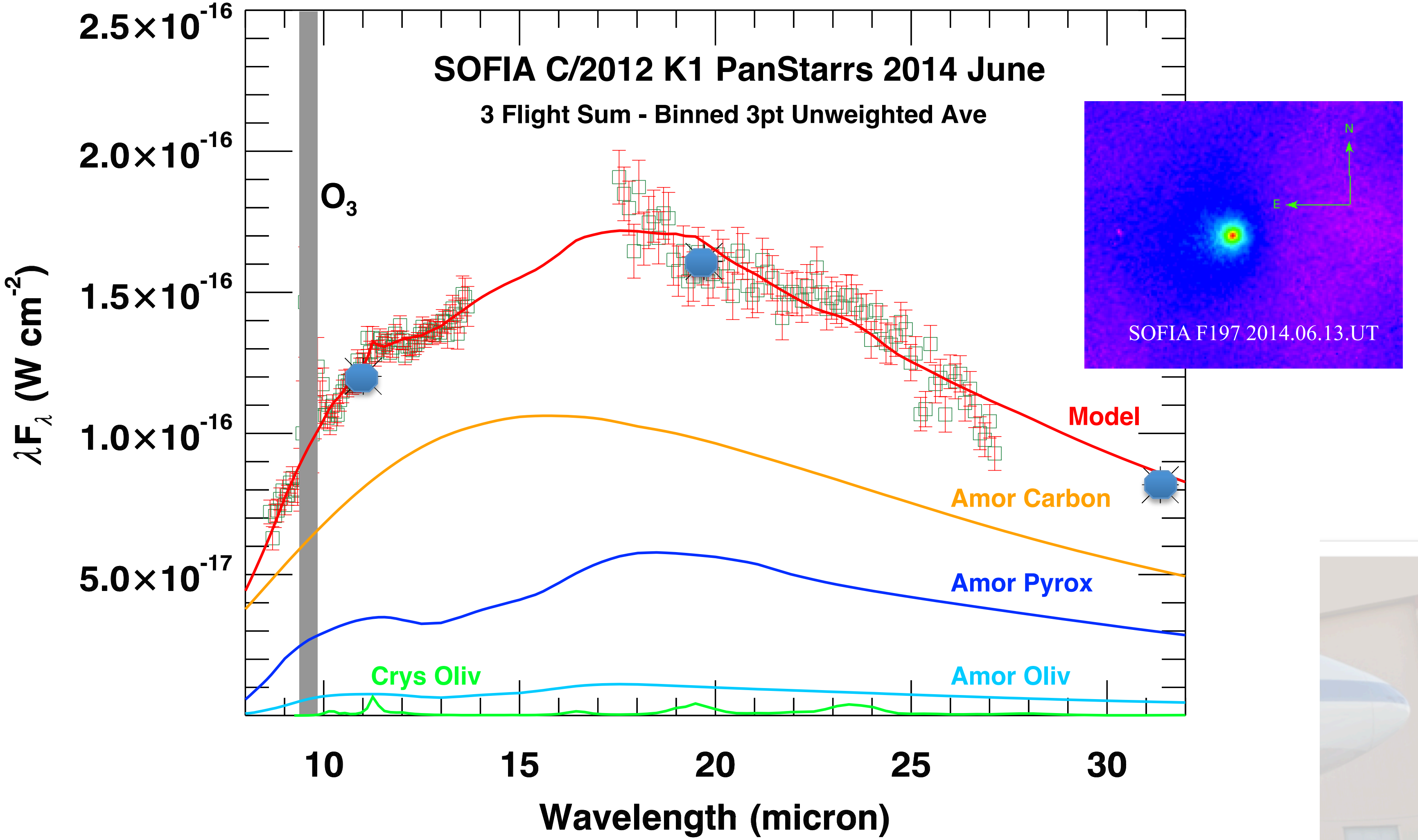
Geometry:

Average Heliocentric Distance 1.64 AU
Average Geocentric Distance 1.76 AU
Average Phase Angle 34.5°
$1/a_{orig} = 2.1e\text{-}6\ AU^{-1}$ (MPC)



Science Results – The Spectral Energy Distribution

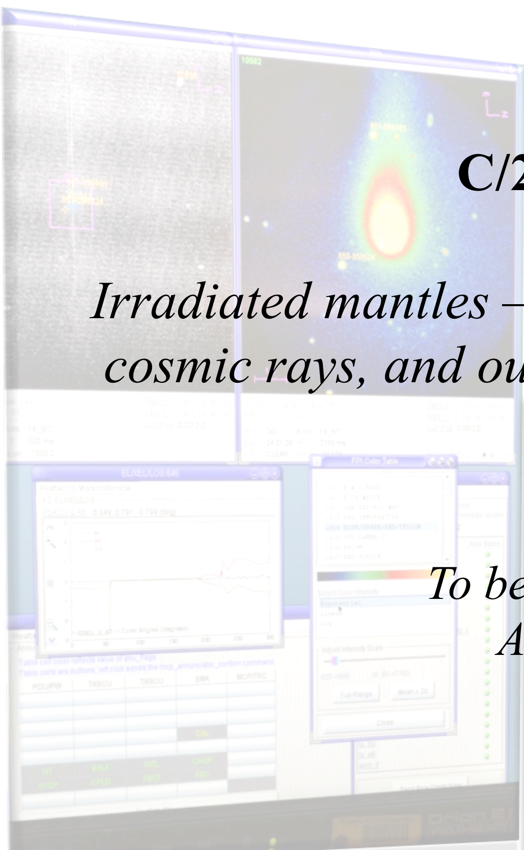
Best-Fit Model Parameters: N = 3.4, M = 17, a_{peak} = 0.6 micron, $D_{porosity}$ = 3.0, Sil/C = 0.64
Crystalline Mass Fraction ~ 0.2



Outstanding Questions

C/2012 K1 (PanStarrs) is DN yet Coma Carbon Dominated with Large Grains

If there are carbon-dominated DN comets then there are probably carbon-dominated KBOs or Trojans and there is a potential for a wide range of (dwarf) planetary surfaces other than water- or methane (or other ice) dominated surfaces.



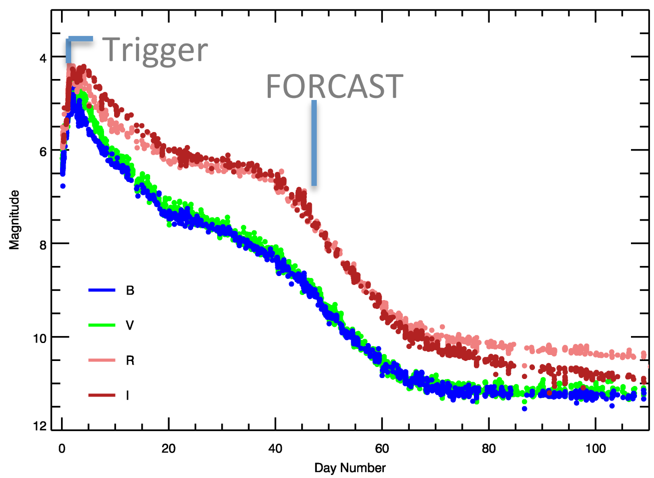
C/2012 K1 (PanStarrs) is DN yet $f_{cryst} < 20\%$

Irradiated mantles – Have the surface crystals have been amorphized by Galactic cosmic rays, and our spectrum is of a coma dominated by dust from this mantle?

To be summarized Woodward, C.E. et al. 2015 (in prep)
Also see Poster by Kelley, M.S.P. # 453.05

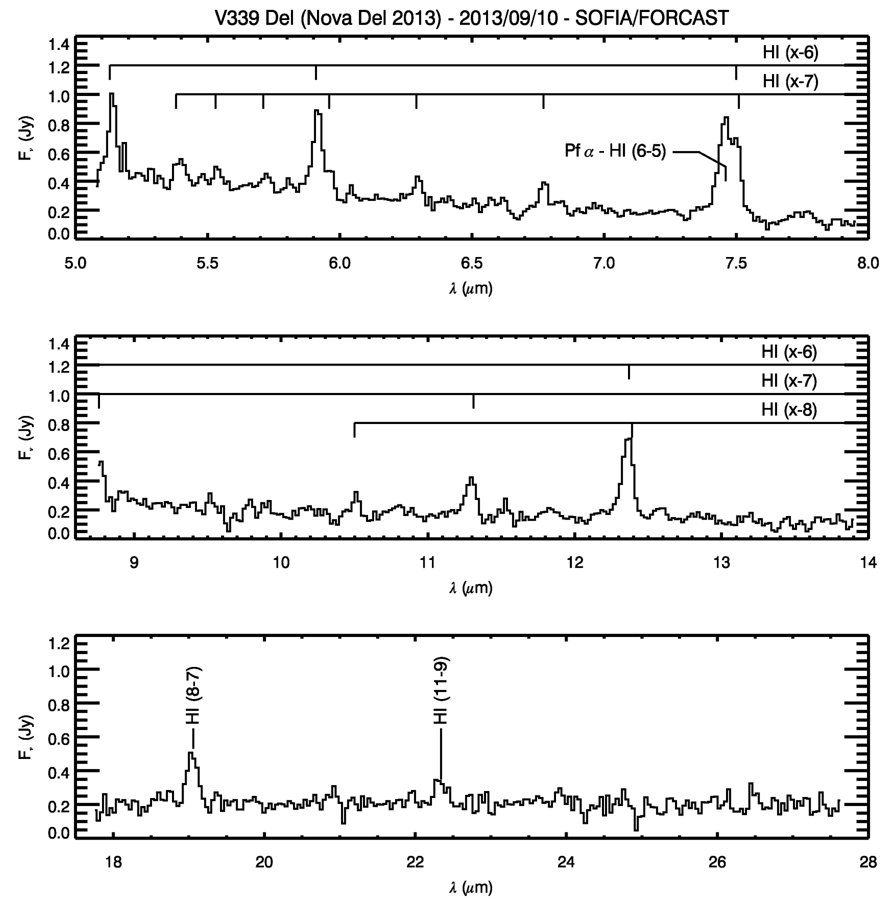
Transient Objects: V339 Del (Nova Delphini 2013)

SOFIA Target of Opportunity (ToO) Observations of Bright Classical Novae in Outburst – P.I. Gehrz



Ejecta mass estimates critical for:

- Constraining models of the thermonuclear runaway
- Determining the WD masses
- Estimating the contribution of CNe ejecta to the ISM on local scales



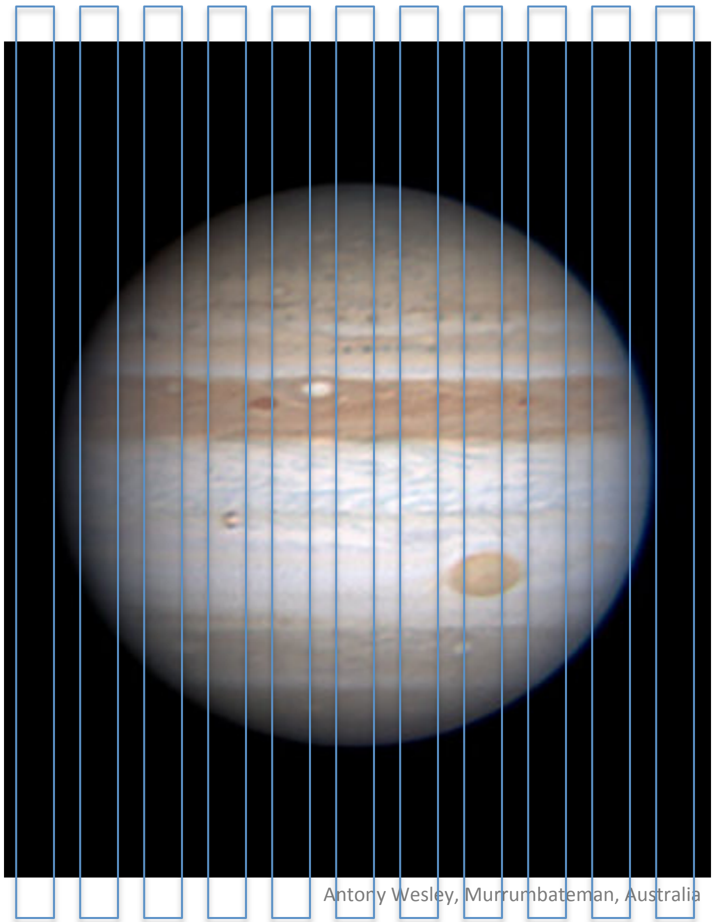
Ejected Gas Mass: M_{gas} ~ 5 x 10^{-6} $M_\odot$

Ejected Dust Mass: M_{dust} ~ 8 x 10^{-8} $M_\odot$

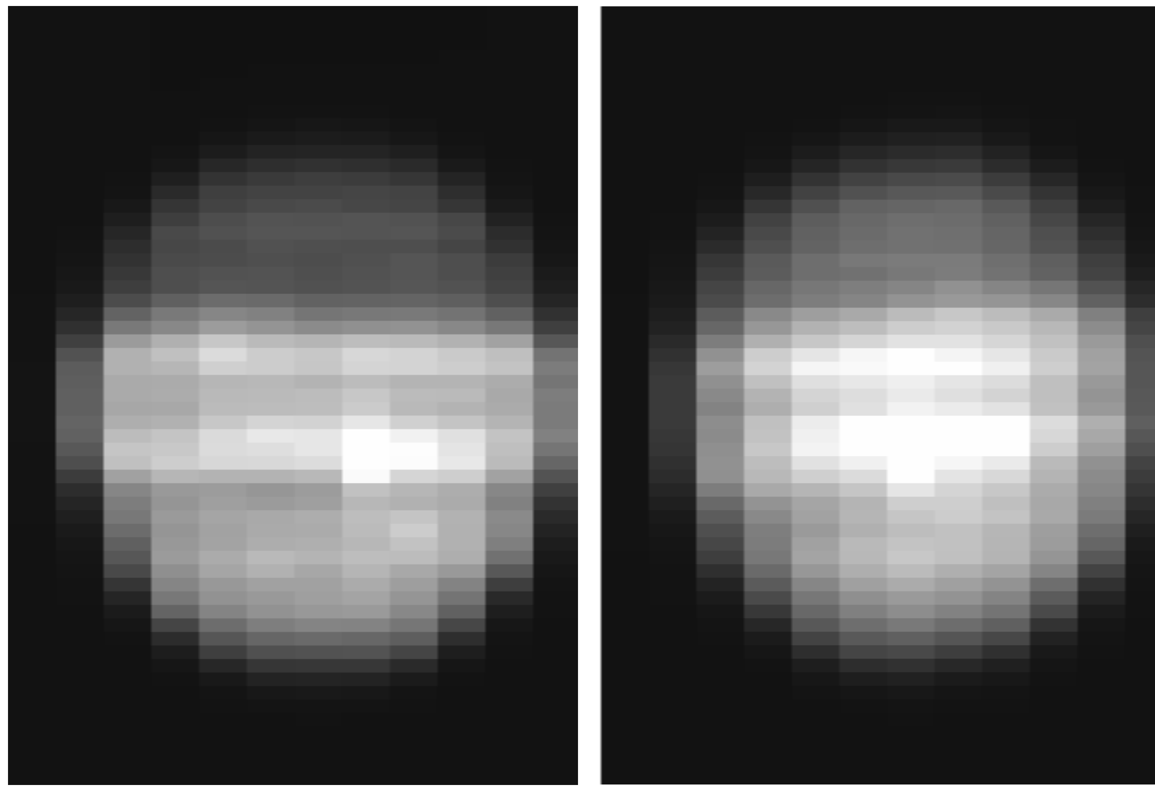
Gas-to-Dust Ratio ~70 → Carbon Enrichment of ~3x solar

Planetary Science: Jupiter

Jupiter's Tropospheric Dynamics from SOFIA Mapping of Temperature, Para-Hydrogen, and Aerosols – P.I. de Pater



FORCAST Slitscan



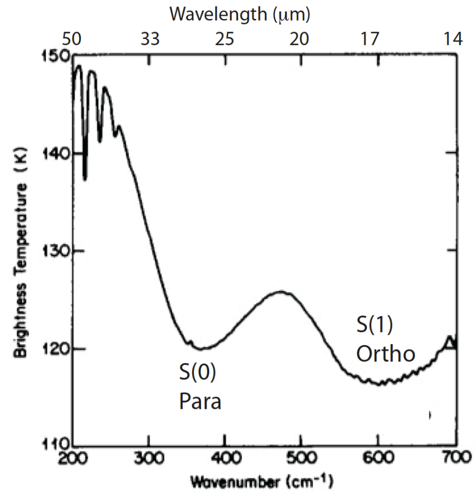
G227 – 17.9 µm

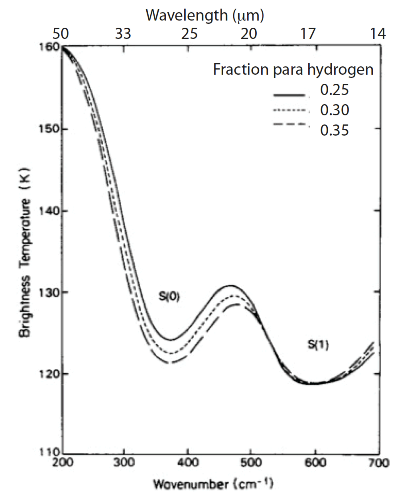
G329 – 28.9 µm

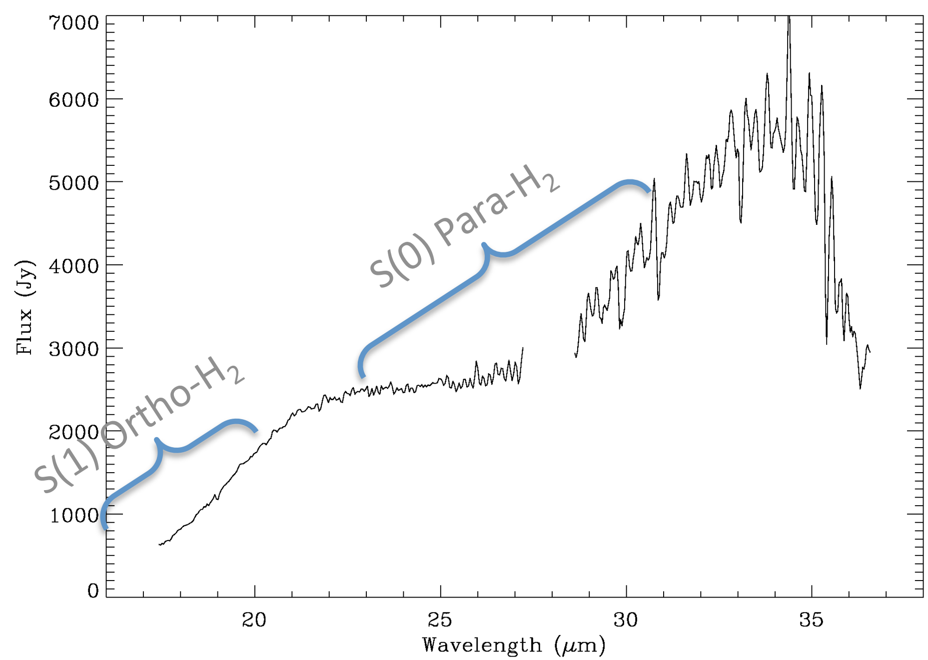
Planetary Science: Jupiter

Ortha- to Para-H_2 Ratio in Jovian Atmosphere:

- Measure the Ortha- to Para-H2 ratio vs. latitude below the tropopause
- Ortho- to Para- conversion rate is a function of temperature
- Variations in the ratio reveal atmospheric dynamics and indicate gas from different altitudes
- Complements EXES observations of the narrow stratospheric line instead of the pressure broadened lines
- Previous observations conducted 30 years ago by Voyager spacecraft (top figures)
- Analysis is under way!







Summary

- FORCAST – 5-40 μm Imager and Grism Spectrometer
- Provides the **only access** to much of the mid-infrared for the general astronomical community today and to the ~30-40 μm range for the foreseeable future
- Provides critical insight into a wide range of astronomical fields of interest, including
  - Star Formation
  - Stellar Evolution
  - Planetary Science
  - Active Galactic Nuclei
  - And more!

SOFIA Observer's Workshop