

SOFIA 2020 Vision Workshop Conference Summary

Erick Young
University of Arizona

General Observation

- SOFIA People are Tough
 - 14-hour days
 - Sub-Kelvin lunches

The Context

- After a very long development, SOFIA is on the verge of finally being able to conduct real scientific observations.
- The Community views SOFIA as a major NASA facility with associated costs.
- The astronomical community will soon be in the middle of the Decadal Review process.
 - Like it or not, SOFIA will be in competition with everything else on the platter.
 - Excellent cases will need to be made for both the science and the implementation.
 - A goal of the workshop is to identify important science themes for SOFIA in the next 20 years.

Cautionary Tale

- It's very difficult to look 20 years into the future.
- Some interesting things have turned up in the past 20 years...
 - Dark energy
 - Many, many exoplanets
- There is hope since some things haven't changed though:

Facility	Most Important Attributes
SOFIA	High-resolution spectroscopy at $\lambda > 30 \mu\text{m}$ 2.5 ($\lambda/30 \mu\text{m}$) arcsecond imaging at $\lambda > 30 \mu\text{m}$ Training of instrumentalists

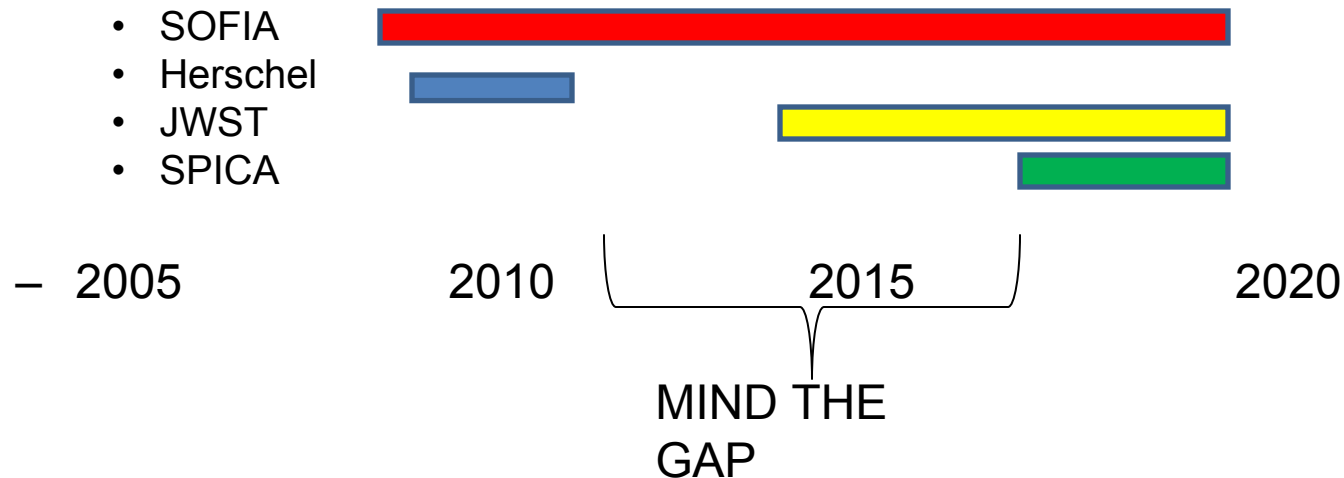
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Observatory Status

- It flies!
- First science flights in 2009
- After many years, there will be support for new instrumentation
- Full operation in 2014
 - Need to explain to the community why this takes so long

Facilities Context

- Herschel
 - 2009 – 2011
 - Many parallels in capabilities
- JWST
 - 2014 launch
 - Wonderful sensitivity and angular resolution
 - No capabilities beyond 25 μm
- SPICA
 - 2018 ???
 - Bigger, colder telescope



Instrumentation

- New instruments will be central to the viability of SOFIA in the future
 - FIR Imaging Arrays
 - Harvey Moseley's talk showed continuing improvements in mapping performance
 - Heterodyne Arrays
 - Chris Walker review talk showed feasibility of 10^2 pixel arrays
 - Jianrui Gao showed 100X improvement over KAO at 4 THz
 - FIR Spectrometers
 - Jason Glenn described the kind of bold thinking needed to allow SOFIA to reach its potential in 2020.
- Will the resources be really enough to go from demonstration technology to full scale instruments?

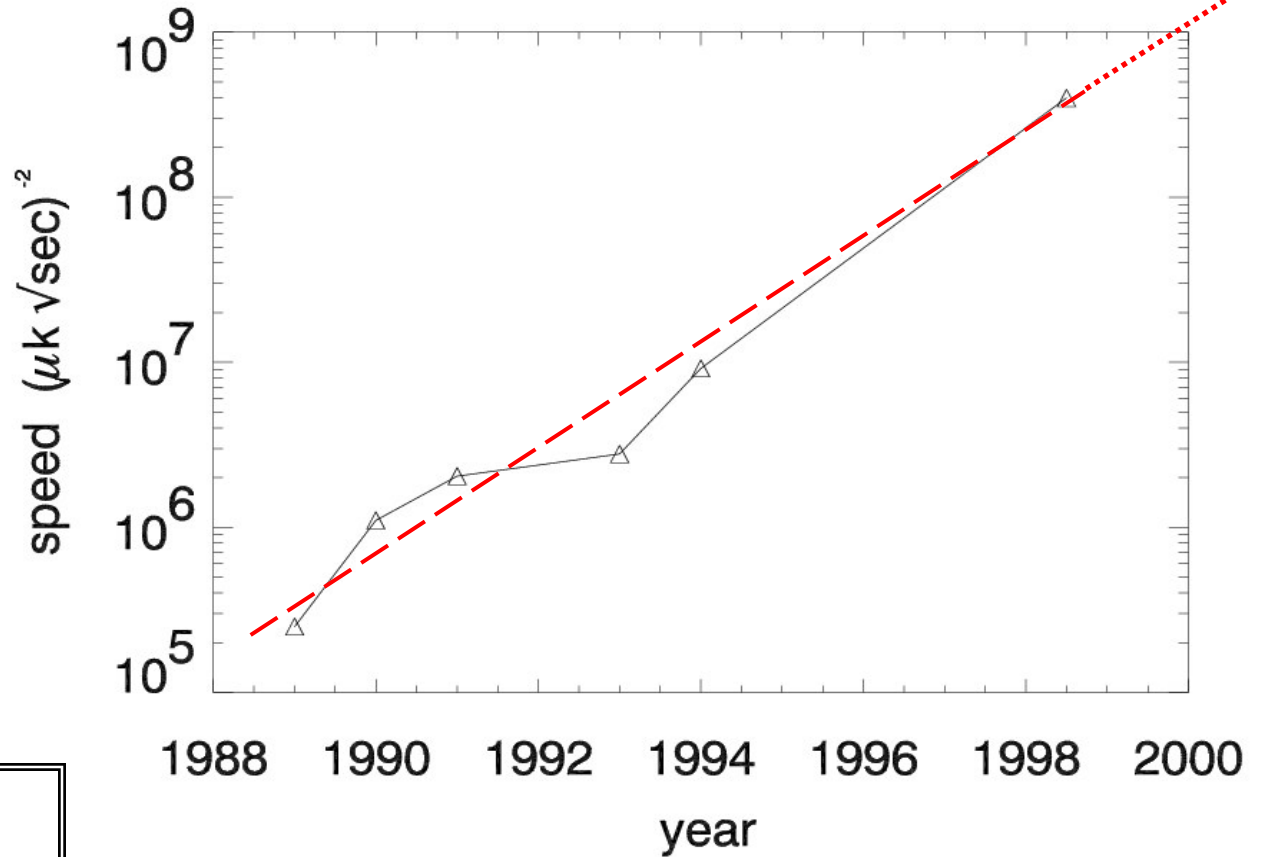
History of Detectors

Past is Prologue?

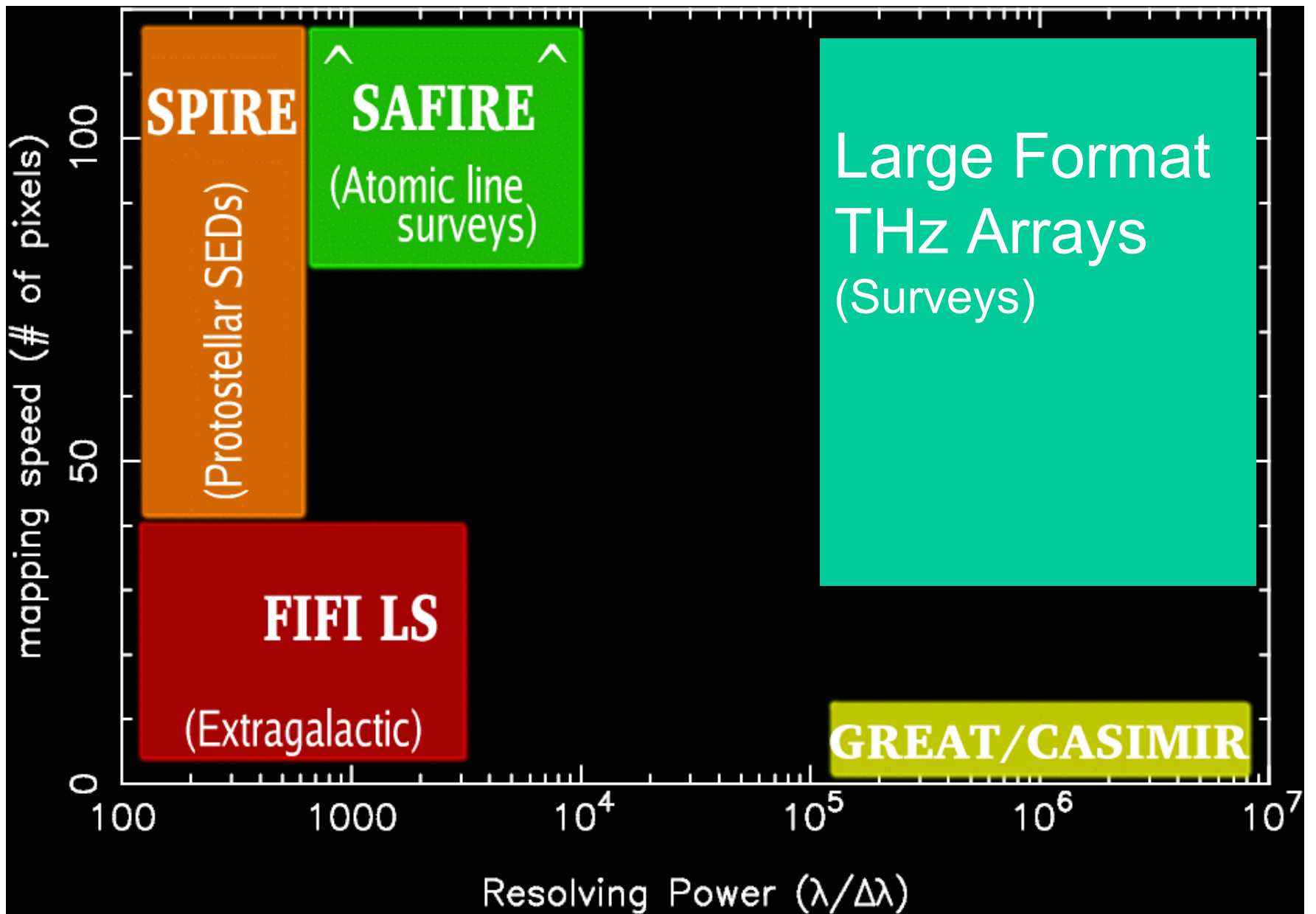
*What has limited observing in the past is **detector sensitivity**.*

Richards' Law predicts:

Far-IR detector speed increases by a factor of 2 per year.

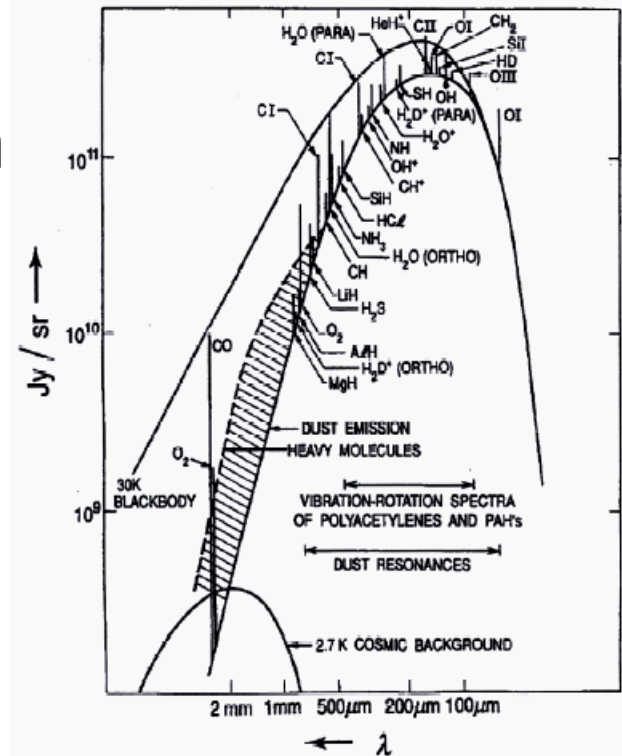


From 1960 to 2000:
Sensitivity $\times 10^8$
Number of pixels $\times 10^2$
Speed of measurement $\times 10^{18}$
Doubled every 12 months for 40 years!



Observational Themes

- High Resolution Spectroscopy
 - Everybody wants to observe [C II]
 - This parallels the history on the KAO where FIFI was one of the most heavily used instruments.
 - Virtually all the action in understanding ISM falls in SOFIA wavelengths
 - c.f., talks by Ted Bergin and Mark Wolfire



Observational Themes - II

- Time Critical Phenomena
 - Occultations
 - HIPO
 - Far IR as a new niche?
 - Transits

Observational Themes - III

- Polarimetry
 - Few other polarimetric capabilities are anticipated
 - Far-Infrared is uniquely placed to address key questions
 - Magnetic fields in clouds

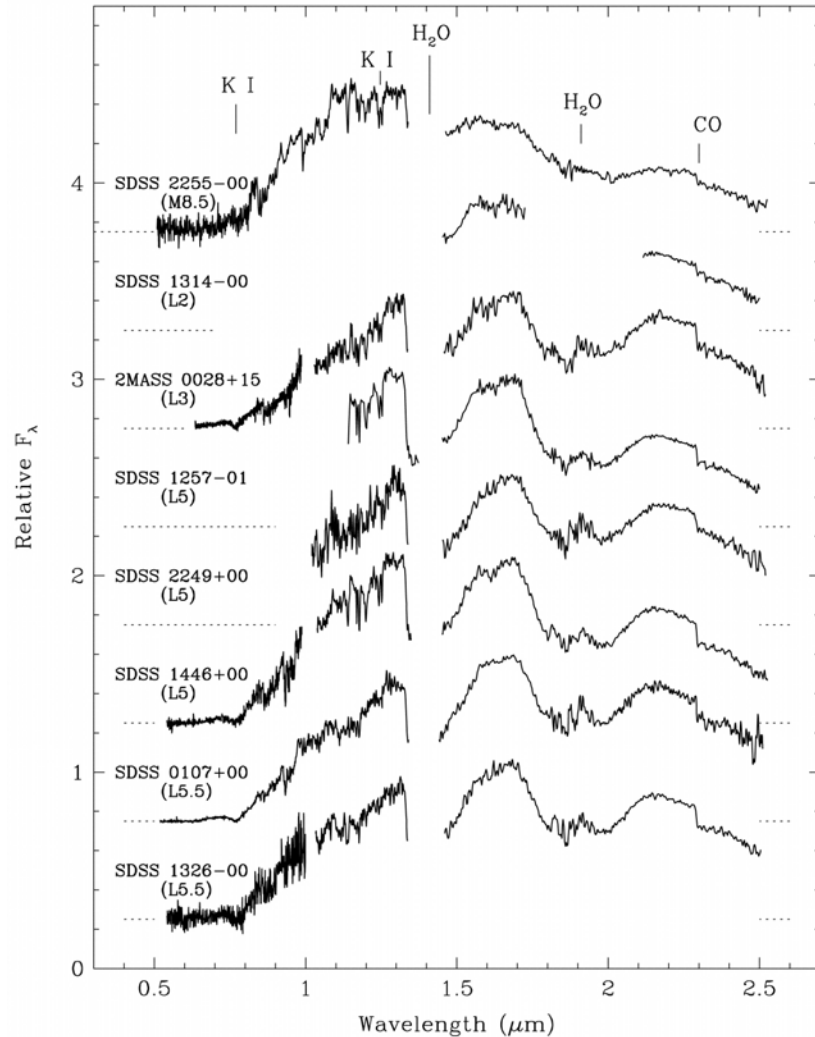
Galaxy Evolution

- SOFIA has the spatial resolution to address key issues extragalactic star formation
 - How much in terms of fundamental questions will be left in the post Herschel area?
 - One possible area would in spectral mapping where SOFIA will be able to take advantage of advances in detector arrays

Brown Dwarfs Spectra as an Example of the Power of SOFIA

Many of the key features are present in both the Earth's atmosphere and the BD atmospheres.

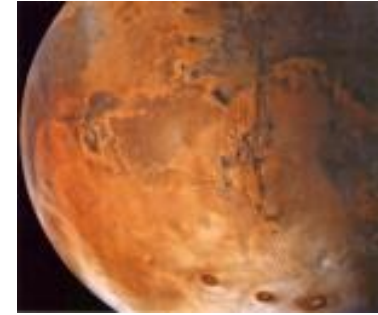
An open area is spectroscopy below the Spitzer IRS short wavelength limit. Useful to the study of many molecules in the ISM and planetary atmospheres.



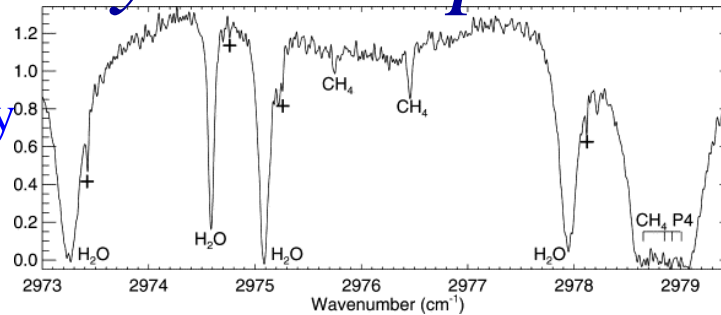
Galactic Center

- The Galactic Center region may be an ideal region for SOFIA
 - Sensitivity is less of an issue for many problems
 - Many different phenomena
 - Magnetic Fields
 - Chemistry of shocks

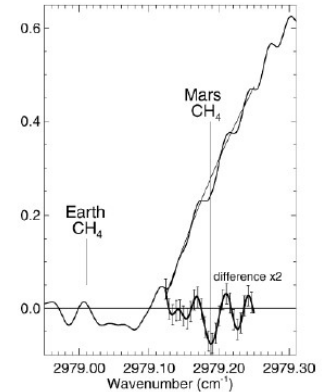
Planetary Atmospheres



SOFIA will study planetary atmospheres



The ground-based infrared spectrum of Mars is dominated by broad lines in the Earth atmosphere. A weak feature on the wing of the strong terrestrial methane line may be the Doppler-shifted methane line in the Mars atmosphere. If true, the methane abundance is very high and may reflect biogenic activity.



The high resolution spectrograph on SOFIA can probe between the much narrower terrestrial lines at airborne altitudes and uniquely address:

Is there methane in the Martian atmosphere?

If so, where does it come from? What is its global distribution? How does it vary with the seasons on Mars?

NASA strategic sub-goal 3C.2