First Italian SKA National Congress

MIUR, Rome, Italy, June 19-20, 2012

SKA and the Future of Astrobiology and SETI

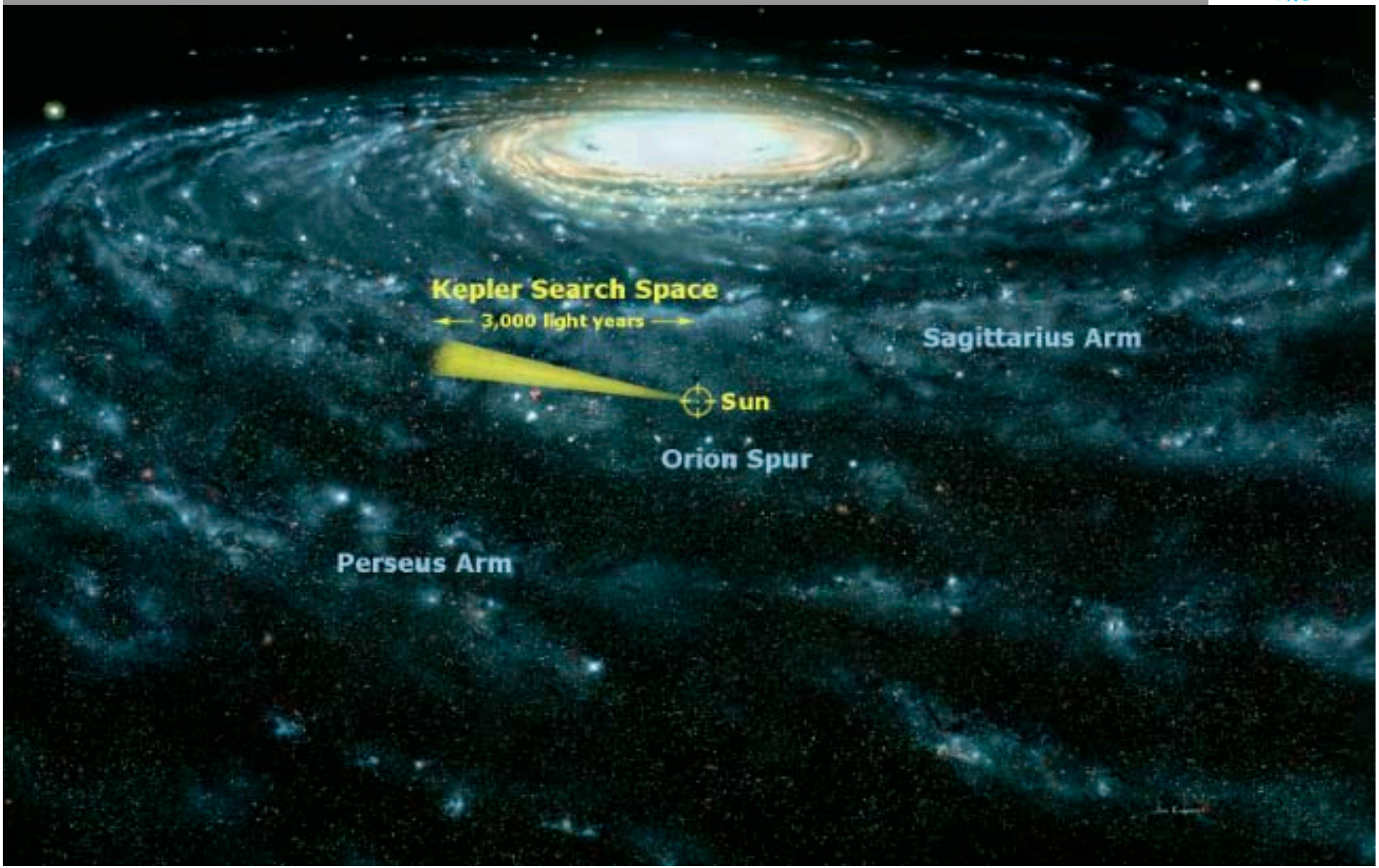
Claudio Maccone

Co-Vice Chair, SETI Permanent Study Group,
International Academy of Astronautics,
and IASF-INAF Associate

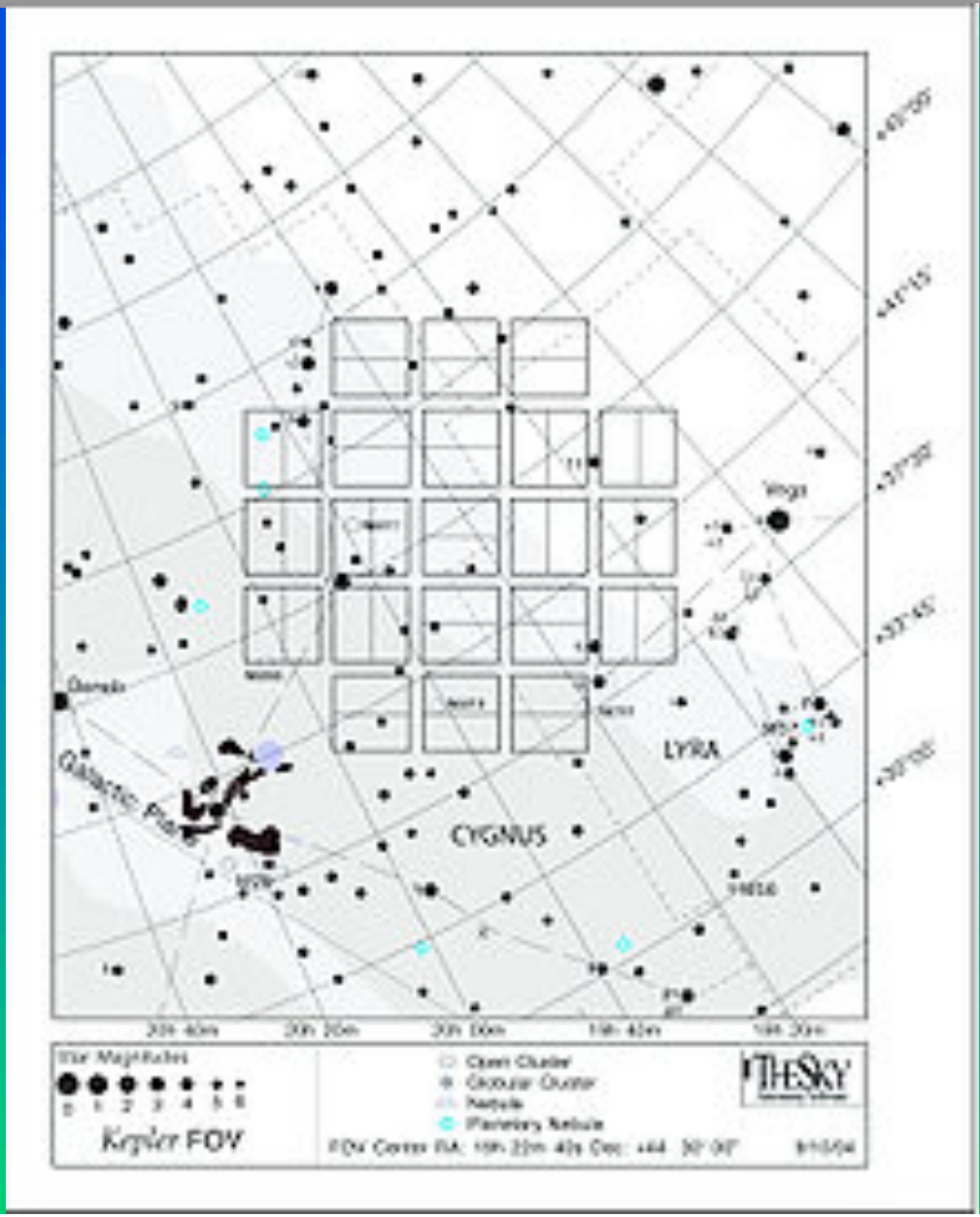
E-mail: clmaccon@libero.it

Home page: http://www.maccone.com/

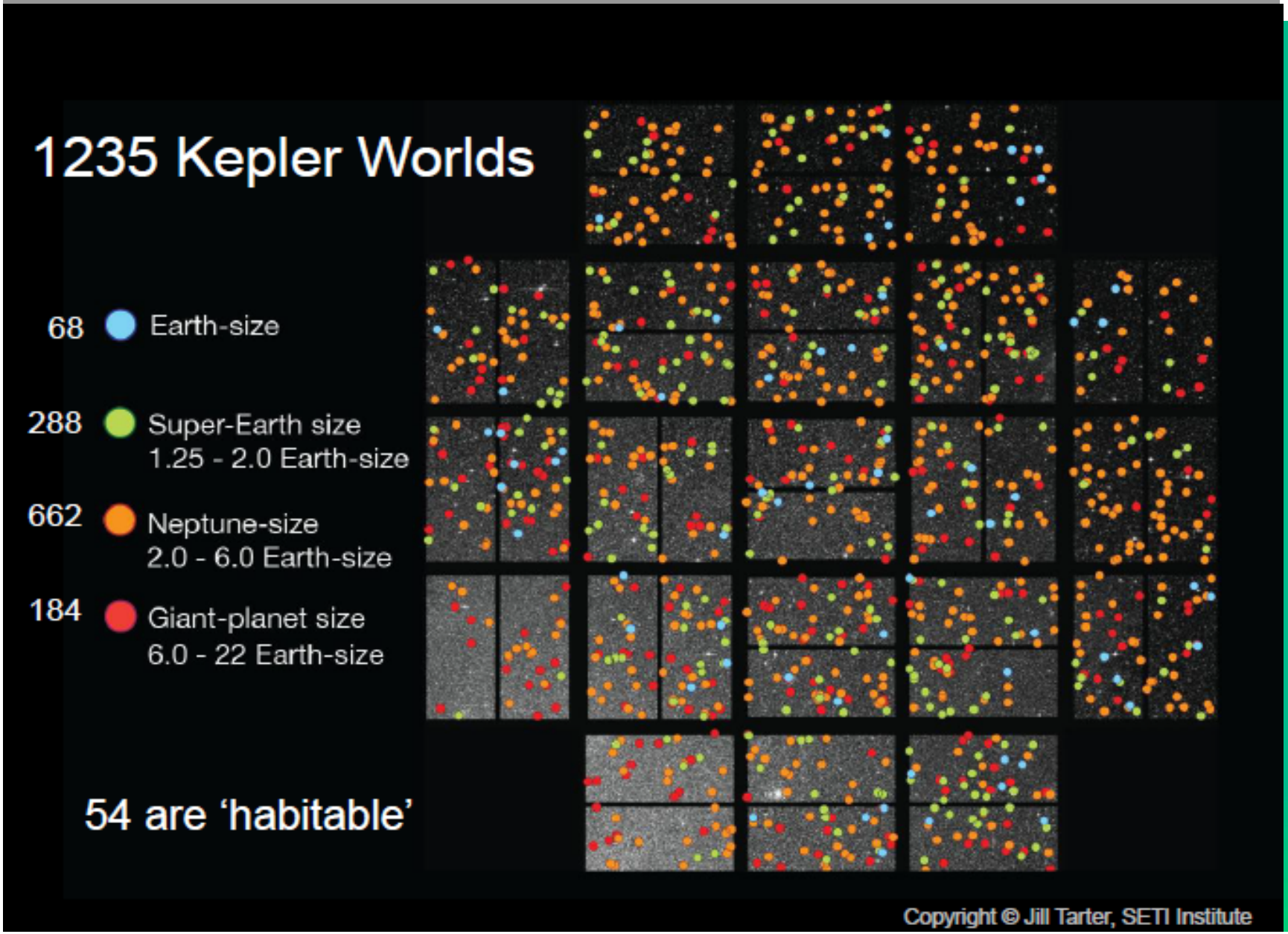
Kepler space mission 2009 - now



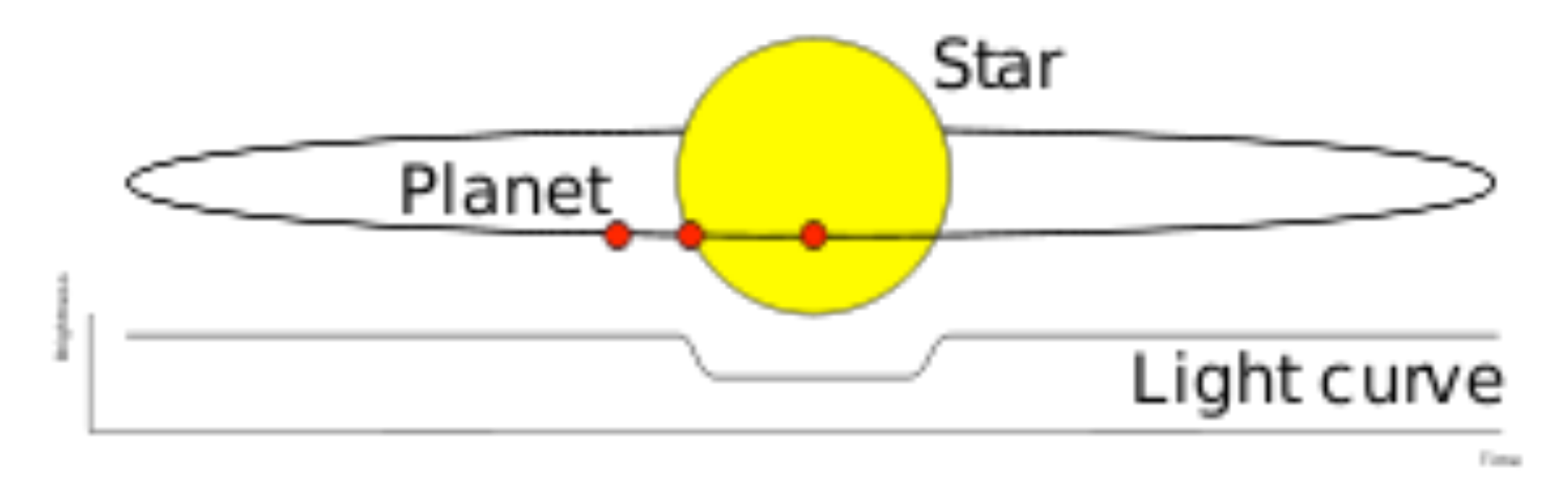
Kepler space mission FOV



1235 Kepler Worlds



Kepler space mission: TRANSITS



- **Thus, Kepler can detect ONLY exoplanets having their orbital plane in the line of sight.**
- **This leads us to think that A HUGE NUMBER of exoplanets exist in the Galaxy (~100 billions?).**

We cannot be alone: thus, SETI !

- **SETI is the Search for Extraterrestrial Intelligence.**
- **SETI began in 1960 with "Project Ozma" conducted by Frank Drake.**
- **No ET signal was found so far, but we only explored distances < 100 pc.**
- **The simplest form of SETI is to look for an alien CARRIER on a very narrow band (< 1 Hz)**

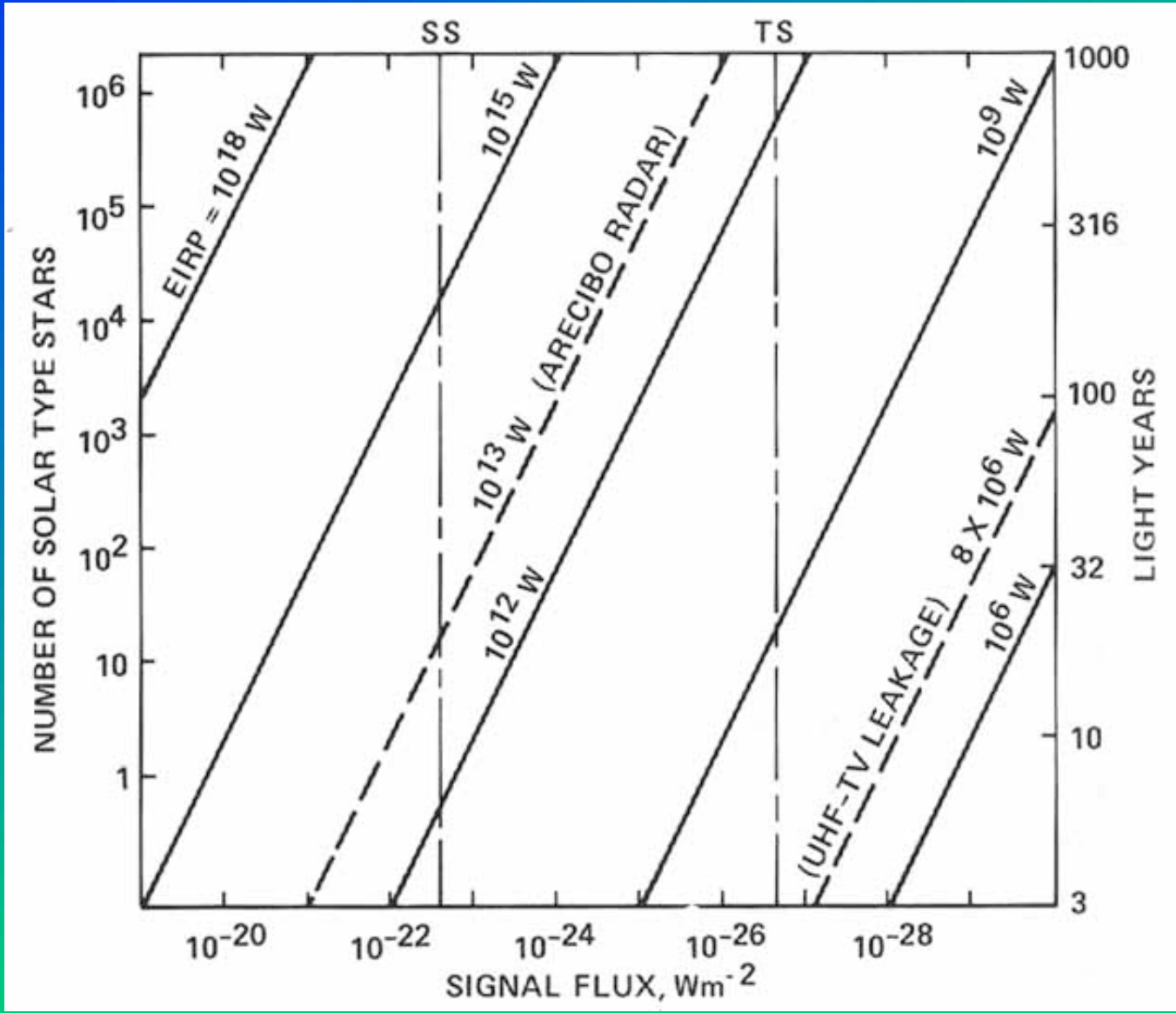
5 Complexity Levels for SETI

- Level 1: **Piggyback SETI at 1.420 GHz by FFT.**
- Level 2: **Wideband SETI by KLT (LOFAR ?).**
- Level 3: **Targeted Searches (on HabCat stars).**
- Level 4: **Leakage Searches (by SKA << ~ 1 pc).**
- Level 5: **Entanglement & Encrypted SETI (?).**

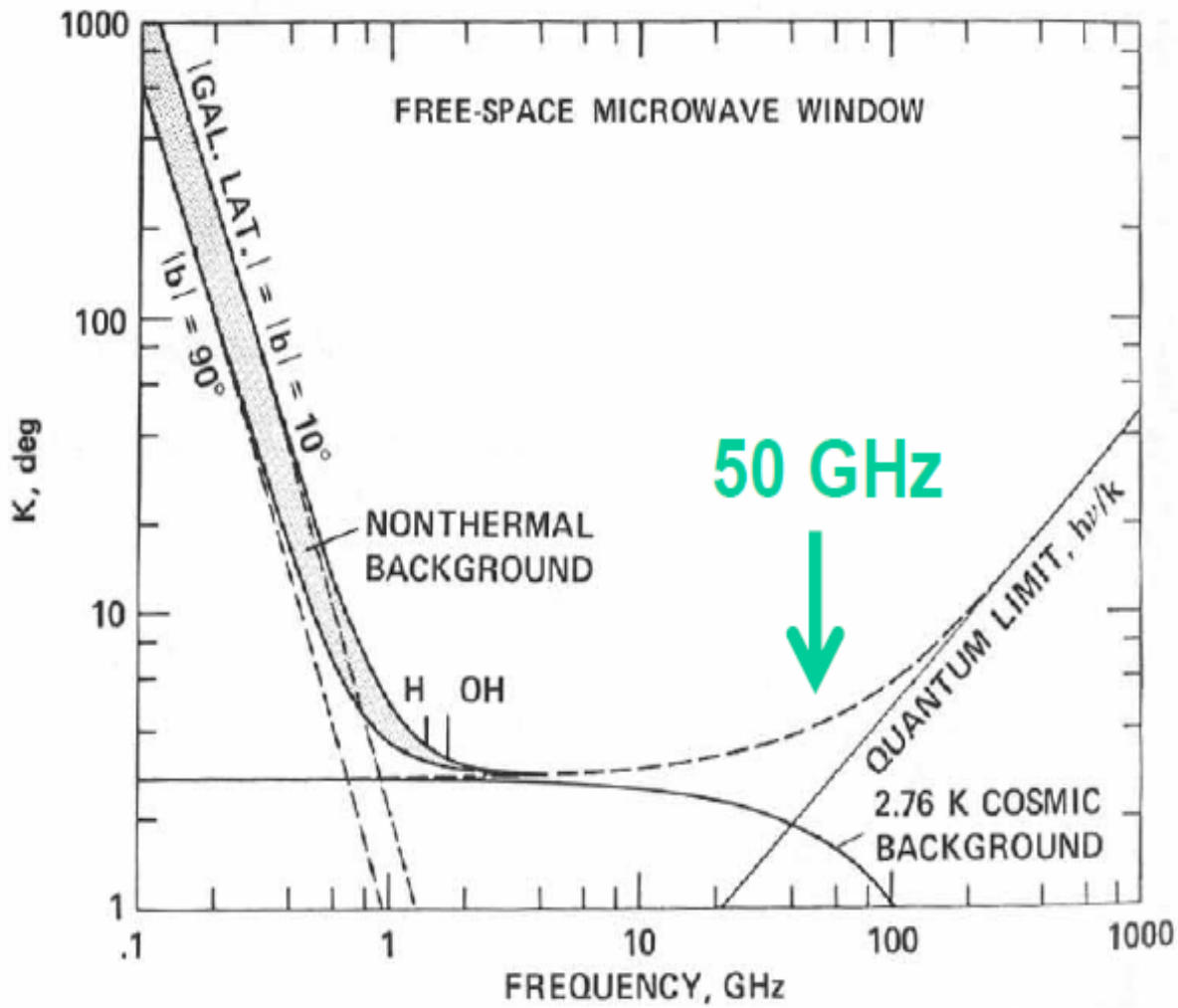
NASA SETI (1992-93)

- **Sensitivity vs. Range for NASA SETI radio searches.**
- **X axis is the received flux = Sensitivity of the search.**
- **Y axis on the right is the Range in light years, and on the left is the Number of sun-like stars within this range.**
- **The vertical line labeled SS is the typical sensitivity achieved by a full Sky Survey such as BETA (1995-99).**
- **The vertical line labeled TS is the typical sensitivity achieved by a Targeted Search (Phoenix 1995-2004).**
- **The diagonal lines show transmitters of different effective powers.**
- **Source: NASA technical report CP-2156 (1979).**

NASA SETI (1992-93)



SETI Frequency Range



- Terrestrial microwave window: **~1 – 10 GHz**
- Free-space microwave window: strong case for **~50 GHz**

SETI at **Medicina (Italy)**

- Italy is running the only non-stop SETI search in Europe by doing PIGGYBACK by the 32-meter dish at Medicina.
- The Serendip IV spectrometer has 24 million channels and a 15 MHz input bandwidth around the hydrogen line at 1.420 GHz, as traditional in SETI since 1960.
- New post-processing algorithms have been successfully tested: the **Hough transform** for the Doppler effect recognition (i.e. to better cope for **drifting signals**) and
- The **Karhunen-Loève Transform (KLT)** to filter very weak signals out of any **colored background noise**.

SETI by LOFAR (Netherlands)

- LOFAR (= Low Frequency Array) is currently under construction in the Netherlands, with additional antennas to be setup in the future also in Germany, Britain, France, Italy, Poland, the Ukraine, etc.
- LOFAR is an interferometric array of radiotelescopes that will operate (approximately) in between 15 and 250 MHz.
- SETI searches will be allowed on LOFAR.

What is Astrobiology ?

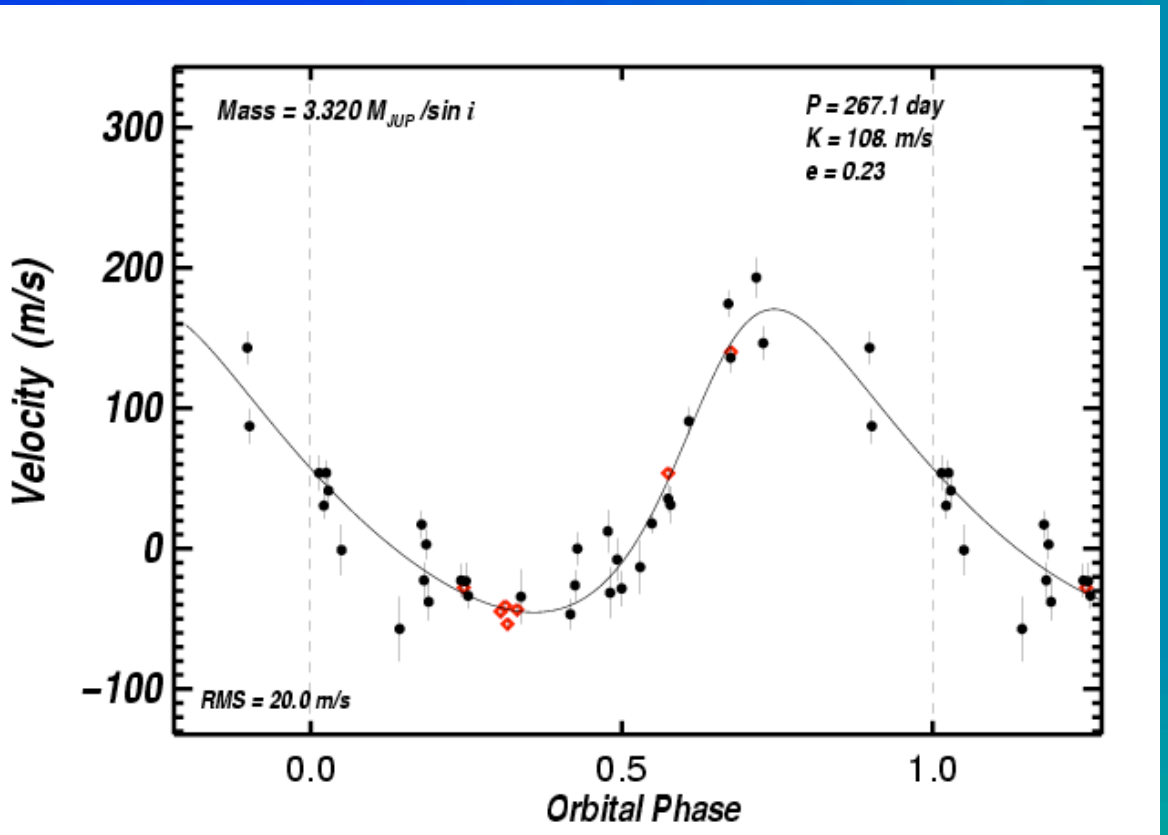
Astrobiology makes use of physics, chemistry, astronomy, biology, molecular biology, ecology, planetary science, geography, and geology to investigate the possibility of life on other worlds and help recognize biospheres that might be different from the biosphere on Earth.

Astrobiology at Long Wavelengths

T. Joseph W. Lazio

W. M. Farrell, T. Bastian, G. Bower, M. Hollis, J. Tarter, P. Zarka, & Thomas Jefferson high school students

Astrobiology: Are We Alone?



In last decade, exciting discovery of extrasolar planets

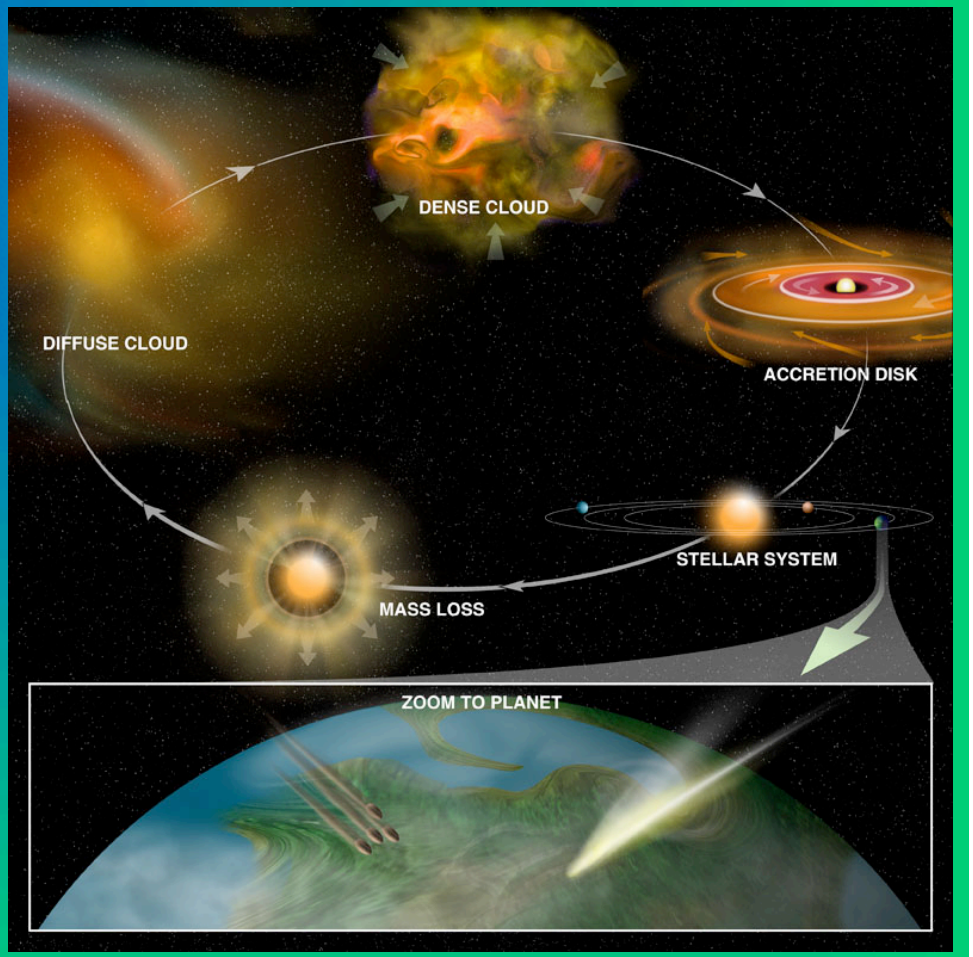
- **~ 500 planets**
- **Indirect detection via optical signature from host star**

HD 40979 3.32 M_J in 267 d orbit (a = 0.811 AU), e = 0.23 (Fisher et al. 2003)

"Do there exist many worlds, or is there but a single world? This is one of the most noble and exalted questions in the study of Nature."—St. Albertus Magnus, *De Caelo et Mundo* (13th century)

Astrobiology and the SKA

- Biomolecules in molecular clouds
- Protoplanetary disks
  (B. Gaensler)
- Extrasolar planets
  - Astrometry
  - Magnetospheric emissions
- SETI
  (J. Tarter)

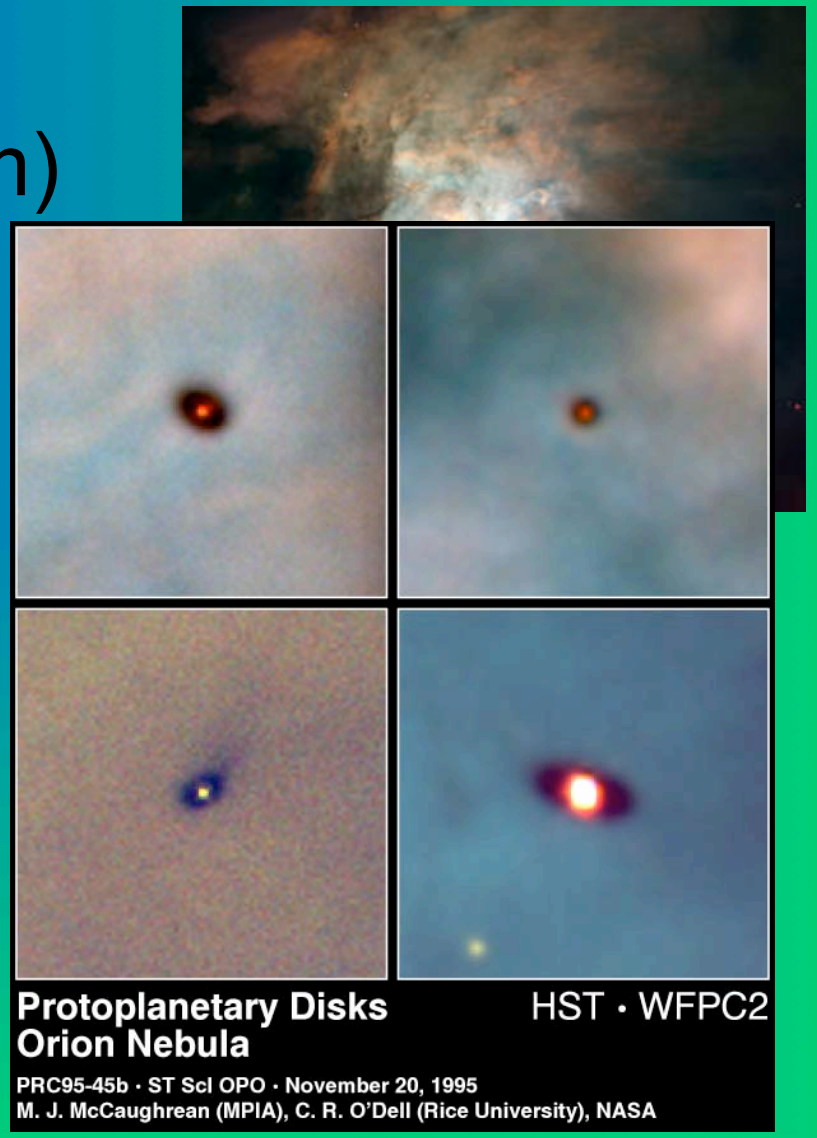


Bill Saxton, NRAO/AUI/NSF

Astrobiology at Long Wavelengths

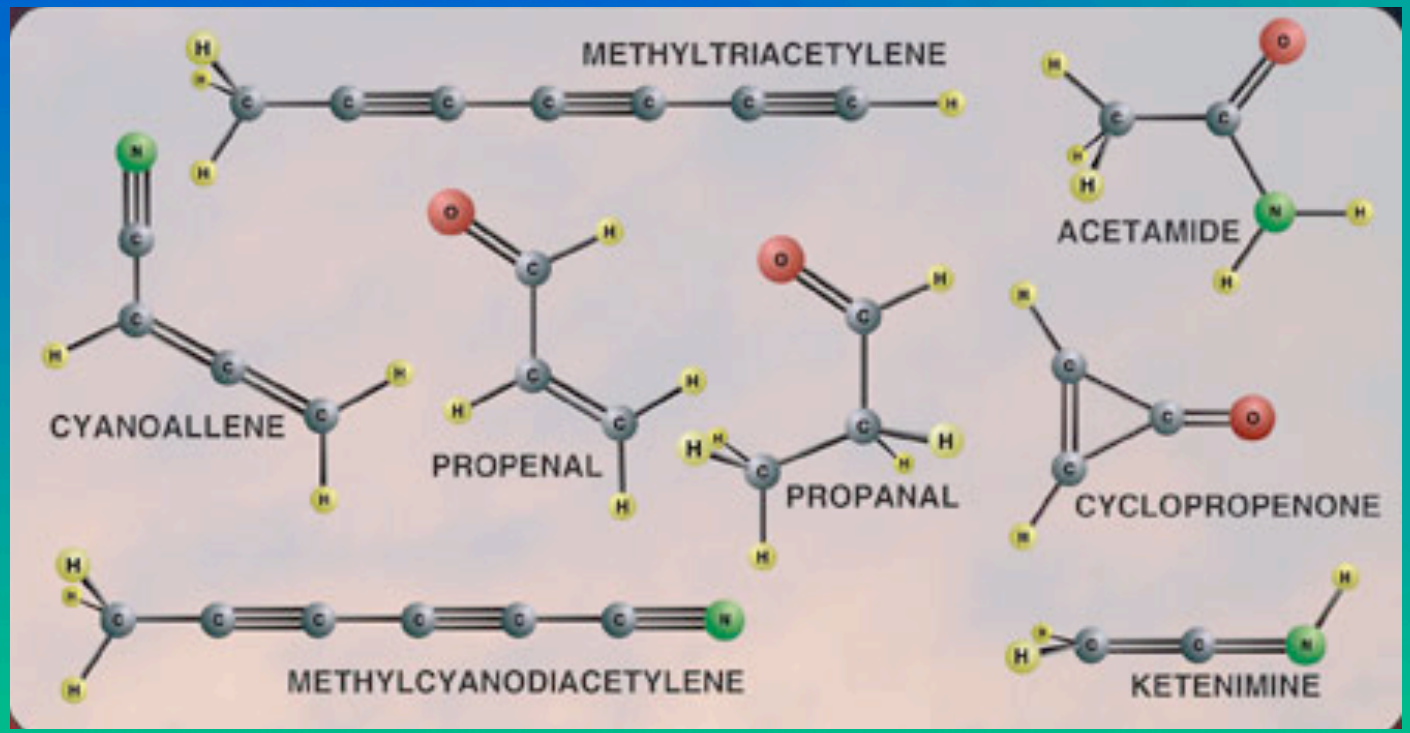
Long Wavelengths ($\lambda > 1$ cm)

- Not affected by dust
- Complex molecules have transitions at longer wavelengths
- “waterhole” (1.4–1.7 GHz)
- Magnetically-generated emissions



Interstellar Molecules

Nearly 150 molecules detected in interstellar space.

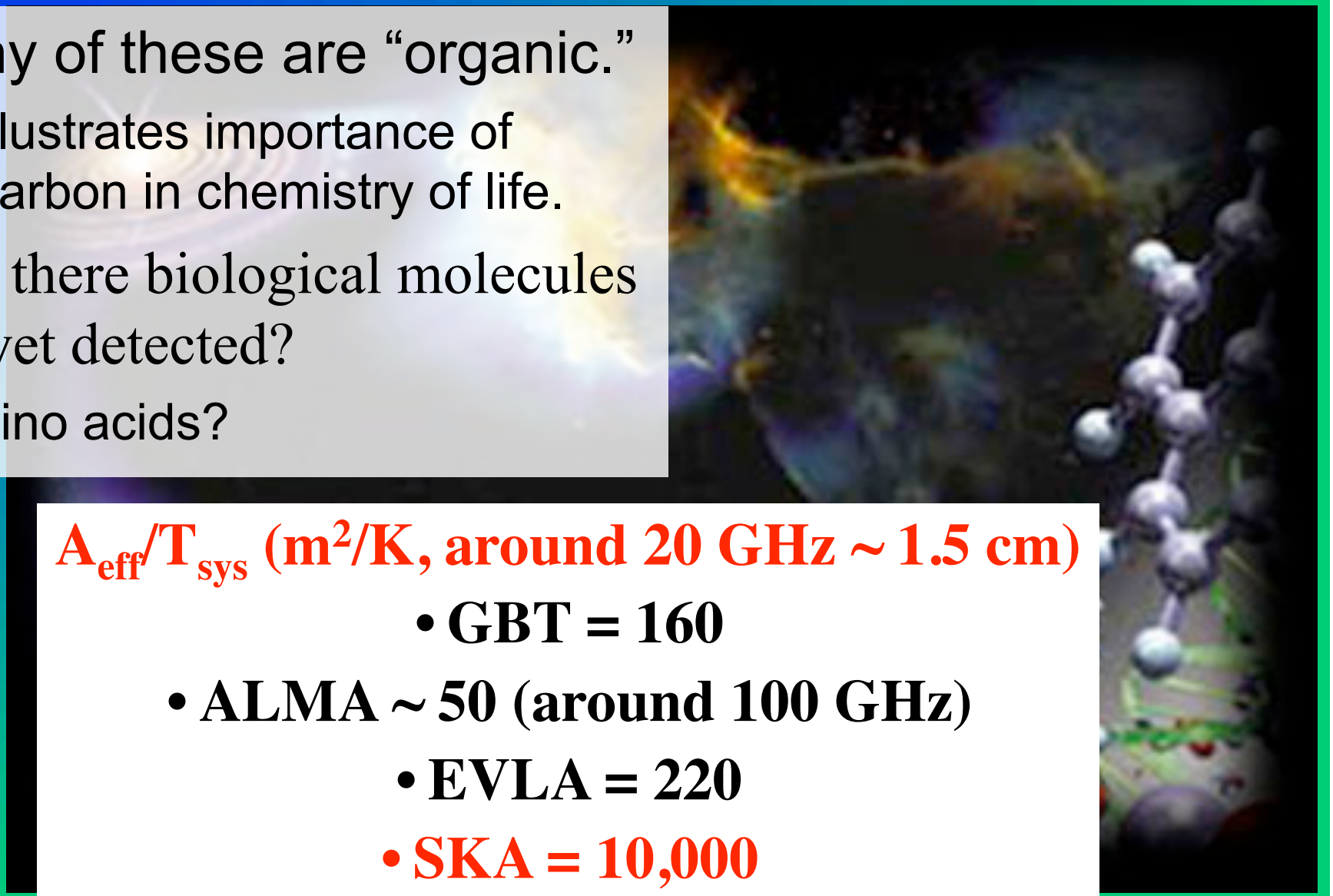


Recently detected interstellar molecules from the GBT (Hollis and collaborators)

Interstellar Molecules

- Many of these are "organic."
  - Illustrates importance of carbon in chemistry of life.
- Are there biological molecules not yet detected?

  Amino acids?



A_{eff}/T_{sys} (m^2/K, around 20 GHz ~ 1.5 cm)

- **GBT = 160**
- **ALMA ~ 50 (around 100 GHz)**
- **EVLA = 220**
- **SKA = 10,000**

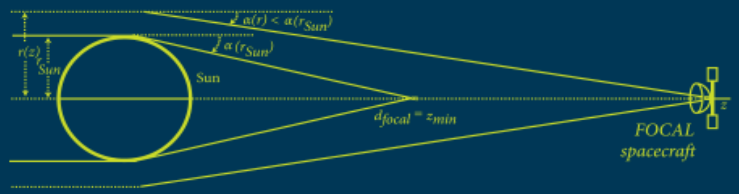
Conclusions

1. **SETI, the Search for ExtraTerrestrial Intelligence, has so far been investigated since 1960 only modestly (< 100 pc).**
2. **The International Academy of Astronautics (Jill Tarter et Al. ~ 1980) issued SETI PROTOCOLS for "ethical behavior" in case of a Contact.**
3. **ASTROBIOLOGY is now in full swing. In the USA the ABSCICON Conference is run by NASA every two years. In Europe, EANA (European Astrobiology Network Association) meets every year (Stockholm is next).**
4. **The SKA will enable far more refined SETI and ASTROBIOLOGICAL searches.**

700-pages BOOK about "Mathematical SETI"

This book introduces the Statistical Drake Equation where, from a simple product of seven positive numbers, the Drake Equation is turned into the product of seven positive random variables. The mathematical consequences of this transformation are demonstrated and it is proven that the new random variable *N* for the number of communicating civilizations in the Galaxy must follow the lognormal probability distribution when the number of factors in the Drake equation is allowed to increase at will.

Mathematical SETI also studies the proposed FOCAL (Fast Outgoing Cyclopean Astronomical Lens) space mission to the nearest Sun Focal Sphere at 550 AU and describes its consequences for future interstellar precursor missions and truly interstellar missions. In addition the author shows how SETI signal processing may be dramatically improved by use of the Karhunen-Loève Transform (KLT) rather than Fast Fourier Transform (FFT). Finally, he describes the efforts made to persuade the United Nations to make the central part of the Moon Far Side a UN-protected zone, in order to preserve the unique radio-noise-free environment for future scientific use.



ISBN: 978-3-642-27436-7

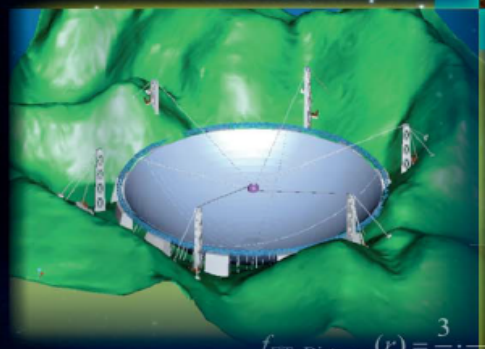
springer.com
www.praxis-publishing.co.uk

PRAXIS

Maccone

Mathematical SETI

Mathematical
SETI
Statistics,
Signal Processing,
Space Missions



$N = Ns \cdot fp \cdot ne \cdot fl \cdot fi \cdot fc \cdot fL$

$f_N(n) = \frac{1}{n} \cdot \frac{1}{\sqrt{2\pi}\sigma} e^{\frac{(\ln(n)-\mu)^2}{2\sigma^2}} \quad (n \geq 0)$

$f_{ET\_Distance}(r) = \frac{3}{r} \cdot \frac{1}{\sqrt{2\pi}\,\sigma} \cdot e^{\frac{\left(\ln\left[\frac{6\,R_{Galaxy}^2\,h_{Galaxy}}{r^3}\right]-\mu\right)^2}{2\sigma^2}}$

Claudio Maccone

$X(t) = \sum_{n=1}^{\infty} Z_n\,\phi_n(t) \quad \text{with} \quad 0 \leq t \leq T.$

Springer

PRAXIS

Thank you very much !