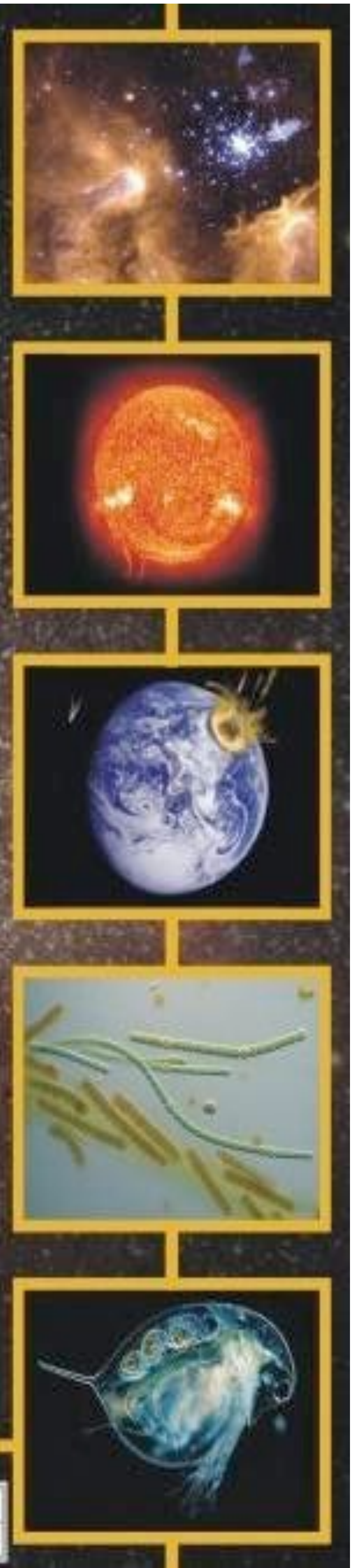

FUNDAMENTOS DE ASTROBIOLOGIA
AST – 416 – 3

Aula 7
SETI e Discussões finais

C.A.Wuensche

INPE – Divisão de Astrofísica

http://www.das.inpe.br/~alex

SETI e Discussões finais

Leitura:

☑ Caps. 14, 15 e 16 do livro "Astrobiologia: uma ciência emergente"

☑ Cap. 17 do livro "Astrobiology: a multidisciplinary approach"

SETI (Search for Extraterrestrial Inteligence)

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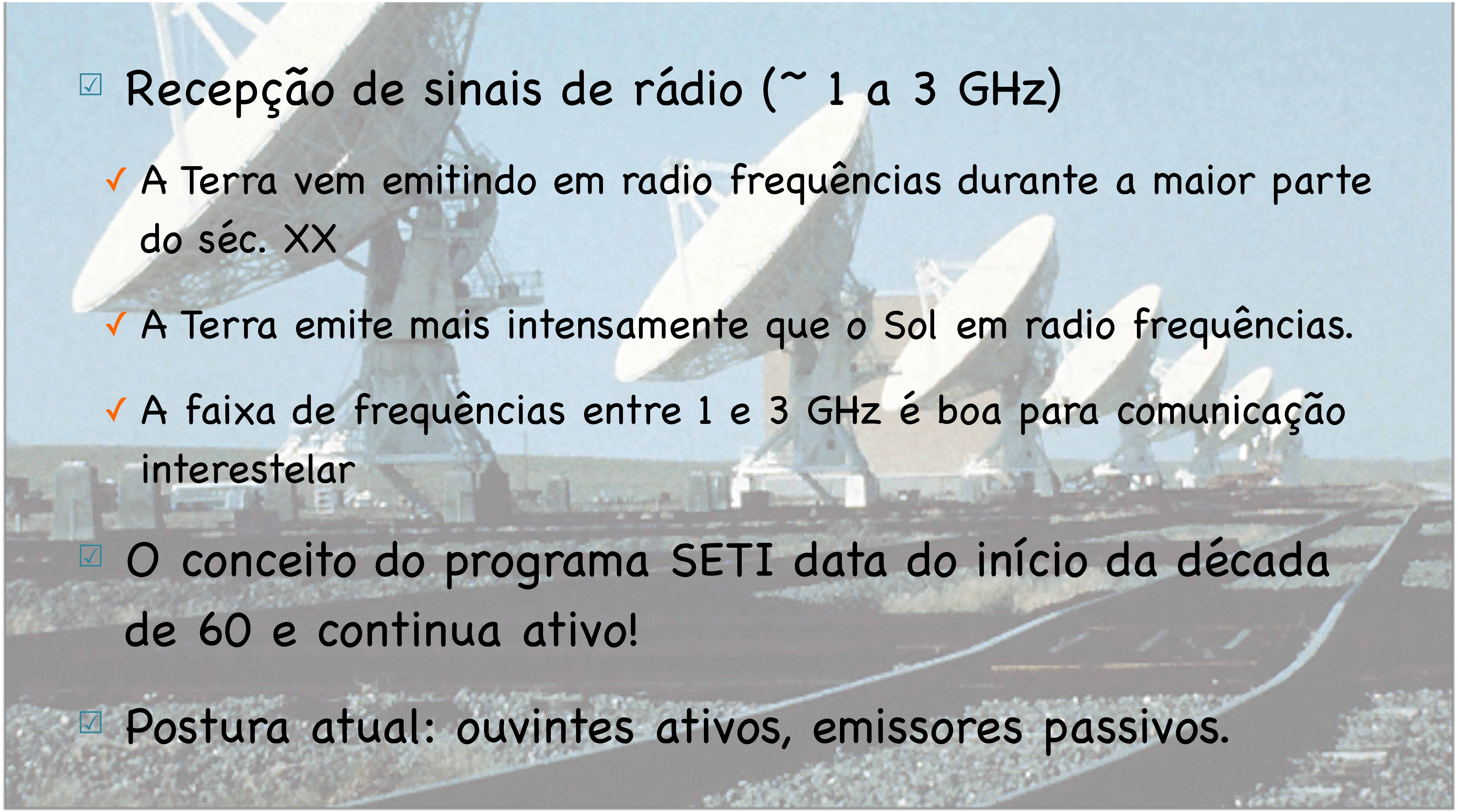
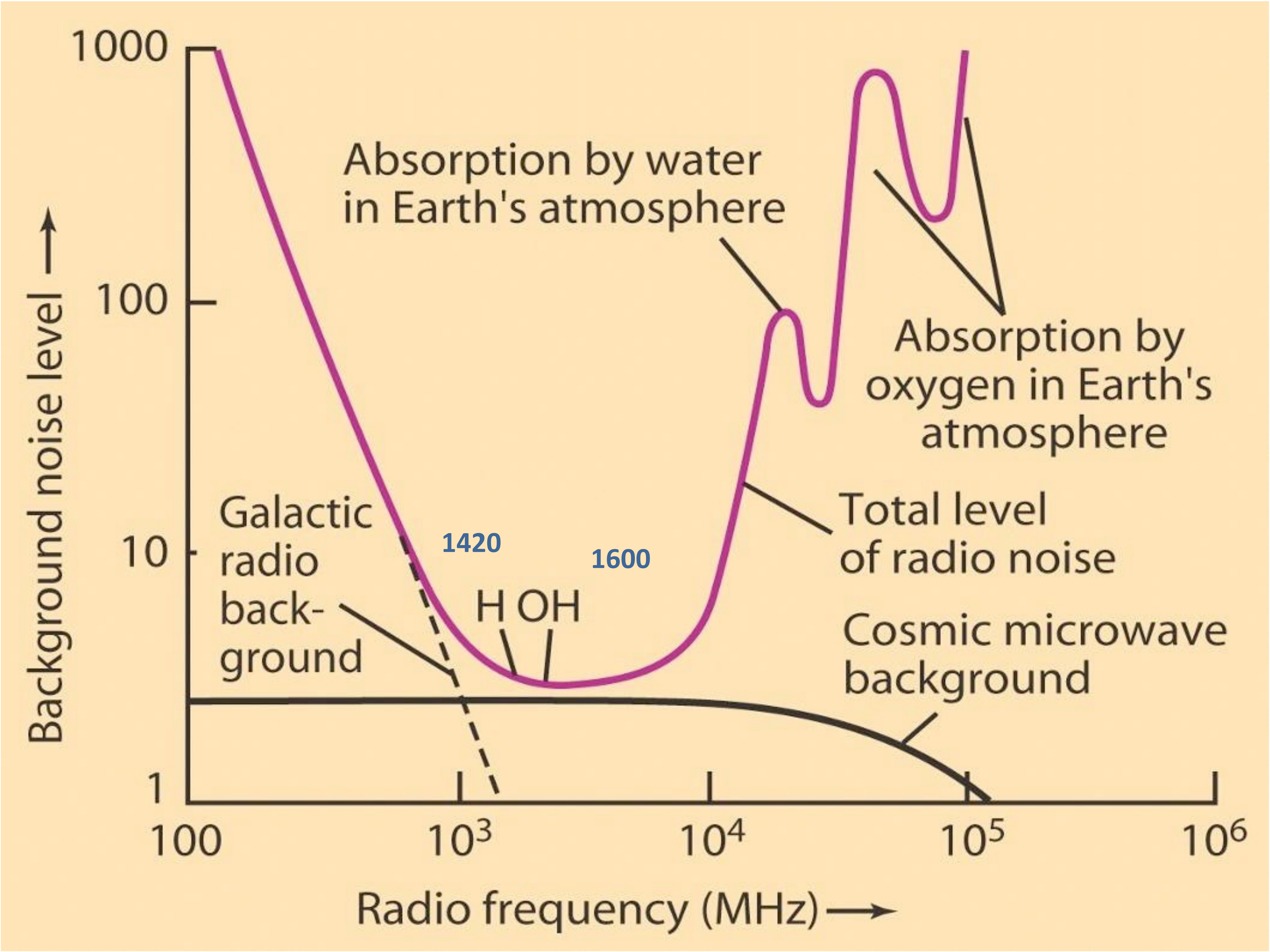
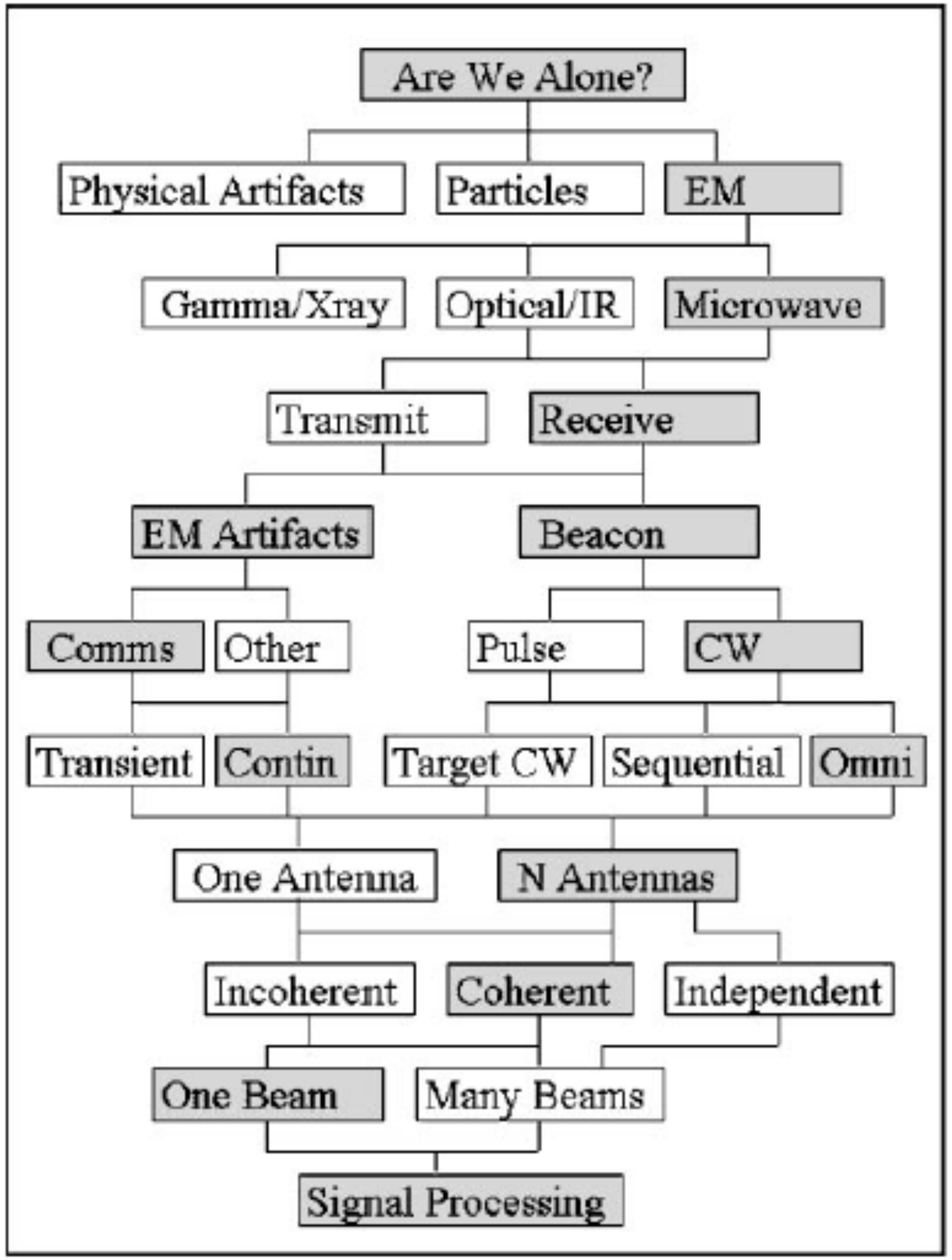


- Recepção de sinais de rádio (~ 1 a 3 GHz)
  - A Terra vem emitindo em radio frequências durante a maior parte do séc. XX
  - A Terra emite mais intensamente que o Sol em radio frequências.
  - A faixa de frequências entre 1 e 3 GHz é boa para comunicação interestelar
- O conceito do programa SETI data do início da década de 60 e continua ativo!
- Postura atual: ouvintes ativos, emissores passivos.

A janela da água...



A árvore de decisão do SETI...



Equação de Drake

Frank Drake

$$N = R_{*} \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

Equação de Drake

Frank Drake

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

~ 1/ano

Equação de Drake

Frank Drake

$$N = R_{*} \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

~ 1/ano

~ 1

Equação de Drake

Frank Drake

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

~ 1/ano

~0.1?

~ 1

Equação de Drake

Frank Drake

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

~ 1/ano

~ 1

~0.1?

~1??

Equação de Drake

Frank Drake

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

~ 1/ano ~0.1? ~1???

~ 1 ~1??

Equação de Drake

Frank Drake

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

~ 1/ano ~0.1? ~1???

~ 1 ~1?? ~1??!

Equação de Drake

Frank Drake

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

100 anos?

~ 1/ano

~ 1

~0.1?

~1??

~1???

~1??!

Equação de Drake

Frank Drake








$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

100 anos?

10

~ 1/ano

~ 1

~0.1?

~1??

~1???

~1??!

Equação de Drake

Frank Drake

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

100 anos?

10

~ 1/ano

~ 1

~0.1?

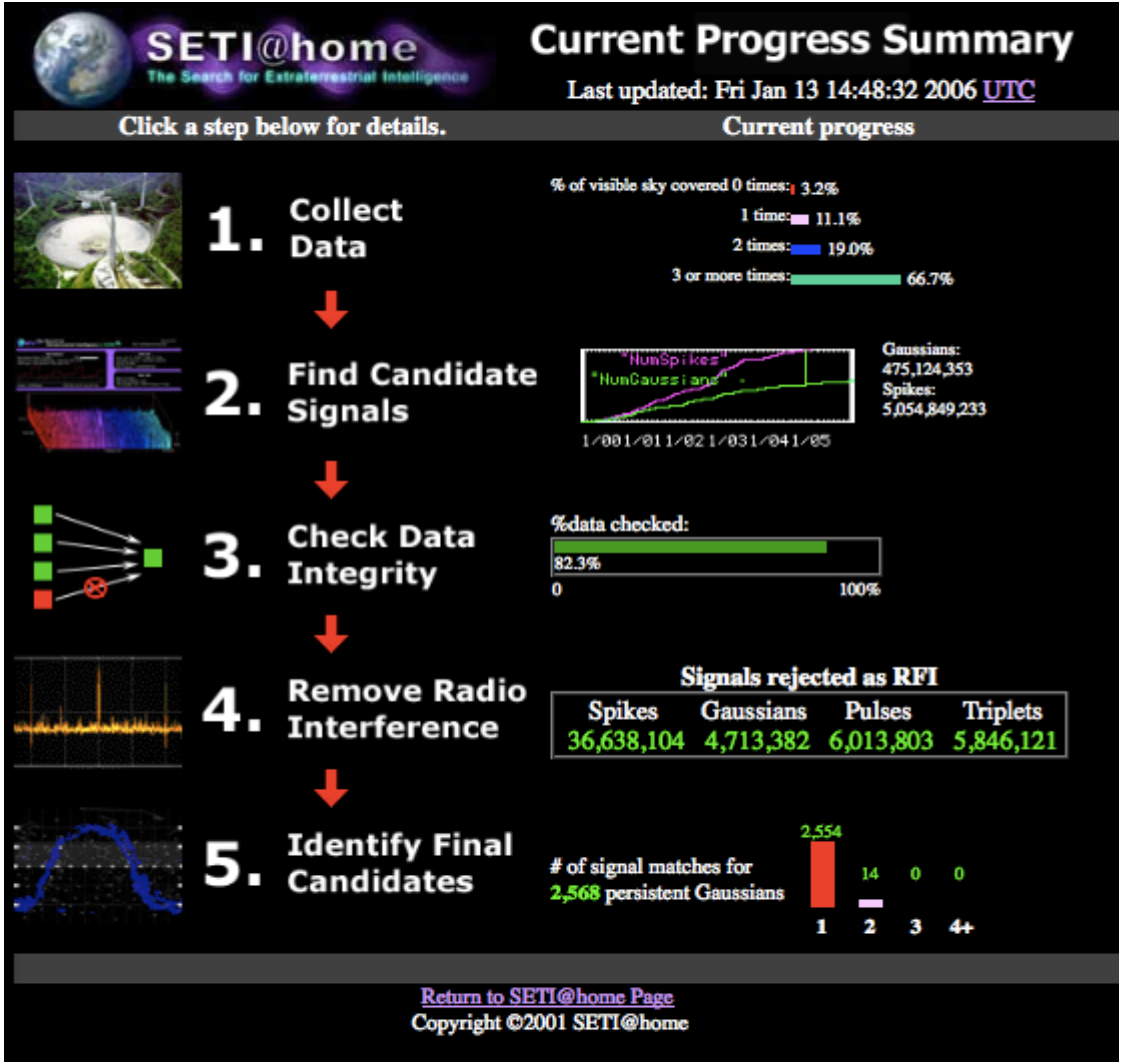
~1??

~1???

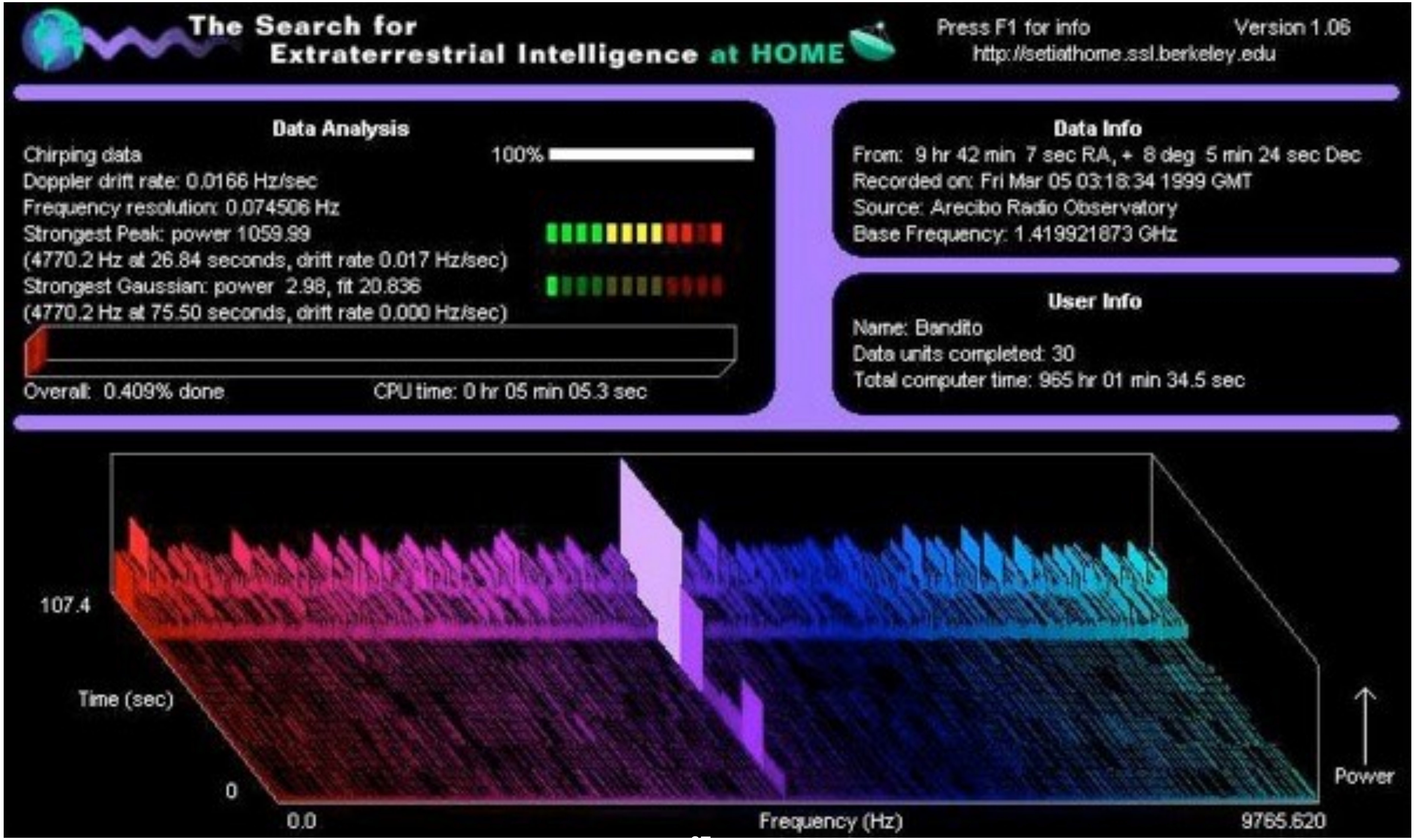
~1??!

N = 1000 ou 0,000000001...

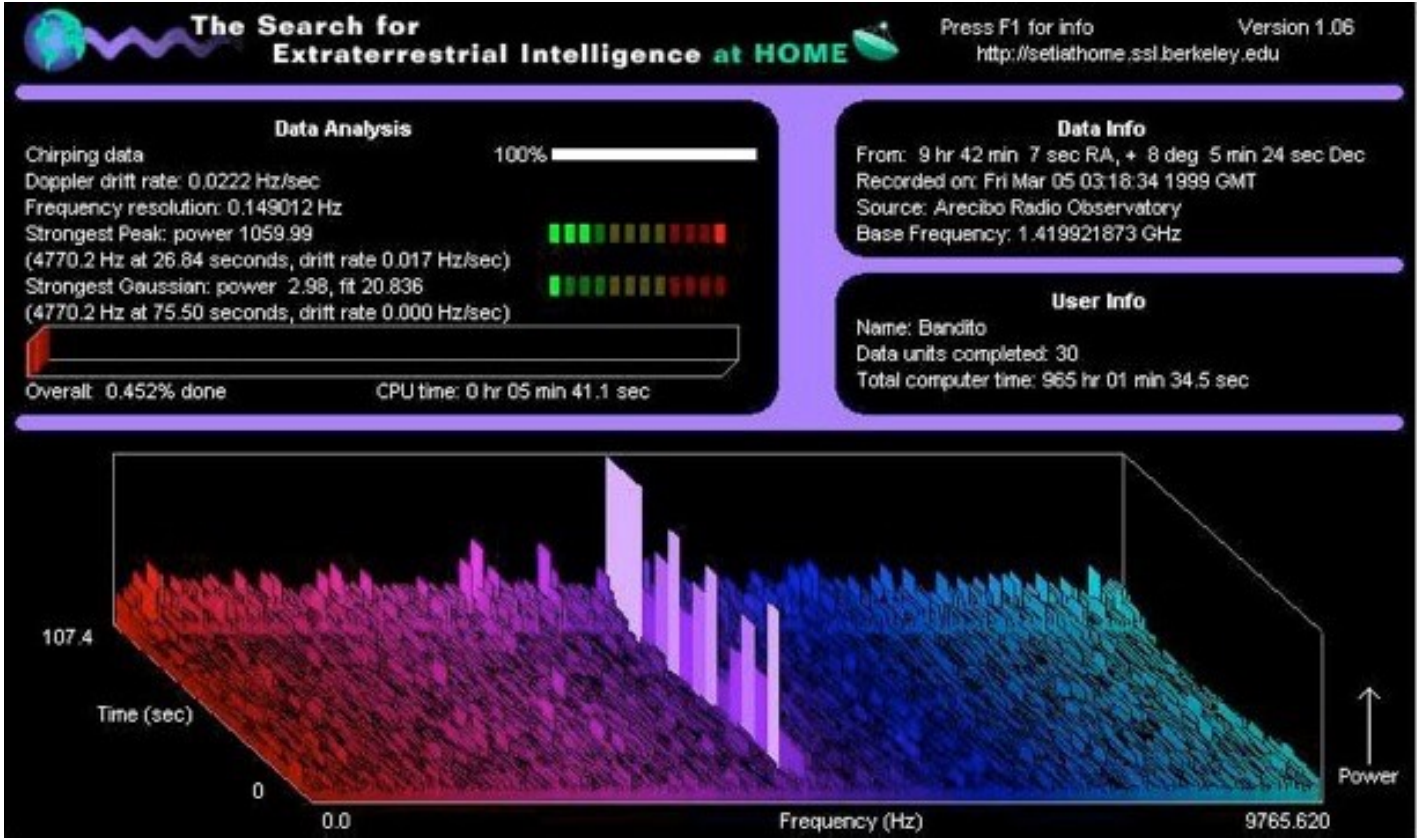
Fluxograma de operação do SETI



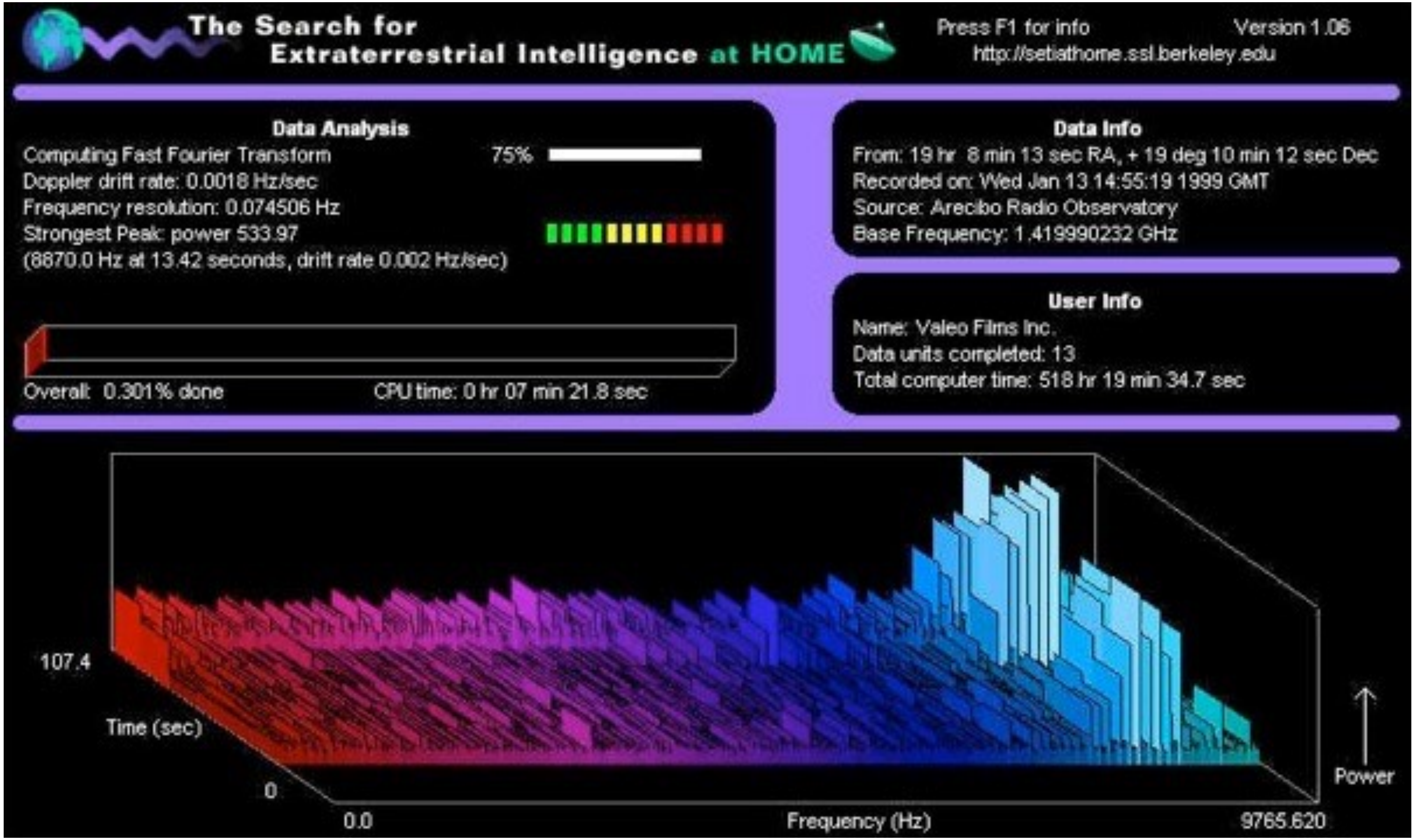
SETI – Interferência de banda estreita



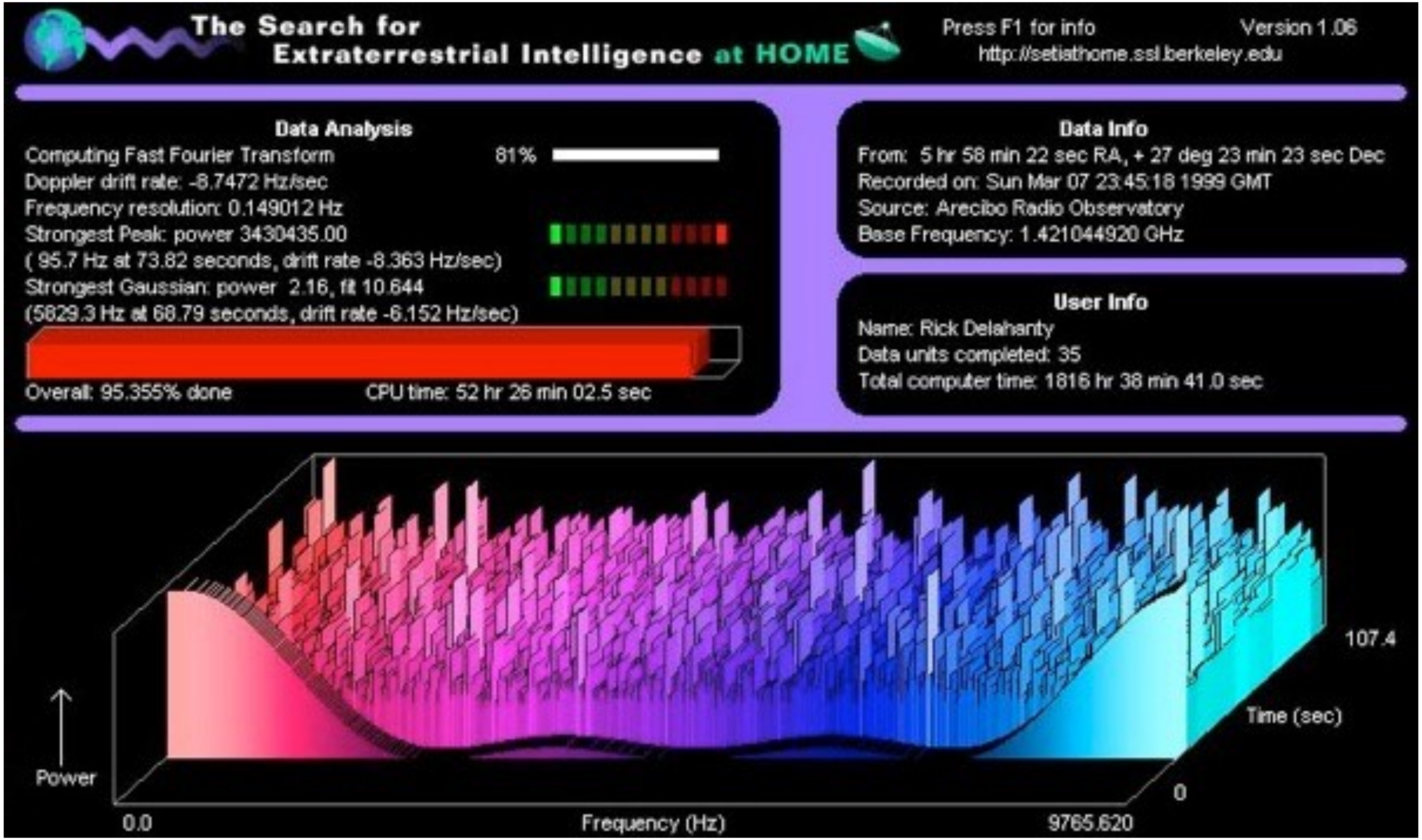
SETI - Interferência de banda estreita



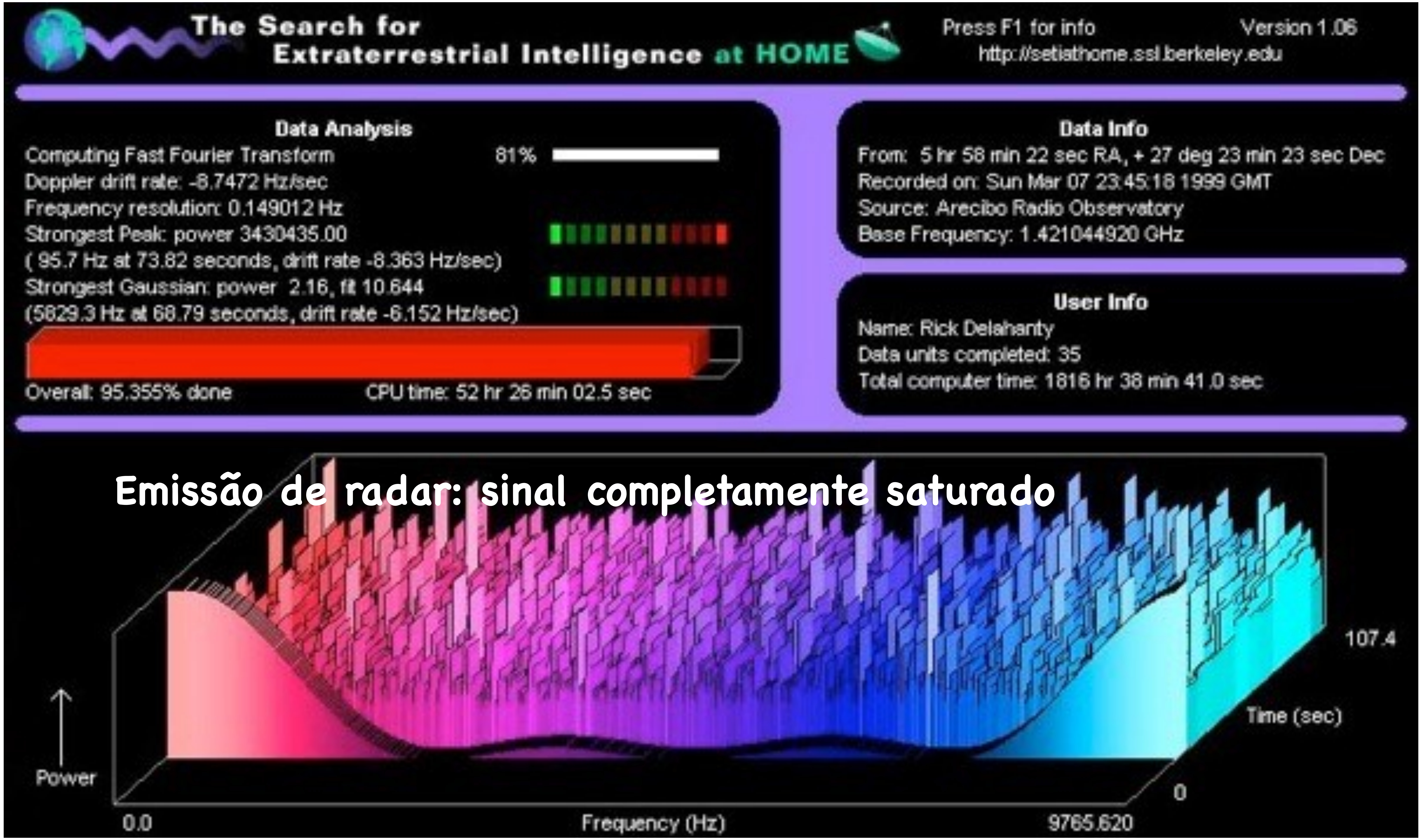
SETI – Interferência de banda larga



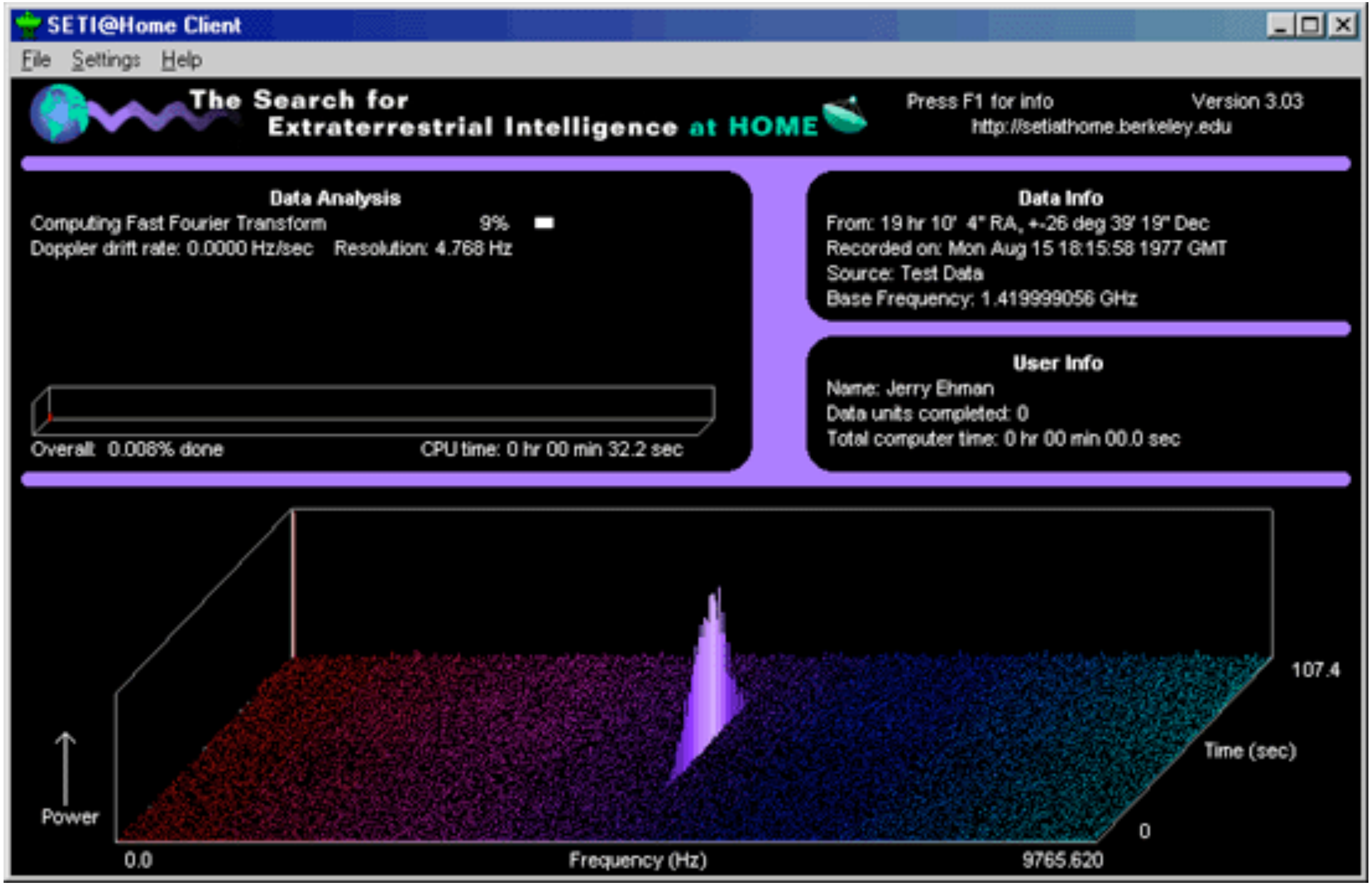
SETI - Interferência de banda larga



SETI – Interferência de banda larga

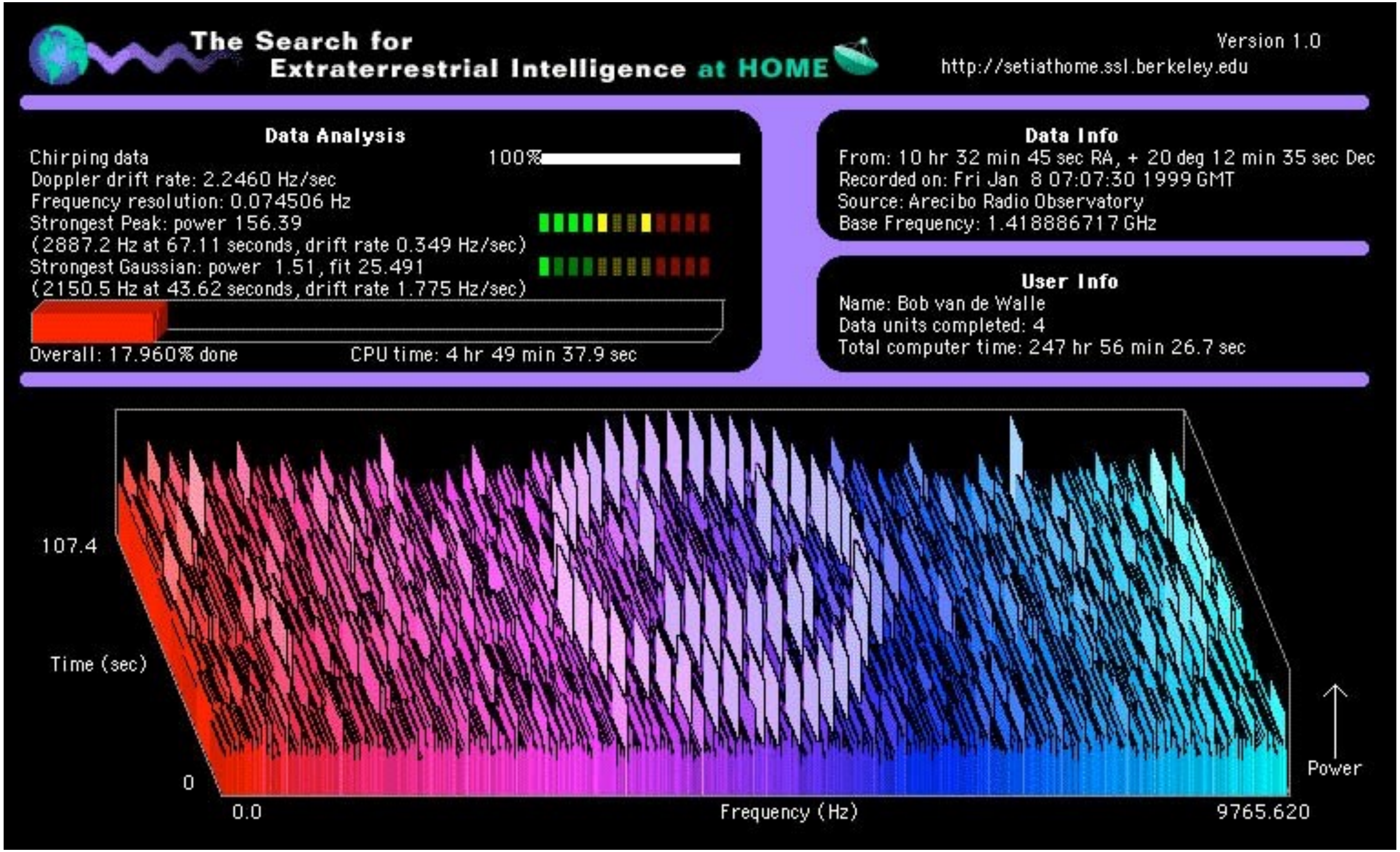


SETI – sinal gaussiano

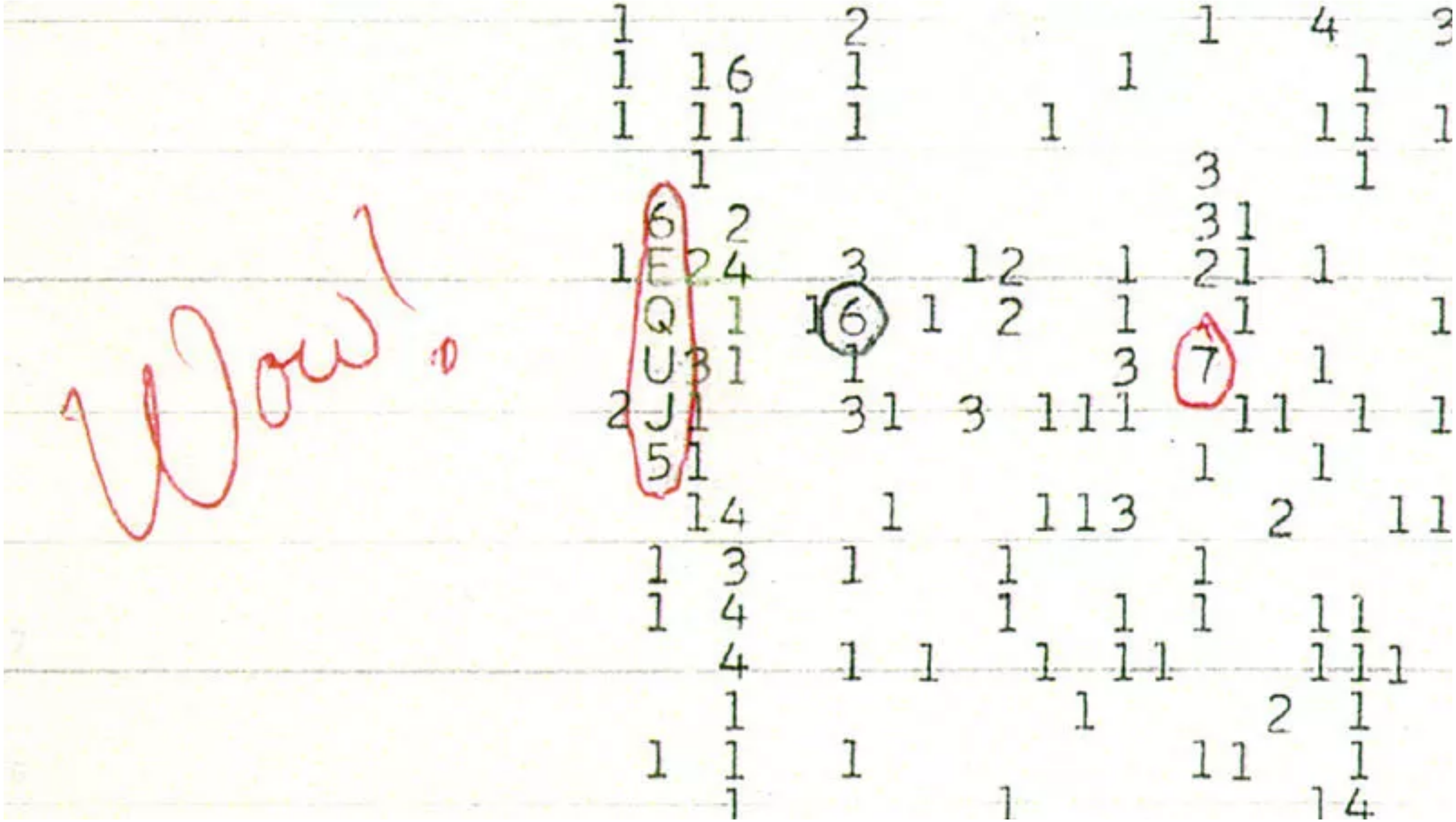


E o que desejaríamos?

E o que desejaríamos?



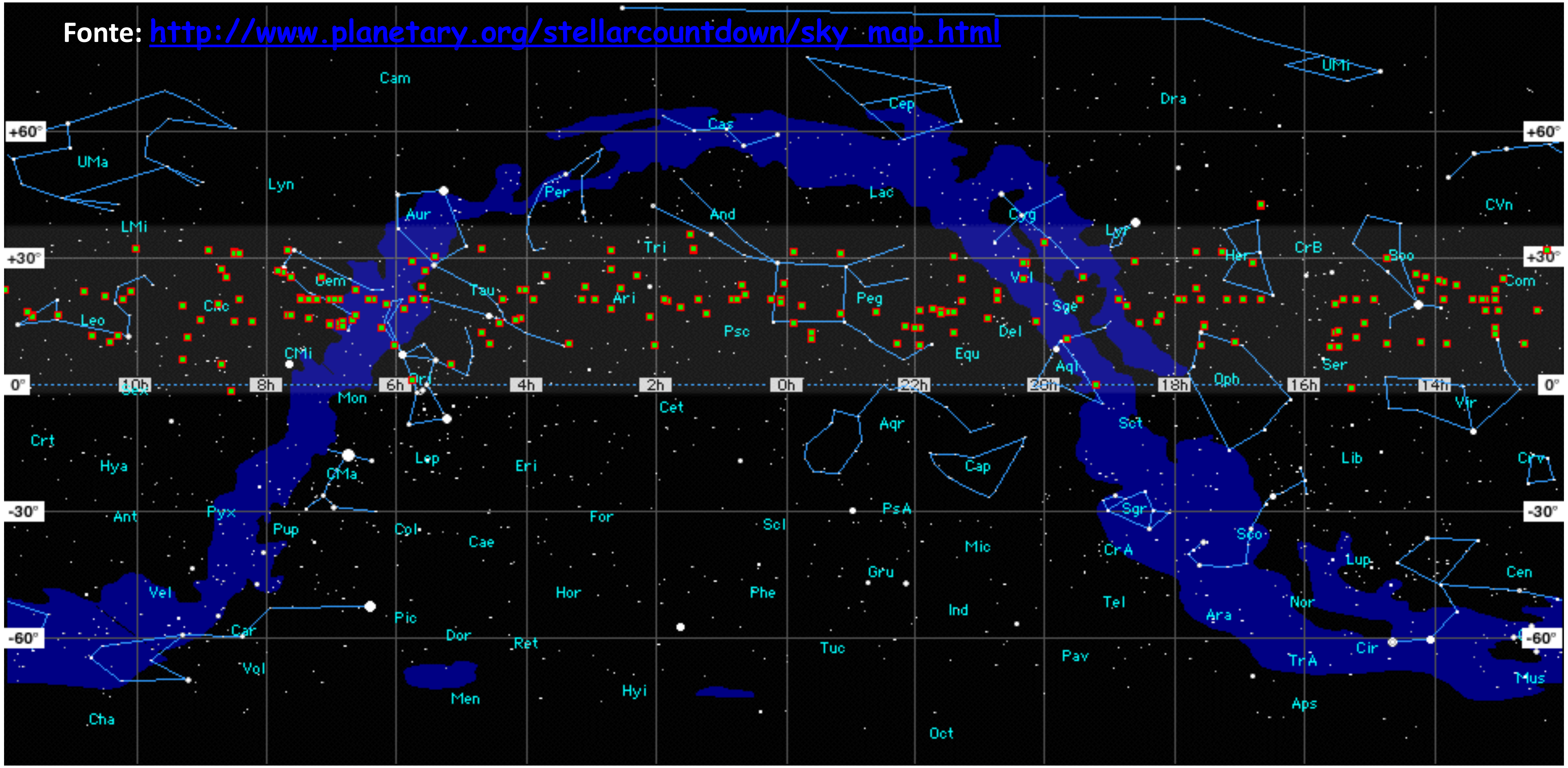
O sinal WOW



Mapa celeste dos candidatos mais promissores do SETI@home

A area azul delimita o plano da nossa Galáxia.

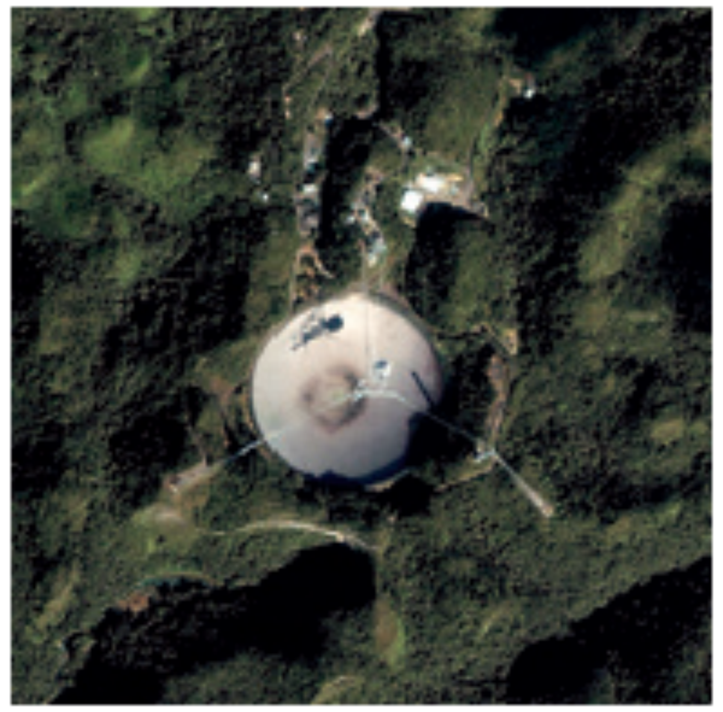
Os quadrados amarelos marcam a posição dos candidatos mais promissores.



Fonte: http://www.planetary.org/stellarcountdown/sky_map.html

SETI no Séc. XXI

RADIO SETI



SETI AT BERKELEY
Analyses data from the Arecibo radio telescope in Puerto Rico and includes SETI@home, which uses processing power donated by home computers.

Cost: ~$175,000 plus ~$550,000/year
Funder: Various, including SETI@home participants

SOUTHERN SETI
One of the few Southern Hemisphere SETI projects, this uses two 30-metre antennas at the Argentinian Institute of Radio Astronomy, near Buenos Aires.

Cost: ~$16,500/year
Funder: The Planetary Society in Pasadena, California

PROJECT ARGUS
Coordinating SETI observations by hobbyist radio astronomers, this project currently comprises 147 home-built dishes.

Cost: ~$4,000/dish
Funder: Participants

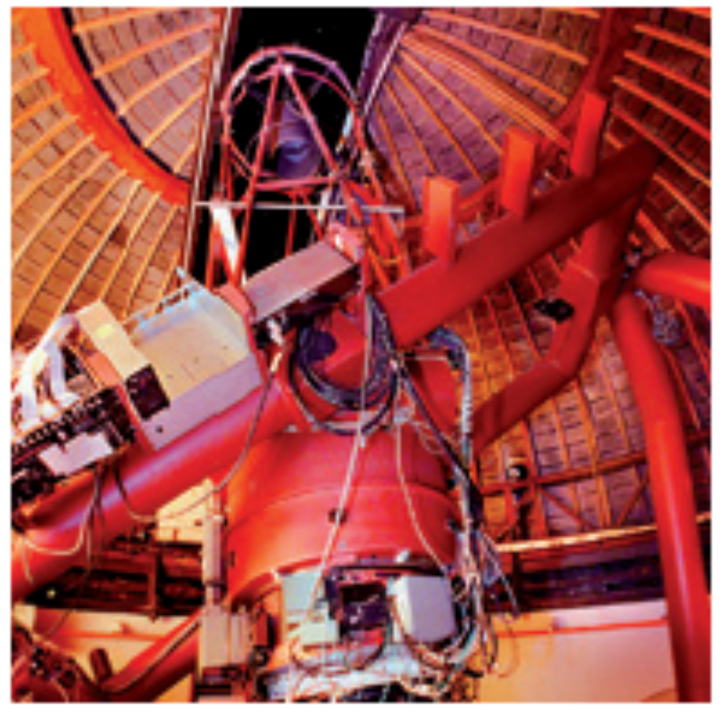
OPTICAL SETI:

SETI AT BERKELEY
A detector on a 0.76-metre telescope at the University of California, Berkeley's Leuschner Observatory searches for nanosecond pulses of laser light.

Cost: ~$70,000 plus ~$12,000/year
Funder: The SETI Institute in Mountain View, California, and Planetary Society

SETI OPTICAL TELESCOPE
This 1.8-metre telescope in Harvard, Massachusetts, also looks for nanosecond laser pulses.

Cost: ~$350,000 plus ~$20,000/year
Funder: SETI Institute; Planetary Society; and Bosack–Kruger Charitable Foundation in Redmond, Washington



LICK OBSERVATORY OPTICAL SETI
A detector on a 1-metre telescope at Berkeley's Lick Observatory looked for laser pulses in 2000–07. Berkeley is seeking $100,000 to resume the search.

Cost: ~$20,000 plus ~$12,000/year
Funder: SETI Institute and Planetary Society

Allen Telescope Array

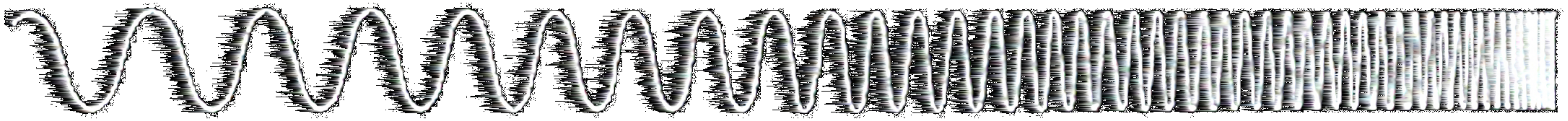
The 42 antennas of the Allen Telescope Array in California listened for alien radio signals for four years, until lack of funding forced the array's closure in April.

Allen Telescope Array

The 42 antennas of the Allen Telescope Array in California listened for alien radio signals for four years, until lack of funding forced the array's closure in April.

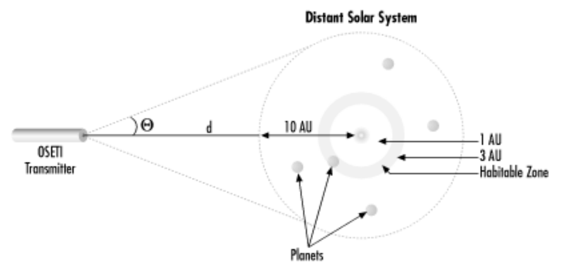
OpticalSETI@berkeley:Searching for Nanosecond Pulses

Griffin Foster, Andrew Howard, Dan Logan, Andrew Siemion, Dan Werthimer
University of California, Berkeley



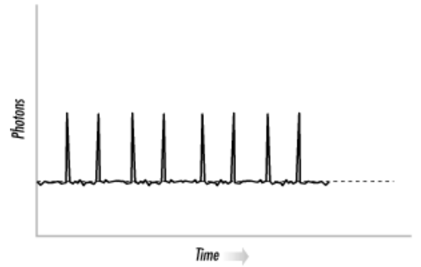
Background

The Optical SETI program at UC Berkeley searches for nanosecond scale optical light pulses, possibly transmitted by a powerful pulsed laser operated by a distant intelligence. The idea of searching for pulses in the optical band was originally presented in 1961 by Townes and Schwartz, suggesting that using a powerful LASER a distant civilization could transmit a light pulse at Earth which would be strong enough to outshine their own star by many orders of magnitude.



Spread of a Transmitted LASER Pulse

In radio band SETI, possible signals are assumed to be transmitted isotropically from the source, essentially leaking into space and eventually passing Earth. Optical SETI, however, relies largely on the premise that a distant civilization might actively send highly focused pulses deliberately towards our solar system. Nanosecond-scale optical pulses are not known to occur naturally from any astronomical source.
The optical SETI project was started at UC Berkeley in 1997, where it was the first of its kind.



Predicted Optical Pulse Signal

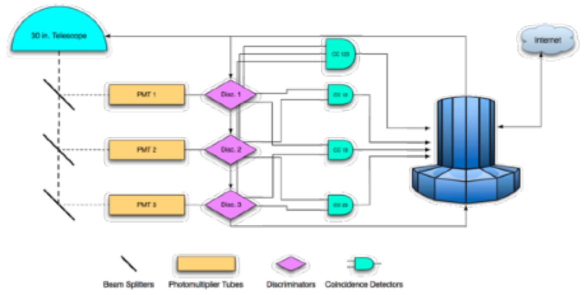
Telescope and Instrument

The optical pulse search utilizes UC Berkeley's 30 inch automated telescope at Leuschner Observatory in Lafayette (15 miles east of campus). The instrument is a custom built photometer, which uses three photomultiplier tubes fed by a beamsplitter to detect concurrent arrival of incoming photons.

The photometer uses a digitally adjustable threshold level to set the false alarm rate for a particular sky/star brightness. Automated observations are performed remotely using the internet.
A duplicate OSETI photometer is in place at the Lick Observatory near San Jose

Leuschner 30 in. Telescope

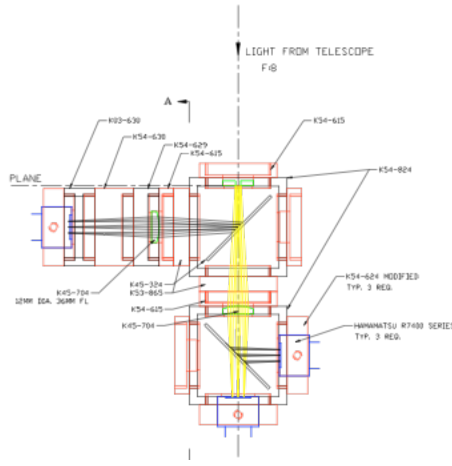
Schematic Diagram of SETI Photometer



Optical SETI Specs

Band:	300-650 nm
Average Flux Limit:	1.5×10^{-28} W/m^2
Peak Flux Limit:	1.5×10^{-17} W/m^2
Stars Surveyed:	11,000 nearby FGK
Galaxies Surveyed:	104

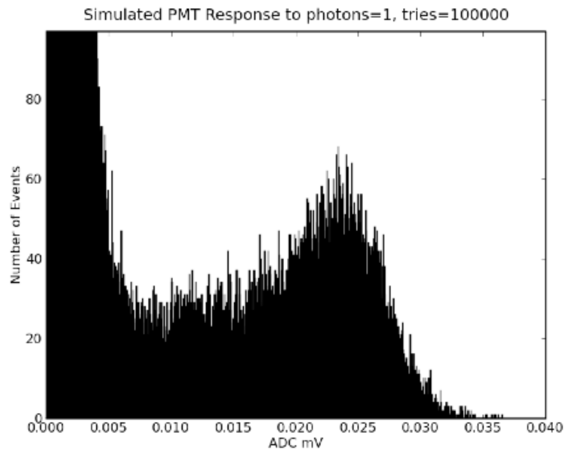
Current Work

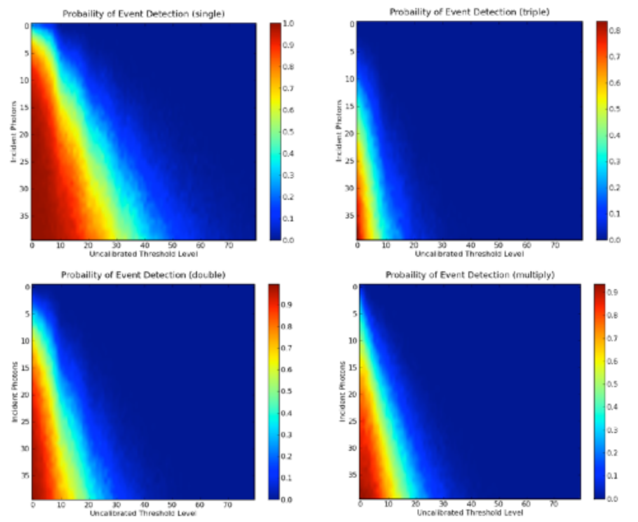


Photometer Schematic

During a typical observation, the telescope is centered on the brightest portion of the field of view and detection thresholds are adjusted such that the false alarm rate is a sufficiently low constant. Currently we record three types of events: 'single' events, when an individual PMT output is greater then the voltage threshold originally set, 'double' events, when any two of the PMTs output exceeds the threshold in the same nanosecond-scale time period. and 'triple' events, when all three PMTs concurrently exceed threshold. Voltage thresholds are set so that false triple events are very rare and false double events occur only a few times in an ~5 minute observation.

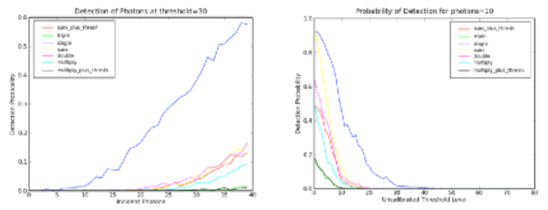
We are also investigating more elaborate algorithms for detecting an incoming pulse. We would like to find the detection algorithm which minimizes false alarm rates and maximizes the likelihood of detection of real events. To wit, we have built a simulation of the current photometer instrument in software. Using this simulation we can examine different detection algorithms, looking at the relative likelihood of detecting 'real' incoming photons versus false alarm events.





Probability Distribution of Detecting Photons Using Various Algorithms

While the simplest algorithm, counting an event if any of the PMT outputs are above a particular threshold, we expect to get the largest number of events. But this method does not do well with system noise. Currently we do a very stringent triple event algorithm to find events which are most likely caused by pulses. Between these two methods there is a variety of other algorithms which may prove more efficient in detecting pulses.



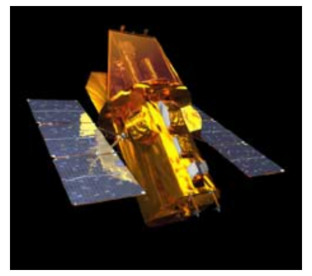
Relative Effectiveness of Algorithms

Further Work

The future of the OSETI project is open to various new additions and upgrades. In investigating new detection algorithms we may find it is advantageous to implement new features in the instrument. We are also looking at adding a fast folding method to look for weak but periodic signals in our data.

Our current catalog of target stars is in the process of being extended to include the most up to date exoplanet lists, the HAPCAT catalogue and other star classes. The photometer is also being setup for fast response GRB follow-up. Using a signal from the SWIFT satellite, we can automatically slew the telescope a new GRB event in tens of seconds.

Exoplanets



SWIFT

M Stars: the hip, new SETI stars?

An important future upgrade to the instrument is to replace the current PMTs (which have the highest efficiency in the optical band) to infrared PMTs. Infrared pulse detection of this type has never been done before.

C. A. Wuensche (2022)

Resultados dos programas SETI...

- Tecnologicamente, é possível detectar sinais equivalentes a potência de:
  - uma emissora de TV a um a.l.,
  - um radar militar a 300 a.l.
  - um radar planetário semelhante ao de Arecibo a 3000 a.l.
- Poucos objetos observados no volume definido acima.

Resultados dos programas SETI...

- ☑ Baixa sensibilidade dos instrumentos atuais impede qualquer conclusão mais bem fundamentada sobre o assunto. Melhoria necessária > 10^5
- ☑ Resultados científicos significativos, desde a década de 60, a partir de 99 projetos científicos: **NENHUM!**
- ☑ Resultados do SETI@home: cerca de 2600 "candidatos finais", com 1σ de significância, submetidos a reanálise

O desdobramento do SETI: Phoenix

☑ Requisitos:

- ✓ Procura de sinais artificiais que possuam uma largura de banda estreita (< 300 Hz), sejam altamente polarizados, tenham uma mínima deriva em freqüência e sejam continuamente pulsados ou estejam continuamente presentes.
- ✓ Utilizar os maiores radiotelescópios (maior sensibilidade),
- ✓ Observar cada banda de freqüência por, no mínimo, 5 minutos.

O desdobramento do SETI: Phoenix

- Requisitos:
  - Observar aproximadamente 1000 estrelas do tipo Solar, num intervalo de distância de 150 anos luz.
  - Realizar a busca utilizando processamento de sinais em tempo real, de modo que candidatos possam ser testados imediatamente.
  - Ser totalmente automatizado para minimizar intervenções humanas e aumentar a qualidade e uniformidade da procura.

The detection of extraterrestrial life and the consequence for science and society

- ☑ The evolution of organic matter in space (Ehrefreund et al.)
- ☑ The search for life in our solar system and the implications for science and society (C. McKay)
- ☑ Life as a cosmic imperative? (C. de Duve)
- ☑ The search for extraterrestrial inteligence (F. Drake)
- ☑ The implications of the discovery of extraterrestrial life for religion (T. Peters)
- ☑ Is life what we made of it? (K. Denning)
- ☑ Searching for a shadow biosphere on Earth as a test o the cosmic imperative (P. Davies)

Ref: Phil. Trans. of the Royal Society (Inglaterra), 369, pags. 497-699 (2011)

Que tal também enviar sinais?

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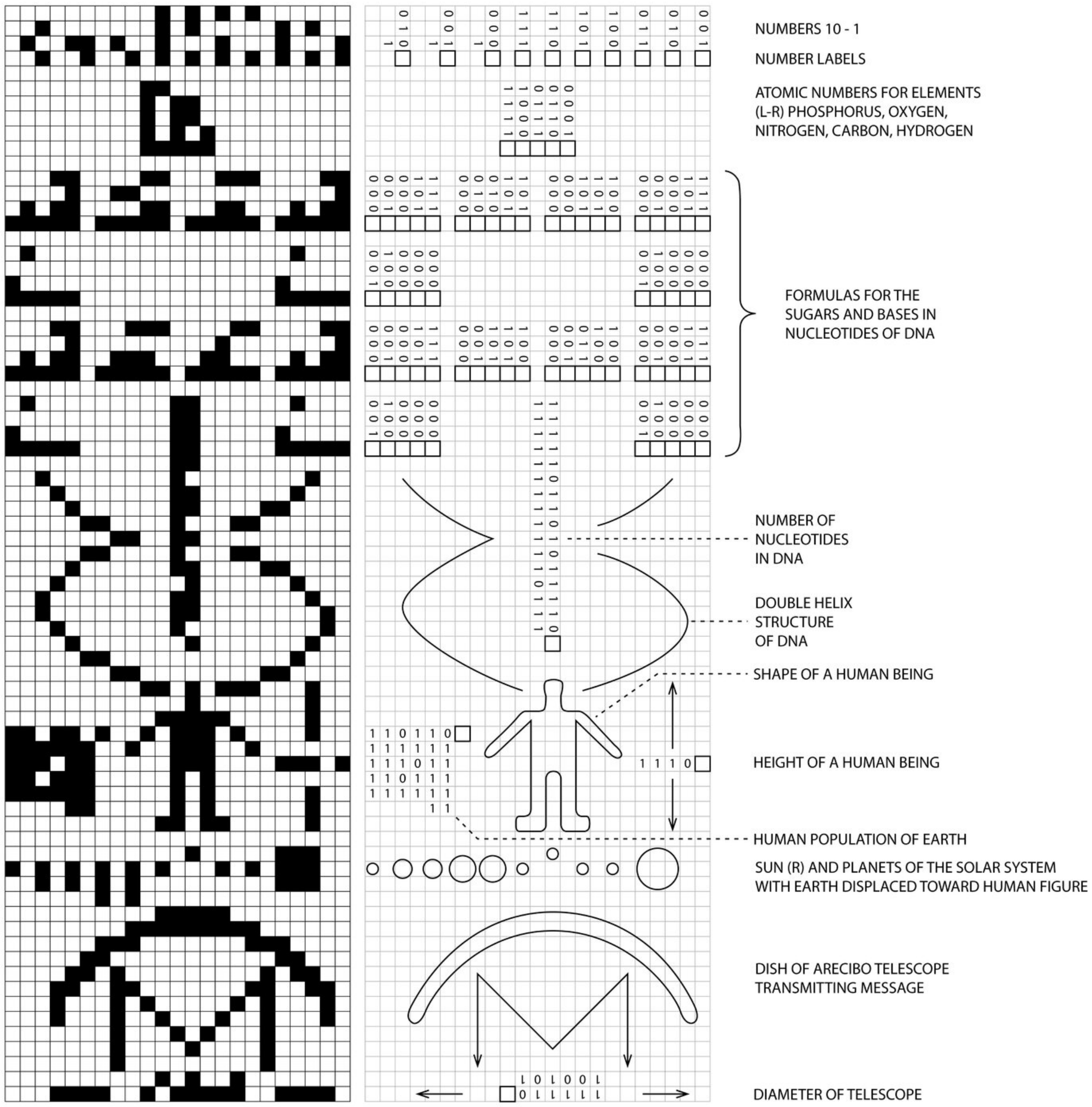

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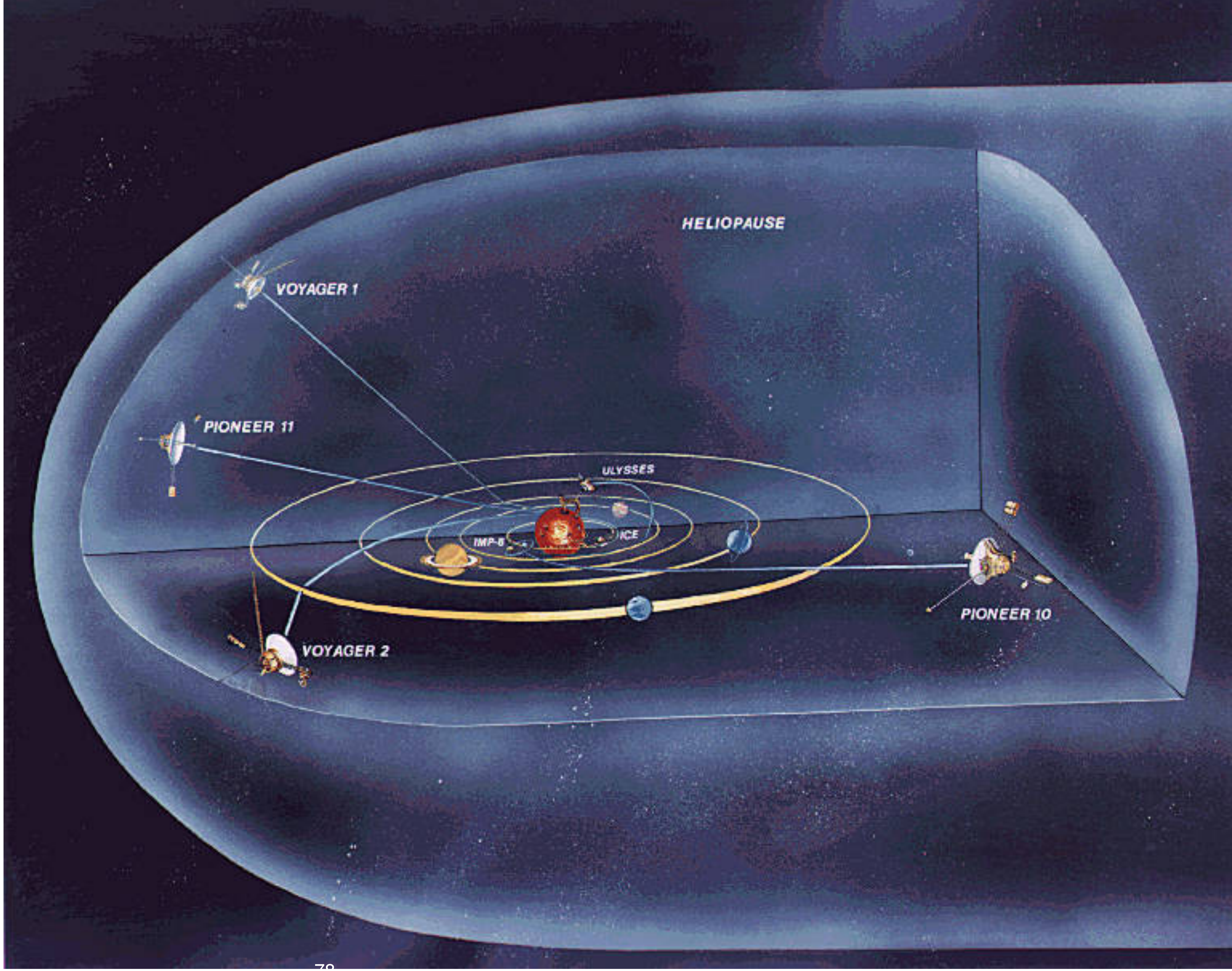

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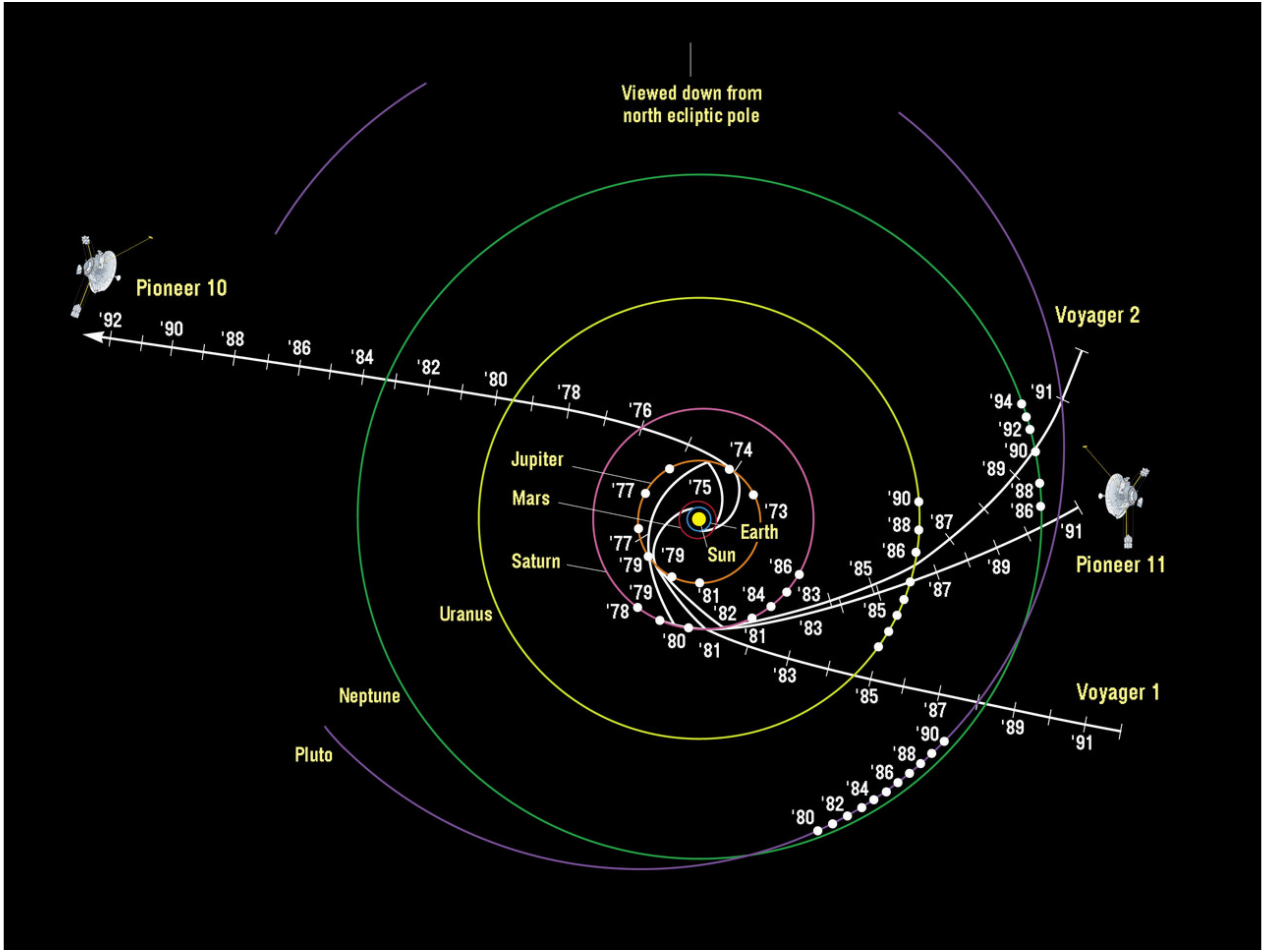
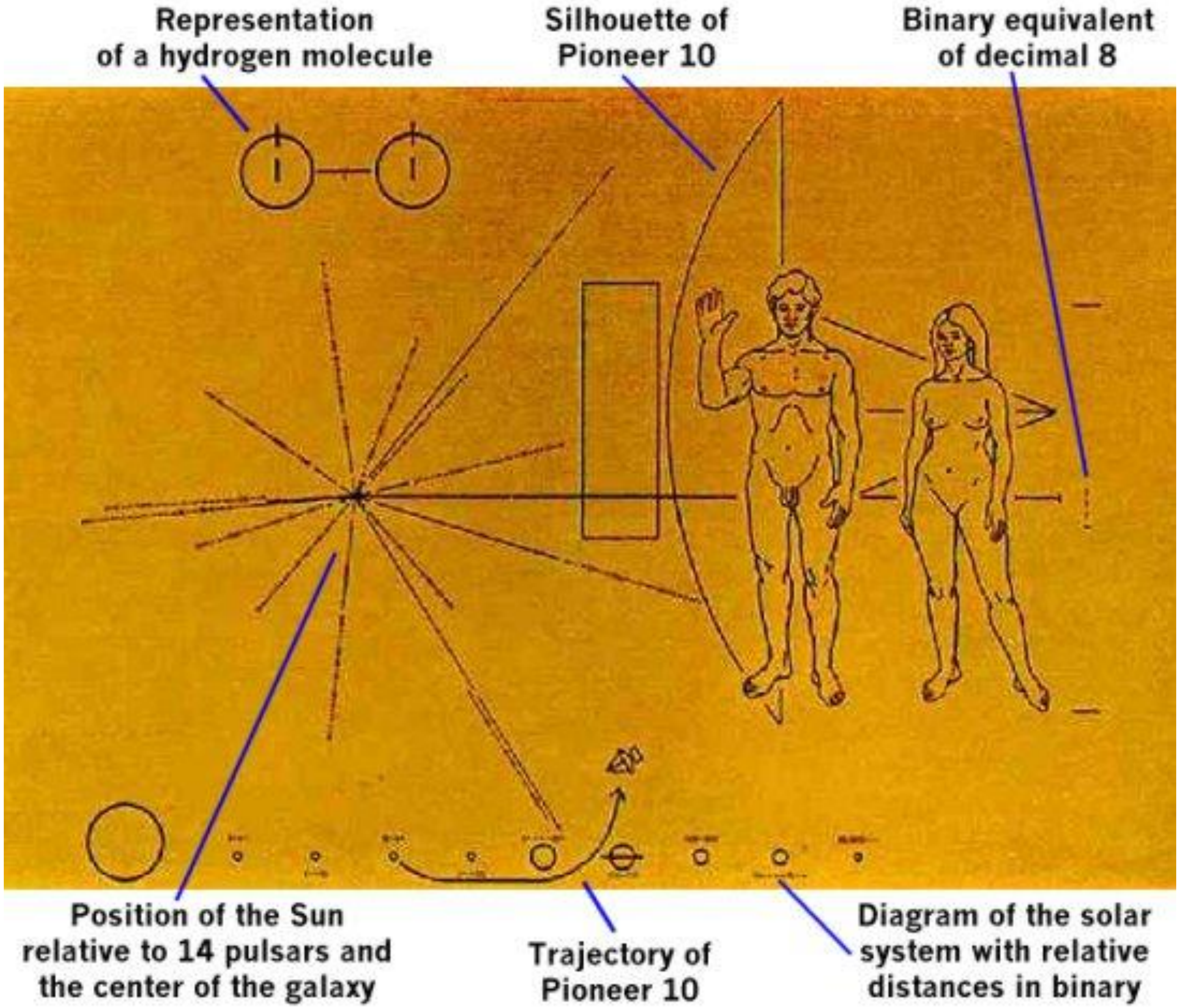
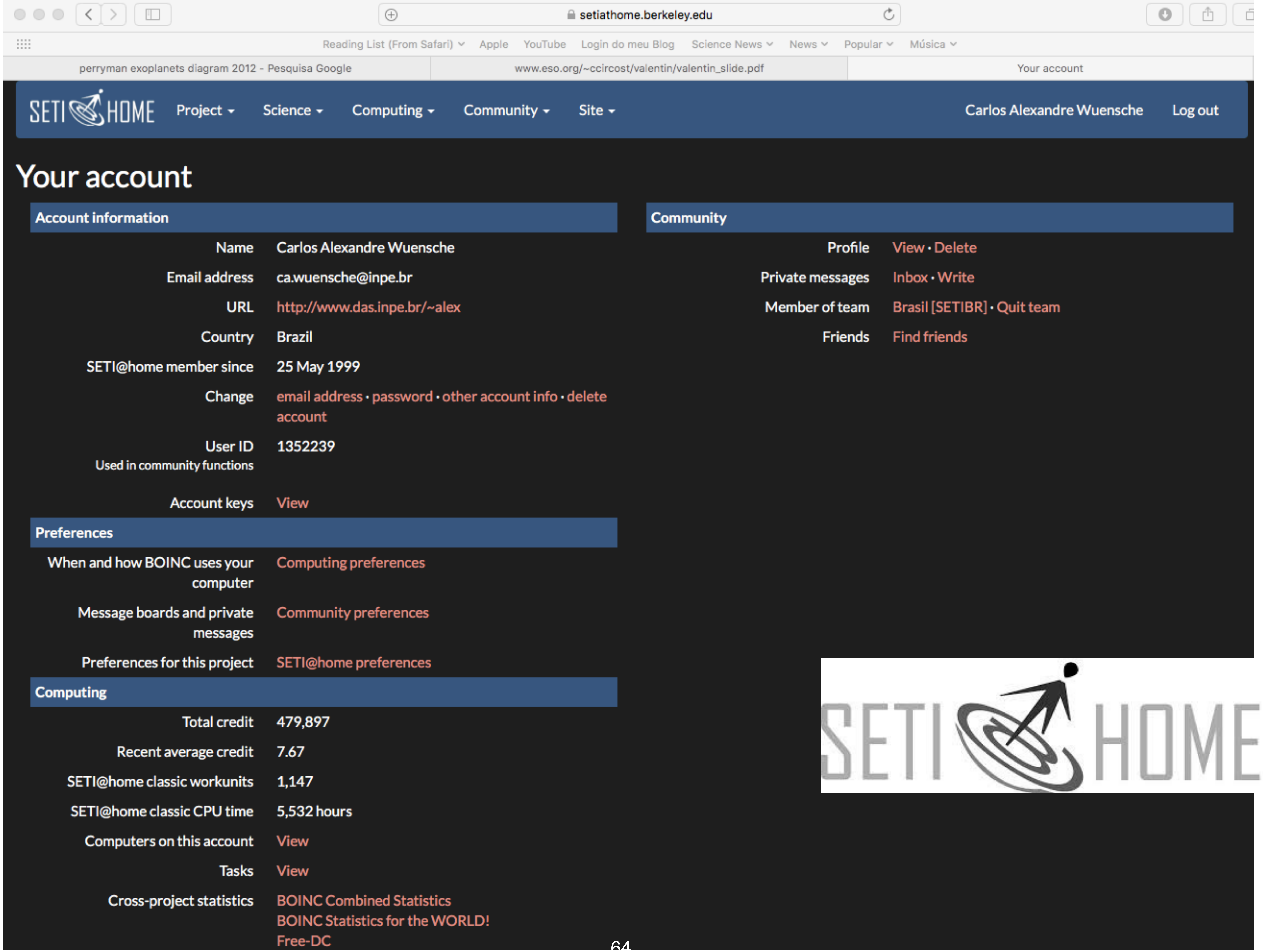


Codificacão das informações na Pioneer 10

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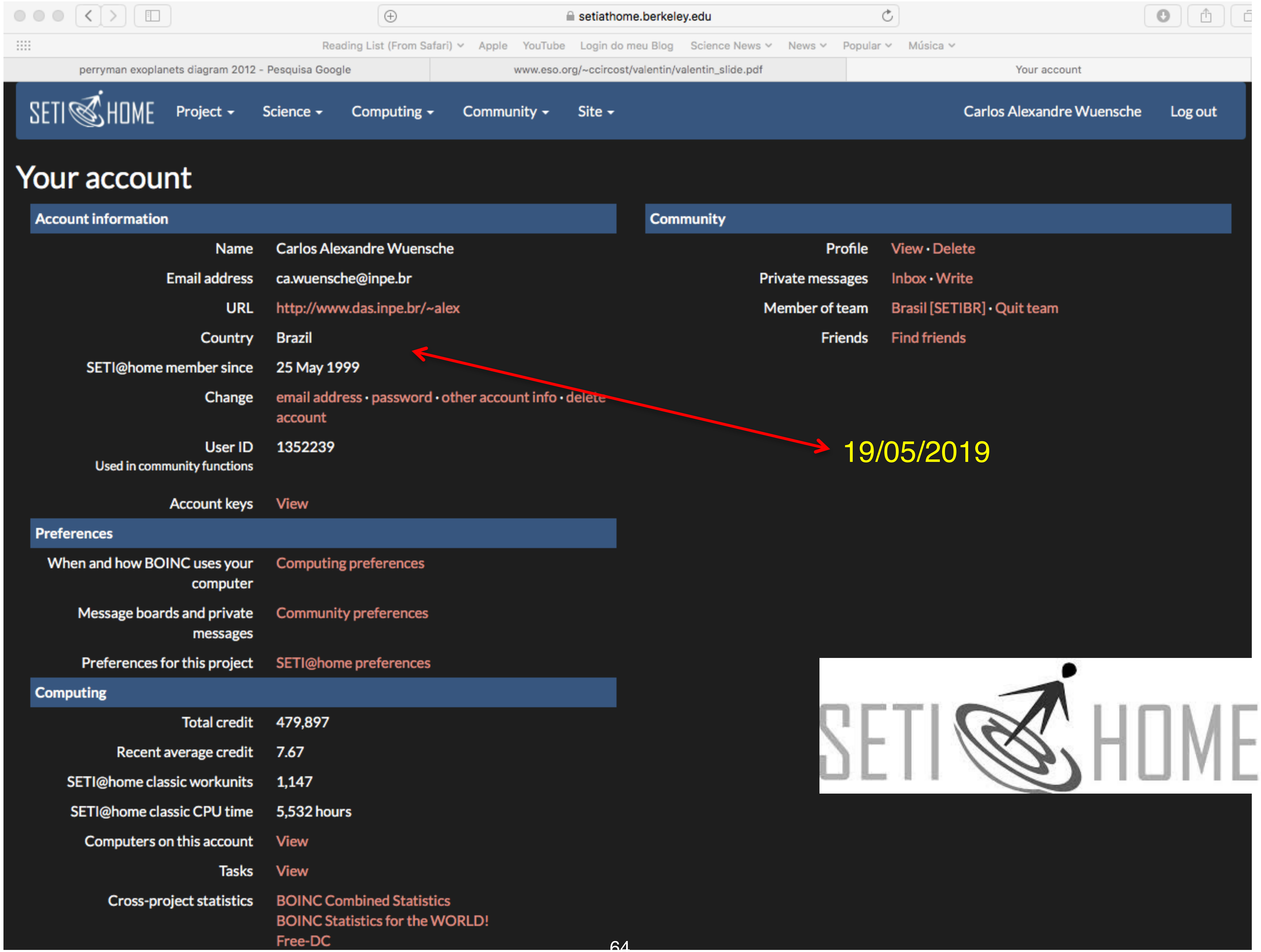
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Free-DC
Community
Profile View · Delete
Private messages Inbox · Write
Member of team Brasil [SETIBR] · Quit team
Friends Find friends

19/05/2019

FONTE: Hyperphysics.

Resultados dos últimos 60 anos

- ☑ Os elementos e condições básicas para a formação da vida como a conhecemos estão espalhados pelo Universo.
- ☑ Existe vida em condições extremas na Terra e já se sabe que sua sobrevivência talvez seja possível no espaço (resultados do programa Apollo)
- ☑ Foram encontrados até hoje milhares de planetas extra-solares, e vários de tamanho semelhantes à Terra, sendo o primeiro planeta terrestre descoberto em 2005.
- ☑ A busca de sinais extraterrestres inteligentes ainda não apresentou, depois de mais de 50 anos, nenhum resultado positivo confirmado.

Ainda não sabemos se...

- ☑ a origem da vida é um acidente ou um "imperativo cósmico"
- ☑ há relação entre vida complexa e inteligência

Com base nos fatos atuais, é possível fazer as seguintes conjecturas:

- ✓ Se a vida surgiu por acaso no Universo, é muito provável que estejamos sós no nosso volume de Hubble, mesmo que planetas terrestres sejam comuns.
- ✓ Caso a origem da vida seja um "imperativo cósmico" e planetas terrestres sejam comuns, ainda assim a vida complexa não deve ser comum (e a vida inteligente, ainda menos comum).

Perspectivas...

- ☑ Radiotelescópios, satélites, e missões espaciais continuarão procurando evidências de bio-traçadores nos planetas e satélites do Sistema Solar
- ☑ Idem, para planetas extra-solares e sinais de vida inteligente em estrelas próximas.
- ☑ A "química do Silício", ligada ao aparecimento de computadores inteligentes, pode originar uma forma de "vida artificial", mas não resolve a questão da **ORIGEM**.
- ☑ Podemos imaginar a existência de vida baseada em outros processos?

A questão da procura de inteligência extraterrestre não deve centrar-se na probabilidade da vida em si, mas na probabilidade de, uma vez criada, ela possa sobreviver e evoluir, dominando o meio ambiente..." **(Norman Pace, Universidade da Califórnia, Berkeley)**

FIM DA AULA 7