Space exploration, not only celestial bodies. A scientific approach to extraterrestrial life

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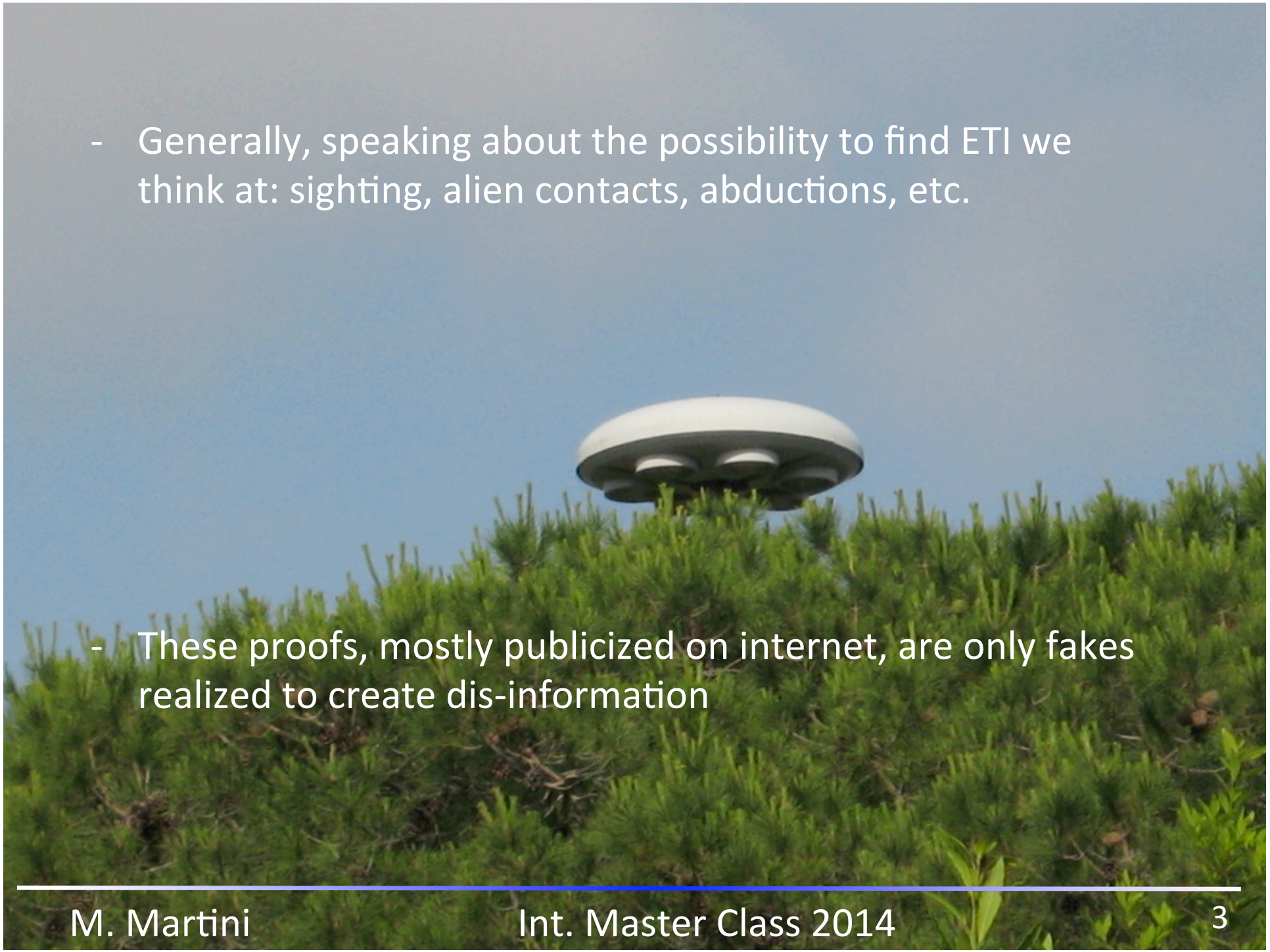
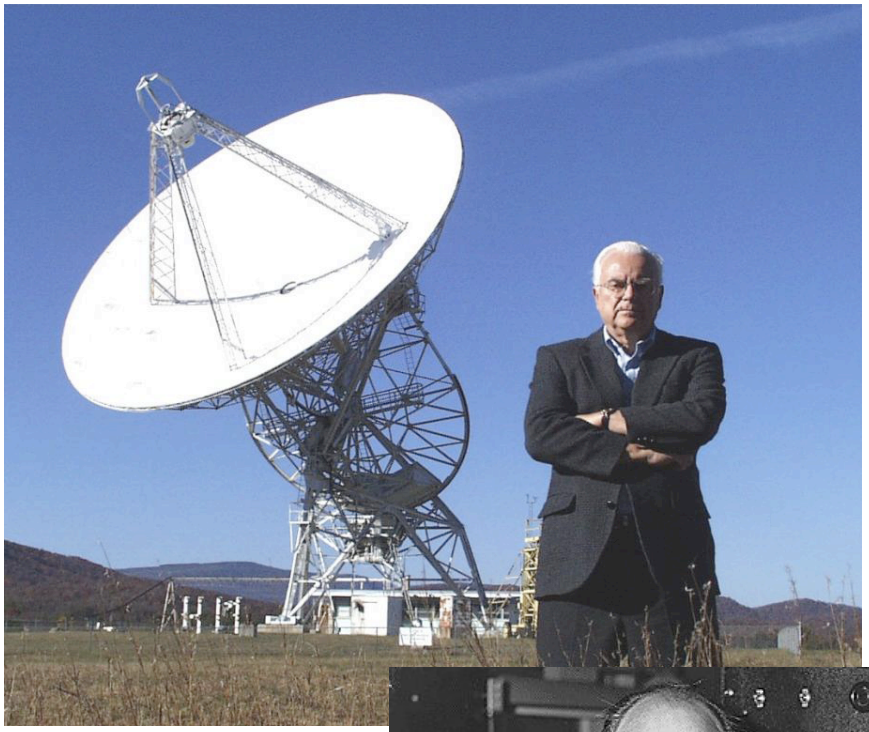
- Search for extraterrestrial intelligence (ETI) is considered matter of fanatic, crazies, fans, etc.



- Generally, speaking about the possibility to find ETI we think at: sighting, alien contacts, abductions, etc.

- These proofs, mostly publicized on internet, are only fakes realized to create dis-information



- Is it possible to perform a scientific search for ETI?

- Scientific research has never tried to search for ETI?

- Scientists can believe in ETI?

During a lunch in 1950, Enrico Fermi, Edward Teller, Hilbert York and Emil Konopinski were talking about some mundane problems. One of these was the existence or not of intelligent life outside Earth.

Fermi formulated in this context what become his paradox:

”Where is everybody?”

Or in other words:

If the extraterrestrial civilization exists, why we have not met them till now?

Given:

- planets (protoplanetary disks) are common
- life originated early on Earth, is easy to evolve
- only a matter of time before intelligence arises
- the vastness of the universe
  - 100 billion stars in the Milky Way galaxy
  - 100 billion galaxies in the universe
- the tremendous age of the universe

Then:

- expect to have a large number of civilizations. It is only a matter of time before they develop the ability for intergalactic travel.

Give a response to Fermi's paradox is not simple and requires a deep analysis not only in scientific aspects of the universe.

Possible answers to Fermi paradox are:

- ETI exists but has not yet civilized entire galaxy
- ETI exists but is not in our galaxy
- ETI exists but do not know where we are
- ETI exist, know our position and do not want to meet us
- **ETI not yet exists**

Try to consider different implications of Fermi's paradox:

Having life somewhere in the universe is not sufficient for our purposes:

- A bacterial colony is LIFE but we want ETI
- ETI must be in a planet "close" to us
- ETI must be able to communicate outside their planet
- ETI must exist NOW!

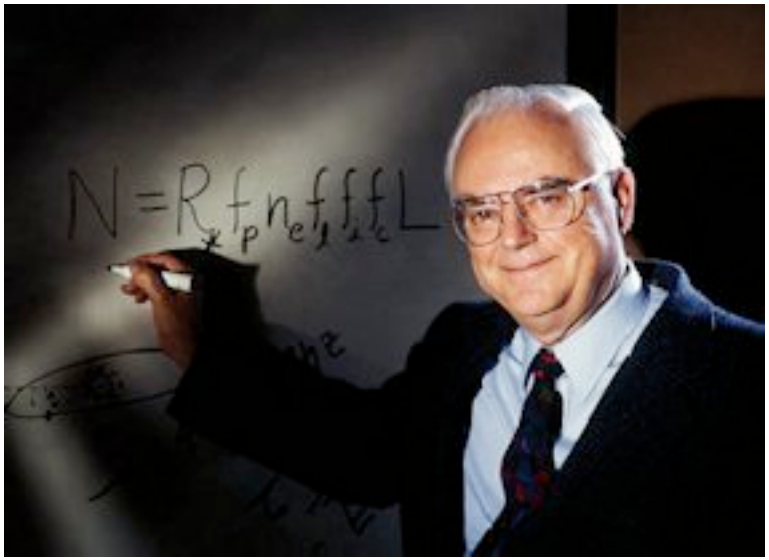
The Drake Equation is a hypothetical equation created in an attempt to estimate the number of extraterrestrial civilizations in our galaxy.

It was developed by Dr. Frank Drake in the 1960's.

Who is Drake? Another fanatic creating fake movie in Youtube?

Astronomers and astrophysicist, Drake was a professor at Cornell University and Director of the National Astronomy and Ionosphere Center (NAIC). Pioneer of radio astronomy developed some programs to search for ETI.

Calling N the number of communicative civilizations in our galaxy, right now, we have:



$$N = N_s \times f_{s\text{-}p} \times f_{p\text{-}e} \times f_{p\text{-}l} \times f_{l\text{-}l} \times f_{i\text{-}c} \times T_c$$

Sometimes this equation can be written in a different form but with the same meaning.

What are all these terms?

N_s = number of stars in the Galaxy

$f_{s\text{-}p}$ = fraction of stars with planets

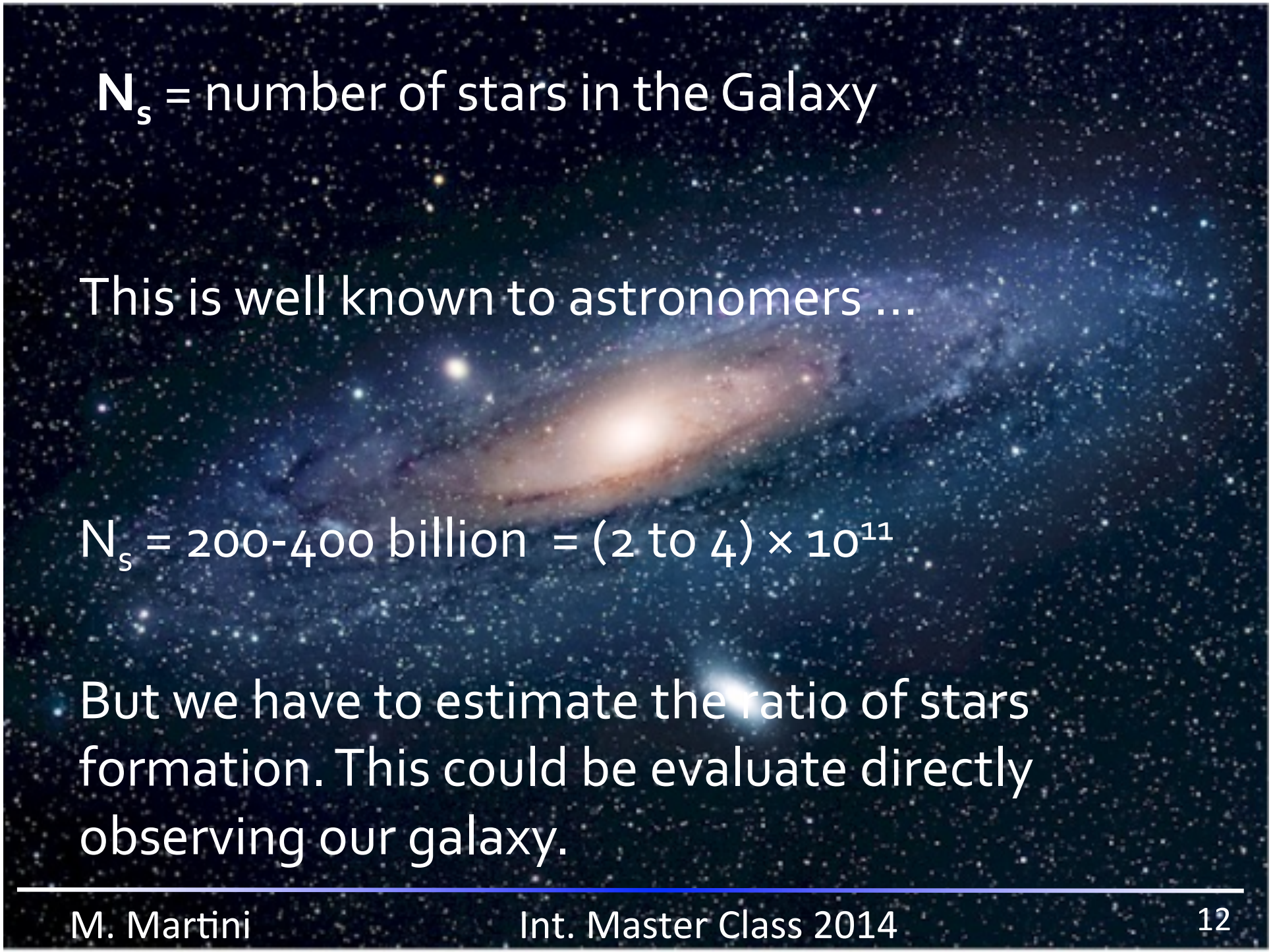
$f_{p\text{-}e}$= fraction of planets that are “earthlike”

$f_{p\text{-}l}$ = fraction of “earthlike” planets that develop life

$f_{l\text{-}i}$ = fraction of above that develop intelligence

$f_{i\text{-}c}$= fraction of above that develop communication

T_c = lifetime of communicative civilization



$\mathbf{N_s}$ = number of stars in the Galaxy

This is well known to astronomers …

N_s = 200-400 billion = (2 to 4) × 10^{11}

But we have to estimate the ratio of stars formation. This could be evaluate directly observing our galaxy.

Where life may be?

$\mathbf{f_{s\text{-}p}}$ = fraction of stars with planets
$\mathbf{f_{p\text{-}e}}$= fraction of planets that are "earthlike"
$\mathbf{f_{p\text{-}l}}$ = fraction of "earthlike" planets that develop life

Surely this is also matter of astronomy

Where look for life? From our experience, ourselves, we could imagine carbon-based life.

To define an earth-like planet we have to consider some parameters: temperature, gravity, density, orbit, liquid water, etc.

Actually we have a lot of telescope, both on Earth than in orbits, searching for exo-planets outside Solar system.

This search is done looking for planets outside Solar System, rotating around stars but in a "habitable zone"

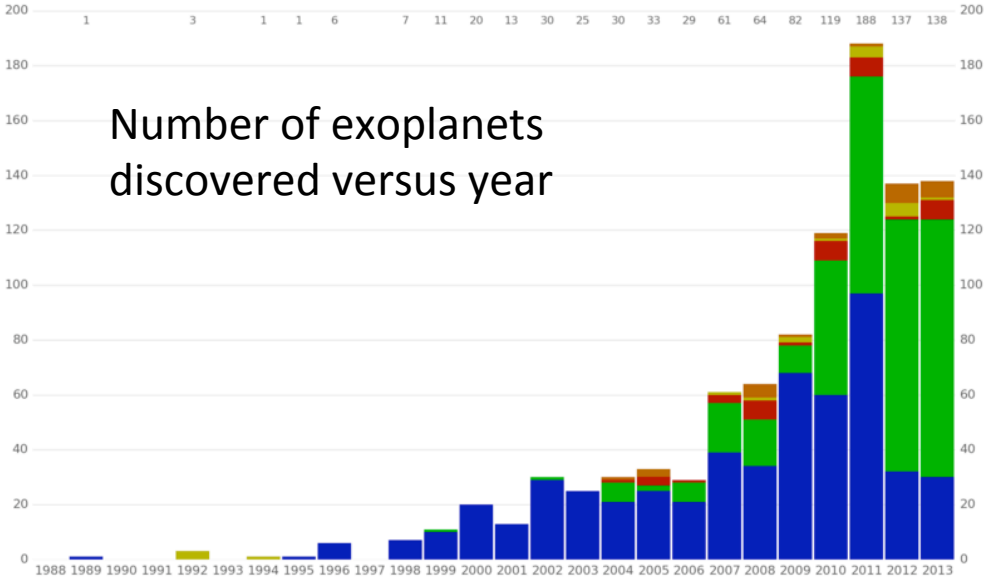
Too close: TOO HOT!
Too far: TOO COLD!
Orbit too elliptical:
Temperature varies too much!
Need a stable orbit over time!

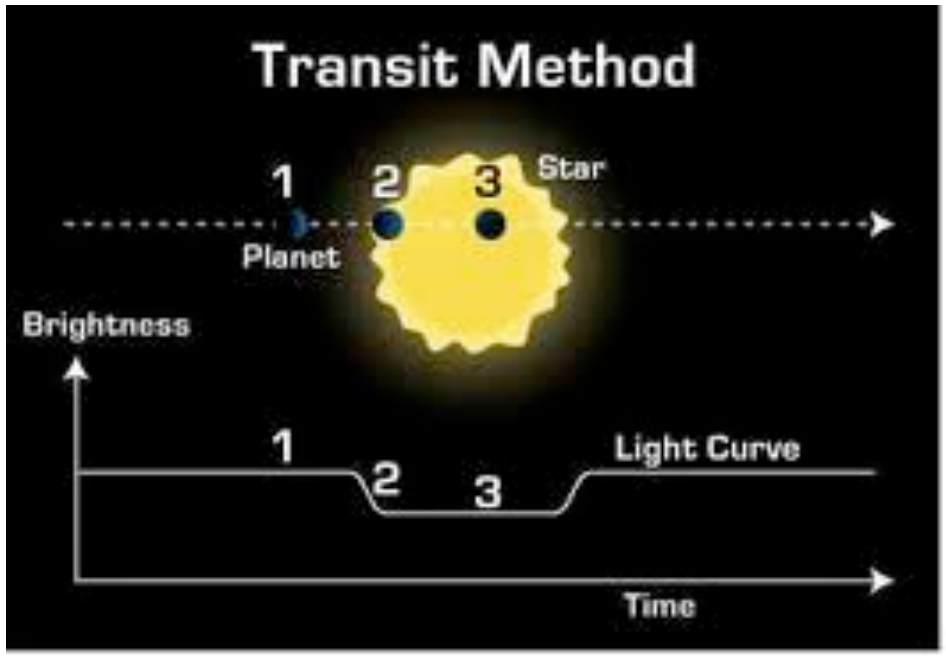
Defines "habitable zone"

In 1960 no exo-planets were identified and only a preliminary guess was possible for this parameters

In the last 50 years …. Some work has been done on space exploration and observation.

Today, we have identified 1075 planets outside Solar System in 813 planetary systems. Some of these planets are in the habitable zone.





Kepler 22-b

Better candidate ever found (up to now)

610 lyrs from our Sun in Cygnus Constellation

Rocky planet

Rotating around Kepler-22 (yellow dwarf) In 290 terrestrial days

Average temperature between -11 and 22 degrees (depending on the presence of greenhouse effect)

Now, we found the probability to have an Earth-like planet in the right zone of its system and in which life can be formed.

To evaluate missing terms astronomy is not sufficient!

Statistically, every guess we made is affected by a great uncertainty since we have only one example in our sample : the Earth!

To obtain an estimation of the probability to form intelligent life from bacteria, looking to Earth we conclude that this probability is 100% but with a statistical error of 100%!

For the other parameters, e.g. lifetime of ETI, we need a deep consideration on biological, social, anthropological and historical development of society.

Estimation of these parameters is possible but never forget uncertainties!

In 1960 Drake, using information about universe available, obtained N=10.

From a statistical point of view, in our Galaxy there are, in average, 10 planets with intelligent life able to communicate with us presently!

Today, using better astronomical values, the current values of N is about 23.

Concerning uncertainty, we could define a large band of possible values for N between 1 and 600000. The bounds of this windows goes from "absolutely probable" to "absolutely not probable".

Be careful: Since N is evaluated in our galaxy, we could not have a value lower than 1.

For sure we have an ETI now able to communicate: HUMANS!

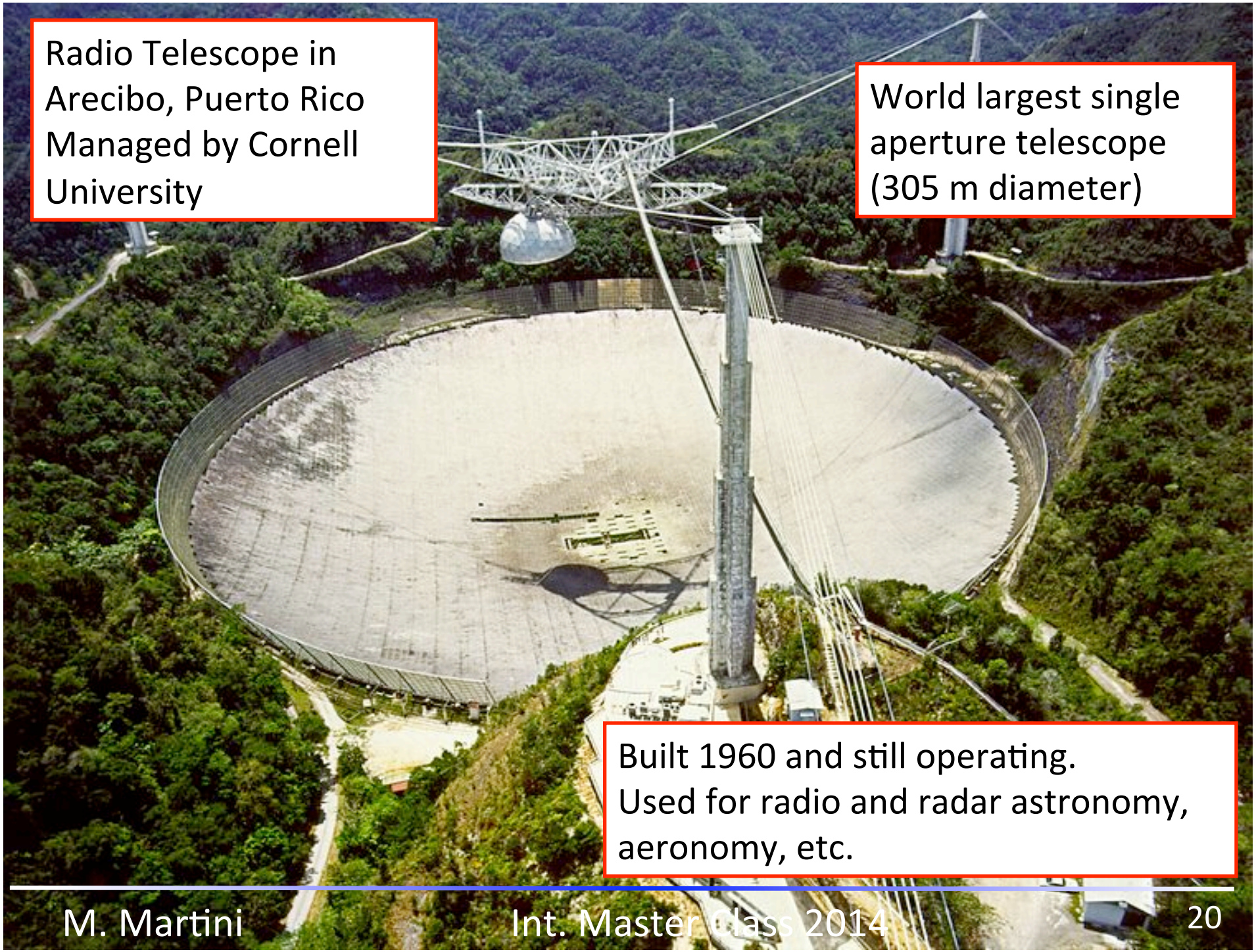
Communication's test

Supposing an ETI exists ….

this is not crazy but is a possible solution of Drake's equation.

… How we could communicate?

As in normal conversation, we have two possibilities: speak or listen!

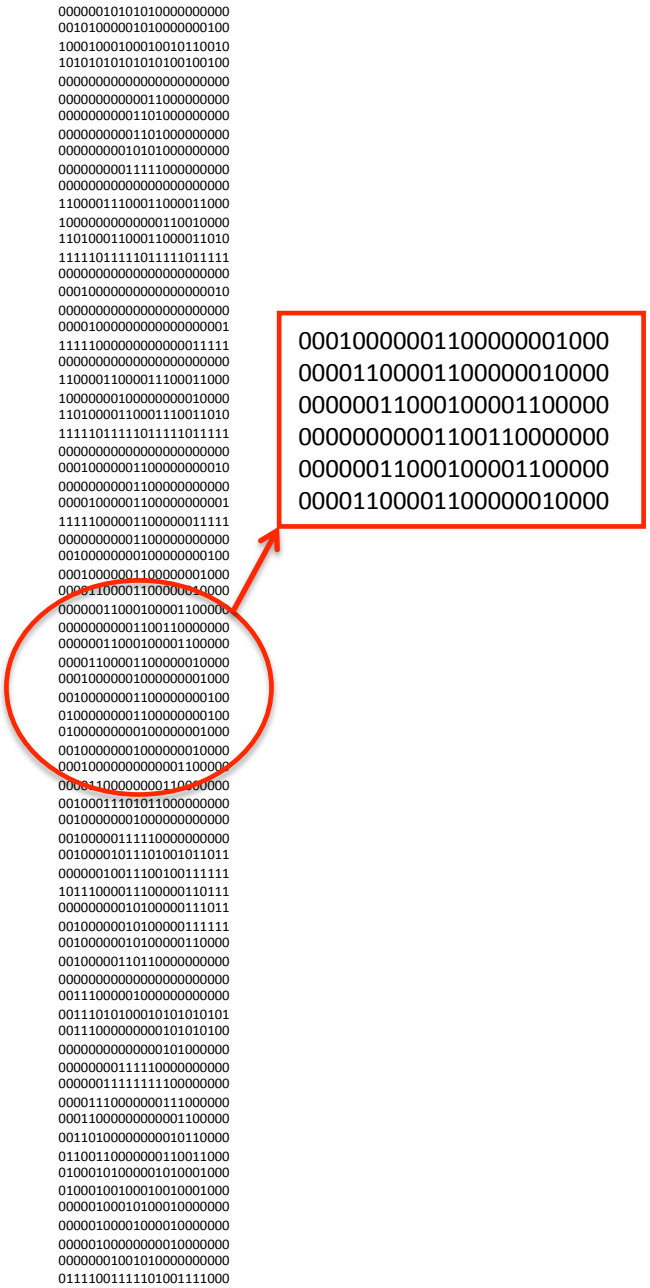

Radio Telescope in Arecibo, Puerto Rico Managed by Cornell University
World largest single aperture telescope (305 m diameter)
Built 1960 and still operating.
Used for radio and radar astronomy, aeronomy, etc.

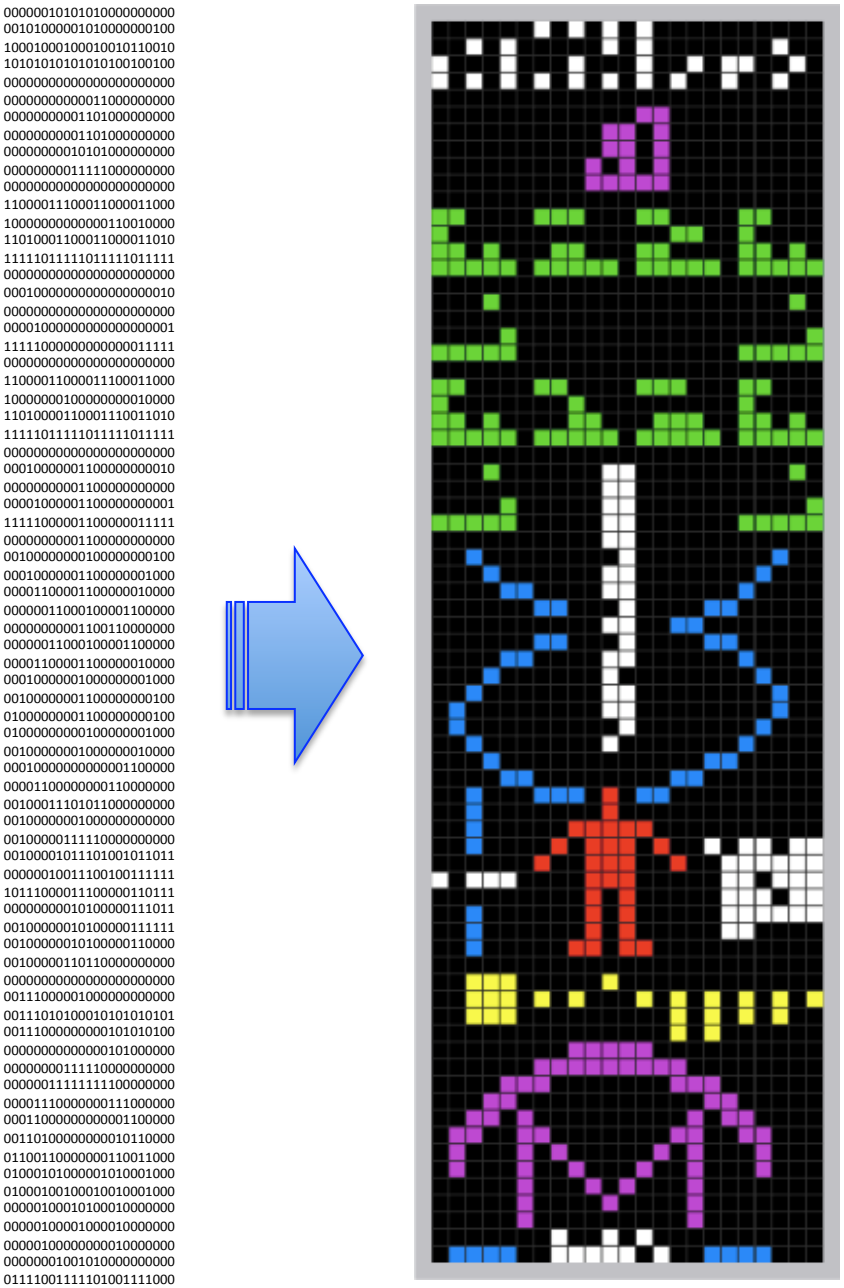
Speak

1974: Arecibo radio telescope, Puerto Rico
most powerful message deliberately beamed into space.
Message sent to globular cluster M13 (21,000 lyrs away) detectable anywhere in the galaxy given a radio telescope of the size of Arecibo. Bits transmitted by frequency shifting at 10 bits/sec

This digital message is a summary of our knowledge containing: our solar system, a radio telescope, DNA, etc.

Arecibo message was realized by Franck Drake together with some collaborators (one of these was Carl Sagan).



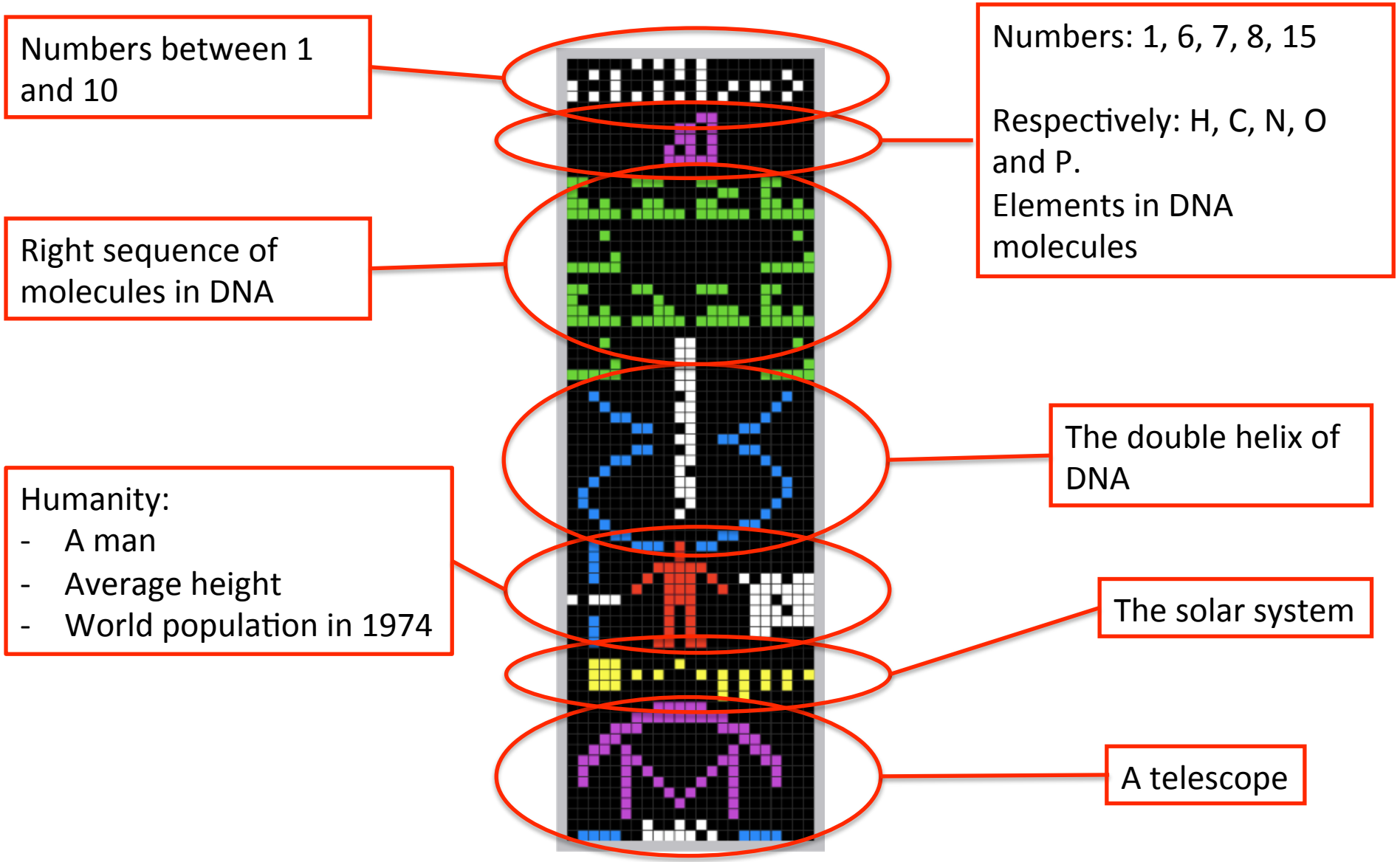


Arecibo message was a pictorial text realized to summarize our knowledge of life, universe and technologies (1974)

Is a matrix of 23x73 bits

0 –OFF
1 – ON

Speak


Numbers between 1 and 10
Right sequence of molecules in DNA
Humanity:
- A man
- Average height
- World population in 1974
Numbers: 1, 6, 7, 8, 15
Respectively: H, C, N, O and P.
Elements in DNA molecules
The double helix of DNA
The solar system
A telescope

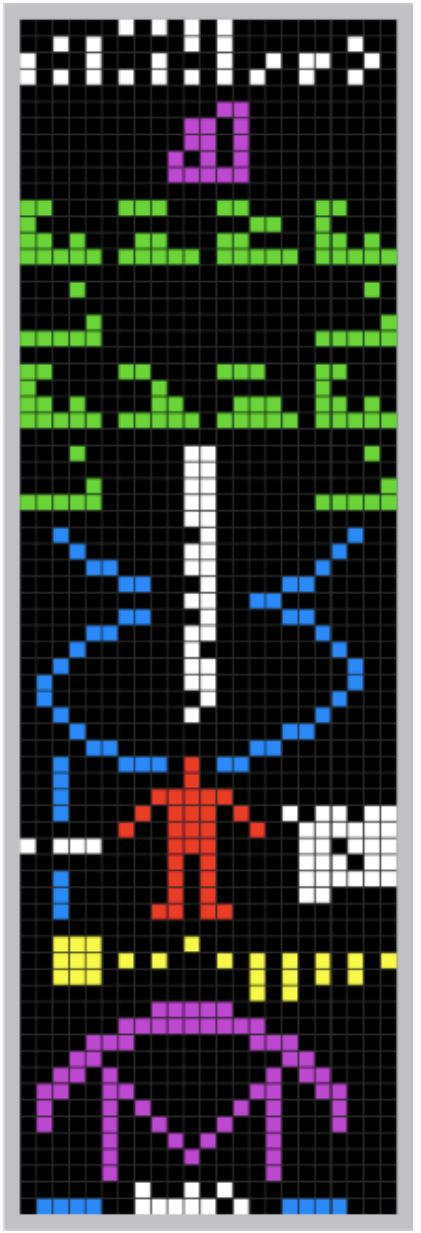
Can this message be considered a tentative communication's test?

Probably not:

- M13 has been chosen for the high probability to have habitable exoplanets (guess in 1974)
- M13 is 21000 lyrs away: 21000 years is required to reach M13 and other 21000 to obtain a possible response
- When signal reach M13, position of M13 will be changed!

Why this message was sent?
In 1974 using Arecibo radio telescopes Hulse and Taylor identified for the first time a Pulsar.

Arecibo message was only a spot to demonstrate capabilities of this radio telescope



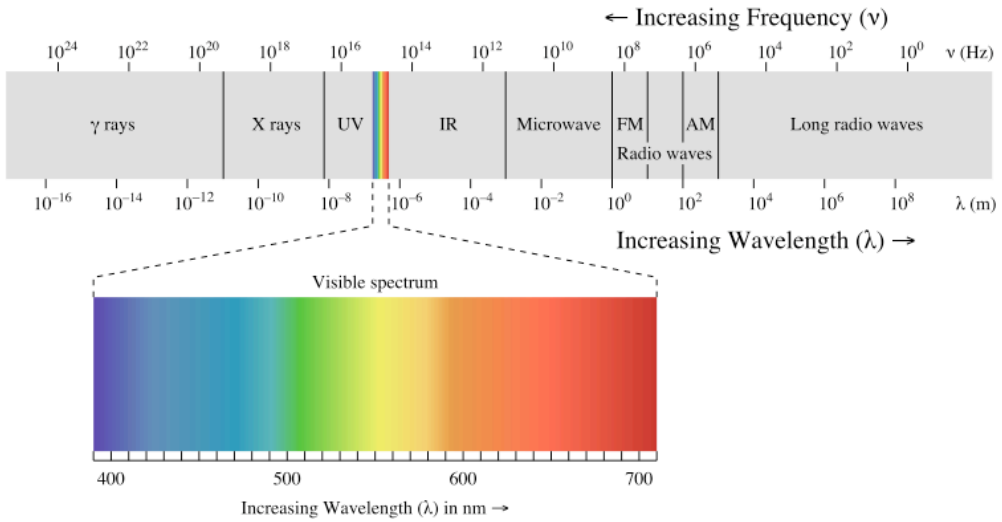
Listen

Trying to listen signals from universe:

- Which signals?

- Signals from where?

We could not think to receive all frequencies from everywhere!

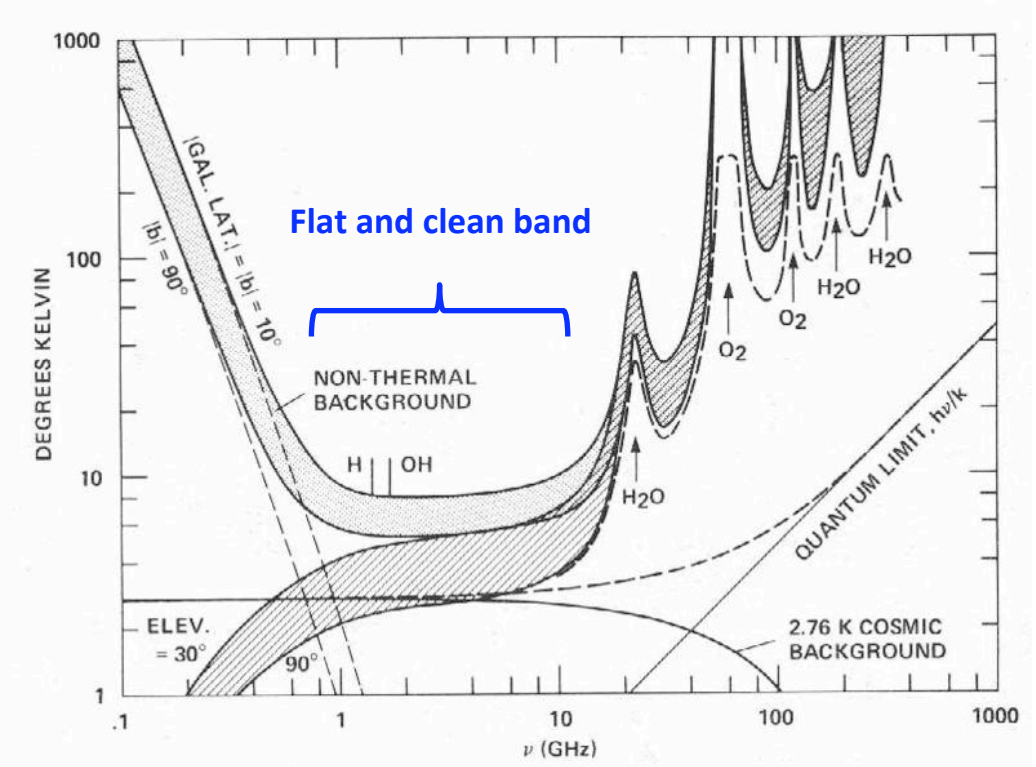


Listen

To avoid background contamination, we have to select frequencies in which there are no known source in universe.

Looking at natural emission from universe we have a flat and less populate band between 1 and 10 GHz. In this region we have also emission from H and OH molecules.

A civilized life would have astronomers who have built radio telescopes to observe H (hydrogen) and OH in the Galaxy.



Communication's test

Using radio telescope we have to decide a set of directions to point out the searching

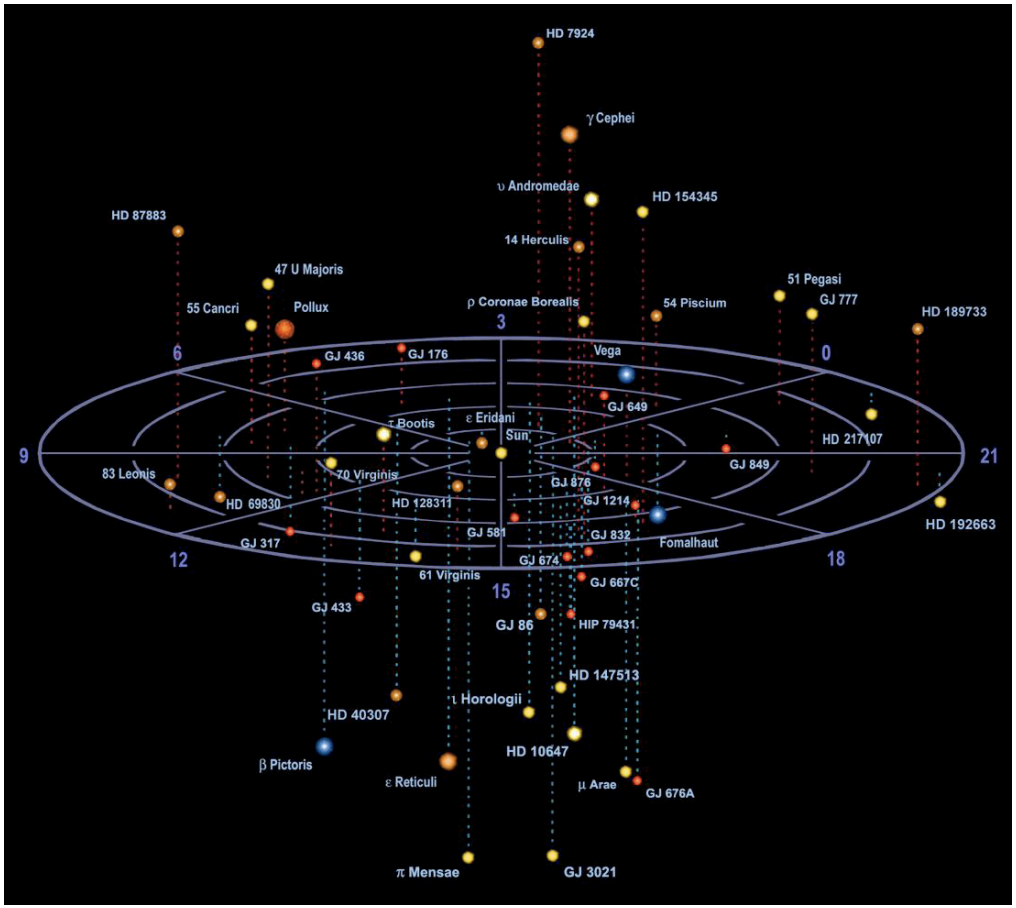
Communication's test

Using radio telescope we have to decide a set of directions to point out the searching

All the stars listed here have exoplanets and are within 60 light years from Earth. This would be a TARGETED search

But, as astronomers say, universe is homogeneous and isotropic

A SURVEY search would sweep the sky randomly.



The most famous “project” for signal listening is SETI, Search for ExtraTerrestrial Life.

SETI project, proposed initially by Drake in 1974, is constituted by a network of radio telescopes which sweep the sky randomly and is sensitive for signals between 1 and 10 GHz.

In 1999 SETI started the program SETI@Home. Anyone could collaborate to this search offering his PC to build a CPUs network able to analyze signals coming from radio telescopies.

There are some critics to this search:

- Sweep entire space without a preferred direction is like to look for a needle in a haystack
- Currently we could not know when (and if) this project will found something
- If a signal was catched, is this measure repeatable?

Last item is fundamental. Suppose to find a signal coming from space, only 1 signal only 1 time.

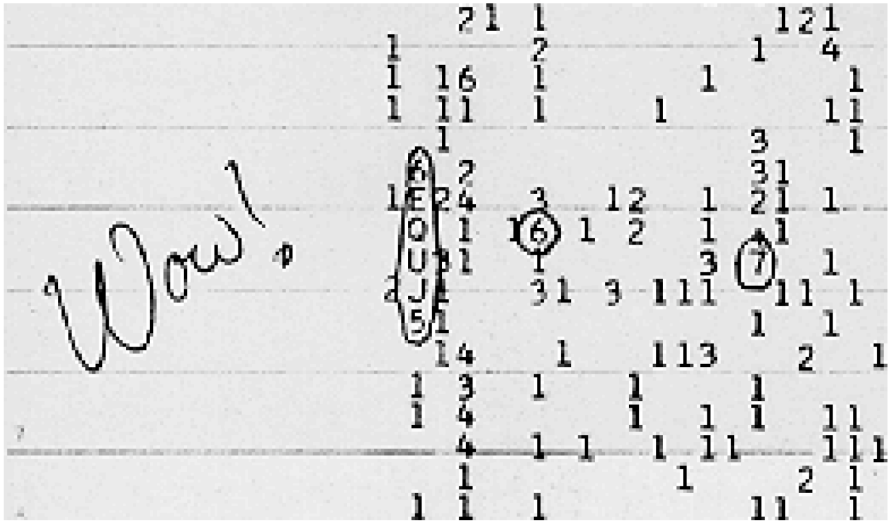
What can you conclude? Uncertainty will be dominant giving a statistical uncertainty of 100%.

What SETI has found up to now?

On 15 August 1977, the radio telescope Big Ear in Ohio listen a signal.

Short duration very high energy pulse.

The name “WOW!” is due to a comment written by Dr. Ehman, a SETI volunteer, to express his surprise.



Was only picked up by one of the telescopes at Ohio State University.

It has never been seen again even with more sensitive equipment.

Big Ear is fixed and explore sky thanks to Earth rotation.

Since this, a possible ET signal could be listen only for 72 seconds.

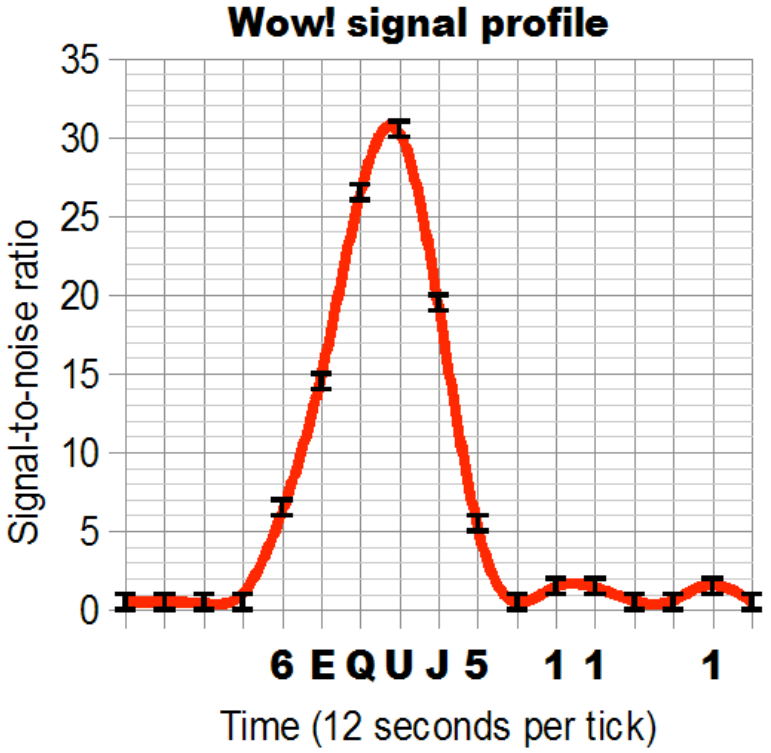
Shape, power and timing match perfectly how an ET signal may appear.

WOW! Signal was sent from something in Sagitarius.

What was WOW! Signal?

Today we still not know what this signal was. Probably a rational solution exists but this was not yet found.

Typical example of 100% uncertainty!



Conclusion of this presentation:

- There were and there are scientific searches for ETI? YES
- There are proofs for the existence of ETI? NO

As seen, a statistical and probability analysis for the existence of ETI is possible and involve not only physics and astronomy.

To evaluate single terms of Drake equation, different considerations are required and most of them have a high uncertainty since based on 1 “ETI” only: ourselves.

What we could conclude now is:

”Where is everybody?”

- They do not exist
- They are somewhere in universe in a region too far from us, probably not in our galaxy

Could a scientist believe in ETI?
Yes, but this is matter of personal considerations.

My personal position:

- ETI may exists (We cannot exclude or confirm ETI's existence)
- Considering Human the only intelligent form of life is an anthropo-centric consideration
- From a scientific point of view, if an intelligent life is present on Earth, it may be present in other planets of our universe

- This conclusions do not imply necessary the possibility to meet ETI
- The only way is go ahead in scientific research and learn, step by step, the, always still present, secrets of our universe!