The Search For Extraterrestrial Intelligence (SETI) In The Optical Spectrum

Dr. Stuart A Kingsley
CEng, MIET, SMIEEE

Adult Education Series
Murray Muscat Centre, Glen Fern Road
June 22, 2009

www.coseti.org
skingsley@coseti.org

Goodbye Columbus

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The Columbus Dispatch

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WEDNESDAY, JULY 18, 2007

VOINOVICH A 'NO'

Before an all-night Senate debate on Iraq, Ohio's George V. Voinovich said yesterday that he will vote against a Democratic plan to withdraw troops. Voinovich, a war foe, said Democrats are playing politics. See story, Page A3

Al-Qaida's Iraq affiliate feared

Group may help in attack on U.S., report says

By Jonathan S. Landay
MCCLATCHY NEWSPAPERS

WASHINGTON — Al-Qaida is still plotting a major attack on the United States and probably will use its Iraqi affiliate, a combat-tested group that sprang up after the U.S.-led invasion in 2003, to carry it out, a new U.S. intelligence report warned yesterday.

The National Intelligence Estimate made it clear that Osama bin Laden's militant Islamic network, bolstered by the Iraq war and growing anti-U.S. anger in the Muslim world, remains a potent danger nearly six years after President Bush launched his "Global War on Terror" in response to the Sept. 11, 2001, attacks.

The United States faces "a persistent and evolving terrorist threat over the next three years," said the report, an analysis representing the consensus of all 16 U.S. intelligence agencies.

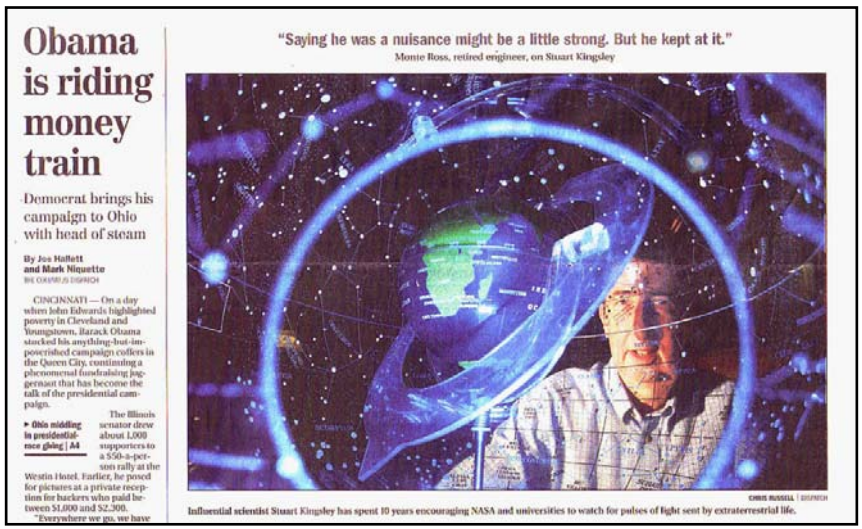
"We assess that al-Qaida's Homeland plotting is likely to continue to focus on prominent political, economic and infrastructure targets with the goal of producing mass casualties, visually dramatic destruction, significant economic aftershocks, and/or fear among the U.S. population," the report said.

It warned that a rejuvenated

See AL-QAIDA Page A5

ON THE WEB
▸ Read a declassified version of the National Intelligence Estimate at Dispatch.com/web.

July 18, 2007



Obama is riding money train

Democrat brings his campaign to Ohio with head of steam

By Joe Hallett and Mark Niquette
THE COLUMBUS DISPATCH

CINCINNATI — On a day when John Edwards highlighted poverty in Cleveland and Youngstown, Barack Obama stocked his anything-but-impoverished campaign coffers in the Queen City, continuing a phenomenal fundraising juggernaut that has become the talk of the presidential campaign.

The Illinois senator drew about 1,000 supporters to a $50-a-person rally at the Westin Hotel. Earlier, he posed for pictures at a private reception for backers who paid between $1,000 and $2,300.

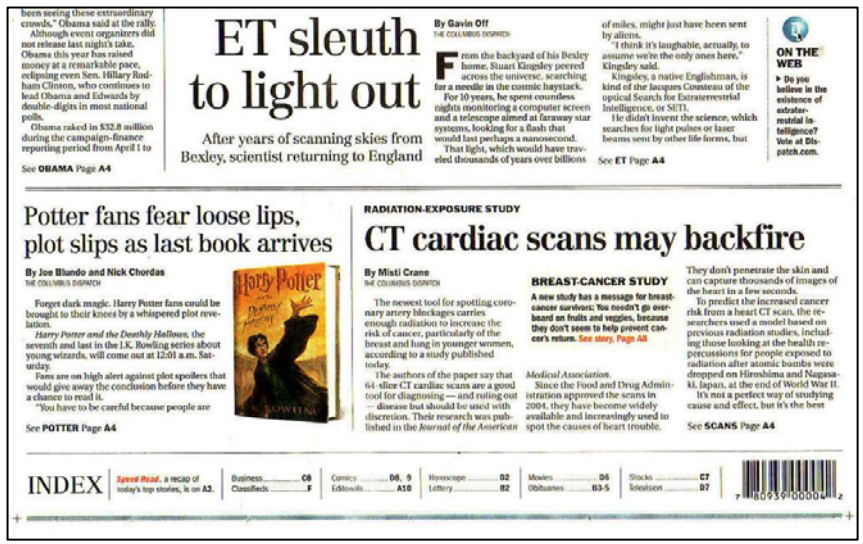
"Everywhere we go, we have

▸ Ohio middling in presidential-race giving | A4

"Saying he was a nuisance might be a little strong. But he kept at it."
Monte Ross, retired engineer, on Stuart Kingsley

CHRIS RUSSELL | DISPATCH

Influential scientist Stuart Kingsley has spent 10 years encouraging NASA and universities to watch for pulses of light sent by extraterrestrial life.



been seeing these extraordinary crowds," Obama said at the rally.

Although event organizers did not release last night's take, Obama this year has raised money at a remarkable pace, eclipsing even Sen. Hillary Rodham Clinton, who continues to lead Obama and Edwards by double-digits in most national polls.

Obama raked in $32.8 million during the campaign-finance reporting period from April 1 to

See OBAMA Page A4

ET sleuth to light out

After years of scanning skies from Bexley, scientist returning to England

By Gavin Off
THE COLUMBUS DISPATCH

From the backyard of his Bexley home, Stuart Kingsley peered across the universe, searching for a needle in the cosmic haystack.

For 10 years, he spent countless nights monitoring a computer screen and a telescope aimed at faraway star systems, looking for a flash that would last perhaps a nanosecond.

That light, which would have traveled thousands of years over billions of miles, might just have been sent by aliens.

"I think it's laughable, actually, to assume we're the only ones here," Kingsley said.

Kingsley, a native Englishman, is kind of the Jacques Cousteau of the optical Search for Extraterrestrial Intelligence, or SETI.

He didn't invent the science, which searches for light pulses or laser beams sent by other life forms, but

See ET Page A4

ON THE WEB
▸ Do you believe in the existence of extraterrestrial intelligence? Vote at Dispatch.com.

Potter fans fear loose lips, plot slips as last book arrives

By Joe Blundo and Nick Chordas
THE COLUMBUS DISPATCH

Forget dark magic. Harry Potter fans could be brought to their knees by a whispered plot revelation.

Harry Potter and the Deathly Hallows, the seventh and last in the J.K. Rowling series about young wizards, will come out at 12:01 a.m. Saturday.

Fans are on high alert against plot spoilers that would give away the conclusion before they have a chance to read it.

"You have to be careful because people are

See POTTER Page A4

RADIATION-EXPOSURE STUDY

CT cardiac scans may backfire

By Misti Crane
THE COLUMBUS DISPATCH

The newest tool for spotting coronary artery blockages carries enough radiation to increase the risk of cancer, particularly of the breast and lung in younger women, according to a study published today.

The authors of the paper say that 64-slice CT cardiac scans are a good tool for diagnosing — and ruling out — disease but should be used with discretion. Their research was published in the *Journal of the American Medical Association*.

Since the Food and Drug Administration approved the scans in 2004, they have become widely available and increasingly used to spot the causes of heart trouble.

They don't penetrate the skin and can capture thousands of images of the heart in a few seconds.

To predict the increased cancer risk from a heart CT scan, the researchers used a model based on previous radiation studies, including those looking at the health repercussions for people exposed to radiation after atomic bombs were dropped on Hiroshima and Nagasaki, Japan, at the end of World War II.

It's not a perfect way of studying cause and effect, but it's the best

See SCANS Page A4

BREAST-CANCER STUDY

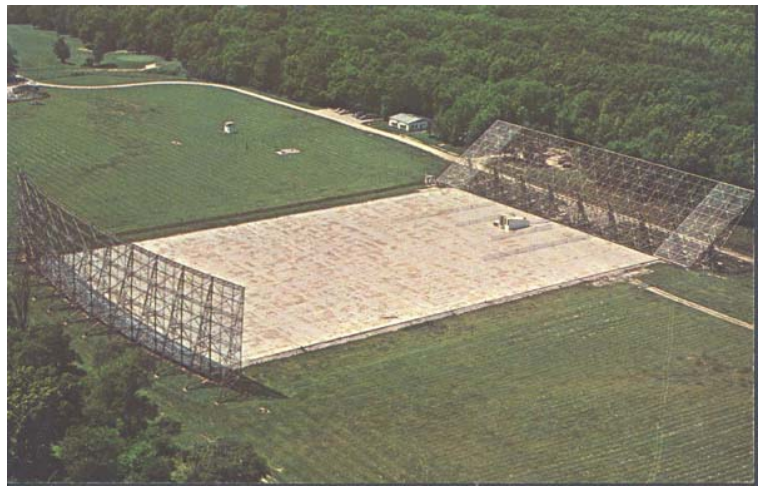
A new study has a message for breast-cancer survivors: You needn't go overboard on fruits and veggies, because they don't seem to help prevent cancer's return. See story, Page A8

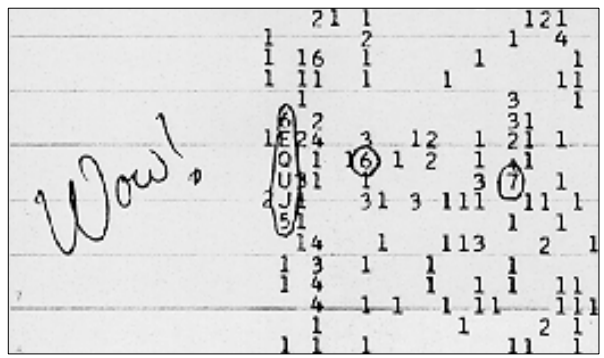
INDEX | Speed Read, a recap of today's top stories, is on A2.

Ohio-State University SETI

Big Ear Radio Telescope

The Observatory was a Kraus-type radio telescope, named for Dr. John D. Kraus, the founder and director of the observatory, who was also the designer and builder of the telescope. Big Ear covered an area larger than three football fields. The telescope was famous for discovering some of the most distant known objects in the universe, as well as for the **"Wow!" Signal** and the **longest-running SETI project** entered into the ***Guinness Book of Records***. This unique probe of the depths of the cosmos was located in **Delaware, Ohio** (about 30 miles north of Columbus). In late 1997, after almost 40 years of operation, the Ohio State University Radio Observatory, with its "Big Ear" radio telescope, ceased operation. The telescope was destroyed in early 1998 to make way for an enlarged golf course.



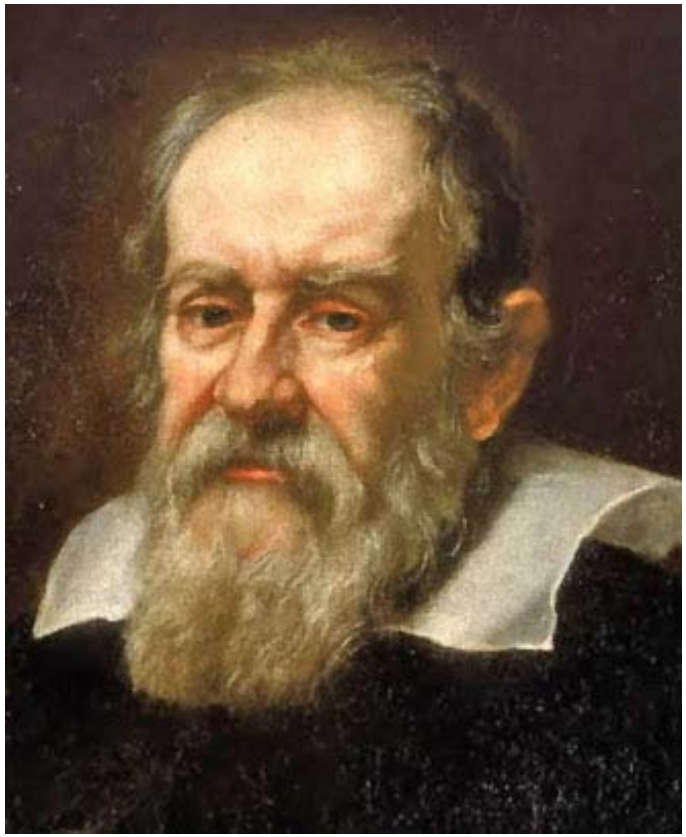


Jerry Ehman, Aug. 15, 1977

Hello Bournemouth

The Great Pyramid, Honeycombe Beach

Galileo Galilei
1564 - 1642



- Galileo's championing of Copernicanism was controversial within his lifetime, when a large majority of philosophers and astronomers still subscribed to the geocentric view that the Earth remained motionless at the centre of the universe. After 1610, when he went public, he met with bitter opposition from some philosophers and clerics, and two of the latter eventually denounced him to the Roman Inquisition early in 1615.

- Stephen Hawking says, "Galileo, perhaps more than any other single person, was responsible for the birth of modern science."

Charles Darwin

- This year marks the 150th anniversary of the publication of Darwin's Theory of Evolution, *On the Origin of Species,* the 200th anniversary of his birth, and the International Year of Astronomy (400 years since Galileo first turned his telescope towards the night sky).

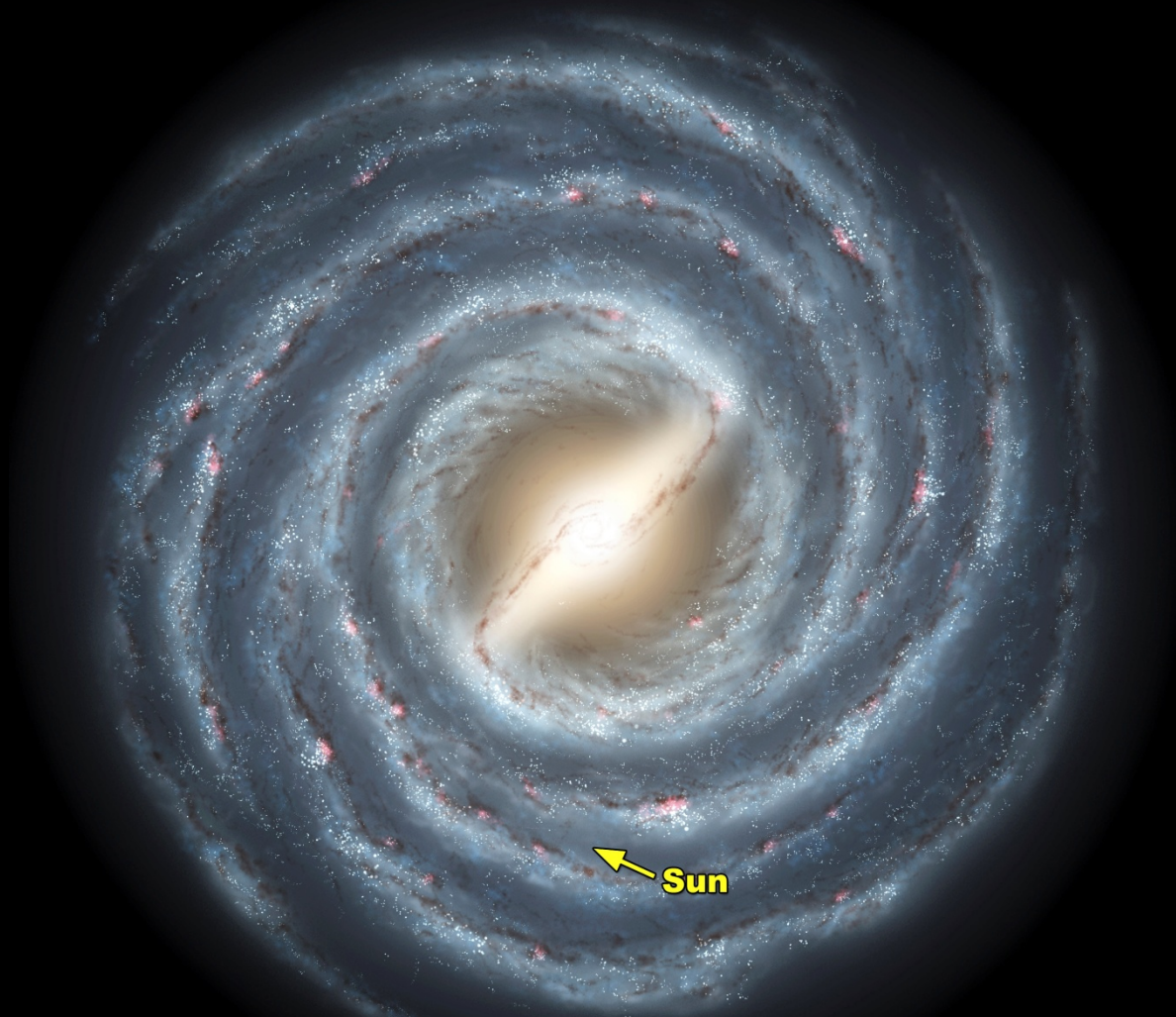
Guglielmo Marconi

Noble Prize in Physics 1909

- In 1895 he began laboratory experiments at his father's country estate at Pontecchio where he succeeded in sending wireless signals over a distance of one and a half miles.

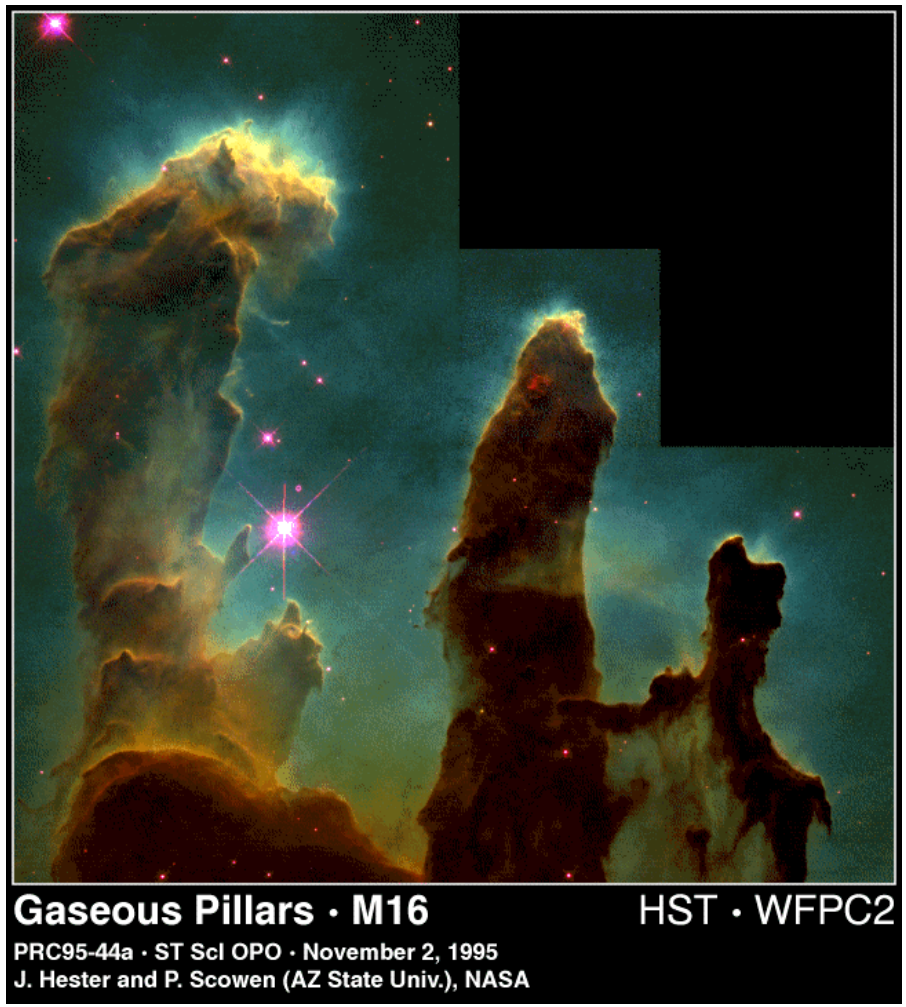
  In 1896 Marconi took his apparatus to England where he was introduced to Mr. (later Sir) William Preece, Engineer-in-Chief of the Post Office, and later that year was granted the world's first patent for a system of wireless telegraphy. He demonstrated his system successfully in London, on Salisbury Plain and across the Bristol Channel, and in July 1897 formed The Wireless Telegraph & Signal Company Limited (in 1900 re-named Marconi's Wireless Telegraph Company Limited). In the same year he gave a demonstration to the Italian Government at Spezia where wireless signals were sent over a distance of twelve miles. In 1899 he established wireless communication between France and England across the English Channel. **He erected permanent wireless stations at The Needles, Isle of Wight, at Bournemouth and later at the Haven Hotel, Poole, Dorset.**

Milky Way Galaxy



Big Numbers - 1

- Age of Universe
  - 13.6 Billion Years, i.e., 13,600,000,000 Years
- Age of Earth
  - 4 Billion Years, i.e., 4,000,000,000 Years
- Age of Technical Civilization
  - 300 Years

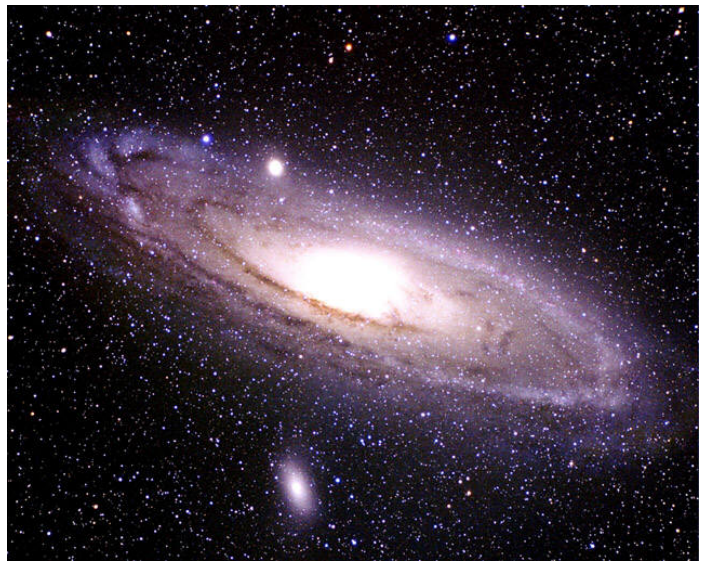


Big Numbers - 2

- Age of Radio Frequency Telecommunications
  - 100 Years
- Age of Lasers
  - 48 years
- Age of SETI
  - 49 Years

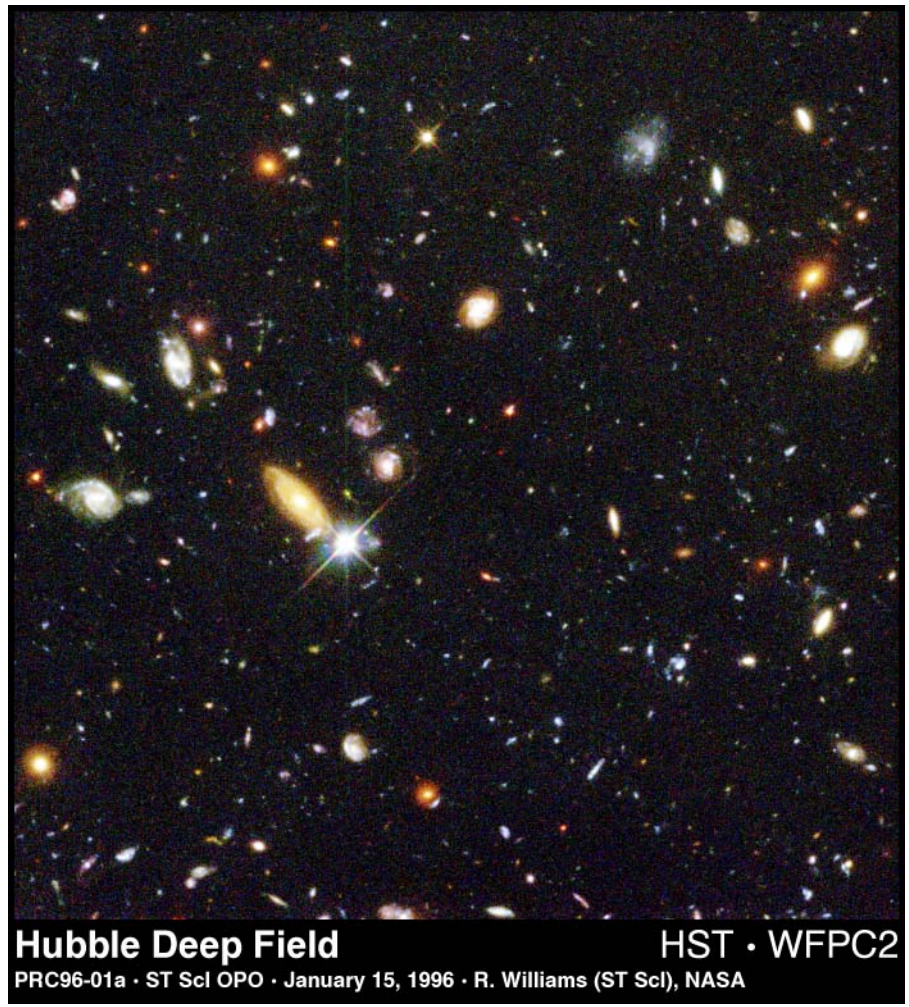
Distances

- Size of Observable Universe
  - >100 Billion Light Years
- Size of Milky Way Galaxy
  - 100,000 Light Years



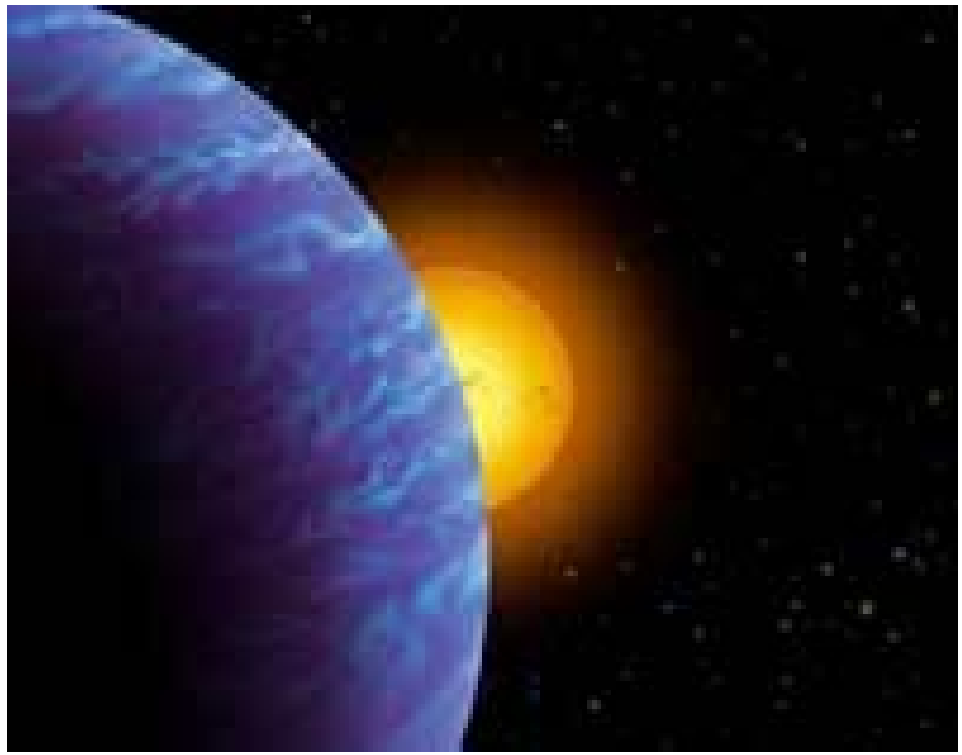
Stars

- Number of Galaxies in Universe
  - 3 Billion
- Number of Stars in Galaxy
  - 3 Billion
- Number of Solar Type Stars in Milky Way
  - 1 Million



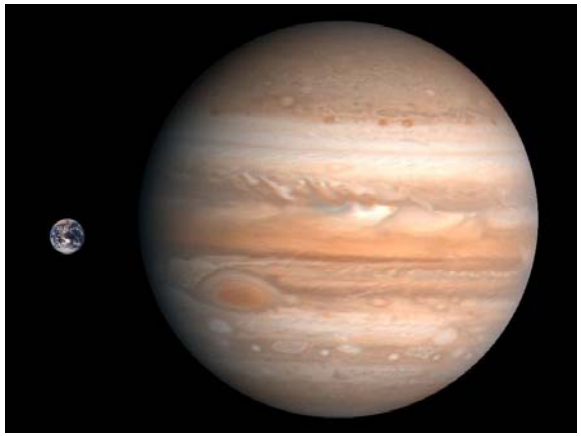
Number of Known Extra Solar Planets

- Year 1990
  - 0
- Year 1992
  - 1
- Year 2000
  - 33
- Year 2009
  - 340

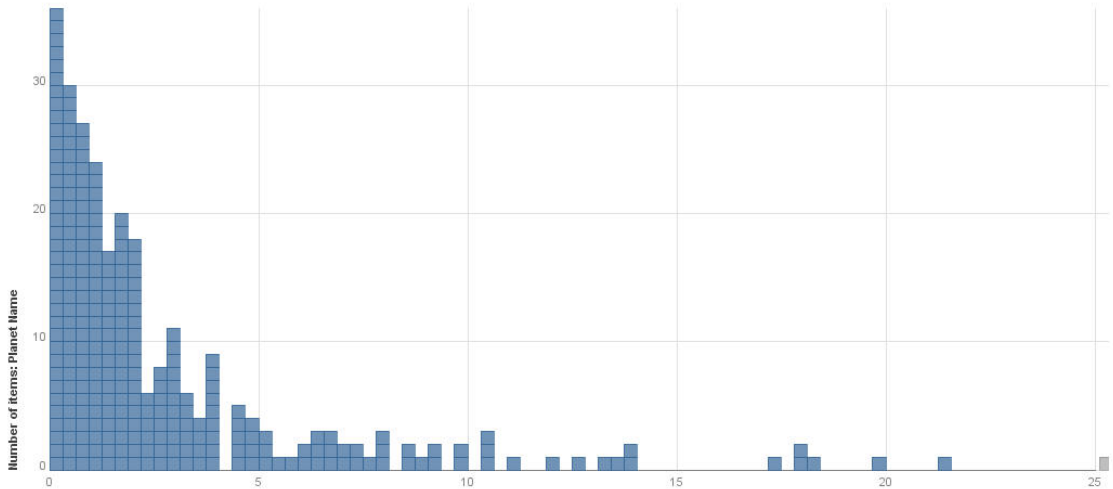


Extrasolar Planets

Number Versus Mass



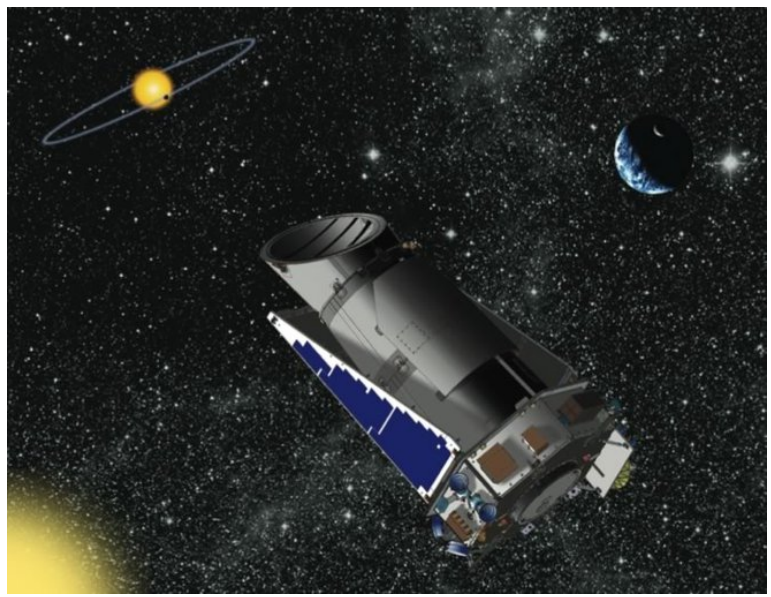
January 2009



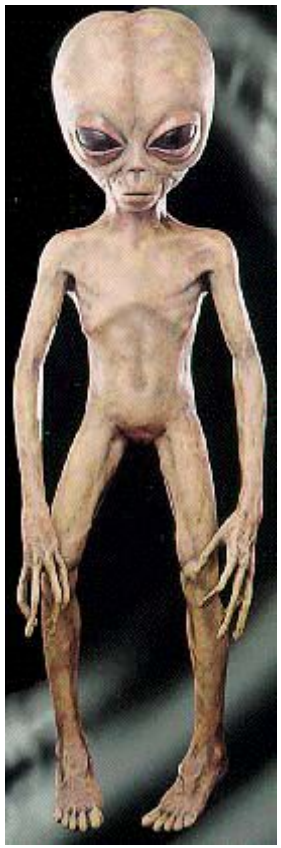
Kepler Planet Finder

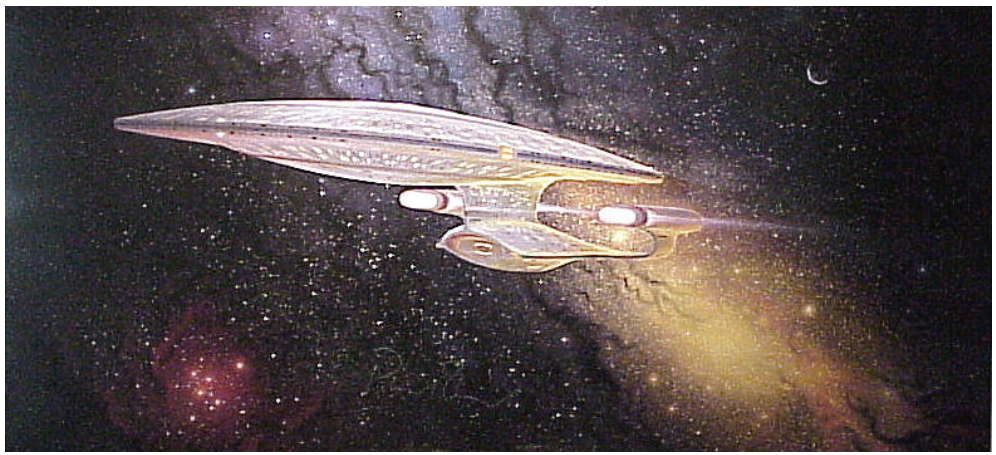
Lauched on March 6, 2009

- Kepler differs from most planet-hunting projects, which use the Doppler-shift method to search for stars that wobble due to the small gravitational pull of an orbiting planet. With existing technology, that method can only detect planets that are more massive than Earth, whose gravitational pull is large enough to tug at their parent stars with a strength we would notice.
- Instead, Kepler will use a powerful optical telescope to detect the slight dimming of light that results when a planet moves between us and its star. This technique, as opposed to the Doppler method, does not depend on a planet's mass, so is better suited to reveal smaller planets.



UFOs





British Government Statement Regarding UFOs

- The following is a statement prepared by the UK Ministry of Defence (MOD) civil servants for Professor, Sir D.E.N. Davies, FRS (then Chief Scientific Adviser to the Ministry of Defence) in case he was asked a question concerning the attitude of her Majesty's Government to the "UFO" phenomenon. As it turned out, the question was not asked during my IEE lecture on May 21, 1996 but comments were made by members of the audience about the *X-Files*, which at that time had developed a cult following on the BBC. The "official" brief opposite was read to a small group of guests present at the IEE dinner held immediately after the lecture.

- **MOD POLICY ON REPORTS OF "UNIDENTIFIED" FLYING OBJECTS**
- The MOD does not have a direct interest, expertise or role with respect to "UFO/Flying saucer" matters, or the question of the existence or otherwise of extraterrestrial lifeforms, about which we remain open-minded.
- To date we are not aware of any evidence which substantiates the existence of lifeforms of extraterrestrial origin.
- The MOD does look into reports of "UFO" sightings that are sent to us, many of which are very vague, but only to establish if what was seen may have defence significance, e.g., hostile foreign military aircraft in UK airspace. We believe that down-to-earth explanations are available for most reported "UFO" sightings, such as aircraft seen from unusual angles, or natural phenomena.
- If there is no evidence to suggest a matter of defence relevance we do not investigate or seek to establish the precise nature of what was observed.
-

Exotheology

- Would extraterrestrial intelligence (ETI) mean the end of religion on Earth? While many non-religious people tend to think this is the case, religious believers seem to welcome such an encounter and see little threat to their beliefs according to a new report by the Center for Theology and the Natural Sciences at the Graduate Theological Union in Berkley, California.

- The Peters ETI Religious Crisis Survey of 2008 was designed to test the view, common among SETI and other space scientists, that the confirmation of life elsewhere would be devastating to religious traditions. Typically the thinking is that ETI would disprove the special place of humans and the Earth thought to be a key ingredient in religion and thus lead to the dissolution of religion on the planet. The Survey asked 1325 participants from seven religious traditions (Roman Catholicism, mainline Protestantism, evangelical Protestantism, Orthodox Christianity, Mormonism, Judaism and Buddhism) as well as self-identified "non-religious" a series of questions about the impact of contact with ETI on their belief systems. Non-religious respondents were much more likely to predict a crisis for religious belief than the religious. As one Orthodox Christian reported, "Nothing would make me lose my faith." In contrast to the commonly held view of systems of religious belief as fragile, the Survey shows a strong resilience among believers even in the face of a truly momentous discovery.

- http://www.counterbalance.net/etsurv/index-frame.html

ETIs & Religion

Ted Peters ETI Religious Crisis Survey of 2008

Q5. Even though my religious (or non-religious) viewpoint would remain unaffected, contact with extraterrestrials would so undercut traditional beliefs, that the world's religions would face a crisis.

	Catholics	Prot Evan	Prot Ml	Orthodox	Mormon	Jewish	Buddhist	Non-Relig
Agree/Strongly agree	30%	31%	35%	36%	34%	40%	40%	69%
Neither agree nor disagree	30%	24%	26%	16%	39%	33%	31%	10%
Disagree/Strongly disagree	40%	45%	39%	48%	26%	26%	29%	21%

- http://www.counterbalance.org/etsurv/PetersETISurApp2.pdf
- Dr. Ted Peters is at the Pacific Lutheran Theological Seminary (PLTS) in Berkeley, California

ETIs & Judaism

- **What does Judaism say about the Discovery of Aliens?**
- By Aron Moss (Rabbi Aron Moss teaches Kabbalah, Talmud and practical Judaism in Sydney, Australia)
- ***Question:***
- Would the discovery of ETs (extra-terrestrials) threaten organized religion?
- ***Answer:***
- The discovery of ETs would pose no more of a threat to Judaism than would the discovery of a new species of rabbit.
- It would be limiting G-d's power to say that He could not have placed life on other planets. In fact, there is a reference in the biblical Book of Judges (5:23) to an inhabited place called Maroz, which the Talmud identifies as a star.
- But Jewish thought has always believed that the most weird and wonderful creatures are to be found right here on earth. We can explore the remotest extremities of space but still remain alien to our own humanity. The real secrets of the universe lie hidden in the depths of the human soul.

http://www.chabad.org/library/article_cdo/aid/160985/jewish/What-does-Judaism-say-about-the-Discovery-of-Aliens.htm

ETIs & Protestantism

- In general, Christian theologians don't have a problem in this area.
- In the USA, evangelical preacher Billy Graham welcomed the prospect of both ETI and UFOs. 'I firmly believe there are intelligent beings like us far away in space who worship God,' he told an interviewer.
- It was thanks to Aristotle that Christianity had a problem with there being many worlds. By the early 19th century, Copernicus's heliocentrism had been widely accepted.
- There is a fundamentalist fright argument, which is very prevalent in the USA, where fear of acknowledging the possibility of ETIs is driven by having to accept the theory of evolution. In the USA, the drive to teach so-called "Intelligent Design" or "Creationism" as science is, unfortunately, very strong these days.

ETIs & Catholicism

- **Wednesday, May 14, 2008, Vatican : It's OK to believe in aliens**
  - VATICAN CITY (AP) — Believing that the universe may contain alien life does not contradict a faith in God, the Vatican's chief astronomer said in an interview published Tuesday.
  - The Rev. Jose Gabriel Funes, the Jesuit director of the Vatican Observatory, was quoted as saying the vastness of the universe means it is possible there could be other forms of life outside Earth, even intelligent ones.
  - "How can we rule out that life may have developed elsewhere?" Funes said. "Just as we consider earthly creatures as 'a brother,' and 'sister,' why should we not talk about an 'extraterrestrial brother'? It would still be part of creation.“
  - In the interview by the Vatican newspaper L'Osservatore Romano, Funes said that such a notion "doesn't contradict our faith" because aliens would still be God's creatures. Ruling out the existence of aliens would be like "putting limits" on God's creative freedom, he said.

ETIs & and Islam

- From a search on the web it would appear that belief in extraterrestrials is not incompatible with Islam. However, like some previous Popes, some Muslim clerics take this belief a bit too far as can be seen by this recent report:

- *London, Jan 3, 2009 : Militant leader Omar Bakri has ordered his followers to convert 'aliens' to Islam.*
- *Bakri, 50, is said to have issued the decree during a bizarre rant posted on an extremist website, in which he said Muslims needed to spread the word of Islam all over the world and across the galaxy too.*
- *"We are obliged as Muslims to make the whole galaxy subservient to almighty Allah. Allah has created all living beings in order to obey him and worship him," the Sun quoted him as saying.*
- *A security source commented: "Perhaps he could show his people the way - it would give everyone a break if he was beamed up."*

We Are Not Alone!

Fermi Paradox

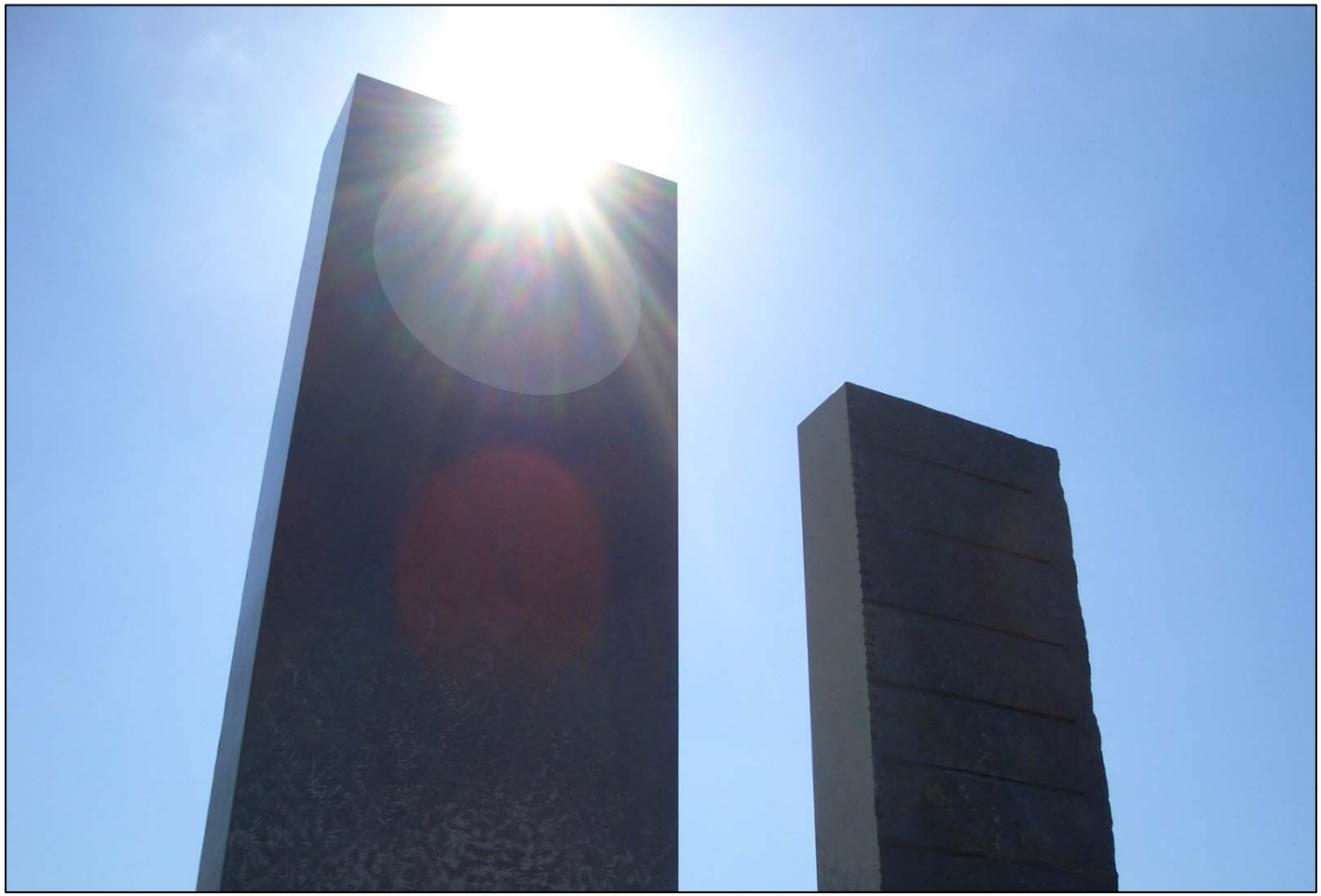
While lunching with colleagues at the Los Alamos National Labs in 1950, Enrico Fermi began a discussion about the likelihood of intelligent life existing elsewhere in the universe. The size and age of the universe makes it seem probable that many advanced societies ought to exist. But if they did, where are they? he asked.

The Fermi Paradox leads some to conclude that humans have the only advanced civilization in this galaxy, either because civilization formation is very rare or because intelligent civilizations inevitably destroy themselves.

SETI or CETI?

- SETI is the Search for Extraterrestrial Intelligence. It is about passively "listening" for ETI signals.
- CETI is Communicating with Extraterrestrial Intelligence. It about actively transmitting and listening for ETI signals.
- There are no official CETI activities at this time.

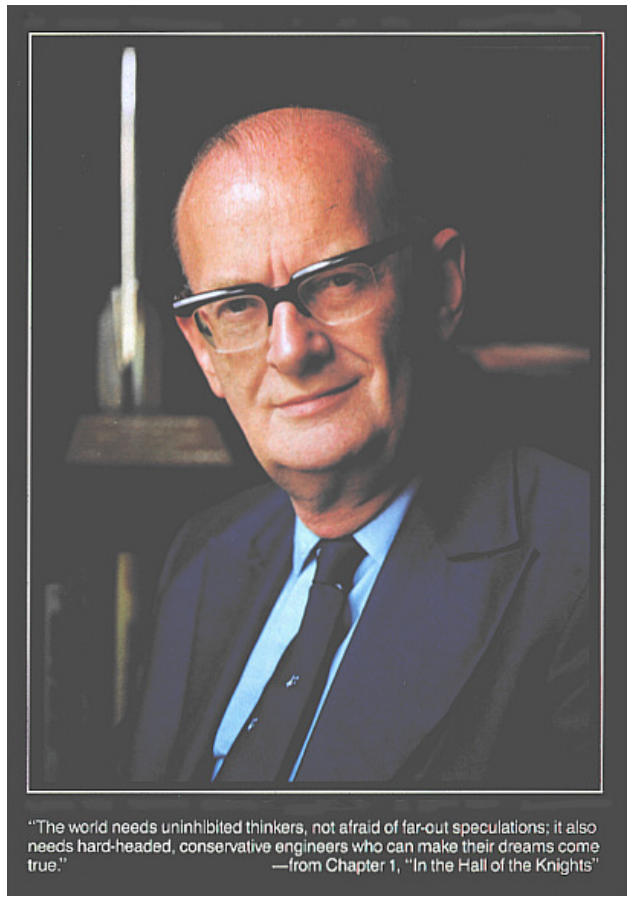
Boscombe's Monoliths
2009 – A Space Odyssey!



Arthur C. Clarke

ARTHUR C. CLARKE ENDORSES OPTICAL SETI

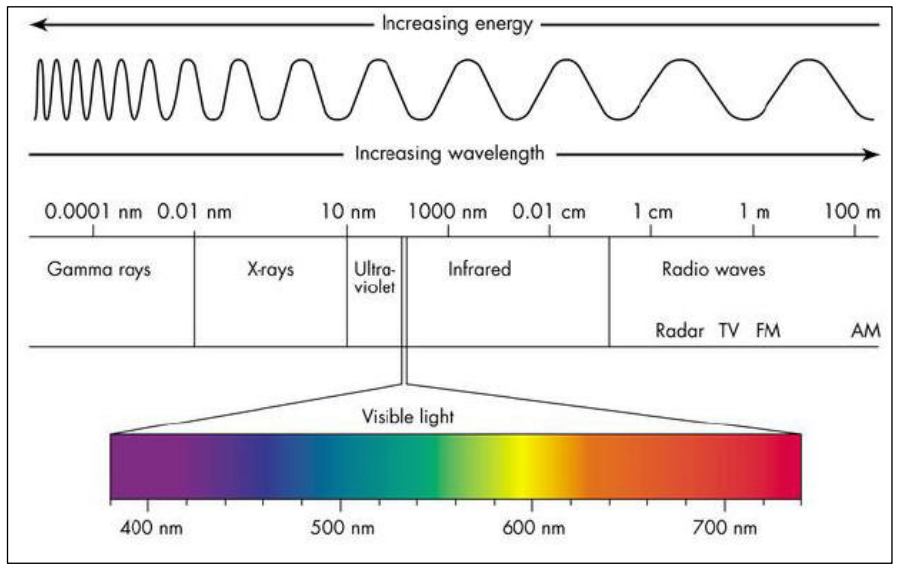
- I applaud Dr. Stuart Kingsley's almost single-handed efforts to hunt for intelligent signals from other civilizations in the optical spectrum. Although I know that many authorities in the SETI field are extremely skeptical of success, the experts have often been proved wrong in the past! What makes Dr. Kingsley's approach so interesting is that useful work can be done by amateurs with modest equipment. In fact, I am proposing that the 45 cm telescope being donated to the Arthur Clarke Centre by the Japanese Government may be used for this search. I hope that anyone who is in a position to do so will offer Dr. Kingsley moral and financial support in his laudable enterprise.



- Sri Lanka Colombo, Sri Lanka 28 September 1994

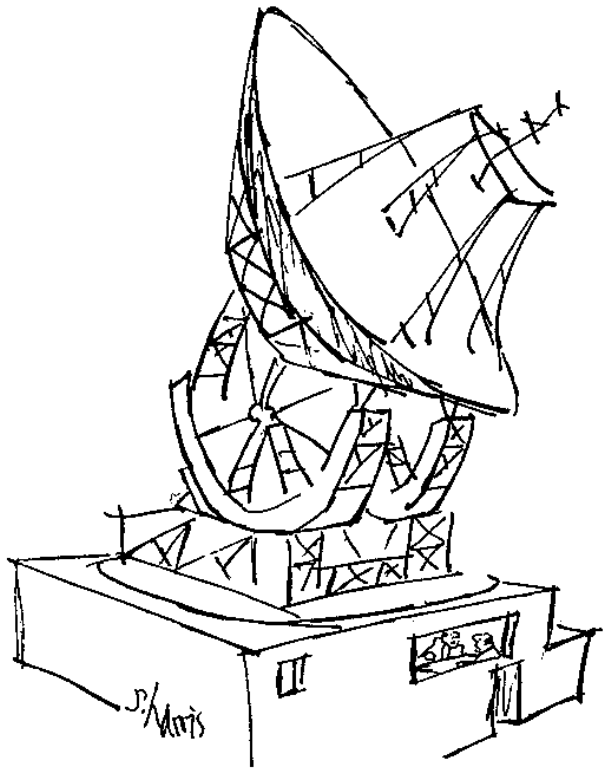
The Electromagnetic Spectrum

- The Electromagnetic Spectrum.
  - The “Optical” spectrum regime covers the range of wavelengths from 10^{-3} m (far-infrared) to 10^{-8} m (ultra-violet).



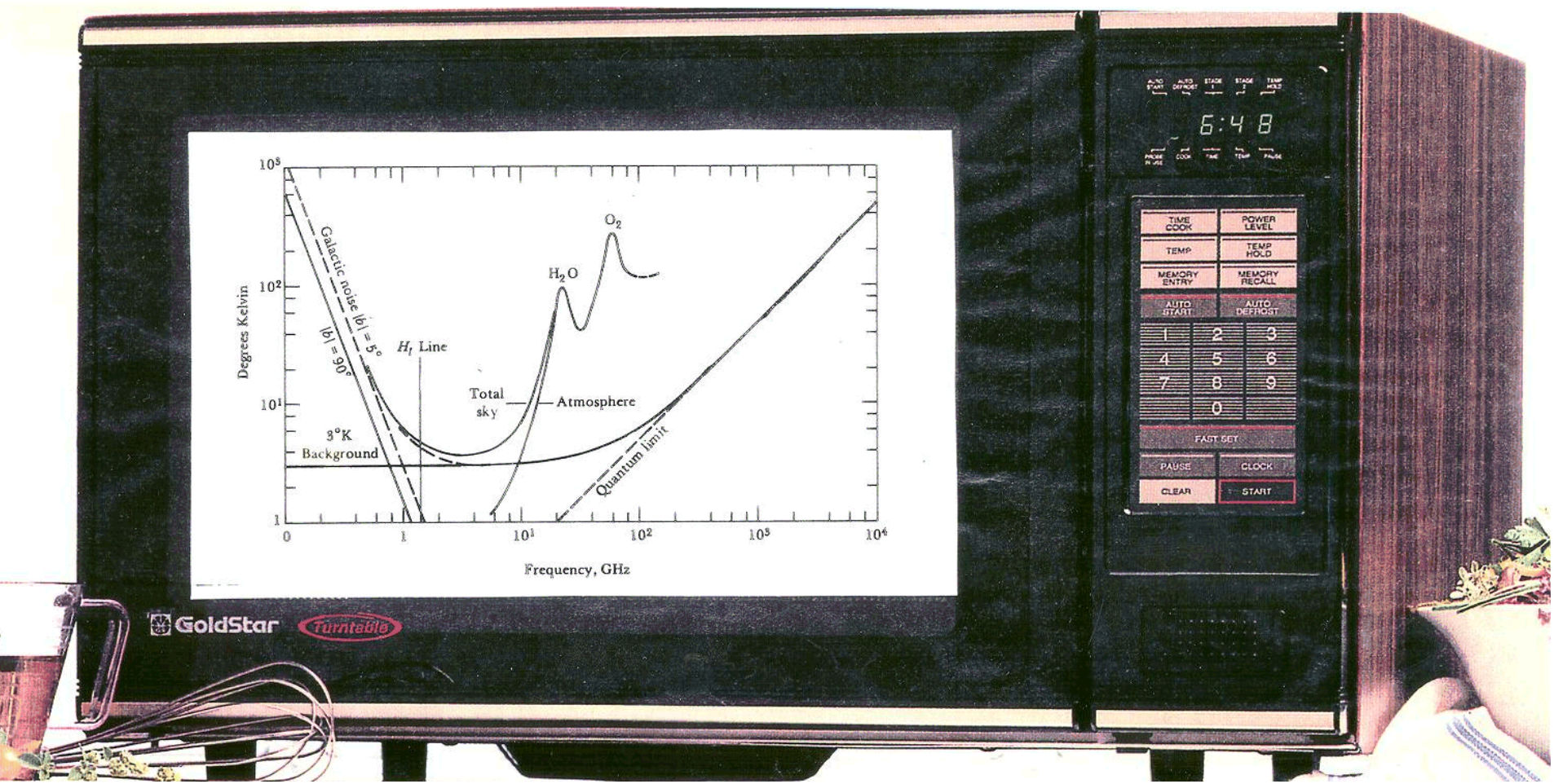
- SETI “Magic Optical Wavelengths”.
  - Carbon Dioxide CO_2 (10.6 microns).

ETI Humour 1

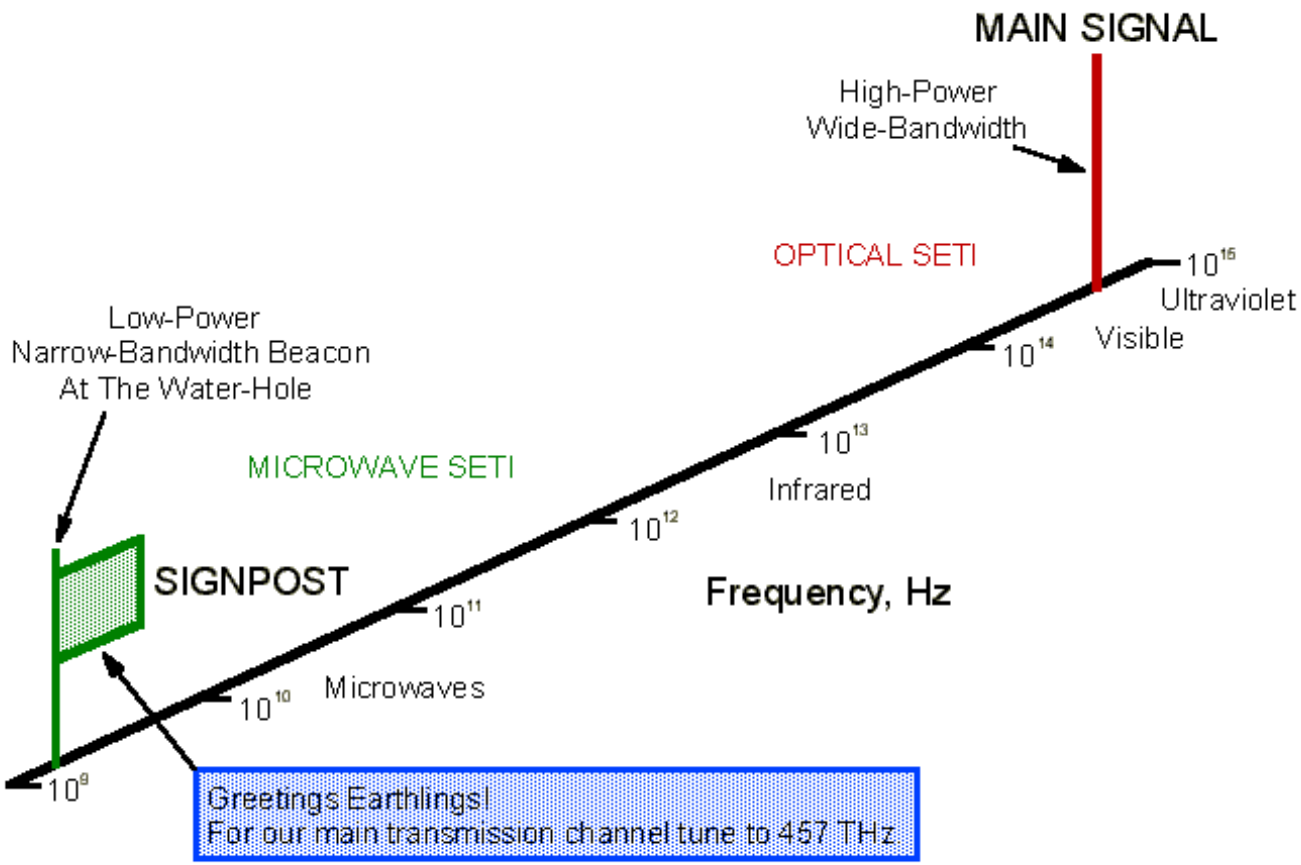


"As I understand it, they want an immediate answer. Only trouble is, the message was sent out 3 million years ago."

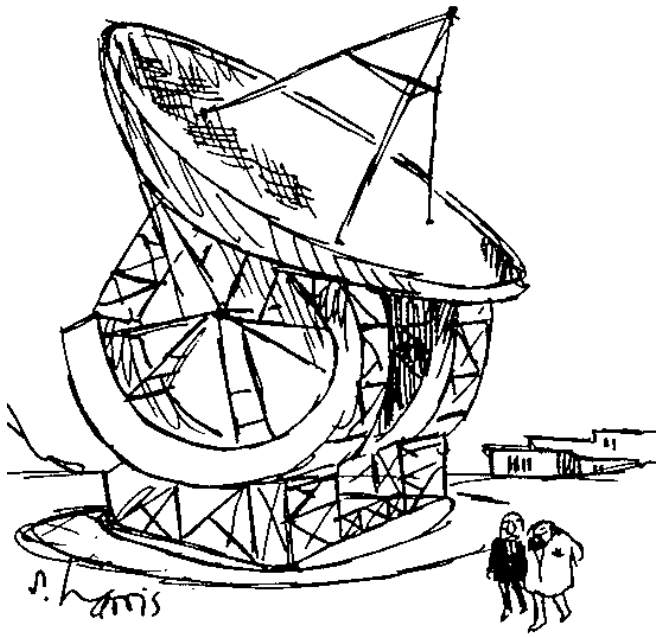
The Microwave Window



Signpost SETI



ETI Humour 2



" We sent a message to any extraterrestrial beings in deep space. It was picked up by an observatory in Great Britain. They didn't understand it."

The Modified Drake Equation

R* = Rate of star formation.

s = Fraction with good suns.

p = Fraction with planets.

e = Fraction earth-like.

l = Fraction with life.

i = Fraction with intelligence.

c = Fraction wishing to communicate.

o = Fraction using optical means.

L = Lifetime of civilization.

- The subscript "o" accounts for the matching of electromagnetic transmitting and receiving technologies.
- If all ETIs use laser technology to transmit and we use microwave technology to receive, the number of detectable civilizations falls to zero!

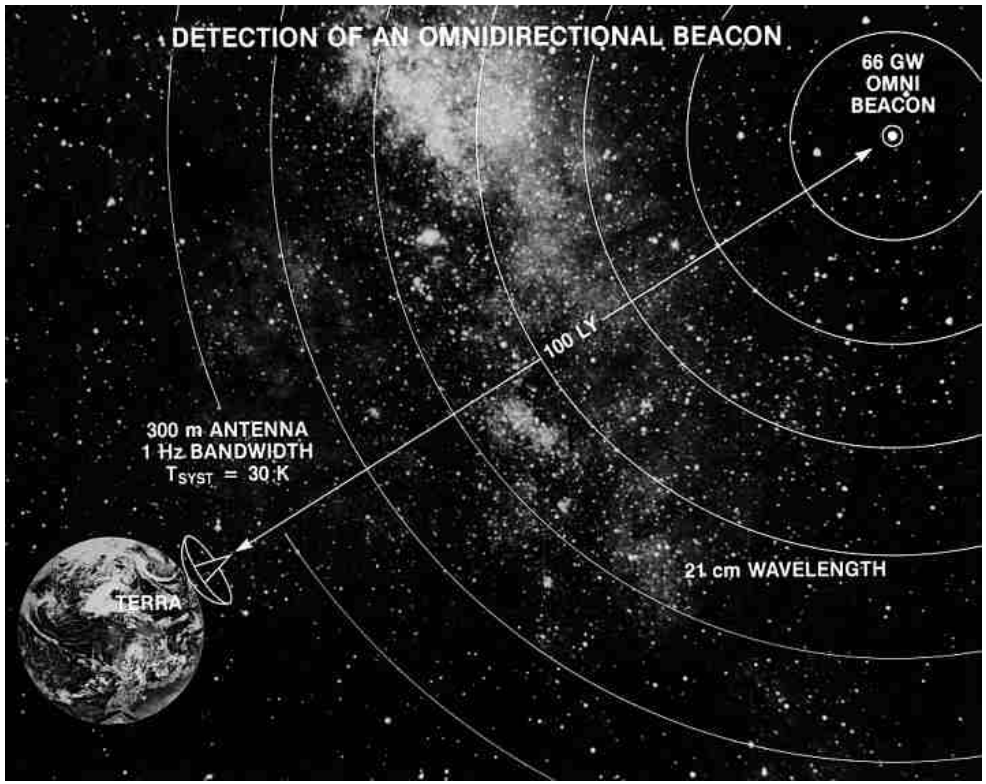
- One estimate of the number of civilizations in our galaxy trying and capable of making contact with us at this time:

$$N^* = R \times f_s \times f_p \times f_e \times f_l \times f_i \times f_c \times f_o \times f_L$$

$$N^* \approx 10{,}000$$

Omni-Directional Transmitter

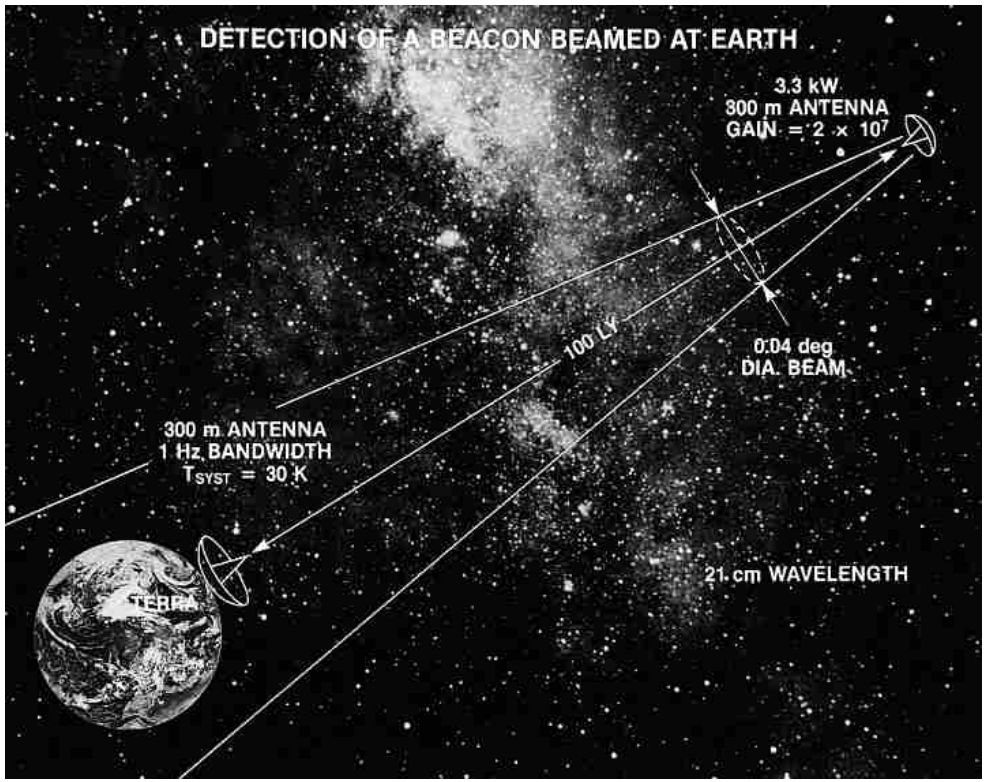
- Omni-directional Beacon
  - Very inefficient but easy to implement



NASA illustration

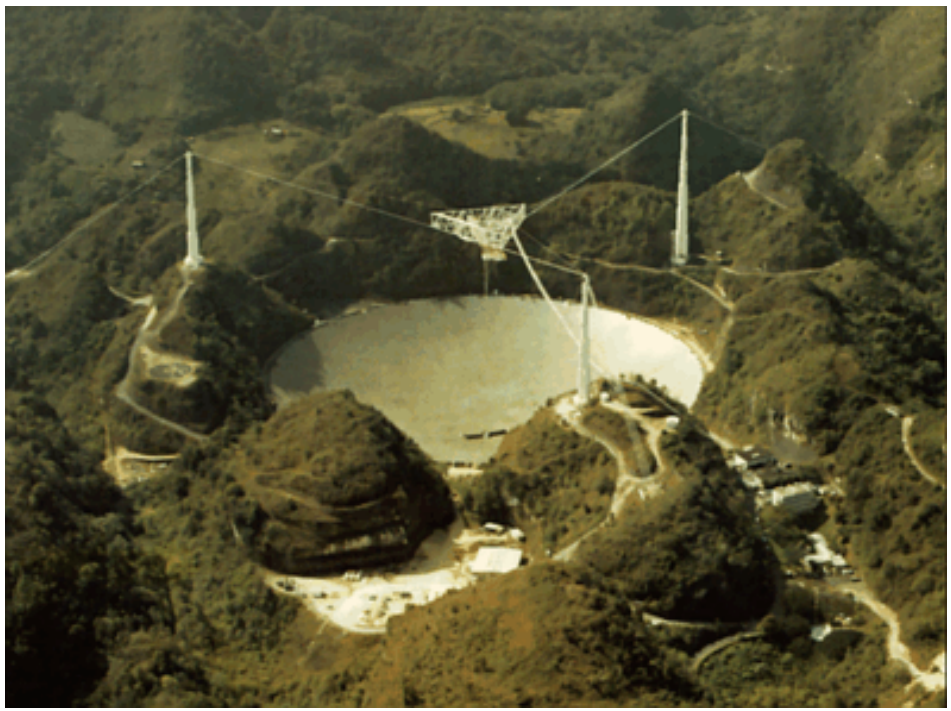
Directional Transmitter

- Directional Beacon.
  - Most efficient, though most of the energy is still wasted illuminating empty space.
  - Beamwidth at a range of 100 light years is 3,500 A.U.
  - High point-ahead targeting skills not required.



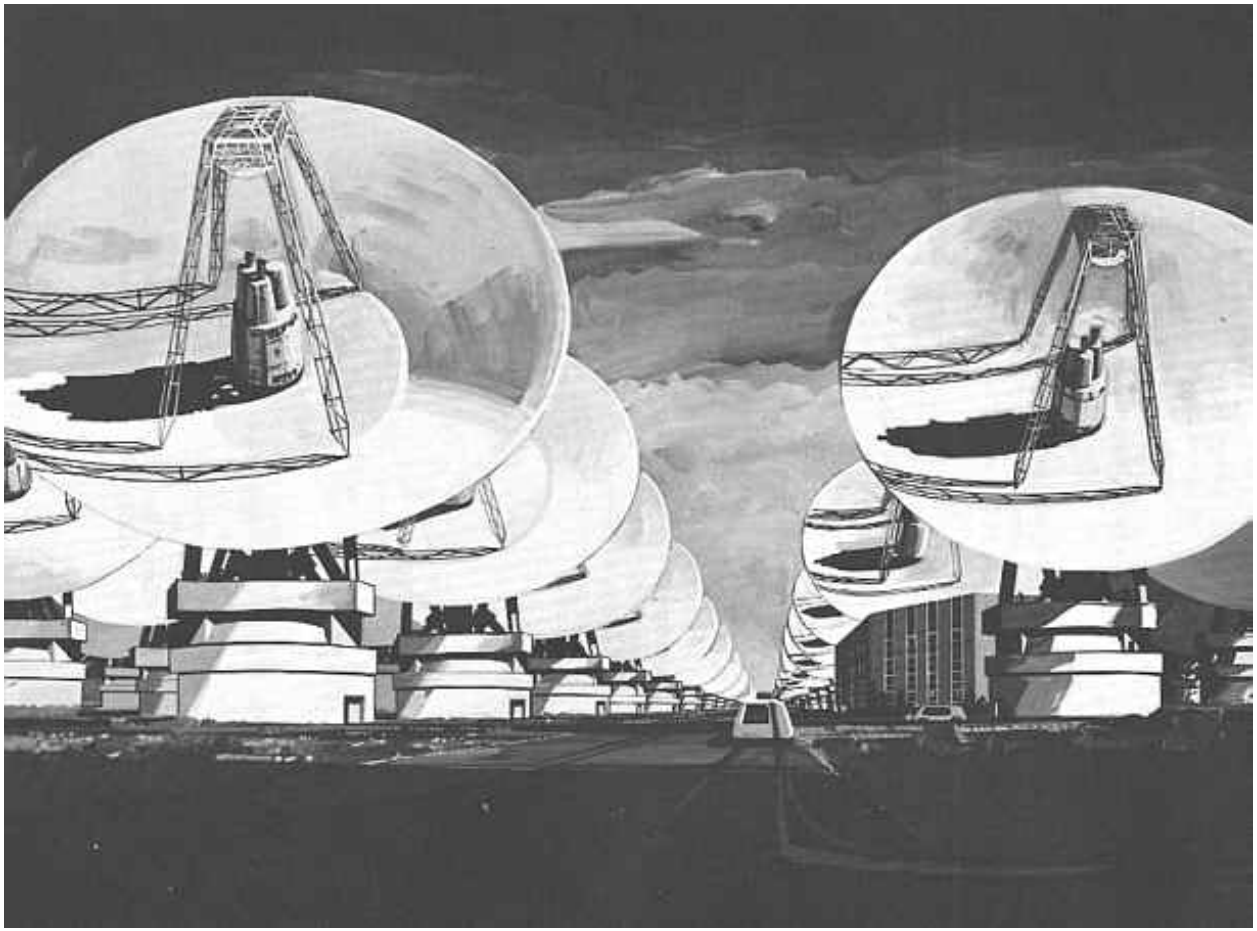
NASA Ilustration

300-Metre Arecibo Radio Telescope



Ellie Arroway (Jodie Foster),
the heroine of the movie “Contact”

Project Cyclops

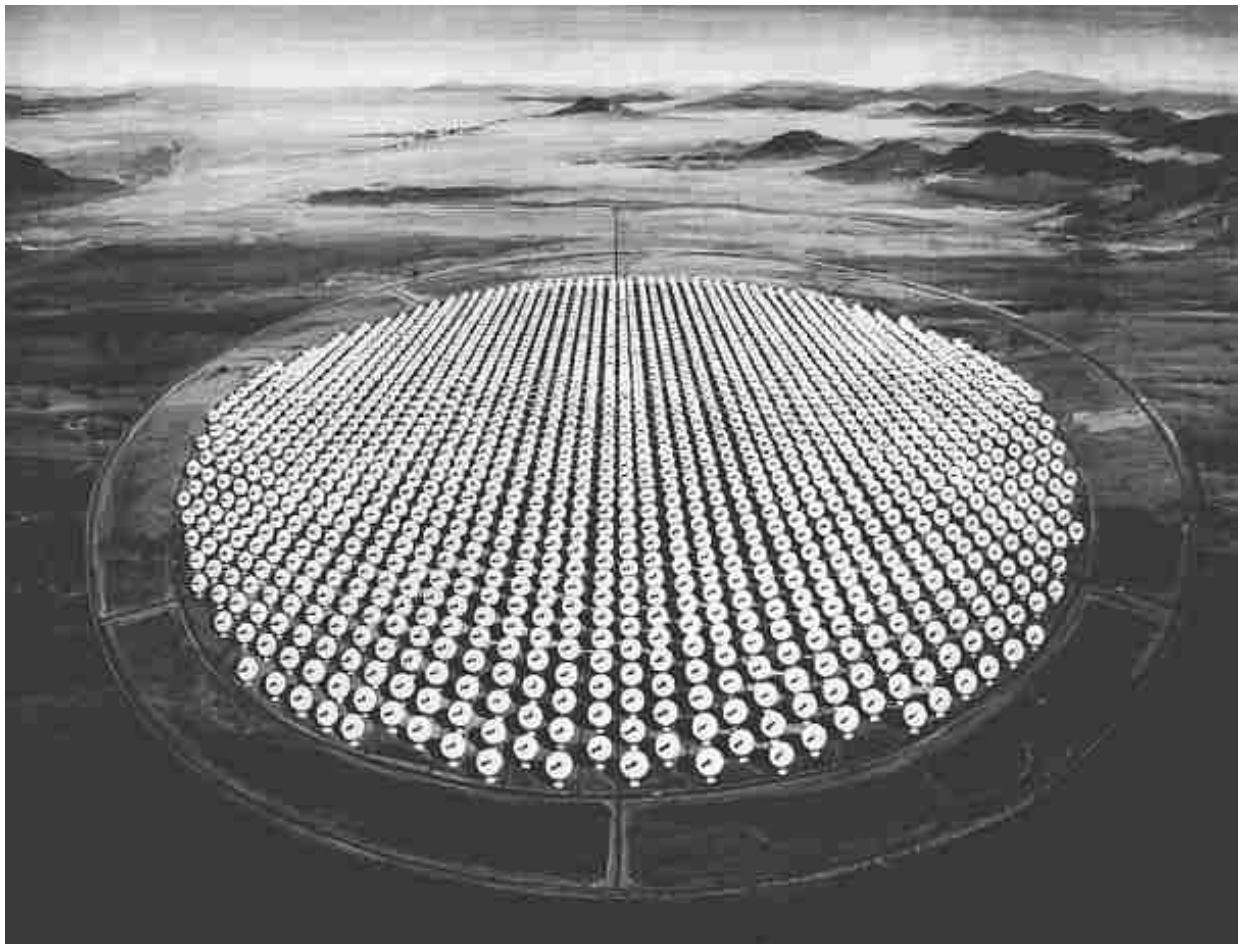


The Cyclops Array

Project Cyclops

- Project Cyclops.
  - A project proposed in the early 70's but never funded by Congress. If the full array had been built it would have consisted of 900 dishes, each 100 meters in diameter, and arranged in a circle some 6.4 km in diameter.
  - The report on this project, which has become a sort of SETI Bible, probably bears the major responsibility for distorting how SETI research has been carried out on this planet. Since the report was published, too much emphasis has been placed on the microwave approach to SETI. The assumption that ETIs would have to limit their transmitter apertures to 22.5 cm to prevent the beamwidth becoming too small, thus severely crippling their transmitter uplink gains, does not survive close scrutiny!
  - This is a very informative and fascinating design study. However, the comparative performance table on page 50 is severely flawed. Order your copy of the Cyclops Report from: www.seti.org or www.setileague.org

Project Cyclops

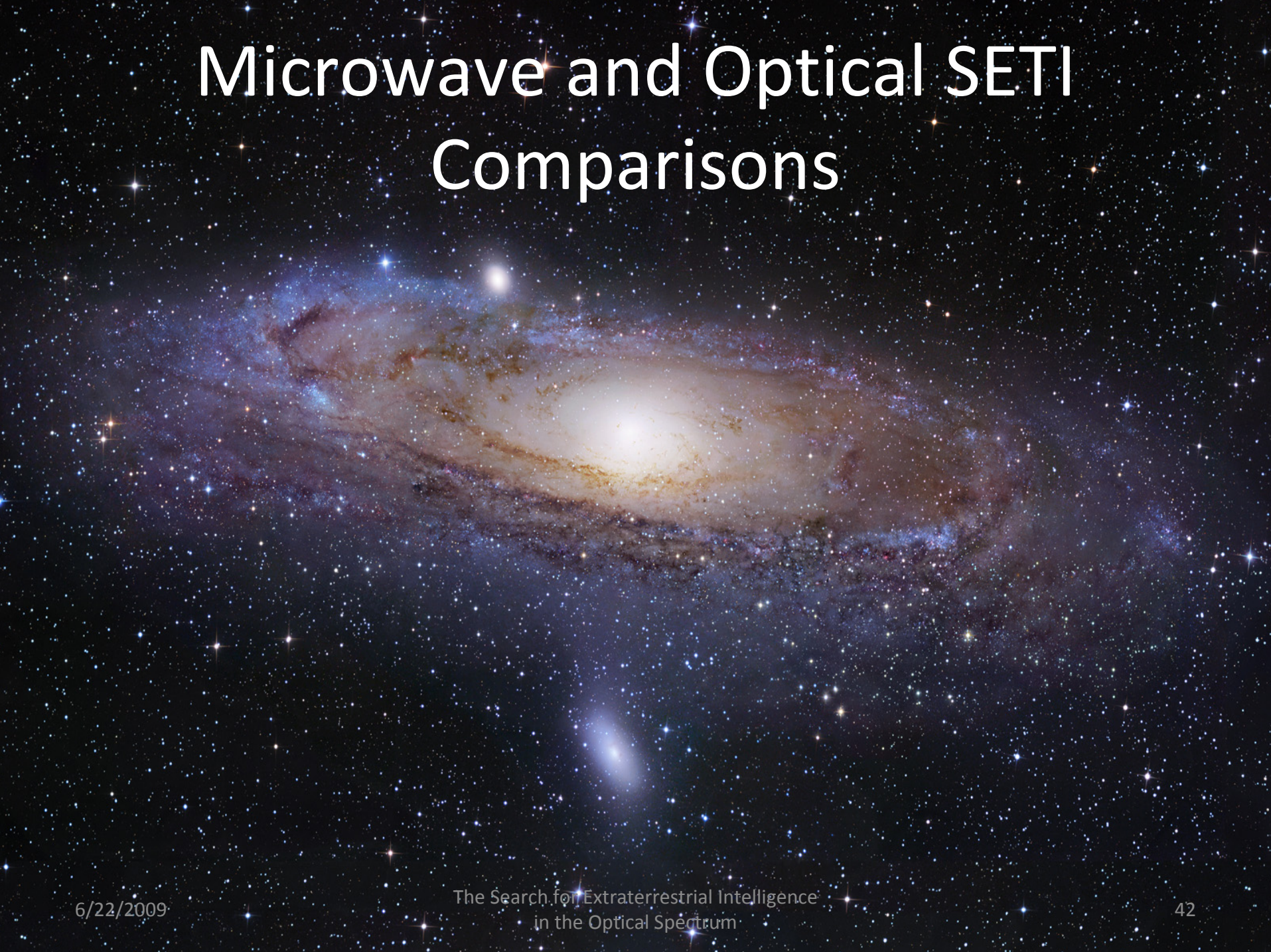


The Cyclops Array

The Late Dr. Bernard M. Oliver 1916 - 1995

- Director of Research and VP of Hewlett-Packard
- Principal author of The Cyclops Report
- Former Deputy Chief of the NASA SETI Office
- National Medal of Science Winner

Microwave and Optical SETI Comparisons



Performance Comparison

	OPTICAL		INFRARED		MICROWAVE	
PARAMETER	A	B	A	B	A	B
Wavelength	1.06 μm	1.06 μm	10.6 μm	10.6 μm	3 cm	3 cm
TRANSMITTER						
Antenna Diameter	***22.5 cm***	***22.5 cm***	2.25 m	2.25 m	100 m	3 km
No. of Elements	1	1	1	1	1	900
Element Diameter	22.5 cm	22.5 cm	2.25 m	2.25 m	100 m	100 m
Antenna Gain	4.4×10^{11}	4.4×10^{11}	4.4×10^{11}	4.4×10^{11}	1.1×10^{8}	9.8×10^{10}

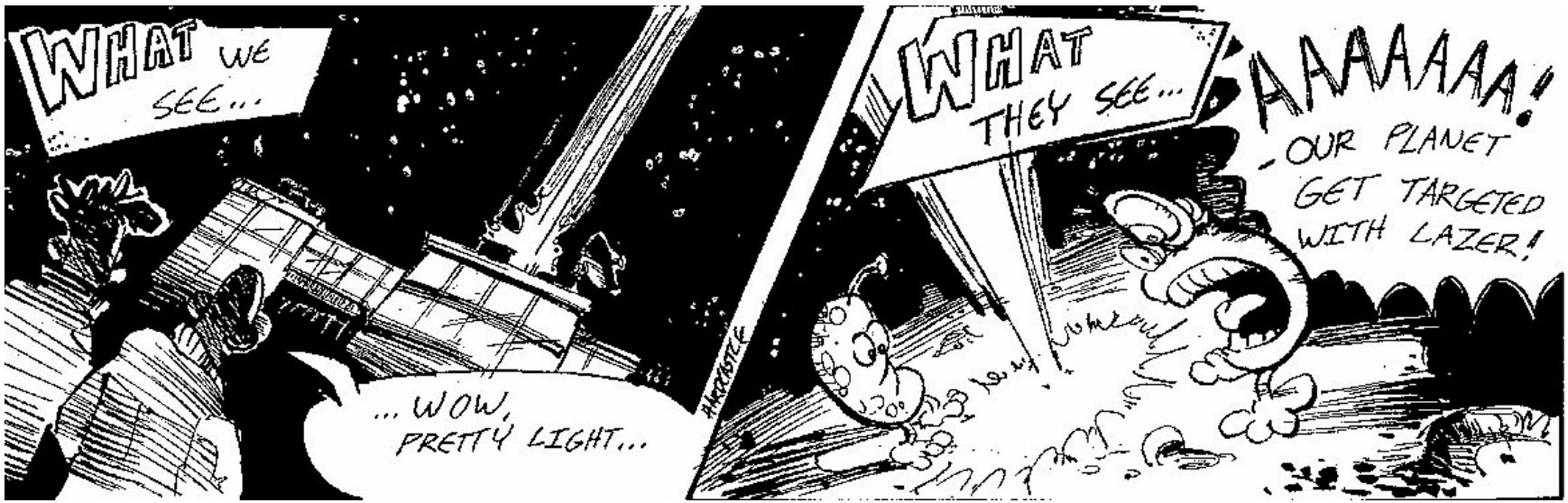
The proposed antenna diameter (22.5 cm) for the ETI uplink at near-infrared is actually slightly smaller than the telescope aperture used by The COSETI Observatory to receive such signals!

Mini-Cyclops
The One Hectar Telescope

- SETI Institute
- 500 antennas of 5 m diameter
- Collecting area exceeds a 100 m telescope

CALLING ALL STARS: The SETI Institute plans to scan a million stars over 10 billion channels at its Hat Creek radio telescope facility north of Sacramento.

ETI Humour 3


WHAT WE SEE...
... WOW, PRETTY LIGHT...
WHAT THEY SEE...
AAAAAAA!
OUR PLANET GET TARGETED WITH LAZER!

Definition of Optical SETI

- Definition.
  - Optical SETI is a subset of Electromagnetic SETI covering the spectrum from the far-infrared, through the near-infrared, the visible region, to the ultra-violet. The word “Optical SETI” is NOT to be used as a synonym for “Visible SETI”. It is a superset of Visible and Infrared SETI.
  - Lasers can operate throughout the infrared, visible and ultra-violet spectral regions. Although the “L” in “Lasers” stands for “Light”, there is no implication that the “light” must be visible. Thus, there are Infrared Lasers and there are Visible Lasers.
- Why Optical SETI?
  - Simply, lasers are superior for point-to-point, free-space interstellar communications. In the not-to-distant future, when mankind sends out probes to the outer reaches of the solar system and to nearby stars, communications with Earth will be via lasers. “Photonics”, otherwise called “Optoelectronics” or “Optronics”, will be the major communications technology of the future.

Three Types of Optical SETI

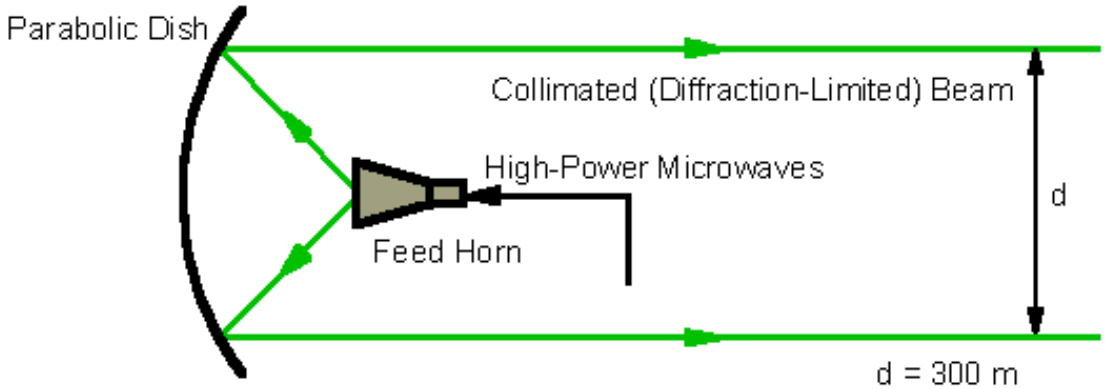
- Three Types of Optical SETI.
  - Professional
    - Large telescopes and sophisticated signal processing.
      - Expensive.
  - Amateur
    - Small telescopes and simple signal processing.
      - Relatively inexpensive.
  - Retrospective
    - A search through the historical record of stellar spectrographic plates.
      - Inexpensive.

Free-Space Laser Communications

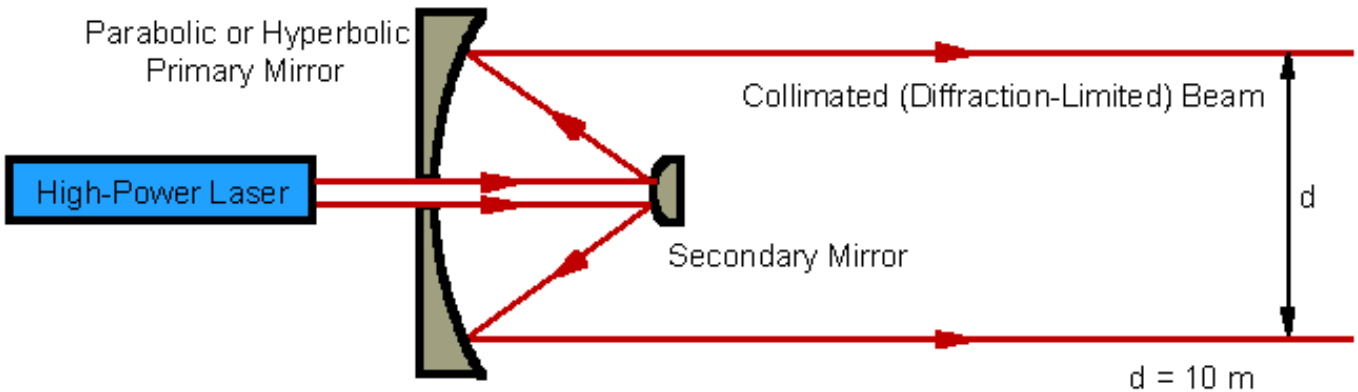
- Free-Space Laser Communications
  - In the future, NASA will be using free-space laser communications for its deep space probes.
  - Next century, the first HDTV pictures from our space probes sent to investigate the nearest stars will be transmitted by laser.
  - Communications between geostationary satellites and low earth orbit satellites will also be supplemented by laser links.
  - The future of communications is largely photonic, be it on the earth or between us and other stars!

Starfire Optical Range

Free-Space Links

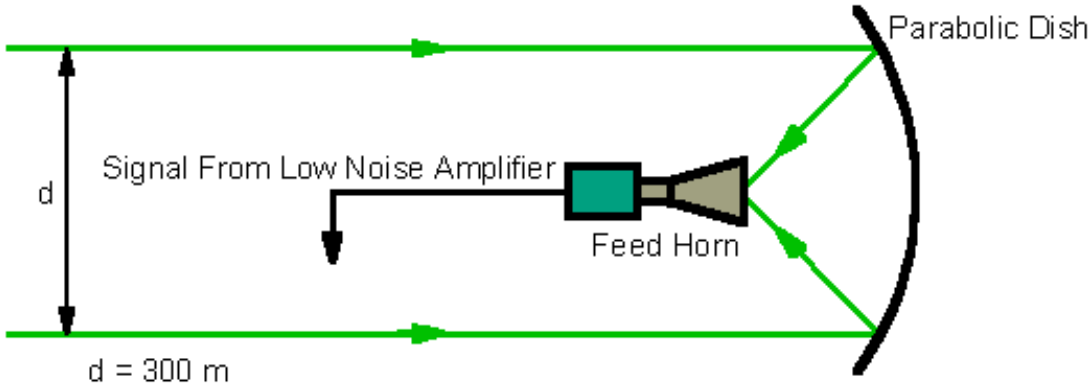


(a) Microwave Transmitting Dish

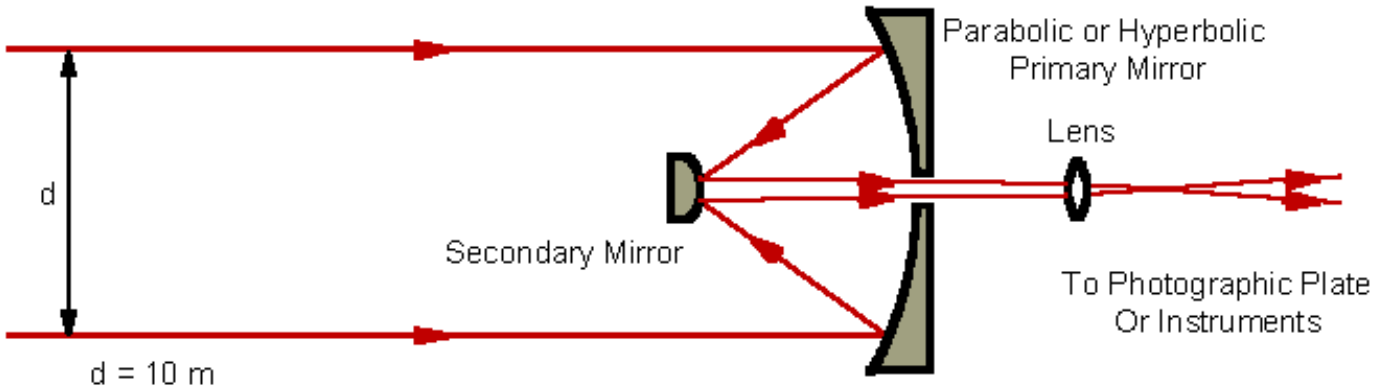


(b) Optical Transmitting (Cassegrain) Telescope

Free-Space Links



(a) Microwave Receiving Dish



(b) Optical Receiving (Cassegrain) Telescope

Search Strategy

- Search Strategy
  - Targeted Star Search only.
    - A diffraction-limited “All Sky Survey” doesn’t make much sense at optical wavelengths as there are too many pixels to search in the celestial sphere.
  - Look at the same stars that are the subject of the Microwave Targeted Search.
    - 1,000 solar-type stars out to a distance of about 100 light years.

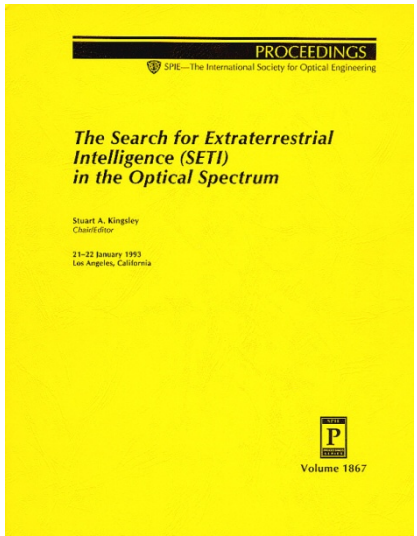
Keck 2 Telescope

Pre-Dome COSETI Observatory

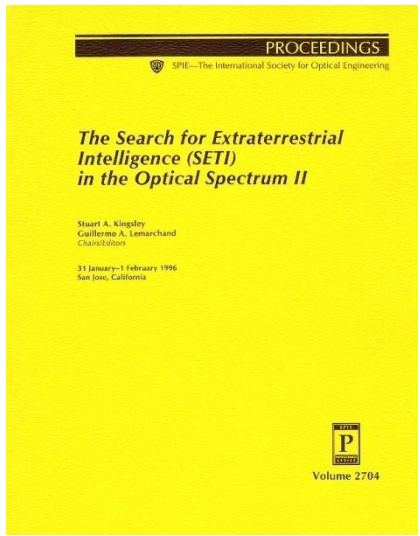
Post-Dome COSETI Observatory

The COSETI Dome

Optical SETI Conferences



Optical SETI I
January 1993
Proceedings No. 1867



Optical SETI II
January 1996
Proceedings No. 2704

Optical SETI III
January 2001
Proceedings No. 4273

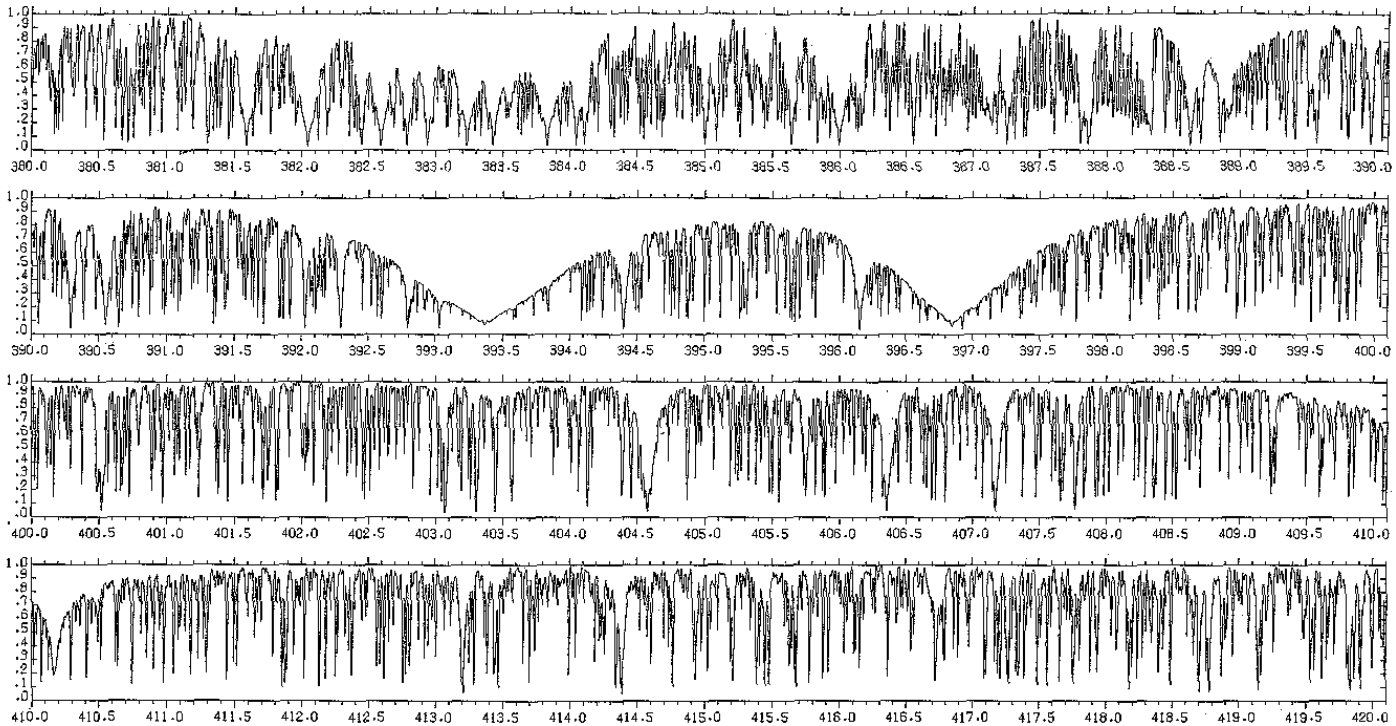
Optical SETI Conferences arranged by SPIE
(The International Society for Optical Engineering) and held in California.

The Bournemouth Connection

June 14, 2000, at the Highcliff Hotel

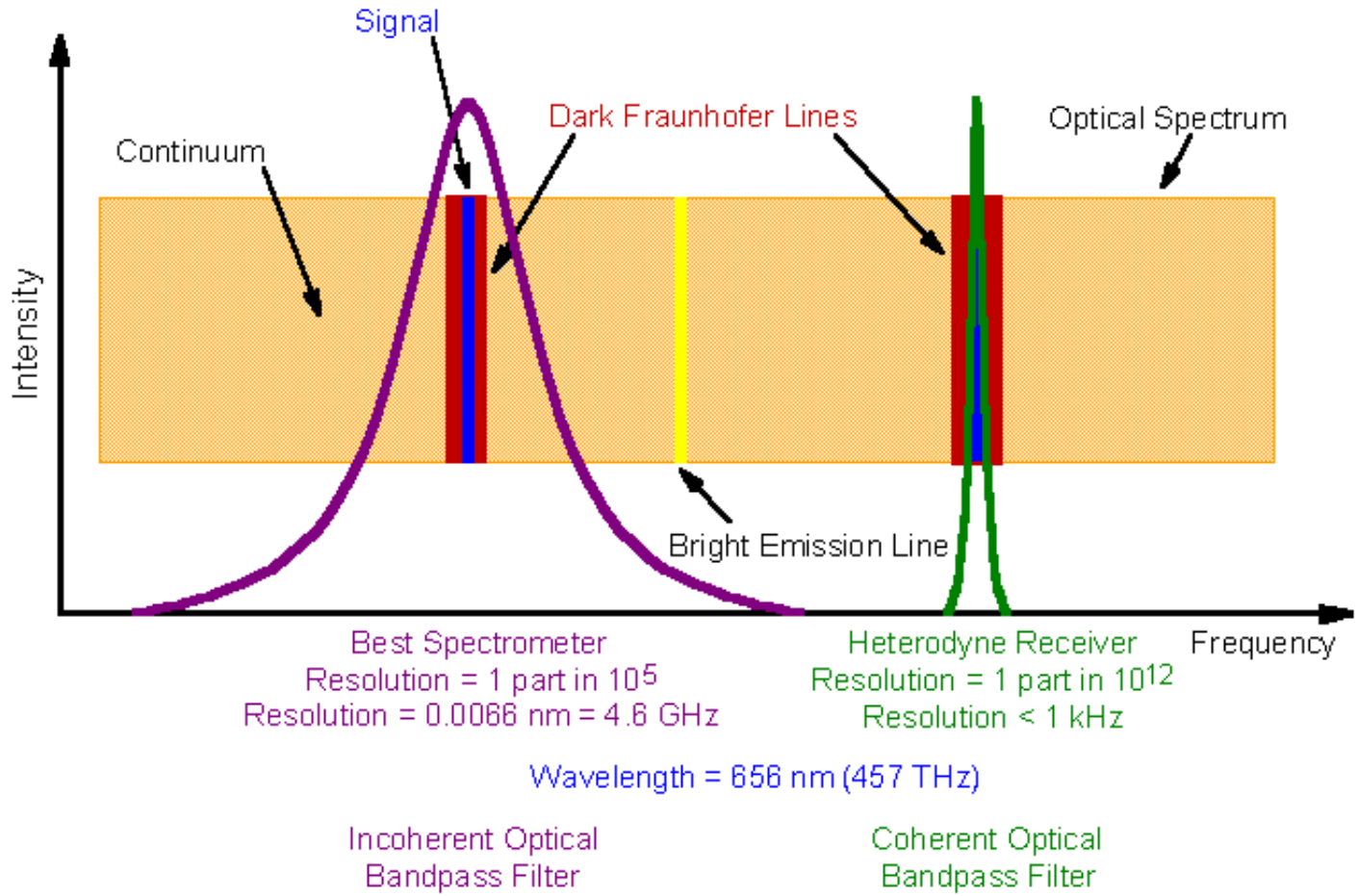
Time for a Blue Plaque!

Solar Spectrum

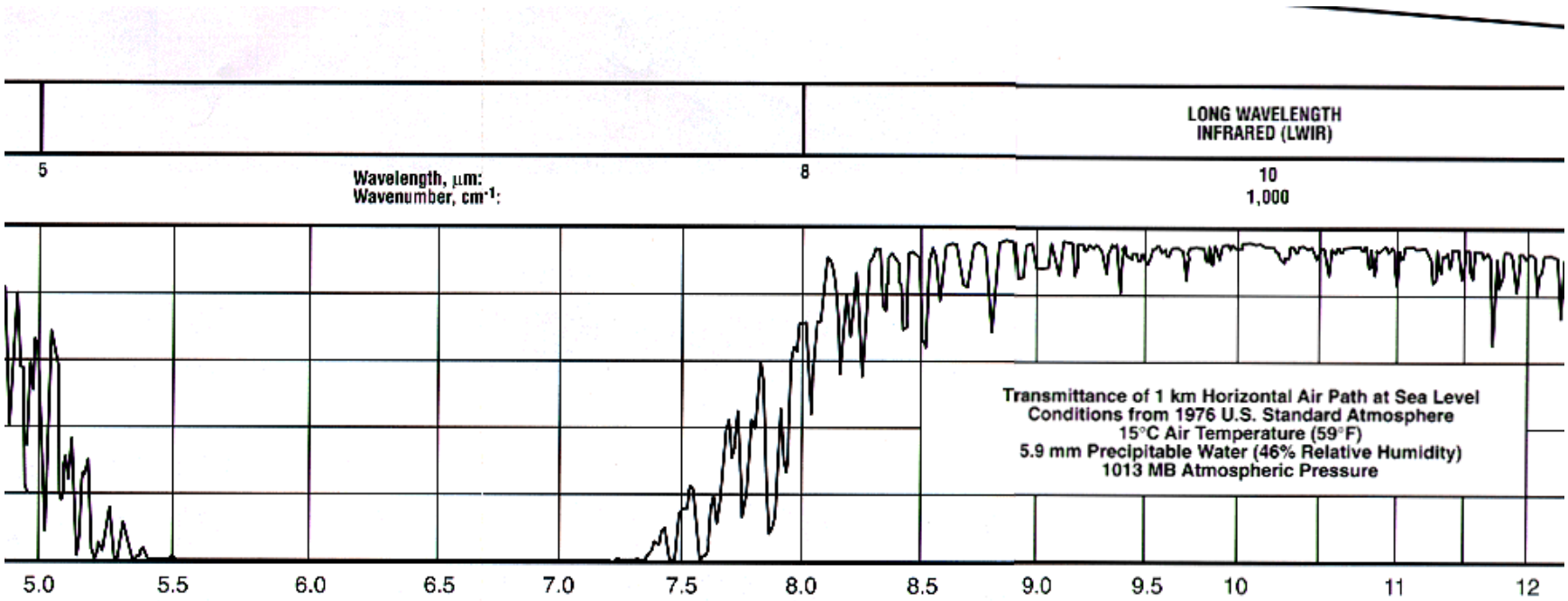


24

Optical Bandpass Filtering

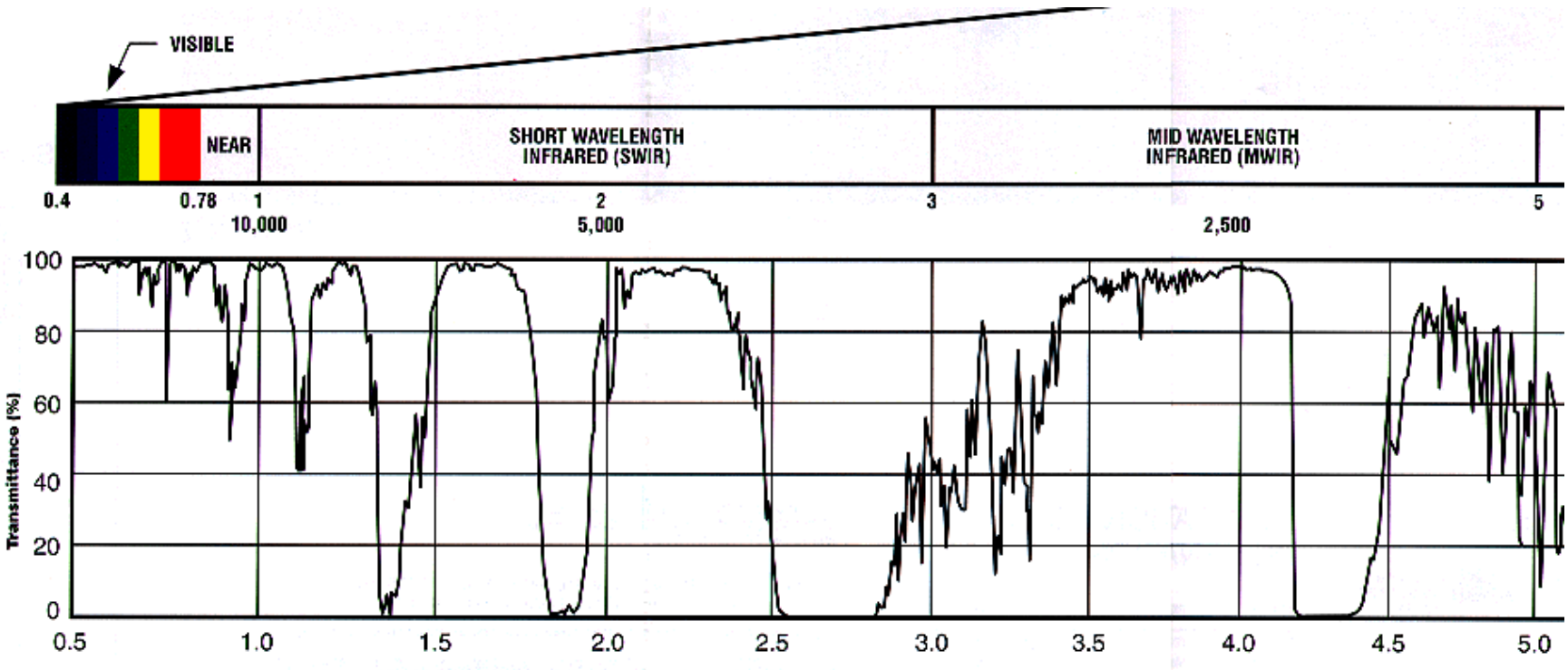


Atmospheric Transmission



Santa Barbara Research Center

Atmospheric Transmission



Interstellar Link Performance

- Comparisons of Interstellar Link Performance for the following Electromagnetic SETI systems:
  - Microwave SETI
  - Infrared SETI
  - Visible SETI

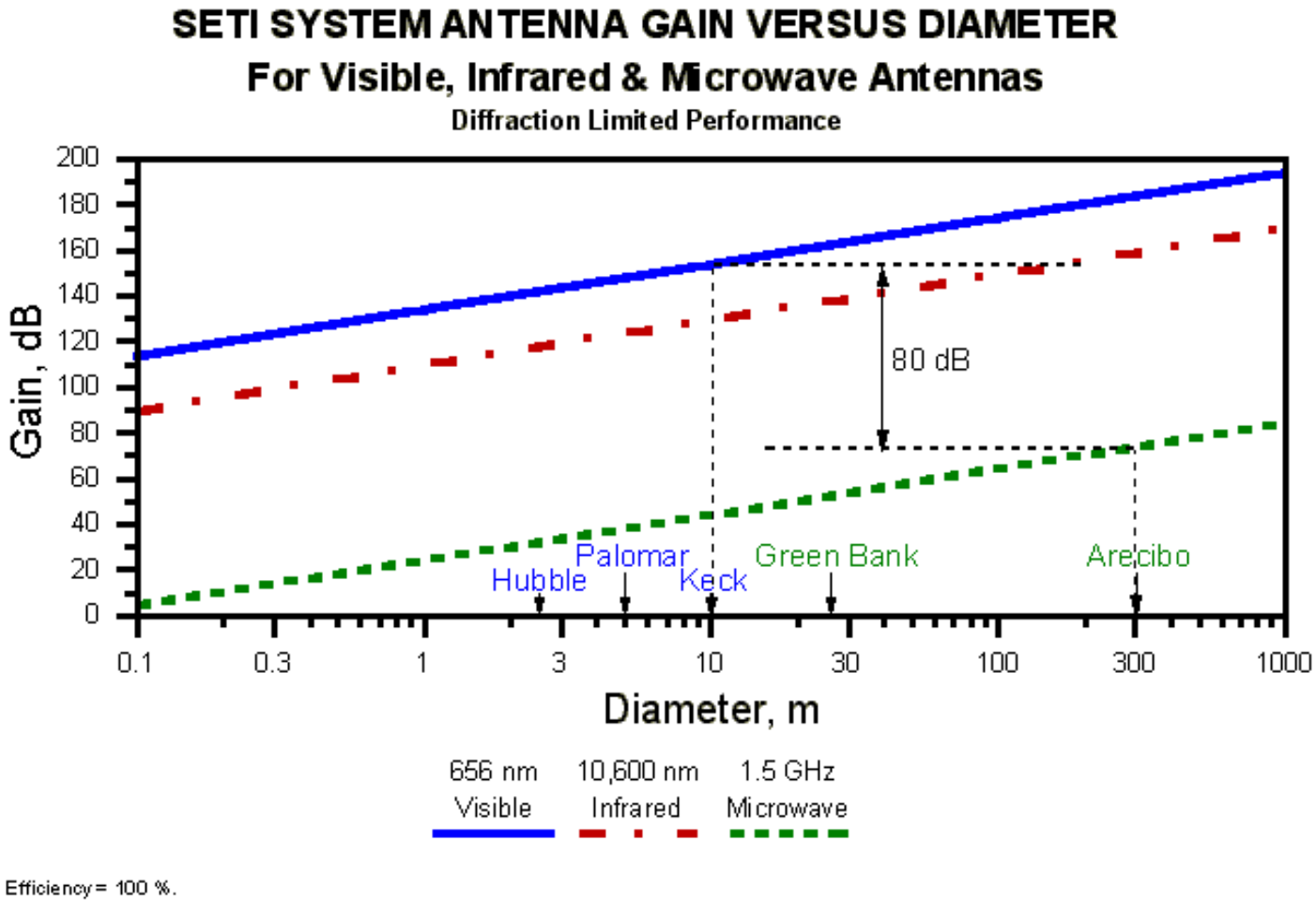
    - All transmitters normalized to a 1 kW reference power for comparison purposes only.
    - Performance compared on a spectral density and SNR basis.
    - At 10 light years range, a 1 GW visible laser transmitter could result in a 94 dB SNR referred to a 1 Hz bandwidth.

NASA's Deep Space Network

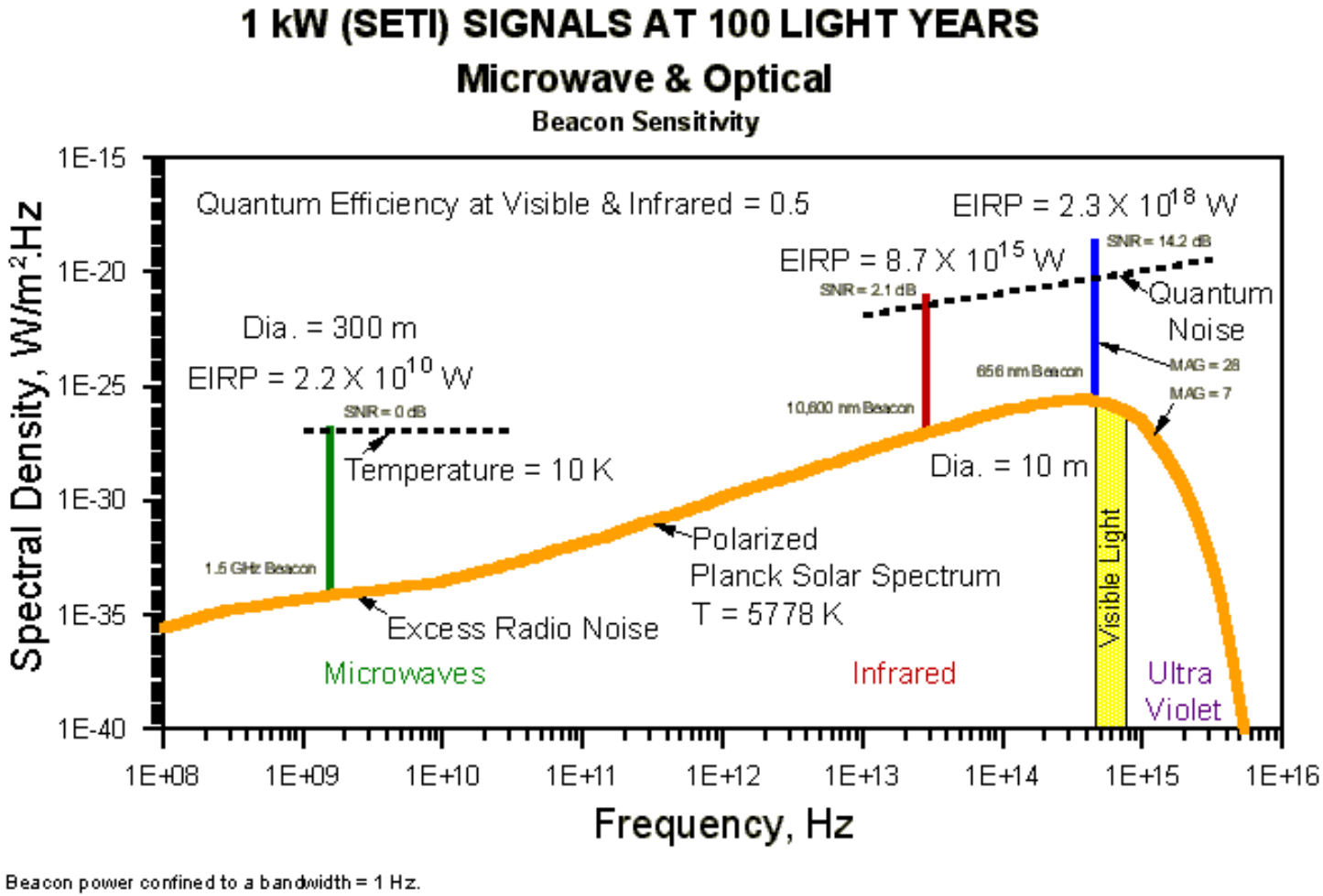
Relative Antenna Gains

- Relative Antenna Gains.
  - Optical transmitters can have effective isotropic radiated powers (EIRPs) 100 million times stronger than their microwave counterparts for the same transmitter power. A 10-meter Keck-type optical telescope can be 80 dB more powerful than a 300-meter Arecibo-type radio telescope.
  - Many in the MSETI community would suggest that transmitter antenna gains in excess of 74 to 94 dB are not practical because of the point-ahead targeting problem. However, other OSETI researchers have suggested optical transmitter gains as high as 174 dB. Stuart Kingsley has proposed gains as high as 154 dB (> 10^{15}).
- Relative Doppler Shifts.
  - Over 100,000 times greater at optical frequencies.

Antenna Gains Versus Diameter



1 kW SETI Signals at 100 L.Y.

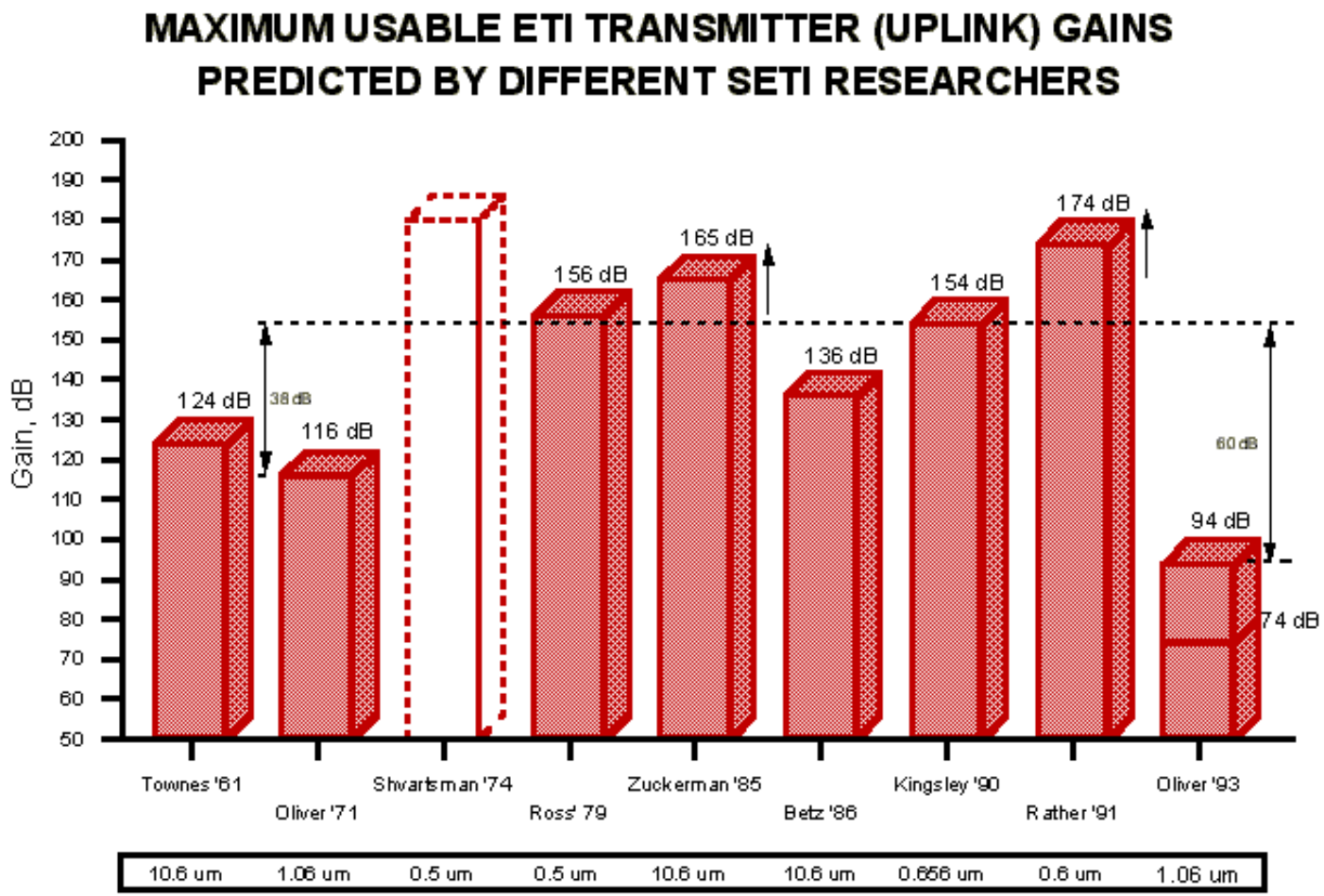


Beacon power confined to a bandwidth = 1 Hz.

Transmitter Gain Comparisons

- Diffraction-Limited Beams
  - ETI Transmitter Gains
  - ETI Transmitter EIRPs
- Antenna Gains
  - Microwave SETI
    - 300 meter Arecibo dish at 1.5 GHz
    - Gain = 74 dB
  - Optical SETI
    - 10 meter Keck-type telescope at visible wavelengths
    - Gain = 154 dB
    - 80 dB (100 million gain advantage)

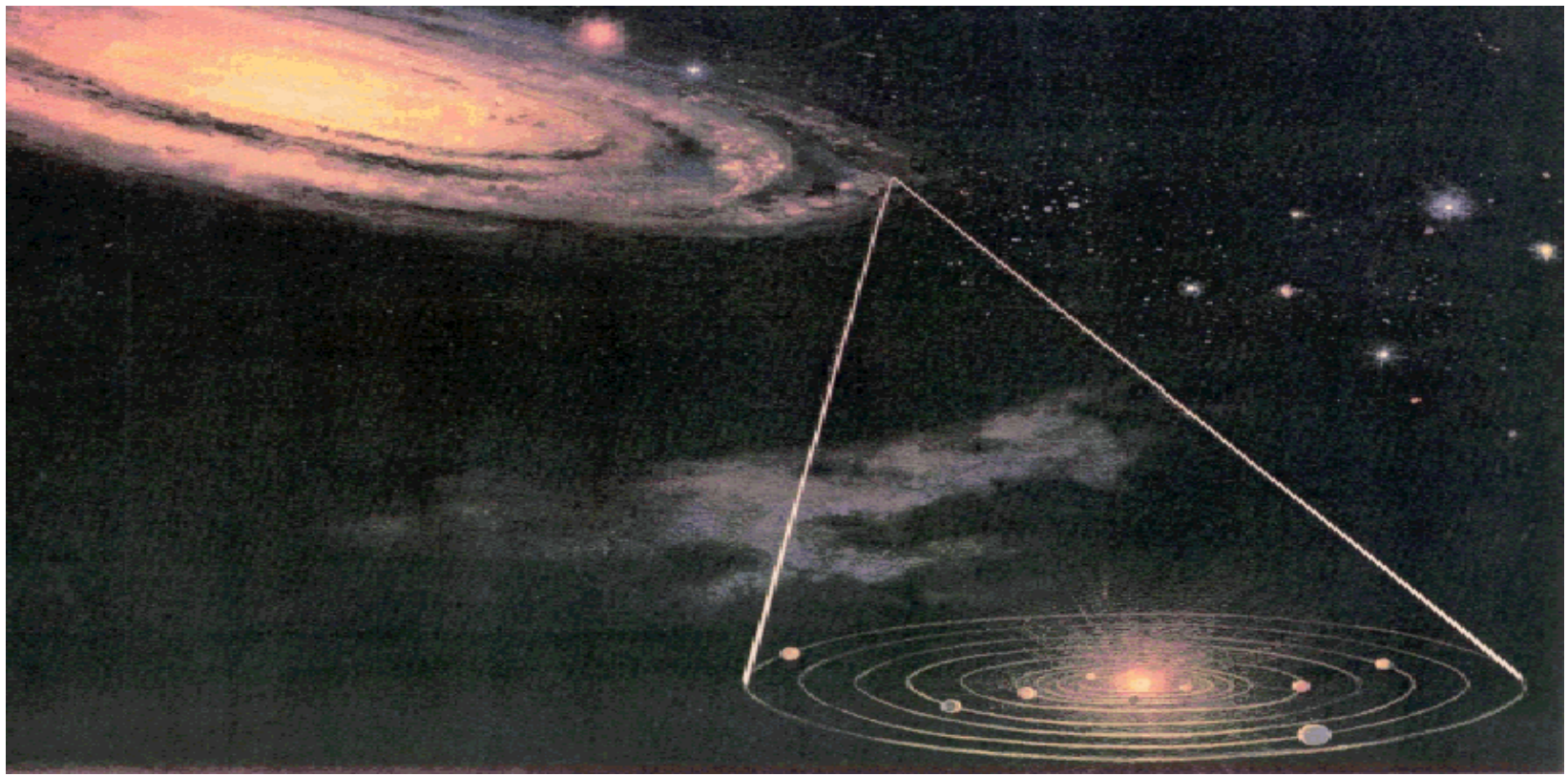
Transmitter Gain Comparisons



Gain & Beamwidth Comparisons

- Transmitting Antenna Beamwidth
  - Microwave SETI
    - 300 meter dish (Gain = 74 dB at 1.5 GHz)
      - 0.039 degrees
      - 35,000 A.U. at 1,000 light years (450 solar system diameters)
  - Optical SETI
    - 10 meter telescope (Gain = 154 dB at 550 nm)
      - 0.012 arcseconds
      - 3.5 A.U. at 1,000 light years (approximate zone of life)

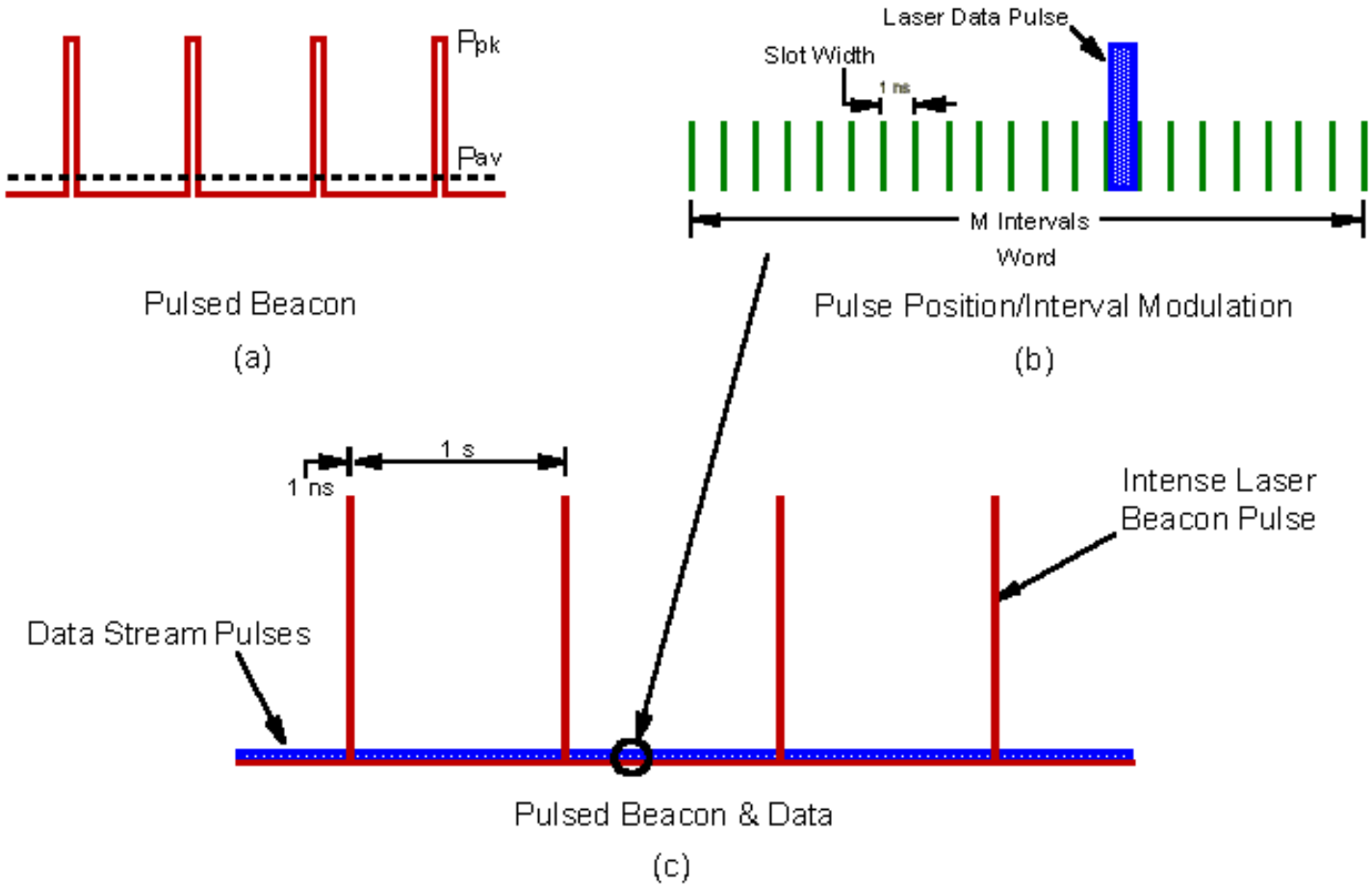
Illuminating the Zone of Life



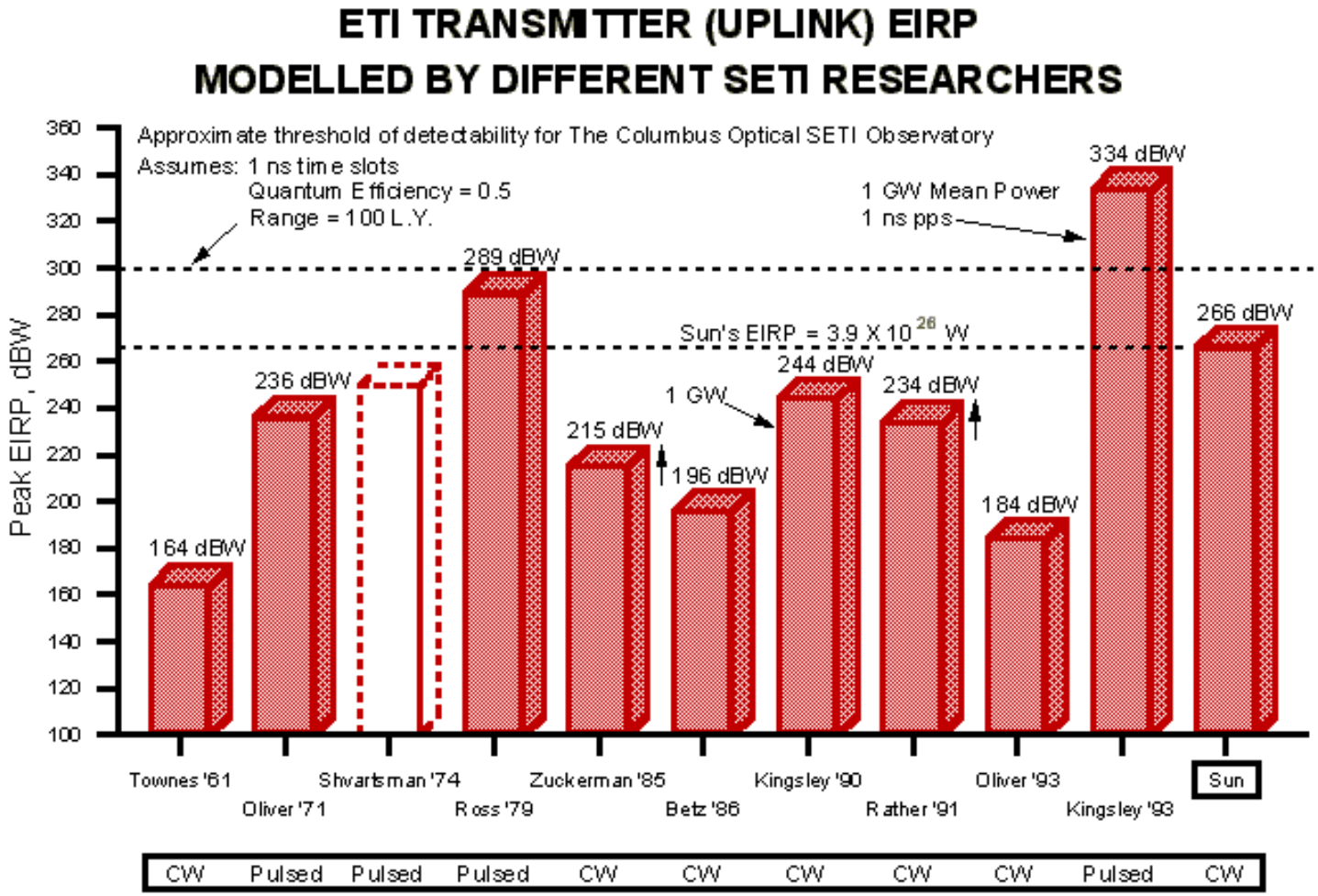
Transmitter EIRPs

- Antenna EIRPs
  - Assume mean transmitter power = 1 GW
    - Pulse duration = 1 nanosecond
    - Repetition rate = 1 pulse per second
    - Peak Power = 10^{18} W
  - Microwave SETI
- 300 meter Arecibo dish at 1.5 GHz, Gain = 74 dB
    - Peak EIRP = 3.2×10^{25} W
  - Optical SETI
    - 10 meter Keck-type telescope at visible wavelengths, Gain = 154 dB
    - Peak EIRP = 3.2×10^{33} W (Sun's EIRP = 3.9×10^{26} W)
    - Laser lighthouse flash briefly outshines star by 70 dB (10 million times)!

Pulsed Laser Beacon Signals



Pulsed Transmitter EIRPs



Pulsed Laser Beacon Signals

- Professional OSETI
- EIRP = 3.2 x 10^{33} W
  - Range = 10 L.Y.
    - 68,000,000 cpp
  - Range = 100 L.Y.
    - 680,000 cpp
  - Range = 1,000 L.Y.
    - 6,800 cpp

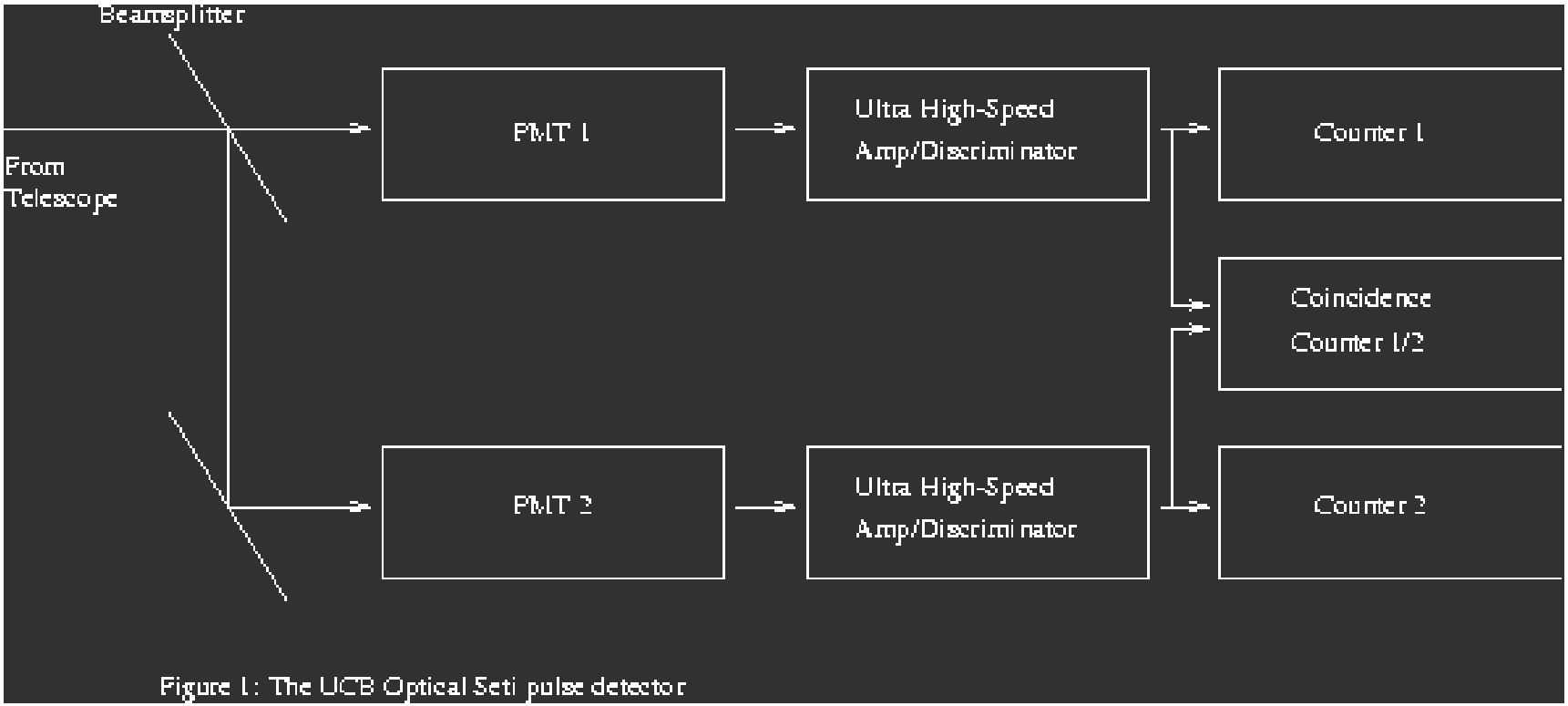
- Amateur OSETI
- EIRP = 3.2 x 10^{33} W
  - Range = 10 L.Y.
    - 44,000 cpp
  - Range = 100 L.Y.
    - 440 cpp
  - Range = 1,000 L.Y.
    - 4 cpp

cpp = photon counts per pulse

Single Photon Counting Module

- Single Photon Counting Module (SPCM) produced by Perkin Elmer (formerly EG&G).
  - Suitable for pulse detecting type of Optical SETI

Optical SETI Coincidence Detector

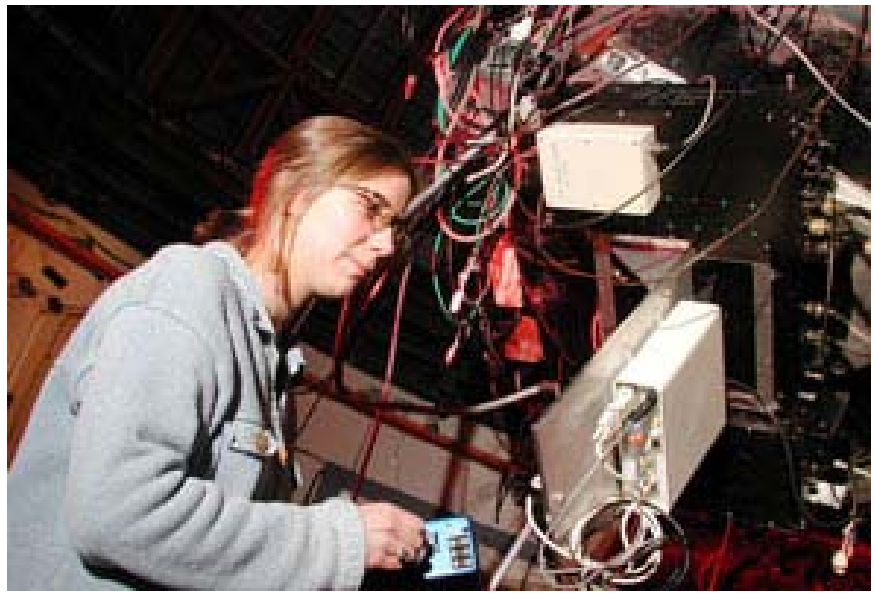


Other Optical SETI

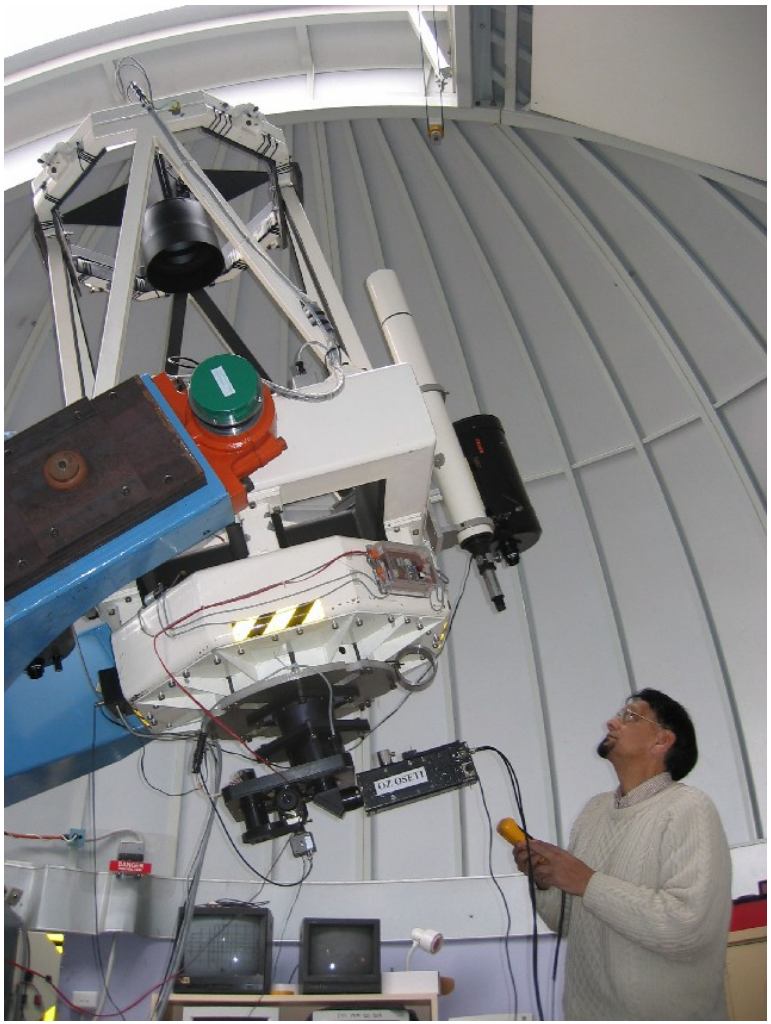
- Other Optical SETI
  - Announced in September 1998
  - Sponsored by The Planetary Society
    - Harvard
      - Paul Horowitz
  - Announced in January 1999
    - University of California
      - Dan Werthimer
      - Geoff Marcy
      - Charles Townes

SETI Institute

- The SETI Institute, along with scientists from the University of California's Lick Observatory, UC Santa Cruz, and UC Berkeley has coupled the Lick Observatory's 40-inch Nickel Telescope with a new pulse-detection system capable of finding laser beacons from civilizations many light-years distant. Unlike other optical SETI searches, this experiment is largely immune to false alarms, due to a novel approach incorporating 3 light detectors.



Optical SETI in Australia



- The OZ OSETI Project searches for extremely fast (a billionth of a second) flashes of laser light beamed at planet Earth by a Star Wars type powerful laser operated by an advanced extraterrestrial civilization. For that brief instant of time the light flash from that laser will outshine the light from its Sun by several orders of magnitude. This means that anyone looking for a pulsed ETI signal should be able to detect it quite easily.
- The OZ OSETI Project uses two telescopes with beam splitters, high speed amplifiers, discriminators, and coincidence detectors to eliminate any false "hits".

The Planetary Society

72” Telescope

The new Optical SETI telescope at the Oak Ridge Observatory in Harvard, Massachusetts, which was inaugurated on April 11, 2006, is the latest and greatest of the optical SETI projects sponsored by The Planetary Society over the years. It is, however, far from the first. Over the years the Society has sponsored several other optical SETI programs, making it a world leader in the funding of optical SETI research.

And The Search Continues . . .

www.coseti.org
www.boseti.org
skingsley@coseti.org

Max Dias Giving the Vote of Thanks

About 50 people attended the talk in the Menorah Suite.
Stuart Kingsley was introduced by Esther Stern at the start of the talk.

Further Reading

- If you were at the talk and want to know more or couldn't be present, the following links provide substantive support for the material presented. Much of this material is highly technical:
  - www.coseti.org
  - www.boseti.org
  - www.oldsynagogues.org/wessexjnews_1.htm
  - www.planetary.org/programs/projects/seti_optical_searches/
  - www.seti.org/Page.aspx?pid=330
  - http://seti.ssl.berkeley.edu/opticalseti/
  - http://seti.harvard.edu/oseti/
  - http://seti.ucolick.org/optical/
  - http://articles.adsabs.harvard.edu/full/seri/ASPC./0213//0000553.000.html
  - www.setileague.org/general/optical.htm
  - www.planetquest.org/about/faqs/

Other, more technical COSETI Powerpoint presentations from previous talks may be found here: www.coseti.org/powerpnt/Cardiff University, November 6,7, 2000.zip, www.coseti.org/powerpnt/coseti00.zip, www.coseti.org/powerpnt/Ohio University, February 27, 2000.zip, www.coseti.org/powerpnt/coseti01.zip

This Presentation

- This presentation will be found archived at the following URL:
  - www.coseti.org/powerpnt/Bournemouth Murray Muscat Centre, June 22, 2009.pdf