

God's Handiwork Seen Through an Engineer's Eyes

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BYU Department of Electrical and Computer Engineering
Faith and Engineering Lecture Series
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Fun with Big Science: Radio Astronomy

ATNF Compact Array, Narrabri



Image credit:
Australian
Telescope
National
Facility

Observing the Invisible in Deep Space

Super nova remnant
Casiopeia-A

Active Galactic Nucleus, Cygnus-A

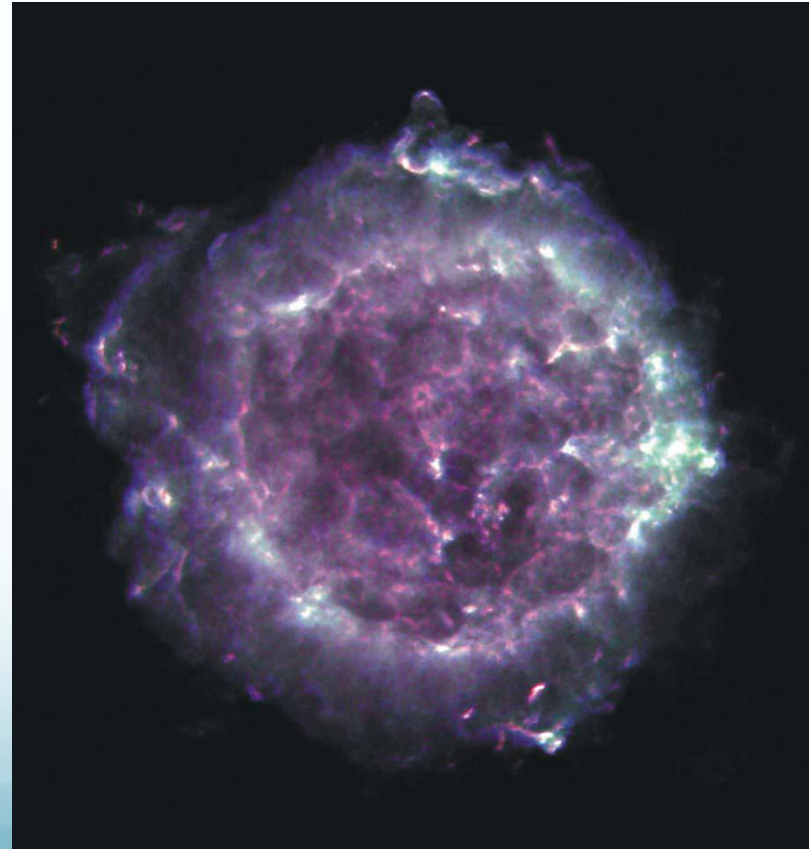
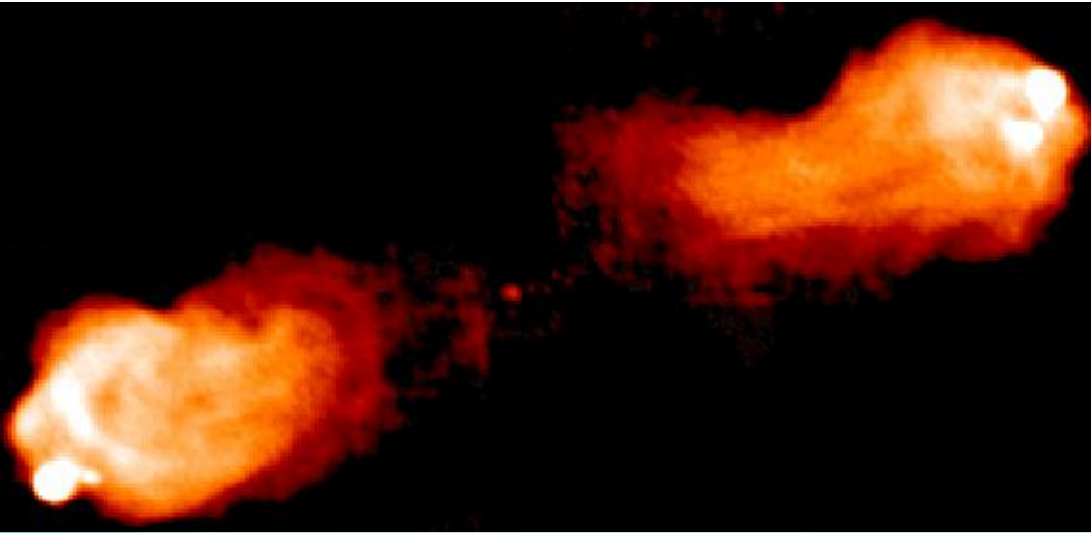


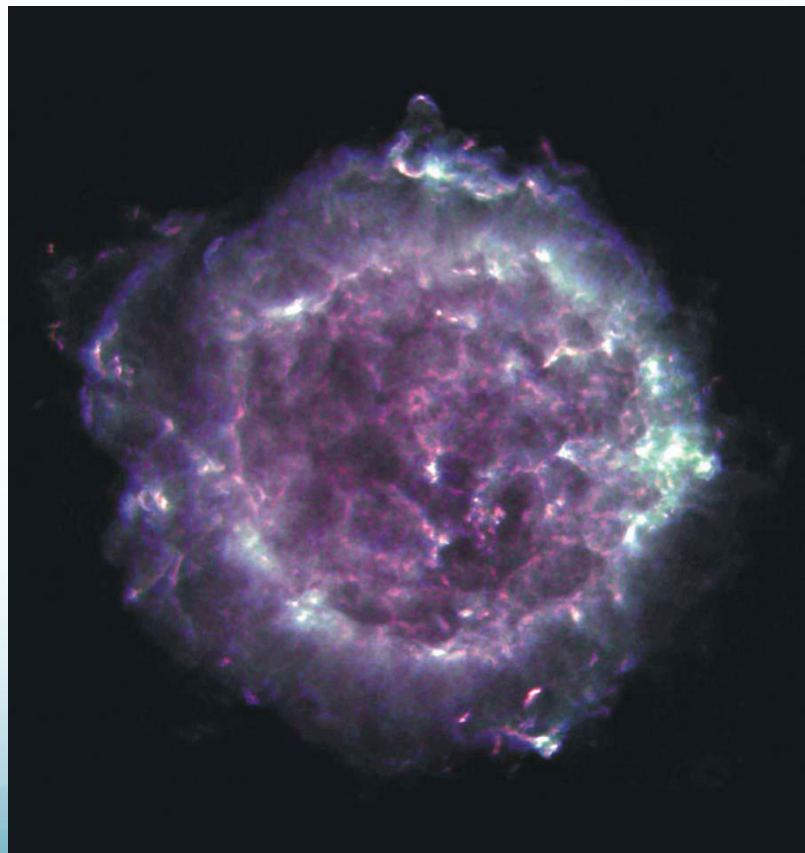
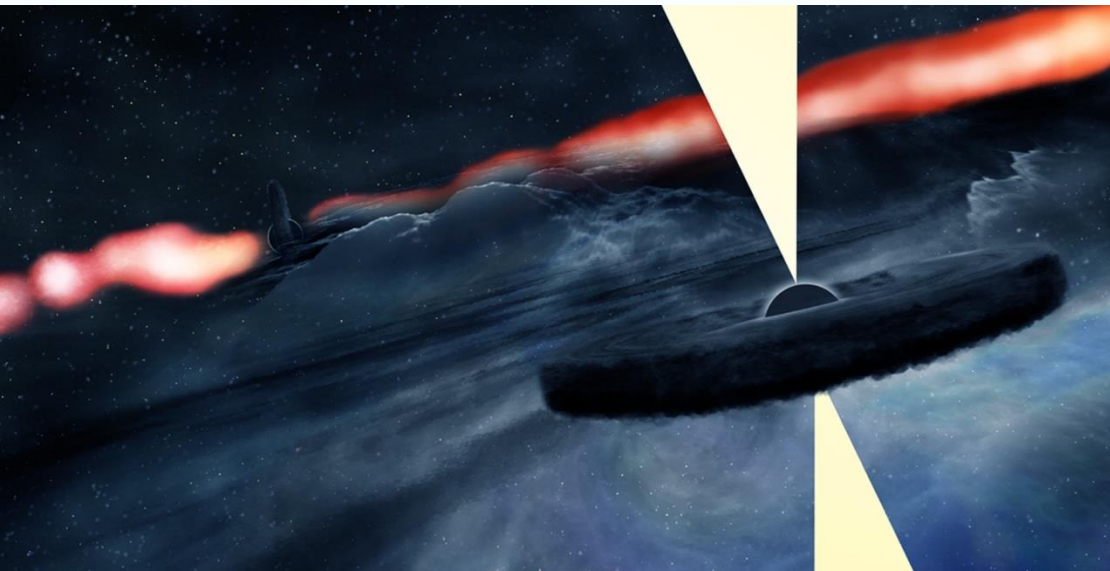
Image credits: National Radio Astronomy Observatory / Associated Universities, Inc. / National Science Foundation.

Observing the Invisible in Deep Space

Super nova remnant
Casiopeia-A

Active Galactic Nucleus, Cygnus-A

Image Credit: Bill Saxton, NRAO/AUI/NSF

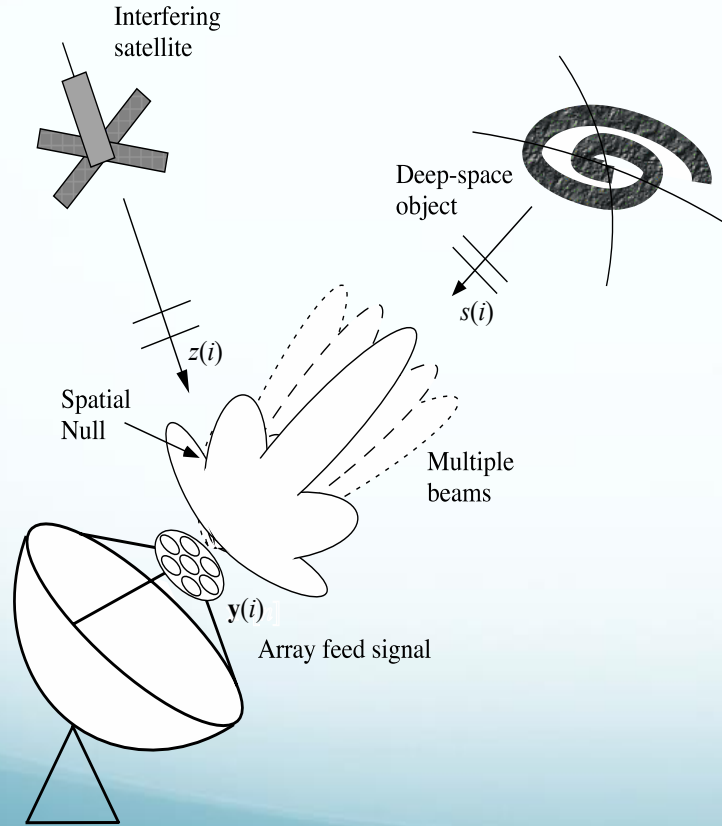


Parkes 64m Telescope



Image credit:
Australian
Telescope National
Facility

Phased Array Feed Research



Radio telescope dish with a phased array feed



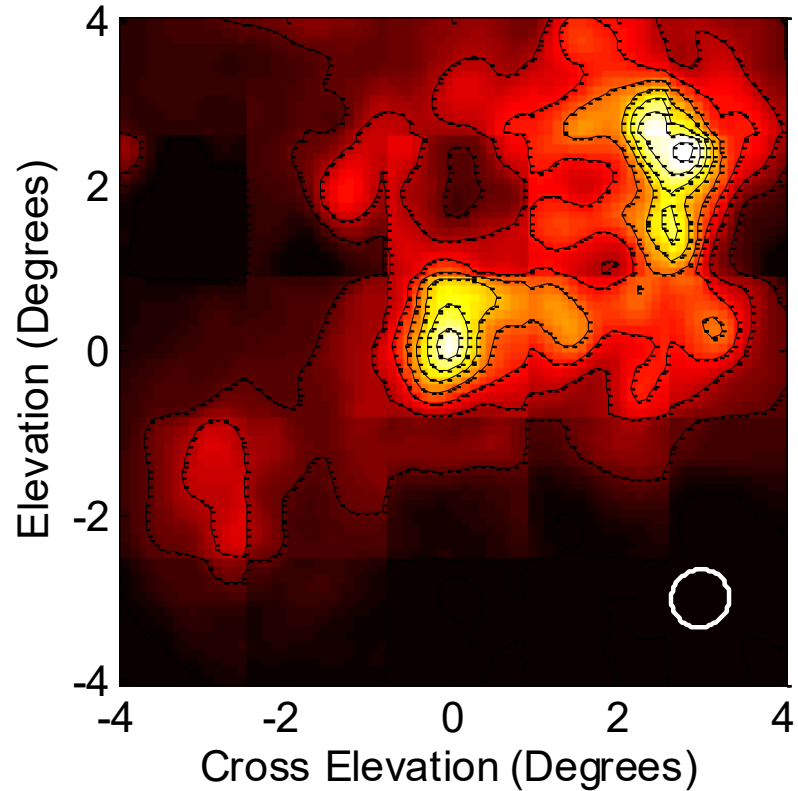
Wider field of view, faster sky surveys

Phased Array Feed Research



Image credit: National Radio Astronomy Observatory

Green Bank Telescope, West Virginia



Cygnus X region at 1612 MHz



The Arecibo 305m Telescope

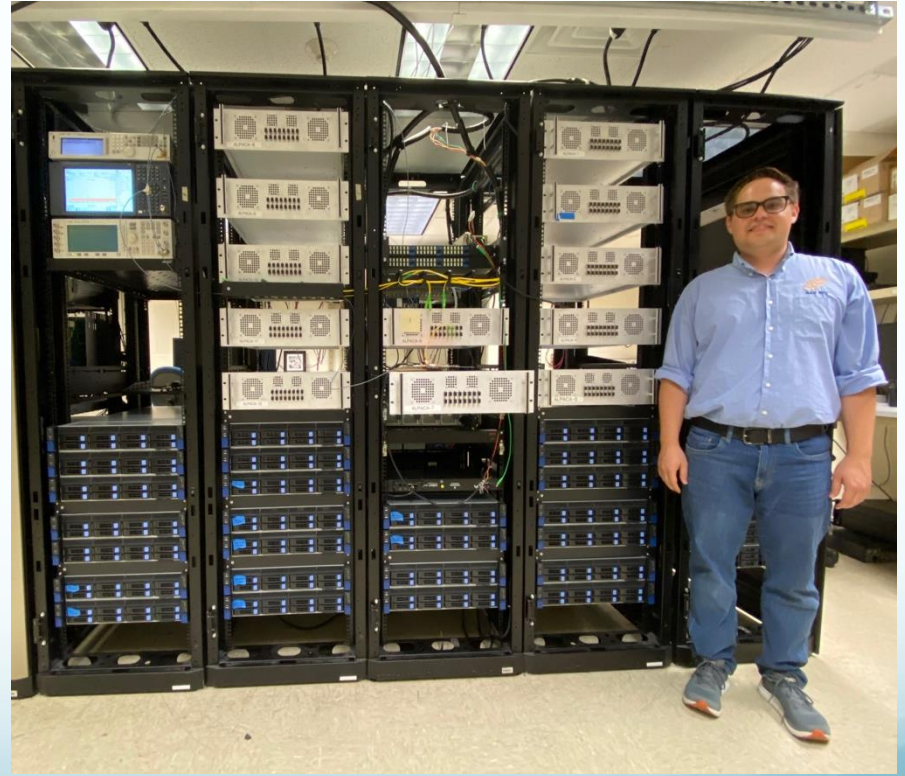
Arecibo, Feb. 2019



The ALPACA Phased Array Feed



Cryogenic array receiver front end
Mitch Burnett and Rebecca Haymore

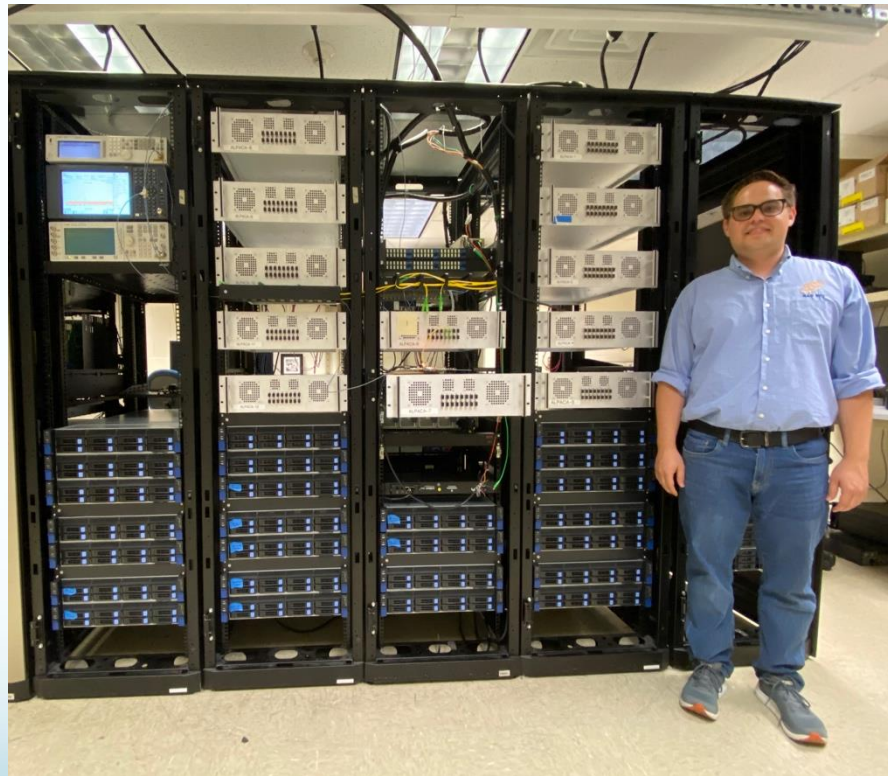


Digital array beamformer back end
Mitch Burnett: Lead Project Engineer

The ALPACA Phased Array Feed



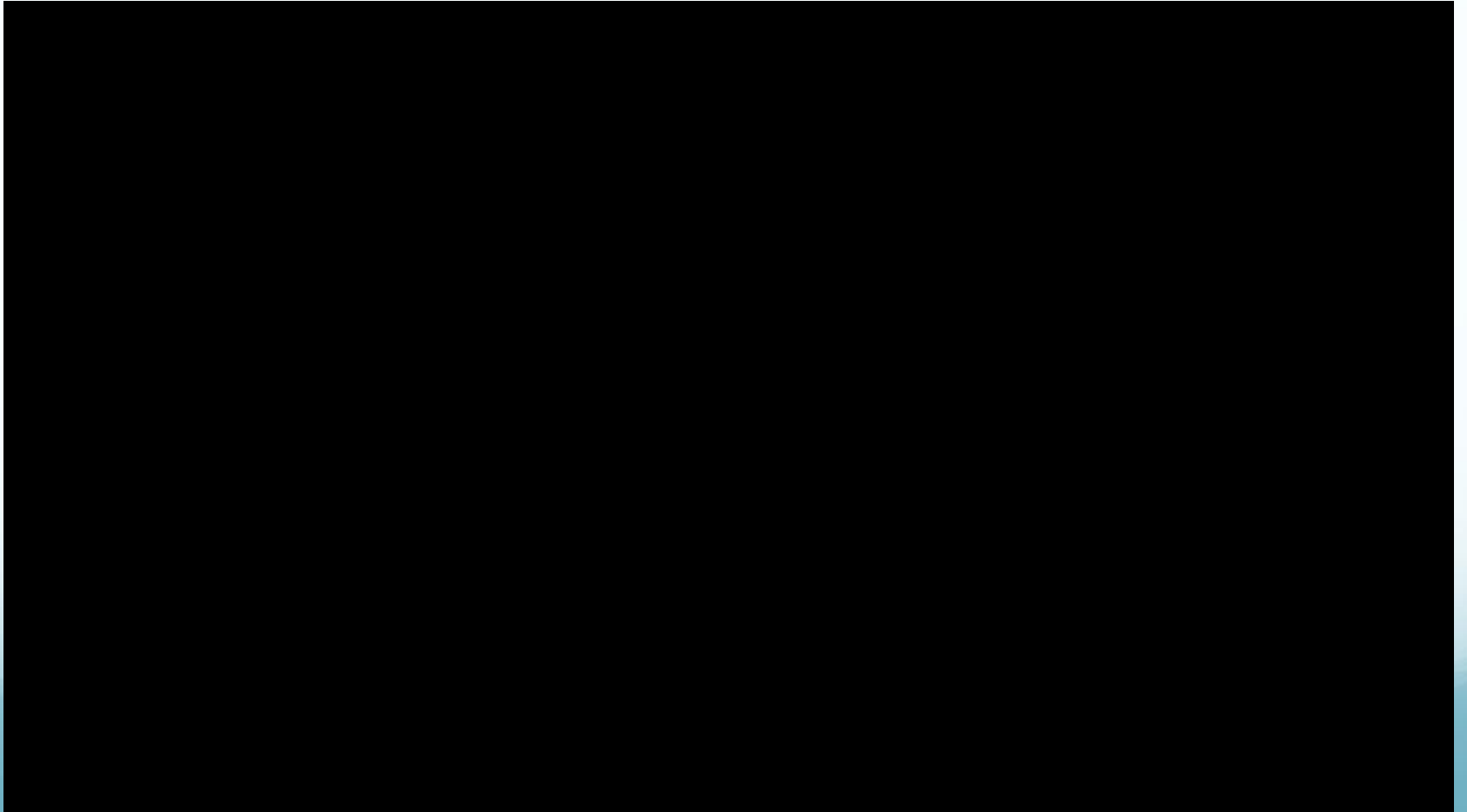
Cryogenic array receiver front end
Amit Vishwas (Cornell) & Mitch



Digital array beamformer back end
Mitch Burnett: Lead Project Engineer

Why do bad things happen
to good projects?

Arecibo Collapse, Dec. 2020



Dealing with Unplanned Setbacks

- Moved ALPACA Project to Green Bank Observatory (GBO)
- After 4 years, GBO withdrew due to current NSF funding uncertainties
- Searched high and low for another host telescope
 - Lots of interest, but ALPACA is too large and heavy for other telescopes
- 8 year long, \$7,000,000 effort could be wasted
- Another option:
 - SETI Institute ground mounted all-sky monitor
 - More on this later

The Wonders of Astronomy Beg Big Questions for Persons of Faith

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How big is God's Plan?

What's out there?

Is it *all* His?

Where do I fit in?

The Milky Way Galaxy

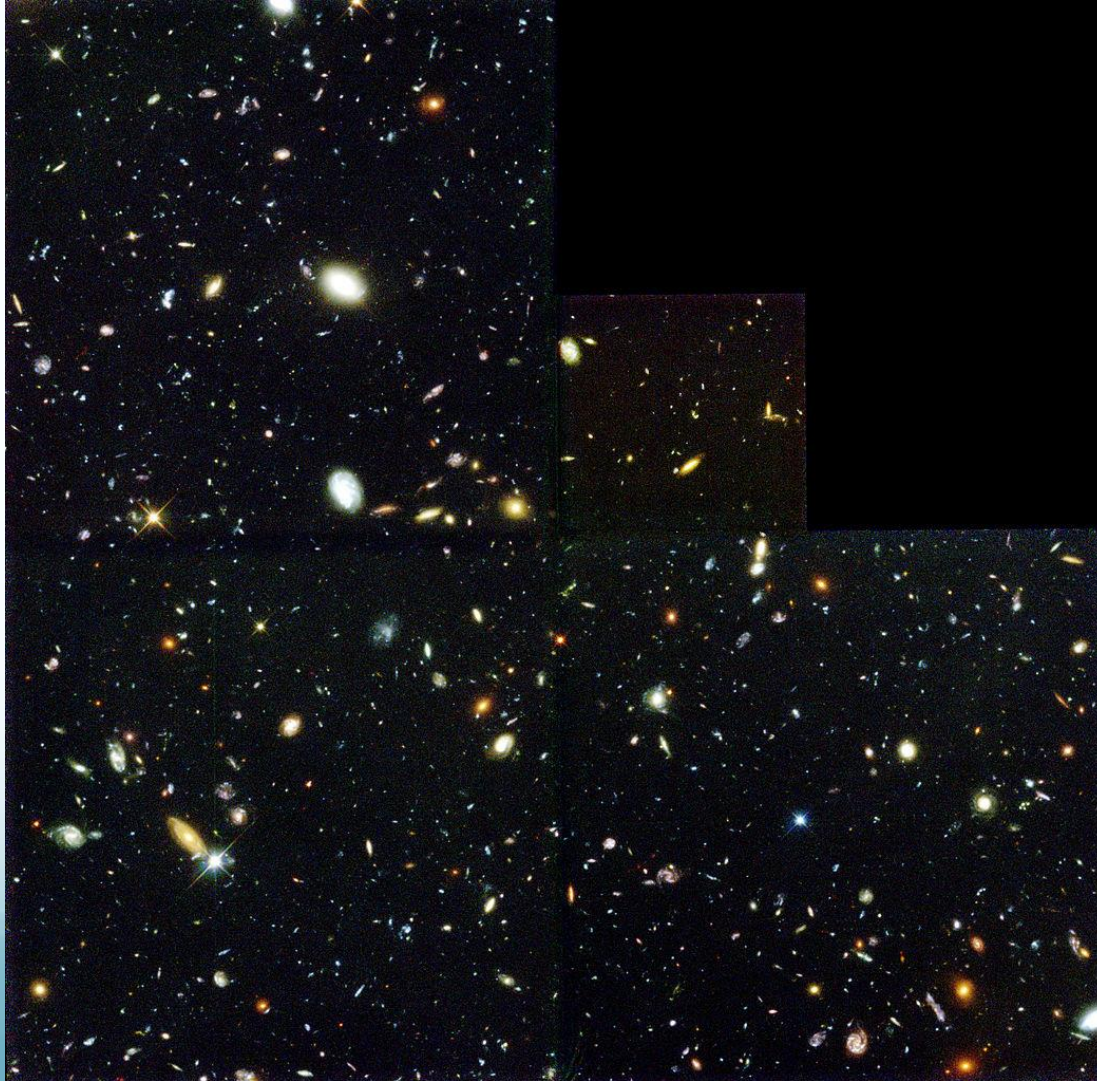


- All stars we can see with the naked eye are in our galaxy
- This is our local home
- 100-400 billion stars
- 100,000+ light years across

The Andromeda Galaxy



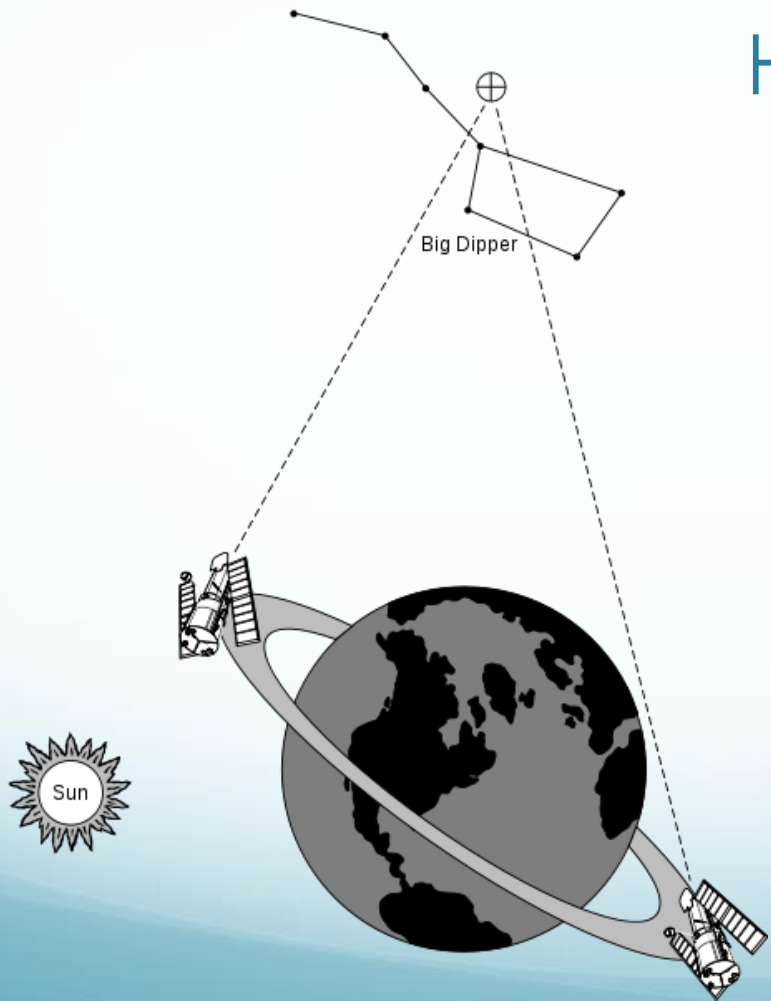
- ❑ Nearest “full sized” galaxy neighbor
- ❑ 2.5 million light years away
- ❑ Spiral galaxy like Milky Way
- ❑ 1 trillion stars (3-10 times more than Milky way)
- ❑ Naked-eye-visible in Northern Hemisphere.



Hubble Deep Field Image

Image credit: NASA, Robert Williams, and the Hubble Deep Field Team (STScI)

Hubble Deep Field Image



- Blank area of sky near the Big Dipper
- No Milky Way stars in the area
- Area the size of a tennis ball at distance of 100m
- 10-day long exposure in 1995
- 3,000 galaxies shown
- Each galaxy contains 100 - 200 billion stars
- Most distant objects are 12.7 billion light years away
- Farthest objects are seen as they were 1 billion years after Big Bang



Hubble Ultra Deep Field Image

Image credit: NASA, ESA,
G. Illingworth, D. Magee,
and P. Oesch, et al

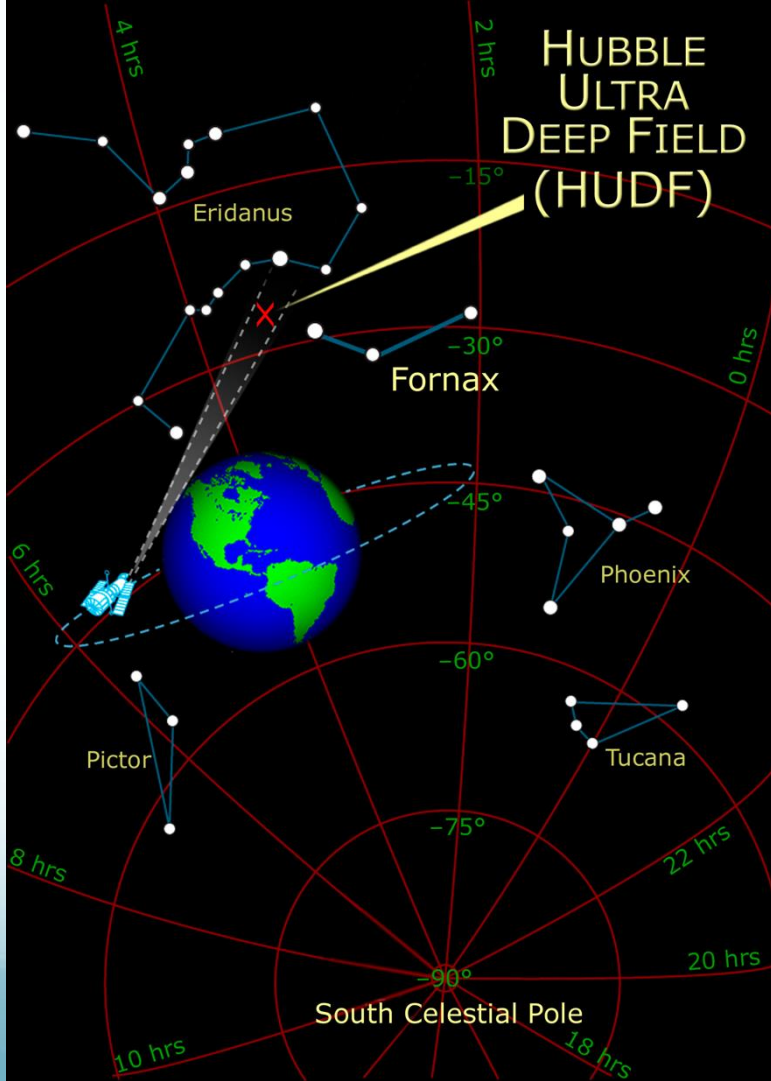
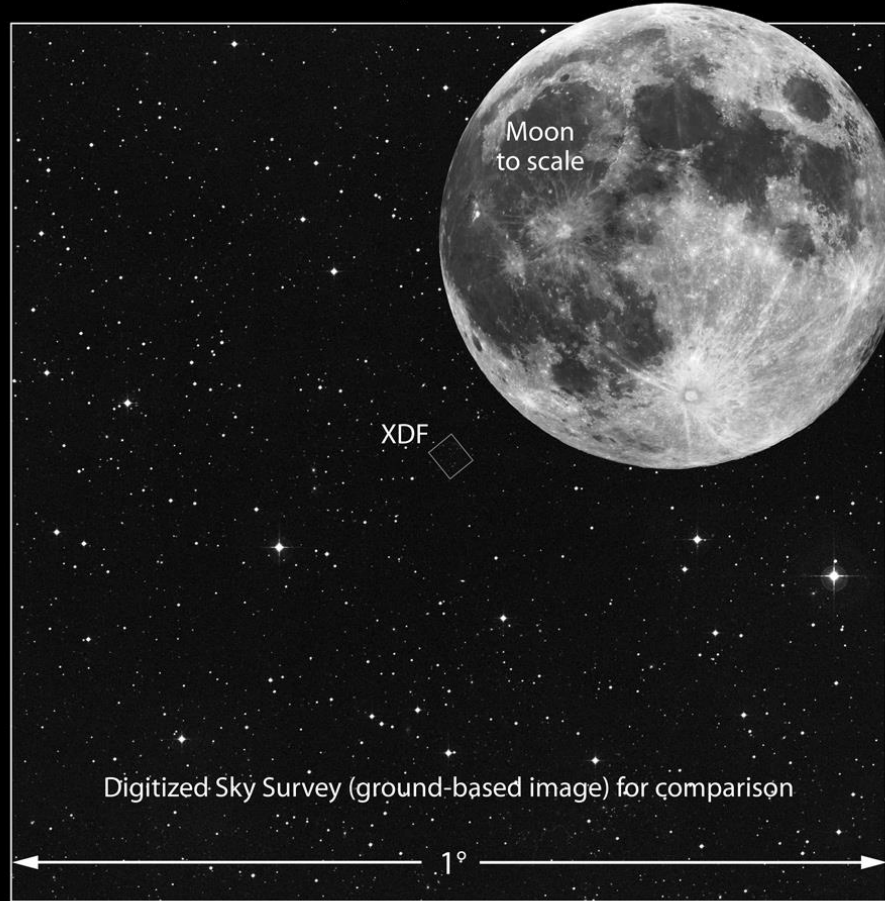


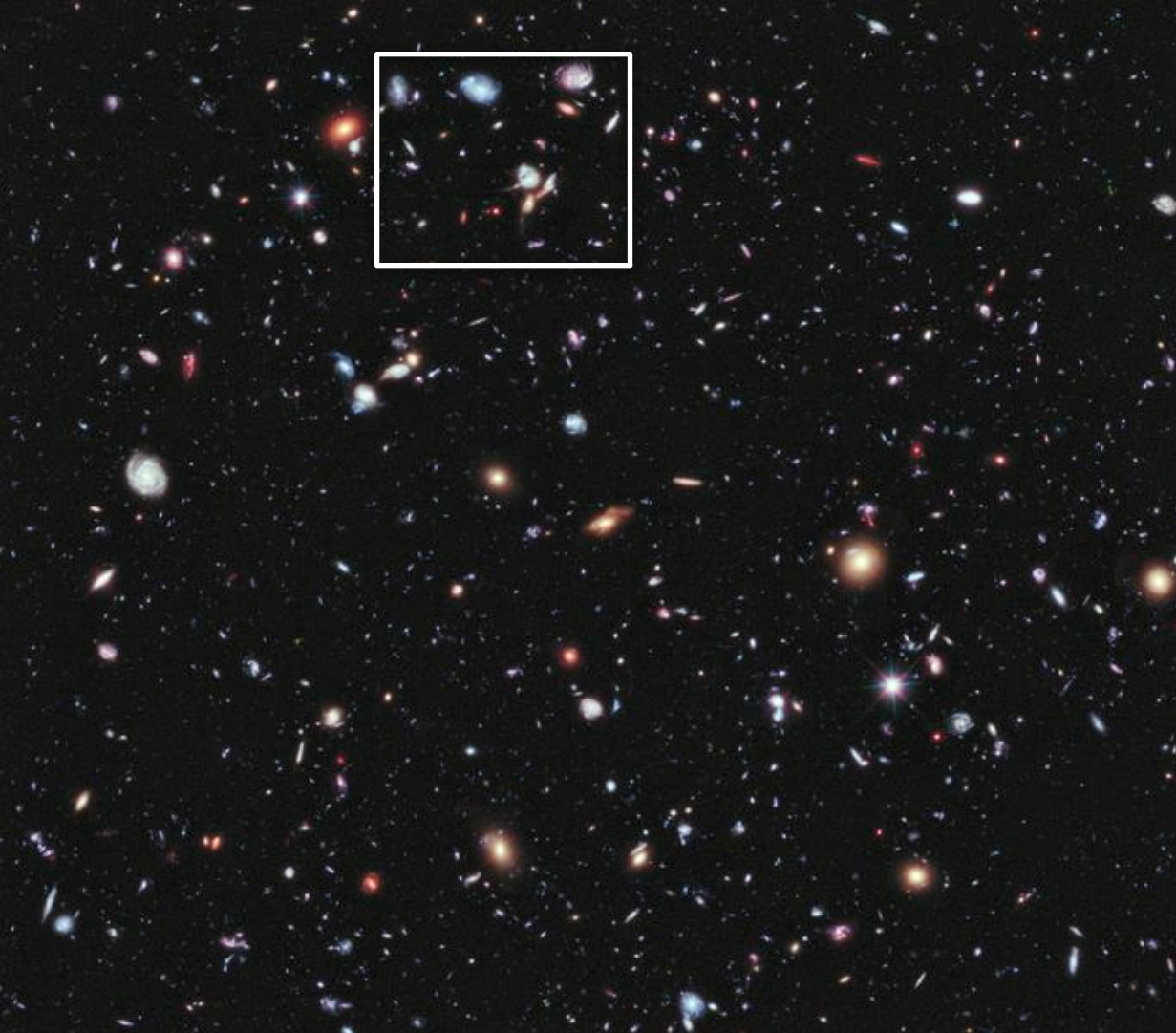
Image
Credit:
NASA

- ❑ Blank area of sky near the constellation Fornax
- ❑ No Milky Way stars in field
- ❑ Area the size of a fraction of the deep field image.
- ❑ 25-day long exposure in 2012
- ❑ 5,500 galaxies shown
- ❑ Each galaxy contains 100 - 200 billion stars
- ❑ Most distant objects are 13.2 billion light years away
- ❑ 500 M years after big

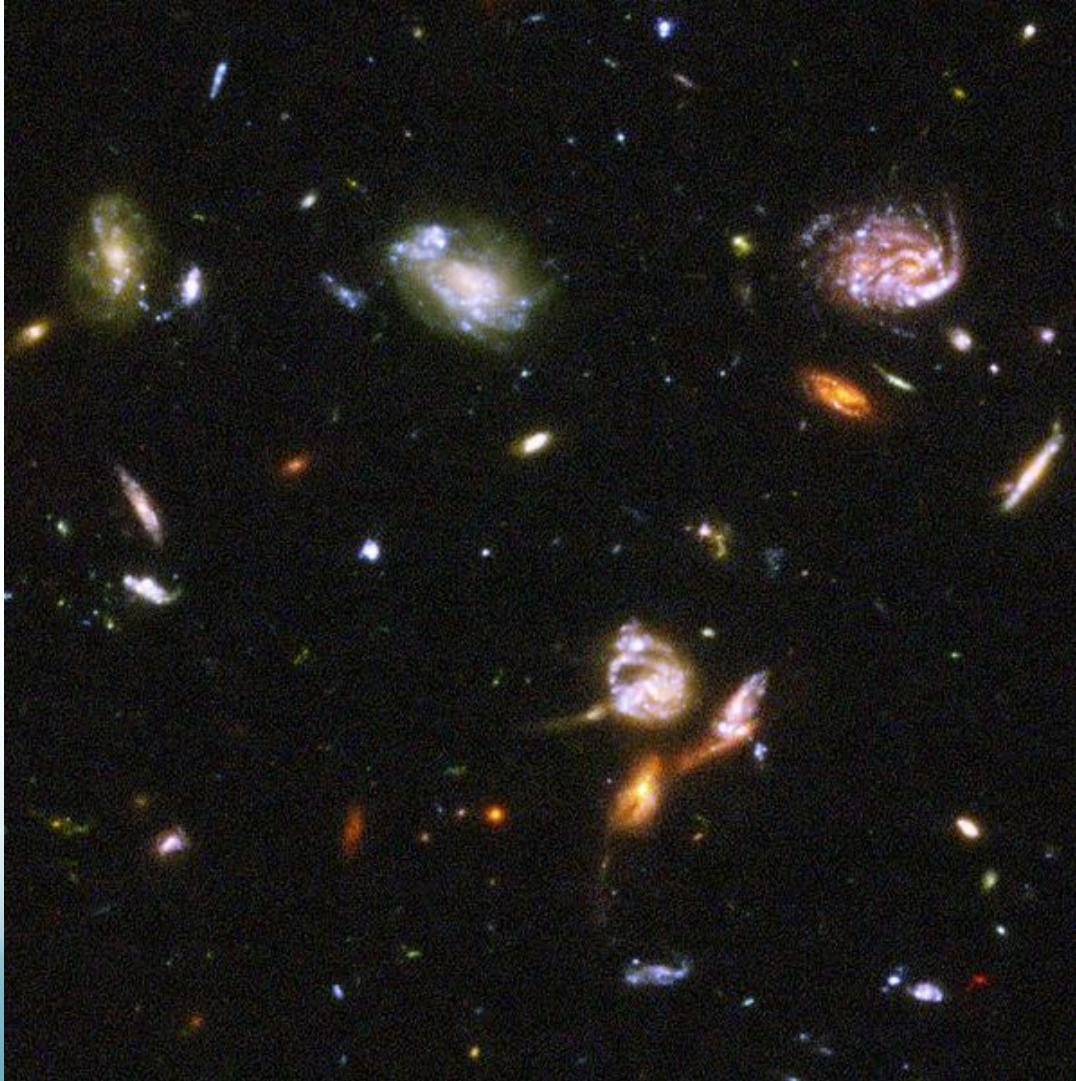
Size of Hubble eXtreme Deep Field on the Sky



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Hubble Ultra Deep Field Image



Hubble Ultra Deep Field Image

- Zoomed in

How big is God's Plan? What's out there? Is this *all* His?

- Hebrews 1:1,2

God, ... Hath in these last days spoken unto us by his Son, whom he hath appointed heir of all things, **by whom also he made the worlds**

How big is God's Plan? What's out there? Is this *all* His?

- Hebrews 1:1,2
- Moses 1:29, 32, 33

And he beheld many lands; and each land was called earth, and there were inhabitants on the face thereof. And by the word of my power, have I created them, which is mine Only Begotten Son, who is full of grace and truth. And **worlds without number have I created;**

How big is God's Plan? What's out there? Is this *all* His?

- Hebrews 1:1,2
- Moses 1:29, 32, 33
- Moses 7:30

And were it possible that man could number the particles of the earth, yea, **millions of earths like this**, it would not be a beginning to the number of thy creations; and thy curtains are stretched out still

How big is God's Plan? What's out there? Is this *all* His?

- Hebrews 1:1,2
- Moses 1:29, 32, 33
- Moses 7:30
- Moses 1:8,10

And Moses beheld the world and the ends thereof, and all the children of men which are, and which were created; of the same he greatly marveled and wondered ... he said unto himself: Now, for this cause
I know that man is nothing, which thing I never had supposed.

How big is God's Plan? What's out there? Is this *all* His?

- Hebrews 1:1,2
- Moses 1:29, 32, 33
- Moses 7:30
- Moses 1:8,10

Anyone feeling humble and insignificant yet?

Where do we fit in? Do we count?

- Psalms 8:3-4

When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained; **What is man, that thou art mindful of him?** and the son of man, that thou visitest him?

Where do we fit in? Do we count?

- Psalms 8:3-4
- Moses 1:12, 13

Satan came tempting him, saying: Moses, son of man, worship me. And ... Moses looked upon Satan and said: Who art thou? ... **I am a son of God, in the similitude of his Only Begotten**; and where is thy glory, that I should worship thee?

Where do we fit in? Do we count?

- Psalms 8:3-4
- Moses 1:12, 13
- Doctrine and Covenants 76:22-24

For we saw him, even on the right hand of God; and we heard the voice bearing record that he is the Only Begotten of the Father— That by him, and through him, and of him, the worlds are and were created, and **the inhabitants thereof are begotten sons and daughters unto God.**

Where do we fit in? Do we count?

- Psalms 8:3-4
- Moses 1:12, 13
- Doctrine and Covenants 76:22-24
- Doctrine and Covenants 84:37,38 & Romans

8:16,17

And he that receiveth me receiveth my Father; And he that receiveth my Father receiveth my Father's kingdom; therefore all that my Father hath shall be given unto him.

Where do we fit in? Do we count?

- Psalms 8:3-4
- Moses 1:12, 13
- Doctrine and Covenants 76:22-24
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Wow, this is big!
These are key “mysteries” of the
Eternities!

SETI Institute Allen Telescope Array



SETI Institute



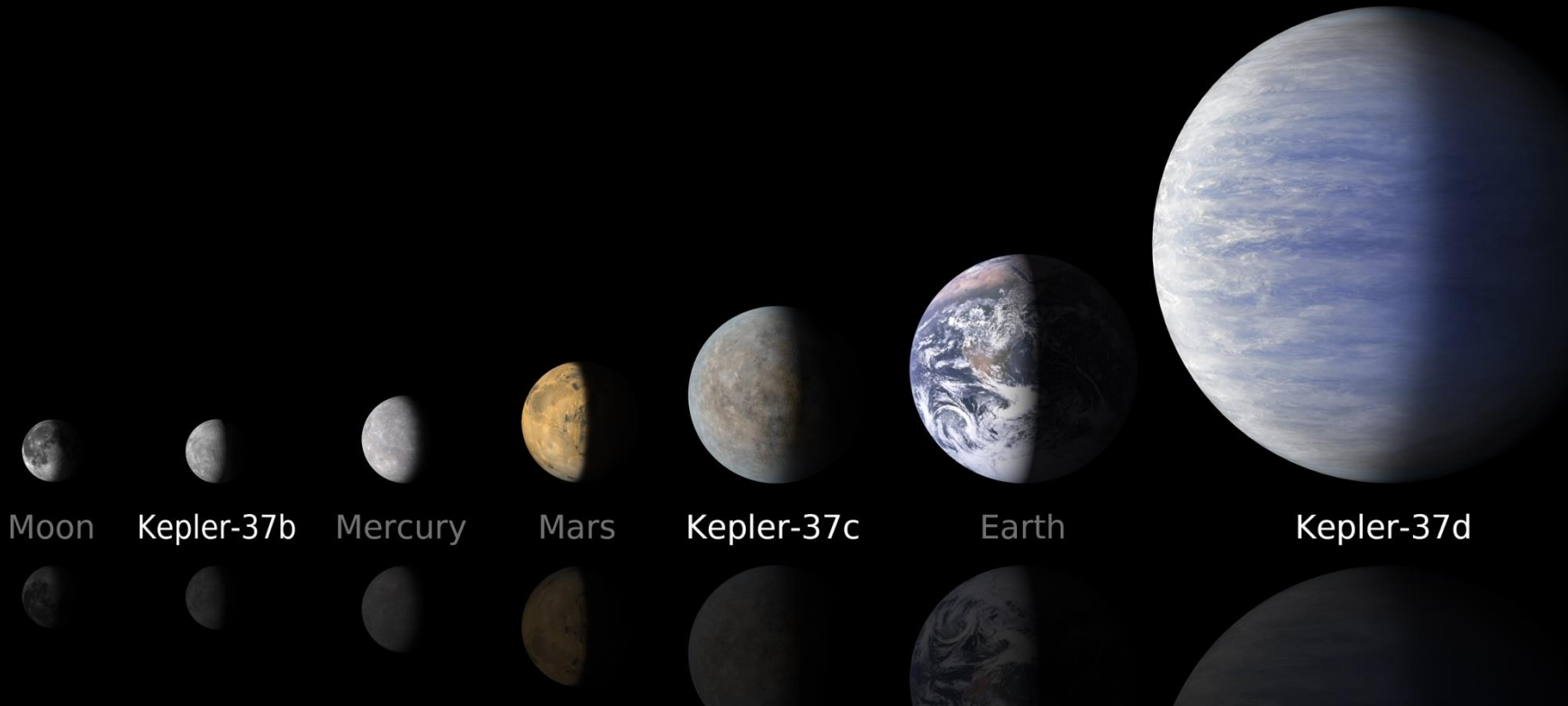
- **The Search for Extra Terrestrial Intelligence**
- **Slogan: “Are we alone? Let’s Find out:
Leading the Search for Life Beyond Earth”**
- **Strategic sky surveys looking for “technosignature” signals**
- **Silicon Valley main campus and remote Hat Creek Radio Observatory (HCRO) with Allen Telescope Array (ATA)**
- **Many SETI receiver instruments installed at world’s leading telescopes**
- **120+ Affiliated scientists**
- **Privately funded, large endowment (\$100M+)**

An Interesting Conversation

- Dr. Gerald Harp, former director of SETI Institute
 - A devout Catholic and believer in Christ
 - A good friend. We met regularly at astronomy conferences
 - Asked me to present as a world-wide broadcast seminar at SETI

An Interesting Conversation

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 - A devout Catholic and believer in Christ
 - A good friend. We met regularly at astronomy conferences
 - Asked me to present as a world-wide broadcast seminar at SETI
- I shared the above scriptures with him, and a triple combination
 - He asked, “when was this written?”
I said, “translated or received by revelation in the 1830s.”
 - He said, “That was very forward thinking of Joseph Smith.”
 - 1832 scientists knew not what galaxies are. No exoplanets known
 - Beginning in 1995, planets have been found orbiting most stars
 - 6,128 confirmed exoplanets, 4,560 planetary systems



Moon

Kepler-37b

Mercury

Mars

Kepler-37c

Earth

Kepler-37d

Kepler-37 is 210 light years away
Image credit: NASA/Ames/JPL-Caltech

ALPACA Delivered to SETI Institute

- Our plan C: System shipped to Hat Creek 3 weeks ago
- Will be a permanent instrument
- Fixed full sky fly's-eye monitor searching for fast radio bursts & technosignature transients
- It's mission: find evidence of ET, our fellow children of God



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- God hears prayers! We have felt God's hand guiding us to find useful work for ALPACA





What is the “take home” message?

- God’s handiwork is unimaginably, incomprehensibly, beautifully, knee bendingly grand!
- You and I matter to God, even as great as He is and even with our failings.
- He created this for us!
“For behold, this is my work and my glory, to bring to pass the immortality and eternal life of man” [Moses 1:39].
- The Atonement of Jesus Christ makes it possible for us to become joint heirs and participate in His work and glory!