

NASA Astrophysics Education and Public Outreach:

Engaging Educators and Students
in Exploring the Cosmic Frontier



Office of Public Outreach
Space Telescope Science Institute





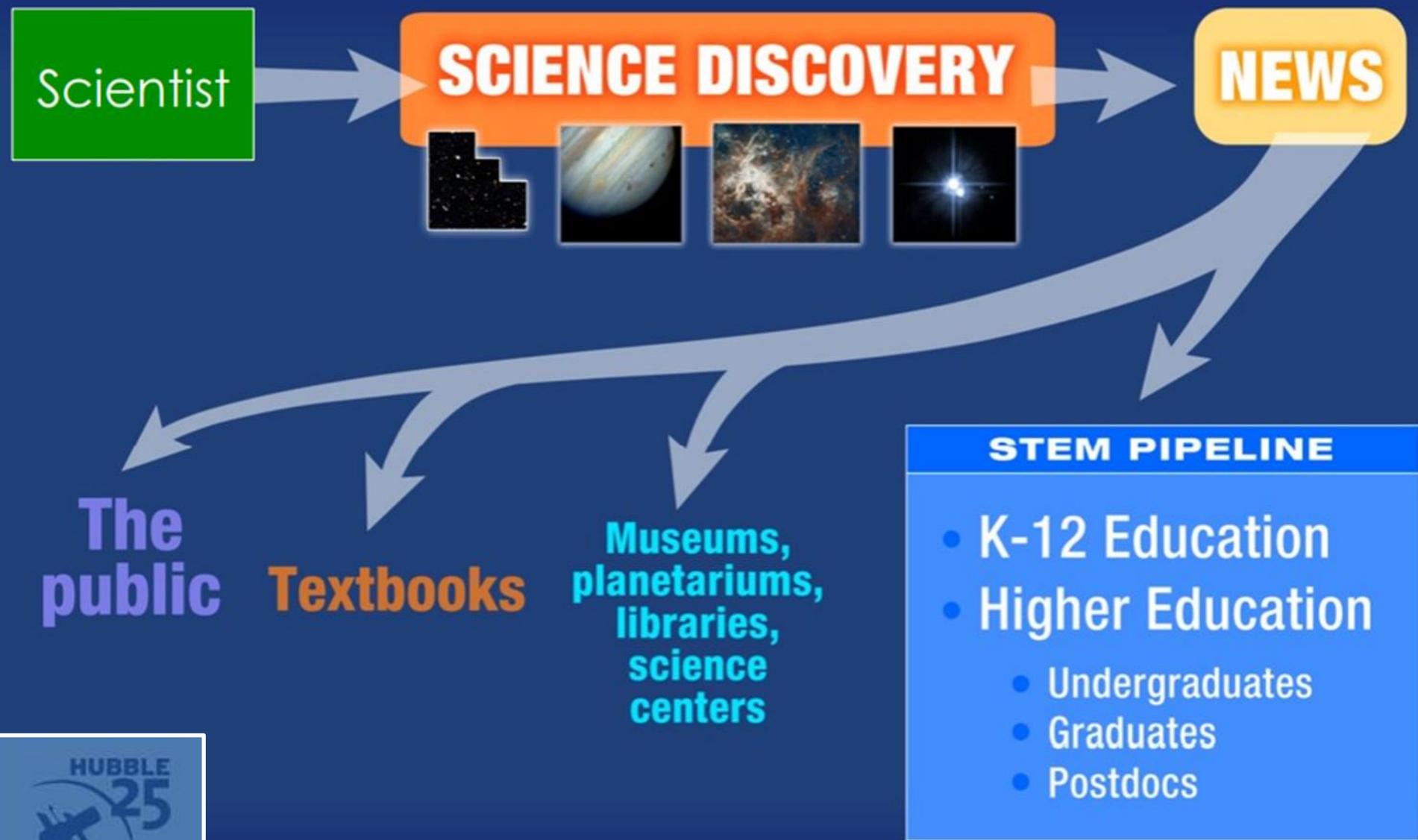
FRONTIER
F I E L D S



Abell 2744



NEWS of DISCOVERIES reaches STUDENTS



Press Releases

NASA's Great Observatories Begin Deepest Ever Probe of the Universe

Introduction **NASA Release** **The Full Story** **Release Images** **Fast Facts** **Related Links**



OCTOBER 24, 2013: NASA's Great Observatories are teaming up to look deeper into the universe than ever before. With a boost from natural "zoom lenses" found in space, they should be able to uncover galaxies that are as much as 100 times farther than what the Hubble, Spitzer, and Chandra space telescopes can typically see. This ambitious collaborative program is called The Frontier Fields.

Astronomers will spend the next three years peering at six massive clusters of galaxies. Researchers are interested not only as to what's inside the clusters, but also what's behind them. The gravitational fields of the clusters brighten and magnify distant background galaxies that are so faint they would otherwise be unobservable.

Despite several deep field surveys, astronomers realized that a lot is still to be learned about the distant universe. And, such knowledge will help in planning the observing strategy for the next-generation space observatory, the James Webb Space Telescope. Join several members of the Frontier Fields collaboration during the live Hubble Hangout event at 4:00pm (ET) on Thursday, October 24 to discuss more on what's to come from these observations, how the clusters were chosen, and what we hope to learn from them. Visit: https://jwst.nasa.gov/content/0/essentials/pdf/presskit/FrntFlds_0313.pdf

See the rest:

- [NASA Press Release](#)
- [The Full Story](#)
- [See All the Images](#)

Oct. 24, 2013

Hubble's First Frontier Field Finds Thousands of Unseen, Faraway Galaxies

Introduction **The Full Story** **Release Images** **Release Videos** **Fast Facts** **Related Links**

An American Astronomical Society Meeting Release



JANUARY 7, 2014: With the help of a natural "zoom lens" in space, Hubble astronomers are looking farther than anyone has before. The ambitious, collaborative, multi-year program among NASA's Great Observatories is called The Frontier Fields. The first of a set of unprecedented, super-deep views of the universe contain images of some of the intrinsically faintest and youngest galaxies ever detected. This is just the first of several primary target fields in the program. The immense gravity in this foreground galaxy cluster, Abell 2744, warps space to brighten and magnify images of far-more-distant background galaxies as they looked over 12 billion years ago, not long after the big bang. The Hubble exposure reveals nearly 3,000 of these background galaxies interwoven with images of hundreds of foreground galaxies in the cluster.

See the rest:

- [The Full Story](#)
- [See All the Images](#)

Jan. 7, 2014

Hubble and Spitzer Space Telescopes Find One of the Youngest Galaxies in the Universe

Introduction **Release Images** **Release Videos** **Fast Facts** **Related Links**

A News Nugget Release



FEBRUARY 7, 2014: An international team led by astronomers from the Instituto de Astrofísica de Canarias (IAC) and La Laguna University (ULL) has just released the first analysis of the observations of the Abell 2744 cluster of galaxies, a coordinated program of the Hubble and Spitzer space telescopes. They have discovered one of the most distant galaxies known to date, which clearly shows the potential of the multi-year Frontier Fields project. The object uses a phenomenon called "gravitational lensing" where distant background galaxy clusters amplify the light from far more distant background objects. By combining Hubble and Spitzer data, these astronomers have determined the properties of this young galaxy with a better precision than previous studies of other samples of similar cosmic epochs. This galaxy, named Abell2744_V1, is about 30 times smaller than our galaxy, the Milky Way, but is producing at least 10 times more stars. From Earth, this galaxy is seen as it was 652 million years after the big bang. It is one of the brightest galaxies discovered at such a lookback time, say researchers. This study provides new constraints on the density and properties of the galaxies in the early universe. These results are accepted for publication in the scientific journal *Astronomy and Astrophysics Letters*.

In addition to the Instituto de Astrofísica de Canarias (IAC) and La Laguna University (ULL), the team is composed of researchers from France (Institut de Recherche en Astrophysique et Planétologie and Centre de Recherche Astrophysique de Lyon), Switzerland (Geneva University and Ecole Polytechnique Fédérale de Lausanne), and the United States (University of Arizona). For more information about these results, visit: <http://www.iac.es/observacion/2014/02/07/Abell2744V1.htm>

See the rest:

- [The Full Story](#)
- [See All the Images](#)

Feb. 7, 2014

Hubble Finds Extremely Distant Galaxy through Cosmic Magnifying Glass

Introduction **The Full Story** **Release Images** **Fast Facts** **Related Links**



OCTOBER 16, 2014: Peering through a giant cosmic magnifying glass, NASA's Hubble Space Telescope has spotted one of the faintest, farthest, and smallest galaxies ever seen. The dimmative object is estimated to be more than 13 billion light-years away. This new detection is considered one of the most reliable distance measurements of a galaxy that existed in the early universe, said the Hubble researchers. Hubble detected the galaxy due to the lensing power of the mammoth galaxy cluster Abell 2744, nicknamed Pandora's Cluster. The cluster is so massive that its powerful gravity bends the light from galaxies far behind it, making the background objects appear larger and brighter in a phenomenon called gravitational lensing.

In this Hubble image, the cluster produced three magnified images of the background galaxy, marked by the small white boxes, labeled "A," "B," and "C." The arrows in the enlarged view point to the tiny galaxy far behind the cluster. Each magnified image makes the galaxy appear as much as 10 times larger and brighter than it would look without the intervening lens. The galaxy was detected as part of the Frontier Fields program, an ambitious three-year effort, begun in 2013, that teams Hubble with NASA's other Great Observatories — the Spitzer Space Telescope and the Chandra X-ray Observatory — to probe the early universe by studying large galaxy clusters.

See the rest:

- [The Full Story](#)
- [See All the Images](#)

Oct. 16, 2014

Hubble Sees 'Ghost Light' From Dead Galaxies

Introduction **The Full Story** **Release Images** **Fast Facts** **Related Links**



OCTOBER 30, 2014: The universe is an infinite sea of galaxies, which are majestic star-cities. When galaxies group together in massive clusters, some of them can be ripped apart by the gravitational tug of other galaxies. It's a giant cosmic mosh pit. Astronomers using the Hubble Space Telescope to probe the massive galaxy cluster Abell 2744 — nicknamed Pandora's Cluster — have found forensic evidence of galaxies torn apart long ago. It's in the form of a phantom-like faint glow filling the space between the galaxies. This glow comes from stars scattered into intergalactic space as a result of a galaxy's disintegration.

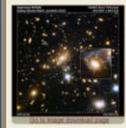
See the rest:

- [The Full Story](#)
- [See All the Images](#)

Oct. 30, 2014

Hubble Sees Supernova Split into Four Images by Cosmic Lens

Introduction **The Full Story** **Release Images** **Release Videos** **Fast Facts** **Related Links**



MARCH 5, 2015: Three-leaf clover plants abound everywhere — on lawns, in gardens, and in forests. But spotting a four-leaf clover is a rare, lucky find. Astronomers using the Hubble Space Telescope have found the equivalent of a four-leaf clover with the discovery of four images of the same supernova. The images are arranged around a giant foreground elliptical galaxy embedded in a cluster of galaxies. The arrangement forms a cross-shaped pattern called an Einstein Cross. The powerful gravity from both the elliptical galaxy and its galaxy cluster magnifies the light from the supernova behind them in an effect called gravitational lensing. The elliptical galaxy and its galaxy cluster, MACS J1148.0+2223, are 5 billion light-years away from Earth. The supernova behind it is 12.5 billion light-years away.

Once the four images fade away, astronomers predict they will have a rare opportunity to watch a re-run of the supernova's appearance. Computer models of the cluster predict that another image of the stellar blast will appear within five years. Astronomers may have missed an earlier appearance of the supernova in 1960. These multiple appearances of the exploding star are due to the various paths its divided light is taking through the maze of clumpy dark matter in the galactic grouping. Each image takes a different route through the cluster and arrives at a different time, due, in part, to differences in the length of the pathways the light follows to reach Earth.

Join Hubble astronomers during the live Hubble Hangout discussion at 3pm EST on Thurs., March 5, to learn still more. Visit: <https://www.youtube.com/watch?v=5e273388Xt0>

See the rest:

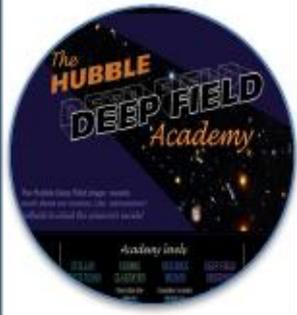
- [The Full Story](#)
- [See All the Images](#)

March 5, 2015



OPO EDUCATION PROGRAM

We bring the universe to the formal and informal education communities, and engage educators and students in the adventure of scientific discovery.



Standards-based Curriculum Support Tools (online, hardcopy & mobile platform)



Professional Development



Student Activities



Exhibits & Standards-based Exhibit Support Materials



Interns/Externs



Education Community Support & Community Events

Unique Content, Educator-Scientist Teams, Research-based, Evaluation (internal/external), Partnerships, Diversity

Formal Education

Science Content Reading

Star Witness News

Science content reading articles that deliver the latest Hubble discoveries to younger readers

National Aeronautics and Space Administration 

THE STAR WITNESS

A PUBLICATION OF NASA'S "AMAZING SPACE" EDUCATION PROGRAM

Special Feature

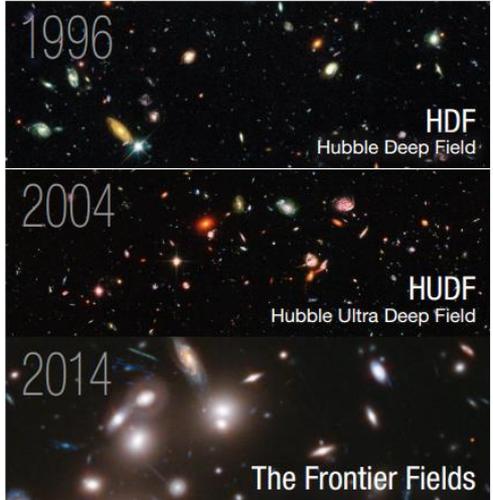
Frontier Fields: Hubble Goes Deep

By NASA's Amazing Space reporters
January 2014

ASTRONOMERS MADE a bold move in the mid-1990s, using the Hubble Space Telescope to stare at a seemingly vacant patch of sky.

Their efforts paid off. Looking deeper into space than ever before, Hubble uncovered 3,000 galaxies. The light from many of these galaxies had traveled for billions of years, meaning that Hubble sees them as they were billions of years ago. Looking deeper into space is also seeing farther back in time. The observations, called the Hubble Deep Field (HDF), gave astronomers a glimpse of galaxies in the early universe.

Astronomers, however, wanted more: more deep fields, more directions on the sky, and more distant galaxies that would help them understand how galaxies grow and change over time. They took



Going deeper in 2014: The Hubble Deep Field and the Hubble Ultra Deep Field are two of Hubble's famous deep views from the past. Astronomers in 2014 are starting to exploit clever ways to look back even farther with Hubble.

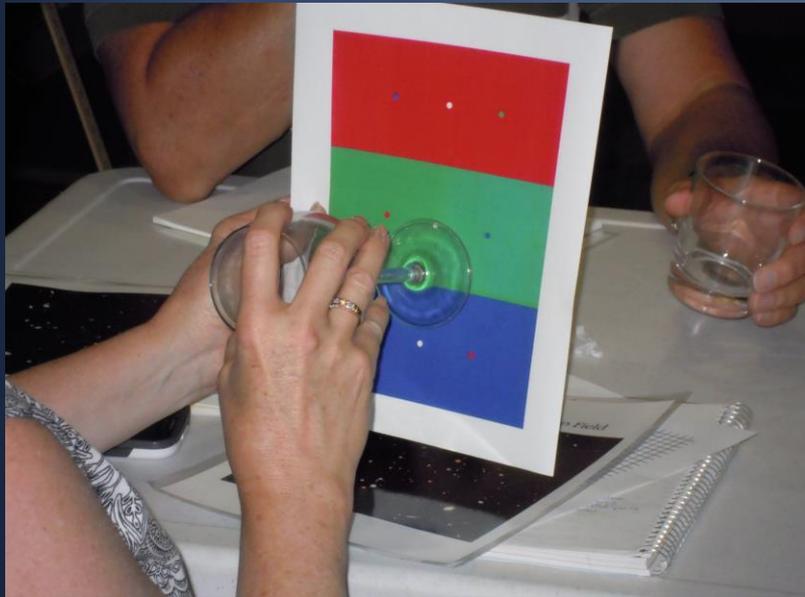
Continued, page 3...

www.nasa.gov

Formal Education

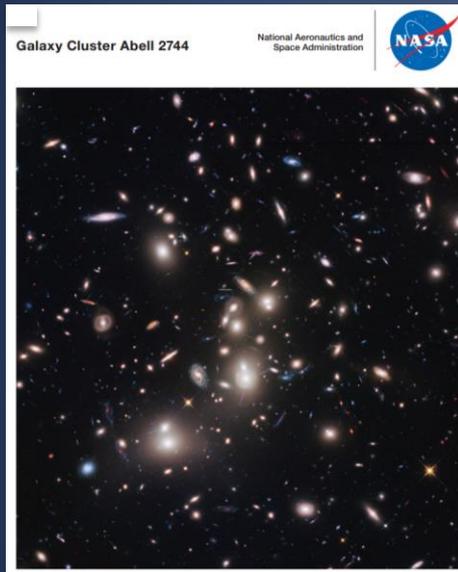
Educator Professional Development

Pennsylvania Educators Workshop



Formal Education

Curriculum Support Materials



Lithograph



Poster



THE FRONTIER FIELDS PROJECT IS EXPLORING THE MOST Distant AND EARLIEST GALAXIES EVER SEEN BY THE Hubble SPACE TELESCOPE, PROVIDING A SNEAK PEEK AT THE FIRST BILLION YEARS OF THE UNIVERSE.

Galaxy Cluster Abell 2744 Research Activity

Galaxy Cluster Abell 2744

Gravitational Lensing: Bending Light Using Mass Instead of Glass

Edwin Hubble Expands the Universe

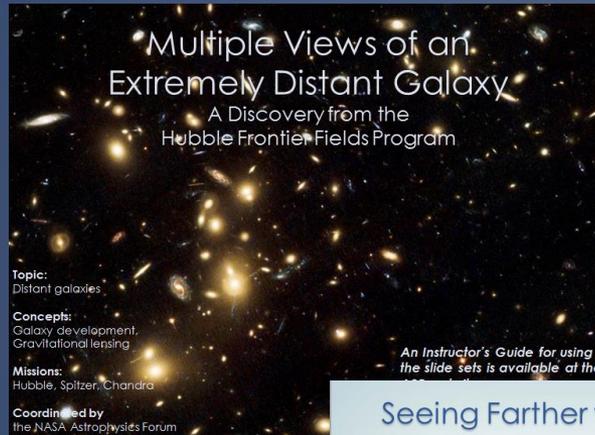
Embarking on a Journey to the Deep

Hubble's Views of the Parallel Fields

HUBBLE SPACE TELESCOPE

Formal Education

Higher Education Materials: Astro101 slide-sets



Multiple Views of an Extremely Distant Galaxy
A Discovery from the Hubble Frontier Fields Program

Topic:
Distant galaxies

Concepts:
Galaxy development,
Gravitational lensing

Missions:
Hubble, Spitzer, Chandra

Coordinated by:
the NASA Astrophysics Forum

An Instructor's Guide for using the slide sets is available at the

The Frontier Fields

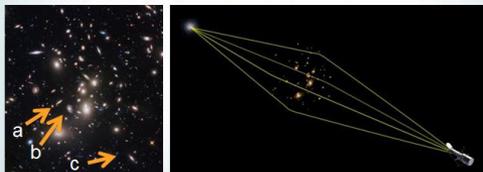
- NASA's three Great Observatories – the Hubble Space Telescope, the Spitzer Space Telescope, and the Chandra X-ray Observatory – have teamed up on an ambitious project to study the distant universe.
- The Frontier Fields project is deeply observing six massive galaxy clusters, looking for extremely distant galaxies that have been gravitationally lensed.
- The project is also observing six new (non-cluster) deep fields to improve our statistical sample of the distant and early universe.
- Other science from the Frontier Fields project include detailed mapping of the mass distributions in the galaxy clusters and searches for supernova explosions in distant galaxies.



The three NASA Great Observatories participating

Seeing Farther with Cosmic Lenses

- Einstein's general relativity describes how mass warps space.
- A massive cluster of galaxies can warp space enough to bend light that passes through it, thus acting like a giant lens in space.
- The light from a distant galaxy can be distorted, magnified, and split into multiple images by the galaxy cluster.
- Without the help of "gravitational lensing", this newly discovered extremely distant galaxy is too faint for Hubble to observe.



On the left is the Hubble image of galaxy cluster Abell 2744. The three arrows point out where the images of the extremely distant galaxy were observed. On the right is an illustration of gravitational lensing by a galaxy cluster. The light from a distant galaxy is re-directed by the warped space around the cluster.

NASA Astrophysics Forum

For more info on the Astro 101 slide sets
see Poster DCp.1.09 (James G. Manning)

Informal Education

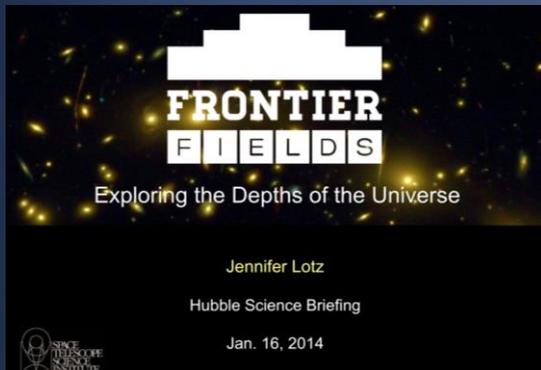
Viewspace



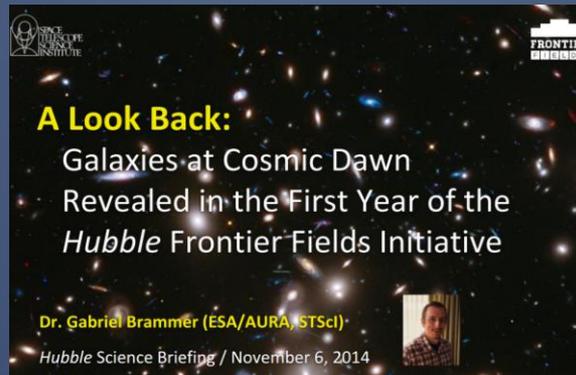
An Internet-fed, self-updating, multimedia exhibit that features the latest images and digital animations from earth and space science as well as interpretive text

Informal Education

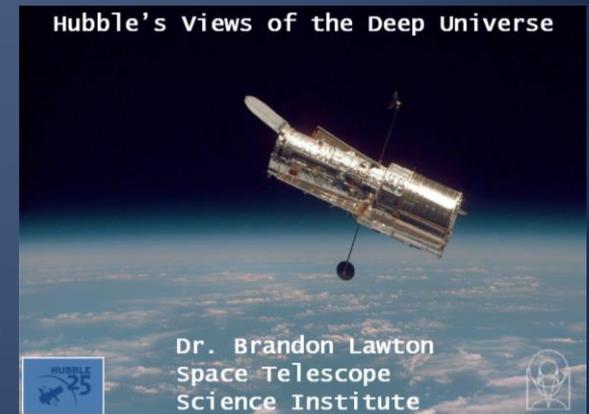
Science Briefings: NASA Museum Alliance & Night Sky Network



PI Jennifer Lotz



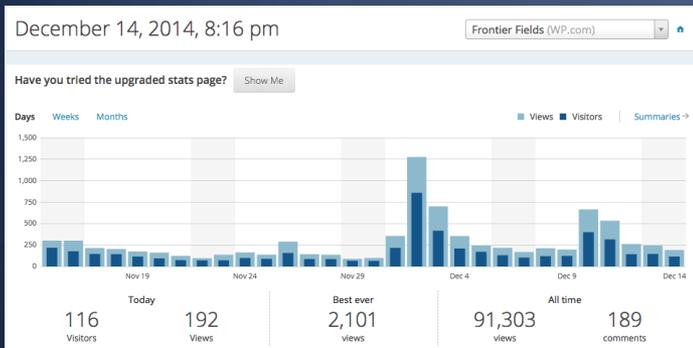
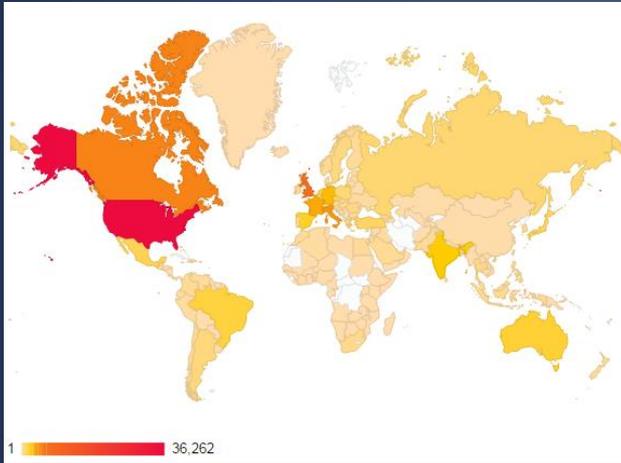
Gabriel Brammer



Brandon Lawton

Outreach

Blog for the General Public



Stats:

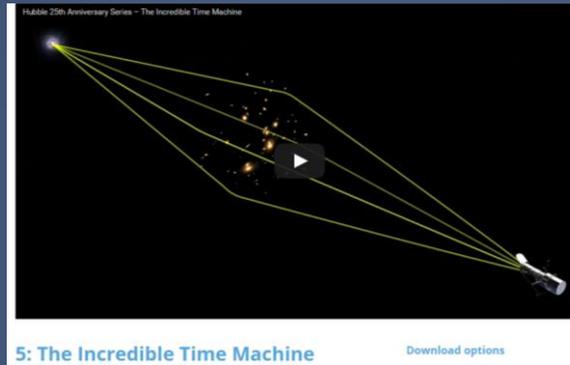
- 7 authors
- 49 posts
- > 80,000 visitors
- > 135,000 views
- 85 comments
- > 150 countries viewed FF blog

Outreach

HST 25th Anniversary Website:
<http://hubble25th.org/>



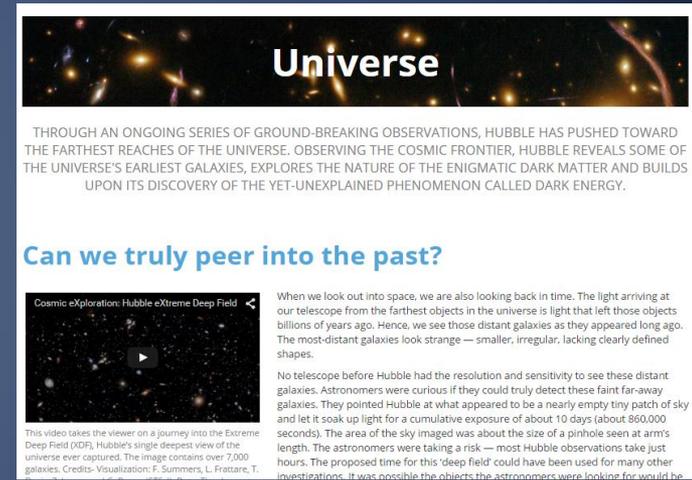
Abell 2744 Frontier Field



5: The Incredible Time Machine

Download options

Video Gallery



Universe

THROUGH AN ONGOING SERIES OF GROUND-BREAKING OBSERVATIONS, HUBBLE HAS PUSHED TOWARD THE FARTHEST REACHES OF THE UNIVERSE. OBSERVING THE COSMIC FRONTIER, HUBBLE REVEALS SOME OF THE UNIVERSE'S EARLIEST GALAXIES, EXPLORES THE NATURE OF THE ENIGMATIC DARK MATTER AND BUILDS UPON ITS DISCOVERY OF THE YET-UNEXPLAINED PHENOMENON CALLED DARK ENERGY.

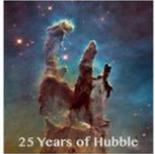
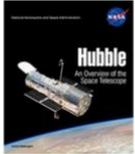
Can we truly peer into the past?

When we look out into space, we are also looking back in time. The light arriving at our telescope from the farthest objects in the universe is light that left those objects billions of years ago. Hence, we see those distant galaxies as they appeared long ago. The most-distant galaxies look strange — smaller, irregular, lacking clearly defined shapes.

No telescope before Hubble had the resolution and sensitivity to see these distant galaxies. Astronomers were curious if they could truly detect these faint far-away galaxies. They pointed Hubble at what appeared to be a nearly empty tiny patch of sky and let it soak up light for a cumulative exposure of about 10 days (about 860,000 seconds). The area of the sky imaged was about the size of a pinhole seen at arm's length. The astronomers were taking a risk — most Hubble observations take just hours. The proposed time for this "deep field" could have been used for many other investigations. It was possible the objects the astronomers were looking for would be

Image Gallery

Science Articles

			
<p>A Quarter-Century of Discovery with the Hubble Space Telescope</p> <ul style="list-style-type: none"> • ePUB 3 219 MB • Interactive PDF 189 MB 	<p>Hubble 25th Anniversary Commemorative Slides (for higher education instructors to present to the general public)</p> <ul style="list-style-type: none"> • PowerPoint 28.4 MB • PDF 27.1 MB • PDF (slides and notes) 53.4 MB 	<p>25 Years of Hubble Presentation</p> <ul style="list-style-type: none"> • PowerPoint 27.4 MB • PDF 30.7 MB • PDF (slides and notes) 5.42 MB 	<p>Hubble: An Overview of the Space Telescope</p> <ul style="list-style-type: none"> • Fixed-layout EPUB 9.58 MB • Fixed-layout MOBI (for Kindle Fire) 38.4 MB • Fixed-layout PDF 29.8 MB

Presentations & ebooks

Thank You!

The logo for Frontier Fields consists of a stylized grey bar at the top with a stepped, pixelated appearance. Below it, the word "FRONTIER" is written in a bold, white, sans-serif font. Underneath "FRONTIER", the word "FIELDS" is written in a white, sans-serif font, with each letter contained within its own grey rectangular box.

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Press Releases:

<http://hubblesite.org/newscenter/>

Education:

<http://amazing-space.stsci.edu/>

Blog:

<http://frontierfields.org/>

NASA Wavelength:

<http://nasawavelength.org/>

