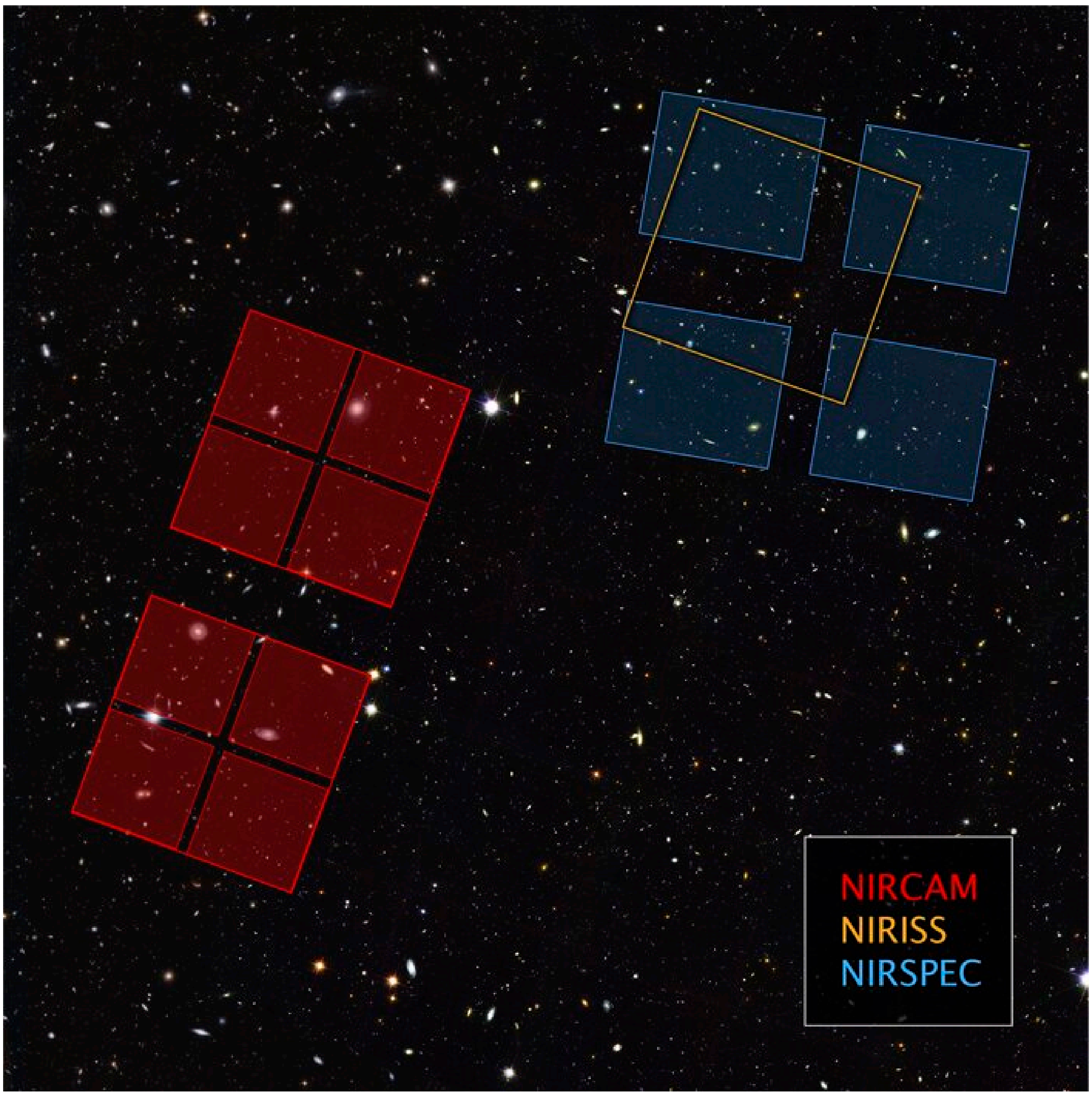
NASA's Webb to uncover riches of the early universe

June 22 2022, by Jamie Adkins



This image shows where the James Webb Space Telescope will observe the sky within the Hubble Ultra Deep Field, which consists of two fields. The Next Generation Deep Extragalactic Exploratory Public (NGDEEP) Survey, led by Steven L. Finkelstein, will point Webb's Near-Infrared Imager and Slitless Spectrograph (NIRISS) on the primary Hubble Ultra Deep Field (shown in orange), and Webb's Near-Infrared Camera (NIRCam) on the parallel field (shown in red). The program led by Michael Maseda will observe the primary field (shown in blue) using Webb's Near-Infrared Spectrograph (NIRSpec). Credit: SCIENCE: NASA, ESA, Anton M. Koekemoer (STScI) ILLUSTRATION: Alyssa Pagan (STScI)

For decades, telescopes have helped us capture light from galaxies that formed as far back as 400 million years after the big bang—incredibly early in the context of the universe's 13.8-billion-year history. But what were galaxies like that existed even earlier, when the universe was semi-transparent at the beginning of a period known as the Era of Reionization? NASA's next flagship observatory, the James Webb Space Telescope, is poised to add new riches to our wealth of knowledge not only by capturing images from galaxies that existed as early as the first few hundred million years after the big bang, but also by giving us detailed data known as spectra. With Webb's observations, researchers will be able to tell us about the makeup and composition of individual galaxies in the early universe for the first time.

The Next Generation Deep Extragalactic Exploratory Public (NGDEEP) Survey, co-led by Steven L. Finkelstein, an associate professor at the University of Texas at Austin, will target the same two regions that make up the Hubble Ultra Deep Field—locations in the constellation Fornax where Hubble spent more than 11 days taking deep exposures. To produce its observations, the Hubble Space Telescope targeted nearby areas of the sky simultaneously with two instruments—slightly offset from one another—known as a primary and a parallel field. "We have the same advantage with Webb," Finkelstein explained. "We're using two science instruments at once, and they will observe continuously." They will point Webb's Near-Infrared Imager and Slitless Spectrograph (NIRISS) on the primary Hubble Ultra Deep Field, and Webb's Near-Infrared Camera (NIRCam) on the parallel field, getting twice the bang for their "buck" of telescope time.

For the imaging with NIRCam, they'll observe for over 125 hours. With each passing minute, they'll obtain more and more information from deeper and deeper in the universe. What do they seek? Some of the earliest galaxies that formed. "We have really good indications from Hubble that there are galaxies in place at a time 400 million years after the big bang," Finkelstein said. "The ones we see with Hubble are pretty big and very bright. It's highly likely there are smaller, fainter galaxies that formed even earlier that are waiting to be found."

This program will use only about one-third of the time Hubble has spent to date on similar investigations. Why? In part, this is because Webb's instruments were designed to capture infrared light. As light travels through space toward us, it stretches into longer, redder wavelengths due to the expansion of the universe. "Webb will help us push all the boundaries," said Jennifer Lotz, a coinvestigator on the proposal and director of the Gemini Observatory, part of the National Science Foundation's NOIRLab (National Optical-Infrared Astronomy Research Laboratory). "And we're going to release the data immediately to benefit all researchers."

These researchers will also focus on identifying the metal content in each galaxy, especially in smaller and dimmer galaxies that haven't yet been thoroughly examined—specifically with the spectra Webb's NIRISS instrument delivers. "One of the fundamental ways that we trace evolution across cosmic time is by the amount of metals that are in a galaxy," explained Danielle Berg, an assistant professor at the University of Texas at Austin and a co-investigator on the proposal. When the universe began, there was only hydrogen and helium. New elements were formed by successive generations of stars. By cataloging the contents of each galaxy, the researchers will be able to plot out precisely when various elements existed and update models that project how galaxies evolved in the early universe.

Peeling Back New Layers

Another program, led by Michael Maseda, an assistant professor at the University of Wisconsin-Madison, will examine the primary Hubble Ultra Deep Field using the microshutter array within Webb's Near-Infrared Spectrograph (NIRSpec). This instrument returns spectra for specific objects depending on which miniature shutters researchers open. "These galaxies existed during the first billion years in the history of the universe, which we have very little information about to date," Maseda explained. "Webb will provide the first large sample that will give us the chance to understand them in detail."

We know these galaxies exist because of extensive observations this team has made—along with an international research team—with the ground-based Very Large Telescope's Multi Unit Spectroscopic Explorer (MUSE) instrument. Although MUSE is the "scout," identifying smaller, fainter galaxies in this deep field, Webb will be the first telescope to fully characterize their chemical compositions.

These extremely distant galaxies have important implications for our understanding of how galaxies formed in the early universe. "Webb will open a new space for discovery," explained Anna Feltre, a research fellow at the National Institute for Astrophysics in Italy and a co-investigator. "Its data will help us learn precisely what happens as a galaxy forms, including which metals they contain, how quickly they grow, and if they already have black holes."

This research will be conducted as part of Webb's General Observer (GO) programs, which are competitively selected using a dual-anonymous review, the same system that is used to allocate time on the Hubble Space Telescope.

Provided by NASA's Goddard Space Flight Center