Blueshift - August 14, 2009

Maggie: Welcome to Blueshift, the podcast from the Astrophysics Science Division at NASA's Goddard Space Flight Center. I'm Maggie Masetti.

What image first comes to mind when you think of the Hubble Space Telescope? The great multi-colored eye of the Helix Nebula? Or the vast dusty columns of the so-called "Pillars of Creation"? Maybe it's the Ultra Deep Field, full of far-flung galaxies at the very limit of Hubble's vision.

Francis Reddy takes us on a behind-the-scenes look at another famous Hubble image.

Frank: In January 2006, astronomers revealed a ginormous mosaic of the famous Orion Nebula from the Hubble Space Telescope. Three-and-a-half years later, astronomers continue to mine that data. One result -- a dramatic simulated fly-through of the nebula -- will play on an IMAX screen near you in 2010. But I'm getting ahead of myself.

The story begins in 2003, when Massimo Roberto at the Space Telescope Science Institute in Baltimore decided a newly upgraded Hubble should tackle the Orion Nebula in a big way. What's so special about Orion?

Massimo: It's one of the most important star forming regions, so it's one of the places where we can more clearly understand how star formation goes. What makes Orion special in particular is the fact that, in Orion, we see the full range of stars. And the big stars play the major roll because they emit a lot of ultraviolet light and the ultraviolet light is a major influence on the circumstellar environment. The result of these big stars is that they are actually carving the nebula called dust in which the stars form. For all these reasons, the Orion Nebula is the place to go for understanding star formation.

Frank: And what's so special about Hubble?

Massimo: Hubble is needed in particular because the fact that there is this very bright background, which is the nebula itself, makes observations from the ground, from the Earth, especially hard because you get a lot of background light. So there are special reasons to see with the Hubble not only because you see better but because you go fainter. There's always this combination of sensitivity and resolution that make the telescope unique.

Orion is only one million years old. We have two, three thousand young stars, more or less all of the same age. If we could make a census, things like that could tell us information about how star formation proceeds in Orion.

Frank: While previous Hubble observations had focused on the material that surrounded stars in the Orion Nebula, Roberto wanted to study the young stars themselves. So, in 2003, he and a group of experts worked up a detailed plan to map the nebula over more than 200 Hubble orbits.

Whether or not a proposal results in telescope time is determined by a panel that weighs the science case against the amount of time required. Only about one in ten proposals wins.

Massimo: So the proposal I know was highly ranked, but eventually they could not give us time because of its size, basically. The science was strong, but there were other projects in completely different areas that were also big. Also there was at the time a much smaller proposal but by another team, a competing team, that also targeted Orion in a much simpler way. We wanted everything they wanted, just one thing. So the panel said, well, for this cycle, for 2003, we think we'll go with the small one, but this is a very strong case, maybe you'll want to apply again, but think about making things a little bit less fancy and reduce the size.

Frank: The original plan called for many images using short exposures so Hubble could capture bright stars without overexposing them. But this is a very inefficient way to use Hubble. It takes as much time to read image data for a 10 second image as it does for a much longer exposure. Besides, bright stars can be imaged almost as well using telescopes on the ground.

Massimo: We accepted this sacrifice, so to say. But we killed 50 percent of the time and the program then was much more targeted to the same stuff that cannot be certainly done from the ground no matter what you do. And it was even stronger. And what I heard, the program was ranked the best in the hundreds that were proposed. And I said to my mother in Italy, "I won what the World Cup of astronomy, at least of Hubble astronomy."

Frank: Now, the team has to work out all of the specific details of the observation. When will the telescope observe? With what filters? In what orientation?

Massimo: And this is why, really, weeks of work with the software tools, here at the Space Telescope Science Institute. We squeezed our observations leaving one second of time unused per orbit.

Frank: And so, between October 2004 and April 2005, Hubble repeatedly turned to the Orion Nebula and captured data with three instruments. Only the images from the Advanced Camera for Surveys, or ACS, were included in the publicly released mosaic. What's it like when the images start arriving?

Massimo: It's really something. You call your colleagues, your co-investigators, your start posting on your door… Basically there is an army, a marching army of people that start immediately working, reducing the data, cleaning, doing all of the processing needed.

Frank: Every image from Hubble was actually black and white. The images for each filter were combined into individual mosaics and included ground-based data taken from Chile to fill it out the square picture and include the bright stars. Finally, each of these mosaics was assigned a color and combined to create the final, glorious four-color image.

Massimo: The nominal ACS image is 4,000 by 4,000 pixels, so it's a 16-megapixel image. Each pixel has its own personality and we can characterize the type of problem that a pixel may have. In our case only with ACS we had 520 images. Then you start really having gigabytes of space. The mosaic with ACS came out to be so large 30,000 by 30,000, which is a one-terapixel image, that we could not handle it with the machines that we had. So we needed to cut the mosaic in chunks of still-pretty-huge 14,000 by 13,000 pixels.

Frank: A picture may make a thousand words, but it can provide years of science.

Massimo: And this was presented at the AAS [American Astronomical Society] eventually and one of the first products of our proposal. But science comes from measuring each individual star and getting mass, age, luminosity, the radius of the star, information about variability, mass accretion, and basically characterize the entire cluster of young stars on the basis of the best measured fundamental parameters of the stars. And this is what we are still doing.

The final super-catalogue, as I call it, should come out in the fall. This is a dataset that, once it's published, will still remain an object of work in the years to come, because we will get more and more data in other filters from these sources. We will get more infrared data, for example, with JWST.

Frank: And next spring, you'll be able to take a flight through the data captured by Hubble at your neighborhood IMAX.

Massimo: Here at the Institute, they are building the 3D model that will be rendered in an IMAX fly-through of the full nebula. And I've seen a demo. It's fantastic, it's really breathtaking. It's beautiful.

Maggie: The proposal process sounds complicated and time-consuming, but astronomers who want to observe targets with other satellites or ground-based observatories go through it regularly.

You can find more information on today's story, as well as some links at our website: universe.nasa.gov/Blueshift. You can also see what we're up to by following us on Twitter. We're @NASABlueshift. That's it for this time, this Maggie Masetti, bringing the universe closer to you with Blueshift.