that the South Pole is the ideal location for launching balloons carrying experiments to measure the cosmic microwave background? Or that having travelled all the way to the bottom of the world to do an experiment, one would still be at the mercy of the weather? Or that the sign marking the site of the South Pole has to be moved by nine metres every year to allow for the motion of the ice? Or that the lead used to shield the CDMS experiment contains close to no radioactive lead-210 atoms because it was salvaged from ships that sunk off the coast of Italy some 2,000 years ago? What emerges from these passages is the sheer hard work and physical demands involved in these experiments, which might explain why these chapters are more rewarding than those about CERN and various observatories.

Ultimately, like the experiments it describes, *The Edge of Physics* is ambitious in the extreme, testing both the resolve and the imagination of all those involved. But equally, like our understanding of the Universe itself, everything is not quite in place. ❐

PETER RODGERS

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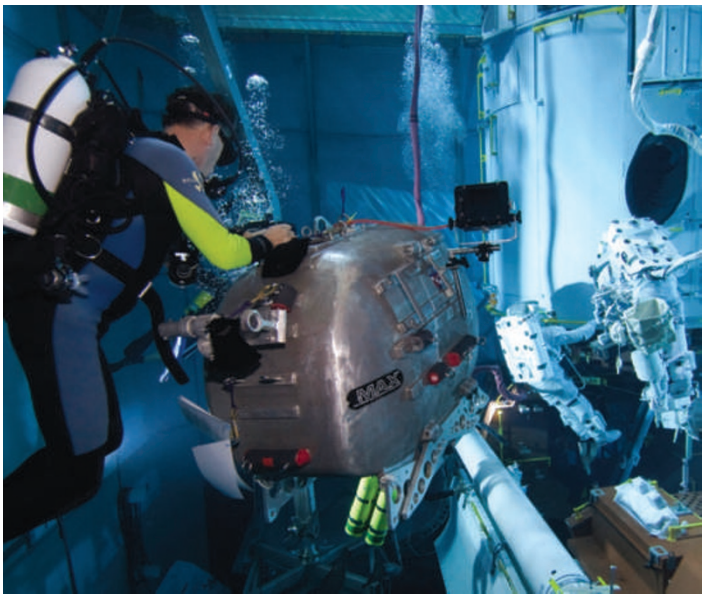
Astronaut for a day



FILM

Space: the final frontier. Do do dooo … No wait, I'm at the Science Museum watching the latest IMAX film, *Hubble 3D*. It's real and the images of galaxies and star nurseries look more fantastic than anything in a science-fiction film (have you seen what's being passed off as a black hole in the latest *Star Trek*?). Thanks to modern telescopes, we have no need to imagine our cosmos as colourful, surprising and beautiful. It is. And flying to the Orion nebula with stars whizzing by felt exhilarating; several audience members held out their arms, Superman style.

The film documents the fifth and final space-shuttle mission to upgrade the Hubble Space Telescope, the first orbiting telescope, which turned twenty last month. Confusingly known as Servicing Mission 4, the mission almost didn't happen following the Columbia disaster, but public outcry helped in part to convince NASA and the Bush administration that Hubble was worth one last visit by the crew of Atlantis in May 2009 — on condition that a second space shuttle be ready should the need arise to rescue the astronauts in space. The shuttle's cargo bay would carry an IMAX camera holding 8-minutes-worth of film. Other shots would be made with regular high-definition cameras and converted later to 3D.

What I hadn't appreciated before was the amount of preparation before a launch. All five of the space walks were choreographed and practised for two years in a huge swimming pool containing a replica of Hubble (left-hand image). As well as replacing failed or outmoded components, the astronauts were to install two new instruments, Wide Field Camera 3 and Cosmic Origins Spectrograph. They even held replica cameras underwater to establish the best shots 18 months before filming!

Time to blast off. The launch itself was very cool, especially as a second shuttle stood ready in the background. There was a well-protected IMAX camera 57 m below the rocket boosters, as well as microphones to enhance our sensorial experience. Once in the upper atmosphere, the crew tracked down Hubble and gently docked it onto a stand in the cargo bay — not a trivial task at 28,000 kph. The work went more or less according to plan, but one task in particular was the most tense, on account of a stripped bolt. After trying for hours to remove a cover, astronaut Mike Massimino was told to break off the handle, which he managed to do without damaging anything, including his spacesuit. Once all the jobs were completed, the improved Hubble was relaunched. It will continue gathering data until 2014.

At 45 minutes it is a short film, although it does not feel rushed. Of course, the coverage of Hubble's scientific value is superficial; but the main aim of this documentary is for the general public of all ages to experience space travel and the wonders of our Universe. But don't take my word for it. Go and see it yourself. ❐

MAY CHIAO