

Radiation detectors in space

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DLR researchers evaluate results from the Matroshka experiment

Six thousand lithium fluoride crystals, each one holding information about radiation in space – this is the payload that astronaut Paolo Nespoli and his colleagues removed from the life-size Matroshka human dummy on the International Space Station (ISS) and sent back to Earth. Researchers at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) are now starting work on an evaluation of these small radiation detectors.

Neatly distributed and arranged in individual compartments, these tiny and almost transparent crystals look fairly unimpressive. Not so, however, for researchers at the DLR Institute of Aerospace Medicine and their colleagues in the USA, Japan, Russia and Europe, for whom they are enormously exciting. They provide information about the levels of radiation to which astronauts are exposed during their stay in the Japanese Kibo module on the ISS. From May 2010 to March 2011, these radiation detectors were in the body of the Matroshka mannequin. "First and foremost, we want to investigate the long-term effect of radiation," says project manager Thomas Berger from the DLR Institute of Aerospace Medicine.

Slice by slice, information about radiation exposure

The head and torso of the Matroshka mannequin are made up of a total of 33 'slices'. At the core of the torso is a synthetic human skeleton, the 'bones' of which are embedded in moulded polyurethane plastic that simulates the varying densities of human body tissue. Slice by slice, the astronauts dismantled the Matroshka mannequin and removed the small tubes containing the radiation detectors from 1600 measurement points. "Above all, we wish to find out which organs are affected by radiation, and to what extent," explains Berger. The researchers integrate these small detectors throughout the synthetic body, which enables them to establish the varying extent to which different organs such as lungs, stomach and skin surface respond to cosmic and solar radiation. "The measurements which entail astronauts wearing dosimeters on their bodies only record levels at the body's surface." While on Earth, the atmosphere protects people from this radiation – it offers protection comparable to ten metres of water. In space, when astronauts leave their spacecraft, they are protected by just their space suit and the protective water equivalent shrinks to just one centimetre.

The Matroshka mannequin has now been employed as a measuring instrument on four occasions. During its first deployment in 2004, astronauts mounted the torso on an outside panel of the space station for 539 days. In the following years, each time equipped with new detectors, Matroshka served as an additional crewmember in the Russian Pirs and Zvezda modules – in which astronauts sleep – then finally in the Japanese Kibo module. "The evaluation of these detectors has provided us with some interesting results. The dosage level experienced by internal organs is virtually unaffected by Matroshka being inside or outside the space station. The deeper an organ is located in the body, the more effectively it is shielded by the body." Particularly sensitive organs were found to be the lungs, the stomach, the genitals and blood-forming organs such as the bone marrow. In contrast, measurements conducted by DLR researchers have shown that the skin is comparatively unaffected. "We already know that some areas of the space station offer more protection against radiation, and that others offer less," states Berger, a radiation physicist. He anticipates that it will take up until about September to complete a detailed evaluation of the data that was recorded in the Kibo module. In its capacity as project management organisation for the Matroshka experiment, DLR has already sent samples to facilities operated by the various international partners involved in the

project. The results will be used to generate a more comprehensive database for use when simulating radiation exposure.

Future plans for the mannequin

The research work of these scientists encompasses more than just the ISS: "We are also endeavouring to gather knowledge for a flight to Mars." In interplanetary space, astronauts not only have to manage without the protection afforded by Earth's atmosphere, they also have to live without Earth's magnetic field. Mannequins like Matroshka are also being used on Earth; in collaboration with the GSI Helmholtz Centre for Heavy Ion Research (GSI Helmholtzzentrum für Schwerionenforschung) in Darmstadt, DLR is using a twin of Matroshka to simulate the irradiation of a human suffering from cancer. "Here, for example, we are conducting research to determine the radiation dosage received by organs that are located some distance from the actual irradiation site."

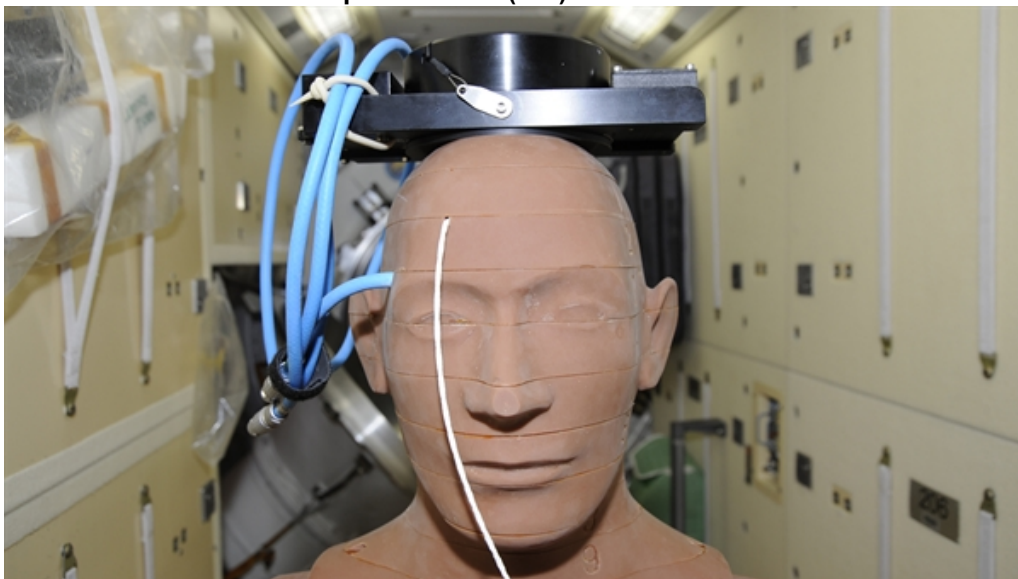
For the Matroshka mannequin on board the ISS, a short period of rest is currently on the agenda. After removing its radiation detectors, Paolo Nespoli and his fellow astronauts took the additional crewmember out of the Kibo module and placed it in intermediate storage in the Russian Zarya module. New plans are already being made: "Matroshka is scheduled for another period of exposure on the exterior of the ISS," explains the scientific director of the Matroshka experiments, Günther Reitz, also from the DLR Institute of Aerospace Medicine. Since 2004, the most recent external deployment of Matroshka, solar activity has changed. "We will therefore be obtaining another dataset relating to external deployment of an astronaut. This will provide a contrasting view to the first exposure period, since the data will be recorded under a different solar activity profile."

Contacts

Manuela Braun
German Aerospace Center (DLR)
Media Relations Section
Tel.: +49 2203 601-3882
Fax: +49 2203 601-3249
Manuela.Braun@dlr.de

Dr. Thomas Berger
German Aerospace Center (DLR)
Institute of Aerospace Medicine, Radiation Biology
Tel.: +49 2203 601-3135
Fax: +49 2203 619-70
thomas.berger@dlr.de

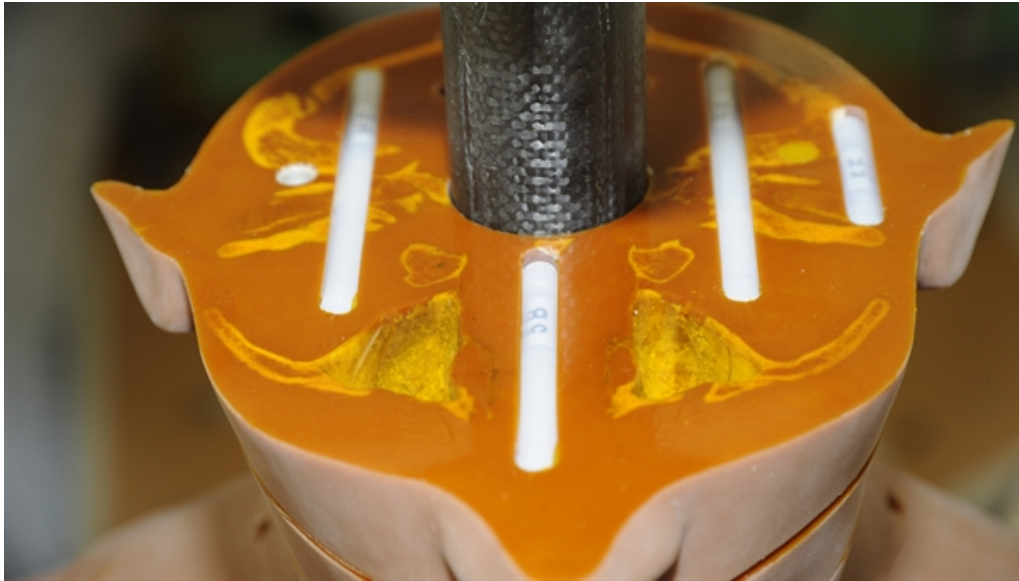
The additional crew member: the MATROSHKA Human Phantom is already being used on the International Space Station (ISS) to measure radiation



MATROSHKA's head and upper body are made of 33 discs in total. A human skeleton is located inside the torso, and these bone parts are cast in polyurethane to simulate the varying densities of human tissue.

Credit: NASA.

Radiation detectors in the Matroshka



The researchers integrate small detectors throughout the body of the Matroshka dummy, which enables them to establish the varying extent to which different organs such as lungs, stomach or skin surface respond to cosmic and solar radiation. The lighter-coloured components represent the bone structure of a human skeleton.

Credit: NASA.

Crew working with Matroshka



Alexander Kaleri, Dmitry Kondratyev, Paolo Nespoli and Oleg Skripochka store the Matroshka mannequin in the Russian Zarya module.

Credit: NASA.

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