Space RAD Health Newsletter

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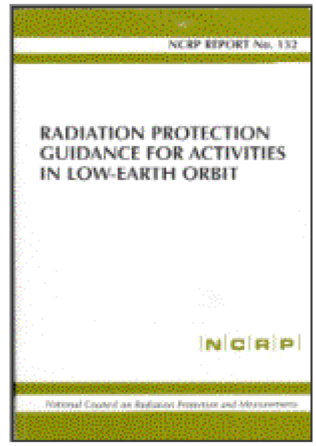
Release of the new NCRP Report No. 132: Radiation Protection Guidance for Activities in Low-Earth Orbit



The National Council on Radiation Protection and Measurement (NCRP) released a new publication (NCRP Report No. 132, December 2000) that provides radiation protection guidance and radiation exposure limit recommendations for astronauts working in low-earth orbit. In response to NASA's request, the NCRP Scientific Committee-75 prepared this report. Dr. R. J. Michael Fry of the Oak Ridge National Laboratories who served as the Chairman of the Scientific Committee-75 emphasized that, *"The guidance in this Report (no. 132) supersedes the radiation exposure limit recommendations provided in NCRP Report No. 98 that was published in 1989."*

	NCRP Report No. 98 (1989) (Sv)		NCRP Report No. 132 (2000) (Gy-Eq)	
Anatomical Location	**30 day limit**	**1 year limit**	**30 day limit**	**1 year limit**
Eye	1.0	2.0	1.0	2.0
Skin	1.5	3.0	1.5	3.0
BFO	0.25	0.50	0.25	0.50

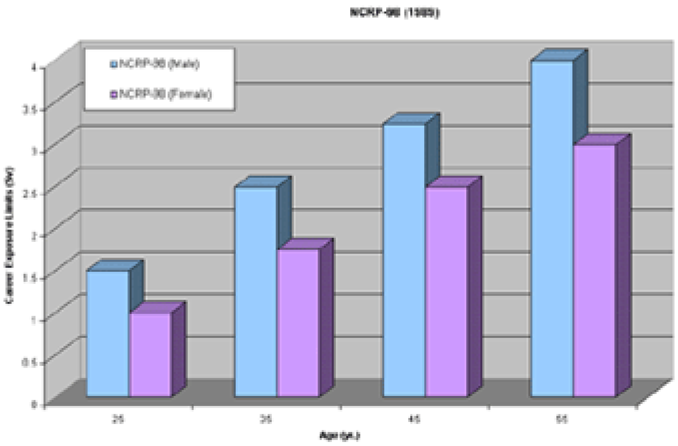
Table-1: Radiation Dose Limits for Deterministic Effects Defined a Decade Apart

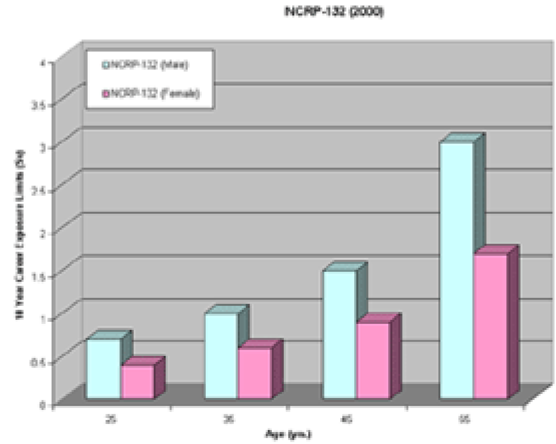
Short-term radiation dose limits for the eye, skin, and BFO (Blood Forming Organs) are presented and compared from the 1989 and 2000 NCRP reports. NASA's 30-day and 1-year radiation dose limits, which are defined for preventing deterministic radiation effects have been based on the recommendations from NCRP Report No. 98 (1989). The NCRP in their recently released report, NCRP Report No. 132 (2000), proposed the implementation of limits for preventing deterministic radiation effects that incorporates a relative biological effectiveness, RBE for such effects are expressed as gray-equivalent, Gy-Eq. This is a significant change from the prior use of radiation quality factors, Q that are based on data for late-effects, most importantly cancer, although few studies with HZE (High Z=atomic number and Energy) particles have been made for determining both short-term and career limits. Based on these new NCRP recommendations, more emphasis on research for determining the appropriate RBE values for deterministic effects will be needed. As shown in Table-1 there is no change in the values for short-term dose limits recommended in the new report.

	Career Exposure Limits NCRP Report No. 98 (1989) (Sv)		10 Year Career Exposure Limits NCRP Report No. 132 (2000) (Sv)	
Age (yr)	**Male**	**Female**	**Male**	**Female**
25	1.5	1.0	0.7	0.4
35	2.5	1.75	1.0	0.6
45	3.25	2.5	1.5	0.9
55	4.0	3.0	3.0	1.7

Table-2: Career Radiation Dose Limits for Late Effects Defined a Decade Apart

Career dose limits (in Sv) corresponding to probability of 3% excess cancer mortality for a 10-year career are shown in Table-2. These limits are dependent on the age and gender with values from both the NCRP No.98 (1989) and NCRP No.132 (2000) listed. In the new NCRP recommendations, the doses corresponding to the 3% fatal risk for males and females are reduced significantly based on the findings from more recent analysis of the survivors of the atomic-bomb explosions during World War II and other exposed cohorts.





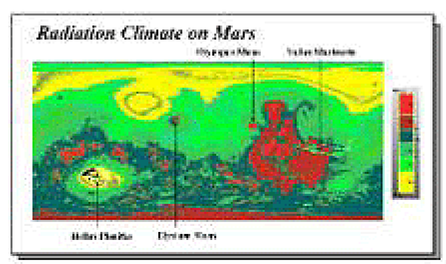
Click charts to view larger images.

In the above two charts, career exposure limits (NCRP-98 vs. NCRP-132) for a lifetime excess risk of fatal cancer of 3% as a function of age at exposure are shown. Changes in the methodologies for organ-dose evaluations, discussion of the higher average quality factors that are now known to occur in low Earth orbit, and research needs in radiobiology, environments, and dosimetry are also discussed in the new report.

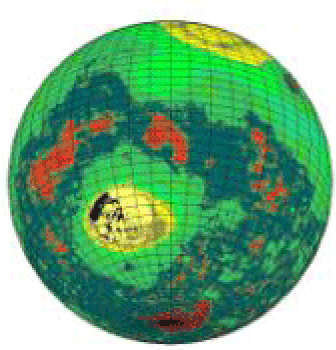
"Uncertainties for Cancer Risk Projections for Deep Space Human Exploration: JSC-29295

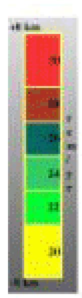

SPACE RADIATION CANCER RISK PROJECTIONS FOR EXPLORATION MISSIONS: UNCERTAINTY REDUCTION AND MITIGATION

NASA Johnson Space Center in collaboration with investigators from, NASA Langley Research Center, Baylor College of Medicine, and Johns Hopkins University School of Medicine, completed and released a report on the assessment of radiation induced cancer risk for the deep space exploration class missions that are likely to take place in the next decades (JSC-29295: SPACE RADIATION CANCER RISK PROJECTIONS FOR EXPLORATION MISSIONS: UNCERTAINTY REDUCTION AND MITIGATION). These results anticipate long duration exposure to the radiation environment beyond Earth's protective magnetosphere en route to the moon, a deep-space outpost, Mars, or beyond. The study provides for the first time a quantitative assessment of the uncertainties in cancer risk projections for exploration using subjective probability functions and Monte-Carlo error propagation methods and shows an uncertainty of ±500-600% dependent on shielding configurations. These large uncertainties limit the usefulness of phase-A design studies for longer mission (> 100 days) in deep space. The report summarizes radiobiology data requirements and research areas that would reduce the uncertainties in order for mission design studies to continue.



Visualization of Radiation Doses Estimated on the Martian Surface





During the past year, the Space Radiation Health Project (SRHP) developed a model to calculate and visualize the radiation doses in the human body for twelve different anatomical locations for projecting organ doses during human missions to Mars. The NASA MGS (Mars Global Surveyor) mission has been collecting the Mars surface topographical and altitude data with its MOLA (Mars Orbiter Laser Altimeter) instruments. This data provides the most precise altitude information of the Mars surface. The MOLA altitude data was used with the HZETRN radiation transport model and the QMSFRG nuclear interaction model to evaluate the shielding offered by the Martian atmosphere that is abundant with CO_2 content (11 - 22 g/cm^2 of areal density), and the radiation doses as a function of the altitude on the Marian surface were calculated. In the following illustration the skin dose equivalent received by an astronaut as a function of geographical position over the entire Mars surface is shown.

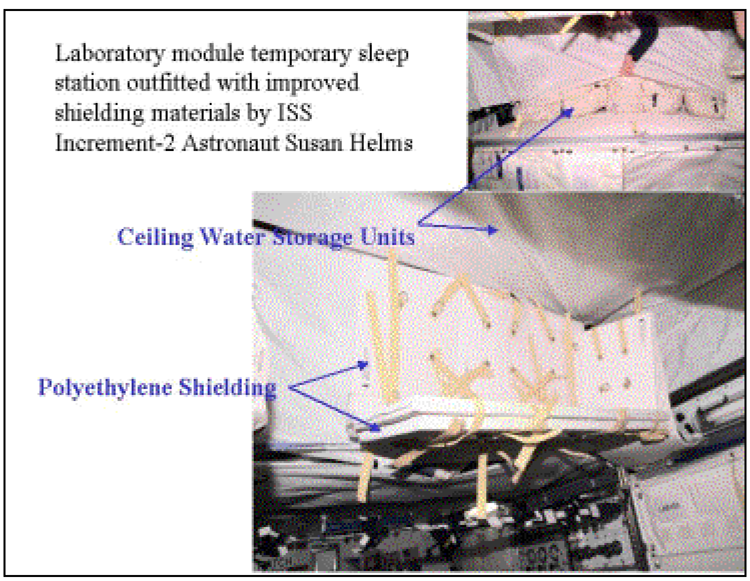
In the very near future, the 2001 Mars Odyssey (launched on April 7th, 2001 and expected to arrive Mars by October 24th, 2001) will be gathering the first Martian radiation environment data with the MARIE (Martian

Radiation Environment Experiment) instrument. The MARIE instrument was designed and developed from the NASA Johnson Space Center by a team led by the PI, Dr. Gautam D. Badhwar. Though the original radiation measurement plans included an instrument to be placed on the *lander*, from the current 2001 Mars Odyssey Mission, such measurements from the *lander* have been curtailed and MARIE instrument will collect data from the orbiter. The first radiation measurements of the GCR environment en route to Mars are expected from the MARIE instrument during the later part of April-2001. The first measurements of the Martian radiation environment are expected during the later of the year 2001. Some of these radiation measurements from the MARIE instrument will be made available in the year 2002. More information and description of the MARIE instrument from the PI, Dr. Badhwar is also available.

ISS Expedition Crew and Shielding Augmentation: "*Christmas Bricks for a Safer Heaven*"

The First ISS Expedition Crew (2R – 5A.1) returned to earth after spending 136 days on the ISS. The Second ISS Expedition Crew (5A.1 – 7A.1) is expected to spend about 126 days. During the current solar cycle we have been experiencing several Solar Flares including a flare on April 2nd the most powerful solar flare in 25 years. However, only a minor solar particle event occurred from this solar flare and it did not have any impact on the ISS crewmembers and their health. At this time, providing ISS crewmembers with shielding augmentation approaches using hydrogen rich materials has been a primary goal for the Space Radiation Health Project.

On December 13, 2000, ISS Program Office confirmed the decision to deliver a Personal Radiation Protection System (PRPS) for Flight 5A.1 to be used by the Second ISS Expedition Crew. After 24 months of advocacy and a recommended design approach for such shielding by the Radiation Health Office, the design of the polyethylene bricks (POLY-Bricks) was completed, developed, and delivered in less than 30 days on January 11, 2001, by the NASA Johnson Space Center team assigned to this task. Mark McDonald of NASA-JSC who served as a project manager for this PRPS request commented that, "*Thirty days from request to delivery. Many people did not believe this task could be accomplished both over the Christmas Holidays and in such a short time. The team delivered all requested hardware on January 11 - on schedule, under budget and cut hundreds of pounds off the original weight estimates while meeting all requirements.*" In recognition of this contribution to the ISS program several key individuals were recognized with Space Flight Awareness Team Award on the April 18th, 2001. The PRPS marks the first-time that radiation shielding has been flown in space. This thirty-day effort proceeds more than 10-years of research at NASA-LaRC and NASA-JSC, and by investigators at Lawrence Berkeley National Laboratory on the establishment of space radiation shielding materials, and a two-year effort by the SRHP to design and implement approaches to be used on ISS common occupation areas. Shielding augmentation approaches for other ISS crew quarters and common areas are being developed in consistent with the ALARA Principle.

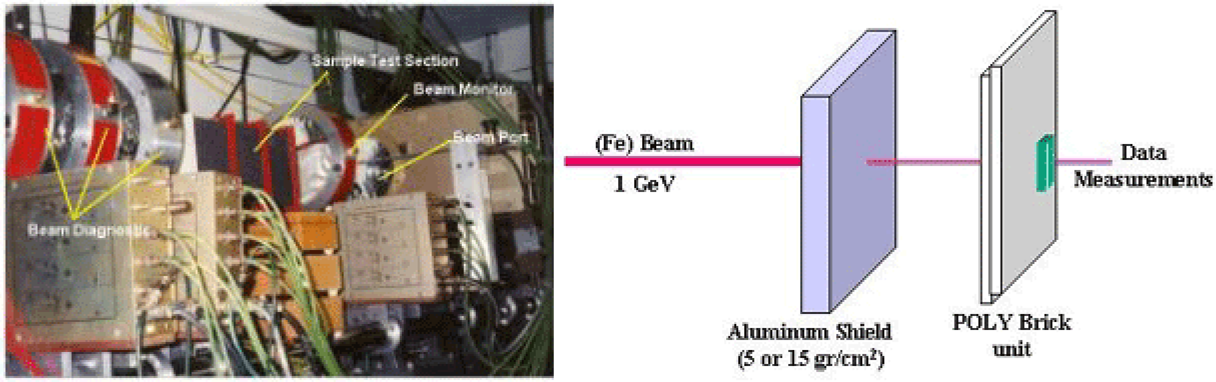


The picture to the left describes the augmentation of the shielding with POLY-Bricks and the use of stowage water for the Expedition Crew as part of their temporary sleep quarters in the ISS Lab module. The PRPS milestone was preceded by many years of effort by researchers at Langley Research Center, Johnson Space Center, and the Lawrence Berkeley National Laboratory in understanding and validating the optimal shielding materials to be used in reducing the effects of space radiation.

January AGS Run (BNL-7) and Radiobiology Investigations

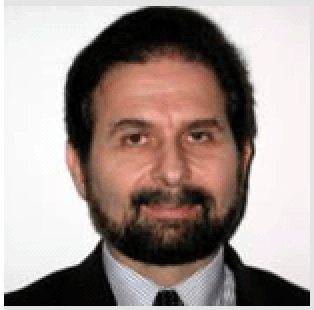
During January 8-15, 2001, the SRHP sponsored a series of radiobiological and physics experiments utilizing the Brookhaven National Laboratory's (BNL) Alternating Gradient Synchrotron (AGS) facility with iron ion beam. These experiments were part of the seventh consecutive radiobiology investigations (BNL-7). For BNL-7, a total of 24 different proposals and 81 users were supported that represented 19 U.S. institutions and five international collaborators (from Italy, Japan, and U.K.). More than 1600 biological samples were irradiated with iron beam. Typical ^{56}Fe beam used for majority of the radiobiology studies included the following: ^{56}Fe beam = 1.046

GeV/nucleon with LET 148 keV/µm and dose rate range from 10 cGy/min to 15 Gy/min. Results and analysis from these studies are forth coming. An executive summary of BNL-7 is also available.



NASA test samples (ISS shielding material) irradiation tests with iron beam (^{56}Fe, 1GeV/nuceon) at the BNL's AGS facility are shown in the above picture and illustration.

Featured Investigator



George Iliakis, Ph. D.
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More than 15 years ago, Dr. Iliakis joined the Thomas Jefferson University as an Associate Professor of Radiation Therapy and Nuclear Medicine. At present, Dr. Iliakis serves as a Professor of Radiation Oncology and as the Director for the Division of Experimental Radiation Oncology, Kimmel Cancer Center of the Jefferson Medical College. Prior to the work at the Thomas Jefferson University, Dr. Iliakis also served as Project Scientist at the Cleveland Clinic Foundation, Ohio. Dr. Iliakis's educational background includes: M. Sc., in physics (1975) from the University of Athens, Greece; and a Ph. D., in biophysics (1978) from the University of Frankfurt/Main, Germany.

During the past two decades as a distinguished research scientist, Dr. Iliakis served as a principal investigator on several research grants supported by the National Institute of Health (NIH), the National Cancer Institute (NCI), and NASA. Dr. Iliakis also served as the Associate Editor of *Radiation Research* and *International Journal of Radiation Biology*. At present, Dr. Iliakis serves as an associate editor for the journal of *Radiation Environmental Biophysics* and also as the president of the Philadelphia Cancer Research Association. Dr. Iliakis authored or co-authored more than 120 peer reviewed research publications. See the enclosed short CV on his most recent studies of the radiation induced cell damage.

Most recently, Dr. Iliakis became the vice-President elect of the Radiation Research Society, and will have the honor to serve this Society as president in 2003.

Dr. Iliakis notes on his research as follows: "*During the last 20 years the central goal of my research was the elucidation of the chain of events that leads from damage induction in the DNA to chromosome damage and ultimately to cell death. Induction and repair of DNA double stranded breaks was studied extensively, and was complemented by measurements of induction and repair of inter-phase chromosome breaks. At the cell level, cellular repair reactions including repair of potentially lethal and repair of sub-lethal damage have been studied, together with the mechanism of the cell cycle dependent fluctuations in radiosensitivity. My laboratory was the first to show the presence of different forms of potentially lethal damage in cells exposed to sparsely ionizing radiation, and the first to propose that variations in the fixation of this type of damage causes the fluctuations in radiosensitivity throughout the cell cycle. Recent work focuses on the genetics and the biochemistry of the repair of DNA double strand breaks, as well as in the elucidation of S-phase checkpoint.*" See for more description of the research.

One of the current NASA funded studies with Dr. Iliakis as the principal investigator is a study on understanding the radiation damage process and repair mechanism at various cell cycle phases, "Factors Modulating Radiation-Induced G-2 Delays." Results from these investigations are expected to provide data for assessing the radiation damage process at the cell level and develop appropriate counter measures to minimize the radiation induced cancer risk. Some of the preliminary results and current research progress shows such a promise. See the list of research publications (2000-2001) on this on-going NASA supported research.

Joint DOE and NASA Radiation Programs Workshop

Low Dose Radiation Research Program of Department of Energy (DOE) and Space Radiation Health Program of NASA are conducting a joint workshop and NASA's 12th Annual Radiation Investigators Meeting. Registration and abstract submission details are available on-line. Also, NASA investigators travel awards application material is available.

2001 DOE/NASA Radiation Investigators' Workshop