Life Sciences in Space Research ••• (••••) •••–•••

Contents lists available at ScienceDirect

Life Sciences in Space Research

www.elsevier.com/locate/lssr

Review article

Genesis of the NASA Space Radiation Laboratory

Walter Schimmerling

Department of Physics, East Carolina University, United States

ARTICLE INFO

Article history:
Received 12 January 2016
Received in revised form 3 March 2016
Accepted 3 March 2016

Keywords:
Space radiation research
Accelerators
History
NSRL
PPA
Bevalac

ABSTRACT

A personal recollection of events leading up to the construction and commissioning of NSRL, including reference to precursor facilities and the development of the NASA Space Radiation Program.

On October 14, 2003 a crowd of nearly 200 gathered in a festive tent to mark the official opening of the newly completed NASA Space Radiation Laboratory (NSRL) on the grounds of Brookhaven National Laboratory in Upton, Long Island, NY. Fig. 1 shows the ribbon cutting, featuring a large number of dignitaries.[1] The NSRL was designed as an experimental facility to examine the effects of charged particle radiation constituting the galactic cosmic ray and solar particle environment in space.

NSRL was not the first time that NASA operated a particle accelerator facility. Already in 1961, Virginia Polytechnic Institute, the University of Virginia, and the College of William & Mary joined forces in a consortium, Virginia Associated Research Campus (VARC) and in conjunction with NASA, established the NASA Space Radiation Effects Laboratory (SREL). VARC purchased a parcel of surplus government land in Newport News, on which it erected a building to house what at the time was a state of the art 710 MeV proton synchrocyclotron, similar to the 184-in. synchrocyclotron at the Lawrence Berkeley Laboratory. By 1980, NASA's interest had waned and attempts to use the facility for radiation therapy were not successful (Aceto et al., 1979). VARC widened their partnership and formed SURA (Southeastern University Research Association). The Department of Energy (DOE) subsequently took management responsibility of the facility. The NASA synchrocyclotron was dismantled and replaced with an electron accelerator and the laboratory was renamed the Continuous Electron Beam Accelerator Facility (CEBAF), now the highly successful Thomas Jefferson National Accelerator Facility.

Ionizing radiation was first known to exist outside the Earth atmosphere when Victor Hess coined the name "Cosmic Rays" for the particles measured by his electroscope in balloon flights conducted in the early years of the 20th century. Balloon flights continued to be an important way to measure radiation incident on the Earth atmosphere well into the 1970s, when a series of deep space satellites began to map the interplanetary space radiation environment (Nelson, 2008; O'Neill, 2011). Fig. 2 is an iconic plot of the abundances of galactic cosmic ray elements, and a schematic diagram of energy spectra for representative elements.

That exposure of humans to this radiation in space could have serious consequences had been assumed from the beginning of space exploration. In a 1952 article, Cornelius Tobias addressed possible radiation hazards at high altitude (Tobias, 1952). Tobias also predicted the light flashes that would be seen by the Apollo astronauts (Pinsky et al., 1973); cataracts resulting from passage of cosmic rays through the eyes have been the subject of serious research since then (Chylack et al., 2009, 2012), Other risks, with even more serious possible consequences, are listed in Table 1.

Recommendations by the National Academy of Sciences (NAS) in (1967) noted that radiation protection in manned space flight is philosophically distinct from protection practices of terrestrial workers, because of the high-risk nature of space missions. The 1967 NAS report did not recommend "permissible doses" for space operations, noting the possibility that such limits may place the mission in jeopardy and instead made estimates of what the likely effects would be for a given dose of radiation (McPhee and Charles, 2009a).

Subsequent considerations of this issue led to much less cavalier assessments. As the federal agency with institutional responsibilities to conduct and evaluate a wide range of spaceflight mis-

E-mail address: walter2205@mac.com.

[1] Space Radiation Health Newsletter, Vol. 3 No. 3 – December, 2003.

http://dx.doi.org/10.1016/j.lssr.2016.03.001
2214-5524/

Please cite this article in press as: Schimmerling, W. Genesis of the NASA Space Radiation Laboratory. Life Sci. Space Res. (2016), http://dx.doi.org/10.1016/j.lssr.2016.03.001

Fig. 1. Ribbon cutting. The author is on the far right, standing behind Mary Kicza, Associate Administrator, NASA Office of Biological and Physical Research. Dignitaries included Dr. Praveen Chaudhari, Director of BNL, Mr. Michael Holland, Manager of the DOE Brookhaven Area Office, and Dr. Shirley Strum Kenny, Chairperson, Brookhaven Science Associates. Mr. John Schumacher, NASA Chief of Staff; Dr. Raymond Orbach, Director, DOE Office of Science; Congressman Timothy Bishop, 1st District of New York State; General Jefferson D. Howell, Jr., Director, Johnson Space Center; and Dr. Dennis Kovar, Associate Director, DOE Office of Nuclear Physics.

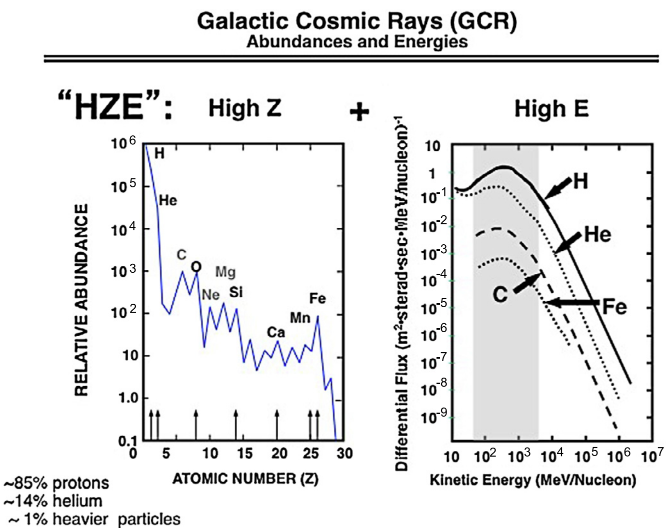

Fig. 2. Abundances of GCR, taken from Fig. 1 of the review by Simpson (1983), and energy spectra of four representative nuclei (G. Badhwar, private communication). The gray band identifies the range covered by US accelerators before commissioning of RHIC.

Table 1
Space radiation risks and possible impacts (McPhee and Charles, 2009a).

Radiation Risks	Potential Impacts
• Carcinogenesis – Leukemias – Solid Cancers – Age/Gender differences • Degenerative Tissue Effects – Heart disease – Cataracts – Respiratory disease – Digestive Diseases • Damage to the Central Nervous System – Motor skills – Behavior – Accelerated aging • Acute Risks – Death – Vomiting/nausea	• Mortality: reduced lifespan • Mortality: In-flight (acute from SPE) • Performance Degradation: – In-flight (GCR or SPE) – Changes in functional thresholds (trauma, wound healing, nausea) • Morbidity: post-flight Quality of life

sions, NASA has an obligation to provide a safe working place. Unfortunately, the aura surrounding NASA and space exploration tends to blur the line between reality and fantasy for many individuals not familiar with the quotidian reality of an engineering enterprise. This reality does not justify the assumption of extraordinary risks, such as deflecting an asteroid from impact with Earth in order to save humanity, or engaging in "one-way missions" of one kind or another. The job description of NASA crews does not include martyrdom or sainthood. If ever there will be a need for a sacrifice mission, it is more likely to be entrusted to the military, even if NASA provides the vehicles. Otherwise, the United States does not engage in suicide missions.

Occasionally, NASA managers and engineers described themselves with proud understatement of their superb achievements as "a trucking company." Unfortunately, the concept of being "a trucking company" is too limiting because it does not include scientific research, essential for justifying the NASA mission and for establishing the intellectual capital required to conduct it successfully. The fact is that crews are not in space to evangelize pagans or engage in mortal combat with alien invaders. They are in space to work. Their work consists of checking computer screen displays, tightening bolts, operating cranes, moving materials, assembling structures, performing measurements, maintaining their environment, and carrying out experiments designed by others. The sounds of work in space are not ZAP! POW! BAM! They are clicks and pings, the rush of air conditioning, the clattering of machinery, and the creaking of metal structures expanding and contracting in temperature extremes.

A long series of reports, by the National Council on Radiation Protection and Measurements (NCRP) and several bodies at the National Academies of Sciences and National Research Council (NRC), including the Institute of Medicine (IOM), and Space Science Board (SSB) recommended criteria for radiation exposure limits and research required to reduce the inevitable uncertainties in the prediction of radiation risk. Recent reports by the National Academy of Sciences/Institute of Medicine (Kahn et al., 2014), and the NCRP (National Council on Radiation Protection and Measurements, 2014) provide full discussions of the science and related ethical issues.

The process by which NASA came to establish research at a ground facility as a top priority required disentangling several disparate cultures. The engineering prowess that led to successfully land men on the moon was based on a culture of building rock-

Please cite this article in press as: Schimmerling, W. Genesis of the NASA Space Radiation Laboratory. Life Sci. Space Res. (2016), http://dx.doi.org/10.1016/j.lssr.2016.03.001