Ground-based Particle Accelerator Facilities

Ground-based accelerator exposure facilities provide beams of protons and HZE particles, at energies within the range of space radiation. The main purpose of simulating space radiation at these facilities is to determine the biological factors of risk. However, they can also be used to obtain required data on the physical interactions of these beams with materials and space instruments. Data about the interaction of HZE particles with materials is required especially for the design of light-weight optimized shielding configurations. The calibration and design of instruments is required in order to interpret reliably the data about the space radiation environment collected on Shuttle, Mir, Space Station, in robotic precursor missions and other assets.

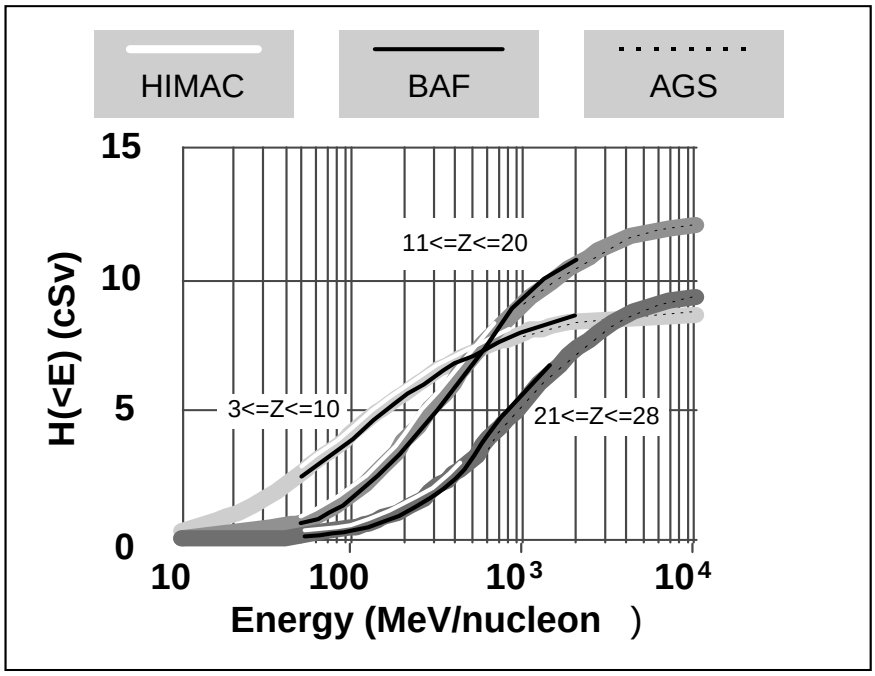

Figure I. 1.Cumulative yearly dose equivalent from HZE particles in 3 charge groups, up to energy per nucleon E, for blood-forming organs behind 5 g/cm2 of aluminum (gray bands), compared with capabilities of 3 accelerator facilities.

The facilities available for simulation of space radiation are severely limited. While proton beams can be produced at many facilities, currently only the Loma Linda University Therapy Proton Synchrotron facility is equipped to handle the sophisticated biological research required for radiobiological studies simulating protons in space.

The situation for HZE simulation is even more constrained (Figure I. 1). There are only 4 facilities considered practical for use by the Initiative. One of these, the heavy ion accelerator SIS at the GSI research institute in Darmstadt, Germany, is in high demand

by the German nuclear physics community. In addition, use of the facility for cancer therapy started in December, 1997 and the facility can be considered unavailable for all intents and purposes. The HIMAC facility at the National Institute of Radiological Sciences in Chiba, Japan, has a moderate amount of beam time available and an active collaboration between the NASA Space Radiation Health Program and this laboratory has been under way since 1995.

The other two facilities for HZE delivery are the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory (BNL) in Long Island, New York, and the Booster Synchrotron, used as an injector in the accelerator chain leading to the AGS (Figure I. 2). These accelerators are currently operated by the high energy and nuclear physics programs of DOE, and NASA purchases beam time for several experimental campaigns per year. As of the writing of this Plan, four campaigns of 150 hrs each, denoted by BNL-1 through BNL-4, have been successfully accomplished.

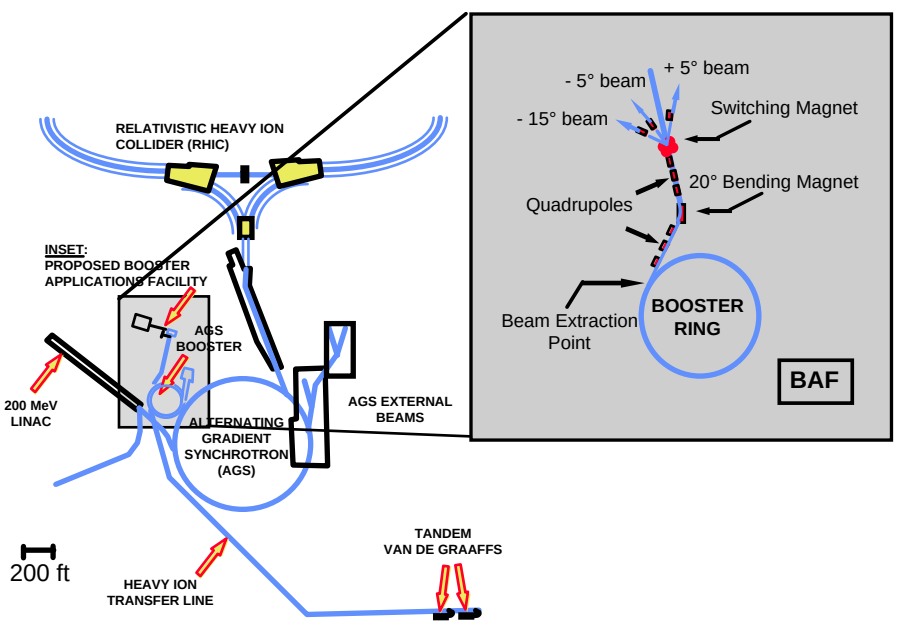

Figure I. 2. Accelerator facilities at Brookhaven National Laboratory.

Protons originate with either the LINAC injector and HZE particles originate in one of the two Tandem Van de Graaffs. The Booster synchrotron then accelerates particles for injection into the AGS, where they are accelerated further for injection into the Relativistic Heavy Ion Collider (RHIC).

The NASA Space Radiation Laboratory (NSRL), has been constructed and was commissioned in Summer, 2003, with an official inauguration in October, 2003. It includes incorporation of the second Van de Graaff (to provide a source of particles independent of the ones used for RHIC), addition of accelerator controls and beam extraction equipment to the Booster synchrotron, a beam line and beam line tunnel to the NSRL irradiation room, and an experiment building with laboratories for NASA investigators using the facility.