The ACCESS Mission: ISS Accommodation Study

John P. Wefel[1] and **Thomas L. Wilson**[2]
for the ACCESS Accommodation Study Team
[1]*Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA 70803, USA*
[2] *Johnson Space Center, SN3, 2101 NASA Road 1, Houston, TX 77058, USA*

Abstract
ACCESS (Advanced Cosmic-ray Composition Experiment for Space Station) is a new mission concept payload for the International Space Station (ISS) which has undergone a preliminary accommodation study. ACCESS science goals include new measurements of the rare ultra-high energy and ultra-heavy components of the cosmic radiation above the Earth's atmosphere. The critical resource made available by the ISS is collecting power; up to 10,000 m^2-sr-days, for a four-year stay on-orbit, allows ACCESS to go beyond balloon-borne detectors. The instrument, consisting of a charge module, a transition radiation detector, and a calorimeter, measures nuclei throughout the periodic table. The study demonstrates that the ISS, as a stable science platform at the threshold of space, can make improved cosmic-ray investigations possible in the next century.

1 Introduction:

The advent of the era of the International Space Station offers new opportunities for high energy cosmic ray science. ACCESS, a new mission concept study initiated in 1997, is designed to take advantage of the ISS and utilize one of the external attach points to obtain new, improved data on ultra-high energy and ultra-high charge cosmic ray nuclei. Figure 1 shows one possible configuraton for ACCESS as it would appear mounted on the ISS truss to the Payload Attach System (PAS) at the S3UI site. The view is along the truss from the starboard solar arrays to the port side. At this location there is a minimum of obstruction in the field-of-view of a zenith looking experiment.

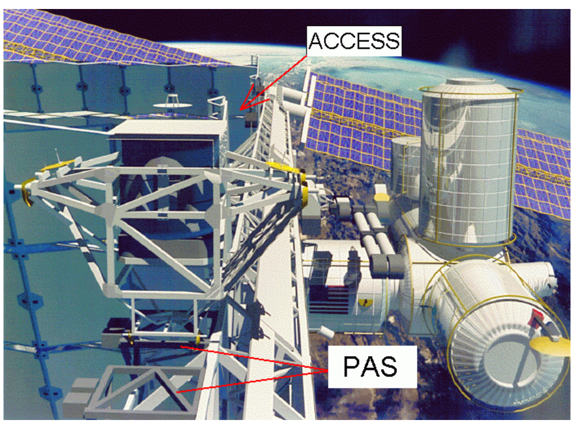

Fig. 1. ACCESS on ISS

The study team first defined a "strawperson" instrument that could make the needed measurements. This "baseline" was then taken into an engineering study to determine if there were any major problems in accommodating such an experiment both on-board the Space Shuttle (STS), for transport up and down, and on-board the ISS. The study utilized the engineering team at JSC who have extensive experience with shuttle payloads and worked on the AMS (Alpha Magnetic Spectrometer) experiment which flew successfully last year on STS-91. AMS is scheduled for deployment to the ISS in ~2003 and will be mounted on the S3UI site. ACCESS could follow AMS on the station in the 2006-07 time-frame. The ACCESS study, described here, was able to utilize the expertise available at JSC as a result of the AMS flight.

It should be noted that ACCESS is a mission "concept". ACCESS has not been approved for flight by NASA; it is in an early study stage. Nevertheless, ACCESS (or a mission like it) has the potential to address some of the outstanding questions in cosmic ray science. The full Accommodation Study report is available as NASA Technical Publication (TP-1999-209 202).

2 Instrumentation and Measurements:

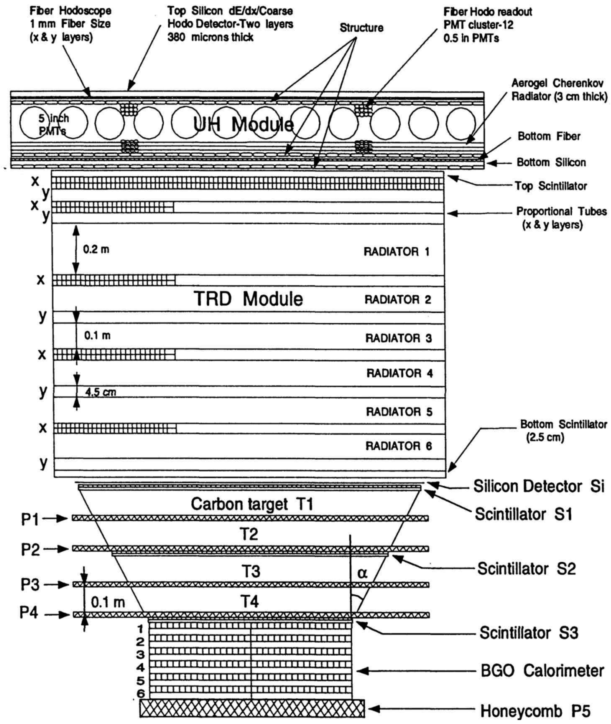

Fig.2. The ACCESS Instrumentation

A schematic diagram of the baseline ACCESS configuration (not to scale) is shown in Figure 2, and is composed of three modules: from top, the UH module (also called the ZIM for Z identification module), the Transition Radiation Detector (TRD) module and the Hadron Calorimeter composed of a carbon target followed by a fully active Bismuth Germanate (BGO) calorimeter. The top module measures the charge of all incident events and utilizes silicon detectors and Cherenkov counters to measure the ultra-heavy nuclei (Z>28) up to uranium with single-charge resolution. The TRD module measures particle velocity (Lorentz factor, γ) for nuclei 3<Z=28 in the ultra-high energy region up to ~50 TeV/nucleon. The hadron calorimeter measures the total energy of the cosmic ray nuclei, focusing on hydrogen and helium, from just below 1 TeV to beyond 1000 TeV, with the high energy limit determined by the event statistics from the 1000 day minimum exposure planned for ACCESS.

The measurements to be made will provide data on both the energy spectra of the Z<28 nuclei, element by element, to the highest energies achievable and the detailed composition, again element-by-element, up to the Pt-Pb region. Such a dataset allows ACCESS to address several of the major outstanding questions in cosmic ray astrophysics: the nature of the acceleration process (bounding theoretical models for shock acceleration in supernova remnants); the source of the matter accelerated (e.g. gas versus grains); the energy dependence of escape from the galaxy (i.e. secondary to primary ratios); and "clues" to the source(s) of the cosmic rays beyond the "knee" in the all-particle spectrum (e.g. see Gaisser et al., 1995; Ellison et al., 1994; Swordy, 1994; Meyer, Drury and Ellison, 1997; Ellison, Drury and Meyer, 1997; Wiebel-Sooth and Biermann, 1999; and other papers at this conference).

3 ISS and STS Accommodations

For a payload to be accommodated on the ISS, it must meet all of the requirements for both ISS and STS including mechanical support, thermal control, power, command, data handling, environment, astronaut involvement and, above all, safety. ACCESS readily meets these requirements.

3.1 Experiment Carrier Structure (ECS): The mechanical interface is the ECS which must attach to the instrument, hold the experiment in the shuttle cargo bay and support the payload on the ISS. Since the ACCESS configuration was undergoing optimization in a parallel effort at GSFC, for this accommodation study a block approach was used, with each of the detector modules represented by a volume, whose mass and dimensions could be altered. This allowed investigation of a variety of ACCESS configurations from 5000-7000 kg. Thirteen different ECS structures were analyzed within the available center-of-gravity (CG) vs mass restraints for the ISS attach site (see document SSP 42131) to determine acceptable frequency response and margins. All ECS candidates were viable, and one was selected as a baseline.

A fundamental problem between the STS and ISS is the location of a payload CG. The STS needs a high CG, close to the sill of the cargo bay, while the ISS wants the CG to be low, close to the PAS. This inconsistency is resolved by turning ACCESS on its side in the shuttle and mounting the PAS connector on the bottom of the calorimeter which contains most of the mass. This is illustrated in Figure 3 which shows an ACCESS instrument mounted within the ECS. The STS keel pin is at the bottom and the sill trunions are on the left. Note the "avionics" boxes for electronics that do not have to be mounted near the detectors,

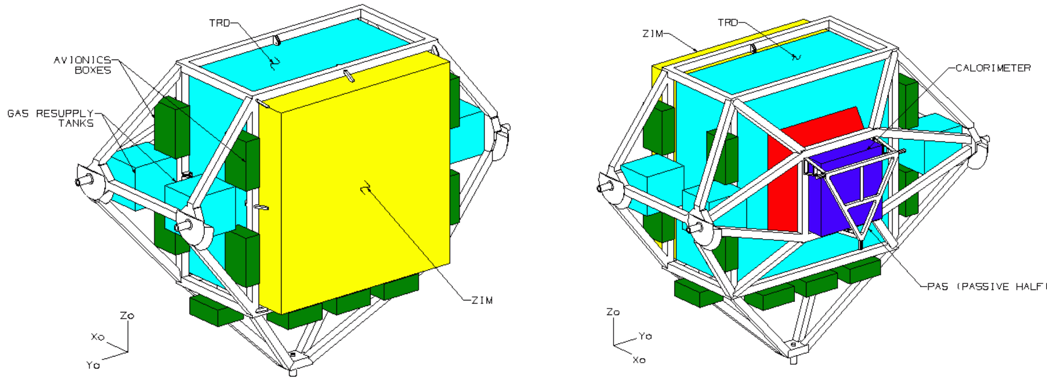

Fig. 3. ACCESS within ECS(top view, left; bottom view, right).

plus the gas re-supply tanks for the TRD. The payload is removed from the STS robotically and rotated 90° so the passive half of the PAS mates with the active half (Figure 1) as ACCESS is emplaced onto the ISS attach site.

The ECS of Figure 3 provides a stiff support structure, but still requires the instruments to provide some internal structure. A finite element model analysis shows only six modes below 50 Hz and margins exceeding 20%. As more integration between the instruments and the ECS is performed, the margins can be reduced to save additional weight.

In addition, ACCESS will require a thermal control system, since there is no active cooling provided by the ISS. Preliminary analysis shows that a louvered radiator system will be necessary to achieve a stable temperature for the instruments. This will be mounted on the wake facing side of the ECS and connected via heat pipes to the instrument/electronics.

3.2 Avionics: The ISS provides up to 1 kW of power at ~120 Vdc as well as two data resources; a 1553B bus for command, control and monitoring and a high rate fiber-optic link for the majority of the data. A concept for the ACCESS avionics and power interface is shown in Figure 4. This "box" would distribute power to the instruments, control heaters as needed for thermal stability, decode and pass commands to the proper destination, provide housekeeping/monitoring data blocks to ISS and the ground, and format instrument data for transmission to the ISS data system via both of the data links. The current ACCESS payload requires ~500 watts of power and has an average data rate <300 kbps, both well within the available resources. In addition, keep-alive power at the 100 watt level will be provided for periods when the solar arrays are feathered or there is a high demand for power. Due to such operational constraints, the anticipated duty cycle for ACCESS is about 80%.

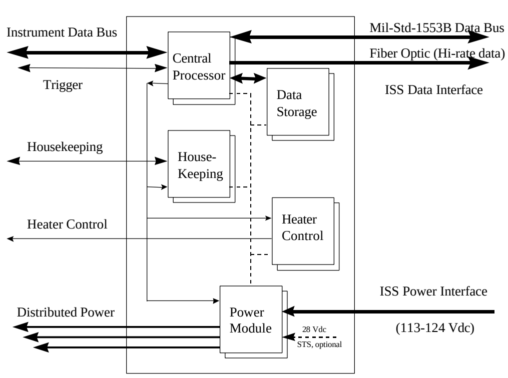

Fig. 4. ACCESS Avionics and Power Interface

3.3 Environment: ACCESS must survive, and perform in, the ISS environment which includes plasma (e.g. atomic oxygen), ionizing radiation (particularly passes through the South Atlantic Anomaly),

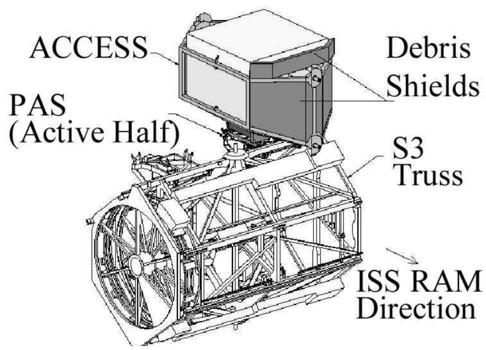

Fig. 5. ACCESS as it Might be Deployed.

electromagnetic interference, contamination, and orbital debris/micro-meteoroids. Many of these are straight forward to deal with while others require control or mitigation plans, often involving additional hardware and/or design modifications. There are defined reviews at which ACCESS will have to demonstrate compliance. One of the areas of concern involves orbital debris. Preliminary analysis indicates the ACCESS will probably require debris shields, at least in the ram direction, and a concept for this is illustrated in Figure 5. One possibility is to use such a debris shield as part of the radiator area in the thermal control system, which might reduce the size of the louvered array. One should also note that there is a volume envelope for the attach sites of 2.6 m x 4.3 m x height. Any hardware such as debris shields, thermal blankets or the ECS itself subtracts from the area that can be occupied by detectors.

3.4 Data Flow -- Ground Segment: The ACCESS data is transmitted to the ISS which utilizes two links to the ground, S-band and Ku-band, both nominally via TDRSS. Figure 6 shows a diagram of the data flow. Upon reception at White Sands the data is routed to various NASA sites. Experiment data goes to Marshall (MSFC) which provides the Payloads Operations Interface. Data packets are decoded and routed to remote investigator sites or to the non-US partner sites. Conversely, command uploads generated by users/partners must be routed through MSFC (where they are checked) before being sent for uplink to ISS. MSFC is developing systems for use at the investigator sites that should provide an easy interface between an ACCESS data center and the ISS.

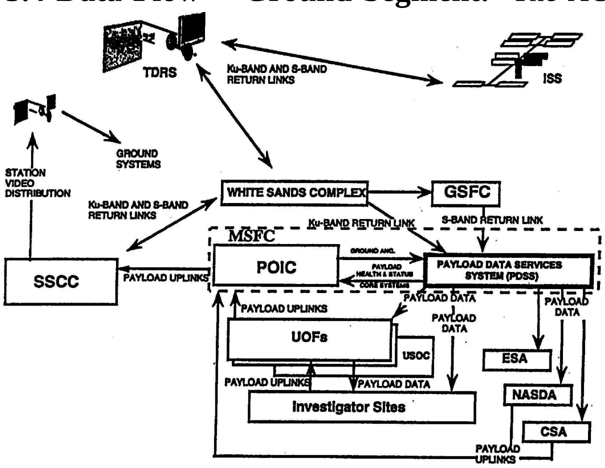

Fig.6. End-to-end ISS Payload Data Flow

4 Conclusions:

ISS enables ACCESS in a very real sense. The study found no "show stoppers" or major engineering problems that would preclude an ACCESS mission. The ISS platform is being constructed; instruments exist to do the measurements; and the science is compelling. If ACCESS is approved, it will make a major contribution to the astrophysics of cosmic rays.

References

Ellison, D.C., *et al*. 1994, Publ. Astron. Soc. Pacific 106, 780.

Ellison, D.C., Drury, L.O'C., and Meyer, J.P. 1997, ApJ 487, 197.

Gaisser, T.K., *et al*. 1995, *Opportunities in Cosmic-Ray Physics and Astrophysics*, National Research Council, National Academy Press, Washington, DC.

Meyer, J.P., Drury, L.O'C., and Ellison, D.C. 1997, ApJ 487, 182.

Swordy, S.P., 1994, in *Proc. 23rd Int'l. Cosmic Ray Conf. (Calgary)*, eds. D.A. Leahy, R.B. Hicks, and D. Venkatesan (World Scientific, Singapore), p. 243.

Wiebel-Sooth, B. and Biermann, P. 1999, in "Astronomy & Astrophysics - Interstellar Matter, Galaxy, Universe," Landolt-Börnstein, Group IV, vol. 3C (Berlin/Heidelberg: Springer Verlag), p. 37.