3rd Workshop on Radiation Monitoring for the ISS

KFKI Atomic Energy Research Institute, 24-26 March, 1998, Budapest, Hungary

PROTOCOL

The objective of the workshop was to elaborate an optimal set of instruments for radiation protection issues and to develop and agree on methodologies so that data from these instruments can be compared and properly interpreted. Recommendations on the kind of research required and on the improvement in instrumentation were agreed upon which shall be distributed to all agencies and relevant bodies. A compilation of the program of the meeting together with the transparencies of the presentations is available from the author upon request.

The workshop comprised several presentations of recent measurements of particle fluxes, LET-spectra and dose rates on spacecrafts, one contribution on space environmental models, two fragmentation papers and one paper on calibrations using heavy ions. In addition, four papers focused on measurements in human phantoms and another four papers described the Russian and US radiation monitoring package. It was noted that a considerable part of the data available are of limited use for the understanding of the radiation field in space and for the improvement of current models, since attitude data, adequate shielding distributions and viewing directions of single instruments are often not well known. Proper spectral information in the high LET region is still only available from passive detectors up to now. There was one presentation on neutron measurements using passive devices, clearly indicating the difficulties to obtain reliable results. In the same paper a new active device based on silicon detectors for neutron measurement was described. Recent measurements and calculations indicate that neutrons are an important component for radiation risk assessment. It is noted that calibration and analysis procedures of detector systems shall be made available through a common web page. A lack in cross section data of nucleus-nucleus reactions, especially for lighter ions, was identified.

Presentations were followed by a round table discussion in which special attention was given to differences in measurements, response functions of detector systems, the relevance of secondary products, average Q versus LET calculations and on ISS dosimetry tasks i.e. instrumentation, modelling and intercalibration. The group agreed that if beam time is available an intercomparison of the instruments shall be performed as part of the July campaign at CERN in the CERN reference field..

The discussions result in the following conclusions:

At this time, with the International Space Station slated for construction in less in a year, and radiation instrumentation nearly ready for launch by member nations, it is impractical to have not a common agreed upon set of instruments. It is therefore, important to agree and develop methodologies so that the data from these instruments can be compared and properly interpreted. No single instrument can describe the complex mixed field of the ISS.

Instrumentation + Calibration

A. Passive Detectors

Passive detectors (TLDs, PNTD) to be used onboard the ISS should be calibrated using ground based accelerators. In particular, the HIMAC (Japan) machine is ideally suited for such calibration.

Calibration methods and analysis procedures should be made available through a common web site.

Intercomparison of passive dose and LET spectra in flight is crucial. This can only be done if the spacecraft shielding distributions are identical. Since these are rather small detectors, early flight opportunities should be taken to establish this intercalibrations.

TLDs have lower efficiency for high LET particles. Based on the TLD response curves and an agreed upon LET spectrum, both uncorrected and corrected dose should be reported. All investigators should use the same correction technology. Information on angular dependence of TLDs is missing.

Measurements of the high temperature peaks (the HTR method) have added a new and useful component to the normal low LET dose measurements. Average LET for both the low and low and high LET should be reported. Since, the average Q is not the same as Q(average LET), a mean Q should not be reported from such measurements.

B. Active personnel dosimeters

Only passive (TLD) measurements of crew exposures are made. It is recommended that active personnel dosimeters be developed and be flown together with passive devices.

C. Instruments for neutron measurements

The neutron component has received virtually no attention in radiation risk assessment. This was partly due to the difficulty in measuring neutron spectra. There is increasing evidence to suggest that this is an important component. The following is recommended:

- Compact instruments that can measure neutron spectrum from 1 to at least 20 MeV needs to be developed and flown.

- Serious consideration should be given to body worn instruments (for example, nuclear emulsions or other proton recoil detectors) to estimate the relative dose equivalent contribution of neutrons.

D. Phantom measurements

Only skin dose measurements are currently made. However, it is organ level doses that are required. It is recommend that phantom experiments be carried in space environment to both validate body transport model and correlate organ level dose to skin dose, if applicable.

E. Calibrations

Calibration includes the measurement of response functions at accelerators, the report of uncorrected and corrected data with the used correction technology and intercomparison onboard spacecrafts. At HIMAC energies (MeV/u) provided for the ions He, C, N, O, Ne are typically 6, 100, 180, 230, 290, 350, 400 with the highest energy for He of 230 MeV. Energies for Si are 6 and 800, for Ar 6 and 350. Other suitable facilities are the AGS with energies for Fe of 600 and 1000 MeV/u and possibly other ions and energies in future and the Loma Linda facility with 40-250 MeV protons.

As benchmark for the environment relativistic iron can be used as example and for dose measurements the CERN-EC High Energy Reference Field. The first comparison of the instruments is planned at CERN from July 15-22.

Modelling and Analysis

The following actions are recommended.

Time dependent and density dependent trapped belt model in a form that is user friendly. Both the AP8 and AE8 models are static models and cannot be applied to the ISS in an effective manner. Comparison of model predictions of dose, LET, and spectrum, should be made to improve the AP8 or newer versions of these models.

ISS is an oriented platform. Although, the attitude would be changed for power and thermal consideration, different station modules would experience different radiation flux. Directional trapped belt models should be used for station prediction and comparison. Verification of these models is an important and urgent need. Data already acquired on Shuttle, Mir, and other spacecrafts should be utilised to validate these models. More radiation instruments should be installed on satellites.

There is an electron flux enhancement associated with even small geomagnetic storms. The fluxes can stay at elevated levels for many days. This can impact EVA planning and activity. Models of such enhancements and external electrons are needed for the very substantial EVA activity.

Although models of the geomagnetic cut-off for quiet conditions exist (DGRF 90 and IGRF 95), these models are not adequate for analysis of solar energetic particles. For three SEP events analysed using post event GOES proton spectra give dose rates by a factor of 2 to 6 different to that observations. The following is recommended.

- Develop cut-off grid that is valid for various K_p values.
- Develop model that take into consideration the local day night effect on these cut-offs.
- Using these newer models, analyse the existing eight event data base from the Mir station to validate and improve such models.

For neutrons there is the albedoneutron model of Lingenfelter which was found still valuable.

New cross section data

New cross section data are needed, particularly for light ions and at low energies to improve the radiation transport models.

Combination of PNTDs and silicon detectors shall be exposed at ground based accelerators to understand how to extrapolate data acquired with silicon detectors to tissue equivalent detectors. Target fragments are an extremely important component, particularly, in the body tissues. Target fragments are clearly different from body tissues and silicon.

Data base

It was agreed to have a distributed data base in a common format. Before data will be put to a Webpage they need to be reducted. An improved mission protocol is needed, e.g. exact viewing directions, changes of shielding distributions due to movable equipment and especially attitude information is necessary to compare with or include data into models.

Next activities:

The group should try to get part of the July campaign at CERN. Dr. Hoefert will be contacted (**Action: G. Reitz**). In case time for the investigators is available following investigators are ready to participate in this calibration: R. Beaujean, G.D. Badhwar, Ts. Dachev, S. Deme, K. Fujitaka, W. Heinrich, M. Luszik-Bhadra, M. Panasyuk, G. Reitz, W. Schoener, E.G. Stassinopoulos.

Installation of data base and WEBpage for the workshop. Data Format (**Action: D. Heynderickx, G. Reitz, End July 98**)

Next Meeting is planned at BIRA/IASB or Louvain-La-Neuve, Belgium, March-April 1999, Organiser: D. Heynderickx

Major recommendations are listed below:

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RECOMMENDATIONS

An update of the common models (trapped environment, geomagnetic cut-off and solar storm) is urgently needed, due to the discrepancy between models and measurements. A simple access routine to the models should be provided. More instrumentation on satellites is required to provide new data on proton and electron fluxes.

Distributed data base in a common format shall be used for detailed information, a common data base shall be established for all data in a reduced form. Criteria which information is required have to be set up.

Cross calibration is an indispensable work in order to allow for adequate data comparison. For calibrations HIMAC, AGS, Loma Linda facility and the CERN calibration field shall be used. Intercalibration onboard ISS is deemed necessary. Response functions has to be determined, uncorrected and corrected data need to be provided included correction procedure. For each detector system a common correction technology shall be used. Benchmarks - e.g. relativistic iron peak or CERN calibration field- relevant to the environment needs to be defined and used for proper testing of the instrument characteristics

Active and passive personal dose measurements are strongly recommended. The same holds for measurements inside human phantoms. The required tissue absorbed doses can be determined by combining the information of surface absorbed doses at the human body with depth dose data provided by the phantom measurements.

Recent results show that secondaries deliver a significant contribution to the dose. The high biological effectiveness of such components call for additional efforts. Fragmentation studies should therefore be intensified. Improved measurements of the neutron component is required especially at energies between 1 and 20 MeV and if possible also at higher energies. Advanced instrumentation is absolutely necessary.

Regular organisation of workshops dedicated for developing and modelling, measuring and evaluation technics significantly helps the improvement of dosimetry on the ISS.