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ENVIRONMENTAL RADIATION MEASUREMENTS ON MIR STATION:
Program 1 — Internal Experiment
Program 2 — External Experiment

Year 2 Progress Report

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Abstract: Environmental radiation levels on the Russian space station Mir are being monitored under differing shielding conditions by a series of six area passive dosimeters (APDs) placed at individual locations inside the Core and Kvant 2 modules, and by an External Dosimeter Array (EDA) to be deployed on the exterior surface of the Kvant 2 module. Each APD and the EDA contains CR-39 plastic nuclear track detectors (PNTDs) for measurement of LET spectra and TLDs for absorbed dose measurements. Two of the missions, NASA-2/Mir-21 and NASA-3/Mir-22 have been completed and the six APDs from each mission returned to Earth from Mir. This report covers progress to date on the analysis of TLDs and PNTDs from these two missions. For NASA-2/Mir-21, average mission absorbed dose rates varied from 271 to 407 μGy/d at the APDs. For NASA-3/Mir-22, average mission absorbed dose rates varied from 265 to 421 μGy/d.

1. Introduction:

Exposure of crew, equipment and flight experiments to environmental radiation during extended space missions such as space station habitation in LEO and planetary exploration poses complex scientific and technological problems which need to be resolved before accurate prediction of accumulated doses and adequate radiation protection for crew and sensitive equipment can be achieved. The development of environmental cosmic ray and trapped radiation models and of computer codes for propagation of radiation through matter is essential to the space radiation protection effort, so that dose rates in spacecraft can be predicted based on the orbit, epoch and duration of flight and the physical attributes of the spacecraft. Detailed experimental mapping of the space radiation environment is necessary for comparisons with and rectification of the predictive models and codes.

The NASA-Mir Program provides an opportunity to extend the present database of U. S. measurements of the space radiation environment to the 51.6° inclination of the Mir space station orbit. Since the International Space Station will occupy a similar orbit, radiation measurements made on the Mir can also be used for extrapolation of dose rates to the International Space Station environment. Measurements made at a series of locations on the Mir will provide detailed information on shielding effectiveness in the 51.6° orbit. The NASA-Mir Program will also facilitate the intercomparisons of U. S. and Russian space radiation measurements from both passive and active detectors. The intercomparisons are needed in order to determine the equivalence between the different instruments and techniques used. Results obtained with the APDs will also be compared to the NASA-JSC TEPC microdosimeter measurements made during the NASA-2 mission and with other Russian active and passive dosimeters.

Deployment of separate sets of APDs on the NASA-2, NASA-3 and NASA-4 missions will also contribute to determination of solar cycle effects on the environmental radiation levels. The period includes the approach of solar minimum (Sept. 1997) where maximum doses of galactic cosmic rays (GCRs) will be encountered for this solar cycle. Deployment of the EDA on the exterior surface of Mir will provide LET spectra and dose rate information of very low (<1 g/cm^2) shielding.

2. Experiment:

2.1 Area Passive Dosimeters (APD)

Six APDs per mission are deployed throughout the interior of Mir, four inside the Mir Base Block and two inside the Kvant 2 module. The purpose of the APDs is to measure cumulative radiation exposure at different locations inside Mir throughout the mission. Locations of the six APDs are listed in Table 1. The APDs consist of polycarbonate boxes filled with CR-39 plastic nuclear track detectors (PNTDs) and thermoluminescent detectors (TLDs) supplied by University of San Francisco and the IMBP Moscow. Each APD measures 10.0 cm × 10.0 cm × 5.5 cm and has a mass of 0.28 kg. The APDs are attached to the walls and ceiling of the station by means of Velcro. During transfer to and from the Shuttle, the six APDs are stored in a soft stowage pouch.

Table 1. Locations of the APDs inside Mir station.

Detector	Module	Location
APD-1	Base Block	Door to Engineer's Cabin
APD-2	Base Block	Ceiling Panel #325
APD-3	Base Block	beneath Command Console
APD-4	Base Block	near Window #3
APD-5	Kvant 2	Airlock bulkhead
APD-6	Kvant 2	Ceiling Panel #303

2.2 External Dosimeter Array (EDA)

The EDA consists of one U.S. and one Russian dosimeter package in aluminum containers that are mounted on a spring-loaded aluminum platform. The EDA assembly measures 34 cm × 16 cm × 12 cm and has a mass of 1.78 kg. The EDA is pictured in Figure 1. The EDA interfaces by means of a spring-loaded mechanism with the stationary STD platform currently mounted on the exterior of the Kvant 2 module. The STD platform was developed by the Russians and previously deployed. Similar radiation experiments have been carried out by the Russians using the STD platform in June 1991.

The U.S. dosimeter set, supplied by the University of San Francisco, consists of two aluminum canisters (5 cm diameter, 0.95 cm thick) containing CR-39 PNTDs and a TLD block (6.0 cm × 3.5 cm × 2.0 cm). The CR-39 canisters have 2 cm diameter Kapton thin-shielding windows on top. The TLD block contains 2 stacks of TLDs mounted inside 1 cm diameter holds and covered by thin-shielding Kapton windows. Care should be taken to not puncture the Kapton windows. The PNTD capsules and TLD block are mounted on a hollow Al plate (12.0 cm × 10.0 cm × 3.0 cm) which is in turn mounted on the front of the EDA base. A 12.0 cm × 10.0 cm × 4.0 cm protective cover is mounted on top of the Al plate and covers the PNTD canisters and TLD block while the EDA is stowed on the inside of Mir Station. The protective cover is held in place by means of clips. The Russian dosimeter package, supplied by the Institute of Biomedical Problems, consists of 2 aluminum containers assembled as one unit. The smaller container (7.2 cm × 2.0 cm × 2.3 cm) contains 6 stacks of TLDs. The larger container (10.0 cm × 6.5 cm × 4.2 cm) contains CR-39 PNTDs together with holders containing TLDs. The tops of each container are covered by thin Kapton windows.

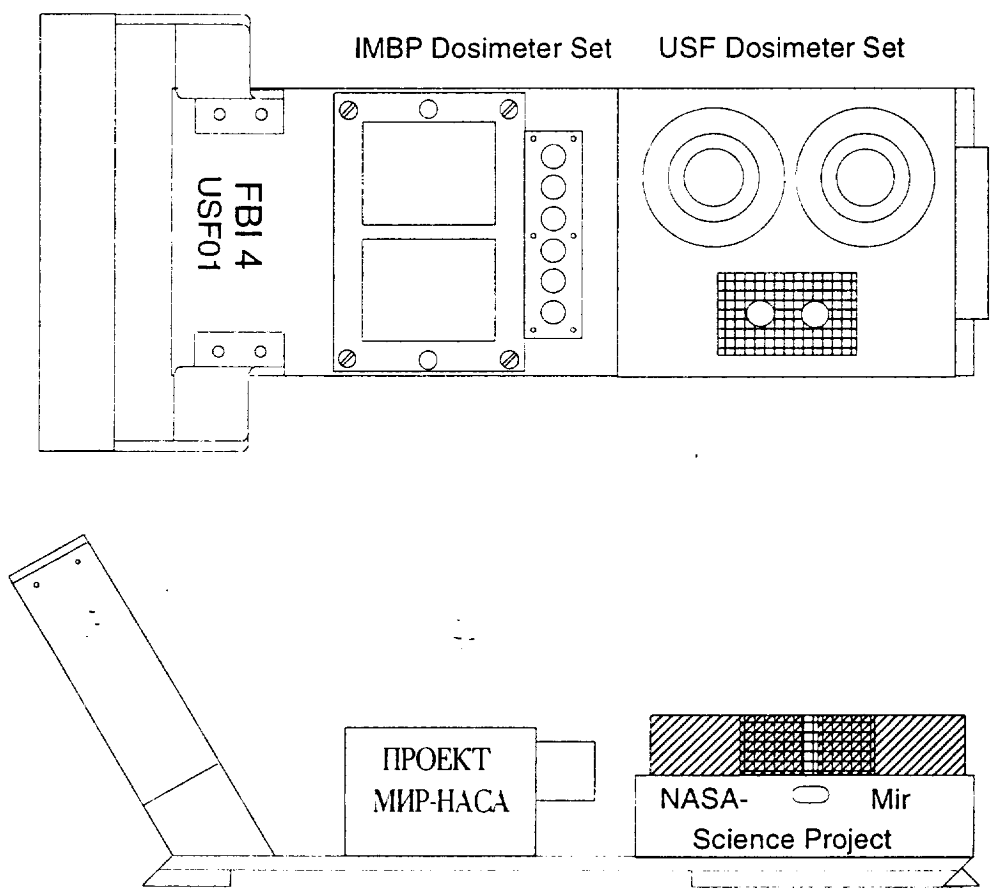

Figure 1. External Dosimeter Array.

2.3 Mission Anomalies

Two of the three NASA/Mir missions (NASA-2/Mir-21, 22 March to 26 September 1996 and NASA-3/Mir-22, 16 September 1996 to 22 January 1997) have been successfully carried out. The APDs from these two missions were returned to USF for detector processing and analysis. The third set of APDs for the NASA-4/Mir-23 mission was delivered to Mir aboard STS-81. STS-81 also delivered the EDA to Mir for deployment during the April 1997 EVA.

Six APDs (Serial Nos. 0001 to 0006) were delivered to Mir aboard STS-76 and deployed in the four locations inside the Core (Base Block) and two inside the Kvant 2 module. Six APDs (Serial Nos. 0007 to 0012) were delivered to Mir aboard STS-79 to replace those delivered on STS-76. One of the six NASA-2 APDs (No. 0005) was inadvertently left aboard Mir while one of the NASA-3 APDs (Serial No. 0010) was returned along with the five NASA-2 APDs. Six NASA-4 APDs (Nos. 0013 to 0018) were delivered to Mir aboard STS-81. APD No. 0005 was returned aboard STS-81 along with Nos. 0007, 0008, 0009, and 0012. NASA-3 APD No. 0011 was inadvertently left aboard Mir during the STS-81 mission while NASA-4 APD No. 0017 was mistakenly returned.

2.4 Dosimeter Processing and Readout

Following post-mission receipt of the APDs by USF, they were opened and their contents removed. The IMBP portion of the APDs were hand-carried to Moscow and returned to IMBP staff. Fiducial holes were drilled in the CR-39 PNTD stacks and the stacks disassembled. Selected layers from each stack have been chemically processed to reveal the particle tracks. Microscopic analysis of the PNTDs is now underway and preliminary LET spectra from the first of these detectors is expected shortly. The TLDs from the Front and Back plates in each APD were read out with a Model 4000 Harshaw TLD Reader. Background TLDs from a Ground Control APD and TLDs calibrated with a ^{137}Cs standard source were read out with the flight TLDs. All TLDs were then re-calibrated together to generate absorbed doses. The average of 10 TLDs yielded mission dose for each TLD plate.

3. Results:

Selected CR-39 PNTD layers from the NASA-2 and NASA-3 APDs have been chemically processed and are currently being readout using an automated track analysis system. Preliminary LET spectra from the first of these APDs should be available shortly. It will then be compared to similar data from the JSC-TEPC and from Russian dosimeters.

The mission-averaged daily doses for the NASA-2 and NASA-3 TLDs are given in Tables 2. Figure 2 illustrates NASA-2 mission doses and average daily dose rates by location. Figure 3 illustrates NASA-3 mission doses and average daily dose rates by APD location. From the five NASA-2 APDs, doses varied from 51.1 to 76.6 mGy and dose rates varied from 271 to 407 μGy/d. Dose rates from the NMB-4 APD were intermediate indicating that the stowage and storage shielding of this dosimeter was within the range of shielding distributions aboard the Mir. NASA-3 APD doses varied from 33.7 to 48.2 mGy and dose rates varied from 265 to 378 μGy/d. The NMA-5 APD left aboard Mir for both the NASA-2 and NASA-3 missions was exposed for a total of 305 days. Total dose for NMA-5 was 128.g mGy while dose rate was 421 μGy/d. Dose rates from the NMC-5 were somewhat lower than those for NMB-4, indicating the for most of the mission, NMC-5 was stored in a relatively high-shielding location.

4. Discussion and Conclusions:

The dose rates measured in the APDs on the Mir Space Station during the NASA-2/Mir-21 mission ranged from 271 to 407 μGy/d with and average of 324 μGy/d. For the NASA-3/Mir-22 mission, measured dose rates ranged from 265 to 421 μGy/d with and average of 329 μGy/d. On the Mir-18 mission, between February 28, 1995 and July 7, 1995, TLD dose rates from a similar APD were 264 μGy/d, indicating that the location of the Mir-18 APD (also in the Core Module) was rather heavily shielded. The lowest doses measured were from APD NMA-6, which was mounted in the Kvant 2 module. The shielding distribution of the Kvant 2 module (as an individual unit) is less than that of the Core module and the smaller doses inside Kvant 2 would not be expected from a simple shielding assessment. The shielding distribution and attitude dependence presented by the total Mir Space Station in determining internal doses is obviously complex. The local shielding due to equipment and supplies near the APDs may also be a major factor in shielding and radiation levels.

Recent Russian dosimetry measurements (Dachev et al., 1989; Vasilev et al., 1990; Lobakov et al., 1992; Benghin et al., 1992) have results from ionization chamber dosimeters, semiconductor dosimeters and TLDs. Average absorbed dose rates measured by the Russians are typically in the region of 200-400 μGy/d inside Mir. This is in general agreement with the APD measurements.

The PNTDs from the APDs are currently being processed and read out. The measured LET spectra from these detectors will be combined with the TLD doses to generate mission dose equivalents in the near future. Intercomparisons with the results of other active and passive flight dosimeters will then be made.

5. References

Benghin V. V., Petrov V. M., Teltsov M. V., Chernykh I. V. and Shumshurov V. I. (1992), Dosimetric control on board the MIR space station during the solar proton events of Sept.-Oct. 1989, Nucl. Tracks Radiat. Meas. **20**(1), 21-23.

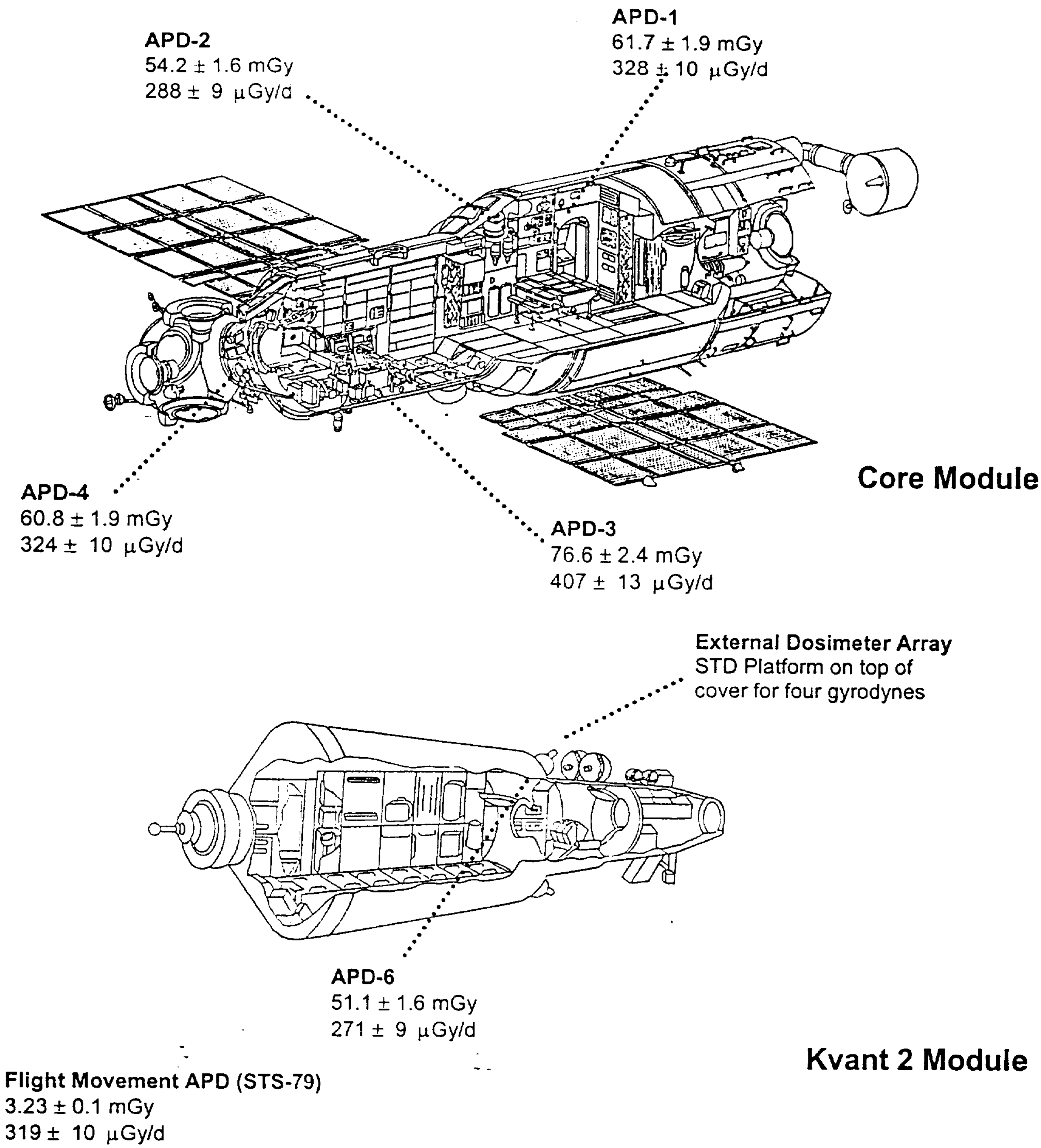

Figure 2. Dose and dose rates measured inside Mir Station during the NASA-2 /Mir-21 mission by the USF Environmental Radiation Measurements Experiment: 22 March - 26 September 1996 (188.2 days)

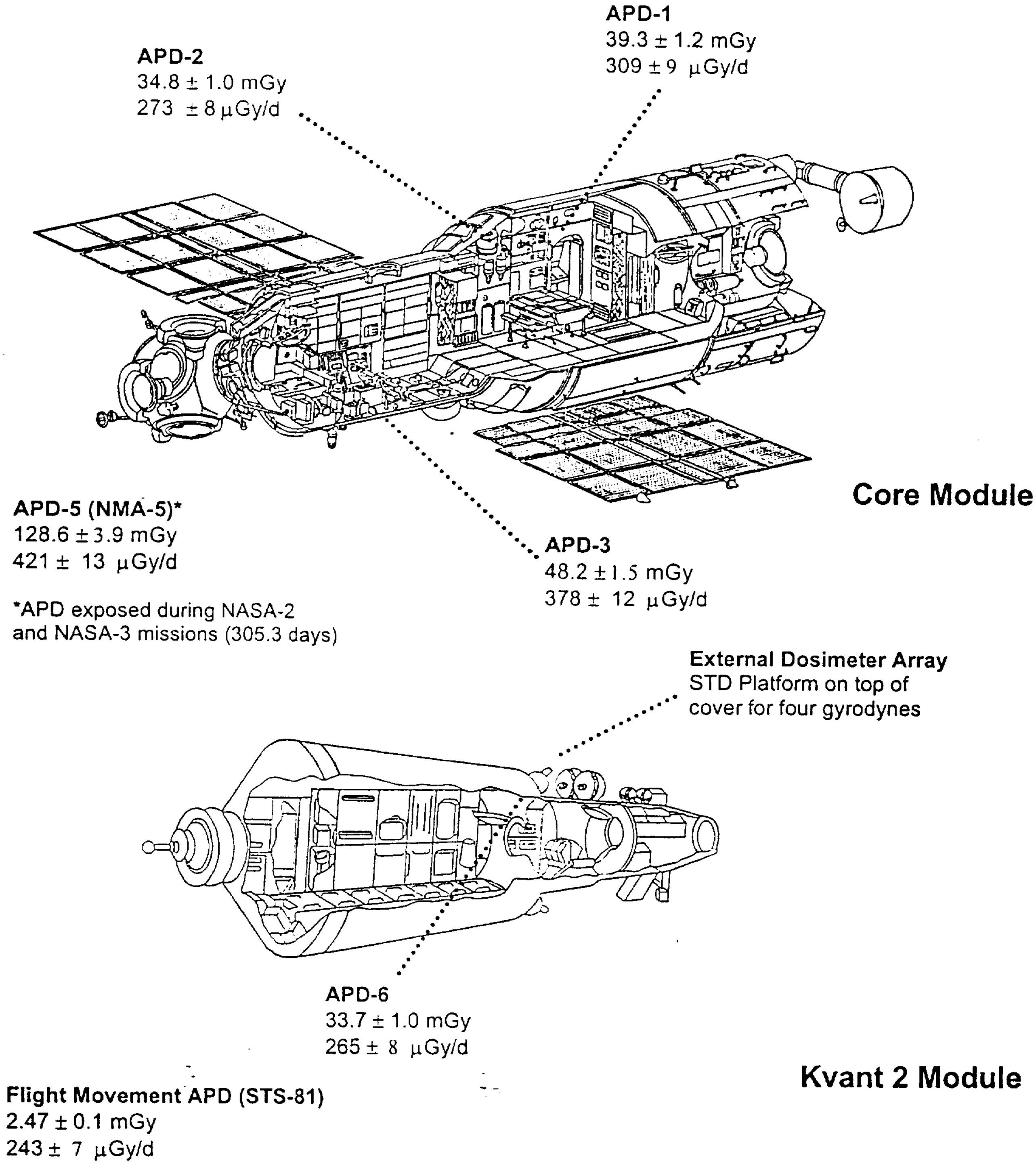

Figure 3. Dose and dose rates measured inside Mir Station during the NASA-3/Mir-22 mission by the USF Environmental Radiation Measurements Experiment: 16 September 1996 - 22 January 1997 (127.2 days)

Dachev Ts. P., Matviichuk Yu. N., Semkova J. V., Koleva R. T., Boichev B., Baynov P., Kanchev N. A., Lakov P., Ivanov Ya. J., Tomo P. T., Petrov V. M., Redko V. I., Kojarinov V. I. and Tykva R. (1989), Space radiation dosimetry with active detections for the scientific program of the second Bulgarian cosmonaut on board the Mir space station, Adv. Space Res. **9-10**, 247-251.

Lobakov A. P., Lyagushin V. I., Panasyuk M. I., Shravrin P. I., Makhmutov V. S., Petrov V. M., Shurshakov V. A., Dachev Ts. P. and Semkova I. V. (1992), Increase in solar cosmic rays on the Mir space station in orbit during September-October 1989. Nucl. Tracks Radiat. Meas. **20**(1), 59-64.

Vasilev T., Pironkov A., Karadzhov A., Traykov A., Akatov Yu. A., Burkovich A. R., Popov V. I. and Portman A. I. (1990), Radiation physics results of the Soviet-Bulgarian "Doza-B" experiment on space station Mir. Space Biology and Aerospace Medicine: Proc. IXth All-Union Conference, Kaluga, June 19-21.