Bubble Detector Measurements On the International Space Station As a Part of Matroshka-R Experiment

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Background

- Since January, 2006, with the intent to characterize the neutron component of the radiation field onboard ISS, as a part of Matroshka R project, more than 10 experiments (cessions) have been carried out during six expeditions, namely ISS-13-18.
- The following apparatus has been used.
- a spherical phantom designed by IBMP,
- special space bubble detector with a mini reader for automatic bubble counting, developed by Bubble Technology Industries (BTI).
- The phantom was located at various places throughout the ISS to evaluate the influence of its shielding (docking module and service module).
- The detectors were positioned on/in the spherical phantom in order to establish the relationship between the neutron dose measured externally and internally.
- A part of the experimental data will be presented.

Experimental Apparatus

1. Space Bubble Detector and Bubble Reader

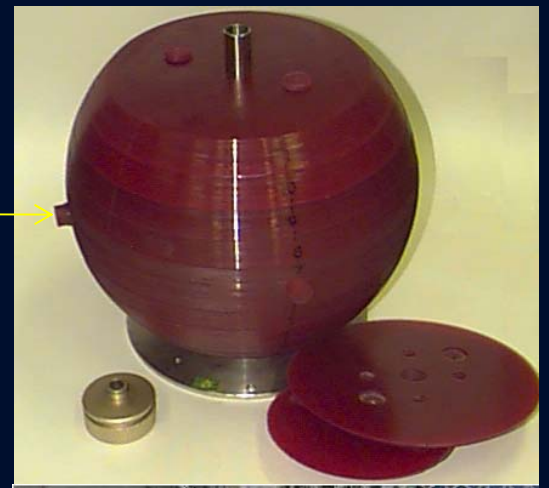
- To meet the space radiation measurement conditions, special space type bubble detectors were produced.
- The detector, with approximately 10^4 microscopic droplets and low sensitivity of 80 to 130 bubbles/mSv, has 10 ml active volume.
- This allows the detector to be used for a longer exposition period.
- The bubble counting was done automatically using a lightweight mini reader also developed by BTI

Space bubble detector before/after exposure

Experimental Apparatus

2. Spherical phantom

The spherical phantom to simulate the human body consists of :

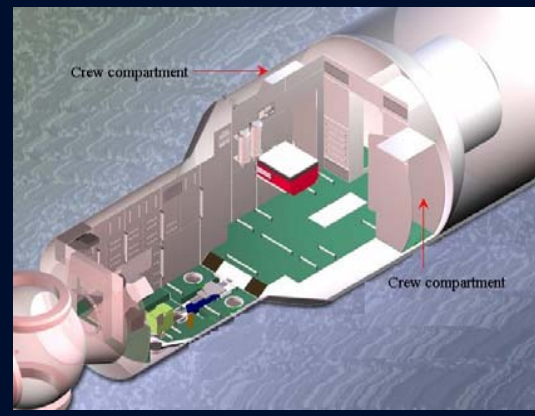


phantom with/without jacket

- 350 mm in diameter, 32kg in mass and has 13 tissue–equivalent slices.
- A working jacket, with 32 pockets, designed to facilitate the mounting of detectors on the surface .
- Radial holes designed to facilitate the insertion of detectors inside the phantom at a depth of 105-65 mm.

Measurements

- Detectors were calibrated using an AmBe source with an emission rate of 1,13.10^{7} s^{-1} and a conversion coefficient of 4.11.10^{-4} $\mu Sv.cm^{2}$.
- Readings were scaled by a factor of 1.62 adopted in ref (1)*.
- The detectors were irradiated for approximately five days and counted immediately after exposure.



ISS Service Module

Measurements with bubble detectors were performed:

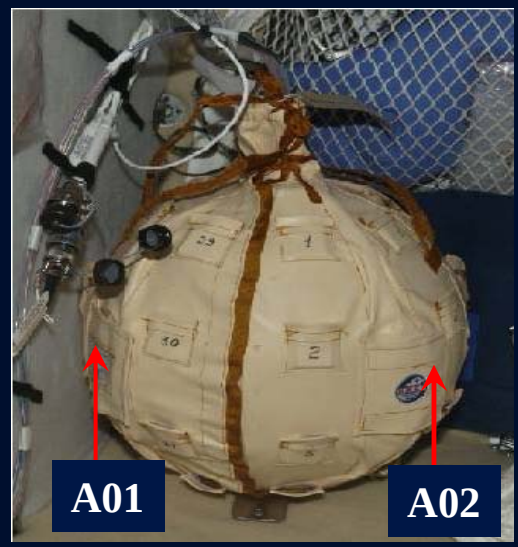
- On the surface of the phantom (external dose)
- Inside the phantom (internal dose)
- At different locations, mainly, in Service module SM and Docking module DM (influence of shielding).

*
1. Green, A. R., et alt., Characterization of bubble detectors for aircrew and space radiation exposure. Radiat. Prot. Dosimetry 120(1–4), 485–490 (2006).

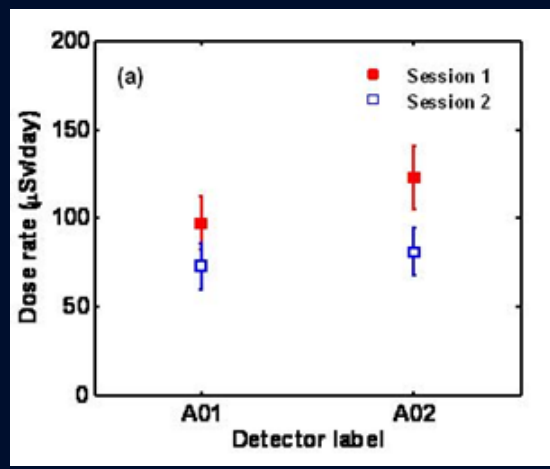
Experimental data

1. Measurements on the surface of the phantom

- Two measurements (sessions) on the surface of the phantom were performed with the phantom located in the right crew cabin in the SM.
- In the first measurement, two bubble detectors were fixed on the surface, at the equatorial level, of the phantom and facing the living area of the cabin towards the centre of the SM.
- In the second measurement, the same set was used, but the detectors were relocated to the back of the phantom facing the outer wall of the crew cabin.



Detector location on the surface



Reading of detectors on the surface

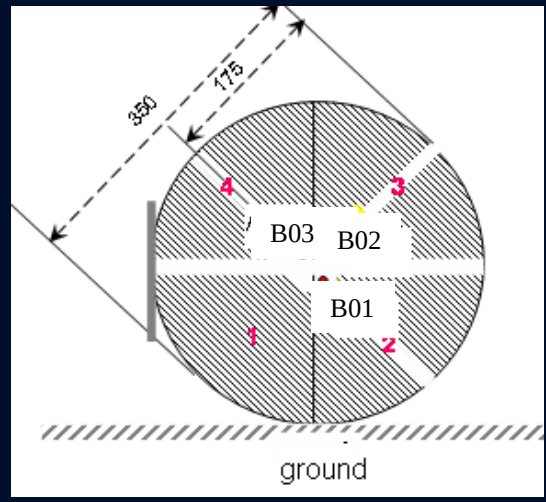
Experimental data (continued)

2. Measurements inside the phantom

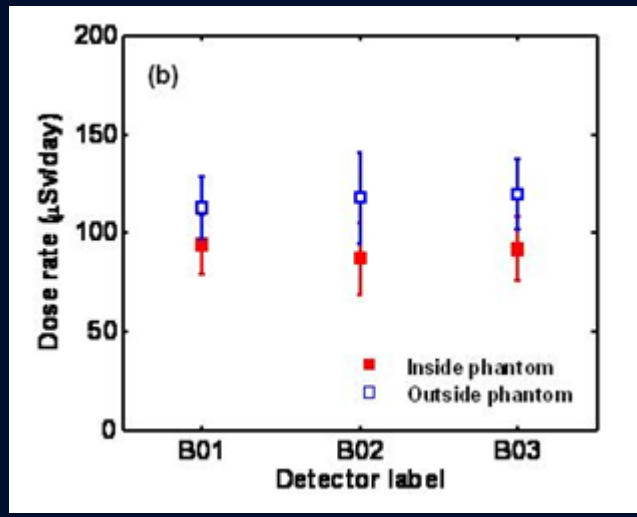
- With the phantom in the DM, the measurements inside the phantom were conducted with another set of three bubble detectors referred to as B01–B03

- To measure the dose received by critical organs (internal dose), the three bubble detectors were inserted into the three radial channels at the centre of the phantom at a depth of 105–165 mm. The measurement was repeated twice to assess data consistency

- Another session was conducted, also in the DM, to compare the dose measured on the surface with the internal dose measurement. During this experiment, detectors B01–B03 were relocated to the surface of the phantom.



inside the phantom setup

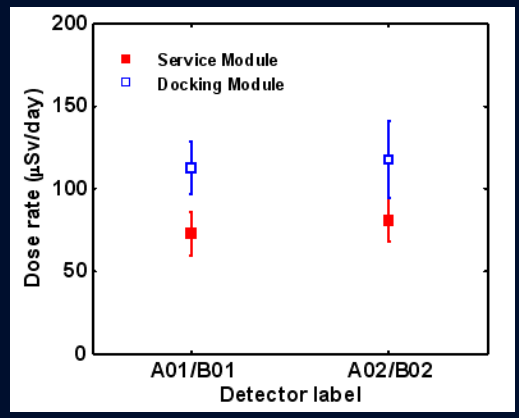


Internal/external comparison

Experimental data (continued)

3. Measurements at different location

- The phantom was positioned in two different locations, namely, in the SM and in the DM.
- The reading of the detectors on the surface of the phantom in both locations show a slight difference in the dose rate due to the difference in the shielding thicknesses.
- The asymmetry of the neutron field in the left and right cabin are comparable
- An important feature of this experiment is to compare the ratio of the internal to external dose at different location which shows no significant difference



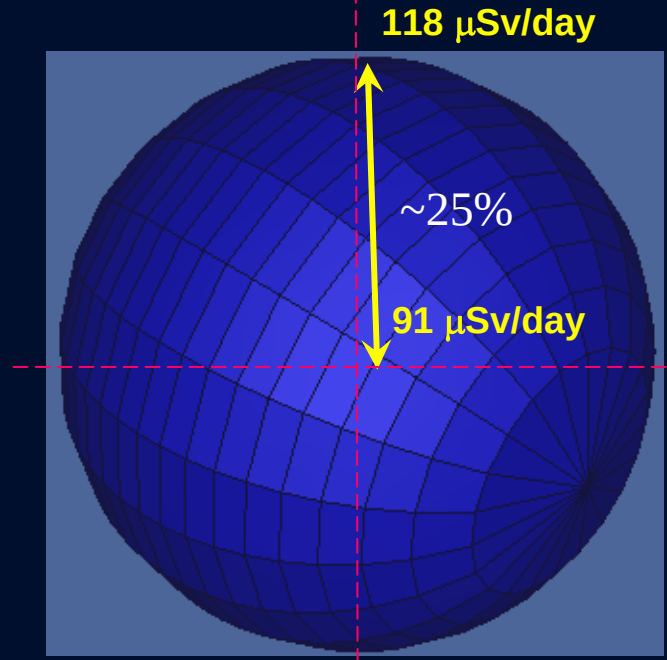
Measurement at different locations

⟶ 86±6 and 86±16 μSv/day

Module	surface	inside
DM	118±33	91±27
PIRS	131±35	114±31

Discussion

- The dose rate inside the phantom is consistent in the 2 measurements done in the docking module and is about 91 μSv/day.
- The comparison of the value of 91 μSv/day (inside) and 118 μSv/day on the surface is within about 20-25%
- Another measurement on PIRS module gives a surface dose of 131 μSv/day and inside dose of 114 μSv/day i.e. a slight difference compared to the data in Docking module



Internal/external doses

Discussion (continued)

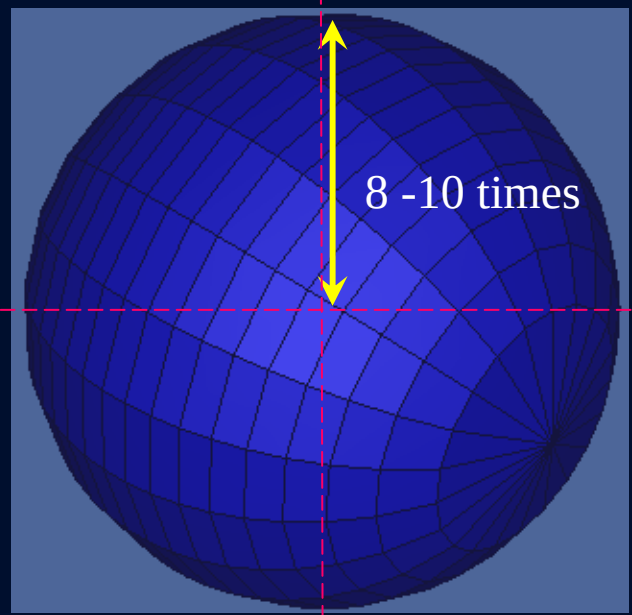
- The difference of the readings in different locations is expected as the neutron production increases with the thickness of the shielding, however, the 25% difference between doses at the center and on the surface is surprising.

- On the earth this difference is about one order of magnitude higher (with ^{252}Cf source shielded by 15cm of tissue with (NCRP 38).

- This difference can be due to:

1. Either to neutron production by other process (charged particles).

2. Or due the slowing down process of neutrons through the phantom, which is less probable.



Spherical phantom
On the earth

Conclusion

Measurements of the neutron dose with bubble detectors have been carried out during different expeditions within the Matroshka-R project.

- Low sensitivity space bubble detectors and a spherical phantom have been used.

- Data taken in the Docking Module showed that the phantom's internal dose was about 20-25 less compared to the phantom's external dose.

- The readings from two symmetrically positioned detectors, shows a comparable dose.

- The values of external to internal dose ratio are comparable in different modules

Ongoing experiments with Bubble Spectrometer

- The measurement of the neutron dose on the surface and in inside the phantom raises a question on the difference (order of magnitude) between the values in Space and on the Earth.

- The measurement of the neutron spectra on the surface and inside of the phantom may ease the understanding of this difference, this measurement is ongoing with bubble spectrometer

- In parallel Simulation using different transport codes are ongoing