Characteristics of radiation environment onboard the Russian segment of the ISS measured by the radiation monitoring system.

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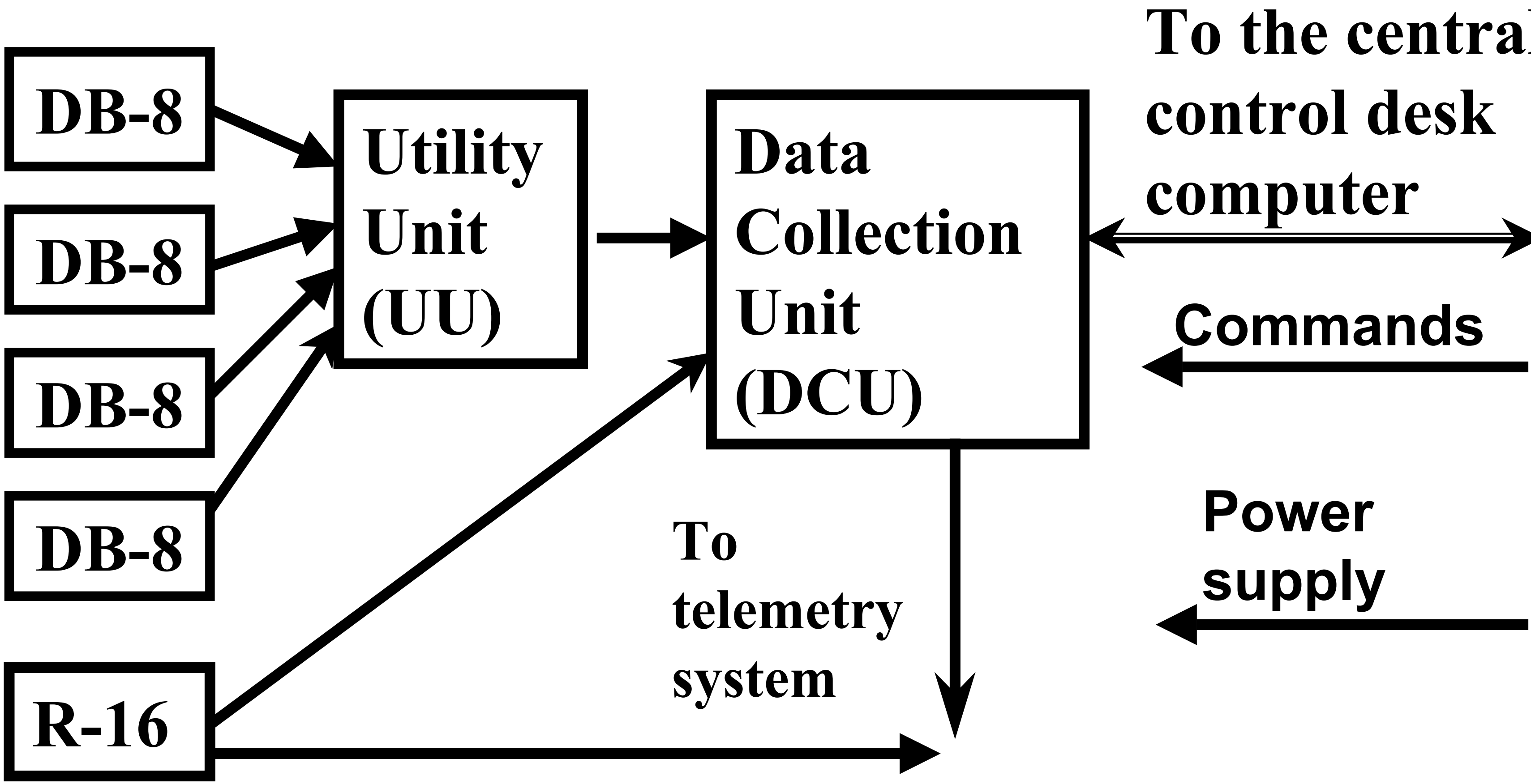
Radiation monitoring system (RMS), being deployed on the International Space Station, is a part of radiation safety implementation system of the station. One of the main goals of Russian RMS consists of obtaining current depth-dose curves for organ-doses calculation in various radiation conditions during the ISS flight. The RMS structure was determined in view of this main goal. The current structure is presented in the next slide. In the future it is planned to expand the system using the Hungarian device PILLE-ISS and Bulgarian LIULIN-ISS, and also to update the software of the DCU.

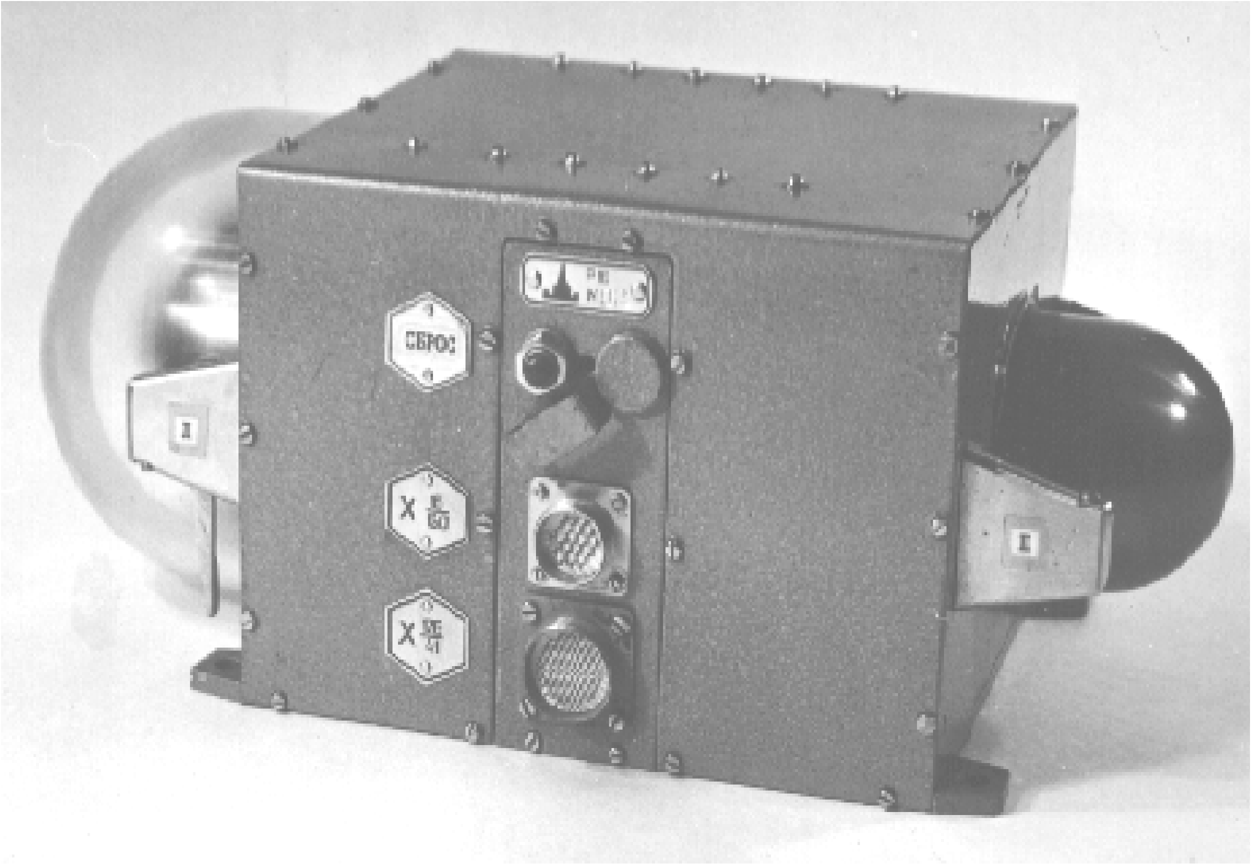
For current structure of the RMS, the detectors of radiation are located in blocks DB-8 and R-16.

Current configuration of the radiation monitoring system (RMS)



R-16 dosimeter

Two argon filled ionisation chambers are sensitive elements of the R-16 dosimeter.
One of the chambers has an additional plastic shielding 3 g/cm^2.



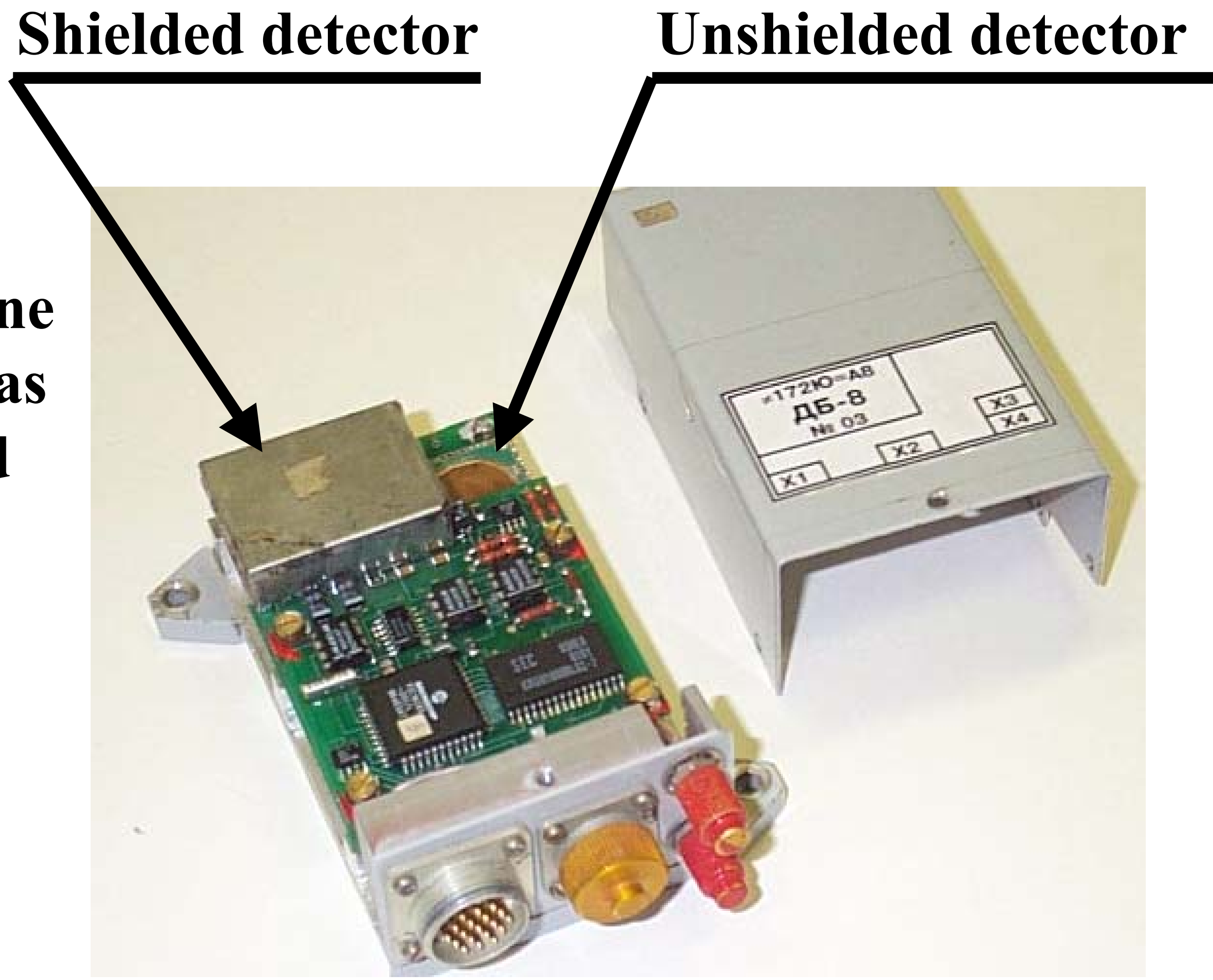
Pulses from ionisation chambers are counted up. The number of the pulses is transferred directly to the telemetry system of RS ISS.

DB-8 unit

All the DB-8 units are similar.
Each of them has 2 fully independent channels consisting of a semiconductor detector and electronic circuit.

The sensitive component is a silicon semiconductor detector of 300 μm sensitive layer covering an area of 1 cm^2.

DB-8 unit without cover

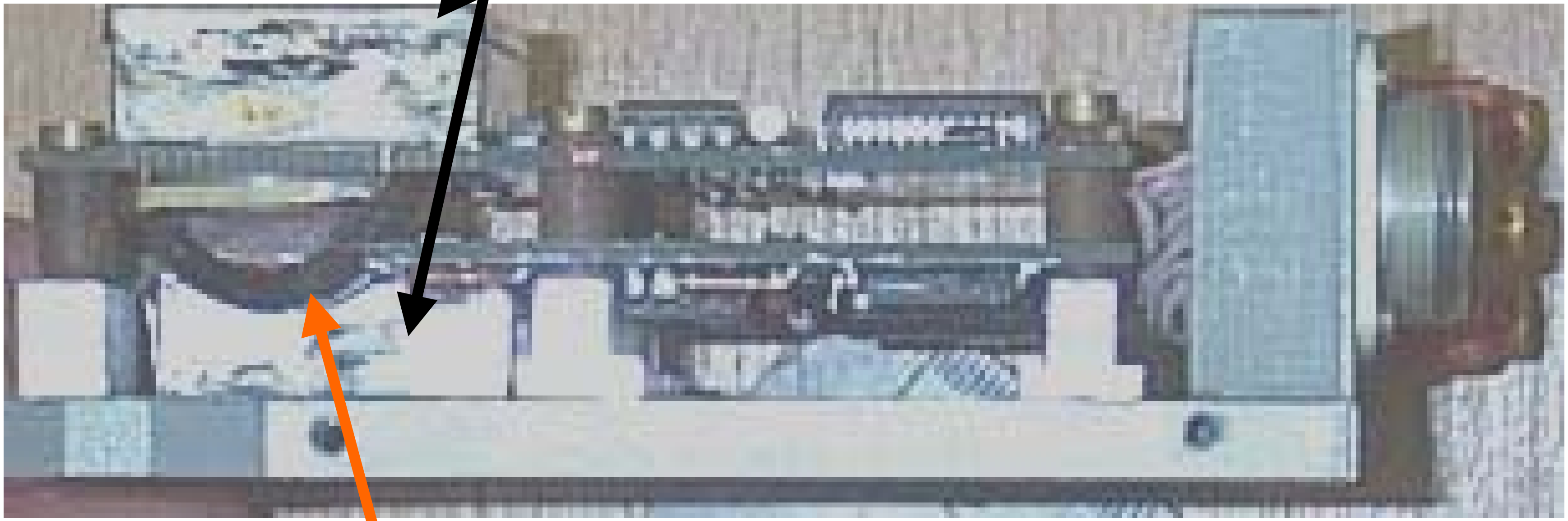


The difference between the two channels is that one of the detectors has an additional lead shielding. The shielding is a sphere surrounding the detector.

The sphere wall thickness is 3 g/cm^2 Pb

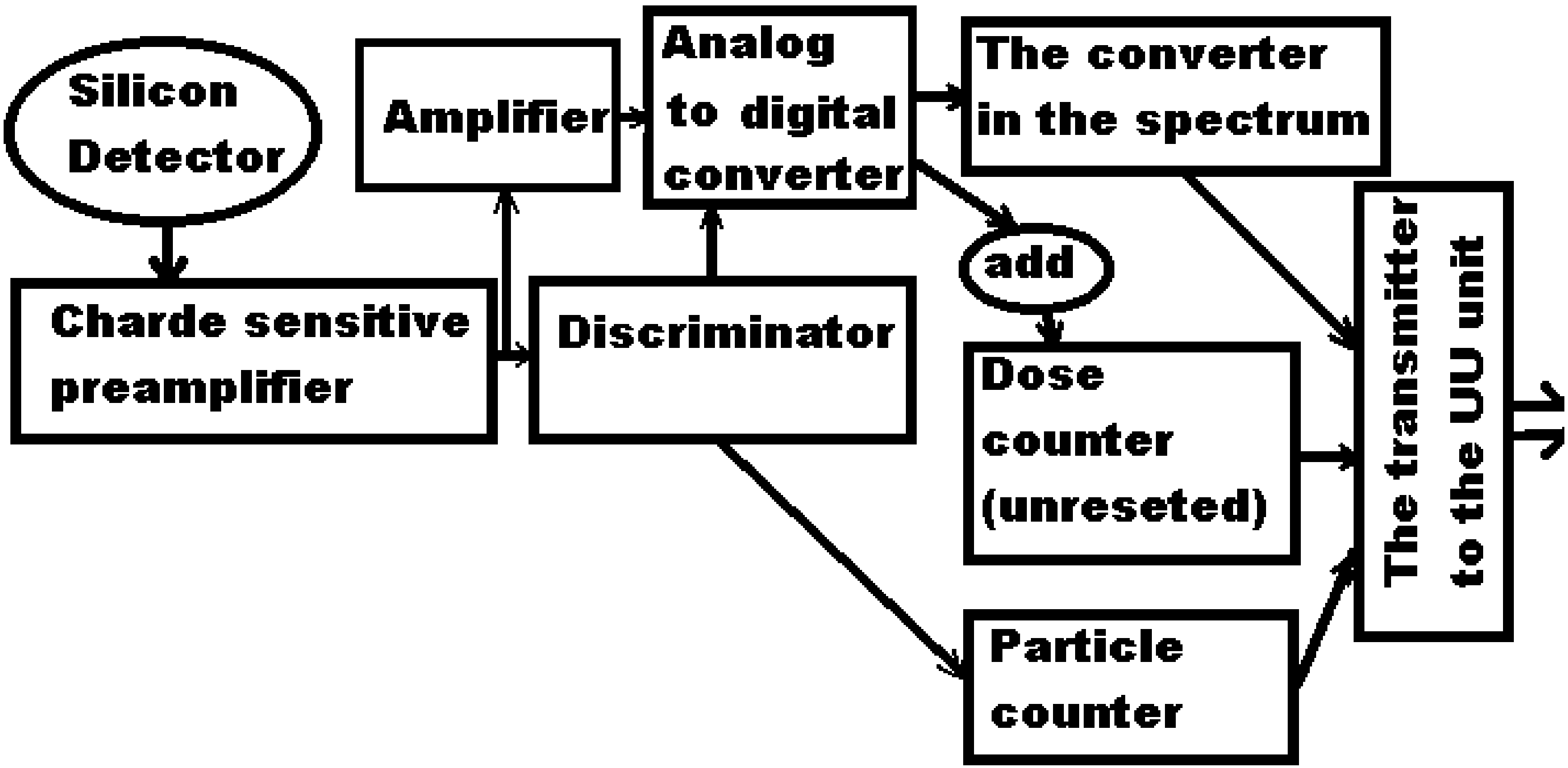
Each DB-8 unit consists of 2 independent dosimeters

Electromagnetic screens of detectors



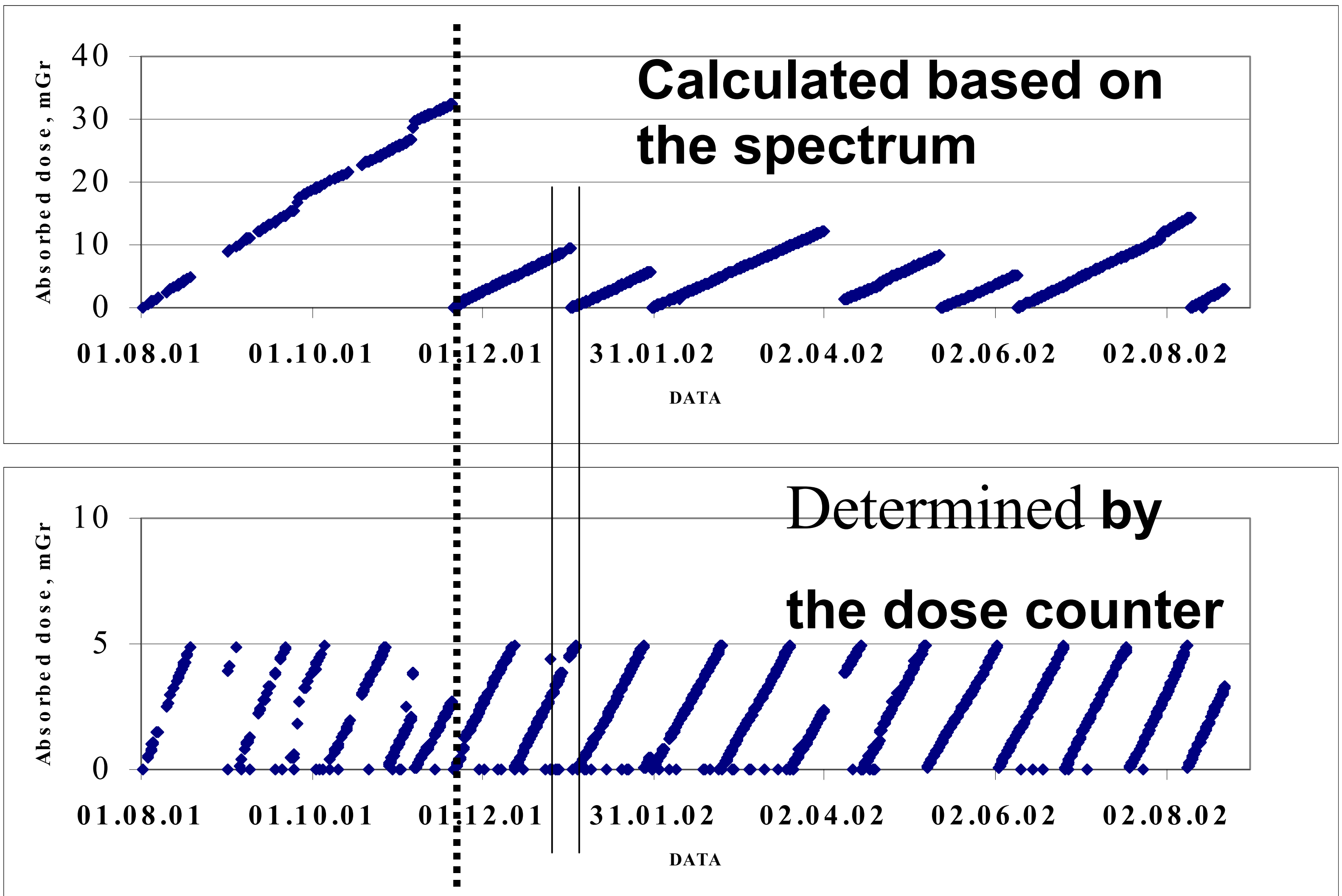
The lead spherical shielding of 2.5 mm thickness which closes the detector

The flowchart of DB-8



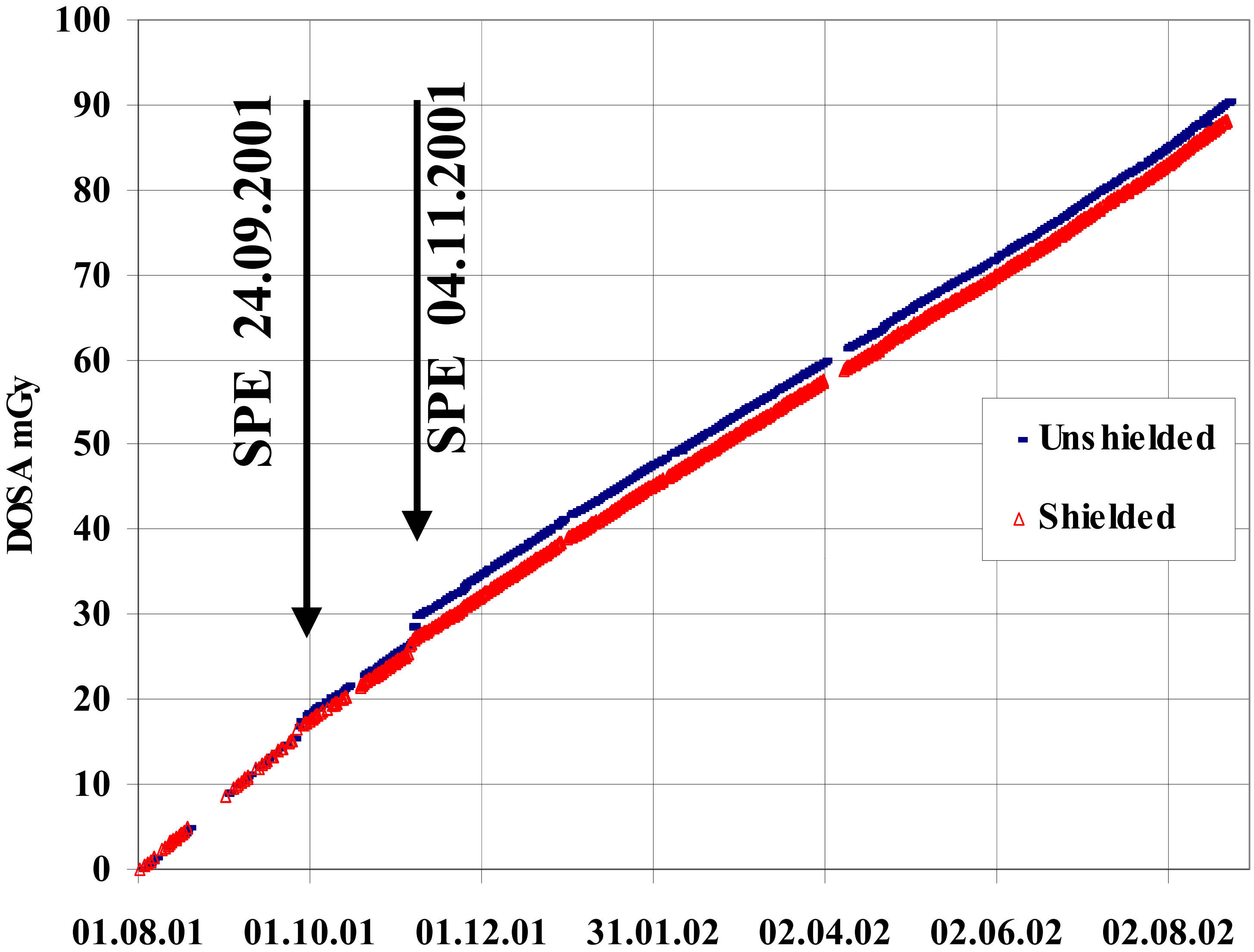
If we neglect the system noise and round off errors then the absorbed dose is proportional to the sum of the ADC output signal.
There are two ways to obtain the dose.
The first way, output signal from the ADC is added to the total dose counter. After power-up of the RMS this 32-bit counter resets and then accumulates signals until overflow after which the cycle loops.
The second way is based on summing up the number of particles in spectrum channels with respective weighting factors. This way allows increasing of the dynamical range of measurements based on the correction of the calculating errors caused by the dead time of the discriminator and ADC.
Dosimetric information obtained by these two ways is presented on the next slide.

Dosimetric information from the unshielded DB-8 number 1 detector

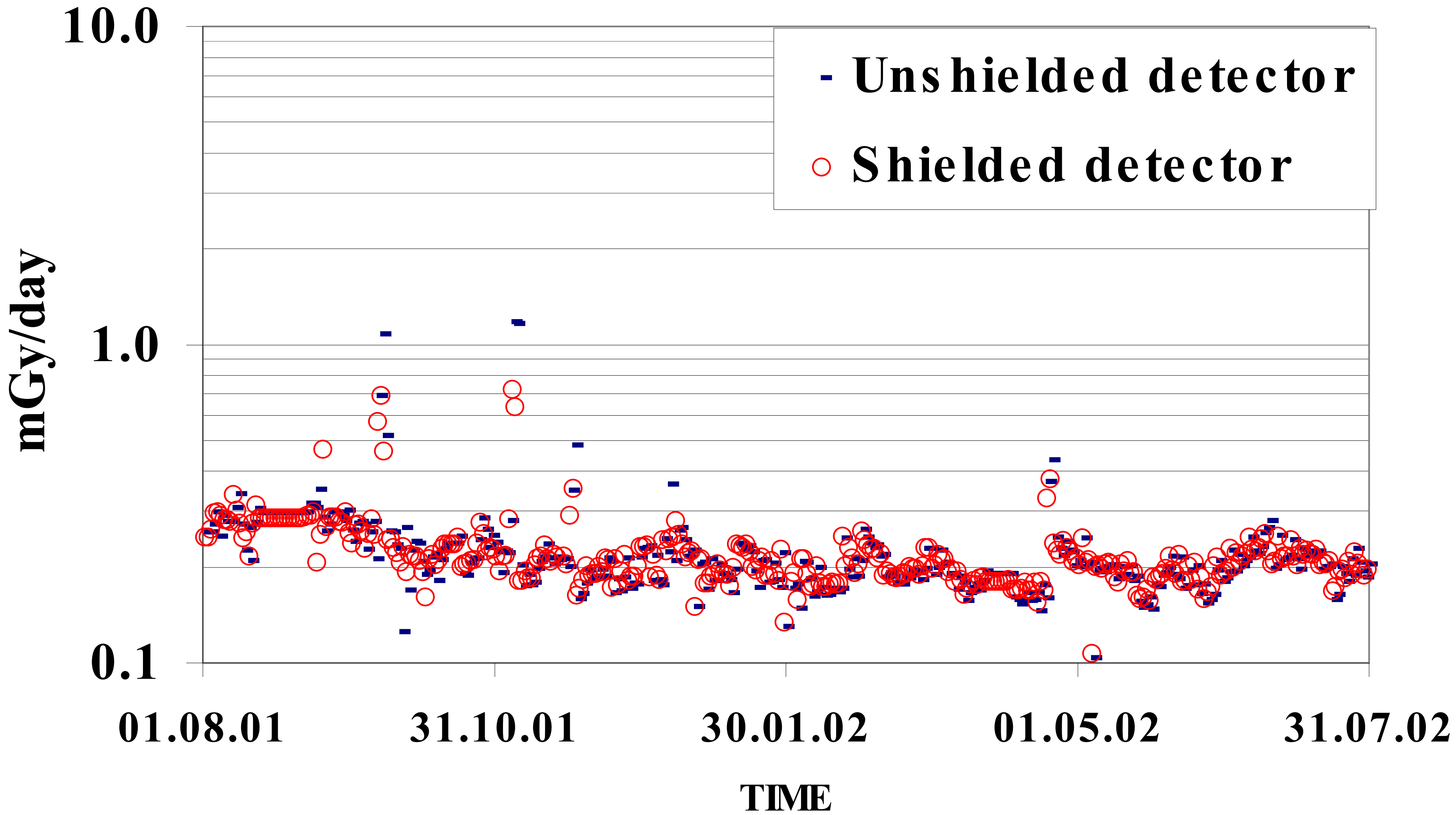


The data given on the previous slide illustrate monotonous increase of the absorbed dose; at some moments the increase is interrupted and dose value restarts the increase from zero (dose resets).
The first reset, is caused by switching off the system on November 20, 2001. At that time crew connected the communication cable between RMS and control desk computer.
Other resets on the lower diagram of the previous slide are caused by overflows of the counter.
Resets on upper diagram are caused by DCU restarts.
However, using the 2 methods of dose calculation permits us to restore the value of the absorbed dose.
Recovered values of the first detector dose are presented on the next slide.
The SPE influence has been marked by arrows.
The dose rate diagrams are presented on the next 2 slides for DB-8 units behind minimum and maximum space station shielding.

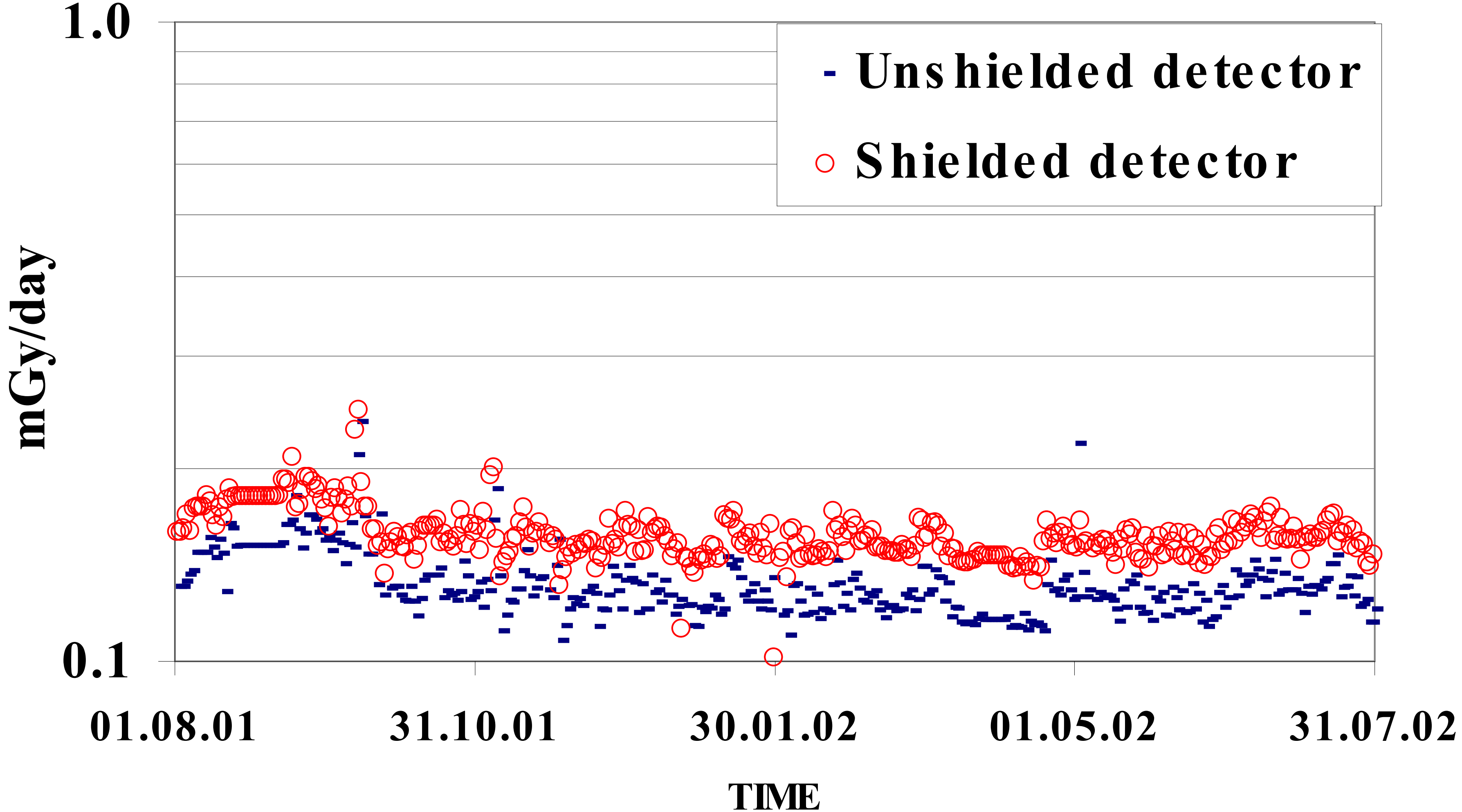
Recovered dose of DB-8 unit number 1



Dose rate measured with number 1 DB-8 unit



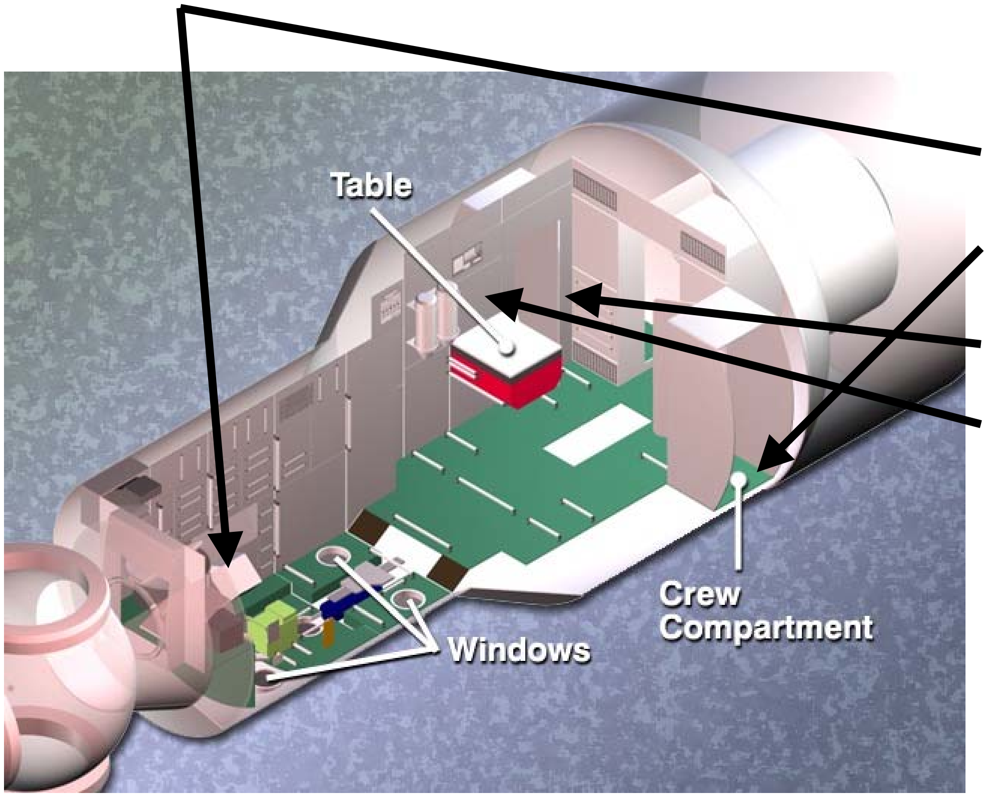
Dose rate measured with number 4 DB-8 unit



Doses measured during the first year of RMS operation

Detector		Dose per year, mGy	Mean dose rate, mGy/day
DB-8 number 1	Unshielded	85,7	0,235
	Shielded	84,3	0,231
DB-8 number 2	Unshielded	68,0	0,189
	Shielded	70,8	0,194
DB-8 number 3	Unshielded	70,2	0,192
	Shielded	73,6	0,202
DB-8 number 4	Unshielded	48,2	0,132
	Shielded	60,0	0,159

Placements of the RMS blocks



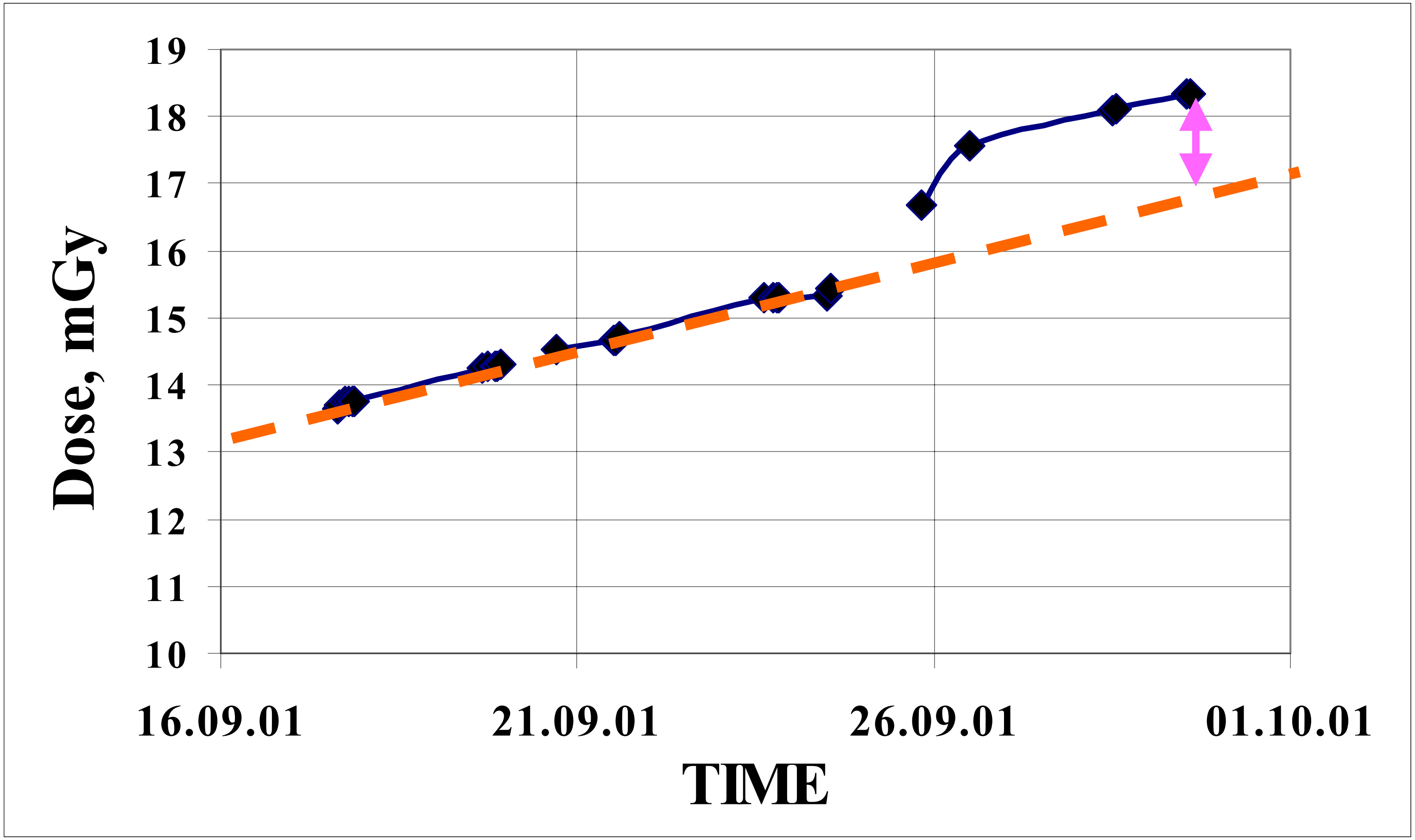
http://spaceflight.nasa.gov/gallery/images/station

/servicemodule/html/jsc2000e26922.html

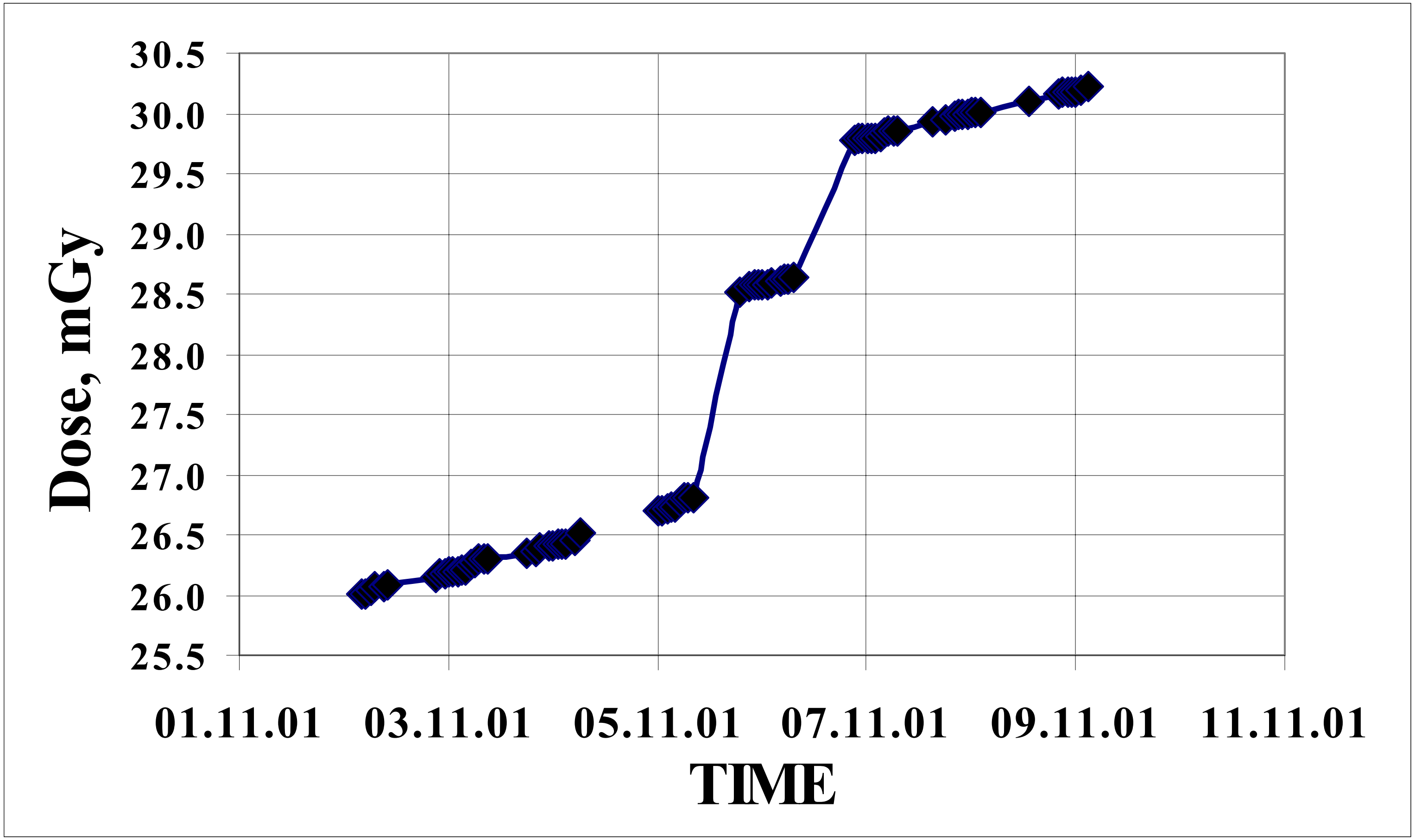
Block	Placement
DB-8 №1	Starboard side, behind board № 410
DB-8 №2	Port side, behind board № 244 (cabin)
DB-8 №3	Starboard side, behind board № 447 (cabin)
DB-8 №4	Starboard side, behind board № 435
R-16	Ceiling of Big diameter bay, behind board № 327
UU	Starboard side, behind board № 447 (cabin)
DCU	starboard side, behind board № 447 (cabin)

The SPE influence is presented in detail on the next a few slides.
Dose values obtained during September 2001 event are presented on the next diagram.
The dose-time dependence for undisturbed conditions (no SPE) was extrapolated (dash line) to determine additional dose caused by the SPE.

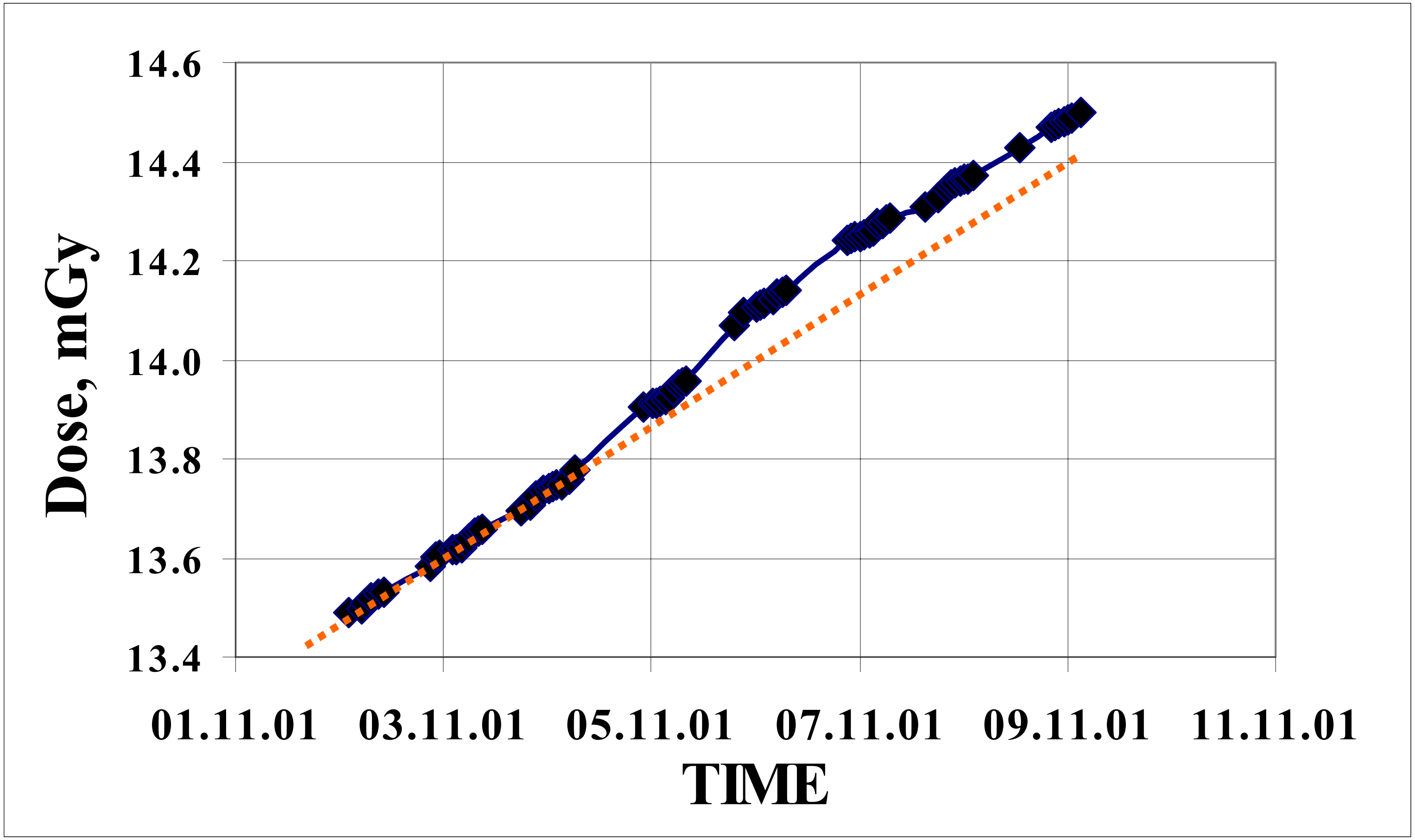
Dose for SPE 24.09.2001, DB-8 unit number 1, unshielded detector



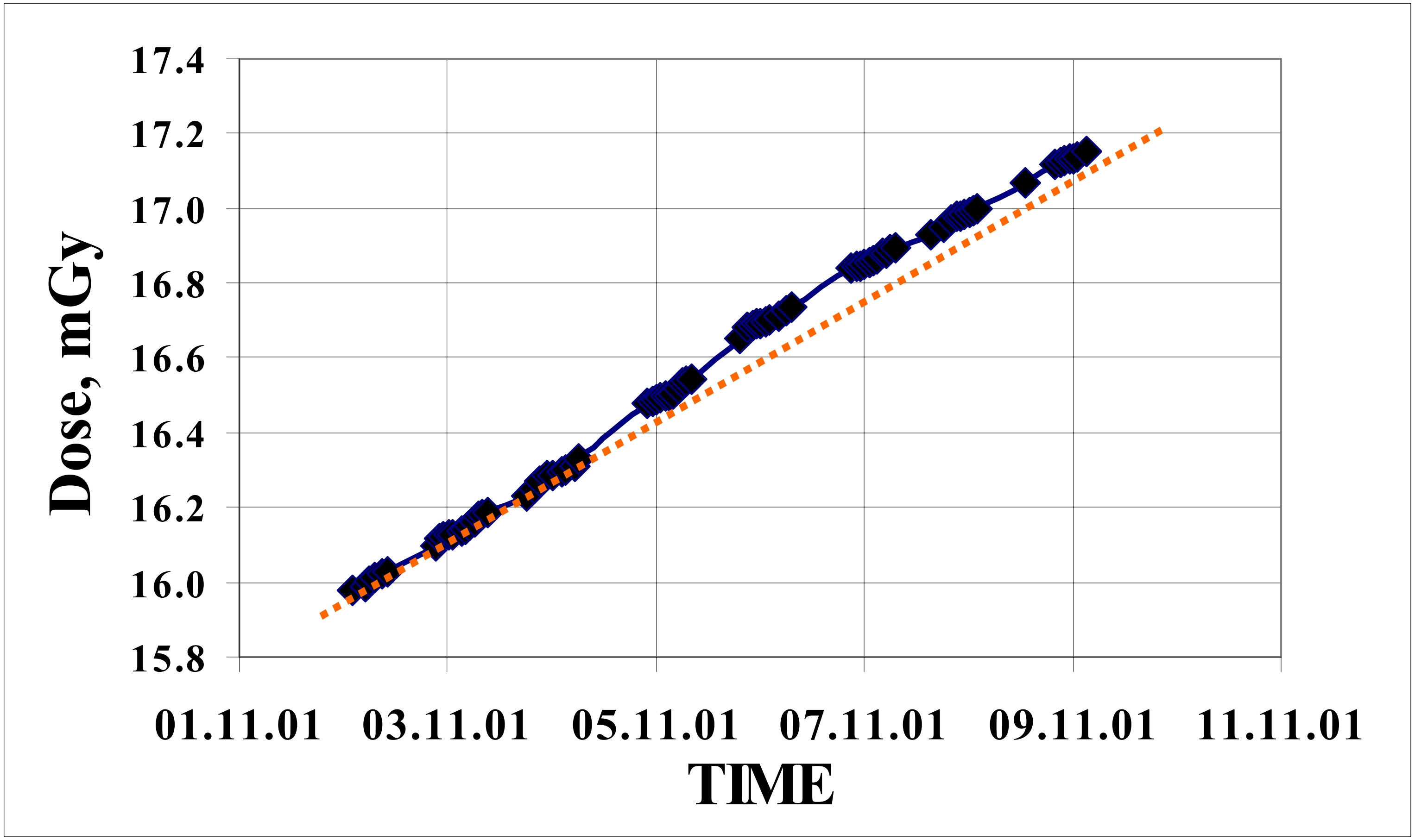
Dose for SPE 04.11.2001, DB-8 unit number 1, unshielded detector



Dose for SPE 04.11.2001, DB-8 unit number 4, unshielded detector



Dose for SPE 04.11.2001, DB-8 unit number 4, shielded detector



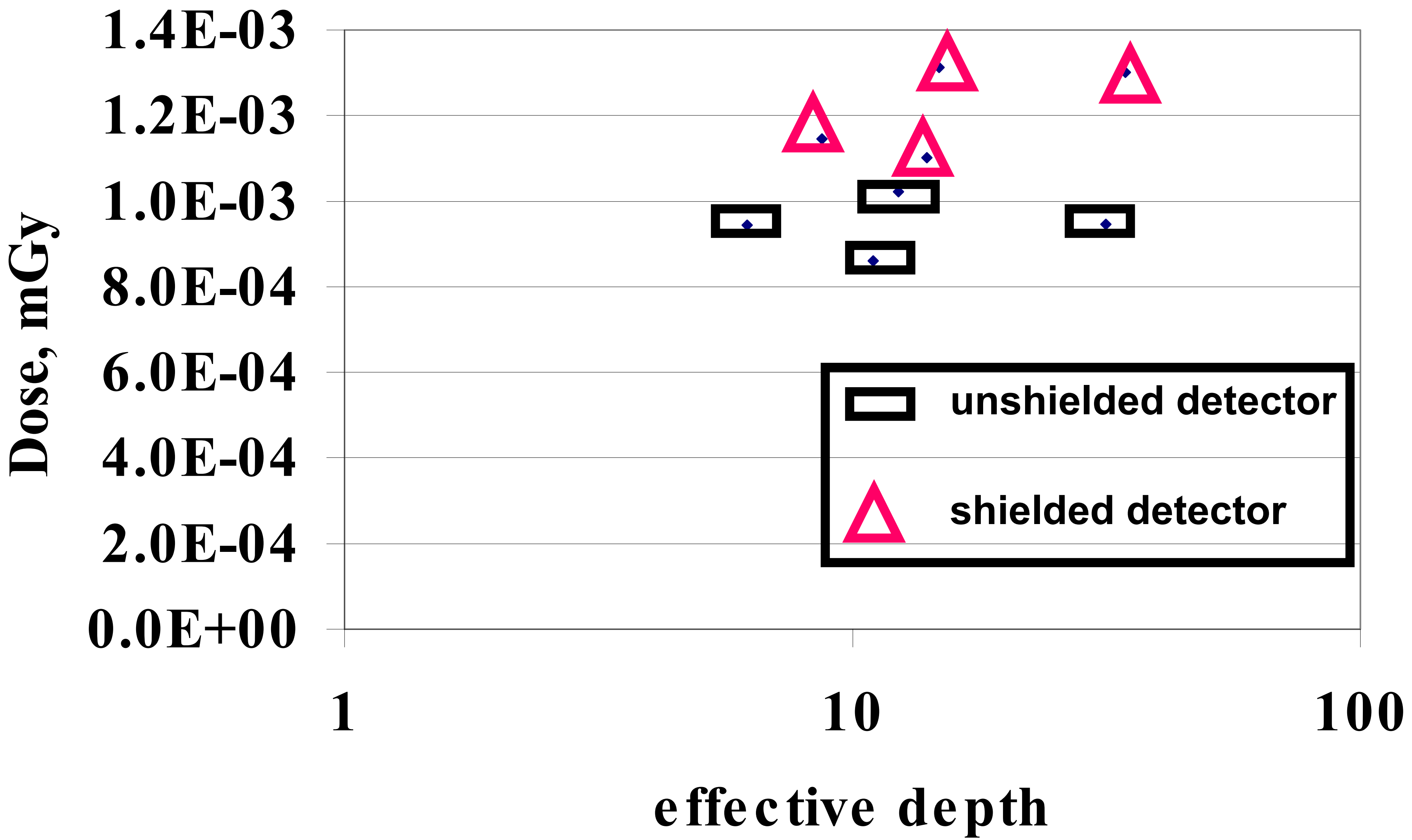
Doses for SPE 24.09.2001 and 04.11.2001

Detector		Dose per SPE 24.09.2001, mGy	Dose per SPE 04.11.2001, mGy
DB-8 number 1	Unshielded	1.65	2,60
	Shielded	0,75	1,10
DB-8 number 2	Unshielded	1,26	1,14
	Shielded	0,80	0,40
DB-8 number 3	Unshielded	0,59	0,75
	Shielded	0,41	0,39
DB-8 number 4	Unshielded	0,19	0,09
	Shielded	0,14	<0,04
R-16 *	Unshielded	1,25	0,60
	Shielded	0,20	0.1÷0,15

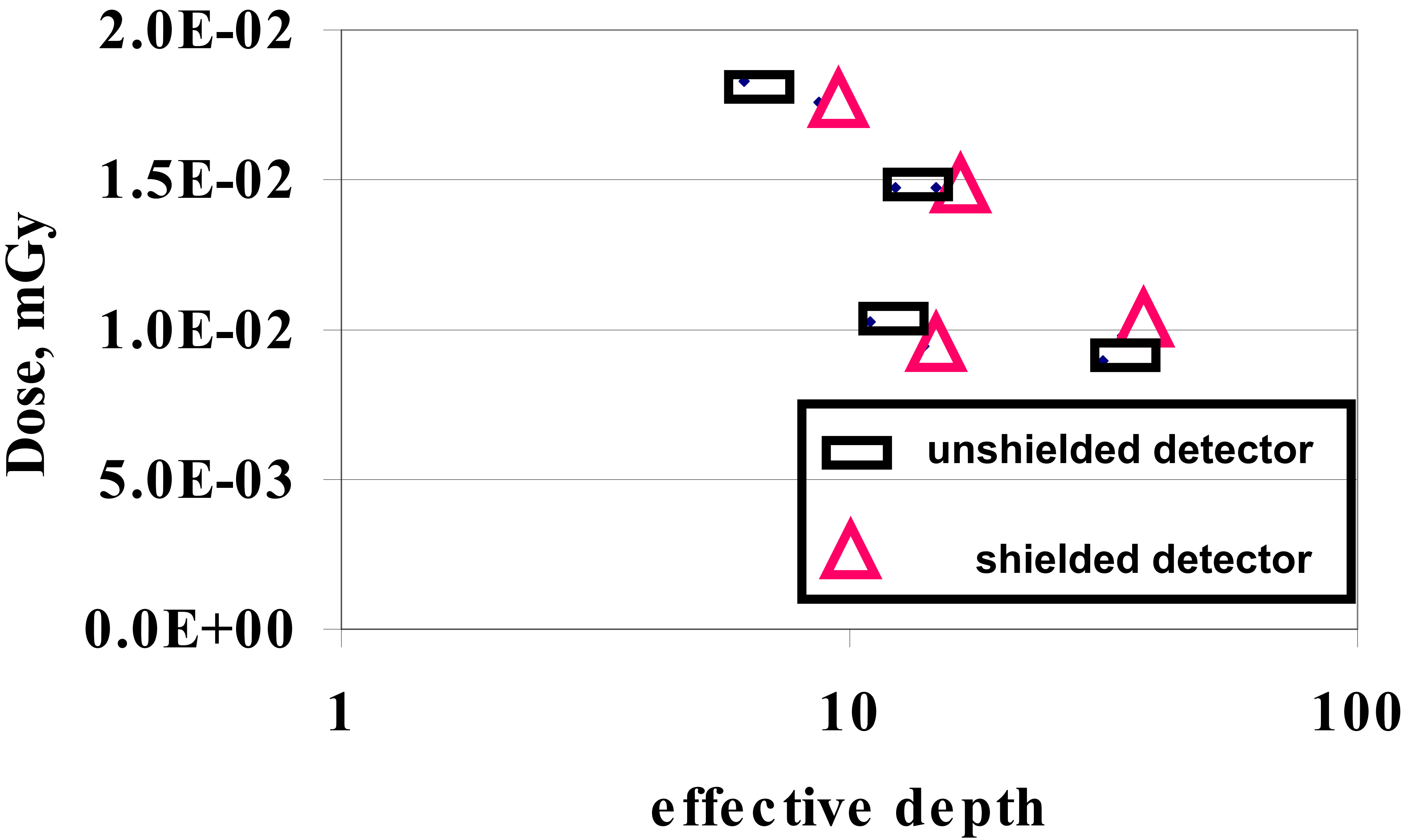
** R-16 data obtained from V. Tsetlin, private communication*

If we attribute an effective shielding depth to each detector we can consider the dose dependence on effective depth. Such dependencies are presented on the next a few slides.
It can be seen, that for GCR (outside the SAA) no reasonable dependence is observed. The dependence is quite marked in other cases, especially for SPE.
In future, using these depth-dose curves the the dose in critical organs can be estimated if shielding functions for space station locations and human body organs are known.

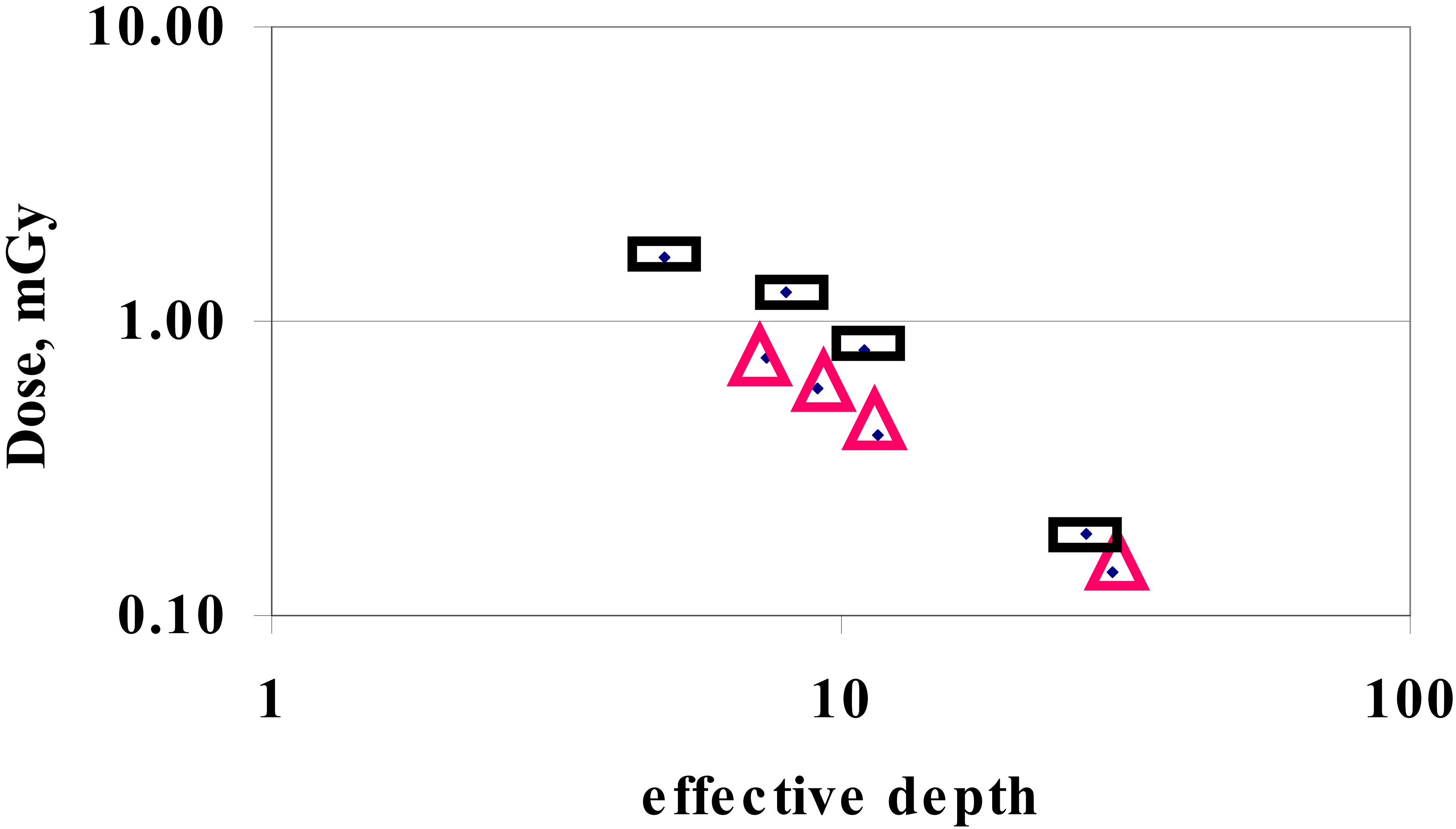
20 minute dose outside SAA.

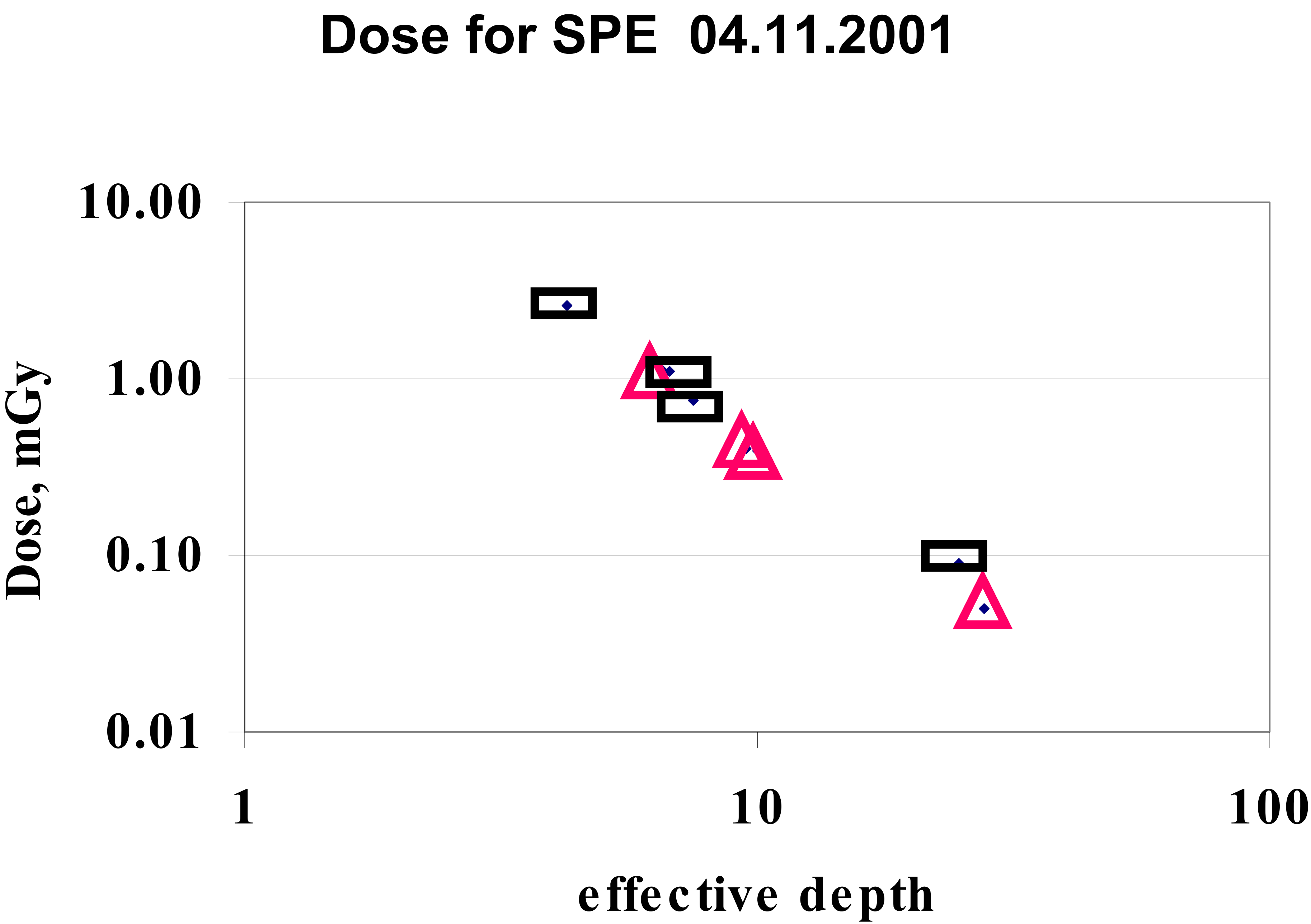


10 minute dose inside SAA.



Dose for SPE 24.09.2001




Dose for SPE 04.11.2001
10.00
1.00
0.10
0.01
Dose, mGy
1
10
100
effective depth

Conclusion

- The RMS equipment specified for the 1st stage of deployment was delivered to the ISS, installed and worked successfully during one year .
- The RMS data permits to estimate the depth-dose curves for calculation the organ doses in various radiation conditions.
- The obtained results show that usage of RMS data permits to expand and improve the radiation monitoring onboard the ISS.