TL dose measurements on board the Russian segment of the ISS during Expedition-9 and -10

I. Apáthy[1], Yu.A. Akatov[2], V.V. Arkhangelsky[2], L. Bodnár[3], S. Deme[1], I. Fehér[1], I. Padalka[4], T. Pázmándi[1], G. Reitz[5], S. Sharipov[6]

[1] KFKI Atomic Energy Research Institute, Budapest, Hungary
[2] Institute for Biomedical Problems, Moscow, Russia
[3] BL-Electronics, Solymár, Hungary
[4] Gagarin Cosmonaut Training Centre, Star City, Russia
[5] German Aerospace Center (DLR), Cologne, Germany
[6] Russia's Federal Space Agency, Moscow, Russia

The *'Pille'* TLD system

- small, portable
- space-qualified
- suitable for reading out the TLDs on board, so
- a solution for EVA dosimetry as well

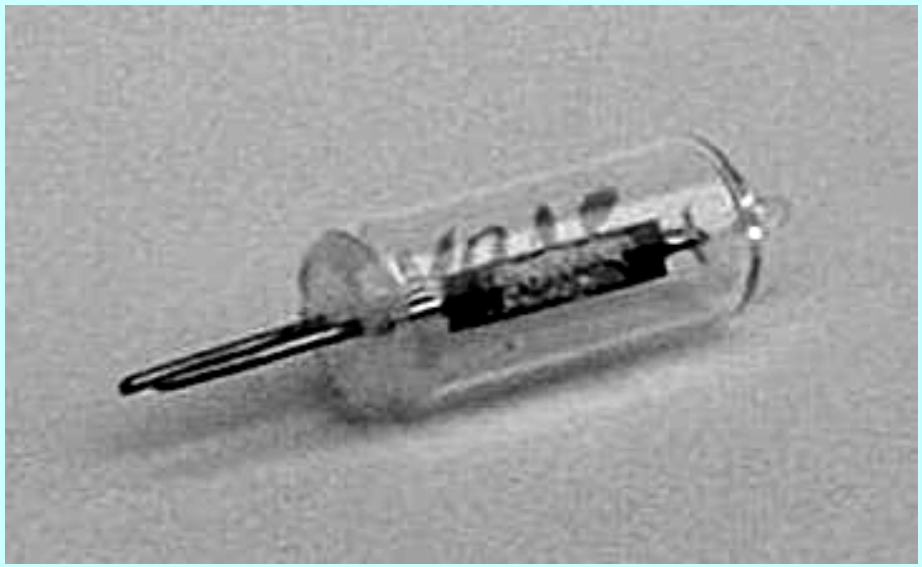
used on board the

- Salyut-6 (from 1980) and -7 space stations by Hungarian and Soviet cosmonauts
- Mir space station by ESA and NASA astronauts
- ISS by NASA astronauts and Russian cosmonauts $\Rightarrow$ service instrument

Main Specifications of the *'Pille'* TLD System

Dosimeters

Type: **bulb**
Material: **$CaSO_4$:Dy**
Dimensions: **ϕ 20 mm * 60 mm**
Mass: **70 g (with carrying case)**



Reader

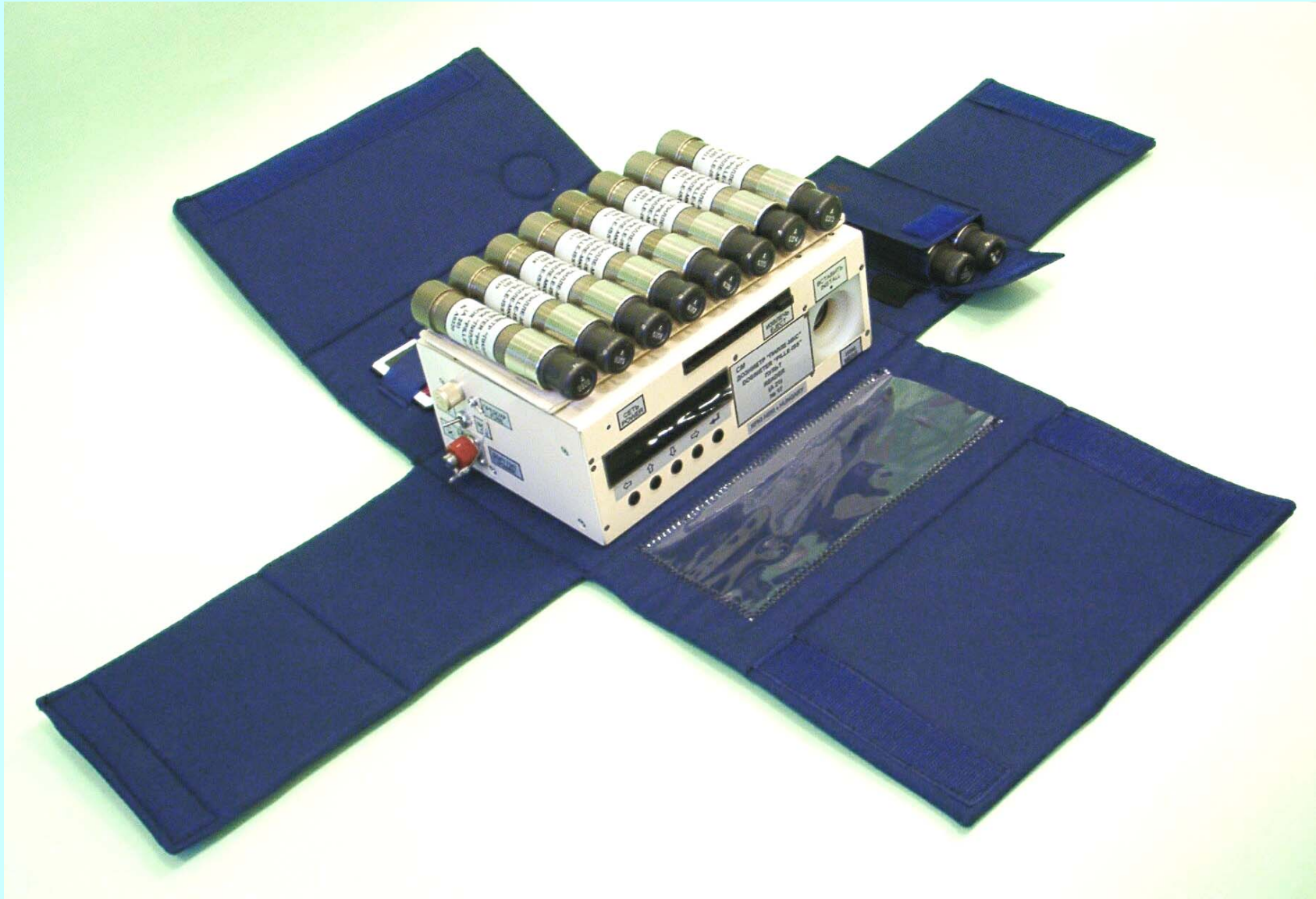
Measuring range (s<10%):	**3 μGy ÷ 10 Gy ($CaSO_4$:Dy)**
TLD Efficiency ε=1±10%	**$LET_\infty H_2O$ < 10 keV/μm**
Read-out precision:	**3 digits + exp.**
Accuracy (above 10 μGy):	**δ < 5%**
Measuring modes:	**manual / automatic read-out**
Display:	**8-digit alphanum. LED**
Storage of information:	**PCMCIA mem. card (> 4000 data sets)**
Computer connection:	**RS-232, (CAN)**
Dimensions:	**70 mm (H)* 190 mm (W) * 120 mm (D)**
Mass:	**1,400 g**
Power consumption:	**0.1 / 1 / 7 W (standby/ready/readout)**


Ins.
Уст.
Mea.
Изм.
Pille • TLD Reader

'Pille-MKS' on the Russian Service Module (Zvezda) of the ISS

- **Consisting of**
  - **10 Dosimeters (№ A0301-A0310)**
  - **Reader**
- **Part of the service system**
- **Applied for**
  - **routine and EVA individual dosimetry and**
  - **onboard experiments**
- **Developed and manufactured by KFKI AEKI, Hungary**
- **Maintained by IBMP, Russia**
- **Launched on Progress-12 cargo S/C on 2003.08.29**

The '*Pille-MKS*' in its transporting case



Pille TLD measurements during Expedition-9 and -10

- **The *Pille-MKS* system was operated by**
  - **Gennady Padalka**

    (Exp.9, Commander, on board 2004.04.21 – 2004.10.23)
  - **Salizhan Sharipov**

    (Exp.10, Flight Engineer, on board 2004.10.15 – 2005.04.24)
- **4531 measurements from 2004.04.24 until 2005.04.21**
- **Results of the measurements were**
  - **partly reported nearly realtime via radio to the Earth**
  - **completely transferred on memory card by S/C**

    (Soyuz-TMA4 and –TMA5) to the Earth

Chronology of the measurements

- **2004.05.14 – 2005.04.21 (11 months)**
  - **regular (monthly) readout of all dosimeters (except № A0308)**
- **2004.04.24 – 2005.04.21 (12 months)**
  - ***№ A0308* dosimeter read out with short interrupts every 1.5 hour automatically**
- **2005.01.17 – 2005.01.22 (5 days)**
  - **frequent (daily) readouts because of a Coronal Mass Ejection**
  - ***№ A0309, A0310* used as personal dosimeters**
- **2004.04.24 / 06.30 / 08.03 / 09.03 / 2005.01.26 / 03.28**
  - **prior and post readouts of EVA (4 EVAs at Exp.9, 2 EVAs at Exp.10)**
  - ***№ A0309, A0310* personal EVA, *№ A0307* reference dosimeters**

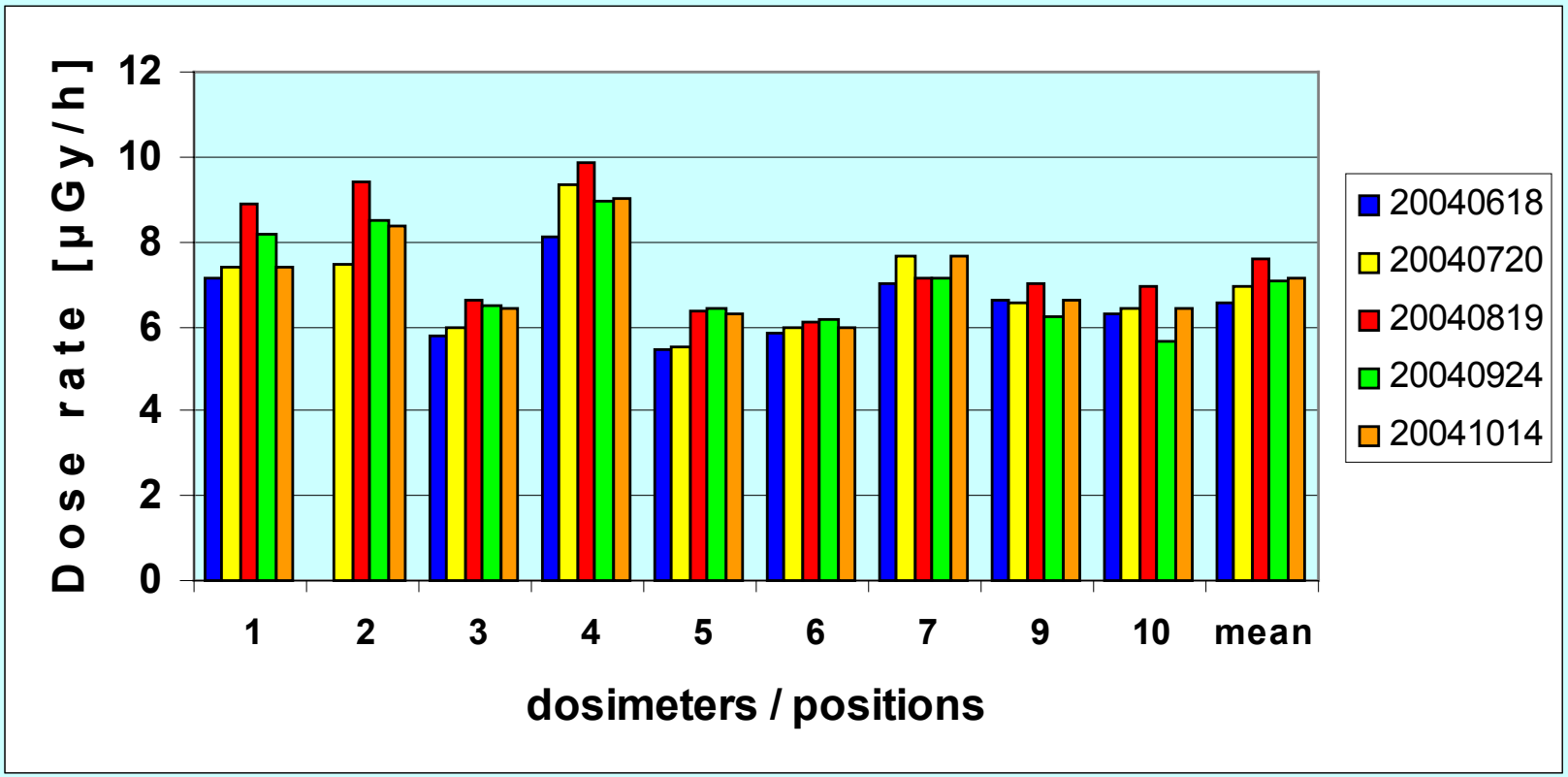
General location and designation of the dosimeters

Dosimeter №	Location in *Zvezda* module
A0301, A0302	Cabin of the right board, on both sides of the illuminator
A0303, A0304	Cabin of the left board, on both sides of the illuminator
A0305, A0306	Ceiling, on the system radiometer R-16
A0307	Right board, beside of the cabin, on ceiling of the lavatory *Dedicated for EVA reference measurement inside ISS*
A0308	Inserted in the Reader, which is fixed on the floor, right to illuminator Nº 9 *Dedicated for automatic measurements*
A0309, A0310	In the transporting case of the Reader, left to illuminator Nº 9 *Dedicated for EVA personal measurements*

Results of the *'Pille-MKS'* measurements

Dose rates of the single dosimeters

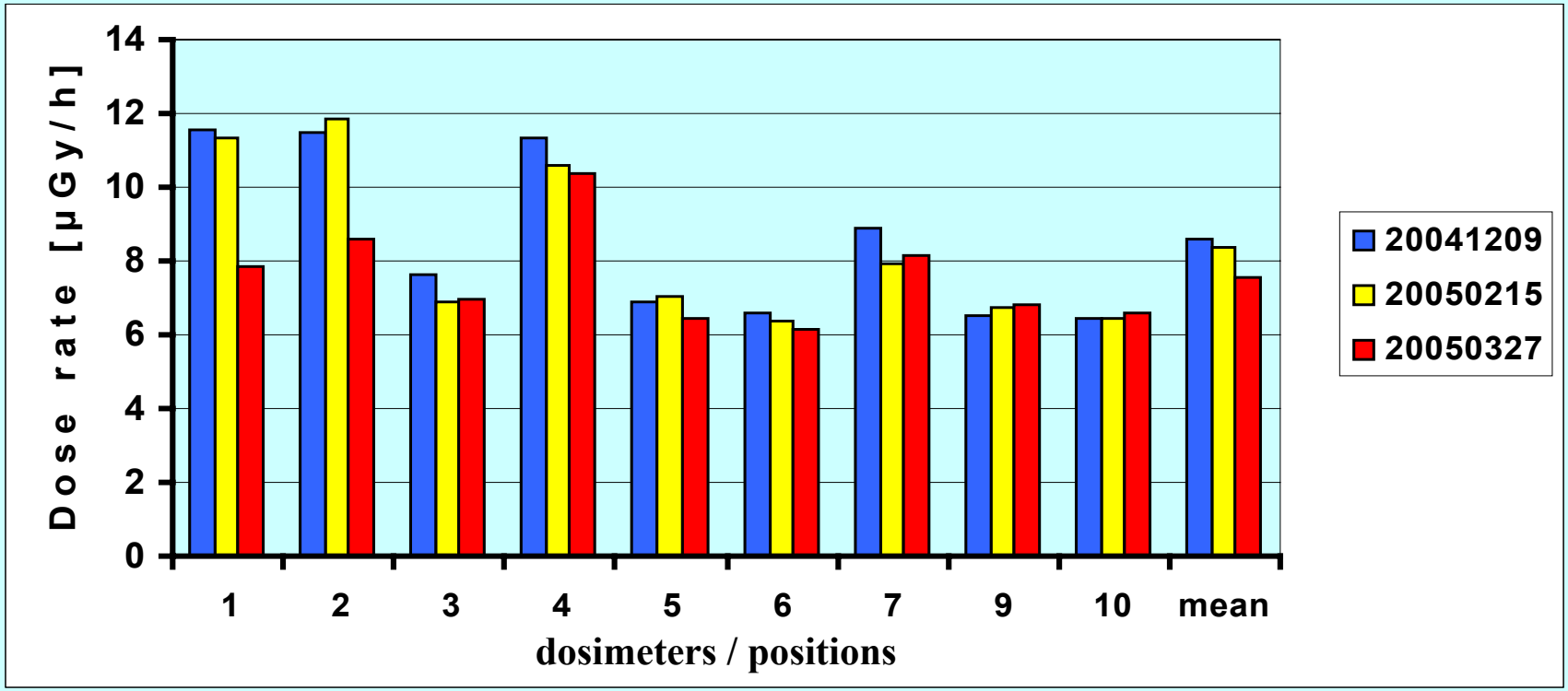
Readouts: **2004.06.18 - 2004.10.14 (Expedition 9)**
Average: **~ 7.1 µGy/h**



Results of the *'Pille-MKS'* measurements

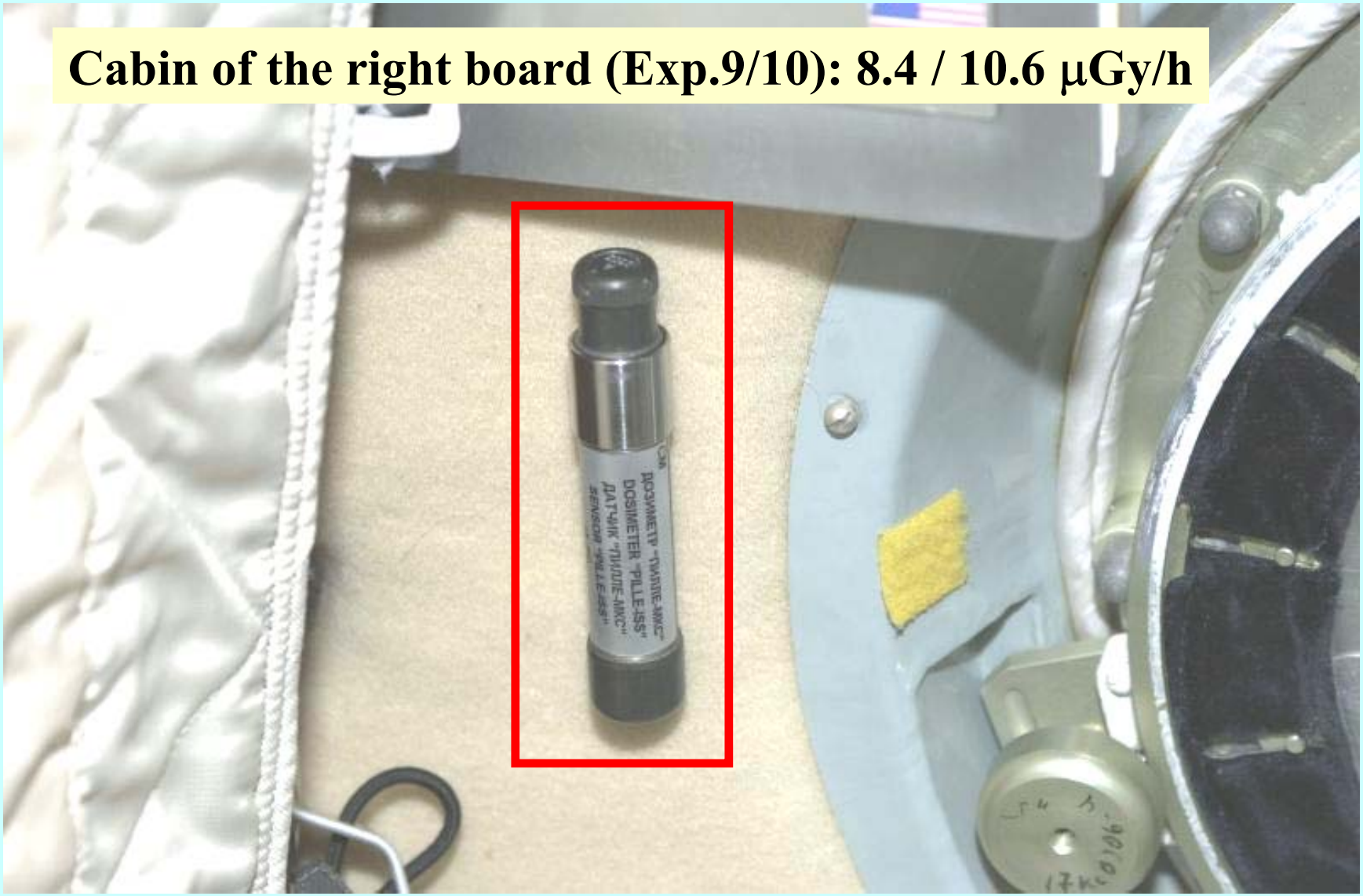
Dose rates of the single dosimeters

Readouts: 2004.12.09, 2005.02.15, 2005.03.27 (Expedition 10)
Average: ~ 8.2 µGy/h *(Expedition 10 – 7.1 µGy/h)*

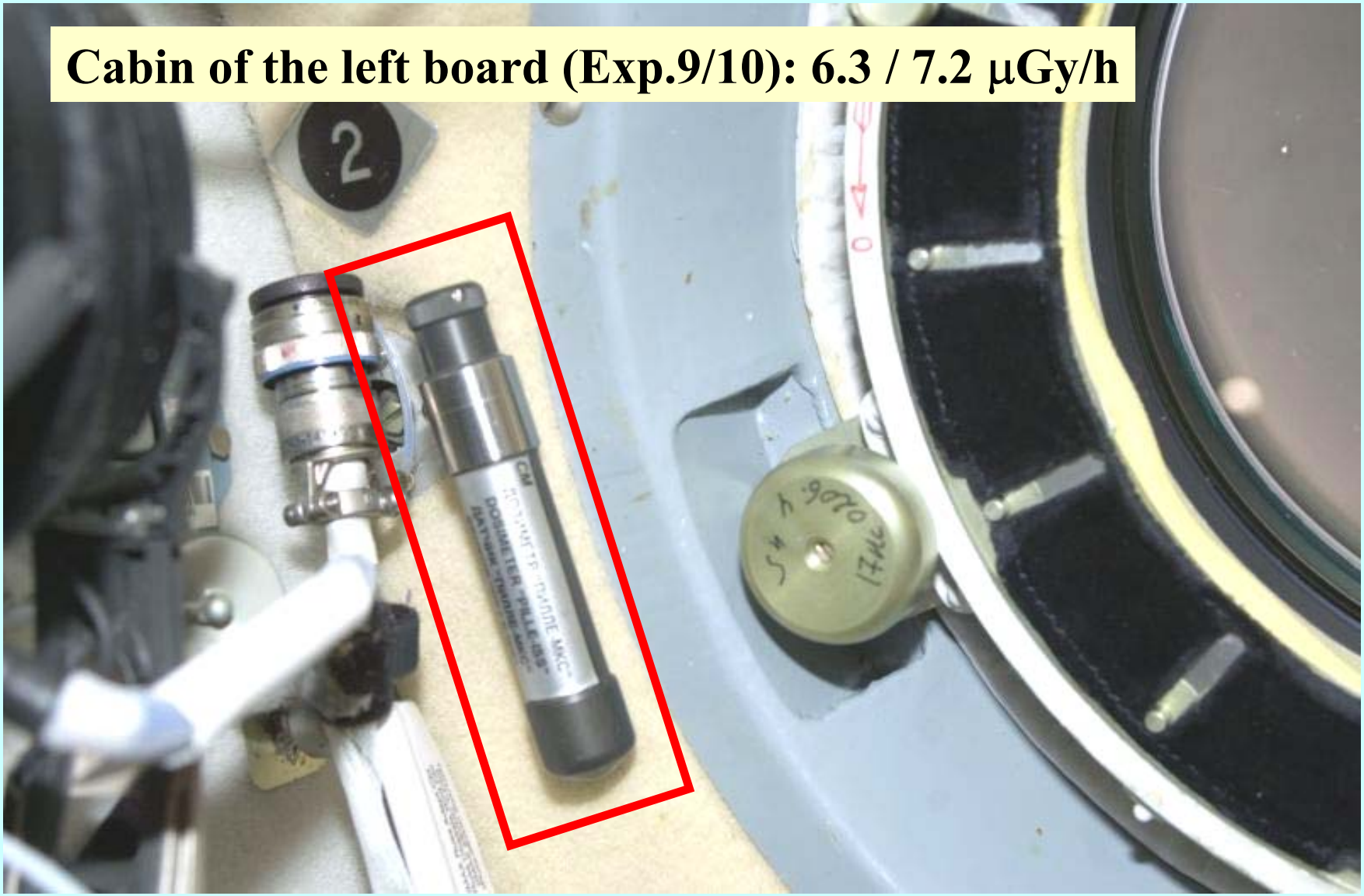


Dosimeter № A0301

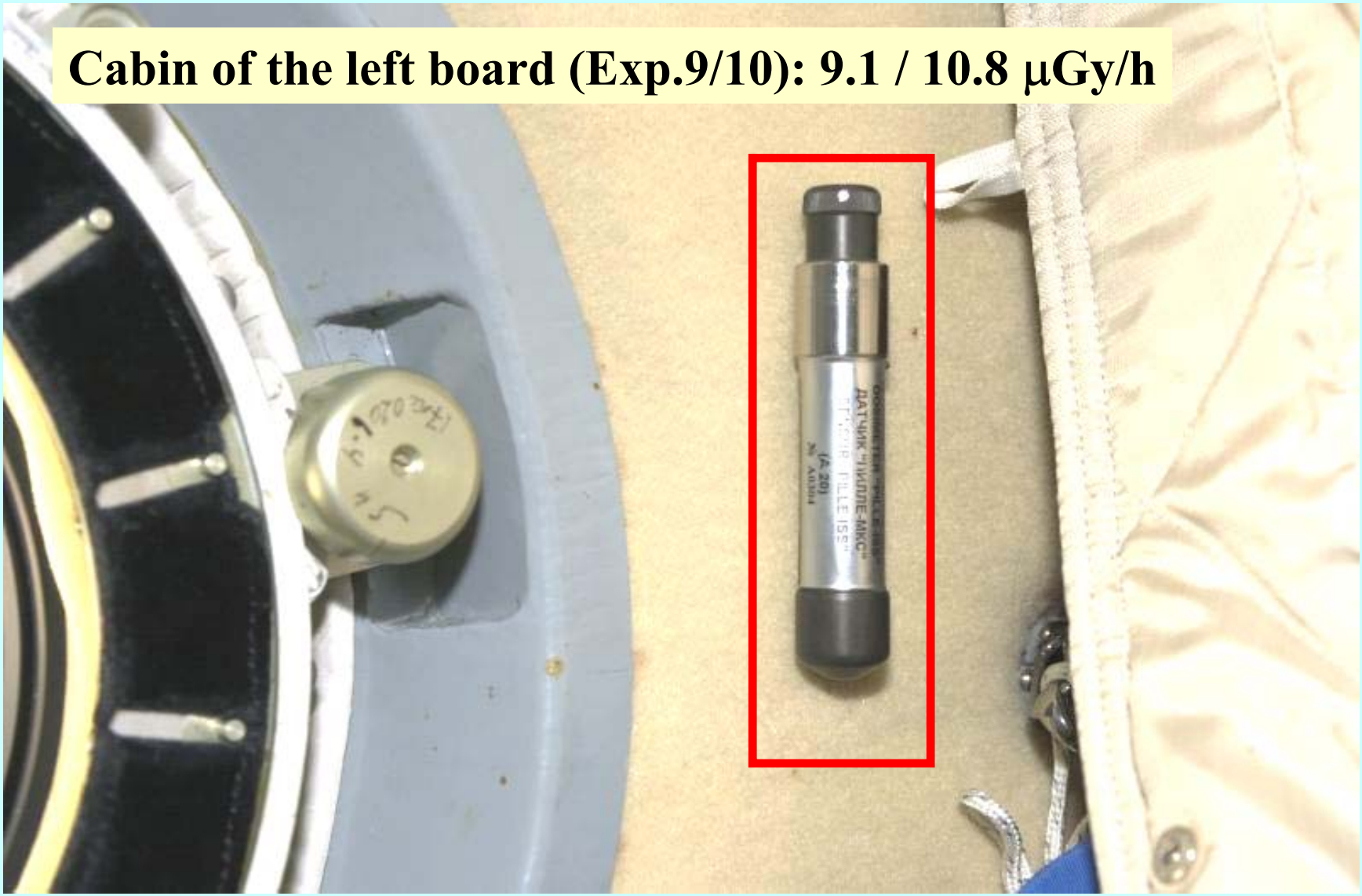
Dosimeter № A0302



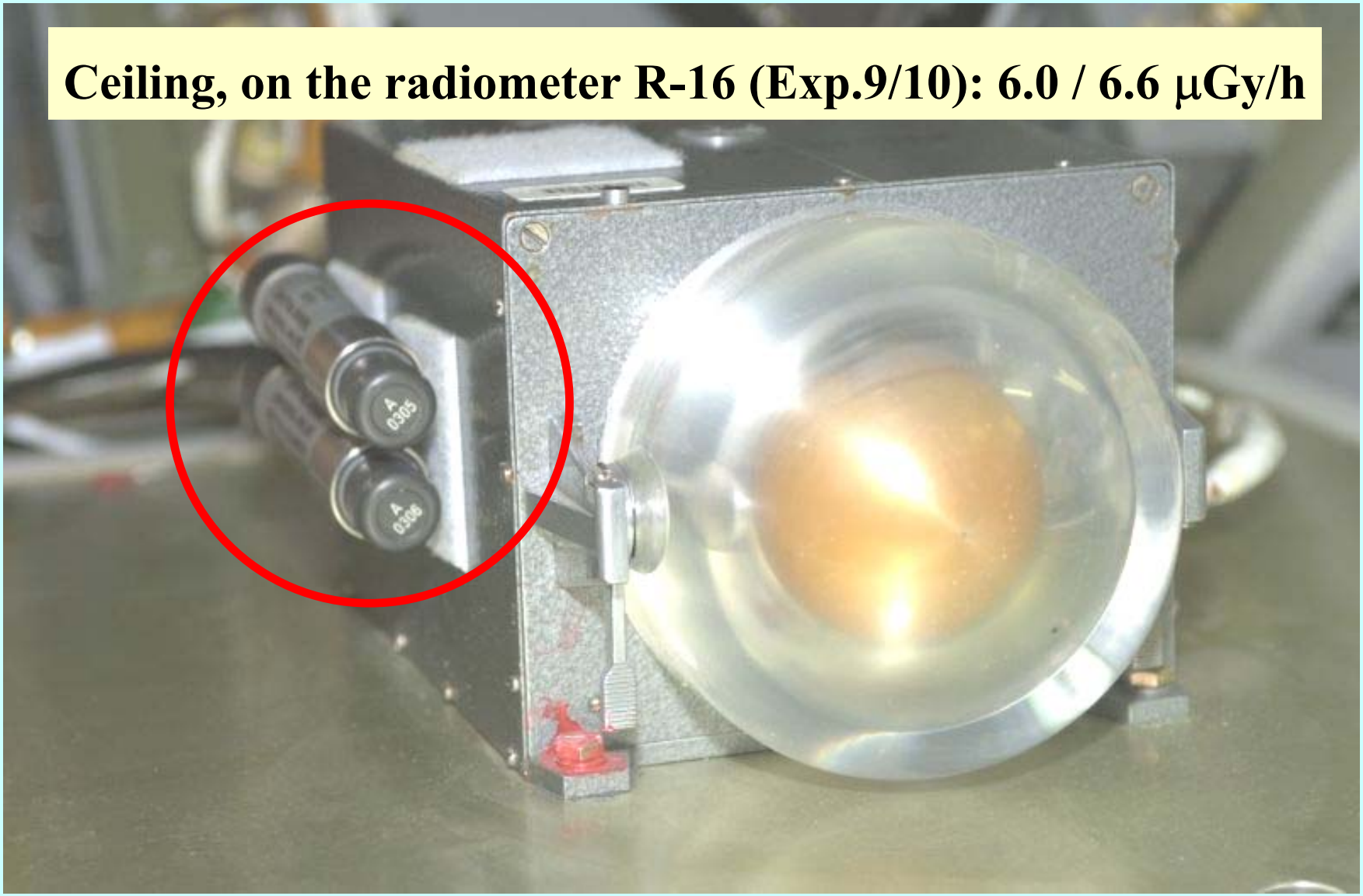
Dosimeter № A0303



Dosimeter № A0304

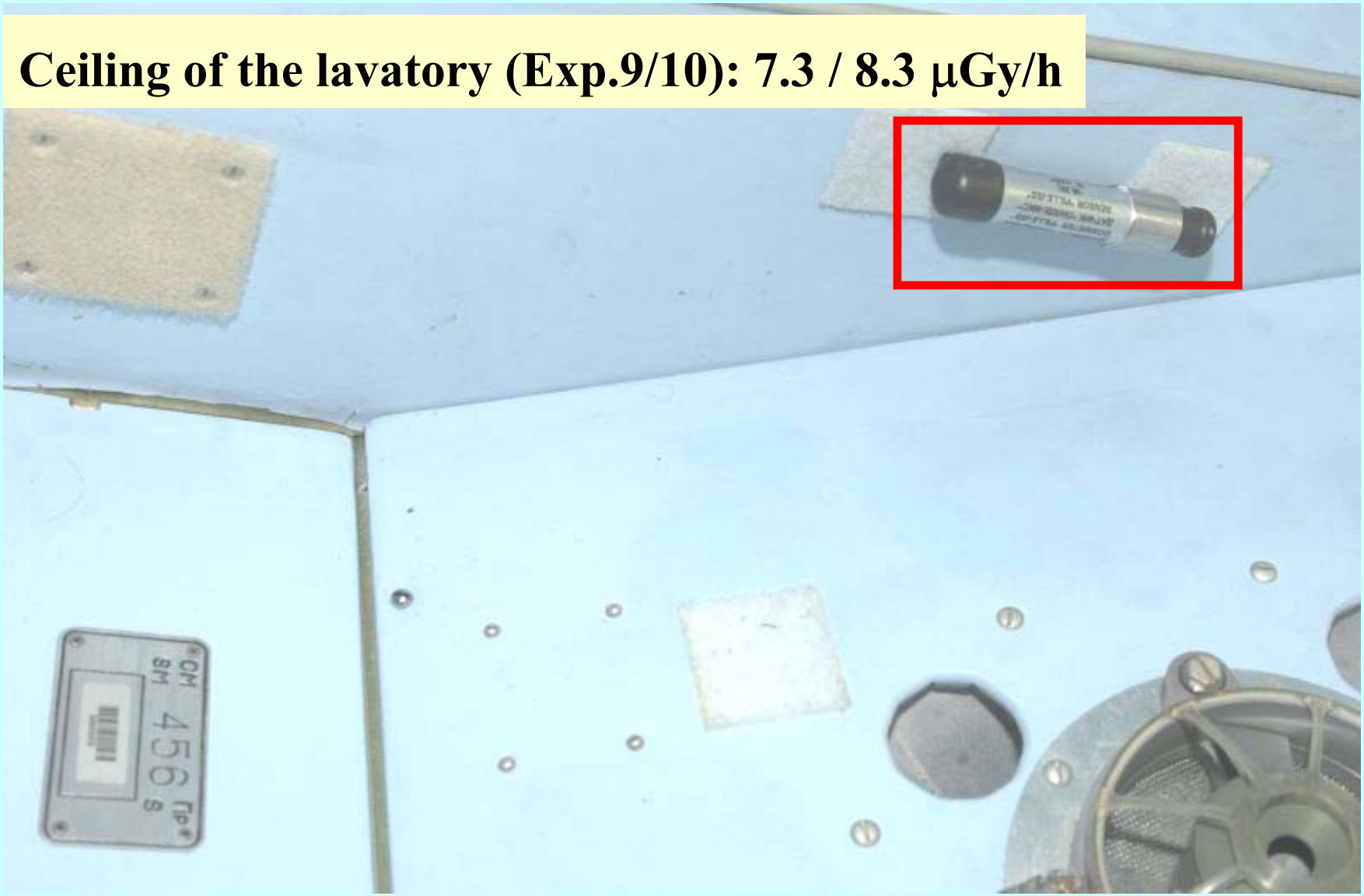


Dosimeters № A0305 – A0306

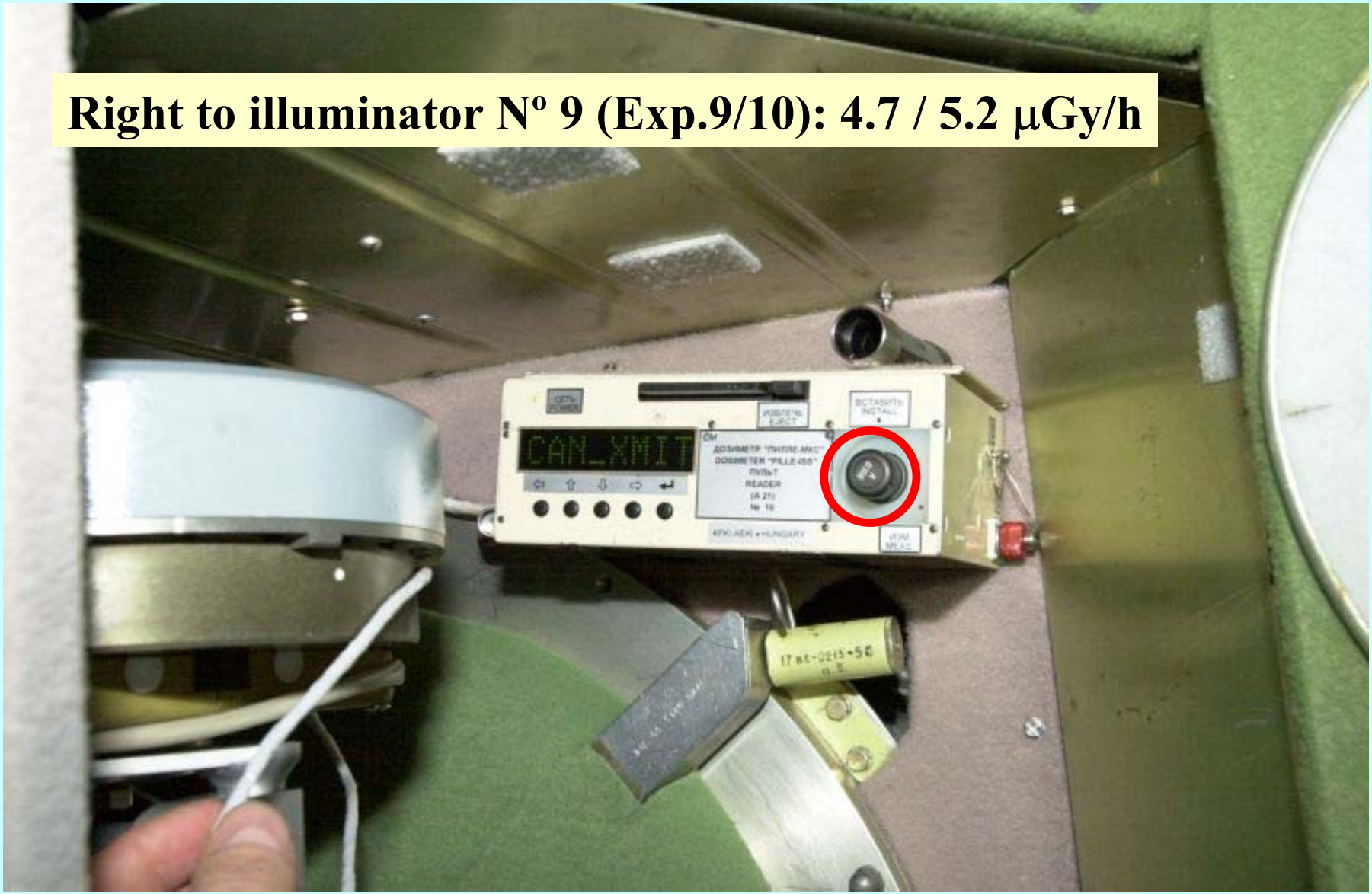


Dosimeter № A0307

Ceiling of the lavatory (Exp.9/10): 7.3 / 8.3 μGy/h



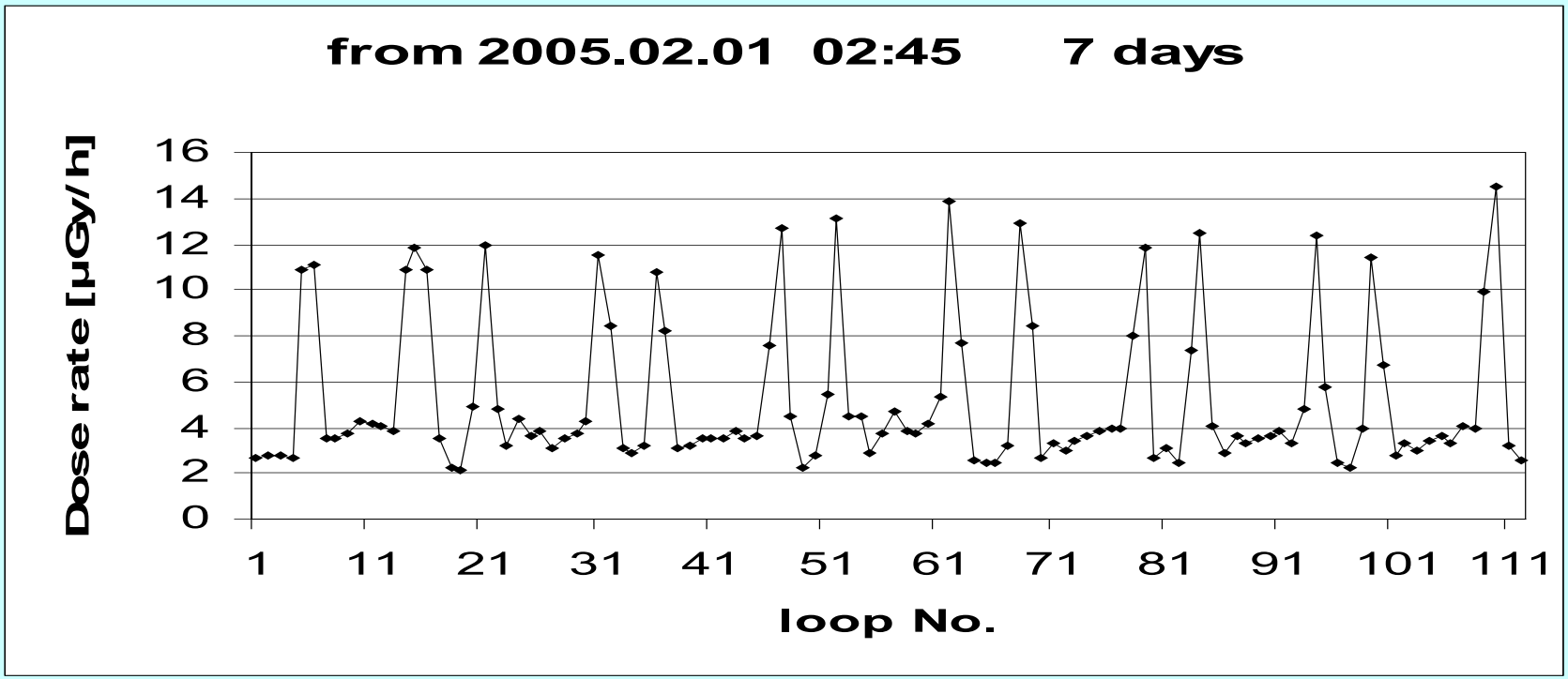
Dosimeter Nº A0308 in the Reader



Results of the *'Pille-MKS'* measurements

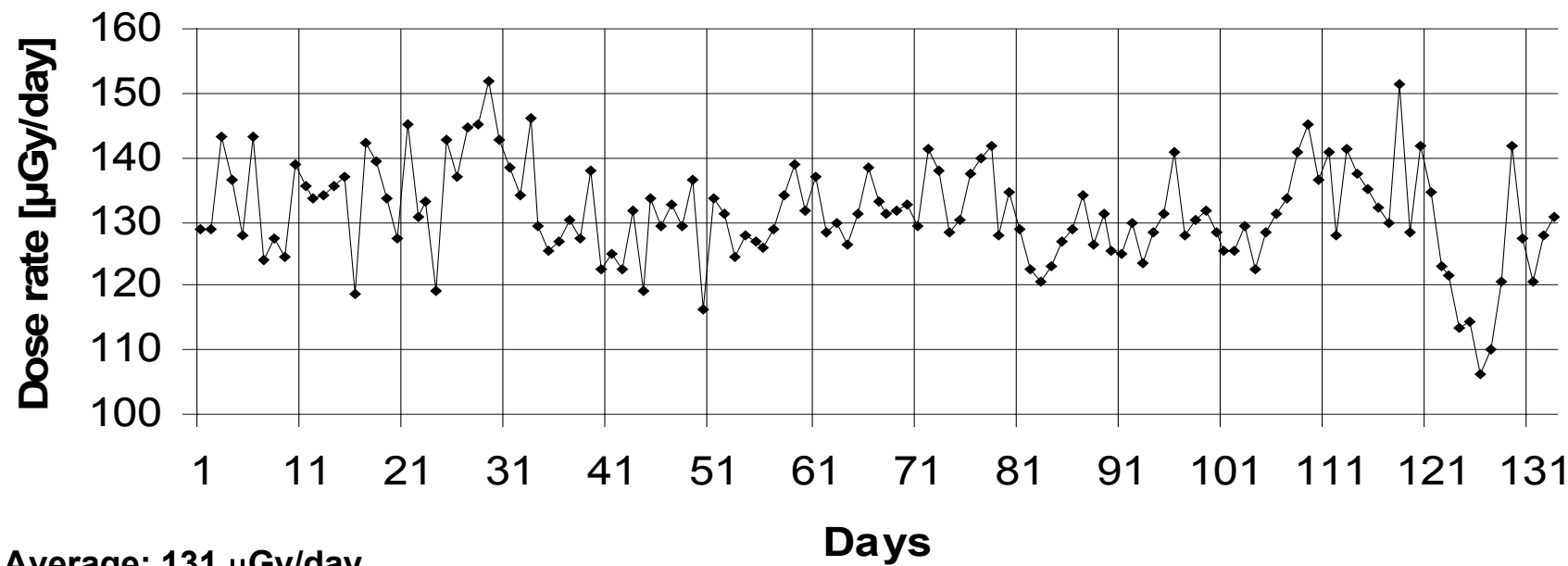
7-days sample of automatic measurements

Starting of readouts:	**2005.02.01 02:45**
Loop: 90 minutes ≅ orbital time	**peaks: 0, 5, 16, 21, 32 etc. loop**
Range of time:	**7 days**
Avarage dose rate total:	**5.2 µGy/h (inside reader)**



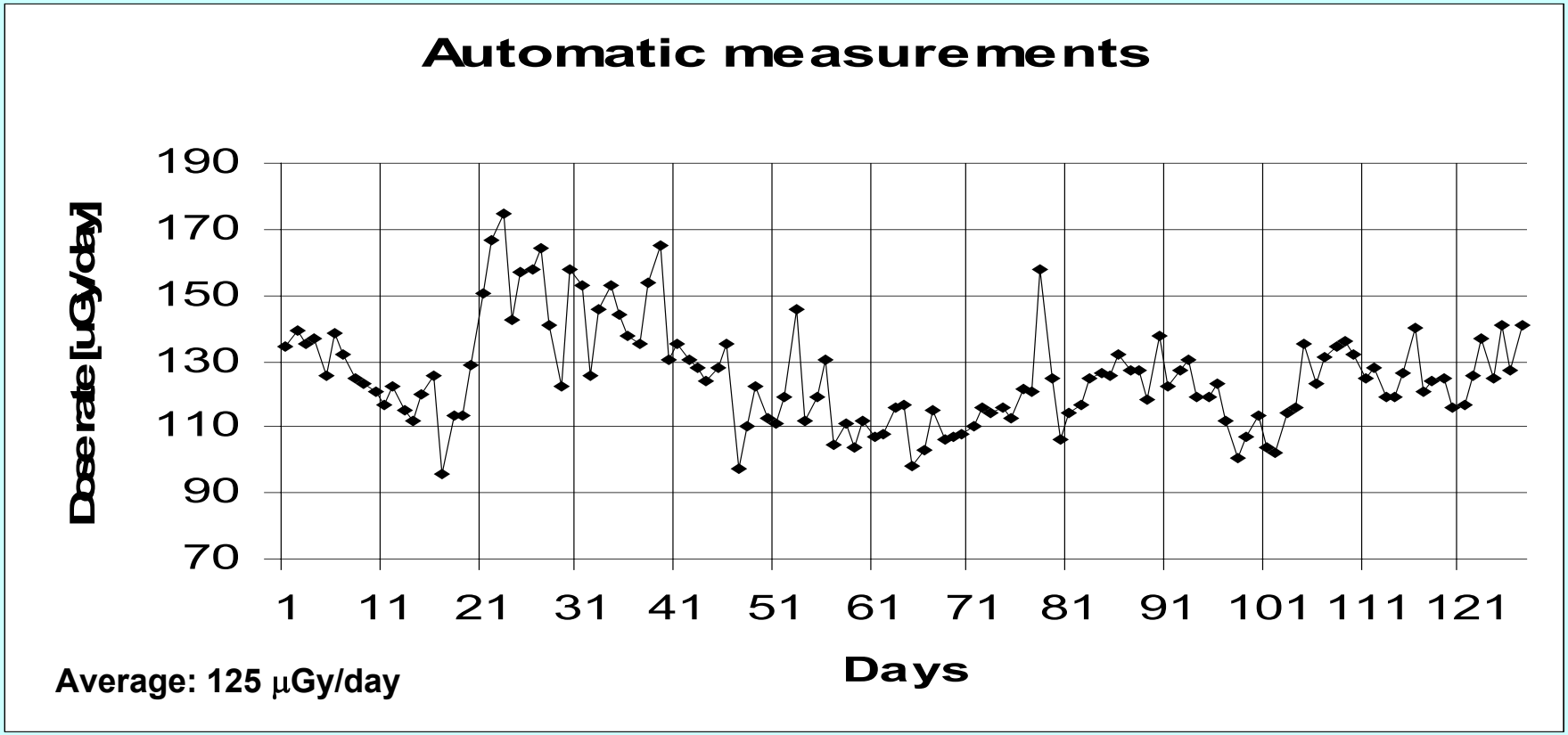
Results of the *'Pille-MKS'* measurements

Daily dose rates (Exp.9, dosimeter No.8)



Results of the *'Pille-MKS'* measurements

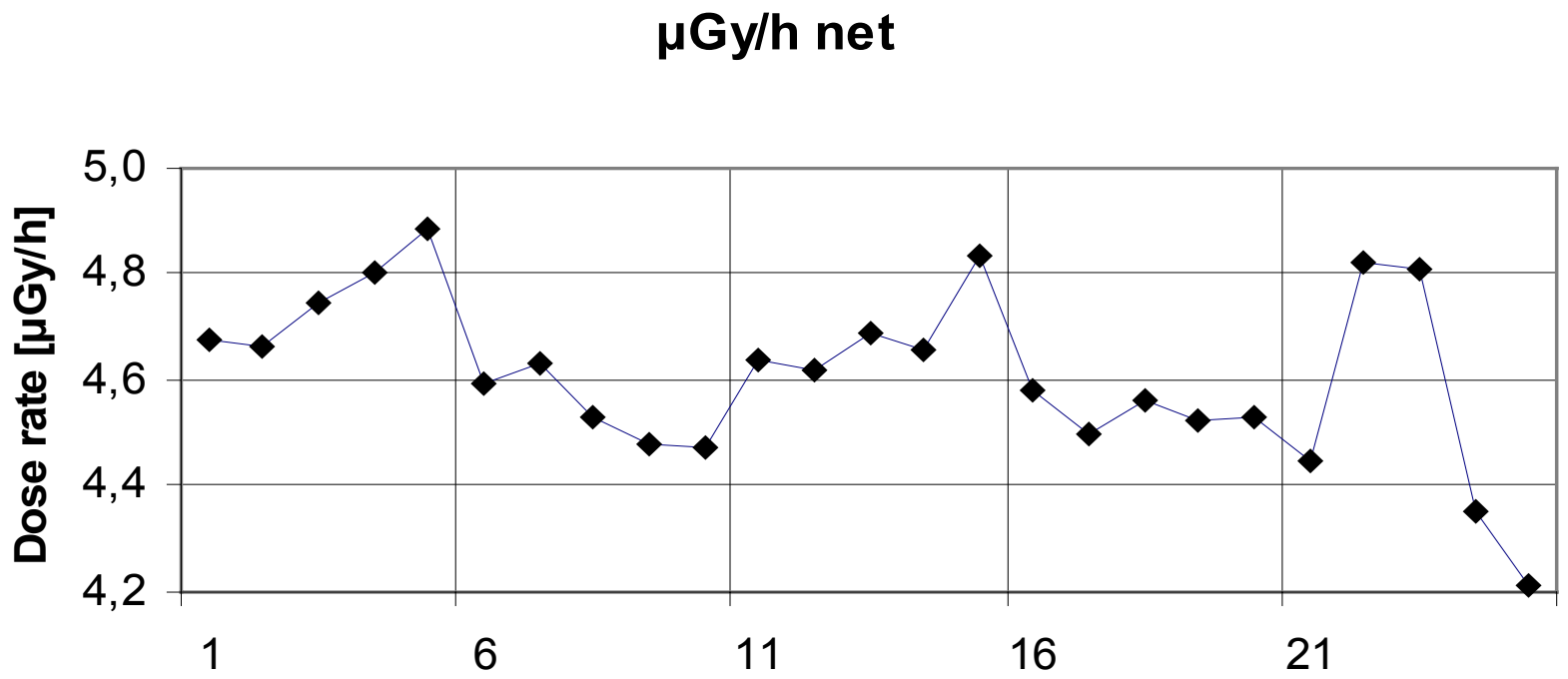
Daily dose rates (Exp.10, dosimeter No.8)



Results of the *'Pille-MKS'* measurements

Weekly dose rates (Exp.9, dosimeter No.8)

2004.04.25 - 2004.10.21

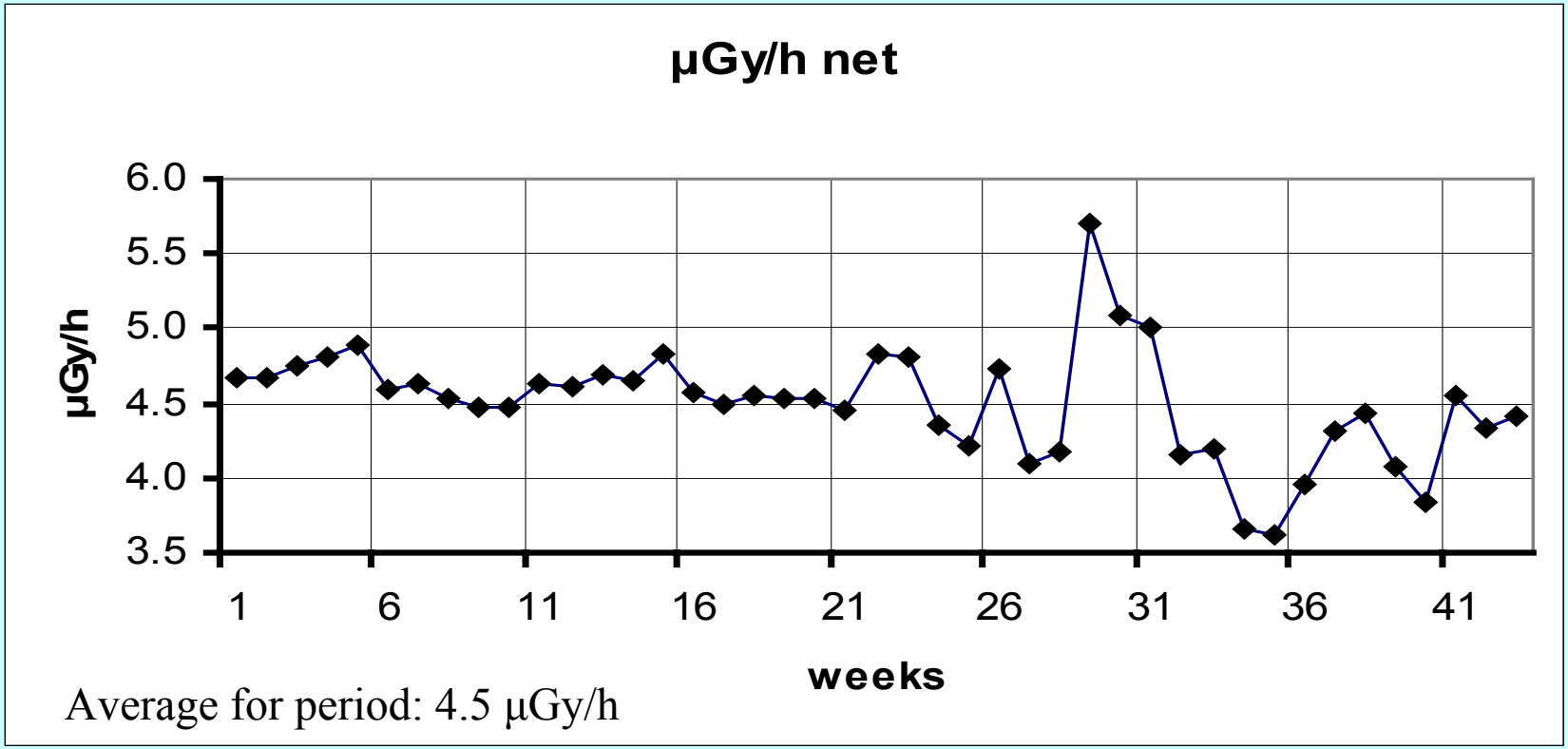


Average for period: 4.6 µGy/h

Results of the *'Pille-MKS'* measurements

Weekly dose rates (Exp.10, dosimeter No.8)

2004.10.23 - 2005.04.20

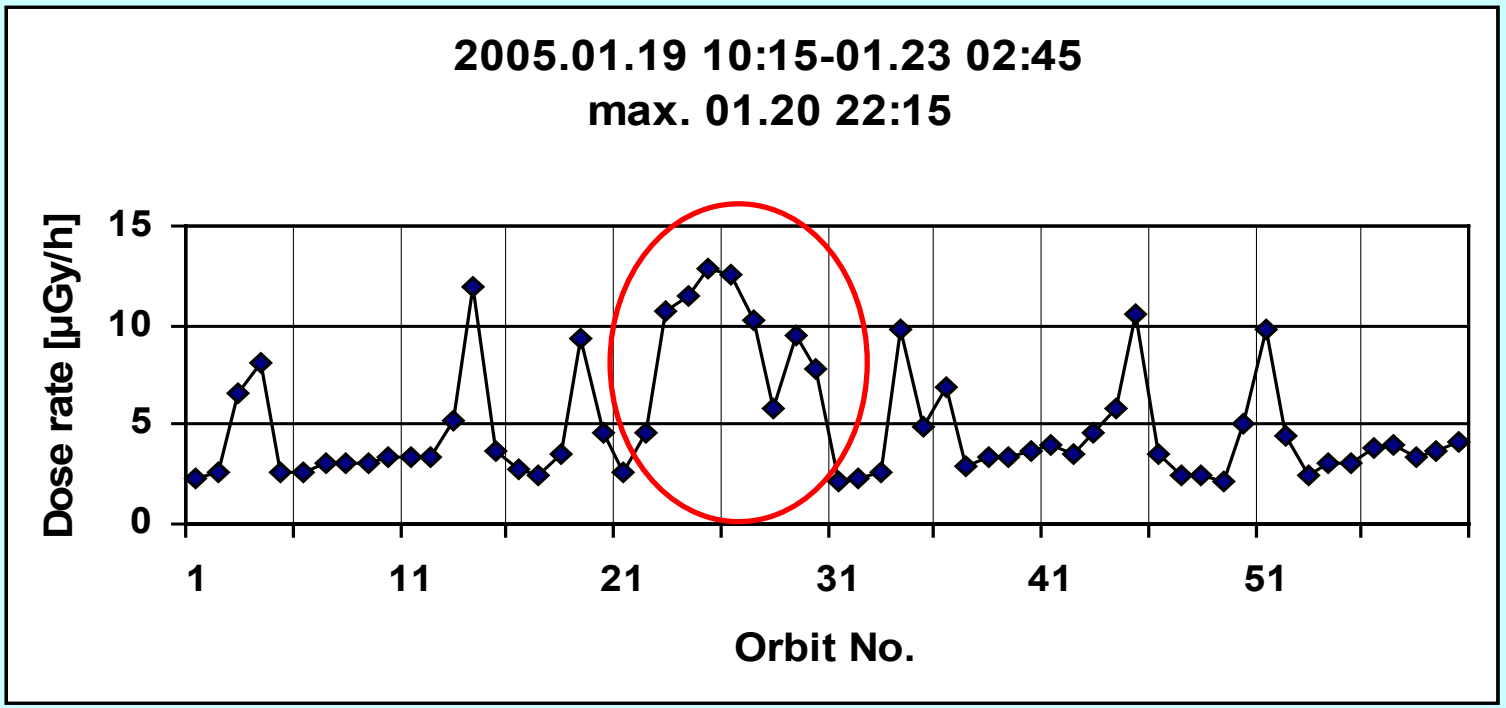


Average for period: 4.5 µGy/h

Results of the *'Pille-MKS'* measurements

Sample from an increased solar activity period

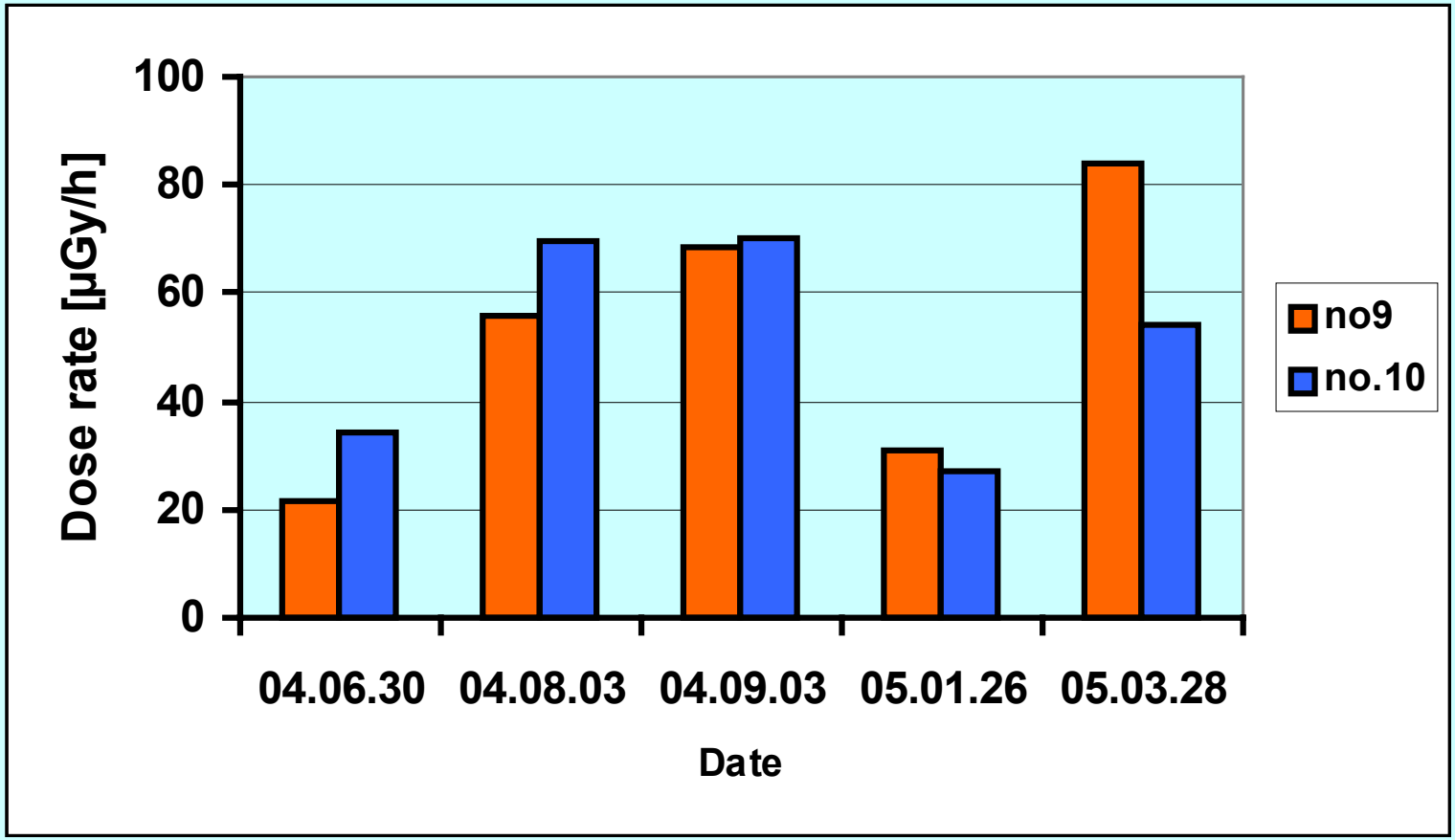
- range of time: 2005.01.19-23
- average dose rate: 5.0 µGy/h
- maximum dose rate: 12.9 µGy/h



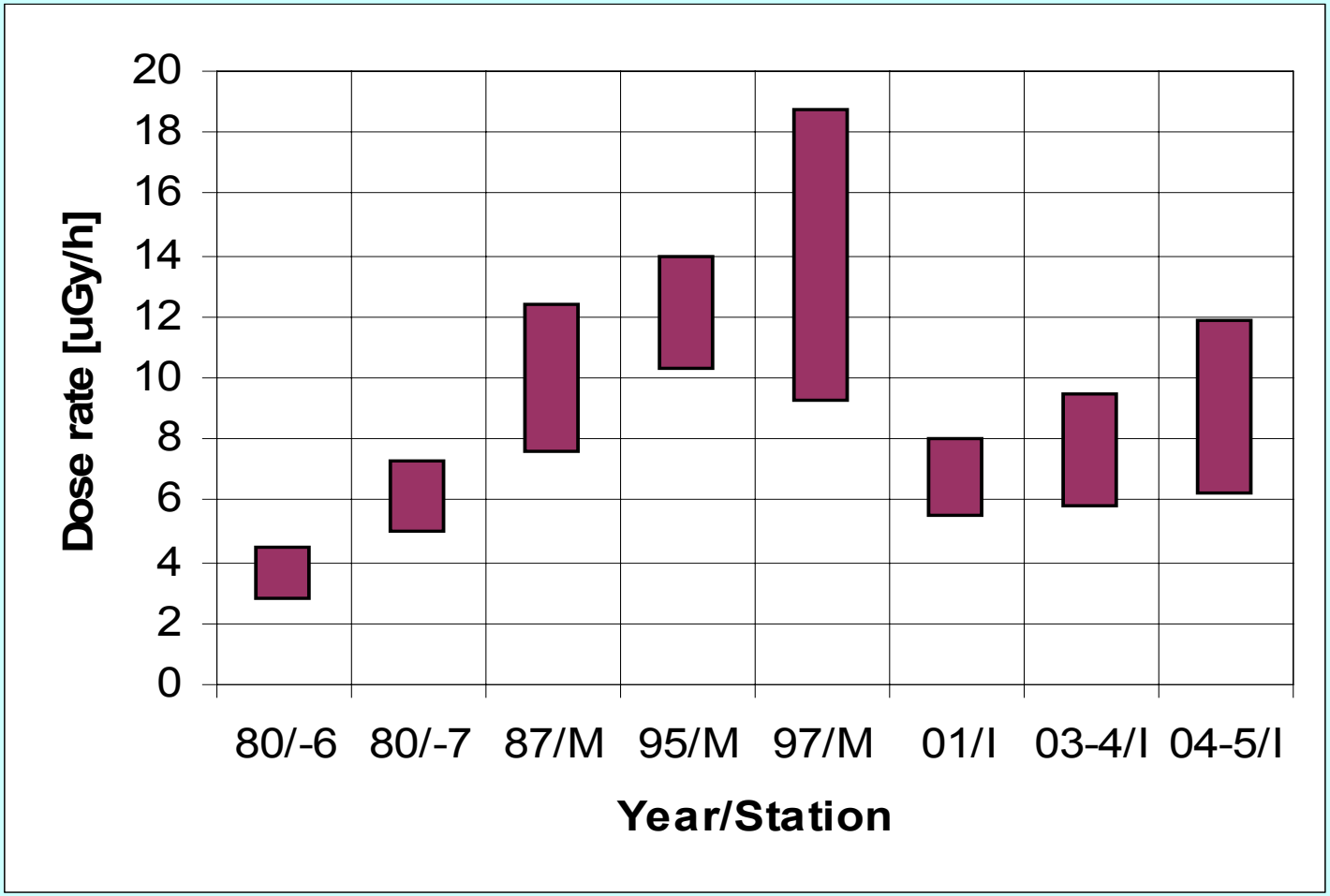
Results of the *'Pille-MKS'* measurements

EVA excess dose rates

Duration of EVAs 4.3...5.5 hours



Comparing dose rate ranges measured by 'Pille's on different Space Stations (1980-2005)



Legend
-6: Salyut-6
-7: Salyut-7
M:Mir
I: ISS

Special thanks to

- **Gennady Padalka**
  Commander of ISS Expedition 9

- **Salizhan Sharipov**
  Flight Engineer of ISS Expedition 10

for operating the *'Pille-MKS'* system

during half a year so outstanding

Thank you for your attention!