

Pille Measurements on ISS (June 2016 – April 2017)

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Outline

- The Pille TLD system
- Pille on the ISS
- Practice in reporting data
- Results of June 2016 (December 2015) – April 2017



The Pille TLD system



The Pille thermoluminescent dosimeter system

- Space qualified, on-board TLD system
- Dosimeters and a reader device

Dosimeters	
Type:	bulb
Material:	$\text{CaSO}_4:\text{Dy}$
Dimensions:	$\phi 20 \text{ mm} * 60 \text{ mm}$
Mass:	70 g (with carrying case)



Reader	
Measuring range ($s < 10\%$):	$3 \mu\text{Gy} \div 10 \text{ Gy}$ ($\text{CaSO}_4:\text{Dy}$)
TLD Efficiency ($\varepsilon = 1 \pm 10\%$):	$\text{LET}_{\infty}(\text{H}_2\text{O}) < 10 \text{ keV}/\mu\text{m}$
Accuracy (above $10 \mu\text{Gy}$):	$\delta < 5\%$



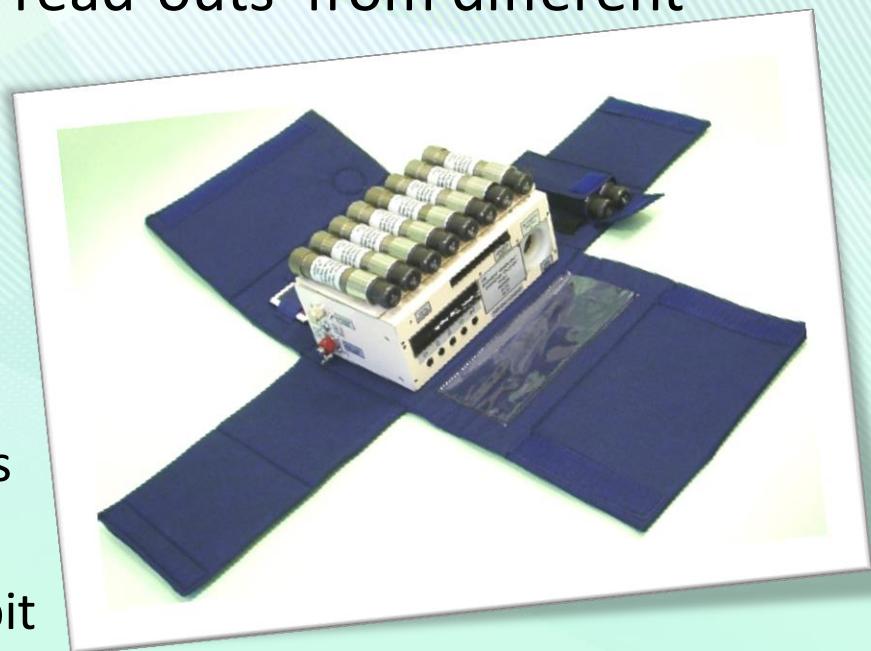
- High sensitivity \Rightarrow Even hourly read-outs are possible

Pille on board ISS



Pille on board the ISS

- On board every space station since Salyut-6
- More than 53 000 comparable read-outs from different space stations
- DOSMAP project in 2001
- Service dosimetry system on Zvezda since 2003 (Exp. #8)
 - Dose mapping
 - Personal dosimetry during CME-s
 - Personal dosimetry during EVA-s
 - Automatic read-out on every orbit
- 4 new dosimeters were delivered to ISS and 2 old ones retrieved in 2009



Pille on board the ISS



- Currently 12 dosimeters on board
- Warranty period of the Pille reader is over
- FM2 reader + 8 additional dosimeters passed acceptance t.
- Delivery to ISS this year



New type of Pille dosimeters

- Checking the prototype by IMBP and RSC Energia specialists in October 2017
- ~1 mm Al eq. thickness (instead of ~4 mm); smaller dimensions
- Planned to be used inside MTR-III and on the poncho of the phantom



NASA Pille (PDS system)

- 2001: DOSMAP
- 2011: return to ground with the last Shuttle
- 2017: return to its birthplace (all models and dosimeters)



Many thanks to Kris Vogelsong, Dana Bolles and Cherise Field!

Practice in reporting data



Accuracy and corrections

- Usual accuracy: $\pm 10\%$
- Bulbs are selected for flight for which the **reproducibility** is within an accuracy of 5%.
- Dosimeters are calibrated with a standard ^{137}Cs source beam (gamma-rays) on ground (measure air kerma).
- Data presented are **not corrected for $\text{LET}_{\text{H}_2\text{O}} > 10 \text{ keV}/\mu\text{m}$.**
- **No conversion to absorbed dose in water or tissue-equivalent material is applied.**

Experiences and corrections

- The **only correction** we perform is **based on the regular cross-calibration** of the dosimeters on board.
- Except from dosimeter A0303, none of the Pille dosimeters used exclusively for dose mapping or personal dosimetry showed any decrease in their sensitivity.
- But it is NOT sudden (in the past the frequency of cross-calibration measurements was inadequate).
- It depends on the total number of read-outs!



Results of June 2016 – April 2017



From 9 December 2015



Dosimeter No.	Locations (except during cross-calibration measurement)
A0301	On Panel 406
A0302	Starboard (right side) crew quarters, left of window
A0304	MIM1 (Small Research Module Rassvet) , under Panel 204
A0305	In the saloon of large diameter on Panel 327
<u>A0306</u>	“Service” dosimeter, inserted in the Reader (fixed on the floor, right to illuminator № 9)
<u>A0307</u>	Docking port 1 (to module Pirs-1), hemisphere, on panel III, <i>RS EVA ref. dosim.</i>
A0309	MIM2 (Small Research Module Poisk), cylindrical part at the entrance (handrail 6111)
A0310	Behind panel 447 at detector DB-8 No.3
A0311	Port (left side) crew quarters, left of window
<u>A0312</u>	NODE2 of the Russian crew quarters; <i>US EVA ref. dosim.</i>
A0313	On panel 435 (table)
A0314	MIM2 (Small Research Module Poisk), cylindrical part on Plane III

From 29 July 2016



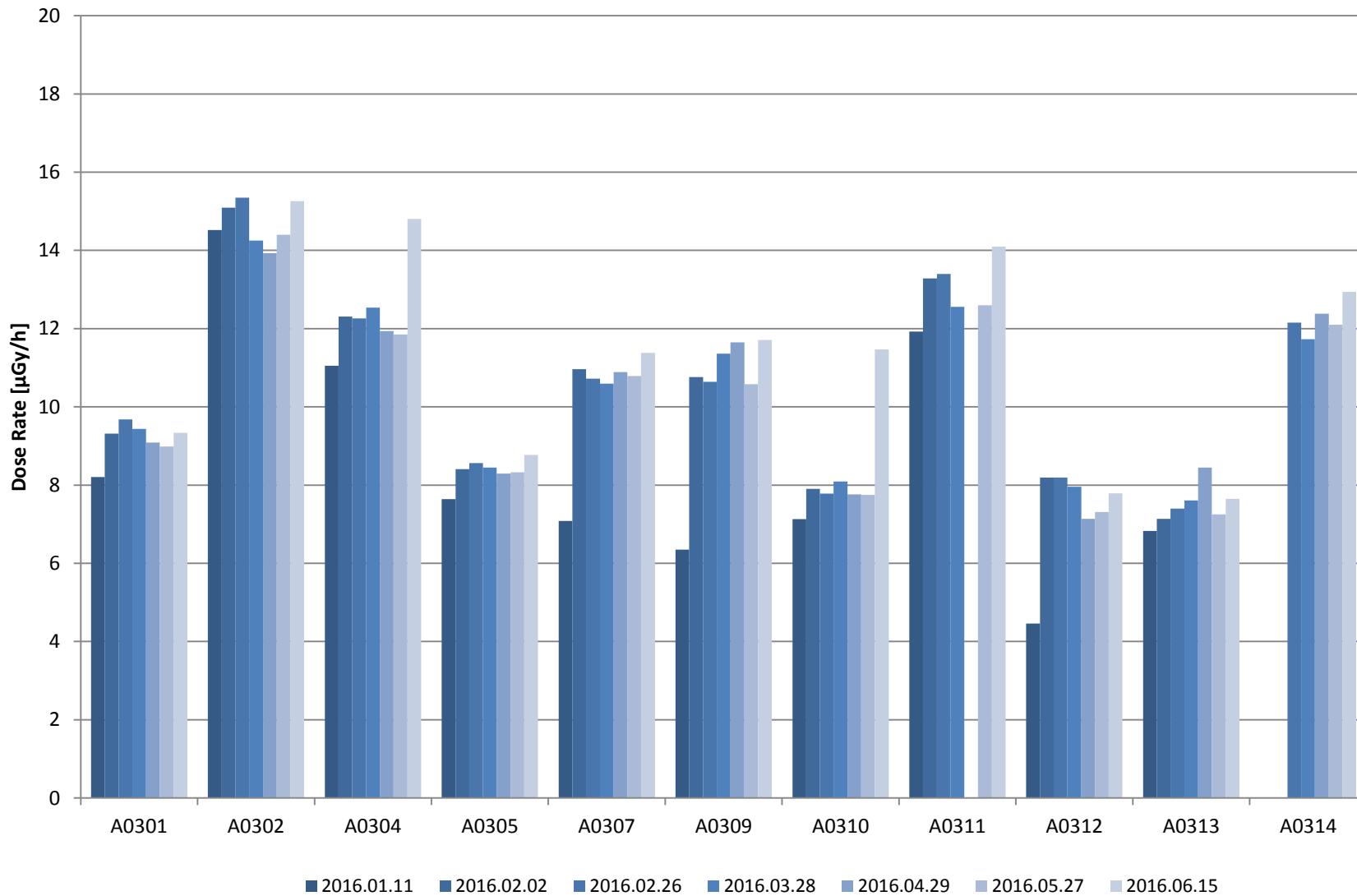
Dosimeter No.	Locations (except during cross-calibration measurement)
A0301	On Panel 406
A0302	Starboard (right side) crew quarters, left of window
A0304	Right ложемент TK Soyuz MS
A0305	In the saloon of large diameter on Panel 327
<u>A0306</u>	“Service” dosimeter, inserted in the Reader (fixed on the floor, right to illuminator № 9)
<u>A0307</u>	Docking port 1 (to module Pirs-1), hemisphere, on panel III, <i>RS EVA ref. dosim.</i>
A0309	Central ложемент TK Soyuz MS
A0310	Behind panel 447 at detector DB-8 No.3
A0311	Port (left side) crew quarters, left of window
<u>A0312</u>	NODE2 of the Russian crew quarters; <i>US EVA ref. dosim.</i>
A0313	On panel 435 (table)
A0314	Left ложемент TK Soyuz MS

From 27 September 2016 (as before)

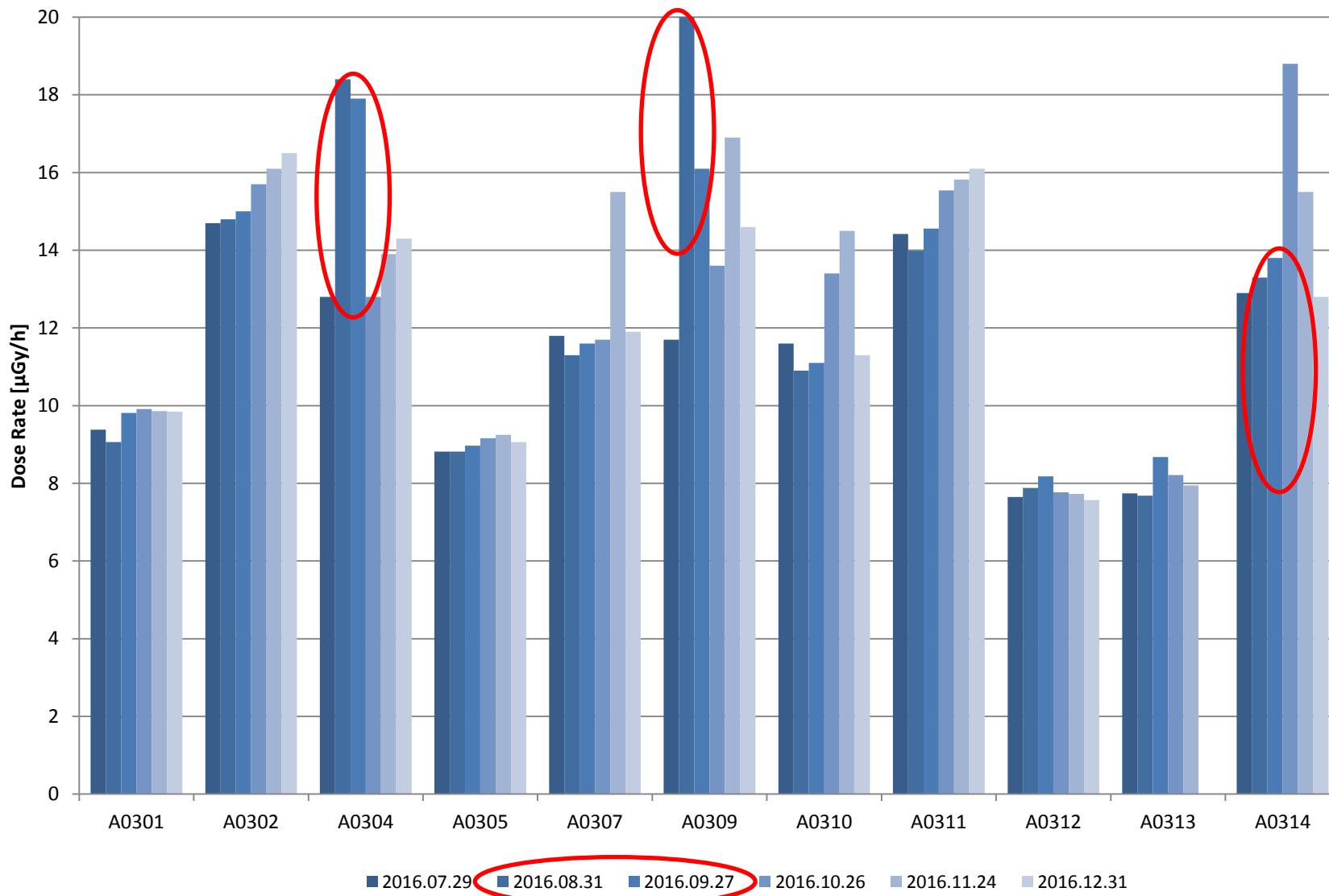


Dosimeter No.	Locations (except during cross-calibration measurement)
A0301	On Panel 406
A0302	Starboard (right side) crew quarters, left of window
A0304	MIM1 (Small Research Module Rassvet) , under Panel 204
A0305	In the saloon of large diameter on Panel 327
<u>A0306</u>	“Service” dosimeter, inserted in the Reader (fixed on the floor, right to illuminator № 9)
<u>A0307</u>	Docking port 1 (to module Pirs-1), hemisphere, on panel III, <i>RS EVA ref. dosim.</i>
A0309	MIM2 (Small Research Module Poisk), cylindrical part at the entrance (handrail 6111)
A0310	Behind panel 447 at detector DB-8 No.3
A0311	Port (left side) crew quarters, left of window
<u>A0312</u>	NODE2 of the Russian crew quarters; <i>US EVA ref. dosim.</i>
A0313	On panel 435 (table)
A0314	MIM2 (Small Research Module Poisk), cylindrical part on Plane III

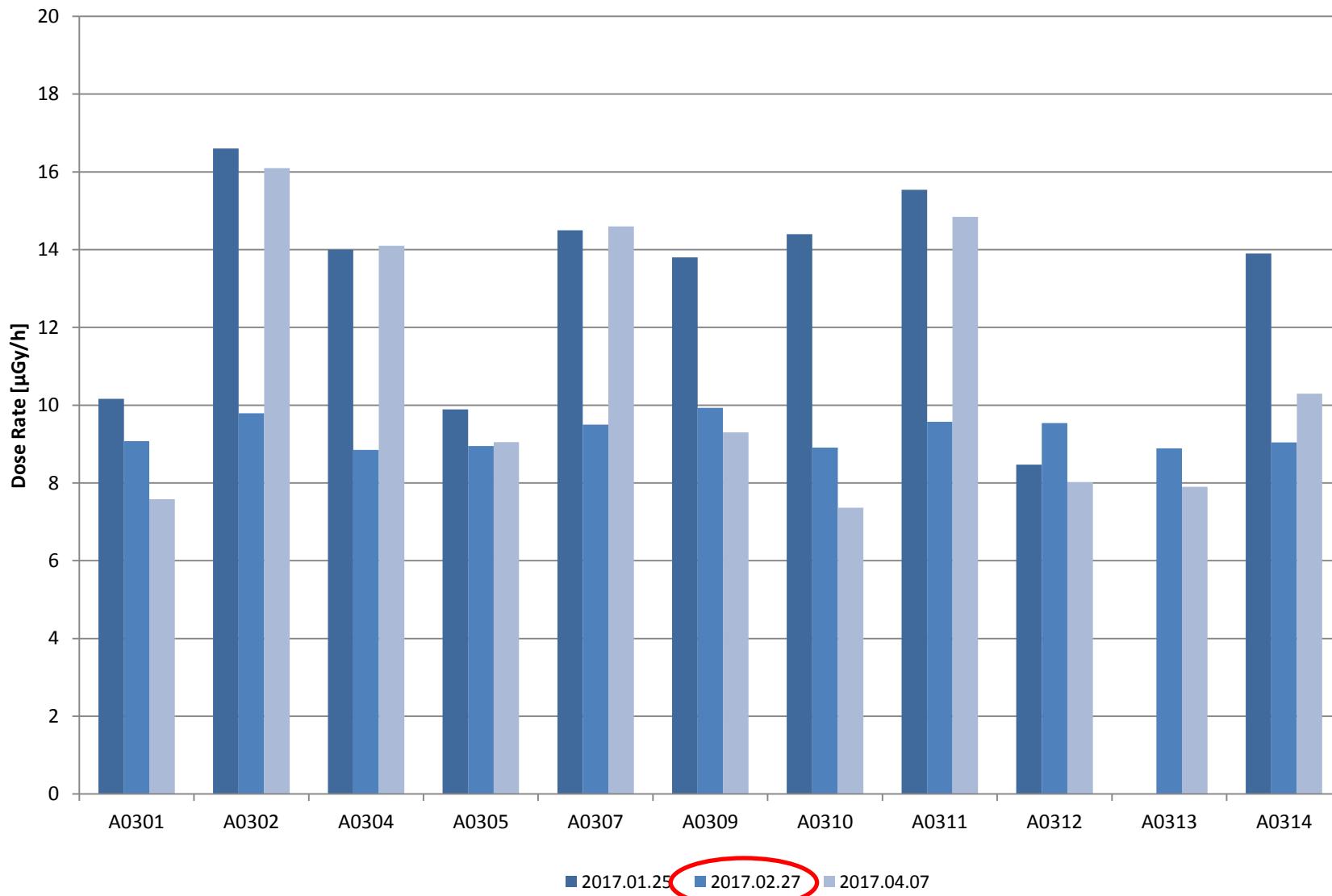
Monthly manual read-outs, January 2016 - June 2016



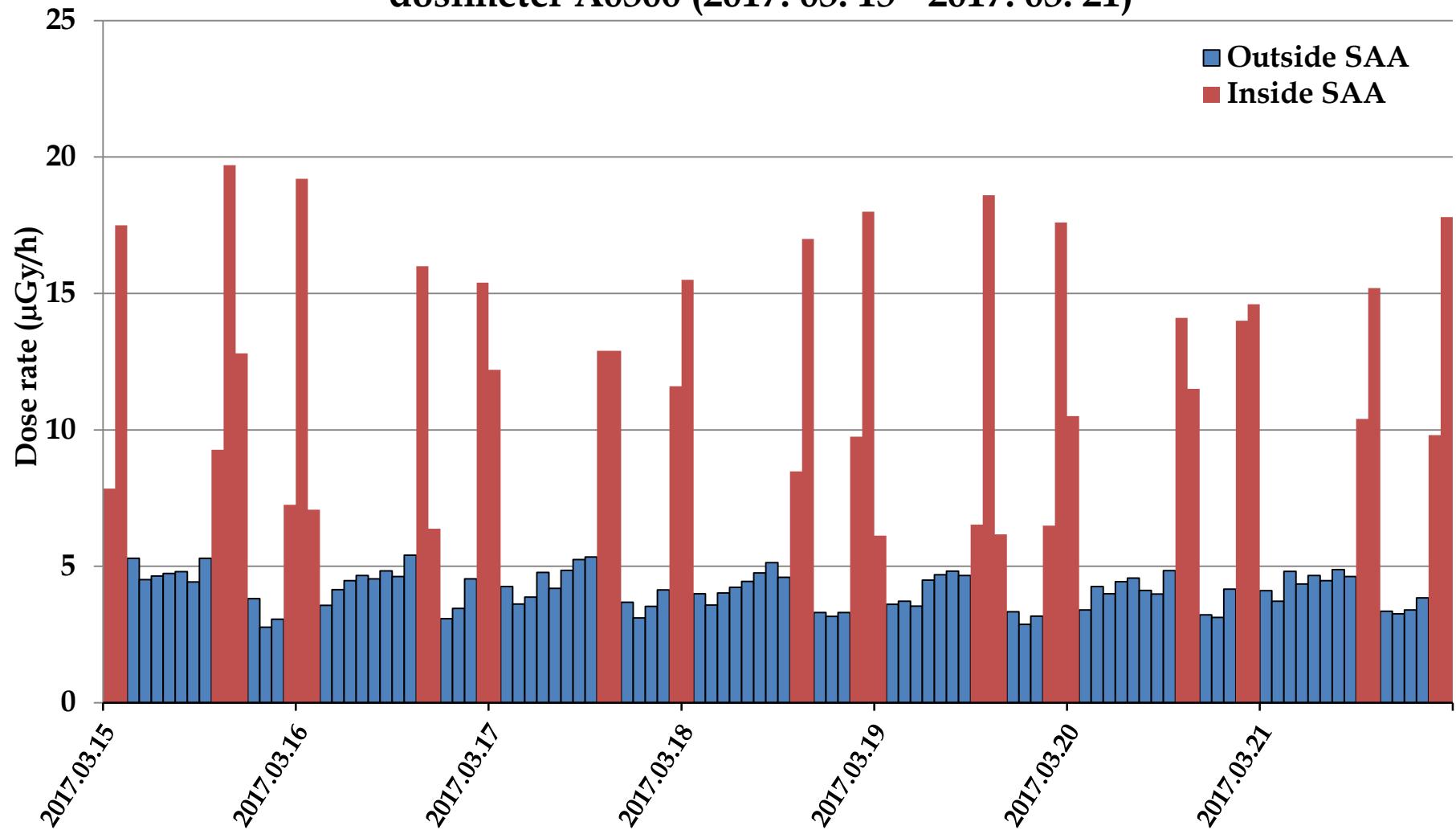
Monthly manual read-outs, July 2016 - December 2016



Monthly manual read-outs, January 2017 - April 2017



Sample of the automatic measurements, dosimeter A0306 (2017. 03. 15 - 2017. 03. 21)



EVA measurements

US EVA-34; Dec. 21, 2015. 13:45–16:01 UTC; duration 3 hrs 16 min 

Reference dosimeter: A0312 (NODE-2)

Dosimeter	Total dose [μGy] / time [h]	Total EVA dose [μGy]	Extra EVA dose [μGy]	Total EVA dose rate [μGy/h]	Extra dose rate [μGy/h]
A0312	312 (46.8)	21.8	-	6.7	-
A0307	424 (46.8)	134	112	40.9	34.3
A0309	342 (46.8)	51.8	30	15.8	9.2

US EVA-35; Jan. 15, 2016. 12:48–17:31 UTC; duration 4 hrs 43 min 

Reference dosimeter: A0312 (NODE-2)

Dosimeter	Total dose [μGy] / time [h]	Total EVA dose [μGy]	Extra EVA dose [μGy]	Total EVA dose rate [μGy/h]	Extra dose rate [μGy/h]
A0312	439 (46.9)	44.2	-	9.4	-
A0307	573 (46.9)	178	134	37.8	28.4
A0309	502 (46.9)	107	63	22.7	13.3

EVA measurements

RS EVA-42; Feb. 3, 2016. 12:55–17:40 UTC; duration 4 hrs 45 min 

Reference dosimeter: A0307 (on top of the Reader, Zvezda Service Module)

Dosimeter	Total dose [μGy] / time [h]	Total EVA dose [μGy]	Extra EVA dose [μGy]	Total EVA dose rate [μGy/h]	Extra dose rate [μGy/h]
A0307	521 (51.0)	48.5	-	10.2	-
A0309	1240 (51.0)	768	719	162	151
A0310	1120 (51.0)	648	599	136	126

US EVA-36; Aug. 19, 2016. 13:04–19:02 UTC; duration 5 hrs 58 min 

Reference dosimeter: A0312 (NODE-2)

Dosimeter	Total dose [μGy] / time [h]	Total EVA dose [μGy]	Extra EVA dose [μGy]	Total EVA dose rate [μGy/h]	Extra dose rate [μGy/h]
A0312	438 (46.9)	55.8	-	9.3	-
A0305	489 (46.9)	107	51	17.9	8.5
A0307	602 (46.9)	220	164	36.8	27.5

EVA measurements

US EVA-37; Sep. 1, 2016. 11:53–17:41 UTC; duration 6 hrs 48 min



Reference dosimeter: A0312 (NODE-2)

Dosimeter	Total dose [μGy] / time [h]	Total EVA dose [μGy]	Extra EVA dose [μGy]	Total EVA dose rate [μGy/h]	Extra dose rate [μGy/h]
A0312	364 (42.7)	58.0	-	8.5	-
A0306	286 (42.7)	45.5	-	6.7	-
A0305	367 (42.7)	61	3	9.0	0.4
A0307	484 (42.7)	178	120	26.2	17.6

US EVA-38; Jan. 6, 2017. 11:23–17:55 UTC; duration 6 hrs 32 min



Reference dosimeter: A0312 (NODE-2)

Dosimeter	Total dose [μGy] / time [h]	Total EVA dose [μGy]	Extra EVA dose [μGy]	Total EVA dose rate [μGy/h]	Extra dose rate [μGy/h]
A0312	411 (49.6)	54.9	-	8.3	-
A0307	635 (49.6)	279	224	42.1	33.8
A0309	562 (49.6)	206	151	31.1	22.8

EVA measurements

US EVA-39; Jan. 13, 2017. 11:23–17:55 UTC; duration 6 hrs 32 min 

Reference dosimeter: A0312 (NODE-2)

Dosimeter	Total dose [μGy] / time [h]	Total EVA dose [μGy]	Extra EVA dose [μGy]	Total EVA dose rate [μGy/h]	Extra dose rate [μGy/h]
A0312	407 (51.4)	47.3	-	7.9	-
A0307	647 (51.4)	287	240	48.1	40.2
A0309	742 (51.4)	382	335	64.0	56.1

US EVA-40; Mar. 24, 2017. 12:48–17:31 UTC; duration 4 hrs 43 min 

Reference dosimeter: A0312 (NODE-2)

Dosimeter	Total dose [μGy] / time [h]	Total EVA dose [μGy]	Extra EVA dose [μGy]	Total EVA dose rate [μGy/h]	Extra dose rate [μGy/h]
A0312	420 (47.2)	58.5	-	8.9	-
A0304	513 (47.2)	151	93	23.1	14.2
A0307	646 (47.2)	284	226	43.3	34.4

EVA measurements

US EVA-41; Mar. 30, 2017. 12:29–19:33 UTC; duration 7 hrs 4 min 

Reference dosimeter: A0312 (NODE-2)

Dosimeter	Total dose [μGy] / time [h]	Total EVA dose [μGy]	Extra EVA dose [μGy]	Total EVA dose rate [μGy/h]	Extra dose rate [μGy/h]
A0312	406 (52.4)	54.7	-	7.8	-
A0306	340 (52.4)	45.5	-	6.5	-
A0304	505 (52.4)	154	99	21.8	14.0
A0307	555 (52.7)	204	149	28.9	21.1

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