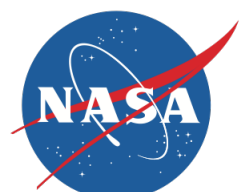
ARTEMIS-HERA ON SPACE STATION

2022 Workshop on Radiation Monitoring for the ISS

Sept 07, 2022



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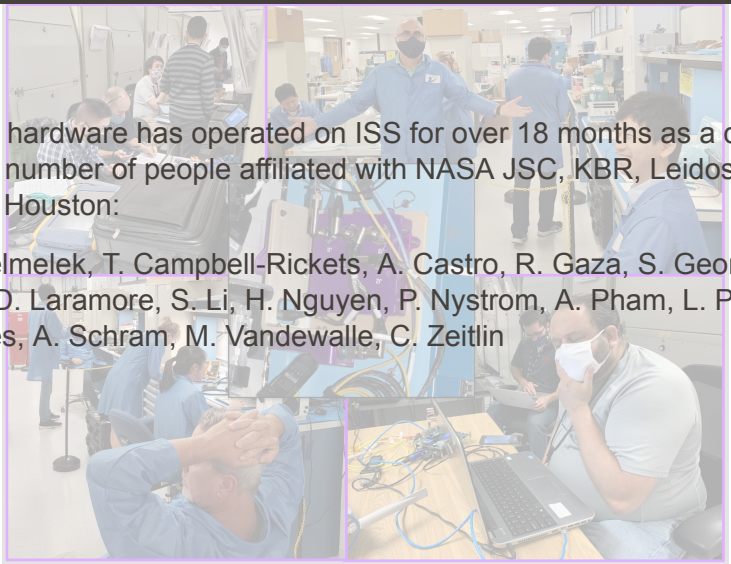
on behalf of the SRAG Science Team

Leidos, Inc.
NASA JSC Space Radiation Analysis Group

ACKNOWLEDGEMENTS



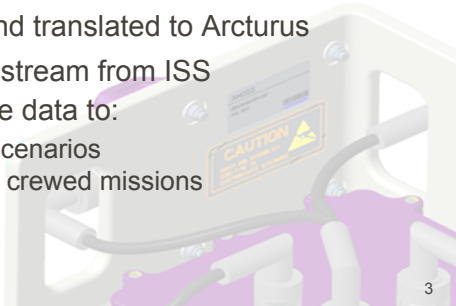
The A-HoSS hardware has operated on ISS for over 18 months as a direct result of effort by a number of people affiliated with NASA JSC, KBR, Leidos, and the University of Houston:

- M. Abdelmelek, T. Campbell-Rickets, A. Castro, R. Gaza, S. George, B. Hayes, D. Laramore, S. Li, H. Nguyen, P. Nystrom, A. Pham, L. Pinsky, E. Semones, A. Schram, M. Vandewalle, C. Zeitlin

OBJECTIVE AND MOTIVATION

Artemis-HERA on Space Station (A-HoSS) demonstrates the operational readiness of the Artemis-II HERA radiation detection system and provides ground teams with a data stream similar to that received from Artemis-II

- The hardware provides a full data set daily via SSC interface and associated OCA downlinks
- HERA Artemis-2 telemetry stream is captured and translated to Arcturus
- Arcturus provides the HERA real-time telemetry stream from ISS
- Radiation console in MCC-H utilizes the real-time data to:
  - build and test Artemis displays and operations scenarios
  - gain in-flight experience with the system prior to crewed missions



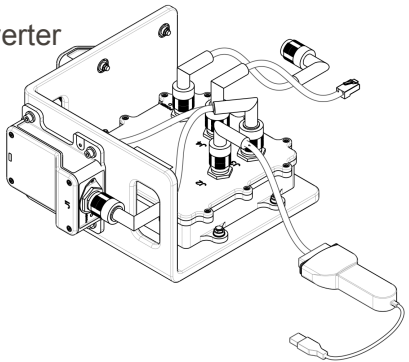
SYSTEM OVERVIEW

Artemis-II HERA system operating on ISS

- As-delivered Artemis-II system – similar to ISS HERA (returned Jan 2020)
- 1 processing unit and 2 sensing units mounted on an Ultem printed bracket
- 120V Power via UOP

- Telemetry via Arcturus using RS422-to-USB converter
- Full data sets via Ethernet connection to SSC
- SSC software included in SSC load (ISS HERA)
- Arcturus software provides real-time telemetry and commanding

- Hardware expected delivered to ISS on NG-15
- Demonstrated continuous operation for 30 days
- Operating in USLab since March 02, 2021



HYBRID ELECTRONIC RADIATION ASSESSOR (HERA)

Exploration Mission monitoring hardware

- Up to 4 Timepix sensors per system
  - Local sensor on Processing Unit
  - Up to 3 remote Sensor Units
- On-system processing and analysis
- Active telemetry available for crew displays and ground monitoring
- Caution and Warning capability (on Artemis-II)

TIMEPIX DETECTORS

CERN-developed Timepix hybrid pixel detectors

- Pixelated sensors with independent pixel electronics
- Time over Threshold measurements per pixel
- Calibrated to provide energy deposited per pixel
- Provides deposition pattern characteristics
- Utilized in REM hardware for ISS monitoring

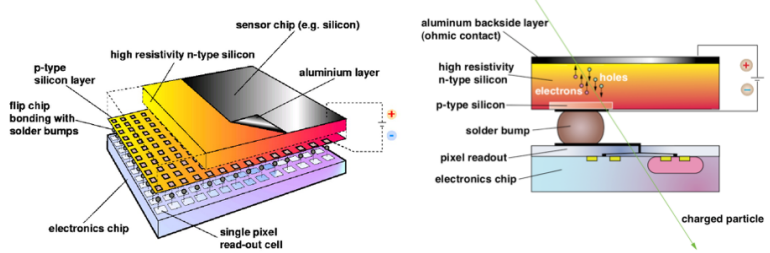
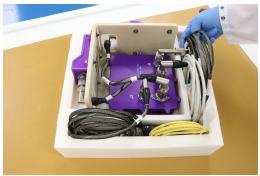
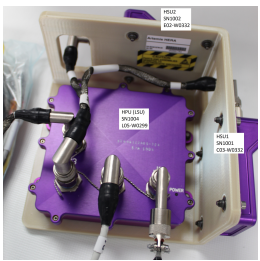


Image source: CERN/Medipix

A-HOSS





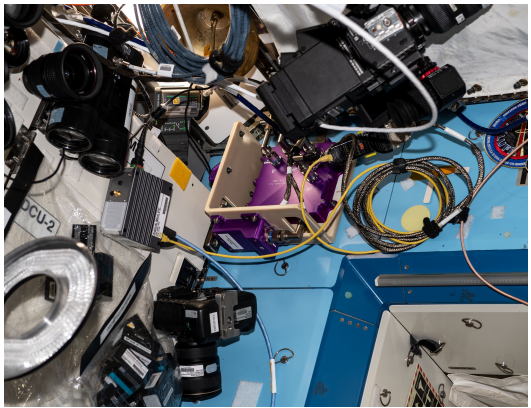
- Artemis-II HERA certified for ISS
  - 1 Processor Unit
  - 2 Sensor Units
  - 3D printed frame (Ultem)
  - Power and Data cables
- Mounting frame allows minimal footprint and orthogonal measurements
- Station Support Computer interface allows data transmission via TCP/IP
- Arcturus interface (RS422-to-USB) allows telemetry via Ku

OPERATIONS CONCEPT - SSC

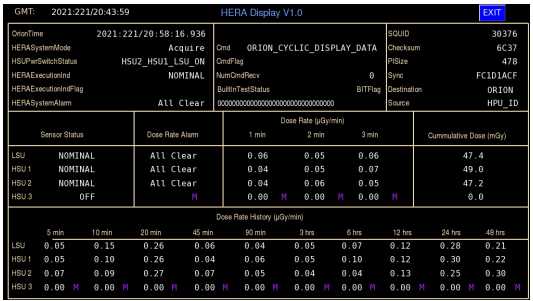
- Deploy AHoSS at LAB1O6 near ISS RAD
- SSC application transfers data from HERA to SSC
- Application then transfers data from SSC to server location
- OCA performs daily file downlinks of logs and raw data
- Continuous acquisition with stable AHoSS power
- Occasional data interruptions from SSC operations

OPERATIONS CONCEPT - ARCTURUS

- Deploy and utilize Adlink hardware near LAB1O6
- AHoSS application on Adlink
  - Catches telemetry stream from the RS422-USB interface
  - Packs HERA generated telemetry for Arcturus ingestion/downlink
- Capability to command HERA system
  - No impacts outside HERA
  - Detector mode changes
  - System memory management
  - Housekeeping tasks



A-HOSS DATA PRODUCTS



GMT: 2021:221/20:43:59 — HERA Display V1.0 — EXIT

OrionTime	2021:221/20:58:16.936			SQUID	30376
HERASystemMode	Acquire	Cmd	ORION_CYCLIC_DISPLAY_DATA	Checksum	6C37
HSUPwrSwitchStatus	HSU2_HSU1_LSU_ON	CmdFlag		PISize	478
HERAExecutionInd	NOMINAL	NumCmdRecv	0	Sync	FC1D1ACF
HERAExecutionIndFlag		BuiltInTestStatus	BITFlag	Destination	ORION
HERASystemAlarm	All Clear	00000000000000000000000000000000		Source	HPU_ID

	Sensor Status	Dose Rate Alarm	Dose Rate (µGy/min) 1 min	2 min	3 min	Cummulative Dose (mGy)
LSU	NOMINAL	All Clear	0.06	0.05	0.06	47.4
HSU 1	NOMINAL	All Clear	0.04	0.05	0.07	49.0
HSU 2	NOMINAL	All Clear	0.04	0.06	0.05	47.2
HSU 3	OFF	M	0.00 M	0.00 M	0.00 M	0.0

Dose Rate History (µGy/min)

	5 min	10 min	20 min	45 min	90 min	3 hrs	6 hrs	12 hrs	24 hrs	48 hrs
LSU	0.05	0.15	0.26	0.06	0.04	0.05	0.07	0.12	0.28	0.21
HSU 1	0.05	0.10	0.26	0.04	0.06	0.05	0.10	0.12	0.30	0.22
HSU 2	0.07	0.09	0.27	0.07	0.05	0.04	0.04	0.13	0.25	0.30
HSU 3	0.00 M	0.00 M	0.00 M	0.00 M	0.00 M	0.00 M	0.00 M	0.00 M	0.00 M	0.00 M

- Full data via SSC path
  - Daily file downlinks
  - Timestamped frames
  - Science, Engineering, Display, and CW message sets
- Telemetry via Arcturus
  - Artemis vehicle message sets
  - Limited file downlinks
  - Real-time ground displays

ARTEMIS-II HERA MESSAGE SETS

A-HoSS incorporates the Artemis-II HERA which uses 4 primary message sets

Science

- Message rate of 0.016 Hz (1/60s)
- Dose rate in water [mGy/min]
- Rotating Bin sets [0-4] of 21 bins
- Bins for Protons, Alphas Photons & Electrons, Heavy Ions, LET1, LET2

Display

- Message rate of 1 Hz (1/s)
- Current dose rate in water [mGy/min]
- Cumulative mission dose [mGy]
- Dose rate history table
- System mode and status
- Sensor mode and status

Engineering

- Message rate of 0.1 Hz (1/10s)
- System uptime
- Memory usage
- System and Sensor Health and Status
  - Voltages and Currents
  - Timepix and board temperatures
  - System and sensor fault status

Caution and Warning

- Message rate of 1 Hz (1/s)
- Built-In Test Status
- System-level alarm
- Sensor-level alarms

POTENTIAL COMPARISONS

Mostly static location allows linking data with vehicle location and orientation

- Better comparisons with other (mostly) static instruments
- Possibility of extracting information such as SAA pitch angle from data
- Orthogonal detector mounting provides directional information on radiation field

A-HOSS PER-MINUTE DOSE RATES

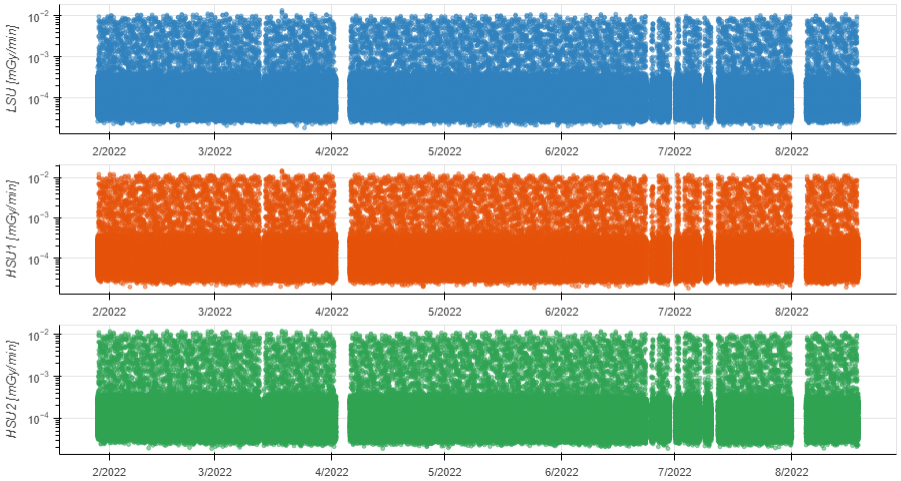


Figure 1: Per-minute doses (in water) for 2022 GMT 026 to GMT 230

A-HOSS PER-MINUTE DOSE RATES

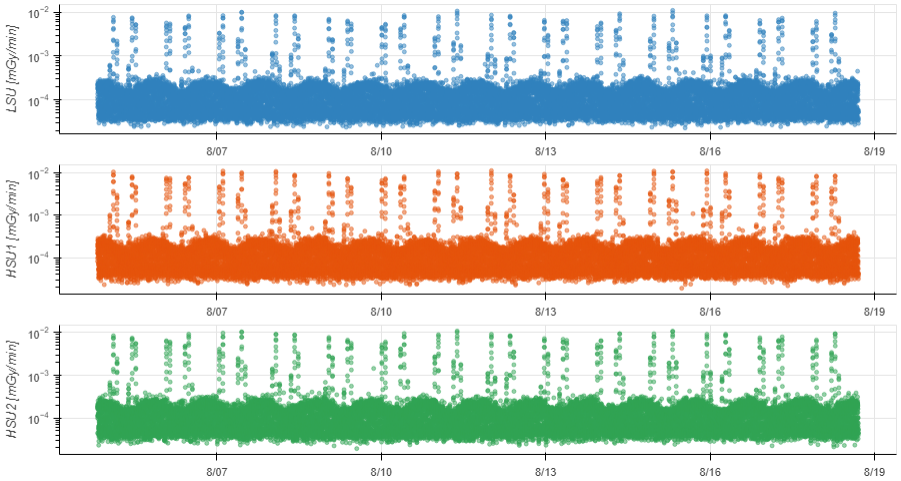


Figure 2: Per-minute doses (in water) for 2022 GMT 213 to GMT 230

A-HOSS PER-MINUTE DOSE RATES

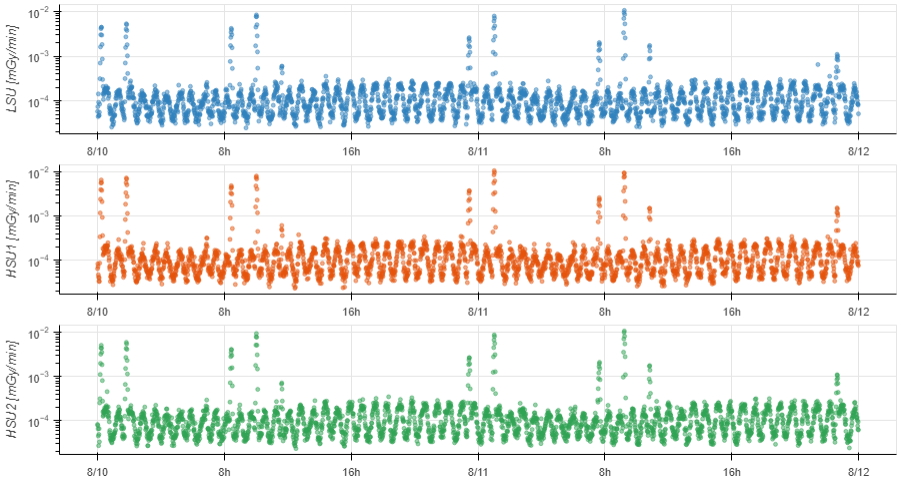


Figure 3: Per-minute doses (in water) for 2022 GMT 222 to GMT 224

A-HOSS DAILY DOSE RATES

Figure 4: Daily doses (in water) by detector for 22GMT026 to GMT230

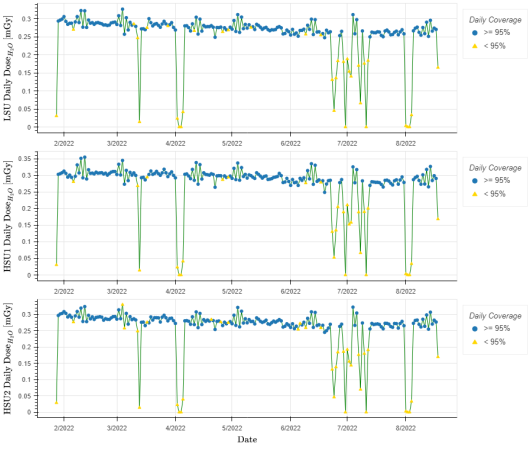


Figure 5: Coverage rates by detector for 22GMT026 to GMT230. SSC outages account for drops in coverage from data transfer gaps.

A-HOSS DOSE RATES BY REGION

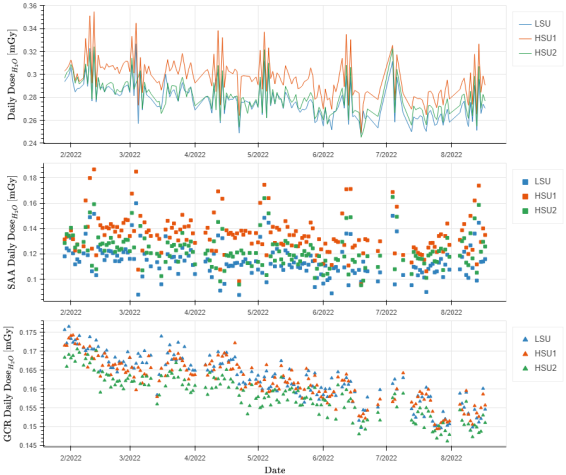


Figure 6: Daily doses in water by region for 2022 GMT 026 to GMT 230. Bad frames (4) removed.

DOSE RATE COMPARISON TO RAD

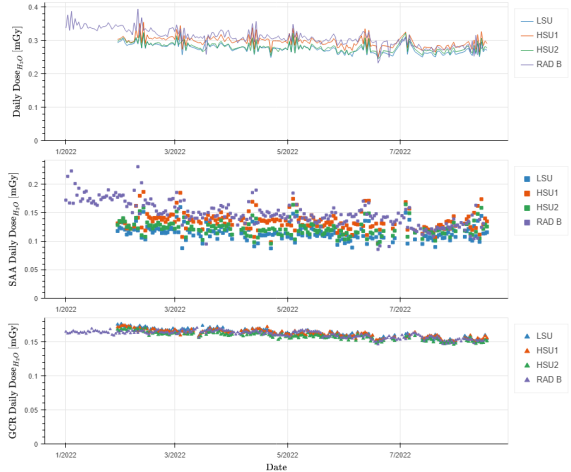


Figure 7: Comparison of A-HoSS and RAD daily doses in water. Bad frames and <95% coverage removed.

SUMMARY

- A-HoSS is a Timepix-based Artemis-II flight system deployed on ISS
- Delivered on NG-15 (Feb 2021) and deployed at Lab1S6 on 02 March, 2021
- Demonstrates Artemis-II system readiness
- Opportunity for experience with real-time Artemis-like data
- Transition to ISS operations hardware in discussion

Additional Slides

A-HOSS PER-MINUTE FRAME COUNT AND LIVETIMES

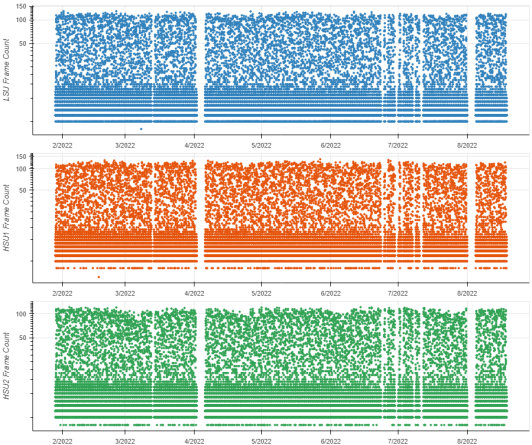


Figure 8: Frame count per minute by detector for 22GMT026 to GMT230

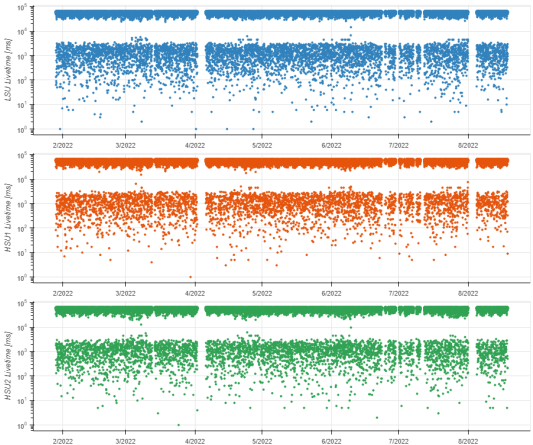


Figure 9: Livetime per min in ms by detector for 22GMT026 to GMT230

A-HOSS PER-MINUTE DOSE RATES - UNCORRECTED

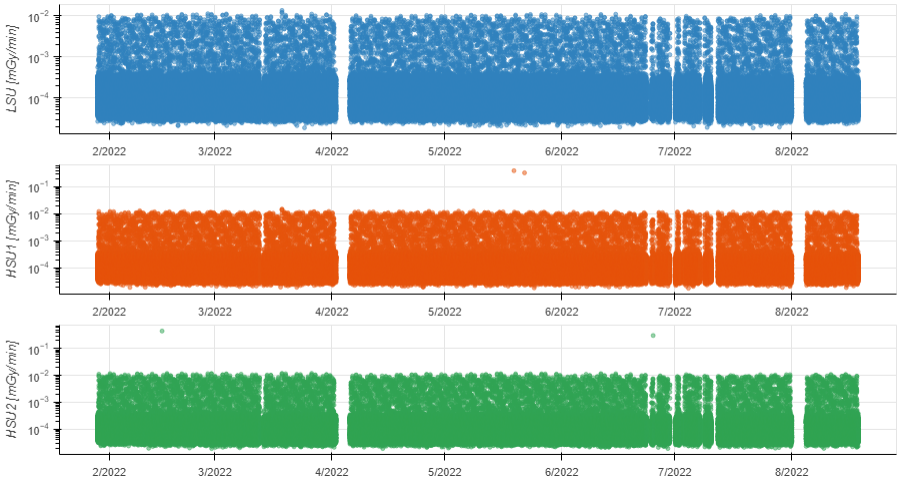


Figure 10: Per-minute doses (in water) for 2022 GMT 026 to GMT 230

A-HOSS DAILY DOSE RATES - UNCORRECTED

Figure 11: Daily doses (in water) by detector for 22GMT026 to GMT230

Figure 12: Coverage rates by detector for 22GMT026 to GMT230

A-HOSS DOSE RATES BY REGION - UNCORRECTED

Figure 13: Daily doses (in water) by region for 2022 GMT 026 to GMT 230

DOSE RATE COMPARISON TO RAD - UNCORRECTED

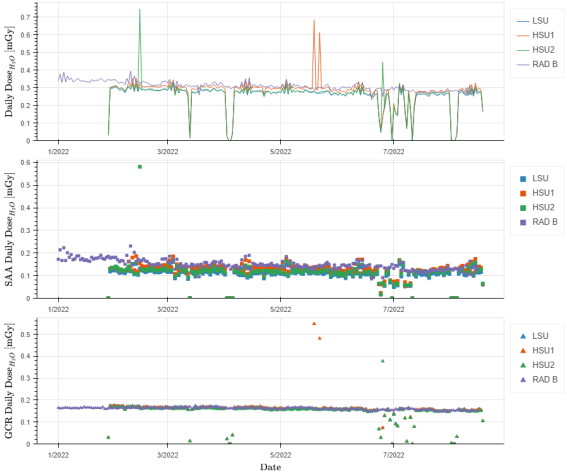


Figure 14: Comparison of A-HoSS and RAD daily doses (in water)

A-HOSS PER-MINUTE DOSE RATES - 4 HIGH DOSE RATE MINUTES REMOVED

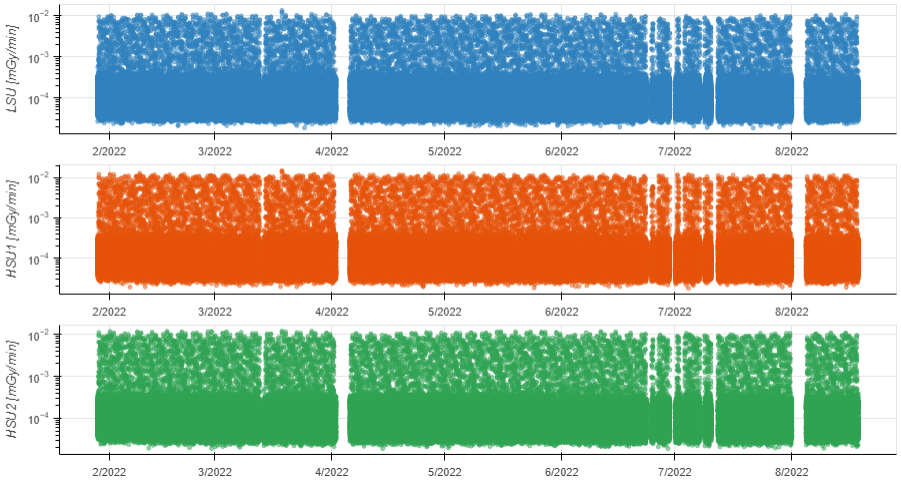


Figure 15: Per-minute doses (in water) for 2022 GMT 026 to GMT 230

A-HOSS DAILY DOSE RATES - 4 HIGH DOSE RATE MINUTES REMOVED

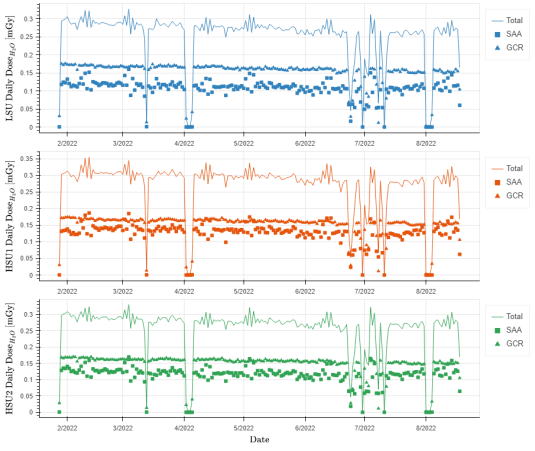


Figure 16: Daily doses (in water) by detector for 22GMT026 to GMT230

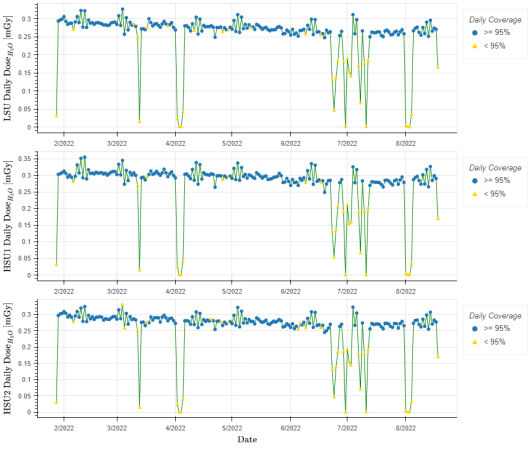


Figure 17: Coverage rates by detector for 22GMT026 to GMT230

A-HOSS DOSE RATES BY REGION - 4 HIGH DOSE RATE MINUTES REMOVED

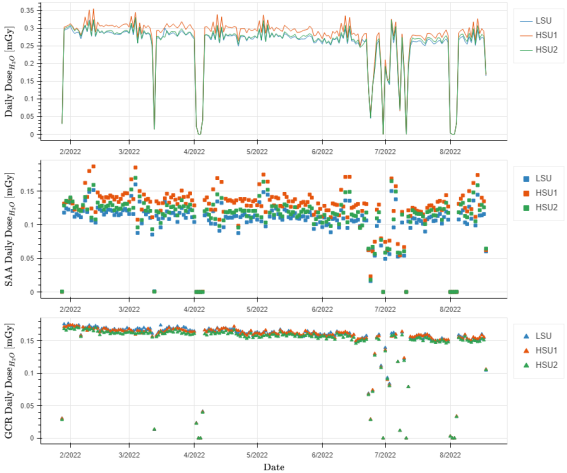


Figure 18: Daily doses in water by region for 2022 GMT 026 to GMT 230. Note the 4 high dose rate minutes have been removed.

DOSE RATE COMPARISON TO RAD - 4 HIGH DOSE RATE MINUTES REMOVED

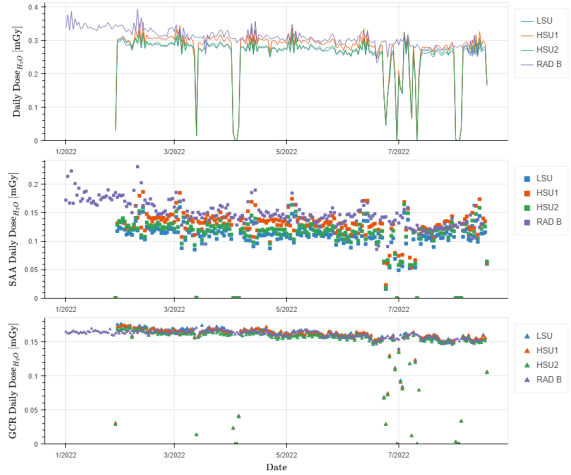


Figure 19: Comparison of A-HoSS and RAD daily doses in water. Note the 4 high dose rate minutes have been removed.