

# UPDATE ON ARTEMIS-HERA ON SPACE STATION (A-HOSS)

2023 Workshop on Radiation Monitoring for the ISS

Sept 07, 2023

N. Stoffle, Ph.D., P.E.  
*on behalf of the SRAG Science Team*

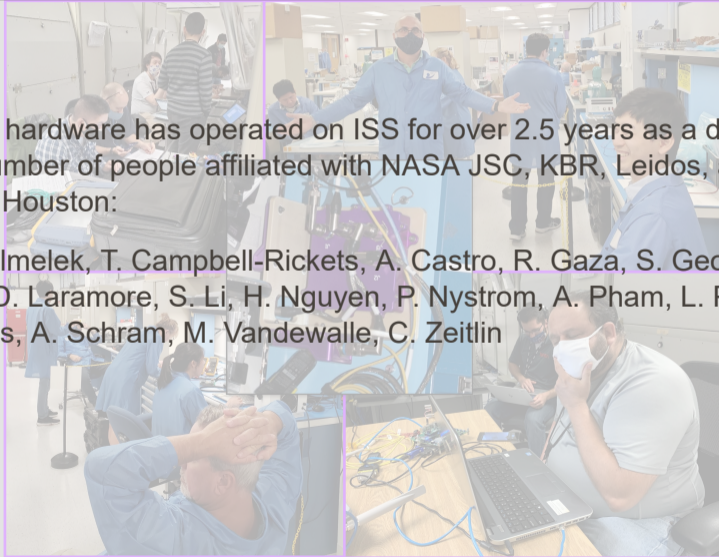
Leidos, Inc.  
**NASA JSC** Space Radiation Analysis Group



# ACKNOWLEDGEMENTS

The A-HoSS hardware has operated on ISS for over 2.5 years 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-Ricketts, 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

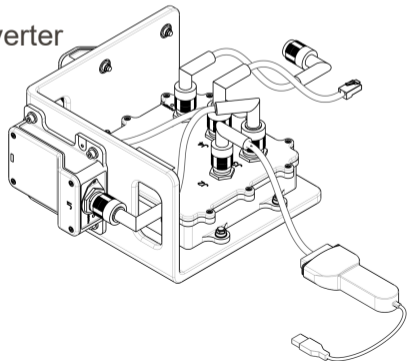
- Full data set daily via SSC interface and associated OCA downlinks
- HERA telemetry stream is captured and translated to Arcturus
- Arcturus provides the HERA real-time telemetry stream from ISS
- Radiation console in MCC-H utilizes the real-time data to:
  - build and test Artemis displays and operations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



# SYSTEM OVERVIEW

## Artemis-II HERA system operating on ISS

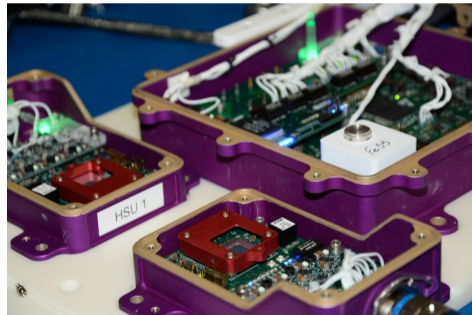
- As-delivered Artemis-II system – similar to ISS HERA (returned Jan 2020)
- 1 processing unit and 2 sensing units mounted on an Ultem printed bracket
- 120V Power via UOP
- Telemetry via Arcturus using RS422-to-USB converter
- Full data sets via Ethernet connection to SSC
- SSC software included in SSC load (ISS HERA)
- Arcturus software provides real-time telemetry and commanding
- Hardware 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 messages available for 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

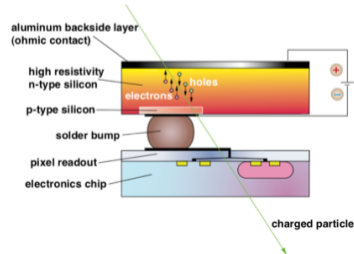
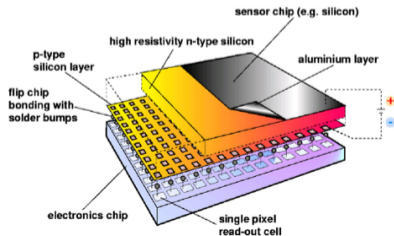
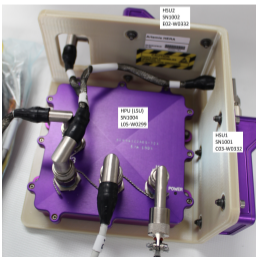


Image source: CERN/Timepix

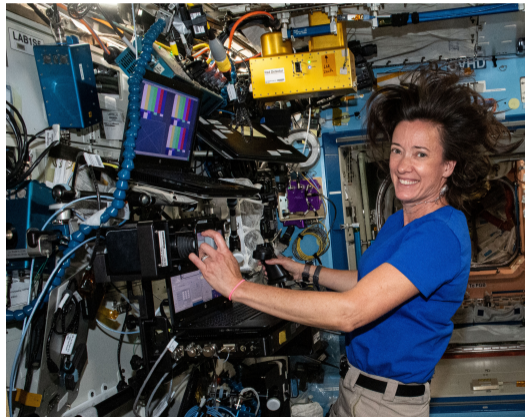
# A-HOSS



- 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

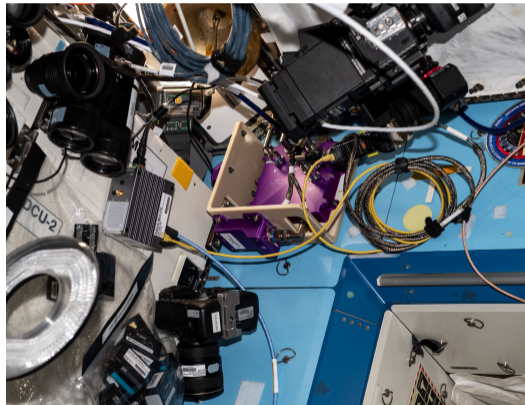
- Deploy AHoSS at LAB106 near ISS RAD
- SSC application transfers data from HERA to SSC
- Application then transfers data from SSC to server location
- OCA performs daily file downlinks of logs and raw data
- Continuous acquisition with stable AHoSS power
- Occasional data interruptions from SSC operations





# OPERATIONS CONCEPT - ARCTURUS

- Deploy and utilize Adlink hardware nearby AHOSS
- AHOSS application running 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

Sensor Status		Dose Rate Alarm	Dose Rate (μGy/min)			Cumulative Dose (mGy)
			1 min	2 min	3 min	
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

# A-HOSS PER-MINUTE DOSE RATES FOR 2023 MAY 10

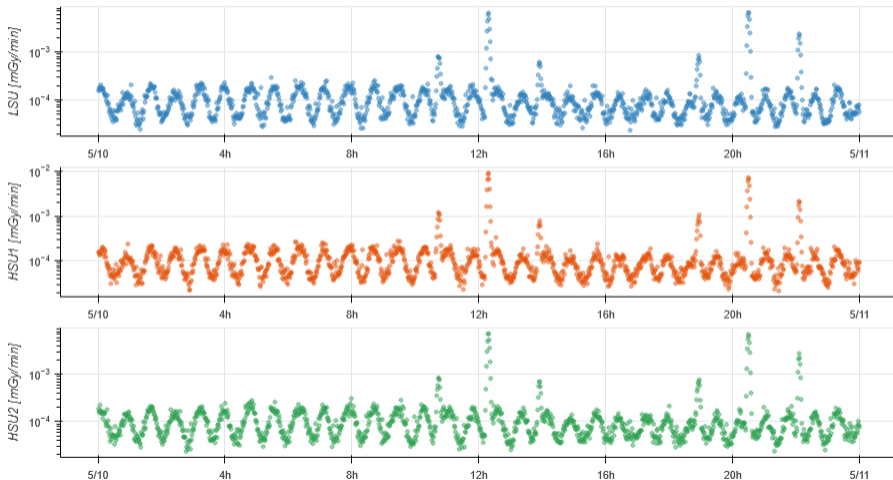
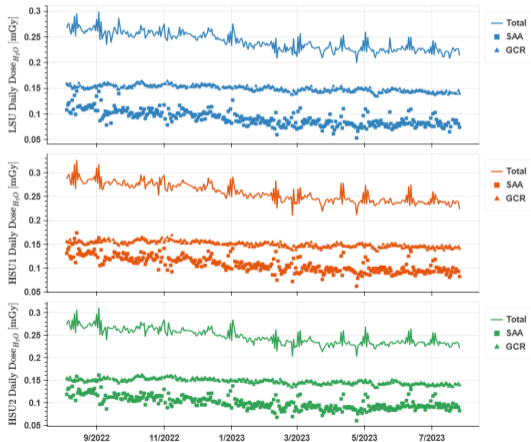
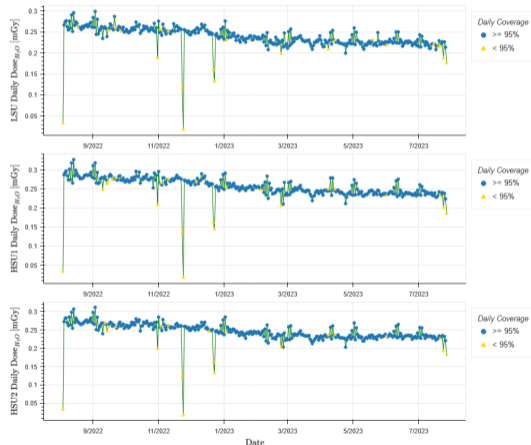


Figure 1: Per-minute doses (in water) for 2023 GMT 130

# A-HOSS DAILY DOSE RATES



**Figure 2:** Daily doses (in water) by detector for 22GMT216 to 23GMT237 for days with >95% coverage



**Figure 3:** Coverage rates by detector for 22GMT216 to 23GMT237. SSC outages account for drops in coverage from data transfer gaps.

# A-HOSS DOSE RATES BY REGION



**Figure 4:** Daily doses in water by region for 22GMT216 to 23GMT237. Bad frames (3) removed.

# TRANSITION TO OPERATIONS



AHOSS has been operating as a payload since 02 March, 2021

- Performing well for 2.5 years as of this presentation
- Payload operations are complete and objectives met
- Transition to ISS operations hardware approved and targeted for Oct 01

## NEW AHOSS LOCATION

New location provides additional data point to compliment RAD and REM data across ISS

- Good history of data overlap and comparisons with ISS RAD
- Deploy location identified during ISS Topology review with JAXA input
- AHOSS relocation to JPM in work





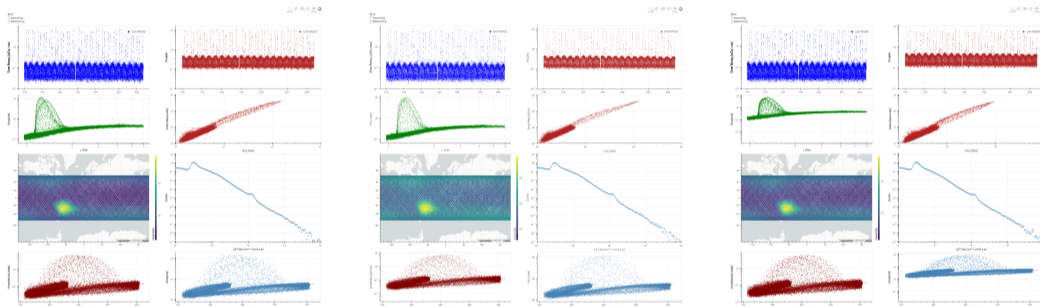
# SUMMARY

- A-HoSS is a Timepix-based Artemis-II flight system operating on ISS
- Delivered on NG-15 (Feb 2021) and deployed at Lab1S6 on 02 March, 2021
- Demonstrated Artemis-II system readiness
- Provides experience with real-time Artemis-like data
- Transition to ISS operations expected by 2023 Oct 01



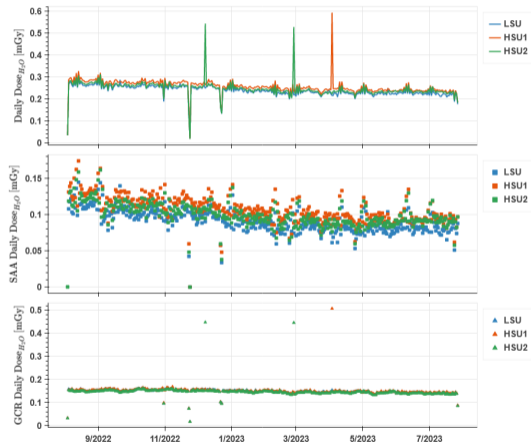
## Additional Slides

## ADDITIONAL IMAGES



**Figure 5:** Interactive AHoSS Data for 2023  
GMT 197 to 217

# UNFILTERED DAILY DOSES



**Figure 6:** AHoSS daily doses for 22GMT216 to 23GMT237 including all data points including data outages and 3 bad frames