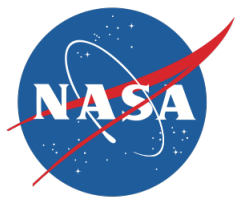
RECENT MEASUREMENT OF THE ISS ENVIRONMENT USING TIMEPIX-BASED HARDWARE

24th Workshop on Radiation Monitoring for the ISS
Athens, Greece

Sept 04, 2019

N. Stoffle, Ph.D., P.E.

Leidos Innovations Corporation
NASA JSC Space Radiation Analysis Group



TIMEPIX SCIENCE TEAM

The majority of support on Timepix-related projects at NASA consists of people affiliated with NASA Johnson Space Center and the University of Houston:

→ T. Campbell-Rickets, D. Fry, R. Gaza, S. George, M. Leitab, L. Pinsky, E. Semones, N. Stoffle, M. Vandewalle, S. Wheeler, C. Zeitlin

Additional people that support(ed) the science team include:

→ A. Bahadori, S. Hoang, J. Idarraga, M. Kroupa, R. Rios, D. Turecek

TIMEPIX ON ISS

Timepix hardware on ISS

→ REM

→ MPT

→ REM2

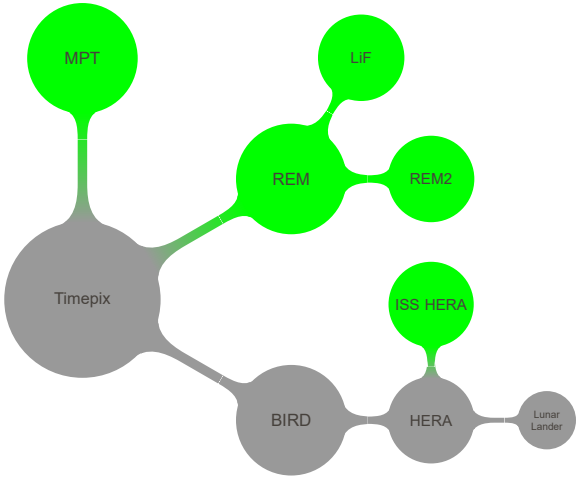
→ ISS HERA

Timepix Review

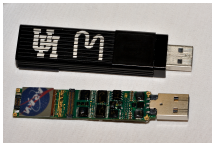
→ Hybrid pixel detector

→ 256 x 256 @ 55μm pitch

→ ToT mode with energy calibration



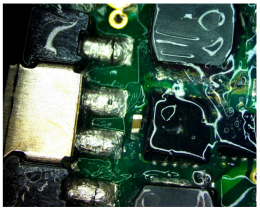
RADIATION ENVIRONMENT MONITOR PAYLOAD[1]



- → Modified IEAP Timepix Lite Units
- → 5 delivered to ISS in 2012
- → 9 units flown in total
  - → 3 units currently on ISS
  - → 2 functioning and 1 disconnected
  - → 300 and 500 μm sensors
- → Payload support to end in 2019

HARDWARE FAILURES AND LESSONS LEARNED

7+ years experience with Timepix in space



Observed Failure Modes

→ FET component

→ USB solder bonds

Applied Failure Repair

→ Shunted FET

→ Reflow solder

Lessons Learned

→ Extension cables minimize crew impact / vibration stress

→ Software as a service or dedicated hardware to address up-time

→ Wirebond damage possible during ground disassembly/repair

RADIATION ENVIRONMENT MONITOR 2 - HARDWARE UPDATES

Goal: Replace passive detectors with active instruments

→ Move REM from experiment to area monitoring

→ Flight certification of Advacam MiniPIX units and USB cables

→ 7 units/cables flown on SpX-16

→ 6 flight spares ready for manifest

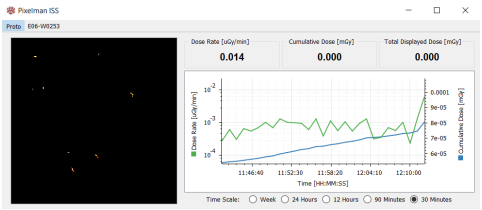
Benefits:

→ Increase cadence of area monitoring data

→ Minimize up/down mass

→ Reduce crew time for passive hardware retrieval/deploy

ACQUISITION OPS



→ Data acquisition controlled via Pixelman[2] application on Station Support Computers (SSCs)

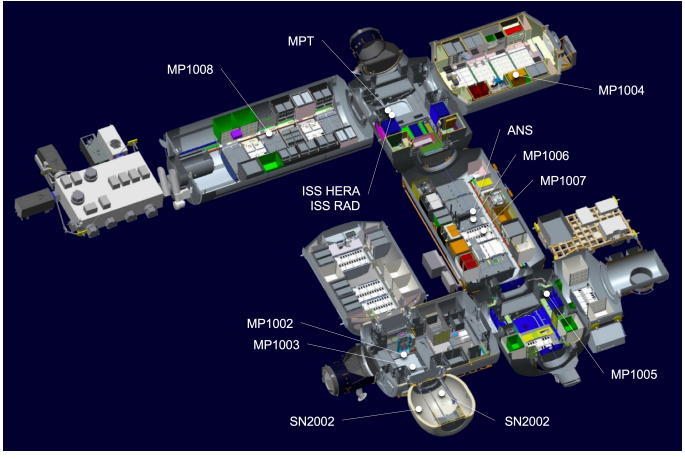
→ As of GMT041, Pixelman runs as a service on SSCs
  → Increases hardware up-time
  → Allows plug-and-play capability for hardware deploy and tracking

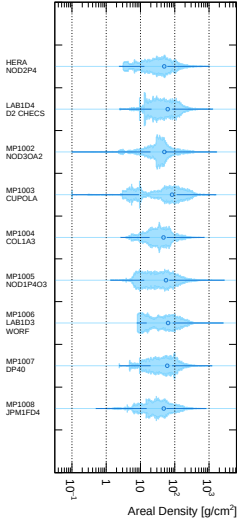
→ Oreo SSC load (GMT163) includes Pixelman on all ops SSCs

→ Minimal crew time required; reconnect or move units

→ GUI included to allow crew to view current data and trending

DEPLOY LOCATIONS





ISS hardware and shield distributions as of May 2019

DAILY DOSES

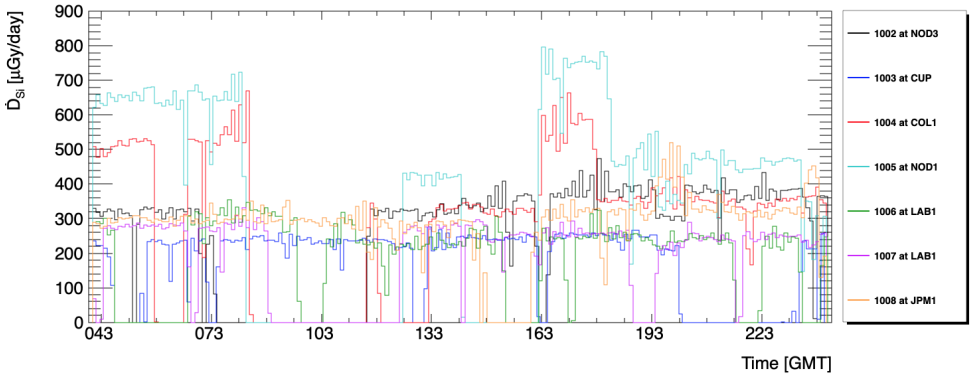
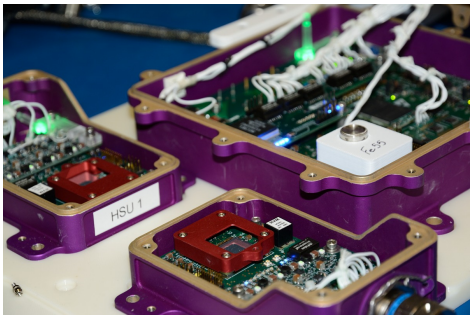


Figure 1: REM2 daily doses (in si) as measured since hardware was deployed on 2019 GMT041

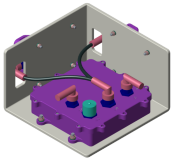
HYBRID ELECTRONIC RADIATION ASSESSOR (HERA)

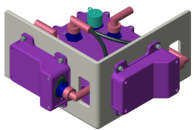
Exploration Mission monitoring hardware

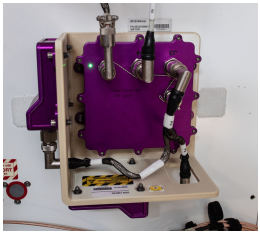
- → Capable of 4 sensors per system
  - → Local sensor on Processing Unit
  - → Up to 3 remote Sensor Units
- → On-system processing and analysis
- → Active telemetry for crew displays and ground monitoring
- → Caution and Warning capability for crew/ground alerts



ISS HERA







→ EM-1 HERA unit certified for ISS

- → 1 Processor Unit
- → 2 Sensor Units
- → 3D printed mounting frame (Ultem)
- → Power and Data cables

→ Mounting frame allows minimal footprint and orthogonal measurements

→ Station Support Computer interface allows data transmission via TCP/IP

ISS HERA PAYLOAD OBJECTIVES

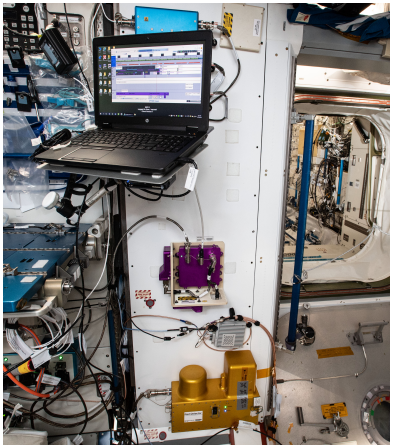


Figure 2: ISS HERA deployed with RAD in Node 2

→ Test Artemis-1 HERA in the space environment

→ Verify system capability for 30+ days of continuous operation

→ Gain experience with hardware and data analysis in a mission environment

MEASUREMENT COMPARISONS

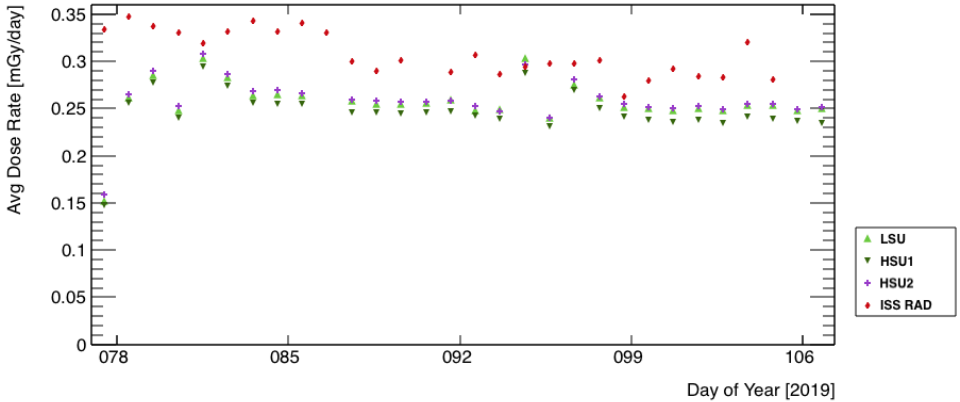


Figure 3: ISS HERA daily doses (in si) compared with RAD B detector

MEASUREMENT COMPARISONS

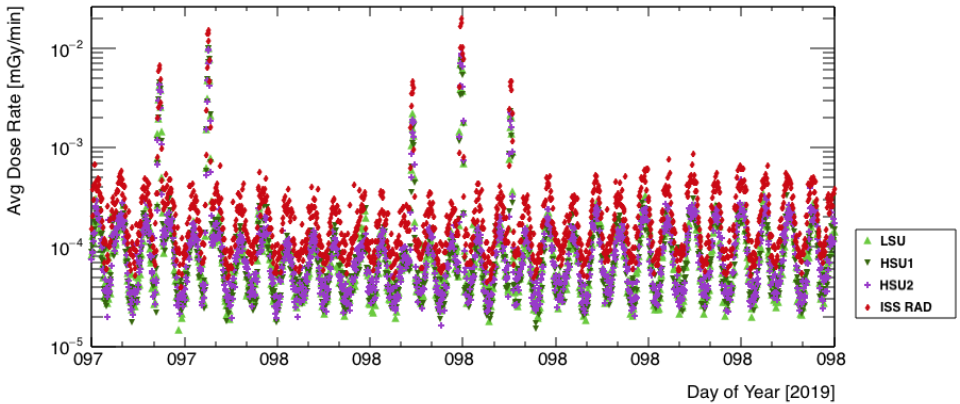
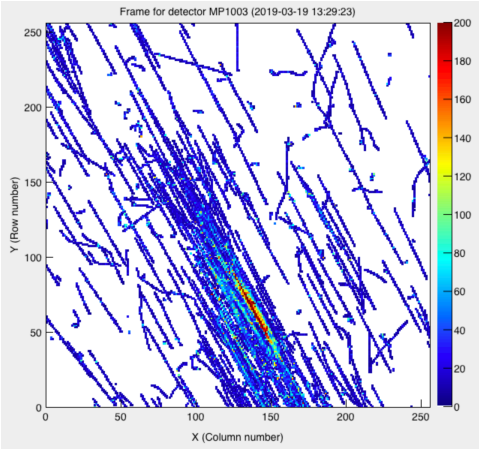


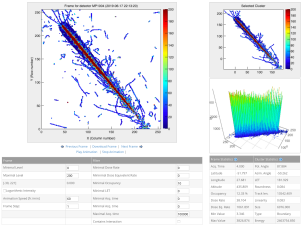
Figure 4: ISS HERA minute doses (in si) compared with RAD B detector

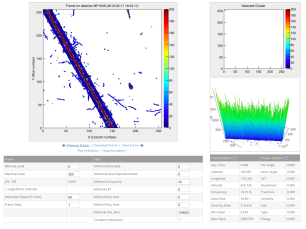
HADRONIC SHOWERS

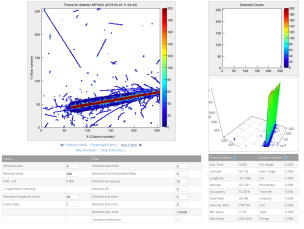


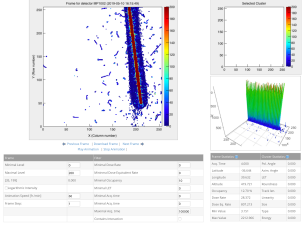
Frames such as this occur outside the SAA region on a regular basis and seem to be more common in areas with higher shielding mass

HEAVY IONS



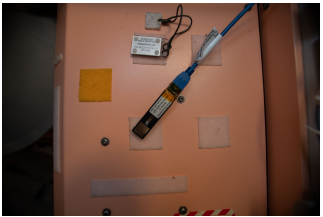






Heavy Ion tracks are also found consistently, though some are more spectacular than others

DIRECTIONALITY



→ Static deploy locations allow detector coordinates to be linked with vehicle coordinate frame

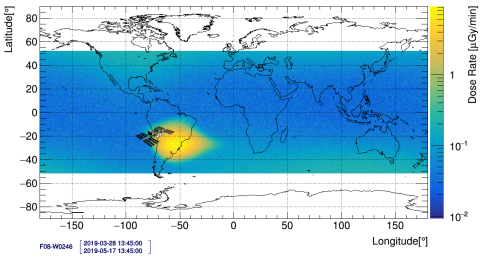
→ Possibility of extracting data such as SAA pitch angle from REM2 data

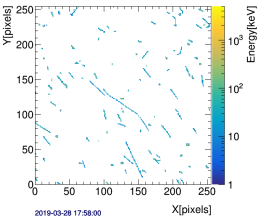
SUMMARY

→ REM2 hardware replaced passive area monitoring on ISS

→ ISS HERA payload successfully demonstrated Artemis-1 system readiness

→ Opportunities remain to extract additional information from Timepix on ISS





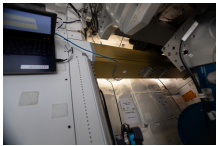
Questions?

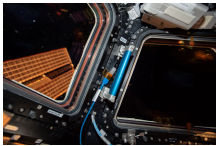
REFERENCES

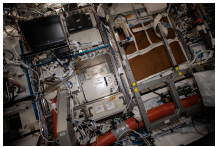
[1] N. Stoffle et al., *Timepix-based radiation environment monitor measurements aboard the International Space Station*, Nuclear Instruments and Methods in Physics Research A **782** (2015) 143–148.

[2] D. Turecek et al., *Pixelman: a Multi-platform Data Acquisition and Processing Software Package for Medipix2, Timepix and Medipix3 Detectors*, Journal of Instrumentation **6** (2011) C01046.

REM2 DEPLOY IMAGES







ADDITIONAL SHOWER FRAMES