

Robotic External Leak Locator (RELL) leak plume field detection on the International Space Station (ISS)

SPACE ENVIRONMENT EFFECTS

| External Contamination | Plasma | IR | Acoustics |

Mission Success • Safety • Reliability



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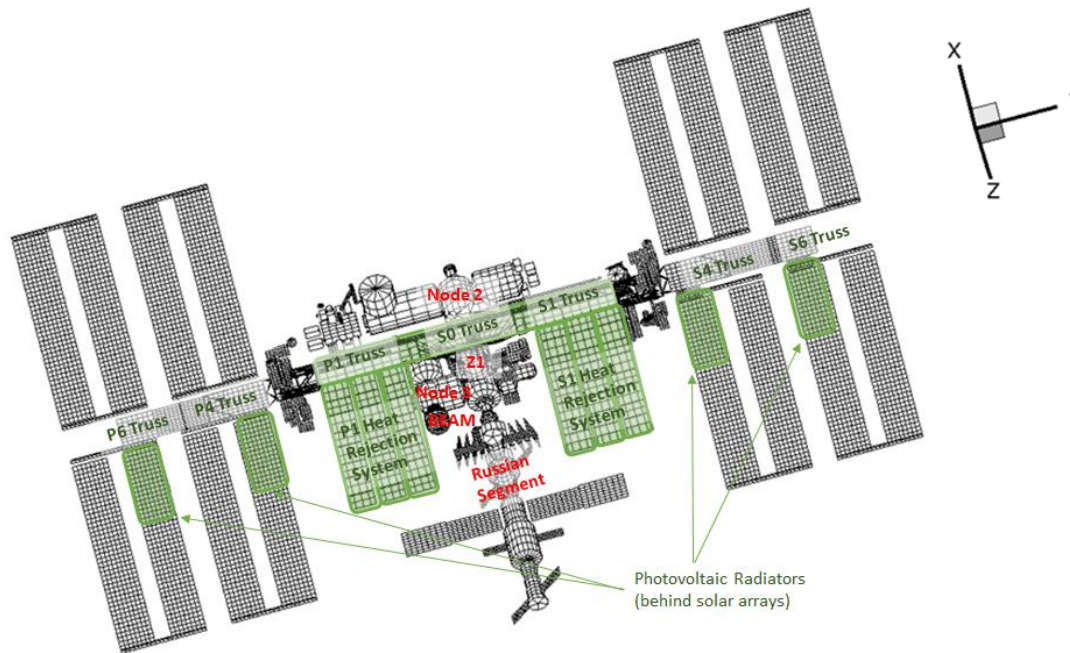




Background



- **The United States External Active Thermal Control System (EATCS) on the International Space Station (ISS) uses liquid ammonia in closed loops to collect, transport, and reject heat.**
- **Detection and location of small ammonia leaks (estimated to be < 50 lbm per day) from the EATCS was identified as a risk by the ISS program and the Robotic External Leak Locator (RELL) was commissioned to demonstrate the capability to locate these small leaks.**



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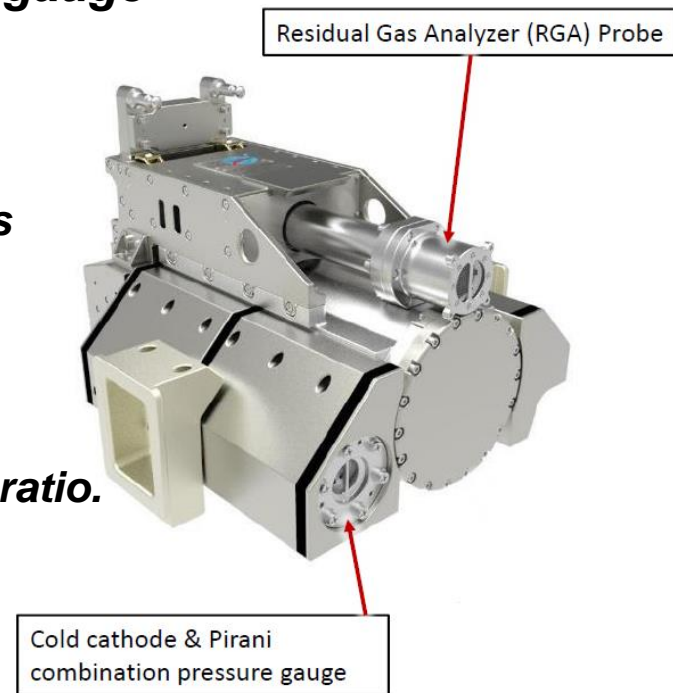




Robotic External Leak Locator



- **Collaboration between NASA's Goddard Space Flight Center and Johnson Space Center**
- **Maneuvered with Space Station Remote Manipulator System (SSRMS) and Special Purpose Dexterous Manipulator (SPDM) robotic arms**
- **PKR 251 Ion Gauge: Combination total pressure gauge**
 - **Pirani gauge**
 - **Cold cathode system**
- **Residual Gas Analyzer – 100**
 - **Quadrupole gas analyzer that measures for a mass range from 1 to 100 ion mass-to-charge ratios**
 - **Heated filament bombards incoming gas with electron creating positive ions.**
 - **The ions are directed toward the quadrupole filter where they are separated by their mass-to-charge ratio.**
 - **A Faraday Cup detector measures current directly and for increased sensitivity, an electron multiplier measures the electron current proportional to ion current.**

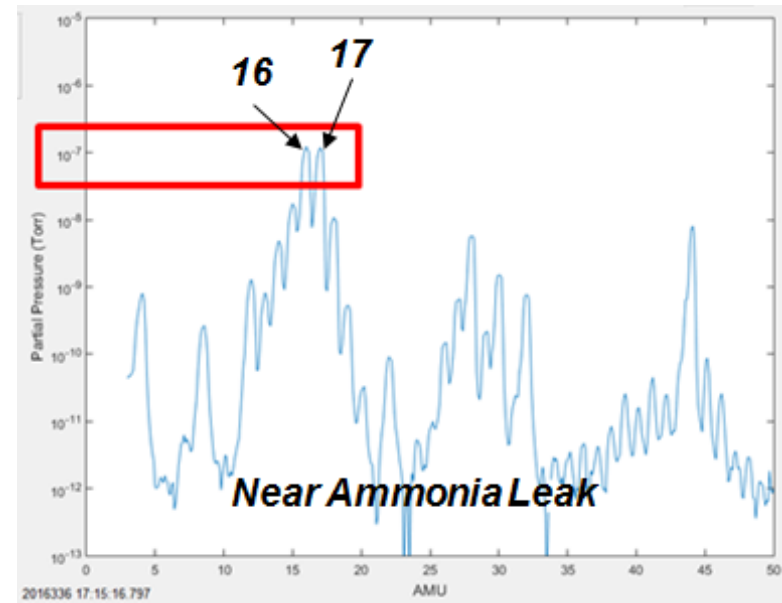
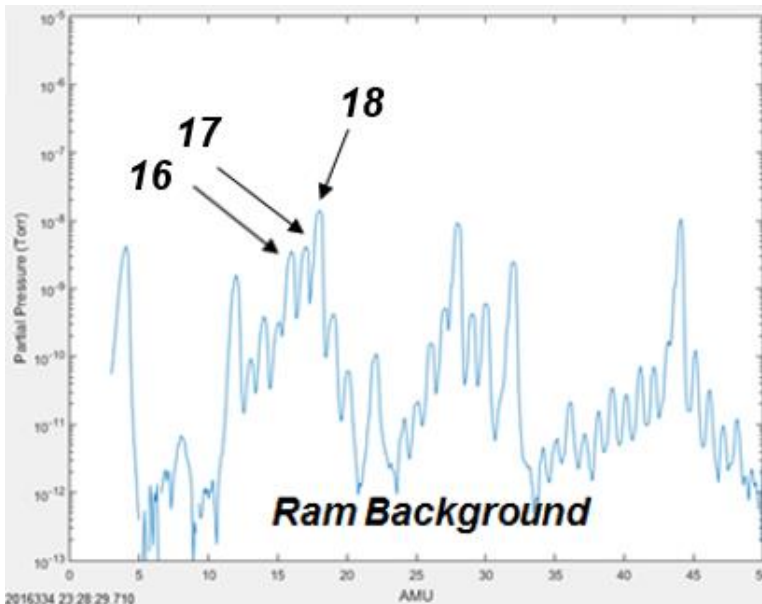




RELL Measurement of Water and Ammonia



- Use ion mass ratios of 16 to 17, in addition to total pressure, to distinguish between water and ammonia
 - Water: 0.04
 - Ammonia: 0.80



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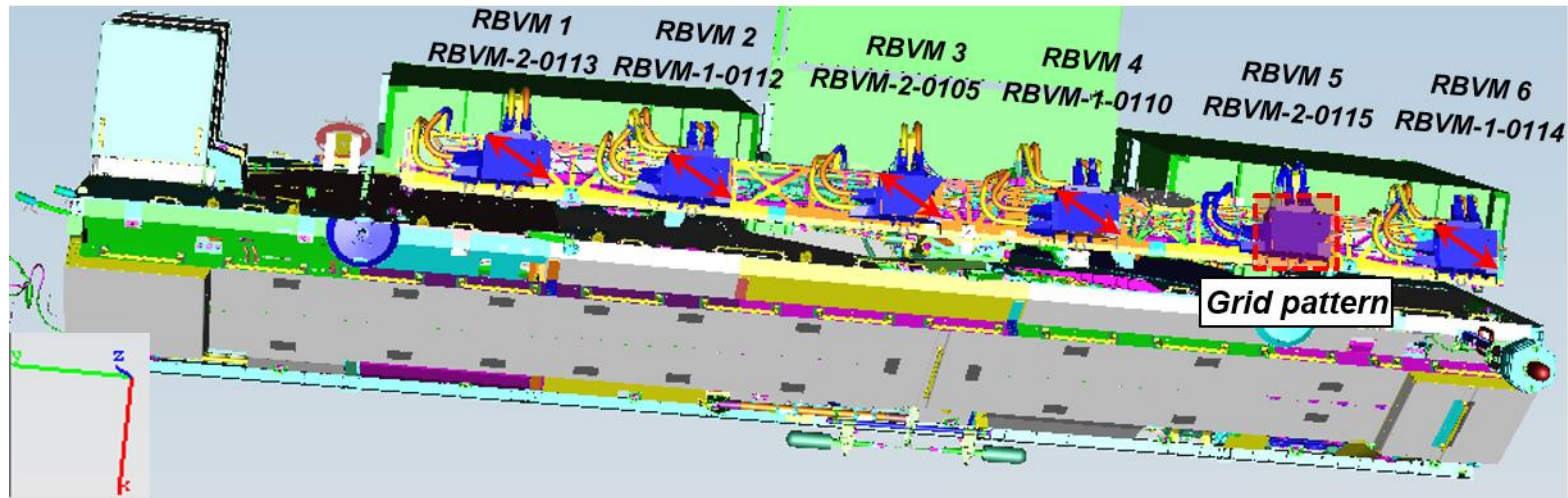




RELL Scanning of RBVMs

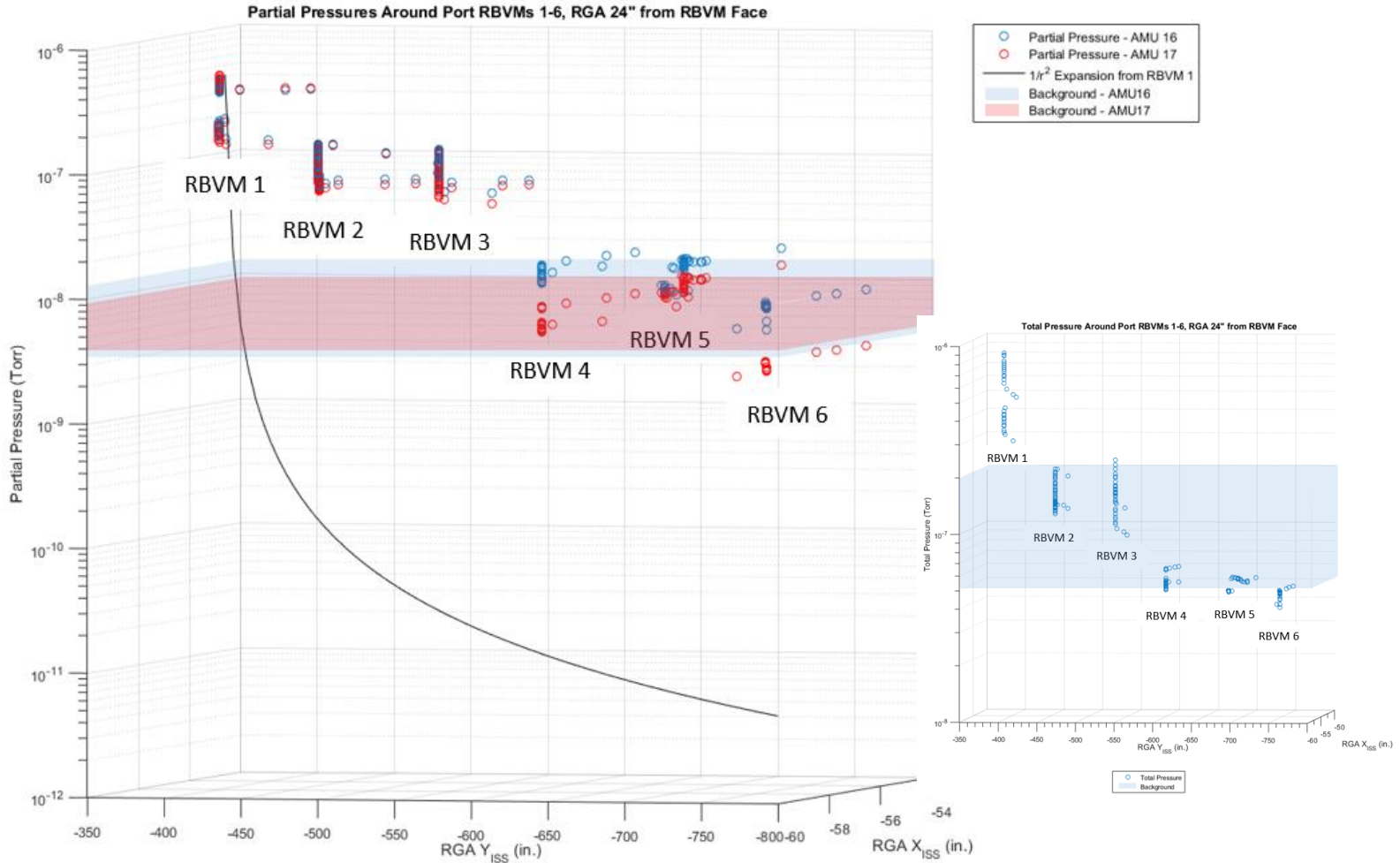


- **Six Radiator Beam Valve Modules (RBVMs) on each side of the ISS**
 - **Two per radiator panel**
- **Etc**



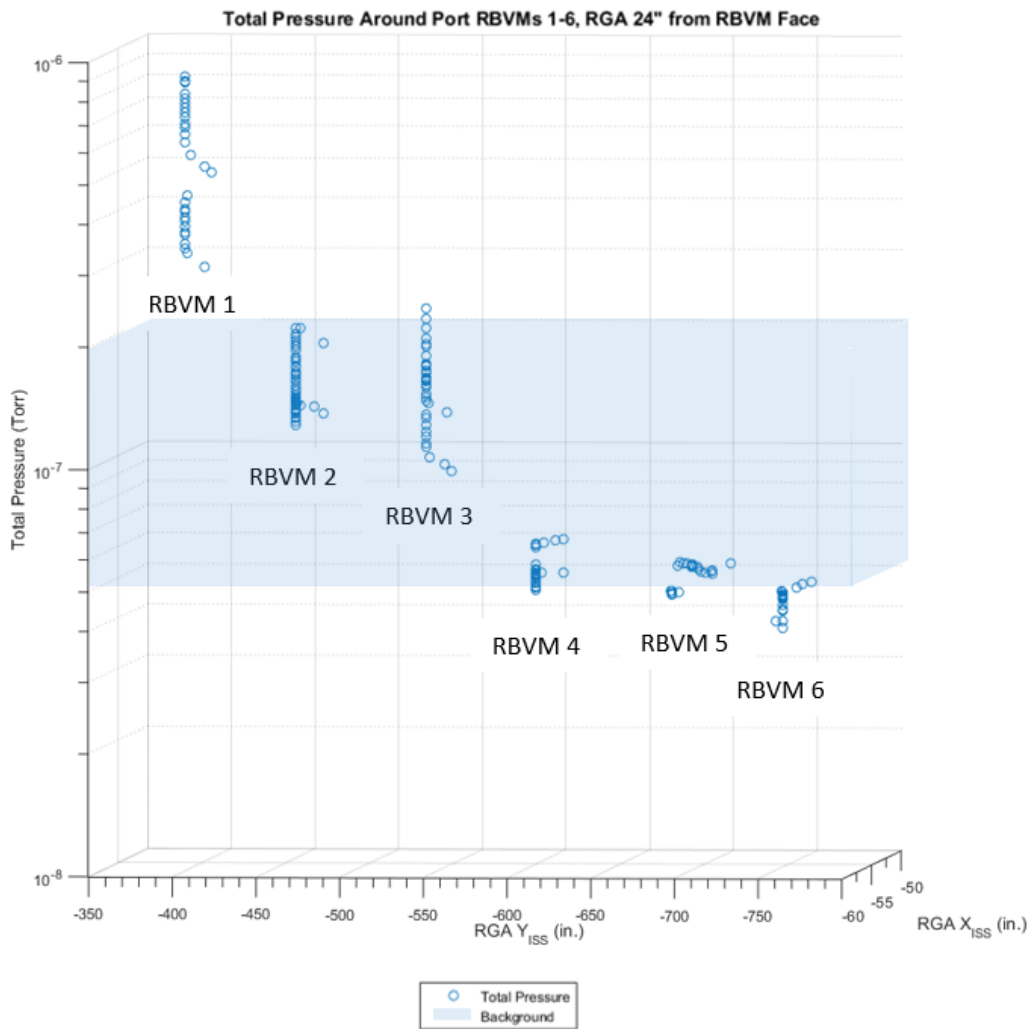


RBVM Scans – Partial Pressure





RBVM Scans – Total Pressure

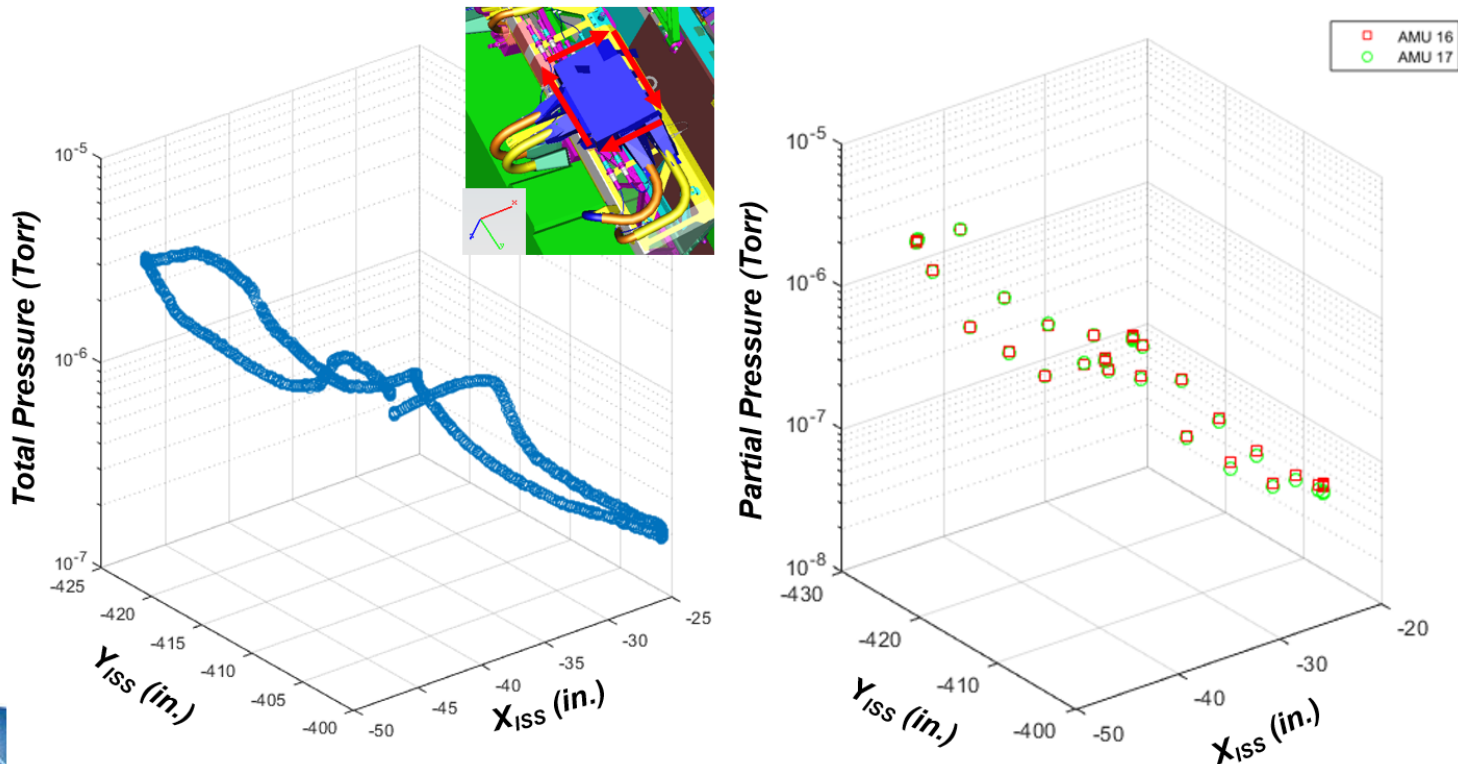




Rescan of RBVM 1



- **An additional day of scanning was planned for the end of the on-orbit demonstration in December 2016 after reviewing the initial scanning data**

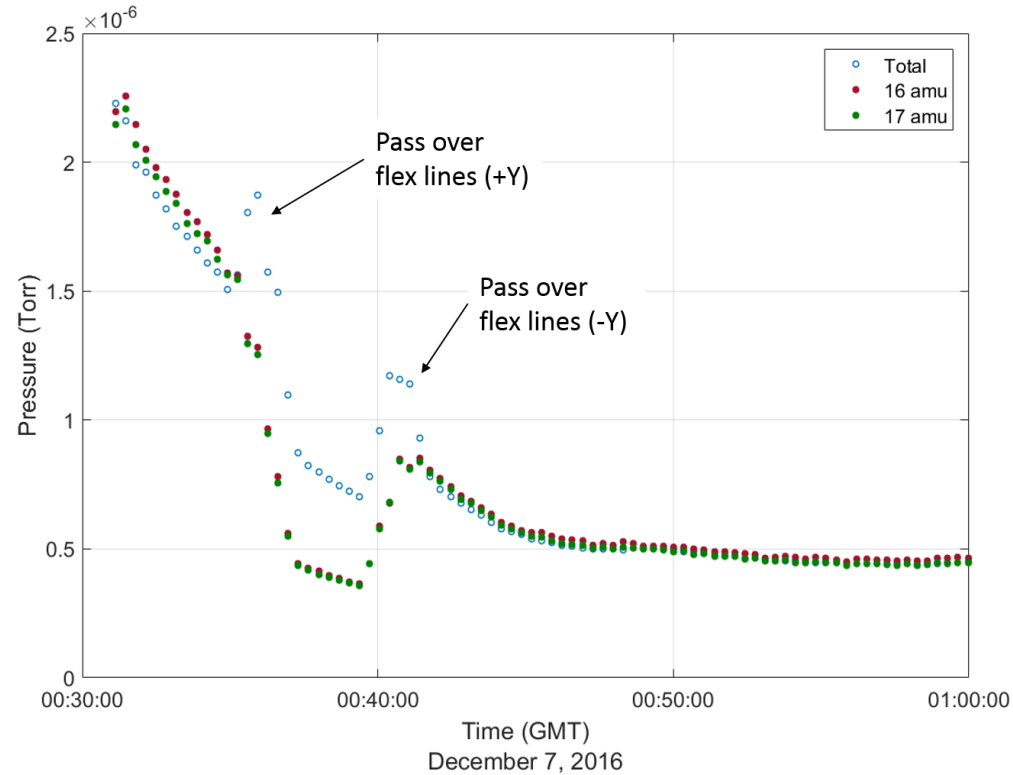
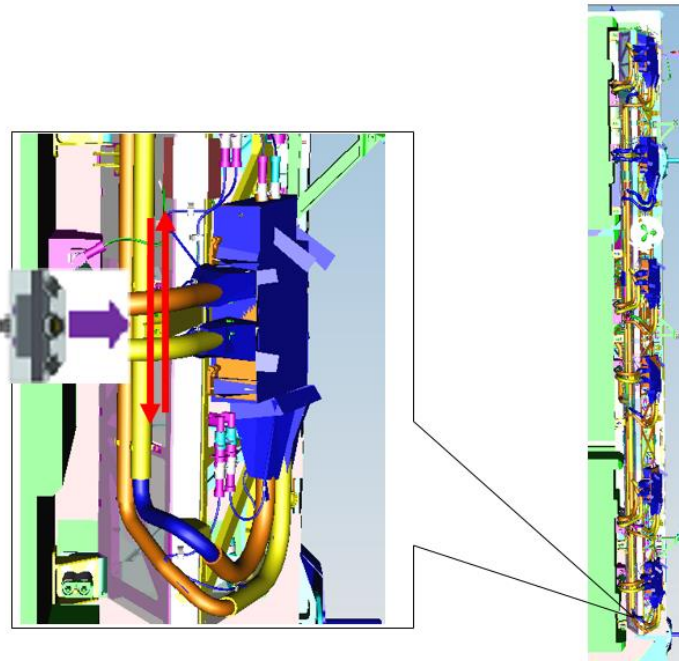




Rescan of RBVM 1



- **An additional day of scanning was planned for the end of the on-orbit demonstration in December 2016 after reviewing the initial scanning data**
- **Pass over RBVM flex hoses and quick disconnects (QDs)**



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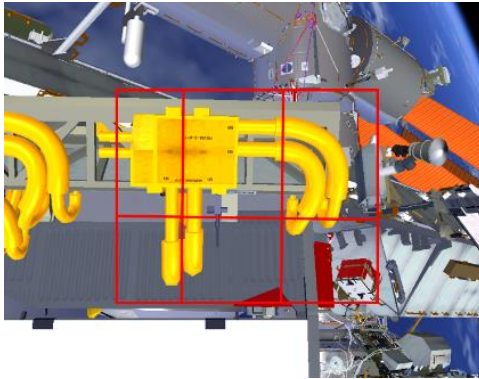




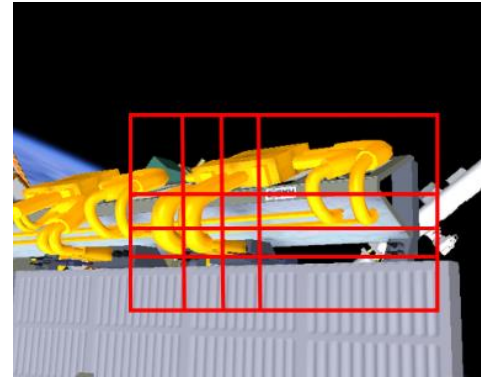
Focused RBVM 1 Inspection



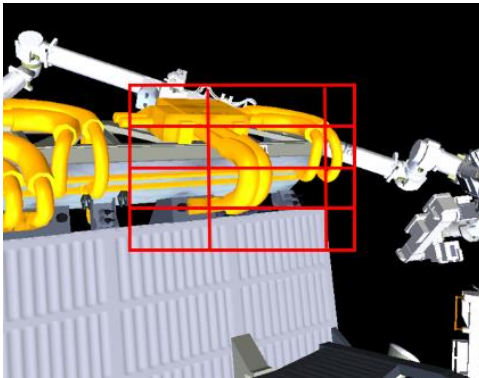
- ▶ **RELL approved for external operations in February 2017 after observed EATCS leak rate increased.**



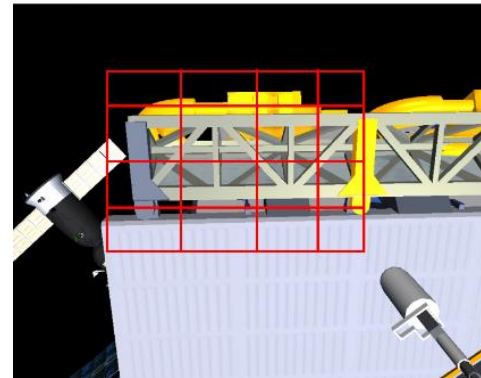
Zenith (-Z) face



Aft-Starboard (-X / +Y) face



Aft-Port (-X / -Y) face

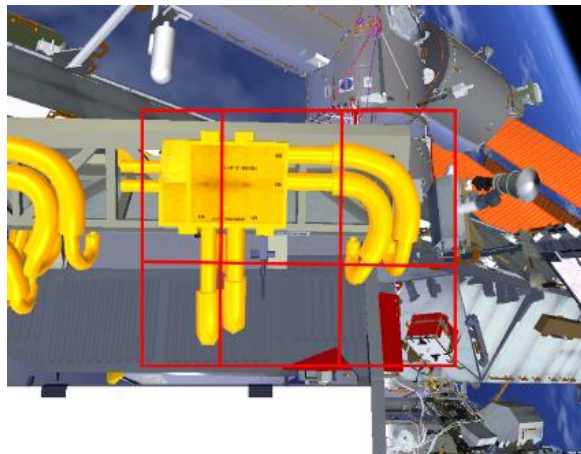


"Back" face

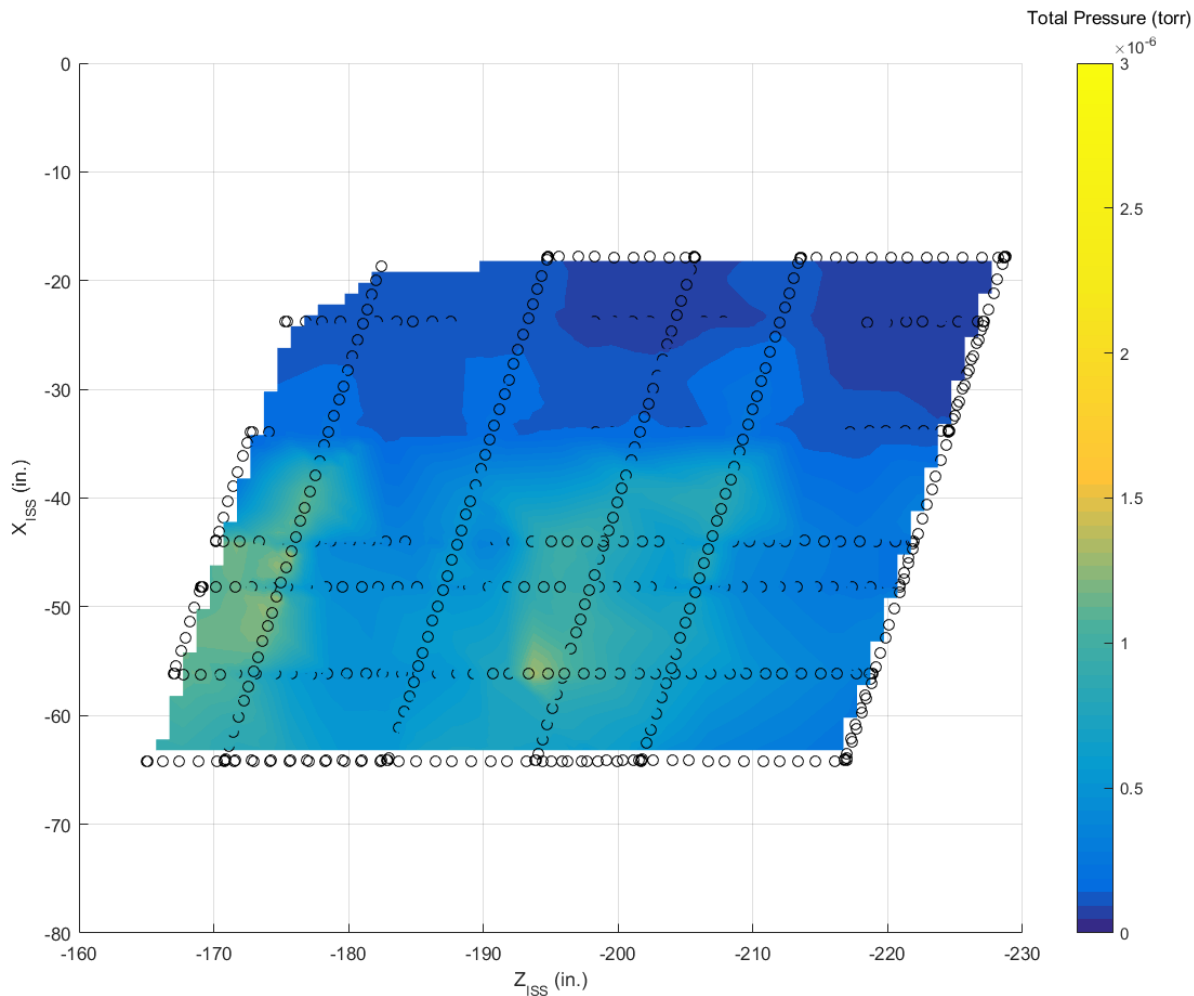




Focused RBVM 1 Inspection: Zenith (-Z) Face



Zenith (-Z) face



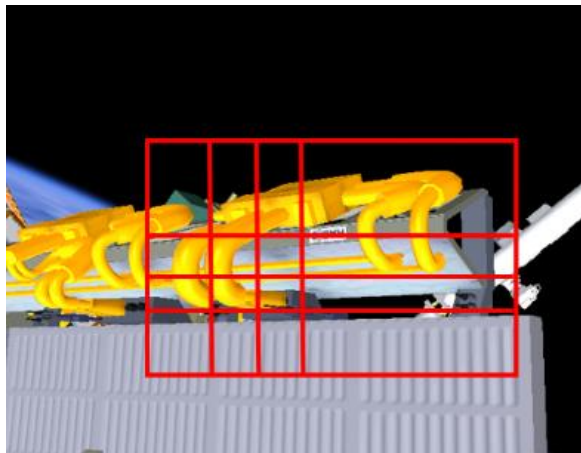
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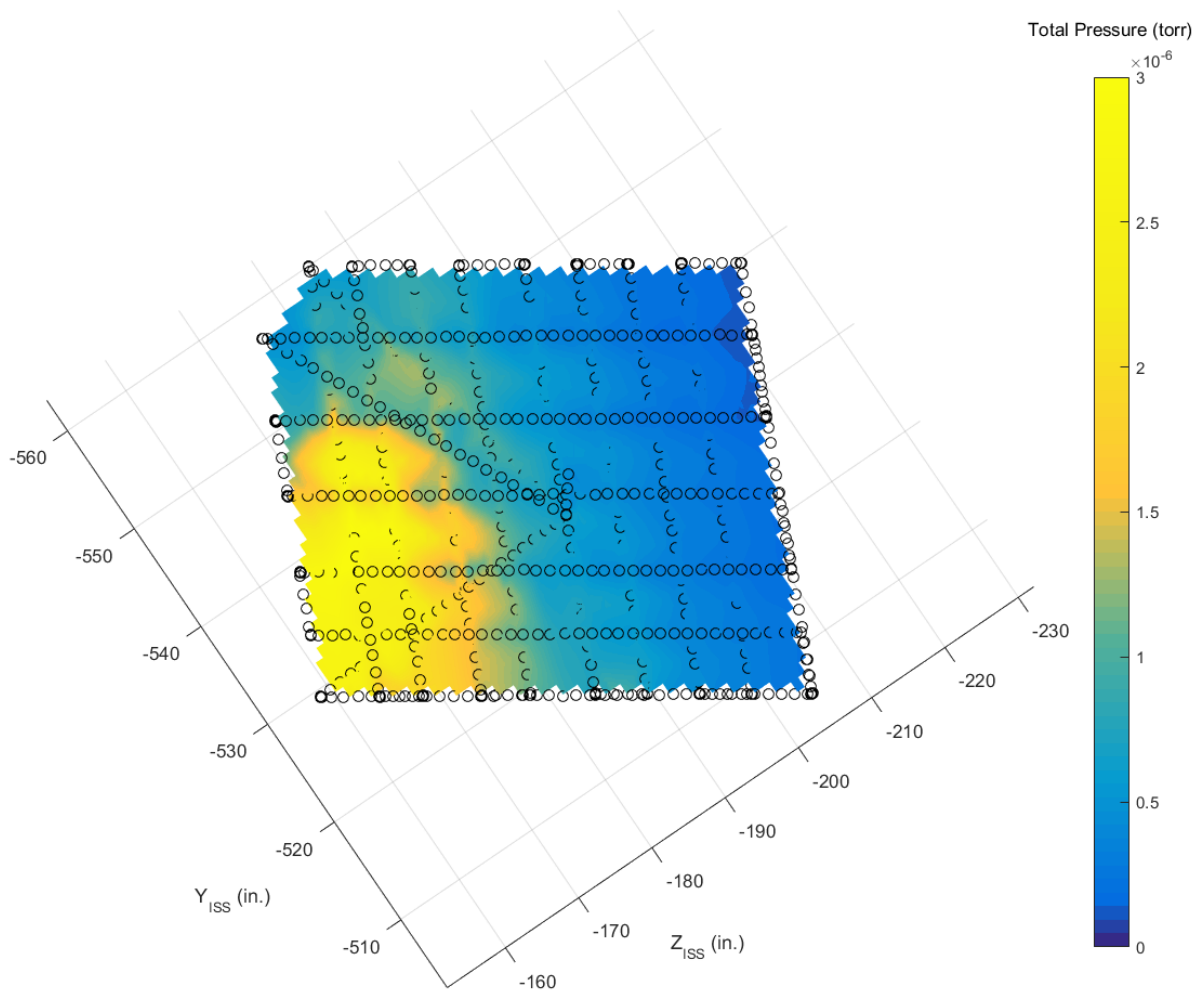




Focused RBVM 1 Inspection: Aft-Starboard (-X | +Y) Face



Aft-Starboard (-X / +Y) face



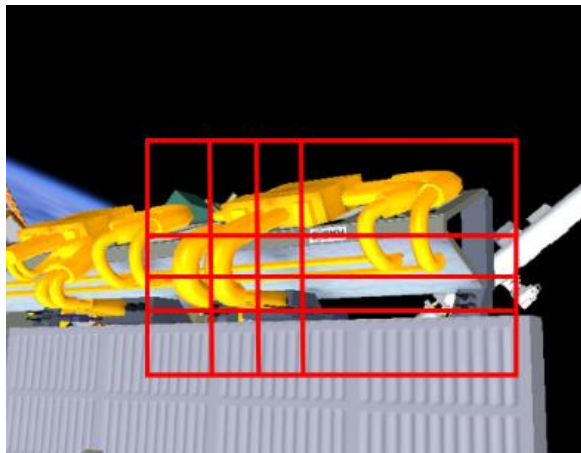
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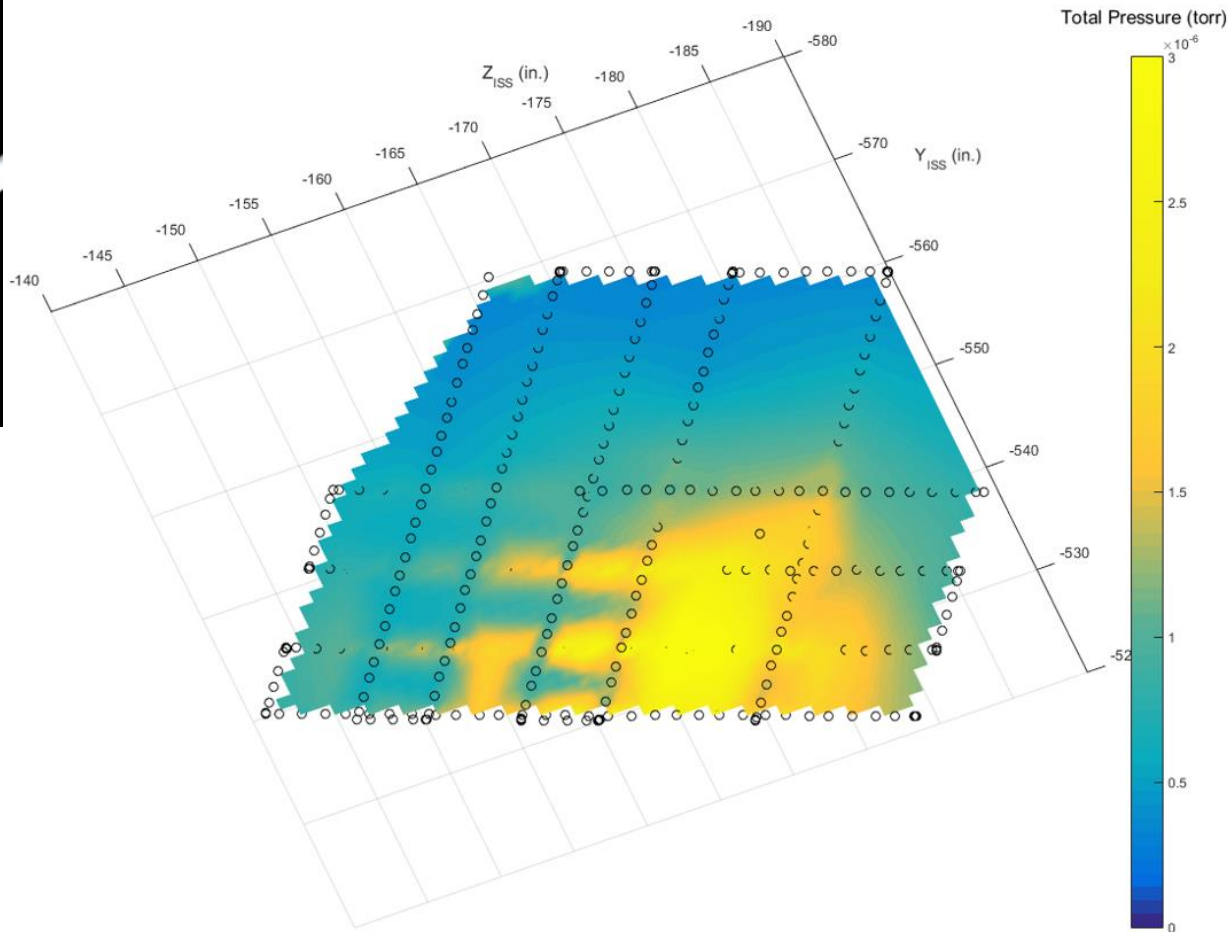


Focused RBVM 1 Inspection: Aft-Starboard (-X / +Y) Face



Aft-Starboard (-X / +Y) face

Expanded Scan



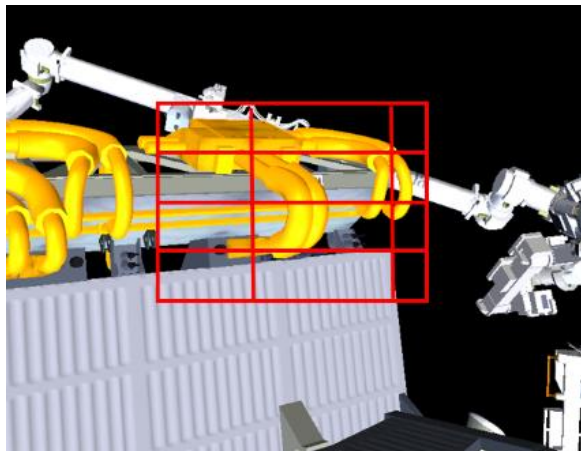
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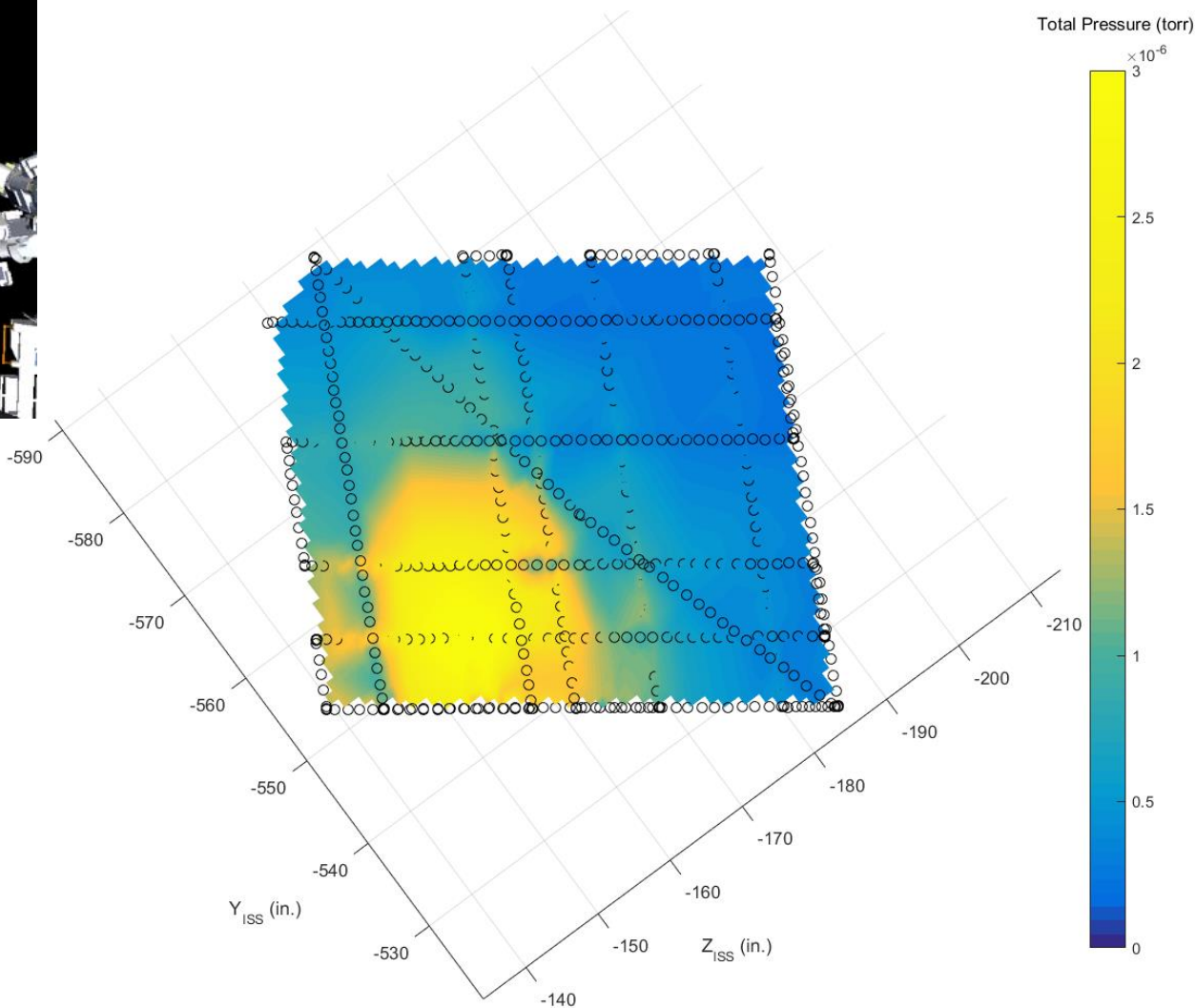




Focused RBVM 1 Inspection: Aft-Port (-X | -Y) Face



Aft-Port (-X / -Y) face



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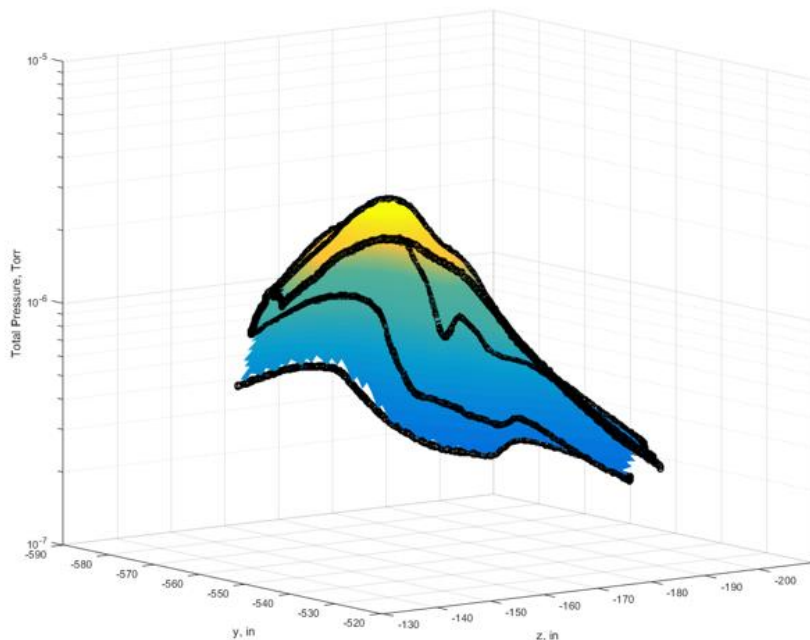




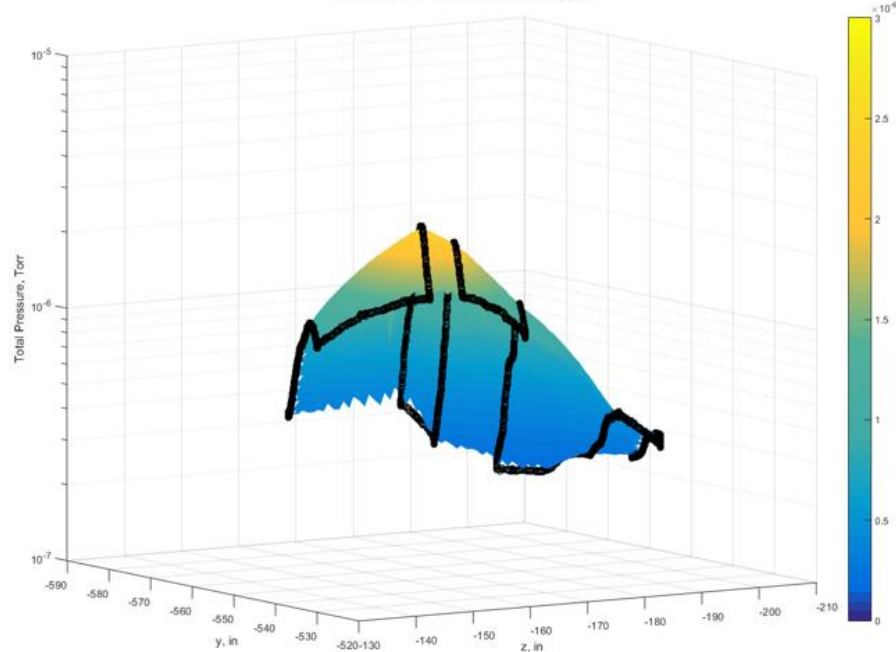
Focused RBVM 1 Inspection: Aft-Port (-X | -Y) Face



'Horizontal' Direction Scans

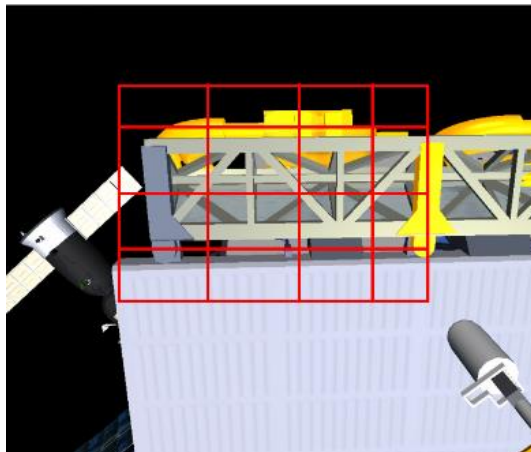


'Vertical' Direction Scans

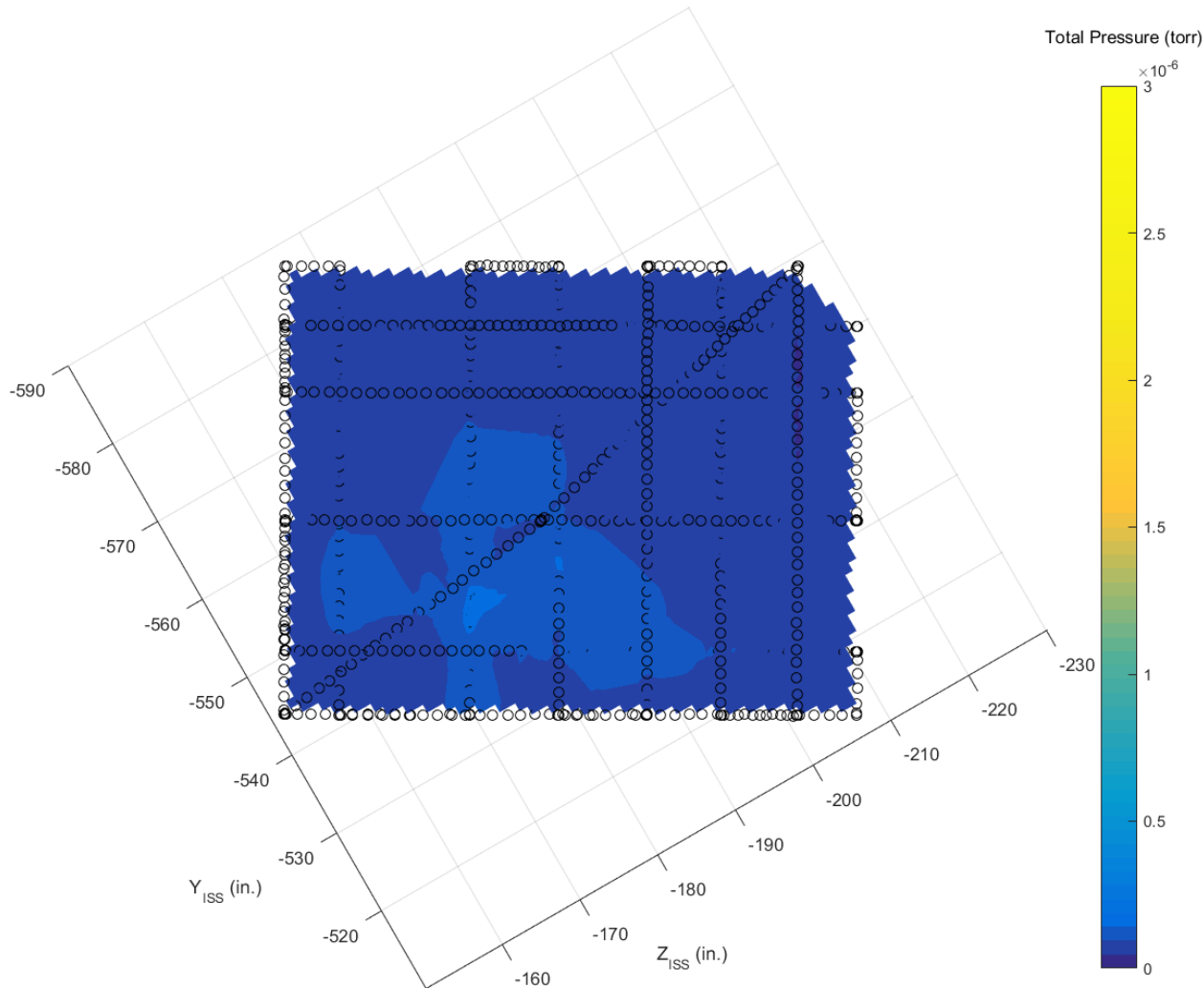




Focused RBVM 1 Inspection: "Back Side"



"Back side"



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Conclusions



- ***RELL was successful in detecting and locating an ammonia leak during the on-orbit demonstration and additional inspection in February 2017.***
 - ***Potential leak site inspected by a crew member during an EVA in March 2017 and HD video showed small flakes originating from the coolant lines.***
 - ***Coolant lines isolated in April 2017 and subsequent monitoring of system pressures showed the leak had stopped.***
 - ***Radiator-side coolant line retrieved by EVA in March 2018 for inspection on the ground.***
- ***Grid scanning technique is effective and repeatable for locating leaks.***
 - ***Total pressure measurements using the ion gauge are useful in building contour maps of pressure.***
 - ***Need to be combined with RGA partial pressure measurement data to determine what is causing the differences in total pressure.***





Acknowledgements



- **Contributions during the design and verification stages of the Robotic External Leak Locator:**
 - **Jesse A. Buffington**
 - **David Autrey**
 - **Carlos E. Soares**
 - **Matthew J. Roode**
 - **Steven B. Morris**
 - **Michael S. Woronowicz**
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 - **Matt Kowit**
 - **Dave Doheny**



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➤ **Questions?**



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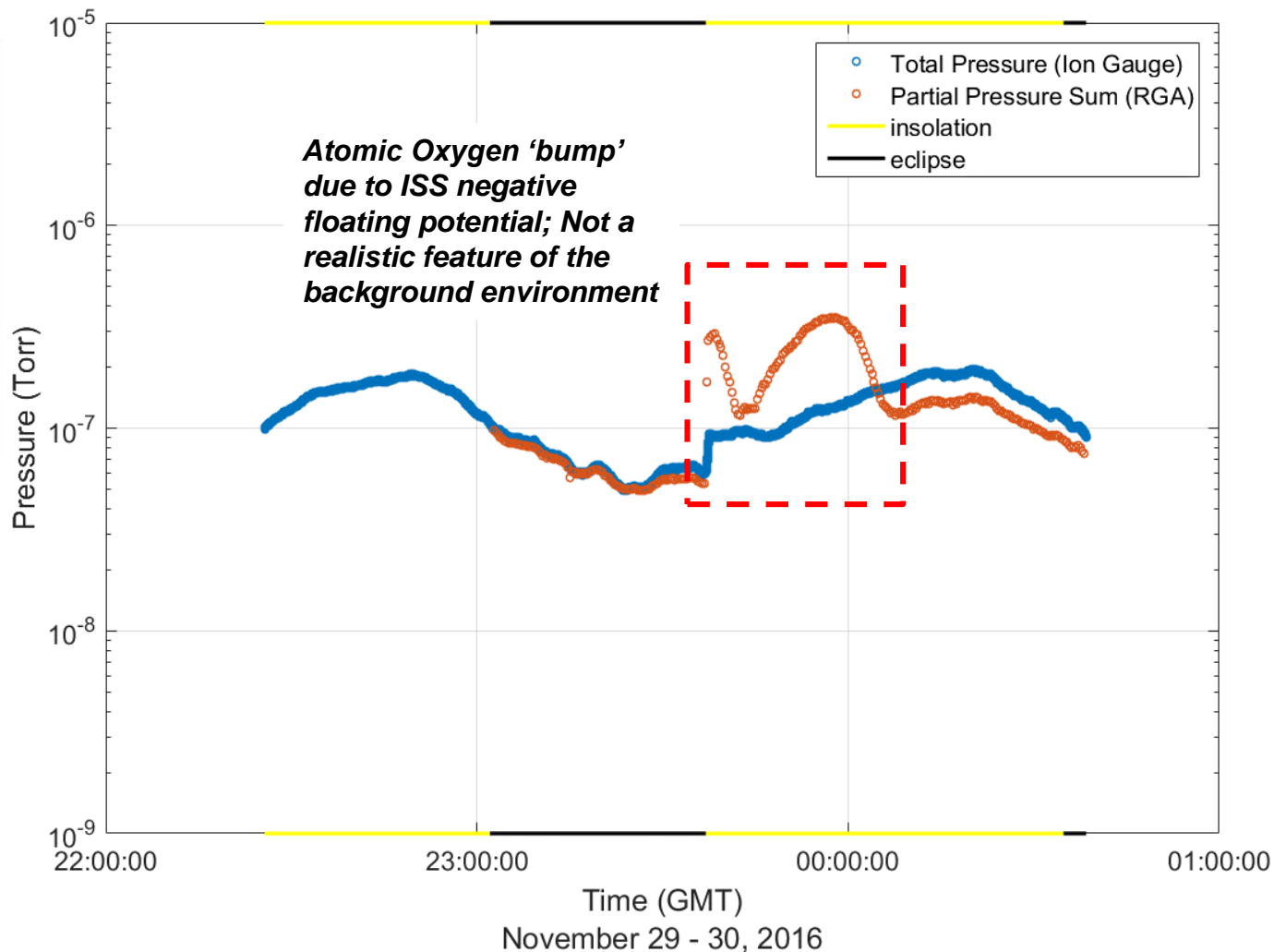
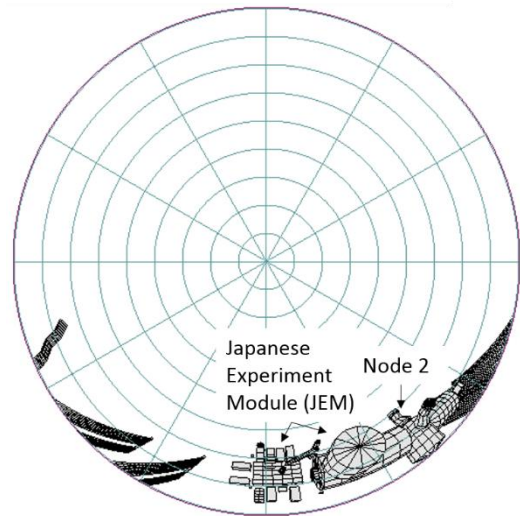


Back Up





Background Scanning A: Ram (+X)

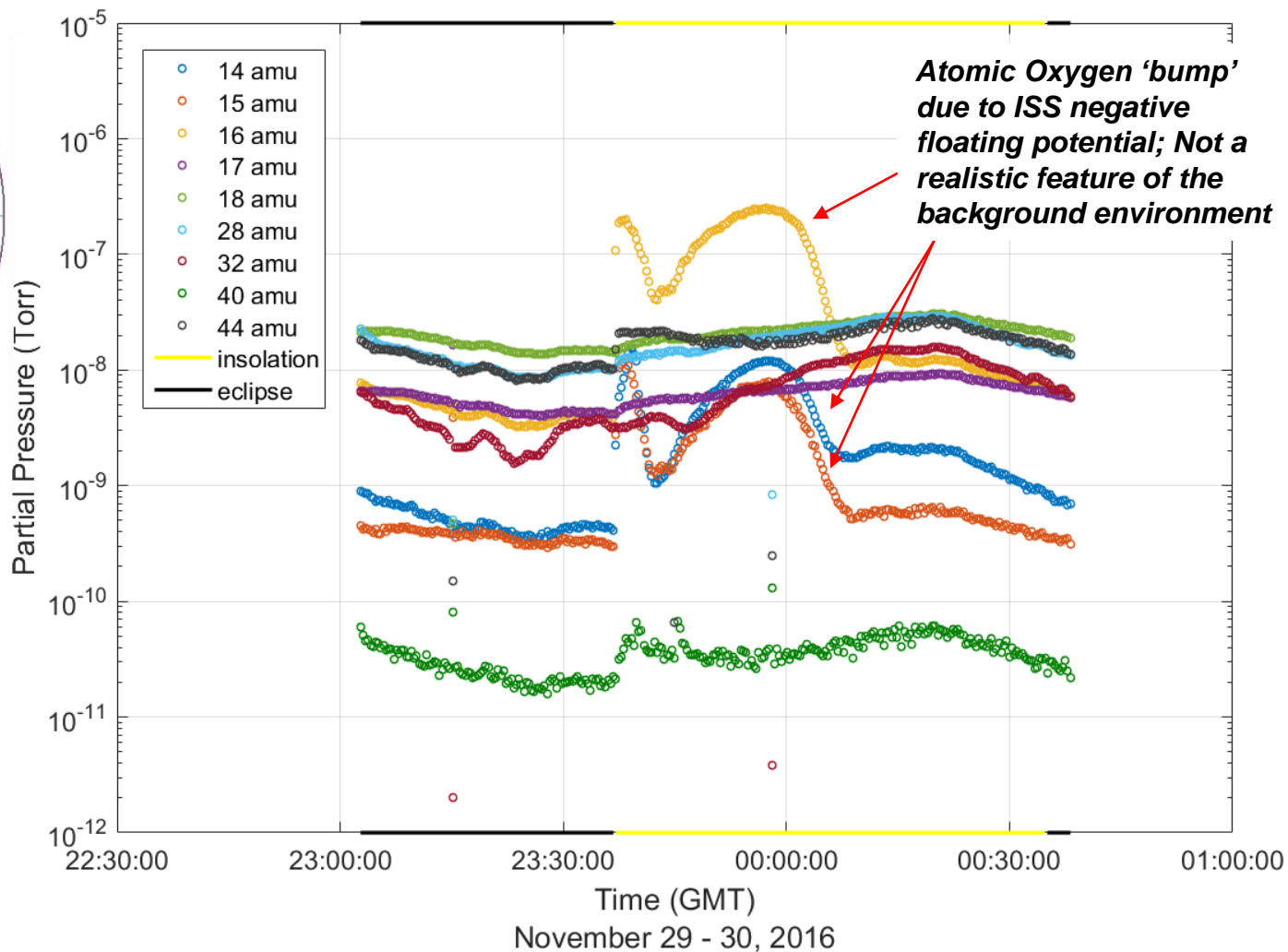
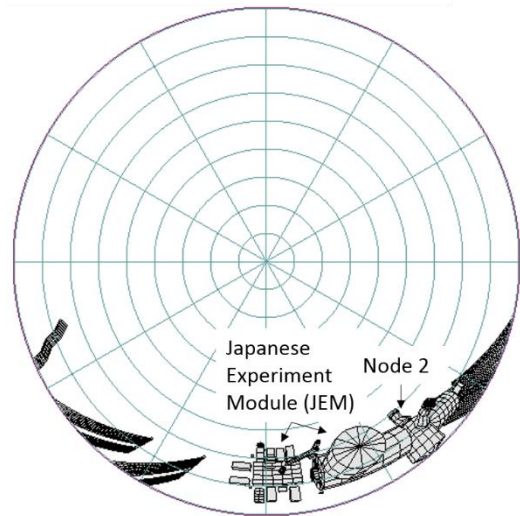


➤ **Sum of RELL RGA partial pressures includes AMU 3 to 50**





Background Scanning A: Ram (+X)



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