



Three-Dimensional Vibration Isolator for SAGE III Contamination Monitoring Package (CMP)

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Purpose



- ISS payloads launching in the SpaceX Dragon Trunk (unpressurized) are mounted in an inverted configuration
- SpaceX still characterizing launch loads and some payloads will require isolation systems for sensitive hardware
 - Structural coupling exists between payload and attachment mechanism
 - Maintain positive structural margins
 - Reduce hardware risk of loads increases
- Wire rope isolators (WRI) typically perform well in compression, shear, and roll directions
 - Limited vendor data available for WRI in tension
- WRI testing completed in an inverted orientation to characterize dynamic behavior

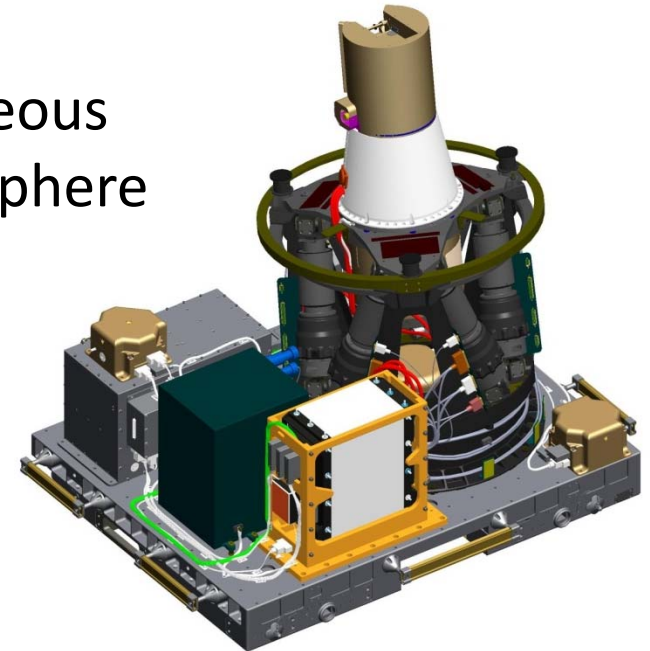
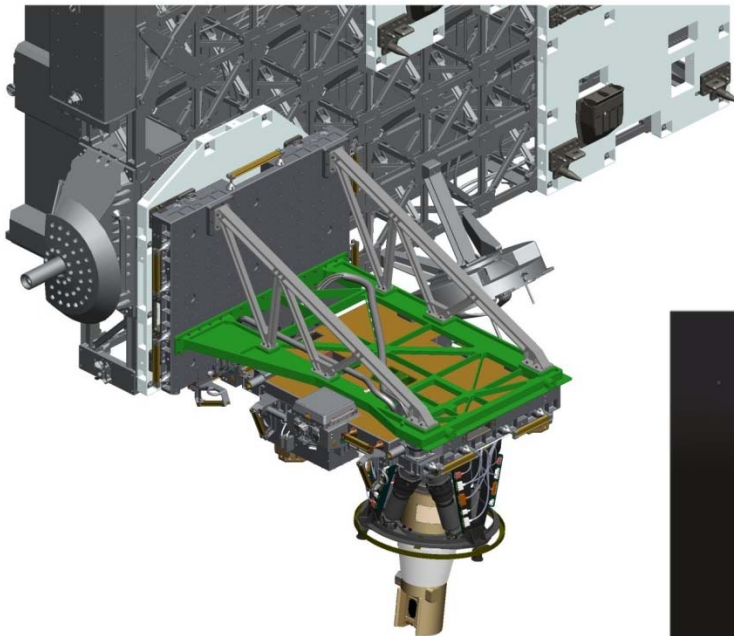




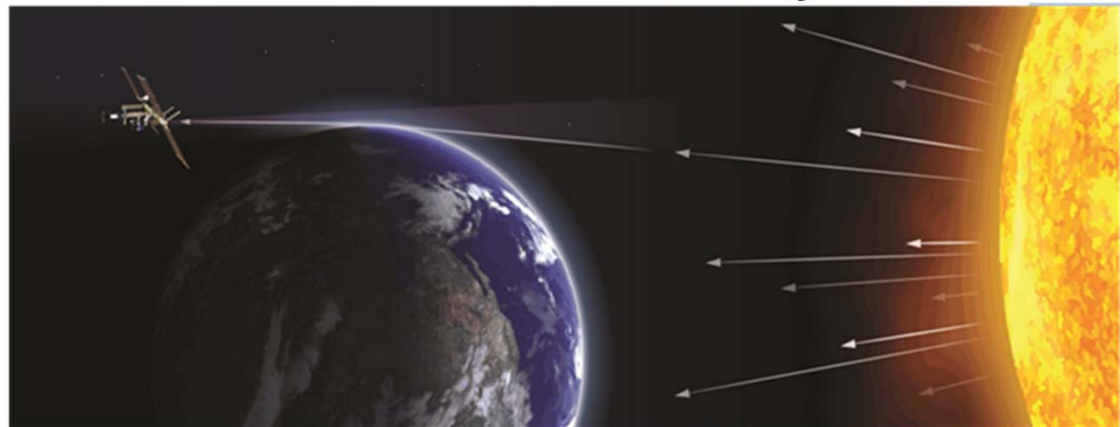
Stratospheric Aerosol and Gas Experiment III (SAGEIII)



- Developed for monitoring aerosols and gaseous constituents in the stratosphere and troposphere



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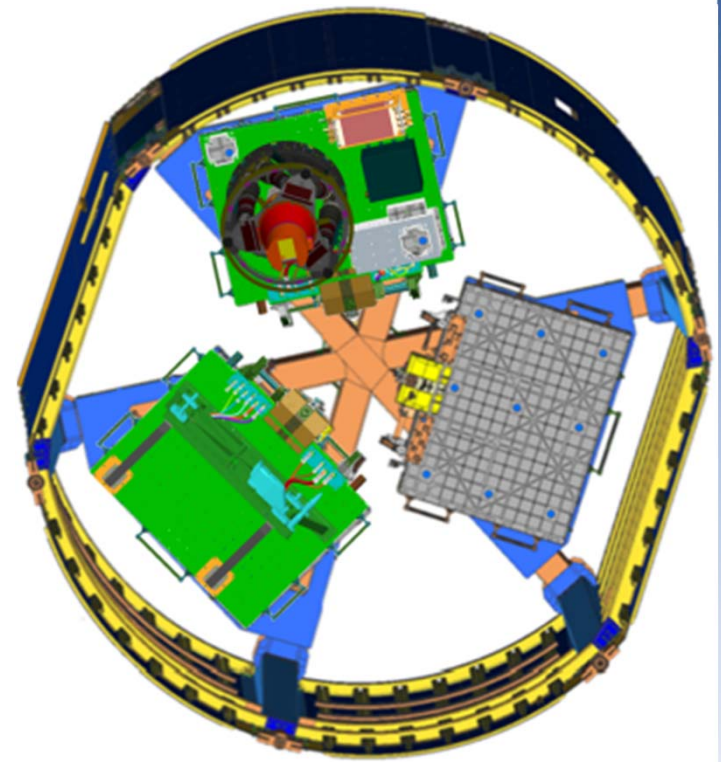
Launch Configuration



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Dragon Unpressurized Cargo Module

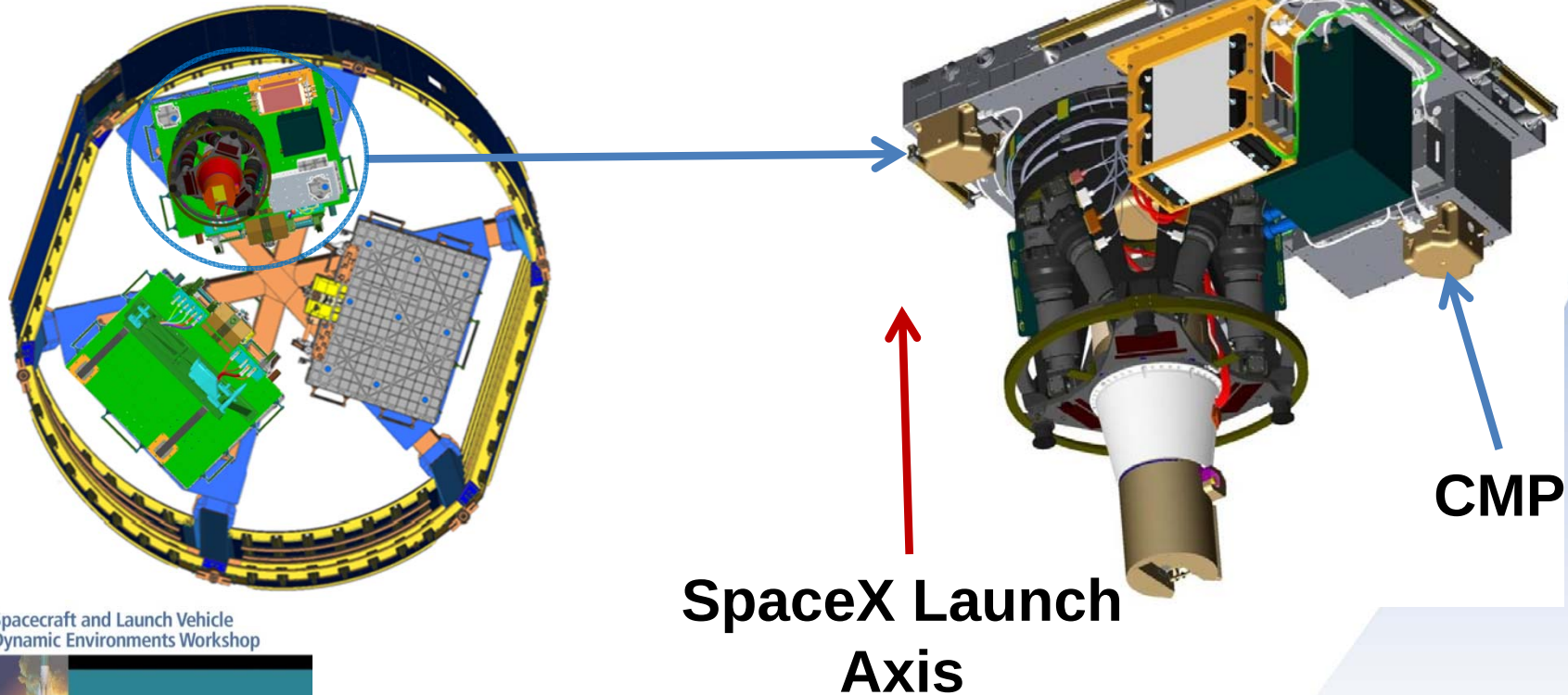


<http://nasasearch.nasa.gov/search/images?affiliate=nasa&m=false&query=spacex>



SAGEIII Launched in SpaceX Dragon Trunk

- Payload launches inverted inside the Dragon Trunk
- Mounted to Flight Releasable Attachment Mechanism (FRAM)



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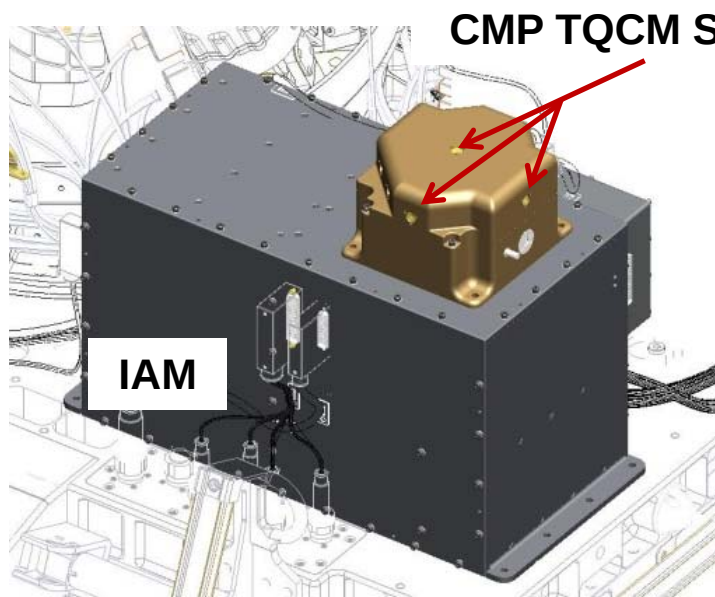




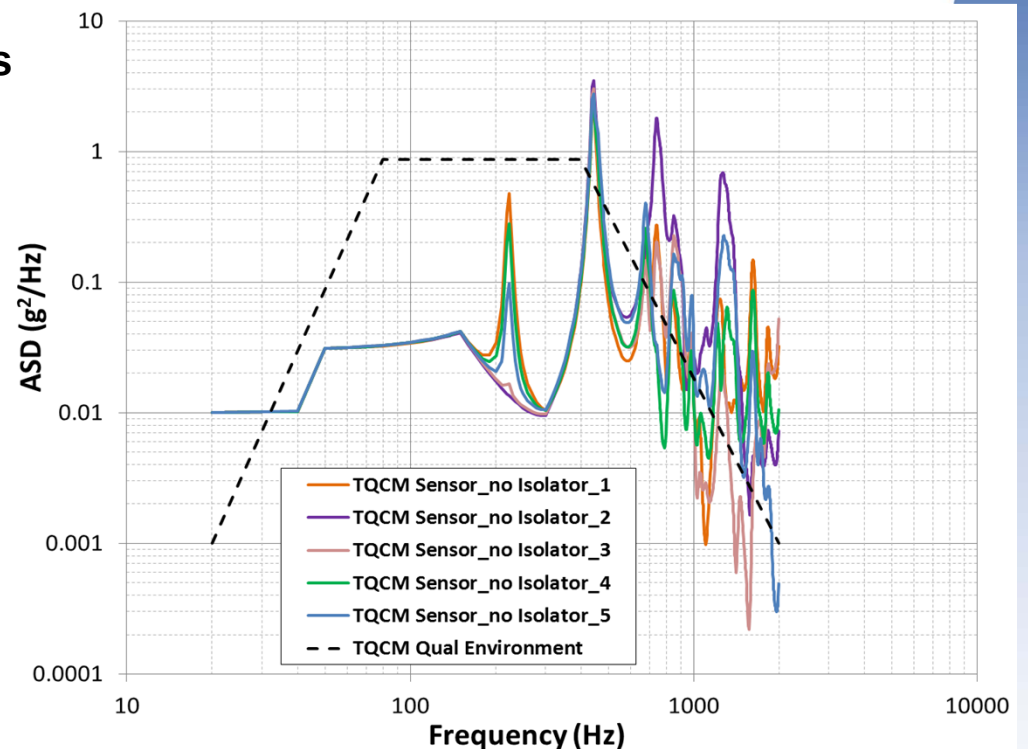
CMP Structural Response Issue



- Structural coupling through the SAGEIII Instrument Adapter Module (IAM) causes high qual exceedence
 - Thermoelectric Quartz-Crystal Microbalances (TQCM) sensors qualification limit exceeded in all directions
 - 3D Isolation system required between IAM and CMP



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3D Isolator Selection



- Enidine (CR6-100) wire rope isolators (WRI) selected
 - Expected good isolation performance in all axes
 - Low contamination/off-gassing issues
 - Least impact to SAGEIII hardware and low cost
- 3D isolator issue in inverted configuration
 - Most isolators designed to operate in compression, roll, and shear (WRI especially)
 - No vendor performance data for WRI isolator in tension
 - Testing required to quantify isolator performance in tension



www.enidine.com

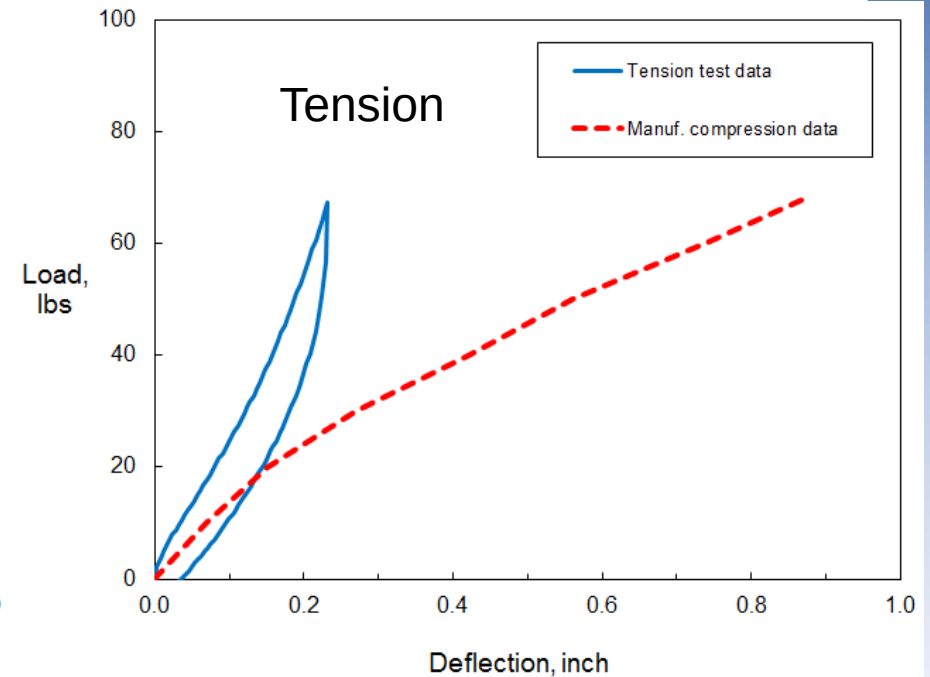
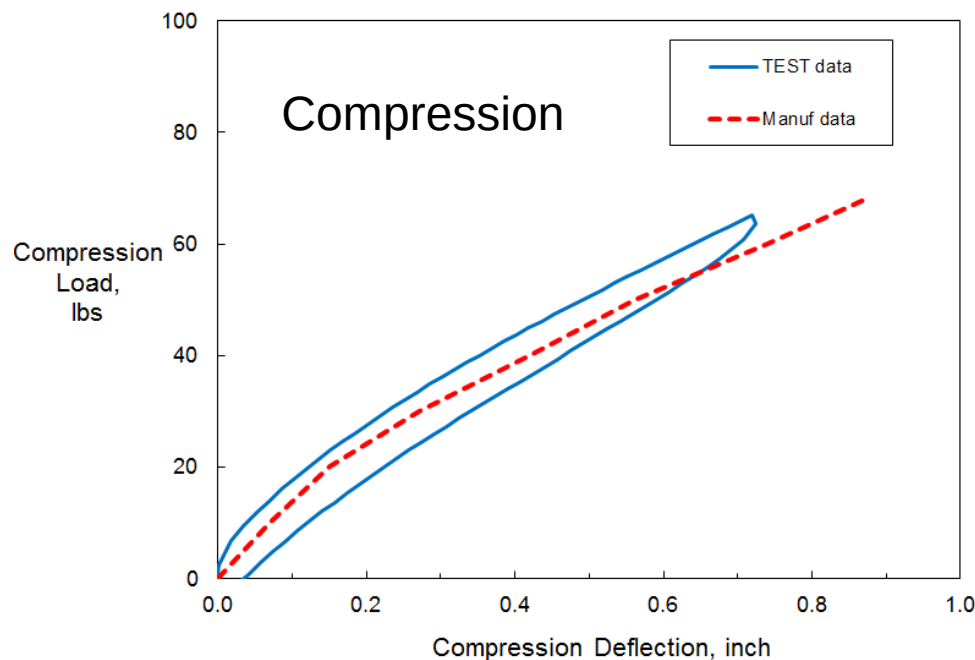




WRI Compression and Tension Tests



- Static Compression tests compared well with vendor specs
- Tension test shows significant load increase vs. compression
 - No vendor data available for tension loads
 - Expected frequencies to shift higher during vibe testing

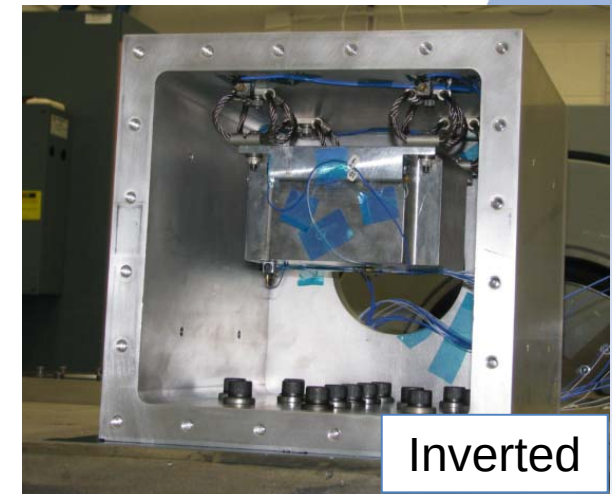
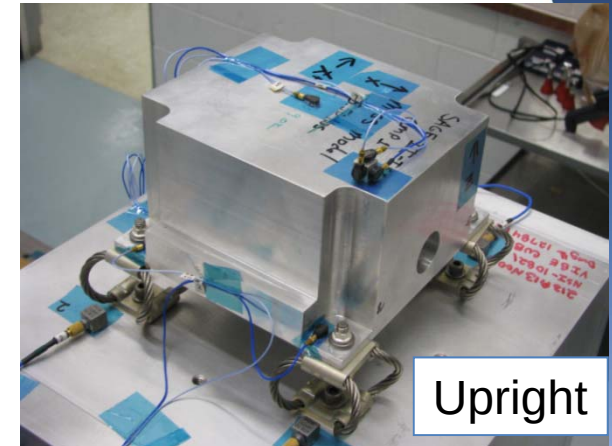




Isolator Vibration Test Configurations



- Tested isolated CMP in upright and inverted configurations
 - Test in three orthogonal axes separately
- WRI sized to isolate at approximately 35 Hz
- CMP mass model used in vibration tests
 - Same mass and CG as flight CMP
- Designed a cube test fixture to mount CMP & isolators inverted and upright configs
- Instrumented above mount, below mount, and at TQCM locations

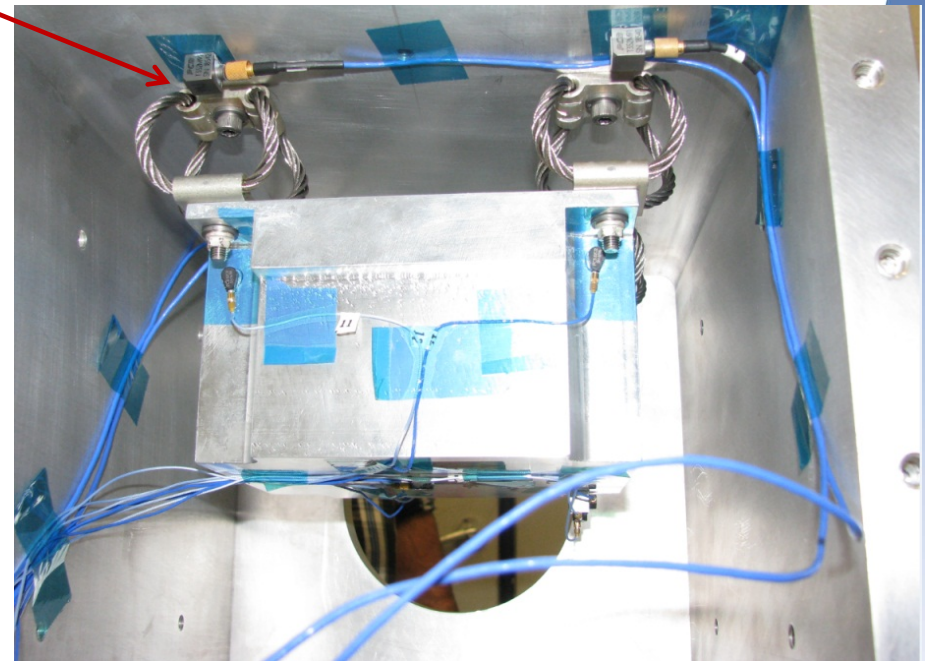
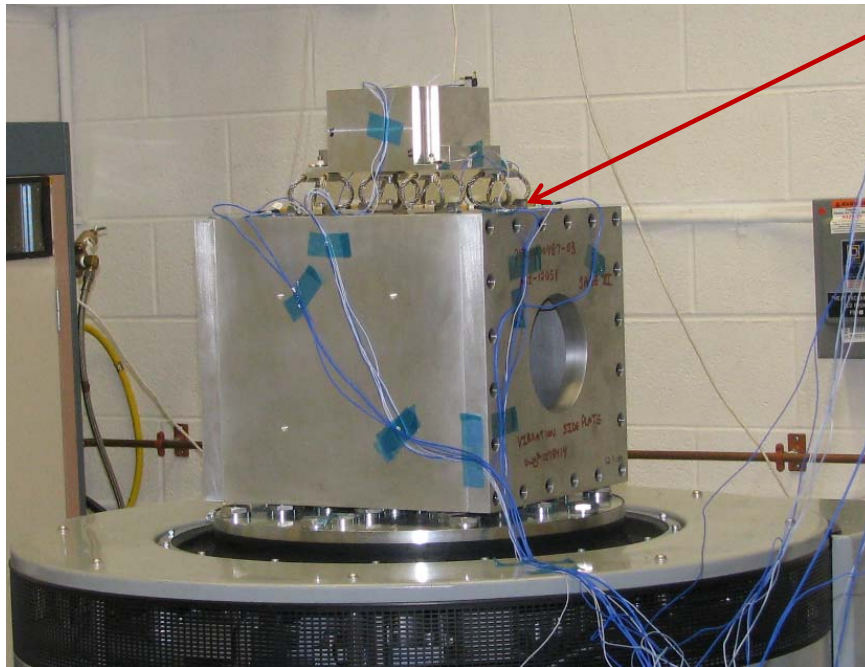




Vertical Axis Test Configurations

- Random and sine inputs controlled at “below mount” locations, controlled to average of four accels
- CMP mounted inside cube for inverted configuration

Control locations



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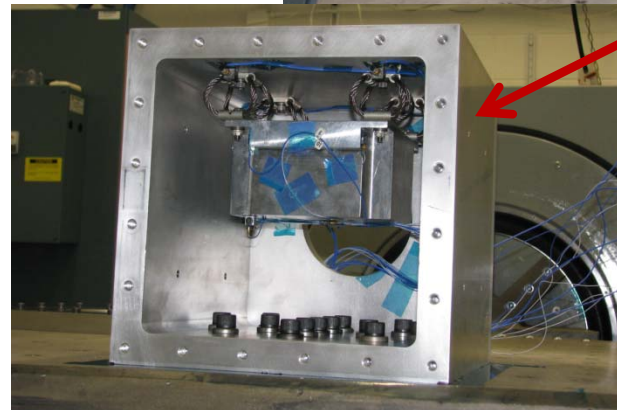
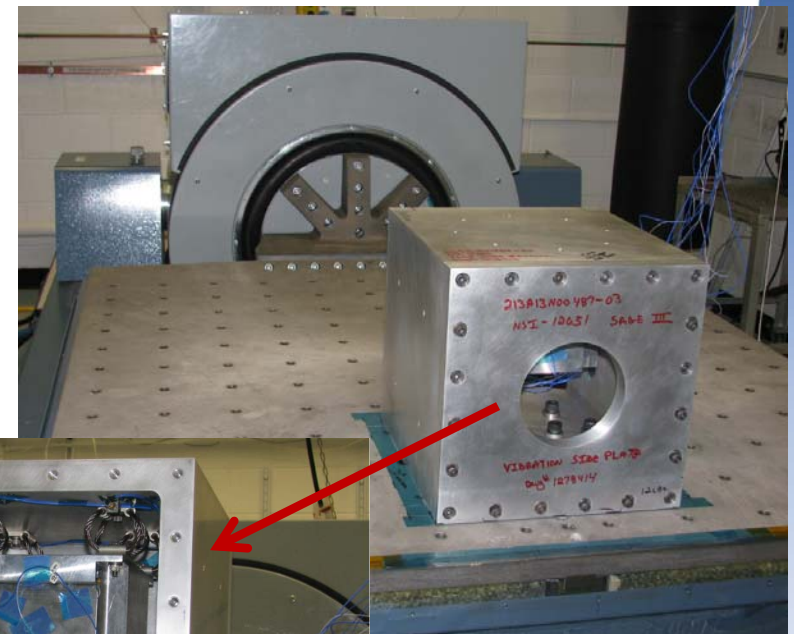
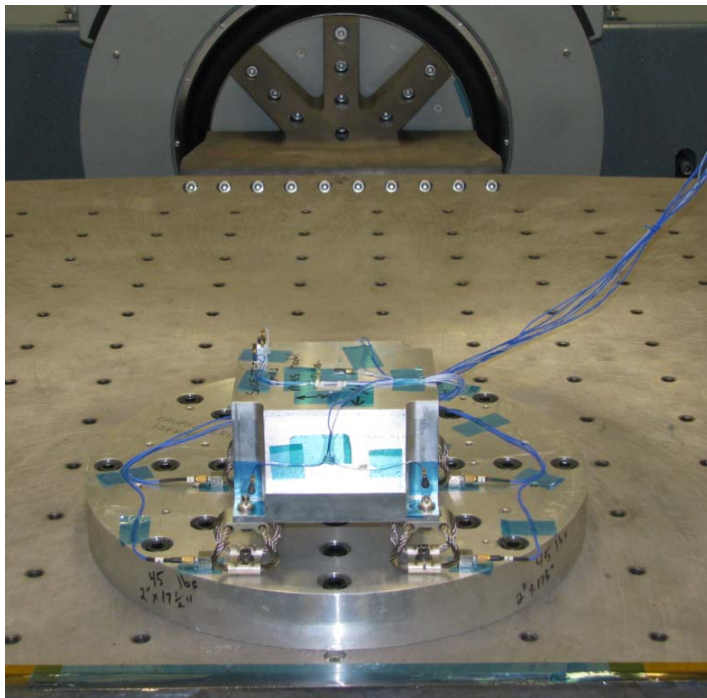




Lateral Axis Test Configurations



- Both lateral axes tested in upright and inverted configurations
 - Cube/adaptor plate rotated 90°



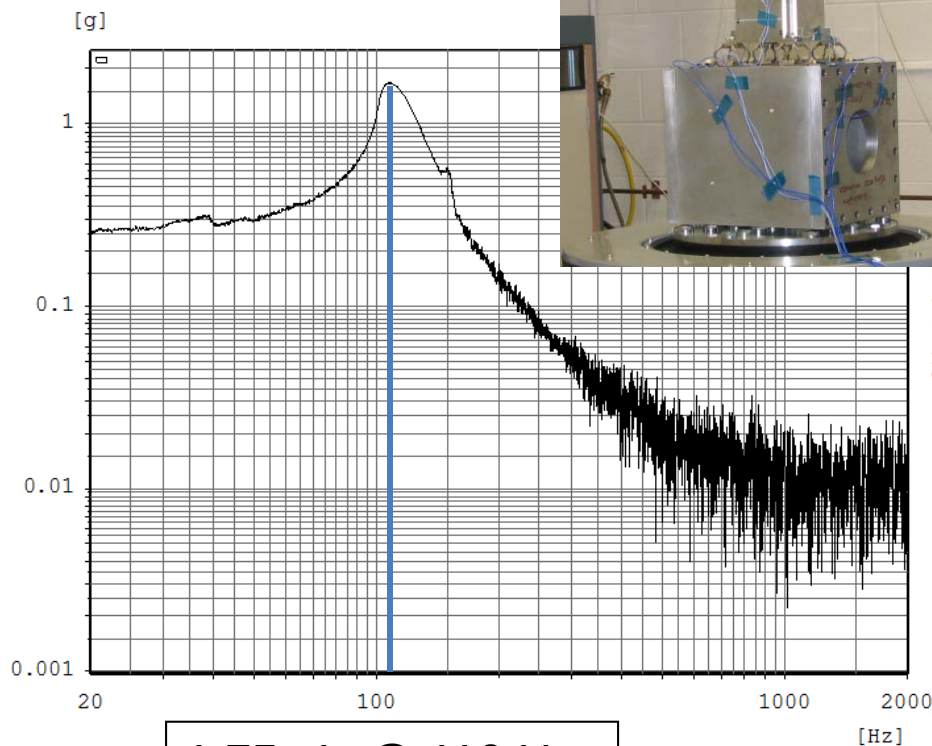


Vertical Axis Sine Sweeps (Upright vs. Inverted)



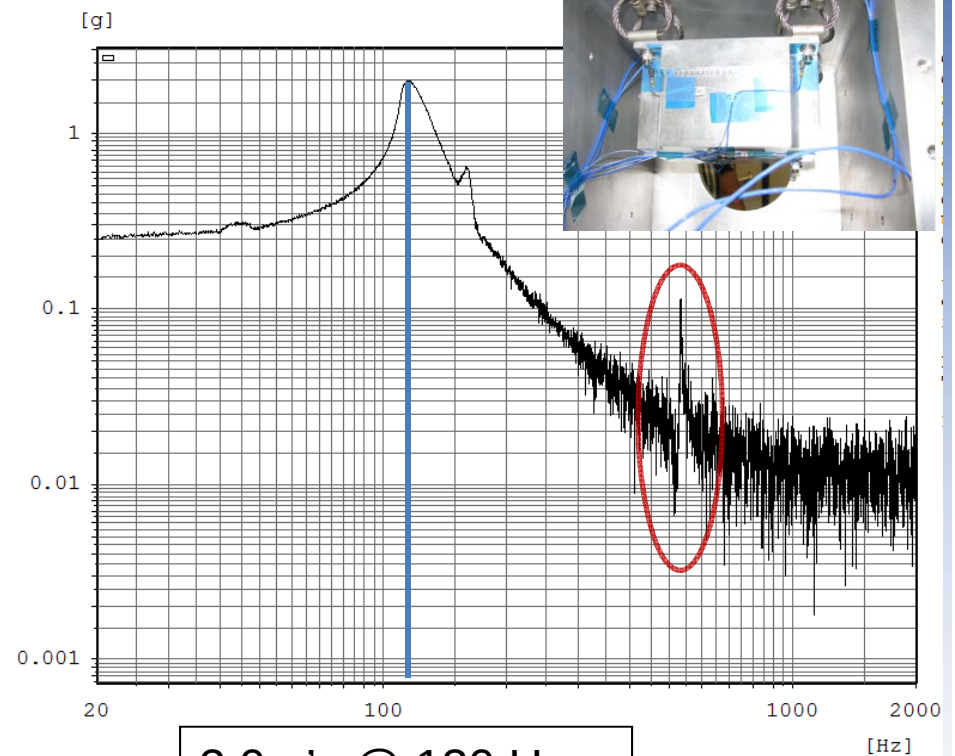
- Frequency shifted and amplitude increased ~20% higher for inverted configuration
 - Secondary mount mode at 550 Hz, only occurs with inverted configuration

0.25g input



1.75 g's @ 110 Hz

0.25g input



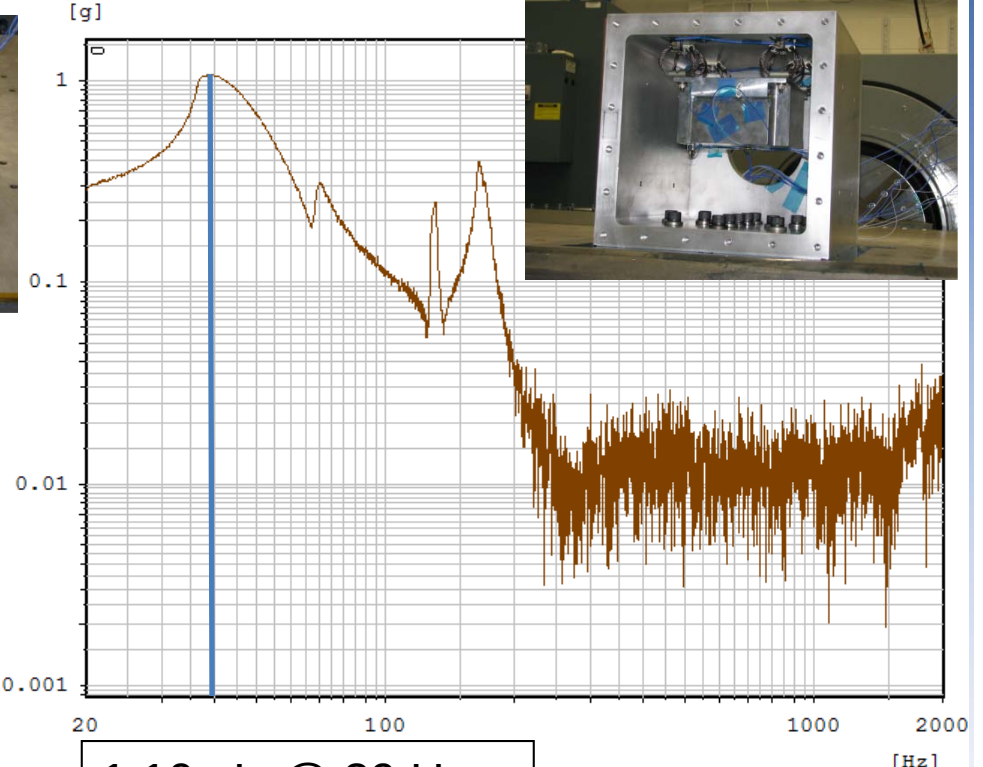
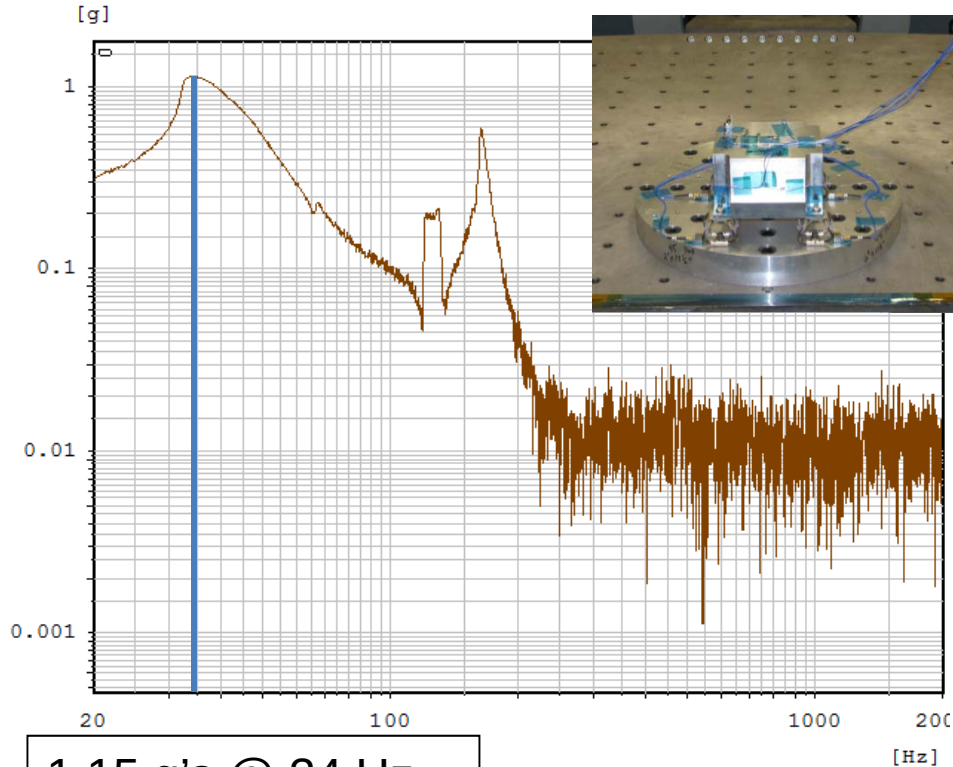
2.0 g's @ 130 Hz



Lateral Axes Sine Sweeps (Upright vs. Inverted)



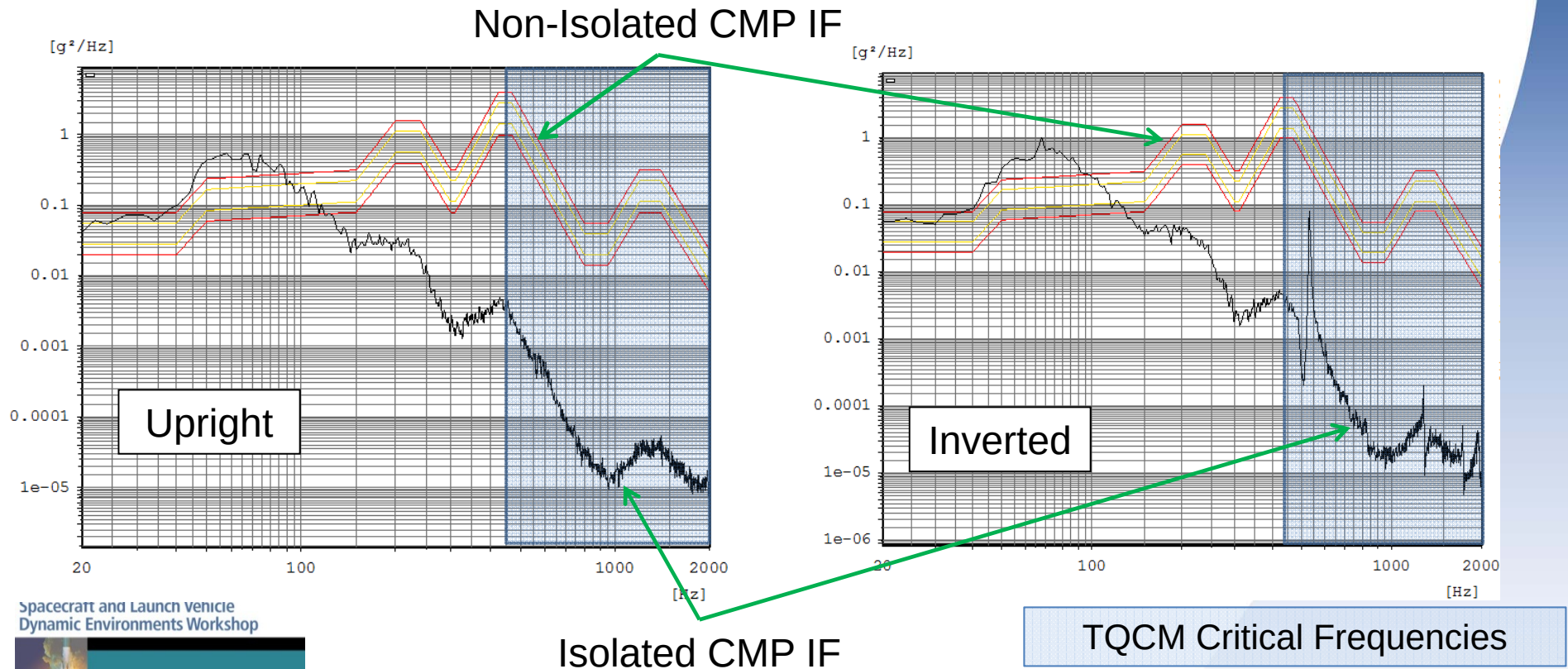
- Frequency shifted 10% higher for inverted configuration
 - Negligible change in amplitude
 - Secondary mount mode evident in both configurations





Isolator Response to SAGEIII Random Vibe

- WRI significantly reduced random vibe responses at high frequencies (same for all axes)
 - Measured between 5% and 15% critical damping



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Inverted Wire Rope Isolator Conclusions

- WRI installation orientation has an impact on the performance at the isolation frequency
 - Inverted installation increases stiffness (increases frequency)
 - Inverted installation decreases damping (increases response)
- Inverted WRI isolators still performed well at high frequencies
- Inverted WRI isolators introduced isolator modes that are not evident in the normal installation
 - In this example, very little impact on performance
- SAGEIII has implemented WRI between IAM and CMP for flight
 - Solved CMP TQCM sensor issue

