PACE Acoustic and Sine Vibration Tests and Supporting Analyses

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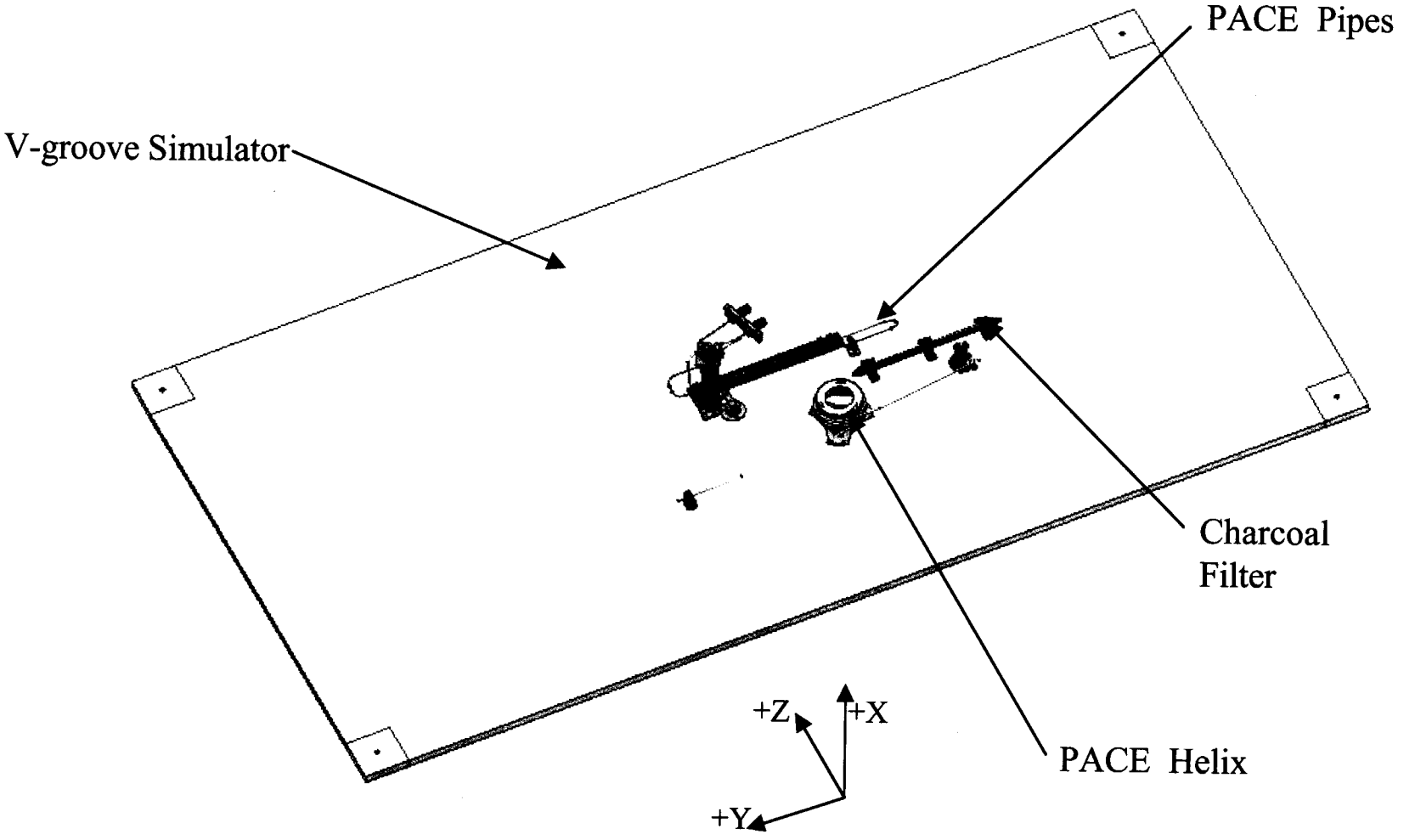
PACE Acoustic and Sine Vibration Tests and Supporting Analyses Summary

¥ Planck Sorption Cooler Piping System (PACE) hardware mounted on a light weight radiator
¥ PACE design criteria
¥ Design issues
¥ Describe acoustic tests and sine vibration tests planned to verify PACE for dynamics environments
¥ Summarize preliminary pre-test analysis

Radiator Simulator with Selected PACE Hardware



Dynamics Environmental Requirements for Planck Sorption Cooler Piping System

¥JPL Design Parameters for Piping System

- ¥ Quasi-static load on complete piping system:100 G s
- ¥ Fixed base resonance above 100Hz
- ¥ V-groove relative dynamic displacement: 6mm long., 3mm lateral

PACE System Random Vibration Issues

¥Predicted radiator random vibration input to pipes was 10.0 g^2/Hz to 71.0 g^2/Hz
¥Extremely high design loads predicted pipes failure
¥Decision made to verify pipes design for vibration on radiator simulator

Predicted Pipe Response Using Miles Equation

Q assumed	Fn assumed	g2 /Hz input	grms	gpk 3 sigma
20	45	71.0	316.82	950.45
20	60	71.0	365.83	1097.49

PACE Verification Test Objectives

- ¥ Obtain data to facilitate verification of pipes design acoustically induced random vibration environments with margin
  - —Section of pipes and precooler corresponding to highest predicted response
- ¥ Acoustic test of V-groove radiator simulator with PACE hardware
  - —Measure panel only modes
  - —Measure coupled PACE equipment/ panel modes and vibration responses

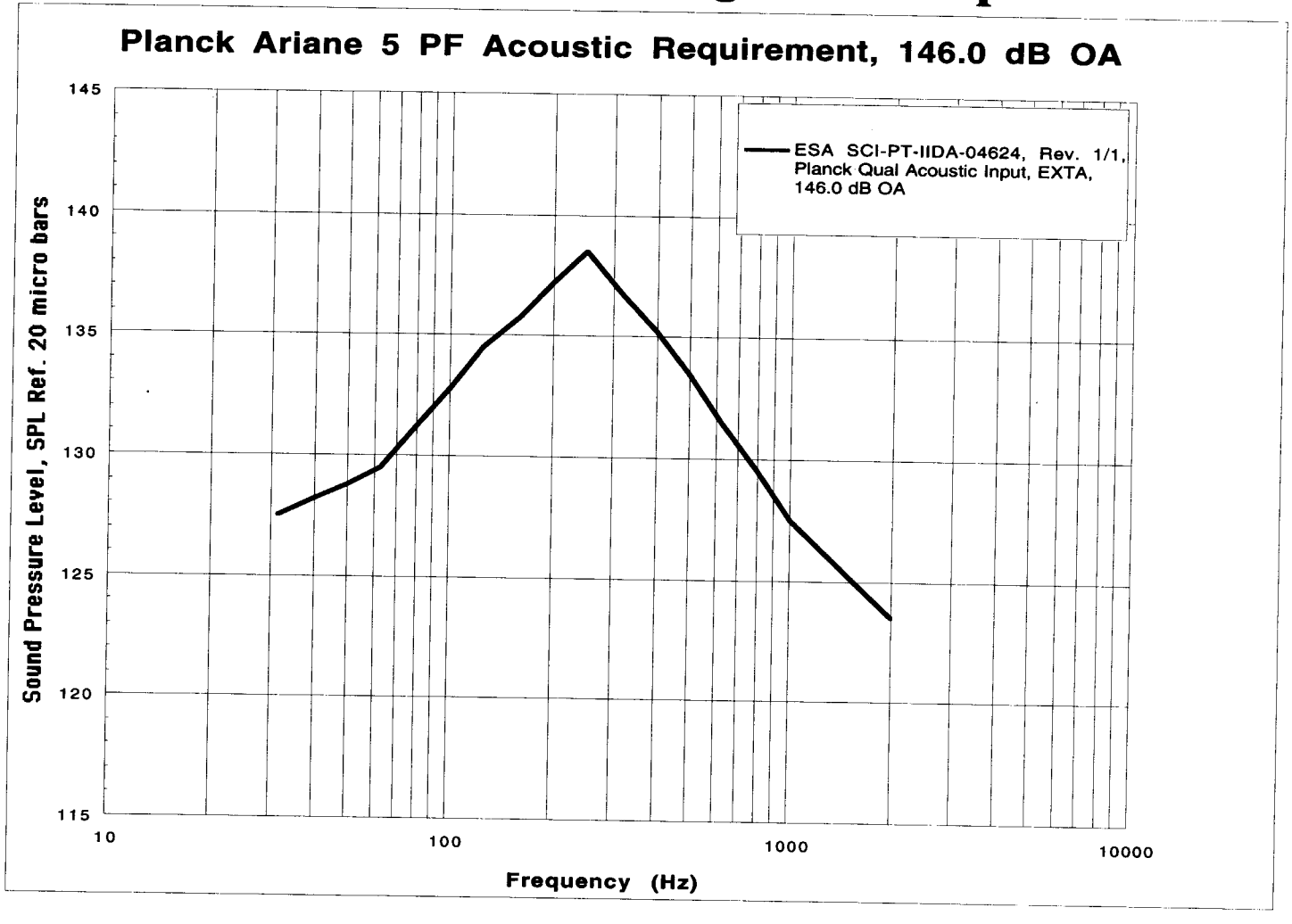
PACE Acoustic and Sine Vibration Tests

- Acoustic test to be performed on bare radiator simulator to measure panel modes
  - 146.0 dB overall SPL for Ariane 5 launch
  - Show pipe and panel modes overlap; worst case pipes environment
  - 146.0 dB overall SPL + 3 dB, margin and uncertainties
- Obtain pipe modes and damping from separate sine vibration test

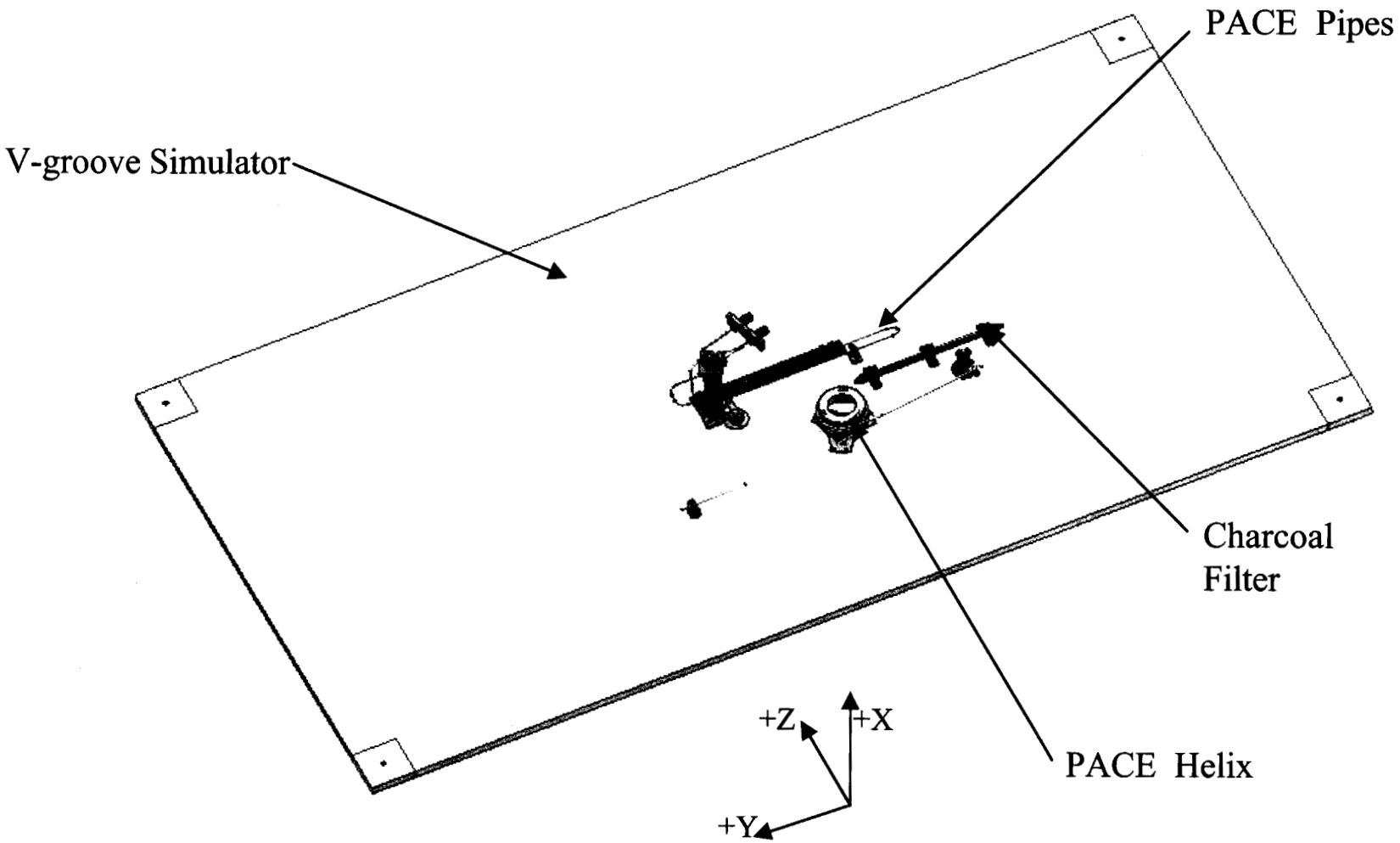
PACE Acoustic and Sine Vibration Tests

- ¥ Acoustic test to be performed of combined pipes and V-groove radiator simulator
  - —Measure coupled pipes/ panel vibration responses and frequencies
- ¥ Verify Pipes design by analysis
  - —Test verified model

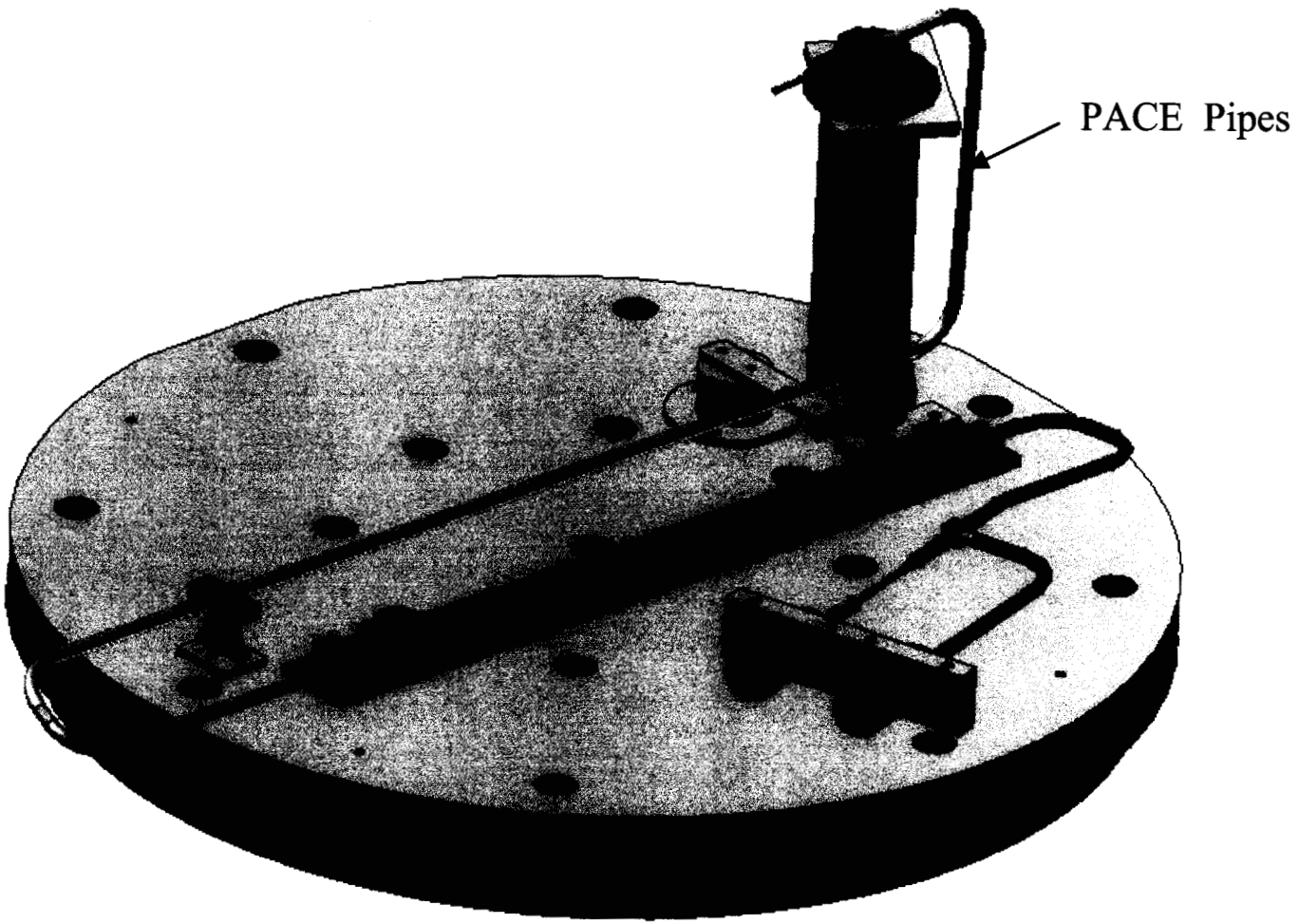
PACE Acoustic Protoflight Test Input



V-groove Acoustic Test Simulator with PACE Hardware



PACE Pipes Sine Vibration Test Setup for Damping Measurement



V-groove Simulator Acoustic Analysis Approach

- Perform FEA of honeycomb panel (with and without PACE pipes) to obtain modes up to 750 Hz.
- Import modes to BEA software, assign modal damping, excite honeycomb panel boundary element model with PF diffuse sound field, recover results at PACE pipes mounting interfaces.

V-groove Simulator Acoustic Analysis Approach, Continued

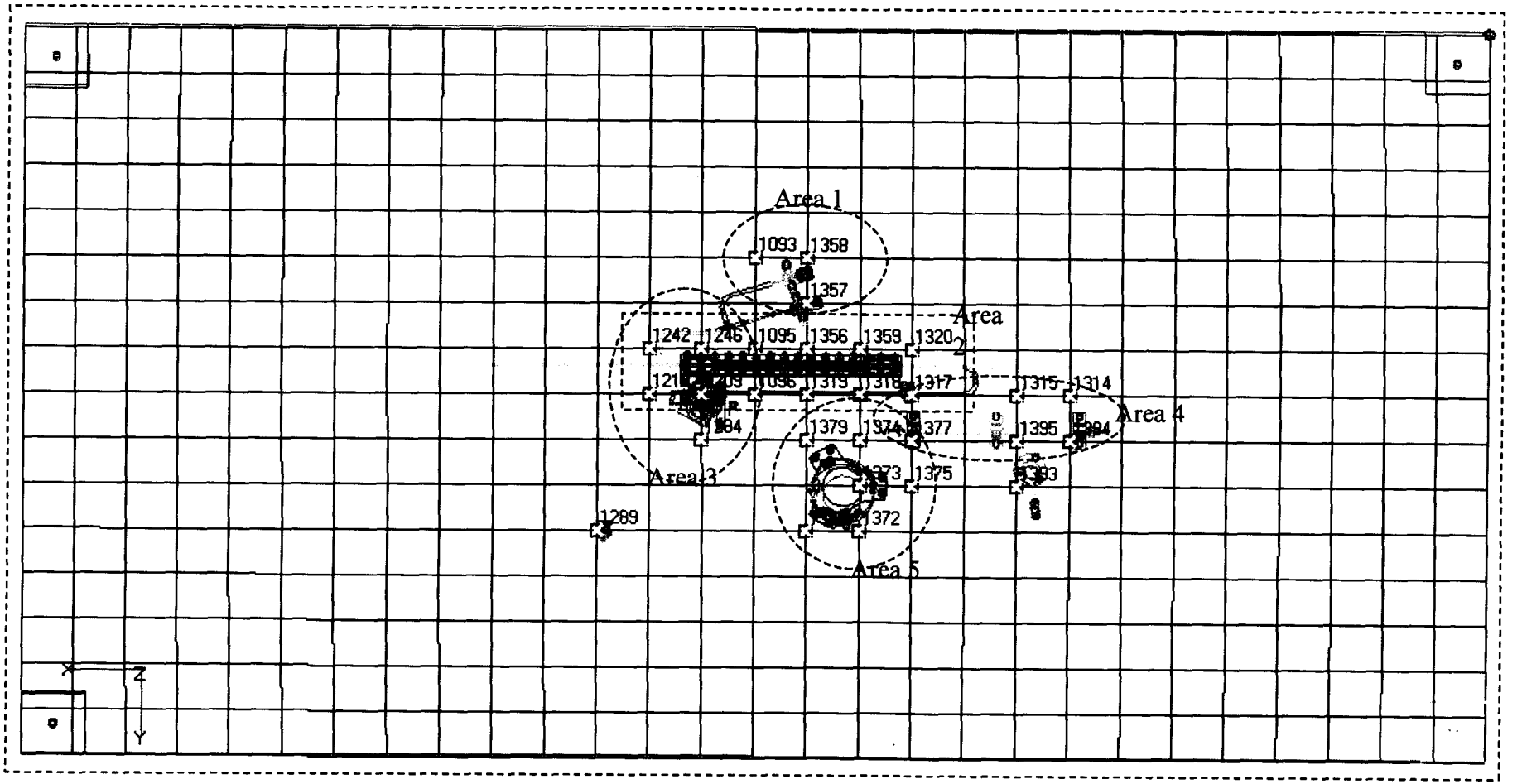
- Perform random vibration analysis using FEA with inputs from BEA at mounting interfaces to obtain responses on piece parts
  - —V-groove Simulator test set up determined from predicted modal densities of possible test configurations
  - —Clamped corners gave additional panel modes in range of pipes modes

Correlate the PACE BEM and the FEM to qualify the PACE Design

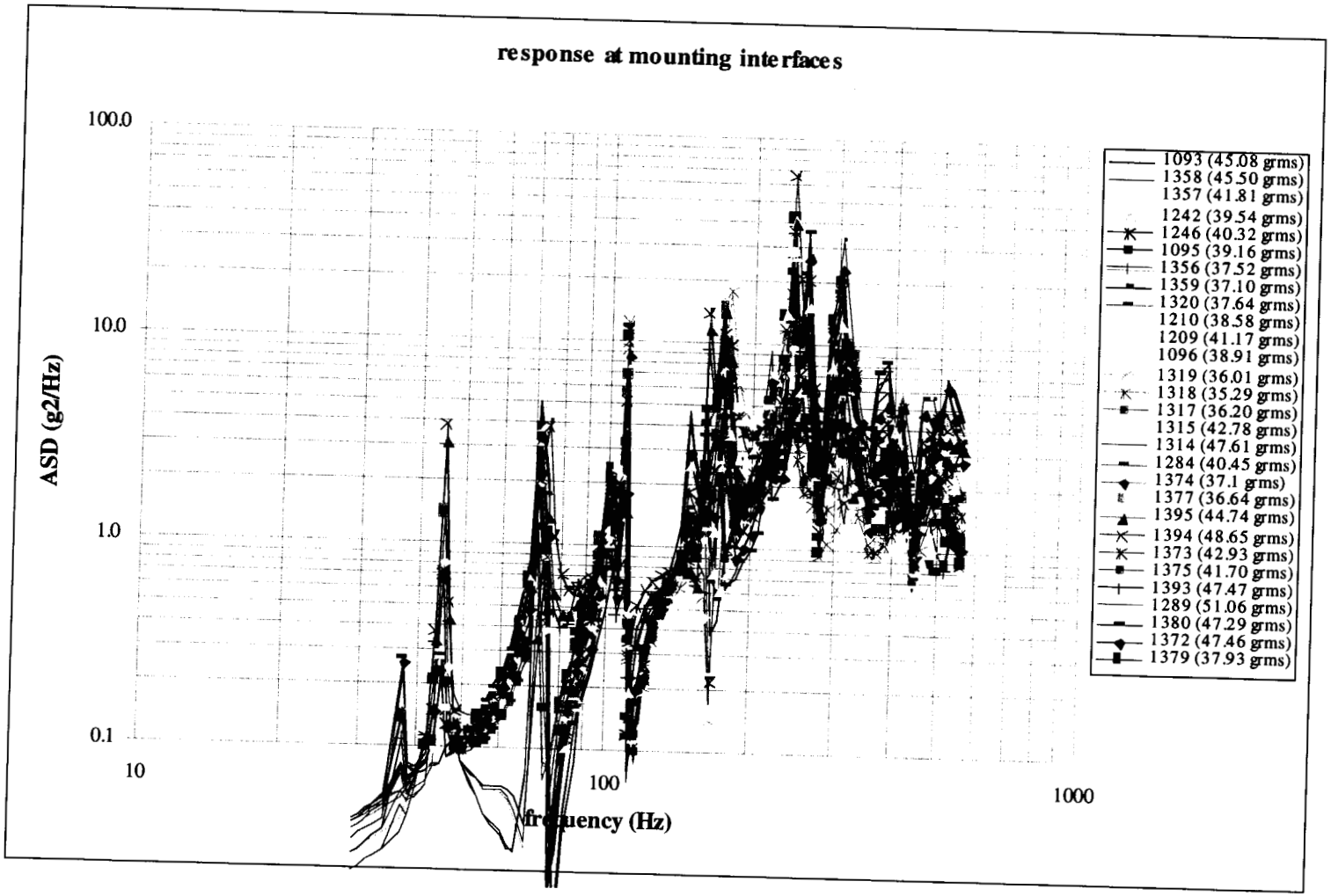
- Perform parametric BEM/FEM study (varying pipe stiffness, etc) to predict worst case pipe response (couple pipe modes with panel modes)
- Use shaker sine test data to obtain damping values to update models
- From the acoustic panel/pipe test results we will:
    - Correlate with BEM/FEM models to match stress values (or acceleration responses on pipe,
    - Add factor to account for worse case coupling,
    - Calculate equivalent static load with worst case coupling based on stress measurements

Correlate the PACE BEM and the FEM to qualify the PACE Design

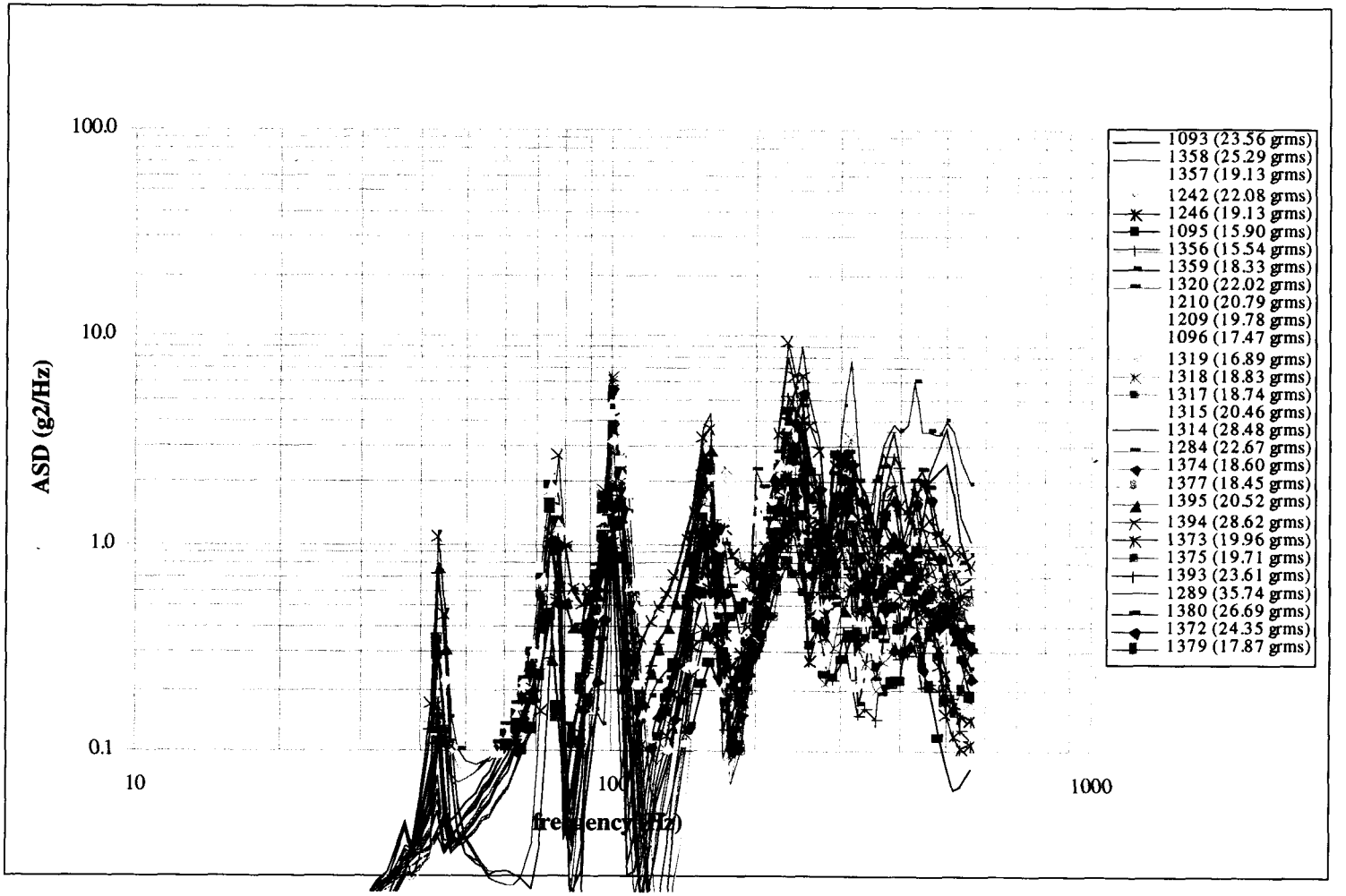
- If calculated equivalent static load is well within design load limit correlation/ verification is finished
- If not perform additional steps to lower prediction:
  - Model real radiator, extrapolate panel/pipe test response to real radiator model.
  - Perform additional acoustic test (possibly with pipe of different stiffness) to refine the worst case coupling



PACE Development Harware Mounting Locations on V-groove Simulator



Response at Mounting Interface of Bare V-groove Simulator



Response at Mounting Interface of V-groove Simulator with All Piece Parts