

The Effect of “Fixed” Joint Variability on Dynamic Properties

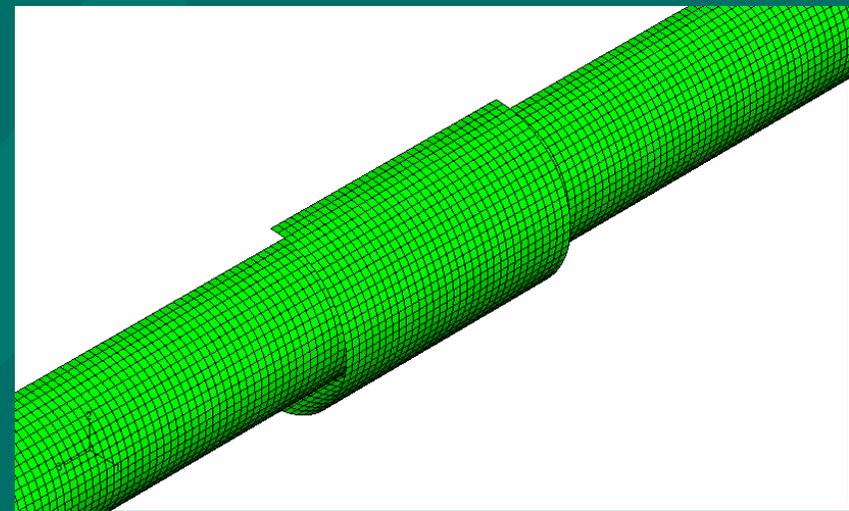


By

Catherine Whyte - WUSTL

Dean Pask - AWE

Paul Rael - CSU



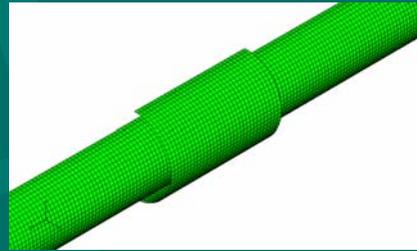
Mentors: Mandy Rutherford, Jason Pepin

Los Alamos Dynamics Summer School 2005

Introduction

- Background and Motivation

- Modeling



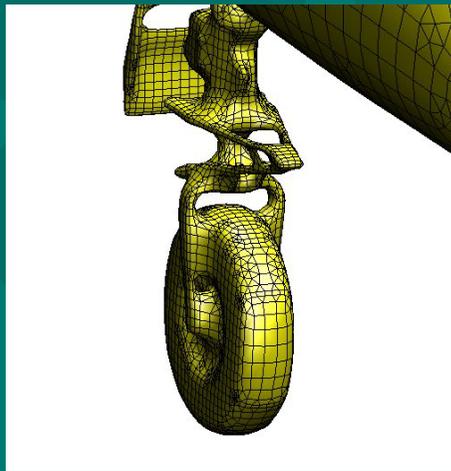
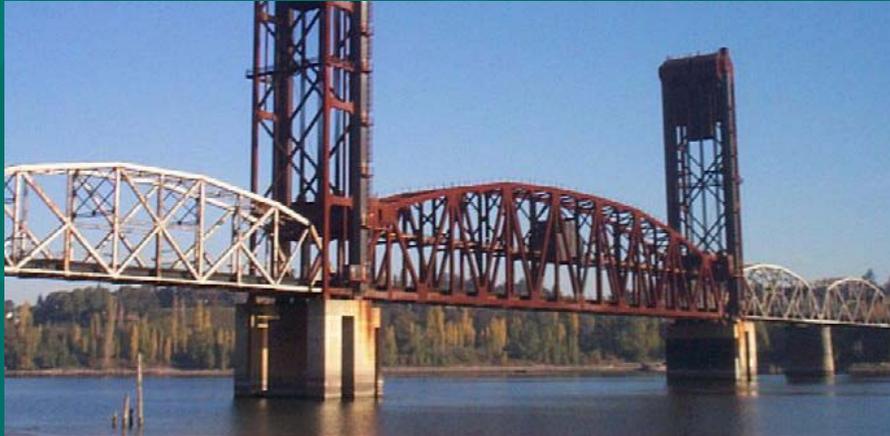
- Testing



- Comparison (FEA vs. Test)

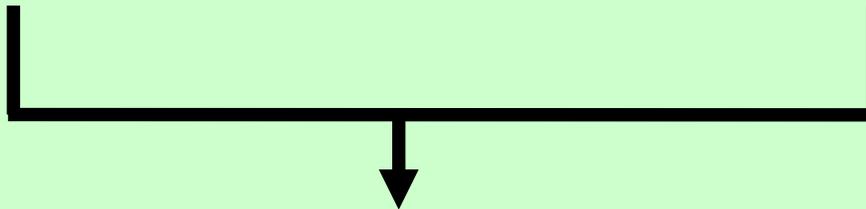
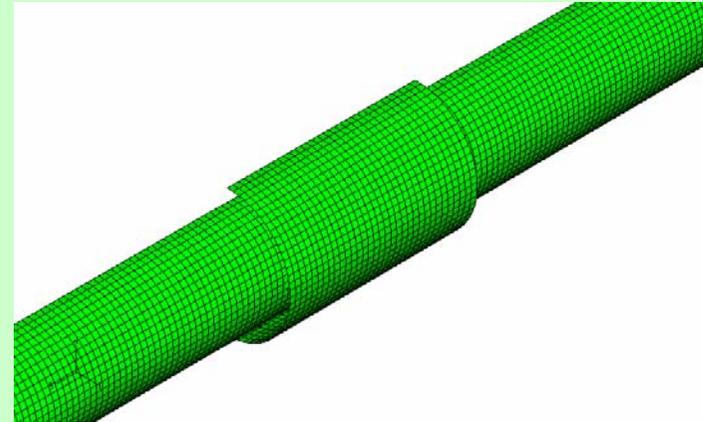
- Conclusion and Future Work

Our main motivation stems from the common practice of defeaturing structural joints



- The characterization of joints is one of the most difficult aspects of structural dynamics modeling
- Joints provide one of the main paths of energy dissipation

Our goal was to compare the model data to the test data

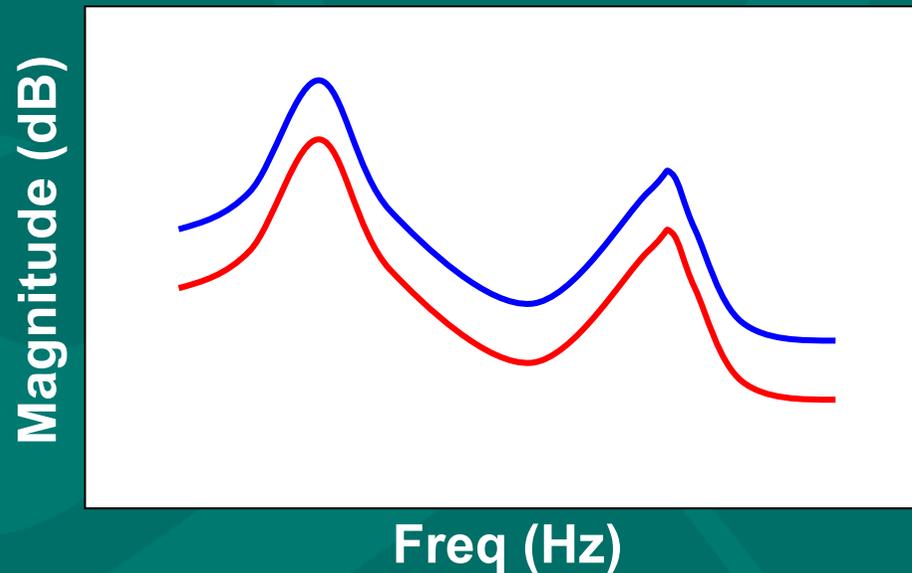


Dynamic Testing and Computational
Model Compared (validated)

Dynamics of Interest: “High” Frequency Range (>2000 Hz)

$$H_1 = \frac{\text{CrossPowerSpectrum}}{\text{AutoPowerSpectrum}} = \frac{\text{Output} * \text{Input}}{\text{Input}^2}$$

Stage 1: Visual Inspection



Dynamics of Interest: “High” Frequency Range (>2000 Hz)

$$H_1 = \frac{\text{CrossPowerSpectrum}}{\text{AutoPowerSpectrum}} = \frac{\text{Output} * \text{Input}}{\text{Input}^2}$$

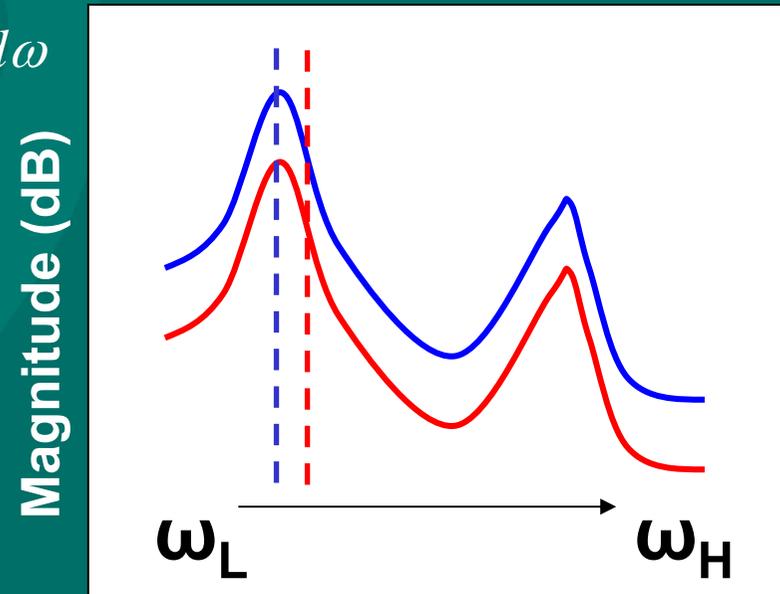
Stage 2: $M_i = \int_{\omega_L}^{\omega_H} \omega^i H_1(\omega)^2 d\omega$

$$E = M_0$$

$$\tau = \frac{M_1}{M_0}$$

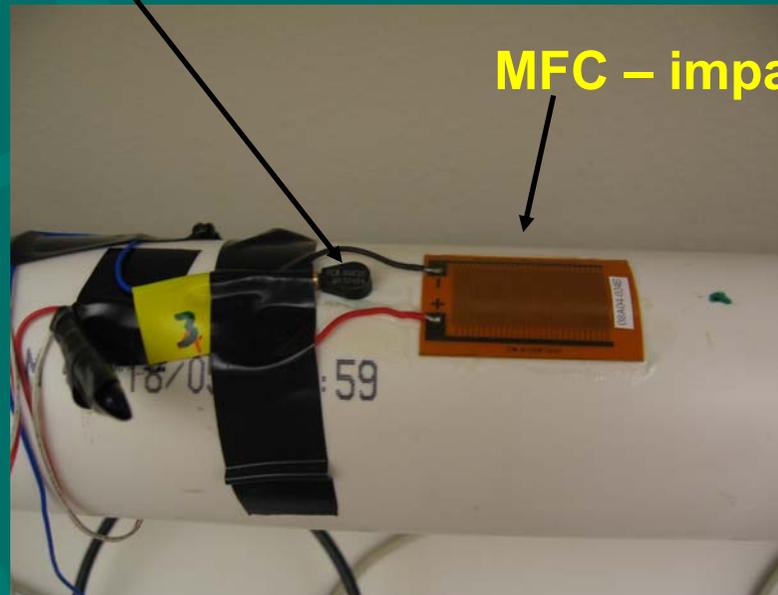
$$\omega_L = 2000 \text{ Hz}$$

$$\omega_H = 9000 \text{ Hz}$$



MFCs were used to excite the test structure.

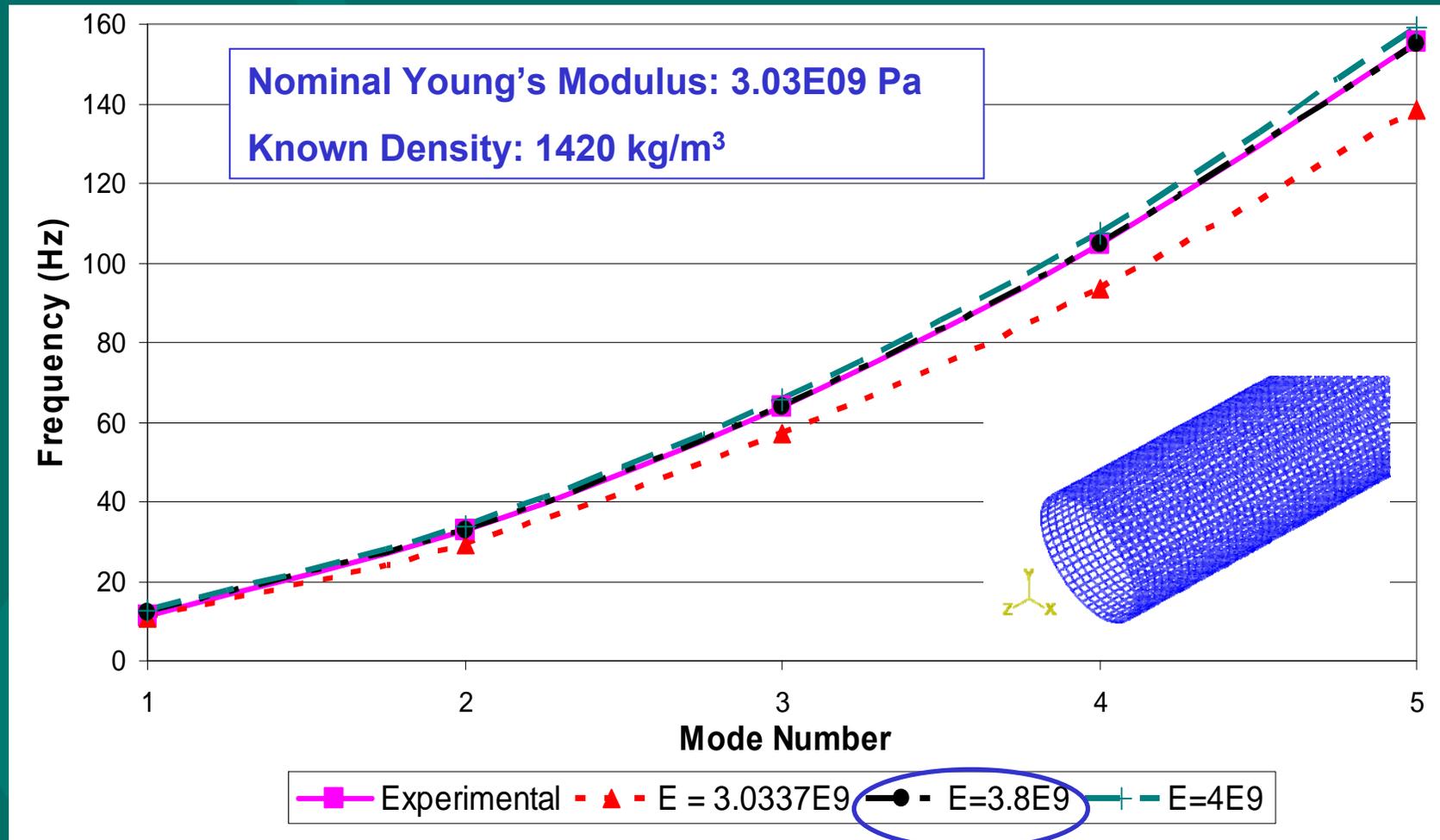
Accelerometer – records radial acceleration



MFC – imparts bending moment

- MFCs operate on the same principle as PZTs
- Motivation for MFCs is increased flexibility

A modal test was used to find the appropriate Young's Modulus.



For the high frequency study, two pipe sections were modeled in ABAQUS.

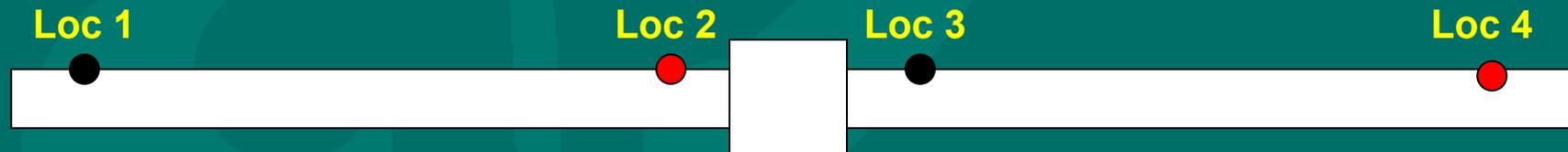
2.5 ft monolithic pipe



E: 3.80E09 Pa

Density: 1420 kg/m³

Pipe assembly with threaded joint



● = input signal location

● = response location

ABAQUS Model

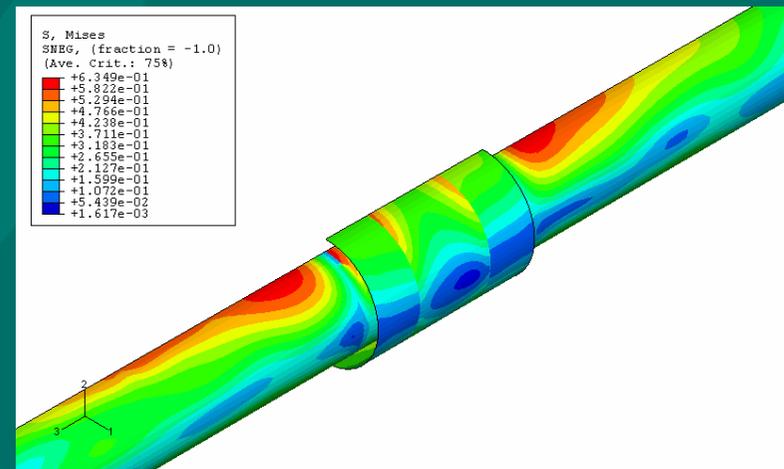
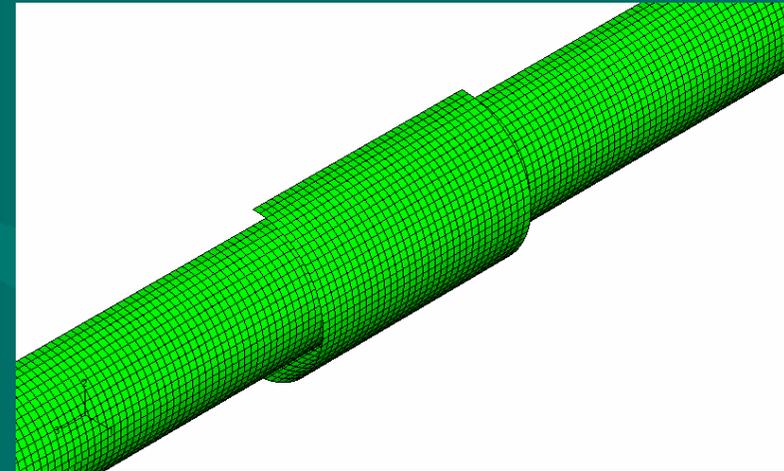
Assembled pipes and threaded joint using tied connection

Free-free boundary conditions

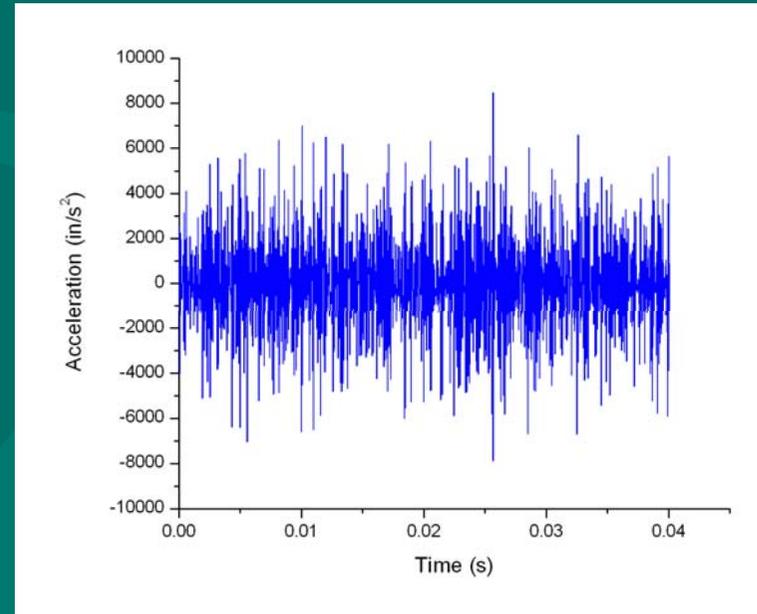
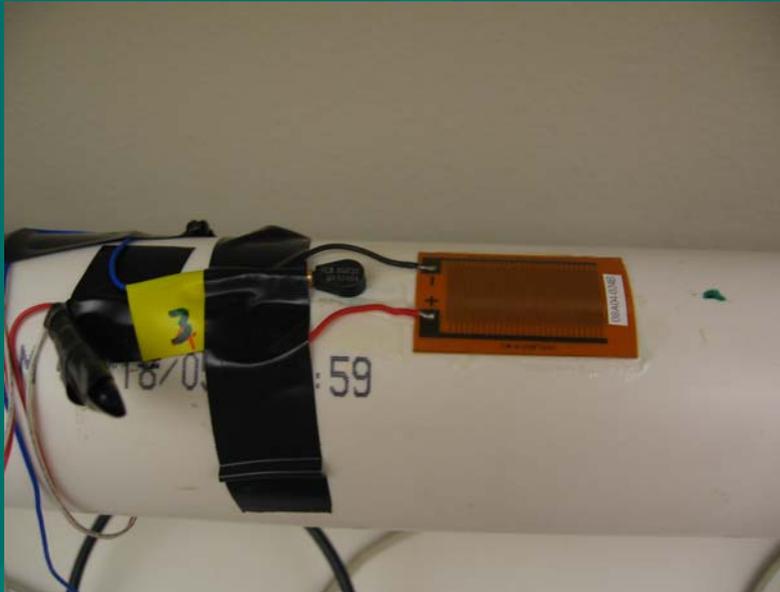
Threaded joint modeled as simple cylinder with varying thickness

16917 shell elements in assembled model

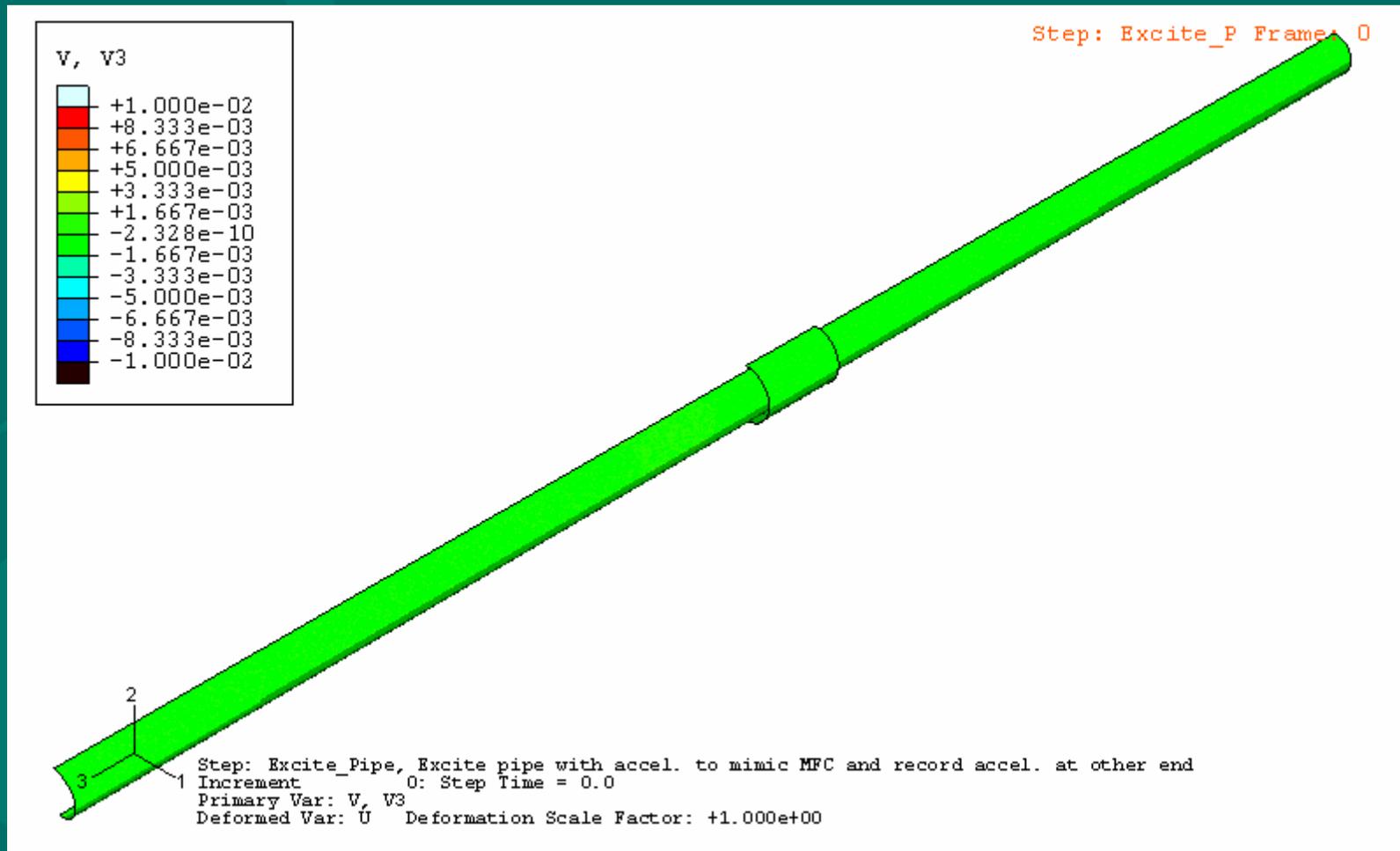
Approximated accelerometers as single nodes for excitation and history output



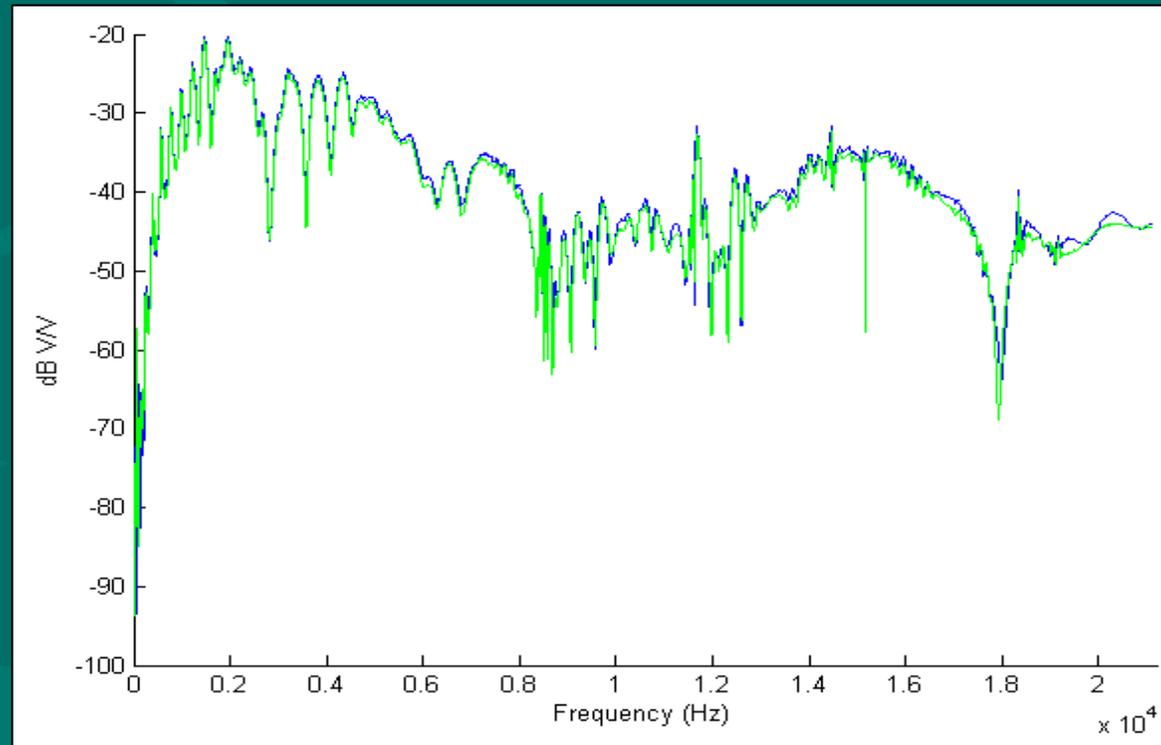
The input signal for the ABAQUS model was the acceleration time history measured by an accelerometer located next to the MFC patch.



Velocity propagation is shown along the pipe assembly with a simply modeled threaded joint.

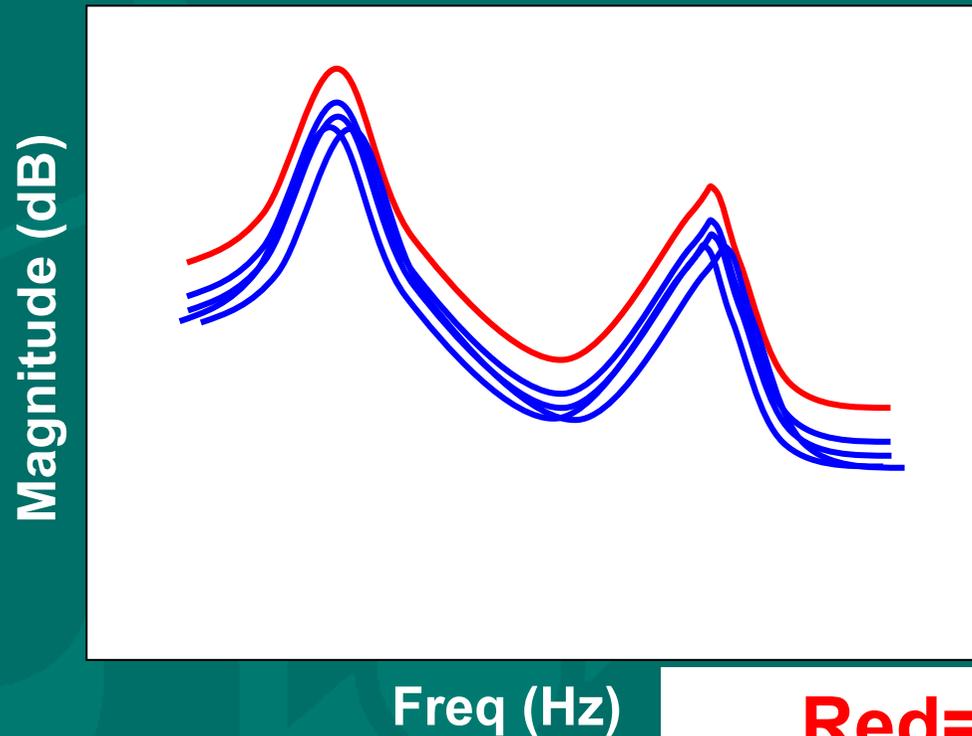


Demonstration of Reciprocity



Test Analysis Comparison

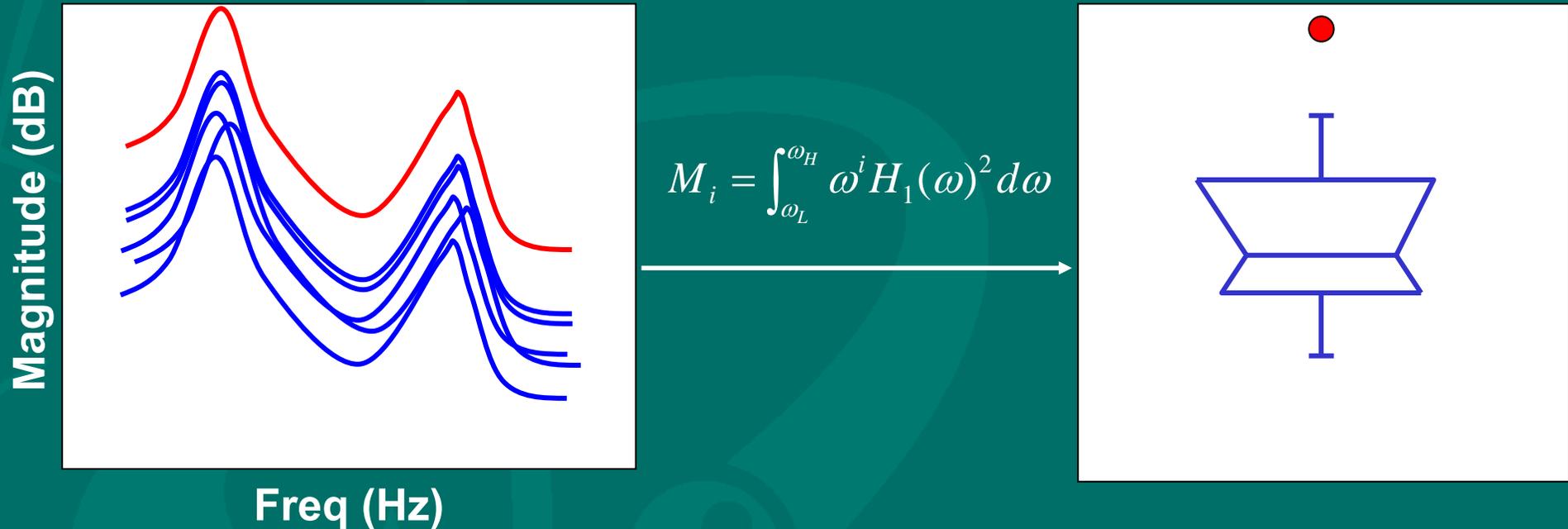
Stage 1: Visual Inspection



Red=Analysis
Blue=Experiment

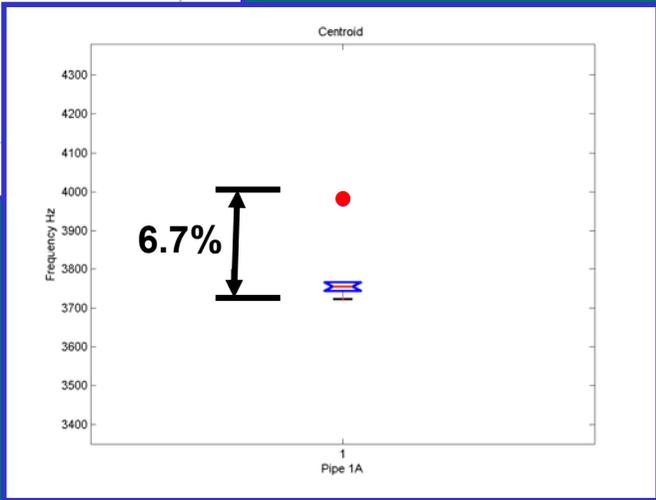
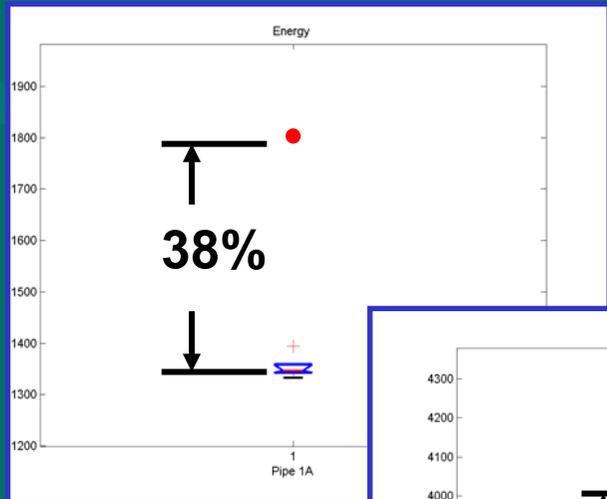
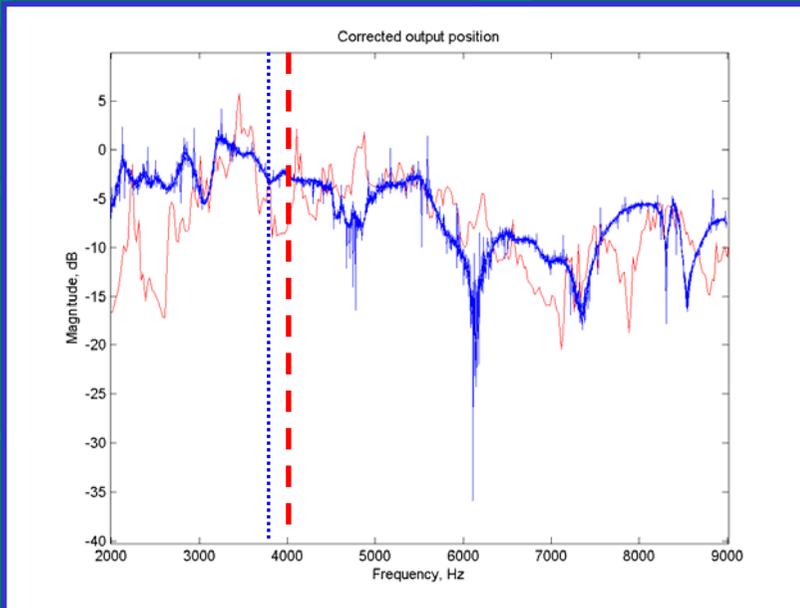
Test Analysis Comparison

Stage 2: Low order feature comparison



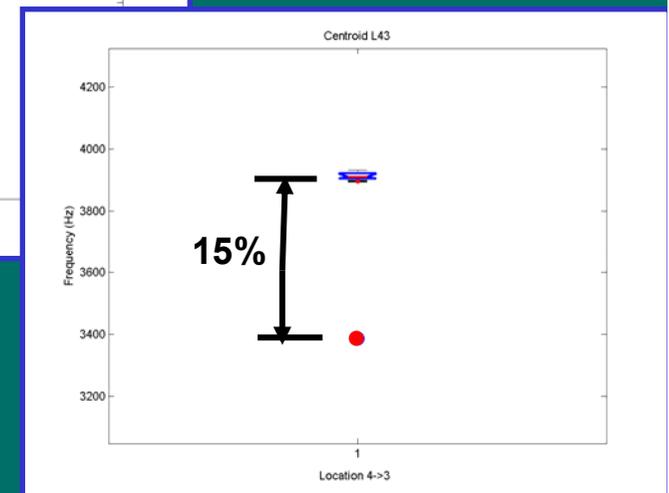
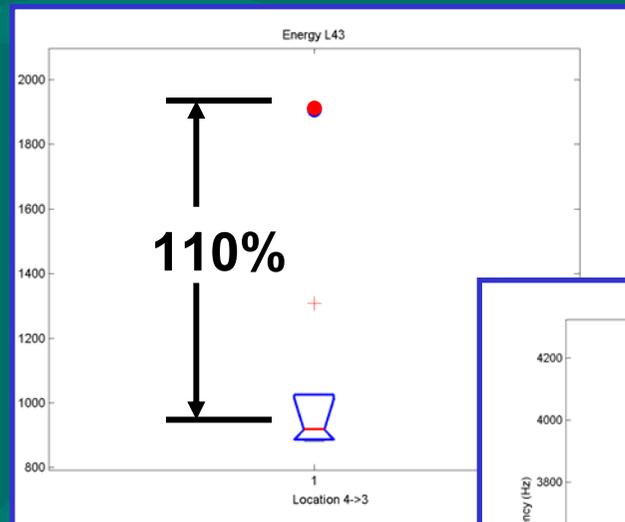
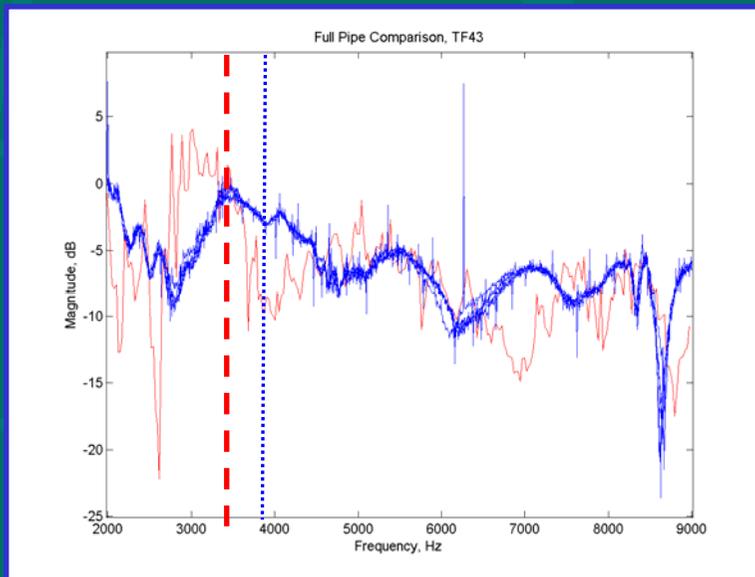
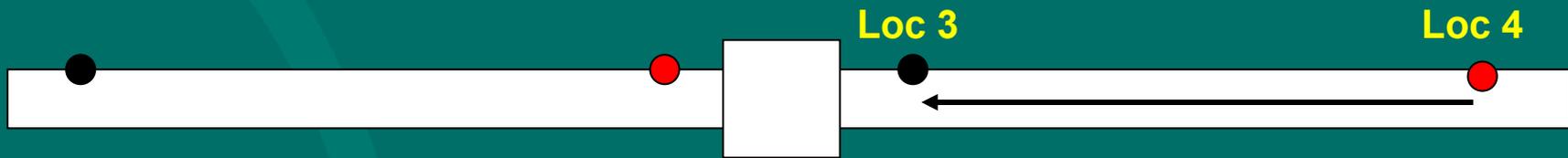
Red=Analysis
Blue=Experiment

Test Analysis Comparison



Red=Analysis
Blue=Experiment

Test Analysis Comparison



Red=Analysis

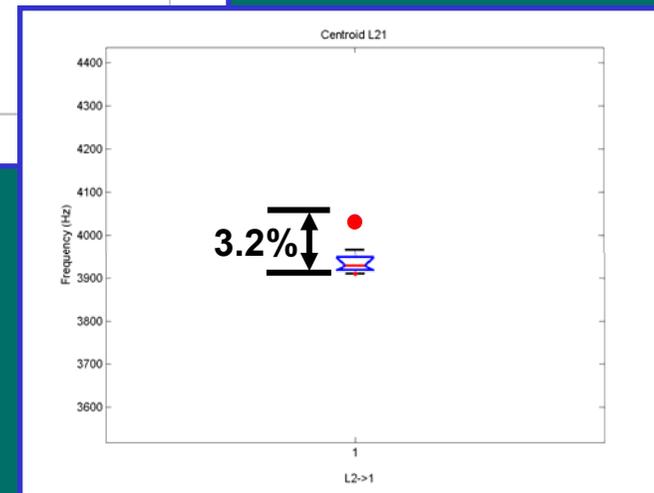
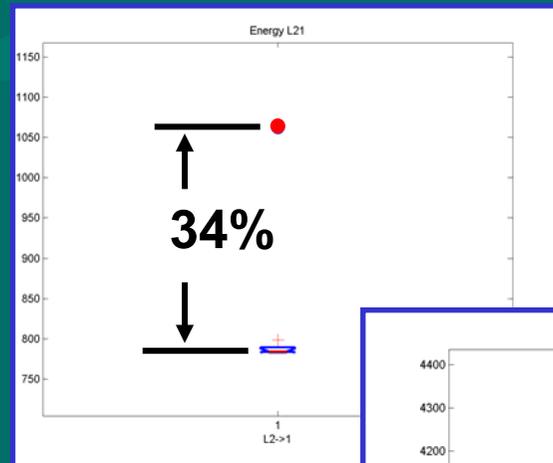
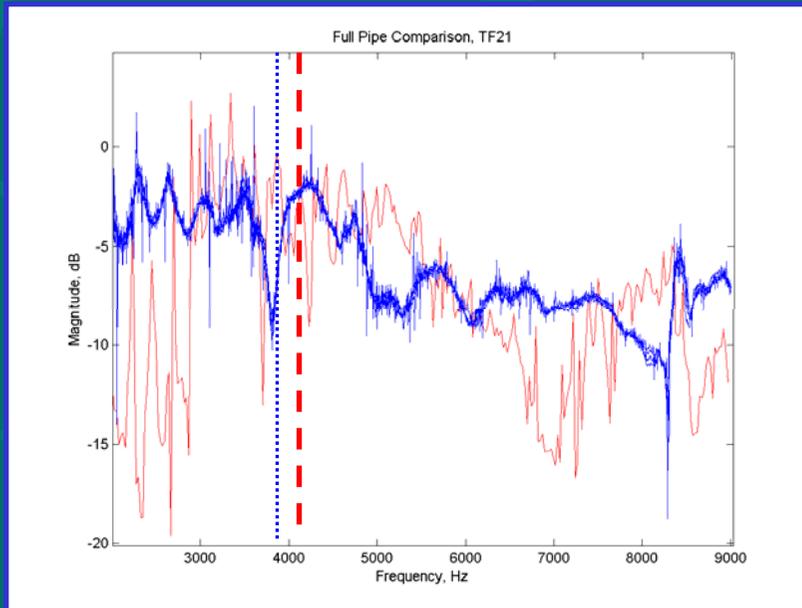
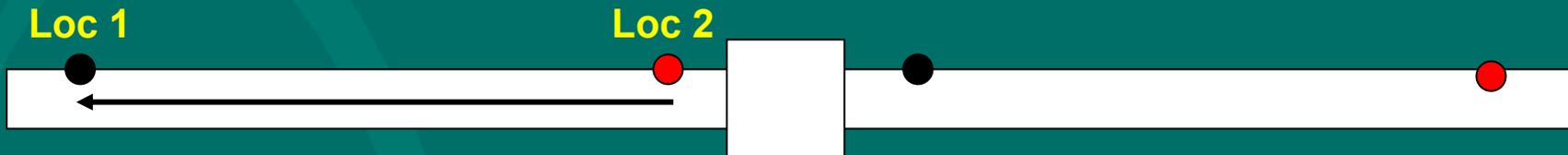
Blue=Experiment

Los Alamos Dynamics Summer School 2005

IMAC XXIV, Jan. 31

Slide 17
Unclassified

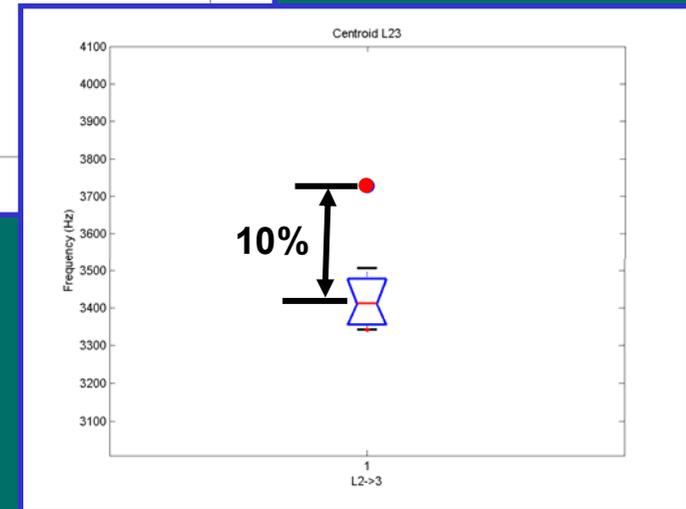
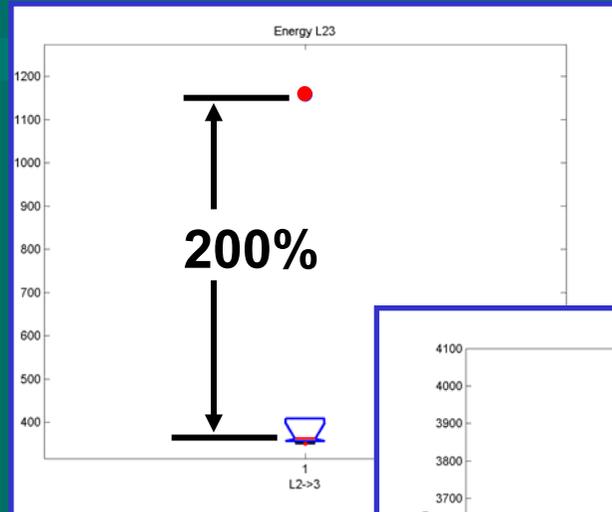
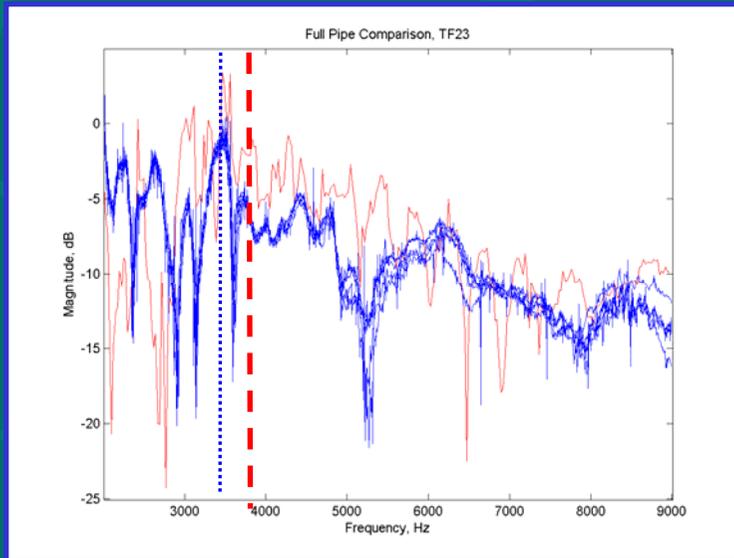
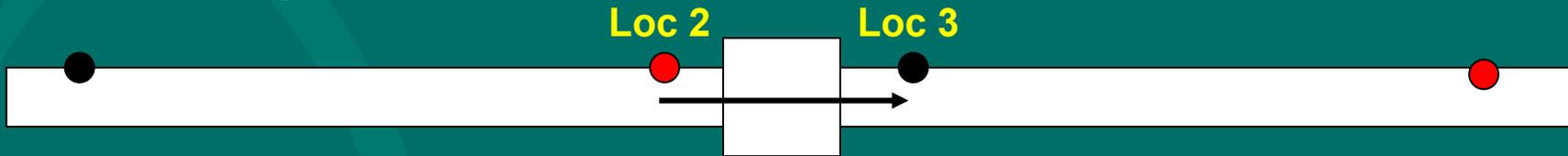
Test Analysis Comparison



Red=Analysis

Blue=Experiment

Test Analysis Comparison



Red=Analysis
Blue=Experiment

Conclusions and Future Work

- If capturing low-order features is the goal, model may be acceptable in the frequency range of interest.
- Details of the transfer function not captured.
- More focus on modeling input and BCs.
- Parameter variation study on simulation.

We would like to acknowledge....

- Engineering Sciences and Applications Division at Los Alamos National Laboratory.
- The Mathworks, Inc. (MATLAB Software).
- ABAQUS, Inc. (ABAQUS Finite Element Software).
- Vibrant Technology Inc. (MEScope Software).
- Chuck Farrar, Gyuhae Park, and Phillip Cornwell.
- Mandy Rutherford and Jason Pepin.
- All other mentors and students who have advised us.