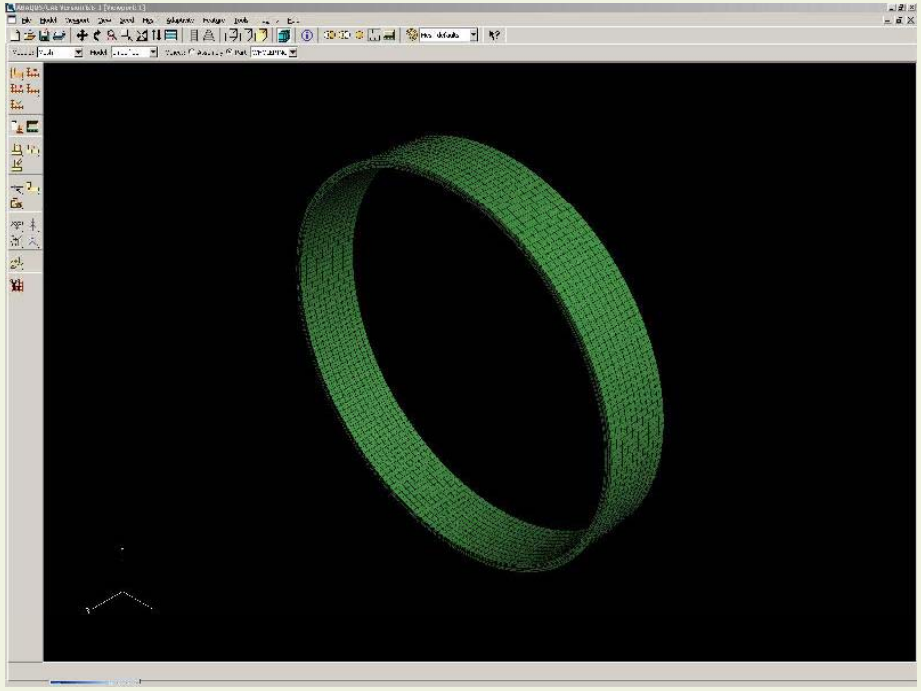
Validation Study of a Silastic J Viscoelastic Model



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Los Alamos Dynamics Summer School
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Motivation: Why do a validation study of the Silastic J material model?

- Numerical models (FE) must be verified and validated to be useful
- Specifically, we need to validate the model we have at higher frequencies
- Numerical modeling can reduce the amount of experimentation needed
- This study will serve as a basis for simulations of the future

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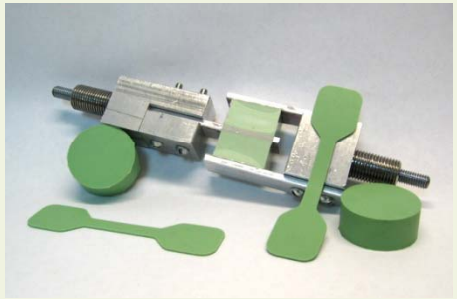
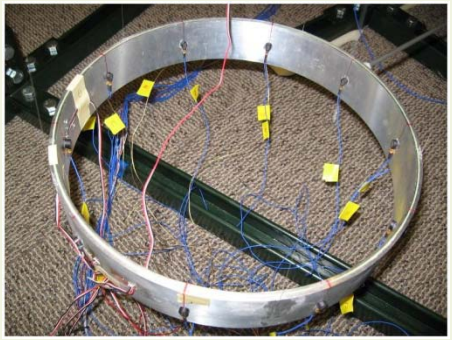
Outline

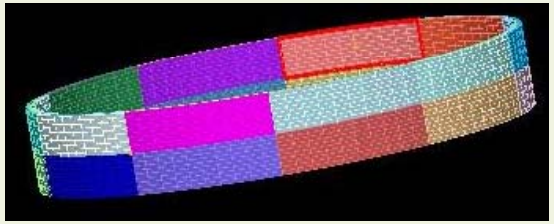
- Silastic J



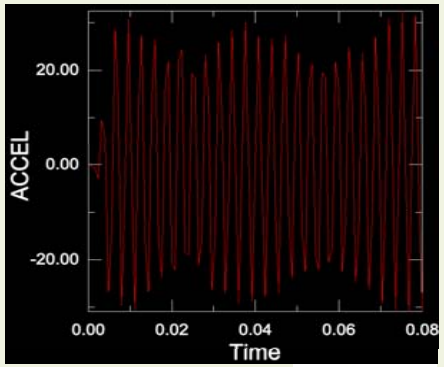
- Experimental Procedure



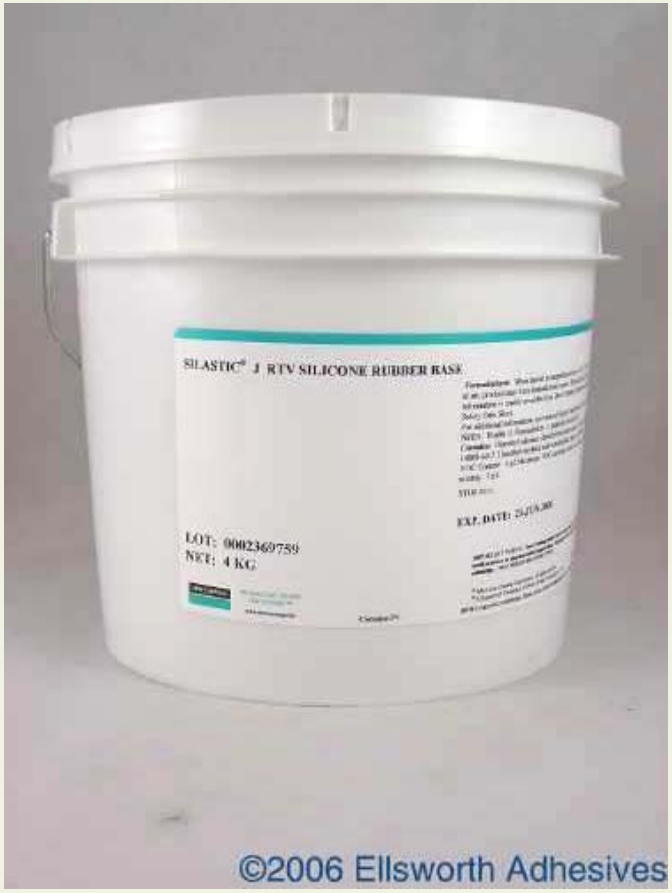
- Modeling



- Results

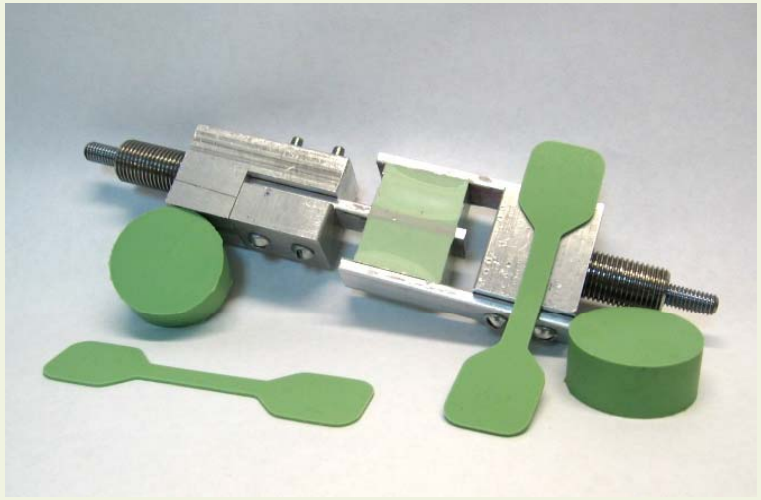


Silastic J is a silicone reinforced rubber that displays viscoelastic properties



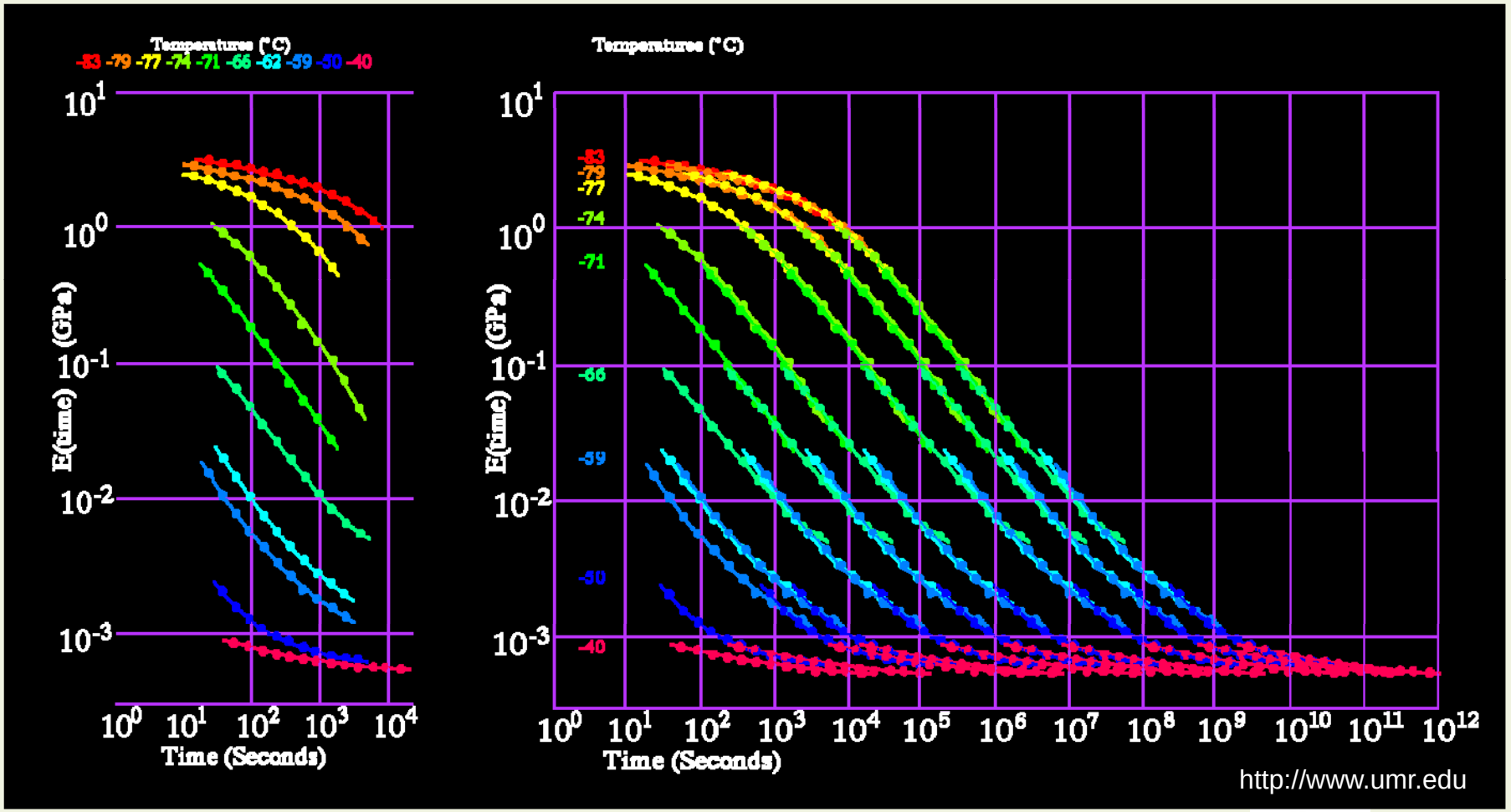
- Normally used as a damping material
- Chemically resilient and also commonly used for seals and gaskets
- Wide variety of applications: sports equipment, automotive, aerospace

Silastic J is easily manufactured via a two part mix



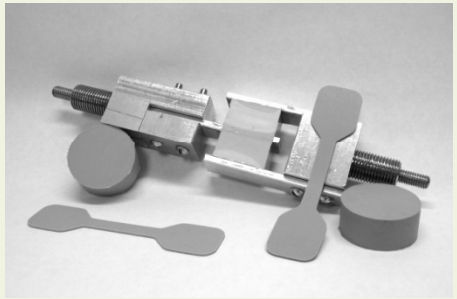
- Can be mixed and poured directly into the application or can be put into a mold for a desired shape
- Adheres well to metal for damping and sealing applications

Time-Temperature Superposition is an extrapolation of time and temperature data

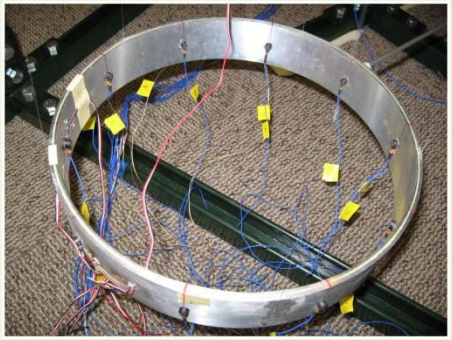


Outline

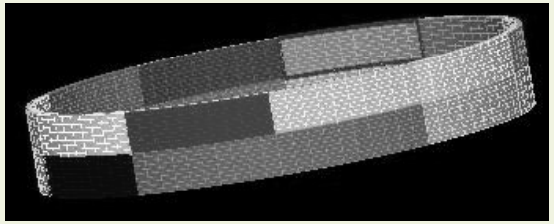
- Silastic J



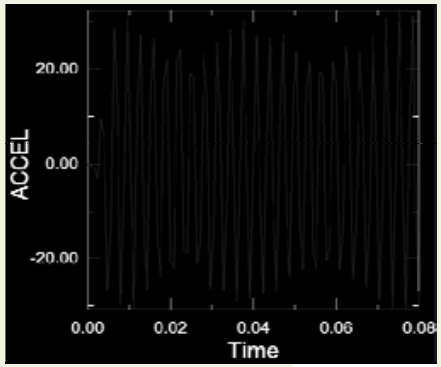
- **Experimental Procedure**



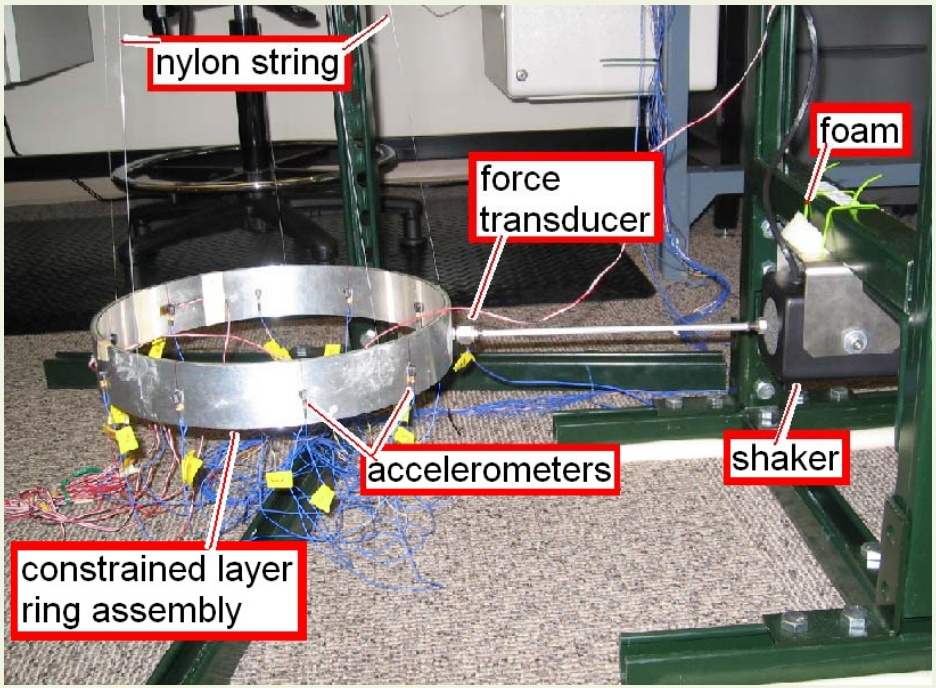
- Modeling



- Results

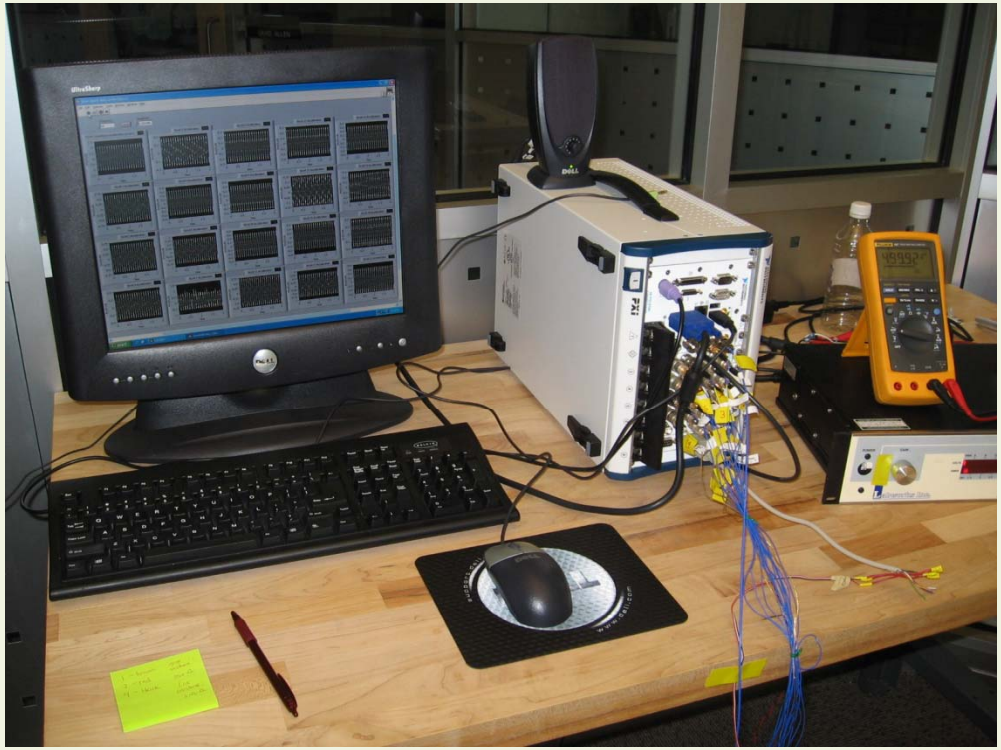


The experiment is setup to provide free-free conditions for sine-dwell testing



- Ring is suspended from monofilament line and super-glued to the side of the ring
- Shaker is isolated via foam
- Sine dwell testing performed to get steady state response

The experimental setup was designed to collect as much information as possible



- National Instruments PXI data acquisition system
- 20 channels of input
  - 19 accelerometers
  - 1 force transducer
- Thermocouple for temperature measurement

The experimental procedure was designed to eliminate experimental bias

Frequency

Magnitude

→ Temperature

Shaker used

Stinger position

User

There are many variables that affect the outcome of the experiment

Our goal is to:

Control the parameters of interest

Randomize the parameters we can not control

Block the parameters we can control

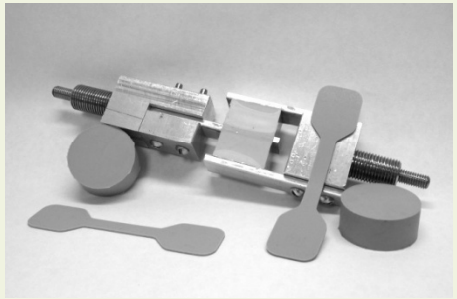
The Design of Experiments is finalized with the choice of parameter values

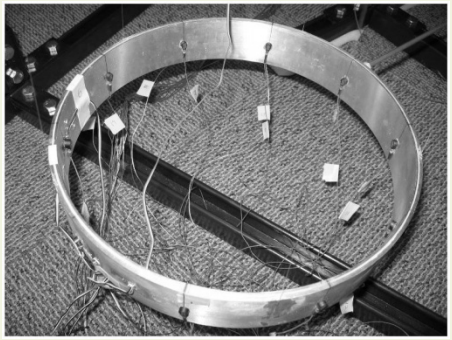
Trial	Voltage (mV)	Frequency (Hz)	Temp (°C)
1	800	8	
2	500	12	
3	800	1130	
4	500	12	
5	500	1130	
6	300	2220	
7	300	1900	
8	300	2780	
9	300	12	
10	300	2780	

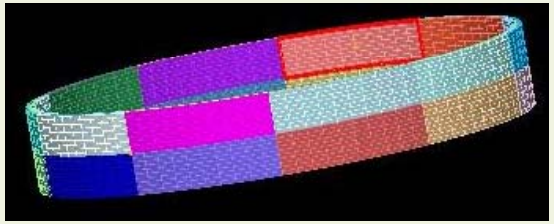
- Voltages: 0.3, 0.5, and 0.8V
- Frequencies: 8, 12, 320, 800, 1130, 1560, 1900, 2220, 2780, and 2960 Hz
- 10 trials or “replicates” each
- Total of 300 runs

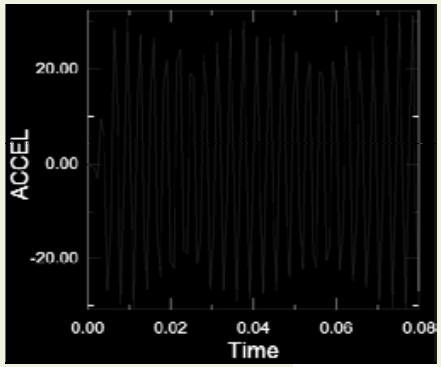
Outline

- Silastic J
- Experimental Procedure
- **Modeling**
- Results







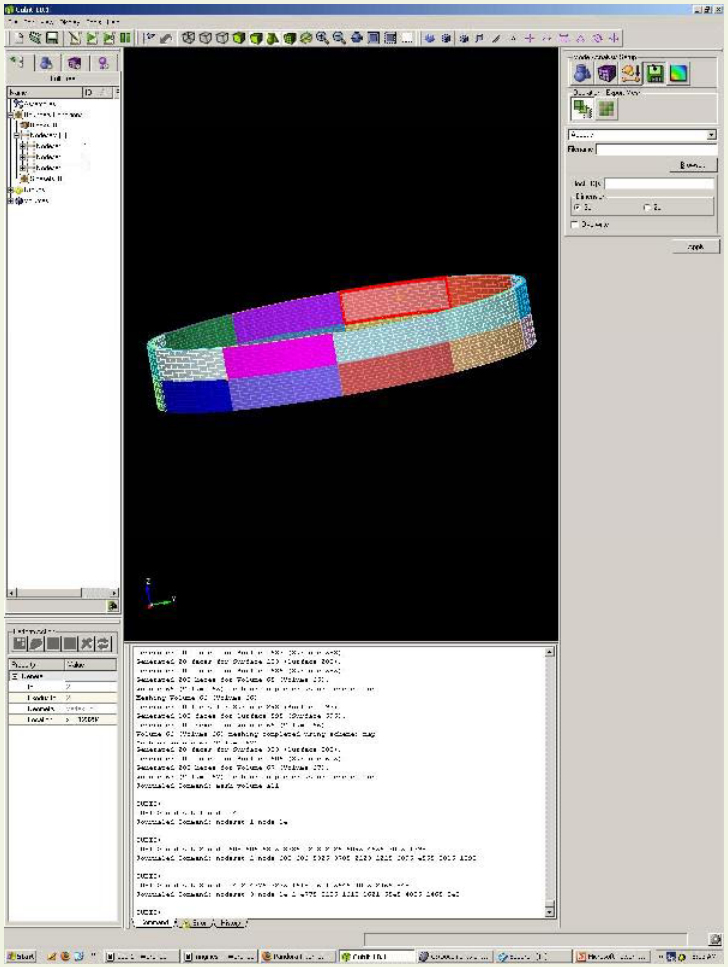


Design the simulation to account for variation in material properties

- We have estimated material properties Including a Young's modulus and Prony-series
- We varied the Young's modulus by -10,-5,+5, and +10 %
- ABAQUS® normalizes the Prony-series

http://www.ptli.com

We modeled of the ring in ABAQUS with the help of Cubit

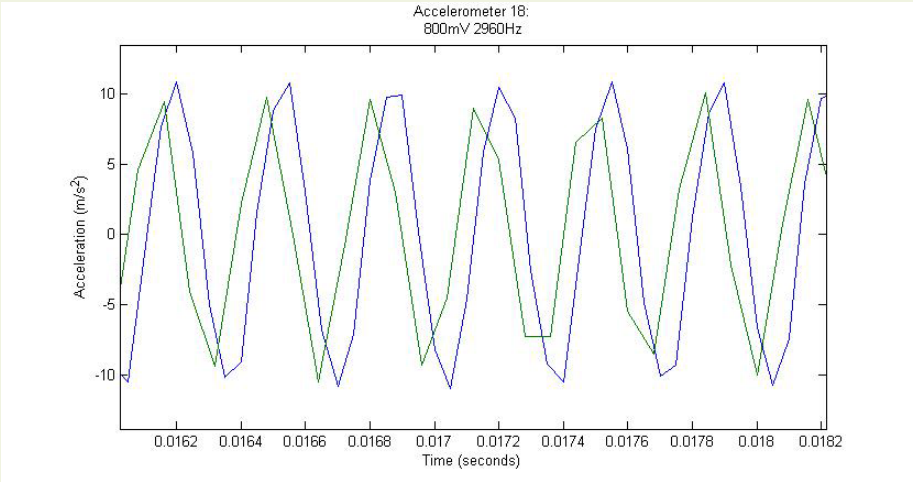


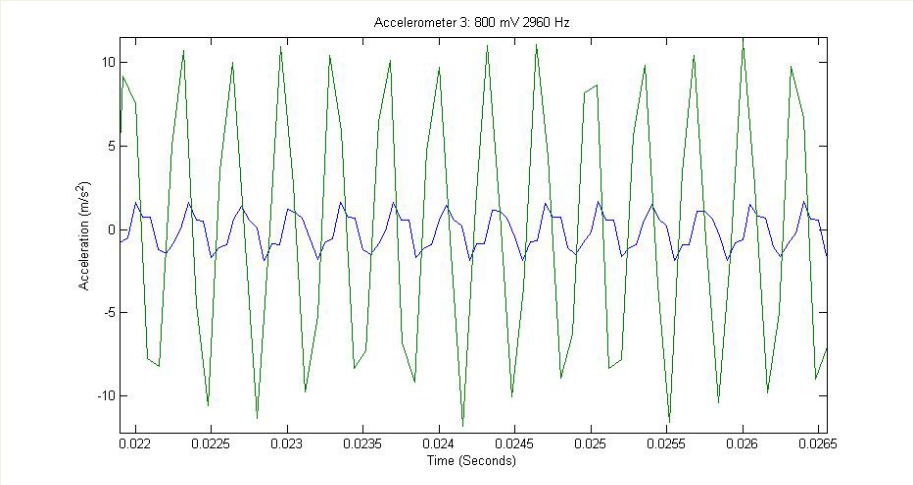
- Viscoelastic data doesn't work with eigenvalue extraction
- Too many elements in first model
- Difficulty with tie constraint
- Sandia National Laboratory's Cubit program
- One part with three different 'sections'

Even with the revised model, computing time is very significant for dynamic response

- First impact test model took ~60 hours to run
- Steady state responses can be modeled in shorter periods of time (~6-7 hours)
- Once the model was confirmed to be working properly, we submit the input decks to be run on multiple machines simultaneously
- Took acceleration data from the nodes where the accelerometers were placed on the ring

Viewgraph comparison of accelerometer data

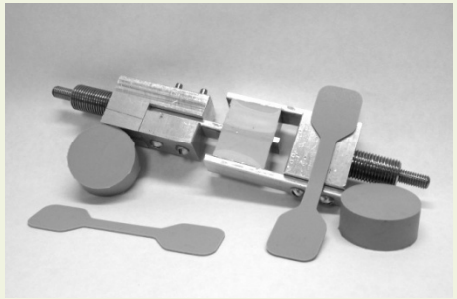




- Viewgraph norm for most accelerometers were quite good
- Since looking at signal power, phase is not of interest
- Accelerometers pairs on opposite sides (inside/outside) of the ring showed consistent data

Outline

- Silastic J



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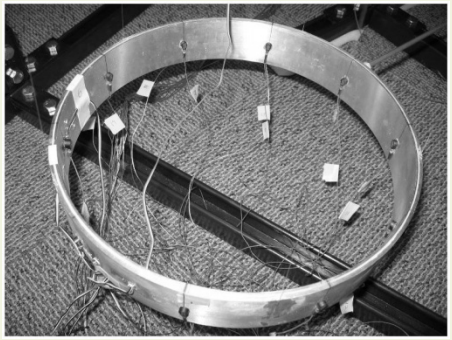

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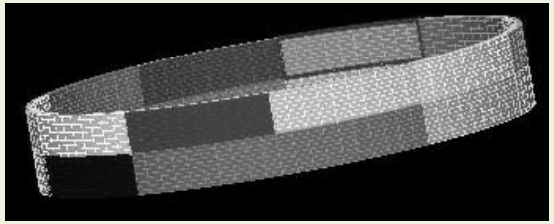
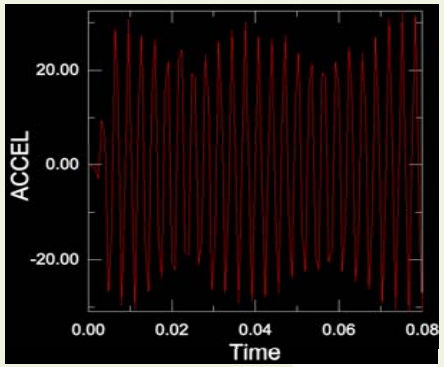
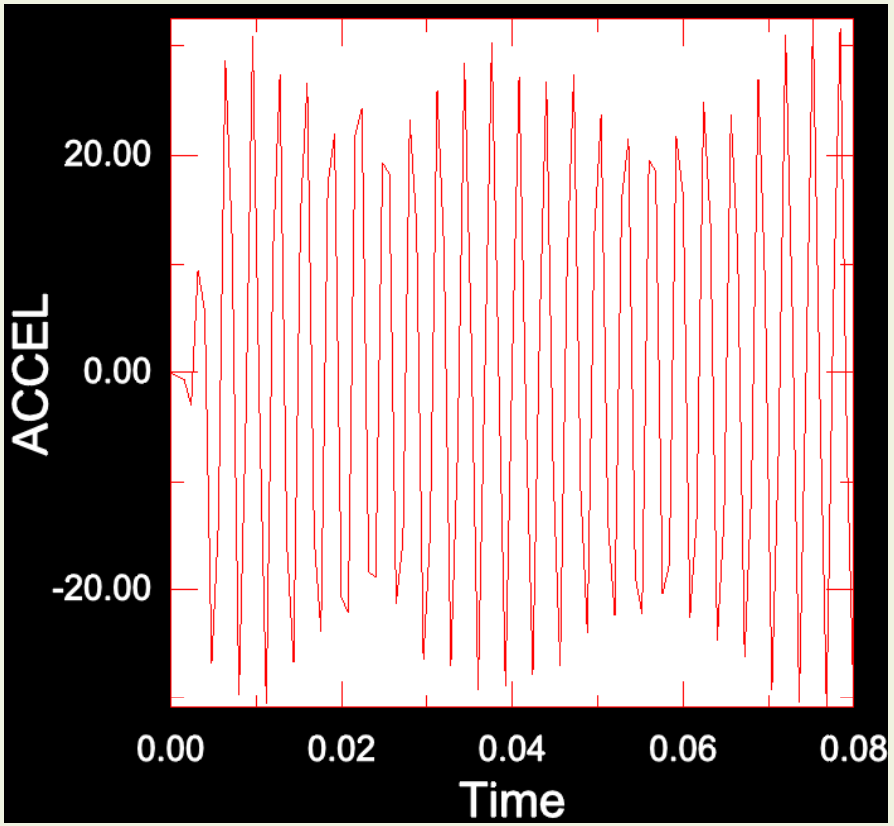


- **Results**



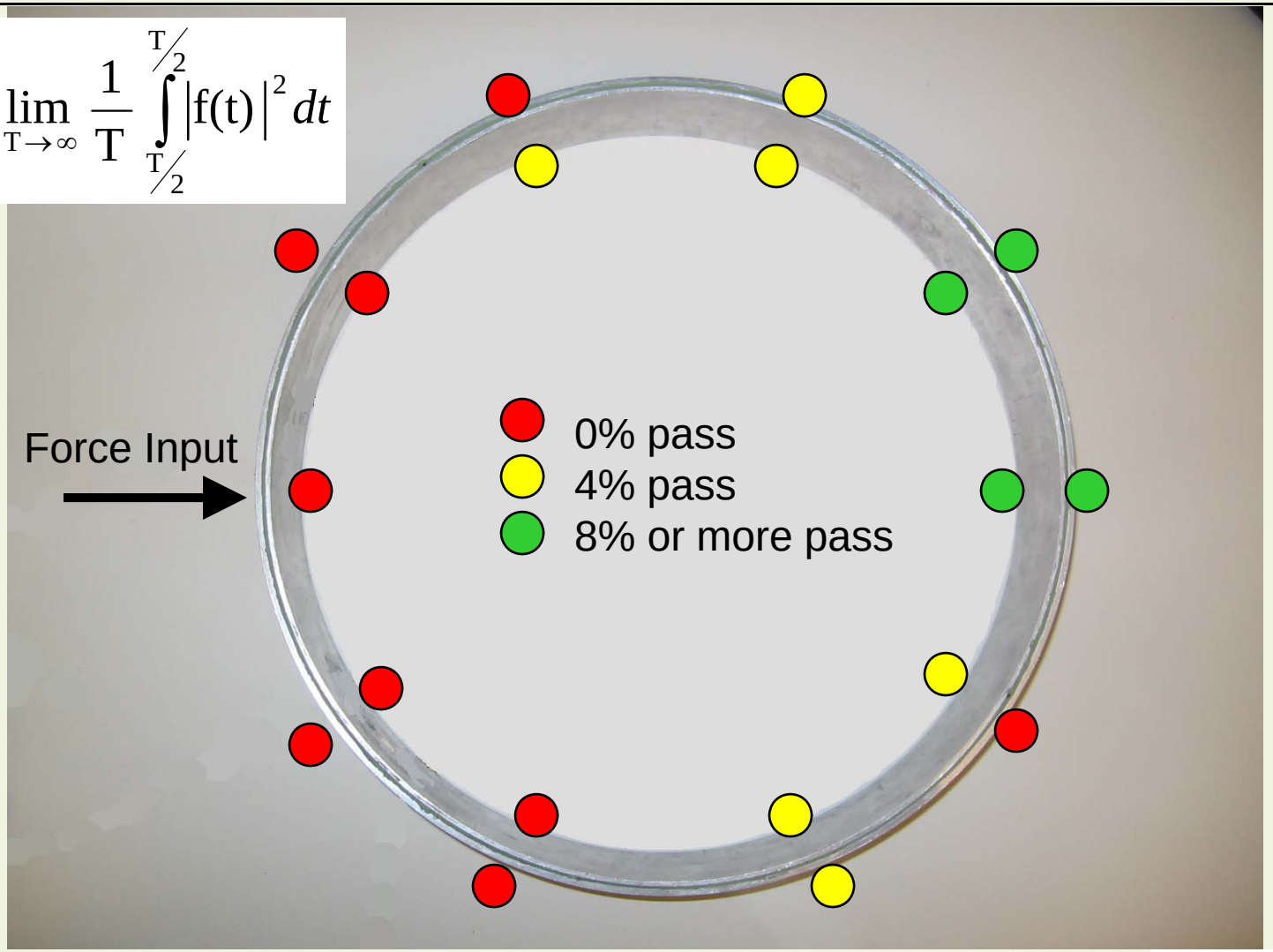
Results

- The experiment and FEA yielded acceleration time-history data
- MATLAB was used to import and post-process data
- Statistics were used to compare simulation and experimental results

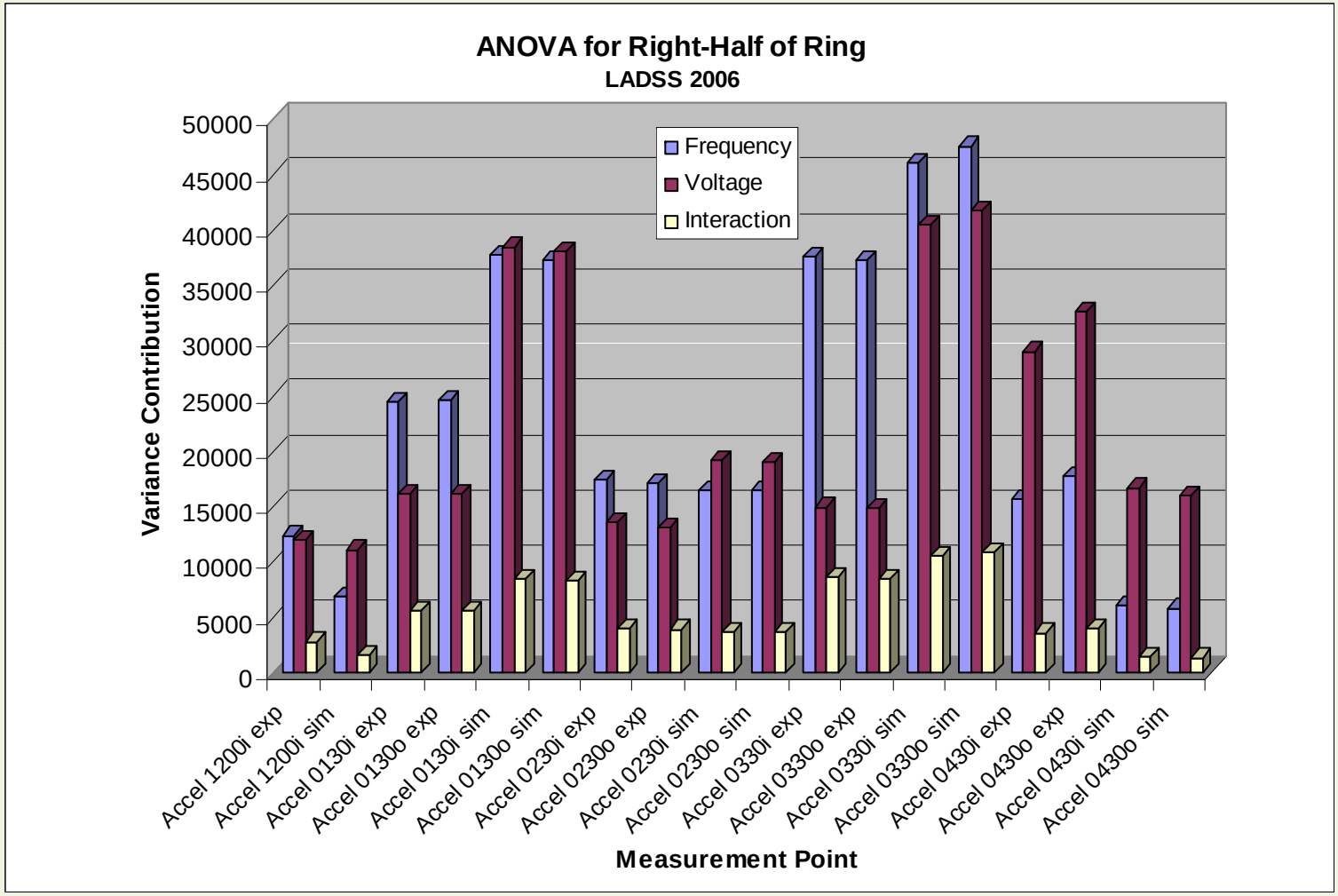


Results Continued: T-Test

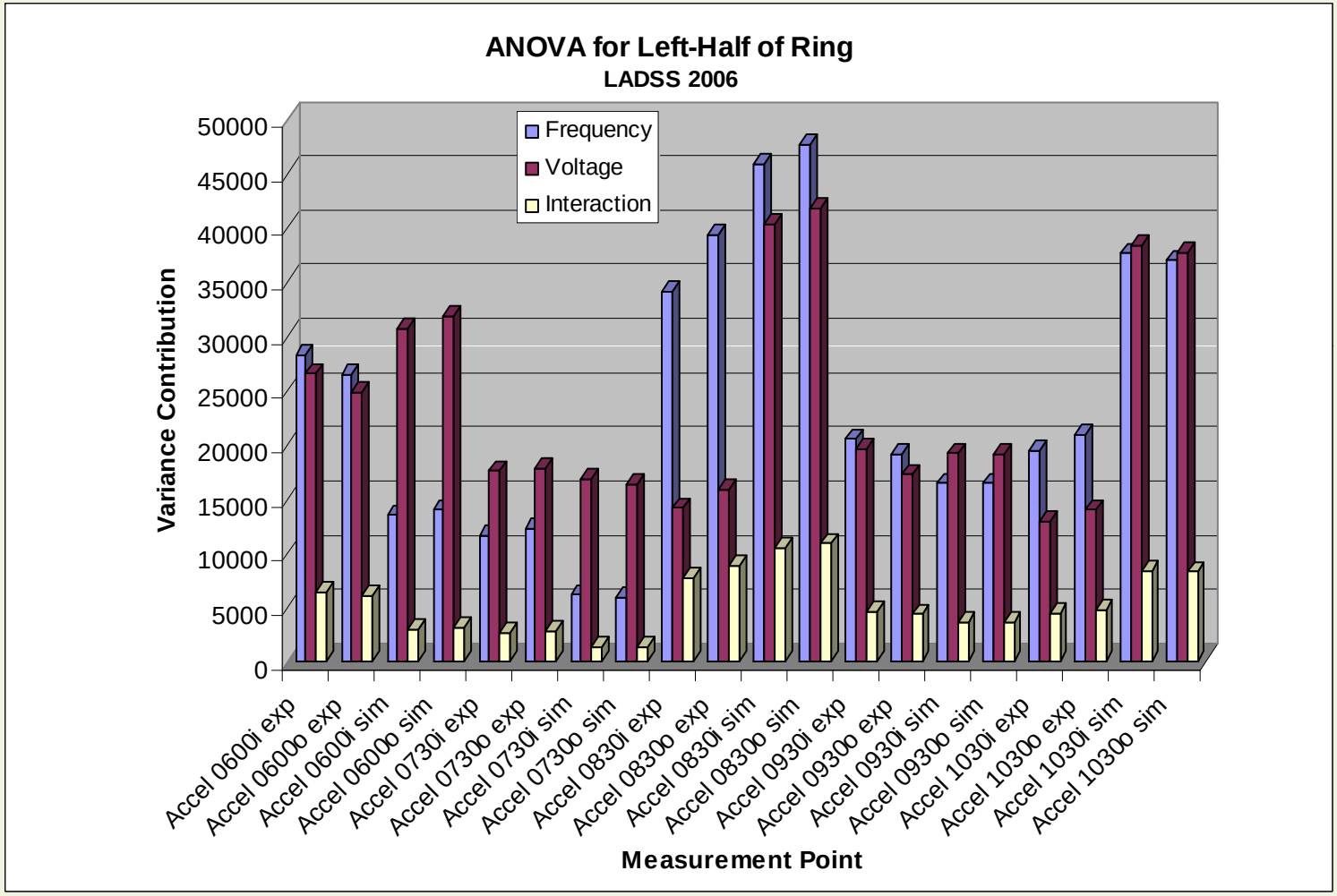
$$P_f = \lim_{T\to\infty} \frac{1}{T} \int_{T/2}^{T/2} |f(t)|^2 dt$$



Results Continued: ANOVA



Results Continued: ANOVA



Principle Component Decomposition

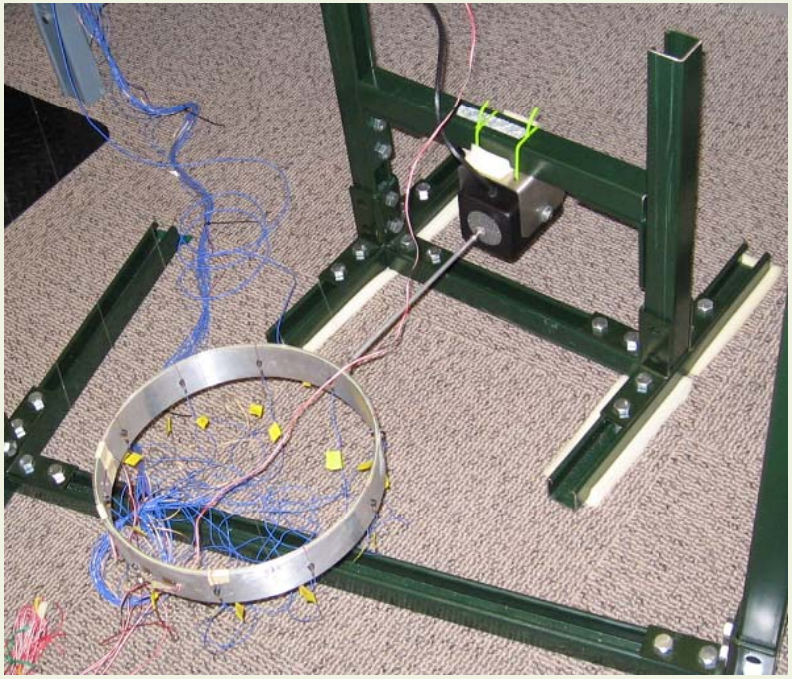
- Use the Singular Value Decomposition to compare two matrices of time-history data

$$A = U \sum V^T$$

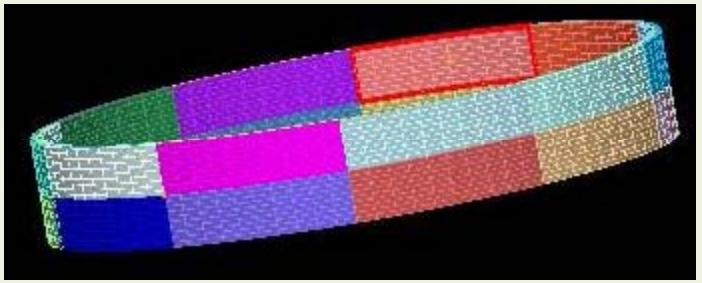
- Take the SVD of each time-series matrix to give three new matrices
- U and V are unitary, therefore $U^T U$, and $V^T V = I$, and this allows for two comparisons
- The final comparison is between the $\sum$ matrices of singular values for the experimental and simulation data

Overview and Questions

- Conducted experiments via DOE



- Used ABAQUS for FE modeling



- Performed statistical and other validation methods to compare data

Questions?

Acknowledgements

HKS (ABAQUS)& Mathworks (MATLAB)
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Los Alamos National Laboratory

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Miles Buechler

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Anthony Puckett

Bob Stevens

Our fellow LADSS students