Cryomodule Transport Studies at Fermilab

July 20, 2007

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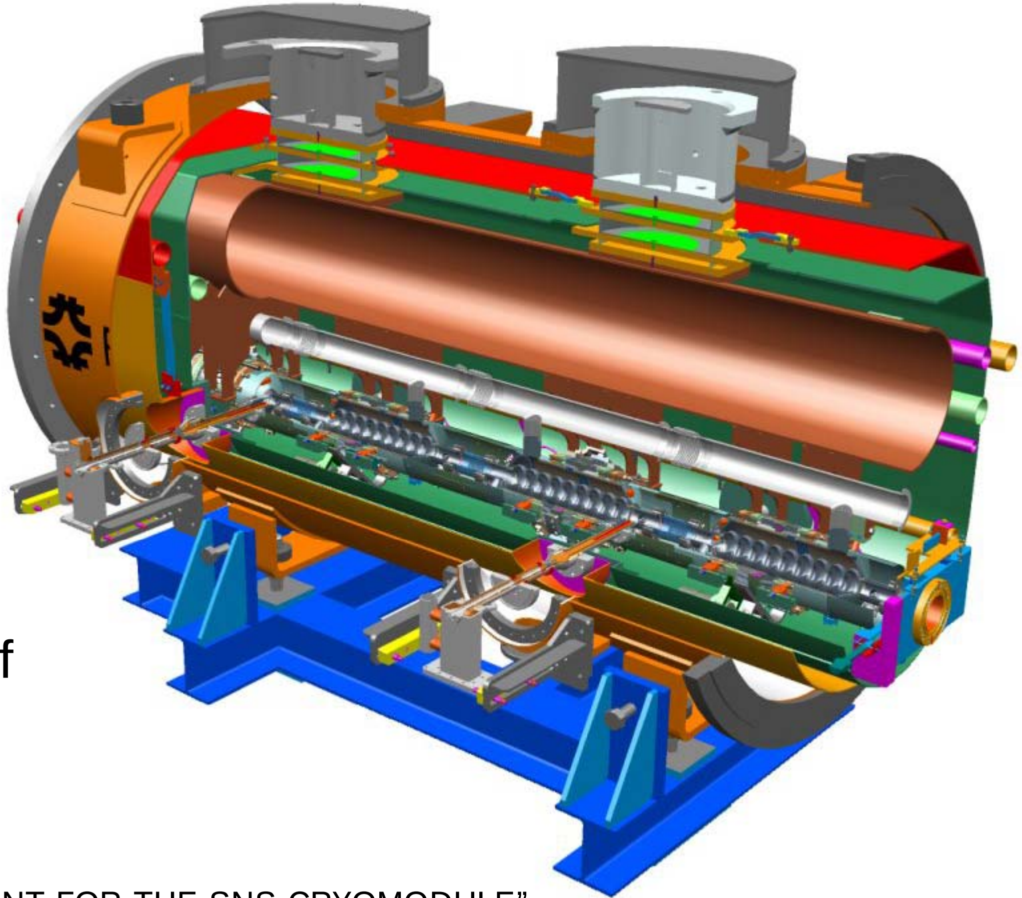
3.9 GHz Cryomodule Shock Evaluation



Preliminary Shock Criteria:
- 4g Vertically
- 5g Axially (along beamline)
- 0.5g Transverse

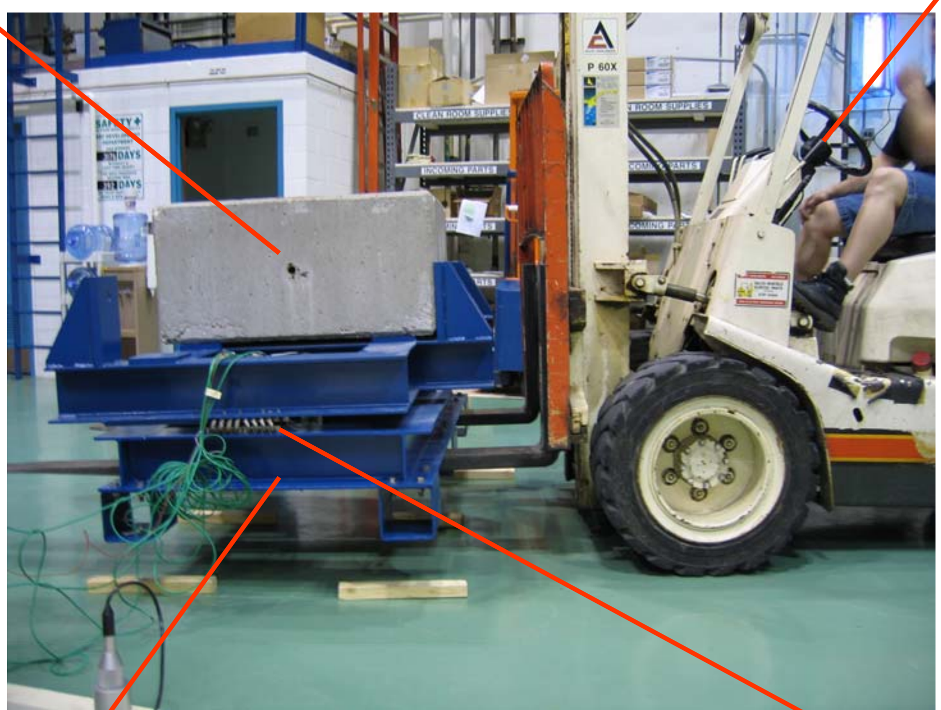
To be updated for 3.9 GHz, based on impact properties of materials at RT (e.g. input coupler)

T. Whitlatch et al., "SHIPPING AND ALIGNMENT FOR THE SNS CRYOMODULE"

3.9 GHz Cryomodule Shock Evaluation

Dummy Load (w/ similar C.G.)

Fork Truck

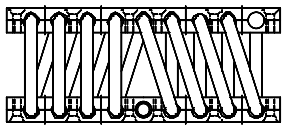


Addition of Base Frame

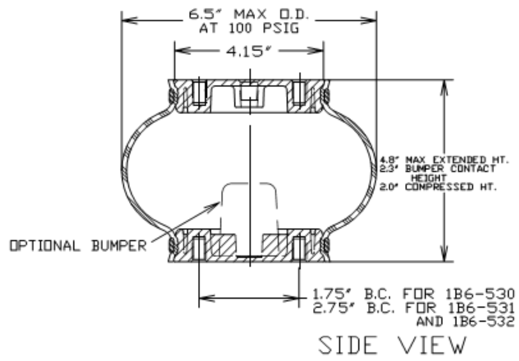
Addition of Isolators

Preliminary 3.9 GHz Transport Fixture Vertical Shock Results

- Drop tests using a fork truck
  - Geophones and accelerometers were used to evaluate isolator designs at maximum shock load (~ 8-g vertical)
- Isolators
  - Coil type



  - Goodyear air spring type
    - Inflated to 35 psi
    - Inflated to 50 psi
    - Inflated to 80 psi



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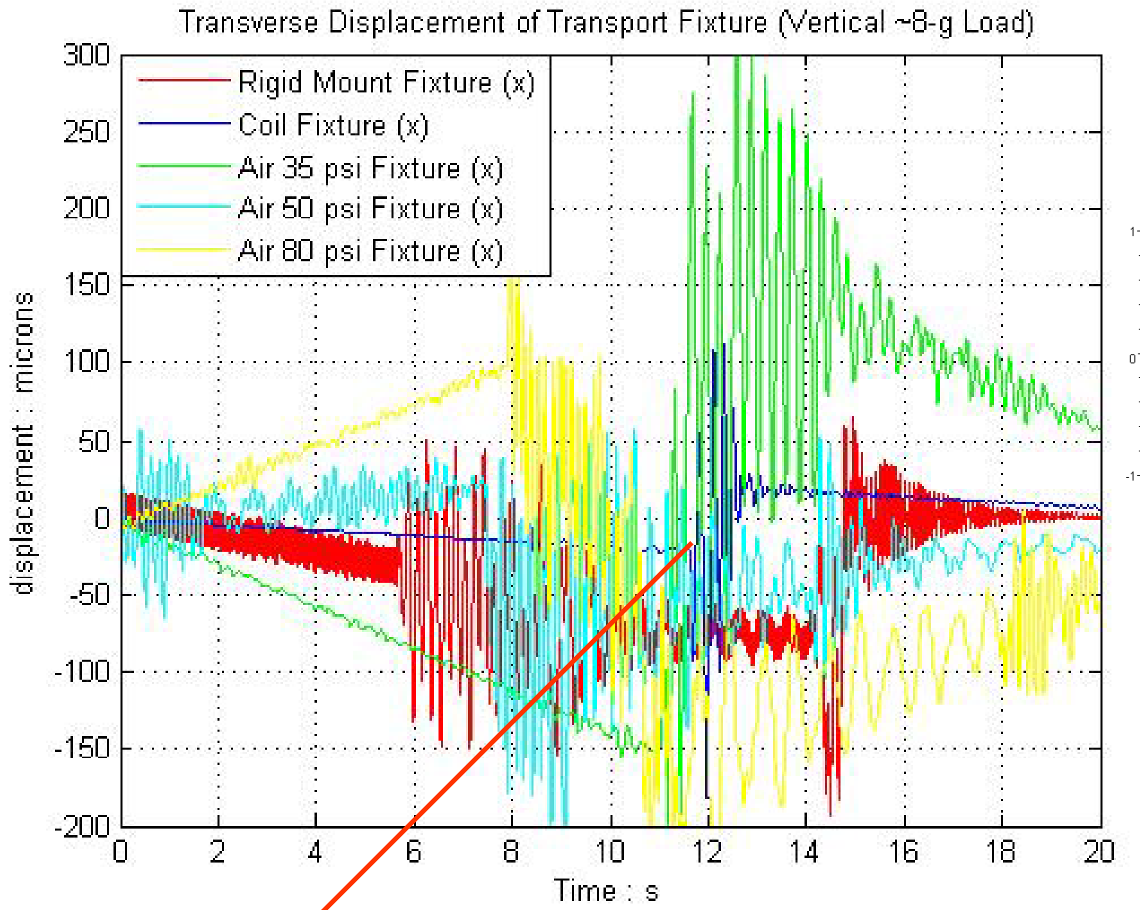
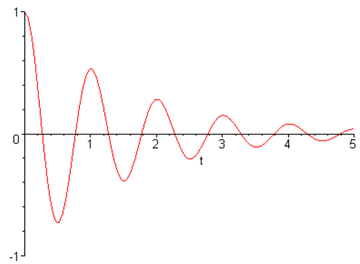
Transverse Displacement Response to Vertical Shock



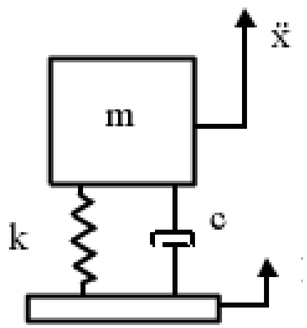


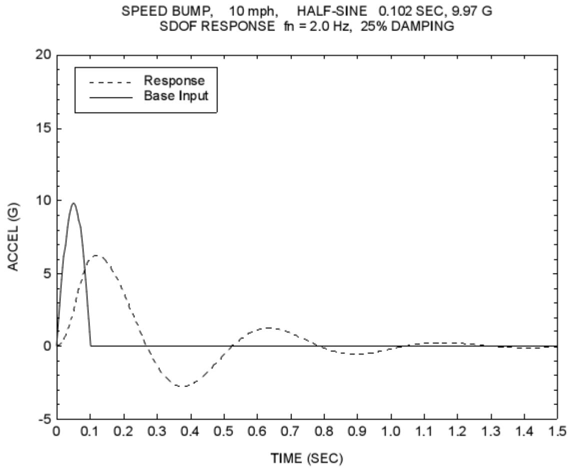
Under-damped systems

Coil Isolator had the least displacement with the quickest recovery

Shock Example

- Car passing over a speed bump
  - 3" high half-sine wave speed bump
  - Traveling 10 mph, 0.102 sec pulse
  - Natural frequency 2.0 Hz with 25% damping
- Vertical response
  - 8.2 g at base
  - 5.2 g on mass (m)





3.9 GHz Transport Fixture Vertical Shock Result Summary

Case	Shock at Fixture (g)	Vertical		Transverse	
		Q-factor	Condition	Q-factor	Condition
Rigid Mount	8.0	2.8	Under-damped	6.2	Under-damped
M12A Coil (3/8" wire)	5.6	7.8	Under-damped	1.6	Under-damped
M16 Coil (1/2" wire)	**4.9**	**4.7**	**Under-damped**	**0.3**	**Over-damped**
Air Spring 35 psi	7.4	1.9	Under-damped	20.1	Under-damped
Air Spring 50 psi	4.8	3.1	Under-damped	2.0	Under-damped
Air Spring 80 psi	5.8	5.9	Under-damped	10.9	Under-damped

Critically Damped System: Q = 0.5

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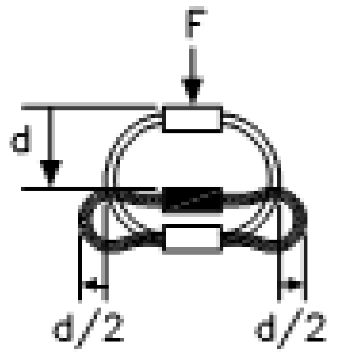
Coil Versus Air Spring Isolator

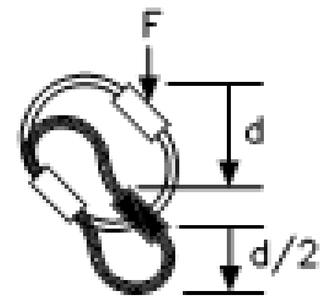
- Coil design benefit over air spring
  - Reduces shock to same level
  - Reduces vibratory motion after impact
  - Offers passive design (no maintenance)
  - Leads to greater over-the-road stability

Investigating 45 Degree Coil Isolator Configuration

- Compression Configuration
  - Slightly under-damped vertically
  - Slightly over-damped transversely



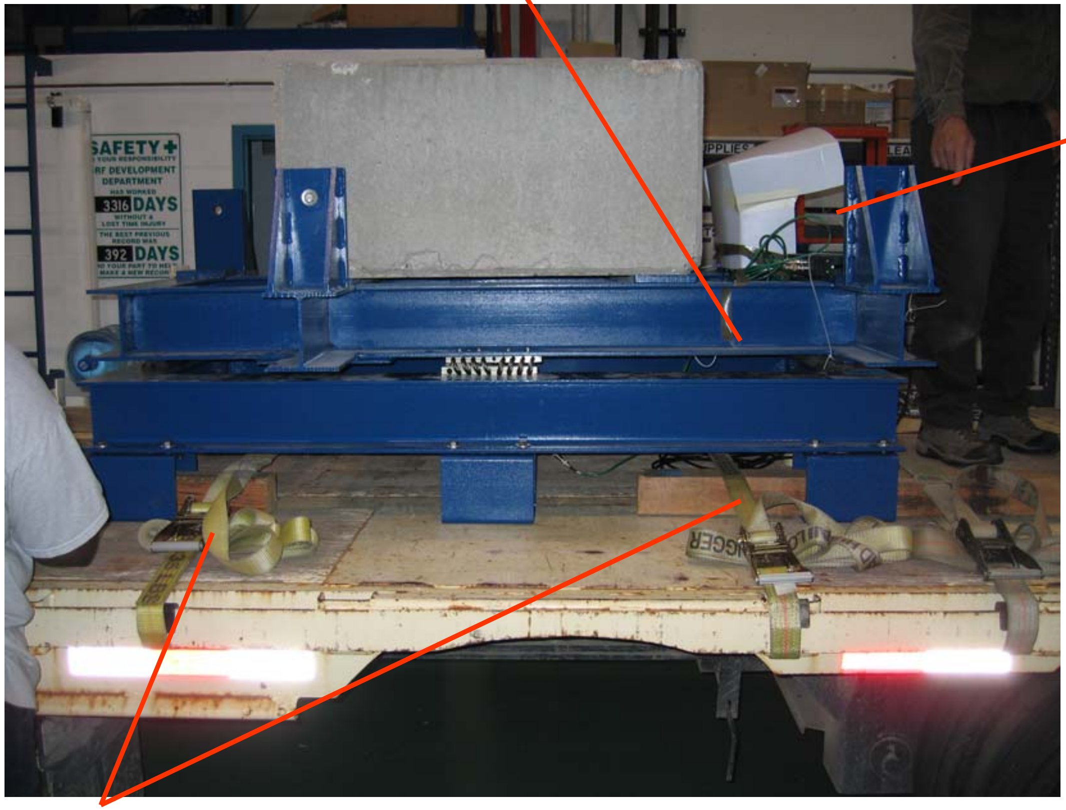
- 45 degree Compression Roll Configuration
  - May converge vertical and transverse response towards greater overall stability (or balance)



3.9 GHz Cryomodule Over-the-Road Studies

Geophones (in x & y direction)
on frame and fixture

DAQ system
onboard



Base frame rigidly attached to air ride flat bed

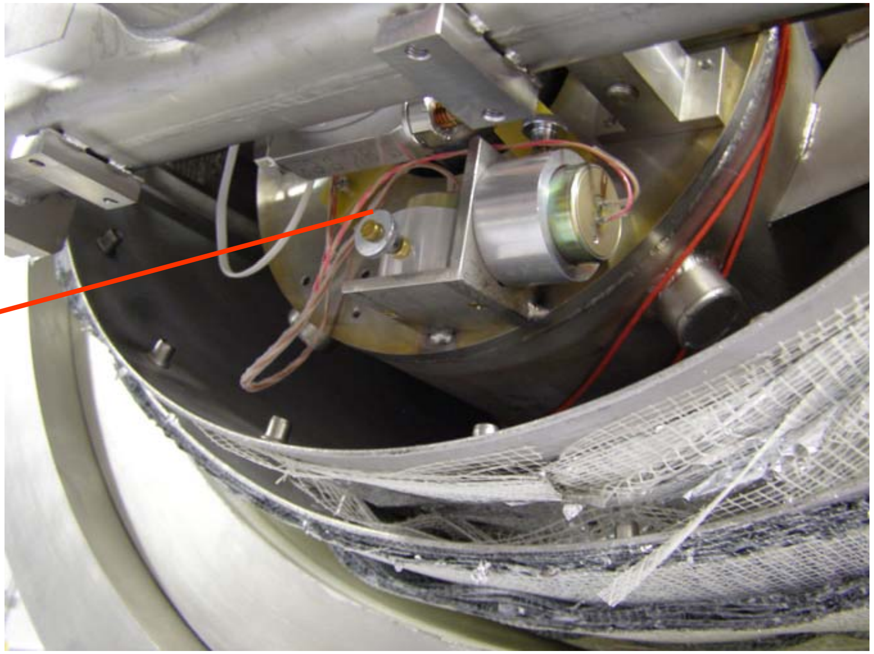
Over-the-Road Studies

- Characterize vibratory motion in terms of displacement and frequency
- Evaluate isolator design's response to dynamic shock
- Estimate design transmissibility

Cold Geophone Location Selection for TTF Coldmass Transport

a) Input from Alessandro Bertolini and Ramila Amirikas (DESY) based on cold measurements on TTF Cryomodule #6

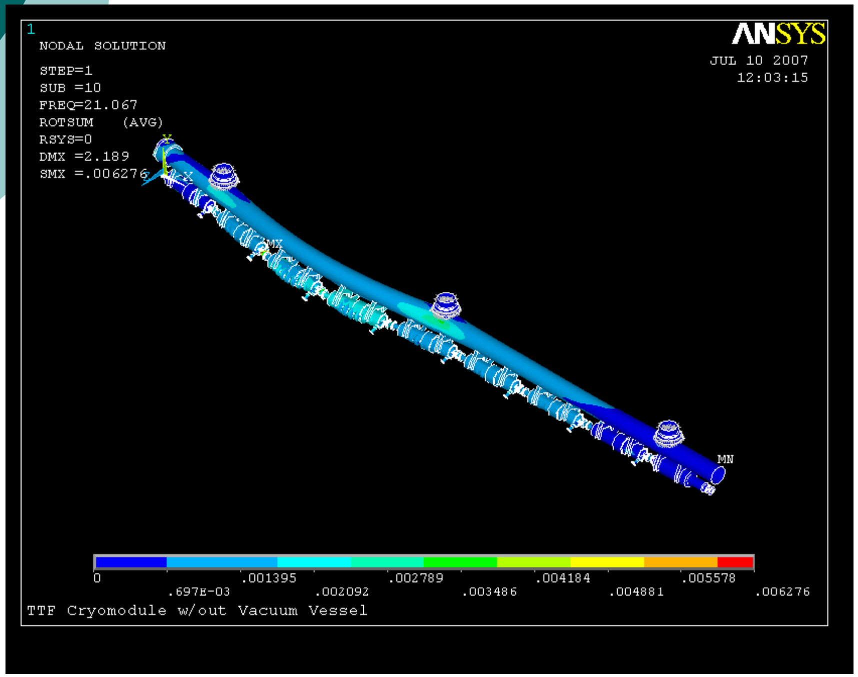
Geophones on quad at DESY



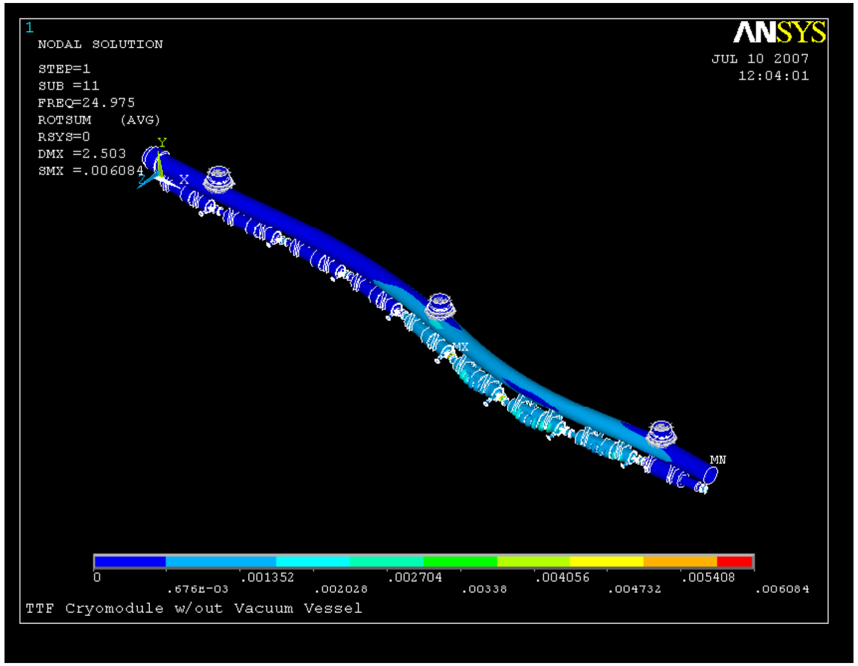
Also, Cryomodule Instrumentation Team input and support

Warm Geophone Location Selection for TTF Coldmass Transport

b) Warm points of interest defined by FEA study regarding motion during transport



Mode 10 (21 Hz)

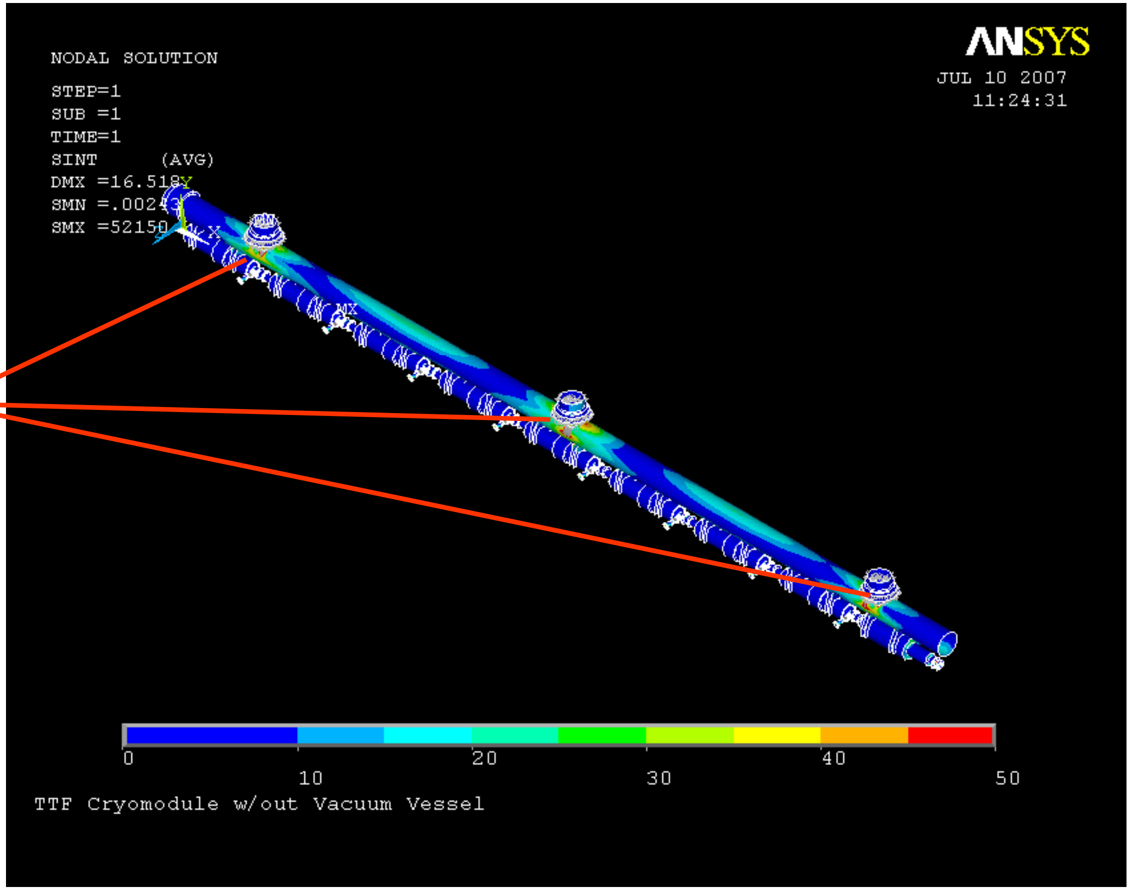


Mode 11 (25 Hz)

Strain Gauge Location Selection for TTF Coldmass Transport

Strain gauges applied along HeGRP at points of interest

Provides: deflection and stress



Future Work

- 3.9 GHz fixture transverse and vertical shock testing of 45 degree coil design
- 3.9 GHz fixture over-the-road studies continue
- Prepare for transport of 1.3 GHz CM coldmass to study dynamic response of movement
- TTF Cryomodule transport studies
  - Shock
  - Over-the-road