Simulating and Testing the Damping of Targets in Accelerator Based Experiments

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FERMILAB-POSTER-21-081-STUDENT

Background

All accelerator based experiments use targets when converting high-energy proton beams into new particles. This process, however, results in aftershock oscillations that can apply a great deal of stress to it. These aftershock oscillations, if not accounted for, can result in inaccurate life span estimations. The amount of oscillations, however, can be reduced by increasing damping, the gradual dissipation of energy over a period of time. Therefore, the main purpose of this project is to measure the damping ratio of the beam. This is done by modelling and testing a basic target design so a deflection can be applied to it. By deflecting it a certain amount and then observing its release, we will be able to measure the frequency of the movements that occur post deflection and then calculate the ratio.

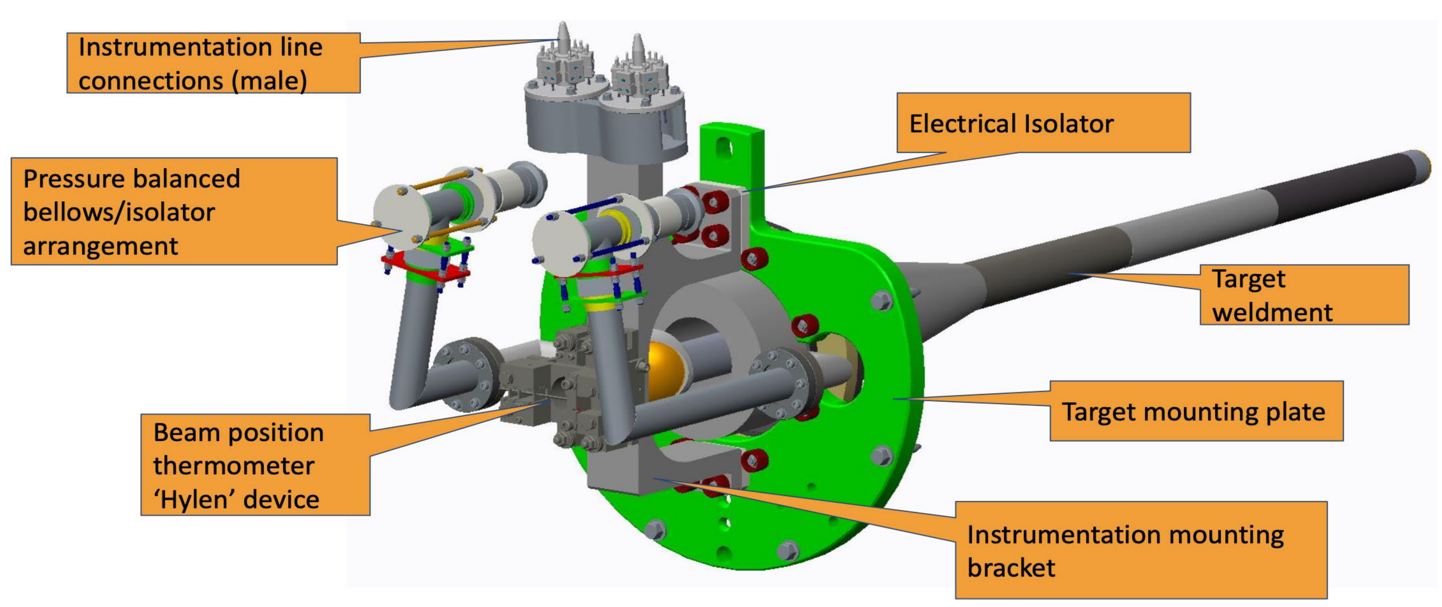

Figure 1. Target for LBNF/Dune Project

Process

The beam is modelled in ANSYS and a modal analysis program is used to determine the natural frequencies. A transient analysis program is then used to determine the time-dependent response so the damping ratio can be found after the calculated force is removed from the beam.

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.

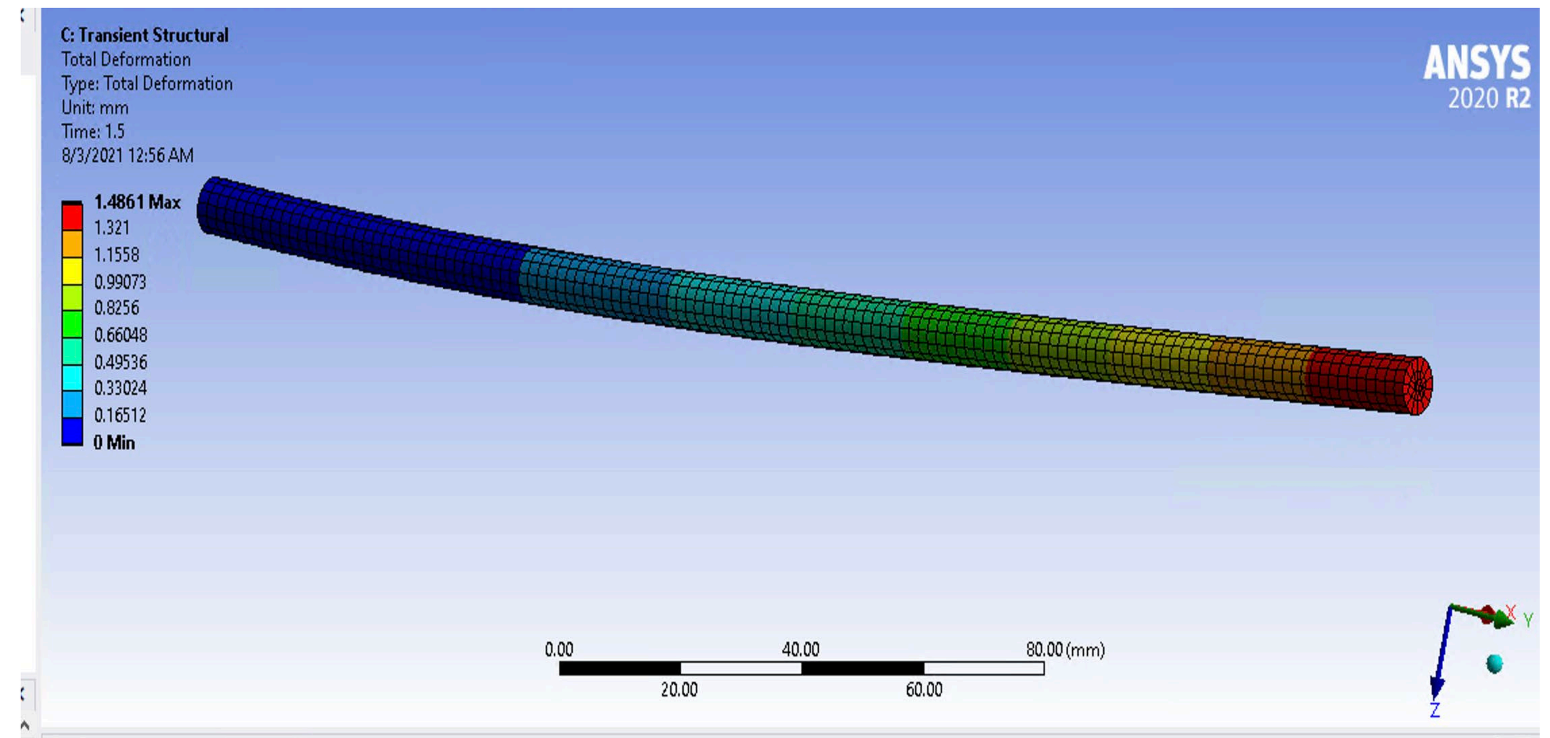

Figure 2. Basic ANSYS Cantilever Beam Design Used to Mimic the Target

Current Results

Below are the graphs illustrating the deflection of the beam over 0.4 seconds and 1.5 seconds. The top graph shows in more obvious detail the damping effects of the material when the deflection is reduced gradually, while the bottom graph shows the wavelength when the force is removed immediately. Figure 3 has a damping ratio of about .0123, and figure 4 has a damping ratio of about .001019.

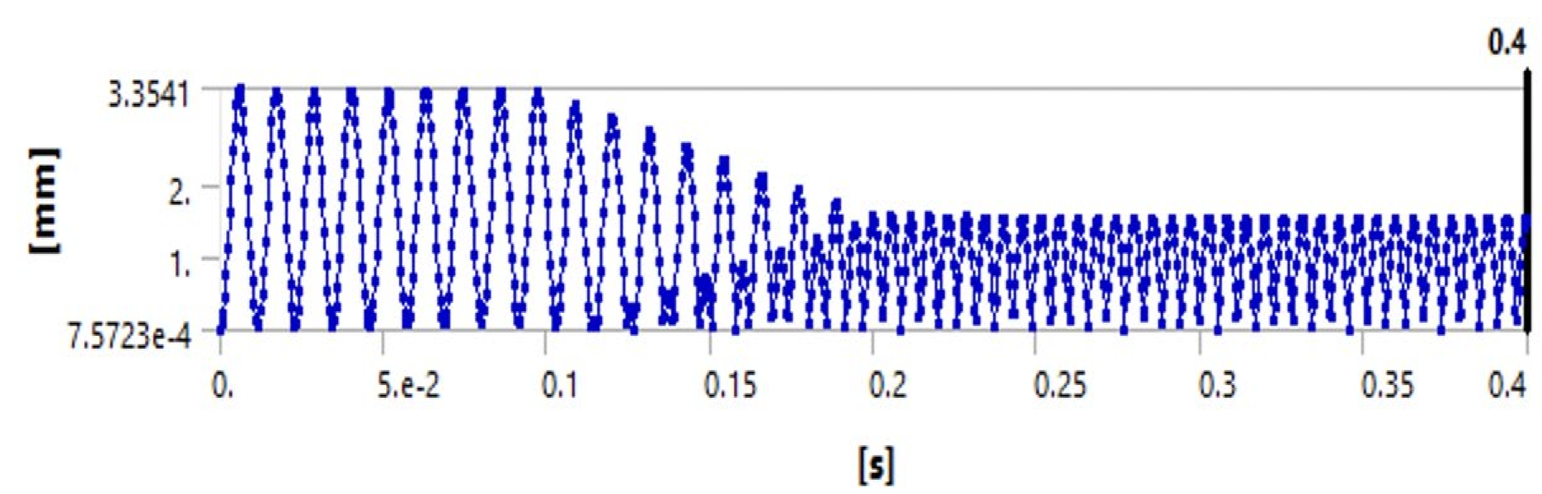

Figure 3. Deflection of Target After Gradually Released Force – 0.4 seconds

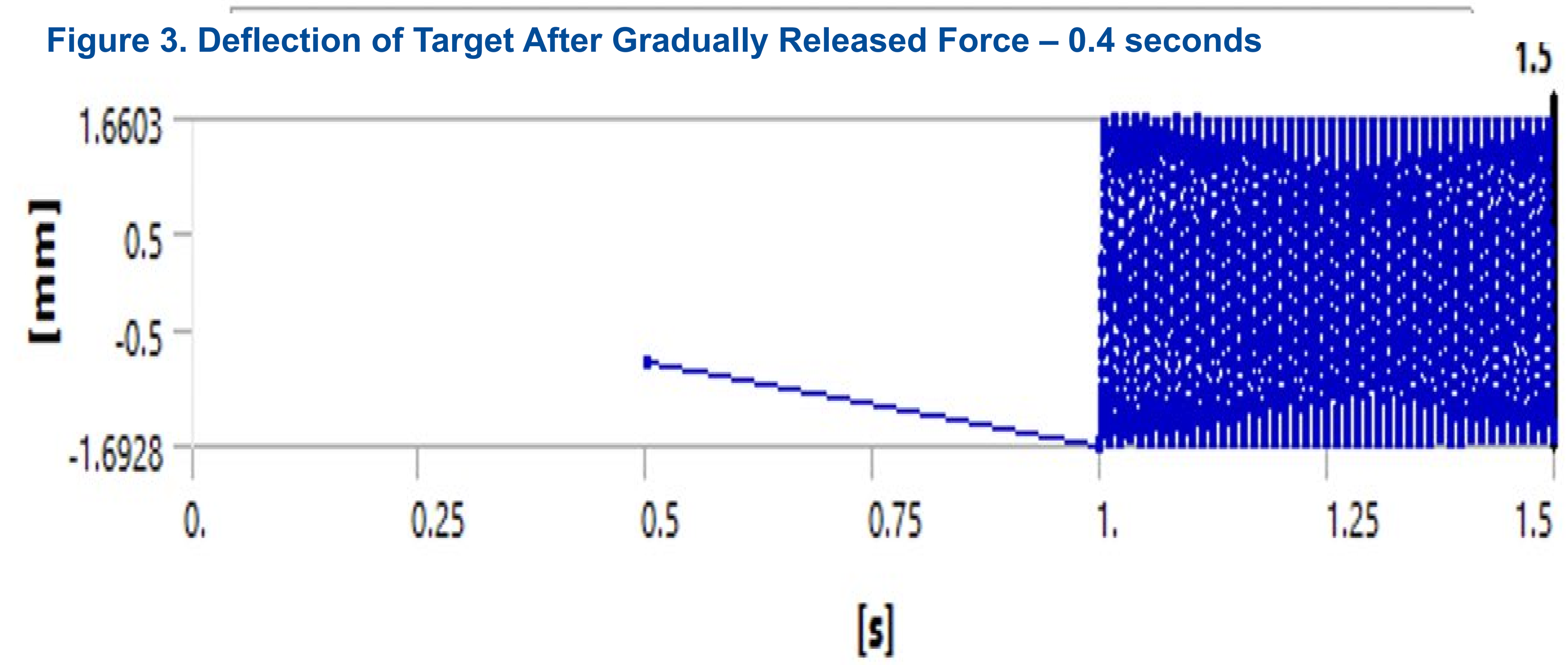

Figure 4. Deflection of Target After Force is Released Instantaneously – 1.5 seconds

Concept Design

The basic concept design will include a base with a clamping mechanism to hold the cantilever beam in place in a vertical position. The initial deflection will be applied by a linear sliding actuator which will deform it a certain amount before being retracted and allowing the beam to oscillate freely. The deflection will be measured by two different sensors. A strain gauge will be placed on the cantilever beam to measure the deflection through contact, while a laser doppler vibrometer will do the same through a contactless method.

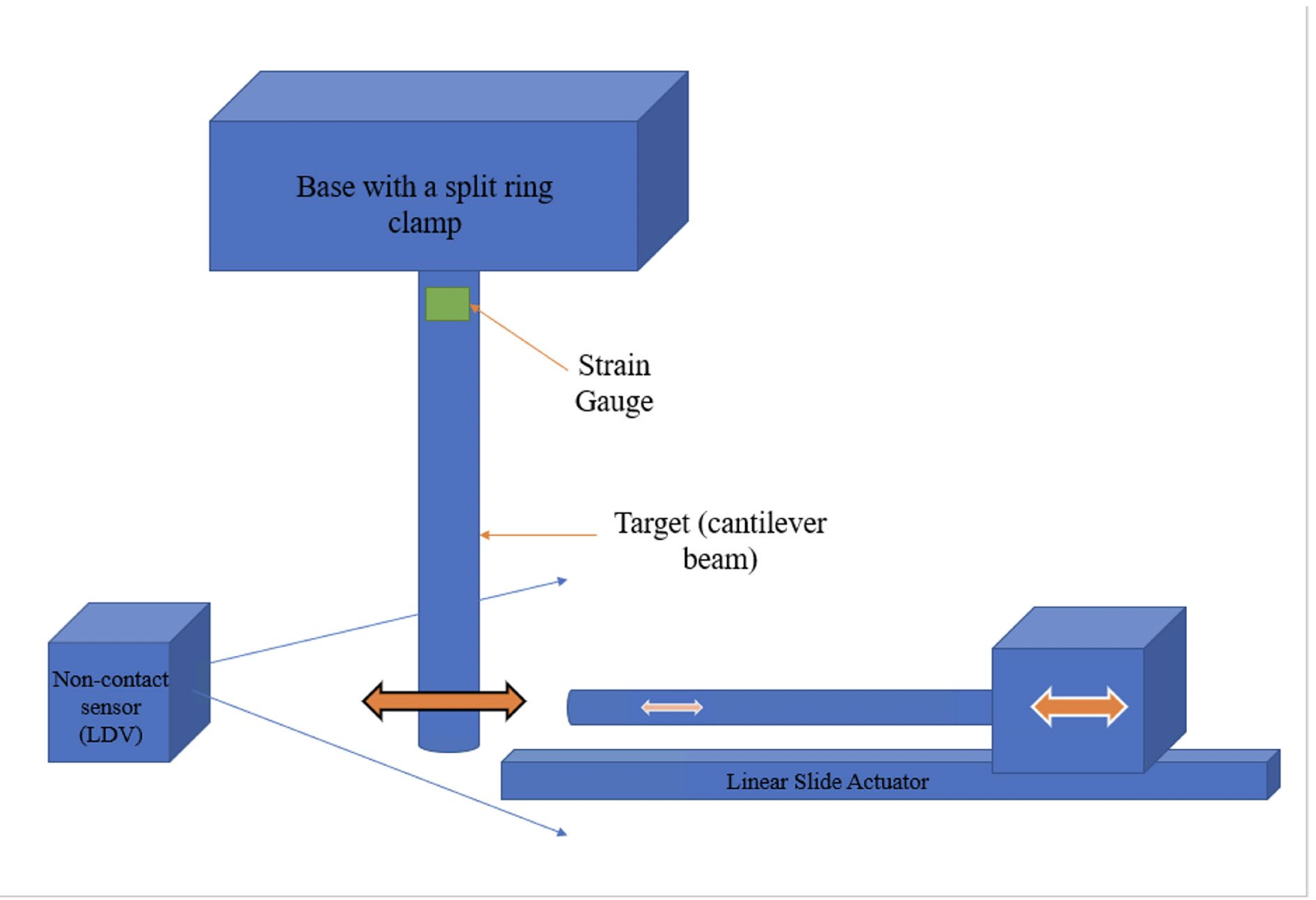

Figure 5. Basic Concept Design of Physical Experiment

Future Work

As the project continues, the next steps would be to construct and use the concept design to benchmark the simulation results. From there, more complexities will be added to the model in ANSYS so sensitivity studies can be run. After adding each new complexity, the same steps will be repeated so the simulation results can once again be compared to the experimental.