MAGIS-100 Atom Source Support Preliminary Design

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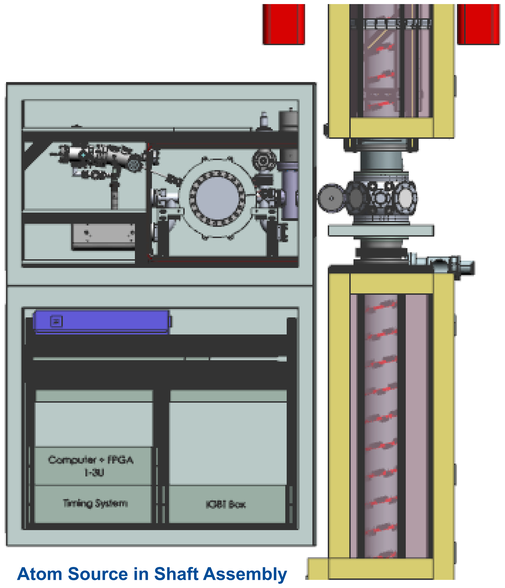
FERMILAB-SLIDES-20-084-AD

Atom Source overview

There are three Atom Sources within the MAGIS-100 experiment, located at the ends and midpoint of the shaft, adjacent to the vacuum tube.

Each Atom Source weighs approximately 700 pounds and contains the optical components for the atom interferometry and delivers the Strontium.



Atom Source in Shaft Assembly

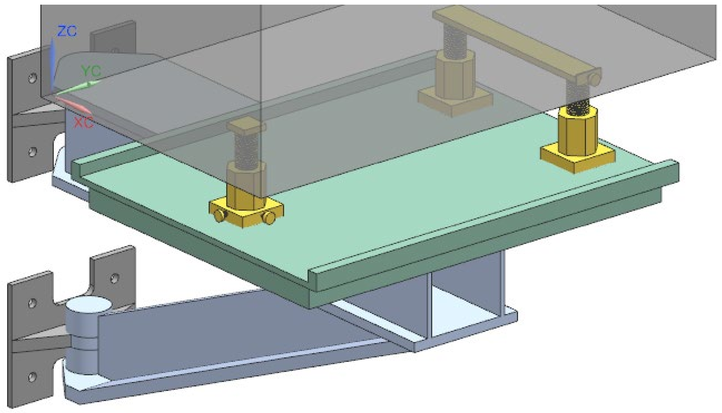
Process

My process for the design followed three main steps:

Initial hand sketches were completed to lay out the possible designs of each component, beginning with the main support structure.

NX models were then made to visualize the structure in three dimensions, allowing for easier redesigns.

Finally, NASTRAN simulations were done, and the model was adjusted from the data received.



NX assembly model of the support. Adjustors mounted to the bottom of Atom Source frame.

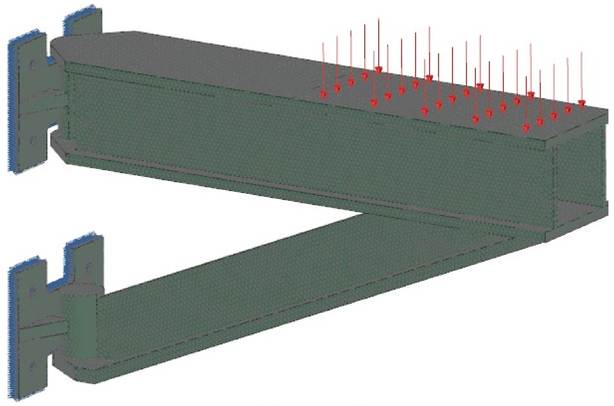
The supports are made of three main components:

Main Support Structure: Made of two flat plates, 47 inches in length, ending in rounded triangles to allow for pivoting.

Wall Attachment Plate: 12x10 inch plate with triangular attachment points and space for the support to rotate through it. Specifics of securing the plate will be analyzed by FESS civil engineers.

Adjusters and Adjuster Plate: 3-point adjuster design based off existing Fermilab designs. Adjuster plate design is not final.

Additional designs for a pivoting system were made and accounted for, but the completion of which was outside the scope of this internship.

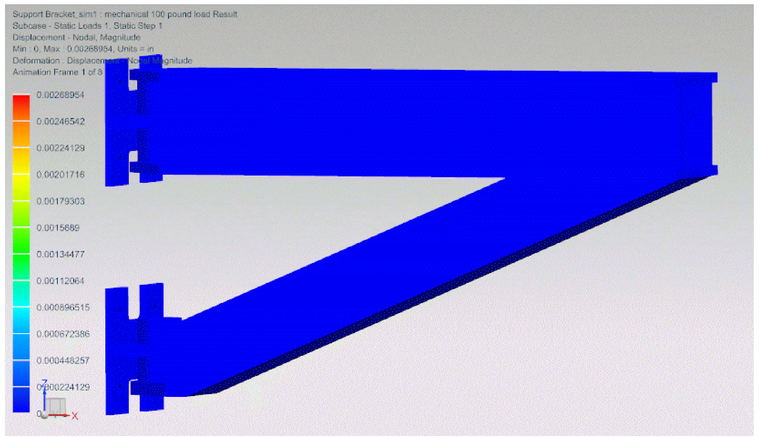


Simulations were done with NASTRAN. A 1000 pound force placed on half of the top plate and the back of the attachment plates were restricted to static placement.

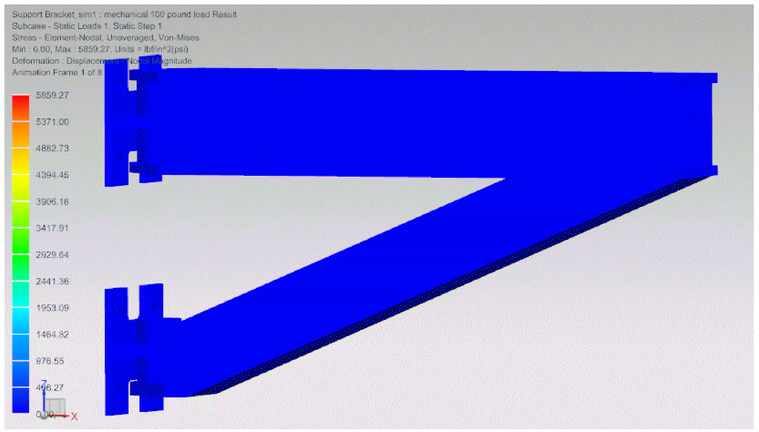
Simulation Results

The stress and displacement of the structure were simulated with NASTRAN. All components were set to be made of 304 Stainless Steel (also known as 18/8), however 316 Stainless Steel would also be acceptable for this application for their shared corrosion resistance and non-magnetic properties.

A 1000-pound force was placed on the top plate of the Main Support Structure in the area which overlapped with the Adjuster Plate. Additionally, the back face of the Attachment Plates was secured to remain static as they would be when installed.



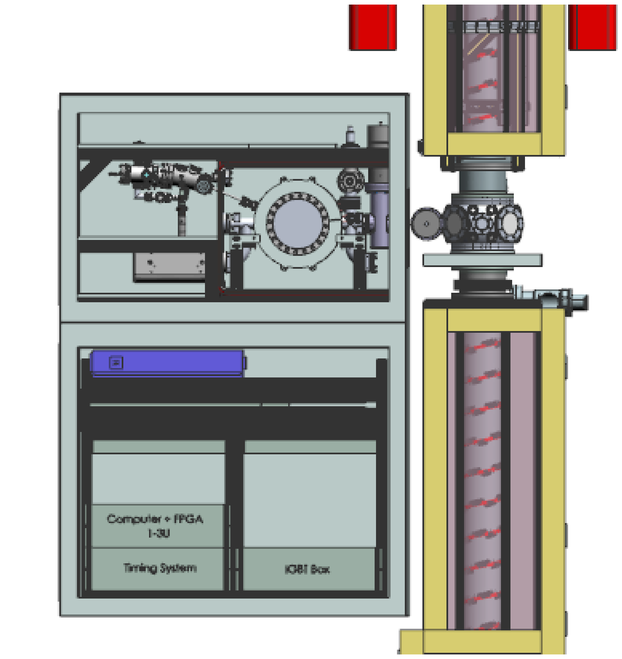
Displacement of the Main Support Structure and Attachment Plate. Maximum Displacement: 0.00268954 in,



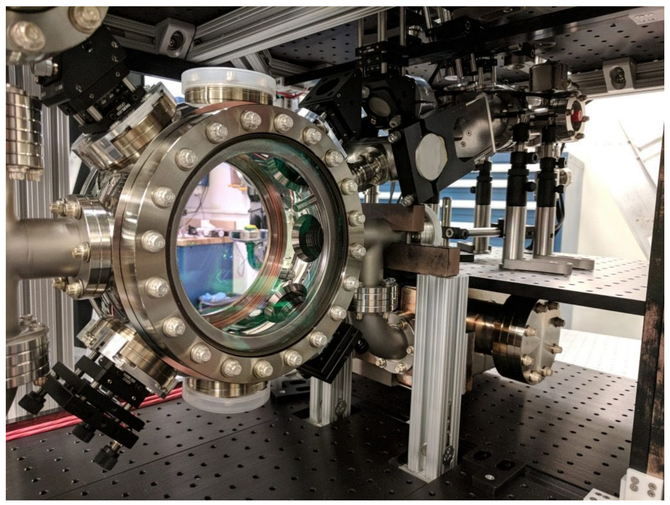
Stress placed on the Main Support Structure and Attachment Plate. Maximum Stress: 5859.27 psi (lbf/in^2). Ultimate Tensile Strength of 304: 73,200 psi

MAGIS-100 and the Atom Sources

MAGIS-100: **M**atter wave **A**tomic **G**radiometer **I**nterferometric **S**ensor

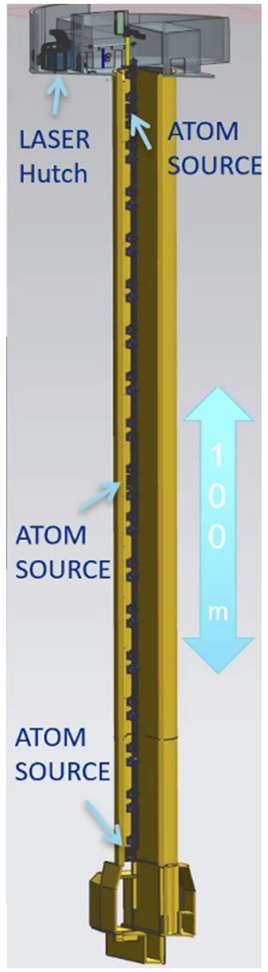


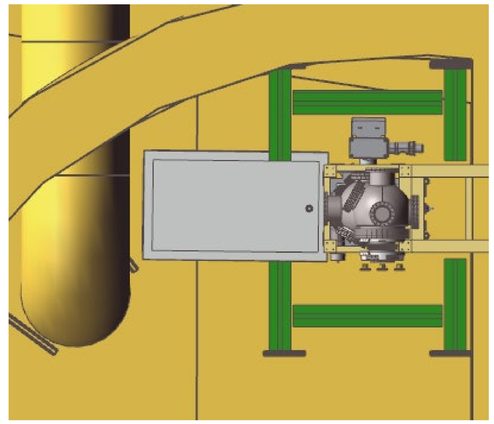
Atom Source in the NX Top Assembly.



Atom Source optics; being assembled at Stanford.
Photo: Stanford University

- MAGIS-100 has three Atom Sources located at key locations within the shaft.
- Each Atom Source weighs approximately 700 pounds and is located directly adjacent to the vacuum tube, around 22 inches from the back wall.
- Each Atom Source contains the major optical components for the atom interferometry, the focus of this experiment.

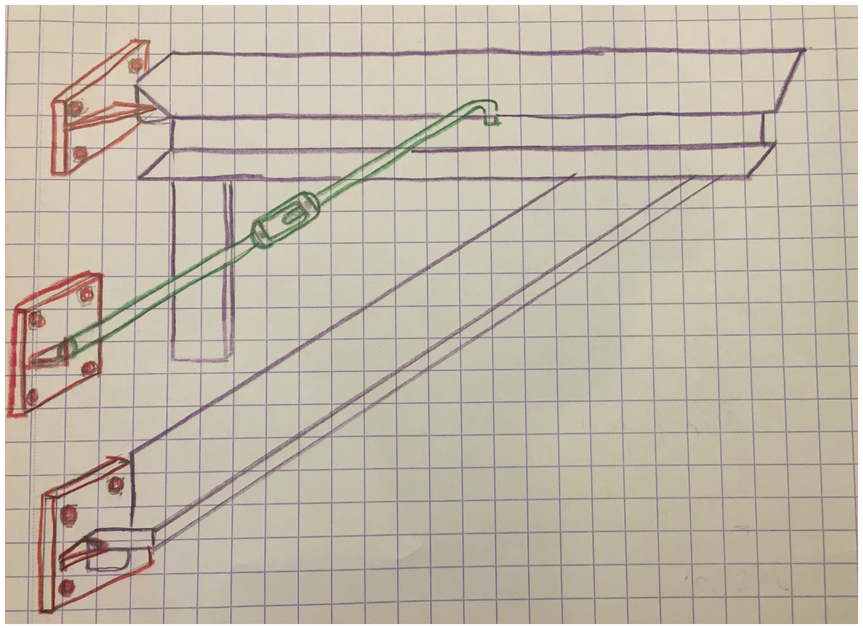




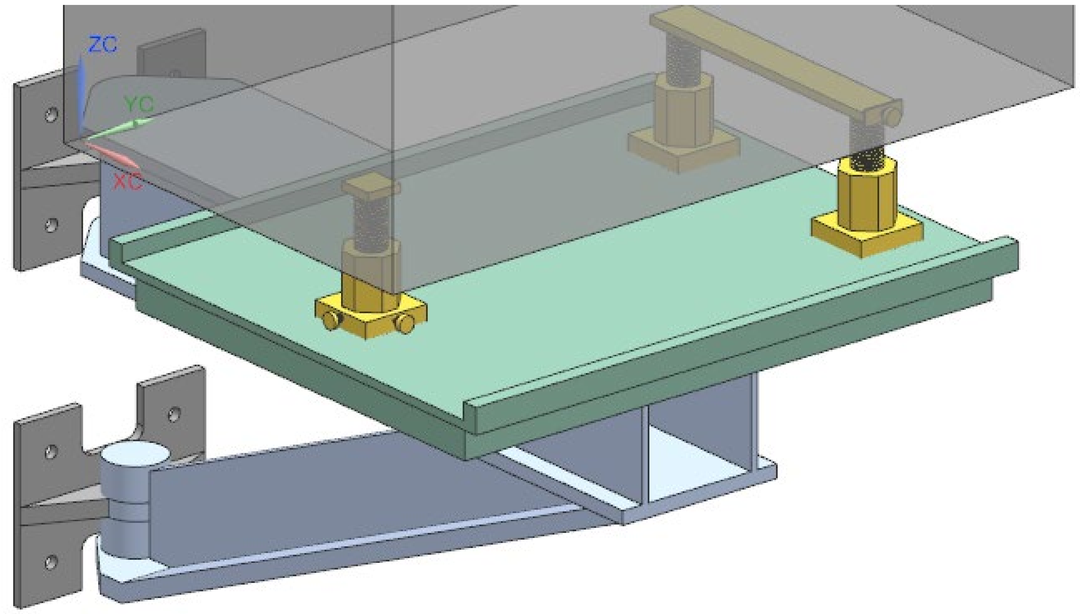
Requirements and Method

- Non-Magnetic
- Non-Corrosive
- Non-Movement Impeding
- Minutely Adjustable
- Attach to curved wall

- Initially beginning with hand sketches, multiple iterations for most components.
- Modeling in NX, pivot system explored.
- Final testing in NASTRAN



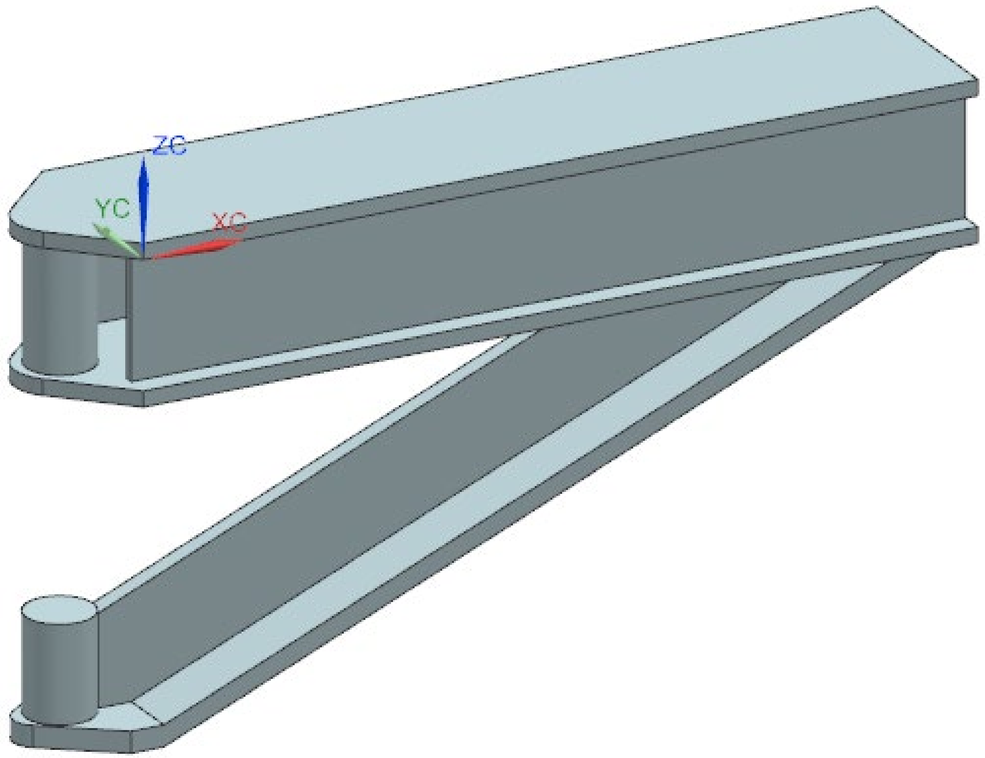
Initial hand sketches



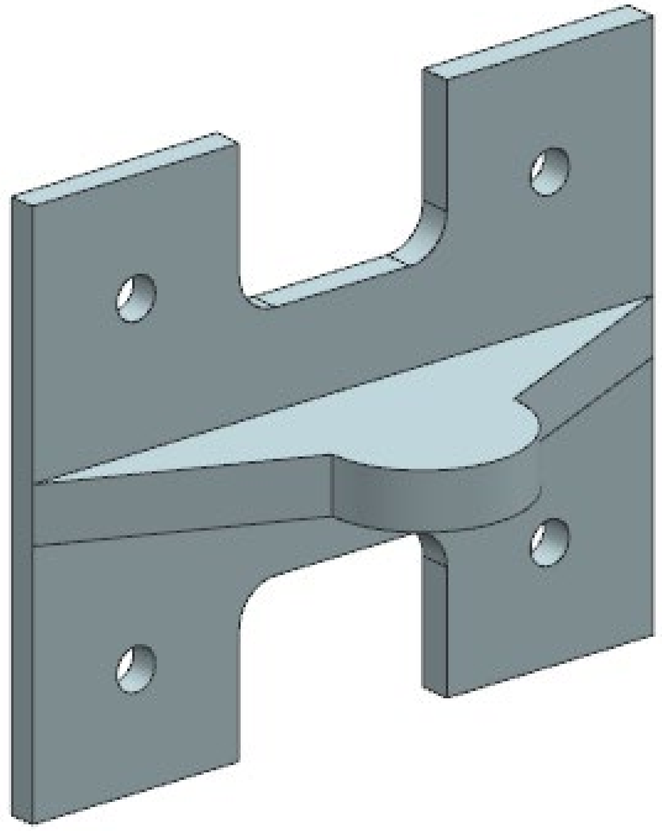
Final NX Model

Structural Parts

- All parts are made from 18/8 stainless steel, also known as 304
  - Non-Magnetic
  - Corrosion resistant
  - High Tensile Strength



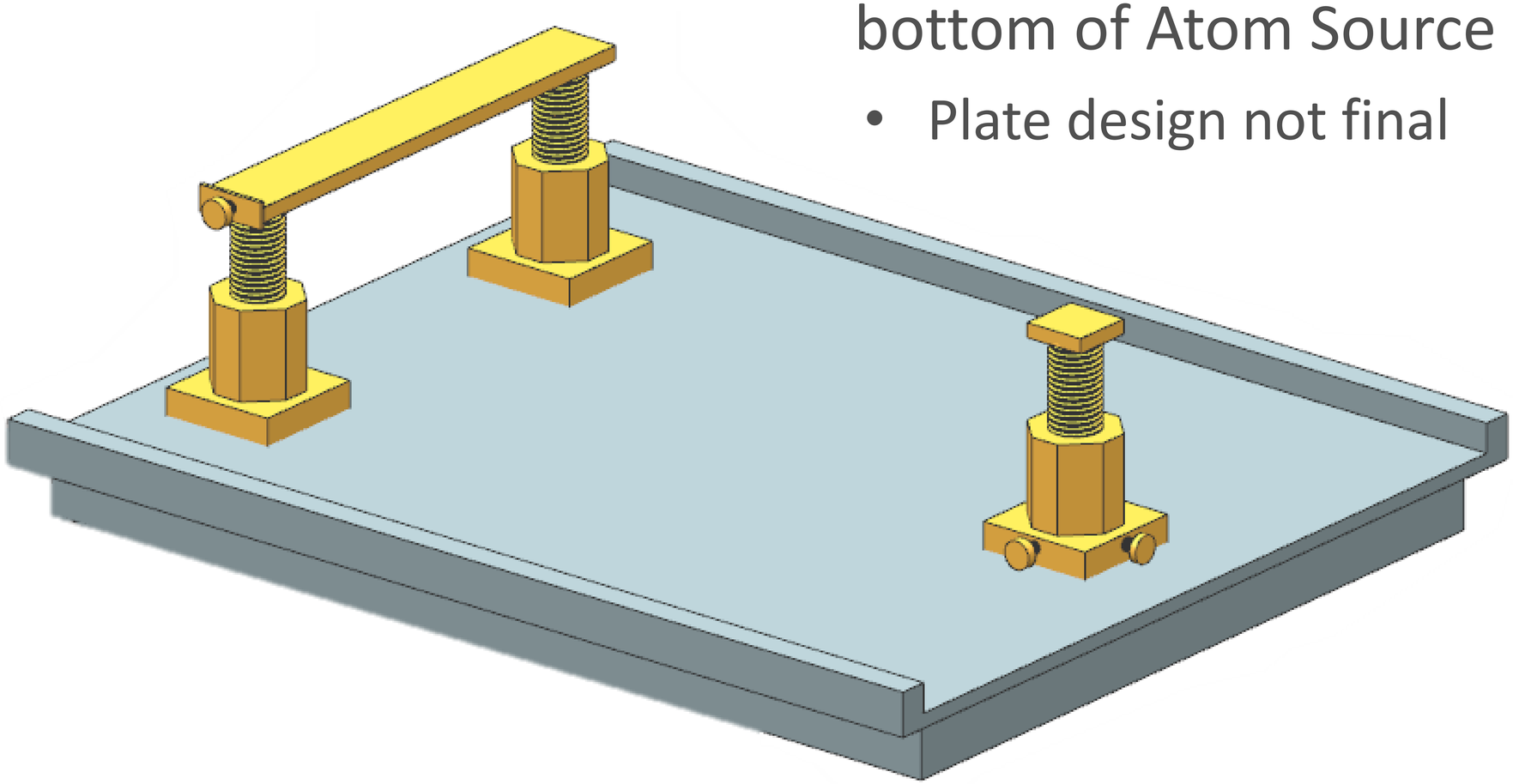
Main Support Structure



Wall Attachment Plate

Adjustment System

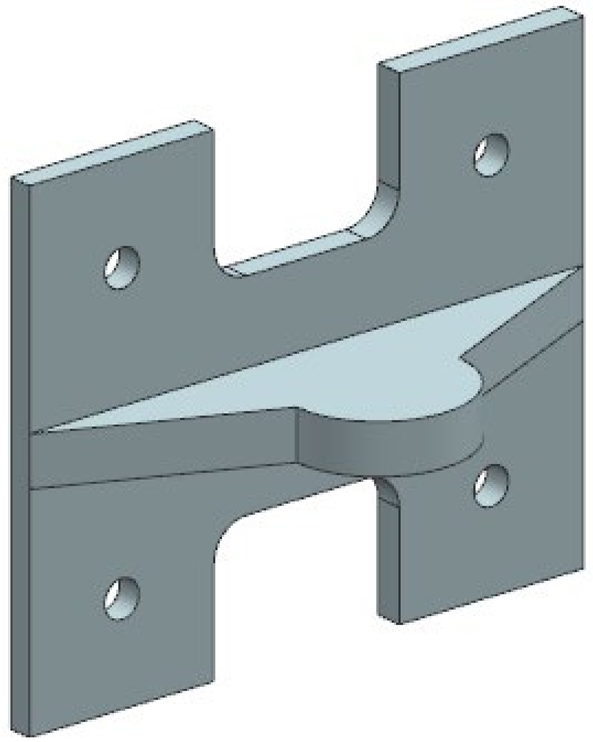
- Adjusters based off existing Fermilab design used for accelerator magnets.
  - 3-point adjusters
  - Adjuster Plate bottom latticed for additional support
  - Adjusters attach precisely to bottom of Atom Source
    - Plate design not final



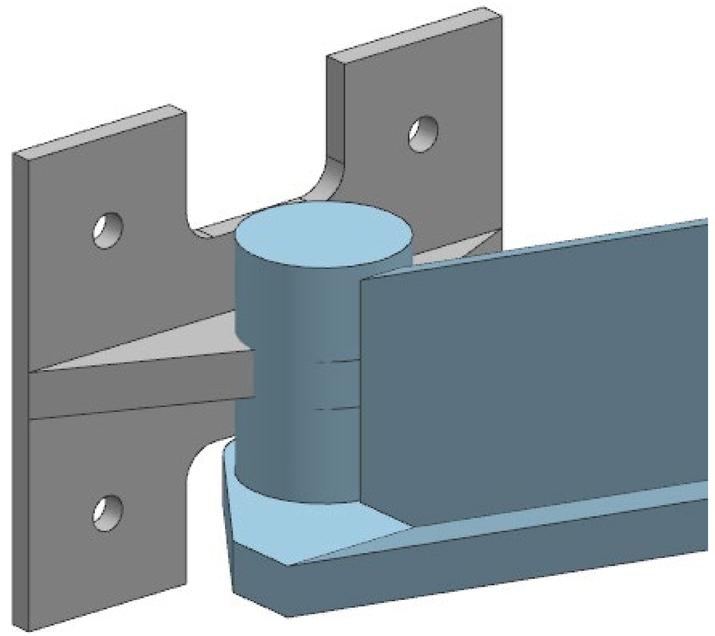
Picture of Adjusters and Adjuster Plate

Pivoting System

- Space has been left for a pivoting system.
- Necessary because all Sources are aligned vertically.
  - Allows for the removal of lower Atom Sources
  - “Slice” of attachment plate goes into cylindrical connection. Either bearings or glacier plates allow for movement.
  - A locking mechanism is needed to prevent supports from moving when not required.



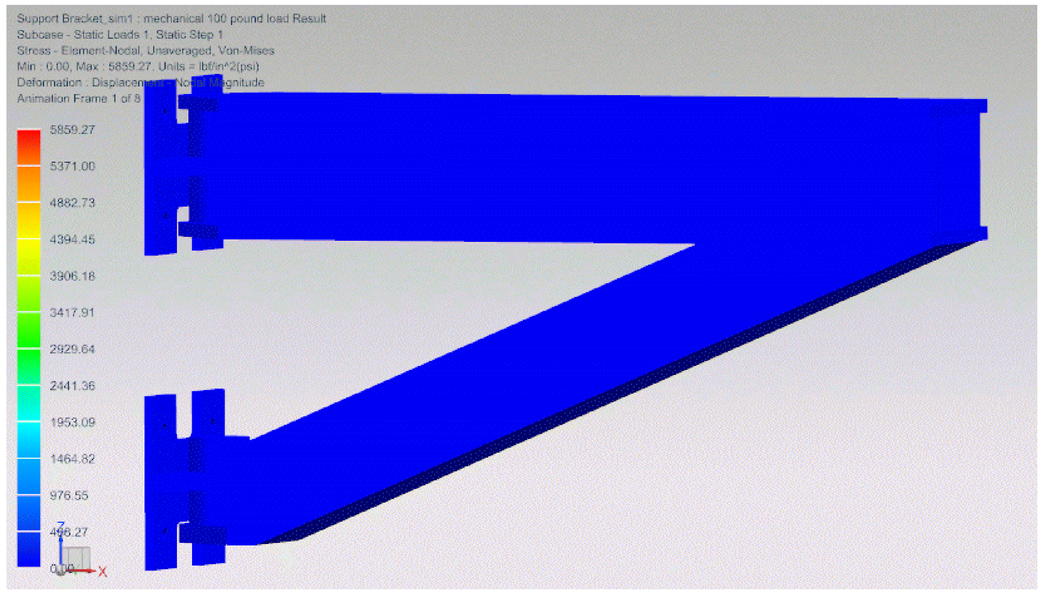
Adjuster Plate with “Slice”



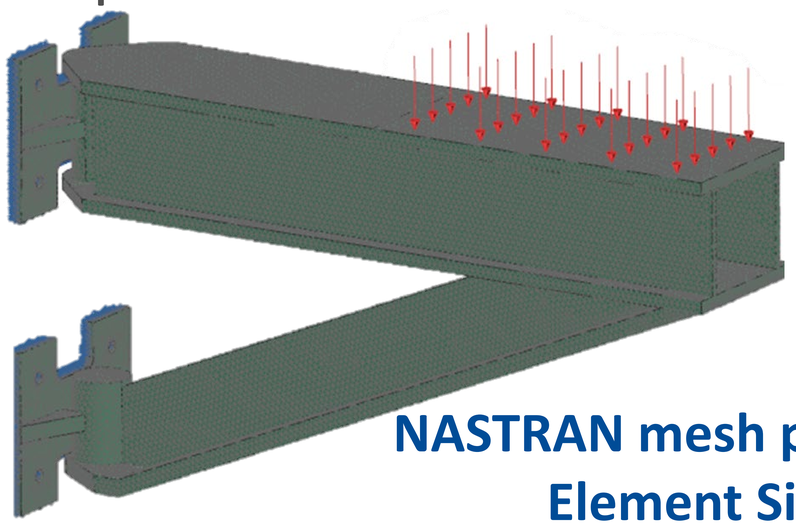
Close view of pivoting section

Simulations/Results

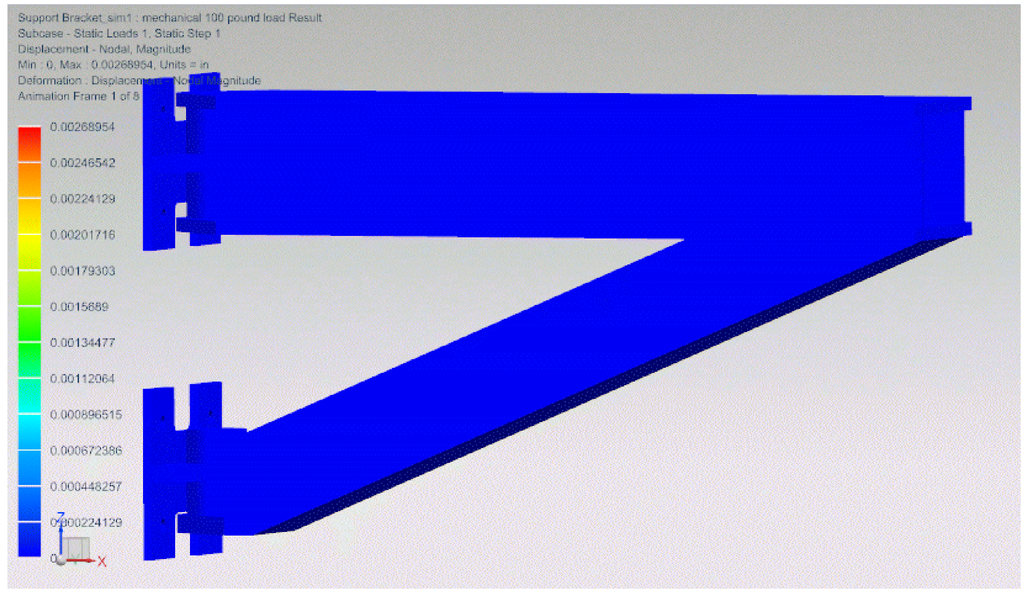
- Simulations done in NASTRAN
  - 1000-pound force on top plate of support
  - Static mounting plate to simulate connection to wall
- Ultimate Tensile strength of 304: 73,200 psi



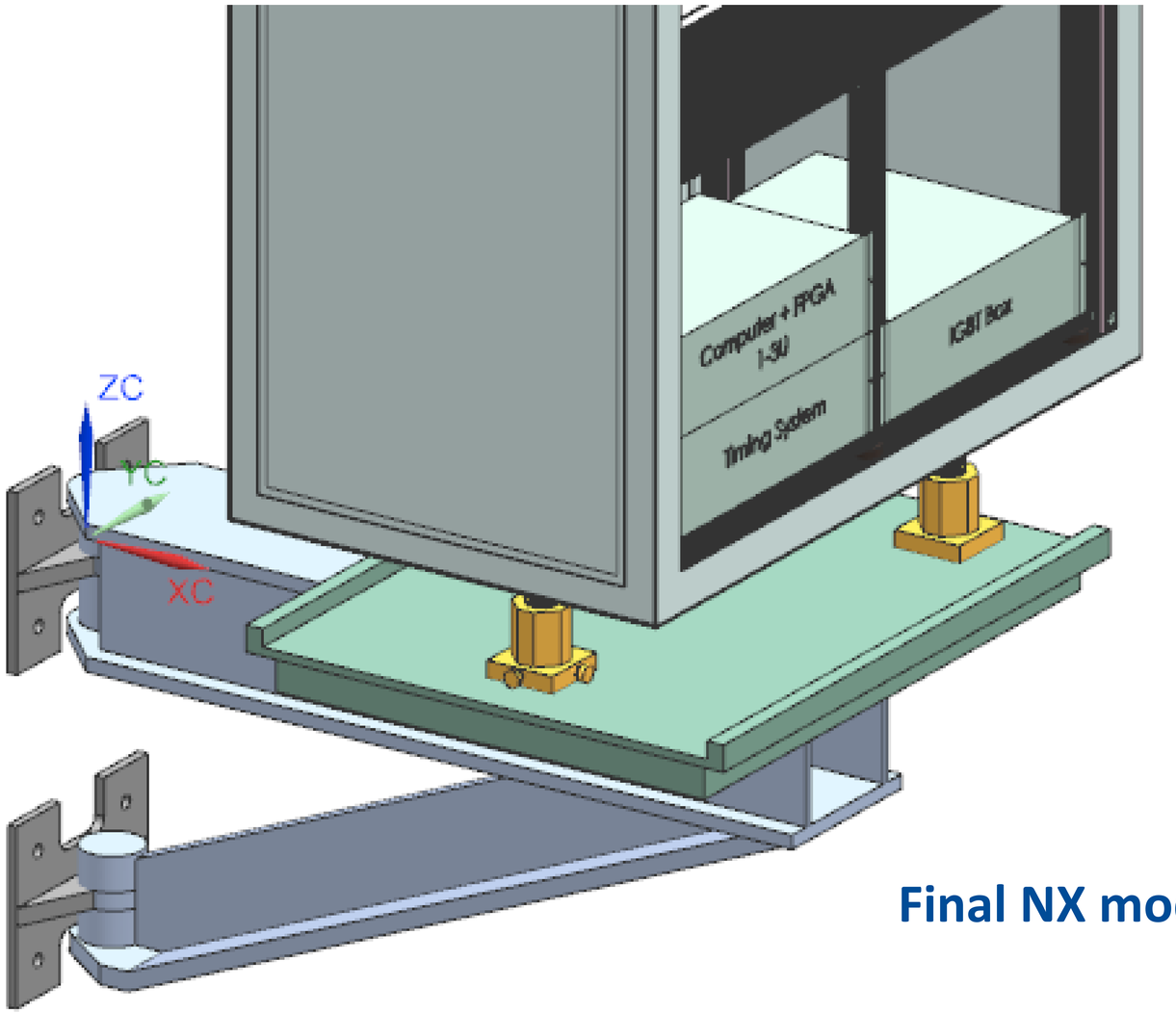
Stress simulation max: 5859.27 psi (lbf/in^2)

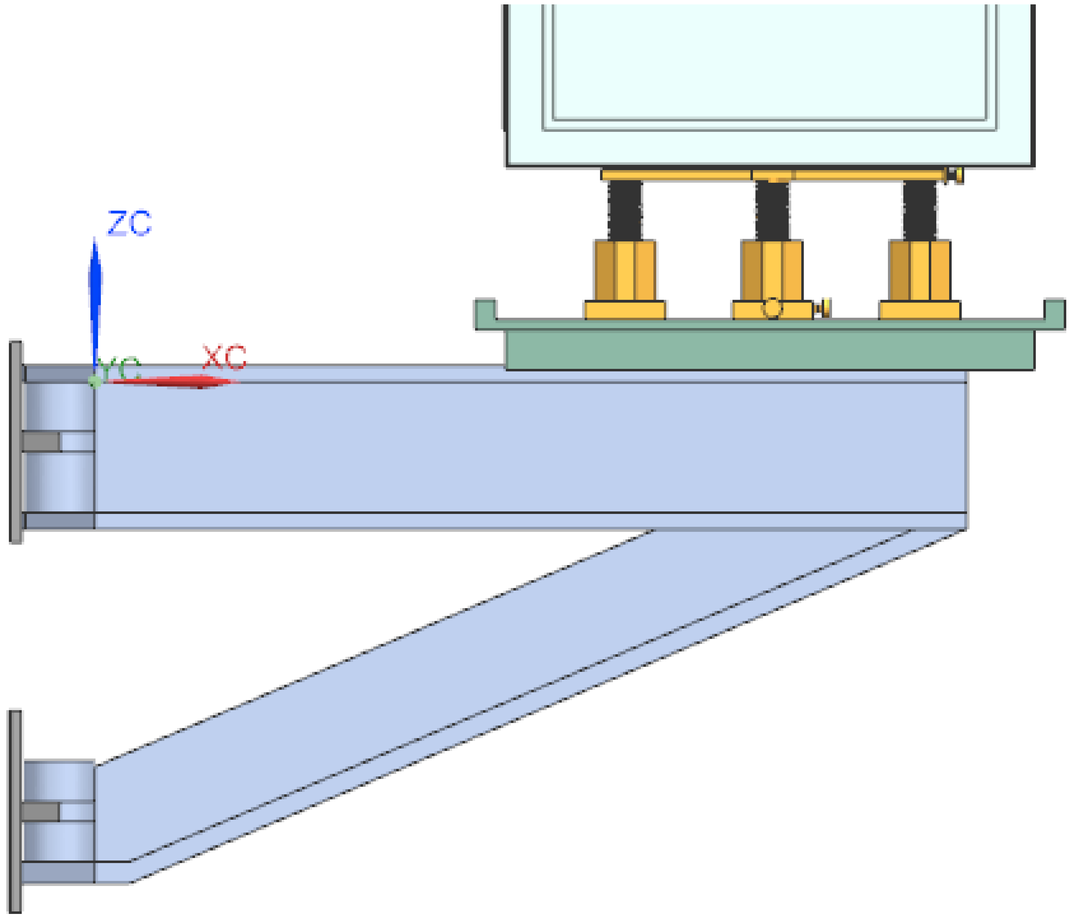


NASTRAN mesh prior to simulation. Element Size: .4 inches



Deformation simulation max: 0.00268954 in





Final NX model