NLC - The Next Linear Collider Project

Development of Nanometer resolution Beam Position Monitor support structure

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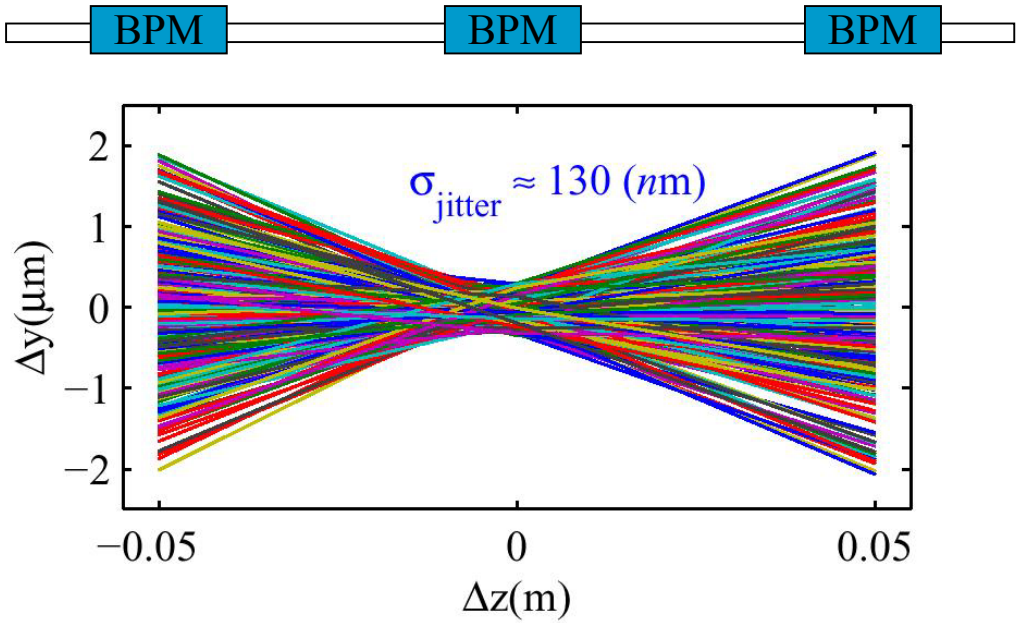
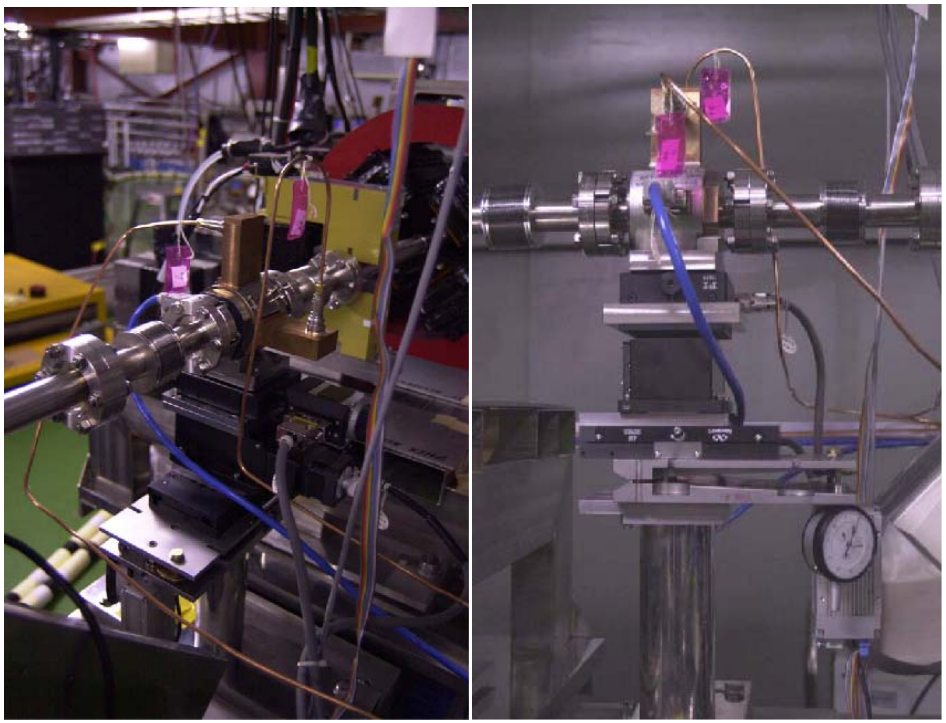
Three BPMs are used to remove the beam jitter from the resolution measurement

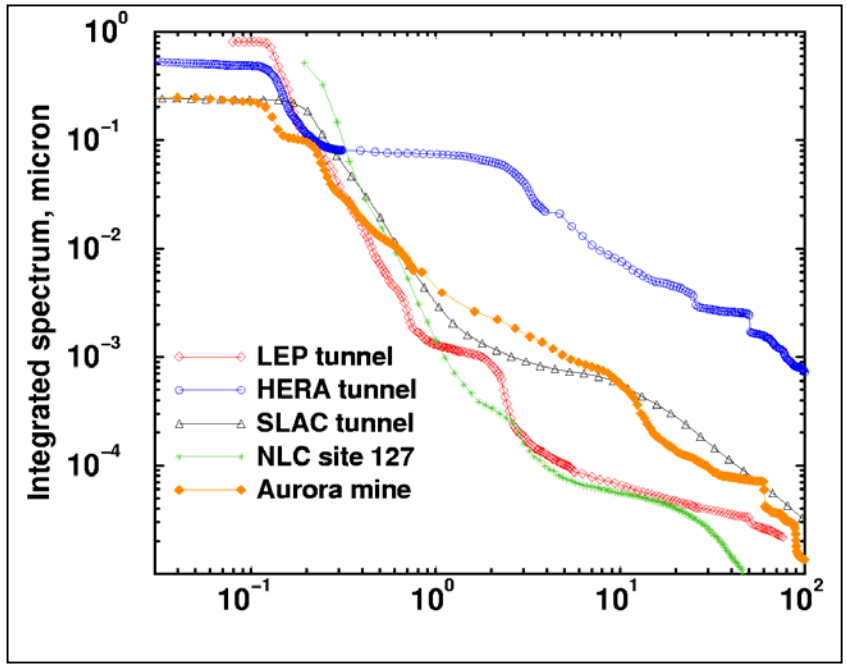


To demonstrate nanometer resolution the BPMs must be stable at the nanometer level with respect to one another.

Current positioning system is not designed to protect against vibration

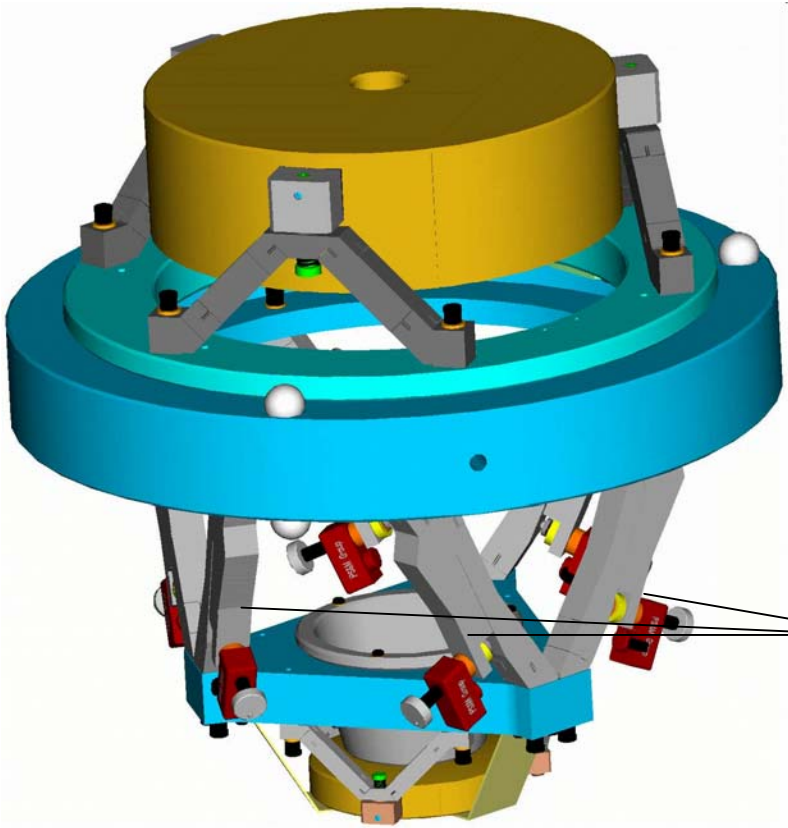
Cavity BPMs installed on the beamline at the ATF

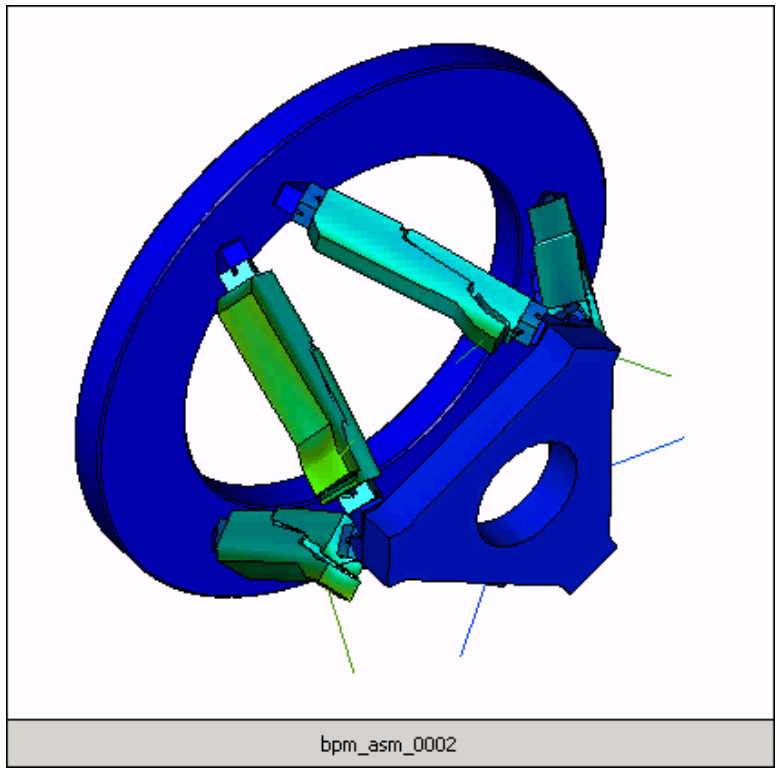




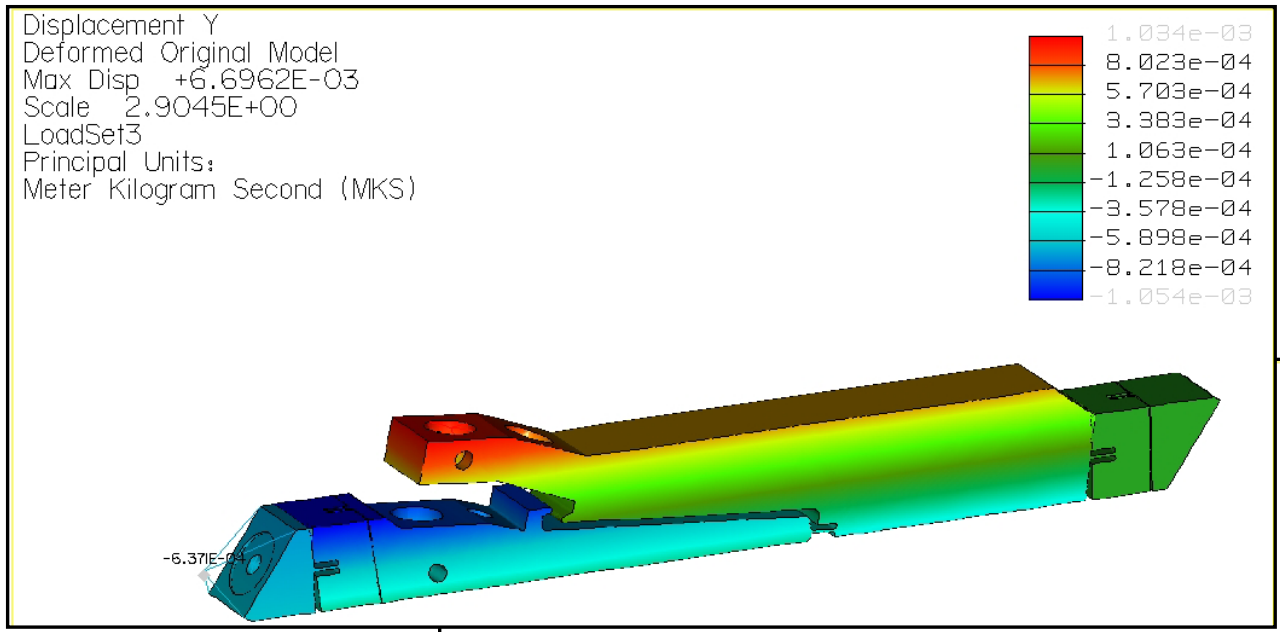
Conceptually much the same problem as protecting the final focus magnets against ground motion

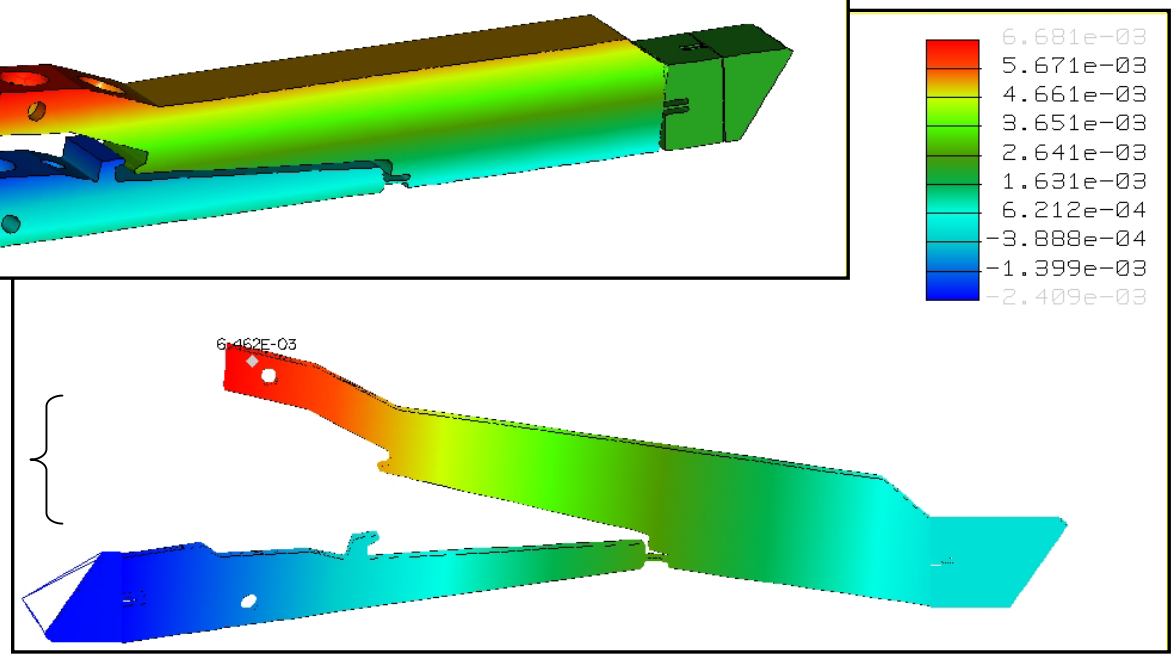
Hexapods were used for vibration resistant alignment for EUVL



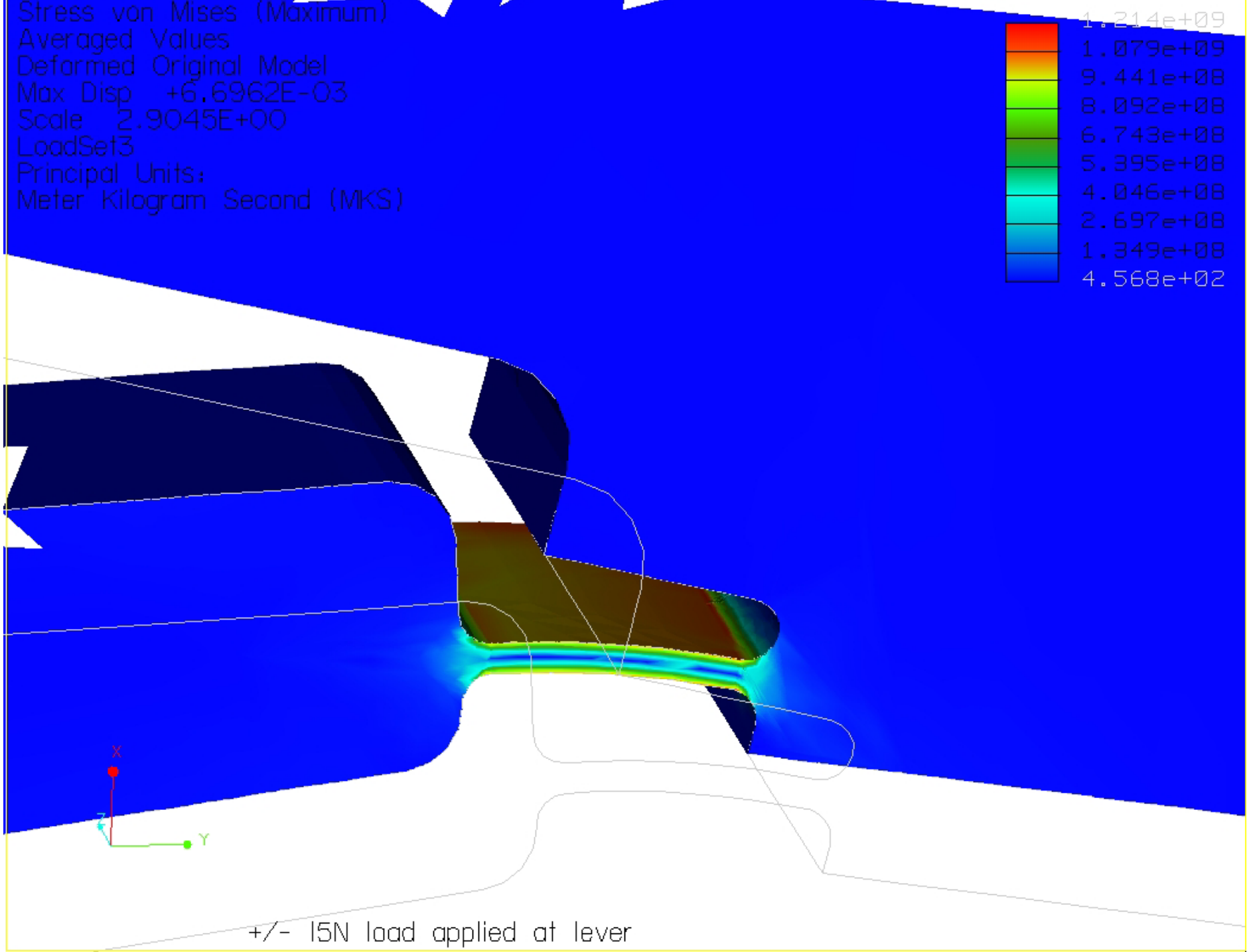


The strut displacement range is set by the elastic limit of the material

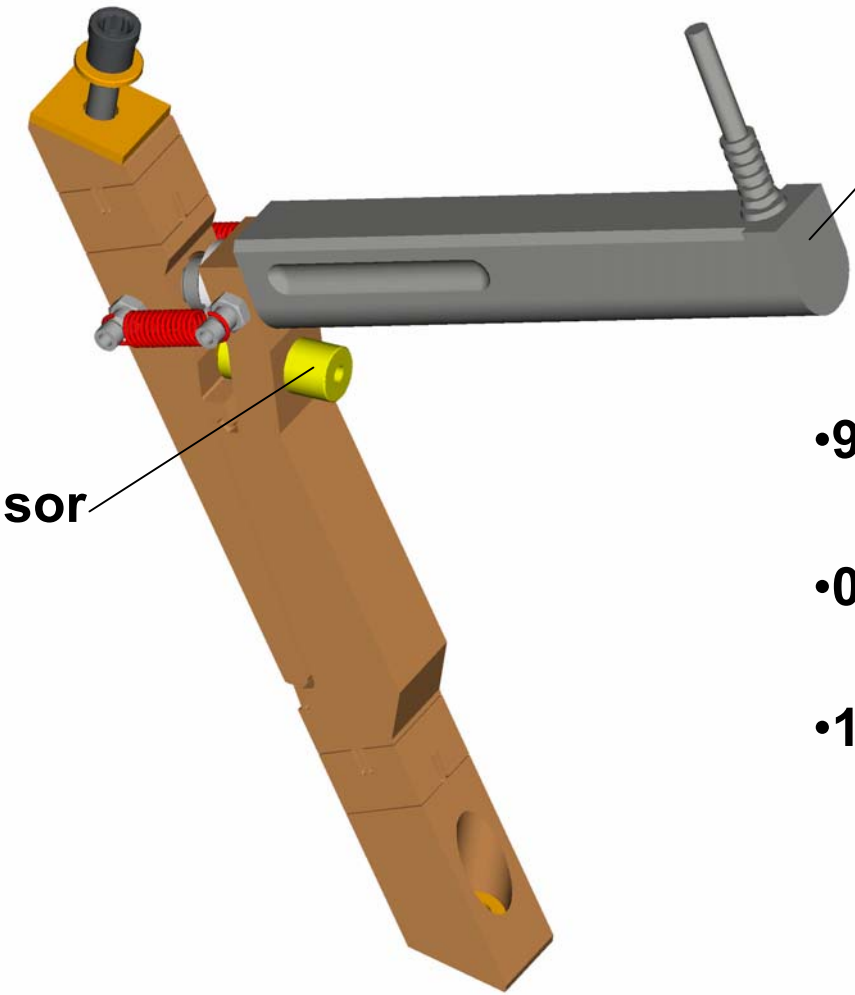




7mm


Stress von Mises (Maximum)
Averaged Values
Deformed Original Model
Max Disp +6.6962E-03
Scale 2.9045E+00
LoadSet3
Principal Units:
Meter Kilogram Second (MKS)
1.214e+09
1.079e+09
9.441e+08
8.092e+08
6.743e+08
5.395e+08
4.046e+08
2.697e+08
1.349e+08
4.568e+02
X
Z
Y
+/- 15N load applied at lever

Stepper Motor



- 90 N Maximum Force
- 0.2 micron resolution
- 12.5mm range

BPM Range of Motion Objectives

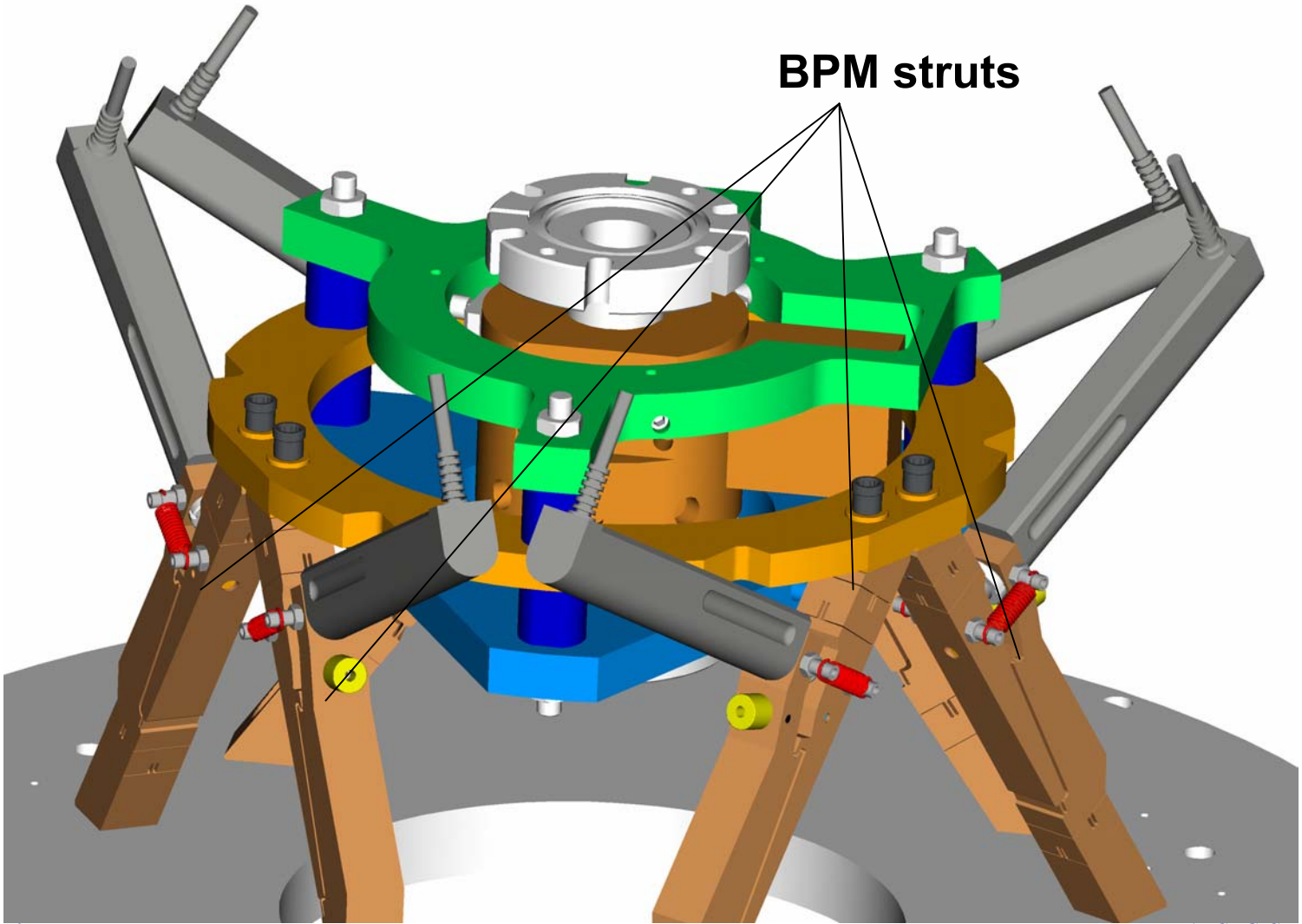
$$\mathbf{x, y} = \pm 200\ \mu\mathbf{m}$$

$$\text{Resolution } x, y = \pm 0.1\ \mu\text{m}$$

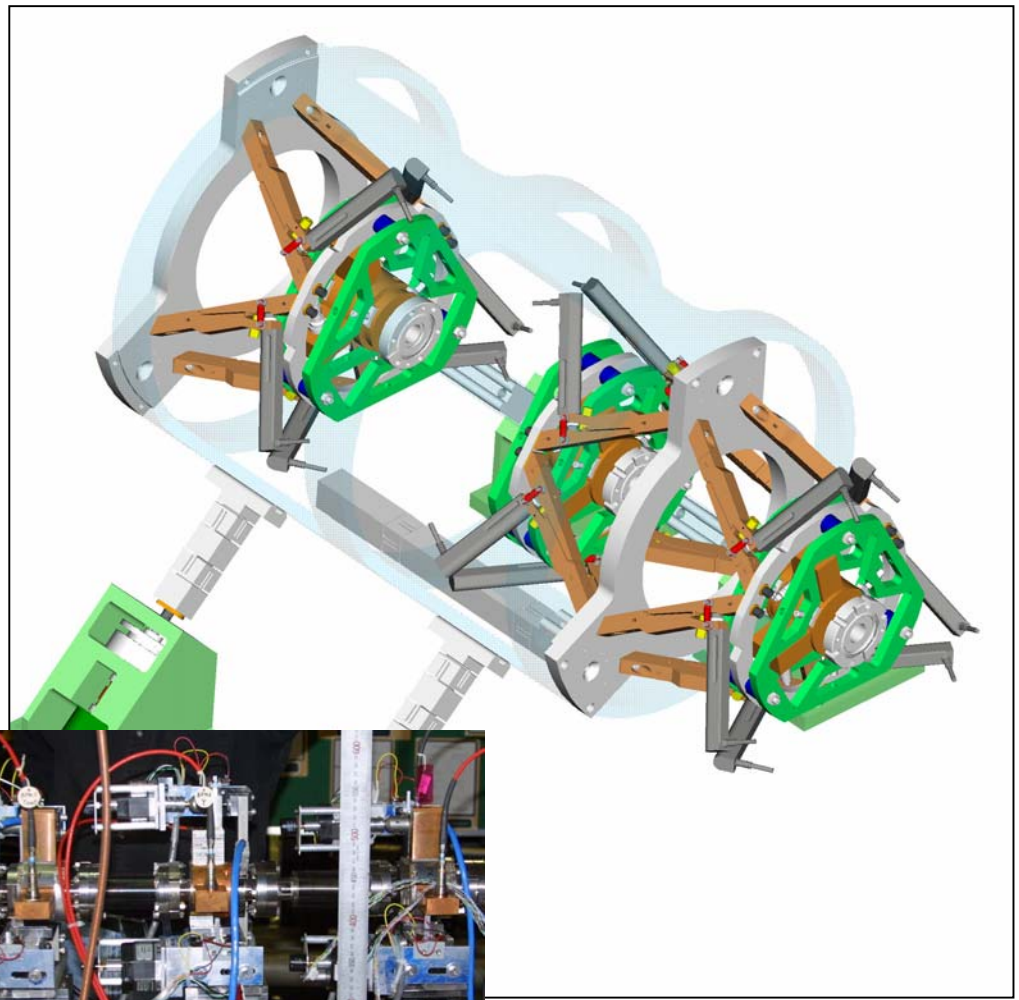
$$\theta_x, \theta_y = \pm 2000\ \mu\mathbf{rad}$$

$$\text{Resolution } \theta_x, \theta_y = \pm 10\ \mu\text{rad}$$

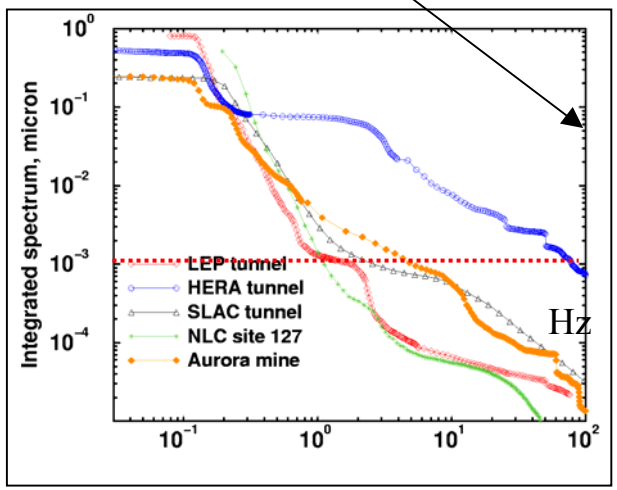
The fundamental vibrational mode of the hexapod is at 250Hz



The alignment structure rigidity should prevent ground motion from inducing relative BPM motions



- Extended structure introduces new modes of motion
- Fundamental mode that is dangerous for us is a drumhead motion
- Frequency is still above 100 Hz

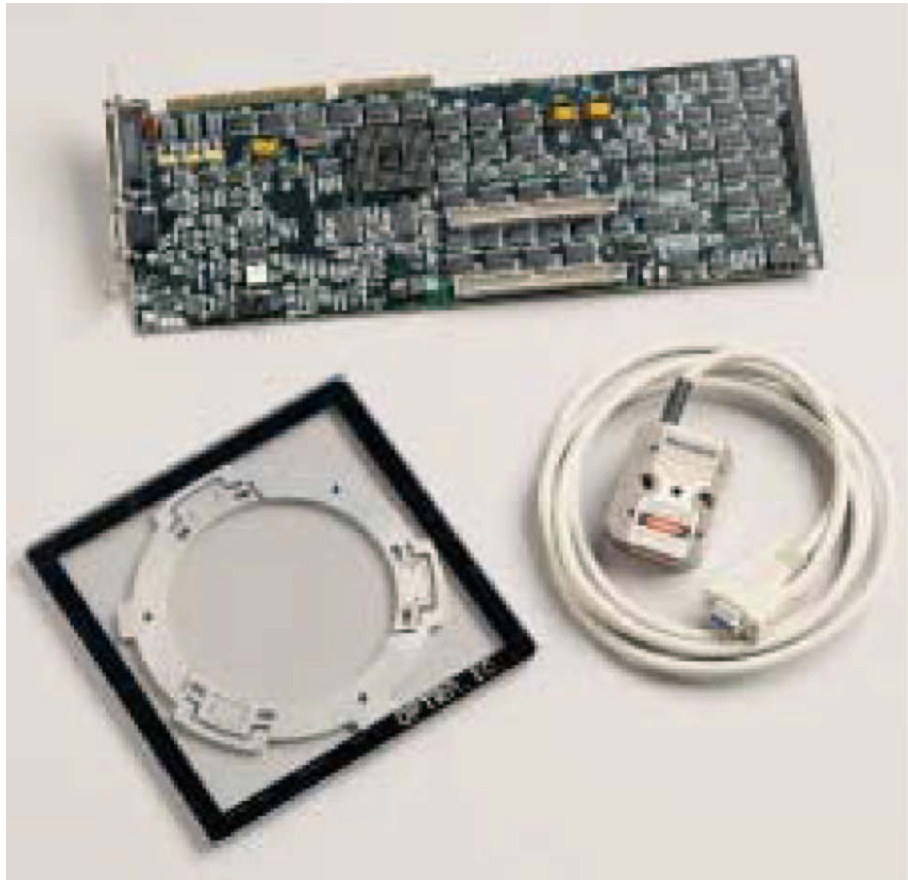


Alignment frame will also include a metrology frame

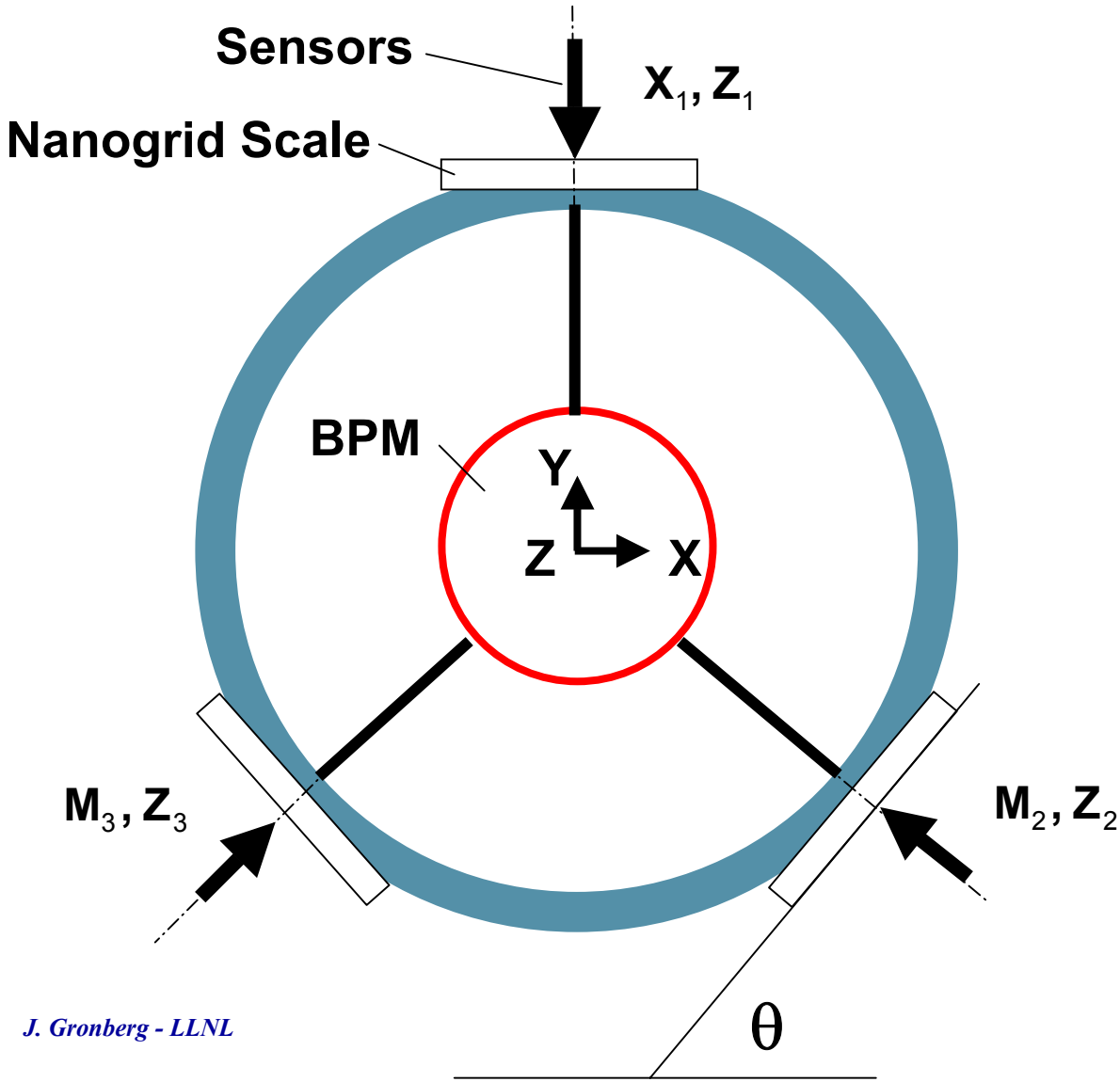
- Alignment frame seems sufficient to passively protect against environmental vibrations
  - Test the motion with geophones and a shaker table at LLNL
- Additional we will include a sub-nanometer resolution metrology frame, two reasons:
  - Take out slow thermal drift
  - Demonstrate that BPM motion is not the problem if the BPMs do not achieve nanometer resolution

Commercial sub-nanometer position measurement systems are available

- Optical Nanogrids
  - Attach a grid with grating etched onto it to the BPM
  - Optical head observes the grid
  - Meaurements in two dimensions



3 Sensors / BPM gives all 6 degrees of freedom



$$X_2 = M_2 \mathrm{Cos}\,\theta$$
$$Y_2 = M_2 \mathrm{Sin}\,\theta$$

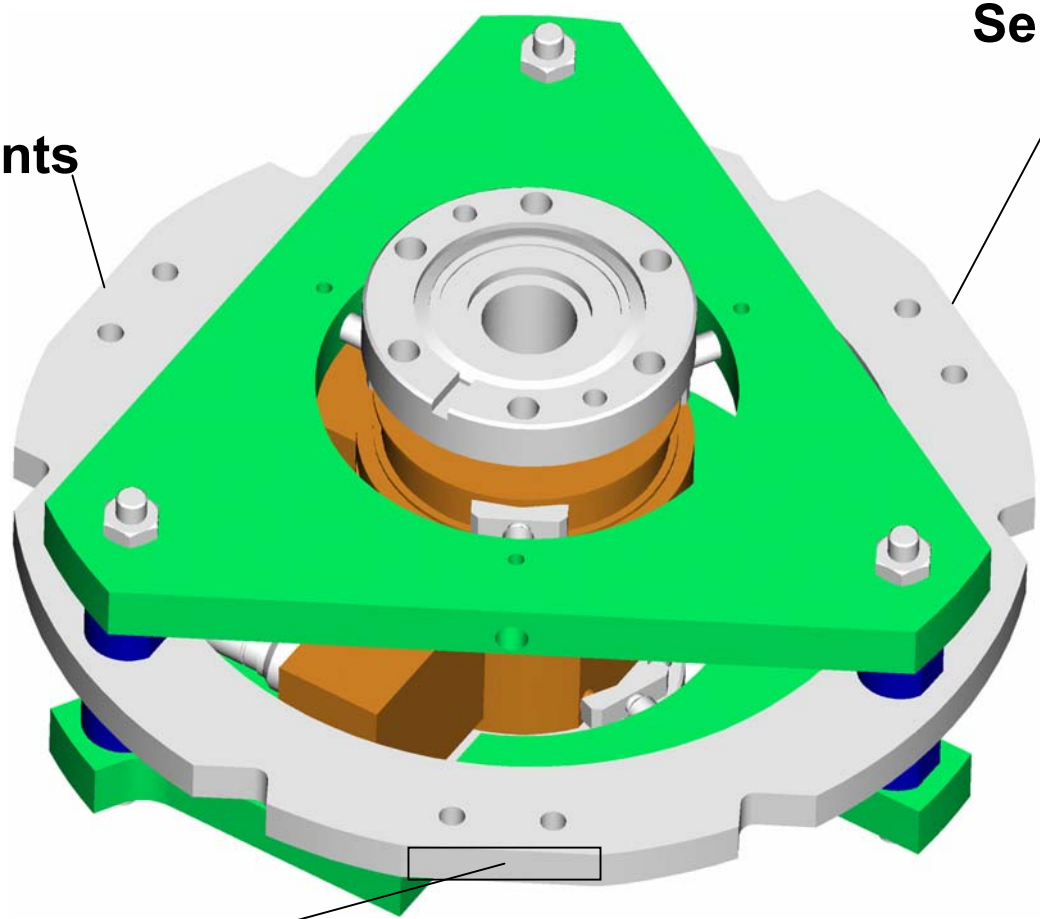
$$X_3 = M_3 \mathrm{Cos}\,\theta$$
$$Y_3 = M_3 \mathrm{Sin}\,\theta$$

$$Y_1 = f(Y_2, Y_3)$$

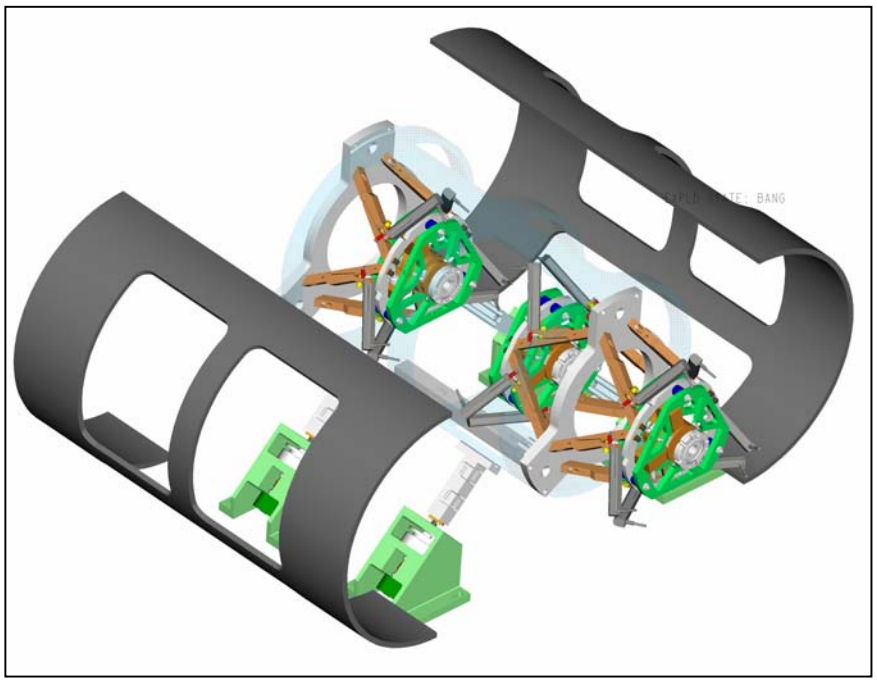
$$\theta_x = f(Z_1, Z_2, Z_3)$$

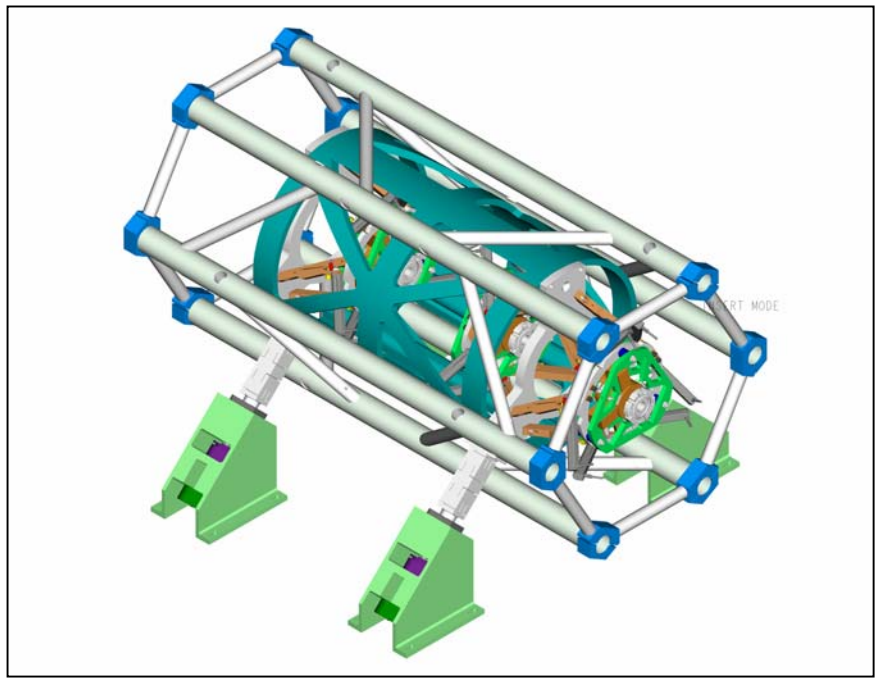
$$\theta_y = f(Z_2, Z_3)$$

Sensor mounts are on the BPM main support ring



An external space frame with zero ZTE provides a metrology reference frame





Summary

- Alignment frame is under construction
  - Vibration simulation done
  - Detail part design is complete
  - Parts fabrication in progress
  - Assembly and delivery October ’03
  - Beam tests October ‘03
- Metrology frame
  - Procuring nanogrid sensors
  - Final design and construction FY04