GG payload and read-out

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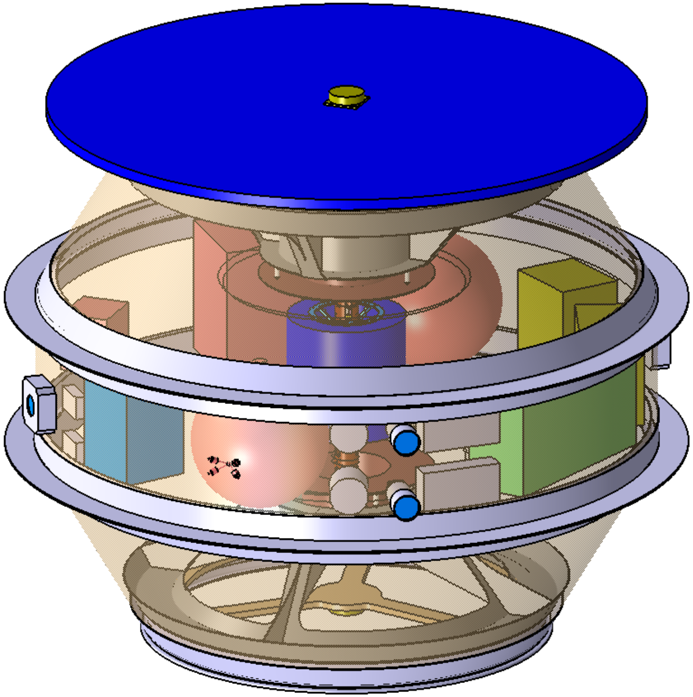
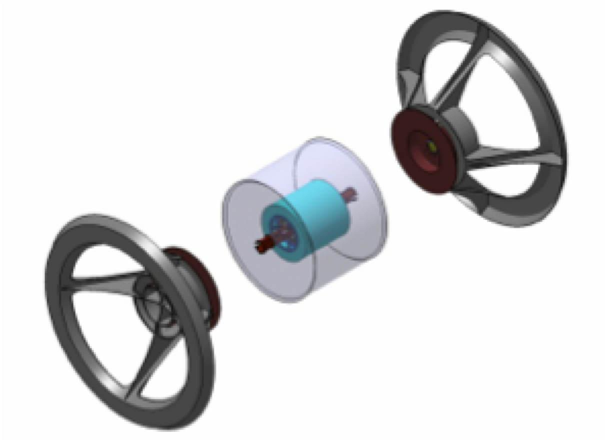
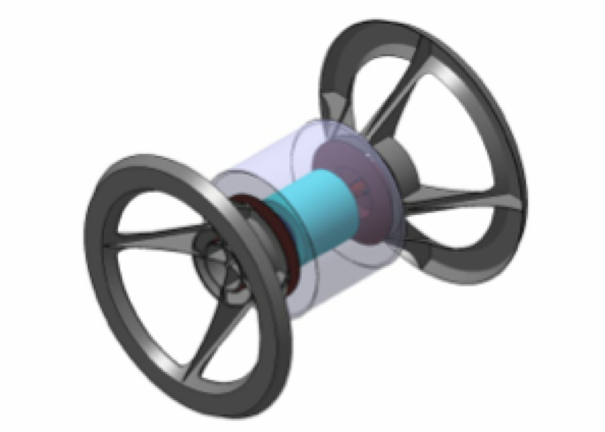
GG spacecraft

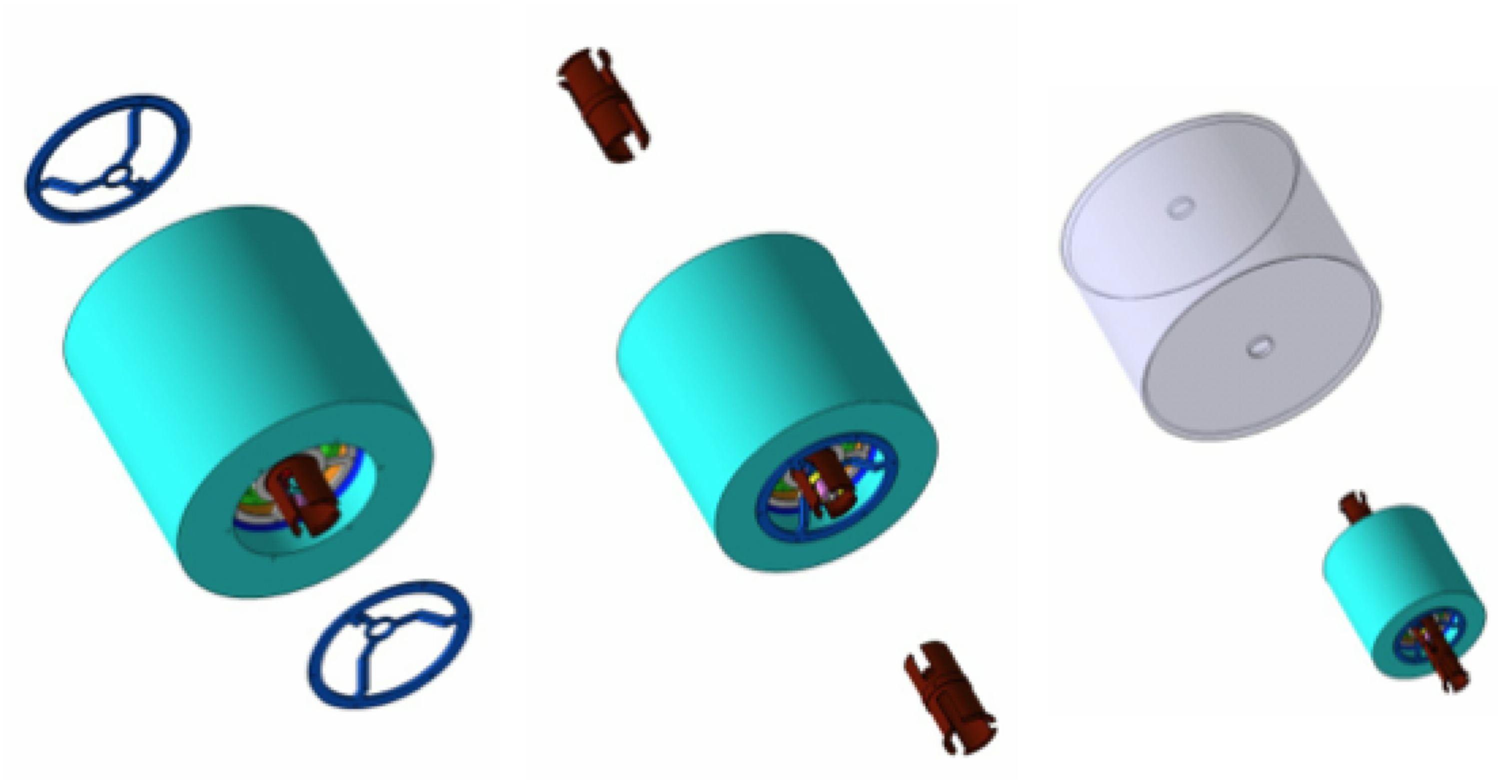


PGB (Pico Gravity Box) intermediate stage

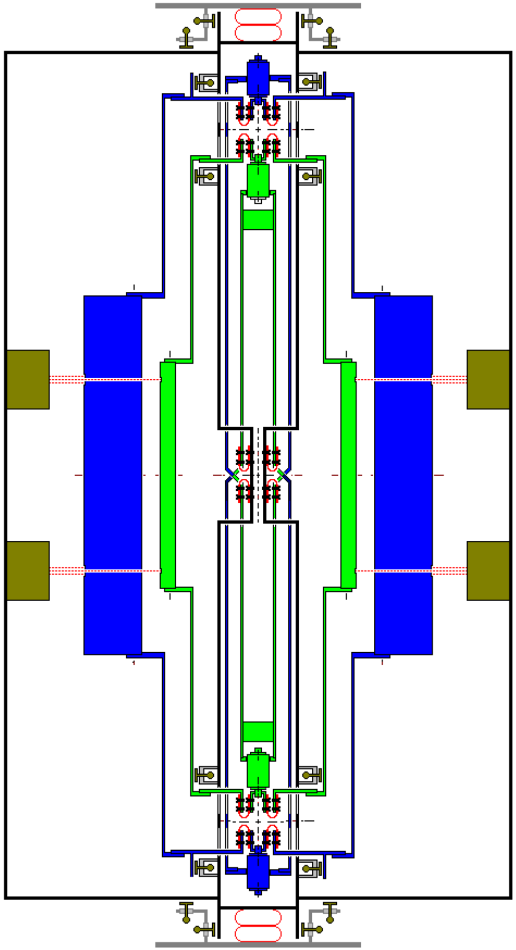




GG accelerometer assembly



GG accelerometer: section along spin/symmetry axis



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GG accelerometer

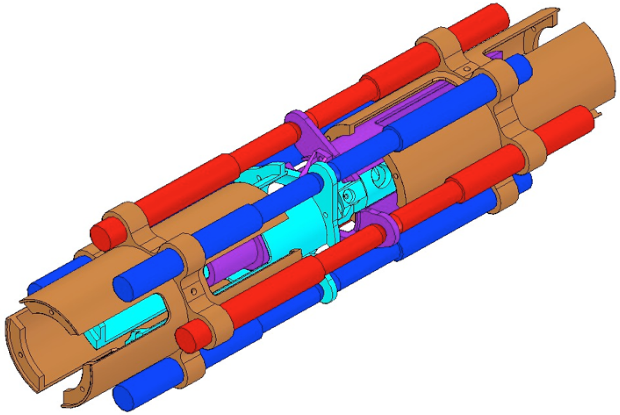
response to differential effect

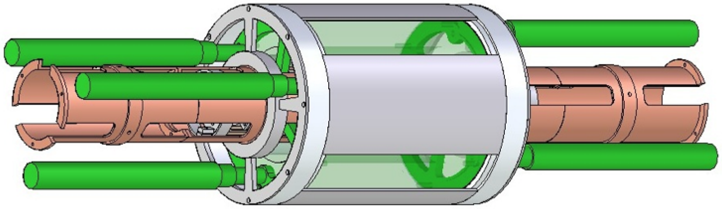
(click to activate)

GG accelerometer 3D tour

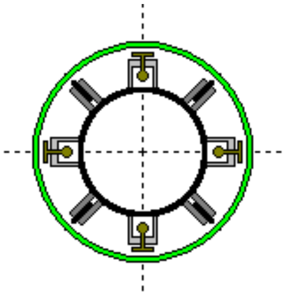
(click to open 3D PDF, then click on drawing to start 3D tour of all parts)

Launch lock-unlock

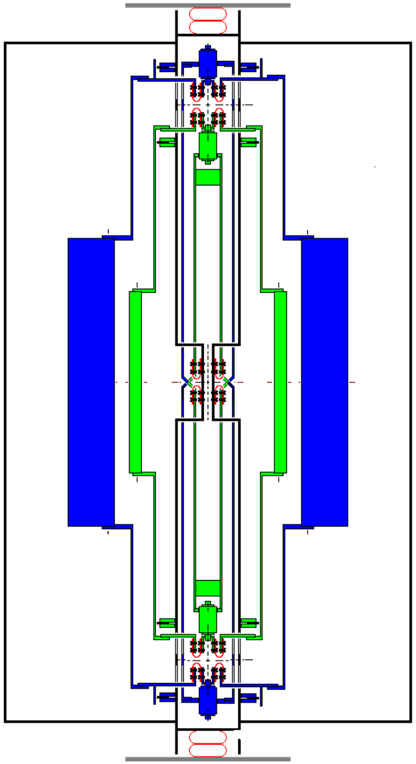




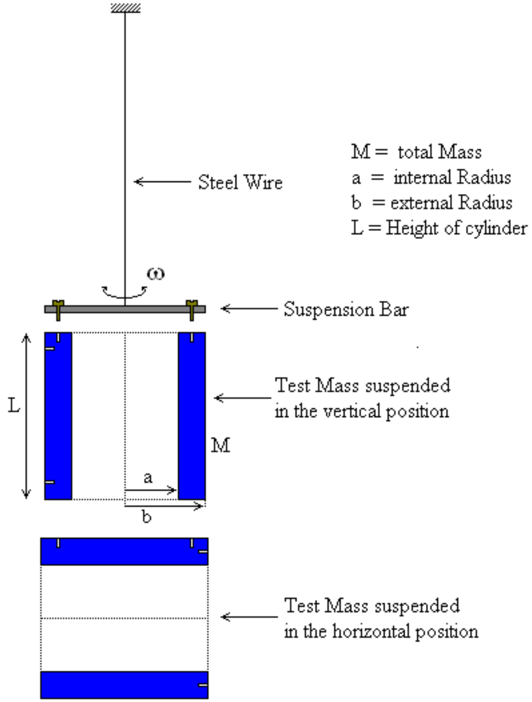
Fine lock-unlock at zero g



Section showing Inch-Worms at 45° with respect to Capacitors



Fractional mass moments of test cylinders



The differential acceleration due to the Earth's monopole coupling differently with the (inevitably) different quadrupole mass moments of the test cylinders mimics (in each measurement) a UFF/WEP violation.

It is proportional to $\beta = \frac{\Delta I}{I} = \frac{I_z - I_{x,y}}{I_{x,y}}$ which must be positive (z is teh rotation axis) but sufficiently small for this effect (known from celestial mechanics) to be below the target violation signal.

We can measure β by measuring the torsional oscillation frequencies around the 3 principal moments of inertia. If the same bar farme is used in all 3 measuremenst it will not affect the measurement.

Once the measurement is made, careful machining allows small changes to achieved the required value. With 10 kg cylinders this is not an issue, also because....

Rotation around symmetry axis of test cylinders makes their mass anomalies not a crucial problem (they give DC effects and do not compete with the signal.)

Material choice of test cylinders

Rotation around the symmetry axis of test cylinders unique to GG.
It makes requirements on mass anomalies much less strict.
In GG test cylinders have large masses (10 kg), which also makes precision manufacturing easier.
(Experiment at room temperature).

This is why it appears to be possible to use materials known to be more sensitive to violation ... but ruled out in torsion balance and other experiments where manufacturing of test masses is far more demanding.

Laser Gauge Advantages

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- Cap gauges measure 1/D, Lasers measures D.
  - Differential measurements at the picometer level are more or less routine.
  - Common mode signals at the 10's nm level are not a problem.
- No electrical systematic errors (patch effects)
- Very high SNR. 0.6pm in a few seconds. When you have SNR to burn, that makes things possible that weren't before
  - Possibly better calibration of the balance. (better mechanical CMRR)
  - If systematic errors provide different signal signatures, we can throw SNR at it to separate the EP signal from the systematic effect.
    - (next page)

Beam Launcher Schematic (based on SIM Internal Met)

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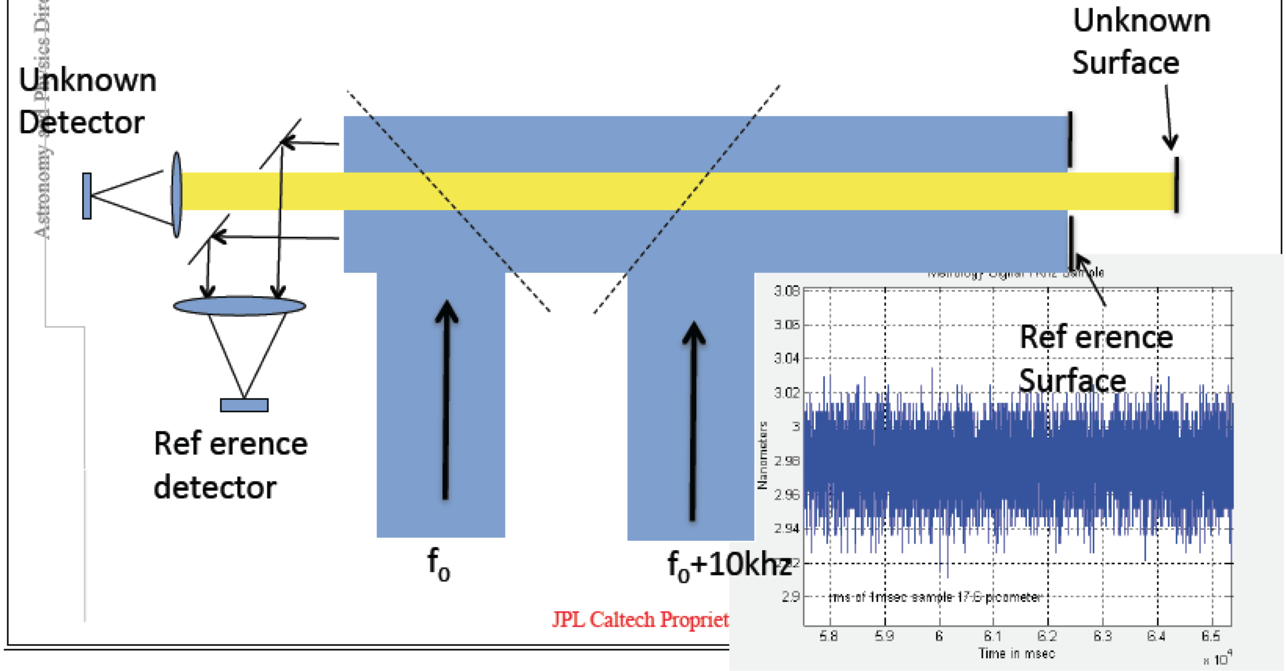
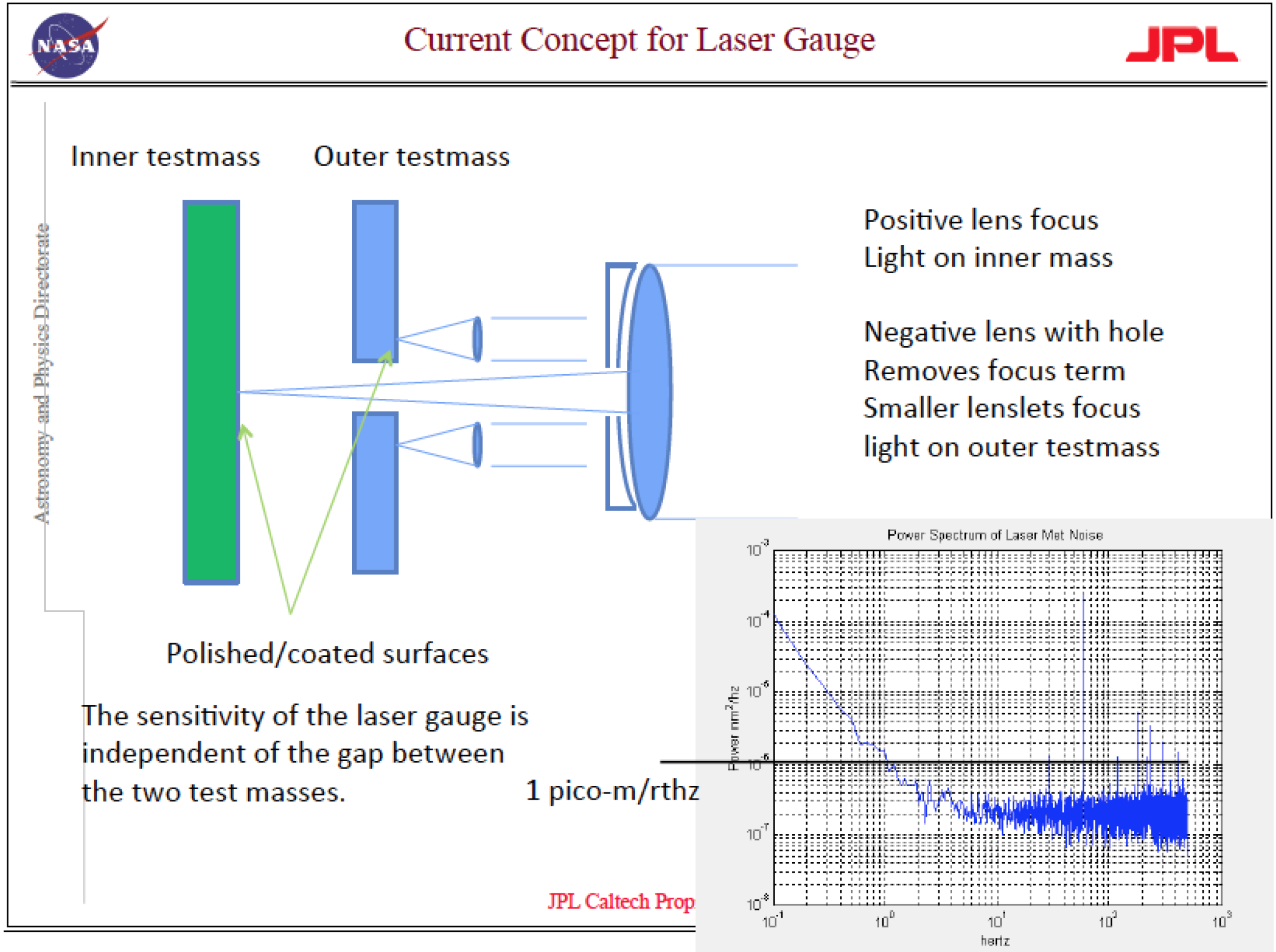
- An alternate configuration is one where the gauges is external to the two optical fiducials (most useful for GG)




Current Concept for Laser Gauge
JPL
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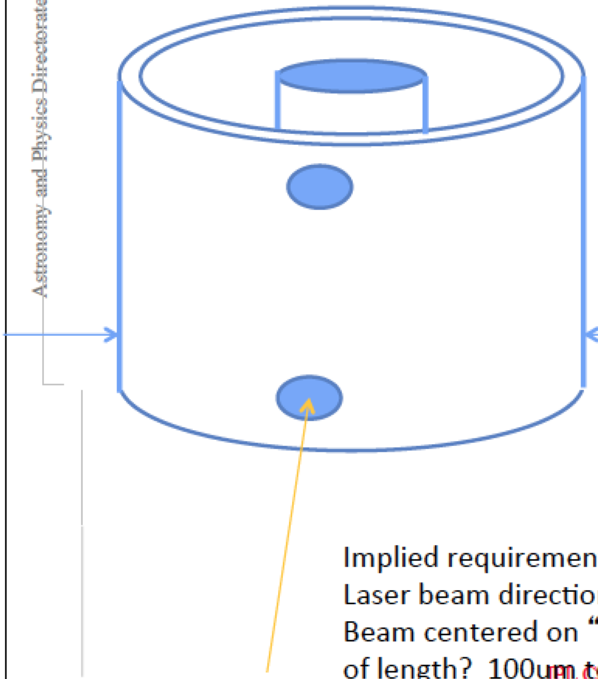
Inner testmass
Outer testmass
Positive lens focus
Light on inner mass
Negative lens with hole
Removes focus term
Smaller lenslets focus
light on outer testmass
Polished/coated surfaces
The sensitivity of the laser gauge is
independent of the gap between
the two test masses.
1 pico-m/rthz
JPL Caltech Prop
Power Spectrum of Laser Met Noise
Power nm²/rhz
hertz

GG case (II)

6-8 Laser Gauges?



Minimum 3 gauges through the center of the cylinders

With 6 gauges we can measure the position of the center without needing precise alignment of the Z location of the gauges.

8 gauges would provide redundancy (if needed)

The inner cylinder can move with respect to the outer cylinder by up to 10nm. Measure that motion to 1 pm.

Implied requirements:
Laser beam direction aligned to 1e-4 radians?
Beam centered on “middle” of cylinder to ?? 1% of length 0.1% of length? 100um to 1mm?