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OMICS Group has organized 500 conferences, workshops and national symposiums across the major cities including San Francisco, Las Vegas, San Antonio, Omaha, Orlando, Raleigh, Santa Clara, Chicago, Philadelphia, Baltimore, United Kingdom, Valencia, Dubai, Beijing, Hyderabad, Bengaluru and Mumbai.

***Advanced Propulsion In The
Era Of Wormhole Physics:
Is It Space Drive Time Yet?***

***J.F. Woodward and H. Fearn
Physics, CSU Fullerton***

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A “generation” starship under construction in Earth orbit.

That ship, nuclear powered, getting under way.

We need a way to dispense with the vast amounts of propellant required by conventional rockets

- * Like Columbus, who found the New World while seeking a way to the Old, explorers who make landfall on unexpected continents of ideas are often unprepared to accept what they have found. They keep seeking what they set out to find.

Frank Wilczek

- * Wrong theories are not an impediment to the progress of science; they are a central part of the struggle.

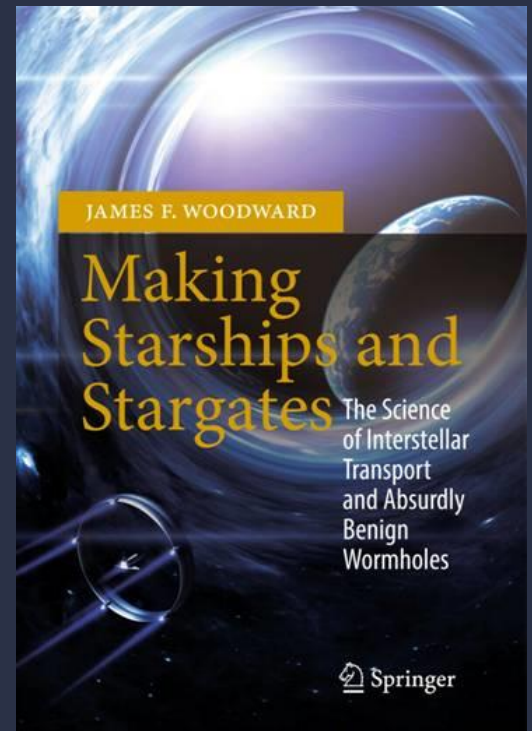
Freeman Dyson

Is There Any Plausible Physics For More “Realistic” Transport?

Wormholes and warp drives?

Zero point fields of the quantum vacuum?

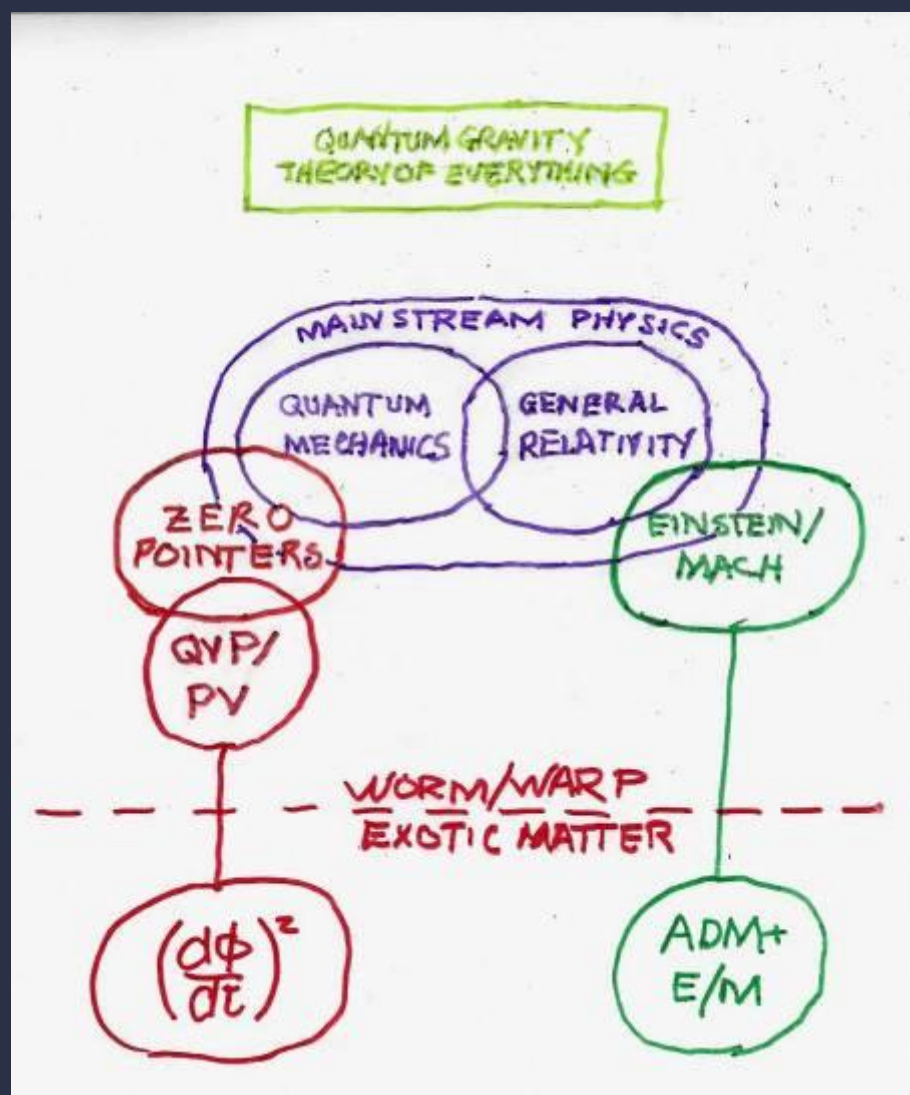
Mach effects?



A craft in a warp bubble generated by exotic matter in the ring shaped nacelles amidships. The distortion of the space is shown by the grid lines that are normally flat.

The cover of the
August 2002
Scientific American.

An absurdly benign
wormhole connecting
Times Square and
North Africa.



A Venn diagram of the grouping of those engaged in exotic propulsion and their relationship to the general community of physicists. The long sought theory of quantum gravity is thought by some to be prerequisite to achieving exotic propulsion.

Roger Shawyer and the EMdrive

- * We need to find a way to produce propulsion without blasting great gobs of stuff out of a tail pipe.
- * The machinery to do this must be based on techniques available to us now – that is, it must be based on electromagnetic equipment.
- * How can electromagnetism be used to produce thrust?
- * **Shawyer: electromagnetic resonant cavities.**

An artistic rendition of an EMdrive from a show on George Lucas and his influence on science fiction.

In the USA, work on Shawyer type devices is being pursued by Sonny White and Paul March in their Eagleworks lab at NASA Johnson. They are seeing thrusts on the order of tens of μN .

But only when high density polyethylene disks are affixed to one end of the cavity.
(Teflon works too.)



Paul

Sonny

How does this work?

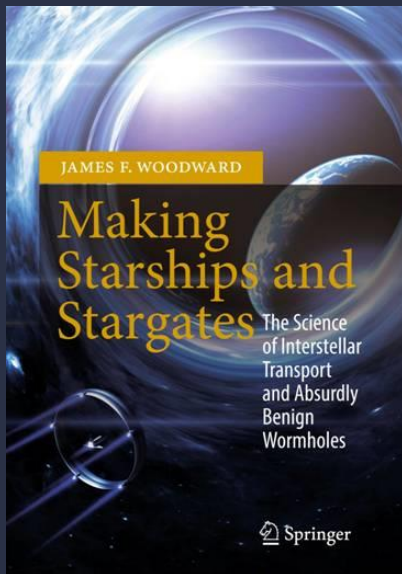
- *Standard mainstream physics: *It doesn't.*
- *Sonny White and Paul March: It's a “quantum vacuum plasma thruster”.
- *Mach effects can explain the operation of these devices – but that's not the chief subject of this talk.

The Quantum Vacuum Plasma

- * Is nonsense in the view of mainstream quantum mechanics.
- * According to Hal Puthoff and Sonny White consists of electron-positron pairs that flit into existence, and are then quickly annihilated.
- * According to White, these pairs are “densified” in the presence of matter **and** externally applied electric fields.
- * These pairs, which violate energy conservation, are allowed by the Heisenberg Uncertainty Principle for energy and time.
- * How long does a pair live?
- * 3×10^{-22} seconds or less.
- * How many pairs do you need to produce observed thrusts?

A Digression on Mach Effect Thrusters

- A Mach Effect Thruster [MET] is a solid state device that produces thrust without the irreversible ejection of propellant.
- METs are not “free energy” devices. They require a power source to operate.
- Power can be supplied, for orbital spacecraft, by solar arrays or onboard reactors.
- Since METs do not require propellant, they can operate indefinitely without propellant resupply.
- METs would dramatically reduce the cost of satellite station keeping, orbit transfer, and collision avoidance.
- If successfully scaled, METs may become viable for primary, heavy lift propulsion.



How do METs Work?

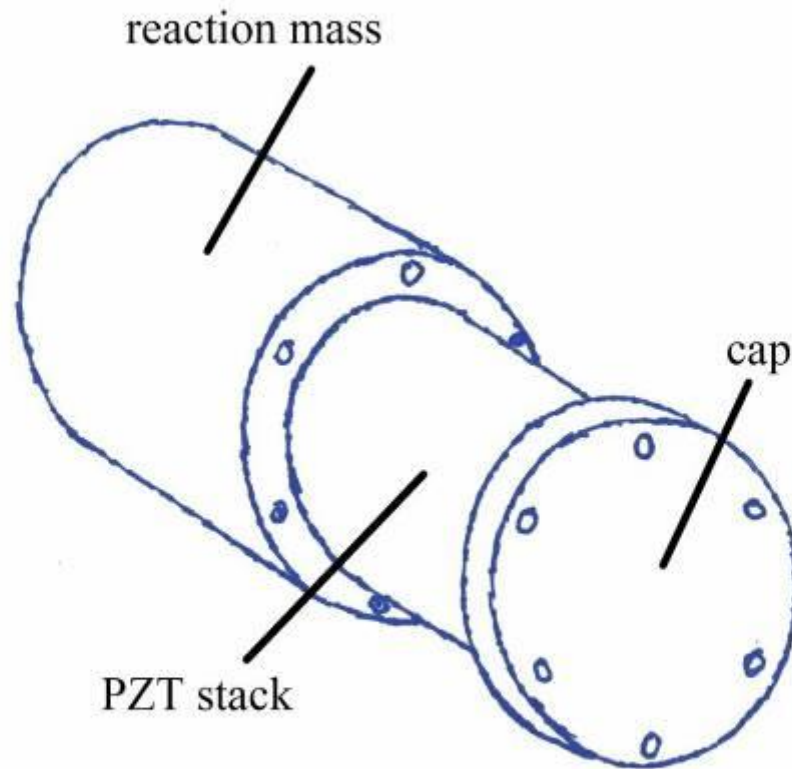
- METs depend on “Mach’s principle” being correct.
- Mach’s principle is the proposition that all inertial forces – the forces of reaction in Newton’s third law of mechanics – are produced by the gravitational action of all of the “matter” (everything that gravitates) in the universe.
- In our universe, the conditions needed for this to be true in general relativity are those in fact observed – spatial flatness at cosmic scale.
- When the action of gravity on accelerating local objects is analyzed in relativistically correct fashion, it is found that the rest masses of accelerating objects that are also changing their internal energies (being squished) change. They fluctuate.
- If these rest mass fluctuations are produced periodically, and a second periodic force is brought to bear, you can push heavy, pull light on the fluctuating mass and produce a steady thrust.

THE “MACH EFFECT” EQUATION

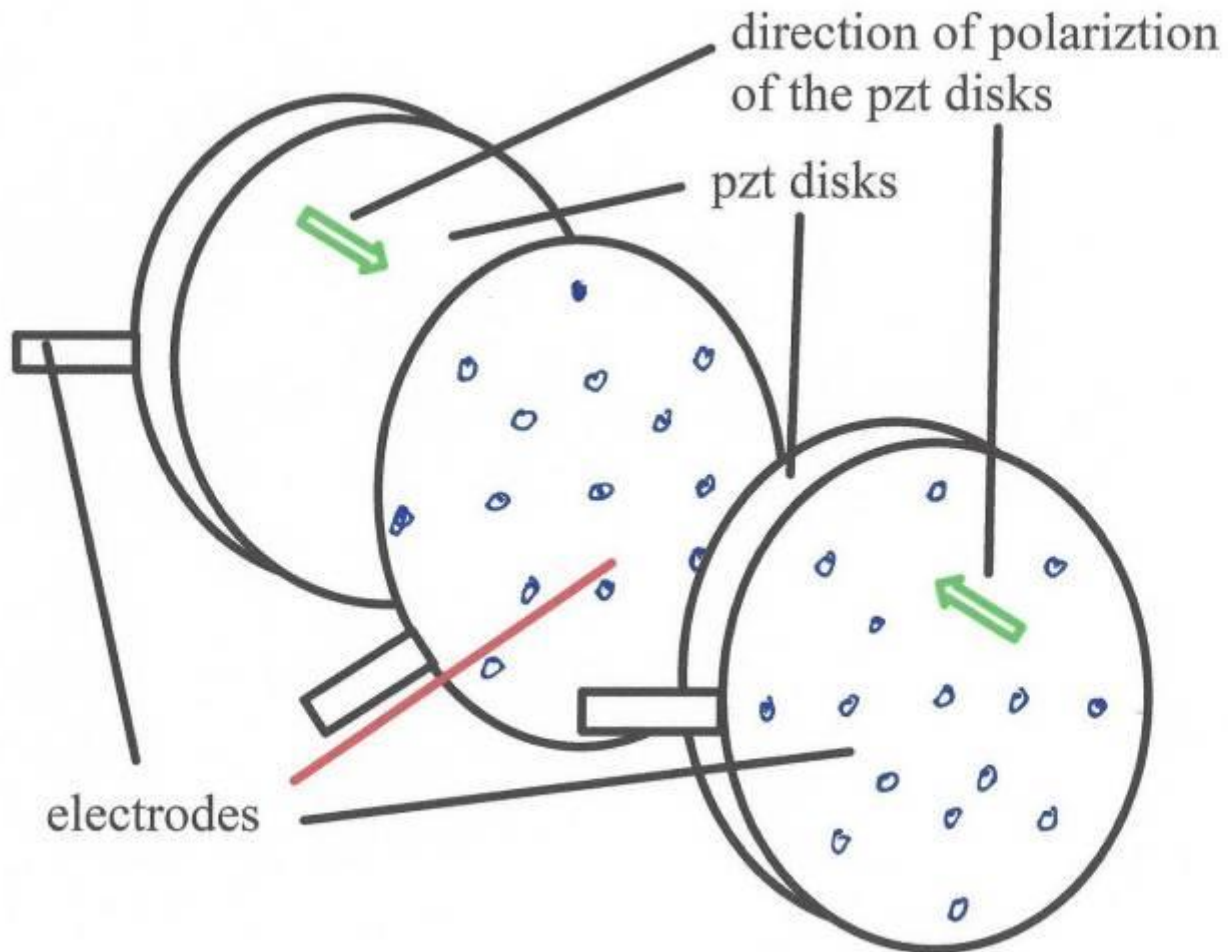
QUANTIFIES THE MAGNITUDE OF THE PREDICTED MASS FLUCTUATIONS IN ACCELERATED OBJECTS:

$$\delta m_0 \approx \frac{1}{4\pi G} \left[\frac{1}{\rho_0 c^2} \frac{\partial P}{\partial t} - \left(\frac{1}{\rho_0 c^2} \right)^2 \frac{P^2}{V} \right]$$

- * The linear term in P [the power delivered to a capacitor] is the “impulse engine” term.
- * The quadratic term in P is the “wormhole” term (because it is always negative), normally a factor of $1/c^2$ smaller than the impulse engine term.

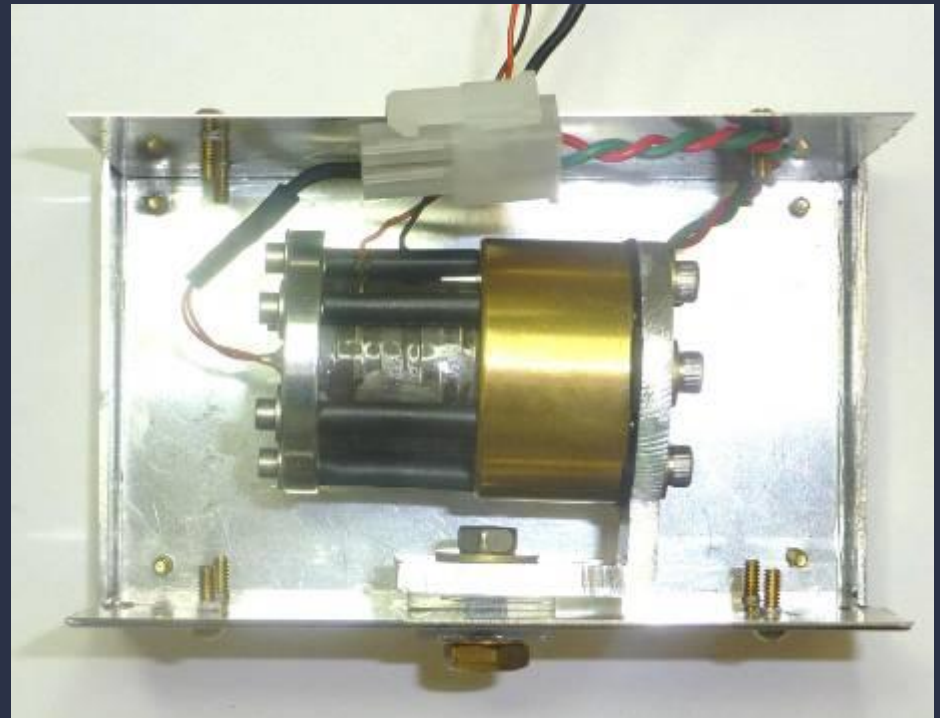
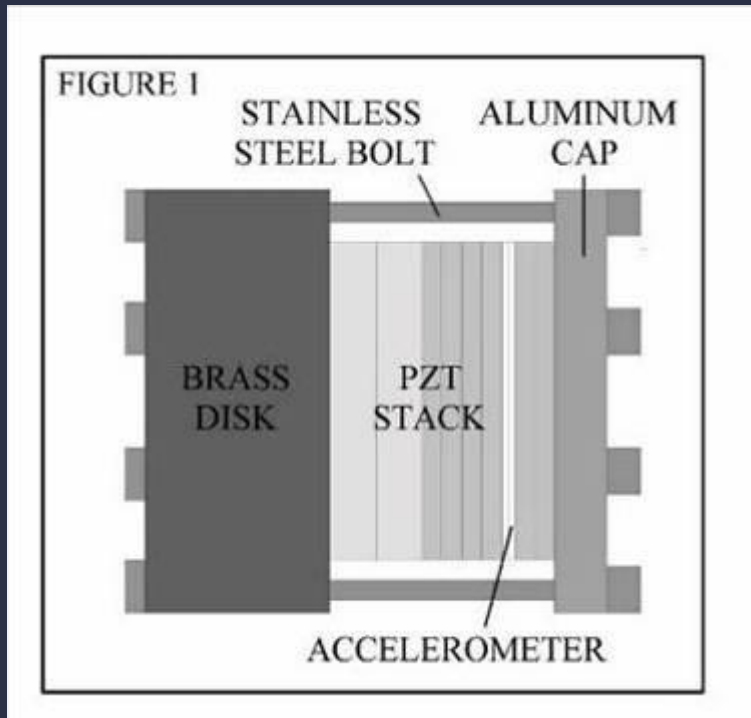


The chief parts of a MET.



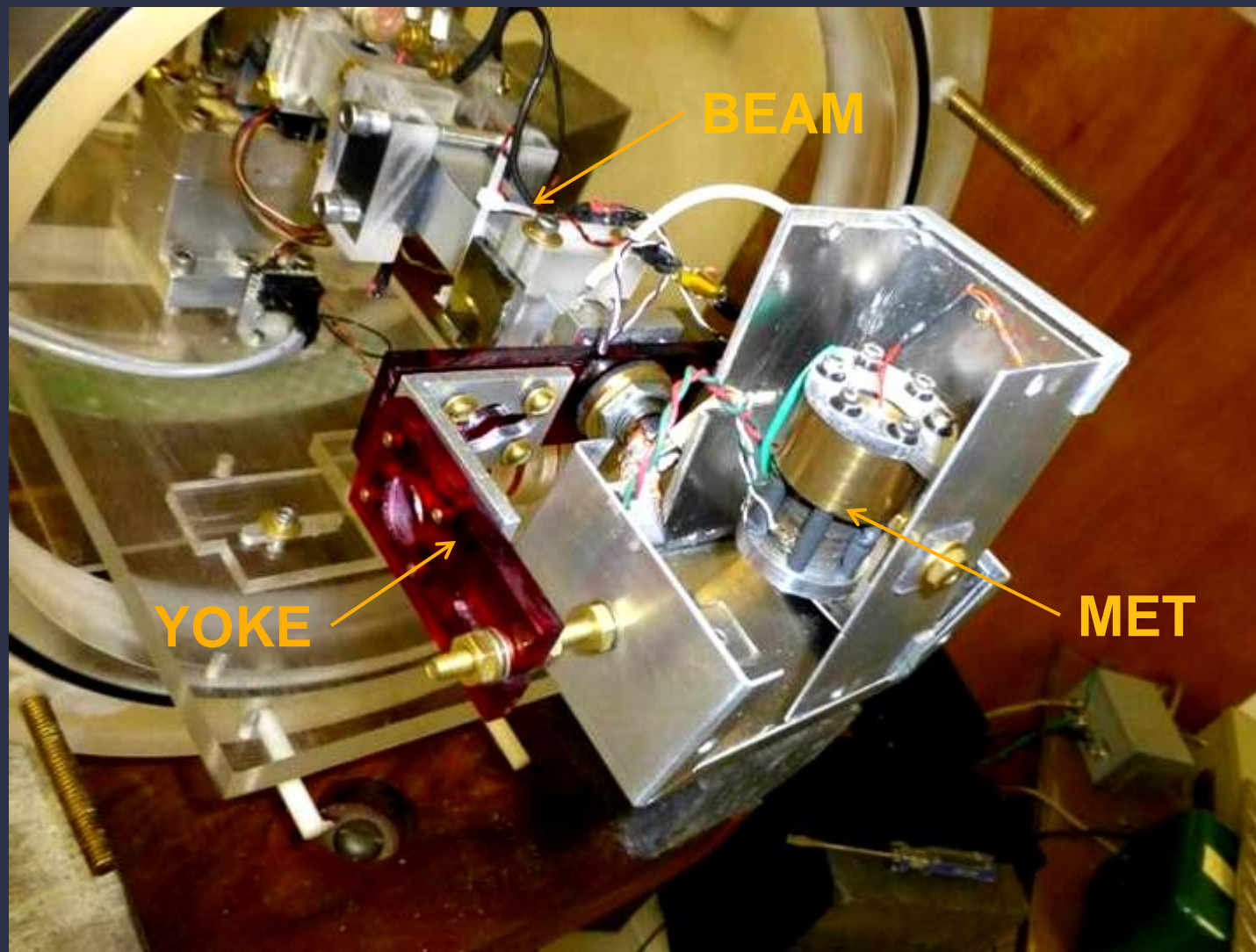
Exploded parts of an element of the PZT stack.

The Mach Effect Thruster

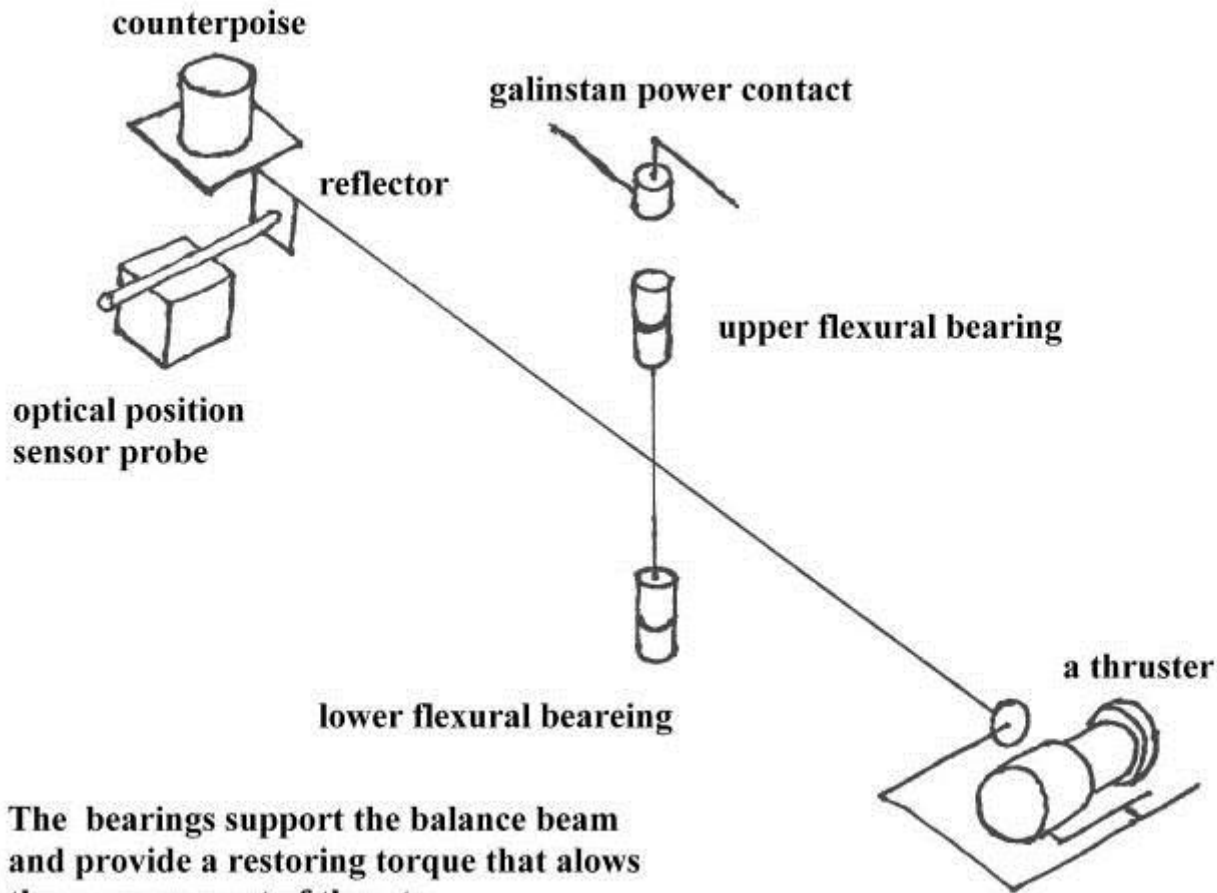


- On the left, a sectional diagram of a MET. A stack of PZT disks is clamped to a brass reaction mass and excited with a periodic voltage, causing the stack to expand and contract. The induced acceleration of the end of the stack near the aluminum cap produces mass fluctuations. A second induced acceleration transforms the mass fluctuation into a force.
- On the right, a current realization of such a MET mounted in the half-shell of a Faraday cage.

The small thrusts produced by METs now in use are detected with a sensitive thrust balance. A MET is shown here mounted in the partially assembled Faraday cage attached to the end of the thrust balance beam.



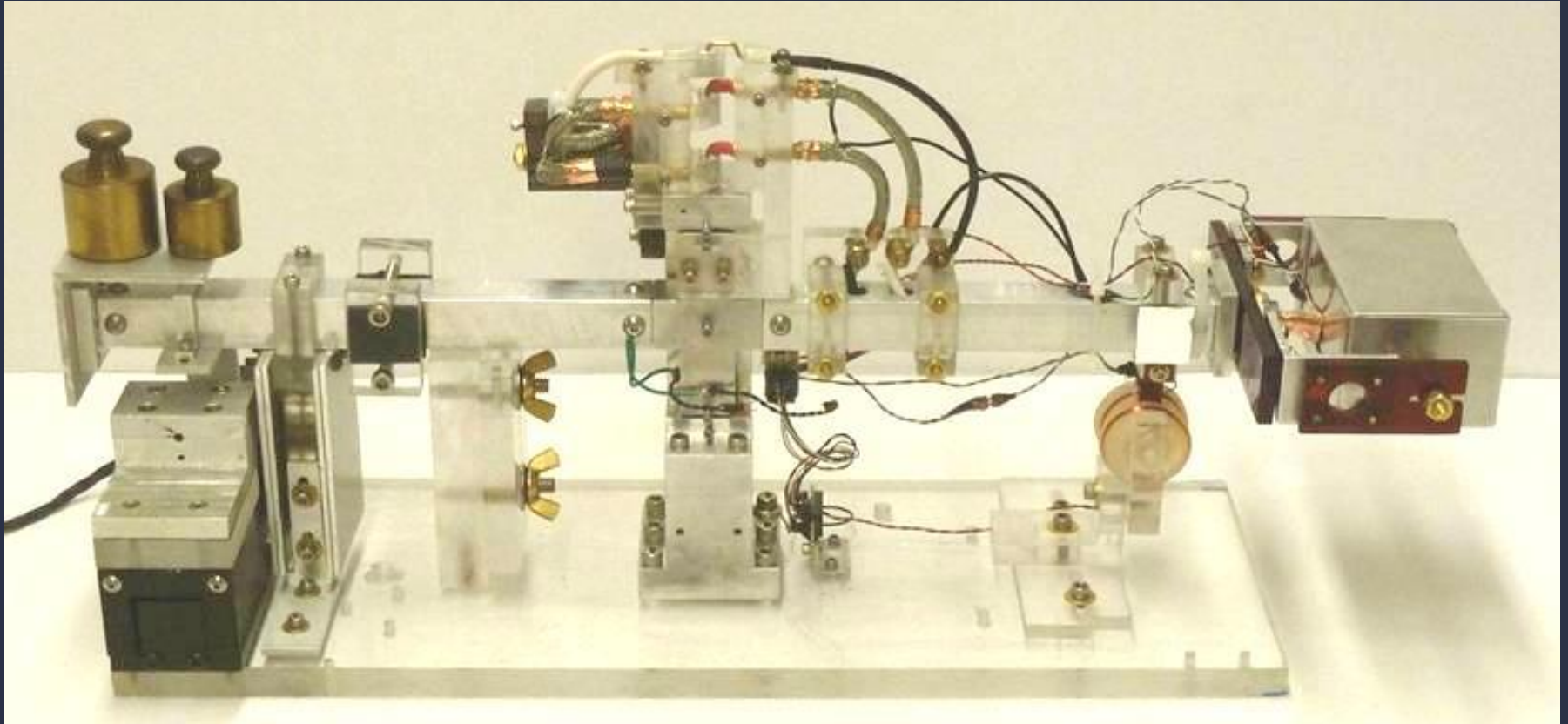
Note the red plastic and aluminum yoke that enables rotation of the device and cage on the end of the balance beam so the direction of the MET can be reversed.



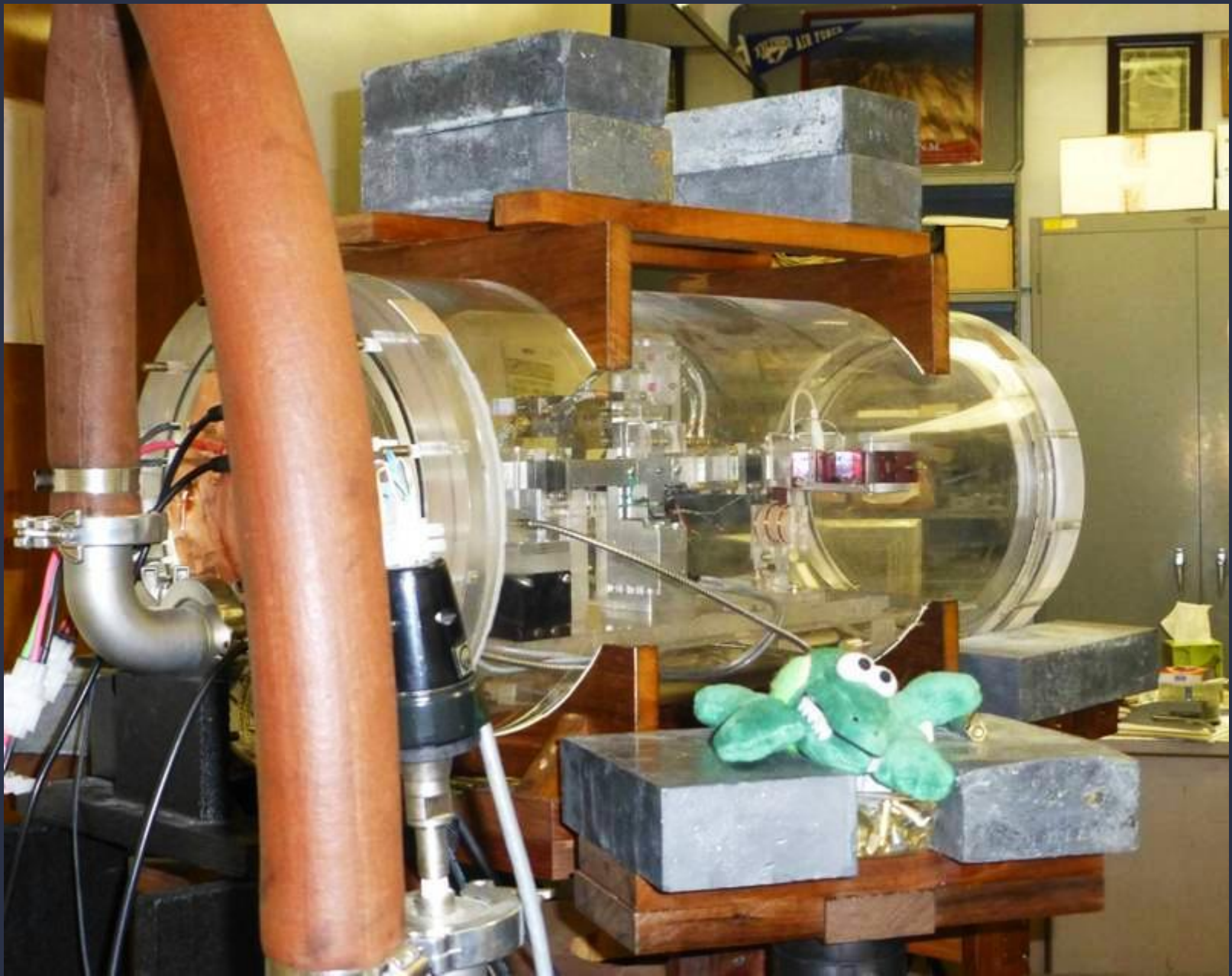
The bearings support the balance beam and provide a restoring torque that allows the measurement of thrusts.

The small thrusts produced by prototype METs are measured on a very sensitive thrust balance. The thrusts are typically on the order of several micro-Newton.

THE USC/ARC STYLE THRUST BALANCE



The assembled thrust balance outside of the vacuum chamber. A Philtec optical probe is mounted on the stepper (positioning) motor at the left end of the beam. Power connections are made through galinstan contacts mounted coaxially above the flexural bearing assembly in the center that supports the beam. Instrumentation leads to the beam are bundled just to the right of the central column. Coils used to calibrate the balance are located on the right just below the beam. A magnetic damper (slightly less than critical) is located to the right of the stepper motor.



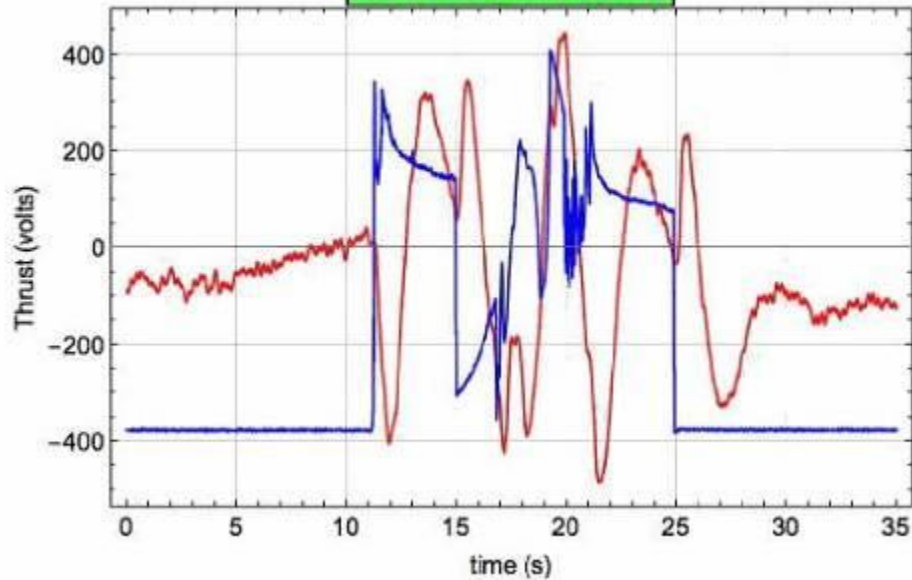
The balance in the vacuum chamber (pumped typically to < 50 mT).

Mass Fluctuations for Propulsion

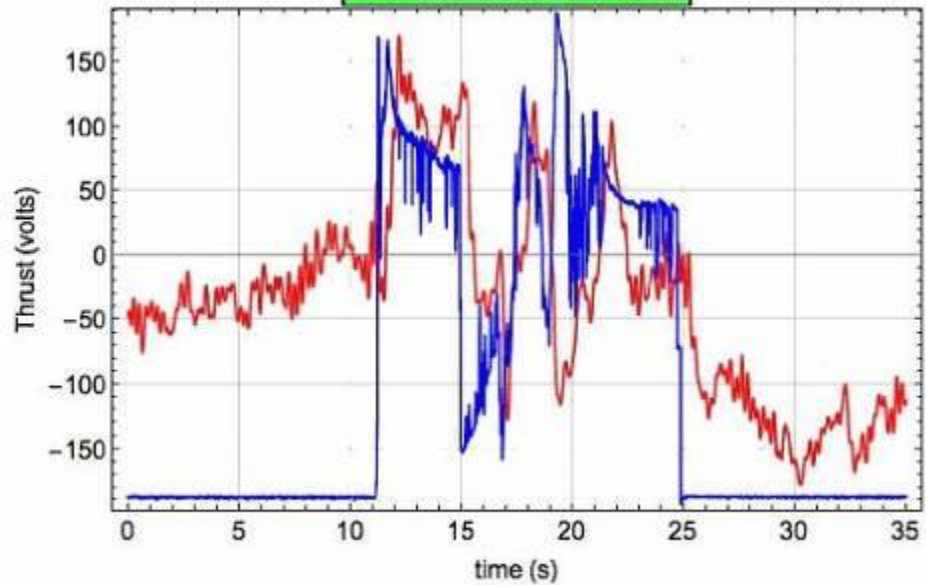


An actuator between the two masses periodically pushes them apart and then pulls them together in sync with the fluctuations of the mass on the right.

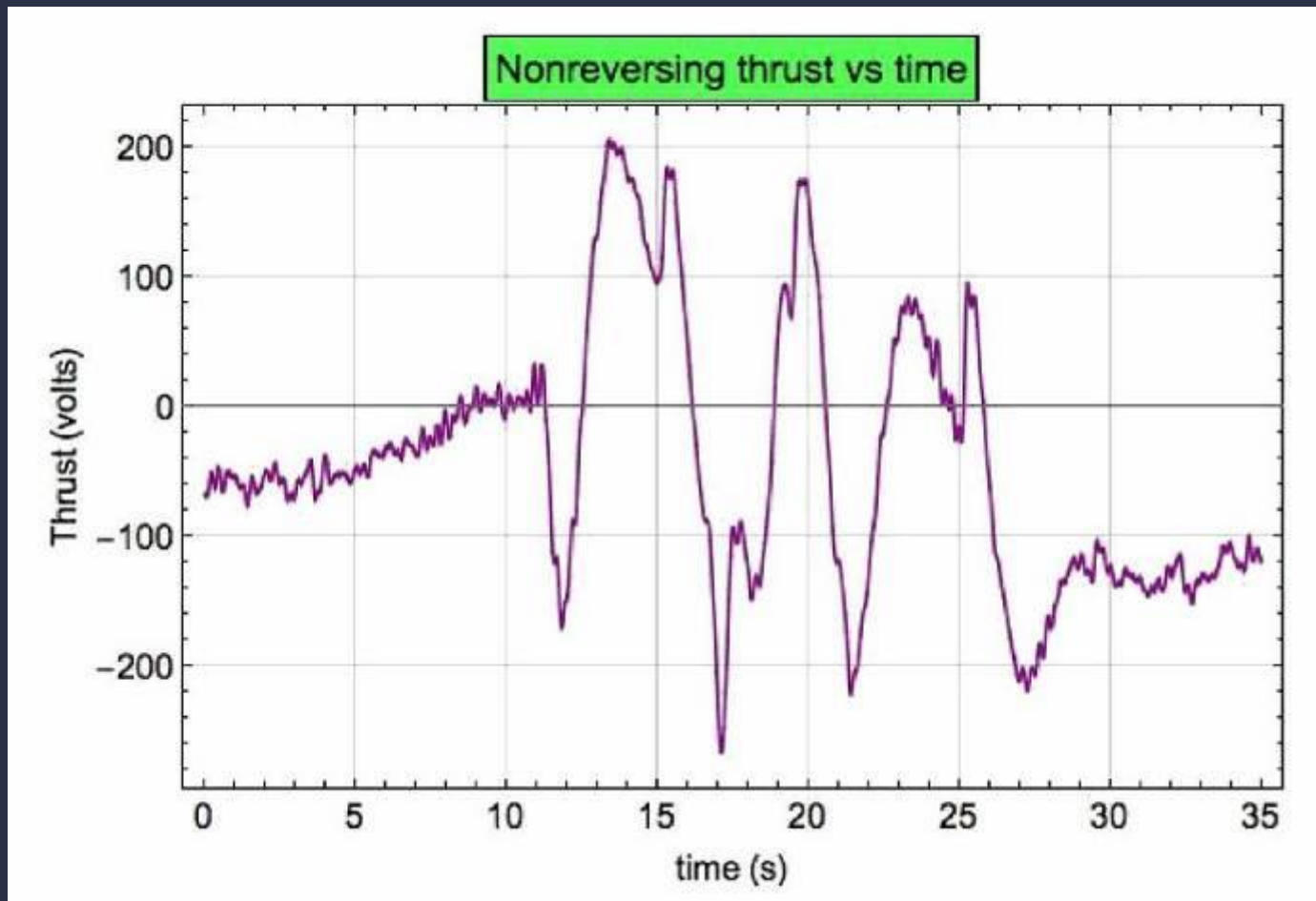
Av. Forward data vs time



Av. Reversed data vs time

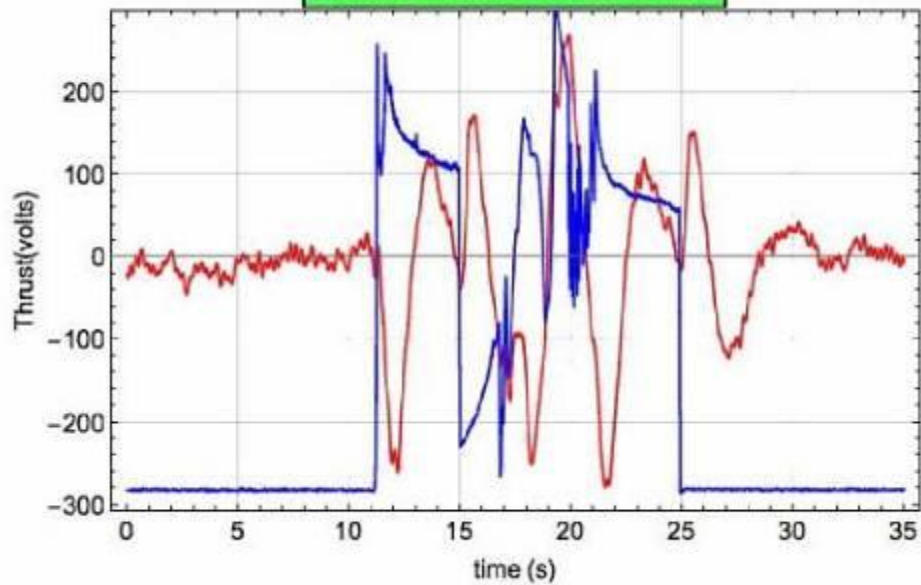


Recently obtained results – the averages of 2 or 3 “runs” – with a MET. The voltage delivered to the device, normally off, is the blue trace. Note that the thrust trace (red) changes when the direction of the device on the balance beam is reversed.

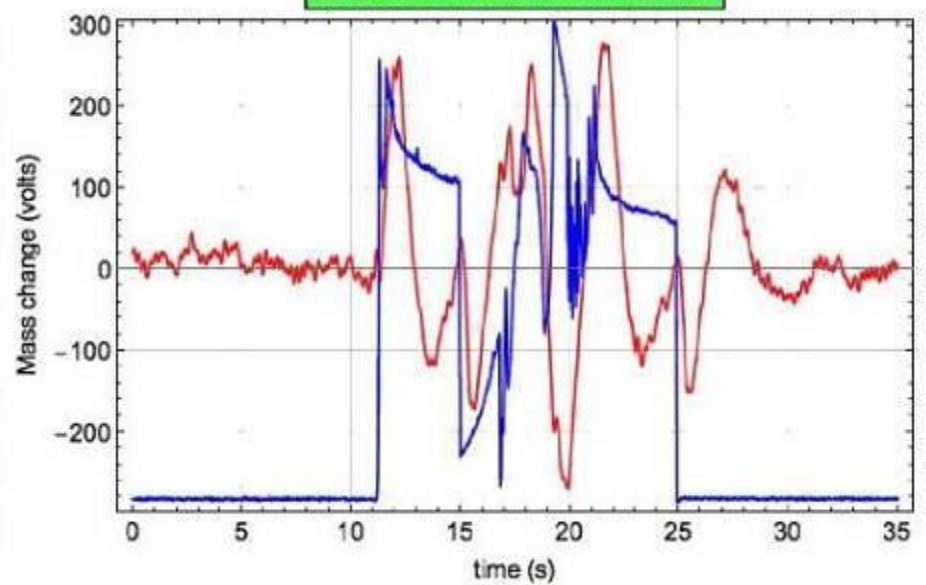


The thrust traces for the “forward” and “reversed” directions in the previous slide are not mirror images because part of the thrust is not produced in the MET, and doesn’t reverse with the device. The non-reversing thrust can be obtained by adding the two averages and dividing by 2. This can then be subtracted from the averages to isolate the reversing thrust.

Forward - Nonrev thrust vs time



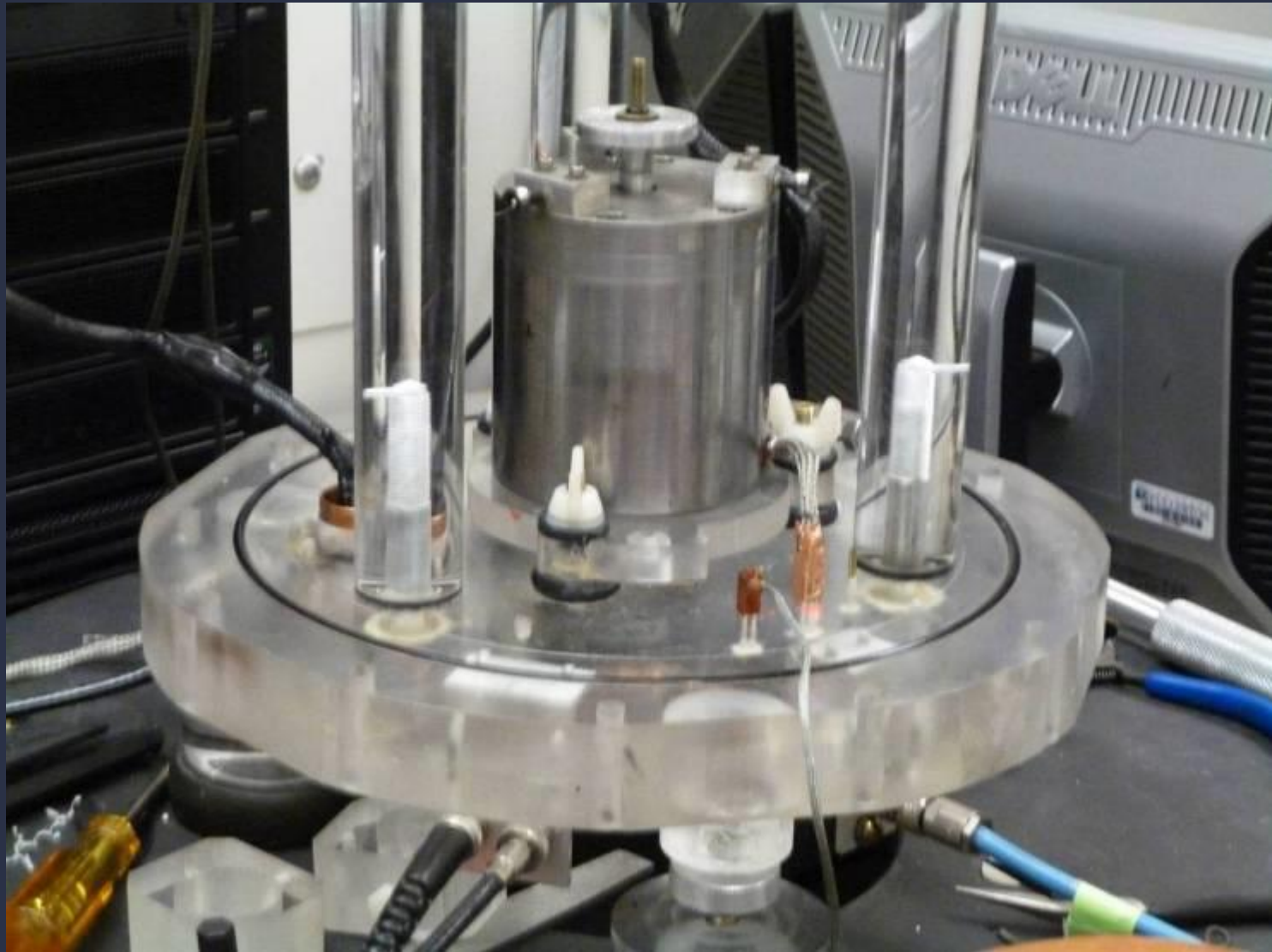
Reverse - Nonrev thrust vs time



The forward and reversed thrust traces with the non-reversing Thrust subtracted out. Full-scale thrust is about 20 μN .

With the predecessor of the thrust balance. A force sensor based on the Unimeasure U – 80 position sensor shown in the next slide.

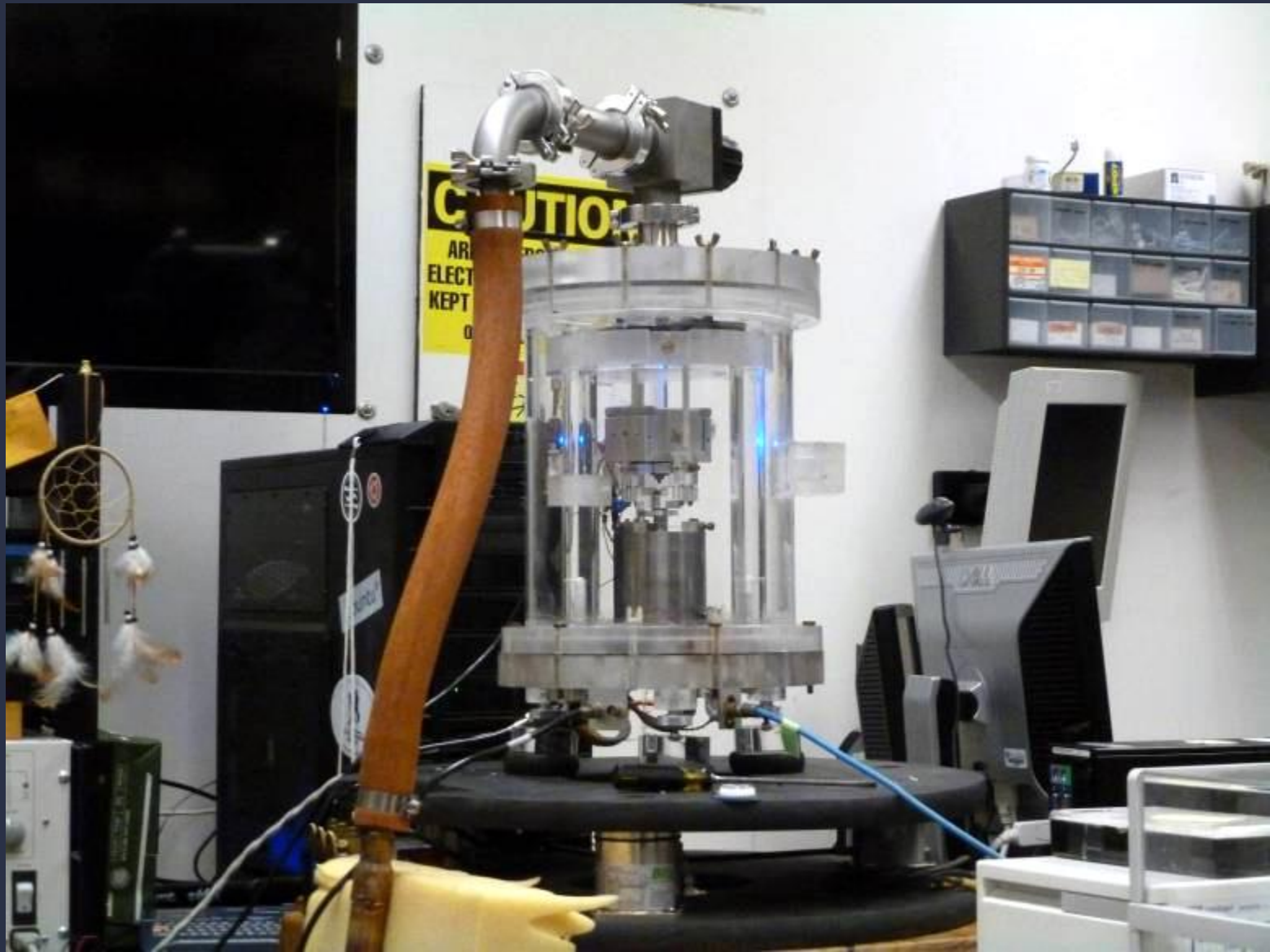
The diaphragm spring transforms the position sensor into a force sensor.



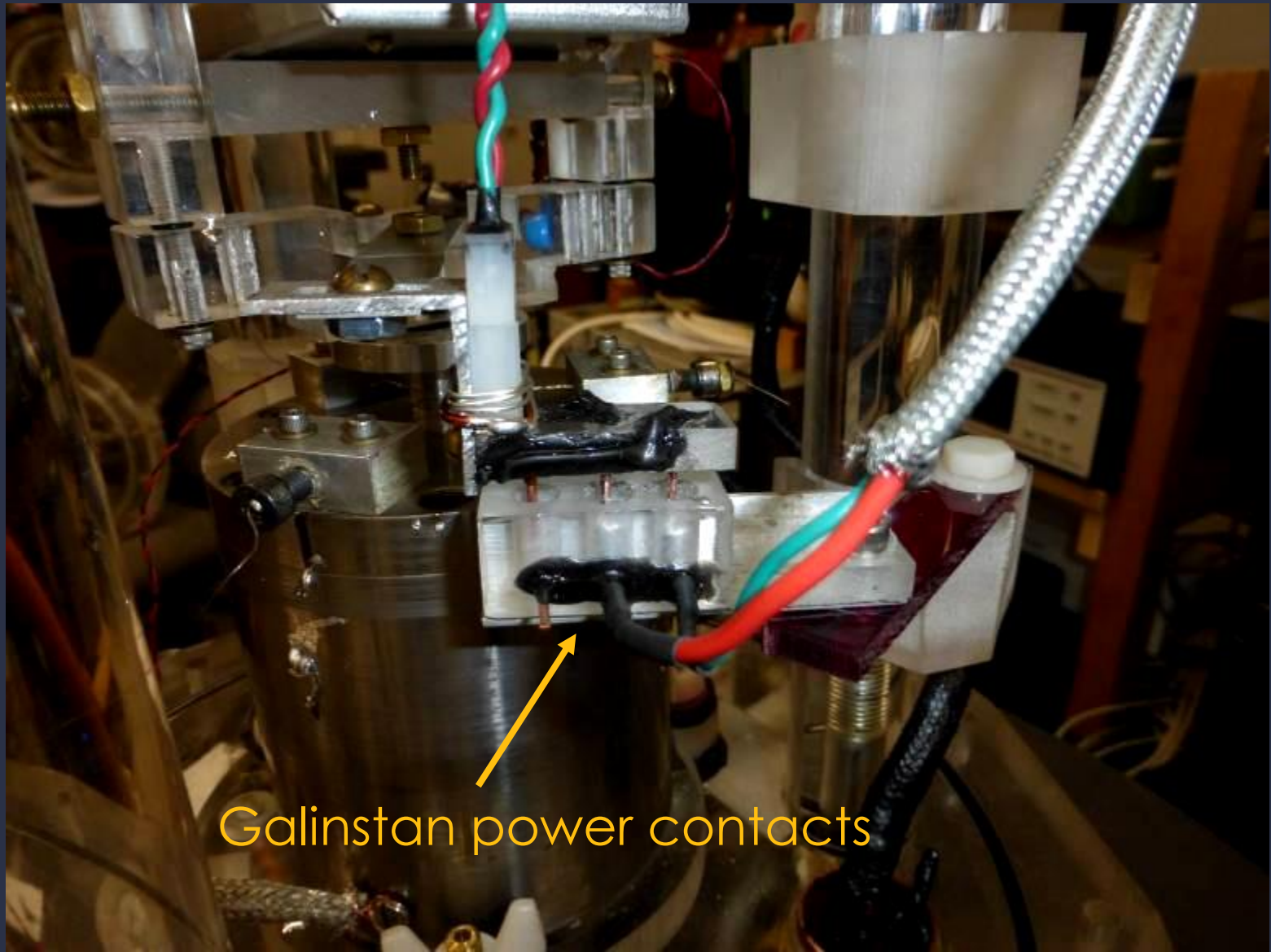
The U-80 in its 1 cm thick steel case that shields the sensor from EM fields on the base of its vacuum chamber.



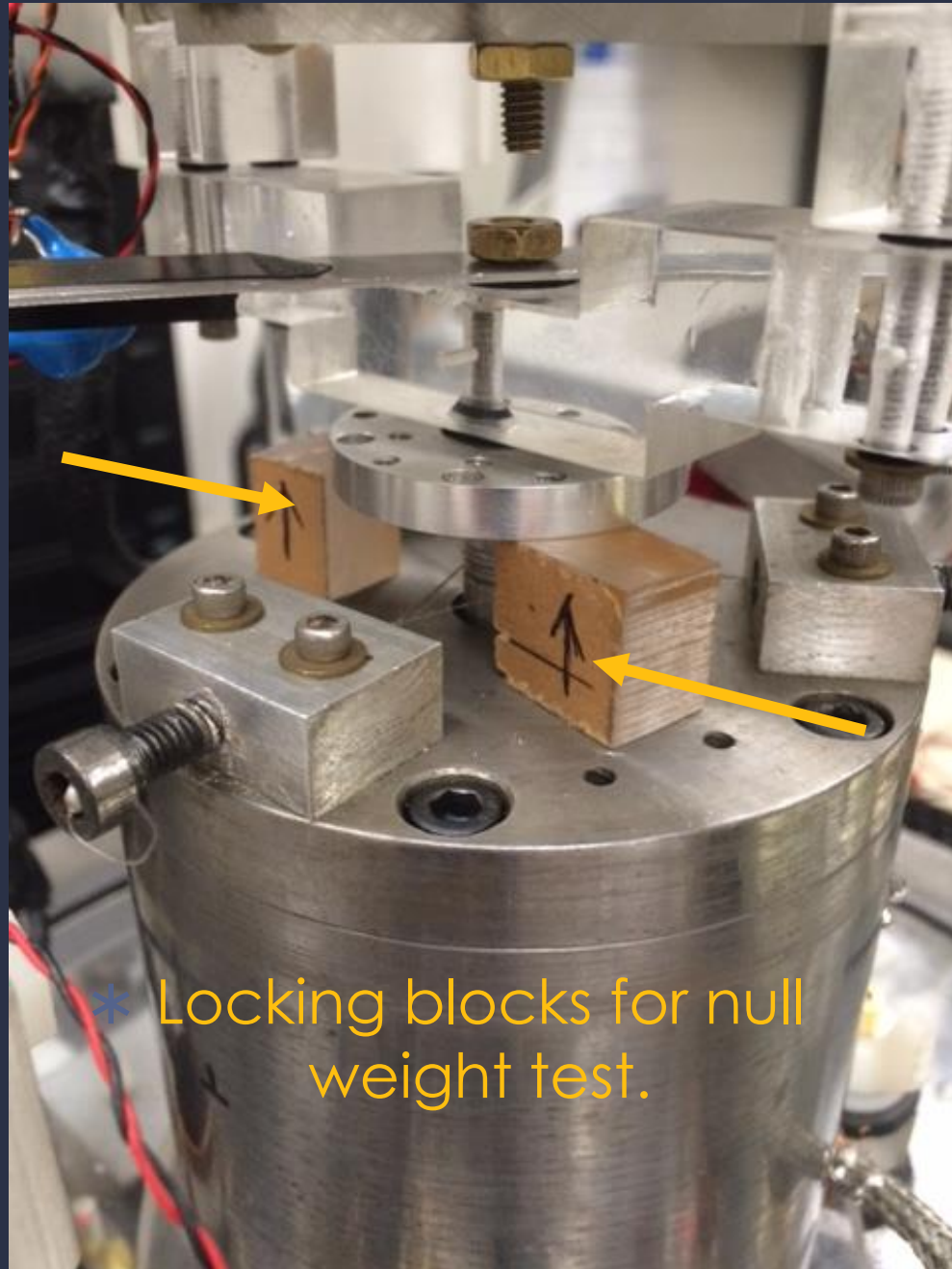
Partial reassembly.



The vacuum chamber fully reassembled.



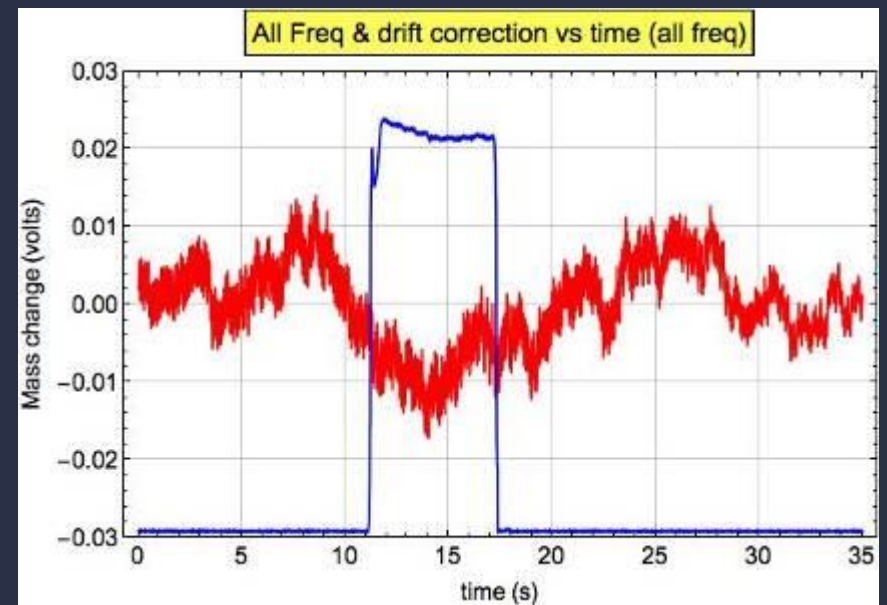
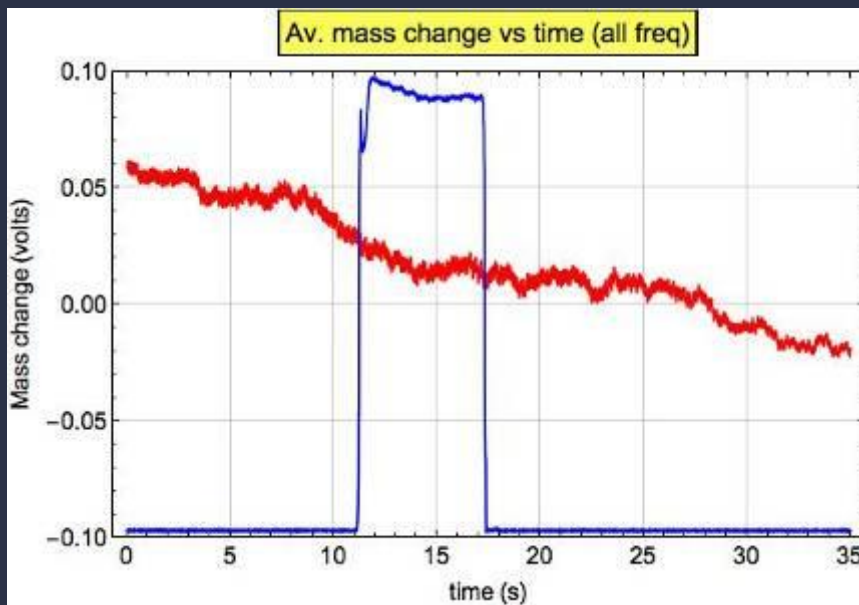
Galinstan power contacts



* Locking blocks for null weight test.

All frequencies averaged together: raw and drift corrected.

As before, blue is the voltage applied to the MET. And red is the weight of the device. The weight scale goes as 0.1 gram equals 0.3 volts. So the weight scale for the plot on the right is plus or minus 10 milligrams.



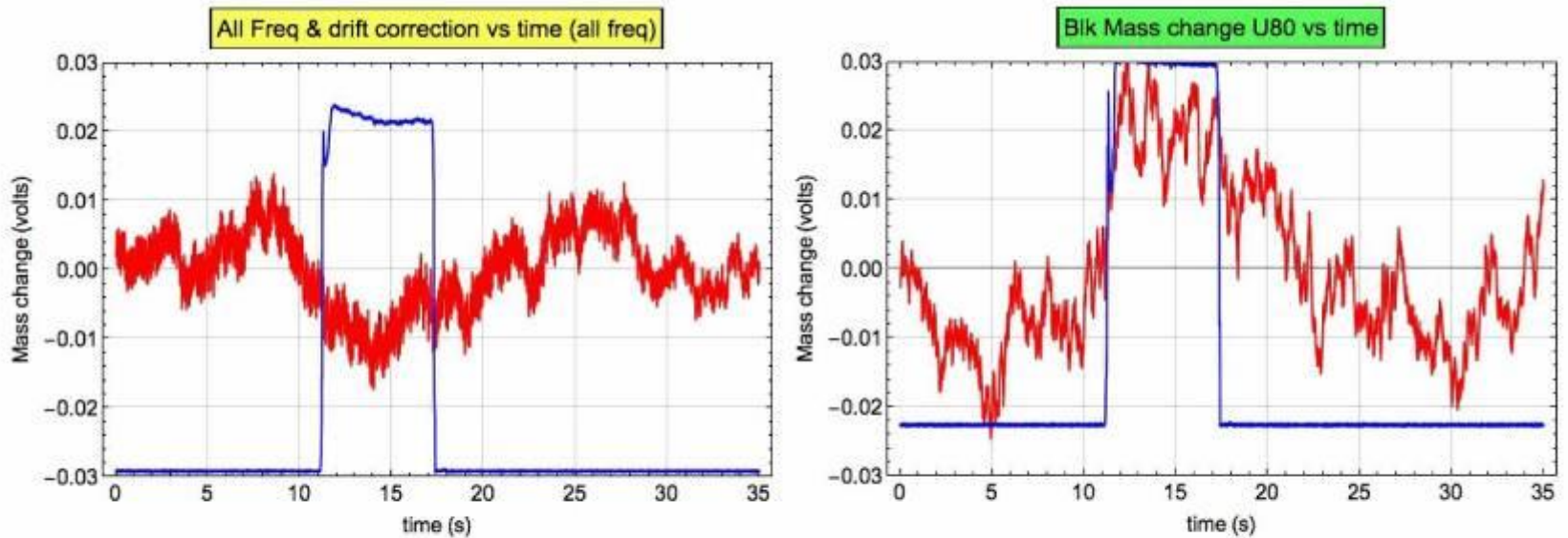


Figure 20: The averages of all data at all frequencies for the drift corrected free (left) and locked (right) weigh stage. When the locked weight signal is subtracted from the free weight signal, the mechanical weight response to the application of power is exposed.

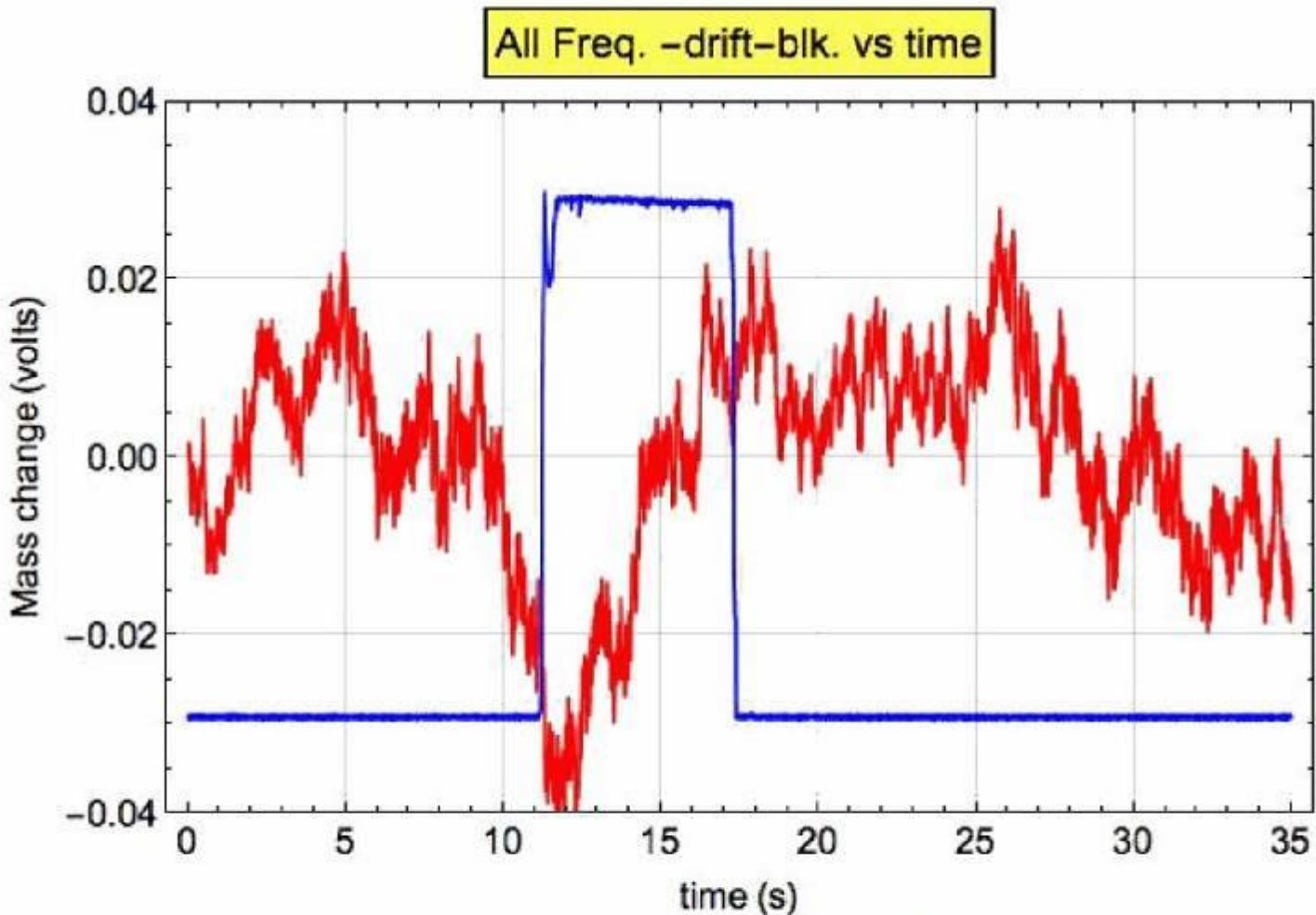


Figure 21: The net weight trace with corrected stage-locked data. The large dip at power-on results chiefly from a fluke low value of the weight at power-on and a small switching transient in the stage-locked data. There is no evidence for a constant weight increase of a milligram or more during the power-on interval.

Does the failure of the quantum vacuum plasma conjecture mean that it is not yet “space drive” time?

No. The experiments done with EMdrives show that it is indeed possible to produce thrust without traditional propellant.

But the underlying physics must involve gravity, for that is the only long range force that can provide the coupling needed to effect momentum transfer to/from the external (to the cavity of the drive) world.

