

LISA Pathfinder Coldgas Thrusters

Joseph Martino/Eric Plagnol - LPF collaboration



Lisa Symposium September 2016 Zurich



Outline



System Description

External Disturbances and thruster noise

In Flight dedicated experiment

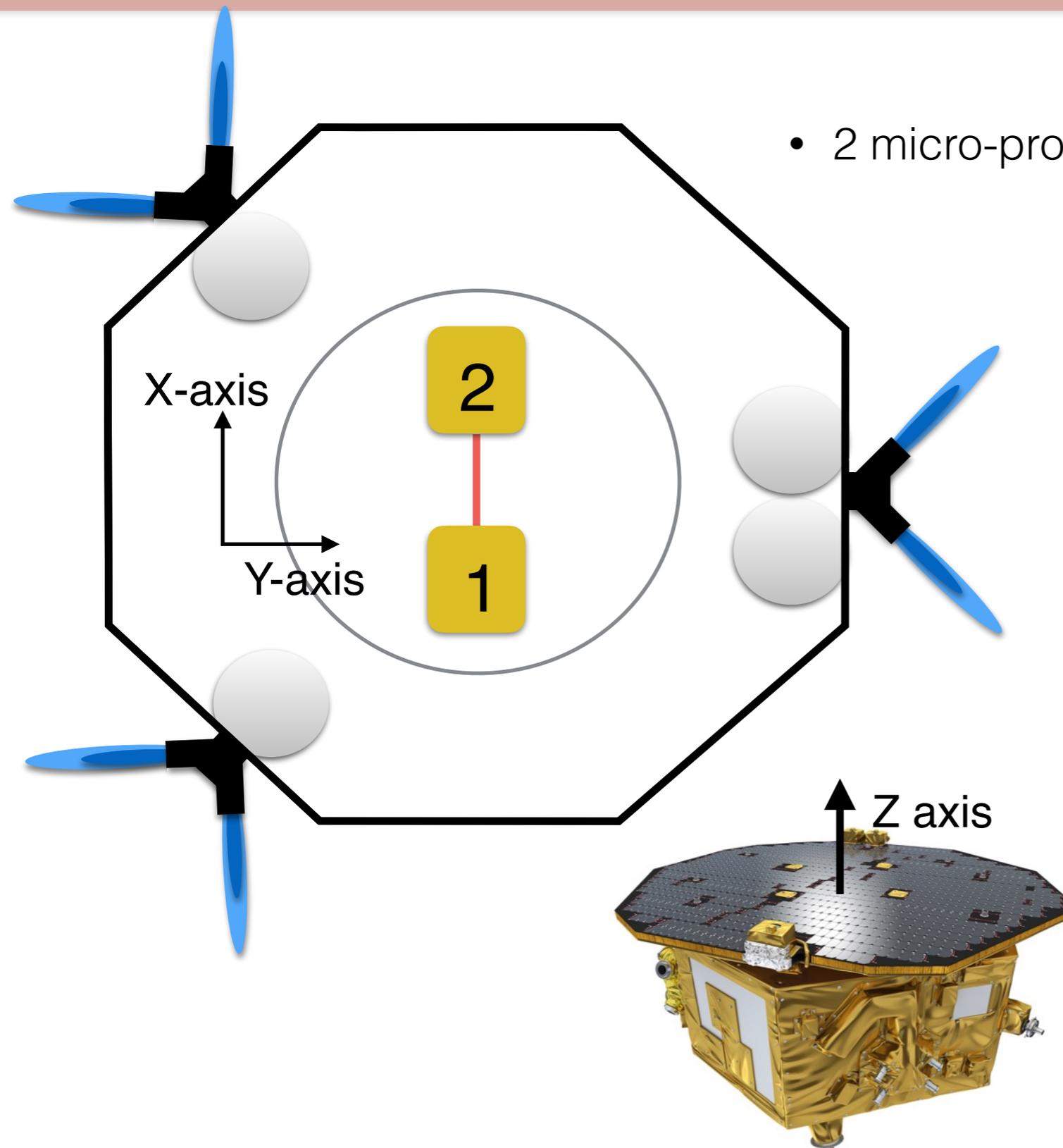
Conclusion

MicroNewton Coldgas Thrusters

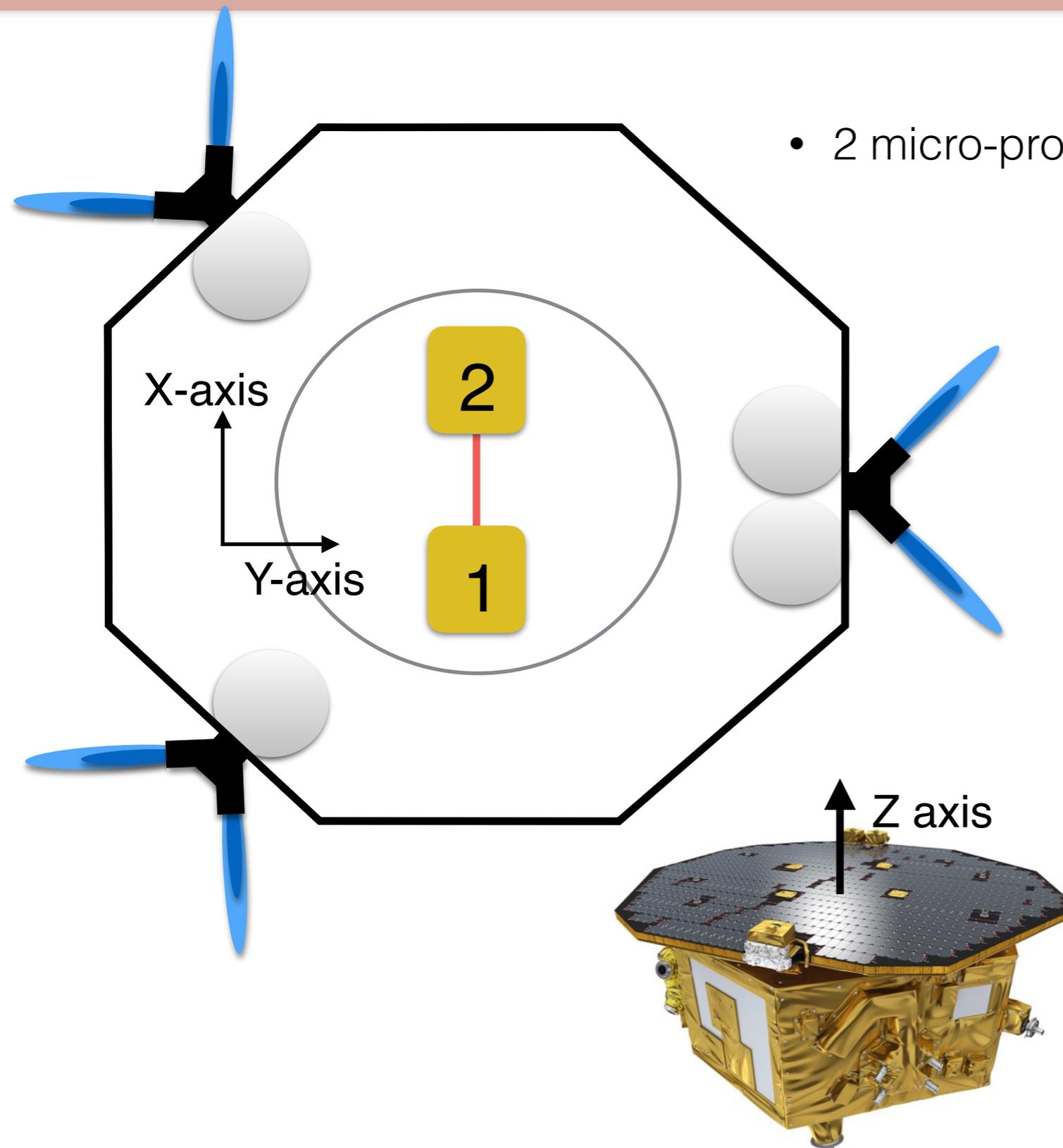
- 2 micro-propulsion systems : **Coldgas** - Colloidal

Description

- 6 thrusters ~**10 - 500 μ N** nominal mission
- Truster = Mass Flow Sensor connected to a piezo controlled valve
- 4 High Pressure N₂ Gas Tanks



MicroNewton Coldgas Thrusters

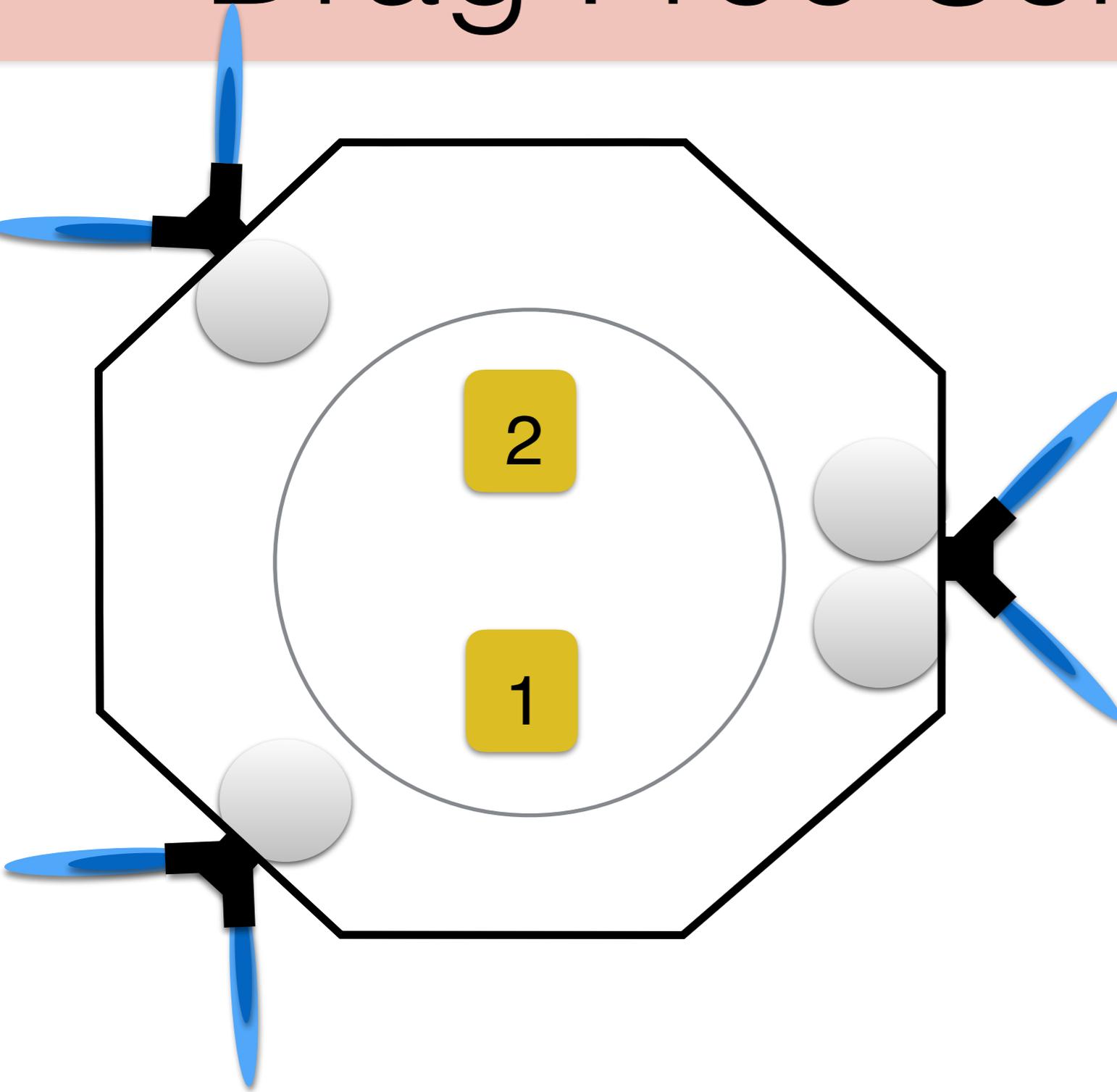


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 - Truster = Mass Flow Sensor connected to a piezo controlled valve
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-
- **2% of the total Mass** : 10kg
 - 30% already used 3kg used during 9 months
 - deltaG driven **emptying strategy**

Drag Free Scheme

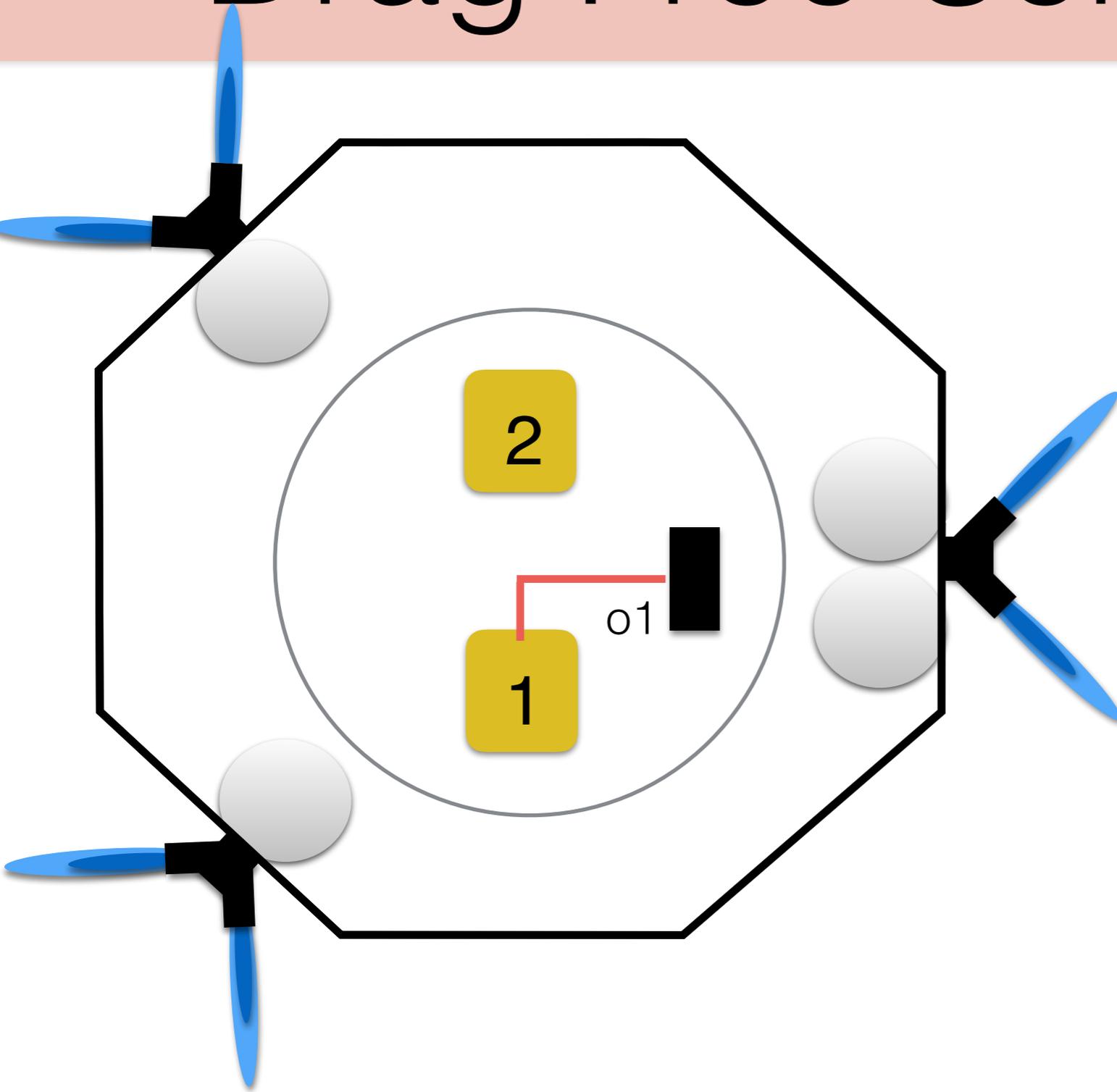


Attitude Control : sun orientation / earth communication

Drag Free control (x y z and theta) :
(i.e. : Satellite follow test Mass 1 on X)

Goal : reduce external disturbances

Drag Free Scheme



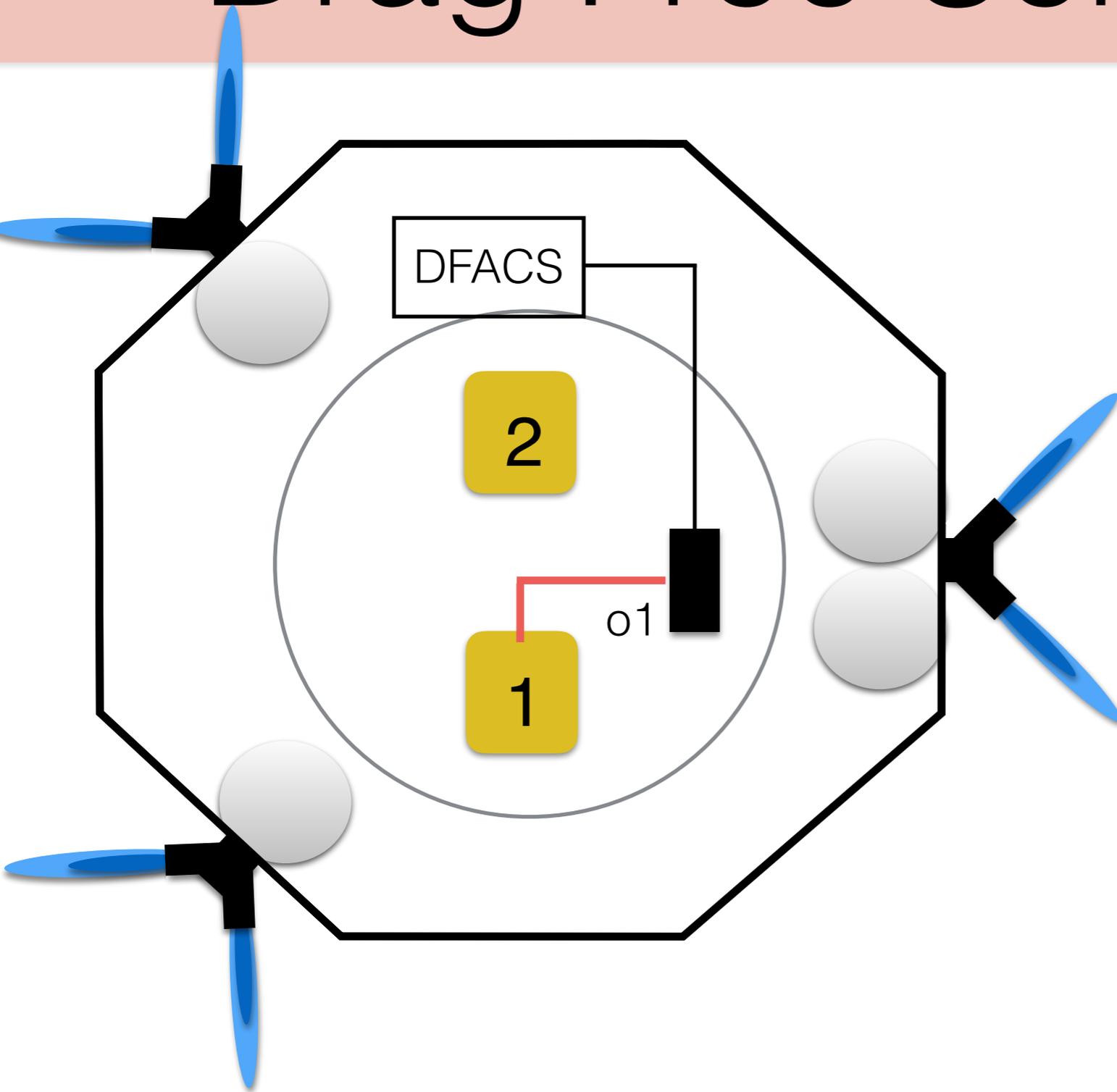
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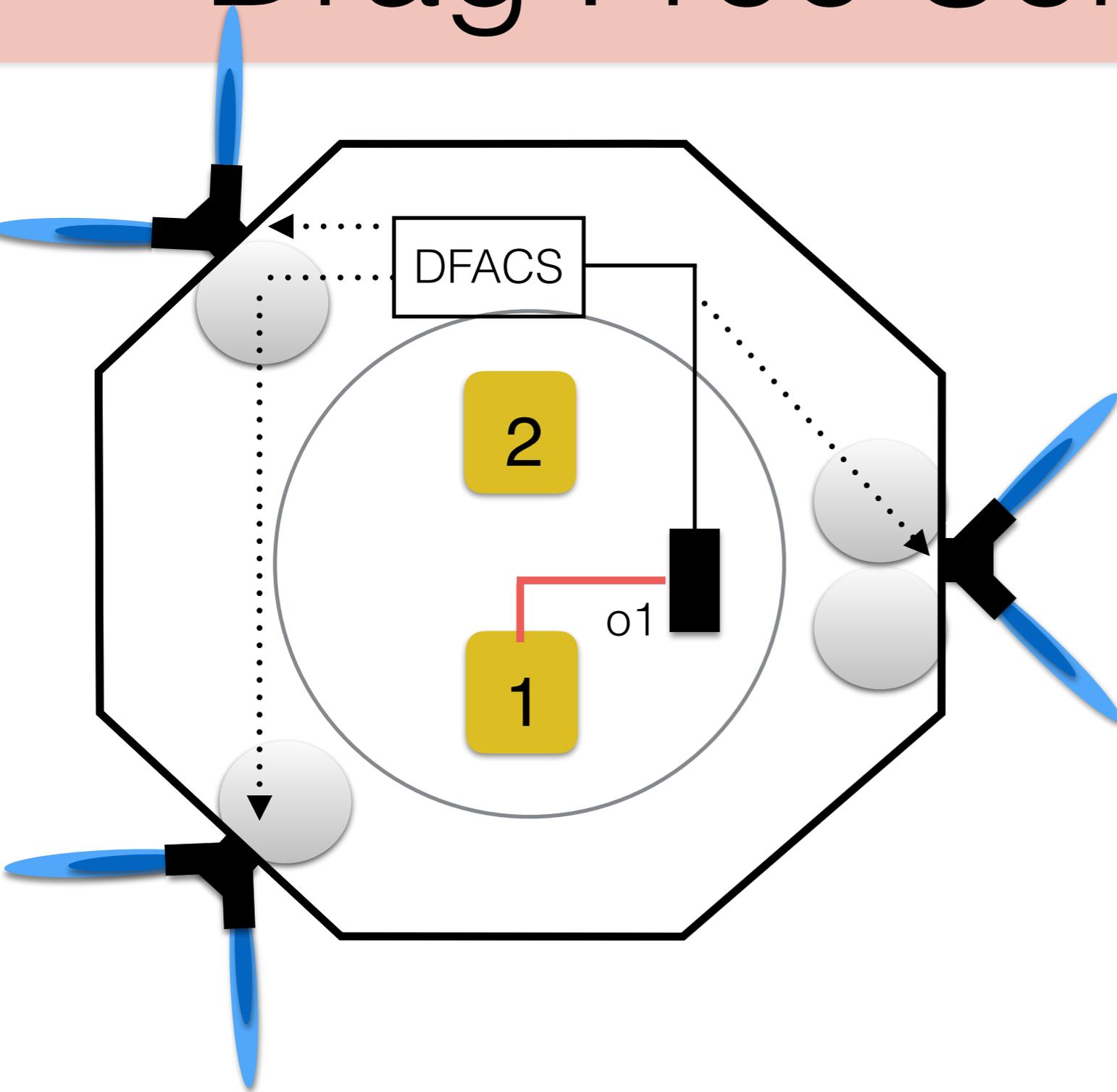
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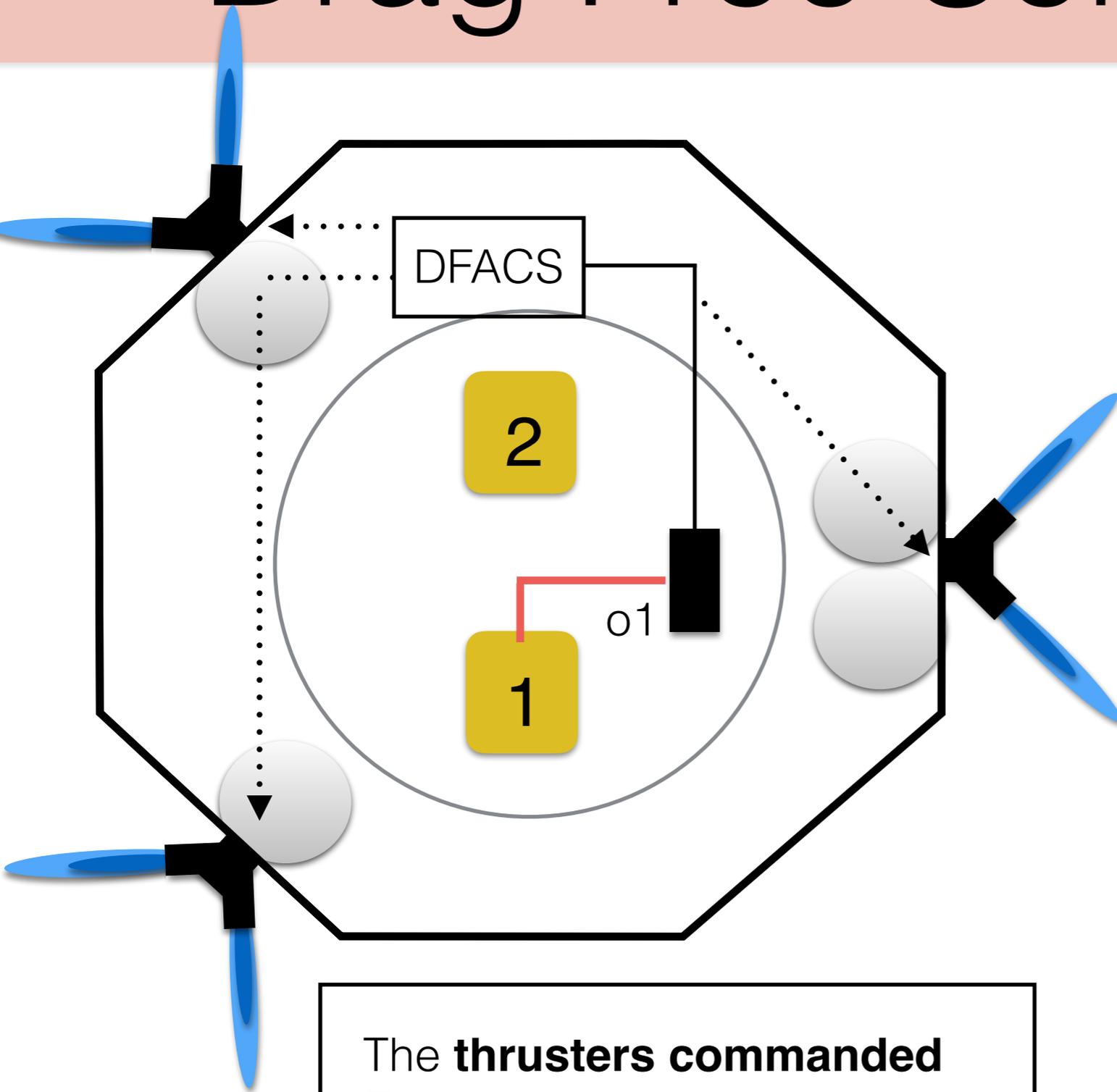
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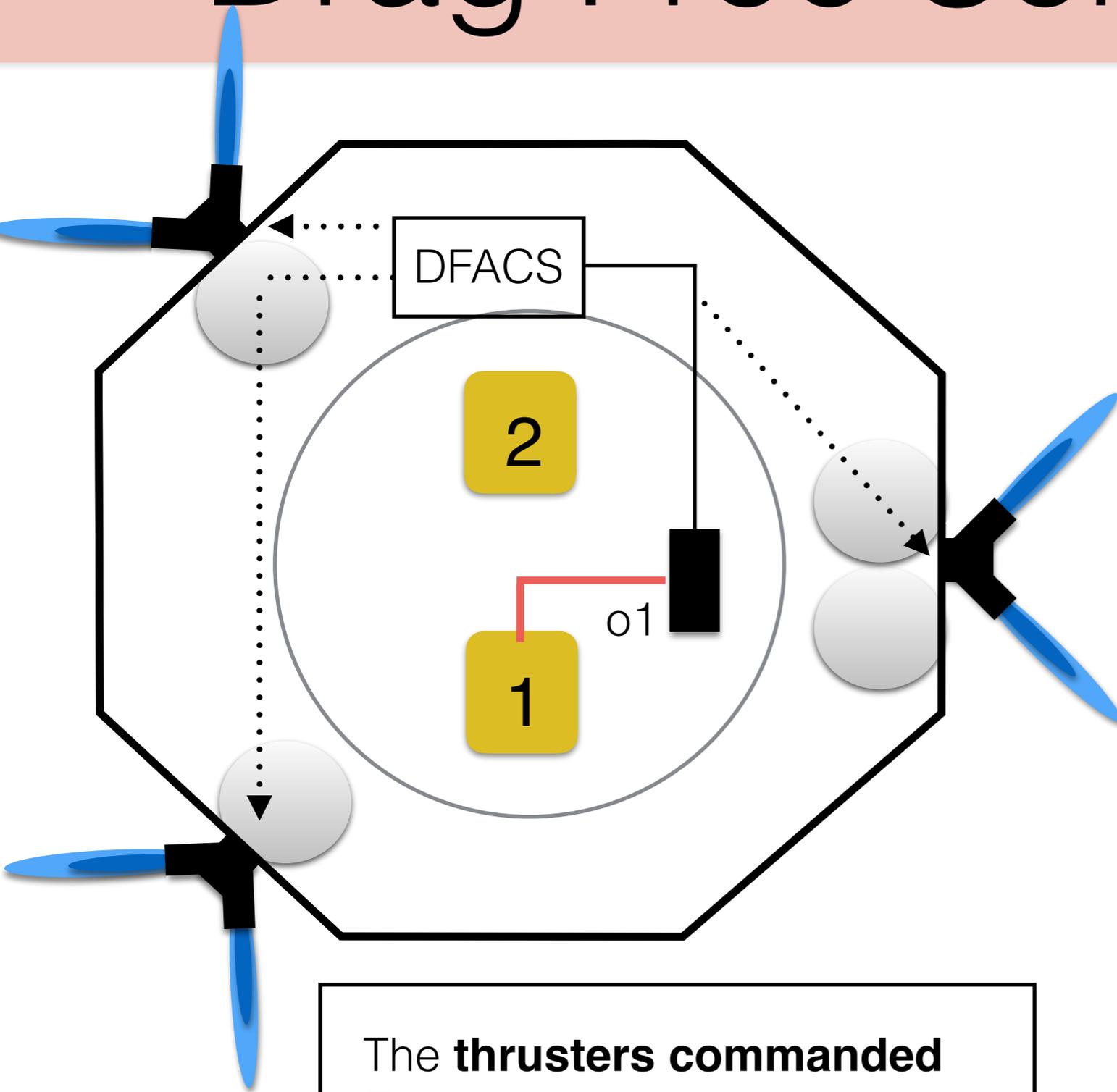
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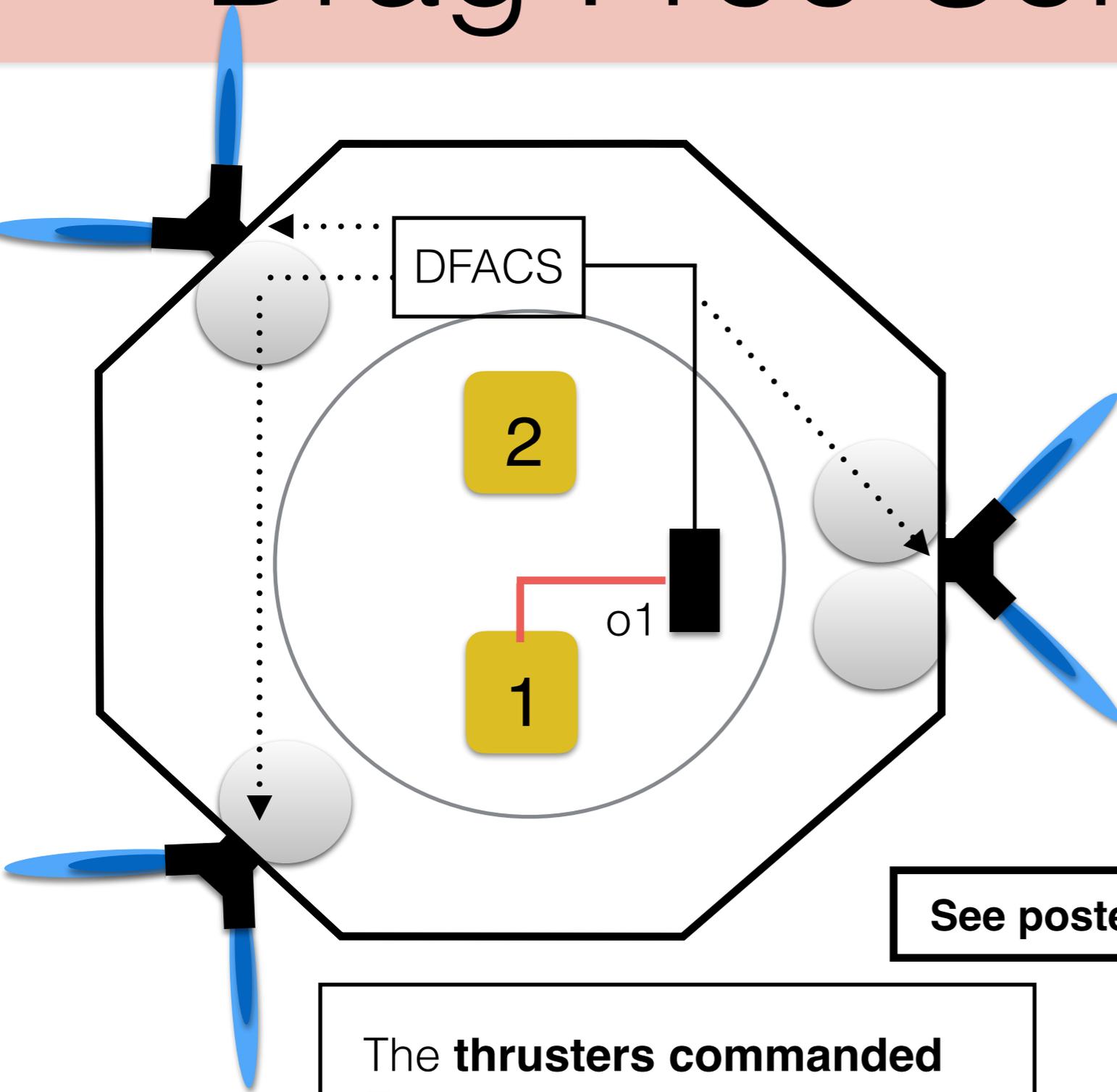
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See poster by Henry Inchauspe

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External Disturbances



DC contribution

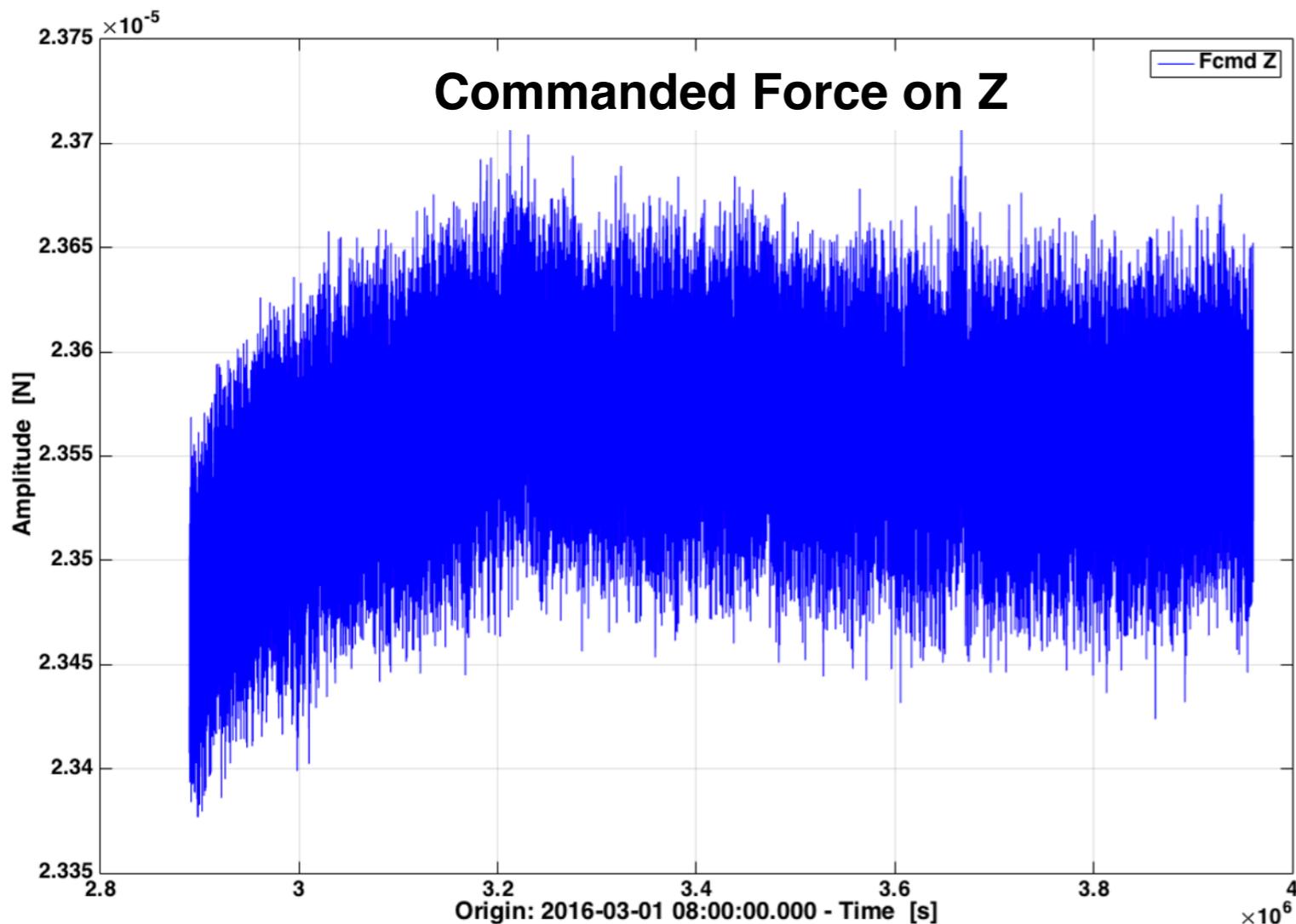
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- Thermal IR of the satellite (mainly Z-axis)
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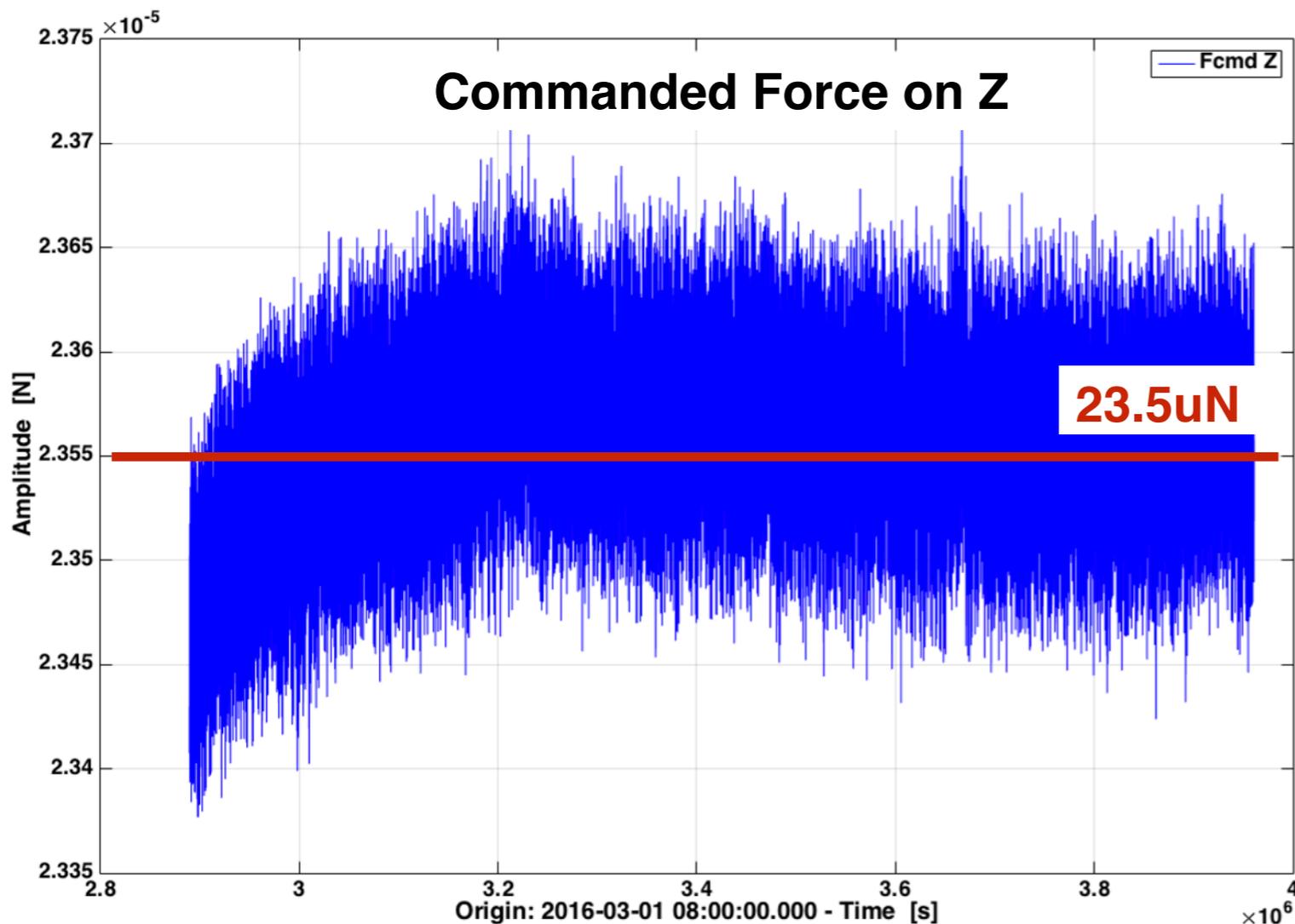
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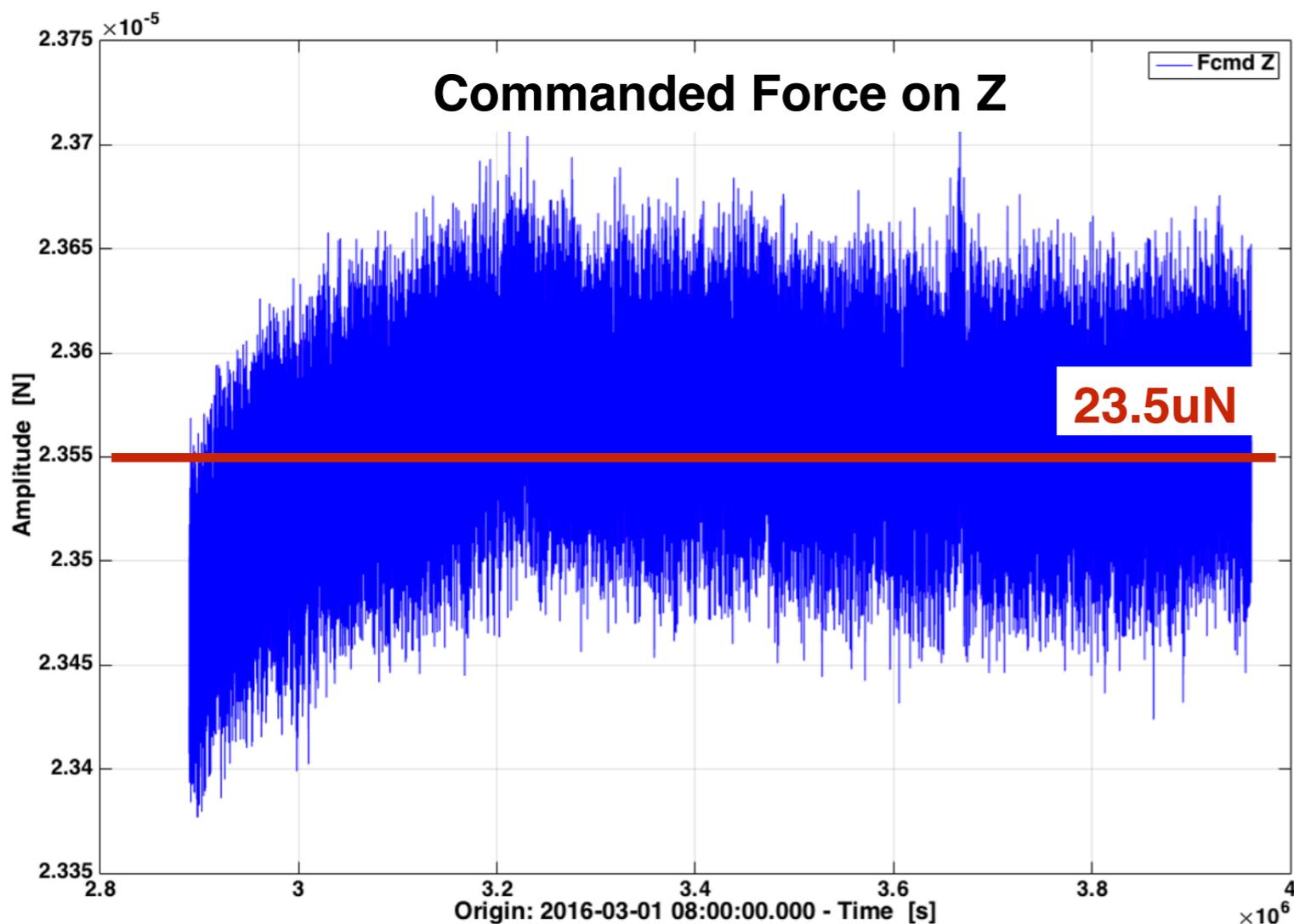
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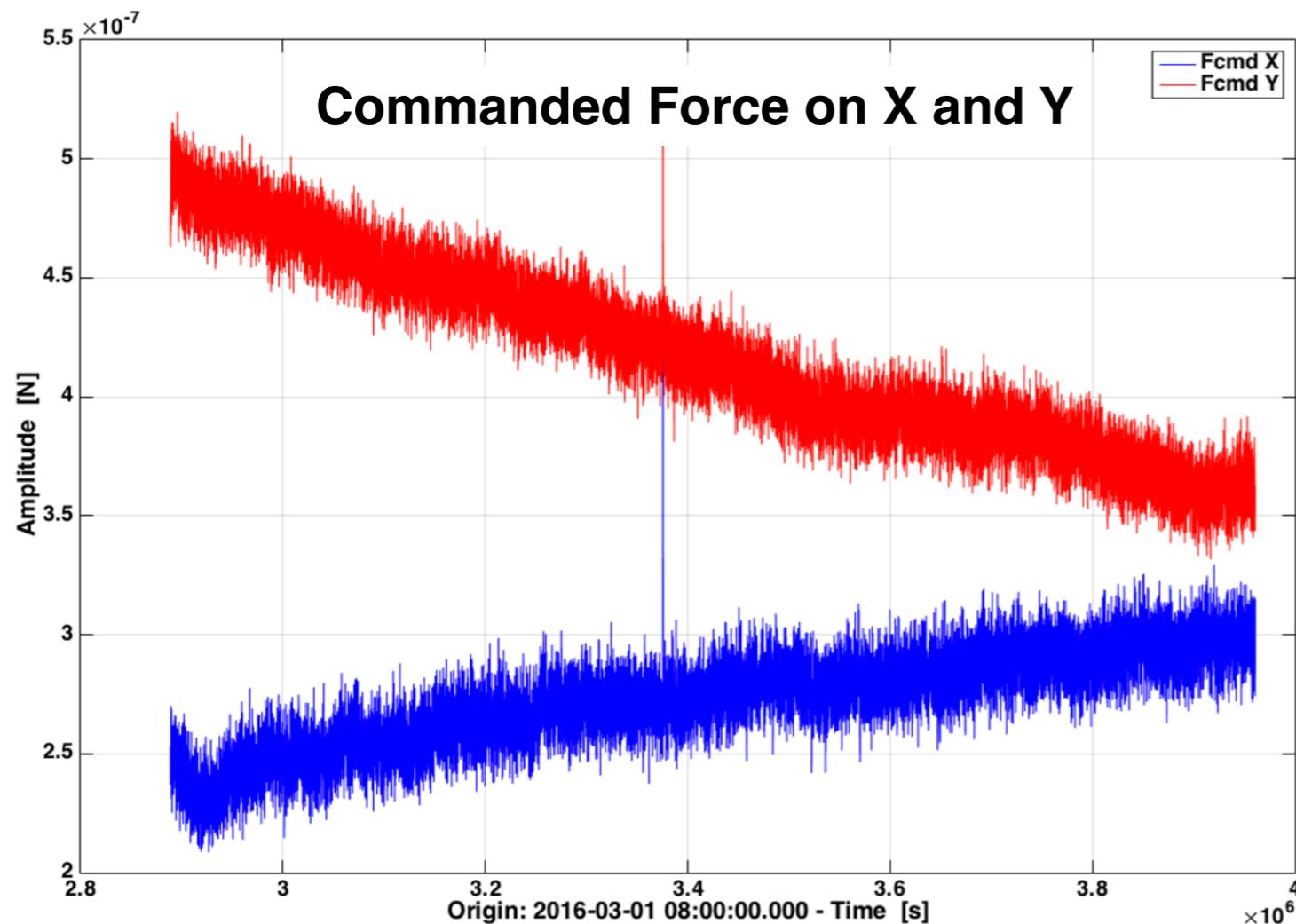
=> Constrain the mean Thrusts value at $\sim 10\mu\text{N}$ per thrusters (thrusters geometry)

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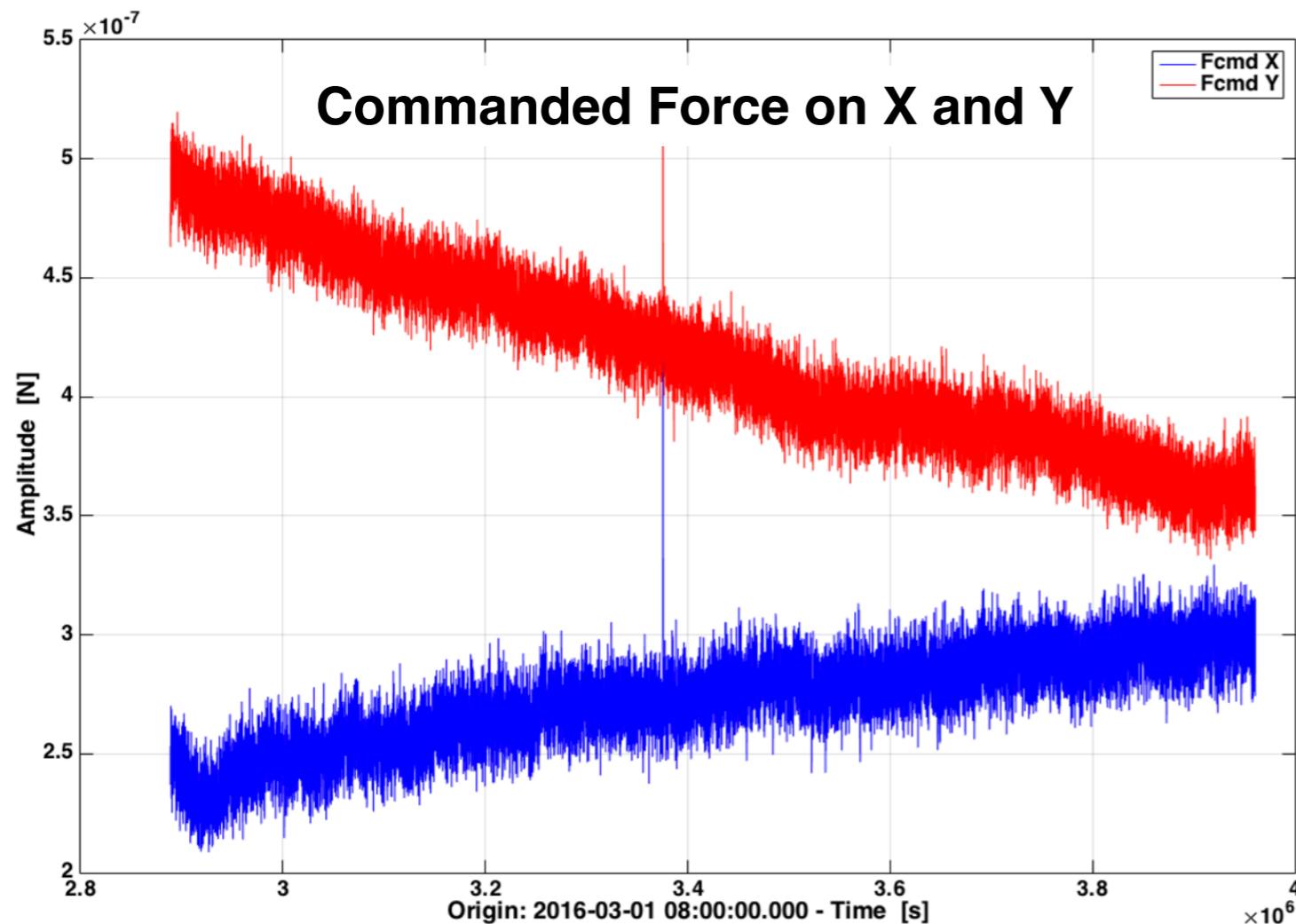
- Thruster Noise
- Solar radiation pressure
- Solar Wind Protons

Events

- Micro-meteorites
- Magnetic Field

Daniel Hollington

See poster by Ira Thorpe



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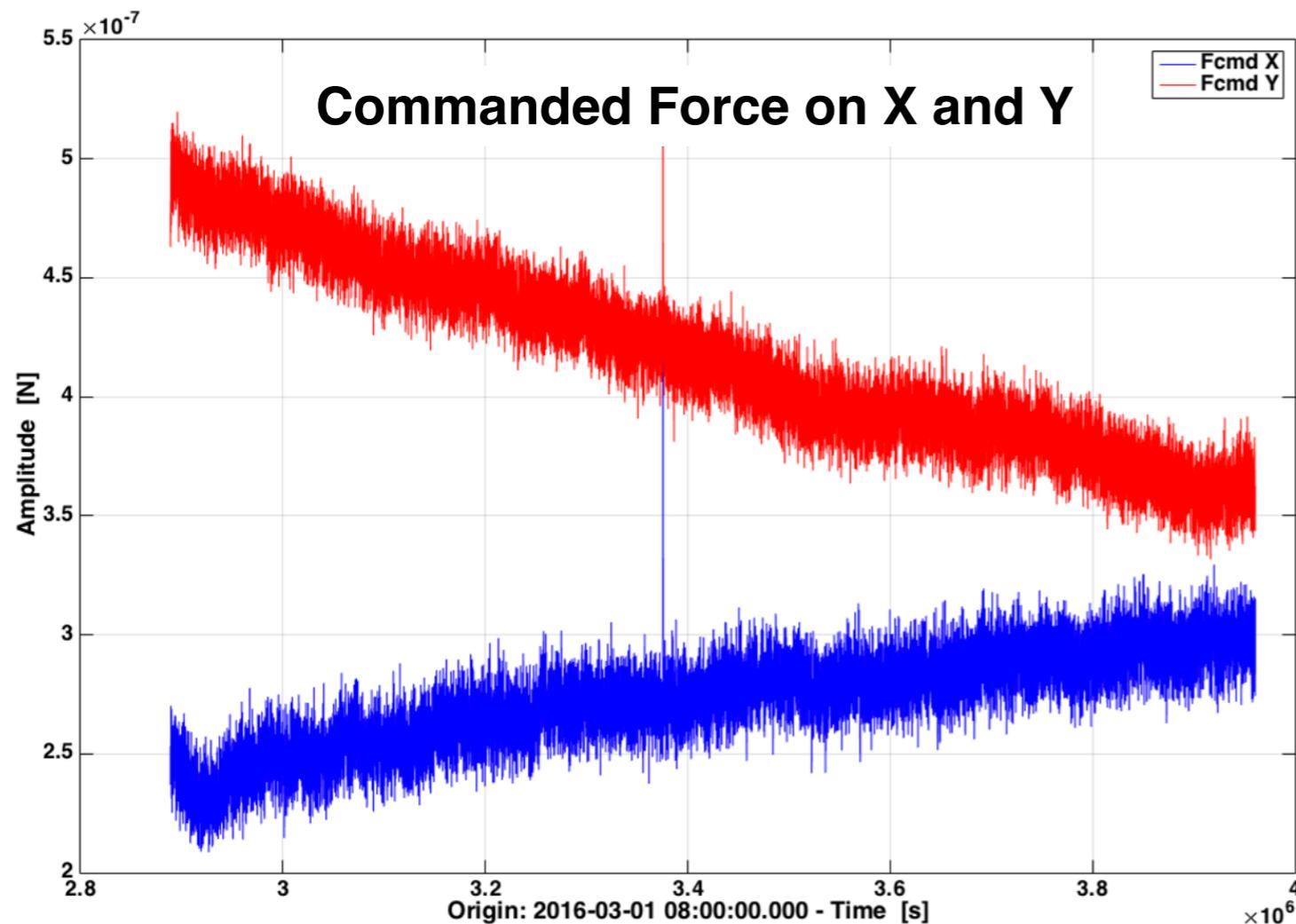
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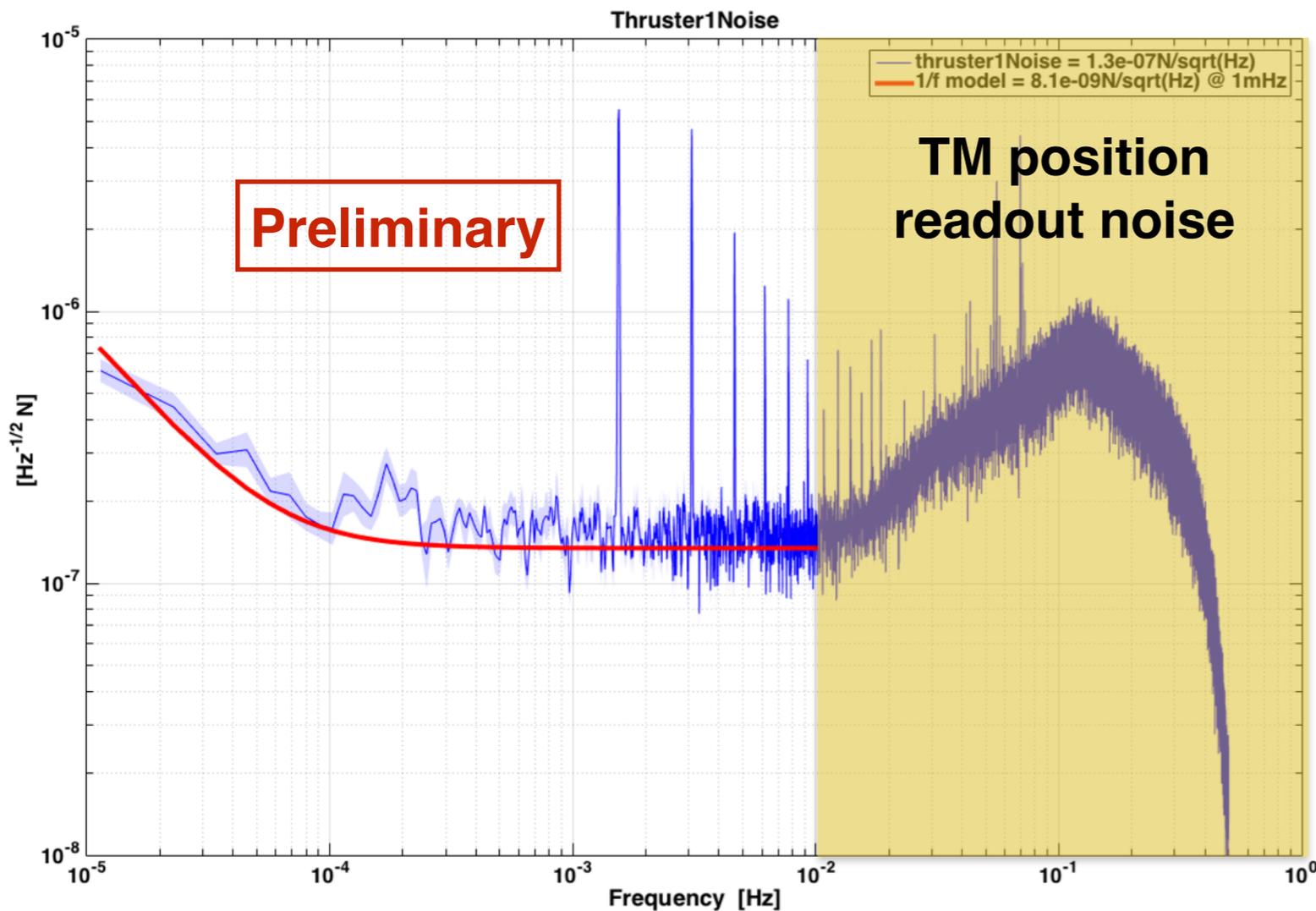
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Thrusters noise

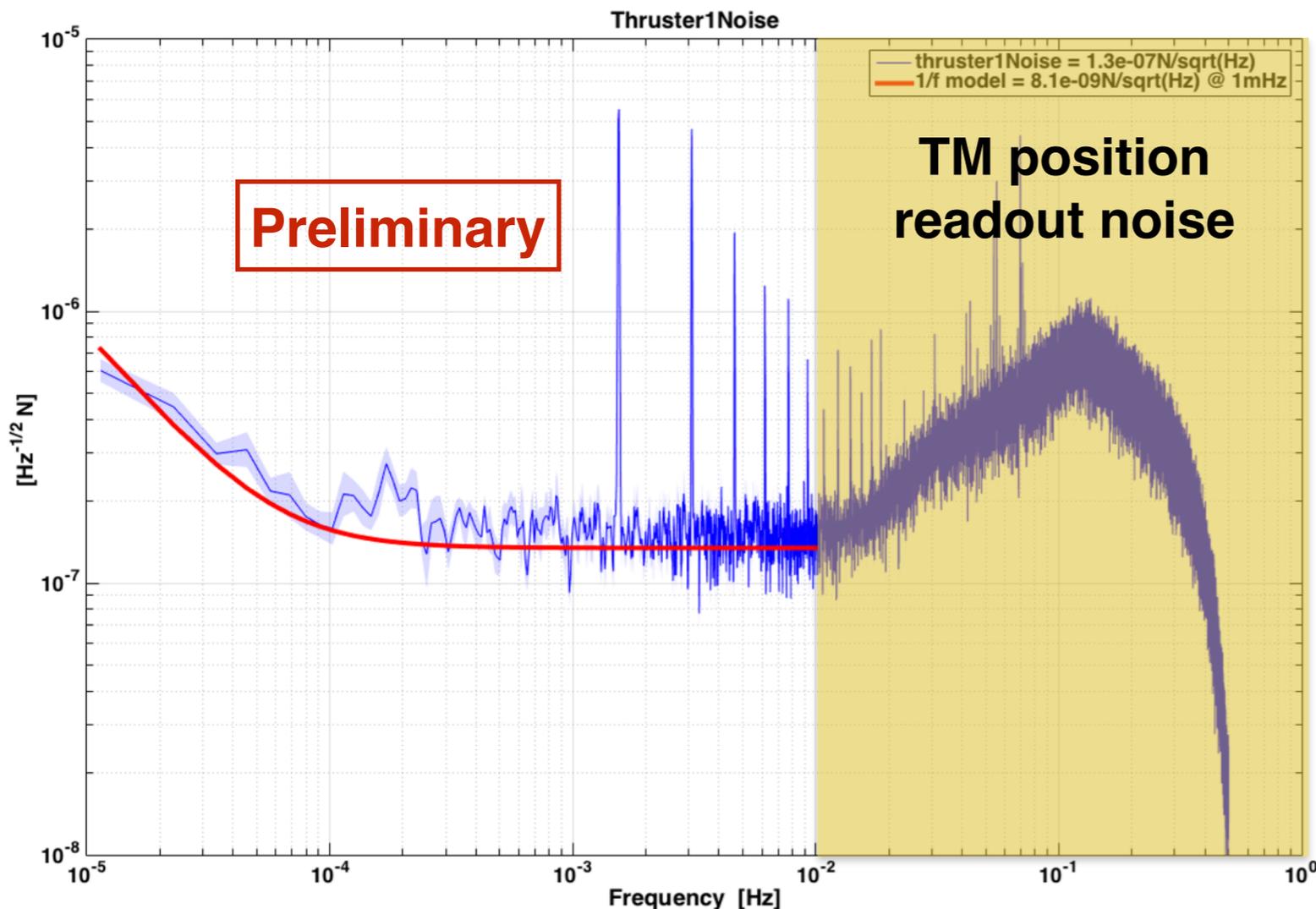
Hypothesis: Main external disturbance = Thruster Noise



- Presence of Lines (also in the laser pump current)
- We fit a 2 components noise model **white noise + 1/f**

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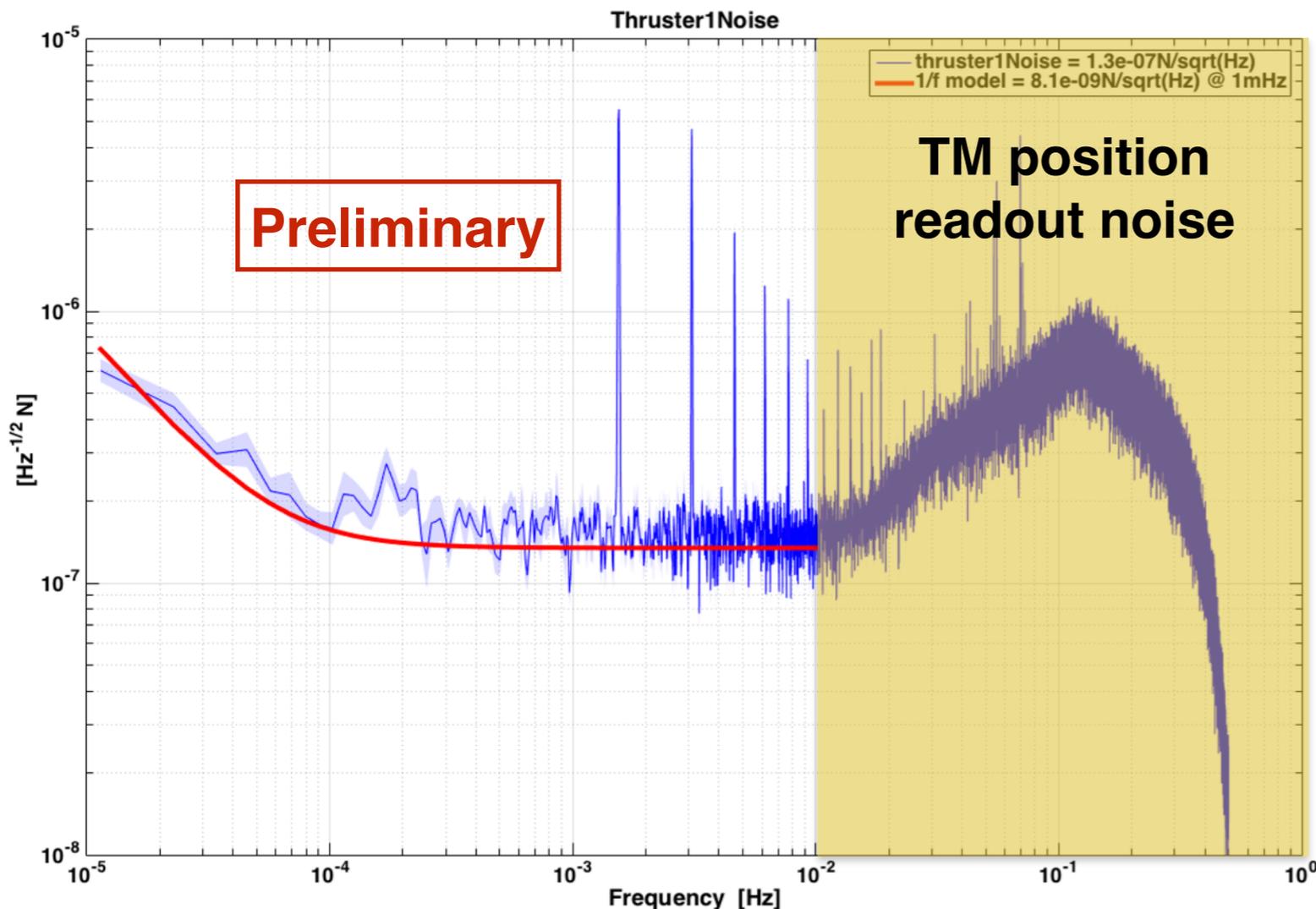
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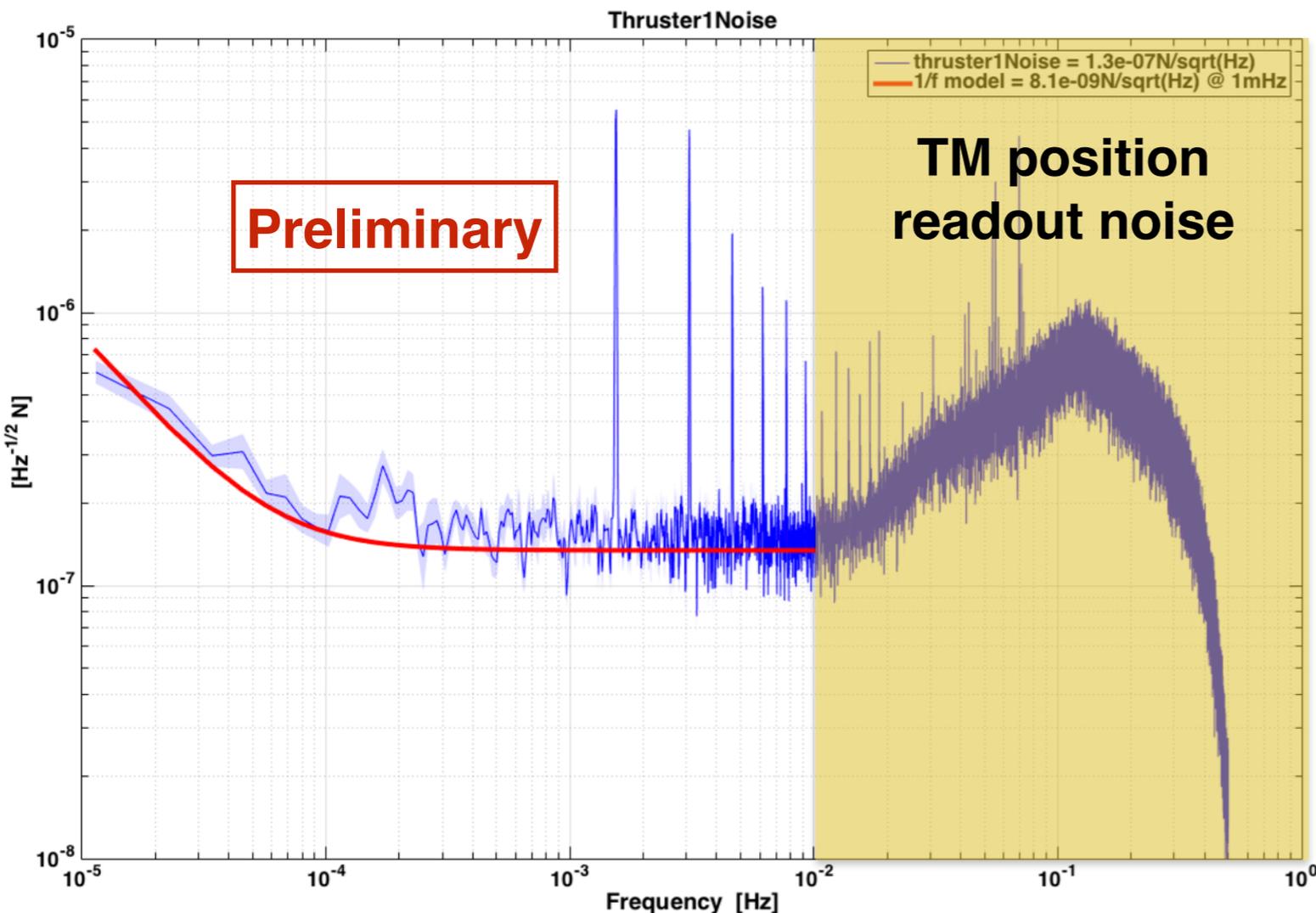
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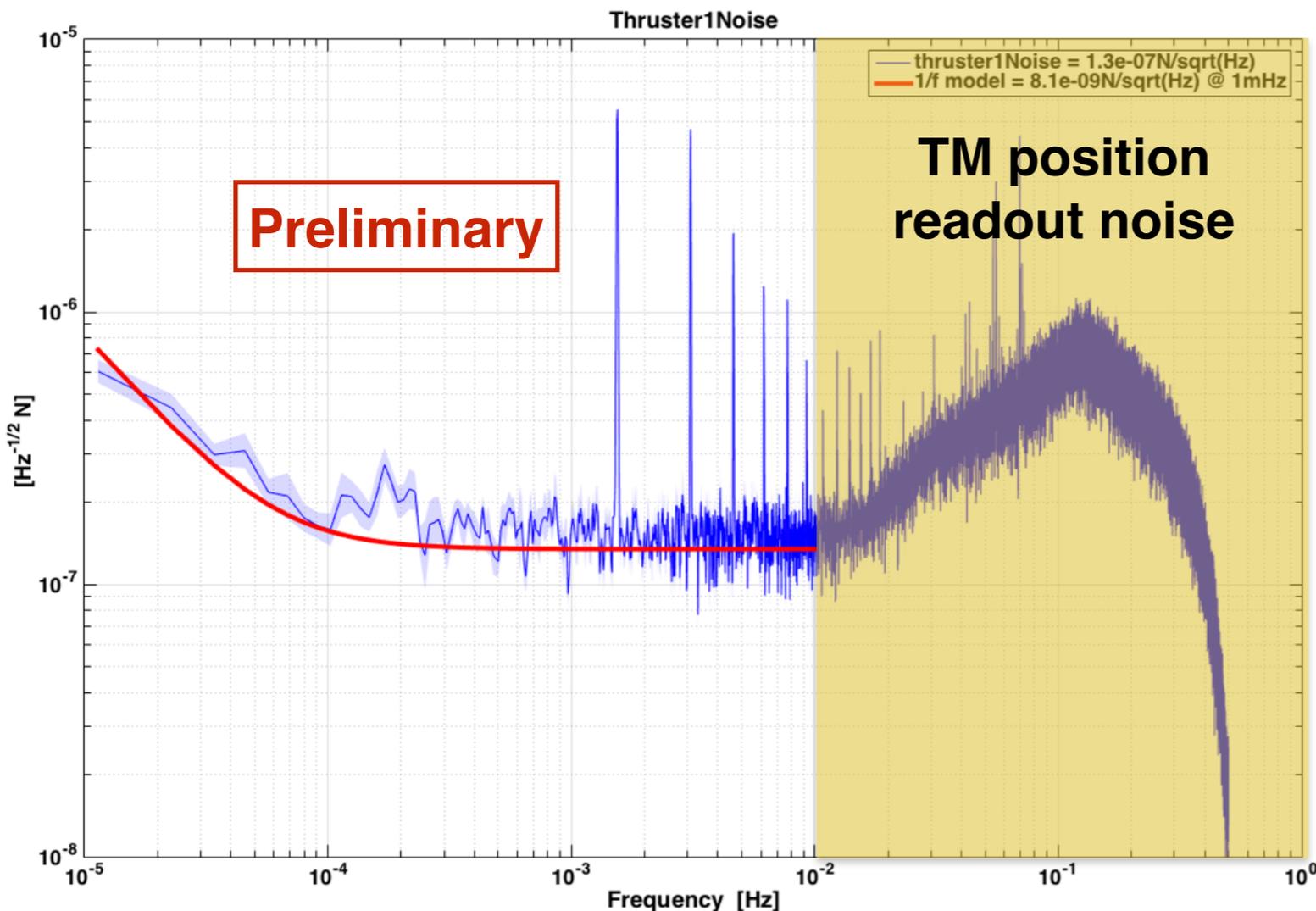


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Upper Limit

A part of the 1/f could be due to the attitude control

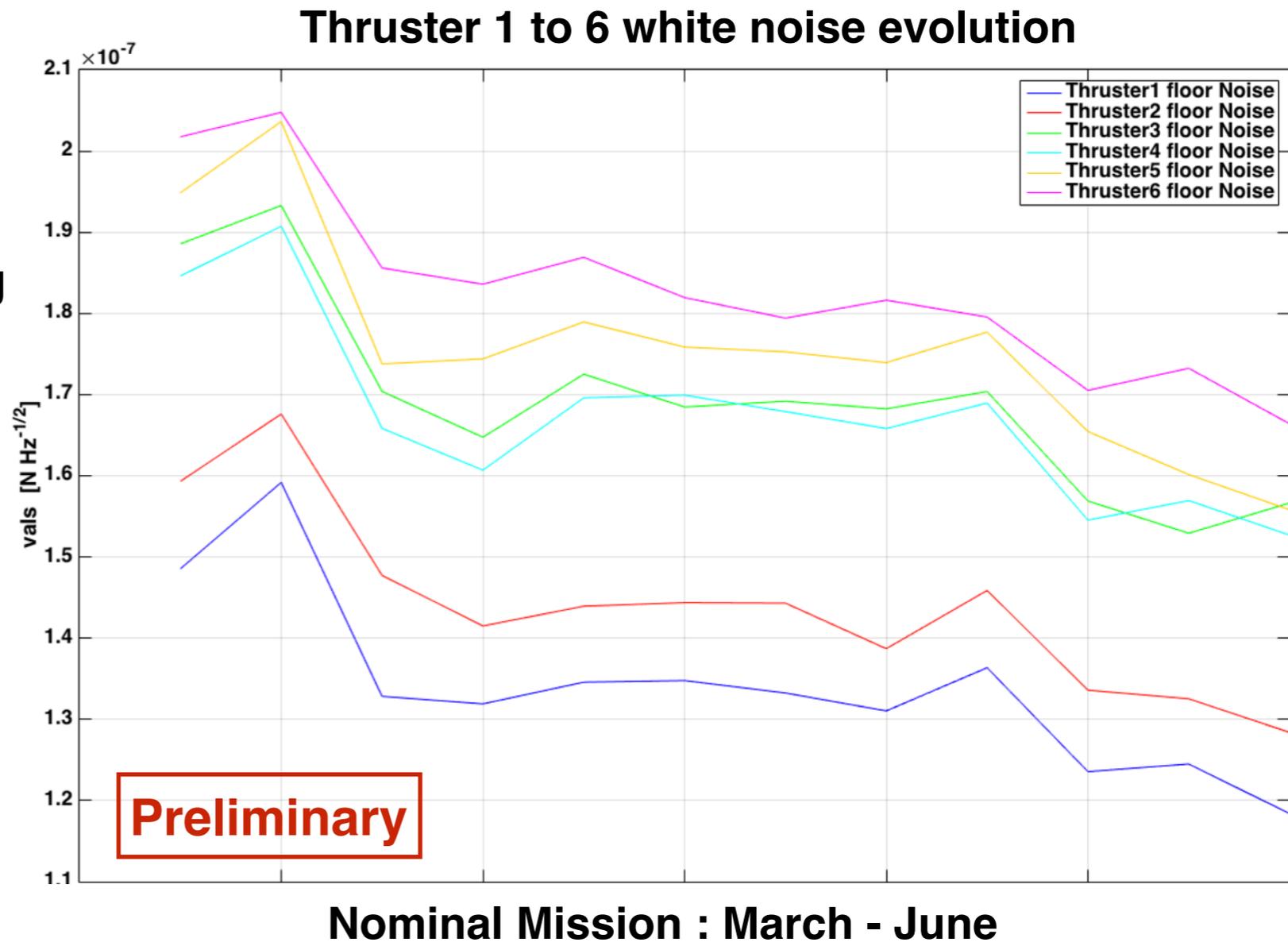
Thrusters noise long term



Thrusters white noise is decreasing

Thrusters 1 and 2 are less noisy.

Noise is correlated 0.5 to 0.8



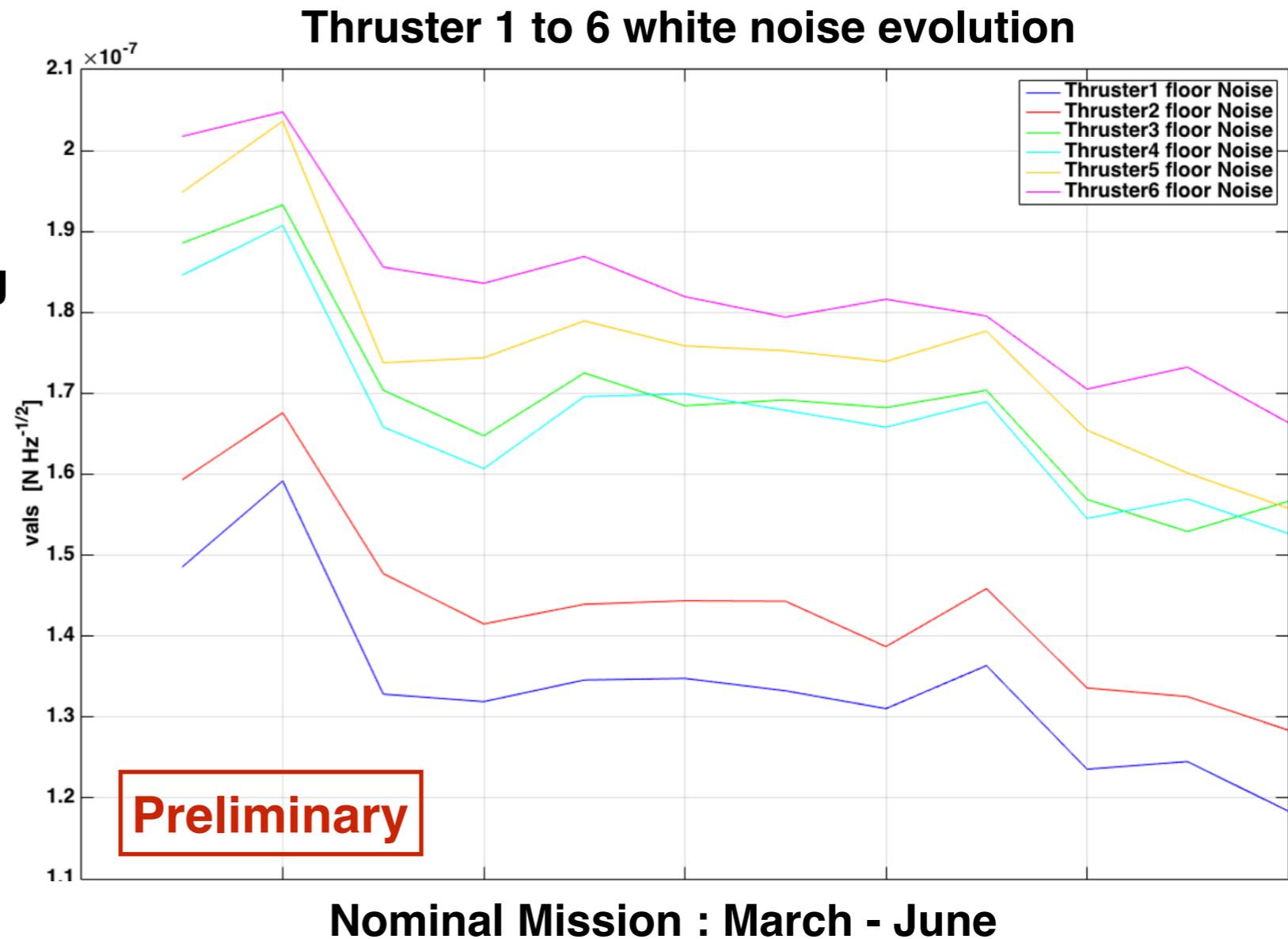
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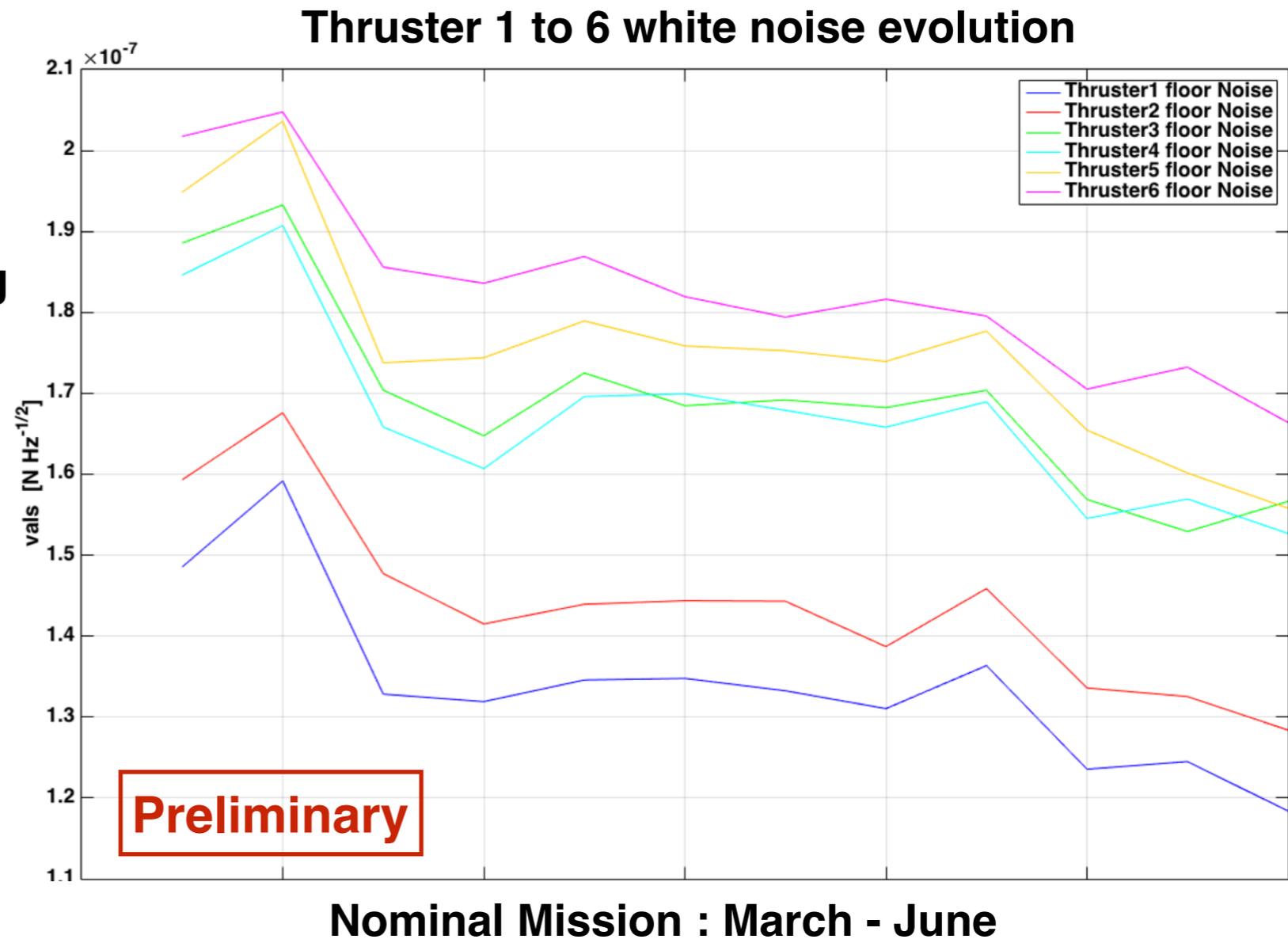
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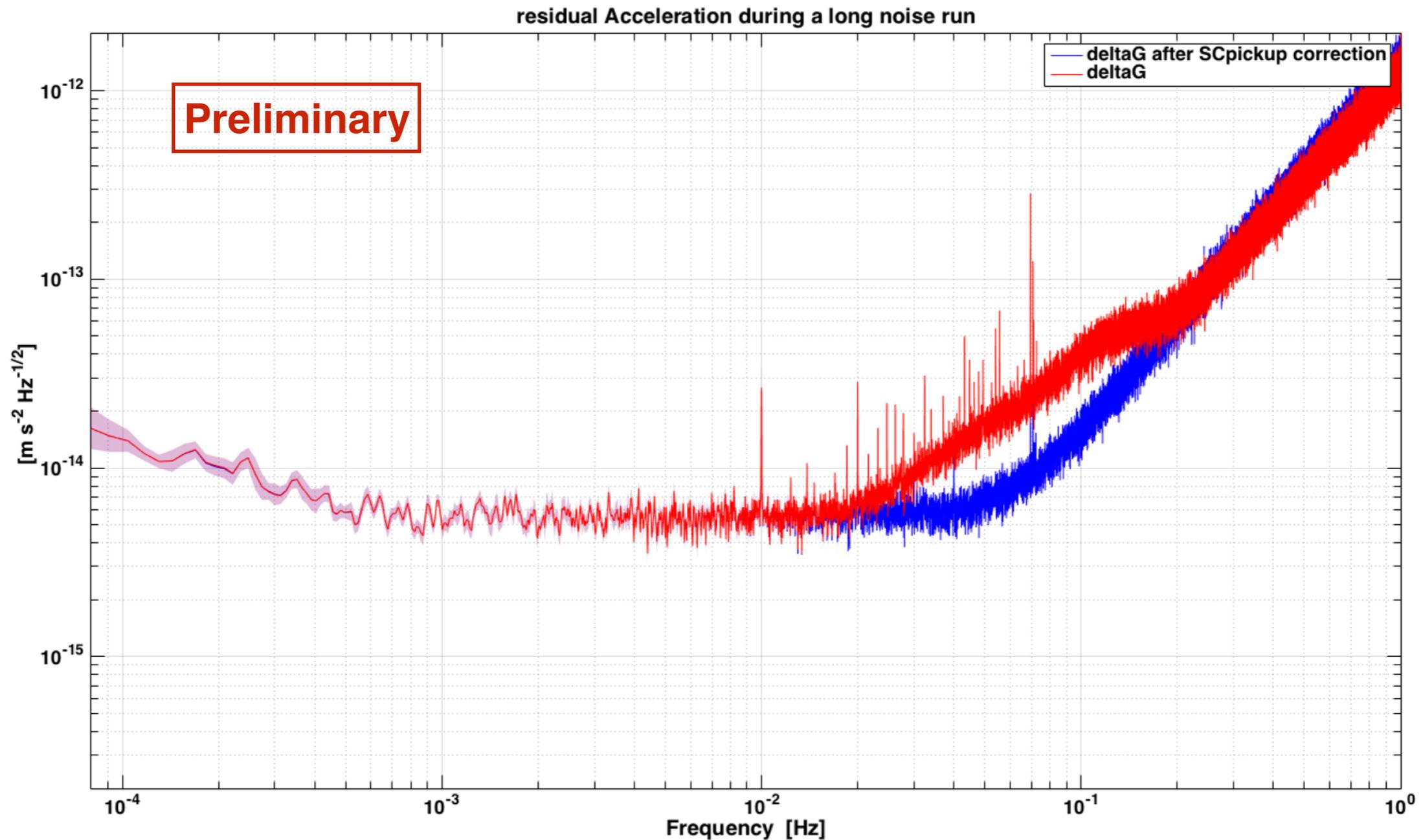
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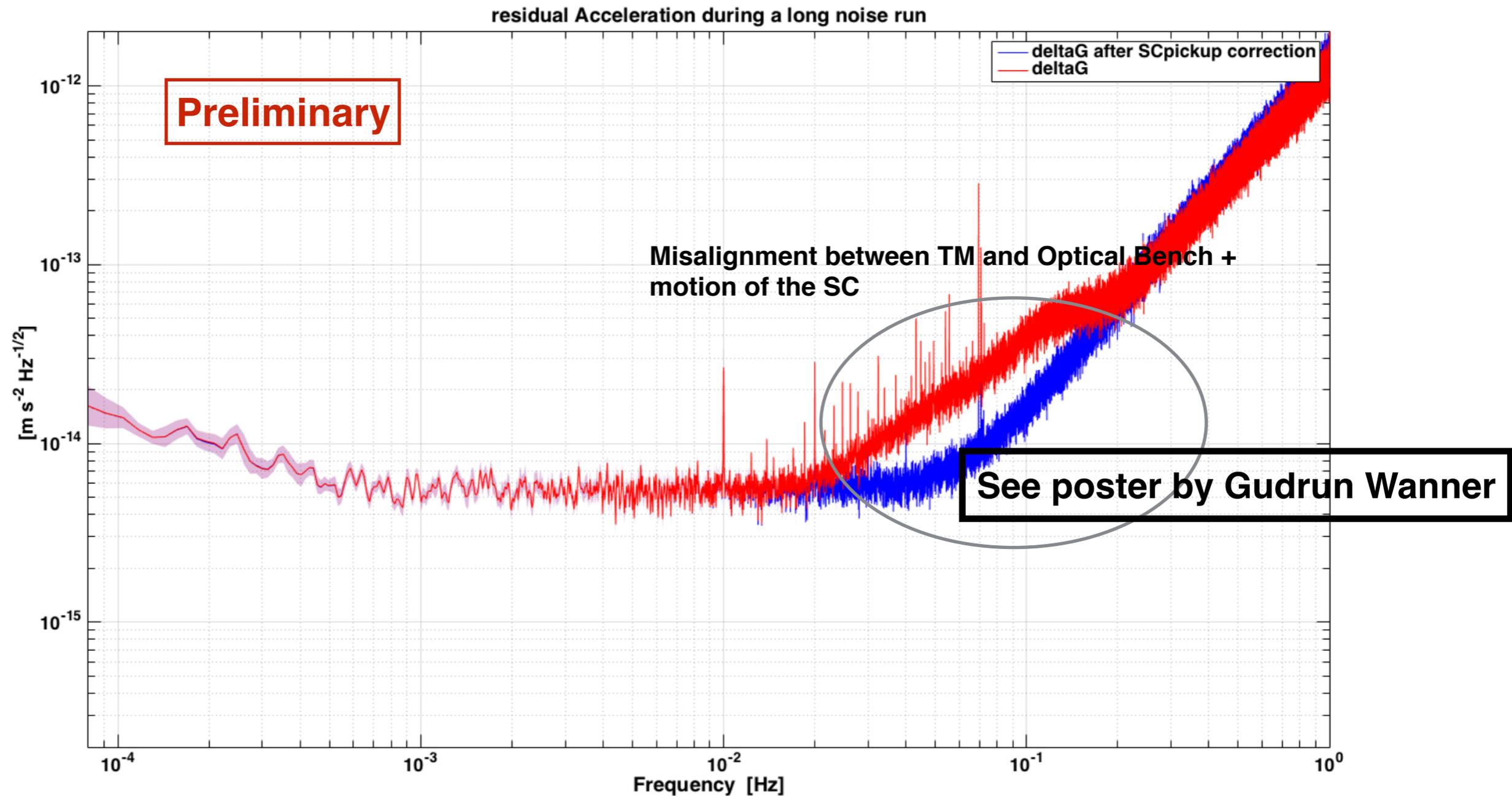


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- Or a **common thrusters noise source** drifting with time. They share the same electronic/ColdGas feed line.

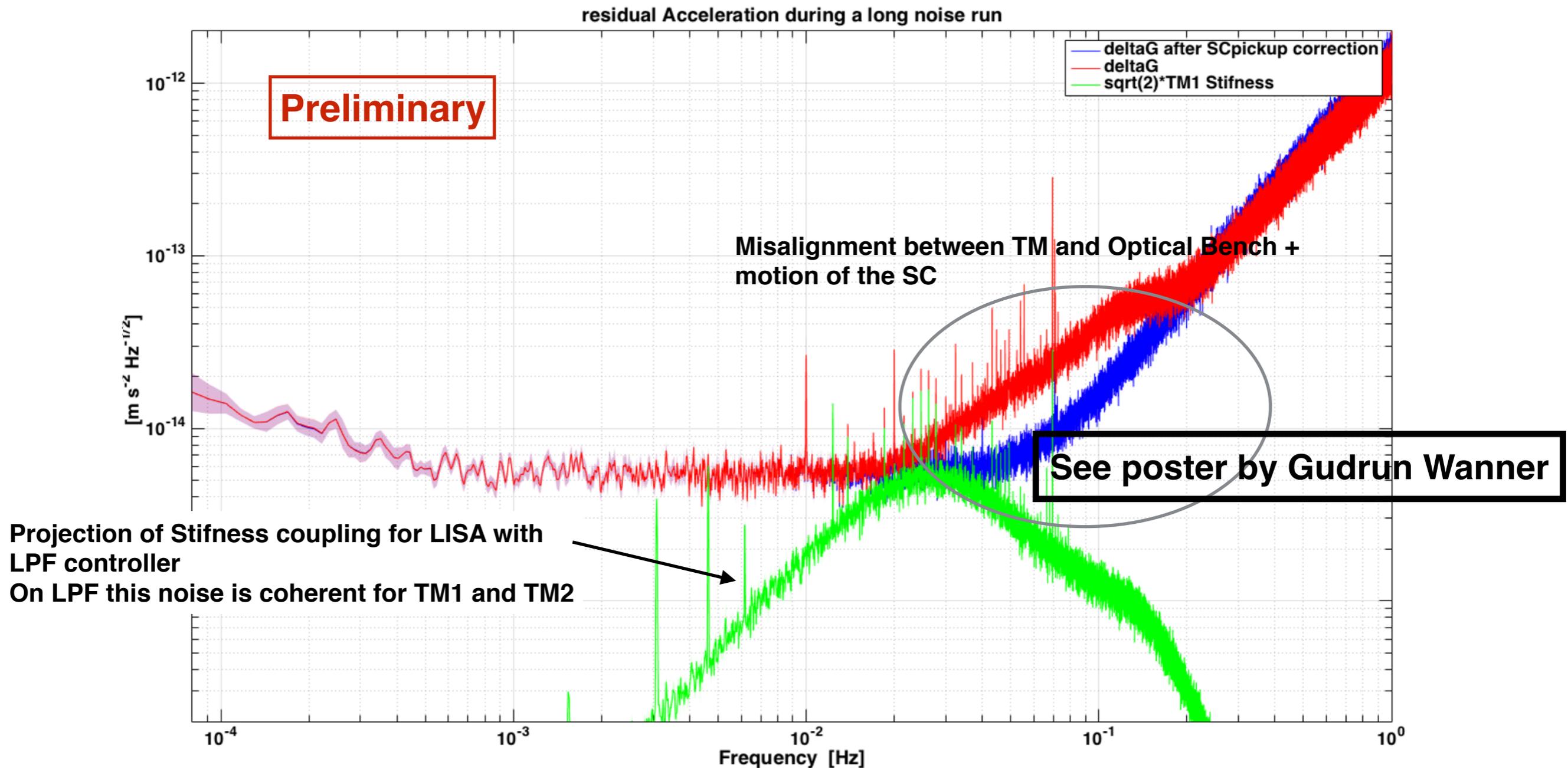
Thruster Noise contribute to Jittering of the Spacecraft



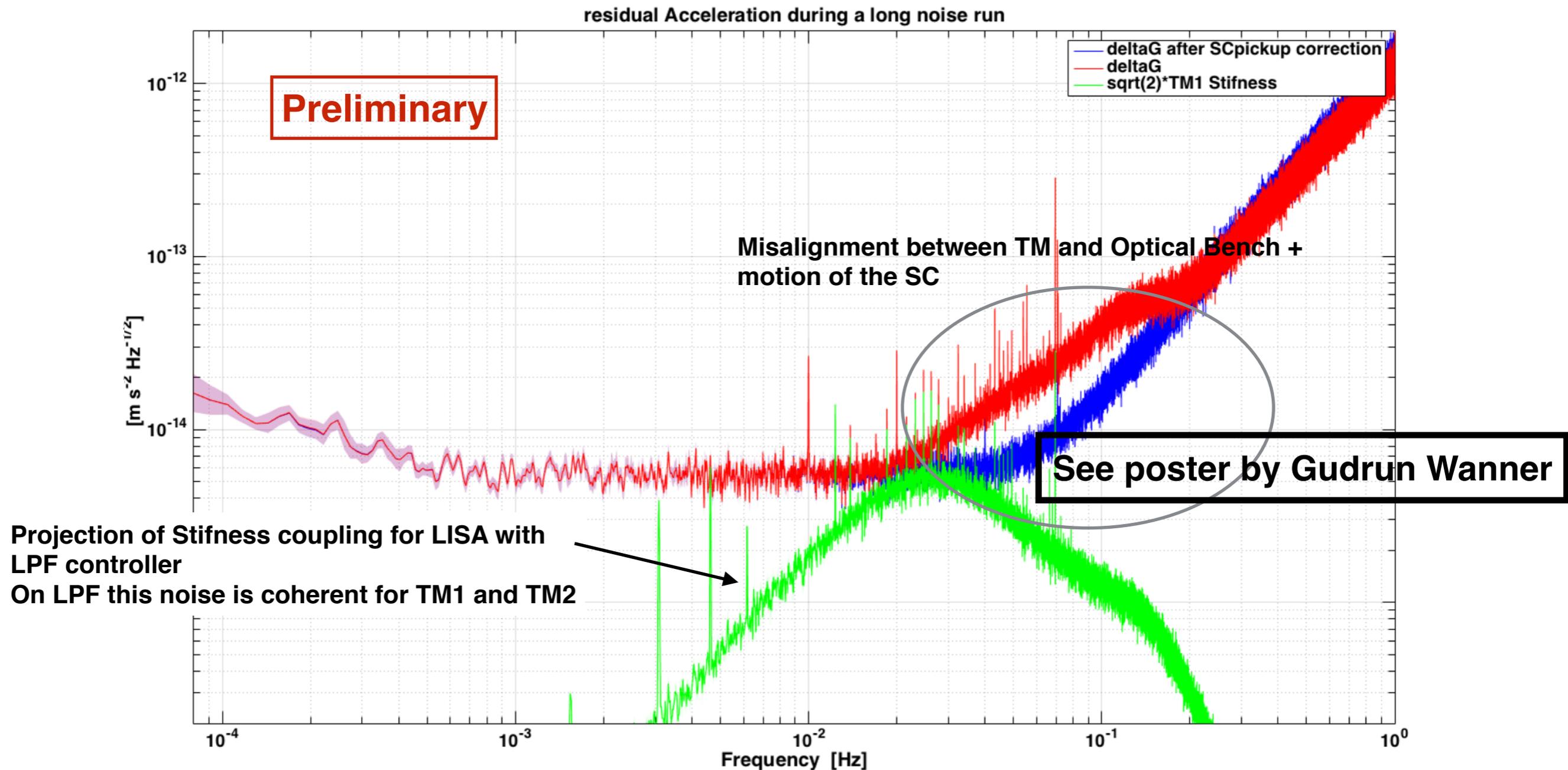
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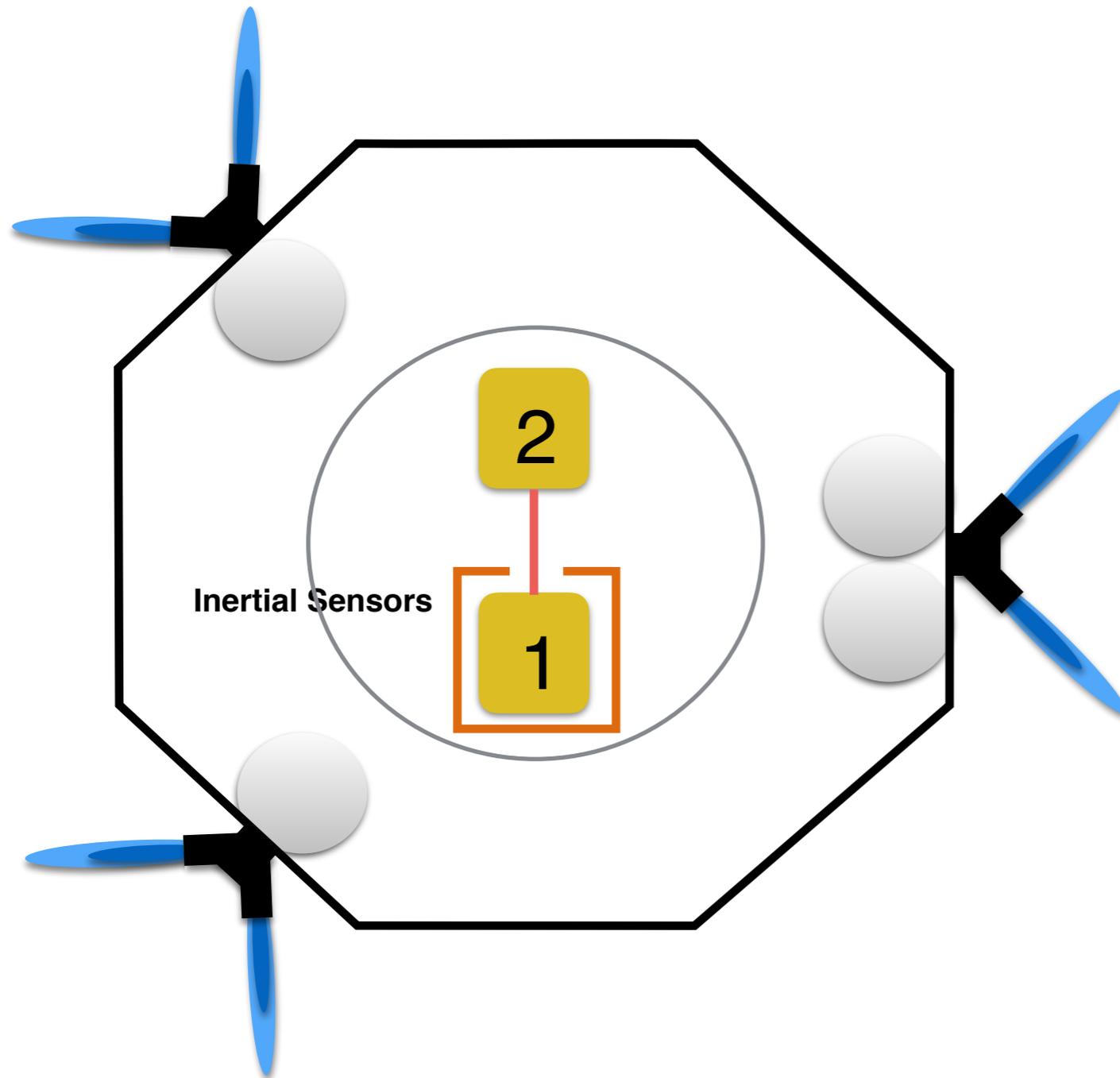
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Quasi DC drift due to Propellant depletion

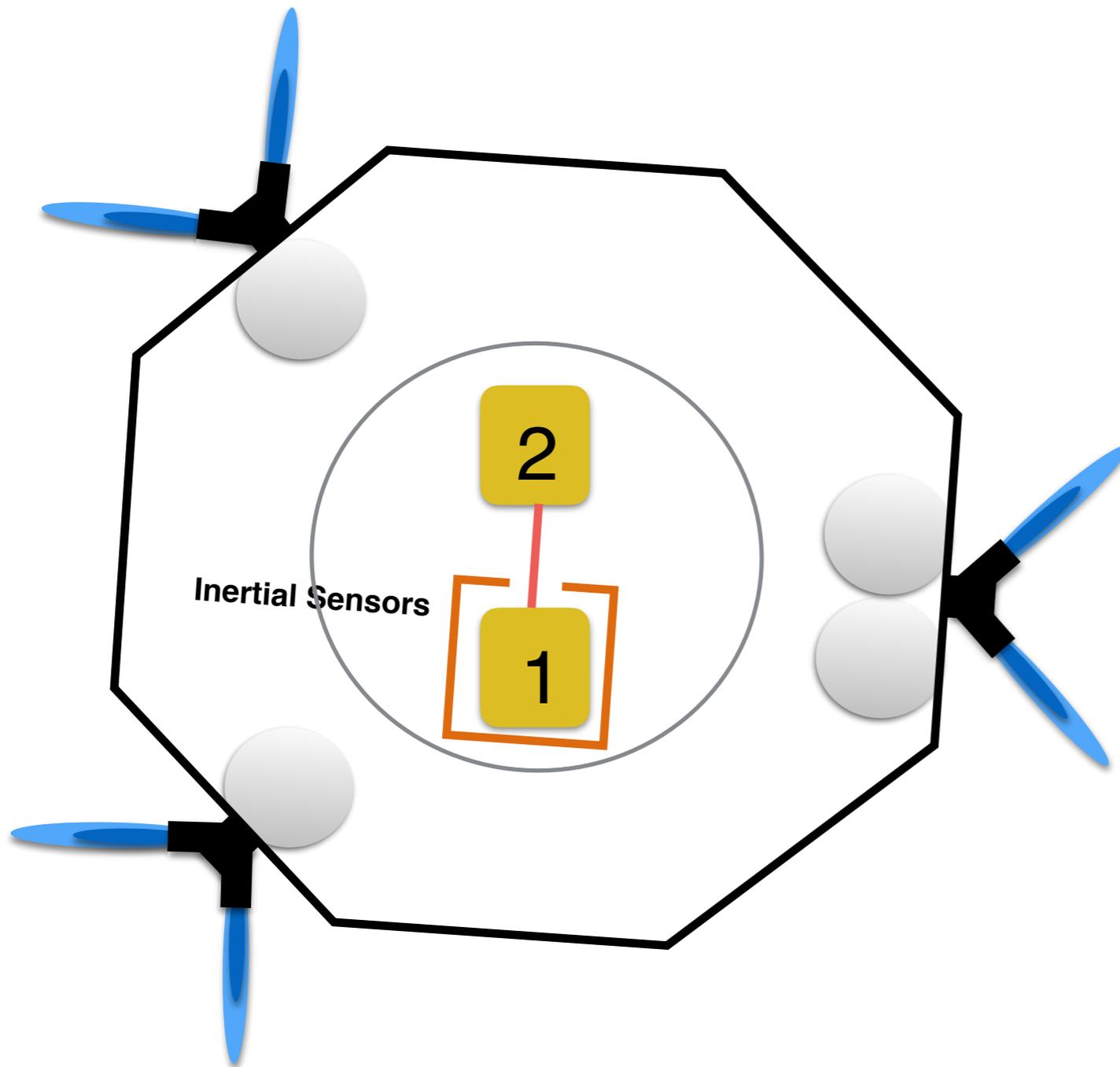
See Poster by Valerio Ferroni

Thrusters dedicated investigation



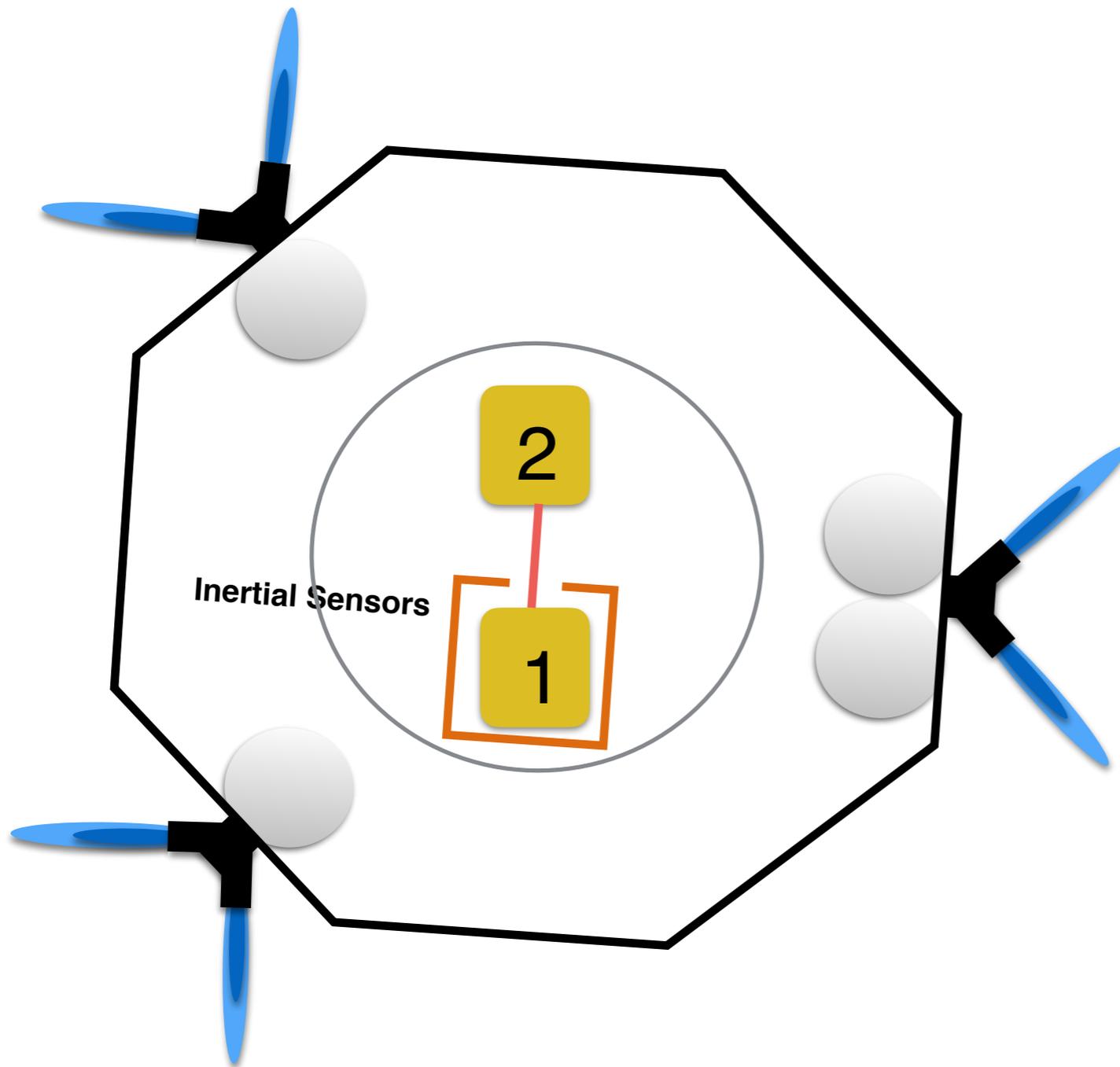
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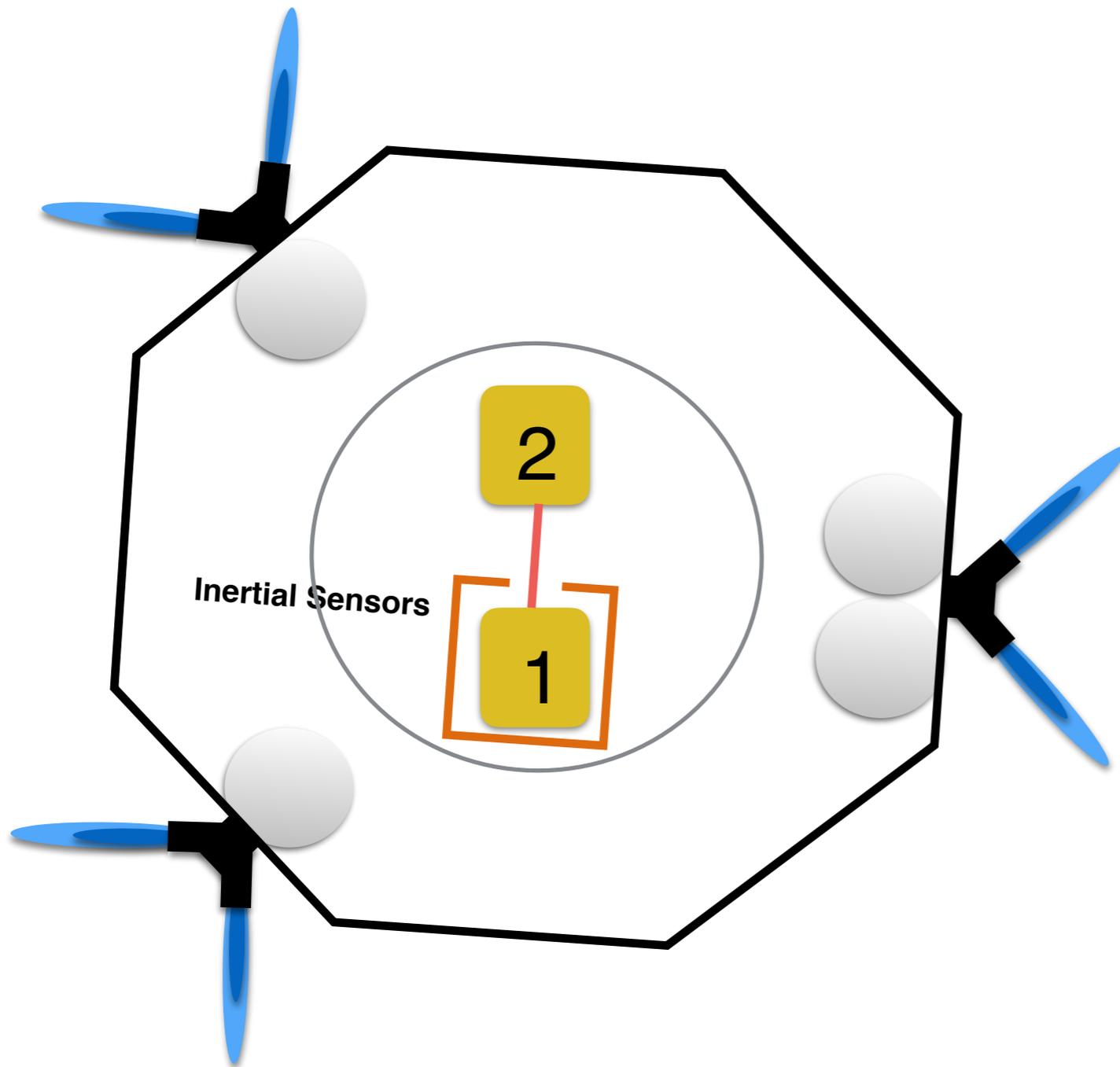
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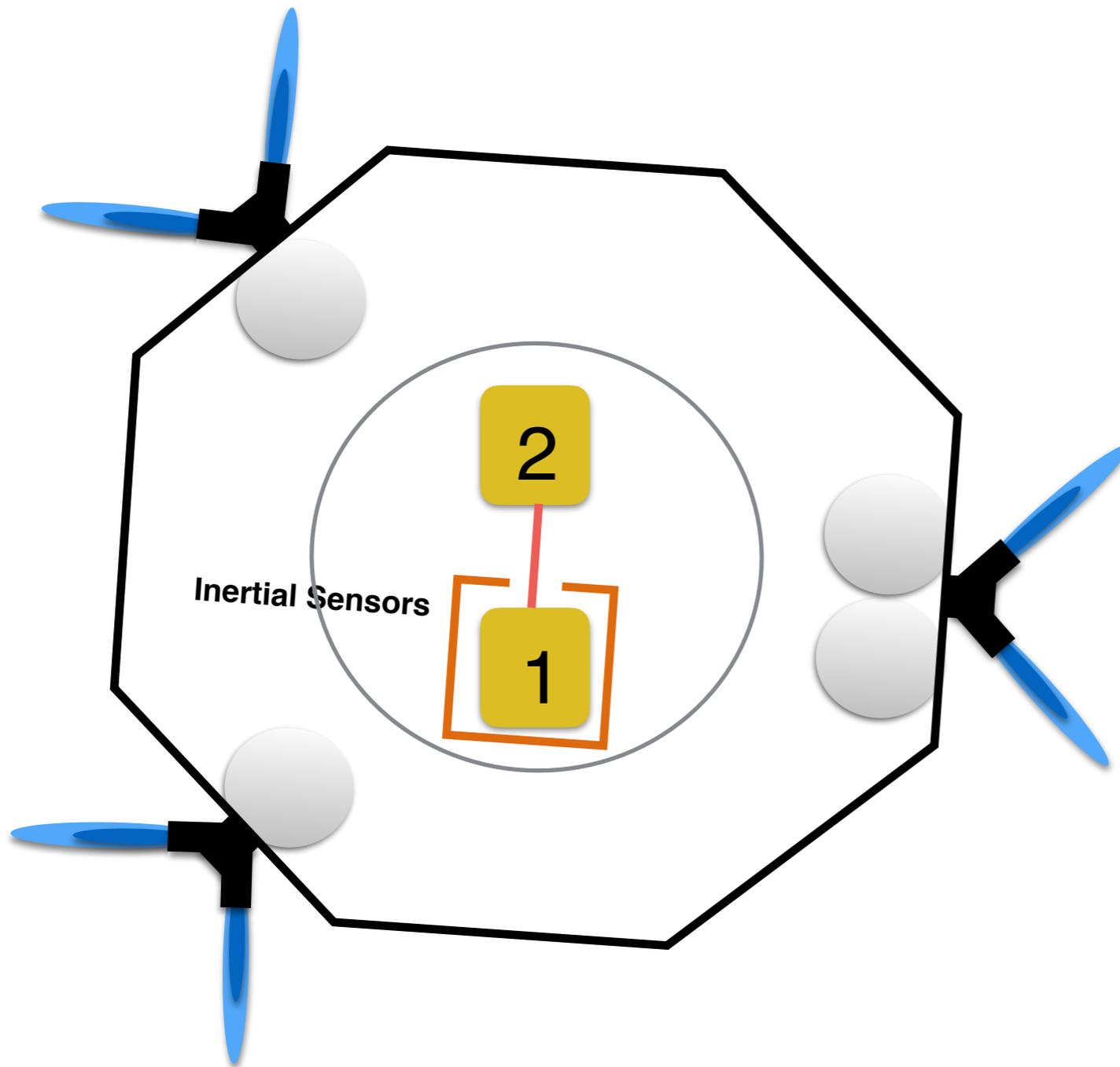
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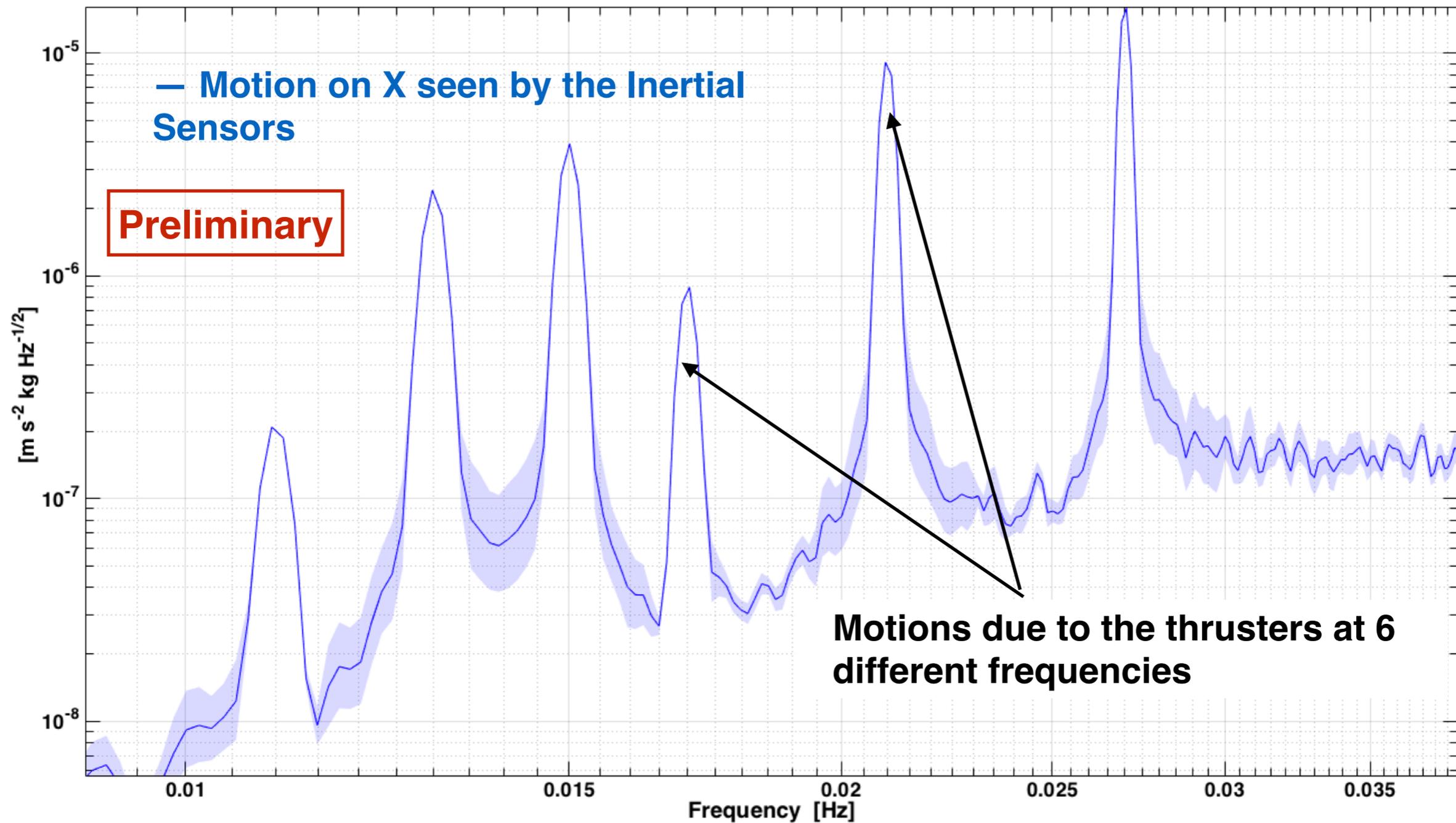
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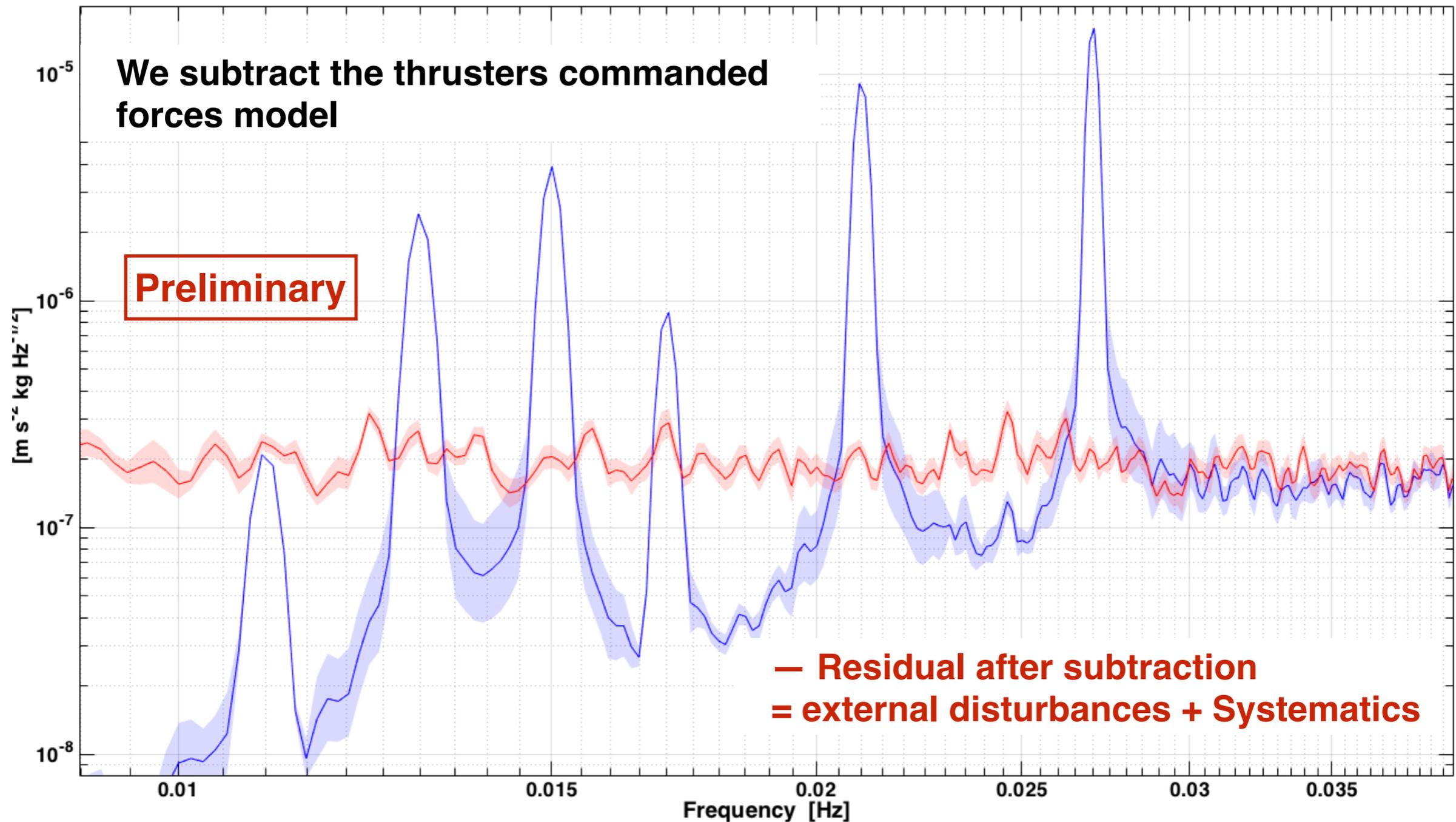
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Motion on X



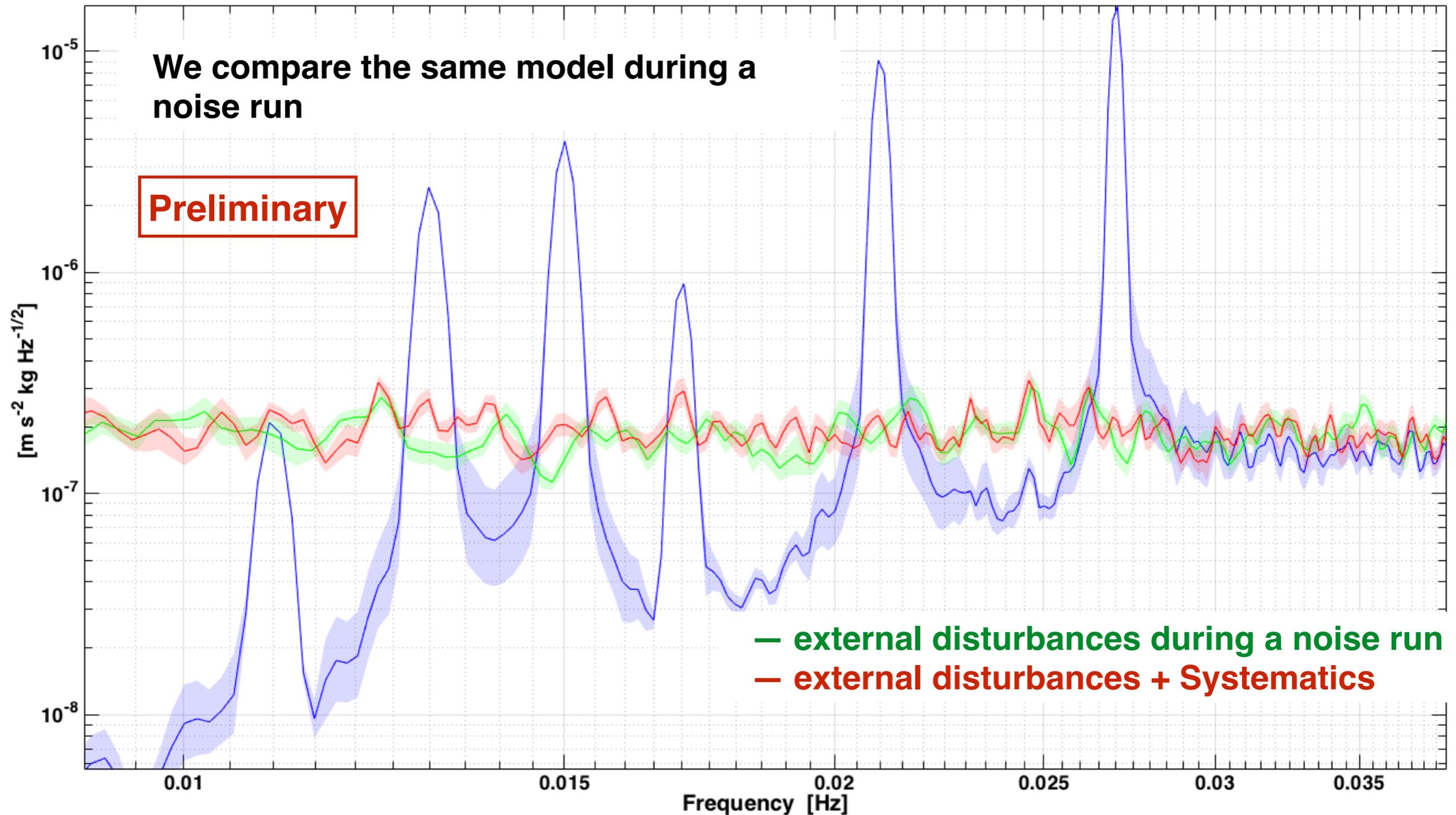
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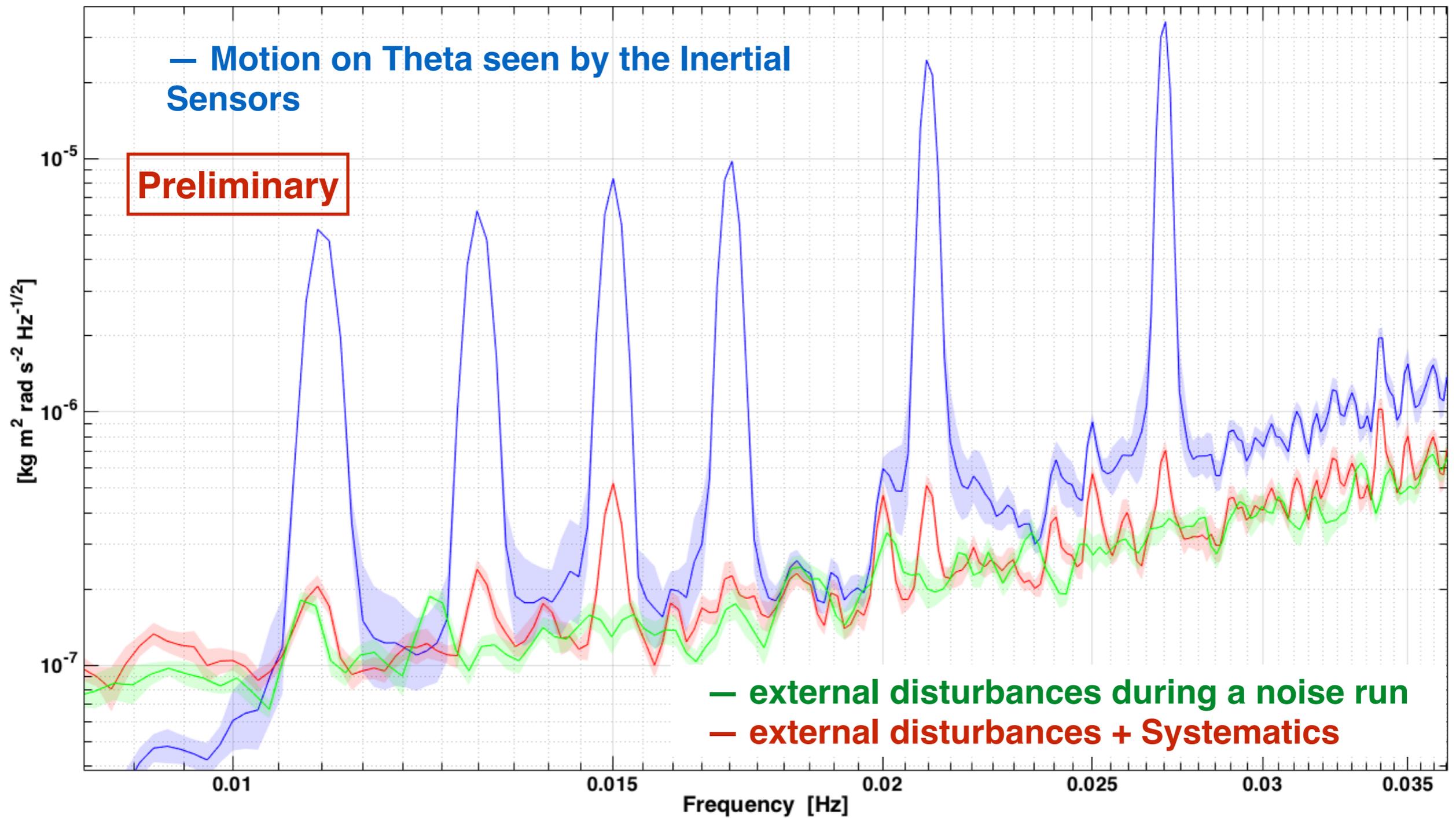
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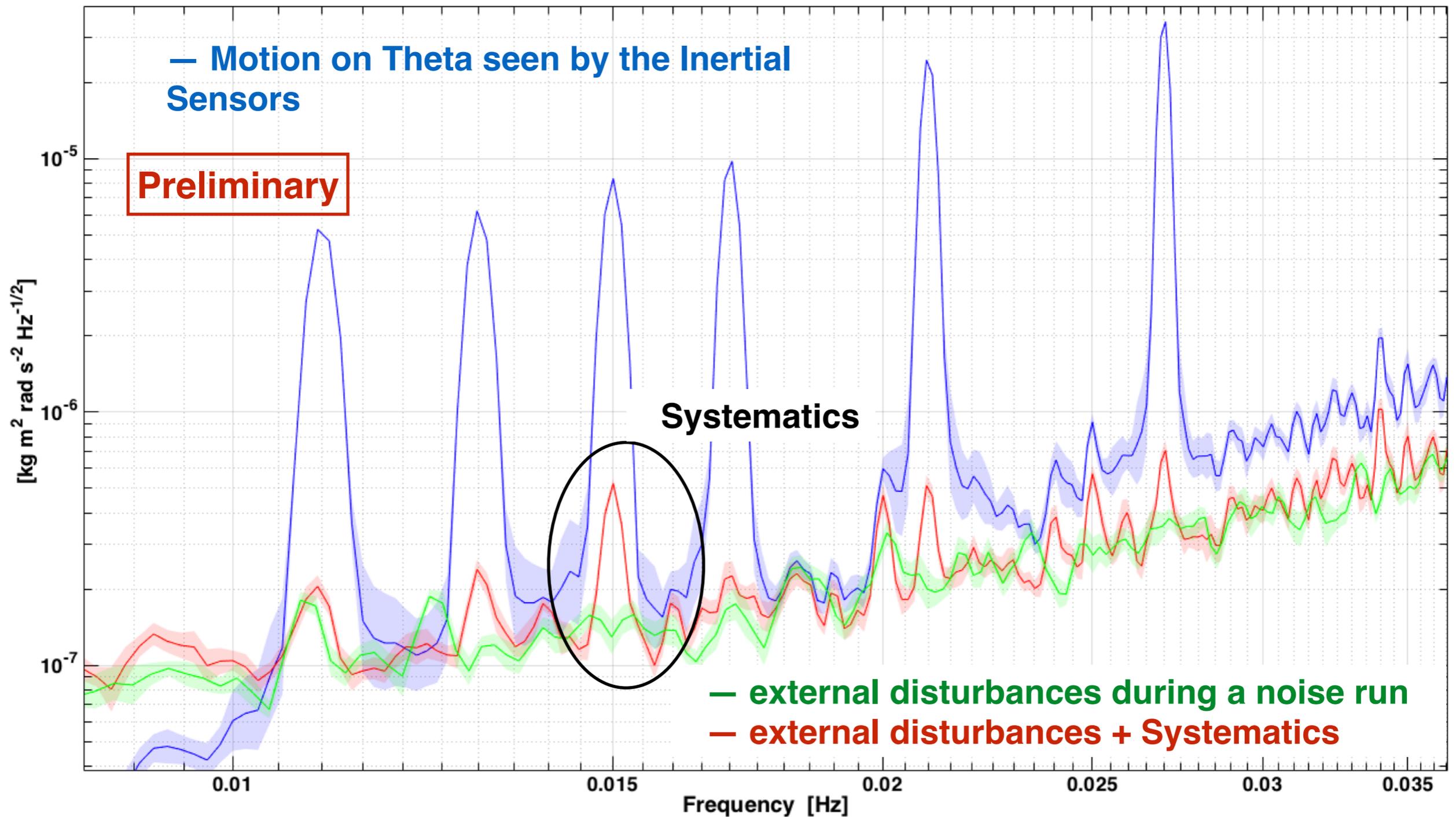
Thrusters dedicated investigation

Motion on Theta



Thrusters dedicated investigation

Motion on Theta



Main results

- Gains = 0.91 and 1 - Thruster 4 off by 8.3%
- Center Of Mass seems offset by ~ 4 cm in Z

Limits

- Limited by measurements systematics - Set the estimation errors to **a few percent.**
- Model is not complete - **Moment Of Inertia - Cross Sensing - thrusters position**
- Consolidate some geometrical parameters like housing position

Next

- This experiments = Calibration of the thrusters against IS
- Repeat the experiment during Acceleration Mode (= TM follow SC) to **calibrate against Electrostatic Forces/Torques.**

Conclusion



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- We extent the frequency range characterization of more than an order of magnitude compare to the on-ground measurements
- Set an **upper limit** on the $1/f$ and the white noise part.
- This white noise measurements is 30 % higher than the on-ground measurements ($0.1\mu\text{N}/\sqrt{\text{Hz}}$)
- But the thruster noise is decreasing with time -> **could be another external disturbance**
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Cold gas microNewton are good for LISA => with the same controller performances