6th International LISA Symposium

Goddard Space Flight Center
Greenbelt, Maryland

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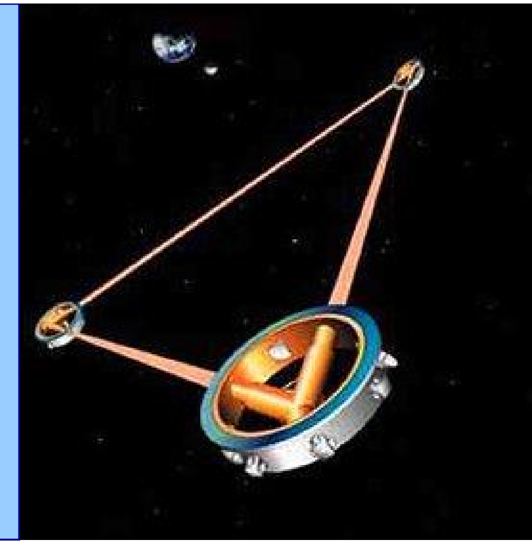

High Sensitivity Torsion Balance Tests for LISA Proof Mass Modeling

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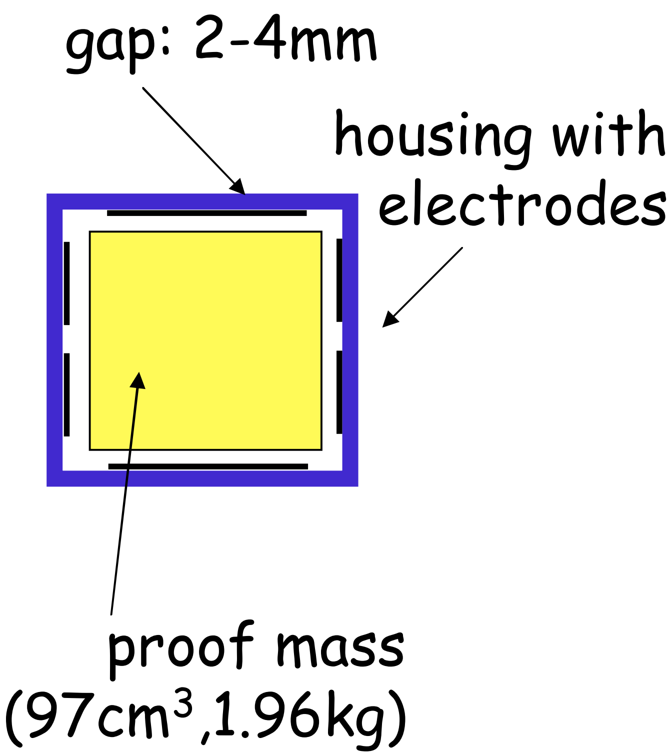
Motivation

Acceleration noise requirement
0.1 mHz - 1mHz

$$S_a^{1/2} < 3 \times 10^{-15}\ \mathrm{m/s^2/\sqrt{Hz}}$$



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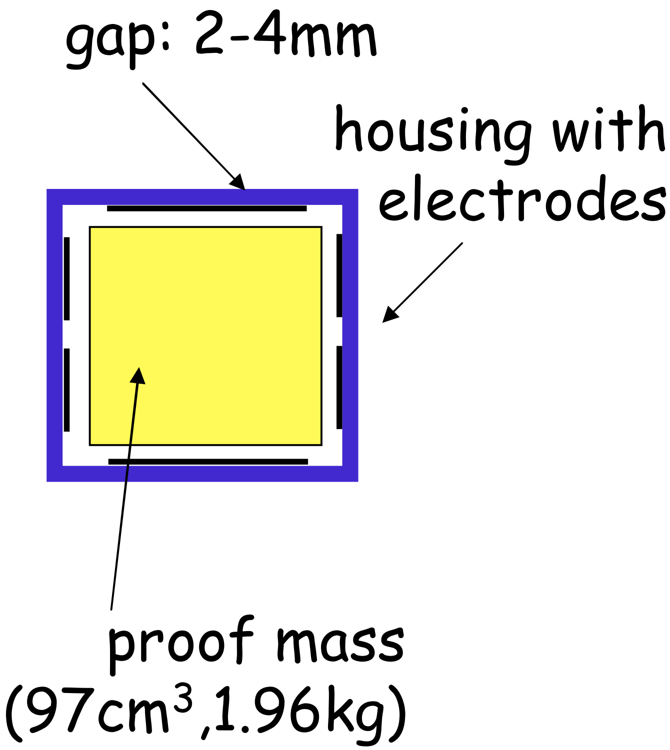

- patch effects
- outgassing
- charge accumulation
- magnetic impurities

- radiometer effect
- gravitational forces
- actuation cross talk
- .....

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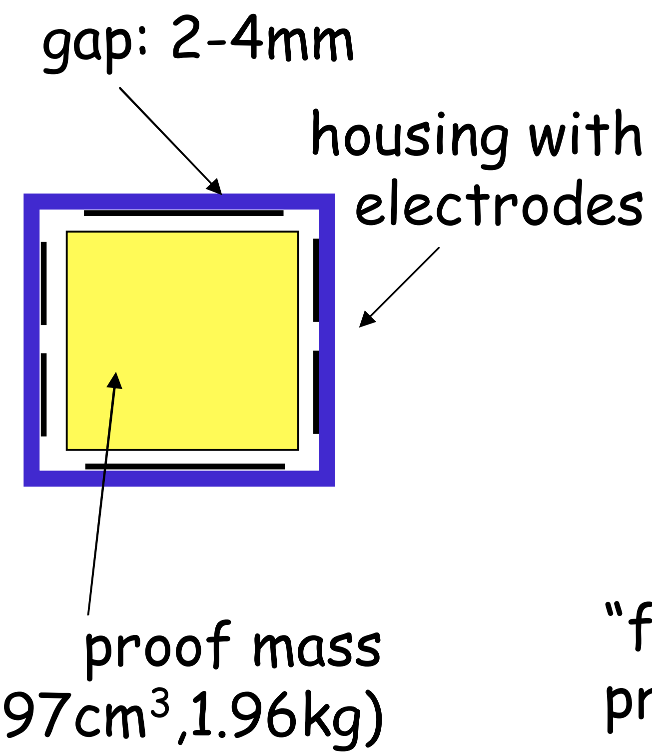
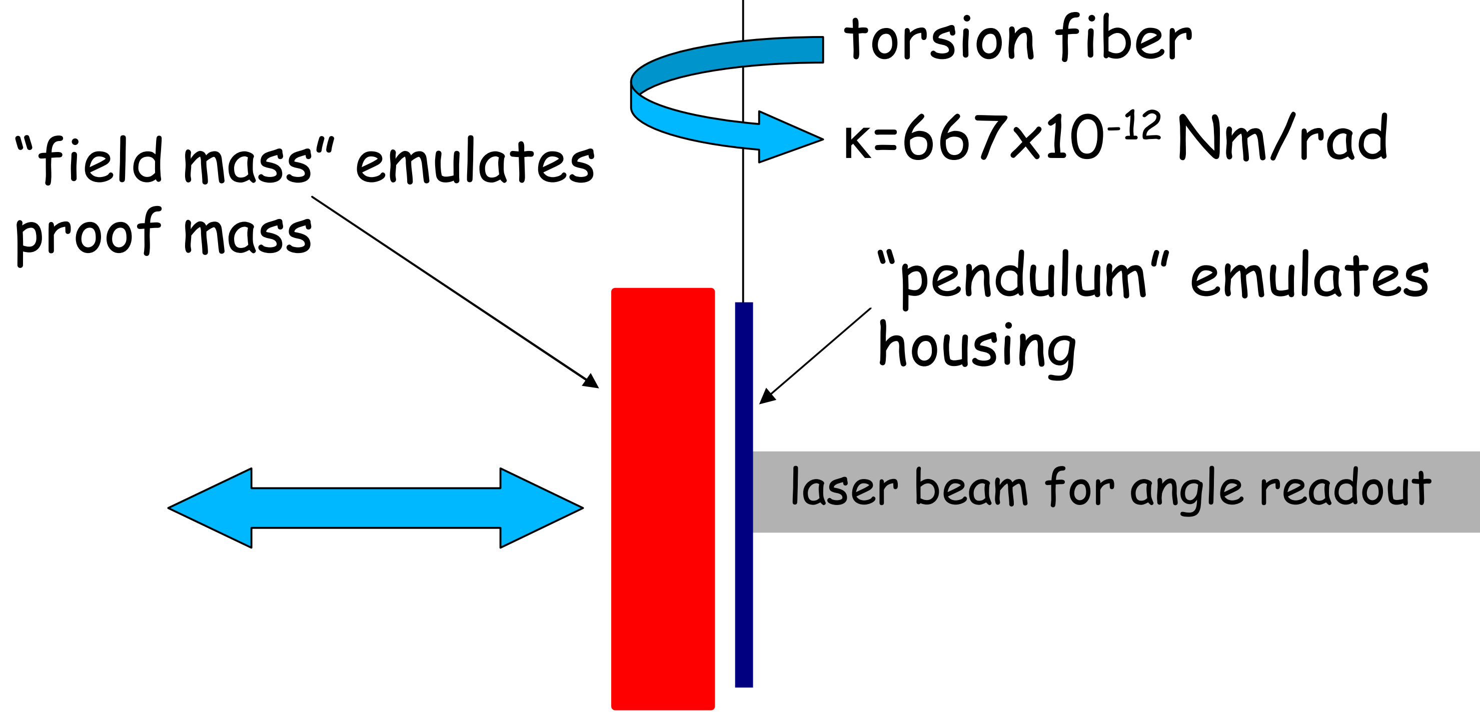
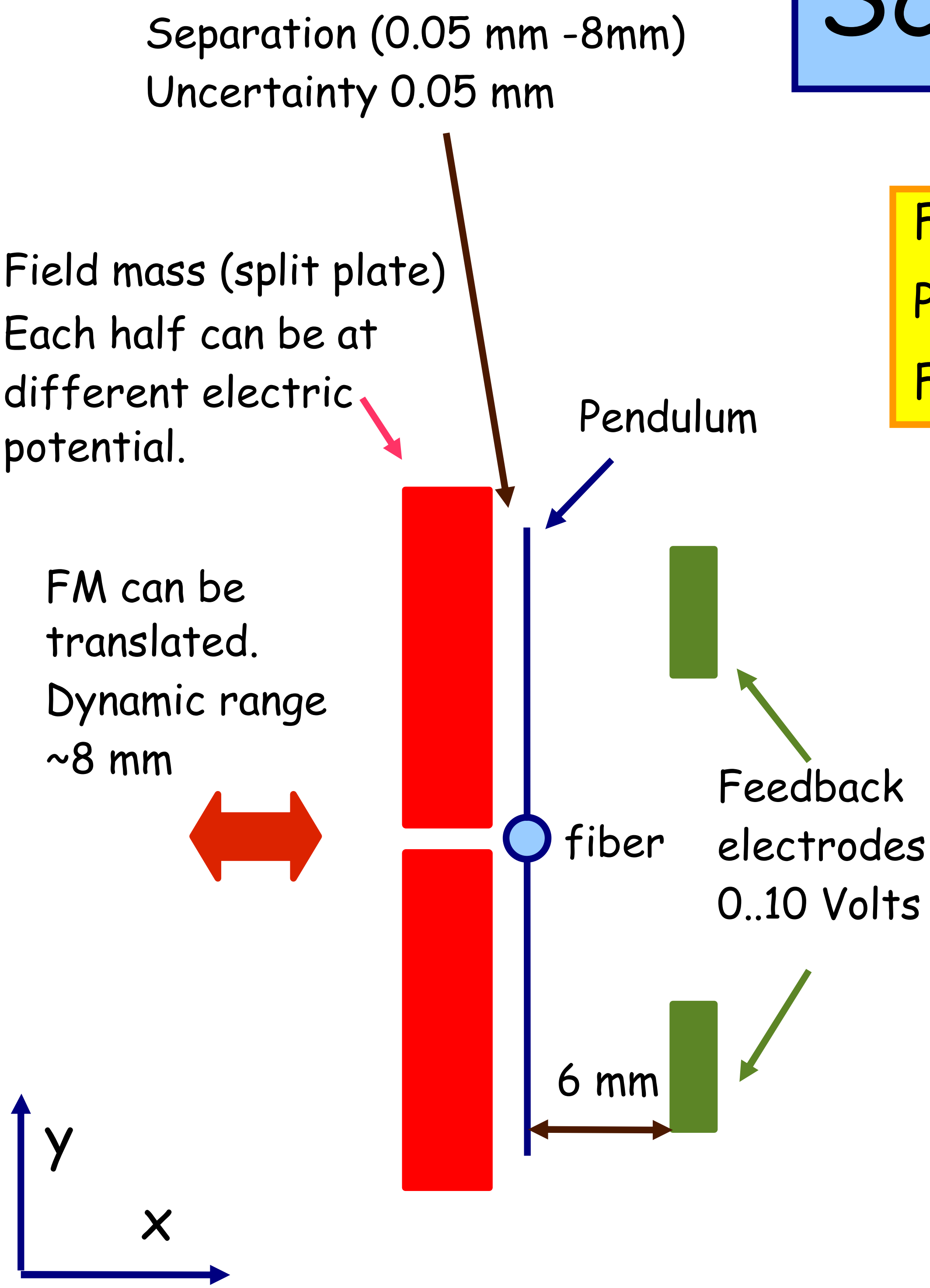




Schematic Top View



Field mass: gold coated OFHC **copper**

Pendulum: gold coated **silicon**

Fiber: **tungsten** 13 μm diam. 0.6 m

Two types of measurement

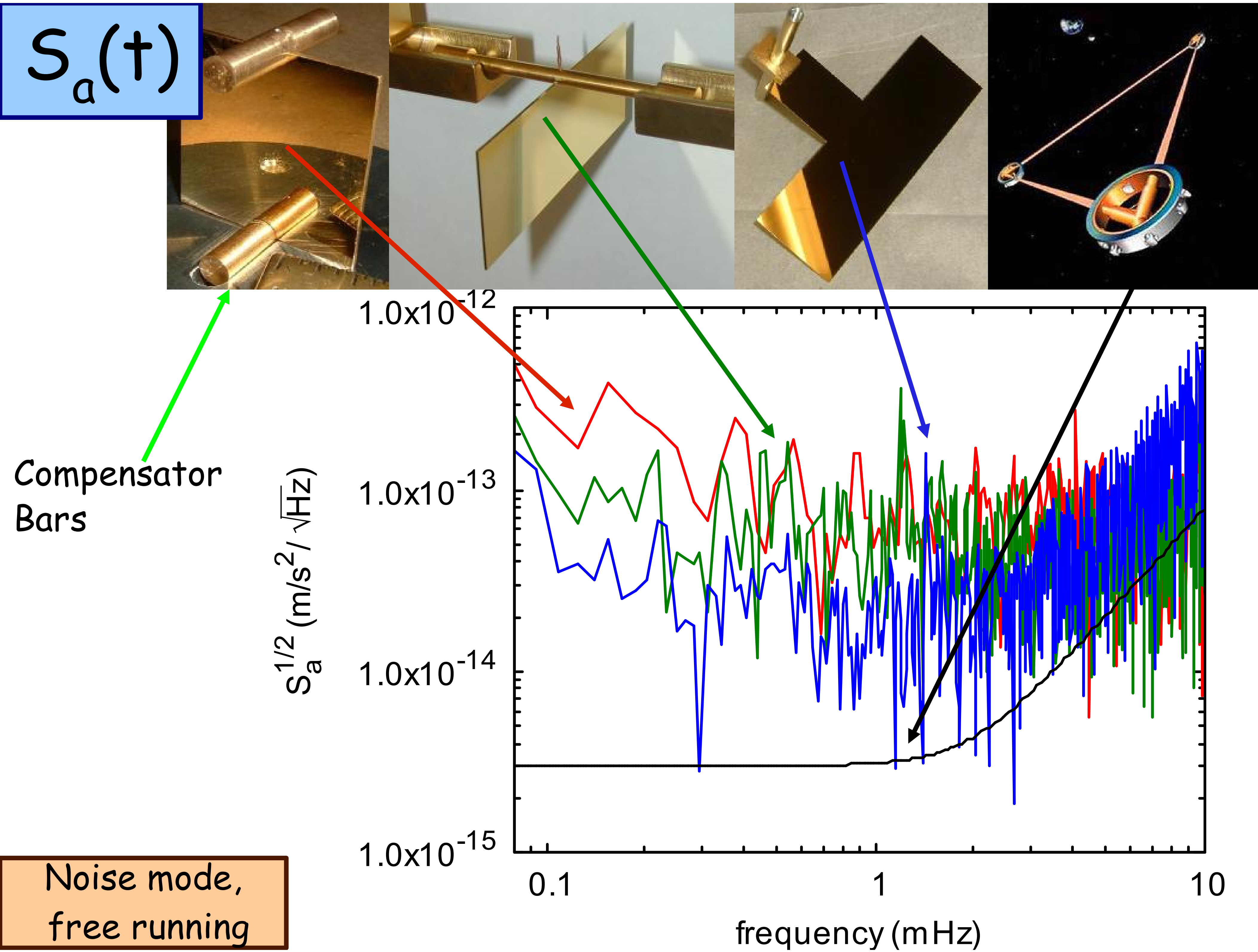
(1) Noise mode

(2) Torque mode

Two possible ways of readout

(A) Free running

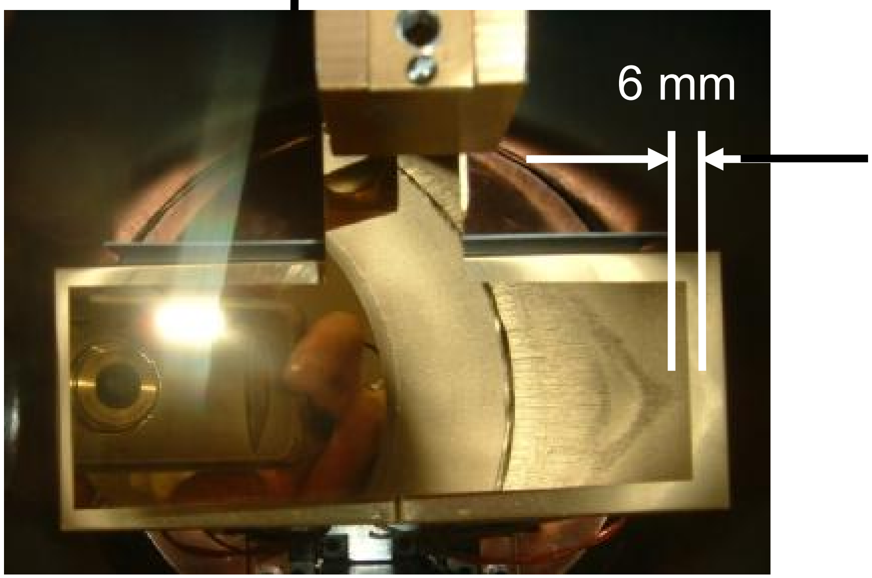
(B) Electrostatic Feedback



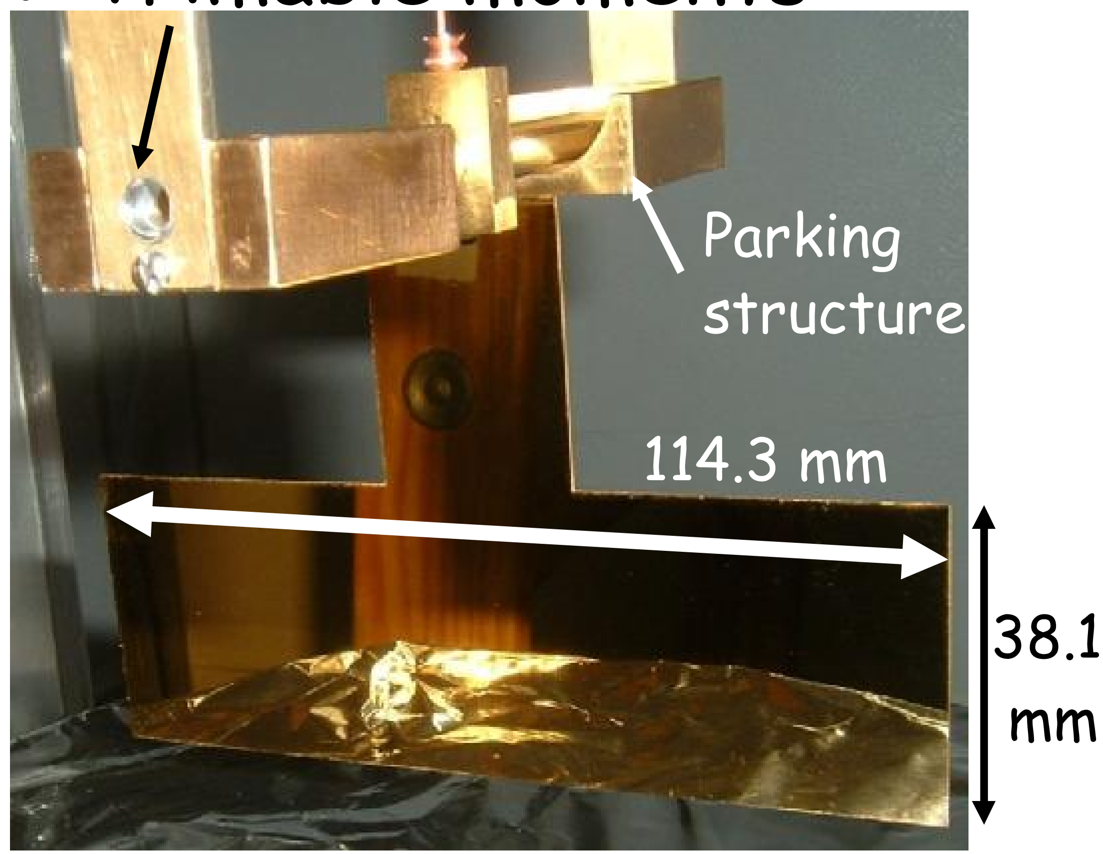
$S_a(t)$
Compensator Bars
$S_a^{1/2}$ (m/s^2/ $\sqrt{\text{Hz}}$)
1.0x10^{-12}
1.0x10^{-13}
1.0x10^{-14}
1.0x10^{-15}
0.1
1
10
frequency (mHz)
Noise mode, free running

The new torsion pendulum

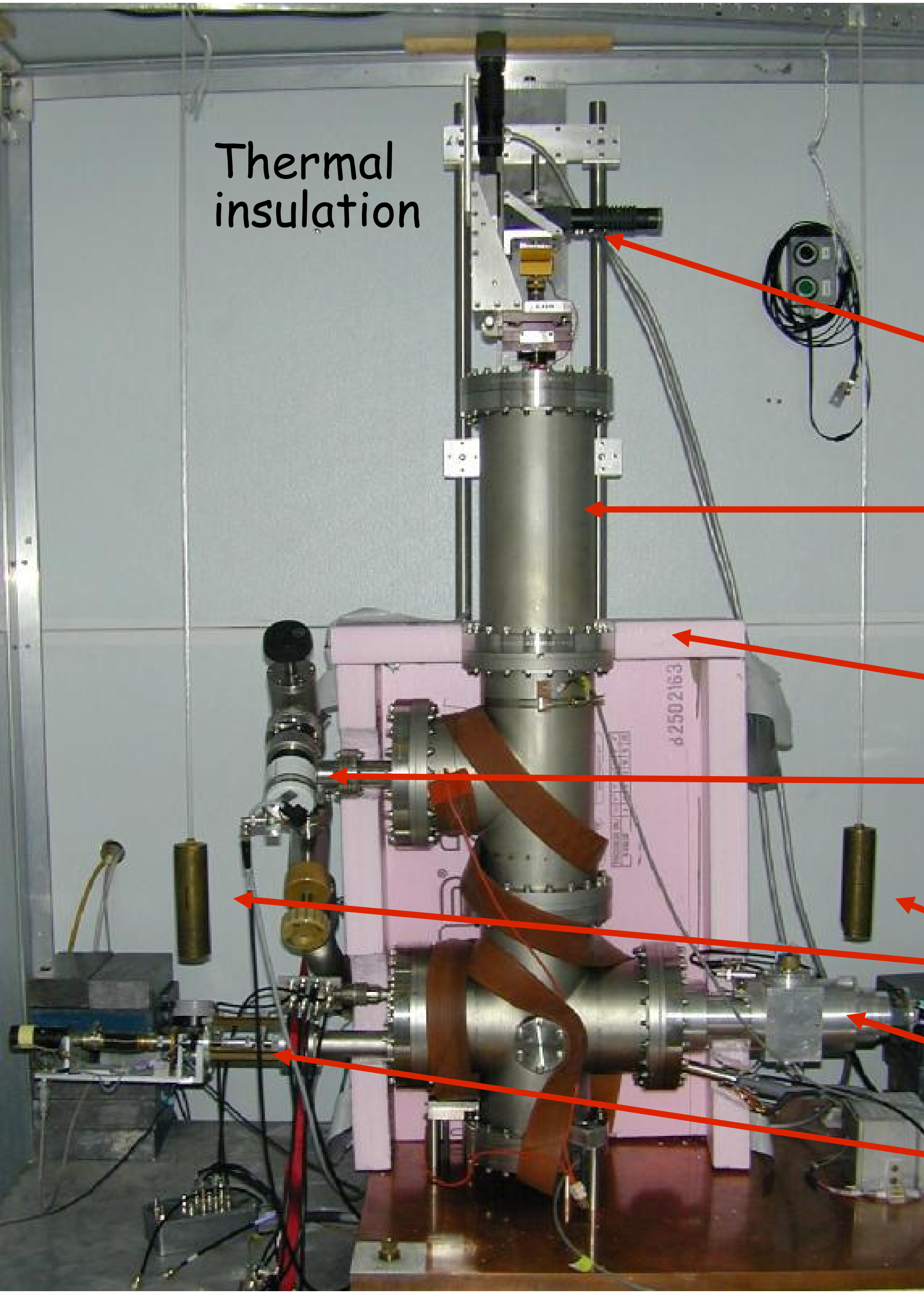
- Semi-conducting base material (Si)
- Shape allows full overlap with FM



- Thin (0.43 mm) and light (12 g), but large area
- Sputter coated (21 nm TiW/230 nm Au)
- Better fiber suspension
- Trimable moments



The Apparatus



Fiber positioner

Vacuum vessel
(p=10^{-5} .. 10^{-1} Pa)

Inner thermal insulation

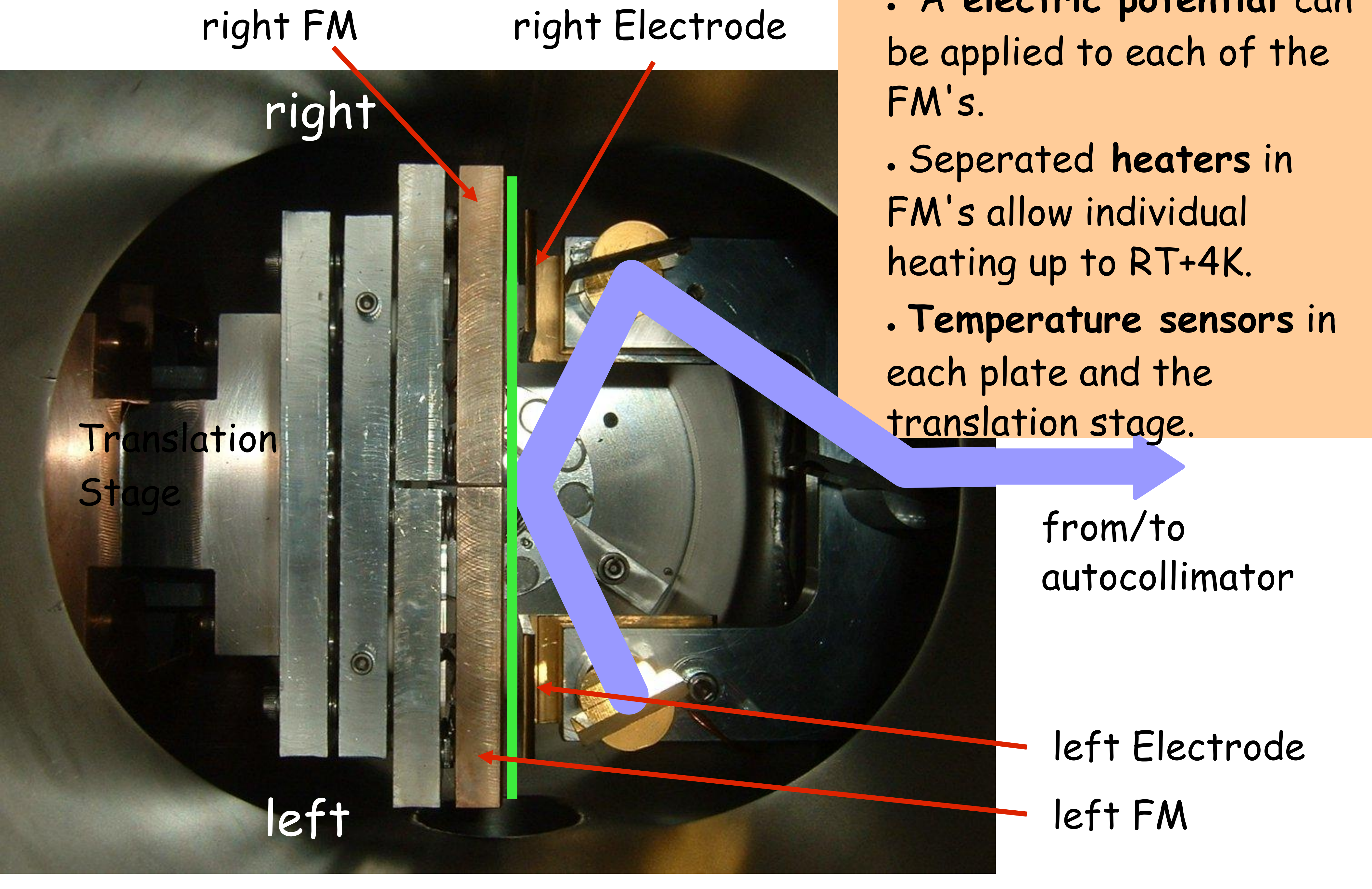
Pressure gauge (~60 cm
from pendulum)

Rotating masses for
torque calibration

Autocollimator

FM positioner

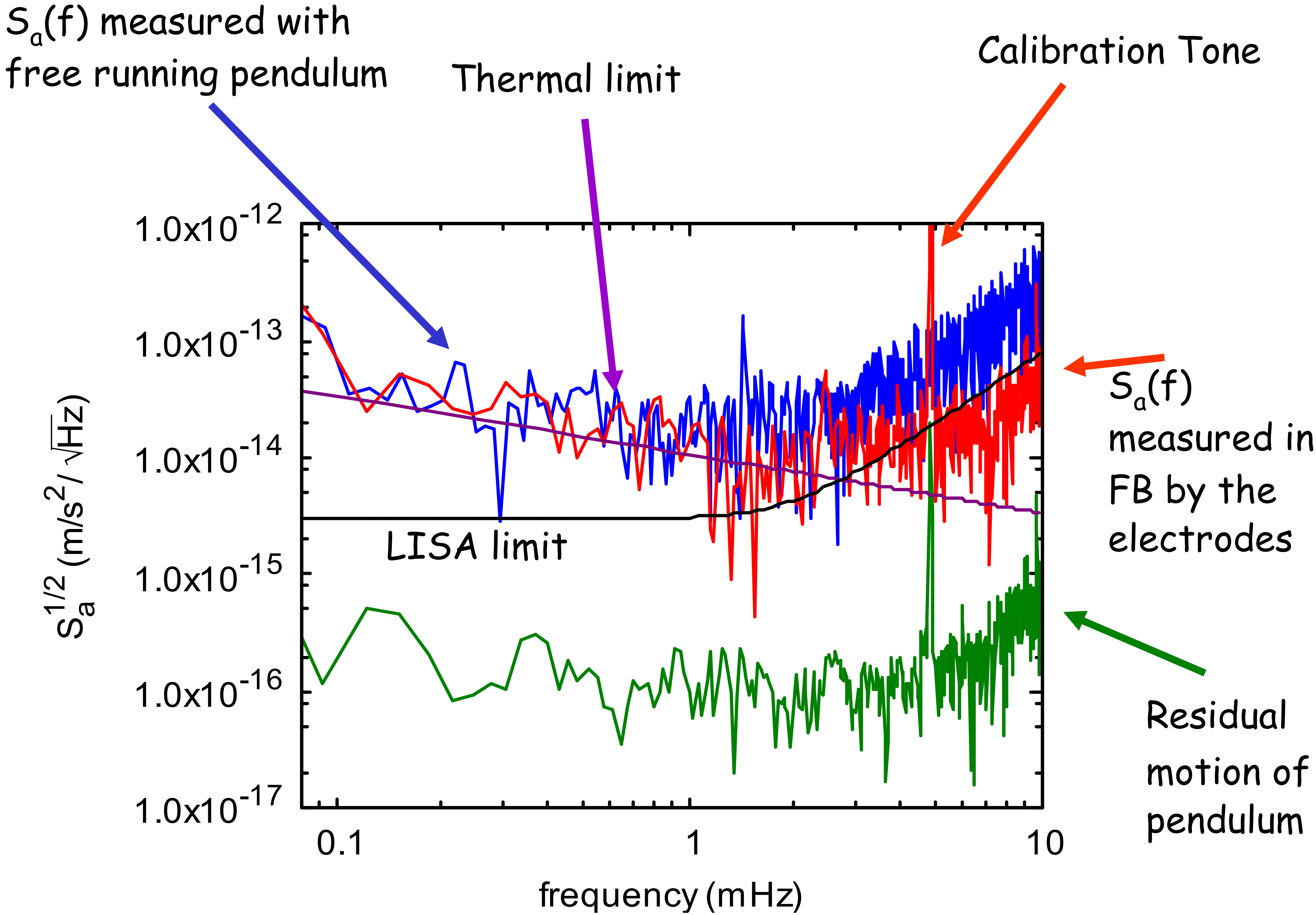
A Peek Inside



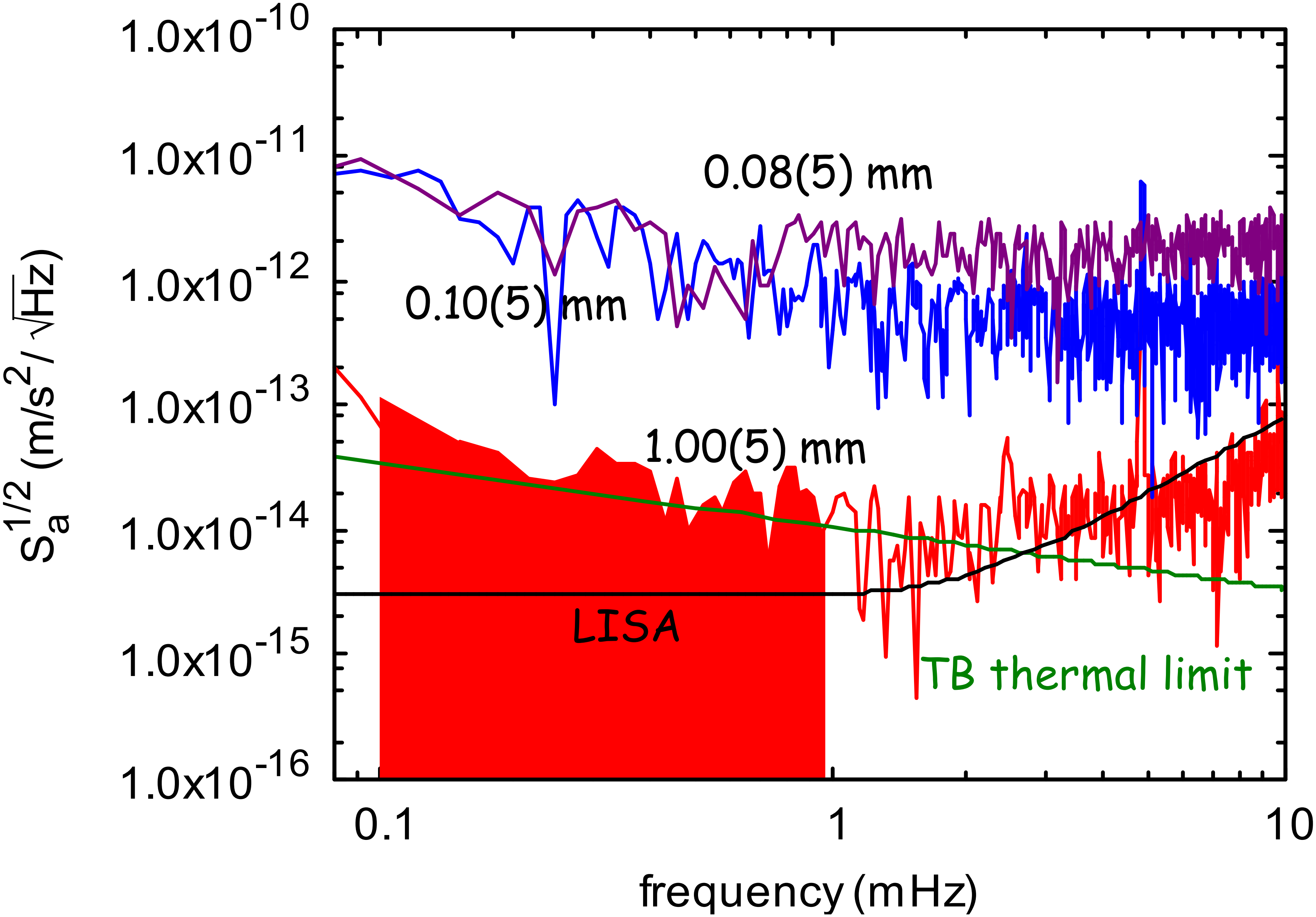
Features:

- A **electric potential** can be applied to each of the FM's.
- Seperated **heaters** in FM's allow individual heating up to RT+4K.
- **Temperature sensors** in each plate and the translation stage.

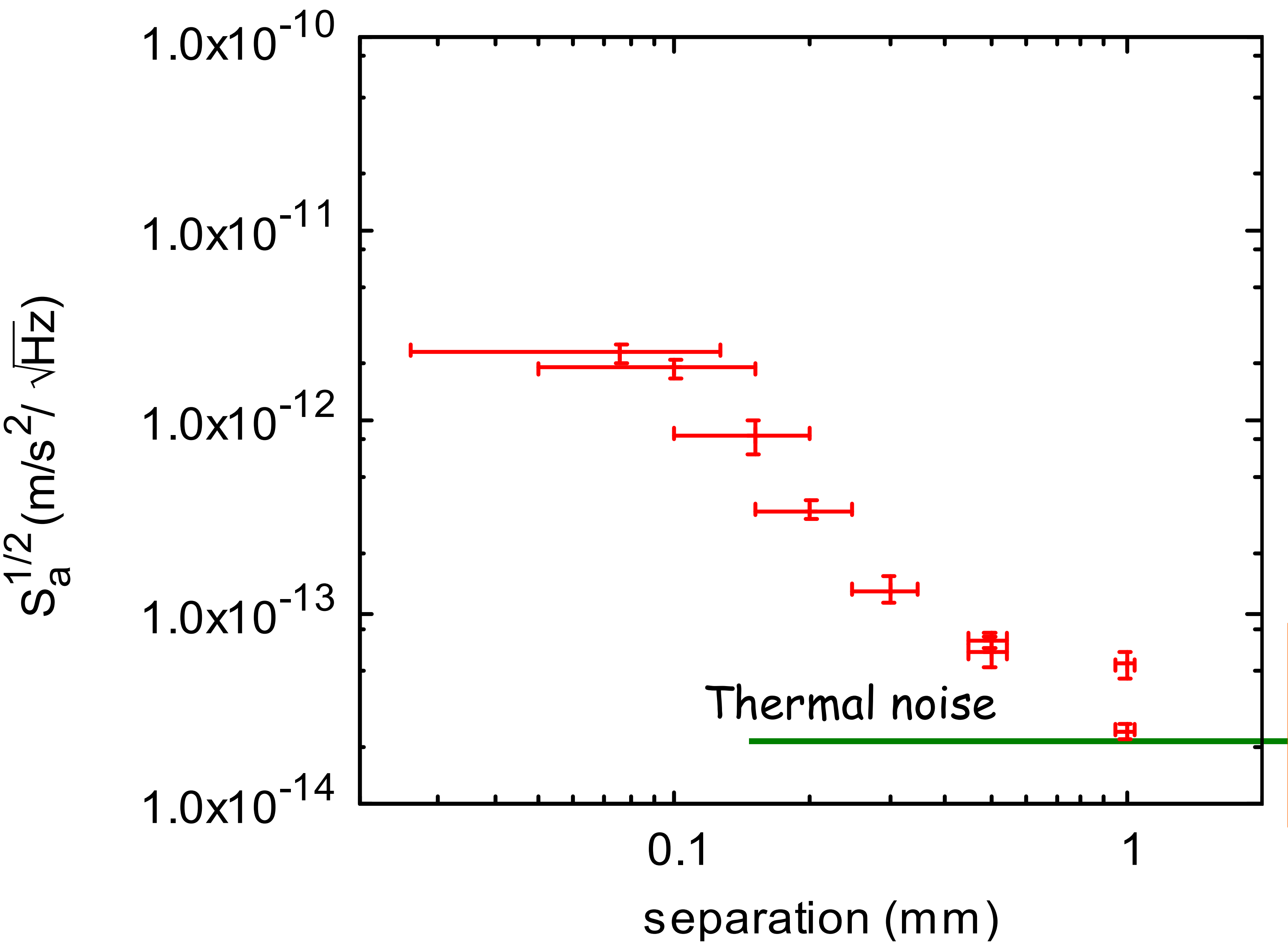
Pendulum in Feedback



S_a(Separation)

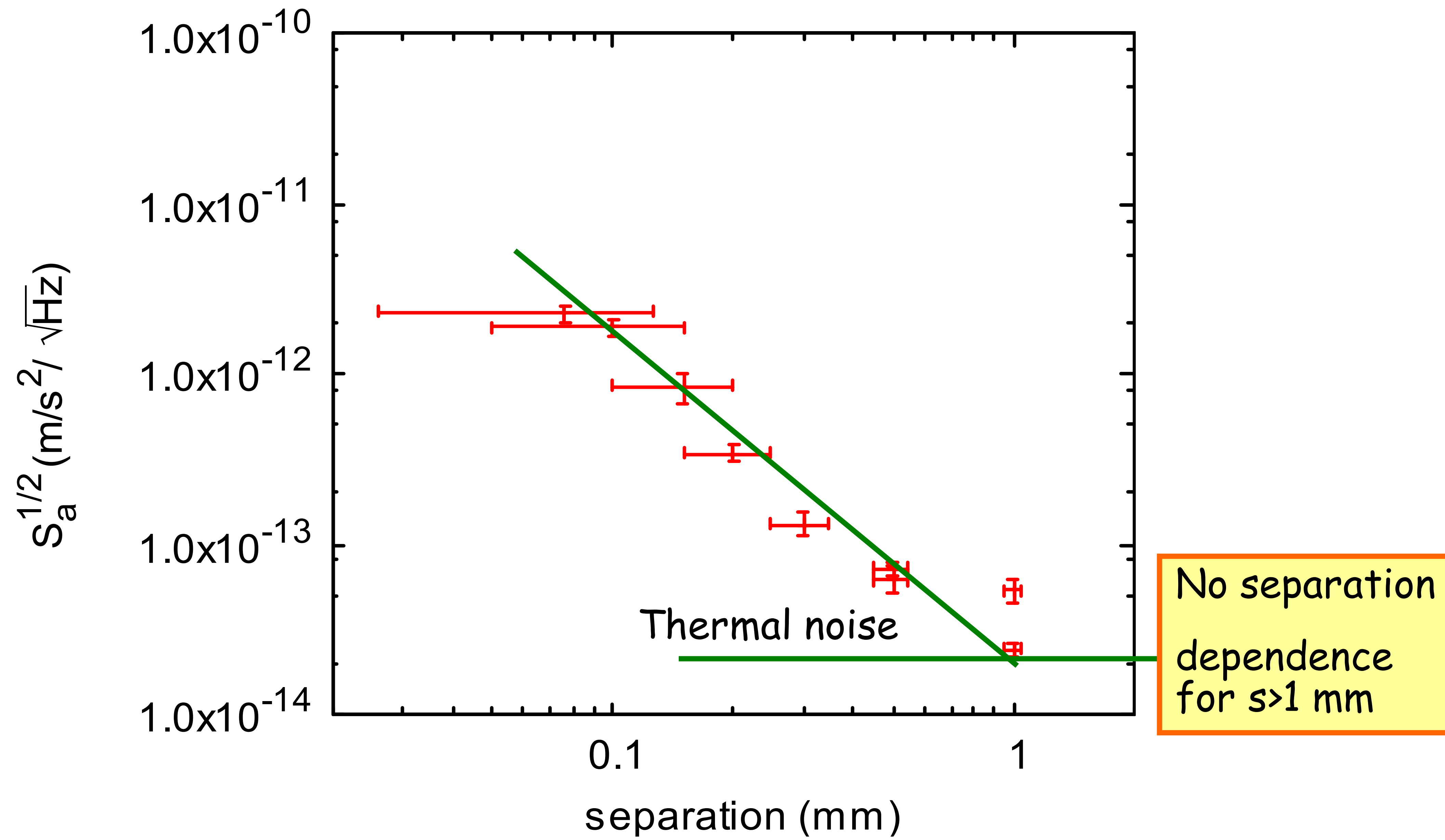


Noise as a Function of Distance



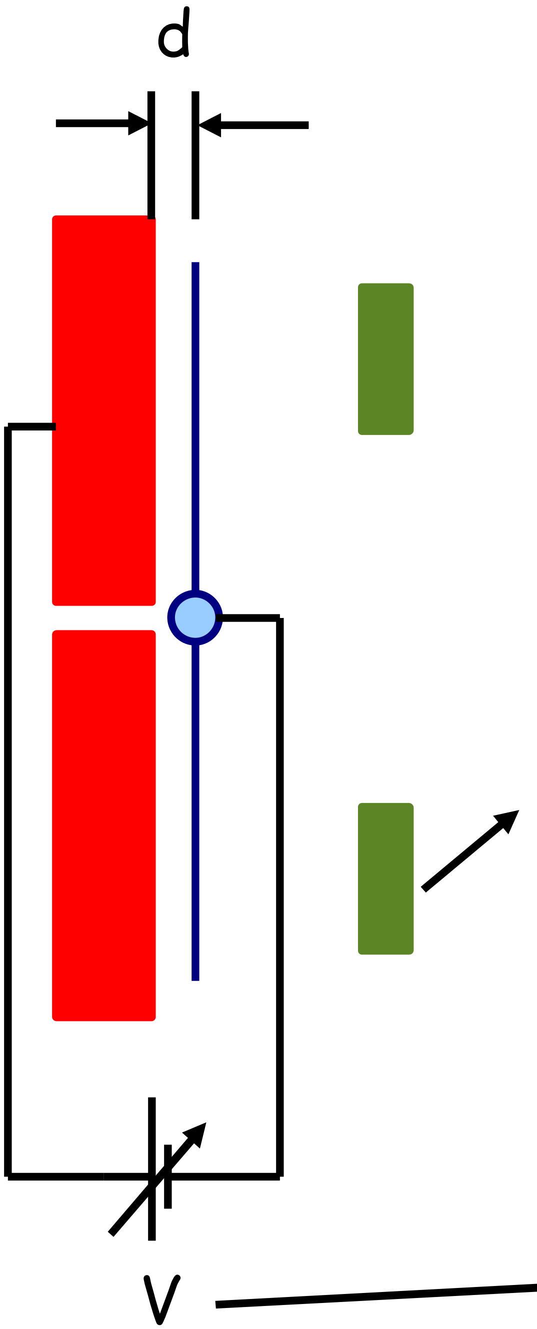
No separation dependence for s>1 mm

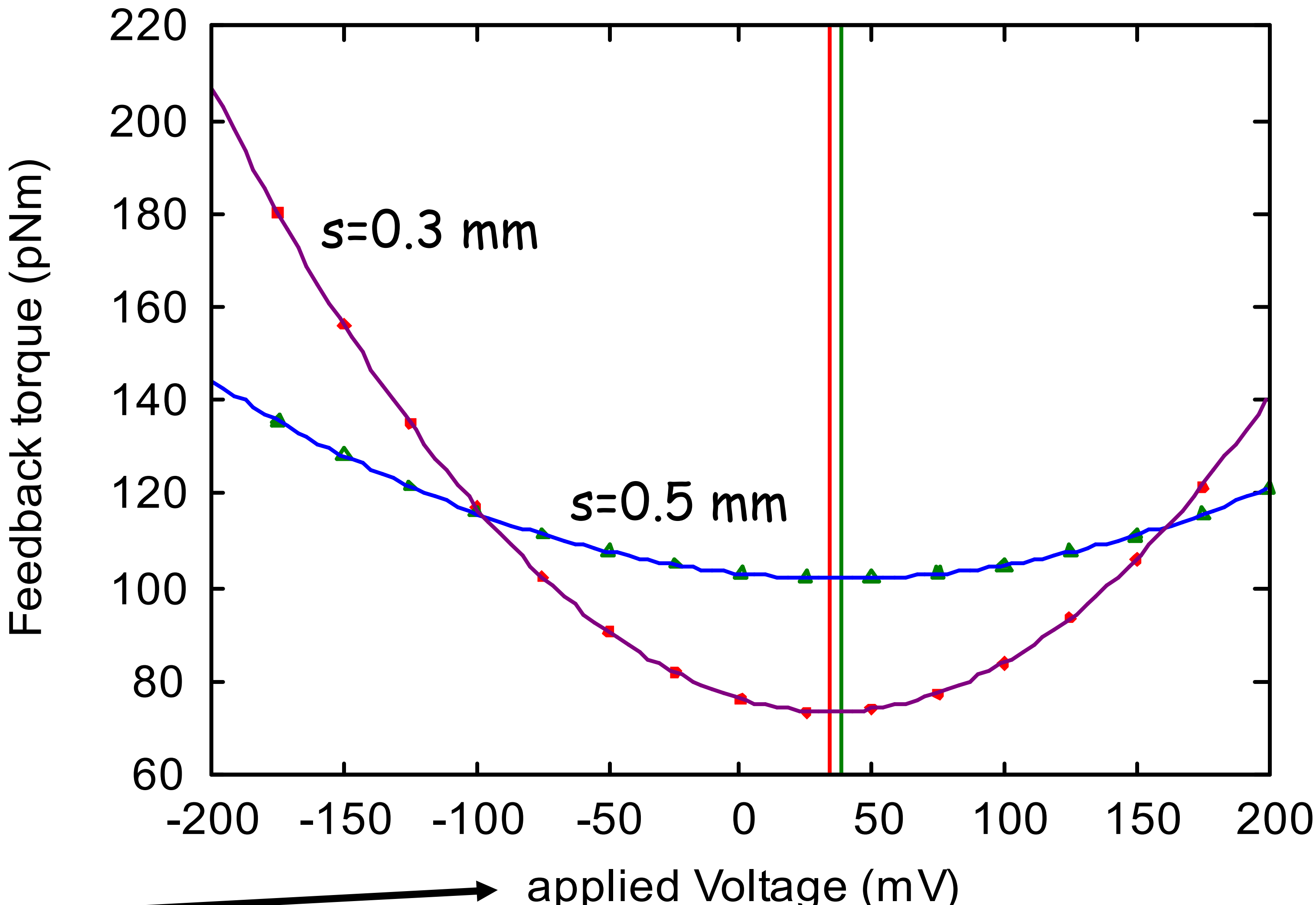
Noise as a Function of Distance



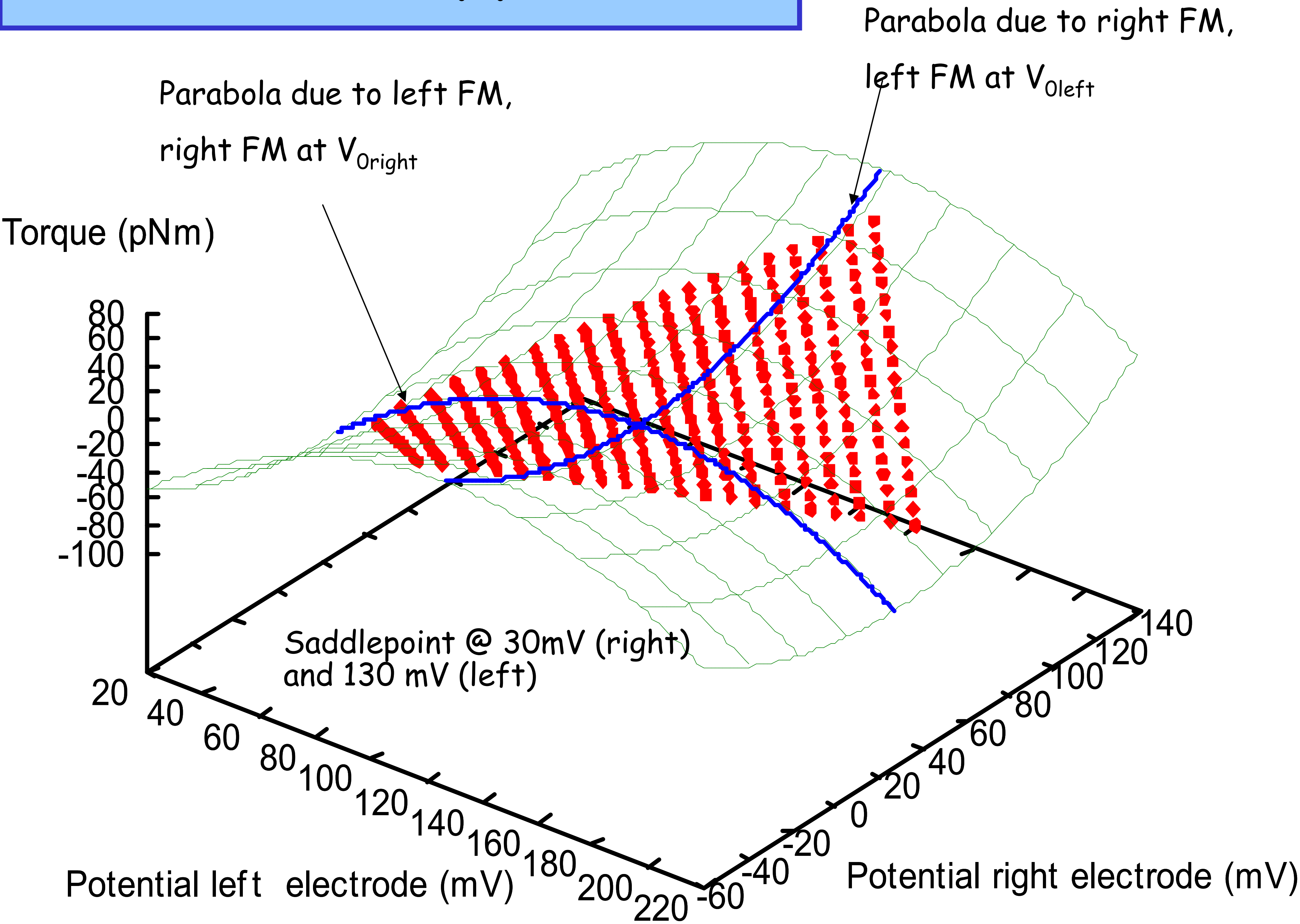
Potential Difference

$$\tau = k_{geom}(V - V_0)^2$$

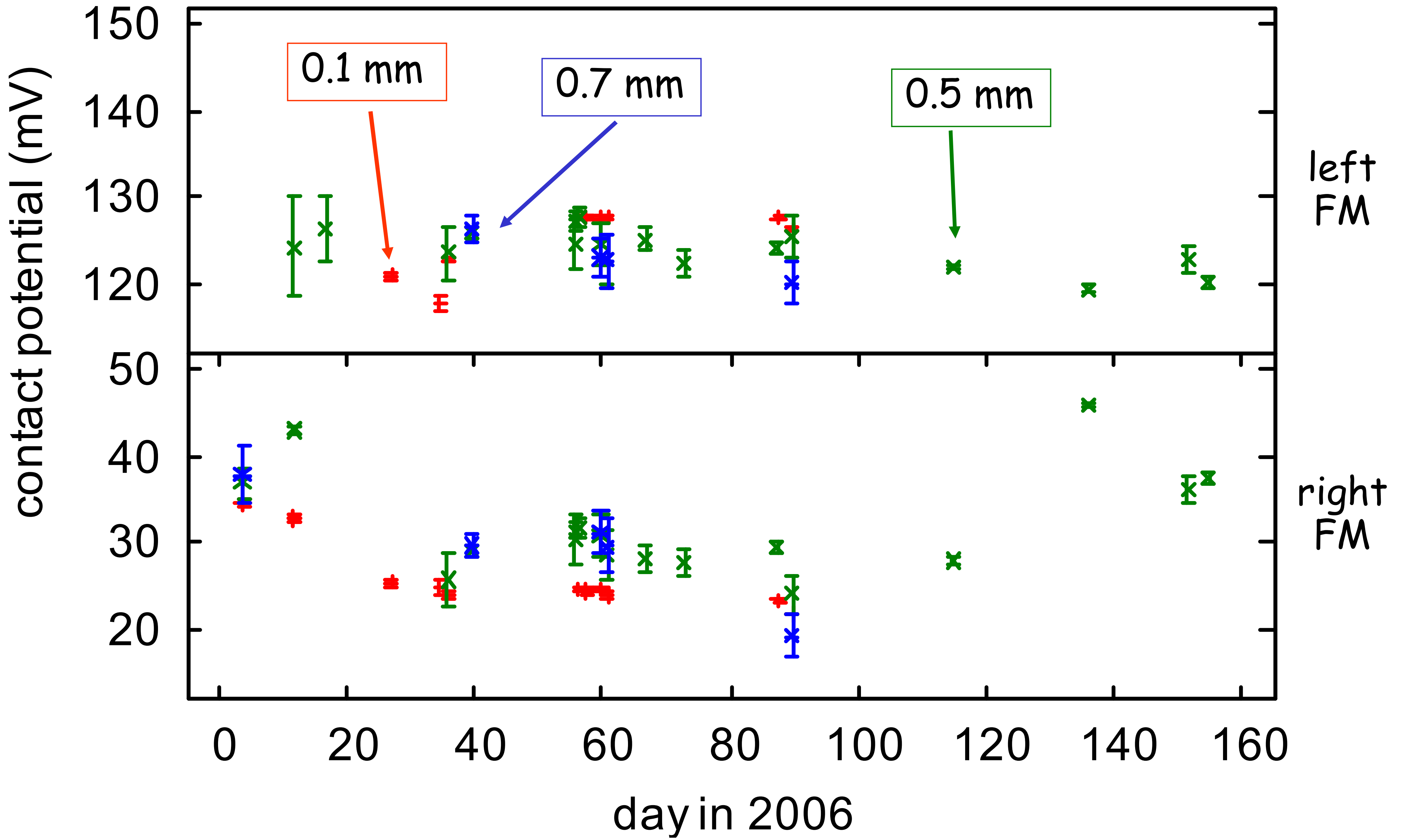




Potential Difference



Potential Difference (time)



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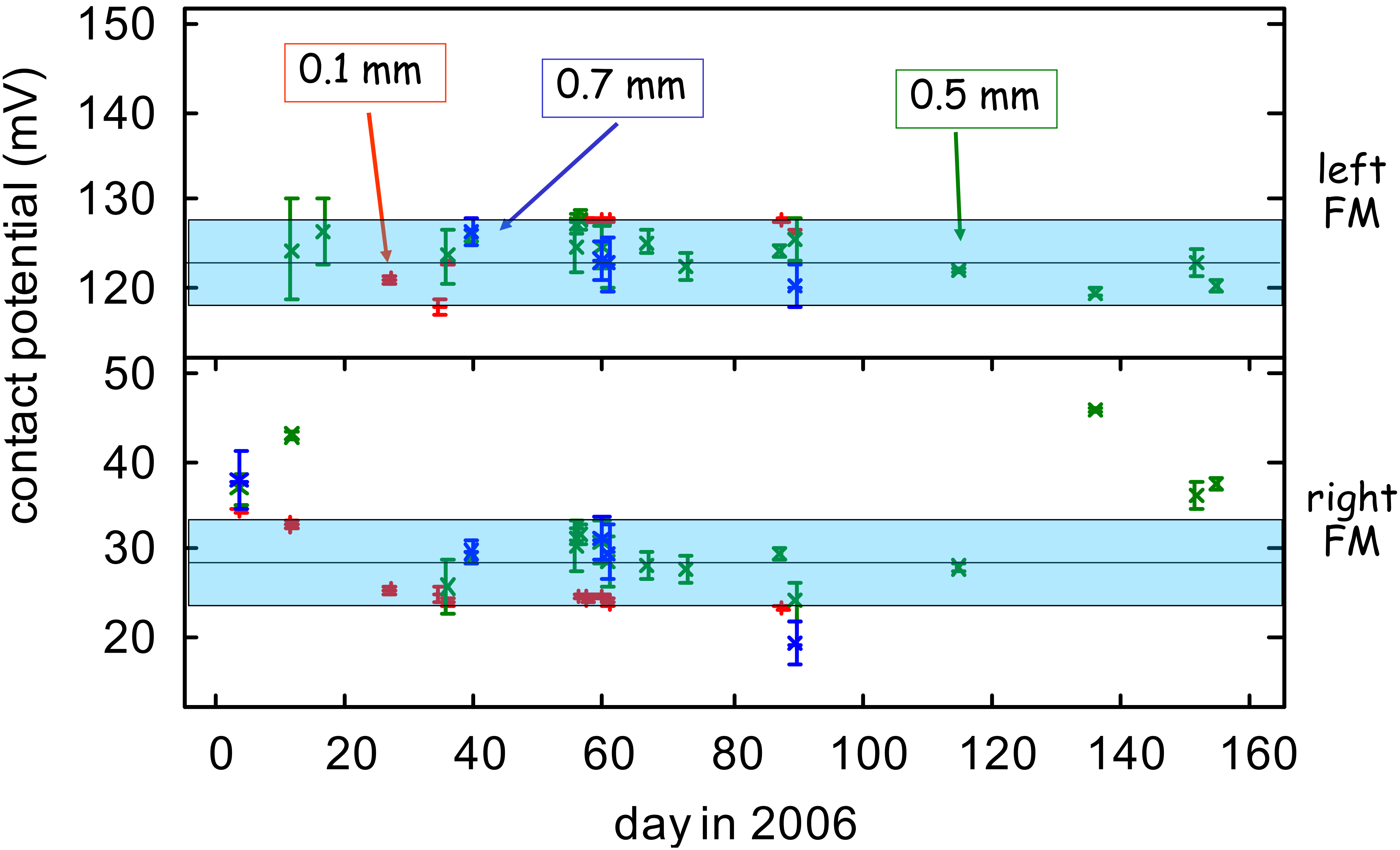

Conclusion

- We have built a highly sensitive torsion balance.

- We reach the thermal noise level with or without electrostatic feedback.

- We see a rapid increase ($\sim d^{-5/3}$) in measured noise for distances smaller than ~1 mm.

- Potential difference is approx. 30/120 mV.

    - Slow Variation of approx. 10 mV.

    - Shows a slight distance dependence.

Outlook

- Measure potential as function of
  - bake out and vacuum history.
  - Position of pendulum (displacement)

- Provide powerspectrum of potential difference at high (1 mHz) resolution.