

Short-range gravity experiment

~ Direct probe for Nature of Space-Time ~

Masaki Ando
 (ando@scphys.kyoto-u.ac.jp)

ISL of Gravity

Gravity: First force acknowledged in Physics

Falling body Galileo (1564-1642)
 Law of Motion Newton (1687)
 General Relativity Einstein (1916)



Newton's Gravity

$$F(r) = G \frac{m_1 m_2}{r^2}$$

'Inverse-Square Law of Gravity'

Fundamental law in physics

Should be tested with best accuracy we have.

Experimental tests

• **Gravitational Inverse square Law**

Assume $\propto 1/r^{2+\delta}$

Upper limit of $|\delta| < 10^{-9}$

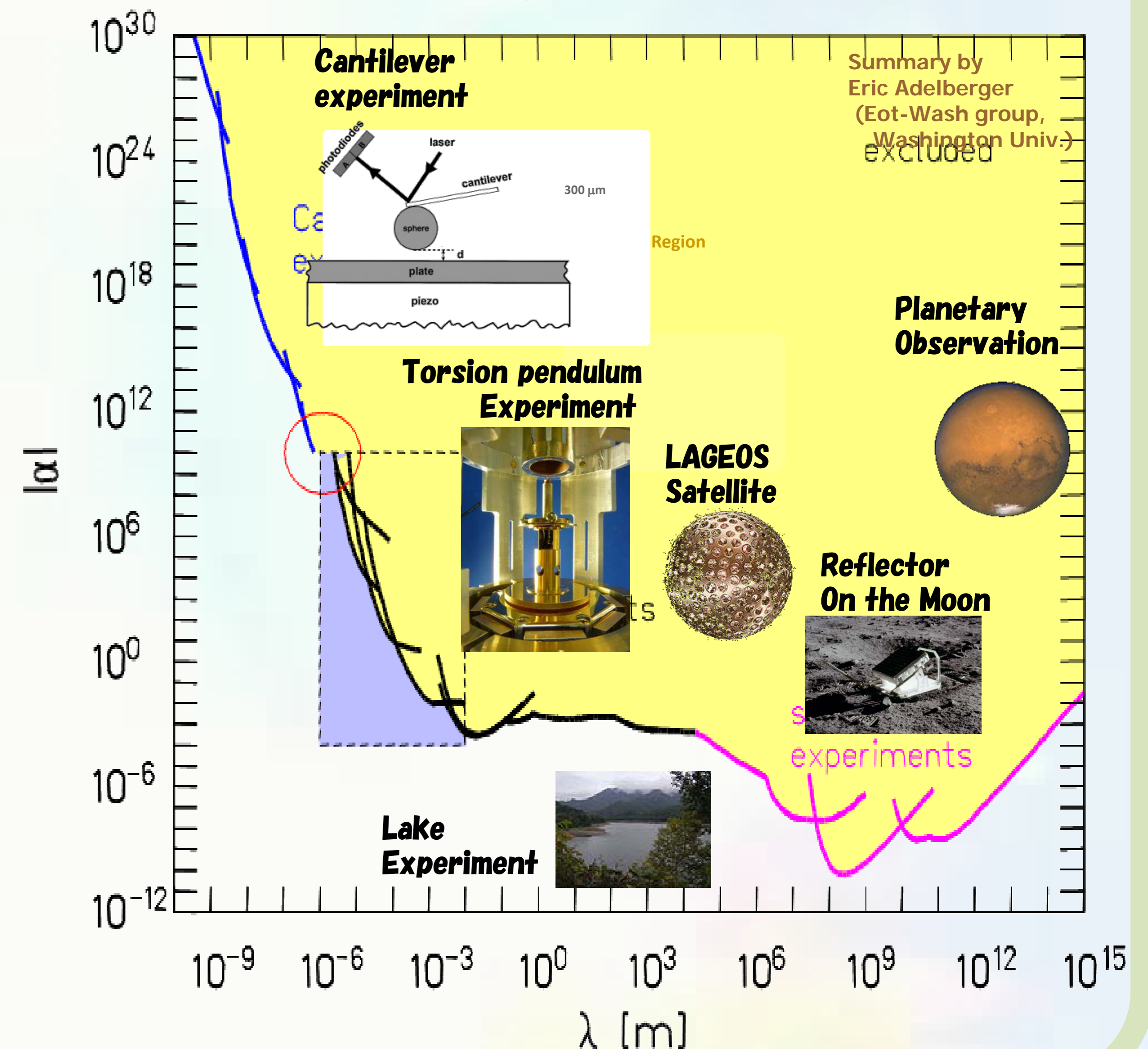
c.f. Coulomb's law $|\delta| < 10^{-16}$

• **Assume Yukawa potential correction**

$$V(r) = -G \frac{m_1 m_2}{r} \times \left[1 + \frac{\alpha e^{-r/\lambda}}{\lambda} \right]$$

Correction term α : Size λ : Scale

1mm distance \Rightarrow 1% accuracy



Gravity in modern physics

Gauge Hierarchy Problem

Gravity is too weak to explain (by 16 orders)



Large extra dimensions ?

N. Arkani-Hamed, et al., Phys. Lett. B 429 (1998) 263

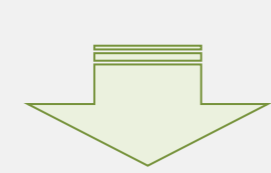
Gravitational force works even in extra dimensions

According to these theories ...

Violation of ISL in short range

Cosmological-Constant Problem

Density of dark energy is too small (by 60 orders)



Fat graviton ?

R.Sundrum, Phys. Rev. D 69 (2004) 044014

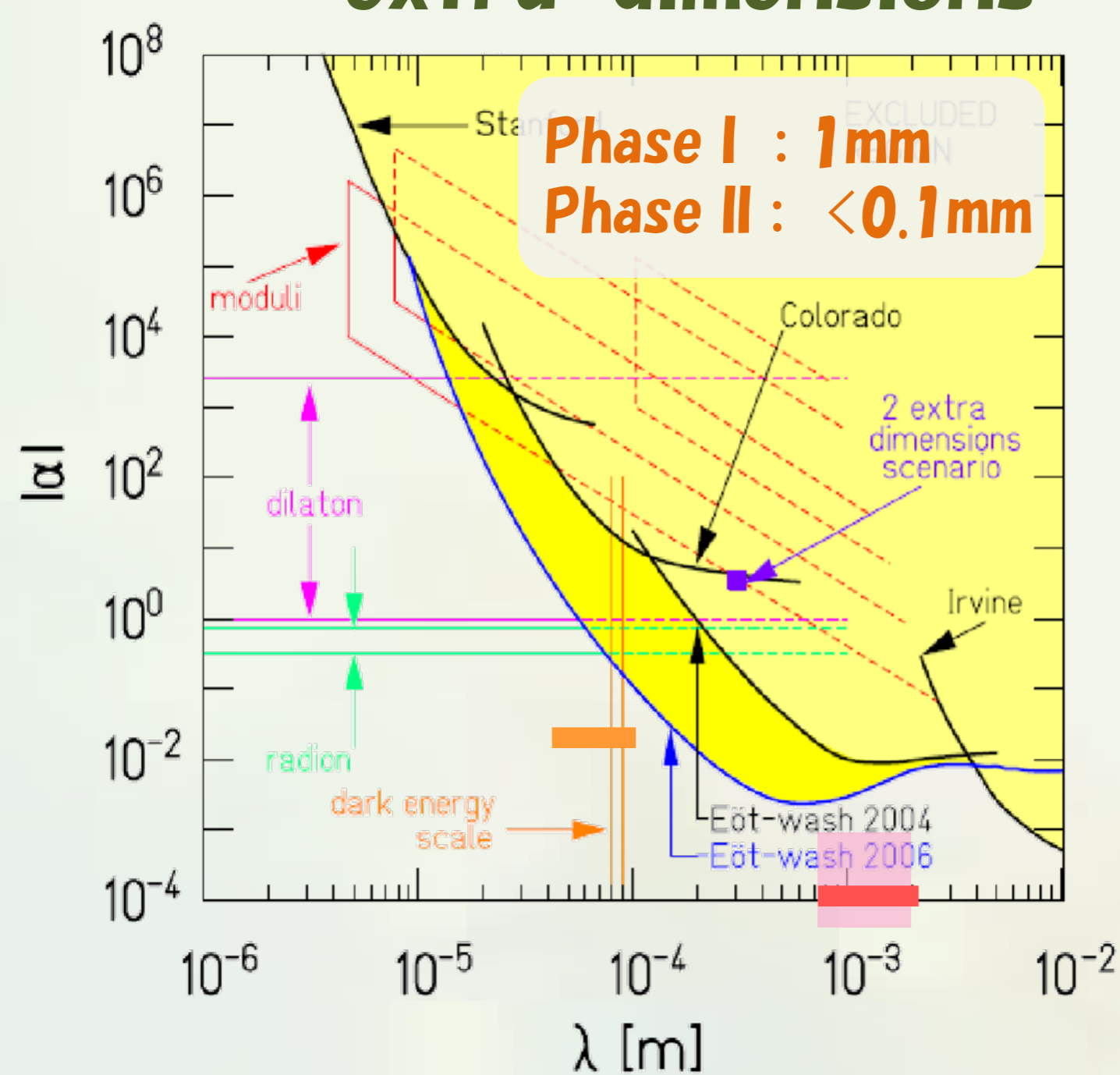
Graviton has finite size

Experiment at Kyoto University

Target

Test gravitational ISL at short range

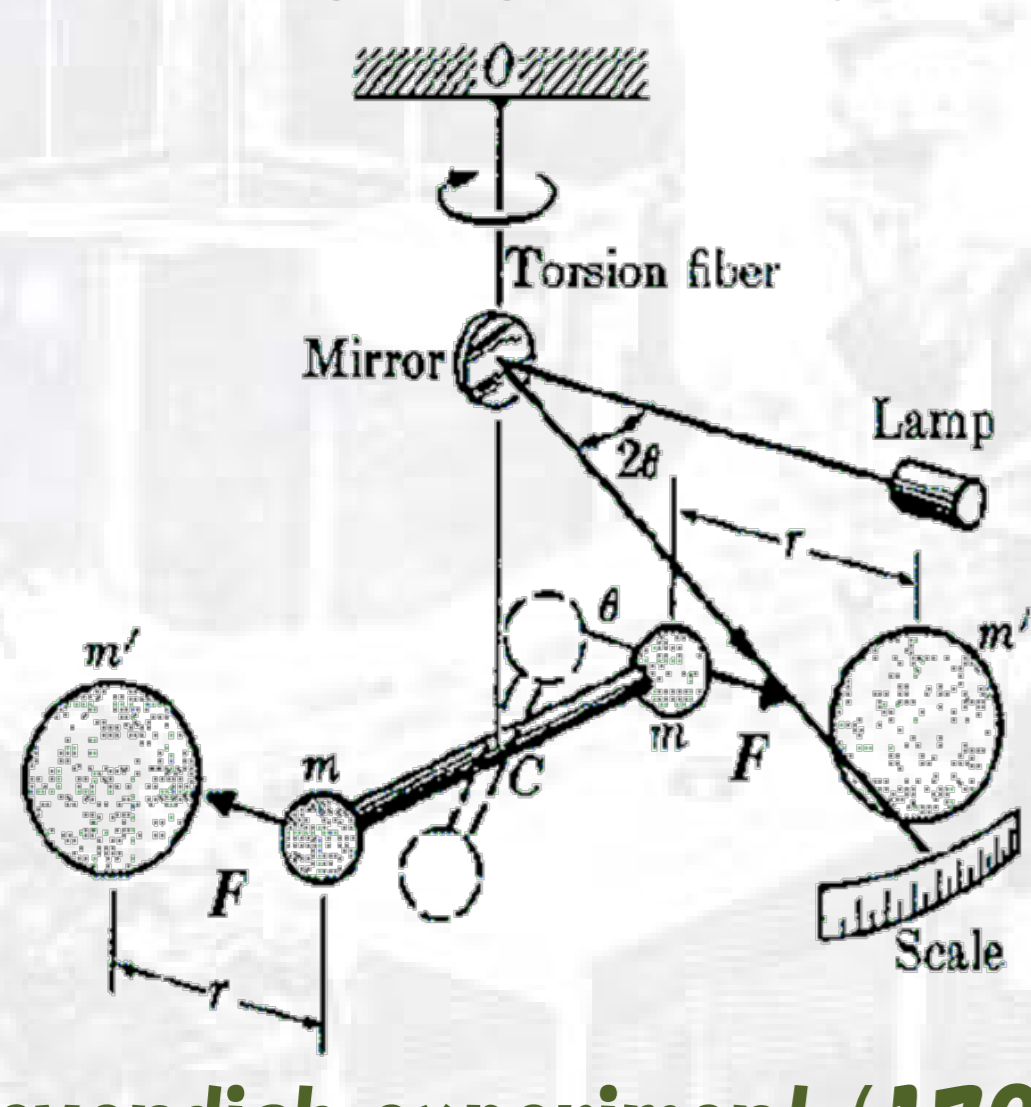
Prospects on theories of space-time and extra-dimensions



Principle

Based on Cavendish-type force measurement

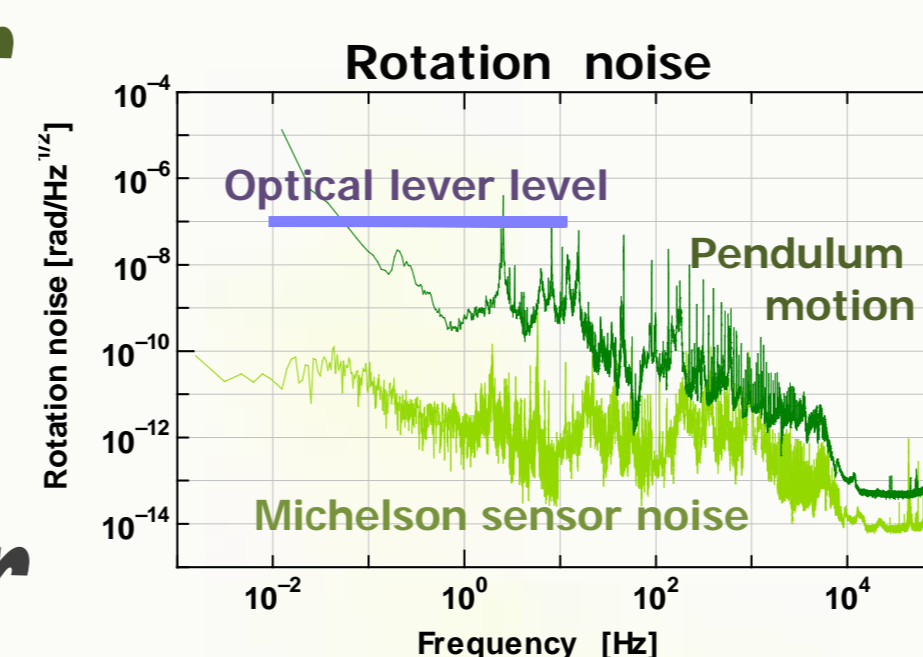
Original ideas for better accuracy



Cavendish experiment (1798)

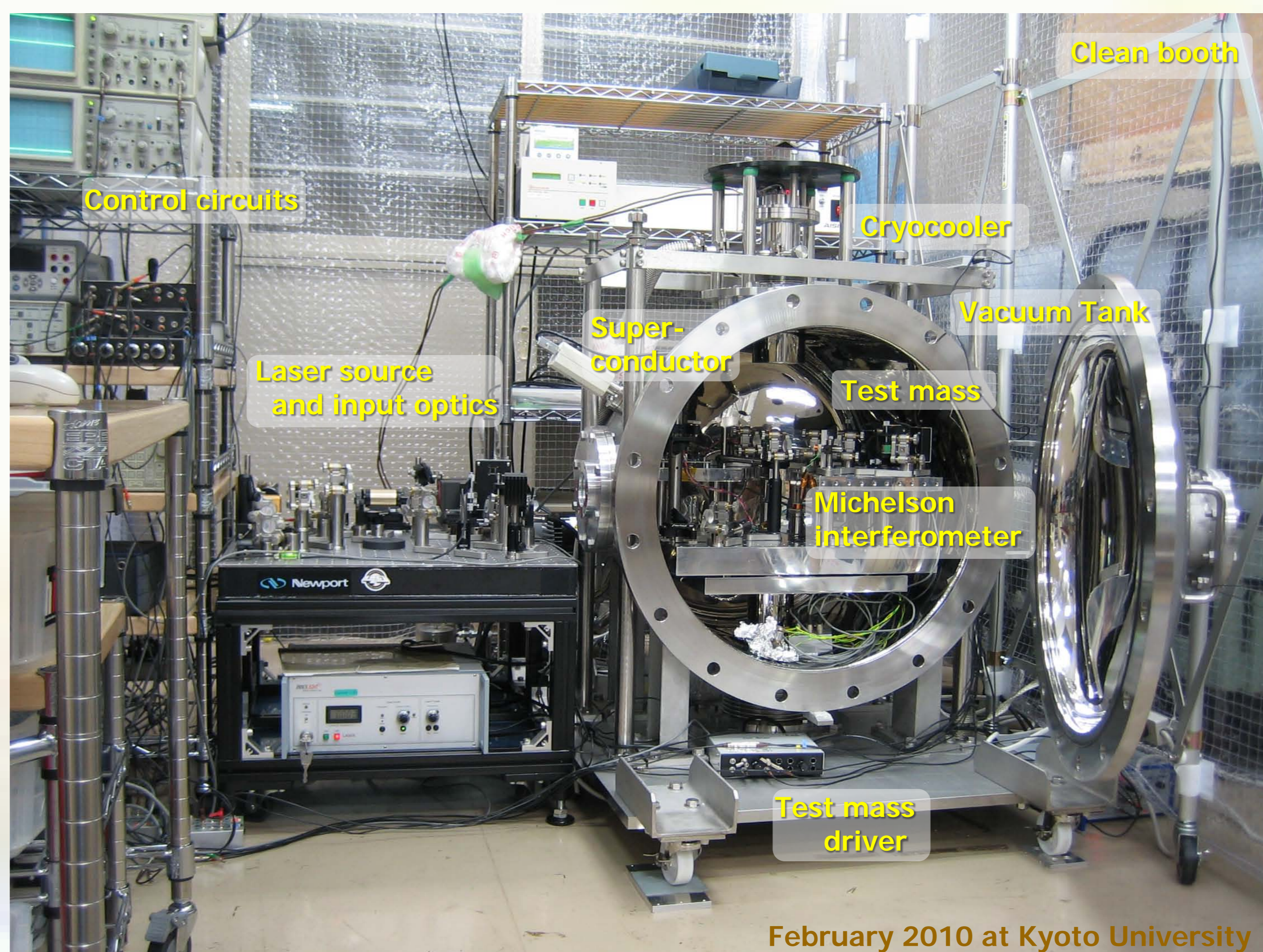
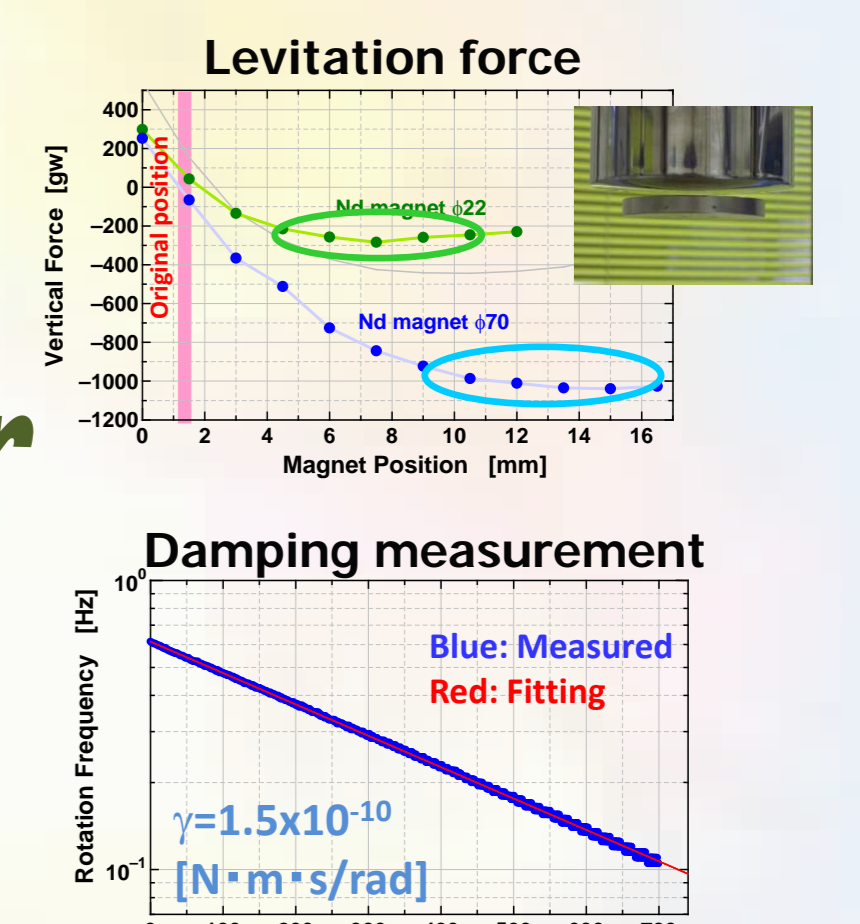
Sensor

Laser interferometer for measurement of test mass rotation ~10^4 sensitive than optical lever

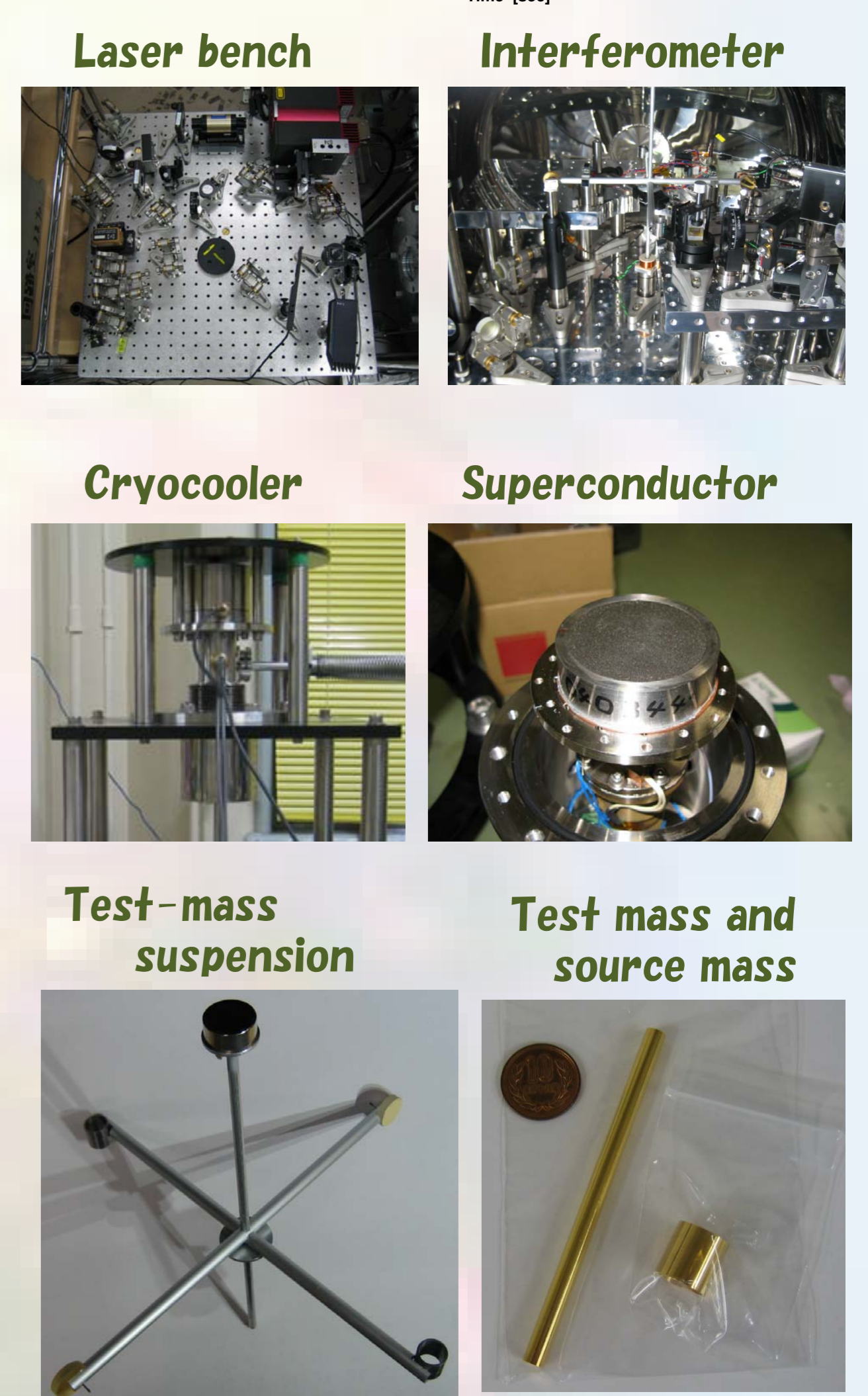


Suspension

Magnetic levitation with superconductor Small frictional and restoring force \rightarrow Low thermal noise



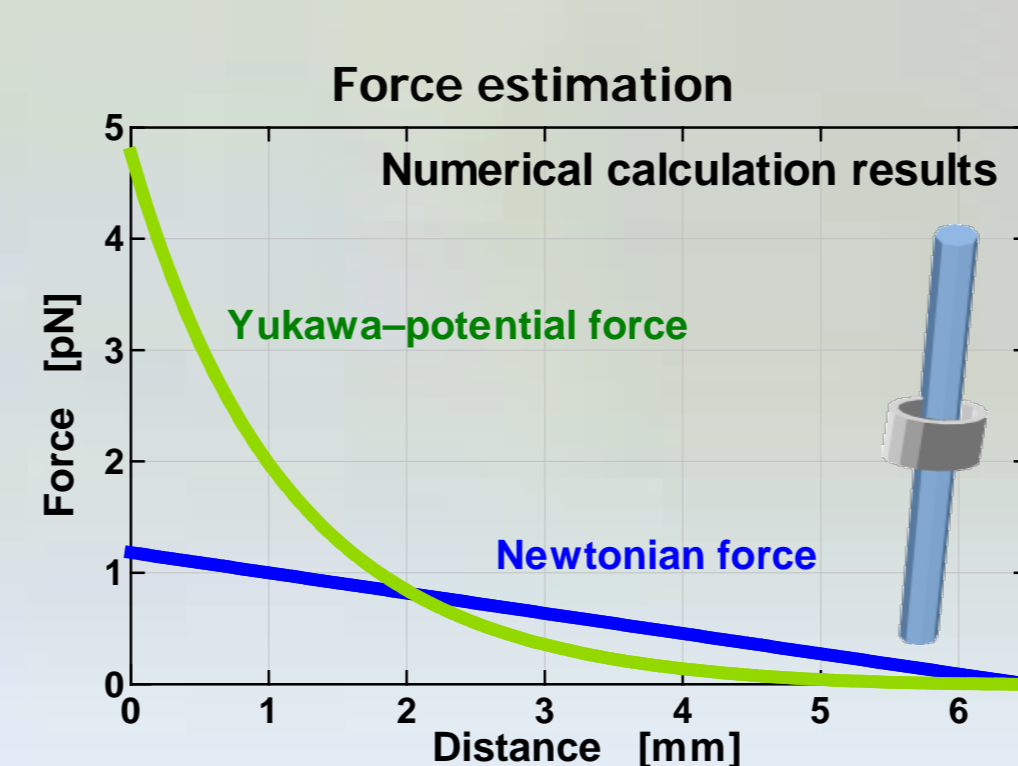
February 2010 at Kyoto University



Test mass and source mass

Cylinder and Bar Null measurement by suppressing Newtonian force

Gold-coated Tungsten High density and good electro-magnetic property



Measurement and Data processing

Lock-in measurement

Search coherent signals \rightarrow Reject background and spurious noises

Compare the results with models estimated by numerical integration