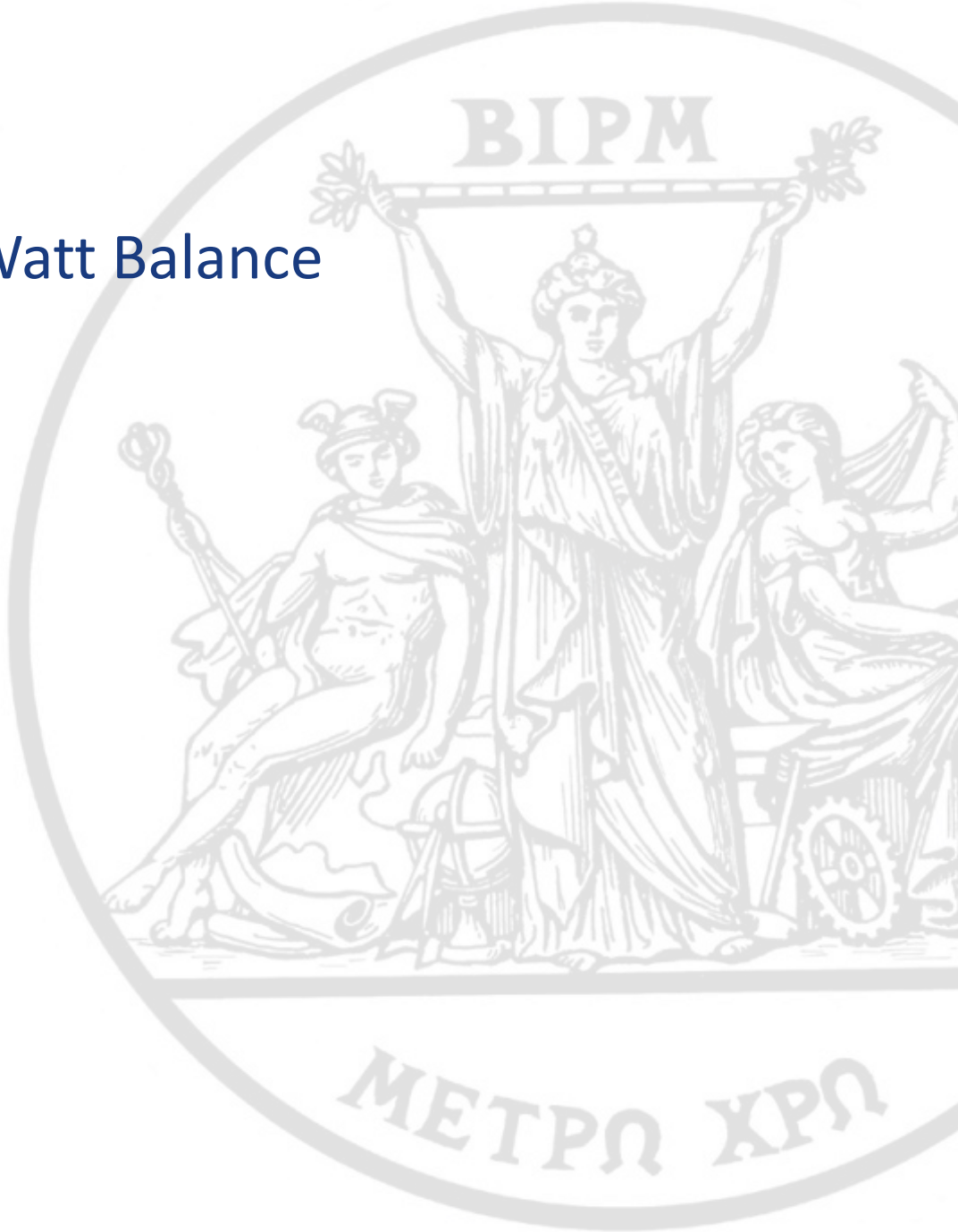
Update from the BIPM Watt Balance

15th CCM meeting

27 February 2015



Bureau International des Poids et Mesures

BIPM watt balance

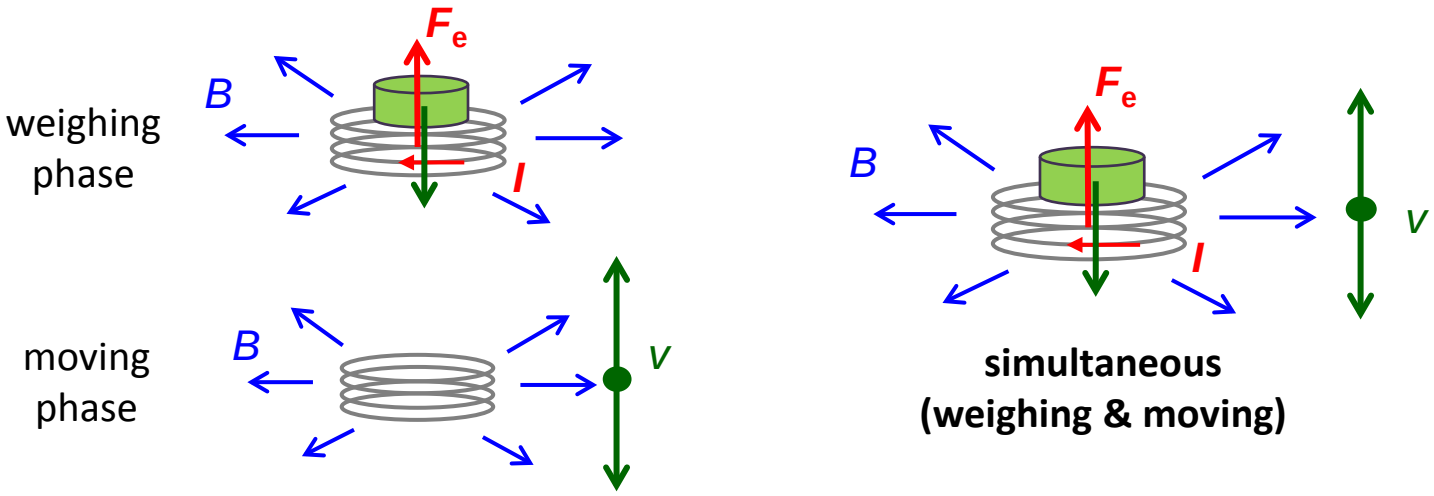
- Motivation

  provide long-term sustainable operation for a primary realization of the kilogram on a cost-shared basis

- Main feature

  capability of implementing a "one-phase" measurement scheme

  in addition to conventional "two-phase" scheme



Brief overview over project history

2005: start of construction

2009: operational in air

2010: first *h* determination

2011: improved repeatability

move to the new lab.

Early 2013: new laboratory

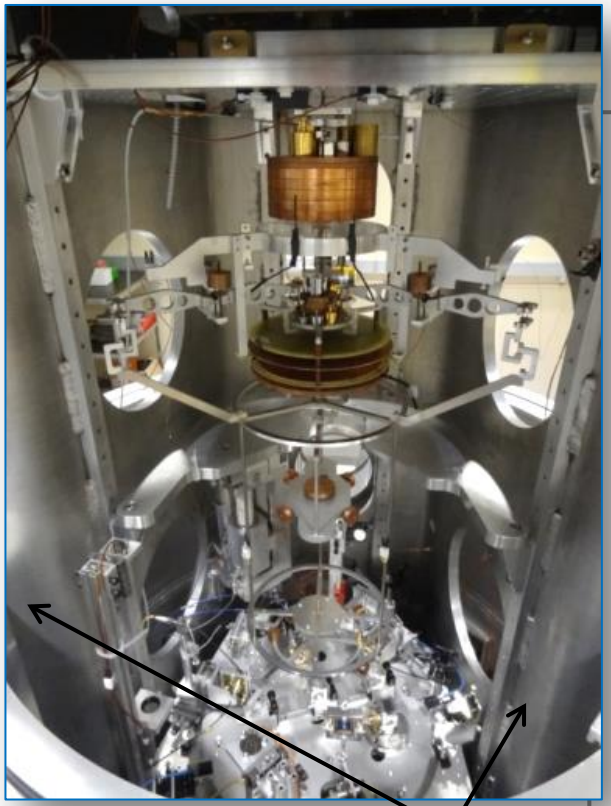
(improved thermal and vibrational environment)

Planck constant determination

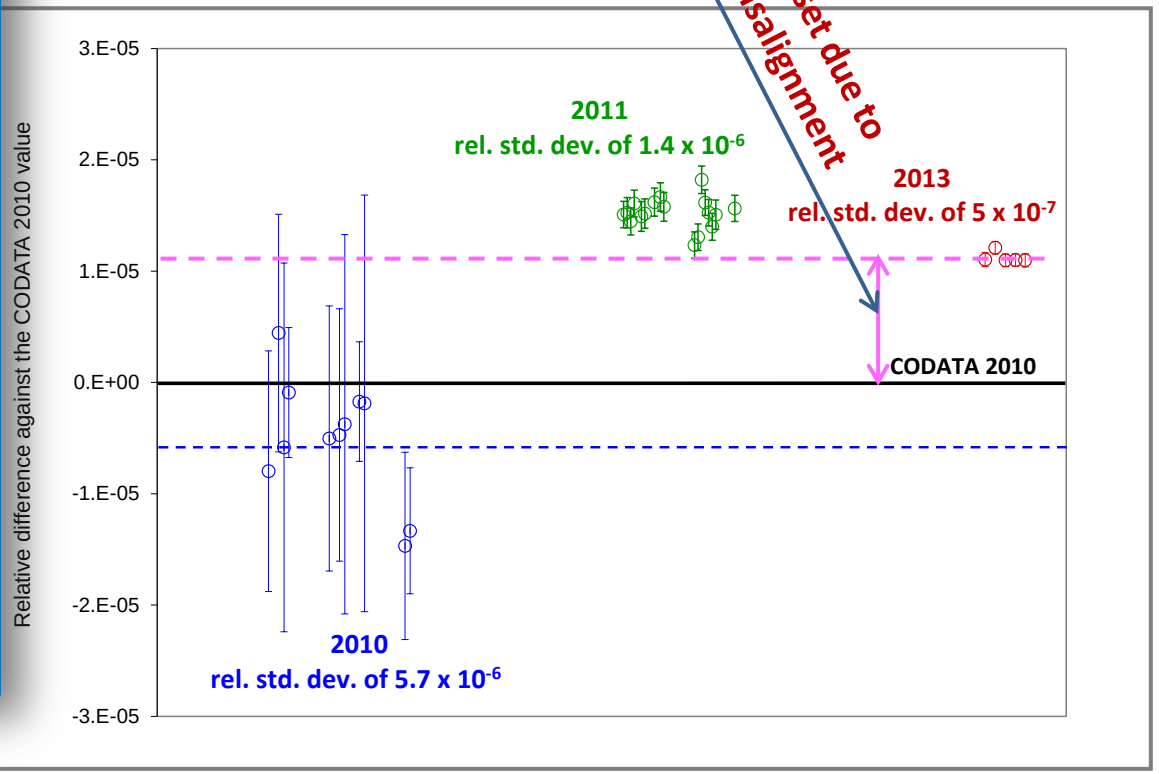
Determination of the Planck constant *h*

Type A: ~ 5 x 10^{-7}

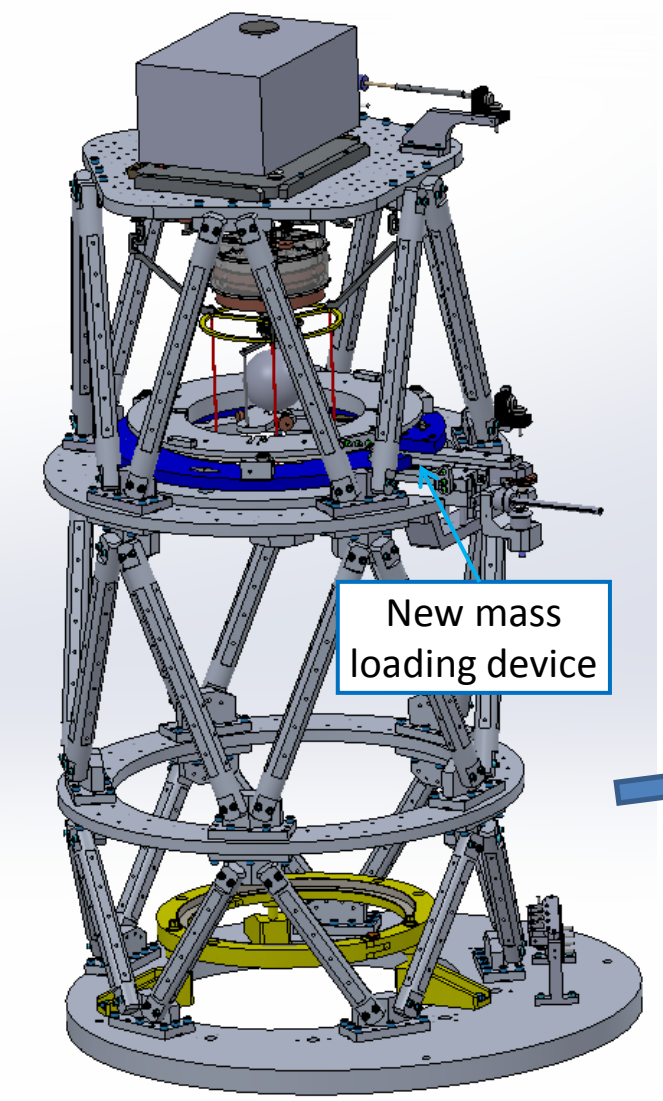
Type B: ~ 5 x 10^{-5}



massive "closed" support structure

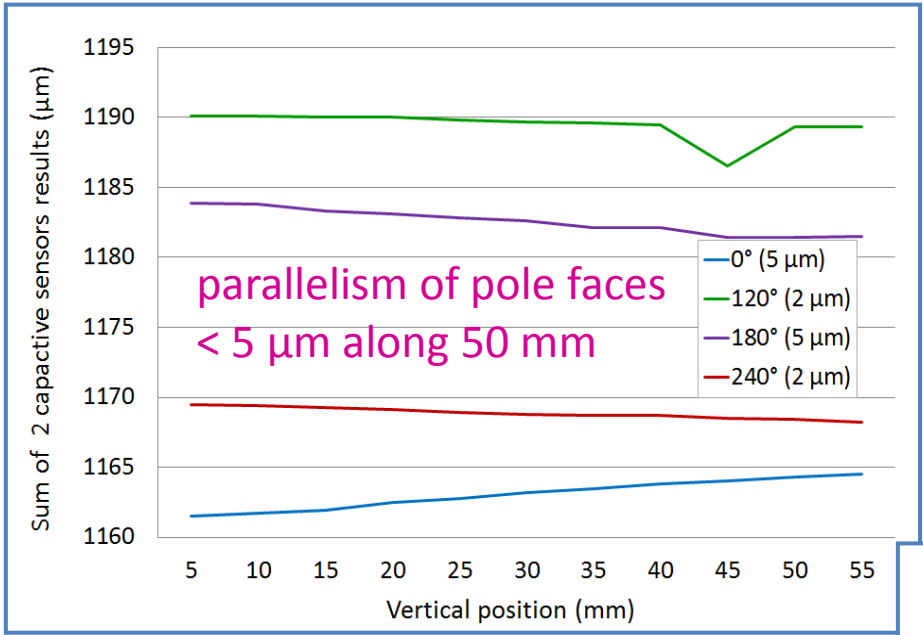


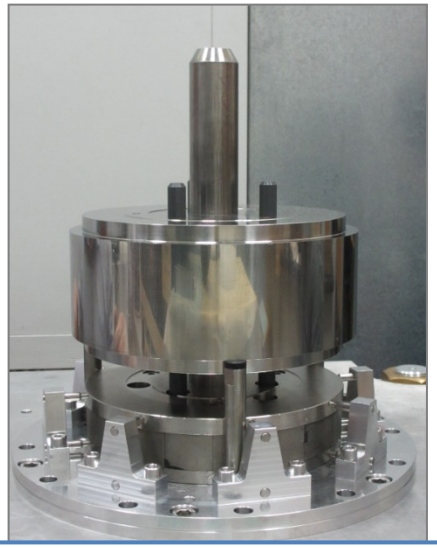
New support structure & new mass loading device

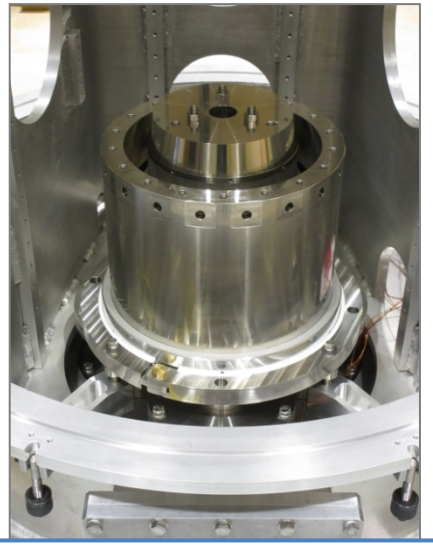


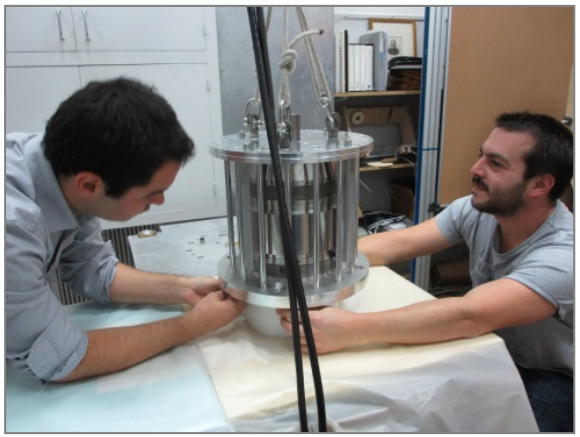
- Pentapod structure
  - ✓ open access
  - ✓ rigid & stable
- Finite elements analysis → no resonance frequencies in vertical direction below 200 Hz

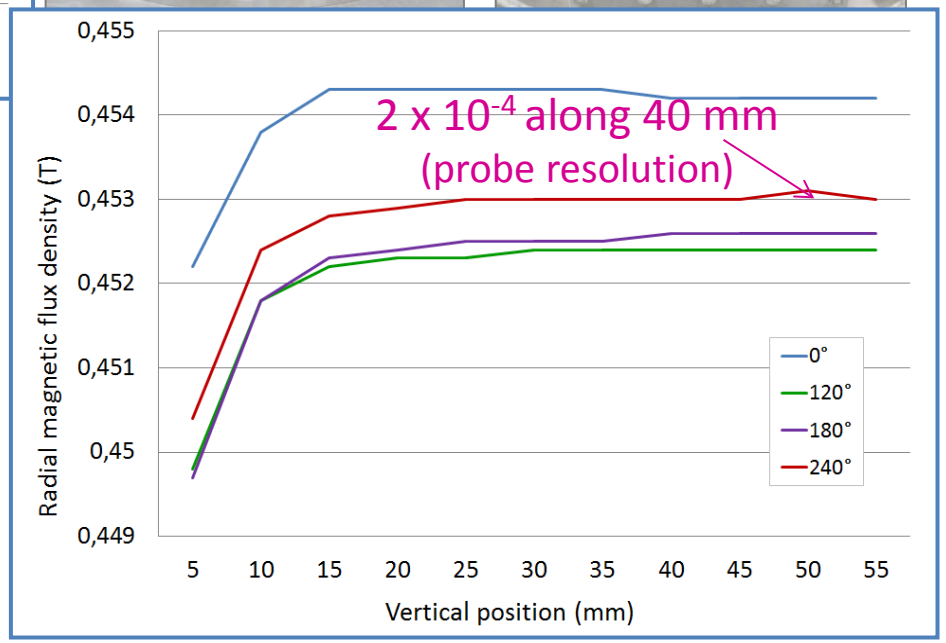
New magnet


Sum of 2 capactive sensors results (µm)
1195
1190
1185
1180
1175
1170
1165
1160
5
10
15
20
25
30
35
40
45
50
55
Vertical position (mm)
0° (5 µm)
120° (2 µm)
180° (5 µm)
240° (2 µm)
parallelism of pole faces
< 5 µm along 50 mm

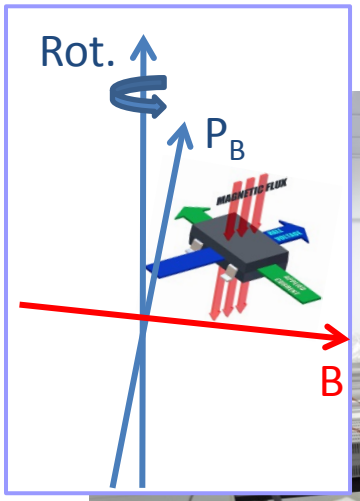




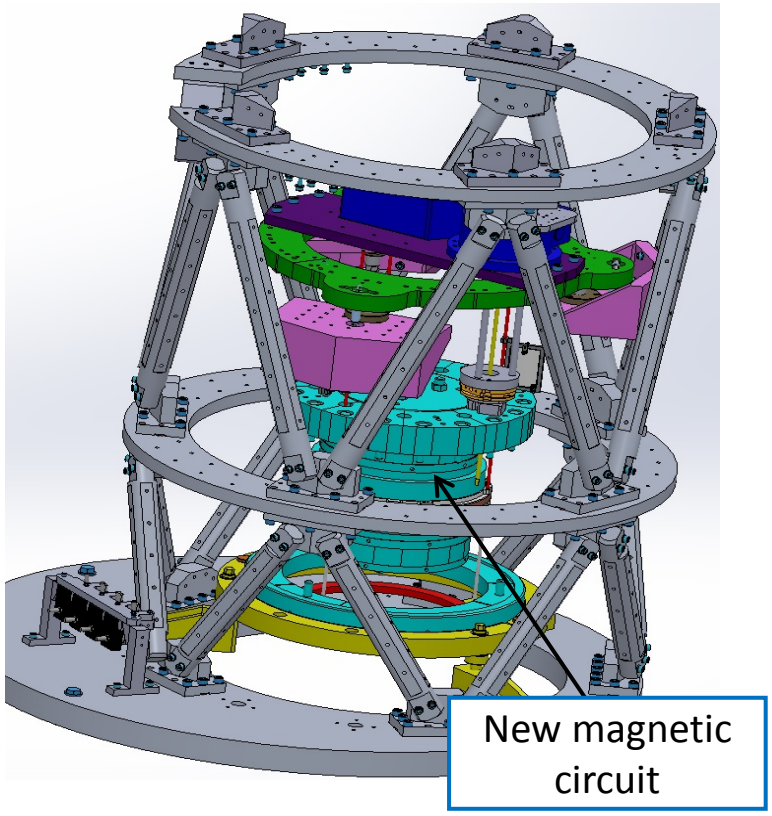



Radial magnetic flux density (T)
0,455
0,454
0,453
0,452
0,451
0,45
0,449
5
10
15
20
25
30
35
40
45
50
55
Vertical position (mm)
0°
120°
180°
240°
2 x 10-4 along 40 mm
(probe resolution)

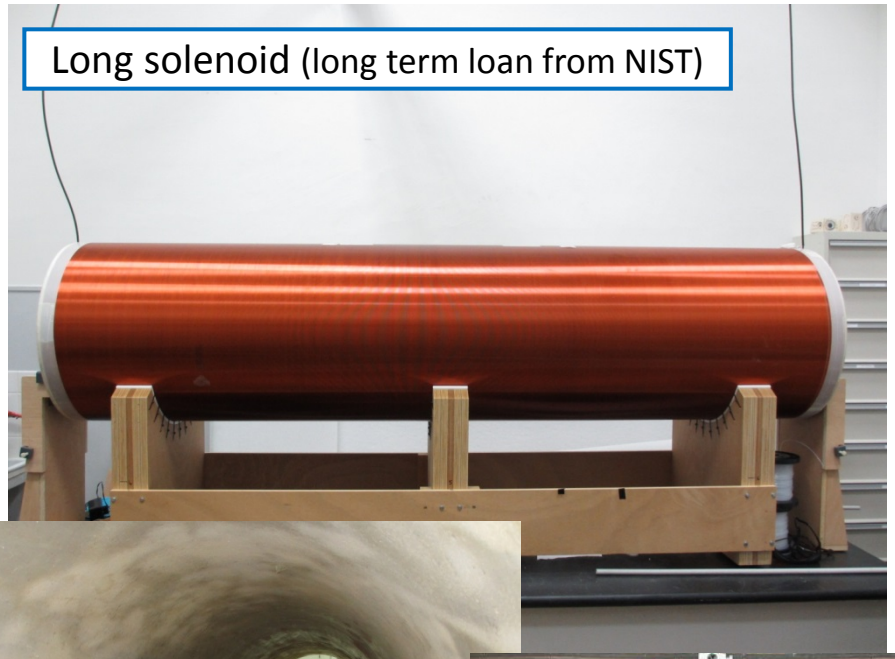
New method for magnet alignment



- Horizontal alignment of the magnetic field of the simple circuit with an uncertainty of 50 µrad
- Alignment of the new magnet next month



Coil alignment

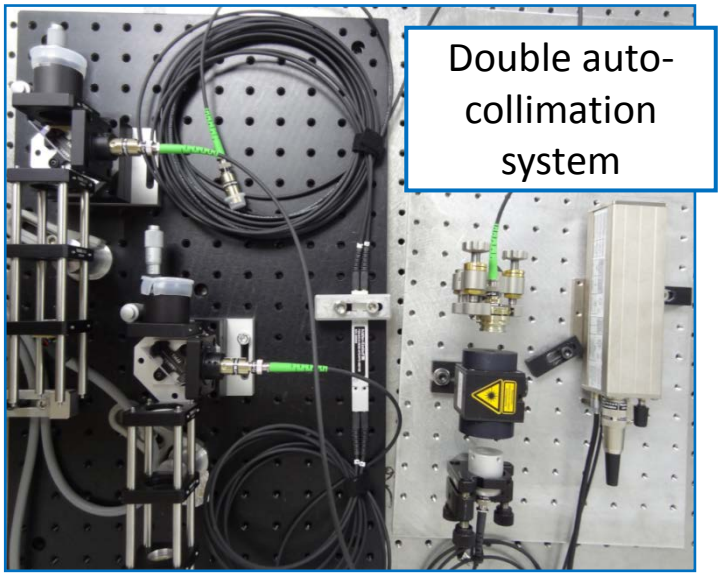


Long solenoid (long term loan from NIST)

Watt balance coil inside the solenoid

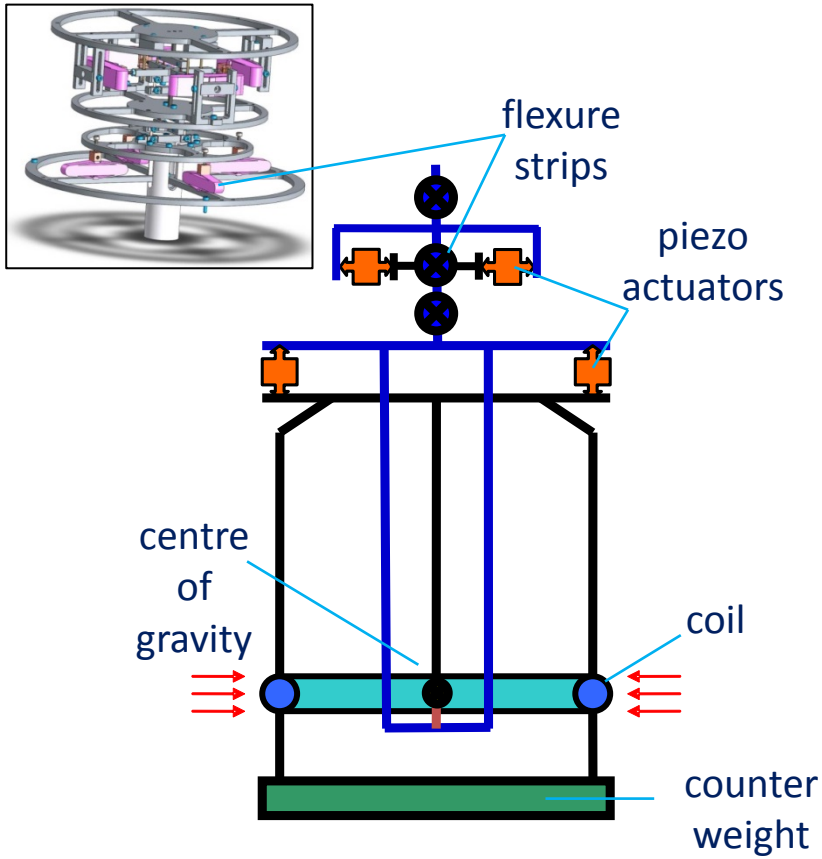
Old watt balance coil (PVC former)

- Alignment of the electric plane of a watt balance coil with an uncertainty of 150 µrad
- Alignment to be repeated on the new coil based on Macor former
- Alignment to be transferred using several small mirrors fixed onto the coil



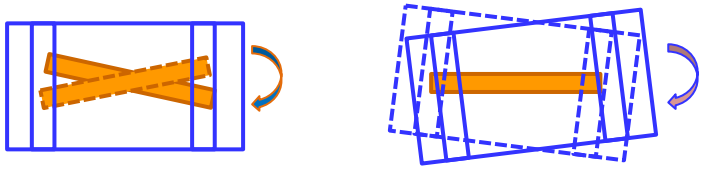
Double auto-collimation system

Dynamic coil alignment mechanism

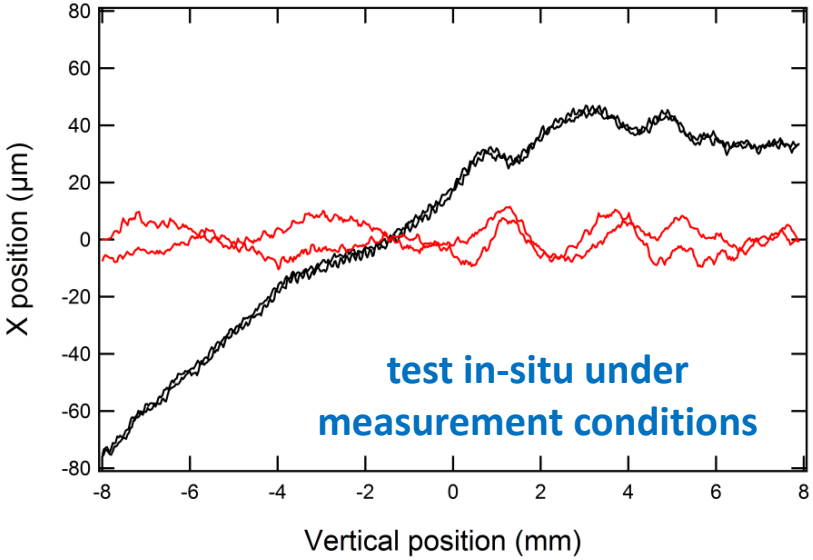


- Initial alignment of the apparatus

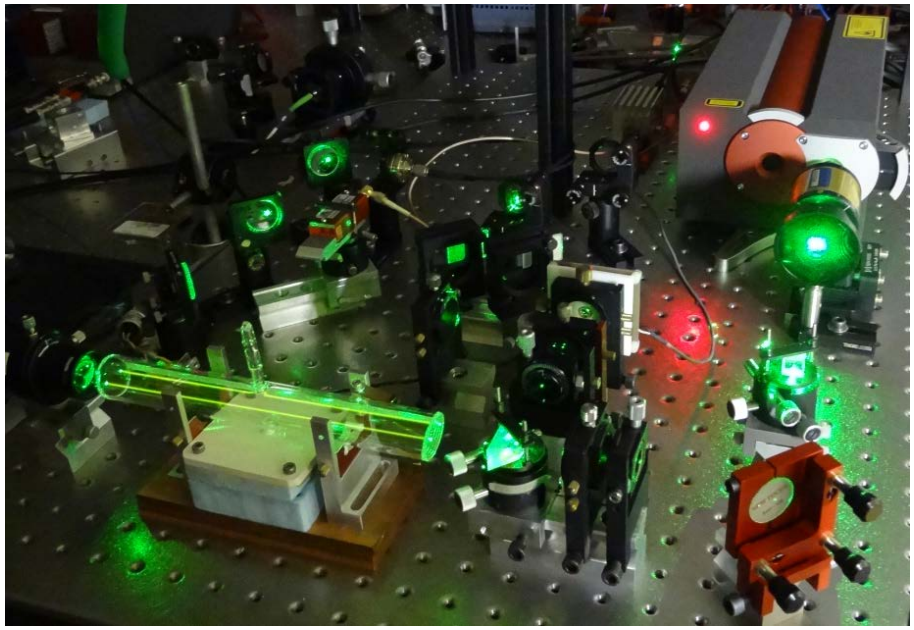
  magnet alignment ↔ coil alignment



- Dynamic correction of the coil trajectory in working mode

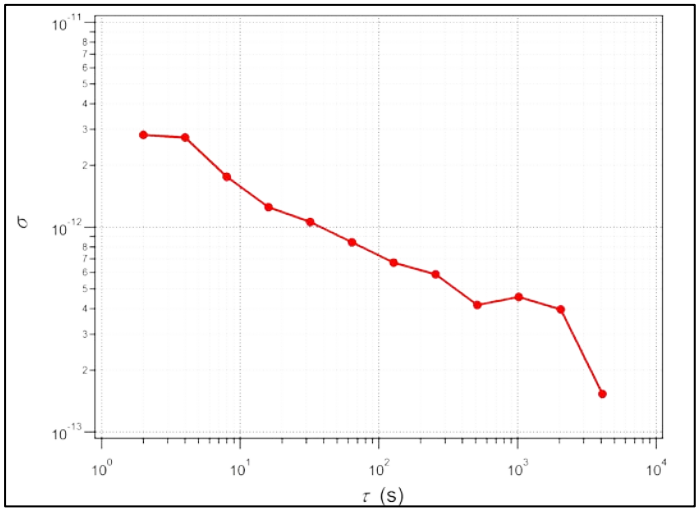


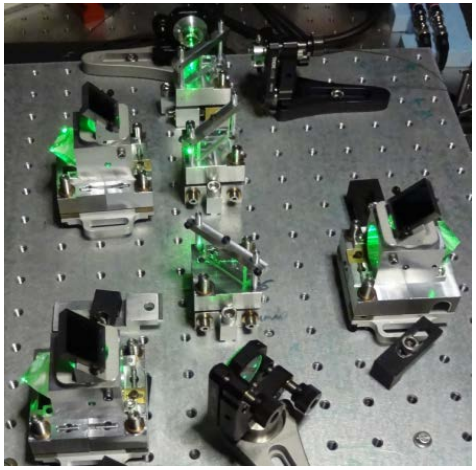
New interferometer



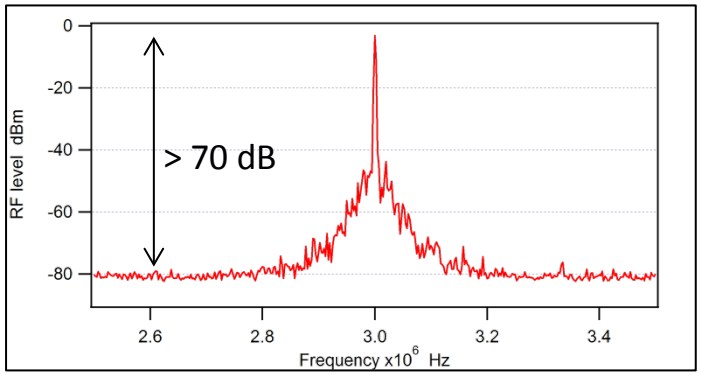
Frequency stabilized laser source

Beat between two frequency stabilized lasers





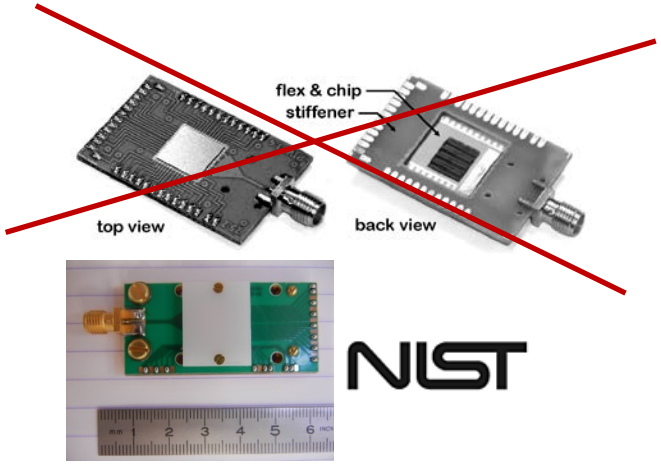
3-heterodyne interferometers



Interferometric signal

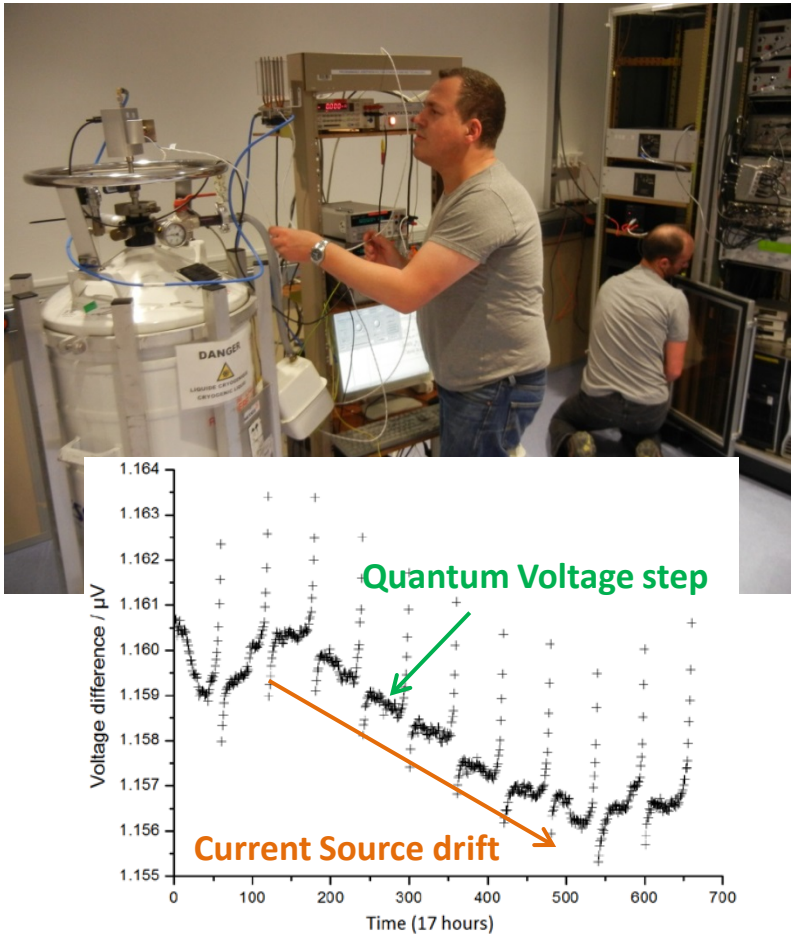
Josephson voltage standards (2 independent systems)

Induced voltage



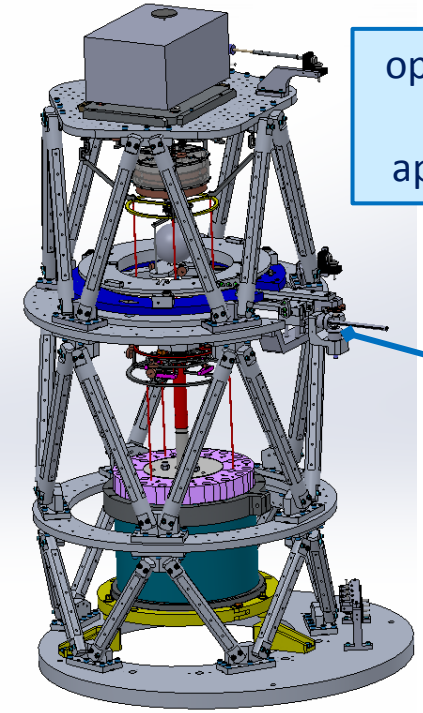
- Design of a new chip carrier at NIST in replacement of the traditional “flexboard”
- Delivery of a new 1 V SNS programmable array in June 2014
- Tests of the new array are underway

Current



Installed on the experiment in Sept. 2014 and successfully tested

Expected progress



operation of the improved apparatus in air

Deadline CODATA
1 July 2017

vacuum operation JVSs

continuous improvement mass from 100 g to 1 kg

early 2016
$u_{rA}(h) = 1 \times 10^{-7}$
$u_{rB}(h) = 5 \times 10^{-7}$

early 2017
$u_{rA}(h) = 5 \times 10^{-8}$
$u_{rB}(h) = 1 \times 10^{-7}$

end 2018
$u_{rA}(h) = 1 \times 10^{-8}$
$u_{rB}(h) < 5 \times 10^{-8}$

Target
$u_r(h) = 2 \times 10^{-8}$