BIPM Kibble balance progress

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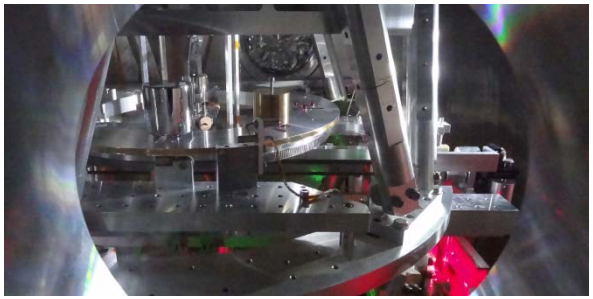
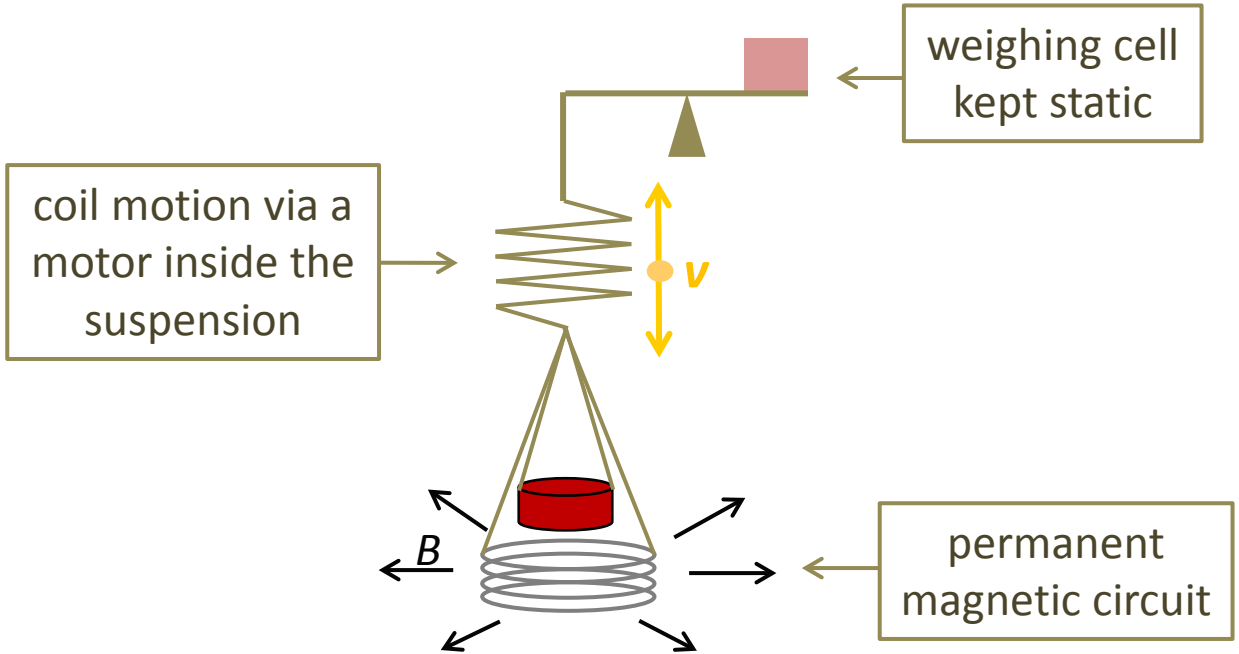
16 May 2019

17th CCM meeting



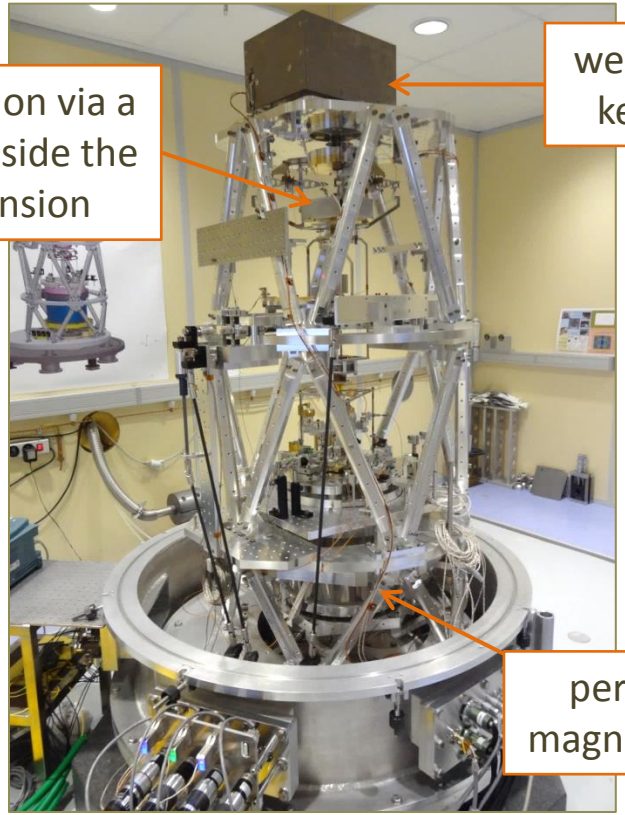
BIPM Kibble balance



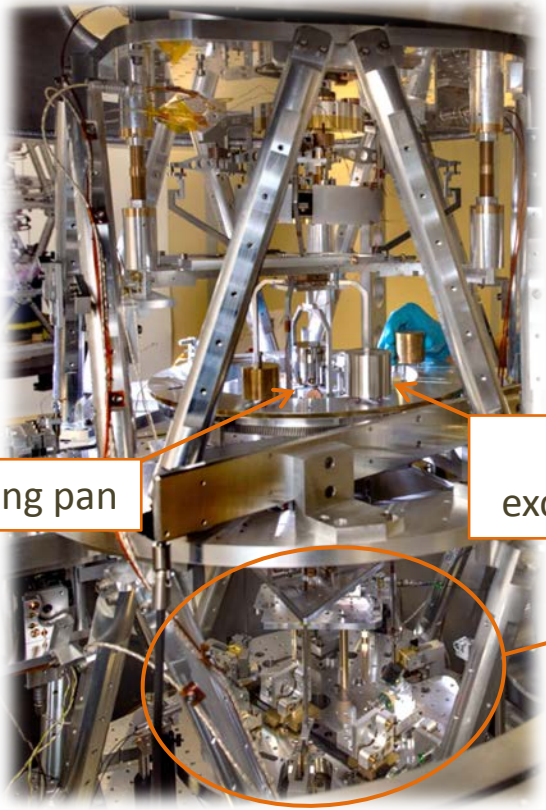
$$\frac{m}{h} = \frac{n_1 n_2}{4r} \frac{f_1 f_2}{gv}$$

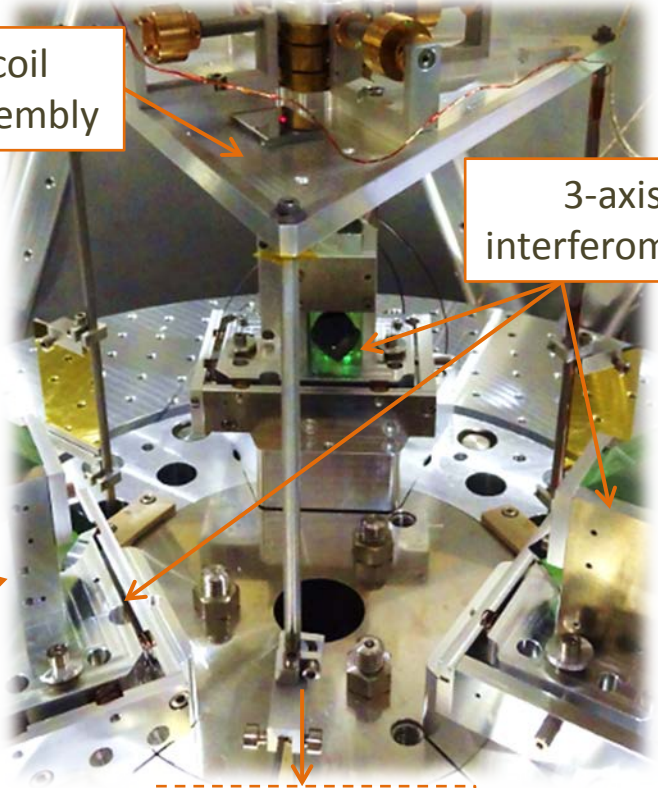
n: integer number
f: frequency
r: calibration factor

Experimental set-up (I)

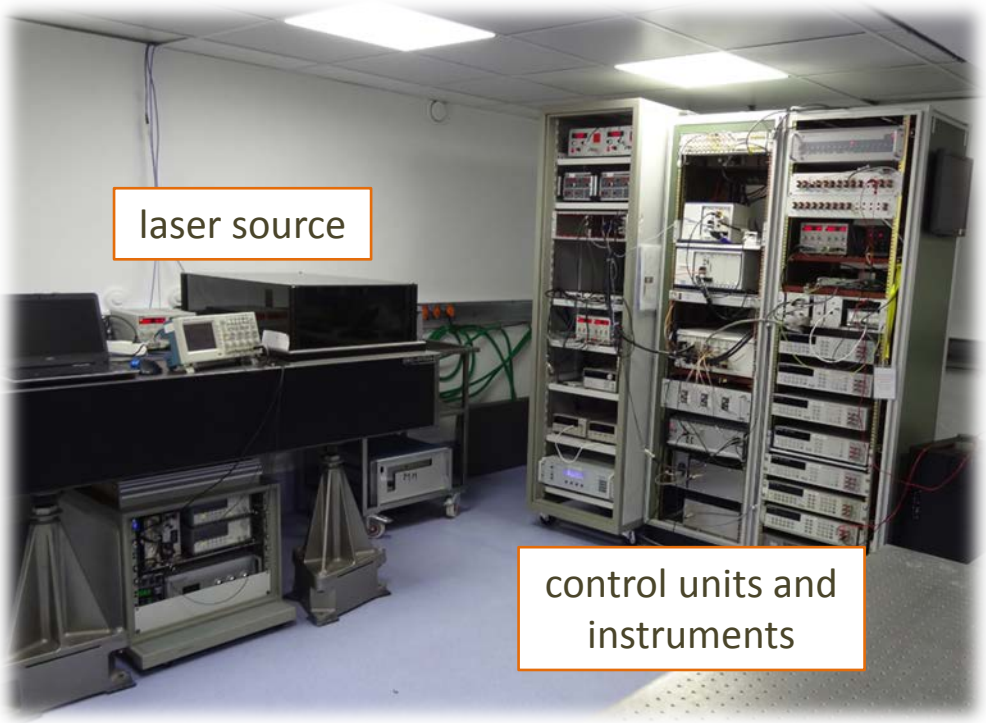


Experimental set-up (II)



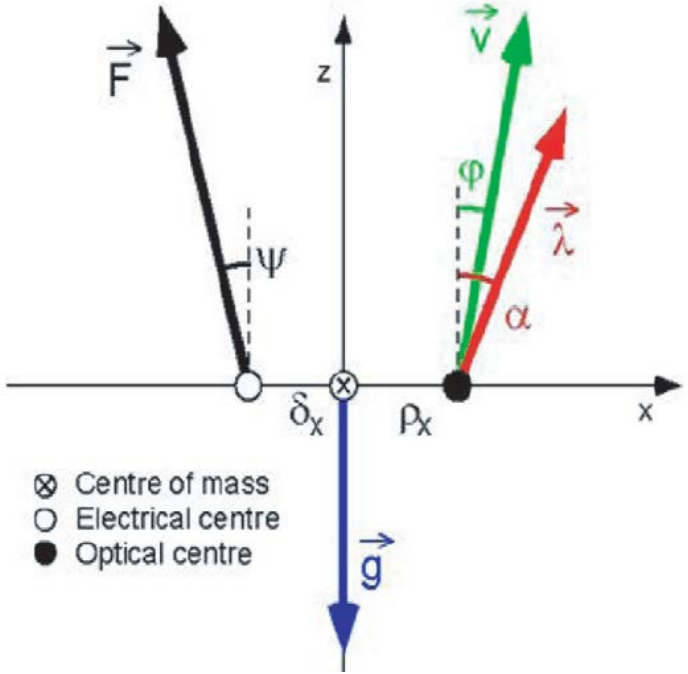


Experimental set-up (III)



programmable Josephson voltage standard (PJVS)

Alignment



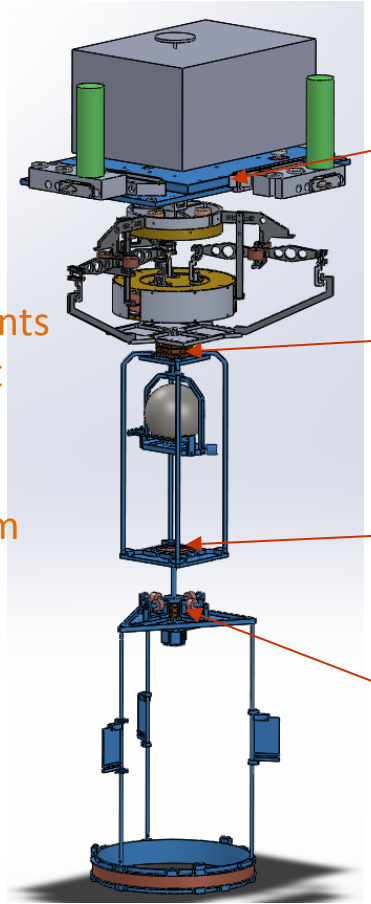
METAS paper, *Metrologia* **40** (2003) 356–365

- ✓ electro-magnetic force exerted on the coil
- ✓ laser beam of the interferometer
- ✗ velocity of the coil

Refined suspension

Main objectives:
- independent alignment of all elements
- more accurate and easier alignment

→ typically achieved alignment:
tilt < 10 µrad and decentering < 5 µm



mounted on a motorized large translation stage → coil position adjustment wrt magnet in vacuum

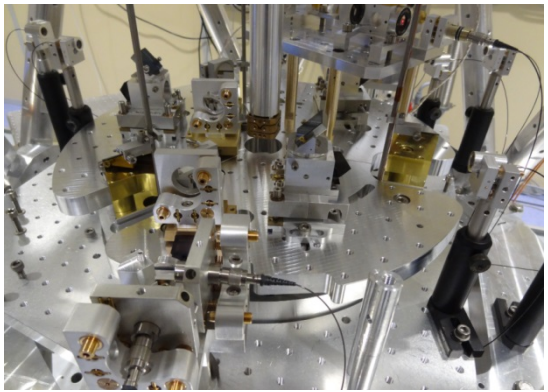
double gimbal
→ common point of application of weight & electro-magnetic force

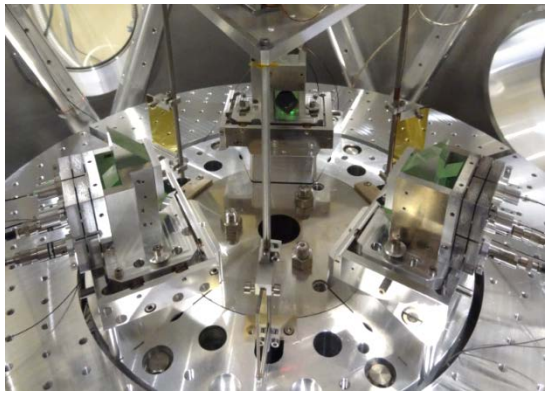
mass mounted on a translation stage
→ mass centre adjustment of the middle support

four masses on the coil assembly → coil inclination adjustment wrt magnet

New three-axis interferometer

- reduction of the misalignment of the interferometer laser beams thanks to the use of much stiffer supporting mounts and an electronic telescope
  100-200 µrad → about 20 µrad
- each axis independently illuminated by two incident laser beams through optical fibres





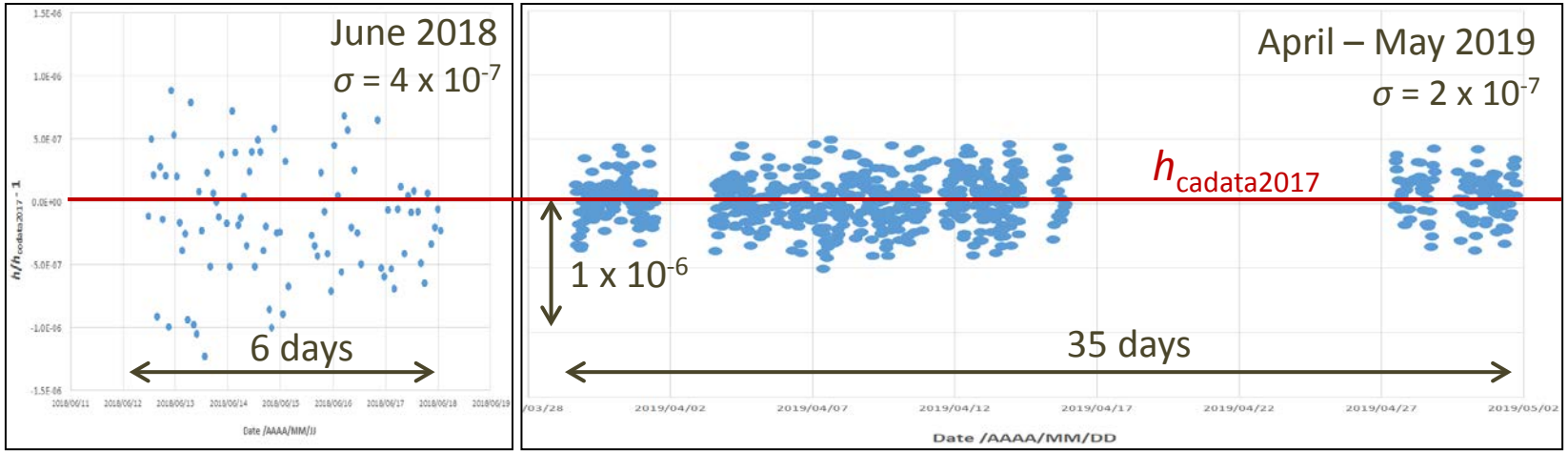
- doubling of the number of optical passes
- S/N ratio improvement on voltage/velocity ratio by a factor of 2-3

Additional improvements

- Use of a PJVS in direct opposition for voltage measurement
- Current source
  - → battery damaged in summer 2018
  - → containing two sets of batteries which allow continuous measurement
- Integration of an additional interferometer
  - → improving the coil vertical displacement servo-control
  - → including an position sensor based on a large corner cube which avoids the need of frequent realignment
- Integration of additional optical sensors for better monitoring of 6 degrees of freedom of the coil assembly
- Complete revision of the control and data acquisition programs
  - → using FPGA and organized in a well-structured and flexible scheme
  - → successfully tested in working condition; use of new programs since early 2019

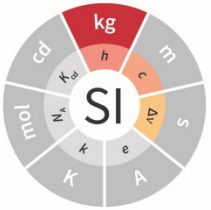
Planck constant measurements 2018-2019

BL = 370 T m; m = 1 kg; I = 13.3 mA; v = 1 mm s^{-1}; U = 0.37 V



- Reduction of the type A uncertainty on h measurement by a factor of 2
- Measurement uncertainty of about 8 x 10^{-8}, **BUT** still needs to be confirmed

Outlook



- Publication of a result with a relative uncertainty of about 8 x 10^{-8}
- Participation in the first CCM comparison of kilogram realizations

- Develop a new motor & guiding mechanism
- Achieve a target uncertainty of 2 x 10^{-8} by further improvements
- Participation in subsequent CCM KCs

Thank you for your attention !