

Operating an industry-grade quantum differential gravimeter

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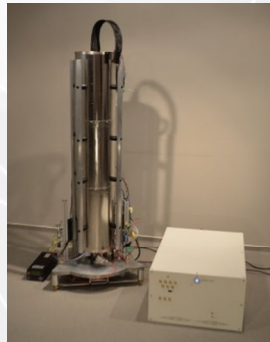
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MUQUANS: QUANTUM SENSORS & LASER SYSTEMS FOR SENSING AND METROLOGY

- ✓ Company created in 2011
- ✓ 30 employees
- ✓ Technology transfer from **LNE-SYRTE** and **LP2N laboratories**



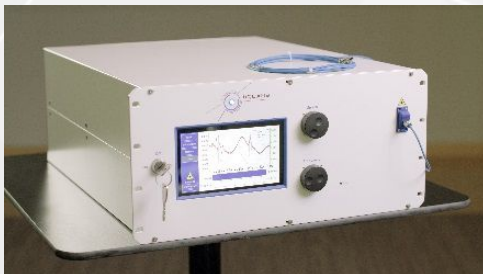
Cold atom gravity meters ($\Delta g/g \approx 10^{-9}$)



Cold atom atomic clock for VLBI ($\Delta f/f \approx 10^{-15}$)



Laser solutions for optical and fiber sensing ($\Delta \lambda/\lambda \approx 10^{-10}$)

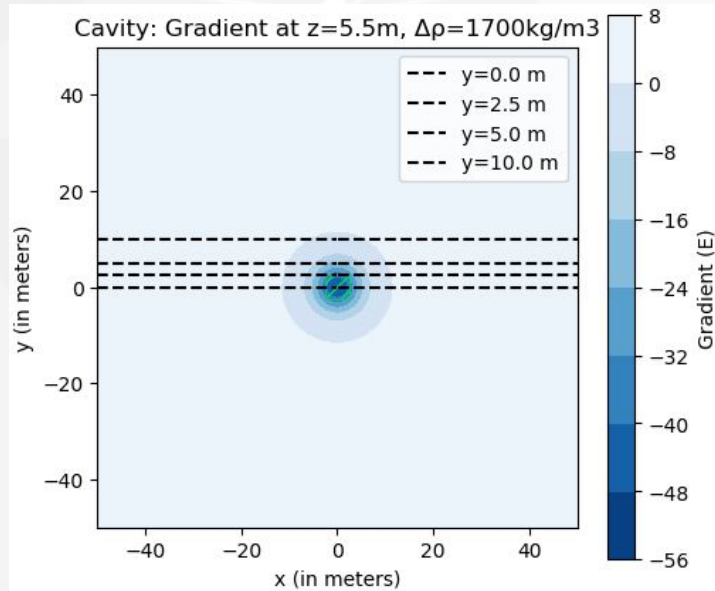


Optical frequency transfer for chronometric geodesy ($\Delta f/f \approx 10^{-20}$)

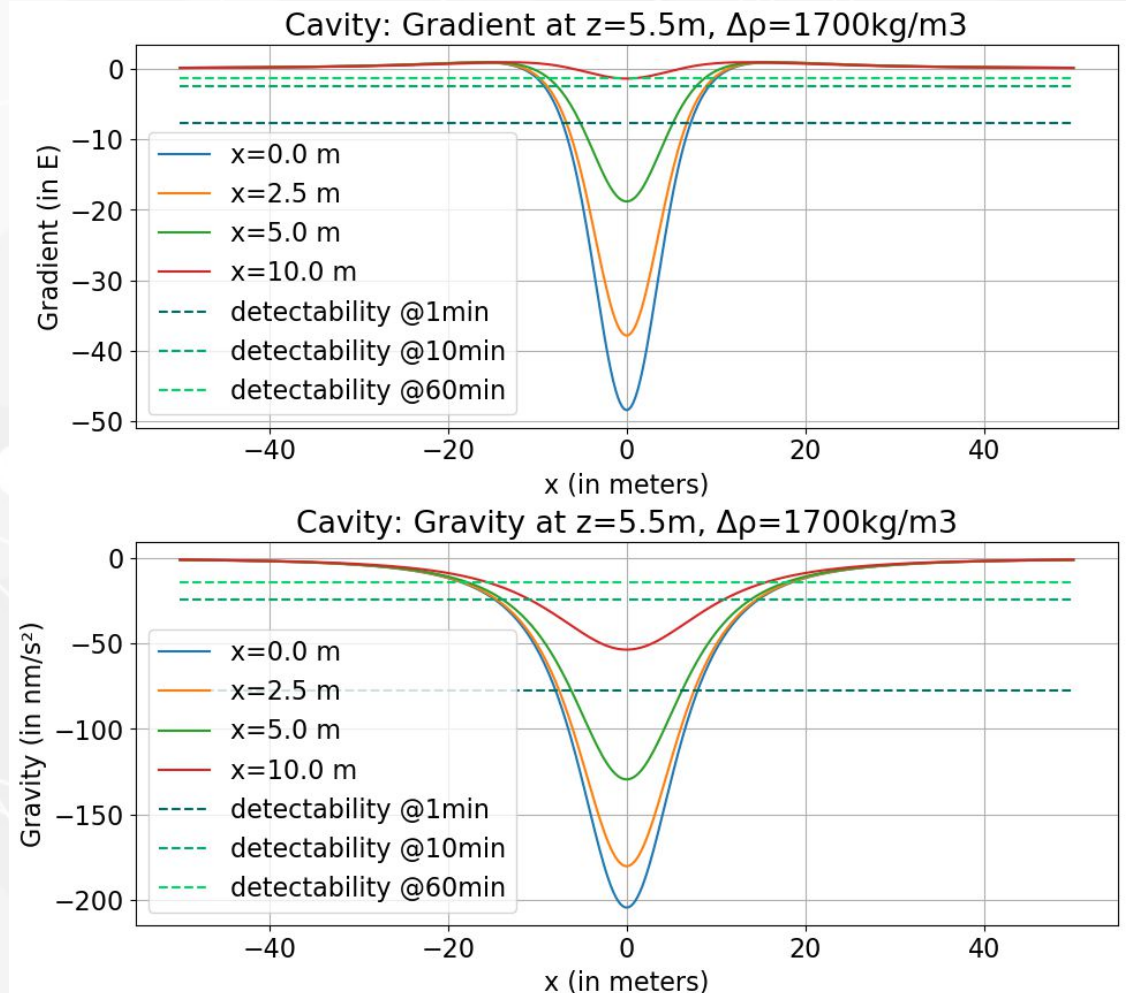


WHY THE A-DIG: EXAMPLE OF SUB-SURFACE STRUCTURE DETECTION

Simulated signals for a cavity of 5 x 5 x 5 m

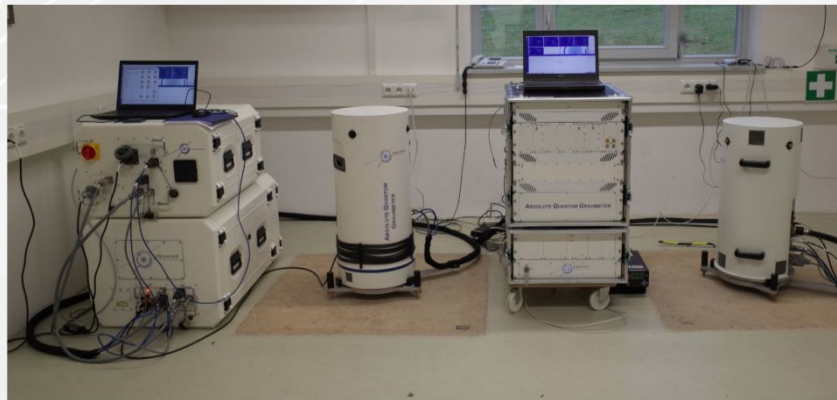


$$1\text{E} = 0.1\mu\text{Gal/m}$$



MUQUANS QUANTUM GRAVITY METERS: BACKGROUND

- Same technology as the Absolute Quantum Gravimeter



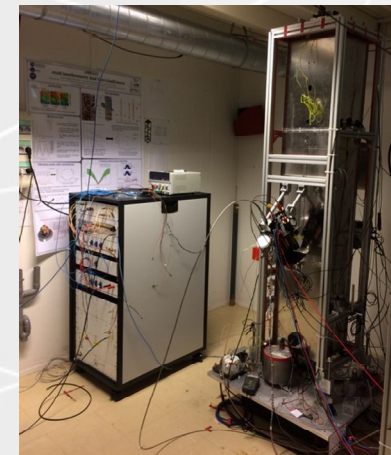
See also:

EGU2020-8969 | Displays | [G4.4](#)
[Operating the Absolute Quantum Gravimeter outside of the laboratory](#)



Federal Agency for
Cartography and Geodesy

- Tight scientific collaboration with



A-DIG: MUQUANS QUANTUM DIFFERENTIAL GRAVIMETER

- An instrument that measures **simultaneously** the absolute gravity acceleration and its gradient.
- Measures the vertical variation of the gravity (Γ_{zz}) from the differential measurement of two atom interferometers using laser-cooled atoms¹.

¹M.Langlois et. al. Phys.Rev.A **96**, 053624 (2017)

- Demonstrated performance:

Gravity measurements :

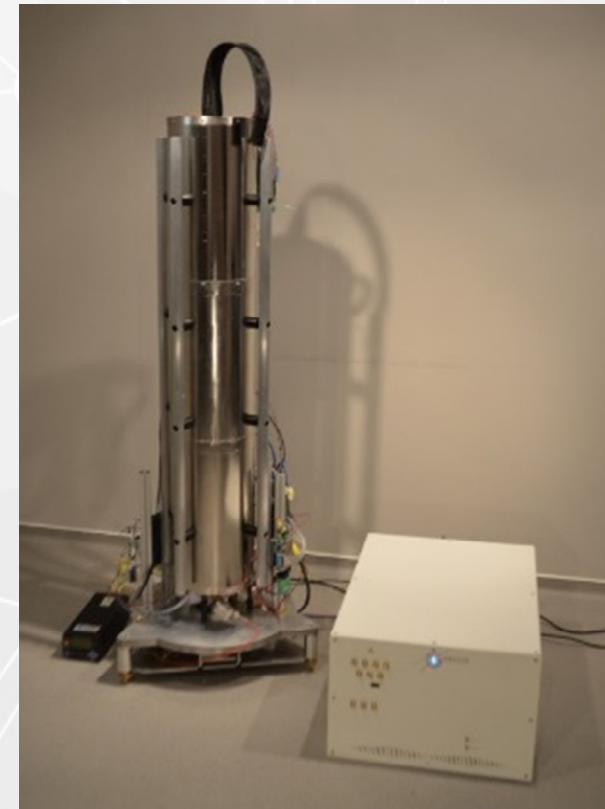
Sensitivity = 30 $\mu\text{Gal}/\sqrt{t}$

Resolution of 1 μGal

Gravity gradient measurements :

Sensitivity = 70 E/ \sqrt{t}

Resolution of few E

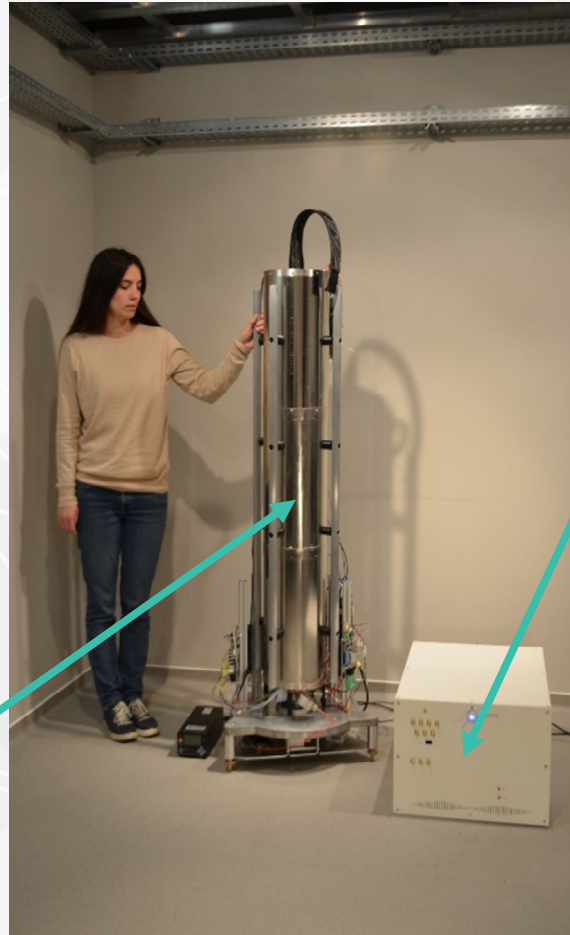


$1\text{E} = 0.1\mu\text{Gal}/\text{m}$

A-DIG: MUQUANS QUANTUM DIFFERENTIAL GRAVIMETER

The sensor head

- . Vacuum system
- . Electronics
- . Magnetic shield

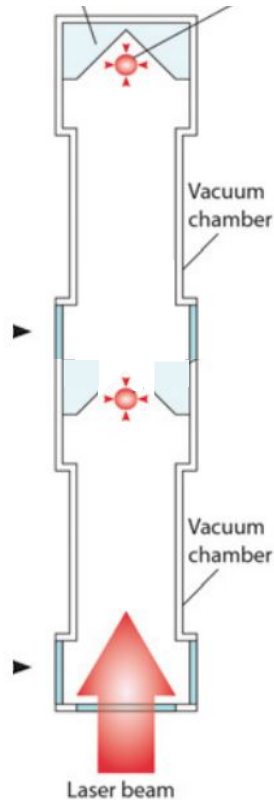


The control unit

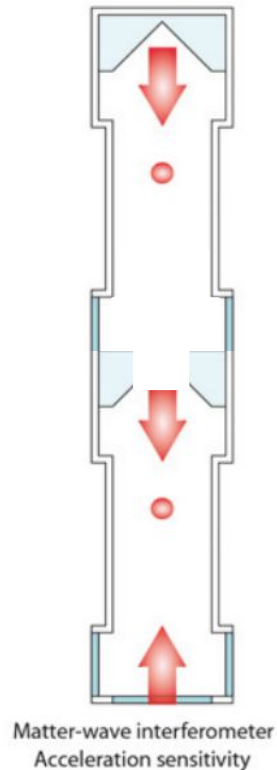
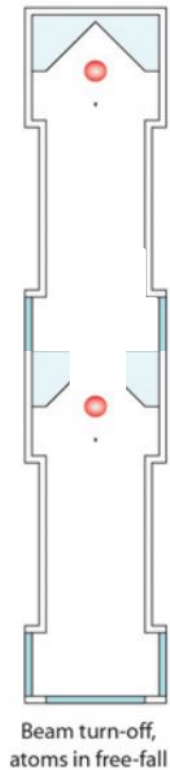
- . Lasers and amplifiers
- . Ultra-low noise electronics
- . Frequency synthesizer
- . On-board computer & controller
- . Power supplies

A-DIG: PRINCIPLE OF OPERATION

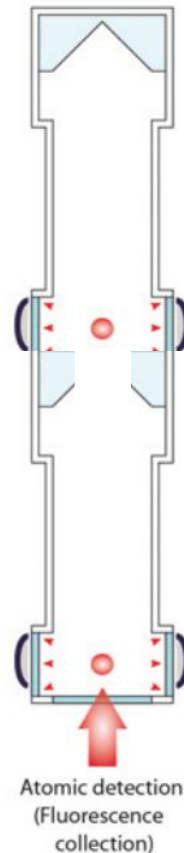
Atom trapping
And laser cooling



Free-fall
(atom interferometry)



Read-out of the measurement

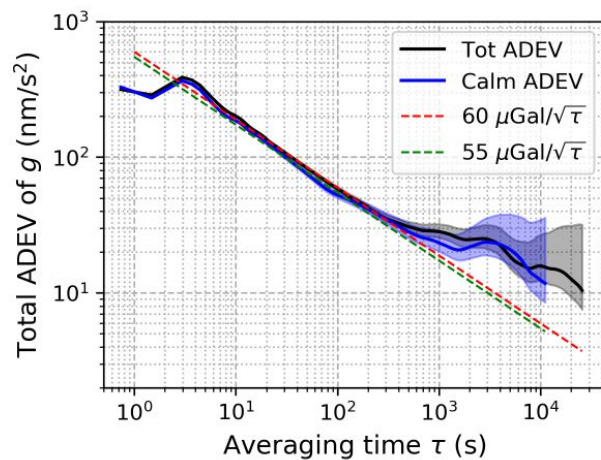
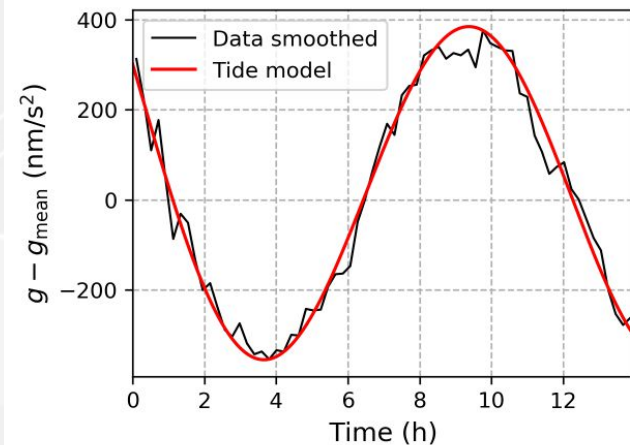


*patent WO2014106811A3
'cold atom
Gravity gradiometer'*

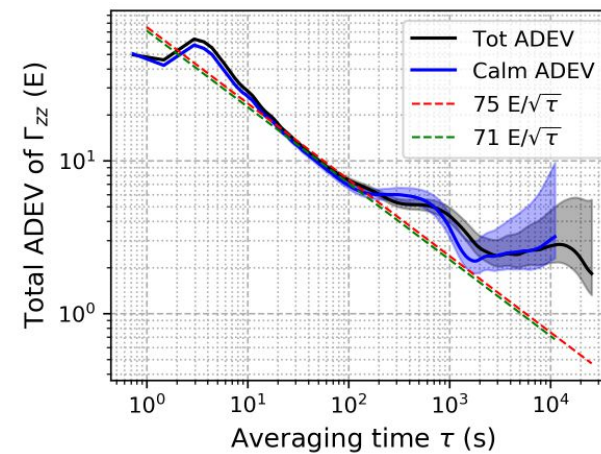
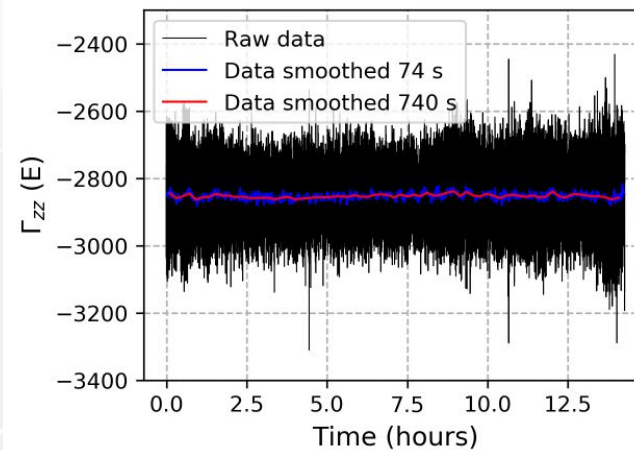
A-DIG measures the vertical gravity gradient using the differential measurement of two quantum gravimeters.

More details: *M.Langlois et. al. Phys.Rev.A 96, 053624 (2017)*

A-DIG: PRELIMINARY EVALUATION OF PERFORMANCE (dec. 2019)



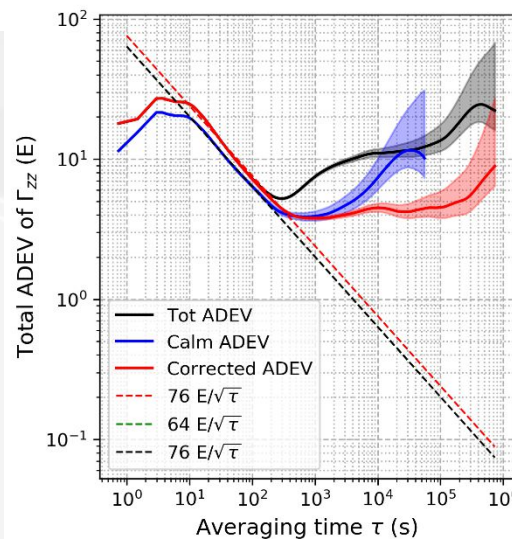
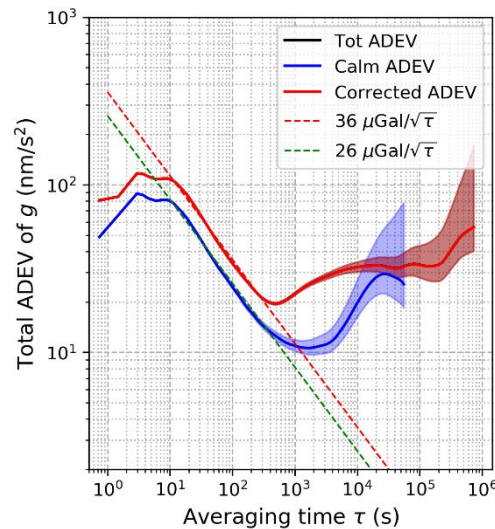
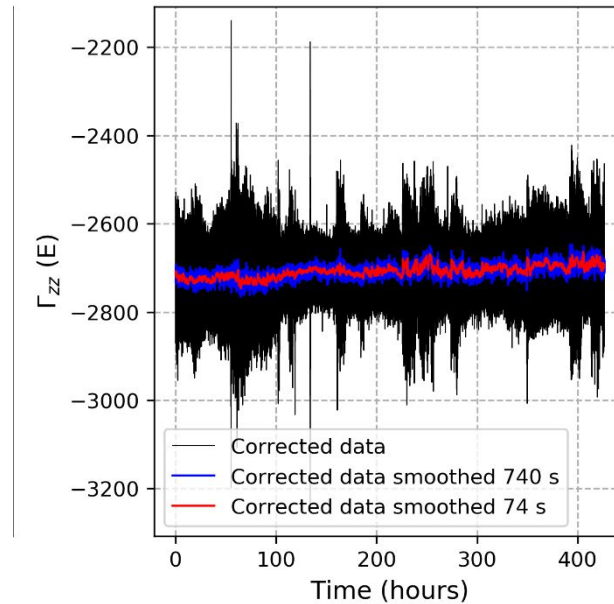
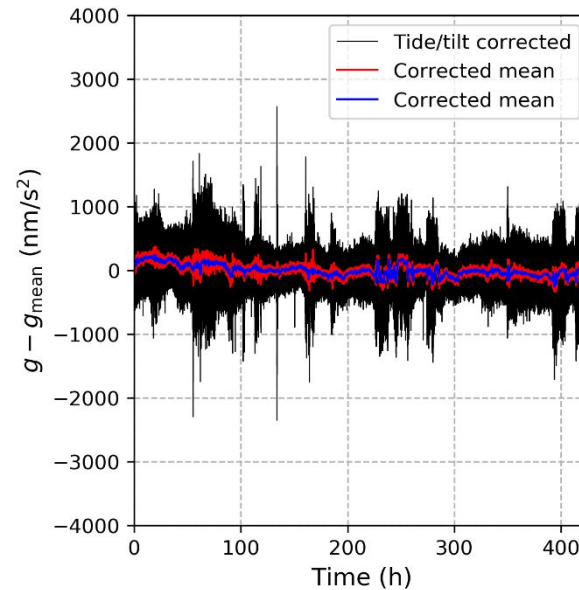
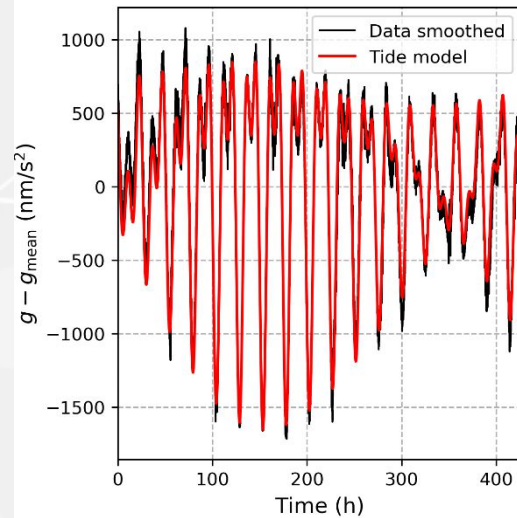
Gravity measurements :
Sensitivity = $60 \mu\text{Gal}/\sqrt{t}$



Gravity gradient measurements :
Sensitivity = $70 \text{ E}/\sqrt{t}$

$$1\text{E} = 0.1\mu\text{Gal}/\text{m}$$

A-DIG: LONGER MEASUREMENTS (jan. 2020)



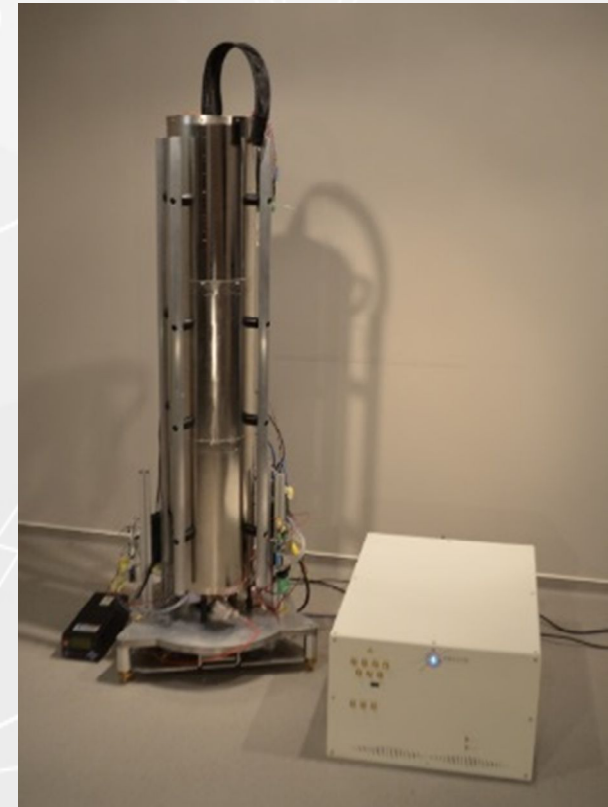
Gravity measurements :
Sensitivity = $30 \mu\text{Gal}/\sqrt{t}$
Resolution of $1 \mu\text{Gal}$

Gravity gradient measurements :
Sensitivity = $70 \text{ E}/\sqrt{t}$
Resolution of few E

$$1\text{E} = 0.1\mu\text{Gal}/\text{m}$$

A-DIG: CONCLUSIONS AND PERSPECTIVES

- A differential gravimeter has been developed and demonstrated
- Simultaneous measurements of both g and dg/dz
- Preliminary characterizations at nominal performances
- 18 day continuous operation validated
- Next steps: improvement of performances and utilization for geosciences (observatory measurement)



See also:

EGU2020-8969 | Displays | [G4.4](#)

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