GRAVI an experiment to test NEWTON in the laboratory at very small acceleration

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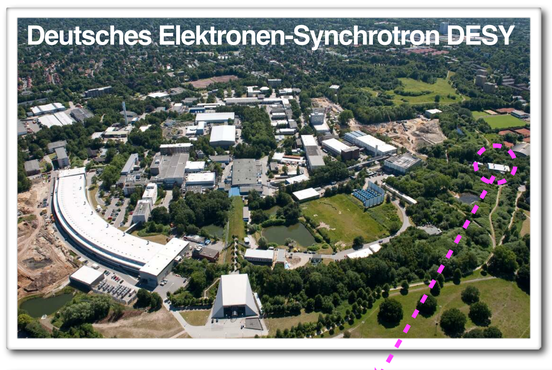
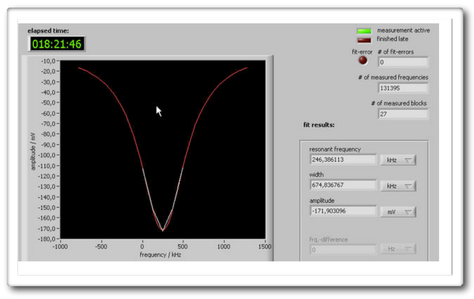
Goals of GRAVI at DESY

- **Measurements in the MOND region at very small values of acceleration:** m ≈ 1-10 kg
- **Accurate determination of G:** m ≈ 500 kg

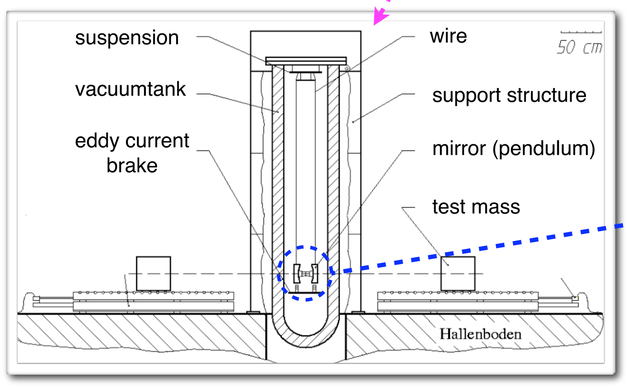
MOND MOdified Newtonian Dynamics

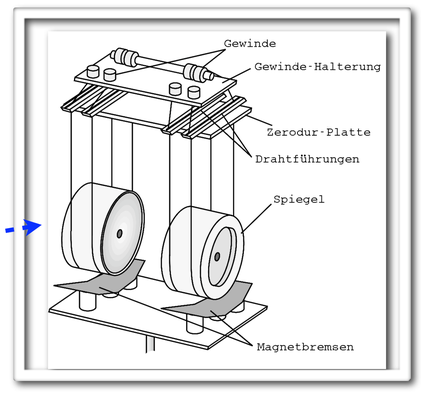
- 1983 proposed by Mordehai Milgrom
- Change Newtons law at accelerations $a < 10^{-10}$ m sec^{-2}
- Provides an excellent description of the non-Newtonian behaviour with just one additional universal parameter a_0





5 point scan around 21GHz @ 1Hz

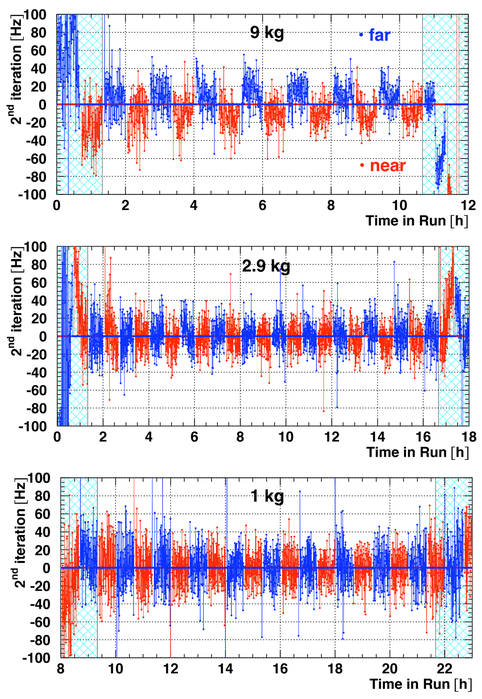


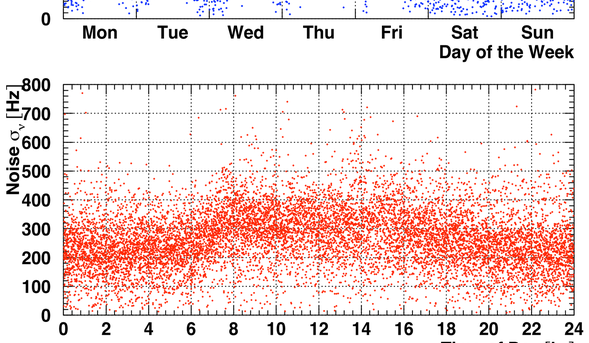


Principle of Experiment

- Detect gravitational effect of test masses on mirrors of RF cavity
- High sensitivity by measuring change of resonance frequency of cavity with $F_{res} \approx 21$ GHz
- Periodically alternate between „near“ (0.77 m) and „far“ (2.2 m) position of test masses (T = 40 min)
- Use 3 different test masses with m = 9kg, 2.9kg and 1kg

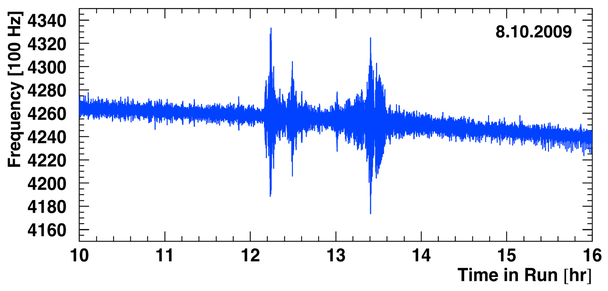
Observed frequency shift for the three different test masses

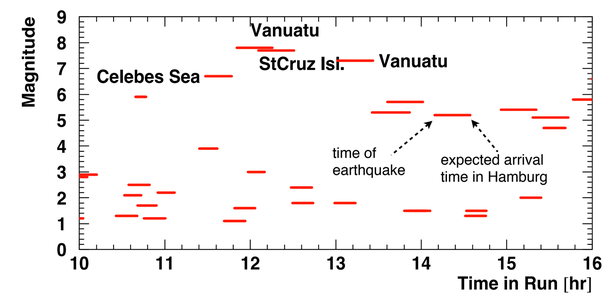




High sensitivity of experiment to external effects like:

- Cultural noise
- Wave height in Elbe estuary
- Earth quakes

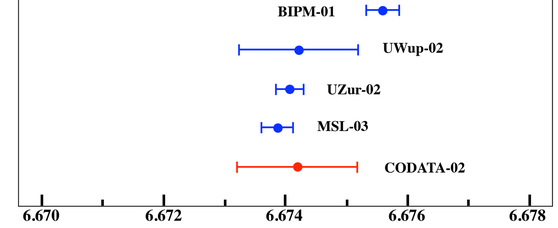




$$G = \Delta\nu \cdot \frac{b\,\omega_0^2}{F_{res}} \cdot \frac{1-\Delta_{modes}}{f(d_{n,i};d_{f,i};b)} \cdot \frac{1}{M\cdot(1-r_{point})}$$

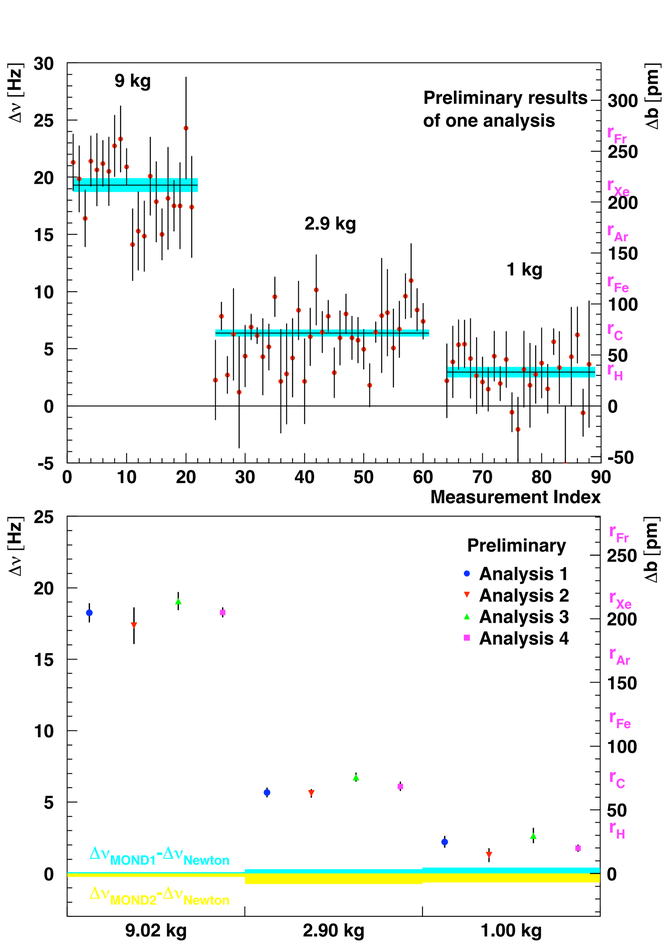
source	value	absolute error	contrib. to ΔG/G
Δν [Hz]	19,12	0,54	2,82%
b [m]	0,238	0,001	0,42%
$f_{pend} = \omega_0/2\pi$ [Hz]	0,305	0,001	1,31%
F_{res} [GHz]	21,3905	0,0001	0,00%
$1-\Delta_{modes}$	1,000	0,005	0,50%
f [m^{-2}]	1,32	0,02	1,52%
M [kg]	9,02	0,01	0,11%
$1-r_{point}$	0,976	0,002	0,20%
quadratic sum			3,53%
model			*< 1,00%*
$G \pm \Delta G$ [10^{-11}m^3 kg s^{-2}]	**6,72**	**0,24**	
$(G - G_{PDG})/\Delta G$ [σ_{exp}]	**0,20**		

PDG: $G = (6{,}67428 \pm 0{,}00067)\cdot 10^{-11}\ \frac{m^3}{kg\cdot s^2}$



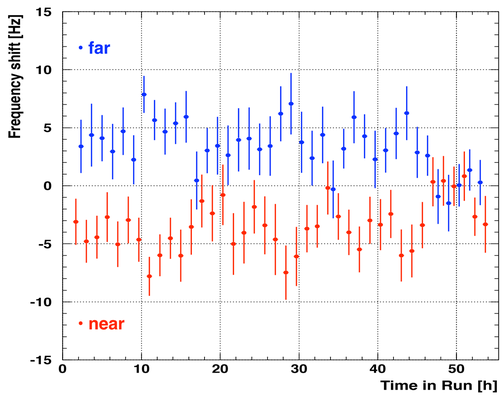
Consistency check:

- Calculate G from 9 kg data
- Result agrees within errors with PDG value



In case of Newton expect strict proportionality between frequency shift and value of test mass.

Four independent lines of analysis in order to minimize potential bias from reconstruction methods.



In some periods observe an unexplained periodic variation of signal size. This effect is under study.

Summary

- Useful data available since September 2009
- Use 3 test masses (9, 2.9 and 1kg) at d = 77 cm
- Preliminary results are consistent with Newton
- Still see some unexplained systematic effects
- Have to do some further adjustments to the setup, but we are optimistic to come out soon with a word on Newton versus MOND