

60 years of Earth Tide observations in Strasbourg (1954-2014)

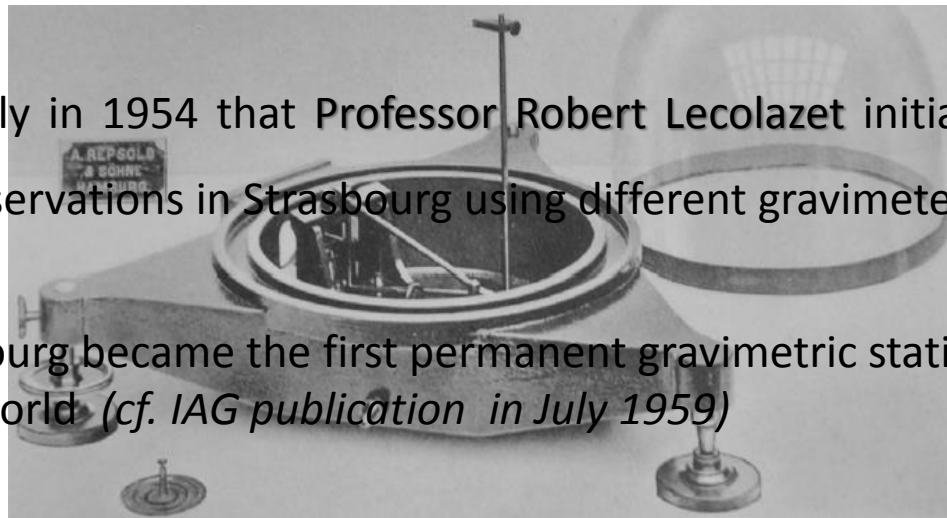
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J.-P. Boy⁽¹⁾ Y. Rogister⁽¹⁾ B. Luck⁽¹⁾ J.-D. Bernard⁽¹⁾ F. Littel⁽¹⁾

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In **1892** Ernest Von Rebeur-Paschwitz observed for the first time at Strasbourg the periodic oscillations of the vertical due to the Earth tides using a Repsold horizontal pendulum installed from April 1892 to September 1893

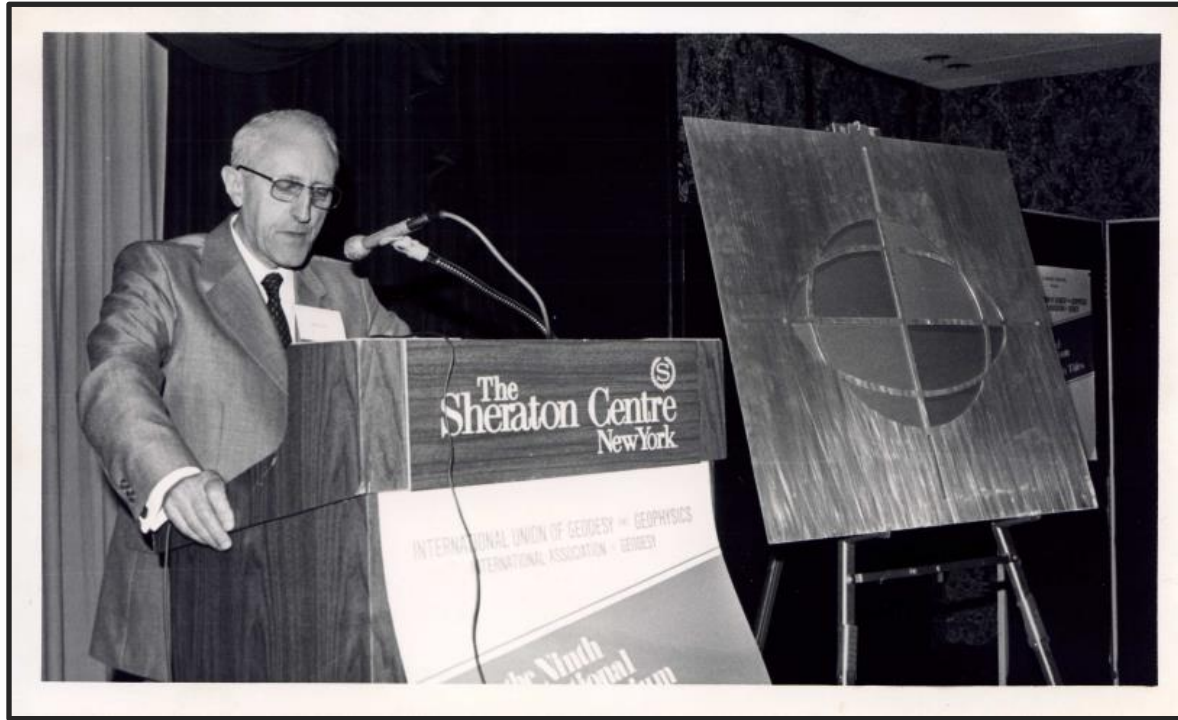
But it was only in 1954 that Professor Robert Lecolazet initiated continuous Earth Tide observations in Strasbourg using different gravimeters

Hence Strasbourg became the first permanent gravimetric station for Earth tides in the world (*cf. IAG publication in July 1959*)



We focus on the observational period with gravimeters

1954 - 2014

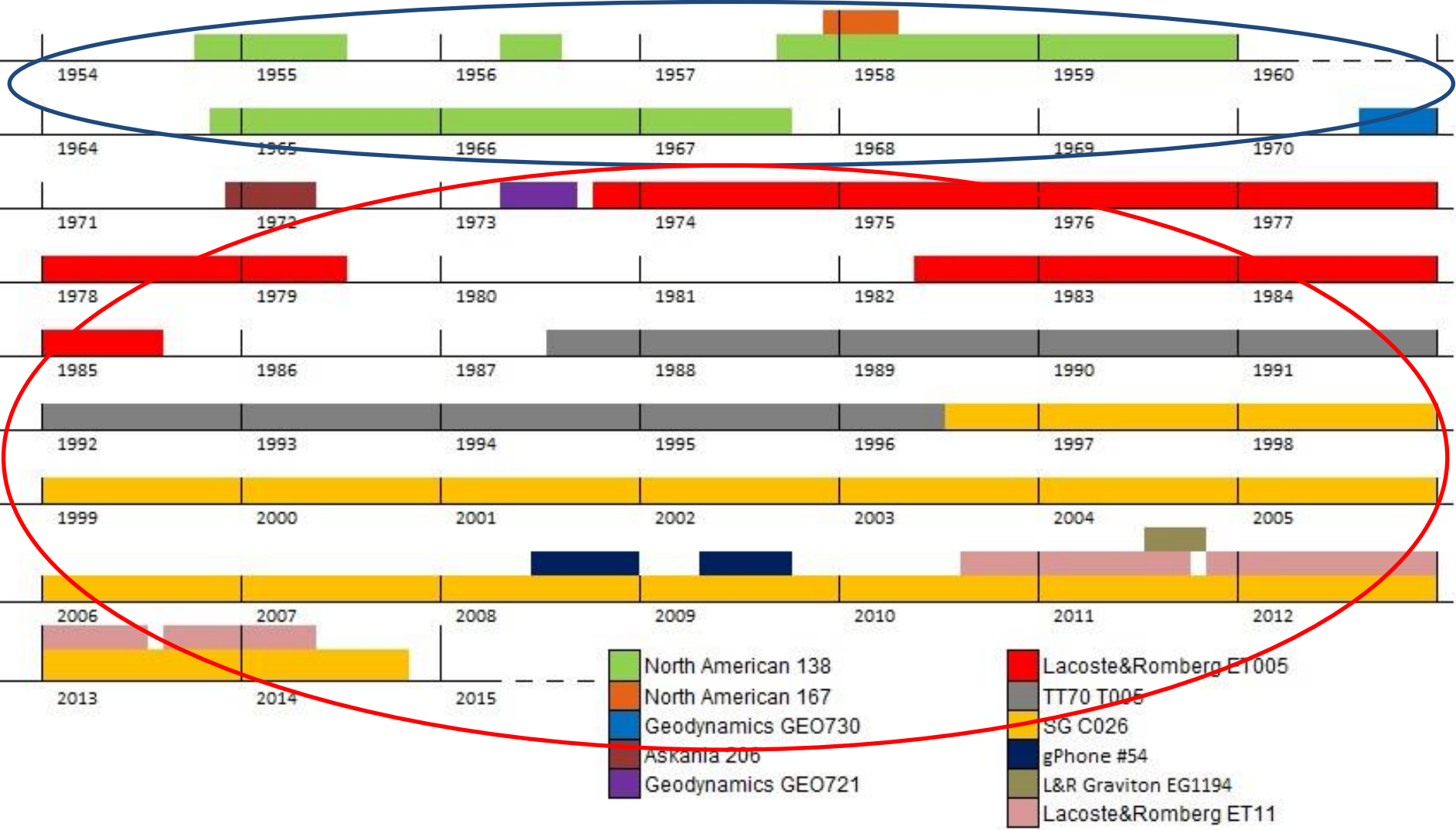


9th Earth Tide Symposium
New York, 1981

Prof. Robert Licolazet (1910-1990)

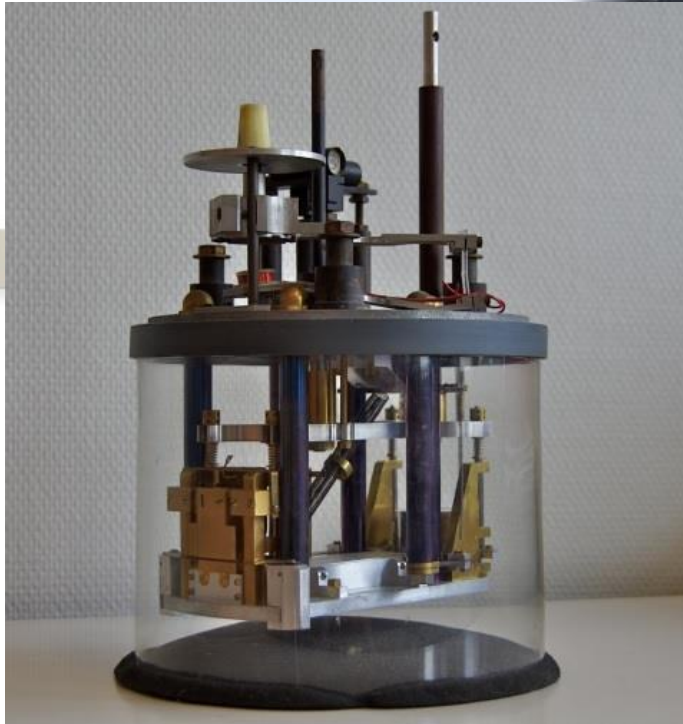
- ✓ Worked at 'Institut de Physique du Globe de Strasbourg (IPGS)' since 1937
- ✓ Focusing his work into the gravity field (especially devoted to the study of Earth Tides) from 1954
- ✓ 1962 -1979 President of 'Permanent Commission on Earth Tides'

Seismological Observatory of Strasbourg (1954-1971)



Gravimetric Observatory of Strasbourg: J9 (1971-today)

Seismological Observatory of Strasbourg



48.583 N
7.767 E
138 m

Seismological Observatory of Strasbourg

North American 138

North American 167

GEO 730

163 +860+1012+ days

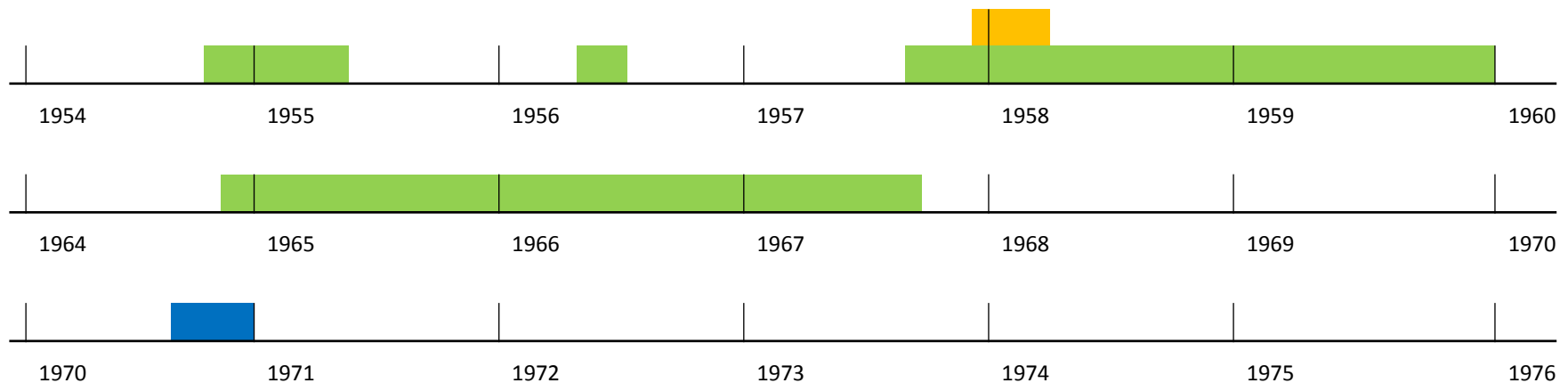
82 days

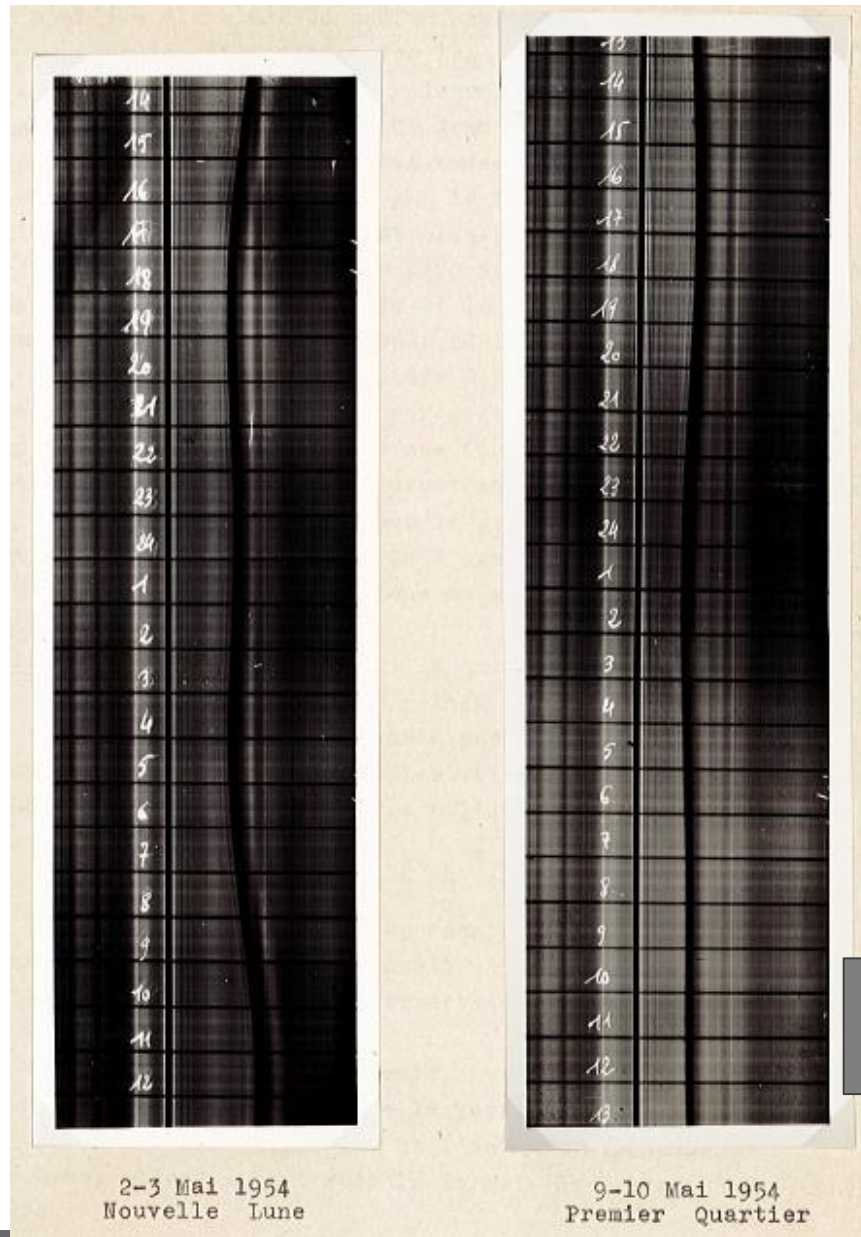
79 days

R.Lecolazet

R.Lecolazet

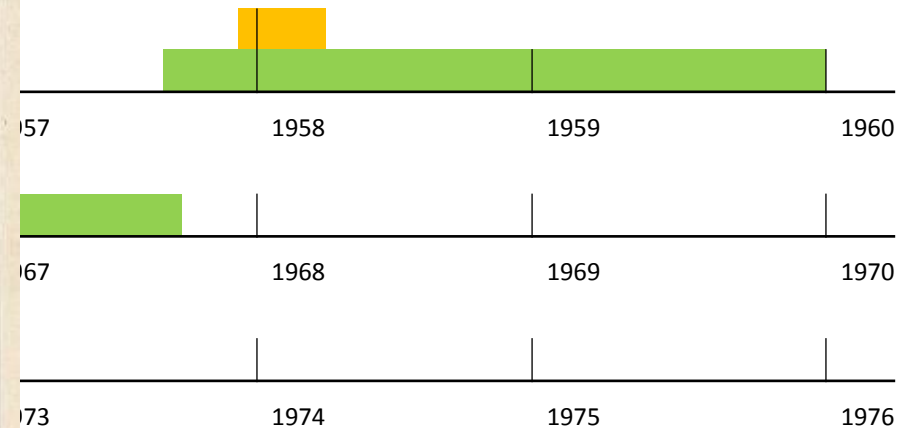
J.T. Kuo





1012+ days

R.Lecolazet
R.Lecolazet
J.T. Kuo



The NA 138 was equipped with a photographic recording device

les observations de la marée gravimétrique, de la méthode
Y. Labrouste, dite par combinaisons linéaires d'ordonnées
Lecolazet, 1956

Seismo

North A

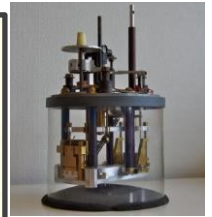
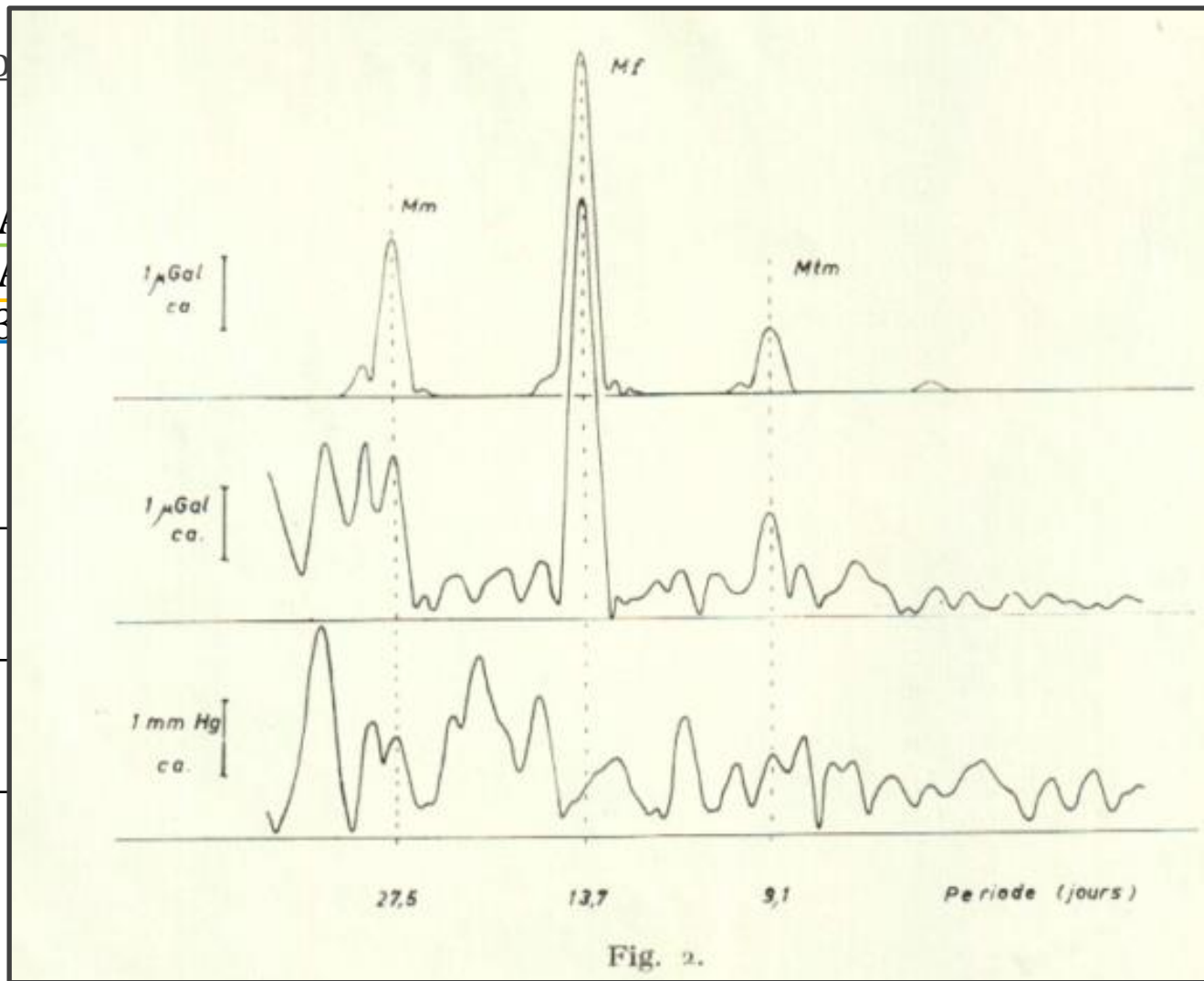
North A

GEO 73

1954

1964

1970



1960

1970

1976

*Premiers résultats expérimentaux concernant la variation semi-mensuelle
lunaire de la pesanteur à Strasbourg
Lecolazet, Steinemetz, 1966*

Seismological Observatory of Strasbourg

North American 138

North American 167

GEO 730

163 + 860 + **1012** + days

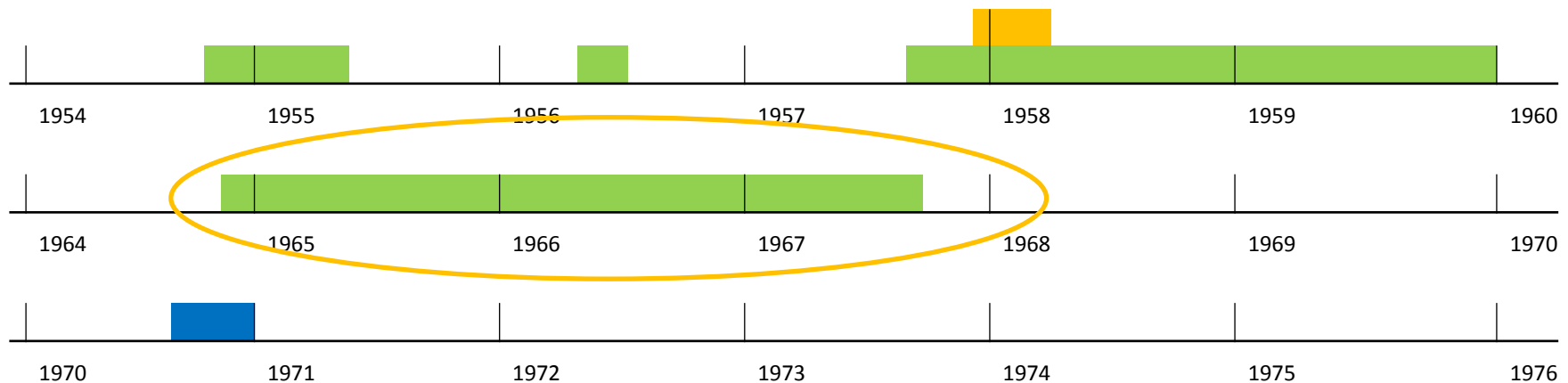
82 days

79 days

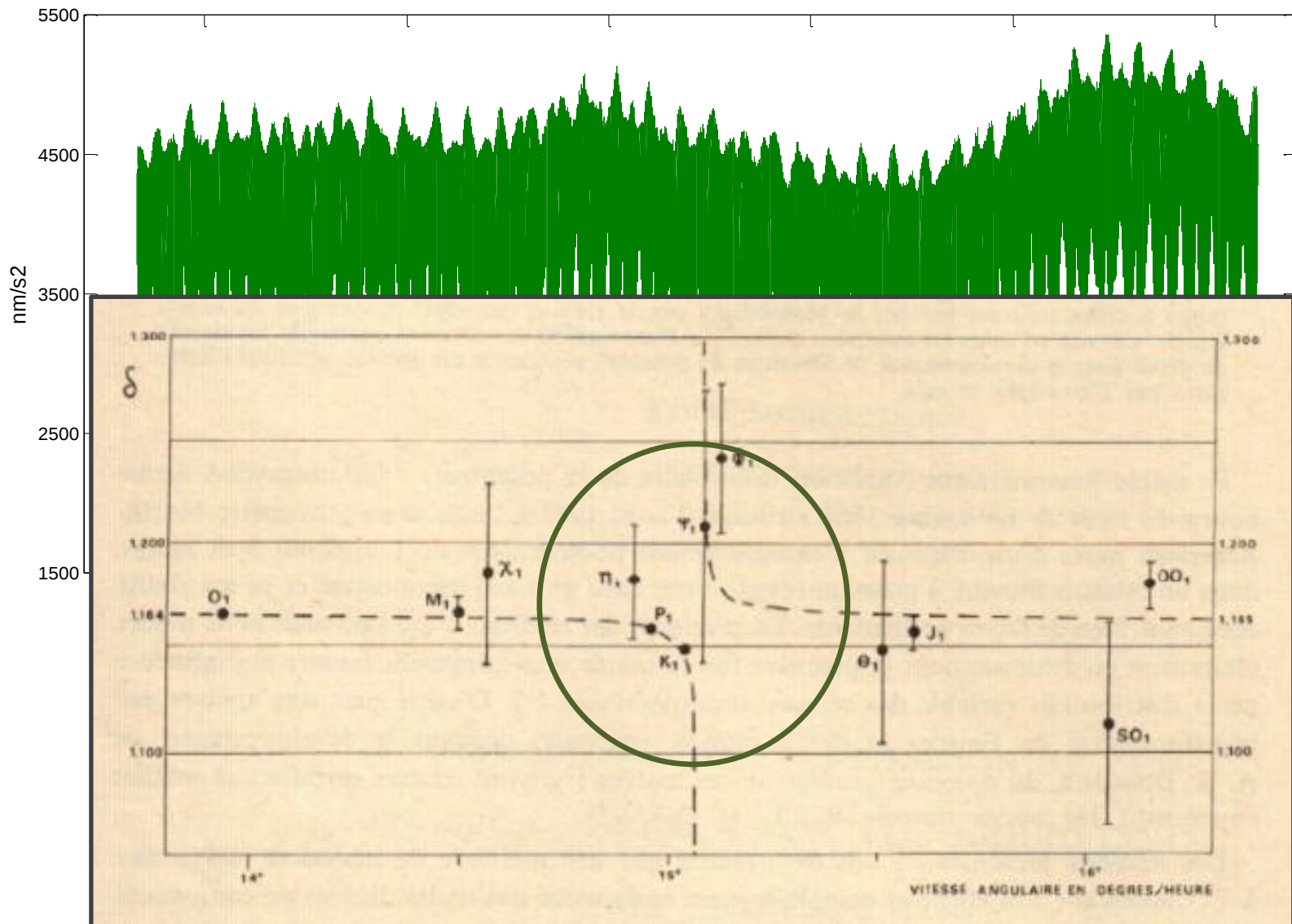
R.Lecolazet

R.Lecolazet

J.T. Kuo

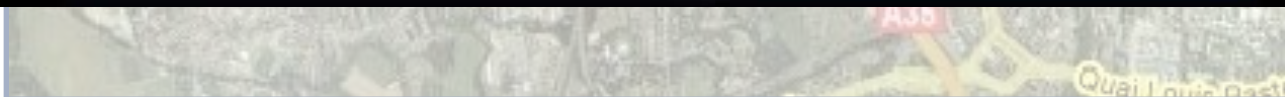
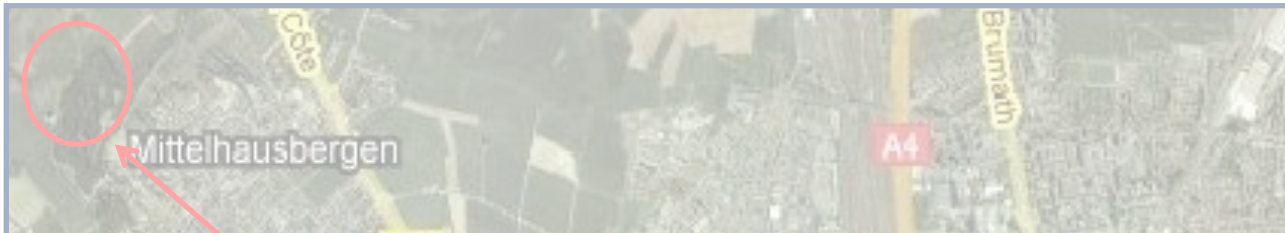


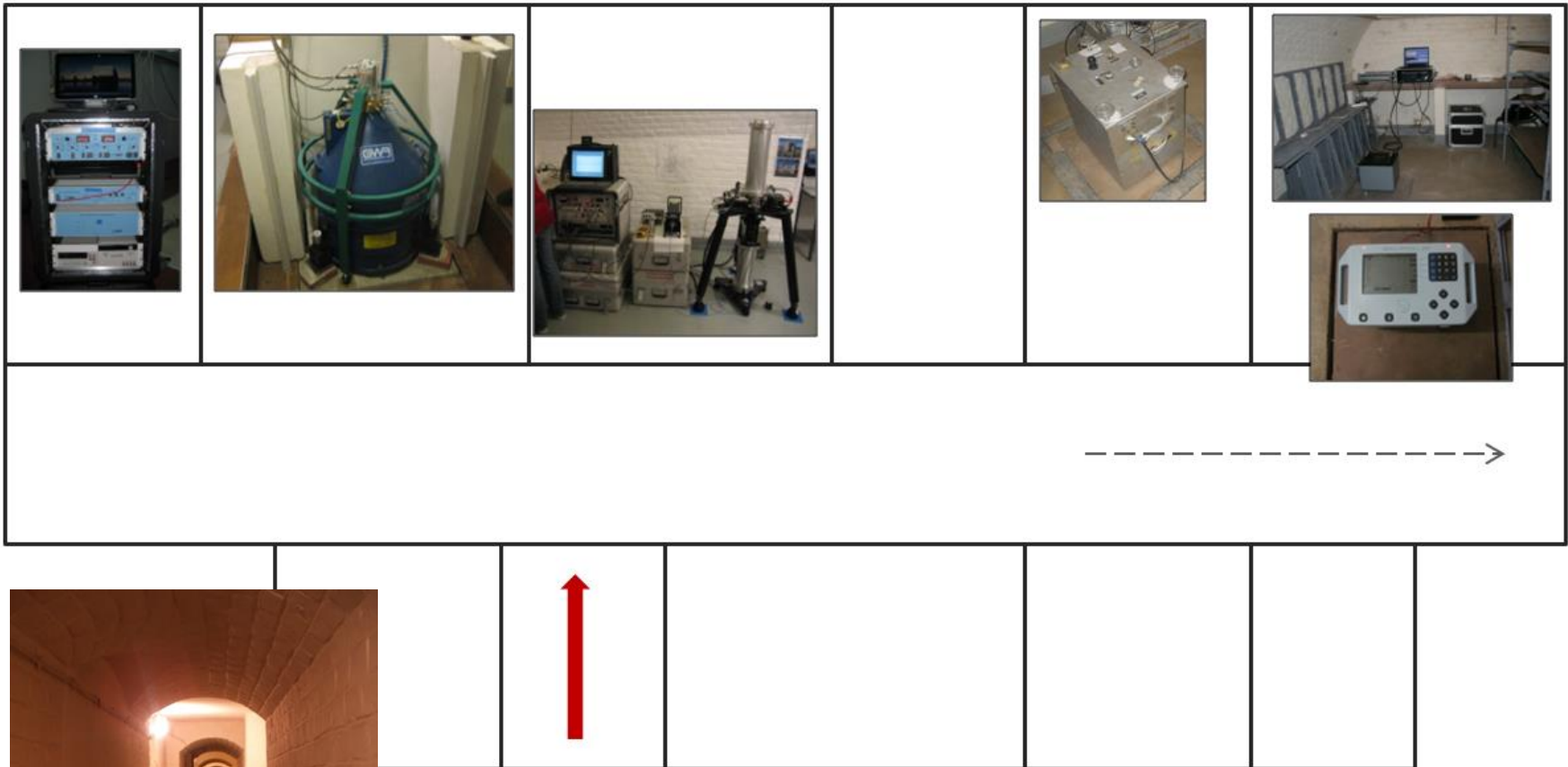
Installed in an isolated box thermostatically controlled



Sur les ondes diurnes de la marée gravimétrique observée à Strasbourg
Lecolazet, Steinmetz, 1974







J9

48,622°N
7,648°E
180 m

Changes in the observatory





Spring gravimeters

The first 10 years of observations were carried out by different models of spring meters

Askania 206

77 days

M. Bonatz

GEO 721

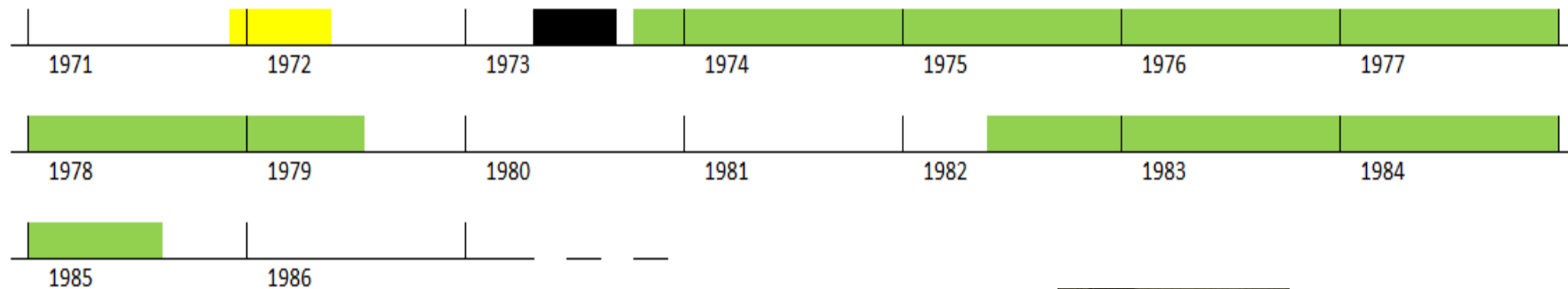
83 days

P. Melchior / J.T. Kuo

L&R ET005

2 periods (2098 + 1121 days)

R. Lecolazet / Gostoli



ASKANIA GS15-212
UCM

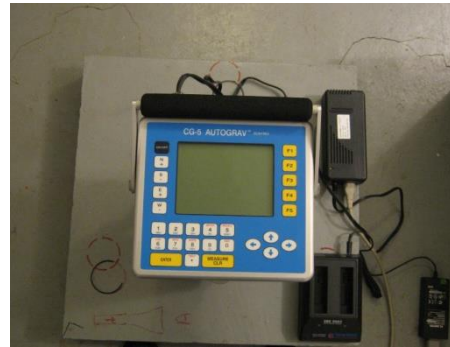


L&R RT005
EOST

Spring gravimeters



gPhone 054
IGN-Spain
2008-2009



Scintrex CG-3
Scintrex CG-5



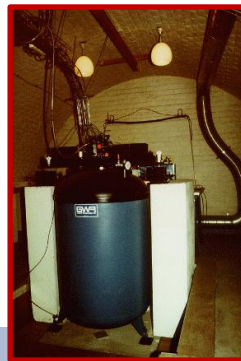
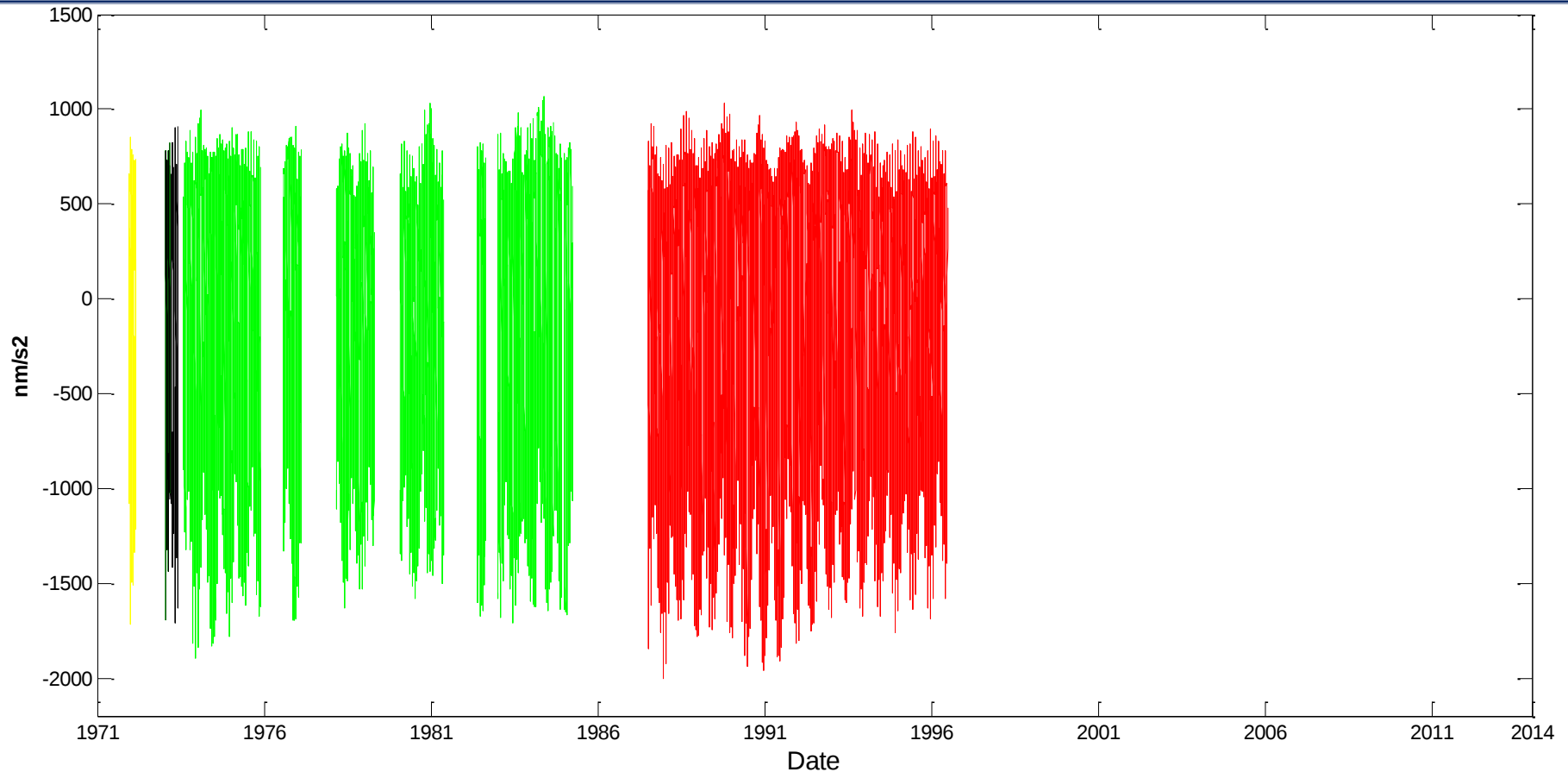
Graviton-EG1194
Instituto de Geociencias-Spain
2011

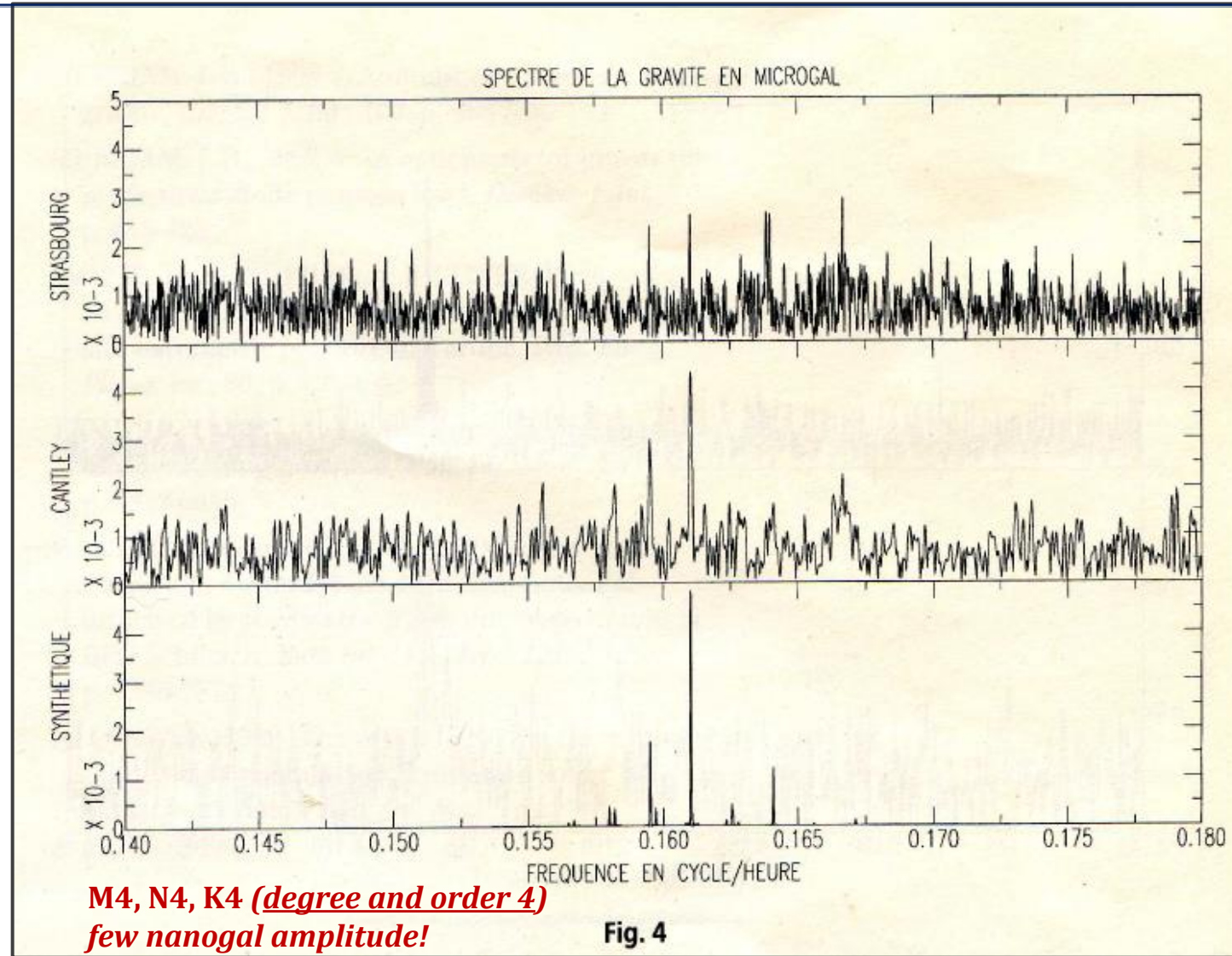


L&R ET11
BFO Germany
2012-2014

Superconducting gravimeters







*Mise en évidence d'ondes de marée quart-diurnes de quelques pico-g d'amplitude
à l'aide de gravimètres supraconducteurs
Florsch, Hinderer, Legros, 1995*

Superconducting gravimeters

Since 1987, two different superconducting gravimeters have been recording in two consecutive periods

The first SG was a TT70 model from GWR Instruments installed in July 1987. This meter was recording for almost 10 years

In July 1996, it was replaced by a more compact model, the SG C026, which is still recording



Superconducting gravimetry

Since 1987, two different

consecutive periods

The first SG was

meter was recorded

In July 1996, it was

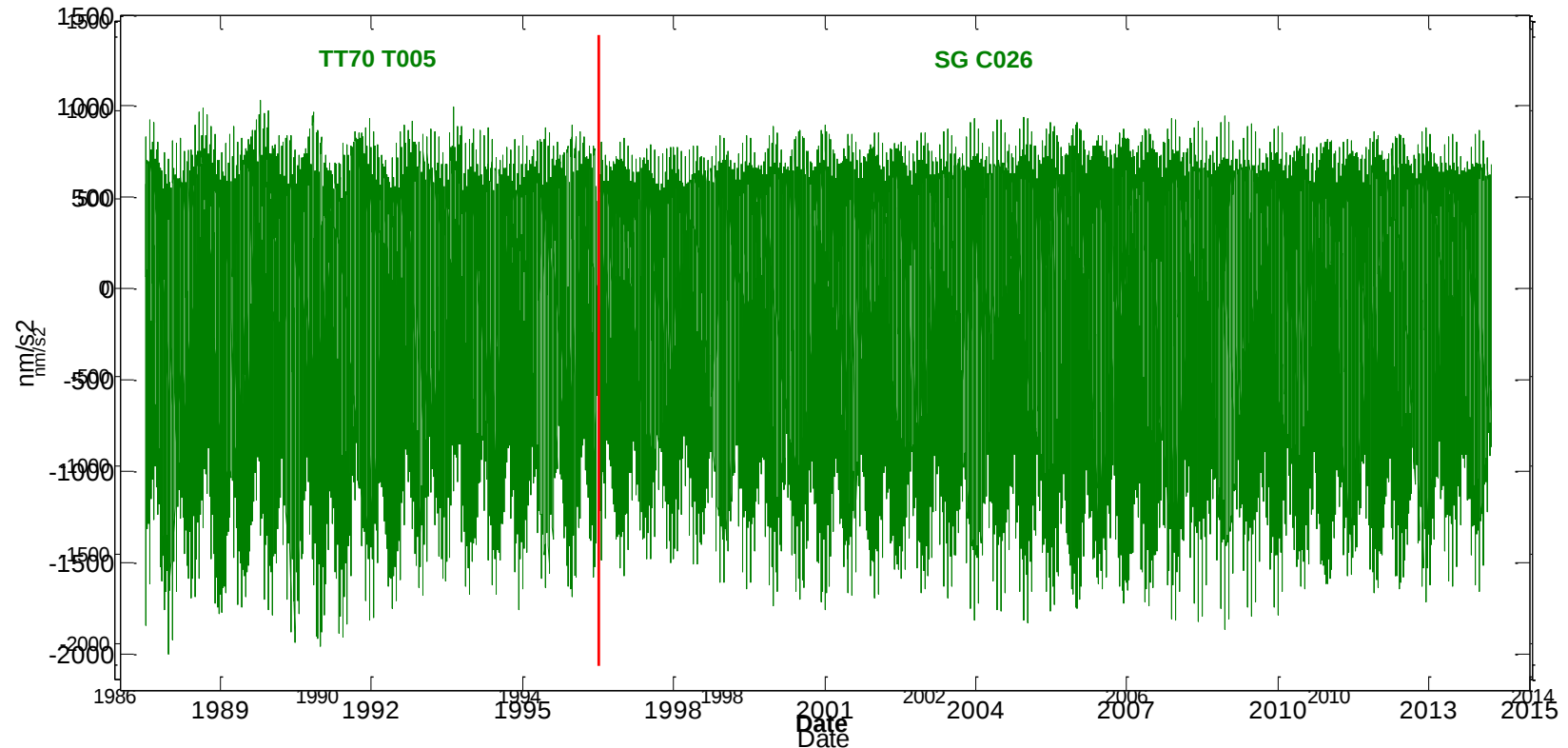
recording

have been recording in two

July 1987. This

1996, which is still

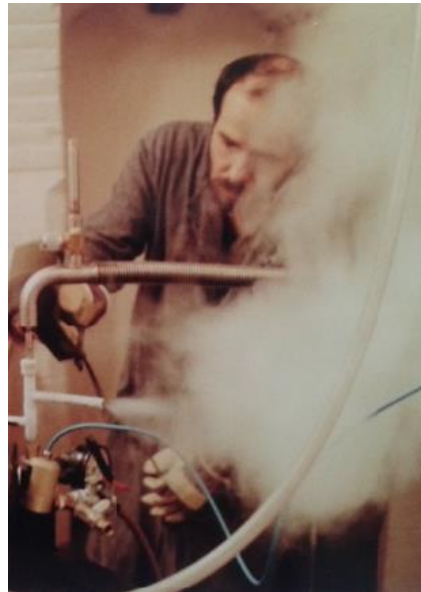




T005 9970 days **C026**

Both SGs have been installed on the same pillar

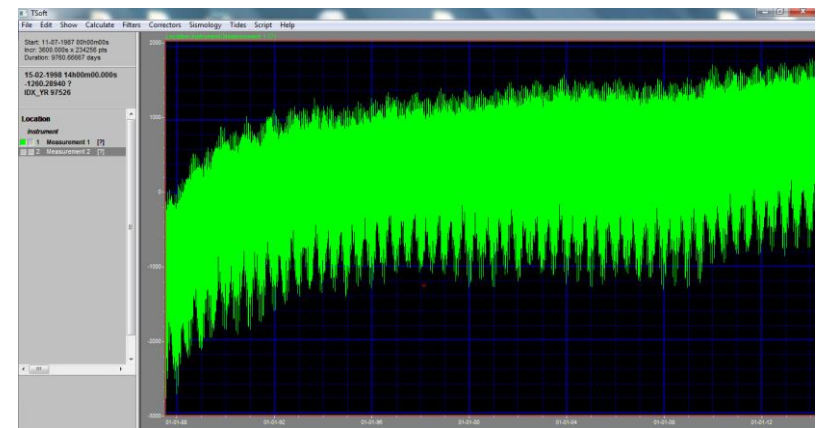
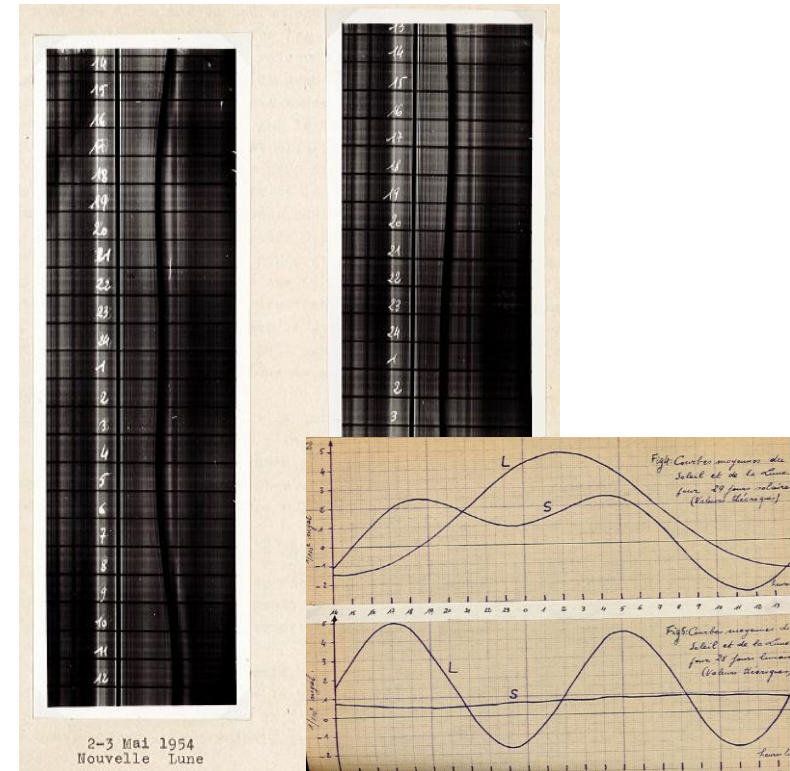
There were only few days between the removal of the T005 and the installation of the C026 (11 days compared to 27 years, almost negligible)



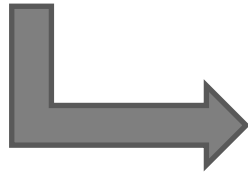
Electronics & acquisition system improvements



GWR acquisition



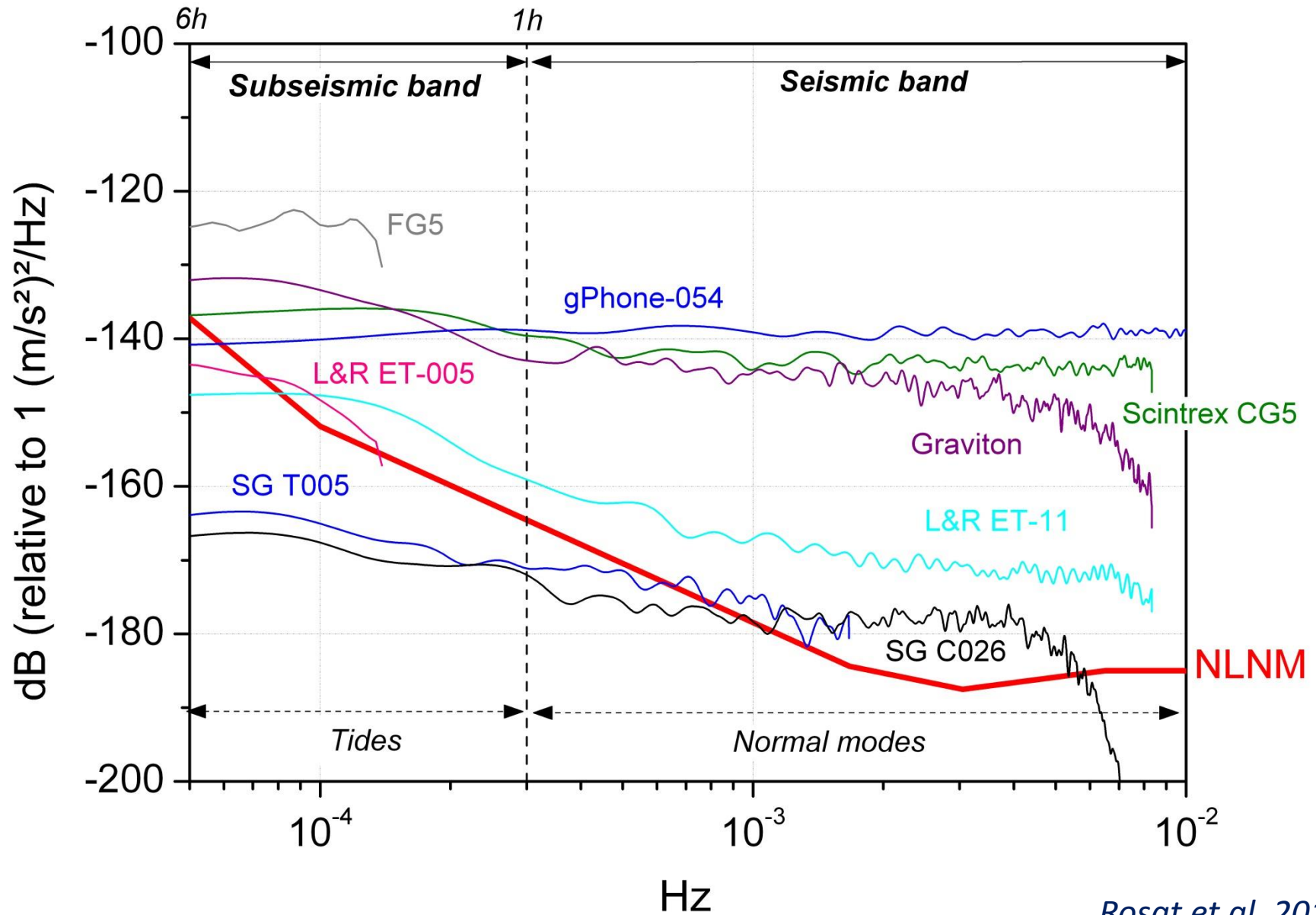
- ✓ Sensor improvements
- ✓ Electronics & acquisition system improvements

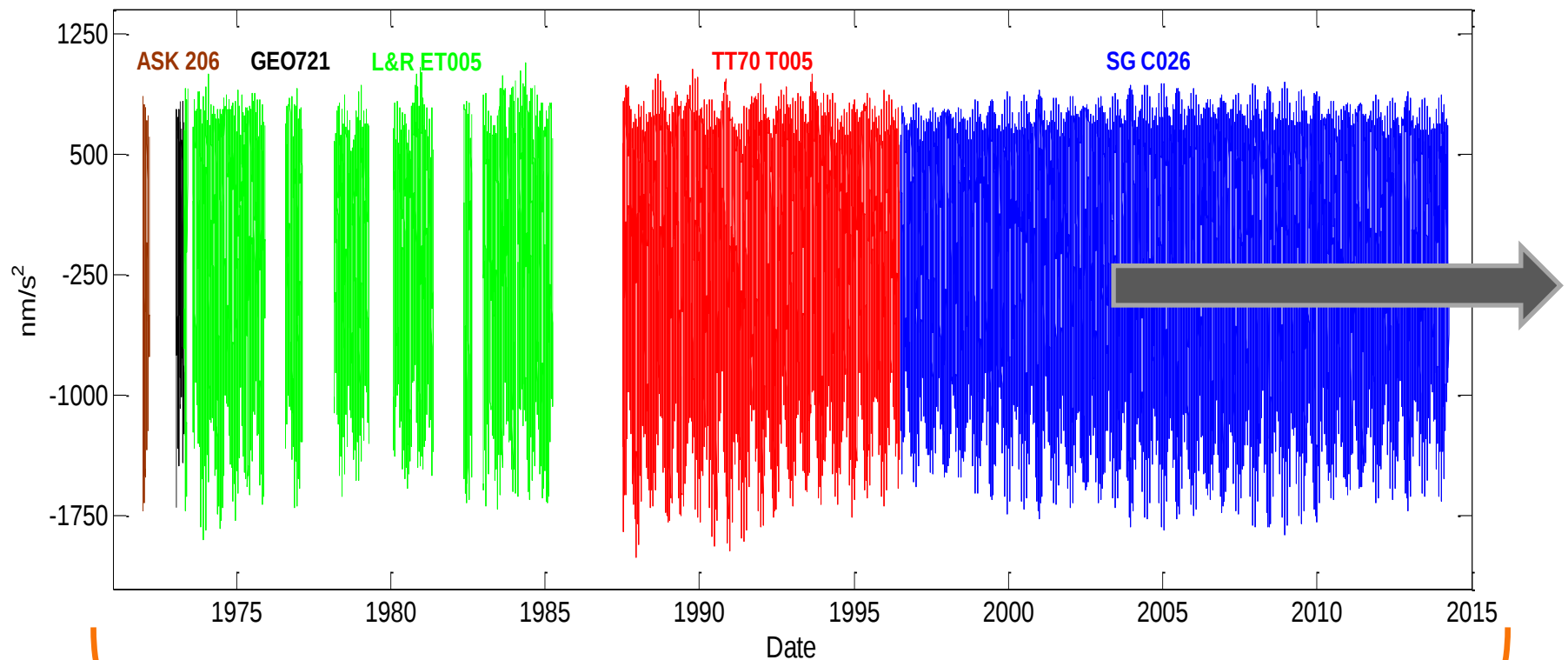


These improvements increased the measurement accuracy by more than 10 times

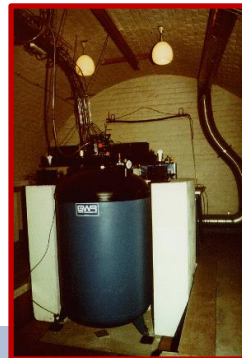
(Calvo et al., 2014)

PSD on 5 quietest days





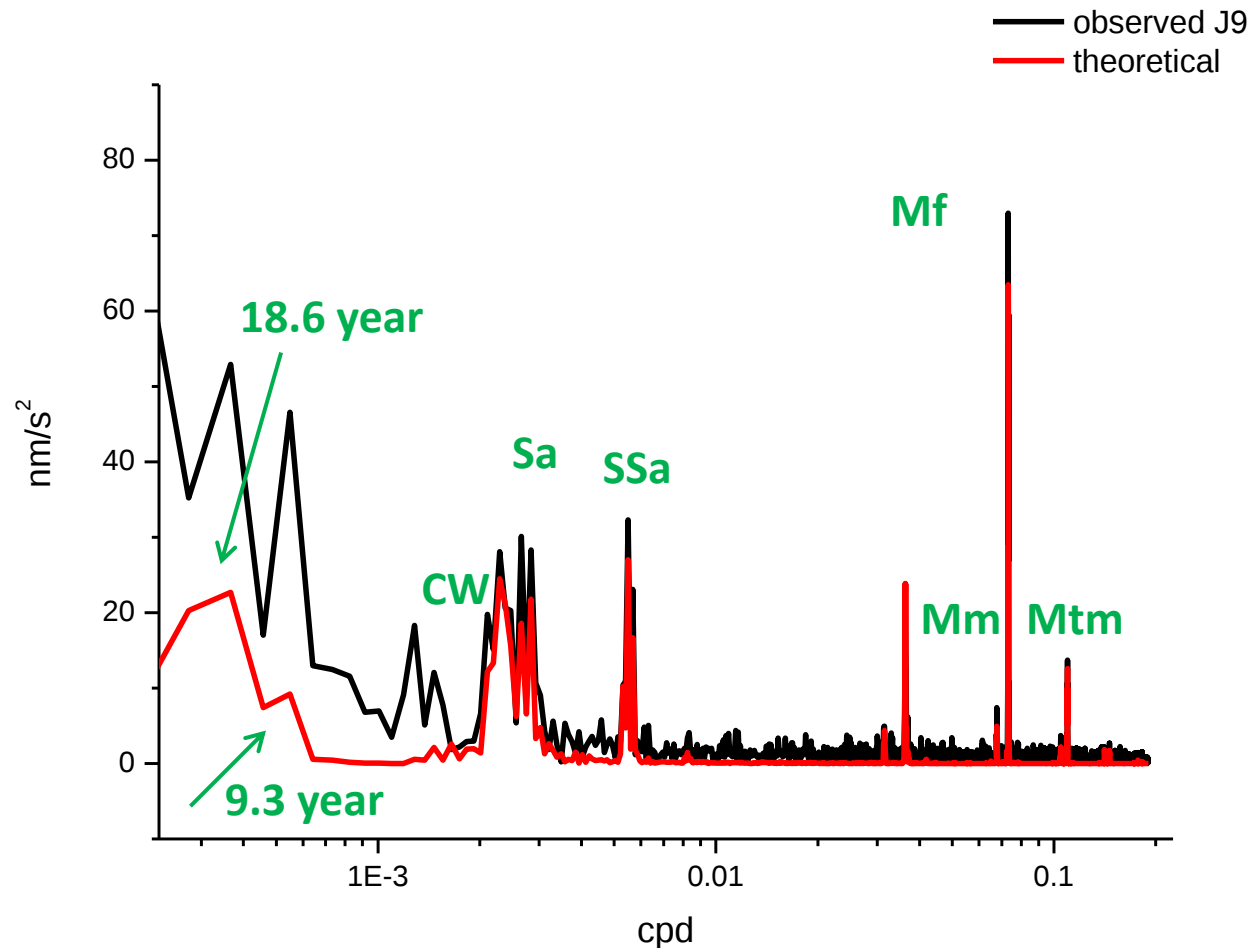
40 years
~12700 effective
analysis days



27 years
~10000 effective
analysis days

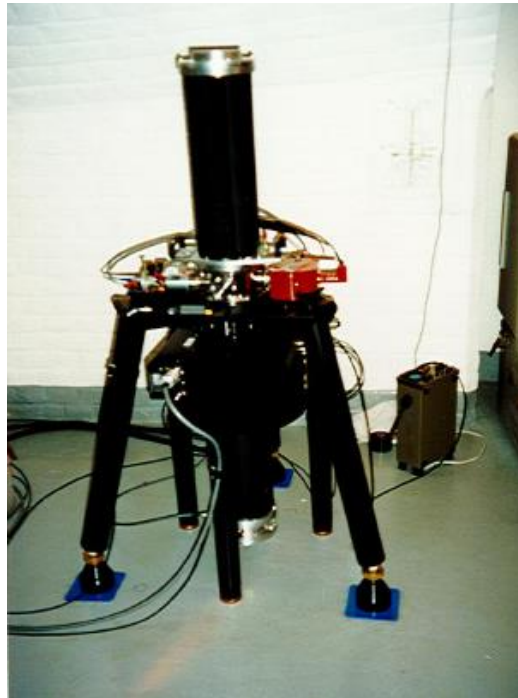


Spectral analysis of the merged 27-year series (T005&C026)

*Calvo et al. 2014*

Absolute gravimeters

Since 1997, there is also a portable absolute gravimeter FG5 # 206 manufactured by Micro-g Solutions which is regularly measuring at the J9 Observatory in parallel with the SG



Absolute gravimeters

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Some other absolute gravimeters have measured at the station, as the JILAg or the A10 models



JILAg-5

Finnish Geodetic Institute



A10#006

IGN - Spain

Absolute gravimeters

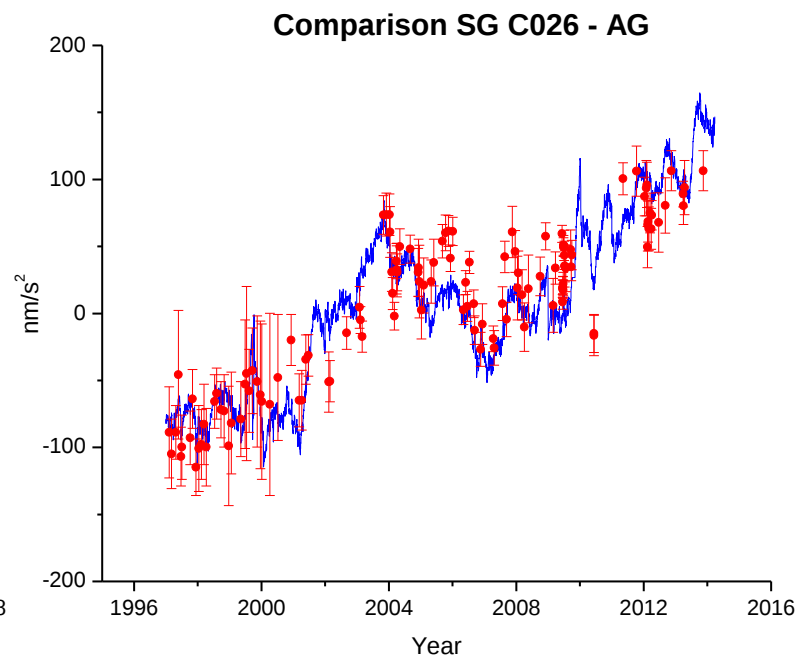
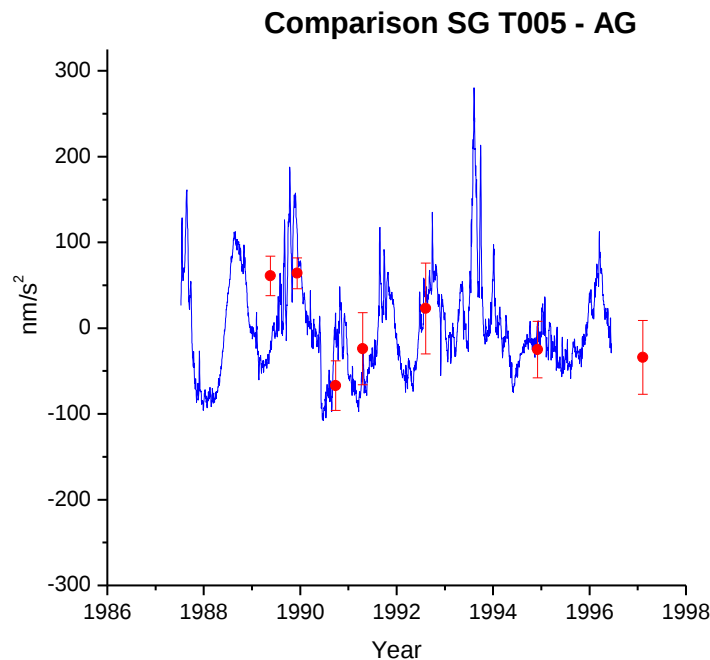
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The main purposes of these AG measurements performed at J9 are the drift control and the calibration of the superconducting gravimeters (T005 and C026)

Drift control

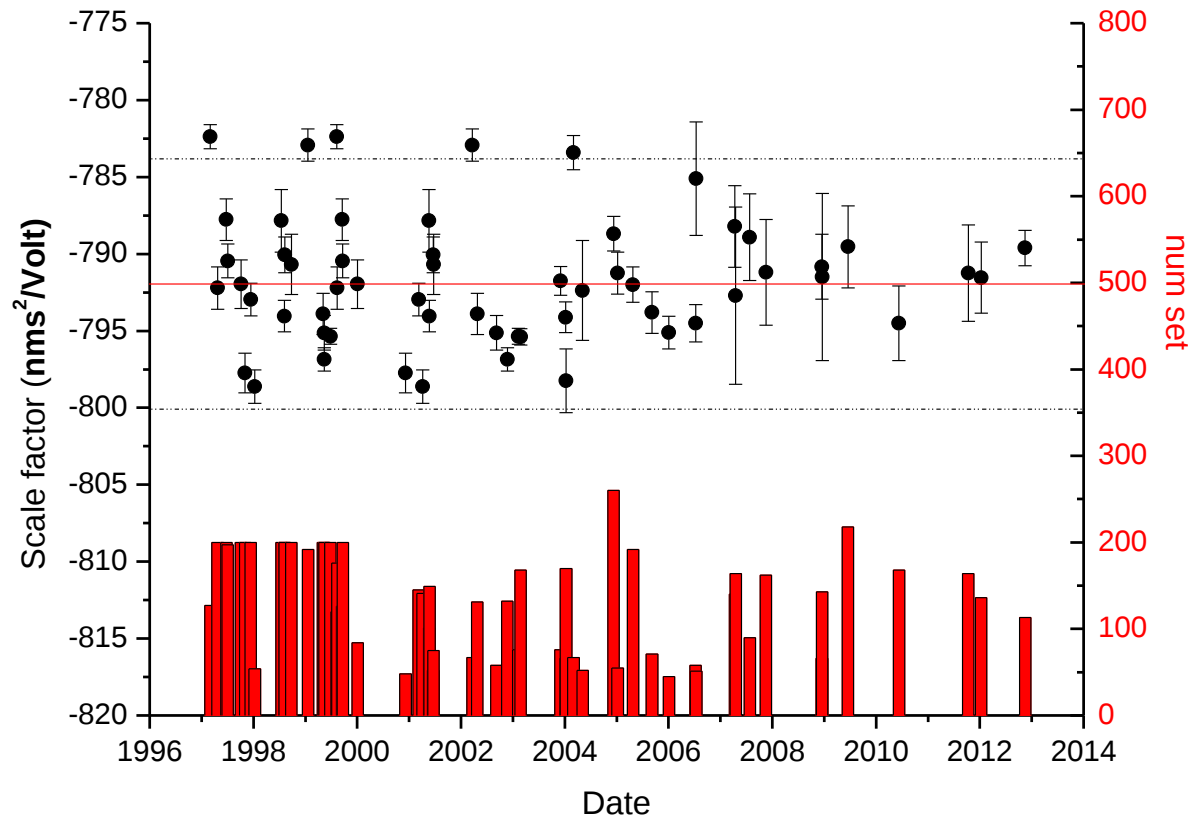
Superposition of SG gravity residuals (continuous line) with AG measurements (dots with error bars) (left) between SG (T005) and AG (JILAg-5) for the period 1987–1996, (right) between SG (C026) and AG (FG5#206) data for the period 1996–2014



Amalvict et al., 1999

SG calibration

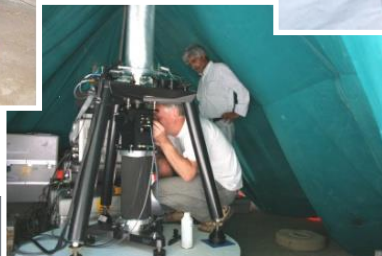
Calibration experiments of different durations (from 2 to 10 consecutive days) carried out by co-located AG measurements since 1997 to 2014



Calvo et al. 2014

Absolute gravimeter FG5#206

This gravimeter has also been involved in several field missions in France and all around the world.



What's coming next?



The SG C026, will be replaced in a near future by a more compact observatory model iSG

What's coming next?



THANK YOU!

FOR ANOTHER 60 YEARS!



We especially express our thanks to people involved at various levels in the Strasbourg gravimetric Observatory including (for the SG period):

J. Bonnin, Y. Legros, N. Florsch, P. Gegout, M. Greff-Lefftz, D. Crossley, O. Jensen, D. Smylie, U. Riccardi, O. Francis, M. Van Camp, B. Ducarme, W. Zürn, H. Wilmes, J. Mäkinen, V. Pálinkás, etc...

Thank you: C.Heimlich for pictures & F. Littel for video