

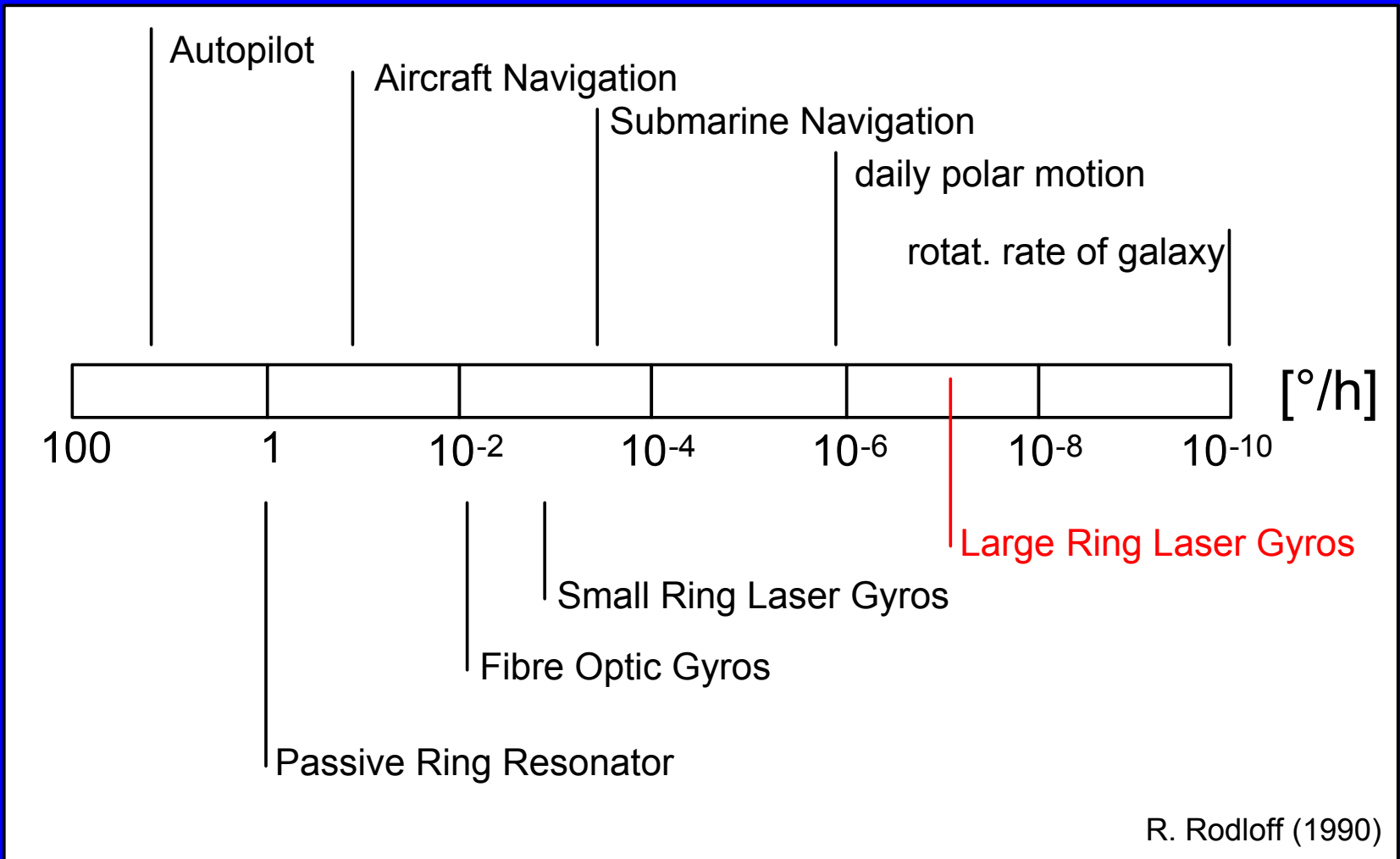
# Ring Laser Principles and Design Considerations

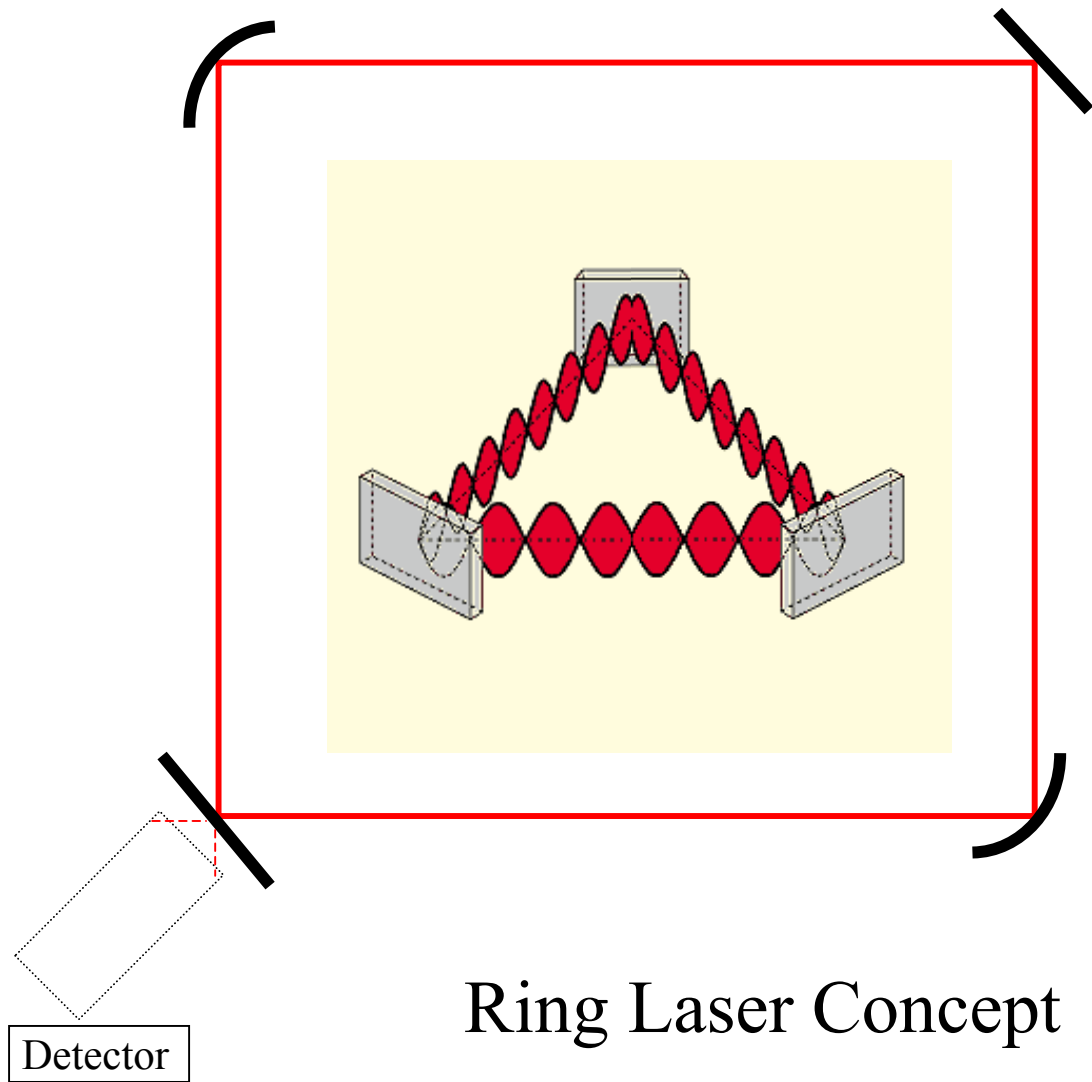
Ulrich Schreiber



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University of Canterbury, New Zealand  
Bundesamt für Kartographie und Geodäsie  
Ludwig-Maximilians-Universität, München

# Requirements and Achievements





Ring Laser Concept

# Contributions to the Sagnac Signal

$$\delta f = \frac{4A}{\lambda P} \vec{n} \cdot \vec{\Omega} + f_{nr}$$

- Scaling factor
- Rotation rate
- Orientation
- Nullshift
- Backscatter

# Design Considerations

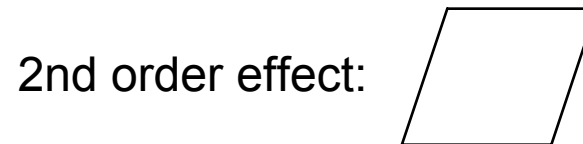
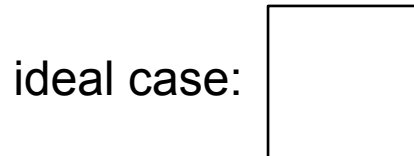
- Sensitivity goes up as scaling factor increases
- Operation at laser threshold ensures mono-mode excitation
- Low loss mirrors reduce backscattering
- Scaling factor “self-adjusting”

# Scaling Factor and Large Rings

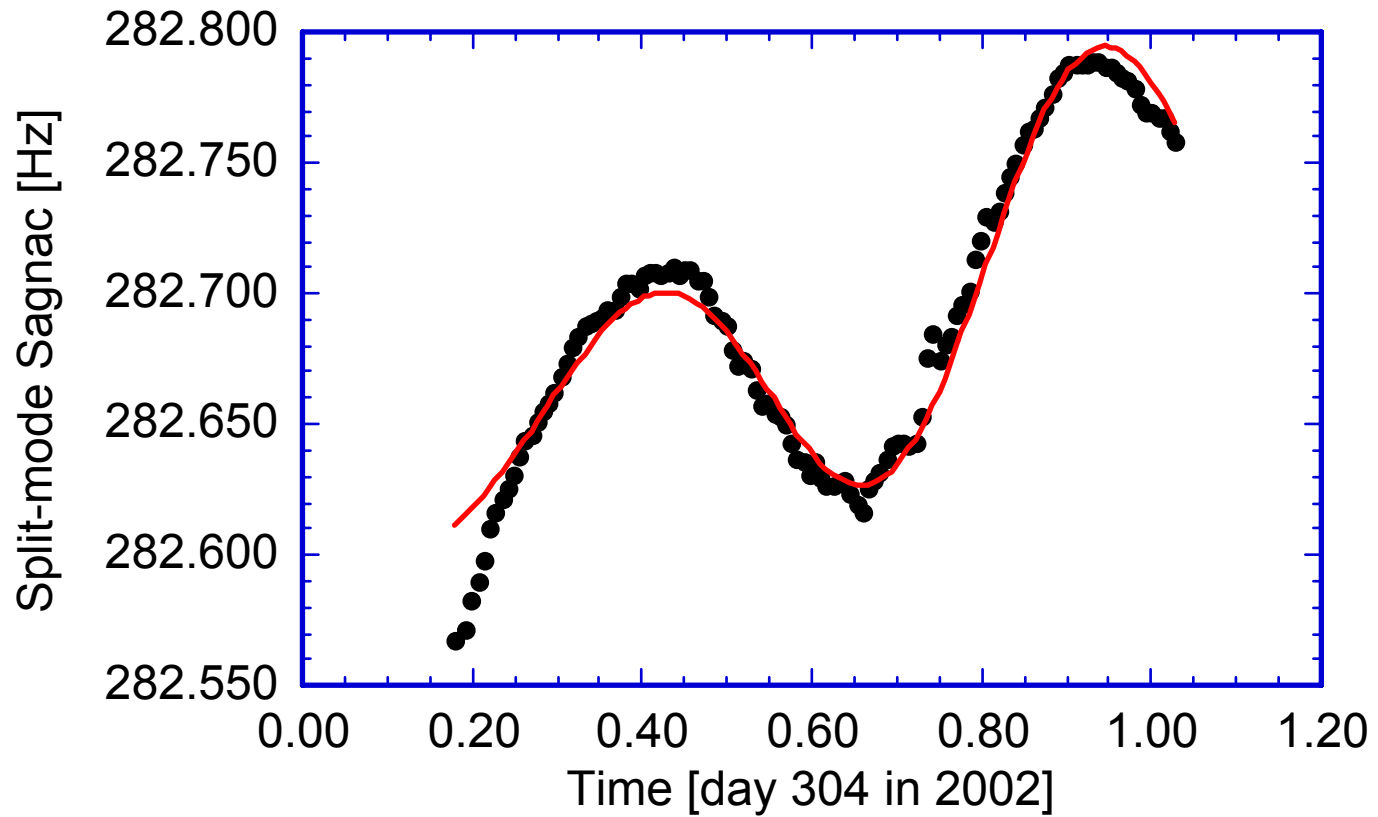
Scaling Factor:  $\frac{4 \cdot A}{\lambda \cdot P}$

Lasing Condition:  $(P = I \cdot \lambda)$

For an ideal square this reduces to:  $\frac{I}{4}$

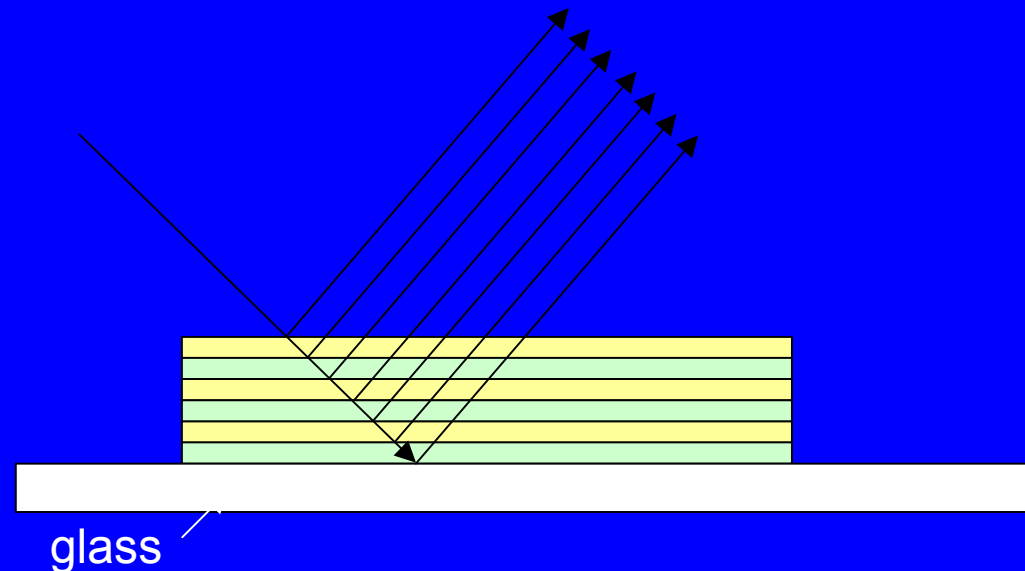
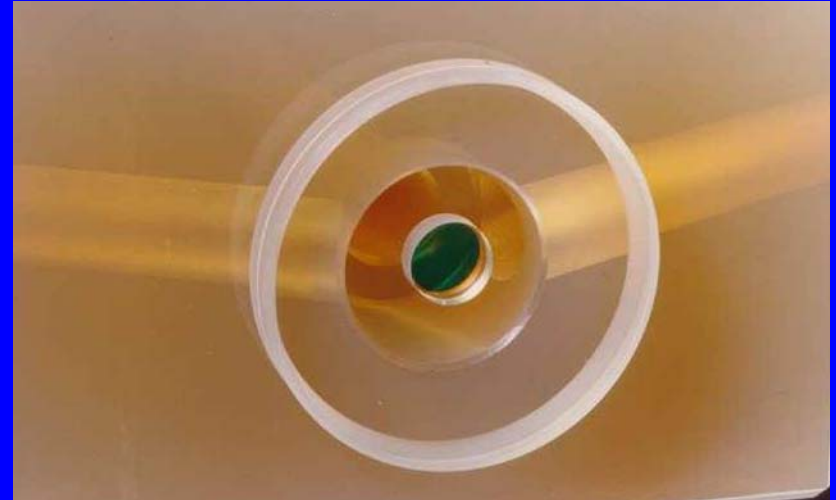


Strain and Pressure fitted to Splitmode-Sagnac

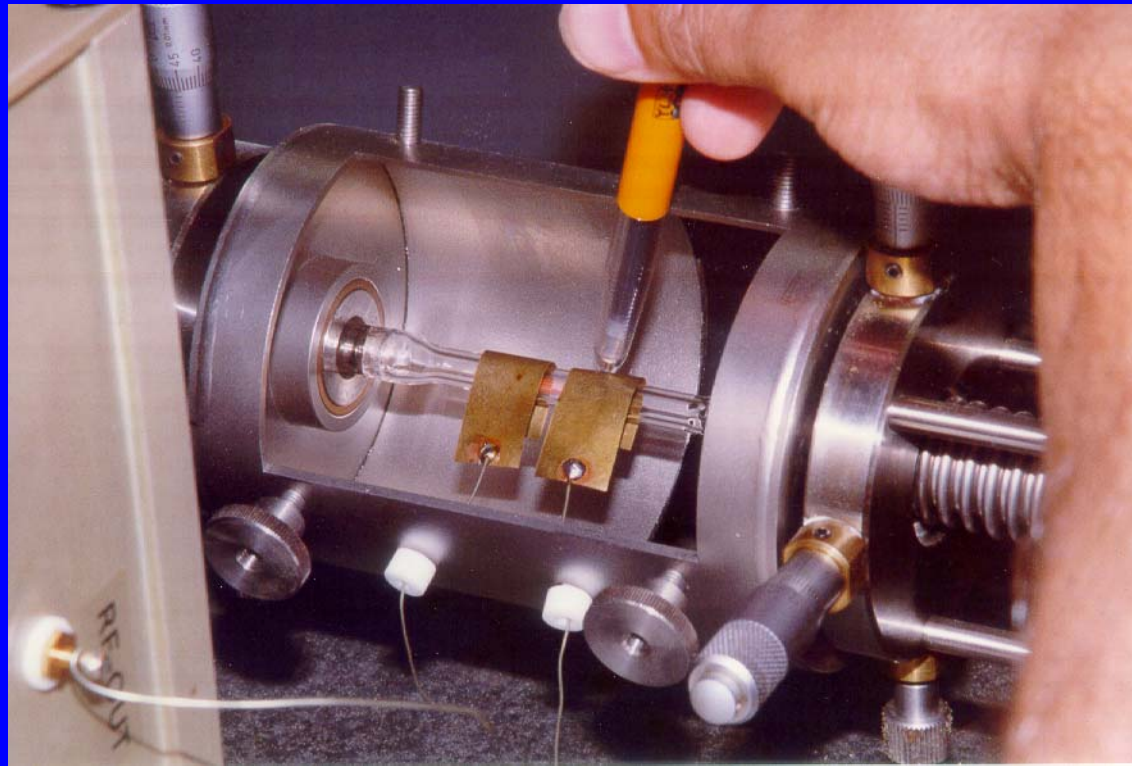


# Supermirrors

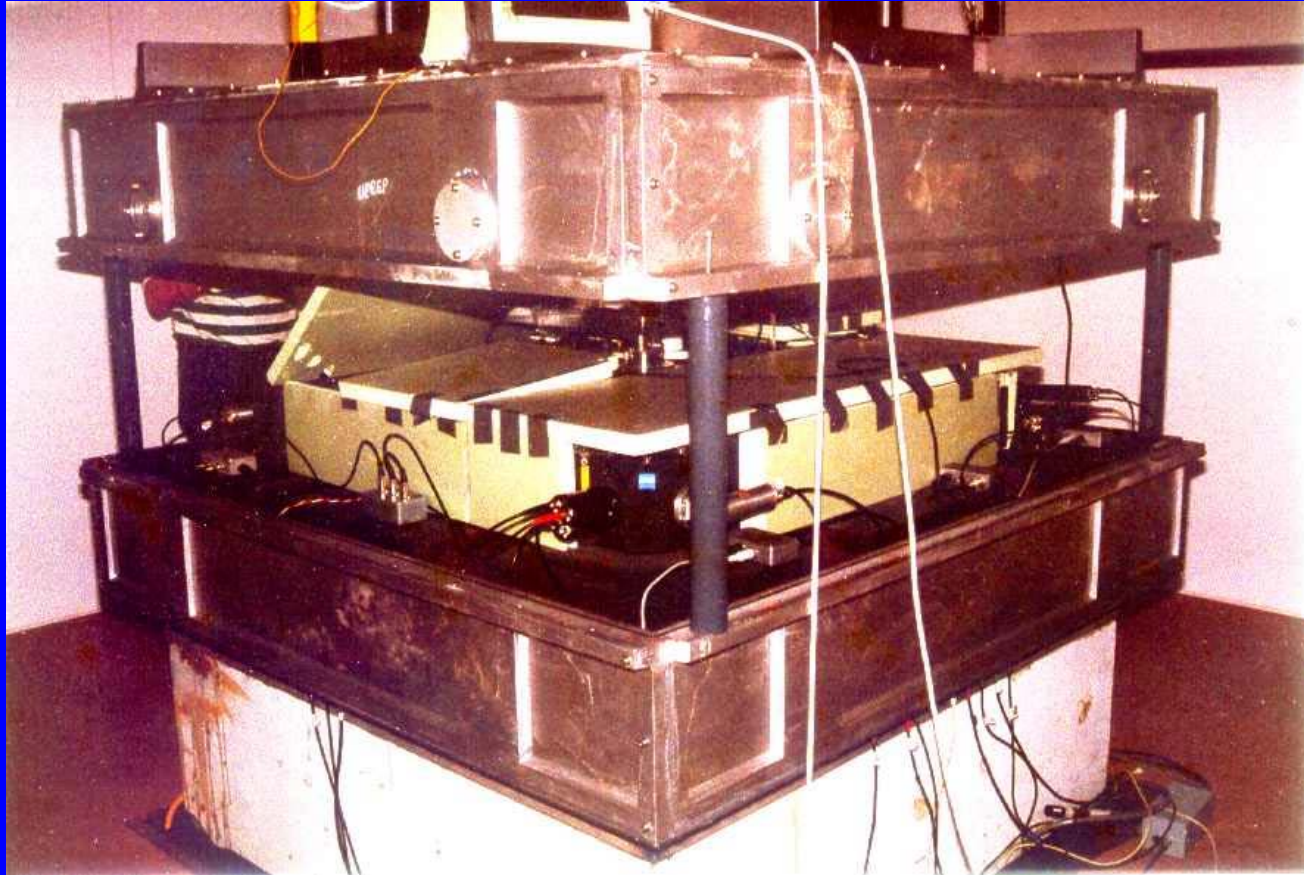
- Reflect 99.999% of the light falling on them
- Made of many layers of transparent material
- Designed for Helium-neon laser wavelength



# C-II Ring Laser Gain Tube



# C-II in Cashmere Cavern in Christchurch

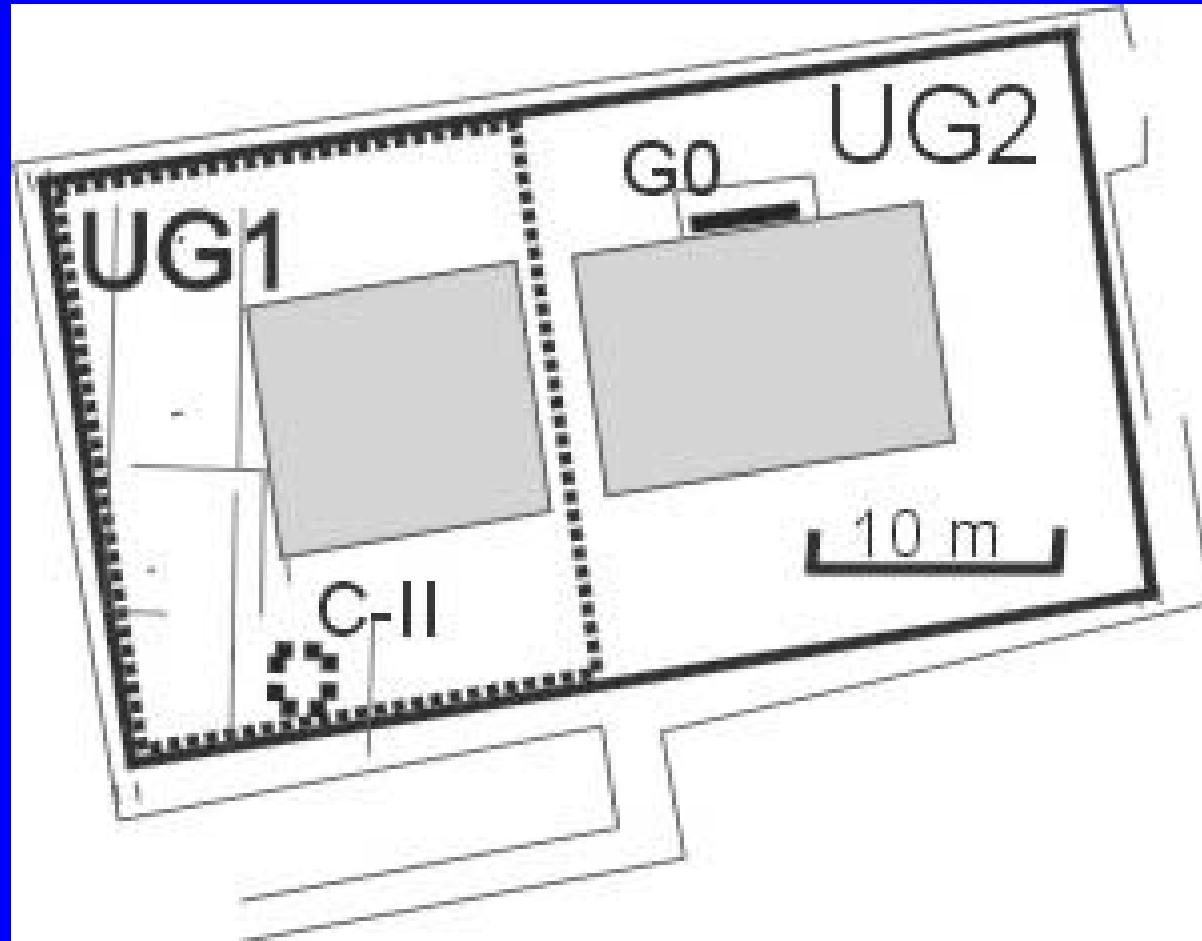


# The New Zealand Ring Laser Laboratory

Zur Anzeige wird der QuickTime™  
Dekompressor „Foto - JPEG“  
benötigt.



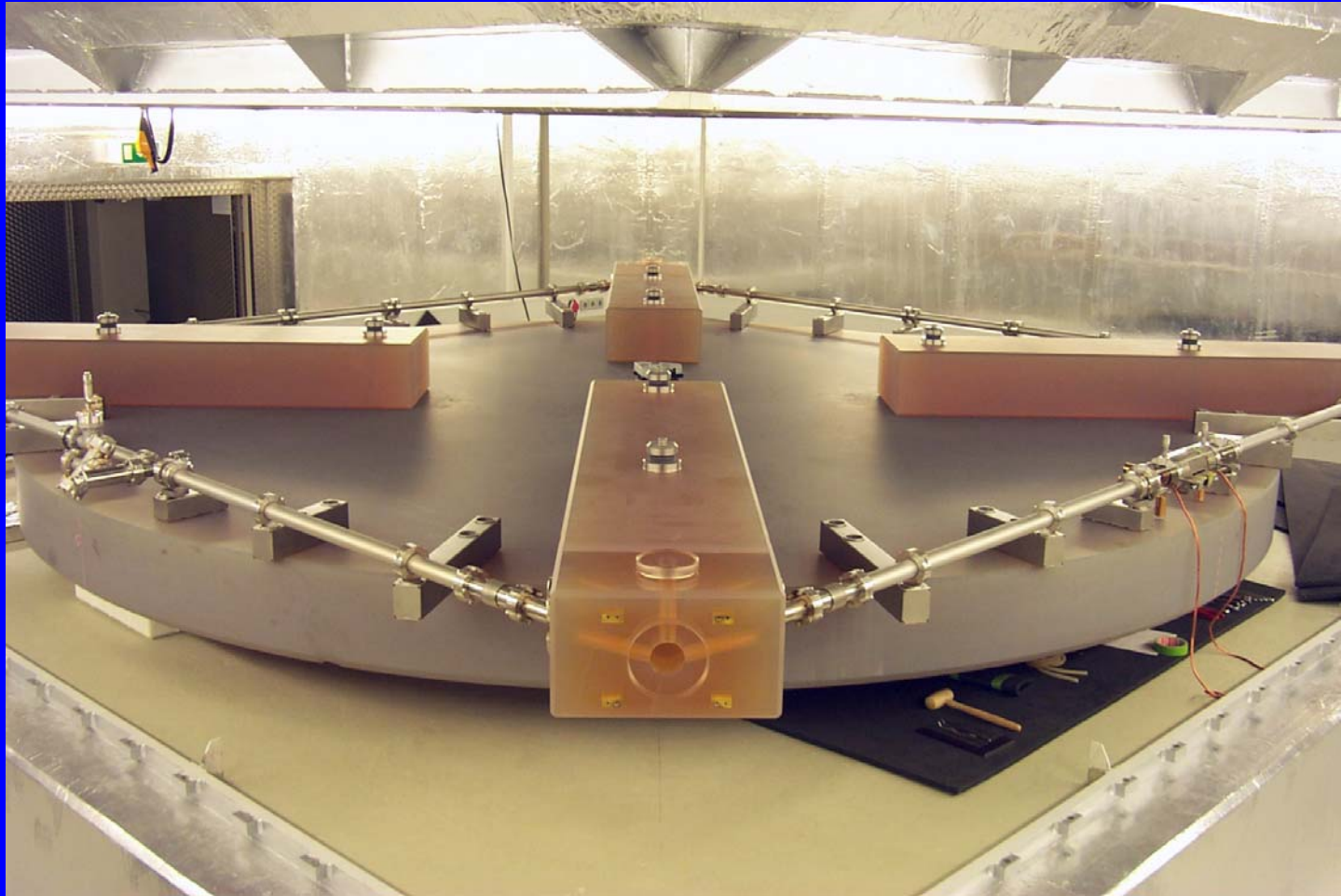
# Layout of Cashmere Cavern



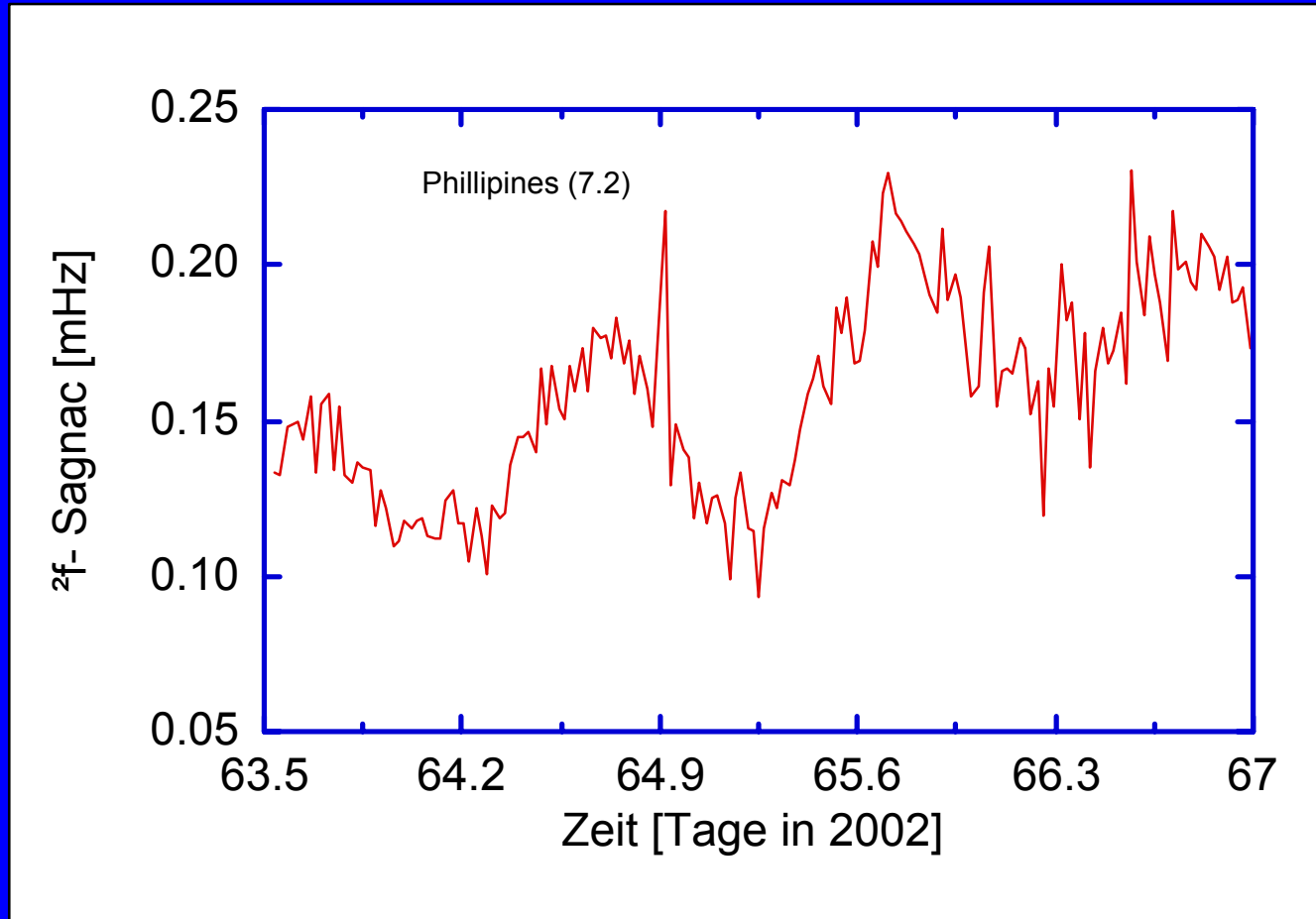
# Installation of the G-Ring Laser Base



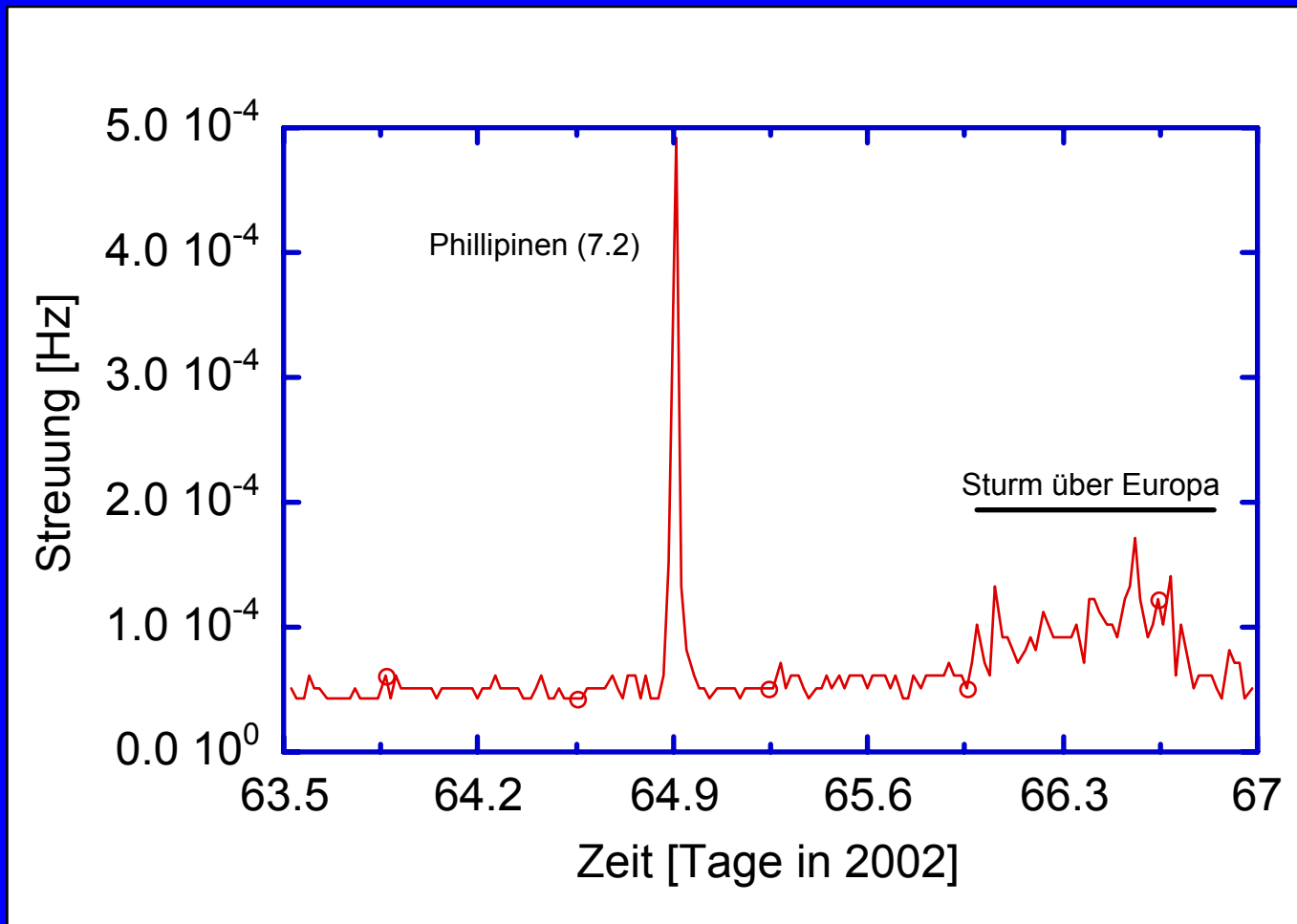
# G Ring Laser



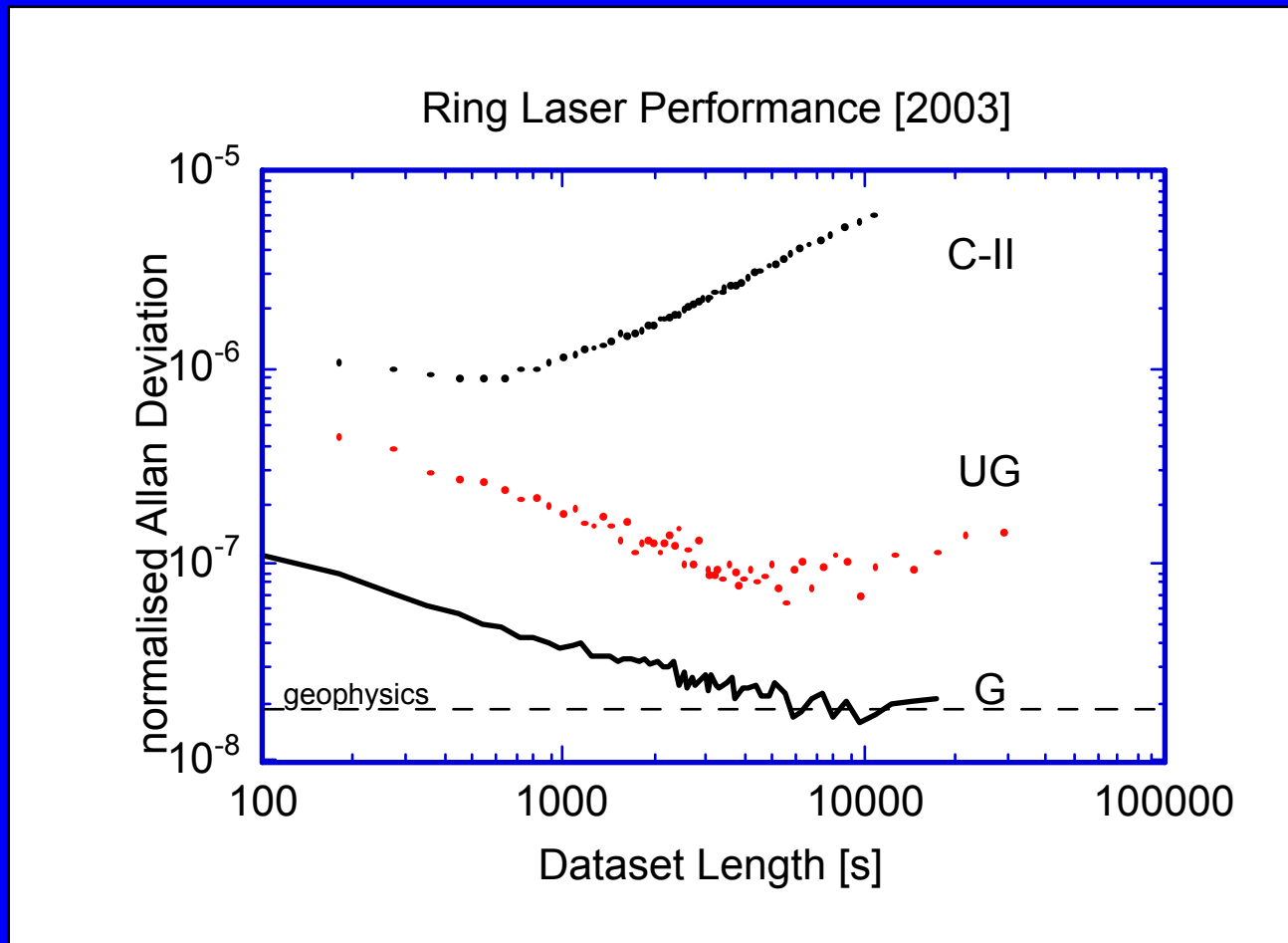
# Timeseries of Sagnac Frequency



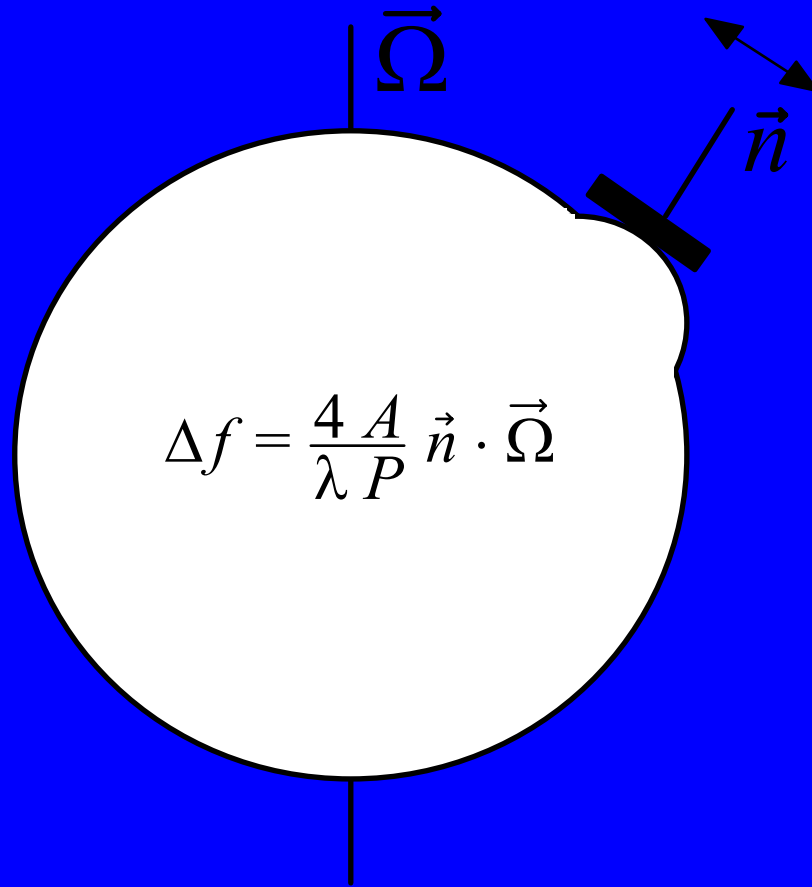
# Scatter of Ring Laser Data



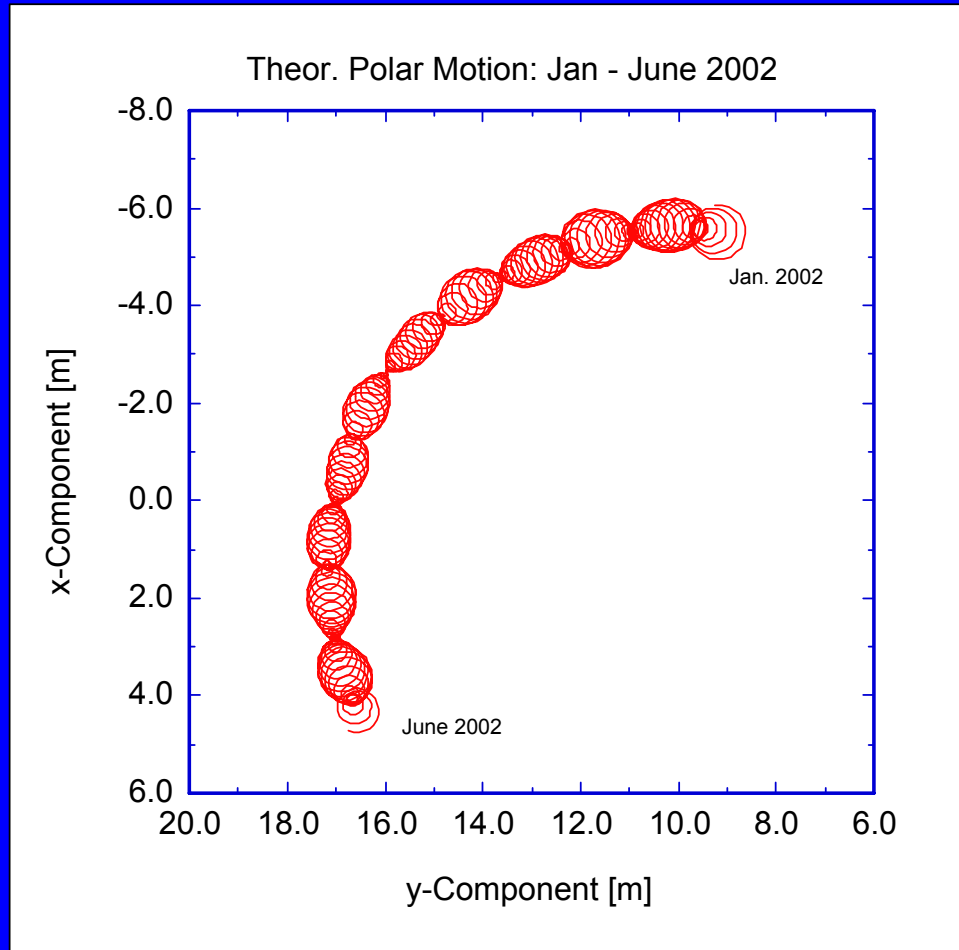
# Characterisation by Allan Variance



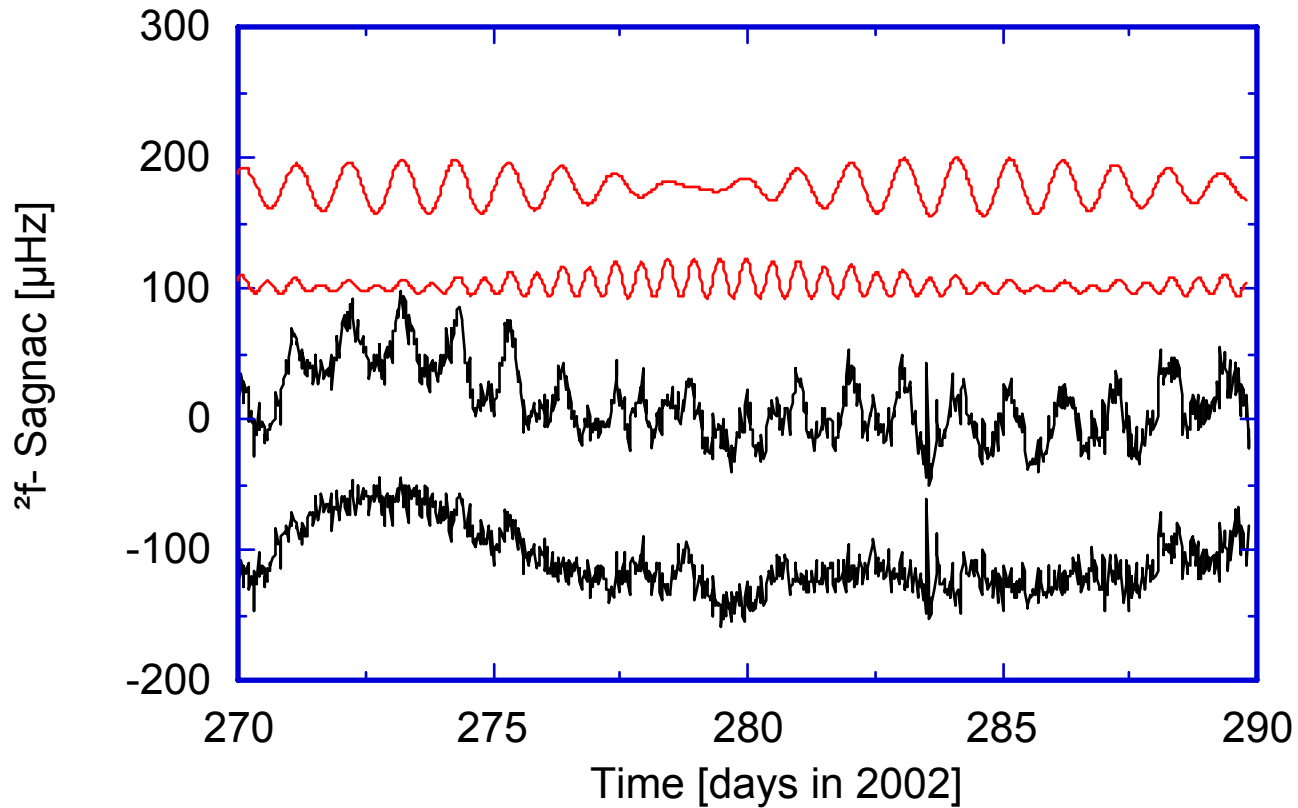
# Ring Lasers measure Orientation:



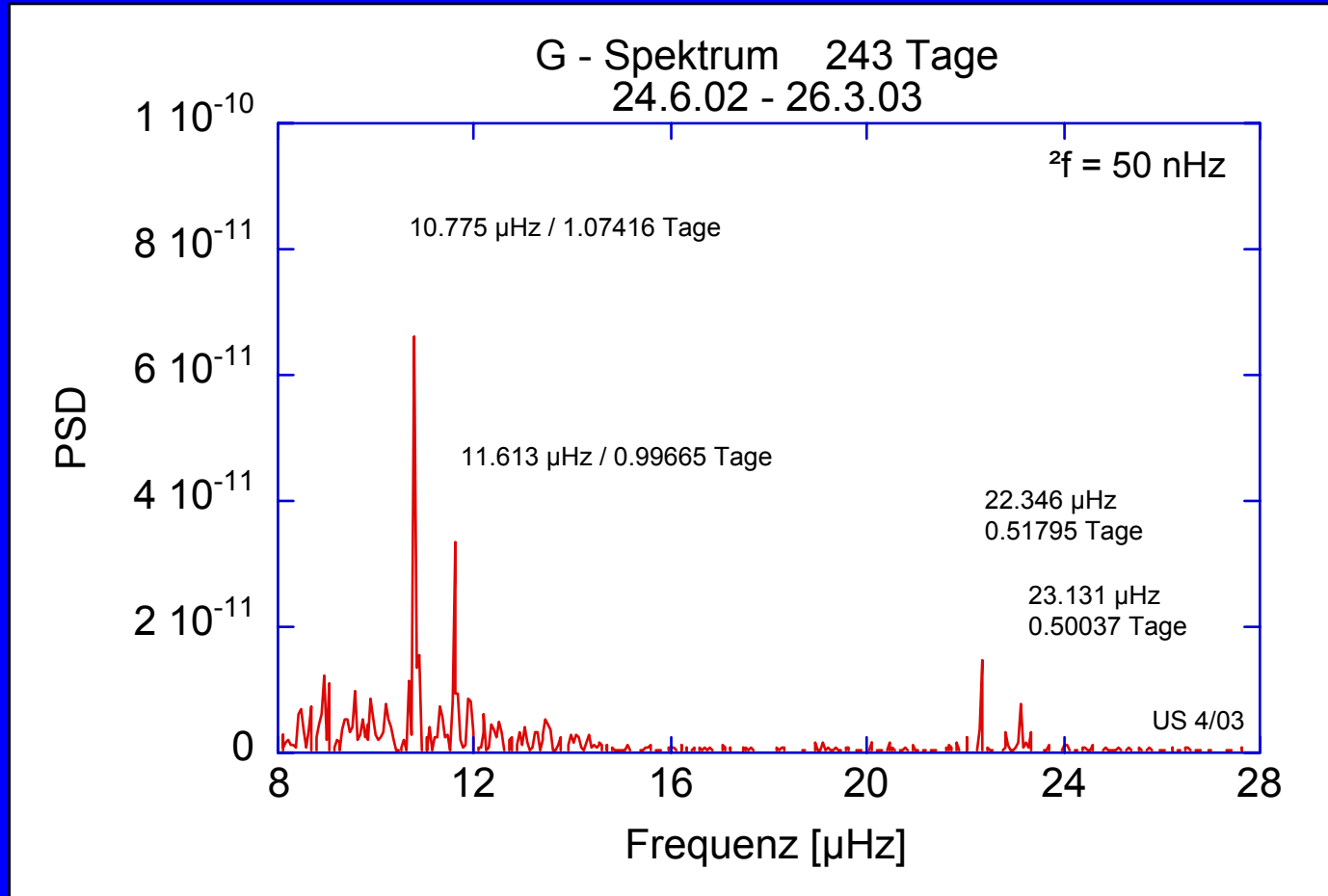
# Diurnal Polar Motion



# ... and the G- Ring Results

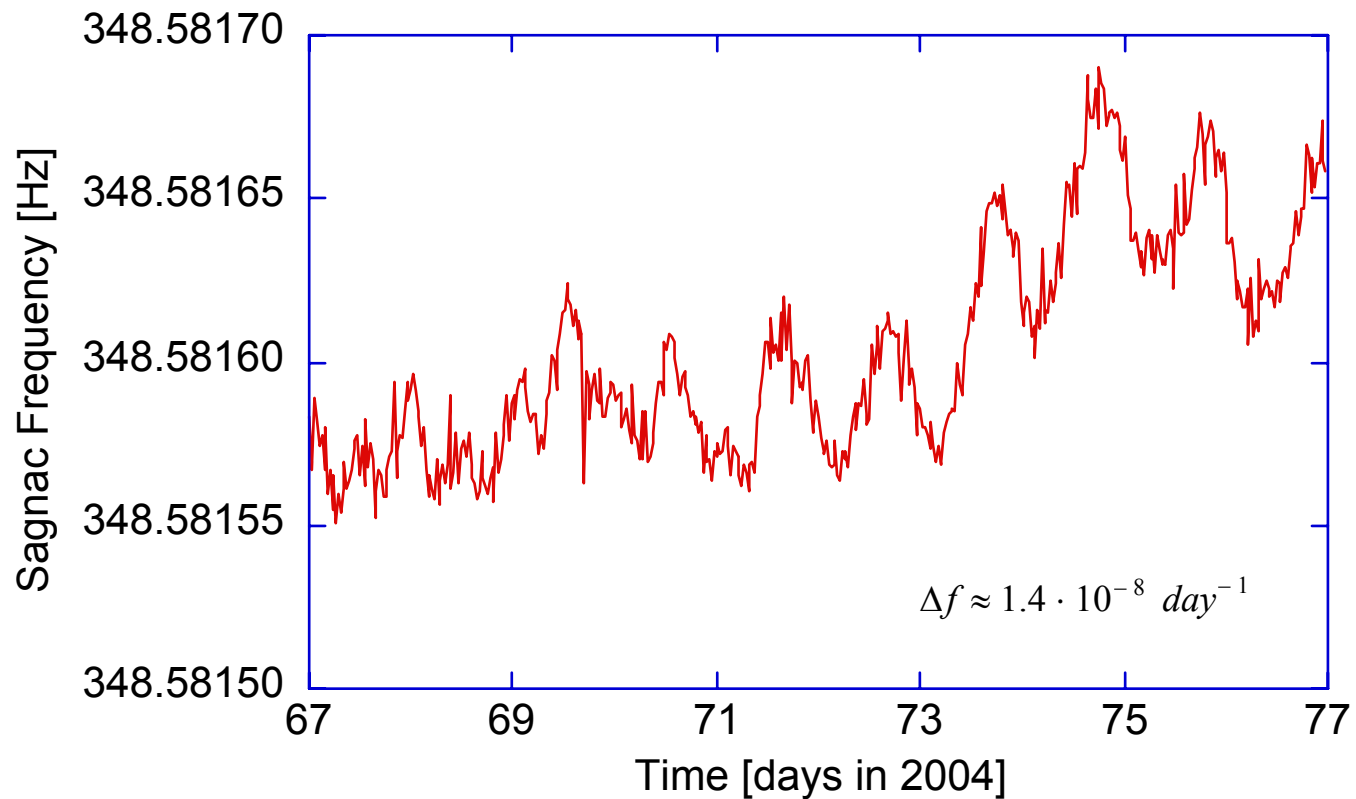


# The best resolved Spectrum to date:

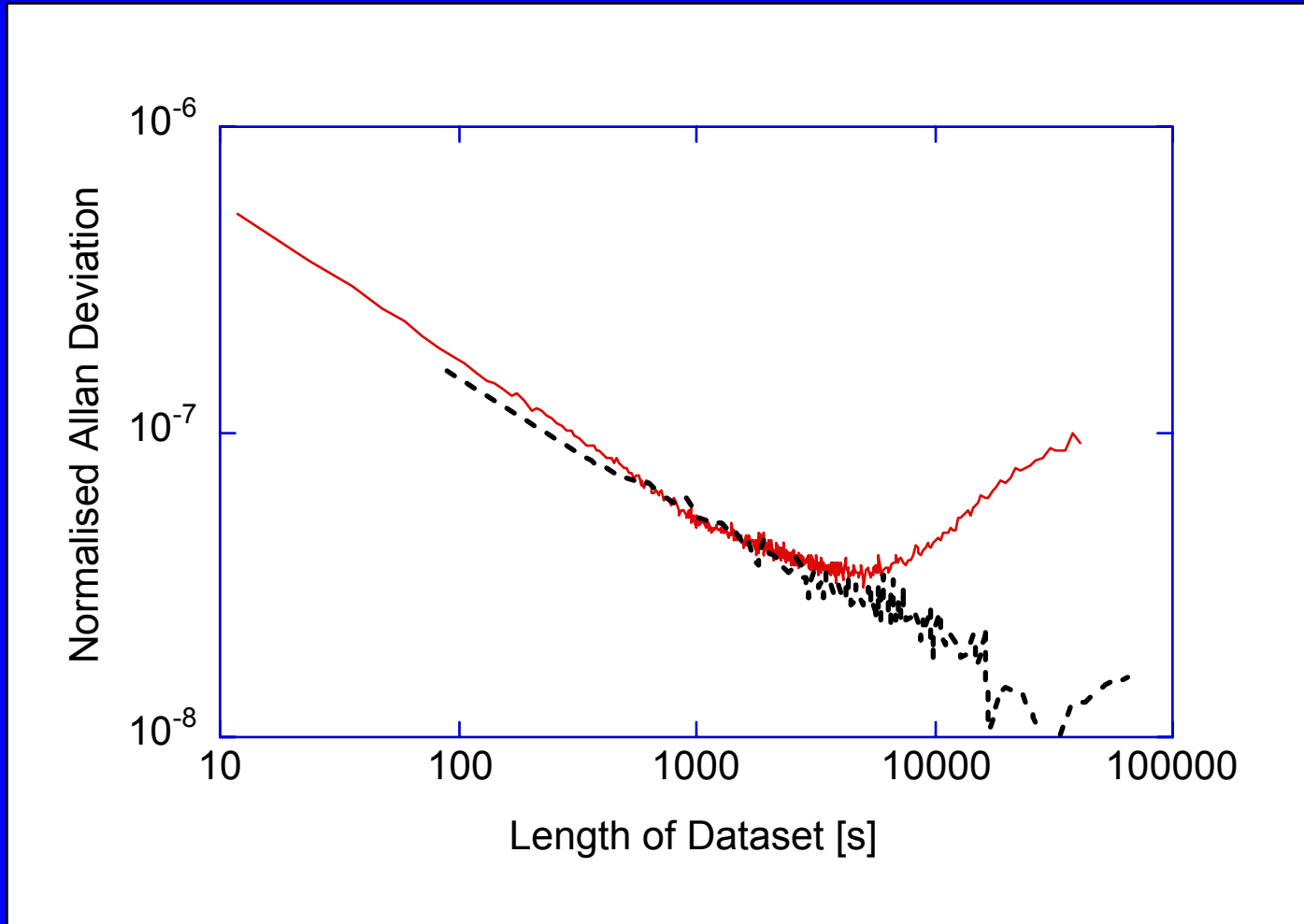


submitted to: JGR (2003)

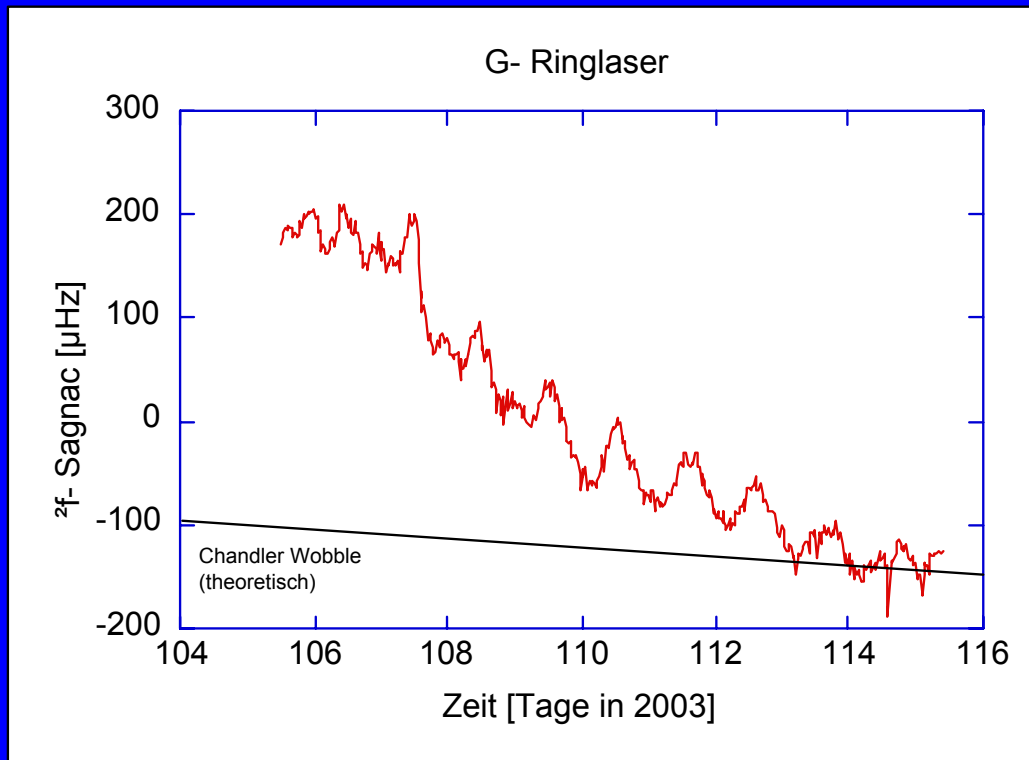
# G Ring Laser Raw Data



# Allan Variance: Geophysical Signals removed



# G- Ring Facts



relative  
error

$$\frac{\Delta f}{f} = 72 \frac{\text{ppb}}{\text{Tag}}$$

non-  
reciproc.

$$\frac{\Delta f_{nr}}{f_{opt.}} = 8 \cdot 10^{-18}$$

Offset

$$f_{off} \approx 10 \text{ ppm}$$

## Ring Laser Performance

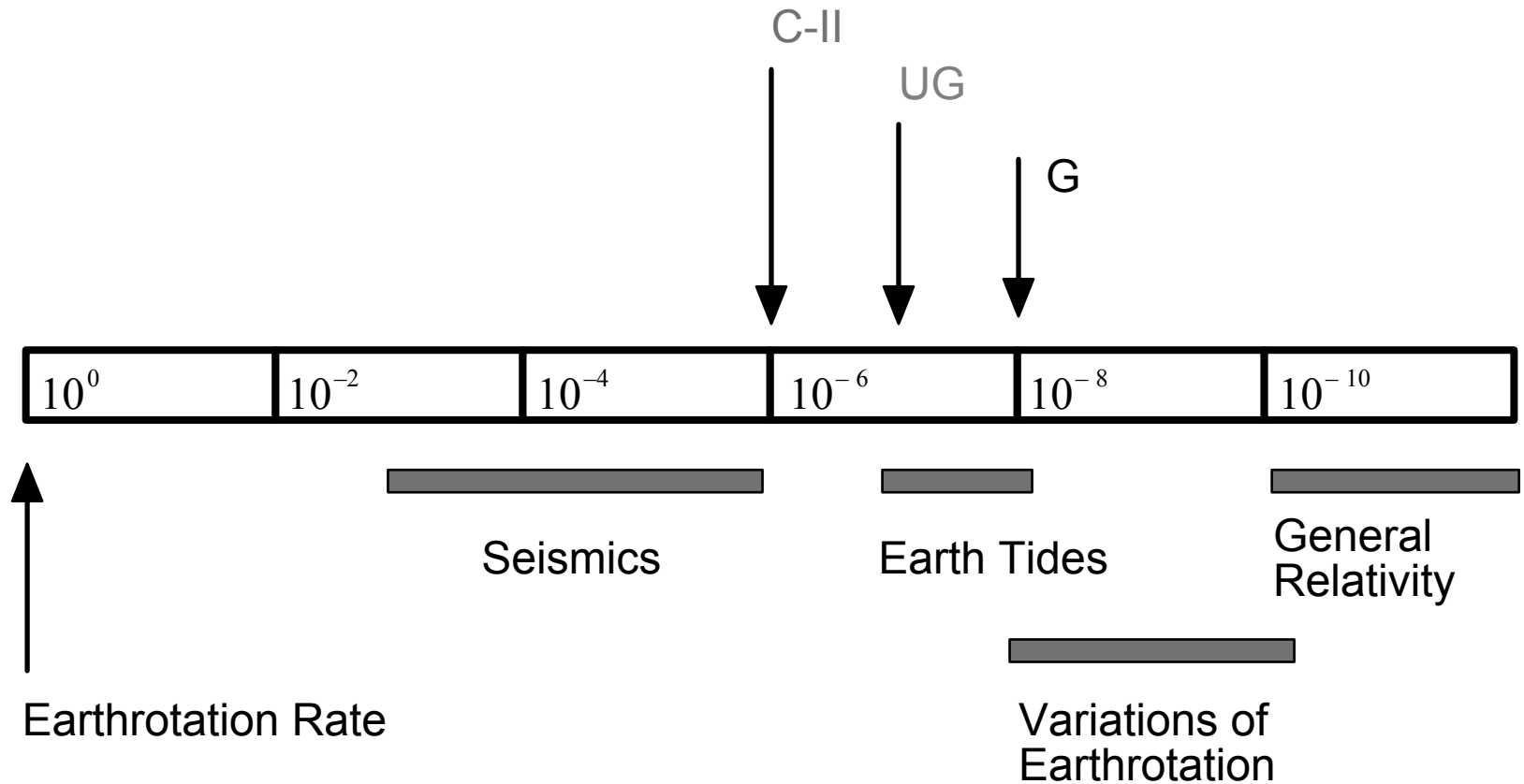
Ring	Area [ $m^2$ ]	Resolution [ $rad / s / \sqrt{Hz}$ ]	rel. Error 1 / day	Drift* [ $degree / hour$ ]
<i>C-II</i>	1	$7.2 \cdot 10^{-10}$	$7.5 \cdot 10^{-6}$	$< 4.5 \cdot 10^{-5}$
<i>G</i>	16	$9.1 \cdot 10^{-11}$	$5.6 \cdot 10^{-8}$	$< 1.8 \cdot 10^{-6}$
<i>UG1</i>	366	$7.3 \cdot 10^{-12}$	$6.6 \cdot 10^{-7}$	$< 1.5 \cdot 10^{-3}$

Yale Atom Interferometer:  $5.8 \cdot 10^{-10} \frac{rad}{s\sqrt{Hz}}$

\* taken from datasets of at least 15 days

as of April 2002

# Ring Laser Status Chart



↑  
Earthrotation Rate

RL

short-term

# Status Quo

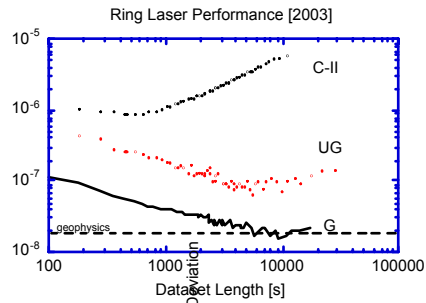
- Stability over periods longer than 1.5 days is not yet available in the ppb-domain
- Instruments could always do with more sensitivity

You are here

Stability



Instrumental Resolution

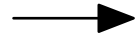


Gasdynamics  
Freq. Stab.  
Q- Factor

$$\delta f = \frac{4A}{\lambda P} \vec{n} \cdot \vec{\Omega} + f_{nr}$$

UG2  
UG100  
Hybrid

Relativity



# Installation of the Geosensor



June 2003