Ring Lasers

UG-1
Cashmere, NZ
Rectangular
21 m x 17.5 m
Sagnac ~1513 Hz

AR-1
(Under Construction)
Arkansas, USA
Triangular
55 m / Side
Sagnac ~2150 Hz

MEMORANDUM OF UNDERSTANDING

BETWEEN

HENDRIX COLLEGE, Conway, AR, USA, represented by the DEPARTMENT OF PHYSICS (DOP)

AND

the FORSCHUNGSGRUPPE SATELLITENGEODÄSIE (FGS) represented by FORSCHUNGSEINRICHTUNG SATELLITENGEODÄSIE (FESG) of the TECHNICAL UNIVERSITY OF MUNICH.

AND

THE UNIVERSITY OF CANTERBURY (UoC), CHRISTCHURCH, NEW ZEALAND represented by DEPARTMENT OF PHYSICS AND ASTRONOMY (DPA)

DOP, FESG and DPA recognise that they have research interests in common in the development of ring-laser gyroscopes and that there will be mutual benefits from closer collaboration and co-operation. In order to facilitate such collaboration, the parties agree to establish a framework for co-operative activities.

- From time to time, a current work plan for activities will be prepared and will constitute an annex to this agreement.

- It is agreed that this linkage will facilitate short- and long-term personnel visits between Hendrix College, UoC and FGS to exchange information and to plan and undertake specific co-operative projects.

- It is agreed that certain collaborative activities can be carried out using existing resources. Other activities will require added funding and all institutes agree to work together in the joint development of proposals to external funding agencies.

- The parties do not intend this Agreement to be a binding contract. It serves only as a record of their consensus pending execution of specific agreements which result from specific projects jointly completed as a result of this Agreement. Without limiting the generality of this clause, the parties acknowledge that this Agreement does not constitute, create, give effect to, or otherwise imply a joint venture, partnership or formal business organisation of any kind, nor an obligation or commitment on the part of either party to submit a proposal to or to perform a contract with the other party.

- The parties agree that all the results of their co-operative effort shall, unless there is specific agreement to the contrary, be jointly owned and any commercial exploitation of the intellectual property shall be the subject of a separate agreement.

- The parties agree that they may during the course of their collaboration be given access to confidential information of the other parties and these results and the results of their collaborative work should be treated as confidential to the parties. All parties agree to enter into proprietary information agreements as and when requested by the other party.

- This agreement shall come into effect when signed by all parties. Within an initial three year period, the terms of the Agreement may be altered subject to approval by each party.

Signed on behalf of

Hendrix College
by
Robert L. Entzminger President and Dean of the College
Chief Executive Officer

Date: Dec. 17, 2003

In the presence of:

Name: Sharon E. Allard

Occupation: Assistant

Address: Hendrix College

Signed on behalf of

FORSCHUNGSEINRICHTUNG SATELLITENGEODÄSIE
by M. Rothacher
Chief Executive Officer

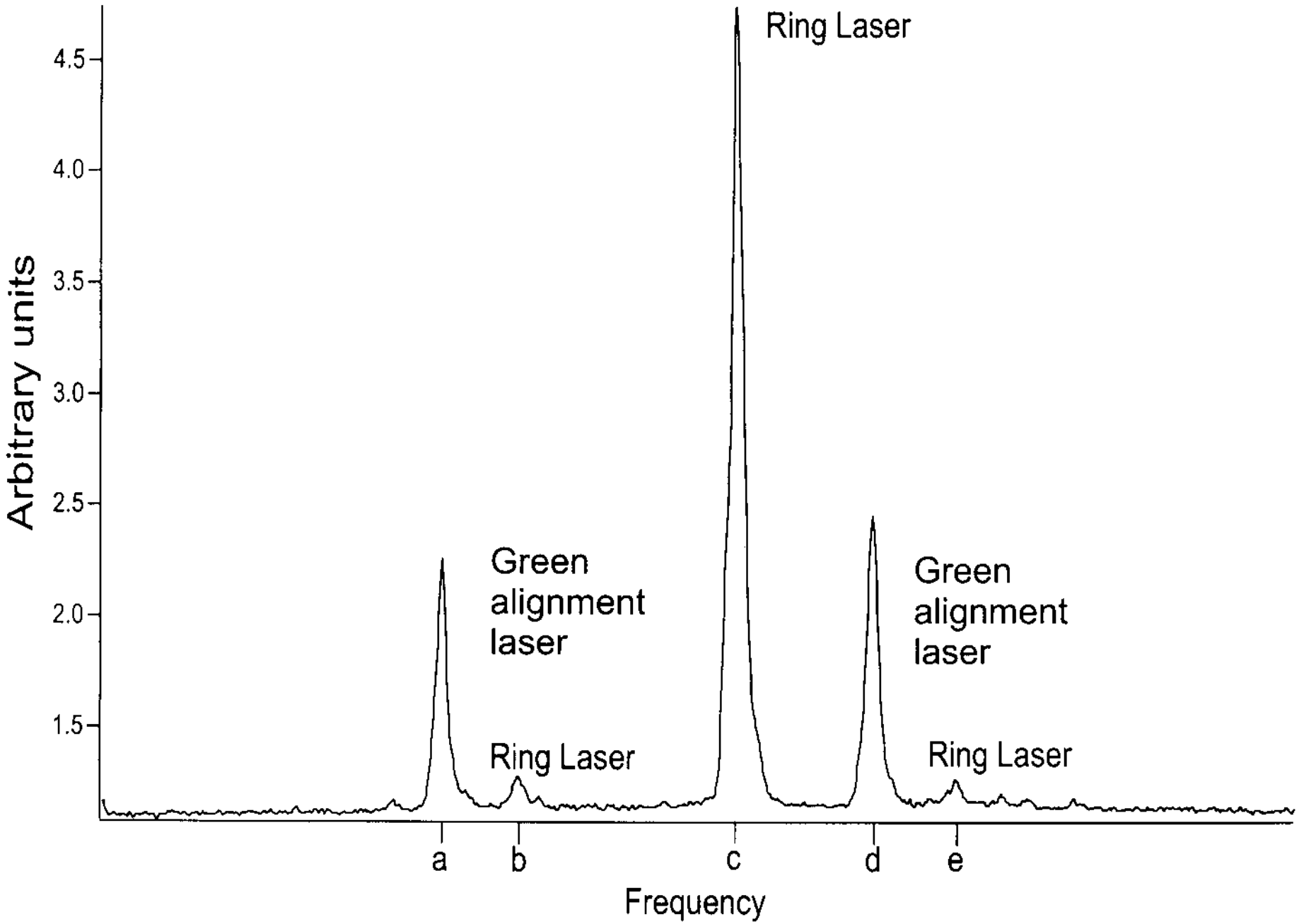
Date: 28.11.03

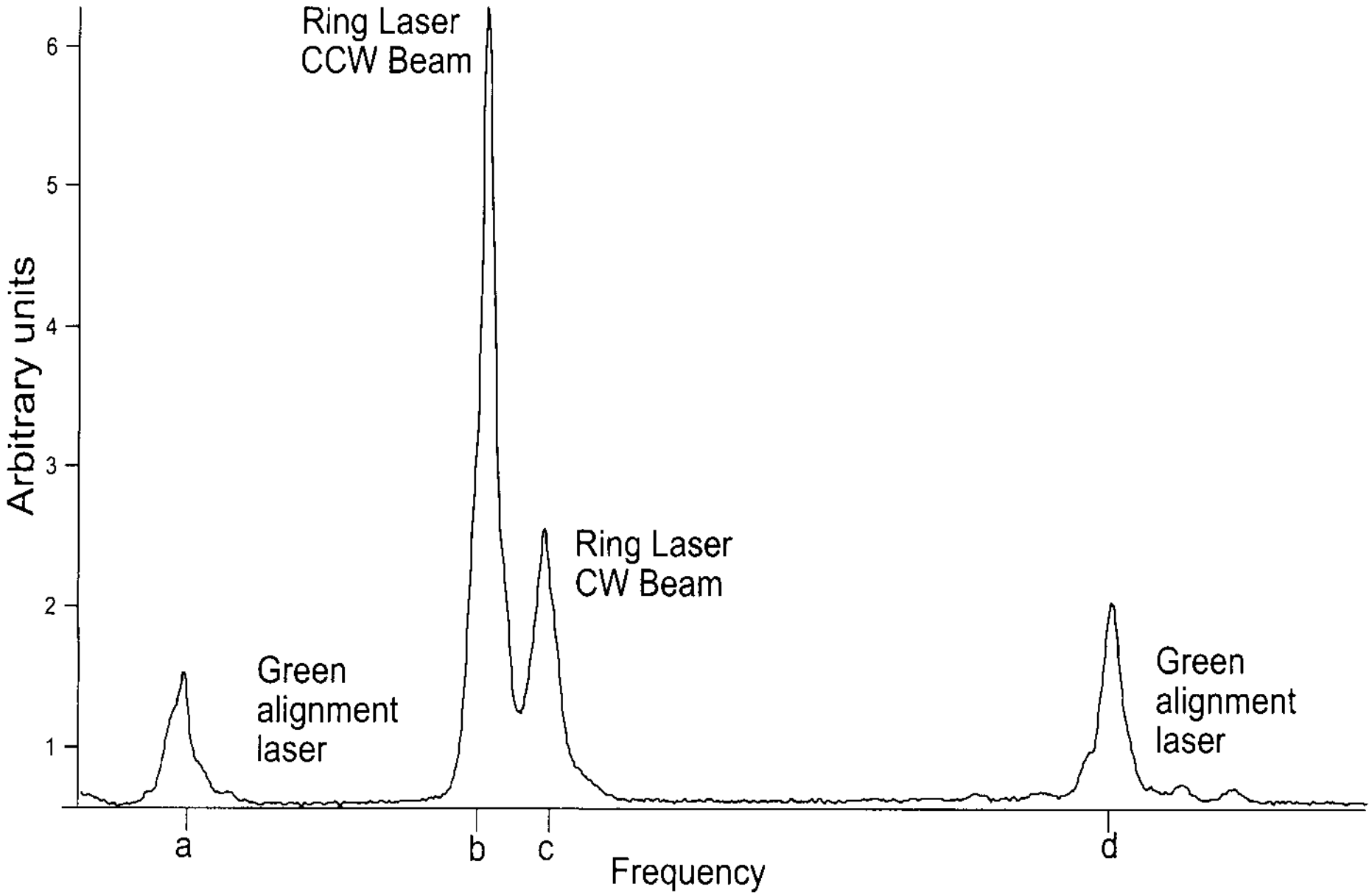
In the presence of:

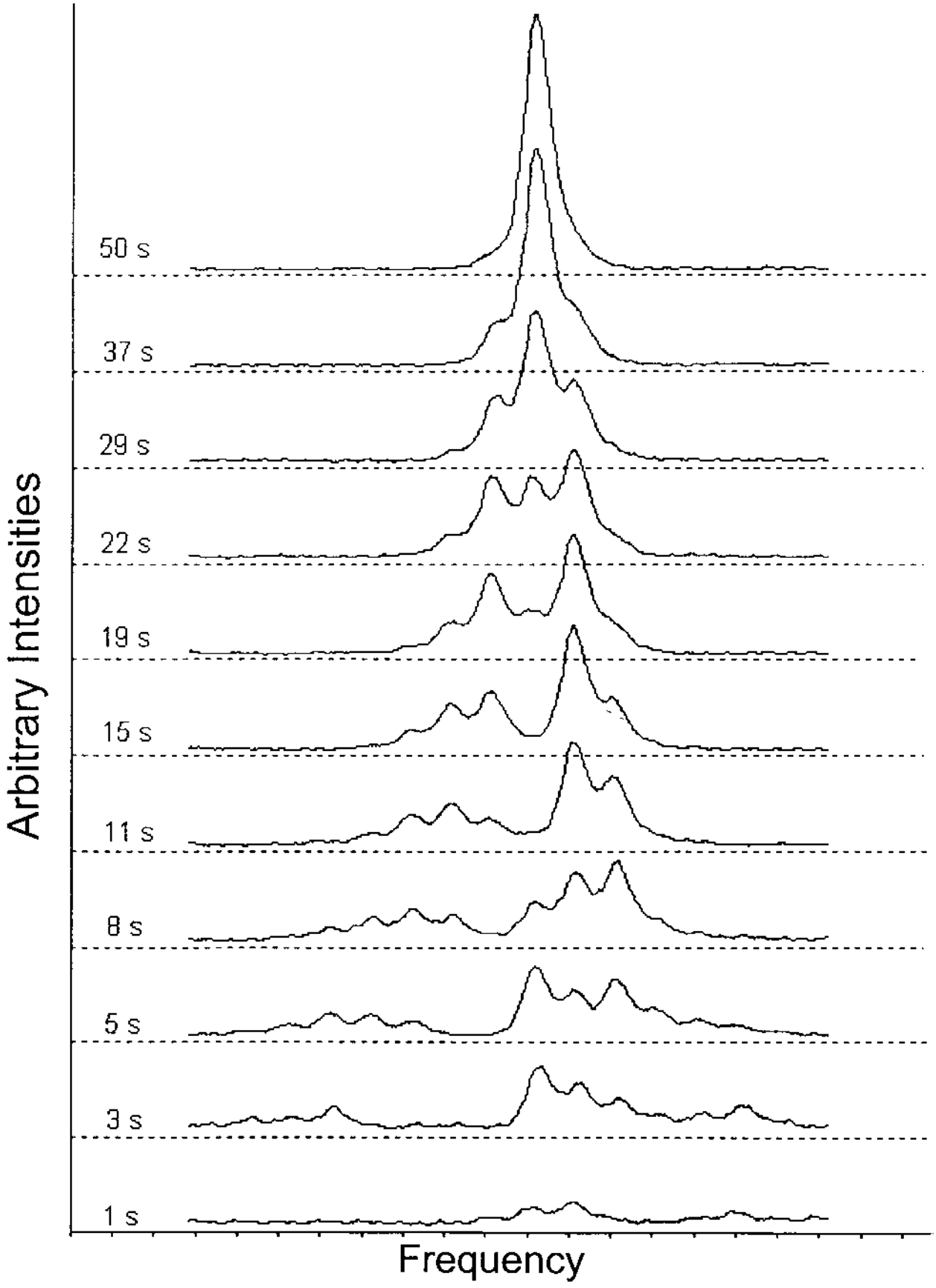
Name: M. Thaller

Occupation: TECHNISCHE UNIVERSITÄT MÜNCHEN
Forschungseinrichtung - Satellitengeodäsie
ARCISSTRASSE 21 · D-80333 MÜNCHEN

Address:


Ring Laser
4.5
4.0
3.5
3.0
2.5
2.0
1.5
Arbitrary units
Green alignment laser
Ring Laser
Green alignment laser
Ring Laser
a
b
c
d
e
Frequency


Ring Laser
CCW Beam
Ring Laser
CW Beam
Green
alignment
laser
Green
alignment
laser
Arbitrary units
6
5
4
3
2
1
a
b
c
d
Frequency


50 s
37 s
29 s
22 s
19 s
15 s
11 s
8 s
5 s
3 s
1 s
Arbitrary Intensities
Frequency

The Biggest Laser Gyro in the World

Ring laser developments in Cashmere cavern and beyond, 1985-2002

People currently involved:

Geoff Stedman
Ulli Schreiber
Bob Dunn
Rob Thirkettle
Graeme MacDonald
Clive Rowe
Bob Hurst
David Wiltshire
Bryn Currie

Chronology of Cashmere Ring Laser developments

1988 C1 ~0.7 m^2

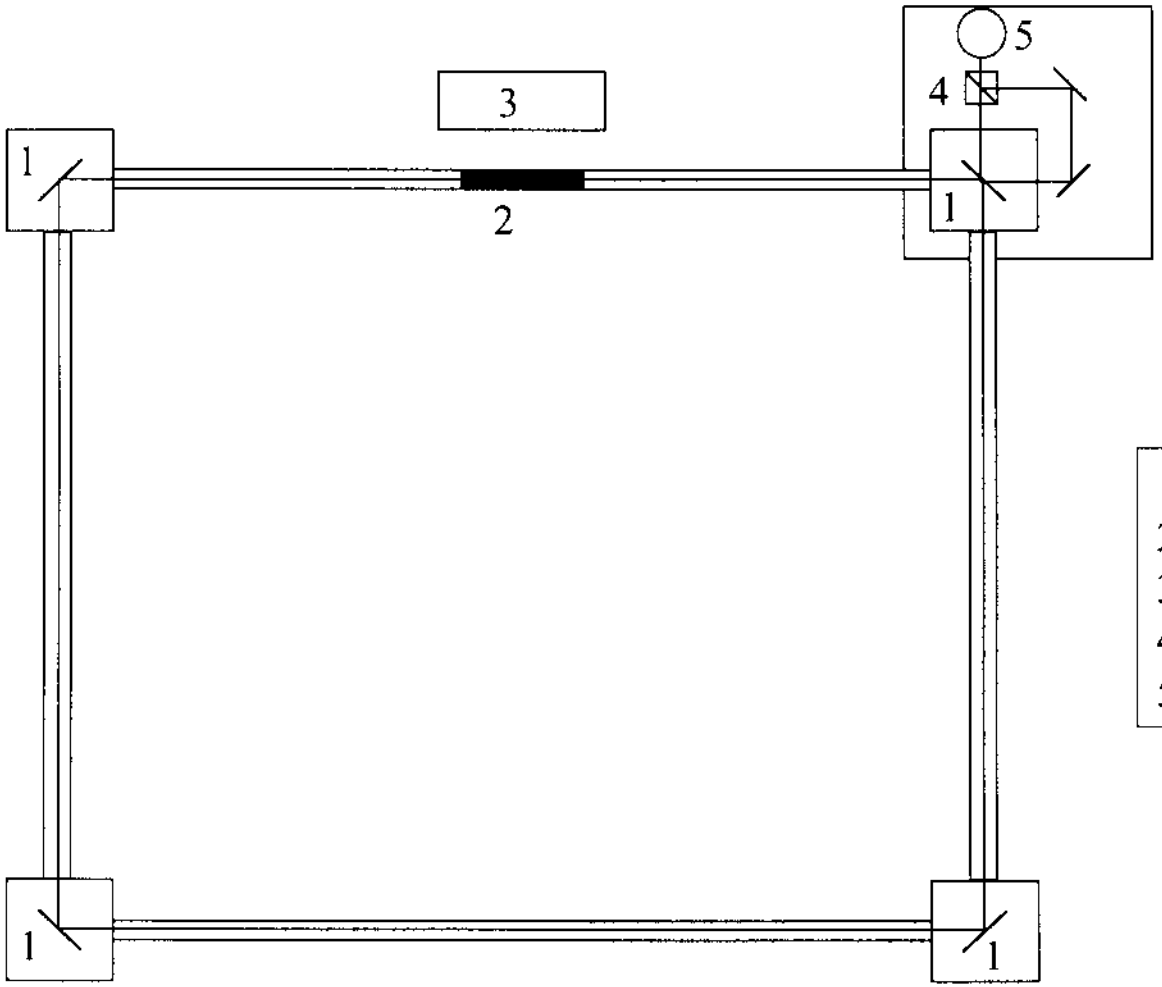
1997 C2 1 m^2

1997 G0 (Prototype for G) ~12 m^2

2000 UG1 (Ultra-grossring) ~370 m^2

2004 UG2? ~840 m^2

Layout of UG-1



1	*Corner boxes*
2	*Plasma tube*
3	*RF generator*
4	*Beamsplitter*
5	*Photomultiplier*

UG-1 vital statistics

Cavity dimensions		17.5 m x 21 m
Sagnac frequency from earth rotation		1512.8 Hz
Laser wavelength	633.0 nm	
Mirrors: *Reflectivities*		0.999988
Radii of curvature	20 m	
Ring-down time		~1 ms
Output power		~10-20 nW
Gas fill		Ne_{20},Ne_{22} 0.2 mb He 8 mb

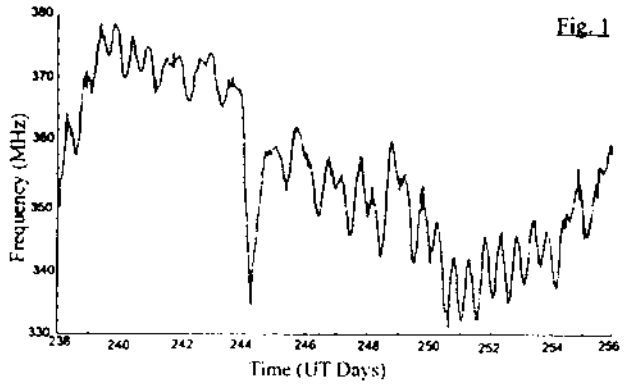


Fig. 1

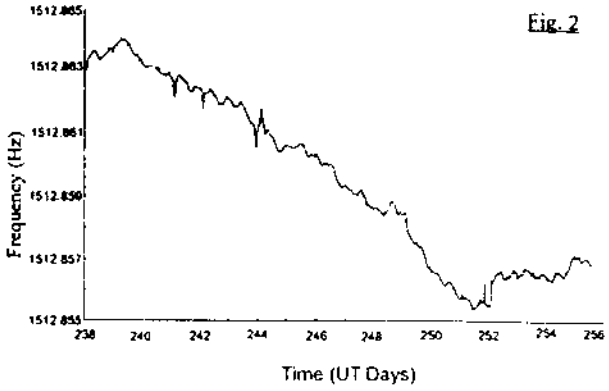


Fig. 2

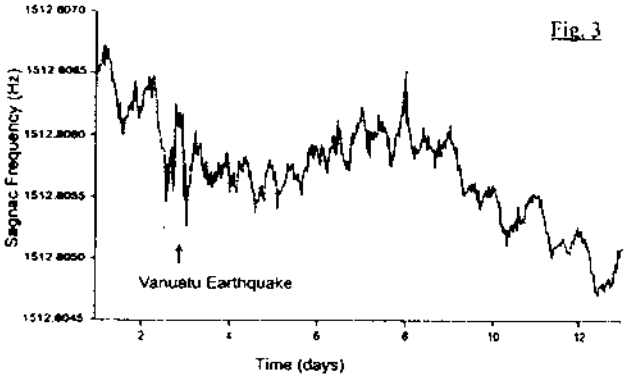


Fig. 3

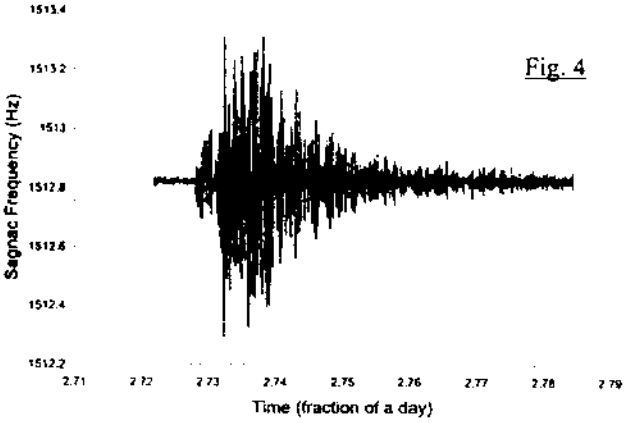


Fig. 4

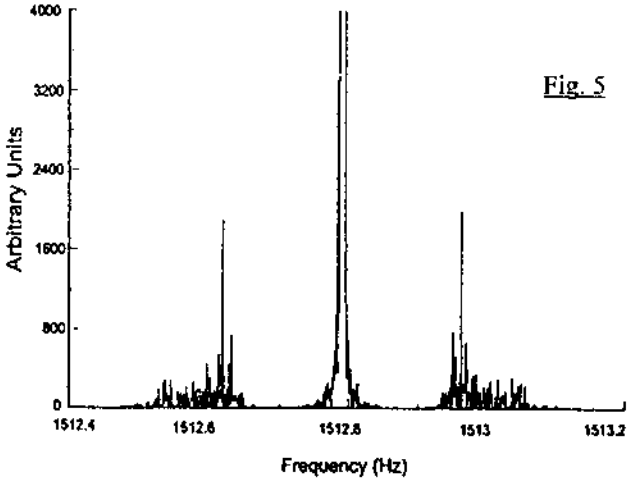


Fig. 5

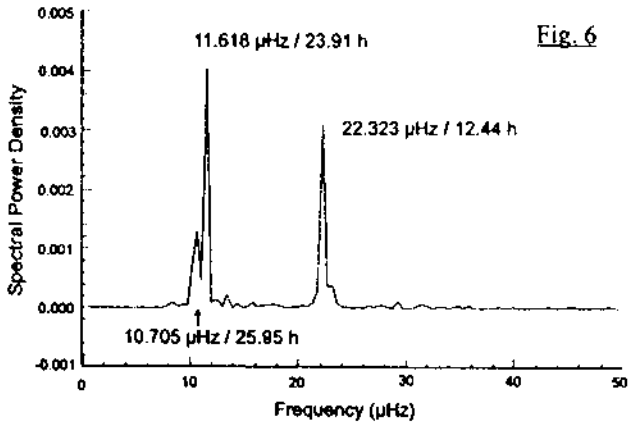


Fig. 6

Measurement of small angular disturbances

The ring lasers are usually thought of as measuring ***rotation rate***, but the signal can easily be processed to extract ***angular deviation*** in the laboratory frame.

Relative to the (actually rotating) lab frame, rotations appear as phase perturbations of the Sagnac signal.

$$\Delta\phi = \frac{8\pi A}{\lambda p}\,\Delta\theta$$

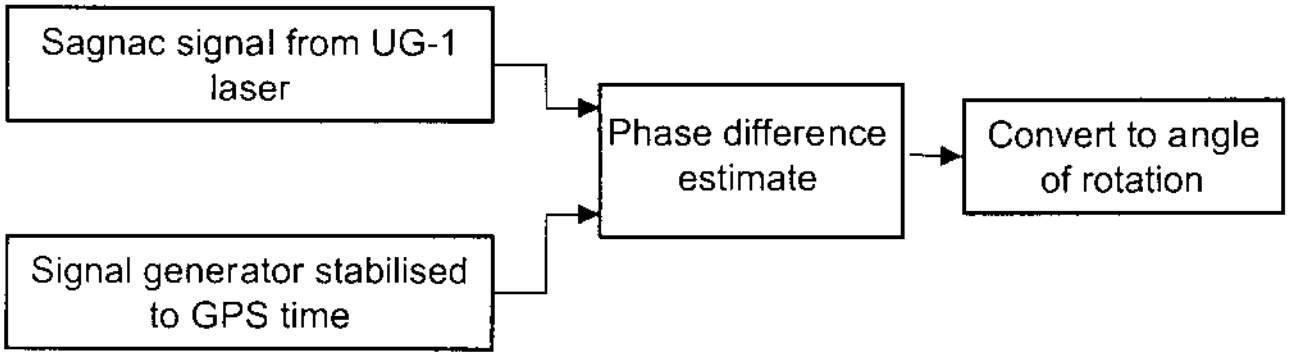
where: $\Delta\theta$, $\Delta\phi$ are angle and phase perturbations

A = area of laser

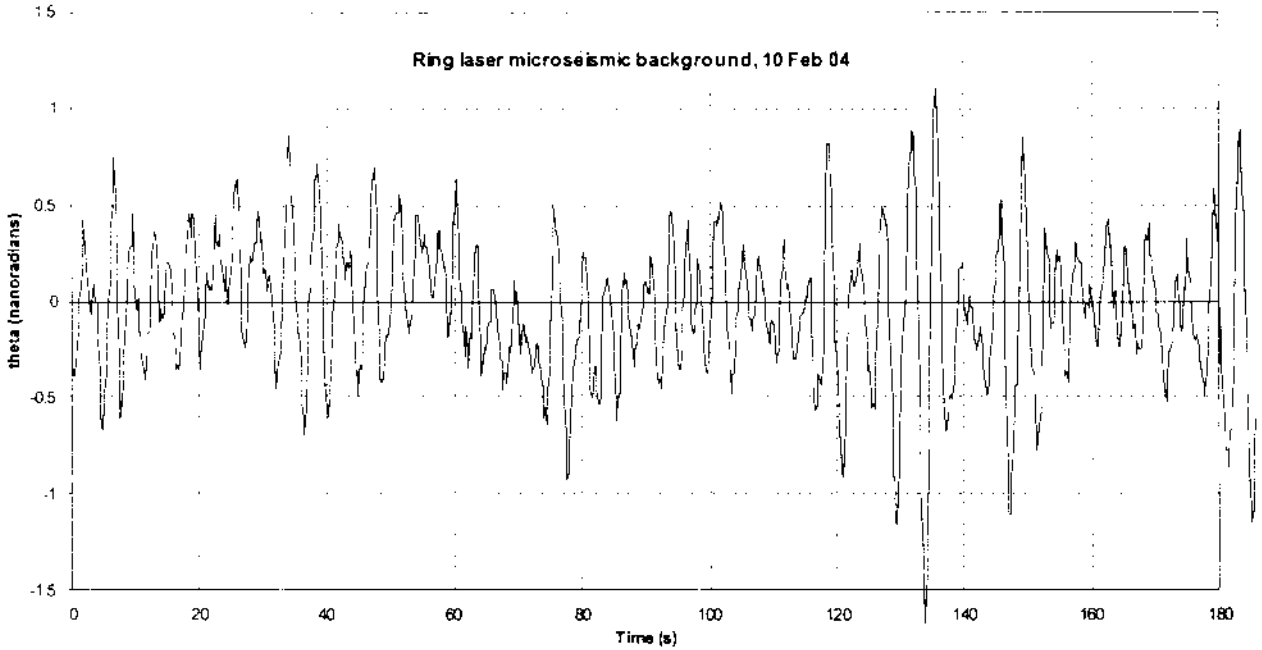
p = perimeter

($\Delta\theta = 5.3 \times 10^{-9}\,\Delta\phi$ for UG-1)

This description often makes more sense for small rapid transients.



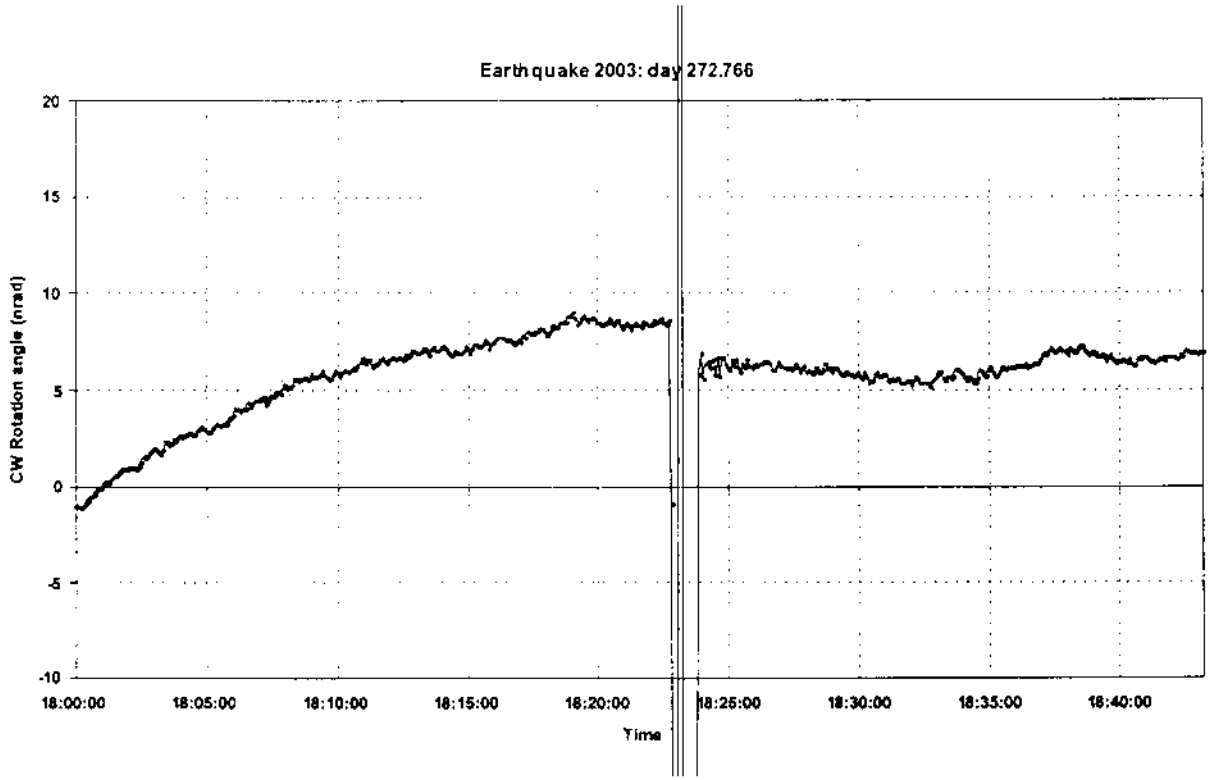
Microseismic background rotations



Always present;

Amplitude varies by factor ~2 on timescale of days;

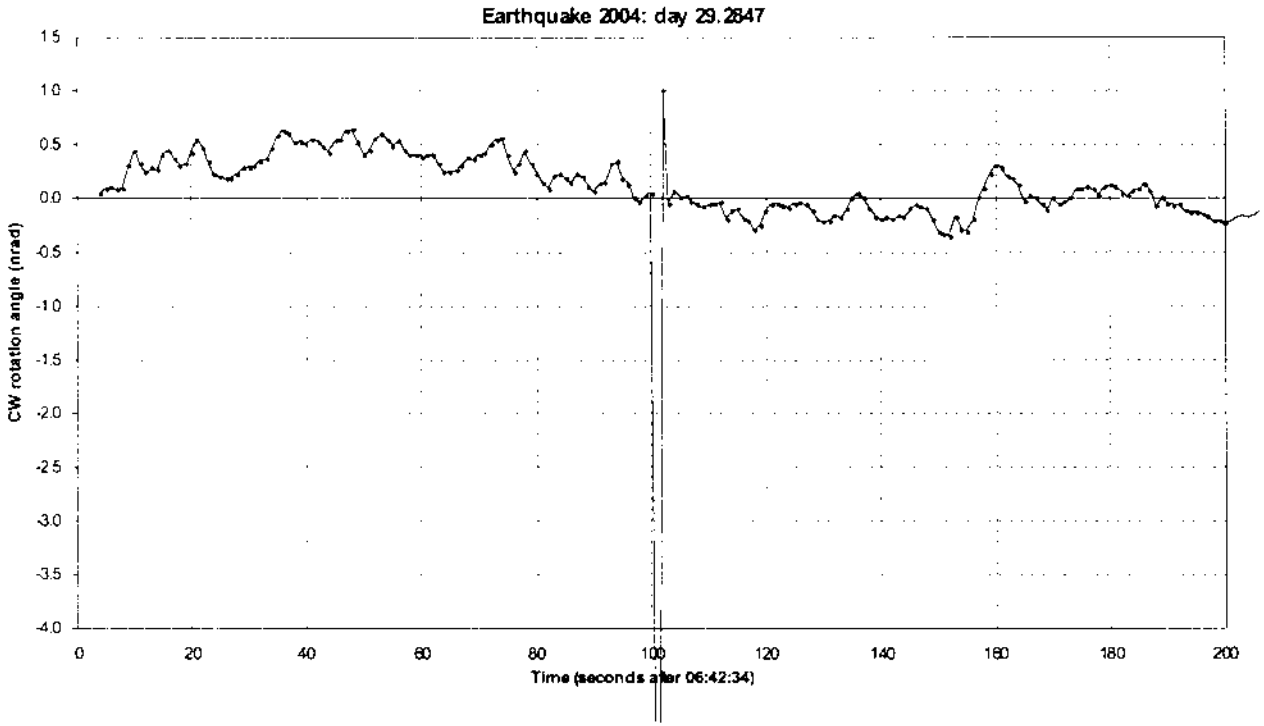
Quasi-sinusoidal, period ~5 s (the record shown is very typical).



Example 1:

Magnitude 4.9, 40 km NW from Cashmere, depth 30 km

There appears to be a residual rotation of -2.5 nrad.



Example 2:

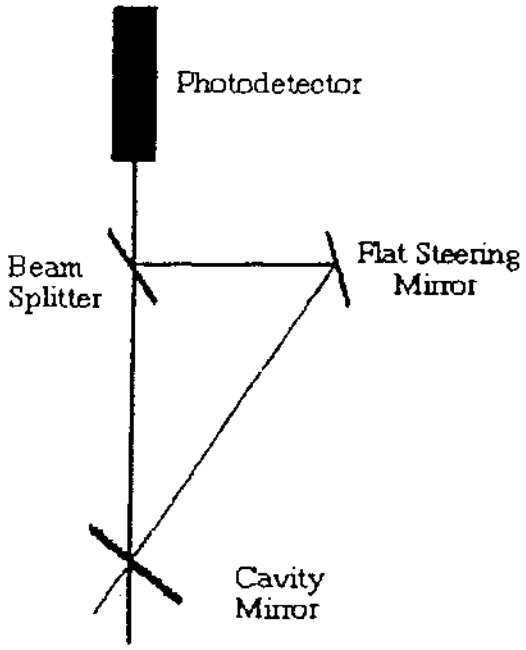
Magnitude 3.6, ~5 km from Cashmere, depth 11 km

No residual rotation at ~0.2 nrad level!

For this example, the *absence* of residual rotation is becoming difficult to explain, for reasonable choice of source parameters.

Large Triangular Ring Laser for Earth Science Measurements

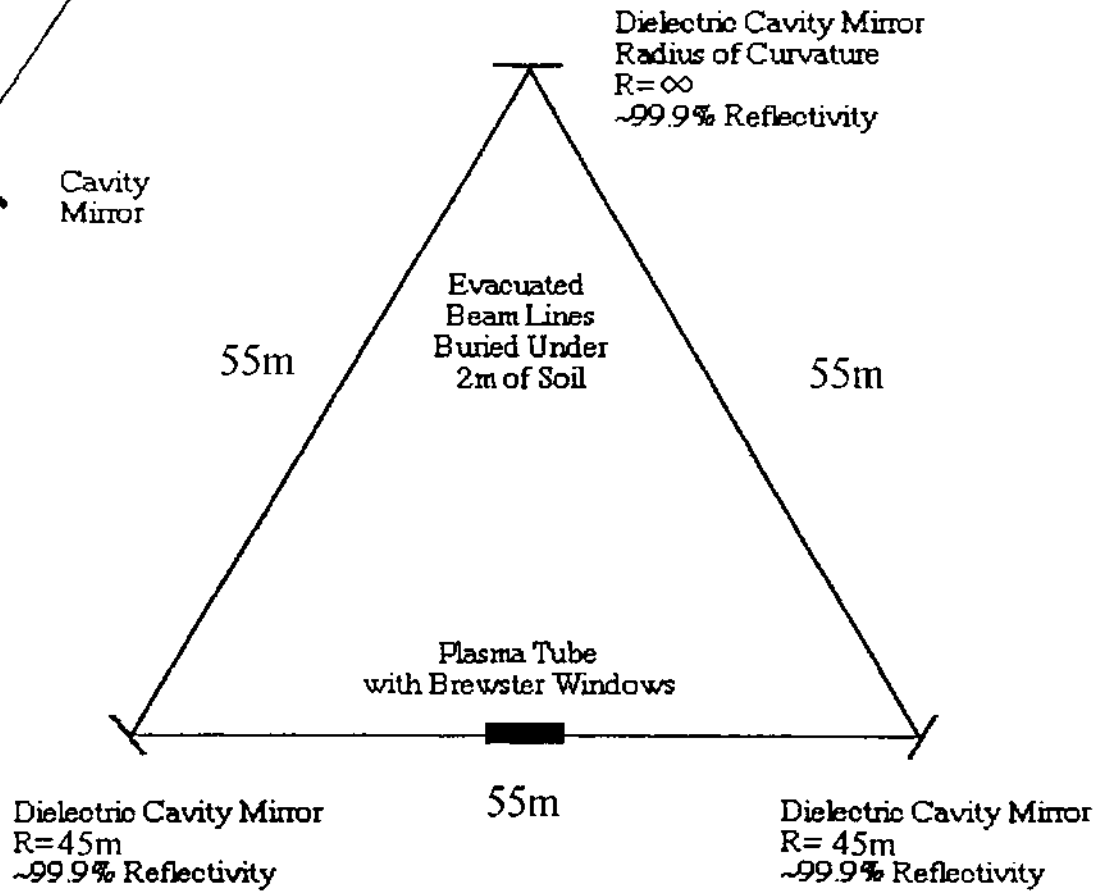
Combining Optics



Sagnac Frequency

$$\Delta f = \frac{4A \cdot \Omega}{\lambda p} \sim 2{,}150 \text{ Hz}$$

Laser Cavity



*the path length control for the laser cavity is not shown