Update on White-light Interferometry Experiment

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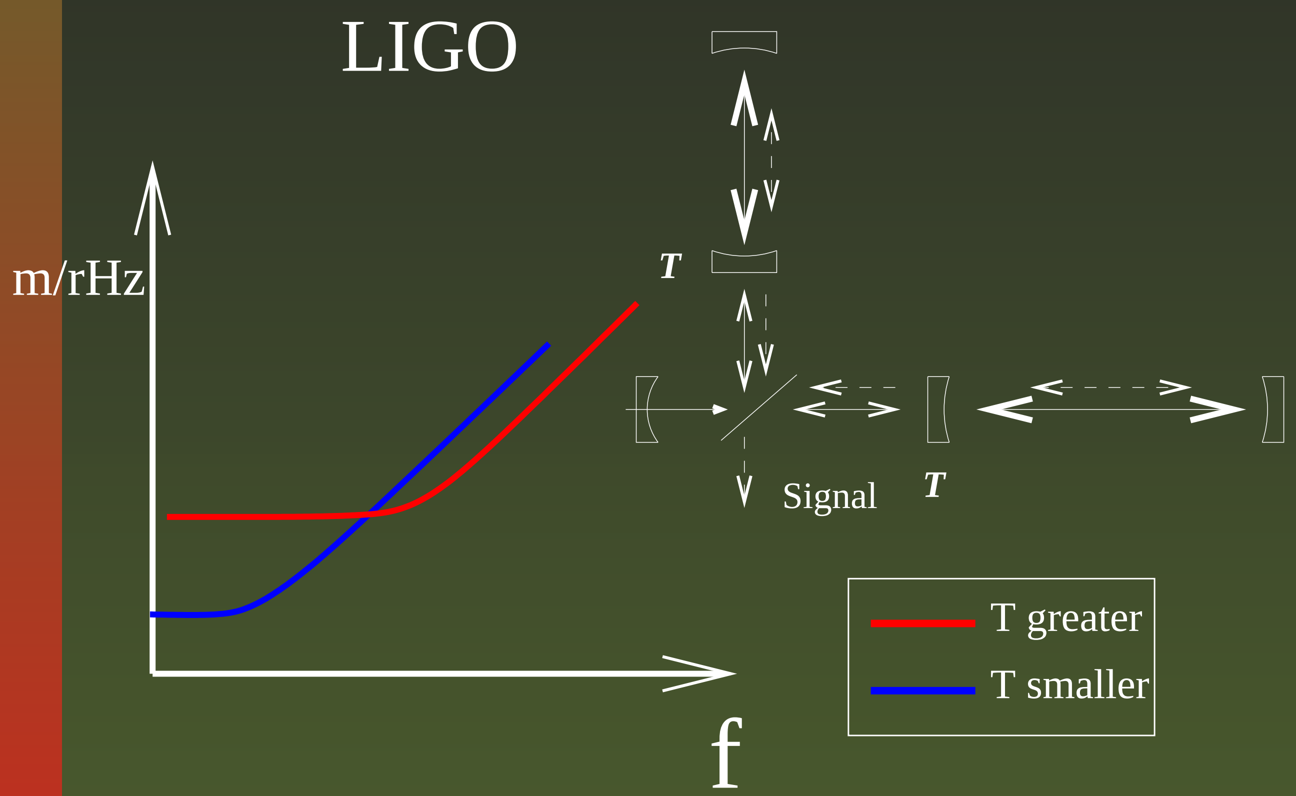
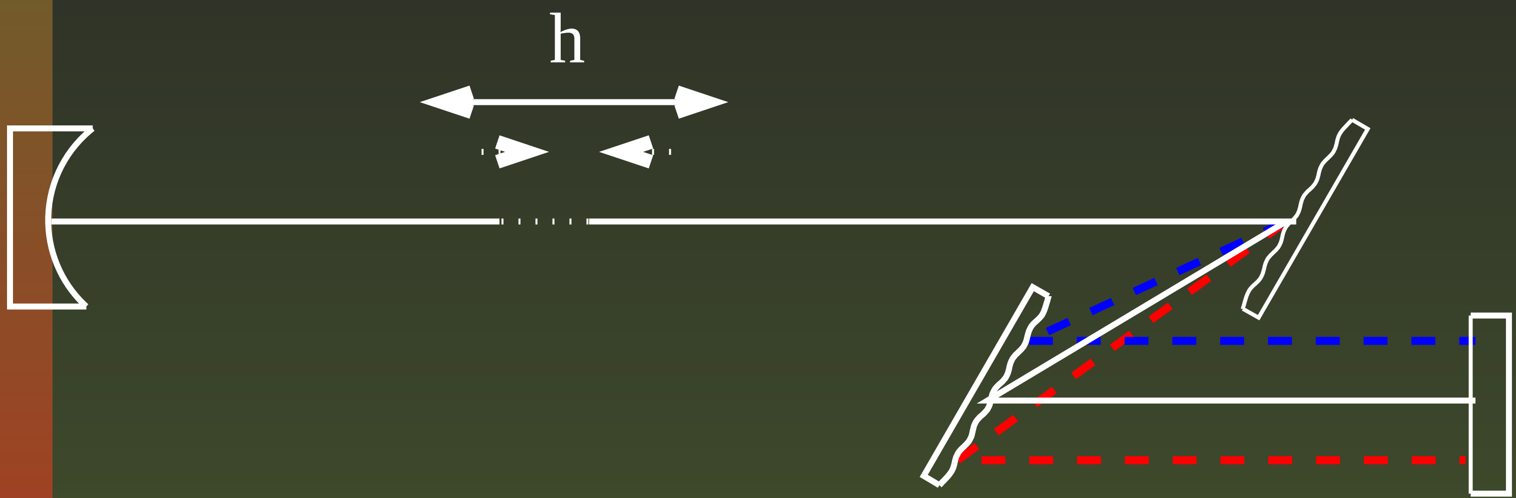
The Motive



Bandwidth limited by Gain:
(T = Intensity Transmittance)

$$B \propto T \qquad G \propto 1/T$$

The Problem/The Idea



ϕ : round-trip phase shift $= \dfrac{2\pi L}{\lambda}$

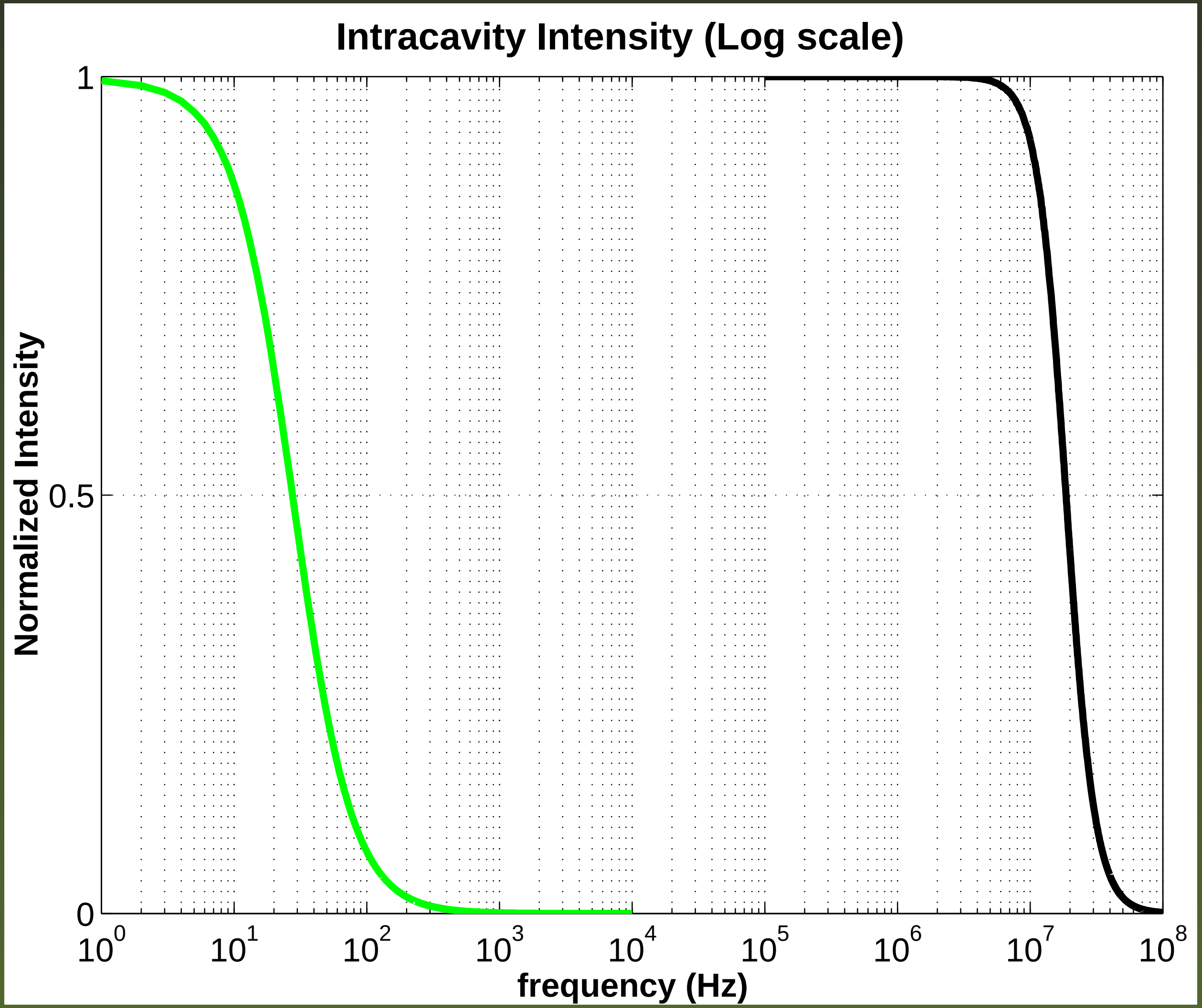
Modify optical path length

$$\rightarrow \phi_{WL} = \frac{2\pi L(\lambda)}{\lambda} = constant$$

If $\frac{\partial \phi_{WL}}{\partial \lambda} = 0$, a “white-light cavity”

The Concept

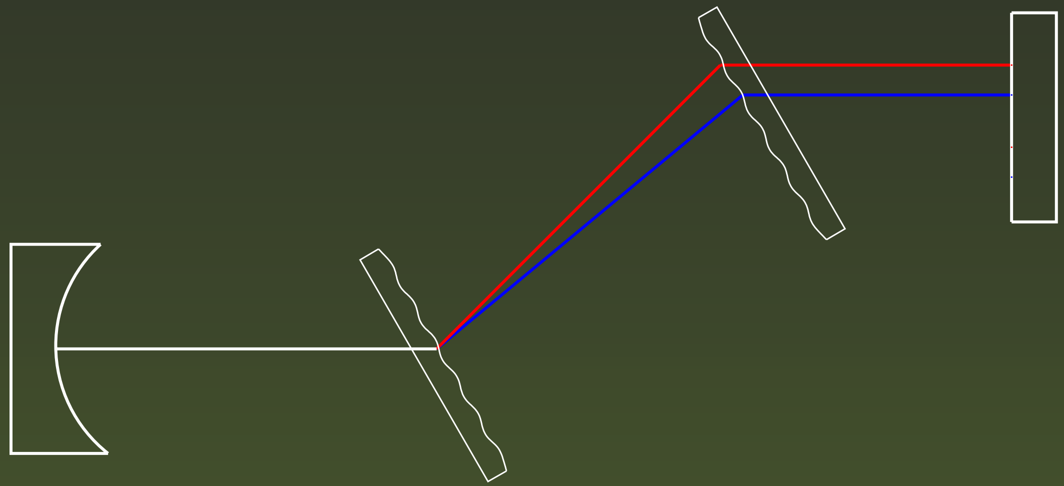
Comparison of bandwidths (static frequency response)



$T = 0.5\%$

White-Light Trials

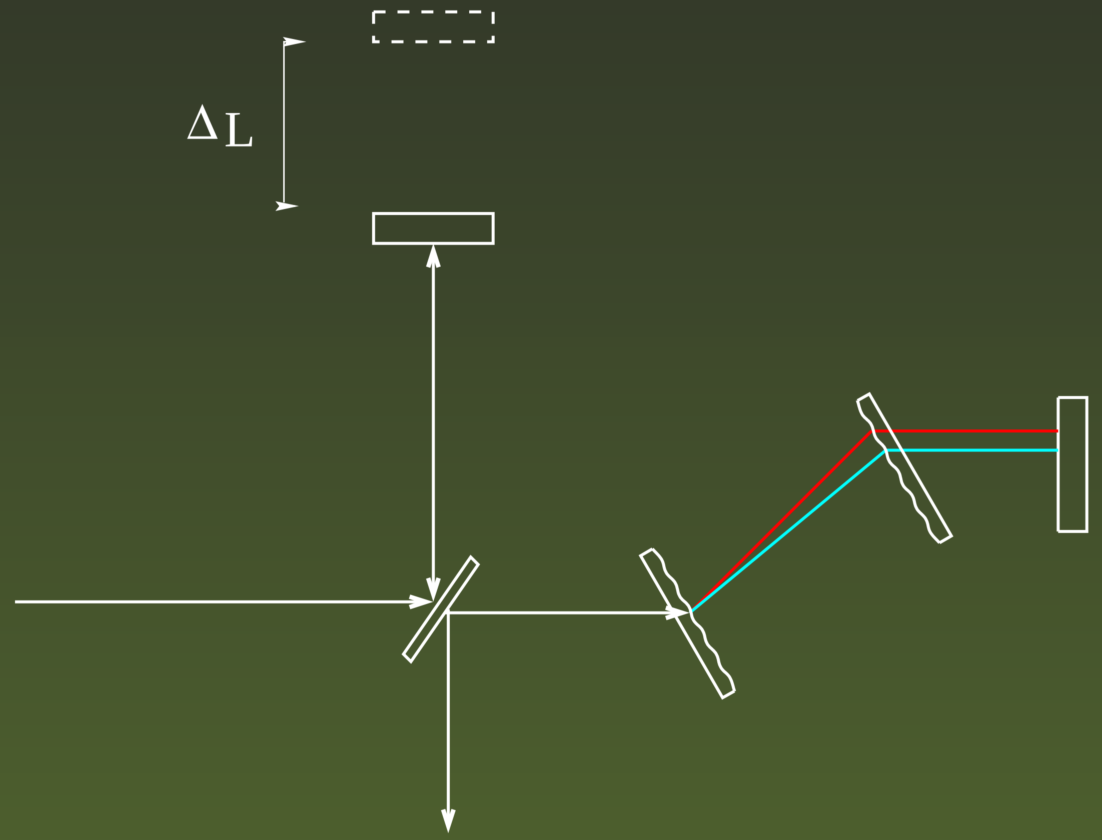
Grating-enhanced cavity



- high efficiency (95%) gratings with 1500 gr/mm
- 10 cm perpendicular distance
- incident angle of 43 degrees
- $1.064\mu m$ diode laser with 7 GHz continuous f tuning

White-Light Trials

De-whiten an interferometer?

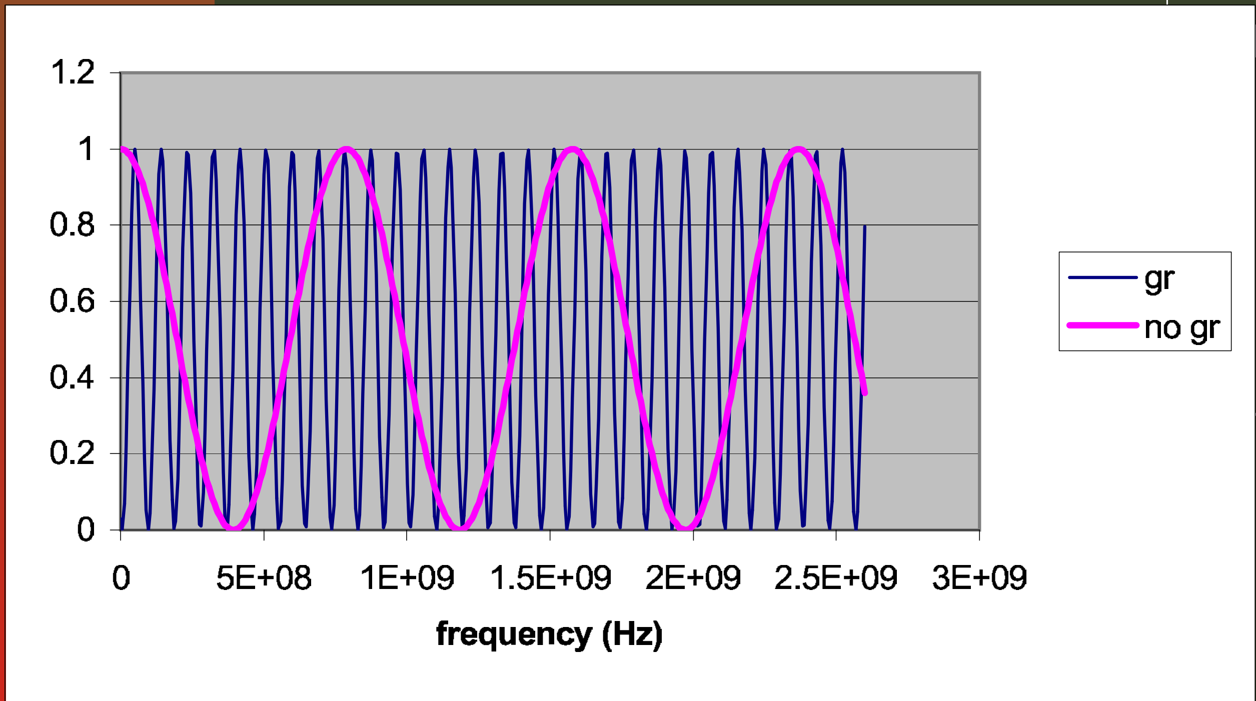


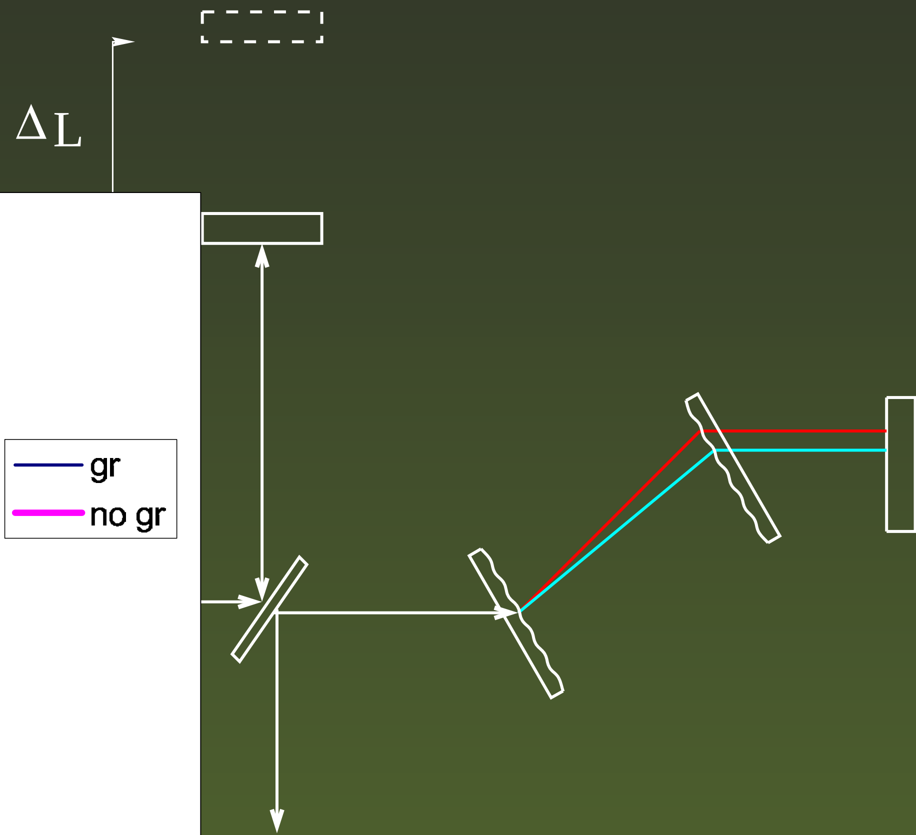
$$\cos\left(\frac{2\pi\Delta L f}{c}\right)$$

White-Light Trials

De-whiten an interferometer?

Predicted Result

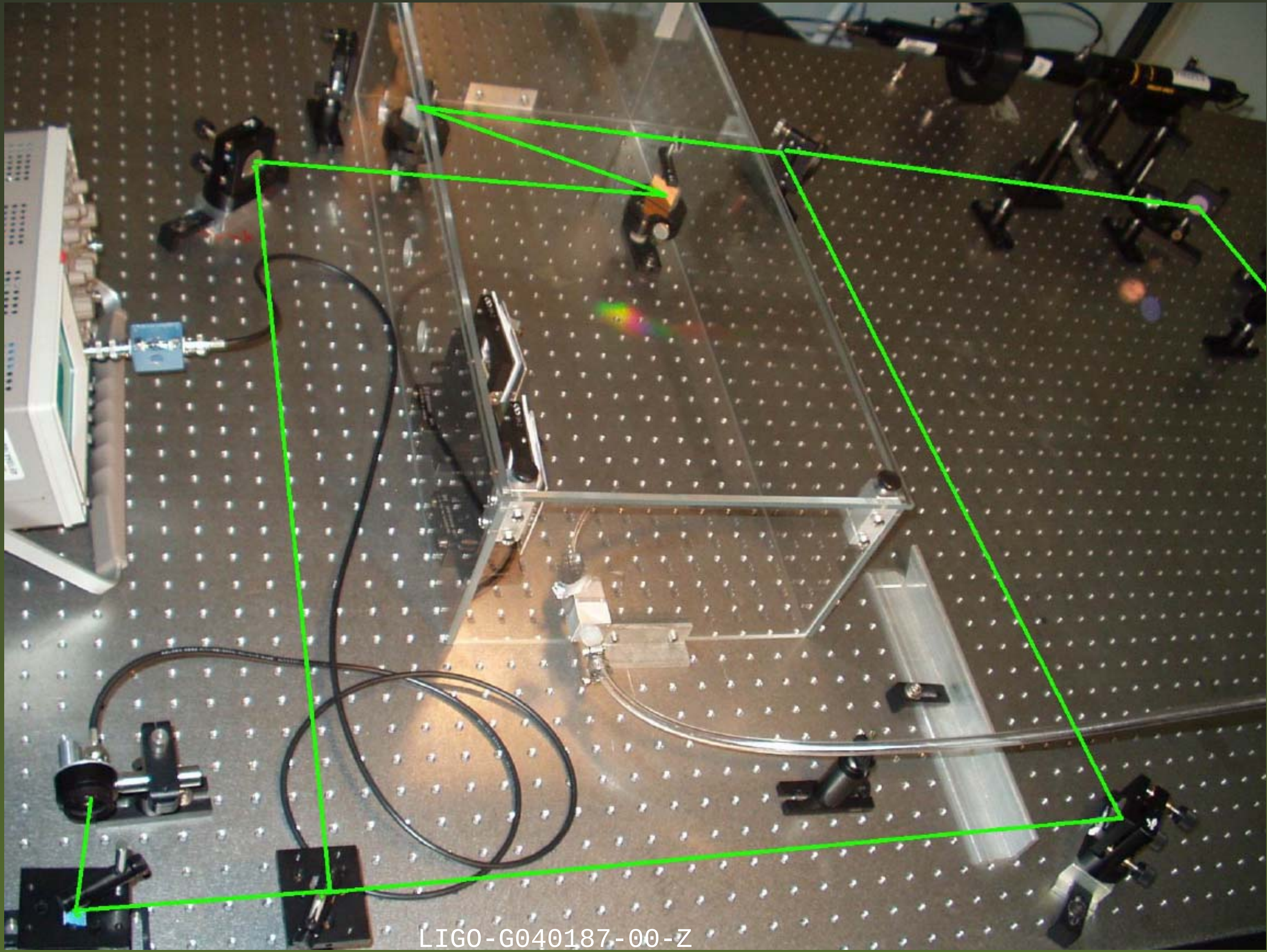




$$\cos\left(\frac{2\pi \Delta L f}{c}\right)$$

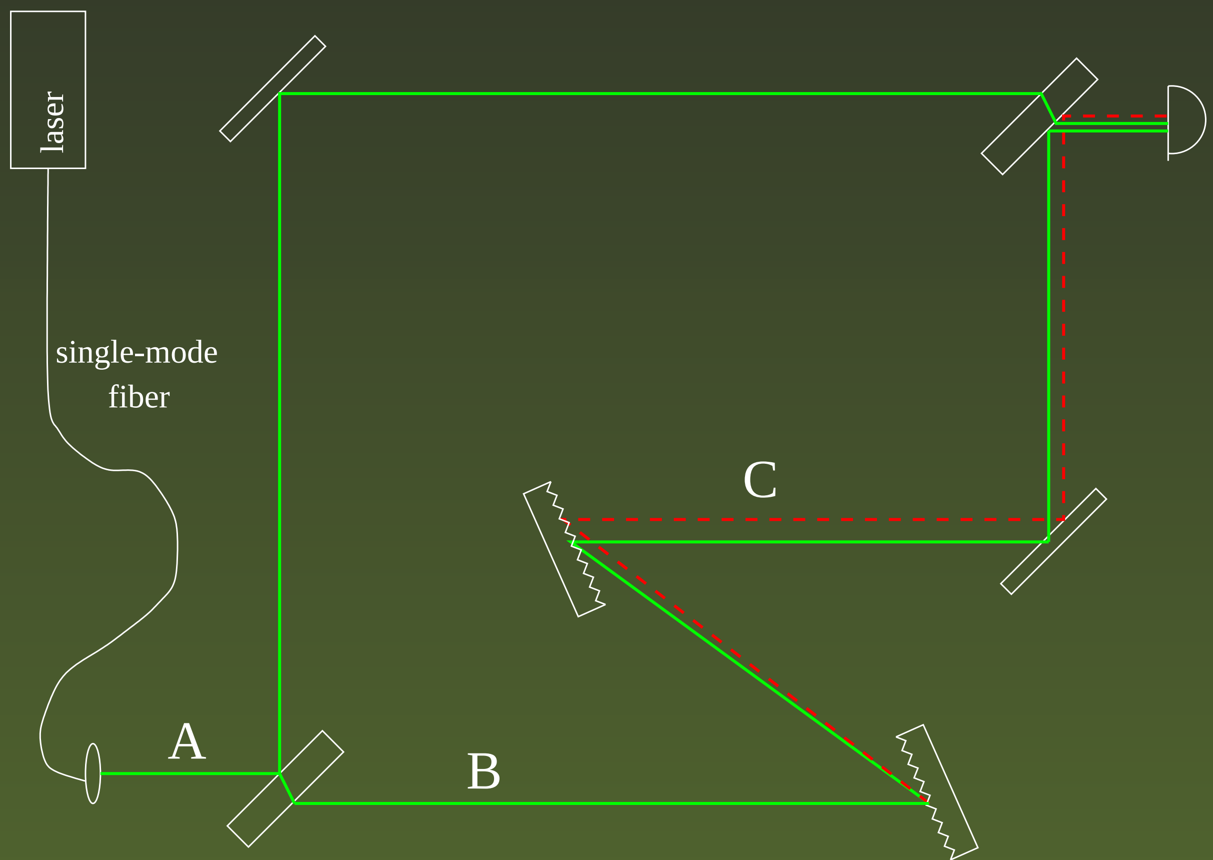
White-Light Trials

Table-top experiment at UF



White-Light Trials

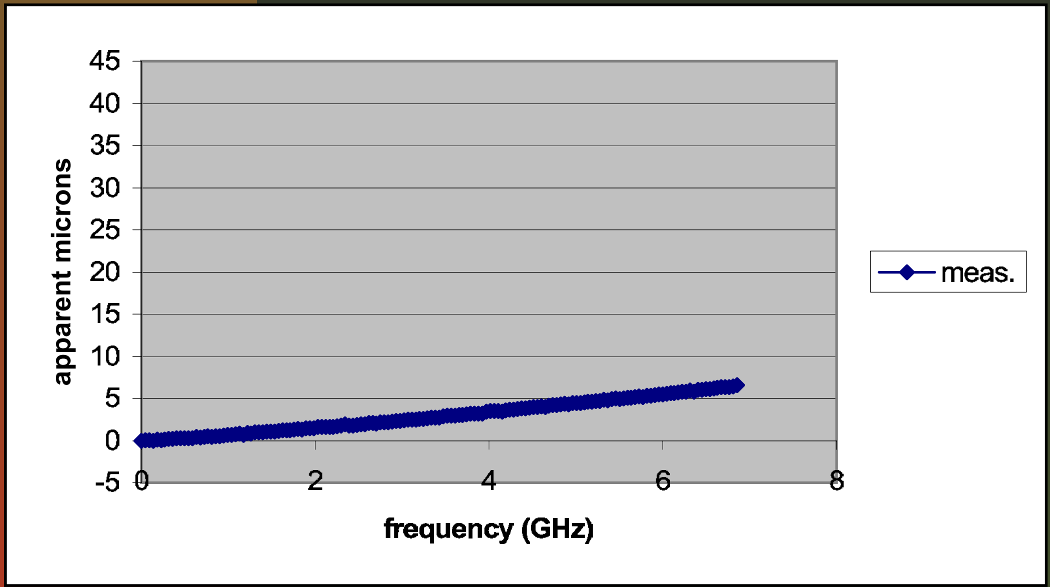
Grating-Enhanced Mach-Zender IFO



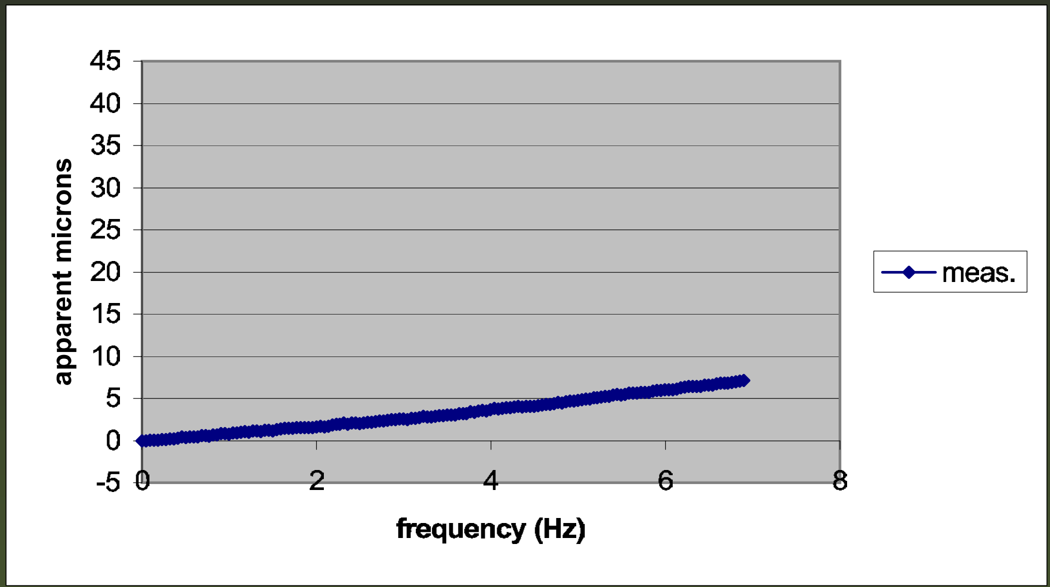
Measure beam position at A, B and C to confirm pathlength variation

White-Light Trials

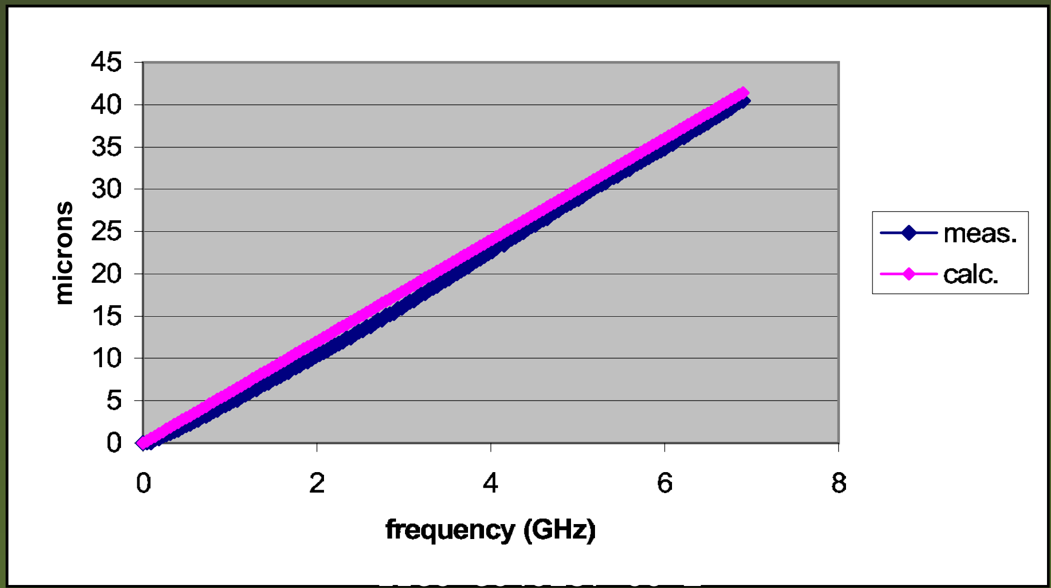
Point A



Point B

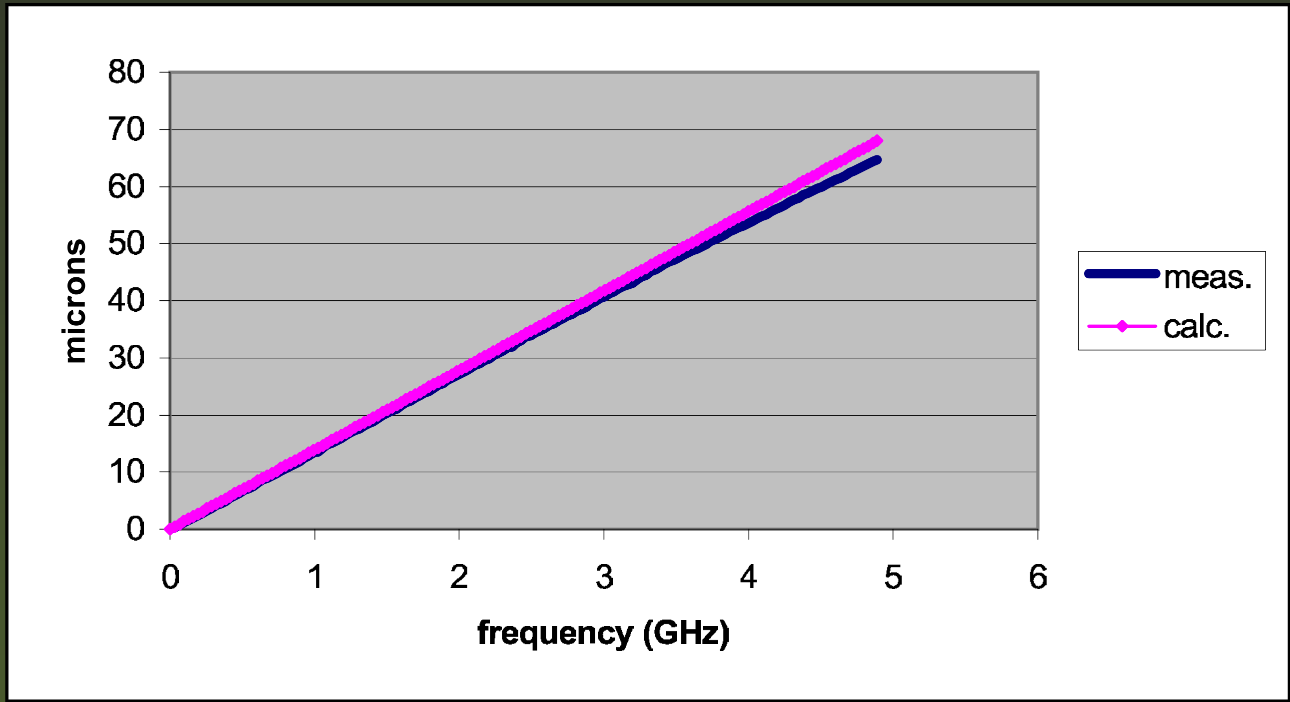


Point C



White-Light Trials

Grating tests



$L(\lambda)$ is
as predicted

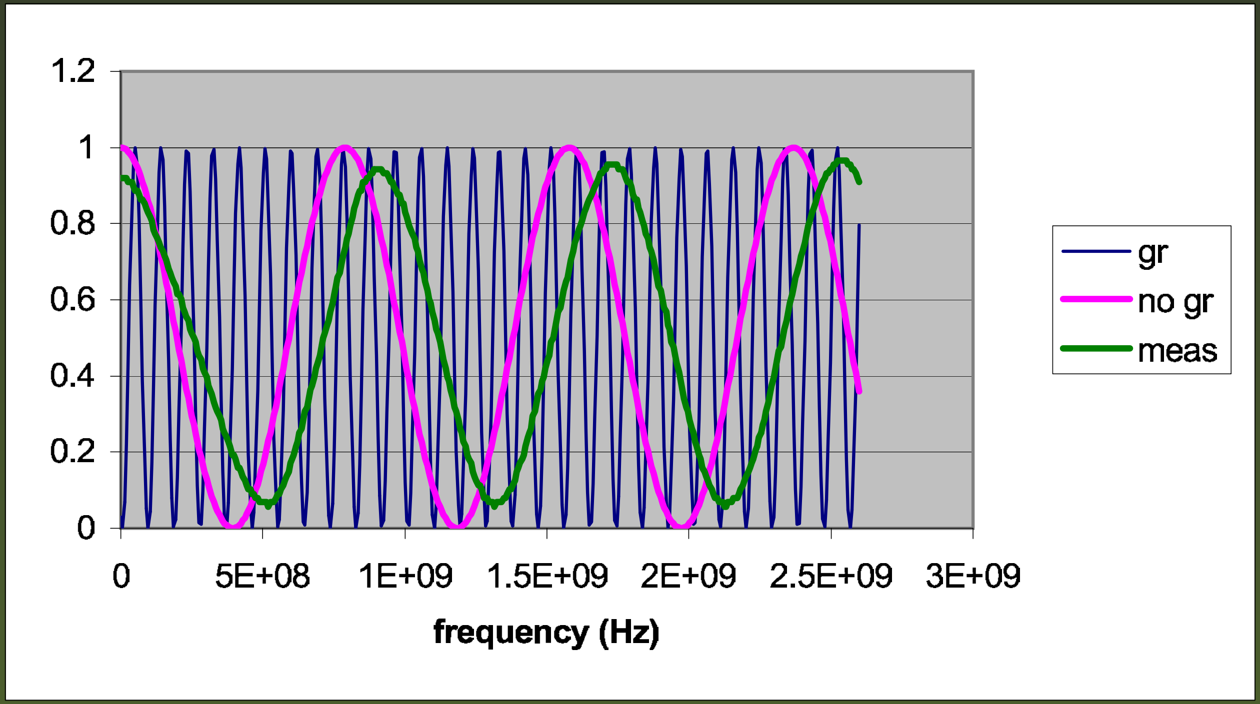
Grating equation

$$sin(\beta(f)) = \frac{c}{df} - sin(\alpha)$$

White-Light Trials

$L(\lambda)$ OK, but $\Phi(\lambda)$ is not!

Mach-Zender Output Intensity



evidence that phase shifts have same frequency-dependence in each arm

Phased and Confused

Evidently, $\Phi(\lambda) \neq \frac{2\Pi L(\lambda)}{\lambda}$!

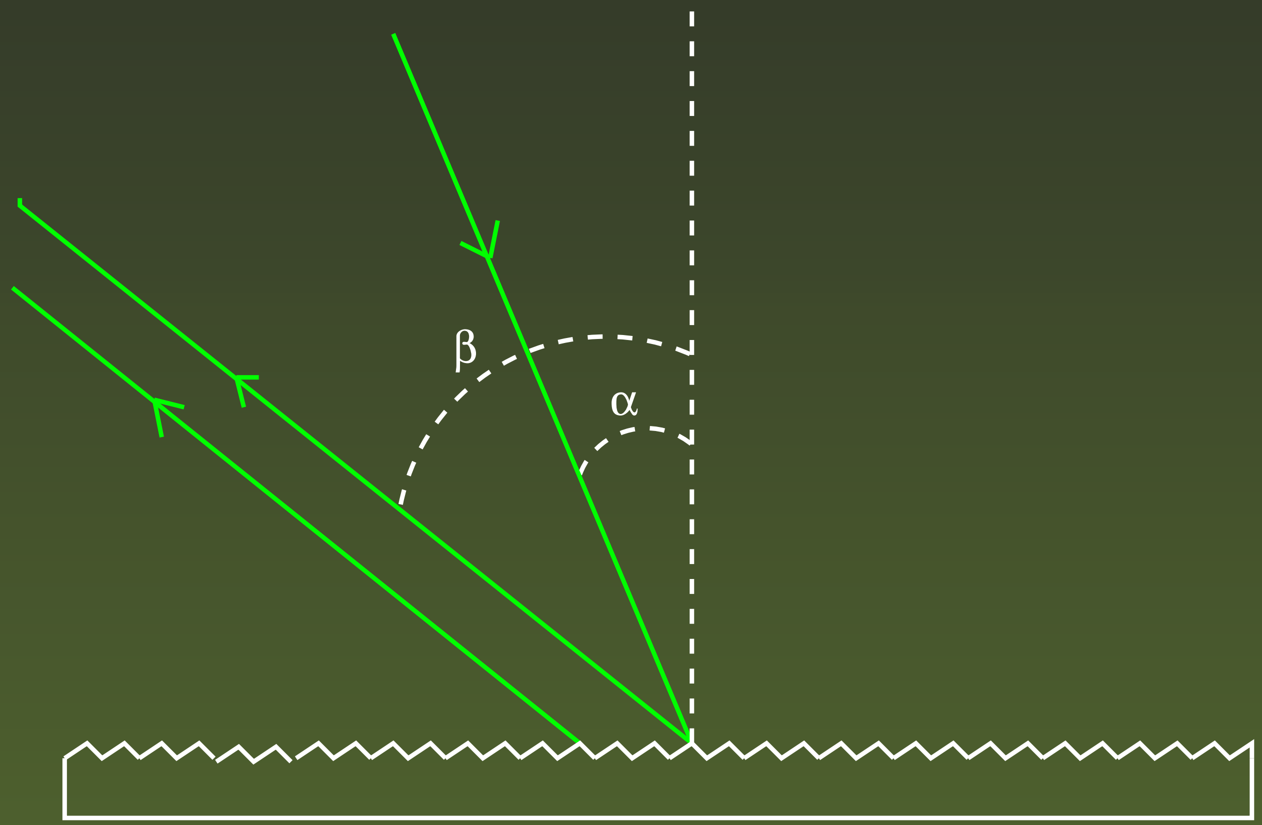
Pulse-Compressors use same parallel gratings to affect group velocity of pulse:

$$\frac{\partial \Phi}{\partial \omega} = \tau_g = \frac{L(\omega)}{c} \rightarrow \Phi_g = \int_{\Delta\omega} \frac{L(\omega) d\omega}{c}?$$

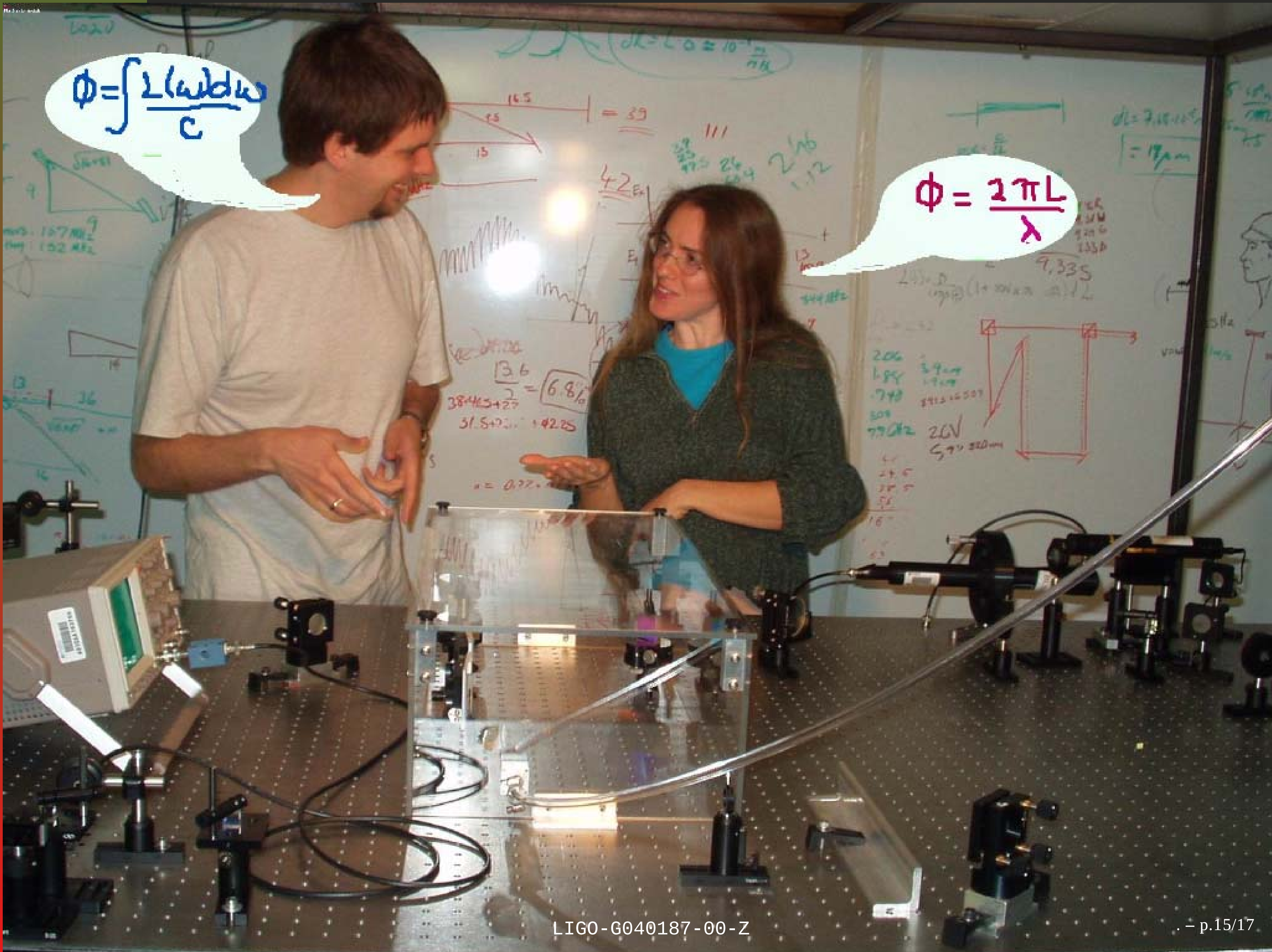
E. Treacy, *Optical Pulse Compression With Diffraction Gratings*, IEEE J. Quant. Elec. Vol QE-5, No. 9, 1969

Phased and Confused

Schreier et. al.$\rightarrow$ gratings cause lateral and angular shift



F. Schreier et. al., *Beam displacement at diffractive structures under resonance conditions*, Opt. Lett. Vol. 23, No. 8, 1998


$\Phi = \int \frac{L(\omega)d\omega}{c}$
$\Phi = \frac{2\pi L}{\lambda}$

Next Step

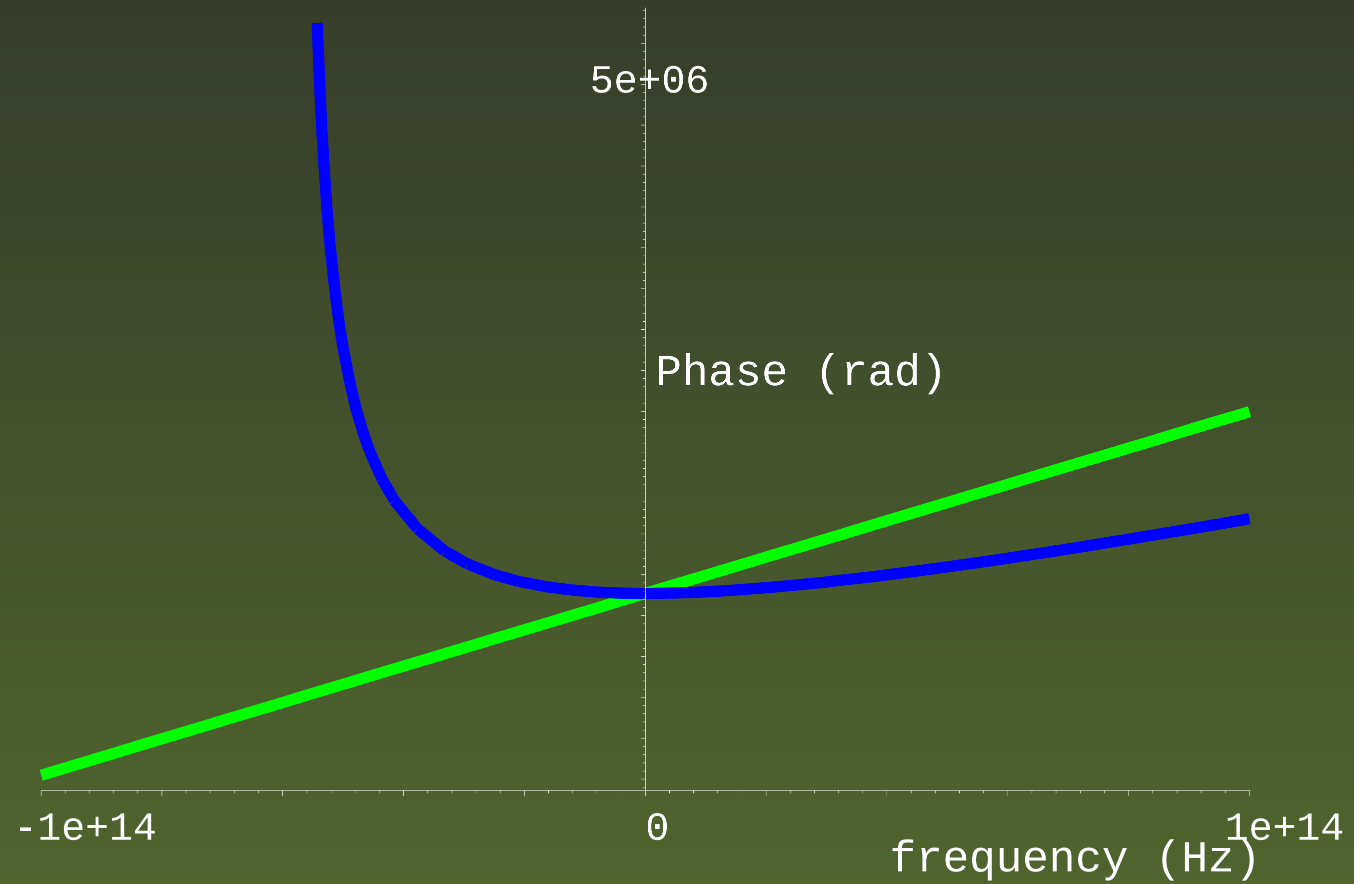
Rigorous calculation of grating effect

- calculate $E(x, z, t)$ via Huygen's integrals
- consider Gaussian instead of plane waves
- consider effect of grating resolution
- different grating profiles
- include laser bandwidth

The Concept

Round-trip phase shifts, ϕ_{WL} vs. ϕ

Frequency-Dependent Phase



Superior bandwidth wherever slope of WLC phase $<$ standard phase