Seiji Kawamura's

Top Ten

Sources of Noise

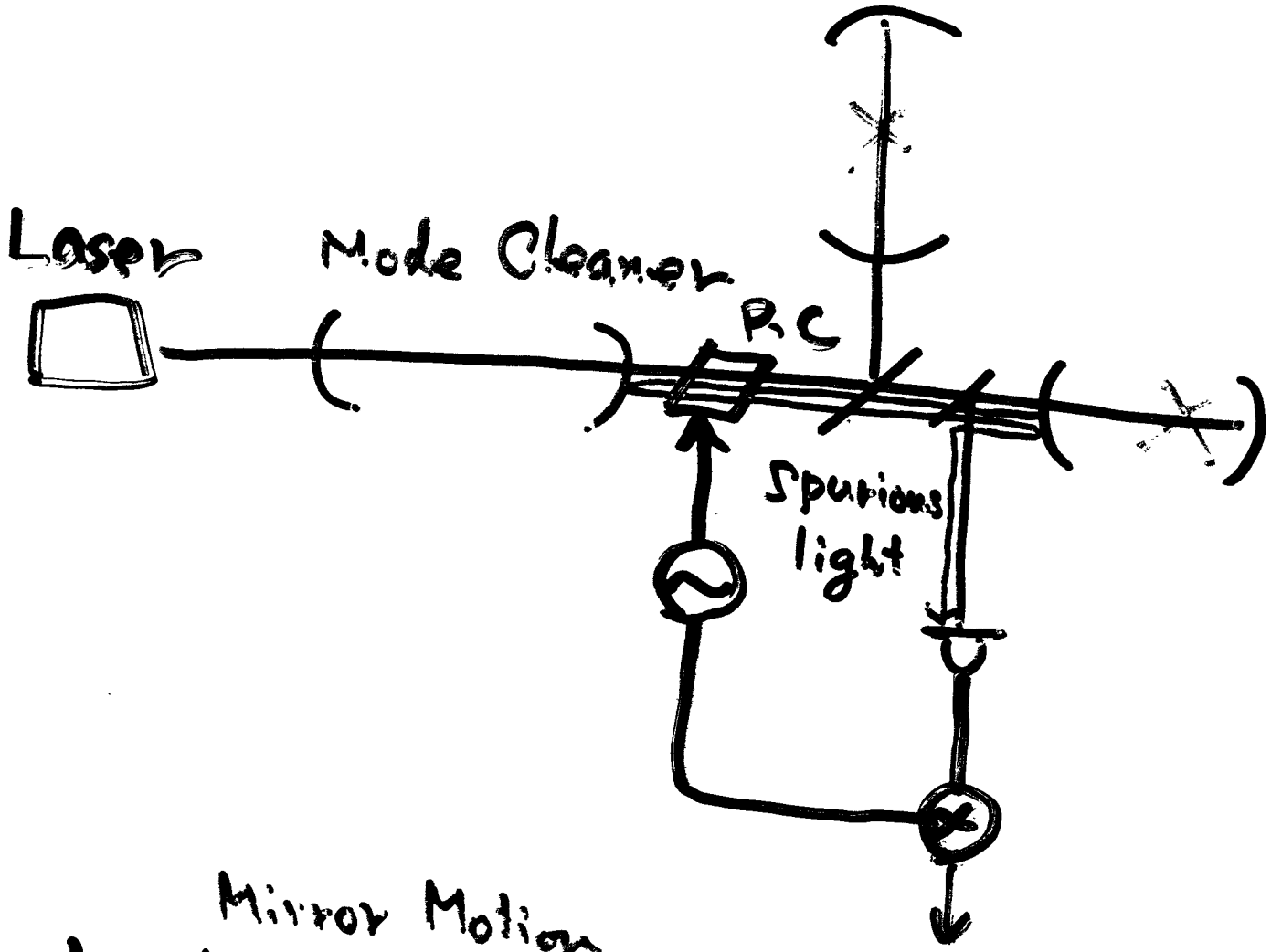
LIGO-G970227-00-R

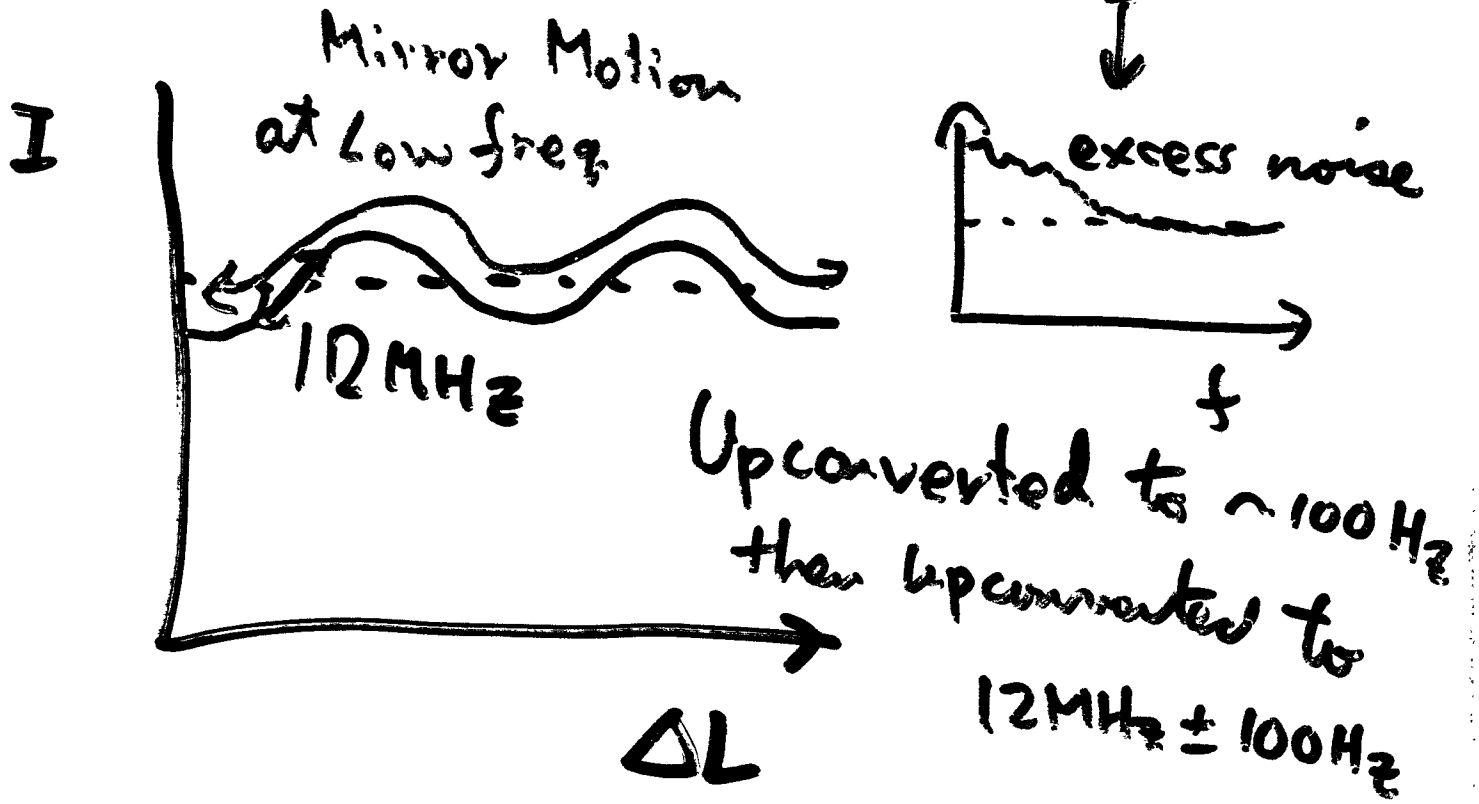
Sep. 9, 97
LIGO Seminar
Seiji Kawamura

No. 10

RFAM

hoise


Laser
Mode Cleaner
P.C
Spurious light


Mirror Motion at Low freq
I
12MHz
ΔL
excess noise
f
Upconverted to ~100Hz
then upconverted to
12MHz ± 100Hz

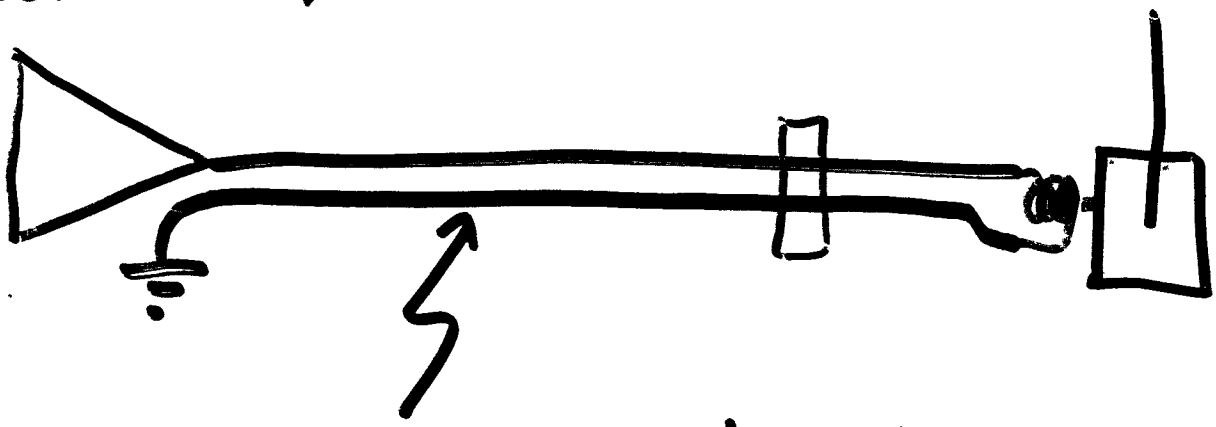
No. 9

Coil ground loop

due to

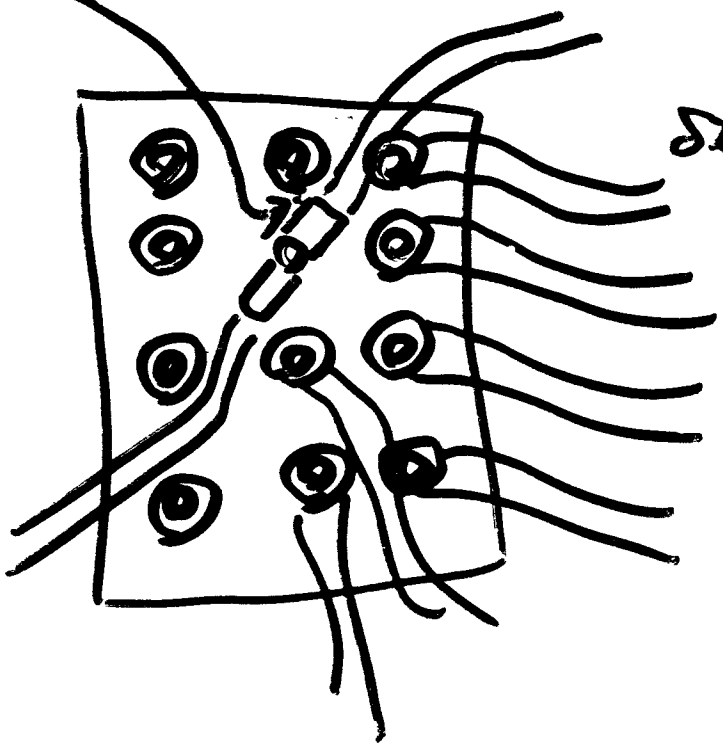
T-connector

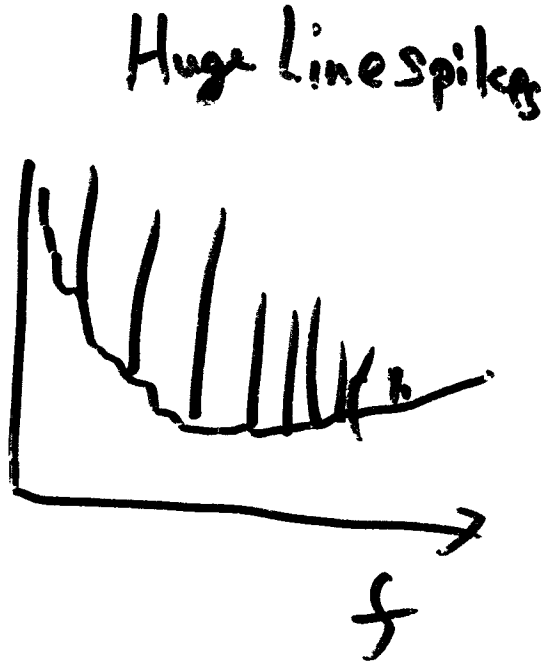
Coil Driver



This ground should not be shorted to other ground.

Touched

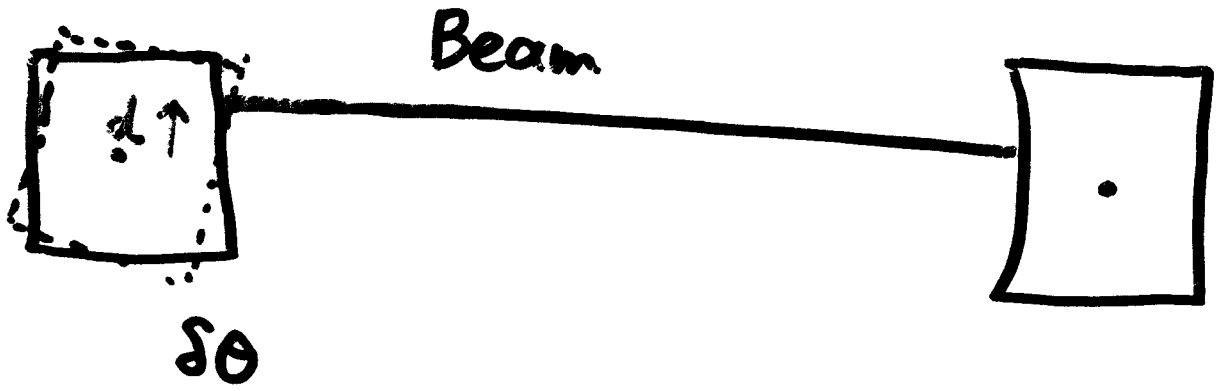




No. 8

Orientation

noise



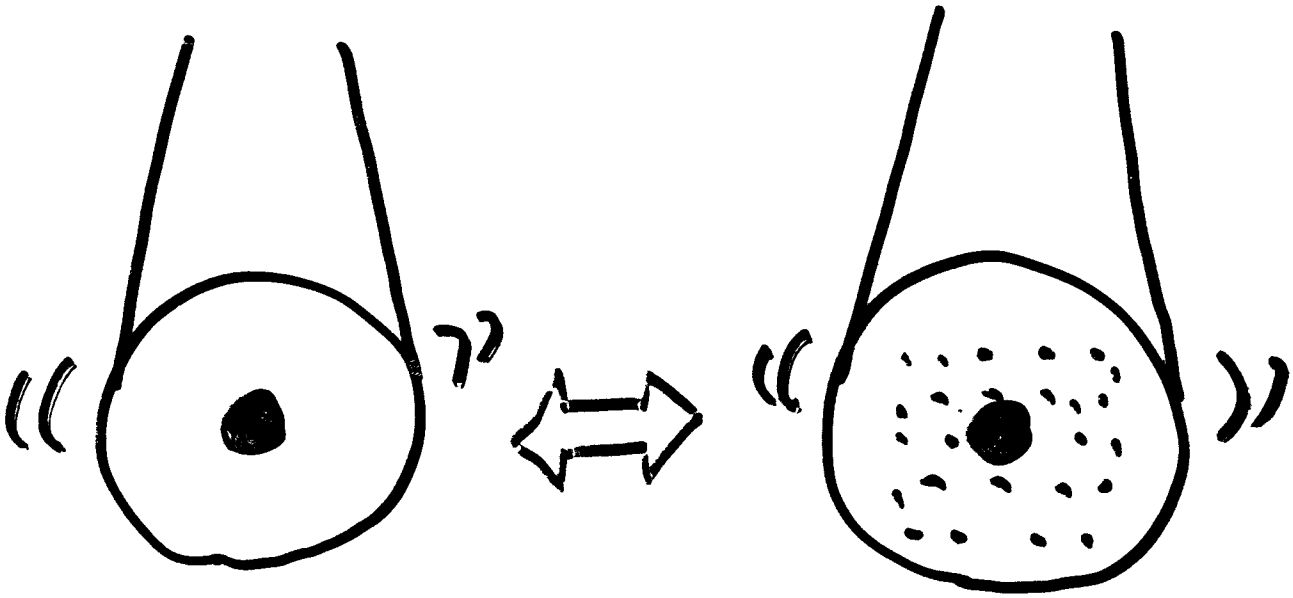
$$\delta x = \underset{\sim}{d} \cdot \delta\theta$$

beam spot offset

The orientation noise can be suppressed by $d \to 0$

No. 7

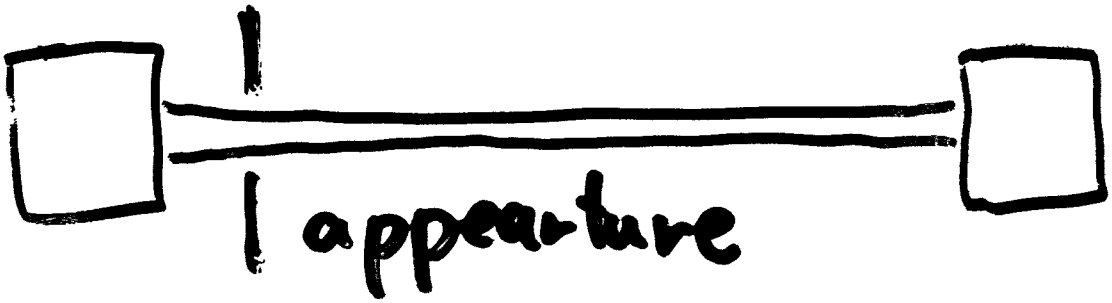
Higher order mode Flashing



Higher order mode flashing makes burst-type noise.

Correlated with angle stability of the mirror

appeature to prevent the flashing

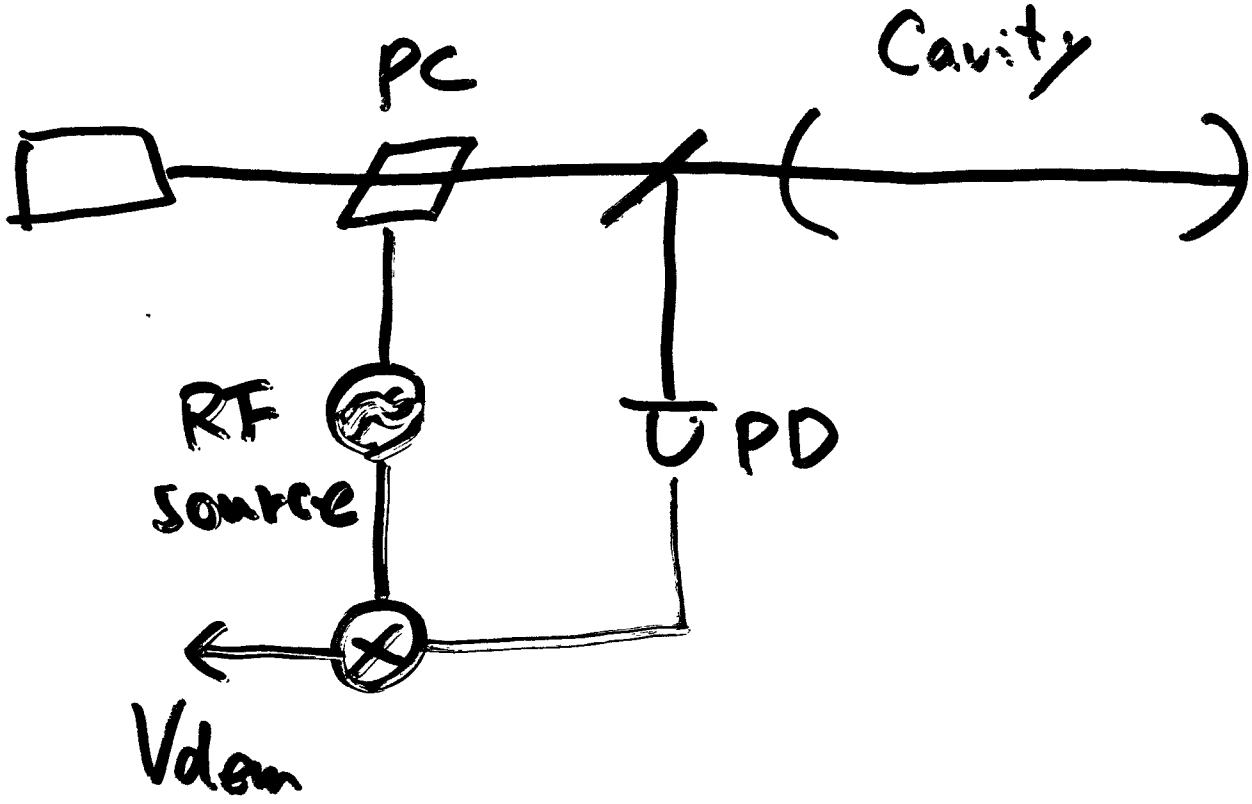


No. 6

RF amplitude

Fluctuation

noise



Vdem $\propto$ amplitude of RF modulation

Vdem $\propto$ Intensity of light

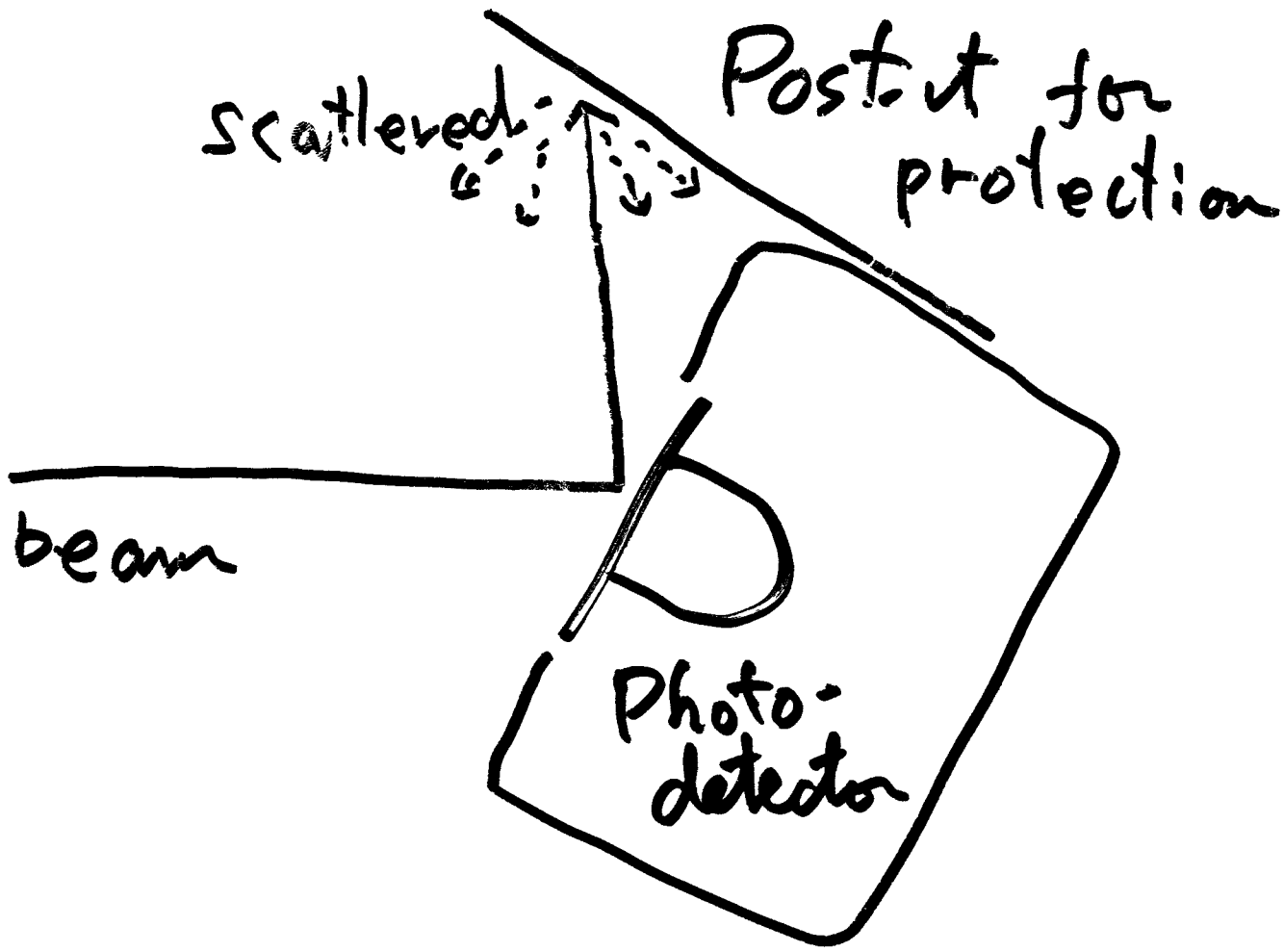
Therefore

can be treated likewise

No. 5

Post-it

noise



Interferometer noise was enhanced !

No. 4

Pockels Cell Misalignment Effect

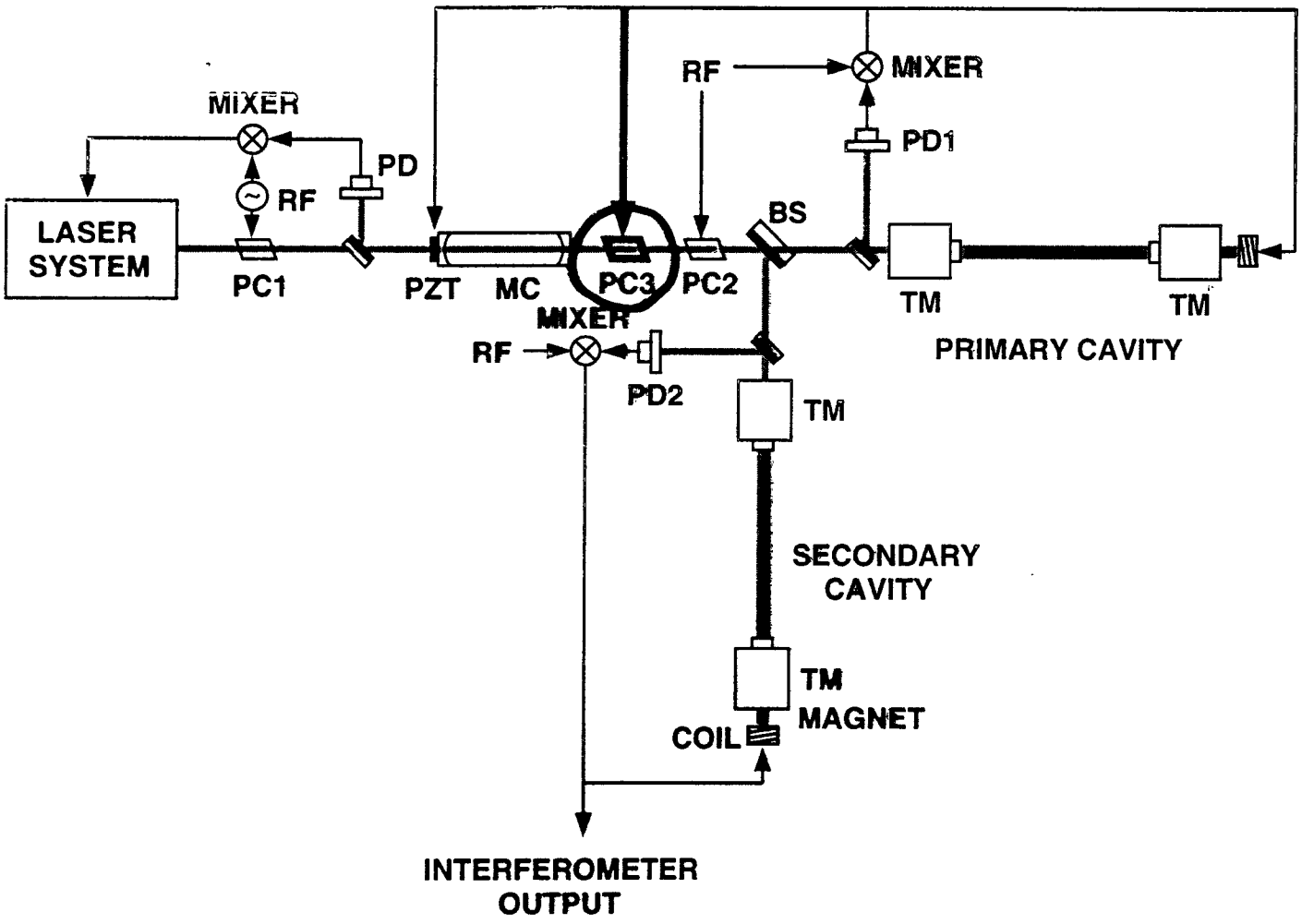
In 1991. two mysteries:

① Interferometer noise correlated with frequency noise although high enough gain

② Interferometer noise dependent on DC voltage to the Phase-correcting Pockels cell

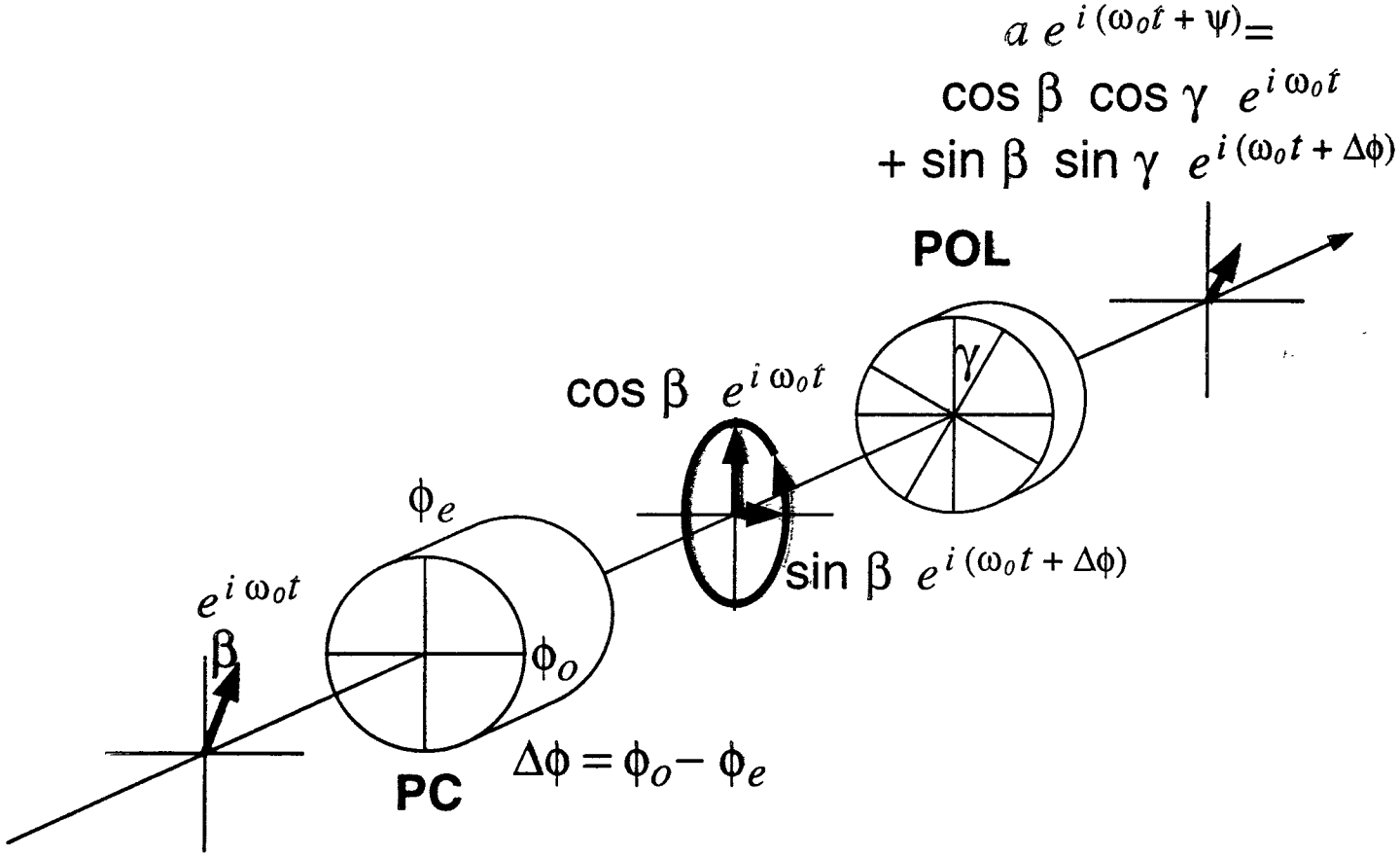
Can't be!

Phase correcting Pockels cell

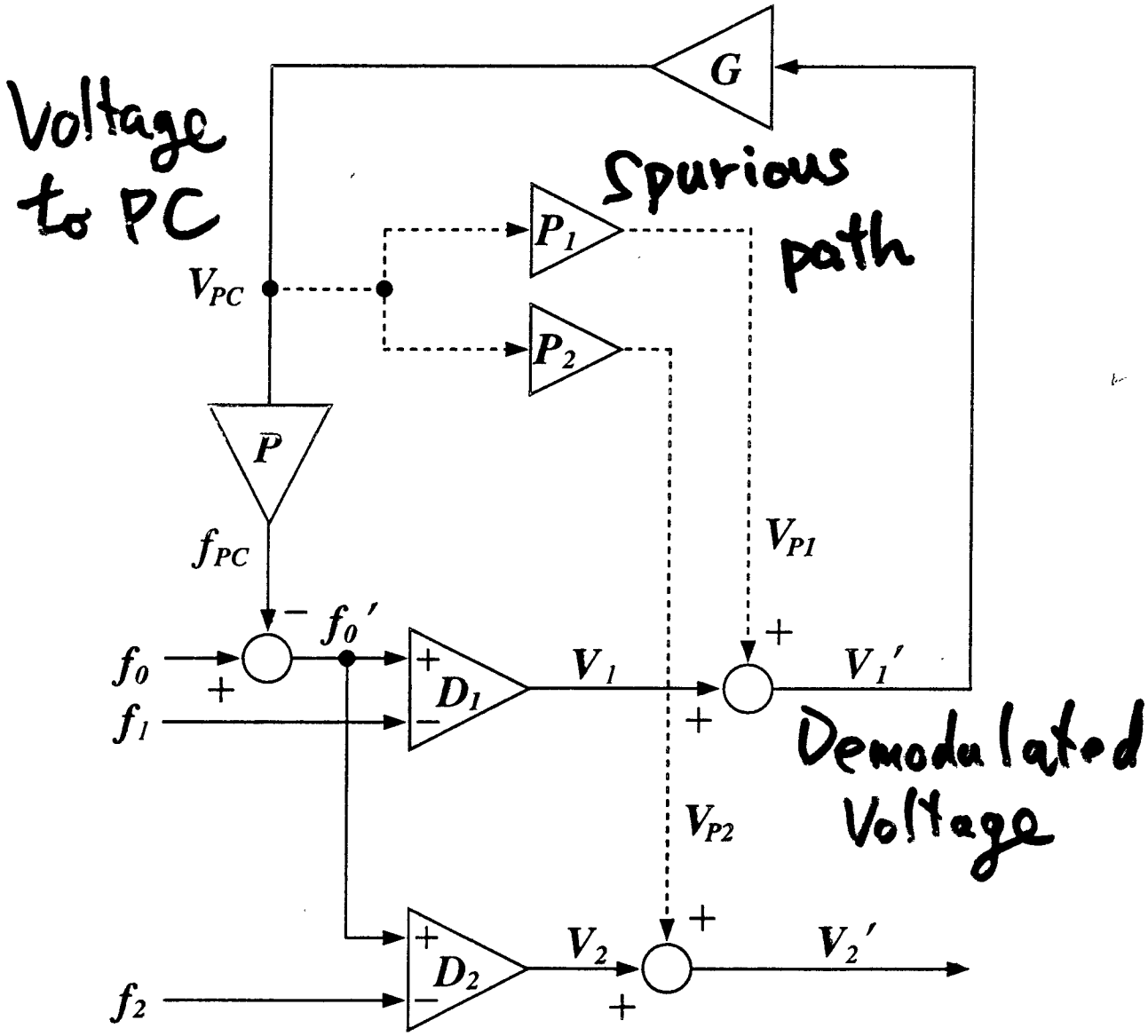


Old 40m configuration

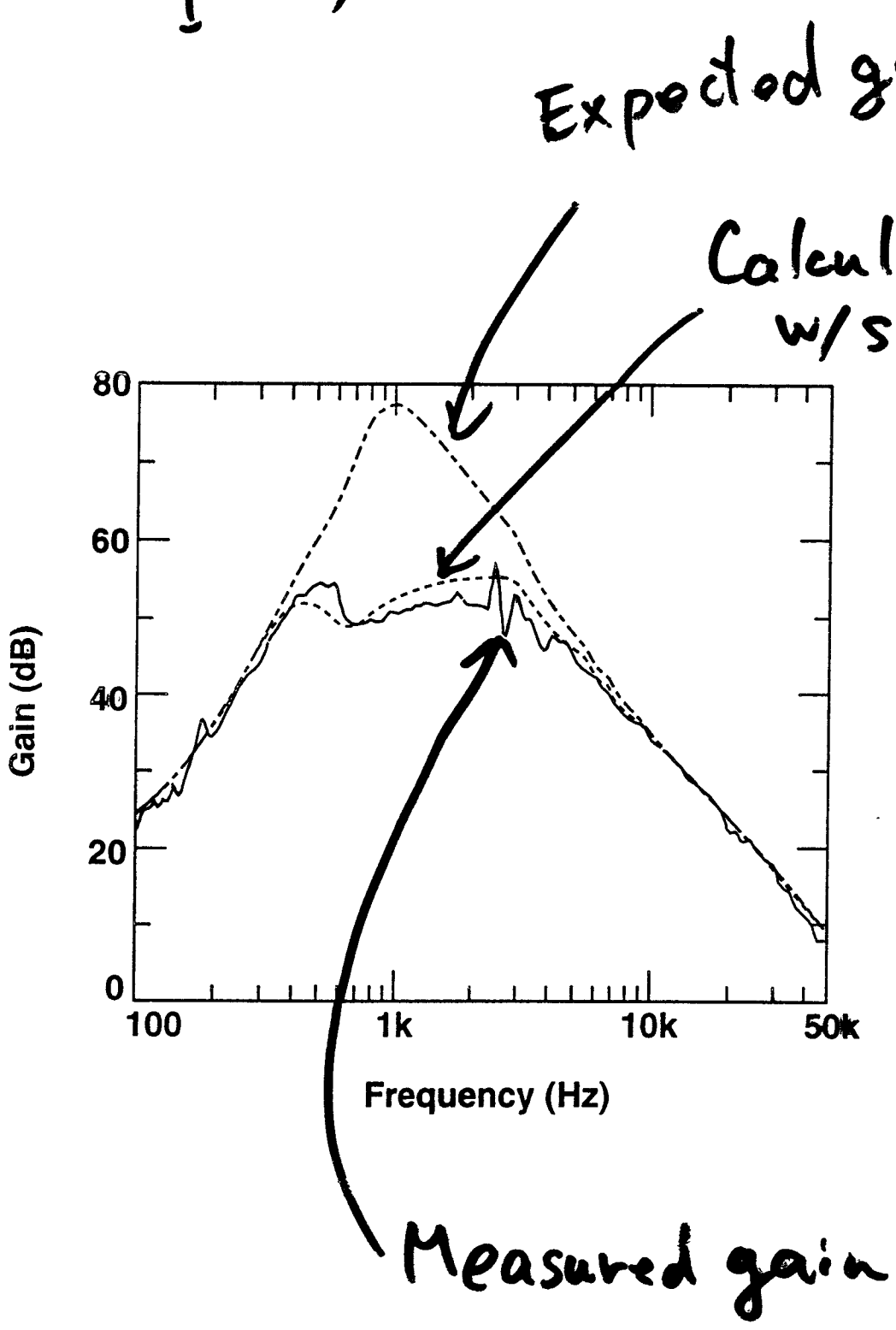
~91



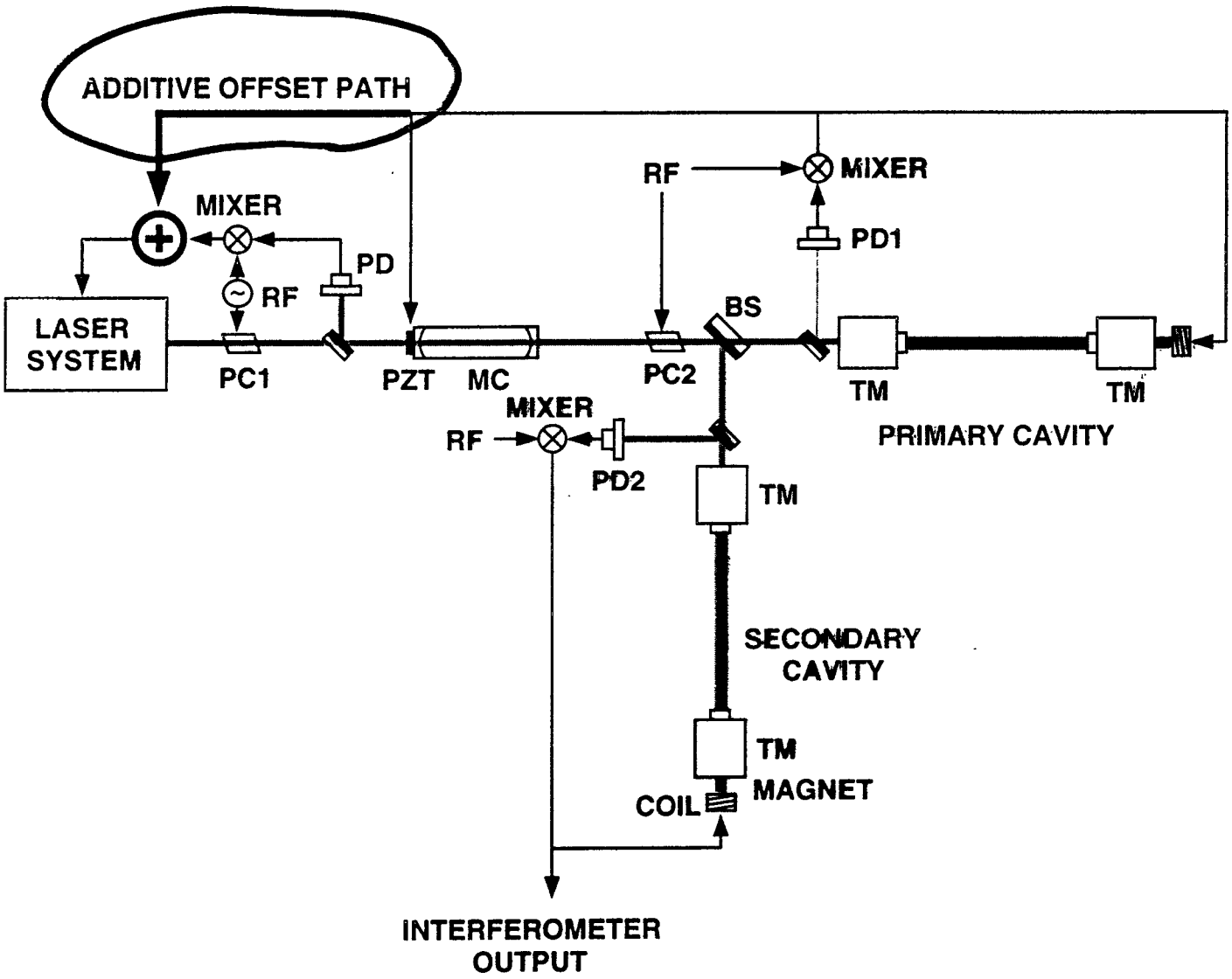
Amplitude changes as well as phase due to Pockels cell misalignment!


Voltage to PC
G
Spurious path
P_1
V_{PC}
P_2
P
f_{PC}
V_{P1}
f_0
f_0'
f_1
D_1
V_1
V_1'
Demodulated Voltage
V_{P2}
f_2
D_2
V_2
V_2'

Frequency Stabilization



solved the problem



No. 3

Mode cleaner

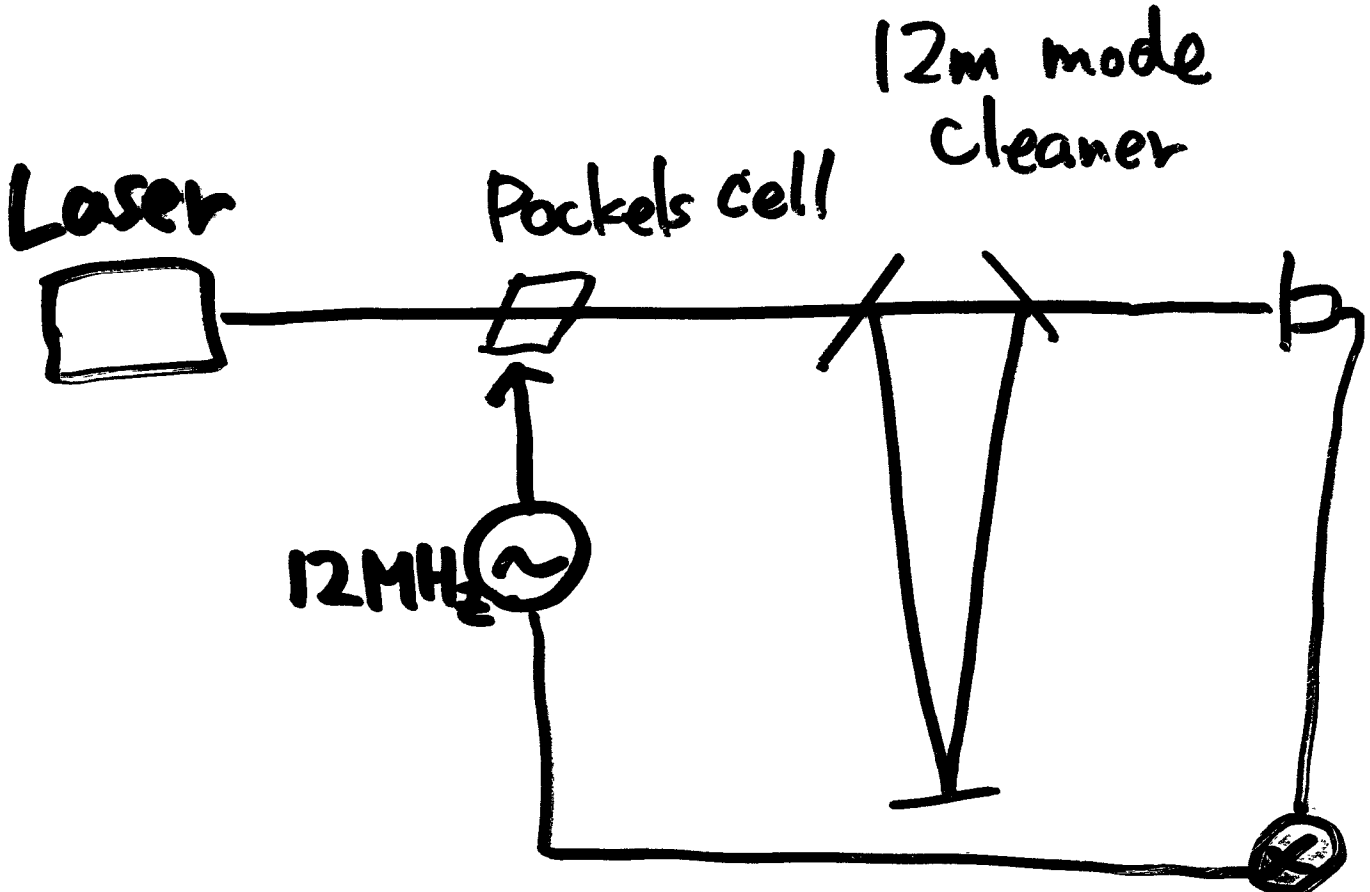
Transmitted light

noise due to

Pockels cell

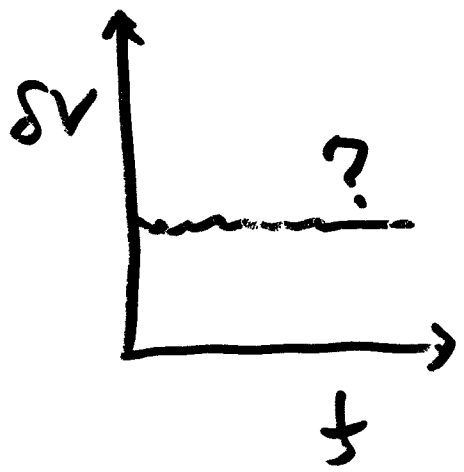
misalignment

In 1995 we were investigating RF excess noise in the mode cleaner transmitted light ... and we found a very mysterious...



The 12MHz sideband goes through the mode cleaner

shot noise limited?

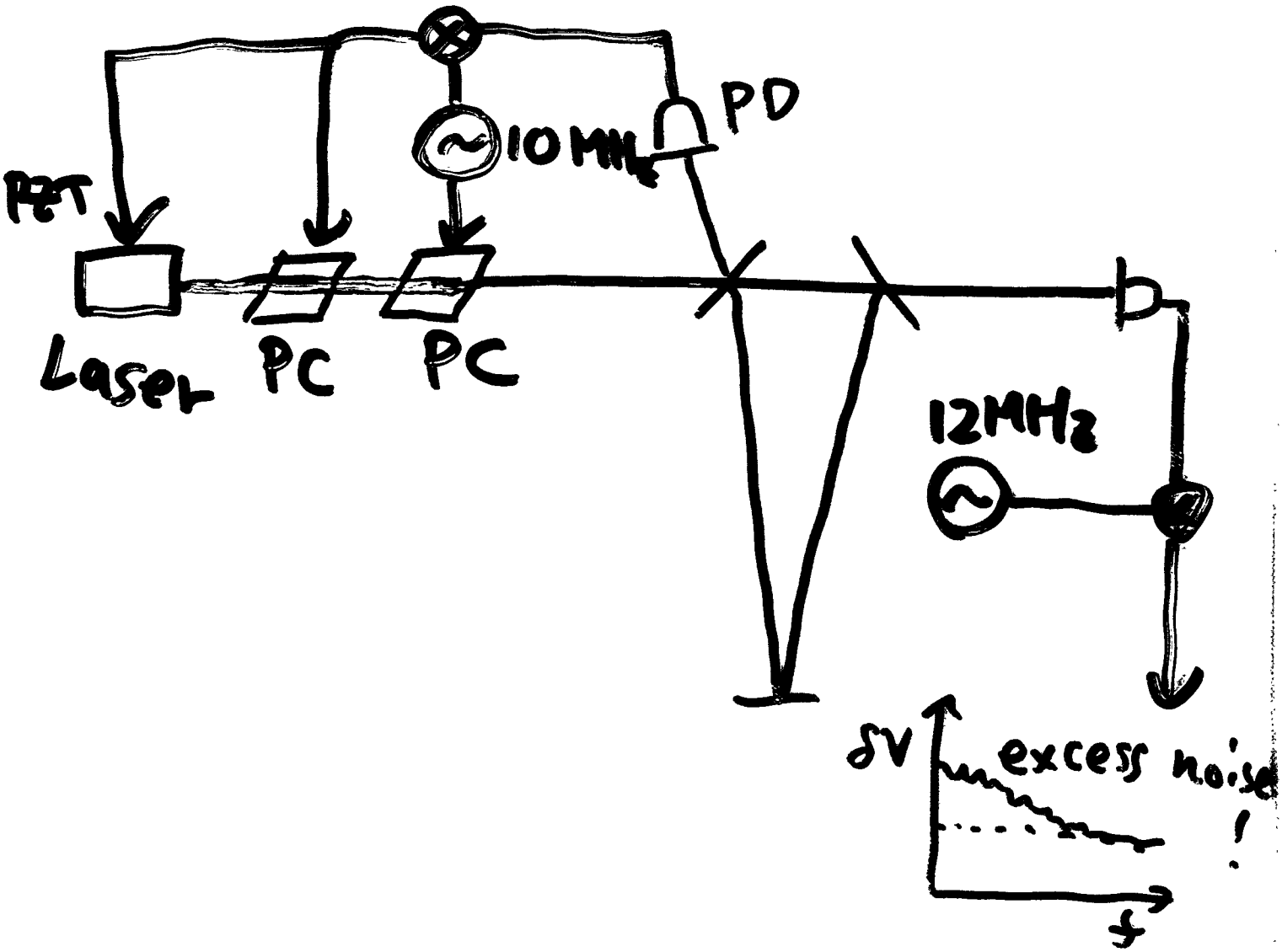


For shot noise limited performance,

1. The modulation frequency should be precisely matched to FSR of Mode Cleaner.
2. The mode cleaner length should be controlled at low frequencies.

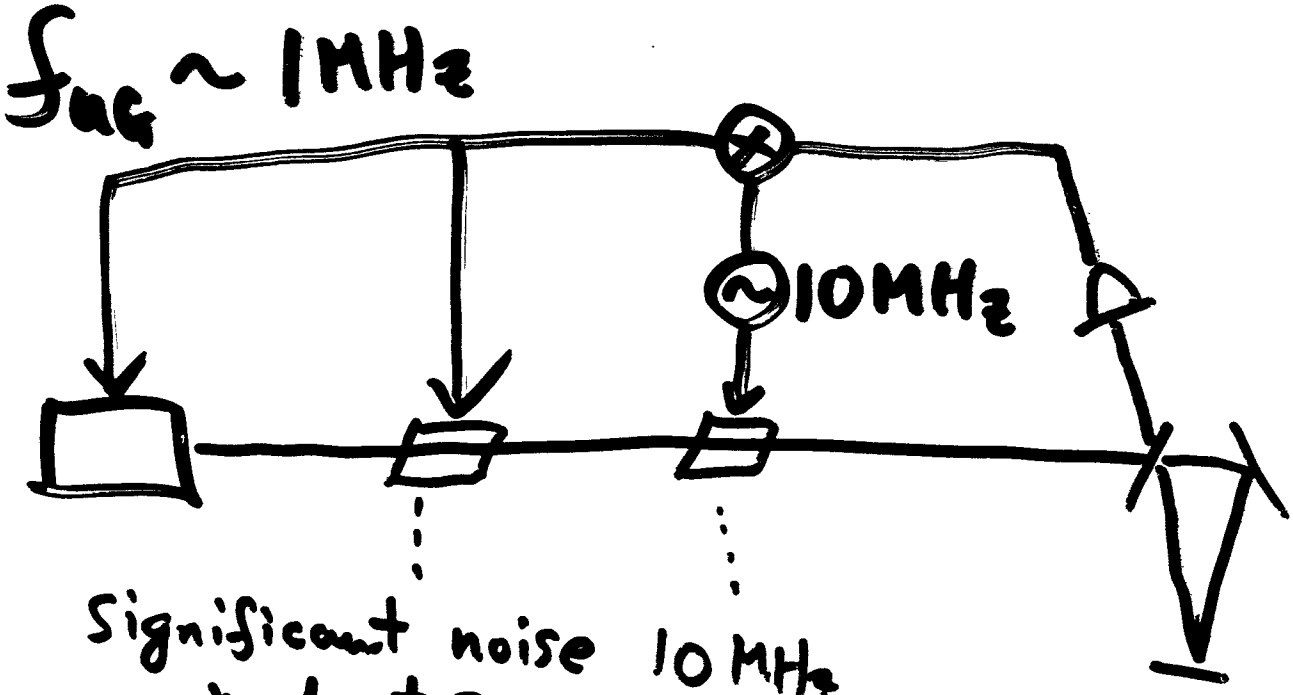
But, but. but
we found ...

excess noise
even without
12 MHz phase modulation!



We found the exces noise depend on gain of the MC locking servo.

Finally we found ...



Significant noise applied at ~2MHz thus, amplitud modulation at ~2Hz

10 MHz amplitude modulation

↘ ↙ Upconverted

~12MHz amp. mod.

No. 2

Cable Tray -

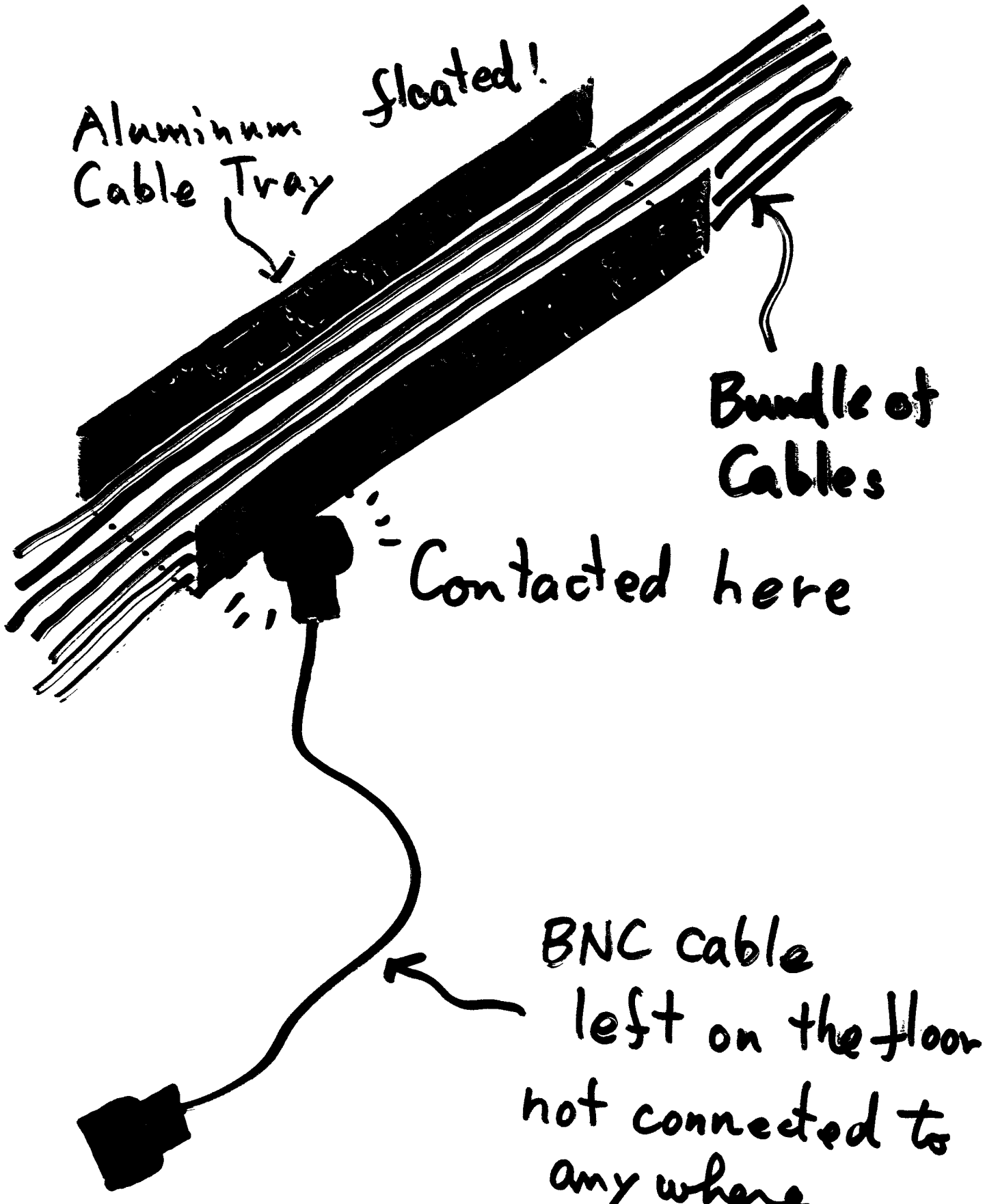
BNC cable

Noise

In 1994, the 40m started squeaking suddenly.

It seemed that the squeaking was outstanding when we pushed the rack.

We pushed various places and finally found ...


floated!
Aluminum
Cable Tray
Bundle of
Cables
Contacted here
BNC cable
left on the floor
not connected to
any where

No. 11

Intensity - Frequency

Downconversion

Noise

In 1992, people were talking about "Downconversion" noise.

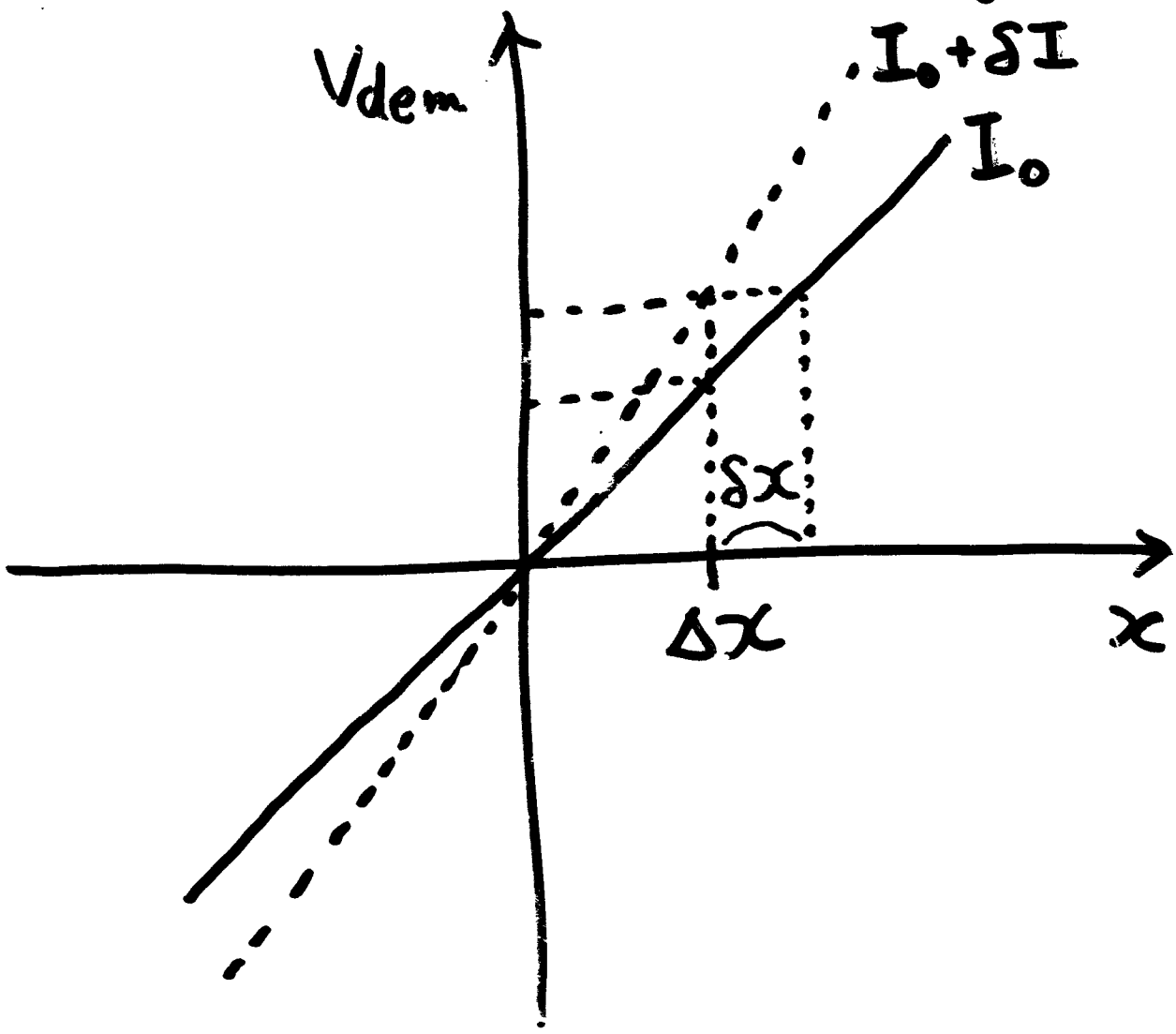
I was investigating "Intensity" noise.

Suddenly they were sparked!

Intensity Noise

$$\delta x = \frac{\delta I}{I_0} \Delta x$$

Δx: Deviation of Operating Point from Dark Fringe



$$\delta x = \frac{\delta I}{I_0} \Delta x$$

generalized
($\Delta x \rightarrow$ Frequency Noise)

$$\delta x = \alpha \cdot I \otimes F$$

Convolution

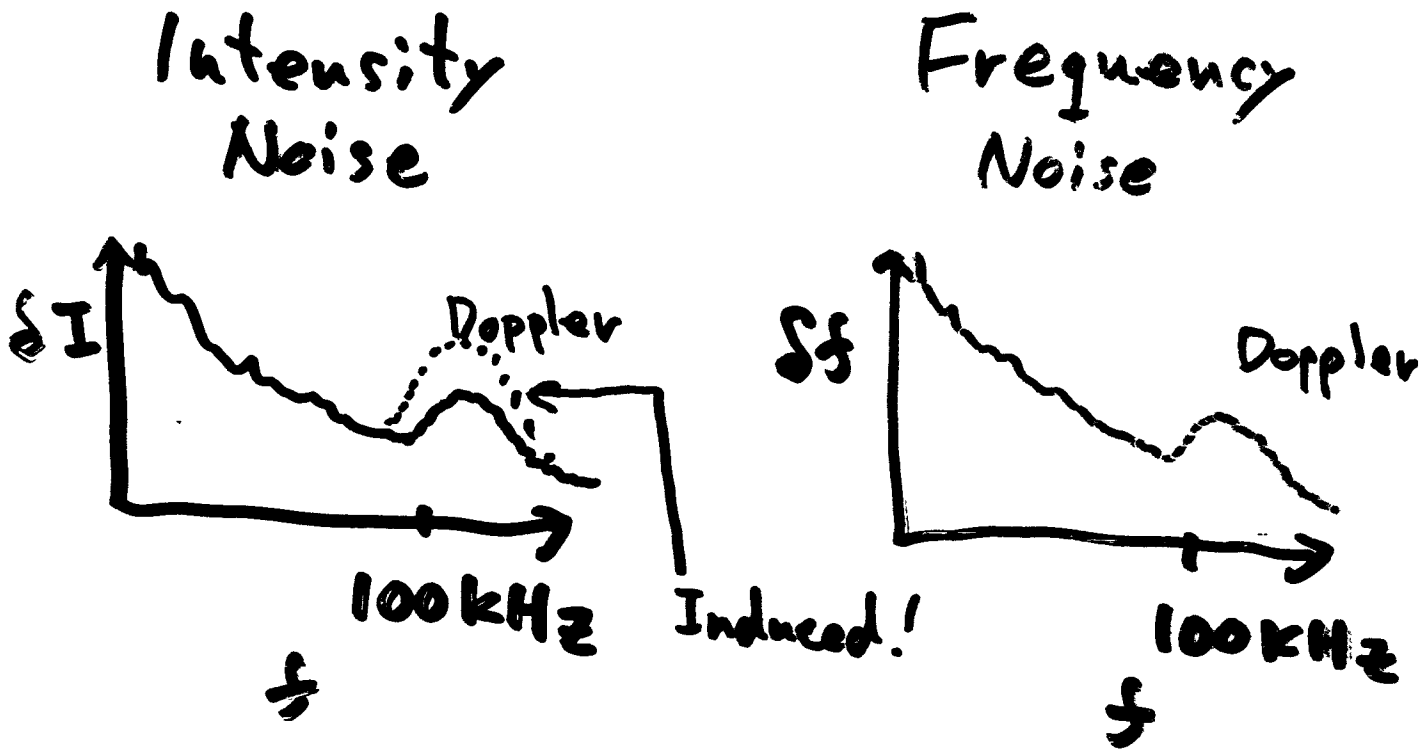
Downconversion

Intensity Noise at 100 kHz

Frequency Noise at 101 kHz

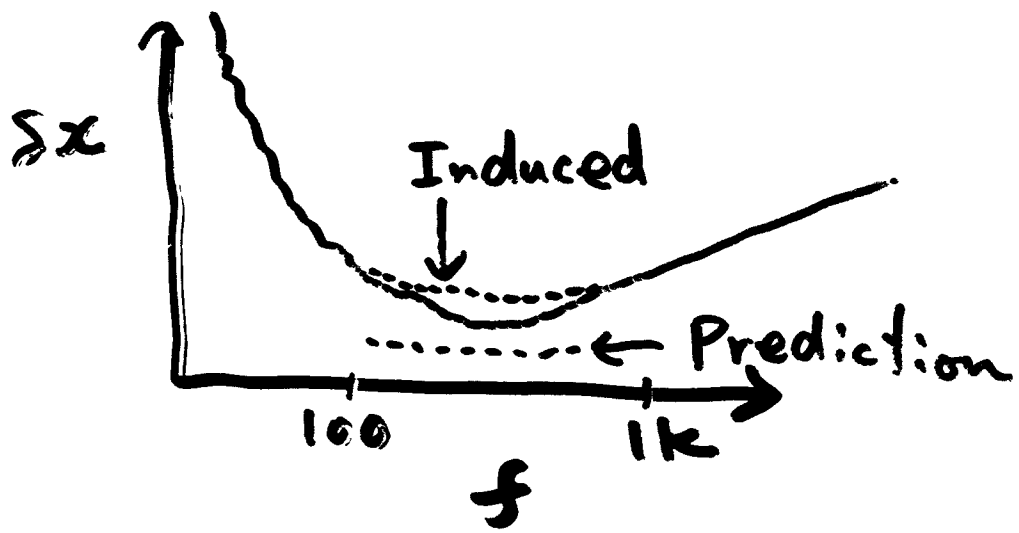
→ Displacement Noise at 1 kHz

Verified by Experiment!



Stabilized

Displacement Noise



Conclusions

Noise is Signal

until we detect

real signal.

Be nice to them!