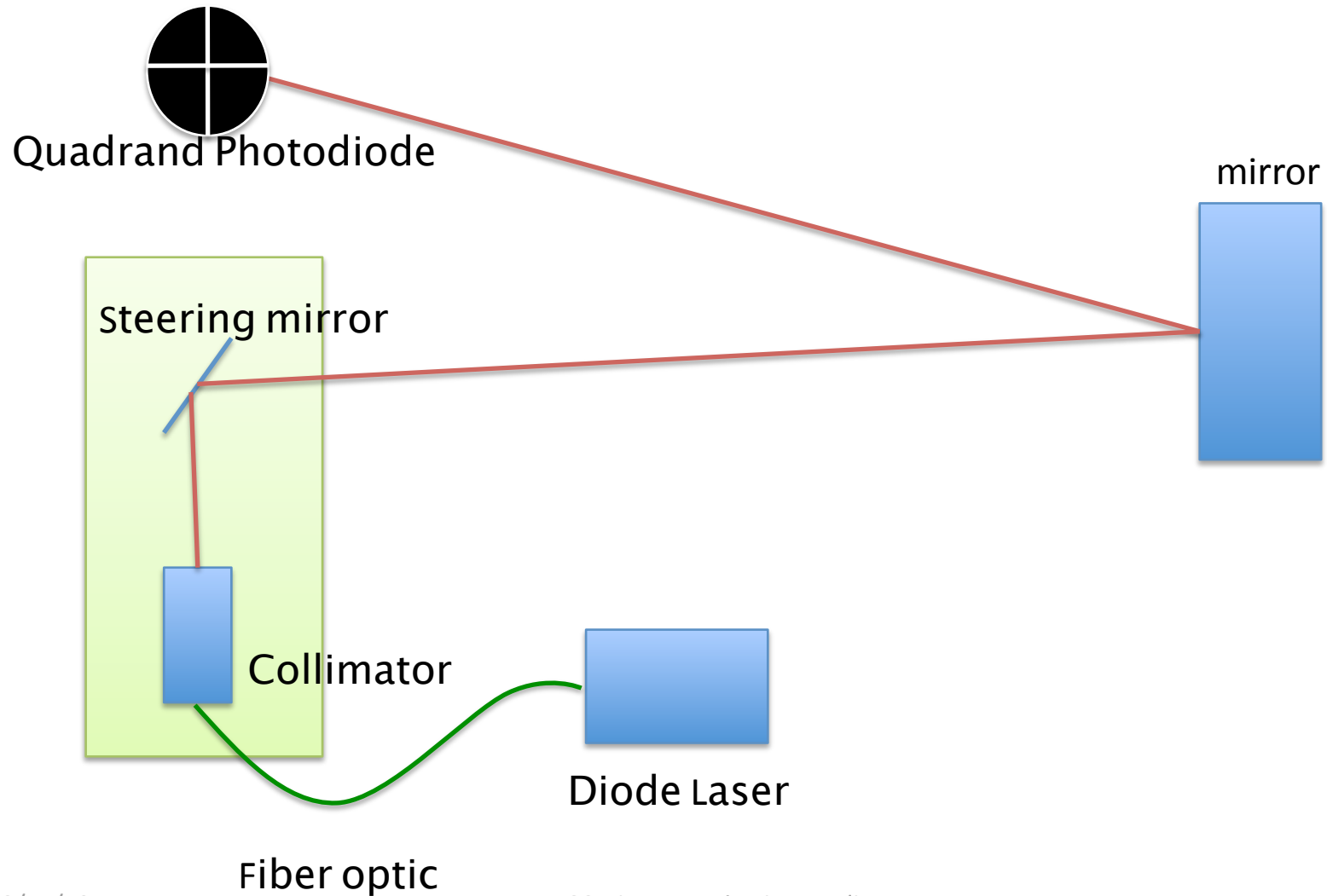


LIGO_G1000309

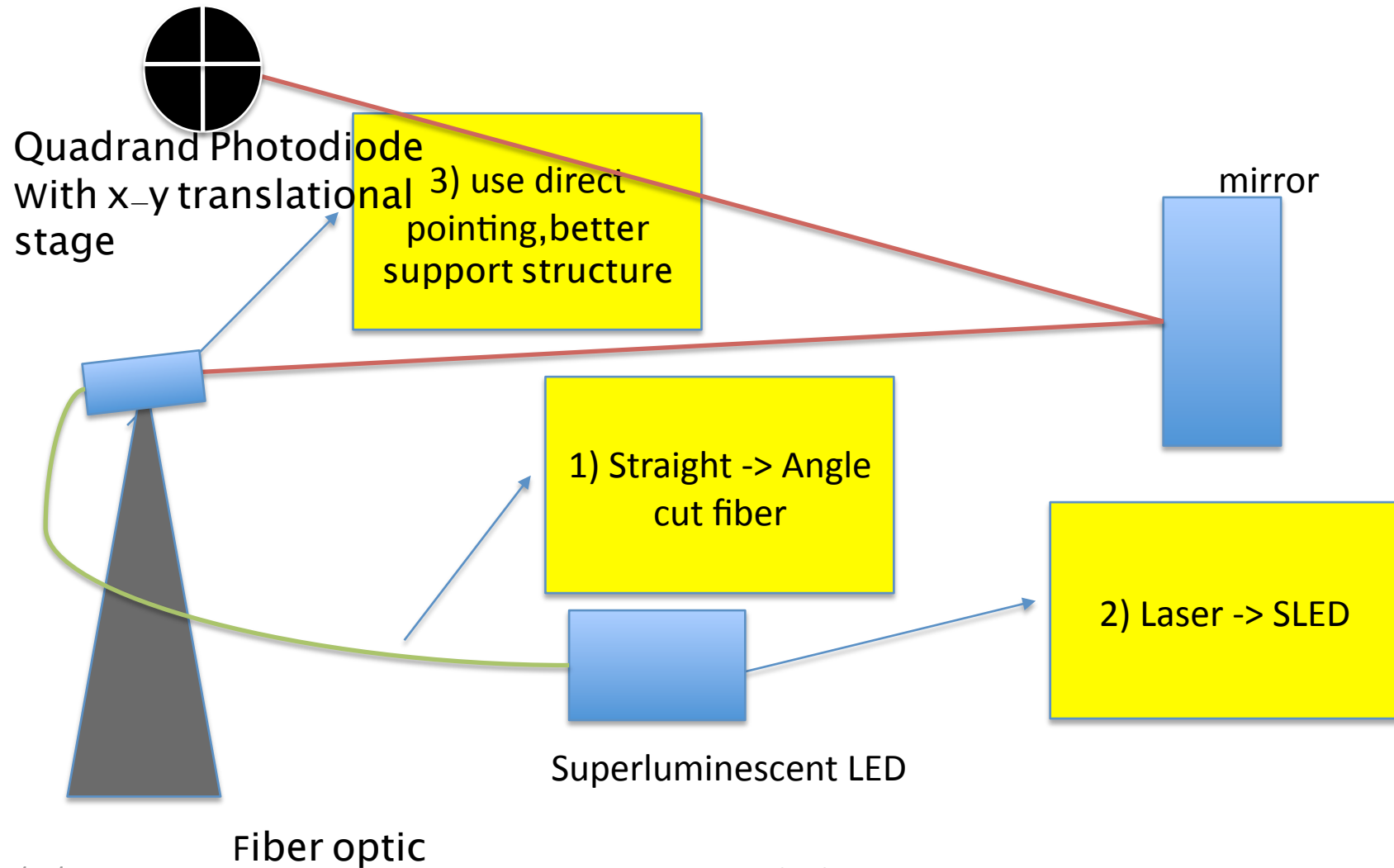
Advanced-LIGO optical lever progress

Richard Abbott, Eric Black, **Tara Chalermongsak**, Craig
Conley, Vladimir Dergachev,
Doug Cook, Riccardo DeSalvo, Andrea Lottarini, Gerardo
Moreno, Mohana Mageswaran,
Rick Savage, Robert Schofield, Michael Smith, Cheryl
Vorvick, Hiro Yamamoto

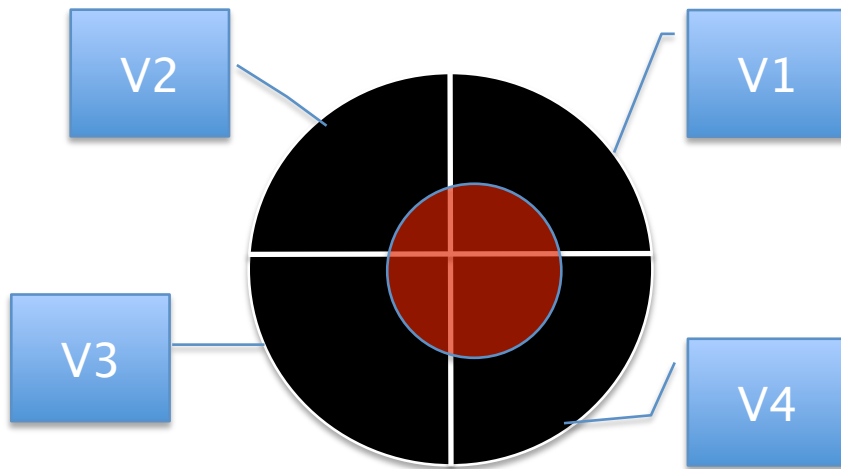
Initial LIGO Optical Lever Setup



AdvLIGO Optical Lever Setup



How to reconstruct beam position from QPD's signal



$V_{sum} (S) = V1 + V2 + V3 + V4$
Vsum corresponds to the total power of the beam

$$\text{Right (R)} = V1 + V4$$

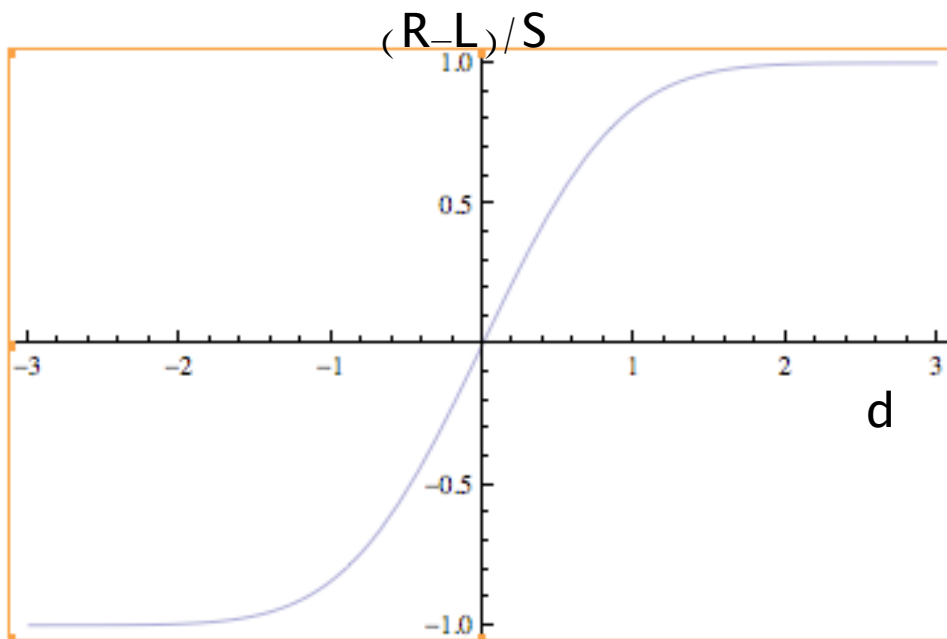
$$\text{Left (L)} = V2 + V3$$

$$\text{Top (T)} = V1 + V2$$

$$\text{Bottom (B)} = V3 + V4$$

$$Vx_{normalized} = (R - L) / S$$

$$Vy_{normalized} = (T - B) / S$$



Scan the beam across the QPD,
the signal $(R-L)/S$ will be
the Error function.

slope at center $\sim \text{const}/w$

Near center

$$(R-L)/S = \text{const} * d$$

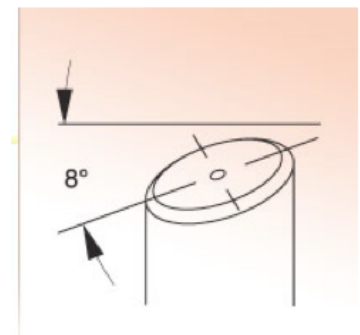
Then the voltage readout
can be reconstructed to
distance from the center.

angle = $d / \text{armlength}$.

$$(R-L)/S = \text{Erf}\left[\frac{\sqrt{2}d}{w}\right],$$

1) Changing from straight cut to angle cut fiber connector

- Why?
 - Vibration on PC (Physical Contact) fiber causes the fluctuation on apparent beam position
 - Back reflection → mode jump in the laser
 - Angle cut connector, APC, (Angled Physical Contact) reduces the effect of the reflection → immune to vibration

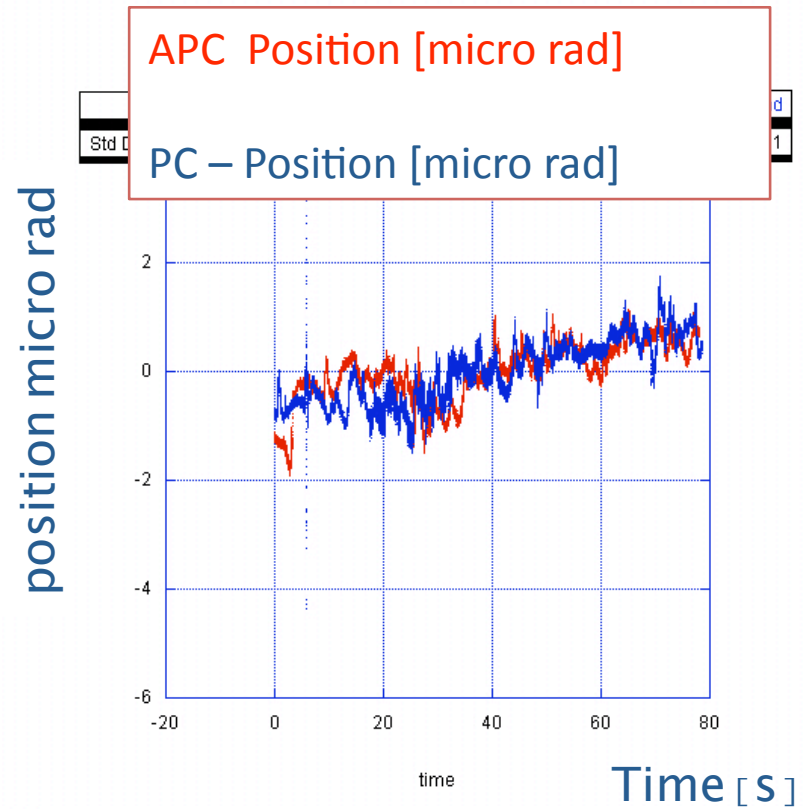
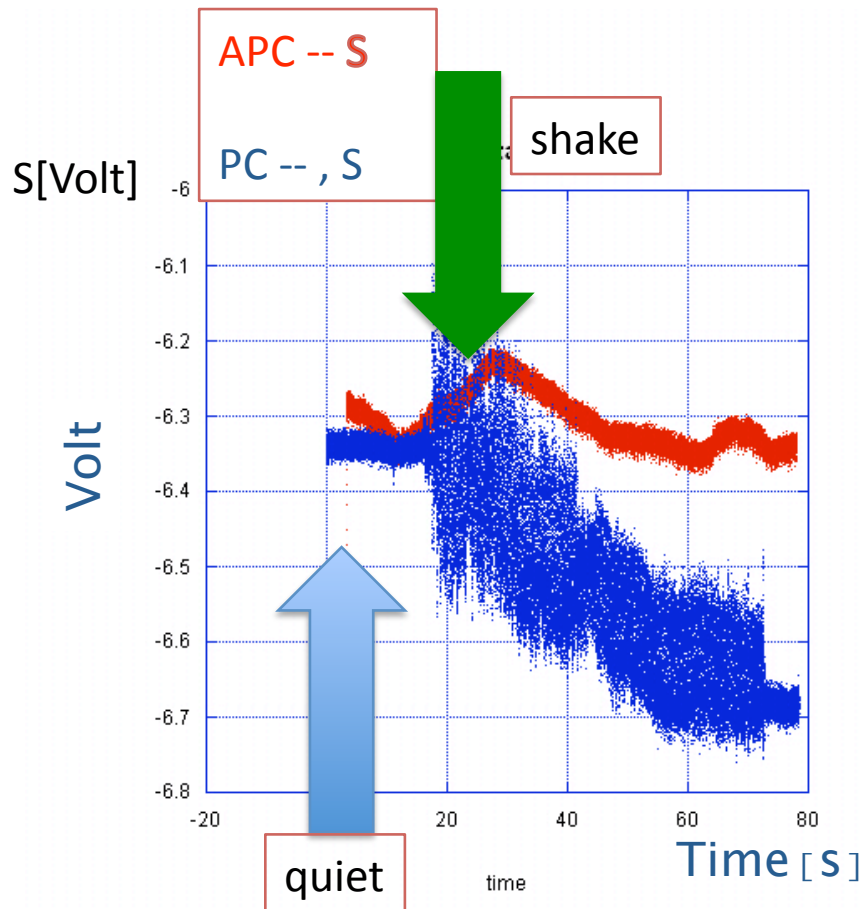
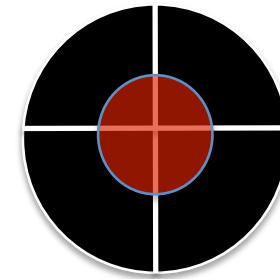


Test of APC and PC fiber

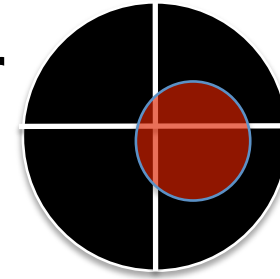
- A loud speaker, driven by a function generator, shakes the test fiber.
- Fiber ends are strain relieved



Result 1) the beam at center

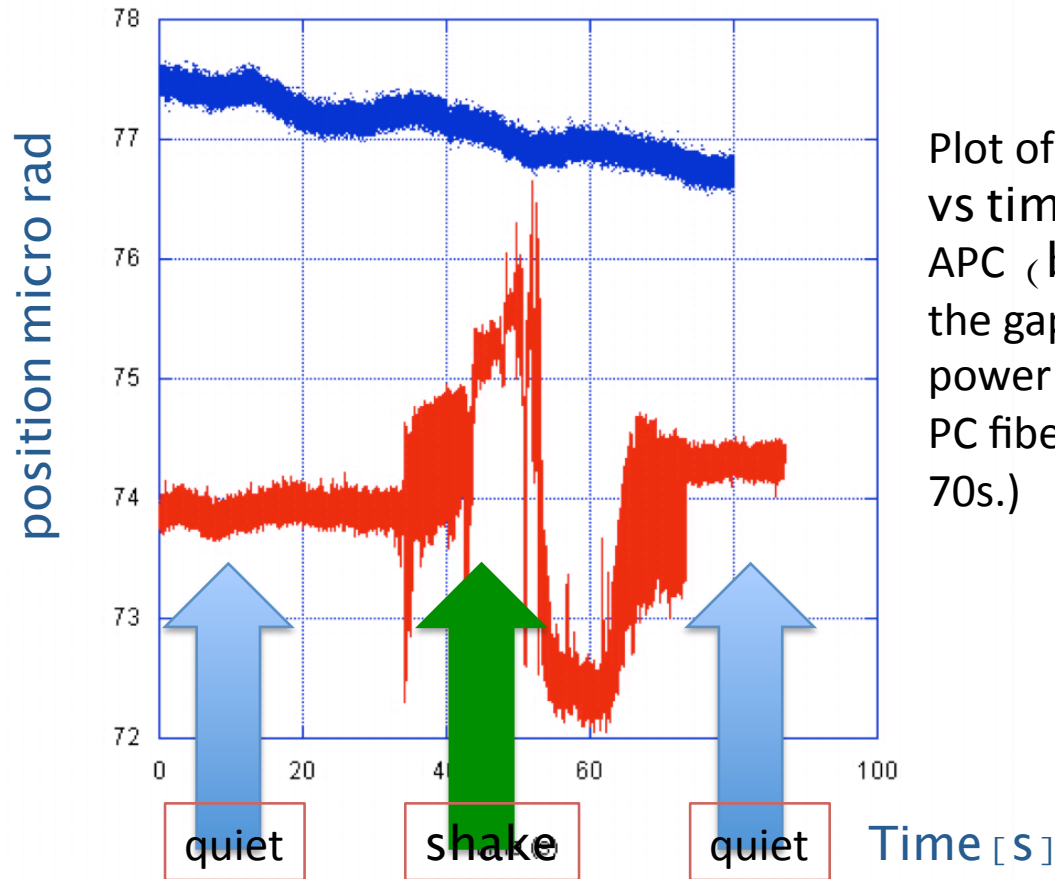


Result 2) the beam off center



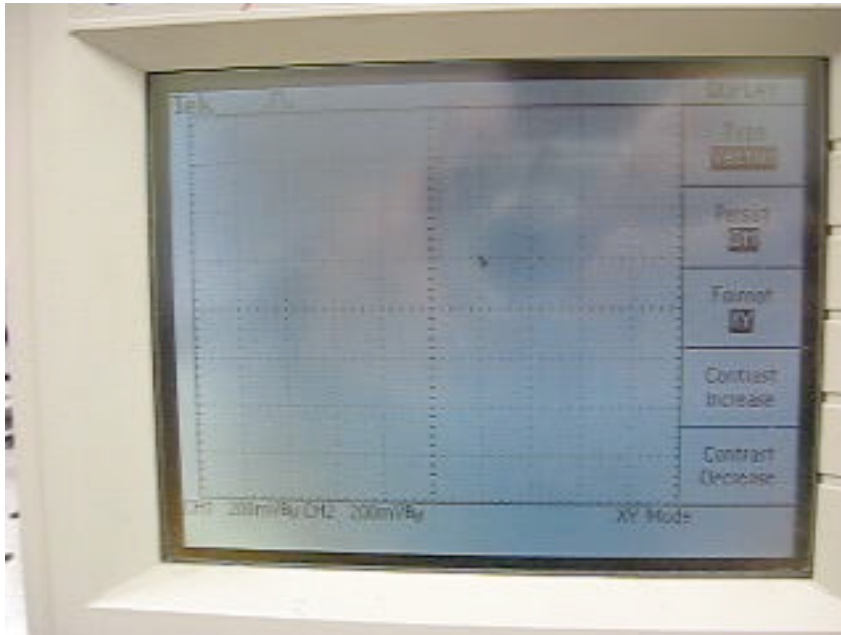
APC – position micro rad
PC – position micro rad

Data 15



Plot of reconstructed x-position vs time [s] between PC (red) and APC (blue), 100 micron away from the gap. The APC fiber can maintain power stability much better than the PC fiber during the shake (30s < t < 70s.)

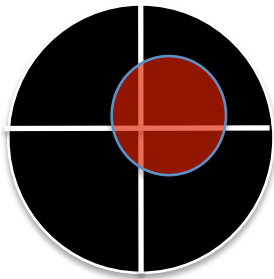
Another Instabilities



The oscilloscope is in x-y mode
X axis \rightarrow R - L (horizontal)
Y axis \rightarrow T - B (vertical)

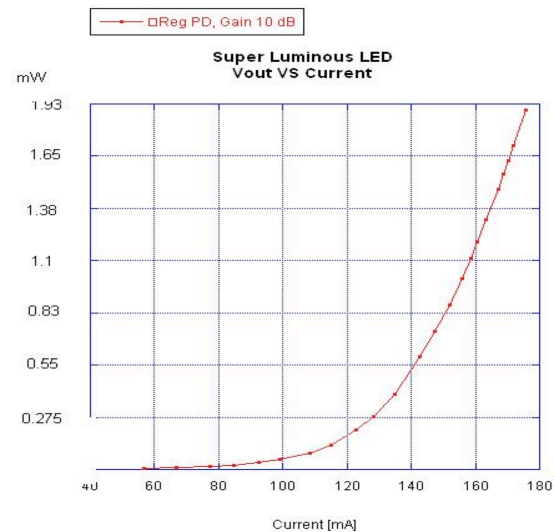
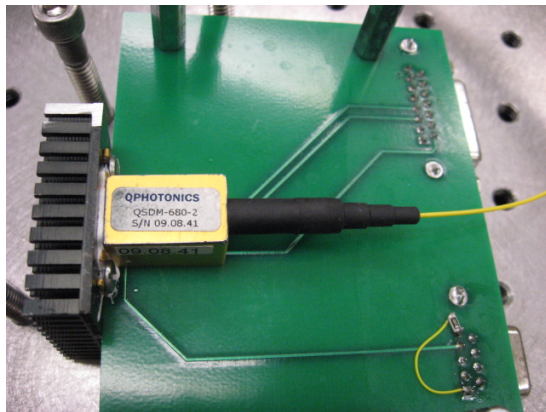
At certain areas, the apparent
beam position fluctuates.

The fluctuation subsides as
The beam goes to the center
Or far away in one quad



2) SLED as a Light Source

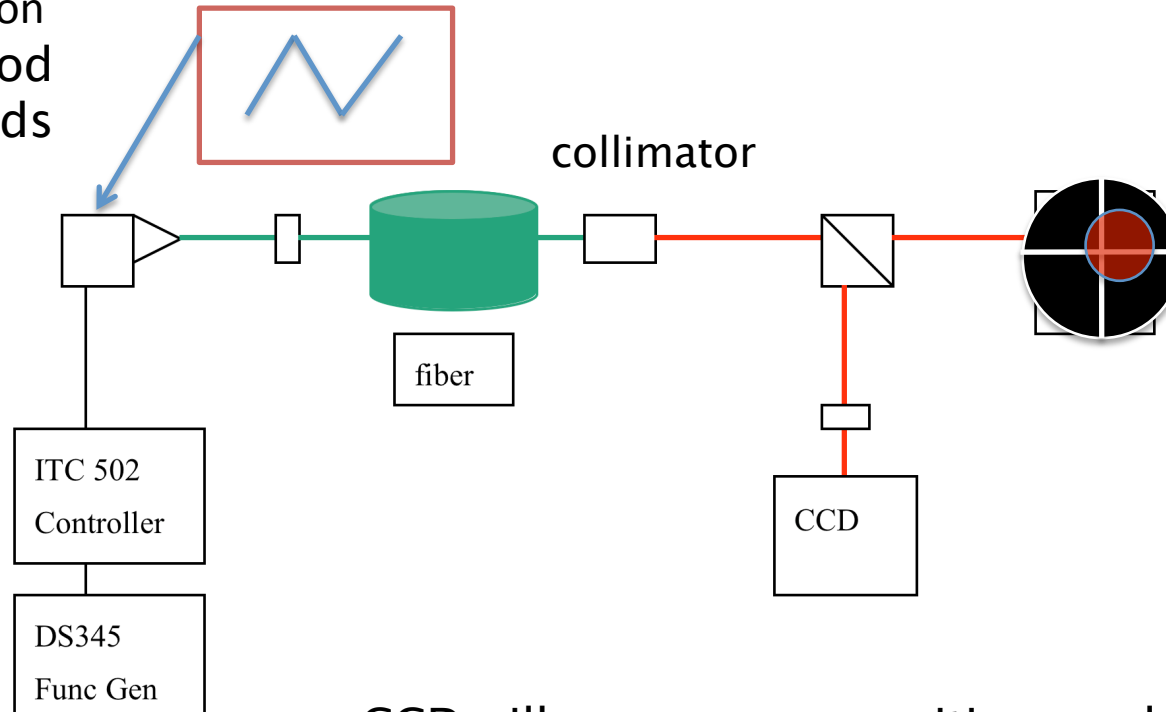
- Current/temperature fluctuation → mode hopping → position fluctuation
- With SLED → no mode hopping → no current-fluctuation induced instability



Q-photonics Super-luminescent Diodes, pigtail single mode fiber 14-Pin DIL, typically driven by a ITC502-IEEE remote control - Benchtop Laser Diode and Temperature Controller ± 200 mA / 16 W

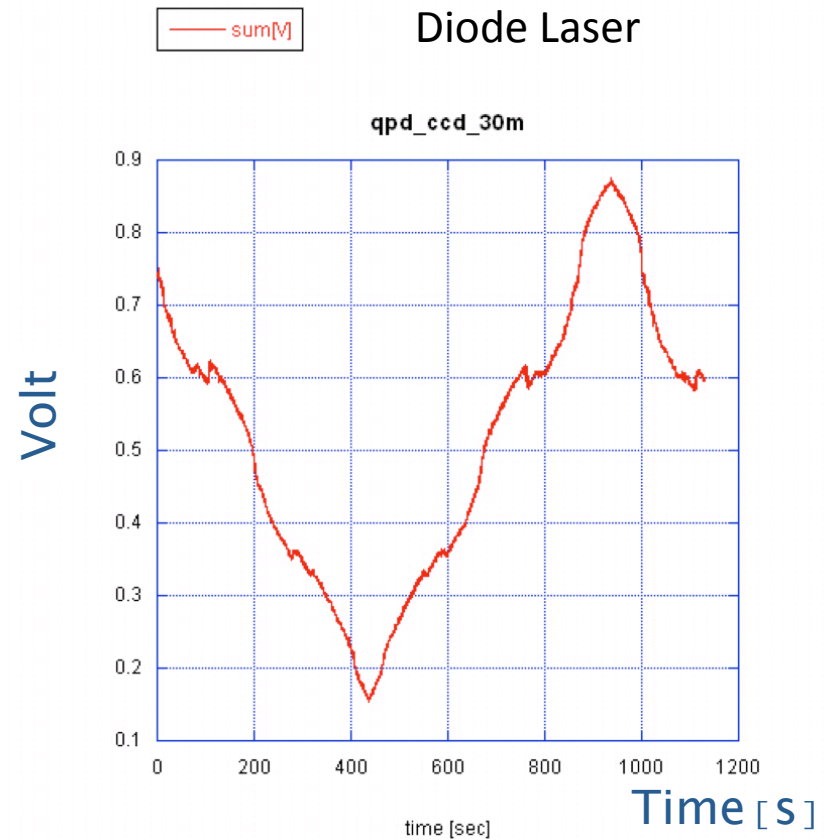
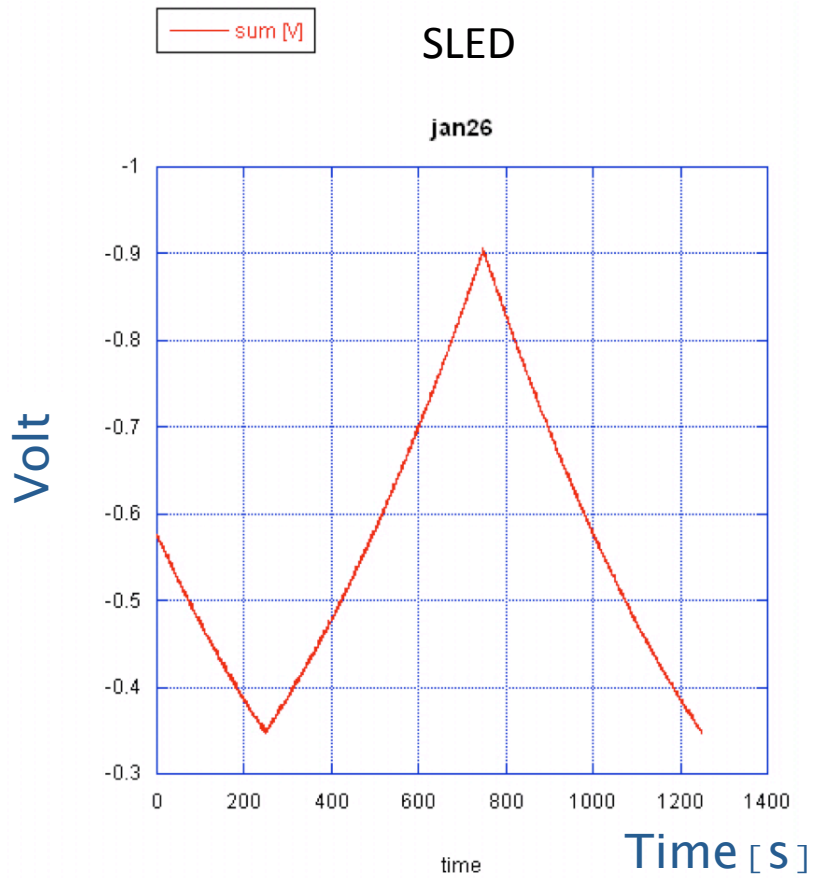
Current Modulation

Triangular function
32 +/- 2mA period
of 1000 seconds

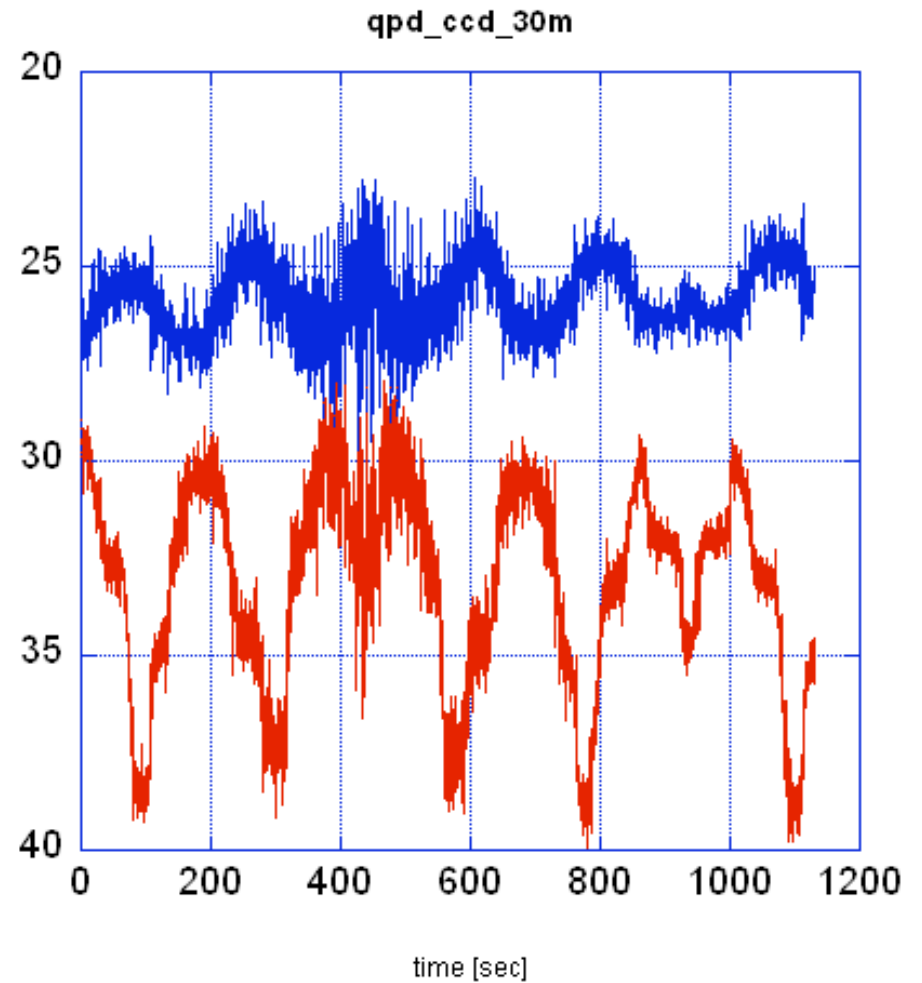
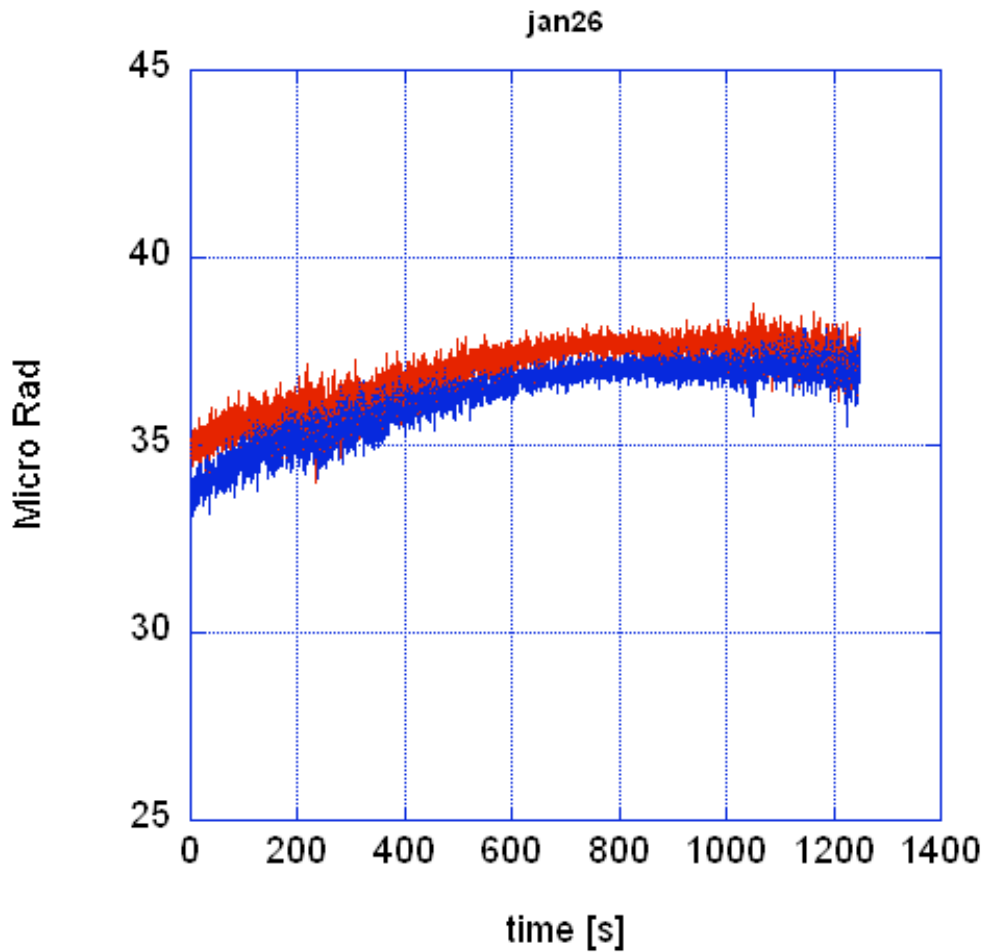
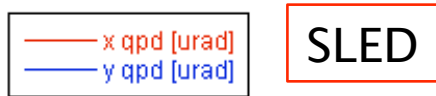


CCD will measure x-y positions and spot size.

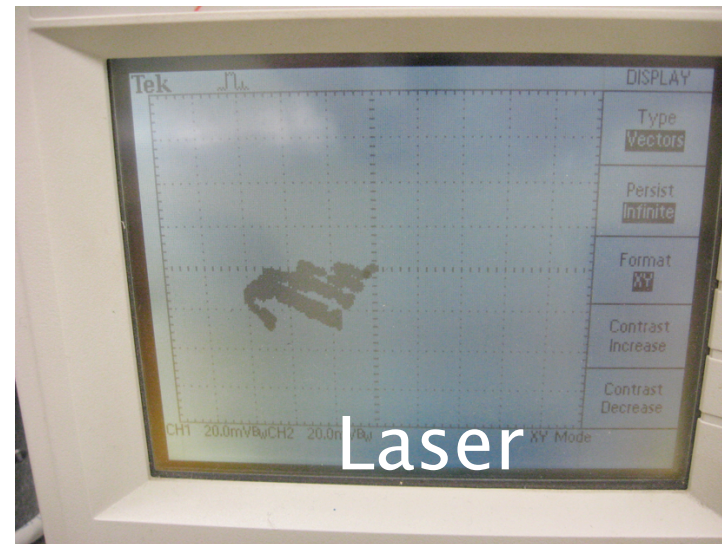
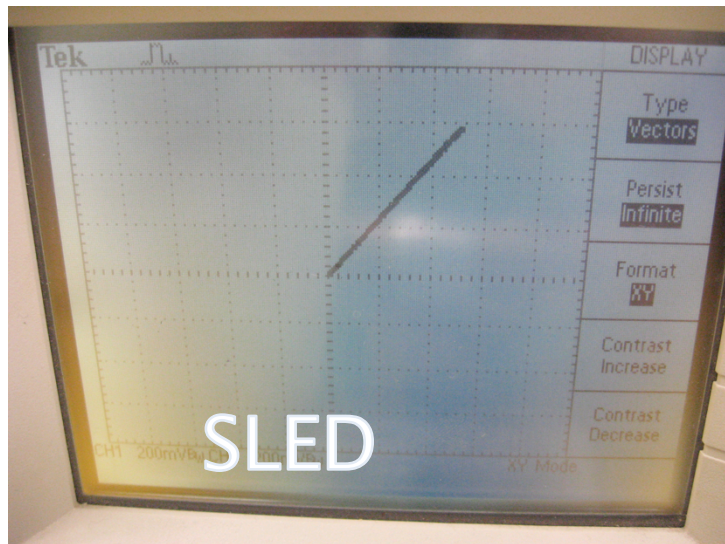
Sum Voltage readout vs Time During Current Modulation



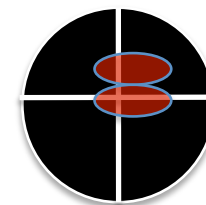
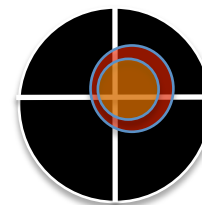
Influence of input current on Normalized Beam Position Data from QPD



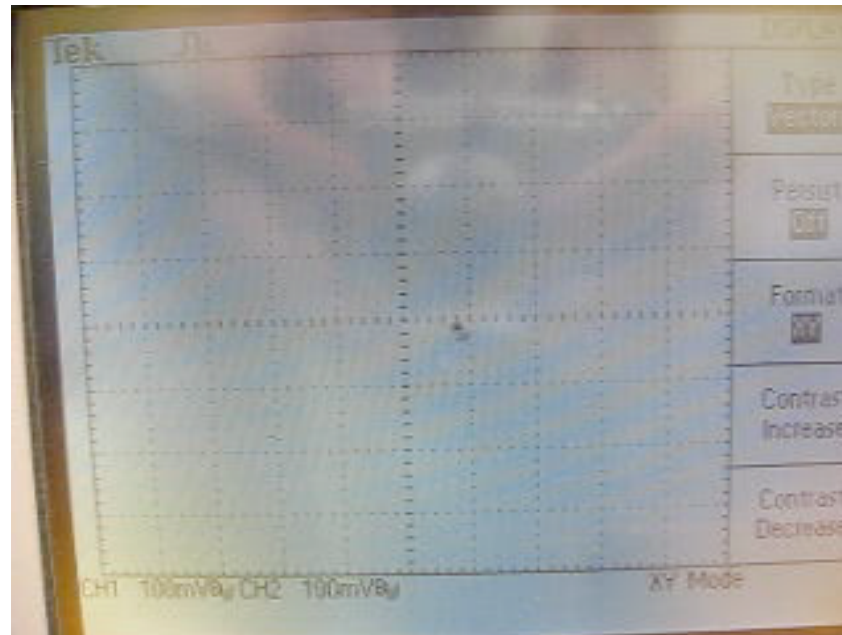
Trace on the Oscilloscope



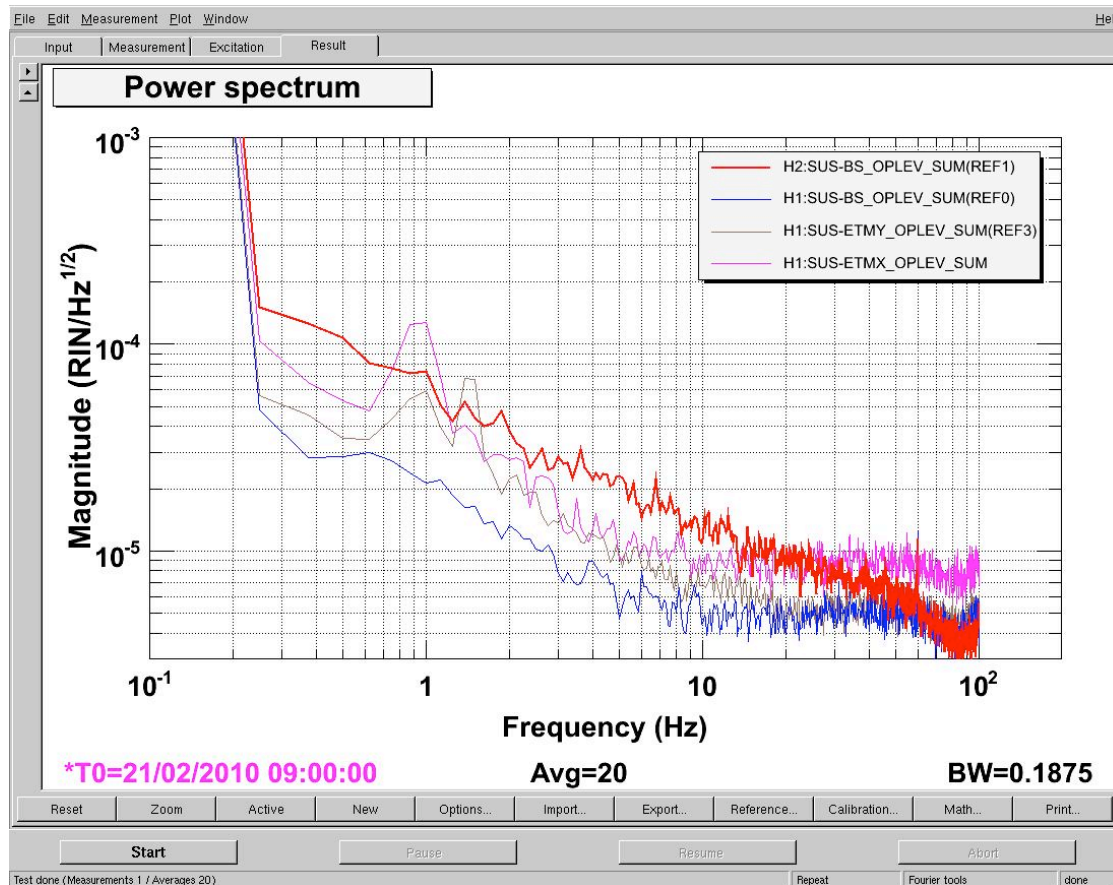
R-L and T-B (un-normalized Voltage) are displayed on x and y axes of the scope. The spot is off center. The current is modulated by the triangular function.



Trace on the Oscilloscope (laser)



SLED results from LHO

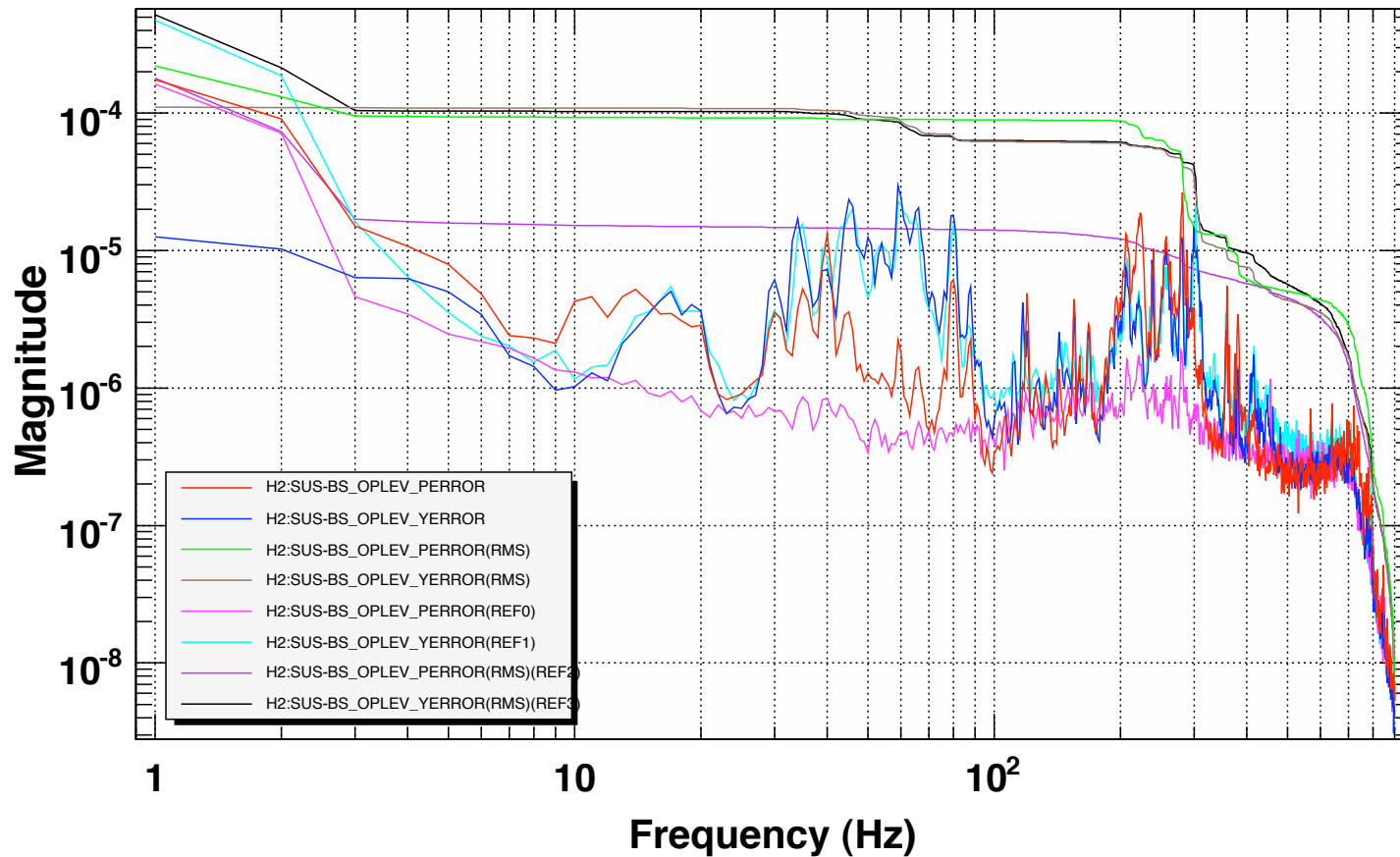


Red is SLED, others are lasers.

SLED results from LHO (2)

free swinging noise read out by the optical levers

REF = w/o LED

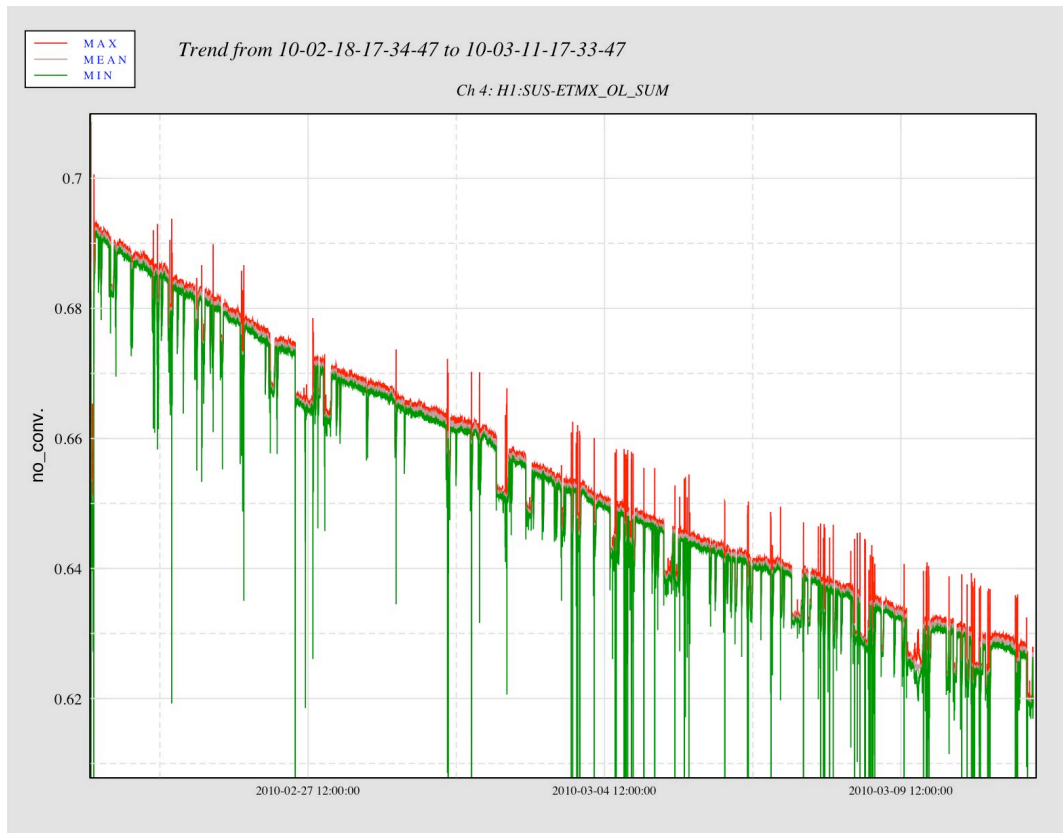


*T0=22/02/2010 12:24:51

Avg=10

BW=1.5

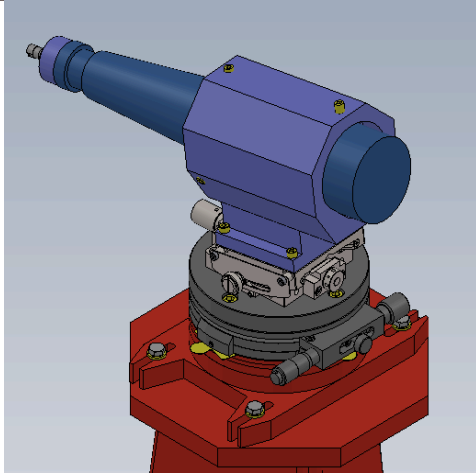
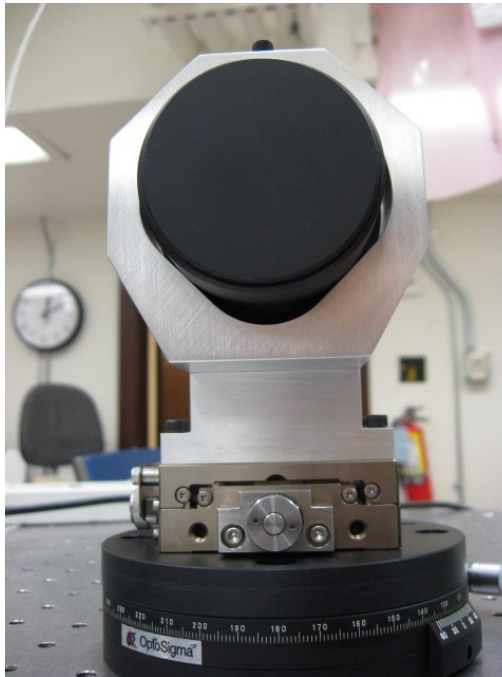
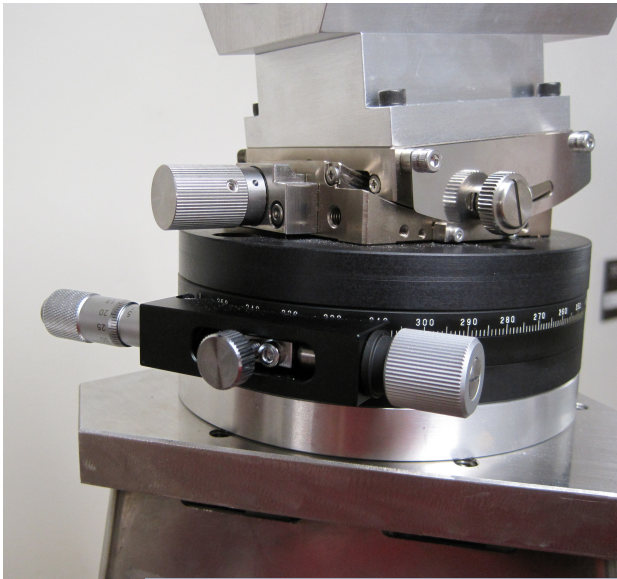
SLED results from LHO (3)



Power decreases
By ~ 7% over 16 days

Rodruck M. Hanford elog, Mar 11 19:51:47 2010 URC

3) Mounting Mechanism



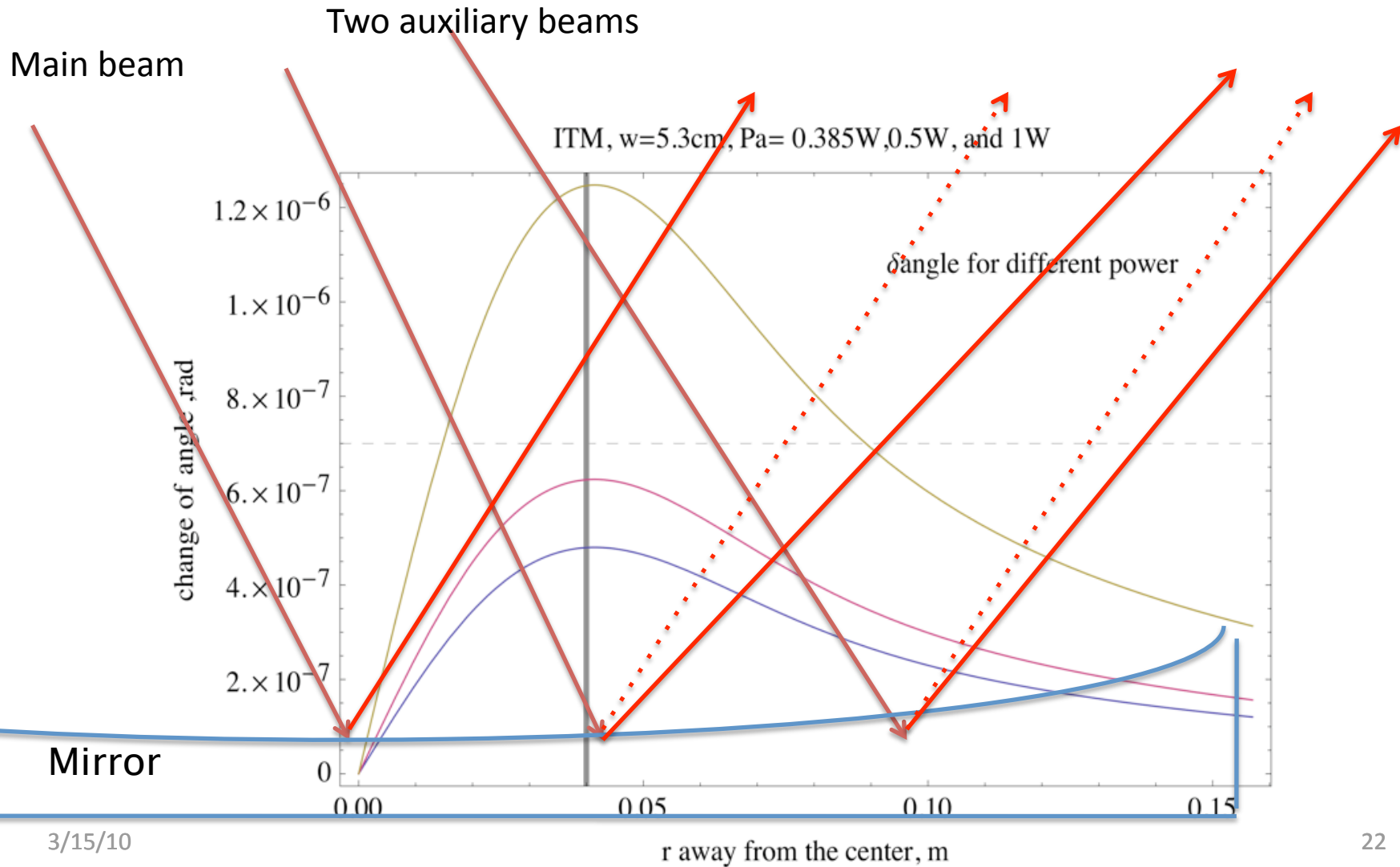
Fifty mm diameter test mass telescope launcher on its yaw-tilt micrometric pointing mechanism; note the locking mechanisms.

Pylon



The pylon is made with sheet metal laser cut, bent and stitch welded.
The pylon will be grouted and bolted on the ground

Observing Thermal Distortion



summary

- Use angle cut fiber connector to reduce vibration induced instabilities
- Use SLED instead of a diode laser -> no mode hopping effect due to current fluctuation.
- More rigid mounting and locking mechanism to ensure better stability.
- Add auxiliary beams to monitor ROC of the mirrors. Fitting algorithm and CCDs will be used for obtaining the data