The ST7 Interferometer

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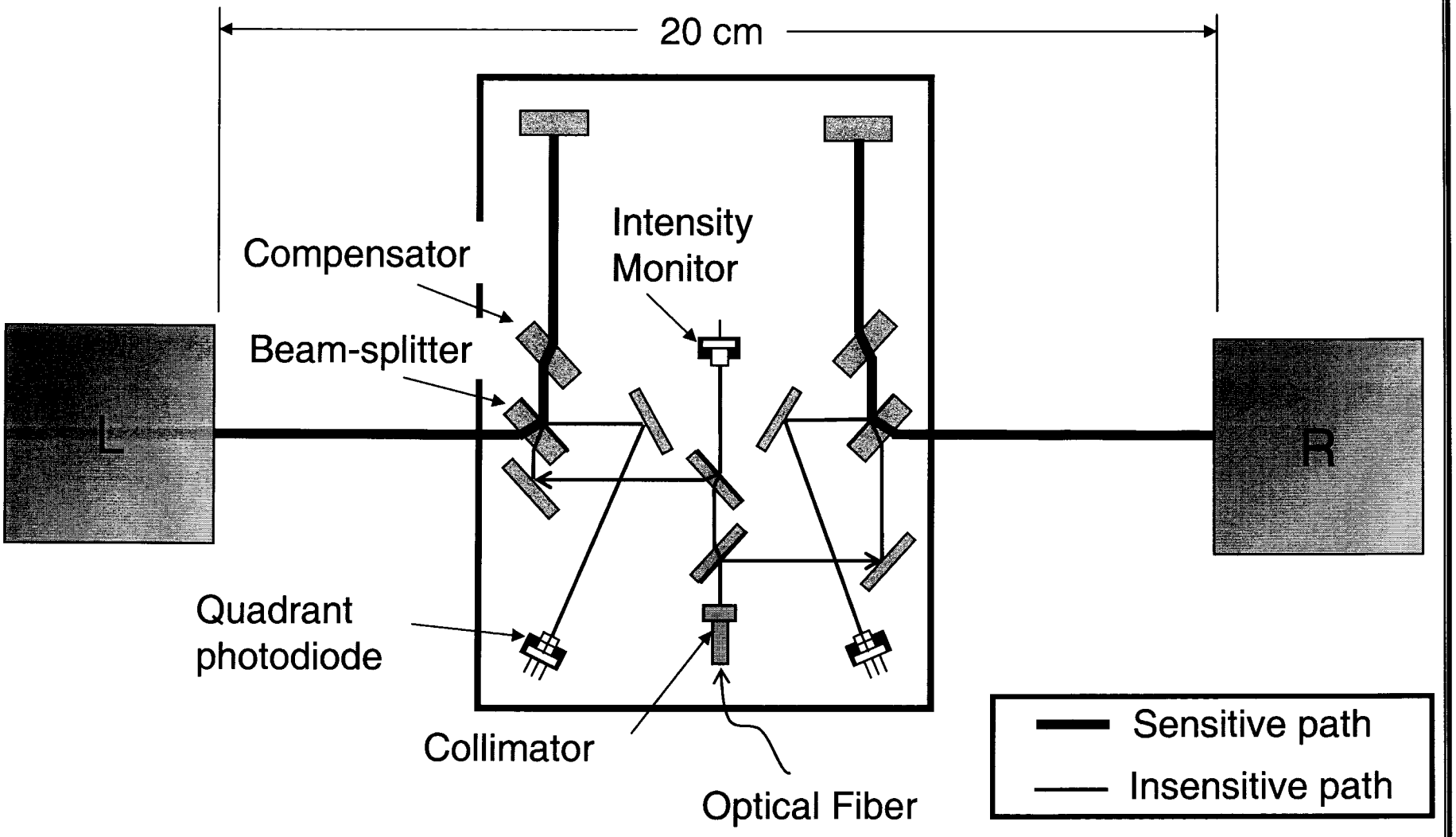
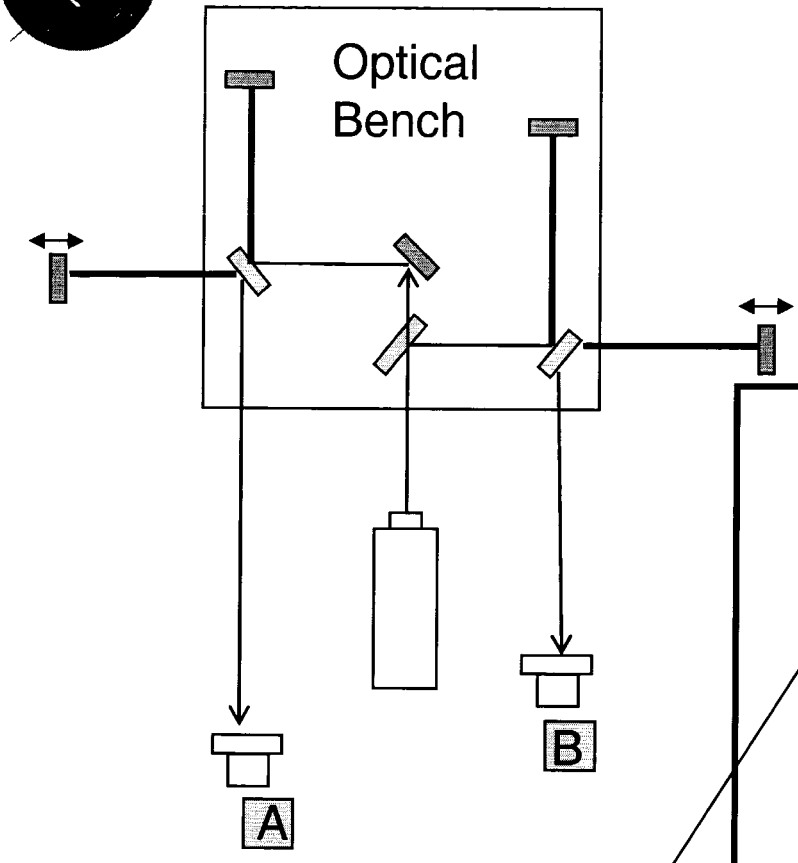
Optical Bench

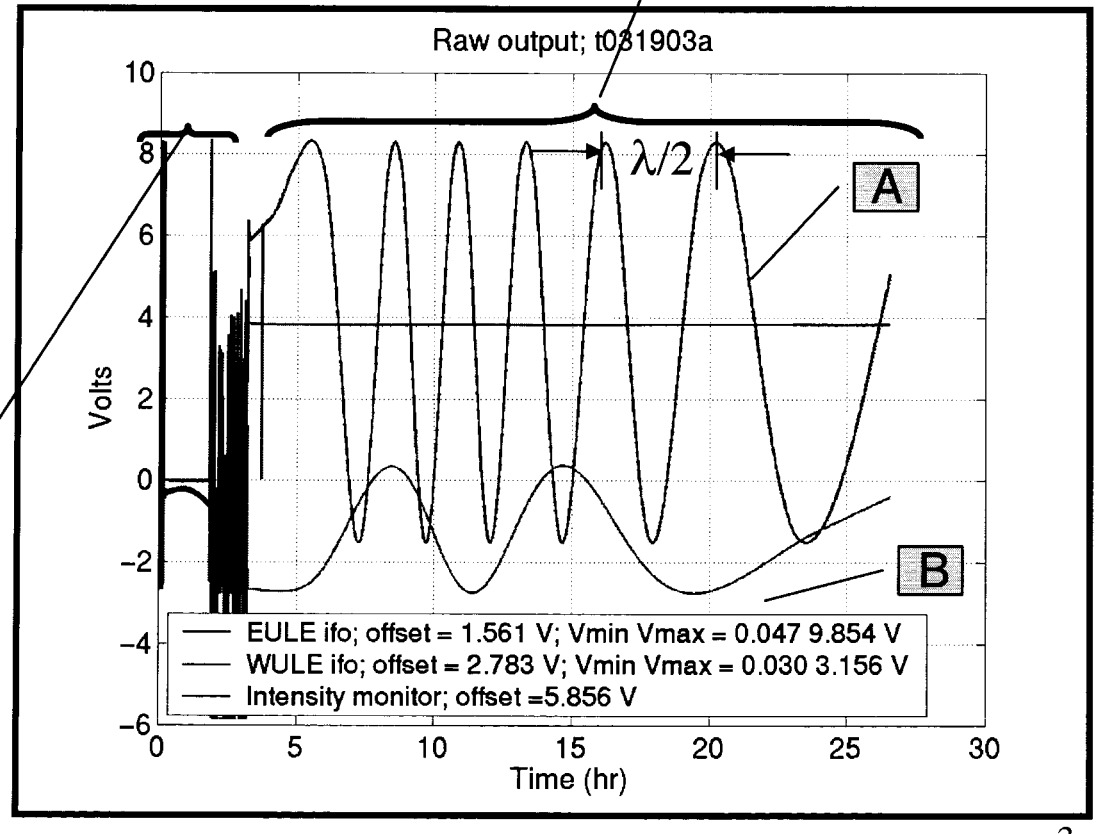


Homodyne Signal

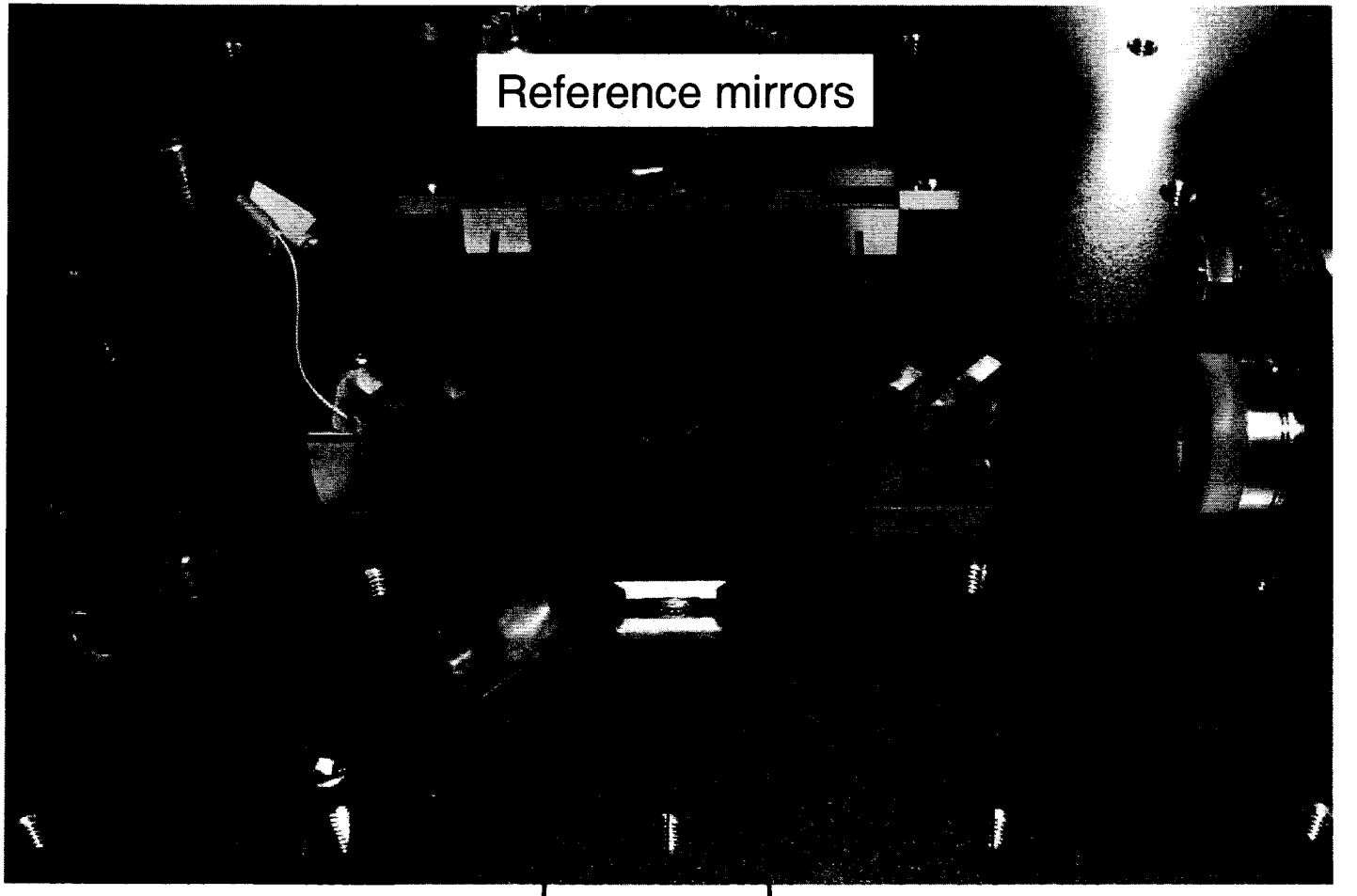


Thermal Expansion

Manual Alignment

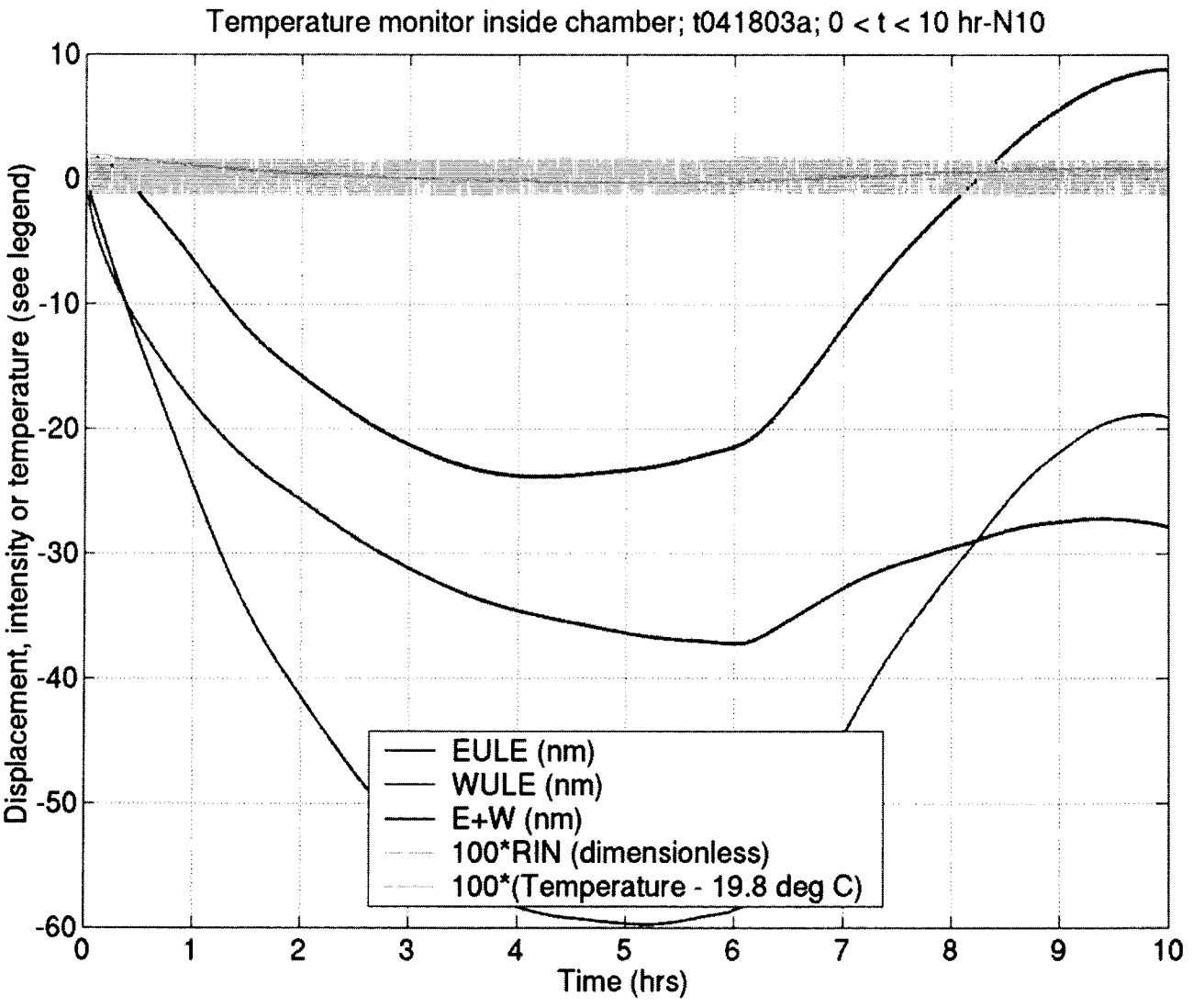


Contacted Optics in Vacuum Chamber

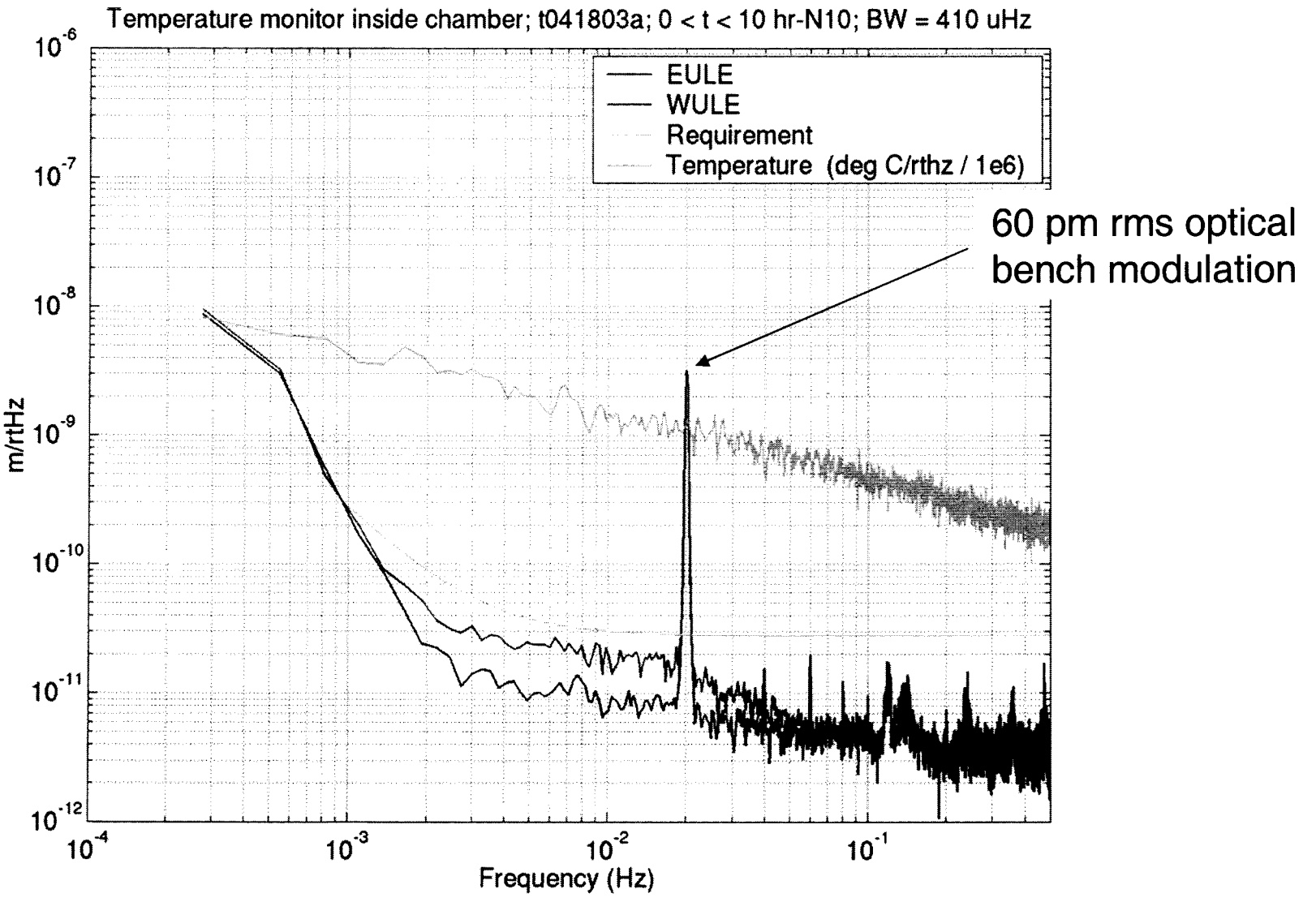


Laser light in

Testbed Drift

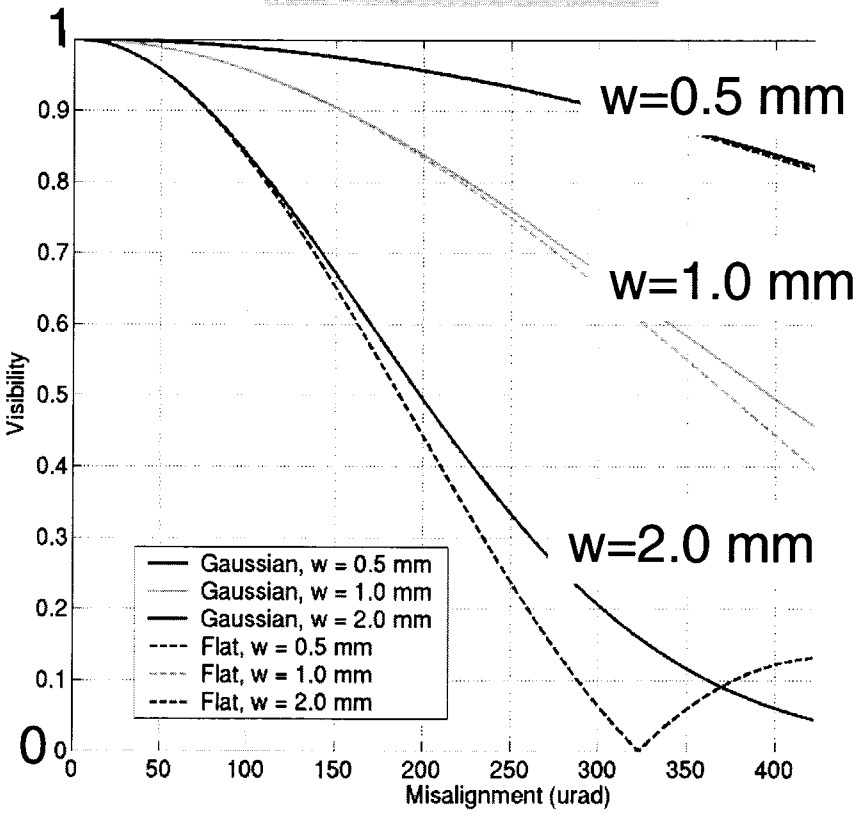


Testbed Noise



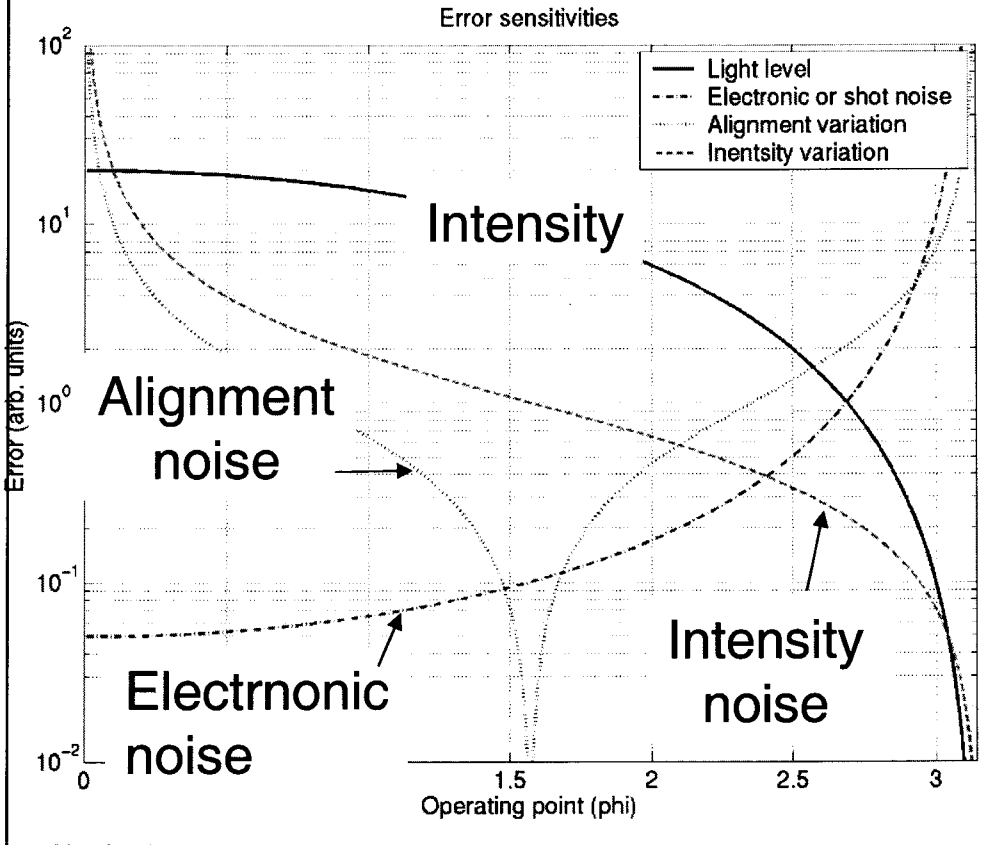
Effect of Static Misalignment

Fringe Visibility



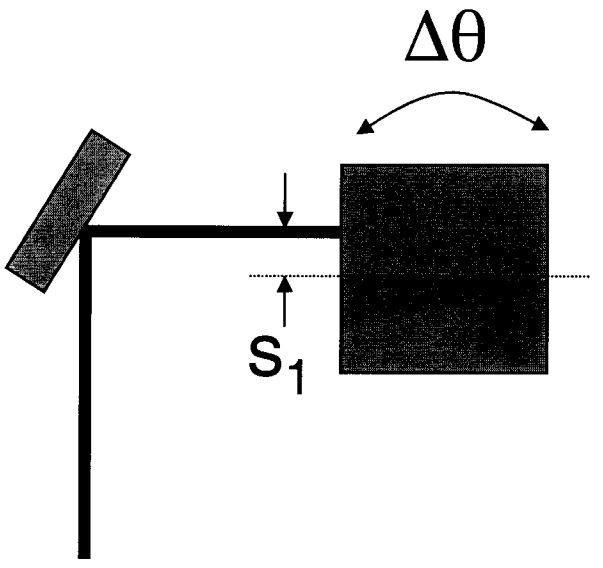
Misalignment (μrad)

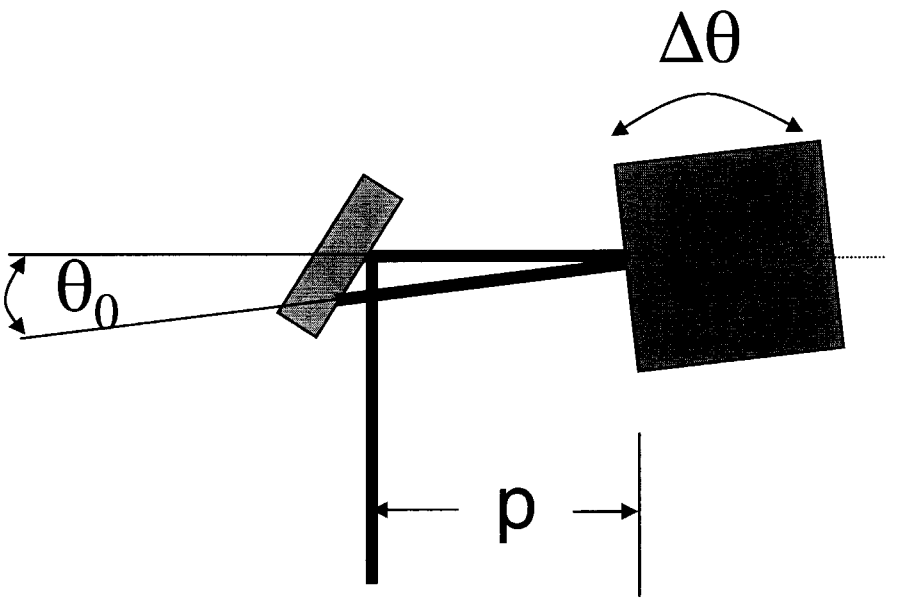
Error Sensitivity



Bright Mid Dark

Alignment Sensitivity 1: Geometric Errors





$$\Delta z_S = s_1 \Delta\theta$$

$$\Delta z_c = p\,\theta_0 \Delta\theta$$

Cancellation of Geometric Errors

sin and cosine errors can be made to cancel:

$$\Delta z_S = s_1 \Delta\theta \qquad \Delta z_c = p\,\theta_0 \Delta\theta$$

$\Delta z_s + \Delta z_c = 0$ when $s_1 = -p\theta_0$,
eliminating sensitivity to $\Delta\theta$.

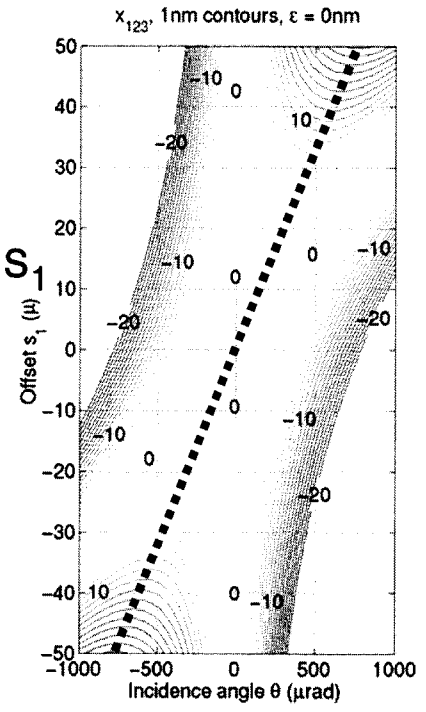
Implementation: Adjust translational or angular offset for extremum of interferometer response (intermittently or in control loop, depending on drift rates).

The catch (for homodyne interferometer): Cancellation fails if mirror position drifts

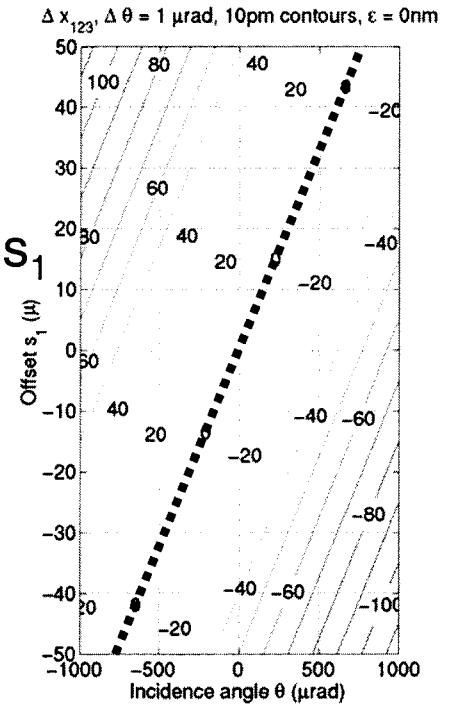
Alignment Sensitivity 2: Readout Errors

Fringe Center: saddle in z(θ)

z(θ)

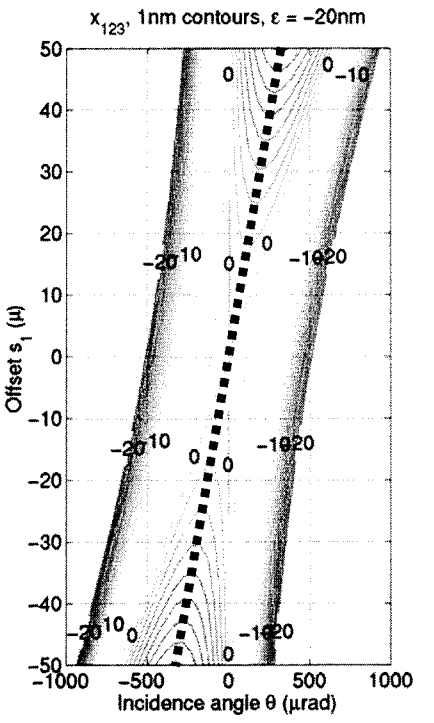


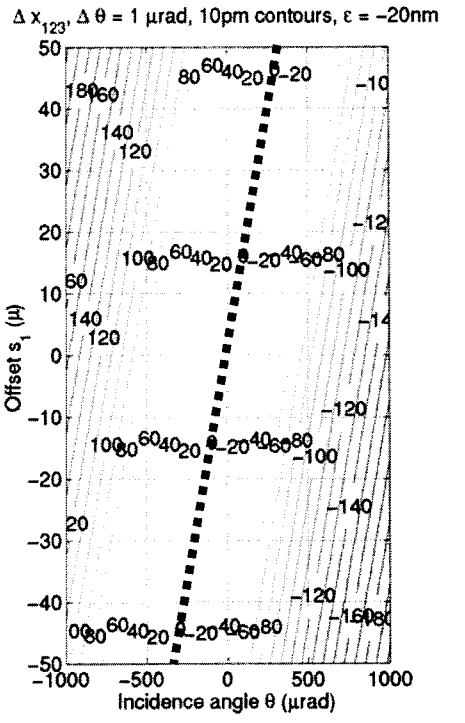
dz/dθ



S_1 θ S_1 θ

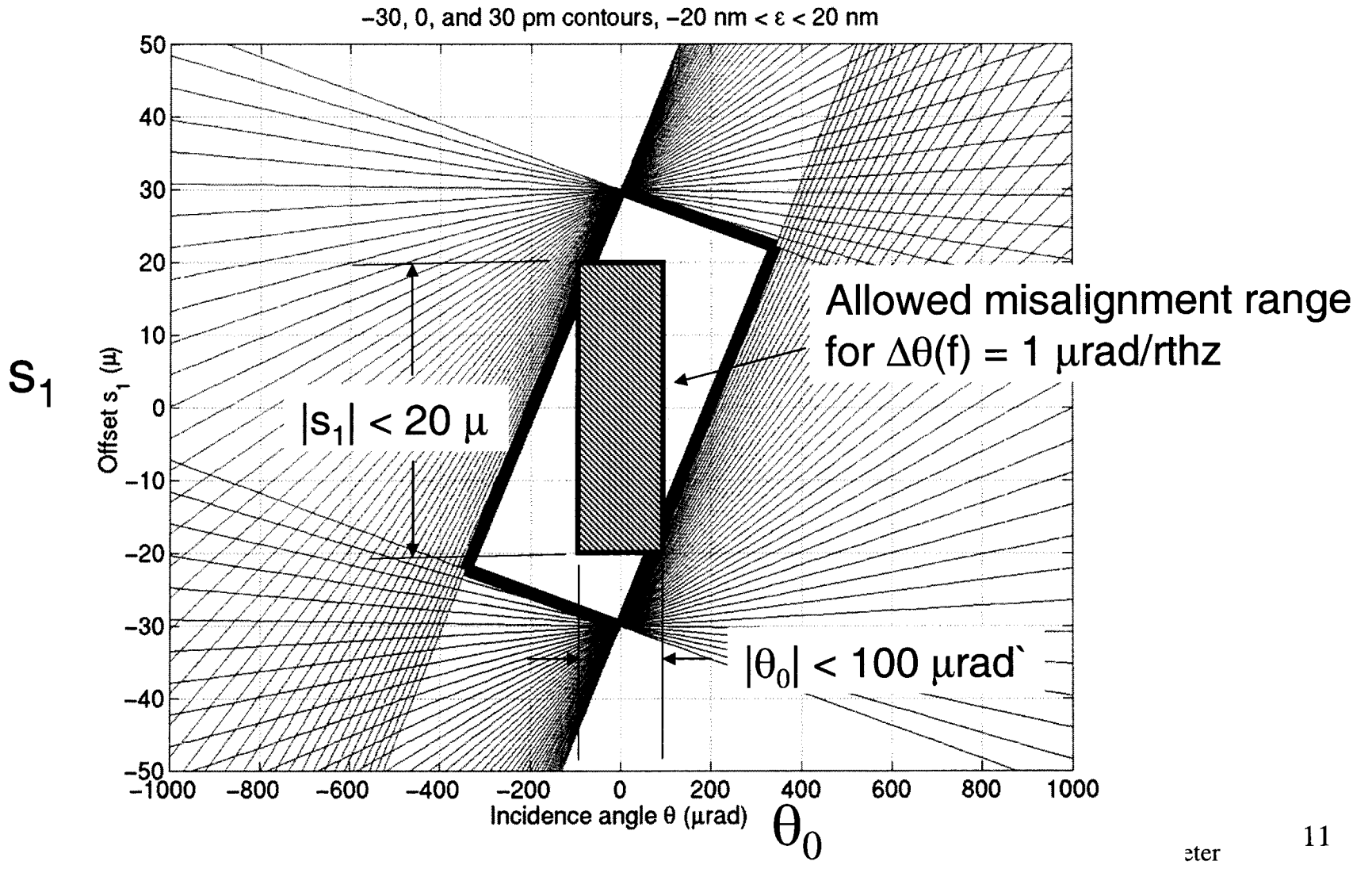
Fringe Center +20 nm: saddle shifts





Effect of Misalignment with Fringe Drift

Union of 30 pm contours for +/- 20 nm drift in z



Options for Reduction of Alignment Noise

1. Tighten tolerances on $\theta(f)$ itself, alignments s_1, θ_0, or test mass position drift Δz . Require:

   $\theta(f)\ s_1\ \theta_0\ \Delta z < 1\ \mu\text{rad/rthz} * 20\ \mu * 100\ \mu\text{rad} * 20\ \text{nm}$

2. Fringe-tracking interferometer to force $\Delta z = 0$. Requires actuated reference mirrors or feedback to both test mass along sensitive axis.

3. Intermittent calibrations to find optimum s_1 or θ_0.

4. Monitor $\theta(f)$ with quadrant photodiodes, and subtract scaled version of measured noise from main displacement signal.