T1300422 H1 Hartmann ITM Probe Scatter
3/19/12

BRDF of plate beam dump, sr^-1 $BRDF_{platebd} := 0.05$

BRDF of chamber wall, sr^-1 $BRDF_{wall} := 0.1$

Motion of HEPI @ 200 Hz, m/rt Hz $x_{hepi} := 2 \cdot 10^{-10}$

Motion of HAM table @ 100 Hz, m/rt Hz $x_{ham} := 3.7 \cdot 10^{-14}$

Motion of HAM flange @ 100 Hz, m/rt Hz $x_{hamflange} := 1.7 \cdot 10^{-11}$

laser wavelength, m $\lambda := 1.064 \cdot 10^{-6}$

wave number, m^-1 $k := 2 \cdot \frac{\pi}{\lambda}$ $k = 5.905 \times 10^{6}$

IFO waist size, m $w_{ifo} := 0.0120$

solid angle of IFO mode, sr $\Delta_{ifo} := \pi \cdot \left(\frac{\lambda}{\pi \cdot w_{ifo}} \right)^2$ $\Delta_{ifo} = 2.502 \times 10^{-9}$

Transfer function @ 100 Hz, ITM AR $TF_{itmar} := 3.16 \cdot 10^{-11}$

Transfer function @ 100 Hz, BS from SR $TF_{srbs} := 4.46 \cdot 10^{-11}$

Ref. T070247

Transmissivity of ITM HR $T_{itmhr} := 0.014$

Transmissivity of ETM HR $T_{etm} := 5 \cdot 10^{-6}$

ETM transmitted power, W $P_{etmtr} := 4.4$

input laser power, W $P_{psl} := 125.0$

arm cavity gain $G_{ac} := 13000$

arm cavity power, W	$P_a := \frac{P_{psl}}{2} \cdot G_{ac}$	$P_a = 8.125 \times 10^5$

Ref. Hiro e-mail 8/29/11

power in power recycling cavity both arms, W	$P_{rc} := \frac{2P_a \cdot T_{itmhr}}{4}$	$P_{rc} = 5.688 \times 10^3$
power in power recycling cavity arm, W	$P_{rca} := \frac{P_a \cdot T_{itmhr}}{4}$	$P_{rca} = 2.844 \times 10^3$
Gaussian power parameter in recycling cavity	$P_{0rc} := P_{rca}$	$P_{0rc} = 2.844 \times 10^3$
Power recycling cavity gain	$G_{rc} := \frac{2 \cdot P_{rca}}{P_{psl}}$	$G_{rc} = 45.5$
refl port signal ratio	$G_{refl} := 0.0010$	
as port signal ratio	$G_{as} := 0.001080$	
output signal power, W	$P_{sc} := P_{psl} \cdot G_{as}$	$P_{sc} = 0.135$
power after SRM, W	$P_{srm} := G_{as} \cdot P_{psl}$	
transmissivity of SRM HR	$T_{srmhr} := 0.200$	
power in signal recycling cavity, W	$P_{src} := \frac{P_{srm}}{T_{srmhr}}$	$P_{src} = 0.675$
reflectivity of BS HR	$R_{bshr} := 0.50$	
reflectivity of BS AR	$R_{bsar} := 50 \cdot 10^{-6}$	
Reflectivity of ITM HR	$R_{itmhr} := 0.9860$	
Reflectivity of ITM AR	$R_{itmar} := 50 \cdot 10^{-6}$	

reflectivity of AS septum port $R_{sp} := 0.0025$

transmissivity of PRM HR $T_{prmhr} := 0.212$

reflectivity of PRM HR $R_{prmhr} := 1 - T_{prmhr}$ $R_{prmhr} = 0.788$

reflectivity of PRM AR $R_{prmar} := 50 \cdot 10^{-6}$

transmissivity of PRM AR $T_{prmar} := 1 - R_{prmar}$ $T_{prmar} = 1$

reflectivity of SRM HR $R_{srmhr} := 1 - T_{srmhr}$ $R_{srmhr} = 0.8$

reflectivity of SRM AR $R_{srmar} := 50 \cdot 10^{-6}$

transmissivity of SRM AR $T_{srmar} := 1 - R_{srmar}$ $T_{srmar} = 1$

reflectivity of PR2 HR $R_{pr2hr} := 0.9999$

transmissivity of PR2 HR $T_{pr2hr} := 1 - R_{pr2hr}$ $T_{pr2hr} = 10 \times 10^{-5}$

reflectivity of PR2 AR $R_{pr2ar} := 50 \cdot 10^{-6}$

transmissivity of PR2 AR $T_{pr2ar} := 1 - R_{pr2ar}$ $T_{pr2ar} = 1$

reflectivity of SR2 HR $R_{sr2hr} := R_{pr2hr}$ $R_{sr2hr} = 1$

reflectivity of SR2 AR $R_{sr2ar} := R_{pr2ar}$ $R_{sr2ar} = 5 \times 10^{-5}$

transmissivity of SR2 HR $T_{sr2hr} := T_{pr2hr}$ $T_{sr2hr} = 10 \times 10^{-5}$

transmissivity of SR2 AR $T_{sr2ar} := T_{pr2ar}$ $T_{sr2ar} = 0.99995$

reflectivity of PR3 HR $R_{pr3hr} := 0.9999$

transmissivity of PR3 HR $T_{pr3hr} := 1 - R_{pr3hr}$ $T_{pr3hr} = 10 \times 10^{-5}$

reflectivity of PR3 AR $R_{pr3ar} := 50 \cdot 10^{-6}$

transmissivity of PR3 AR $T_{pr3ar} := 1 - R_{pr3ar}$ $T_{pr3ar} = 1$

reflectivity of SR3 HR $R_{sr3hr} := R_{pr3hr}$ $R_{sr3hr} = 1$

reflectivity of SR3 AR $R_{sr3ar} := R_{pr3ar}$ $R_{sr3ar} = 5 \times 10^{-5}$

transmissivity of SR3 HR $T_{sr3hr} := T_{pr3hr}$ $T_{sr3hr} = 10 \times 10^{-5}$

transmissivity of SR3 AR $T_{sr3ar} := T_{pr3ar}$ $T_{sr3ar} = 1$

reflectivity of FM HR $R_{FMhr} := R_{pr3hr}$ $R_{FMhr} = 1$

reflectivity of BS AR $R_{bsar} = 5 \times 10^{-5}$

Reflectivity of SR3 $R_{SR3} := 0.9999$

Reflectivity of dichroic DCBS1 $R_{DCBS1} := 0.99$

Transmissivity of dichroic DCBS1 $T_{DCBS1} := 1 - R_{DCBS1}$ $T_{DCBS1} = 0.01$

Transmissivity of lens $T_{lens} := 1 - 0.005$ $T_{lens} = 0.995$

Reflectivity of viewport $R_{vp} := 0.0025$

Reflectivity of HWS mirrors $R_{HWS} := 0.99$

transmissivity of SR2 HR $T_{sr2hr} = 10 \times 10^{-5}$

BRDF of viewport $BRDF_{vp} := 0.005$

BRDF of mirror, sr^-1
recent measurement Thorlabs PF20-03-PO1,
@ 10 deg. $BRDF_{mirror} := 6 \cdot 10^{-5}$

BRDF of dichroic DCBS1 $BRDF_{DCBS1} := 0.01$

BRDF of lens $BRDF_{lens} := 1$

Beam Waist after H1 SR3 $w_{h1sr30} := 0.114 \cdot 10^{-3}$

Beam waist after H1 SR2 $w_{h1sr20} := 0.096 \cdot 10^{-3}$

Beam waist after H1 VAC LENSX $w_{h1vaclensx0} := 0.523 \cdot 10^{-3}$

Beam waist after H1 VAC LENSY $w_{h1vaclensy0} := 0.152 \cdot 10^{-3}$

H1 HARTMANN X

H1 HWSX M1

power incident on H1 HWSX M1, W

$$P_{h1hwsxm1} := R_{bsar} \cdot P_{rca}$$

$$P_{h1hwsxm1} = 0.142$$

power scattered from HWSX M1, W

$$P_{h1hwsxm1s} := R_{bsar} \cdot P_{h1hwsxm1} \cdot BRDF_{mirror} \cdot \frac{w_{ifo}^{2}}{w_{h1sr30}^{2}} \cdot \Delta_{ifo}$$

$$P_{h1hwsxm1s} = 1.183 \times 10^{-14}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{h1hwsxm1sifo} := TF_{itmar} \cdot \left(\frac{P_{h1hwsxm1s}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{h1hwsxm1sifo} = 1.343 \times 10^{-25}$$

H1 HWSX M2

power incident on H1 HWSX M2, W

$$P_{h1hwsxm2} := R_{HWS} \cdot R_{bsar} \cdot P_{rca}$$

$$P_{h1hwsxm2} = 0.141$$

power scattered from HWSX M2, W

$$P_{h1hwsxm2s} := R_{HWS} \cdot R_{bsar} \cdot P_{h1hwsxm2} \cdot BRDF_{mirror} \cdot \frac{w_{ifo}^{2}}{w_{h1sr30}^{2}} \cdot \Delta_{ifo}$$

$$P_{h1hwsxm2s} = 1.159 \times 10^{-14}$$

displacement noise @ 100 Hz,
m/rtHz

$$DN_{h1hwsxm2sifo} := TF_{itmar} \cdot \left(\frac{P_{h1hwsxm2s}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{h1hwsxm2sifo} = 1.33 \times 10^{-25}$$

H1 HWSX M3

power incident on H1 HWSX M3, W

$$P_{h1hwsxm3} := R_{HWS} \cdot R_{HWS} \cdot R_{bsar} \cdot P_{rca}$$

$$P_{h1hwsxm3} = 0.139$$

power scattered from HWSX M3, W

$$P_{h1hwsxm3s} := R_{HWS} \cdot R_{HWS} \cdot R_{bsar} \cdot P_{h1hwsxm3} \cdot BRDF_{mirror} \cdot \frac{w_{ifo}^{2}}{w_{h1sr30}^{2}} \cdot \Delta_{ifo}$$

$$P_{h1hwsxm3s} = 1.136 \times 10^{-14}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{h1hwsxm3sifo} := TF_{itmar} \cdot \left(\frac{P_{h1hwsxm3s}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{h1hwsxm3sifo} = 1.317 \times 10^{-25}$$

H1 DCBS1X

power incident on H1 DCBS1X, W

$$P_{h1dcbs1x} := R_{HWS} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{bsar} \cdot P_{rca}$$

$$P_{h1dcbs1x} = 0.138$$

power scattered from DCBS1X, W

$$P_{h1dcbs1xs} := R_{HWS} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{bsar} \cdot P_{h1dcbs1x} \cdot BRDF_{DCBS1} \cdot \frac{w_{ifo}^{2}}{w_{h1sr30}^{2}} \cdot \Delta_{ifo}$$

$$P_{h1dcbs1xs} = 1.856 \times 10^{-12}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{h1dcbs1xsifo} := TF_{itmar} \cdot \left(\frac{P_{h1dcbs1xs}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{h1dcbs1xsifo} = 1.683 \times 10^{-24}$$

H1 VAC LENSX

power incident on H1 VAC LENSX, W

$$P_{h1vaclensx} := T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{bsar} \cdot P_{rca}$$

$$P_{h1vaclensx} = 1.38 \times 10^{-3}$$

power scattered from VAC LENSX, W

$$P_{h1vaclensxs} := T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{bsar} \cdot P_{h1vaclensx} \cdot BRDF_{lens} \cdot \frac{w_{ifo}^{2}}{w_{h1sr30}^{2}} \cdot \Delta_{}$$

$$P_{h1vaclensxs} = 1.856 \times 10^{-14}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{h1vaclensxsifo} := TF_{itmar} \cdot \left(\frac{P_{h1vaclensxs}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{h1vaclensxsifo} = 1.683 \times 10^{-25}$$

H1 Hartmann X viewport scatter

power incident on Hartmann X viewport, W

$$P_{h1hxvp} := T_{lens} \cdot T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{bsar} \cdot \left(P_{rca} \right)$$

$$P_{h1hxvp} = 1.373 \times 10^{-3}$$

power scattered from H1 Hartmann X viewport, W

$$P_{h1hxvps} := T_{lens} \cdot T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{bsar} \cdot P_{h1hxvp} \cdot BRDF_{vp} \cdot \frac{w_{ifo}^{2}}{w_{h1vaclensx0}^{2}} \cdot \Delta_{ifo}$$

$$P_{h1hxvps} = 4.365 \times 10^{-18}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{h1hxvpsifo} := TF_{itmar} \cdot \left(\frac{P_{h1hxvps}}{P_{psl}} \right)^{0.5} \cdot x_{hamflange} \cdot 2 \cdot k$$

$$DN_{h1hxvpsifo} = 1.186 \times 10^{-24}$$

H1 Hartmann X viewport reflected wall scatter

power incident on Hartmann X viewport reflected wall, W

$$P_{h1hxvprwall} := R_{vp} \cdot T_{lens} \cdot T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{bsar} \cdot \frac{P_{rc}}{2}$$

$$P_{h1hxvprwall} = 3.432 \times 10^{-6}$$

power scattered from Hartmann X viewport reflected wall, W

$$P_{h1hxvprwalls} := R_{vp} \cdot T_{lens} \cdot T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{HWS} \cdot R_{bsar} \cdot P_{h1hxvprwall} \cdot BRDF_{wall} \cdot \frac{w_{ifo}^{2}}{w_{h1vaclensx}}$$

$$P_{h1hxvprwalls} = 5.456 \times 10^{-22}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{h1hxvprwallsifo} := TF_{itmar} \cdot \left(\frac{P_{h1hxvprwalls}}{P_{psl}} \right)^{0.5} \cdot x_{hamflange} \cdot 2 \cdot k$$

$$DN_{h1hxvprwallsifo} = 1.326 \times 10^{-26}$$

H1 HARTMANN Y

H1 HWSY M1

power incident on H1 HWSY M1, W

$$P_{h1hwsym1} := T_{sr2hr} \cdot P_{src}$$

$$P_{h1hwsym1} = 6.75 \times 10^{-5}$$

power scattered from H1 HWSY M1, W

$$P_{h1hwsym1s} := T_{sr2hr} \cdot P_{h1hwsym1} \cdot BRDF_{mirror} \cdot \frac{w_{ifo}^{2}}{w_{h1sr20}^{2}} \cdot \Delta_{ifo}$$

$$P_{h1hwsym1s} = 1.584 \times 10^{-17}$$

displacement noise @ 100 Hz,
m/rtHz

$$DN_{h1hwsym1sifo} := TF_{srbs} \cdot \left(\frac{P_{h1hwsym1s}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{h1hwsym1sifo} = 6.937 \times 10^{-27}$$

H1 HWSY M2

power incident on H1 HWSY M2, W

$$P_{h1hwsym2} := R_{HWS} \cdot T_{sr2hr} \cdot P_{src}$$

$$P_{h1hwsym2} = 6.682 \times 10^{-5}$$

power scattered from HWSY M2, W

$$P_{h1hwsym2s} := R_{HWS} \cdot T_{sr2hr} \cdot P_{h1hwsym2} \cdot BRDF_{mirror} \cdot \frac{w_{ifo}^{2}}{w_{h1sr20}^{2}} \cdot \Delta_{ifo}$$

$$P_{h1hwsym2s} = 1.552 \times 10^{-17}$$

displacement noise @ 100 Hz,

m/rtHz

$$DN_{h1hwsym2sifo} := TF_{srbs} \cdot \left(\frac{P_{h1hwsym2s}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{h1hwsym2sifo} = 6.868 \times 10^{-27}$$

H1 DCBS1Y

power incident on H1 DCBS1Y, W

$$P_{h1dcbs1y} := R_{HWS} \cdot R_{HWS} \cdot T_{sr2hr} \cdot P_{src}$$

$$P_{h1dcbs1y} = 6.616 \times 10^{-5}$$

power scattered from DCBS1Y, W

$$P_{h1dcbs1ys} := R_{HWS} \cdot R_{HWS} \cdot T_{sr2hr} \cdot P_{src} \cdot P_{h1dcbs1y} \cdot BRDF_{DCBS1} \cdot \frac{w_{ifo}^{2}}{w_{h1sr20}^{2}} \cdot \Delta_{ifo}$$

$$P_{h1dcbs1ys} = 1.711 \times 10^{-15}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{h1dcbs1ysifo} := TF_{srbs} \cdot \left(\frac{P_{h1dcbs1ys}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{h1dcbs1ysifo} = 7.211 \times 10^{-26}$$

H1 VAC LENSY

power incident on VAC LENSY, W

$$P_{h1vaclensy} := T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot T_{sr2hr} \cdot P_{src}$$

$$P_{h1vaclensy} = 6.616 \times 10^{-7}$$

power scattered from VAC LENSY, W

$$P_{h1vaclensys} := T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot T_{sr2hr} \cdot P_{h1vaclensy} \cdot BRDF_{lens} \cdot \frac{w_{ifo}^{2}}{w_{h1sr20}^{2}} \cdot \Delta_{ifo}$$

$$P_{h1vaclensys} = 2.535 \times 10^{-17}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{h1vaclensysifo} := TF_{srbs} \cdot \left(\frac{P_{h1vaclensys}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{h1vaclensysifo} = 8.777 \times 10^{-27}$$

H1 HWSY M3

power incident on H1 HWSY M3, W

$$P_{h1hwsym3} := T_{lens} \cdot T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot T_{sr2hr} \cdot P_{src}$$

$$P_{h1hwsym3} = 6.583 \times 10^{-7}$$

power scattered from H1 HWSY M3, W

$$P_{h1hwsym3s} := T_{lens} \cdot T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot T_{sr2hr} \cdot P_{h1hwsym3} \cdot BRDF_{mirror} \cdot \frac{w_{ifo}^{2}}{w_{h1vaclensy0}^{2}} \cdot \Delta_{if}$$

$$P_{h1hwsym3s} = 6.007 \times 10^{-22}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{h1hwsym3sifo} := TF_{srbs} \cdot \left(\frac{P_{h1hwsym3s}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{h1hwsym3sifo} = 4.273 \times 10^{-29}$$

H1 Hartmann Y viewport scatter

power incident on H1 Hartmann Y viewport, W

$$P_{h1hyvp} := R_{HWS} \cdot T_{lens} \cdot T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot T_{sr2hr} \cdot P_{src}$$

$$P_{h1hyvp} = 6.517 \times 10^{-7}$$

power scattered from Hartmann Y viewport, W

$$P_{h1hyvps} := R_{HWS} \cdot T_{lens} \cdot T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot T_{sr2hr} \cdot P_{h1hyvp} \cdot BRDF_{vp} \cdot \frac{w_{ifo}^{2}}{w_{h1vaclensy0}^{2}} \cdot \Delta_{ifo}$$

$$P_{h1hyvps} = 4.907 \times 10^{-20}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{h1hyvpsifo} := TF_{srbs} \cdot \left(\frac{P_{h1hyvps}}{P_{psl}} \right)^{0.5} \cdot x_{hamflange} \cdot 2 \cdot k$$

$$DN_{h1hyvpsifo} = 1.774 \times 10^{-25}$$

H1 Hartmann Y viewport reflected wall scatter

power incident on H1 Hartmann Y viewport reflected wall, W

$$P_{h1hyvprwall} := R_{vp} \cdot R_{HWS} \cdot T_{lens} \cdot T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot T_{sr2hr} \cdot P_{src}$$

$$P_{h1hyvprwall} = 1.629 \times 10^{-9}$$

power scattered from H1 Hartmann y viewport reflected wall, W

$$P_{h1hyvprwalls} := R_{vp} \cdot R_{HWS} \cdot T_{lens} \cdot T_{DCBS1} \cdot R_{HWS} \cdot R_{HWS} \cdot T_{sr2hr} \cdot P_{h1hyvprwall} \cdot BRDF_{wall} \cdot \frac{w_{ifo}^{2}}{w_{h1vaclens}}$$

$$P_{h1hyvprwalls} = 6.133 \times 10^{-24}$$

displacement noise @ 100 Hz,
m/rtHz

$$DN_{h1hyvprwallsifo} := TF_{srbs} \cdot \left(\frac{P_{h1hyvprwalls}}{P_{psl}} \right)^{0.5} \cdot x_{hamflange} \cdot 2 \cdot k$$

$$DN_{h1hyvprwallsifo} = 1.984 \times 10^{-27}$$

ifo

$\frac{}{2}\cdot\Delta_{ifo}$
0

$\frac{}{2} \cdot \Delta_{ifo}$
$_{y}0$