T1300403 Wide Angle Scatter from ETM
8-20-12

Displacement noise requirement @ 100 Hz, m/rt Hz $D_{req} := 1 \cdot 10^{-21}$

Motion of manifold @ 100 Hz, m/rt Hz $x_{manifold} := 8 \cdot 10^{-11}$

motion of ACB @ 100 Hz, m/rtHz $x_{ACB} := 1 \cdot 10^{-12}$

motion of ISI optical table @ 100 Hz, m/rtHz $x_{ISI} := 3 \cdot 10^{-14}$

Transfer function @ 100 Hz, ITM HR $TF_{itmhr} := 1.1 \cdot 10^{-9}$

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

BRDF of oxidized un-polished steel, sr^-1 $BRDF_{oxiunpolish} := 0.05$

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

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

wide angle hemispherical scattering loss fraction from TM wide, ref: T070089 $\alpha_L := 10 \times 10^{-6}$

see T070303 with arm cavity gain = 13000

arm power, W $P_a := 8.125 \times 10^{5}$

input laser power, W $P_{psl} := 125$

arm cavity length, m $L := 4000$

The following data comes from ZEMAX sensor data; see /ALIGO/SLC/ACB ETM power summary.xlsx

SCATTER PATH LENGTH

distance from spool 7A2, m	$L_{7A2} := 7.446$
distance from PCal structure, m	$L_{PCal} := 2.371$
distance from BSC bottom, m	$L_{bscbottom} := 2.248$
distance from BSC front, m	$L_{bscfront} := 1.566$
distance from BSC back, m	$L_{bscback} := 1.967$
distance from SUS mid, m	$L_{SUS} := 0.172$
distance from ACB PLATE Top ETM, m	$L_{acbptop} := 0.764$
distance from ACB PLATE Bottom ETM, m	$L_{acbpbot} := 0.572$
distance from ACB PLATE 2 ETM, m	$L_{acbp2} := 0.716$
distance from ACB PLATE 3 ETM, m	$L_{acbp3} := 0.605$
distance from ACB PLATE 4 ETM, m	$L_{acbp4} := 0.468$
distance from ACB PLATE 5 ETM, m	$L_{acbp5} := 0.475$
distance from ACB PLATE 6 ETM, m	$L_{acbp6} := 0.443$
distance from ACB PLATE 7 ETM, m	$L_{acbp7} := 0.231$
distance from peak and cabling, m	$L_{cable} := \frac{L_{acbp2} + L_{acbp6}}{2}$

$L_{cable} = 0.58$

distance from ETM to WIDE ANGLE BAF TOP LEDGE ITMX, m $L_{wabtop} := 0.901$

distance from ETM to WIDE ANGLE BAF BOTTOM LEDGE ETM m $L_{wabbot} := 0.748$

distance from WIDE ANGLE BAF SIDE right, m $L_{wabsr} := 0.895$

distance from WIDE ANGLE BAF SIDE left, m $L_{wabsl} := 0.788$

SCATTER ANGLE

angle from spool 7A2, rad $\theta_{7A2} := 0.1$

angle from PCal structure, rad $\theta_{PCal} := 0.09$

angle from BSC bottom, rad $\theta_{bscbottom} := 1.8$

angle from BSC front, rad $\theta_{bscfront} := 1.83$

angle from BSC back, rad $\theta_{bscback} := 1.73$

angle from SUS mid, rad $\theta_{SUS} := 1.81$

angle from ACB PLATE Top ETM, rad $\theta_{acbptop} := 0.99$

angle from ACB PLATE Bottom ETM, rad $\theta_{acbpbot} := 0.67$

angle from ACB PLATE 2 ETM, rad $\theta_{acbp2} := 0.82$

angle from ACB PLATE 3 ETM, rad $\theta_{acbp3} := 0.605$

angle from ACB PLATE 4 ETM, rad $\theta_{acbp4} := 0.45$

angle from ACB PLATE 5 ETM, rad $\theta_{acbp5} := 0.34$

angle from ACB PLATE 6 ETM, rad $\theta_{acbp6} := 0.31$

angle from ACB PLATE 7 ETM, rad $\theta_{acbp7} := 0.15$

angle from peak and cabling, m $\theta_{cable} := \frac{\theta_{acbp2} + \theta_{acbp6}}{2}$

$\theta_{cable} = 0.565$

angle from ETM to WIDE ANGLE BAF TOP LEDGE ITMX, rad $\theta_{wabtop} := 0.71$

angle from ETM to WIDE ANGLE BAF BOTTOM LEDGE ETM, rad $\theta_{wabbot} := 0.51$

angle from WIDE ANGLE BAF SIDE right, rad $\theta_{wabsr} := 0.54$

angle from WIDE ANGLE BAF SIDE left, rad $\theta_{wabsl} := 0.46$

FRACTION of LAMBERTIAN SCATTER FROM COC HITTING SURFACE

fractional power from spool 7A2, W $PF_{7A2} := 0.0122$

fractional power hitting PCal structure, W $PF_{PCal} := 0.0278$

fractional power passing through hole in ACB, W $PF_{acbhole} := PF_{7A2} + PF_{PCal}$

$PF_{acbhole} = 0.04$

fractional power from BSC bottom, W $PF_{bscbottom} := 0.0311$

fractional power from BSC front, W $PF_{bscfront} := 0.0544$

fractional power from BSC back, W $PF_{bscback} := 0.00444$

fractional power from SUS mid, W $PF_{SUS} := 0.0456$

fractional power from ACB PLATE Top ETM, W $PF_{acbptop} := 0.00444$

fractional power from ACB PLATE Bottom ETM, W $PF_{acbpbot} := 0.0278$

fractional power from ACB PLATE 2 ETM, W $PF_{acbp2} := 0.0689$

fractional power from ACB PLATE 3 ETM, W $PF_{acbp3} := 0.0211$

fractional power from ACB PLATE 4 ETM, W $PF_{acbp4} := 0.00889$

fractional power from ACB PLATE 5 ETM, W $PF_{acbp5} := 0.0578$

fractional power from ACB PLATE 6 ETM, W $PF_{acbp6} := 0.0633$

fractional power from ACB PLATE 7 ETM, W $PF_{acbp7} := 0.00778$

fractional power hitting ACB box, W

$$PF_{acbbox} := PF_{acbp2} + PF_{acbp3} + PF_{acbp4} + PF_{acbp5} + PF_{acbp6}$$

$$PF_{acbbox} = 0.22$$

fractional power from ETM to WIDE ANGLE BAF TOP LEDGE ITMX, W

$PF_{wabtop} := 0.0722$

fractional power from ETM to WIDE ANGLE BAF BOTTOM LEDGE ETM, W

$PF_{wabbot} := 0.219$

fractional power from WIDE ANGLE BAF SIDE right, W

$PF_{wabsr} := 0.192$

fractional power from WIDE ANGLE BAF SIDE left, W

$PF_{wabsl} := 0.0567$

fractional power hitting ACB plus wide angle box, W

$PF_{acb} := PF_{acbp2} + PF_{acbp3} + PF_{acbp4} + PF_{acbp5} + PF_{acbp6} + PF_{acbp7} + PF_{wabtop} + PF_{wabbot} + PF$

$PF_{acb} = 0.768$

INCIDENT POWER

incident power from spool 7A2, W $P_{7A2} := P_a \cdot PF_{7A2} \cdot \alpha_L$ $P_{7A2} = 0.099$

incident power hitting PCal structure, W $P_{PCal} := P_a \cdot PF_{PCal} \cdot \alpha_L$ $P_{PCal} = 0.226$

incident power from BSC bottom, W $P_{bscbottom} := P_a \cdot PF_{bscbottom} \cdot \alpha_L$ $P_{bscbottom} = 0.253$

incident power from BSC front, W $P_{bscfront} := P_a \cdot PF_{bscfront} \cdot \alpha_L$ $P_{bscfront} = 0.442$

incident power from BSC back, W $P_{bscback} := P_a \cdot PF_{bscback} \cdot \alpha_L$ $P_{bscback} = 0.036$

incident power from SUS mid, W $P_{SUS} := P_a \cdot PF_{SUS} \cdot \alpha_L$ $P_{SUS} = 0.37$

incident power from ACB PLATE Top ETM, W $P_{acbptop} := P_a \cdot PF_{acbptop} \cdot \alpha_L$ $P_{acbptop} = 0.036$

incident power from ACB PLATE Bottom ETM, W $P_{acbpbot} := P_a \cdot PF_{acbpbot} \cdot \alpha_L$ $P_{acbpbot} = 0.226$

incident power from ACB PLATE 2 ETM, W	$P_{acbp2} := P_a \cdot PF_{acbp2} \cdot \alpha_L$	$P_{acbp2} = 0.56$
incident power from ACB PLATE 3 ETM, W	$P_{acbp3} := P_a \cdot PF_{acbp3} \cdot \alpha_L$	$P_{acbp3} = 0.171$
incident power from ACB PLATE 4 ETM, W	$P_{acbp4} := P_a \cdot PF_{acbp4} \cdot \alpha_L$	$P_{acbp4} = 0.072$
incident power from ACB PLATE 5 ETM, W	$P_{acbp5} := P_a \cdot PF_{acbp5} \cdot \alpha_L$	$P_{acbp5} = 0.47$
incident power from ACB PLATE 6 ETM, W	$P_{acbp6} := P_a \cdot PF_{acbp6} \cdot \alpha_L$	$P_{acbp6} = 0.514$
incident power from ACB PLATE 7 ETM, W	$P_{acbp7} := P_a \cdot PF_{acbp7} \cdot \alpha_L$	$P_{acbp7} = 0.063$
incident power from ETM to WIDE ANGLE BAF TOP LEDGE ITMX, W	$P_{wabtop} := P_a \cdot PF_{wabtop} \cdot \alpha_L$	$P_{wabtop} = 0.587$
incident power from ETM to WIDE ANGLE BAF BOTTOM LEDGE ETM, W	$P_{wabbot} := P_a \cdot PF_{wabbot} \cdot \alpha_L$	$P_{wabbot} = 1.779$
incident power from WIDE ANGLE BAF SIDE right, W	$P_{wabsr} := P_a \cdot PF_{wabsr} \cdot \alpha_L$	$P_{wabsr} = 1.56$
incident power from WIDE ANGLE BAF SIDE left, W	$P_{wabsl} := P_a \cdot PF_{wabsl} \cdot \alpha_L$	$P_{wabsl} = 0.461$

POWER SCATTERED INTO IFO MODE

$P_{inc} := 1$ $\qquad$ $L_s := 1$

$w_{ifo} := 1$

$BRDF_s := 1$

$\theta_{inc} := 1$

$\theta_{s1} := 1$

$\theta_{s2} := 1$

$\theta := 1$

$d\Omega := 1$

$P_{sTM} := 1$

$A_{TM} := 1$

Lambertian scatter function for the TM

$$BRDF_L := \alpha_L \cdot \frac{\cos(\theta)}{\pi}$$

differential wide angle scattered light from TM onto adjacent surfaces

$$dP_{sadj} := P_a \cdot BRDF_L \cdot d\Omega$$

total wide angle scattered light from TM onto each adjacent surfaces

$$P_{sadj} := P_a \cdot \alpha_L \cdot \int_{\theta_{s1}}^{\theta_{s2}} \frac{\cos(\theta)}{\pi} \, d\Omega$$

ZEMAX power fraction

$$PF_s := \int_{\theta_{s1}}^{\theta_{s2}} \frac{\cos(\theta)}{\pi} \, d\Omega$$

incident power hitting the adjacent surface is

$$P_{inc} := P_a \cdot \alpha_L \cdot PF_s$$

irradiance of TM by power scattered from adjacent surface, W/m^2

$$E_s := P_{inc} \cdot BRDF_s \cdot \frac{1}{L_s^2}$$

Flanagan-Thorne scattering cross-section

$$\sigma := \lambda^2 \cdot BRDF_L$$

power scattered by TM into IFO mode

$$P_{sifo} := E_s \cdot \sigma$$

$$P_{sifo} := P_{inc} \cdot BRDF_s \cdot \frac{\lambda^2}{L_s^2} \cdot \alpha_L \cdot \frac{\cos(\theta_{inc})}{\pi}$$

incident power hitting the adjacent surface is

$$P_{inc} := P_a \cdot \alpha_L \cdot PF_s$$

combining these equations, we get

$$P_{sTMifo} := P_{inc} \cdot BRDF_s \cdot \frac{\lambda^2}{L_s^2} \cdot \alpha_L \cdot \frac{\cos(\theta_{inc})}{\pi}$$

spool 7A2, W

$$P_{7A2ifo} := \sqrt{4} \cdot P_{7A2} \cdot BRDF_{wall} \cdot \left(\frac{\lambda^2}{L_{7A2}^2} \cdot \alpha_L \cdot \frac{|\cos(\theta_{7A2})|}{\pi} \right)$$

$$P_{7A2ifo} = 1.282 \times 10^{-21}$$

PCal structure, W

$$P_{PCalifo} := \sqrt{4}\cdot P_{PCal}\cdot\left(\frac{\lambda^2}{L_{PCal}^{\ 2}}\cdot BRDF_{wall}\cdot\alpha_L\cdot\frac{\left|\cos\left(\theta_{PCal}\right)\right|}{\pi}\right)$$

$$P_{PCalifo} = 2.884\times 10^{-20}$$

BSC bottom, W

$$P_{bscbottomifo} := \sqrt{4}\cdot P_{bscbottom}\cdot\left(\frac{\lambda^2}{L_{bscbottom}^{\ 2}}\cdot BRDF_{wall}\cdot\alpha_L\cdot\frac{\left|\cos\left(\theta_{bscbottom}\right)\right|}{\pi}\right)$$

$$P_{bscbottomifo} = 8.188\times 10^{-21}$$

BSC front, W

$$P_{bscfrontifo} := \sqrt{4}\cdot P_{bscfront}\cdot\left(\frac{\lambda^2}{L_{bscfront}^{\ 2}}\cdot BRDF_{wall}\cdot\alpha_L\cdot\frac{\left|\cos\left(\theta_{bscfront}\right)\right|}{\pi}\right)$$

$$P_{bscfrontifo} = 3.329\times 10^{-20}$$

BSC back, W

$$P_{bscbackifo} := \sqrt{4}\cdot P_{bscback}\cdot\left(\frac{\lambda^2}{L_{bscback}^{\ 2}}\cdot BRDF_{wall}\cdot\alpha_L\cdot\frac{\left|\cos\left(\theta_{bscback}\right)\right|}{\pi}\right)$$

$$P_{bscbackifo} = 1.065\times 10^{-21}$$

SUS mid, W

$$P_{SUSifo} := \sqrt{4} \cdot P_{SUS} \cdot \left(\frac{\lambda^2}{L_{SUS}^2} \cdot BRDF_{oxiunpolish} \cdot \alpha_L \cdot \frac{\left| \cos\left(\theta_{SUS}\right) \right|}{\pi} \right)$$

$$P_{SUSifo} = 1.069 \times 10^{-18}$$

ACB PLATE TOP ETM, W

$$P_{acbptopifo} := \sqrt{4} \cdot P_{acbptop} \cdot \left(\frac{\lambda^2}{L_{acbptop}^2} \cdot BRDF_{oxiunpolish} \cdot \alpha_L \cdot \frac{\left| \cos\left(\theta_{acbptop}\right) \right|}{\pi} \right)$$

$$P_{acbptopifo} = 1.222 \times 10^{-20}$$

ACB PLATE Bottom ETM, W

$$P_{acbpbotifo} := \sqrt{4} \cdot P_{acbpbot} \cdot \left(\frac{\lambda^2}{L_{acbpbot}^2} \cdot BRDF_{oxiunpolish} \cdot \alpha_L \cdot \frac{\left| \cos\left(\theta_{acbpbot}\right) \right|}{\pi} \right)$$

$$P_{acbpbotifo} = 1.95 \times 10^{-19}$$

ACB PLATE 2 ETM, W

$$P_{acbp2ifo} := \sqrt{4} \cdot P_{acbp2} \cdot \left(\frac{\lambda^2}{L_{acbp2}^2} \cdot BRDF_{oxiunpolish} \cdot \alpha_L \cdot \frac{\left| \cos\left(\theta_{acbp2}\right) \right|}{\pi} \right)$$

$$P_{acbp2ifo} = 2.685 \times 10^{-19}$$

ACB PLATE 3 ETM, W

$$P_{acbp3ifo} := \sqrt{4} \cdot P_{acbp3} \cdot \left(\frac{\lambda^2}{L_{acbp3}{}^2} \cdot BRDF_{oxiunpolish} \cdot \alpha_L \cdot \frac{\left|\cos\left(\theta_{acbp3}\right)\right|}{\pi} \right)$$

$$P_{acbp3ifo} = 1.388 \times 10^{-19} \qquad L_{acbp3} = 0.605$$

ACB PLATE 4 ETM, W

$$P_{acbp4ifo} := \sqrt{4} \cdot P_{acbp4} \cdot \left(\frac{\lambda^2}{L_{acbp4}{}^2} \cdot BRDF_{oxiunpolish} \cdot \alpha_L \cdot \frac{\left|\cos\left(\theta_{acbp4}\right)\right|}{\pi} \right)$$

$$P_{acbp4ifo} = 1.07 \times 10^{-19}$$

ACB PLATE 5 ETM, W

$$P_{acbp5ifo} := \sqrt{4} \cdot P_{acbp5} \cdot \left(\frac{\lambda^2}{L_{acbp5}{}^2} \cdot BRDF_{oxiunpolish} \cdot \alpha_L \cdot \frac{\left|\cos\left(\theta_{acbp5}\right)\right|}{\pi} \right)$$

$$P_{acbp5ifo} = 7.071 \times 10^{-19}$$

ACB PLATE 6 ETM, W

$$P_{acbp6ifo} := \sqrt{4}\cdot P_{acbp6}\cdot\left(\frac{\lambda^2}{{L_{acbp6}}^2}\cdot BRDF_{oxiunpolish}\cdot\alpha_L\cdot\frac{\left|\cos\left(\theta_{acbp6}\right)\right|}{\pi}\right)$$

$$P_{acbp6ifo} = 8.994\times10^{-19}$$

ACB PLATE 7 ETM, W

$$P_{acbp7ifo} := \sqrt{4}\cdot P_{acbp7}\cdot\left(\frac{\lambda^2}{{L_{acbp7}}^2}\cdot BRDF_{oxiunpolish}\cdot\alpha_L\cdot\frac{\left|\cos\left(\theta_{acbp7}\right)\right|}{\pi}\right)$$

$$P_{acbp7ifo} = 4.221\times10^{-19}$$

WIDE ANGLE BAF TOP LEDGE ITMX, W

$$P_{wabtopifo} := \sqrt{4}\cdot P_{wabtop}\cdot\left(\frac{\lambda^2}{{L_{wabtop}}^2}\cdot BRDF_{oxiunpolish}\cdot\alpha_L\cdot\frac{\left|\cos\left(\theta_{wabtop}\right)\right|}{\pi}\right)$$

$$P_{wabtopifo} = 1.975\times10^{-19}$$

WIDE ANGLE BAF BOTTOM LEDGE ETM, W

$$P_{wabbotifo} := \sqrt{4}\cdot P_{wabbot}\cdot\left(\frac{\lambda^2}{{L_{wabbot}}^2}\cdot BRDF_{oxiunpolish}\cdot\alpha_L\cdot\frac{\left|\cos\left(\theta_{wabbot}\right)\right|}{\pi}\right)$$

$$P_{wabbotifo} = 1\times10^{-18}$$

WIDE ANGLE BAF SIDE right W

$$P_{wabsrifo} := \sqrt{4}\cdot P_{wabsr}\cdot\left(\frac{\lambda^2}{L_{wabsr}^{\ 2}}\cdot BRDF_{oxiunpolish}\cdot\alpha_L\cdot\frac{\left|\cos\left(\theta_{wabsr}\right)\right|}{\pi}\right)$$

$$P_{wabsrifo} = 6.019\times 10^{-19}$$

WIDE ANGLE BAF SIDE left, W

$$P_{wabslifo} := \sqrt{4}\cdot P_{wabsl}\cdot\left(\frac{\lambda^2}{L_{wabsl}^{\ 2}}\cdot BRDF_{oxiunpolish}\cdot\alpha_L\cdot\frac{\left|\cos\left(\theta_{wabsl}\right)\right|}{\pi}\right)$$

$$P_{wabslifo} = 2.396\times 10^{-19}$$

DIFFUSE SCATTERING FROM PEEK AND CABLING

length of cabling, m $\quad l_c := 2$

diameter of cabling, m $\quad d_c := 0.006$

frontal area of cabling, m^2 $\quad A_c := l_c\cdot d_c = 0.012$

diameter of peek end cap, m $\quad d_{pc} := .025$

number of peek end caps $\quad N_{pc} := 4$

total area of scattering surfaces, m^2 $\quad A_{tpc} := A_c + N_{pc}\cdot\frac{\pi}{4}\cdot d_{pc}^{\ 2}$

$$A_{tpc} = 0.014$$

frontal area of ACB, m^2 $\quad A_{acb} := 0.7$

Incident Power, W

PEEK AND CABLING, W

$$P_{ipc} := P_a \cdot PF_{acbbox} \cdot \frac{A_{tpc}}{A_{acb}} \cdot \alpha_L = 0.036$$

$$PF_{acbcable} := PF_{acbbox} \cdot \frac{A_{tpc}}{A_{acb}}$$

$$PF_{acbcable} = 4.388 \times 10^{-3}$$

Power Scattered into IFO Mode, W

PEEK AND CABLING, W

$$P_{pcifo} := \sqrt{4} \cdot P_{ipc} \cdot \left(\frac{\lambda^2}{L_{cable}^{\ 2}} \cdot BRDF_{wall} \cdot \alpha_L \cdot \frac{\left|\cos\left(\theta_{cable}\right)\right|}{\pi} \right)$$

$$P_{pcifo} = 6.463 \times 10^{-20}$$

TOTAL ACB BACK, W

$$P_{wacbbackifo} := \left(P_{acbptopifo}^{\ 2} + P_{acbpbotifo}^{\ 2} + P_{acbp2ifo}^{\ 2} + P_{acbp3ifo}^{\ 2} + P_{acbp4ifo}^{\ 2} + P_{acbp5ifo}^{\ 2} \cdot \right.$$

$$P_{wacbbackifo} = 1.278 \times 10^{-18}$$

TOTAL ACB BACK AND BOX, W

$$P_{wacbboxifo} := \left(P_{wacbbackifo}^{\ 2} + P_{wabtopifo}^{\ 2} + P_{wabbotifo}^{\ 2} + P_{wabsrifo}^{\ 2} + P_{wabslifo}^{\ 2} \right)^{0.5}$$

$$P_{wacbboxifo} = 1.758 \times 10^{-18}$$

TOTAL BSC Walls, W

$$P_{bscifo} := \left(P_{bscbottomifo}^{2} + P_{bscfrontifo}^{2} + P_{bscbackifo}^{2}\right)^{0.5}$$

$$P_{bscifo} = 3.43 \times 10^{-20}$$

DISPLACEMENT NOISE @ 100 Hz, m/rtHz

$\theta_t := 0$ $\quad x_s := 1$

Displacement Noise Requirement @ 100 Hz, m/rt Hz

$D_{req} = 1 \times 10^{-21}$

$$P_{sifo} := 1$$

Amplitude spectral density of sine phase fluctuations of the injected field

$$S := \sqrt{8 \cdot \pi^{2} \cdot \frac{x_s^{2}}{\lambda^{2}}}$$

displacement noise according to Flanagan-Thorne

$$DN_{s\_thorne} := \left(\frac{P_{sifo}}{P_a}\right)^{0.5} \cdot \frac{\lambda}{4 \cdot \pi \cdot L} \cdot S \cdot L$$

displacement noise using Smith_Yamamoto formalism

$$DN_{s\_smith} := TF_{itmhr} \cdot \left(\frac{P_{sifo}}{P_{psl}}\right)^{0.5} \cdot \frac{2 \cdot k \cdot x_s}{\sqrt{2}}$$

where the factor 1/rt2 was added to correct for the slow phase motion that is below the gravity wave band

The two different approaches give results within < 5%

TOTAL ACB BACK AND BOX

$$S_{ACB} := \sqrt{8 \cdot \pi^2 \cdot \frac{x_{ACB}^2}{\lambda^2}}$$

$$DN_{wacbboxifo\_thorne} := \left(\frac{P_{wacbboxifo}}{P_a}\right)^{0.5} \cdot \frac{\lambda}{4 \cdot \pi \cdot L} \cdot S_{ACB} \cdot L$$

$$DN_{wacbboxifo\_thorne} = 1.04 \times 10^{-24}$$

$$DN_{wacbboxifo\_smith} := TF_{itmhr} \cdot \left(\frac{P_{wacbboxifo}}{P_{psl}}\right)^{0.5} \cdot x_{ACB} \cdot 2 \cdot \frac{k}{\sqrt{2}}$$

$$DN_{wacbboxifo\_smith} = 1.089 \times 10^{-24}$$

$$\frac{DN_{wacbboxifo\_smith}}{DN_{wacbboxifo\_thorne}} = 1.047$$

SUS

$$DN_{sus} := TF_{itmhr} \cdot \left(\frac{P_{SUSifo}}{P_{psl}}\right)^{0.5} \cdot x_{ISI} \cdot 2 \cdot \frac{k}{\sqrt{2}}$$

$$DN_{sus} = 2.549 \times 10^{-26}$$

TOTAL BSC Walls

$$DN_{bsc} := TF_{itmhr} \cdot \left(\frac{P_{bscifo}}{P_{psl}}\right)^{0.5} \cdot x_{manifold} \cdot 2 \cdot \frac{k}{\sqrt{2}}$$

$$DN_{bsc} = 1.217 \times 10^{-23}$$

spool 7A2

$$DN_{7A2} := TF_{itmhr} \cdot \left(\frac{P_{7A2ifo}}{P_{psl}} \right)^{0.5} \cdot x_{manifold} \cdot 2 \cdot \frac{k}{\sqrt{2}}$$

$$DN_{7A2} = 2.354 \times 10^{-24}$$

PCal structure

$$DN_{PCal} := TF_{itmhr} \cdot \left(\frac{P_{PCalifo}}{P_{psl}} \right)^{0.5} \cdot x_{manifold} \cdot 2 \cdot \frac{k}{\sqrt{2}}$$

$$DN_{PCal} = 1.116 \times 10^{-23}$$

$_{wabsr} + PF_{wabsl}$

$$+ P_{acbp6ifo}^{2} + P_{acbp7ifo}^{2} + P_{pcifo}^{2}\Big)^{0.5}$$