H1 Signal Recycling Cavity
2/28/12

wavelength, mm	$\lambda := 1.064 \cdot 10^{-3}$	
1 ppm beam radius multiple	$m_{1ppm} := \sqrt{3 \cdot \ln(10)}$	$m_{1ppm} = 2.628$
index of refraction of fused silica	$n := 1.458464$	
corrected index, 12/5/12	$n := 1.44963$	
off-axis angle, deg	$\theta := \frac{1}{2}$	$\theta = 0.5$
beam waist in IFO, mm	$w_{01} := 12.0$	
radius1 of ITM mm	$R1_{ITM} := -1934000$	
thickness of ITM mm	$t_{ITM} := 200$	
radius2 of ITM mm	$R2_{ITM} := 10^{64}$	
radius1 of BS mm	$R1_{BS} := 10^{64}$	
thickness of BS, mm	$t_{BS} := 65.8$	
radius2 of BS mm	$R2_{BS} := 10^{64}$	
radius of SR3 mm	$R_{SR3} := -36000$	
radius1 of SR2 mm	$R1_{SR2} := 6430$	
thickness of SR2 mm	$t_{SR2} := 75$	
radius2 of SR2 mm	$R2_{SR2} := 10^{64}$	
radius1 of SRM mm	$R1_{SRM} := 5690$	
thickness of SRM mm	$t_{SRM} := 75$	

radius2 of SRM mm $R2_{SRM} := 10^{64}$

distance from IFO waist to ITM, mm $l_{ifo\_ITM} := 1835000$

distance from ITM to BS Ellip Baf, mm $l_{ITM\_bsellip} := 4890$

distance from ITM to BS, mm $l_{ITM\_BS} := 20 + 100 \cdot n + 4817.4$

$l_{ITM\_BS} = 4.982 \times 10^{3}$

distance from BS to BS Ellip Baf, mm $l_{BS\_bsellip} := l_{ITM\_BS} - l_{ITM\_bsellip}$

$l_{BS\_bsellip} = 92.363$

distance from BS Ellip Baf to SR3, mm $l_{BSellipbaf\_SR3} := 19368 + (65.8 + 65.7) \cdot n + l_{BS\_bsellip}$

$l_{BSellipbaf\_SR3} = 1.9651 \times 10^{4}$

distance from SR3 TO SR2, mm $l_{SR3\_SR2} := 15461.2$

distance from SR2 TO SRM, mm $l_{SR2\_SRM} := 15740.9$

HARTMANN X

distance from SR3 TO SR2 SCRAPER BAF, mm $l_{SR3\_SR2scrapbaf} := 14888$

distance from SR3 TO HWSX M1 mm $l_{SR3\_HWSXM1} := 14888 + 367$

distance from SR3 TO HARTMAN SCRAPER BAF, mm $l_{SR3\_hartscrapbaf} := 14888 + 367 + 792.3$

distance from SR3 TO HWSX M2 mm $l_{SR3\_HWSXM2} := 14888 + 367 + 792.3 + 456.8$

distance from SR3 TO HWSY M3, mm $l_{SR3\_HWSYM3} := 14888 + 367 + 792.3 + 456.8 + 401.6$

distance from SR3 TO dcbs1 mm $l_{SR3\_dcbs1} := 14888 + 367 + 792.3 + 456.8 + 401.6 + 163.4$

distance from SR3 TO vac lens mm $l_{SR3\_vaclens} := 14888 + 367 + 792.3 + 456.8 + 401.6 + 163.4 + 3$

distance from VAC LENSX TO VP, mm $l_{vaclensx\_vp} := 688.1$

focal length VAC LENSX, mm $f_{vaclensx} := -700$

HARTMANN Y

distance from SR2 AR TO SR2 scraper Baffle, mm $l_{SR2ar\_SR2arbaff} := 705$

distance from SR2 AR TO HWSY M1, mm $l_{SR2ar\_HWSYM1} := 705 + 189$

distance from SR2 AR TO Hartmann Scraper Baffle, mm $l_{SR2ar\_hartscraprbaff} := 705 + 189 + 741$

distance from SR2 AR TO HWSY M2, mm $l_{SR2ar\_HWSYM2} := 705 + 189 + 741 + 455$

distance from SR2 AR TO DCBS1, mm $l_{SR2ar\_DCBS1} := 705 + 189 + 741 + 455 + 68$

distance from SR2 AR TO VAC LENS, mm $l_{SR2ar\_vaclens} := 705 + 189 + 741 + 455 + 68 + 152$

distance from VAC LENS to HWSY M3 mm $l_{vaclens\_hwsym3} := 529$

distance from VAC LENS to VP, mm $l_{vaclensy\_VP} := 1292$

focal length VAC LENSY, mm $f_{vaclensy} := 60$

signal recycling cavity length, mm

$L_{src} := 200 \cdot n + l_{ITM\_BS} + l_{BS\_bsellip} + l_{BSellipbaf\_SR3} + l_{SR3\_SR2} + l_{SR2\_SRM}$ $L_{src} = 5.622 \times 10^{4}$

translation IFO waist to ITM

$$T_{ifo\_ITM} := \begin{pmatrix} 1 & l_{ifo\_ITM} \\ 0 & 1 \end{pmatrix} \qquad T_{ifo\_ITM} = \begin{pmatrix} 1 & 1.835 \times 10^{6} \\ 0 & 1 \end{pmatrix}$$

first surface ITM

$$M1_{ITM} := \begin{pmatrix} 1 & 0 \\ \dfrac{1-n}{n \cdot R1_{ITM}} & \dfrac{1}{n} \end{pmatrix} \qquad M1_{ITM} = \begin{pmatrix} 1 & 0 \\ 1.604 \times 10^{-7} & 0.69 \end{pmatrix}$$

thickness of ITM

$$T_{ITM} := \begin{pmatrix} 1 & t_{ITM} \\ 0 & 1 \end{pmatrix} \qquad T_{ITM} = \begin{pmatrix} 1 & 200 \\ 0 & 1 \end{pmatrix}$$

second surface ITM

$$M2_{ITM} := \begin{pmatrix} 1 & 0 \\ \dfrac{n-1}{R2_{ITM}} & n \end{pmatrix} \qquad M2_{ITM} = \begin{pmatrix} 1 & 0 \\ 0 & 1.45 \end{pmatrix}$$

translation ITM to BS
Ellip Baf

$$T_{ITM\_BSellipbaf} := \begin{pmatrix} 1 & l_{ITM\_bsellip} \\ 0 & 1 \end{pmatrix} \qquad T_{ITM\_BSellipbaf} = \begin{pmatrix} 1 & 4.89 \times 10^{3} \\ 0 & 1 \end{pmatrix}$$

translation ITM to BS

$$T_{ITM\_BS} := \begin{pmatrix} 1 & l_{ITM\_BS} \\ 0 & 1 \end{pmatrix} \qquad T_{ITM\_BS} = \begin{pmatrix} 1 & 4.982 \times 10^{3} \\ 0 & 1 \end{pmatrix}$$

translation BS to BS
Ellip baf

$$T_{BS\_BSellipbaf} := \begin{pmatrix} 1 & l_{BS\_bsellip} \\ 0 & 1 \end{pmatrix} \qquad T_{BS\_BSellipbaf} = \begin{pmatrix} 1 & 92.363 \\ 0 & 1 \end{pmatrix}$$

translation BS Ellip
Baf to SR3

$$T_{BSellip\_SR3} := \begin{pmatrix} 1 & l_{BSellipbaf\_SR3} \\ 0 & 1 \end{pmatrix} \qquad T_{BSellip\_SR3} = \begin{pmatrix} 1 & 1.965 \times 10^{4} \\ 0 & 1 \end{pmatrix}$$

SR3 mirror

$$M_{SR3} := \begin{pmatrix} 1 & 0 \\ \dfrac{2}{R_{SR3}} & 1 \end{pmatrix} \qquad M_{SR3} = \begin{pmatrix} 1 & 0 \\ -5.556 \times 10^{-5} & 1 \end{pmatrix}$$

translation SR3 to SR2

$$T_{SR3\_SR2} := \begin{pmatrix} 1 & l_{SR3\_SR2} \\ 0 & 1 \end{pmatrix}$$

SR2 mirror

$$M_{SR2} := \begin{pmatrix} 1 & 0 \\ \dfrac{2}{R1_{SR2}} & 1 \end{pmatrix} \qquad M_{SR2} = \begin{pmatrix} 1 & 0 \\ 3.11 \times 10^{-4} & 1 \end{pmatrix}$$

translation SR2 to SRM

$$T_{SR2\_SRM} := \begin{pmatrix} 1 & l_{SR2\_SRM} \\ 0 & 1 \end{pmatrix} \qquad T_{SR2\_SRM} = \begin{pmatrix} 1 & 1.574 \times 10^{4} \\ 0 & 1 \end{pmatrix}$$

first surface SRM

$$M1_{SRM} := \begin{pmatrix} 1 & 0 \\ \dfrac{1-n}{n \cdot R1_{SRM}} & \dfrac{1}{n} \end{pmatrix} \qquad M1_{SRM} = \begin{pmatrix} 1 & 0 \\ -5.451 \times 10^{-5} & 0.69 \end{pmatrix}$$

thickness of SRM

$$T1_{SRM} := \begin{pmatrix} 1 & t_{SRM} \\ 0 & 1 \end{pmatrix} \qquad T1_{SRM} = \begin{pmatrix} 1 & 75 \\ 0 & 1 \end{pmatrix}$$

second surface SRM

$$M2_{SRM} := \begin{pmatrix} 1 & 0 \\ \dfrac{n-1}{R2_{SRM}} & n \end{pmatrix} \qquad M2_{SRM} = \begin{pmatrix} 1 & 0 \\ 0 & 1.45 \end{pmatrix}$$

first surface SR2

$$M1_{SR2} := \begin{pmatrix} 1 & 0 \\ \dfrac{1-n}{n \cdot R1_{SR2}} & \dfrac{1}{n} \end{pmatrix} \qquad M1_{SR2} = \begin{pmatrix} 1 & 0 \\ -4.824 \times 10^{-5} & 0.69 \end{pmatrix}$$

thickness of SR2

$$T_{SR2} := \begin{pmatrix} 1 & t_{SR2} \\ 0 & 1 \end{pmatrix} \qquad T_{SR2} = \begin{pmatrix} 1 & 75 \\ 0 & 1 \end{pmatrix}$$

second surface SR2

$$M2_{SR2} := \begin{pmatrix} 1 & 0 \\ \dfrac{n-1}{R2_{SR2}} & n \end{pmatrix} \qquad M2_{SR2} = \begin{pmatrix} 1 & 0 \\ 0 & 1.45 \end{pmatrix}$$

translation SR2AR to SR2 AR Baff

$$T_{SR2ar\_SR2arbaf} := \begin{pmatrix} 1 & l_{SR2ar\_SR2arbaff} \\ 0 & 1 \end{pmatrix} \qquad T_{SR2ar\_SR2arbaf} = \begin{pmatrix} 1 & 705 \\ 0 & 1 \end{pmatrix}$$

translation SR2AR to Hartmann Scraper Baff

$$T_{SR2ar\_hartscrapbaf} := \begin{pmatrix} 1 & l_{SR2ar\_hartscraprbaff} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR2ar\_hartscrapbaf} = \begin{pmatrix} 1 & 1.635 \times 10^{3} \\ 0 & 1 \end{pmatrix}$$

translation SR2AR to HWSYM1

$$T_{SR2AR\_HWSYM1} := \begin{pmatrix} 1 & l_{SR2ar\_HWSYM1} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR2AR\_HWSYM1} = \begin{pmatrix} 1 & 894 \\ 0 & 1 \end{pmatrix}$$

translation SR2AR to HWSYM2

$$T_{SR2AR\_HWSYM2} := \begin{pmatrix} 1 & l_{SR2ar\_HWSYM2} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR2AR\_HWSYM2} = \begin{pmatrix} 1 & 2.09 \times 10^3 \\ 0 & 1 \end{pmatrix}$$

translation SR2AR to DCBS1

$$T_{SR2AR\_DCBS1} := \begin{pmatrix} 1 & l_{SR2ar\_DCBS1} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR2AR\_DCBS1} = \begin{pmatrix} 1 & 2.158 \times 10^3 \\ 0 & 1 \end{pmatrix}$$

translation SR2AR to VAC LENS

$$T_{SR2AR\_vaclens} := \begin{pmatrix} 1 & l_{SR2ar\_vaclens} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR2AR\_vaclens} = \begin{pmatrix} 1 & 2.31 \times 10^3 \\ 0 & 1 \end{pmatrix}$$

thin LENSY matrix

$$ML_{vaclensy}(f_{vaclensy}) := \begin{pmatrix} 1 & 0 \\ \frac{-1}{f_{vaclensy}} & 1 \end{pmatrix}$$

translation VAC LENS to HWSYM3

$$T_{vaclens\_HWSYM3} := \begin{pmatrix} 1 & l_{vaclens\_hwsym3} \\ 0 & 1 \end{pmatrix}$$

$$T_{vaclens\_HWSYM3} = \begin{pmatrix} 1 & 529 \\ 0 & 1 \end{pmatrix}$$

translation VAC LENSY to VP

$$T_{vaclensy\_VP} := \begin{pmatrix} 1 & l_{vaclensy\_VP} \\ 0 & 1 \end{pmatrix}$$

$$T_{vaclensy\_VP} = \begin{pmatrix} 1 & 1.292 \times 10^3 \\ 0 & 1 \end{pmatrix}$$

translation SR3 to SR2scraper baf

$$T_{SR3\_SR2scrap} := \begin{pmatrix} 1 & l_{SR3\_SR2scrapbaf} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR3\_SR2scrap} = \begin{pmatrix} 1 & 1.489 \times 10^{4} \\ 0 & 1 \end{pmatrix}$$

translation SR3 to HWSXM1

$$T_{SR3\_HWSXM1} := \begin{pmatrix} 1 & l_{SR3\_HWSXM1} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR3\_HWSXM1} = \begin{pmatrix} 1 & 1.526 \times 10^{4} \\ 0 & 1 \end{pmatrix}$$

translation SR3 to HARTMANN SCRAPER BAF

$$T_{SR3\_hartscrapbaf} := \begin{pmatrix} 1 & l_{SR3\_hartscrapbaf} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR3\_hartscrapbaf} = \begin{pmatrix} 1 & 1.605 \times 10^{4} \\ 0 & 1 \end{pmatrix}$$

translation SR3 to HWSXM2

$$T_{SR3\_HWSXM2} := \begin{pmatrix} 1 & l_{SR3\_HWSXM2} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR3\_HWSXM2} = \begin{pmatrix} 1 & 1.65 \times 10^{4} \\ 0 & 1 \end{pmatrix}$$

translation SR3 to HWSXM3

$$T_{SR3\_HWSXM3} := \begin{pmatrix} 1 & l_{SR3\_HWSYM3} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR3\_HWSXM3} = \begin{pmatrix} 1 & 1.691 \times 10^{4} \\ 0 & 1 \end{pmatrix}$$

translation SR3 to DCBS1

$$T_{SR3\_DCBS1} := \begin{pmatrix} 1 & l_{SR3\_dcbs1} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR3\_DCBS1} = \begin{pmatrix} 1 & 1.707 \times 10^4 \\ 0 & 1 \end{pmatrix}$$

translation SR3 to VAC LENS

$$T_{SR3\_vaclens} := \begin{pmatrix} 1 & l_{SR3\_vaclens} \\ 0 & 1 \end{pmatrix}$$

$$T_{SR3\_vaclens} = \begin{pmatrix} 1 & 1.739 \times 10^4 \\ 0 & 1 \end{pmatrix}$$

thin LENSX matrix

$$ML_{vaclensx}(f_{vaclensx}) := \begin{pmatrix} 1 & 0 \\ \frac{-1}{f_{vaclensx}} & 1 \end{pmatrix}$$

translation VAC LENSX to VP

$$T_{vaclensx\_VP} := \begin{pmatrix} 1 & l_{vaclensx\_vp} \\ 0 & 1 \end{pmatrix}$$

$$T_{vaclensx\_VP} = \begin{pmatrix} 1 & 688.1 \\ 0 & 1 \end{pmatrix}$$

beam parameters at ITM mirror

system matrix from IFO beam waist to ITM mirror

$$M := T_{ifo\_ITM}$$

$$M = \begin{pmatrix} 1 & 1.835 \times 10^6 \\ 0 & 1 \end{pmatrix}$$

$M_{0,0} = 1$ $\quad M_{0,1} = 1.835 \times 10^6$

$M_{1,0} = 0$ $\quad M_{1,1} = 1$

$$w_{itm} := \left[\frac{\lambda}{\pi} \cdot \frac{-(M_{0,1})^2 - (M_{0,0})^2 \cdot \left(\pi \cdot \frac{w_{01}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}^2}{\lambda} \cdot (M_{0,1} \cdot M_{1,0} - M_{0,0} \cdot M_{1,1})} \right]^{0.5}$$

$w_{itm} = 53.162$

10 ppm beam radius multiple

$$m_{10ppm} := \sqrt{\frac{5}{2} \cdot \ln(10)} \qquad m_{10ppm} = 2.399$$

$$R_{itm} := \frac{\left(M_{0,0}\right)^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2 + \left(M_{0,1}\right)^2}{\left(M_{1,0} \cdot M_{0,0}\right) \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2 + M_{0,1} \cdot M_{1,1}} \qquad R_{itm} = 1.934 \times 10^6$$

beam parameters at BS Ellip Baf

system matrix from IFO beam waist
to BS elli baf

$$M := T_{ITM\_BSellipbaf} \cdot T_{ifo\_ITM}$$

$$M = \begin{pmatrix} 1 & 1.84 \times 10^6 \\ 0 & 1 \end{pmatrix}$$

$$M_{0,0} = 1 \ :4 \times 10^6$$

$$M_{1,0} = 0$$

$$w_{bsellipbaf} := \left[\frac{\lambda}{\pi} \cdot \frac{-\left(M_{0,1}\right)^2 - \left(M_{0,0}\right)^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot \left(M_{0,1} \cdot M_{1,0} - M_{0,0} \cdot M_{1,1}\right)}\right]^{0.5} \qquad w_{bsellipbaf} = 53.297$$

beam parameters at SR3 mirror

system matrix from beam waist
to SR3 mirror

$$M := T_{BSellip\_SR3} \cdot T_{BS\_BSellipbaf} \cdot T_{ITM\_BSellipbaf} \cdot M2_{ITM} \cdot T_{ITM} \cdot M1_{ITM} \cdot T_{ifo\_ITM}$$

$$M = \begin{pmatrix} 1.006 & 1.87 \times 10^{6} \\ 2.325 \times 10^{-7} & 1.427 \end{pmatrix}$$

$M_{0,0} = 1.006$ $\qquad$ $M_{0,1} = 1.87 \times 10^{6}$

$M_{1,0} = 2.325 \times 10^{-7}$ $\qquad$ $M_{1,1} = 1.427$

beam radius at SR3

$$w_{SR3} := \left[\frac{\lambda}{\pi} \cdot \frac{-\left(M_{0,1}\right)^2 - \left(M_{0,0}\right)^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot \left(M_{0,1} \cdot M_{1,0} - M_{0,0} \cdot M_{1,1}\right)} \right]^{0.5} \qquad w_{SR3} = 54.15$$

$w_{10ppmSR3} := 2.399 \cdot w_{SR3}$ $\qquad$ $w_{10ppmSR3} = 129.905$

beam curvature radius after SR3

system matrix after the SR3 mirror

$$Mx_{SR3} := M_{SR3} \cdot T_{BSellip\_SR3} \cdot T_{BS\_BSellipbaf} \cdot T_{ITM\_BSellipbaf} \cdot M2_{ITM} \cdot T_{ITM} \cdot M1_{ITM} \cdot T_{ifo\_ITM}$$

$M := Mx_{SR3}$

$$R_{sr3} := \frac{\left(M_{0,0}\right)^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2 + \left(M_{0,1}\right)^2}{\left(M_{1,0} \cdot M_{0,0}\right) \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2 + M_{0,1} \cdot M_{1,1}} \qquad R_{sr3} = -1.824 \times 10^{4}$$

Beam Waist after SR3

system matrix up to the **SR3 mirror**

$Mx := Mx_{SR3}$

distance from **SR3** to beam waist, mm

$$l_{SR30} := \frac{-\left[\left(\pi \cdot \frac{w_{01}^{2}}{\lambda}\right)^{2}\right] \cdot Mx_{1,0} \cdot Mx_{0,0} - Mx_{0,1} \cdot Mx_{1,1}}{\left[\left(\pi \cdot \frac{w_{01}^{2}}{\lambda}\right)^{2}\right] \cdot \left(Mx_{1,0}\right)^{2} + \left(Mx_{1,1}\right)^{2}}$$

$l_{SR30} = 1.824 \times 10^{4}$

translation to beam waist $T_{SR30} := \begin{pmatrix} 1 & l_{SR30} \\ 0 & 1 \end{pmatrix}$

total system matrix to **SR3** beam waist

$M := T_{SR30} \cdot Mx$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

beam waist after **SR3,** mm

$$w_{SR30} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^{2} - A^{2} \cdot \left(\pi \cdot \frac{w_{01}^{2}}{\lambda}\right)^{2}}{\pi \cdot \frac{w_{01}^{2}}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5}$$

$w_{SR30} = 0.114$

beam parameters at SR2 Scraper baf

total system matrix to SR2 Scraper baf

$M_{sr2scrap} := T_{SR3\_SR2scrap} \cdot Mx_{SR3}$

$M := M_{sr2scrap}$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{sr2scrap} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}^2}{\lambda} \right)^2}{\pi \cdot \frac{w_{01}^2}{\lambda} \cdot (B \cdot C - A \cdot D)} \right]^{0.5}$$

$w_{sr2scrap} = 9.956$

$w_{10ppmSR2scrap} := 2.399 \cdot w_{sr2scrap}$ $w_{10ppmSR2scrap} = 23.884$

beam parameters at SR2 HR mirror

total system matrix to SR2 HR

$M_{sr2hr} := T_{SR3\_SR2} \cdot Mx_{SR3}$

$M := M_{sr2hr}$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{sr2hr} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}^2}{\lambda} \right)^2}{\pi \cdot \frac{w_{01}^2}{\lambda} \cdot (B \cdot C - A \cdot D)} \right]^{0.5}$$

$w_{sr2hr} = 8.255$

$w_{10ppmsrhr} := 2.399 \cdot w_{sr2hr}$ $w_{10ppmsrhr} = 19.803$

Beam Waist after SR2 AR

system matrix up to the **SR2 AR**

$$M_{sr2ar} := M2_{SR2} \cdot T_{SR2} \cdot M1_{SR2} \cdot M_{sr2hr}$$

$$Mx := M_{sr2ar}$$

distance from **SR2 AR** to beam waist, mm

$$l_{SR2AR0} := \frac{-\left[\left(\pi \cdot \frac{w_{01}^{2}}{\lambda}\right)^{2}\right] \cdot Mx_{1,0} \cdot Mx_{0,0} - Mx_{0,1} \cdot Mx_{1,1}}{\left[\left(\pi \cdot \frac{w_{01}^{2}}{\lambda}\right)^{2}\right] \cdot \left(Mx_{1,0}\right)^{2} + \left(Mx_{1,1}\right)^{2}}$$

$$l_{SR2AR0} = 2.276 \times 10^{3}$$

translation to beam waist $T_{SR2AR0} := \begin{pmatrix} 1 & l_{SR2AR0} \\ 0 & 1 \end{pmatrix}$

total system matrix to **SR2 AR** beam waist

$$M := T_{SR2AR0} \cdot Mx$$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

beam waist after **SR2 AR,**
mm

$$w_{SR2AR0} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^{2} - A^{2} \cdot \left(\pi \cdot \frac{w_{01}^{2}}{\lambda}\right)^{2}}{\pi \cdot \frac{w_{01}^{2}}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5}$$

$$w_{SR2AR0} = 0.096$$

beam parameters at SR2 AR Baf

system matrix from IFO waist to SR2 AR Baf

$M_{sr2arbaf} := T_{SR2ar\_SR2arbaf} \cdot M_{sr2ar}$

$M := M_{sr2arbaf}$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{sr2arbaf} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}^{\ 2}}{\lambda} \right)^2}{\pi \cdot \frac{w_{01}^{\ 2}}{\lambda} \cdot (B \cdot C - A \cdot D)} \right]^{0.5} \qquad w_{sr2arbaf} = 5.572$$

$w_{10ppmsr2arbaf} := 2.399 \cdot w_{sr2arbaf}$ $w_{10ppmsr2arbaf} = 13.367$

beam parameters at SRM HR

total system matrix to SRM HR

$M_{srmhr} := T_{SR2\_SRM} \cdot M_{SR2} \cdot T_{SR3\_SR2} \cdot Mx_{SR3}$

$M := M_{srmhr}$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{srmhr} := \left[\frac{\lambda}{\pi}\cdot\frac{-B^2 - A^2\cdot\left(\pi\cdot\frac{w_{01}{}^2}{\lambda}\right)^2}{\pi\cdot\frac{w_{01}{}^2}{\lambda}\cdot(B\cdot C - A\cdot D)}\right]^{0.5}$$

$w_{srmhr} = 2.052$

$w_{10ppmsrmhr} := 2.399\cdot w_{srmhr}$ $\qquad w_{10ppmsrmhr} = 4.923$

$$R_{srmhr} := \frac{\left(M_{0,0}\right)^2\cdot\left(\pi\cdot\frac{w_{01}{}^2}{\lambda}\right)^2 + \left(M_{0,1}\right)^2}{\left(M_{1,0}\cdot M_{0,0}\right)\cdot\left(\pi\cdot\frac{w_{01}{}^2}{\lambda}\right)^2 + M_{0,1}\cdot M_{1,1}}$$

$R_{srmhr} = -5.586\times 10^3$

total system matrix to SRM AR

$M_{srmar} := M2_{SRM}\cdot T1_{SRM}\cdot M1_{SRM}\cdot T_{SR2\_SRM}\cdot M_{SR2}\cdot T_{SR3\_SR2}\cdot Mx_{SR3}$

$M := M_{srmar}$

$A := M_{0,0}$ $\qquad B := M_{0,1}$

$C := M_{1,0}$ $\qquad D := M_{1,1}$

output beam radius, mm

$$w_{srmar} := \left[\frac{\lambda}{\pi}\cdot\frac{-B^2 - A^2\cdot\left(\pi\cdot\frac{w_{01}{}^2}{\lambda}\right)^2}{\pi\cdot\frac{w_{01}{}^2}{\lambda}\cdot(B\cdot C - A\cdot D)}\right]^{0.5}$$

$w_{srmar} = 2.025$

$w_{10ppmsrmhr} := 2.399\cdot w_{srmhr}$ $\qquad w_{10ppmsrmhr} = 4.923$

$$R_{srmar} := \frac{\left(M_{0,0}\right)^2 \cdot \left(\pi \cdot \frac{{w_{01}}^2}{\lambda}\right)^2 + \left(M_{0,1}\right)^2}{\left(M_{1,0} \cdot M_{0,0}\right) \cdot \left(\pi \cdot \frac{{w_{01}}^2}{\lambda}\right)^2 + M_{0,1} \cdot M_{1,1}} \qquad R_{srmar} = -3.829 \times 10^3$$

Beam Waist after SRM output

system matrix up to the SRM mirror

$Mx := M2_{SRM} \cdot T1_{SRM} \cdot M1_{SRM}$

distance from SRM mirror to beam waist, mm

$$l_{srm0} := \frac{-\left[\left(\pi \cdot \frac{{w_{01}}^2}{\lambda}\right)^2\right] \cdot Mx_{1,0} \cdot Mx_{0,0} - Mx_{0,1} \cdot Mx_{1,1}}{\left[\left(\pi \cdot \frac{{w_{01}}^2}{\lambda}\right)^2\right] \cdot \left(Mx_{1,0}\right)^2 + \left(Mx_{1,1}\right)^2}$$

$l_{srm0} = 1.259 \times 10^4$

translation to beam waist $\qquad M_{srm0} := \begin{pmatrix} 1 & l_{srm0} \\ 0 & 1 \end{pmatrix}$

total system matrix to SRM beam waist

$M := M_{srm0} \cdot Mx$

$A := M_{0,0}$ $\qquad B := M_{0,1}$

$C := M_{1,0}$ $\qquad D := M_{1,1}$

output beam radius, mm

$$w_{srm0} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5} \qquad w_{srm0} = 0.357$$

HARTMANN Y

beam parameters at HWSYM1

system matrix from IFO waist to HWSYM1

$M_{HWSYM1} := T_{SR2AR\_HWSYM1} \cdot M_{sr2ar}$

$M := M_{HWSYM1}$

$A := M_{0,0}$ $\qquad B := M_{0,1}$

$C := M_{1,0}$ $\qquad D := M_{1,1}$

output beam radius, mm

$$w_{HWSYM1} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5} \qquad w_{HWSYM1} = 4.902$$

$w_{10PPMHWSYM1} := 2.399 \cdot w_{HWSYM1}$ $\qquad w_{10PPMHWSYM1} = 11.759$

beam parameters at HARTMANN Y SCRAPER BAF

system matrix from IFO waist to HARTMANN Y SCRAPER Baf

$M_{sr2hartscrapbaf} := T_{SR2ar\_hartscrapbaf} \cdot M_{sr2ar}$

$M := M_{sr2hartscrapbaf}$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{hartyscrapbaf} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}^{\ 2}}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}^{\ 2}}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5} \qquad w_{hartyscrapbaf} = 2.275$$

$w_{10ppmhartyscrapbaf} := 2.399 \cdot w_{hartyscrapbaf}$ $w_{10ppmhartyscrapbaf} = 5.459$

beam parameters at HWSYM2

system matrix from IFO waist to HWSYM2

$M_{HWSYM2} := T_{SR2AR\_HWSYM2} \cdot M_{sr2ar}$

$M := M_{HWSYM2}$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{HWSYM2} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5} \qquad w_{HWSYM2} = 0.667$$

$$w_{10PPMHWSYM2} := 2.399 \cdot w_{HWSYM2} \qquad w_{10PPMHWSYM2} = 1.6$$

beam parameters at DCBS1Y

system matrix from IFO waist to DCBS1

$$M_{DCBS1} := T_{SR2AR\_DCBS1} \cdot M_{sr2ar}$$

$$M := M_{DCBS1}$$

$$A := M_{0,0} \qquad B := M_{0,1}$$

$$C := M_{1,0} \qquad D := M_{1,1}$$

output beam radius, mm

$$w_{DCBS1Y} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5} \qquad w_{DCBS1Y} = 0.43$$

$$w_{10PPMDCBS1Y} := 2.399 \cdot w_{DCBS1Y} \qquad w_{10PPMDCBS1Y} = 1.031$$

beam parameters at VAC LENSY

system matrix from IFO waist to VAC LENSY

$$M_{vaclensy} := T_{SR2AR\_vaclens} \cdot M_{sr2ar}$$

$$M := M_{vaclensy}$$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{vaclensy} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}^{\;2}}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}^{\;2}}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5}$$

$w_{vaclensy} = 0.153$

$w_{10ppmvaclensy} := 2.399 \cdot w_{vaclensy}$ $w_{10ppmvaclensy} = 0.368$

Beam Waist after VAC LENSY

system matrix up to the **VAC LENSY**

$Mx(f_{vaclensy}) := ML_{vaclensy}(f_{vaclensy}) \cdot M_{vaclensy}$

distance from **VAC LENSX** to beam waist, mm

$$l_{vaclensy0}(f_{vaclensy}) := \frac{-\left[\left(\pi \cdot \frac{w_{01}^{\;2}}{\lambda}\right)^2\right] \cdot Mx(f_{vaclensy})_{1,0} \cdot Mx(f_{vaclensy})_{0,0} - Mx(f_{vaclensy})_{0,1} \cdot Mx(f_{vaclensy})_{1,1}}{\left[\left(\pi \cdot \frac{w_{01}^{\;2}}{\lambda}\right)^2\right] \cdot \left(Mx(f_{vaclensy})_{1,0}\right)^2 + \left(Mx(f_{vaclensy})_{1,1}\right)^2}$$

$l_{vaclensy0}(f_{vaclensy}) = -6.788$

translation to beam waist $T_{vaclensy0}(f_{vaclensy}) := \begin{pmatrix} 1 & l_{vaclensy0}(f_{vaclensy}) \\ 0 & 1 \end{pmatrix}$

total system matrix to **VAC LENSY** beam waist

$M(f_{vaclensy}) := T_{vaclensy0}(f_{vaclensy}) \cdot Mx(f_{vaclensy})$

$A := M(f_{vaclensy})_{0,0}$ $B := M(f_{vaclensy})_{0,1}$

$C := M(f_{vaclensy})_{1,0}$ $D := M(f_{vaclensy})_{1,1}$

beam waist after **VAC LENSY,** mm

$$w_{vaclensy0}(f_{vaclensy}) := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - (M(f_{vaclensy})_{0,0})^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot \left(M(f_{vaclensy})_{0,1} \cdot M(f_{vaclensy})_{1,0} - M(f_{vaclensy})_{0,0} \cdot M(f_{vaclensy})_{1,1}\right)}\right]^{0.5}$$

$w_{vaclensy0}(f_{vaclensy}) = 0.152$

beam parameters at HWSYM3

system matrix from IFO waist to HWSYM3

$M_{HWSYM3}(f_{vaclensy}) := T_{vaclens\_HWSYM3} \cdot ML_{vaclensy}(f_{vaclensy}) \cdot M_{vaclensy}$

$M(f_{vaclensy}) := M_{HWSYM3}(f_{vaclensy})$

$A := M(f_{vaclensy})_{0,0}$ $B := M(f_{vaclensy})_{0,1}$

$C := M(f_{vaclensy})_{1,0}$ $D := M(f_{vaclensy})_{1,1}$

output beam radius, mm

$$w_{HWSYM3}(f_{vaclensy}) := \left[\frac{\lambda}{\pi} \cdot \frac{-(M(f_{vaclensy})_{0,1})^2 - (M(f_{vaclensy})_{0,0})^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot \left(M(f_{vaclensy})_{0,1} \cdot M(f_{vaclensy})_{1,0} - M(f_{vaclensy})_{0,0} \cdot M(f_{vaclensy})_{1,1}\right)}\right]^{0.5}$$

$w_{HWSYM3}(f_{vaclensy})$ $w_{HWSYM3}(f_{vaclensy}) = 1.2$

$w_{10PPMHWSYM3}(f_{vaclensy}) := 2.399 \cdot w_{HWSYM3}(f_{vaclensy})$ $w_{10PPMHWSYM3}(f_{vaclensy}) = 2.878$

beam parameters at HARTMANN Y VP

system matrix from IFO waist to HARTMANN Y VP

$M_{hartyvp}(f_{vaclensy}) := T_{vaclensy\_VP} \cdot ML_{vaclensy}(f_{vaclensy}) \cdot M_{vaclensy}$

$M := M_{hartyvp}$

$A := M_{hartyvp}(f_{vaclensy})_{0,0}$ $B := M_{hartyvp}(f_{vaclensy})_{0,1}$

$C := M_{hartyvp}(f_{vaclensy})_{1,0}$ $D := M_{hartyvp}(f_{vaclensy})_{1,1}$

output beam radius, mm

$$w_{hartyvp}(f_{vaclensy}) := \left[\frac{\lambda}{\pi} \cdot \frac{-\left(M_{hartyvp}(f_{vaclensy})_{0,1}\right)^2 - \left(M_{hartyvp}(f_{vaclensy})_{0,0}\right)^2 \cdot \left(\pi \cdot \frac{w_{01}^{\ 2}}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}^{\ 2}}{\lambda} \cdot \left(M_{hartyvp}(f_{vaclensy})_{0,1} \cdot M_{hartyvp}(f_{vaclensy})_{1,0} - M_{hartyvp}(f_{vaclensy})_{0,0} \cdot M_{hartyvp}(\right.} \right.$$

$f_{vaclensy} = 60$ $f_{vaclensy} := 60$ $w_{hartyvp}(f_{vaclensy}) = 2.889$ 0.153

$w_{10ppmhartyvp}(f_{vaclensy}) := 2.146 \cdot w_{hartyvp}(f_{vaclensy})$ $w_{10ppmhartyvp}(f_{vaclensy}) = 6.199$

HARTMANN X

system matrix up to the **SR3 mirror** Mx_{SR3}

beam parameters at HWSXM1

system matrix from IFO waist to HWSXM1

$M_{HWSXM1} := T_{SR3\_HWSXM1} \cdot Mx_{SR3}$

$M := M_{HWSXM1}$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{HWSXM1} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5}$$

$w_{HWSXM1} = 8.867$

$w_{10PPMHWSXM1} := 2.399 \cdot w_{HWSXM1}$ $w_{10PPMHWSXM1} = 21.271$

**beam parameters at Hartmann-X
Scraper Baf**

system matrix from IFO waist to Hart-X
Scraper Baf

$M_{hartxscrapbaf} := T_{SR3\_hartscrapbaf} \cdot Mx_{SR3}$

$M := M_{hartxscrapbaf}$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{hartxscrapbaf} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5}$$

$w_{hartxscrapbaf} = 6.515$

$w_{10ppmhartxscrapbaf} := 2.399 \cdot w_{hartxscrapbaf}$ $w_{10ppmhartxscrapbaf} = 15.629$

beam parameters at HWSXM2

system matrix from IFO waist to HWSXM2

$M_{HWSXM2} := T_{SR3\_HWSXM2} \cdot Mx_{SR3}$

$M := M_{HWSXM2}$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{HWSXM2} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5}$$ $w_{HWSXM2} = 5.159$

$w_{10PPMHWSXM2} := 2.399 \cdot w_{HWSXM2}$ $w_{10PPMHWSXM2} = 12.377$

beam parameters at HWSYM3

system matrix from IFO waist to HWSYM3

$M_{HWSXM3} := T_{SR3\_HWSXM3} \cdot Mx_{SR3}$

$M := M_{HWSXM3}$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{HWSXM3} := \left[\frac{\lambda}{\pi}\cdot\frac{-\left(M_{0,1}\right)^2-\left(M_{0,0}\right)^2\cdot\left(\pi\cdot\frac{w_{01}^{\ 2}}{\lambda}\right)^2}{\pi\cdot\frac{w_{01}^{\ 2}}{\lambda}\cdot\left(M_{0,1}\cdot M_{1,0}-M_{0,0}\cdot M_{1,1}\right)}\right]^{0.5}$$

$w_{HWSXM3} = 3.967$

$w_{10PPMHWSXM3} := 2.399\cdot w_{HWSXM3}$ $w_{10PPMHWSXM3} = 9.518$

beam parameters at DCBS1X

system matrix from IFO waist to DCBS1X

$M_{DCBS1X} := T_{SR3\_DCBS1}\cdot Mx_{SR3}$

$M := M_{DCBS1X}$

$A := M_{0,0}$ $B := M_{0,1}$

$C := M_{1,0}$ $D := M_{1,1}$

output beam radius, mm

$$w_{DCBS1X} := \left[\frac{\lambda}{\pi}\cdot\frac{-B^2-A^2\cdot\left(\pi\cdot\frac{w_{01}^{\ 2}}{\lambda}\right)^2}{\pi\cdot\frac{w_{01}^{\ 2}}{\lambda}\cdot(B\cdot C-A\cdot D)}\right]^{0.5}$$

$w_{DCBS1X} = 3.483$

$w_{10PPMDCBS1X} := 2.399\cdot w_{DCBS1X}$ $w_{10PPMDCBS1X} = 8.355$

beam parameters at VAC LENSX

system matrix from IFO waist to VAC LENSX

$M_{vaclensx} := T_{SR3\_vaclens} \cdot Mx_{SR3}$

$M := M_{vaclensx}$

$A := M_{0,0}$ $\qquad$ $B := M_{0,1}$

$C := M_{1,0}$ $\qquad$ $D := M_{1,1}$

output beam radius, mm

$$w_{vaclensx} := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - A^2 \cdot \left(\pi \cdot \frac{w_{01}^{\ 2}}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}^{\ 2}}{\lambda} \cdot (B \cdot C - A \cdot D)}\right]^{0.5}$$

$w_{vaclensx} = 2.519$

$w_{10ppmvaclensx} := 2.399 \cdot w_{vaclensx}$ $\qquad$ $w_{10ppmvaclensx} = 6.043$

Beam Waist after VAC LENSX

system matrix up to the **VAC LENSX**

$Mx(f_{vaclensx}) := ML_{vaclensx}(f_{vaclensx}) \cdot M_{vaclensx}$

distance from **VAC LENSX** to beam waist, mm

$$l_{vaclensx0}(f_{vaclensx}) := \frac{-\left[\left(\pi \cdot \frac{w_{01}^{\ 2}}{\lambda}\right)^2\right] \cdot Mx(f_{vaclensx})_{1,0} \cdot Mx(f_{vaclensx})_{0,0} - Mx(f_{vaclensx})_{0,1} \cdot Mx(f_{vaclensx})_{1,1}}{\left[\left(\pi \cdot \frac{w_{01}^{\ 2}}{\lambda}\right)^2\right] \cdot \left(Mx(f_{vaclensx})_{1,0}\right)^2 + \left(Mx(f_{vaclensx})_{1,1}\right)^2}$$

$l_{vaclensx0}(f_{vaclensx}) = -3.807 \times 10^3$

translation to beam waist $\qquad$ $T_{vaclensx0}(f_{vaclensx}) := \begin{pmatrix} 1 & l_{vaclensx0}(f_{vaclensx}) \\ 0 & 1 \end{pmatrix}$

total system matrix to **VAC LENSX** beam waist

$$M(f_{vaclensx}) := T_{vaclensx0}(f_{vaclensx}) \cdot Mx(f_{vaclensx})$$

$$A := M(f_{vaclensx})_{0,0} \qquad B := M(f_{vaclensx})_{0,1}$$

$$C := M(f_{vaclensx})_{1,0} \qquad D := M(f_{vaclensx})_{1,1}$$

beam waist after **VAC LENSX,** mm

$$w_{vaclensx0}(f_{vaclensx}) := \left[\frac{\lambda}{\pi} \cdot \frac{-B^2 - \left(M(f_{vaclensx})_{0,0}\right)^2 \cdot \left(\pi \cdot \frac{w_{01}{}^2}{\lambda}\right)^2}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot \left(M(f_{vaclensx})_{0,1} \cdot M(f_{vaclensx})_{1,0} - M(f_{vaclensx})_{0,0} \cdot M(f_{vaclensx})_{1,1}\right)}\right]^{0.5}$$

$$w_{vaclensx0}(f_{vaclensx}) = 0.523$$

beam parameters at HARTMANN X VP

system matrix from IFO waist to HARTMANN X VP

$$M_{hartmanxvp}(f_{vaclensx}) := T_{vaclensx\_VP} \cdot ML_{vaclensx}(f_{vaclensx}) \cdot T_{SR3\_vaclens} \cdot Mx_{SR3}$$

$$M := M_{hartmanxvp}(f_{vaclensx})$$

$$A := M_{hartmanxvp}(f_{vaclensx})_{0,0} \qquad B := M_{hartmanxvp}(f_{vaclensx})_{0,1}$$

$$C := M_{hartmanxvp}(f_{vaclensx})_{1,0} \qquad D := M_{hartmanxvp}(f_{vaclensx})_{1,1}$$

output beam radius, mm

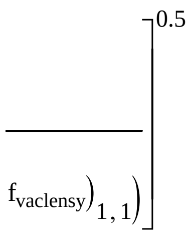
$$w_{hartmanxvp}(f_{vaclensx}) := \left[\frac{\lambda}{\pi} \cdot \frac{-\left(M_{hartmanxvp}(f_{vaclensx})_{0,1}\right)^2 - \left(M_{hartmanxvp}(f_{vaclensx})_{0,0}\right)^2 \cdot \left(\pi \cdot \cdot\right.}{\pi \cdot \frac{w_{01}{}^2}{\lambda} \cdot \left(M_{hartmanxvp}(f_{vaclensx})_{0,1} \cdot M_{hartmanxvp}(f_{vaclensx})_{1,0} - M_{hartmanxvp}(f_{vaclensx})_{0}\right.} \right.$$

$w_{vaclensx} = 2.519$

$f_{vaclensx} = -700$ $f_{vaclensx} := -850$ $w_{hartmanxvp}(f_{vaclensx}) = 2.519$ 2.519

$w_{10ppmhartmanxvp}(f_{vaclensx}) := 2.399 \cdot w_{hartmanxvp}(f_{vaclensx})$ $w_{10ppmhartmanxvp}(f_{vaclensx}) = 6.044$

24.9


0.5
$f_{vaclensy})_{1,1})$

$$\left.\frac{\left(\frac{w_{01}{}^{2}}{\lambda}\right)^{2}}{{}_{,0}\cdot M_{hartmanxvp}\left(f_{vaclensx}\right)_{1,1}\Big)}\right]^{0.5}$$