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PO Beam Waist Size and Location on the ISC Table

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1 OVERVIEW

The PO beam waist location on the ISC table can be varied by defocusing the ISC telescope. An optical schematic drawing of the PO beam optical train, which includes the 8X reflective telescope inside the vacuum housing and the 3.3X ISC telescope on the ISC optical table is shown in Figure 1:.The input beam waist is inside the IFO, approximately 900 m from the PO telescope. The ISC telescope is separated from the PO telescope by approximately 3 m. The input beam waist is transformed by the lens train to an output beam waist of size w_{042}, located in the vicinity of the ISC table at a distance z_{42} from the end of the ISC telescope.

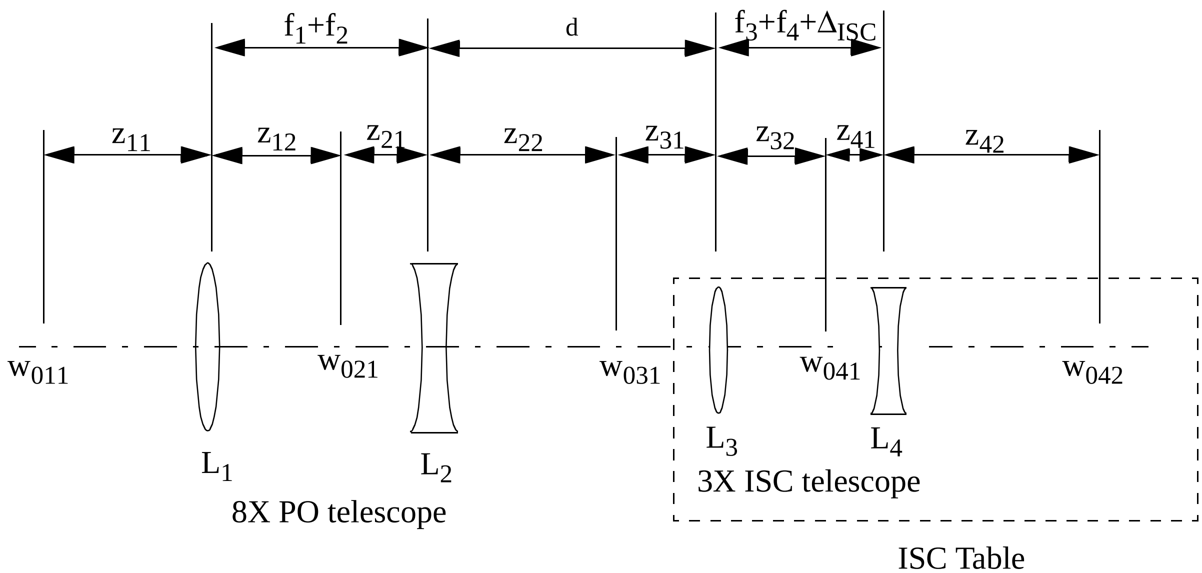

Figure 1: Optical schematic of PO beam optical train

The size and location of the output beam waist can be determined by using Gaussian beam transformation theory.

2 GAUSSIAN BEAM TRANSFORMATION THEORY

An analysis of the dependence of the output beam waist and location on the defocusing of the ISC telescope was made using the following parameters.

2.1. Telescope Parameters

PO Telescope

primary focal length, f_1	1524 mm
secondary focal length, f_2	-190.5 mm

input beam waist position, z_{11}	9×10^{5} mm
input beam waist parameter, w_{011}	36.4 mm
distance to ISC telescope, d	3000mm

ISC Telescope

primary focal length, f_3	251.8 mm
secondary focal length, f_4	-74.172 mm

2.2. Gaussian Beam Transformation Equations

$$z_{12} := f_1 + f_1^2 \cdot \frac{(z_{11} - f_1)}{\left[(z_{11} - f_1)^2 + \left(\pi \cdot \frac{w_{011}^2}{\lambda}\right)^2\right]}$$

$$w_{012} := \left[\frac{1 \cdot \left(1 - \frac{z_{11}}{f_1}\right)^2}{w_{011}^2} + \frac{1 \cdot \left(\pi \cdot \frac{w_{011}}{\lambda}\right)^2}{f_1^2}\right]^{-0.5}$$

$$w_{021} := w_{012}$$

$$z_{21} := f_1 + f_2 - z_{12}$$

$$z_{22} := f_2 + f_2^2 \cdot \frac{(z_{21} - f_2)}{\left[(z_{21} - f_2)^2 + \left(\pi \cdot \frac{w_{021}^2}{\lambda}\right)^2\right]}$$

$$w_{022} := \left[\frac{1 \cdot \left(1 - \frac{z_{21}}{f_2}\right)^2}{w_{021}^2} + \frac{1 \cdot \left(\pi \cdot \frac{w_{021}}{\lambda}\right)^2}{f_2^2}\right]^{-0.5}$$

$$w_{031} := w_{022}$$

$$z_{31} := d - z_{22}$$

$$z_{32} := f_3 + f_3^2 \cdot \frac{(z_{31} - f_3)}{\left[(z_{31} - f_3)^2 + \left(\pi \cdot \frac{w_{031}^2}{\lambda}\right)^2\right]}$$

$$w_{032} := \left[\frac{1 \cdot \left(1 - \frac{z_{31}}{f_3}\right)^2}{w_{031}^2} + \frac{1 \cdot \left(\pi \cdot \frac{w_{031}}{\lambda}\right)^2}{f_3^2}\right]^{-0.5}$$

$$w_{041} := w_{032}$$

$$z_{41}(\Delta_{ISC}) := f_3 + f_4 + \Delta_{ISC} - z_{32}$$

$$z_{42}(\Delta_{ISC}) := f_4 + f_4^2 \cdot \frac{(z_{41}(\Delta_{ISC}) - f_4)}{\left[(z_{41}(\Delta_{ISC}) - f_4)^2 + \left(\pi \cdot \frac{w_{041}^2}{\lambda}\right)^2\right]}$$

$$w_{042}(\Delta_{ISC}) := \left[\frac{1 \cdot \left(1 - \frac{z_{41}(\Delta_{ISC})}{f_4}\right)^2}{w_{041}^2} + \frac{1 \cdot \left(\pi \cdot \frac{w_{041}}{\lambda}\right)^2}{f_4^2}\right]^{-0.5}$$

2.3. Results: Output Beam Waist Size and Location

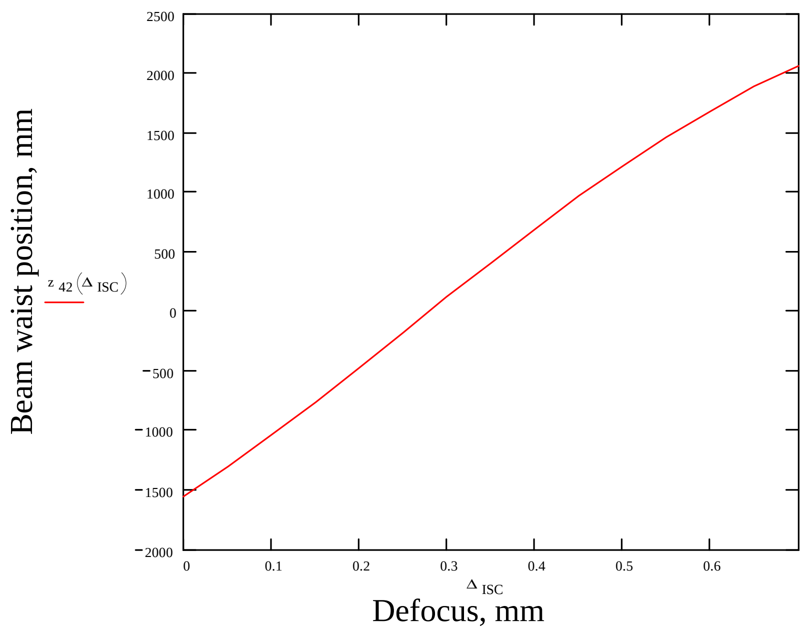

Figure 2: Beam waist position versus ISC defocus, d=3000mm

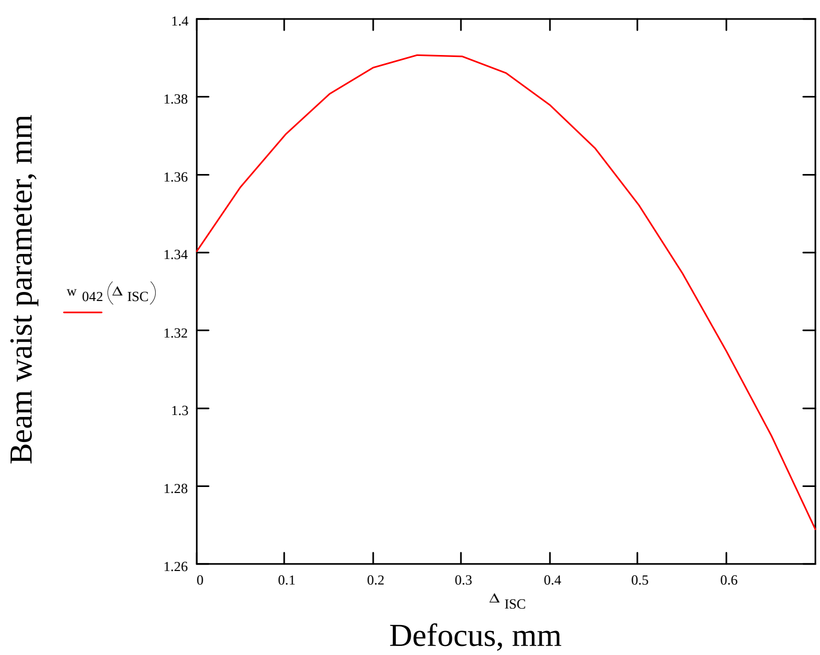

Figure 3: Beam waist size versus ISC defocus, d=3000mm