

# Report on the requirement of SRM/SR2/SR3 RoC error

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The signal recycling cavity of KAGRA consists of three mirrors: SR3, SR2, and SRM in the order from the beamsplitter. The radii of curvature are, respectively,  $R_{\text{SRM}} = 459$  m (concave),  $R_{\text{SR2}} = -2.988$  m (convex), and  $R_{\text{SR3}} = 24.9167$  m (concave). This report gives the requirement of the surface error of these mirrors in the signal recycling cavity according to the simulation results of higher order spatial modes at the dark port that increase shot noise.

Here the radius of curvature of either SRM, SR2, or SR3 is changed by  $\pm 1$  %. The distance of SR2 and SR3 is tuned to maximize the signal at 3 kHz. Higher order modes up to the 7th mode are taken into account in the FINESSE simulation.

Let us see how much higher order modes increase with the errors. We also show the results without the length tuning. See the following table.

|          | HOM/TEM00 | signal      | shift   |
|----------|-----------|-------------|---------|
| default  | 44.4      | 585.3       | -       |
| SRM:+1 % | 44.6→44.6 | 585.3→585.3 | 0       |
| SRM:-1 % | 44.2→44.2 | 585.3→585.3 | 0       |
| SR2+ 1%  | 17.2→35.6 | 576.6→584.7 | -0.125m |
| SR2:-1 % | 48.4→46.6 | 217.0→585.3 | 0.130m  |
| SR3+ 1%  | 41.7→47.3 | 53.0→585.3  | 0.245m  |
| SR3:-1 % | 8.7→49.9  | 548.4→585.3 | 0.009m  |

The results without the length tuning are shown on the left side of an arrow and the results with the tuning are shown on the right side of an arrow. The last column of the table shows how far we should move the SR2 and SR3 mirrors to realize the tuning. **If we were able to move the SR2 and SR3 by 25 cm, the 1 % curvature error of those mirrors could be compensated.**

However, it has been reported that the suspension system will not allow us to move the mirrors for such a large distance. Figure 1 shows signal amplitude, the higher order modes power, and the RF sideband power as functions of the SR2/SR3 curvature error. **If we cannot move the SR2 or SR3 at all, the SR2 and SR3 curvature errors should be smaller than 0.4 % and 0.1 %, respectively, in order not to lose the signal more than 10 %.** The ratios from the higher order modes and RF sidebands power to the TEM00 power at the dark port decrease with the curvature error, so these factors do not change the requirement.

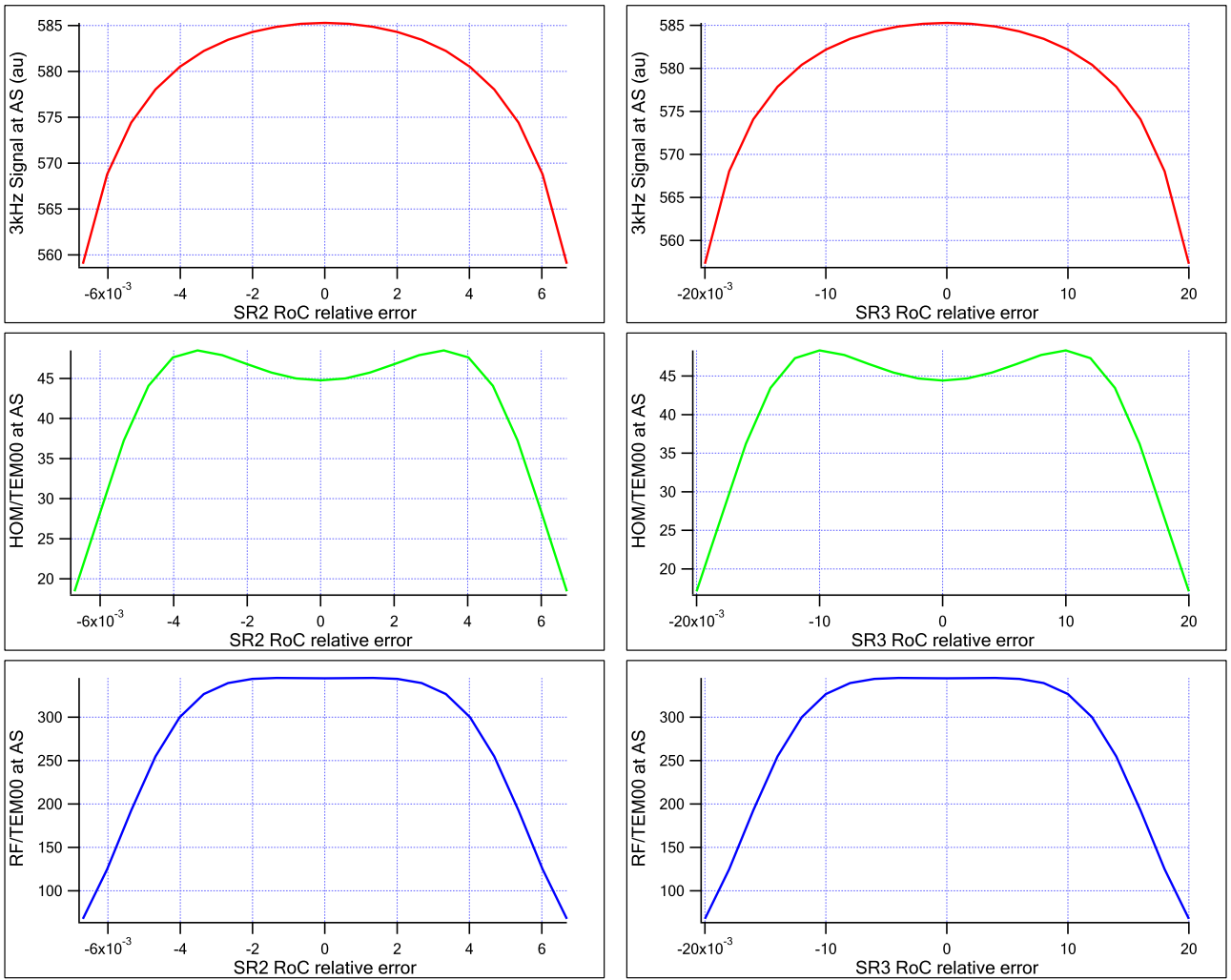


Figure 1: Signal amplitude, higher order mode power, and RF sideband power with an error in SR2 (Left) and SR3 (Right).