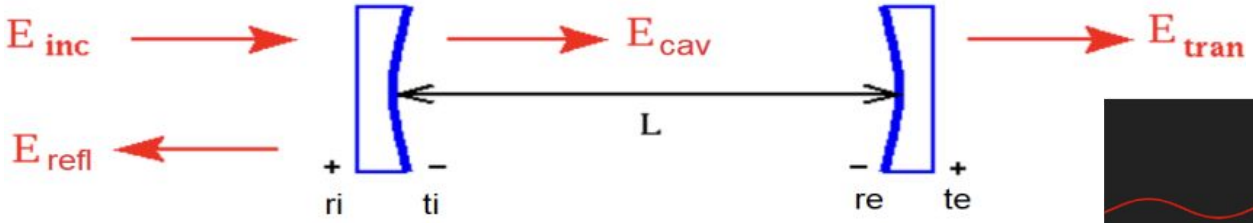
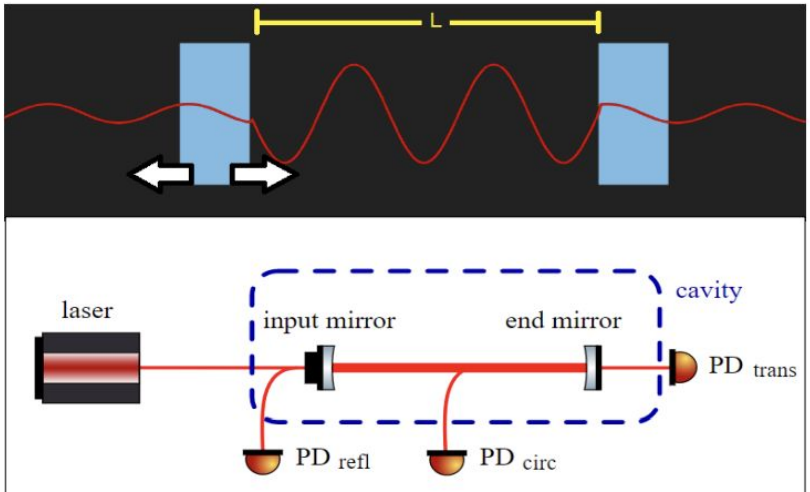
CE Arm Cavity Design for Squeezed Light Optimization

Issue: HOM resonances fall inside the observable spectrum for CE due to a 10x smaller FSR (4km arms -> 40km arms)

Goal: find regions where the number of HOM resonance induced squeezing degradation is minimized (“free up” more of the observable spectrum)

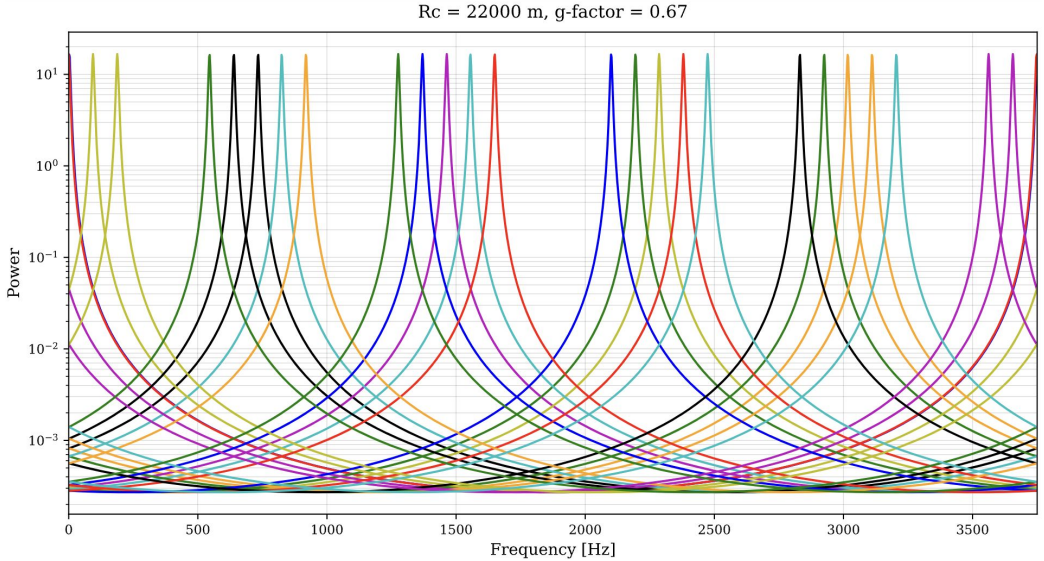
- Do this by changing the radius of curvature on the mirrors



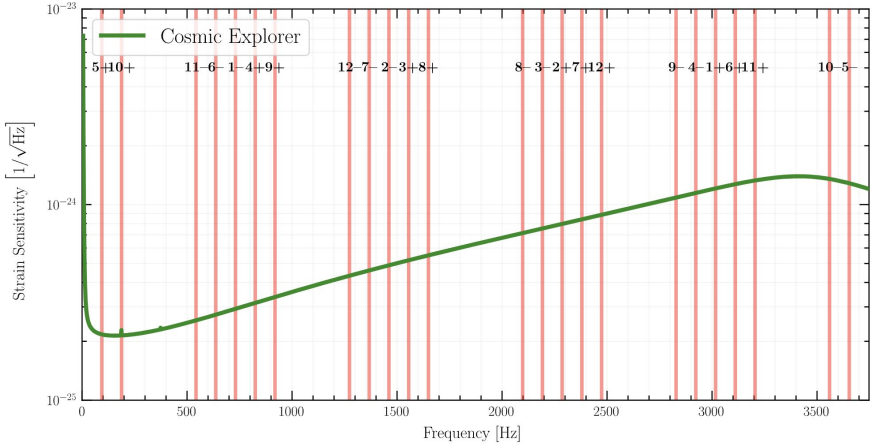


Finesse Simulation vs. Analytical Solution

```
HOM : 0    upper:  0.0    lower:  3750.0
HOM : 1    upper:  3020.0    lower:  730.0
HOM : 2    upper:  2286.0    lower:  1464.0
HOM : 3    upper:  1558.0    lower:  2192.0
HOM : 4    upper:  824.0    lower:  2926.0
HOM : 5    upper:  94.0    lower:  3656.0
HOM : 6    upper:  3114.0    lower:  636.0
HOM : 7    upper:  2380.0    lower:  1370.0
HOM : 8    upper:  1652.0    lower:  2098.0
HOM : 9    upper:  922.0    lower:  2828.0
HOM : 10    upper:  188.0    lower:  3562.0
HOM : 11    upper:  3208.0    lower:  542.0
HOM : 12    upper:  2474.0    lower:  1276.0
```

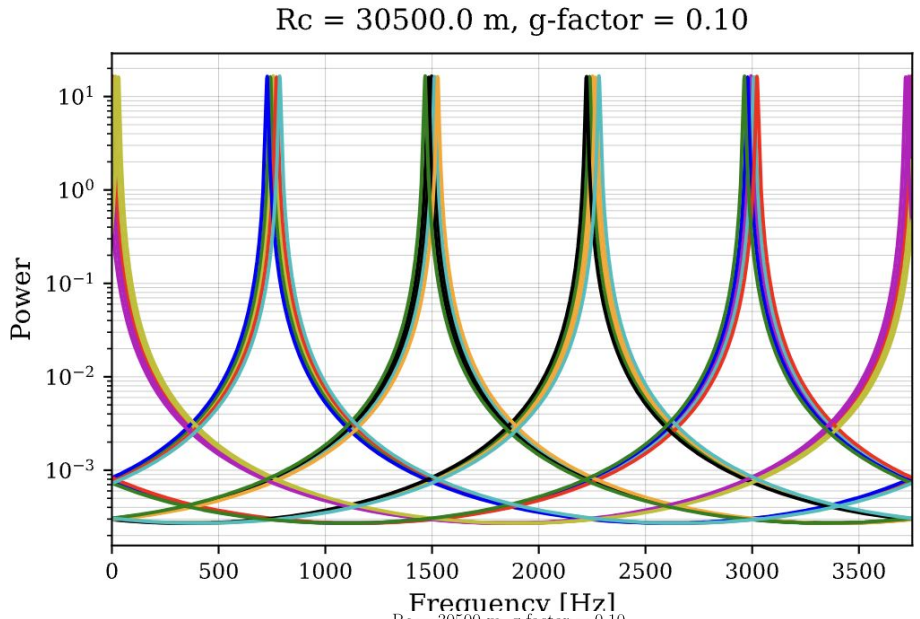


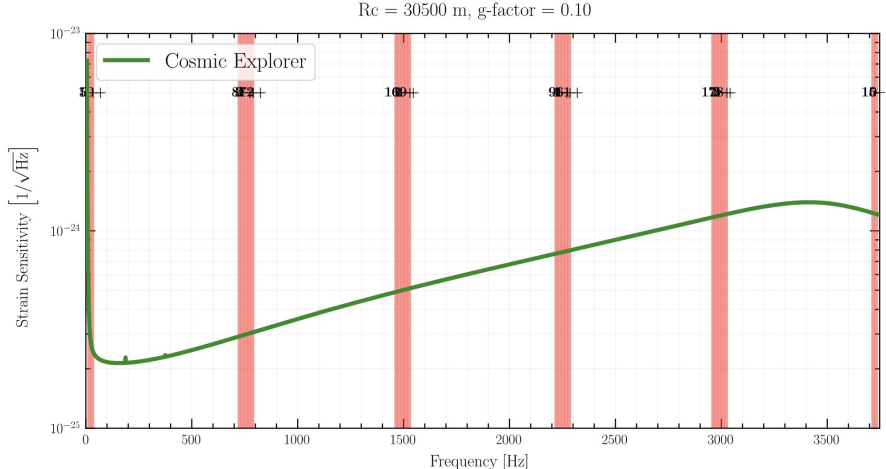
HOM Order:	1	3017 Hz	731 Hz
HOM Order:	2	2286 Hz	1461 Hz
HOM Order:	3	1555 Hz	2192 Hz
HOM Order:	4	825 Hz	2923 Hz
HOM Order:	5	94 Hz	3653 Hz
HOM Order:	6	3111 Hz	637 Hz
HOM Order:	7	2380 Hz	1367 Hz
HOM Order:	8	1649 Hz	2098 Hz
HOM Order:	9	919 Hz	2829 Hz
HOM Order:	10	188 Hz	3559 Hz
HOM Order:	11	3205 Hz	543 Hz
HOM Order:	12	2474 Hz	1273 Hz

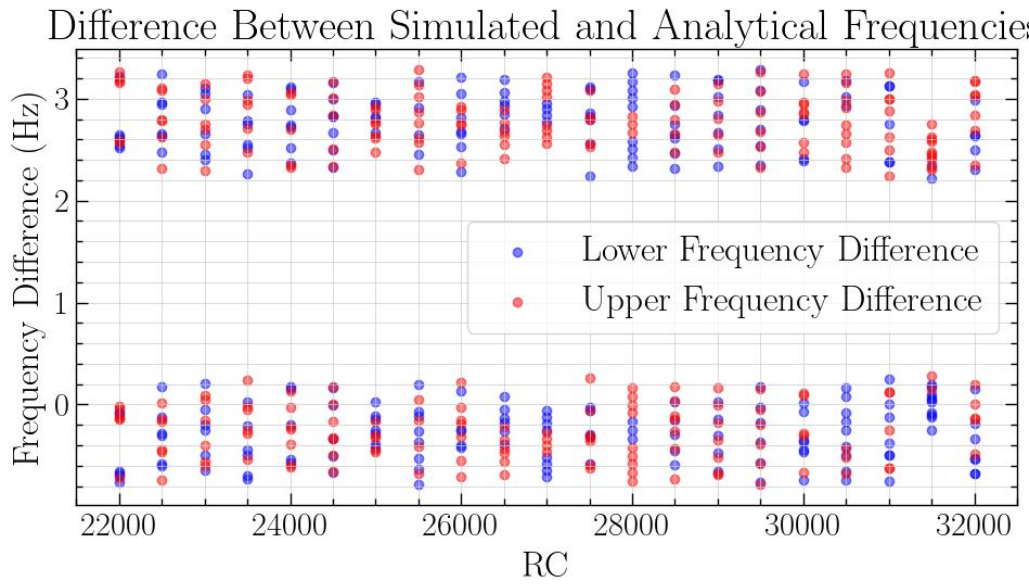


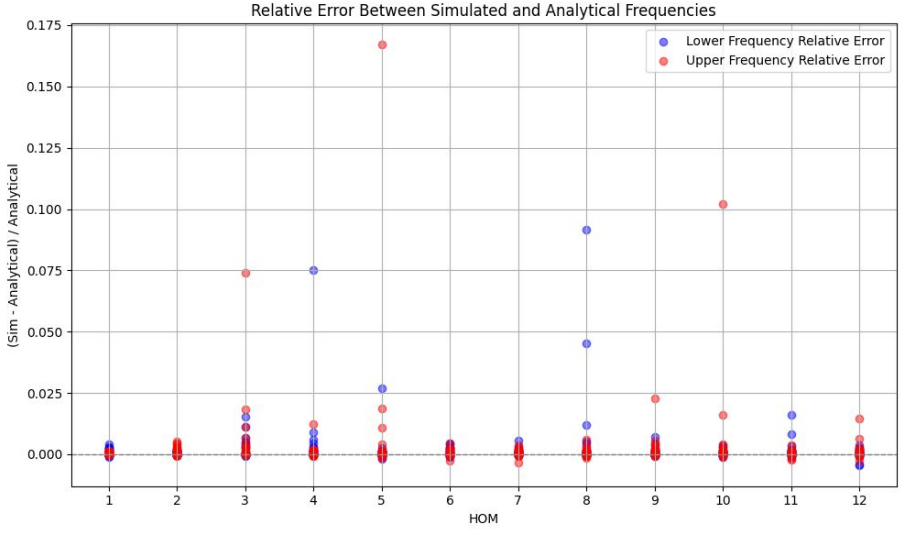
```
HOM : 0    upper:  0.0    lower:  3750.0
HOM : 1    upper:  2254.0    lower:  1496.0
HOM : 2    upper:  758.0    lower:  2992.0
HOM : 3    upper:  3010.0    lower:  740.0
HOM : 4    upper:  1514.0    lower:  2236.0
HOM : 5    upper:  18.0    lower:  3732.0
HOM : 6    upper:  2270.0    lower:  1480.0
HOM : 7    upper:  774.0    lower:  2976.0
HOM : 8    upper:  3022.0    lower:  728.0
HOM : 9    upper:  1530.0    lower:  2220.0
HOM : 10    upper:  34.0    lower:  3716.0
HOM : 11    upper:  2282.0    lower:  1468.0
HOM : 12    upper:  786.0    lower:  2964.0
```

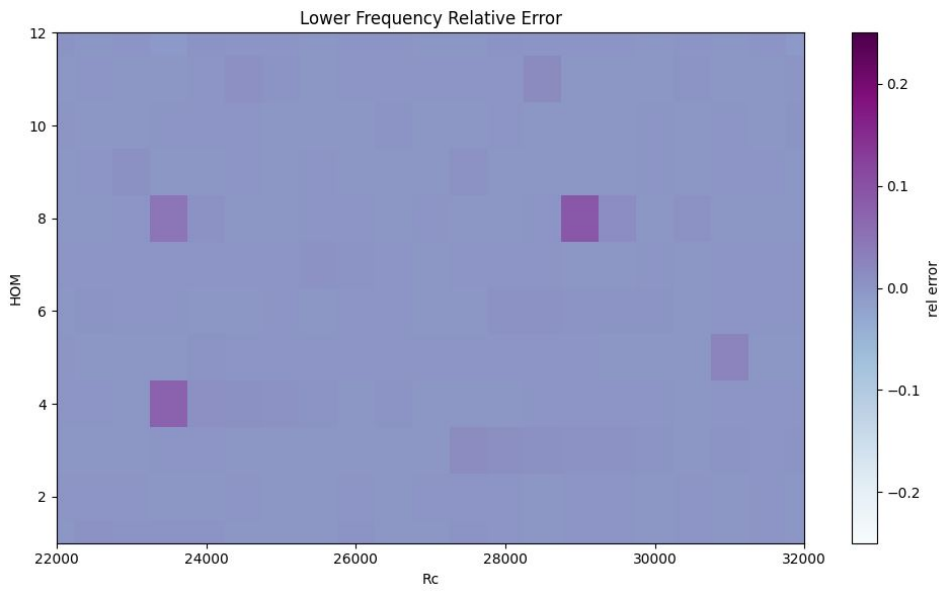
HOM Order:	1	2252 Hz	1496 Hz
HOM Order:	2	756 Hz	2992 Hz
HOM Order:	3	3007 Hz	740 Hz
HOM Order:	4	1511 Hz	2236 Hz
HOM Order:	5	15 Hz	3732 Hz
HOM Order:	6	2267 Hz	1480 Hz
HOM Order:	7	771 Hz	2976 Hz
HOM Order:	8	3023 Hz	725 Hz
HOM Order:	9	1527 Hz	2221 Hz
HOM Order:	10	31 Hz	3717 Hz
HOM Order:	11	2282 Hz	1465 Hz
HOM Order:	12	787 Hz	2961 Hz

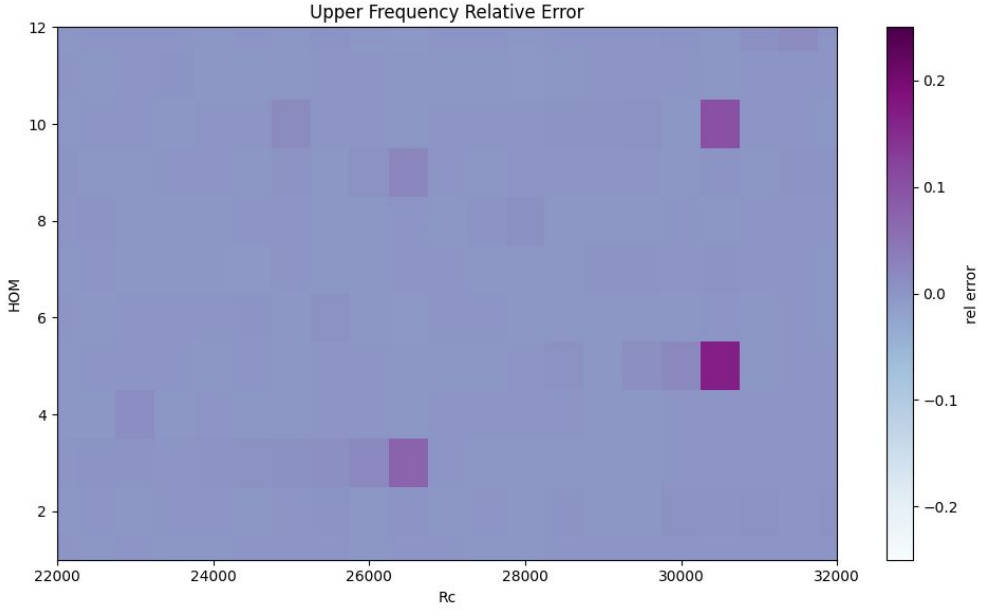





Difference Between Simulated and Analytical Frequencies
Frequency Difference (Hz)
RC
Lower Frequency Difference
Upper Frequency Difference
22000
24000
26000
28000
30000
32000
0
1
2
3


Relative Error Between Simulated and Analytical Frequencies
(Sim - Analytical) / Analytical
HOM
Lower Frequency Relative Error
Upper Frequency Relative Error
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
1
2
3
4
5
6
7
8
9
10
11
12


Lower Frequency Relative Error
HOM
Rc
rel error
12
10
8
6
4
2
22000
24000
26000
28000
30000
32000
0.2
0.1
0.0
−0.1
−0.2


Upper Frequency Relative Error
HOM
Rc
rel error
12
10
8
6
4
2
22000
24000
26000
28000
30000
32000
0.2
0.1
0.0
−0.1
−0.2

Next Steps

- Finish up grouping strategy for ideal case
- Introduce realistic aberrations from thermal aberrations
  - See how this affects resonances
  - Introduce FROSTI as well