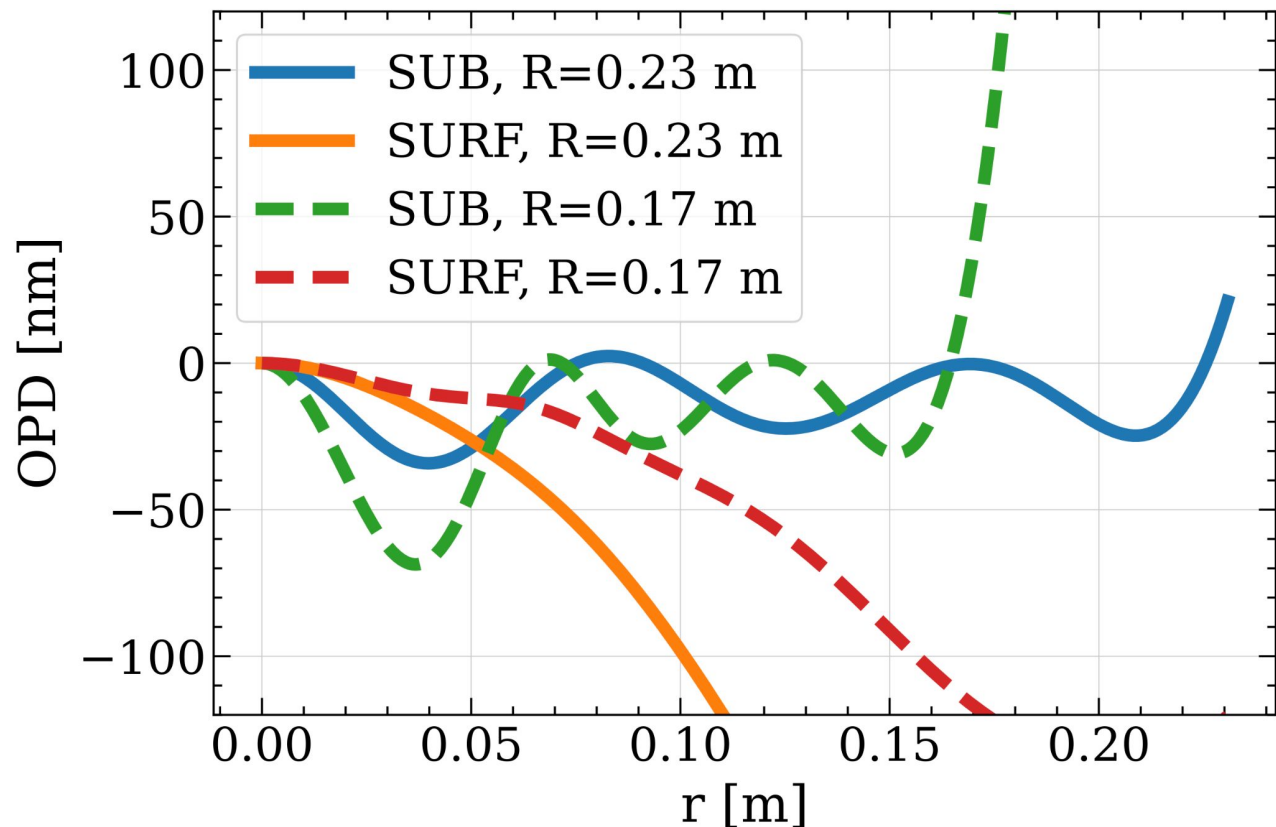# Multi-Ring FROSTI

Residual wavefront error for substrate and surface

Legend:
- SUB, R=0.23 m
- SURF, R=0.23 m
- SUB, R=0.17 m
- SURF, R=0.17 m

OPD [nm] vs r [m]

By setting the region of interest to be 0.17 m instead of the entire radius of 0.23 m for A# test mass, we are able to lower the residual surface error significantly.

This is at the expense of larger substrate error at both small and large radii.

Preliminary result on IFO performance (only ITM distortions)
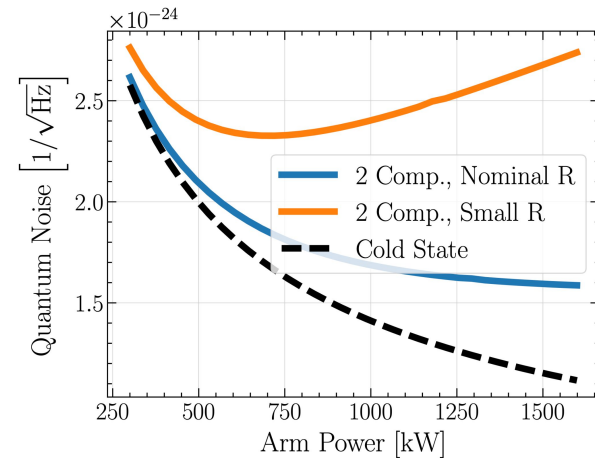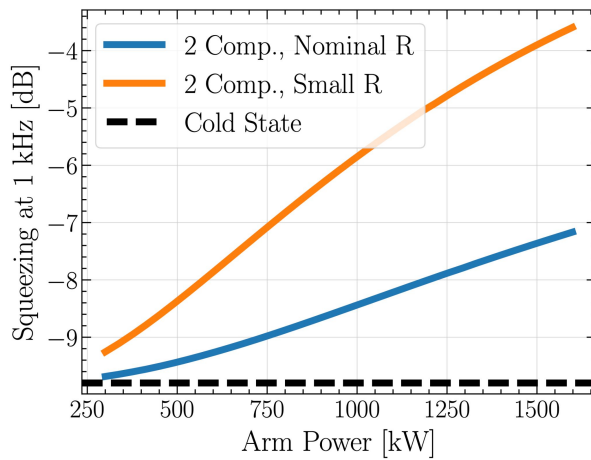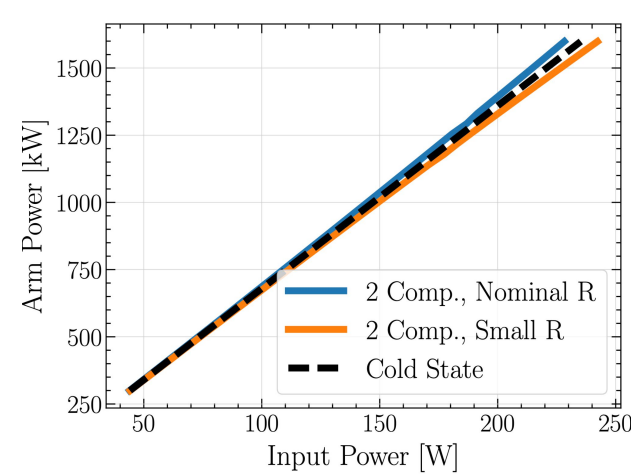
- Arm power buildup seem to perform well, but squeezing degrades a lot, most likely due to the substrate residual
- Arm power for nominal R (larger quadratic residual in surface) outperforms the cold state?
- Quantum noise underperforms relative to cold state.

First look at the PRC-Arm mode matching

(Tangential plane)	cavYARM	cavXARM	cavOMC	cavPRX	cavPRY	cavSRX	cavSRY
cavYARM	0.00e+00	1.12e-08	3.61e-06	2.02e-06	1.79e-06	1.22e-05	1.31e-05
cavXARM	1.12e-08	0.00e+00	3.22e-06	2.11e-06	1.89e-06	1.19e-05	1.29e-05
cavOMC	3.61e-06	3.22e-06	0.00e+00	6.66e-06	6.71e-06	1.20e-05	1.32e-05
cavPRX	2.02e-06	2.11e-06	6.66e-06	0.00e+00	1.66e-08	2.41e-05	2.54e-05
cavPRY	1.79e-06	1.89e-06	6.71e-06	1.66e-08	0.00e+00	2.33e-05	2.46e-05
cavSRX	1.22e-05	1.19e-05	1.20e-05	2.41e-05	2.33e-05	0.00e+00	2.66e-08
cavSRY	1.31e-05	1.29e-05	1.32e-05	2.54e-05	2.46e-05	2.66e-08	0.00e+00

Nominal ITM RoC

(Tangential plane)	cavYARM	cavXARM	cavOMC	cavPRX	cavPRY	cavSRX	cavSRY
cavYARM	0.00e+00	1.14e-08	7.23e-05	2.12e-08	3.78e-10	5.90e-05	6.11e-05
cavXARM	1.14e-08	0.00e+00	7.09e-05	1.93e-08	1.31e-08	5.85e-05	6.06e-05
cavOMC	7.23e-05	7.09e-05	0.00e+00	7.00e-05	7.21e-05	1.80e-04	1.84e-04
cavPRX	2.12e-08	1.93e-08	7.00e-05	0.00e+00	1.75e-08	6.06e-05	6.27e-05
cavPRY	3.78e-10	1.31e-08	7.21e-05	1.75e-08	0.00e+00	5.93e-05	6.14e-05
cavSRX	5.90e-05	5.85e-05	1.80e-04	6.06e-05	5.93e-05	0.00e+00	2.87e-08
cavSRY	6.11e-05	6.06e-05	1.84e-04	6.27e-05	6.14e-05	2.87e-08	0.00e+00

Change ITM RoC by 1 uD

Impact of ITM RoC on Arm power gain
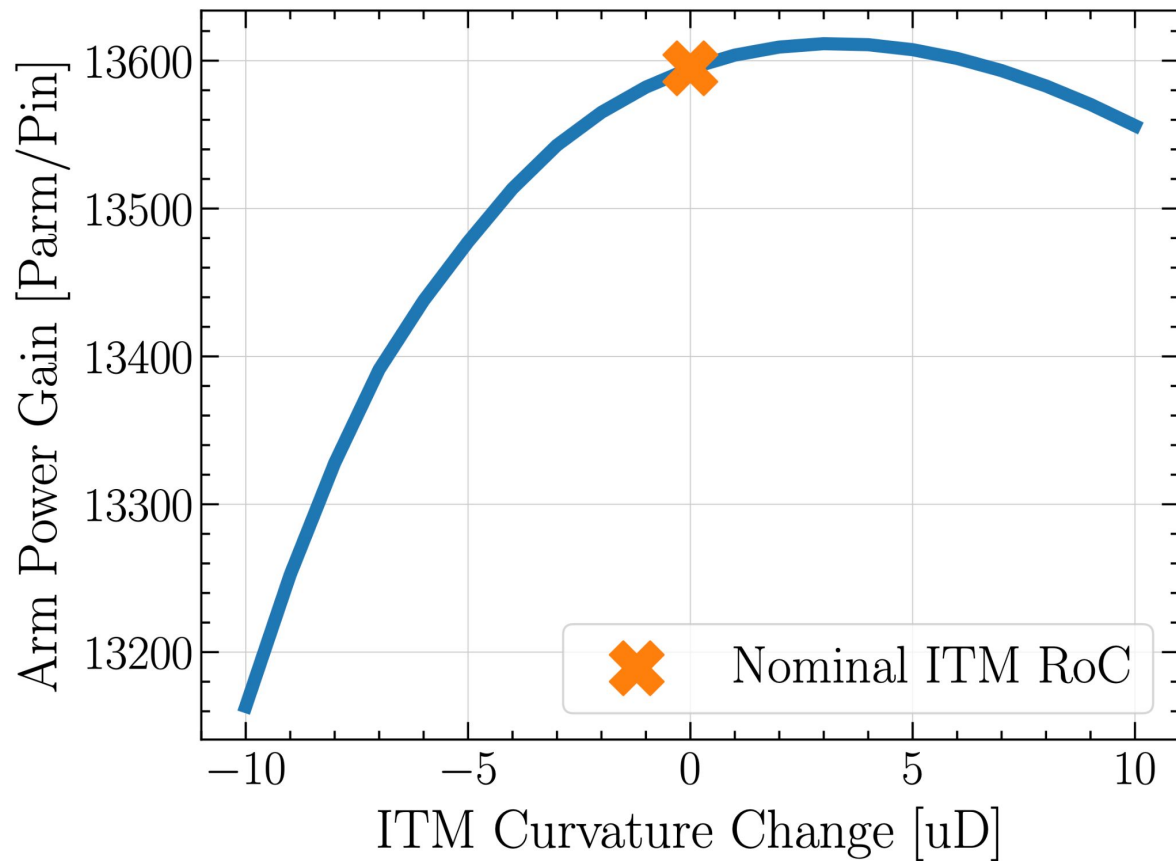
Nominal RoC:
−1934 m

Maximum Gain at
+3 uD: −1945 m

Grid Search over Single Component FROSTI Parameters

|	Lower Bound	Upper Bound	Steps
Major Radius [cm]	5.5	8.5	30
Minor Radius [cm]	5	8	30
FROSTI Power [W]	10	40	30

The RH power is optimized to completely remove the quadratic component the substrate OPD

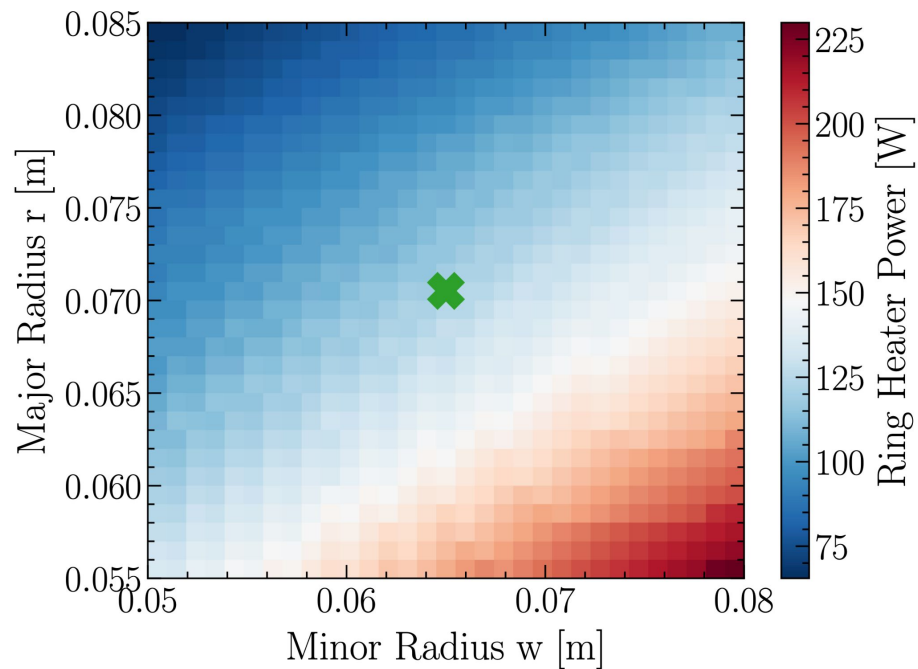In total, there are 30*30*30 = 27000 cases, which takes ~20 hrs over 45 cores.
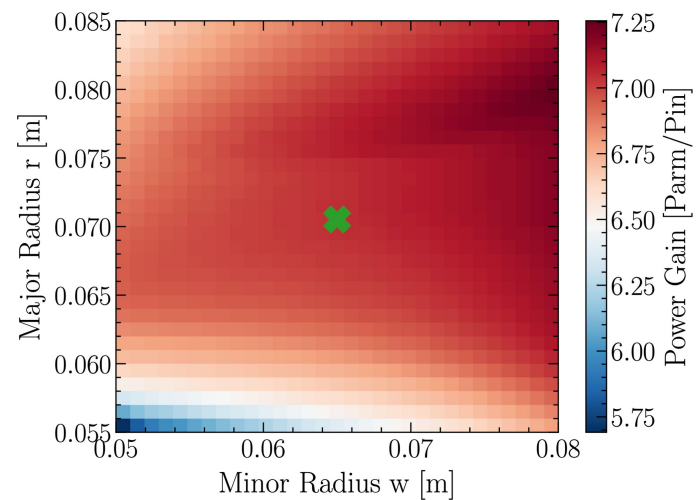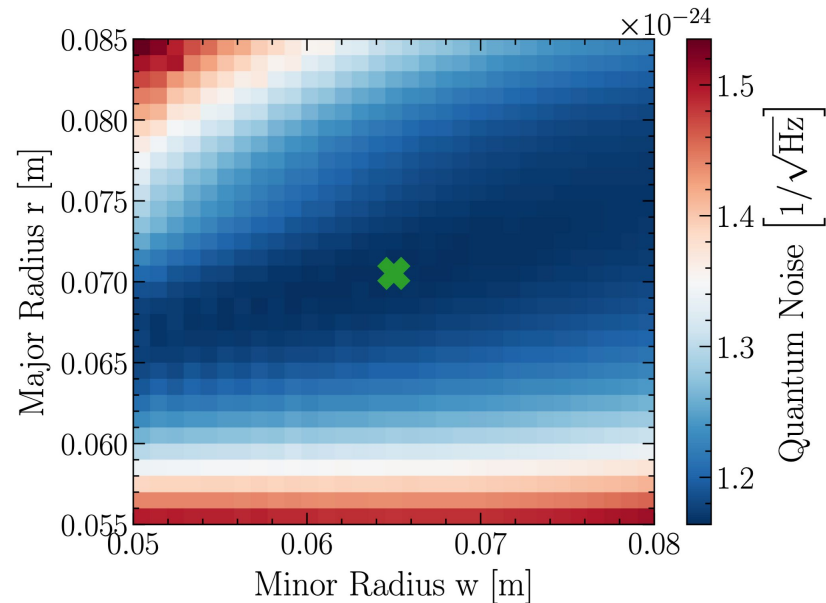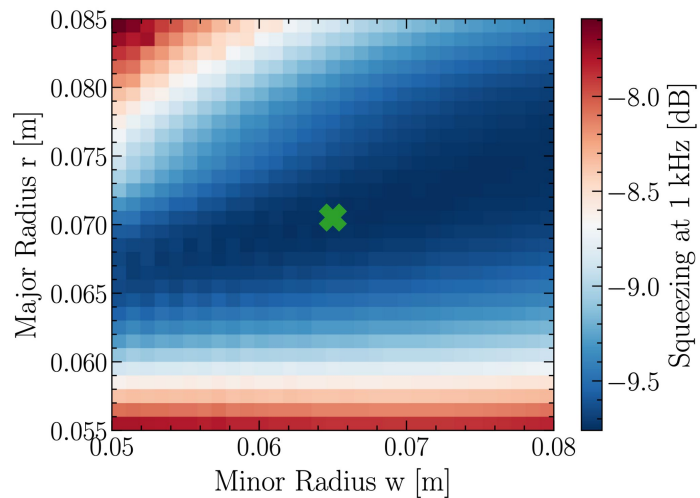
IFO state for the optimal case vs. cold state

	Optimal QN (green cross)	Cold State
QN [1/rt(Hz)]	1.164e-24	1.152e-24
Power Gain	7047	6798
SQZ [dB]	9.76	9.80

The optimal RH power is 122 W (too large?)
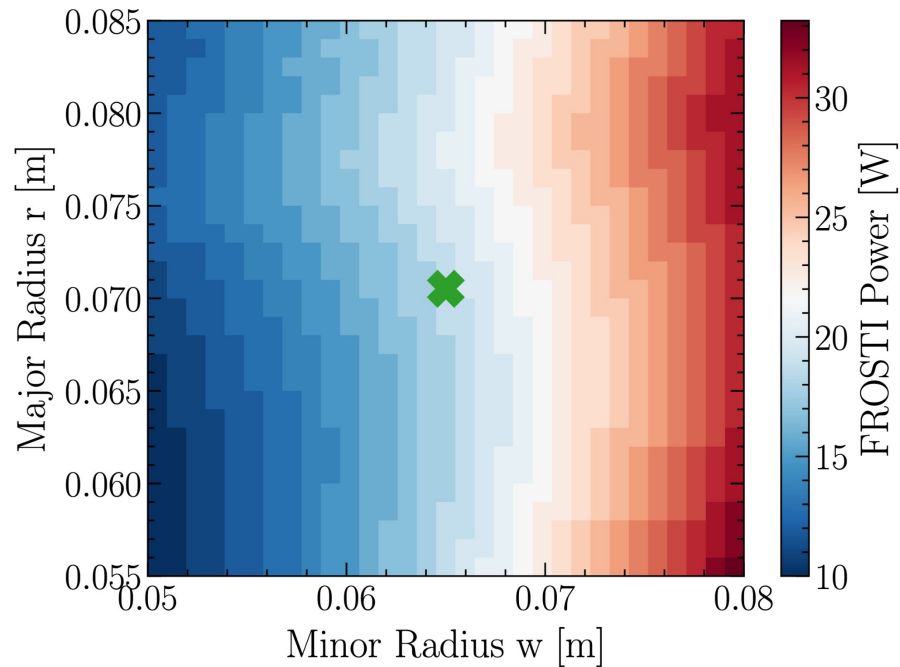
The optimal FROSTI power is 18.7 W

Large Residual Wavefront RMS Error
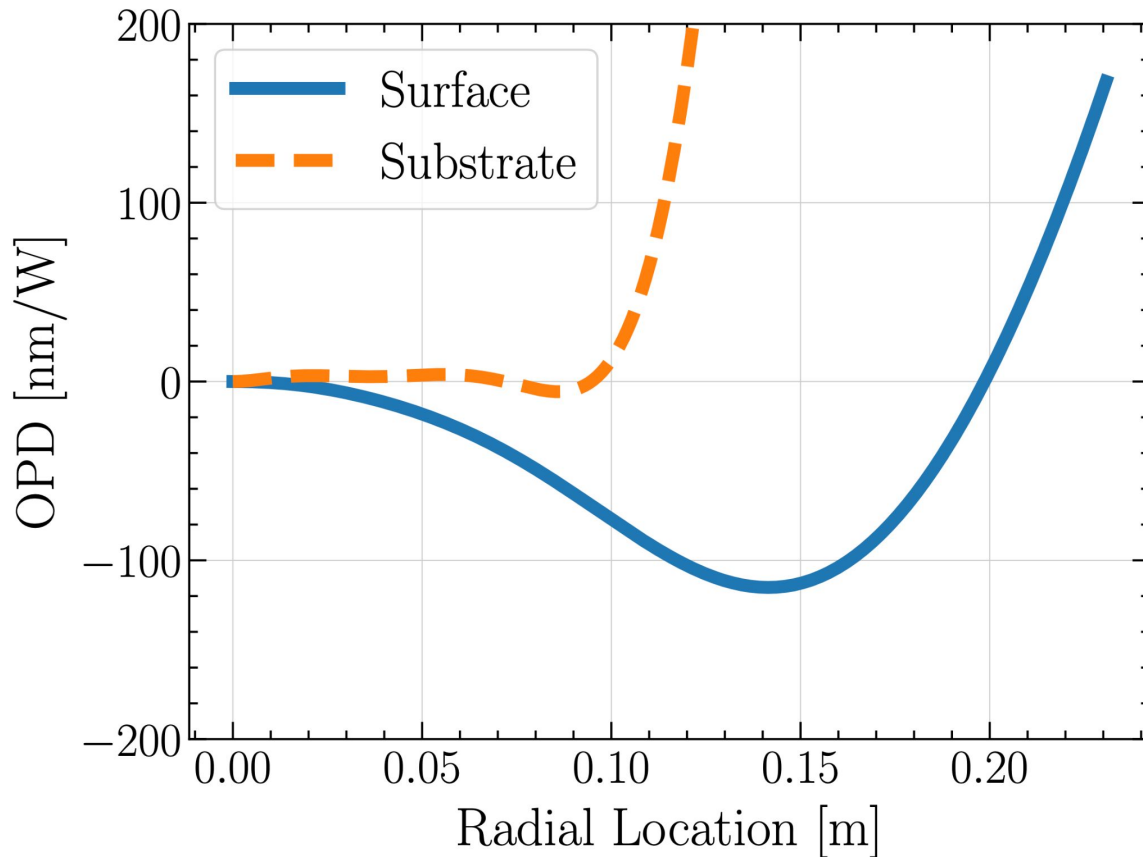
The residual surface and substrate OPD for the optimal case.

The rms is much larger than the heuristic requirement of 10 nm each.