Design study of the KAGRA output mode-cleaner (OMC)

KAGRA F2F meeting

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Roles & Requirements of KAGRA OMC

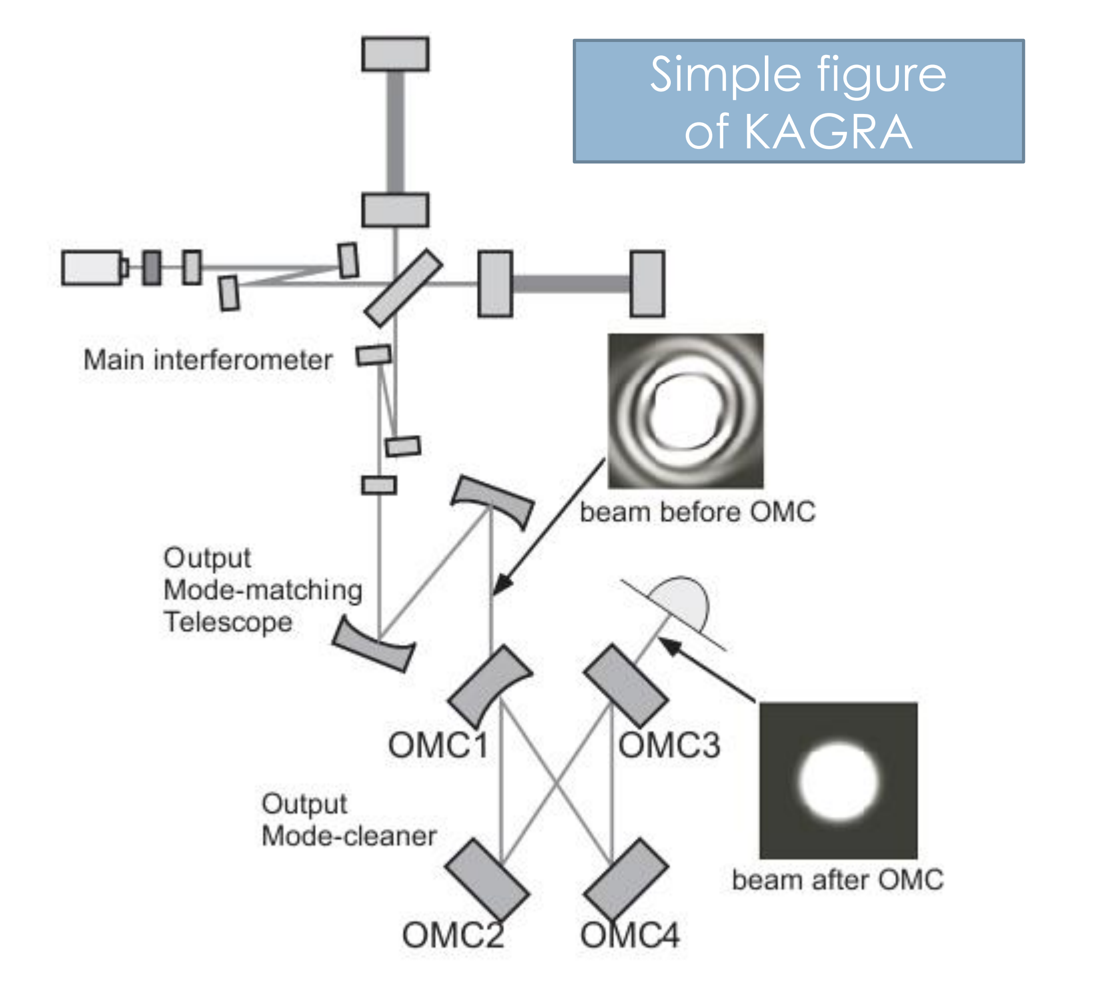
<Roles>

- Filter out
  - the higher order spatial modes (HOMs)
  - RF sidebands (16.88 MHz)

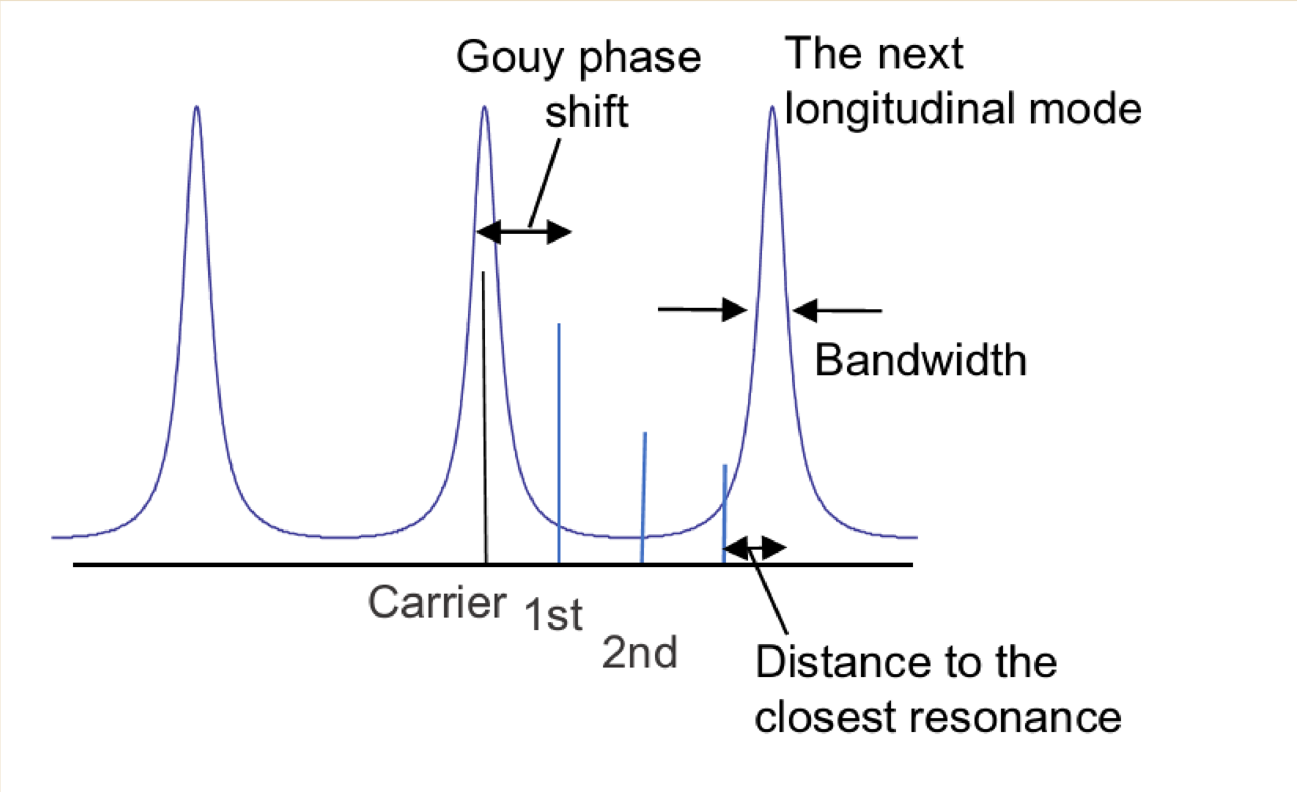
<Requirements>

Not to degrade the shot-noise level by more than 5 %

- Signal loss < 2 %
- HOMs < 10 μW (1 %)
- RF sidebands < 20 μW (2 %)



OMC parameter selection

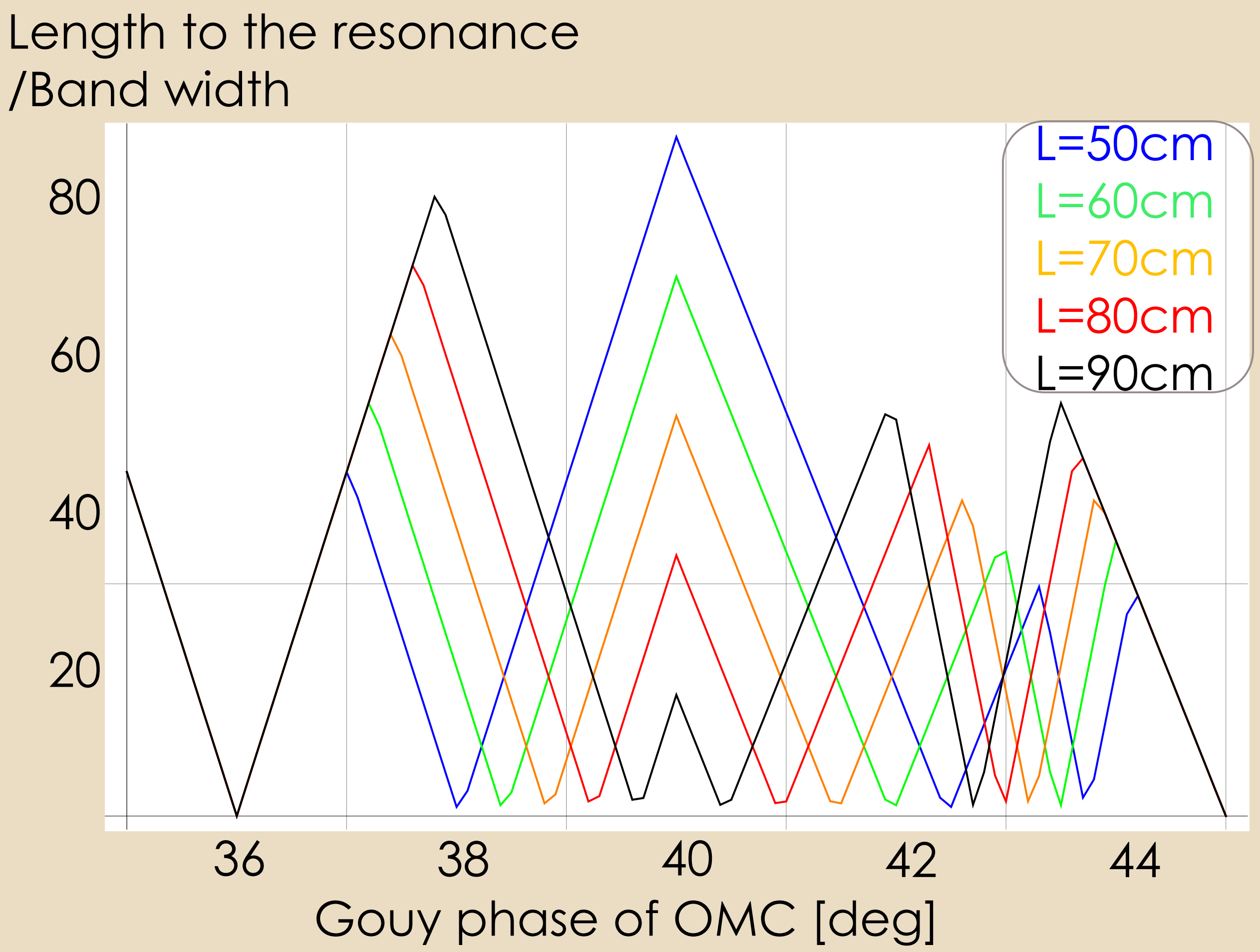


Choose these parameters…

- Cavity length (L)
- Gouy phase (η)
- Finesse (F)

…to satisfy our requirements

OMC parameter selection – old ver.

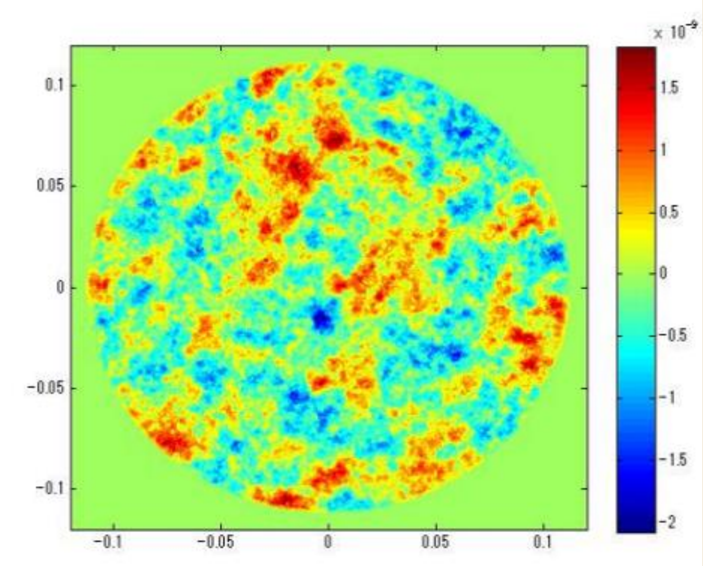


- Calculation up to the 8th higher order modes
- Selection the parameters
  "L = 87 cm, η = 38 degree"

Some Problems

- Is 8 enough?
- Can we treat each mode equally?

OMC parameter selection – new ver.



Mirror map for KAGRA
computed by H.Yamamoto

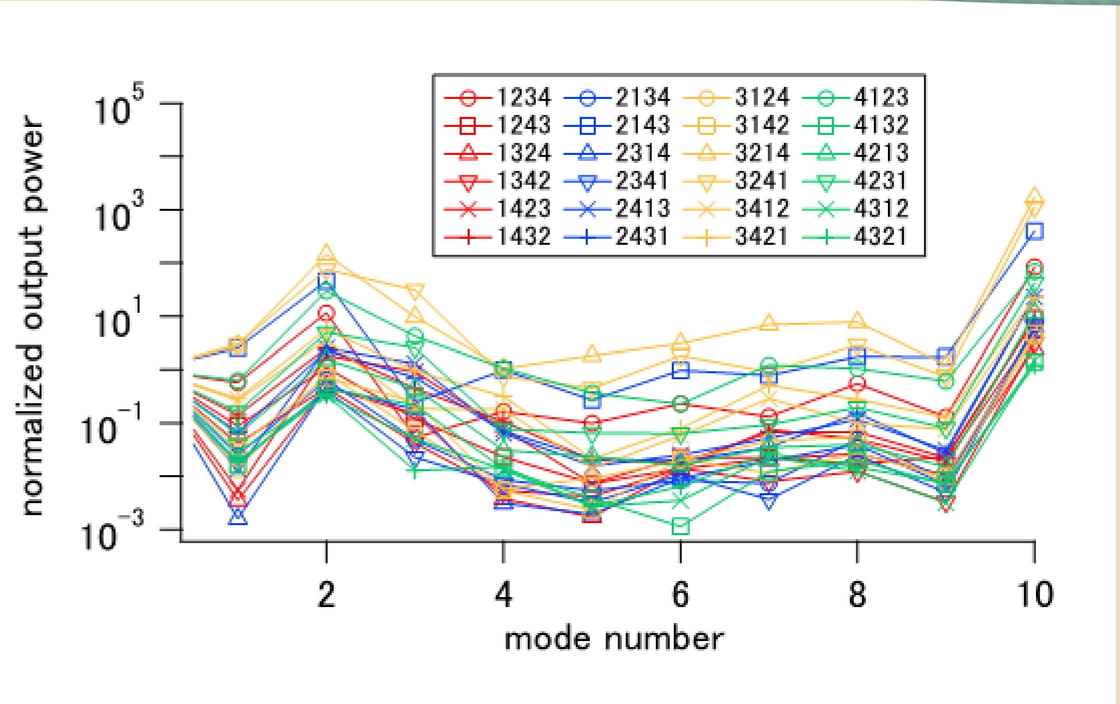
Mirror diameter : 220 mm
RMS surface error : 0.5 nm

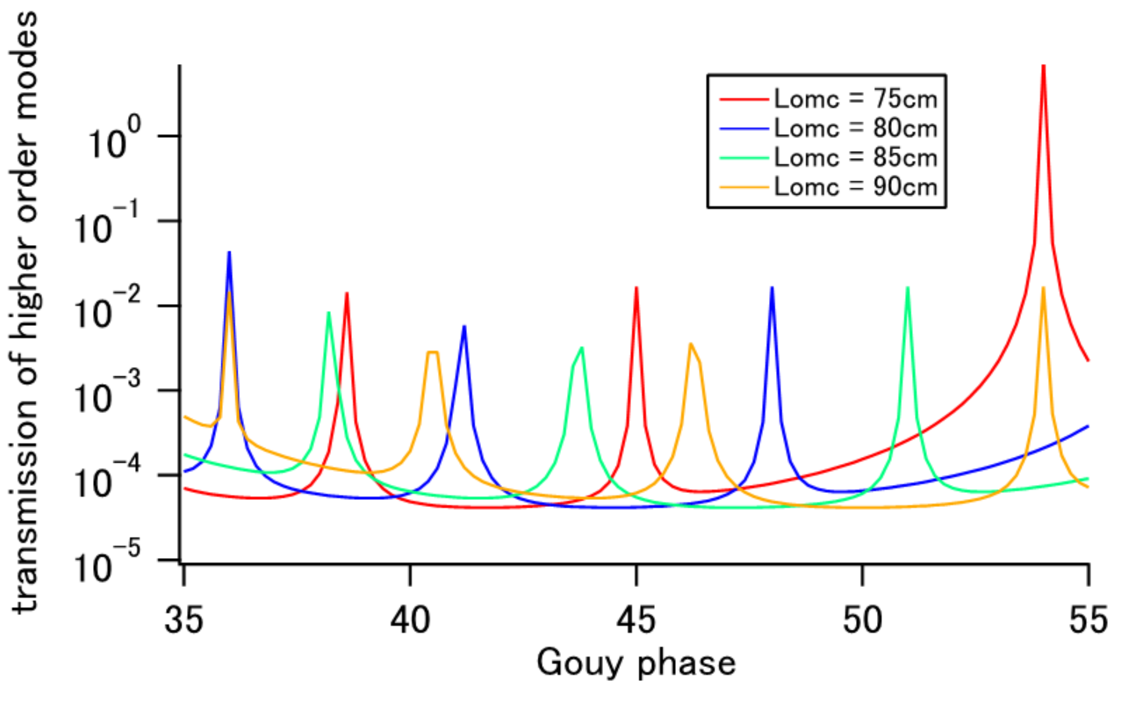
- Use different mirror maps for 4 test masses
- Use 4 mirror maps in KAGRA arm cavities for realistic simulation
- Find a proper weighting factor using FINESSE with 24 combinations of these maps

Select the proper parameters with this weighting factors

OMC parameter selection – new ver.

4 mirror maps, 24 combinations



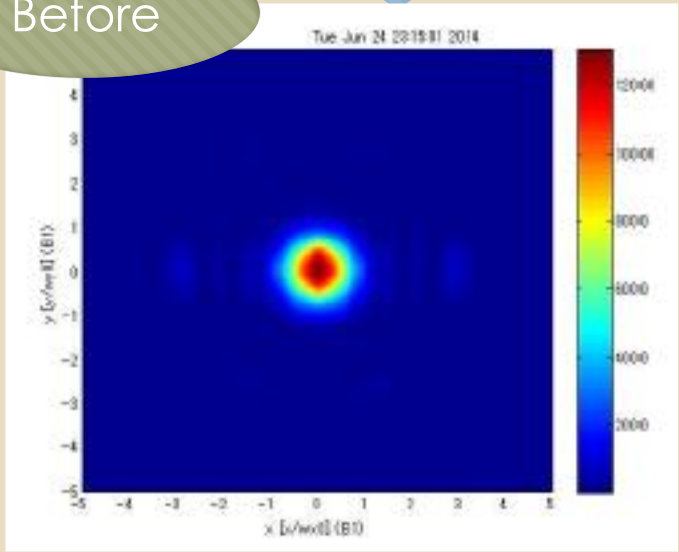


- We found "L = 80 cm, η = 45 degree" are the proper parameter for KAGRA OMC

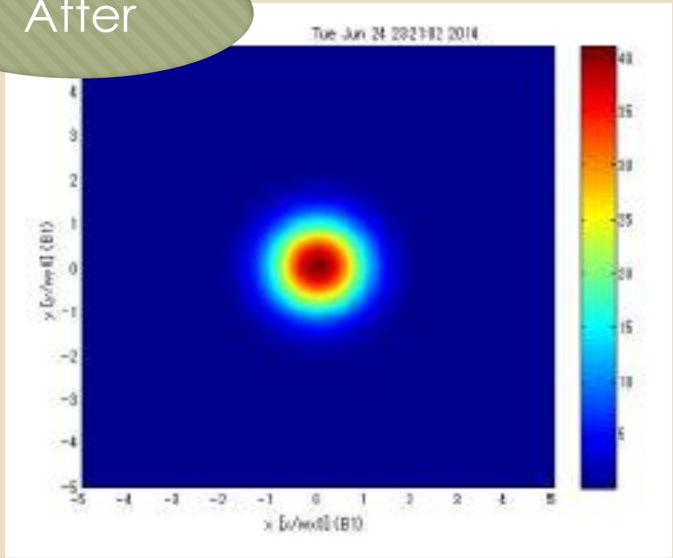
New parameters!!

Current status

Before



After



The power in higher order modes
and RF sidebands

	0^{th}	1^{st}	2^{nd}	3^{rd}	10^{th}	RF
Before OMC	877 μW	504 μW	10.1 mW	46.5 μW	74.2 mW	409 mW
After OMC	853 μW	4.34 nW	39.8 nW	298 pW	340 nW	20.6 μW

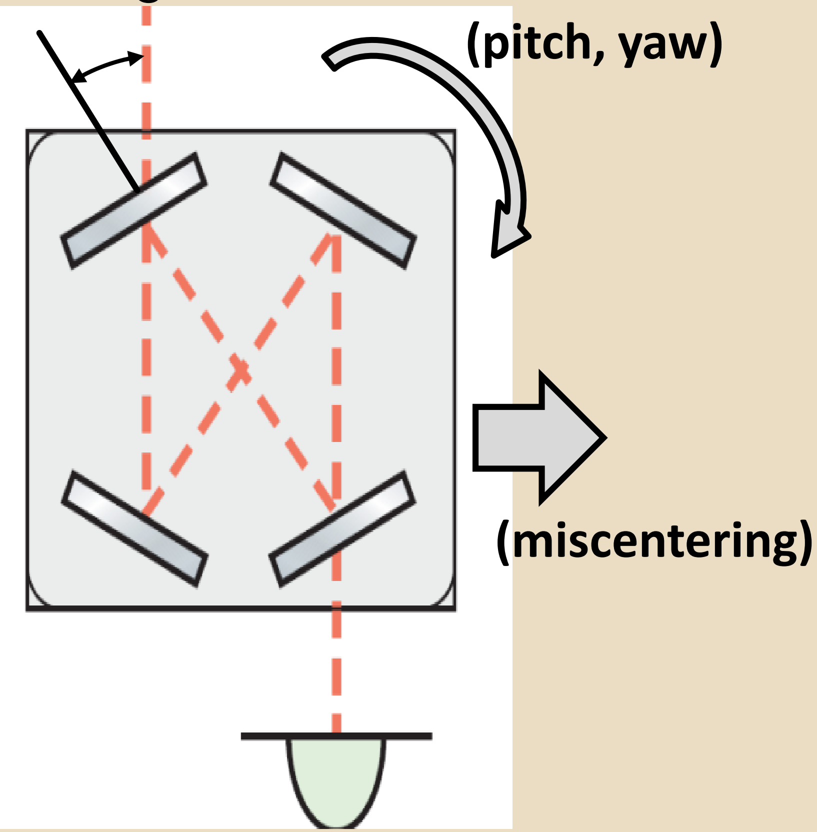
Result & Future

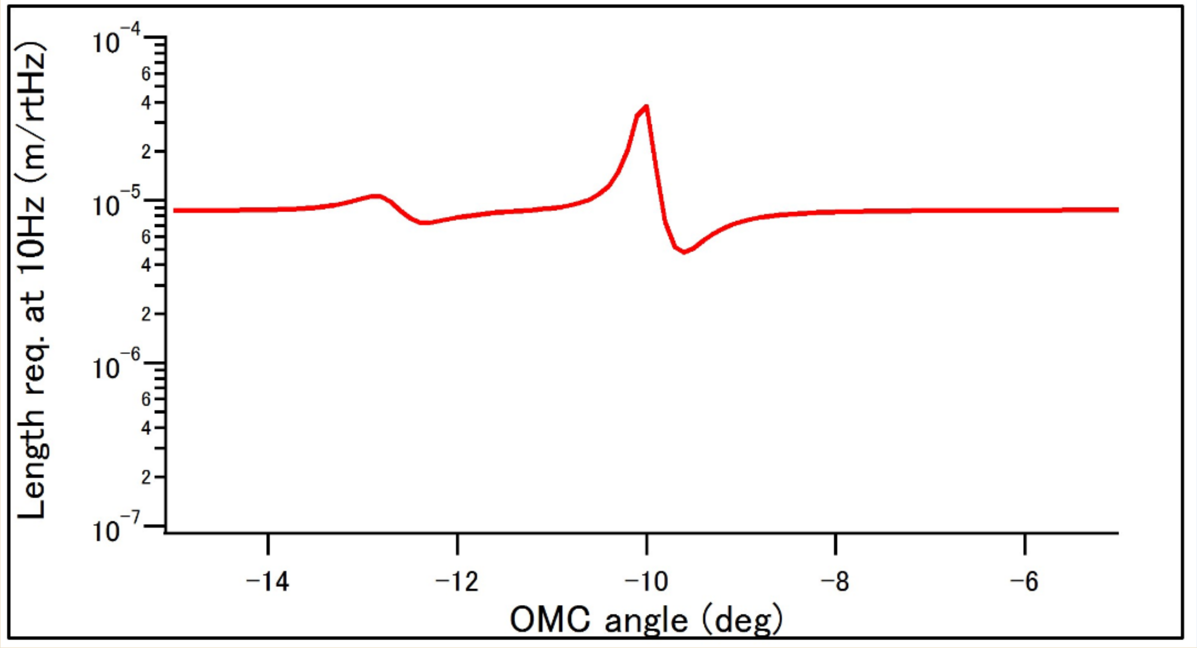
- If there are over 1 mw laser power before OMC, the sensitivity will be attained the aggravation within 5%.
- Next, we have to select the control method of length and alignment of OMC.

Other slides

Dependency of initial angle

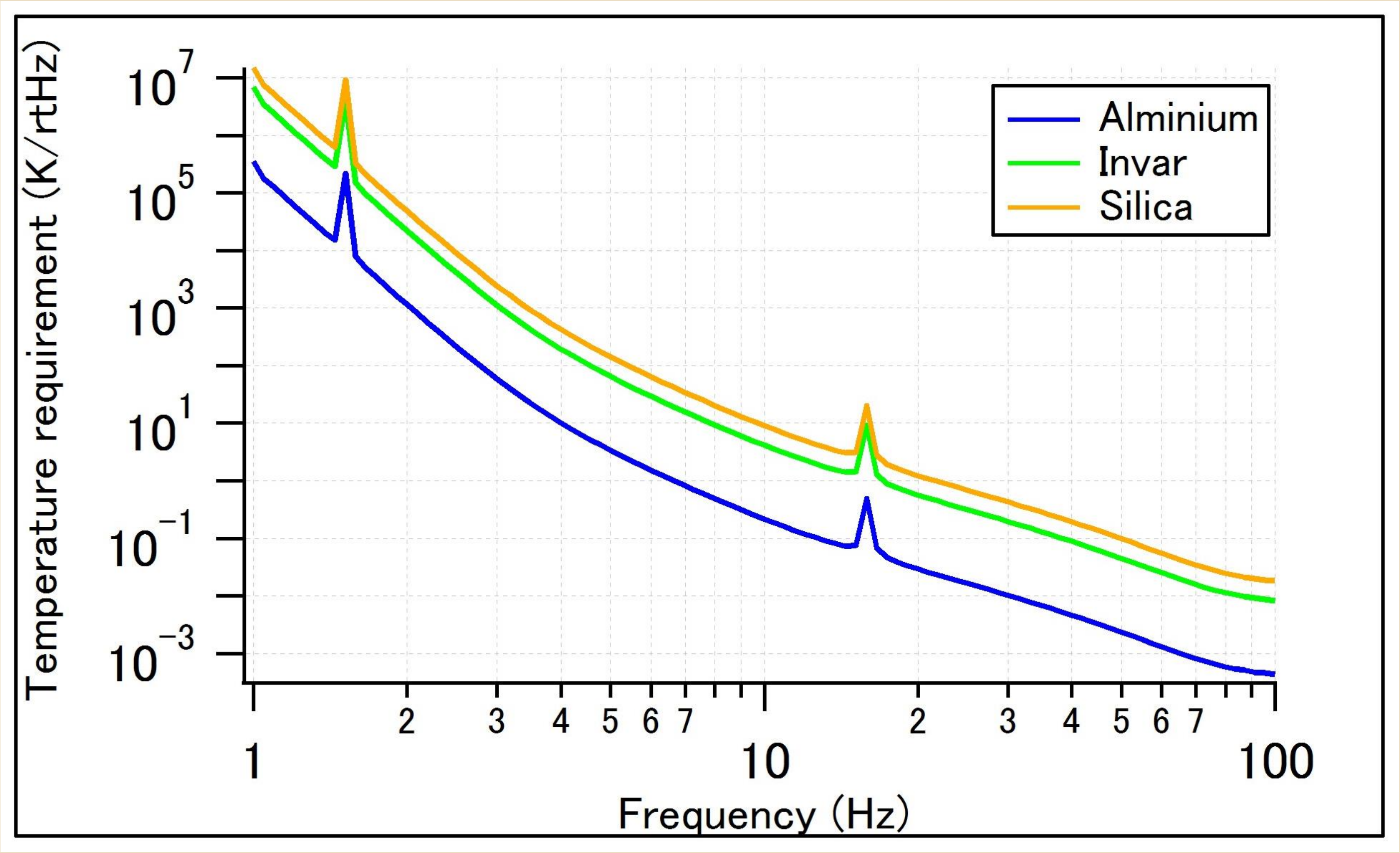
Initial angle: a



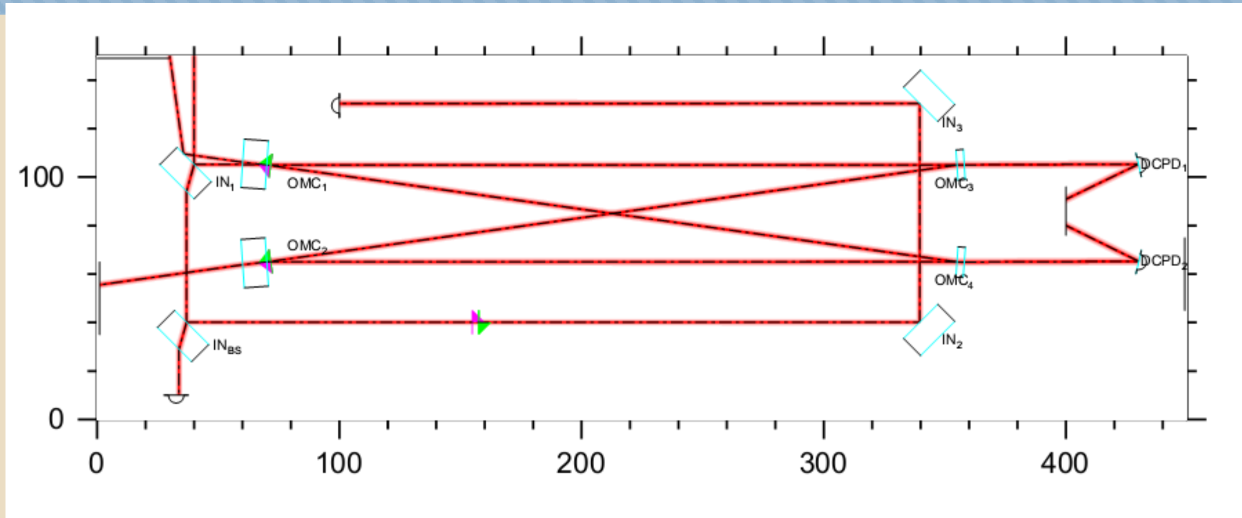


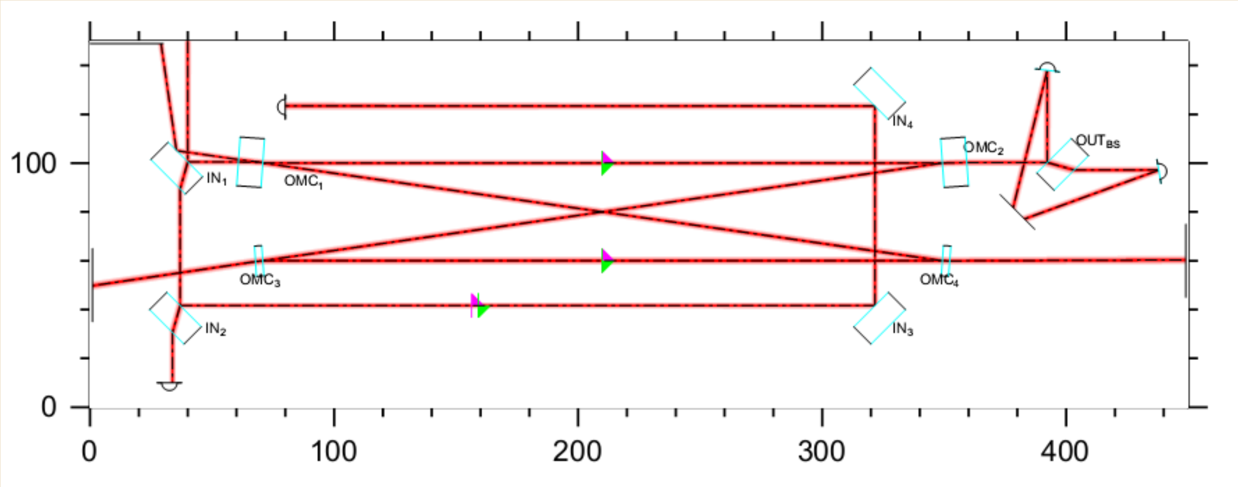
- KAGRA design : Initial angle is 67°
- Only temperature stability depends on initial angle: a ~ 10 deg

Selection of material



Control method - aLIGO ver.





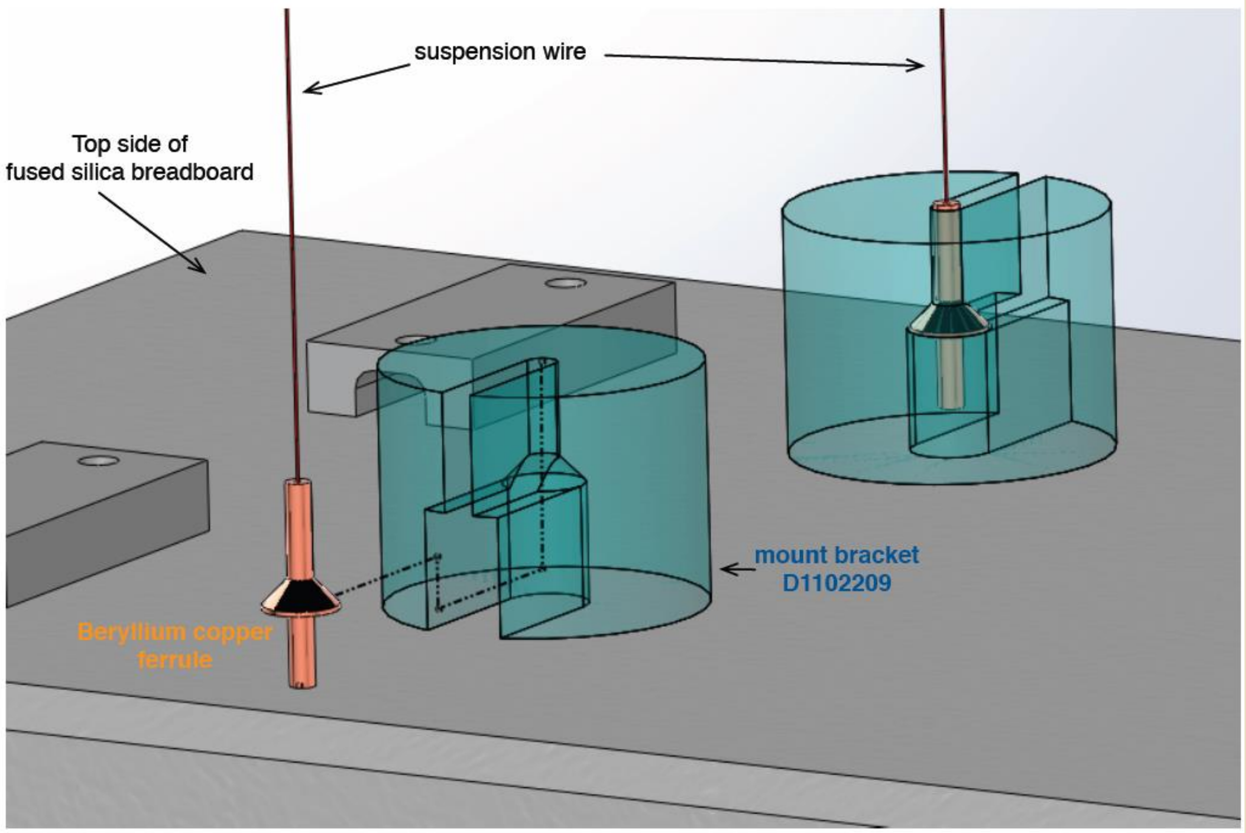
- Optical parameter

  R = 2.5 m, L = 0.57 m

- Use quadratic photo detector (QPD) to the control method of angle and length of OMC

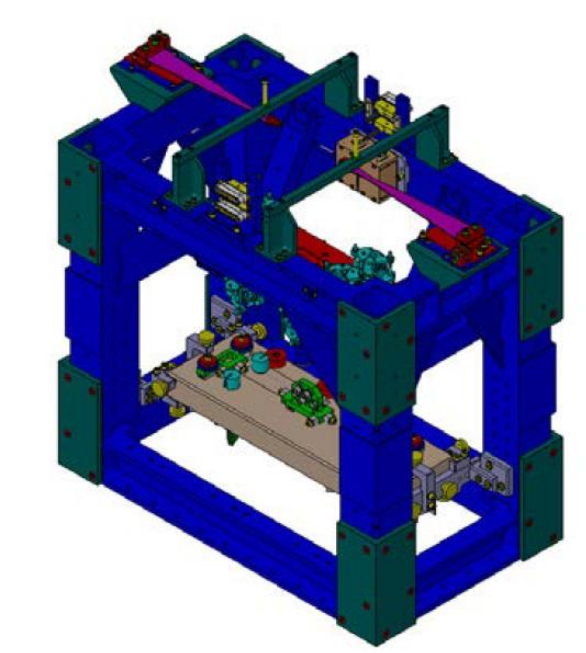
Suspension- aLIGO ver.

3 mm		5 cm	
Freq. [Hz]	ID	Freq. [Hz]	ID
0.48	yaw2,yaw1	0.48	yaw2,yaw1
0.71	pitch2,pitch1	0.70	pitch2,pitch1
0.72	roll2,roll1	0.70	roll2,roll1
0.75	roll2,roll1	1.09	roll2,roll1
0.80	pitch2,pitch1	1.12	z2,z1
1.12	z2,z1	2.12	pitch1,pitch2
2.55	y1	2.56	y1,roll1
2.55	x1	2.78	pitch1
3.60	yaw1	3.60	yaw1
3.92	pitch1	4.03	pitch1
4.48	z1	4.48	z1

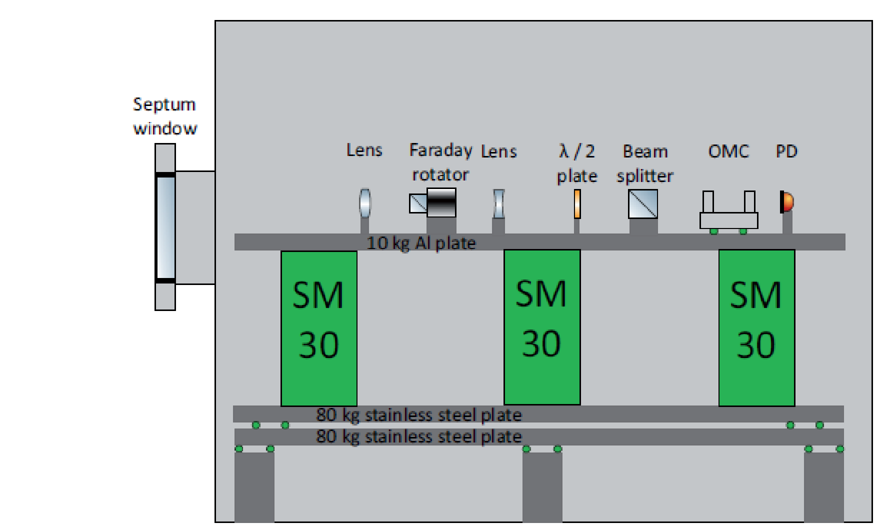


Vibration isolation

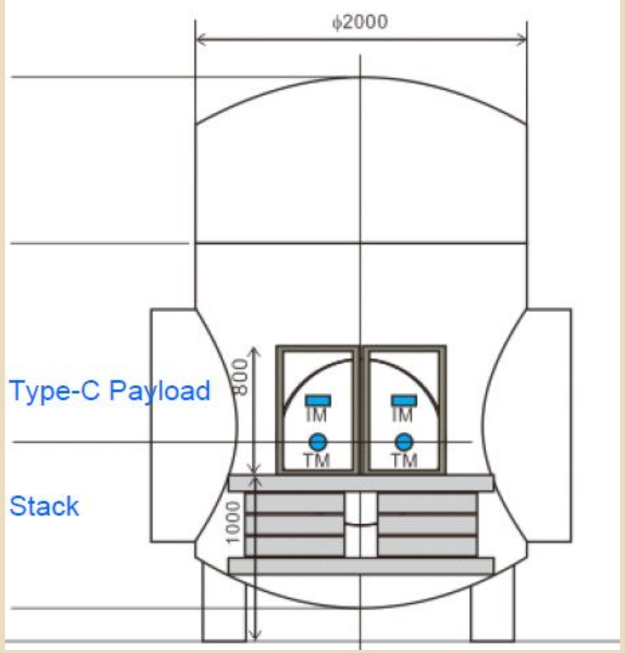
aLIGO OMC



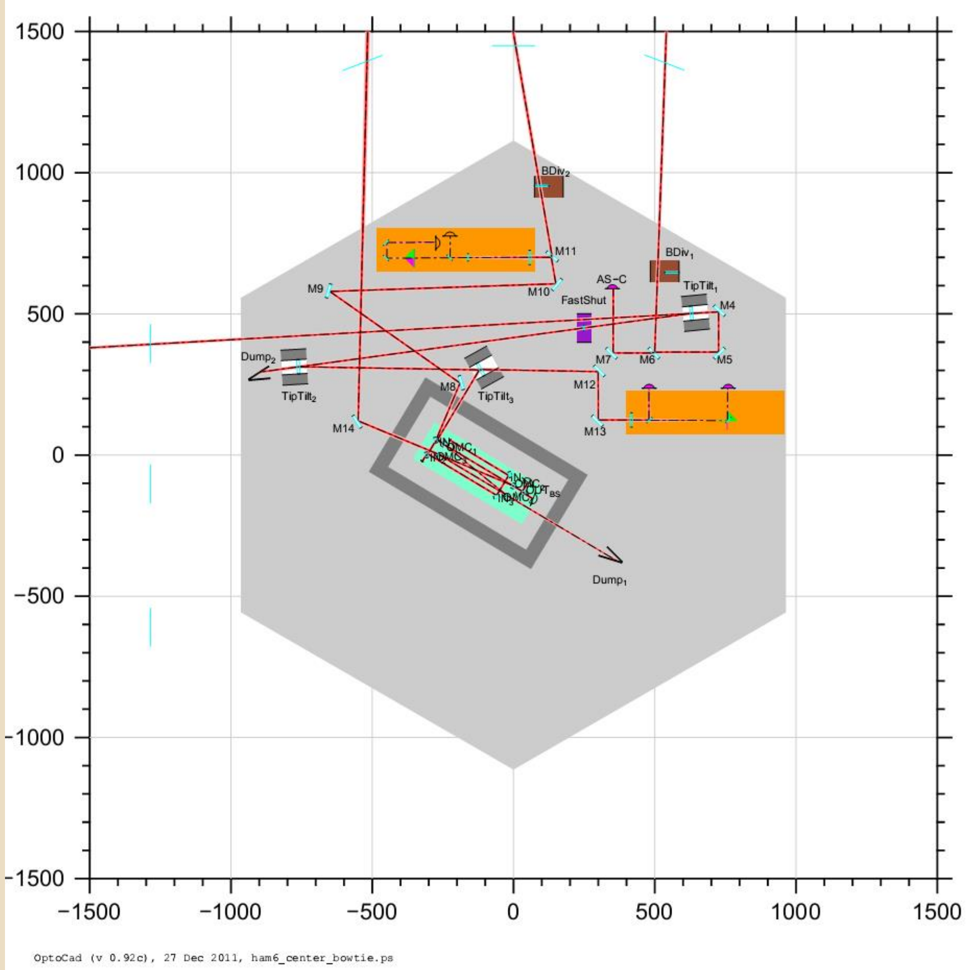
GEO OMC



KAGRA type-C



HAM6 layout - aLIGO ver.



Actuators - aLIGO ver.

Vendor	Noliac
Model	NAC2124
Size	Ring shape: 15 mm OD, 9 mm ID, 2 mm thick
Stroke	2.8 microns at 200 V
Sensitivity	14 nm/V
Capacitance	470 nF

The bottom bonded to the fused silica Breadboard