Height adjustment of Type-A suspension

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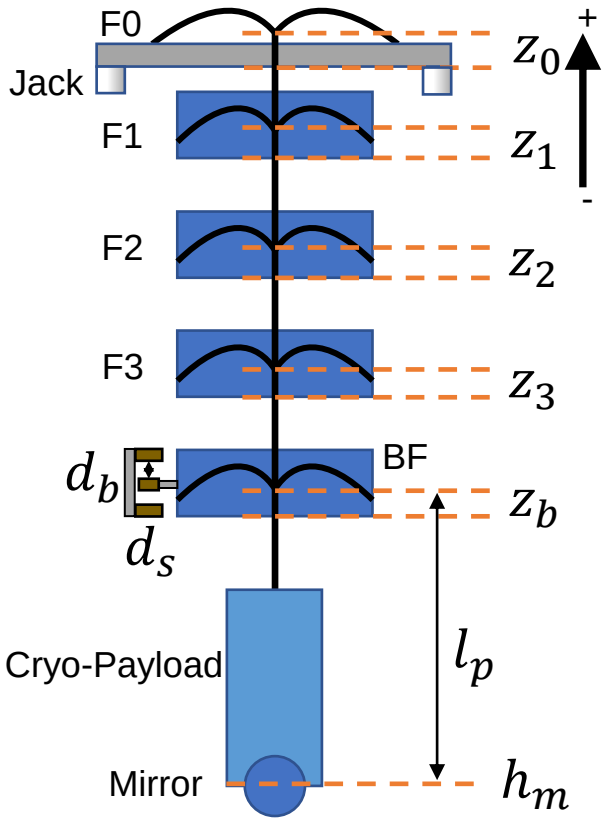
- For an interferometer to work properly, its mirrors need to be kept at a specified height.
- The height of the mirror of a Type-A suspension system changes due to mainly three reasons.
  ①Shrinkage of the cryo-payload by cooling
  ②Change of buoyancy by vacuum evacuation
  ③Temperature change of the tower part
- ③ should be addressed by stabilizing the temperature of the chambers.
- ① and ② are inevitable and the adjustment mechanisms of the Type-A tower should be able to handle them.
- This document shows a procedure to properly compensate for the height change caused by ① and ② .

Definitions of variables and constants



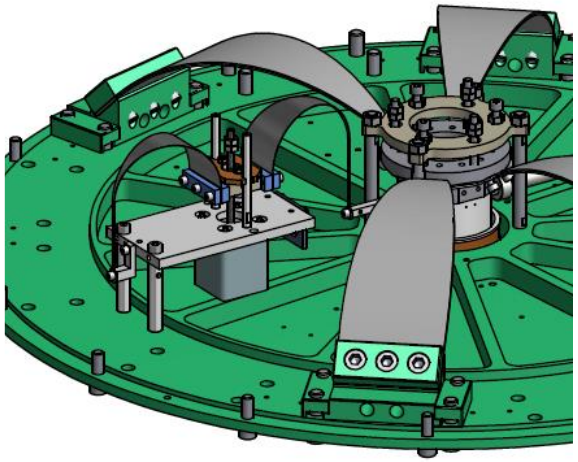
- GAS filters are specified by a subscript $n = \{0,1,2,3,b\}$
- $\{z_0, z_1, \ldots z_b\}$ are the deviation of the keystone position with respect to the GASF body from the nominal ones. These are measured by the keystone LVDTs.
- GAS filters have fishing rods (FR) to move the key stones
- Each FR has moving range of $\pm R_n$ around the nominal positions.
- F0 has a larger adjustment range because we can access it in air.
  - We can add/remove ballast masses to change z_0 larger than R_0.
  - If necessary, we could also use the jacks to support the IP legs to further change the height of F0.
- BF has LVDTs to measure the relative position of its body to the ground.
  - d_b is the reading of the BF LVDT. d_b has a range of $\pm R_{lvdt}$.
  - Position of the secondary coils can be adjusted by opening the side doors of the cross-tube.
- l_p is the length of the cryo-payload from the nominal value.
  - This quantity cannot be measured directly.
- h_m is deviation of the height of the mirror from the nominal height measured from the ground.
  - This should be measured by a surveying instrument from outside of the cryostat with respect to the beam height.
- The following relations should hold:

$$h_m = z_0 + z_1 + z_2 + z_3 + z_b + l_p$$

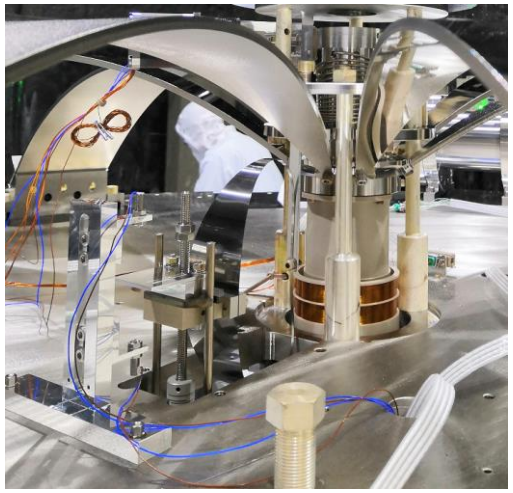
$$d_b = z_0 + z_1 + z_2 + z_3 - d_s$$

Condition

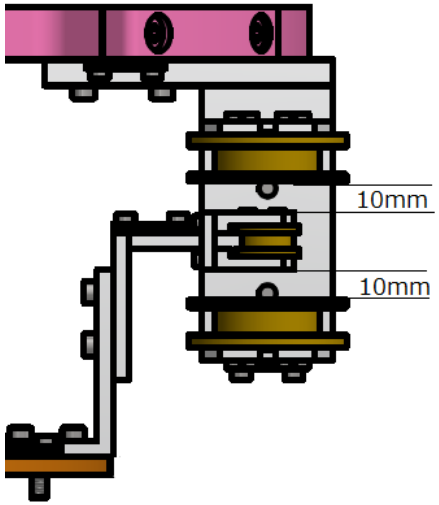
- Predicted shrinkage length by cooling is 10mm.
- Buoyancy effect by evacuation is -0.5mm.
- Though the jack can change the height of F0 baseplate, it is very difficult to keep the tilt of IP during the adjustment.
- Range of BF LVDTs (R_{lvdt}) is +/- 10mm. The height setting of secondary coils must fit the adjustable range of filter height.
- In order to prevent for the FR to stuck and for the keystone to touch the mechanical limit, margin of 0.2mm is necessary for each filter.



Fishing rod (FR)



FR for F0



BF LVDT vertical

Adjustable range of GAS filters

IX

	Min.	Mid.	Max.	R	R-margin
F0	-23.2	-18.5	-13.8	±4.7	±4.5
F1	65.4	66.5	67.6	±1.1	±0.9
F2	67.5	68.6	69.7	±1.1	±0.9
F3	67.6	68.5	69.4	±0.9	±0.7
				±7.8	±7.0
BF	66.8	67.7	68.6	±0.9	±0.7
Total				±8.7	±7.7

EX

	Min.	Mid.	Max.	R	R-margin
F0	-14.4	-13.3	-12.2	±1.1	±0.9
F1	64.0	68.8	73.6	±4.8	±4.6
F2	X	X	X	0	0
F3	63.1	65.3	67.5	±2.2	±2.0
				±8.1	±7.5
BF	66.2	69.4	72.6	±3.2	±3.0
Total				±11.3	±10.5

IY

	Min.	Mid.	Max.	R	R-margin
F0	-12.5	-8.9	-5.3	±3.6	±3.4
F1	64.1	66.5	68.9	±2.4	±2.2
F2	63.3	66.3	69.3	±3.0	±2.8
F3	65.6	66.8	68	±1.2	±1.0
				±10.2	±9.4
BF	67.3	67.7	68.1	±0.4	±0.2
Total				±10.6	±9.6

EY

	Min.	Mid.	Max.	R	R-margin
F0					
F1					
F2					
F3					
BF					
Total					

Mechanical limit

FR limit

LVDT range

[mm]

Case 1

The beam height error is almost zero.

[Room Temp.]

Setpoint of GAS filters: +7.7mm

Adjustable range of ITMX: -15.4mm, +0mm.

[Cryogenic Temp.]

Setpoint of GAS filters: -2.3mm

Adjustable range of ITMX: -5.4mm, +10.0mm.

Case 2

The beam height error and the shrinkage length error are comparable.

[Room Temp.]

Setpoint of GAS filters: +5.0mm

Adjustable range of ITMX: -12.7mm, +2.7mm.

[Cryogenic Temp.]

Setpoint of GAS filters: -5.0mm

Adjustable range of ITMX: -2.7mm, +12.7mm.