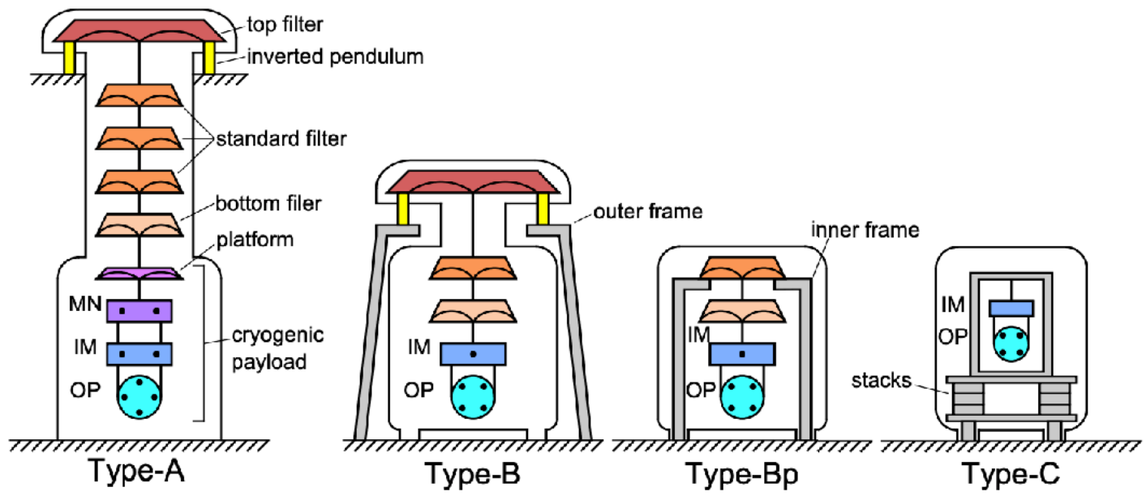
All of the Vibration Isolation System in KAGRA

JGW-E2012144-v11

Optical layout

with Suspensions, Vacuum Chambers, and Optical Table

JGW-E2012144-v11

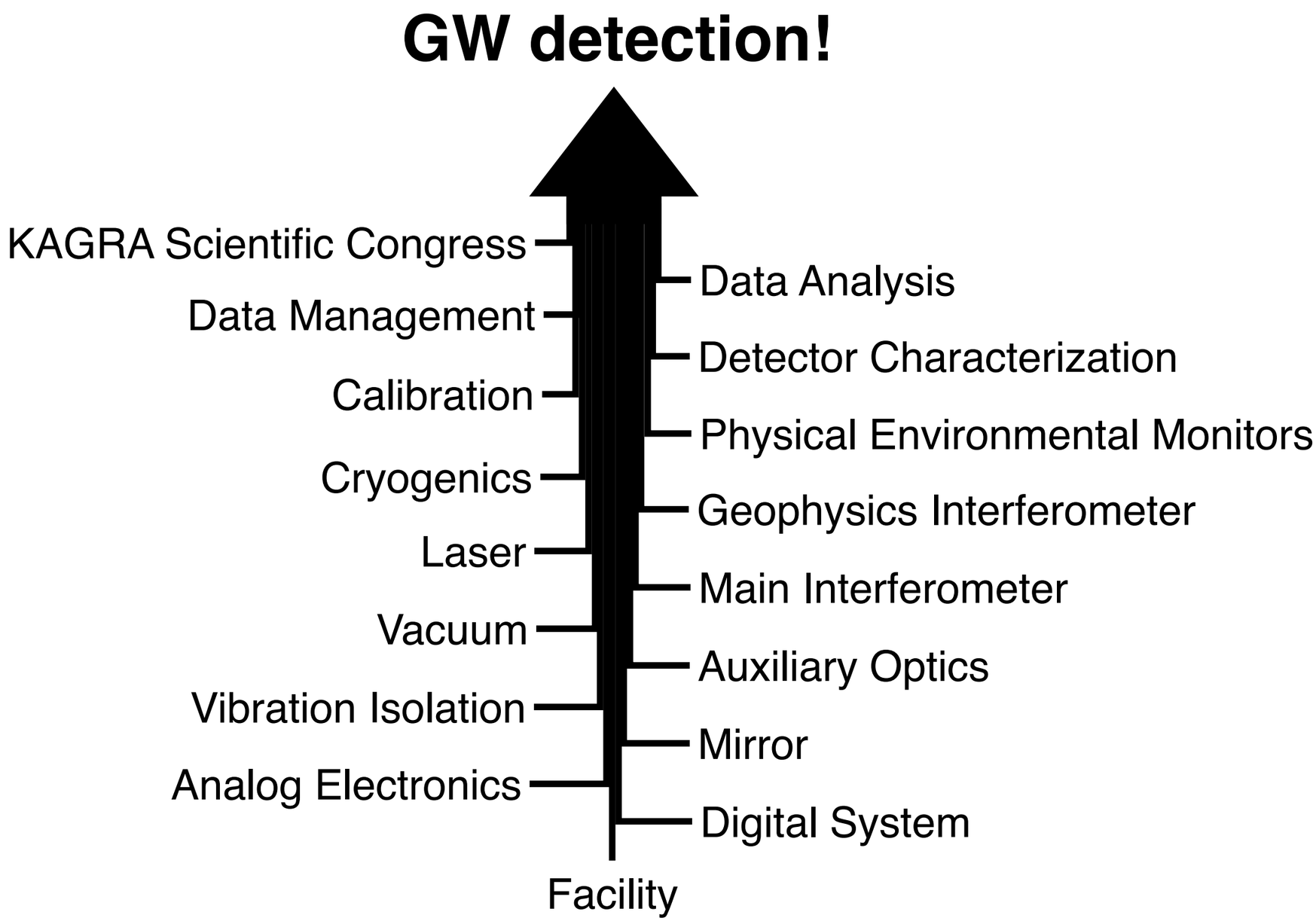


Y. Michimura, et. al (2017)

- Test Mass Type-A Sus
- Beam Splitter Type-B Sus
- Signal Recycling Type-B Sus
- Power Recycling Type-Bp Sus
- Type-C Sus
- OMC-VIS
- TMS-VIS

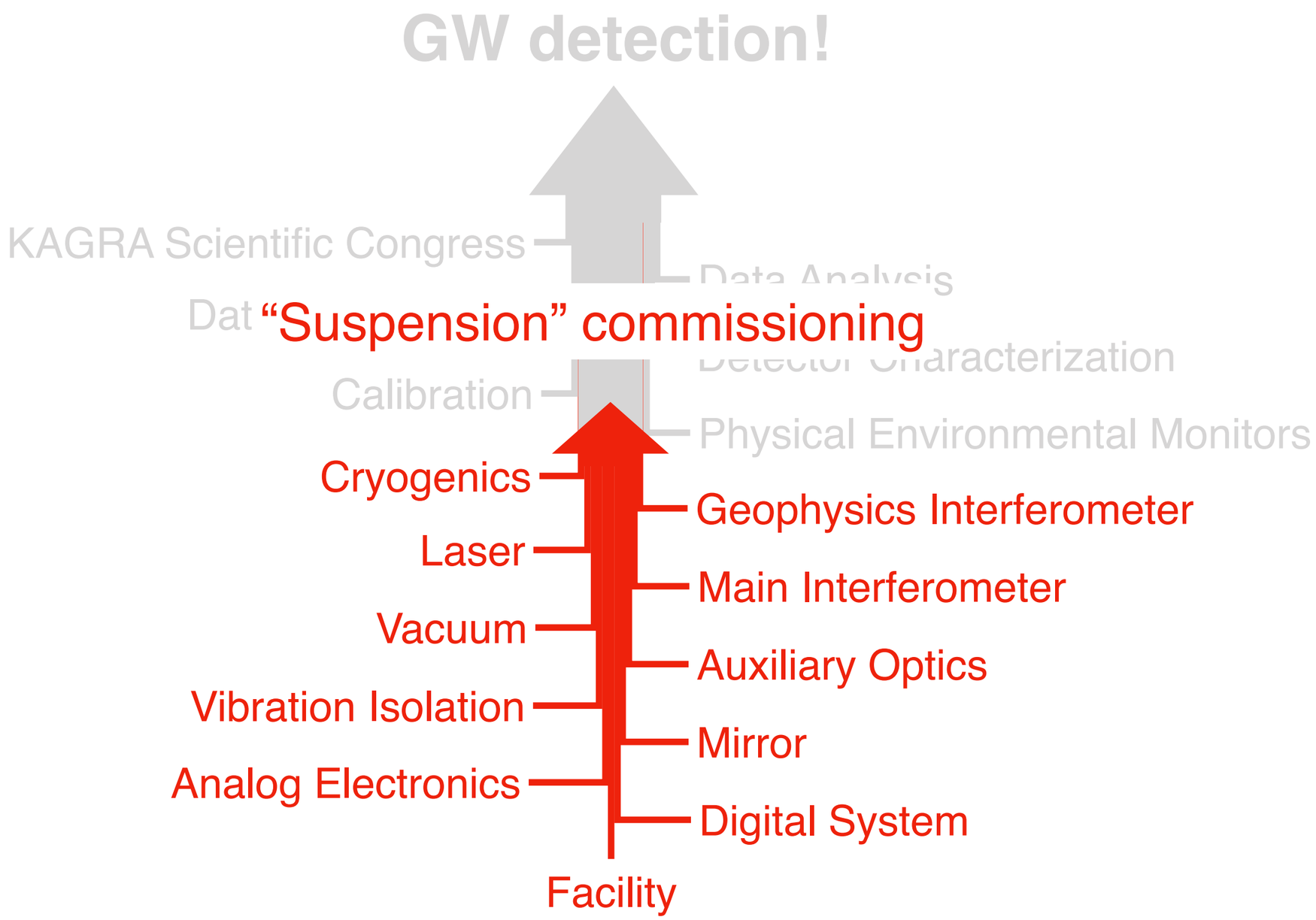
Reference: aLIGO Seismic Isolation and Suspensions Cartoon (G1200071)

Commissioning is …



KAGRA organization chart

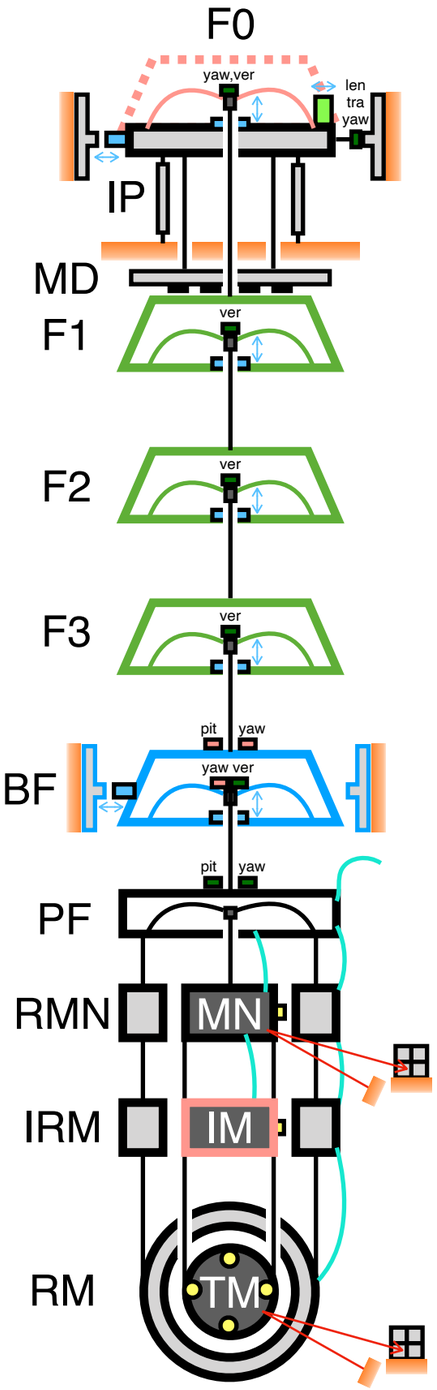
Suspension Commissioning is …



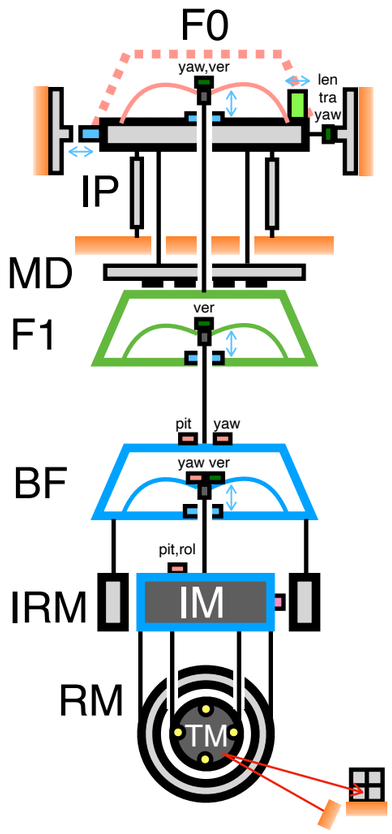
KAGRA organization chart

Suspensions

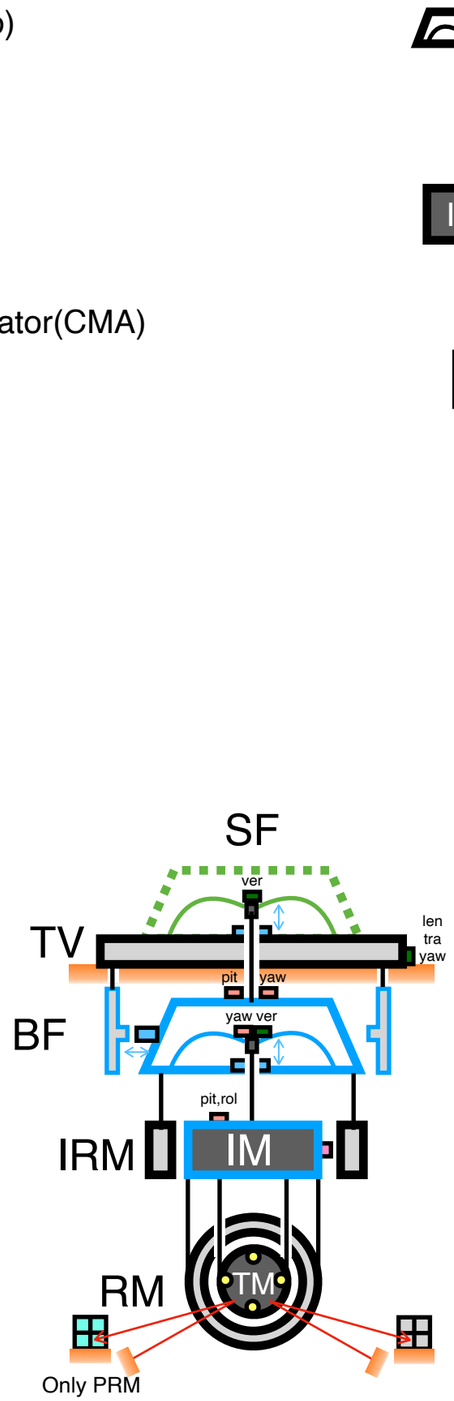
with sensors and actuators



Type-A



Type-B



Type-Bp

- GAS-LVDT/Voice Coil Actuator(VoCo)
- LVDT/VoCo
- Accelerometer
- OSEM
- Optical Lever (OpLev)
- PSD
- CMA
- Photo Sensor (PS)/Coil Magnet Actuator(CMA)
- Stepper motor
- Picomotor
- Magnet

- Geometric Anti Spring filter
  - Top Filter (TF)
  - Standard Filter (SF)
  - Bottom Filter (BF)
- IM Intermediate Mass
  - For Type-A
  - For Type-B, Bp (except BS)
  - For Type-C
- LVDT recoil
  - For IP
  - For BF (only Type-A, Bp)

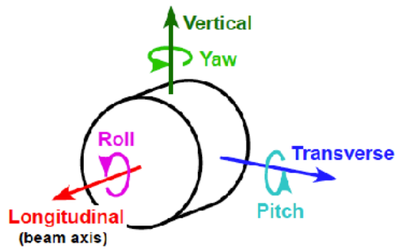
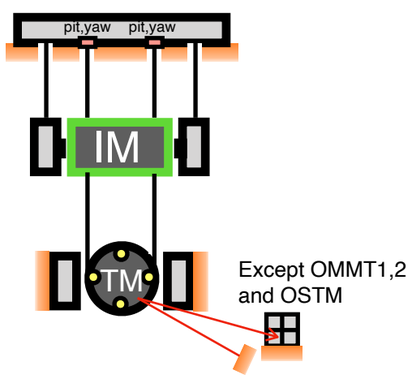


Figure 2.7: Definition of the coordinate system.

from T. Sekiguchi PhD thesis



Type-C

Geometric Anti-Spring

Inverted Pendulum

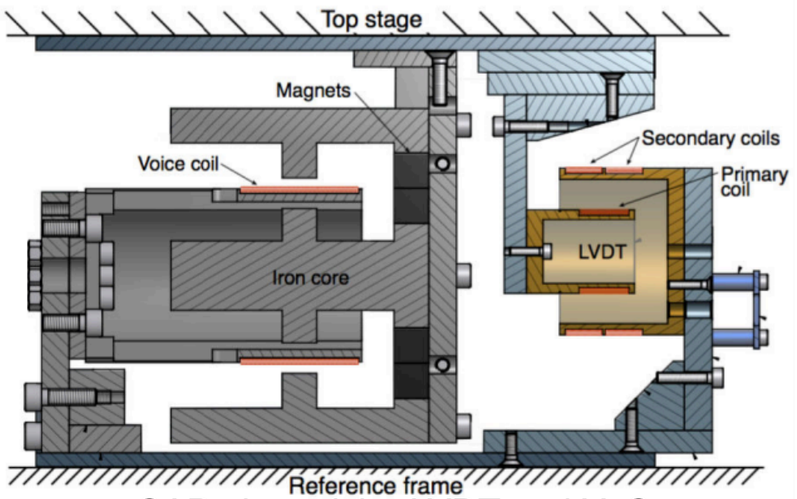
Inverted Pendulum

Magnetic Damper

Maraging Wire

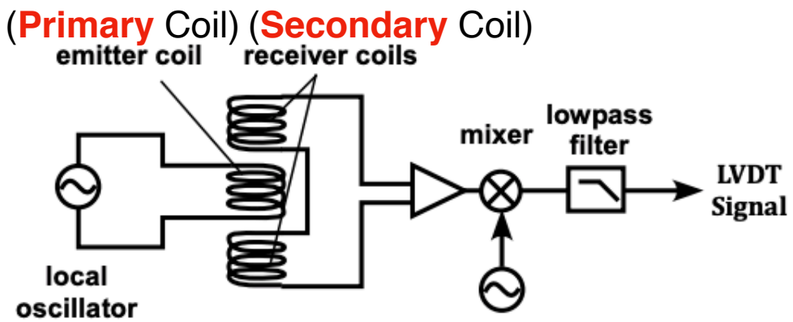
LVDT

IP-LVDT



CAD view of the LVDT and VoCo

Fig. 1.22 from Joris's PhD thesis



Schematic view of LVDT

Fig. 6.5 from Takanori's PhD thesis

GAS-LVDT

No picture?

BF-LVDT

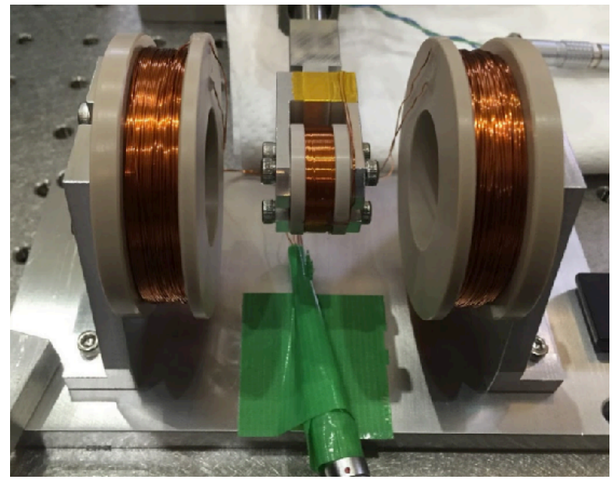


Fig. 6.4 from Yoshinori's PhD thesis

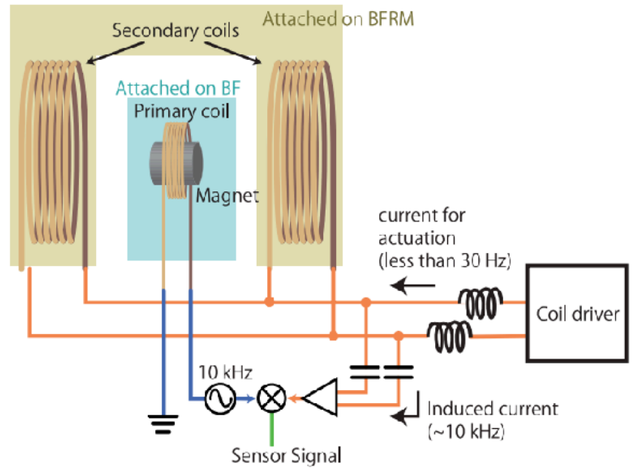
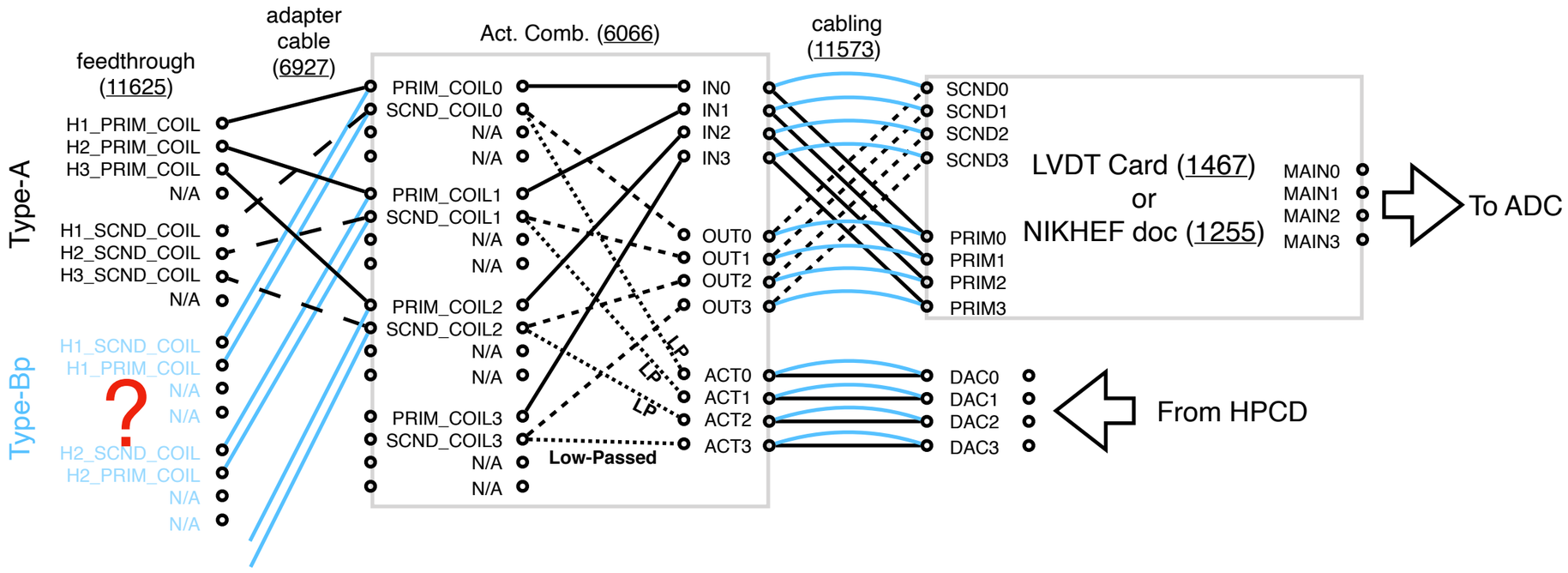


Fig. 5 Y Akiyama et.al (2019)

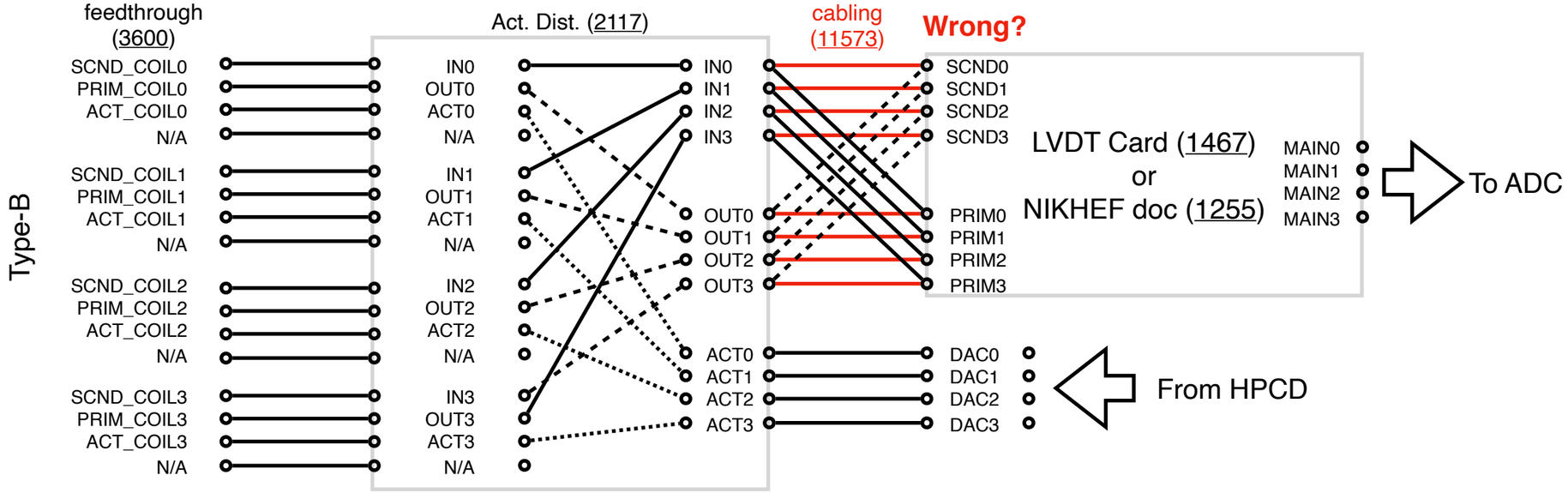
LVDT connections in O3 (in the H case)

JGW-E2012144-v11

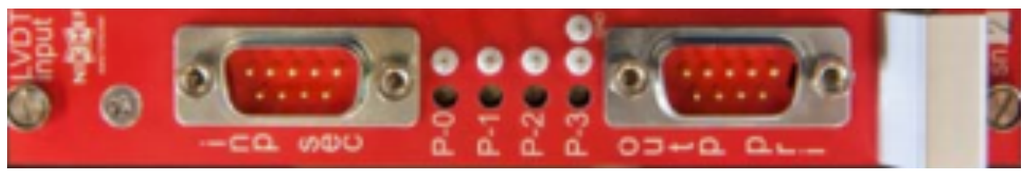
BF-LVDT



GAS/IP-LVDT



[Note] In the TypeB case, at the pin assignment at the feedthrough, the secondary and the primary signal have been swapped out. This means that cabling style like Type-A would be correct. In other word, "**IN**" signal labeled in both Combiner and Distributor should be connected to the "**right**" side connecter on the front panel of the LVDT driver chassis, which is the connecter for the "**Primary coil**".



No Title

LVDT driver chassis (#3045)
Installed at 19th of PRM rack

Photo in Oct. 30 2020

Left side of the front panel

BF-V-IN

For the **secondary** coil

BF-V-OUT

F-V-EXT

For the **primary** coil

BF-V-EXT

Should be labeled "BF-V-OUT" …

BF-V-IN

Swapped!

From "OUT" signal in the LVDT combiner

From "IN" signal in the LVDT combiner

[Ref] front view of the LVDT card in the LVDT driver chassis

Optical Lever

Manual

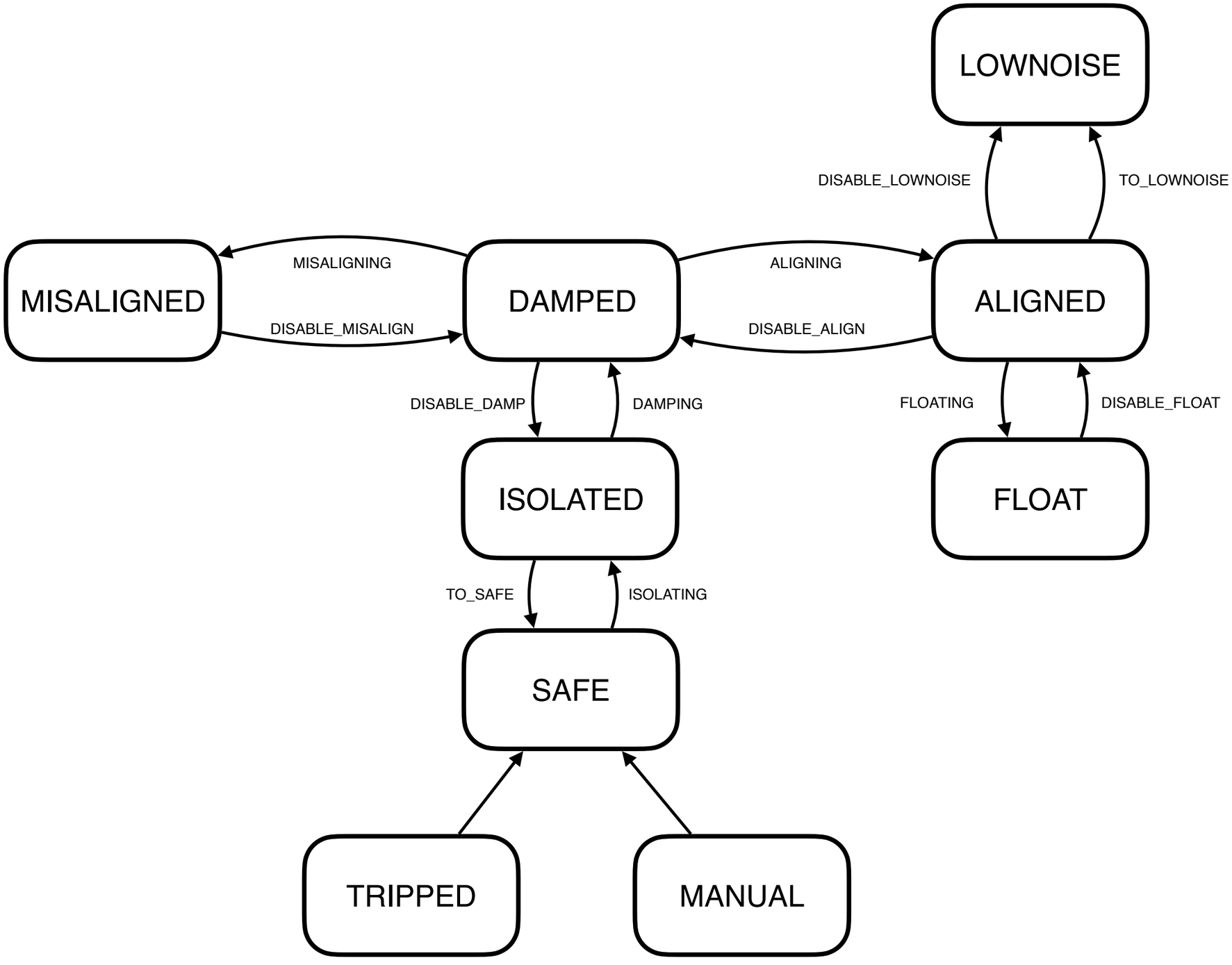
- Installation manual of OpLev : JGW-T1707228-v6
- Length Sensing : JGW-T1605788-v11
- OpLev setup for SR3 : JGW-G1808874-v1

Sketch of the OpLev table

- PRM : JGW-D1909596-v2
- PR2 : JGW-D1605877-v2
- PR3 : JGW-D1605867-v4
- BS : JGW-D1909928-v1 (Old?)
- SRs : JGW-D1809594-v3
- TMs : JGW-D1707064-v2
- MNs : ???

Suspension Commissioning

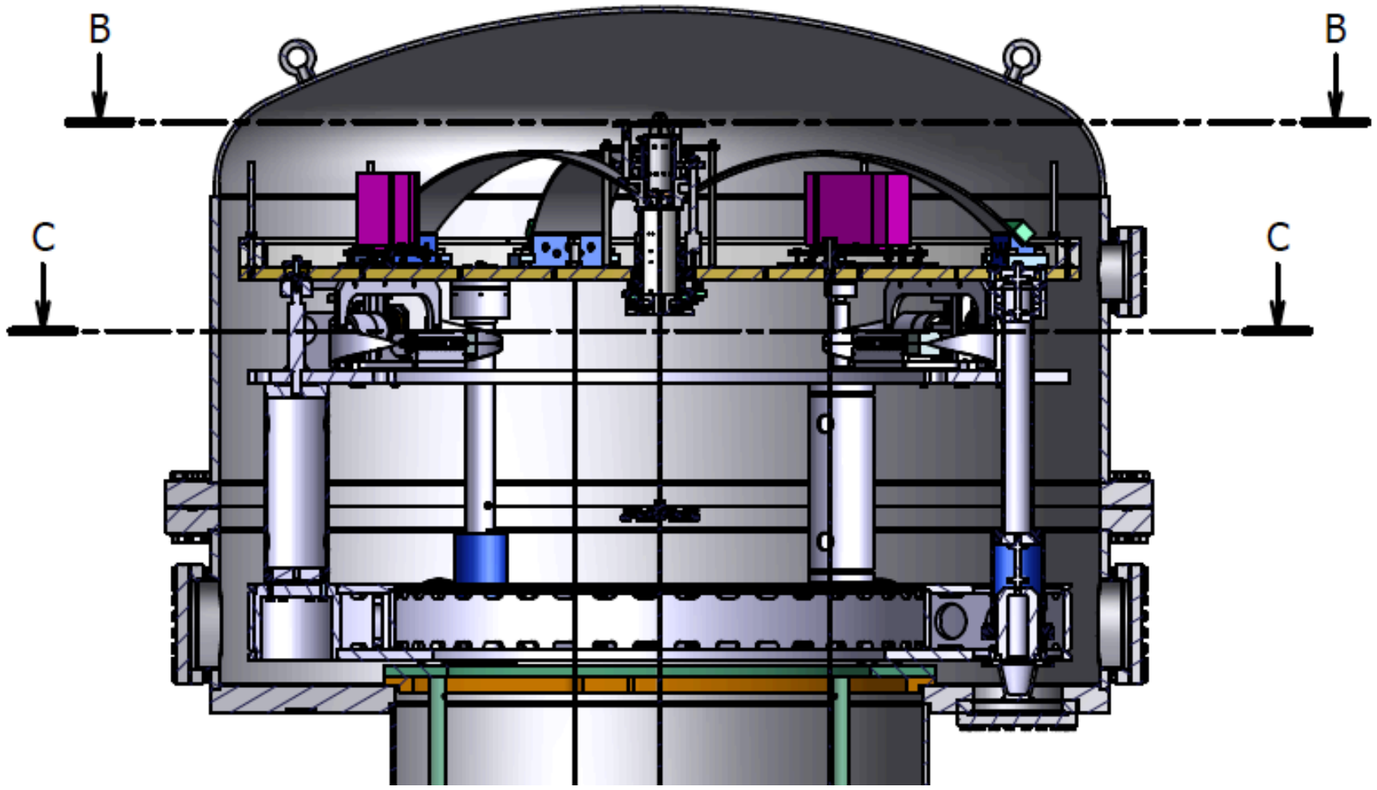
Guardian

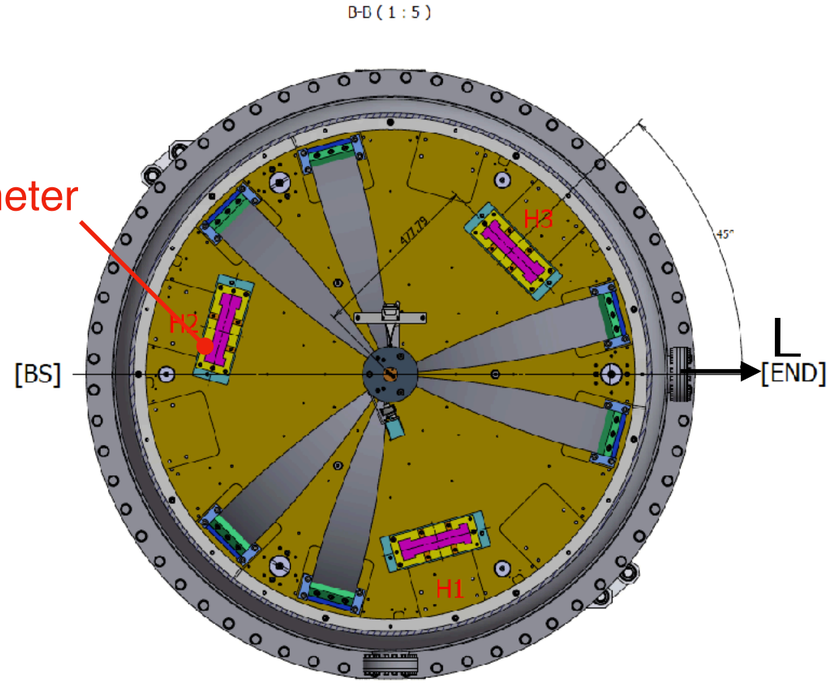

LOWNOISE
DISABLE_LOWNOISE
TO_LOWNOISE
MISALIGNED
MISALIGNING
DISABLE_MISALIGN
DAMPED
ALIGNING
DISABLE_ALIGN
ALIGNED
DISABLE_DAMP
DAMPING
FLOATING
DISABLE_FLOAT
ISOLATED
FLOAT
TO_SAFE
ISOLATING
SAFE
TRIPPED
MANUAL

Diagonalization Matrices

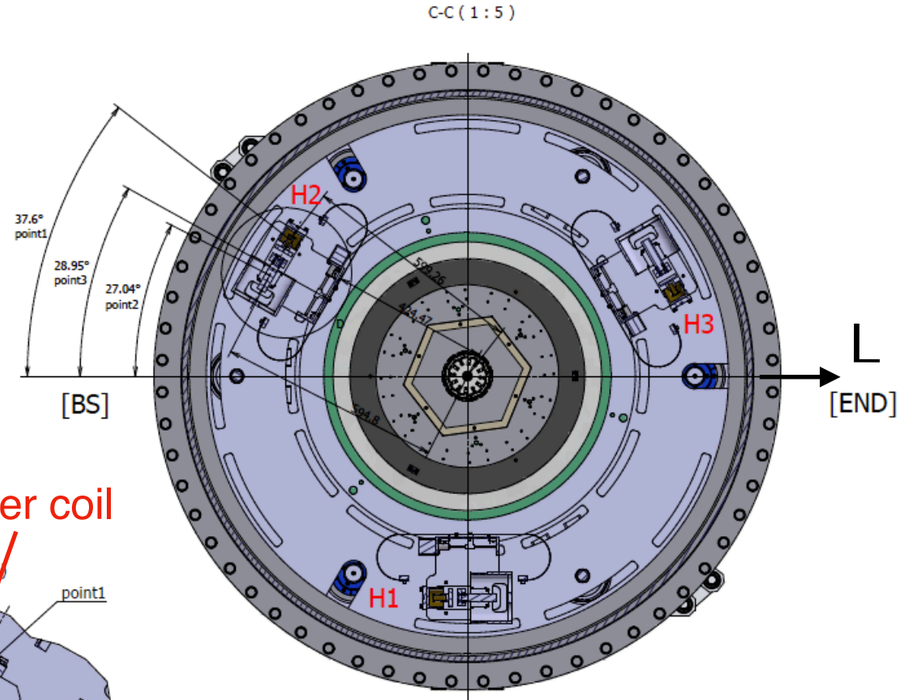
Top plate
BF Damper
MN
IM

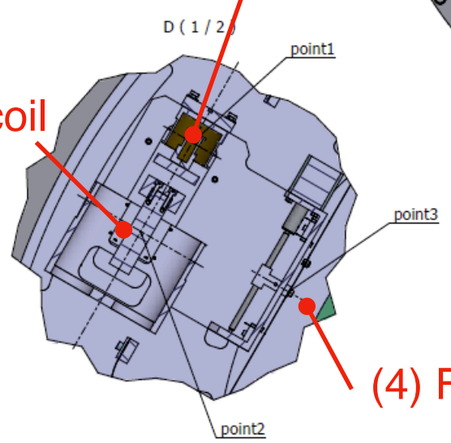
The Top Plate





Above the top plate (B)





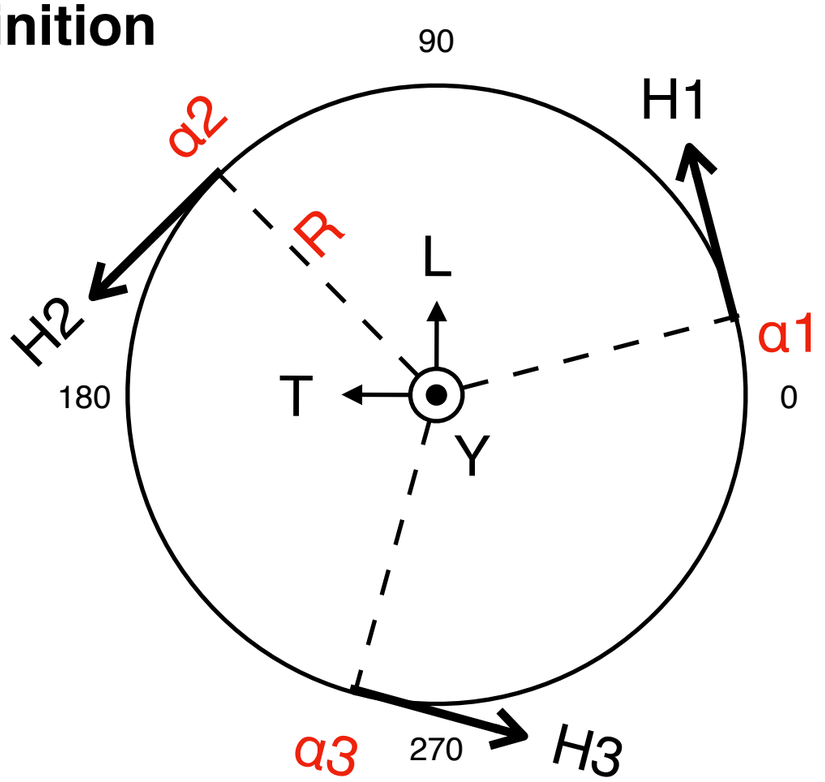
Bellow the top plate (C)

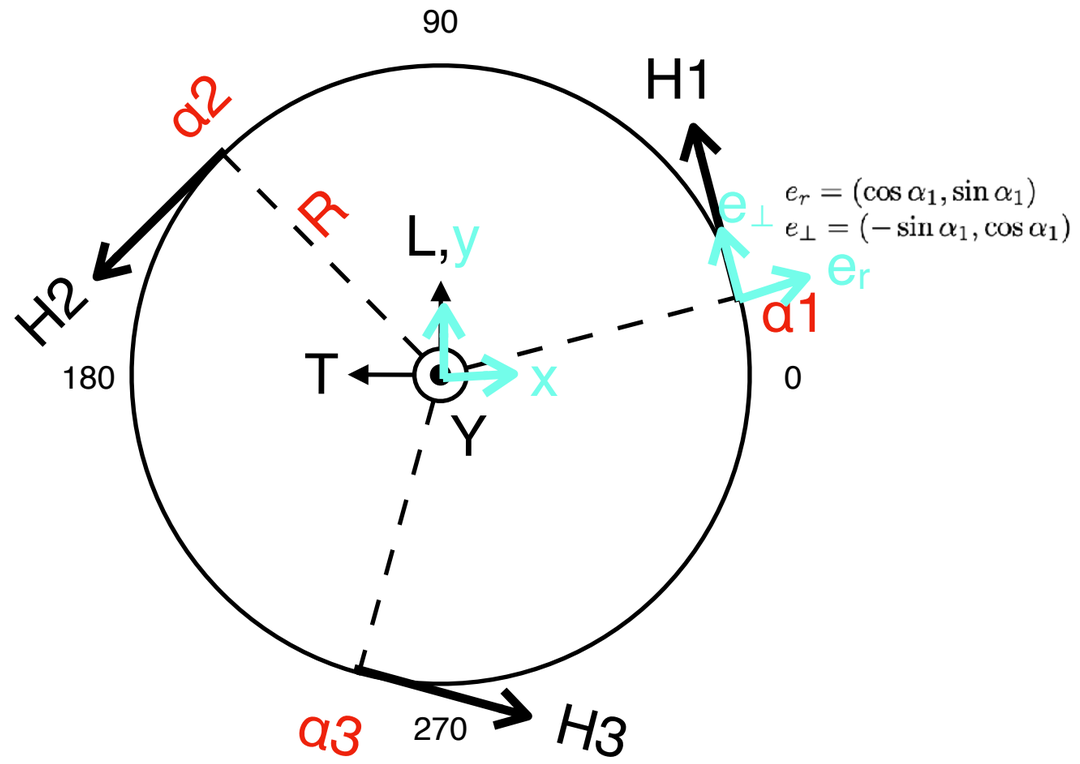
Four components on the top plate

EX, IX, EY, IY, BS, SR have different location of the components

Top plate/ Diagonalization Matrix

Definition





Sensing matrix : S
or
Actuation matrix : D

$$\begin{bmatrix} L \\ T \\ Y \end{bmatrix} = \begin{bmatrix} \cos\alpha_1 & \sin\alpha_1 & R \\ \cos\alpha_2 & \sin\alpha_2 & R \\ \cos\alpha_3 & \sin\alpha_3 & R \end{bmatrix}^{-1} \begin{bmatrix} H_1 \\ H_2 \\ H_3 \end{bmatrix}$$

Consistent with klog7468

$$\begin{bmatrix} H_1 \\ H_2 \\ H_3 \end{bmatrix} = \begin{bmatrix} -\sin\alpha_1 & \cos\alpha_1 & R \\ -\sin\alpha_2 & \cos\alpha_2 & R \\ -\sin\alpha_3 & \cos\alpha_3 & R \end{bmatrix} \begin{bmatrix} x \\ y \\ Y \end{bmatrix}$$

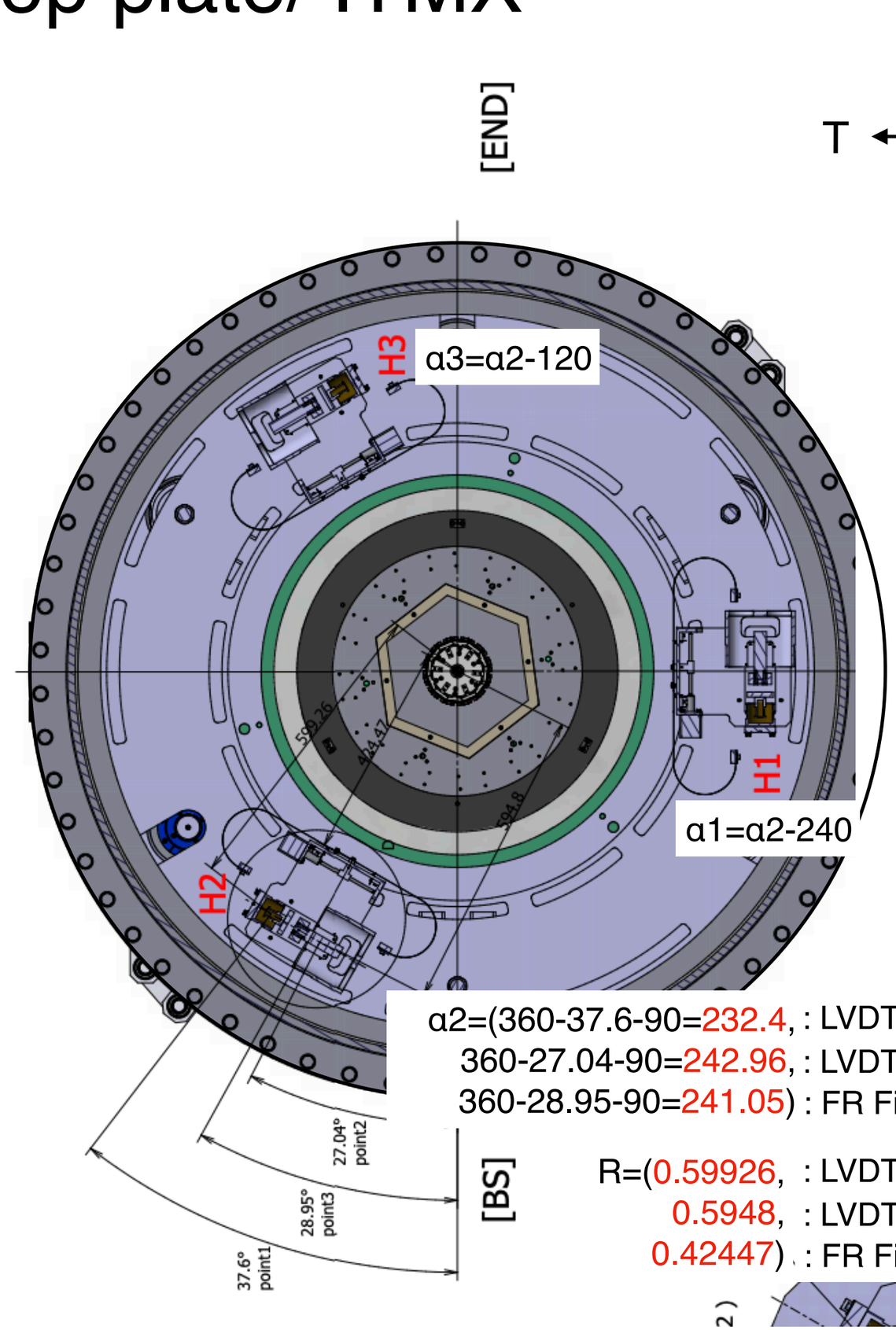
$$\Updownarrow$$

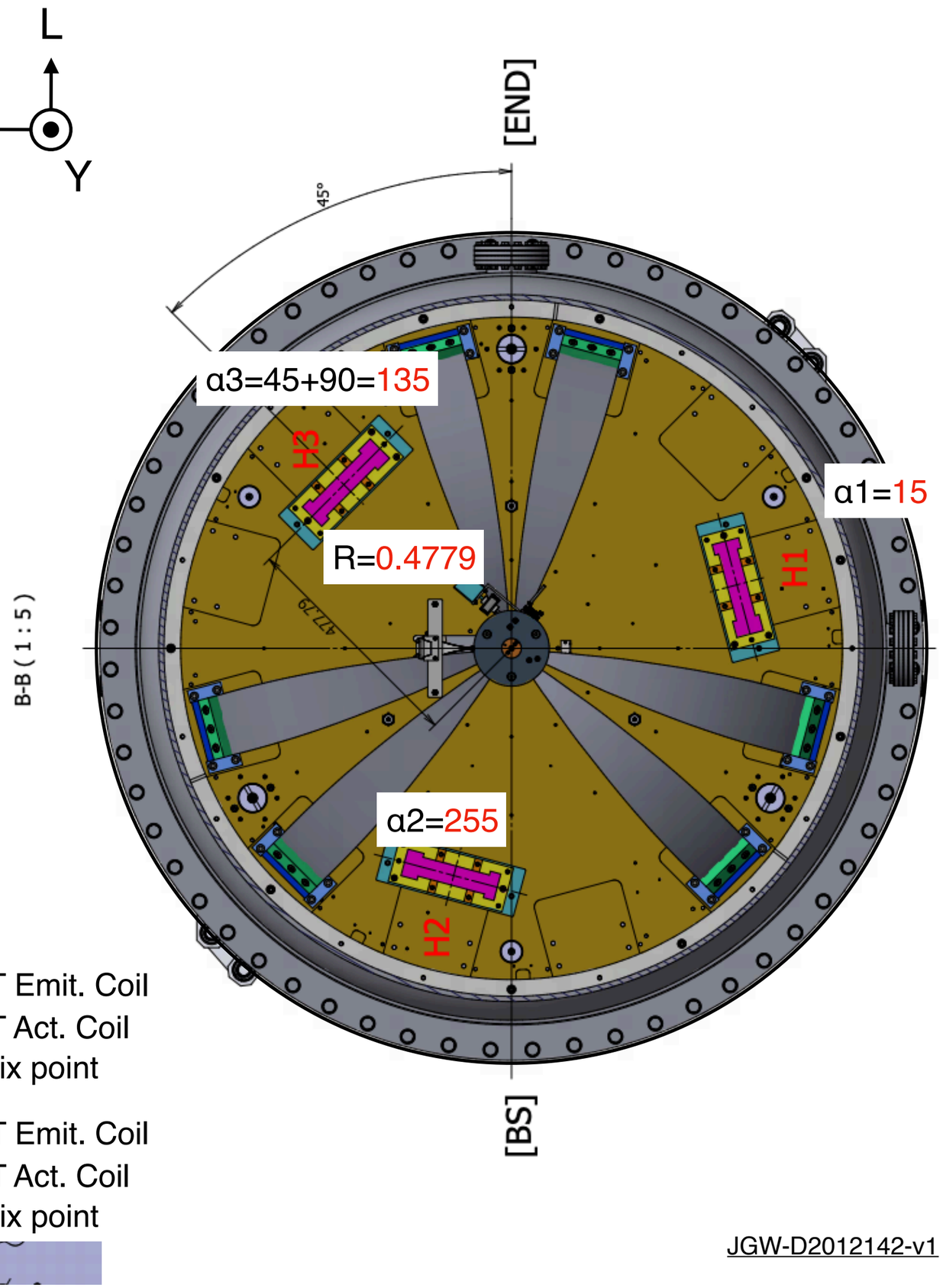
$$\begin{bmatrix} H_1 \\ H_2 \\ H_3 \end{bmatrix} = \begin{bmatrix} -\sin\alpha_1 & \cos\alpha_1 & R \\ -\sin\alpha_2 & \cos\alpha_2 & R \\ -\sin\alpha_3 & \cos\alpha_3 & R \end{bmatrix} \begin{bmatrix} -T \\ L \\ Y \end{bmatrix}$$

$$\Updownarrow$$

$$\begin{bmatrix} H_1 \\ H_2 \\ H_3 \end{bmatrix} = \begin{bmatrix} \cos\alpha_1 & \sin\alpha_1 & R \\ \cos\alpha_2 & \sin\alpha_2 & R \\ \cos\alpha_3 & \sin\alpha_3 & R \end{bmatrix} \begin{bmatrix} L \\ T \\ Y \end{bmatrix}$$

Top plate/ ITMX

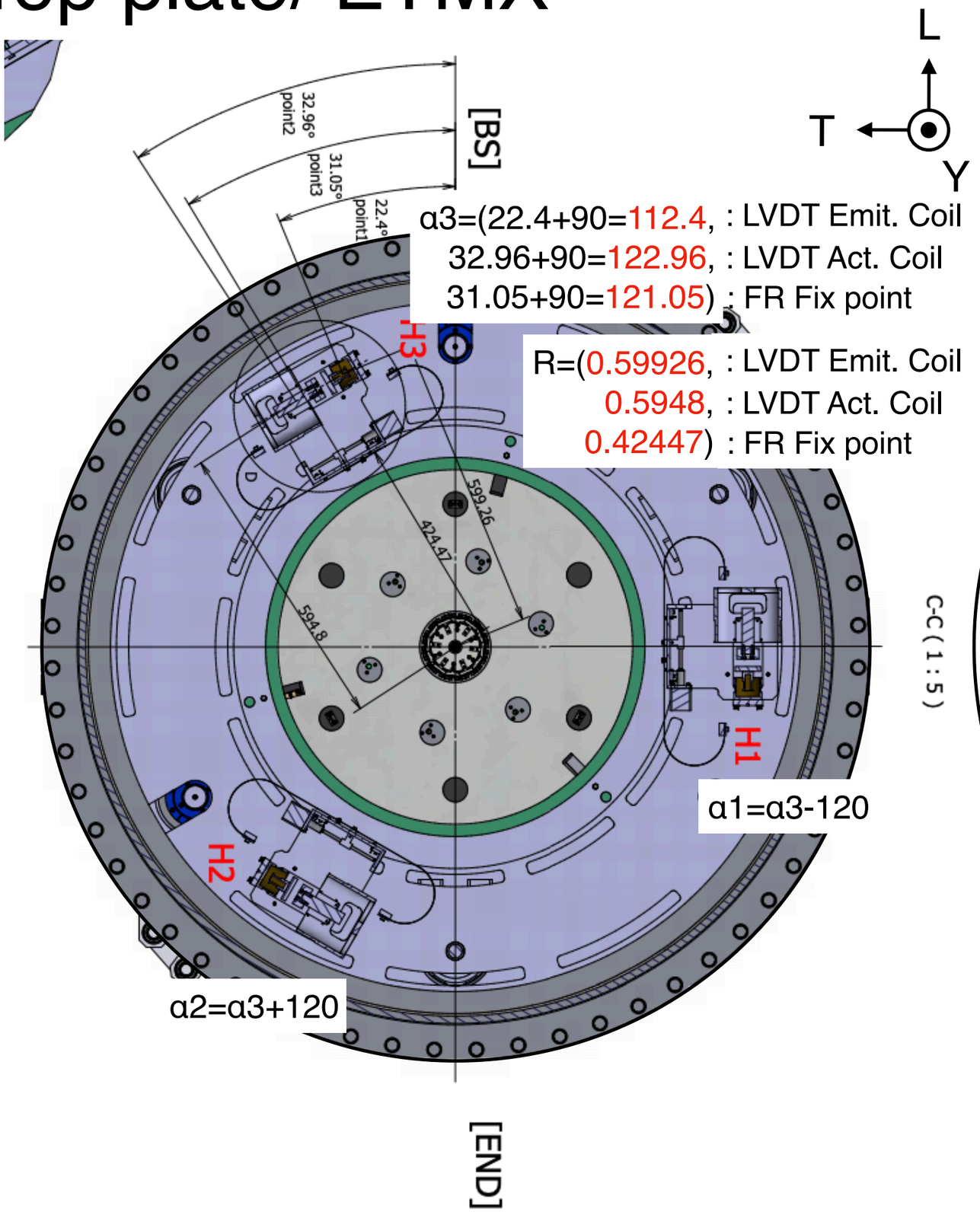




α2=(360-37.6-90=232.4, : LVDT Emit. Coil
360-27.04-90=242.96, : LVDT Act. Coil
360-28.95-90=241.05) : FR Fix point

R=(0.59926, : LVDT Emit. Coil
0.5948, : LVDT Act. Coil
0.42447) : FR Fix point

Top plate/ ETMX



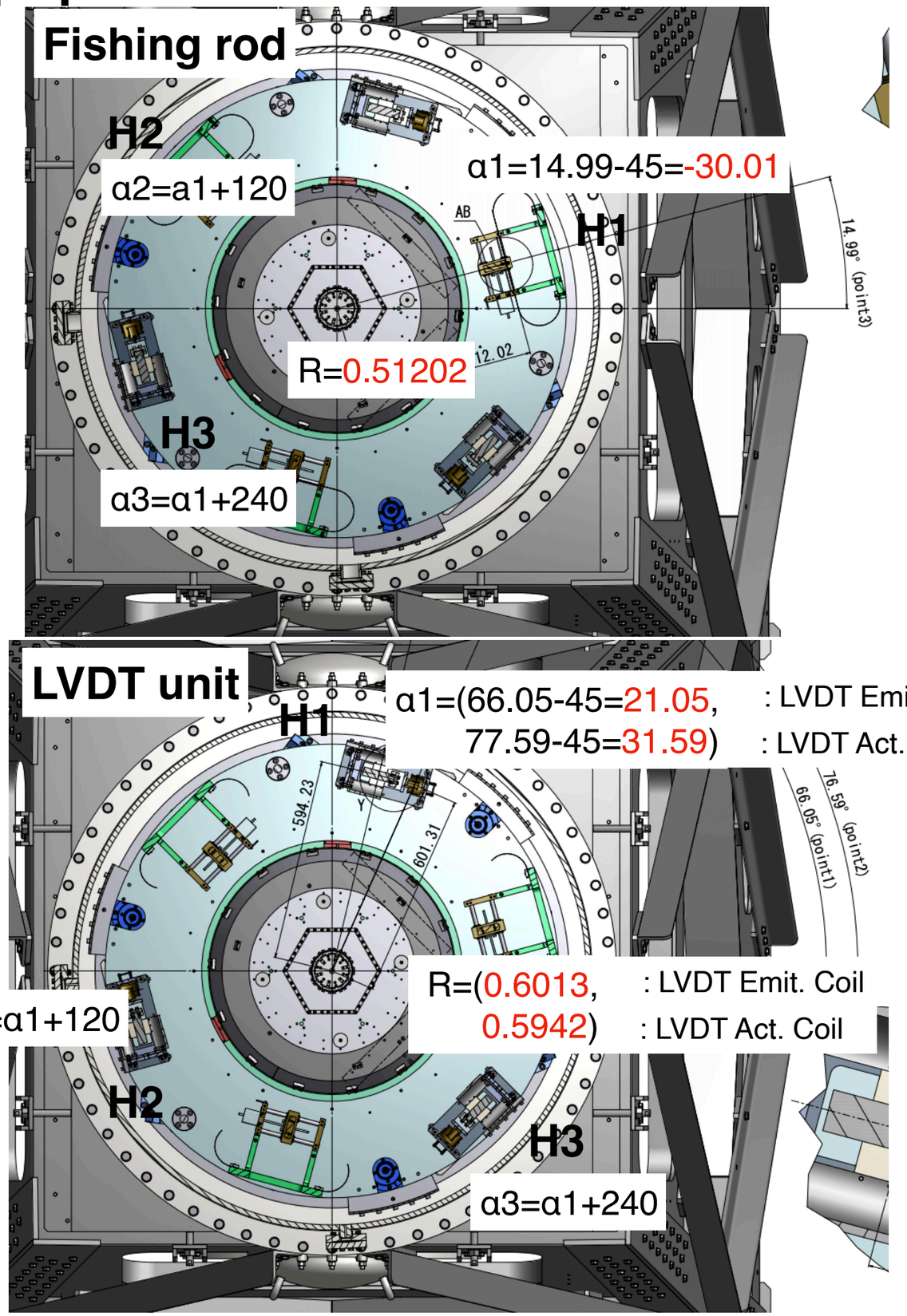
Top plate/ ITMY

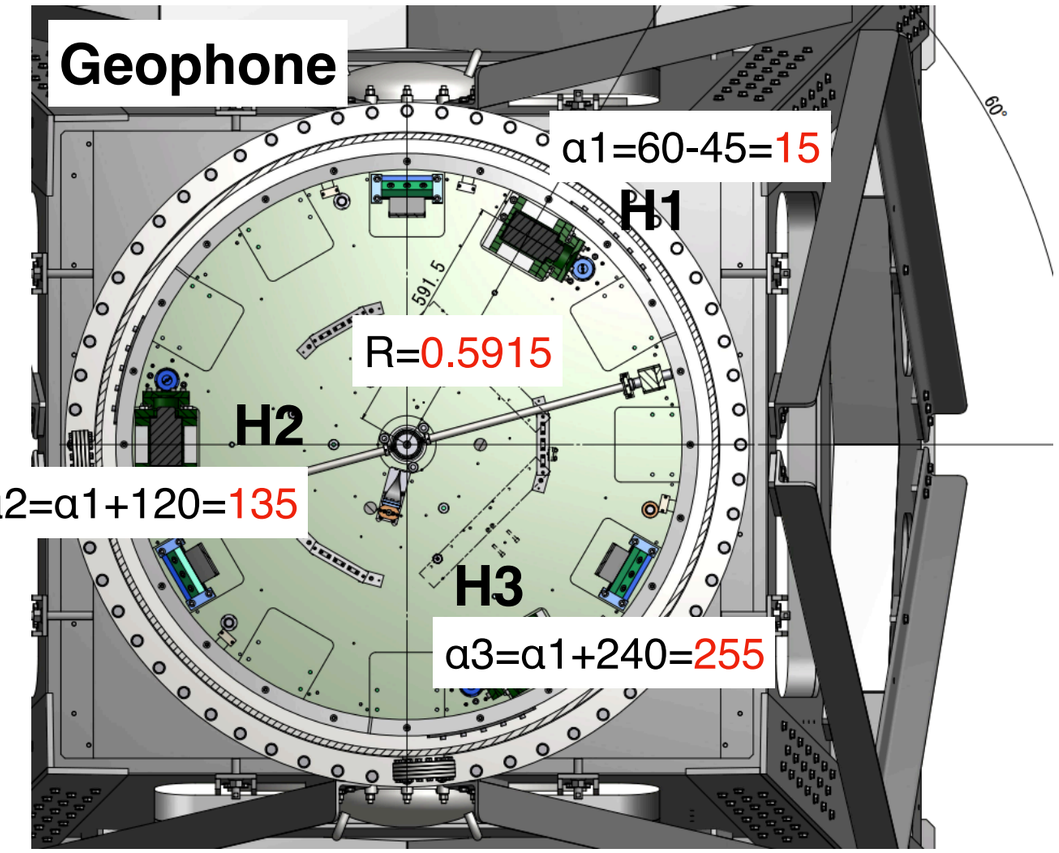
Same as the ITMX

Top plate/ ETMY

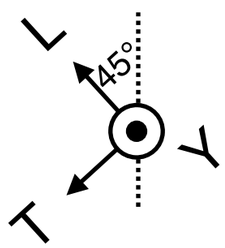
Same as the ETMX

Top plate/ BS

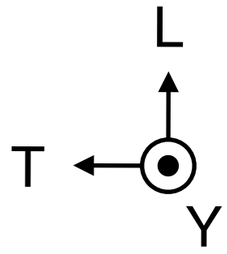

Fishing rod
H2
α2=a1+120
α1=14.99-45=-30.01
H1
AB
14.99° (point3)
R=0.51202
H3
α3=α1+240


Geophone
α1=60-45=15
60°
H1
591.5
R=0.5915
H2
α2=α1+120=135
H3
α3=α1+240=255

LVDT unit
H1
α1=(66.05-45=21.05, : LVDT Emit. Coil
77.59-45=31.59) : LVDT Act. Coil
594.23
601.31
76.59° (point2)
66.05° (point1)
R=(0.6013, : LVDT Emit. Coil
0.5942) : LVDT Act. Coil
α2=α1+120
H2
H3
α3=α1+240


L
45°
Y
T

Top plate/ SR



R=(0.59926, : LVDT Emit. Coil
0.5948, : LVDT Act. Coil
0.42447) : FR Fix point

α2=α1+120

H2[1]

H1[1]

H3[1]

α3=α1+240

α1=(22.4, : LVDT Emit. Coil
32.96, : LVDT Act. Coil
31.05) : FR Fix point

α2=α1+120=135

H2[2]

H1[2]

H3[2]

α1=15

R=0.5915

α3=α1+240=255

[1] Label is referred from Fabian's email "SR IP fishing rods transformation formulas with correct naming" in 2020/10/21.

Top plate/ Summary

(1) LVDT emitter coils

	α1 [deg]	α2 [deg]	α3 [deg]	R [mm]	Reference	Check
ETMX	-7.6	232.4	112.4	599.3	JGW-D2012142-v1 (EX)	
ITMX	-7.6	232.4	112.4	599.3	JGW-D2012142-v1 (IX)	
ETMY	-7.6	232.4	112.4	599.3	JGW-D2012142-v1 (EY)	
ITMY	-7.6	232.4	112.4	599.3	JGW-D2012142-v1 (IY)	
BS	21.05	141.05	261.05	601.3	JGW-D1605092-v4	
SR2	22.4	142.4	262.4	599.3	JGW-D1707077-v7	
SR3	22.4	142.4	262.4	599.3	JGW-D1707077-v7	
SRM	22.4	142.4	262.4	599.3	JGW-D1707077-v7	

(2) LVDT actuator coils

	α1 [deg]	α2 [deg]	α3 [deg]	R [mm]	Reference	Check
ETMX	2.96	242.96	122.96	594.8	JGW-D2012142-v1 (EX)	
ITMX	2.96	242.96	122.96	594.8	JGW-D2012142-v1 (IX)	
ETMY	2.96	242.96	122.96	594.8	JGW-D2012142-v1 (EY)	
ITMY	2.96	242.96	122.96	594.8	JGW-D2012142-v1 (IY)	
BS	31.59	151.59	271.59	594.2	JGW-D1605092-v4	
SR2	32.95	152.95	272.95	594.8	JGW-D1707077-v7	
SR3	32.95	152.95	272.95	594.8	JGW-D1707077-v7	
SRM	32.95	152.95	272.95	594.8	JGW-D1707077-v7	

(3) Accelerometer

	α1 [deg]	α2 [deg]	α3 [deg]	R [mm]	Reference	Check
ETMX	15	255	135	591.5	JGW-D2012142-v1 (EX) [1]	
ITMX	15	255	135	477.8	JGW-D2012142-v1 (IX)	
ETMY	15	255	135	591.5	JGW-D2012142-v1 (EY) [1]	
ITMY	15	255	135	477.8	JGW-D2012142-v1 (IY)	
BS	15	135	255	591.5	JGW-D1605092-v4	
SR2	15	135	255	591.5	JGW-D1707077-v7	
SR3	15	135	255	591.5	JGW-D1707077-v7	
SRM	15	135	255	591.5	JGW-D1707077-v7	

[1] ETMs used a geophone for O3. ETMs will use new LVDT accelerometer which is installed as same as the IX and IY, according to Sato-san.

(4) Fixing point of the FR

	α1 [deg]	α2 [deg]	α3 [deg]	R [mm]	Reference	Check
ETMX	1.05	241.05	121.05	424.5	JGW-D2012142-v1 (EX)	
ITMX	1.05	241.05	121.05	424.5	JGW-D2012142-v1 (IX)	
ETMY	1.05	241.05	121.05	424.5	JGW-D2012142-v1 (EY)	
ITMY	1.05	241.05	121.05	424.5	JGW-D2012142-v1 (IY)	
BS	-30.01	89.99	209.99	512.0	JGW-D1605092-v4	
SR2	31.05	151.05	271.05	424.5	JGW-D1707077-v7	
SR3	31.05	151.05	271.05	424.5	JGW-D1707077-v7	
SRM	31.05	151.05	271.05	424.5	JGW-D1707077-v7	

Marionetta Mass

Intermediate Mass