Vibration Isolation System

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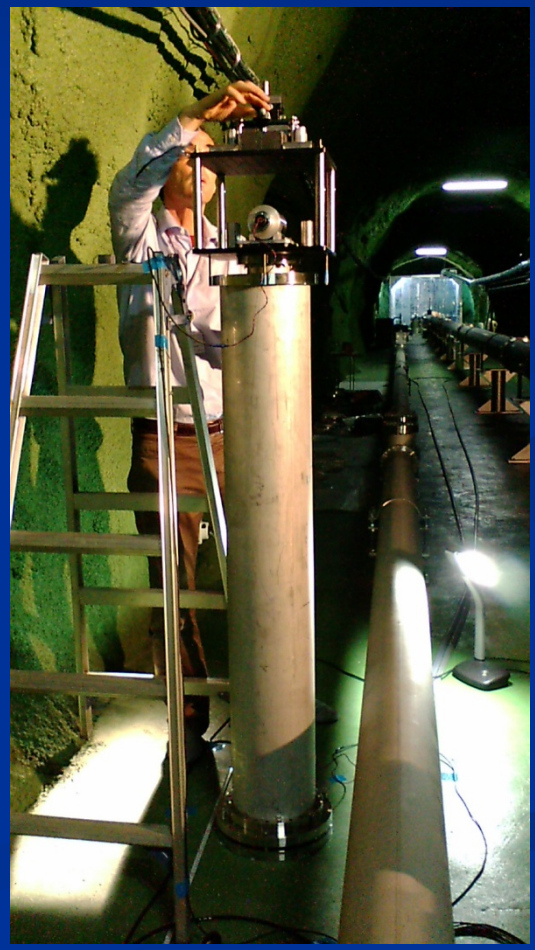

LCGT
2nd f2f meeting
(27 Sep., 2010)

* unofficial member

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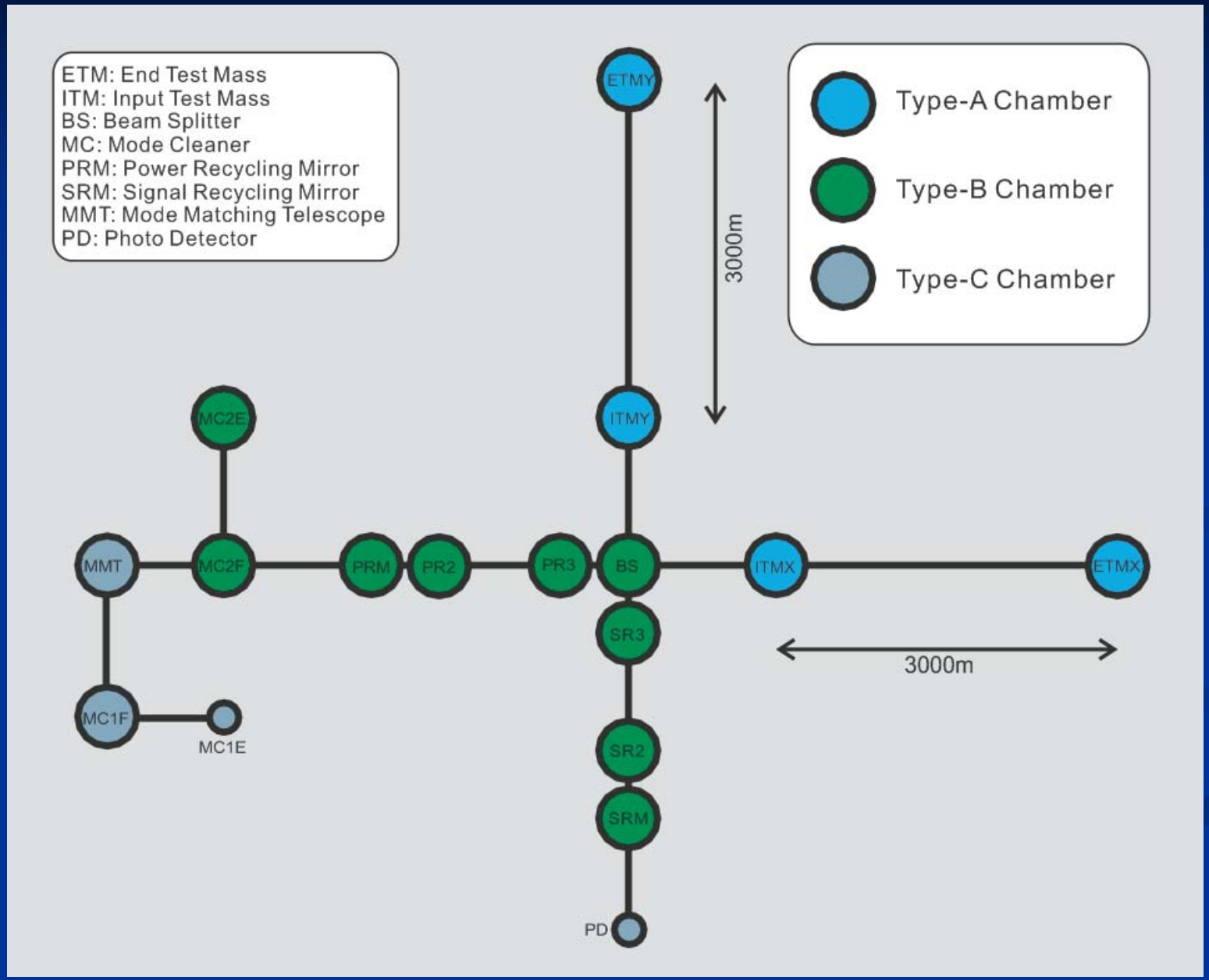
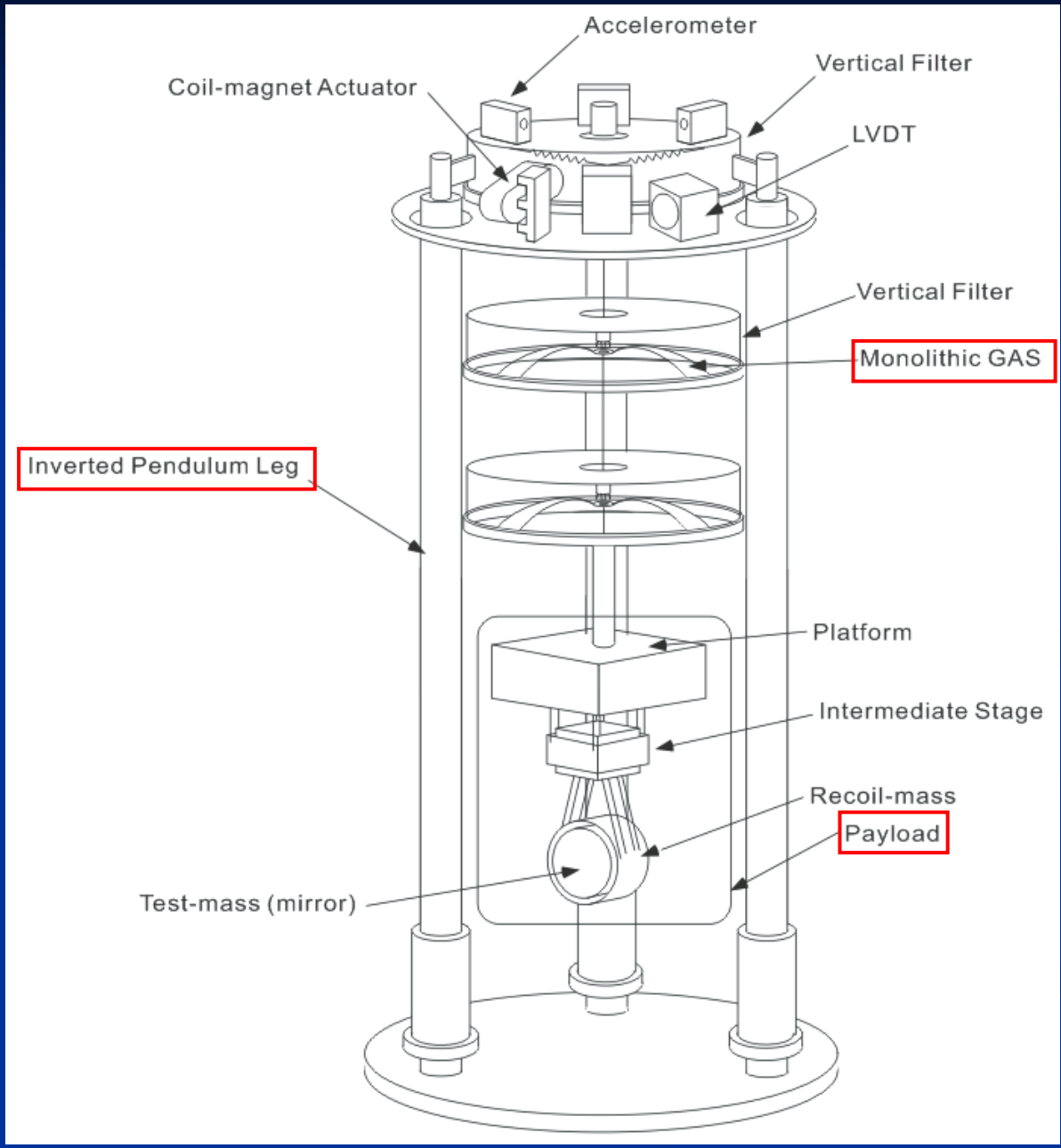
1. Configuration

1-a. Location

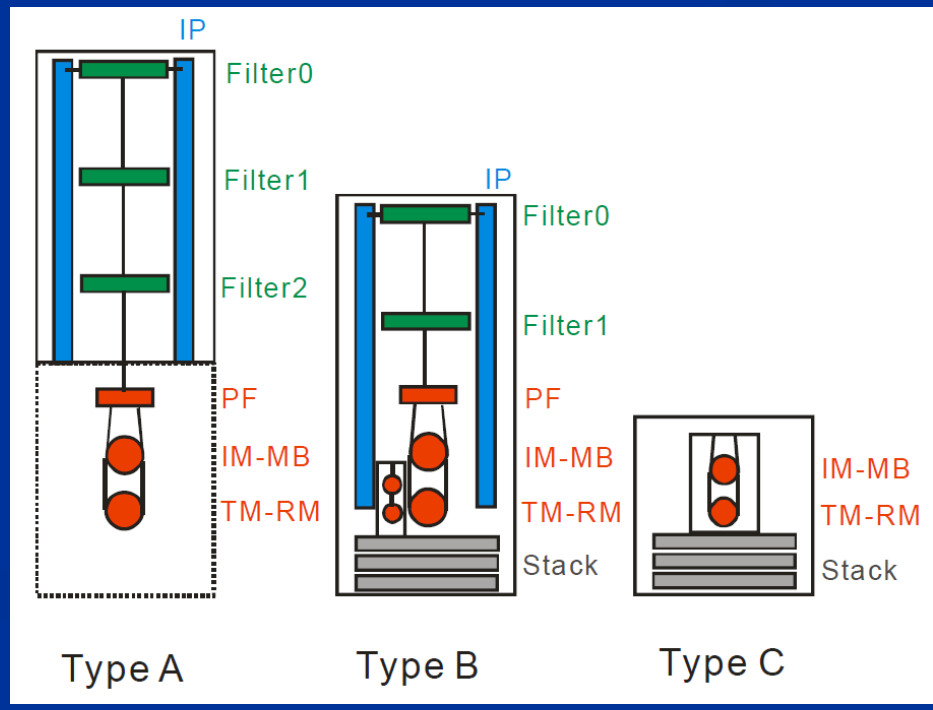

ETM: End Test Mass
ITM: Input Test Mass
BS: Beam Splitter
MC: Mode Cleaner
PRM: Power Recycling Mirror
SRM: Signal Recycling Mirror
MMT: Mode Matching Telescope
PD: Photo Detector
Type-A Chamber
Type-B Chamber
Type-C Chamber
ETMY
ITMY
3000m
MC2E
MMT
MC2F
PRM
PR2
PR3
BS
ITMX
ETMX
SR3
3000m
MC1F
MC1E
SR2
SRM
PD

1-b. Structure



1-c. Configuration

- Vacuum chamber
  - A) ϕ2m × (2.5m + 2.45m cryostat)
  - B) ϕ2m × 4.3m
  - C) ϕ1-2m × 3m
- Vibration Isolation System
  - A) IP + GASF (3 stage) + Payload (cryogenic)
  - B) IP + GASF (2 stage) + Payload (room temp.)
  - C) STACK + Double-pendulum



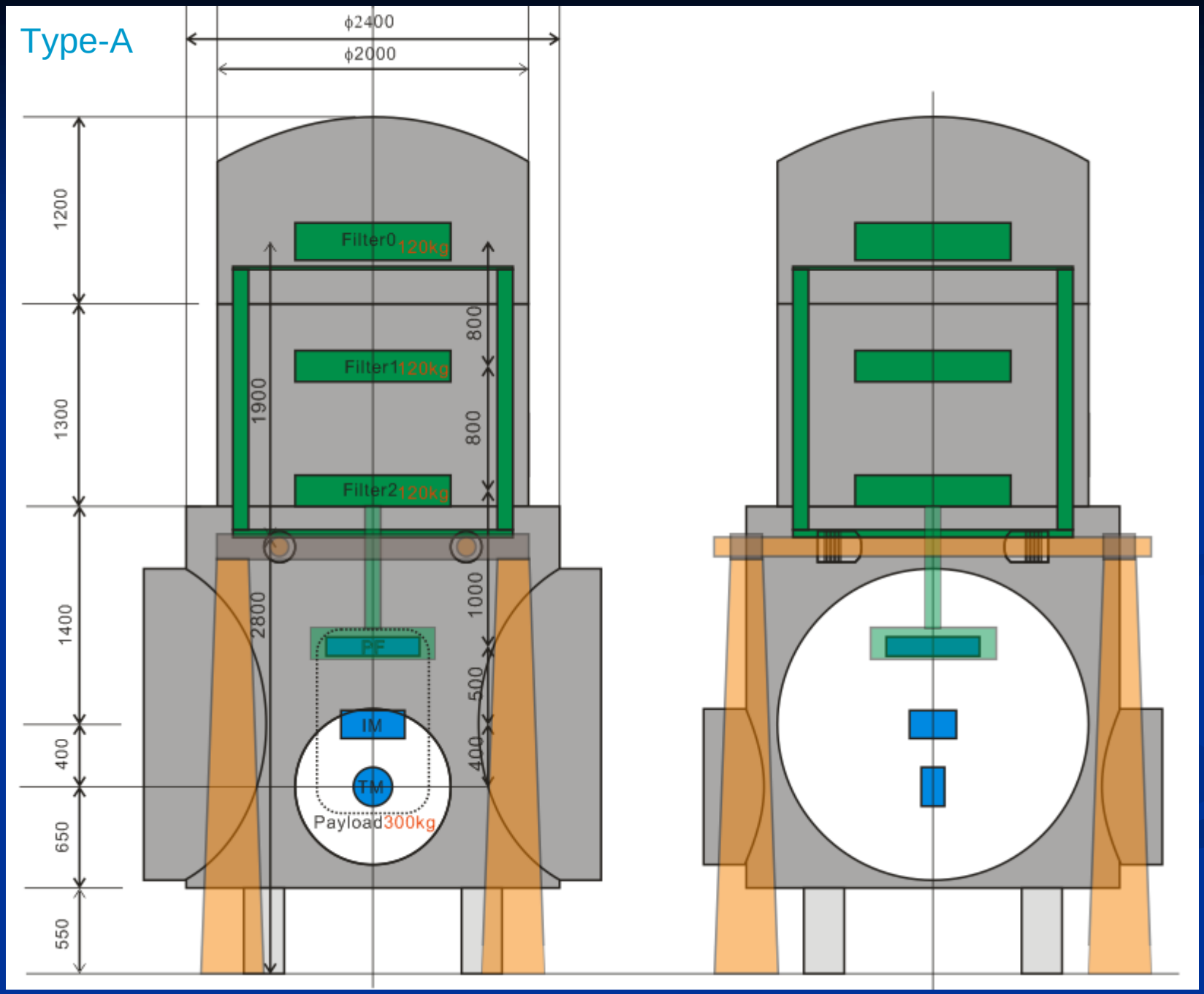
1-c. Configuration (Plan A)

	iLCGT	bLCGT
ITMX, ITMY, ETMX, ETMY	Type-A IP-GASF (Fixed) + Type-B Payload	Type-A SAS
BS, PR2, PR3, SR2, SR3, MC2F, MC2E	Stack + Type-B Payload	Type-B SAS
PRM, SRM	none	Type-B SAS
MC1F, MC1E	none	Type-C
MMT, PD	Type-C	Type-C

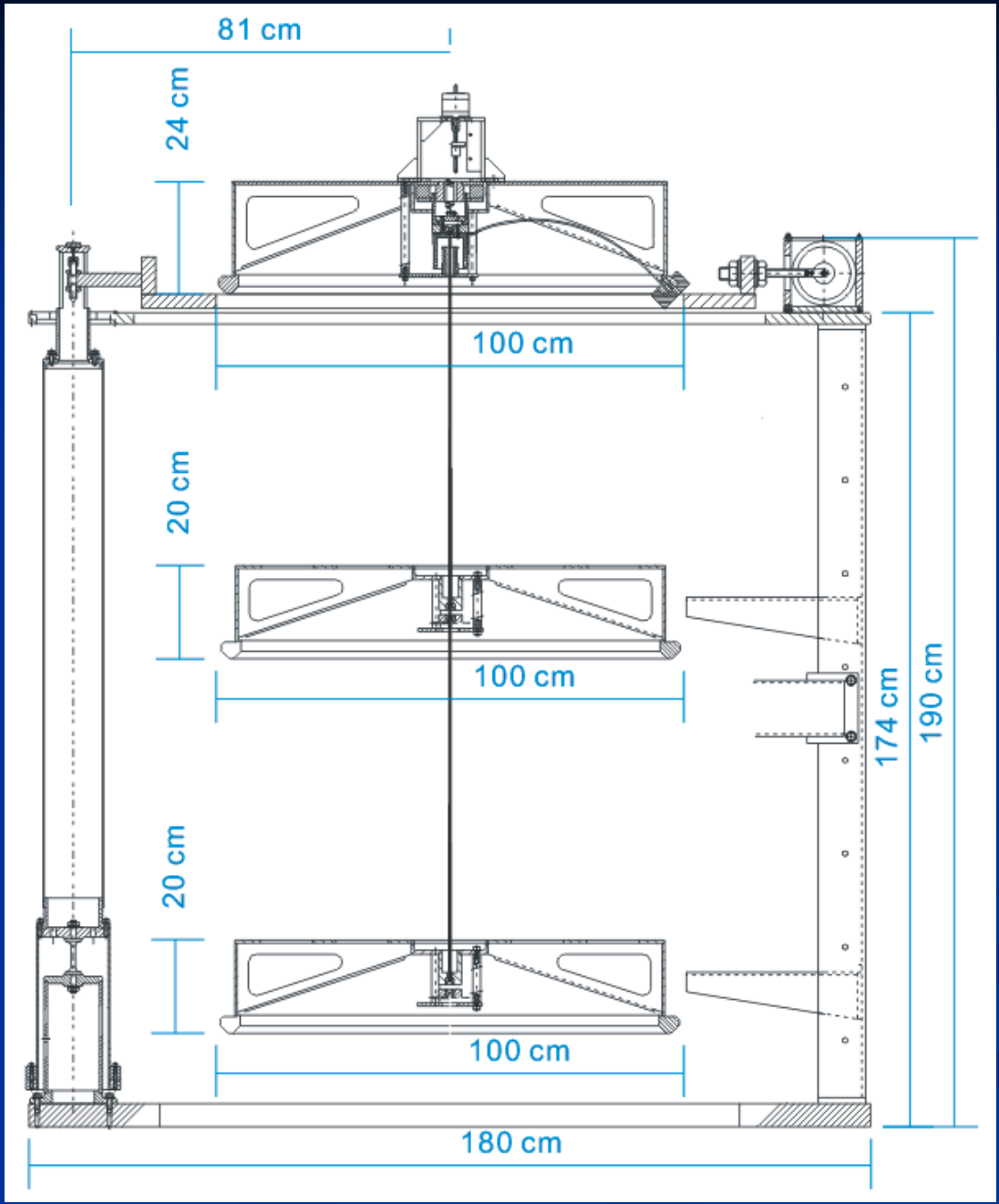
1-c. Configuration (Plan B)

	iLCGT	bLCGT
ITMX, ITMY, ETMX, ETMY	Type-A IP-GASF (Fixed) + Type-A Payload	Type-A SAS
BS, PR3, SR3	Stack + Type-A Payload	Type-B IP-GASF + Type-A Payload
PRM, SRM, MC1F, MC1E	none	Type-C
PR2, SR2, MC2F, MC2E, MMT, PD	Type-C	Type-C

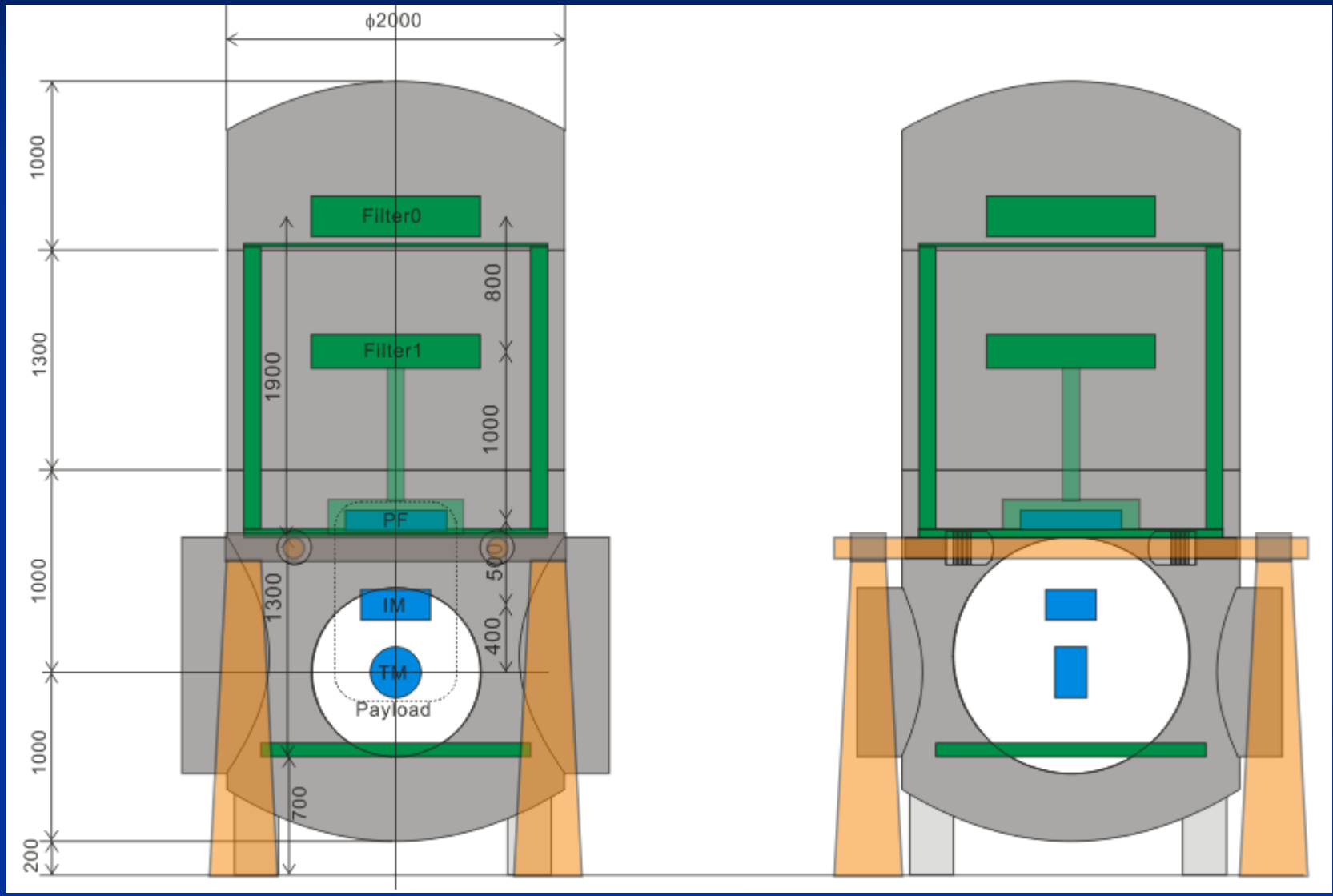
Type-A


ϕ2400
ϕ2000
1200
1300
1400
400
650
550
Filter0 120kg
Filter1 120kg
Filter2 120kg
1900
800
800
2800
1000
500
400
PF
IM
TM
Payload 300kg

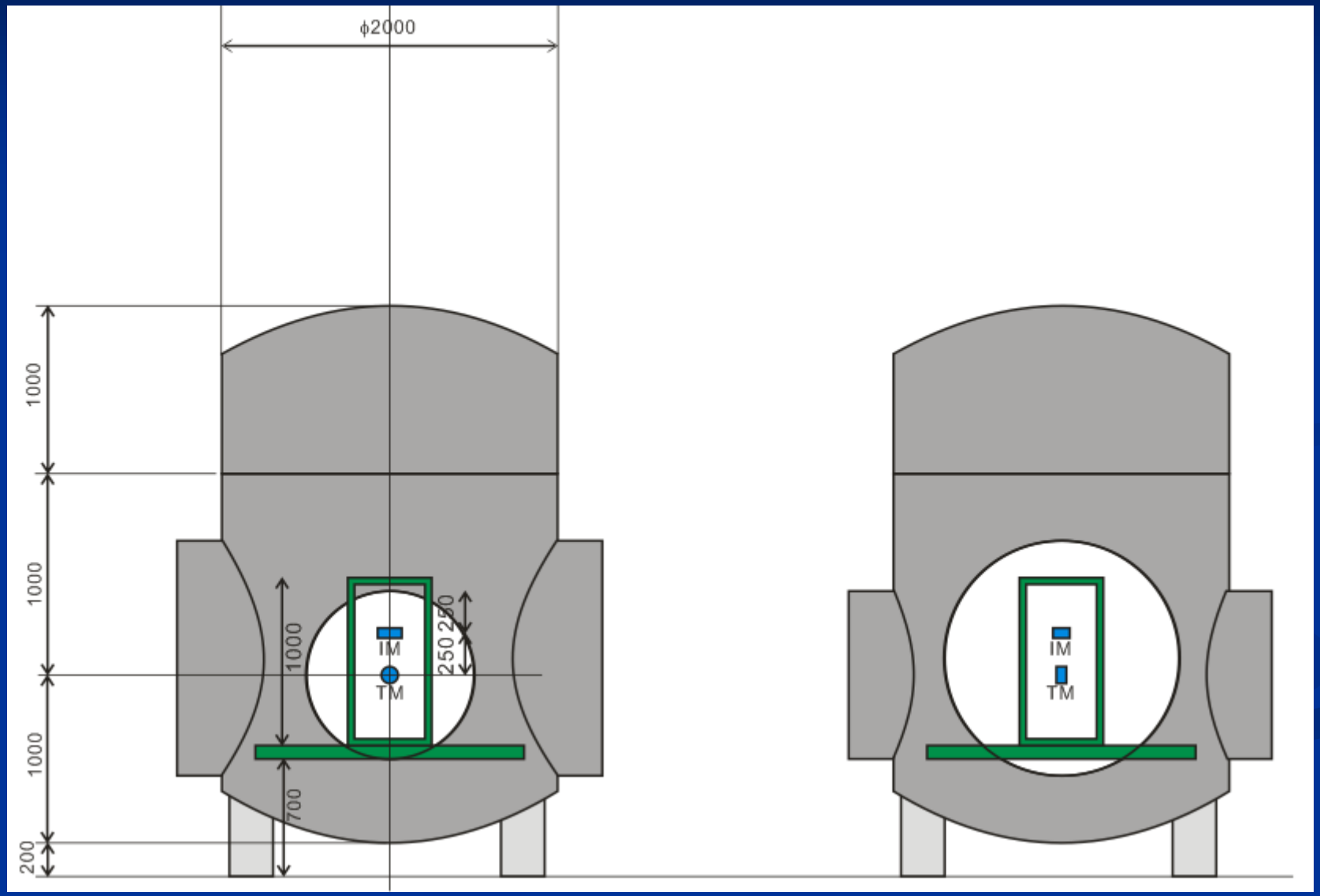
Type-A



Type-B


ϕ2000
1000
1300
1000
1000
200
Filter0
Filter1
PF
IM
TM
Payload
800
1900
1000
500
1300
400
700

Type-C



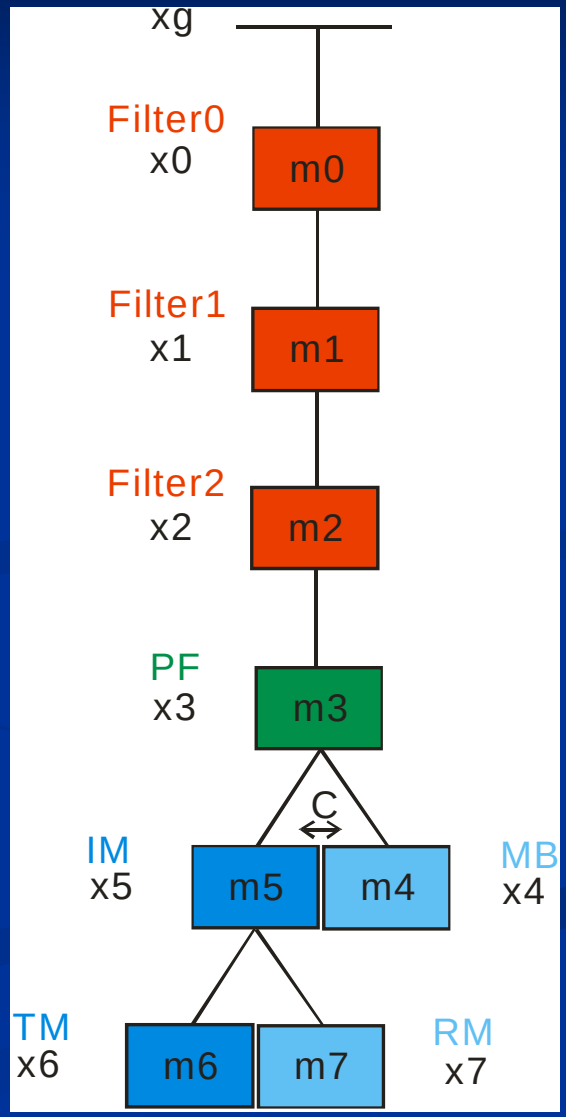
2. Performance

2-a. Modeling

Type-A

- Equation of motion of 8 material points model
- 8x8 stiffness matrix
- Refer parameters of TAMA-SAS
- Calculated by MATLAB

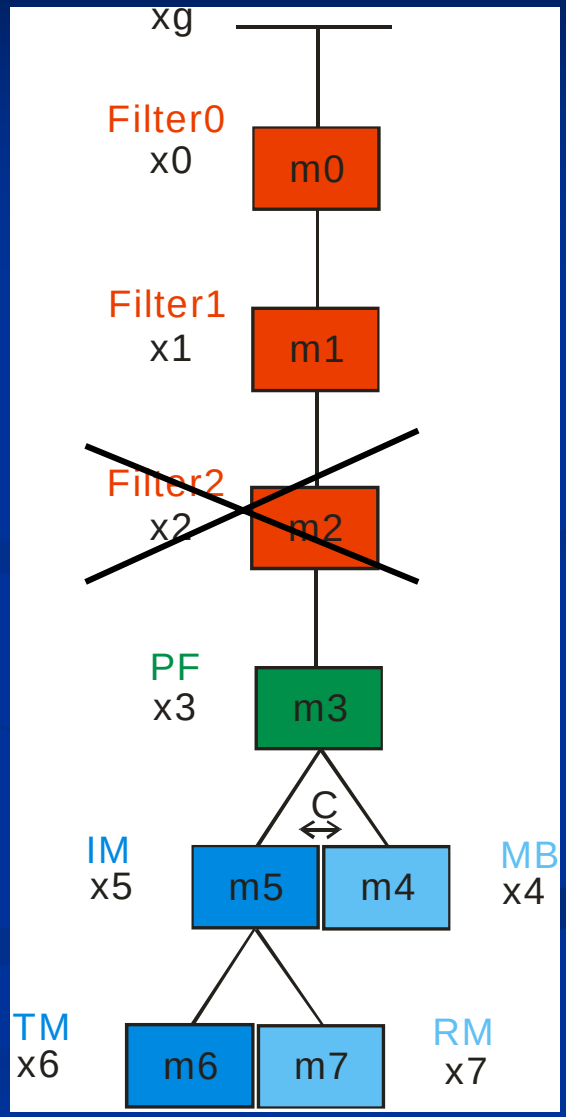
	m	Q	f0	C
	[kg]		[Hz]	[kg･Hz]
Filter0	120	1	0.07	-
Filter1	120	100	0.56	-
Filter2	120	100	0.56	
PF	120	100	0.5	-
IM	60	1000	0.7	530
MB	60	1000	0.7	530
TM	30	1000	0.8	-
RM	30	6	0.8	-



Type-B

- Equation of motion of 7 material points model
- 7x7 stiffness matrix
- Masses are about a half of Type-A's
- Calculated by MATLAB

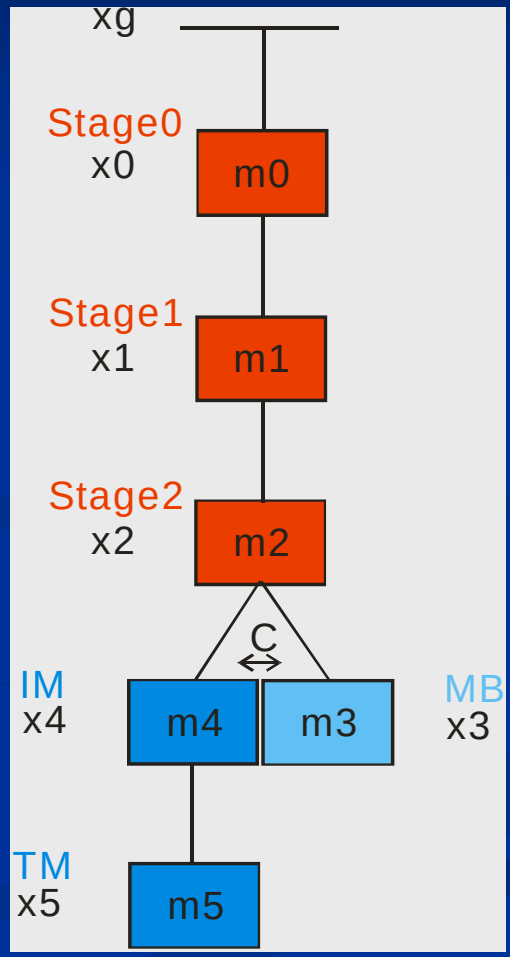
	m	Q	f0	C
	[kg]		[Hz]	[kg･Hz]
Filter0	60	1	0.07	-
Filter1	60	100	0.56	-
PF	60	100	0.5	-
IM	30	1000	0.7	265
MB	30	1000	0.7	265
TM	16	1000	0.8	-
RM	16	6	0.8	-



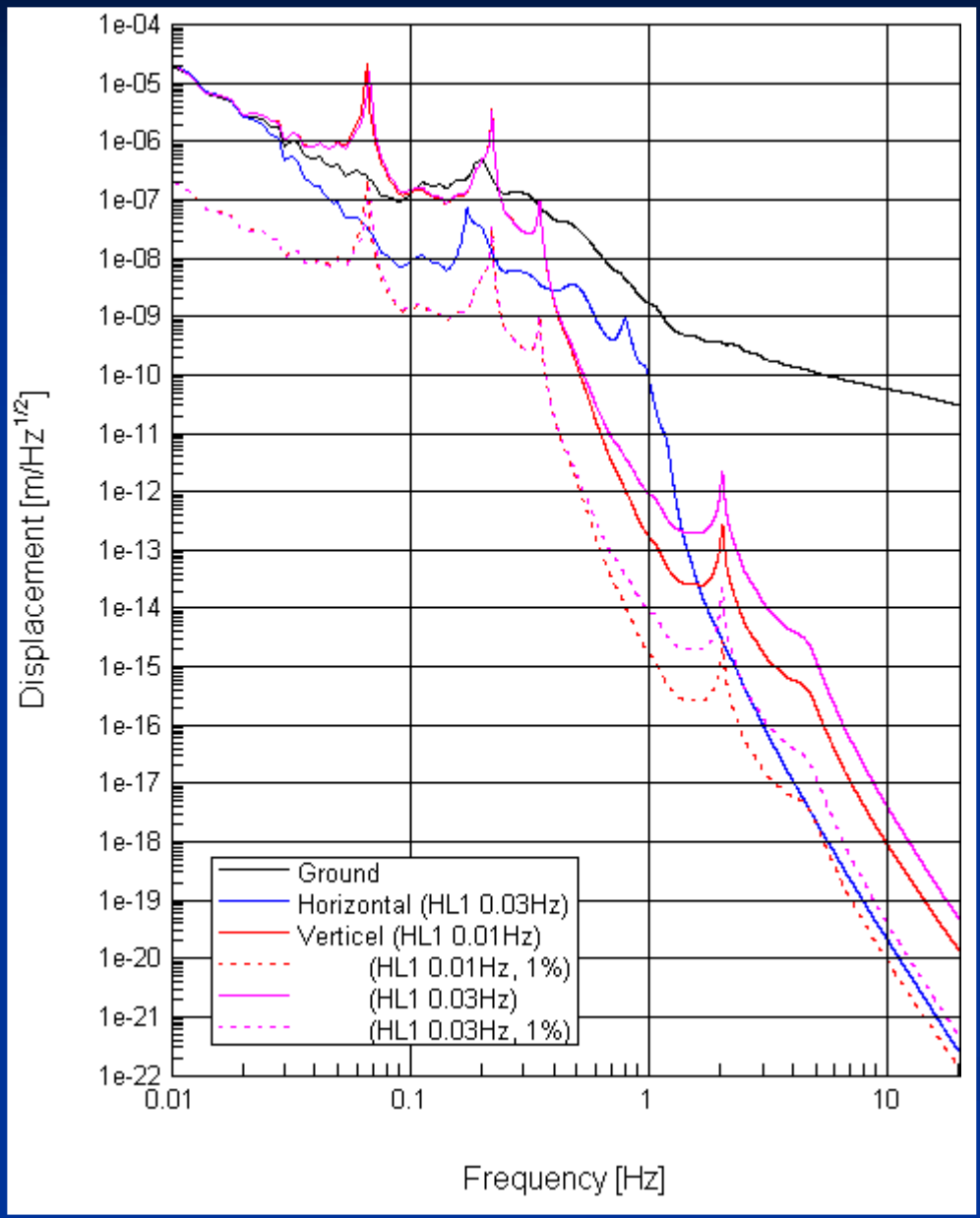
Type-C

- Equation of motion of 6 material points model
- 6x6 stiffness matrix
- Model for Stack is simplified
- Calculated by MATLAB

	m	Q	f0	C
	[kg]		[Hz]	[kg･Hz]
Stage0	200	3	5	-
Stage1	200	3	4.5	-
Stage2	200	3	4	-
IM	1	1000	1	12.5
MB	1	1000	3	12.5
TM	1	1000	1	-

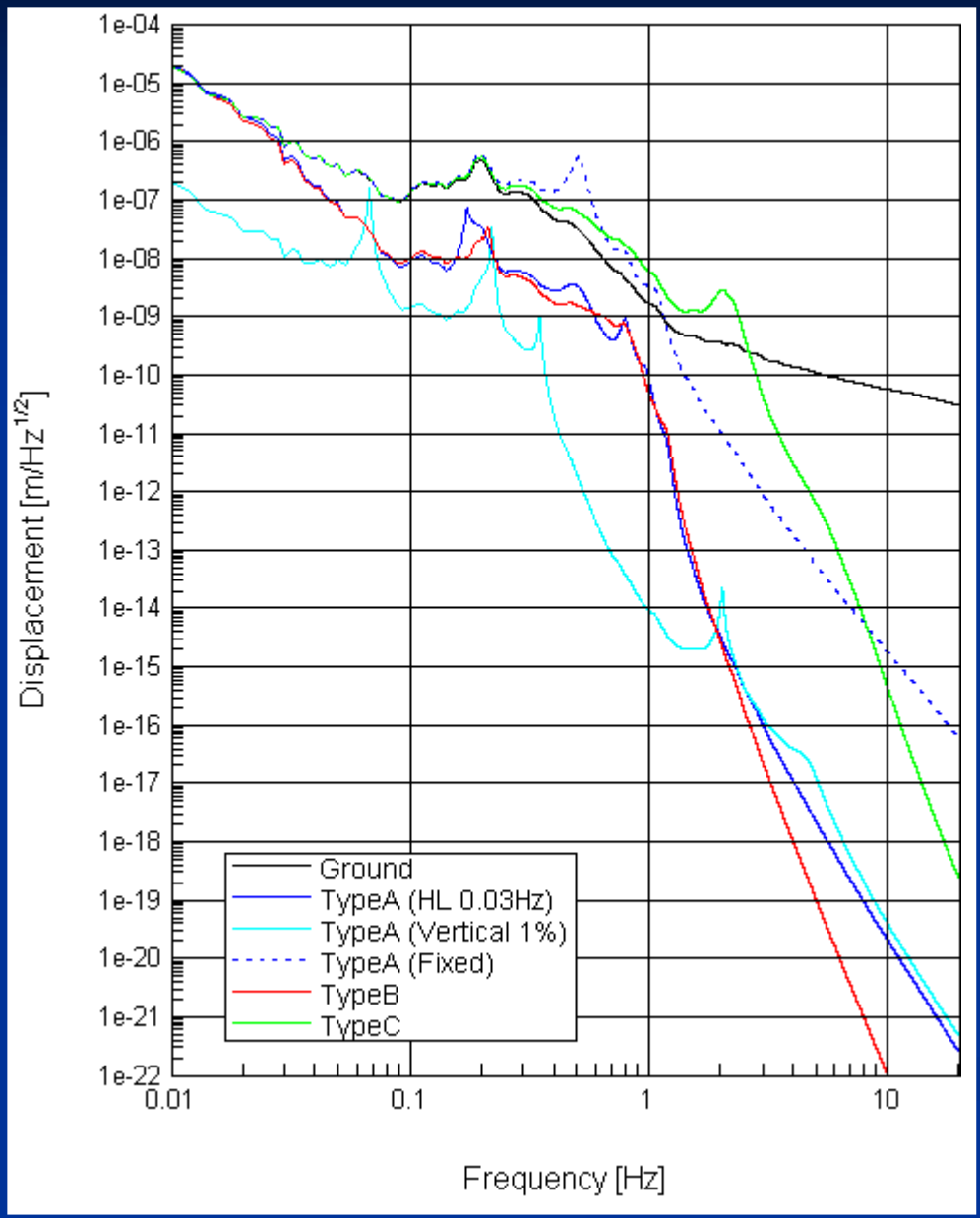


2-b. Displacement of test mass



- The vertical isolation is better than the horizontal isolation around 1Hz because of 3 stage GAS filters.
- Since the final stage (TM) is suspended by 4 sapphire fibers of ϕ1.8mm, the vertical resonant frequency is about 100Hz.
- Heat links of 0.01Hz with 1% coupling from vertical mode satisfy demands at 5Hz. Heat links of 0.03Hz is NG but practically OK.

2-c. Displacement of each system



- The isolation of Type-B is better than the isolation of Type-A with heat links.
- When the part of IP-GASF of Type-A is fixed (iLCGT), the isolation of Type-A is worse than the isolation of Type-C with stack.

2-d. RMS

			Type-A	Type-B	Type-C
Microseisms	normal	[μm]	1.0	1.0	1.0
			(0.006)	(0.006)	(0.1)
		[μm/s]	0.08	0.08	0.2
			(0.008)	(0.008)	(0.2)
	large	[μm]	0.7	0.7	2.0
			(0.10)	(0.09)	(1.9)
		[μm/s]	0.12	0.11	2.3
			(0.11)	(0.10)	(2.3)

Integration 0.01-4Hz
(Integration 0.1-4Hz)

Type-A,B vs. C

0.1 → 2 [μm] x20

0.1 → 2 [μm/s] x20

3. Control

3-a. Sensor and actuator

	Filter0	Filter1	Filter2	PF	IM-MB	TM-RM
Sensor	ACC(H) x3 ACC(V) x1 LVDT(H) x3 LVDT(V) x1	LVDT(V) x1	LVDT(V) x1 OL x1	PS(H) x3 PS(V) x3 OL x1	PS(H) x3 PS(V) x3	PS(H) x1 PS(V) x1 OL x1
Actuator	MC(H) x3 MC(V) x1		MC(Y) x1	MC(H) x3 MC(V) x3	MC(H) x3 MC(V) x3	MC(H) x2 MC(V) x2
Motor	STEP(H) x3 STEP(V) x1		PICO(Y) x1	STEP(H) x2 STEP(V) x2		

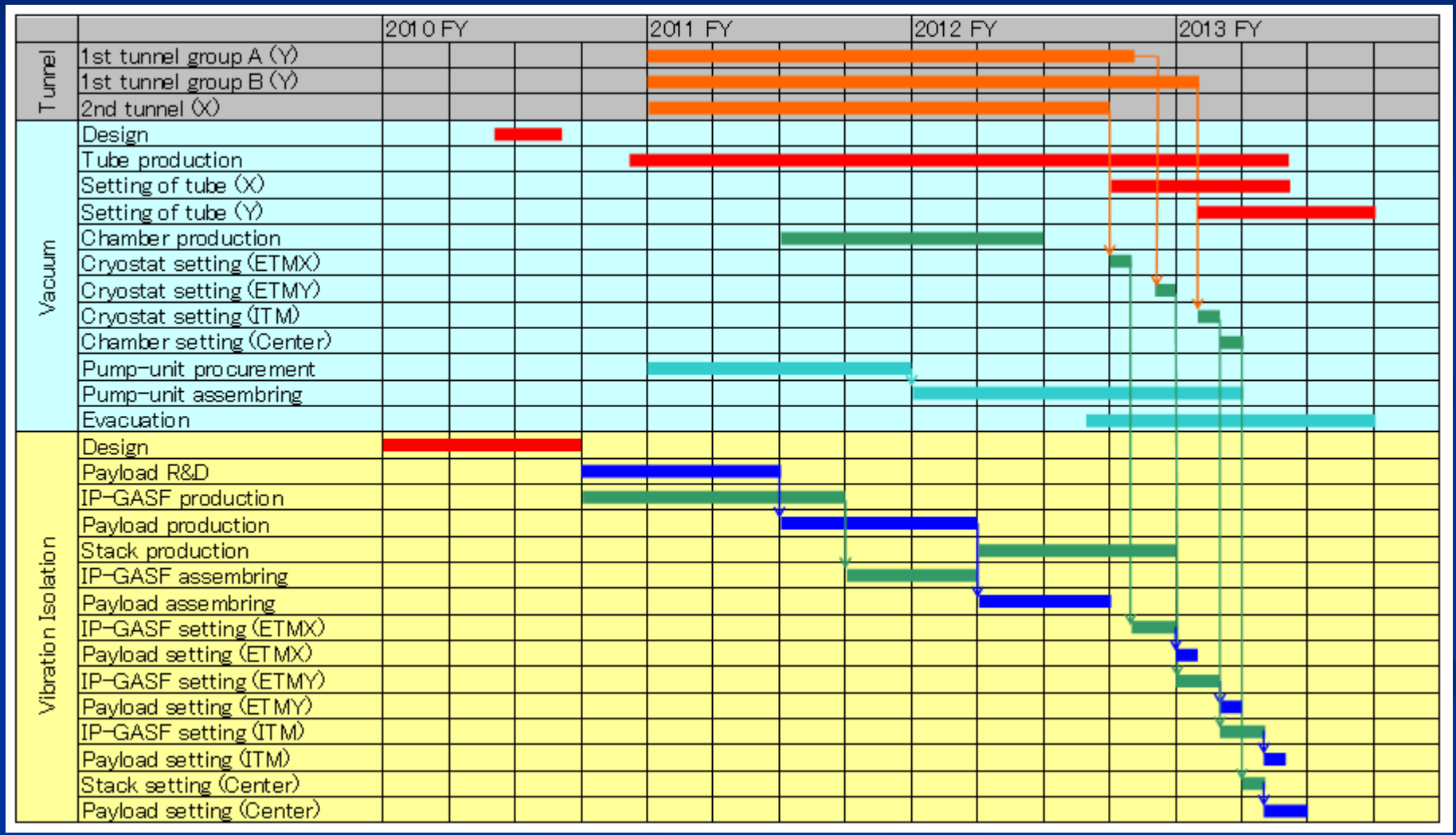
ACC: accelerometer, LVDT: linear variable differential transformer PS: position sensor, OL: optical lever, MC: magnet-coil, STEP: stepping motor, PICO: picomotor

For cryogenic

Stepping motor: tested in Rome, 4.8K ok!

Position sensor: shadow sensor → fiber sensor

4. Schedule


2010 FY
2011 FY
2012 FY
2013 FY
Tunnel
1st tunnel group A (Y)
1st tunnel group B (Y)
2nd tunnel (X)
Vacuum
Design
Tube production
Setting of tube (X)
Setting of tube (Y)
Chamber production
Cryostat setting (ETMX)
Cryostat setting (ETMY)
Cryostat setting (ITM)
Chamber setting (Center)
Pump-unit procurement
Pump-unit assembring
Evacuation
Vibration Isolation
Design
Payload R&D
IP-GASF production
Payload production
Stack production
IP-GASF assembring
Payload assembring
IP-GASF setting (ETMX)
Payload setting (ETMX)
IP-GASF setting (ETMY)
Payload setting (ETMY)
IP-GASF setting (ITM)
Payload setting (ITM)
Stack setting (Center)
Payload setting (Center)