

# (DRAFT)

## Installation procedure for type-B SAS prototype inside TAMA vacuum chamber

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### **1. About this document**

This document describes the installation procedure for the type-B SAS prototype to the vacuum chamber in the TAMA West End Room. The installation happened on May 12th and 13th, 2015.

### **2. Abstract**

On May 12th we prepared to lift up and down the type-B SAS prototype by a crane and check if the lifting can be done safely. Then on May 13th we installed the suspension inside the vacuum chamber. The installation procedure is summarised as follows;

- 1) Lock all the components such as TM, RM, IM, IRM, GAS filters and IPs.
- 2) Attach holders for hanging up, and adjust so that the each components are leveled.
- 3) Lift up the suspension slowly by lowering the jacks footing the pre-isolator.
- 4) Hang up the suspension vertically and move it to right above the vacuum chamber.
- 5) Lift down the suspension with releasing the GAS filters.
- 6) Place the suspension on the pistons on the outer frame.

### **3. Preparation of suspension**

All the suspended components are physically locked in the following way;

- Inverted Pendulums(IPs) are fixed by three locking nuts. Then metal boards are attached to connect the top filter and IP basement rigidly.
- The Test Mass(TM) is fixed to the Recoil Mass(RM) with locking screws. Then RM is rigidly connected to the Intermediate Mass(IM) with metal bars attached.
- IM and the Intermediate Recoil Mass(IRM) are fixed to each other and to the Earthquake Stop(EQS) with locking screws.
- Keystones of Geometric Anti-Spring filters(GASFs) are tightly fixed. Lateral or vertical movements of the Standard Filter (SF) and the Bottom Filter (BF) are restricted by locking screws from side and the bottom.
- The Magnetic Damper (MD) is fixed to the copper plate on SF with clamps. Spacers are inseted between MD and SF to avoid breaking suspension wires for MD.

Pictures of the locking mechanisms are shown in Fig. 1.

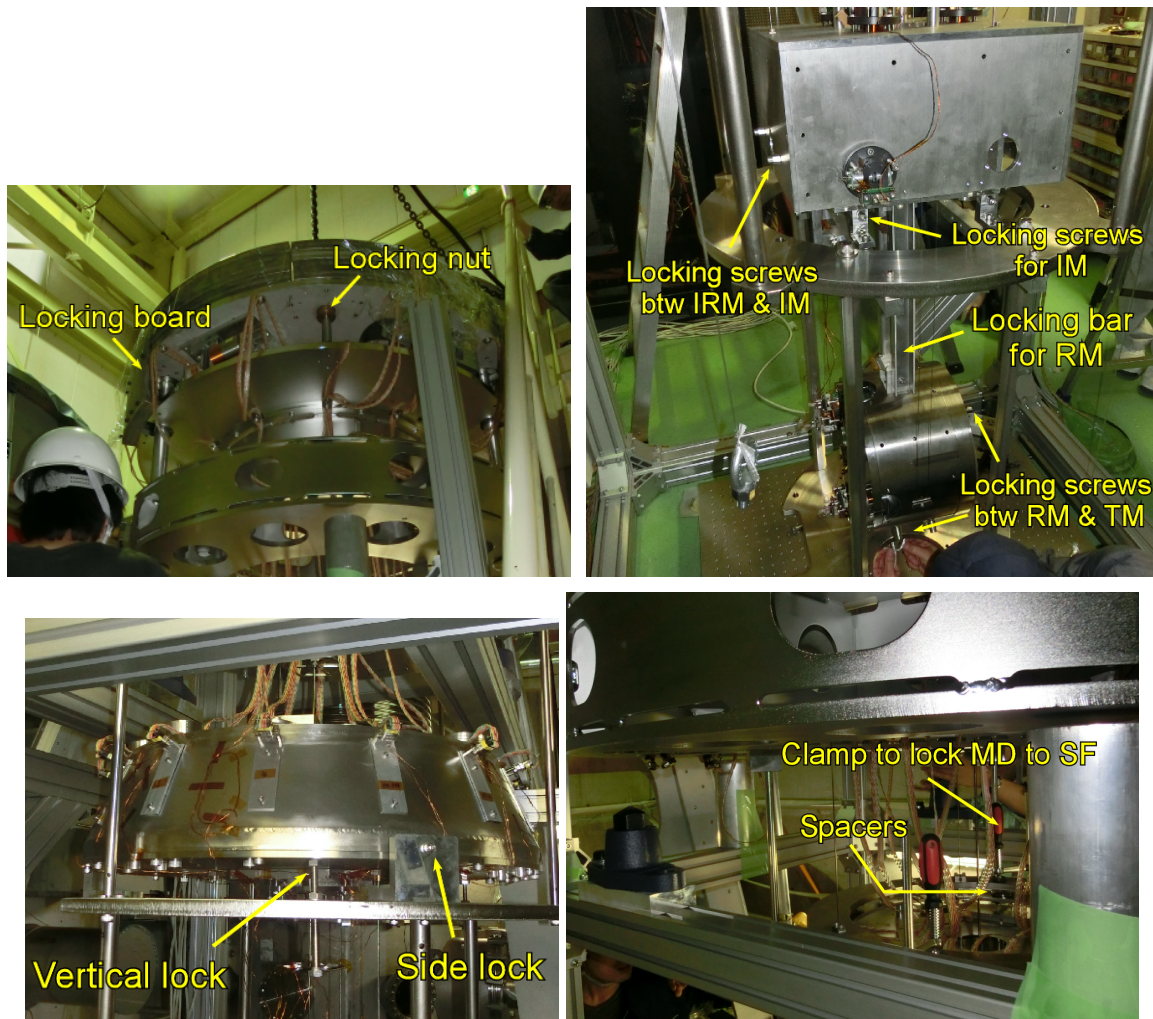


Fig. 1: Overview of locking mechanisms

All the cables between the hardware and the digital system are disconnected around the preisolator. Gender changers/pin turnovers are attached on the side of the cables connected to the digital system.<sup>1</sup>

#### **4. Lifting**

After checking if the lock is done appropriately, the suspension is lifted gently in the following procedure;

- The pre-isolator is placed to the higher position by raising jacks.
- The crane adapter with an eyebolt is suspended by a crane and placed on the top filter. Before fixing the adapter, position of the crane is finely adjusted by looking at the relative position between the through holes on the adapter and screw holes on the top filter.
- Lift the crane up and apply tension on the chain of the crane. This must be done carefully and one has to make sure that the suspension is NOT lifted in this step.
- Lower the jacks and let the suspension system suspended.
- Remove the cups on the bottom surface of the pre-isolator.

<sup>1</sup> Note that the gender and pin assignment turn over at the feedthrough.

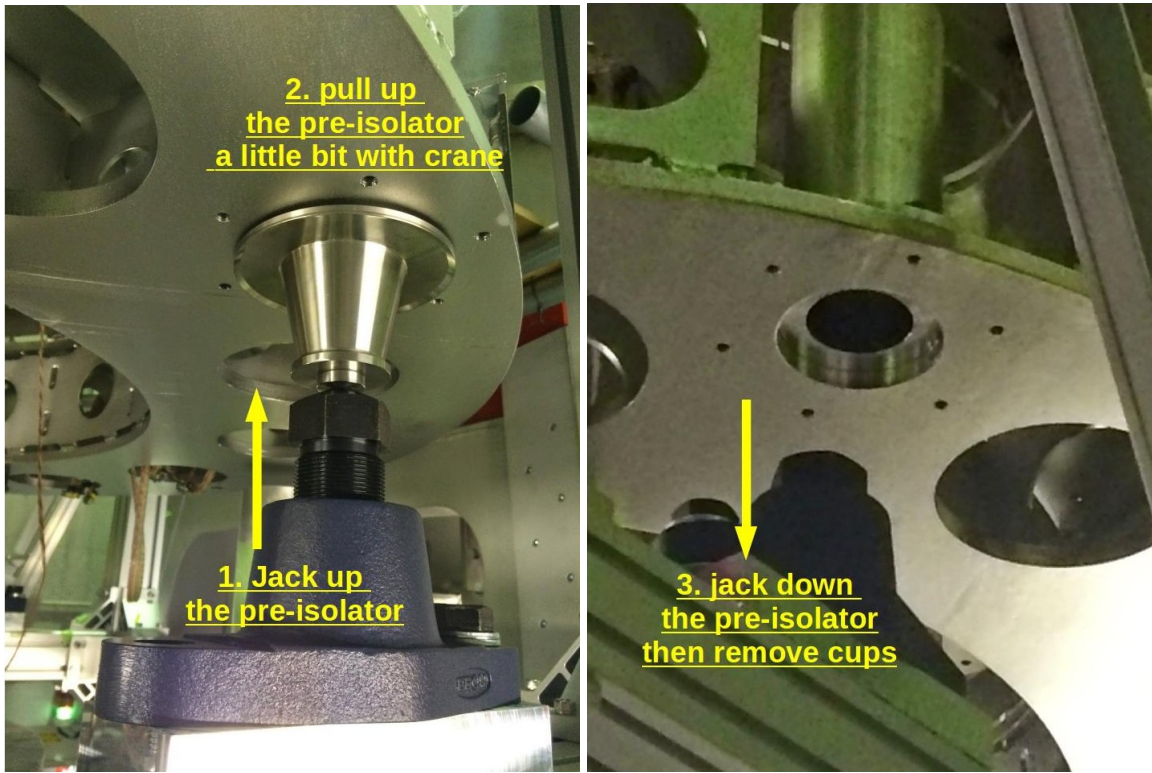


Fig.2: Procedure for hanging up the SAS:

In order to check the verticality of the suspension chain, we attach plumbs on EQS and check the distances between the slings and EQS. Three plumbs are attached to the pillars connecting the plate for SF and the bottom surface of the pre-isolator. The distances between the slings and EQS in the level of BF and SF are measured and compared (see Fig. 3). This time we confirmed that the distances in the level of BF and SF coincide in the range of  $\sim 1$  mm, so the verticality was good enough.

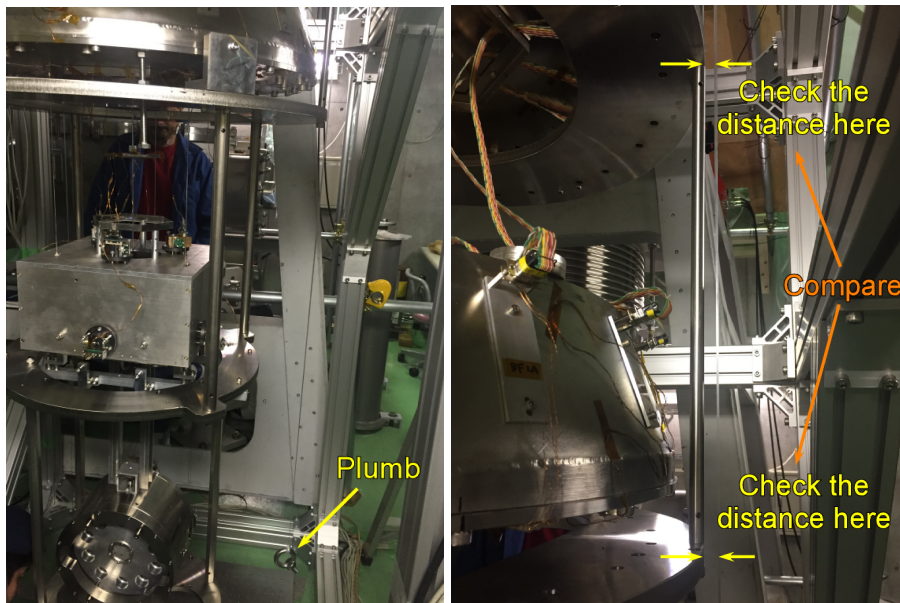


Fig. 3: Plumb to check the verticality of the suspension

## **5. Installation inside chamber**

Some additional preparation is needed for installation of the suspension system in the vacuum chamber;

- Attach a sling to the pre-isolator to control the orientation of the suspension system during the crane operation (Fig. 4). This is also used when you damp the oscillation excited by the crane operation.
- Attach other plumbs to the EQS (Fig. 5)<sup>2</sup>. They are used as guides for positioning the suspension system when lifting it down. Note that the clearance between the suspension and the bellows where the suspension is inserted was only 8 mm in the prototype system, so we had to adjust the position quite finely.
- Open the cap of the top chamber and place it somewhere. Also open flanges of the top chamber just above the hydraulic pistons so that the position of the IP legs are visible during the installation (Fig. 6).

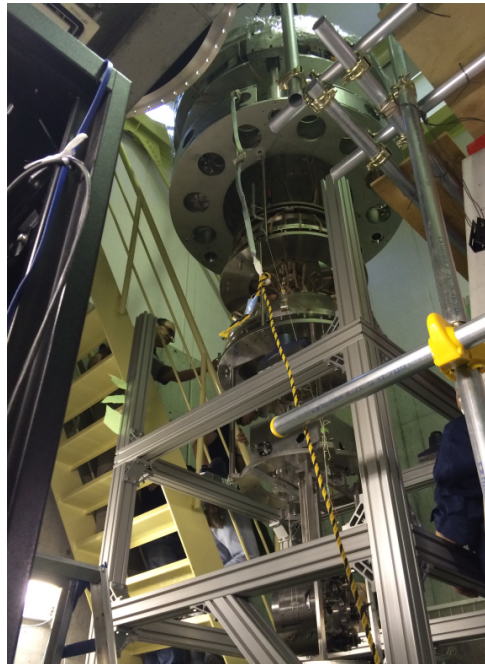


Fig. 4: A sling to control the orientation of the suspension system

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<sup>2</sup> We used kite strings and washers for the plumbs.

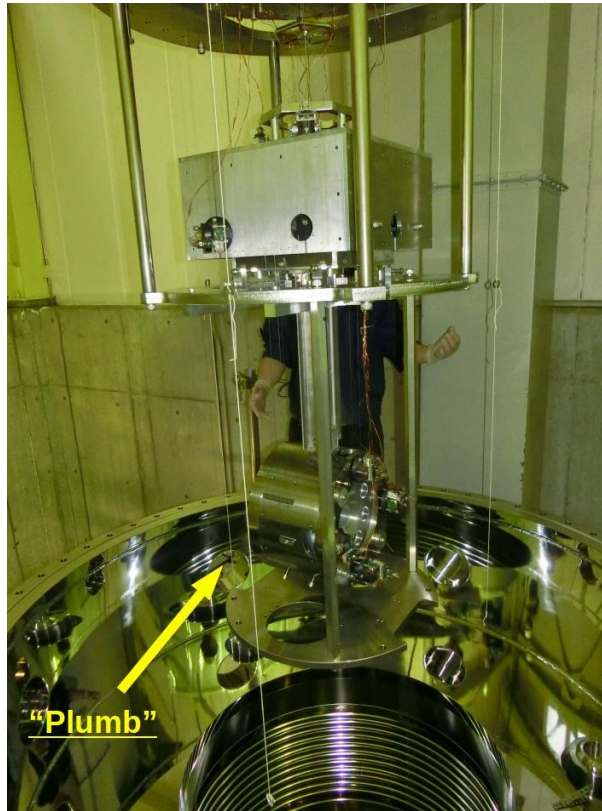


Fig.5: Plumbs as guides for suspension system installation

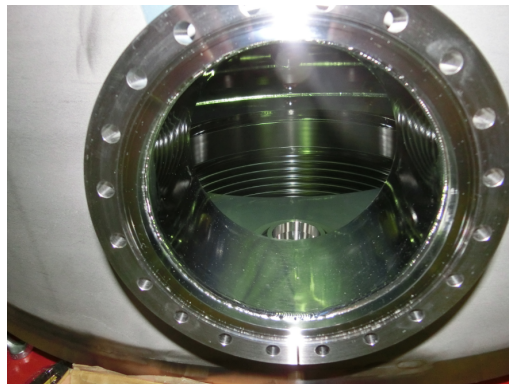


Fig. 6: View from a duct just above a hydraulic piston.  
You can see an adapter to which the base of an IP leg is to be coupled.

For the installation of the suspension inside the vacuum chamber, 7-9 persons are needed;

- |  |                 |
|--|-----------------|
| for working on the outer frame             | →3 or 4 persons |
| for driving a crane                        | →1 person       |
| for telling the position of the suspension | →1 or 2 persons |
| for telling the status inside chamber      | →1 or 2 persons |
| for doing a chore on the floor             | →1 person       |

The procedure of the installation is described below;

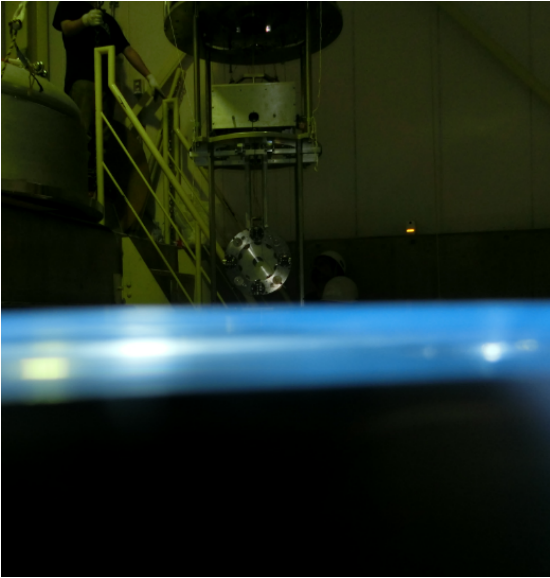
- Lift up the suspension system by a crane until the horizontal movement is not disturbed by surrounding structures (e.g. the assembly frame).



- Move the suspension system in horizontal directions gradually with small steps toward the vacuum chamber. In each step, the oscillation of the suspension system is damped by a sling attached to the pre-isolator.

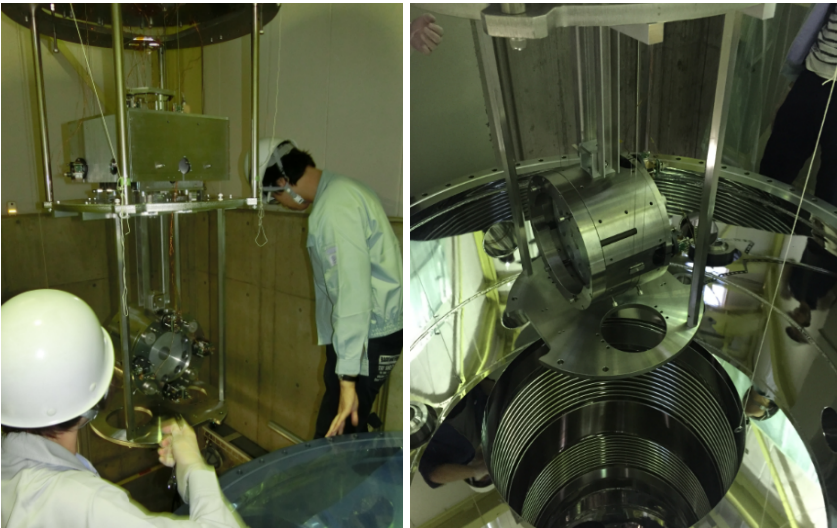


- Raise the suspension system as much as possible and check the height of the suspension system. If the lower surface of the system doesn't reach the height of the top chamber, you need to lower the vacuum chamber.

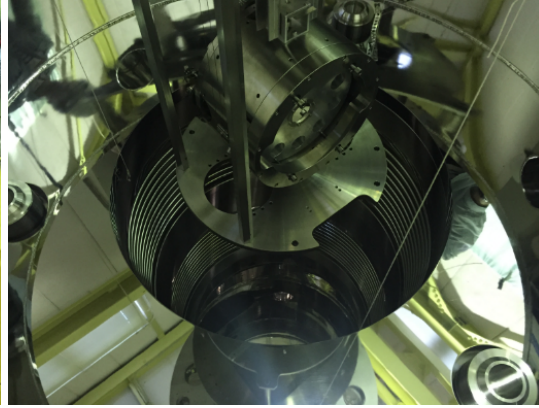


*(View from the edge of the top chamber. The lower surface of the earthquake cannot be seen in this picture. We needed to lower the top chamber in this case.)*

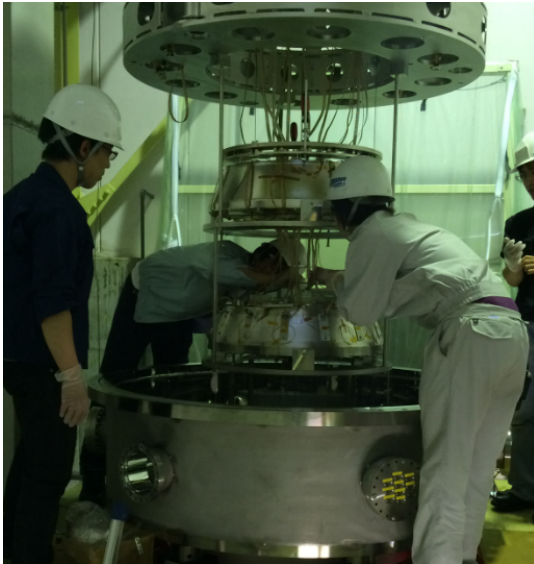
- If the height requirement is met, move the suspension system toward the vacuum chamber again and move it right above the vacuum chamber.



- Center the suspension system with the hole of the vacuum chamber looking at the position of the plumbs.



- Release all the lock for BF. You need to release the keystone<sup>3</sup> and remove/loosen the lock screws on the side/bottom of BF.

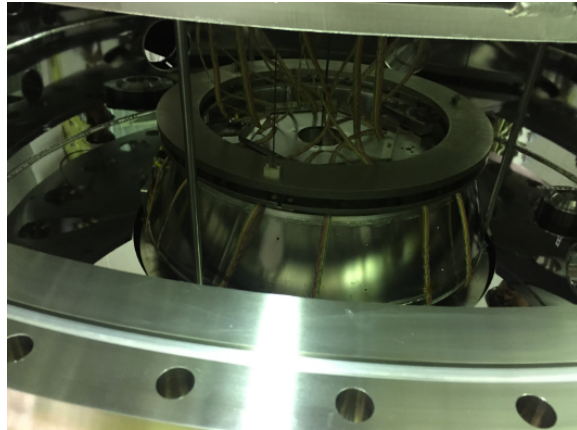
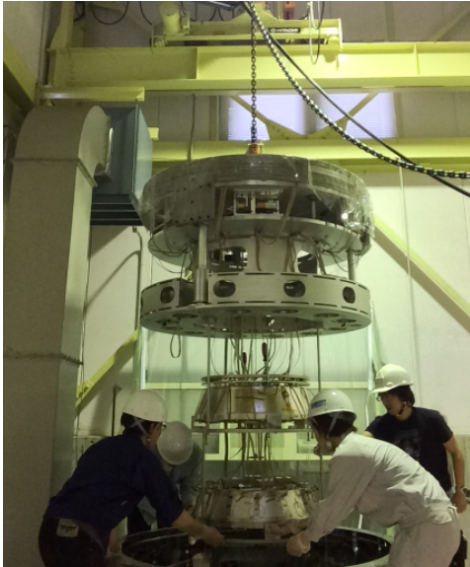


- Lift down the suspension system until the EQS for BF reaches to the hole. Make sure that the the suspension system doesn't hit the chamber. One person should check the centering looking from the bottom.

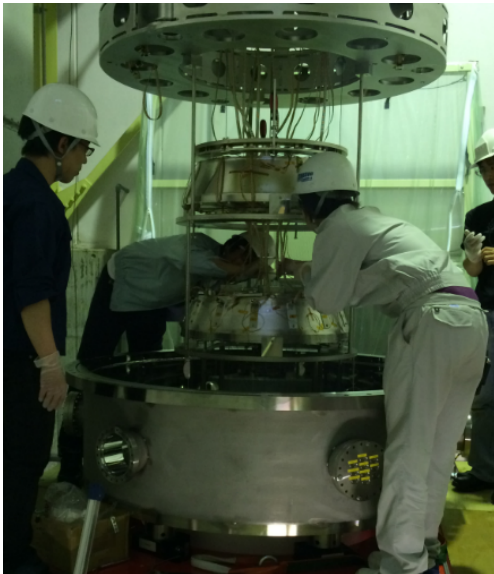
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<sup>3</sup> We rotated the screws/nuts approximately 8 turns this time. The keystone would gain roughly +/- 8 mm movable range.

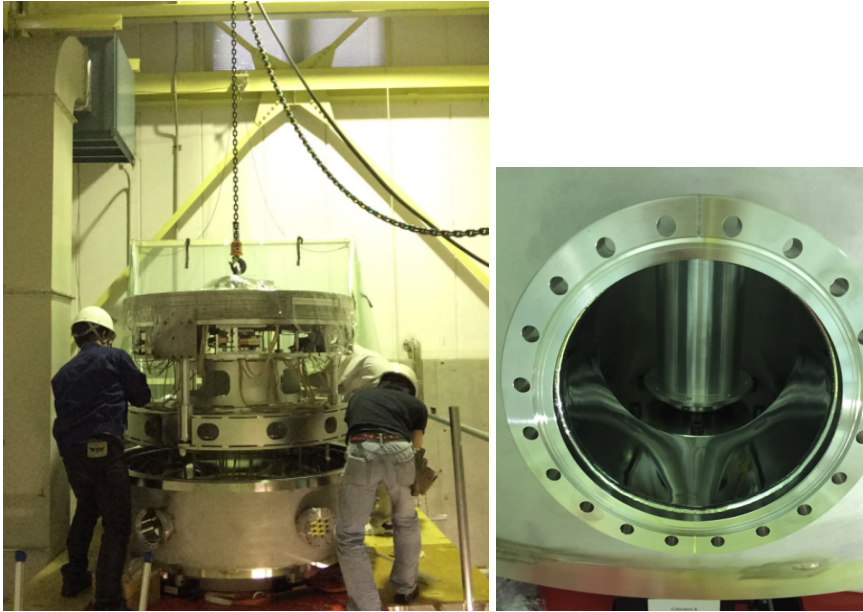




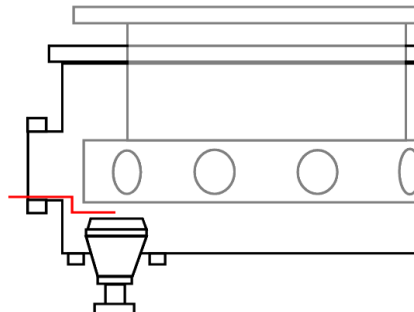
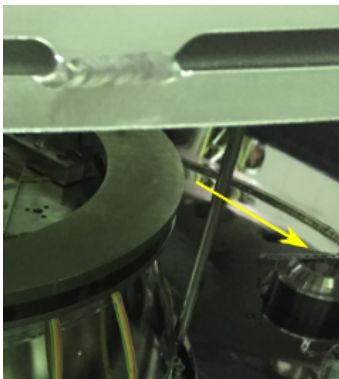
- Release the lock for SF as you did for BF. The clamps for MD are also to be released. Remove plumbs.



- Lift the suspension system down carefully until the the view from the flange ports are covered by the pre-isolator. Rotate the suspension system around the vertical axis so that IP legs come just above the pistons. Remove the sling after that.



- Lift the suspension system down until the IP base approaches to the pistons by  $\sim 1$  cm. Since the gap between the IP base and pistons is not visible from outside, we used S-shape jigs as shown in the figures below. The jigs were placed  $\sim 1$  cm above the pistons. When the IP base touches to the jigs you can see them move vertically.



- Move the pistons up or raise the outer frame until the pistons catch the IP legs. If you confirm that the suspension system sits on the chamber, remove the crane.
- Adjust the height of the chamber and the outer frame so that the each components are leveled, then the initial installation is completed.

## **7. Tips in prototype**

### *1) Modification on crane*

In order to earn the lifting height as much as possible, in the case of the crane in TAMA, we had to bring up a chain-holder box so that it doesn't push the suspension system (see Fig. 5). In this configuration, the chain coming out from the crane was not stored in the box, so we had to prepare another paper box for receiving it. One person had to control the chain during the crane operation so that it doesn't touch to the suspension system and make it dirty by oil.



Fig. 7: A chain-holder (black cuboid) brought up by a plastic rope

### *2) Weight measurement*

Total weight of the suspension was measured during the lifting test using a crane scale. Measured value was 1516 kg, which was roughly consistent with the estimation from the 3D-CAD drawing (1507 kg).

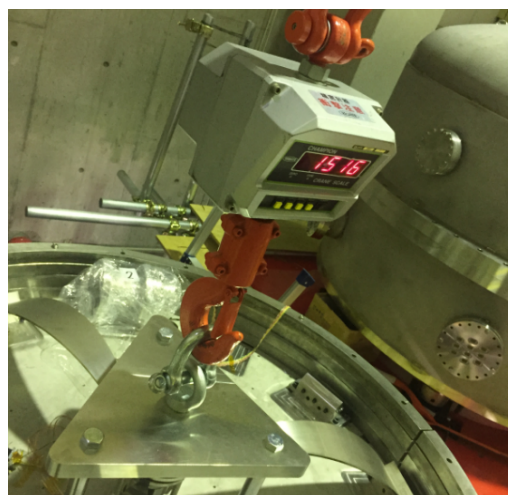


Fig. 8: Weight measurement of the suspension system

## 8. NOTES FOR SAFETY (English follows)

- 適切な服、装備をもって作業すること。（作業着など動きやすい服装＋ヘルメット。必要ならば安全帯（命綱）。）
- 全員が「壊れ物」を扱うということを自覚すること。集中して作業をすること。具合が悪くなったとき、疲れた時は遠慮せずに申し出て作業から離れること。
- 自分が「物を壊すかもしれない、怪我をするかもしれない」と常に思いながら慎重に行動すること。走ったり飛び降りたりしないこと。むやみやたらに周りの物に触らないこと。
- （特に学生など経験の浅い者は）リーダーなどの指示の他に自ら動こうとするときは、必ず全体（リーダー）に一声かけてから動くこと。（把握しきれないところで危険につながる。）（ただし危険時のとっさの判断は除く。）
- リーダーや周りのスタッフなどが危険と判断した場合、その者は速やかに指示に従い作業から離れること。
- リーダーは全体の様子を見て適宜休憩を指示すること。集中力が欠けると事故につながるので、一人でも集中力が欠けていることが見て取れた場合は、その者は速やかに休憩をとらせ、きりのいい時に休憩をとること。

(English)

- Everyone should wear proper clothes and equipments. (work clothes, helmets, safety belt if necessary.)
- Everyone should realize that the system is so fragile and should not do act as one's own pleasure. Concentrate to the work!  
When you feel bad or are tired, do not hesitate to tell a leader and to take a rest.
- Think that you may break something. Think that you may get injured.  
Do not run. Do not jump out. Do not touch anything without good consideration.
- Everyone (especially who do not have much experience, such as students) should say collaborators so when he/she wants to do something not assigned. (If not, it leads to the unnoticed danger.) (except for quick decision for the safety.)
- Everyone should follow instructions of a leader or other staffs. Especially, one should leave the work when a leader or other staffs judges that it is dangerous.
- A leader (responsible person) should take some rests properly. Lack of concentration leads to mistakes, breaking something, and the injury. If a leader (or someone) finds someone lose his/her concentration, make him/her take a rest immediately, and also make everyone take a rest when it is convenient.