

Comments from PAB report 2020

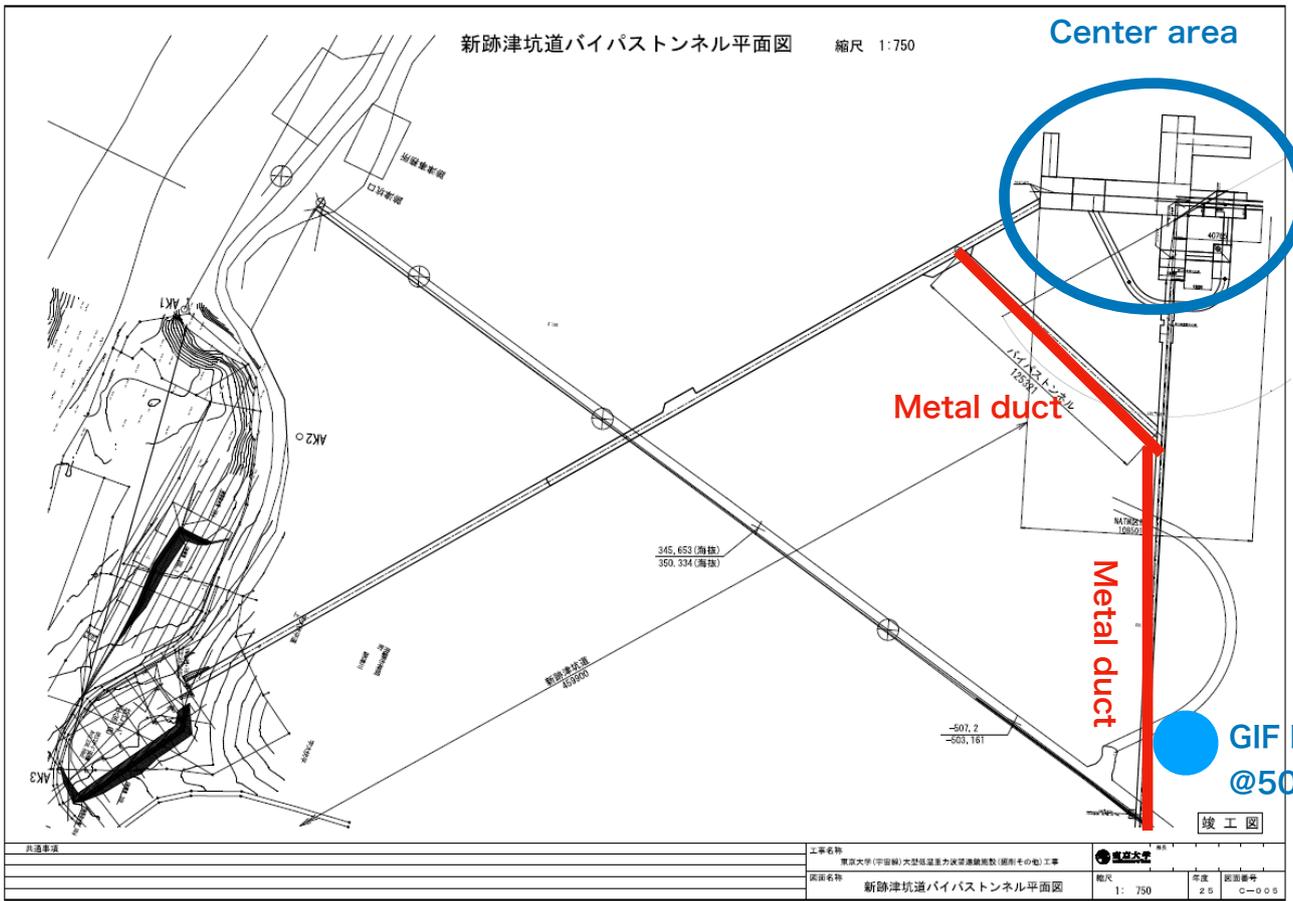
- **Safety**

The responses to last year's PAB recommendations were mixed. The ongoing effort to introduce replacement air to the X end station is commendable and should be completed as soon as possible. The ones that remain unaddressed and that should be of concern include,

- No backup plans have been developed in case design performance cannot be achieved (a likely occurrence given what we heard about sapphire test mass issues).
- The risk registry for the project has not been revived and updated in over 1 year since our recommendation.
- Providing technical project management training to younger engineering staff should remain a priority.
- **A number of safety recommendations are ongoing but not fully addressed and should be addressed as soon as possible** (given the funding situation).
- **Recommendation:** The safety of KAGRA personnel and the instrument is of the highest priority. **KAGRA should work to quickly complete the ductwork needed to bring fresh outside air to the X end station.** KAGRA management should continue to work to address the other items the PAB notes above and the committee looks forward to hearing about further progress by the next meeting.

Answer

- The current status of safety recommendations in the PAB report 2019: Shown later.
- The ductwork for the Xend.
 - We have installed metal air ducts from the start point of the bypass tunnel to 600m in the Xarm tunnel.
 - The metal ducts are connected to the existing air ducts that extend to Xend.
 - New air ducts for Xend will not be affected by fires both in the center area and at the laser source of the geophysical interferometer at 500m in the Xarm tunnel.
 - The GIF laser source and related equipment are considered to be the most possible cause of the fire in the Xarm tunnel. That's the reason why the metal ducts were extended to 600 meters.





Comments from PAB report 2019

5. Additional comments and recommendations for the PAB Safety

The PAB was updated on the status of KAGRA safety. We were encouraged to see that a number of improvements have been made. Nevertheless there remain some outstanding issues which should be addressed, and we detail these in our recommendations below.

Laser Safety

The PAB understands that the interlocks and detailed recommendations from 2018 for laser safety could not be completed due to budget and schedule considerations. While PAB recognizes that great progress has been made in the aim of joining O3, it wishes to remind KAGRA management that an accident involving laser exposure could shut down the experiment. The last time during O3 would be unrecoverable. The international standard requires that an untrained person entering the facility will not be exposed to a

laser risk. A laser warning sign and blinking warning light is necessary but not sufficient. PAB members did not enter the laser room on their visit on this occasion, but noticed that the laser was on and the door to the room was open. The latter was possibly due to the requirement of longitudinal air flow to keep the laser room clean.

Specific recommendations are:

1. Devise a system to ensure that the untrained (in laser safety) personnel cannot receive an accidental exposure. Something as simple as confinement of the laser beams everywhere outside the laser room, including sealed observation ports or windows, combined with restricted access to the laser room should suffice. This basically means that any accidental exposure will be equal to or less than that from a class I laser and thus be deemed safe. PAB has previously made recommendations on this issue but a detailed plan has not been presented. Laser beam dumps have been built, but it is PABs understanding that no automatic use of these has been implemented to date. [Restricted access could be implemented using a card-access based system to allow only laser-safety qualified staff to enter areas where laser hazards are present.](#)
 1. Answer: For the Center area and Yend, an ID card is required when entering the room, and it meets the request for comments. On the other hand, with regard to Xend, once the security is lifted, you can enter the room without an ID card. We need to improve the entry of Xend.
2. A related safety area which was not discussed is how viewports are handled. An accident at Virgo a number of years ago led both Virgo and LIGO to review their protocols regarding handling of viewports, work in their vicinity, and the [rigorous use of protective covers on all unused viewports.](#) We mention this because the PAB wants to make sure that KAGRA is aware of these concerns and protocols in case they do not already have a viewport safety protocol in place.
 1. Answer: When we disconnected vacuum ducts from vacuum chambers for upgrade works toward O4, we covered optical windows by plastic covers.
3. An [automatic shutdown](#) remains something that should be required and installed. The current manual safety shutdown is not sufficient in case of a serious accident.
 1. Answer: We have introduced a system that monitors the beam dump and drops the laser interlock when it senses high temperature. We plan to expand this system to other beam dumps that could hit high-power lasers.
4. A light-tight air exhaust grille in the laser room door could be used to maintain laminar flow if that is the reason the door was open. [The door should be closed](#) at all times and openable only by laser trained personnel. A special override needs to be implemented for safety or fire personnel to be able to enter room safely: [possibly the emergency shutdown button on the outside of the laser room](#) serves this purpose, but this should be made clear.
 1. Answer: We have installed an electronic lock that requires an ID card to the door of the laser room in 2020. Not activated the key yet. We need to make some

rules to give the authorization and so on. We installed emergency stop buttons to kill the laser source in the laser room and in front of the laser room.

5. It was noted during the site visit that there did not seem to be [sufficient goggles](#) of the correct type to provide everyone with adequate protection. More goggles should be made available.

1. Answer: Currently, at least 40 IR & Green laser glasses and 30 IR laser glasses are available. If necessary, continue to purchase.

6. If not already the case, a [single qualified laser expert](#) from KAGRA staff should be assigned the task of overall laser safety on the site.

1. Answer: Currently, Uchiyama is the responsible person.

Recommendations other safety matters

1. KAGRA needs to work to [extend the emergency telephone](#) line all the way to outside the tunnel and a telephone handset should be installed at the entrance house of the tunnel.

1. Answer: The construction to extend the cable to the tunnel entrance has been completed. All that's left is to relocate the phone.

2. The lack of safety egress from the X-end remains a serious concern. In addition to those measures already in place, the PAB strongly advises that [rescue-huts with some storage be placed at the lower level and along the main tunnel from the X-end](#), e.g., at every~ 500 m or where the tunnel widens. Perhaps commercial storage box/hut made of metal can be used.

1. Answer: We decided to place the storage box at 1200m in the Xarm tunnel. Item lists stored in the box have been almost completed.

3. KAGRA should strive to install [a fresh air line duct](#) to the X-end.

1. Already answered.

4. While driving down the arms, one may become disoriented with regard to where along an arm one is located. KAGRA should consider introducing [distance markers](#) (as used, e.g., in roadway tunnels) so one can communicate one's exact position (and direction to the outside) in case of an emergency. [Reflecting marker/seal labelled](#) at the side of the vacuum duct supports/ at the side-end of the vacuum duct may be very helpful for guiding escaping people in dark, in case of power disruption. These can be used to indicate where one is, so a person can assess the remaining distance to escape.

1. Answer: We have done.

5. Seismic motion of the tunnel has been observed. One example the PAB visitors to the site heard was that a falling chunk of concrete barely missed one of the 0.5 mm thick bellows. This indicates that there is an urgent need to [protect these bellows joints](#).

1. Answer: We have done.

