Evaluation of three as-built aLigo optical levers at LHO: PR3, HAM2, ITMY

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Optical Lever Acceptance Review

LHO

6/6/2013

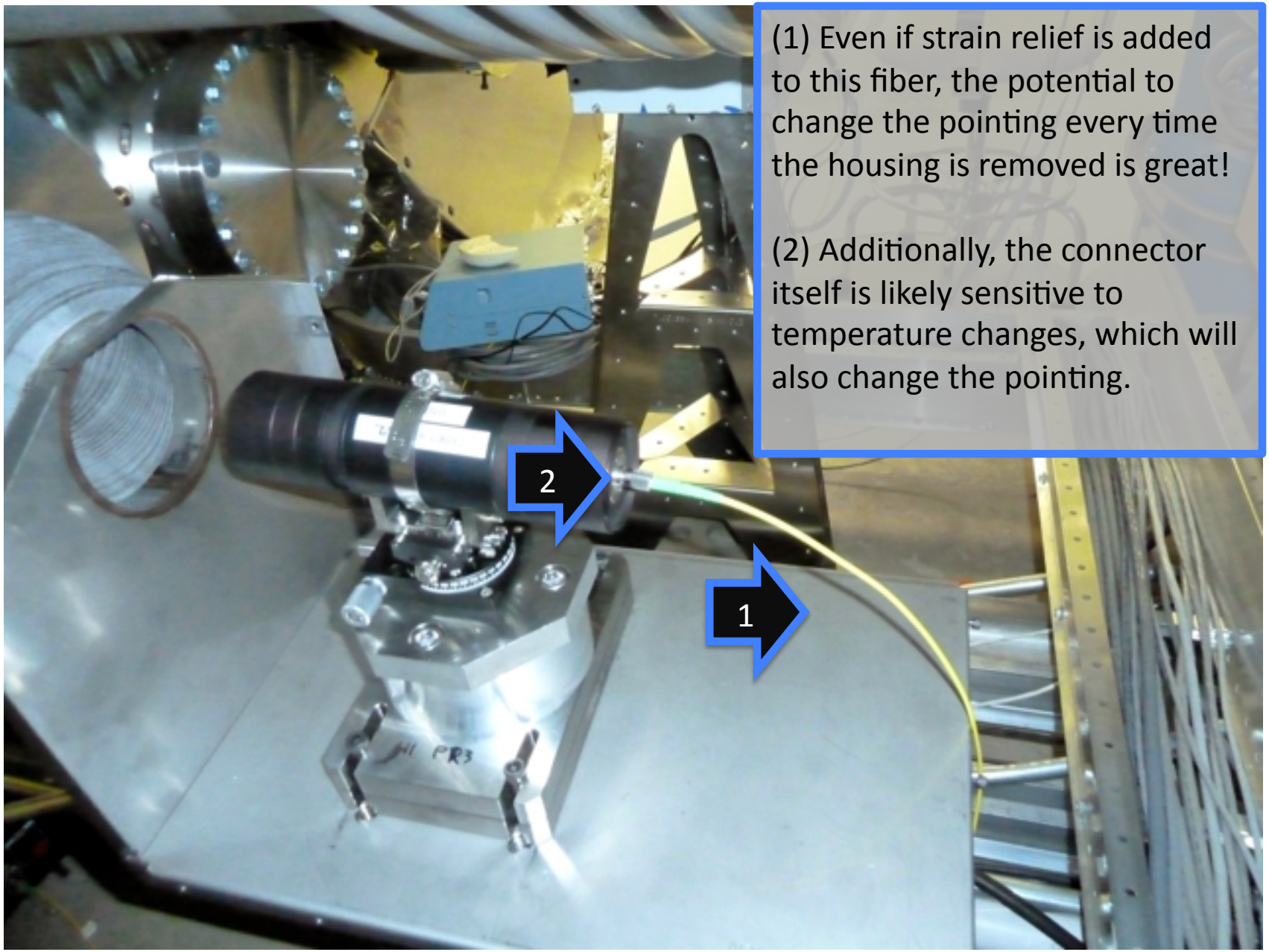
T1300651-v1

Four Main Areas of Concern:

- Pointing
- Noise
- Contamination
- Safety

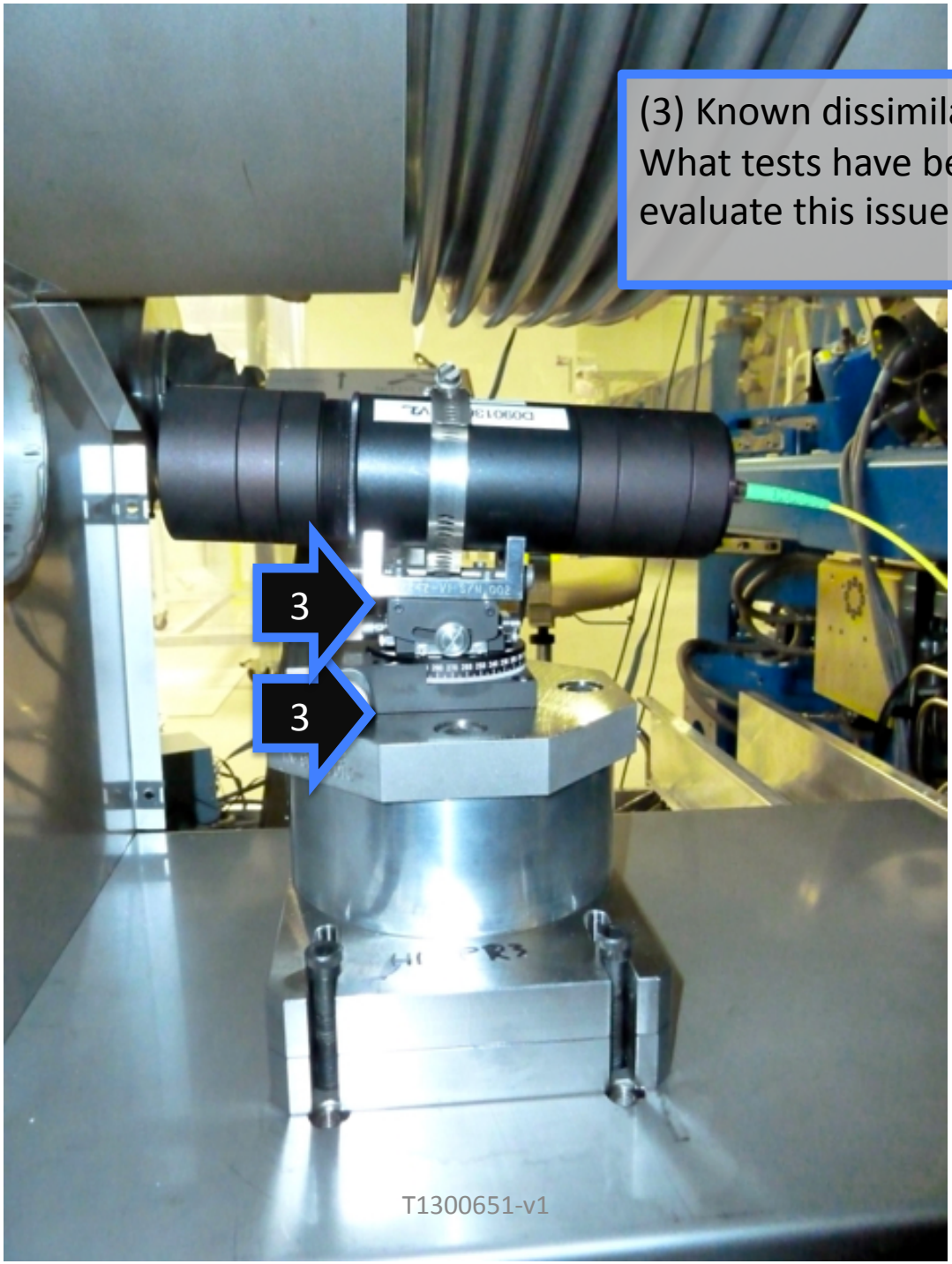
18 specific issues identified

PR3 Optical Lever

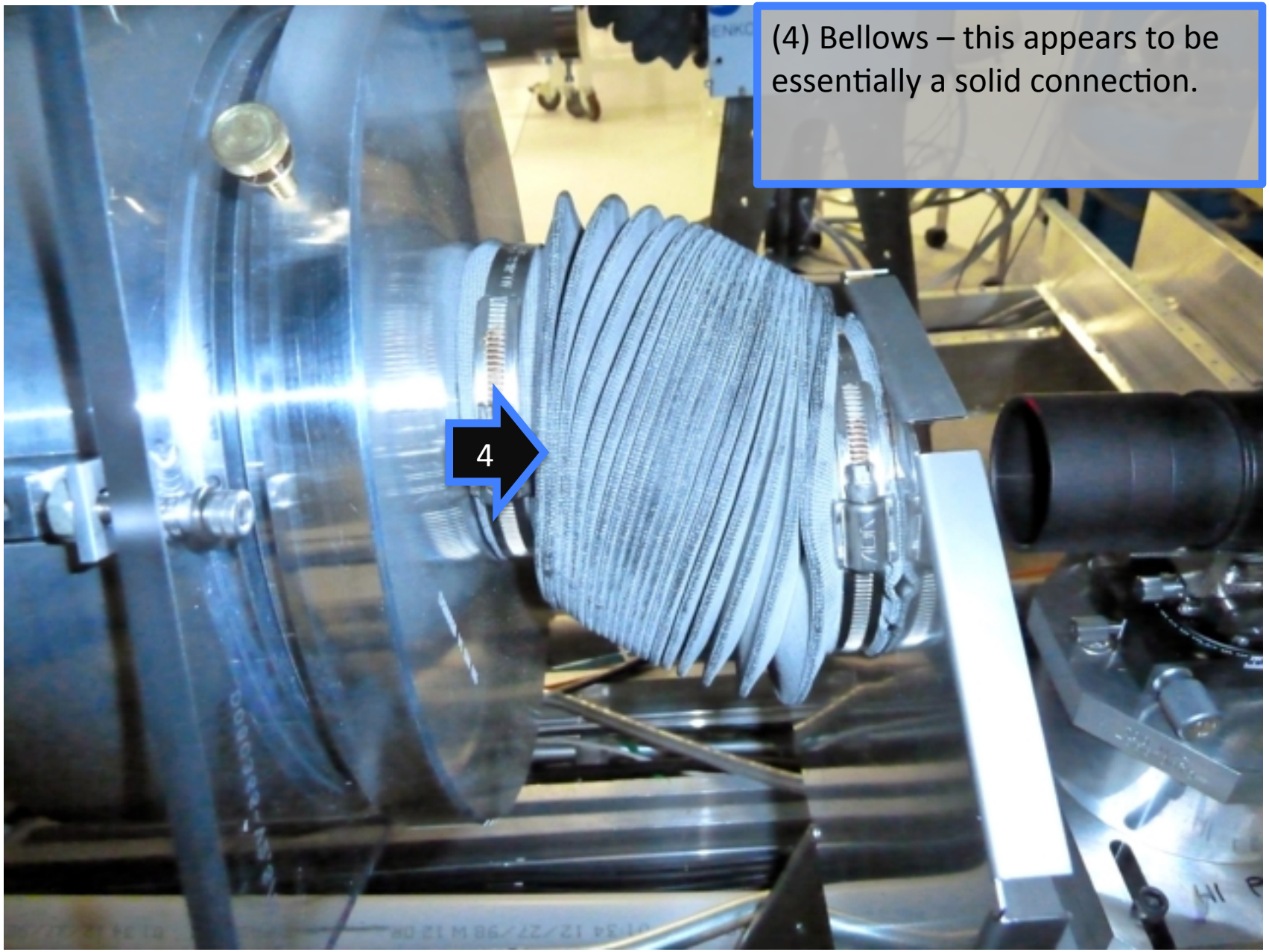


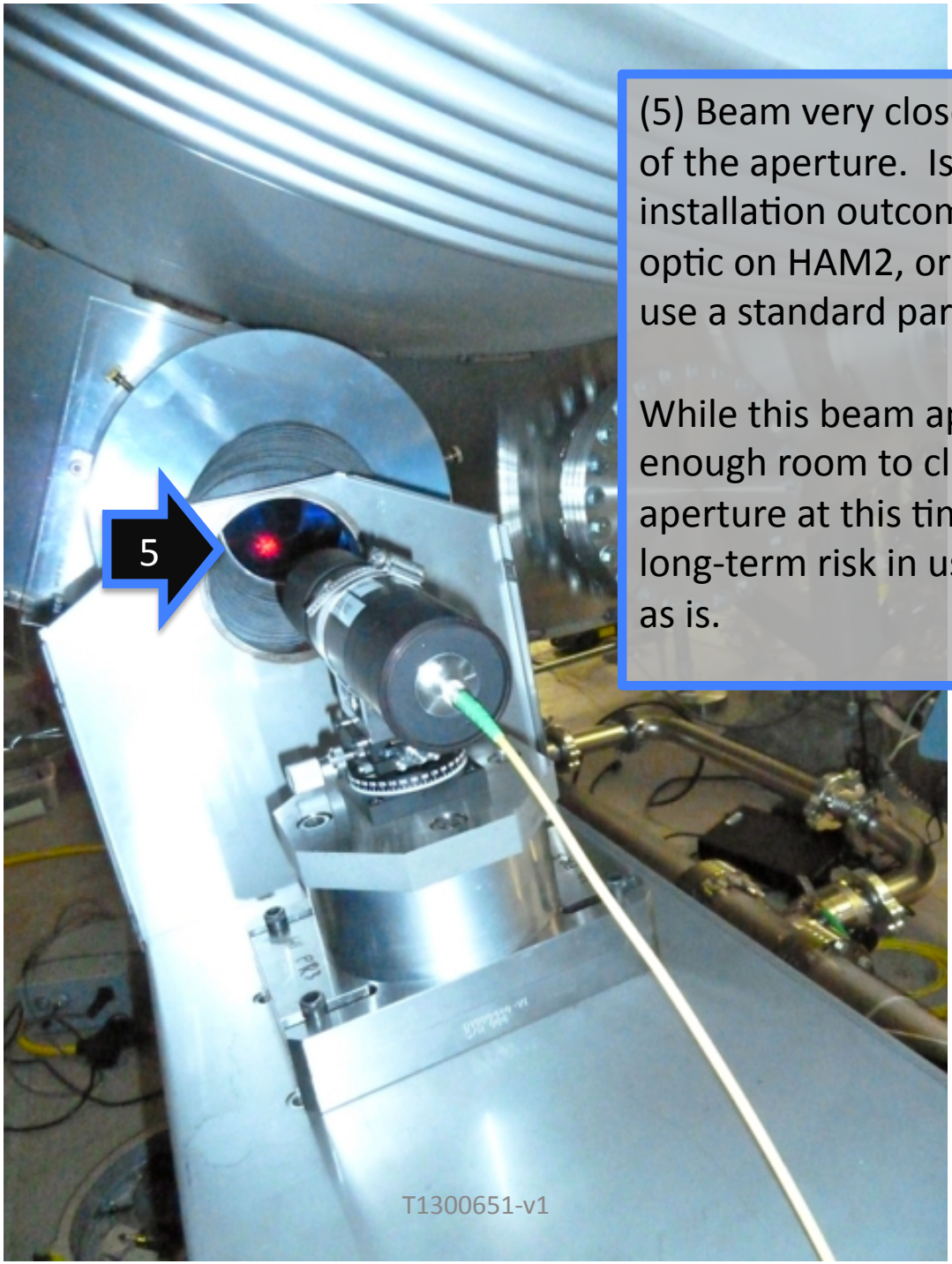
(1) Even if strain relief is added to this fiber, the potential to change the pointing every time the housing is removed is great!

(2) Additionally, the connector itself is likely sensitive to temperature changes, which will also change the pointing.



(3) Known dissimilar metal issue? What tests have been done to evaluate this issue?


(4) Bellows – this appears to be essentially a solid connection.
4

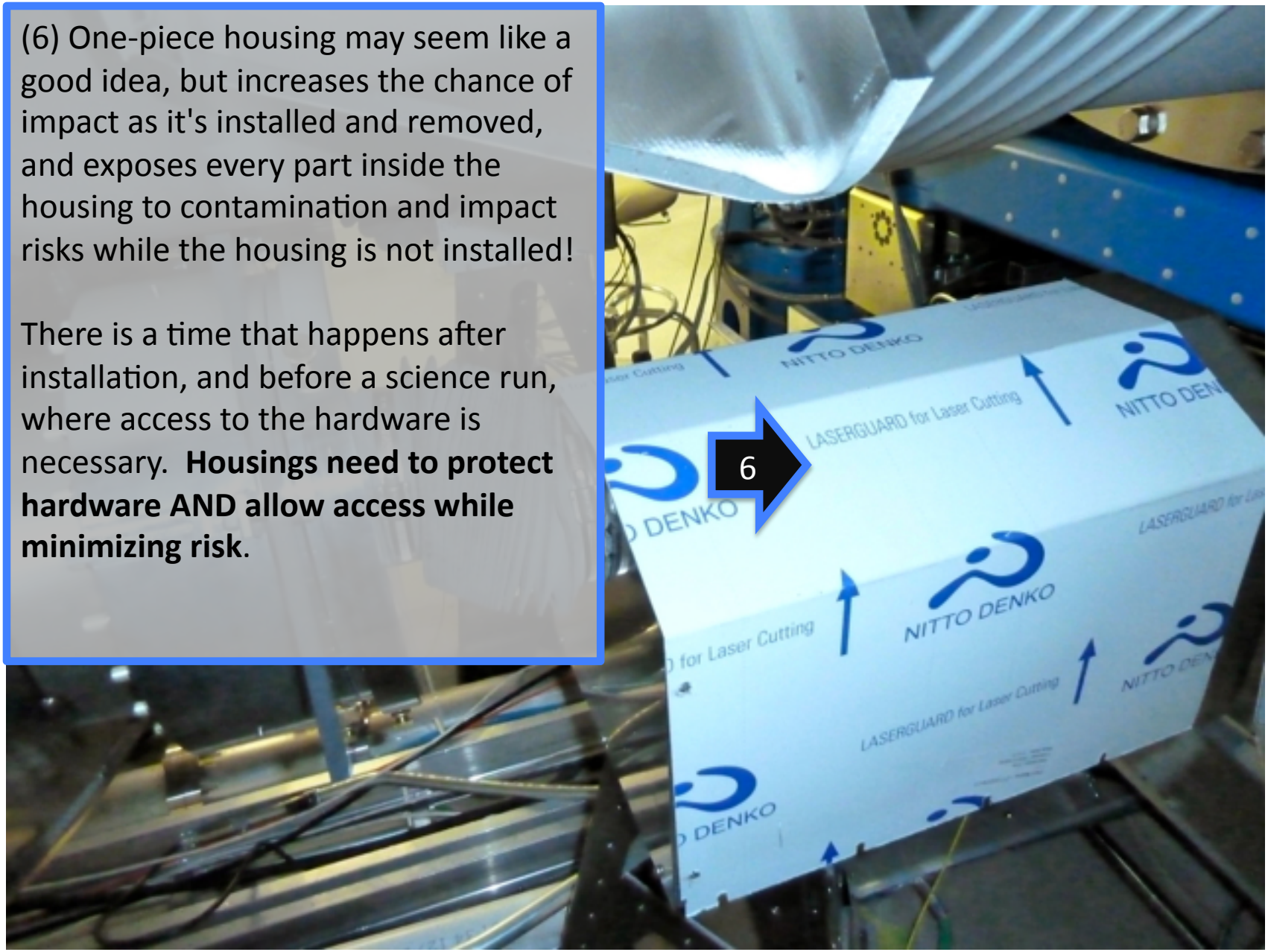


(5) Beam very close to the edge of the aperture. Is this installation outcome due to the optic on HAM2, or some need to use a standard part?

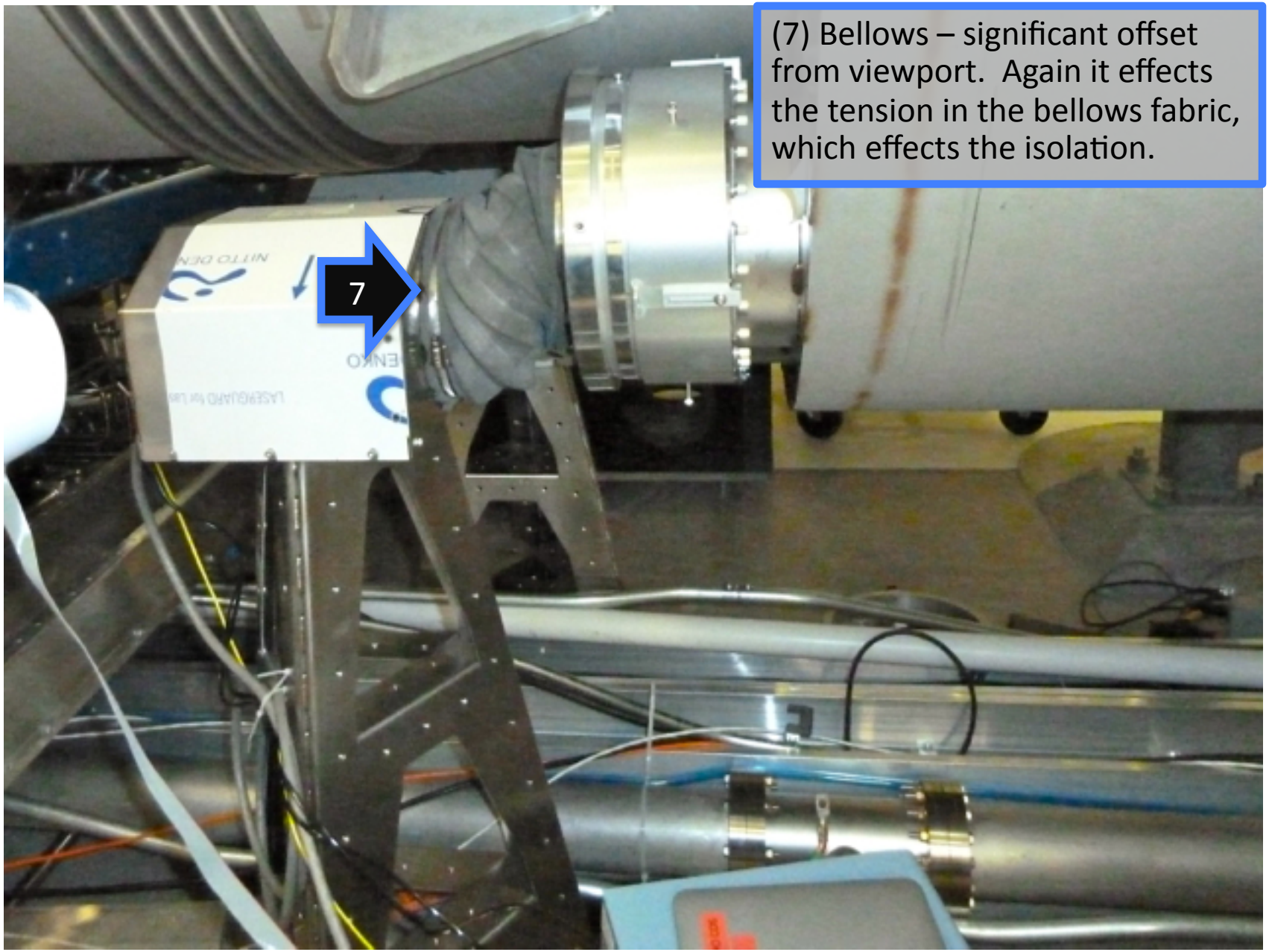
While this beam appears to have enough room to clear the aperture at this time, there is a long-term risk in using the setup as is.

(6) One-piece housing may seem like a good idea, but increases the chance of impact as it's installed and removed, and exposes every part inside the housing to contamination and impact risks while the housing is not installed!

There is a time that happens after installation, and before a science run, where access to the hardware is necessary. **Housings need to protect hardware AND allow access while minimizing risk**.



HAM2 Optical Lever

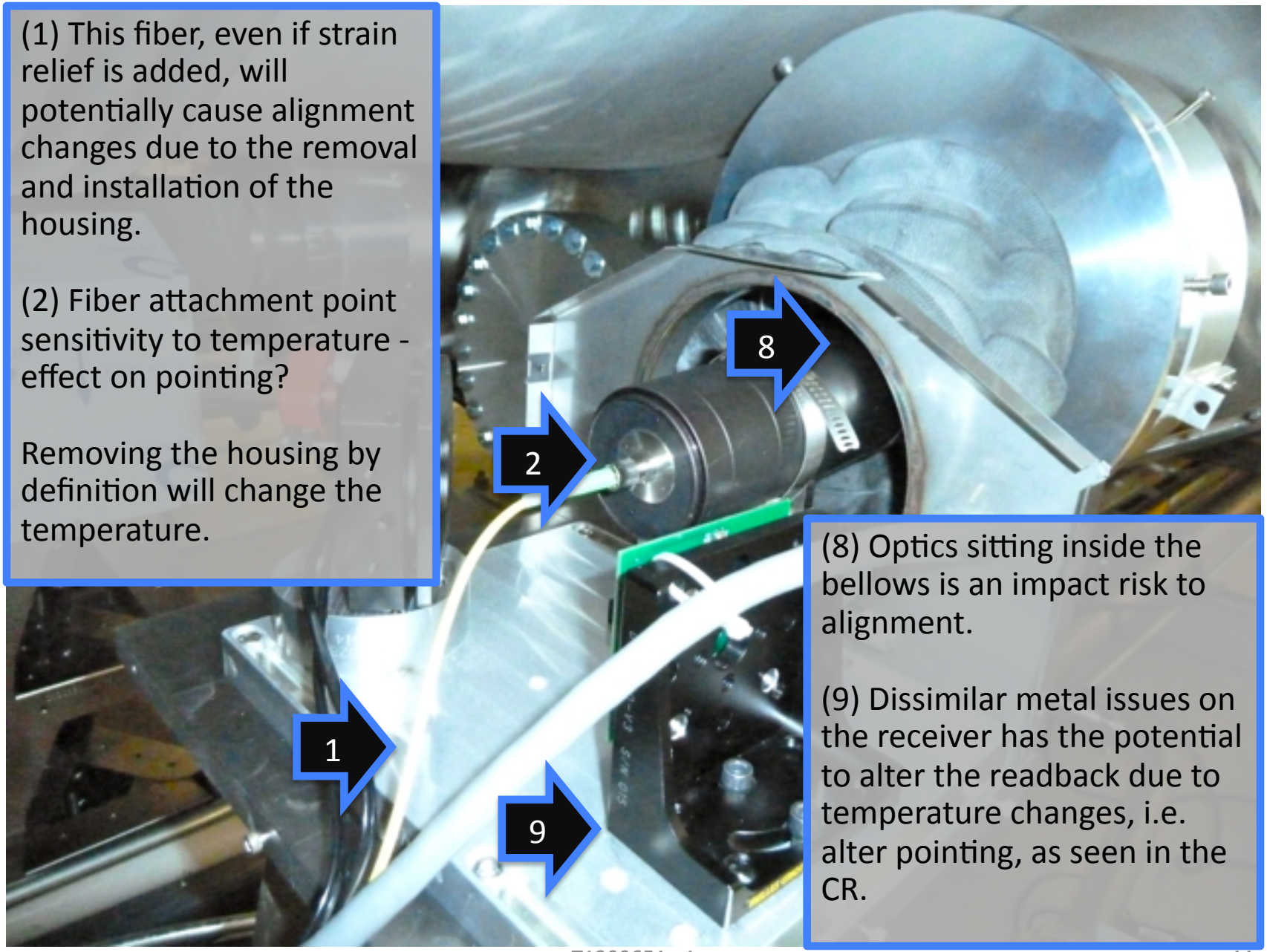


(7) Bellows – significant offset from viewport. Again it effects the tension in the bellows fabric, which effects the isolation.

(1) This fiber, even if strain relief is added, will potentially cause alignment changes due to the removal and installation of the housing.

(2) Fiber attachment point sensitivity to temperature - effect on pointing?

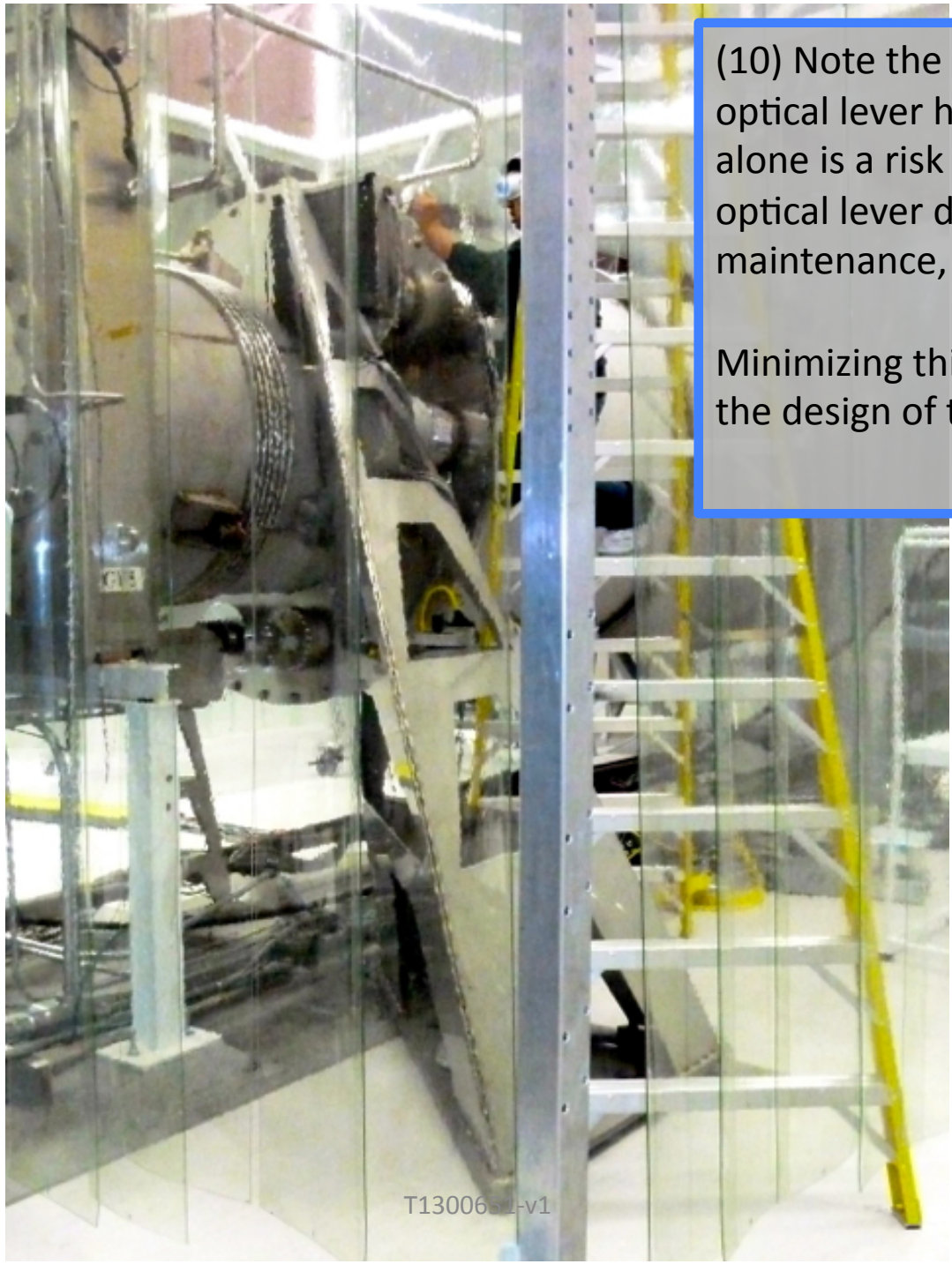
Removing the housing by definition will change the temperature.



(8) Optics sitting inside the bellows is an impact risk to alignment.

(9) Dissimilar metal issues on the receiver has the potential to alter the readback due to temperature changes, i.e. alter pointing, as seen in the CR.

ITMY Optical Lever



(10) Note the height of this optical lever hardware. Height alone is a risk factor for this optical lever during installation, maintenance, and operation.

Minimizing this risk should drive the design of the housing.

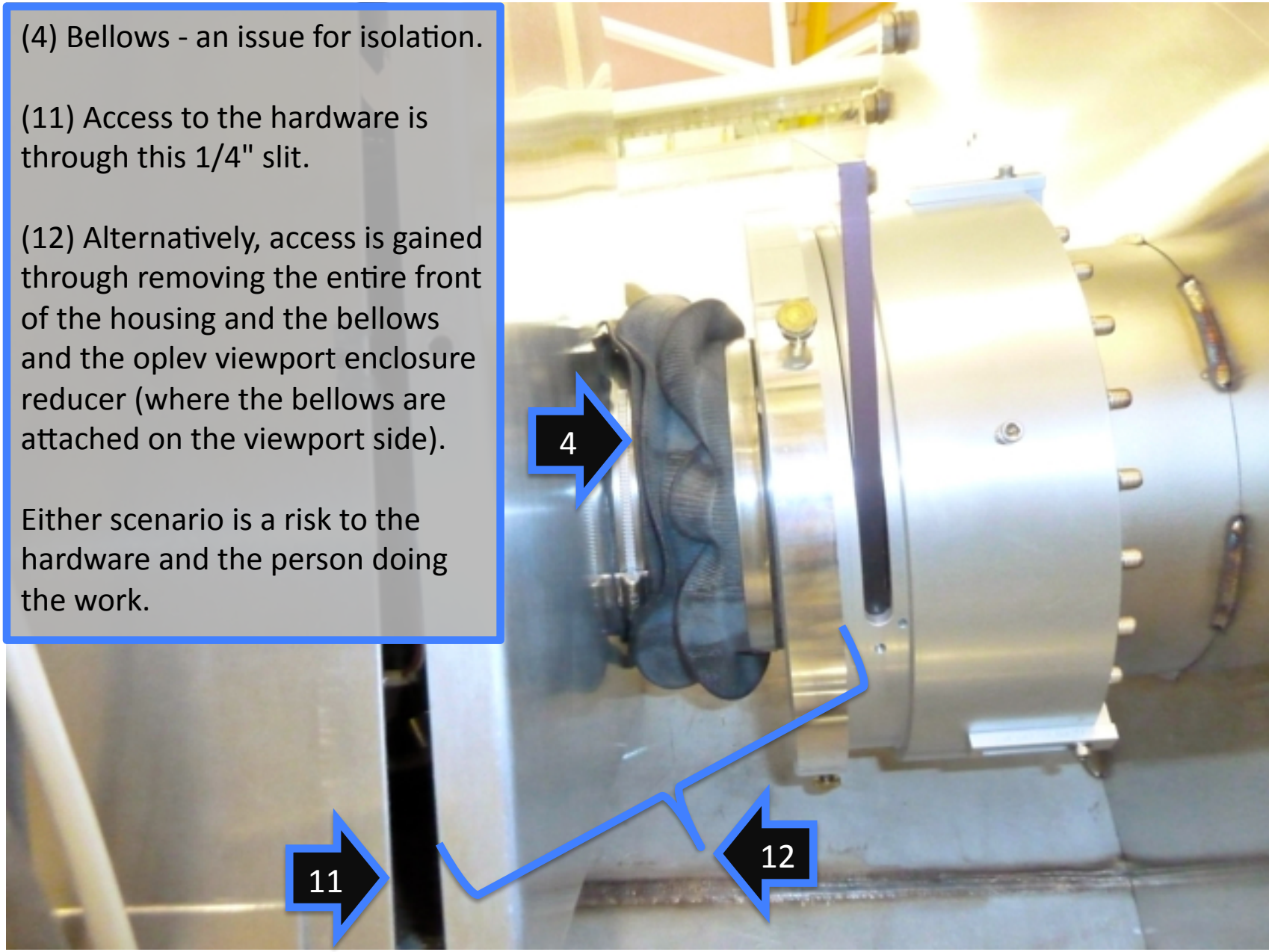
ITMY OpLev Receiver Housing

(4) Bellows - an issue for isolation.

(11) Access to the hardware is through this 1/4" slit.

(12) Alternatively, access is gained through removing the entire front of the housing and the bellows and the oplev viewport enclosure reducer (where the bellows are attached on the viewport side).

Either scenario is a risk to the hardware and the person doing the work.

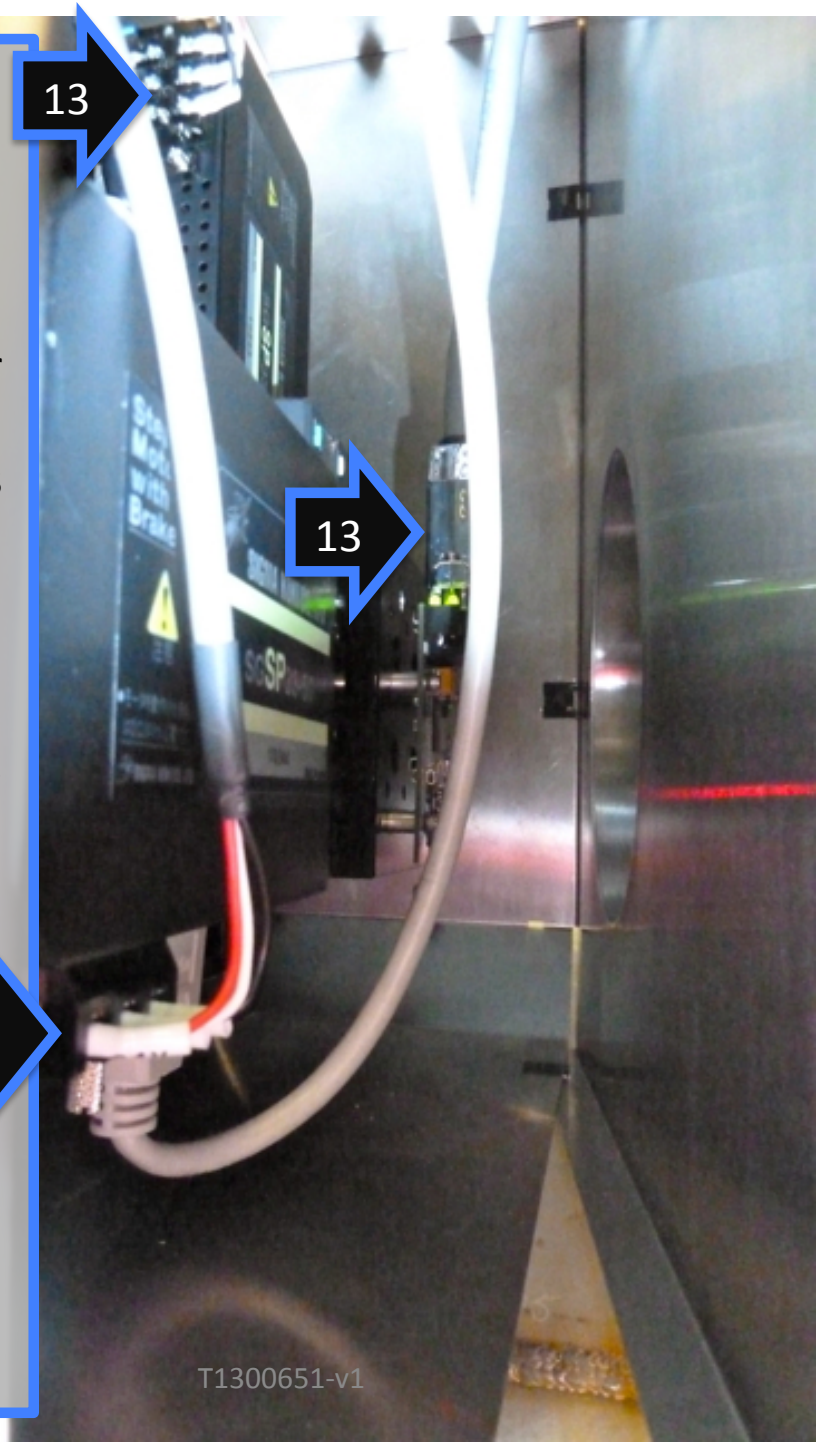


(13a) View through the slit.

Note the exposed raised circuit board, two sets of wires that come in at a 90 degree angle to the cable path, and a connector that is 180 degrees from the cable path. Contact with cables is unavoidable, which puts the cable connections at risk.

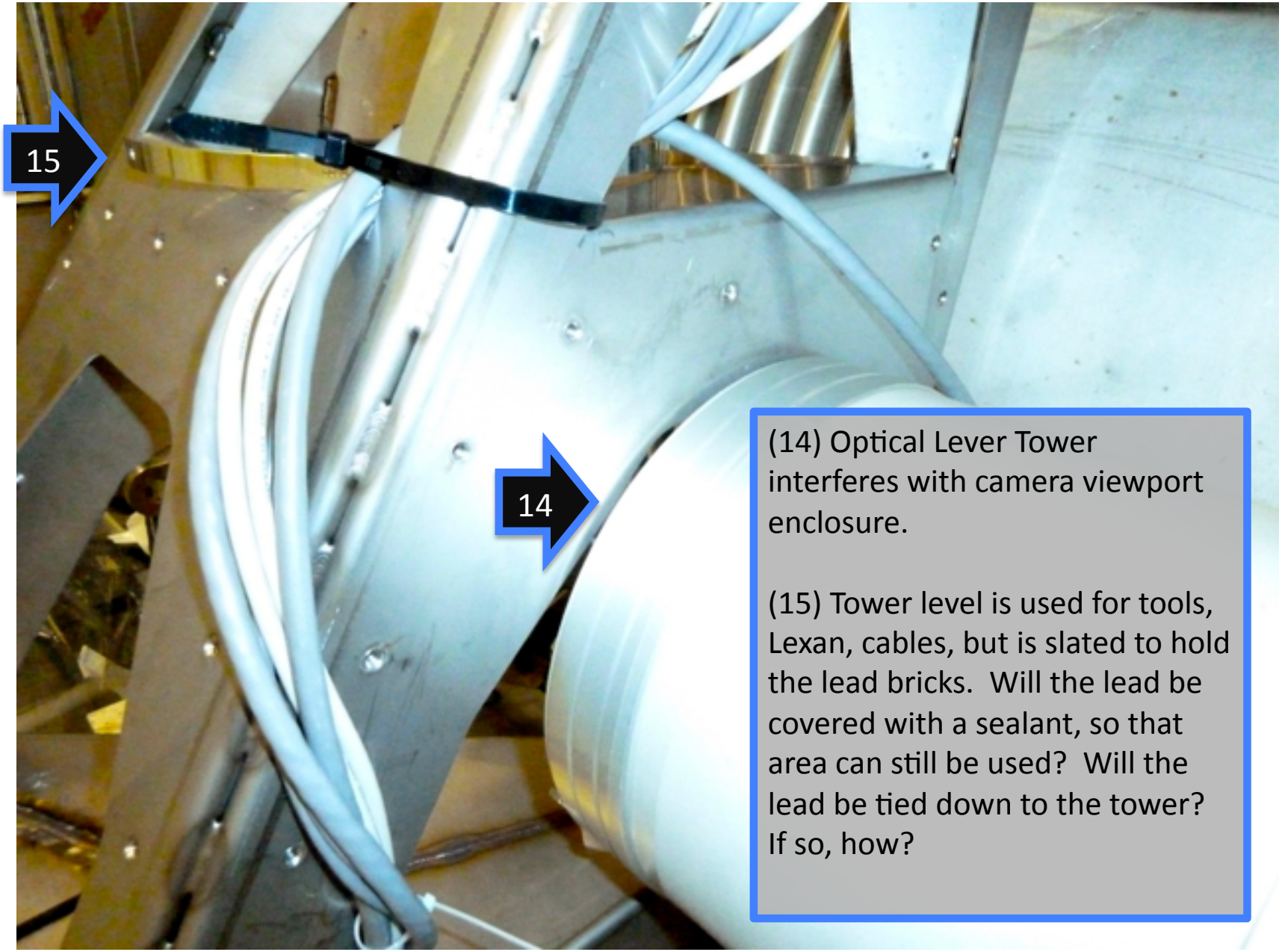
The cables make the back part of the box minimally accessible, and any attempt to work in the box means contact with the stepper motor and it's cables, which will change the alignment of the receiver.

The stepper motor cables themselves are a tether and alter the position of the receiver.



(13b) View through the slit.

A better view of the top wires folded 90 degrees and apparently under tension.



(14) Optical Lever Tower interferes with camera viewport enclosure.

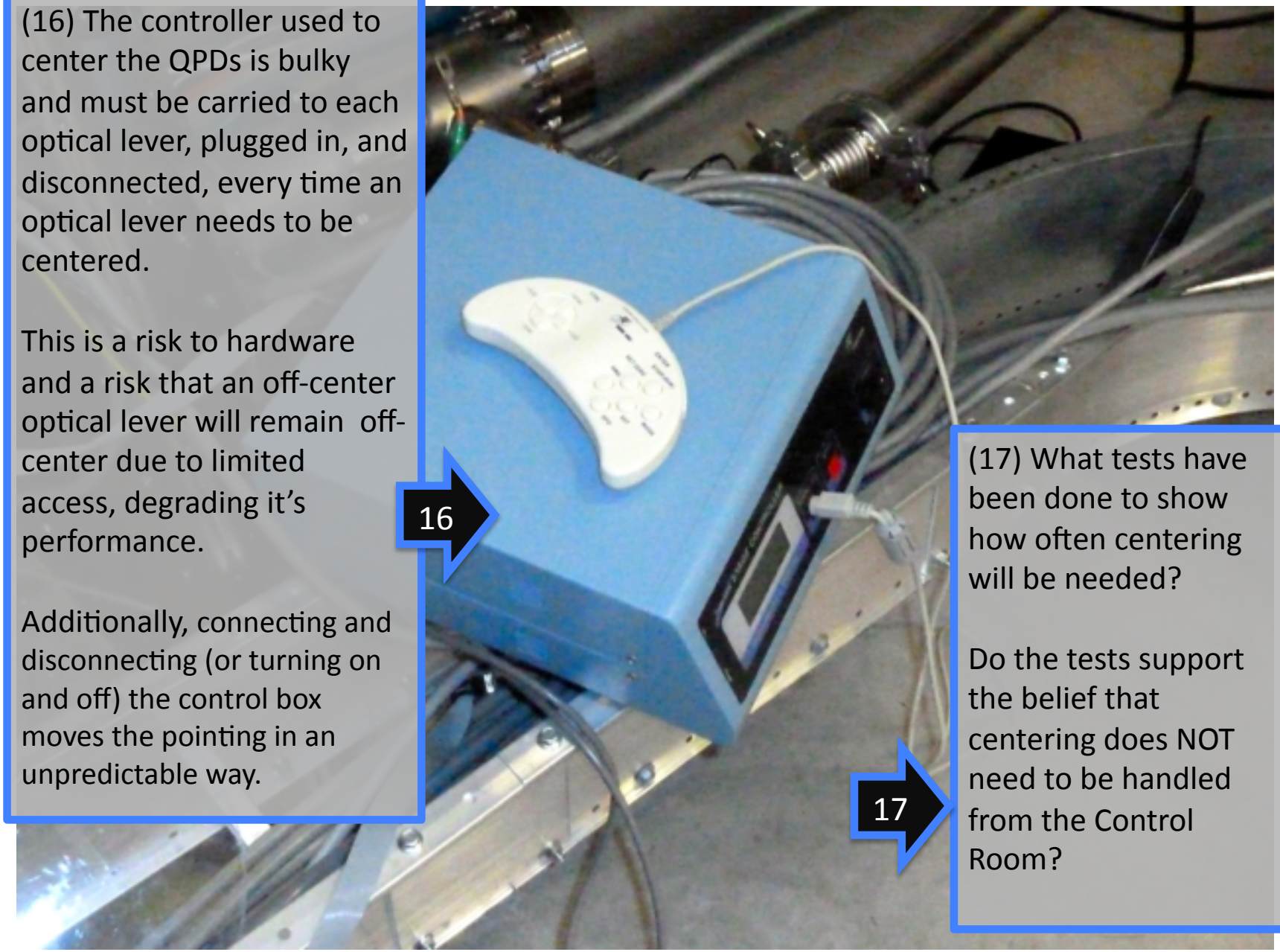
(15) Tower level is used for tools, Lexan, cables, but is slated to hold the lead bricks. Will the lead be covered with a sealant, so that area can still be used? Will the lead be tied down to the tower? If so, how?

All Optical Levers

(16) The controller used to center the QPDs is bulky and must be carried to each optical lever, plugged in, and disconnected, every time an optical lever needs to be centered.

This is a risk to hardware and a risk that an off-center optical lever will remain off-center due to limited access, degrading it's performance.

Additionally, connecting and disconnecting (or turning on and off) the control box moves the pointing in an unpredictable way.

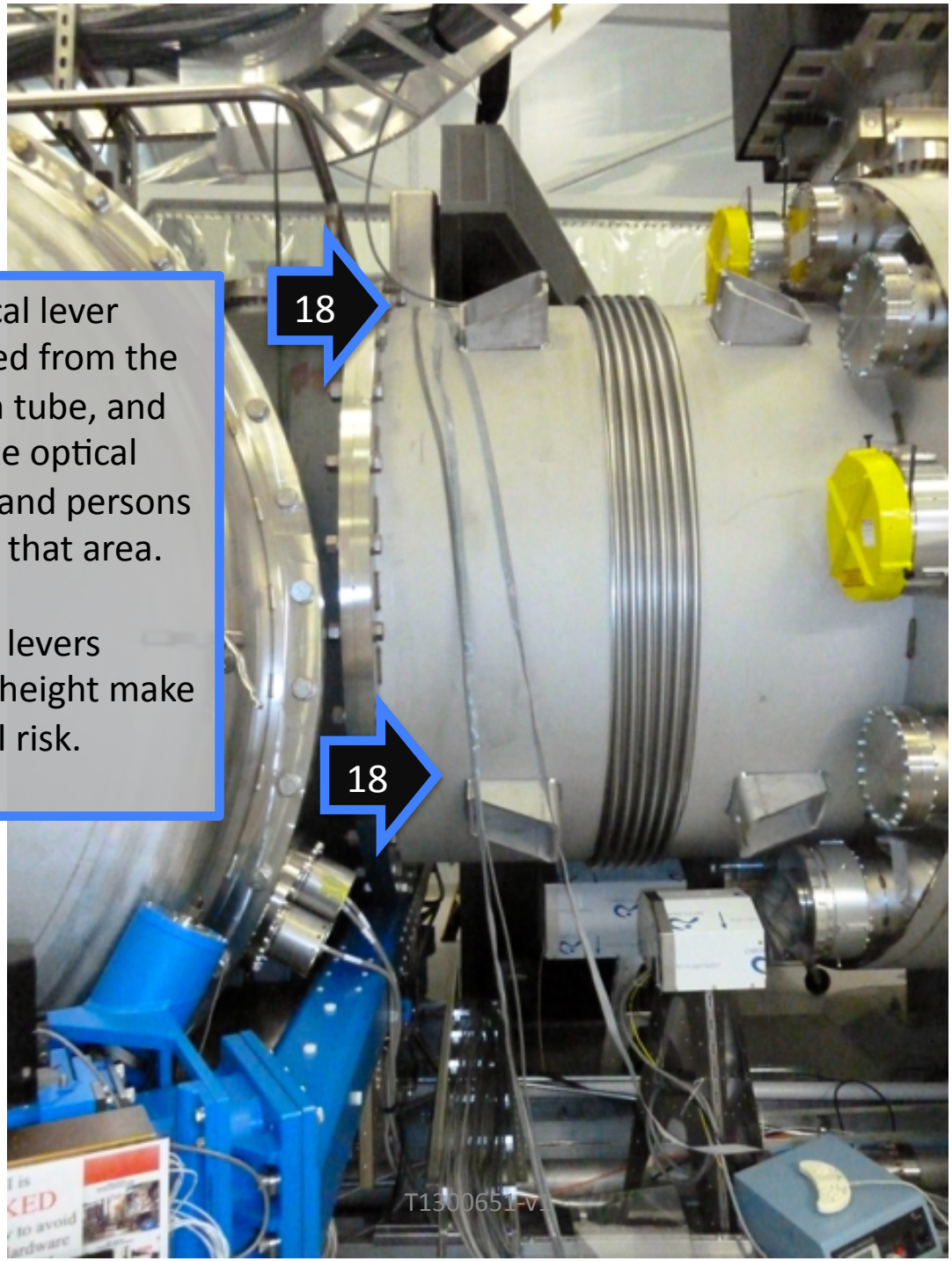


(17) What tests have been done to show how often centering will be needed?

Do the tests support the belief that centering does NOT need to be handled from the Control Room?

(18) These optical lever cables are draped from the top of the beam tube, and pose a risk to the optical lever hardware and persons working around that area.

Multiple optical levers installed at this height make this a non-trivial risk.



Pointing Issue Sources

- Cable installation that puts stress on the QPD receiver stepper-motor
- Cable/fiber strain relief that is either non-existent or poorly implemented
- Cable/fiber connectors that are vulnerable to impact
- Hardware that is known to be, or suspected to be, sensitive to temperature changes
- Know change in alignment due to connecting/disconnecting and powering on/off the centering electronic box

Noise Issues Sources

- Bellows that link the optical lever pier to the vacuum chamber
- Small viewport apertures that increase the risk of clipping
- Lead bricks – if not secured, once moved, will change the noise peaks
- Centering that must be done manually

Contamination Issues Sources

- One-piece housings that expose every part of the optical lever hardware during installation and maintenance
- Housings that require de-installation of bellows, viewport adaptors, etc. for maintenance

Safety Issues Sources

- Difficult access to hardware installed 10 feet above floor level
- Cables for centering the QPD hanging from the top of the beam tube

Summary:

- 18 points of concern identified in just 3 optical lever installations
- Pointing issues, noise issues, contamination issues, and safety issues identified
- Protection from contamination and access for maintenance are at odds with each other due to enclosure/bellows design
- Multiple sources for changes in pointing that stem from the choice of mounting hardware, bellows, fibers, cables, and enclosures
- Manual QPD centering plan that is not yet justified by data

List of my 18 points of concern:

- 1 - poor strain relief of cable
- 2 - fiber connector sensitivity to temperature
- 3 - dissimilar metal issue of the mount - what tests have been done?
- 4 - bellows - connecting the transmitter to the vacuum chamber - poor design
- 5 - viewport aperture design - why so small? Causing beams to be very close to the edge of the aperture
- 6 - one-piece housing a contamination and impact danger to hardware
- 7 - bellows - significant offset from housing - poor design
- 8 - optic inside bellows is an impact and pointing risk
- 9 - dissimilar metals and L-bracket height - risk of pointing issues
- 10 - height alone of ITMY and other optical levers is a risk to hardware and persons working on the oplev - cannot be changed, but it appears that the appropriate consideration for this inherent risk was not taken into account
- 11 - ITMY oplev access through 1/4" slit in the enclosure
- 12 - ITMY oplev access through removing the front of the housing, the bellows, and the viewport adaptor as one large piece, loosely connected together, posing great risk to hardware and persons working 10' above floor height
  13a - exposed electronics and cable placement put hardware at risk during any work inside the enclosure
- 13b - cable installation puts connections at risk
- 14 - tower interferes with camera viewport enclosure
- 15 - tower level used for tools (10' above floor level) - lead being placed here - lead tied down to the tower? covered for safety?
- 16 - external mobile controller for centering - inefficient and a risk to hardware - increase risk of leaving an off-center, thus non-linear, oplev in the off-center state degrading it's performance
- 17 - centering - how often is it needed?
- 18 - oplev cables draped from the top of the vacuum tube - risk to hardware and personnel