Refer to Photon Sources Directorate procedure "Design Reviews" in the Photon Sciences Document Center for complete details and requirements for completing design reviews. Contact the PSD Quality Representative for further guidance.

PHOTON SCIENCES DIRECTORATE
BROOKHAVEN NATIONAL LABORATORY

Report No. PS-DRR-1065
(Obtain from Quality Group)

DESIGN REVIEW REPORT

EDP Report No. (if applicable)

The Design Review Report shall include at a minimum:

- The title of the item or system;
- A description of the item;
- Design Review Report Number;
- The ESH&Q risk level;
- The design parameters;
- The type of design review;
- The date of the review;
- The names and association of the reviewers;
- The major comments and concerns of the reviewers;
- Any reference not appearing in the EDP used to support the design during the Design Review meeting;

TYPE OF REVIEW:

☐ **INITIAL** ☐ **INTERMEDIATE** ☒ **FINAL**

Prepared By:
S. Sherwood

Review Date: 12/6/17

TITLE of ITEM/SYSTEM: **18-ID (FXI) Collimating Mirror Hard Stop**

PRESENTED BY: Wah-Keat Lee

ESH&Q Risk Level: **A-2**
(Application of the Graded Approach Table)

PURPOSE/DESCRIPTION:
The purpose of the collimating mirror hard stops is to limit the motion of the collimating mirror.

REVIEWERS (ASSOCIATION): S. Sherwood (Chair), L. Stiegler (ESH), S. Sharma (Mechanical Engineer), D. Bacescu (Mechanical Engineer), Z. Zhong (Rad Safety), J. Zipper (QA), S. Moss (USI)

Attendees: A. Ackerman, J. Adams, D. Bacescu, B. Kosciuk, B. Lee, S. Sharma, S. Sherwood, J. Zipper,

DISTRIBUTION:
All reviewers and presenter.

Attachments: ☐ **Data Sheets** ☐ **Calculations (Checked and countersigned)** ☒ **Support documentation**
☐ **See Continuation Page** ☐ **Design Checklist**

MAJOR COMMENTS & CONCERNS OF REVIEWERS

Collimating Mirror Hard Stop

A review was held to discuss the findings of Action 1 from the 18-ID (FXI) Collimating Mirror Hard Stop Initial Review – reference design review report PS-DRR-1064. Based on the findings of this review, that action from the Initial Review is considered closed.

Wah-Keat informed the reviewers that documentation pertaining to the breakaway, max torque rating force of the shaft coupler was not available. The FXI team decided to proceed with solution 1 identified in the Initial Design Review report, to manage the stage impact load via a reinforced contact bracket.

Bernie presented his design of a reinforced hard stop. The design takes advantage of additional M8 tapped holes on collimating mirror stages that were noticed when looking at the design in FOE. These holes are currently not being used. Daniel noted some are used for pre-loading linear stage.

Bernie's design uses two blocks with an adjustable screw to set the hard stop position. One block attached to the stationary stage and one is attached to the movable wedge. Advantages of the design were presented, including:

- Design uses larger M8 bolts in shear, rather than previous design using M6 bolts in tension.
- When torqued properly, M8 screws provide enough clamping force and shear stress to withstand the driving force of the collimating mirror stage.
- Uses existing holes, no machining required and simple and inexpensive to manufacture.

Disadvantage is installation of the hard stop on the inboard side of the upstream stage (if necessary) is difficult due to accessibility issues.

The review committee agreed that the new hard stop was only needed for the motor end of the stage and the stop preventing positive vertical motion via the limit switch and encoder housing is robust enough for stopping the motion.

Bernie presented that two M8 bolts in shear are capable of withstanding 18000 lbs which is greater than the driving force of the stage. In order to overcome the driving force of the stage (10000 lbs) and to account for manufacturing tolerance it is assumed the first M8 bolt that is bearing load will begin to plastically deform at which point the second bolt would come into shear contact and provide the stopping force for the stage.

Calculations performed by Bernie show block contact with two M8 bolts provides a clamping force of 3720 lbs.

Members of the review team noted that credit can be taken for the combined static friction clamping force between block and stage and shear strength of bolt. According to Bernie's calculations this would result in a max force of even just one, would overcome the maximum drive force of the stage.

Daniel noted, once the stage comes in contact with the hard stop, if the motor does not disengage equipment failure to the stage will occur.

The review team agreed that the new proposed design of the hard stop is capable of withstanding the driving force of the stage and that one hard stop per stage will be sufficient based on the design and calculations presented.

<u>Actions resulting from the review are identified below and will be included in the NSLS-II Family ATS.</u>

Action Item 1: Tolerance the thru holes on the block for tight tolerances to allow for contact of both bolts act simultaneously.

Action Item 2: Document bolt grade via assembly drawing and include minimum required torque values.

Action Item 3: Document as installed torque value of hard stop bolts via assembly traveler.

REVIEWED DRAWINGS / SPECIFICATIONS	
Presentation file: FXI Hard Stop Design Review.pdf	
APPROVAL:	

Please forward completed original to the PSD Quality Assurance Group.

X

Stephen Sherwood
Design Review Chair
Signed by: Sherwood, Stephen

Sherwood, Stephen

Subject:	18-ID (FXI) Collimating Mirror Hard Stop Mechanism - FDR Part 2
Location:	Bldg. 745 Rm 156
Start:	Wed 12/6/2017 3:00 PM
End:	Wed 12/6/2017 4:00 PM
Recurrence:	(none)
Meeting Status:	Meeting organizer
Organizer:	Sherwood, Stephen
Required Attendees:	Lee, Wah-Keat; Sharma, Sushil; Kosciuk, Bernard; Adams, Julian; Bacescu, Daniel; Zhong, Zhong; Hulbert, Steven; Zipper, Joseph; Stiegler, Lori; Moss, Steven H; Buckley, Michael
Resources:	Bldg. 745 Rm 156

Hi Everyone,

You are invited to follow-up FDR for a Hard Stop Mechanism for the FXI Collimating Mirror. An initial design review was help Nov 11th with the panel recommending pursuing different design options. This FDR will review the FXI teams new design. The presentation and review materials will be sent out prior to the review.

The review team will consist of:

S. Sherwood (chair)
D. Bacescu (Mechanical Engineering)
S. Sharma (Mechanical Engineering)
L. Stiegler (Safety)
Z. Zhong (Rad Safety)
J. Zipper (QA Engineer)

Please let me know if you are not able to attend and advise of a possible delegate, if needed.

Sue- Can you please reserve the room for us?

Thanks,
Steve

18-ID (FXI) Collimating Mirror Hardstop Final Design Review – Part 2 – Attendance Sheet

Date: December 6, 2017

Name	Title	Department/Division or Company
Bob Lee	ESH MGR	NSLS-II
JOE ZIPPON	QA	NSLS II
WAH-KEAT LEE	BL scientist	NSLS II
BERNIE KOSCIUK	M.E.	NSLS II
STEPHEN SHERWOOD	ROS ENGINEER	NSLS-II
Julian Adams	BDN Manager	NSLS II
Ackerman	ESH	NSLS II
Daniel Bocescu	M.E	NSLS II
Sushil Sharma	Group Leader	NSLS II

FXI Collimating Mirror Hard Stop Design Proposal

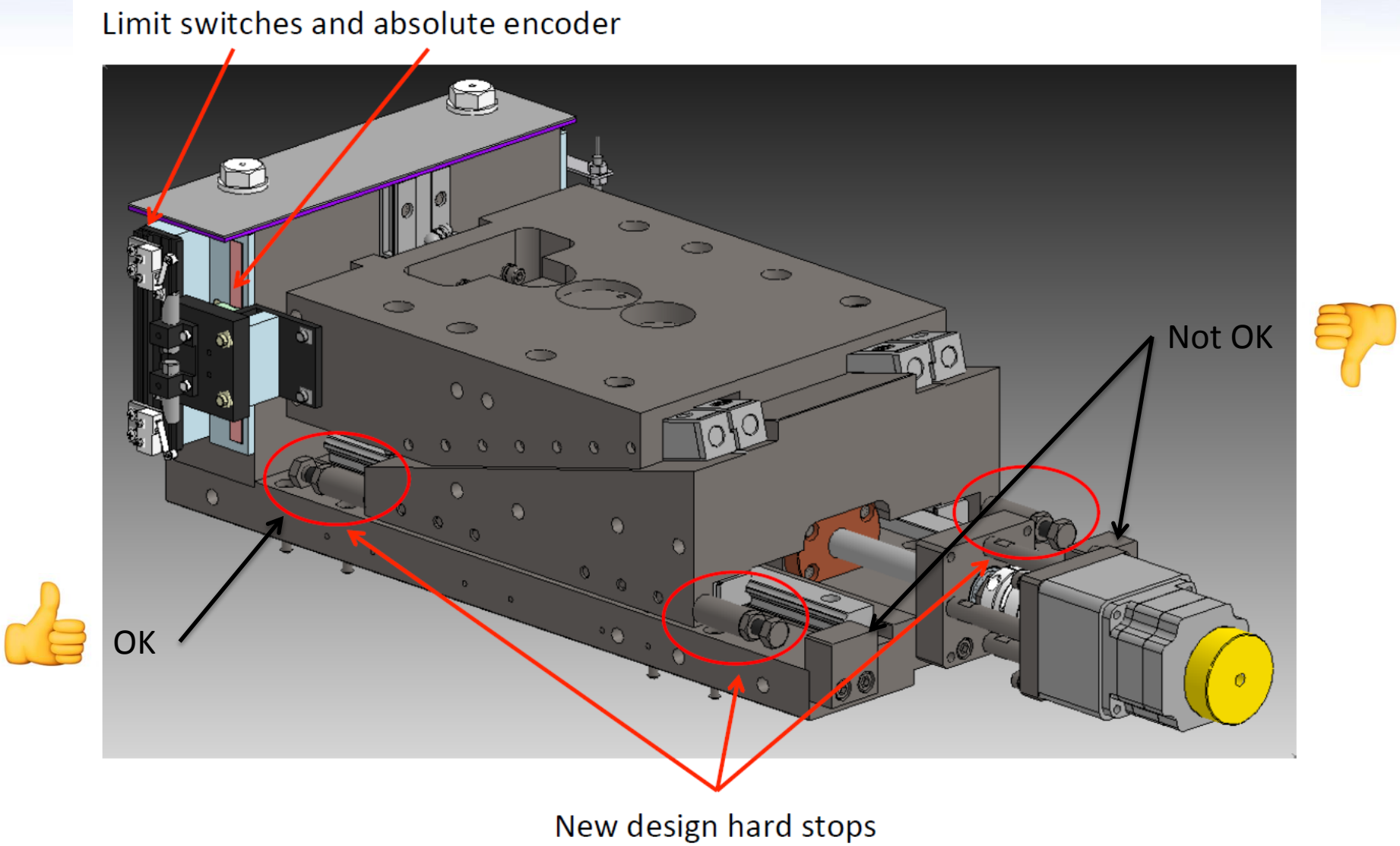
Prepared by Bernard Kosciuk

December 6th, 2017

Outline

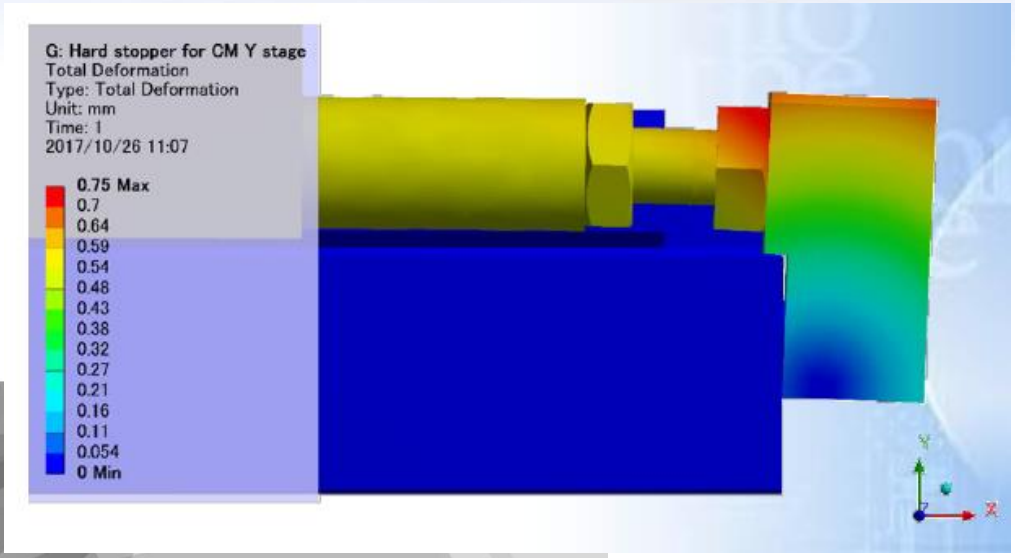
- Current hard stop design provided by Toyama
- Proposed design and its advantages over Toyama design
- Calculations
- Conclusions

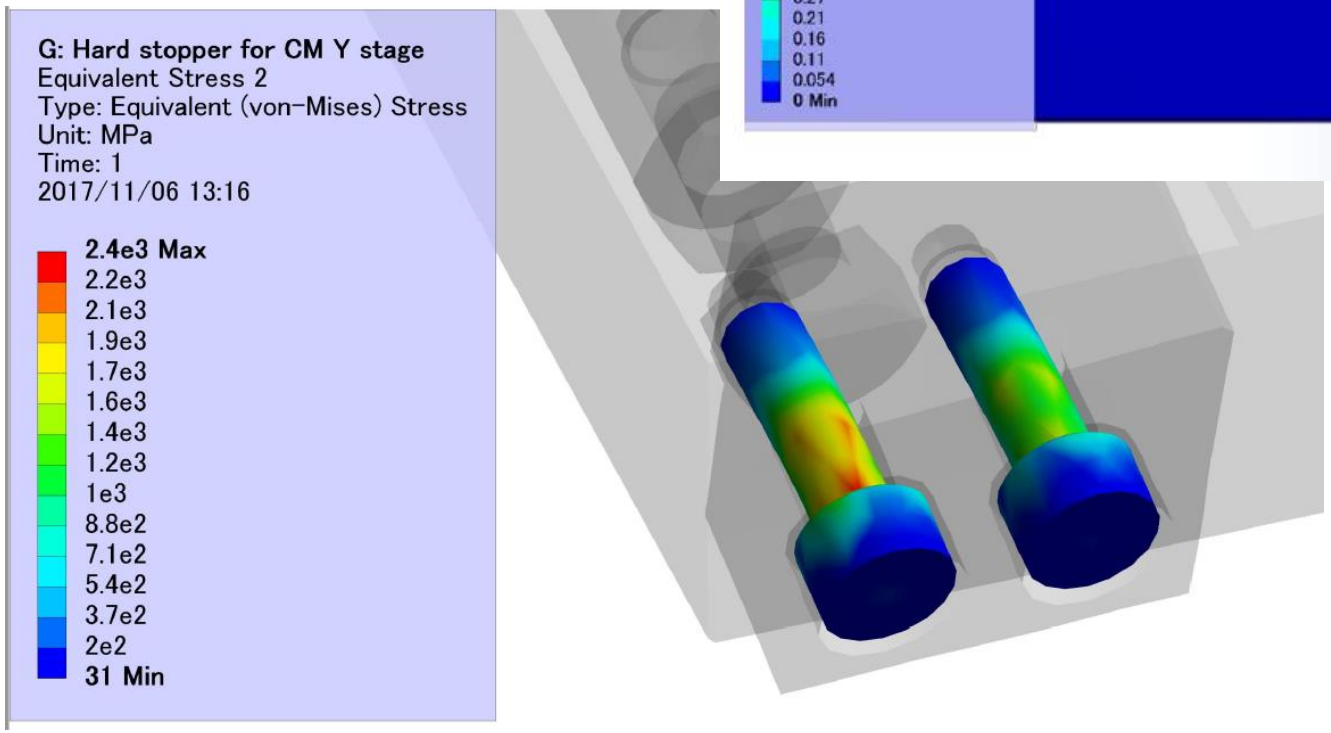
Current Design of Hard Stops (Toyama)



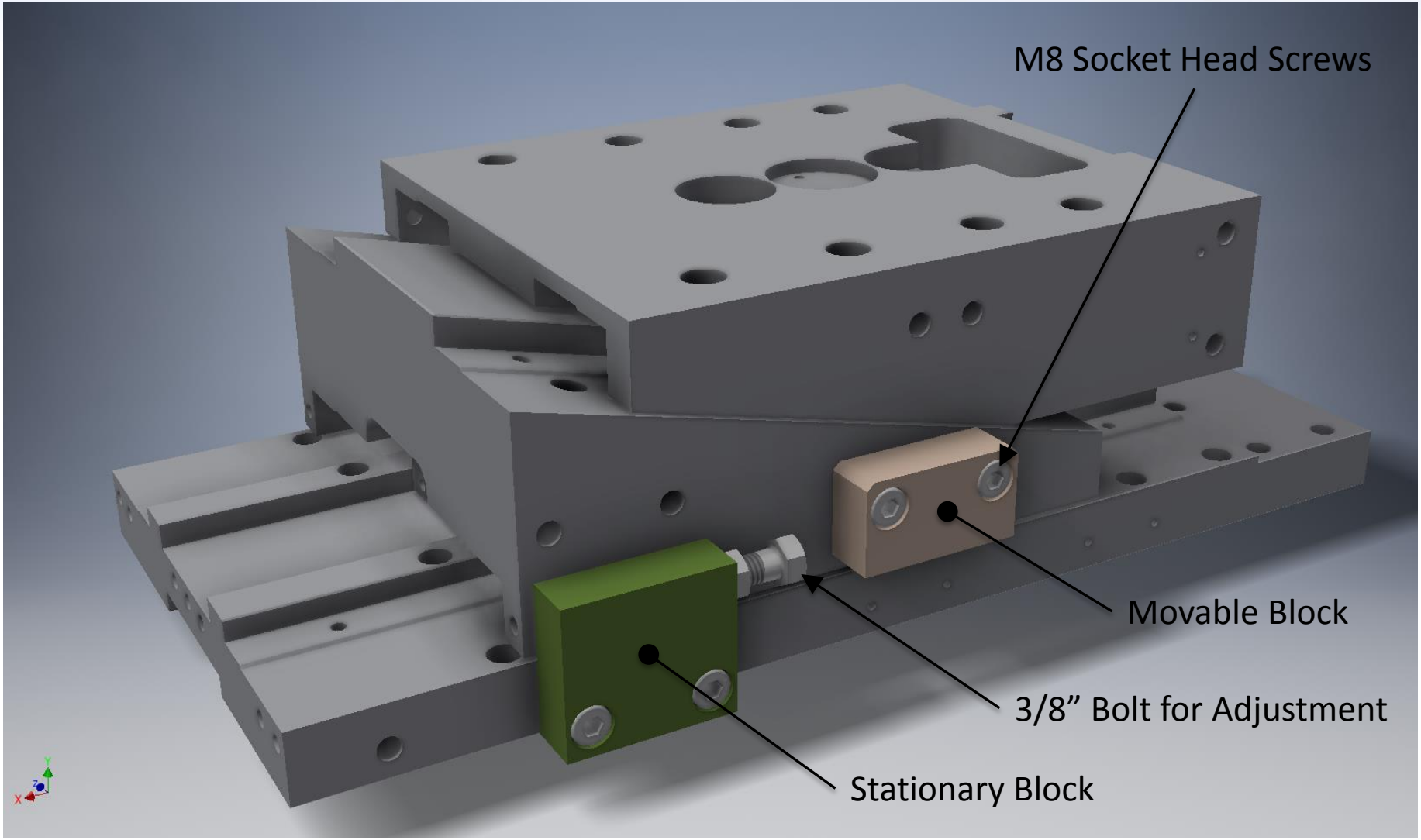
Analysis of Current Hard Stop Design

FEA provided by Toyama shows a failure of the M6 screws under loading.
Findings of 11/7/17 design review concurred.





Proposed Hard Stop Design for Collimating Mirror



Advantages of Proposed Design

- Uses larger M8 bolts that are in shear as opposed to M6 bolts which are in tension. M8 bolt in shear can withstand ~9,000 lbs.
- When properly torqued, M8 screws provide enough clamping force such that the resulting friction between the stop blocks and the stage can bear almost 4000 lbs.
- Utilizes existing holes in the stage to mount hard stop components, no need for in-situ drill and tapping of new holes.
- Components are simple and inexpensive to fabricate.

One disadvantage is that this design cannot easily be applied to both sides of the stage as the far side is not easily accessible.

Friction Calculation

Torque-Tension Relationship for Metric Fasteners

Nominal Dia. (mm)	Pitch	4.6 Class 4.6				8.8 Class 8.8				10.9 Class 10.9				12.9 Class 12.9			
		Clamp Load (lbs)	Tightening Torque Lubricated (ft-lbs)	Tightening Torque Zinc Plated (ft-lbs)	Tightening Torque Plain&Dry (ft-lbs)	Clamp Load (lbs)	Tightening Torque Lubricated (ft-lbs)	Tightening Torque Zinc Plated (ft-lbs)	Tightening Torque Plain&Dry (ft-lbs)	Clamp Load (lbs)	Tightening Torque Lubricated (ft-lbs)	Tightening Torque Zinc Plated (ft-lbs)	Tightening Torque Plain&Dry (ft-lbs)	Clamp Load (lbs)	Tightening Torque Lubricated (ft-lbs)	Tightening Torque As-Received (ft-lbs)	Tightening Torque Plain&Dry (ft-lbs)
4	0.7	333	0.7	0.7	0.9	858	1.7	1.9	2.3	1228	2.4	2.7	3.2	1436	2.8	3.2	3.8
5	0.8	538	1.3	1.5	1.8	1387	3.4	3.9	4.5	1985	4.9	5.5	6.5	2319	5.7	6.5	7.6
6	1	763	2.3	2.6	3.0	1968	5.8	6.6	7.7	2816	8.3	9.4	11.1	3291	9.7	11.0	13.0
7	1	1095	3.8	4.3	5.0	2822	9.7	11.0	13.0	4039	13.9	15.8	18.5	4720	16.3	18.4	21.7
8	1.25	1389	5.5	6.2	7.3	3580	14.1	16.0	18.8	5123	20.2	22.9	26.9	5987	23.6	26.7	31.4
10	1.5	2200	10.8	12.3	14.4	5671	27.9	31.6	37.2	8115	39.9	45.2	53.2	9484	46.7	52.9	62.2

Clamp Load for a high quality M8x1.25 bolt is ~**6000 lbs.**
Coefficient of Static Friction (steel on steel) is **0.31**

2 Bolts x 6000 lbs x .31 = **3720 lbs**

If stage components are stainless steel, the tightening torque will be reduced so as not to strip the threaded holes. Clamping force will be reduce accordingly.

Conclusions

- The proposed hard stop design is more robust than the current design provided by Toyama and should be sufficient to stop all motion of the stage.

- The components for this hard stop design are inexpensive to fabricate and simple to install, requiring no in-situ drilling/tapping.

- This hard stop design cannot easily be installed on the far side of the stage due to limited access. If installed on the near side as proposed, the hard stop would bear the entire load of the stage.