Final Design Review for the new 18-ID (FXI) collimating mirror hard stop mechanism

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November 7, 2017

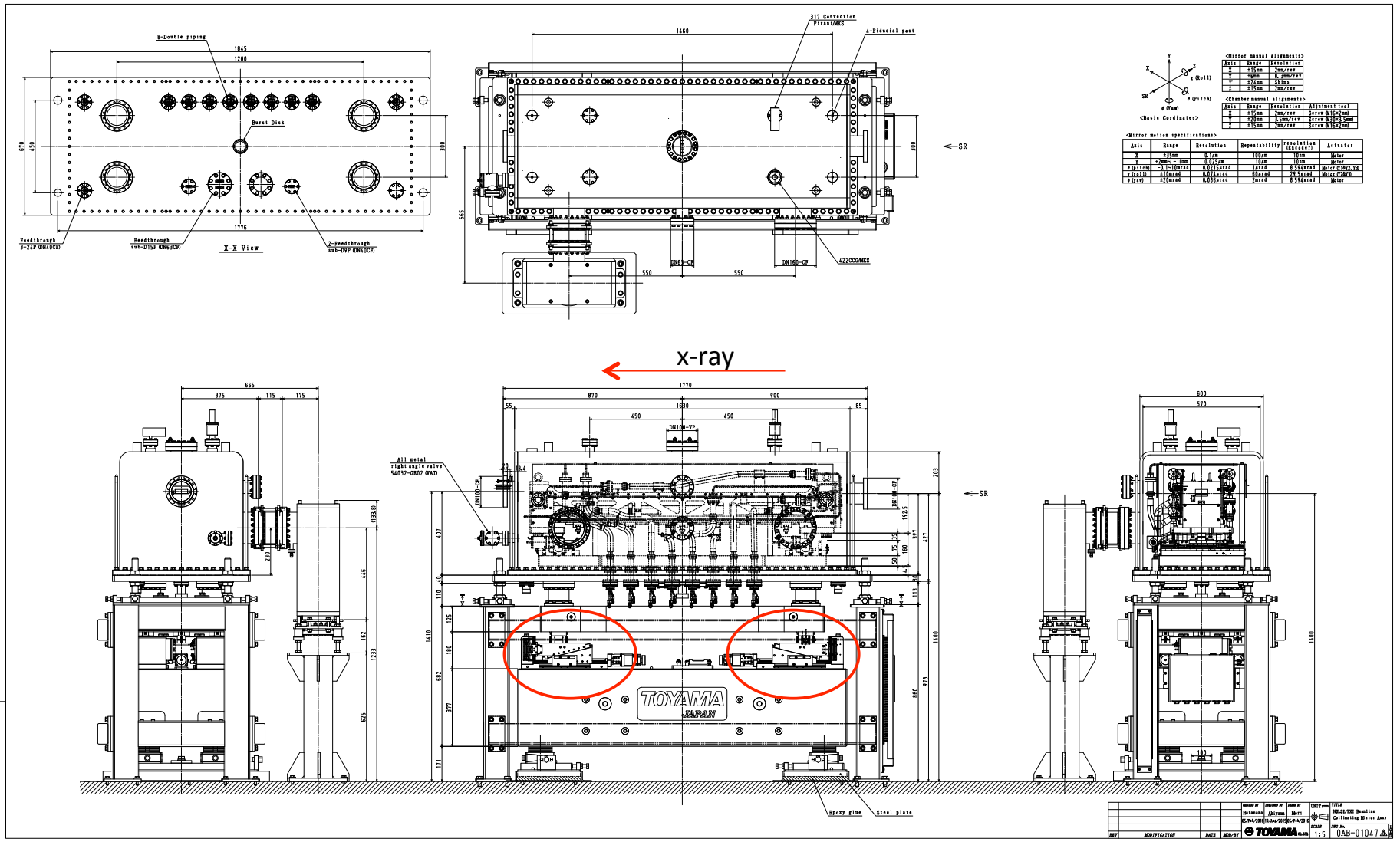
Issue:

At 18-ID (FXI) beamline, the pink beam reflected from the collimating mirror (white beam optic) can have up to ~ 1 kW power. In order to ensure the safe capture of the pink beam, motion limits on the mirror are needed.

The vendor has designed and implemented hard-stops for the associated mirror stages, but these were deemed insufficient by the IRR committee.

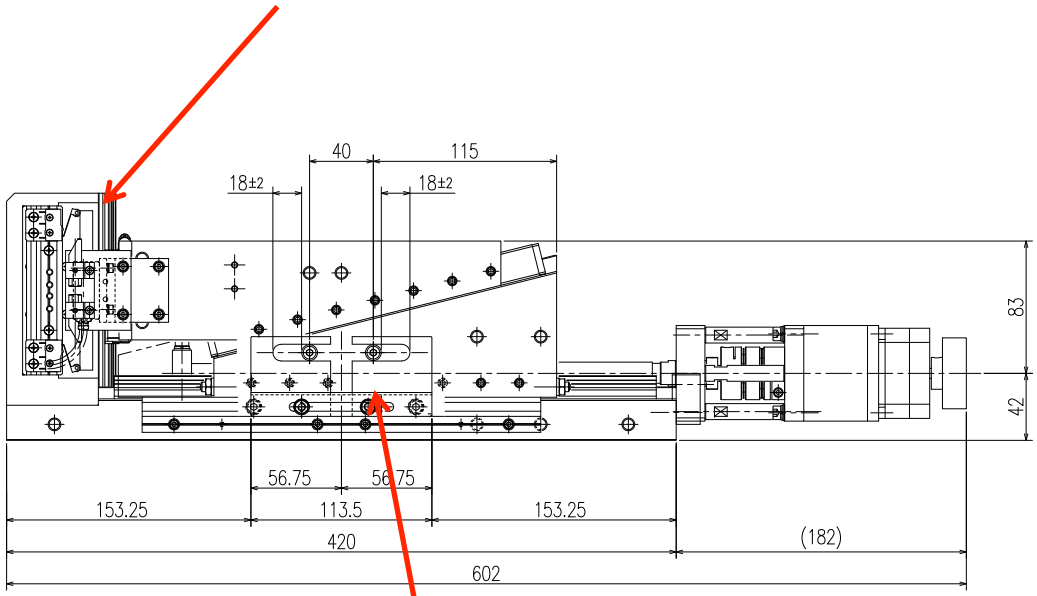
The charge for this committee is to review the new hard-stop design and analysis from the vendor.

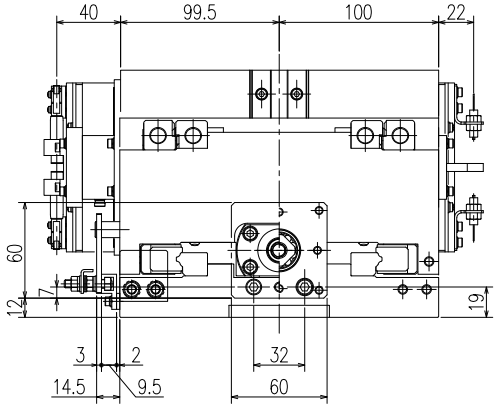
Pink beam from CM is ~ 1 kW.
Need to consider mis-steered pink beam.



Mirror base is supported kinematically by 3 vertical 'wedge' jacks to enable Y translation, pitch and roll

Motion limit switches and absolute encoder





Old hard-stop design (implemented)

Note). The wedge is X:Y=4:1 ratio

				CHECKED BY	DESIGNED BY	DRAWN BY	UNIT:mm	TITLE	
				Akiyama	Akiyama	Mori		Hard stopper	
				15/Sep/2017	15/Sep/2017	15/Sep/2017			
1	HARDSTOPS SET TO ENABLE 18mm +/- 2mm TRAVEL	9/15/2017	CL	TOYAMA CO., LTD.			SCALE 1:2	DWG No. 150183DD-1	⚠
REV	MODIFICATION	DATE	MOD/BY						

Additional information:

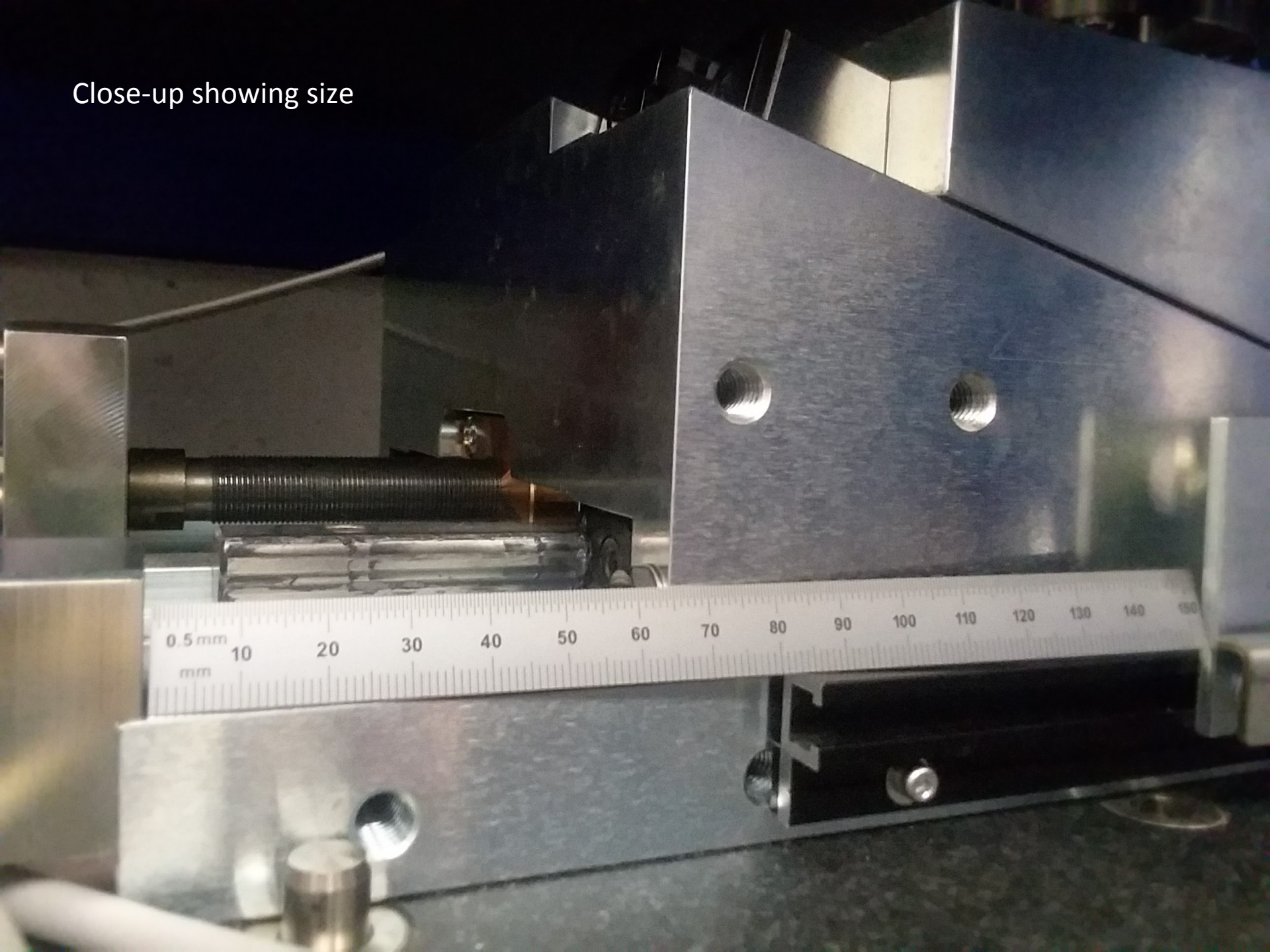
There are usual motion limit switches that are set 'inside' the hard-stop range

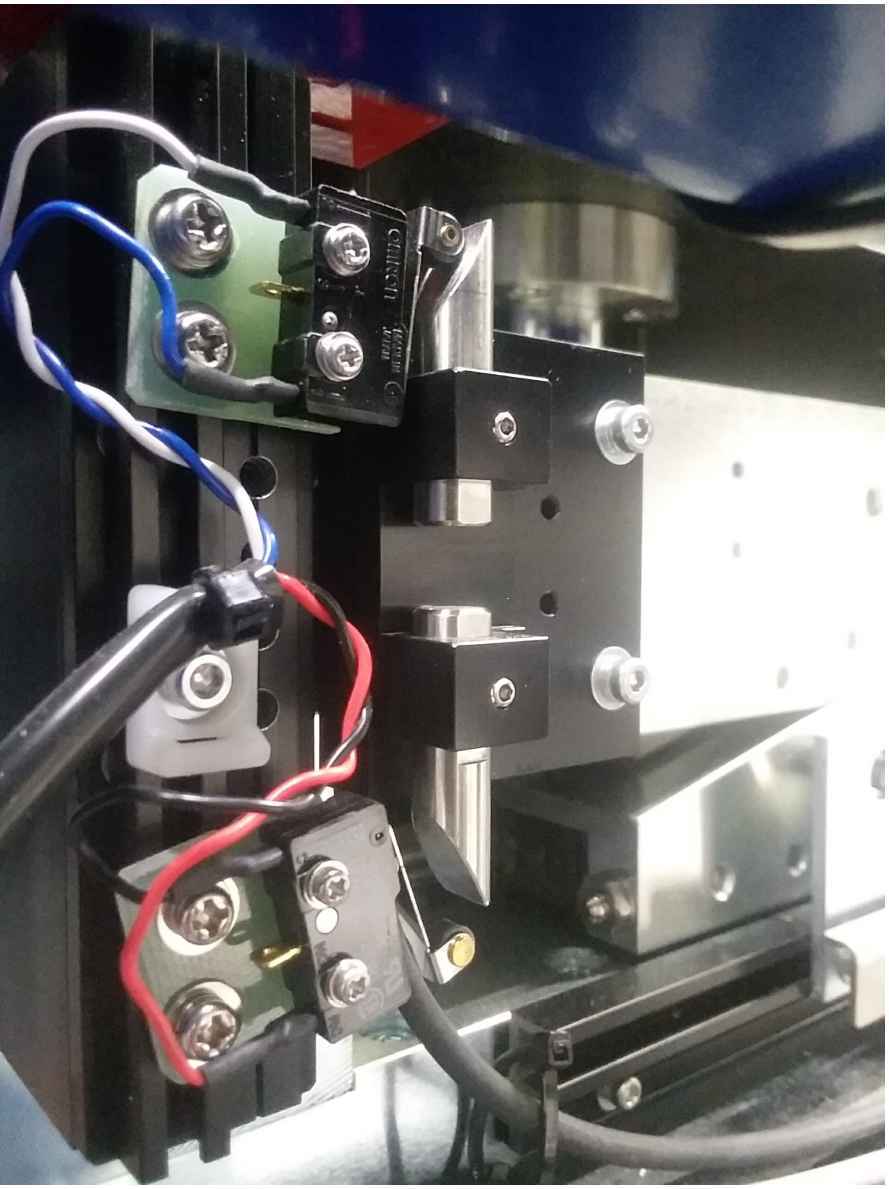
The stages are encoded with absolute encoders

The DeltaTau motion controller is run in a closed loop manner with the absolute encoders

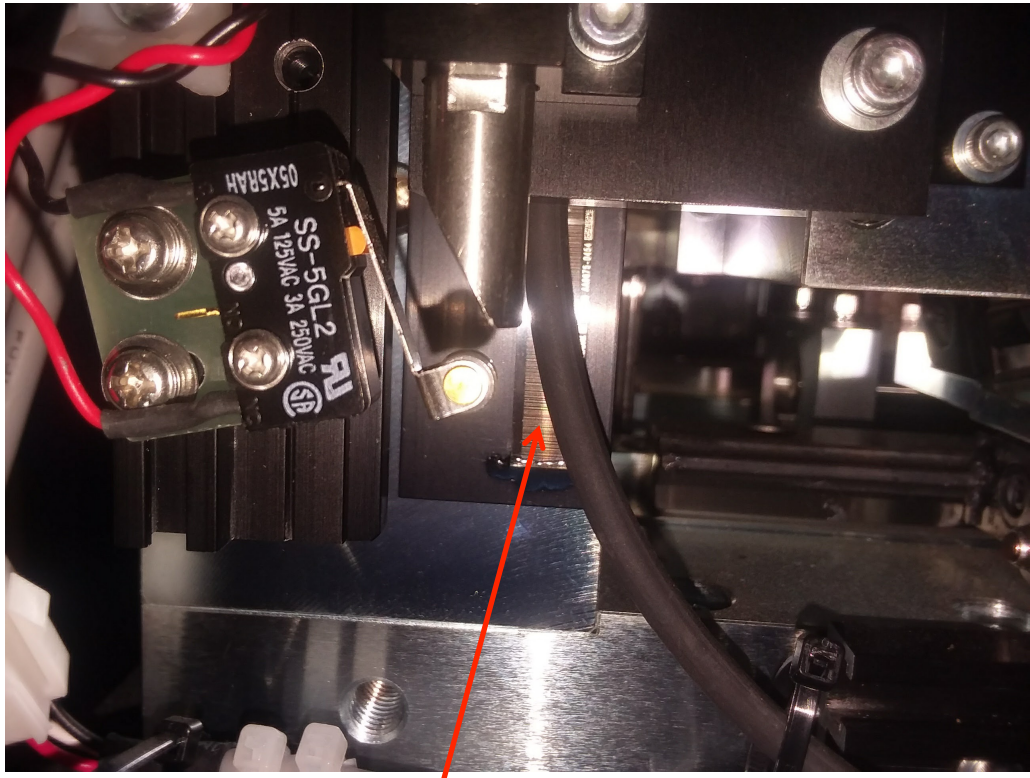
In the event that the stage hits resistance and does not move by the right amount (following error), the DeltaTau will cut power to the motor

However, these are not considered as 'credited control' for safety. That is why a 'hard-stop' is needed.

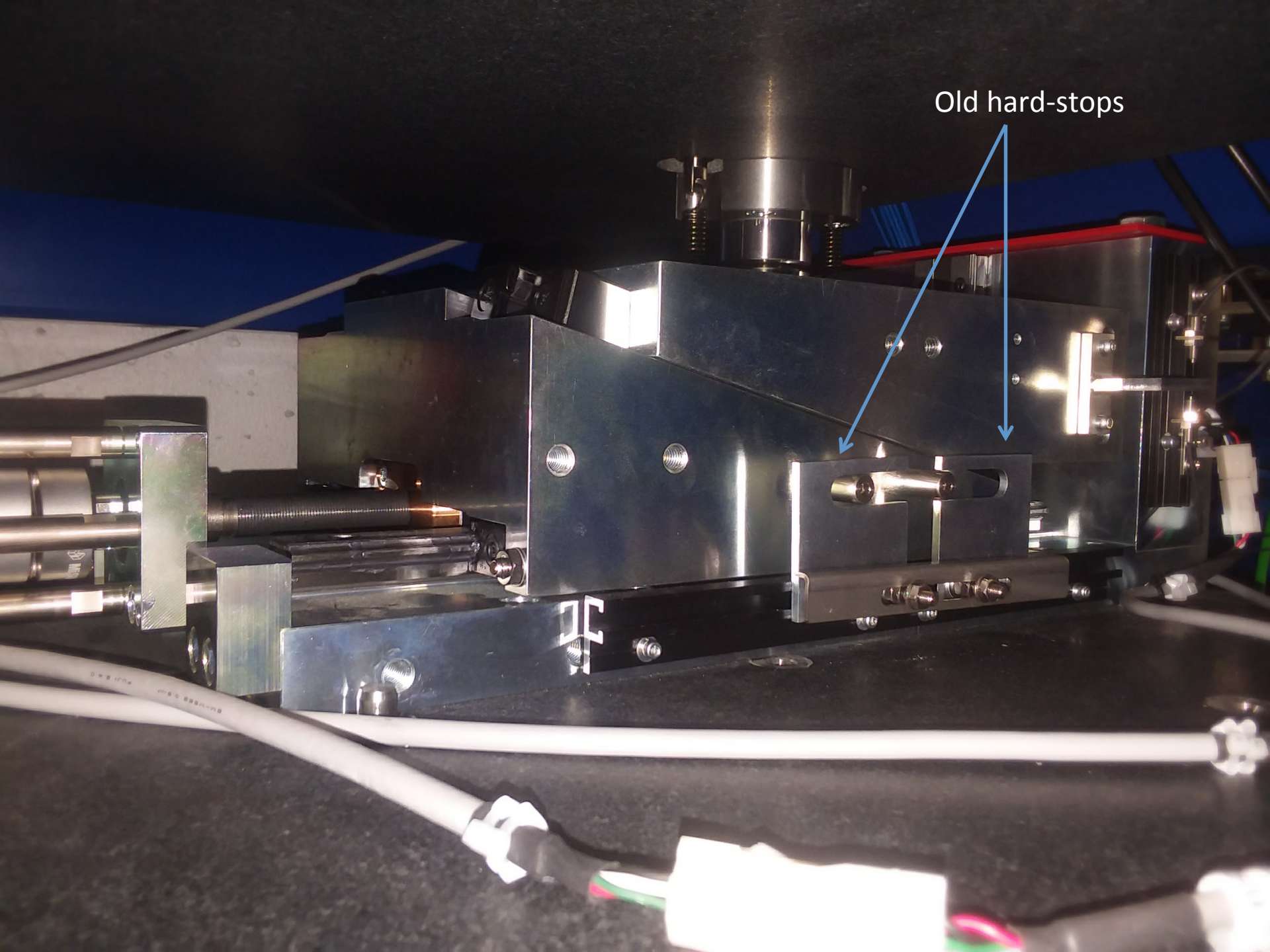

Close-up showing size
0.5 mm
mm
10
20
30
40
50
60
70
80
90
100
110
120
130
140



Limit switches

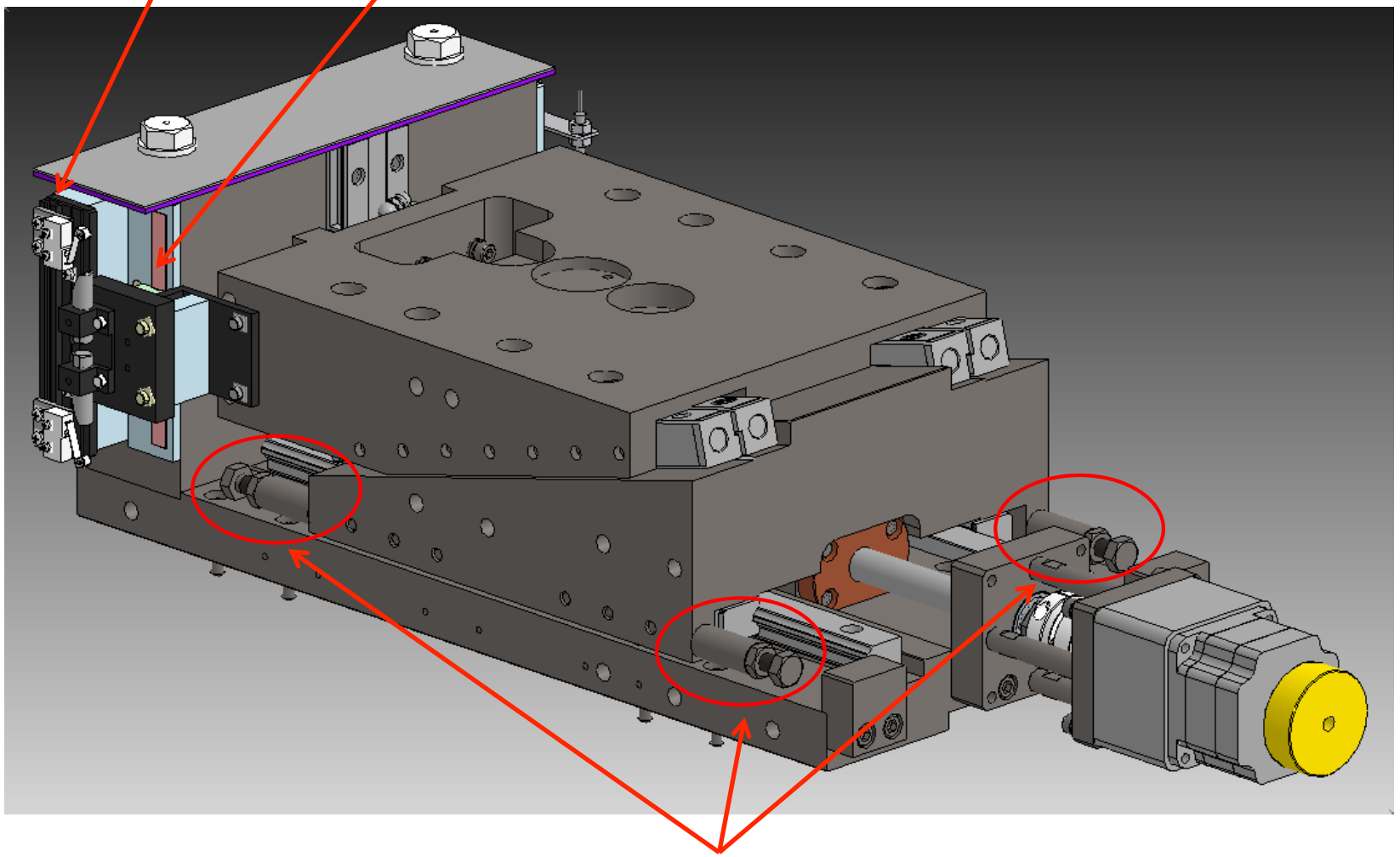


Absolute encoder


Old hard-stops

New hard-stop design

Limit switches and absolute encoder



New design hard stops

Basis for driving force used in FEA (vendor (Toyama) supplied information)

$F = 2\pi\eta T/R$
T = Torque = 0.48 N-m (motor specs)
R = Screw lead = 1 mm
η = Efficiency that converts torque to driving force = 0.3
F = driving force

F = 904 N
The motor has a 50X gear reducer: 904 N x 50 = 45200 N

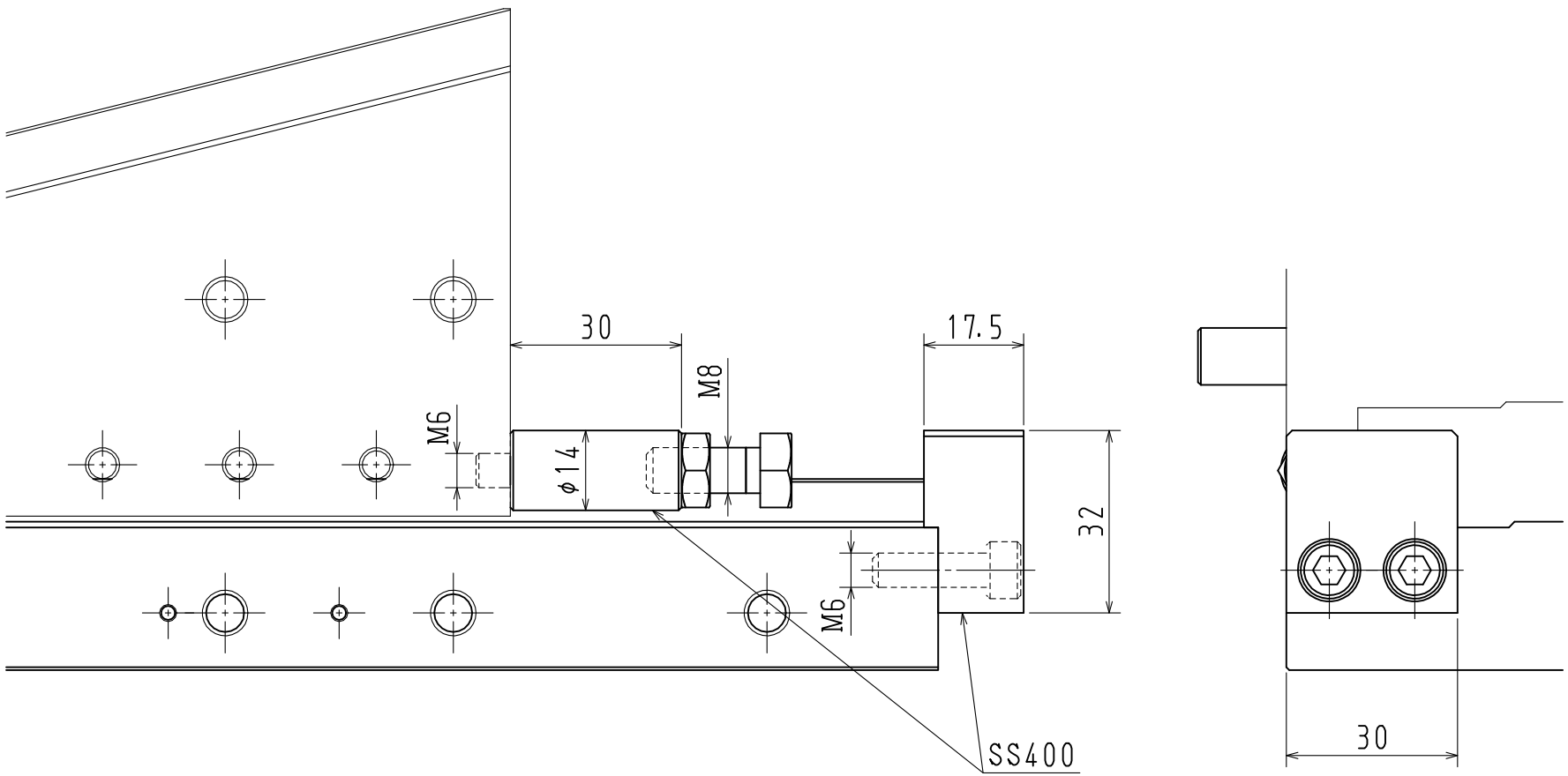
There are two hard stops each direction: 45200 N/2 = 22600 N

So, for FEA (half model), use 22600 N as driving force.

Structural analysis for FXI CM hard stop

October. 27, 2017

***TOYAMA** Co., Ltd*


30
17.5
M8
M6
φ14
32
M6
SS400
30

Analysis model

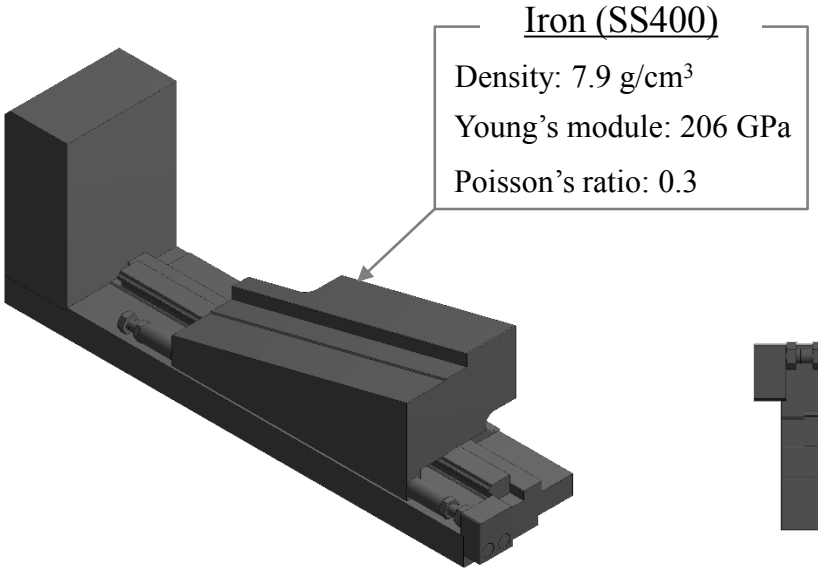


Fig.1.1 Bird's eye view

Fig.1.2 Top view

Fig.1.3 Front view

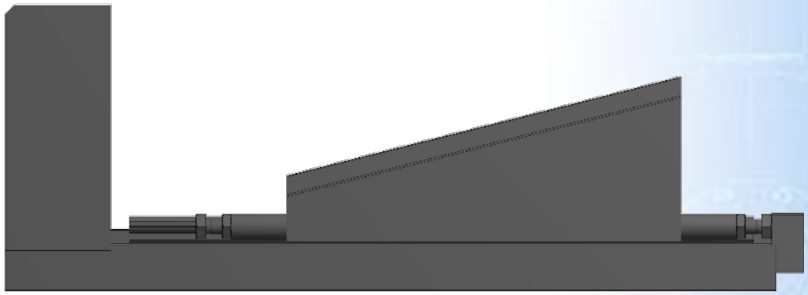


Fig.1.4 Side view

Contact condition

We assumed that the following two contact surfaces are permitted to slide without separation.
All other than these two locations are adherence.

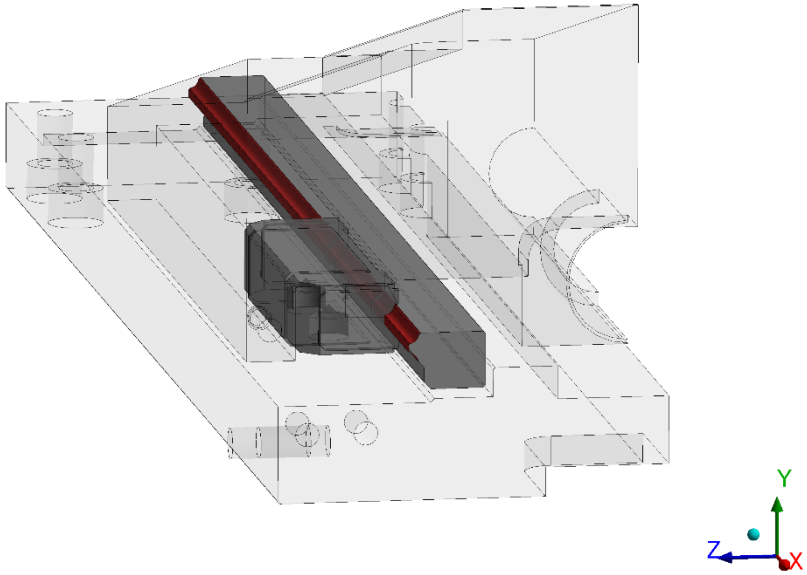


Fig.2.1 Slide rail

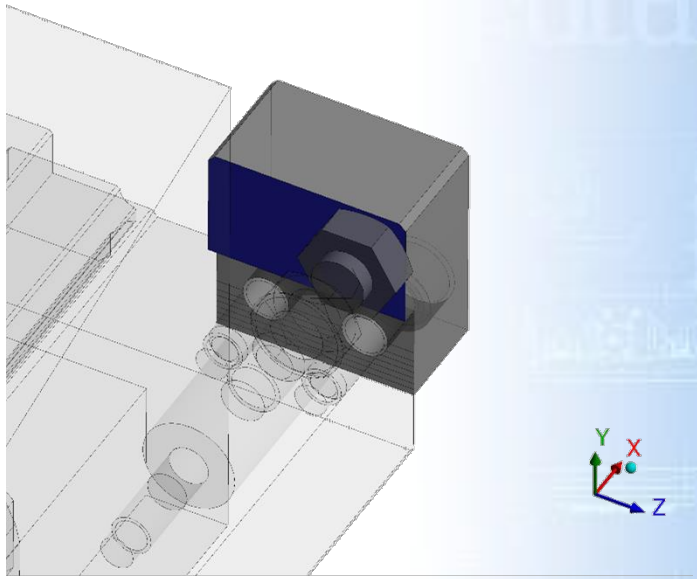


Fig.2.2 Between the stopper block and the bolt

Boundary conditions

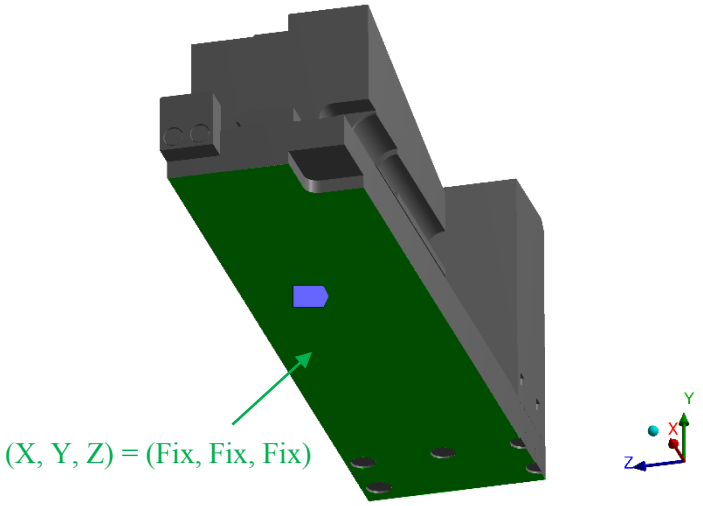


Fig.3.1 Support condition

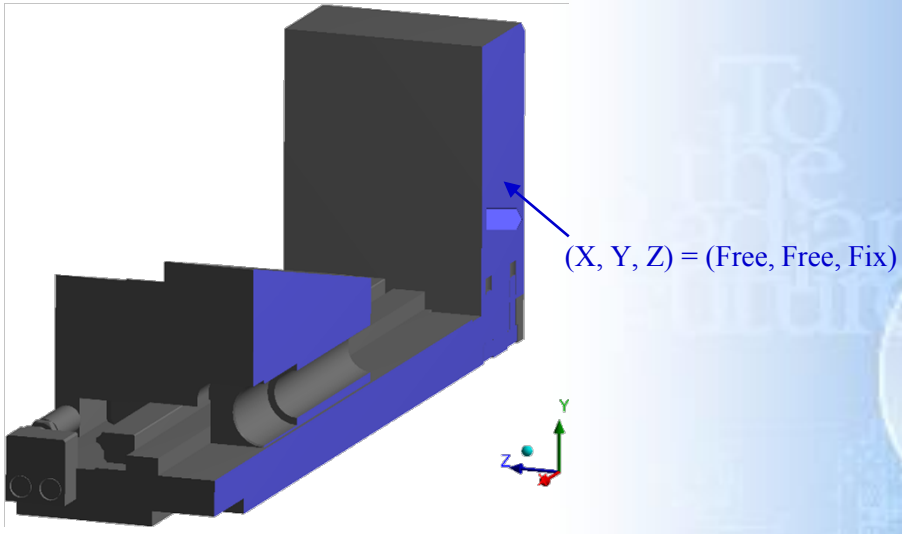


Fig.3.2 Boundary condition for half model

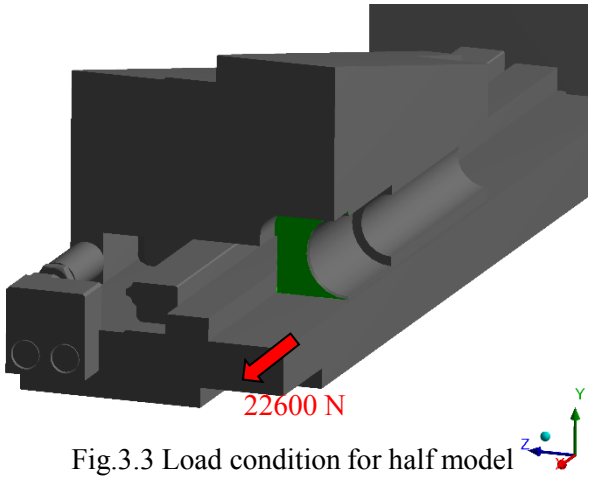


Fig.3.3 Load condition for half model

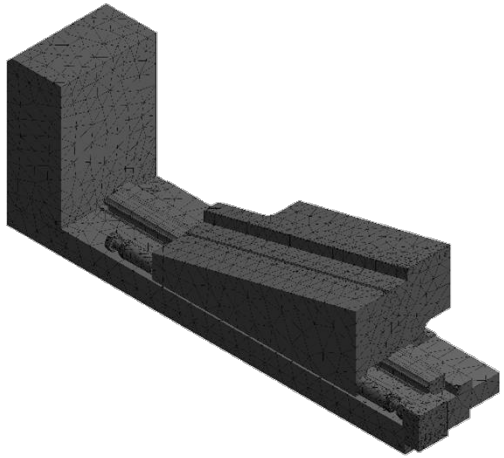


Fig.3.4 Mesh condition

* Analysis was carried out with a half model since it's symmetric.
* Load force of 22600 N corresponds to motor maximum torque of 0.48 N・m.
* All parts are Iron (SS400).

Analysis result

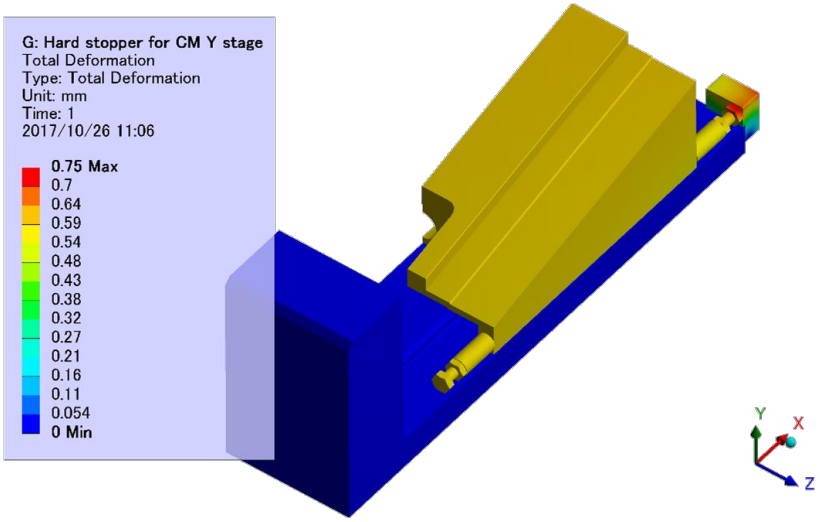


Fig.4.1 Deformation profile

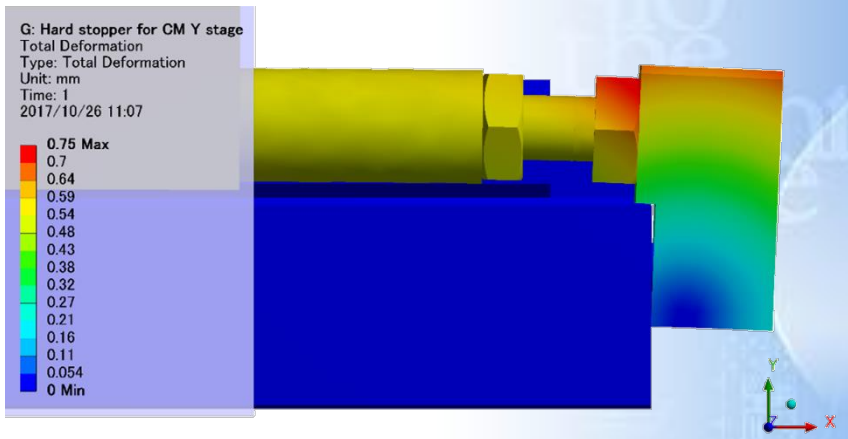


Fig.4.2 Enlarged view of the hard stopper

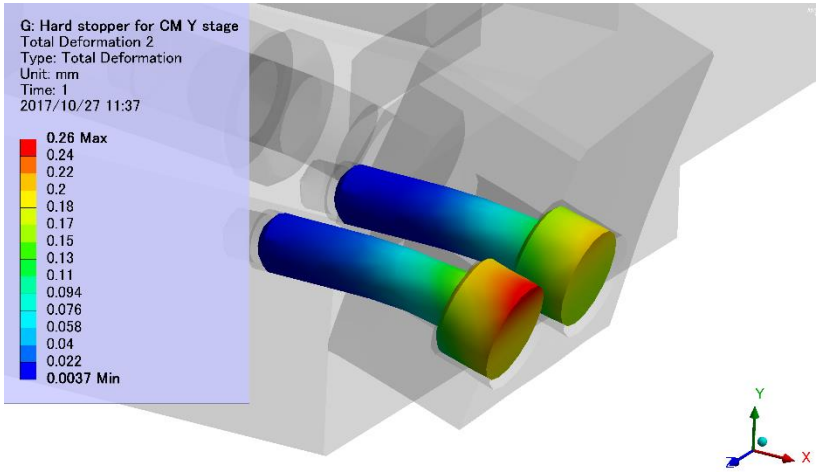
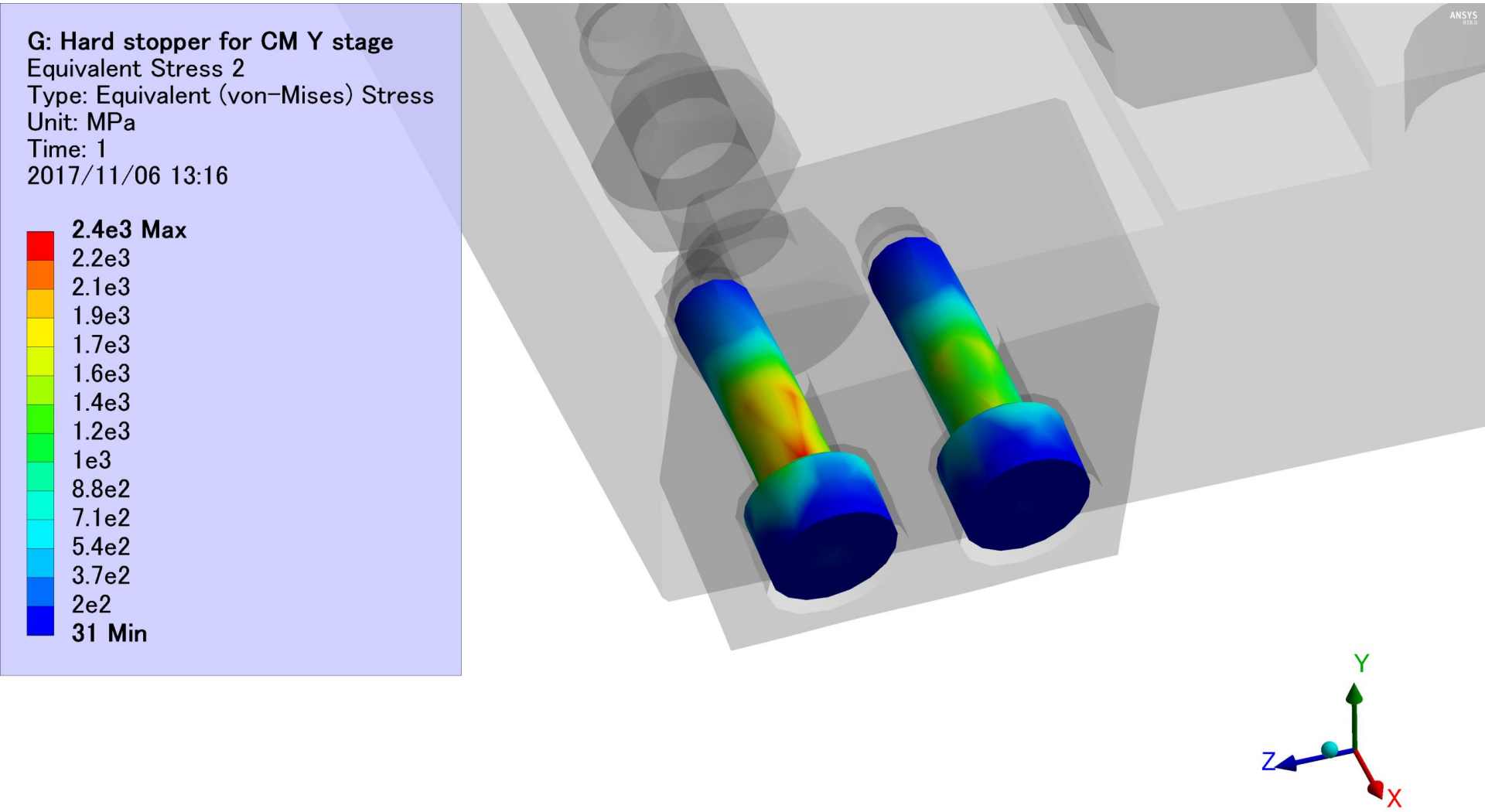


Fig.4.3 Bolt deformation profile


G: Hard stopper for CM Y stage
Equivalent Stress 2
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
2017/11/06 13:16
2.4e3 Max
2.2e3
2.1e3
1.9e3
1.7e3
1.6e3
1.4e3
1.2e3
1e3
8.8e2
7.1e2
5.4e2
3.7e2
2e2
31 Min
ANSYS
Y
Z
X