PAUL SCHERRER INSTITUT

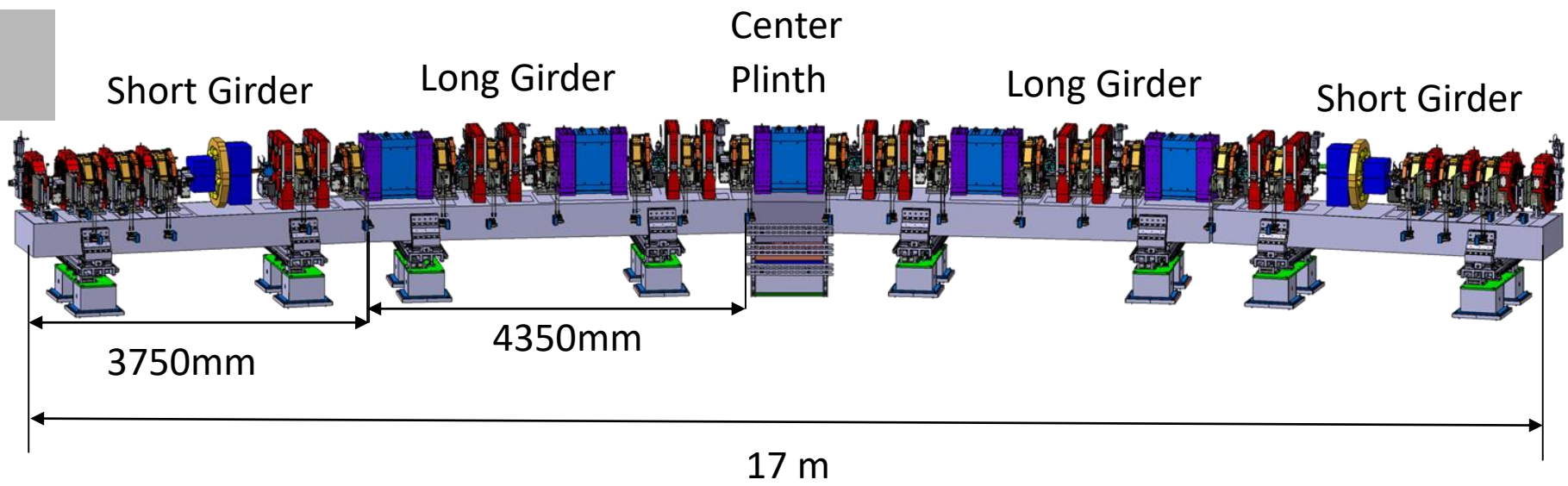
PSI

SLS 2.0 TDR

SLS 2.0 Girder Overview

Haimo Jöhri / Maximilian Wurm

Sector overview



This is an overview of 1 of the 12 sectors:

- 1 arc consists of 1 center plinths and 4 Girders
- In total SLS 2.0 will include 48 Girders and 12 Plinths

Mechanical Requirements

Motorized adjustments (beam based alignment)

- Height and pitch (height on each end)

  range +/- 0.5mm, resolution < 1 micrometer

- Roll:

  range +/- 0.5 millirad, resolution < 1 microrad

Manuel adjustments (During installation and later in shutdowns)

- All adjustments by shimming
- Height on each end : +/- 2.5mm with a wedge-mechanism

Mechanical Requirements

Material:

- Non magnetic

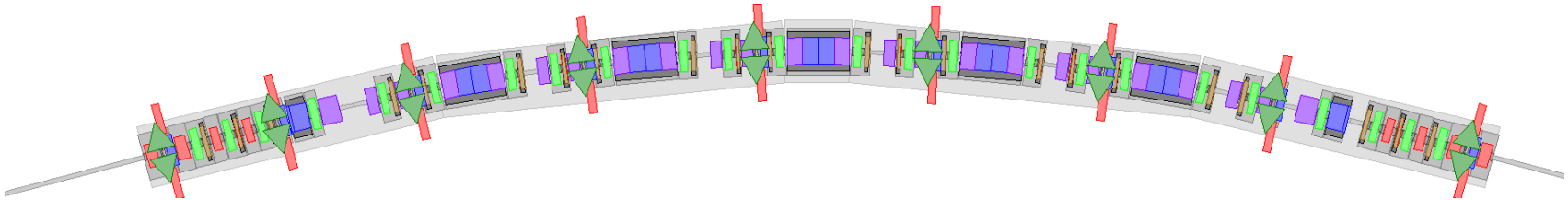
Size:

- Beamheight : 1.4m
- Space (height) for magnets : 400mm (change to 450mm)
- Width: max 1200mm, main body max. 800mm
- Main cooling pipes under the girders

Adjustments

- Cones for lasertracker (lasertracker will define the precision of the installation)

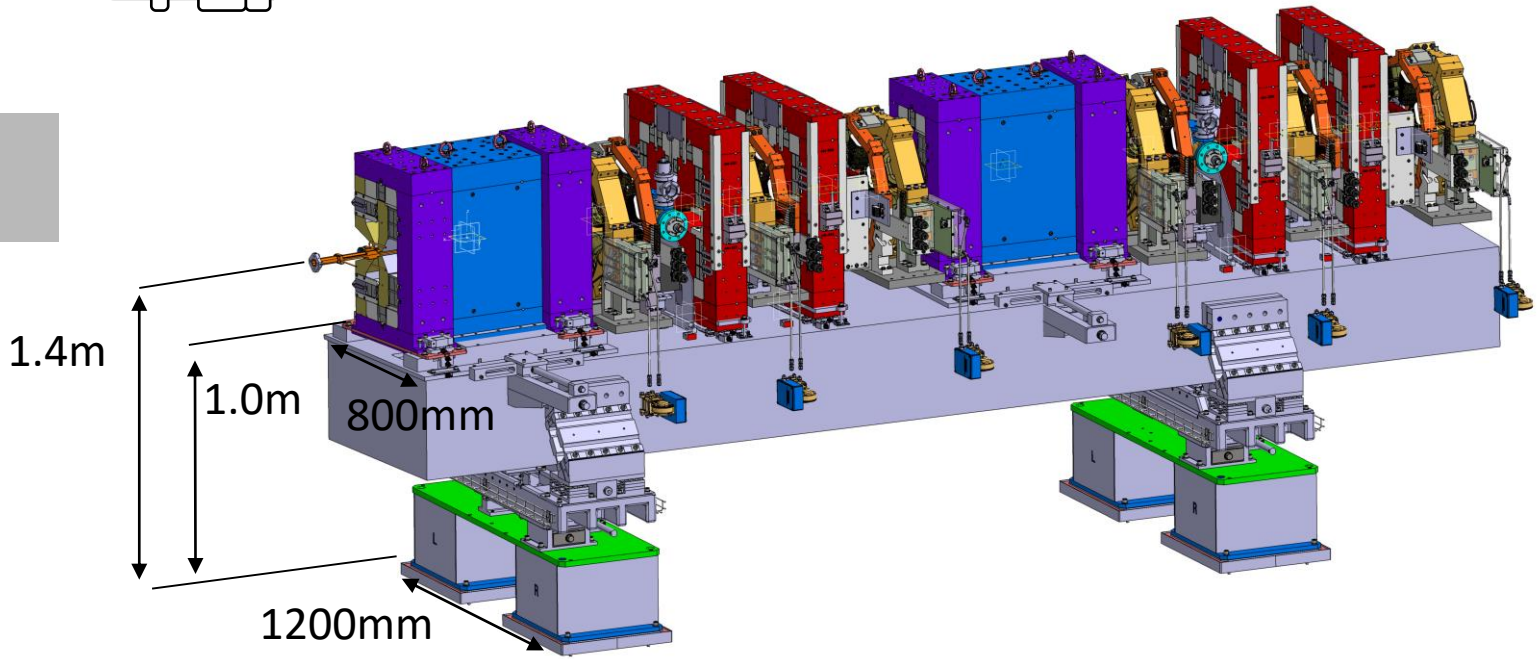
Alignment Requirements



Alignment:

- Absolute girder alignment 60 um RMS, girder-girder alignment 20 um RMS and magnet-magnet alignment 30 um RMS (2 sigma cut of gaussian distribution)
- Vertical re-alignment of girders at commissioning time with stored beam (reduction of vertical rms corrector strength by a factor of ~2 → freeing up strength for deliberate orbit steering for beamlines !)
- Lowest girder eigenfrequency >50 Hz following the SLS 1.0 experience

Size of Girder



- This girder is pre assembled with the 2 feet and all the magnets and then moved into the ring.

Protoypes of Girders

- Prototype Girder from steel with Hydropol super light

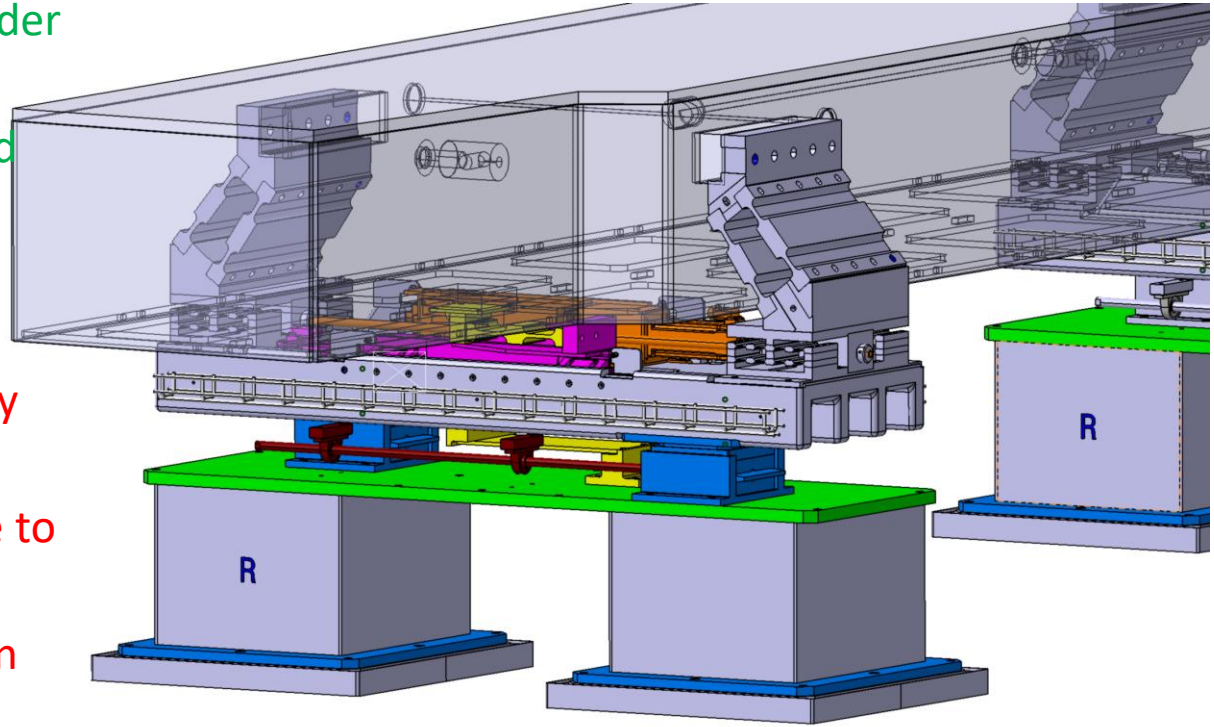
- 3 different versions of adjustments will be tested
  - Flexors with a range of movements of +- 0,5mm and +-0.5mrad
  - Movers like in SLS
  - Fixed support with no online adjustment (as reference)

- Eigenfrequency calculations will be compared to vibration tests

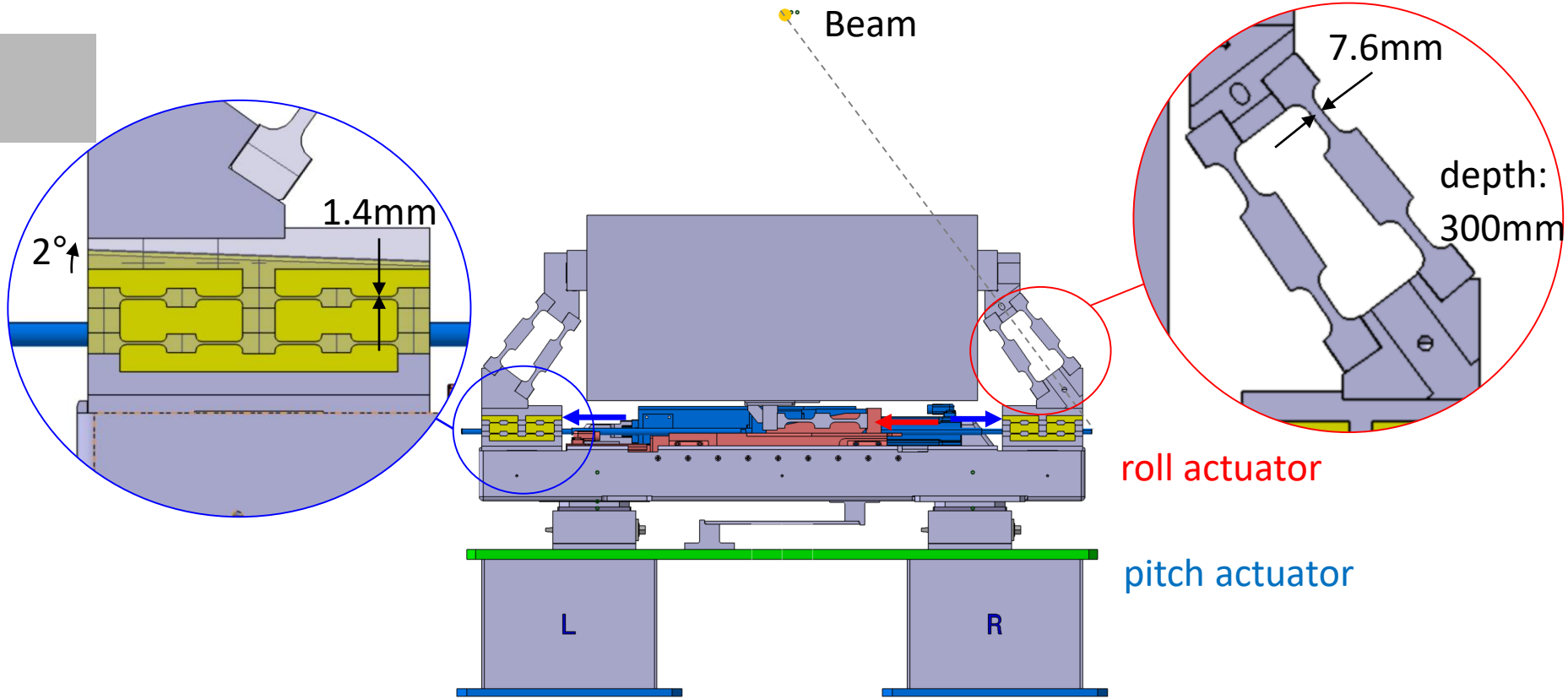
Girder with Flexors

+ rigid connection from girder to the ground
+ in theory more stable and easier to predict stability
+ precise adjustment

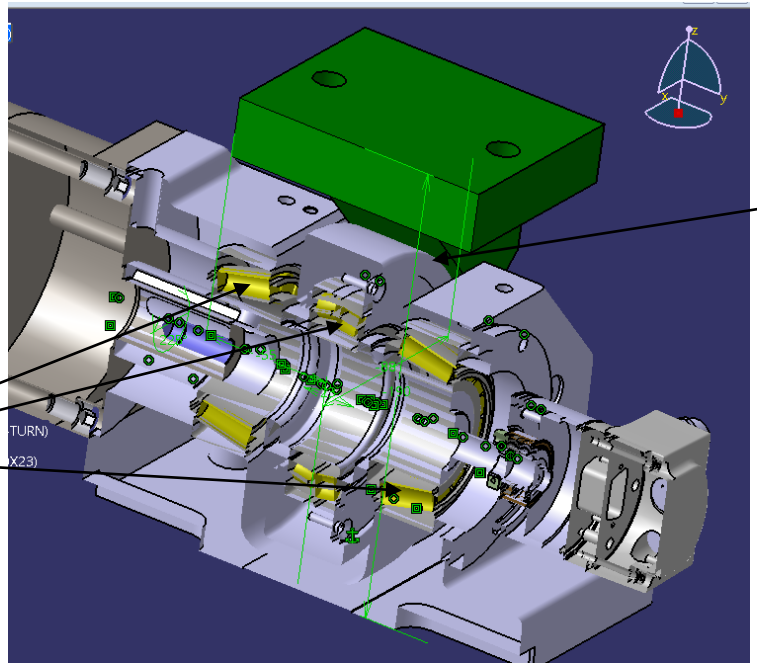
- Thin line between stability and adjustability
- High actuation forces due to strong flexors
- Permanently high stress in adjusted position
- Limited ROM



Flexor Adjustment Details



Weekpoints of movers

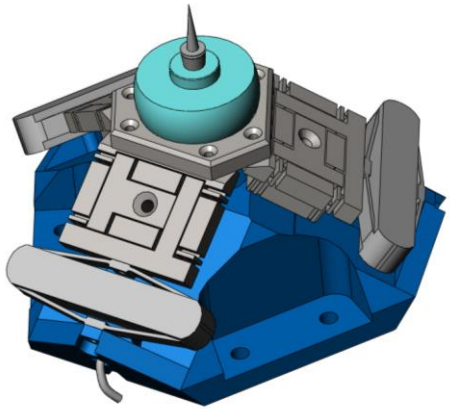


Only Contact
No Fixation

Bearings

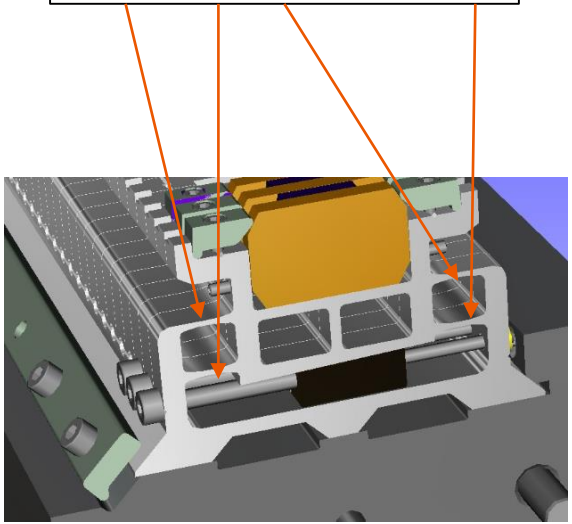
Flexors

Well known in many applications (but small dimensions)



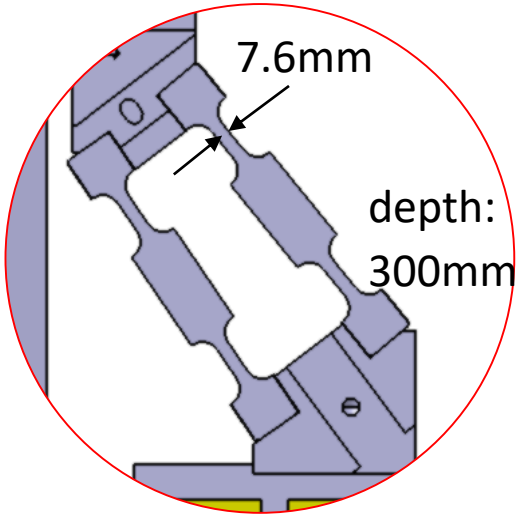
OMNY Sample Stage (PSI)

Also used in Swiss FEL Undulators (Magnet-keeper)



U15 Undulator (PSI)

New for big and heavy structures

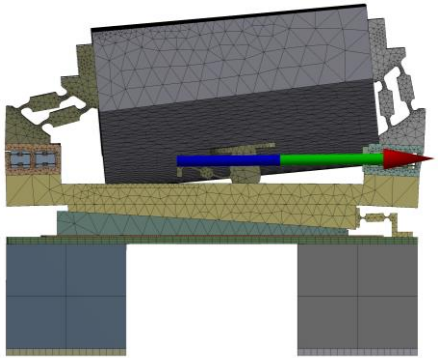


Forces Roll Adjustment

Travel actuator

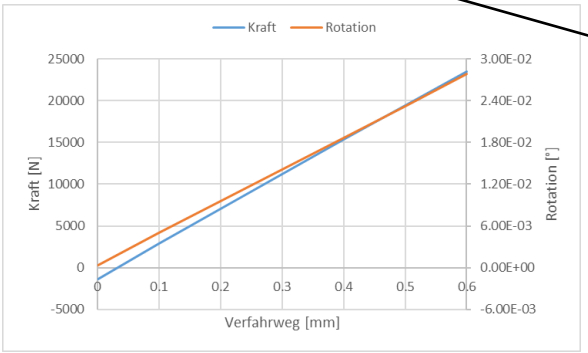
	Schritte	Zeit [s]	X [mm]	Y [mm]	Z [mm]
1	1	0.	= 0.	0.	= 0.
2	1	1.	0.	0.	0.
3	2	2.	= 0.	-0.1	= 0.
4	3	3.	= 0.	-0.2	= 0.
5	4	4.	= 0.	-0.3	= 0.
6	5	5.	= 0.	-0.4	= 0.
7	6	6.	= 0.	-0.5	= 0.
8	7	7.	= 0.	-0.6	= 0.
*					

Maximum travel
0.6mm

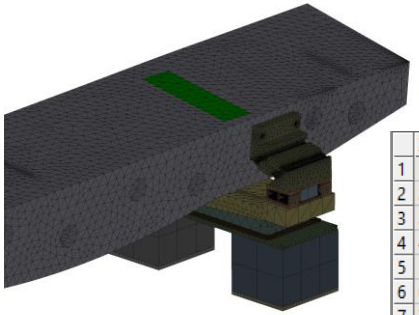


Force Reaction Flexor

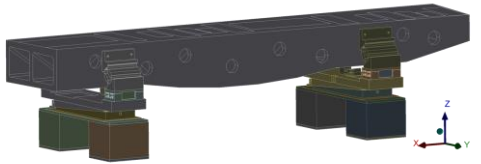
	Zeit [s]	Kraftreaktion 2 (X) [N]	Kraftreaktion 2 (Y) [N]	Kraftreaktion 2 (Z) [N]	Kraftreaktion 2 (Gesamt) [N]
1	1.	58.147	1315.1	115.12	1321.4
2	2.	63.131	-2881.4	142.59	2885.7
3	3.	67.975	-7049.8	169.	7052.1
4	4.	72.411	-11194	194.15	11196
5	5.	76.396	-15317	218.06	15318
6	6.	80.103	-19422	240.68	19424
7	7.	83.587	-23504	262.01	23506



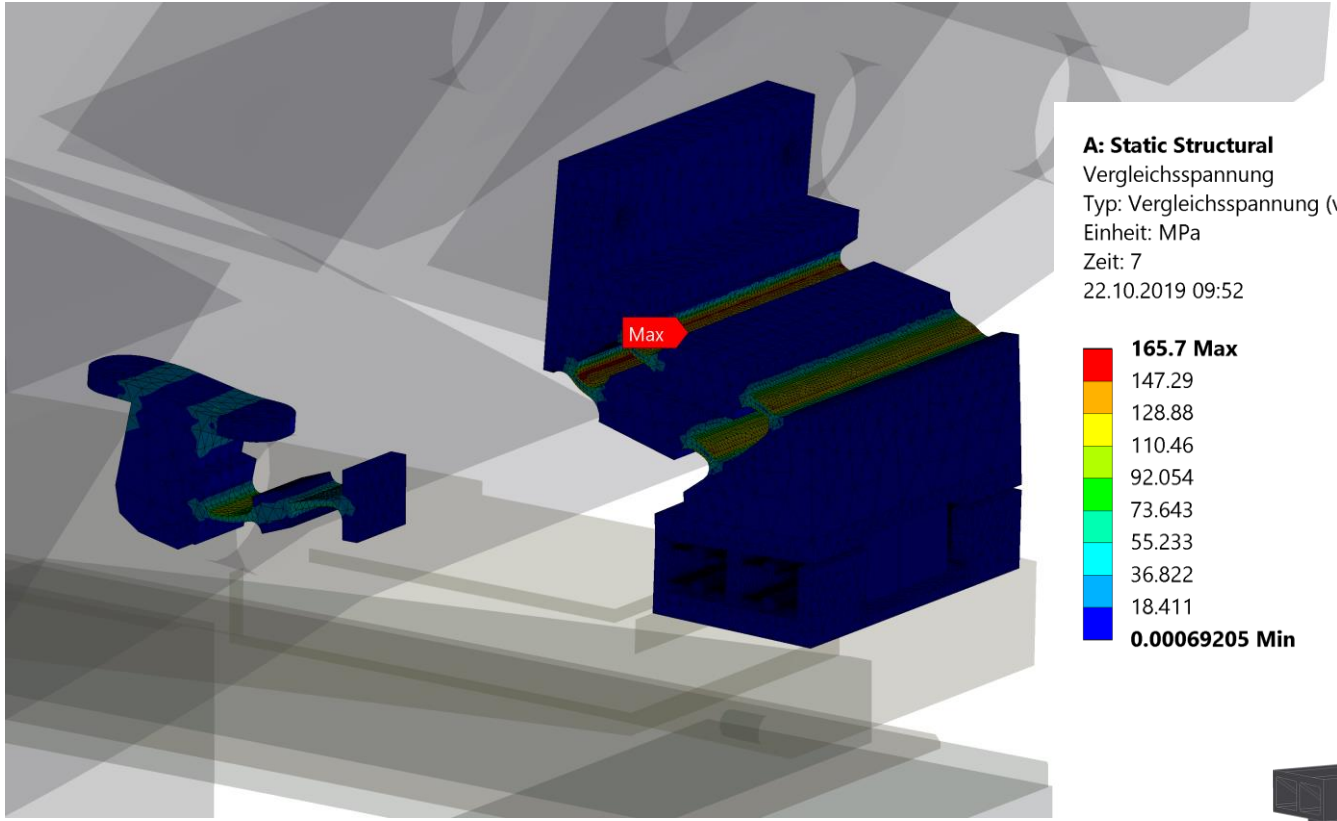
Maximum
Force
23.5kN



	Zeit [s]	Flexible Rotation Probe (X) [°]
1	1.	-3.5878e-004
2	2.	-4.9687e-003
3	3.	-9.5472e-003
4	4.	-1.4115e-002
5	5.	-1.8678e-002
6	6.	-2.3238e-002
7	7.	-2.7798e-002

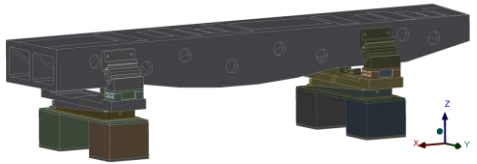


Von Mieses Stress Rotation

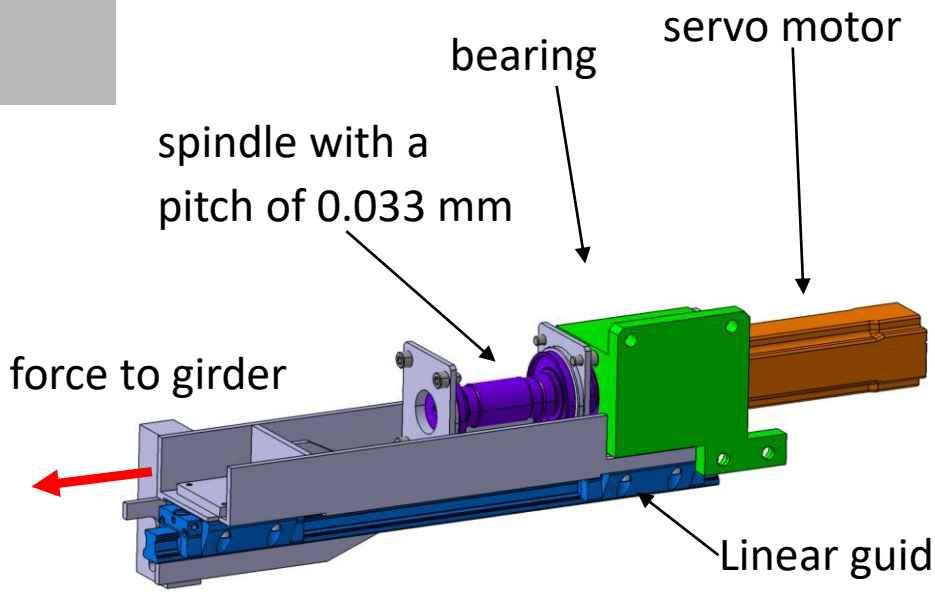


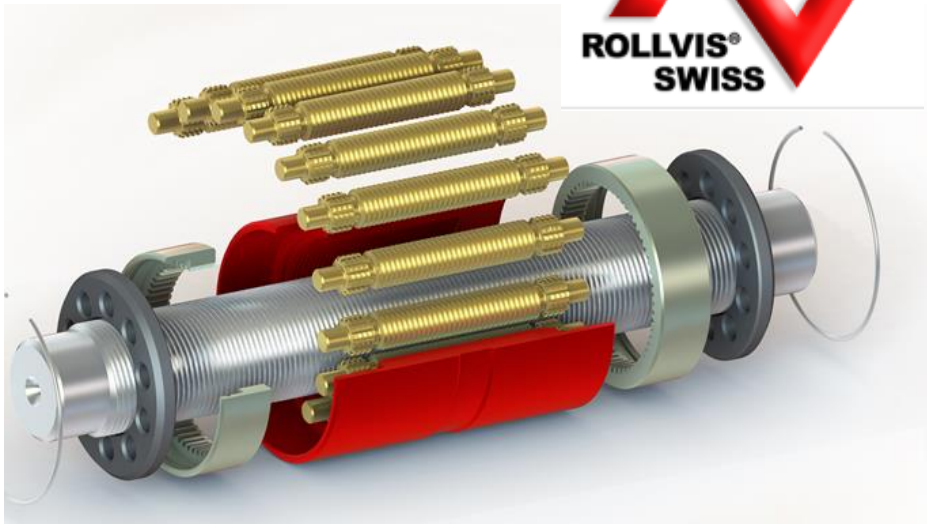
A: Static Structural
Vergleichsspannung
Typ: Vergleichsspannung (von Mises)
Einheit: MPa
Zeit: 7
22.10.2019 09:52

165.7 Max
147.29
128.88
110.46
92.054
73.643
55.233
36.822
18.411
0.00069205 Min



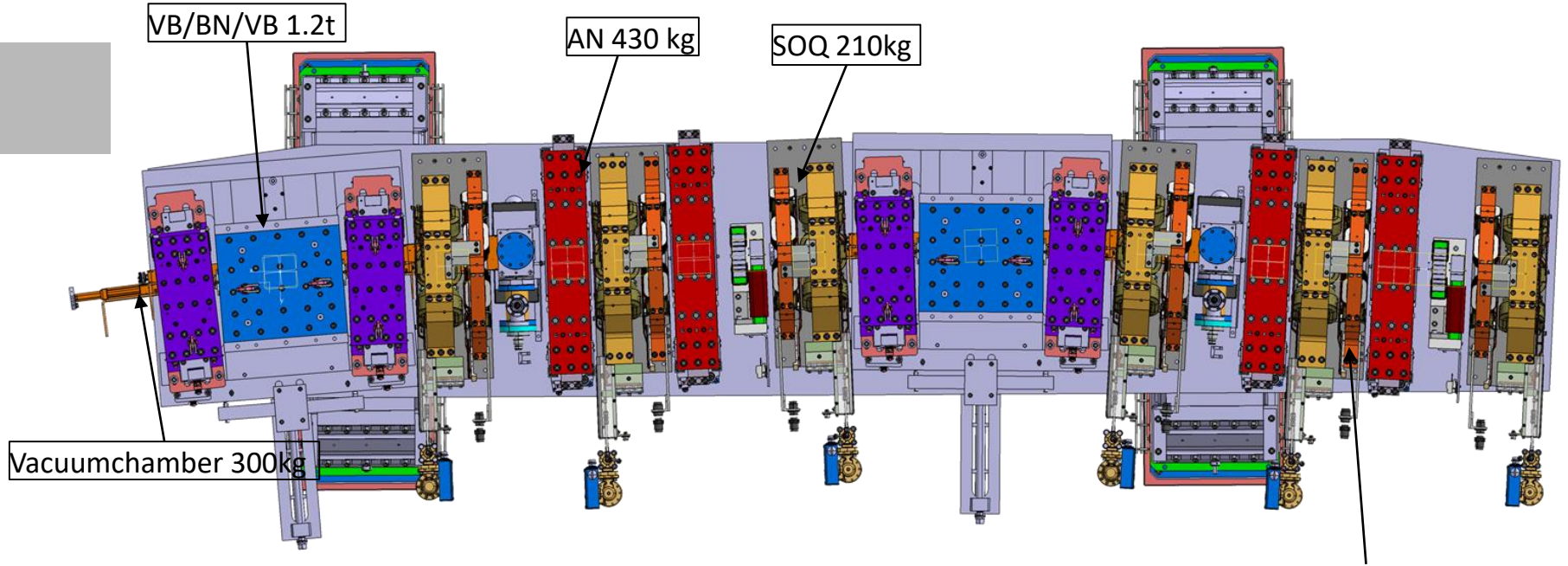
Motor Roll Adjustment





The satellite roller screw drive has a very small effective pitch of 0.033 mm. Combined with a self locking servo motor with 18 bit encoder, the precision of less than 0.13 nm steps can be achieved.

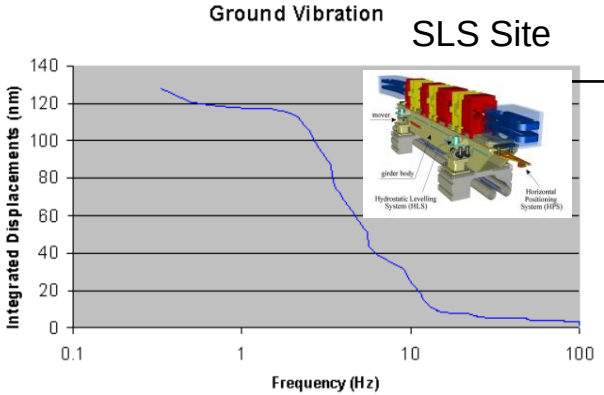
Girder Load

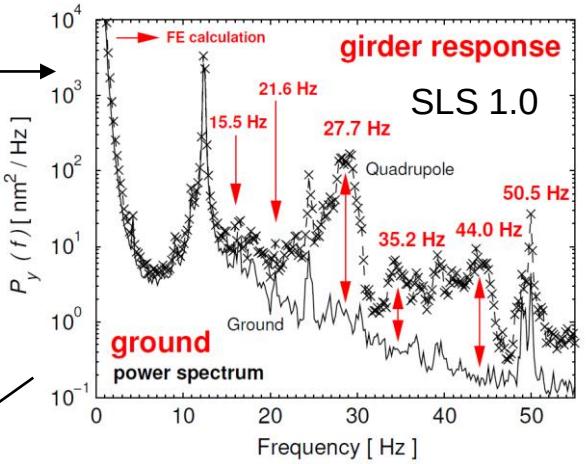


Weight of girder body: 2200kg → total weight on flexors ≈ 8t

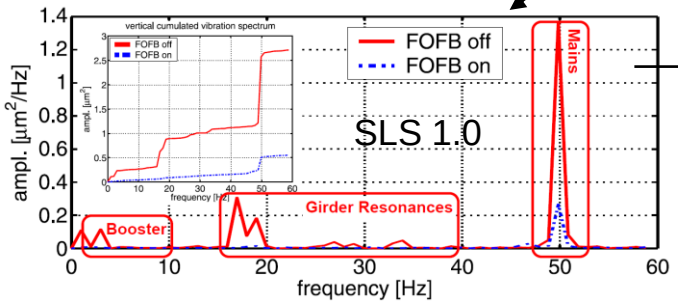
Weigth of feet+ adjustment: 1.5t → girder total weight ≈ 9.5t

Ground noise spectrum and girder response





SLS Girder eigenmodes on orbit

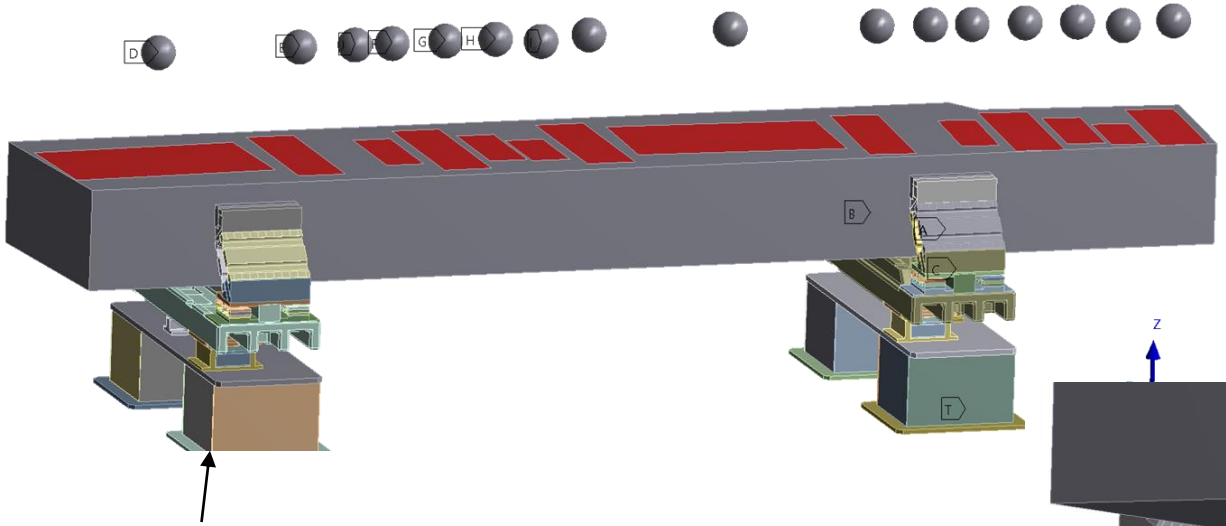


SLS 2.0 girder eigenmodes > 50 Hz

as a prerequisite

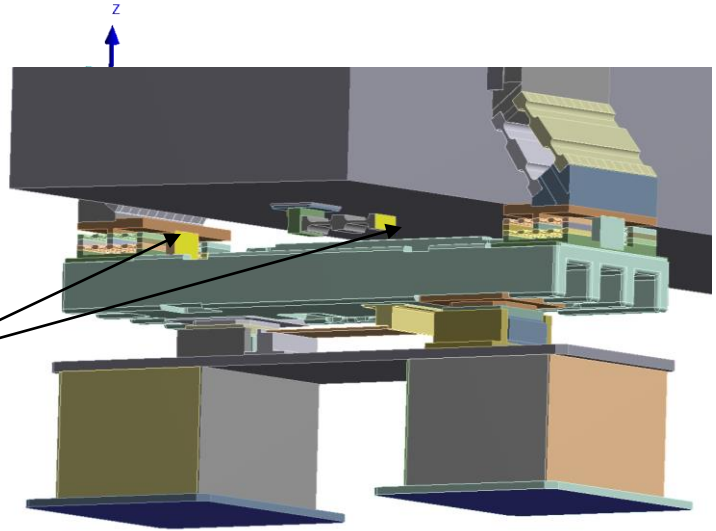
Eigenfrequency Calculation

Point masses on the beam for the magnets



Fixed support on the ground

Wedges and rotational adjustment are locked

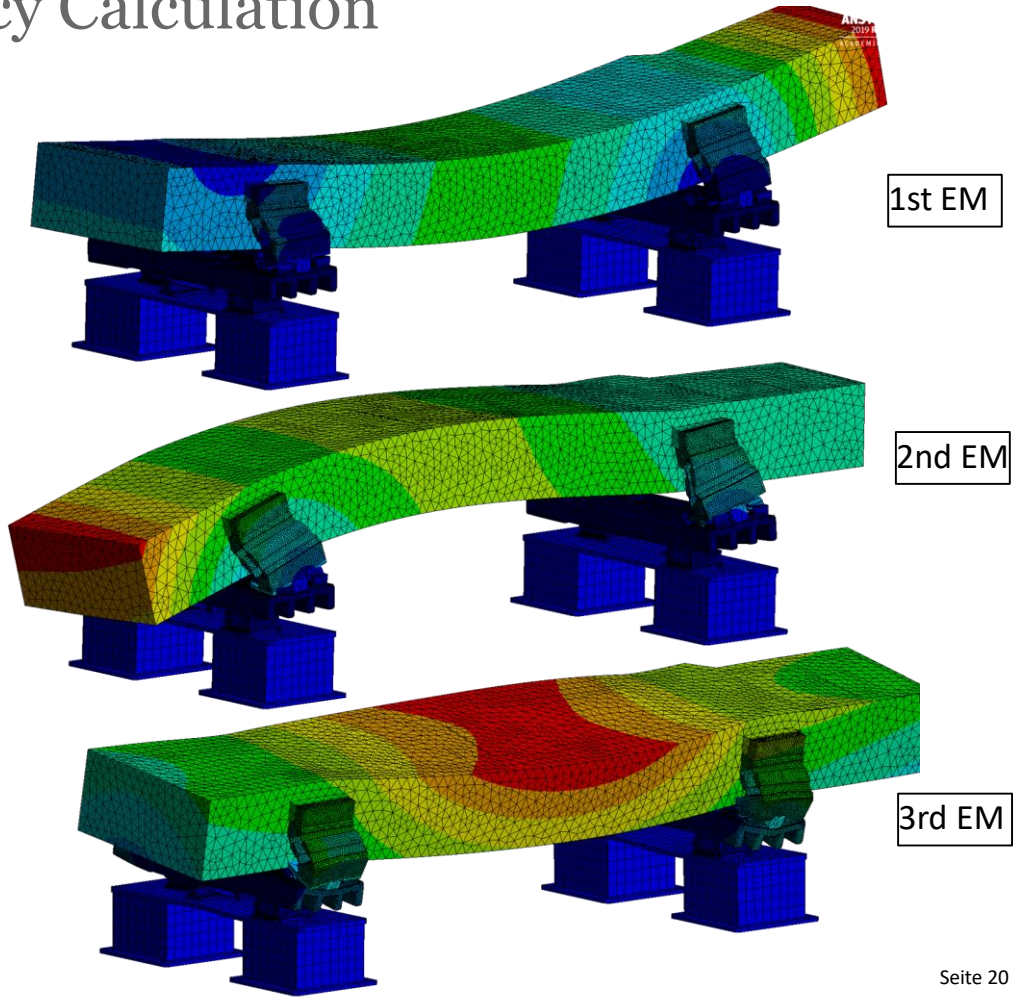


Eigenfrequency Calculation

	Mode	Frequency [Hz]
1	1.	54.237
2	2.	56.154
3	3.	70.226
4	4.	84.81
5	5.	88.844
6	6.	98.073

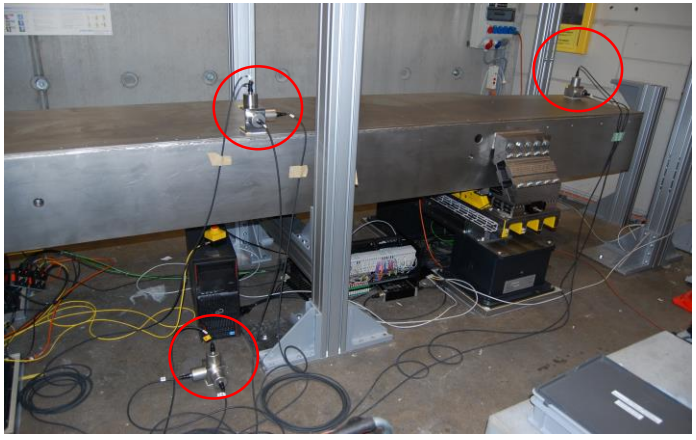
Target > 50 HZ

- 1st EF is Bending of the Girder Body
- 2nd EF is Bending of the Girder + longitudinal movement over the feet
- Only 3rd EF is rotational movement (+ torsion of the girder body)



Vibration Tests

Measurement of 3 variations of the girder support



1. Flexors

2. Mover

3. fixed

Vibration Tests

Integrated RMS displacement 5-200Hz

- Vertical Amplification superior on flexors
- Movers more stable in longitudinal and transversal
- Weak support in Flexor and fixed may affect results

Flexor

Boden_V	20.0
Boden_T	16.8
Boden_L	16.2
GirderM_V	23.8
GirderM_T	24.1
GirderM_L	27.6
GirderE_V	33.0
GirderE_T	30.9

Verstärkungsfaktor

GirderM_V	1.19
GirderM_T	1.44
GirderM_L	1.70
GirderE_V	1.65
GirderE_T	1.84

Mover

Boden_V	22.3
Boden_T	20.7
Boden_L	15.7
GirderM_V	31.8
GirderM_T	25.0
GirderM_L	21.6
GirderE_V	47.3
GirderE_T	44.4

GirderM_V	1.43
GirderM_T	1.21
GirderM_L	1.38
GirderE_V	2.12
GirderE_T	2.14

fixed

Boden_V	30.6
Boden_T	26.4
Boden_L	22.7
GirderM_V	31.5
GirderM_T	33.8
GirderM_L	30.6
GirderE_V	52.0
GirderE_T	35.5

Verstärkungsfaktor

GirderM_V	1.03
GirderM_T	1.28
GirderM_L	1.35
GirderE_V	1.70
GirderE_T	1.34

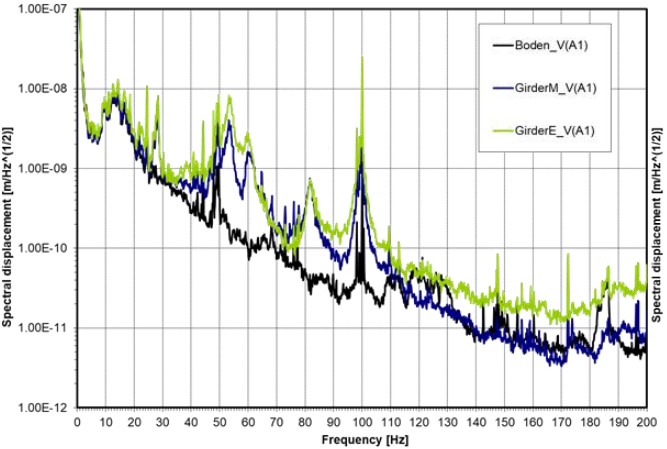
Vibration Tests

Natural frequencies

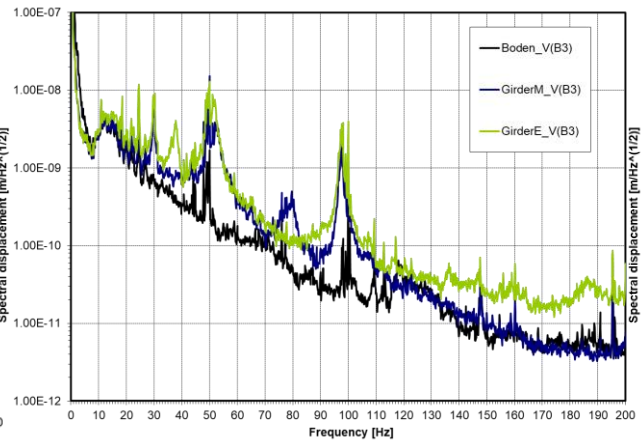
	f_1	f_2	f_3	f_4	f_5
Flexoren	29	41	*53 (_V)*	*60 (_V)*	82
Fest	40	45	85-88		
Mover	30	37	76-80		

- 1st EF is pretty similar for Flexors and Movers
- Flexors not really superior to movers
- Fixed Version also underperforms
- Weak underbody may cause bad results, tests need to be repeated

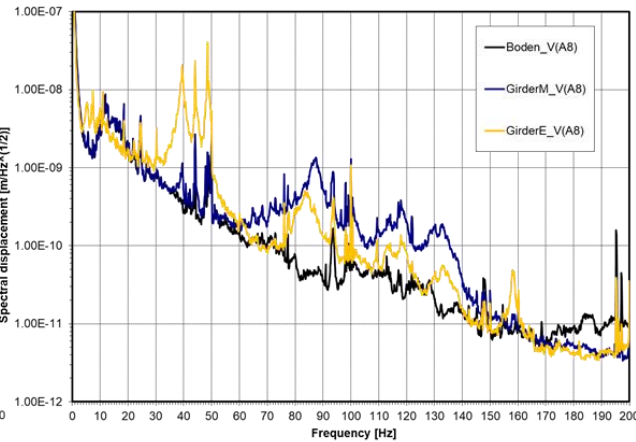
Flexor



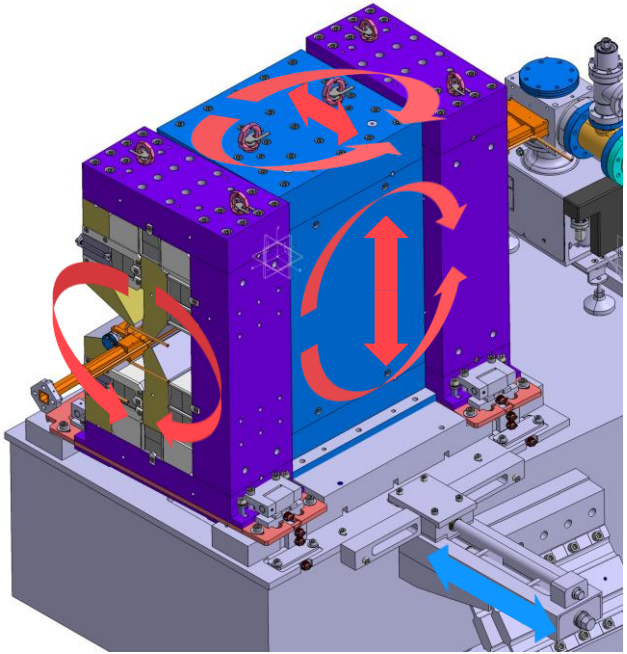
Mover



fixed

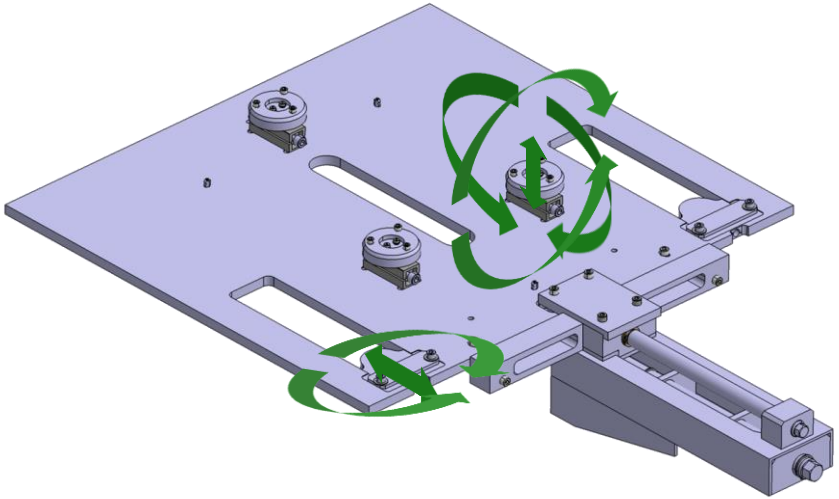


Triplet Drawer Overview



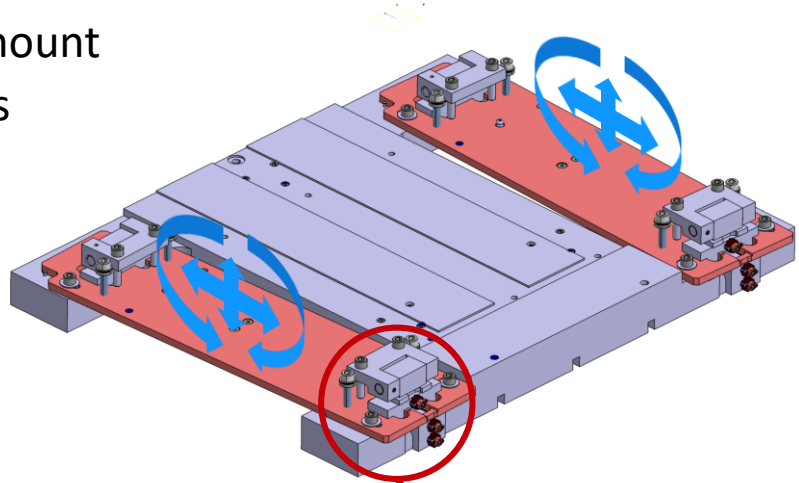
Sliding in and out of the whole Triplet to install the vacuum chamber

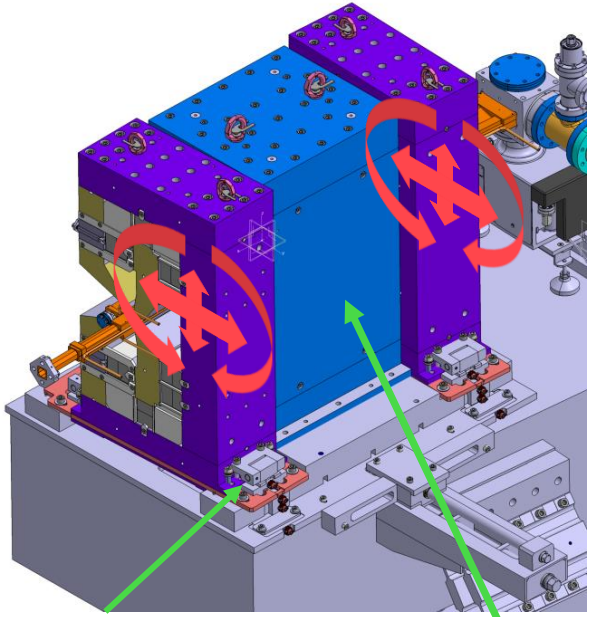
Adjustment of the whole magnet in respect to the beam with wedges and differential screws

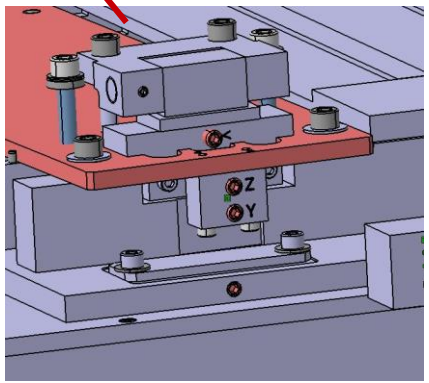


Triplet Support Overview

Upper Drawer Plate is used to pre mount and pre adjust the 3 Triplet Magnets



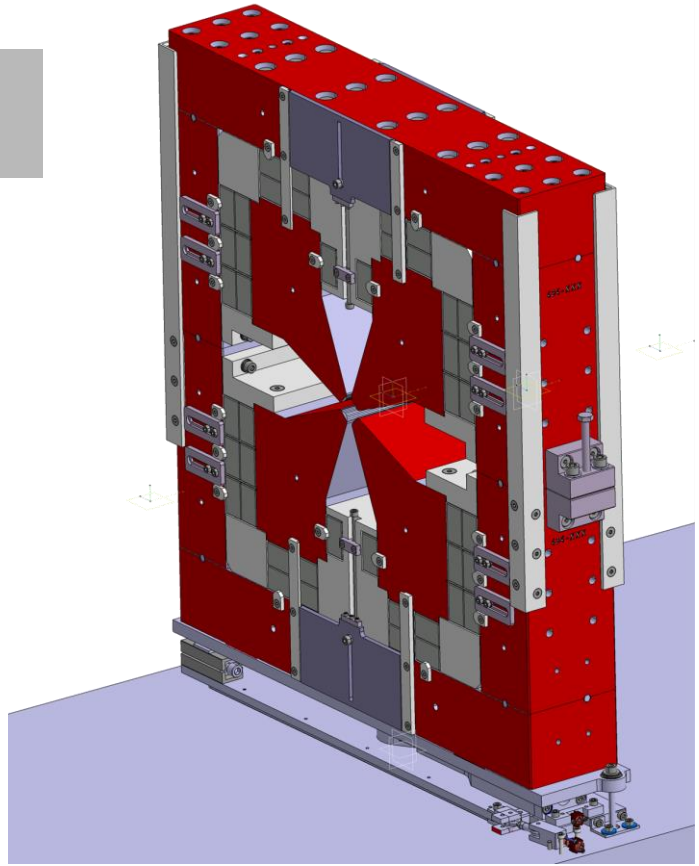


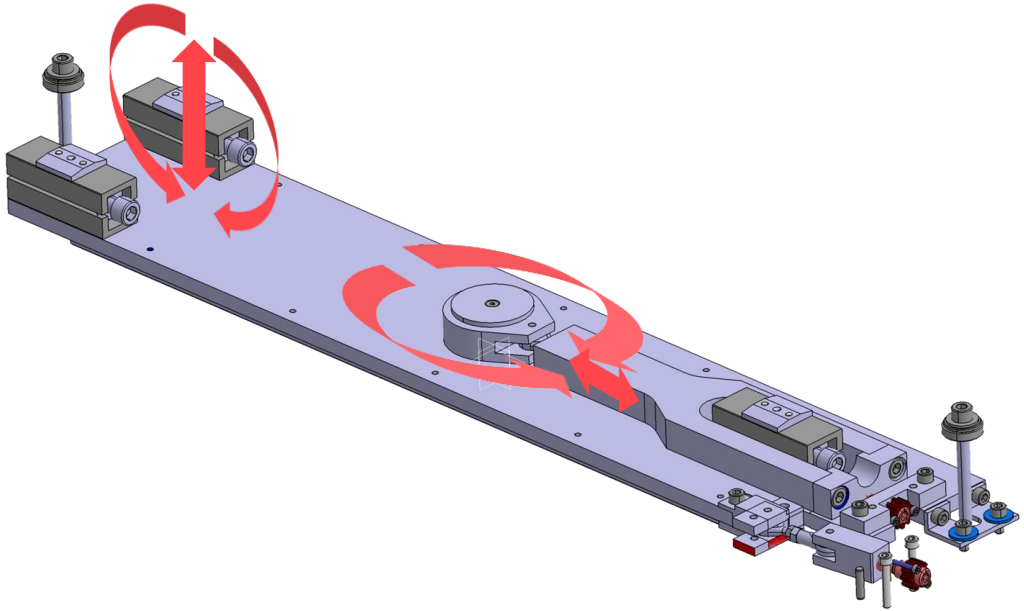


Adjustable Magnet Support

Center Bend not adjustable

Magnet Support Overview





General Magnet support with wedges and differential screws to adjust.

SLS 2.0 Girder

- Thanks to PSI SLS 2.0 Girder Team (H.Jöhri, M.Wurm E. Japichino, M. Brüstle, M. Schneider, A. Keller)