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PSI

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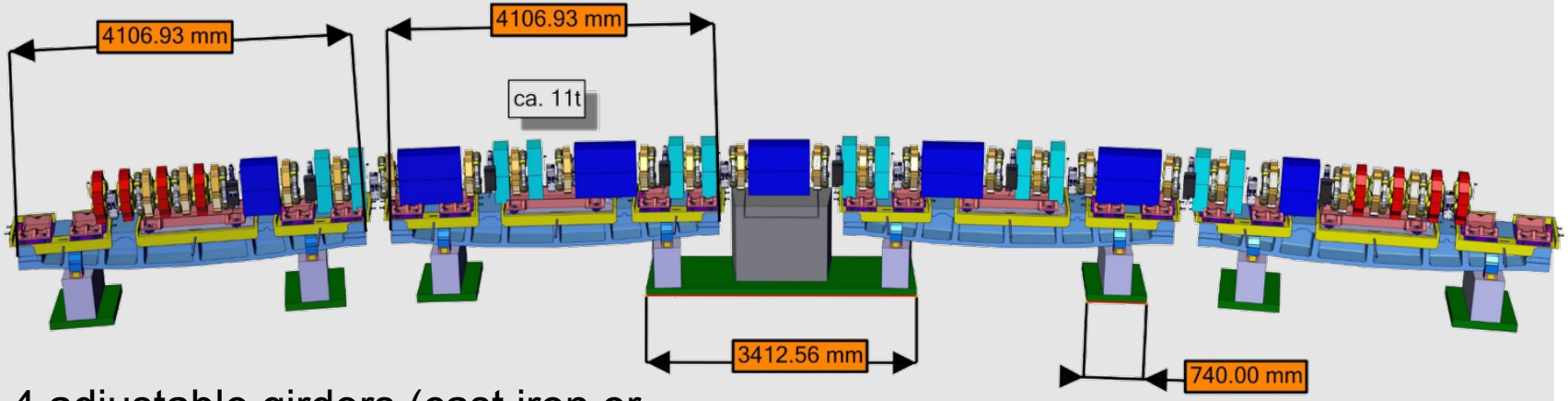
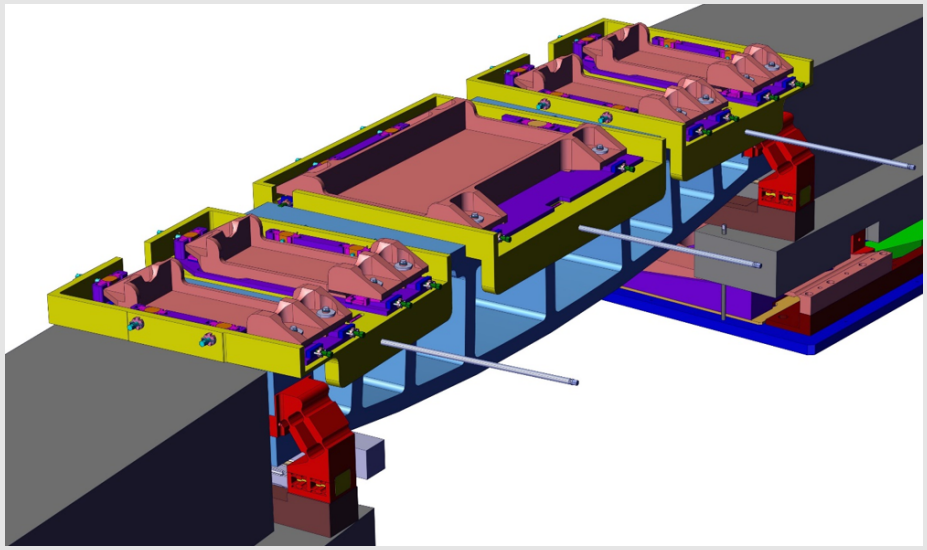
SLS 2.0 AP Stability and Alignment Requirements for Girders and Magnets

DLS/SLS 2.0 Information Exchange Meeting 06/10/20

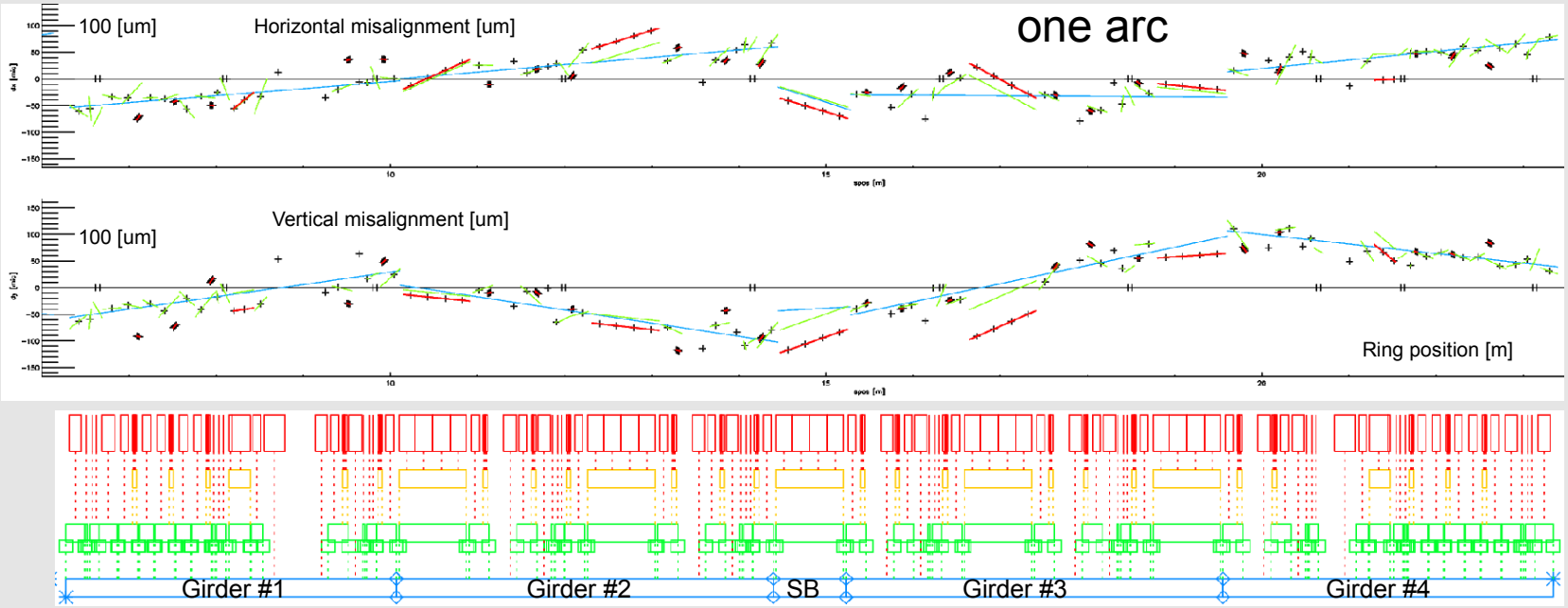
Girders and magnet alignment



4 adjustable girders (cast iron or steel) / arc + 1 fixed (mineral cast or granite) support / arc for the central dipole (superbend)
→ in total 48 adjustable girders with remote vertical adjustment capability (pitch, heave, roll) within range +-500 um and a positioning resolution of +-10 um (motor driven vertical wedges and flexors /pushers)

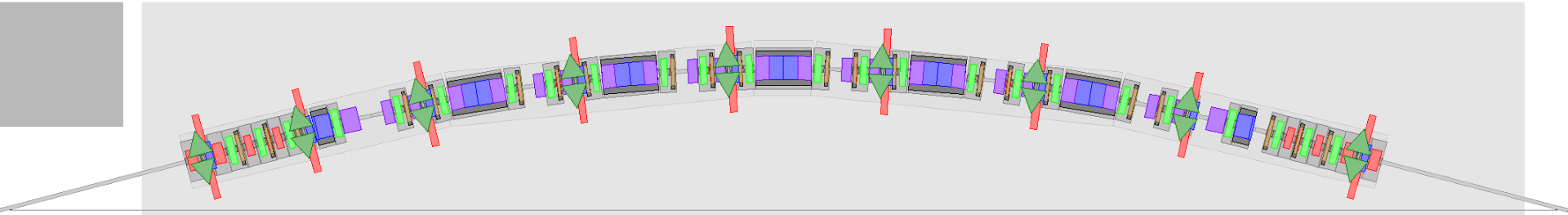


Girder and magnet alignment errors



1) 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)
2) Small (<60 um) girder-girder errors establish virtual train link between girders → minimization of short range distortions
3) BPMs are assumed to be elements correlated within 5 um RMS to the adjacent sextupoles (108 BPMs) (BPMs in straight without adjacent sextupole have 30 um RMS)
4) For the present error studies no roll errors are assumed

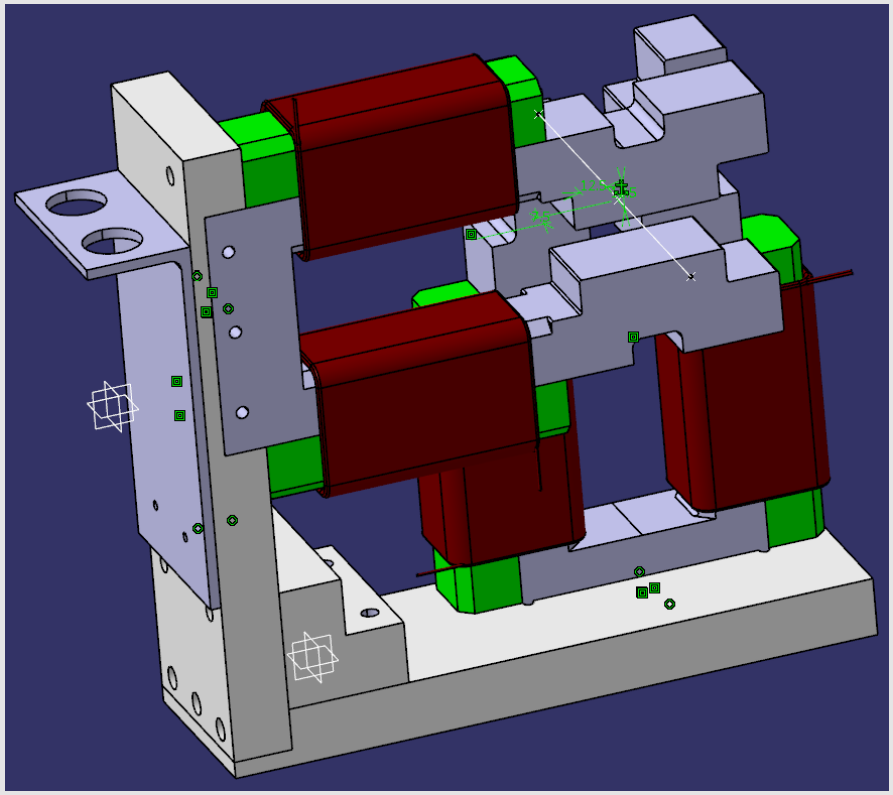
BPM and corrector layout



115 individual horizontal/vertical correctors (CHV) with max +-400urad
115 adjacent beam position monitors (BPMs):

9 CHVs/BPMs / arc + 3*2 CHVs/BPMs center of long straights + extra CHV/BPM in injection straight

CHVs/BPMs adjacent to sextupoles with attached multi-purpose magnet with quadrupole, skew quadrupole and octupole component



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Residual orbit distortion and corrector settings after orbit correction

x_rms_max [m] @ all elements
x_rms 4.73782e-05 3.12491e-06 5.26939e-05 m
x_max 0.00012948 1.28224e-05 0.000149551 m

Max 150um

y_rms_max [m] @ all elements
y_rms 4.73239e-05 2.29959e-06 5.09827e-05
y_max 0.000144476 1.98279e-05 0.000189459

Max 190um

x_mon_rms_max [m]
x_mon_rms 4.85666e-05 3.42102e-06 5.36237e-05
x_mon_max 0.000118551 1.09288e-05 0.000135109

X

y_mon_rms_max [m]
y_mon_rms 4.72549e-05 2.3279e-06 5.17346e-05
y_mon_max 0.000116954 1.02114e-05 0.000141318

Y

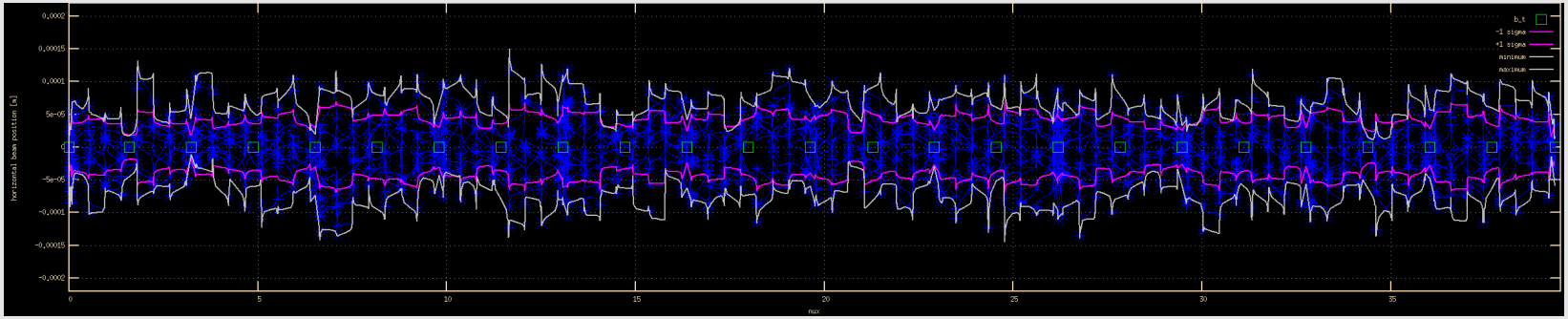
kx_rms_max [rad]
kx_rms 7.93138e-05 9.02379e-06 9.63497e-05
kx_max 0.000272131 6.4292e-05 0.000369759

Max 370urad

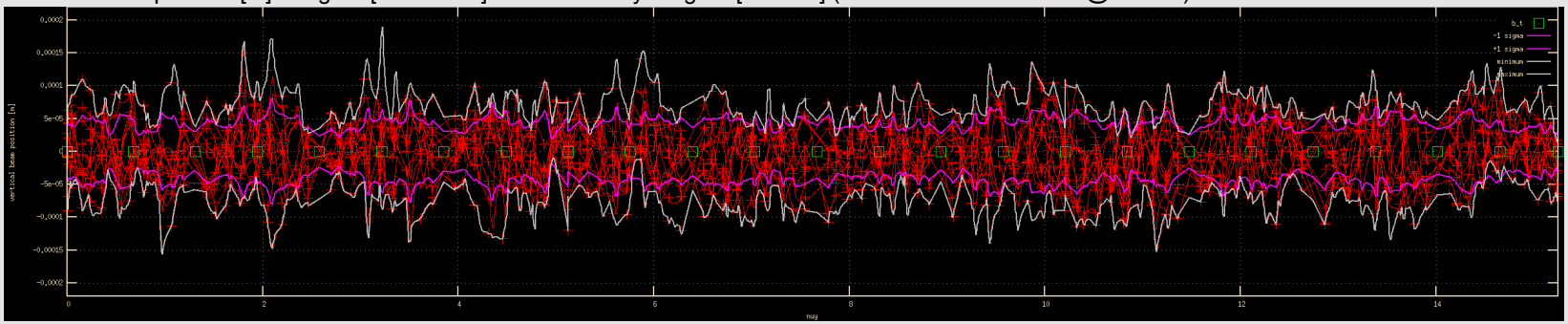
ky_rms_max [rad]
ky_rms 7.10867e-05 6.01257e-06 8.34327e-05
ky_max 0.000234315 4.78075e-05 0.000314917

Max 315urad

Horizontal beam position [m] range = [-220:+220] um versus nux range = [0:39.35] (max 20 nm RMS noise @ BPMs)



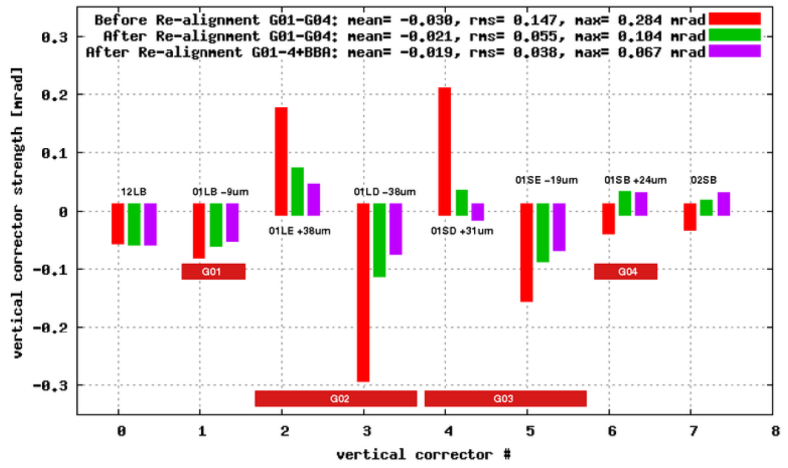
Vertical beam position [m] range = [-220:+220] um versus nuy range = [0:15.25] (max 30 nm RMS noise @ BPMs)



Realignment of girders with stored beam

- High precision BBA and successive orbit correction to BPM centers using ALL orbit correctors (no eigenvalue cut) in order to LOCALIZE alignment errors
- Girder realignment of the ring to optimize the alignment error distribution in favour of machine performance and minimize the needed orbit corrector strength

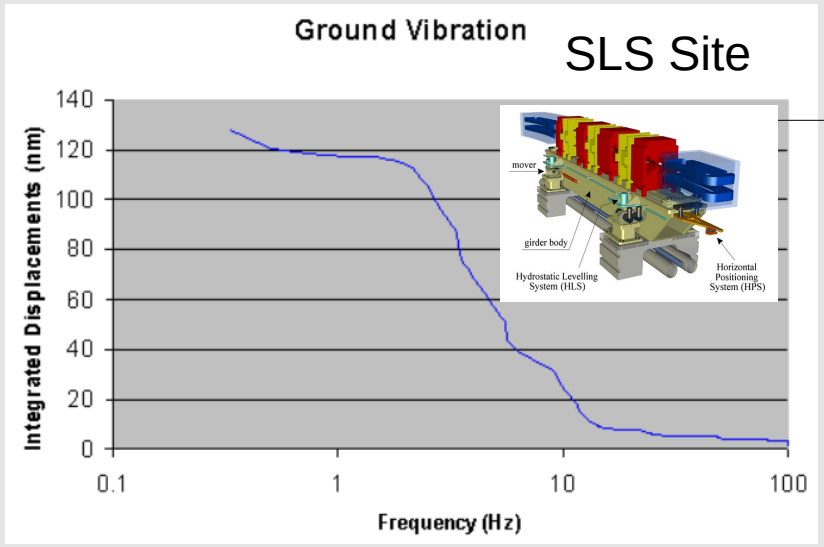
In SLS 1.0 all 48 girders have been used to reduce the total vertical corrector kick ky from 150→50 urad RMS (see example for 4 girders in sector 1). Remotely controlled girders can speed up this realignment since it can be done with stored beam and directly verified by observing the reduction of corrector strength

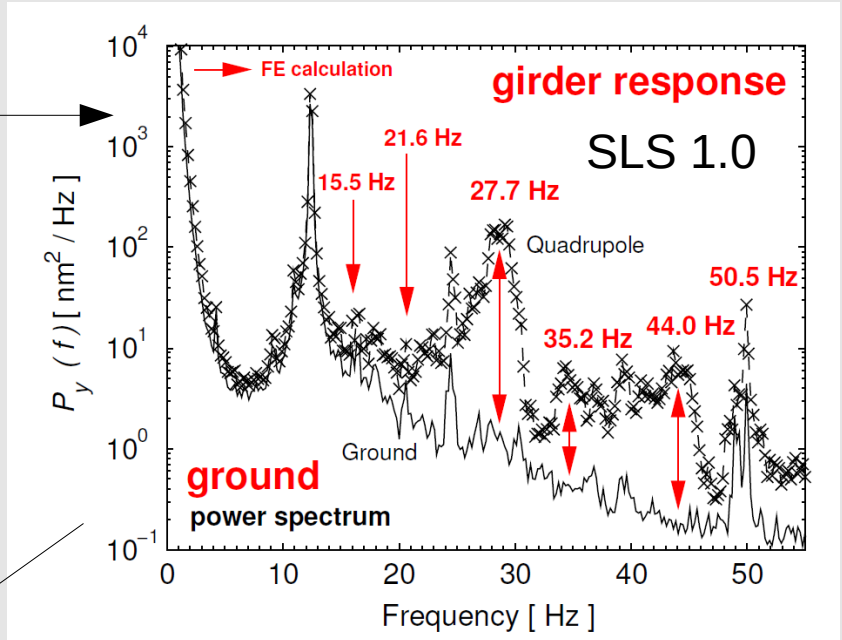


Corrector strengths before and after girder realignment, and after beam based BPM calibration* (sector 1)
(*girder move causes vacuum chamber deformation)
⇒ Factor ≈4 reduction of rms CV kick in sector (= 4 girders)

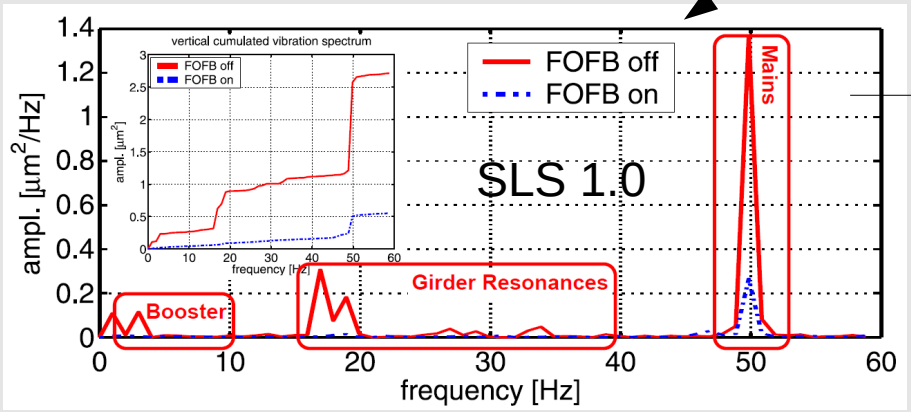
SLS 2.0: +-10um joint precision after girder realignment → adapt error scenario to 60/10/30 1sig cut for joints: ky = 83→45 urad RMS, 310→165 urad MAX → 78%→45% of ky_max = 400 urad

Ground noise spectrum and girder response

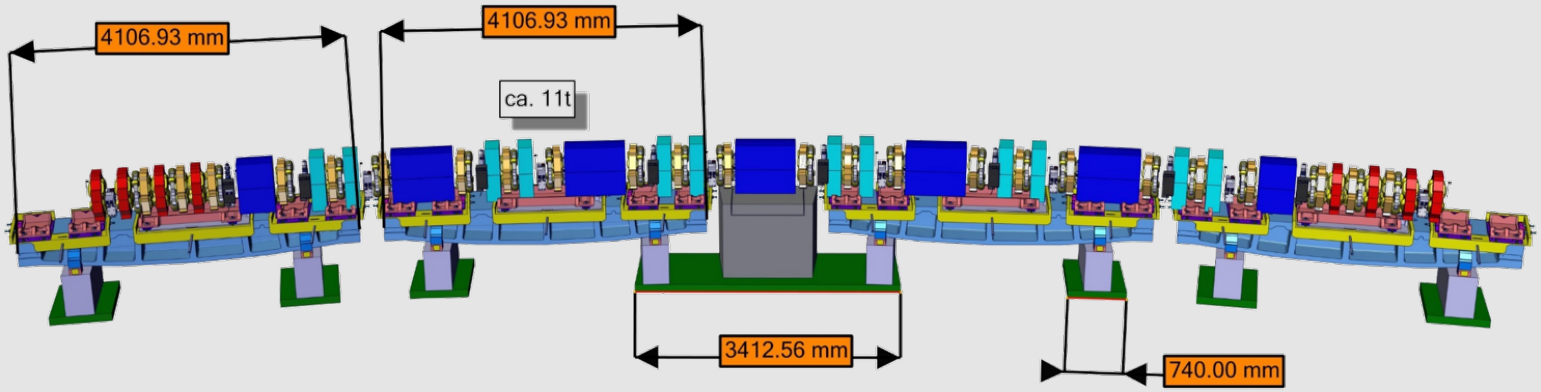




SLS Girder eigenmodes on orbit



SLS 2.0 girder eigenmodes > 50 Hz as a prerequisite

Requirements summary

- 30 um element-element alignment
- 20 um girder-girder alignment (train link)
- 60 um absolute girder alignment
- 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 eigenmode >50 Hz following the SLS 1.0 experience