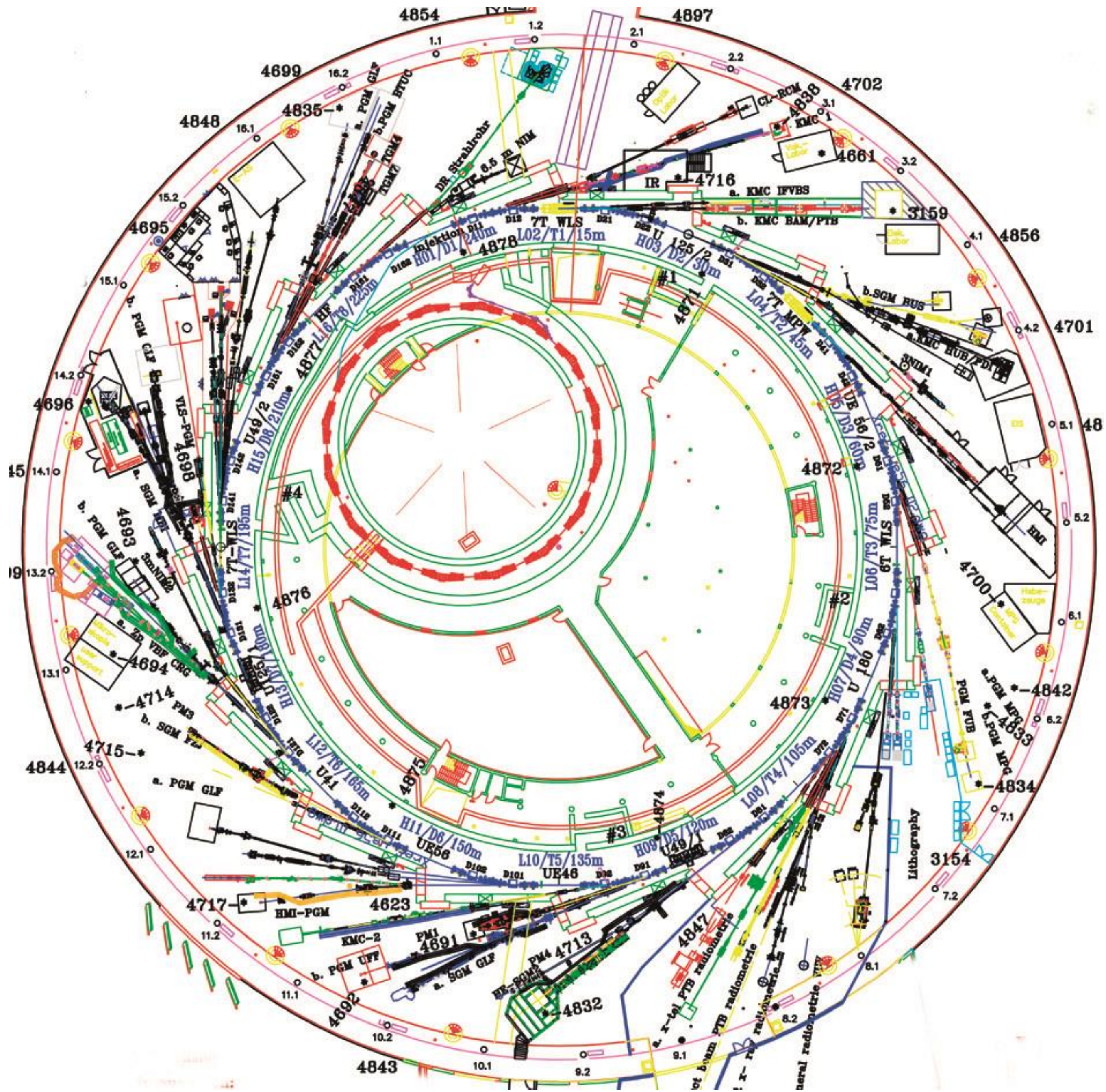
Konstruktionsprinzipien für ultrapräzise Positionierungen

Tino Noll

Max-Born-Institut Berlin, Germany,

Baugröße von Elektronspeicherringen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4700
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4833
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3154
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4715
4714
4694
4693
4717
HMI-PGM
4623
4691
4713
4847
4832
4692
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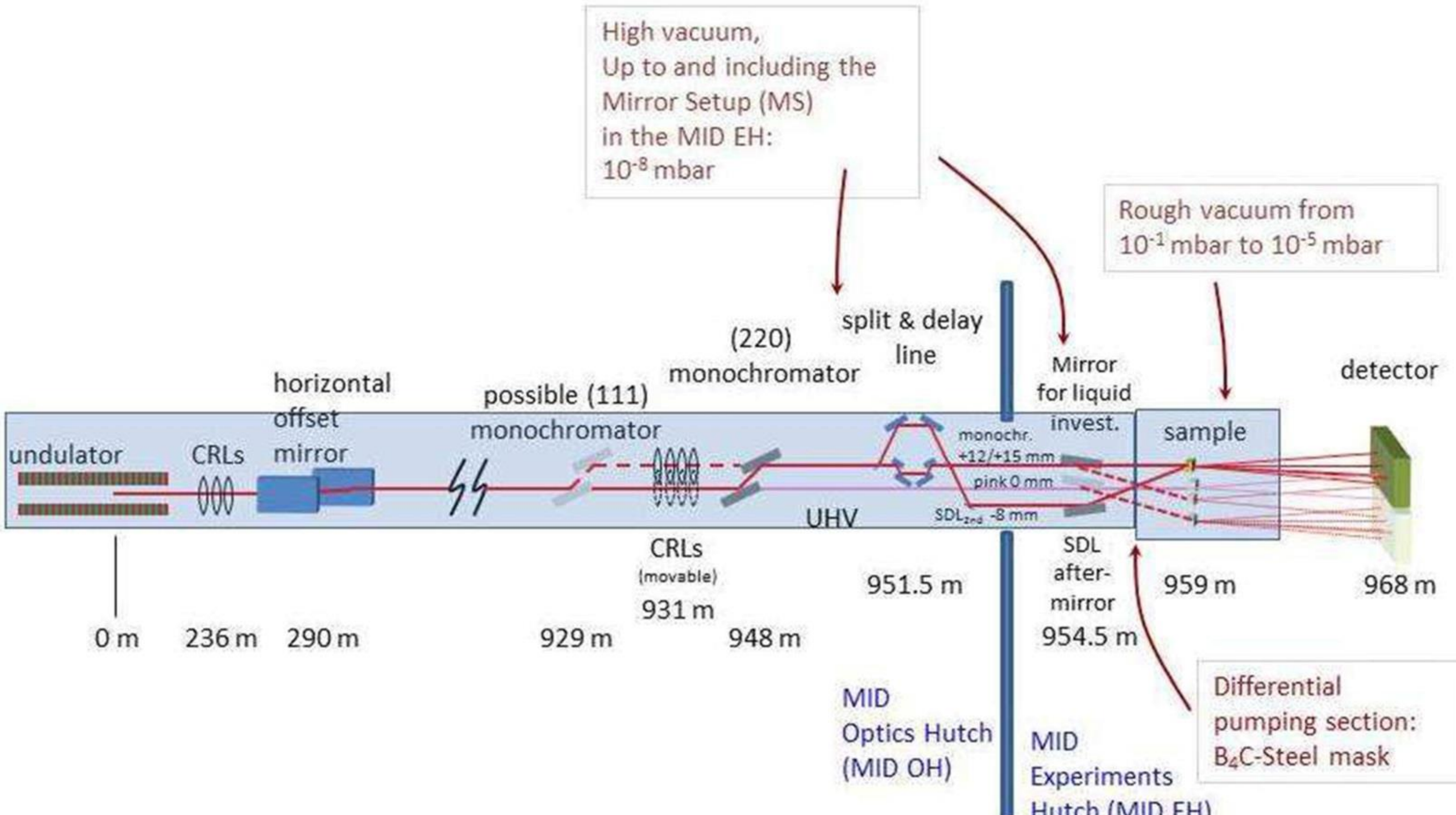
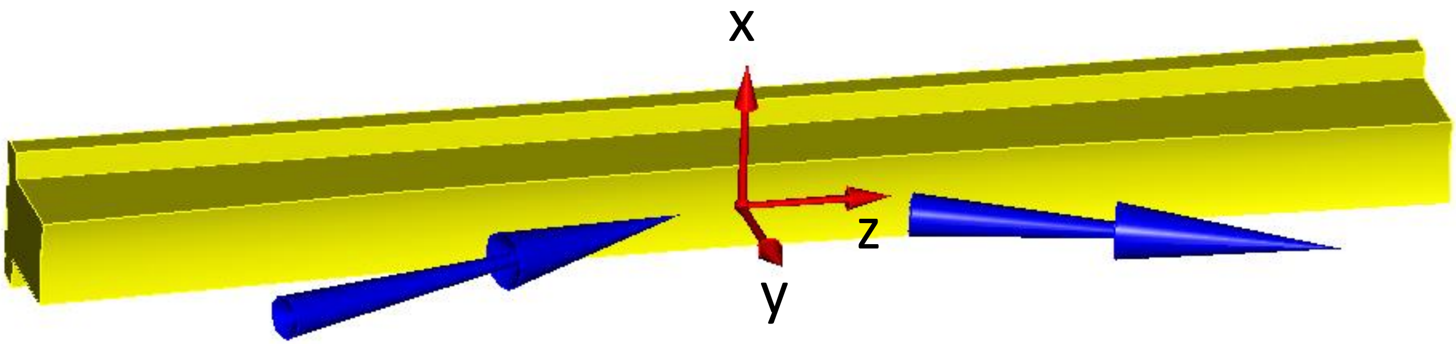
4876
4875
4874
4873
4871
#1
#2
#3
#4
IR
7T WLS
L02/T1/15m
H01/D1/240m
H03/D2/30m
L04/T2/45m
H05/D3/60m
L06/T3/75m
H07/D4/90m
L08/T4/105m
H09/D5/120m
L10/T5/135m
H11/D6/150m
L12/T6/165m
H13/D7/180m
L14/T7/195m
H15/D8/210m
L16/T8/225m
U49/2
UE56
UE46
U41
6T WLS
a. KMC IFVBS
b. KMC BAM/PTB
b.SGM BUS
a.KMC HUB/FDI
a. PGM GLF
b. SGM GLF
b.PGM GLF
a. PGM UFF
KMC-2
PGM FUB
Lithography
PTB radiometrie
DR Strahlrohr
Injektion
HMI

Typischer Strahlengang am Freie Elektronen Laser (FEL)



15th of August 2013, Hamburg
Thomas Roth, MID group, European XFEL



Typische Genauikgeitsanforderungen an die Bewegung von Spiegeln			
moving direction	stroke	reproducibility	resolution
rotation X	2,4 mrad	**10 nrad**	**10 nrad**
translation X	2 mm	1 µm	0.06 µm
rotation Y	4.3 mrad	50 µrad	0,3 µrad
translation Y	50 mm	5 µm	1.5 µm
rotation Z	9 mrad	25 µrad	0,3 µrad
translation Z	-	-	-

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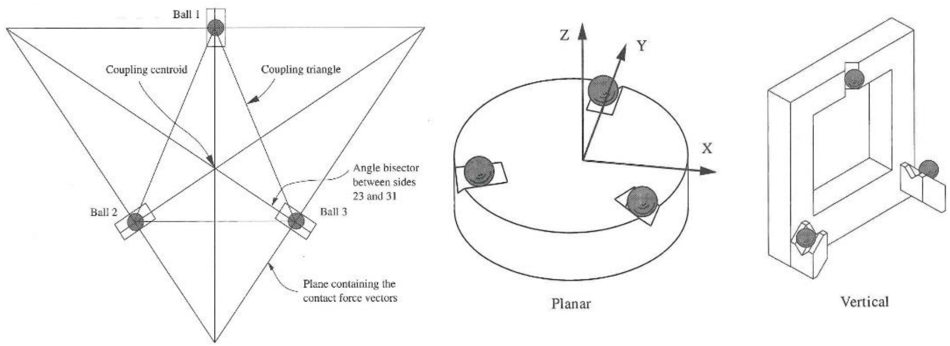
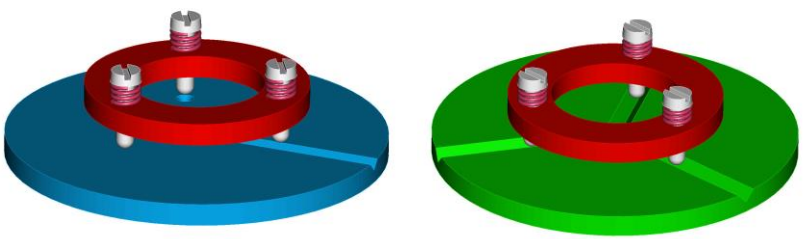
Was sind 10 nrad?

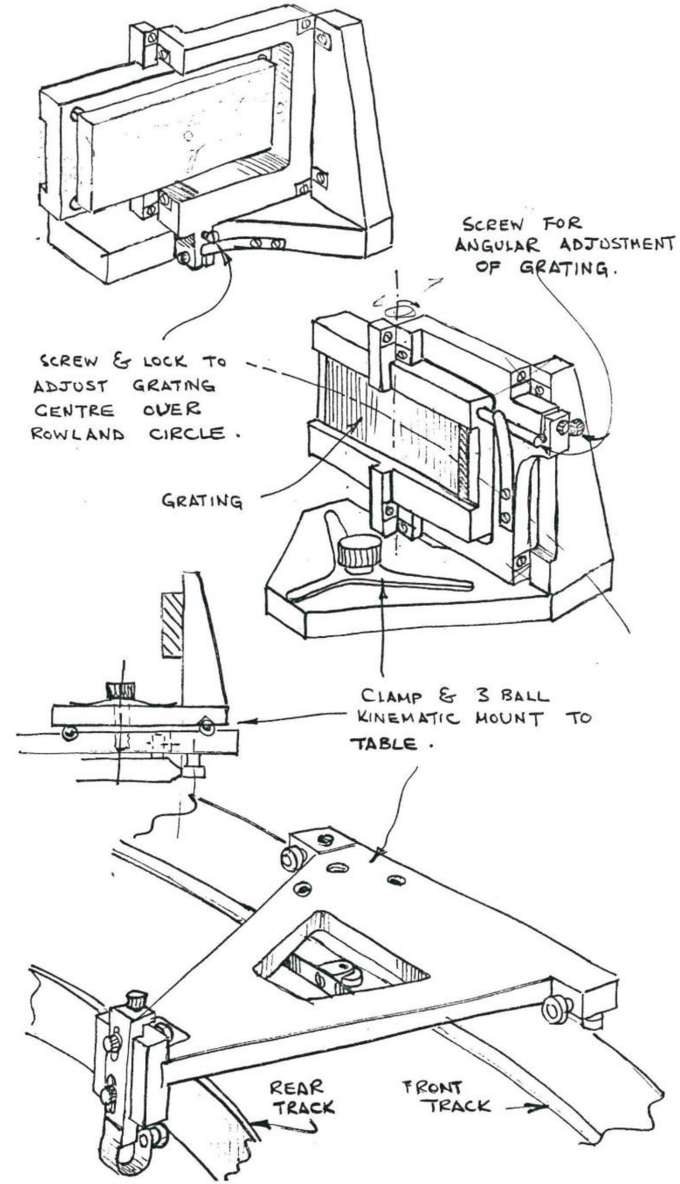
Kinematische Lager



A. Slocum: „Precision Machine Design



Reproduzierbarkeit kinematischer Lager
ist Begrenzt auf ca. 1µm



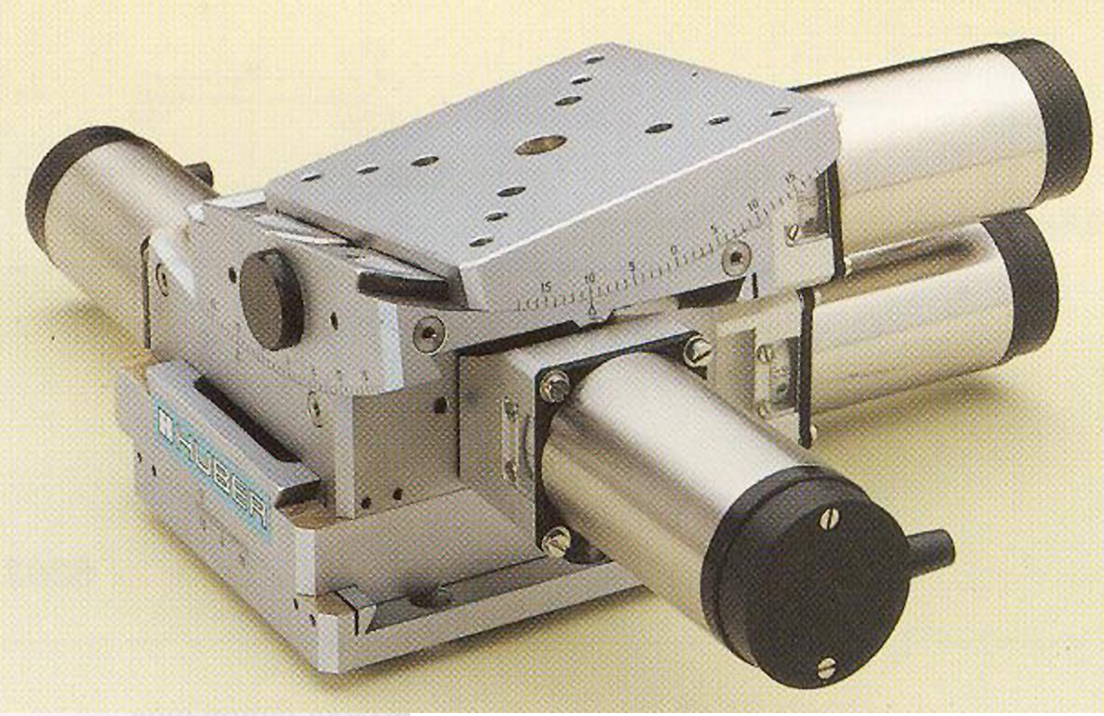
W.B. Peatman: Momochromators from Bird & Tole

Die Lineartische der Serien M-IMS/M-ILS lassen sich zu XYZ- Baugruppen mit hoher Steifigkeit montieren und ermöglichen es damit, große Lasten in drei Achsen zu positionieren.

Rotationstische der Serie RV können vertikal an Verfahrtischen der Serie M-ILS montiert werden und bieten hohe Genauigkeit zu günstigem Preis.

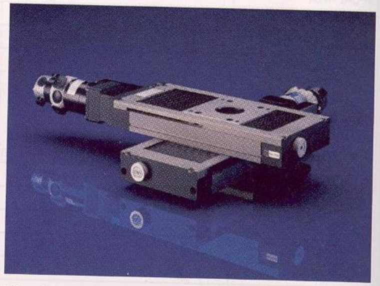
Die Lineartische der VP-Serie lassen sich zu einem kompakten mehrachsigen Positionierer kombinieren.

Diese Baugruppe aus Goniometern der Serie M-BGM kann mit einer "Sphere of Confusion" von 200 µm ausgerichtet werden.

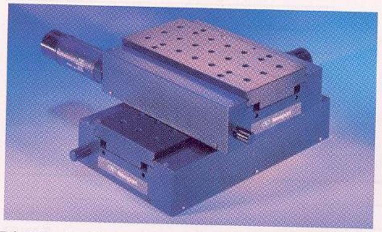


Rotationstische der Serie M-URM können bis auf ±20 µm Achsversatz der Rotationsachsen ausgerichtet werden.

X-Z-Baugruppen aus M-UTM-Tischen können mit einer Orthogonalität von ±100 µrad ausgerichtet werden und bieten Verstellwege bis 150 mm.

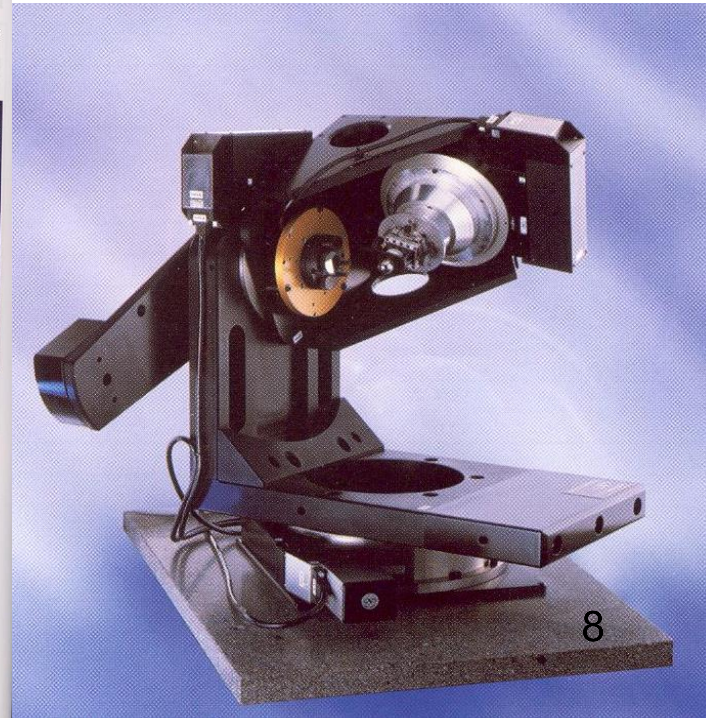


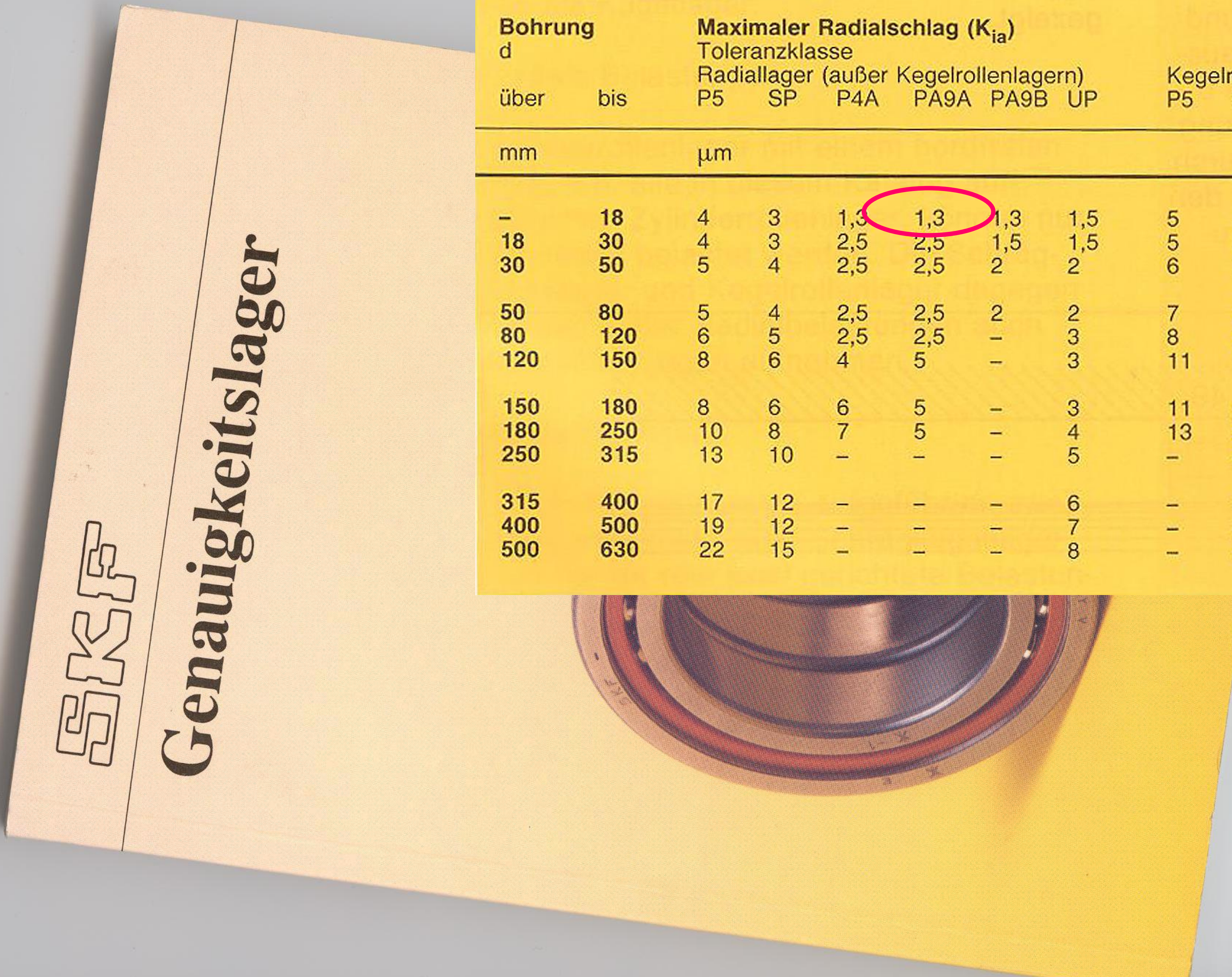
Eine XY-Baugruppe mit Lineartischen der M-UTM-Serie ist eine kostengünstige Lösung, wenn geringe Lasten exakt positioniert werden sollen. Diese Positionierer können mit einer Orthogonalität von ±50 µrad ausgerichtet werden.



Die Lineartische der PM500-Serie können mit einer

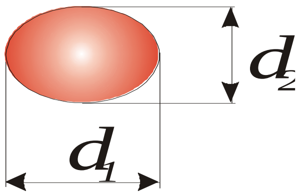
Lineartische der Serie M-PM500-1L und M-PM500-1V



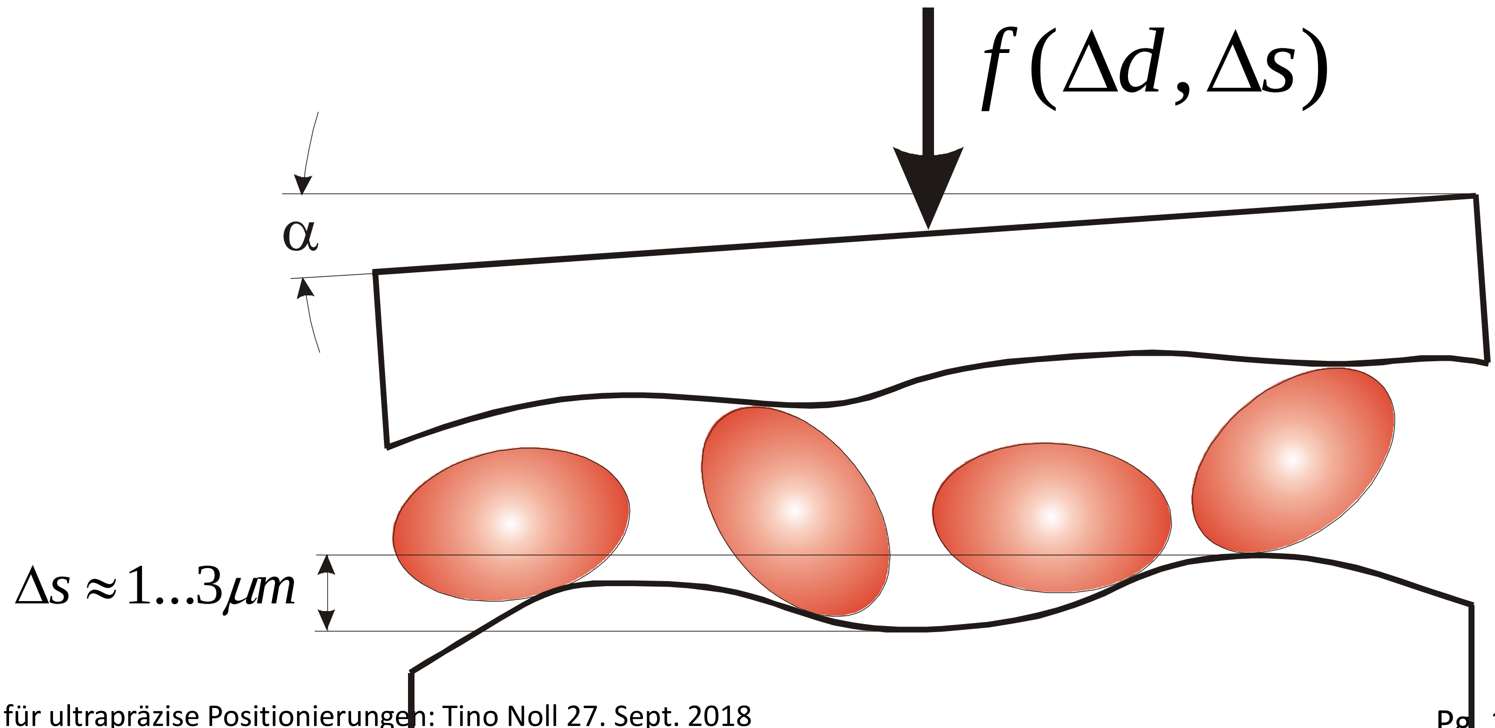


Bohrung d		Maximaler Radialschlag (K_{ia}) Toleranzklasse Radiallager (außer Kegelrollenlagern)						Kegelrollenlager	
über	bis	P5	SP	P4A	PA9A	PA9B	UP	P5	CLB
mm		µm							
–	**18**	4	3	1,3	1,3	1,3	1,5	5	–
18	**30**	4	3	2,5	2,5	1,5	1,5	5	2,5
30	**50**	5	4	2,5	2,5	2	2	6	3,5
50	**80**	5	4	2,5	2,5	2	2	7	3,5
80	**120**	6	5	2,5	2,5	–	3	8	3,5
120	**150**	8	6	4	5	–	3	11	4
150	**180**	8	6	6	5	–	3	11	4
180	**250**	10	8	7	5	–	4	13	5
250	**315**	13	10	–	–	–	5	–	–
315	**400**	17	12	–	–	–	6	–	–
400	**500**	19	12	–	–	–	7	–	–
500	**630**	22	15	–	–	–	8	–	–

Random Error Motions



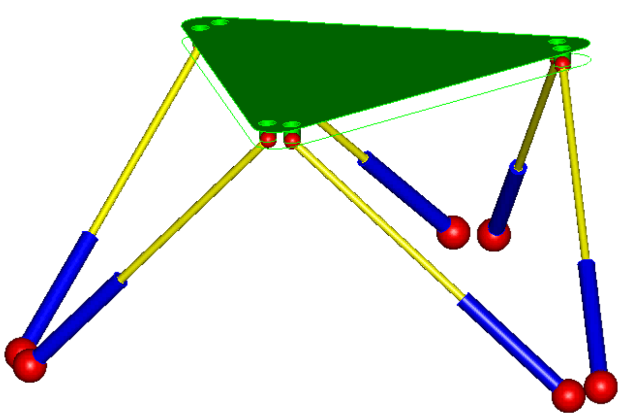
$$\Delta d = d_1 - d_2 \approx 1 \mu m$$



Hexapod

advantages

- DOF 6
- high stiffness
- low mass



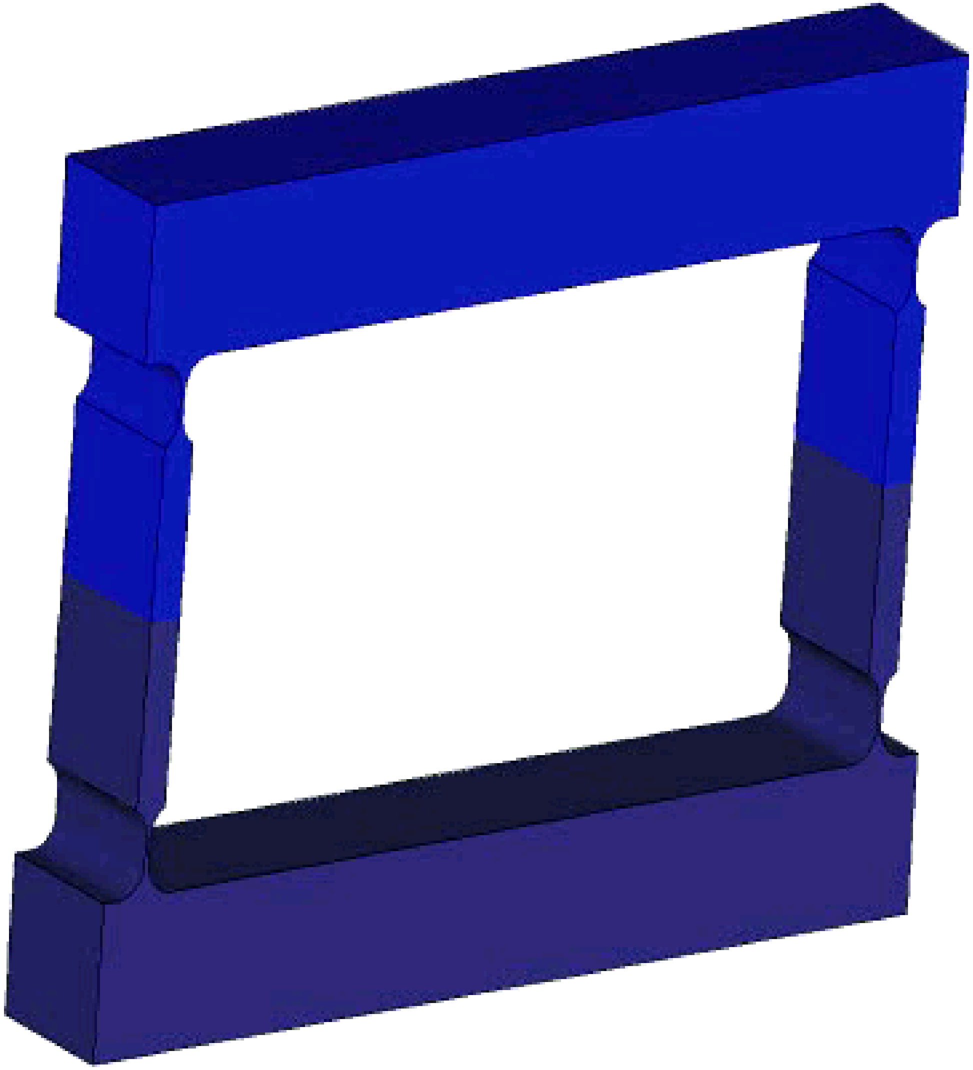
disadvantages

- six motor drives are always necessary
- not intuitively manually movable
- crosstalk is extremly big

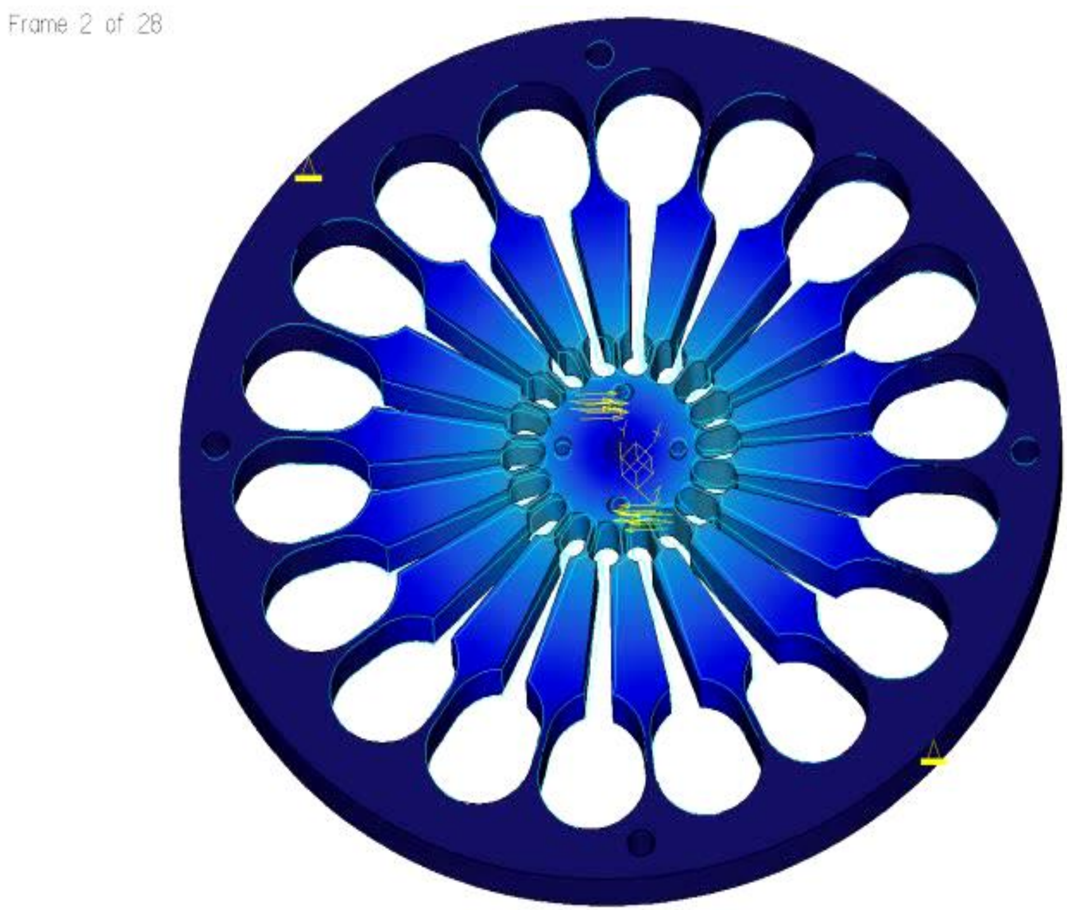
potential of improvements

- Cartesian strut topology
- Back-lash free joints
- drives

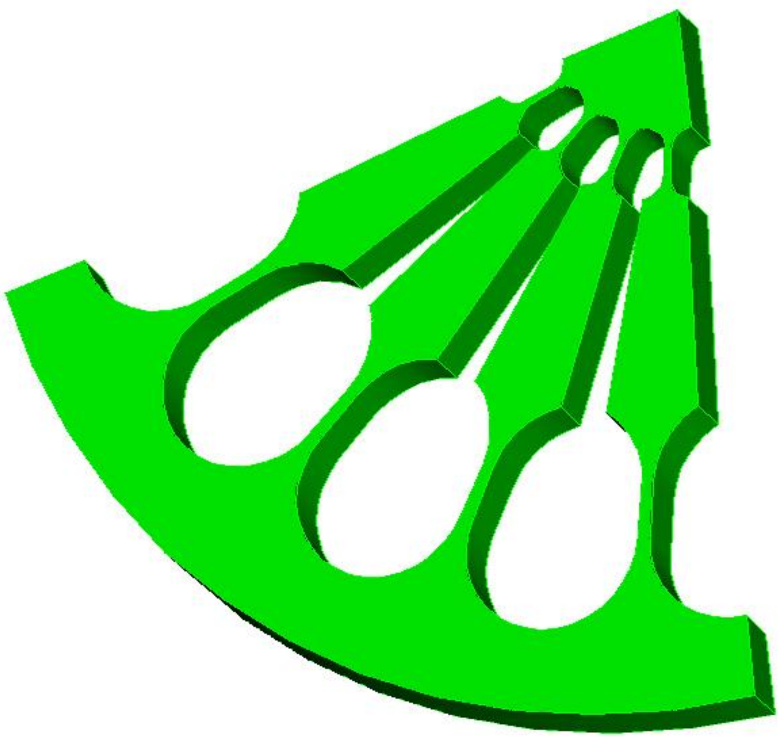
Parallelogramm

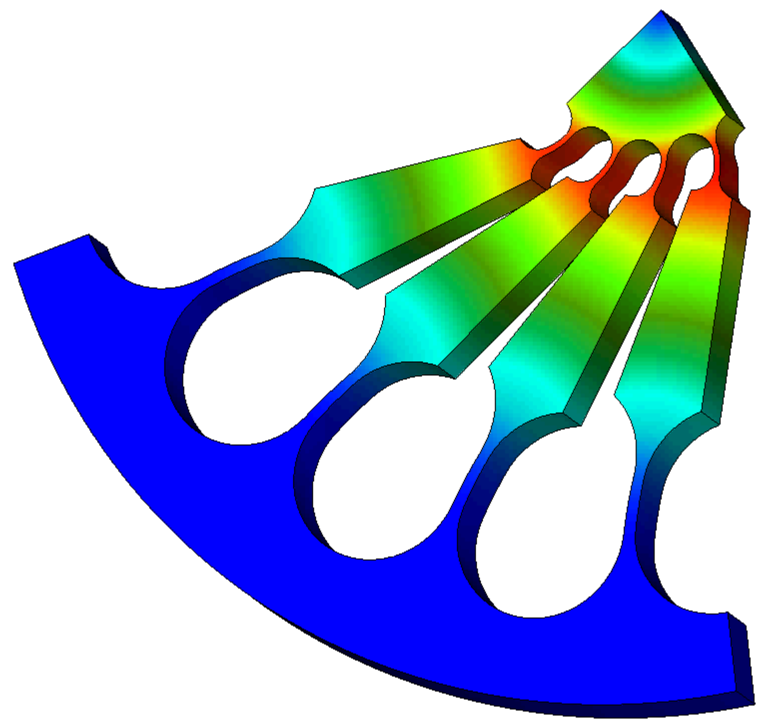


Zirkulares Muster von doppelt gelenkigen Stäben



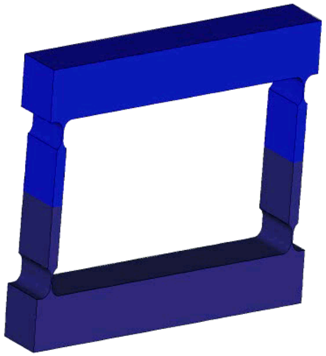
Segment der zirkularen Stabanordnung



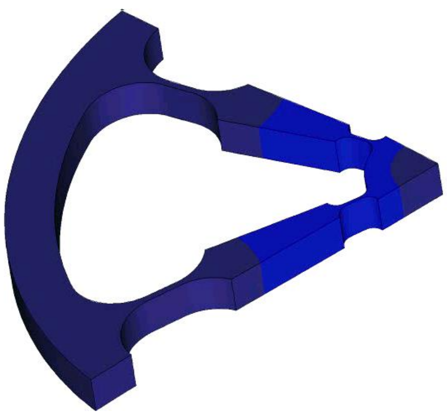


Combination of a Parallelogram with a Trapezoid

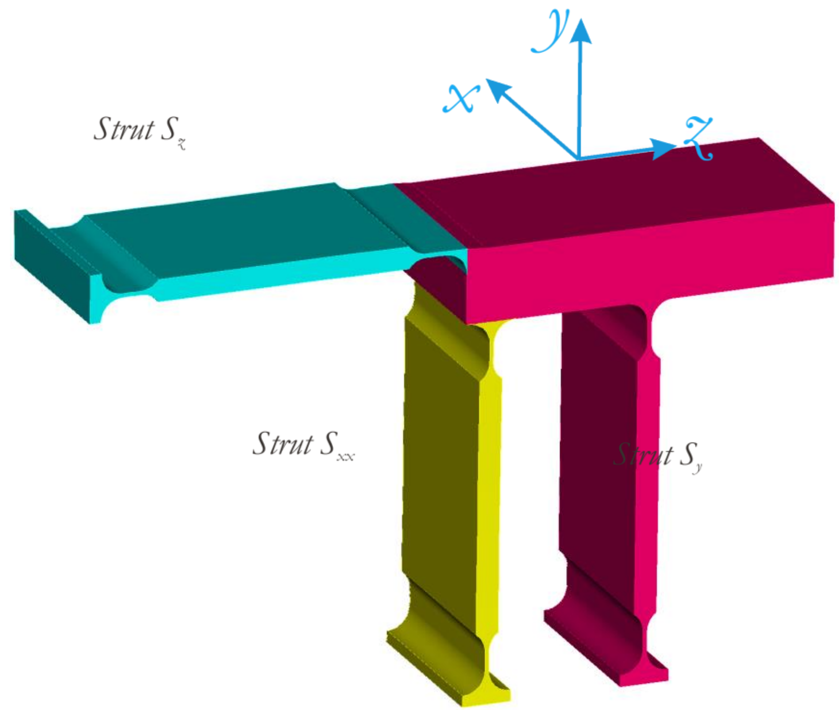
DOF 3



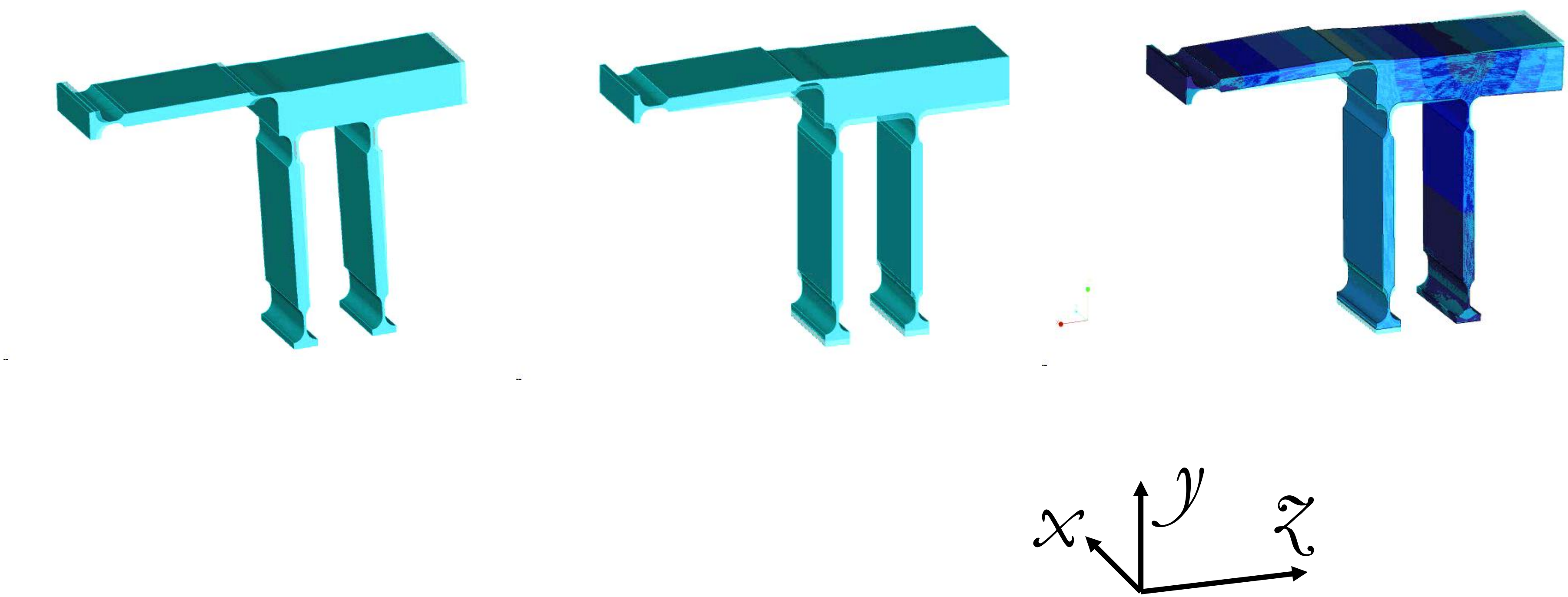
Parallelogram Stage



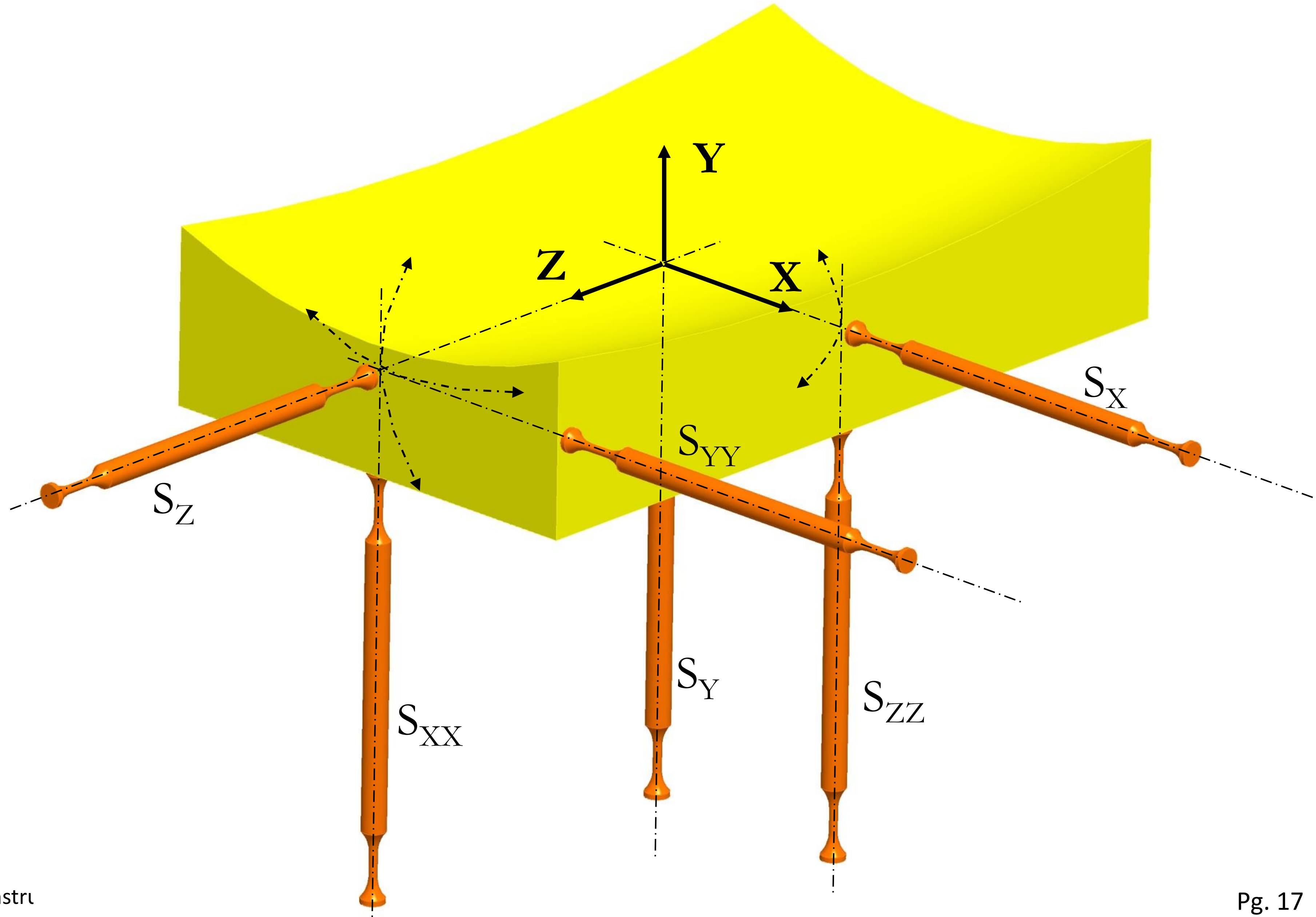
Trapezoid Stage



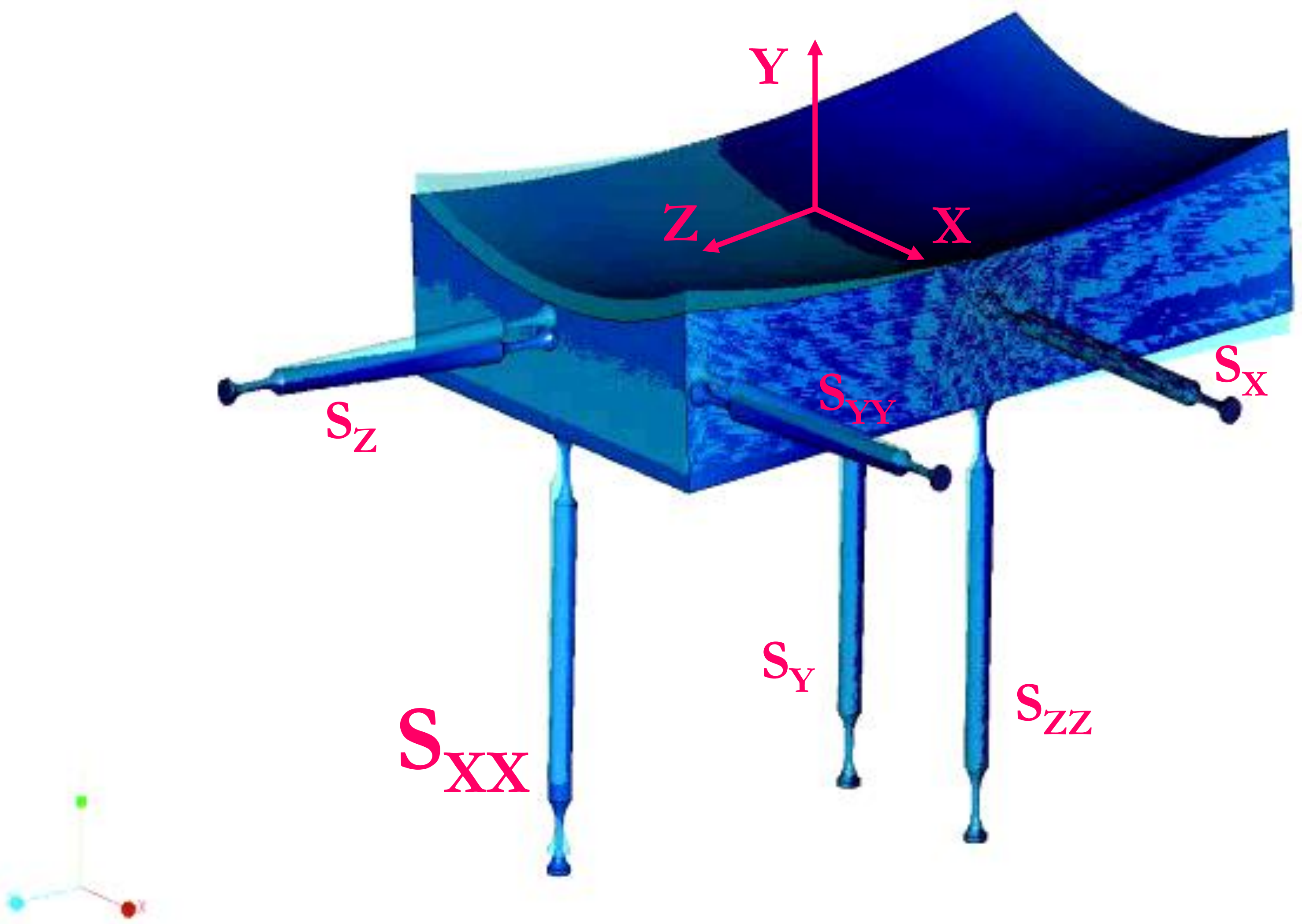
Die drei möglichen Bewegungen im planaren Systen



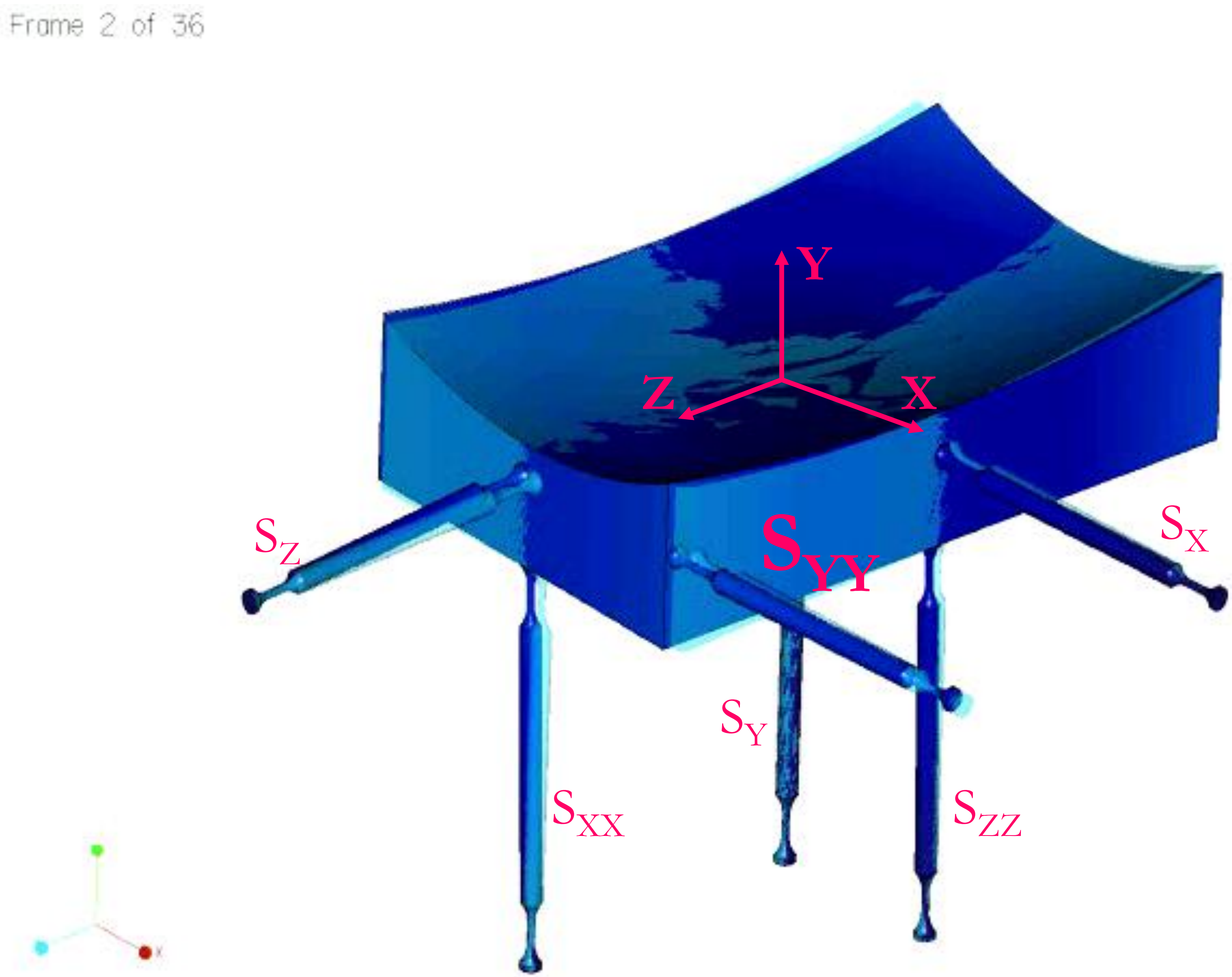
Spatial topology with DOF6



Rotation around the X-axis



Rotation around the Y-axis



Rotation around the Z-axis

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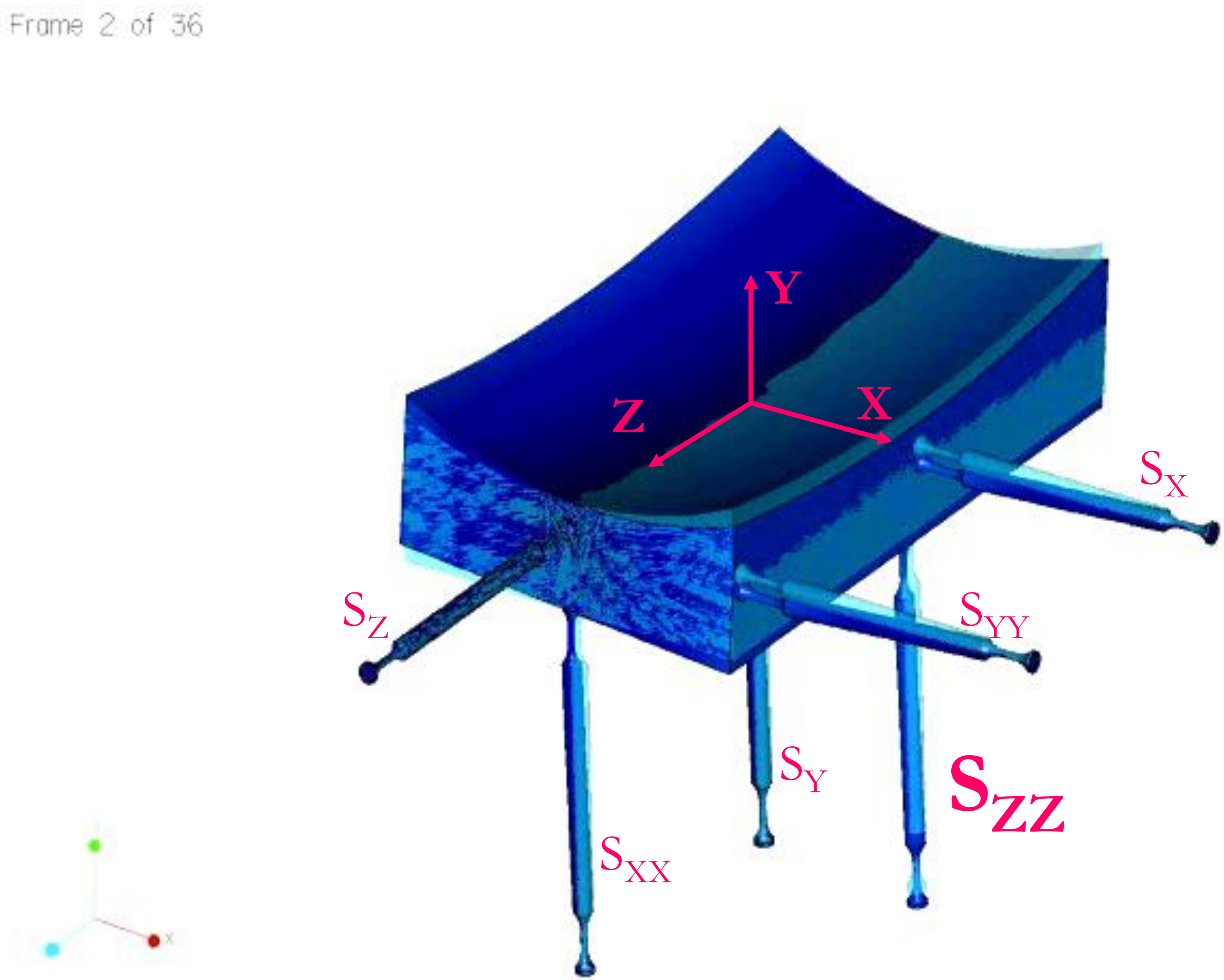
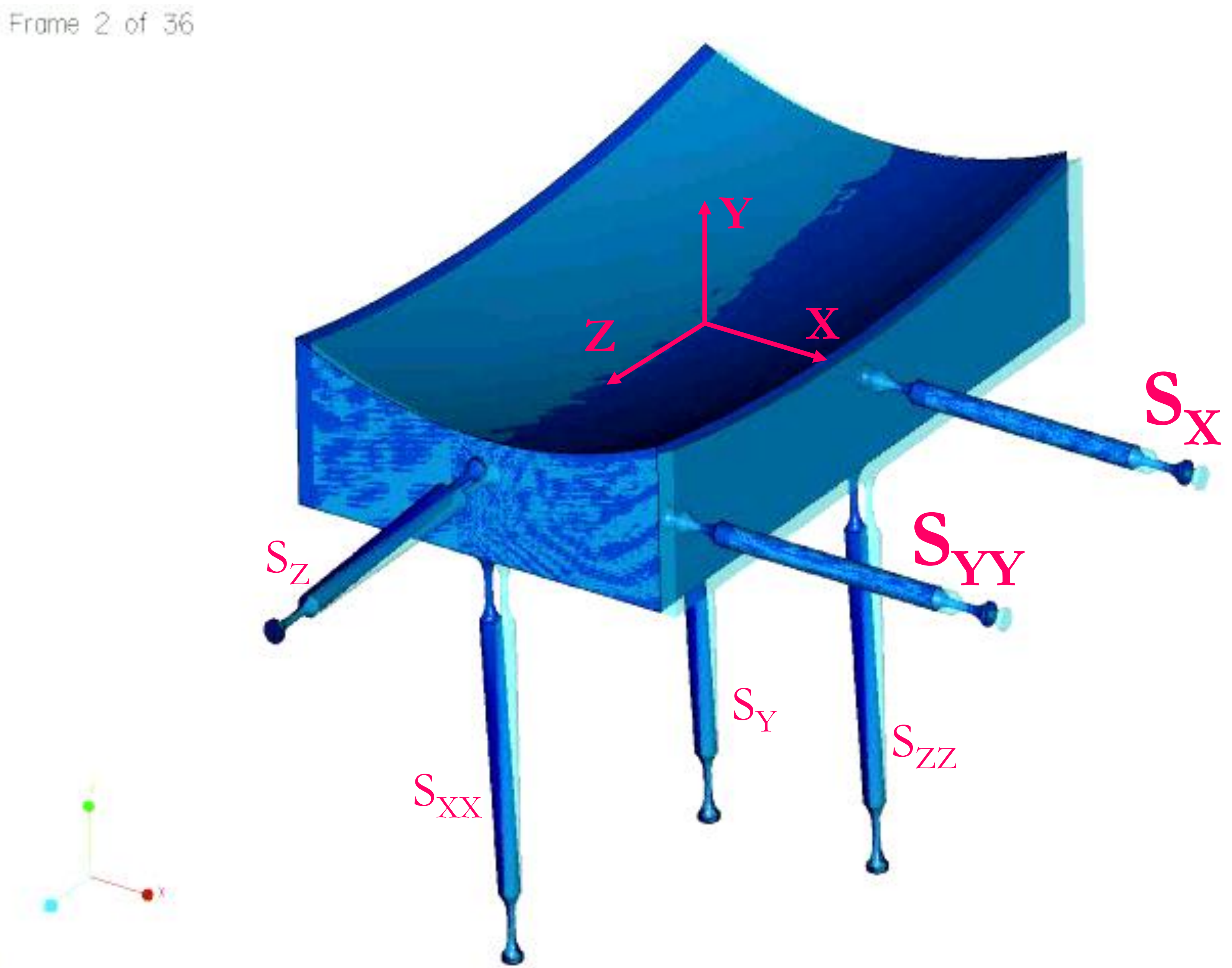
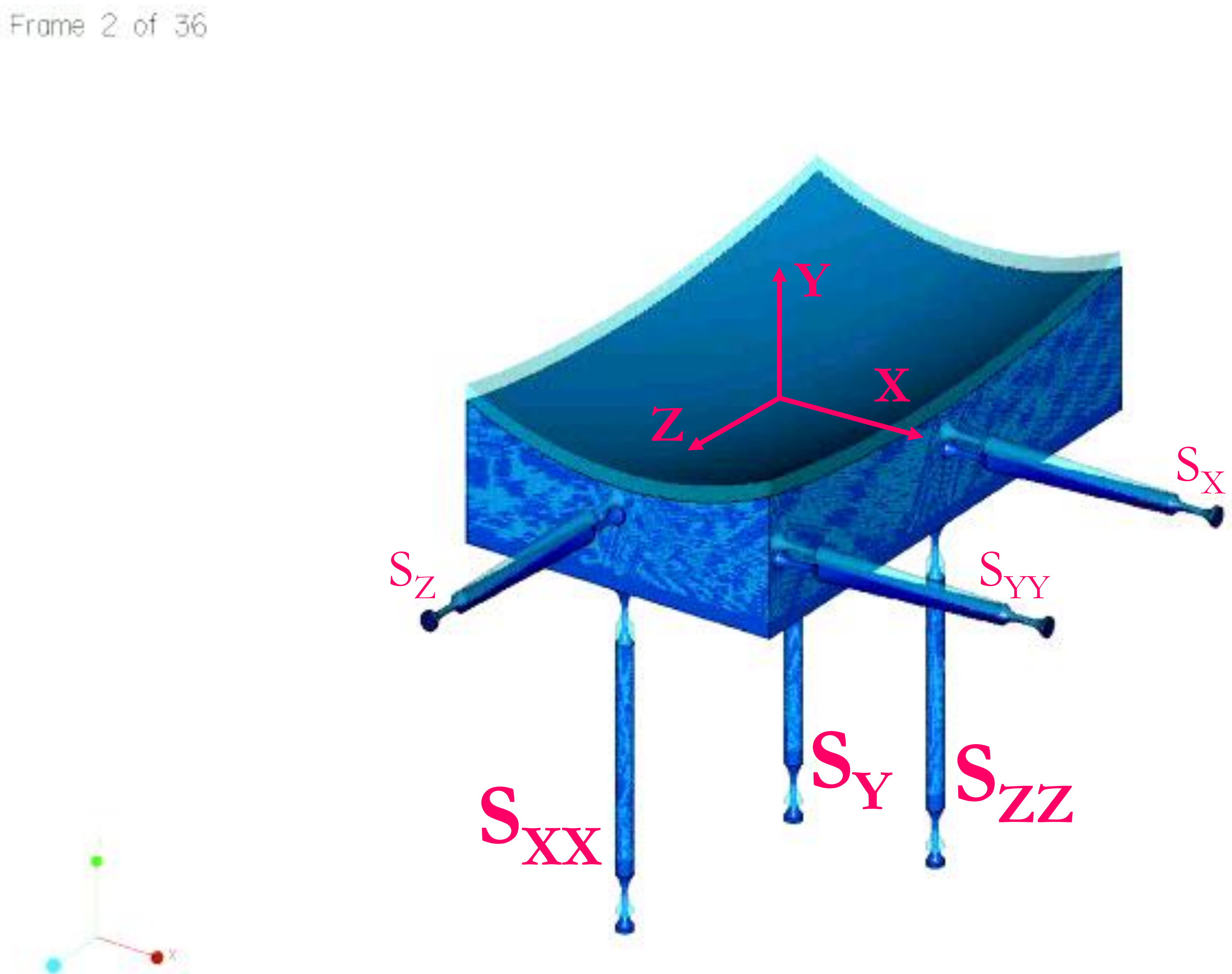


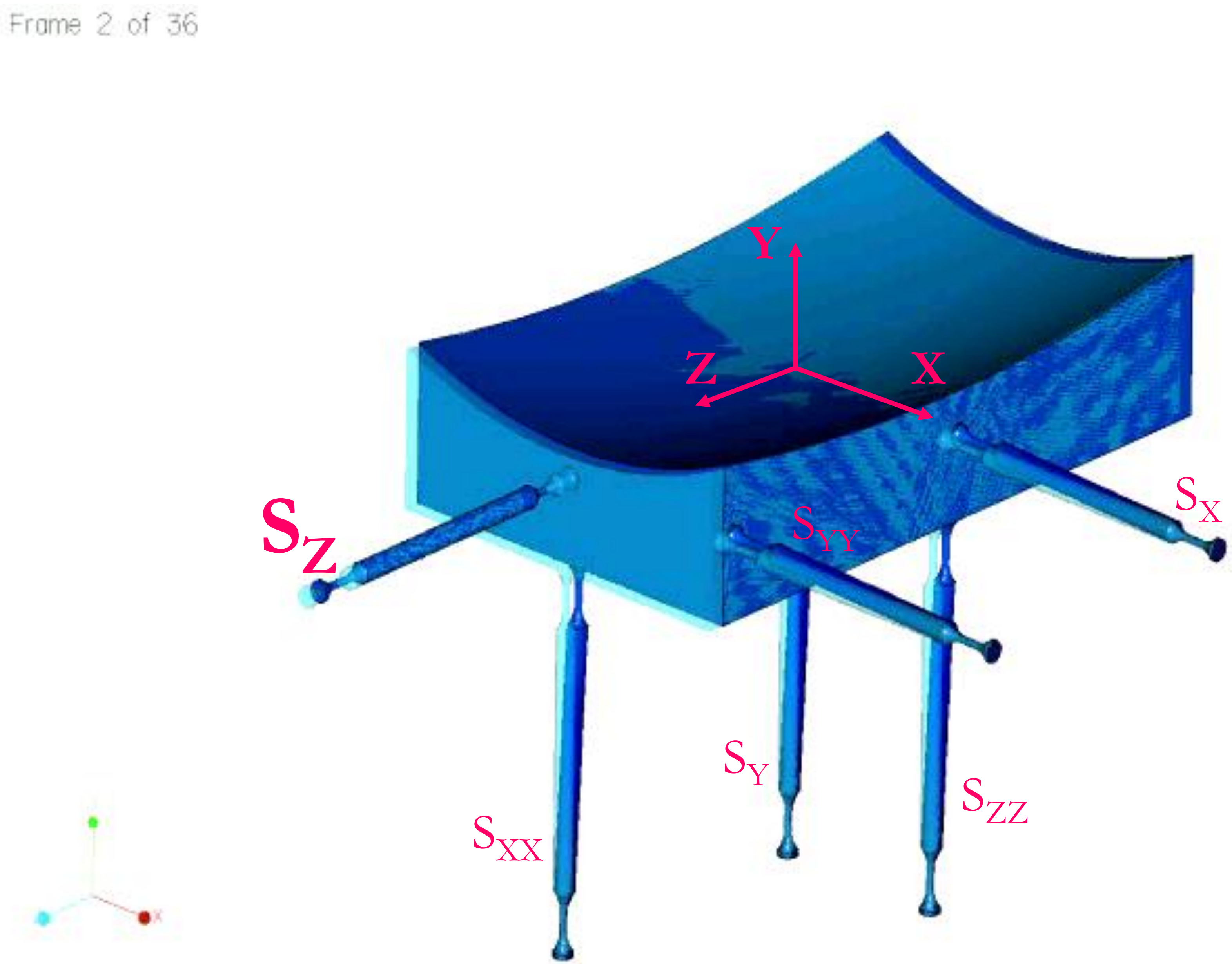
Translation in X-direction



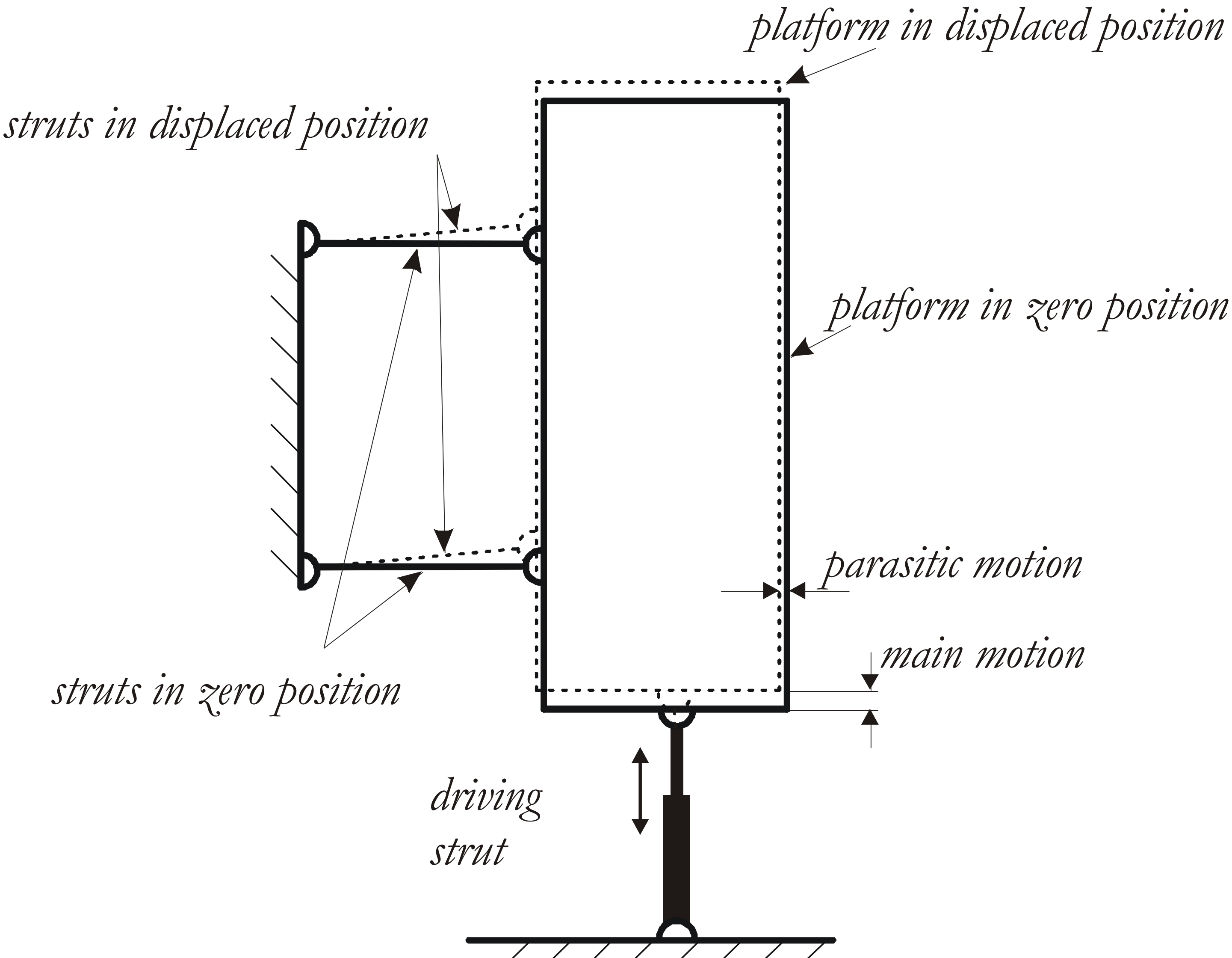
Translation in Y-direction



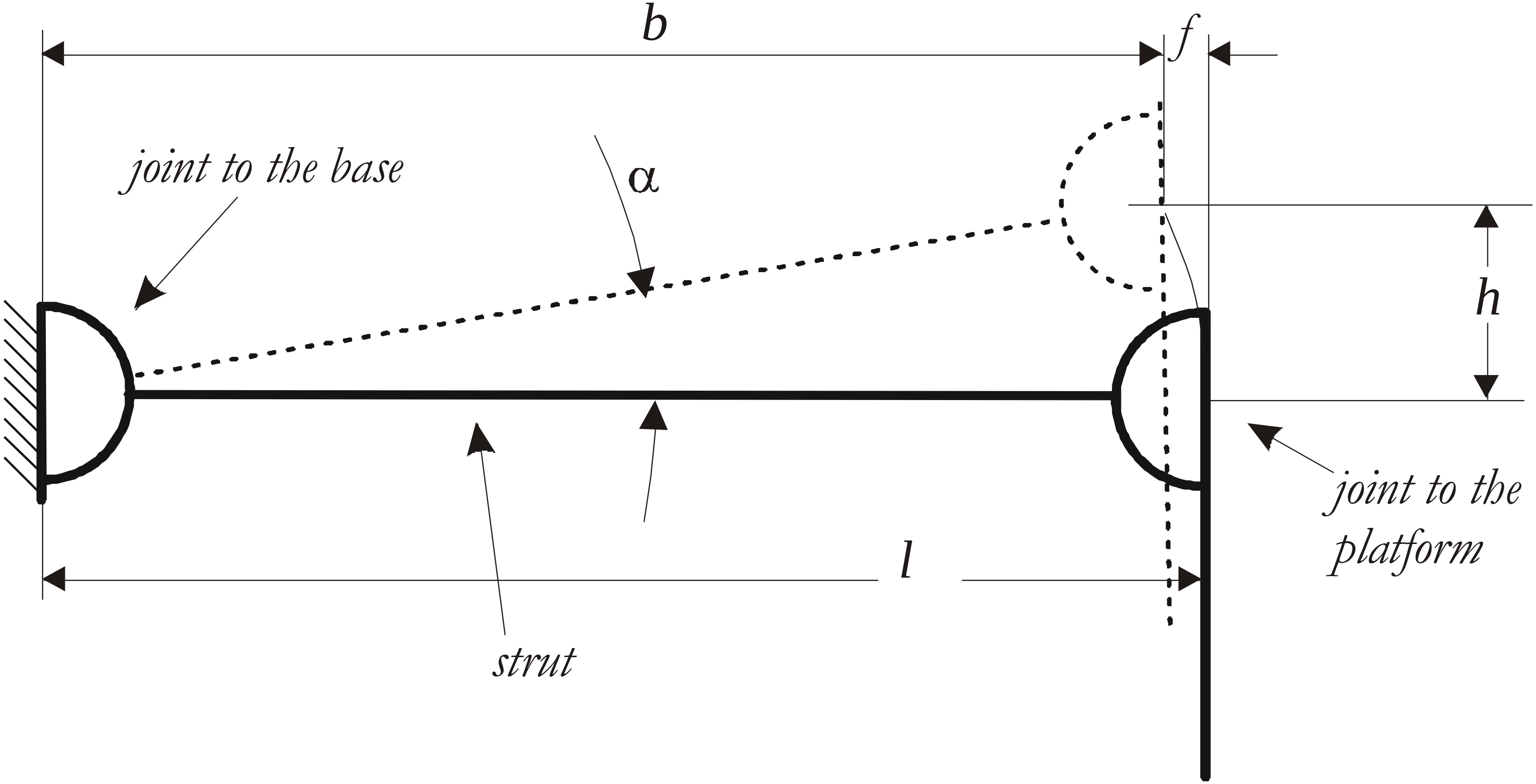
Translation in Z-direction



Reproducible parasitic motion

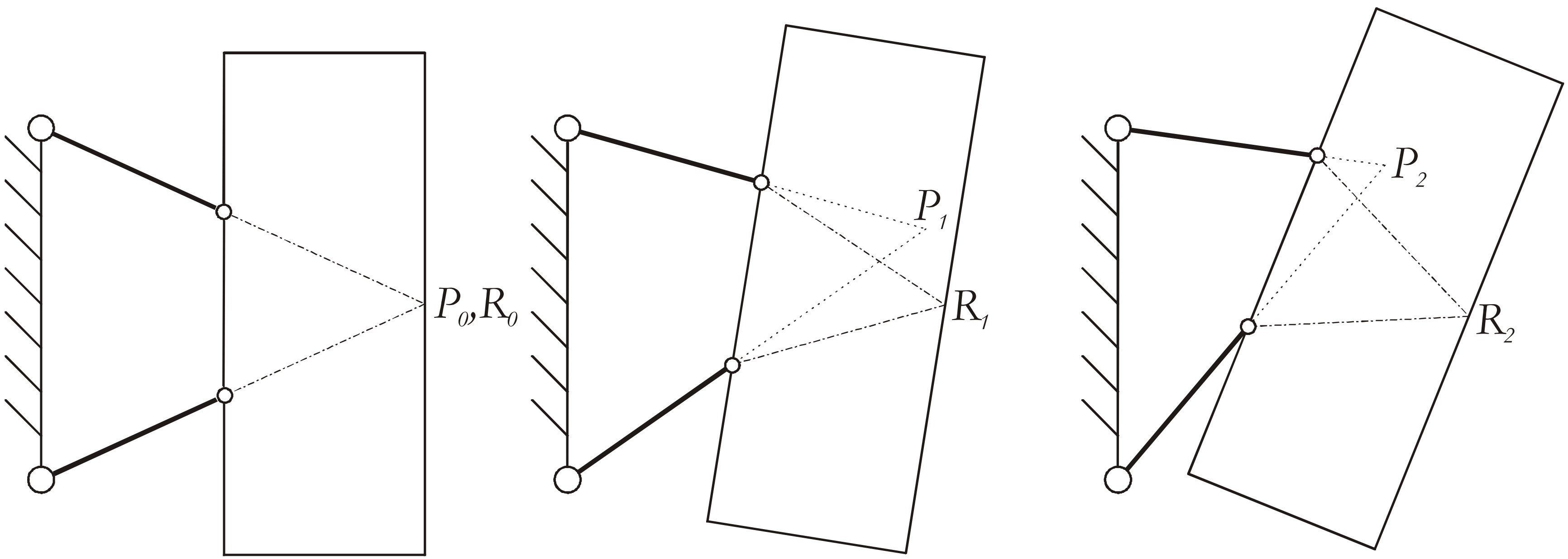


Parasitärbewegung bei Auslenkung



parasitic motion $$f = l - \sqrt{l^2 - h^2} \approx \frac{1}{2}\frac{h^2}{l}$$

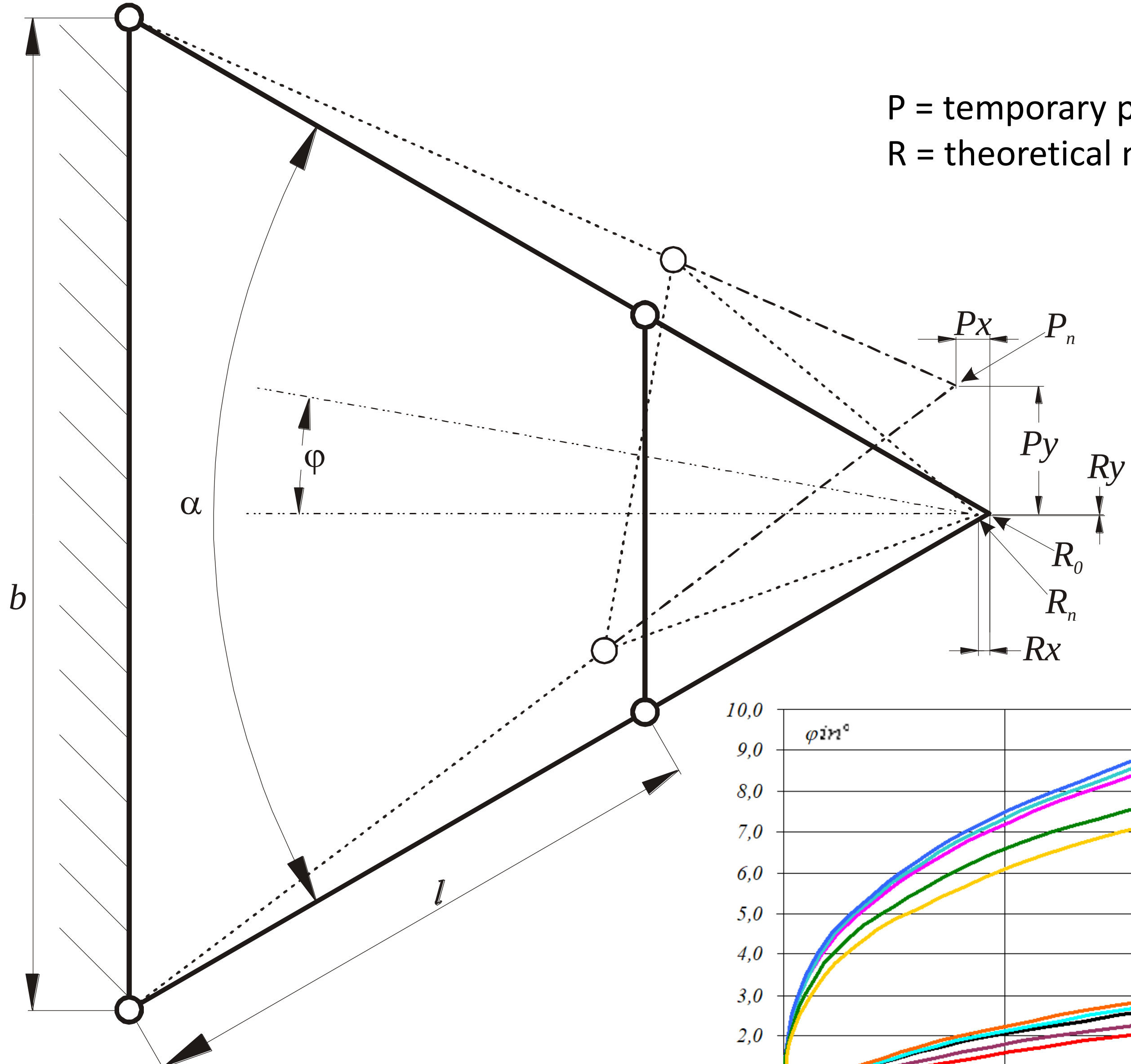
Steps of a rotation

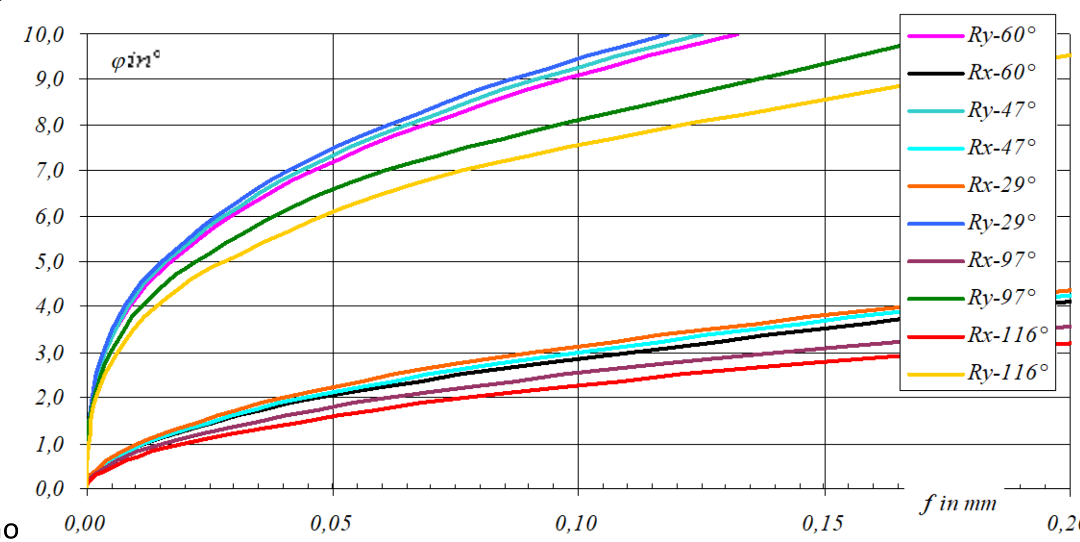


zero position *midle position* *endposition*

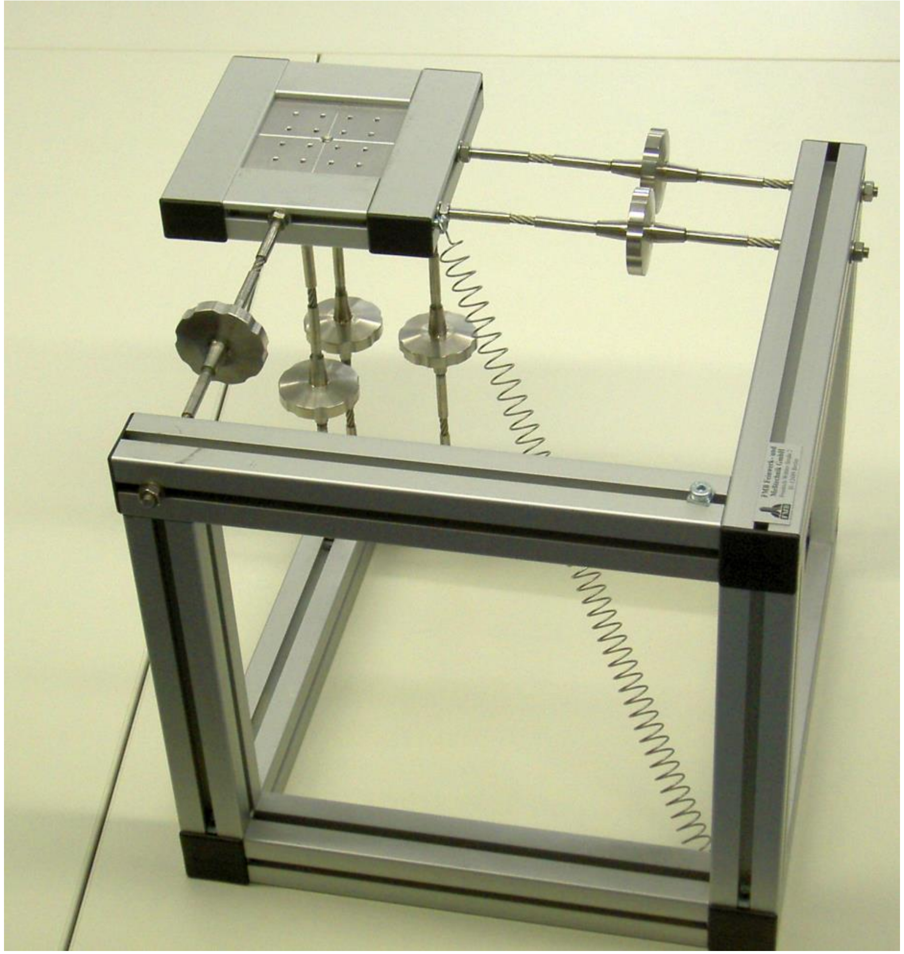
Geometrical calculation in a parametric CAD-system

P = temporary pole
R = theoretical mirror midpoint

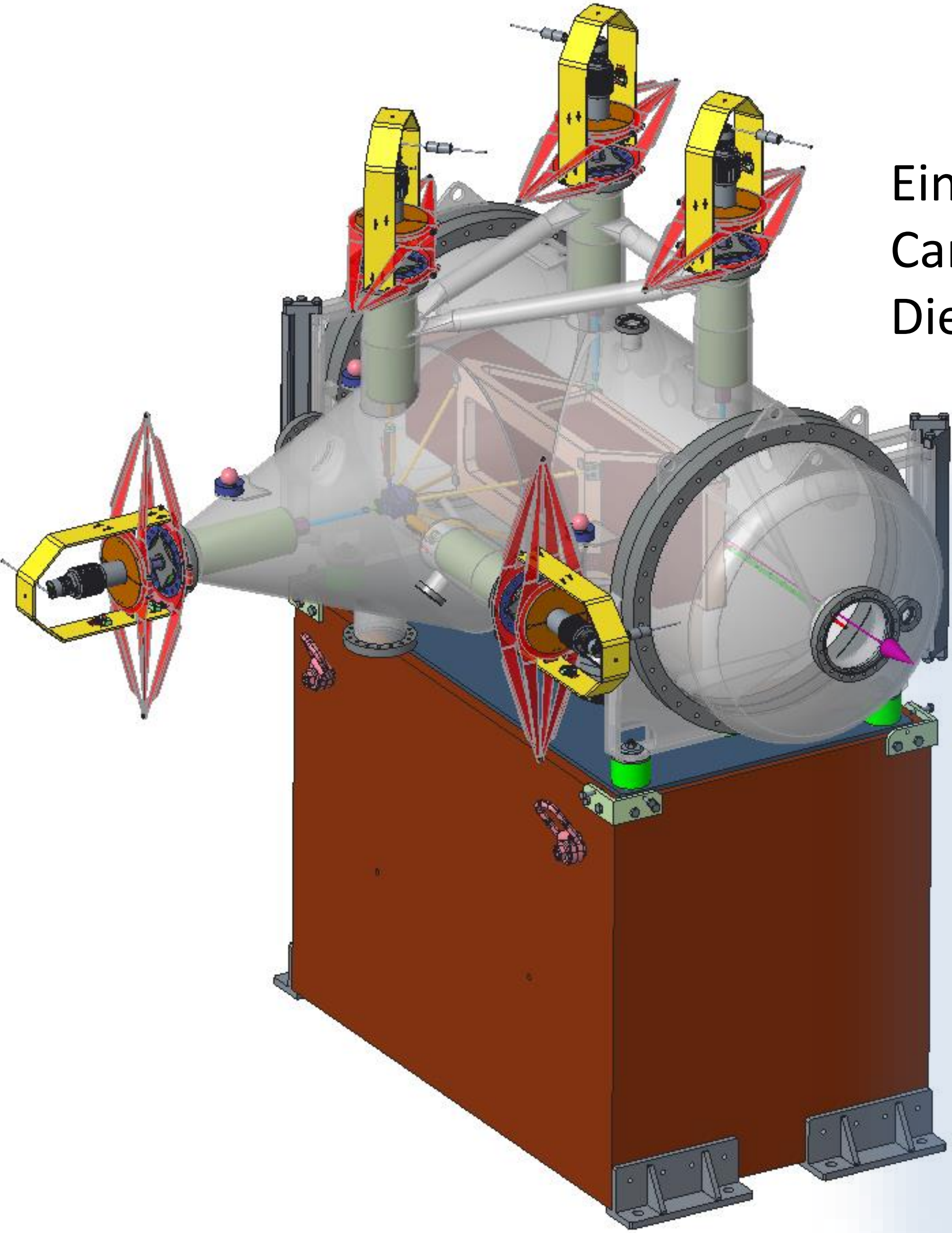


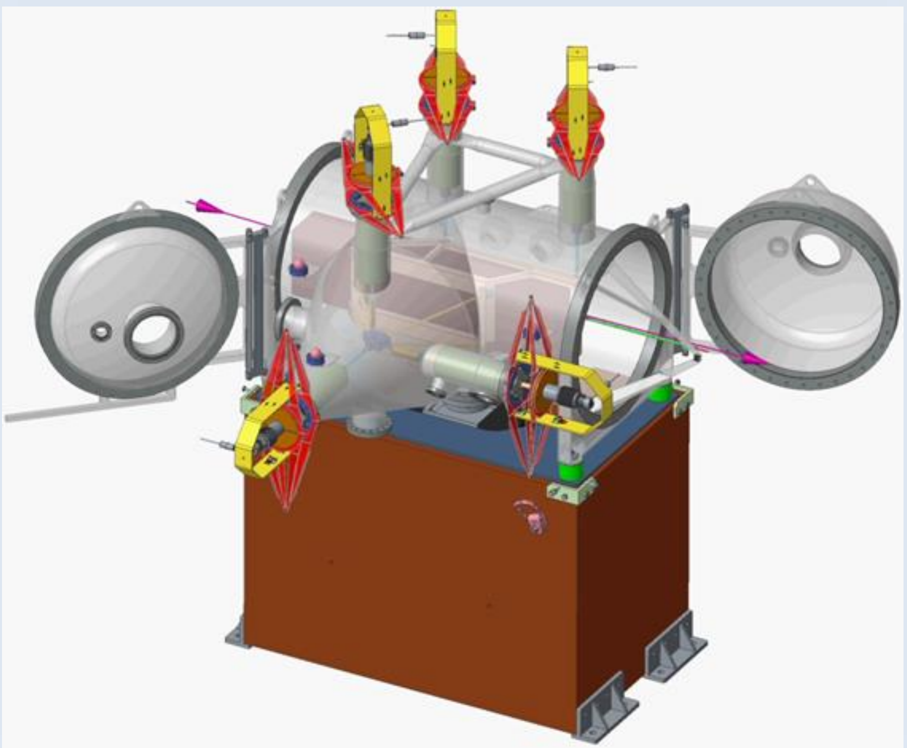


Manuell intuitiv justierbare Platform mit dem Freiheitsgrad 6

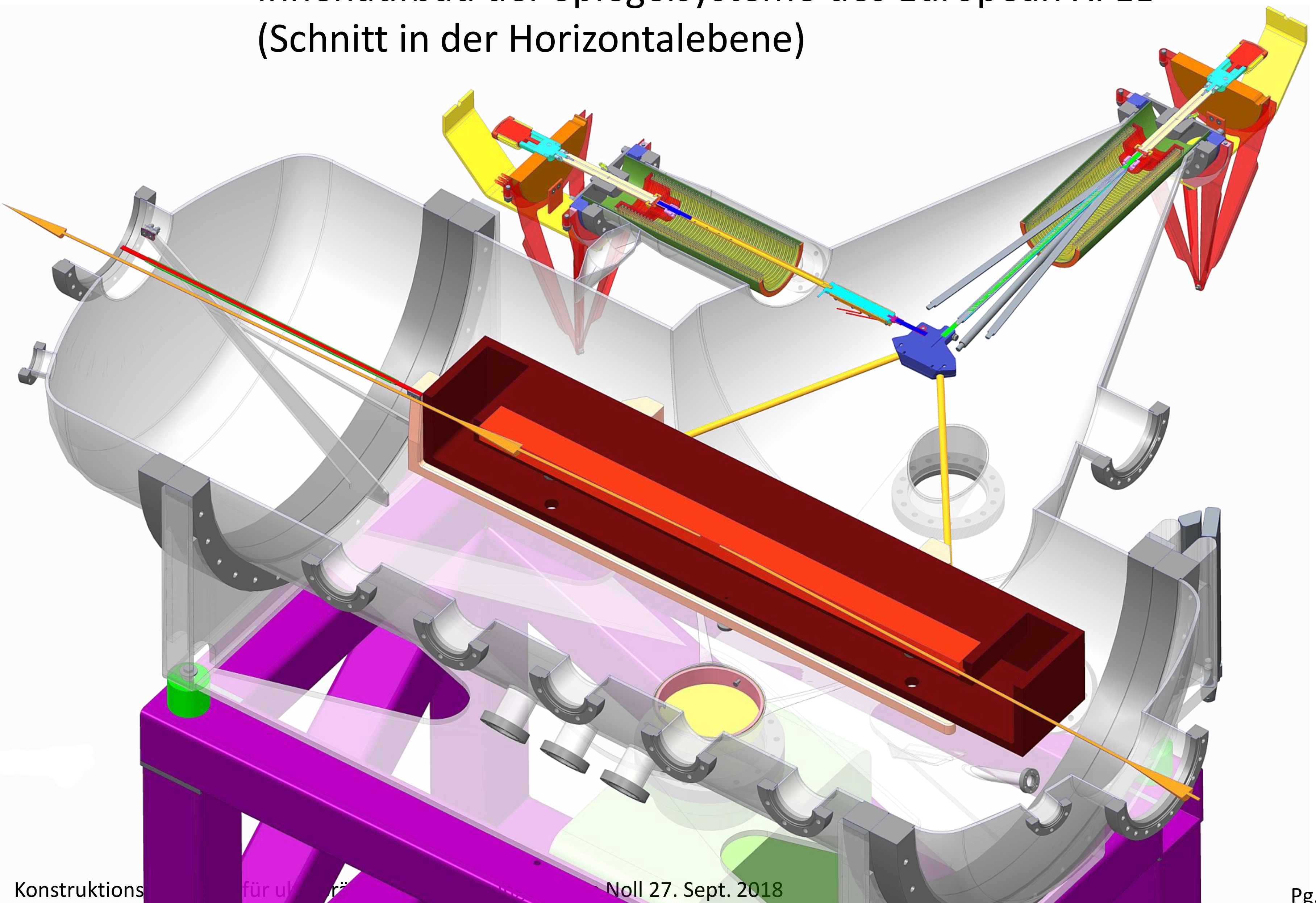


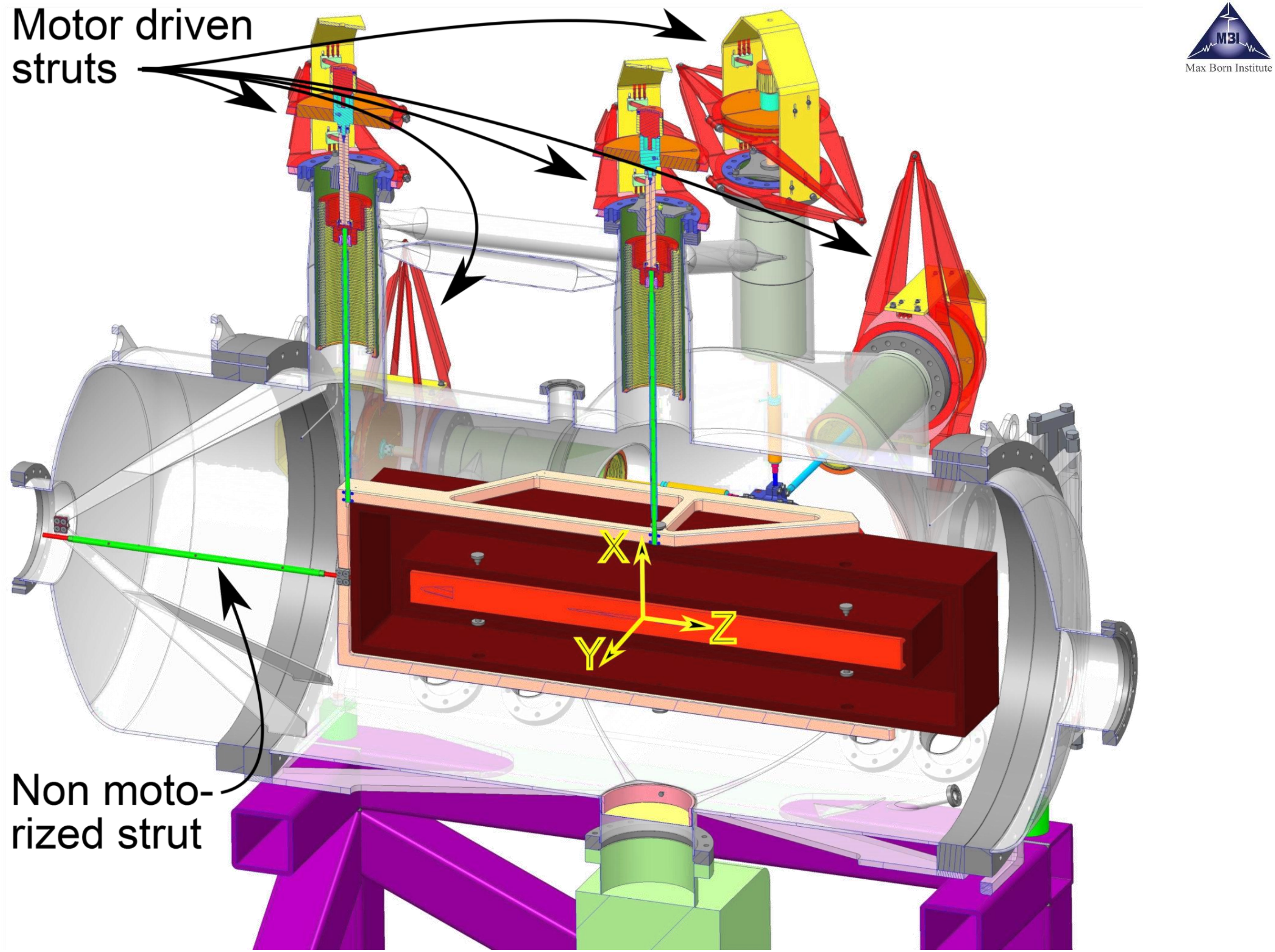
Ein Beispiel für Anwendungen der Cartesischen Parallelkinematik:
Die Spiegelkammern des European XFEL





Innenaufbau der Spiegelsysteme des European XFEL
(Schnitt in der Horizontalebene)




Motor driven
struts
Non moto-
rized strut
X
Y
Z
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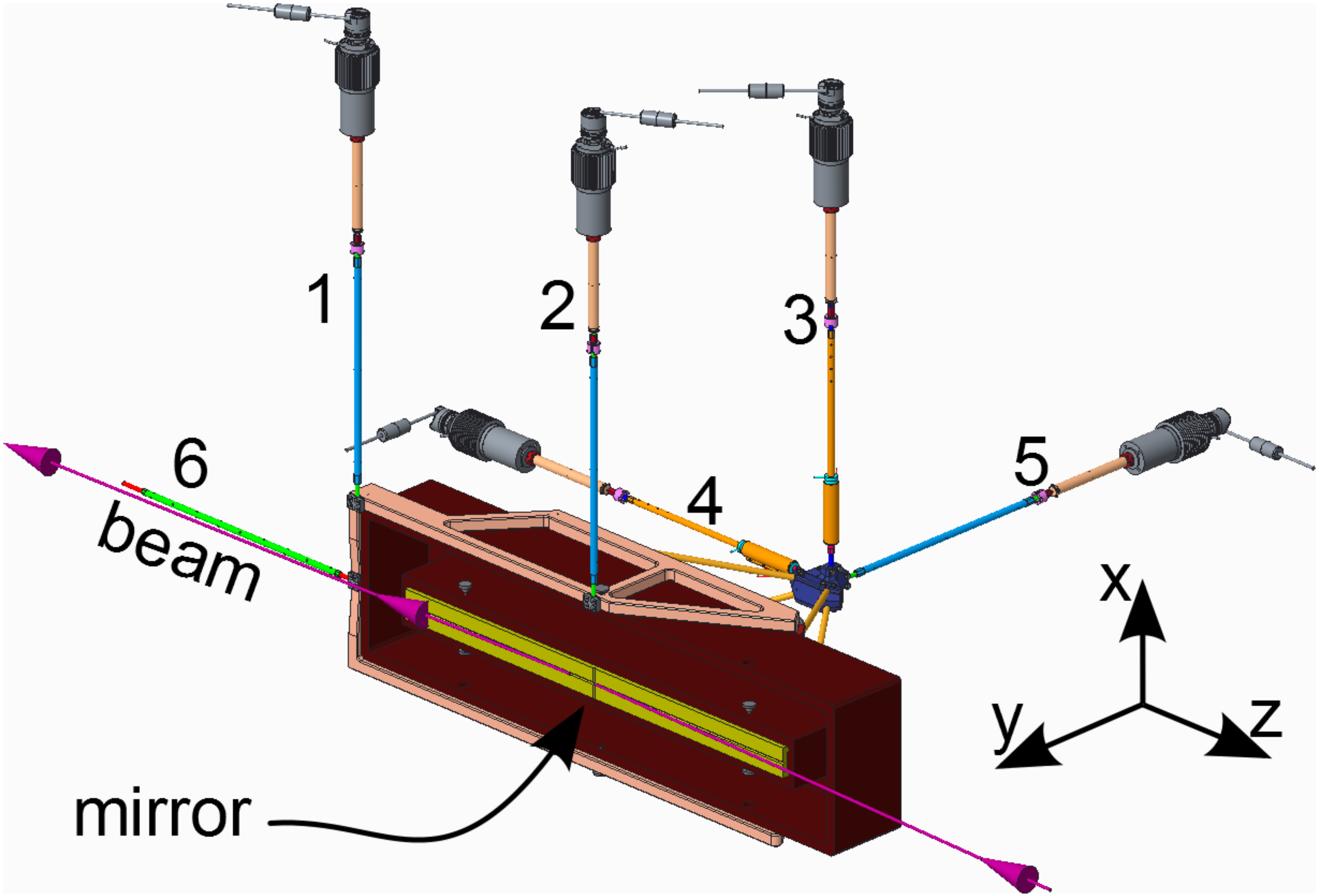
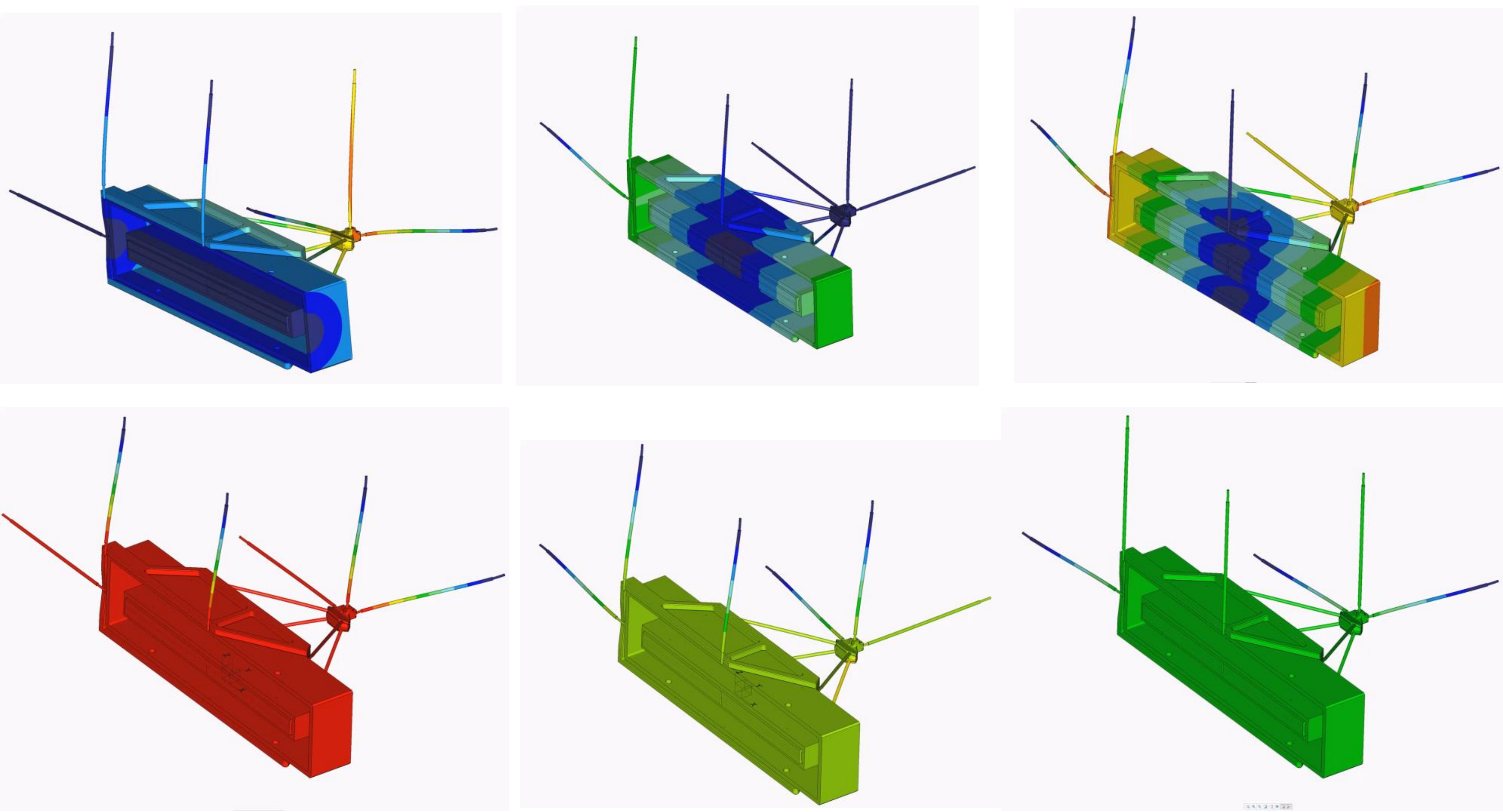
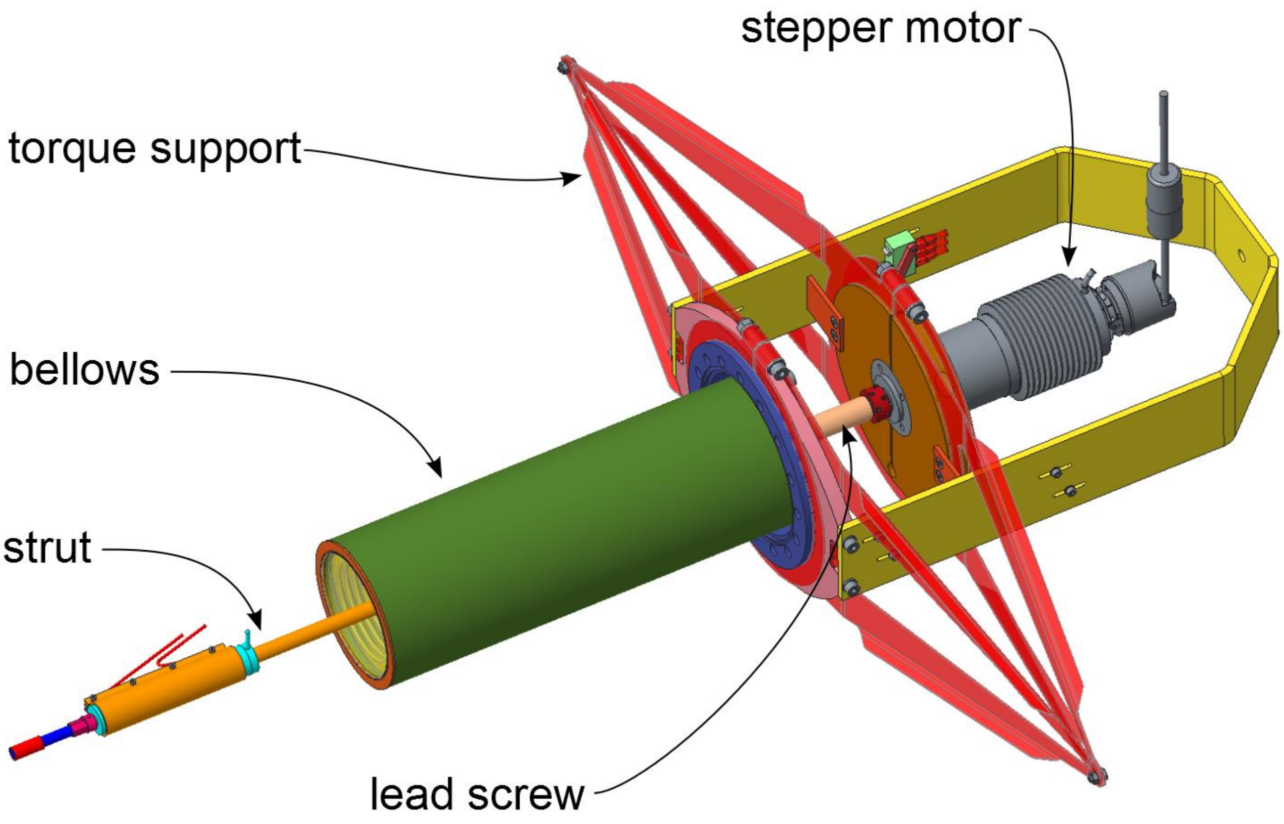
Topology of the Cartesian parallel kinematic

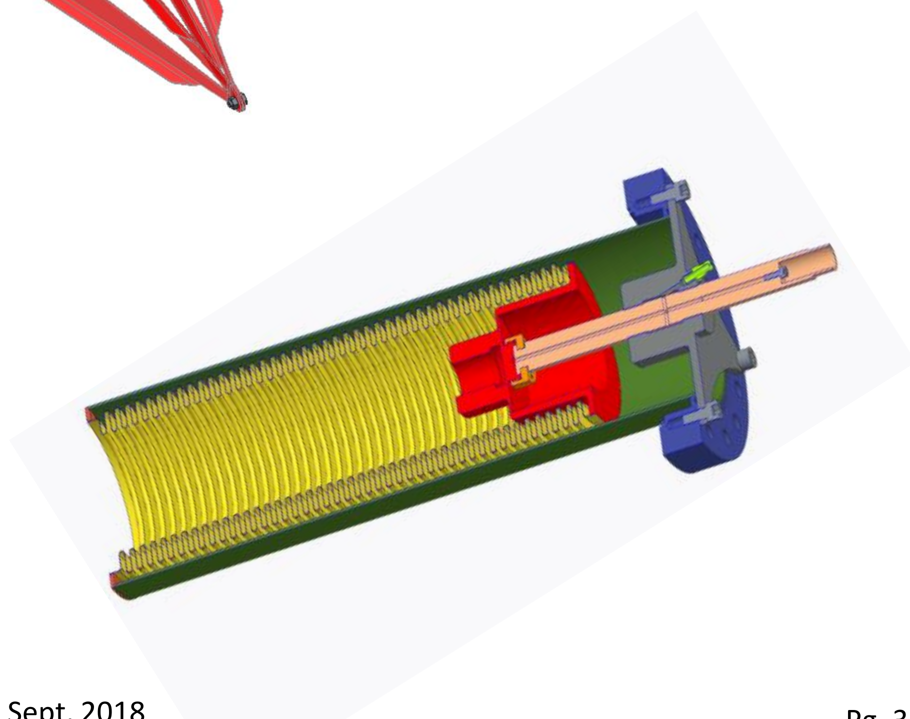


Simulation der Bewegungen

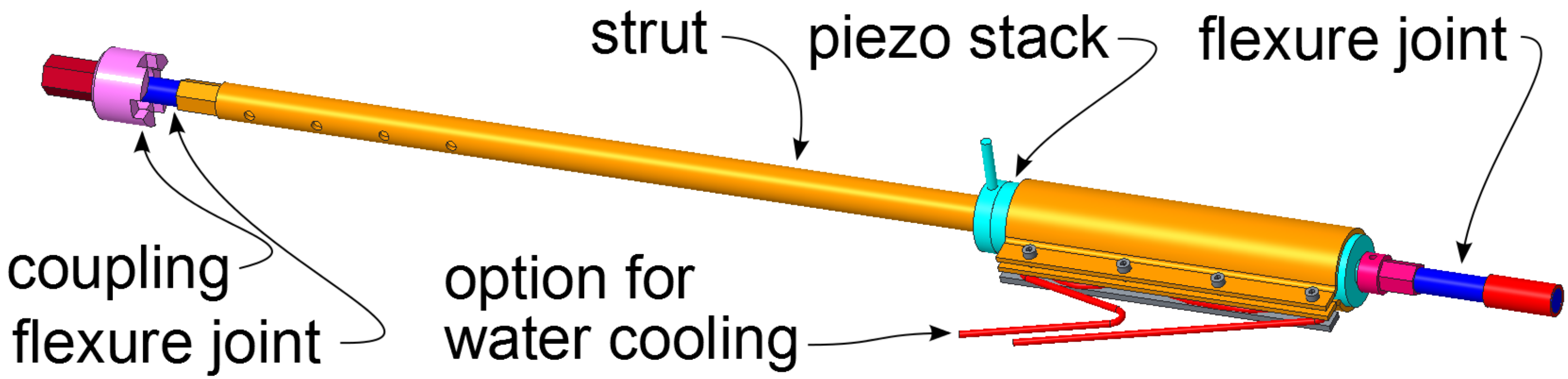


Geeignete Antriebe

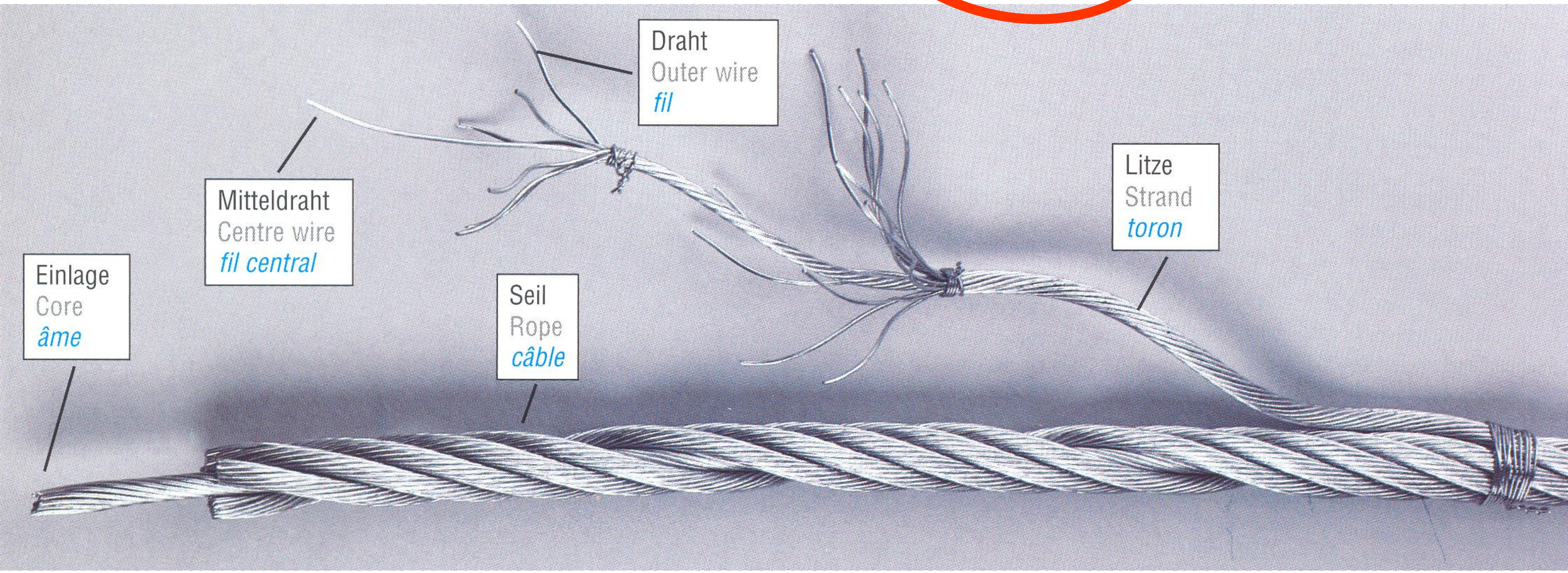




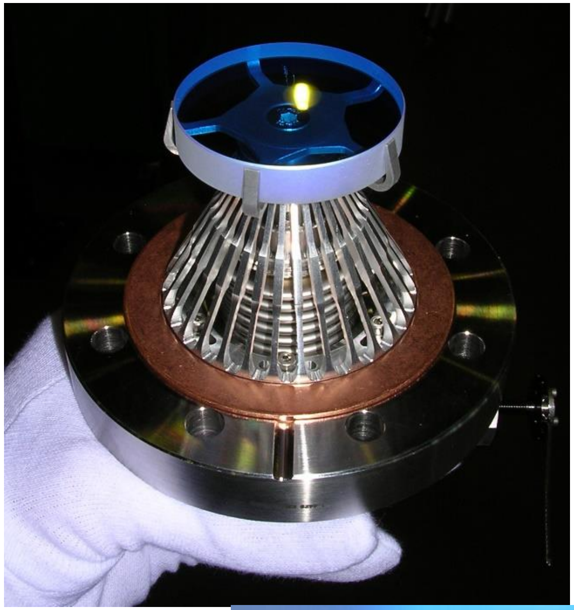
Strut of the Cartesian parallel kinematic with embedded piezo stack drive



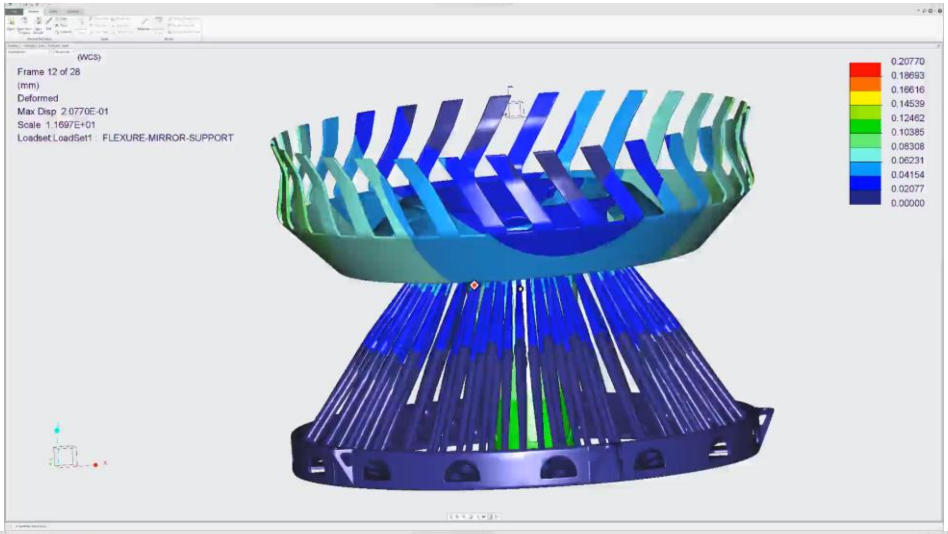

1 x 7
1 x 19
7 x 7
7 x 19

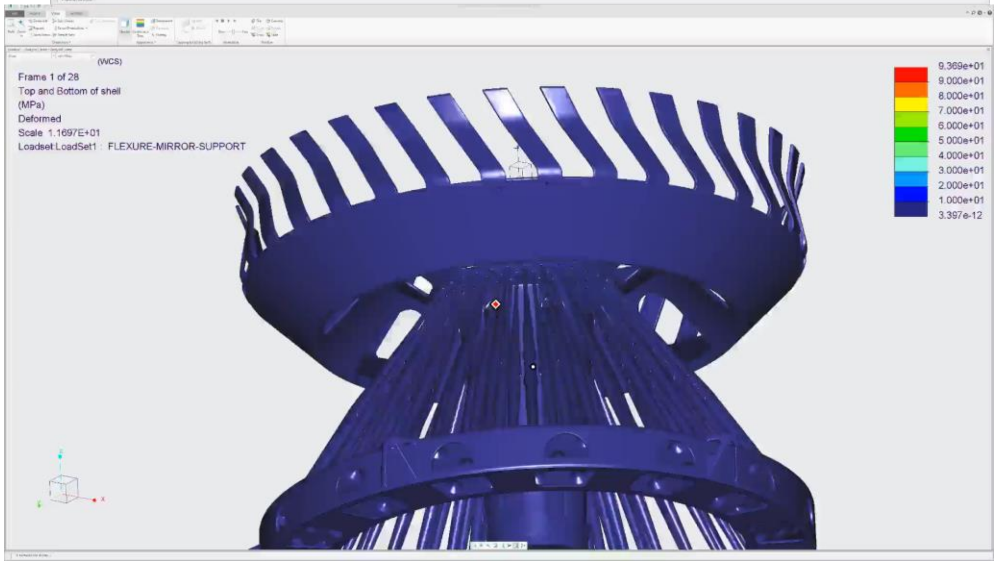

Draht
Outer wire
fil
Mitteldraht
Centre wire
fil central
Litze
Strand
toron
Einlage
Core
âme
Seil
Rope
câble

Zweites Beispiel: monolithisches 3-achsig drehbares Spiegellager, gefräst und Lasergeformt



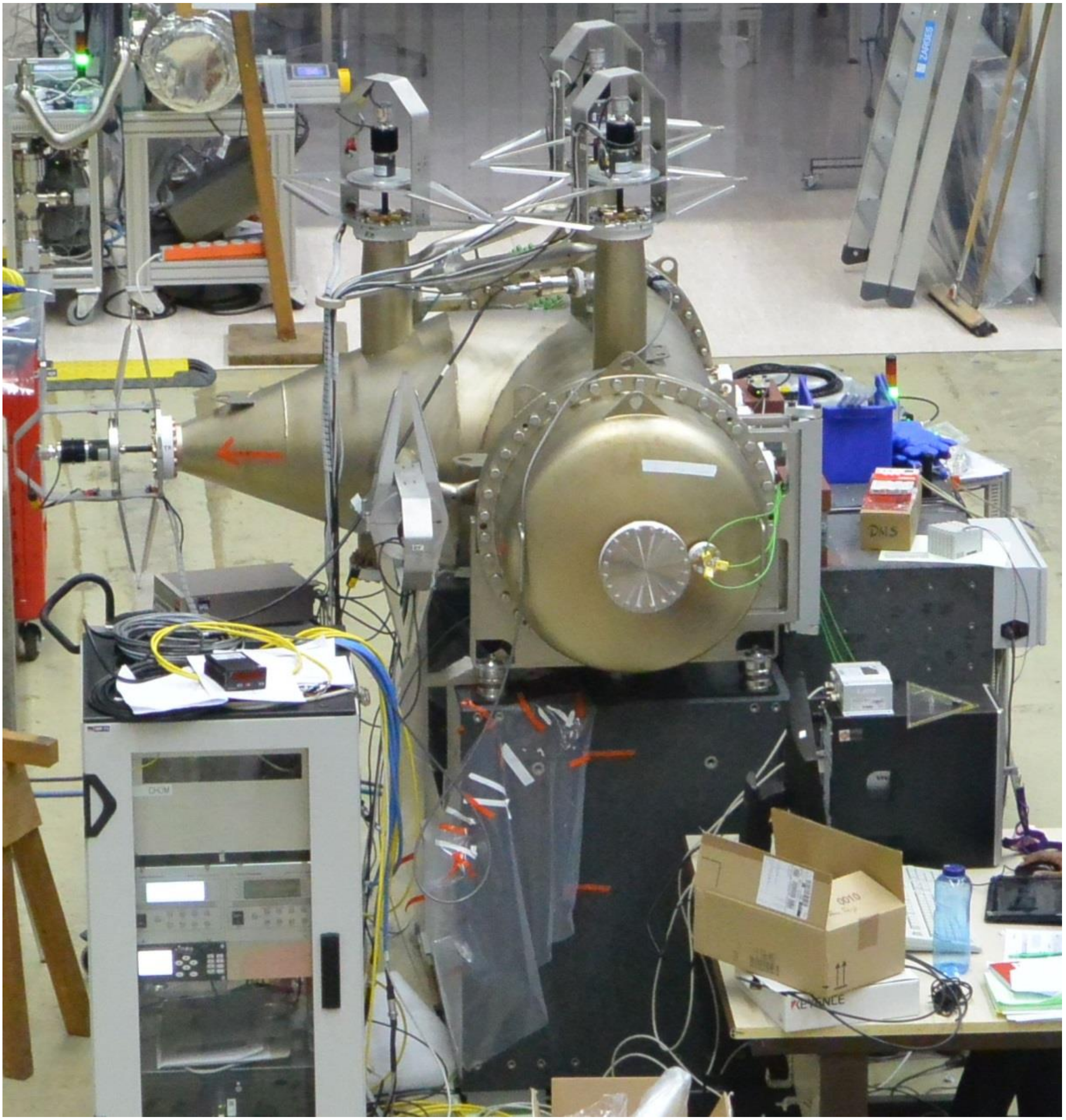
Herstellung + Foto: Innoshape GmbH



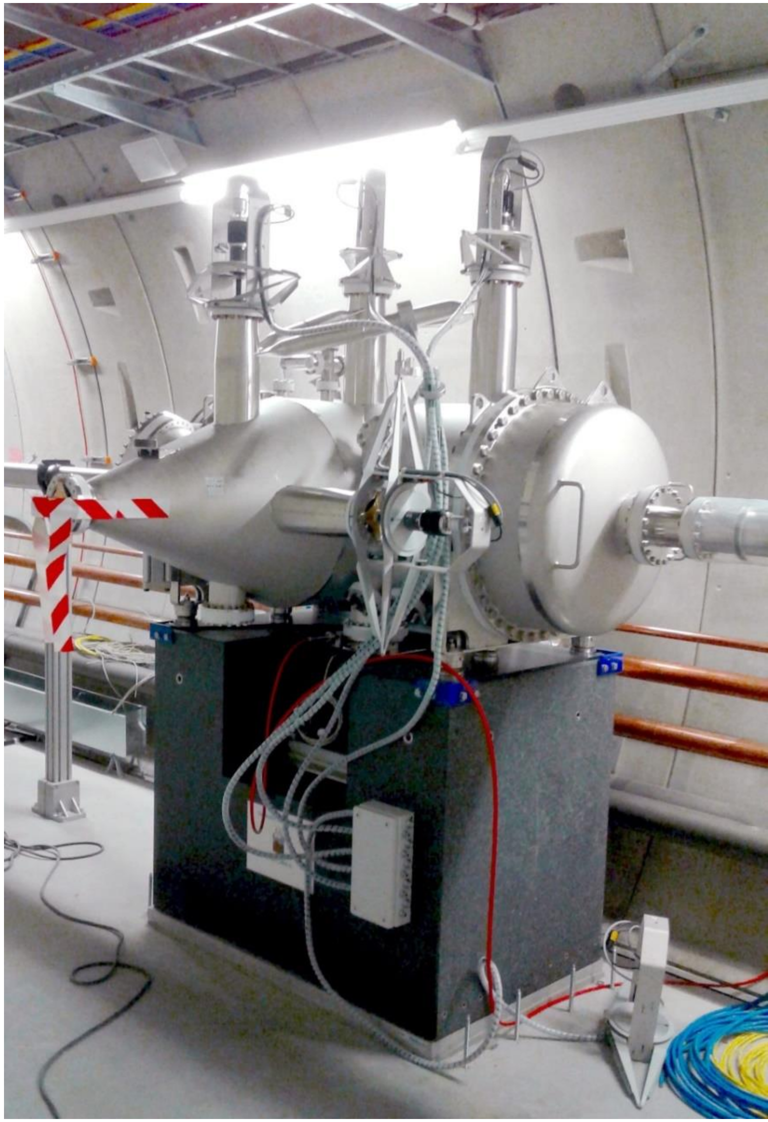


Fertig gebaute Spiegelsysteme

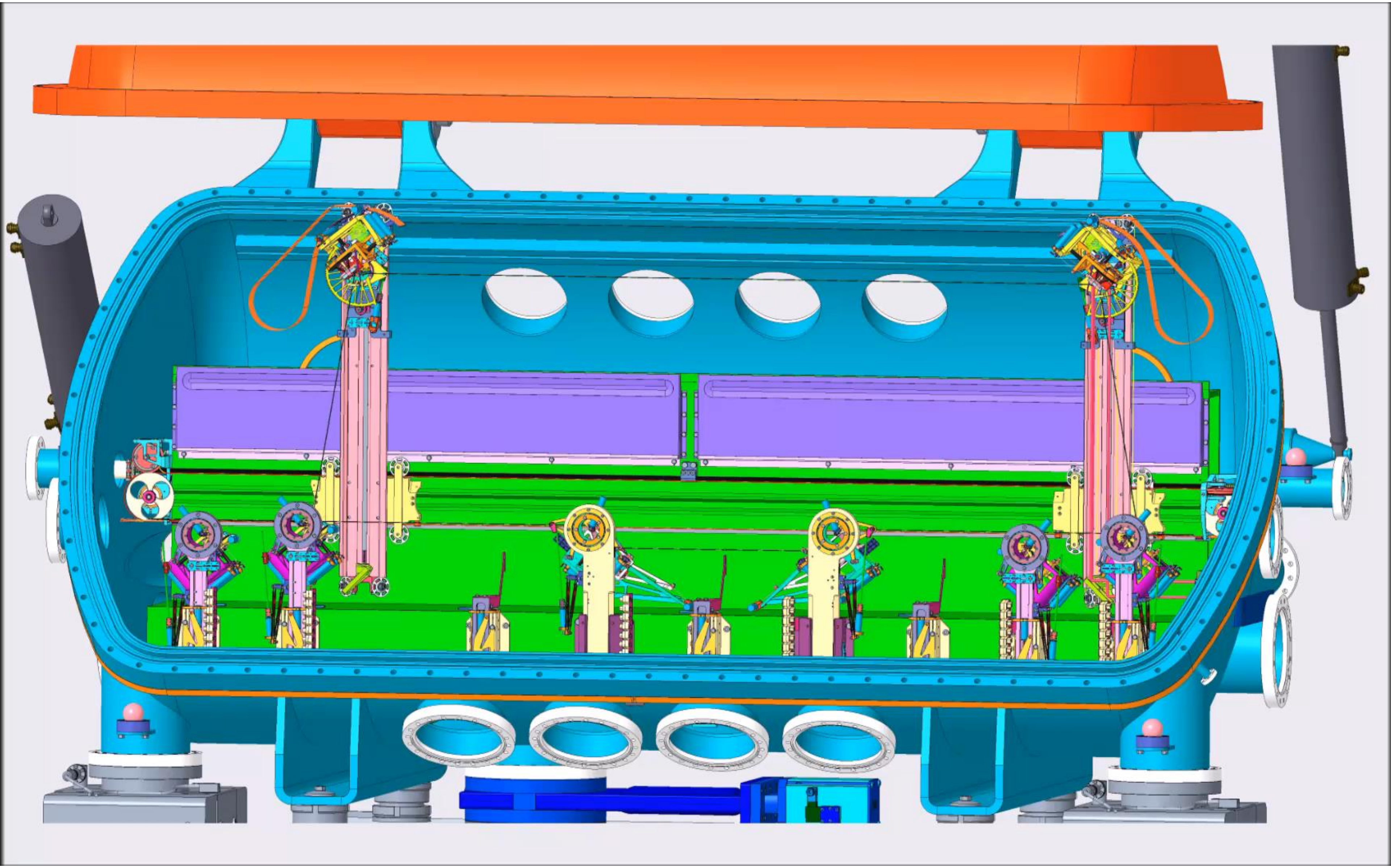
The prototype in the lab for characterization



installed in the beam line



Drittes Beispiel: Split & Delay Line für MID am European XFEL



Zusammenfassung

Cartesische parallelkinematische Führungen:

- Haben höchstes Genauigkeitspotential
- Erfordern relativ einfache und preiswerte Komponenten
- Sind einfach zu konstruieren und anzusteuern
- Entwurf neuer oder angepaßter Topologien erfordert Vorstellungsvermögen