Active Pre-Alignment System

Stabilization Day, CERN
Dez. 8th 2009

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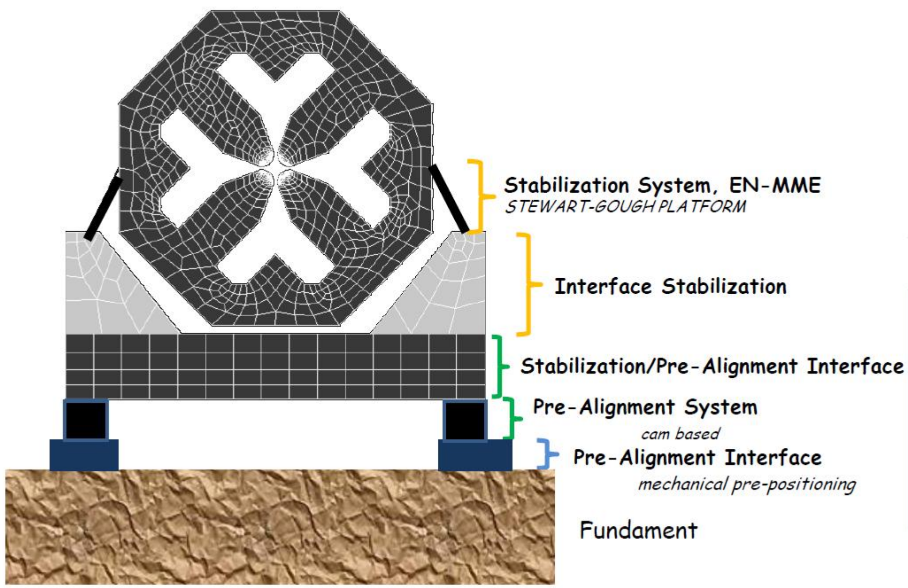
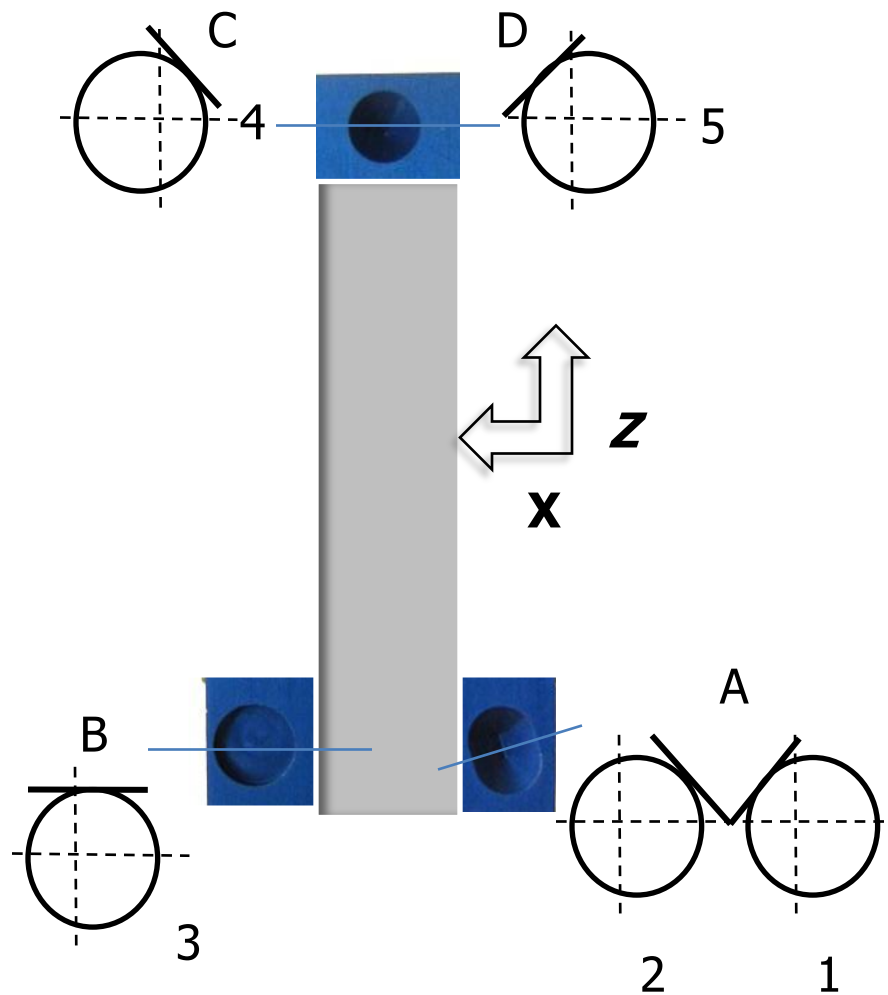
3 point support contact

Requirement : active Pre-alignment within 5 DOF

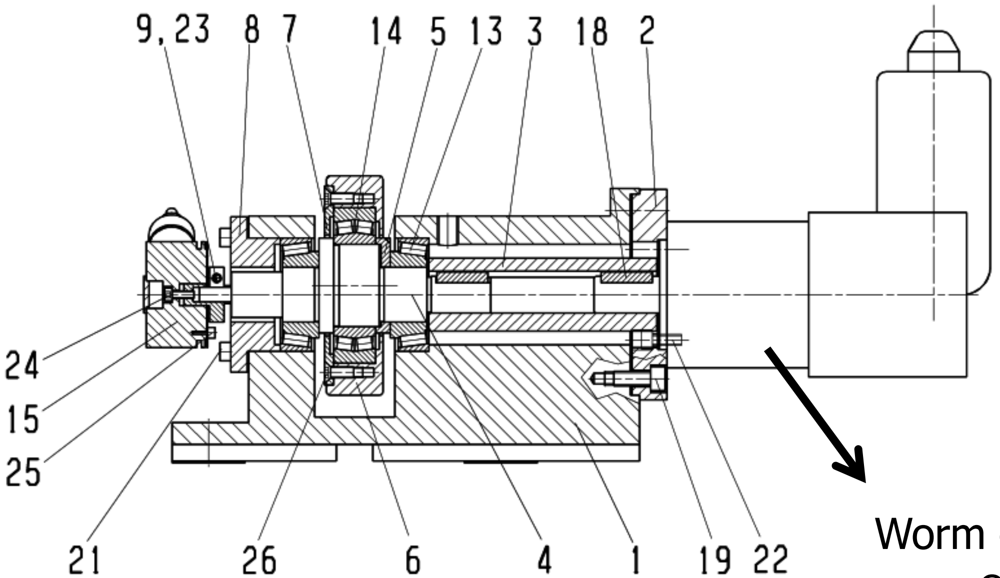
3 - spheres in contact with
Cone, Conical chamfer and flat plane

Separation of conical support leads to perform roll adjustments.





PSI – SLS cam shaft



Rotary encoder – Baumer electronic:

CANopen	CHF 1131.-
DeviceNet	CHF 1312.-
Profibus-DP	CHF 1312.-
EtherCAT	CHF 1058.-

Stepper Motor – Oriental motors:

CHF 54.-

Assembly Motor+Gearbox - Gysin:

Assembly of Worm gear + planetary drive

CHF 1384.-

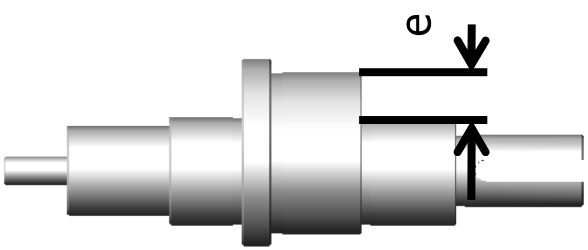
Manufacturing:

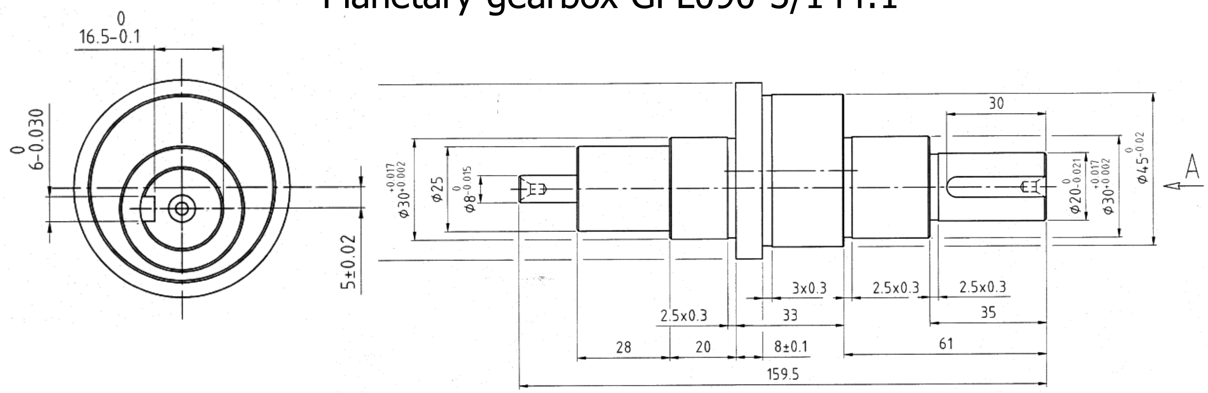
Hardware	CHF 20000.-

Worm gear + planetary

- Oriental Motor PK 268-E2.OB
- Worm gear box GSR025-05/5:1
- Planetary gearbox GPL090-3/144:1

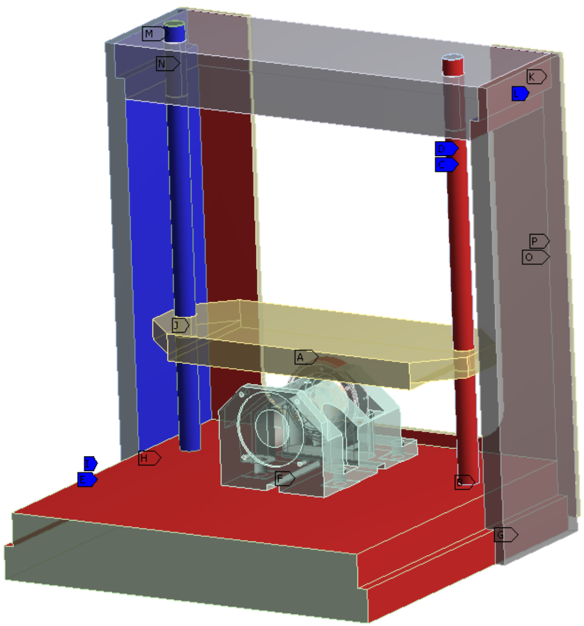
Eccentricity is given in the cam shaft



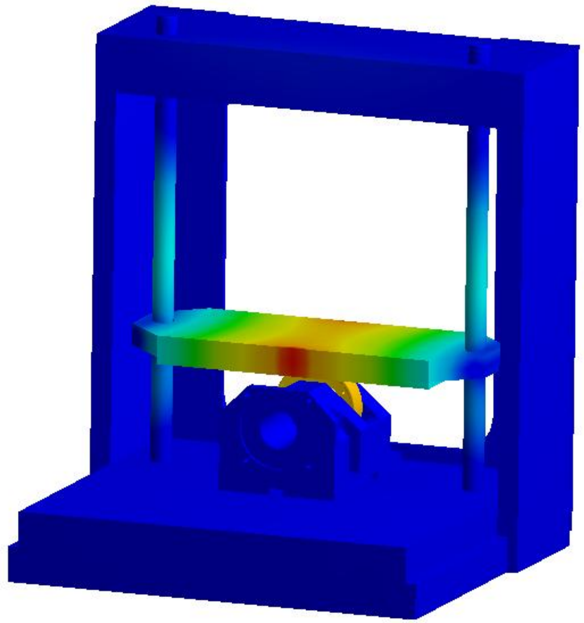


No relative movements in contact region during vertical alignment.
Friction minimized in Pendulum bearing.

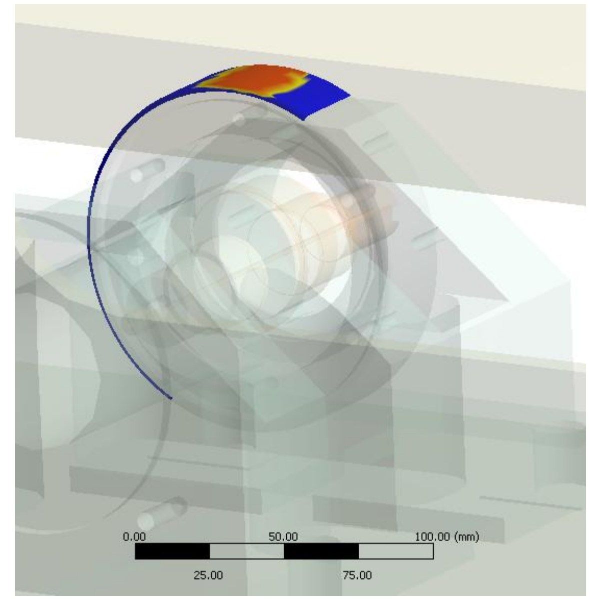
1 DOF test setup and analysis based on PSI cam design



Contact region analysis



Static wheel deformation



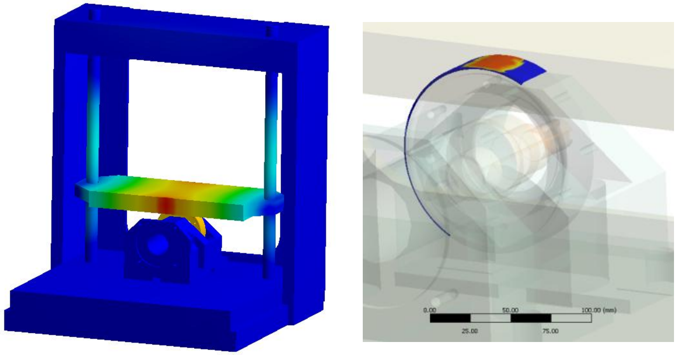
Theoretical results from Hertz contact pressure and stress analysis compared and optimized based on FEA -> Further improvement on the setup

$$p_{max} = \frac{1}{\xi \cdot \eta} \cdot \sqrt[3]{\frac{3F \cdot E^2 \cdot (\sum k)^2}{8\pi^3 (1-\nu^2)^2}}$$

1DOF setup optimization:

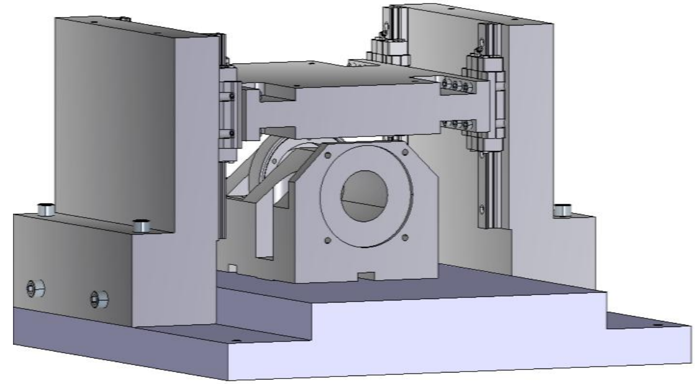
- Improvement of guiding system (IKO)
- Modular assembly
- Load conditions up to 500kg

1 DOF cam mockup:

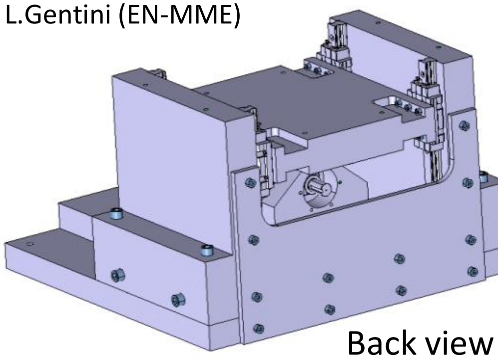


Concept

Optimization



Catia: L.Gentini (EN-MME)



Back view

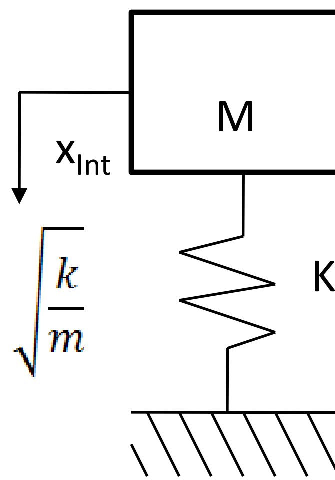
Foreseen Tests will give answers to the following questions:

- Max achievable accuracy with SLS mockup in case of 1DOF
- Modal behavior as a function of load mass (50kg – 500kg)
- Analysis of backlash and clearance in entire assembly
- Further improvements on mechanical design and components

Costs:

• Test mockup	CHF 9740.-
• Stepper Motor and Gear Boxes	CHF 1704.-
• PXI acquisition, DAQ hardware	CHF 1350.-
	CHF 12794.-

$$\omega_n = \sqrt{\frac{k}{m}}$$



Situation:

- Delivery delay concerning the guiding parts (end of January)

  Provide required axial accuracy due roller bearings.

- Control hardware: NI based – Offer received

  To be ordered this week

  NI PCI Stepper control and cable

  Stepper drive, 5A 1 axis

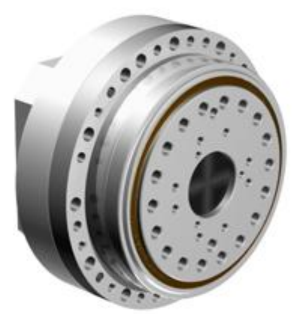
- Stepper motor, worm gearbox, planetary gearbox delivered

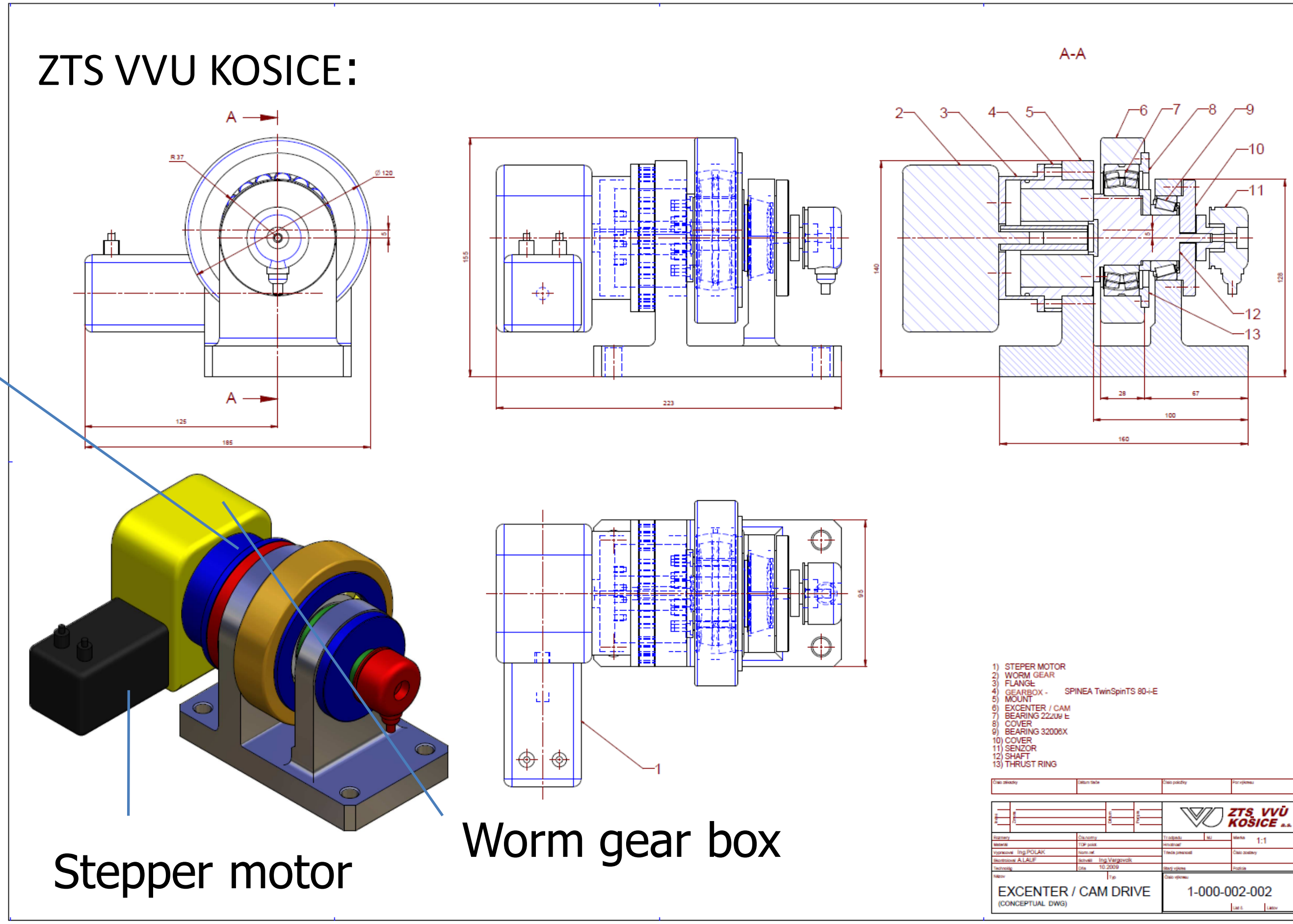
  Decision regarding control: first tests, especially in 1 DOF performed in open loop. Closed loop operation and control strategy discussed with EN-STI, EN-ICE and within SU.

Objectives: Mechanical assembly ready before Christmas, and first tests in January based on cam assembly. Afterwards the guided intermediate plate will be included. Modal tests based on various load conditions.

Gained experience will impact the design of the first 5DOF cam system which will be ordered early 2010.

Improvement study:





Spinea drive:
- High Reduction Ratio
- Zero Backlash
- High Kinematic Accuracy
- Low Lost Motion
- High Moment Capacity
- High Stiffness

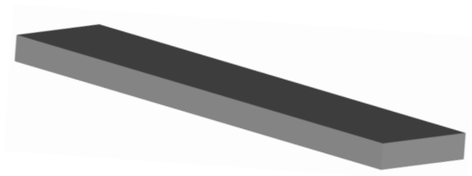
Design:
- Optimization of cam diameter
- Worm gear box requirement
- Self locking mechanism
- Enclosure size reduction

ZTS Cost proposal for 5DOF system pending

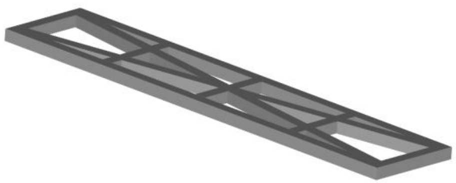
Interface: specific for alignment or compatible with stabilization system?

For alignment tests only (intermediate solution):

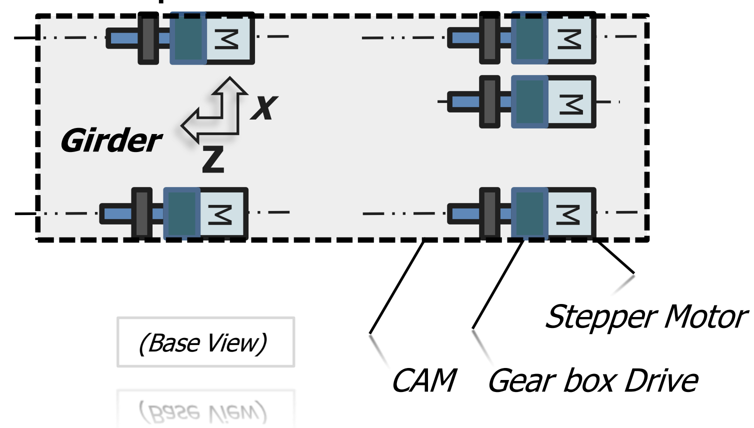
Full profile girder:



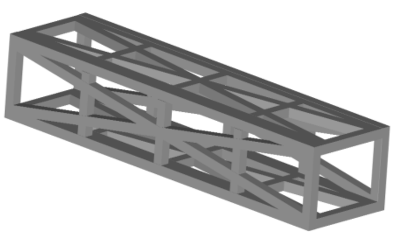
Framework girder:



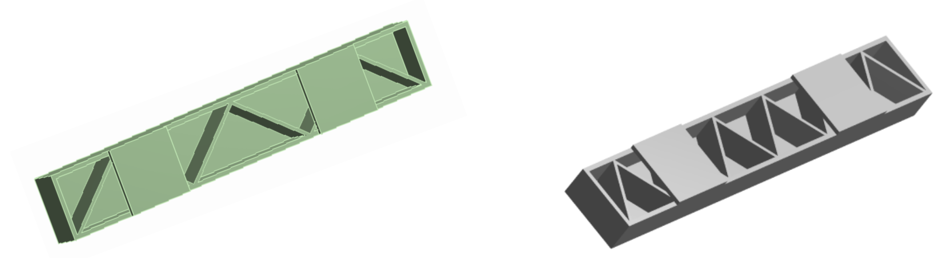
Concept:



For alignment and stabilization interface, (higher stability required):



Framework around magnet?



Reinforced Girder based on steel plates?

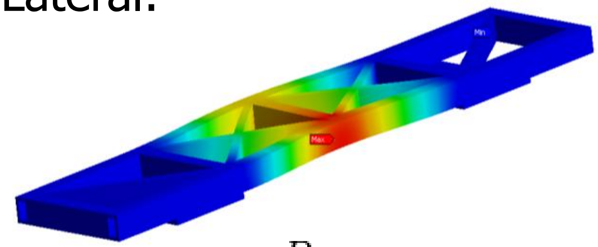
All solutions currently studied based on analytic and numerical approach

Stiffness behavior intermediate alignment framework:

Optimization of a 2d plane framework made from structural steel. Hollow profile: 80x50mm

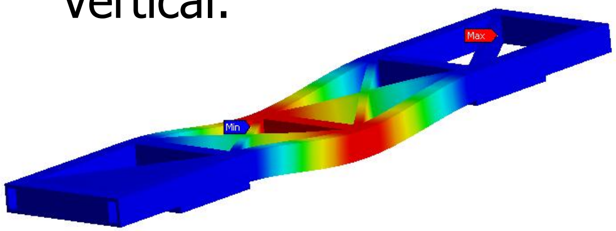
Analytic and numerical optimization -> sufficient results for testing 5DOF alignment:

Lateral:



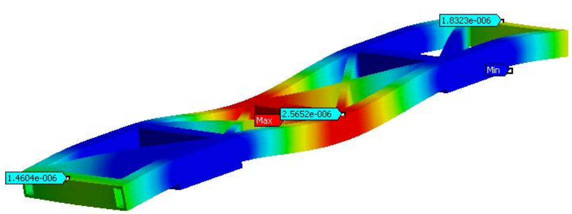
$$k = \frac{P}{\delta}$$ = 8.6E^8 N/m

Vertical:



$$k = \frac{P}{\delta}$$ = 1.6 E^8 N/m

Self load deflection, 1.6µm:

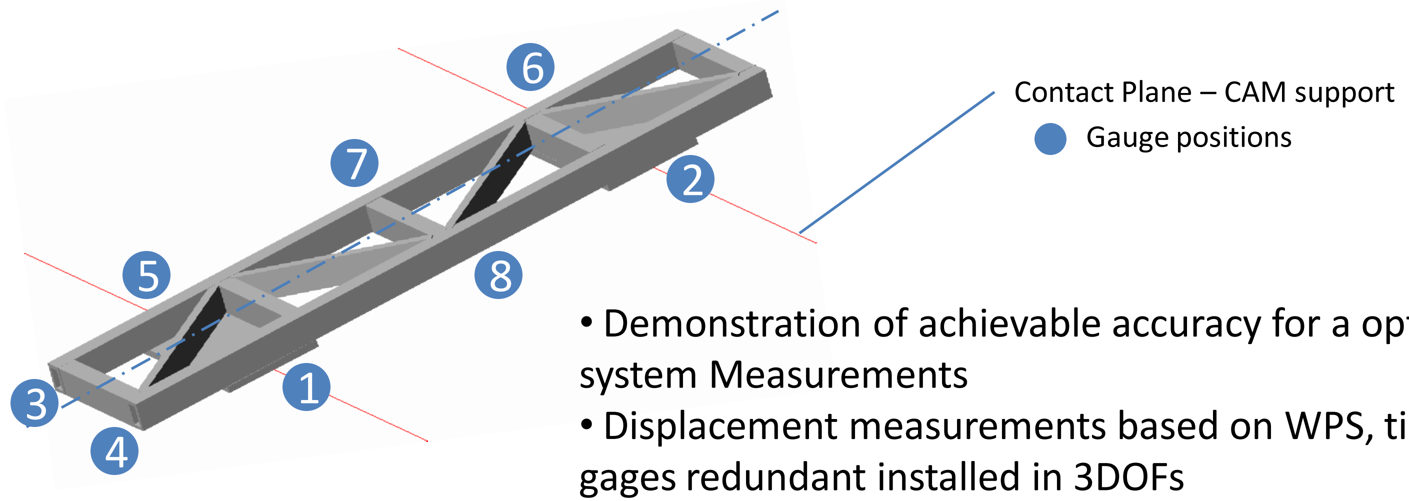


Further improvement for compatibility with
The stabilization system required.

3d model not ready for simulation of
Quadrupole – Stabilization – Alignment assembly

High importance of 1DOF tests regarding system stiffeness

Test strategy and missing hardware:



- Demonstration of achievable accuracy for a optimized 5DOF CAM system Measurements
- Displacement measurements based on WPS, tilt meter and linear gages redundant installed in 3DOFs
- Test of open and closed loop stepper motor operation

Requirement for 8 length gauges:

Proposed hardware: Heidenhain MT1200 + ND2100G (8 channels)
(Costs proposal: CHF 12000.-)

Further hardware for redundant data taking:

- Fogale nanotech or OSI WPS? Requirement for min. 5 WPS
- Interferometer measurement?
- 18 bit rotary encoders for closed loop stepper motor operation