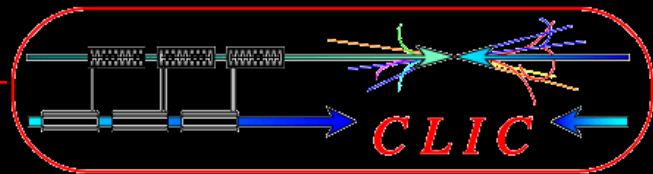


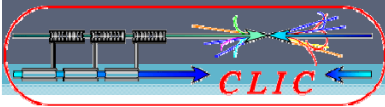
Main Beam Quadrupole Support

Friedrich Lackner
(TS-SU)












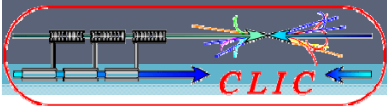
CLIC08 Workshop





Outline:

-  **CLIC Main Beam Quadrupole Magnet**
-  **The Alignment Concept**
-  **Expected Properties of a the Support Structure**
-  **Foreseen Mockups**
-  **FEA on the Quad Mockup**
-  **Mockup-Tests and Lab Studies**
-  **Stepper Systems – Stabilization Systems**
-  **CLIC Alignment Website**
-  **Discussion**



Baseline: Four different types of Main Beam Quadrupoles:

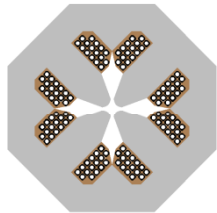
Length:

- 420 mm
- 920 mm
- 1420 mm
- 1920 mm

Weight:

~200 to 500kg

Alignment & Stabilization Concept:



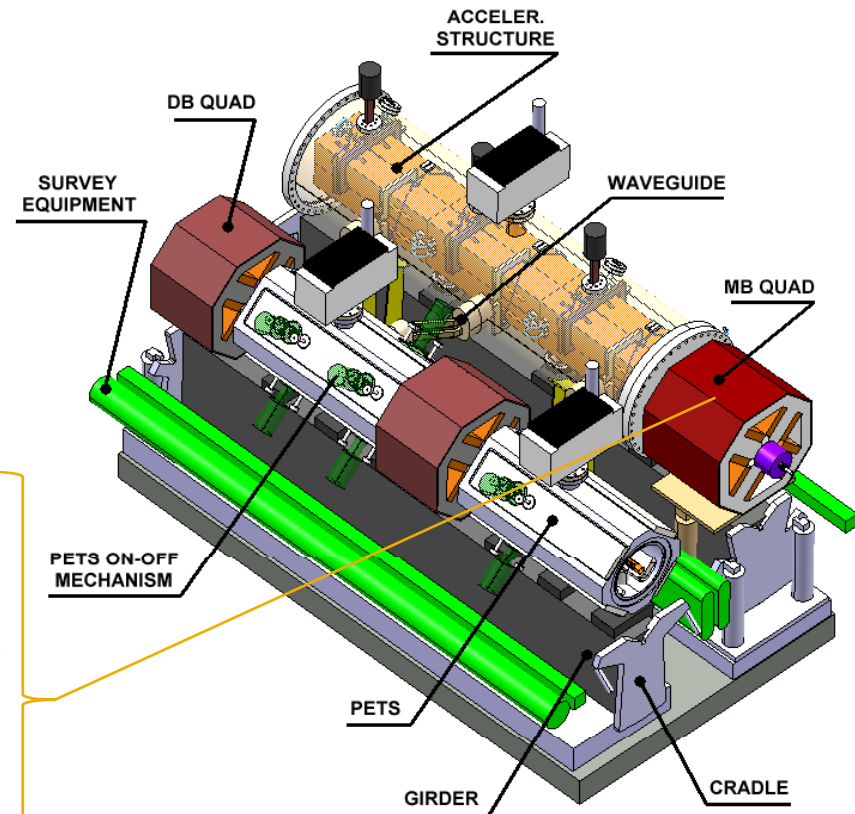
- ~1 nm

• Final alignment/Stabilization (Beam Based) Interval: hours & <
- ~1 μm

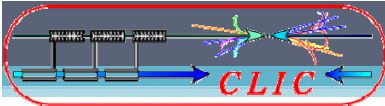
• Active pre-alignment (Beam Based) Interval: hours
- ~10 μm

• Active pre-alignment (Movers) DoF.: 5; Interval: weeks
- ~0.1 mm

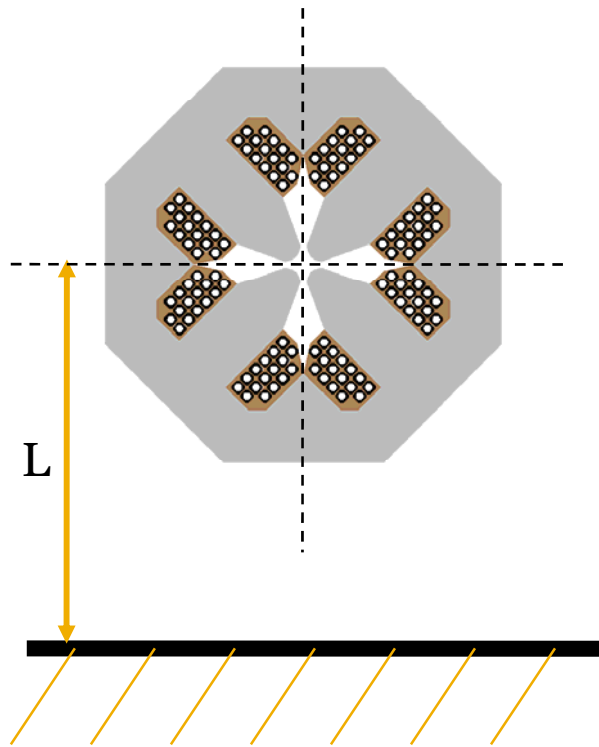
• Mechanical pre-alignment (Movers) DoF.: 6; Interval: year



Current layout: MB Quad is supported to the ground

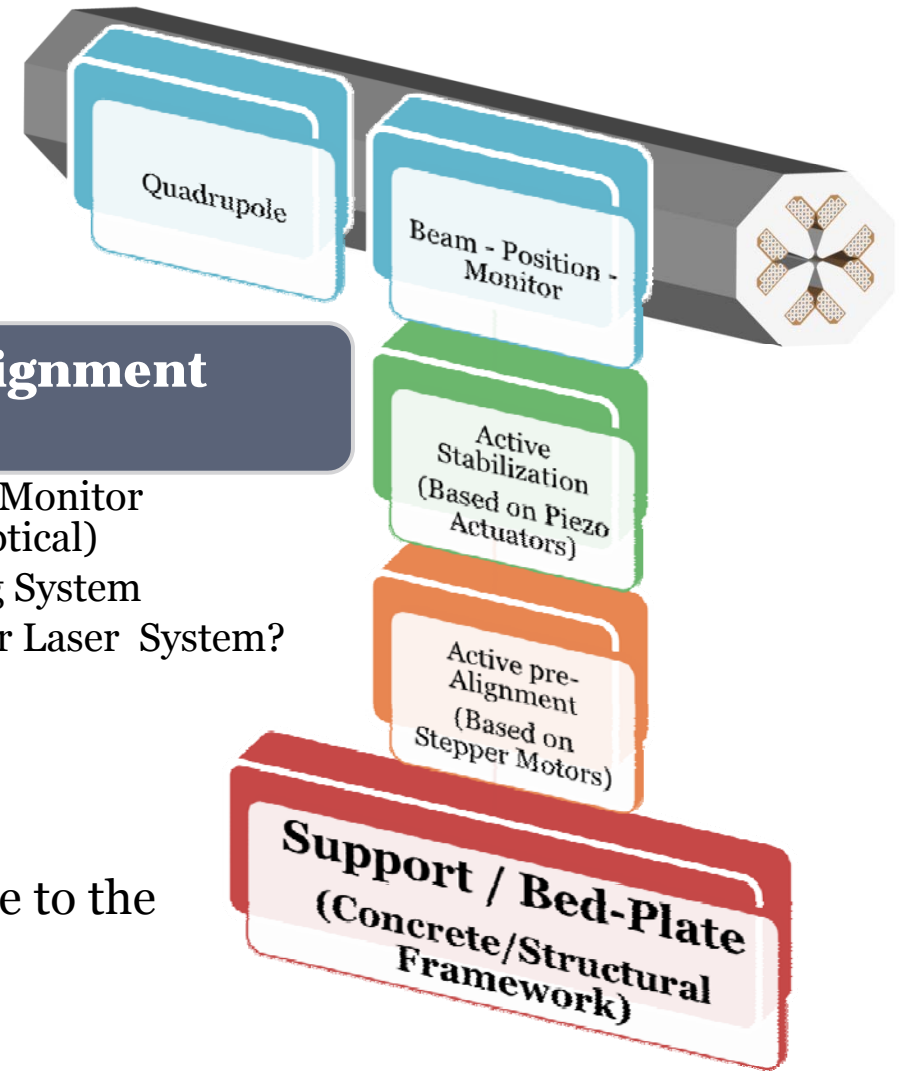


MB-Quad Alignment/Stabilization Concept



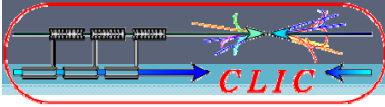
Current Alignment Sensors:

- Wire Position Monitor (Capacitive, Optical)
- Water Leveling System
- Rasclit or other Laser System?



Support height (L) should be minimized due to the high stiffness and damping ratio required .

$$k = \frac{AE}{L} \quad \zeta = \frac{c}{2\sqrt{km}}$$



Expected Properties of a CLIC Mainbeam Quadrupole Support

Installation

Weight (*optimized*)

Compact Design

Easy to Transport

Easy to Align

Easy to re-Adjust

Installation Time (*low*)

Cost-Efficient

Operation

Damping Ratio (*high*)

Stiffness Characteristics (*excellent*)

Availability (*high during entire life cycle*)

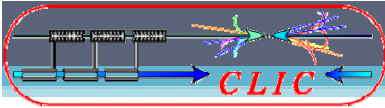
Temperature (*low sensitivity*)

Humidity (*low sensitivity*)

Radiation (*high resistance*)

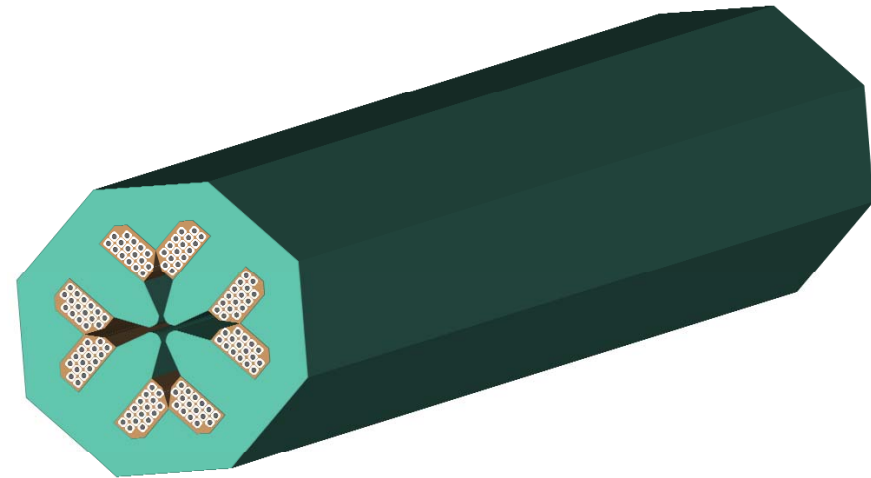
Magnetic field (*high resistance*)

Requires mockup studies to find best solution

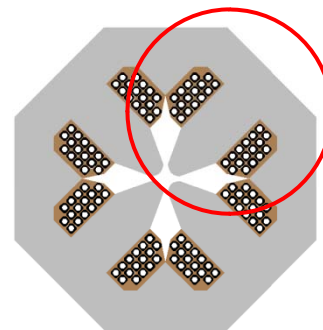


Most complicate version will be studied based on a mockup:

CLIC Main Linac Quadrupole (V4e)	
Magnet	
Nominal gradient	200.1 T/m
Nominal integrated gradient	370.0 Tm/m
Aperture radius	5.0 mm
Iron length	1844.0 mm
Effective length	1849.0 mm
Total magnet weight	393.3 kg
Total magnet length	1914.7 mm
Total magnet width	192.0 mm
Total magnet height	192.0 mm
Coil	
Conductor height	5.6 mm
Conductor width	5.6 mm
Cooling hole diameter	3.6 mm
Total number of turns	16
Cooling	
Number of cooling circuits per coil	1.0
Pressure drop	4 bar
Current density	6.59 A/mm ²
Temperature rise	22.3 K
Coolant velocity	1.1 m/s
Total cooling flow	2.6 l/min
Electrical parameters	
Nominal current	140 A
Magnet resistance (hot)	201.0 mOhm
Power consumption	4108.5 W
Total stored energy	420.7 kJ
Inductance	42.9 mH
Voltage drop (R*I)	29.3 V



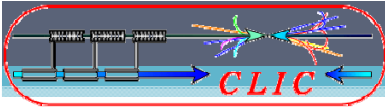
Quadrupole Mockup (Length = 1920mm)



Preliminary Mockup based on a T-shaped Profile will be studied based on a layered assembly and as a solid.

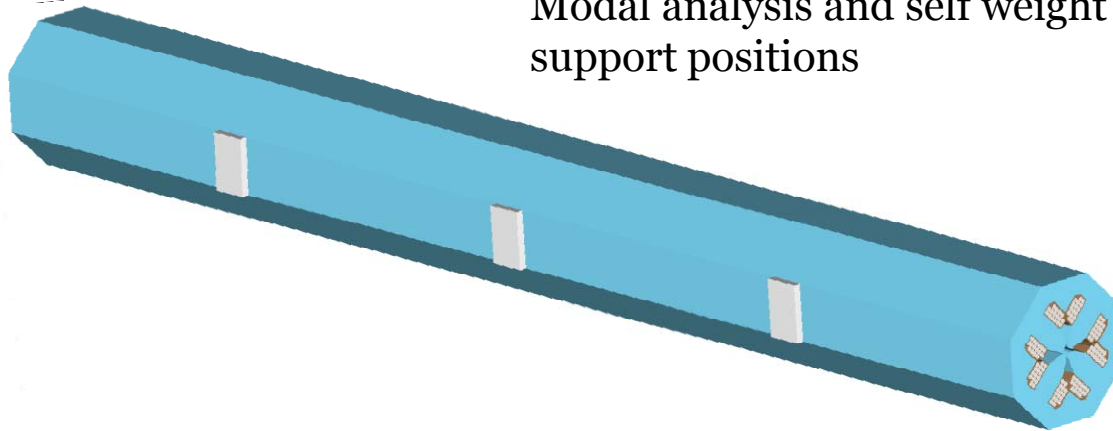
Layerd Profils will be based on Electromagnetic steel (e.g. Stabolit 70 – Thyssen Krupp)

Magnet Mockup Design: Thomas Zickler (CERN)

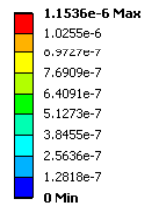


Quadrupole mockup simulation results:

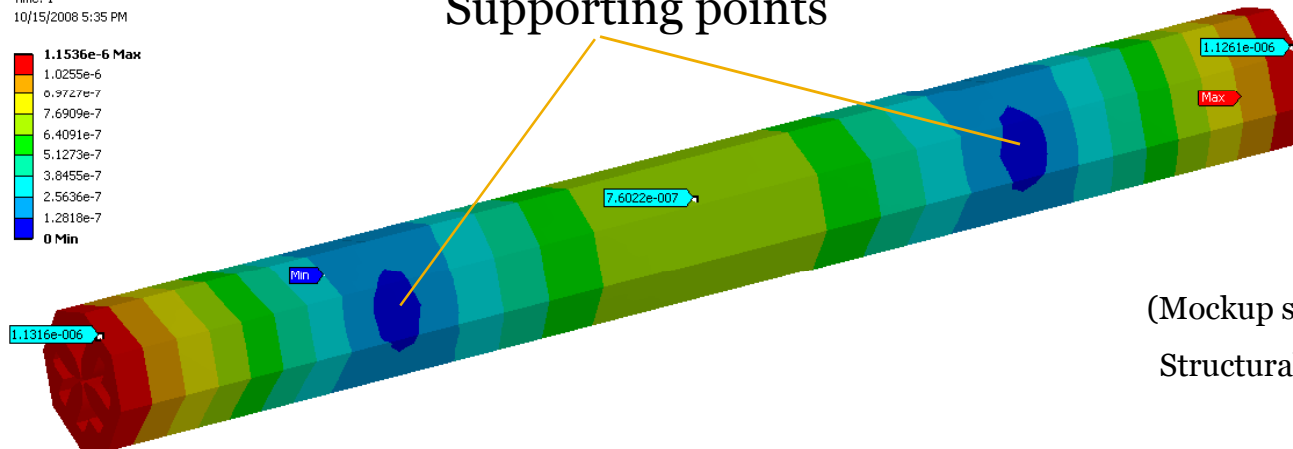
Modal analysis and self weight deformation studied using different support positions



Type: Total Deformation
Unit: m
Time: 1
10/15/2008 5:35 PM



Supporting points



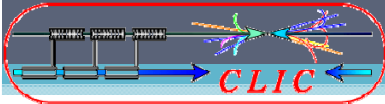
Simulation with ANSYS WB and ANSYS Classic

Solid45 elements & Structural Steel

(Mockup simulation without coil)

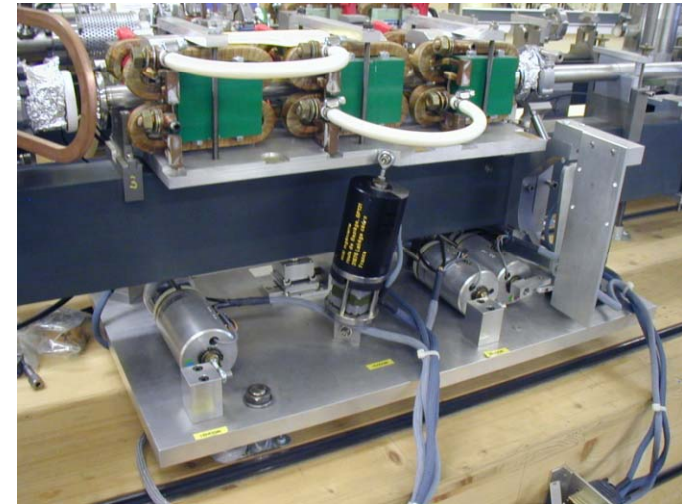
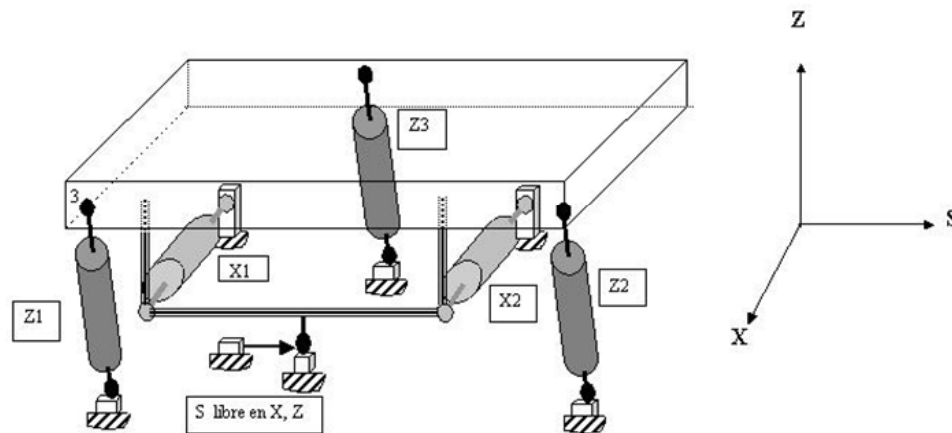
Structural Steel; Mass: 333.45 kg

Quadrupole support in Gaussian points results in a deformation on self load of: 1.1um



Mockup-Tests and Lab Studies

Previous tests (S. Redaelli, CERN):



Main focus in the 90th was given in the vertical stabilization of the quadrupole magnet

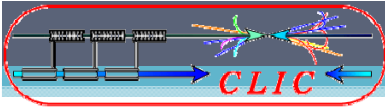
5 Stepper motors were used to align the support to 5 DOF

Supports were joints and bearings with low friction

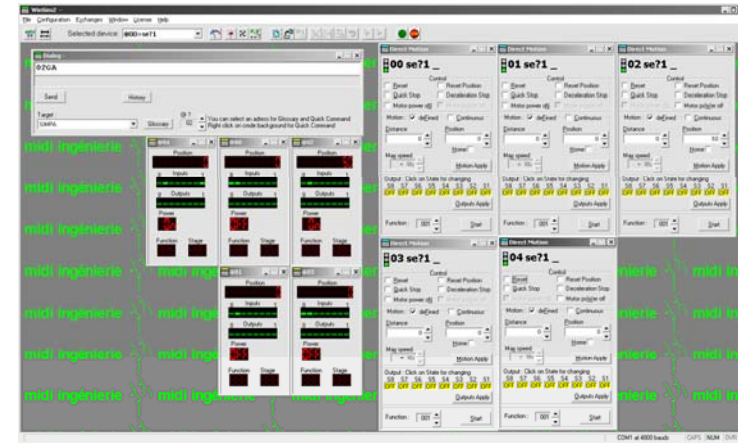
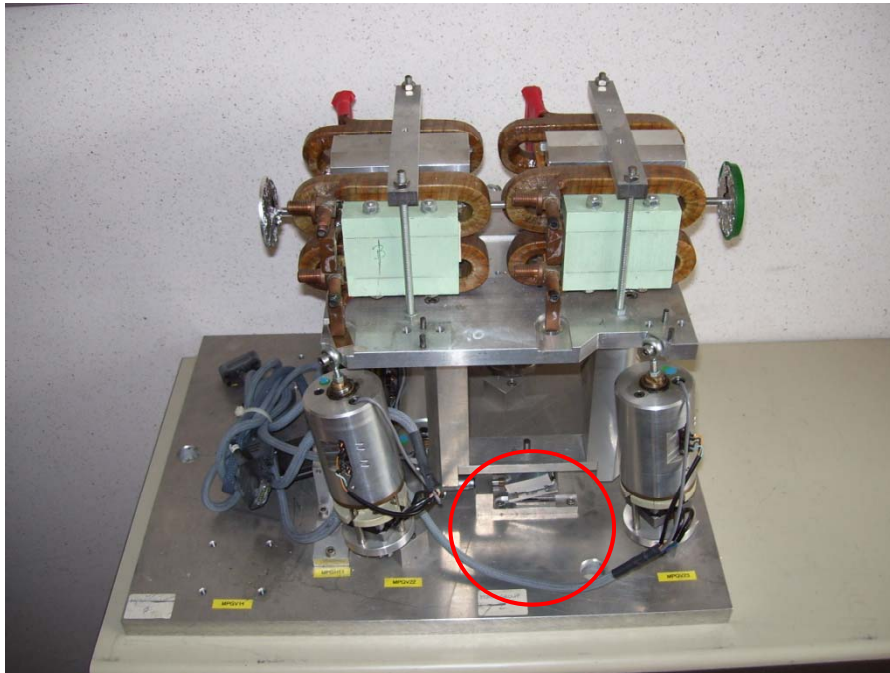
Change of requirements in pre-alignment and especially higher loads requires complete redevelopment. Furthermore documentation regarding reachable Repeatability, Accuracy and Resolution in the 5 DOF of the former System undiscoverable.



Behaviour of Stepper System can be studied by using the old setup as occasionally mockup



CTF2 Stepper System reactivated:



New software version still communicates with the old setup...

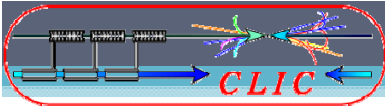
Foreseen steps:

- Implementation of feedback loop
- Redesign of critical parts (guiding)

Frictionless Operation Possible?



First operations...



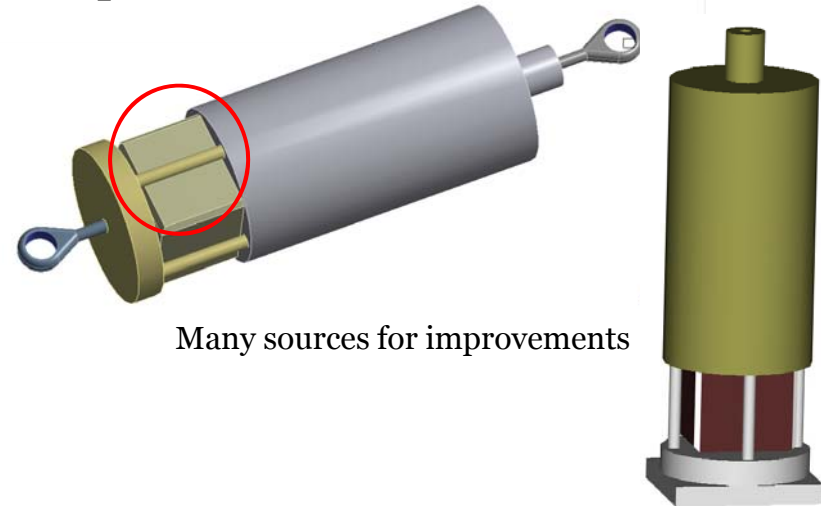
What to learn from an old Setup?



- Will provide important information for the stiffness of the entire support system.
 - Important information of friction and clearance behaviour
- Repeatability of important alignment parameters
 - Important input for ANSYS and for all further studies

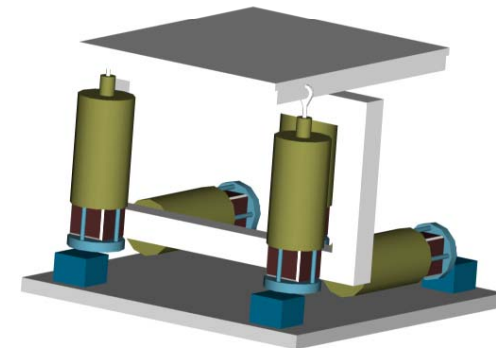
Friedrich Lackner, October 16th, 2008

- Modal measurement for CTF2 stepper motor planned within the next weeks.

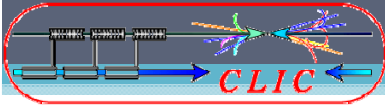


Many sources for improvements

CTF2 Alignment Concept studied using the FEM



Will help to select adequate movers for CLIC
Also answers the question -> Frictionless pre-alignment required?



Regarding Movers:

Main issue: Insufficient load capacity -> most μ movers and hexapods on the market can adjust loads up to max. 40kg

Market research on suppliers for stepper motor development and “frictionless” joints

- PI- Karlsruhe (D)

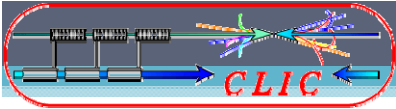
- ZTS -VVU – Kosice (Sk): Stepper system supplier for LHC low beta magnets

- Midi ingenierie – Labege (F): Stepper system supplier for CTF2



E.g.: PI MIKE M-238 unidirectional repeatability: 0.3 μm , max. load: 40kg

Further development of the M-238 for a load of 100kg -> 15000 CHF/Piece and complete new design for loads up to 200kg



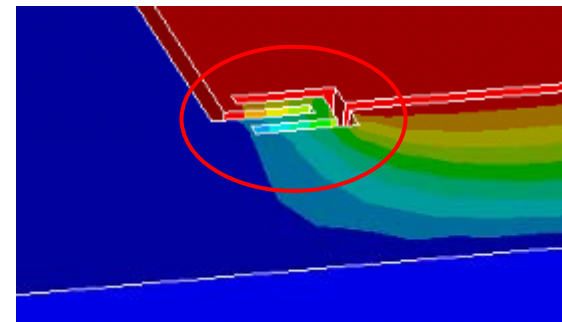
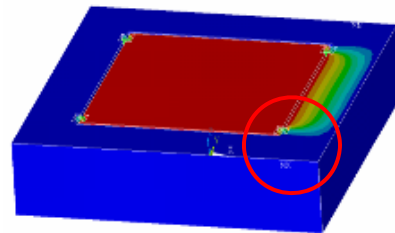
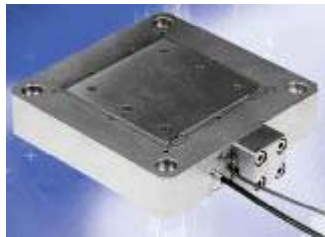
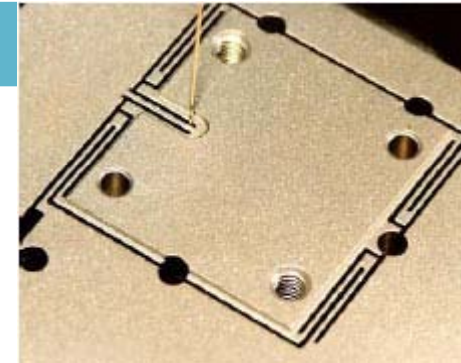
Progress on research for the nano stabilization of the MB-quad:

Nano membran -> studied by Kurt Artoos et al. (TS-MME)

Further possibilities using piezo stacks are studied

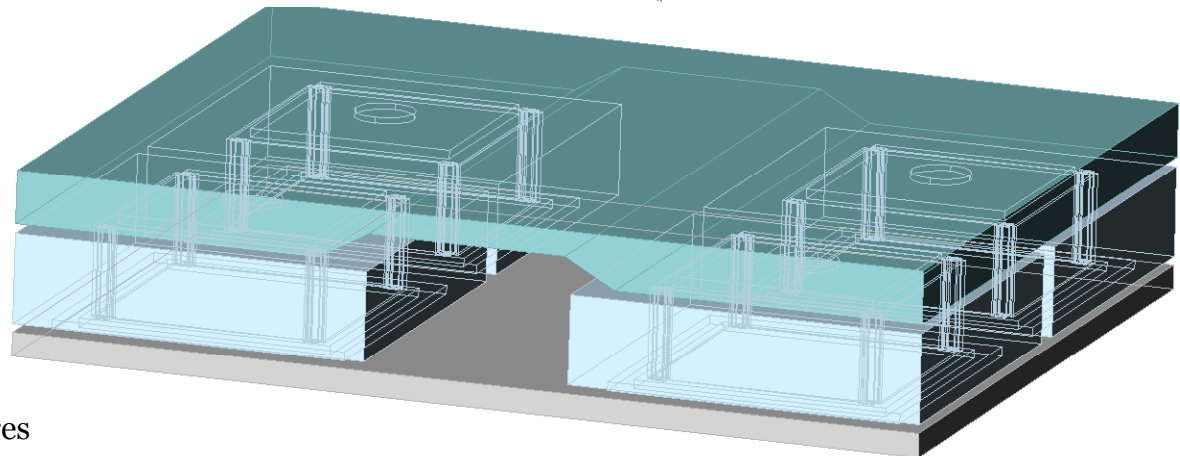
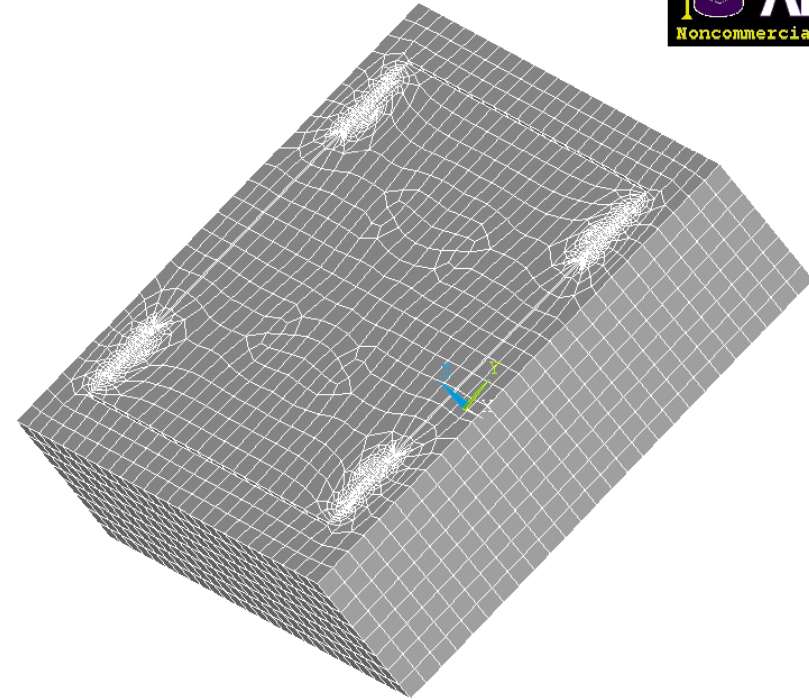
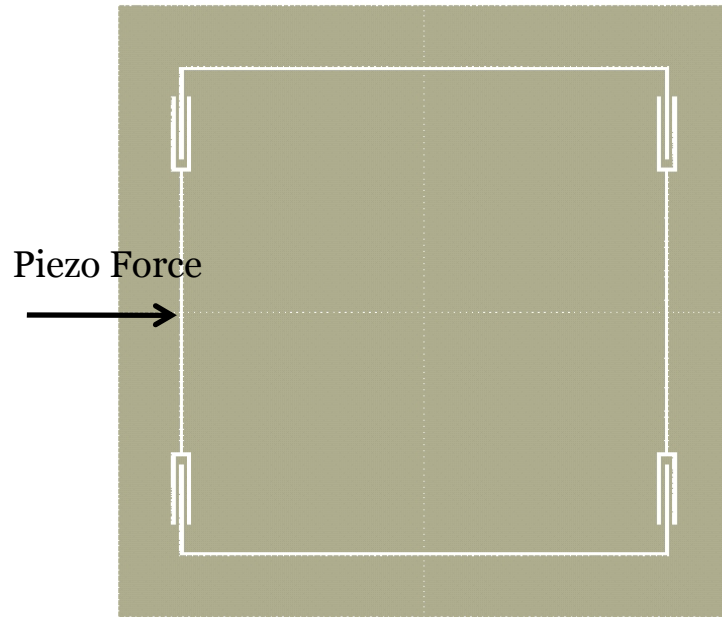
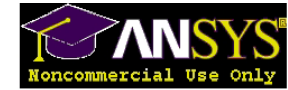
Guiding Flexures: Available solutions are not able to provide required load capacity

Foreseen: Production of a guiding flexure at CERN using wire -electro discharge machining is foreseen.



Critical: Implementation and fixation of the piezo actuator

Frictionless support 'guiding flexure'



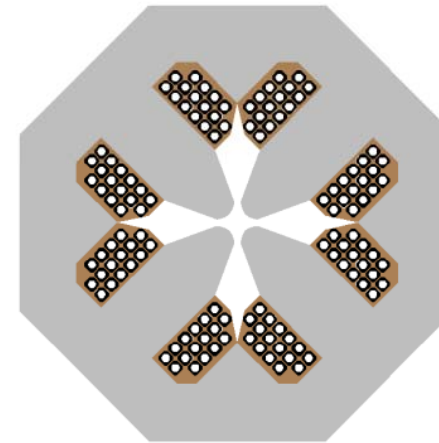
Sketch: Layout using four guiding flexures

How to implement ?

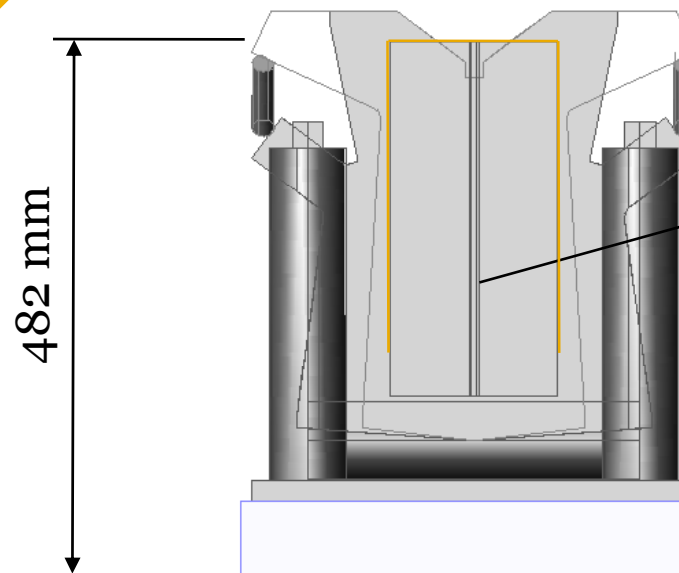
Space limitations on current Module design:

Vertical space to integrate a stabilization system is limited by 100 mm (between MQ and the girder)

Remark: nm stabilization requires a minimum vertical distance.



100 mm

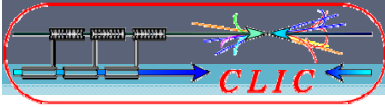


Girder:
150*320mm

94 mm



600 mm



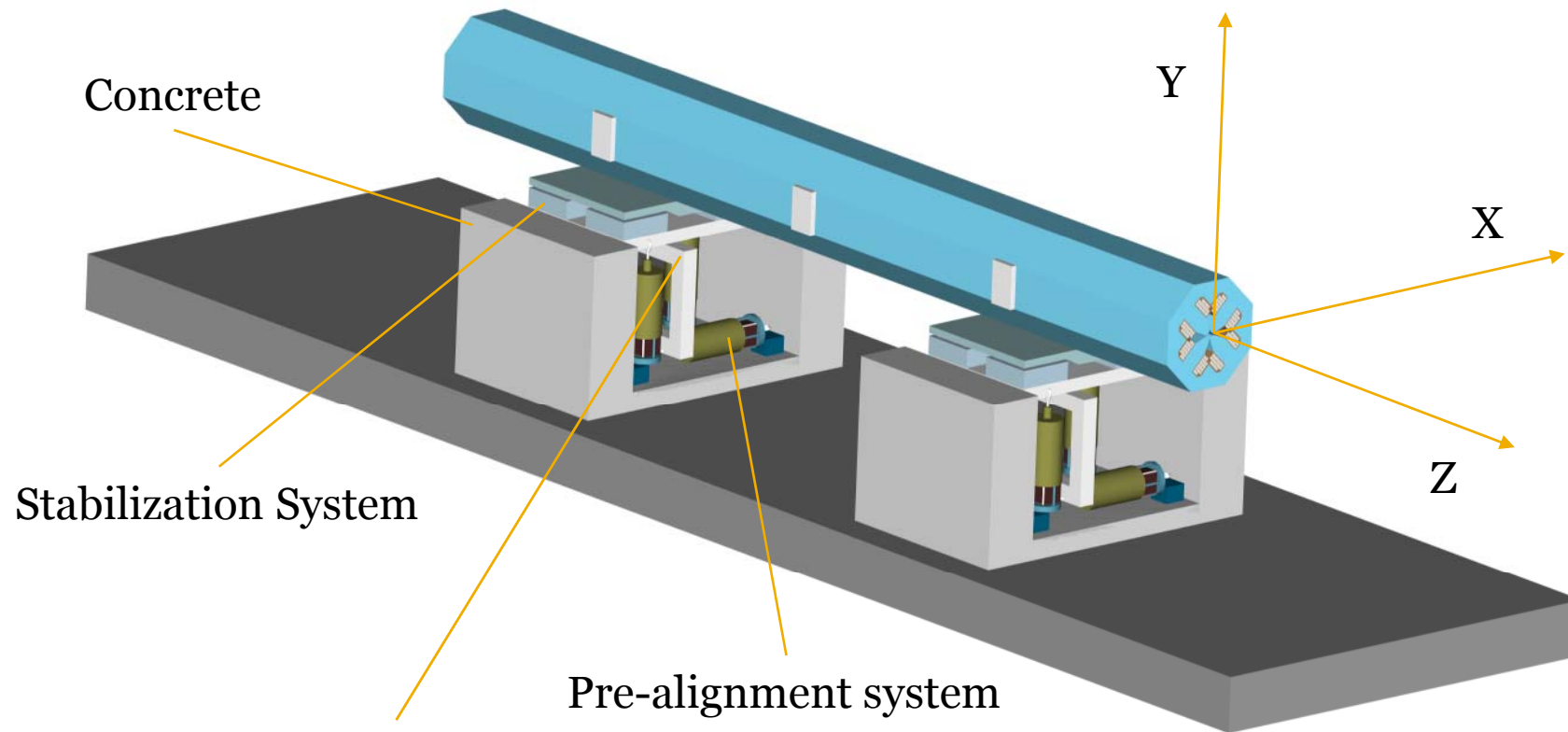
Many solutions, proposals and open work -> still there are so many more open questions to be studied, e.g.:

Frictionless operation of the pre-alignment system by applying linear elastic deformation?

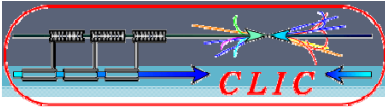
How to provide optimal stiffness characteristics for the stabilization system on beam level?

Decoupling between pre-alignment and stabilization system.

Proposal for Mockup studies:



Idea: Increasing the stiffness for a stabilization system by clamping the pre-alignment system to concrete support (applying clamping force in non critical Z direction).

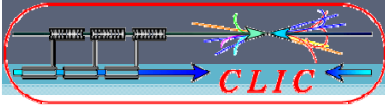


<http://clic-alignment.web.cern.ch/clic-alignment/>

The screenshot shows a web browser window titled "clic-alignment Site" with the URL "http://clic-alignment.web.cern.ch/clic-alignment/". The browser's address bar and tabs are visible. The website content includes a globe with CLIC alignment lines, the title "The CLIC SURVEY and ALIGNMENT Study", and a CERN logo. A paragraph describes the challenge and objective of the study. Below this is a grid of eight content boxes:

<p>CLIC Alignment Concept</p> <p>Strategy Related Documents</p>	<p>Members</p> <p>Hélène Mainaud Durand Thomas Touze Sébastien Guillaume Friedrich Lackner</p>
<p>Survey and Alignment at CERN</p> <p>TS/SU Website Papers and Presentations</p>	<p>CERN Related</p> <p>CLIC Main Page Stability Study Test Facility (CTF3)</p>
<p>Latest Results</p> <p>Latest Presentations, Papers Development of an Optical WPS</p>	<p>Other Interesting Papers</p> <p>Alignment Systems Geodesy Long Term Stability</p>
<p>Facilities</p> <p>Transfer Tunnel 1 (TT1) Building 926 (TS-SU) Transfer Tunnel 83 (TT83)</p>	<p>Useful Links</p> <p>Open Source Instruments NIKHEF</p>

16.09.2008, 11



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- CLIC Main Beam Quadrupole Magnet
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- Discussion**