Looking for a Hall probe bench for closed big magnetic structures

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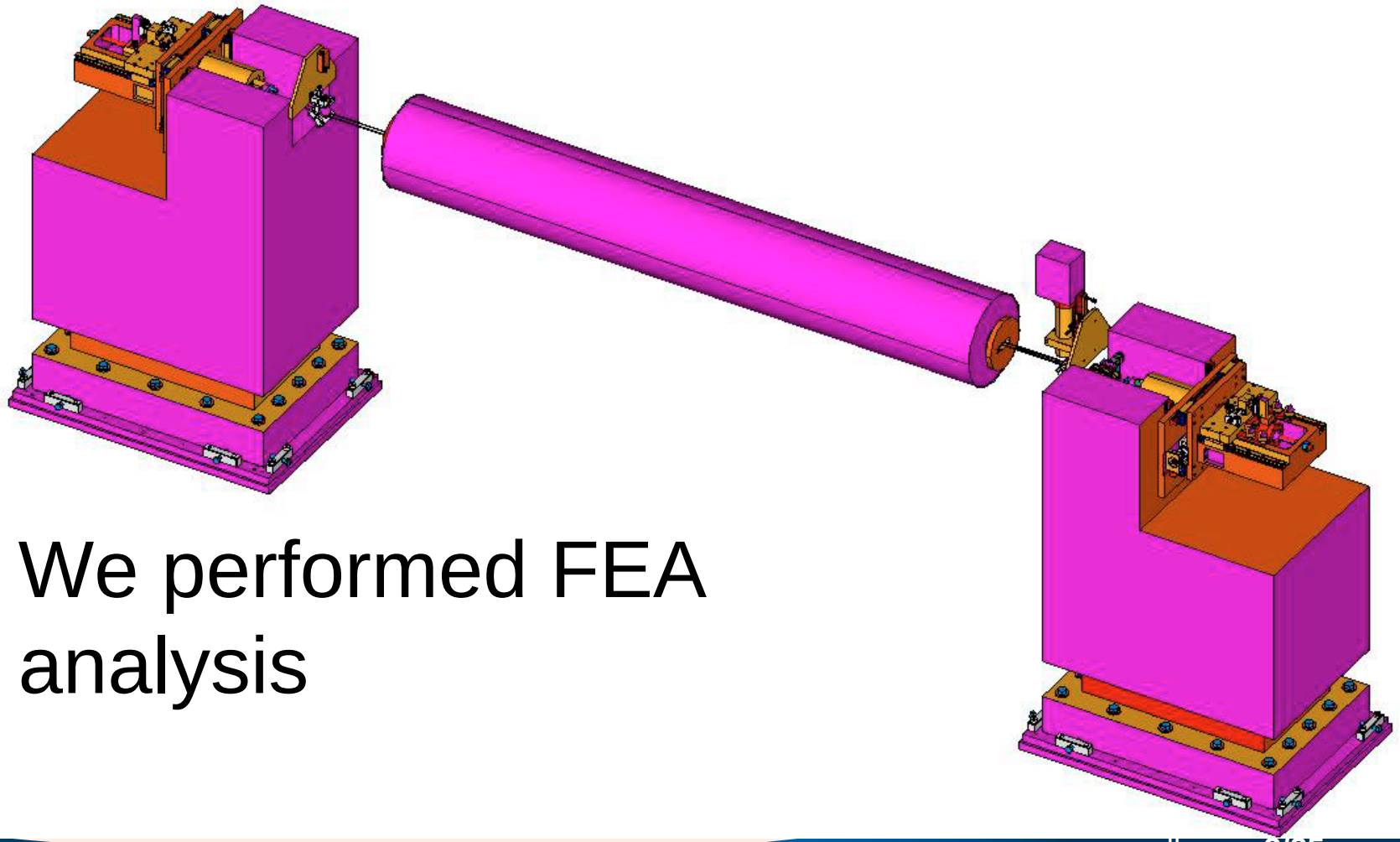
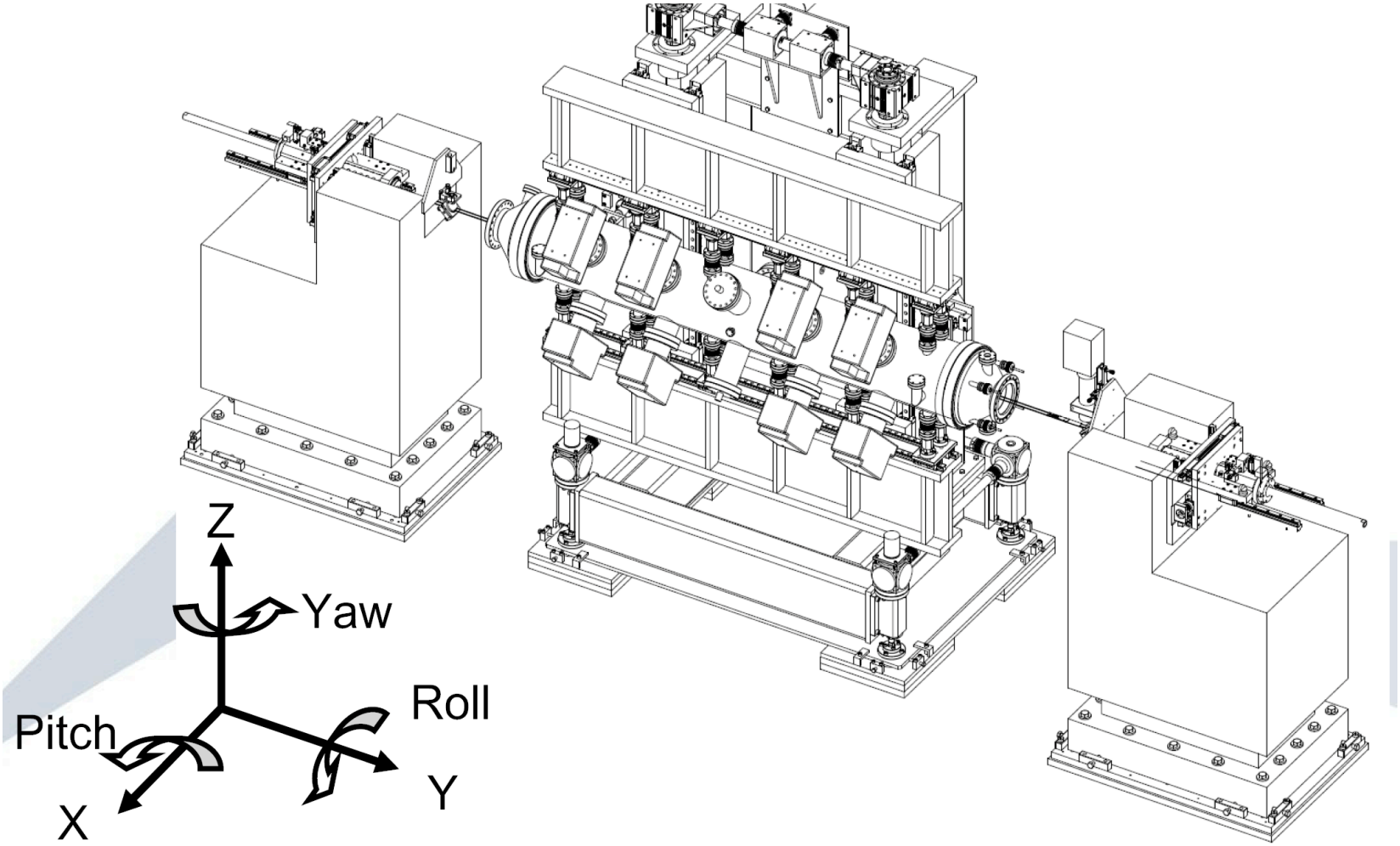
Outline

- Concept presented at IMMW17
- Prototyping
- Results of prototyping
- Discussion
- New proposals

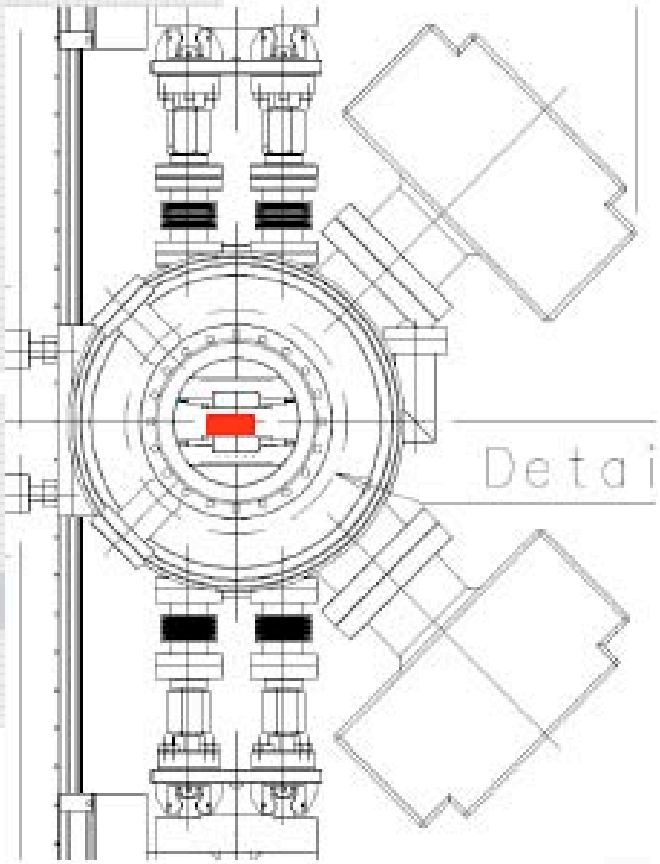
Concept presented at IMMW17



We performed FEA analysis


Z
Yaw
Roll
Pitch
Y
X

- Specifications
  - Measuring range: 3m.
  - Positioning accuracy, Y: ± 50µm.
  - Positioning measurement accuracy, Y: ± 10µm
  - Transversal guidance accuracy, X,Z: ± 25µm
  - Pitch, Roll & Yaw guidance errors:
    - 50µrad, 100µrad, 50µrad.
- Additional constrains
  - Accessibility.
  - Measurement under vacuum
  - Tight cross section: 5mm x 25 mm rectangular

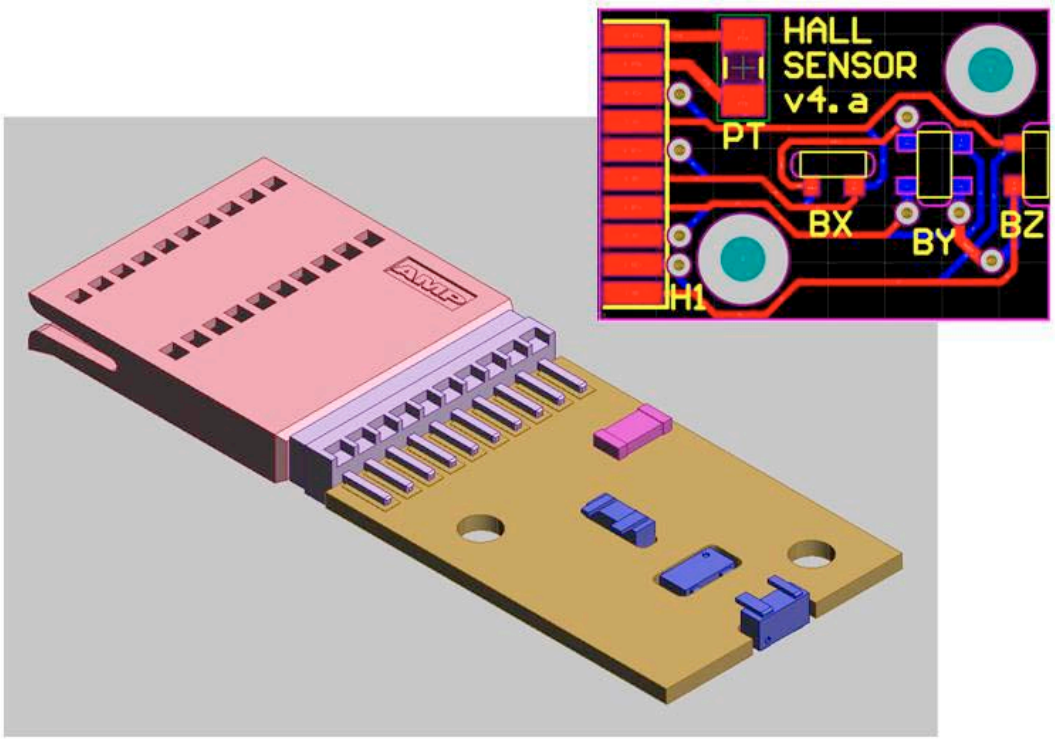


Status of the project in IMMW17:

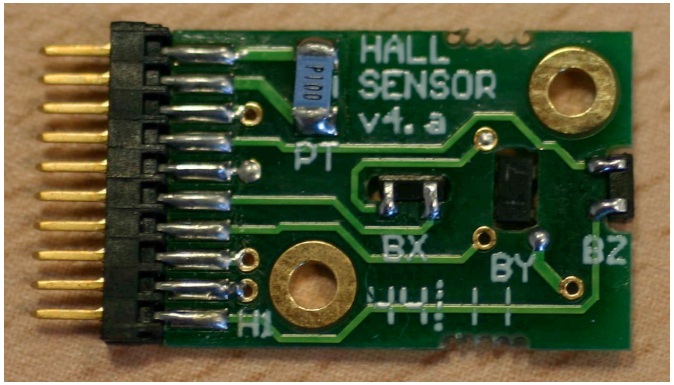
- Hall probe head was designed. Manufactured was programmed
- Optical systems performance to be tested at ALBA Optical Laboratory
- Mechanical prototype without closed loop motors for correcting roll error was designed to test the 3D model.
  - The objective of that prototype was to check the feasability of the roll measurement system using two pin-holes.
  - It involved the use of mirrors, lasers and CCD sensors.

Prototyping: Hall probe head

Hall head was manufactured on time



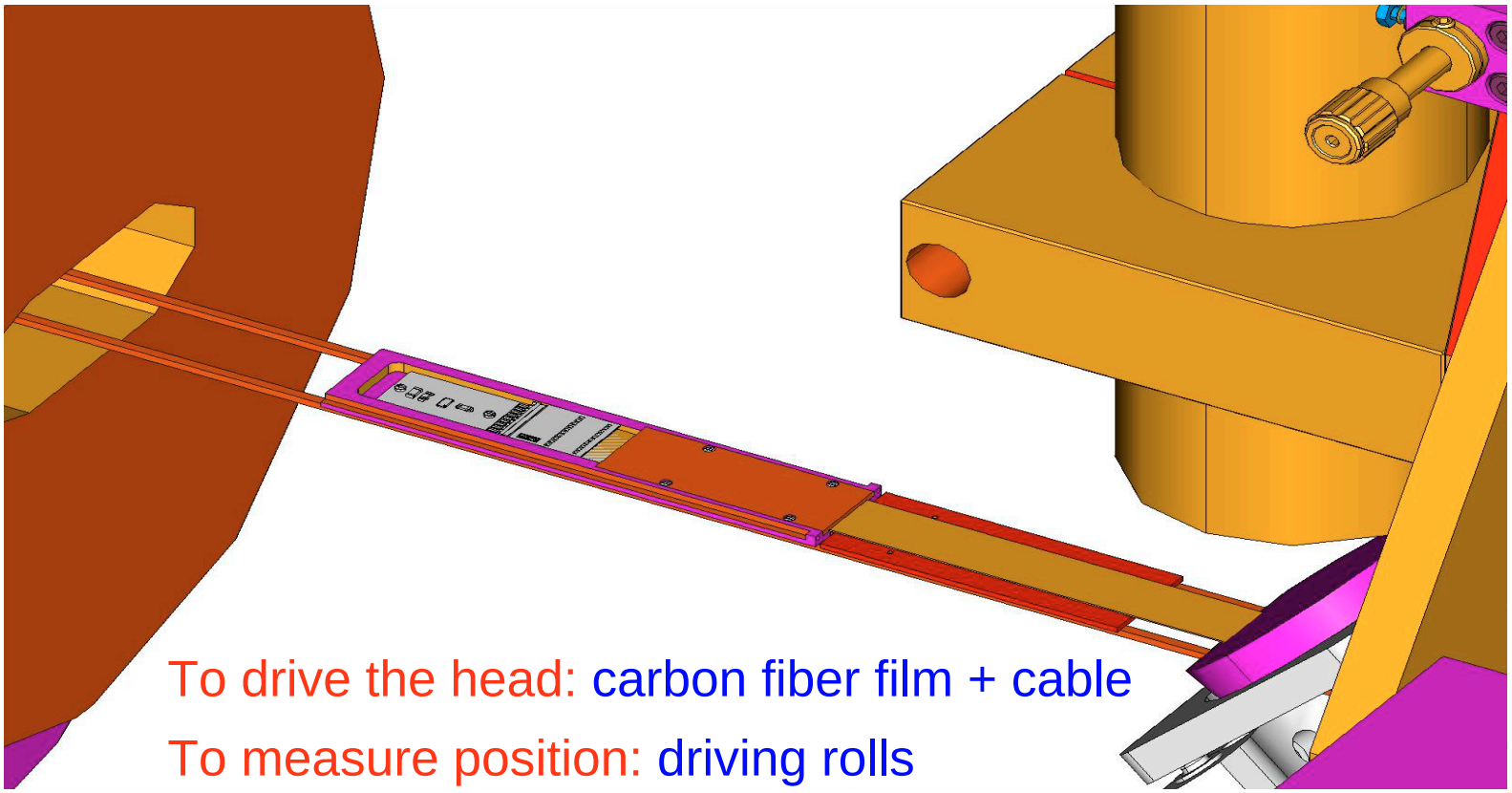
Dimensions: 13 x 25 x 2 mm
Weigth: 0.75 g

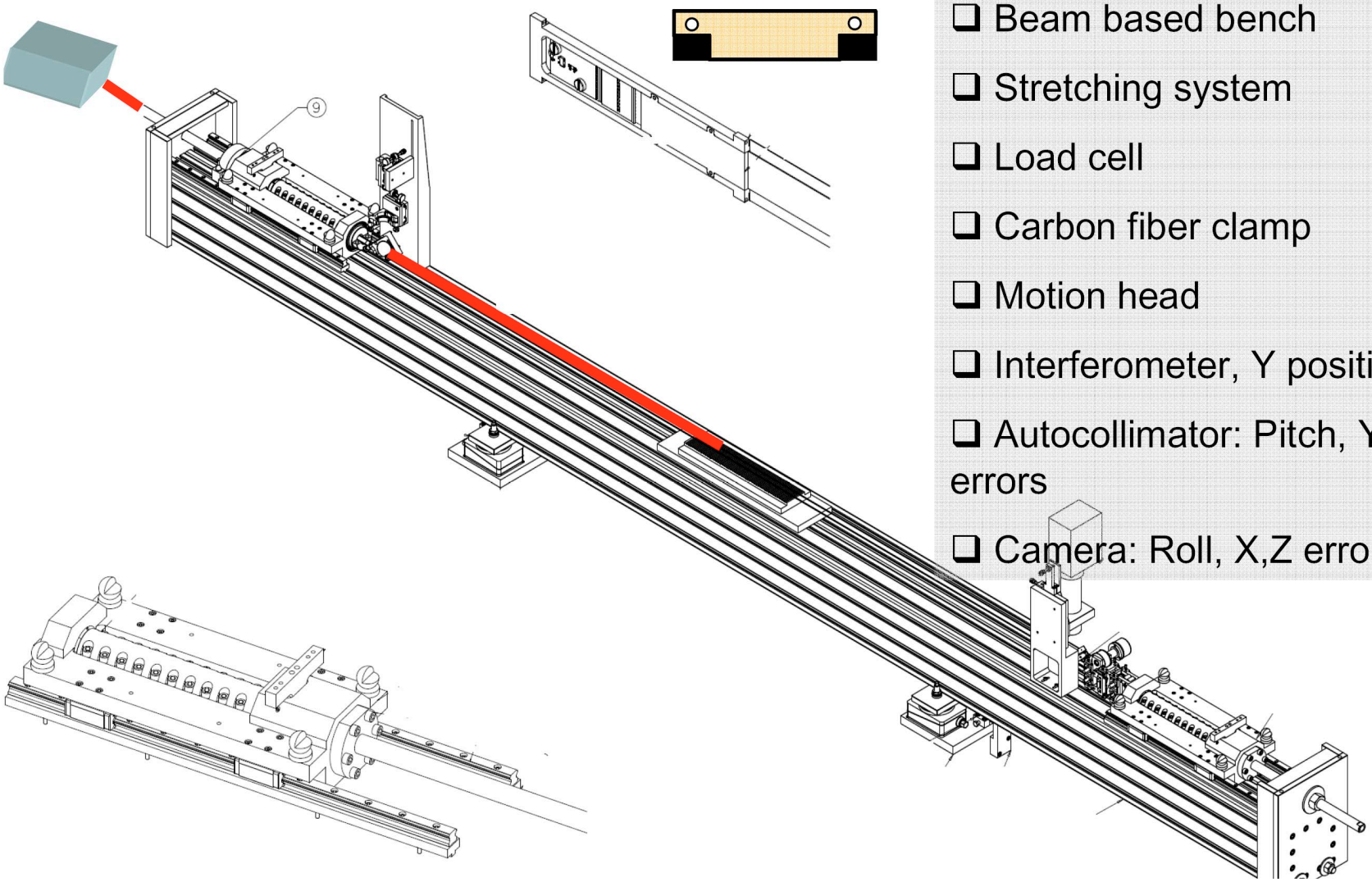


F.W. Bell Hall sensors, **Model GH-700**

Prototyping: Mechanical structure

- Mechanical prototype without motors was made to check the feasability of the roll measurement and control using two pin-holes.



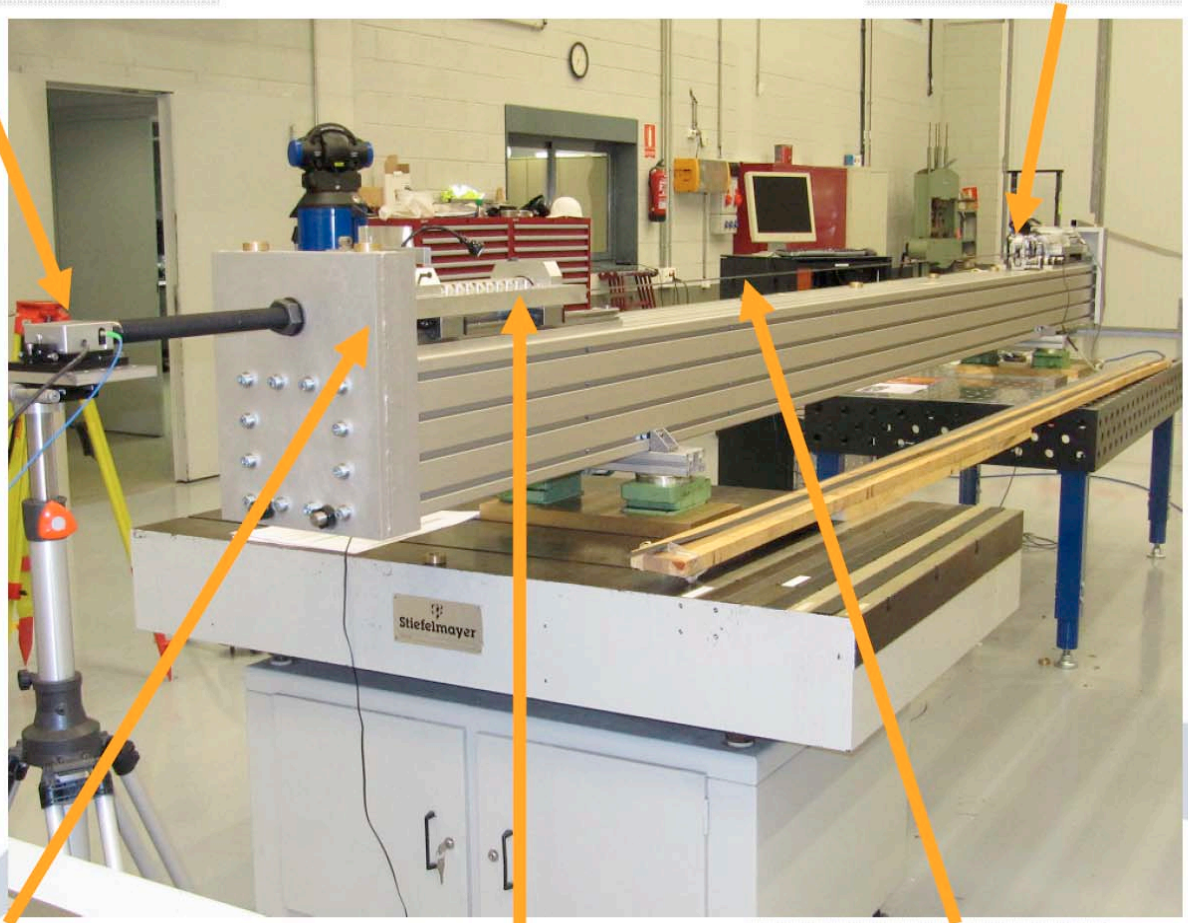


- ❑ Beam based bench
- ❑ Stretching system
- ❑ Load cell
- ❑ Carbon fiber clamp
- ❑ Motion head
- ❑ Interferometer, Y positioning
- ❑ Autocollimator: Pitch, Yaw errors
- ❑ Camera: Roll, X,Z errors

Engineering details, at MEDSI contribution from *C. Colldelram*

Interferometer

Motion head

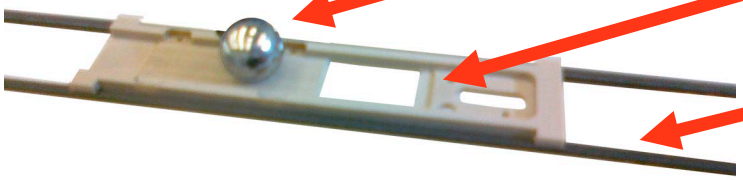


Stretching system

Clamp

Carbon fiber

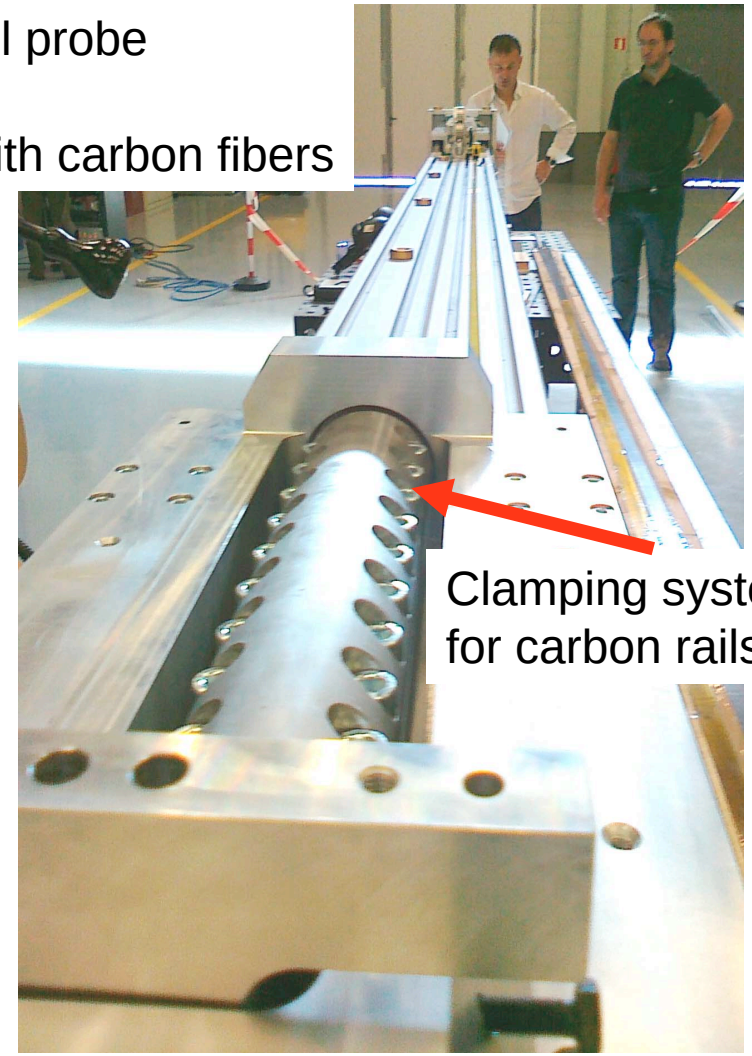
Load cell



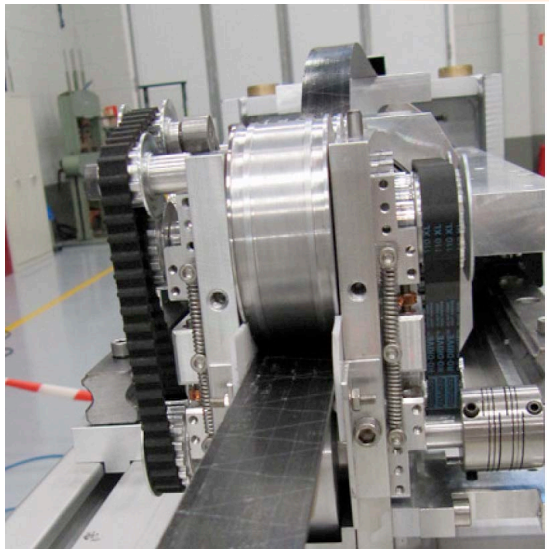
Reference for laser-tracker

Holder for Hall probe

Rails made with carbon fibers



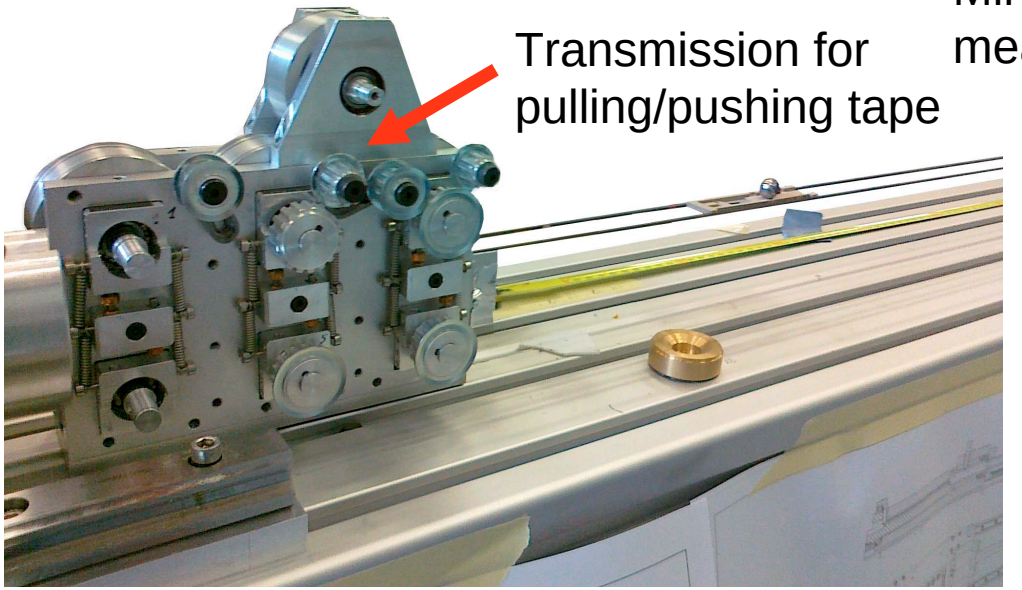
Clamping system for carbon rails



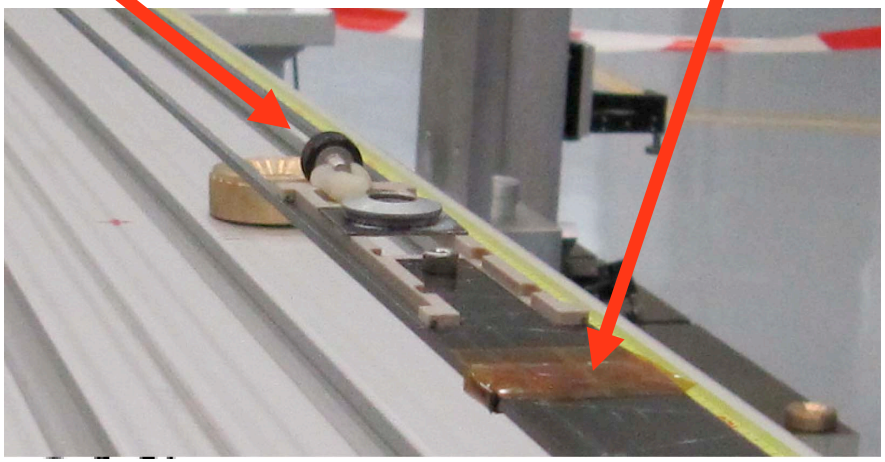
Hall holder with mirrors and Laser tracker references

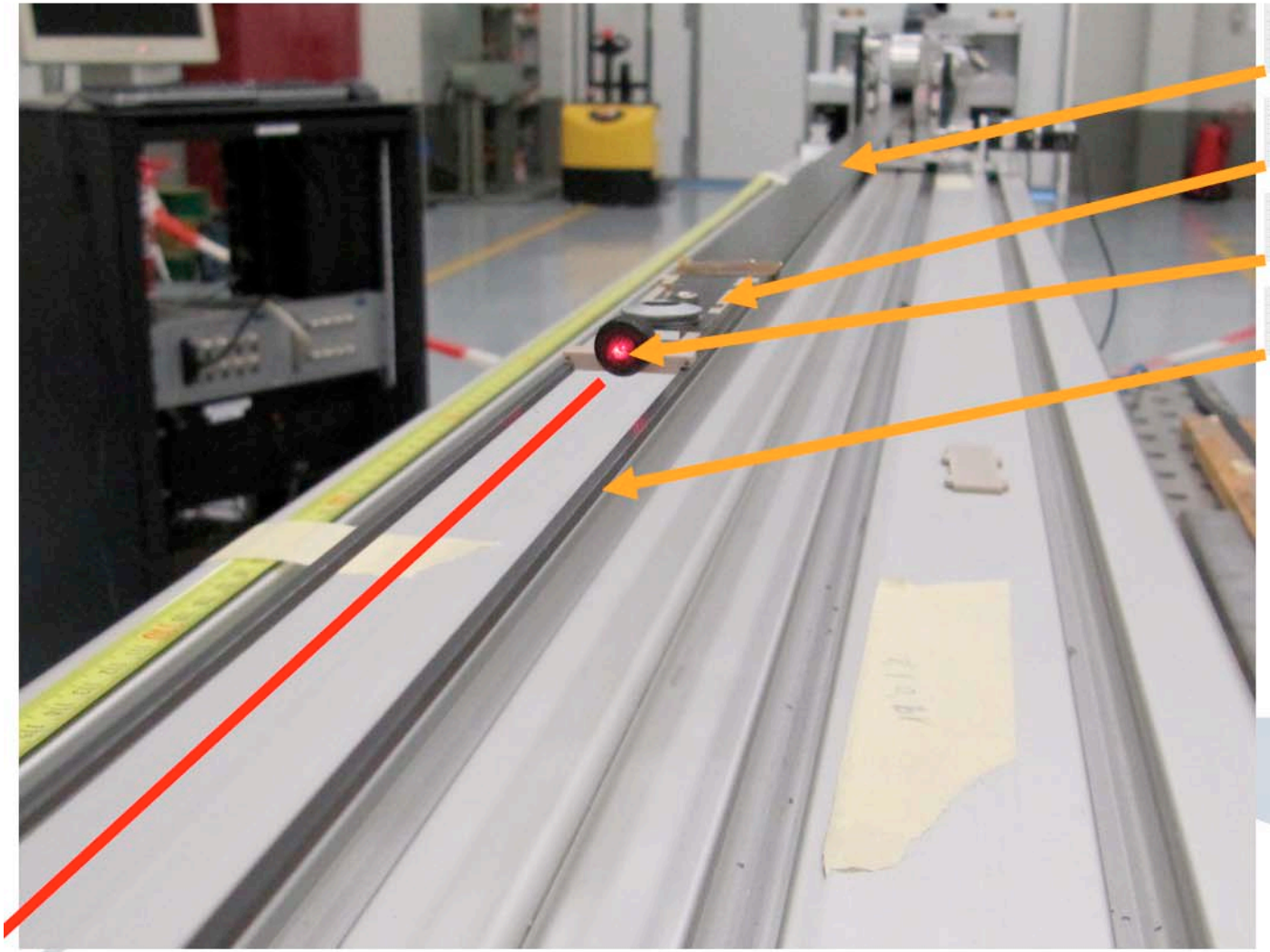
Pushing/pulling tape
Carbon fiber 0.3 x 24 mm

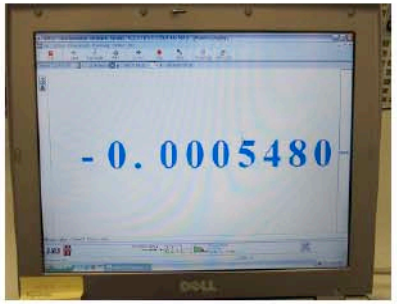
Transmission for pulling/pushing tape



Mirror for angle measurement




Motion tape
Hall probe carriage
Cateye
Carbon fiber guide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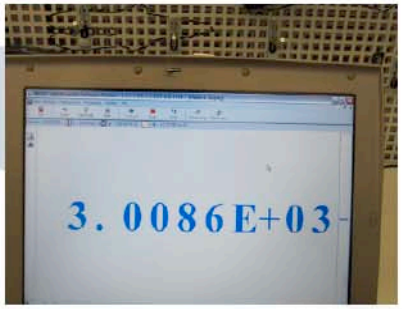
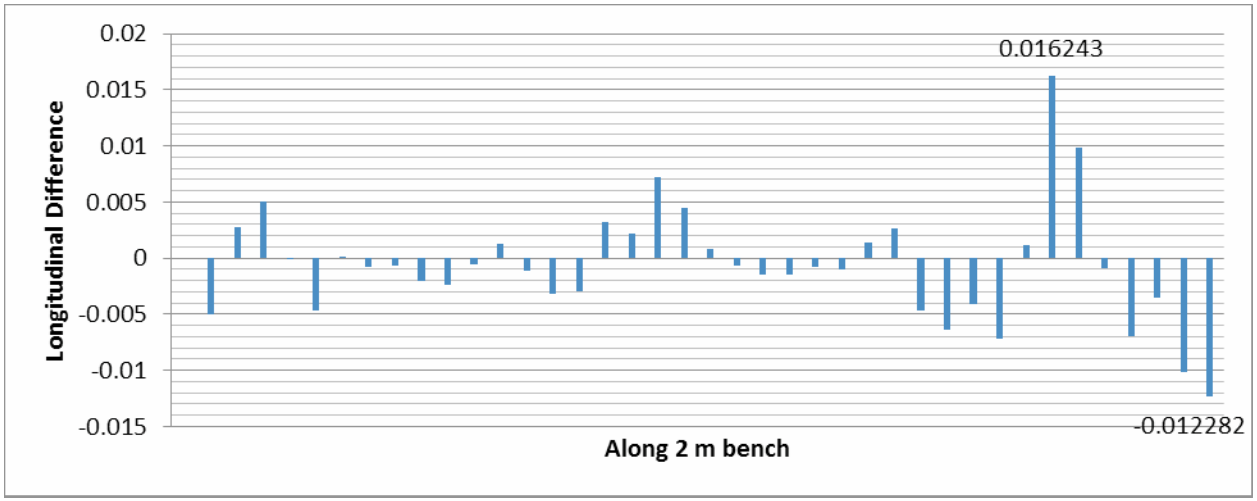

3.0086E+03

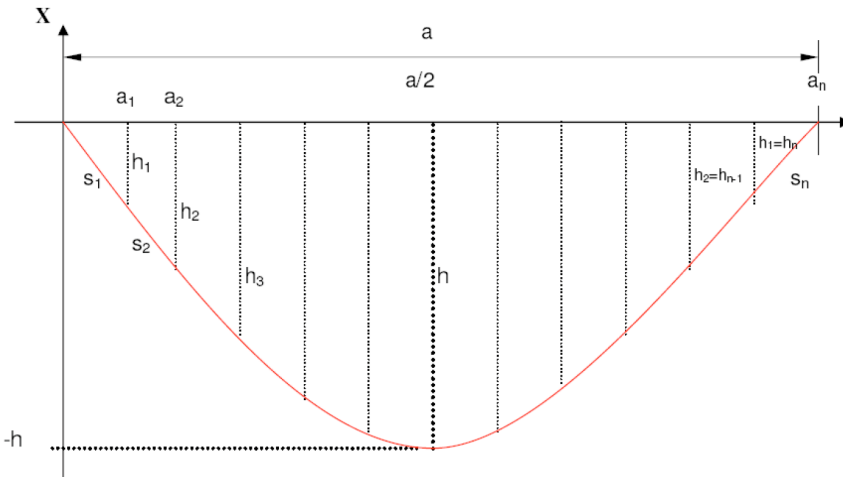
Results of prototype: interferometer

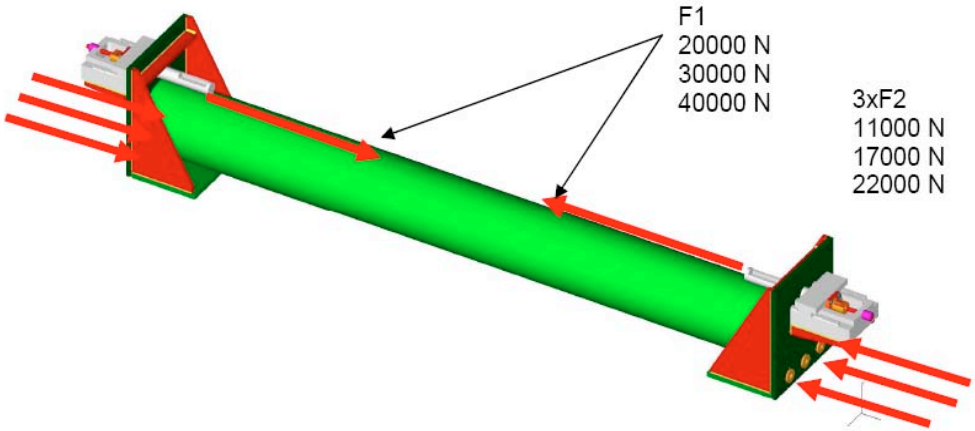
- 1 mm ball was attached on the holder
- Interferometer was able to read the position

Measurements were done with laser tracker and interferometry through a cat eye at same time. Correlation of ± 0,01 mm maximum difference between both different systems has been measured.



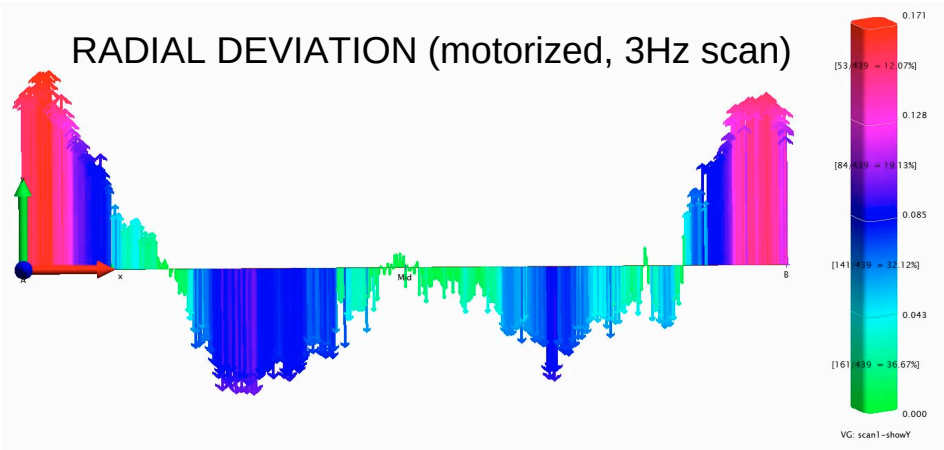
Results of prototype: sag

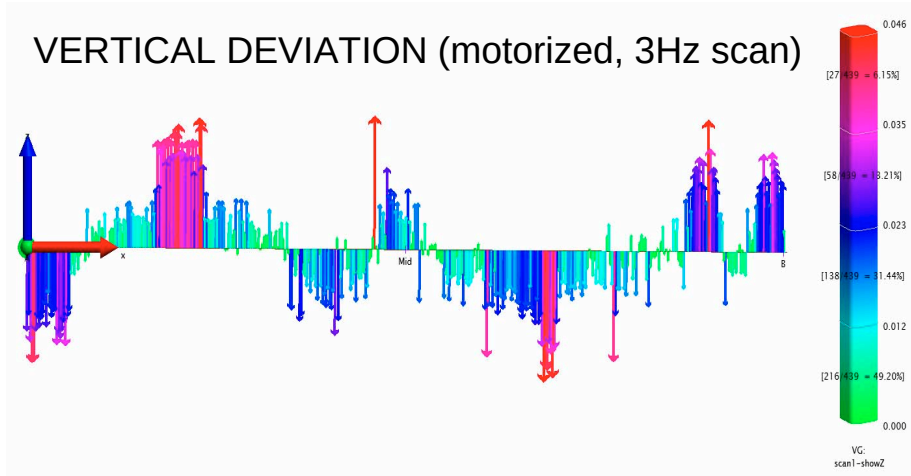


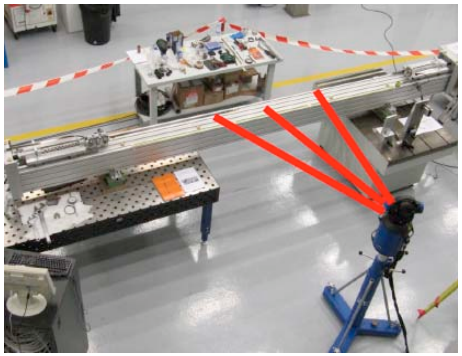


TENSION on the fiber (N)	SAG (mm)
0	0.635
1000	0.125
3000	0.015
6000	-0.005
8000	0.005

Results of prototype: planarity







Tension fiber value (N)	Performance	SCAN frequency	Radial deviation peaks (X) mm		Vertical deviation peaks (Z) mm	
10000	Hand moved	50 mm	-0,081	+0,104	-0,018	+0,018
10000	Motorized	3Hz spatial scan	-0,108	+0,171	-0,046	+0,046

Radial deviation peaks (X) mm		Vertical deviation peaks (Z) Mm		
-0,108	+0,171	-0,046	+0,046	***Peak measured***
-0,025.	**+0,025**	**-0,025**	**+0,025**	***specified***
0,083	**0,146**	**0,021**	**0,021**	***DIFFERENCE***

Results of prototype: problems found

- Planarity not acceptable → We changed the machining process (mechanization instead of grinding)
- Problems with the pulling/pushing tape → Looking for a better supplier

A new prototype of guiding rails and pulling/pushing tape was done

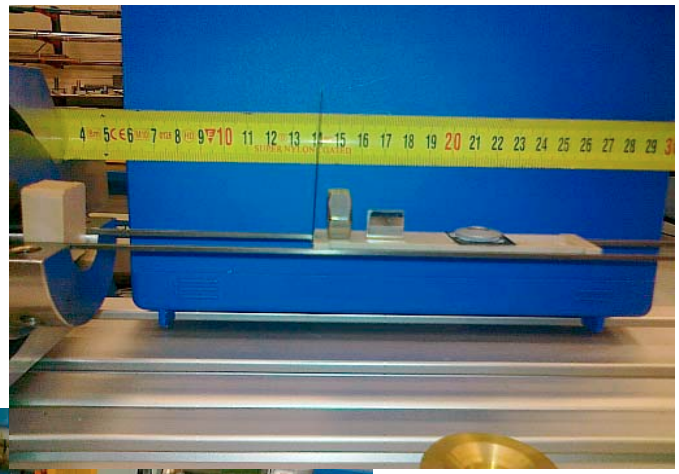
Spec name	*Specification*	*Max and min peak result*
Transversal guidance accuracy (X)	± 0,025 mm	**-0.018**
		+0.028
Transversal guidance accuracy (Z)	± 0,025 mm	**-0.016**
		+0.022

Results of prototype: angular stability

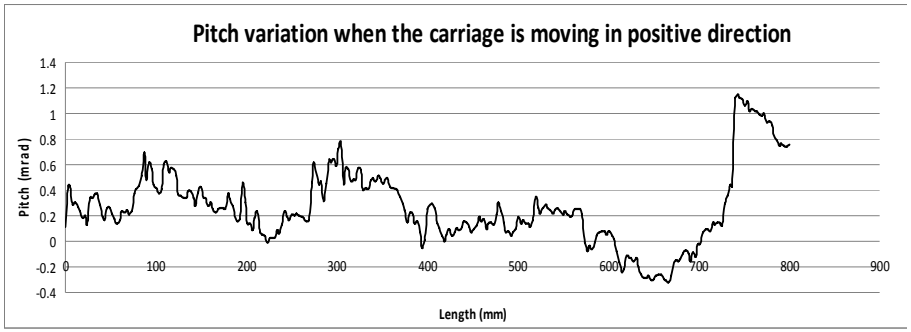
Measurements with autocollimator:

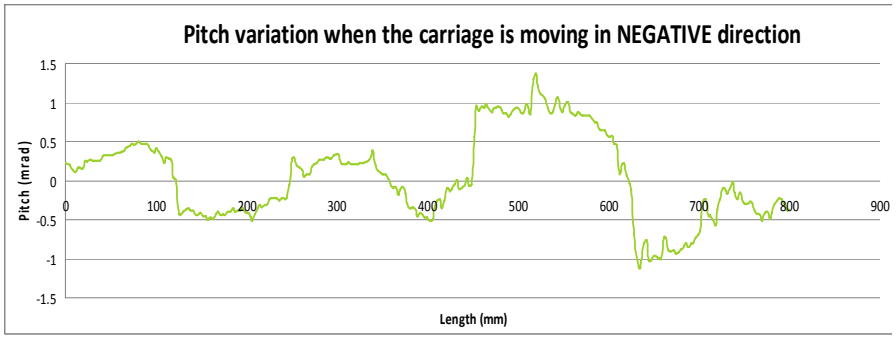
- Yaw
- Pitch

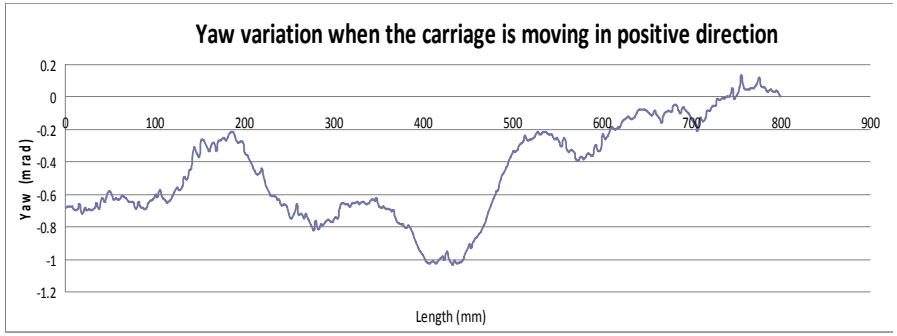
- Roll

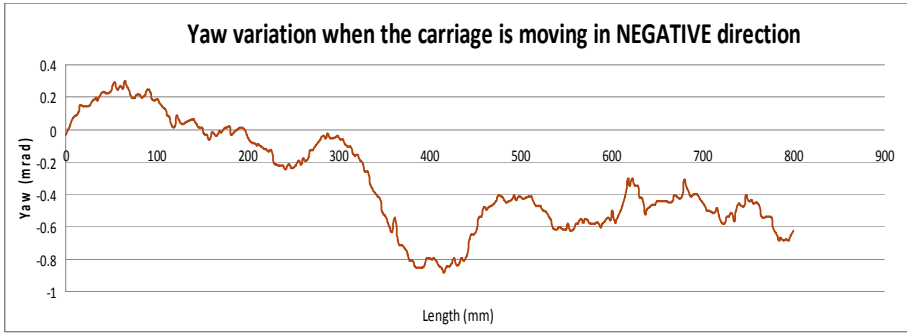


Results of prototype: angular stability



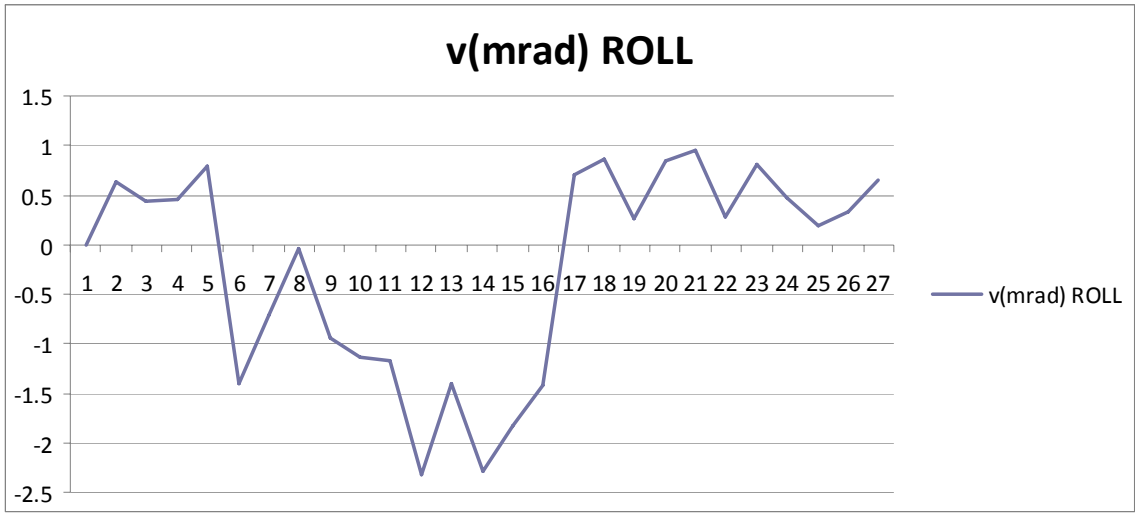






- Yaw: 1.2 mrad (spec: 0.05 mrad)
- Pitch: 2.5 mrad (spec: 0.05 mrad)

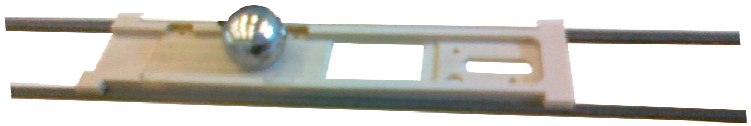
Results of prototype: angular stability



- Roll: 3.0 mrad (spec: 0.1 mrad)

Results of prototype: angular stability

Problem identified: «natural» twisting of rails because of internal filaments

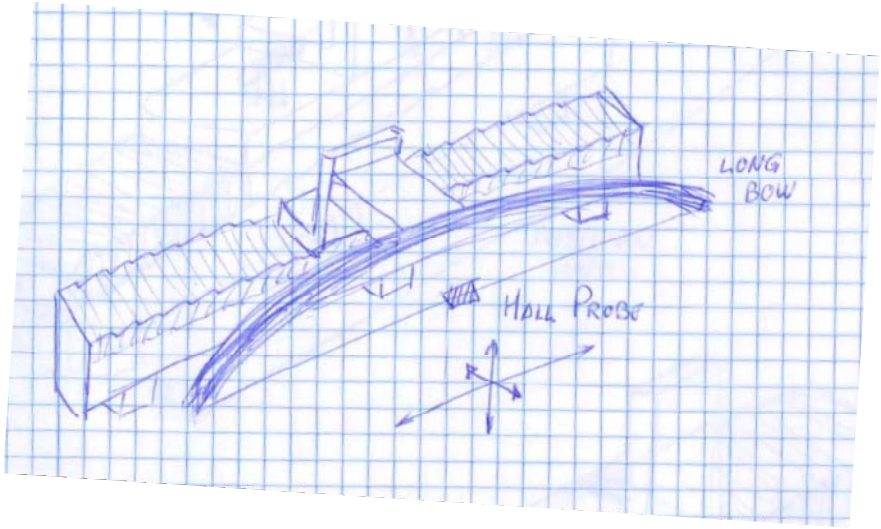


The short distance between rails (~20 mm) implies that deviations of one rail of only ~2 microns yield 0.1 mrad, out of specifications.

Total change of concept required

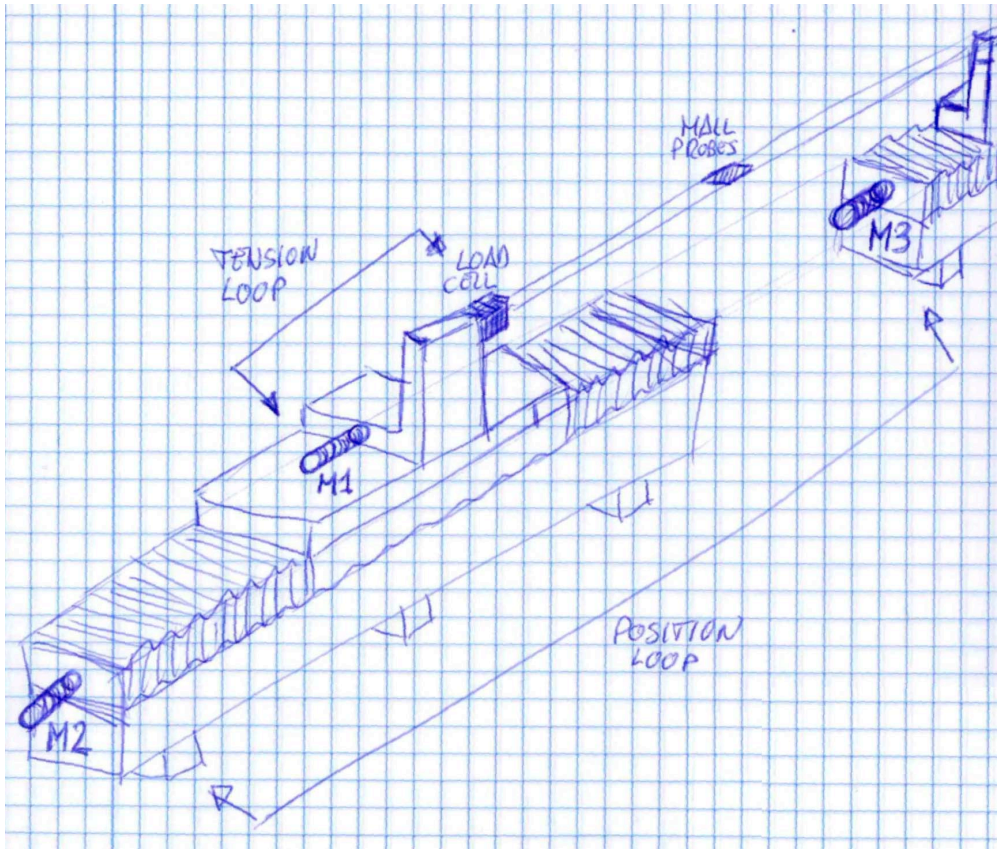
New concepts

Option 1: «longbow»



Using current existing bench with a long bow attached. Main drawback: vibrations. But they depend on tension and f_0 can be shifted to high values (>100 Hz).

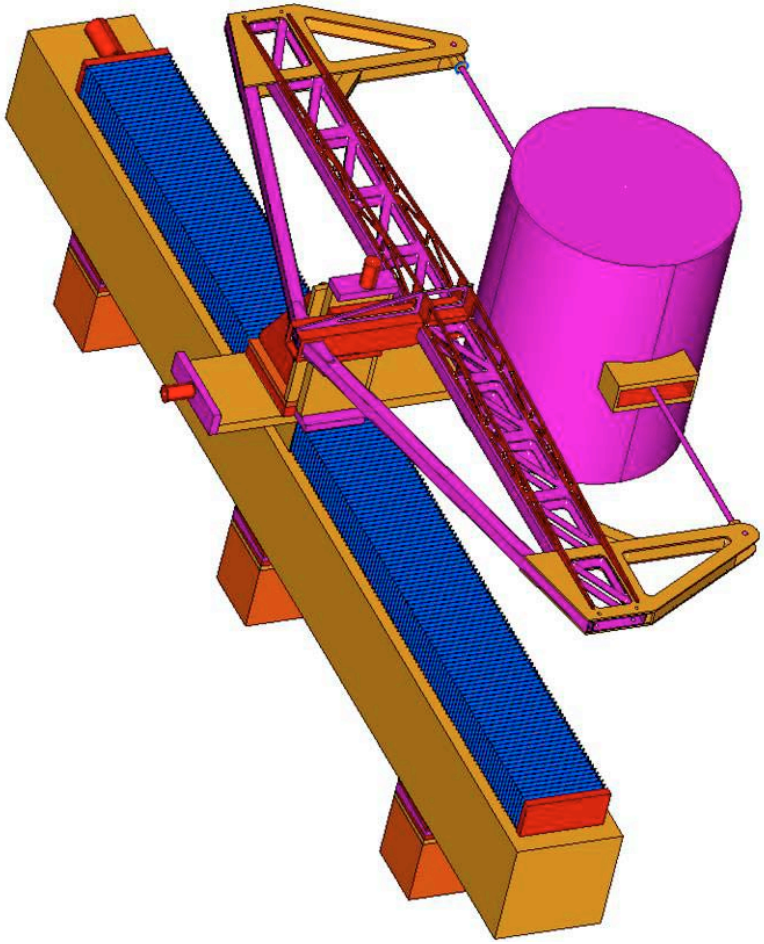
Option 2: double-bench

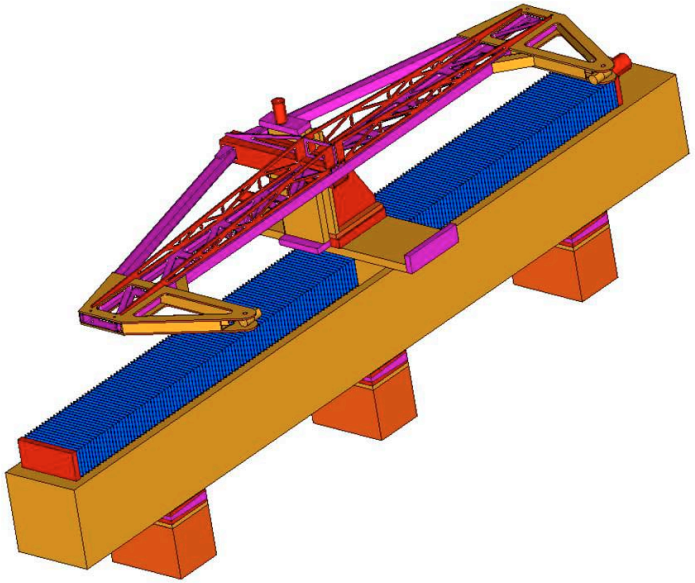


M2 and M3 motors defining position

M1 motor controlled by a load cell at higher frequency

Current status: option 1 to be tested





Current status: option 1

Next actions:

- Vibration calculations
- FEA analysis of deformations and weights
- Manufacturing of a short (1.5 m) prototype of longbow
- Assembly of longbow at CELLS existing Hall probe bench
- Testing of the prototype

Thanks for your attention!