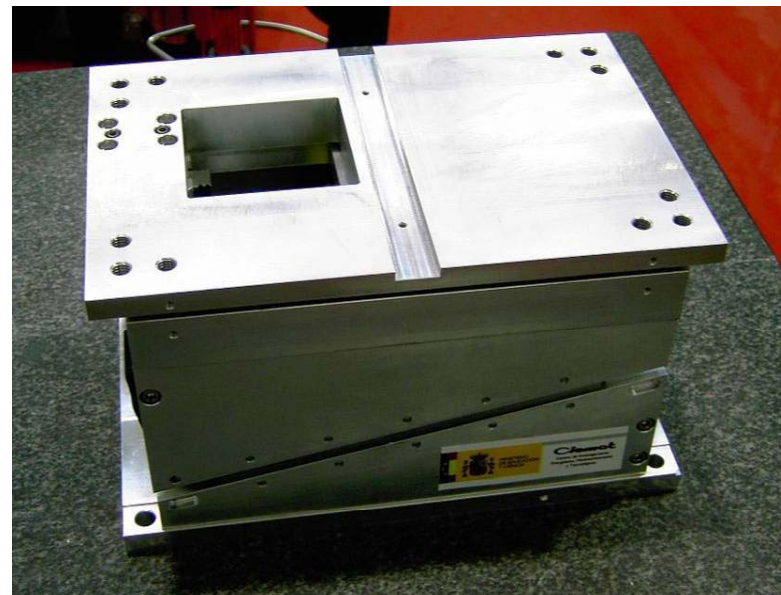
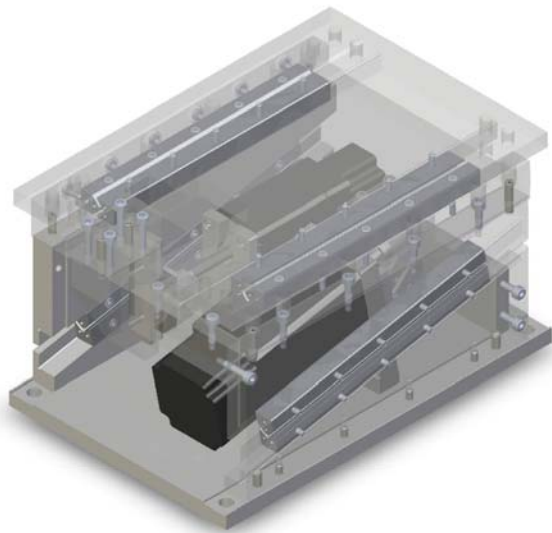
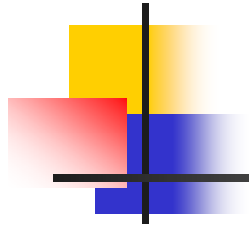


TBL quadrupole mover prototype development





Outline

- ✓ Technical specifications
- ✓ Layout
- ✓ Fabrication and assembly
- ✓ Tests
- ✓ Future work
- ✓ Conclusions



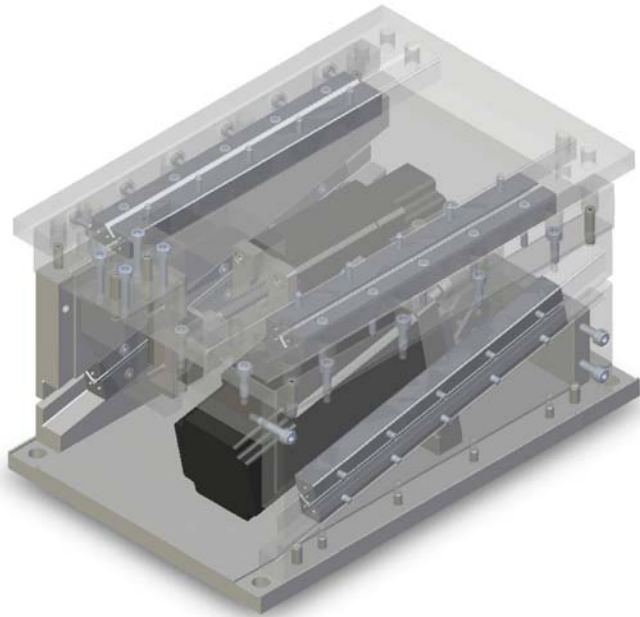
Technical specifications

Length	<200	mm
Stroke	+/- 4	mm
Position resolution	1	micron
Position reproducibility	+/- 5	micron
Movement speed	>0.5	mm/s
Distance from driver to motor	up to 50	m
Mass to move	~50	kg
Number of units	16	

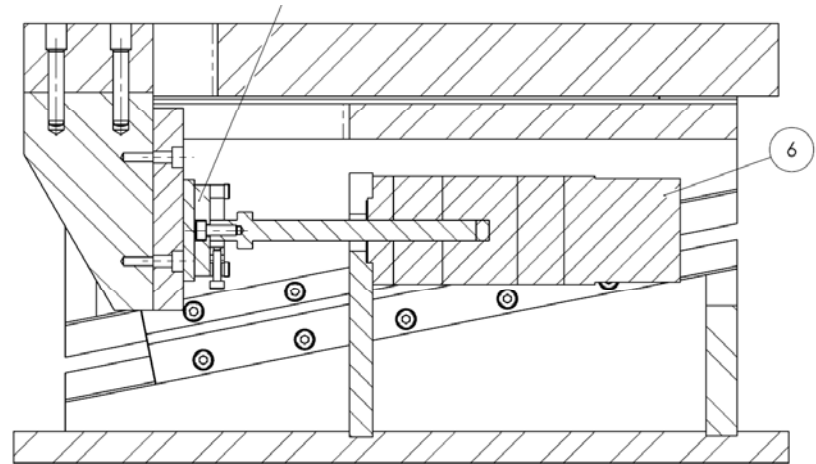
Challenges:

- ✓ Compact design
- ✓ High accuracy
- ✓ Moderate price for series production

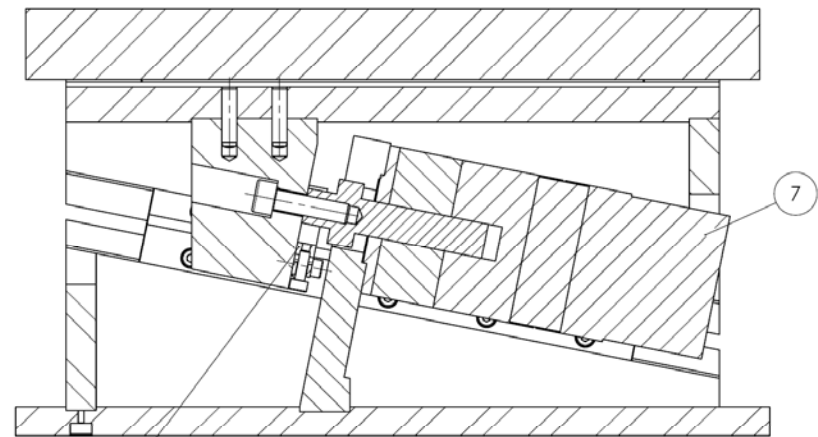
Layout (I)



- Actuators based on 5-phase step motors with integrated screws and electromagnetic brakes.
- Precision linear guides.
- Mechanical micro-switches: home position and end-of-movement detectors.



Horizontal actuator

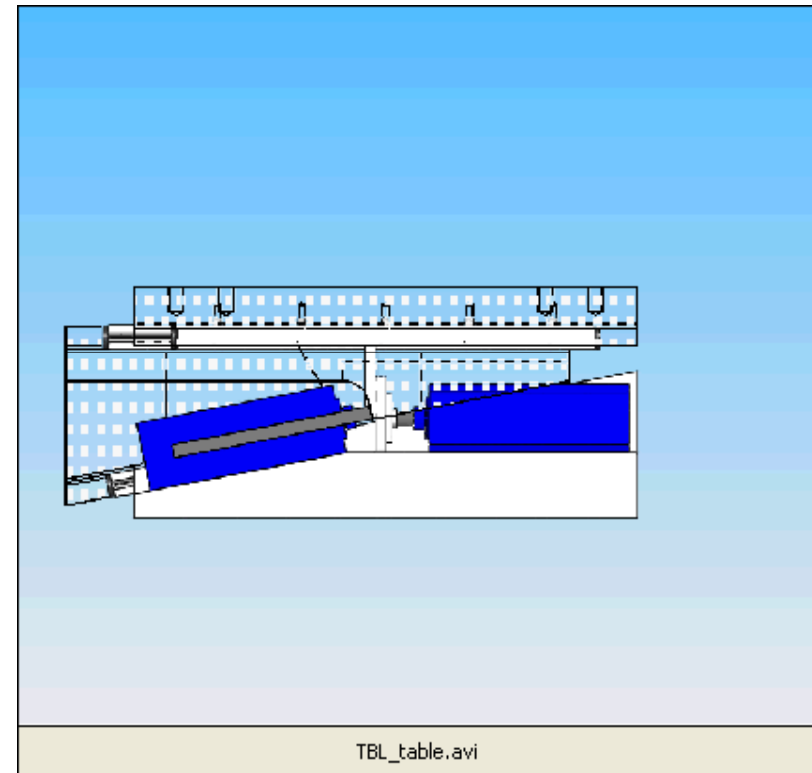


Vertical actuator

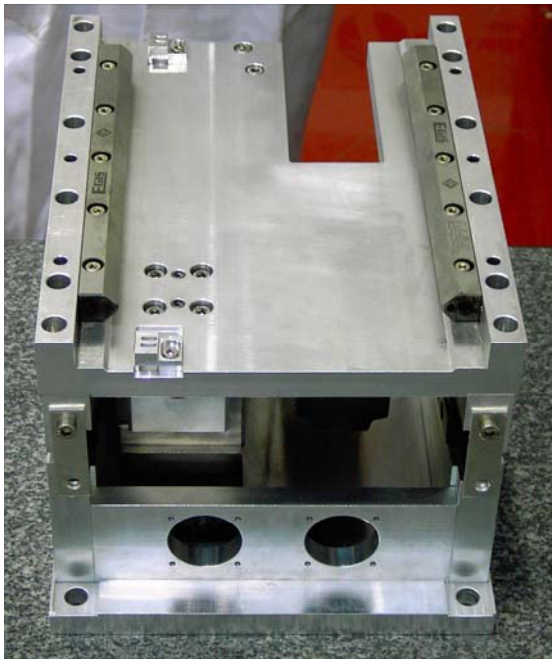
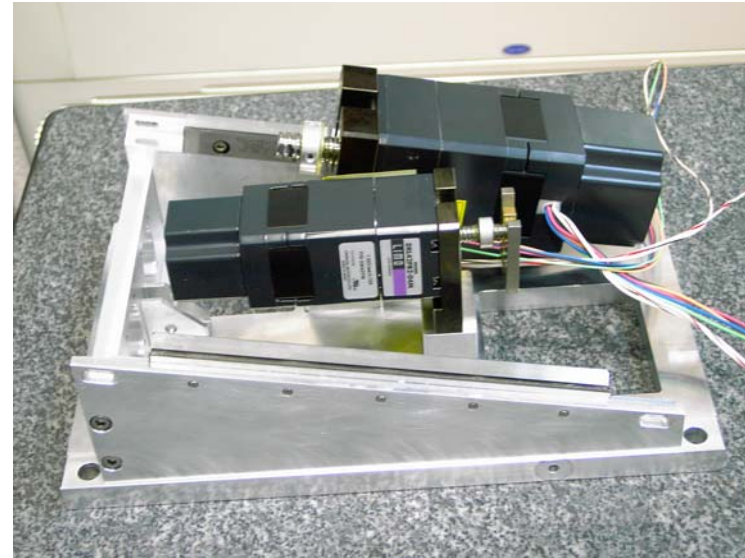
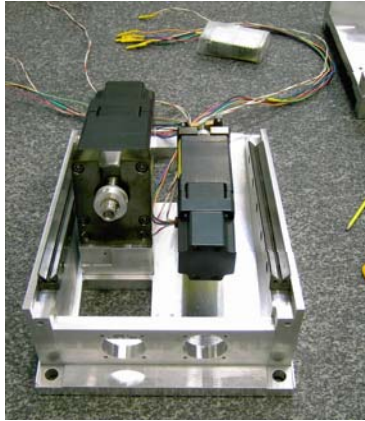
Layout (II)

Vertical actuator

- ✓ The inclination of the **wedge** enhances the vertical force, allowing a smaller motor to lift a given weight, and improving position resolution.
- ✓ There is a **vertical linear guide**, which leans on the horizontal actuator, and so makes vertical and horizontal movements independent.
- ✓ **Drawback**: the required overall length of the screw for the requested vertical stroke increases.



Fabrication and assembly



Tests at CIEMAT (I)

- ✓ Drivers can properly power the motors **50 m away**.
- ✓ No problems to achieve the requested **speed** for the nominal mass.
- ✓ Preload is critical to minimize the **backlash**: spring for the horizontal movement; the own magnet weight for the vertical one.
- ✓ Reproducibility achieved for **horizontal movement**.
- ✓ However, first tests showed that left side movement was not accurate during **vertical movement**.



Tests at CIEMAT (II)

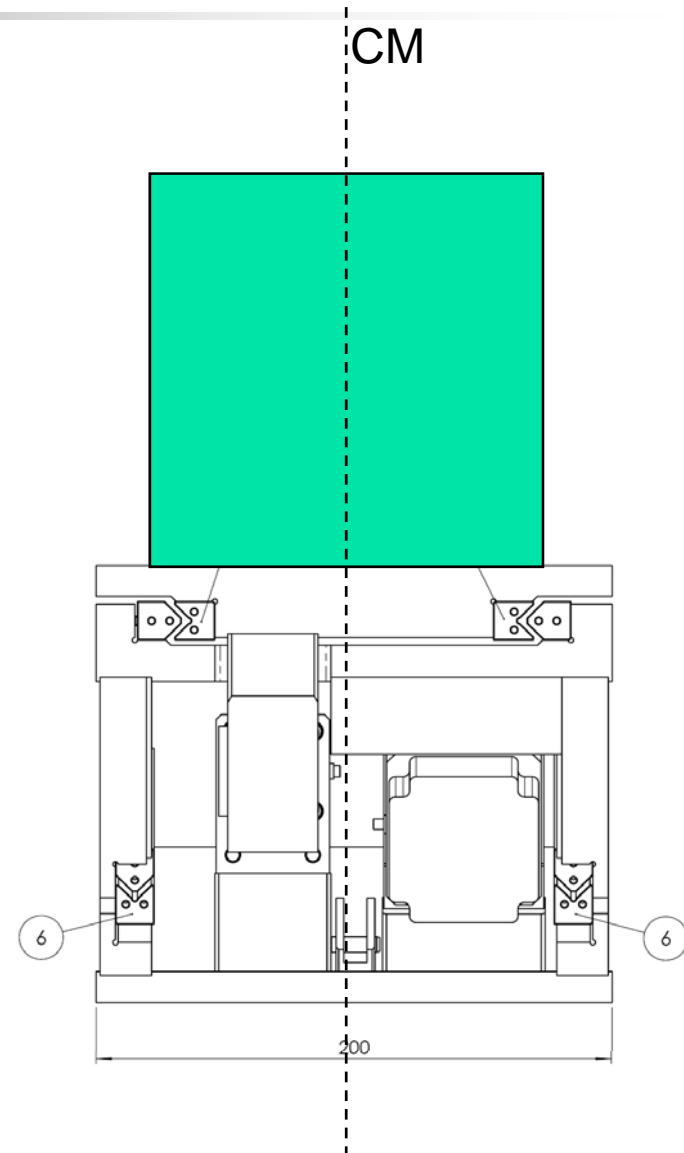
- ✓ We checked the micrometers accuracy.
- ✓ We found no clues for the problem when moving short distances: random errors.
- ✓ However, errors showed saturation for long distances.



LEFT HAND SIDE		RIGHT HAND SIDE		
FORWARD	BACKWARD	FORWARD	BACKWARD	
186	198	203	194	
184	195	204	198	
187	192	208	198	
182	196	203	197	
193	194	202	194	
189	189	202	200	
187	189	202	202	
190	185	197	202	
195	187	195	203	
197	193	194	203	
193	177	195	202	
193	181	196	205	
193	185	194	204	
197	185	195	205	
198	187	200	208	
194	180	195	207	
194	185	195	205	
199	175	197	207	
AVERAGE	191.72	187.39	198.72	201.89

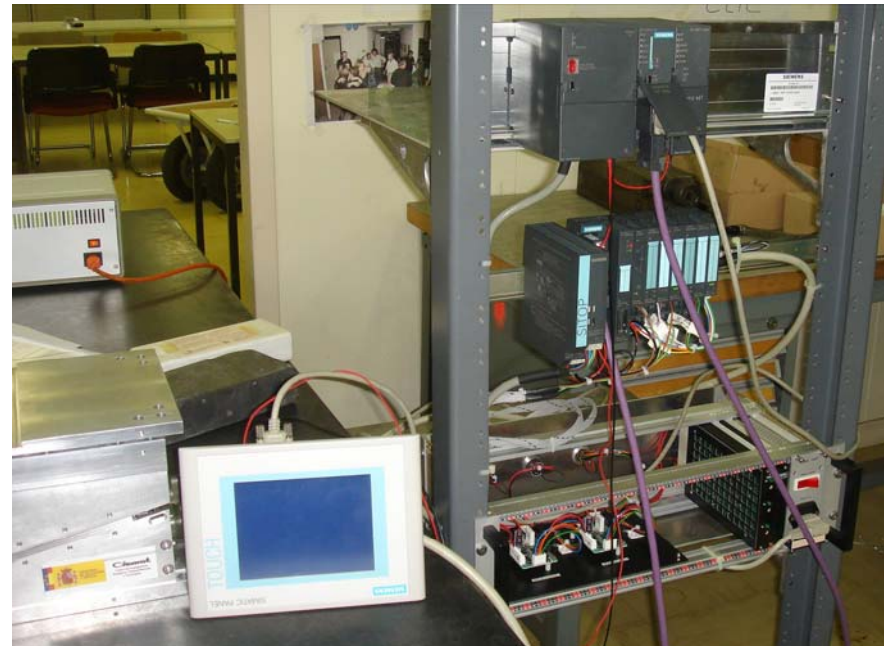
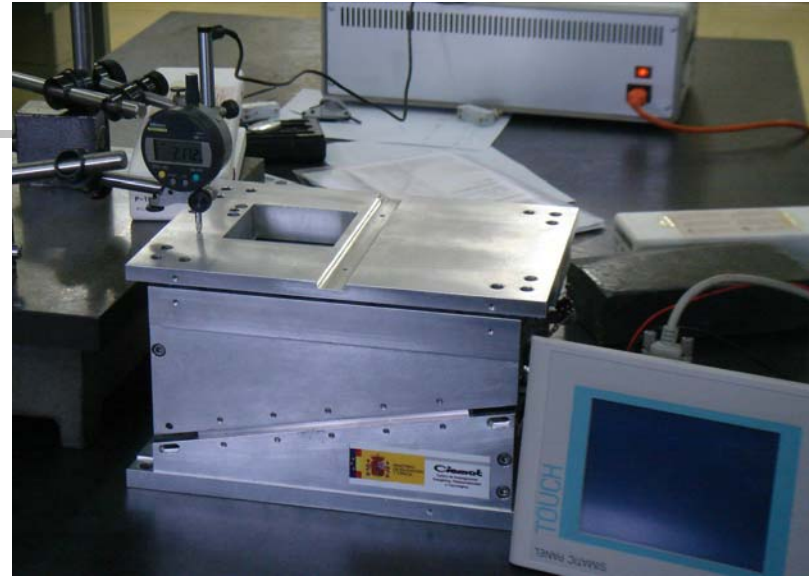
Tests at CIEMAT (III)

- ✓ **SOLUTION**: the center of mass was out of the symmetry axis, due to the position of the micrometers.
- ✓ We are concerned about the reproducibility of few-micron movements (<10 micron). We cannot measure them with enough accuracy.
- ✓ We have found some problems with the reliability of the end-of-movement switches. They have a metallic sheet to detect the position of the mover which does not seem repetitive.



Tests at CERN

- ✓ CERN control system is successfully powering the mover. It is based on a PLC.
- ✓ No problems in the horizontal movement: 1 micron reproducibility!
- ✓ About 10 micron errors and backlash in the vertical movement: more measurements are necessary.
- ✓ End-of-movement sensor stiffness must be improved.
- ✓ Tests are still on-going.





Future works

- ✓ End-of-movement sensors improvements.
- ✓ Tests should be performed also with a dummy quadrupole. Resonances due to the water cooling vibrations are possible.
- ✓ The mover support on the girder is still being designed.
- ✓ The mover design will be updated with the detected mistakes before starting series production (15 units more). The aim is to finish by the end of 2008. The assembly will be likely done at CIEMAT.



Conclusions

- ✓ TBL quadrupole mover has been successfully designed, fabricated and tested at CIEMAT.
- ✓ The actuators are based on stepping motors with integrated linear screws.
- ✓ It is at CERN for acceptance. Some minor problems detected with the end-of-movement sensors and the vertical movement reproducibility.
- ✓ The design must be updated to start with the series production, which should be delivered by the end of 2008.