# Presentation Layout

## Stable Structures for Particle Detectors

## - Alignment Wheel -

Material Requirements

Alignment wheel

Prototype purpose & test campaign

## Shape Control of Structures

Concept

Experimental & Simulation Results

## Future Work

# Materials Requirements

Requirements are more strict at the level of inner detectors. Track reconstruction of the particle's path demand a very high dimensional stability of the supporting structures.

**Minimize multiple scattering** **high $X_0$ , low density**

**Minimize susceptibility to vibrations** **high stiff/mass**

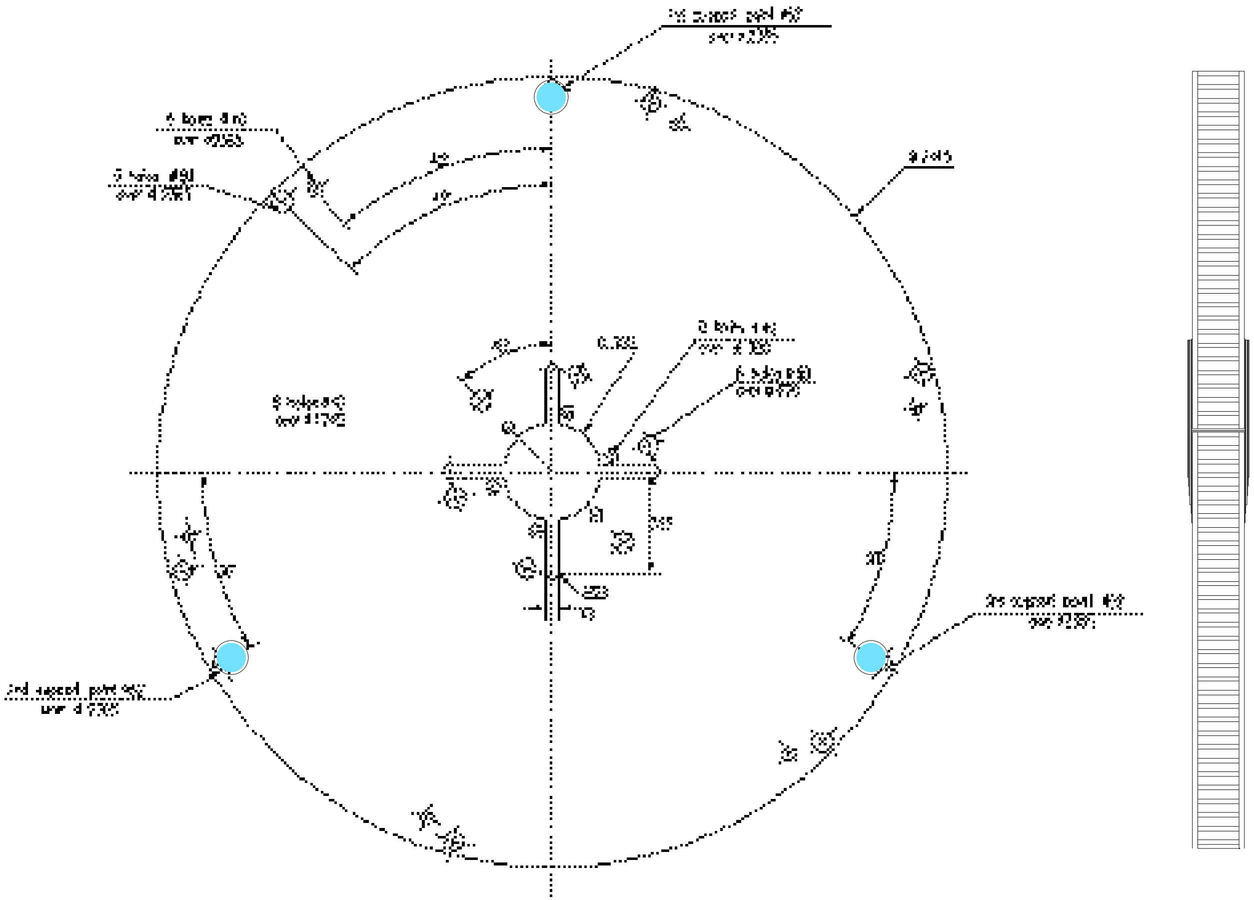
**Stable with time** **insensitive temp./humidity gradients**

**Radiation resistant** **avoid plastics**

**Non magnetic components (4 Tesla)**

**Availability, technological limitations, cost, safety**

# Alignment Wheel Prototype (June 00)



* 2mm carbon fibre skins + 16mm nomex honeycomb
* Fixations for optical components
* Fixed at 3 points to TK support tube

# Prototype Purposes

## # Design Verification

* Check accuracy of FEM results
* Validate analysis method
* Set required tolerances
* Check integration with Tracker/Muon alignment system
* Identify the assembly and maintenance procedures
* Unveil unknowns in the behavior of the structure

## # Qualification

* Establish manufacturing procedure
* Assure manufacturing quality
* Define distribution/support services
* Demonstrate fulfillment of all requirements

# Tests Campaign

# Material characterization tests (intrinsic response; elastic/strength prop.)

# Structural detail testing (validate methodology used to represent fixations)

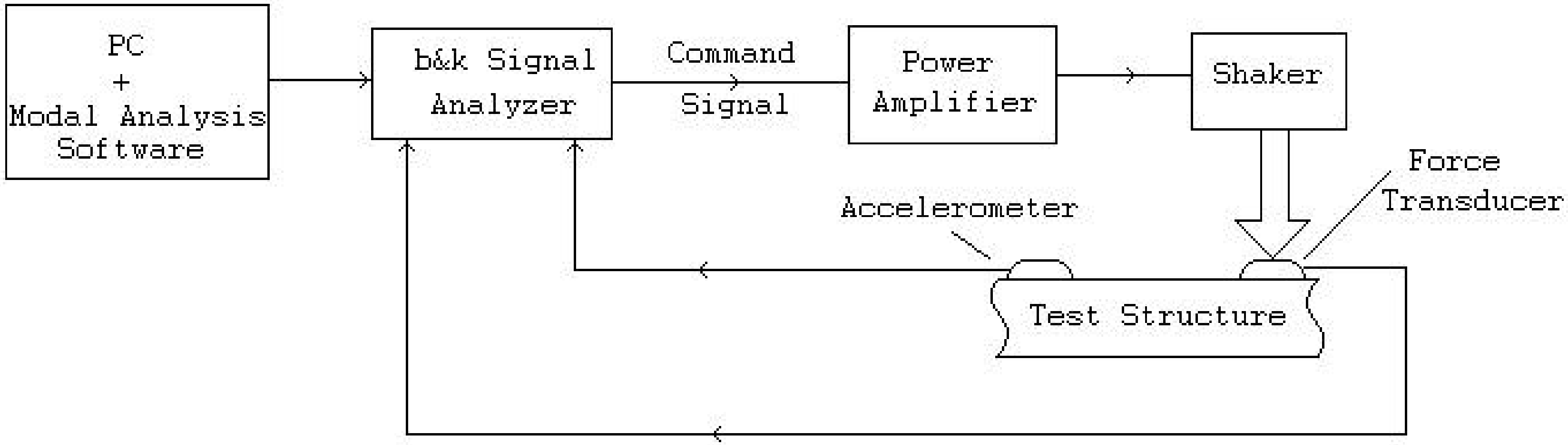
# Static tests (stiffness/strength testing)

# Modal testing (modal parameters)

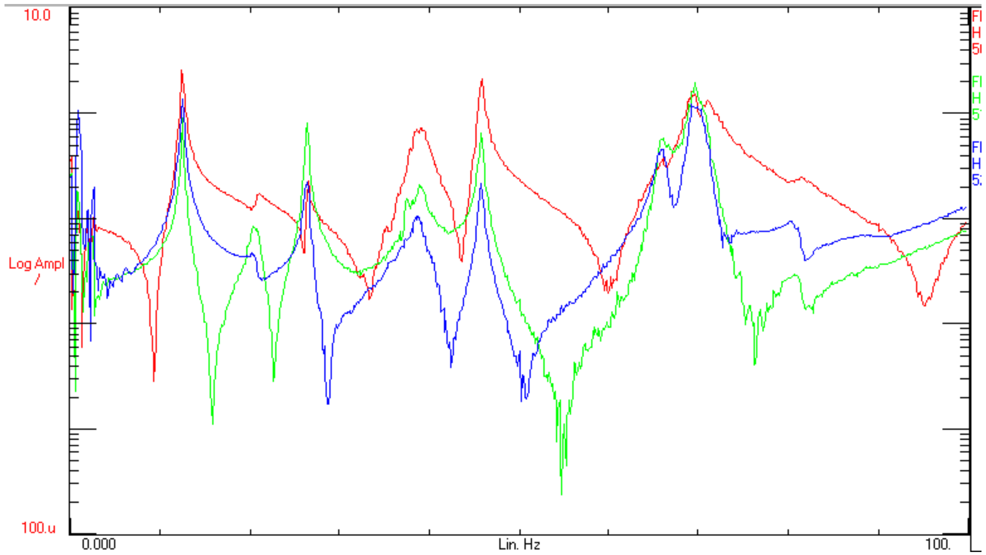
# Sensibility testing

# Modal Testing: Set-up

- Signal Analyzer provides excitation spectrum (random)
- After suitable power amplification excitation signal is applied to the structure through the shaker
- Response signals are measured by accelerometers
- Frequency Response Functions (FRF) built by Signal Analyzer
- Modal Analysis Software extract modal parameters



# Modal Testing: Results

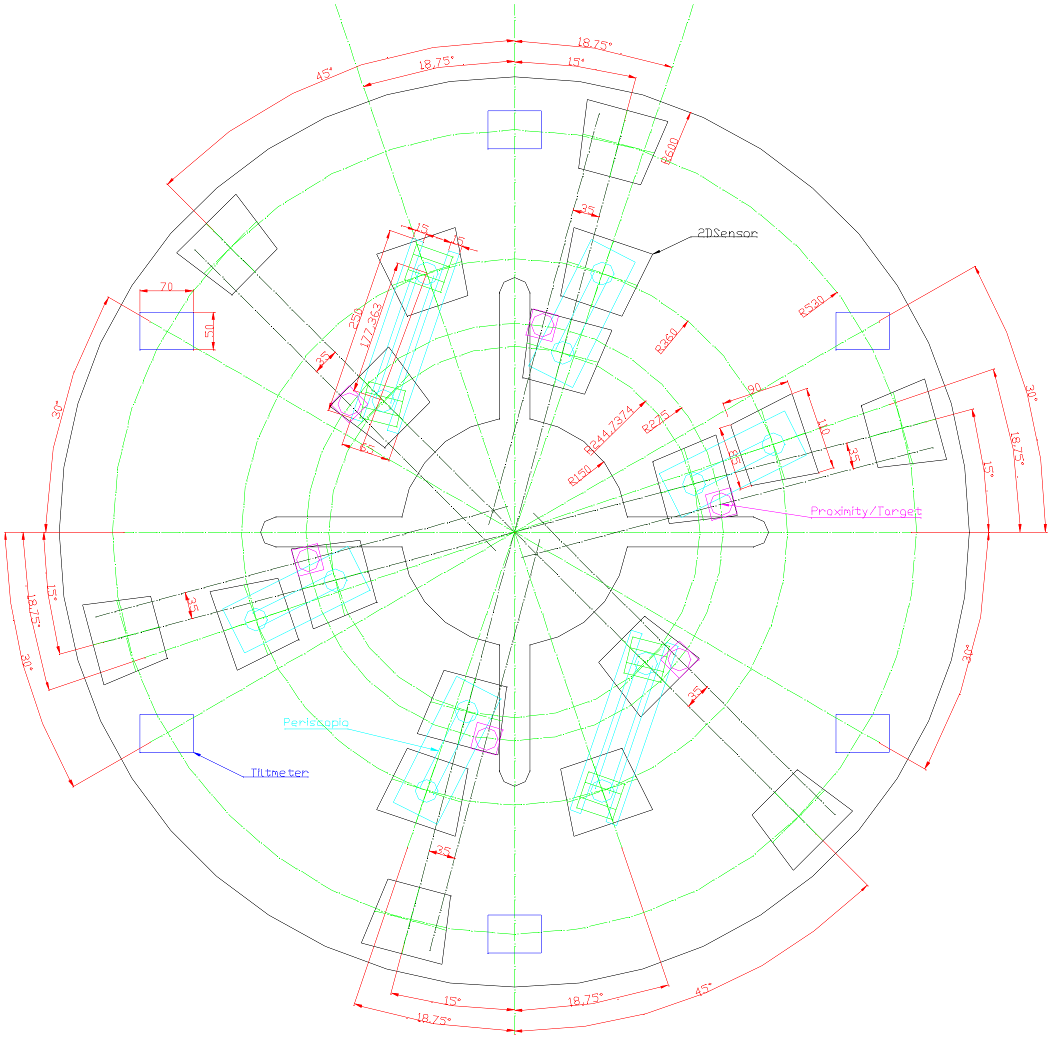



Measurements done in 36 - 128 points mesh

Each FRF is a result of 25 measurements

Frequency bandwidth < 100 Hertz

# Mini Alignment Disk (MAD)




## Common Points:

Æ the MAD is divided into two parts (installation of the Pi)

Æ same inner shape

Æ same material/engineering design

## Differences:

Æ support only the components of the Link System

Æ smaller diameter (1.2m)

Æ the MAD is mechanically connected to the TEC in 6 points

Æ 3 different short periscopes

# Shape Control - Concept

Piezoelectric Actuators
+
Applied Voltages

Forces

Shape Control
+
Correction static deform.

Optimization Problem:

Pre-defined shape structure

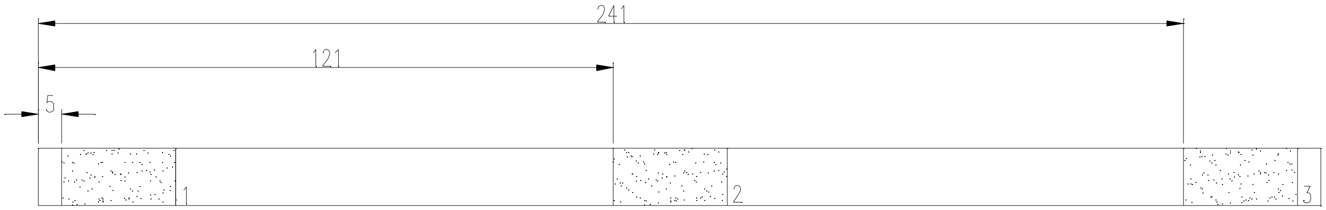
Placement Actuators???
Applied Voltages???

Saturation Voltages
Struct. Constraints: no. piezos

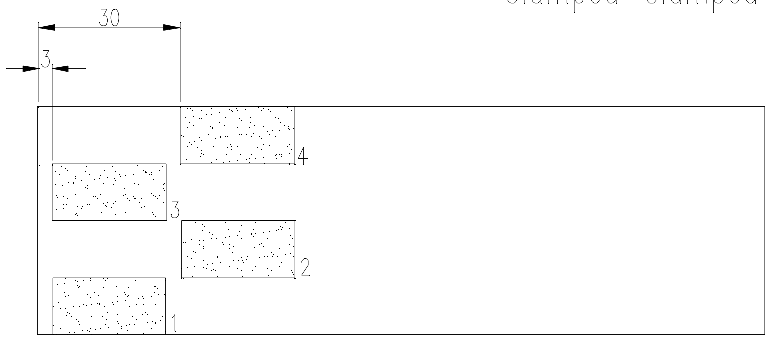
Model (F.E.M.)

Genetic Algorithms

# Shape Control - Case I




Clamped–Clamped Beam




Clamped–Free Plate

**Beam:**

Clamped-clamped aluminium beam

270x48x0.5 mm

3 Piezo. (24x12x0.3 mm) [-100,200] V

**Plate:**

Plate:Clamped-free aluminium plate

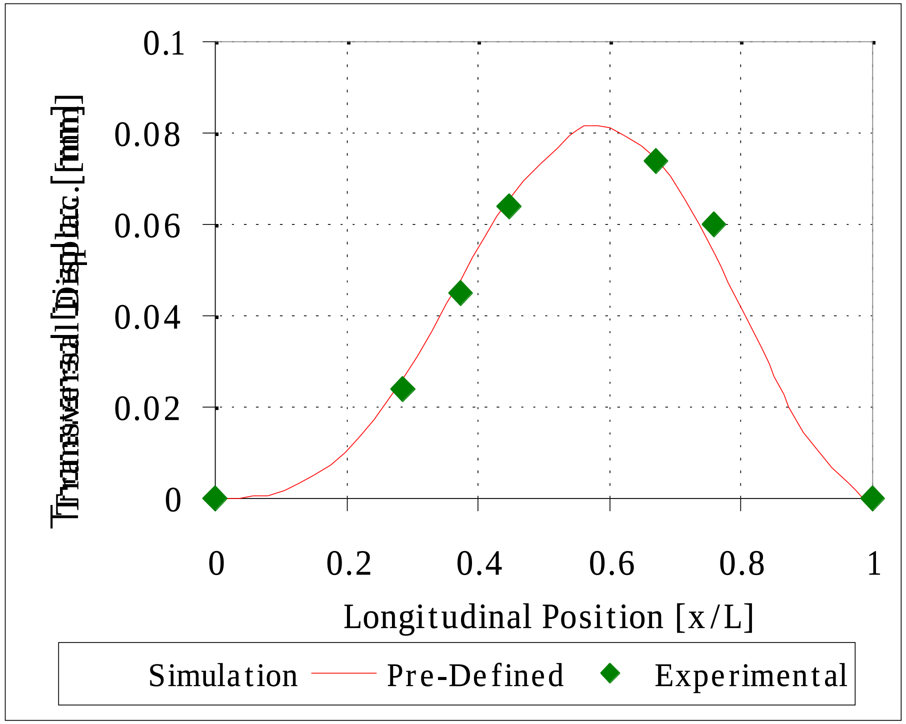
270x48x0.5 mm

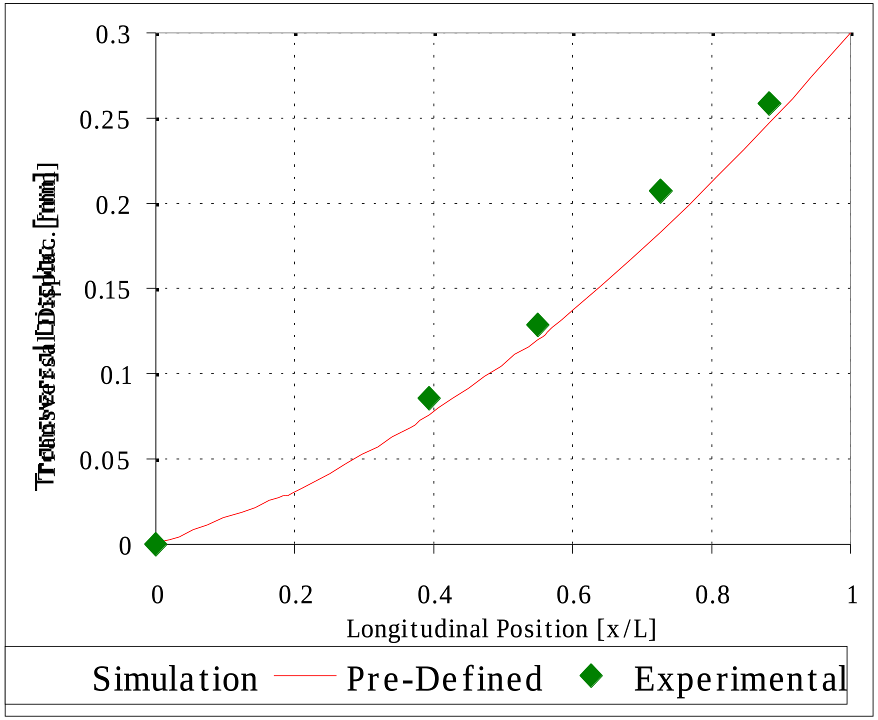
4 Piezo. (24x12x0.3 mm) [-100,200] V

GA Parameters: $Population_{size}$=50,000; $P_c$=0.75; $P_m$=0.15

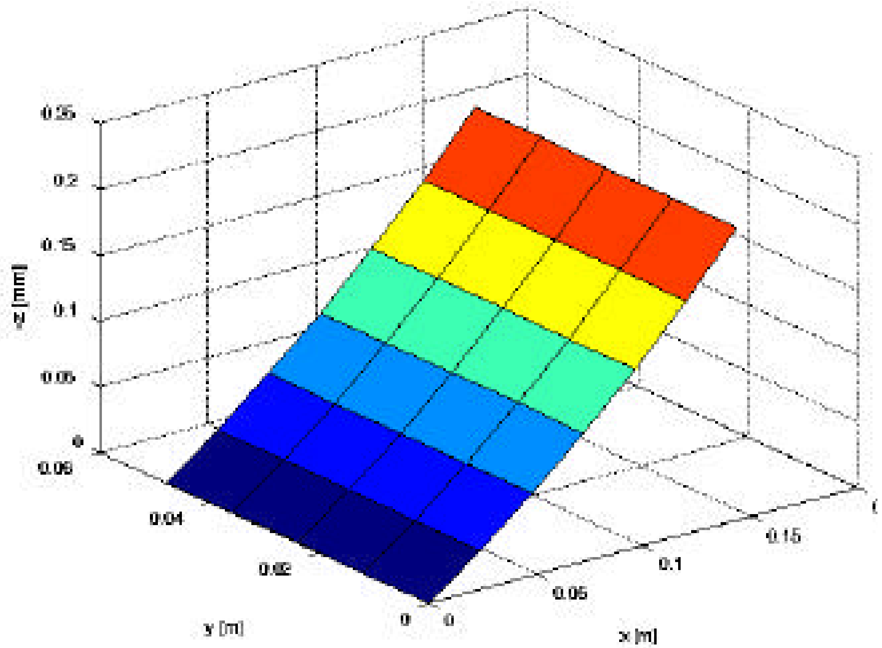
# Shape Control - Case I (cont.)

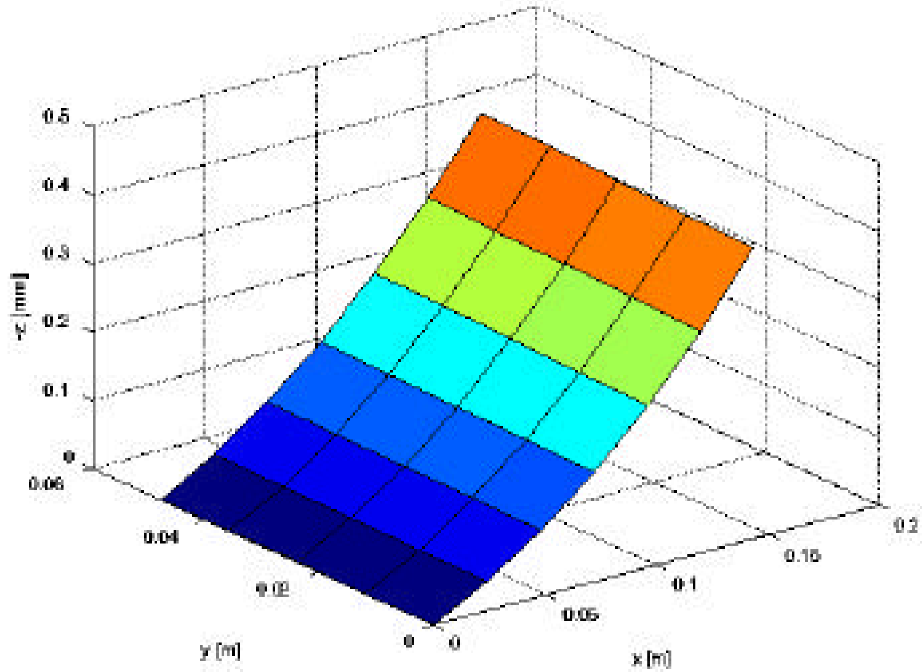
| | Displacement Field [mm] | Piezo1 [V] | Piezo2 [V] | Piezo3 [V] | Piezo4 [V] |
|---|---|---|---|---|---|
| Beam | $f(x) = 0.075\left(1-\cos\frac{2\pi x}{L}\right)\left(\frac{4x}{L}\right)$ | 17 | 74 | -121 | - |
| Plate | $f(x,y) = 8x^2 + 4xy + 0.8x$ | -68 | -100 | 196 | 200 |



# Shape Control - Case II



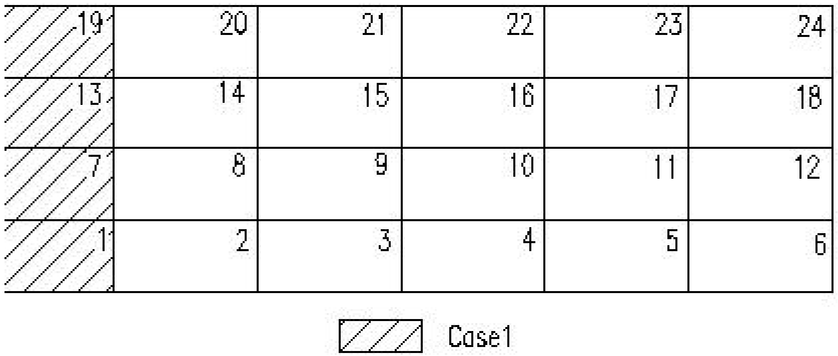

$F(x,y)=0.0012x+0.003x^2$

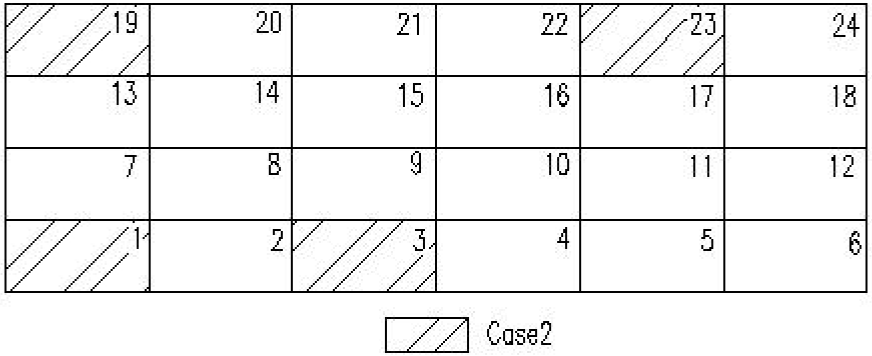
$F(x,y)=0.0015x+0.01x^2+0.002xy$

* Clamped-free aluminium plate (144x48x0.5 mm)
* [-100,200] Volt
* Maximum 4 piezoelectric elements

Objective: Determine optimal placement and optimal voltage

# Shape Control - Case II (cont.)




No penalization due to weight of the actuators 4 actuators

<u>Case 1:</u> bending independent of y co-ordinate all actuators near clamped edge where strain energy/effect of the actuators is maximum.

<u>Case 2</u>: bending + torsion torsion only achieved if actuators are displaced in non symmetric manner/tilted relative to the x axis.

# Future work

- Finish tests on the "old" alignment wheel prototype
  - Static tests
  - Update of finite element model
  - Quantify vibration risk (modal testing)
- Start simulation on the "new" alignment wheel
- Define the new prototype tests campaign
- Use GA and the FEM to optimal placement of actuators for vibration control. Simulation & Experimental verification.