

# ESRF Phase II – New storage ring project Magnet support and Girder design



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- An accurate and stable positioning of magnets (0.5-1.2 tons on girder)
- Test of the main mechanical components (wedges) for magnets and girder
- Overview of the girder equipped with magnets

## Magnets positioning

### Alignments requirements to keep the orbit performances :

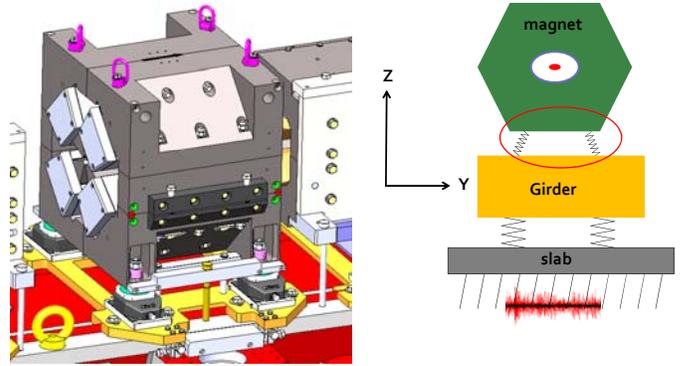
	$\Delta Y$ (rms)	$\Delta Z$ (rms)	$\Delta roll(\Theta X)$
Magnet to magnet	50 $\mu m$	50 $\mu m$	200 $\mu rad$

### Important considerations:

- Easy to install (handling, pre-alignment, magnet disassembly for service)
- Fast, accurate, easy to align (not only with 3 points support, minimize clamping effect)
- Y and Z independent adjustments
- High stiffness and rigidity
- Design goal first frequency > 50Hz → requires multiple support points (more than 3)
- Long term stability

### Challenges are:

- Lack of space between magnets
- Ease of alignment is not compatible with high rigidity → compromise (design criteria 50Hz)
- Dimensions : weight, height of magnets



## Magnets positioning – Designs worldwide

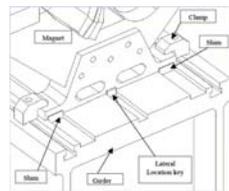
### Adjusting mechanical screws ESRF, SNLS II...



- PROS**
- compactness
  - cost
- CONS**
- difficult to align (time consuming)
  - clamping effect
  - stiffness
  - < 50  $\mu m$  accuracy difficult to achieve

### Mechanical SHIMS

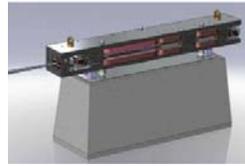
Soleil, Alba, Diamond



- PROS**
- High stiffness
  - compactness
  - clamping effect is acceptable (30  $\mu m$ )
  - < 50  $\mu m$  accuracy
  - Long term stability
  - flexibility
- CONS**
- Need high number of shims and measurements (time and manpower)

### Monolithic design

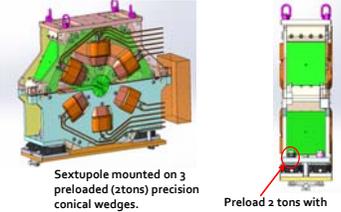
MAX IV - APS upgrade project



Several magnets functions are in one machined block

- PROS**
- high compactness
  - fast alignment (one block)
- CONS**
- internal alignment precision ?
  - no flexibility
  - maintenance

### Proposed design with preloaded wedges



Sextupole mounted on 3 preloaded (2 tons) precision conical wedges.

- PROS**
- No clamping effect
  - Easy and fast to align
  - high vertical stiffness (2000N/ $\mu m$ )
  - Multiple points support
  - Z and Y independent
  - compactness in vertical
  - Commercial units
- CONS**
- horizontal stiffness is unknown → characterization = Mechanical and Vibration tests
  - Need high preload (>2 tons)

## Tests bench to measure transverse stiffness of wedges – Mechanical and vibrations tests

Typical stiffness measurement on magnet wedges

**Dynamic Stiffness of the Néveil and Aircoc system supporting Quadrupole magnet**

Mass of the magnet used in the test M  
 Natural frequency of the reference system without Néveil (or Aircoc)  $f_n$   
 Natural frequency of the system with Néveil (or Aircoc)  $f_s$   
 Global effective stiffness of the reference system without Néveil (or Aircoc)  $K_n$   
 Global effective stiffness of the system with Néveil (or Aircoc)  $K_s$   
 Dynamic stiffness of the Néveil (or Aircoc)  $K_d$

$$K_n = K_0 \left( \frac{L_0}{L} \right)^2$$

$$K_s = K_n \frac{1}{\left( \frac{f_n}{f_s} \right)^2 - 1}$$

$$K_d = \frac{1}{2\xi} \left( \frac{\sigma}{F} \right)_m$$

	3			4		
	Mass	Stiffness	Frequency	Mass	Stiffness	Frequency
M	1750 kg					
Number of supports	3			4		
$f_n$ (Hz)	35.75			52.25	2.186	
$f_s$ (Hz)	88			180		
Stiffness						
Néveil						
middle-T1+0.5mm	33.5	79	636	212		
middle-T1+0.5mm	33.5	75	500	170	43.0	140
middle-T1	35.3	86	200	1020	49.0	186
middle-T1+0.5mm	35.5	90	430	1217	20.8	178
middle-0	28.0	54	140	47	38.5	92
high	33.8	79	524	243		
Aircoc						
middle-T1+0.5mm	33.0	75	500	170	44.8	138
middle-T1	35.3	86	200	1020	49.0	186
middle-T1+0.5mm	35.5	81	4347	2062	30.8	178
middle-0	24.5	41	78	26	24.8	42
high	35.7	85	1650	1000		
Magnet unbalanced	32.0	11	396	118		

## FEA calculations on magnets / girder

### Dipole

Wedges stiffness=>  $K_z=1000N/\mu m$   
 $K_y=50N/\mu m$

6\*wedges  
 $F=79 Hz$   
 3\*wedges  
 $F=49 Hz$

### Sextupole

Wedges stiffness=>  $K_z=1000N/\mu m$   
 $K_y=50N/\mu m$

3 wedges  
 $F=39 Hz$

Wedges stiffness=>  $K_z=1000N/\mu m$   
 $K_y=100N/\mu m$

3 wedges  
 $F=45 Hz$

### Girder – TZ foot

Z support for girder  
 → Preload = 2 - 4 tons  
 → Load (weight) = 3 tons  
 Wedges (max load 40 tons) stiffness =  
 → 2200 N/ $\mu m$  in X-Y (horizontal)  
 → 2200 N/ $\mu m$  in Z (vertical)

### Girder III

5000kg mass

2Y jacks  
 100 N/ $\mu m$  in Y

2Z supports  
 200 N/ $\mu m$  in Z

1 X jack  
 200 N/ $\mu m$  in X

Softness values with wedges/foundation-slab-ground

1<sup>st</sup> frequency: 47.2 Hz (girder + 600kg load)