the Qpoles Alignment of the SOLEIL Storage Ring

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With the collaboration of: Engineering & Magnetism groups

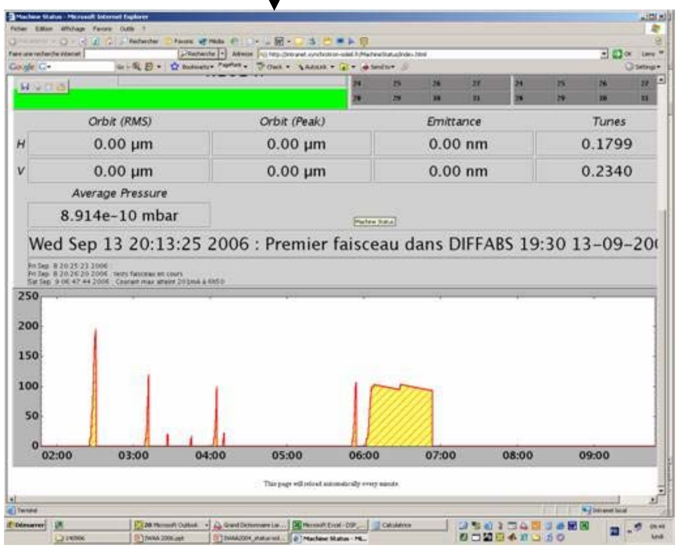
Synchrotron SOLEIL

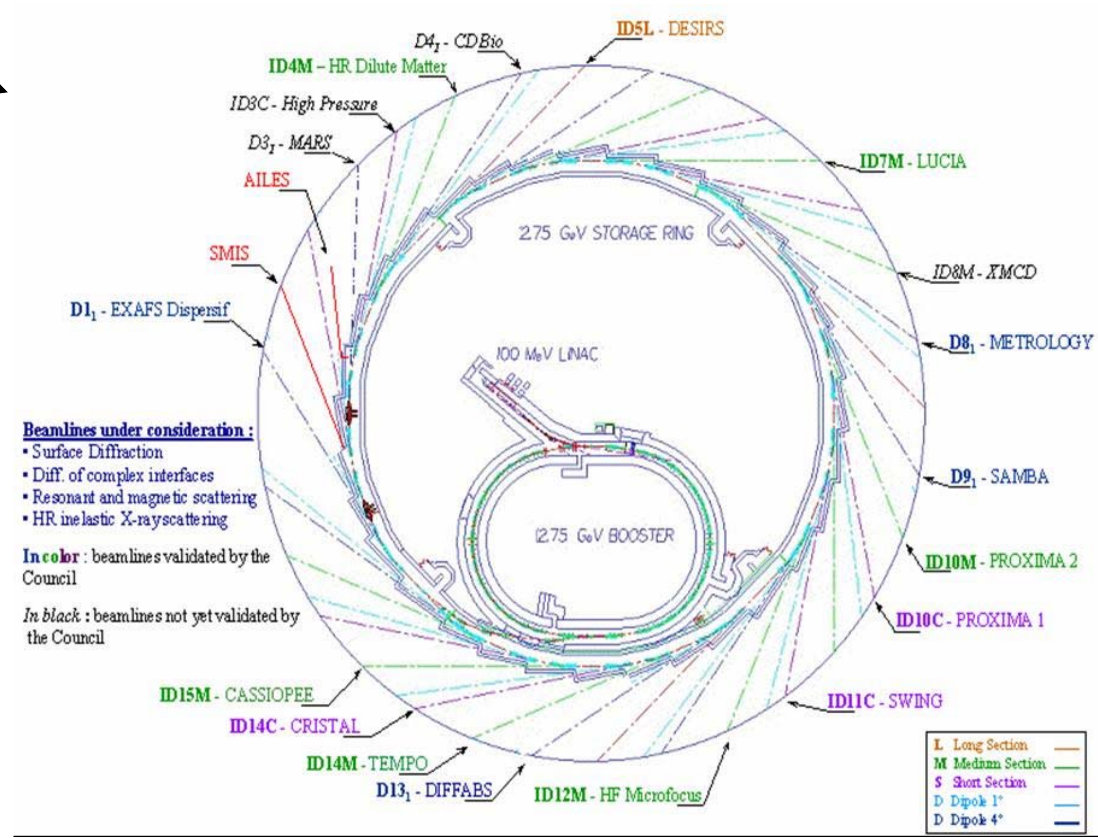
Saint-Aubin, Gif sur Yvette, France

SOLEIL Project

Source 2.75 GeV

Under Commissioning

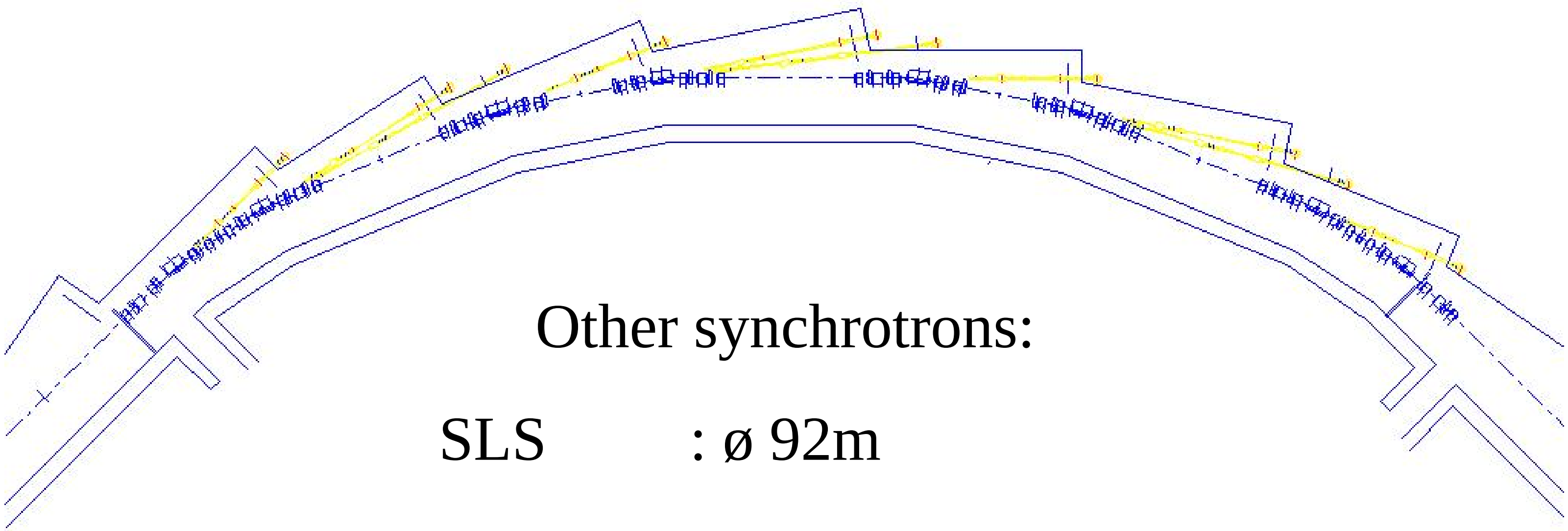




Storage Ring

- **Study of the Qpole alignment => definition of the closed orbit**

- **160 Qpoles, 120 Spoles, 56 girders, 24 straight sections,**
- **354m circumference**



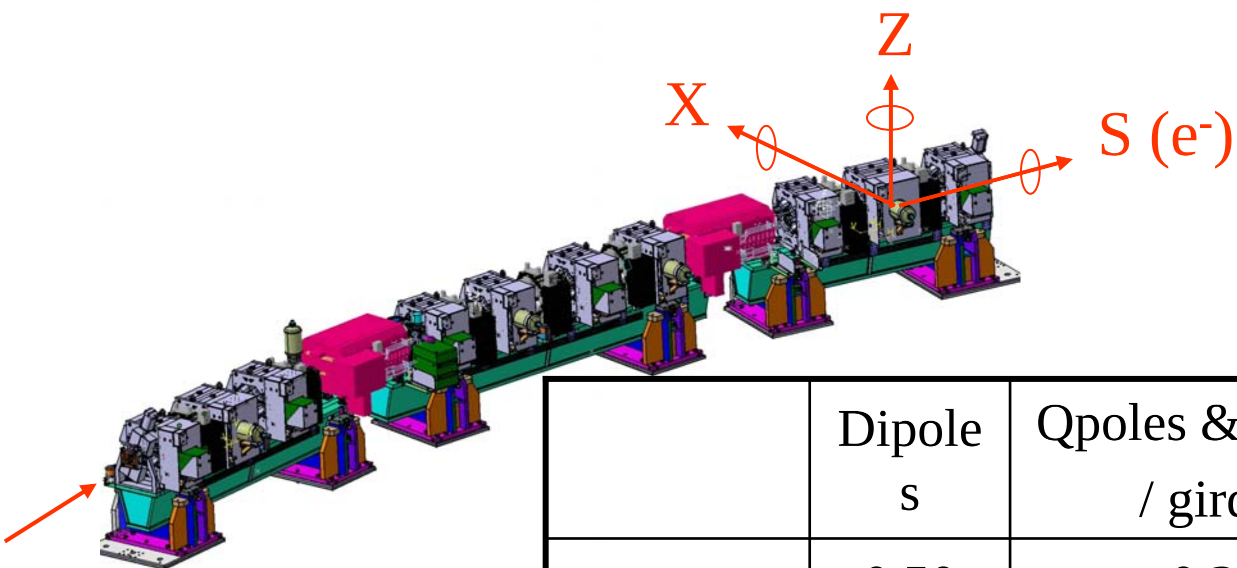
Other synchrotrons:

SLS : ø 92m

SOLEIL : ø 113m

ESRF : ø 273m

Storage ring positioning specifications



	Dipoles	Qpoles & Spoles / girder	girder
$\sigma_{s\ (mm)}$	**0.50**	**0.20**	**0.50**
σ_x	**0.50**	**0.02**	**0.05**
σ_z	**0.50**	**0.02**	**0.05**
$\sigma_{\theta s\ (mrad)}$	**0.1**	**0.1**	**0.1**
$\sigma_{\theta x}$	**0.2**	**1**	**1**
$\sigma_{\theta z}$	**0.2**	**1**	**1**

Physicists's request: minimisation of correctors

First step: Qpole alignement on girders

Qpole

Girder

Magnet comp.

Magnetic bench

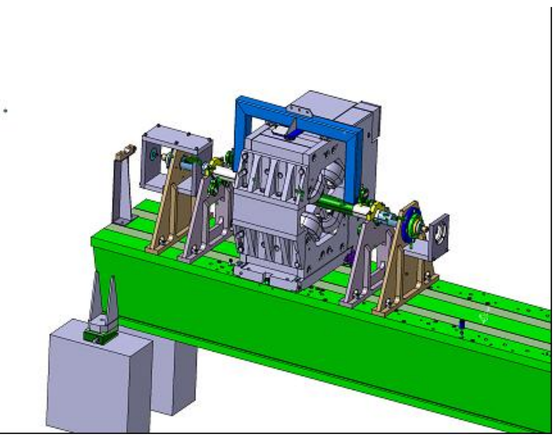
Correction Shims

Machined references

Mounting

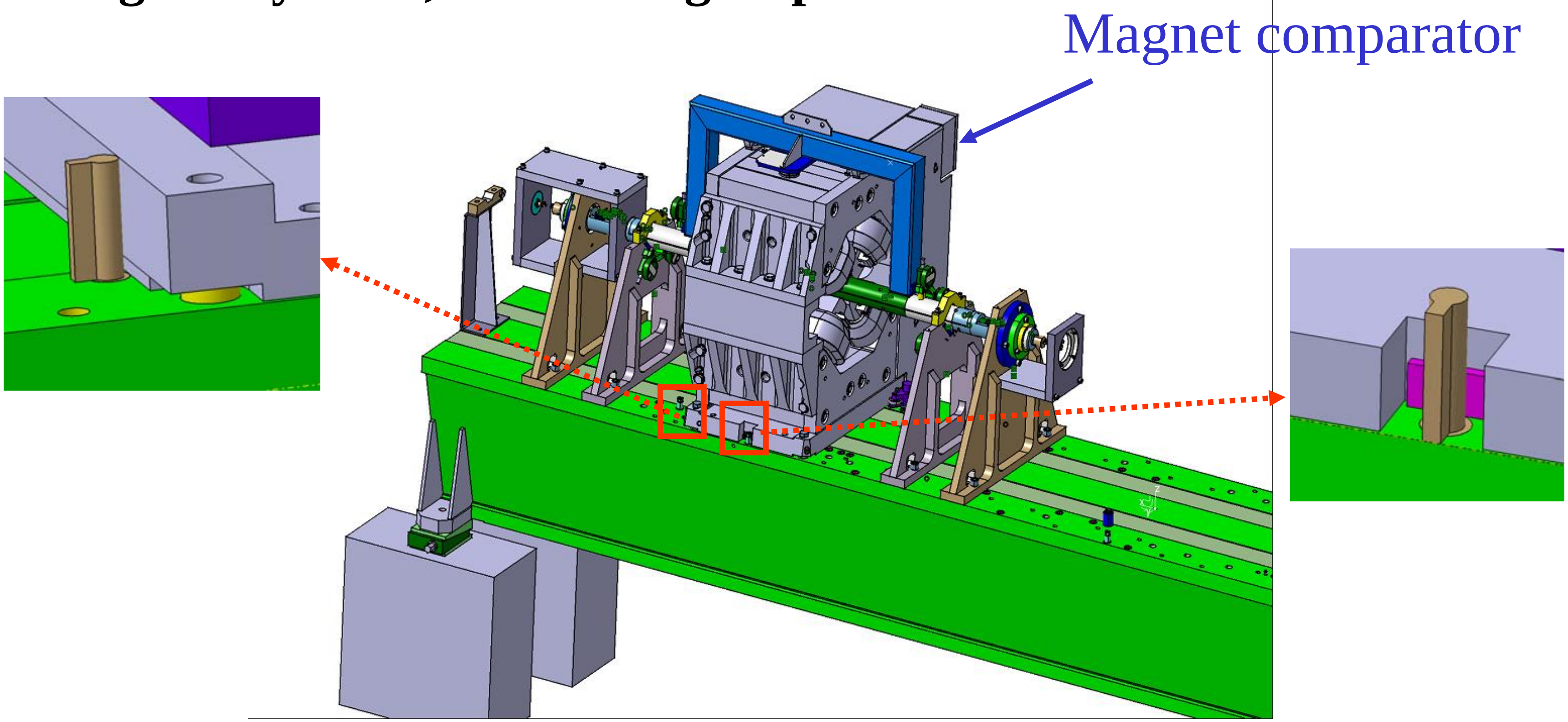
Qpoles / girder

STR500-Nivel20 survey

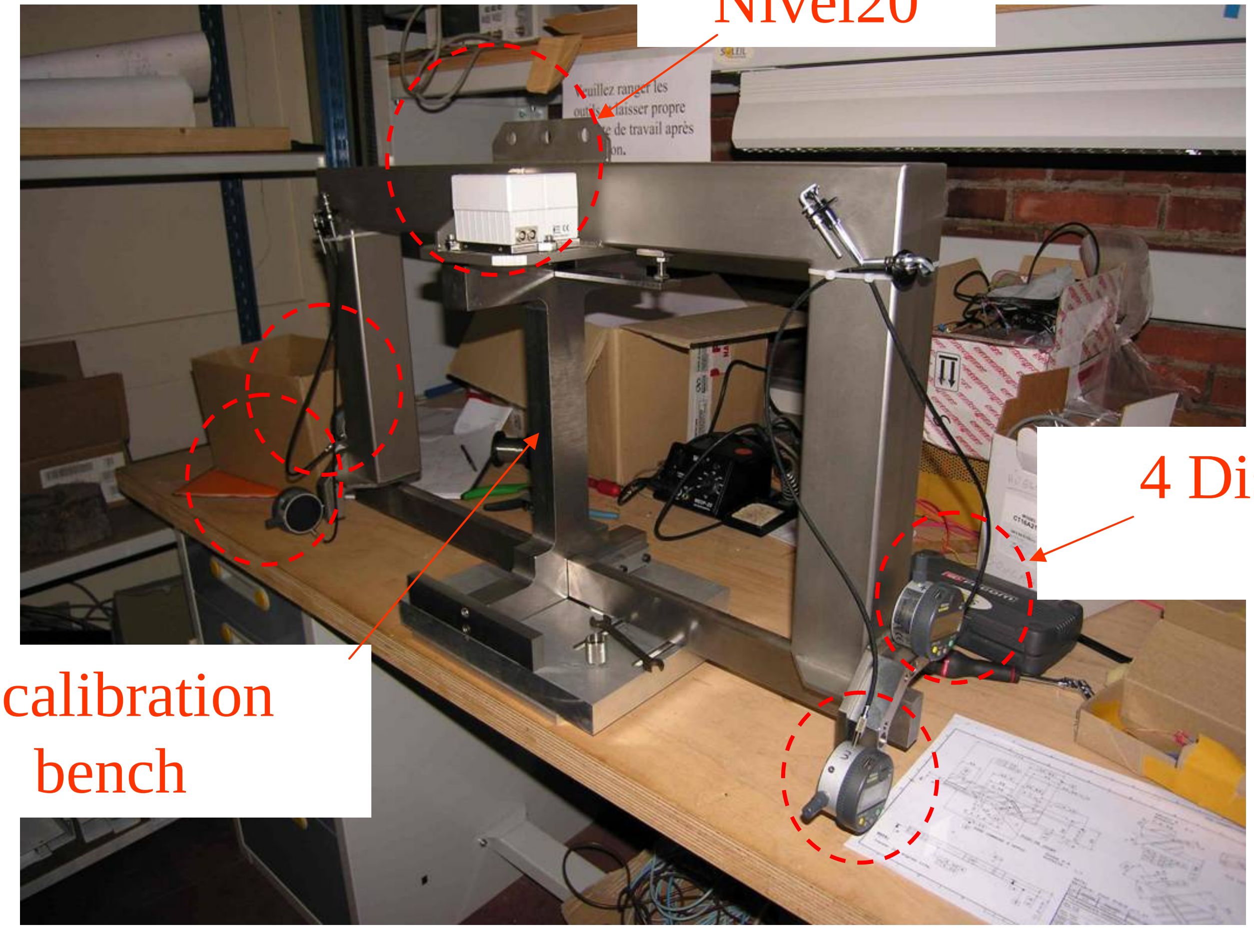


BMS & Positioning systems: Magnet comparator

- **mechanical/magnetic method (shims)**
- **check positioning by optics/mechanics (comparators & laser beam)**
- **Designed by GMI, CI & AM groups**

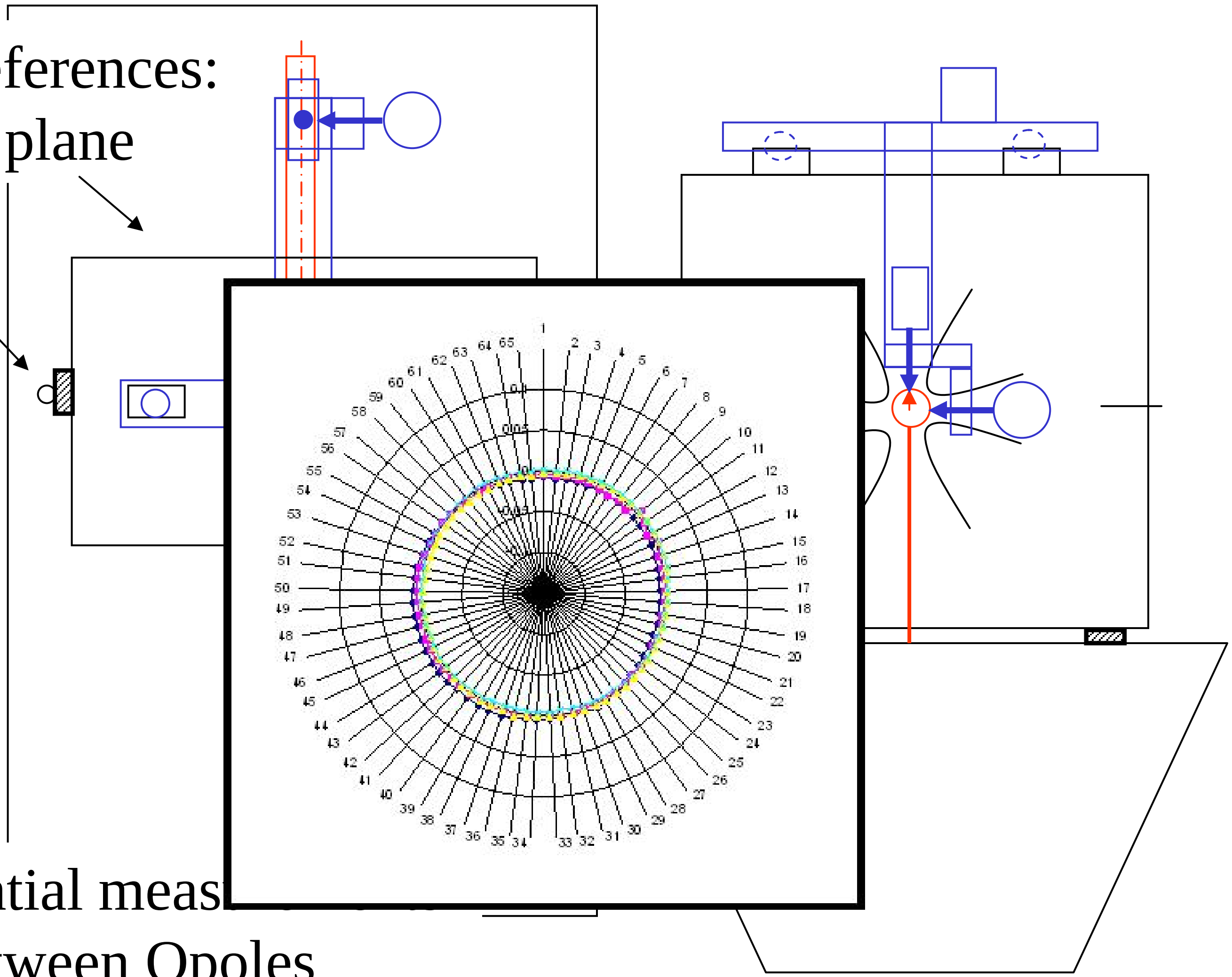


Magnet comparator



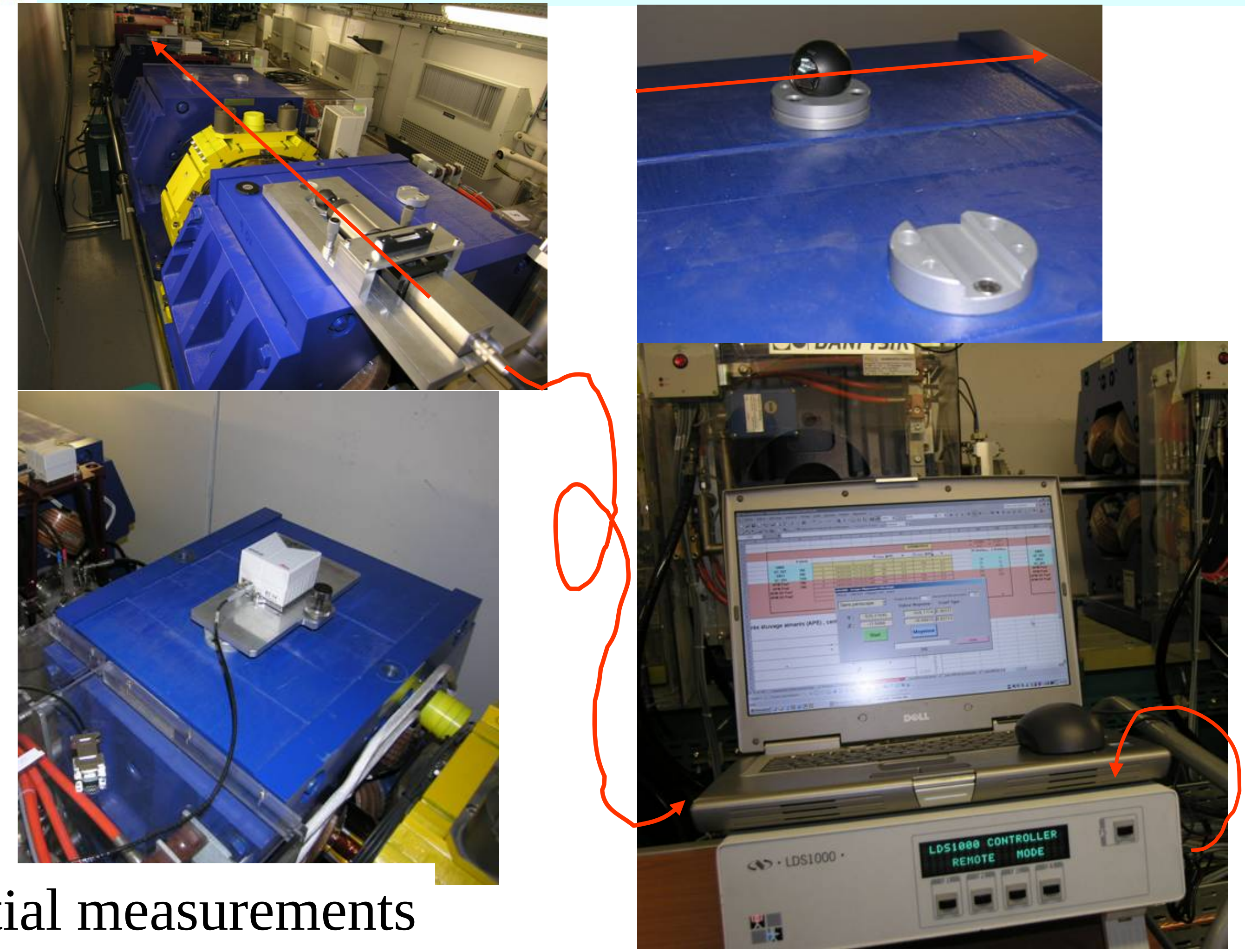
Magnet comparator on the BMS

Bench references:
X pin, Z plane

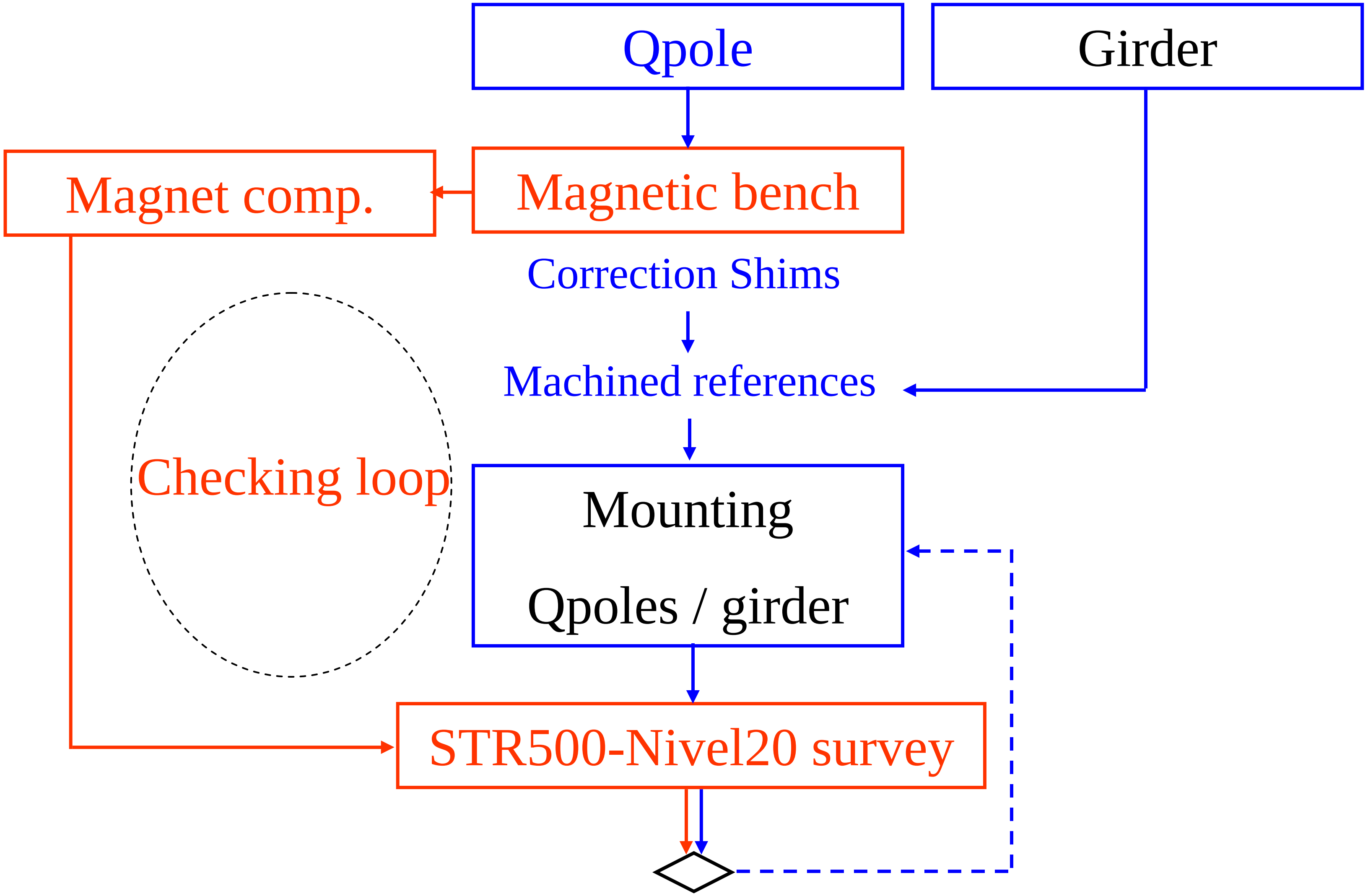


Differential meas
between Qpoles

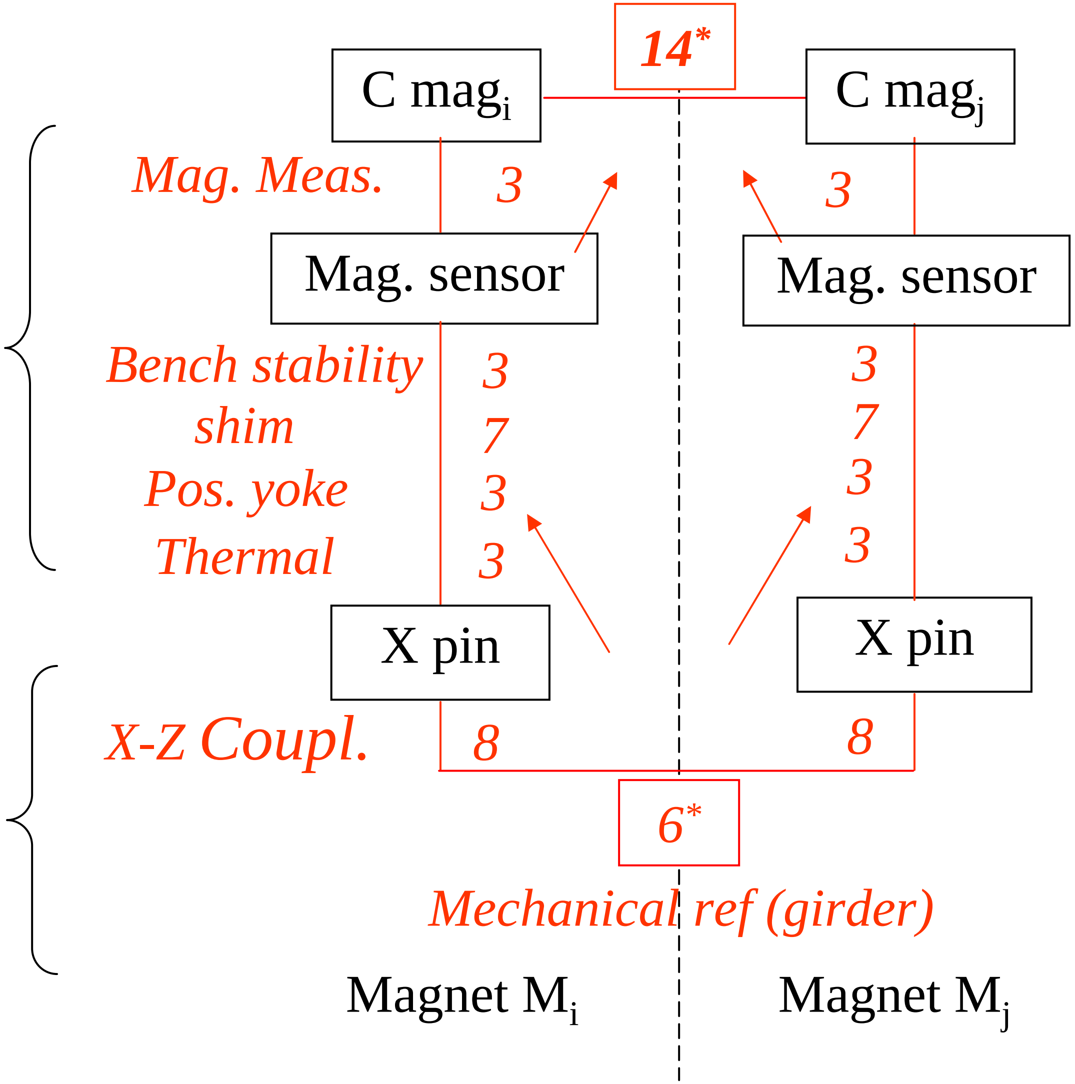
Checking of magnets on their girder



Differential measurements between Qpoles


Qpole
Girder
Magnet comp.
Magnetic bench
Correction Shims
Machined references
Checking loop
Mounting
Qpoles / girder
STR500-Nivel20 survey

Horizontal (σ_X) error budget: magnet/girder



Checking loop on a girder: achievements

Ecart-type:	X_{CM} (µm)	Z_{CM} (µm)	$Tilt_{CM}$ (mm/m)
per girder:	15.2	10.6	0.053
for the orbit:	14	9	0.053

It shows the excellent work of both,
girder machining and magnetic measurements
directed by other Soleil teams (CI, GMI groups)

2nd step: method for the alignment of the girders

Survey

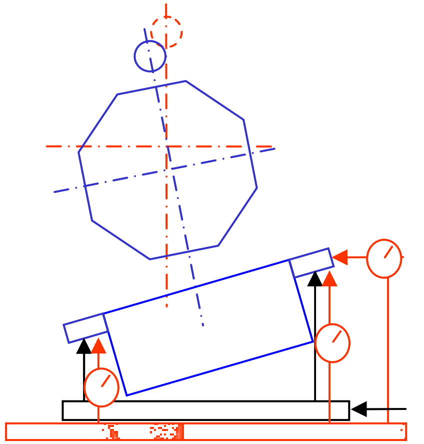
- Survey HLS (z,θ_s)
- Survey (x,s) TDA5005, Ecartometer

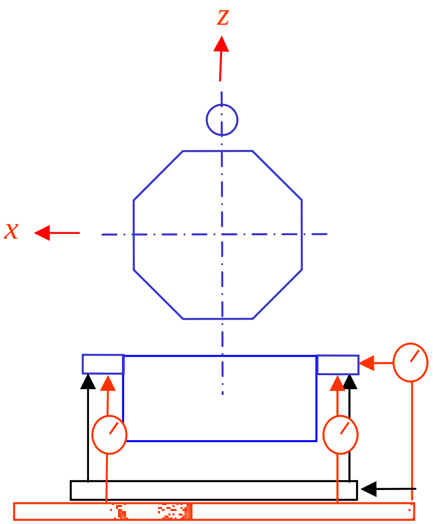
Calculations

- Ring shape calculation (s,x,z)
- 3D parametres of girders (5 DOF)
- Calculation of displ. sensors reading

Adjustment & control of : backlash, x-z coupling blocking effect

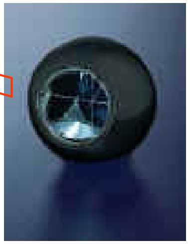
- Reading of displ. sensors
- Displacement (z, θ_s) then (x,s) blocking





Planimetry

- **©Leica TDA5005:**



Accuracy:

$3\ 10^{-4}$ deg

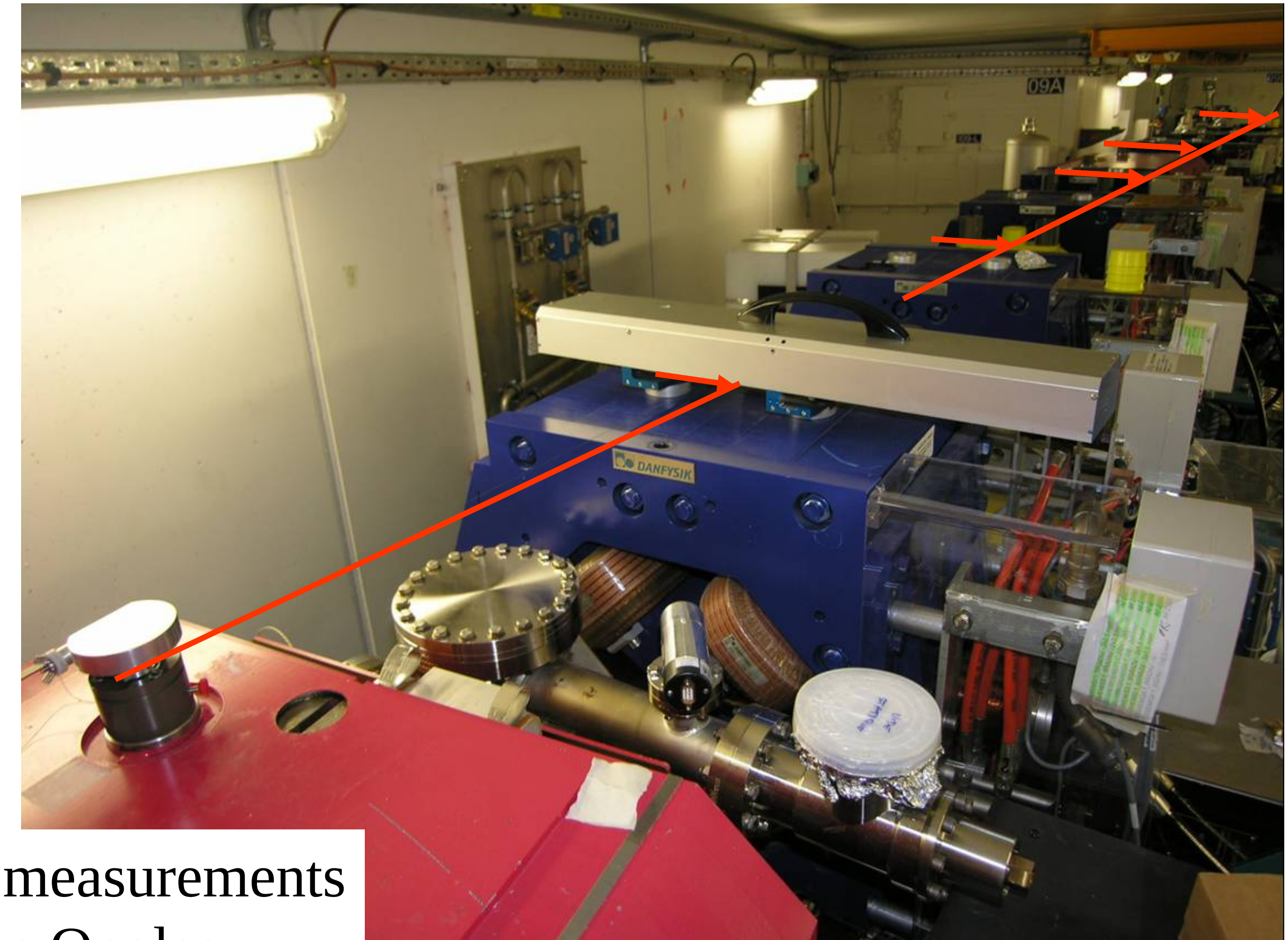
0.10 mm

- **©Symétrie Wire Ecartometre:**

Repetability: < 0.01mm

TDA5005: general shape & diameter

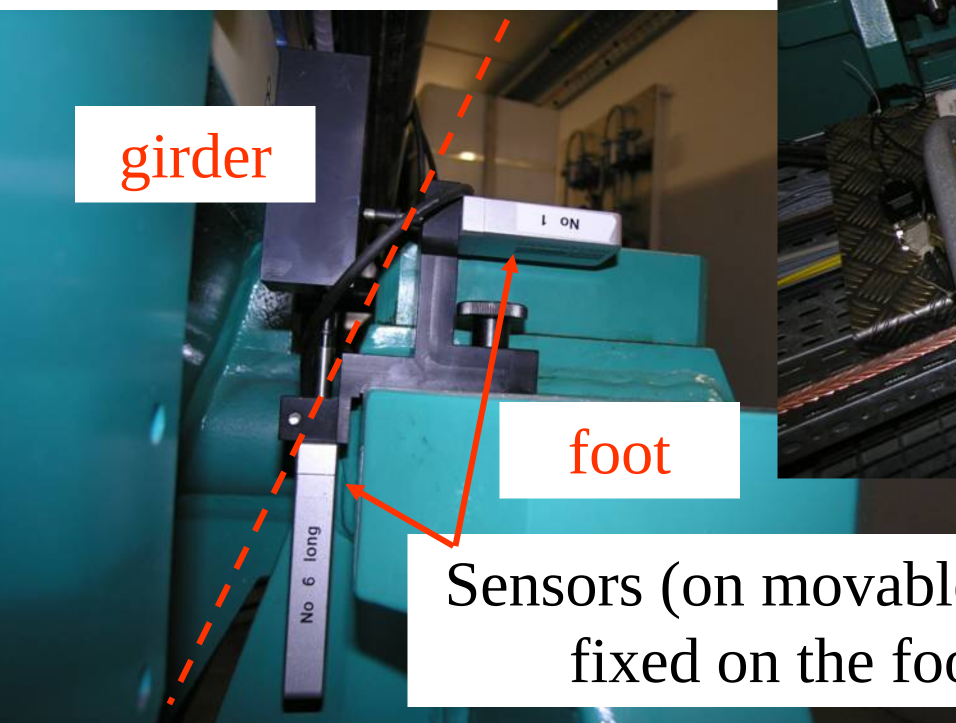
Wire ecartometre: local smoothing



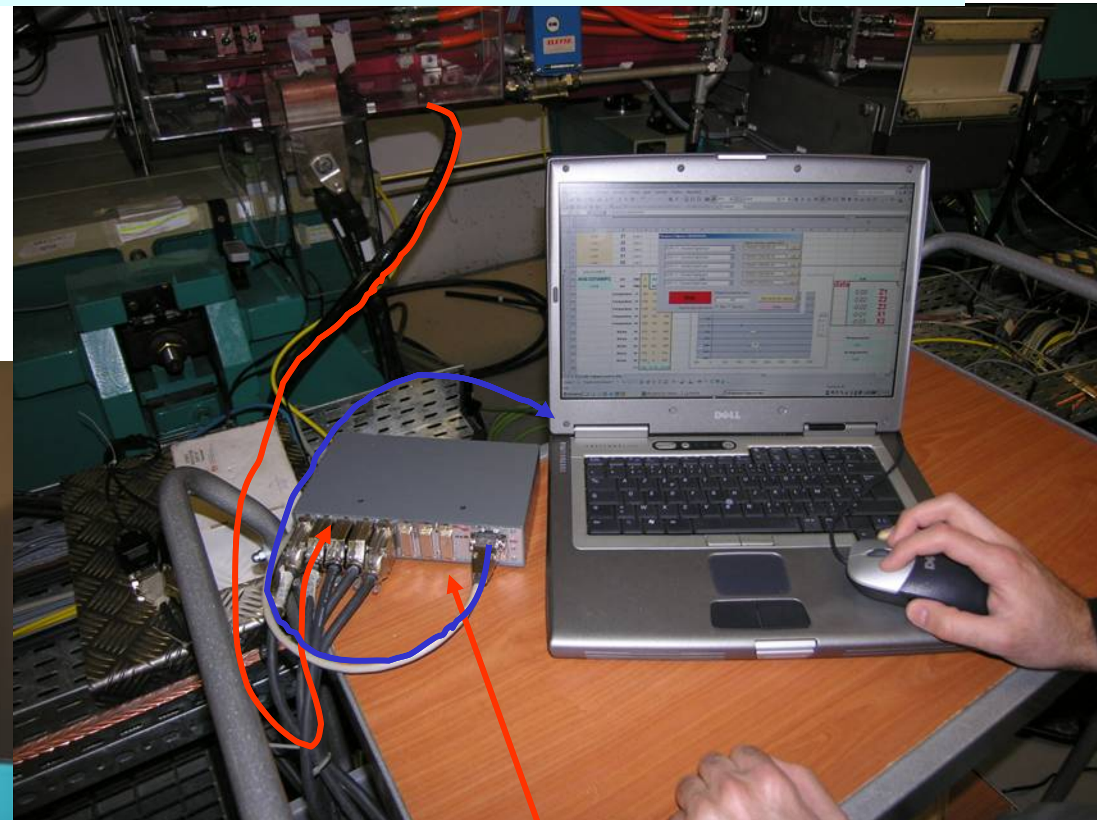
Differential measurements between Qpoles

Heidehnein sensors & Excel for girder adjustment

5 DOF = 5 sensors

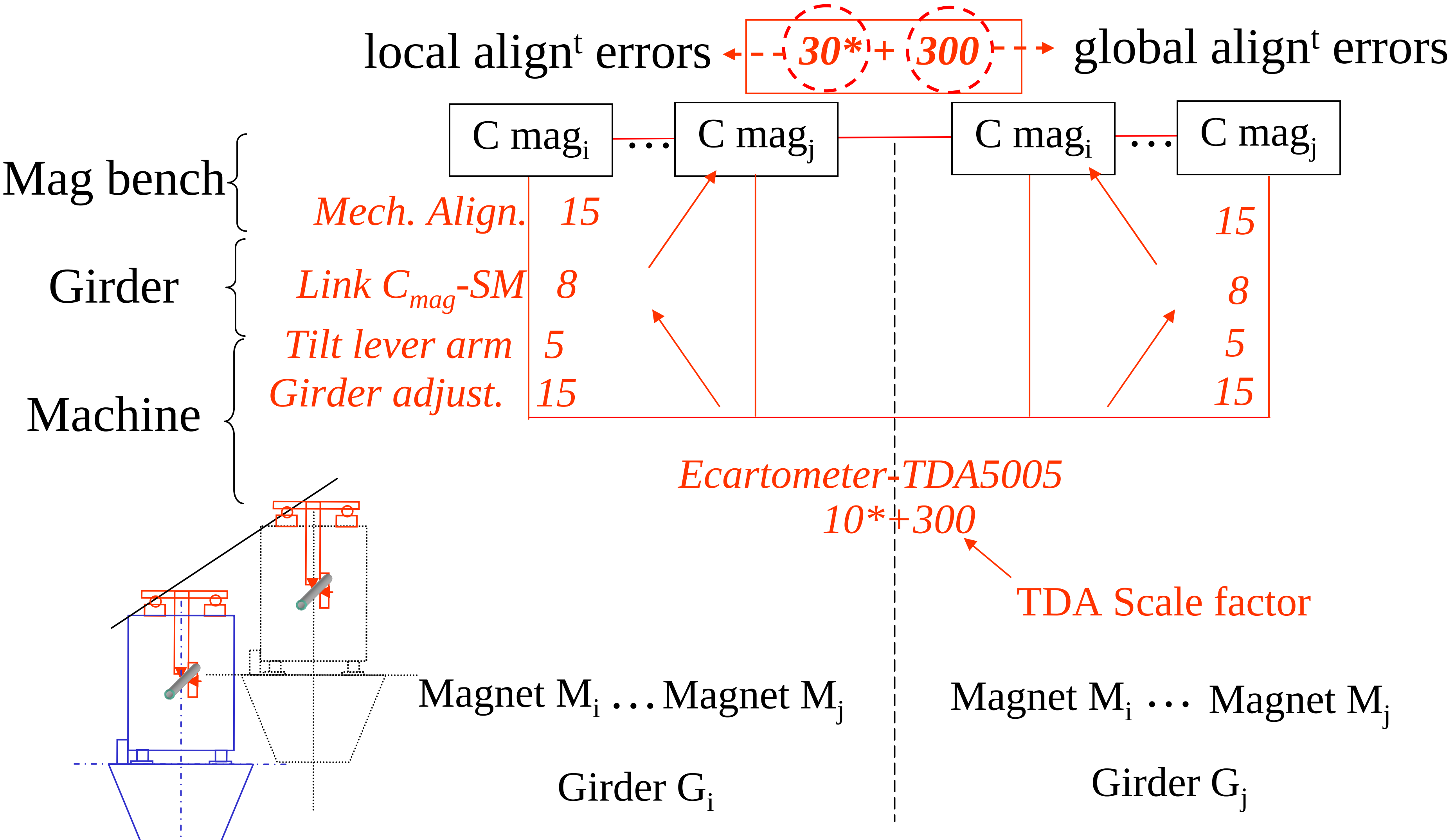


Sensors (on movable tool) fixed on the foot

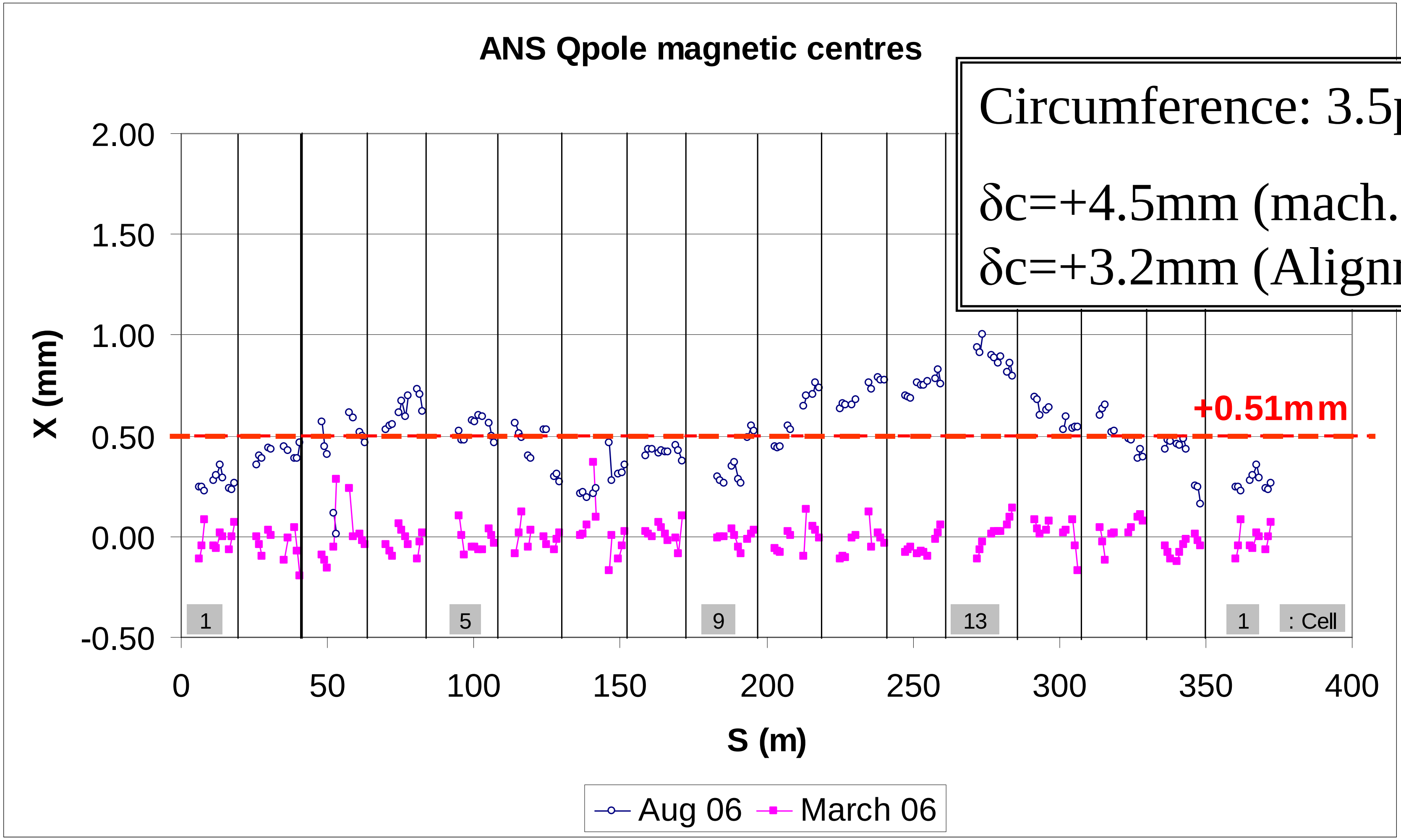


Sensors directly linked to Excel to manage the 3D corrections

Horizontal (σ_X) Error budget: girder/girder (tunnel)



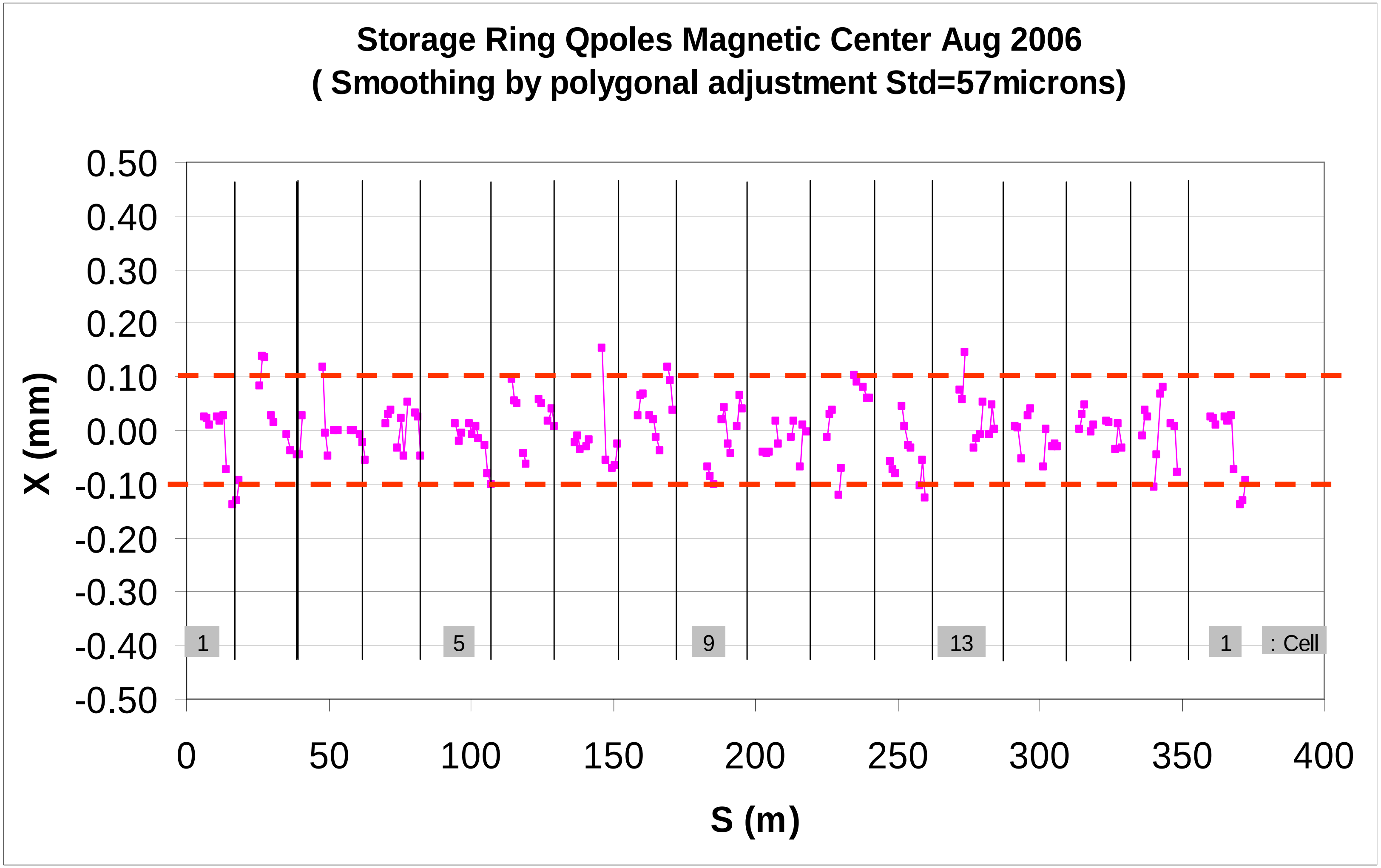
Achievement: global shape



Circumference: 3.5ppm

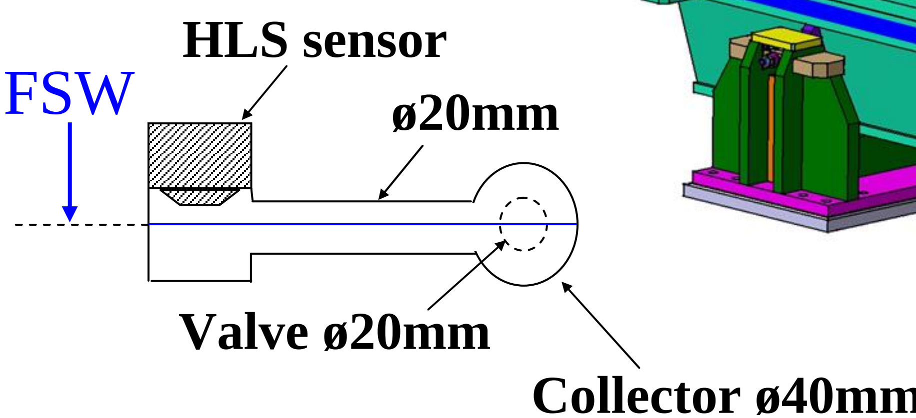
δc=+4.5mm (mach. Phys.)
δc=+3.2mm (Alignment)

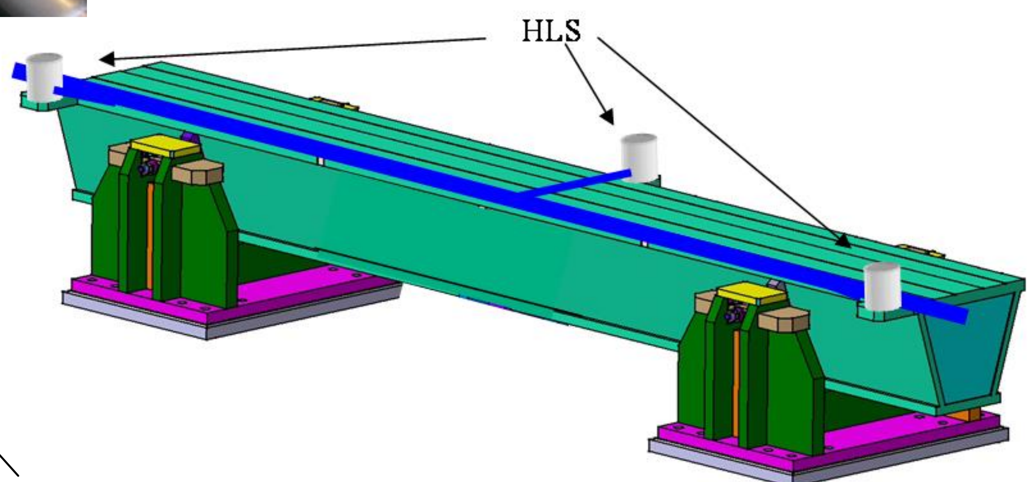
Achievement: local smoothing



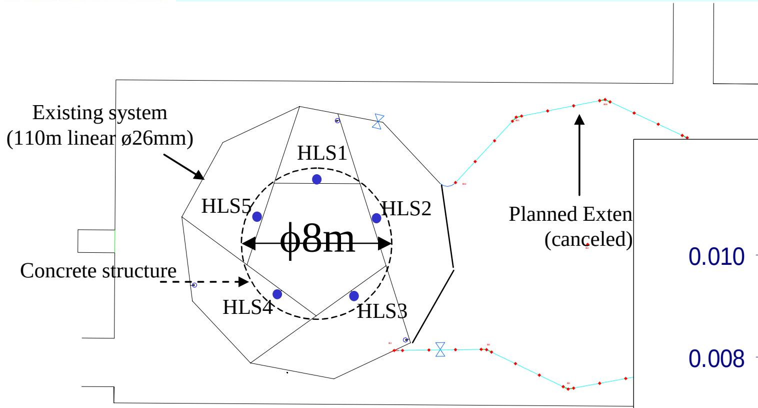
Altimetry: HLS network

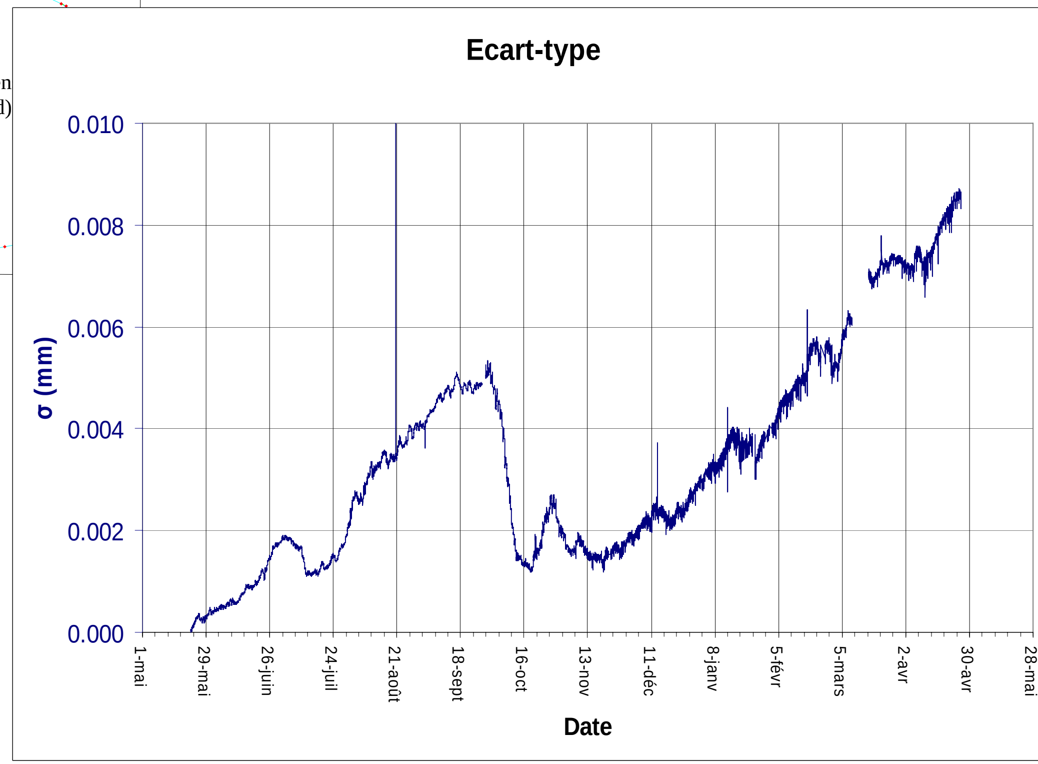
Fogale HLS





Preliminary Stability tests

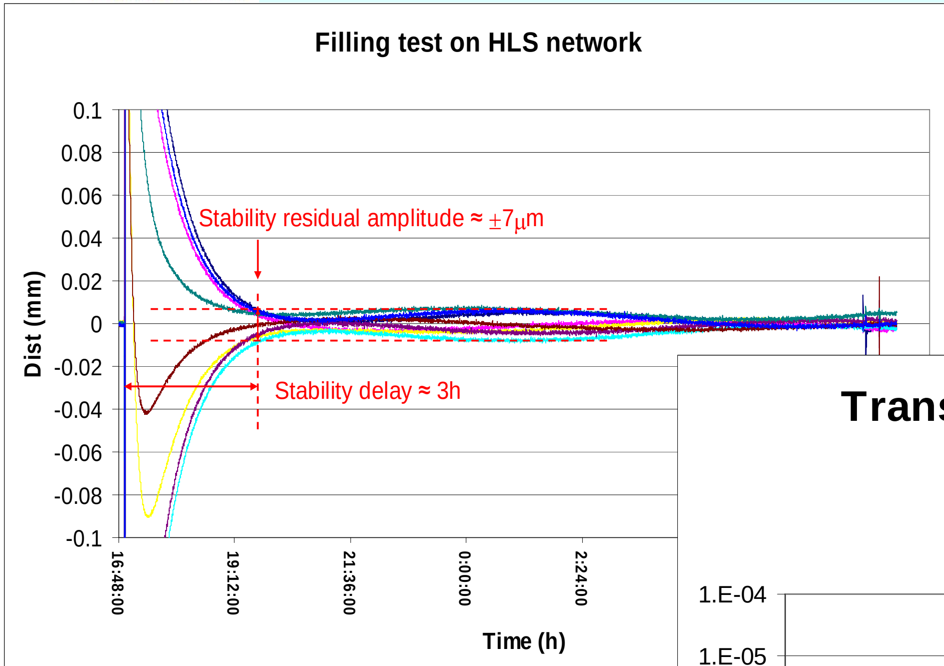




-STCelec = (10µm, 1 year)

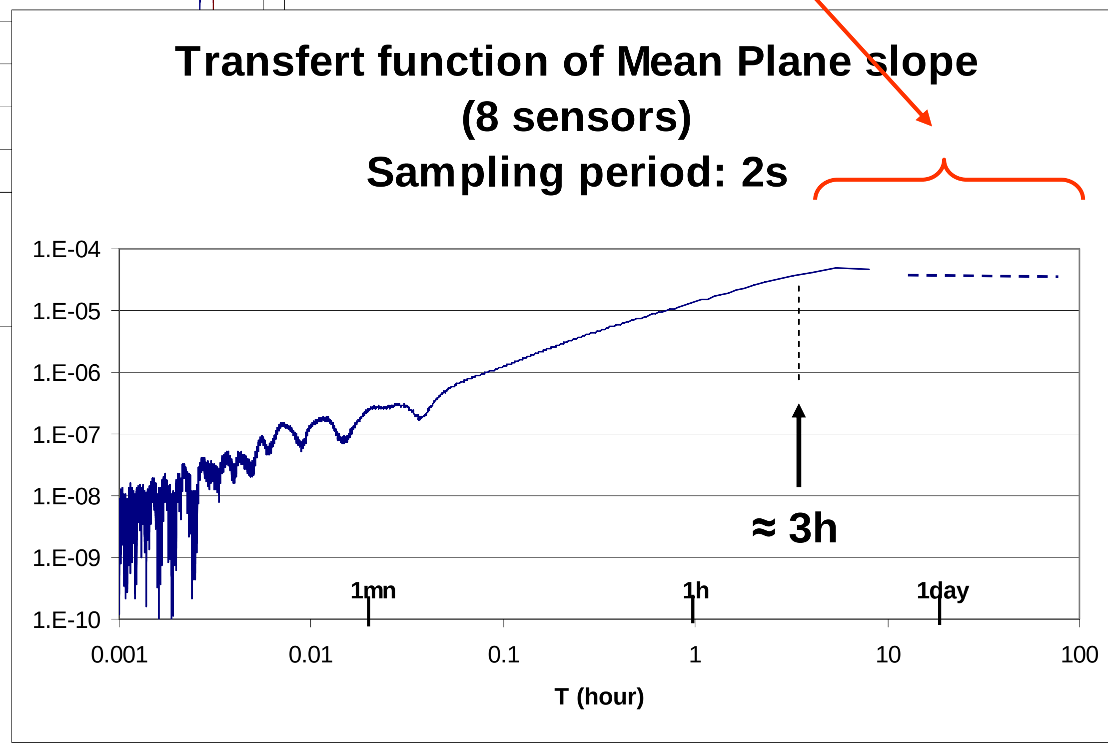
-Worse case since it integrates electronics, mechanical mounting (& slab twist)

1rst order approximation: Free Surface of Water (FSW) as a plane

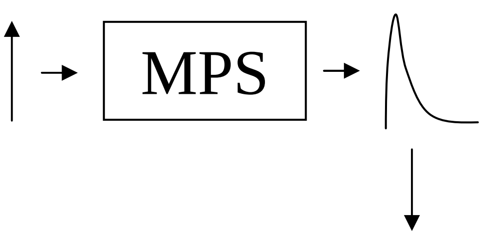


STC = (±7μm, 3h)

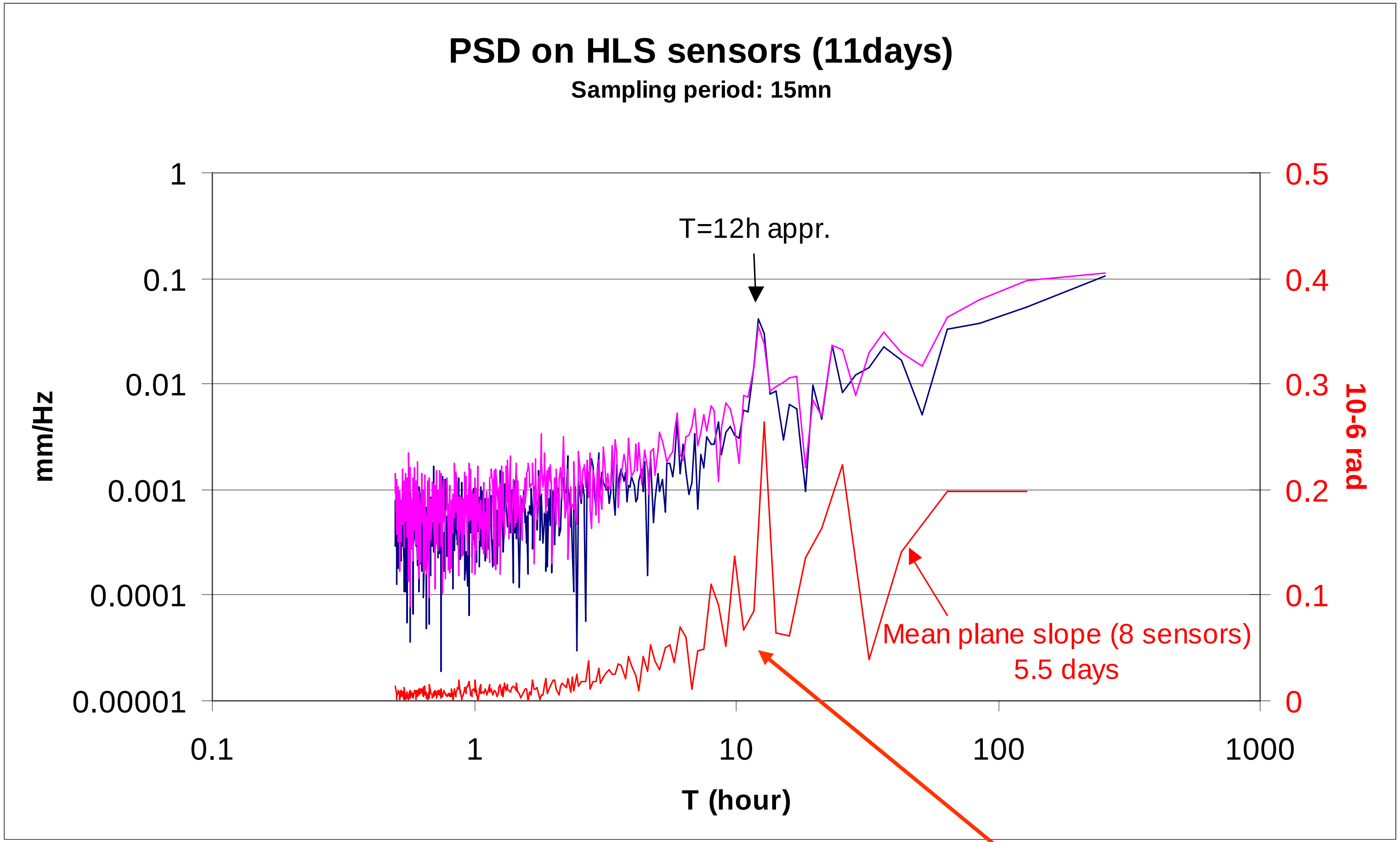
Transparent to any event



Signal processing:

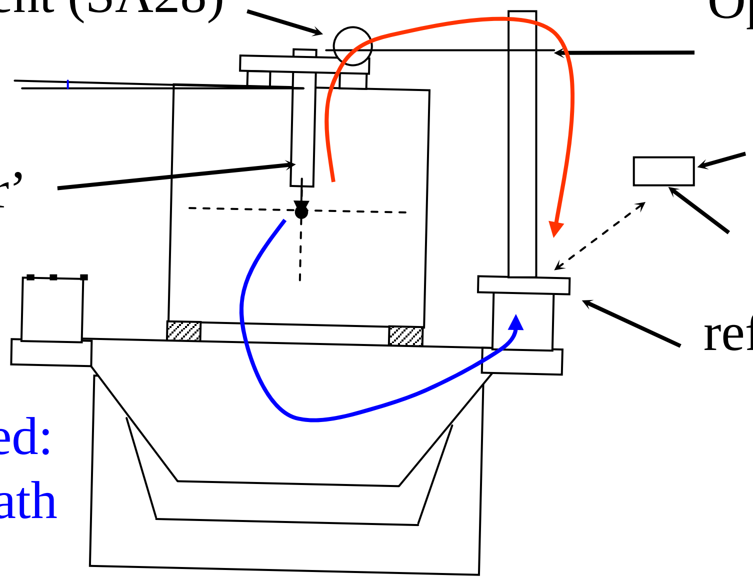


Power spectral density

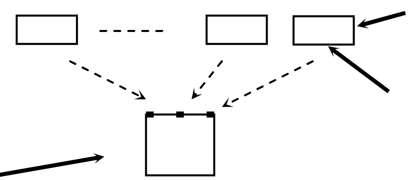


Mean plane slope (8 sensors)

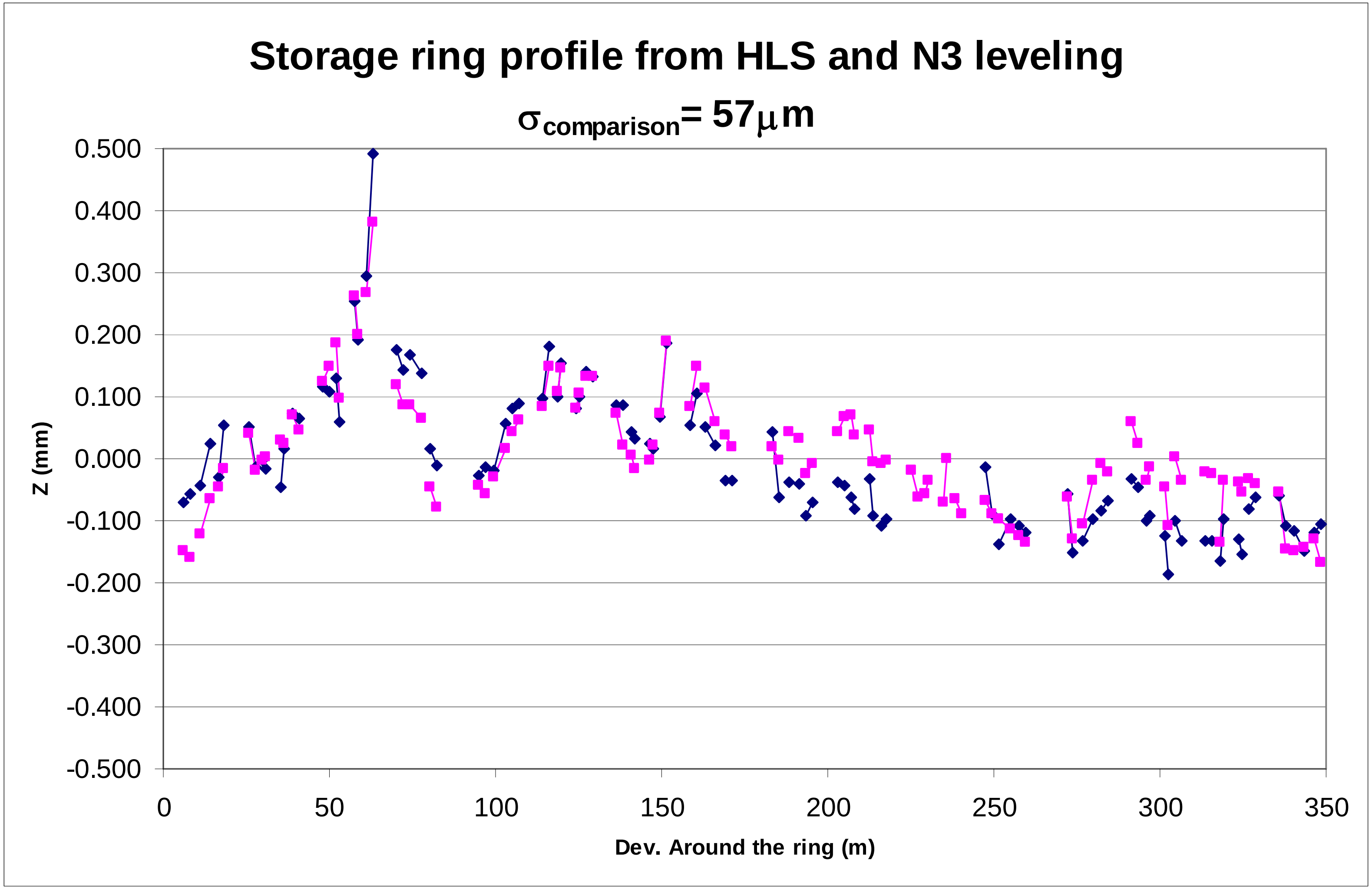
Primary goal: FSW is the adjustment reference plane



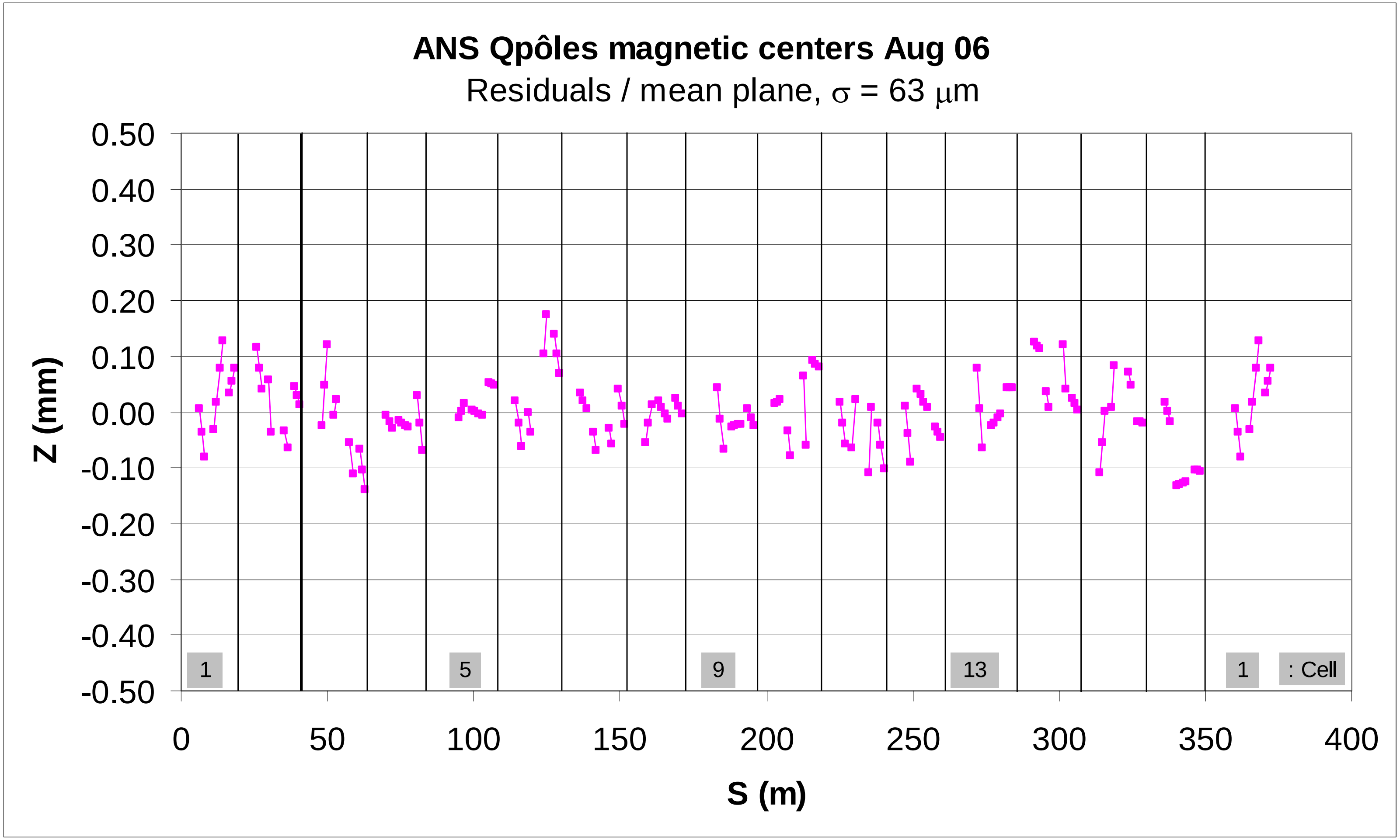
Once a year:



HLS determination compared to N3 leveling



Achievement: Residuals related to FSW



Conclusion

- The achieved result must not be considered as the ultimate accuray
- However, they are excellent according to the machine physics results:

- Beam envelope (BPM measures) => 0.02mm on girder
  0.05mm/girders

- Acknowledgments:
- Alignment is a domain that is essentially ‘transverse’ that concerns:
- magnetism, mechanics, positioning. The AG can be seen as a ‘link’ between the other groups in terms of alignment.