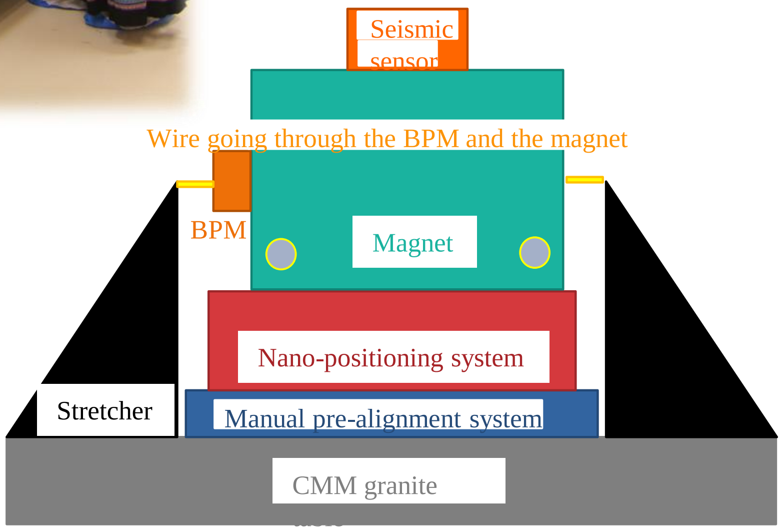
Claude SANZ

Early Stage Researcher 1.1

Work Package 1

2nd PACMAN Workshop
13-15/06/2016

PACMAN



SESHAT, CMM & Wire

- -> Shape Evaluating Sensor: High Accuracy & Touchless
- -> CuBe Φ100 mm

Requirements:

Where to go next?

THE SESHAT, THE CMM & THE WIRE

The SESHAT is the ‘Shape Evaluating Sensor: High Accuracy & Touchless’

The CMM is the Leitz Infinity Coordinate Measuring Machine

The Wire is the PACMAN reference wire

CMM: Coordinate Measuring Machine

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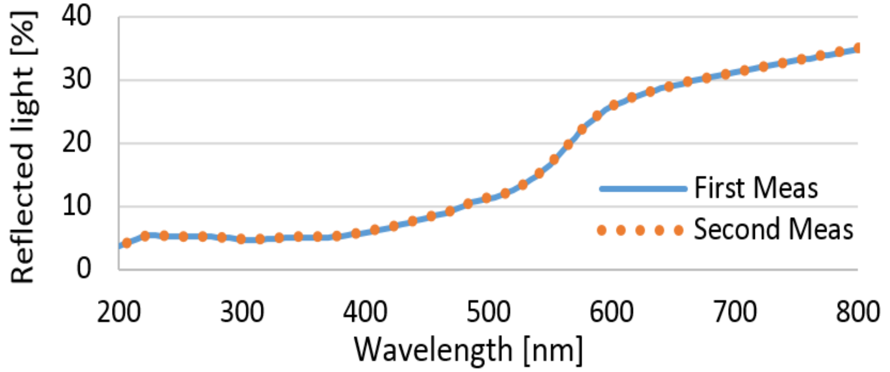
THE SESHAT, THE CMM & THE WIRE

Characteristics of the Ø100µm Cu-Be wire	**PACMAN**		**Nominal Values**	**Measured Values**	
	Min	**Max**		**CFW**	**GF**
Electrical resistivity [µΩ/cm²/cm]	-	-	5.4-11.5	8.35; σ=0.02 ☺	10.86; σ=0.01 ☺
Limit tension [Kg]	**1**	-	0.5-1.3	1.176 ☺	-
Yield strength [MPa]				1573	-
Micro-hardness [Vickers]	**350**	-	100-362	357 ☺	-
Linear mass [mg/m]	-	**70**	64.80	66.34 ☺	65.97 ☺
Diameter [µm]; variation of the diameter	**90**	**125**	100	98.5 ; σ=1.4☺	99.2 ; σ=0.8 ☺
Form error (circularity) [µm]	-	**0.5**	-	2.46 µm |	2.93 µm
Roughness [nm]; variation of the roughness	-	-	-	20.9 ; σ=13.2☺	9.7; σ=5.4 ☺
Spectrometric reflectance of CFW wire					

SEM: Scanning Electron Microscope

AFM: Atomic Force Microscope

www.madrimasd.org

NGK: 1.76 µm

THE SESHAT, THE CMM & THE WIRE

SESHAT, CMM & Wire

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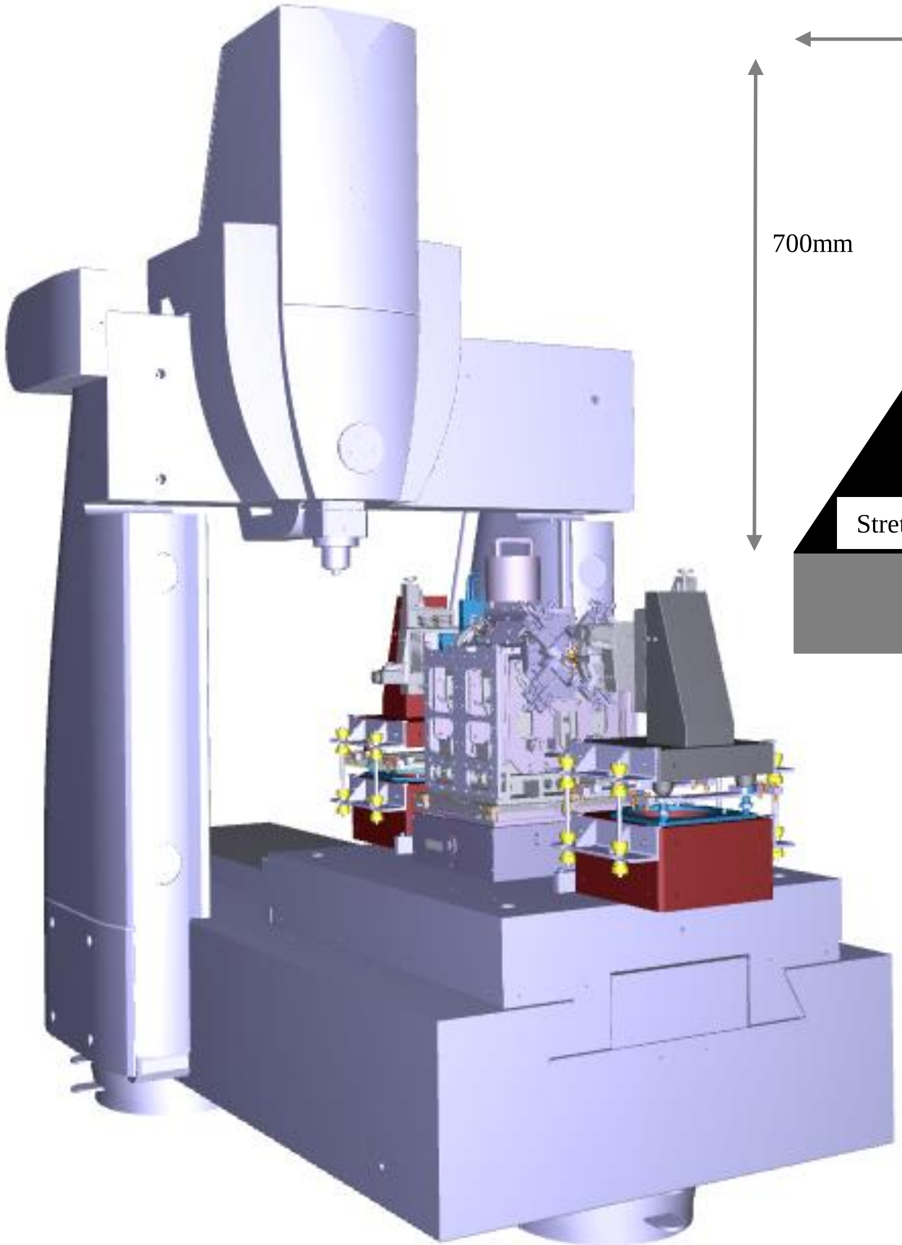
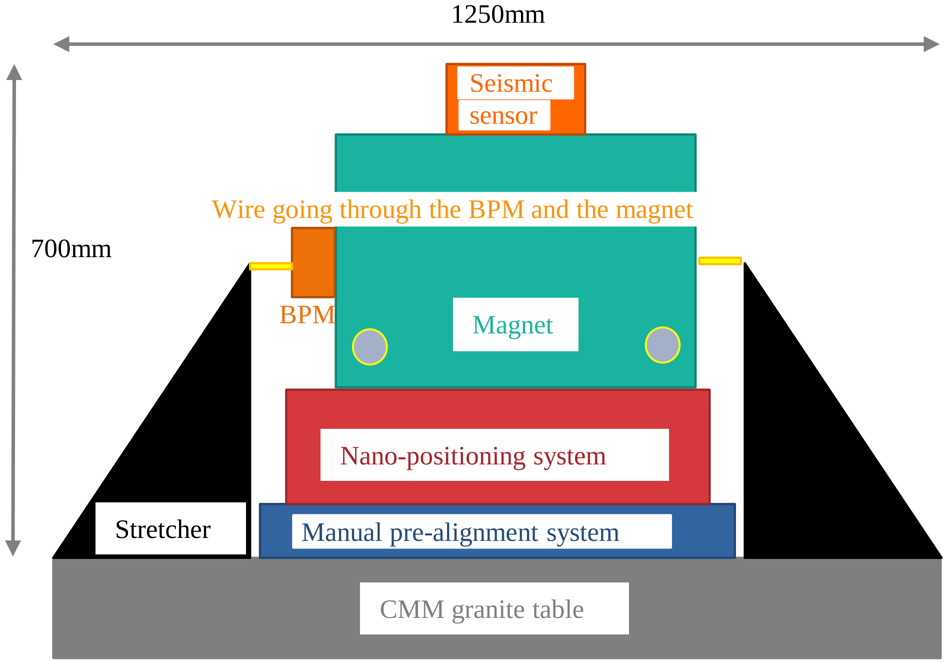
- -> MPE_E [µm]= 0.3+L/1000
- -> CuBe Φ100 mm
- -> 3σ < 0.5 µm for the wire axis positioning

Requirements:

- ->
- -> Weight <1.2 kg
- -> Width <100 mm
- ->
- ->
- -> Stand magnetic field > 15 mT
- -> Can be calibrated
- ->

Where to go next?





- The requirements for the SESHAT:
  - Maximum weight: 1.2 kg
  - Low energy emission
  - Maximum width: 100 mm
  - Not disturb the wire
  - Stand magnetic field
  - Can be calibrated
- Maximum Permissible Error in positioning: MPE_E[µm]=0.3 +L/1000

CMM: Coordinate Measuring Machine

SESHAT, CMM & Wire

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->

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-> Can be calibrated

->

Where to go next?

THE SESHAT'S SENSING ELEMENT

CMM & PACMAN requirements:

- Light
- Small
- Can stand strong magnetic fields
- Highest repeatability
- Measuring the form
- Do not disturb the wire
- Possible to calibrate
- Fitting with the CMM translation

- Sensors available on the market:
  - ~~Low force touch probes~~
  - ~~Eddy current probes~~
  - ~~Acoustic probes~~
  - Optical sensors
    - ~~Interferometers~~
    - Confocal chromatic ~~(several providers)~~
    - ~~Shadow based~~
    - ~~Confocal~~
    - ~~Fringe pattern recognition~~
    - ~~Camera based~~
  - ~~Tunnel effect probes~~
  - ~~Capacitive~~

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Where to go next?

THE SESHAT'S MOUNT FOR THE CHROMATIC CONFOCAL SENSOR

- The parts constituting the SESHAT:
  - ✓ The chromatic confocal sensor
  - A rotor: aluminium is well modelled, cheap and easy to handle, rather light
  - A stator which can be linked to the CMM: with a three ball plate, in aluminium
  - A rotary mechanical connection between the stator and the rotor: a bearing
  - Something mastering the rotor's move: a motor
  - Something giving information on the position with high accuracy: an encoder

How to reach high Accuracy?

- Lowest random motion
  - Highest stiffness for the assembly
  - Low impact of the bearing surfaces
  - Isostaticity (or reduced hyperstaticity)
  - A well mastered move: a piezo motor

} Air bearings: 12 pads, mounted on ball screws, opposite each other

- Reduced vibrations
  - ~~High damping effect~~
  - Fitting Eigen frequencies: the motor's vibrations frequency should fit
- Well known position and high accuracy positioning
  - Reduced Abbe offset: the encoder is as close as possible to the sensor
  - Accurate positioning of the rotor: the motor does nanometric steps

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Requirements:
- -> Stiffness
- -> Weight <1.2 kg
- -> Width <100 mm
- -> Tight tolerances <2 µm
- -> Hardness > = 1175 kg/mm^2
- -> Stand magnetic field > 15 mT
- -> Can be calibrated
- -> The rotor must be open

Where to go next?

THE SESHAT'S MOUNT FOR THE CHROMATIC CONFOCAL SENSOR

- ➢ The parts constituting the SESHAT:
  - ✓ The chromatic confocal sensor
  - ✓ An aluminium rotor
  - ✓ An aluminium stator with the right plate
  - ✓ Air bearing bringing high stiffness and high quality for the rotation
  - ✓ A piezo motor fitting with the miscellaneous requirements
  - ✓ A high accuracy encoder as close as possible to the sensor
- The aluminium part of the stator should be stiff enough
  - ➢ The stator is quite large
    - ➢ The weight is higher
- The air pads require very tight tolerances on form and surface quality: the form error should be less than 2.5 µm on the open rotor (due the air gap size of 5µm)
  - ➢ A company must be able to reach these tolerances!
    - ➢ The machine tool should make it
- The piezo motor requires a hard material to walk on: typically alumina ceramic
  - ➢ An alumina ring must be inserted in the aluminium rotor and opened
    - ➢ There is a high risk of breaking the ring with the motor
- The encoder has a minimum bending radius of 200 mm
  - ➢ The rotor has a minimum radius
    - ➢ The minimum weight is higher

Let's have a look at the SESHAT!

THE SESHAT'S MOUNT FOR THE CHROMATIC CONFOCAL SENSOR

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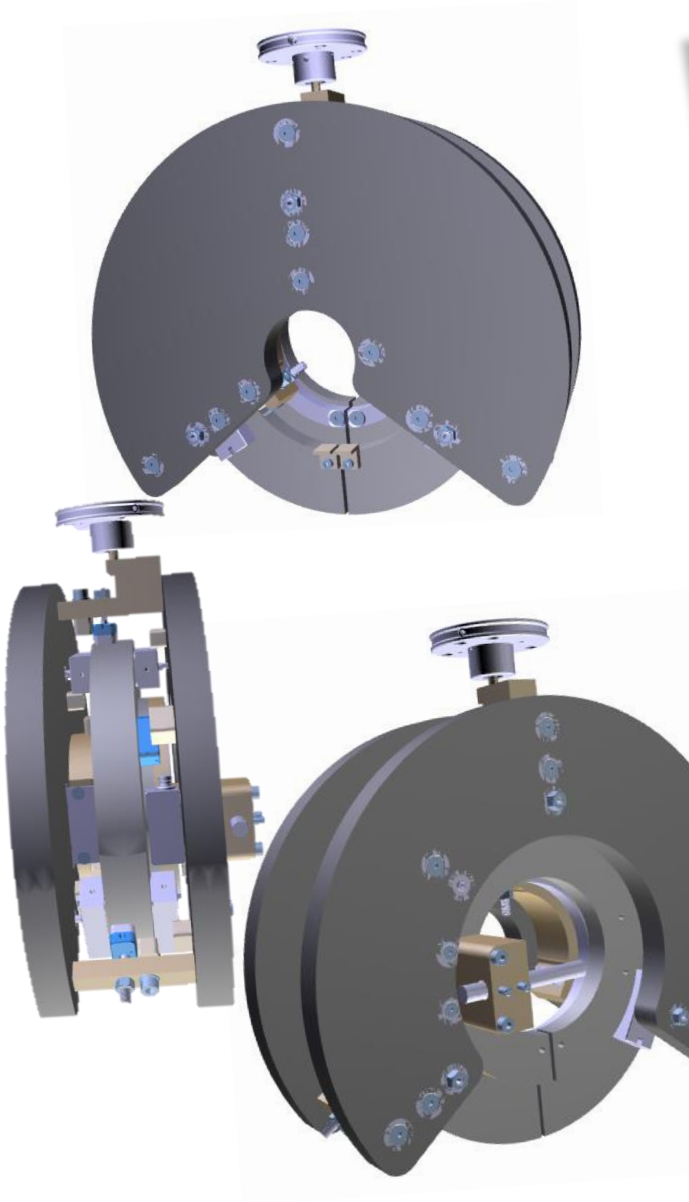

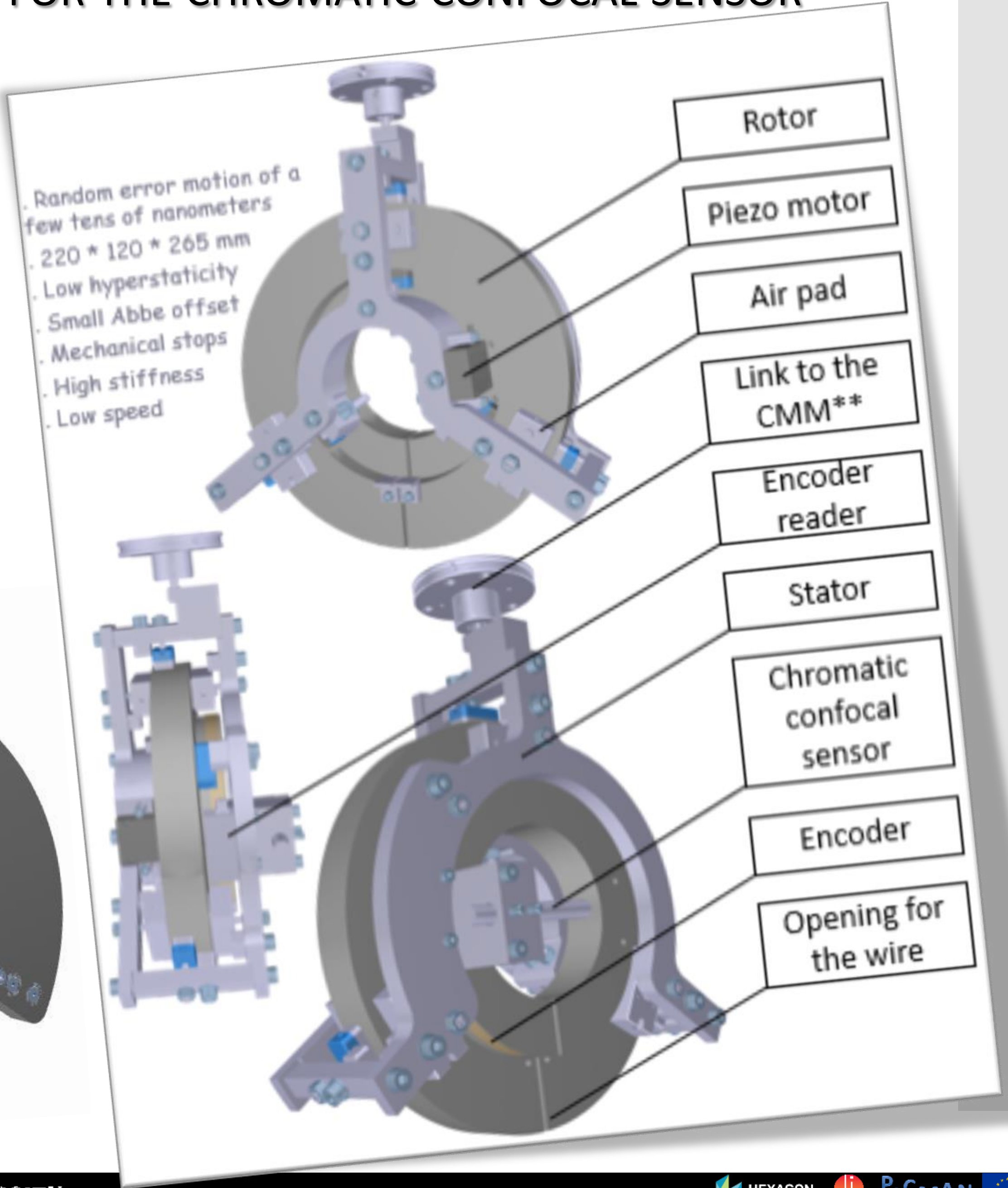

- Random error motion of a few tens of nanometers
- 220 * 120 * 265 mm
- Low hyperstaticity
- Small Abbe offset
- Mechanical stops
- High stiffness
- Low speed

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- ➢ The parts constituting the SESHAT:
  - ✓ The chromatic confocal sensor
  - An aluminium rotor
  - An aluminium stator with the right plate
  - ✓ Air bearing bringing high stiffness and high quality for the rotation
  - ✓ A piezo motor fitting with the miscellaneous requirements
  - ✓ A high accuracy encoder as close as possible to the sensor

- ➢ The weight is too high
  - ➢ Weight optimization should be performed
    - ➢ Stiff and light: Carbon and honey comb structure + peek
      - ➢ The structure is larger than the maximum width allowed
      - ➢ Peek is very unstable with temperature variations

- ➢ There is a high risk of breaking the ring with the motor
  - ➢ The hard material should be very well bounded to the rotor
    - ➢ For the prototype and the proof of concept, it will be plain alumina

- ➢ Optimisation is under process: 3D printed titanium or Scalmalloy with an alumina ring is being considered (Ti and Al_2O_3 behave similarly)

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Where to go next?

WHERE TO GO NEXT…

- Check independently the parts constituting the SESHAT:
    - The chromatic confocal sensor
    - A rotor
    - A stator with the right plate
    - Air bearing bringing high stiffness and high quality for the rotation
    - A piezo motor fitting with the miscellaneous requirements
    - A high accuracy encoder as close as possible to the sensor
- Assemble the SESHAT prototype and proof the concept
    - Measure the influence of the air pad’s air stream on the wire
- Find the optimal material and technique to lighten the SESHAT
- Adapt the sensor on the CMM
    - Determine and apply the best method for the sensor calibration
    - Determine and apply the integration strategy for using the sensor with Q7
- Compare the results with the simulations being performed
- Understand the gap between the contact & non-contact from measurements

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Thank you for your attention…
Do you have questions?

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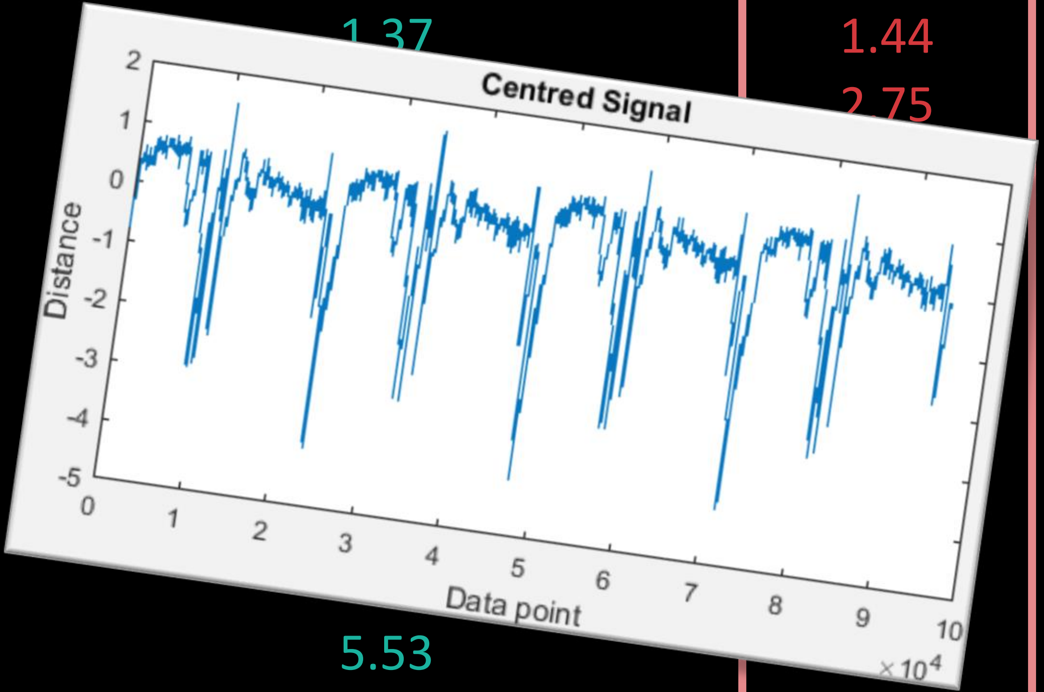
PACMAN

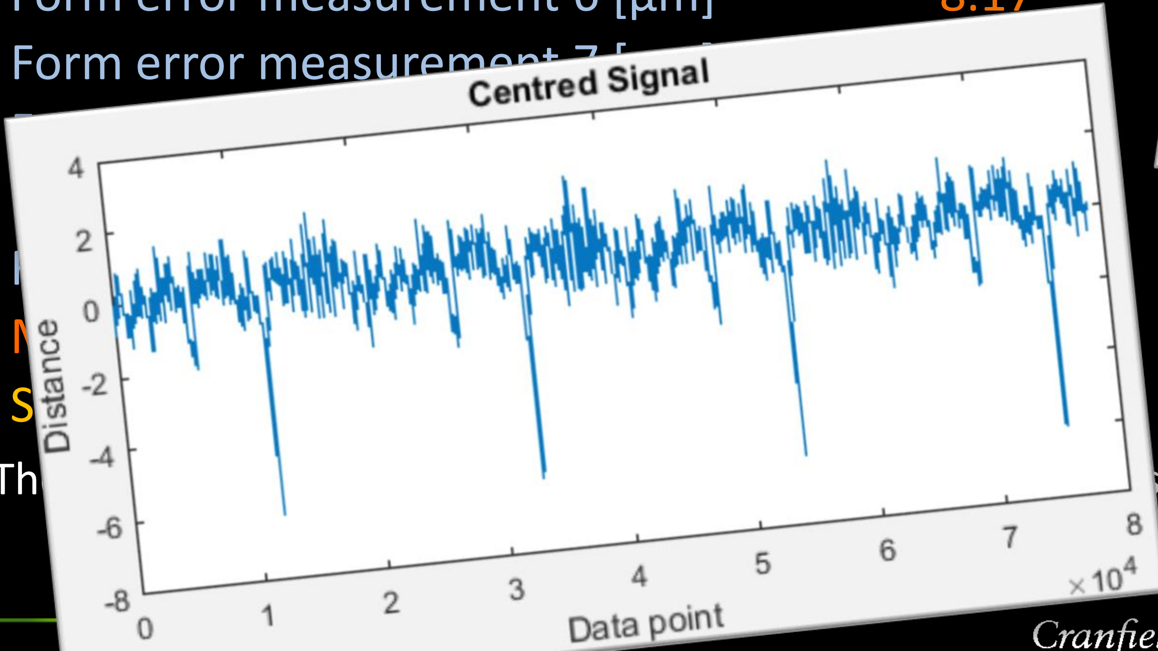
@ Deviant Art, Seshat drawn by Mme Kikue

PACMAN’s Reference Wire

Choice of the wire provider

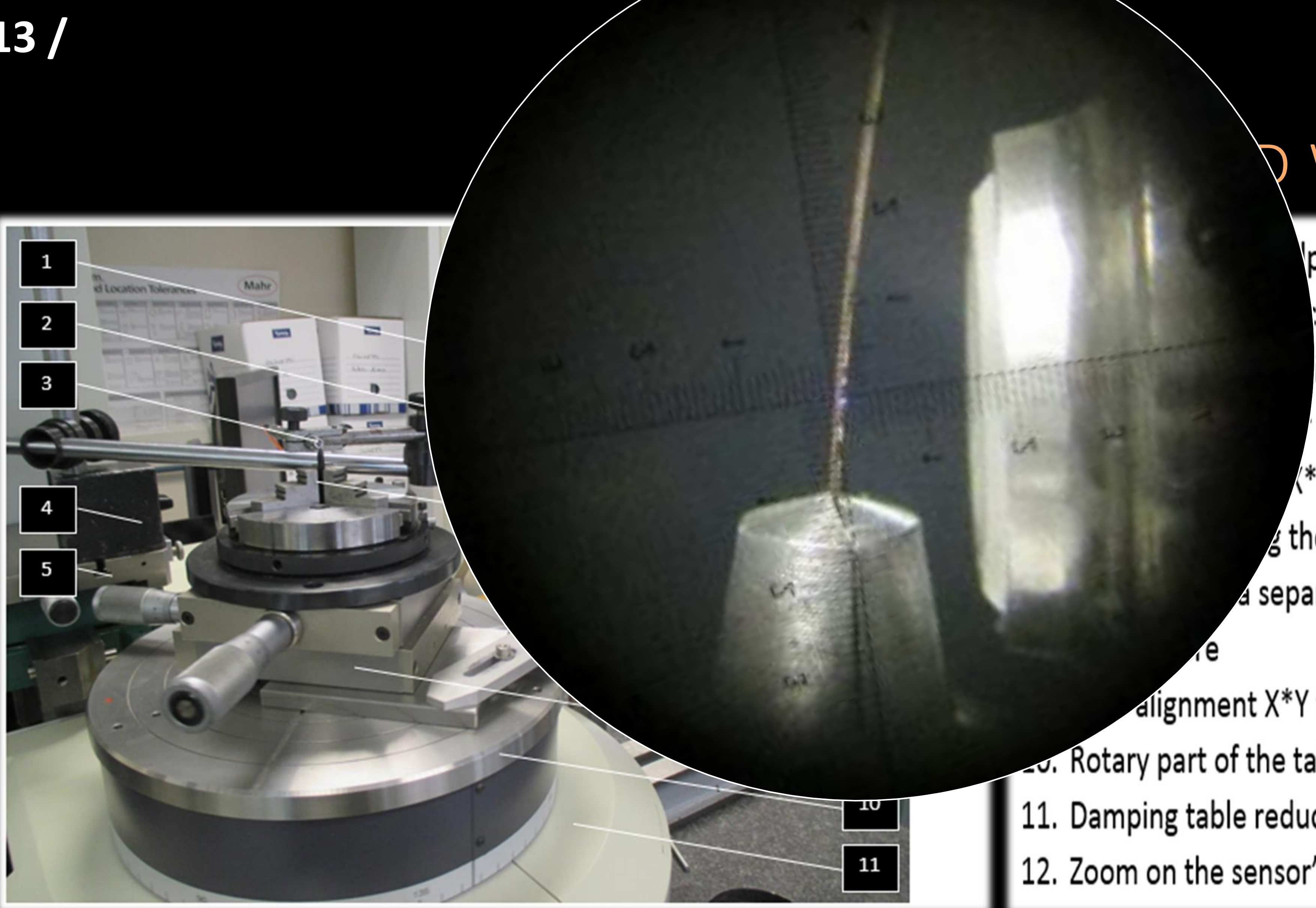
	Good Fellow	California Fine Wire company	NGK
Form error measurement 1 [µm]	~~22.47~~	1.37	1.44
Form error measurement 2 [µm]	1.74		2.75
Form error measurement 3 [µm]	2.88		
Form error measurement 4 [µm]	3.37		
Form error measurement 5 [µm]	3.79		
Form error measurement 6 [µm]	8.17		
Form error measurement 7 [			
F		5.53	
M		2.46	1.76
S		1.23	0.39





Th se measurements had a standard deviation of 81 nm.

D WIRE PROVIDERS



lp with the wire alignment

contact sensor

in front of the wire or gage being measured

sensor's pre-alignment

*Y table

g the wire

a separated table

re

alignment X*Y table

Rotary part of the table

11. Damping table reducing the vibrations

12. Zoom on the sensor's spot as seen during the alignment process