



CERN Workshop organized by Stefan KUBSKY

# Introduction to nanoGPS technology

**Dr. Olivier ACHER**

**Directeur Innovation & PoC, HORIBA France**

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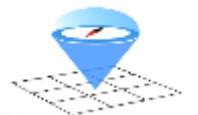
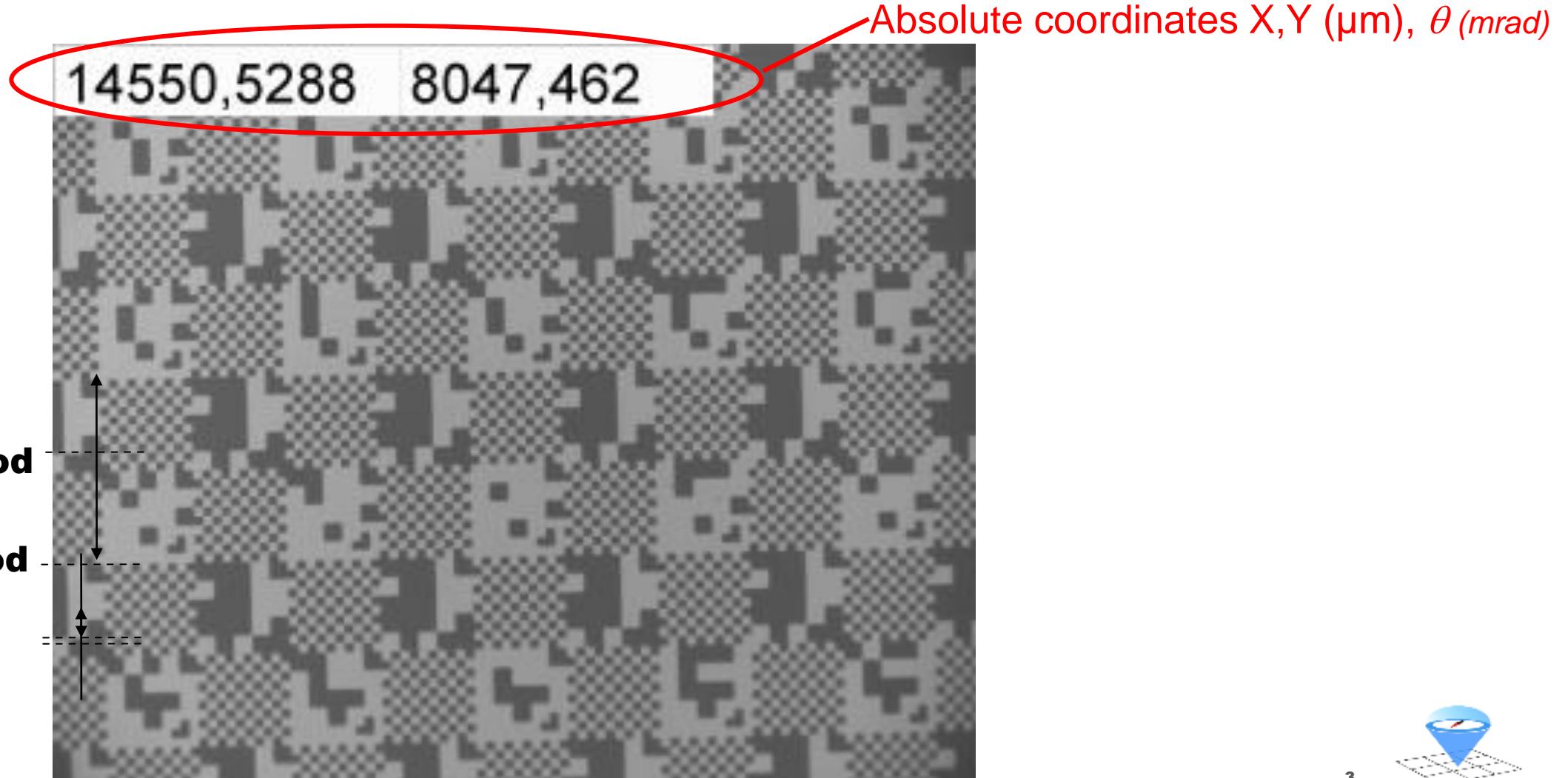
# Outline

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- **The technical basis of the nanoGPS technology**
- **Why nanoGPS technology is trendy regarding position sensing ?**
- **Illustration of some nanoGPS OxyO uses**
- **WANTED: your ideas on any clever application based on smart-phone !**

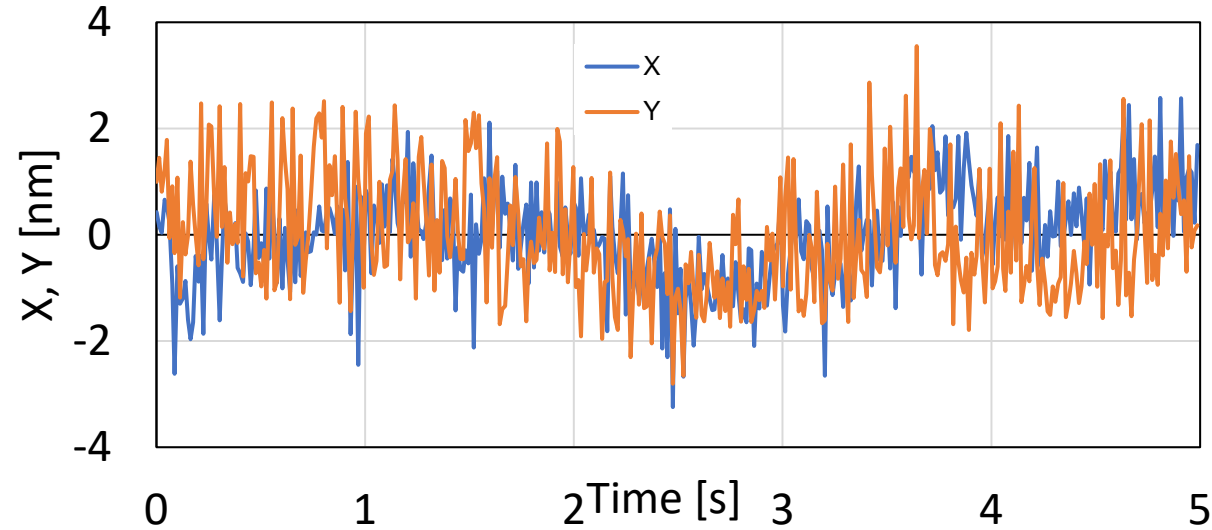
# Principle of nanoGPS OxyO® technology

- A proprietary pattern is imaged, and the position and orientation is deduced from its image

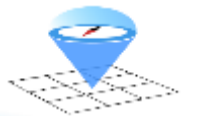
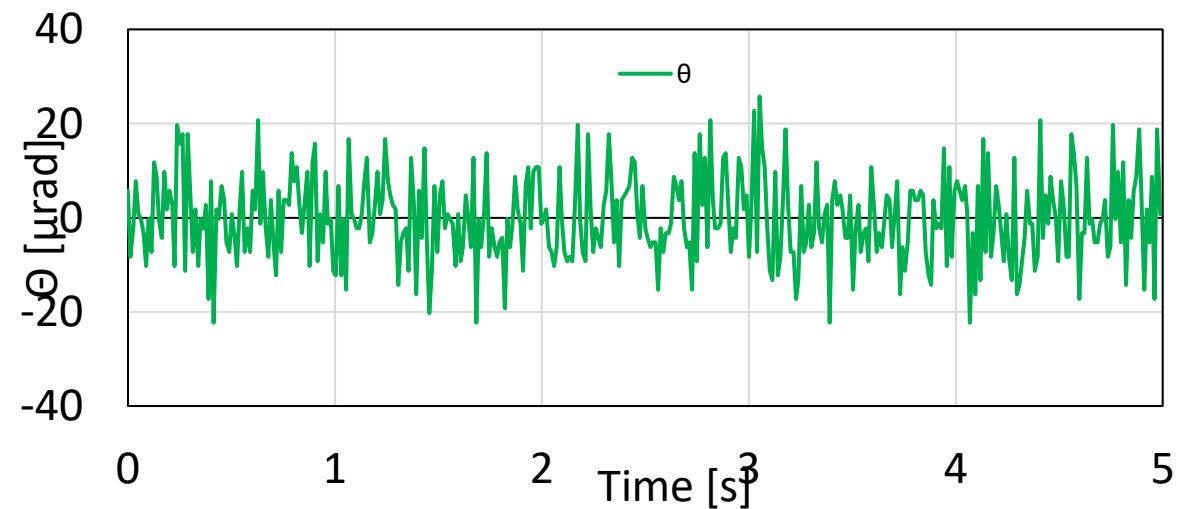


# Noise on position measured down to 1nm, on angle down to 10 $\mu$ rad

$\sigma(X)=0.9\text{nm}$ ;  
 $\sigma(Y)=1.1\text{nm}$

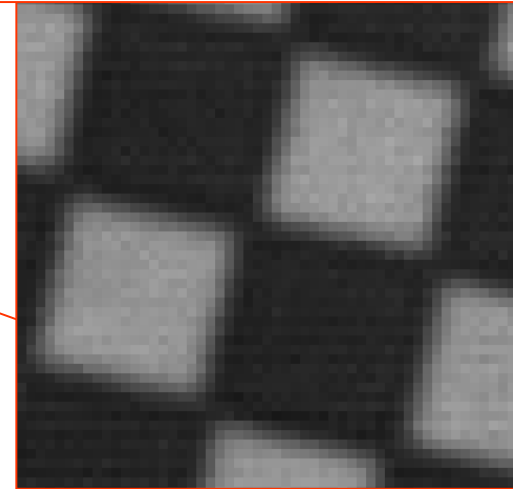
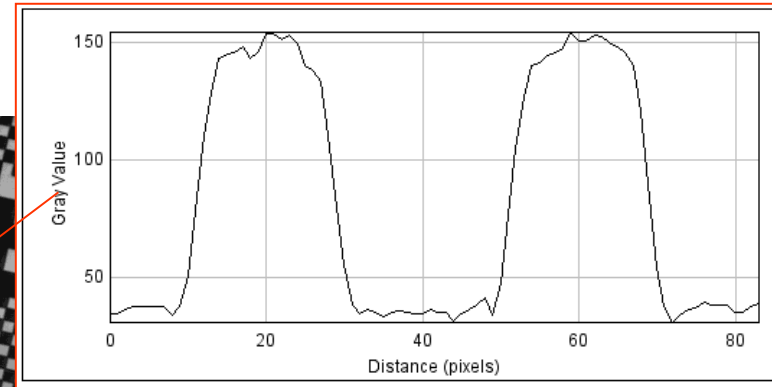
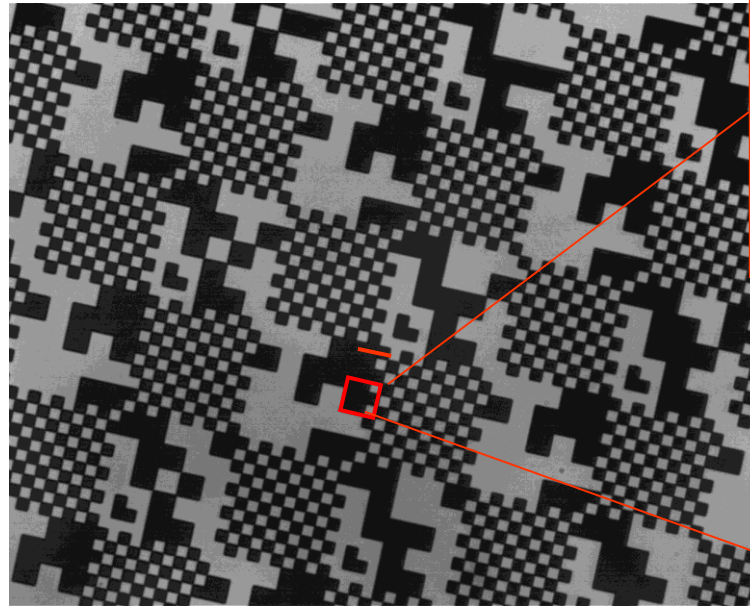


$\sigma(\theta)=9\mu\text{rad}$



# How is it possible to obtain sub $\mu\text{m}$ precision from optical images ?

- **The images are pixellated and blurred at the  $\mu\text{m}$  level**



NA = 0,13  $\Rightarrow$  Abbe limit =  $1,22\lambda/2\text{NA} = 3 \mu\text{m}$   
Pixel size in object plane =  $0,5\mu\text{m}$

- **How is nm precision possible, from  $\mu\text{m}$  blurred images ?**



# How is it possible to obtain sub $\mu\text{m}$ precision from optical images ?

## — Super-resolution imaging —

### The Nobel Prize in Chemistry 2014

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Chemistry for 2014 to

#### Eric Betzig

Janelia Farm Research Campus,  
Howard Hughes Medical Institute,  
Ashburn, VA, USA.

#### Stefan W. Hell

Max Planck Institute for Biophysical  
Chemistry, Göttingen, and German Cancer  
Research Center, Heidelberg, Germany

#### William E. Moerner

Stanford University,  
Stanford, CA, USA

*“for the development of super-resolved fluorescence microscopy”*



■ nanoGPS OxyO®  
technology is working  
in the superresolution  
regime !

See C. Cremer and B. Masters, “Resolution enhancement techniques in microscopy”, Eur. Phys. J. H **38** , 281–344 (2013)



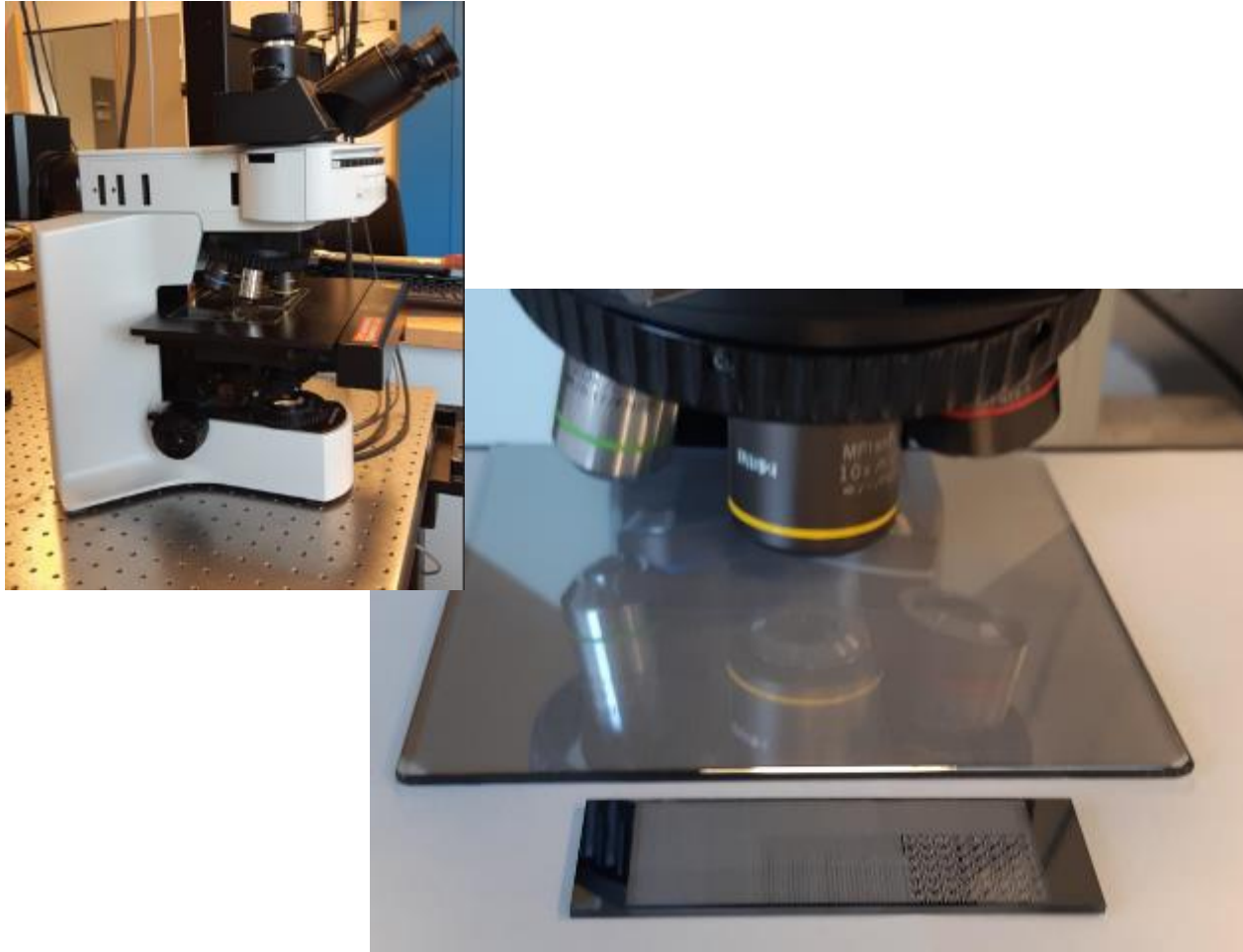
# We introduced this technology at a conference in 2018

- Stefan took the challenge to present our joint work in a conference full of metrology gurus, and it was a success !



# nanoGPS uses in the context of microscopy

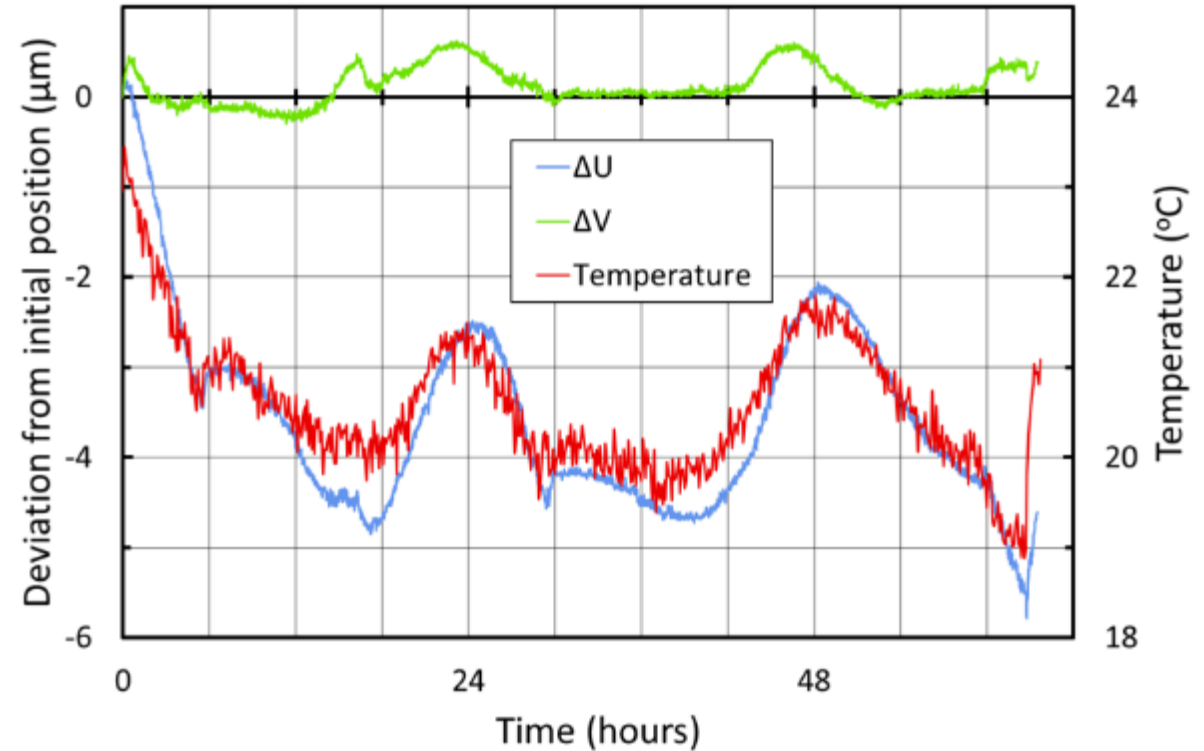
- Experimental details:



- How about staying immobile ?

## ■ Is stability OK for long experiments?

- Experiment: record nanoGPS scale image for 1 week-end

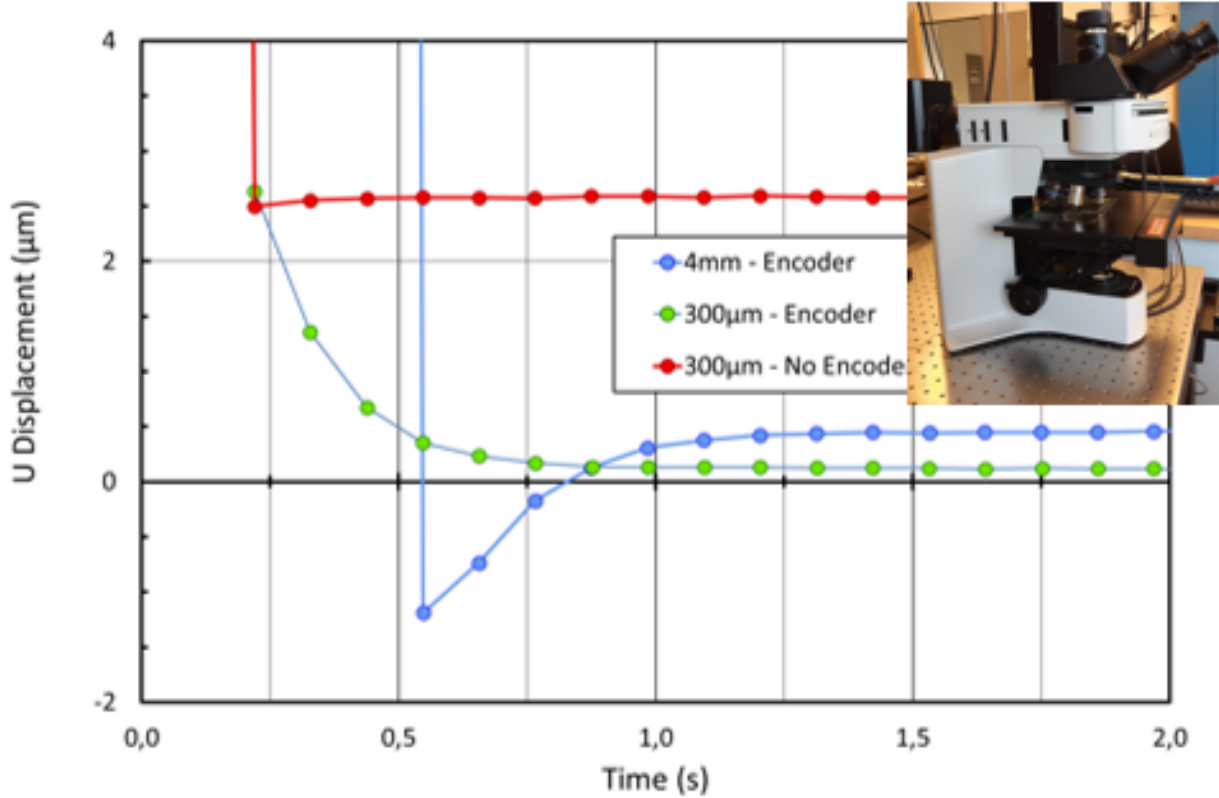




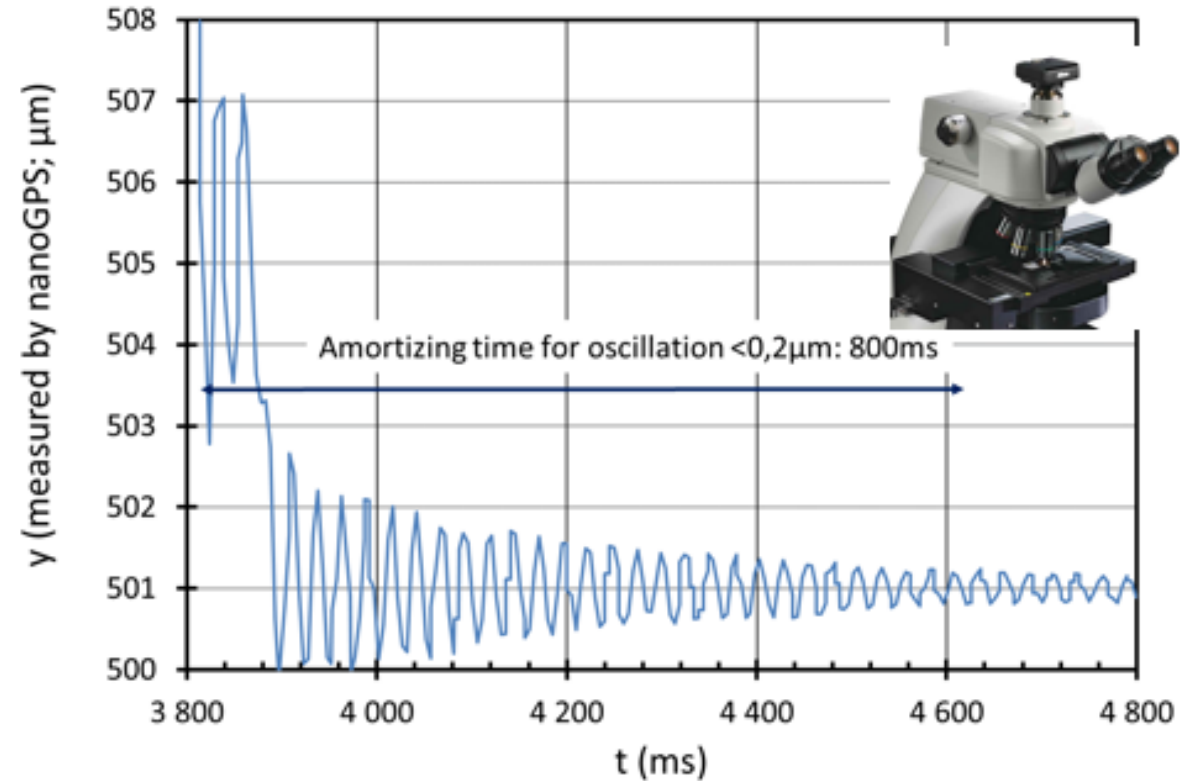
# Experiments

## ■ What is settling time to a new position?

### ■ Experiment 1: (Olympus frame, suspended table)



### ■ Experiment 2: (Nikon frame, suspended table)



# What about your ideas ?

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- **If you come up with an idea of a smartphone-based use-case of nanoGPS technology, I would be happy to hire you as a trainee at our Paris-Saclay facility to create a Proof of Concept of your idea !**

**[olivier.acher@horiba.com](mailto:olivier.acher@horiba.com)**



# Position sensing challenges in 2023

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- **Nanotechnologies**

- Fabrication operations are performed at micro and nanoscale
- Therefore navigating with a  $\mu\text{m}$  or nm accuracy is essential for a

- **Machine vision**

- >100Million Machine-vision cameras produced each year
- In Labs & factories, cameras outnumber humans eyes !

Omoshiro-okashiku  
Joy and Fun



Terima kasih  
谢谢  
Gracias  
Σας ευχαριστώ πάρα πολύ  
धन्यवाद  
شُكْرًا  
Danke  
Tack ska du ha  
Grazie  
**THANK YOU**  
ขอบคุณครับ  
Обольшое спасибо  
Merci  
감사합니다  
Dziękuję  
Cảm ơn  
ありがとうございました