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***“THE AUTOMATED ASSEMBLY  
OF PS MODULES FOR THE  
CMS PHASE II TRACKER”***

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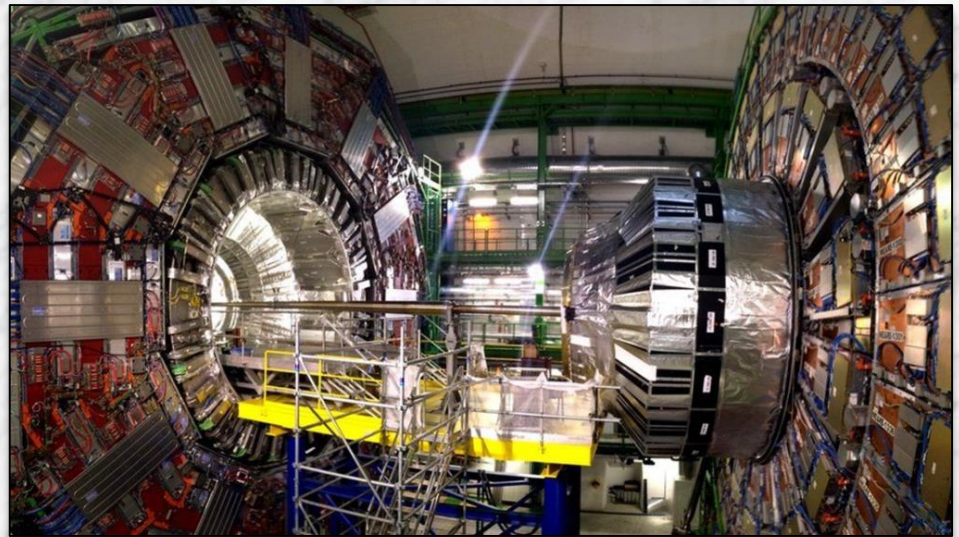
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# ***INTRODUCTION***

Some of the different activities carried on in DESY are:

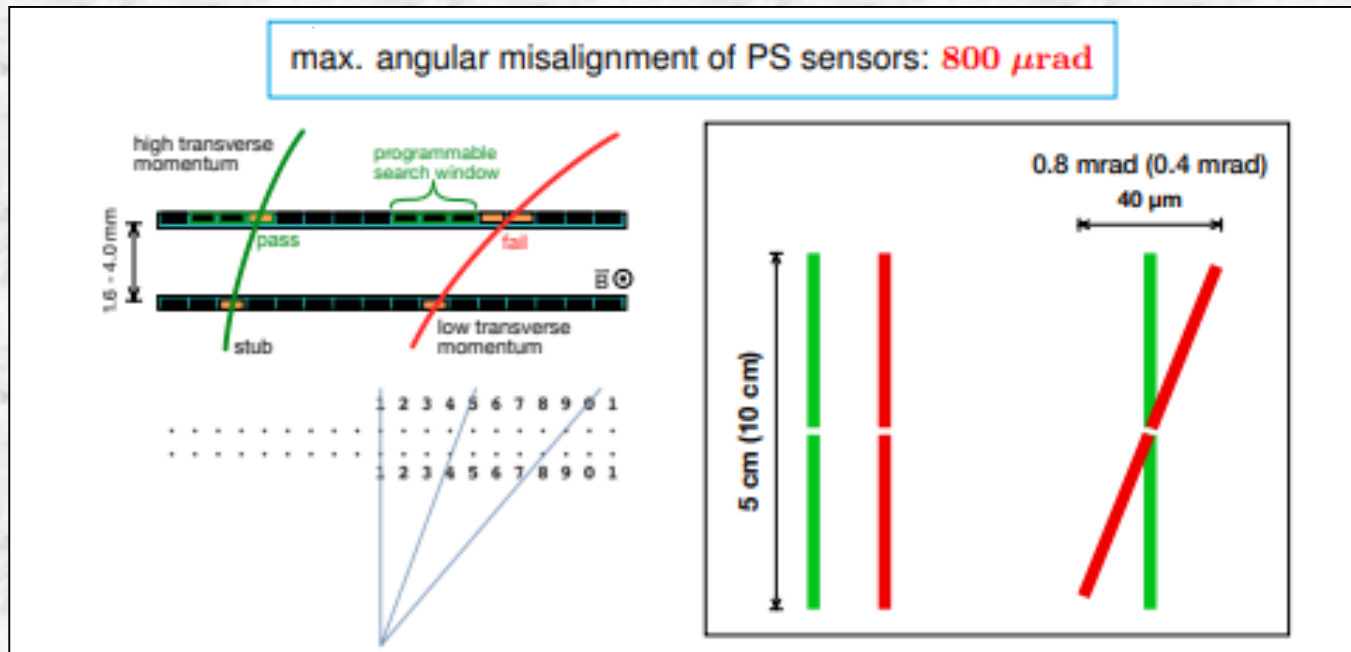
- Monitoring of data
- Analysis of data
- Upgrade of the CMS tracker

The new tracker  
will be installed  
for the High-Luminosity  
LHC (Phase II, 2026-2035)



# THE OVERVIEW PROJECT OF TRACKER UPGRADE

- DESY is one of the institutes involved in the tracker upgrade
- One activity is the assembly of Pixel-Strip (PS) modules
- PS modules: composed of two sensors
- Requirement: precise alignment of the 2 sensors ( $0.045^\circ$ )

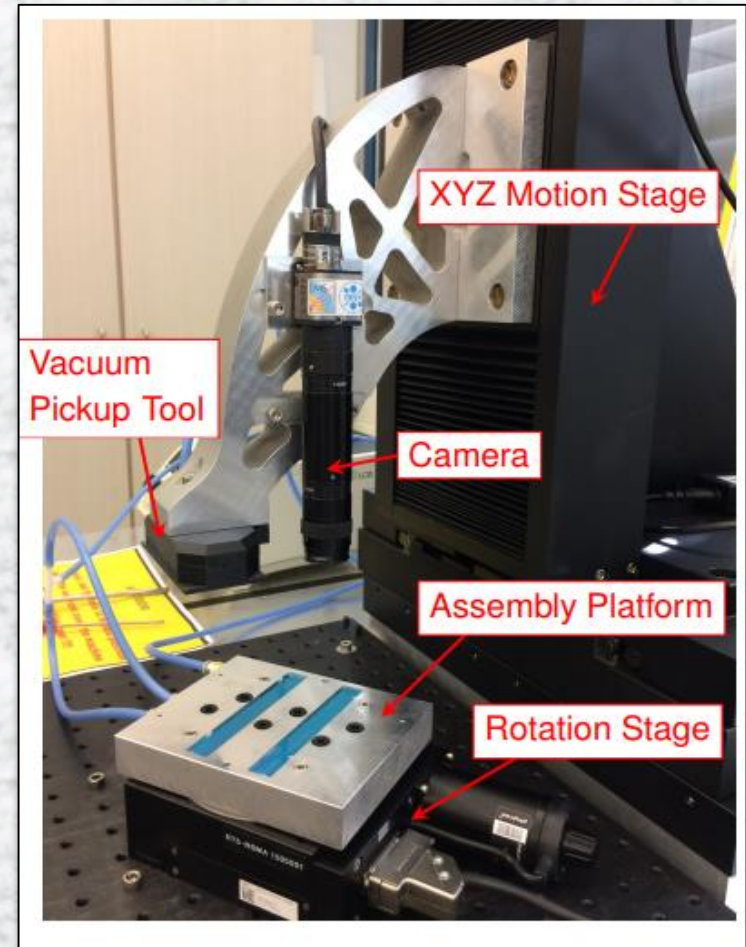


# ***THE AUTOMATED MODULE ASSEMBLY***

System located in the DESY  
DAF (Detector assembly  
facility)

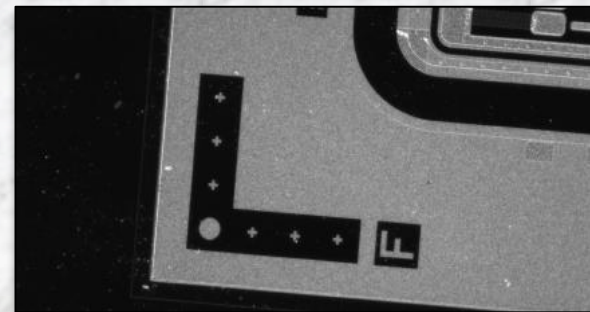
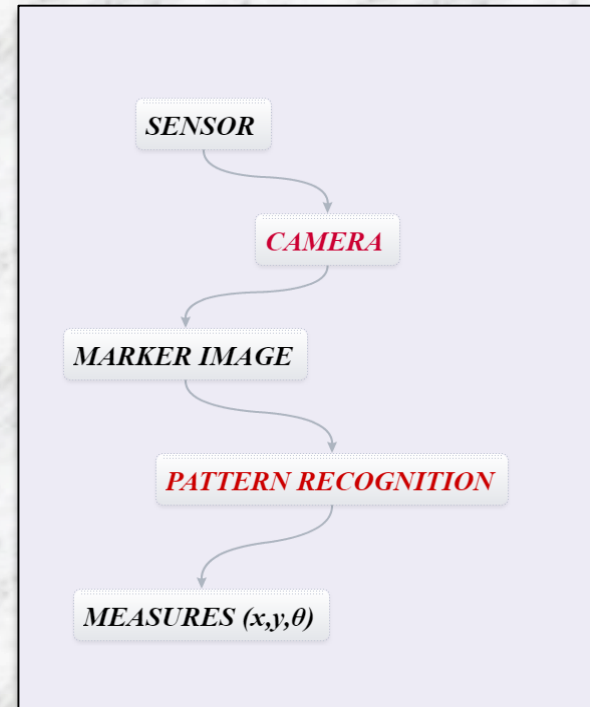
System components:

- XYZ Motion stage with arm
- Vacuum Pickup Tool
- Rotation stage with assembly Platform
- Camera



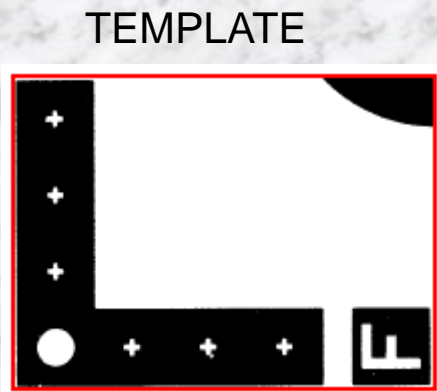
# ***SENSOR ALIGNMENT***

- *Sensor*: located manually on a rotation platform
- *Camera*: used to take pictures of the sensor and to find the marker
- *Pattern recognition*: used to find the precise position of the markers
- *Measurements*:  $(x,y)$  of the marker edge,  $\theta$  is the sensor orientation

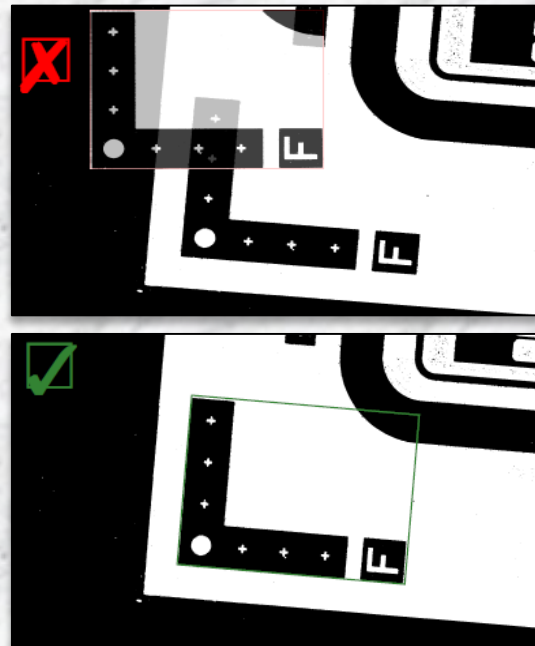


# ***FINDING THE MARKER***

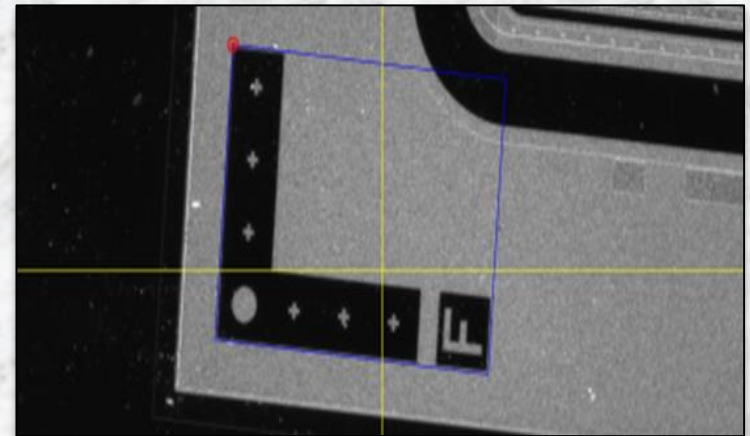
- Template image of the marker
- Thresholding: convert image in B/W to improve contrast
- Pattern recognition finds the best match position
- Measured orientation used to align sensor



## PATTERN RECOGNITION

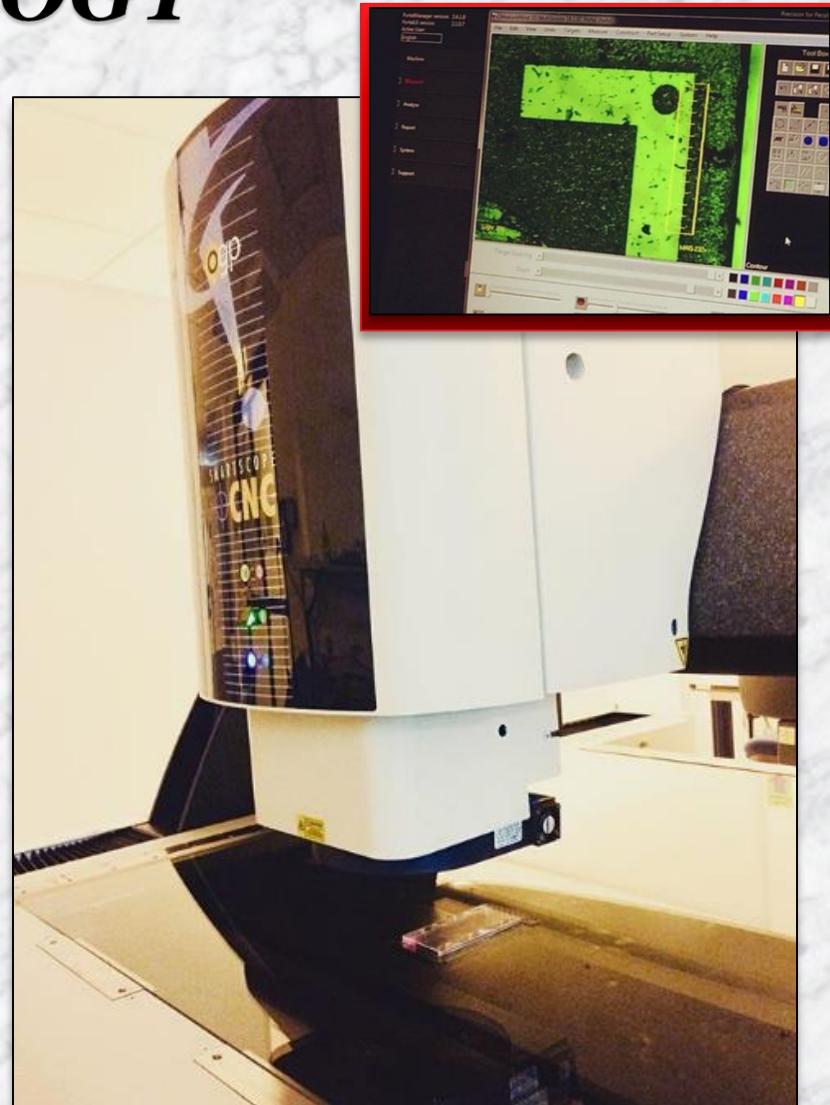
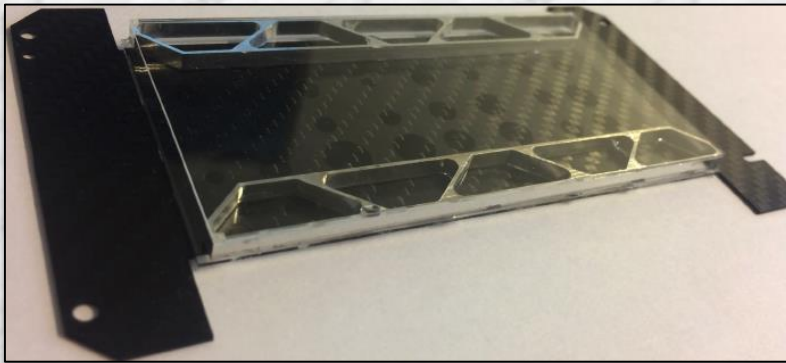


## RESULT



# ***METROLOGY***

- Measurement using a high-precision ( $\sim\mu\text{m}$ ) 3D microscope
- Making use of 2 prototypes made of glass
- Verify the alignment of bottom glass and top glass



# ***METROLOGY RESULTS***

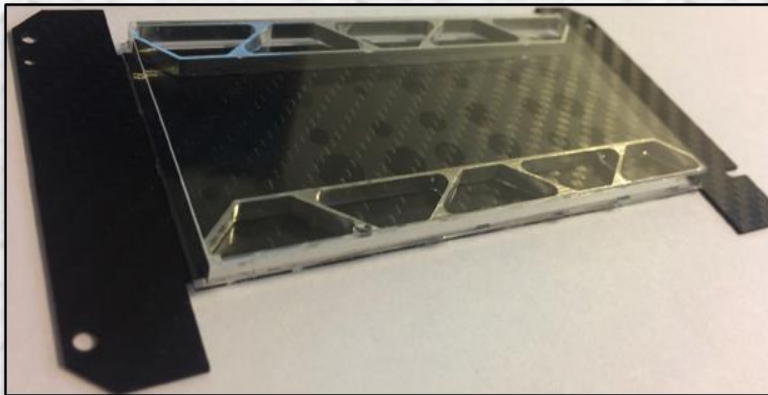
- Maximum allowed misalignment between the 2 sensors:  
800  $\mu\text{rad}$  = 0.045°
- Microscope data analysed with program written in *python*
- Prototype 1 is over 0.045 °,
- Prototype 2 is well aligned
- Prototype 2 was built with several improvements to the assembly procedure

Prototypes	Misalignment (°)
1	-0,082 ± 0,004
2	- 0,001 ± 0,003



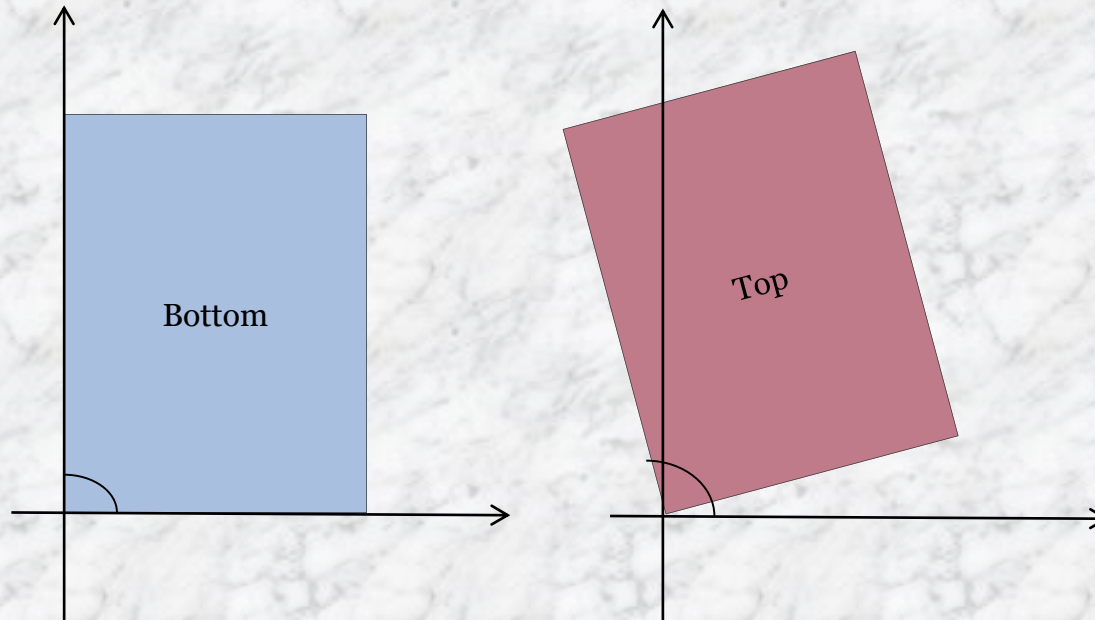
# ***SUMMARY***

- Taken part in a DESY project for the CMS Phase II tracker: the automated assembly of PS modules
- Seen the system at work in the DESY DAF
- Measured the misalignment of 2 prototypes of glass



# **ADDITIONAL MATERIAL**

# ***MISALIGNMENT MEASUREMENTS***



- Measurement of 4 angles per glass
- Misalignment: difference between corresponding top and bottom angles
- Final estimate: average
- Error: maximum difference between 2 misalignment measurements