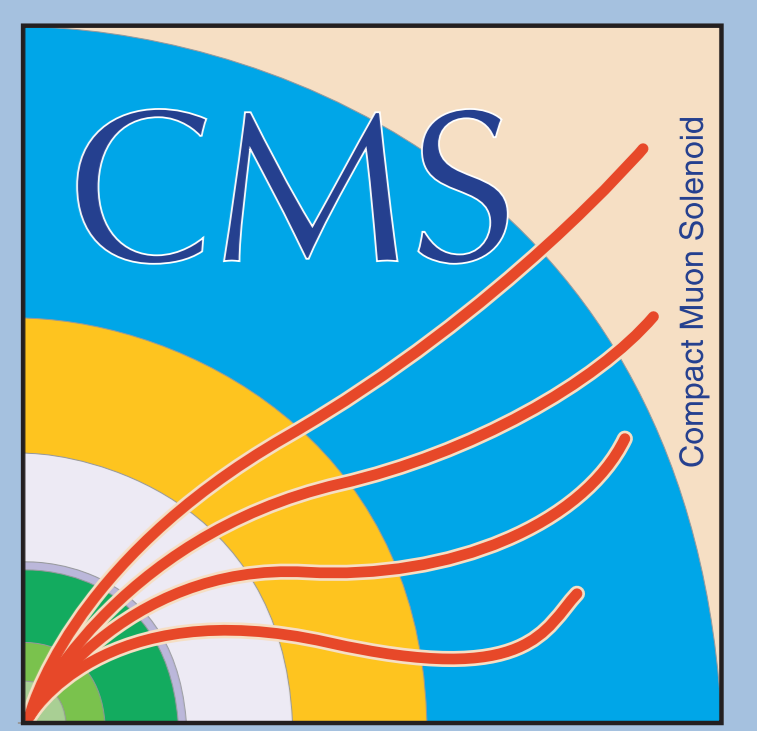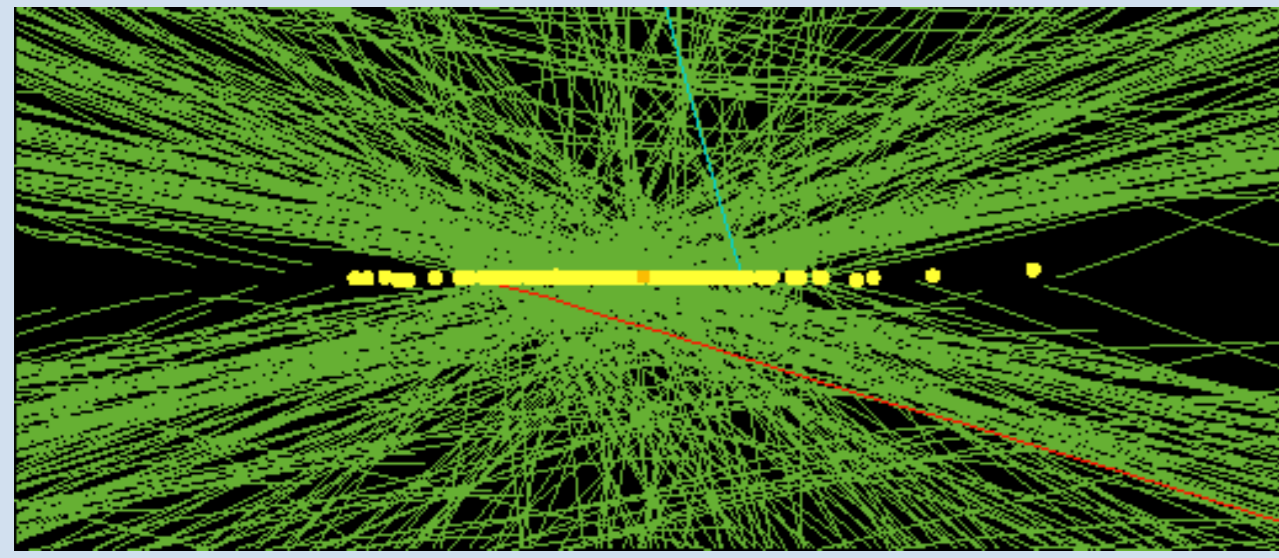# Automated Assembly of *stacked* sensor modules for the CMS outer tracker upgrade
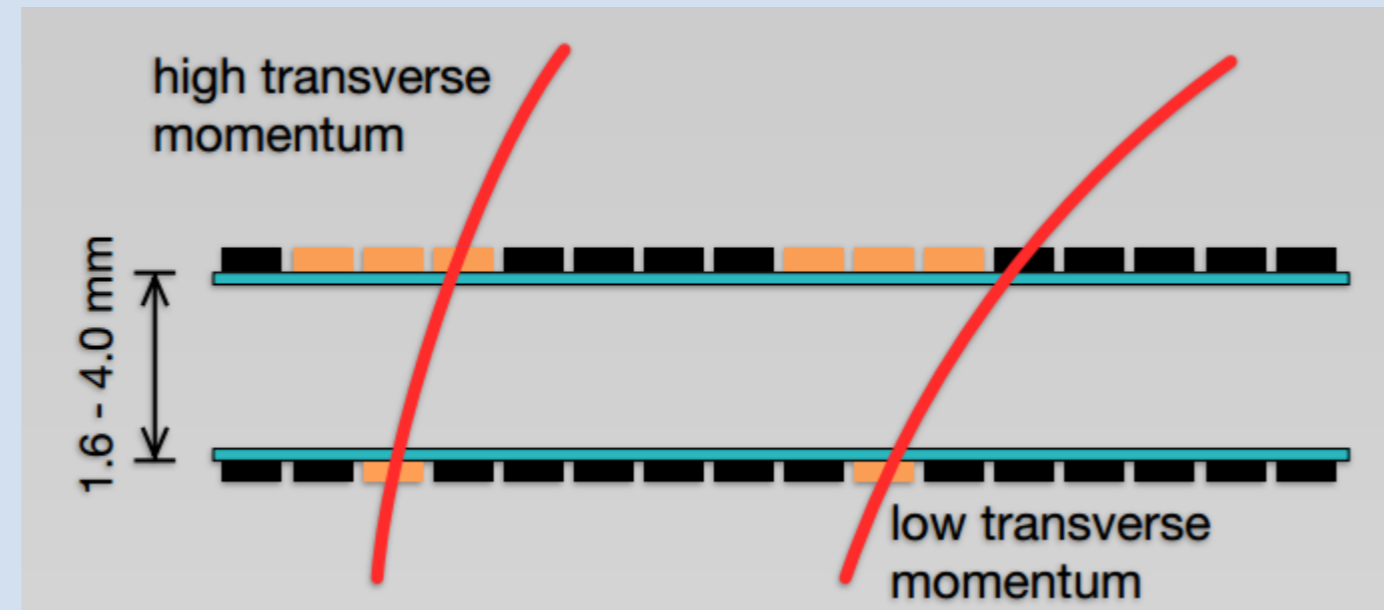
James Keaveney, DESY

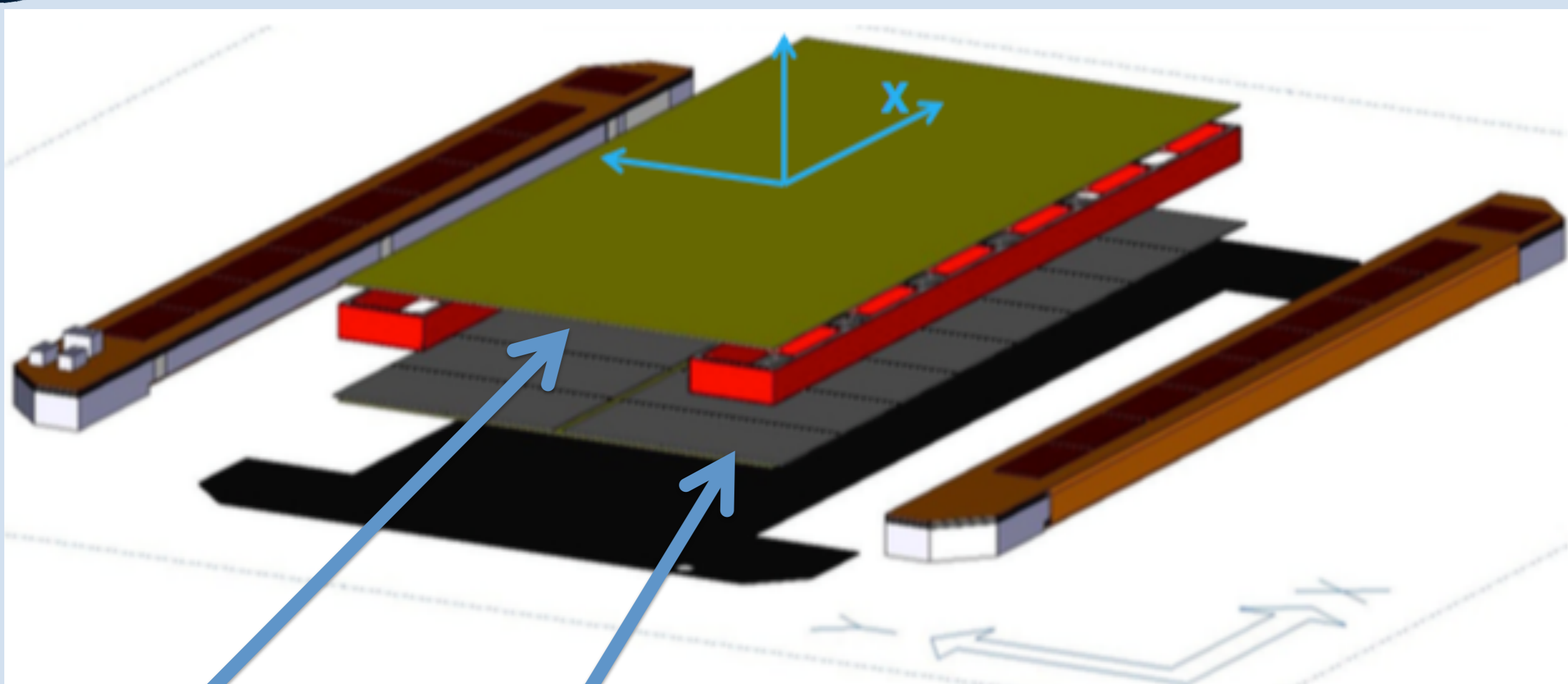### 1 — P_T discrimination in the module

Conditions of the future High-Luminosity LHC demand a drastic data reduction at trigger level

Novel *stacked* sensor module allows track P_T discrimination at the <u>hit level</u> via matching of hits in closely spaced sensors
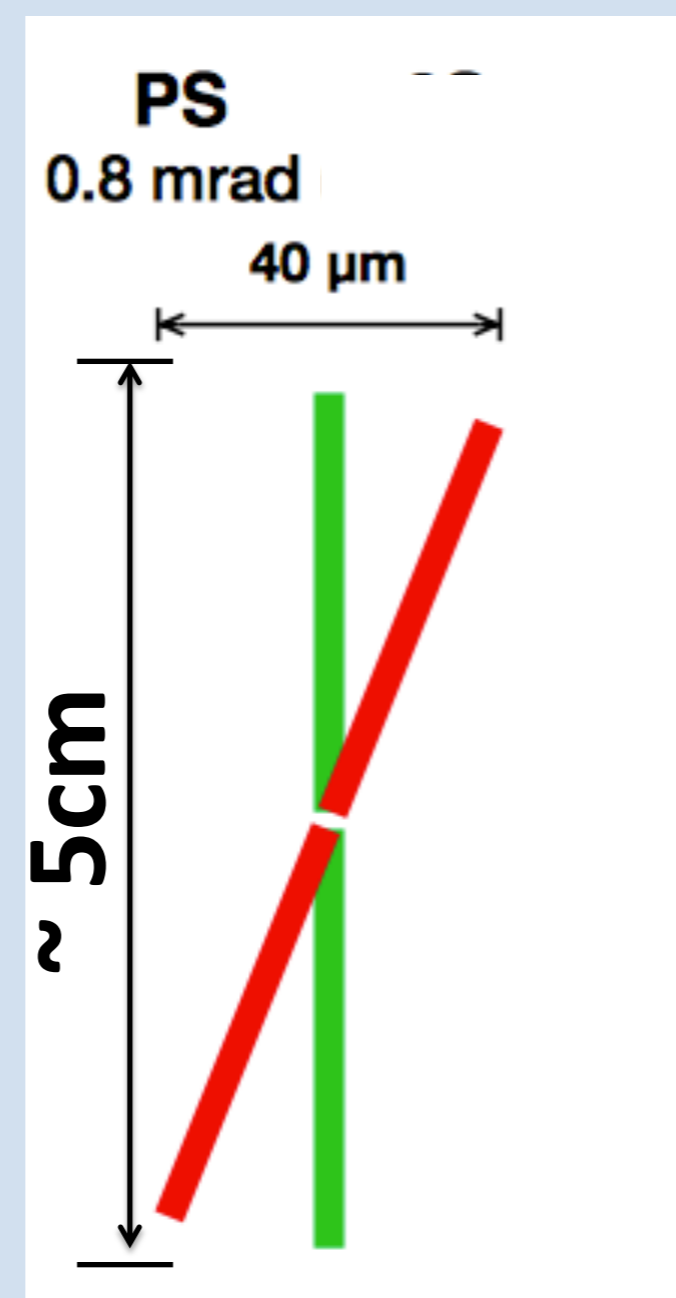

### 2 — Module design

<u>Strip</u> and <u>macro-pixel</u> sensors separated by spacers

- Matching of hits in sensors requires relative rotational alignment of sensors to 0.8 mrad.

- Represents a significant challenge
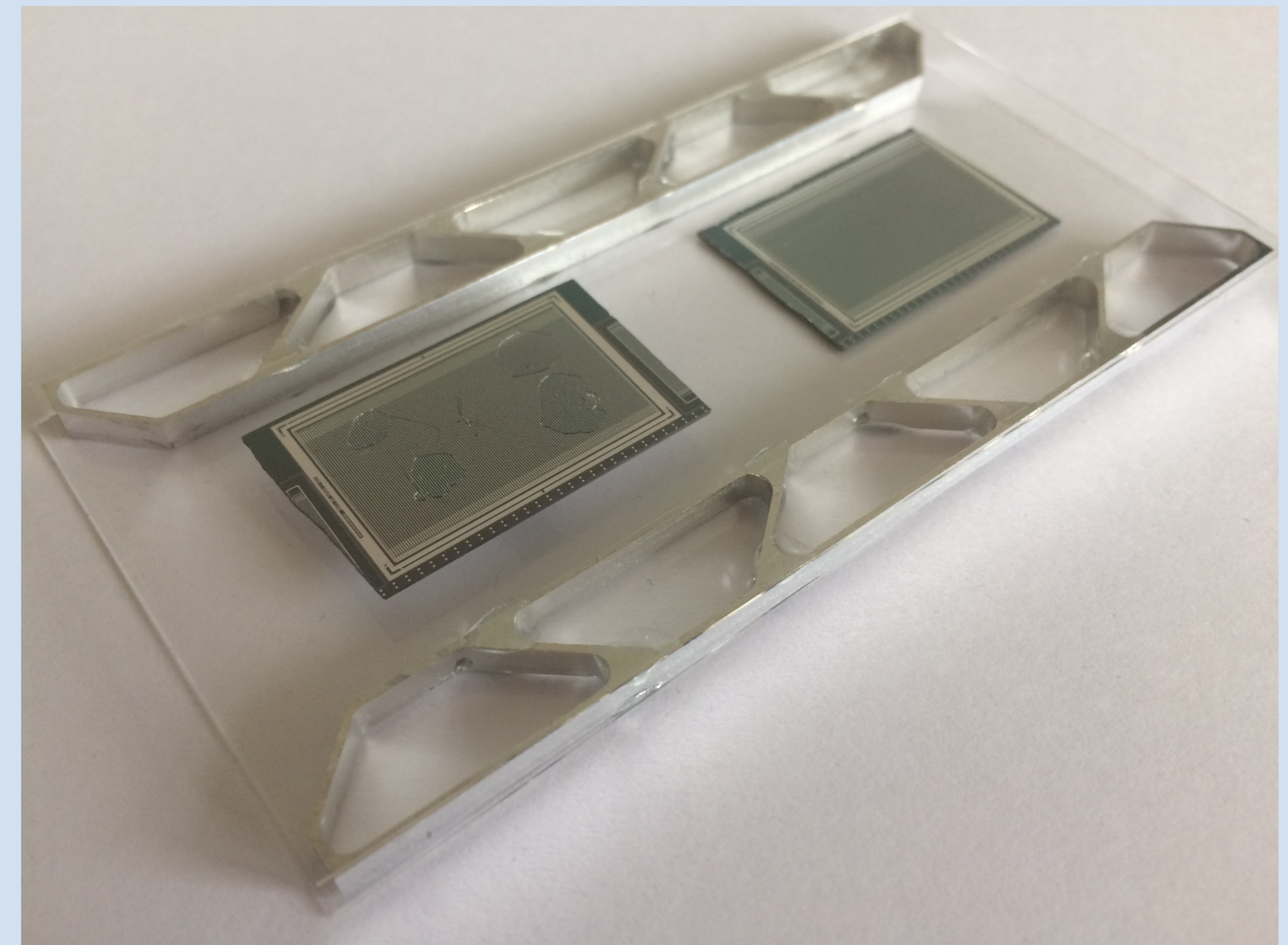 - 14k modules in upgrade outer tracker

3 — Hardware setup

High-resolution camera
- acquires images to locate components

Precision motion stages
- 5µm in X-Y-Z
- 175µrad in angle

Vacuum handling
- 5µm precision in X-Y-Z
- 175µrad precision in angle

4 — Assembly procedure

- Camera acquires images of corner markers on sensors

- Pattern recognition based on *template matching automatically* deduces X-Y and angular orientation of sensor.

- Image acquisition, pattern recognition vacuum and motion control integrated in dedicated Qt application
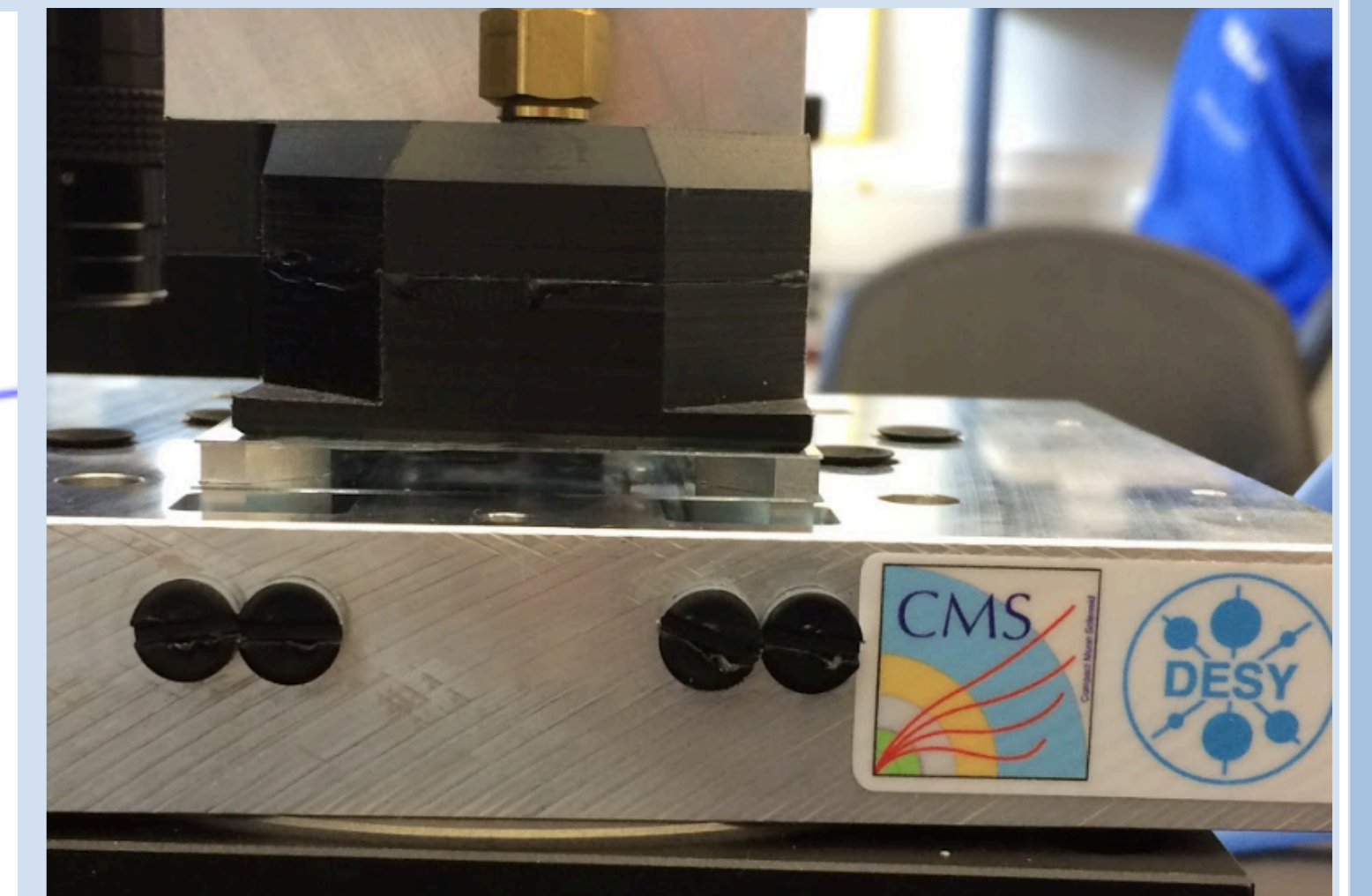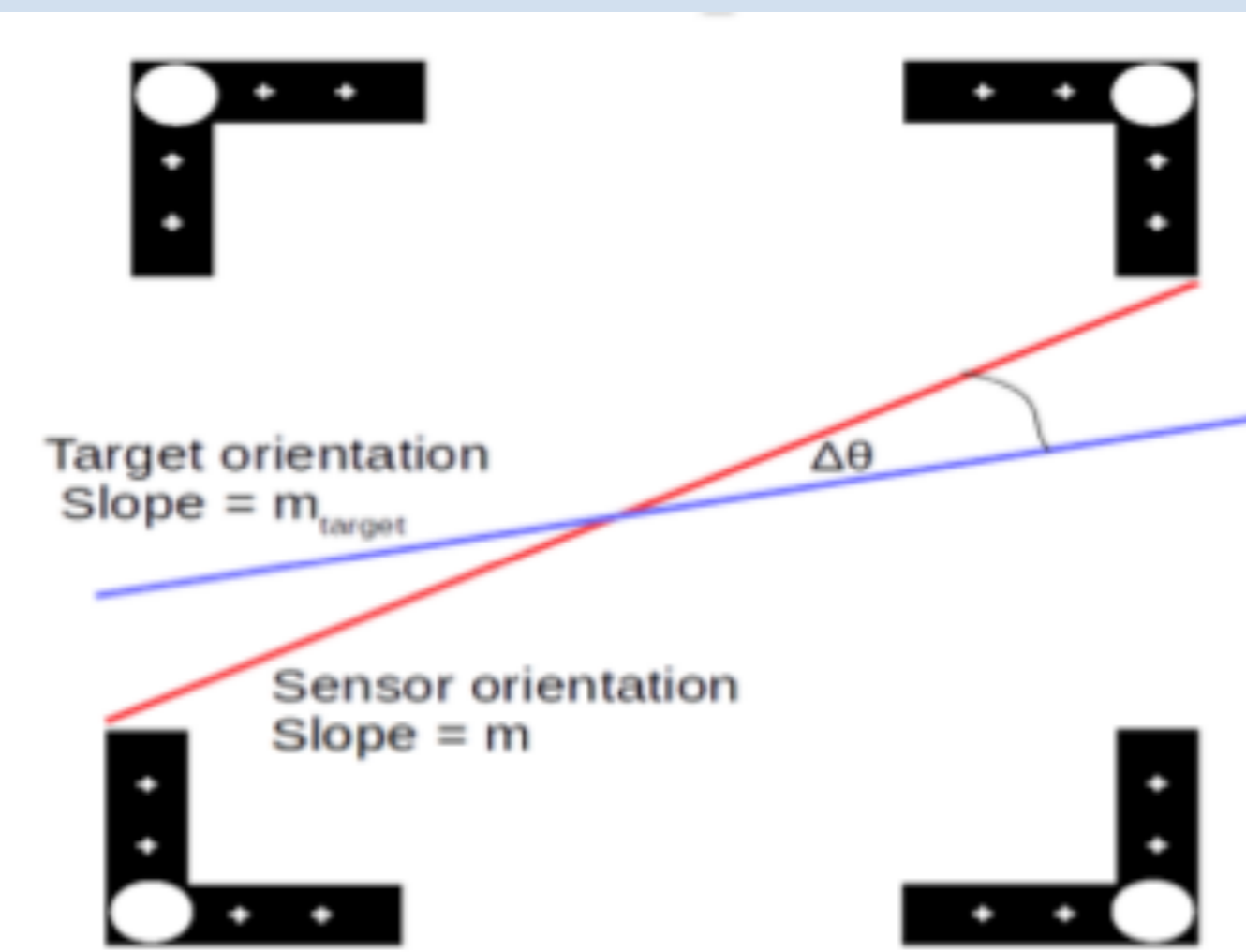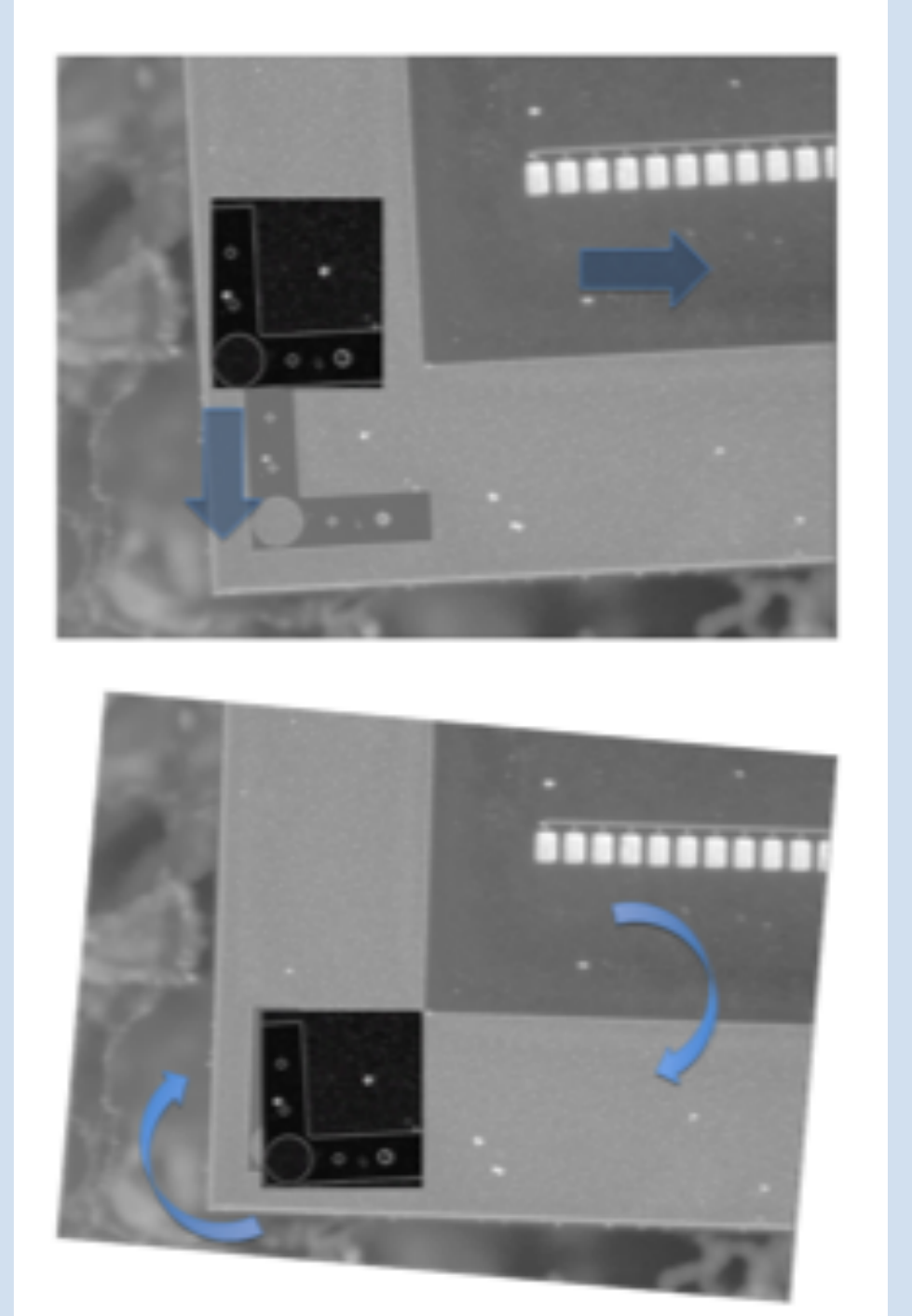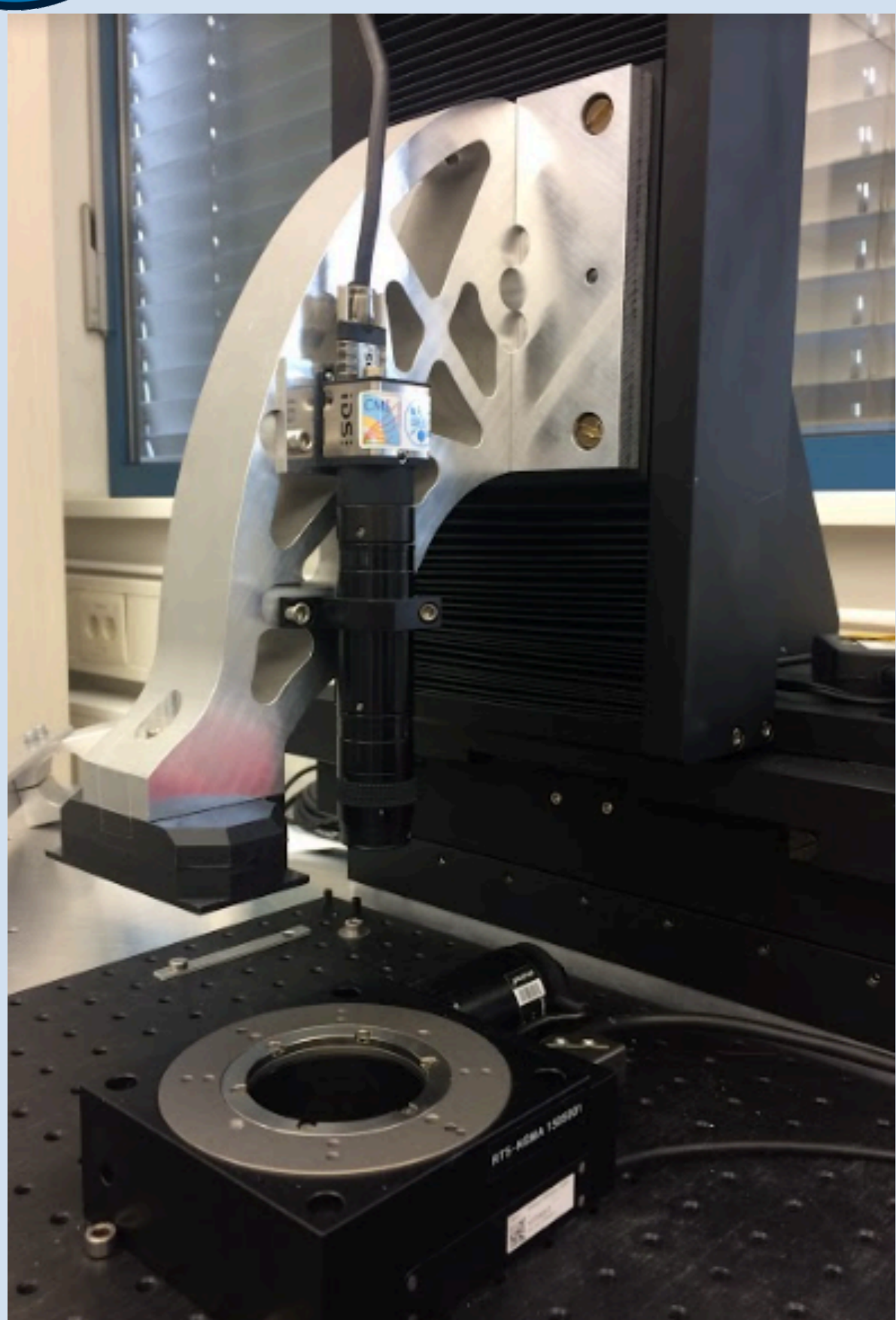

- Sensors brought to same X,Y and angle using motion system

- Sensors lowered onto spacers and glued to form assembly

5 — Protoypes

- Prototypes constructed with Silicon structures, glass dummies and Aluminium spacers.

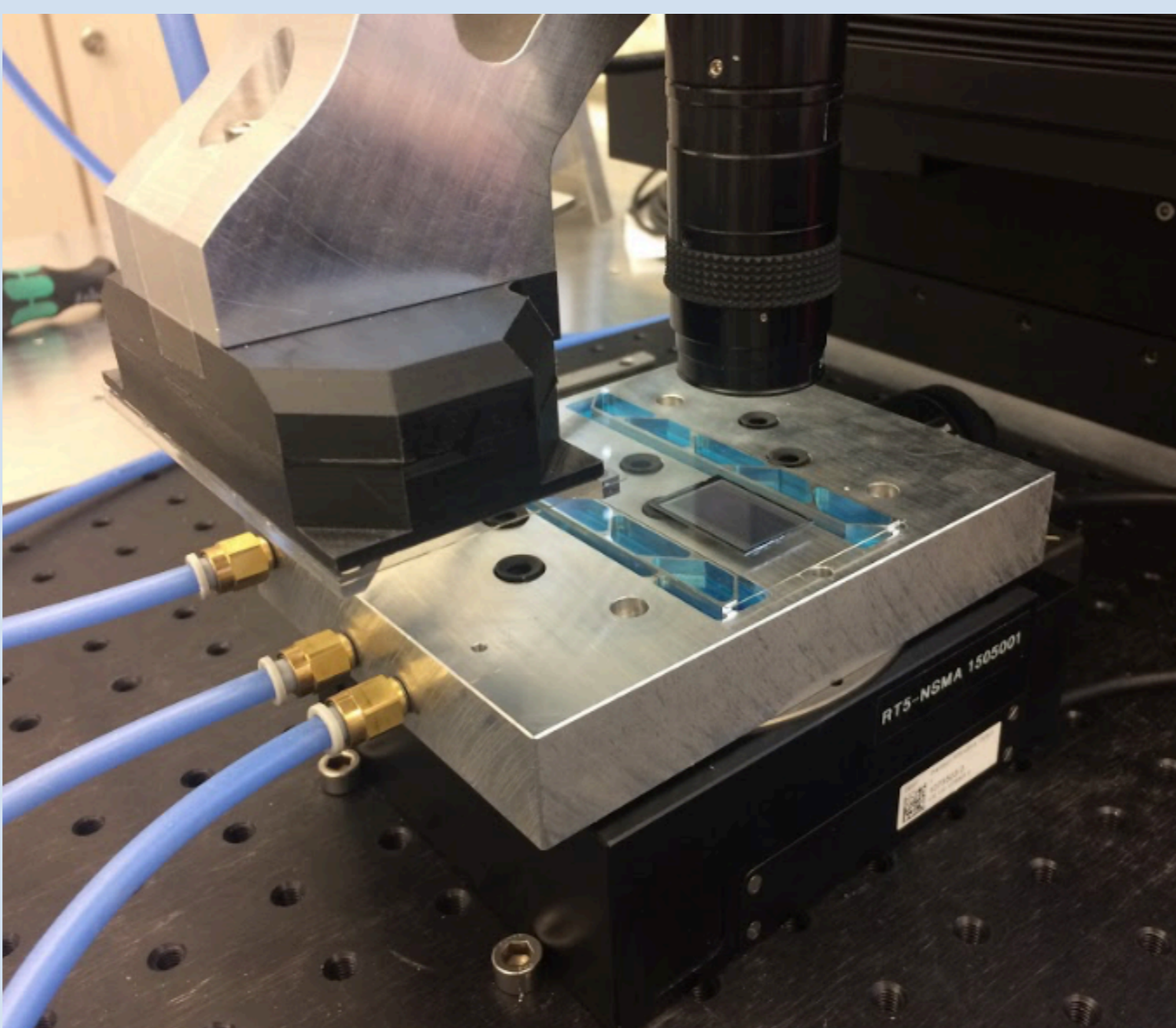- Alignment precision approaching target

- Build time ~80 minutes

6 — Outlook

- Automated assembly demonstrated-

  - Precise with fast build times crucial for CMS outer tracker upgrade

  - Further optimisation to come with more realistic module