BELARUSIAN STATE UNIVERSITY

Automation of CMS Phase II Tracker Module assembly

by

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Abstract

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Doctor of Philosophy

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The CMS phase II upgrade outer tracker is built from two types of modules (PS and 2S) each consisting of two silicon sensors and associated electronics and mechanics. In the case of the PS module, the sensors has be assembled to a precision of approximately 40 mm. In order to satisfy this requirement and a short module assembly time, an automated assembly system is proposed. This systems based on a high-precision motion-stage integrated with high-resolution camera, which provides pattern-recognition, vacuum holding system and control systems. [**?**]

Acknowledgements

James Keaveney, Andreas Mussgiller, Doris Eckstein, Carsten Muhl, Adam Zuber and all the CMS group in DESY for being ready to help anytime I had questions, while I had lots of them…

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Abbreviations

CMS	**C**ompact **M**uon **S**olenoid
LHC	**L**arge **H**adron **C**ollider
...	

Chapter 1

Introduction

The Large Hadron Collider (LHC) is the largest particle accelerator in the world. During the first run of it from 2010 to 2013 its experiments had made remarkable achievements. Perhaps one of the most famous is the discovery of the theorised Higgs particle, which resulted in the Nobel Prize in Physics in 2013 being awarded to Franois Englert and Peter Higgs. The LHC are made to collide particles at four locations around the accelerator ring, corresponding to the positions of four particle detectors ATLAS, CMS, ALICE and LHCb [**?**].

1.1 Compact Muon Solenoid

The Compact Muon Solenoid (CMS) is a cylindrical particle detector designed to measure a wide range of particles produced in the collisions of LHC. The size of the detector is around 28 m long and 15 m in diameter. It is the heaviest detector in the world and weighs approximately 14000 t. The name "CMS" originates from the three key characteristics of the detector: its relatively compact size, its excellent capabilities in the detection and measurement of muons and its central feature, a superconducting 3.8T solenoid magnet.

The CMS detector consists of many separate detector layers, each of them playing an individual role in detecting and measuring the traversing particles. A cross-sectional overview of the layers and its tasks in reconstructing tracks of particles is shown in the Fsigure 1.1.

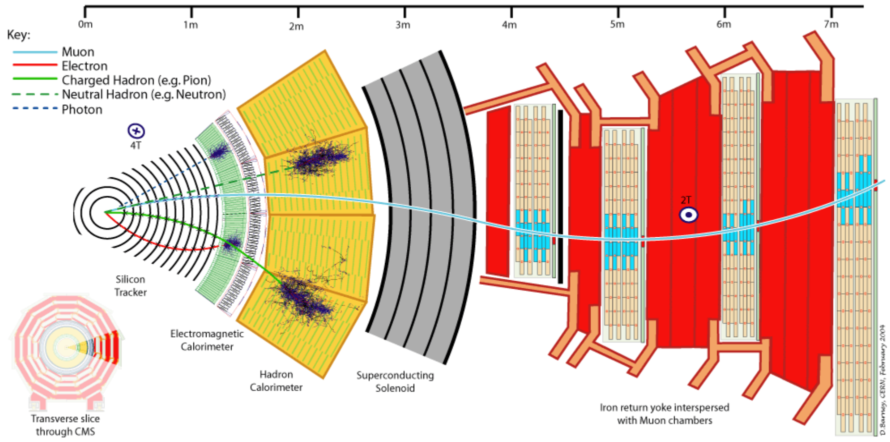

FIGURE 1.1: A cross-sectional view of the CMS detection layers.

1.2 Phase II Upgrade of LHC and CMS

The Phase II Upgrade of LHC will provide much higher luminosity conditions. This will lead to more interactions and producing more particles. Such number of particles is far beyond the data band-width of the current version of CMS Tracker...

1.2.1 Two layer Sensors

The CMS Phase-II Tracker will utilize two types of modules, 2S modules and PS modules. To achieve efficient rejection of low-pT particles throughout the Tracker volume, modules in different regions will make use of a few different sensor spacings. For 2S (PS) modules, spacings of 1.8 and 4 mm (1.6, 2.6 and 4 mm) are foreseen. These modules will be used in the end-cap disks as well as the central barrel region of the Tracker. An exploded view of a PS module is shown in Figure 1.2. In the PS module, the sensors are glued to a carbon-fibre reinforced Aluminium (AL-CF) spacers which act as spacers and provide the thermal conductance crucial for the cooling of the module. The two sensors and spacers are in turn glued the carbon-fibre (CF) baseplate. This structure is henceforth referred to as the sensor-spacer-baseplate-assembly (SSBA). This project will focus on the assembly of the SSBA only. The precision requirements of the SSBA are shown in figure ??. For the PS module, the sensors must align to within 40 mm measured at the sensors short edge. This corresponds to a rotational alignment tolerance of 0.8 mrad.

1.2.2 Assembly of two layer sensors

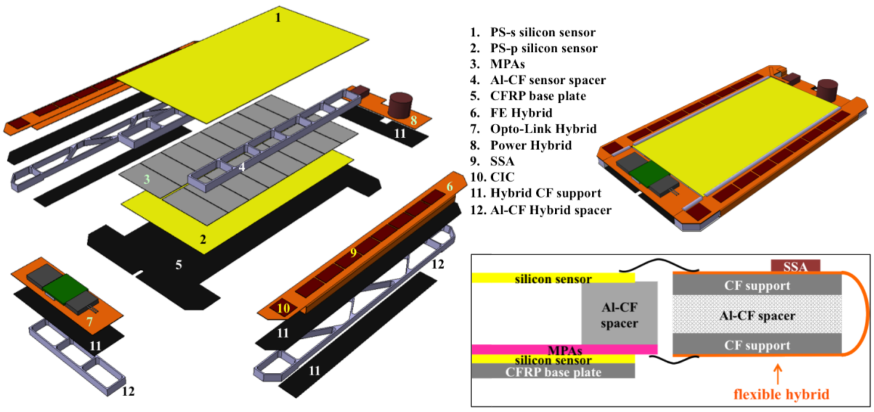

FIGURE 1.2: Exploaded view of Pixesl Sensor Module.

Chapter 2

Modules assembly

[Advantages and disadvantages of automated and manual assembly. Automated assembly is the best!!!]

2.1 Automated assembly steps

[Perhaps I should put this section later...?] Steps [list]: 1) Spacers to platform 2) Glue upper sensor to spacers 3) Rotate 90 degrees 4) Remove spacer+upper sensor 5) Put baseplate on the assembly platform 6) Glue bottom sensor (bare module) to the baseplate 7) Glue Upper sandwitch to the bottom one.

2.2 Assembly platform

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2.2.1 Requirements for assembly platform

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2.2.2 Design

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2.3 Fast adhesive

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Chapter 3

Precision tests

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3.1 Section 1

Chapter 4

Fast adhesive

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4.1 Fast glue implementation options

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4.2 Candidates

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4.3 Tests

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4.4 Glue joint thickness

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4.5 Fast glue conclusions

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Chapter 5

Precision estimation tests

Proof of precision (Butter-butter) Plan of precision tests

5.1 Arm and camera movements repeatability

1) Make a photo 2) Move aside 3) Move back 4) Make control photo

5.2 Vaccuum pick-up and -down precision

0) Move to measurement position 1) Corner position 2) Move to pre-pickup position (!) 3) Move to pickup 4) Toggle vacuum 5) Move up 6) Move down 7) Release vacuum 8) Move to pre-pick-up 9) Move to measurement position 10) Corner position

Chapter 6

Conclusion

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6.1 Results

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6.2 Future plans

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