SEARCH FOR SOMETHING

by

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SEARCH FOR SOMETHING

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my abstract

"... Josefa.

"...laca."

yo y tu.

"...come lady come."

pa darte.

to Nenas and nenita

ACKNOWLEDGMENTS

Many people has contributed to make this work possible that it is impossible to name them all.

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Introduction

Talk about particle physics in general and the organization of the documents

Chapter *2*

The LHC Accelerator and the CMS Experiment

In the 1960s Peter Higgs and others *need ref* put up the finishing touches on a theory combining three of the four fundamental forces. This theory became to be known as the Standard Model (SM) of particles physics. It predicted the existence of several particles which were discovered in the following decades. However, one particle was proving to be elusive, the so-called Higgs bosson. With this in mind the European Organization for Nuclear Research (CERN) started plans to build an accelerator large enough to be able to find this elusive particle. Hence, the Large Hadron Collider (LHC) was born.

2.1 The LHC Accelerator

A circular ring of 27 Km in circumference, the LHC was built at the French-Swiss border outside Geneva, Switzerland, see figure 2.1.

Four experiments were designed and build to test different physics theories and search for undiscovered particles at the LHC. Two of them, A Toroidal Large Aparatus (ATLAS) [1] and the Compact Muon Solenoid (CMS) [2] are large multipurpose experiments. The third experiment is LHCb [3], which is specifically dedicated to study B-meson physics, the last experiment ALICE [4], A Large Ion Collider Experiment,

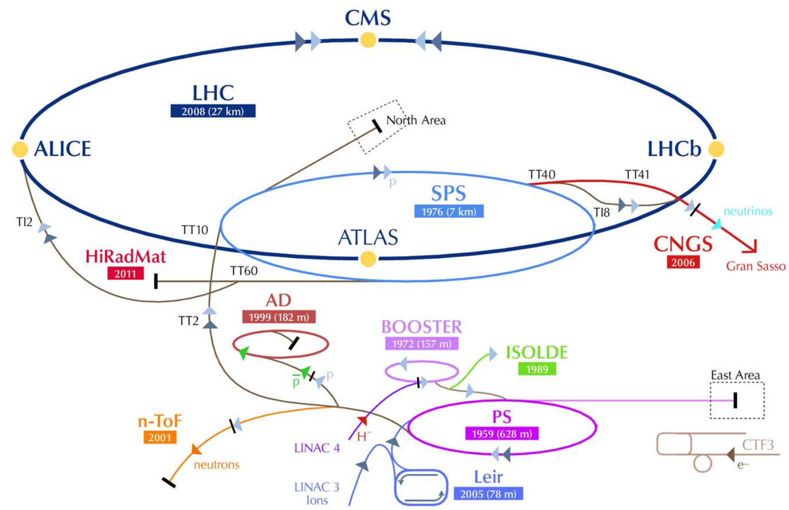

Figure 2.1: The CERN acceleration *facilities* showing the location of the four main experiment as well as the acceleration process[need ref].

was design to investigate heavy ion collisions.

2.2 CMS

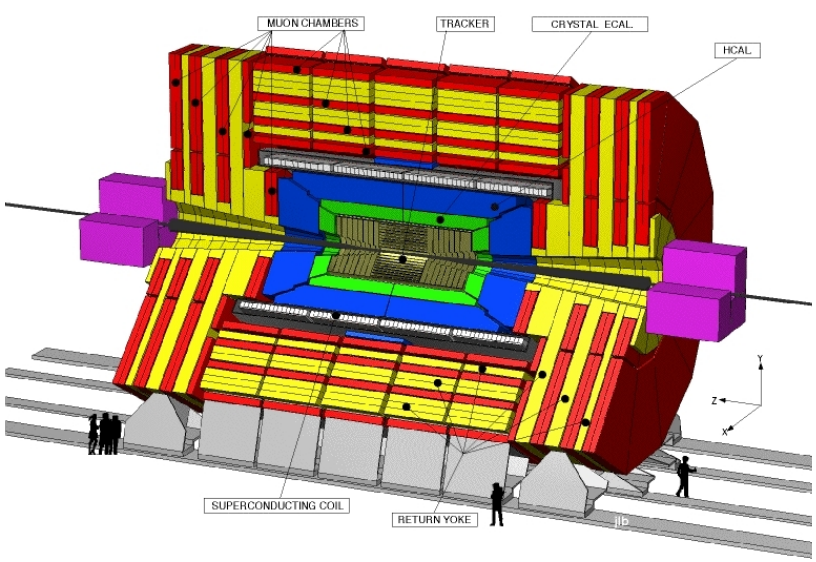

Figure 2.2: CMS cross sectional view.

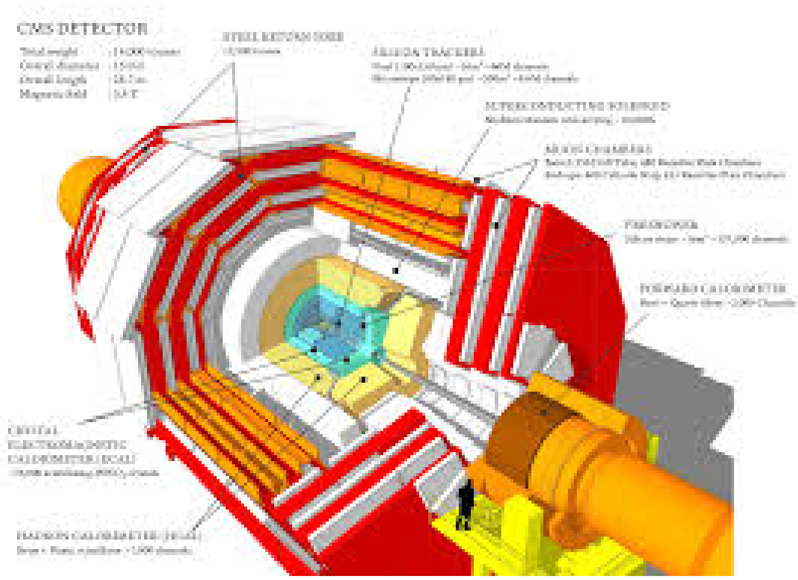

Figure 2.3: CMS cross sectional view.

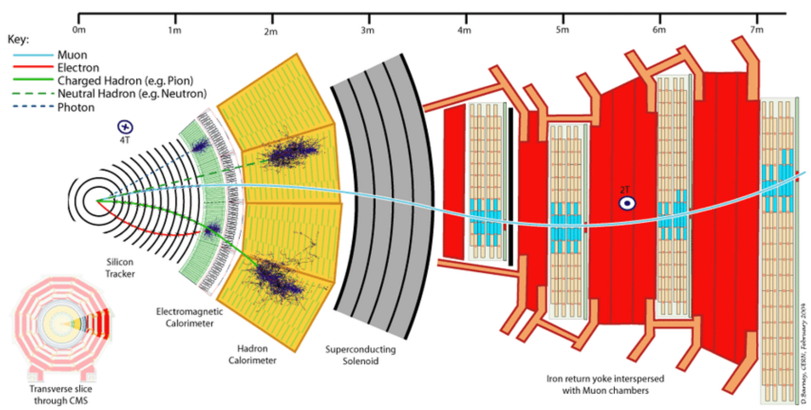

Figure 2.4: CMS cross sectional view.

2.2.1 The Tracker Detector

2.2.2 The Electromagnetic Calorimeter

2.2.3 The Hadronic Calorimeter

2.2.4 The Muon Chambers

Chapter 3

The SM and BSM Theories

Proposed in the 1960s the standard model of particles physics has been successful in describing many phenomena of the particle world

Chapter 4

Event generation, simulation and reconstruction

Description of event generation and simulation

Chapter 5

Search for the particle

Data analysis details

Chapter *6*

More on the Analysis?

More?

Chapter 7

Module Production for the Phase I CMS Pixel Detector Upgrade

As discussed in chapter 2 the CMS pixel detector will *suffer* from radiation damage throughout its lifetime hence the need for periodical updates. The first version of the detector was known as phase 0, it became fully operational 2010 after solving a setback during the original starting period in 2008. In 2017 the pixel detector was replaced during the so-called phase 1 upgrade, the University of Nebraska, high energy group (UNL-HEP) played a major role in assembling and testing over 500 modules, from 2013 to 2016, which then became part of the forward region of the pixel detector (FPix). The next update of this detector (phase 2) is projected to take place in 2025 when the current detector will be reaching its limits. In this chapter we describe why the phase 0 pixel detector needed an upgrade making

the work done by the UNL-HEP group. Some of these steps will be highlighted and described in detail as they were my contributions to this production campaign. Specially the and highlighting

7.1 The CMS Pixel Detector Phase I Upgrade

The CMS pixel detector is composed of two sections, the barrel section (BPix) and the forward section (FPix). Each of these sections (for phase 0) was composed of three layers originally designed to record three 3D positions (tracks) of the particles emerging from the *pp* collisions. As well as to provide information to reconstruct primary and secondary vertices of decaying particles. This detector performed well during the LHC run I,incorporate the bunch crossing? taking data at the design luminosity of $1x10^{34}cm^{-2}s^{-1}$, which was then used in many analysis including the discovery of the Higgs bosson published in 2013. But after a few years of operation the pixel detector started to degrade due to radiation damage, causing an increase of fake rates as well as loose on resolution. Moreover, for run II the LHC planned to double the luminosity with successive increment until reach its peak of $2x10^{35}cm^{-2}s^{-1}$. A simulation of the performance of the pixel detector under different luminosity conditions can be seen in figure 7.1

This degradation promted the need for an improved better

7.2 Module Production at UNL

The UNL module production workflow was designed to follow a pipeline-like as shown in figure 7.5

The UNL-HEP group assembly workflow started by receiving two components: a Bare Bonded Module (BBM) and a High Density Interconnect (HDI), see figure 7.3. Upon receiving, a visual inspection was done on these components to assure they were in good conditions and able to enter the production chain. A image showing the sort of thing we were looking for during the visual inspection could be seen in figure 7.8.

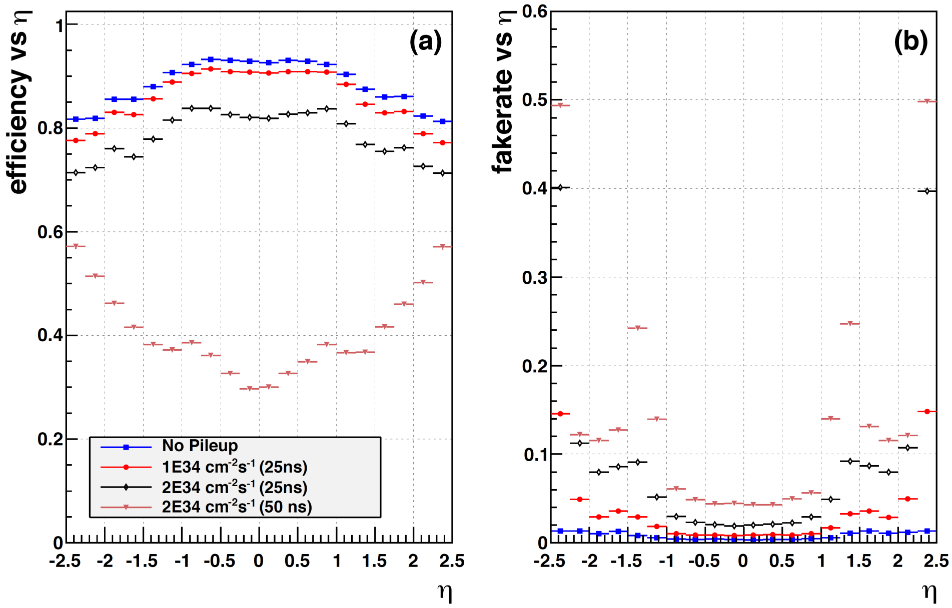

Figure 7.1: Expected performance of the original pixel detector under different luminosity conditions: a) track-finding efficiency; b) fake rate. Conventions are the same for both plots, considering zero pileup (blue squares), average pileup of 25 (red dots), average pileup of 50 (black diamonds), and average pileup of 100 (magenta triangles). [5]

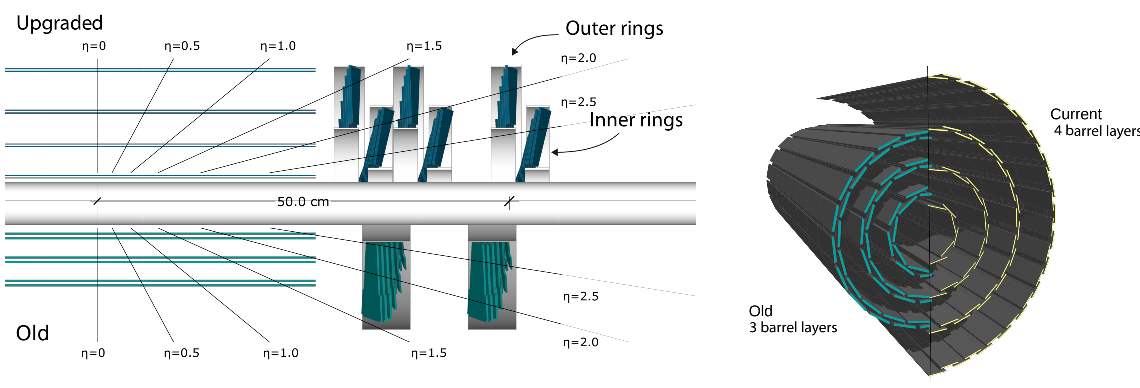

Figure 7.2: Layout and comparison of the layers and disks in the upgraded (Phase I) and old (Phase 0) pixel detectors [5].

Figure 7.3: Photograph of a BBM (left) and HDI (right) as were received by the UNL-HEP group.

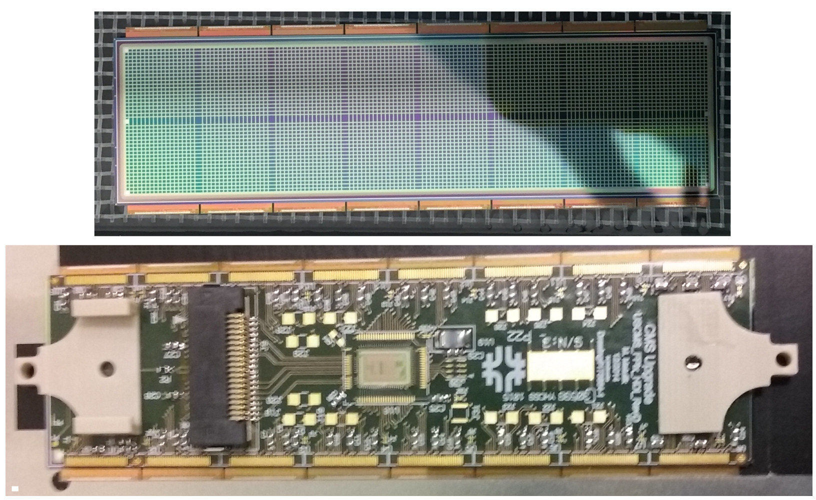

Figure 7.4: Visual inspection of a bare module.

7.2.1 visual inspections

7.2.2 IV-Curve

7.2.3 Module assembly

7.2.4 Electrical Test of a Fully assembly Module

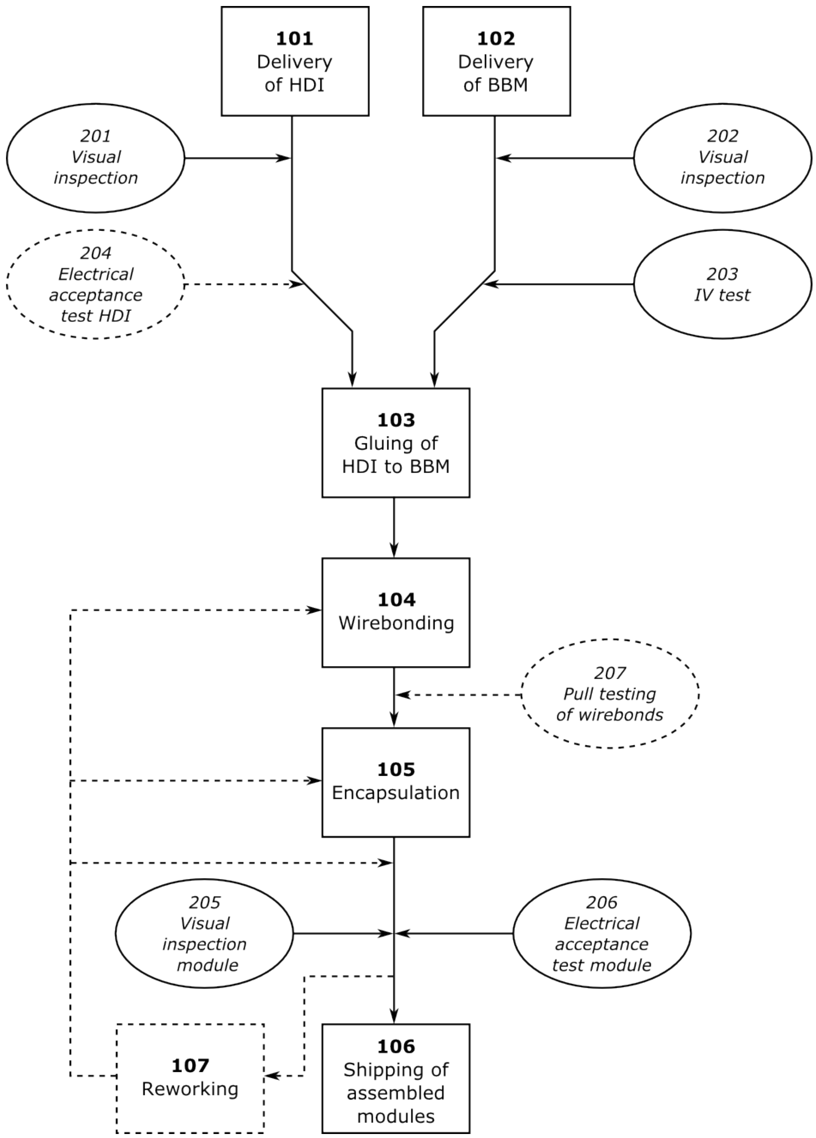

Figure 7.5: UNL module assembly work flow. Dashed lines represent occasional quality testing and reworking procedures; 10X numbers represent the stage within the assembly procedure while 20X numbers represent testing stages along the assembly procedure [**?**].

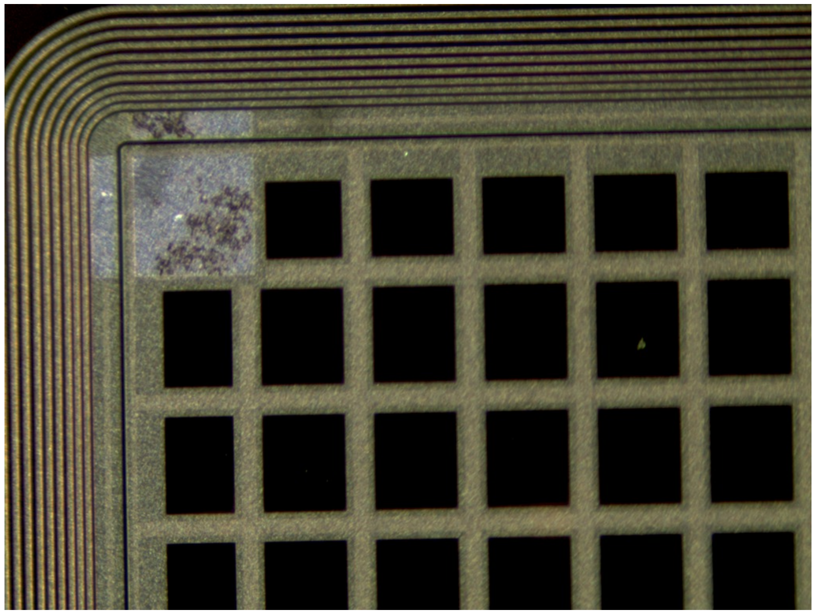

Figure 7.6: Visual inspection of a bare module.

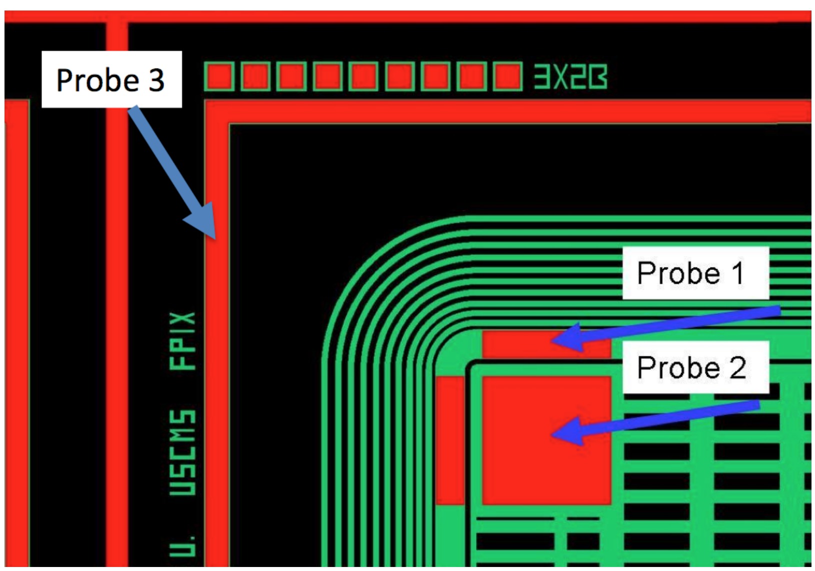

Figure 7.7: bla bla.

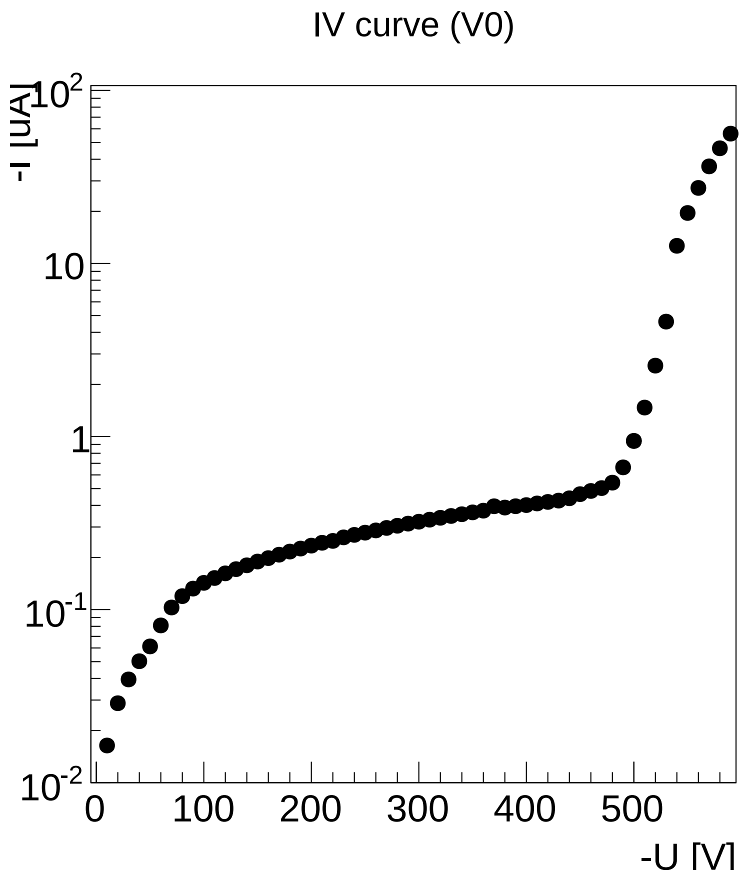

Figure 7.8: bla bla.

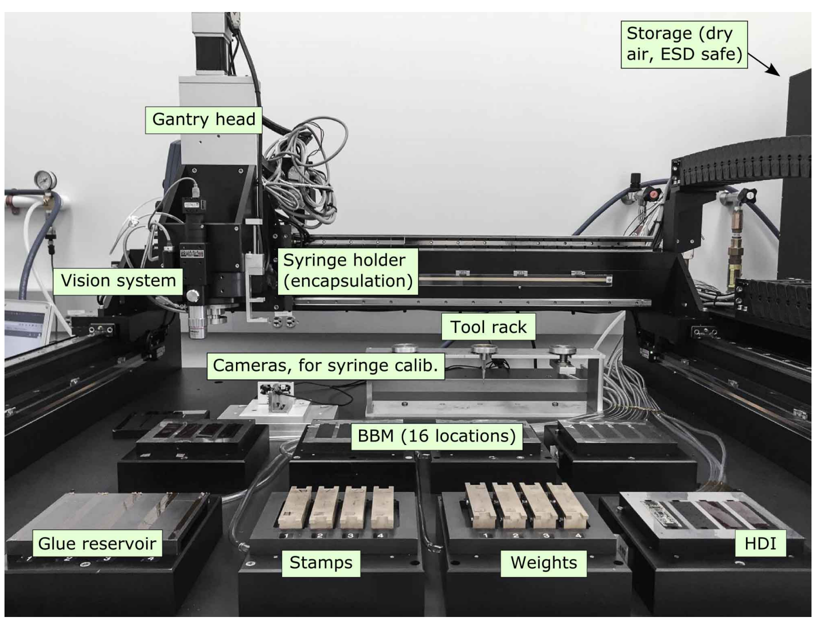

Figure 7.9: bla bla.

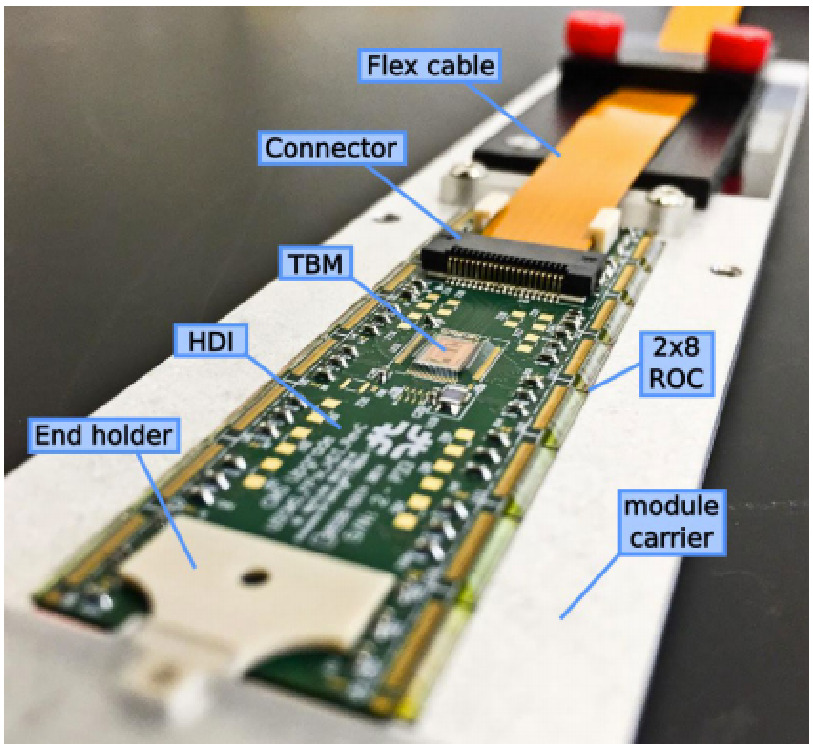

Figure 7.10: bla bla.

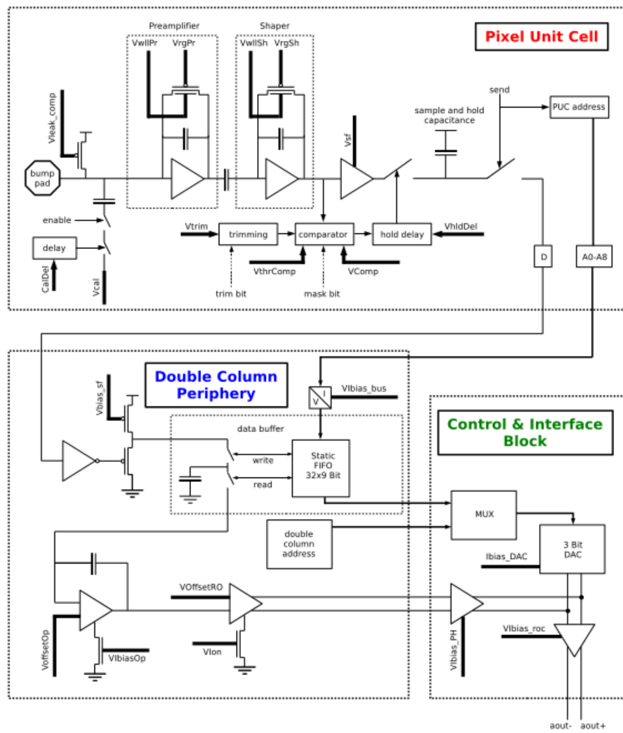

Figure 4. Schematic view of the readout chain

Figure 7.11: bla bla.

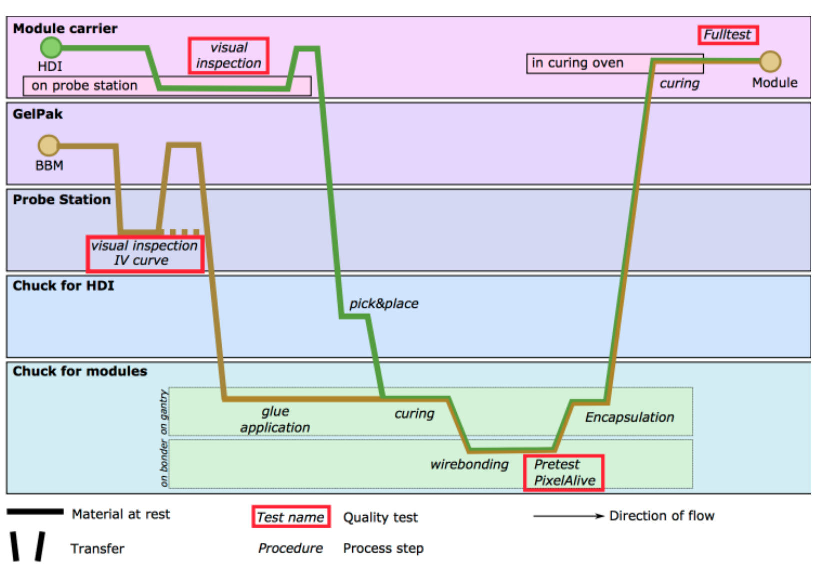

Figure 7.12: bla bla.

Chapter *8*

Beam Test of the RD53 chip for CMS Pixel Detector Upgrade Phase 2

8.1 Introduction

8.2 The RD53 Chip

8.3 Purpose of Test Beam

8.4 Test Beam Set Up

8.5 Results

Chapter *9*

Conclusions

9.1 Analysis

9.2 Phase 1

9.3 Beam Test

References

[1] The Atlas collaboration, Technical Design Report LHCC 99-14, ATLAS TDR 14. CERN, Geneva Switzerland, 1999

[2] CMS Collaboration. The CMS Experiment at the CERN LHC. Volume 3, 2008.

[3] LHCb Collaboration, S. Amato et al., LHCb technical proposal,CERN-LHCC-98-04

[4] ALICE: Technical proposal for a large ion collider experiment at the CERN LHC, CERN-LHCC-95-71.

[5] A. Dominguez et. al. “CMS Technical Design Report for the Pixel Detector Upgrade”, CERN-LHCC-2012-016. CMS-TDR-11.

[6] UNL Phase I FPIX Assembly Standard Operating Procedures. From https://github.com/psi46/unl-sop, 2016.