**Introduction, overview and context**

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This series of tutorials describes the usage of various parts of the Pixel detector and SR1 system that were used while working on Pixel firmware related tasks.

This document also aims to serve as a starting point for new students getting into the Pixel detector, however this guide and most linked theses will be more firmware oriented. This will also include useful references that direct to theses and documentation links. The usage of YARR/FELIX will be covered other manuals. Reading through this entire section is recommended before going into each of the theses and links.

**Getting Started**

There are three main components to know about when it comes to work related to LHC in ACME

- LHC in general (most theses have a section about it). This is a good summary <https://people.ece.uw.edu/hauck/LargeHadronCollider/>

- Current setup in ATLAS Pixel - ROD/BOC - FEI3/4

See this for some context: <https://github.com/uw-acme/acme-lab-documentation/blob/main/lhc/Pixel_IBL/Pixel_IBL_resource_list.md>

- Ongoing development for future upgrade - YARR/FELIX- RD53 (most of the recent theses)

**Reading recommendations**

Refer to these theses for more detailed background on LHC and ATLAS and specific topics as listed below. There are more theses in the same repo and Prof. Hauck’s publications page (<https://people.ece.uw.edu/hauck/publications.html>) but this is a good starting point

* Bing (current system and firmware in detail, some things may be outdated): <https://github.com/uw-acme/acme-lab-documentation/blob/main/lhc/thesese/BingThesis.pdf>
* Nick (overview of current system, useful comparisons in the first half that give good context): <https://github.com/uw-acme/acme-lab-documentation/blob/main/lhc/thesese/NickDreyer_Thesis.pdf>
* Joe (some currently used stuff + future upgrade, might be useful if things are not covered in previous already): <https://github.com/uw-acme/acme-lab-documentation/blob/main/lhc/thesese/Joe_Mayer_Thesis.pdf>
* Douglas (future upgrade): <https://github.com/uw-acme/acme-lab-documentation/blob/main/lhc/thesese/DouglasSmith_MS.pdf>
* Niharika (RD53B, part on readout systems): <https://github.com/uw-acme/acme-lab-documentation/blob/main/lhc/thesese/NiharikaMittal_Thesis.pdf>

**Links to repos (may require access through SR1/CERN account)**

* Everything related to LHC in ACME: <https://github.com/uw-acme/acme-lab-documentation/tree/main/lhc>
* ATAS Pixel DAQ repo: <https://gitlab.cern.ch/atlas-pixel/daq/atlaspixeldaq>
* ATLAS Pixel ROD Slave repo: <https://gitlab.cern.ch/atlas-pixel/daq/pixelrod_firmware/RodSlave>

**Some useful notes**

**Pixel and IBL**

Pixel firmware specifically refers to the outer 3 layers even though IBL is a part of the Pixel Detector.

Frontend chips FEI3 connect to an MCC only in Pixel (FE->MCC->BOC->ROD). This is not the case for IBL’s FEI4 which have some differences compared to FEI3.

The **hardware** (FPGA types and boards) for the readout chain in both Pixel and IBL are the same. However, there are differences in the **firmware** (VHDL) to take into consideration the differences in the front ends.

**Datataking and Calibration**

Datataking is the main function of the system, to collect physics data and send it further in the chain.

Calibration is used to run monitoring scans to check the status of the system. This requires the MicroBlaze (a soft processor) in the ROD slave firmware, mainly to control histogramming.

Initially both of these functionalities were in one ROD Slave firmware version. However, it was later decided that since these both will not be used at the same time, for Run 3 they can be split into 2 different versions to add more features specific to each version. This was not possible earlier with constraints in resources on the FPGA, especially because of the MicroBlaze for calibration that takes up a lot of resources.

**Other important references**

* ROD Manuals: <https://github.com/uw-acme/acme-lab-documentation/tree/main/lhc/Pixel_IBL/IBL_ROD_Manuals>
* MCC Manual Manuals: <https://github.com/uw-acme/acme-lab-documentation/tree/main/lhc/Pixel_IBL/MCC-FE-I3>

<https://github.com/uw-acme/acme-lab-documentation/tree/main/lhc/Pixel_IBL/FE-I4>

* Pixel Dataformat: <https://github.com/uw-acme/acme-lab-documentation/tree/main/lhc/Pixel_IBL/DataFormat/RODByteStreamErrors.pdf>

**Tutorials list**

1. Introduction and setting up SR1, DAQSlice (datataking with emulator)
2. Loading firmware (ace file) from PROM and directory
3. Viewing histograms (datataking)
4. RODSlave firmware local ISE compilation- till bitfile generation
5. Bitfile to acefile that is required
6. Chipscope in SR1 – remotely look at signals in ROD FPGAs
7. GitLab pipeline for compiling firmware and getting ace files (preferred over local setup)
8. Reading and writing registers in ROD while running
9. Operating real modules in SR1 – both datataking and calibration
10. Changing trigger parameters through Dave Card
11. Command cheat sheet – list of all commands used