FPGA Development for the LHCb Vertex Locator Upgrade

Nicholas Mead
8064141
School of Physics and Astronomy
University of Manchester

December 7, 2015

Abstract

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Curabitur blandit purus ut lacus aliquam, a sodales ante sodales. Etiam a elit nunc. Mauris ipsum tellus, ullamcorper et arcu at, cursus malesuada elit. In tempus pellentesque nisi, vel egestas enim cursus tempus. Sed velit urna, luctus sed efficitur sed, laoreet vitae magna. Mauris elementum dignissim lacus vitae tempus. Curabitur laoreet molestie dictum. Donec sit amet auctor nisl.

Duis pellentesque euismod pellentesque. Praesent volutpat tincidunt eros, at faucibus tellus eleifend a. Quisque molestie sed ante sit amet sodales. Duis sed justo quam. Curabitur tellus felis, laoreet et bibendum a, posuere eget nisi. Donec suscipit lacinia porttitor. Aenean posuere sem nibh, et iaculis nisl faucibus eu. Donec ac posuere sapien. Aenean suscipit, nisi eget porttitor viverra, dui sapien vulputate lectus, ut dapibus purus orci nec arcu. Etiam placerat sapien non massa fringilla, et malesuada nibh hendrerit. Vestibulum et porttitor mi. Aliquam turpis velit, rutrum vitae erat at, scelerisque cursus lacus. Praesent libero urna, sodales efficitur eros id, sodales lacinia sem. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas.

Contents

1 Introduction

1.1 The Standard Model of Particle Physics

Central to the moden age of particle physics in the standard model,

$$
\begin{aligned}
L_{GWL} = \sum_f (\bar{\Psi}_f (i\gamma^\mu \partial\mu - m_f)\Psi_f - eQ_f \bar{\Psi}_f \gamma^\mu \Psi_f A_\mu) + \frac{g}{\sqrt{2}} \sum_i (\bar{a}_L^i \gamma^\mu b_L^i W_\mu^+ + \bar{b}_L^i \gamma^\mu a_L^i W_\mu^-) \\
+ \frac{g}{2x_w} \sum_f \bar{\Psi}_f \gamma^\mu (I_f^3 - 2s_w^2 Q_f - I6 e_f \gamma_5)\Psi_f Z_\mu - \frac{1}{4}|\partial_\mu A_v - \partial_v A_\mu - ie(W_\mu^- W_v^+ - W_\mu^+ W_v^-)|^2 \\
- \frac{1}{2}|\partial_\mu W_v^+ - \partial_v W_\mu^+ - ie(W_\mu^+ A_v - W_v^+ A_\mu) + ig' c_w (W_\mu^+ Z_v - W_v^+ Z_\mu|^2 \\
- \frac{1}{4}|\partial_\mu Z_v - \partial_v Z_\mu + ig' c_w (W_\mu^- W_v^+ - W_\mu^+ W_v^-)|^2 - \frac{1}{2} M_\eta^2 \eta^2 - \frac{g M_\eta^2}{8 M_W}\eta^3 - \frac{g'^2 M_\eta^2}{32 M_W}\eta^4 \\
+ |M_W W_\mu^+ + \frac{g}{2}\eta W_\mu^+|^2 + \frac{1}{2}|\partial_\mu \eta + i M_Z Z_\mu + \frac{ig}{2c_w}\eta Z_\mu|^2 - \sum_f \frac{g m_f}{2 M_W} \bar{\Psi}_f \Psi_f \eta. \quad (1)
\end{aligned}
$$

The standard model, shown in equation 1, is a quantum field theory that discribes the fundermental particles and how they interact. While this essay does require, or attempt, to understand the intricate detail of the stardard model; the aim of many particle physics experiments is to Test, measure and varify the model. Dispite being the current best theory to explain particle interactions, the model is not complete. There are many undescribed phemimina, such as the matter domination in the universe, that require physics behond the standard model. To that end, major international efforts, namely in the form of the Large Hardrom Collider, aim to further knowledge and understanding of the underlying physics of the universe. [1]

1.2 The LHCb Experiment

One such Experiment and the Large Hadrom Colider is Large Hadron Colider beauty (LHCb). Located at intersection point

figure **??**.

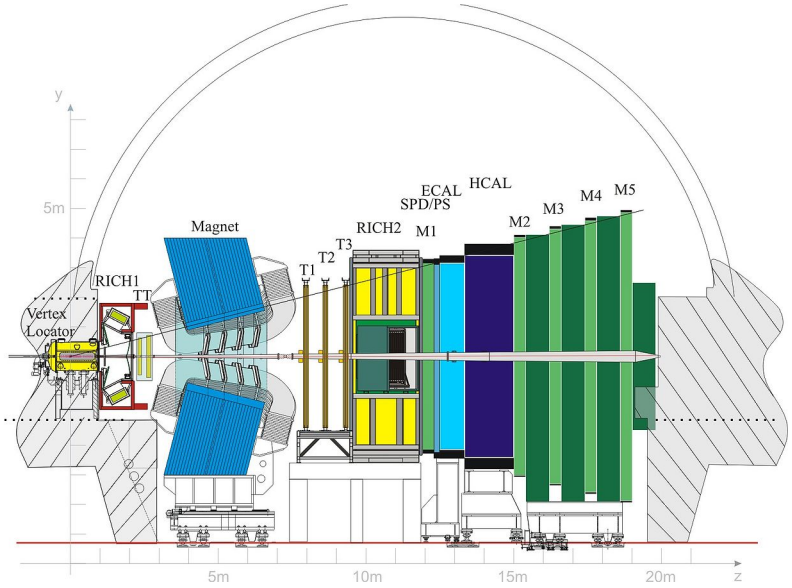

Figure 1: The LCHb Detector along the bending plane.

1.2.1 The Detector

1.2.2 Physics Studied at LHCb

1.2.3 VELO Upgrade

1.3 FPGAs in Particle Detectors

1.3.1 Field Programable Gate Arrays

1.3.2 The Role of FPGA's in the VELO Upgrade

2 Scrambling Algorithms

2.1 The Role of Scrambling Data in the VELO

2.2 Additive and Multiplicative Scramblers

2.3 The Different Options for Scrambleing Algorithms

2.4 Algorithm Analysis

2.4.1 Messurements of the Algorithms

2.4.2 Results of Analysis

2.5 Conclusion

3 Event Isolation Flagging

Event Isosation

3.1 Motivation

Motivation

3.2 Time Sorting Data

Time Sorting

3.3 Bubble Sorting

Bubble Bubble Bubble

3.4 Isotation Checking

Isolation Checking

3.5 Conclusion

In Conclusion, Nick is Awesome

4 Future Development

This is future dev

4.1 LHCb 2020 Upgrade

2020 upgrade

4.2 Further Development of FPGA's in the VELO

fpga in velo

5 Conclusion

This is the Conclusion

6 Acknoledgments

I would like the Acknoledge Pablo Rodriguez and Marco Gersabeck for there continued support and supervision.

References

[1] Cern. *The Standard Model*. 2015. URL: http://home.cern/about/physics/standard-model.