

FPGA Development for the LHCb Vertex Locator Upgrade

Nicholas Mead

8064141

School of Physics and Astronomy
University of Manchester

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Abstract

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1 Introduction

1.1 The Standard Model of Particle Physics

Central to the modern age particle physics is the standard model,

$$\begin{aligned} L_{GWL} = & \sum_f (\bar{\Psi}_f (i\gamma^\mu \partial_\mu - m_f) \Psi_f - e Q_f \bar{\Psi}_f \gamma^\mu \Psi_f A_\mu) + \\ & \frac{g}{\sqrt{2}} \sum_i (\bar{a}_L^i \gamma^\mu b_L^i W_\mu^+ + \bar{b}_L^i \gamma^\mu a_L^i W_\mu^-) + \\ & \frac{g}{2x_w} \sum_f \bar{\Psi}_f \gamma^\mu (I_f^3 - 2s_w^2 Q_f - I 6e_f \gamma_5) \Psi_f Z_\mu - \\ & \frac{1}{4} |\partial_\mu A_v - \partial_v A_\mu - ie(W_\mu^- W_v^+ - W_\mu^+ W_v^-)|^2 - \\ & \frac{1}{2} |\partial_\mu W_v^+ - \partial_v W_\mu^+ - ie(W_\mu^+ A_v - W_v^+ A_\mu) + ig' c_w (W_\mu^+ Z_v - W_v^+ Z_\mu)|^2 - \\ & \frac{1}{4} |\partial_\mu Z_v - \partial_v Z_\mu + ig' c_w (W_\mu^- W_v^+ - W_\mu^+ W_v^-)|^2 - \\ & \frac{1}{2} M_\eta^2 \eta^2 - \frac{g M_\eta^2}{8 M_W} \eta^3 - \frac{g'^2 M_\eta^2}{32 M_W} \eta^4 + |M_W W_\mu^+ + \frac{g}{2} \eta W_\mu^+|^2 + \\ & \frac{1}{2} |\partial_\mu \eta + i M_Z Z_\mu + \frac{ig}{2c_w} \eta Z_\mu|^2 - \sum_f \frac{gm_f}{2M_W} \bar{\Psi}_f \Psi_f \eta. \end{aligned} \quad (1)$$

The standard model, shown in equation 1, is a quantum field theory that describes the fundamental particles and how they interact. While this essay does require, or attempt, to understand the intricate detail of the standard 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. [?]

1.2 The LHCb Experiment

One such Experiment and the Large Hadrom Colider is Large Hadron Colider beauty (LHCb).

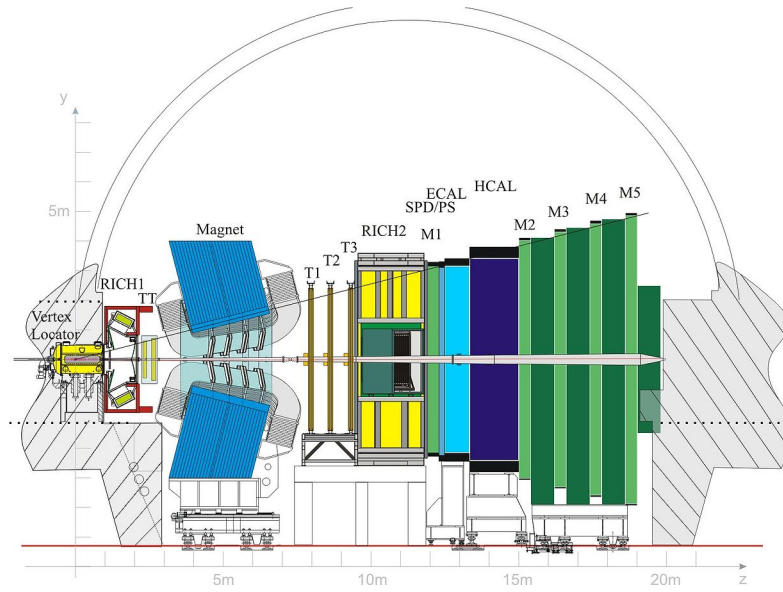


Figure 1: The LCHb Detector along the bending plane.

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

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2.3 The Different Options for Scrambling Algorithms

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2.4.2 Results of Analysis

2.5 Conclusion

3 Event Isolation Flagging

Event Isolation

3.1 Motivation

Motivation

3.2 Time Sorting Data

Time Sorting

3.3 Bubble Sorting

Bubble Bubble Bubble

3.4 Isolation 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 Acknowledgments

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