

FPGA Development for the LHCb Vertex Locator Upgrade

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Abstract

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1 Introduction

1.1 The Standard Model of Particle Physics

$$\begin{aligned}
L_{GWL} = & \sum_f (\bar{\Psi}_f (i\gamma^\mu \partial_\mu - m_f) \Psi_f - e Q_f \bar{\Psi}_f \gamma^\mu \Psi_f A_\mu) + \frac{g}{\sqrt{2}} \sum_i (\bar{a}_L^i \gamma^\mu b_L^i W_\mu^+ + \bar{b}_L^i \gamma^\mu a_L^i W_\mu^-) \\
& + \frac{g}{2x_w} \sum_f \bar{\Psi}_f \gamma^\mu (I_f^3 - 2s_w^2 Q_f - I6e_f \gamma_5) \Psi_f Z_\mu - \frac{1}{4} |\partial_\mu A_v - \partial_v A_\mu - ie(W_\mu^- W_v^+ - W_\mu^+ W_v^-)|^2 \\
& - \frac{1}{2} |\partial_\mu W_v^+ - \partial_v W_\mu^+ - ie(W_\mu^+ A_v - W_v^+ A_\mu) + ig' c_w (W_\mu^+ Z_v - W_v^+ Z_\mu)|^2 \\
& - \frac{1}{4} |\partial_\mu Z_v - \partial_v Z_\mu + ig' c_w (W_\mu^- W_v^+ - W_\mu^+ W_v^-)|^2 \\
& - \frac{1}{2} M_\eta^2 \eta^2 - \frac{g M_\eta^2}{8 M_W} \eta^3 - \frac{g'^2 M_\eta^2}{32 M_W} \eta^4 + |M_W W_\mu^+ + \frac{g}{2} \eta W_\mu^+|^2 + \frac{1}{2} |\partial_\mu \eta + i M_Z Z_\mu + \frac{ig}{2c_w} \eta Z_\mu|^2 - \sum_f \frac{gm_f}{2M_W} \bar{\Psi}_f \Psi_f \eta
\end{aligned} \tag{1}$$

1.2 The LHCb Experiment

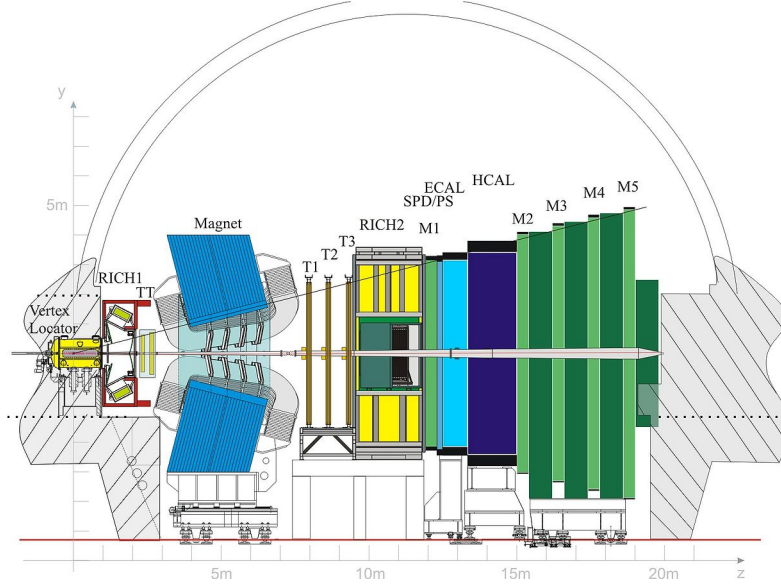


Figure 1: The LHCb Detector along the bending plane.

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 Scrambling Algorithms

2.4 Algorithm Analysis

2.4.1 Measurements of the Algorithms

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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References

- [1] Cern. *LCHb Collaboration*. 2015. URL: <http://lhcb.web.cern.ch/lhcb/> (visited on 11/21/2015).