Primary Vertex Reconstruction with CMS p2gt

By Claire Lundy

Overview

Working on CMS Phase-2 Global Trigger writing a program in VHDL to identify particles coming from primary vertices

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- This identification is important because from it, we can reconstruct events and understand more about what happened during a collision. Generally, it improves efficiency and allows us to select the appropriate downstream algorithms.

Some Explanation

- Specifically, a *primary* vertex is the vertex (collision point) with the largest sum of track momentum.

- To assign tracks to a primary vertex, we can look at z-axis separation. The firmware will be designed to make a comparison between individual tracks and a primary vertex. If this z separation is less than some value, it will be assigned to the primary vertex.

Why use VHDL?

- VHDL is a **Hardware Description Language**. These allow us to describe problems in digital logic. Instead of writing a program that's executed by a computer, HDLs describe the hardware itself.

- The main differences to note between programming languages and HDLs is that HDLs execute code in parallel and work on a clock cycle, which allows for really fast decision making.

So far...

- I've written two programs and simulations in VHDL: one for making cuts based on an absolute difference and one for moving/storing information synched to a clock cycle.
- Both simple designs but the beginnings of what needs to be integrated into the p2gt firmware
- In principle, these concepts aren't hard to imagine but in practice, designing logic that fits into the existing firmware and follows timing constraints will make things more difficult
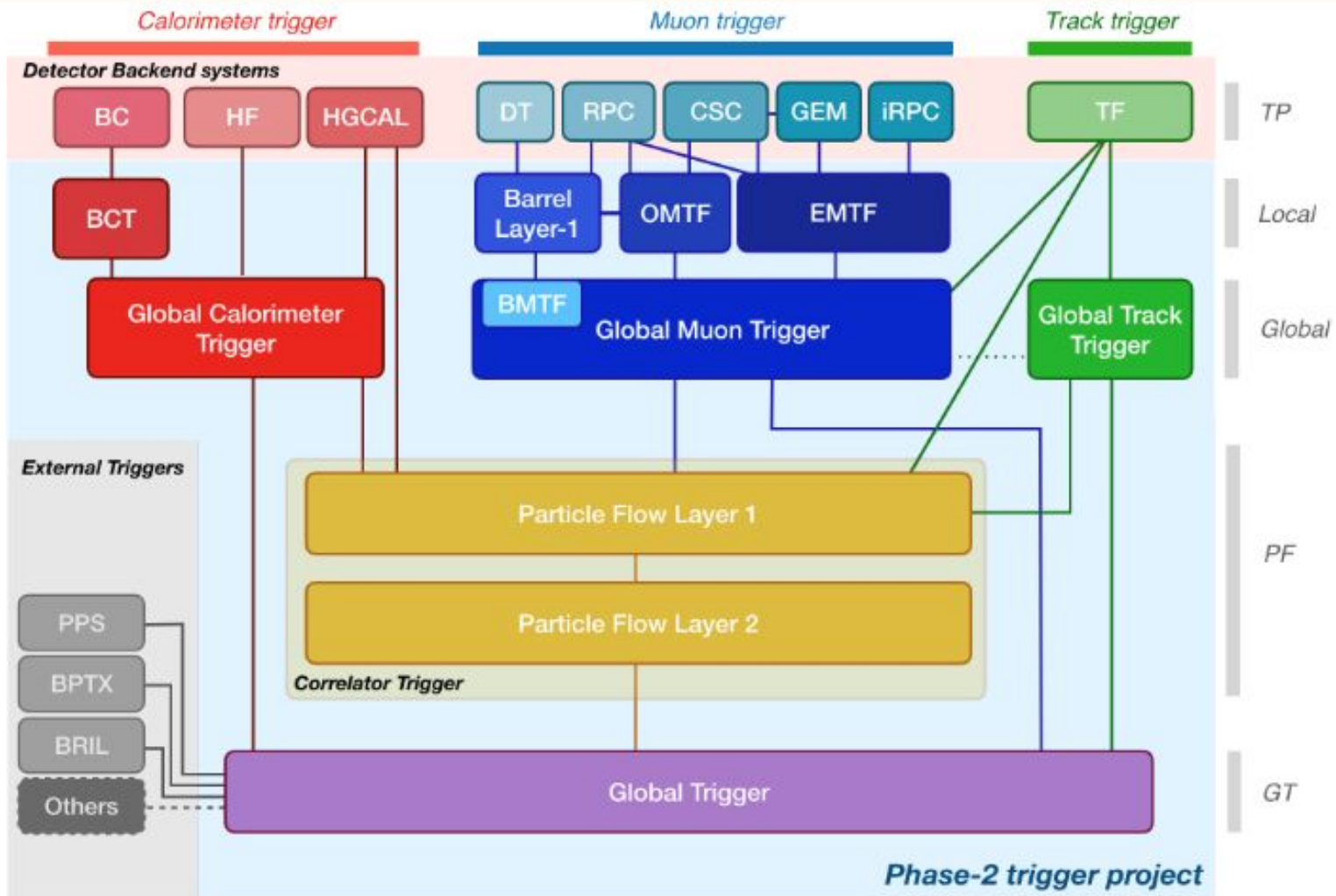
References & I went to Venice last weekend!

https://cds.cern.ch/record/2714892/files/CMS-TDR-021.pdf

E Leutgeb 2023 *Summer Student Programme*

W Erdmann 2008 *J. Phys.: Conf. Ser.* 110 092009

Calorimeter trigger   **Muon trigger**   **Track trigger**

Detector Backend systems

BC | HF | HGCAL | DT | RPC | CSC | GEM | iRPC | TF — *TP*

BCT | Barrel Layer-1 | OMTF | EMTF — *Local*

Global Calorimeter Trigger | BMTF | Global Muon Trigger | Global Track Trigger — *Global*

External Triggers

PPS | BPTX | BRIL | Others

Particle Flow Layer 1

Particle Flow Layer 2 — *PF*

Correlator Trigger

Global Trigger — *GT*

Phase-2 trigger project