

Flexible trigger menu implementation on the Global Trigger for the CMS Level-1 trigger upgrade

Takashi MATSUSHITA for the CMS collaboration

Institute of High Energy Physics, Austrian Academy of Sciences



CMS Level-1 Trigger Upgrade

- Upgraded CMS Level-1 trigger system to improve its performance and to operate within the predefined data-acquisition rate of 100 kHz at the instantaneous luminosity of $2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$.
- Replaced VME based electronics for the calorimeter, muon and global trigger systems with μ TCA based system.
- Upgraded system is flexible for implementing further rate reduction and efficiency improvements with advancements of algorithms.
- The flexibility is accomplished by using high-bandwidth optical links for the data communication between trigger cards, and by using modern, large FPGAs and large memory resources for the trigger logic.

Global Trigger

- Global Trigger (GT) is the final step of the CMS Level-1 Trigger and implements a trigger menu (L1 Menu), a set of selection requirements applied to the final list of objects from calorimeter and muon triggers. [Fig. 1]
- GT implemented on μ TCA system (uGT) has increased processing resources, enabling more algorithms at a time than previously possible, allowing CMS to be more flexible for managing the trigger bandwidth.
- CMS will also be able to match different objects, e.g. muons with jets, with higher resolution and efficiency and be able to calculate more sophisticated quantities such as the mass of a pair of objects.

uGT Trigger Menu Library

- In order to handle the increased complexity of the trigger menu, uGT Trigger Menu (UTM) library, has been developed.
- For expressing selection algorithms in an intuitive way, a set of rules has been introduced (L1 Menu grammar). An algorithm is expressed in an abstract way to enable evolution of the uGT.

L1 Menu grammar

- Select events having at least one muon with minimum p_T of 20 GeV:

MU 20,

threshold value concatenated to trigger object type

Object type: MU, EG, TAU, JET, ETM, ETT etc.

Trigger objects available in 5 bunch crossings [Fig. 2]

- Additional cuts on trigger objects are specified in square brackets:

MU20 [MU-QLTY_SNGL,MU-ETA_2p10]

- More complex algorithms are composed with functions:

dist{ JET32,MU0[MU-QLTY_DBLE] }[DPHI_MAX_0p4],

computes distance of objects in curly brackets then apply $\Delta\phi$ cut.

dist: distance between two objects

mass: invariant mass of two objects

comb: compose multi-object trigger for the same object type

- Evolution of uGT algorithm possible by updating L1 Menu grammar

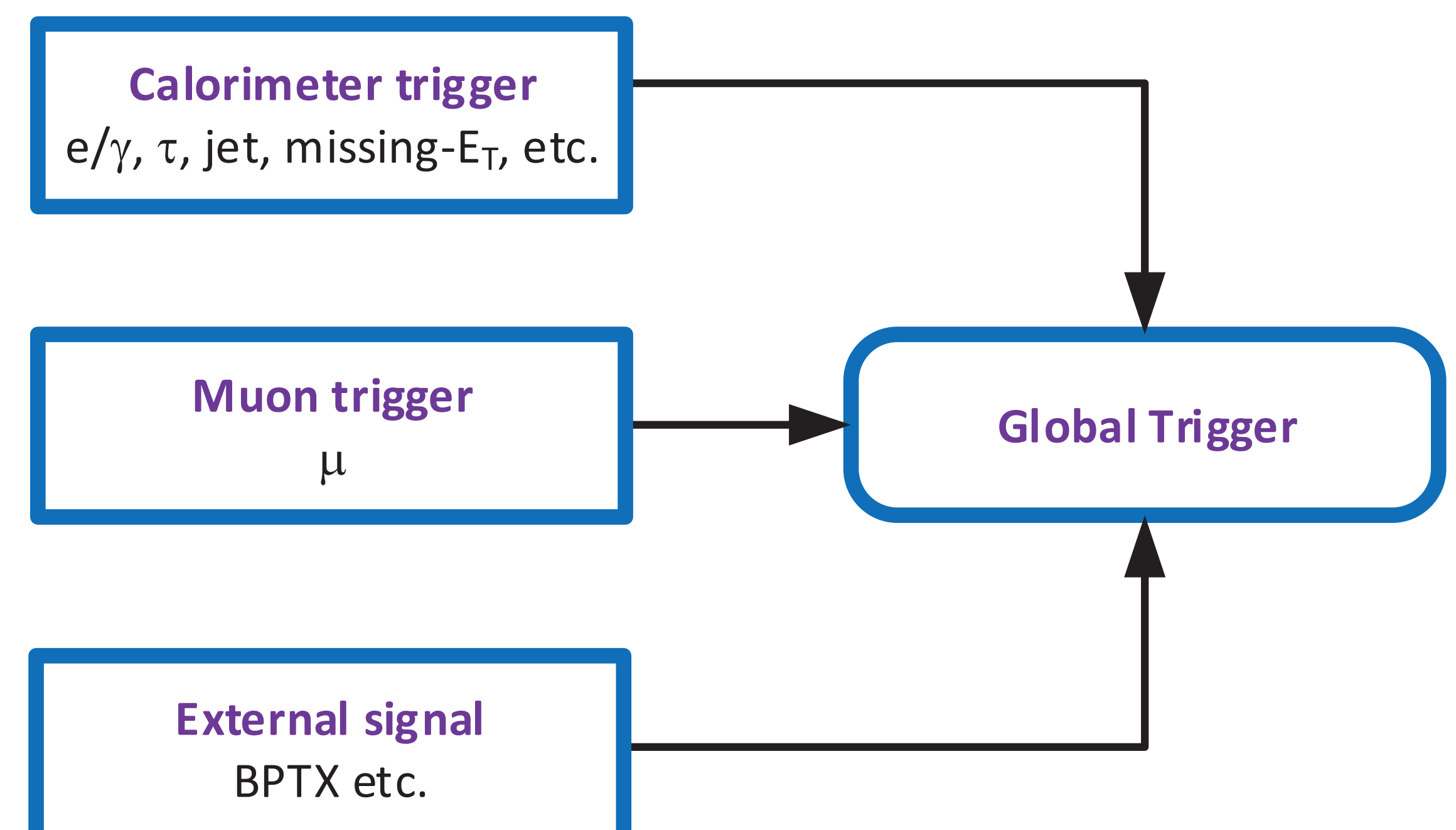


Fig. 1: Schematic view of the CMS Level-1 trigger system

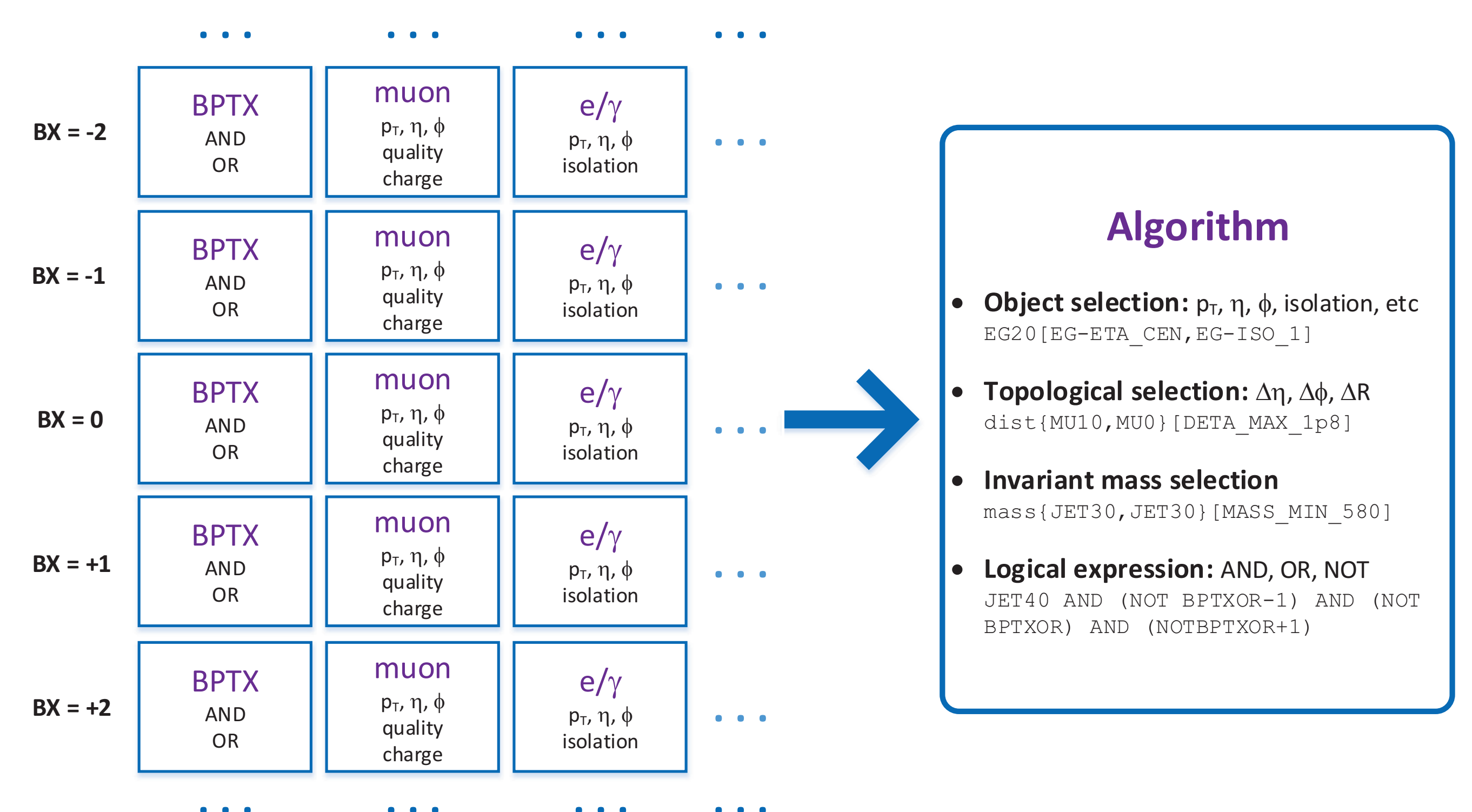


Fig. 2: Trigger objects and algorithms on uGT

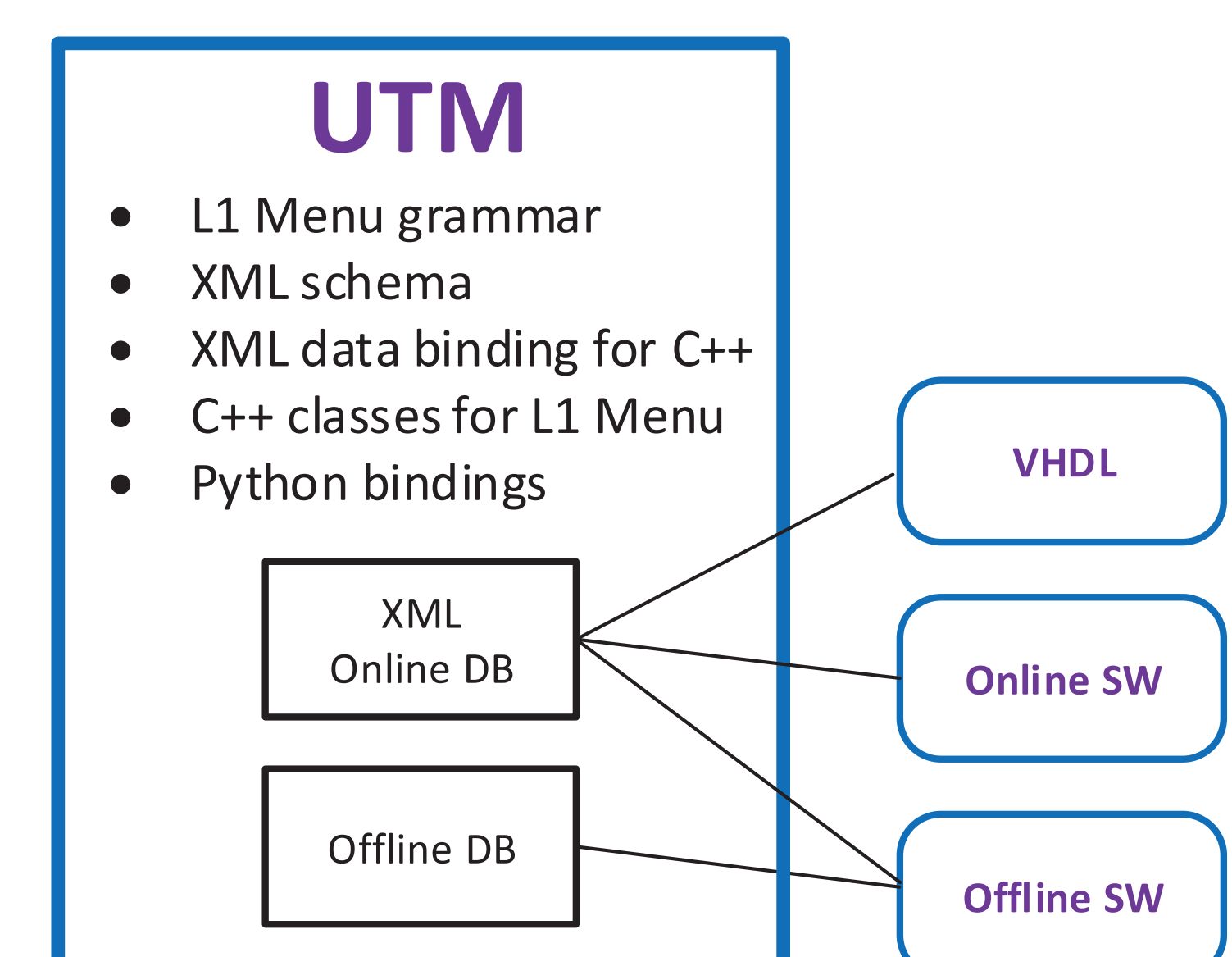
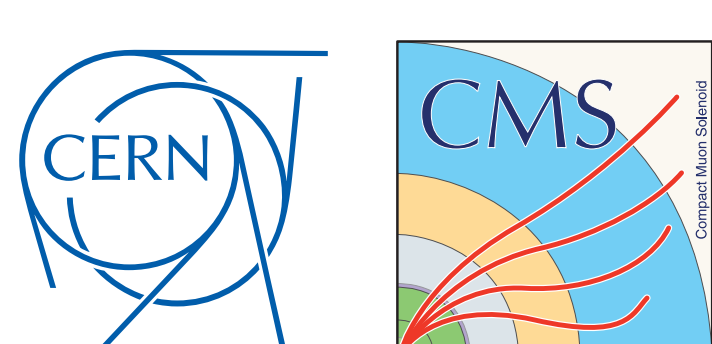


Fig. 3: Overview of uGT Trigger Menu library and its use

UTM library

- Core components of UTM C++ library is the following [Fig. 3].
tmGrammar: L1 Menu grammar with Boost.Spirit
tmXsd: XML data to C++ binding generated from XML schema with Code Synthesis XSD
tmEventSetup: C++ classes for L1 Menu stored in offline DB
- Thanks to the introduction of L1 Menu grammar, evolution of uGT algorithms possible without changing XML schema and C++ classes for L1Menu stored in offline DB.
- Python binding is created with SWIG and used to build GUI for editing L1 Menu and to generate VHDL code from L1 Menu.
- Automatic generation of L1 Menu will be possible for integrating L1 menu studies and L1 menu generation.



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presented by Takashi MATSUSHITA email:takashi.matsushita@cern.ch