Workshop da Rede Nacional de Física de Altas Energias (RENAFAE) 2022

# Trigger de Múons de Primeiro Nível Assistido pela Calorimetria (TileCal) no Experimento ATLAS

VICTOR A. FERRAZ
on behalf of TMDB team

ATLAS EXPERIMENT

UFRN
UNIVERSIDADE FEDERAL DO RIO GRANDE DO NORTE

COPPE UFRJ
Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia

ufjf
UNIVERSIDADE FEDERAL DE JUIZ DE FORA

UFBA
Universidade Federal da Bahia

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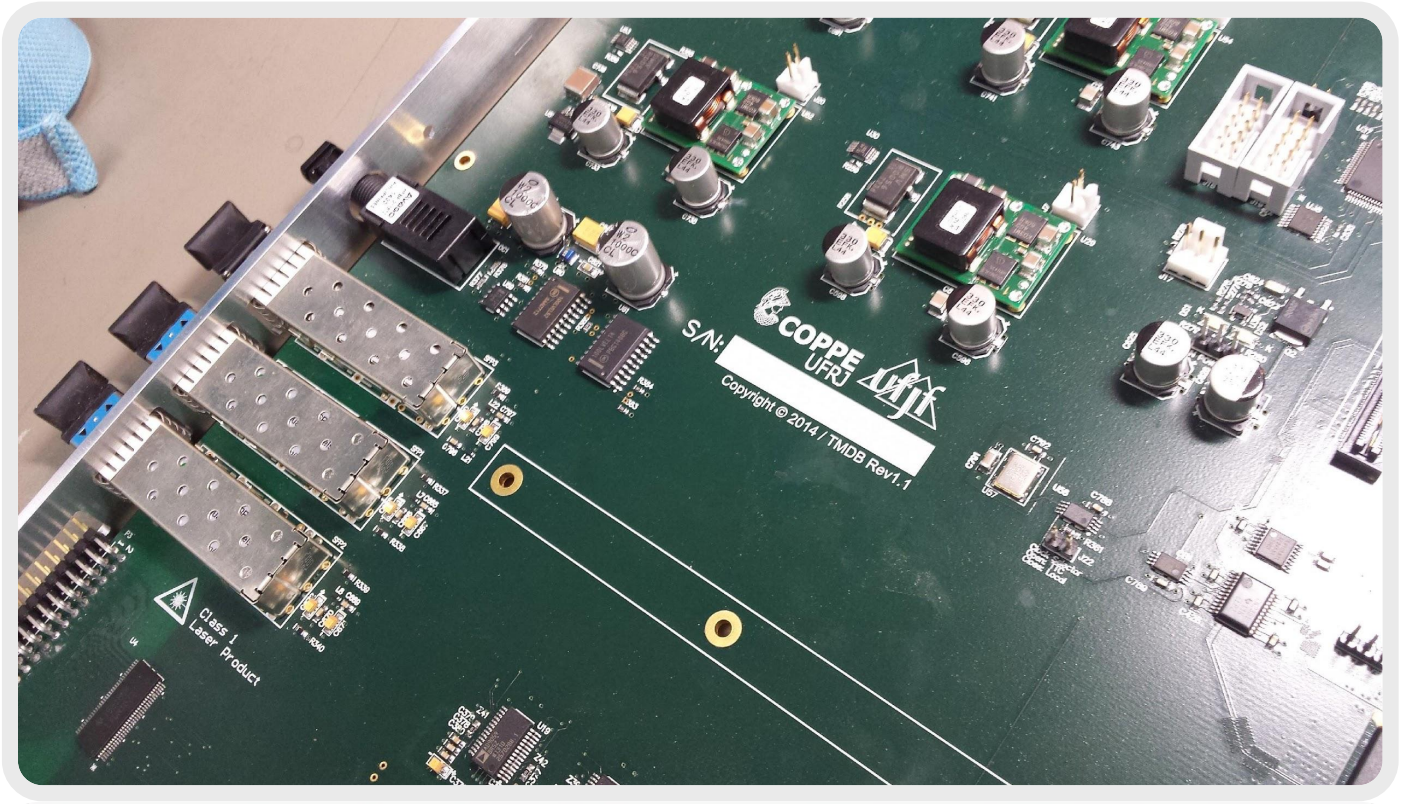
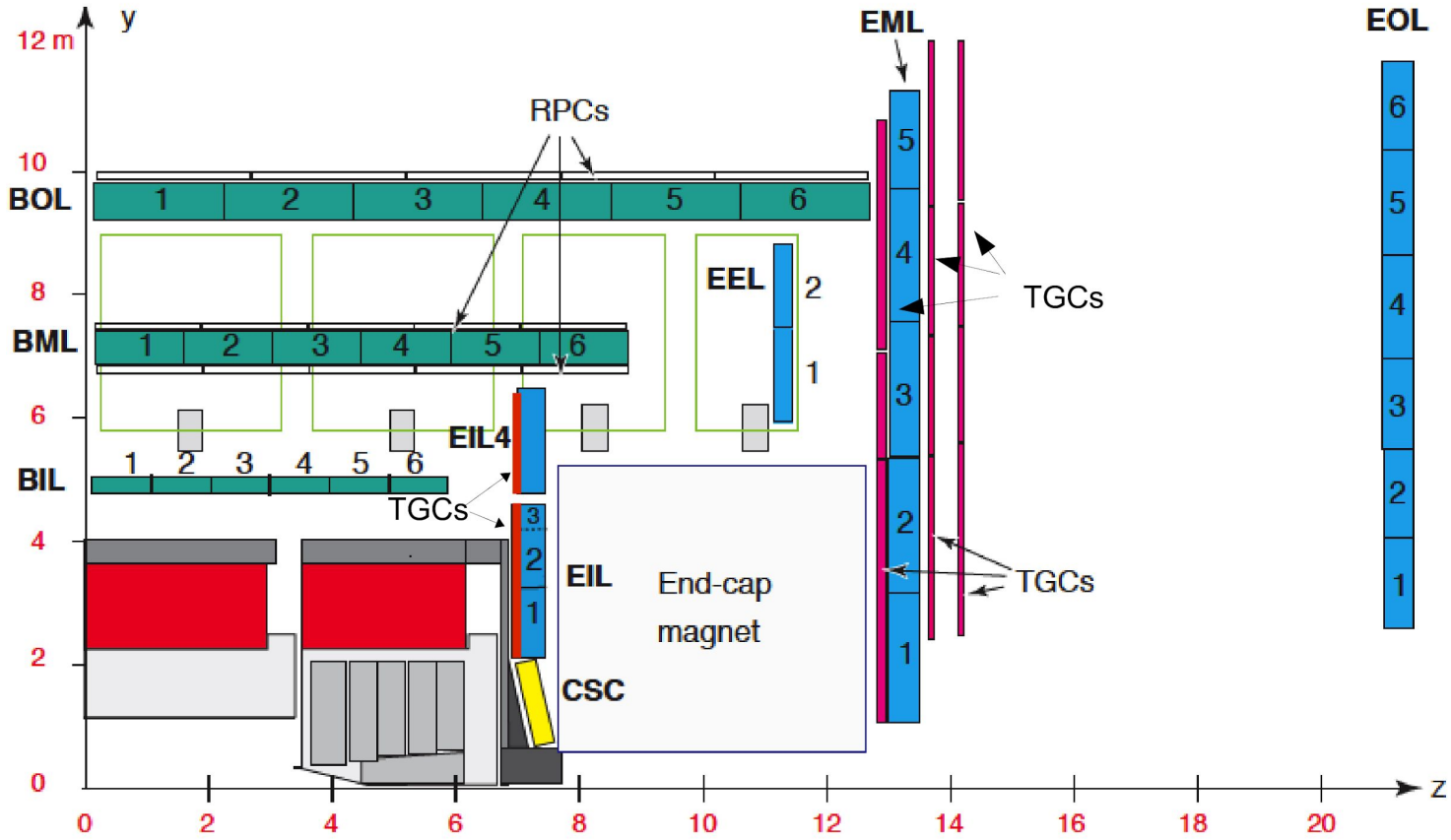


# Muon Trigger Assisted from TileCal

## Introduction

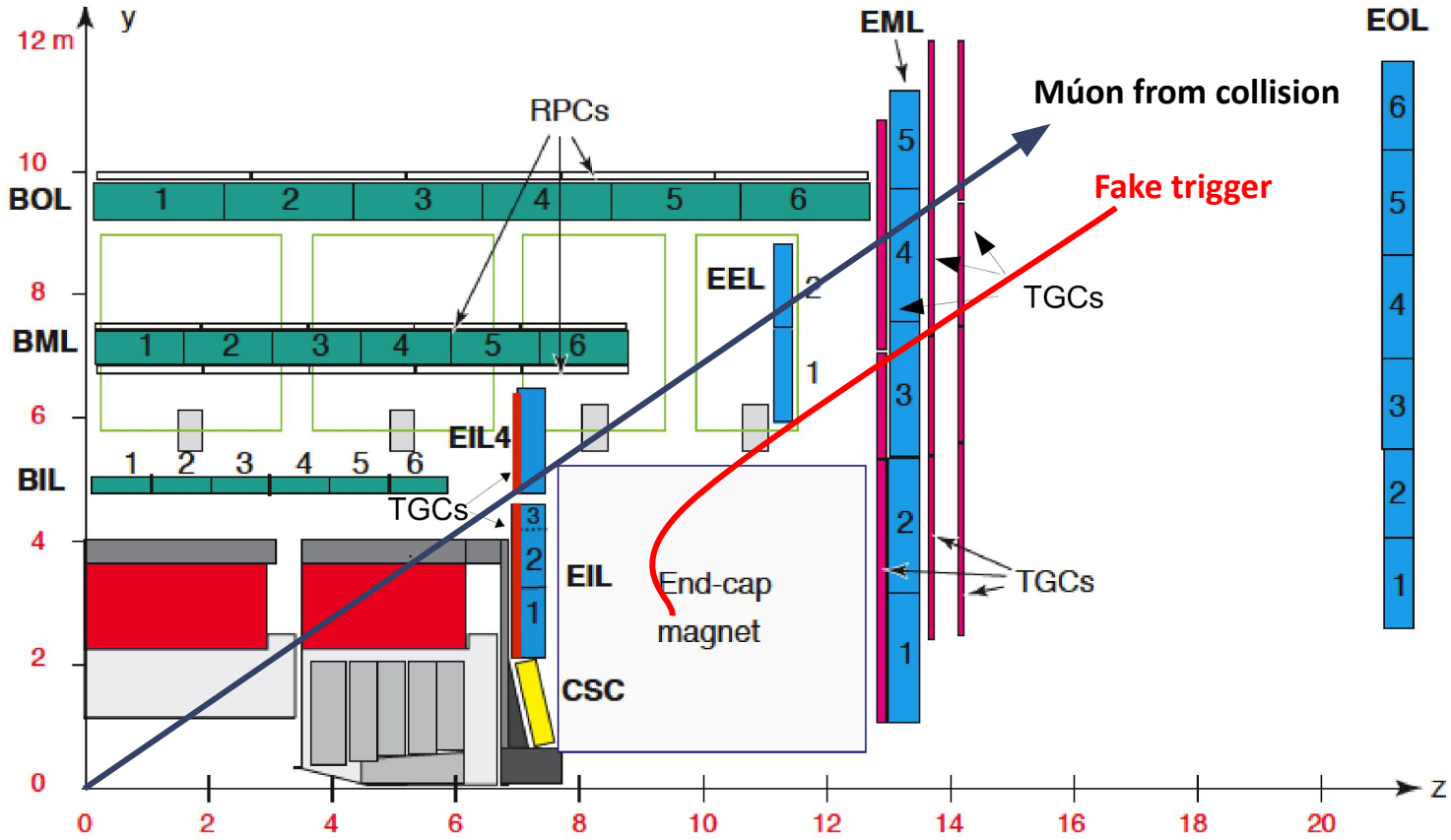
- A significant part of the muon trigger rate in the end-caps is background



# Muon Trigger Assisted from TileCal

## Introduction

- A significant part of the muon trigger rate in the end-caps is background
  - Low energy particles (mainly protons) produce fake triggers by hitting the end-cap trigger chambers



# Muon Trigger Assisted from TileCal

## Introduction

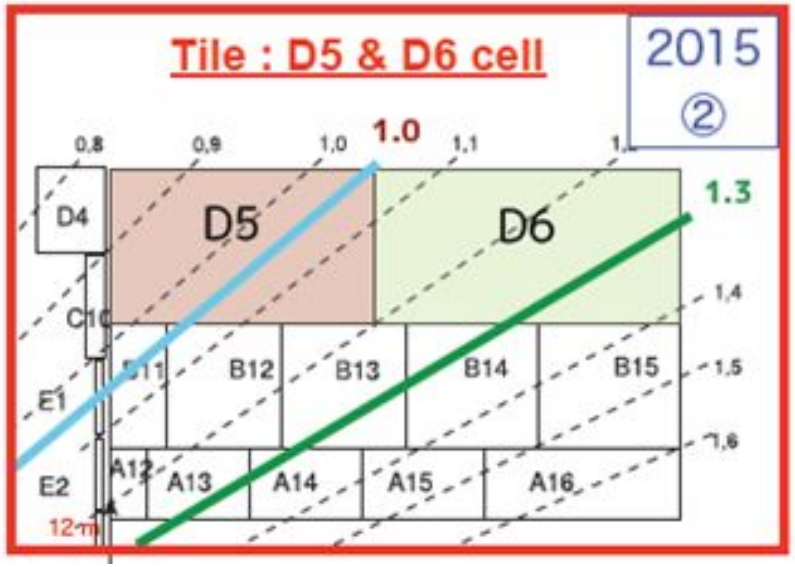
- Expected single-muon Level-1 rate (based on 2012 data and 8 TeV) with bunch spacing 25 ns and instantaneous luminosity 3 $\times 10^{34}$ cm$^{-2}$ s$^{-1}$ for online $p_T > 20$ GeV
  - From ATLAS TDAQ System: Phase-I Upgrade TDR

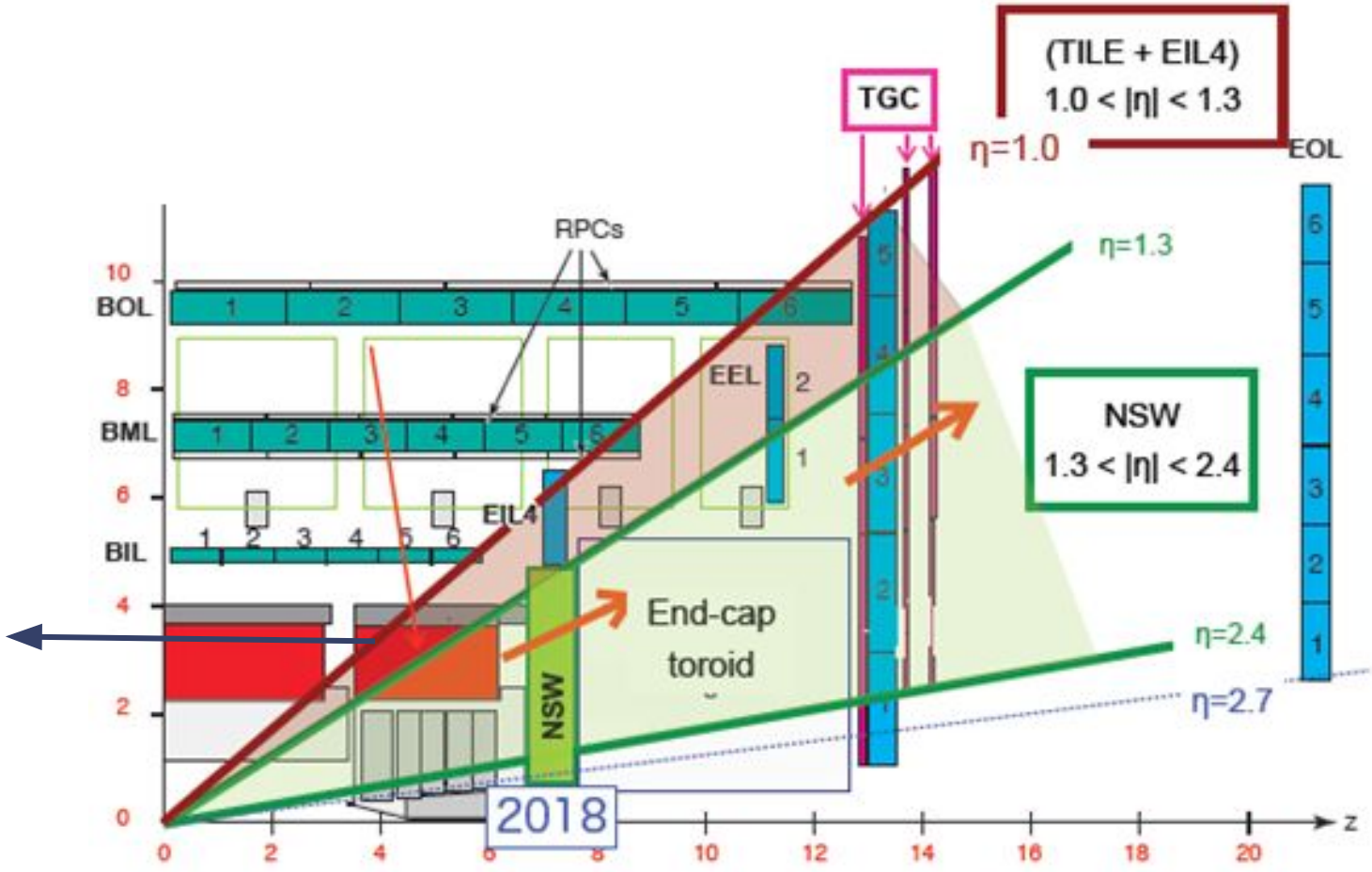
| Online<br>$p_T > 20$ GeV<br>$3 \times 10^{34}$ cm$^{-2}$ s$^{-1}$ | No Change<br><br>Rate [kHz] | TGC EIL4 + (TGC FI or NSW)<br><br>Rate [kHz] | TGC EIL4 + (TGC FI or NSW) + Tile Cal.<br><br>Rate [kHz] | TGC EIL4 + ( TGC FI or NSW) + Tile Cal. + low field mask<br>Rate [kHz] |
|---|---|---|---|---|
| Run 2 (pre NSW) | 51 | 34 | 31 | 28 |
| Run 3 (post NSW) | | 17 | 15 | 13 |

# Muon Trigger Assisted from TileCal

## Introduction

- The **Tile-μ trigger** aim to improve the rejection of fake triggers, by using the using the energy loss in the TileCal outermost layer (D-layer)

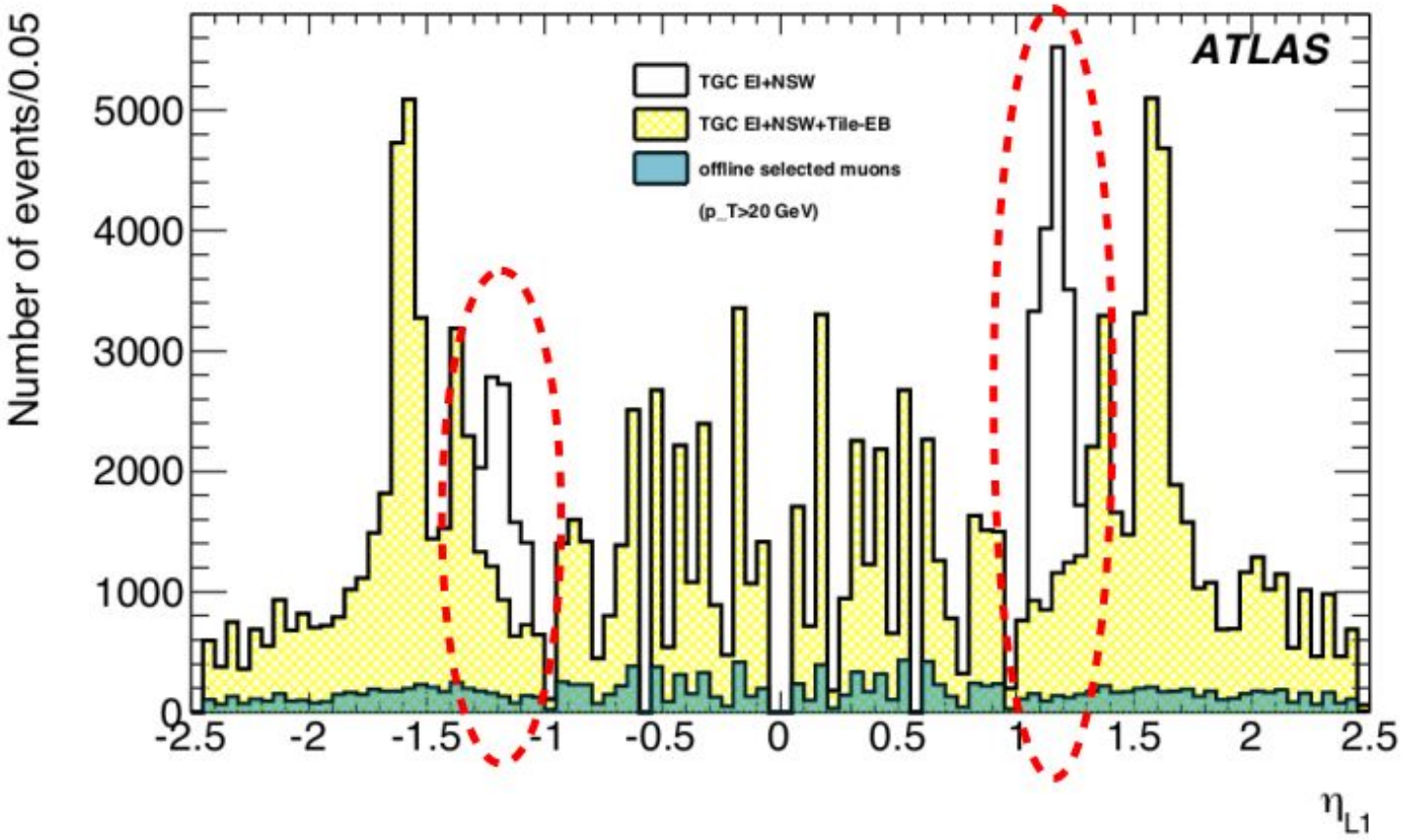


# Muon Trigger Assisted from TileCal

## Introduction

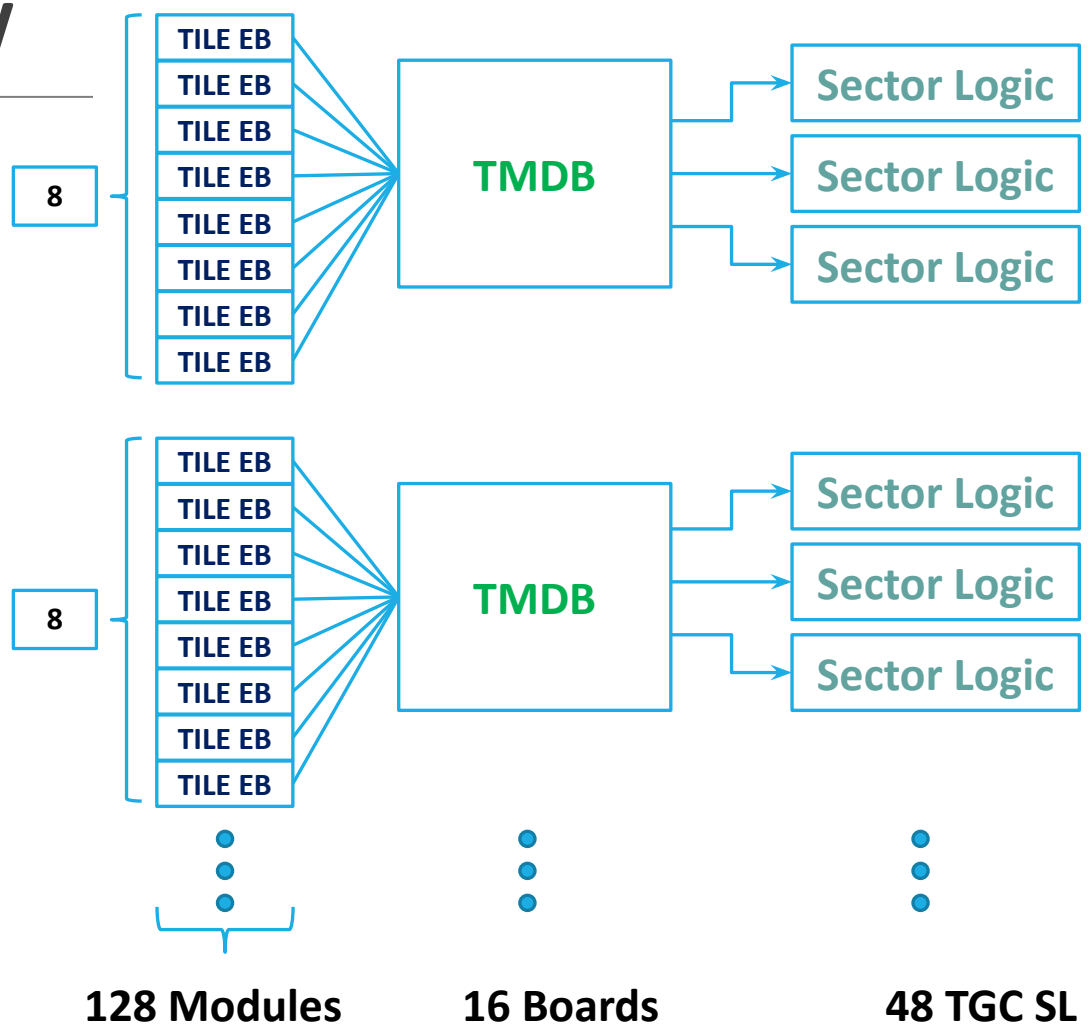
- Use Tile Calorimeter D-layers in the region 1<|η|<1.3 in coincidence with the TGC inner station chambers
- By simulation, using a threshold of 500 MeV:
  - 97 % efficiency
  - 17 % rate reduction



# System Overview

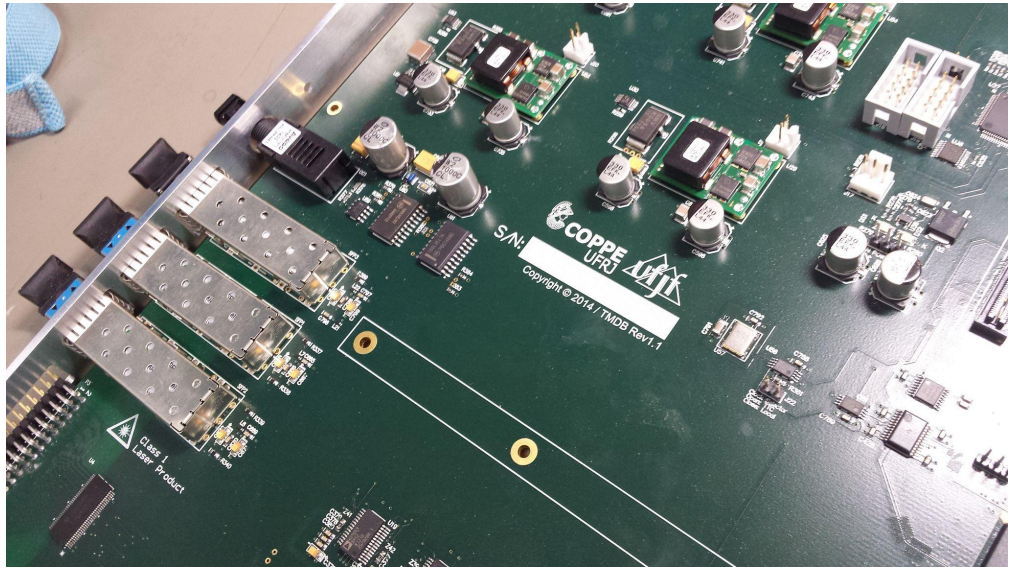
## TileMuon Trigger

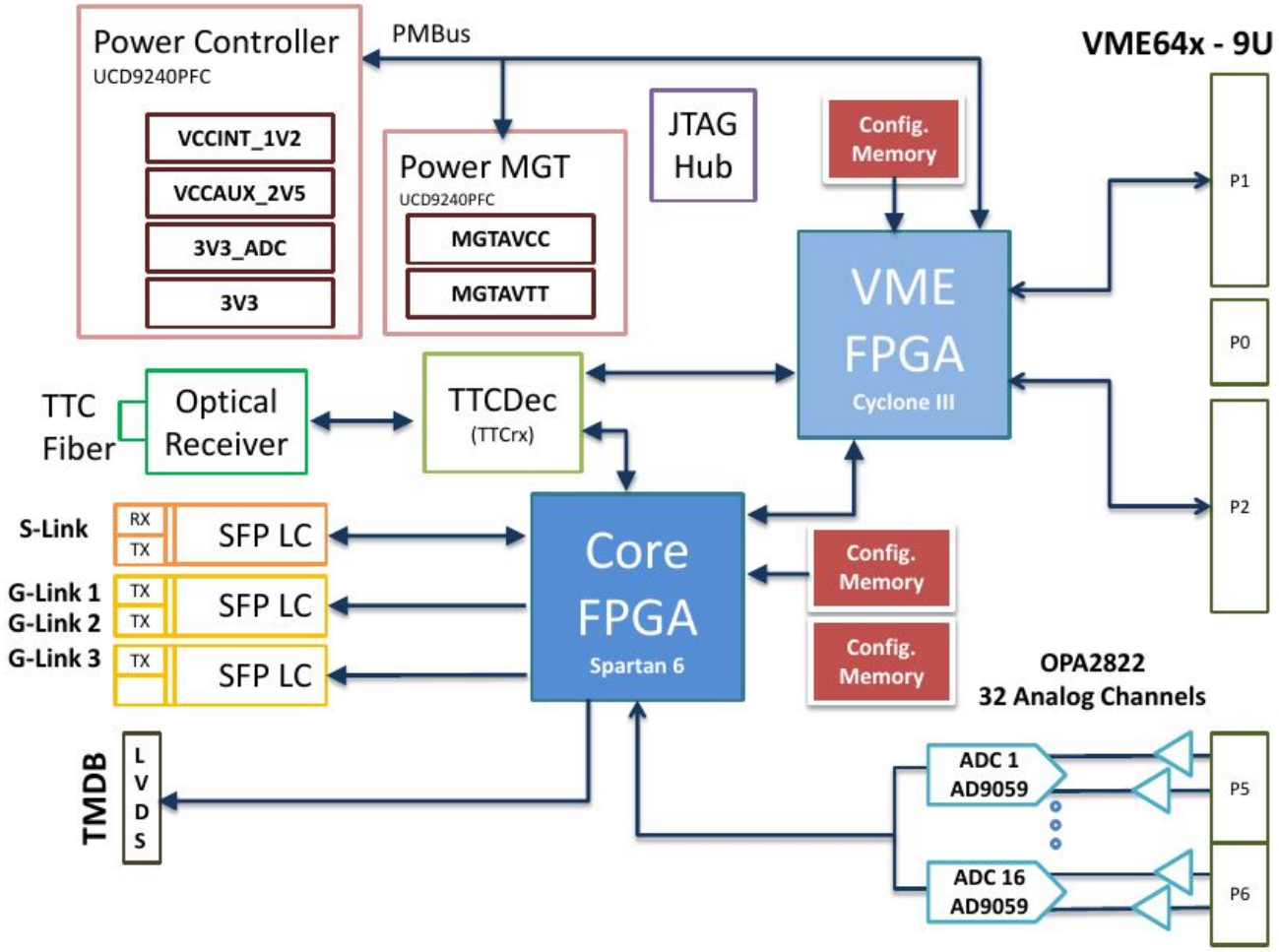
- 128 Extended Barrel Tile modules
  - 4 channels/module
- 16 TMDB's
  - 8 Tile modules per TMDB
- 48 TGC Sector-Logic boards
  - Each TMDB communicates with 3 Sector-Logic boards



# System Overview

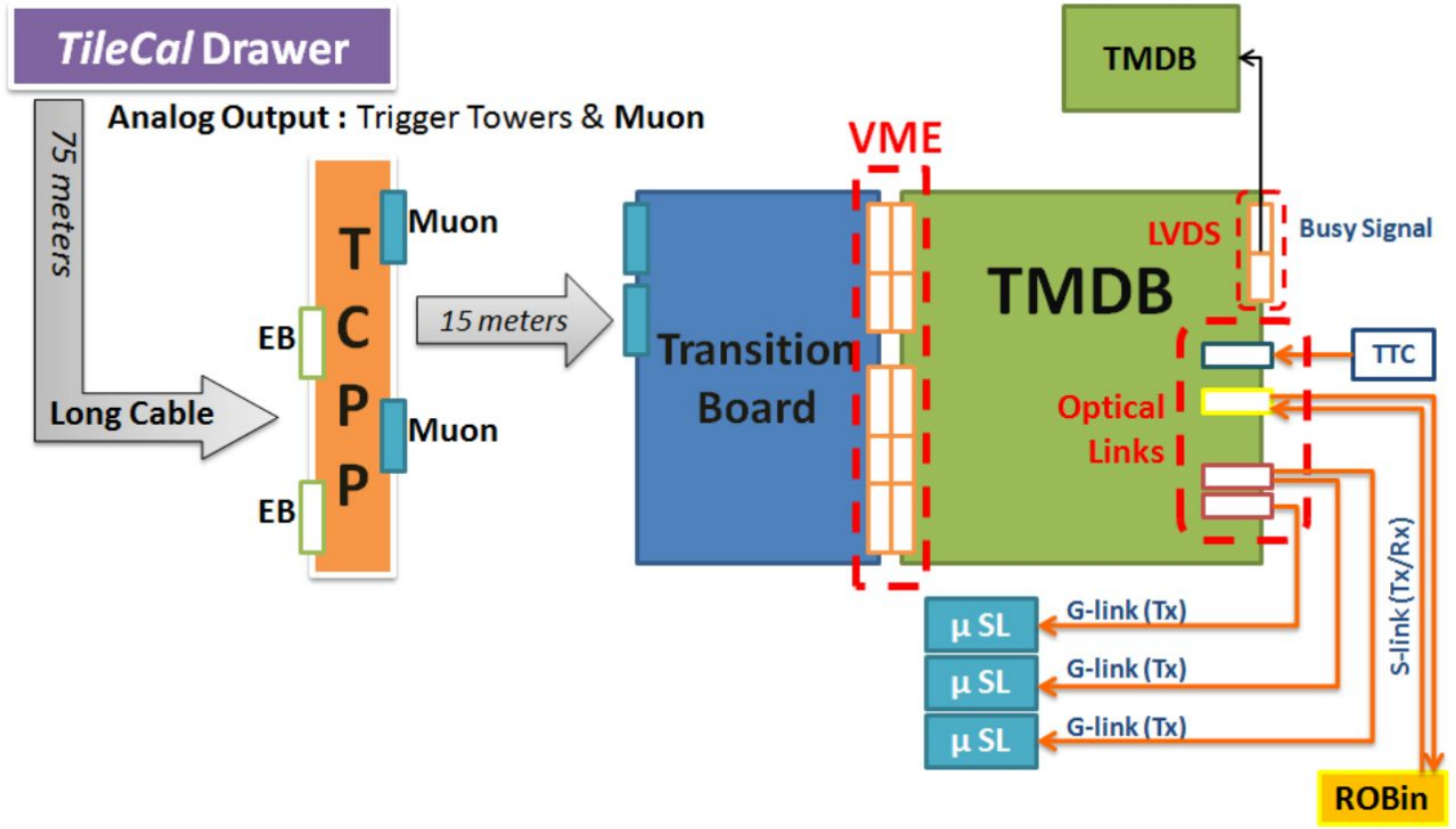
- Hardware
- TileMuon Digitizer Board



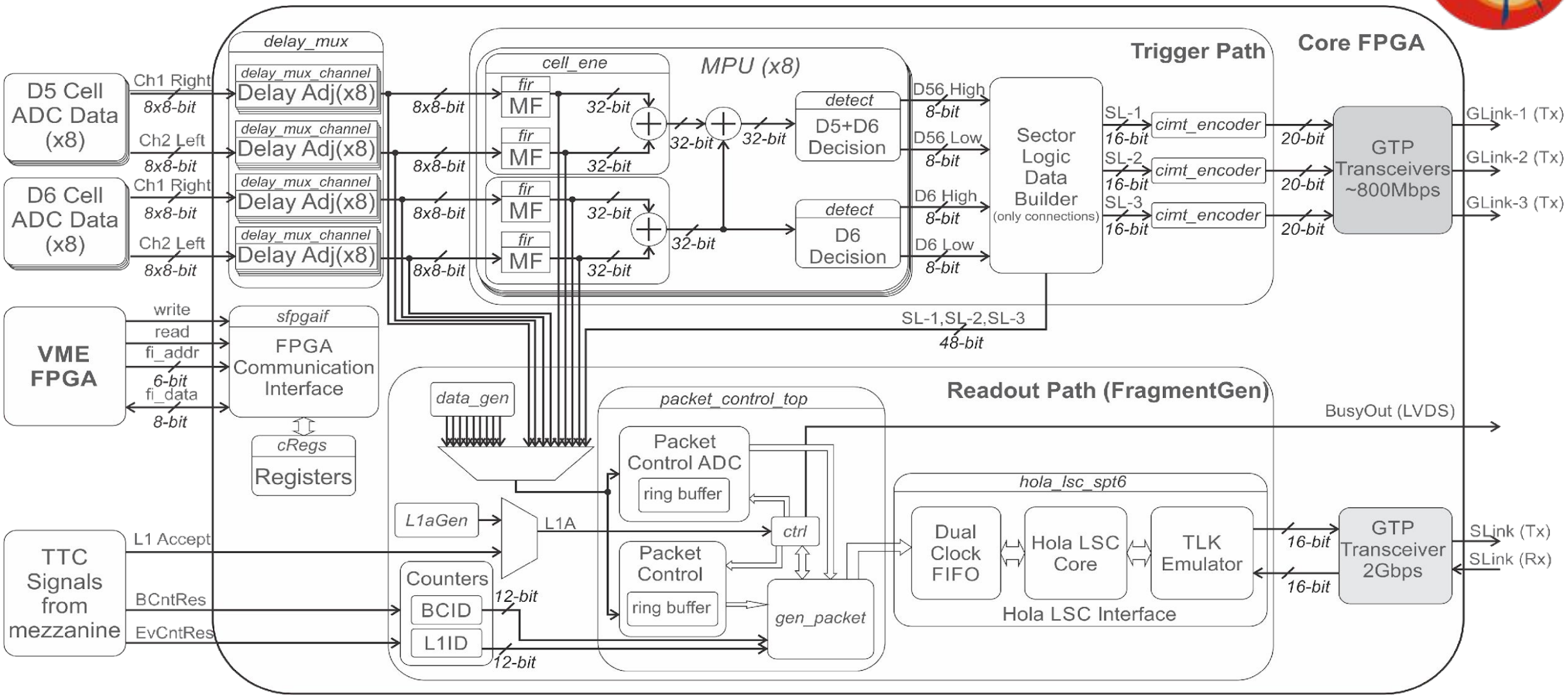



# System Overview

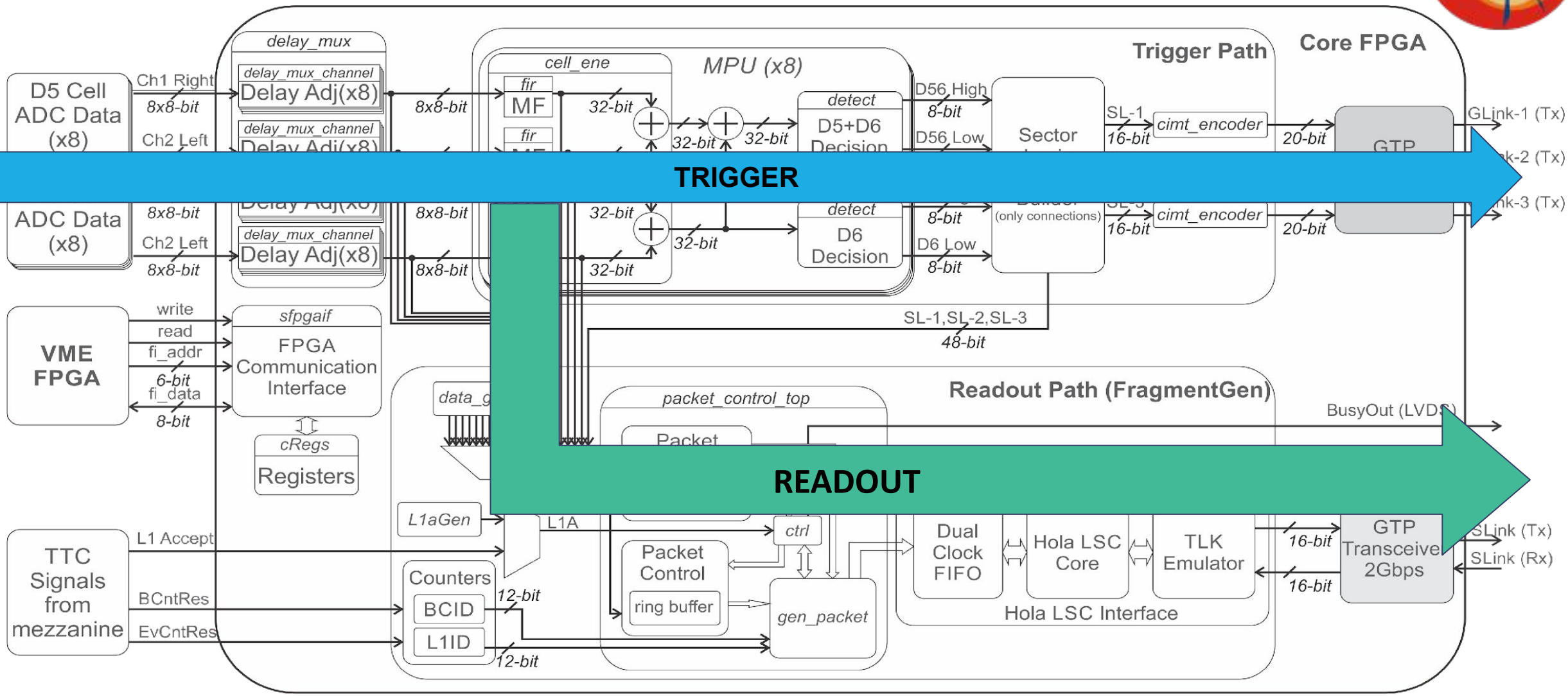
- Signal Path



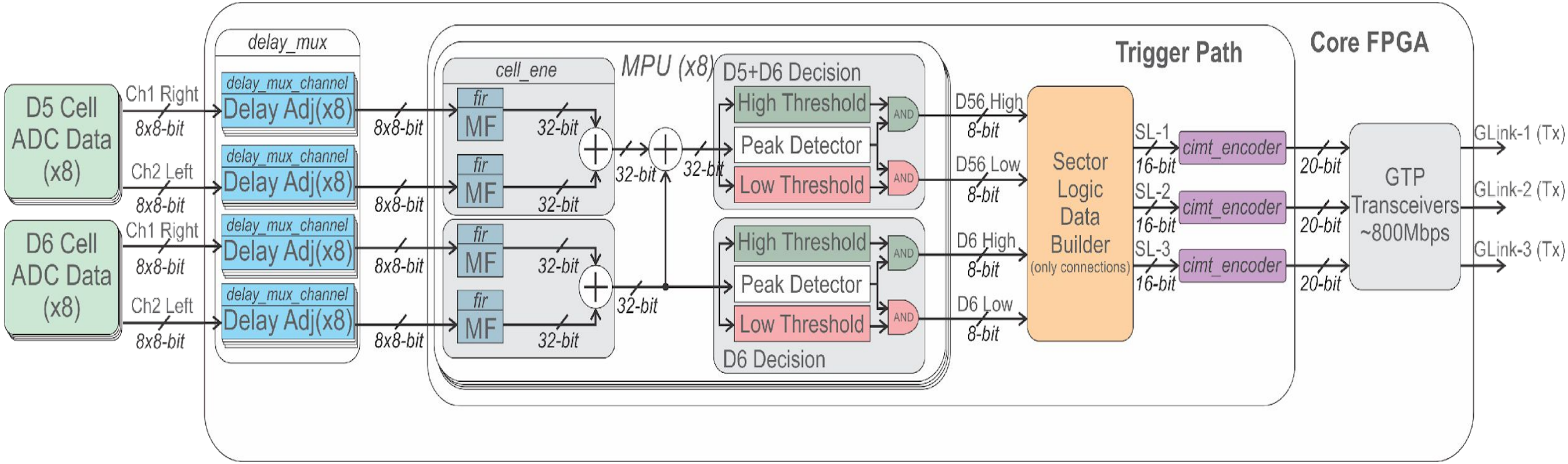
# FPGA Implementation: core



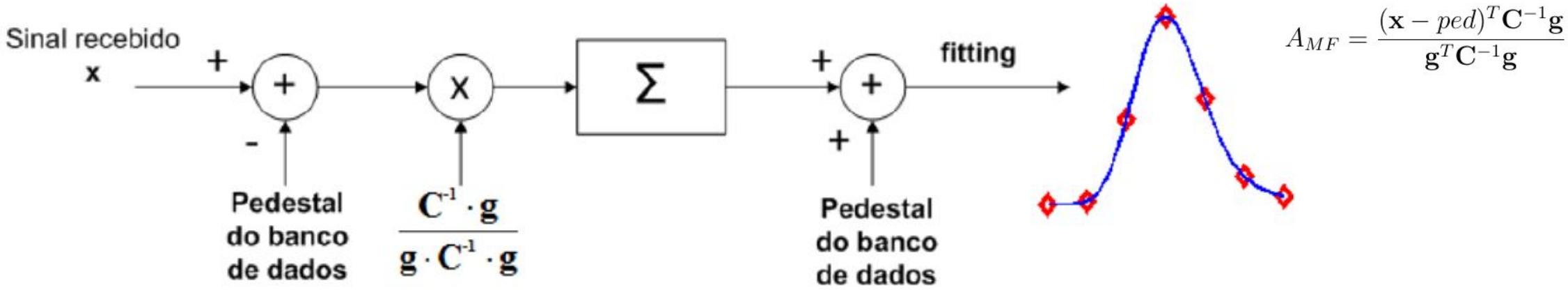
# FPGA Implementation: core



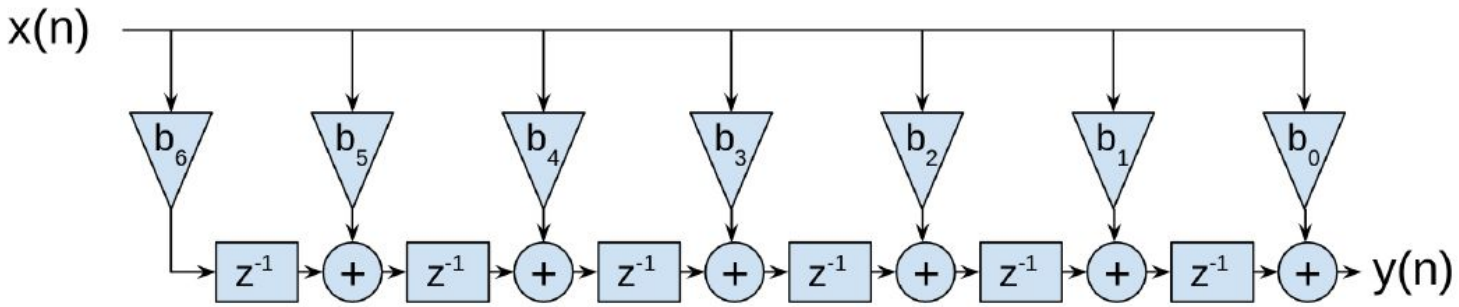
# FPGA Implementation: Trigger



# FPGA Implementation: Matched Filter



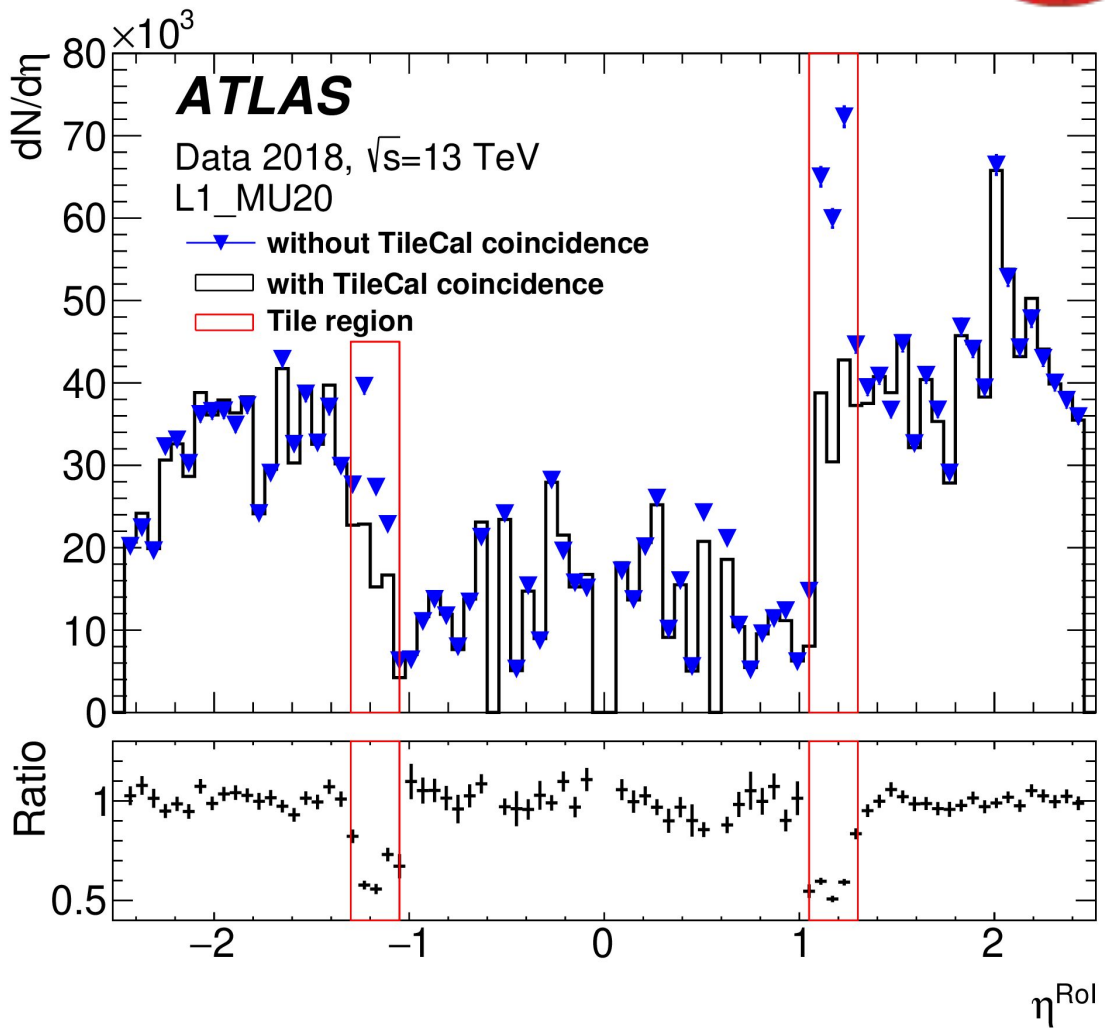

$$A_{MF} = \frac{(\mathbf{x} - ped)^T \mathbf{C}^{-1}\mathbf{g}}{\mathbf{g}^T\mathbf{C}^{-1}\mathbf{g}}$$



# Operation Results

- **The L1 MU20 candidates**

- A comparison between $\eta^{RoI}$ of all the L1 MU20 entries (white histogram) and the subset which passes the TileCal coincidence requirement (blue histogram) shows the amount of the additional reduction at $1.05 < |\eta^{RoI}| < 1.3$ by the TileCal coincidence.

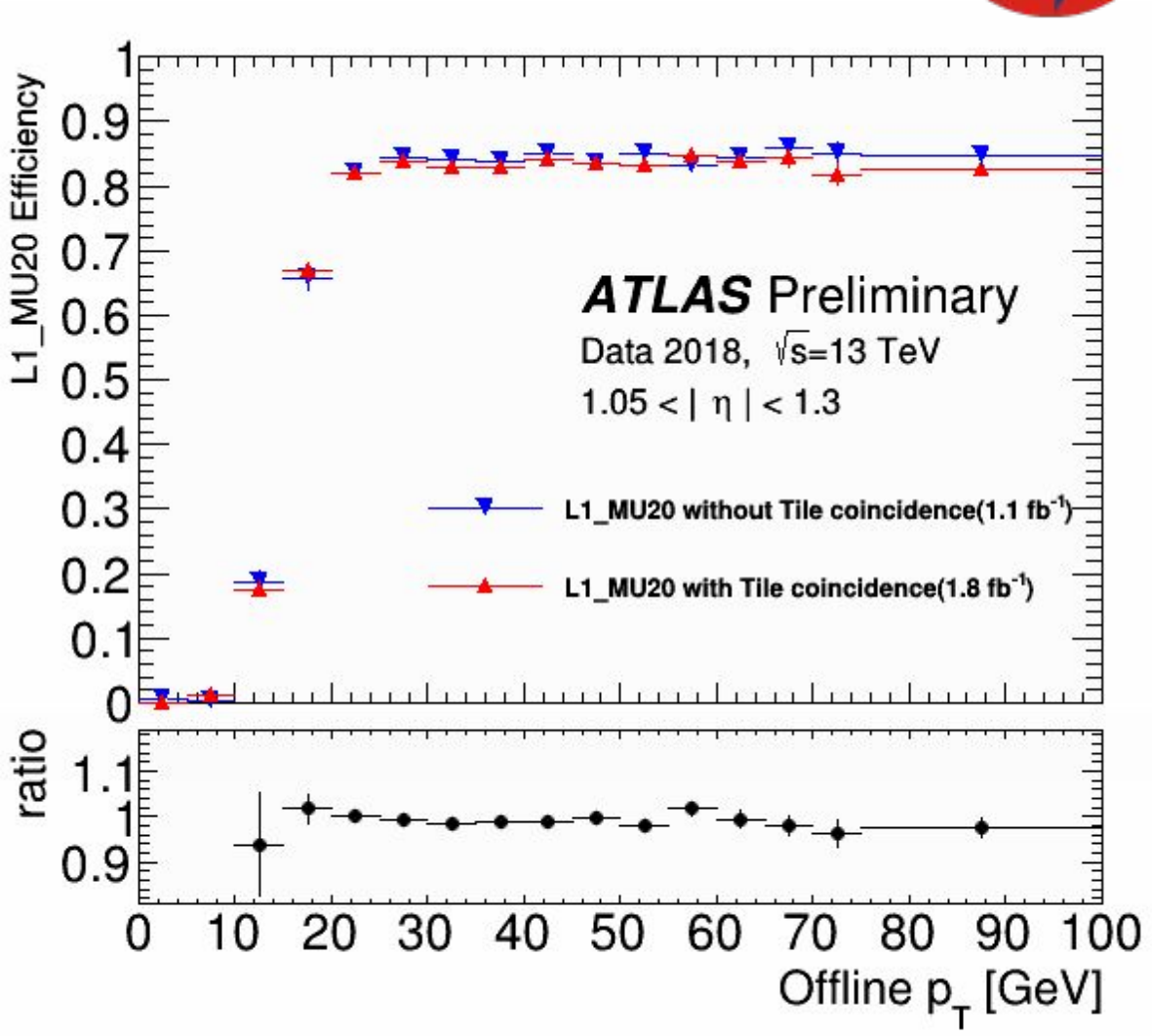


# Operation Results

- **The L1 MU20 efficiency**

- The trigger efficiency is compared between runs when TileCal coincidence is used in the Level-1 trigger decision (red) and is not used in the decision (blue)

- Additional inefficiency due to the TileCal coincidence is limited up to: ~ 2.5%

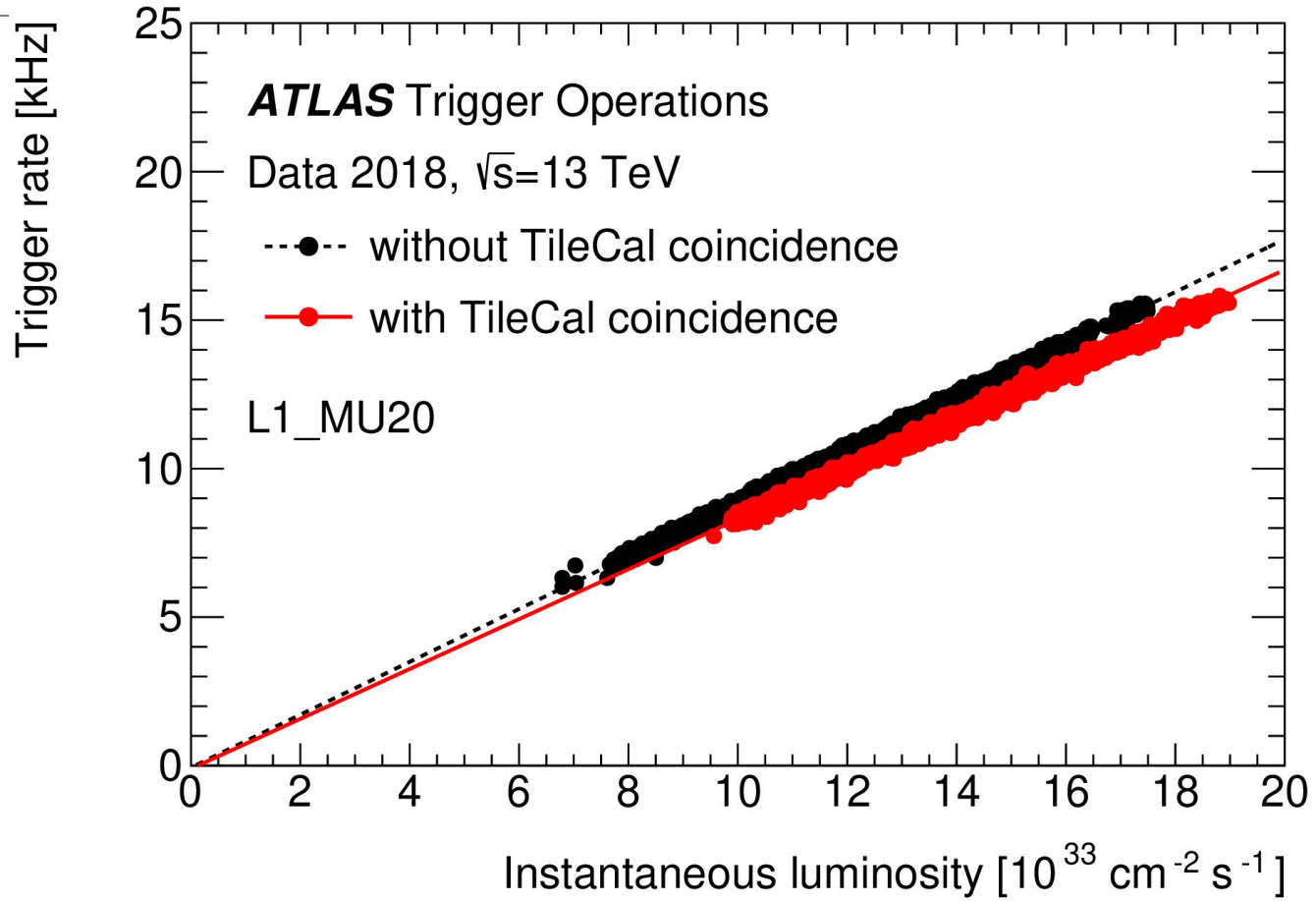


# Operation Results

- **The L1 MU20 trigger rate**

- Coincidence at 1.05 < |η| < 1.3 discards charged particles that only traverse the big wheel, which are originated from secondary interactions in the ATLAS Endcap toroid of the beam backgrounds

- The comparison of the fit results shows that the reduction of the L1_MU20 trigger rate for all the muon spectrometer coverage is about 6% owing to the new TileCal coincidence requirement



# Updates for Run 3

- New “Firmware”
  - Add Idle words for Sector Logic-TGC communication
  - New Data Fragment for S-Link
  - Inclusion of new information from cell D5 (new MF as well)
  - New Data Frame for Sector Logic-TGC
- Analysis
  - Testing the wiener filter efficiency
  - Performing Matched Filters calibration (new coefficients, including D5 cells)
- Extended Applying deep learning/ neural networks to classifying muons
  - Using the offline information to acquire muon event
  - Separating the training/test dataset
  - Implementing deep learning (CNN and RNN - LSTM (Long Short-Term Memory )
  - Increasing statistics