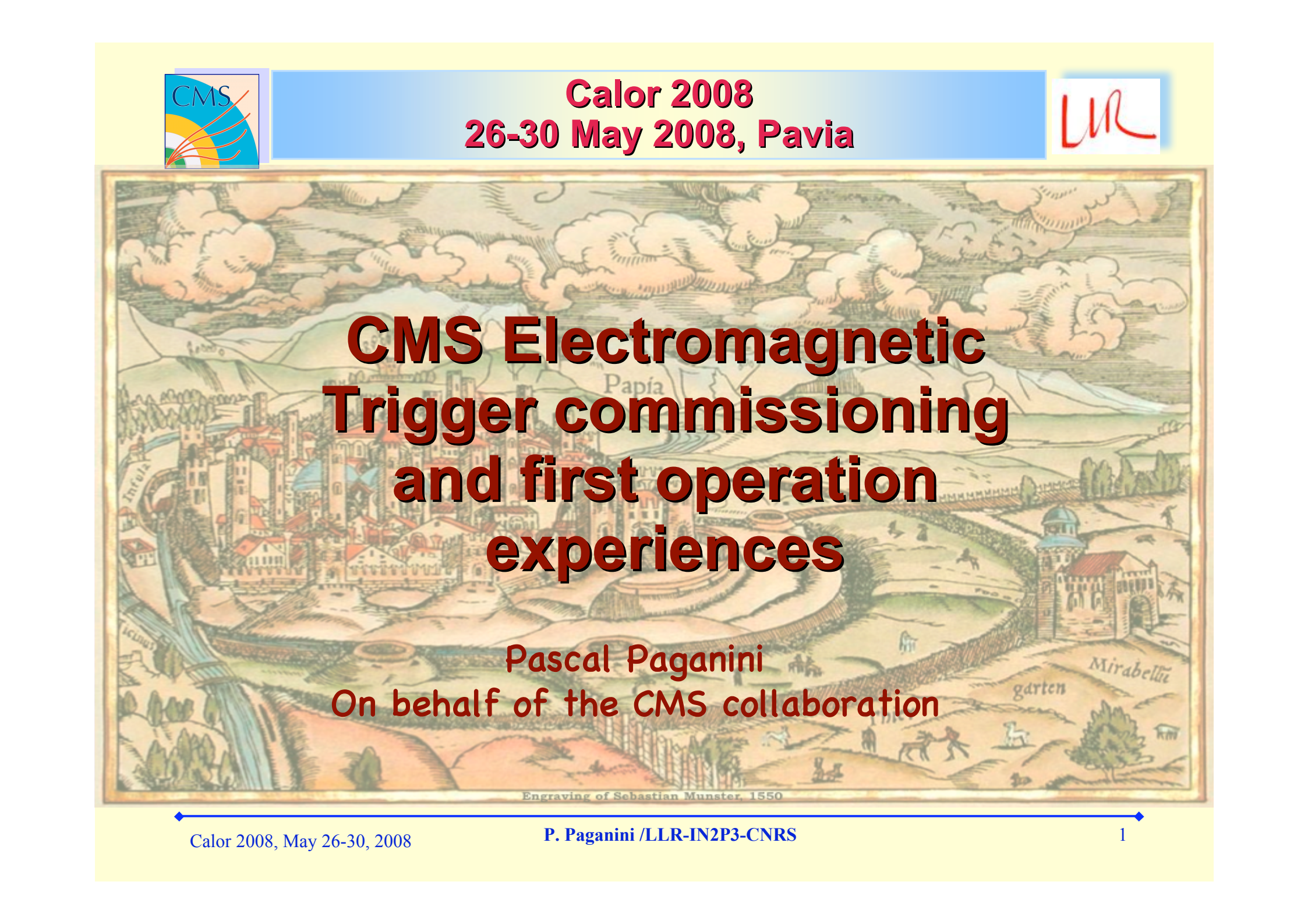
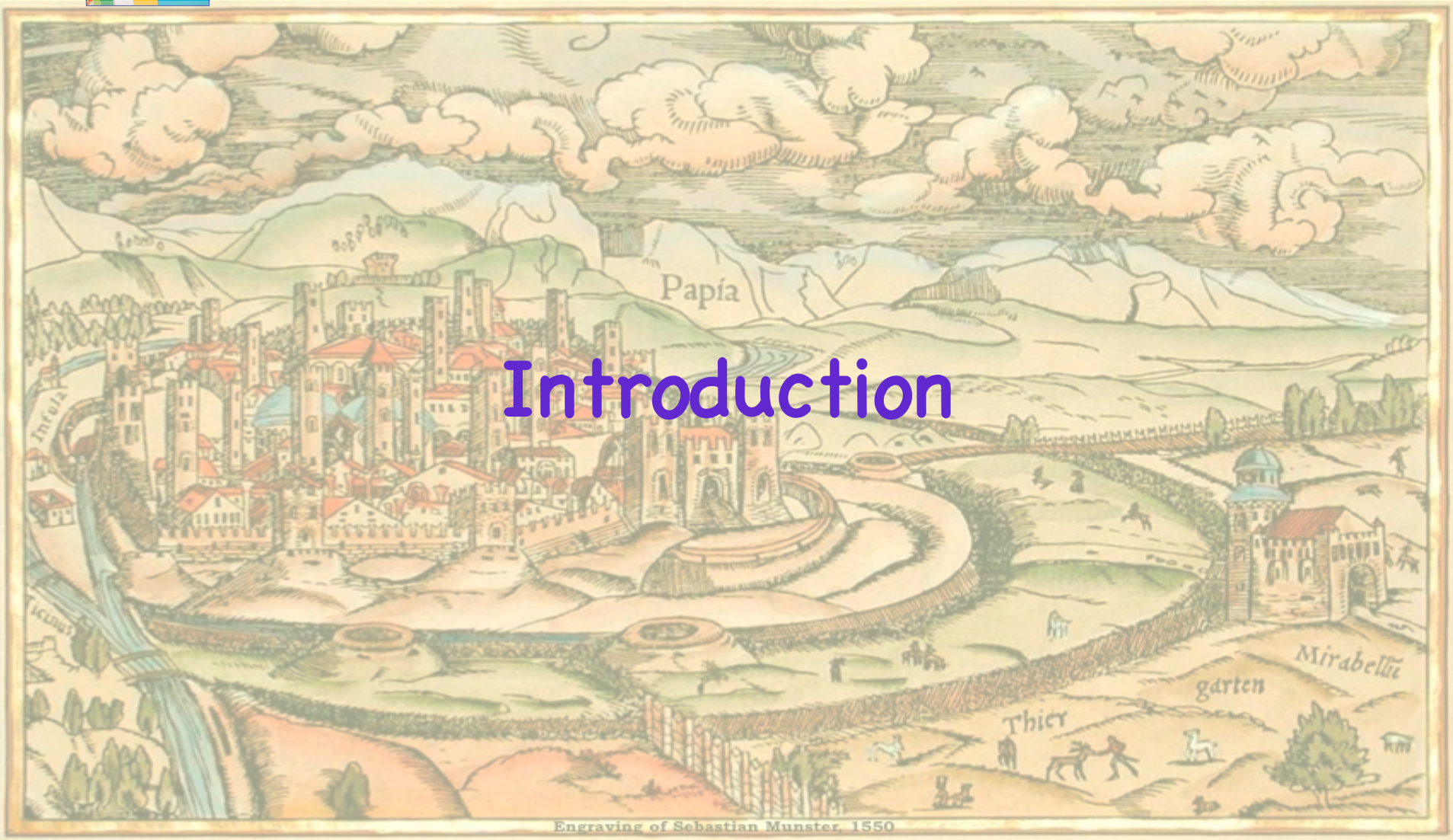

Calor 2008
26-30 May 2008, Pavia
CMS Electromagnetic Trigger commissioning and first operation experiences
Pascal Paganini
On behalf of the CMS collaboration
Papia
Mirabellu
garten
Engraving of Sebastian Munster, 1550
Calor 2008, May 26-30, 2008
P. Paganini /LLR-IN2P3-CNRS
1

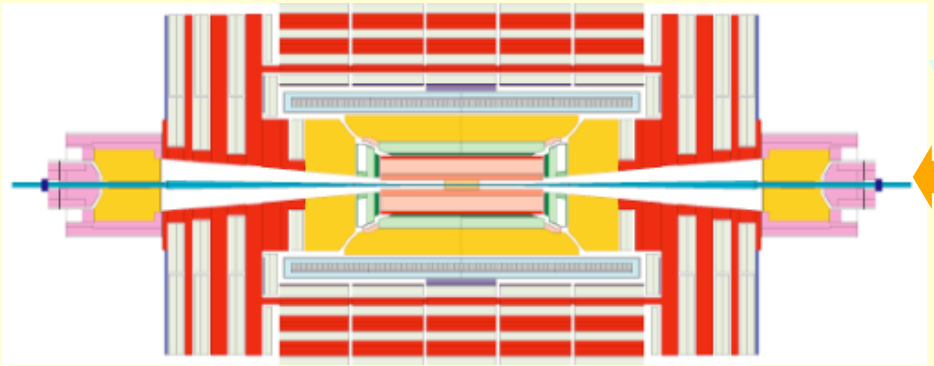
# Outline

- Introduction to CMS Trigger and ECAL detector
- The ECAL trigger
  - ECAL Trigger Primitives
  - Algorithm
- Commissioning of ECAL trigger
  - ECAL Trigger Electronics
  - ECAL Trigger Primitives
- First operation experiences with Global and local Runs



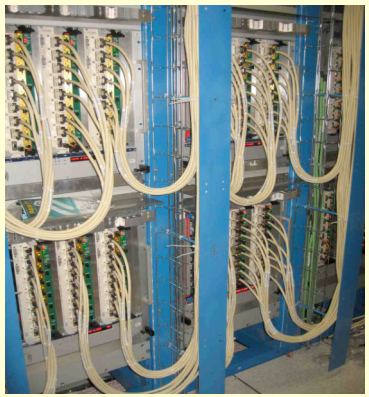

# Introduction

# CMS Trigger



1 Bunch crossing / 25 ns
40 000 000 Hz, ≈ 1000 TB/s
≈ $10^9$ interactions/s

ECAL electronics

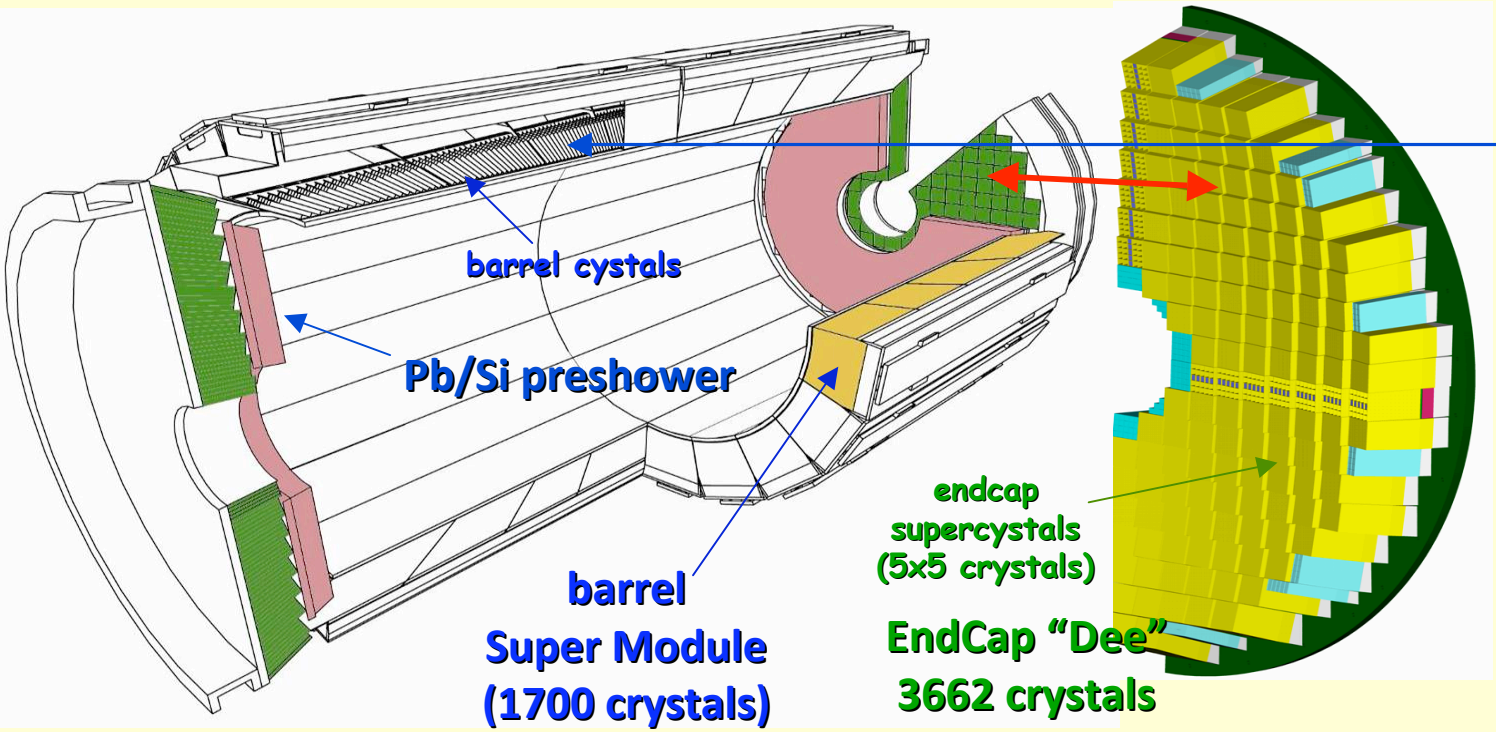


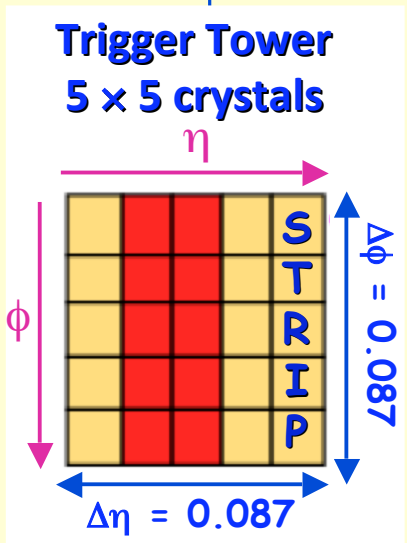
Level 1 Trigger
100 000 Hz, 150 GB/s
Dedicated Hardware
(ECAL + HCAL + Muon)
ECAL Trigger Primitives:
1st step of L1 ECAL trigger

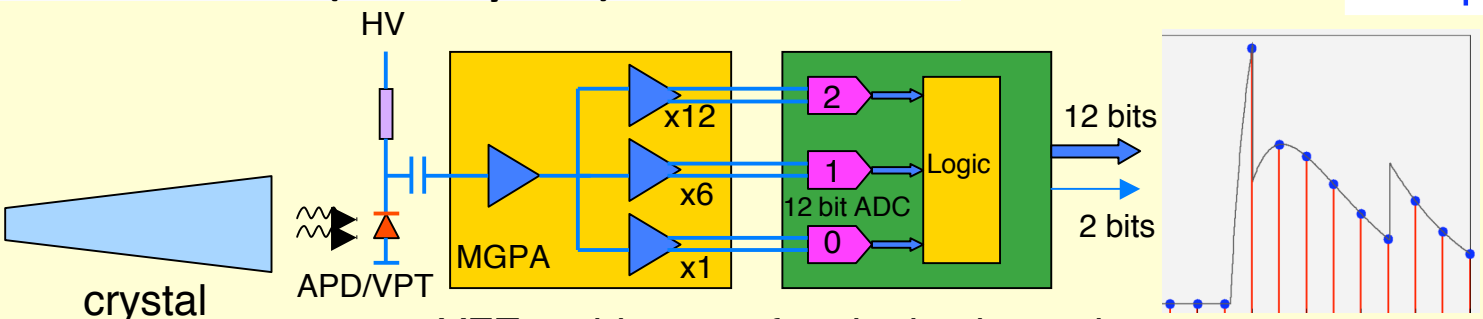
High Level Trigger
150 Hz, 225 MB/s
Computer farm

<---- 1.5 MB / evt ---->

# ECAL Detector



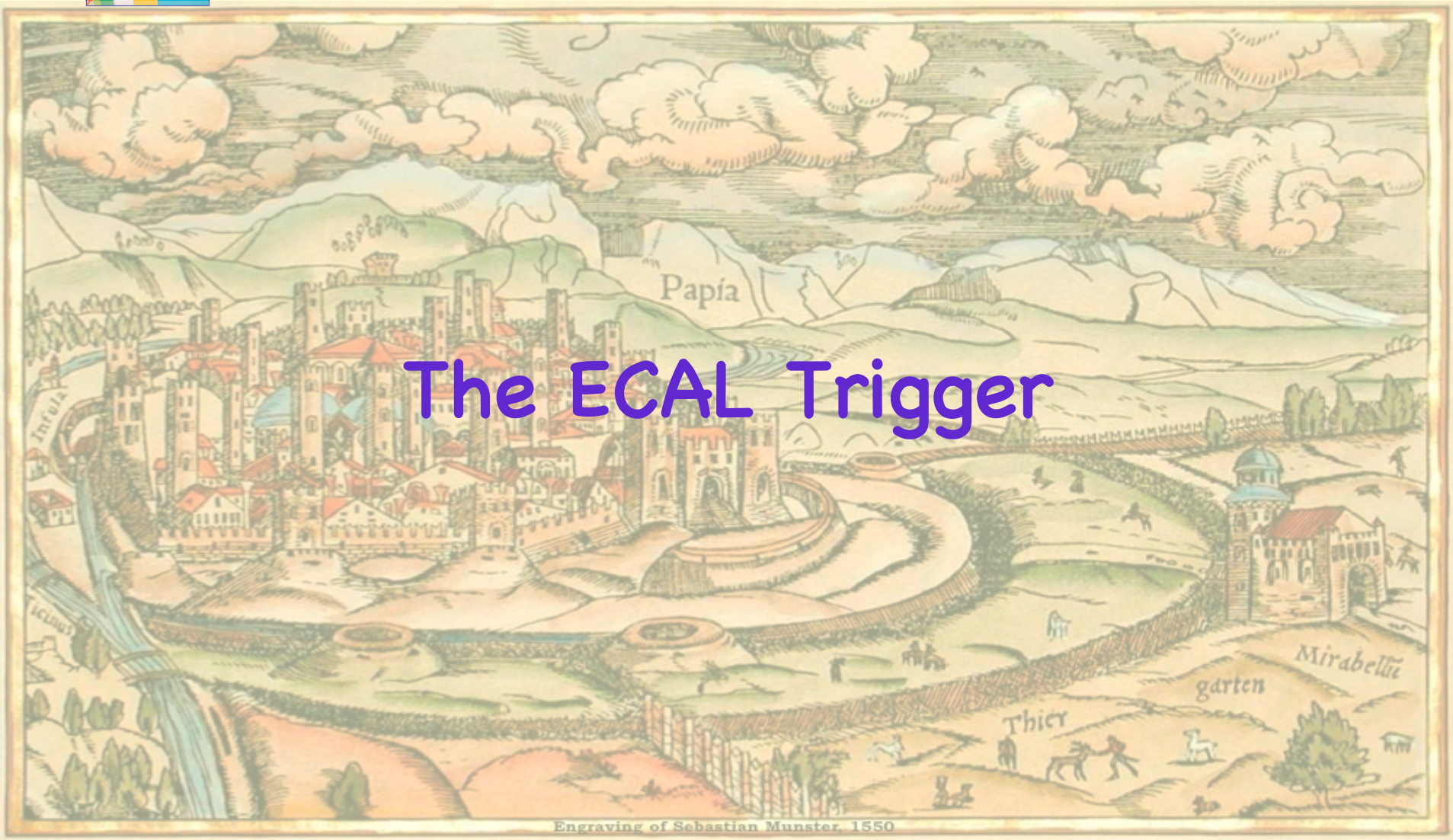




VFE architecture for single channel

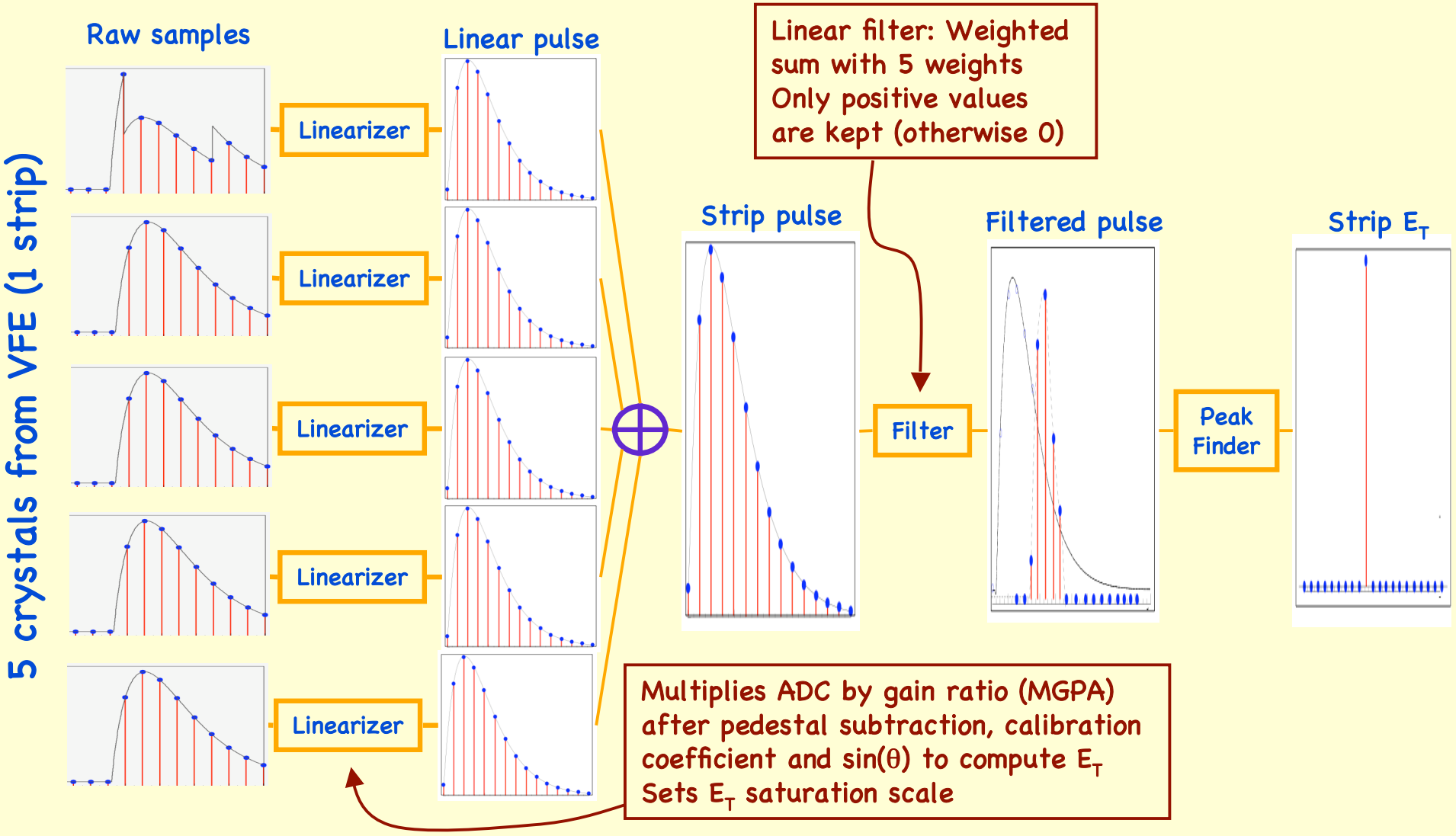


25 ns sampling

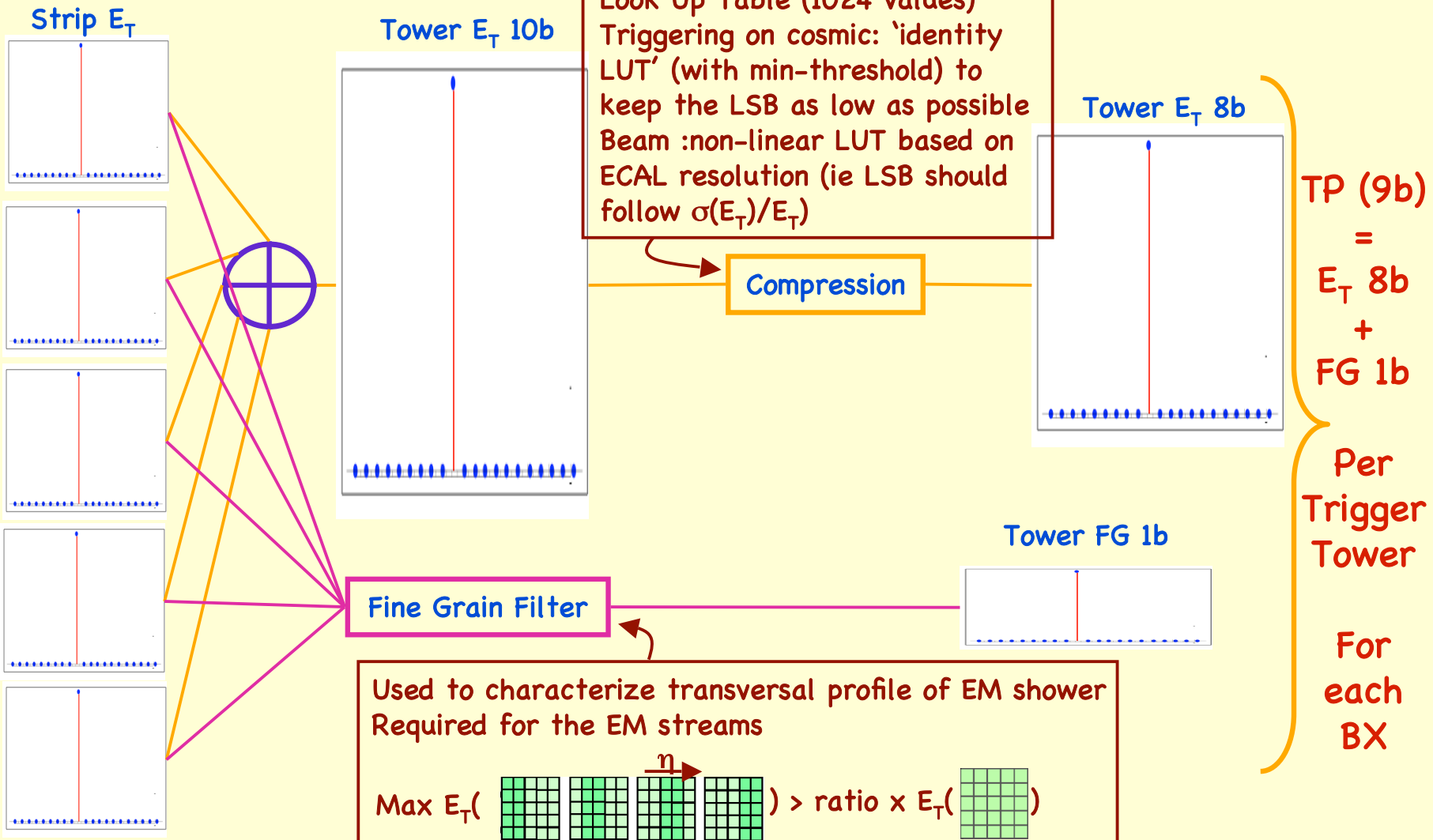



# The ECAL Trigger

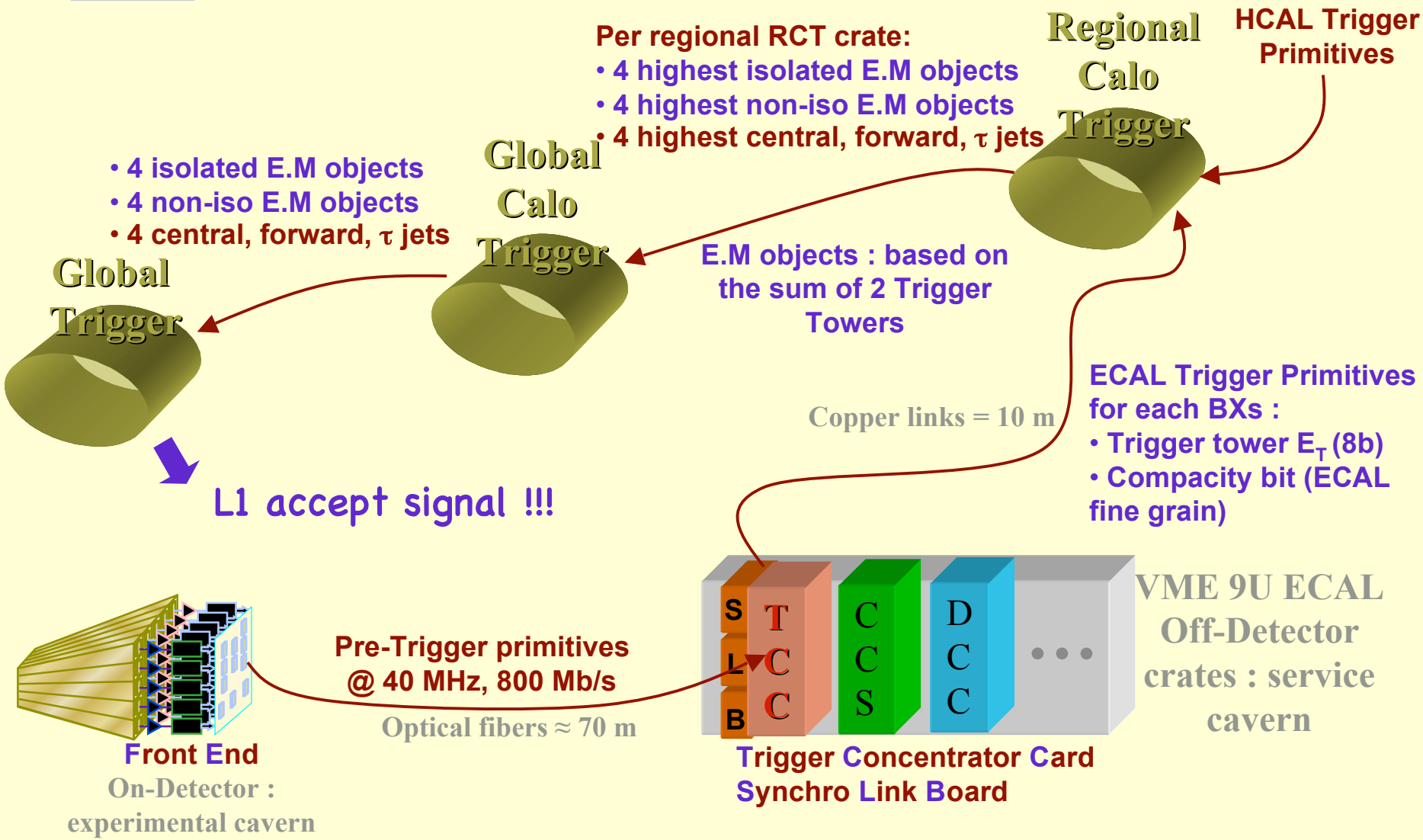
# The ECAL Trigger Primitives: first stage of ECAL Trigger

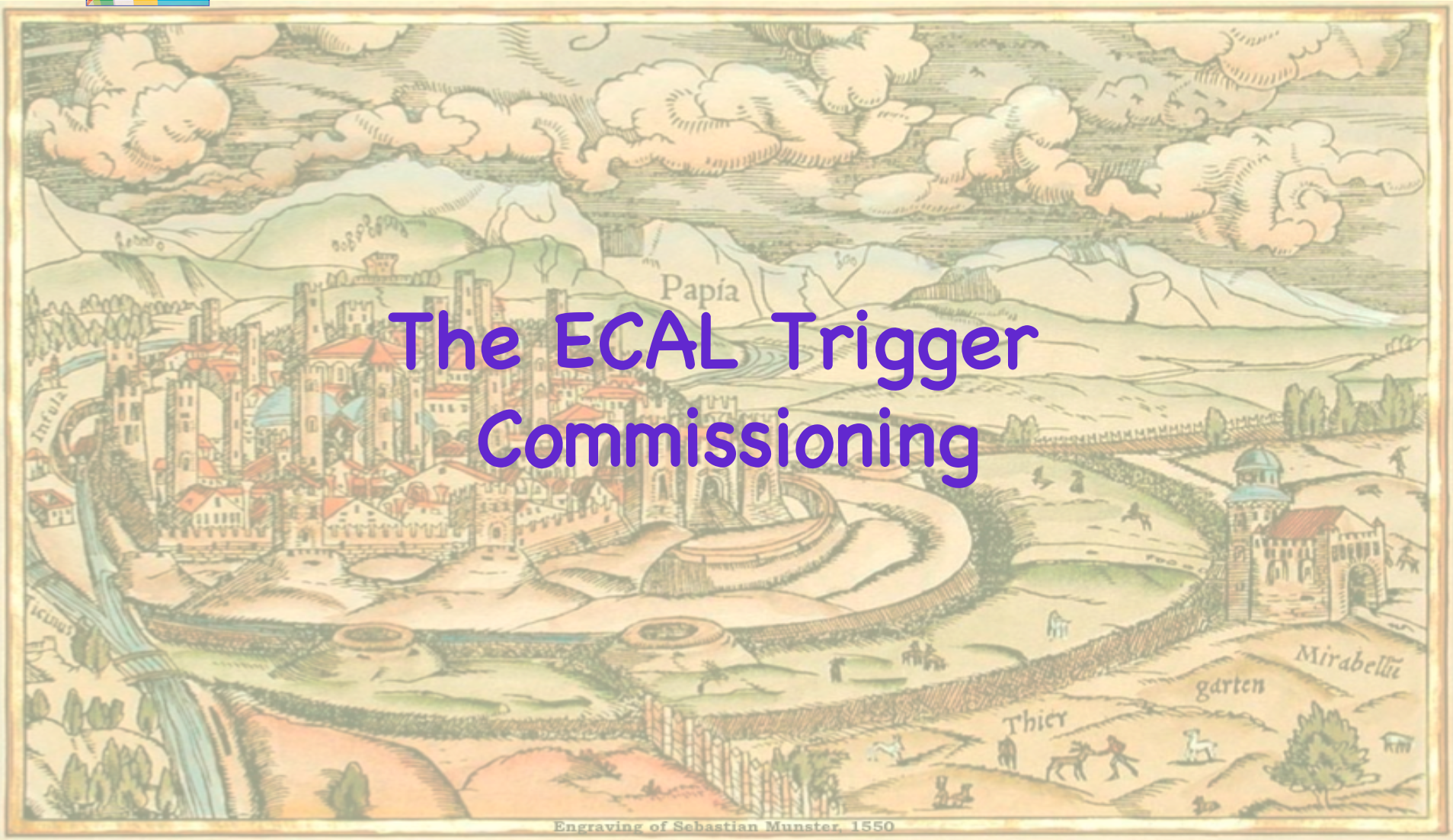


# The ECAL Trigger Primitives : first stage of ECAL Trigger



# The ECAL Trigger path

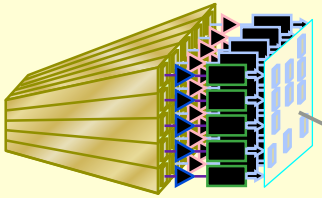




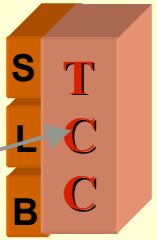

# The ECAL Trigger Commissioning

# ECAL Trigger electronics commissioning

All ECAL-barrel electronics is installed and commissioned

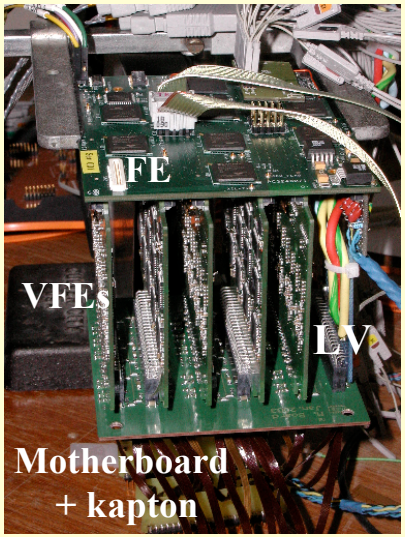


Front End




Trigger Concentrator Card
Synchro Link Board

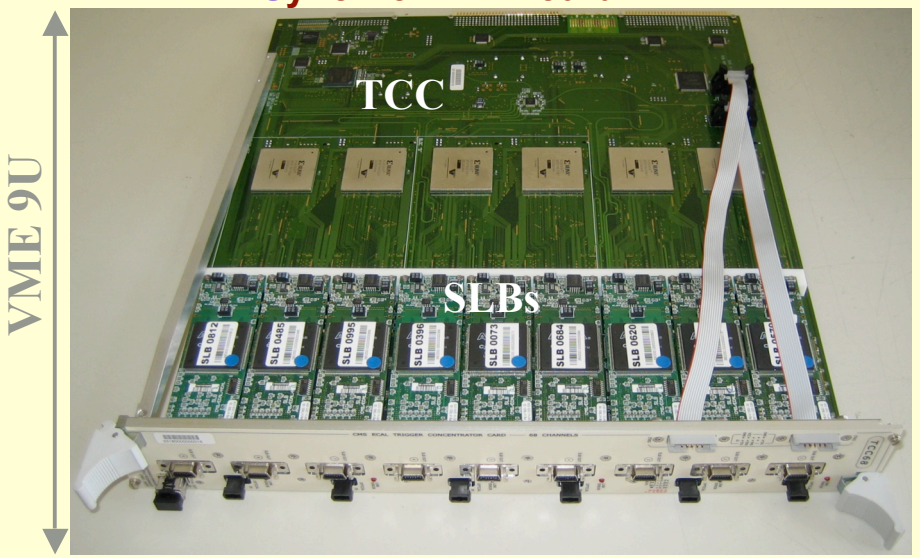
- 2448 FE boards
- 36 TCC cards
- 324 SLB cards




1st step : production tests
Each cards were tested after the production thanks to dedicated test-benches in different labs

2nd step : integration tests

- FE: during the SuperModules integration (cern B867, SM assembly centre)
- TCC/SLB: during the Off-detector crates integrations (cern B904 electronics integration centre)



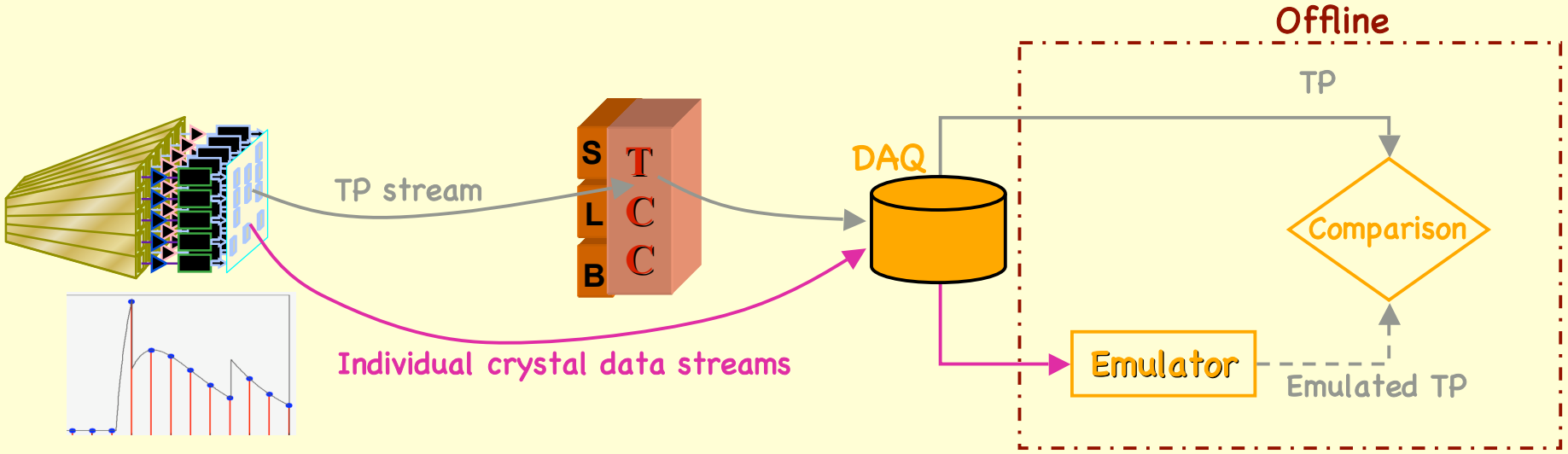

3rd step : commissioning tests in experimental / service cavern

- FE: typically, configure FE to send its ID and use the TCC board in spy mode to check what is received
- FE+TCC/SLB: next slides

# ECAL Trigger Primitives commissioning

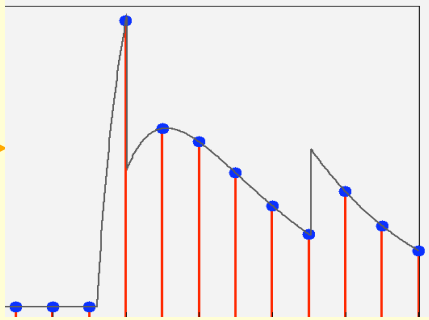
## Commissioning of ECAL Trigger Primitives:

- Based on the comparison with an ECAL-TP Emulator
- Hardware description at bit level (linearizer, filter, peak finder, compression etc)
- Used for L1 studies (MC Production) and monitoring of hardware
- Initially checked with test beam data



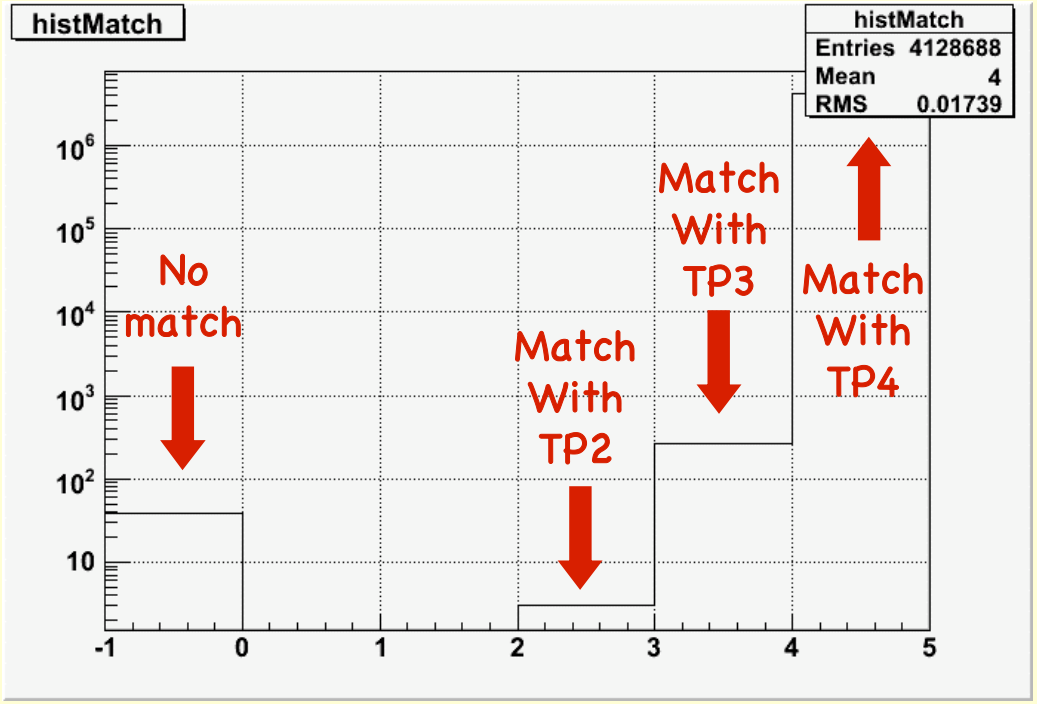
# ECAL Trigger Primitives commissioning

Since beginning of 2008, we take regularly local runs (ECAL only)
Emulator computes 5 possible TPs (TP0, TP1, TP2, TP3, TP4) from the 10 samples of crystal data
Ideally, when all the crystal data/TP data are properly timed in, the TP from the data should always match the same TPi in the emulator



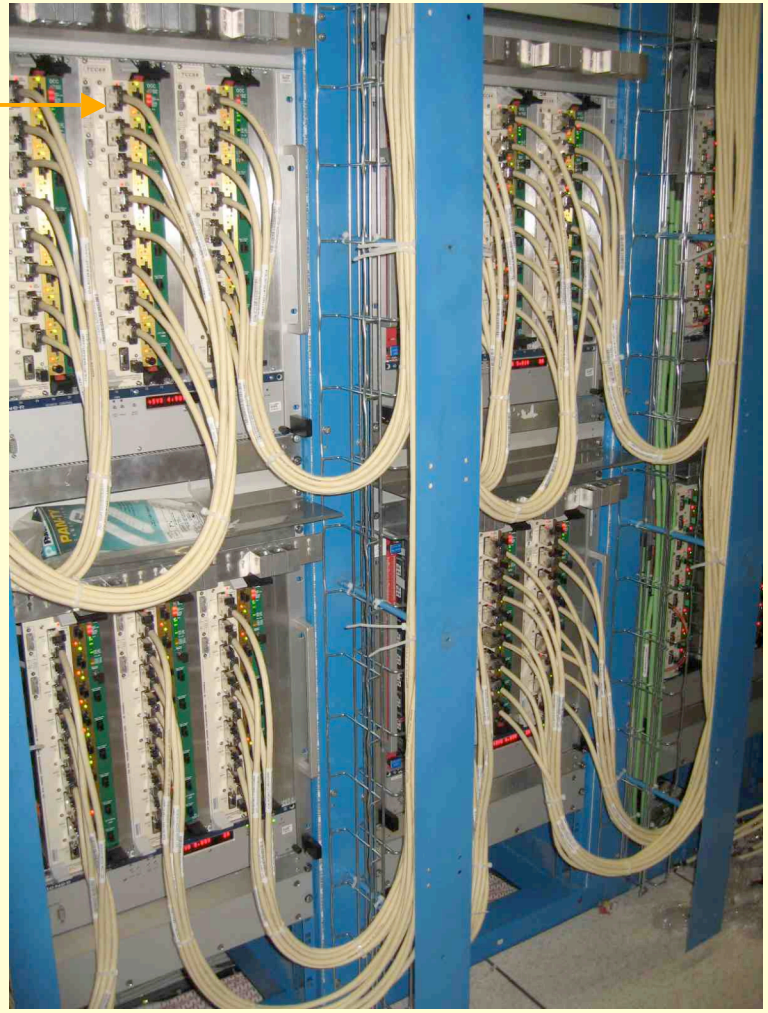
Example with one of these local runs:
4 128 688 Trigger Primitives were read out
- Large number of channels properly timed in (TP4)
- Few need to be shifted by 1 or 2 clock (TP2 and TP3)
- 39 cases which don't match at all (timing too far)

Timing measurement of crystal data/TP is an on-going activity



# ECAL Trigger commissioning

The ECAL off-detector crates in the service cavern



Test of links between ECAL and Regional Calorimeter Trigger :

Initial tests :

- Based on patterns loaded in the TCC memories
- TCC cards used as a pattern generator
- Patterns values allowing to activate each channel one by one
- Data captured by RCT and checked
- Revealed few mapping error of cables

High level tests:

Involved global runs (see next slides)


# First operation experiences with Global and Local Runs

# What are the Global/Local Runs ?

## Global Run :

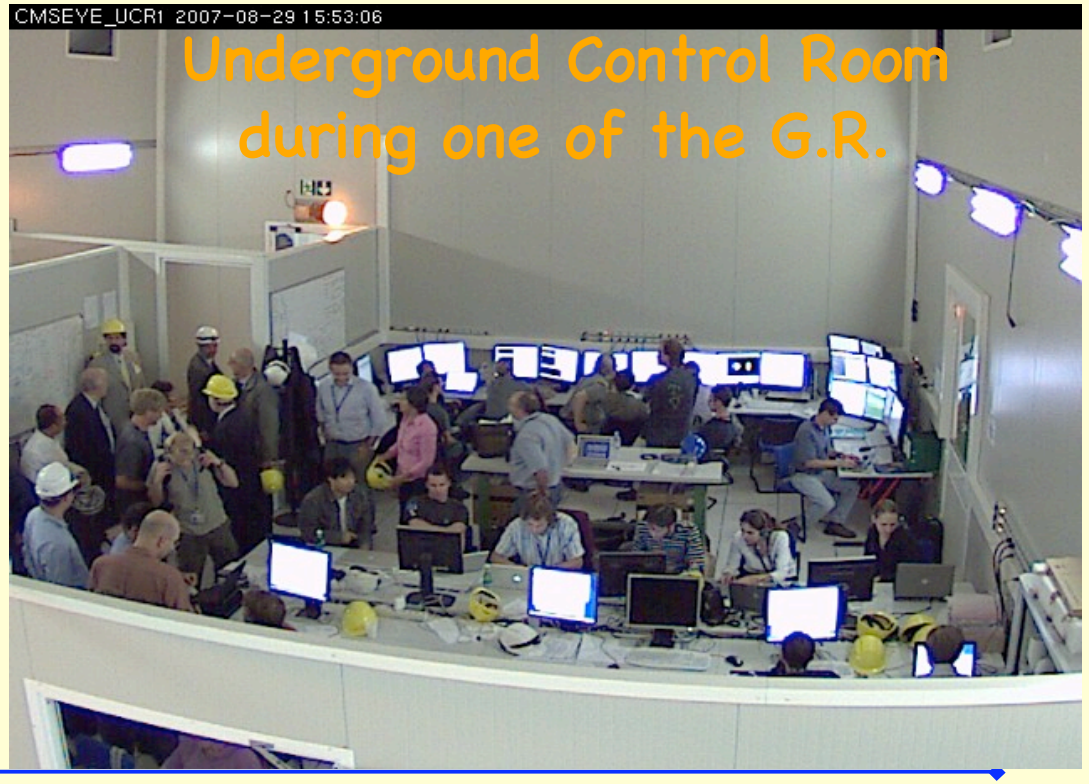
- Coherent exercise of CMS data taking in preparation for collisions
- 1 week of intense activity!
- 6 GR in 2007, 2 in 2008 so far
- Involves more and more subsystems

## ECAL Local Runs :

- only ECAL + optionally Trigger chain are involved
- Readout can be local (VME with low rate) or global

## ECAL participation in GR

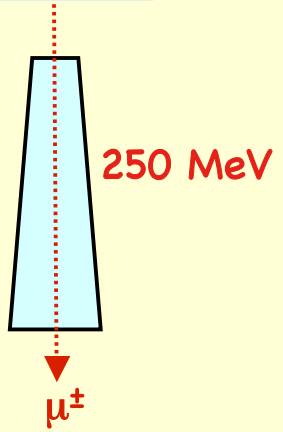
- Several times in 2007 for the readout of data
- First time in 2008 as a trigger source



# The ECAL trigger on cosmic rays

## ECAL setting :

- A muon crossing longitudinally an ECAL crystal ≈ 250 MeV
- Noise level in ECAL ≈ 40 MeV ⇒ Signal/Noise ≈ 6 σ : noise rate would be too large (@ 40 MHz with 61200 crystals!)
- Special setting of ECAL for cosmics: APD gain ×4 ⇒ noise ≈ 10 MeV



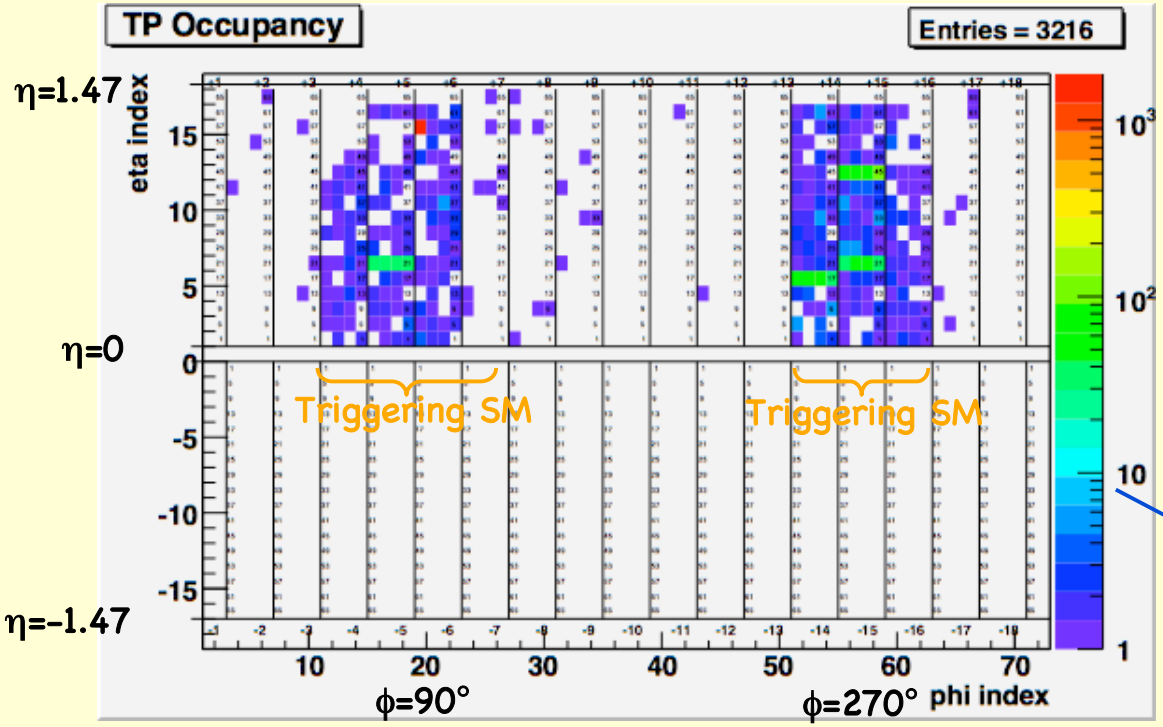

## ECAL Trigger Configuration :

- Further reduction of the noise rate ⇒ threshold applied in ECAL at trigger tower level ≈ 200 MeV (rem: E.M L1 trigger used sum of 2 towers)
- 2 kinds of trigger configuration:
  - Single E.M L1 trigger: with threshold applied in Global trigger on the E.M object
  - Double E.M L1 trigger requiring top-bottom coincidence

Please note that ECAL Trigger is used in **extreme conditions**!
threshold ≈ 0.2 GeV instead of ≈ 20 GeV (LHC) !!!

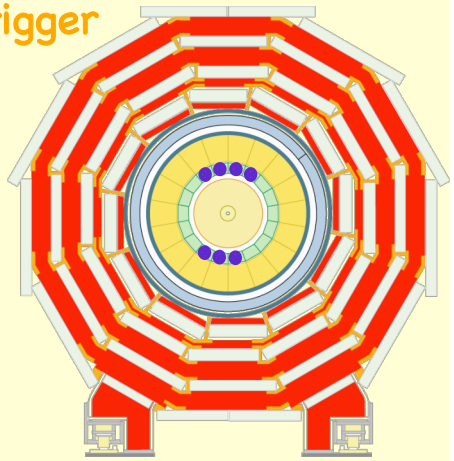
# First experiences with ECAL trigger data

Given the small amplitude of the MIP signal, any problematic channel can pollute the signal and may pass the (very low threshold) trigger ⇒ ECAL trigger revealed easily these problematic channels




Example of an ECAL local run (31955) where:

- single EM trigger with few SM:
- only Barrel+ was readout



ECAL barrel Trigger Primitives occupancy is presented as a grid in η/φ space

- TP occupancy naturally higher for the triggering SM
- few 'hot towers' discovered [red and green] (various reasons: disconnection from APD, high leakage current, HV etc) ⇒ masked for cosmics trigger

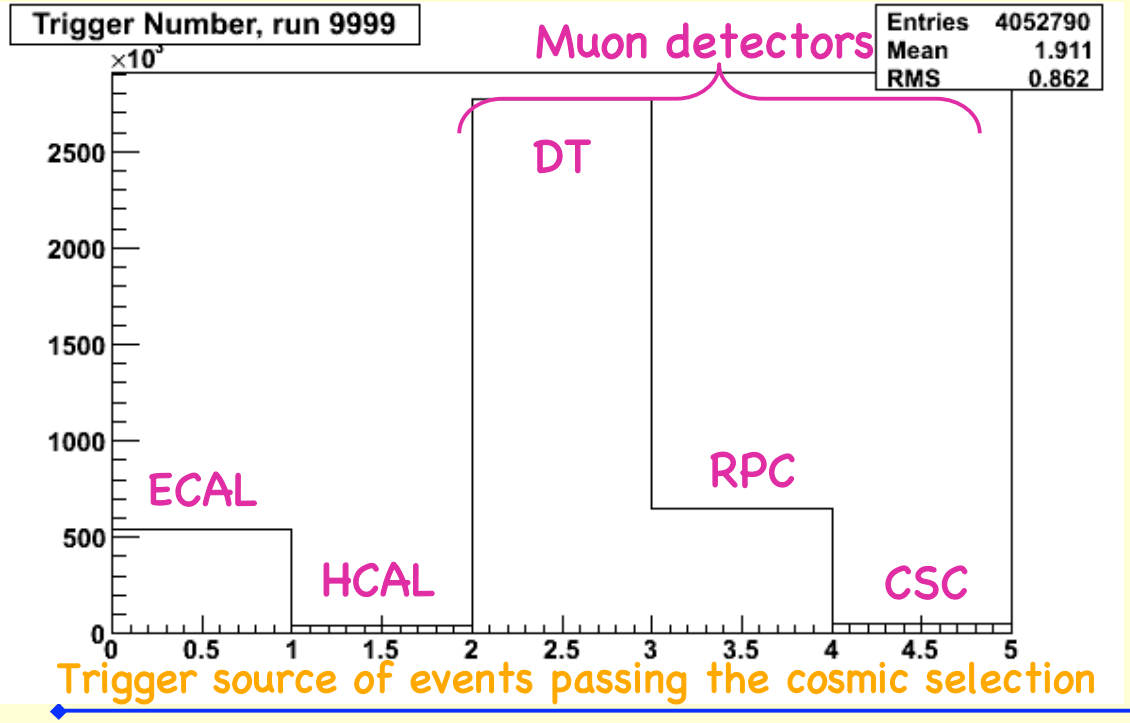
# Search for cosmic events in ECAL trigger data

Definition of a cosmic event for ECAL :

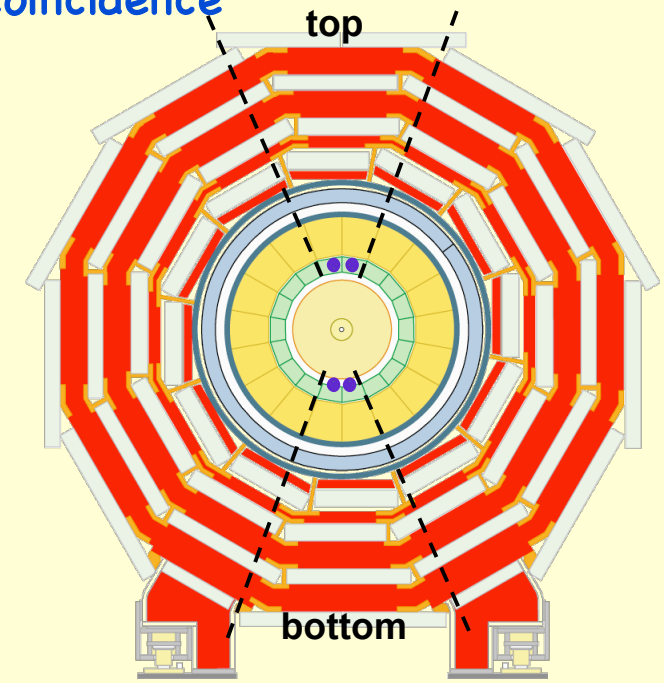
- 1 crystal E>135 MeV or 2 adjacent crystals with each > 45 MeV

May Global Run :

- More than $23.10^6$ events collected in 1 week with whole ECAL barrel readout
- Mainly double E.M L1 trigger stream with top-bottom coincidence



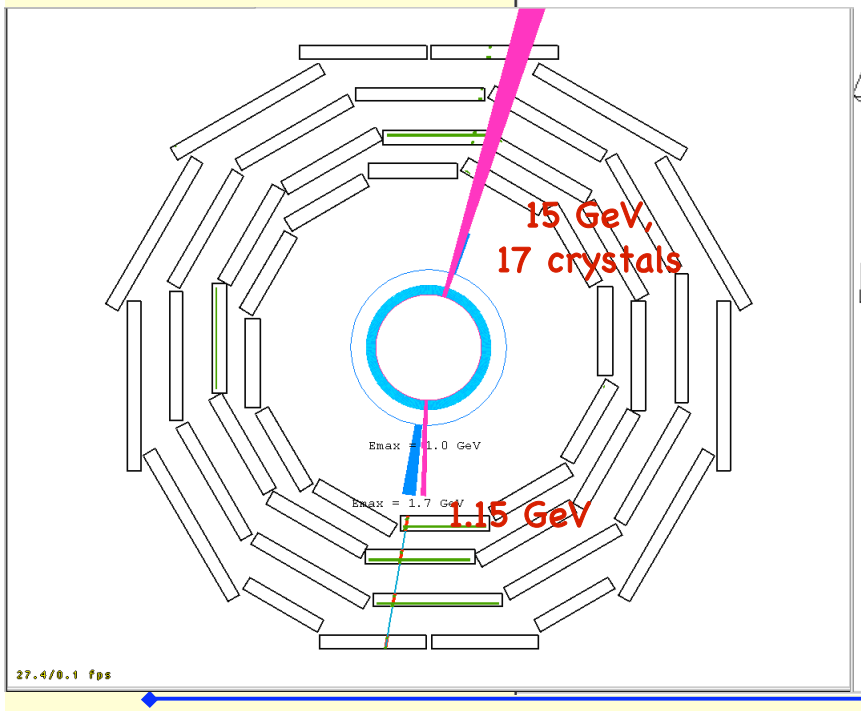

Trigger source of events passing the cosmic selection



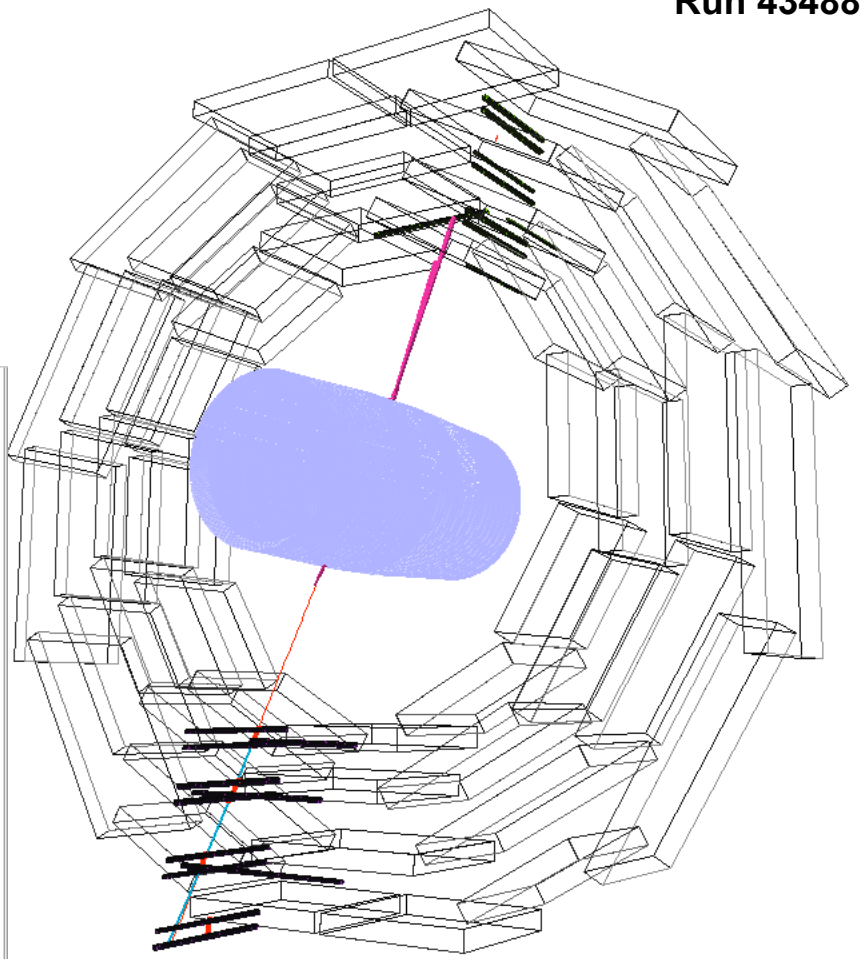

Fraction of ECAL triggers (cosmics) ≈ 2.2%

# Muons triggered and seen by ECAL

A nice example of a cosmic event candidate triggered by ECAL during May Global Run and seen in the muon chambers



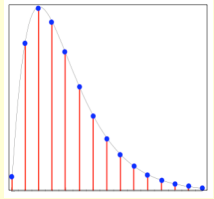

Run 43488



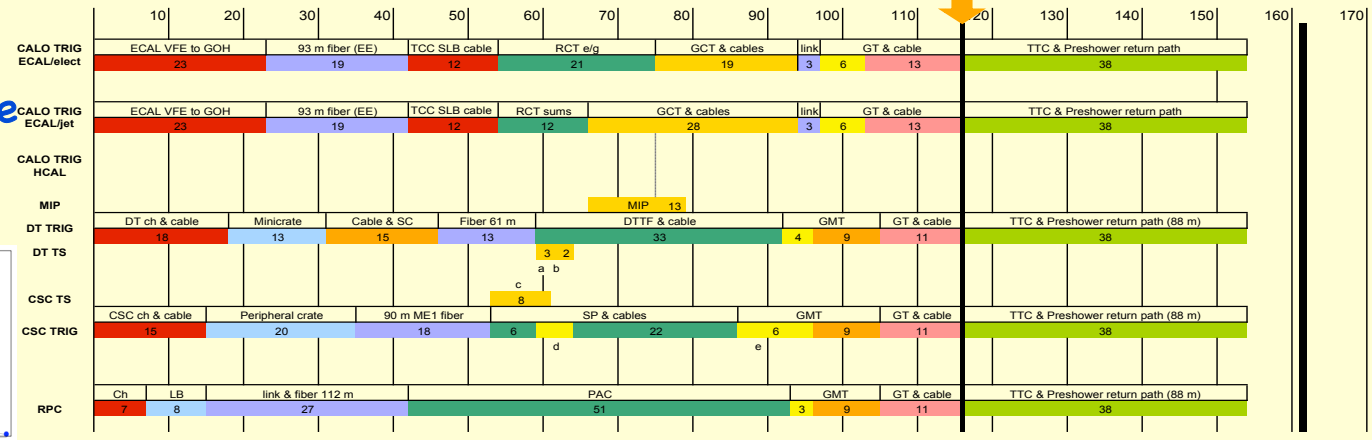
# Alignment of ECAL Trigger and latency

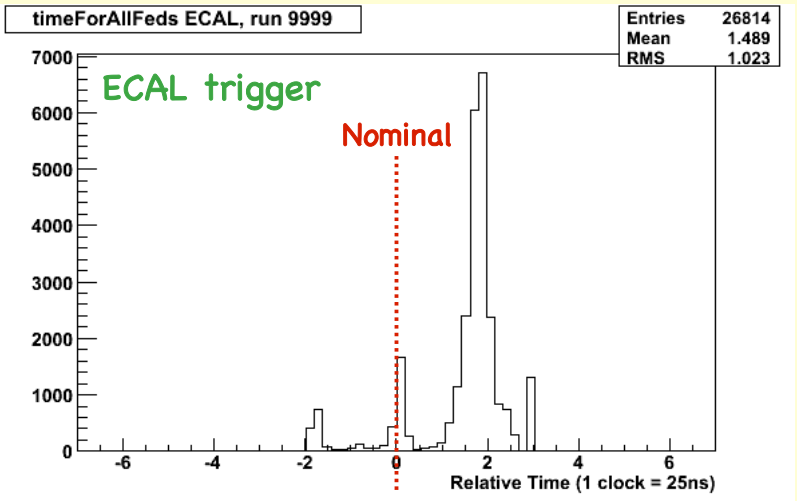
**Global Runs:**

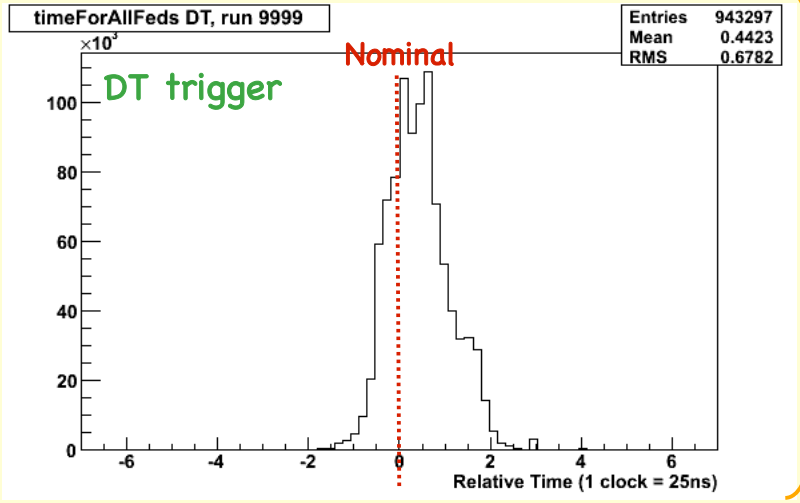
- give the opportunity to align triggers among each others and check compliance with specifications
- For each trigger source, look at the time of the maximum of the signal pulse in the data



116 BX = nominal latency from interaction to GT output



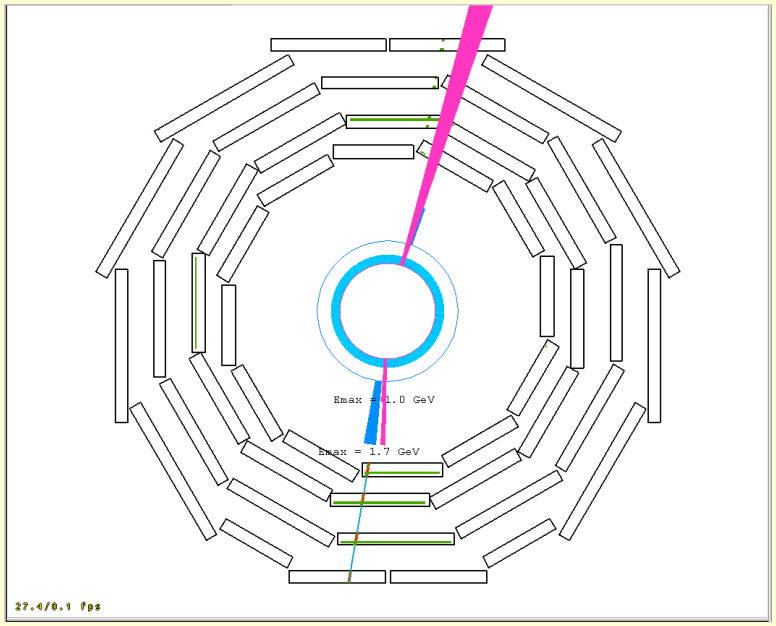

Measured during May GR

ECAL trigger was 2 clocks earlier ⇒ extra delay in now applied

# Conclusion

- ECAL Trigger commissioning (for barrel) well advanced

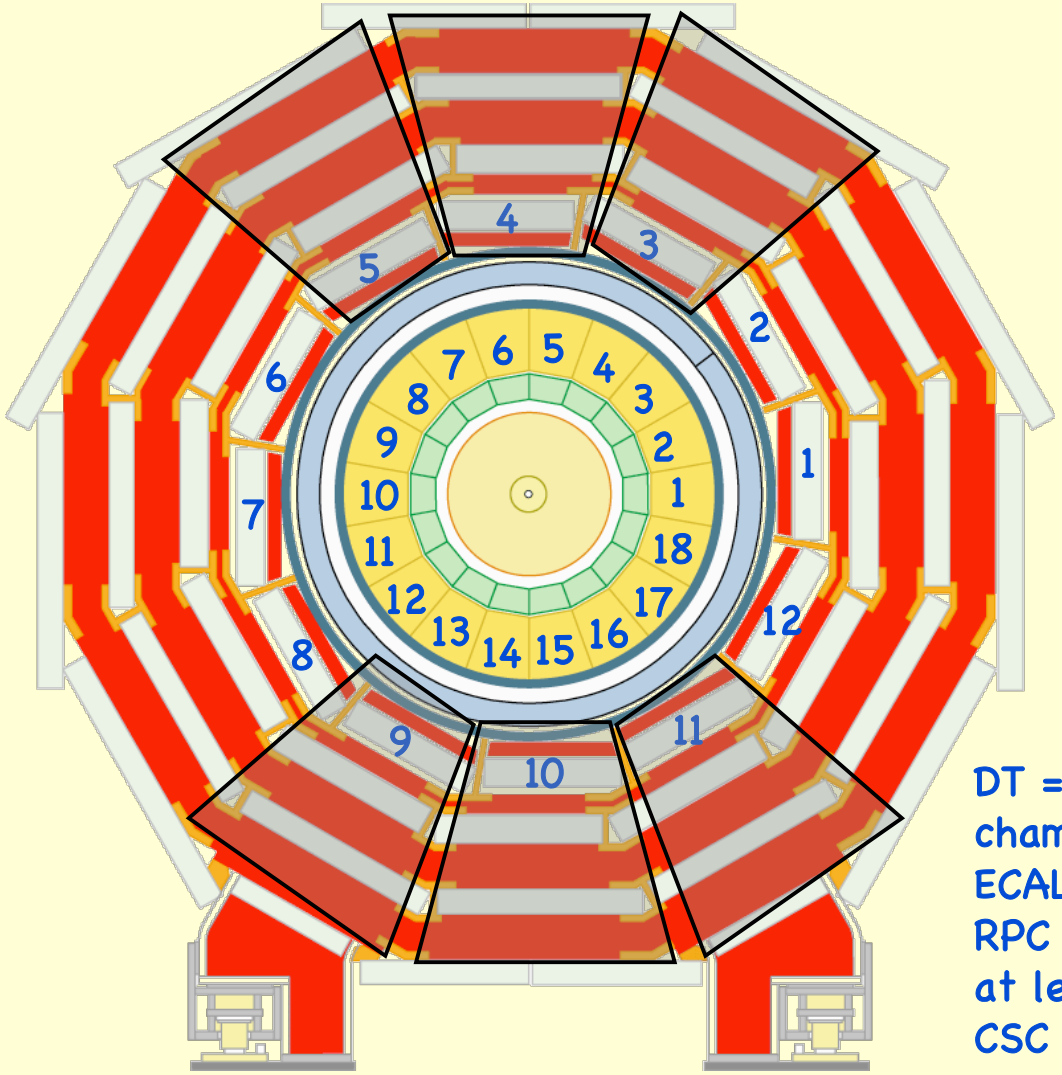
- Regular participation during Global Runs




Lots of exciting times before beam !!!

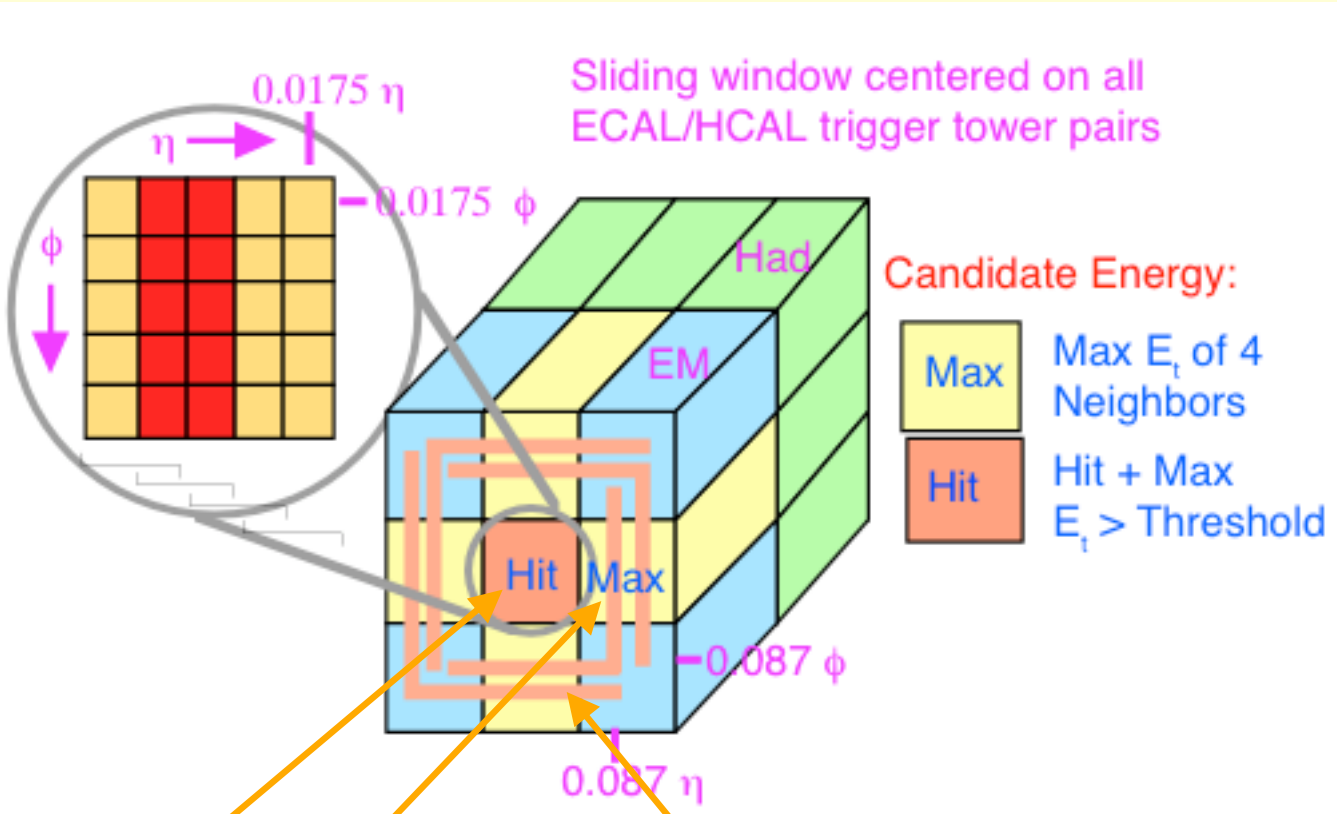

# Back-up slides

# Triggering scheme in May Global Run




DT = all wheels; (3,4,5) or (9,10,11) ; at least 2 chambers
ECAL = EB+ or EB-; (5 or 6)&(14 or 15)
RPC = YB0 or YB1; 10 or 11 or 12 or 1 or 2 or 3; at least 3 rolls
CSC = ME1+,4+; almost all chambers

# The L1 ECAL Trigger algorithm



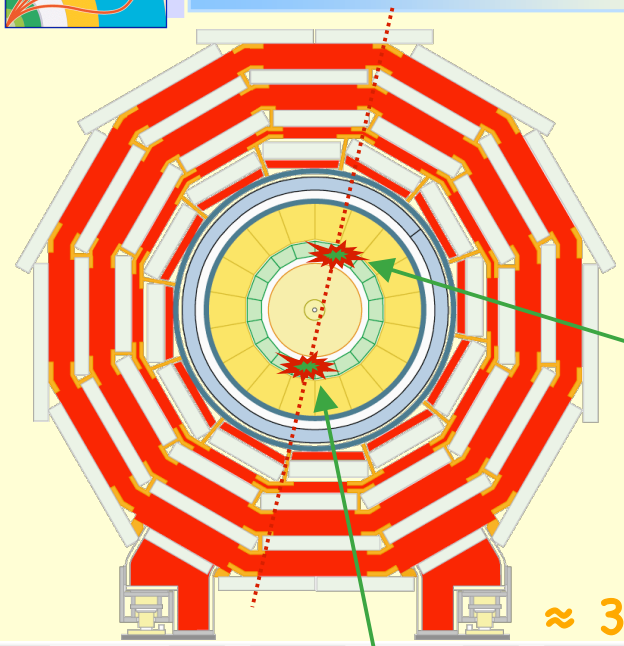

**Electron/photon :**

1. $E_T$ "Hit tower" + "Max tower" > threshold
2. Fine Grain (FG) veto: highest energy adjacent strip pair ≈ large fraction of total (e.g. 90%)
3. H/E veto (e.g. 5%)

**Isolated electron/photon :**

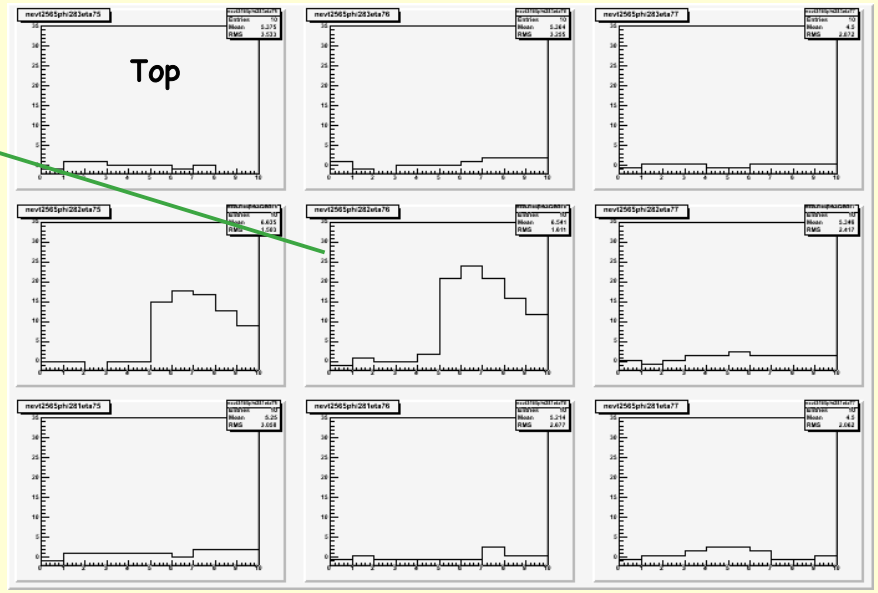
1. 8 neighbours towers with FG veto and H/E veto
2. 1 group of 5 "corner towers" with $E_T$ < threshold

# Muons triggered and seen by ECAL

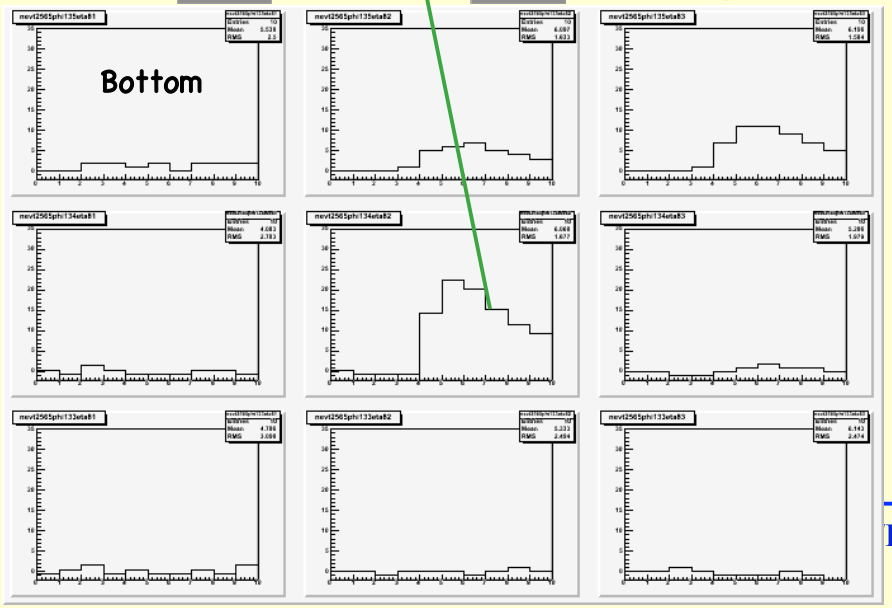


≈ 370 MeV

3×3 crystal window data




≈ 330 MeV




A nice example of a muon candidate
Triggered and readout by ECAL
(Local Run 31955)