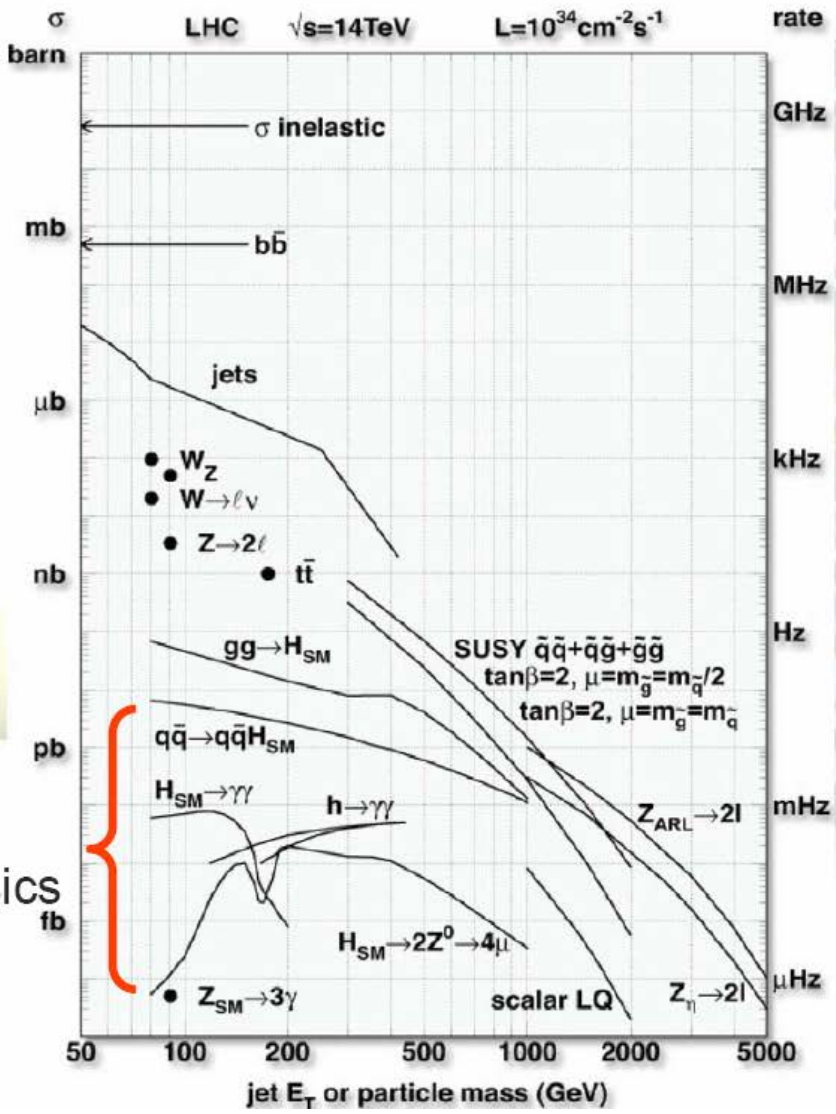


'new' physics

Interaction rate: ~1GHz

event size: 1.5MB (140 million channels)

1PB/sec

! affordable 300MB/sec

online rejection:

99,9995% !

Storage rate: ~200Hz

Enormous rate reduction necessary !

Powerful trigger needed!

3-Level Trigger System:

LVL1:

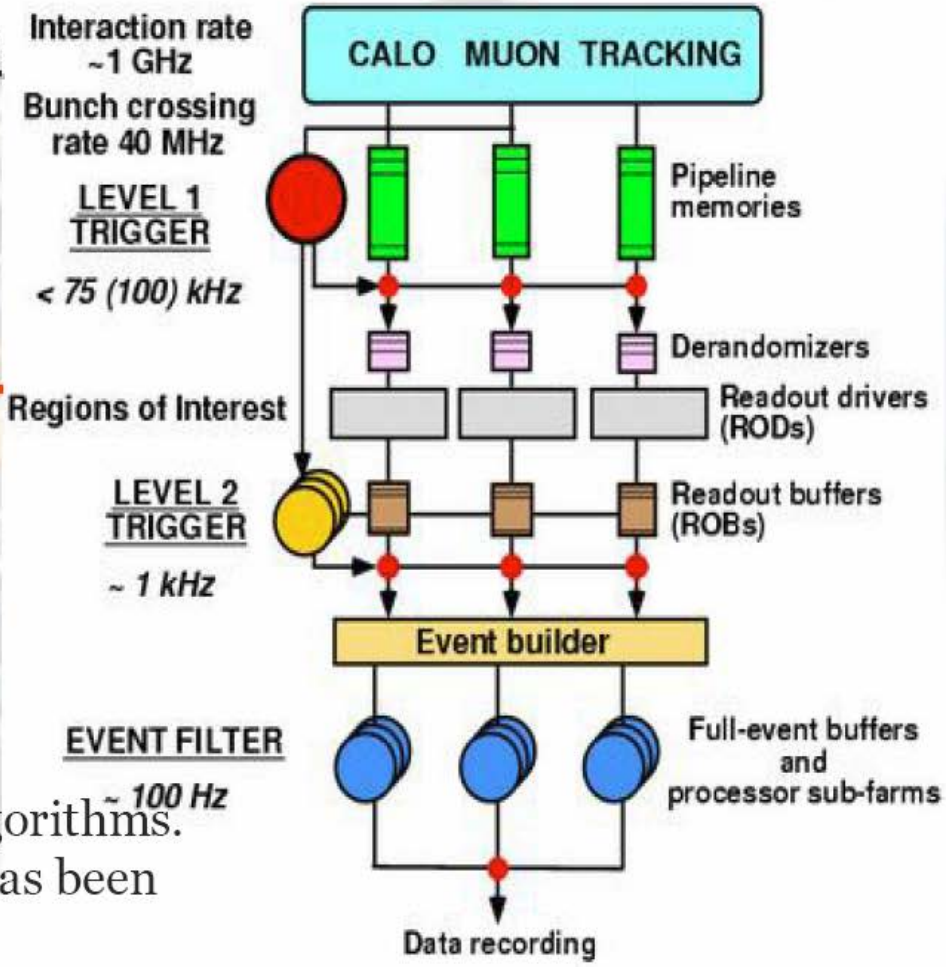
Hardware based system.
Coarse Information from calorimeters and muon trigger chambers.

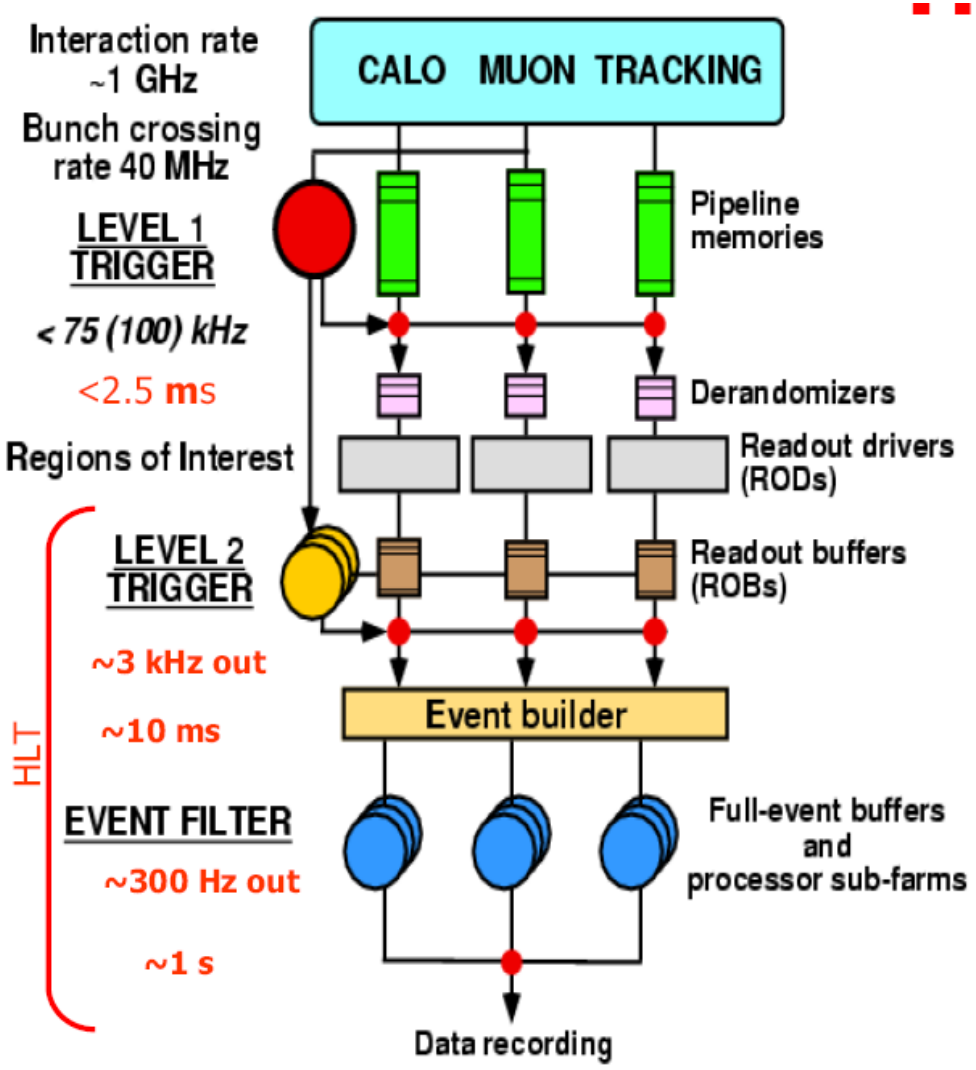
LVL2:

Based on optimized software algorithms.
Full granularity data in RoIs, defined by LVL1, available.

Event Filter:

Implemented using (complex) software algorithms.
Performs its task only after the full event has been assembled in the Event Builder.





LEVEL 1

- hard ware based: FPGAs, ASICs
- uses larger granularity of the calorimeter and muon information
- identify **R**egions **o**f **I**nterest for further processing
- reduction from 1 GHz to 75 kHz
- **latency of 2.2 μs**

LVL1: hardware

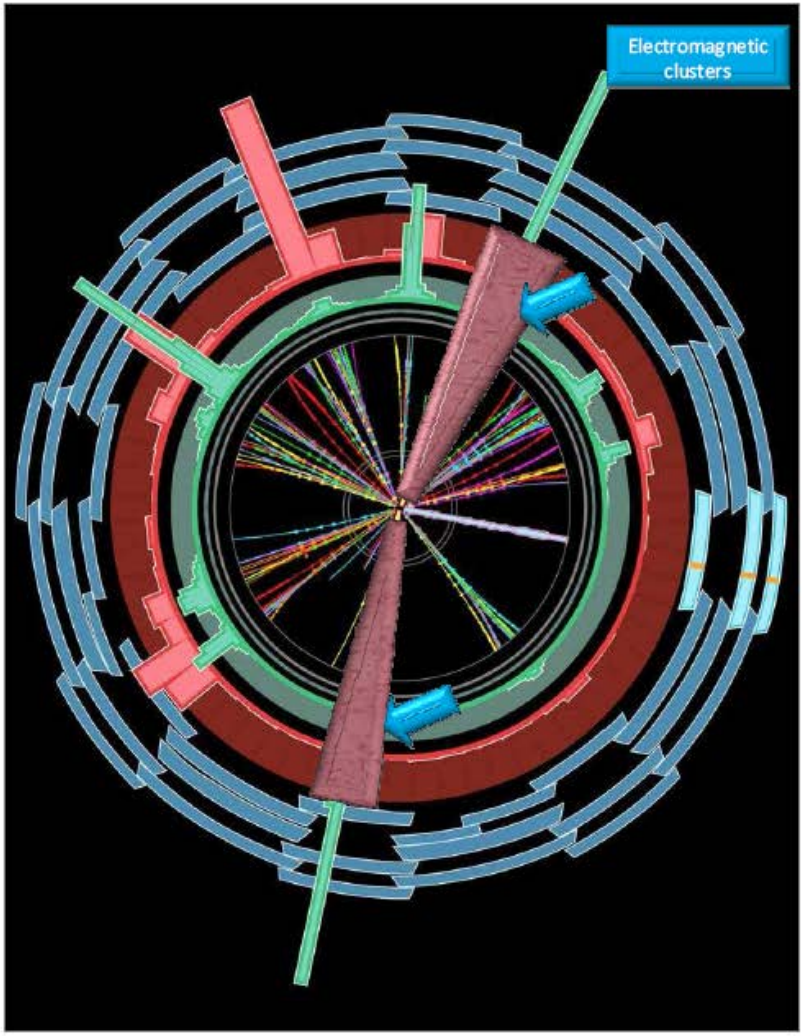
LEVEL 2

- full granularity within the **RoI**
- seeded by LVL1-trigger
- fast reconstruction
- only data within **RoI processed**
- combination of detectors within **RoI**
- reduction from 75 kHz to 1 kHz
- **execution time of ~ 40 ms**

EVENT FILTER

- seeded by level 2
- full event information available
- full granularity of detectors
- "offline like" algorithms
- reduction from 1kHz to 200 Hz
- **averaged execution time of 4 s**

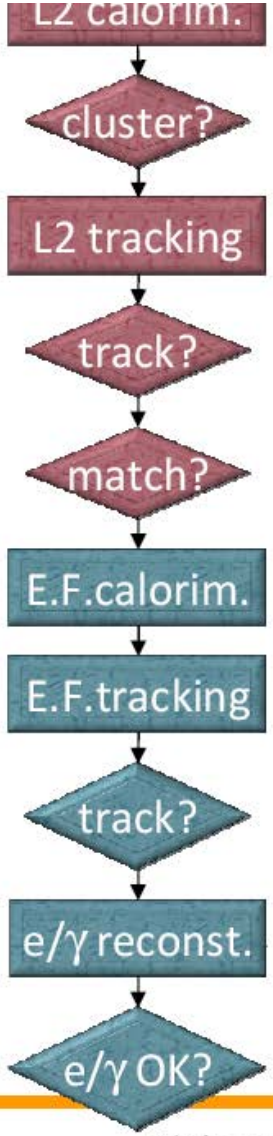
HLT (LVL2 + EF): software



Level1:
Region of Interest is found and position in EM calorimeter is passed to Level 2

Level 2 seeded by Level 1
- Fast reconstruction algorithms
- Reconstruction within RoI

Ev.Filter seeded by Level 2
- Offline reconstruction algorithms
- Refined alignment and calibration



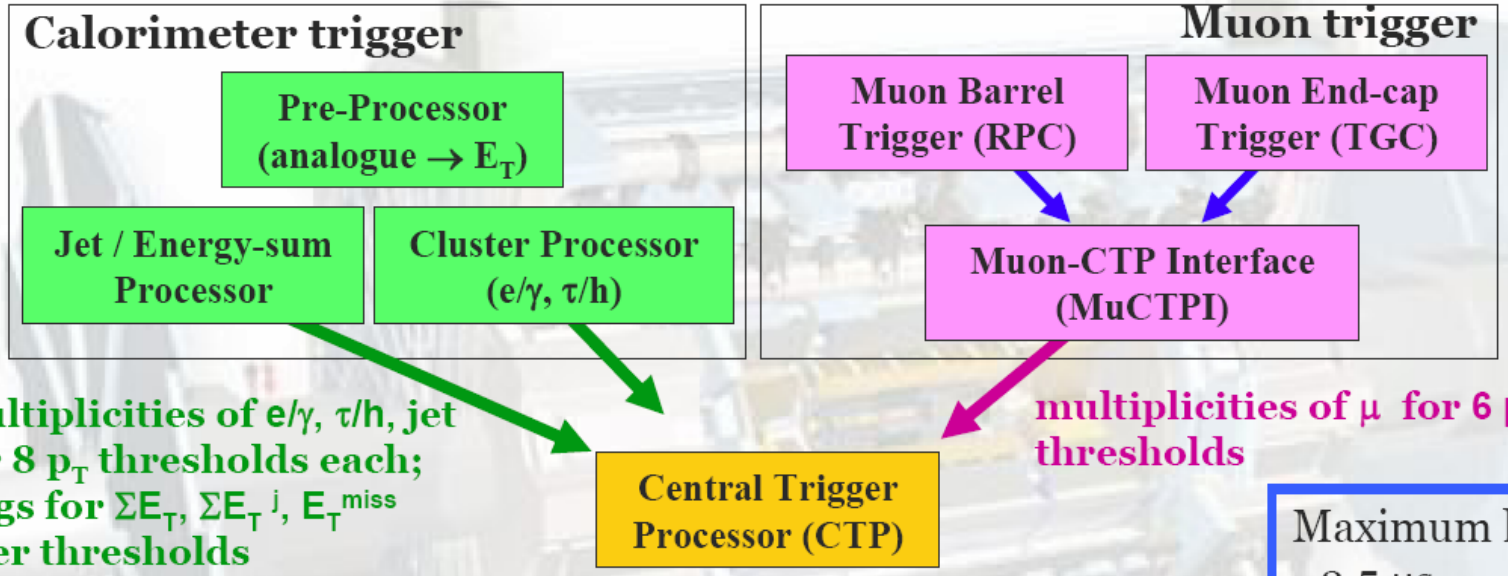
TRIGGER MENU CLASSES

Object	Examples of physics coverage	Nomenclature
Electrons	Higgs (SM, MSSM), new gauge bosons, extra dimensions, SUSY, W, top	e25i, 2e15i
Photons	Higgs (SM, MSSM), extra dimensions, SUSY	γ60i, 2γ20i
Muons	Higgs (SM, MSSM), new gauge bosons, extra dimensions, SUSY, W, top	μ20, 2μ10
Jets	SUSY, compositeness, resonances	j360, 3j150, 4j100
Jet+missing E_T	SUSY, leptoquarks	j60 + xE60
Tau+missing E_T	Extended Higgs models (e.g. MSSM), SUSY	τ30 + xE40

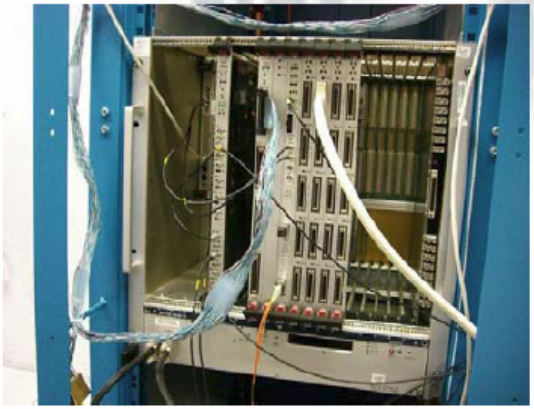
Trigger menu 'NoXXi':

- 'N'= min. number of objects required
- 'o'= type of selection ('e'=electrons, 'γ'=photons, 'μ'=muons, 'b'=b-tagged jet; 'xE'=missing E_T; 'E'=total E_T; 'jE'=total E_T using only jets).
- 'XX'= threshold in transverse Engery
- 'i'= indicates an isolation requirement

LEVEL1 OVERVIEW



central part of LVL1 trigger system.
calculation of trigger decision
based on inputs from L1Calo and L1Muon.



Maximum latency:
~2.5 μs
(=100 BC!)

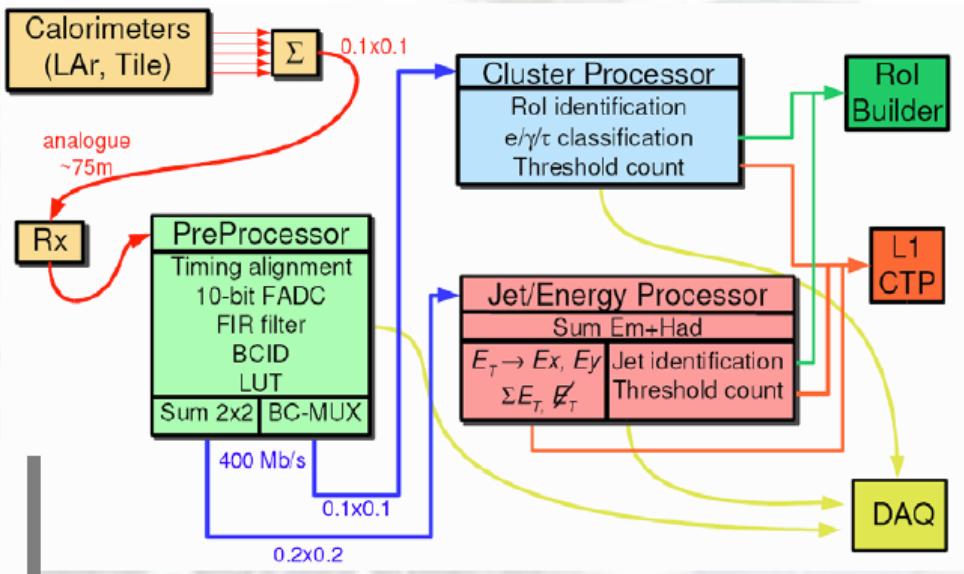
Data fragments held in pipelined Memories. Upon LVL1 acceptance transferred to Read Out Buffers (ROB).

LVL1 CALORIMETER TRIGGER

Electronics on detector: **summation of signals** to form **~7200 Trigger Towers** granularity $\Delta\eta \times \Delta\varphi = 0.1 \times 0.1$

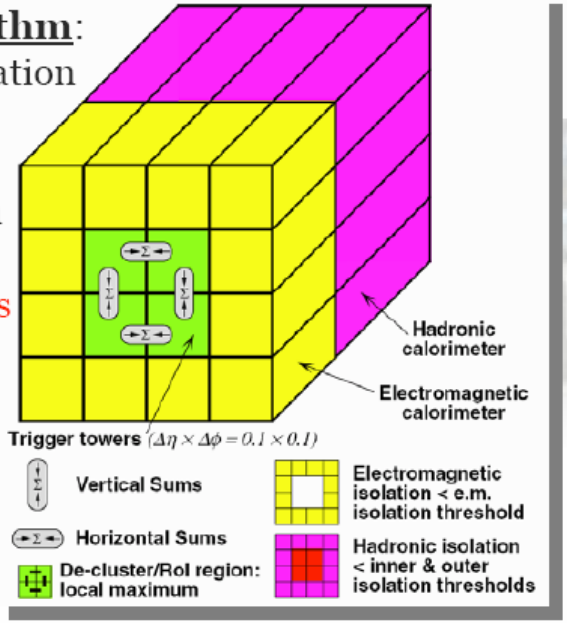
electronic components :

- PPr: digitisation of analogue signals from calorimeters and bunch crossing ID
- JEP: jet finding and energy sums
- CP: e/γ and τ/ had. cluster finding



example: e/γ algorithm:

- goal: good discrimination e/γ ↔ jets
- identify 2x2 RoI with local ET maximum
- cluster/ isolation cuts on various ET sums

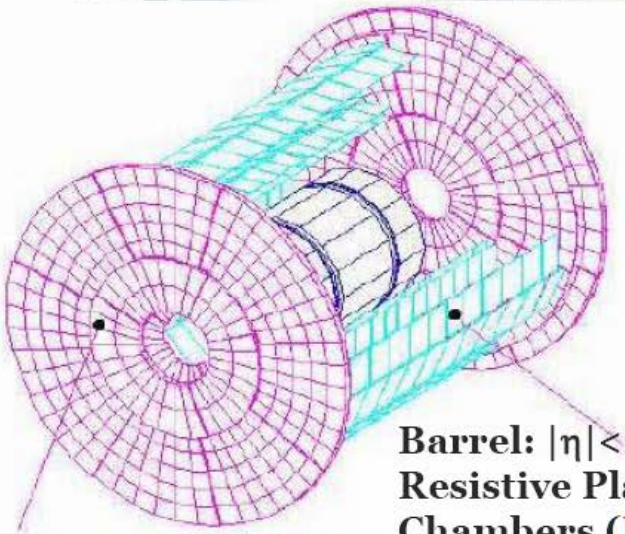


output:

- at 40 MHz: multiplicities for e/γ, jets, τ/had and flags for energy sums to Central Trigger (CTP)
- accepted events: position of objects (RoIs) to LVL2 and additional information to DAQ

LVL1 MUON Trigger

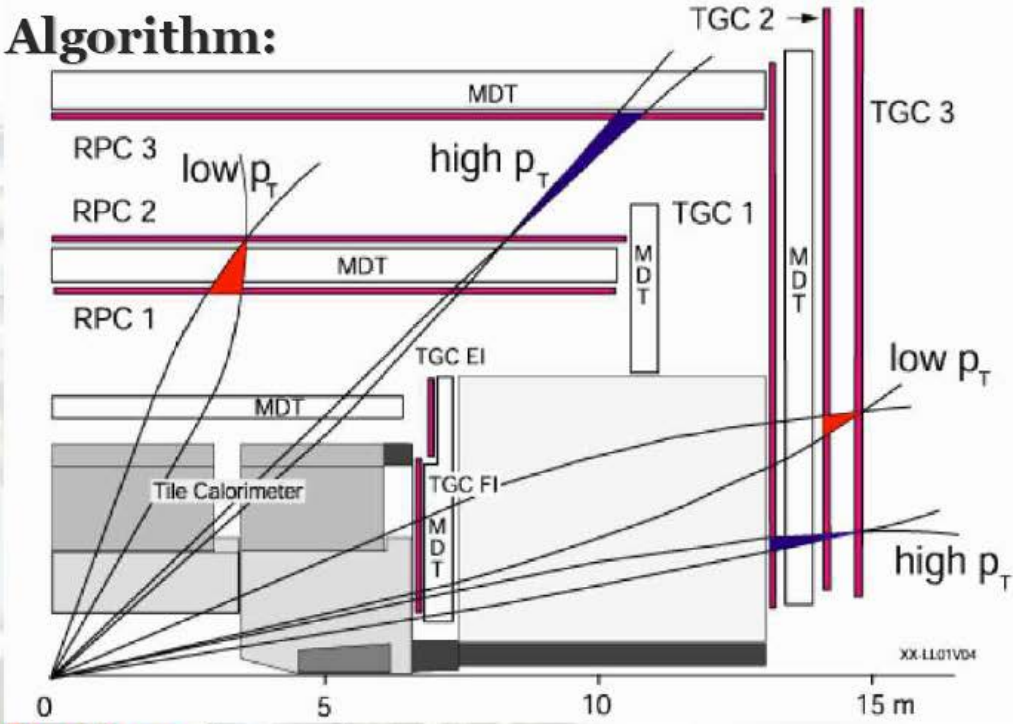
Trigger Chambers:



Barrel: $|\eta|<1.0$ Resistive Plate Chambers (RPCs)

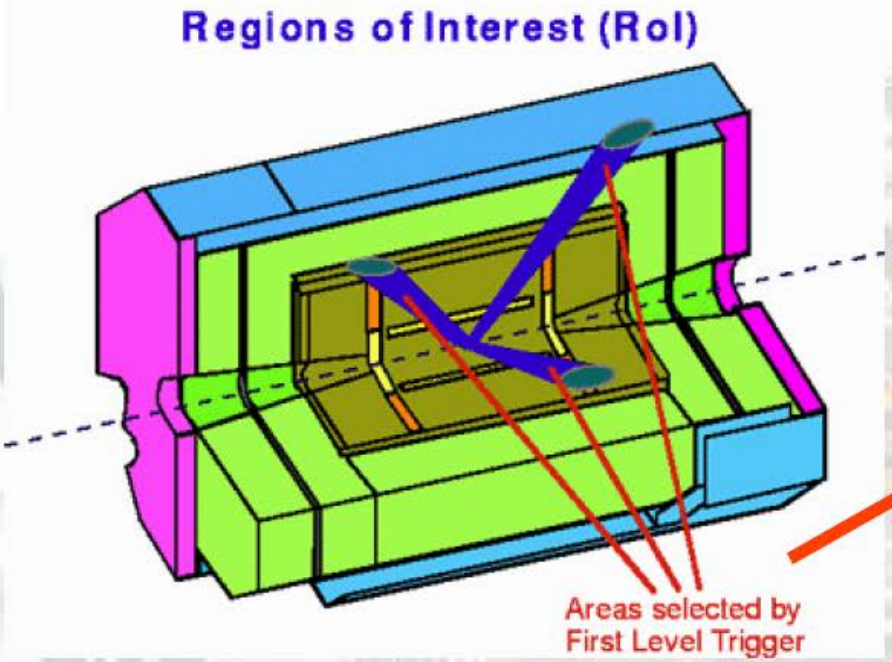
End-caps: $1.0< |\eta|< 2.4$ Thin Gap Chambers (TGCs)

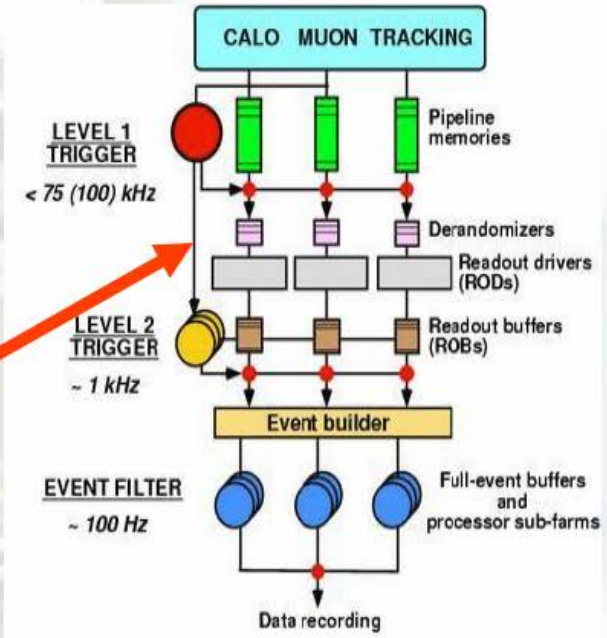
Algorithm:



- **deflection** depends on muon p_T
- programmable width of **6 coincidence windows** determines the p_T threshold.
- MuCTPI collects information form RPC and TGC triggers does overlap removal. Sends results to the CTP for LVL1 event decision

REGIONS of INTEREST



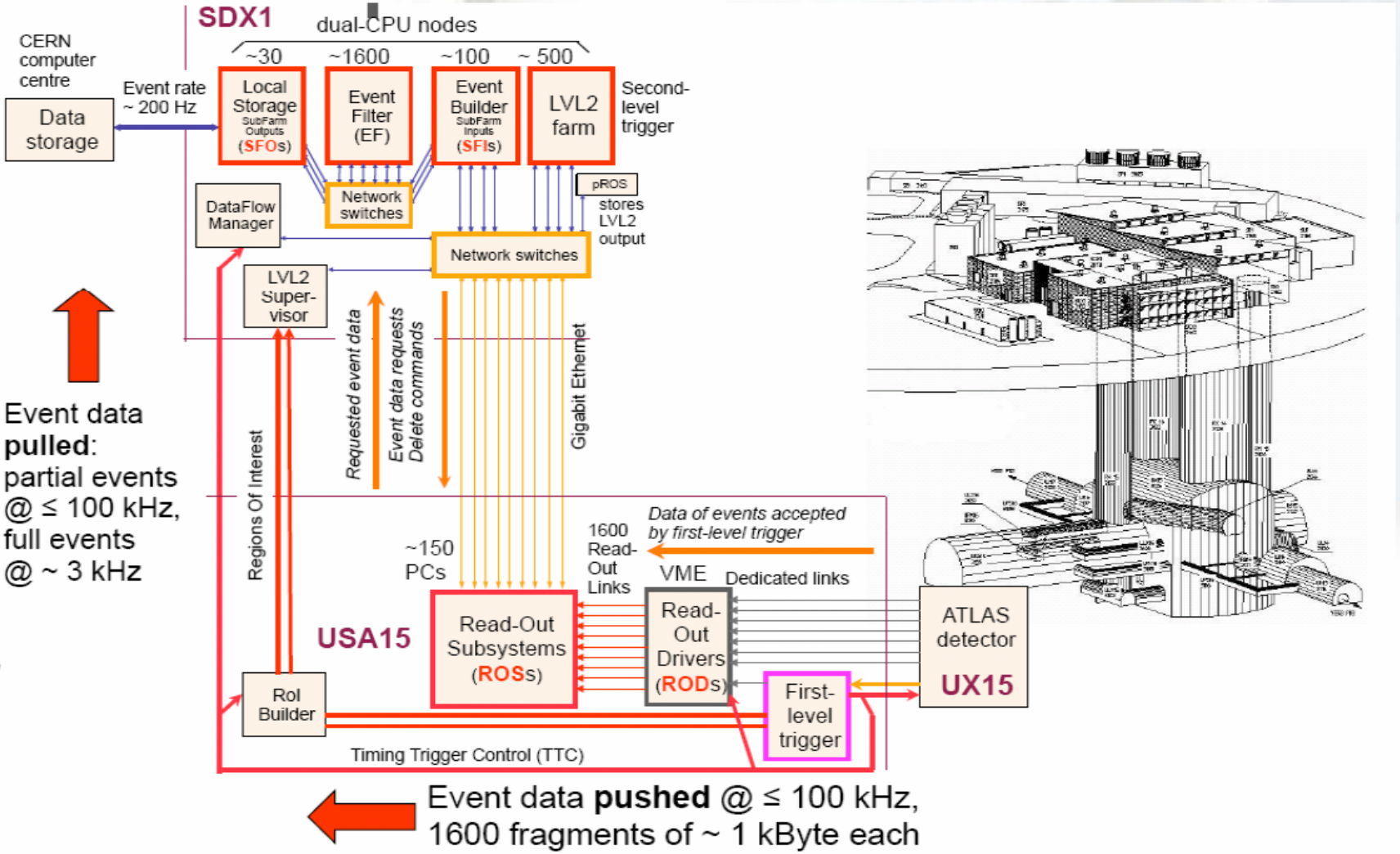


- LVL1 sends Regions of Interest to LVL2 for high p_T e/γ/τ/jet-/μ candidates.
- RoIs are used to 'seed' the LVL2 selection.
- LVL2 uses (in these regions) full precision from the inner tracker in addition to full granularity data from the calorimeters.

total amount of transferred data is small

→ **~2% of the total event data!**

LVL2 and EF run in large PC farms on the surface



Step- wise processing and decision:

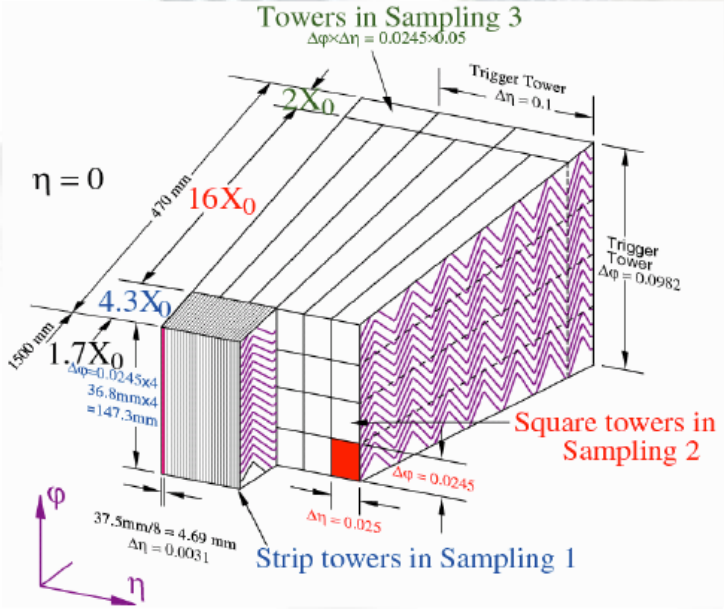
- Inexpensive (data, time) algorithms (clustering) first.
  complicated last (i.e. tracking).

Seeded reconstruction:

- Algorithms use results from previous steps.

HLT Output Rates

Selection	$2*10^{33}$ cm^{-2}s^{-1}	Rates (Hz)
Electron	e25i, e15i	~40
Photon	γ60i, 2γ20i	~40
Muon	μ20, 2μ10	~40
Jets	j400, 3j165, 4j110	~25
Jet & E_T^{miss}	j70 + xE70	~20
tau & E_T^{miss}	τ35 + xE45	~5
b-physics	2μ6 with m_B / $m_{J/\psi}$	~10
Others	pre-scales, calibration, ...	~20
Total		~200



LVL2 confirms & refines LVL1
EF confirms & refines LVL2