The ATLAS Trigger: High-Level Trigger Commissioning and Operation During Early Data Taking

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Royal Holloway
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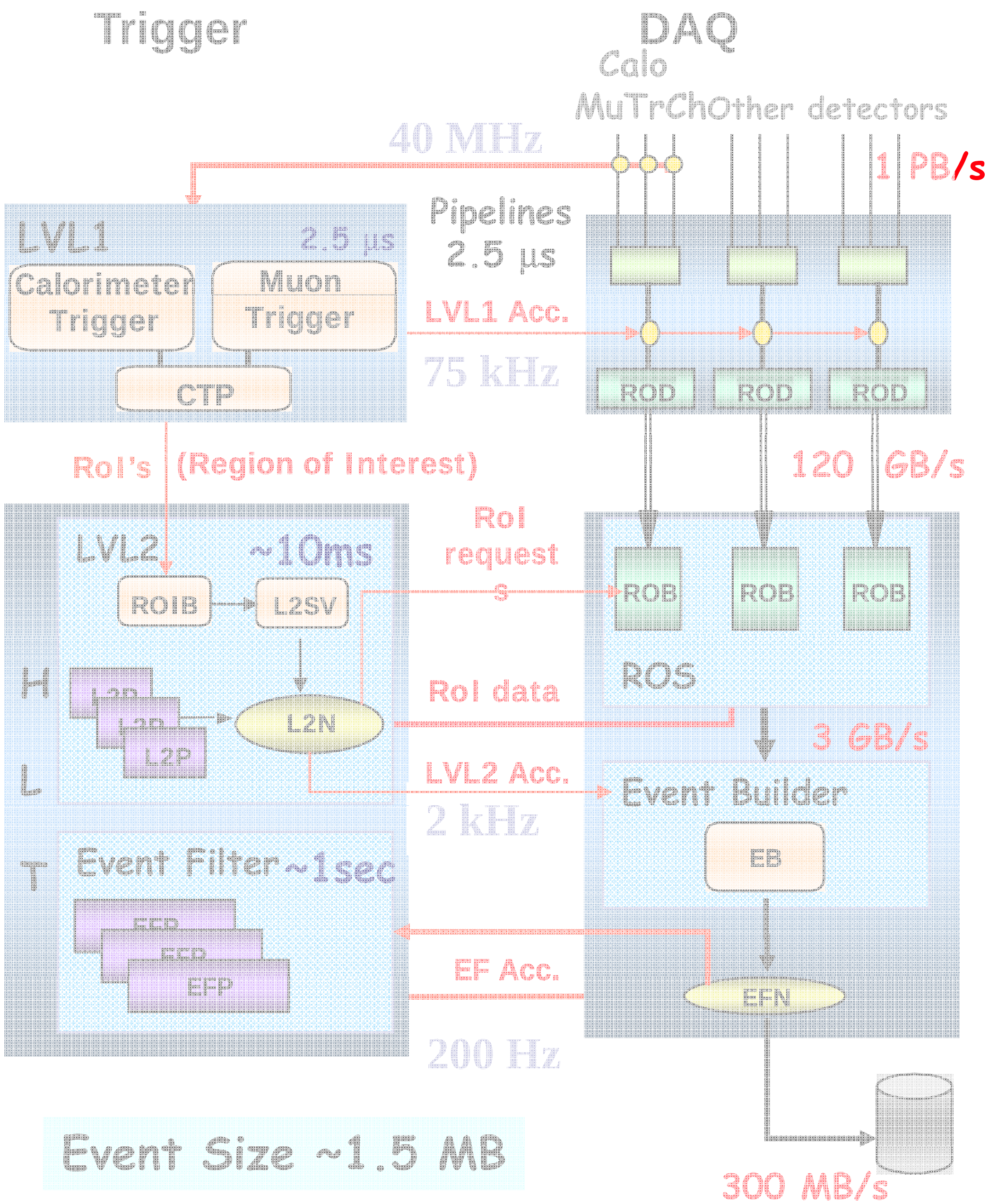
Outline

- The ATLAS High-Level Trigger
  - Overall system design
  - Selection algorithms and steering
  - Selection configuration
- Trigger selection for initial running
  - Trigger groups (slices)
  - Selection optimisation
  - Calibration triggers, (and passthrough and prescales?)XXXX
  - Performance monitoring
  - Measuring trigger efficiency from data
- High-Level Trigger Commissioning
  - Technical runs
  - Cosmic-ray runs
- Timeline
- Summary and outlook

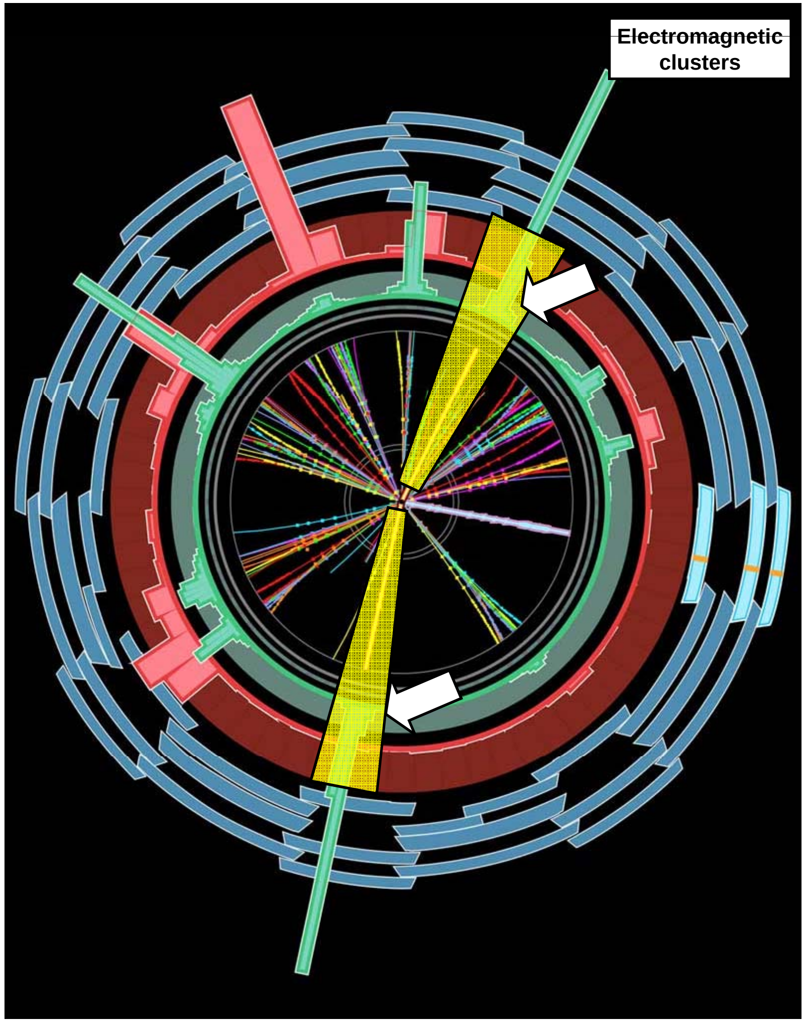
The ATLAS High-Level Trigger

- Three trigger levels:
- Level 1:
  - Hardware based (FPGA/ASIC)
  - Coarse granularity detector data
  - Calorimeter and muon syst. only
  - Latency 2.2 µs (buffer length 2.5)
  - Output rate up to ~75 kHz
- Level 2: ~500 dual-core CPUs
  - Software based
  - Only detector sub-regions processed (Regions of Interest) seeded by level 1
  - Full detector granularity in RoIs
  - Fast tracking and calorimetry
  - Average execution time ~10 ms
  - Output rate up to ~1 kHz
- Event Builder: ~100 dual-core CPUs
- Event Filter (EF):~1600 dual-core CPU
  - Seeded by level 2
  - Full detector granularity
  - Potential full event access
  - Offline algorithms
  - Average execution time ~1 s
  - Output rate up to ~200 Hz



Selection method

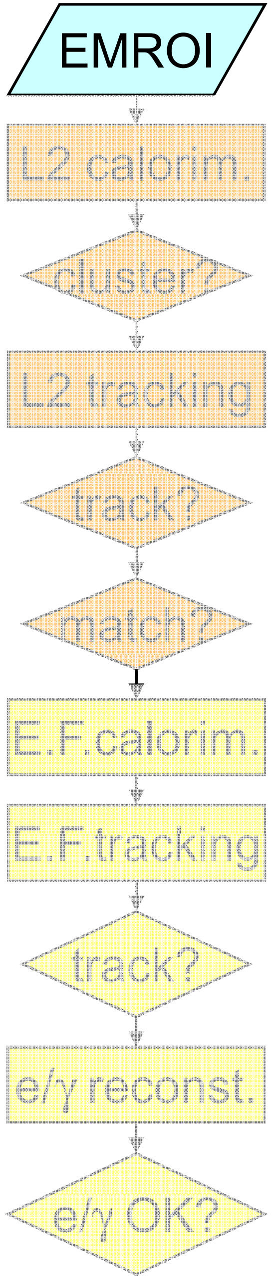
Event rejection possible at each step



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

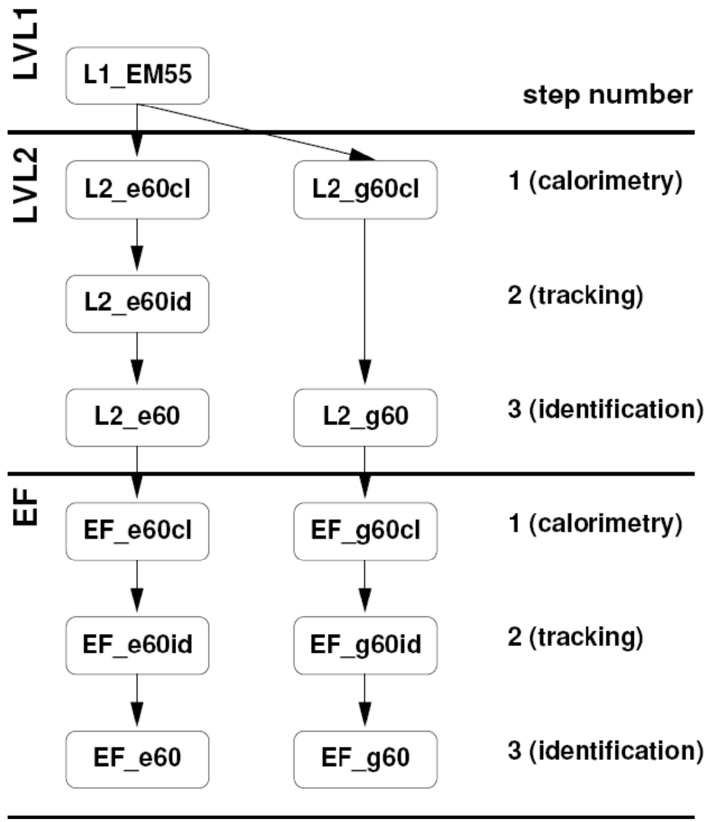
Level 2 seeded by Level 1
Fast reconstruction algorithms
Reconstruction within RoI

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



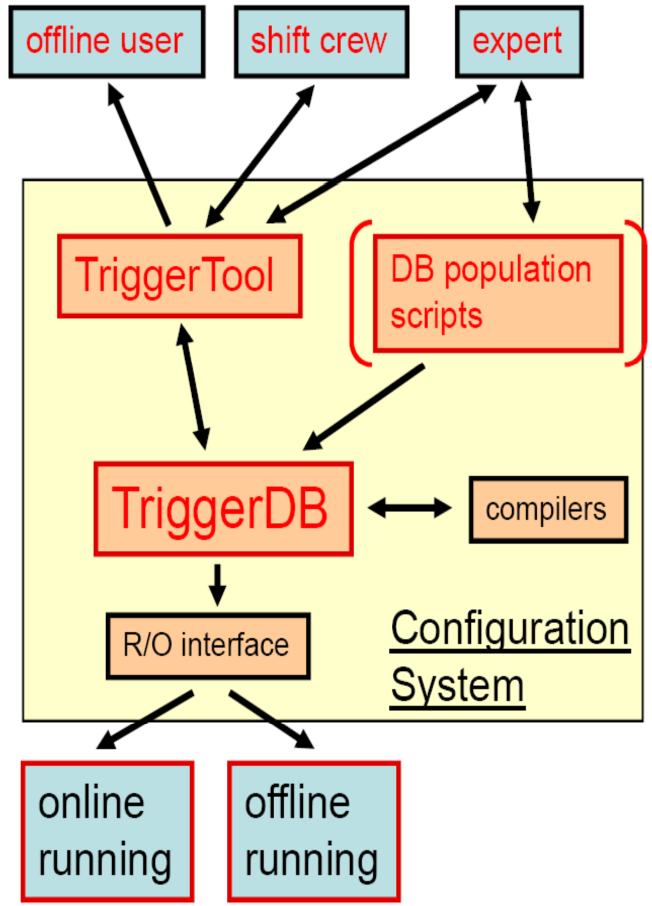
Steering and Configuration

- Algorithm execution managed by Steering
  - Based on static configuration
- Step-wise processing and early rejection
  - Chains stopped as soon as a step fails
  - Reconstruction step done only if earlier step successful
  - Any chain can pass an event
- Prescales applied at end of each level
- Specialized algorithm classes for all situations
  - Multi-objects: e.g. 4-jet trigger
  - Topological: e.g. 2 μ with $m_{\mu\mu} \sim m_Z$
  - ...



Steering and Configuration

- Trigger configuration:
  - Active triggers
  - Their parameters
  - Prescale factors
  - Passthrough fractions
- Needed for:
  - Online running
  - Monte Carlo production
  - Offline analysis
- Relational Database (TriggerDB) for online running
  - User interface (TriggerTool)
  - Browse trigger list (menu) through key
  - Read and write menu into XML format
  - Menu consistency checks
- After run, configuration becomes conditions data (Conditions Database)



Trigger Selection for Initial Running

Algorithm organisation

- High-Level Trigger code organised in groups ("slices"):
  - Minimum bias, e/γ, τ, μ, jets, B physics, B tagging, E_T^{miss}, cosmics, combined algorithms

- For initial running:
  - Crucial to have e/γ, τ, μ, jets, min.bias
  - Cosmics already started!
  - E_T^{miss} and B tagging will require significant understanding of the detector

- Will need to understand trigger efficiencies and rates
  - Zero bias triggers (passthrough)
  - Minimum bias:
    - Coincidence in scintilators placed in calorimeter cracks
    - Counting inner-detector hits
  - Prescaled loose triggers
  - Tag-and-probe method

Slices…

Low p_T			High p_T		
Threshold	Rates (Hz)		Threshold	Rates (Hz)	
	L1	HLT		L1	HLT
MU4	1000	1	MU15	19	19
MU6	227	1	MU20	14	14
MU10	112	1	MU40	8	8
2MU4	~9	~9	2MU20	<1	<1
2MU6	4	4	2MU40	<1	<1
2MU10	~1	~1			

High-Level Trigger Commissioning

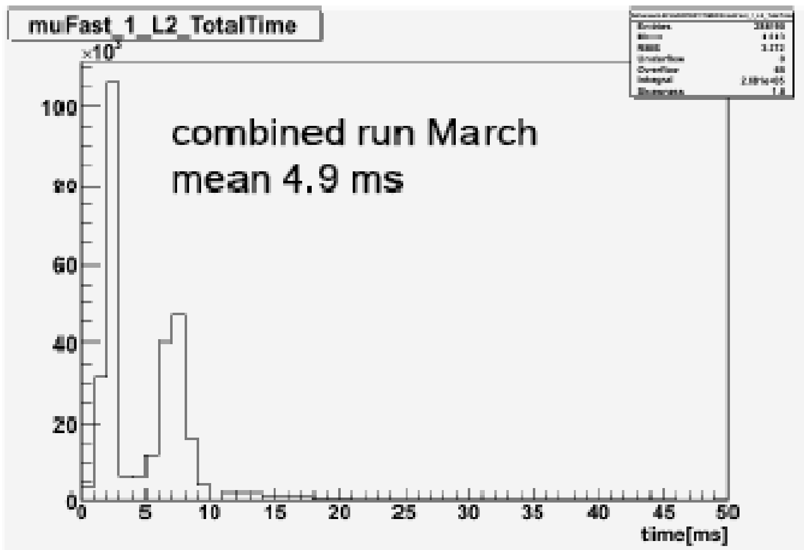
Technical runs

- A subset of the High-Level Trigger CPU farms and DAQ system were exercised in techical runs

- Simulated Monte Carlo events in bytestream format preloaded into DAQ readout buffers and distributed to farm nodes
  - Level 1 trigger simulated in a dedicated algorithm

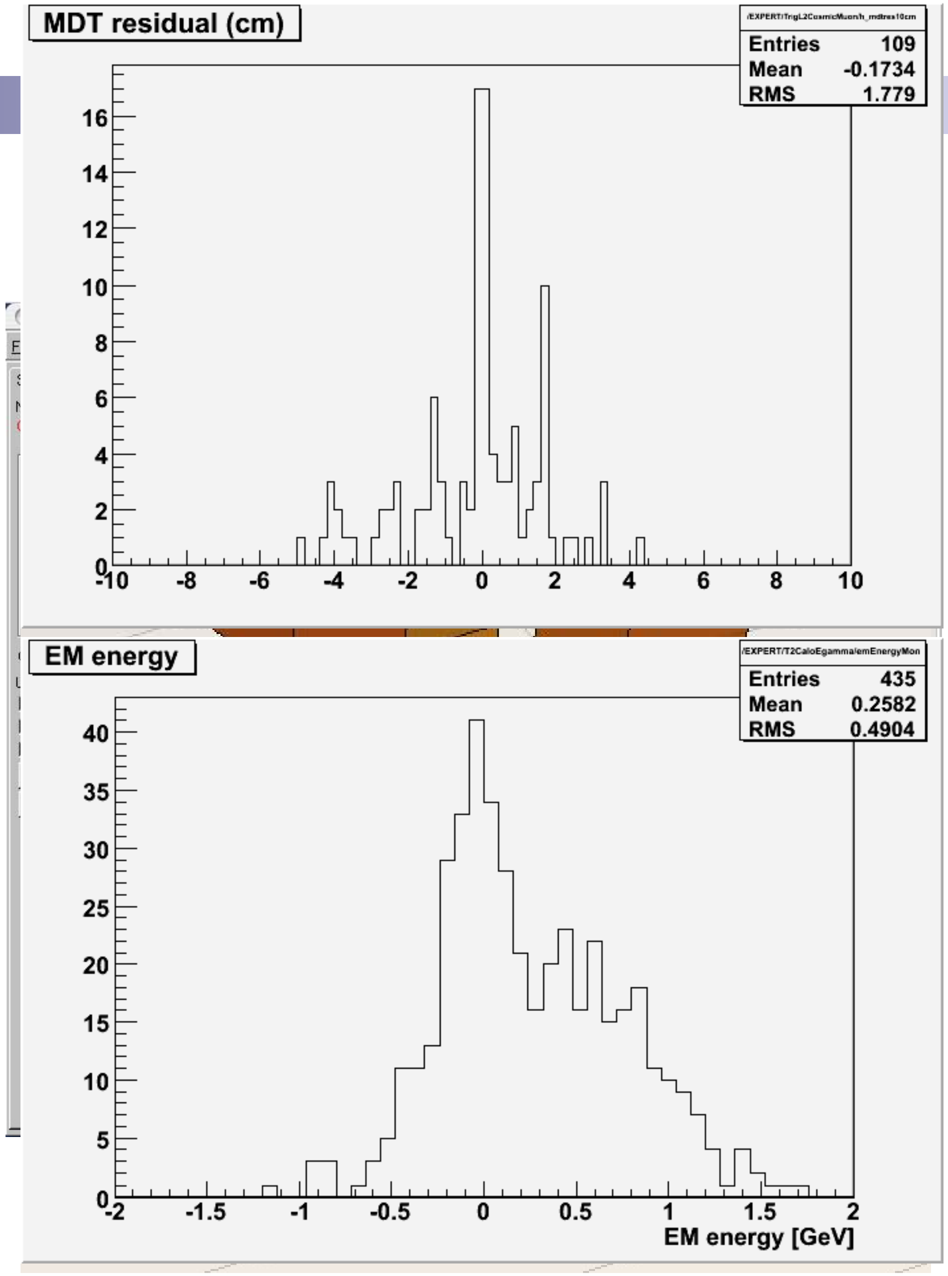
- A realistic trigger list is used (e/γ, jets, τ, B physcs, E_T^{miss}, cosmics)
  - HLT algorithms, steering, monitoring infrastructure, configuration database

- Measure and test:
  - Event latencies
  - Algorithm execution time
  - Monitoring framework
  - Configuration database
  - Network configuration
  - Run-control



Cosmics runs

- A section of the detector was used in cosmics runs (see previous talk)
- Several sub-detectors used:
  - Muon spectrometer
  - LAr calorimeter
  - Tile calorimeter
- The High-level trigger took part and selected real events for the first time!



Conclusions and outlook

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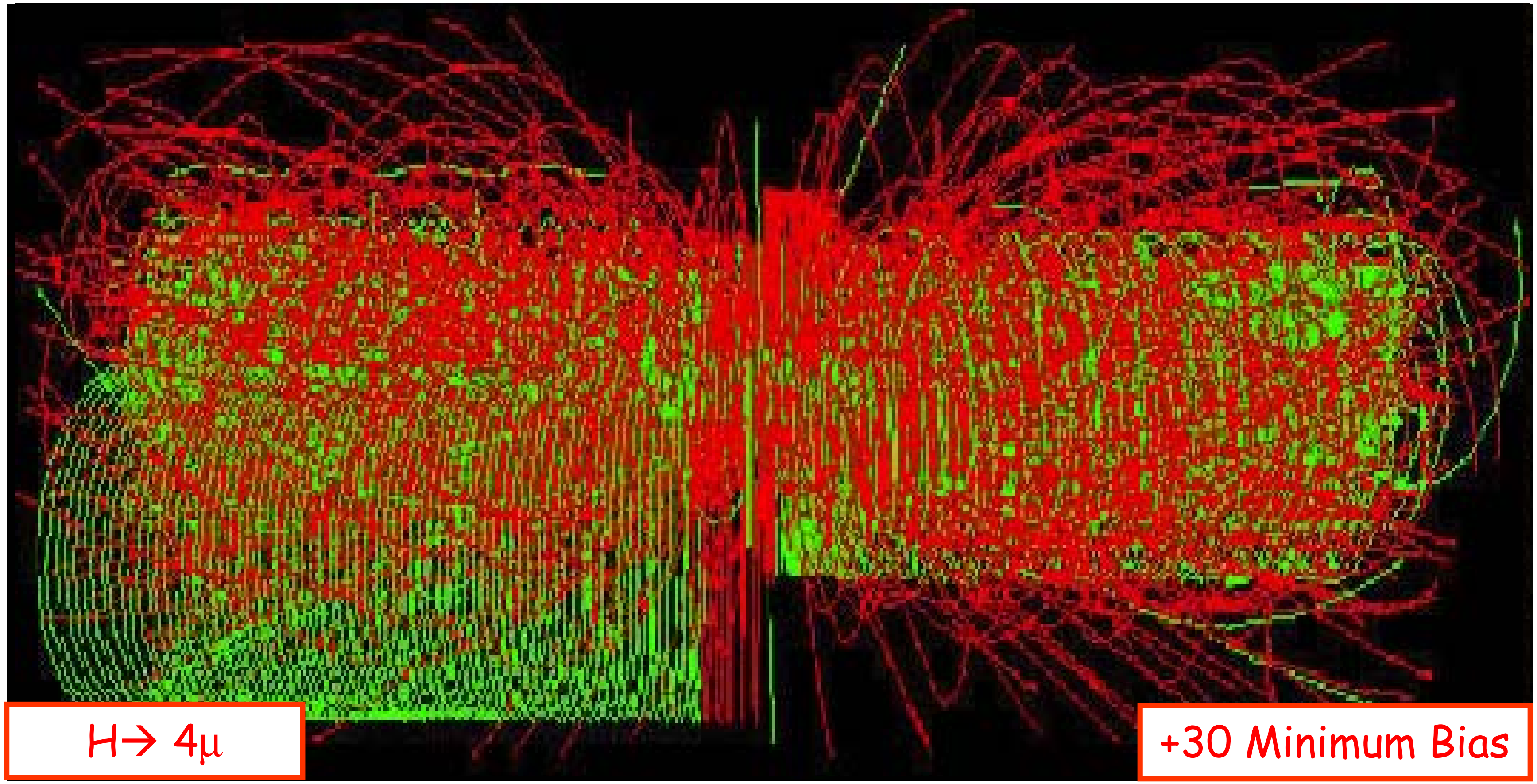
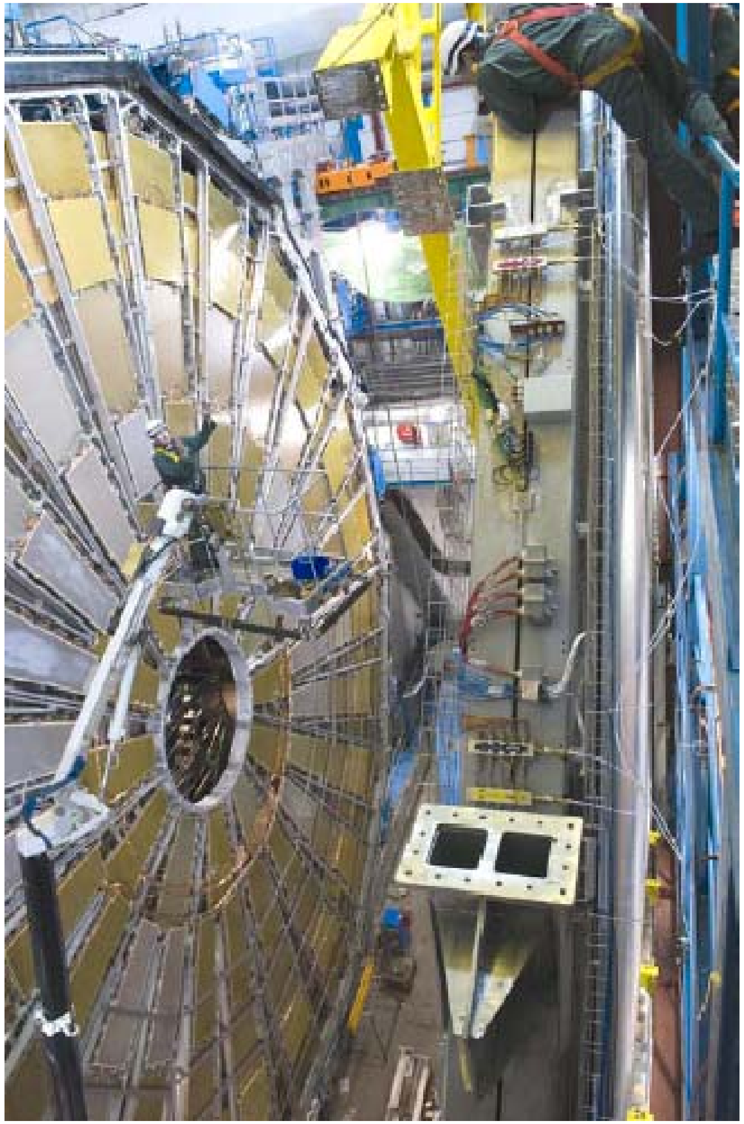
- The LHC will turn on in less than a year

- Looking forward to triggering on real data at the LHC!

What we're up against…



Backup Slides

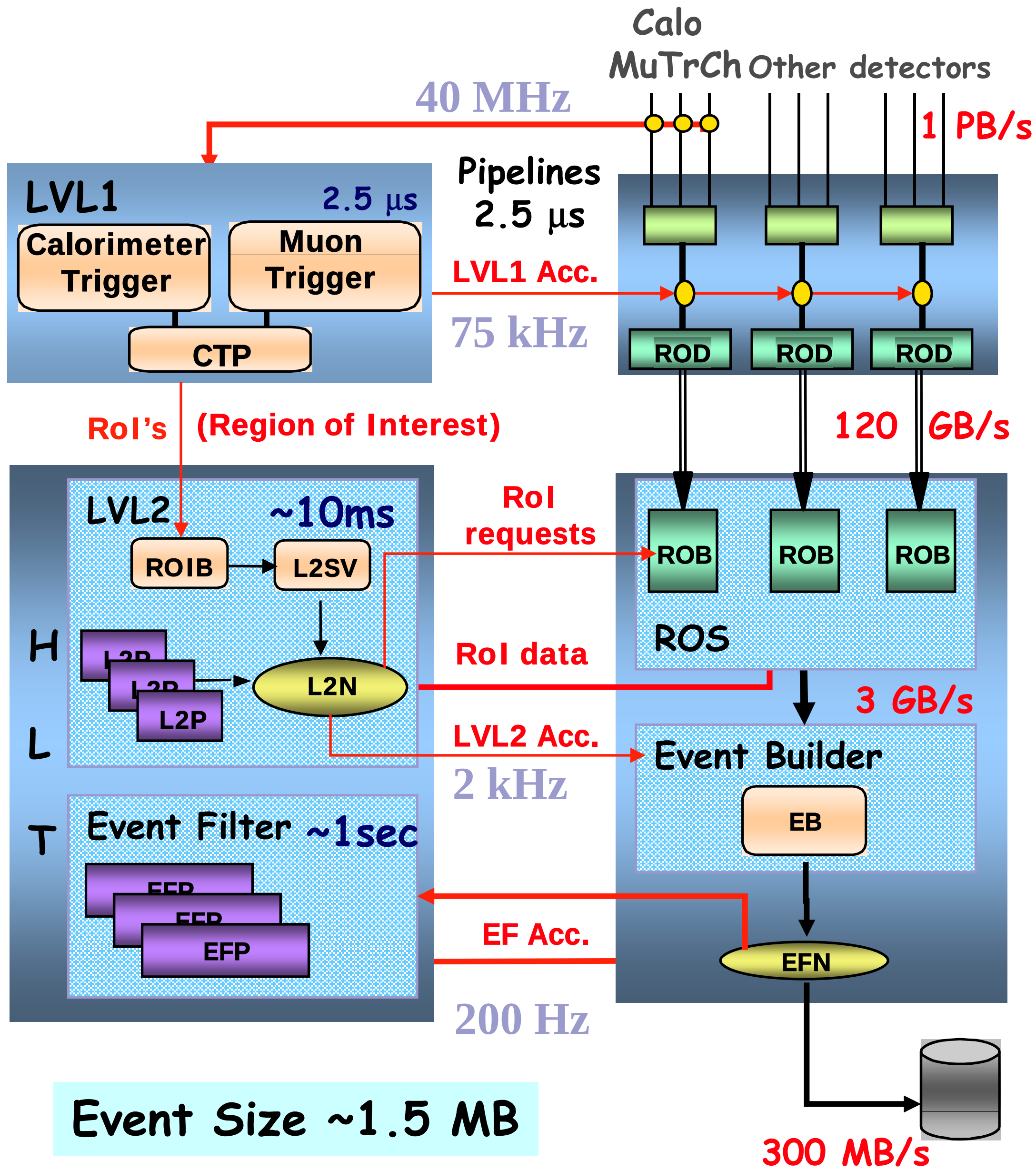


LVL1: Hardware Trigger

- EM, TAU, JET calo. clusters
- μ trigger chambers tracks
- Total and missing energy
- Central Trigger Processor

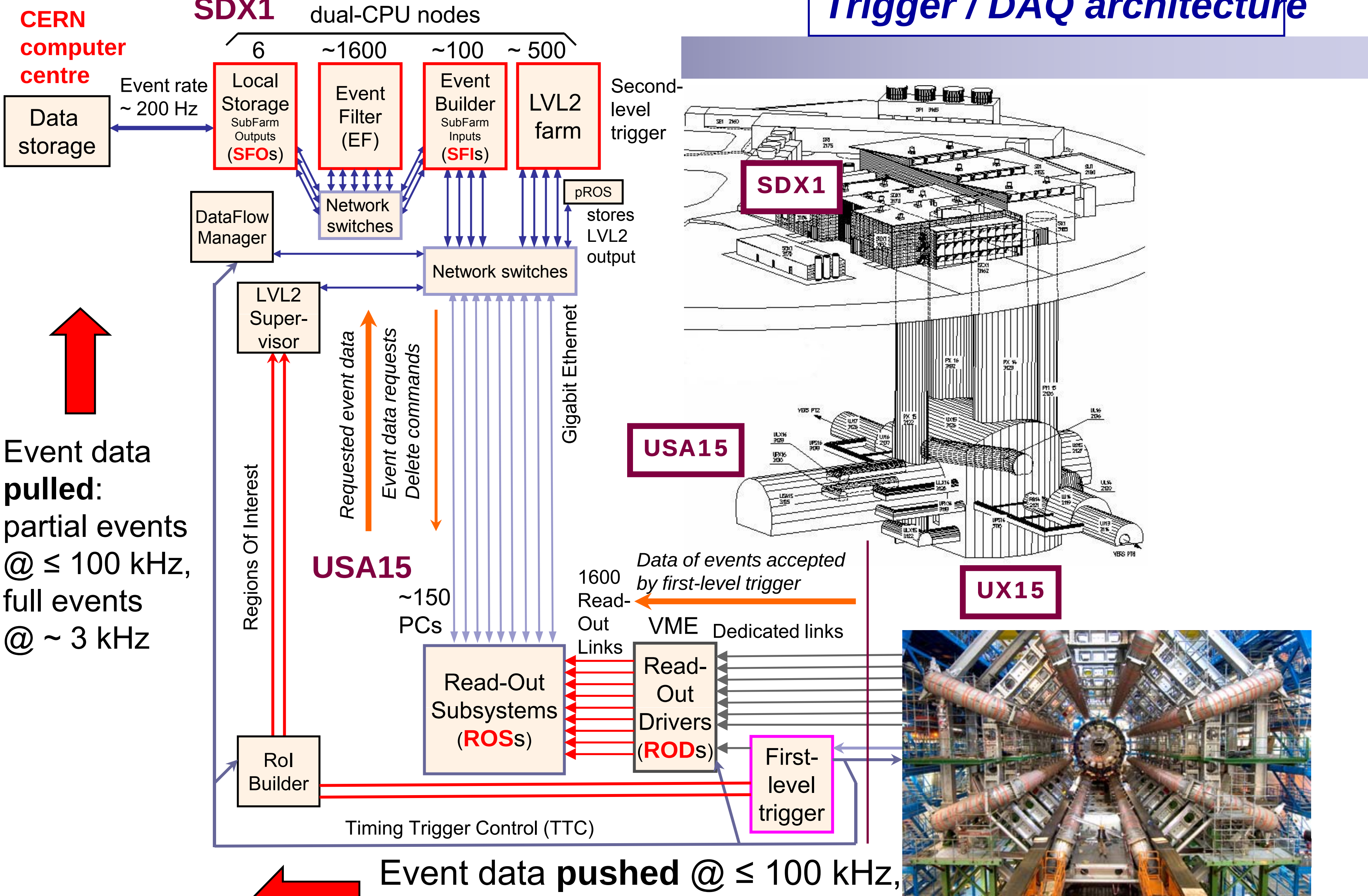
HLT: PC farms

- LVL2: special fast algorithms
  - Access data directly from the ROS system
  - Partial reconstruction seeded with L1 Regions of Interest (RoIs)
- EF: offline reco. algorithms
  - Access to fully built event
  - Seeded with LVL2 objects (full event reconstruction possible)
  - Up to date calibrations



Event Size ~1.5 MB

Trigger / DAQ architecture



Event data **pulled**:
partial events @ ≤ 100 kHz,
full events @ ~ 3 kHz

Event data **pushed** @ ≤ 100 kHz,
1600 fragments of ~ 1 kByte each

The ATLAS trigger

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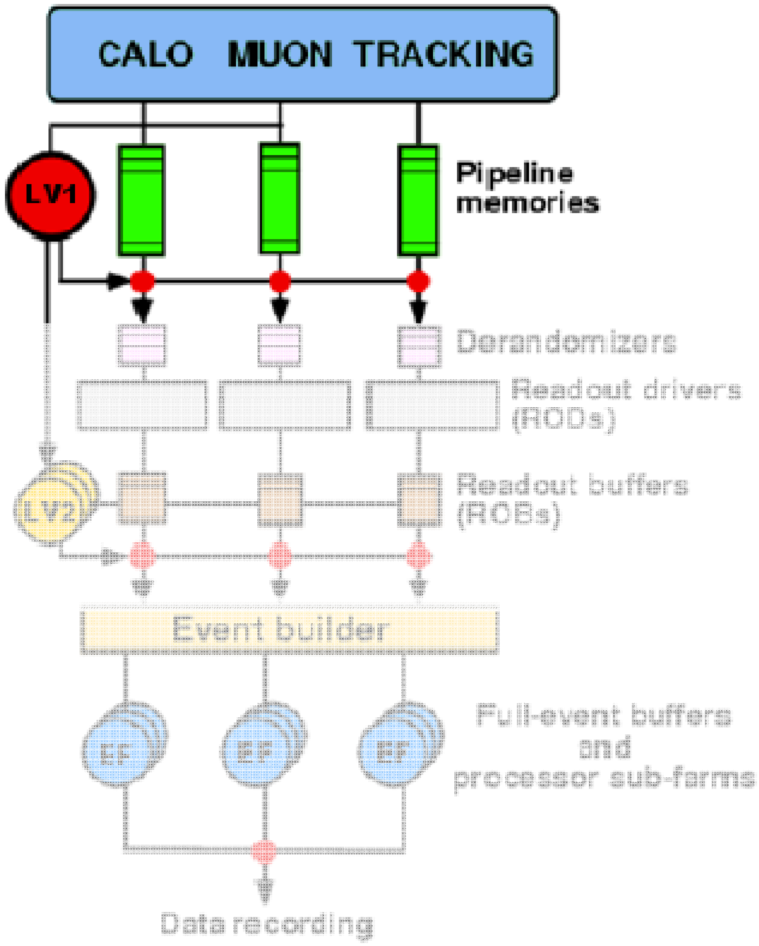
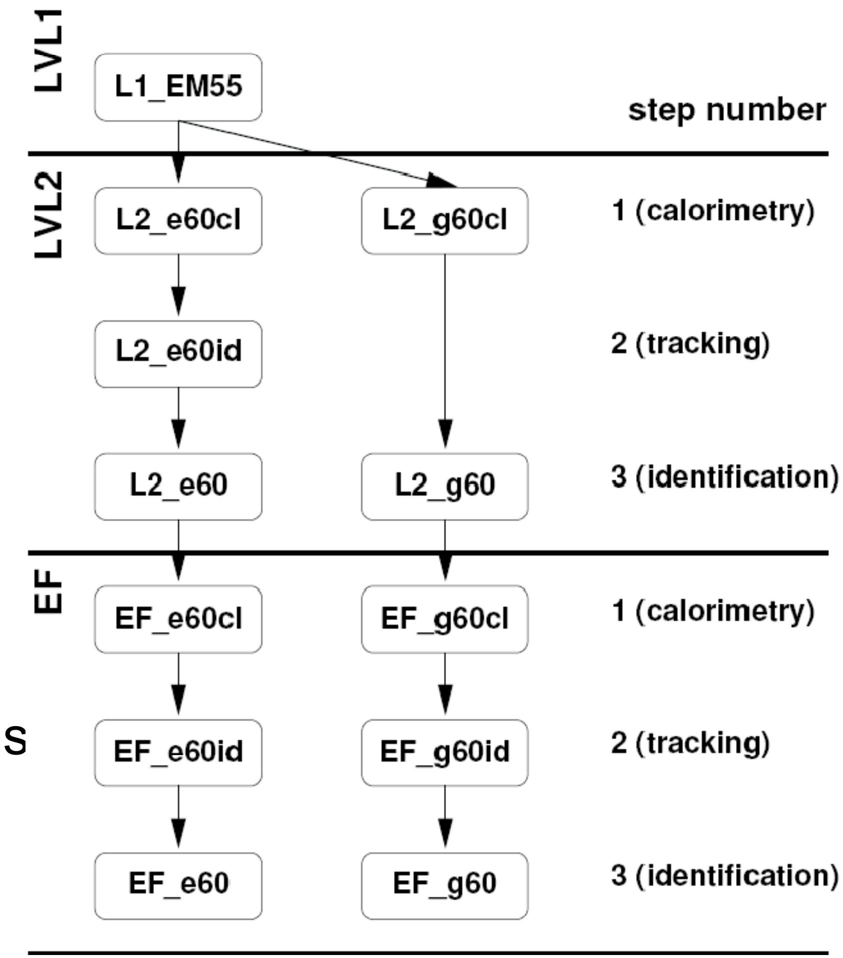
High-Level Trigger



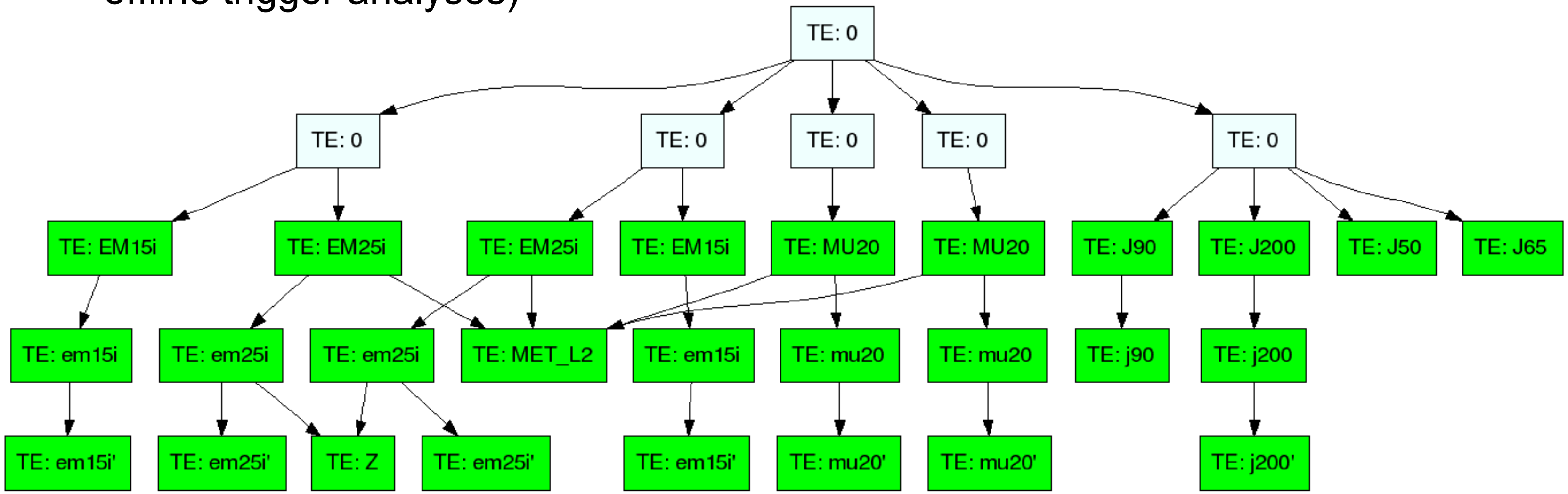
The HLT Steering Controller

- Algorithm executions based on trigger chains (L2_e60, EF_e60, etc)
- Activate chains based on result of previous level
- Step-wise processing
  - Each chain divided in steps
  - Each step executes an algorithm (one or more HLT algos)
  - A step failed to produce a wanted ends the chain
  - Any chain can pass the event.
- Sequence and algorithms caching
  - Avoid same sequence/algo twice on identical
- Several algo classes for all situations
  - inclusive, multi-objects, unseeded, …



HLT Navigation and HLTResult

- HLT Navigation : a data tree keeps the history of algorithm execution and reconstructed trigger objects
  - Implemented as external tool to HLT Steering Controller
  - Don't need to run HLT Steering Controller to accessed the data structure (useful for offline trigger analyses)



- HLTResult: what you get in the raw data
  - Header word (event number, pass/fail, error code, …)
  - Serialized trigger chains info (chain ID, pass/fail, last successful step)
  - Serialized navigation structure