Overview of current ATLAS L1 trigger and plans for Phase 1 upgrades

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With useful comments from: O. Sasaki, M.Landon,
B Barnett, N. Gee, A. Watson , ...

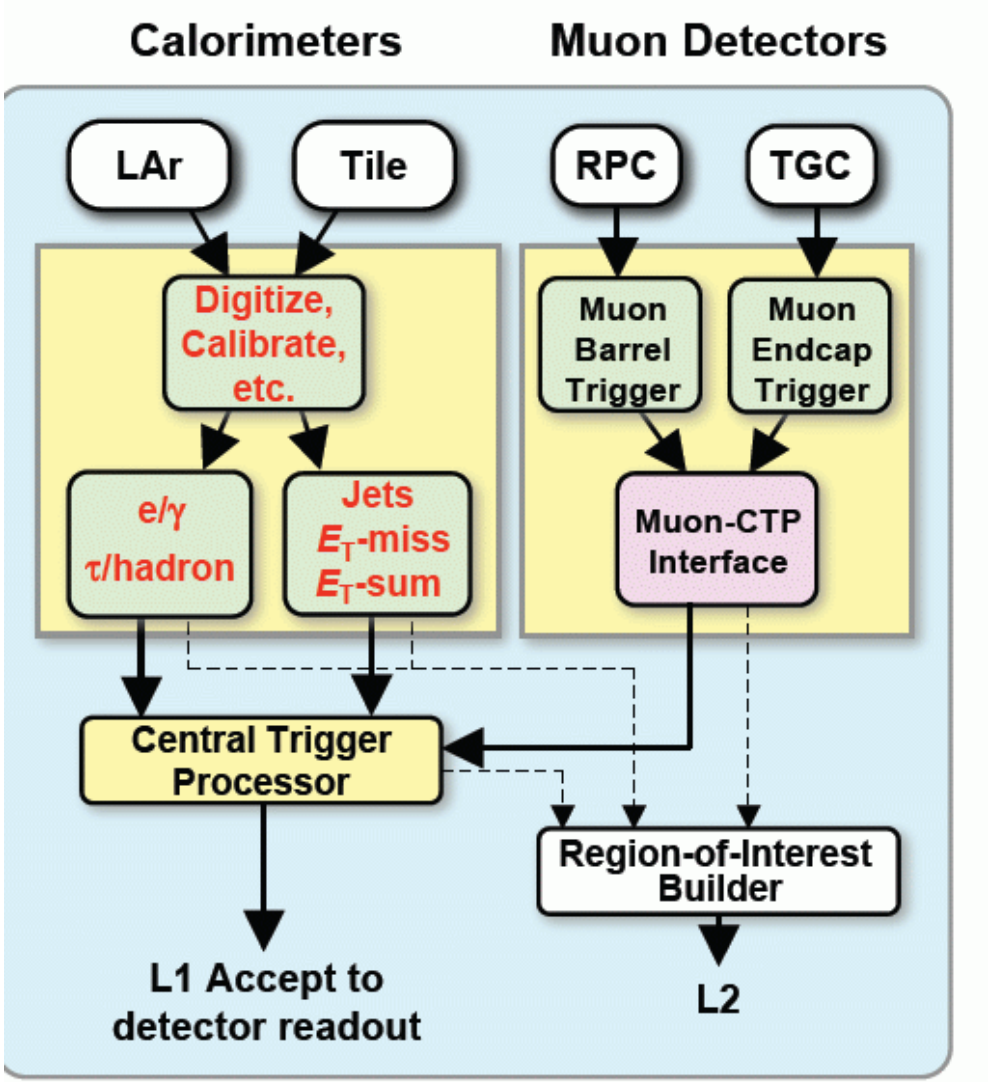
ACES 2011, CERN

- Introduction
- Overview of existing L1 trigger system
- Plans for Phase I upgrade

Structure of ATLAS L1 trigger

- Level-1
  - Custom built HW (ASICS and FPGAs)
  - Fixed latency < 2.5 μs, L1A~75 kHz
- Level-2
  - CPU's
  - Full granularity for areas of activity marked by L1 (RoI)
  - Latency ~40 ms, L2 accept rate ~2kHz
- Event Filter (Level-3)
  - CPU's
  - Offline algorithms on full event
  - Latency~1s, EF accept rate~100Hz

- Level-1 trigger:
  - L1-Muons
  - L1-Calorimeters (L1Calo)
  - CTP
  - ...



L1 calorimeter trigger I

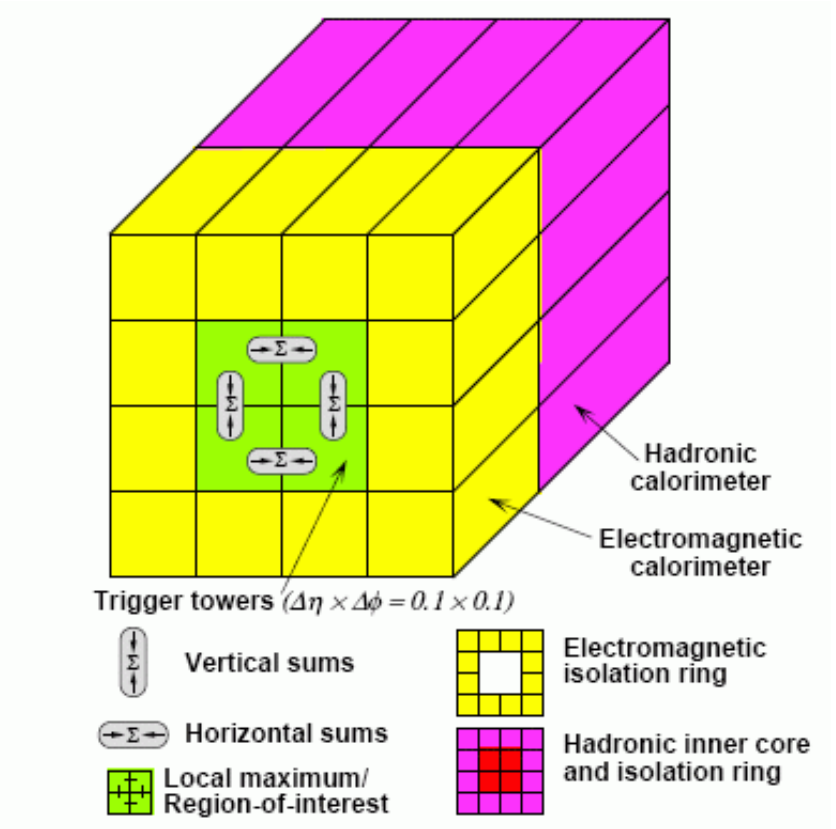
Hard final state objects in an event:

- e/γ and τ/h objects:
- Jet candidates:

Global event properties:

- Total E_T
- Missing E_T
- Missing E_T significance
- Jet sum E_T

- Sends to Central trigger:
  - Multiplicity of electrons/photons, τ's and jets passing thresholds
  - Thresholds passed by total and missing E_T and missing E_T significance
- Sends to Level 2 trigger:
  - position of RoIs and thresholds passed

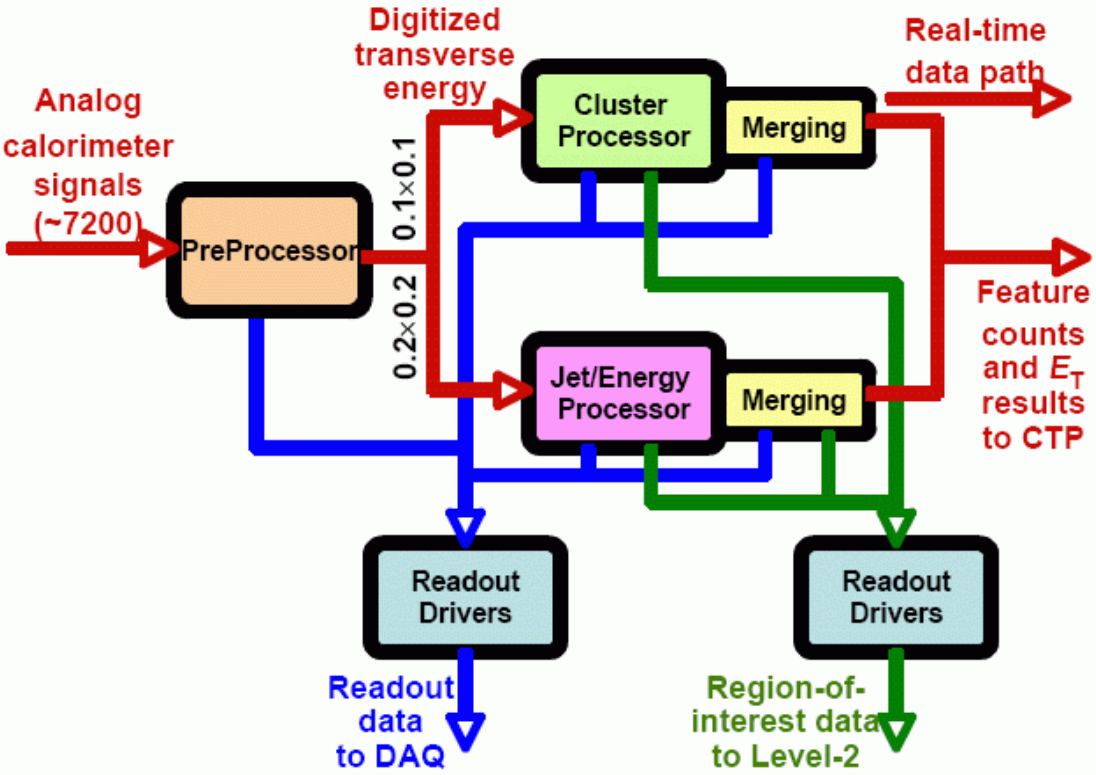


L1 calorimeter trigger II

- Highly parallel, FPGA based
- Mainly custom electronics:
  - ~300 VME modules of 10 types housed in 17 crates

Real-time path:

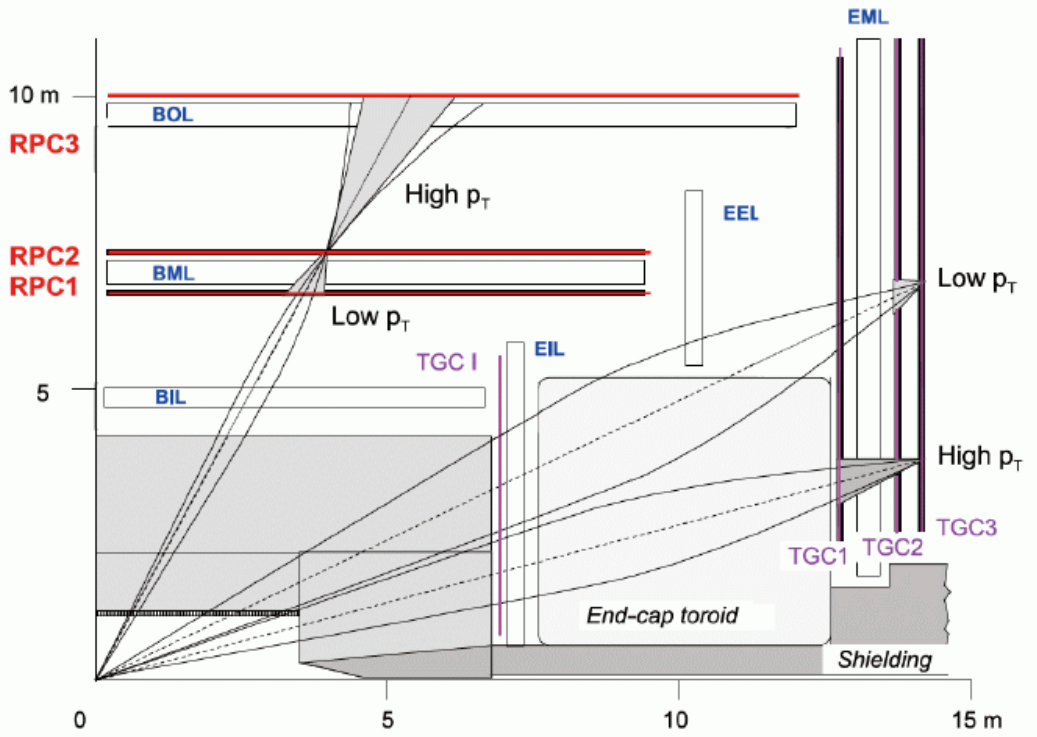
- Preprocessor:
  - Conditioning and calibration of analog signals, digitization, bunch crossing identification
- Algorithmic processors:
  - Cluster processor:
    - Electrons/photons, taus
  - Jet/Energy processor:
    - jets, E_T, Missing E_T
- Number of objects found is sent to merger modules, these calculate system-wide sums



Level 1 muon trigger I

Dedicated muon trigger chambers with good time resolution:

- RPCs (barrel region)
- TGCs (endcap regions)
  - Search for patterns of hits consistent with high P_T muons coming from IP
- Three trigger stations in each region, require coincidence of hits in different stations within a road
- Width of the road defines P_T threshold passed



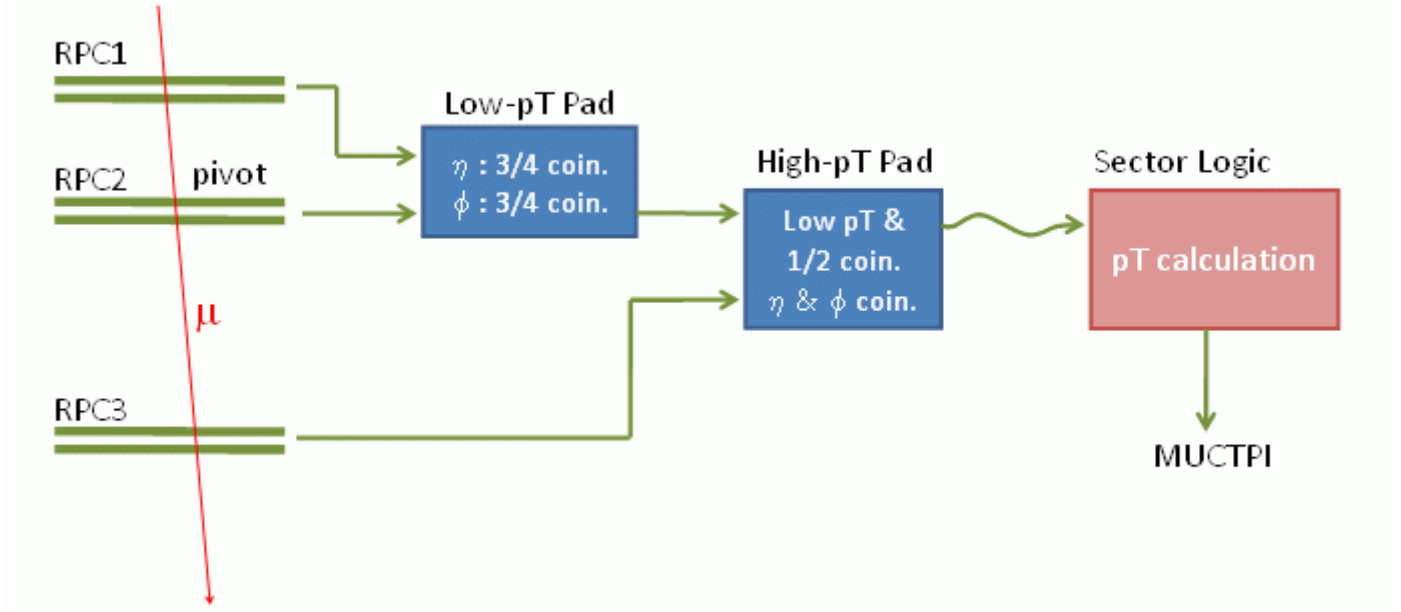
Low P_T trigger:

- Requires coincidences in two stations
- Three thresholds

High P_T trigger:

- Requires coincidences in three stations
- Three thresholds

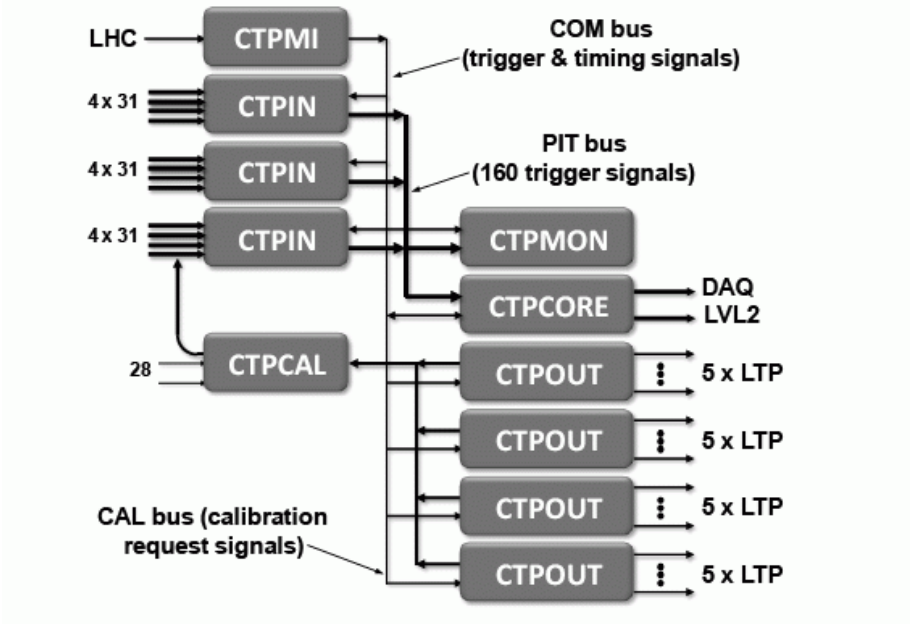
Level 1 muon trigger II

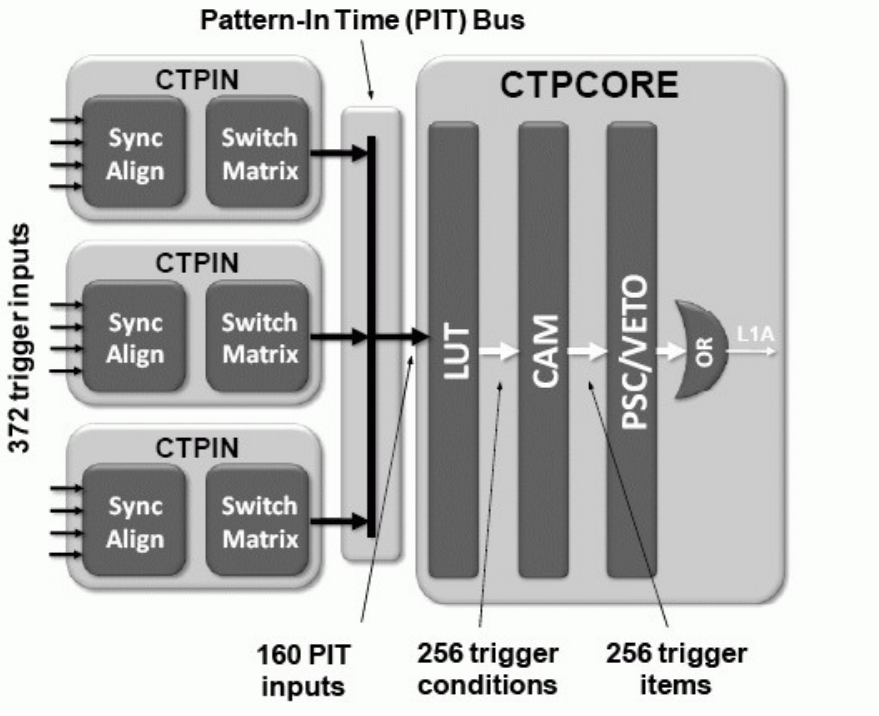


- Each successful hit generates an RoI for L2
- Multiplicities of hits for each threshold summed up
  - Over sectors
  - Over whole system
  - Sent to Central Trigger

More details in talk by Osamu Sasaki

L1 central trigger



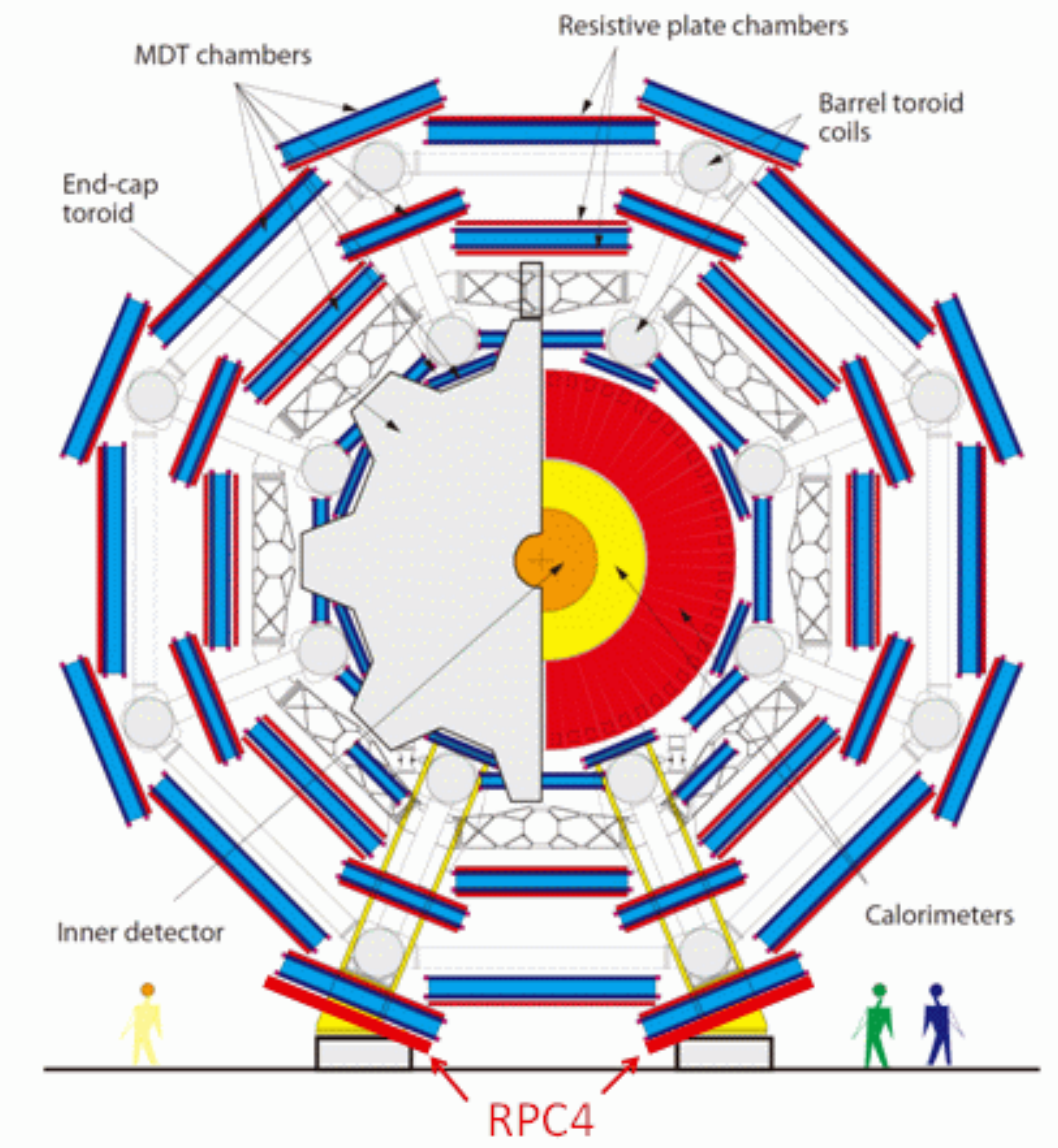


- One custom VME crate
- Input signals received and synchronized by CTPIN modules (372 trigger inputs possible)
- Selected combination of signals distributed via PIT bus (160 of them maximum)
- Received by CTPCORE module, there trigger items generated (using LUT's and CAMs)
- Prescaling, dead time, ...
- Generate L1A (well, sometimes...)

Muon trigger upgrade - barrel

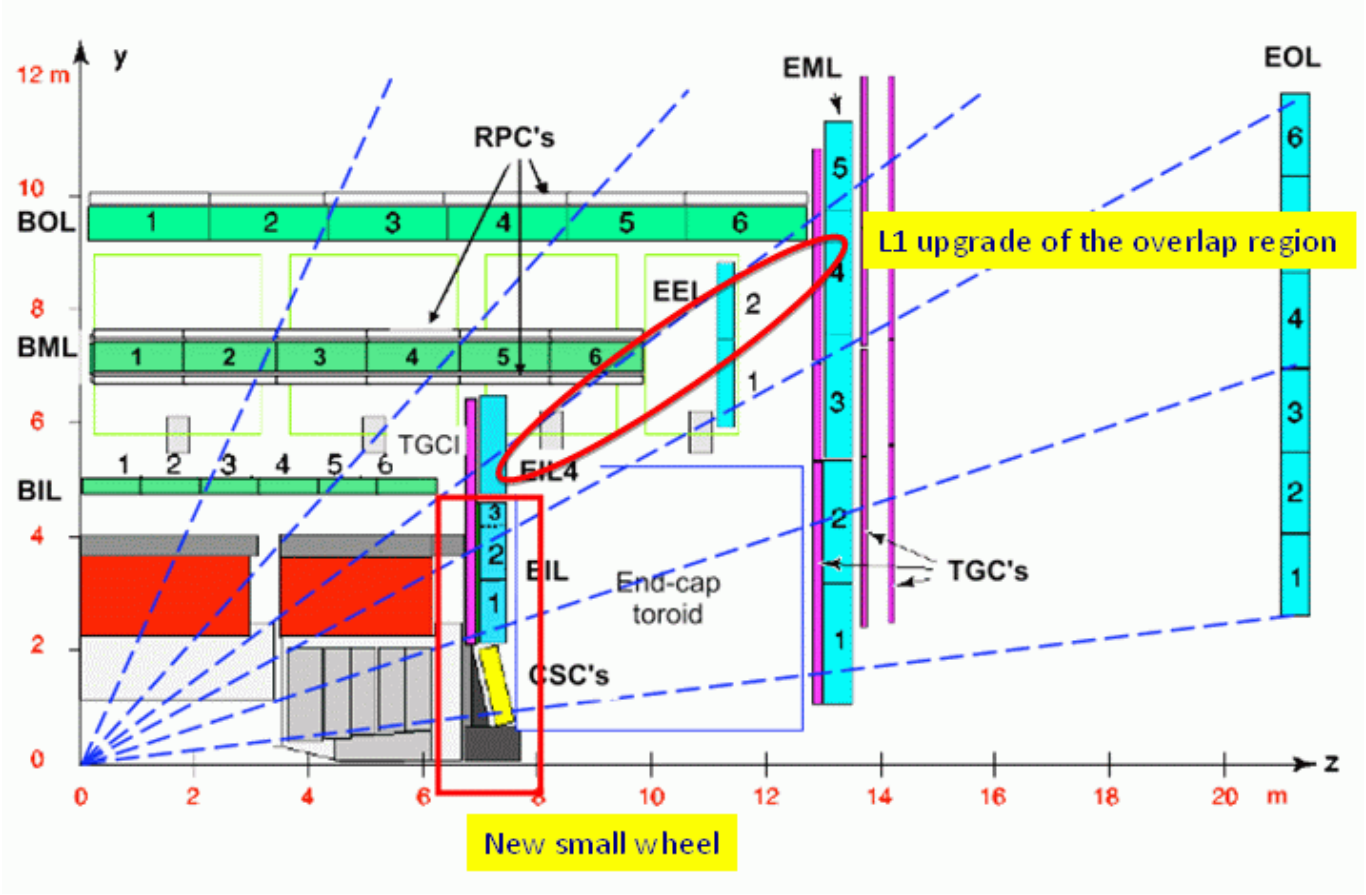
Barrel region:

- L1 muon trigger efficiency in the feet sectors is lower than one in standard sectors
- To improve the efficiency, a fourth layer of RPC (RPC4) has been installed
- Upgrade of electronics is ongoing



Muon trigger upgrade - endcaps

- Replace small wheels in endcap regions
- Several technologies are discussed (sTGC, RPC, microMegas, sMDT) to provide L1 trigger
- Possibly additional chambers in overlap region



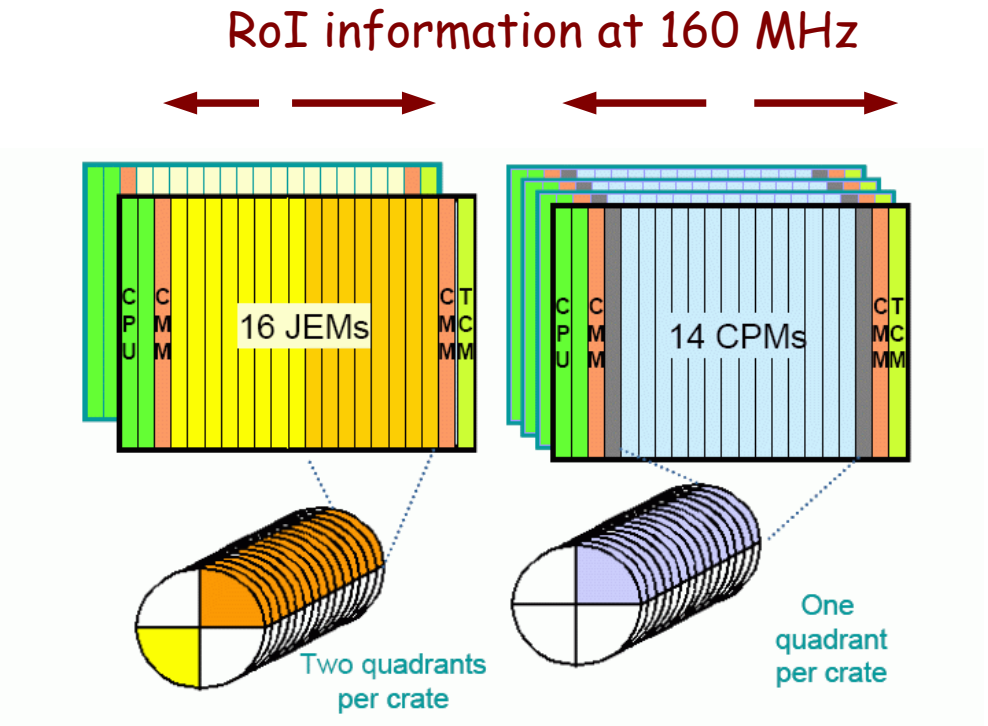
More details in talk by Osamu Sasaki

Calorimeter trigger upgrade I

Phase 1 L1Calo upgrade:

- plan to replace MCMs for PreProcessor, improved BCID and pedestal subtraction
- No change to trigger algorithms

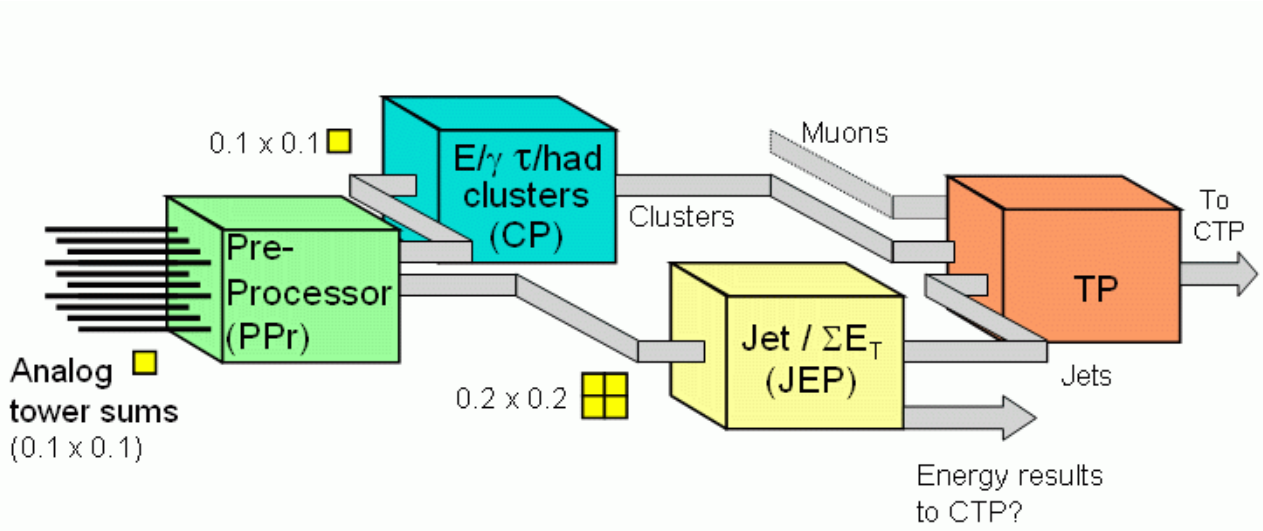
- Main gain in performance expected from adding more information to L1 path
- Use topology of identified objects!



- Processor modules (CPMs, JEMs) know position of object
- Raise backplane bandwidth by running it at 160 MHz
- Allows RoI coordinates, maybe some energies to be sent in L1 real-time path to merger boards (CMMs)

Calorimeter trigger upgrade II

- First step is to build new merger modules (CMM++)
  - Backward compatible with existing HW
  - More links, much higher bandwidth
  - allows some basic topology triggers
- Second step:
  - Add new Topological Processor



- Separate crate with new processor boards
- Use of topology in triggers
- Remove overlap between jet and electron triggers
- (Exciting) possibility to use μ information in TP:
  - μ isolation
  - Include μ in missing E_T calculation

For more details see talk by Sam Silverstein

Conclusions

Efficient and selective L1 trigger is important for data taking at upgraded LHC

Several R&D projects ongoing in ATLAS for Phase-I L1 upgrade :

- L1Calo: add topology to L1
- Muons:
  - RPC4 stations in the feet regions (Phase 0 upgrade)
  - Replace small wheels in forward area
- Combine L1Calo and L1Muon information in topological processor