Event reconstruction algorithms for the ATLAS trigger

Teresa Fonseca Martín (CERN)
on behalf of the ATLAS TDAQ group

CHEP 3 Sept 2007

The ATLAS Trigger System

- Level 1
  - Hardware based
  - Coarse granularity calorimeter and muons only

40 MHz

- High Level Trigger (HLT)
  - Level 2 and Event Filter
  - Software based
  - Mostly commodity hardware (PC + Ethernet)

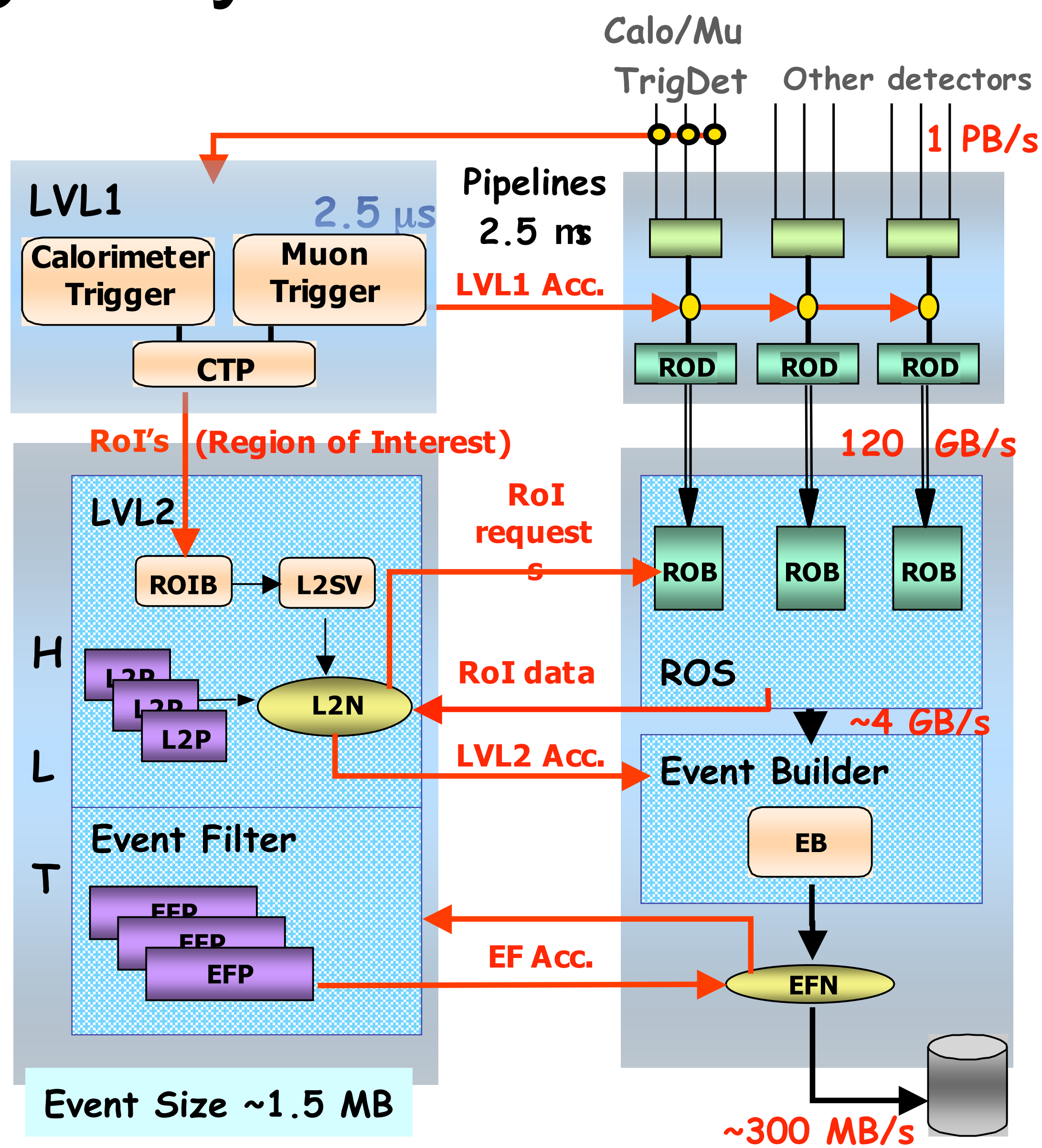
75 kHz

- Level 2 (L2)
  - Data requested from ROBs over network
  - Full detector granularity in RoIs
  - Special fast algorithms

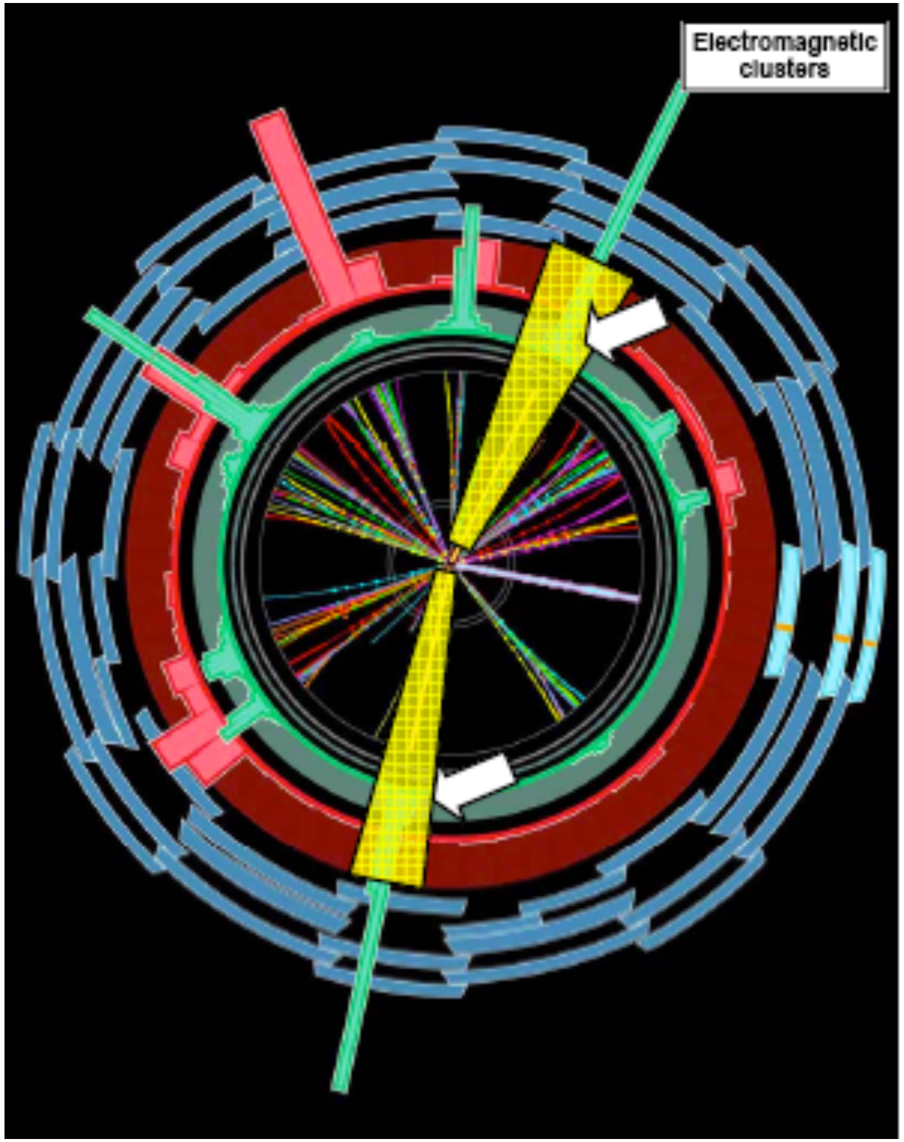
~3 kHz

- Event Filter (EF)
  - Seeded by L2
  - Potential full event access
  - Full detector granularity
  - Offline algorithms

~200 Hz



Region of Interest (RoI)



- L1 indicates the geographical location of candidate objects (η,ϕ)
- L2 only access data from a detector subregion around (η,ϕ): "Region of Interest" (RoI)
- Reduces L2 network bandwith
- Reduces L2/EF processing time

How trigger menu is built

"Trigger selection software for Beauty physics in ATLAS"
D. Emeliyanov Monday 18:10

"The configuration system of the ATLAS trigger"
J. Stelzer Thursday 15:20

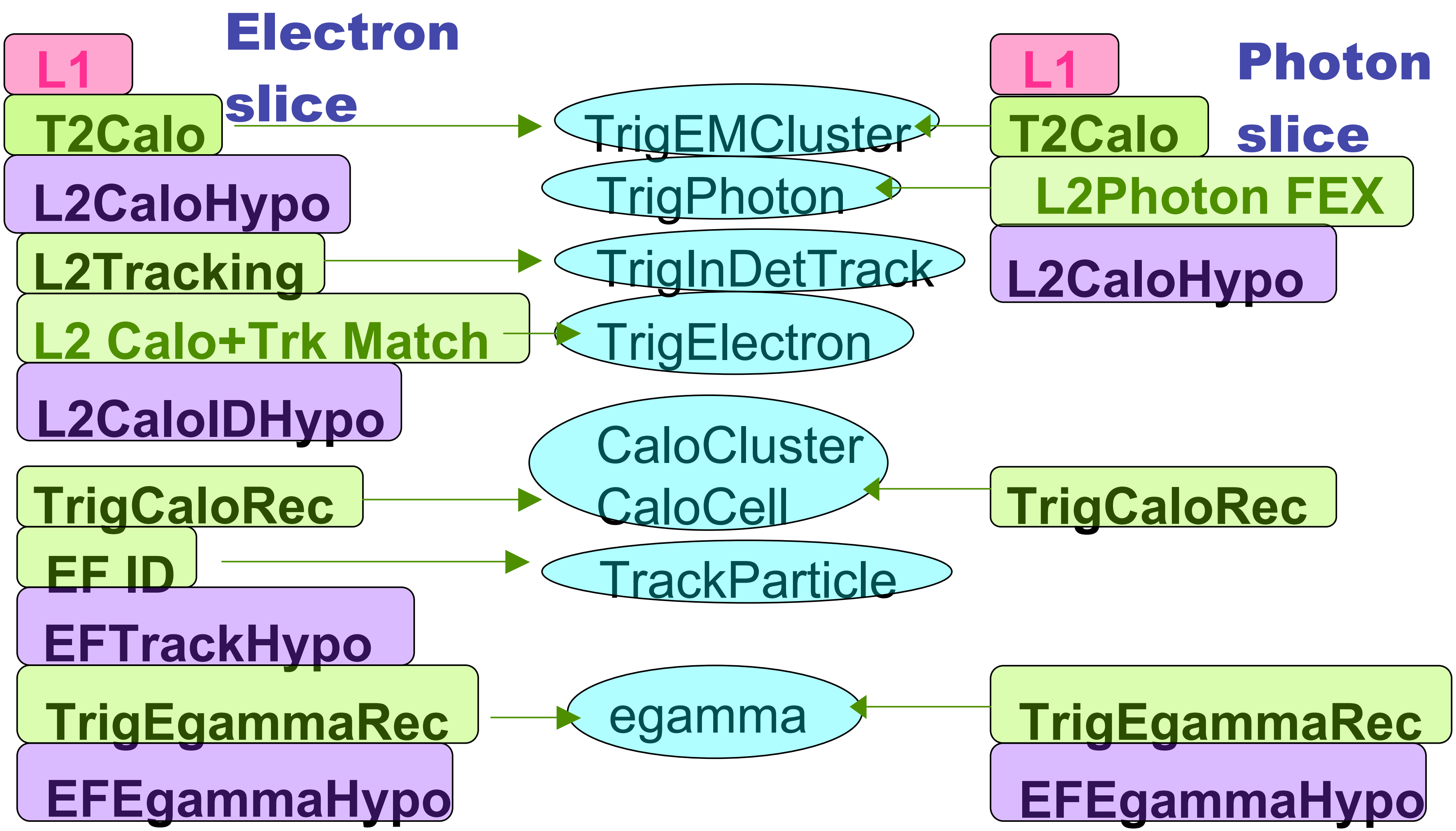
Trigger objects

- Electron/Photon
- Tau
- Jets
- Muon
- B-Physics
- Missing E_T
- b-tagging
- Minimum bias

- Different threshold values in selection cuts can be applied.
  - Ex:
    - e15 electron E_T > 15GeV
    - e15i: isolated e E_T > 15GeV
    - e60: electron E_T > 60GeV
- Different objects combined:
  - Ex: e15i+Missing E_T

Trigger objects defined in so-called slice (sequence of algoritms)

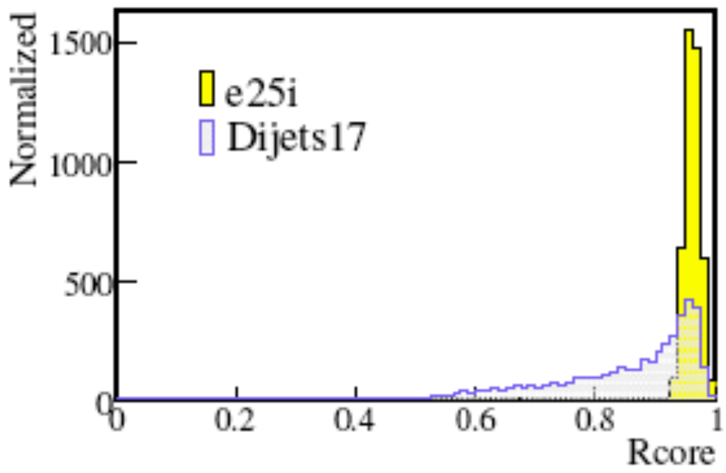
Example of a slice: eγ slice



- •FEX algorithms: create EDM objects
- •Hypothesis alg.: apply selection cuts

- L2: specific trigger algorithms
- EF: use of offline tools as possible

eγ L2



T2CaloEgamma:

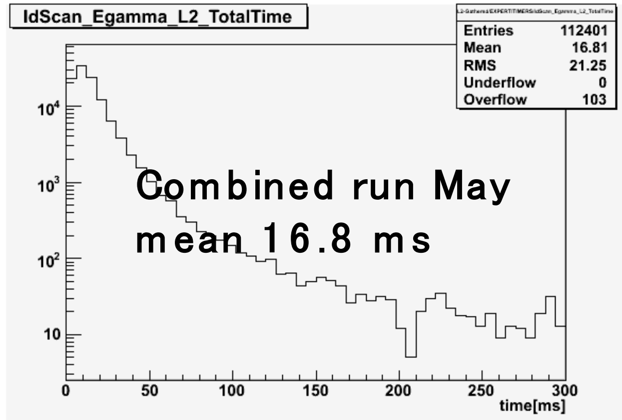
- Performs calorimeter cluster reconstrunction.
- Full detector granularity
- Shower shape variables to discriminate electron/photon of jets

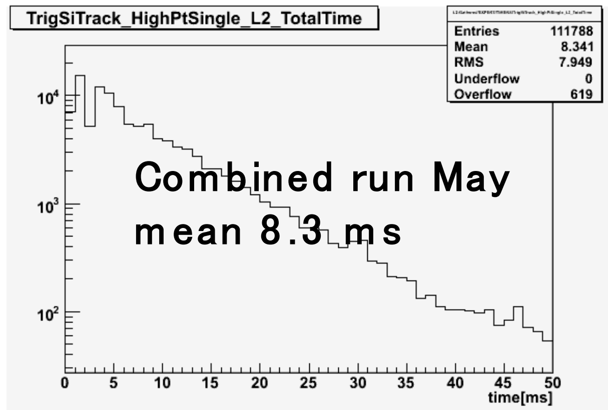
IDSCAN:

- zFinder: Reconstruction of the z-position of the primary pp collision
- hitFilter & groupCleaner: The main pattern recognition step
- trackFitter: final track fit and removal of outliers

SiTrack:

- Space point sorting
- Track seeds formation
- Primary vertex reconstruction
- Track extension





eγ Event Filter

TrigCaloRec:

- Performs calorimeter cluster reconstruction
- Wraps-up offline tools
- Involved also in the tau and jet slices

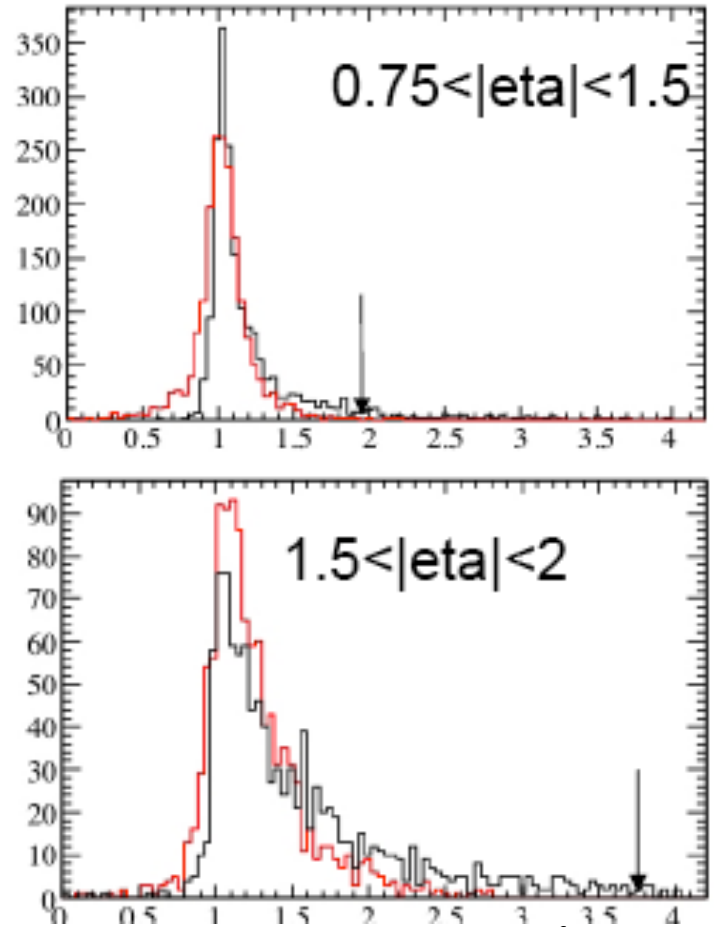
EFID:

- Based on offline tools in a seeded mode
- Involved in the tau, b-physics, b-tagging and muon slices also

TrigEgammaRec

- Reconstructs the EDM egamma object
- Wraps-up offline tools
- Combines Inner Detector and Calorimeter information
- Includes bremstrahlung correction

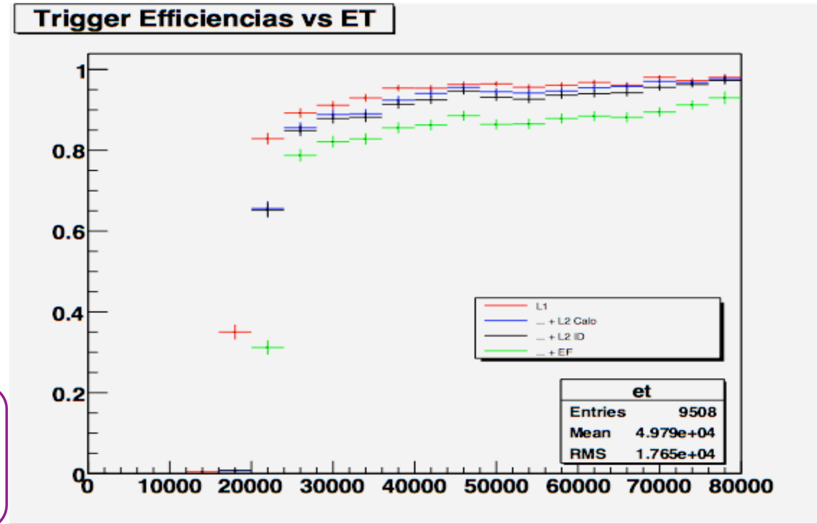
E_T/p_T without brem recovery
with brem recovery



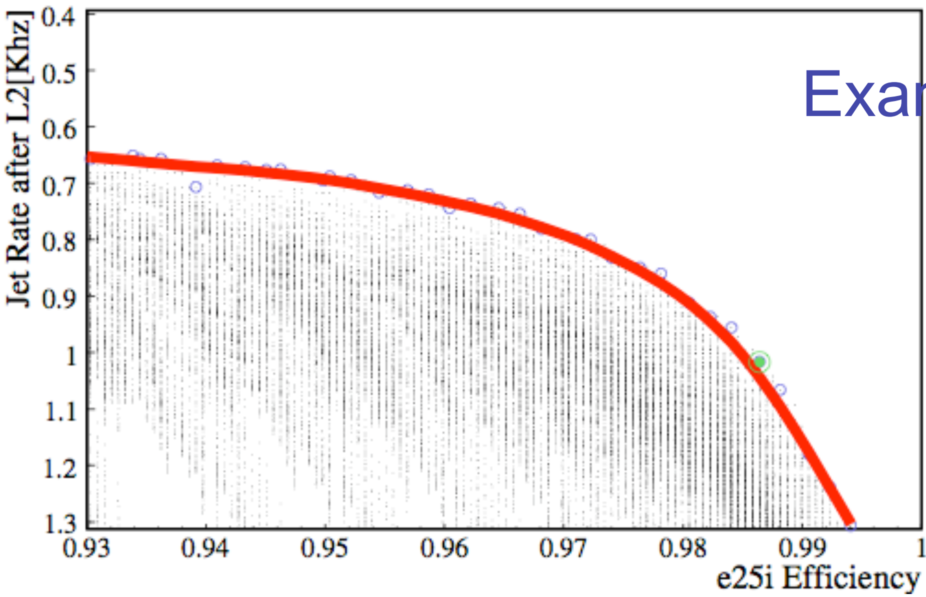
Examples of electron slice performance studies

Ex: e25i signature

- Study trigger efficiency dependencies on individual cuts and E_T, η and ϕ.
- Compare electrons from single electron and from $Z \rightarrow ee$, + pile-up effects



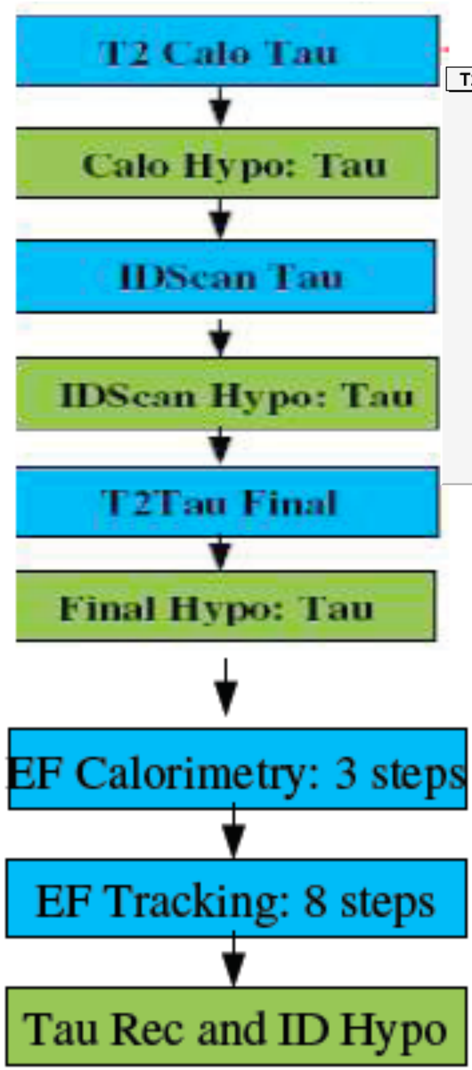
All results shown in this talk
Correspond to full simulation of the detector

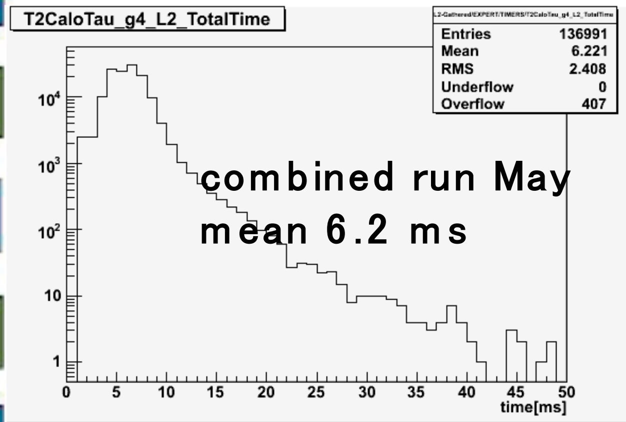


Example of L2 selection optimization

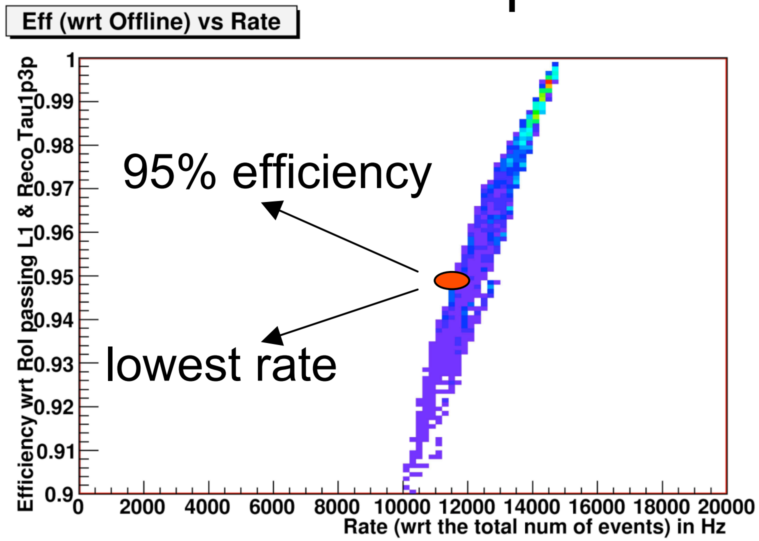
- Scan selection cuts thresholds
- For a given rate maximum trigger efficiency

Tau slice

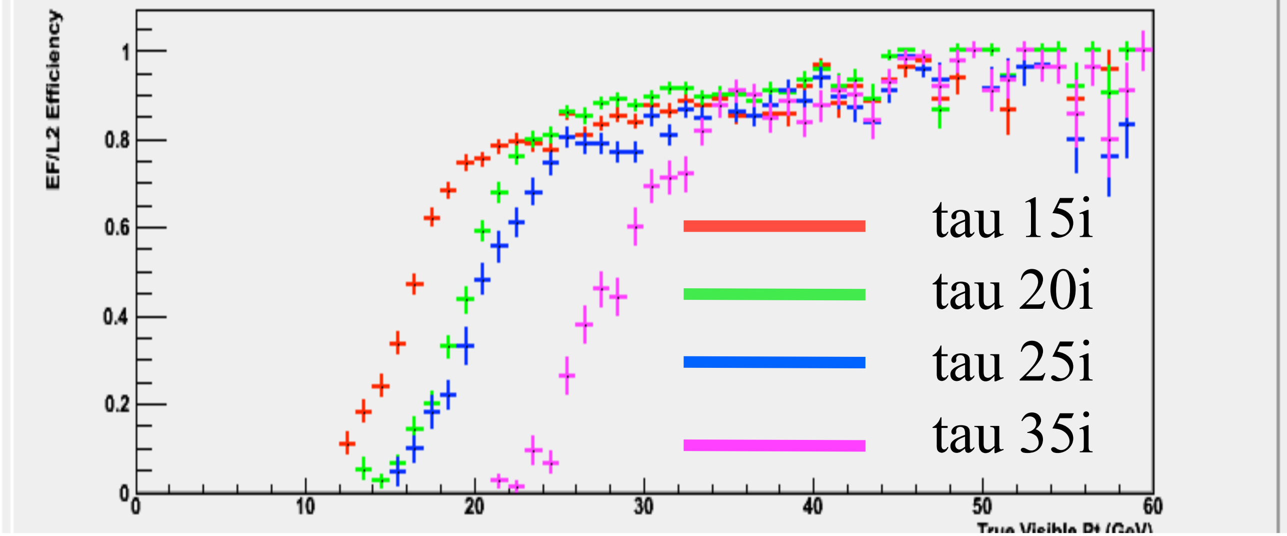




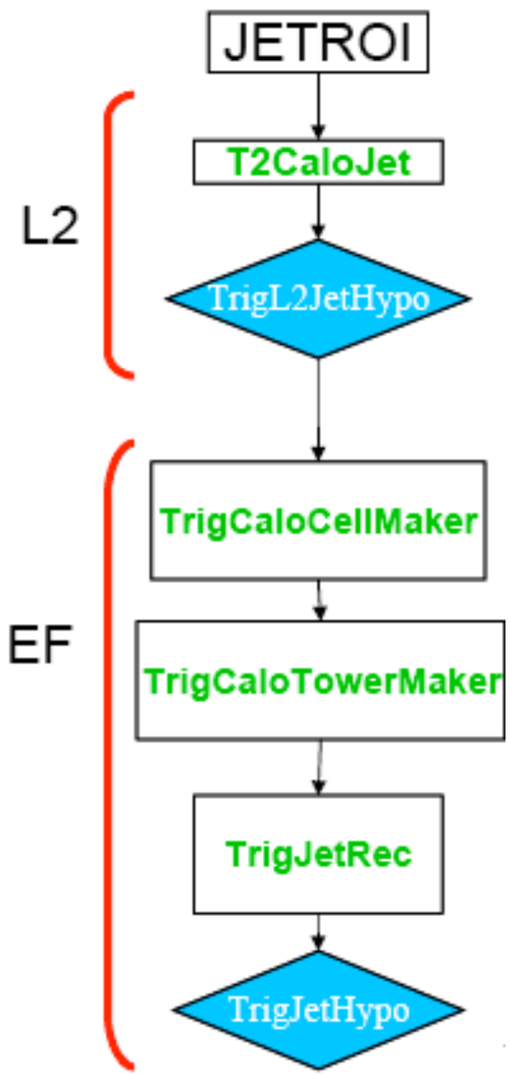
Ex. L2 optimization



EF turn on curves



Jet Slice



Retrieve cells in the RoI
Fast cone algorithm
Calibrate the jet

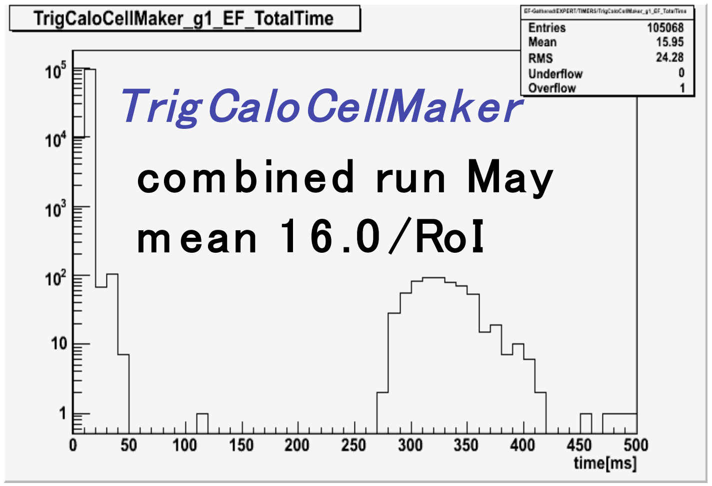
E_T cut

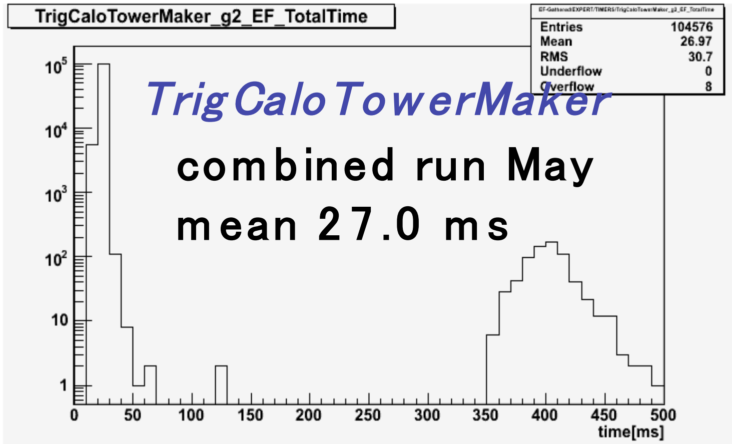
Data unpacking

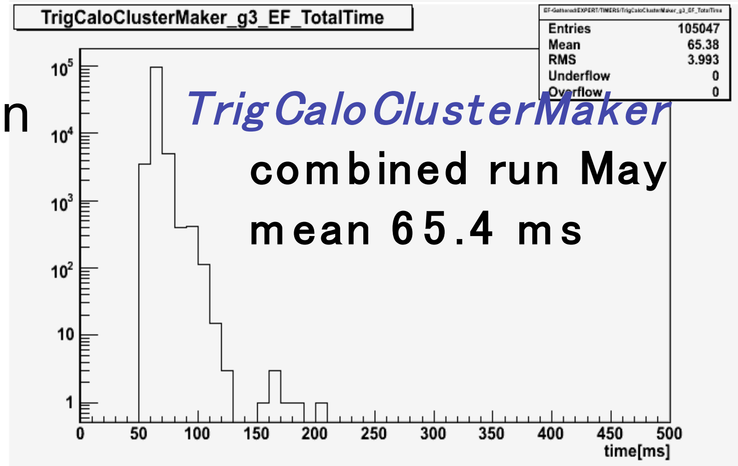
Calorimeter towers

"Offline" jet reconstruction

E_T cut



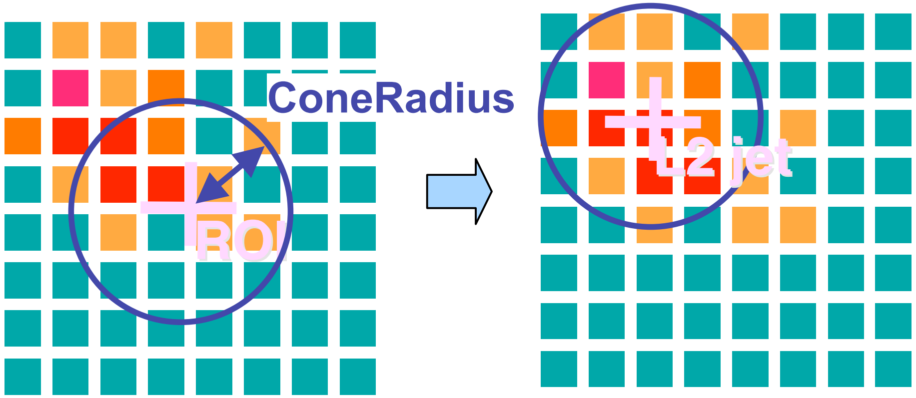




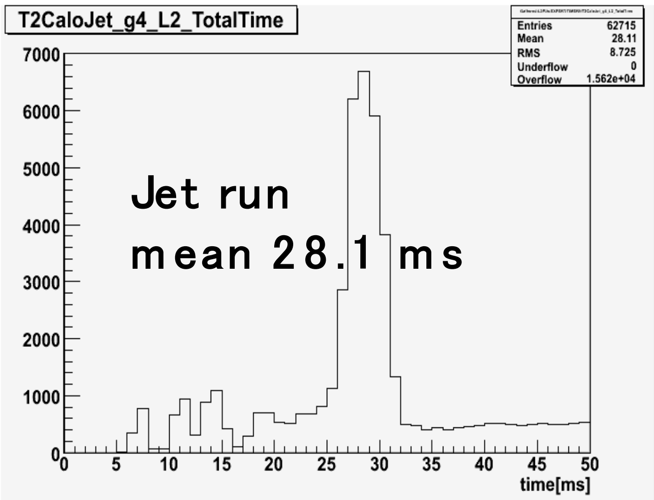
Level-2 jet trigger

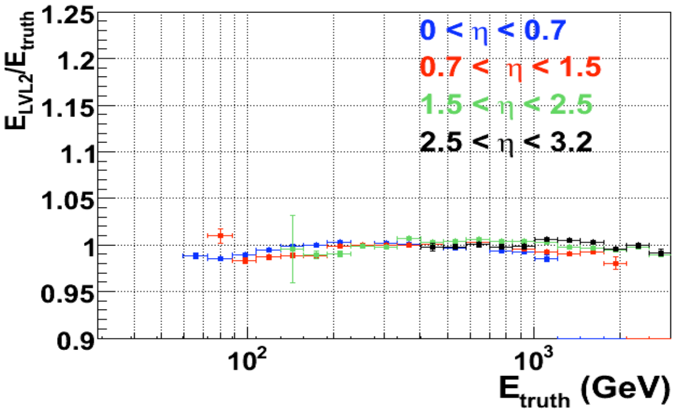
Implementation and Performance of the ATLAS Second Level Jet Trigger
P. Conde Muíño, Poster

- Level-1 RoI is passed to Level-2
- LVL2:
  - iterative (3 iter.) cone algorithm calculates energy-weighted position (η,φ).
  - 3 possible granularities
  - Apply simple, robust, fast calibration procedure.



Main difficulty: jet energy scale ⇔ calibration



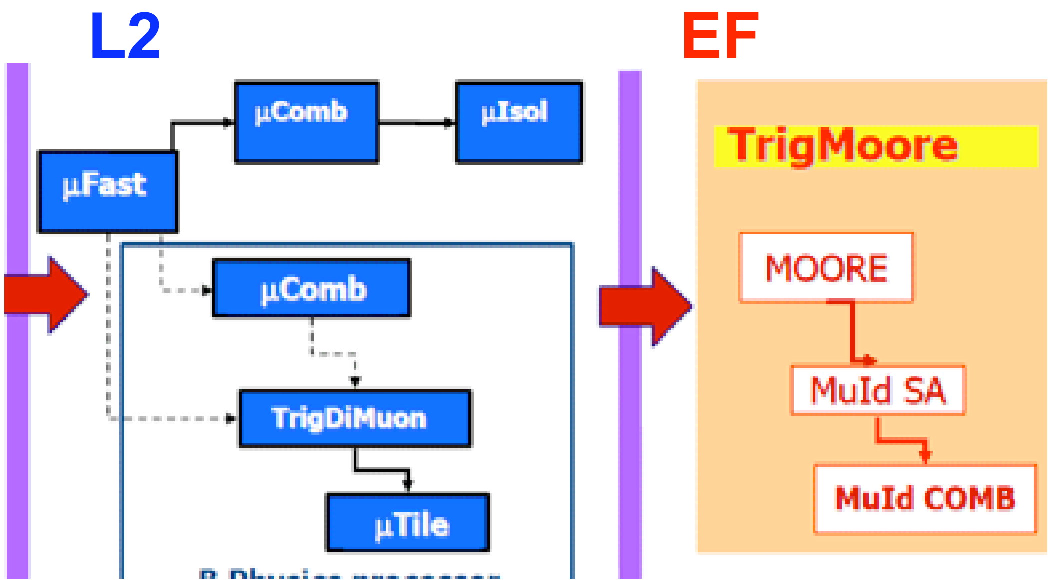


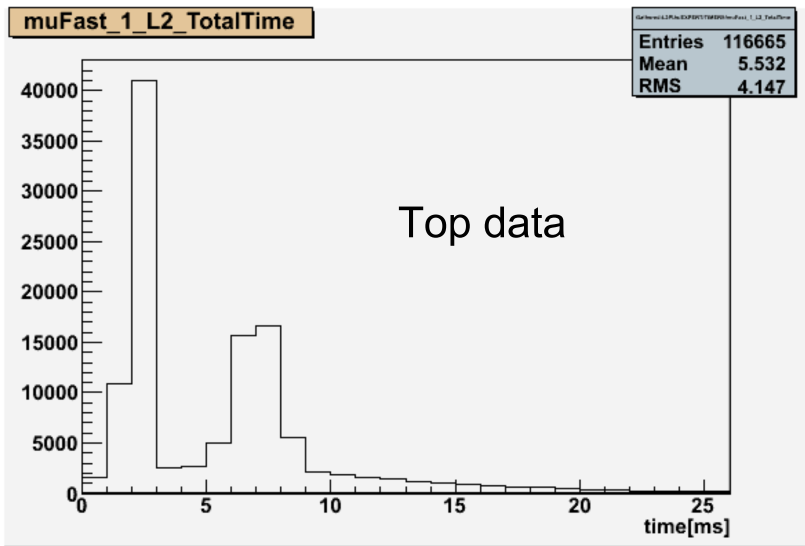
- JES within 2% correct
- Resolution fit to

$$\frac{\sigma(E)}{E} = \frac{a}{\sqrt{E(GeV)}} + b$$

Muon slice

The ATLAS Trigger:
Commissioning with cosmic rays
J. Boyd, Wednesday 17:30





L2:

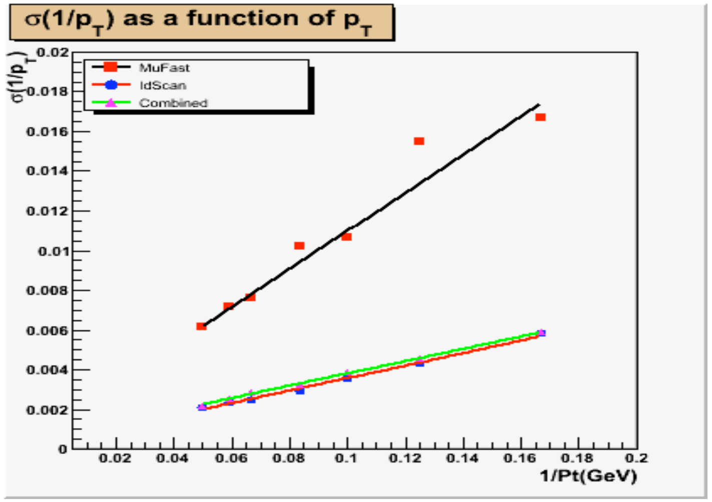
- muFast: muon spectrometer stand alone reconstruction (η, φ and p_T)
  - Track reconstruction efficiency: ~99.5% barrel, ~100% endcap
- muComb: refines muon tracks combining them with the Inner Detector track.
- muIso: Calorimeter isolation algorithm to reject muons from beauty and charm semileptonic decays.

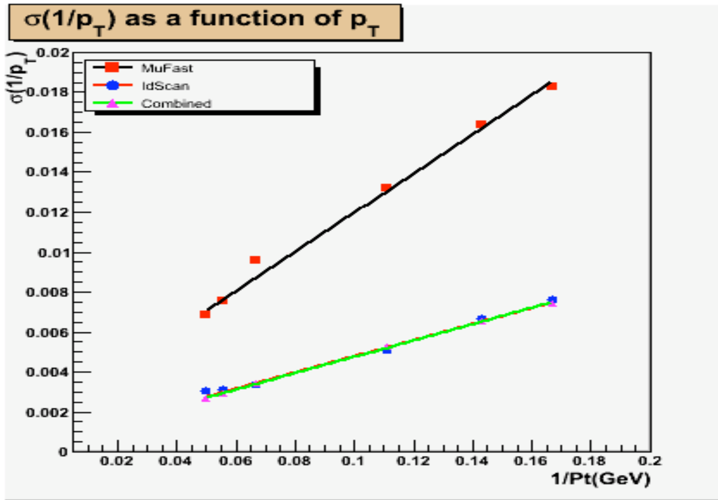
EF:

- Wraps offline reconstruction

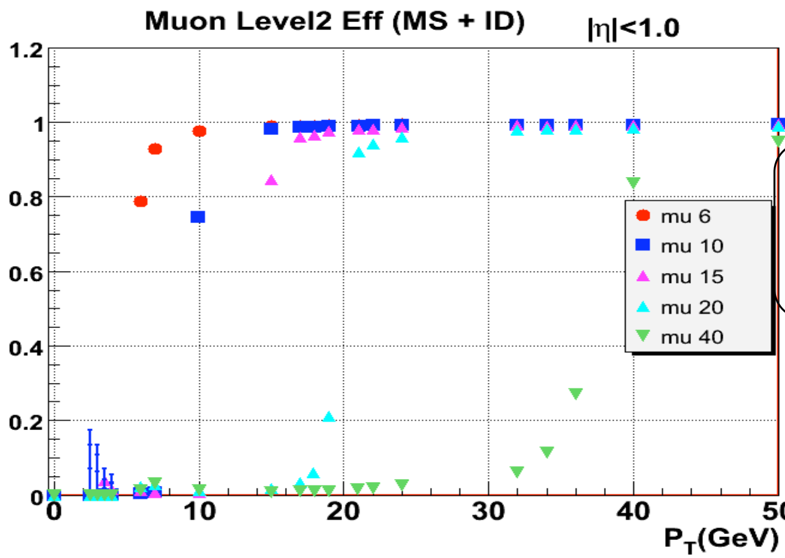
Examples of muon slice performance studies

Extensive studies of efficiency and resolution for different thresholds, η regions, micalibration and misalingment



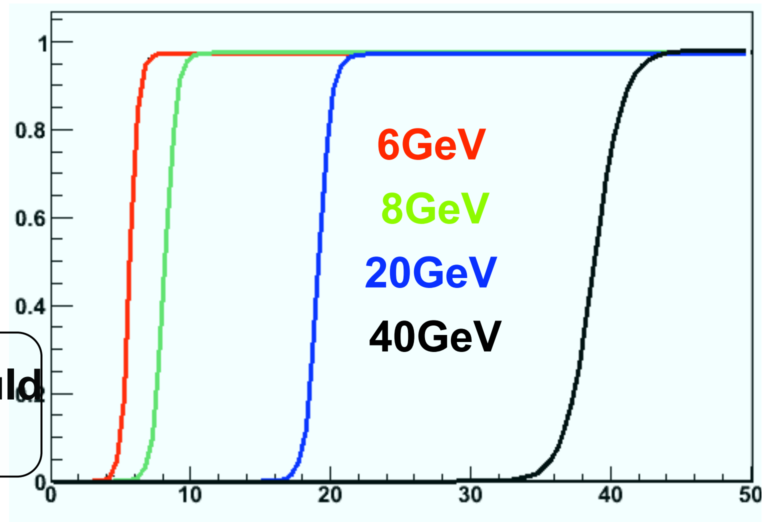


EC L2 resolution μComb recovers the resolution In all regions



Barrel muComb

Barrel EF Muld combined

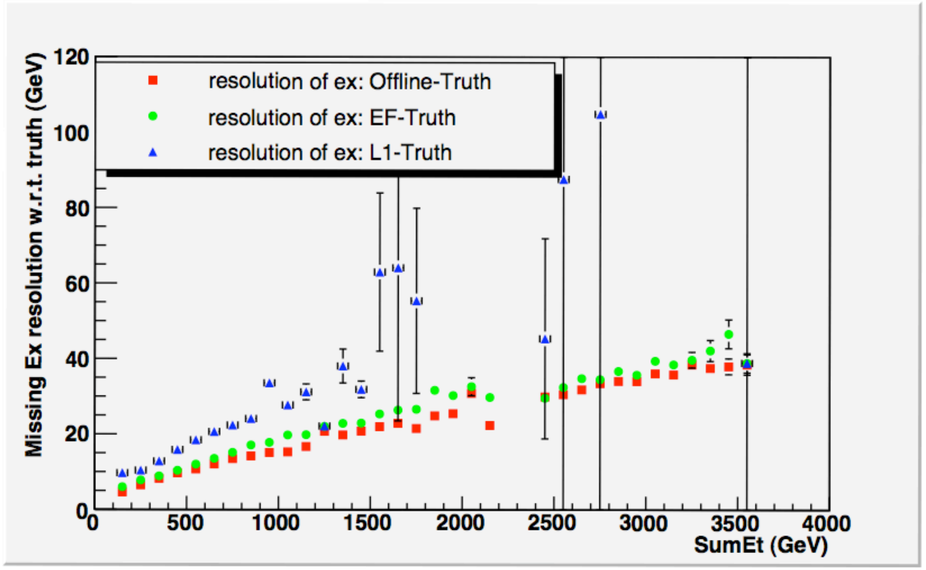


Missing E_T

– RoI concept does not apply to global quantity

– Data preparation is a major concern when accessing entire calorimeter

Ex. resolution studies:



- L2
  - L1 Missing E_T + all L2 Muons
- EF
  - default Algorithm = loop over all cells at EM-scale
  - alternative algorithm = loop over Ex/Ey sums in FEB header
  - + muons
  - simple hadronic calibration

b-tagging

L1: use jet thresholds

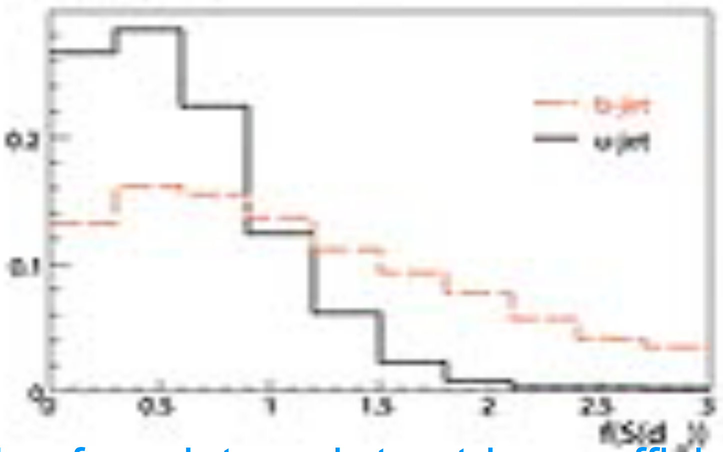
HLT:

- 3j/2b or 4j/3b
  - b-tagging 70%eff.
    - (Offline b-tag 60%)
- L2 tracking
- EF tracking
- Hypo: likelihood based

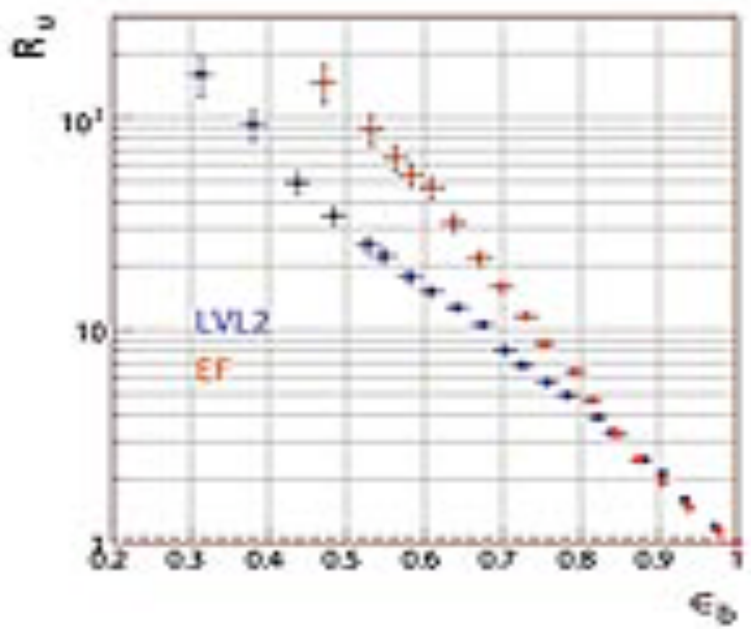
on impact parameter

- Under study:
  - Use cluster to get jet direction
  - Use more offline “tools”, ex.: secondary vertex

Significance of longitudinal impact parameter



Rejection for u-jets vs b-tag trigger efficiency



Present status of trigger algorithms

Integration of the Trigger and Data Acquisition System
B. Gorini, Thursday 14:50

High Level Trigger algorithms:

- Developed offline
- Tested in an “online-like” environment
- Run online in ATLAS experimental area (Point 1)

		eγ	Muons	Jets	Taus	Etmiss	b-tag	Bphys
L2	offline	🙂	🙂	🙂	🙂	🙂	🙂	🙂
	Emulated online	🙂	🙂	🙂	🙂	😐	🙂	🙂
	online	🙂	🙂	🙂	🙂	😐	😐	😐
EF	offline	🙂	🙂	🙂	🙂	🙂	🙂	🙂
	Emulated online	🙂	🙂	🙂	🙂	🙂	🙂	🙂
	online	🙂	🙂	🙂	🙂	😐	😐	😐

🙂 are not finished and frozen, work ongoing to improve performance

😐 have not being tested

Summary

HLT event reconstruction is mature, we are on good track to have a successful startup

- ATLAS High Level Trigger (HLT) allows a sophisticated event reconstruction using full detector granularity
  - Run in large official MonteCarlo productions
  - Tested systematically in "online-like" environment
  - Run at Point 1 (ATLAS experimental area) with cosmics data and with MC data preloaded into DAQ system
  - Everything progresses smoothly

- Anyhow continuous work is ongoing to improve performance (timing, memory leaks, robustness, reconstruction performance, rejection power …) and to implement more and more complex menus

Spares

Brief Summary of the May Technical Run (21/5-25/5)

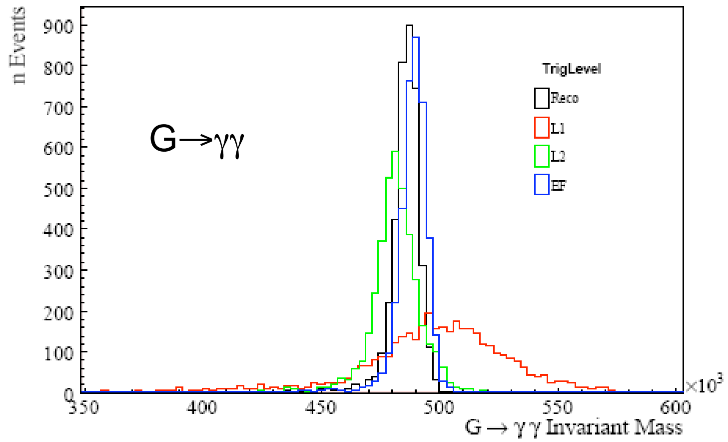
- Hardware
  - ROIB (+ LVL1 emulator), 120 ROSs, 29 SFI
  - 4 HLT racks (130 dual quad-core 1.8 GHz), ~5% final system
- Software
  - tdaq-01-07-00, AtlasHLT 2.0.5-HLT, Offline 12.0.5-HLT-1
  - <u>All basic HLT slices integrated</u>
    - e10, g10, mu6, tau10, jet20, cosmic, Bphysics, met
    - combined : e10+g10+mu6+tau10+jet20
- Input events
  - ~ 6k events (mixed physics processes, ~60% jets and ~40% W/Z)
  - LVL1 simulated with CSC-05
- Main achievement
  - Validated DAQ and HLT infrastructure with final hardware
  - Measurements with dummy algorithm L2 and EF with final hardware

Combined data sample

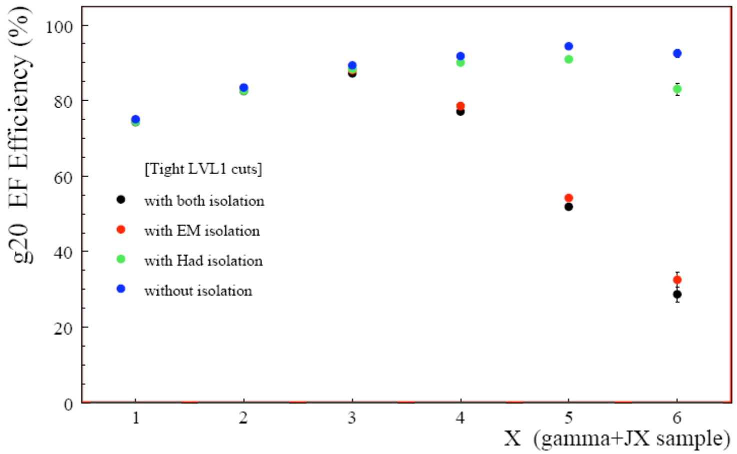
- For technical run May
- ~55% J0, J1, J2, J3, J4, J5, J6 jet-jet samples
- ~15% Wee
- ~13% W
- ~3% Wtauhad
- ~2% Zee
- ~7% Z
- ~5% JF17 (dijets filtered to be very electromagnetic)

Examples of photon slice performance studies

Exotics diphoton studies



Direct Photon Production



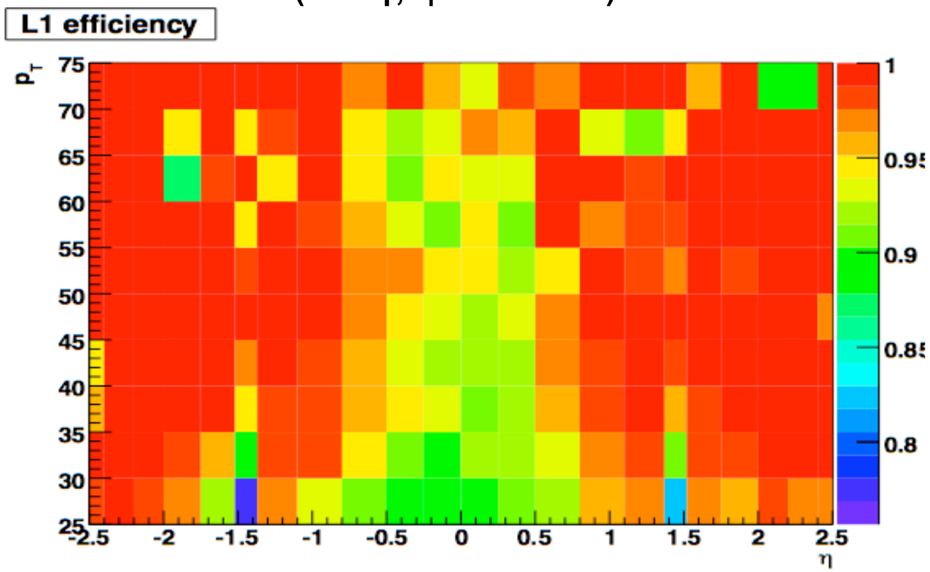
SM H→γγ trigger Studies

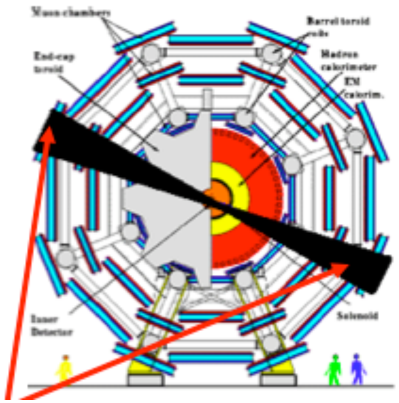
	2g20i Efficiency	
Trigger Level	$H_{120} \to \gamma\gamma$ with Pileup	$H_{120} \to \gamma\gamma$ no Pileup
L1	96.3±0.4%	96.2±0.4%
L2 Calo	90.0±0.6%	90.1±0.6%
EF Calo	83.5±0.7%	84.0±0.7%

Developing methods to determine trigger efficiency from data Z➞ee

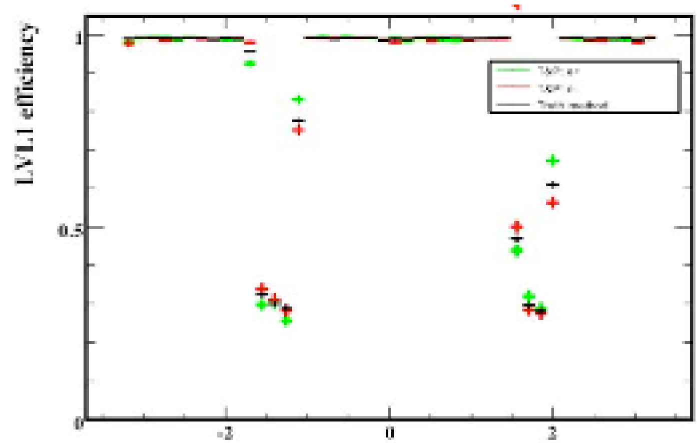
- Control sample: reconstruct Z + 1e trigger
- Determine trigger efficiency checking if second electron has beer triggered

Determine differential trigger efficiency (vs η, ϕ and ET)





2 artificial inefficient regions in ϕ for L1



Z➞ee + Jets