High-level Trigger Algorithm Development

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for the SLAC ATLAS group

Physics selection in the HLT

New physics

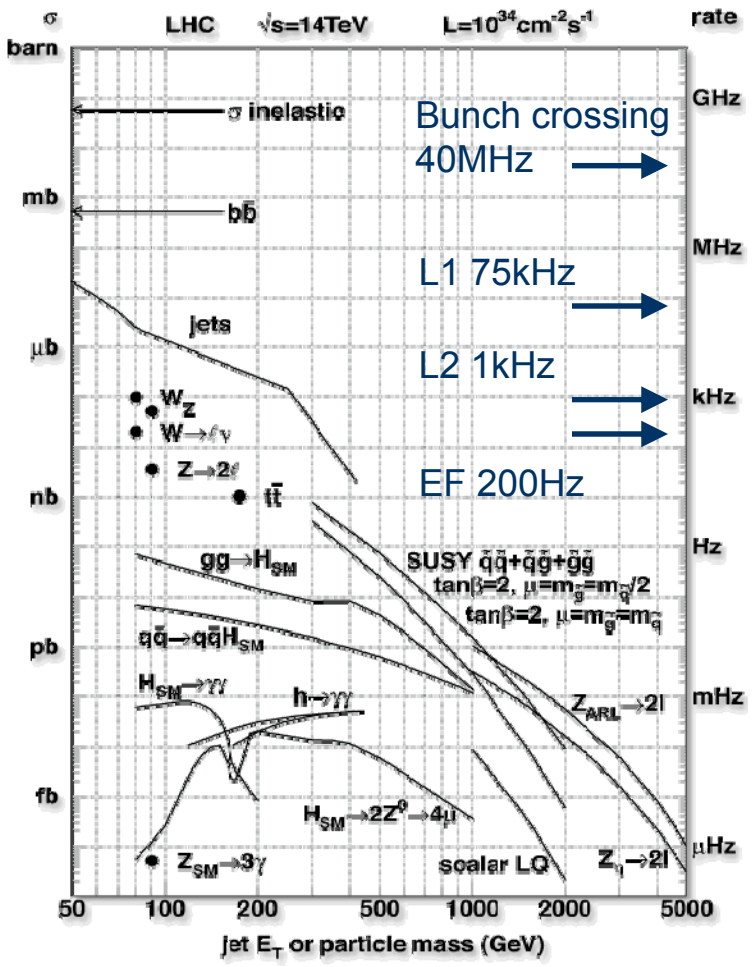
- High-mass objects at low rates
- Background: QCD, electroweak

Trigger on new physics

- Need strong background rejection power
- High signal efficiency

ATLAS trigger system

- 3 Level trigger system
- Level-1 identifies Region of Interest (RoI)
- High-Level Trigger
  - Driven by the RoI concept
  - Allowed Level-2 time budget 40ms
  - Event Filter improves resolution, ~4s latency



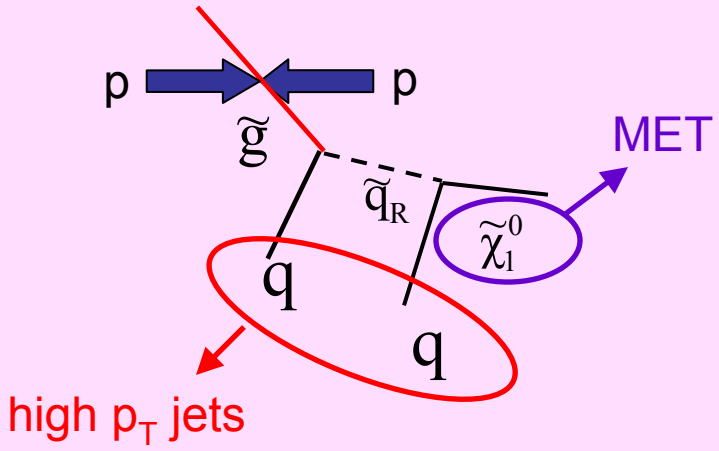
SLAC ATLAS HLT algorithm activities

* **Jet slice**
  - Level-2 algorithm improvements
  - Online integration
* **Missing ET slice**
  - Event Filter MET improvements
  - Level-2 MET development
  - Online integration
* **b-jet slice**
  - New Level-2 b-tag algorithms
* **Tau slice**
  - Online integration

Physics with jets and MET trigger

Generic Supersymmetry signals contain large number of jets and MET

Example



jets + MET in the final state

Need Jets+MET trigger to reject QCD background from SUSY signal

Jet slice

Level-1 :

Jet RoI candidate using sum of calorimeter trigger towers

High-Level trigger:

Jet algorithm:

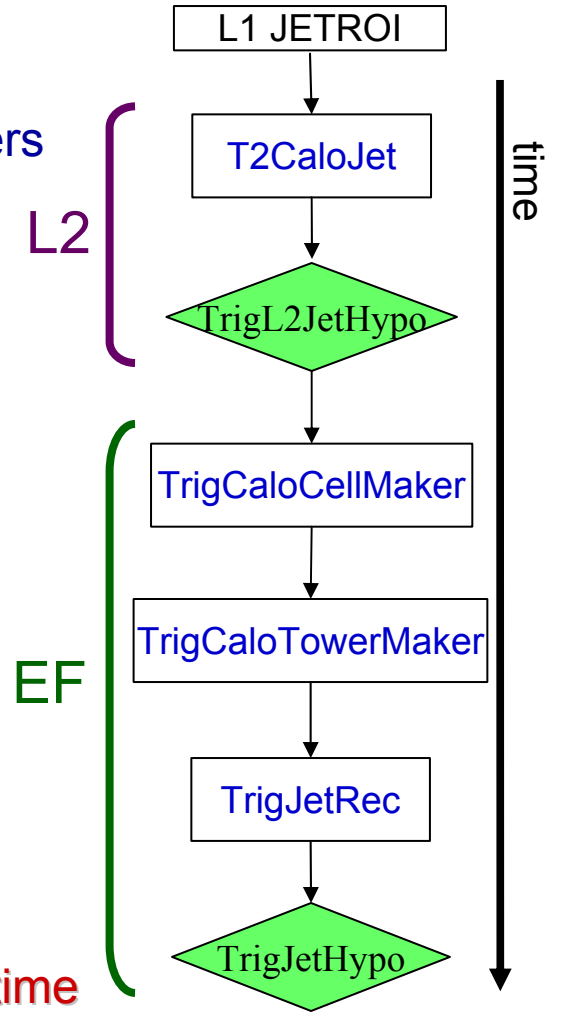
- Use calorimeter information only
- Data preparation in a given (η,ϕ)-window around L1 jet RoI position
- Iterative cone algorithm
- Calibration

Jet hypothesis algorithm:

- Cut on jet ET

Small Level-2 time budget <40ms!

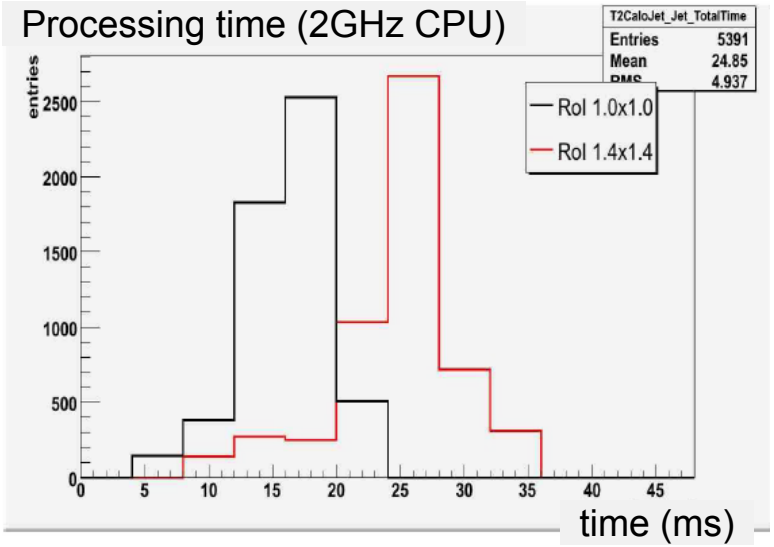
SLAC : Optimize L2 jet parameters, reduce processing time

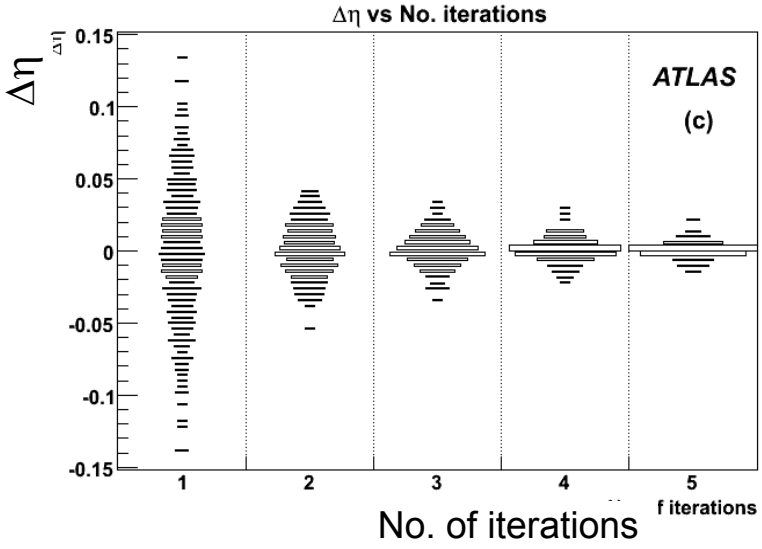


Jet slice

Optimized Level-2 jet algorithm parameters

- Reduced (η,ϕ)-window from 1.4x1.4 to 1.0x1.0
- Reduced number of iterations from 5 to 3 in the cone algorithm
  - ➢Reduce processing time by 32%
  - ➢No significant loss in energy resolution
  - ➢Presented at CHEP07 (ATL-DAQ-CONF-2006-016)





The Missing ET slice

Level-1 :
MET from sum of calorimeter trigger towers

High-Level Trigger

Level-2:

Not sufficient time to transfer full calorimeter data and compute MET in < 40ms

Forward L1 MET result to the Event Filter

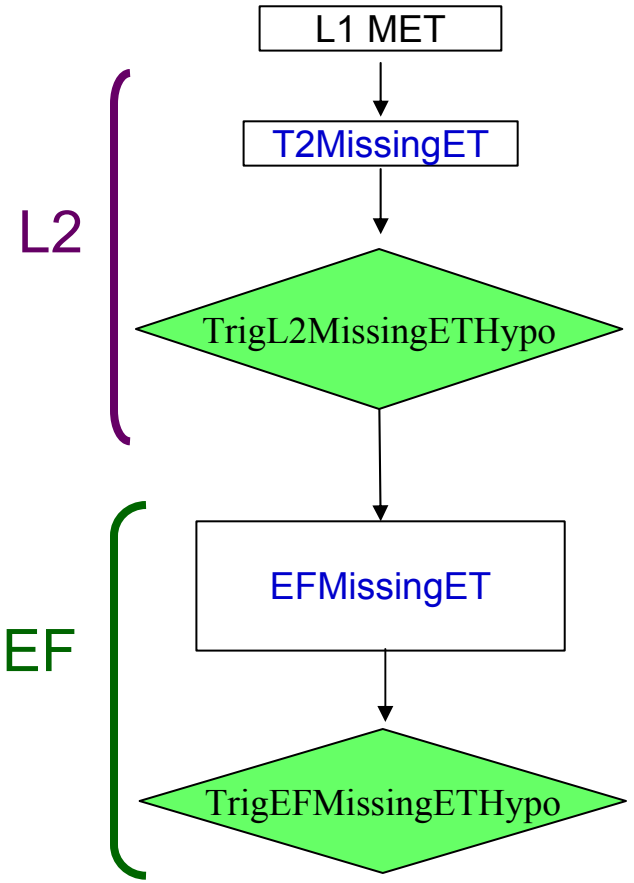
Event Filter:

Full calorimeter data available

MET computation based on energy sums from:

(i) the calorimeter front end read-out boards (FEB)

(ii) individual calorimeter cells



SLAC : investigate L2 MET trigger strategies, primary author of FEB readout

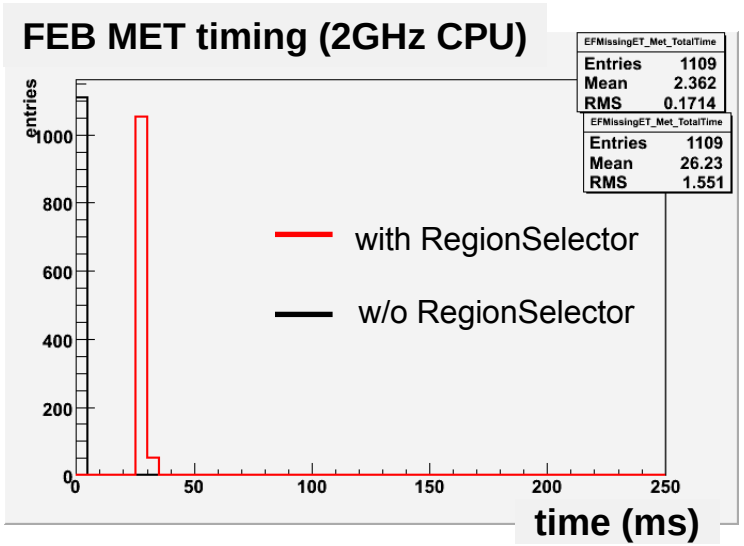
Missing ET in the Event Filter

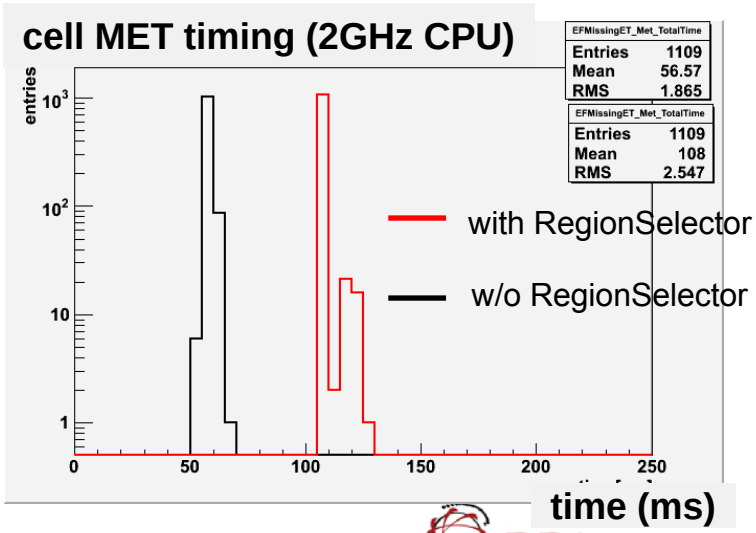
Original Missing ET in the Event Filter

- Use sum over FEBs or cells
- Uses the "RegionSelector" tool:
  - Fill list of detector channels around the RoI
- Fill list of calorimeter cells through the RegionSelector event-by-event

Improve EF MET algorithm speed:

- MET global quantity, does not fit in RoI concept. Do not use RegionSelector
- Load full list of calorimeter cells at initialization
- 90% faster for the FEB loop
- 50% smaller execution time for cell loop
- No impact on physics performance





Physics with b-jet and τ triggers

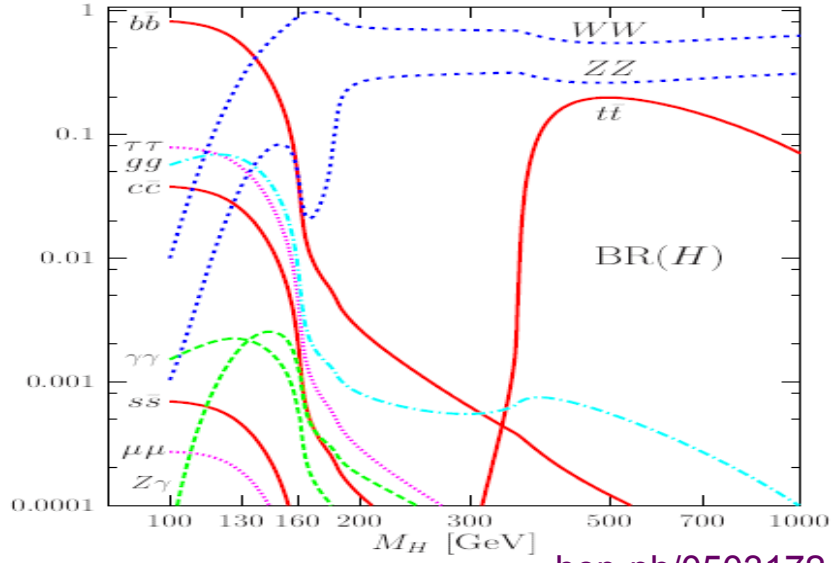
Higgs

Standard Model

- M_H < 135GeV use ttH, H→bb
- VBF H →ττ

Beyond SM

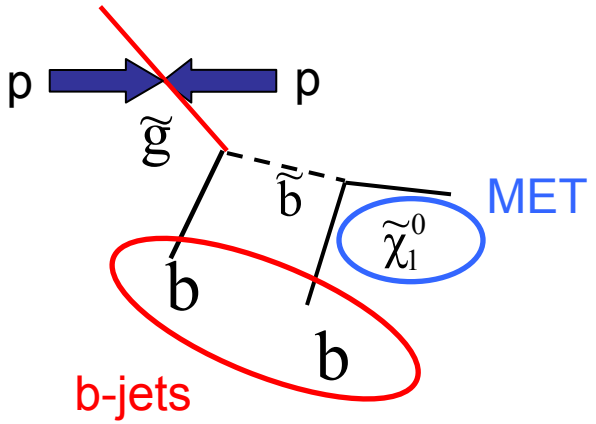
- Charged Higgs tt → bH±bW,H± →τν
- gg →tbH±, H± → tb
- large tanβ, bbA⁰/H⁰, A⁰/H⁰ → ττ



hep-ph/0503172

Supersymmetry

Large tanβ the 3rd generation squarks are lightest, enhanced b-jet production, bbA⁰/H⁰,A⁰/H⁰ → bb

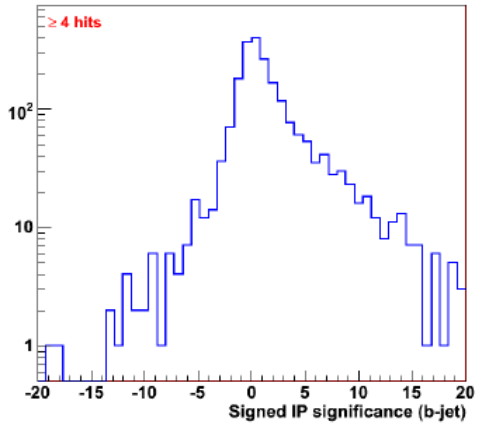


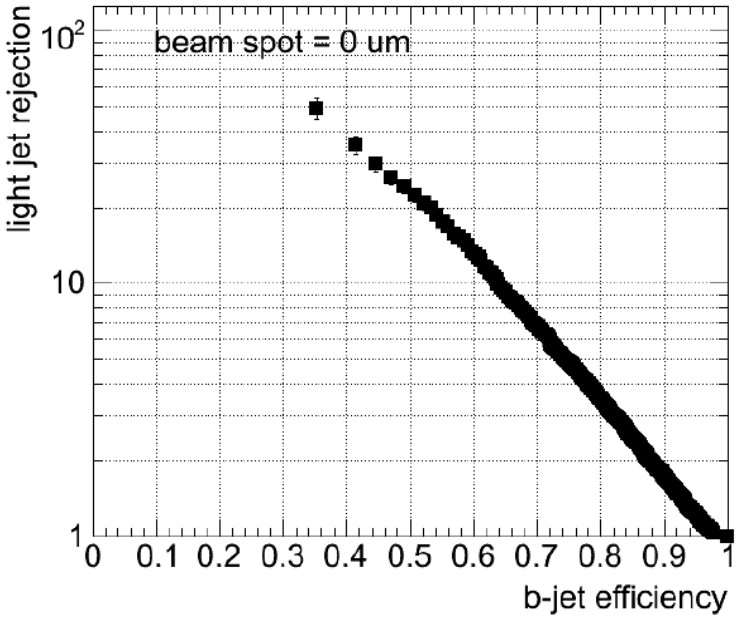
b-jet slice

New L2 b-tagger :

Signed Impact Parameter Chi-Square Probability (IPChi2Prob):

tag b-quarks based on the Impact parameter of tracks pointing to jets





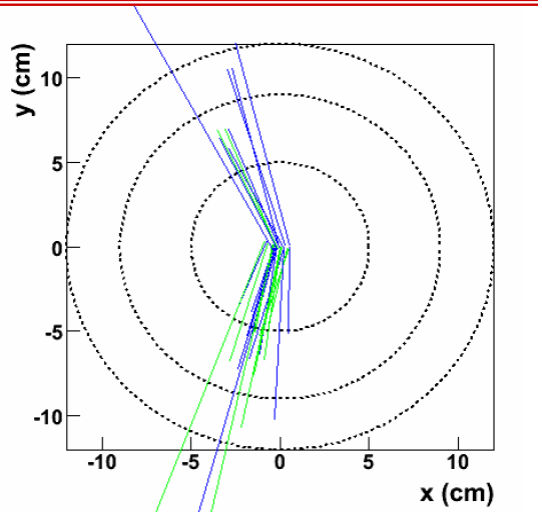
Good angular resolution and good Impact Parameter resolution needed for determining sign of the impact parameter

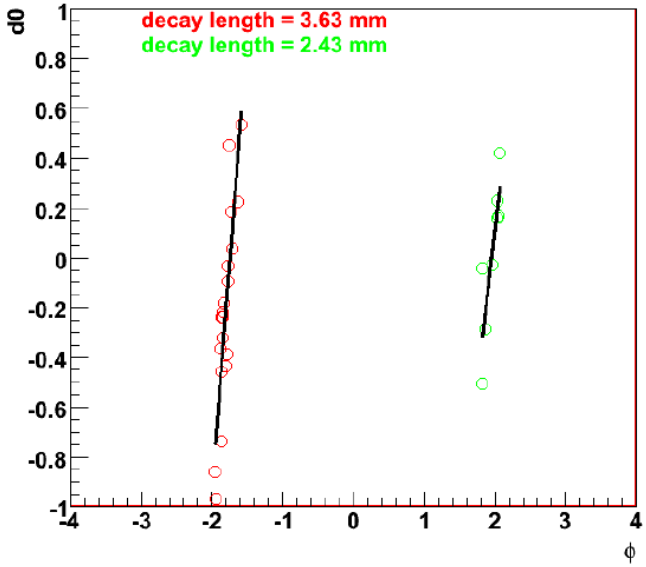
Developed track jets at Level-2 which improves angular resolution by factor 2 with respect to Level-1 jet ϕ

b-jet slice

Level-2 Fast Secondary Vertex b-tagger

- Tracks belonging to a secondary vertex, Impact Parameter and phi are correlated: dca = Lsin($\phi_{trk} - \phi_{SV}$)
- Identify secondary B vertices by fitting the dca-phi distribution
- Build Neural Network with variables: number of tracks with dca/σ > 2.0, mass, p_T-fraction, vertex decay length





Significant rejection improvement for efficiency <50%

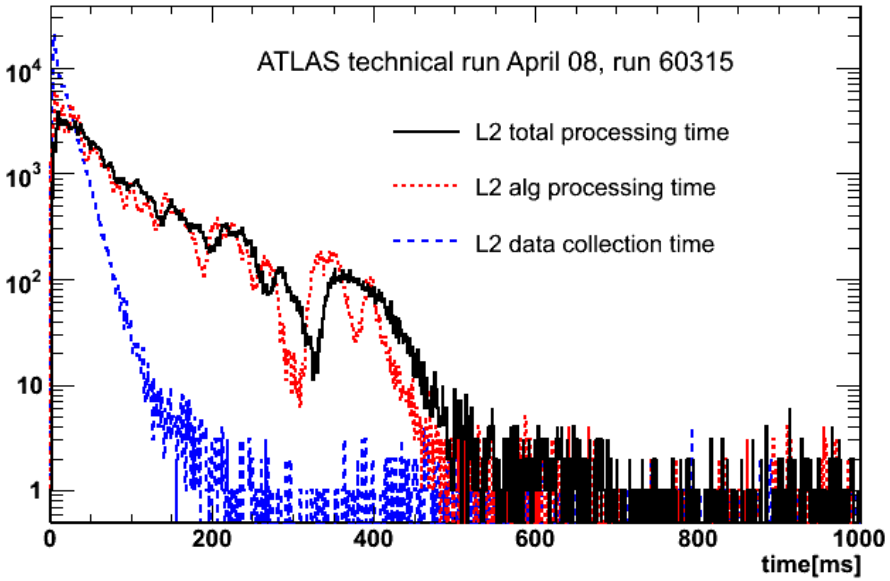
Requires HLT beam spot (see R. Bartoldus' talk) :
Level-2 b-tag performance depends on beam spot shift

HLT online integration

Initial development of HLT algorithms uses the ATLAS offline framework (athena)

Series of tests before a new HLT algorithm can run in the real system at Point1

- First pass compares offline result with online emulator (athenaMT/PT)
- Technical runs: stress test for the HLT at Point1 using simulated physics events
- Monitor HLT performance online:
    - measure algorithm timing, data collection time, rates, memory leaks



Example from technical run April 2008
Using simulated QCD dijet events
Level-2 data collection time + algorithm processing time

SLAC: responsible for online integration of Jet slice, MET slice, τ slice

Conclusions

* SLAC HLT participation is well established within ATLAS
* Our group has improved various HLT algorithms
  - Level-2 jet parameter optimization reduces the processing time without loss of resolution
  - New Level-2 b-taggers with improved efficiency and rejection
  - Fast MET computation at the Event Filter
* We are also strongly involved in the HLT online integration
* The SLAC HLT involvement meets our physics interest
* Our expertise will be a good asset for the definition of the Trigger Menu