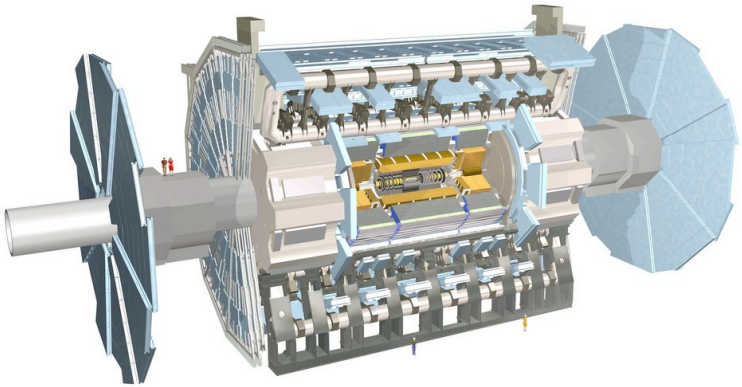
Canadian progress and plans in offline reconstruction, DQ assessment, and monitoring

NSERC Project Review of ATLAS
TRIUMF
14 November 2008



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Outline

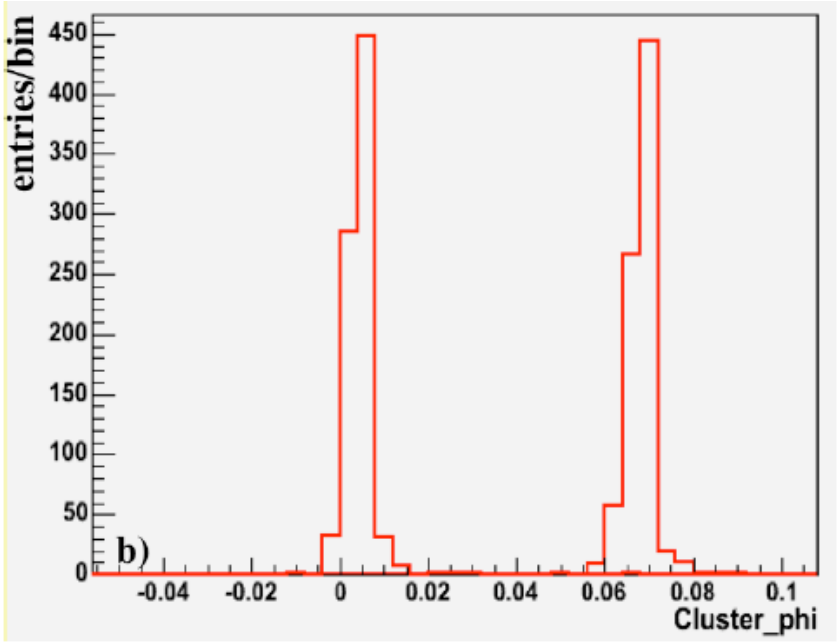
- This presentation
  - reconstruction of high level and detector objects
    - calorimeter clusters
    - jets
    - missing transverse energy
    - muon
  - Data Quality and Monitoring
    - Canadian activities
    - remote monitoring farm
    - remote LAr calorimeter monitoring
    - jets
    - TRT
    - offline monitoring of trigger performance
- Dugan O'Neil's talk
  - reconstruction of high level objects
    - electron, photon, tau
  - beam tests
  - calibration: hadronic and jet energy scale

Calo Cluster Reconstruction

- EM calo clusters are essential for e/gamma reco
  - start from EM calo cells at EM energy scale
  - cells mapped on an eta-phi grid
  - look for pre-clusters using sliding window
  - eta and phi of pre-clusters used as seed for EM cluster finding
- recent improvements to EM cluster reco algorithm (UVic)
  - possibility of different seed for EM cluster finding
    - pre-cluster eta and phi position
    - eta and phi position of clusters found using other clustering algorithms
    - reconstructed tracks
  - flexibility in the steering of the EM clustering stages
  - properly handle the sharing of cells between clusters

Calo Cluster Reconstruction

- spatial separation
  - beam tagged photon run



- energy sharing
  - single photon MC events

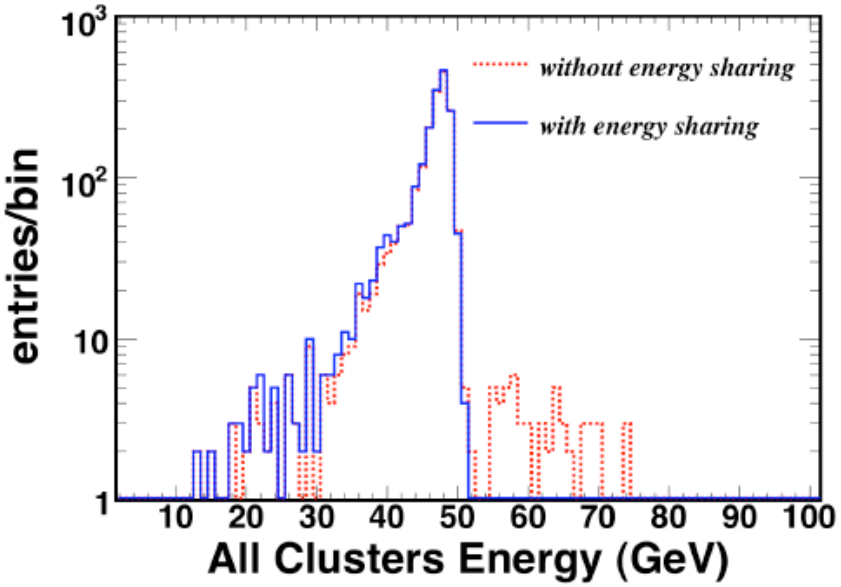


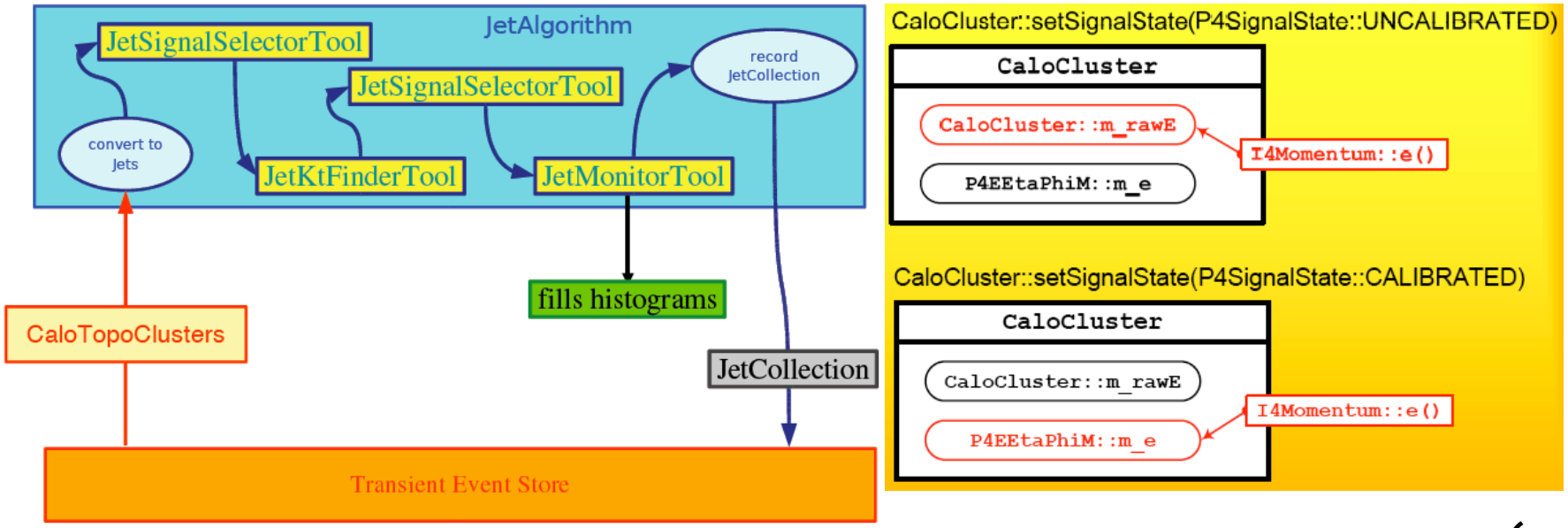
Figure 17: Left: Results of the reconstruction of H8 combined test-beam photon run, after adjustment of different stages in the EM cluster reconstruction showing the cluster ϕ-coordinate distribution. A peak centered around $\phi = 0$ corresponds to impinging photons while the other peak of the distribution origins from primary positrons. **Right:** Reconstructed total energy from 50 GeV single photon events without energy sharing (red dashed histogram) and with energy sharing (blue solid histogram).

Jet Reconstruction

- Jets will be part of nearly all ATLAS analyses
  - decay of new particles likely to produce jets
  - precision measurements such as top quark mass
- Jet reconstruction must satisfy many constraints
  - high reconstruction efficiency
  - low fake jet rate
  - good energy linearity and resolution over all eta range
  - robustness to pileup
- Canadians play a strong role
  - jet software co-convenor (Seuster, Delsart)
  - jet/E_T^{miss} reco task force co-convenor (Teuscher)
  - other important activities
    - MC simulation contact for Jet/E_T^{miss} working group (McGill)
    - jet monitoring (UVic)
    - jet algorithm implementation (UVic, IN2P3)

Jet Reco Software

- A lot of recent activities (UVic)
  - design improvement of jet event data model
    - including the merging of ParticleJet(AOD) and Jet(ESD) classes which has reduced maintenance efforts and improved software flexibility
    - jet (and also jet constituents) “signal states” (access calibrated and raw signal)
  - implementation of new features crucial for 1st data
  - performance optimization
    - CPU and memory usage
  - code testing, maintenance, documentation



Jet Algorithms

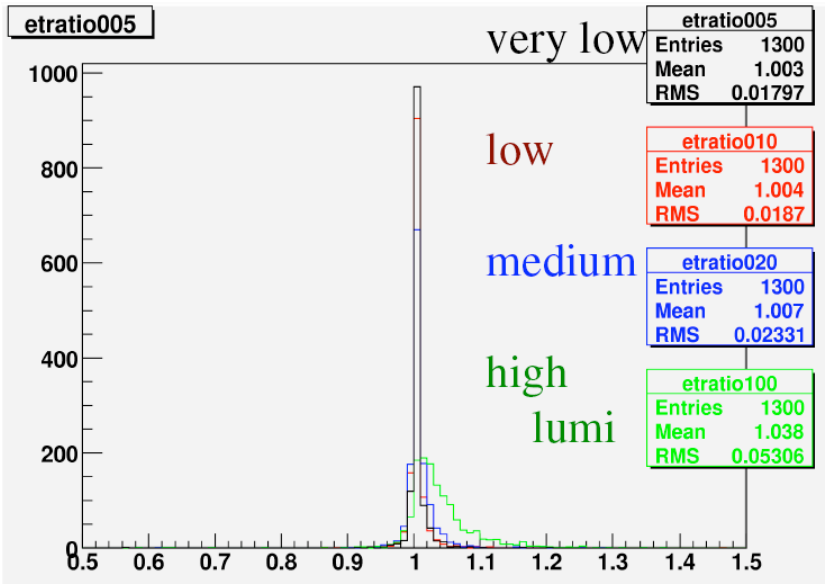
- Various jet algorithms are implemented, including
  - seeded cone algorithms
  - recursive recombination (kT)
  - optimal jet finder (event shape)
- Various jet constituents can be considered
  - calorimeter cells
    - too many to be a practical solution
  - calorimeter towers (0.1 x 0.1 grid)
    - imposes regular grid view on event (natural fro triggers!)
  - topological clusters
    - attempt to reconstruct particle showers
    - growing volume algorithm using seeds and signal threshold

Jet Reco with pileup

- Jet reconstruction should be robust to pileup
- Jet areas
  - measure of jet area (trivial only for some cone algos)
  - important for pileup subtraction studies
- Studies of jets + pileup
  - theoretical investigations with MC only adds pileup
  - ATLAS reconstruction of jet (MC and data) has
    - pulse shape and time structure
    - pileup affecting pulse shape
    - full reconstruction starting from pulse shape and optimal filtering coefficients
    - noise suppression included in jet
- Results indicate important role of noise suppression and detector effects
  - theoretical work predicts an increase in response with luminosity
  - full reconstruction studies seem to indicate a small decrease of response with luminosity!

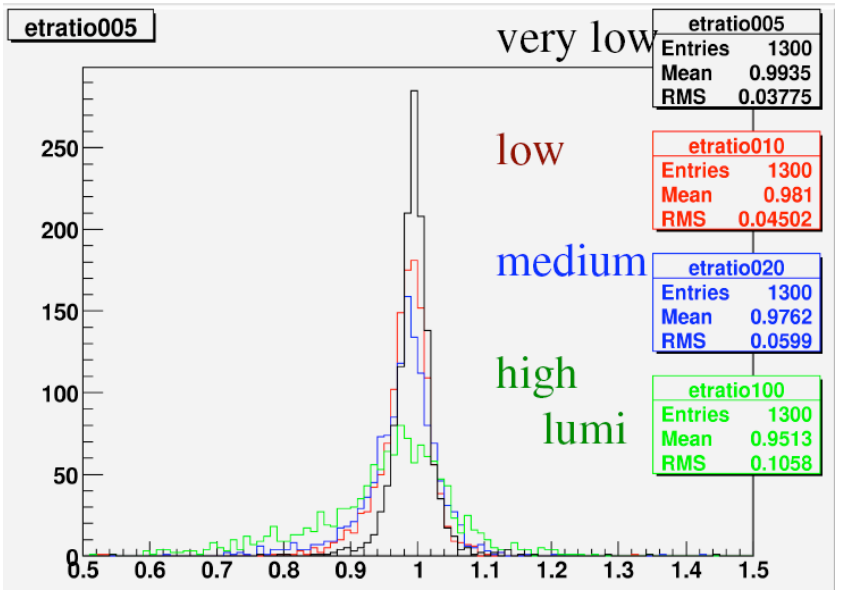
Jet Reco with pileup

- Truth jet response increses with luminosity



E_{Tjet} (pileup)/ E_{Tjet}

- Reco jet response decreases with luminosity!



E_{Tjet} (pileup)/ E_{Tjet}

4 luminosity setting: events per bunch crossing: 1.15, 2.3, 4.6, 23.0
This analysis used SISCone4, 25 ns bunch crossing, only hardest two jets in a dijet sample (p_T between 140 and 280 GeV)

Fake E_T^{miss} Studies - in Canada

- Missing transverse energy (E_T^{miss}) is a key signature for physics beyond the SM
- Global observable, sensitive to many detector effects
- Fake E_T^{miss} must be kept under control for early data
- Instrumental sources of fake E_T^{miss} include
  - mis-modeling of material distribution
  - mis-modeling of instrumental failures
- Fake E_T^{miss} studies can be performed by simulating potential hardware failures
  - high voltage reduction or trips
  - low voltage readout electronics failures
  - noise in calorimeter channels or regions
- Canadians produced fake E_T^{miss} data-cleaning tools
  - using EM calorimeter energy fraction
  - using calorimeter timing information
  - matching jets of charged tracks to calorimeter jets

Fake E_T^{miss} Studies - in Canada

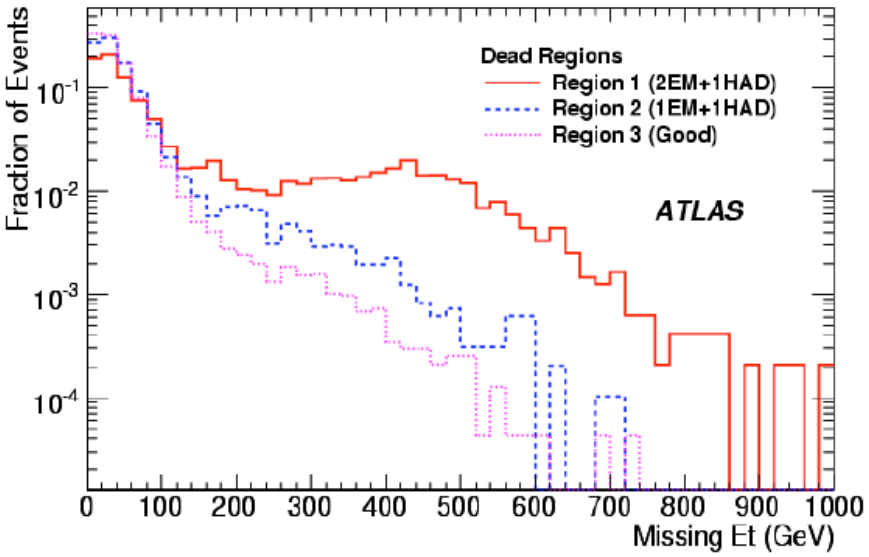
- Using direct photon events (UVic, TRIUMF)
  - use momentum balance: get jet energy resolution
  - use two MC samples
    - a normal MC sample
    - a MC sample with instrumental effects introduced
  - compare jet energy resolution
  - establish corrections
  - study effect on ETmiss distribution
- Validate the method with ATLAS data
  - early data: use di-jet events
    - large cross section and small intrinsic E_T^{miss}
  - later: expand to other processes

Fake E_T^{miss} Studies - in Canada

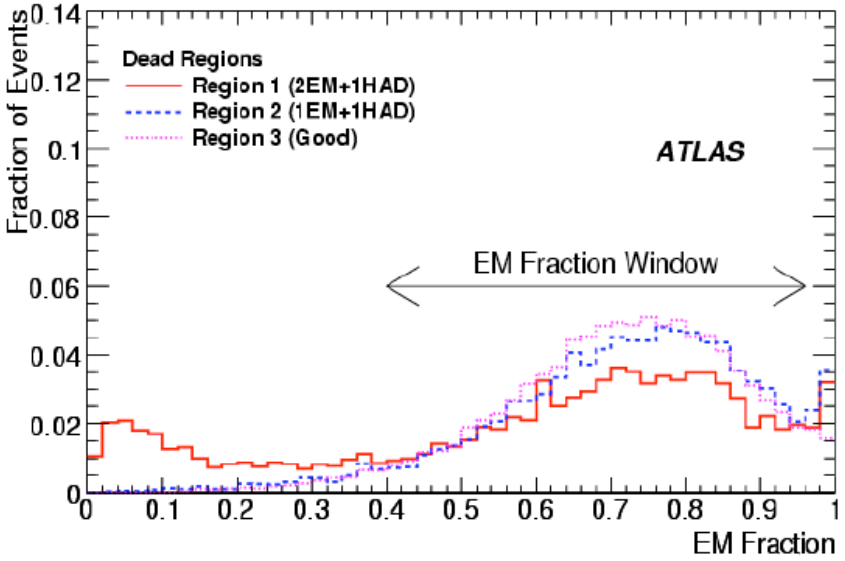
- Using di-jet events (UVic, TRIUMF)
- Identify events with fake E_T^{miss} for removal
  - look at EM fraction of calo jet in E_T^{miss} direction
    - can be used to suppress fake ETmiss background from cosmic ray events
  - look at ratio of E_T of track over E_T of jet

di-jet sample with simulated hardware failures

E_T^{miss} distribution

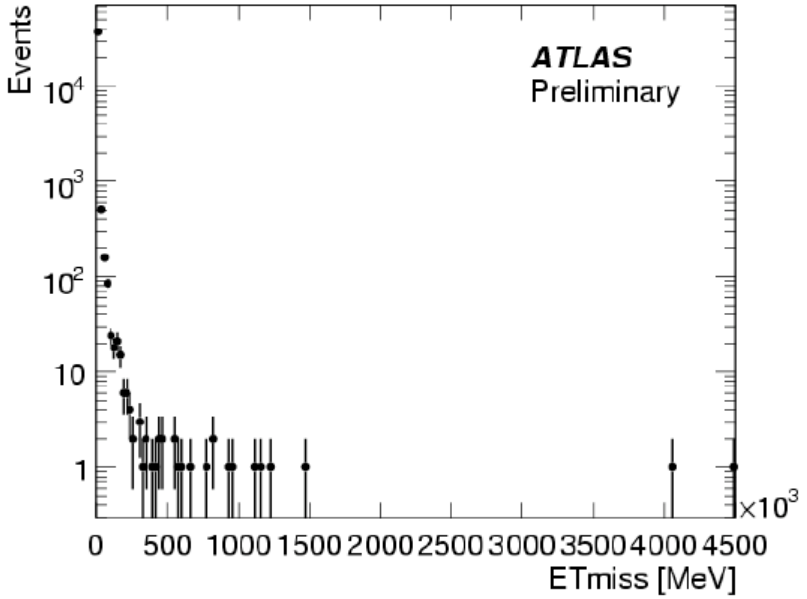


Low EM fraction: EM dead region
High EM fraction: HAD dead region



Fake E_T^{miss} Studies - in Canada

- Study fake E_T^{miss} due to cosmic ray events (Toronto)
  - possible source of large E_T^{miss}
    - large air showers
    - muons undergoing a hard bremsstrahlung



- Reject fake E_T^{miss} due to cosmic ray events
- use EM fraction method
  - typically smaller for cosmic ray events
- exploit calorimeter timing resolution (about 1ns)
  - need to prove that cosmic muon timing can be extracted in a jet event environment

Muon Reco Validation - in Canada

- Test muon chamber alignment (TRIUMF)
  - looking at fitted track segments in middle layer chambers
  - comparing to track position calculated from inner and outer layers, computing residual

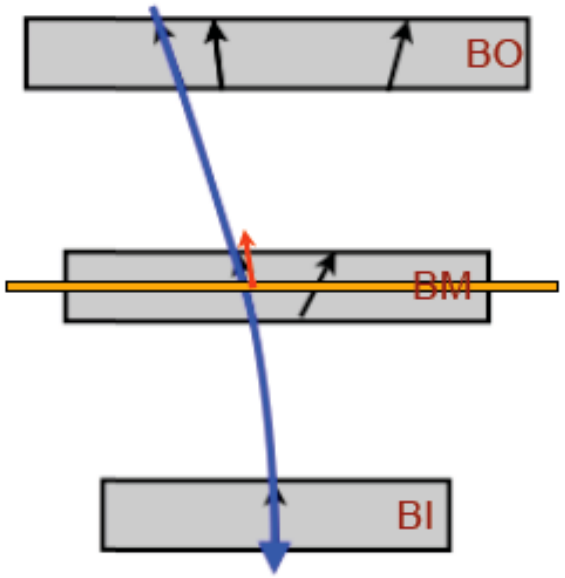


illustration of muon alignment monitoring concept

Muon Reco Validation - in Canada

- Method tested on
  - cosmics at TRIUMF Tier 1
  - on Monte Carlo ($Z \rightarrow \mu\mu$)
- Integrated new MuonAlignMonitoring package into Data Quality Assurance to test hourly updates of alignment constants from optical system
  - runs with offline reconstruction
- Gives resolution of order few 100 microns
  - goal is < 60 microns
  - survey gives mm so this is useful
- More developments ongoing
  - try using stiffer tracks for better performance
  - relative alignment between inner detector and muon system
  - core alignment software

Data Quality

Critical ATLAS activity for past three years

- DQM: Data quality monitoring
- DQA: Data quality assessment

Sets of events (luminosity blocks) will be flagged for usefulness for data analysis

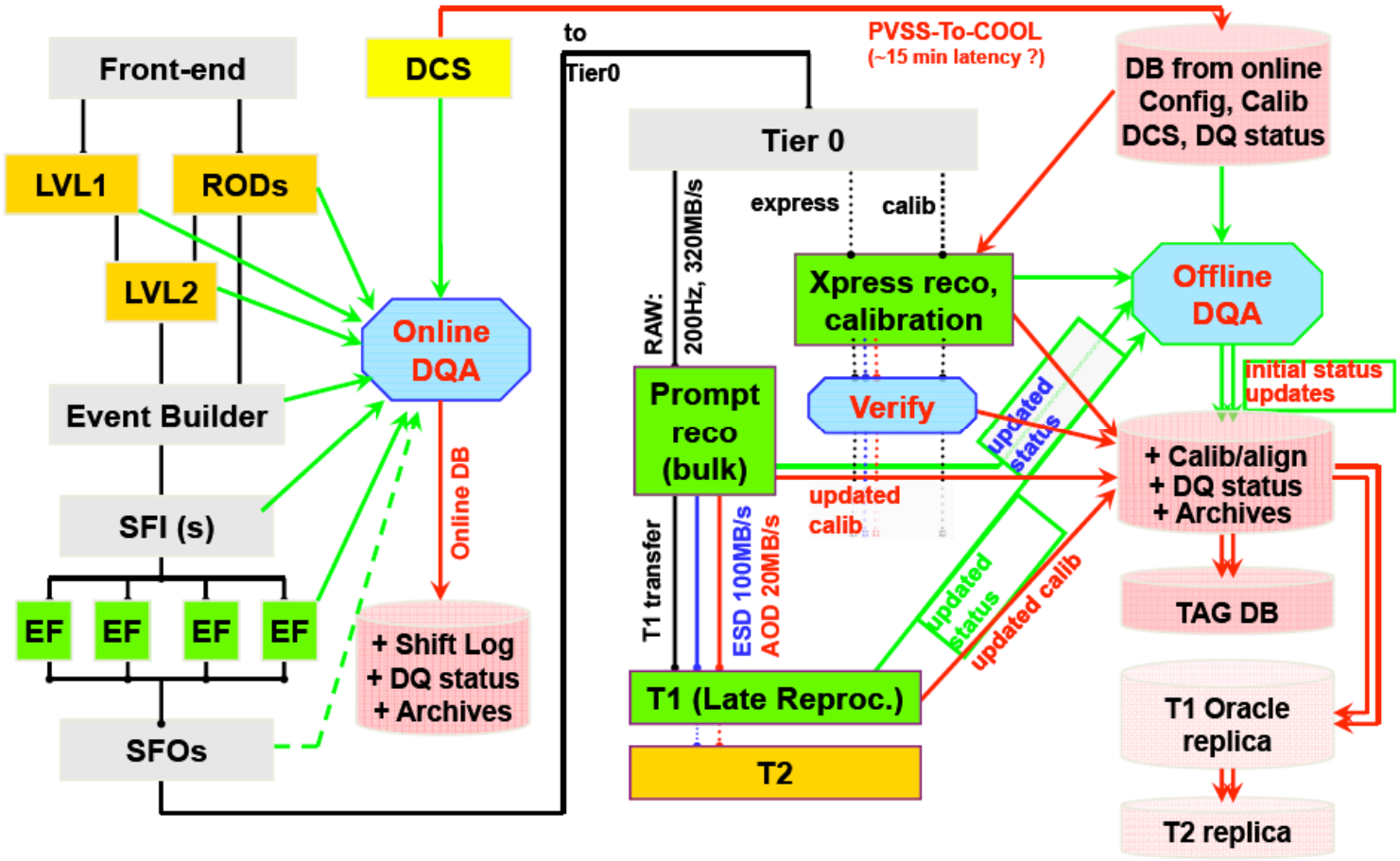
- real-time problem detection
- DQM of first full Tier 0 data processing
- DQM of later Tier 1 data processing

Canadians active in DQ since inception of DQ tasks

- First ATLAS DQ coordinator: R. McPherson
  - policies
  - common tools
- HLT Tau
- HLT and offline E/gamma
- HLT and offline jets

Data Quality

- Online and offline event flow, including processing, calibration and data quality monitoring

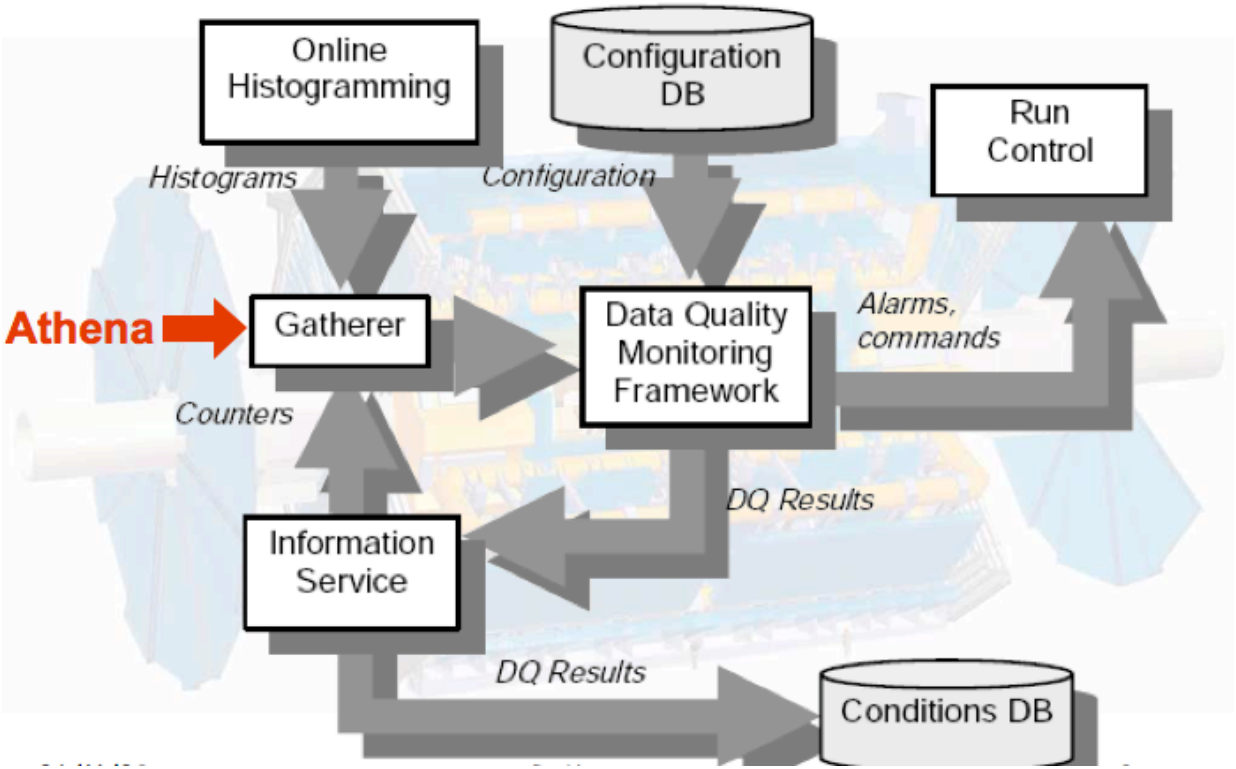


Remote Monitoring Farm

- Sending events from ATLAS point 1 to a remote processor farm at UofAlberta for (online) monitoring
  - CERN-based CPU dedicated to trigger processing
    - partly funded by 2008 RTI
  - network problem does not prevent ATLAS data taking
  - assume 1% of events should be monitored
- Three phase approach (Alberta)
  1. run monitoring remotely on manually fetched files
  2. automatically migrate and run on recent files
  3. full integration into the ATLAS online
- Phase 1 fully achieved on local Alberta cluster
  - process dataset using multiple jobs on different machines
  - merge output histos using gatherer
- Working on phase 2
  - fetch files from TRIUMF

Remote Monitoring Farm

- Online monitoring and DQMF

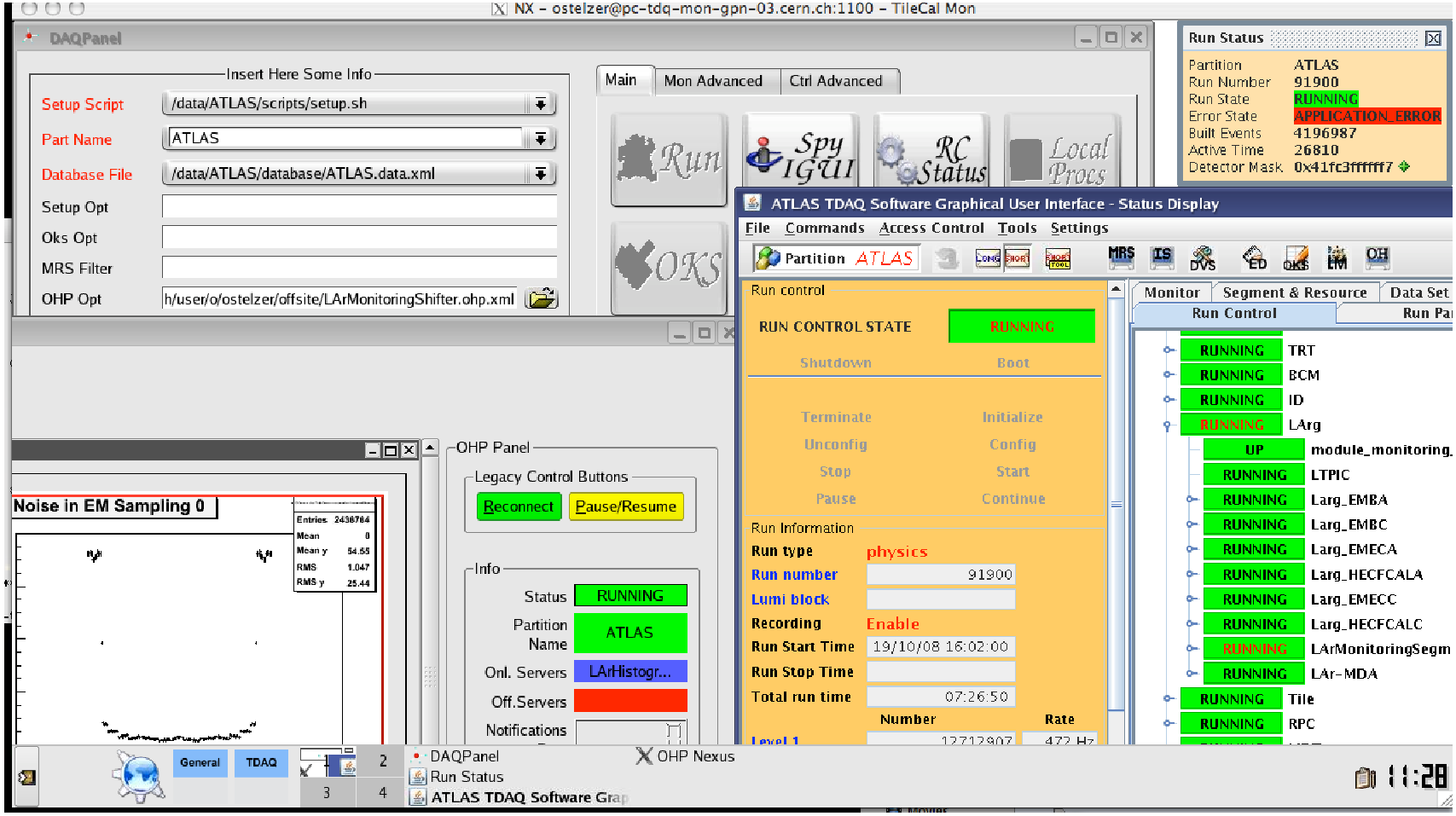


Remote LAr Monitoring

- Many involved in ATLAS-Canada (UVic, TRIUMF, SFU, Toronto)
- Experts need access to same information screens as shifter in ATLAS Control Room
  - But **NOT** desirable for people outside ATLAS Point 1 network to modify detector properties (HV etc.)
- Solution: mirror machine outside Point 1 network makes all information available to world (read-only passive monitoring)
  - Using NX-Server/Client (client is free, server runs on mirror at CERN) can monitor all detector quantities from TRIUMF, BNL or elsewhere, see same “desktop” as in Control Room
  - Building on successful off-site monitoring effort by Tile Calorimeter community at U. Chicago
- Infrastructure in place; beginning to run “shadow” LAr shifts at TRIUMF to learn strengths, limitations of system

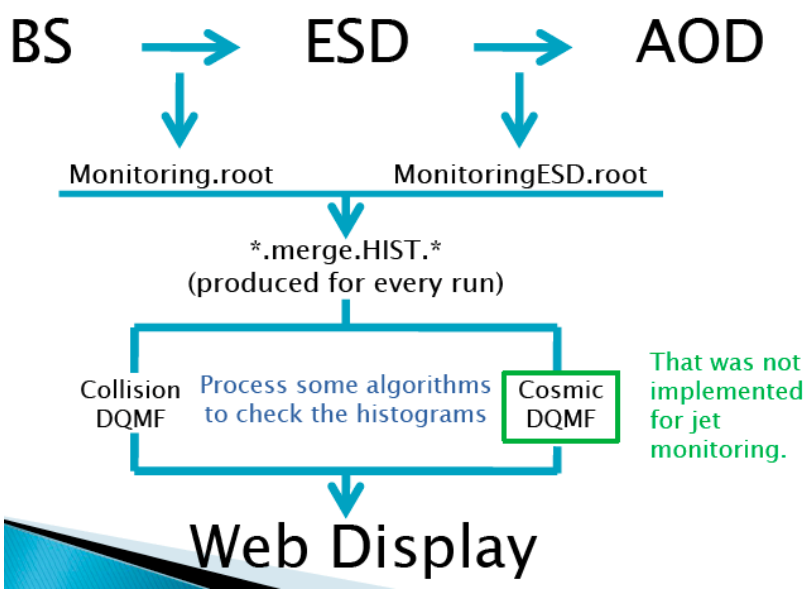
Remote LAr Monitoring

- Remote monitoring desktop



Jet Monitoring

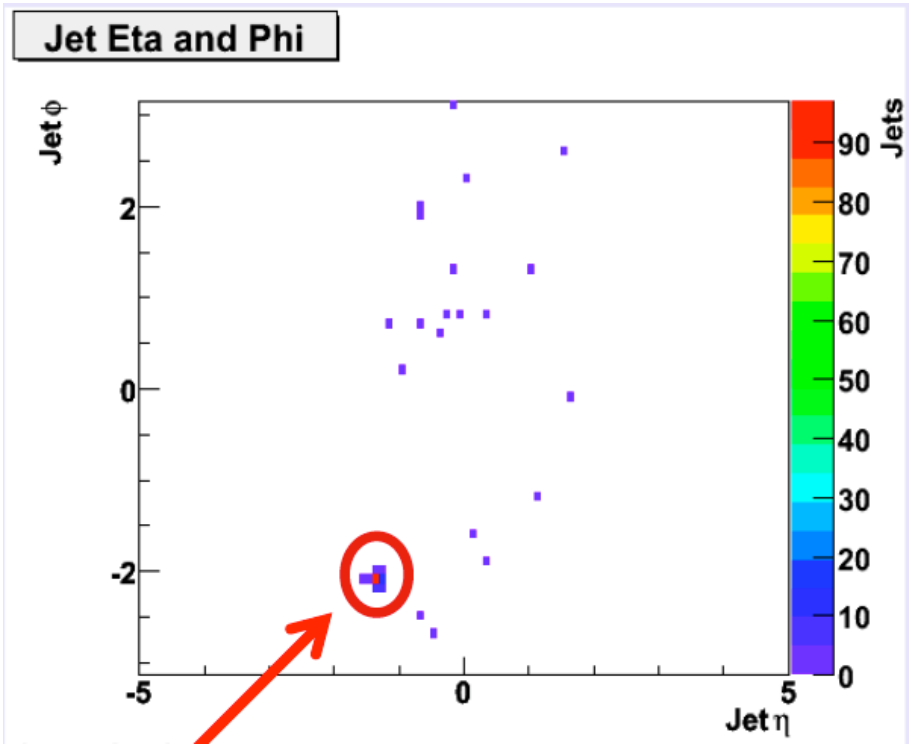
- Most events contain jets: crucial quantity to monitor
- Jet monitoring helps identifying detector problems
  - clearly established during Full Dress Rehearsals
    - simulated detector failures were injected in the mock data (UVic)
    - test of full processing chain
    - jet monitoring first to identify simulated calorimeter failures
- Software developed by UVic and UofArizona
  - new improvements involve automatic checking and Data Quality Monitoring Framework displays (UVic)

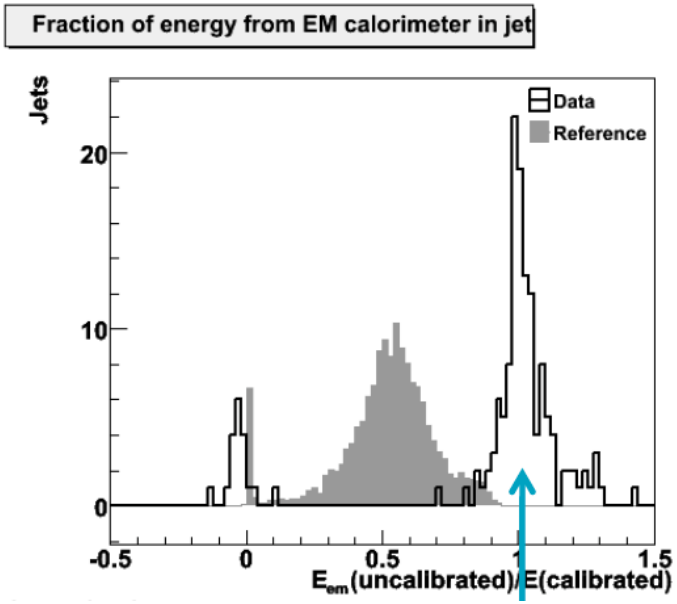


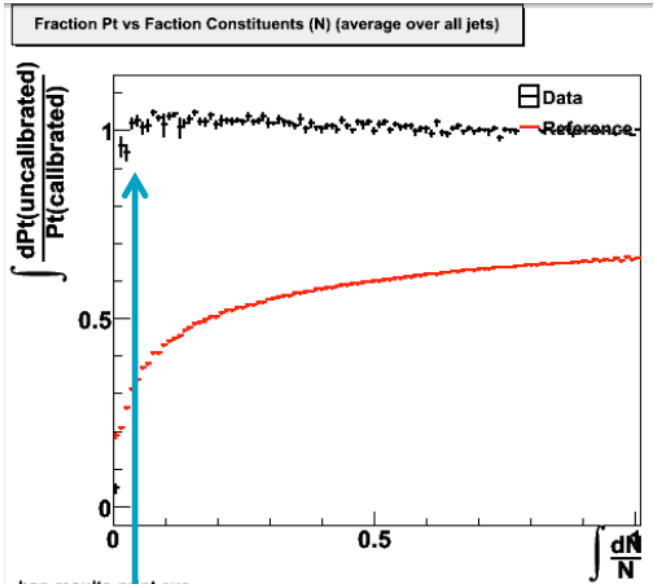
- Overall Status: Yellow
  - Jets: Yellow
    - Cone4H1TopoJets: Green
      - Expert: Undefined
      - Shift: Green
    - Cone4H1TopoJets_EF_J200: Yellow
      - Expert: Undefined
      - Shift: Yellow
    - Cone4H1TowerJets: Green
      - Expert: Undefined
      - Shift: Green
    - Cone4H1TowerJets_EF_J200: Green
      - Expert: Undefined
      - Shift: Green

Jet Monitoring

- Problem with EM calo cell identified
  - a few histos for shifts
  - many experts histos







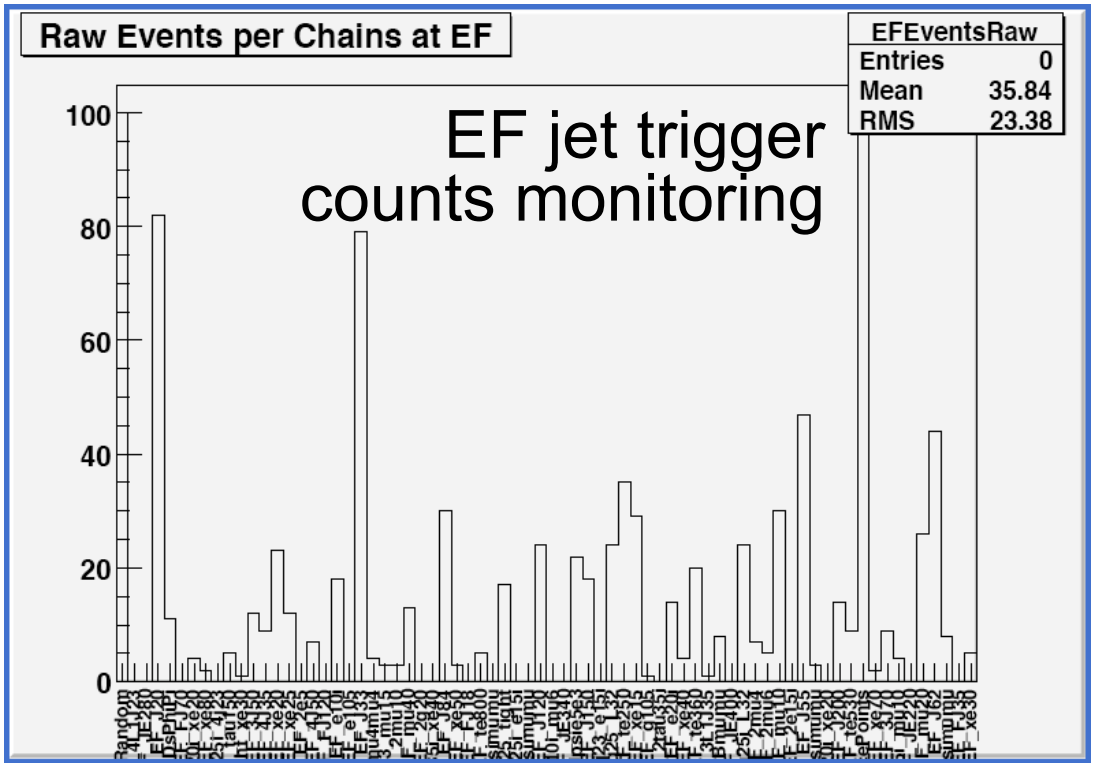
TRT Data Quality

- TRT monitoring an DQ includes
  - real-time monitoring
    - DAQ electronics, low-level DQ, high-level physics quantities
  - offline monitoring of detailed derived quantities
    - time-distance calibrations, alignment, etc.
- TRT low-level data quality monitoring
  - Canadian responsibility (UBC)
    - follows from role in TRT construction, commissioning and maintenance
- LVL1 trigger accept receives a 27-bit word for each straw that encodes the
  - time structure of charge arriving at the wire
  - transition radiation detected
- Monitored quantities include the bit-by-bit structure of these data words
  - knowledge of type and frequency of bit patterns crucial for optimum data reduction in ROD
  - growth in rare data patterns needs to be checked and acted upon

Offline monitoring of trigger

- Active ongoing work by Canadians
  - basic histograms for jet trigger DQ are available in Tier-1 processing
  - still need to fully implement a more refine offline analysis to do a more detailed DQA assessment:

- correlating offline with trigger info from different levels
- automatic assessment of turn-on curves
- etc



Summary

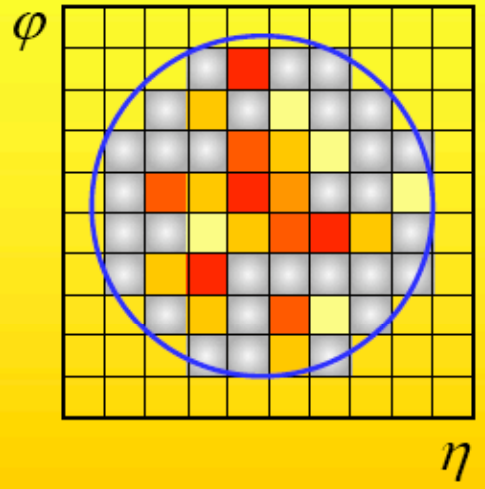
- Strong Canadian involvement
  - reconstruction of high level and detector objects
    - electron, photon, tau, muon
    - calorimeter clusters
    - jets
    - missing transverse energy
  - data quality and monitoring
    - pioneering role in DQ and monitoring
    - remote monitoring farm
    - remote LAr calorimeter monitoring
    - TRT
    - offline monitoring of trigger performance
    - DQA and DQM of quantities crucial to ATLAS
      - high level objects
      - low level hardware performance
  - benefit from long involvement in beam tests
    - calorimetry
    - muon system
  - calibration efforts
    - hadronic energy scale
    - jets, missing transverse energy
    - muon
- Activities expected to increase with first collision data

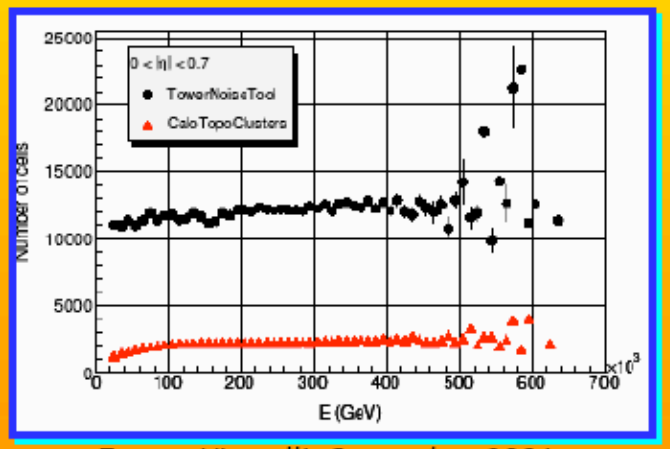
Backup Slides

Why Cluster Jets At All?

Reduce noise contribution

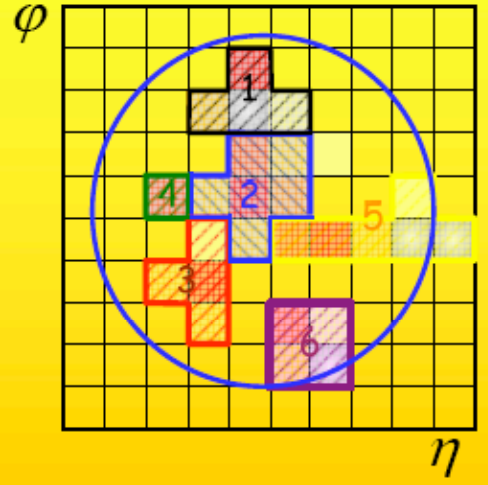
- Fixed cone tower jet

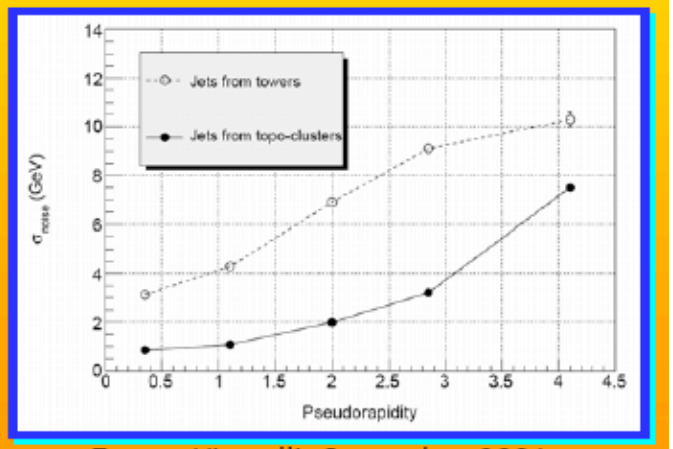




Iacopo Vivarelli, September 2006

- Fixed cone cluster jet





Iacopo Vivarelli, September 2006