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ATLAS Physics Workshop in Rome:

Physics Validation

MPI, July 4^{th}, 2005

Introduction

ATHENA reconstruction tools for different objects:

- muons ____________ (MUONBOY/STACO .VS. MOORE/MUID)
- electrons, photons ____ (EGAMMA)
- jets, b-jets, τ-jets ____ (JETREC, BTAG, TAUREC/TAU1P3P)
- missing energy _______ (MISSINGET)

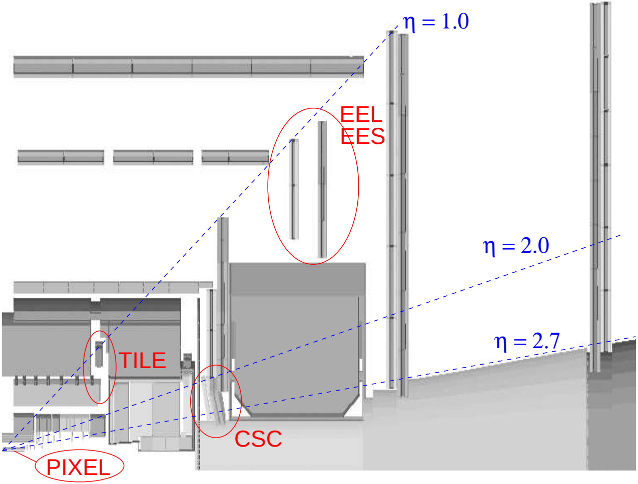
Validation issues:

- reconstruction efficiency $\frac{N_{reco}}{N_{truth}}$ and purity $\frac{N_{fake}}{N_{truth}}$
- energy loss, energy calibration (using MC_truth and data)
- resolution (energy and direction)

Initial Detector Layout

Missing detector pieces:

- middle PIXEL layer and disk; TRT wheel *C*
- TILE gap scintilators
- EEL and EES MDT chambers; one (of two) CSC layers



Muons

Standard algorithm: Muon Spectrometer → Inner Detector

- fit through the track segments in the muon spectrometer
- energy loss corections in the calorimeter (parametrized or directly measured)
- combining with inner detector track for optimum performance

$\Longrightarrow$ Achieved p_T-resolution: 2-10% for $4 < p_T < 1000$ GeV.

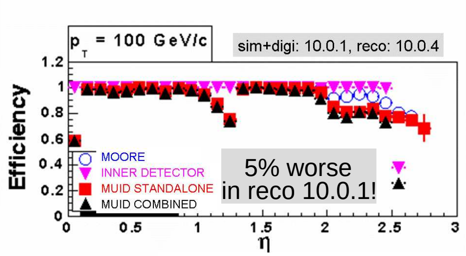
Low-p_T muons (MuidLowPt): Inner Detector → Muon Spectrometer

- Standard reconstruction is inefficient for muons with p_T <5 GeV/c.
- start with the inner detector track
- extrapolate to muon spectrometer and match muon digits (no track fit performed in the spectrometer)
- at least one muon with sufficient momentum needed for triggering

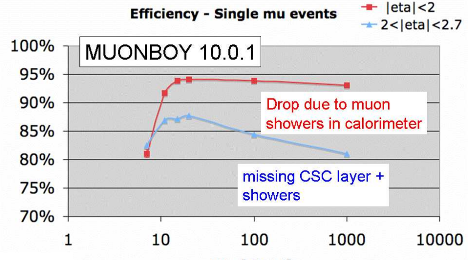
$\Longrightarrow$ p_T-resolution under study

Muon Reconstruction Efficiency

- improved pattern recognition to handle the initial layout
- Similar performance of both reconstruction packages: $\varepsilon(|\eta| < 2) \approx 94\%; \quad \varepsilon(2 < |\eta| < 2.7) \approx 85\%$

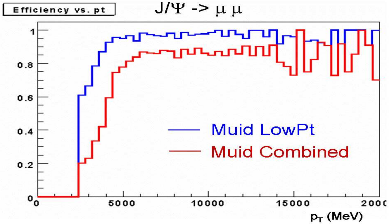


5% worse in reco 10.0.1!



Drop due to muon showers in calorimeter

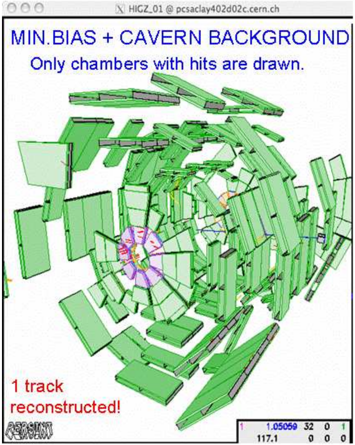
missing CSC layer + showers



Significant improvement using low−pt algorithm.

Min.Bias and Cavern Background (MUONBOY)

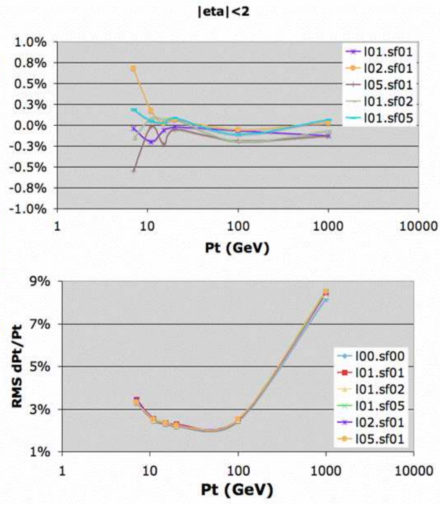
- Luminosity values: (1, 2, 5) x 10^{33} $cm^{-2}s^{-1}$
- Safety factors on cavern background: sf01, sf02, sf05



MIN.BIAS + CAVERN BACKGROUND

Only chambers with hits are drawn.

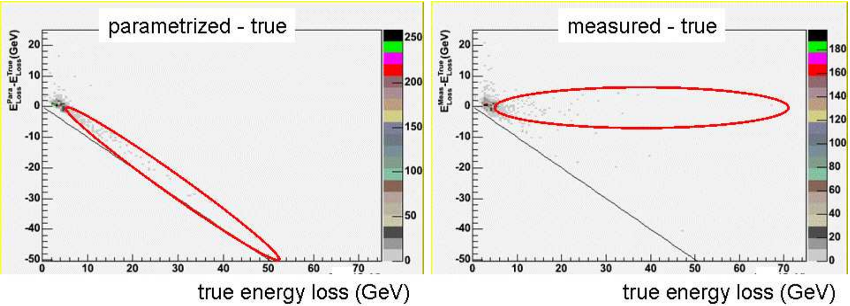
1 track reconstructed!



|eta|<2

MUONBOY efficiency and resolution unaffected, MOORE not tested.

Muon Energy Loss Corrections



- Parametrization related to the map of the detector material: fails at large energy losses.
- Measured energy loss:
  measuremed energy loss in the calorimeter cells
  $$+$$
  parametrization for the dead material,
  $\sim$30% resolution improvement.

Electrons

High-p_T electrons, (EGAMMA):

- candidate selected from the shower properties (leakage in hadron cal., shower shape from energy fractions) and track match with inner detector (E/p, $|\Delta\eta|$, $|\Delta\phi|$)

$\Longrightarrow$ e/jet-separation:
cut-based separation, rejection of $\sim 10^5$ for $\varepsilon \approx 75 - 80\%$
new multivariate techniques, slightly higher rejection (preliminary)

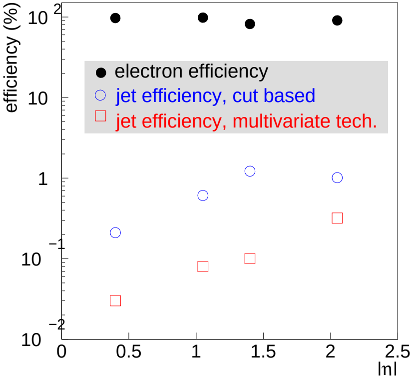
Low-p_T electrons: (SOFTE, new)

- start from inner detector tracks, apply quality cuts
- extrapolate to sampling of EM Calorimeter
- create cluster around the cell

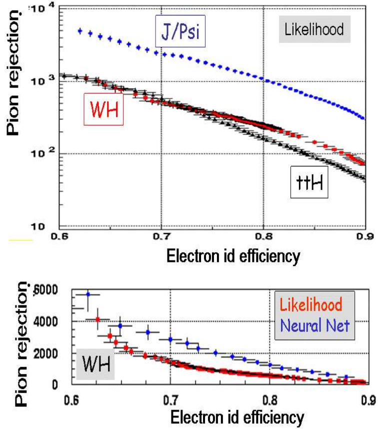
$\Longrightarrow$ e/π-separation using 8 discriminating variables
likelihood and neural network techniques on J/Ψ, WH, ttH

Electron Reconstruction Efficiency

high-p_T electrons (EGAMMA)



low-p_T electrons (SOFTE)



- EGAMMA and SOFTE run separately
- AOD: if the same track is found by both - only EGAMMA stored

Electron Energy Calibration

Each calibration stage gathers additional knowledge and refinements:

- LVL1, ROD, LVL2, offline cell reconstruction, clusters, combined reconstruction, identified particles

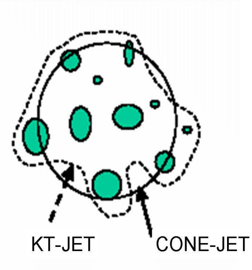
Corrections (energy and/or η dependent)
performed on single electron samples, using MC-truth and $Z \rightarrow ee$:

- shower shape in η, ϕ-offset, energy.vs.(ϕ, η), gap correction; longitudinal weights $E_{rec} = \lambda\left(b + W_0 E_{pres} + E_1 + E_2 + W_3 E_3\right)$
- CaloClusters:
  - linear energy measurement (0.1%) over a wide energy range
  - worse resolution (11-16%) compared to TDR (9-13%) (more material in front of EM)
- preliminary studies using Topological Clusters
  slightly better resolution, non-linearities still to be understood

Jets

Jet Algorithms:

- Cone: simple and fast, easier to calibrate
- K_T: more accurate, harder to calibrate
  $\Longrightarrow$ performance in different physics
  analyses to be studied
  (using different noise treatments)



Jet Calibration Strategies (di-jet calibration samples):

$F = \sum_i \left[(E_{TRUE} - E_{RECO})^2 + \lambda (E_{TRUE} - E_{RECO}) \right], \; E_{RECO} = \sum_i w_i E_i$

E_i (w_i) energy (weight) in different calorimeter region

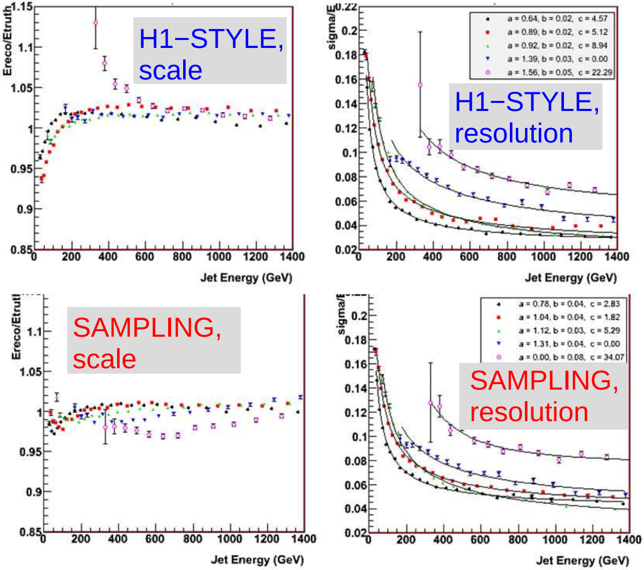
- H1-style (default): $CellWeight = f(CellEnergyDensity)$
- PISA-STYLE: $CellWeight = f(CellEnergy, \; JetEnergy)$
- Sampling Calibration: $SamplingLayerWeight = f(JetEnergy)$

- local hadron calibration:
  based on localized energy deposits in calorimeters

Global Jet Calibration

Global = use full detector to correct analysis dependent effects.

- linearity scale of 1-5%
- better resolution obtained by the cell weighting methods (H1)
- pile-up effects still to be studied

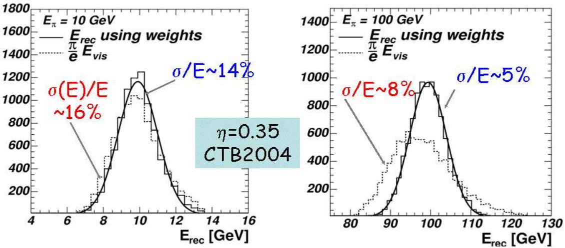


Local Hadron Calibration

Local = use local energy depositions to derive weights.
$\Longrightarrow$ no dependence on the physics process

- separate EM and HAD deposits:
  best modelling of shower processes, best detector description

Calibration based on single pions from MC and testbeam.
(translation for hadrons to be discussed)

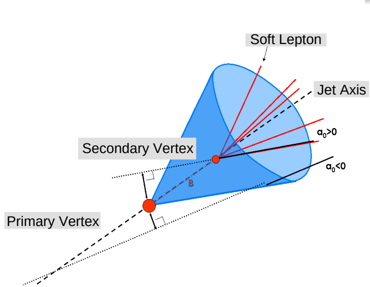


$$E_{corr} = w \cdot E_{reco},$$
$$w = E_{total}(MC)/E_{reco}(MC)$$

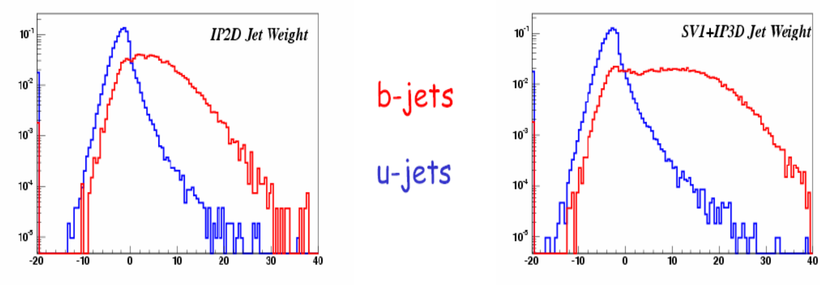
Weighting compared to simple π/e-rescaling.

b-Tagging

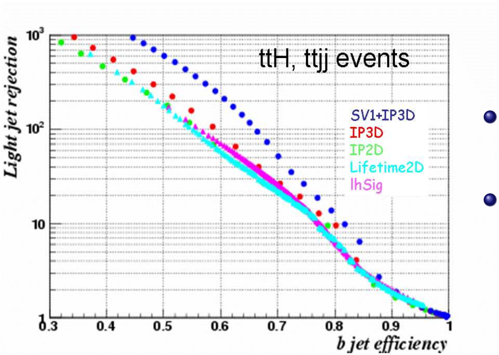
b-taggers (developement mostly done on AOD):



- IP2D (IP3D), Lifetime2D: transverse (+longitudinal) impact parameter
- SV1, SV2: Secondary vertex (select all tracks with big IP inside jet, try to reconstruct 1 common vertex, accept new vertex if far from primary)



b-Tagging Performance

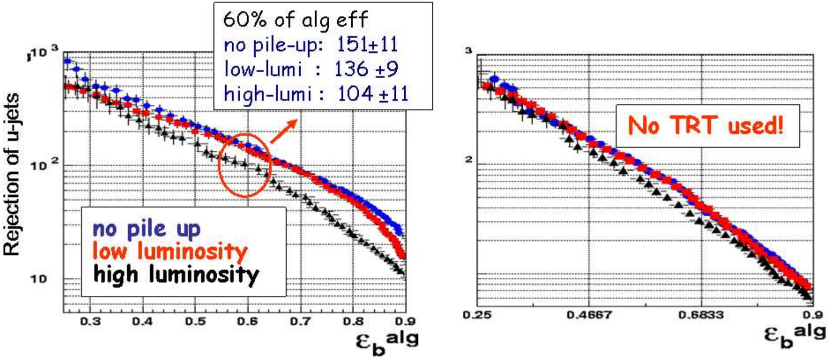


- validation performed on WH, top, ttH *and* $ttjj$ events
- results compatible with DC1 studies (best results with: $SV1 + IP3D$)

Many studies still going on:

- tracking algorithms (iPatrRec .vs. xKalman), jet algs.
- displaced primary vertex - no effect on b-tagging (preliminary)
- influence of commissioning misalignment (estimated from D0)
  10% loss in b-tagging performance $\Longrightarrow$ 10 μm alignment needed.

Soft Lepton b-Tagging



- identification of low-p_T leptons from semileptonic b-decays: looking for jets with at least 1 electron with $p_T > 2$ GeV, discriminating between jet flavors using likelihood, neural network
- complementary to vertex tagging
- studies with pile-up, neural network to improve soft e-id

τ-Jets

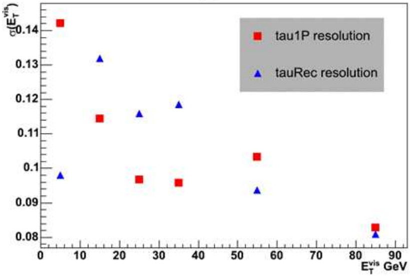
TAUREC

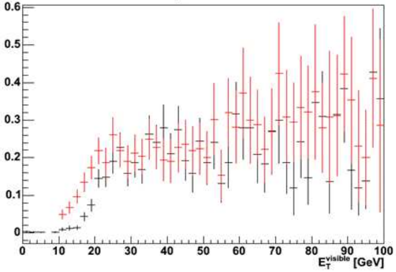
- select candidates from different objects: CaloClusters(default), TopoClusters, Jets, Isolated Tracks
- associate tracks to candidate
- build the set of variables for τ-identification, calculate likelihood
- calibrate the candidate (H1-style), aply selection cuts

Track based approach, TAU1P3P (to be imorted into ATHENA)

- dedicated to searches for light Higgs or soft SUSY
- hadronic $\tau = (1 \text{ track} + \sum \pi^0)$ or $(3 \text{ tracks} + \sum \pi^0)$
- decay products well collimated in space, track provides an estimate of direction

τ-Reconstruction Performance


RESOLUTION .vs. E_T


EFFICIENCY .vs. E_T

- energy resolution similar for both packages
- directional resolution better for $\tau 1P3P$
  (τ reconstructed at vertex,
  while *tauRec* reconstructs τ in the calorimeter)
- $\tau 1P3P$ (red) has higher efficiency at low energies
- lower mistagging rate for $\tau 1P3P$

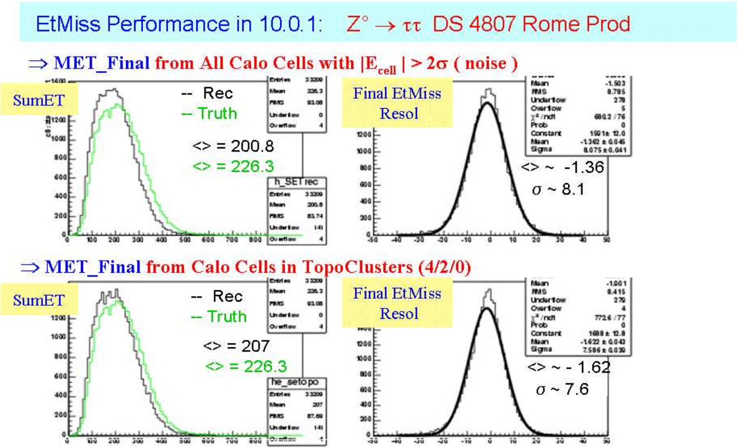
Missing Energy

MISSINGET package

- MET_Final = MET_Calib(Topo) + MET_Muon + MET_Cryo

- MET_Calib:
  from all Calo Cells, H1-style calibration, 2σ-noise threshold
- MET_Topo:
  from all TopoCluster Cells, H1-style calibration, noise threshold 4/2/0
- MET_Myon:
  muon contribution from Muon Spectrometer only (MOORE)
- MET_Cryo:
  estimated energy loss in the cryostat between LAr and Tile

Missing Energy Resolution



EtMiss Performance in 10.0.1: Z° → ττ DS 4807 Rome Prod

⇒ **MET_Final from All Calo Cells with $|E_{cell}| > 2\sigma$ (noise)**

⇒ **MET_Final from Calo Cells in TopoClusters (4/2/0)**

- resolution slightly improves with TopoClusters
- energy shift to higer values at low energies
- tunning of thresholds, refined calibration for lower energies

Summary

- default reconstruction tools for physics analyses are available
- busy development time,
  - efficiency improvements (in low-p_T region), noise suppression
  - ongoing calibration studies, mostly with MC
  (common strategy to be discussed)
  - first studies of pile-up effects

  often outside the official release, or even outside ATHENA
- all performances close to the desired ones

Disclaimer:

not everything shown here has been available
for the official Rome data production (sim+digi 9.0.4, reco 10.0.1)
$\Longrightarrow$ differences between samples produced at different production sites

Rome *post mortem* by the Higgs Working Group (29.06.2005.):
"We need a stable, bugfree software release to continue."