Tau Reconstruction & Identification

An Overview of the Tau1p3p algorithm

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Slac ATLAS Forum
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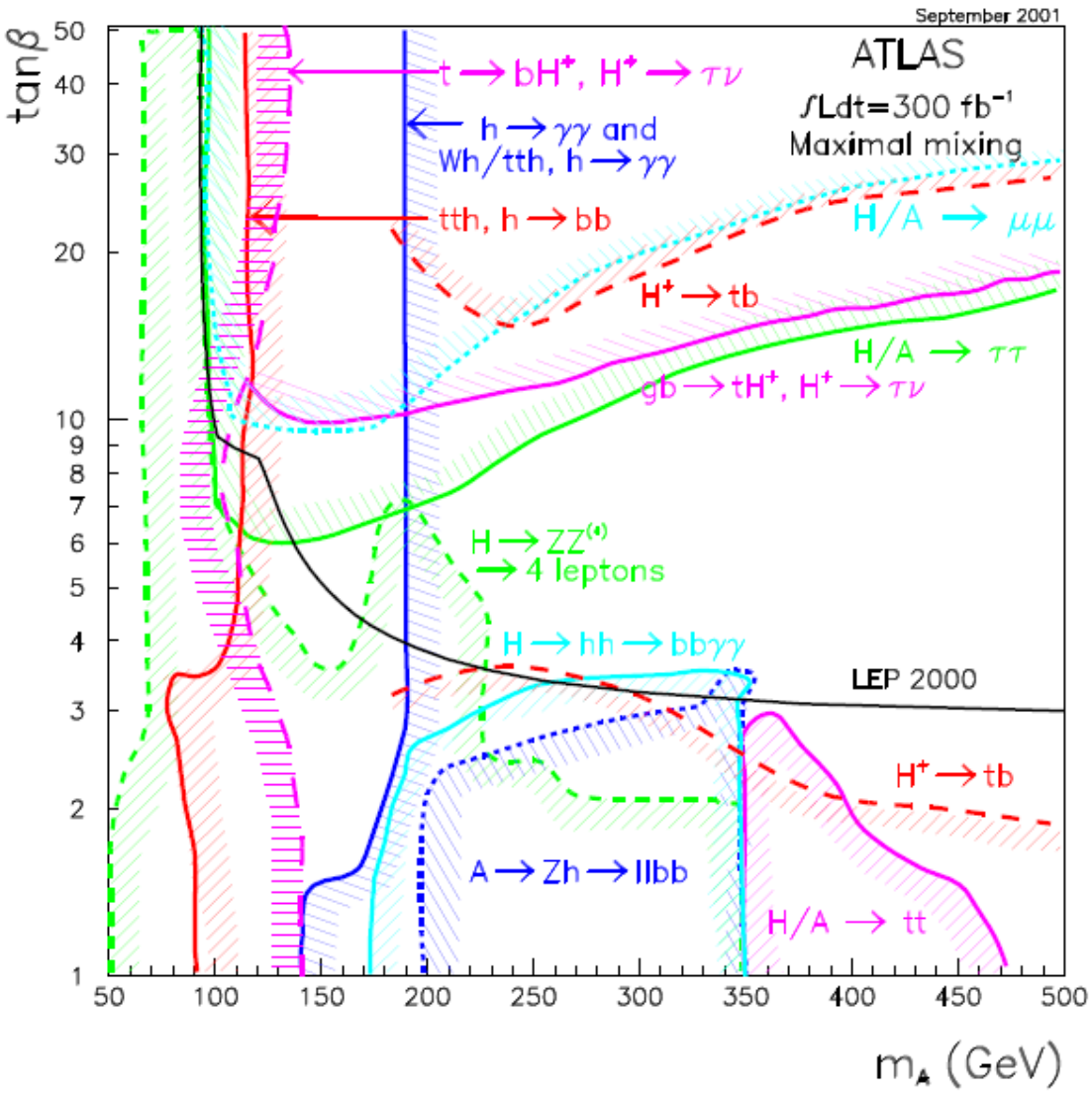
Overview

- Why taus?
- Detector components & resolution
- Tau1p3p algorithm reconstruction
- Tau identification
- Reconstruction & ID efficiencies
- Summary & outlook

Why Taus?

- Provide Early Discovery Potential
  - t + t -> W + b + $H^{\pm}$ + b
    - $H^{\pm}$ -> τ + ν
  - H/A -> t + t
    - t->W + b, W->τ + ν
  - H/A -> τ + τ
- Standard Model Calibration
  - W -> τ + ν
  - Z -> τ + τ

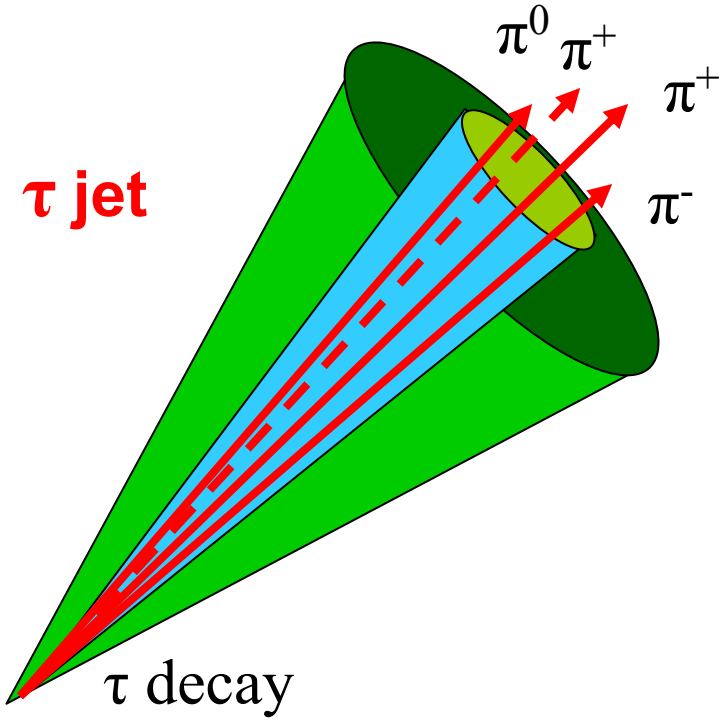


Long Term Project Goal

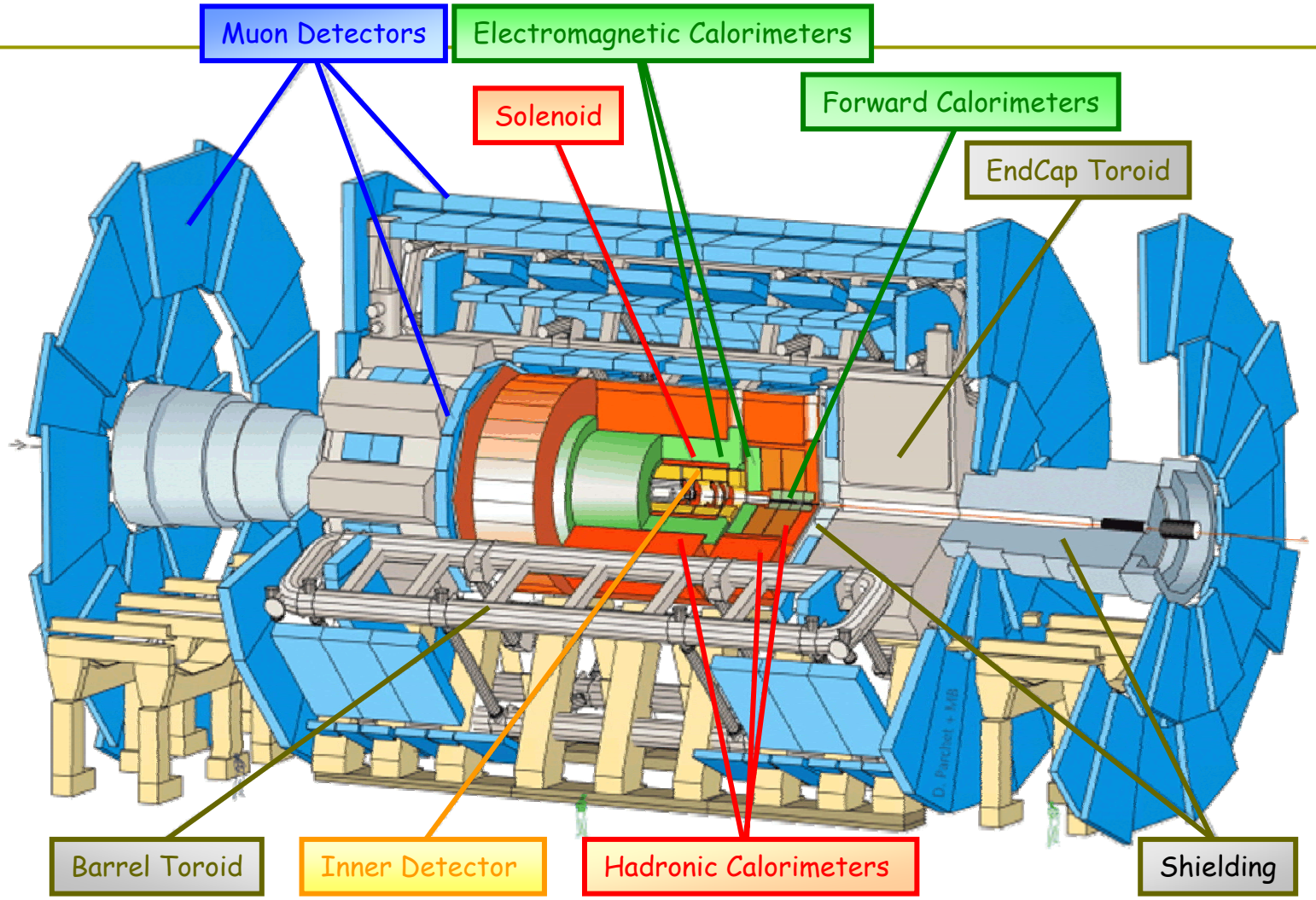
- Studies of electrons show small variations in efficiencies between physics channels
  - Do we see the same thing in taus?
  - Can we understand & model these differences?
  - Non-physical differences lead to bug fixes
- Tau reconstruction & identification efficiency is hard to measure
  - Subtle differences from other jets
  - Messy events: $t + t \rightarrow \tau + 3jets$
- Goal:
  - Assume MC models gross differences between channels
  - Use MC calibrated to early data on 'clean' channels (ex: $Z \rightarrow \tau + \tau$) to project efficiencies for 'intractable' channels

Anatomy of a Tau

- Properties:
  - Mass = 1777 MeV
  - Cτ = 87.11 μm
- Leptonic Decays
  - $\tau \rightarrow \nu + \nu + \ell$ (~35%)
  - Hard to separate from prompt ℓ
  - Veto all e,μ (for now)
- Semi-Hadronic Decays
  - $\tau \rightarrow \nu + h^{\pm} + n\pi^0$ (~50%)
  - $\tau \rightarrow \nu + 3h^{\pm} + n\pi^0$ (~15%)
- Tau Jets are highly collimated

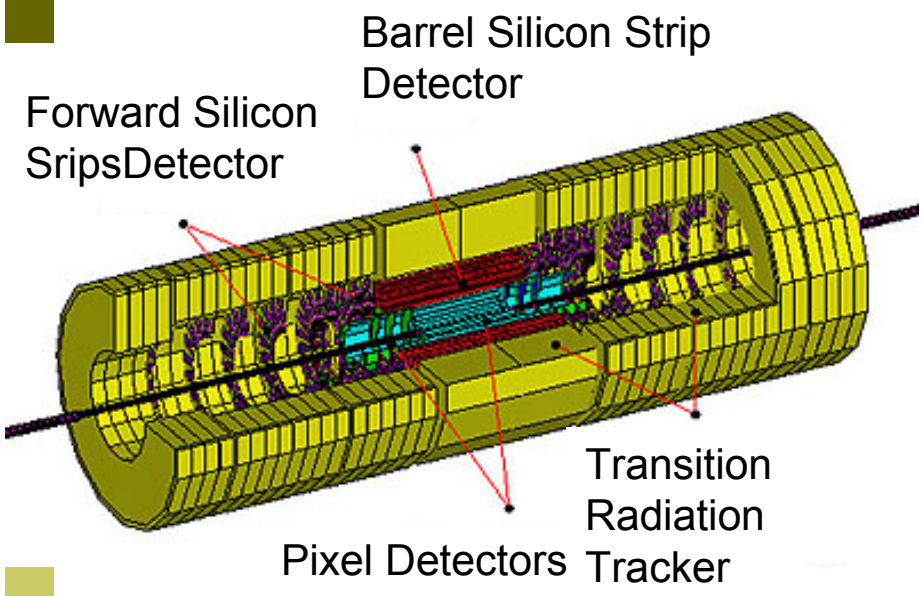


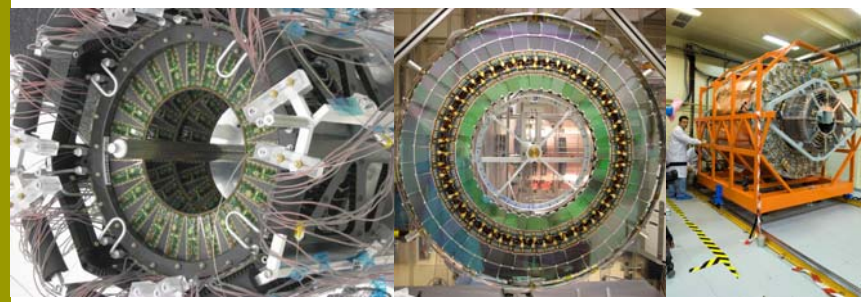
ATLAS layout



ATLAS tracking

Inner Detector





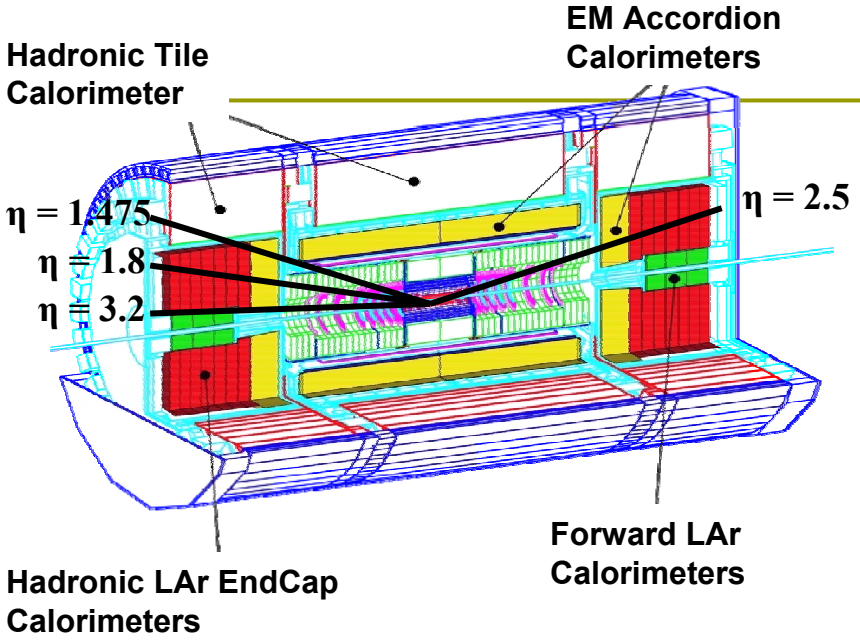
Inner Detectors (ID) :

- **Precision Tracking :**
  Pixel detector, Semiconductor Tracker (SCT)
- **Continuous Tracking for pattern recognition and e id**
  Transition Radiation Tracker (TRT)
- **Resolution :**
  $\sigma(P_T)/P_T = 0.05\% \; P_T\,(GeV) \oplus 1\%$
- **Tracking** in range **$|\eta| < 2.5$**

Magnetic Field :

- ID inside **2 Tesla** solenoid field

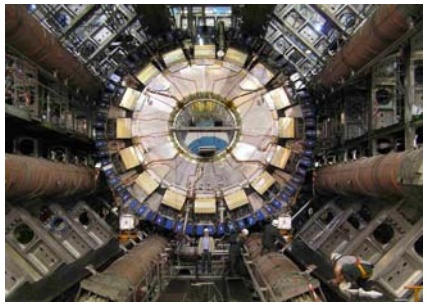
ATLAS calorimetry

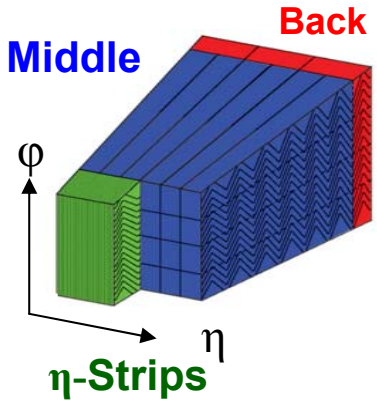


Calorimeter :

- Electromagnetic : (in $|\eta|<3.2$)
  $\sigma_E/E = 10\%/\sqrt{E(GeV)} \oplus 0.245/E(GeV) \oplus 0.7\%$
  (low luminosity)

Layer	Granularity ($\Delta\eta \times \Delta\varphi$)
Pre-sampler	0.025 x 0.1
Strips	0.003 x 0.1
Middle	0.025 x 0.025
Back	0.05 x 0.025



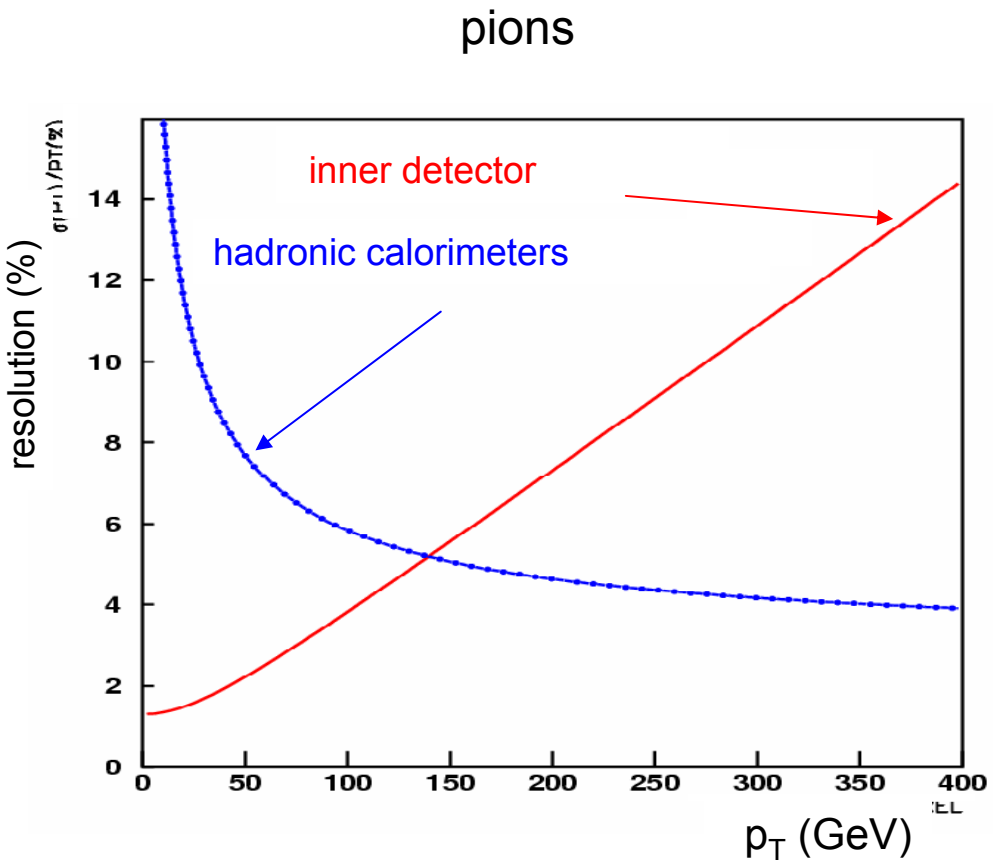


- Hadronic : (in $|\eta|<3$)
  $\sigma_E/E = 50\%/\sqrt{E(GeV)} \oplus 3.0\ \%$

Layer	Granularity ($\Delta\eta \times \Delta\varphi$)
Tile0	0.1 x 0.1
Tile1	0.1 x 0.1
Tile2	0.2 x 0.1

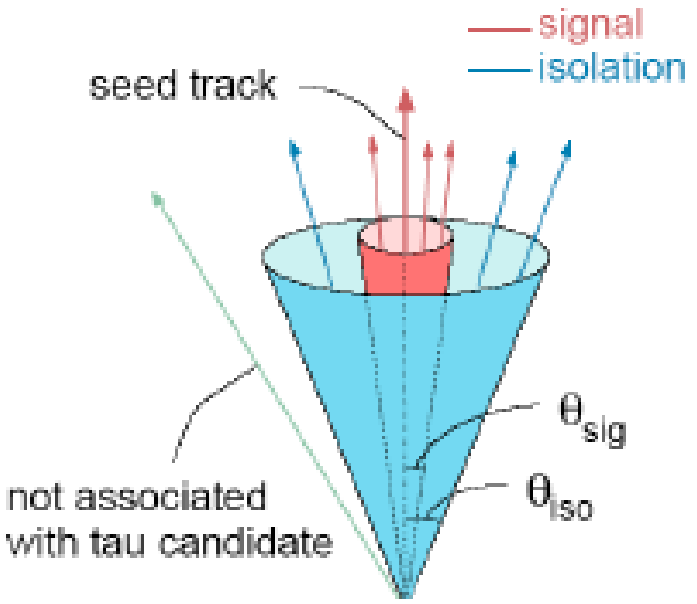
Overview of Tau1p3p

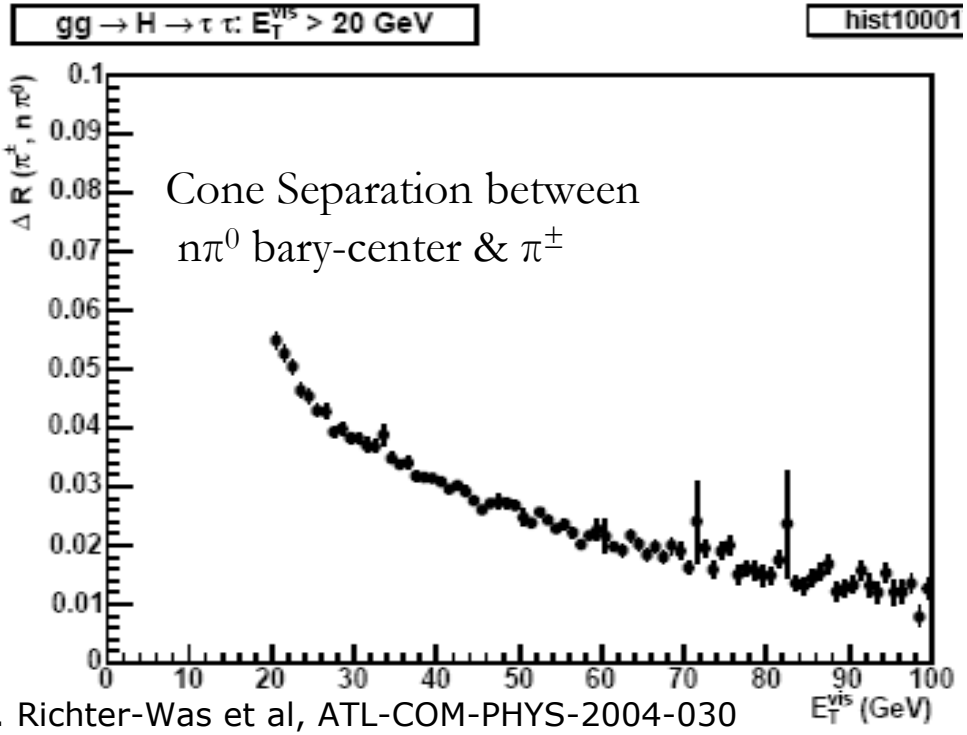
- New 'Track-Based' Algorithm
  - Written by E. Richter-Was et al
  - Supplements/Replaces TauRec
  - Designed for τ jets w/ E_t < 150 GeV
- Seeded by tracks in the inner detector
  - Leverages resolution advantage in inner detector for more accurate energy scale
- Status
  - Algorithm finished
  - Athena-Aware now available
  - Cuts need to be fine-tuned



Tau1p3p Reconstruction

- Start with a *qualified* track
  - Min. silicon, straw chamber hits
  - Cuts on
    - Impact Parameter
    - χ^2 track fit reconstruction
  - Lepton veto (not implemented yet)
- A Track is a *leading hadronic track* if
  - P_t > 10 Gev
  - 0 or 2 qualified tracks w/ P_t > 2 GeV within $\Delta R < .4$
- Set of 1 or 3 tracks forms tau candidate
- Energy scale = E_{flow}





E. Richter-Was et al, ATL-COM-PHYS-2004-030

Energy Flow (E_{flow})

For ΔR < .2:

Any other non-associated energy

Parameterized corrections

$$E_T^{eflow} = E_T^{emcl} + E_T^{neuEM} + \Sigma\, p_T^{track} + \Sigma\, resE_T^{chrgEM} + resE_T^{neuEM}$$

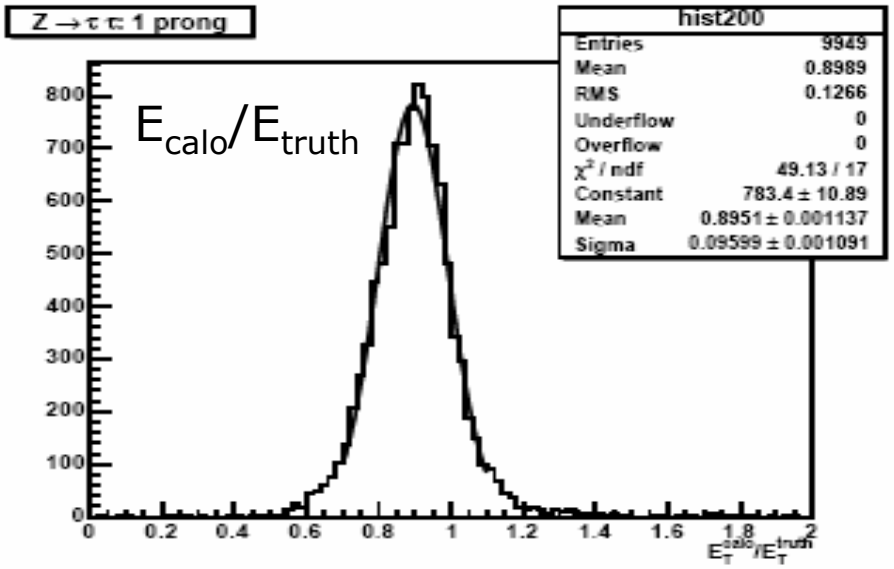
E/G Clusters

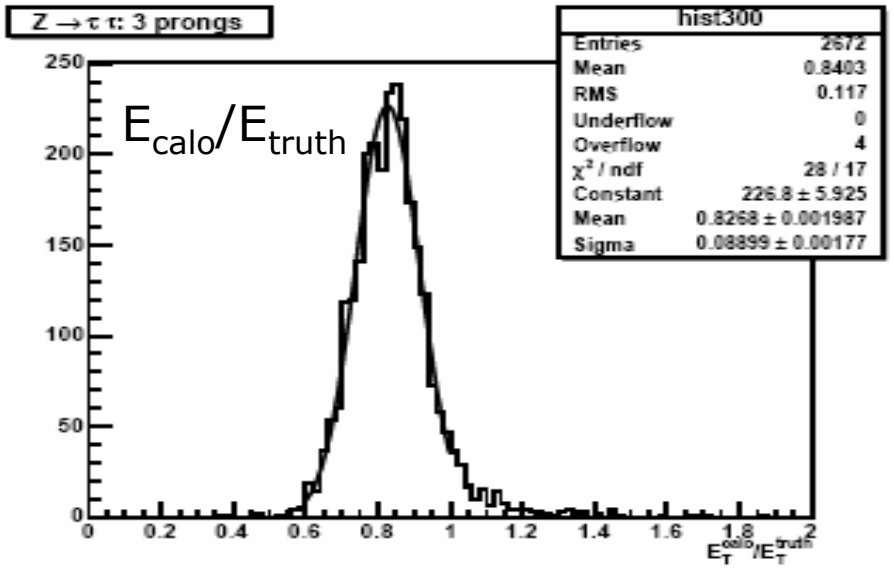
- >0.2 GeV
- Not associated with a track

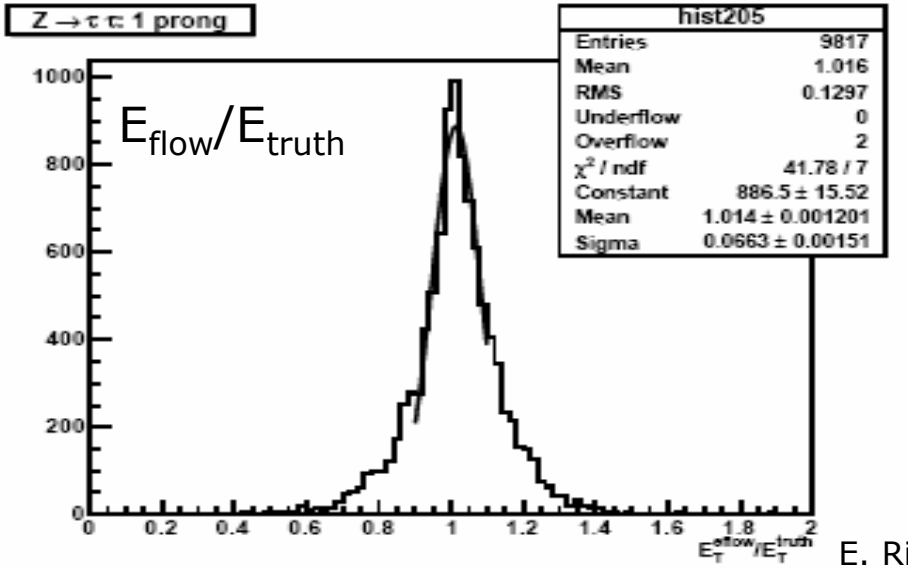
P_t of seed tracks

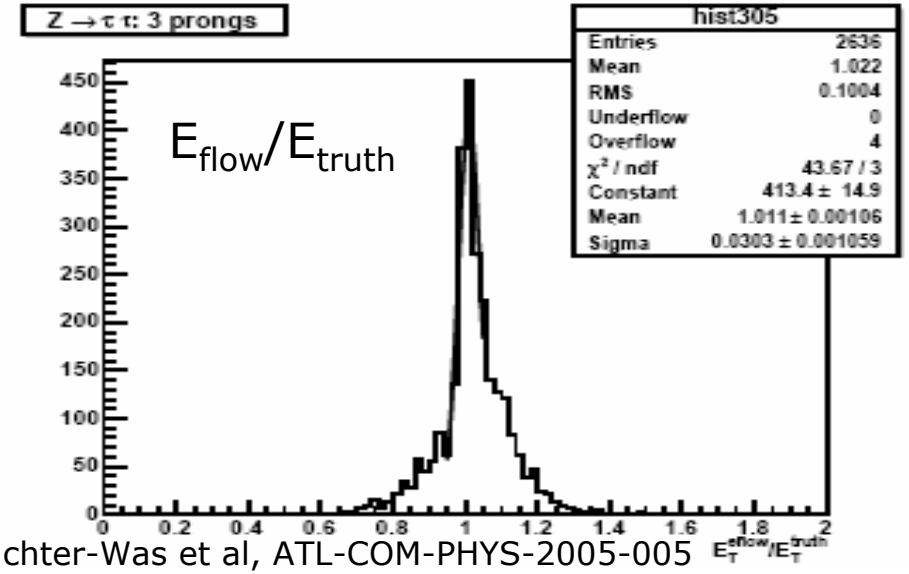
- Leverages advantage of higher resolution in tracker

E^{flow} v $E^{calorimeter}$





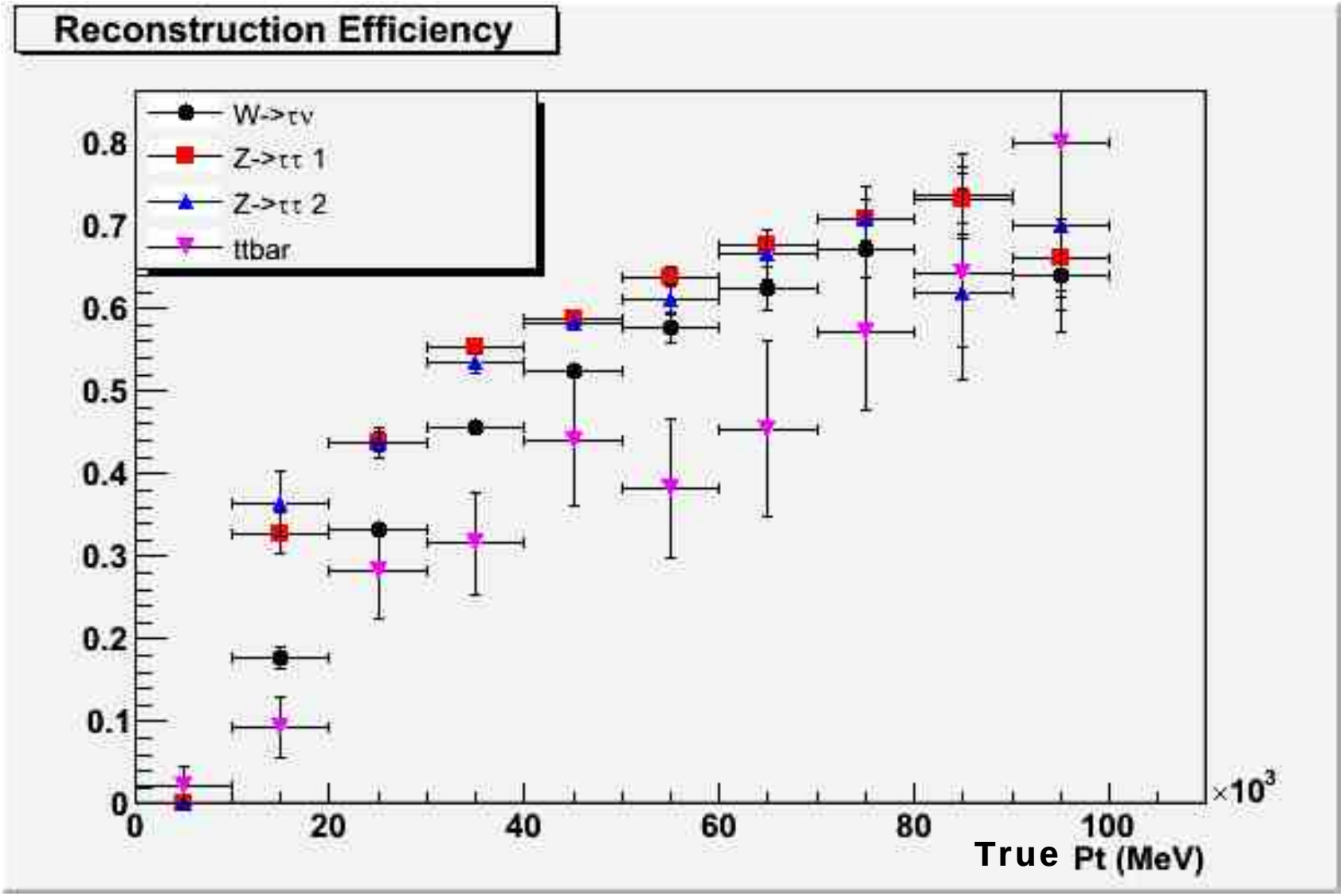




E. Richter-Was et al, ATL-COM-PHYS-2005-005

$$\frac{\text{Reconstructed + Truth}}{\text{True Taus}}$$

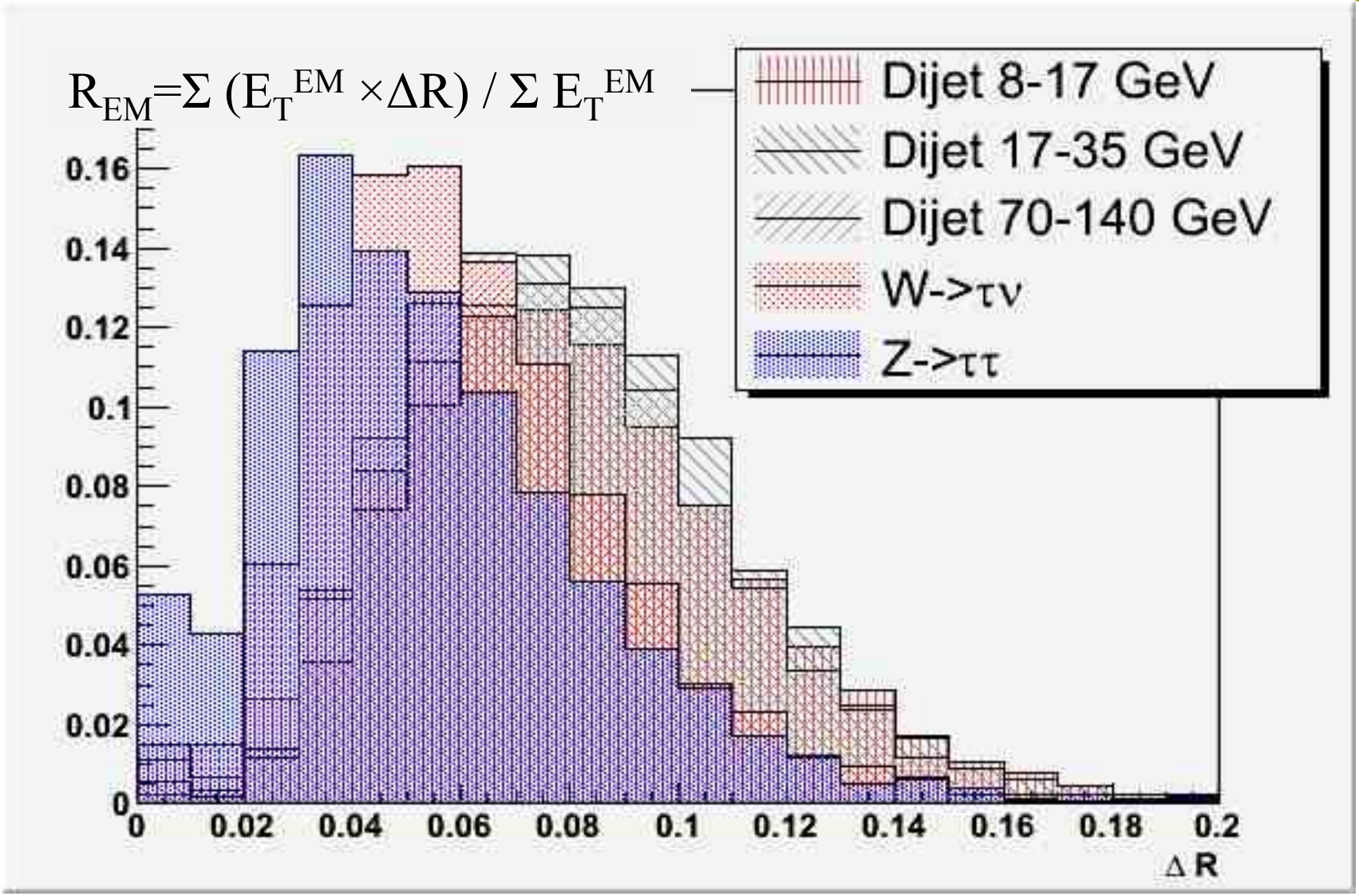
Reconstruction Efficiency



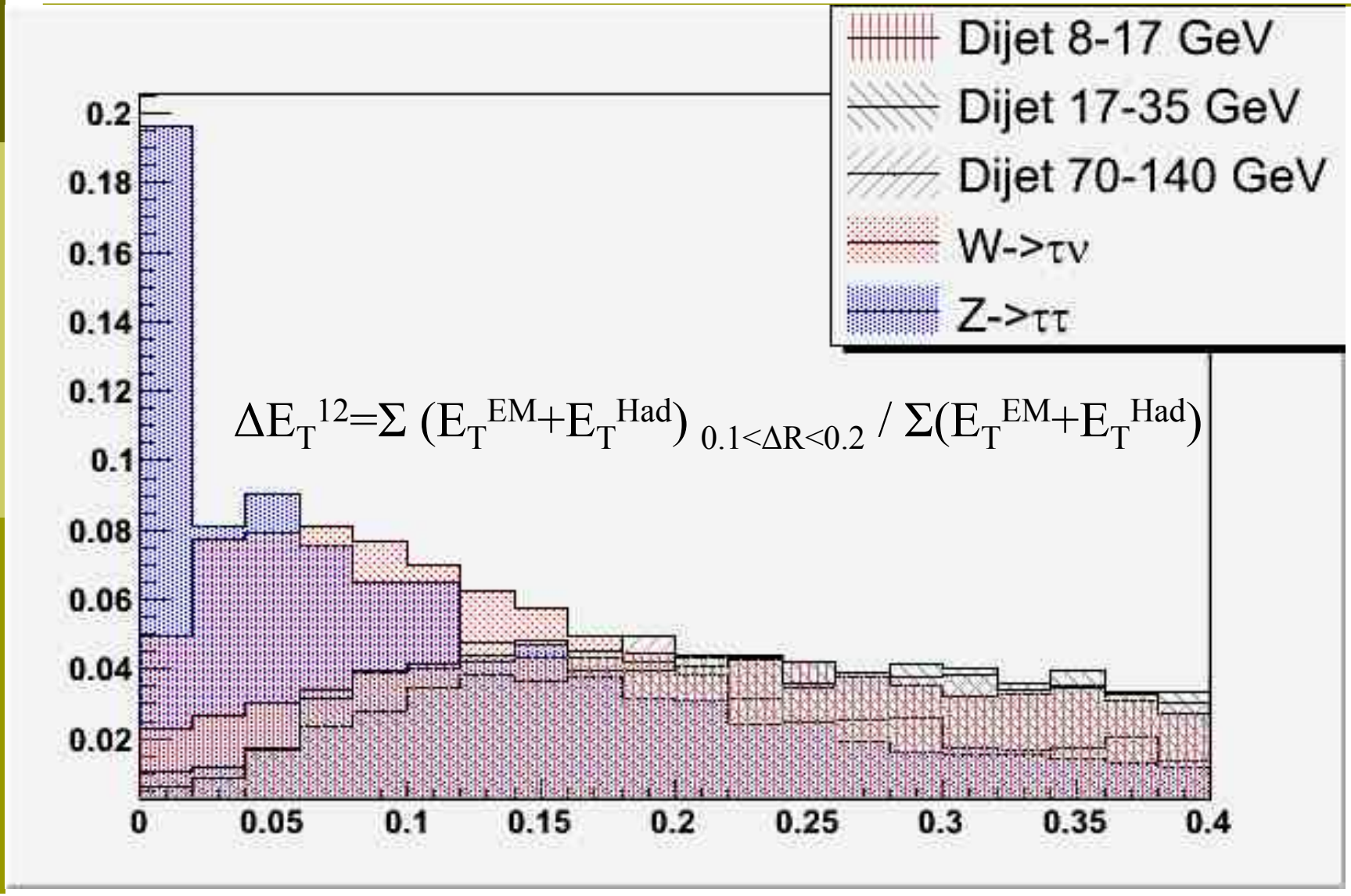
Tau Identification

- Discriminating Variables
  - R^{em} – electromagnetic radius
  - N^{strips} – number of strips above a threshold
  - W^{strips} – weighted variance in eta of energy in strips
  - ΔE^{12} – Difference in energy deposited with $\Delta R < .1$ versus $\Delta R < .2$
  - E^{halo} – Energy deposited within $.2 < \Delta R < .4$
  - Charge – enforce consistency of ±e
- Combine with favorite multivariate analysis
  - ANN
  - PDERS
  - Cut-based

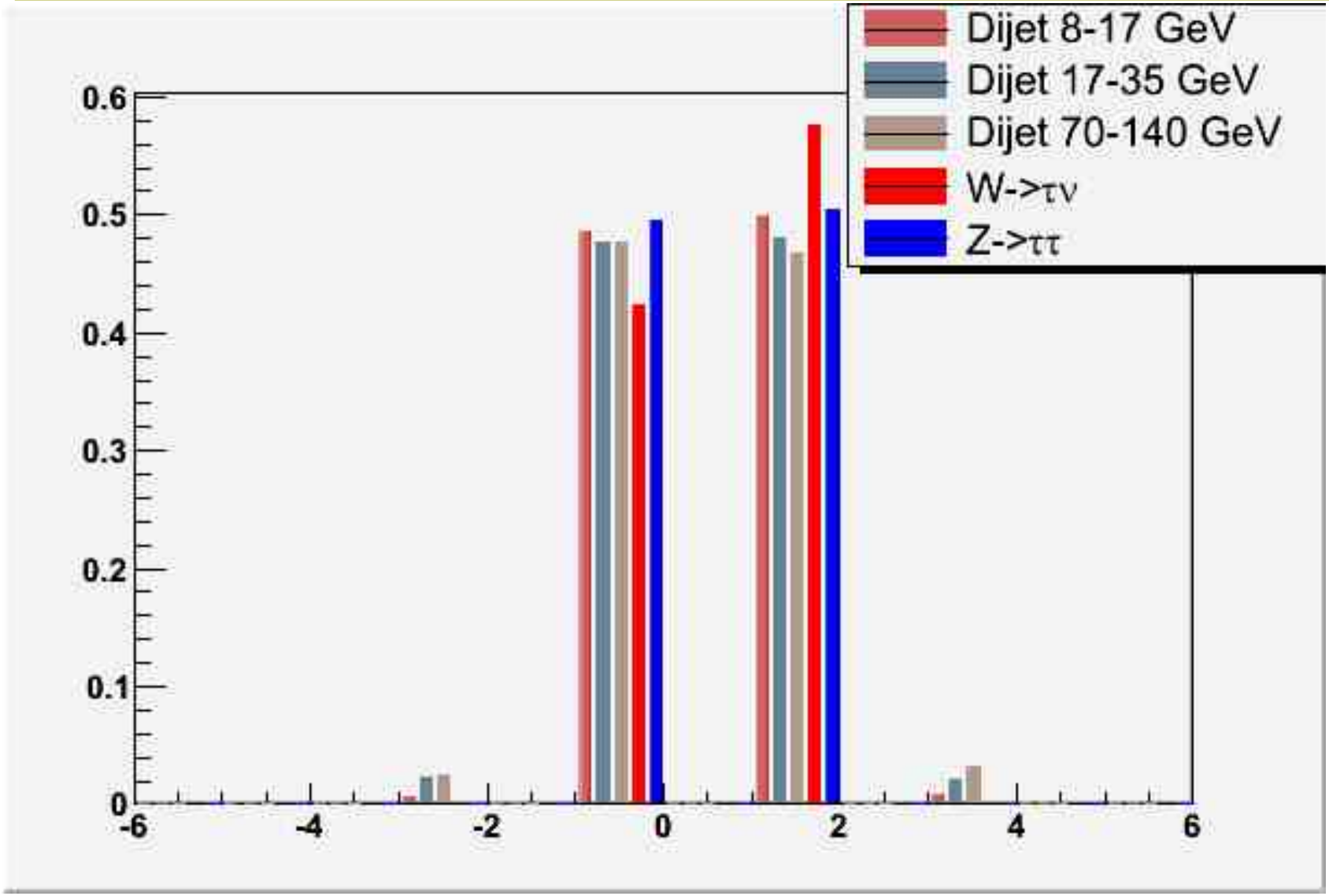
R_{em} – ElectroMagnetic Radius



Isolation Fraction (ΔE^{12})

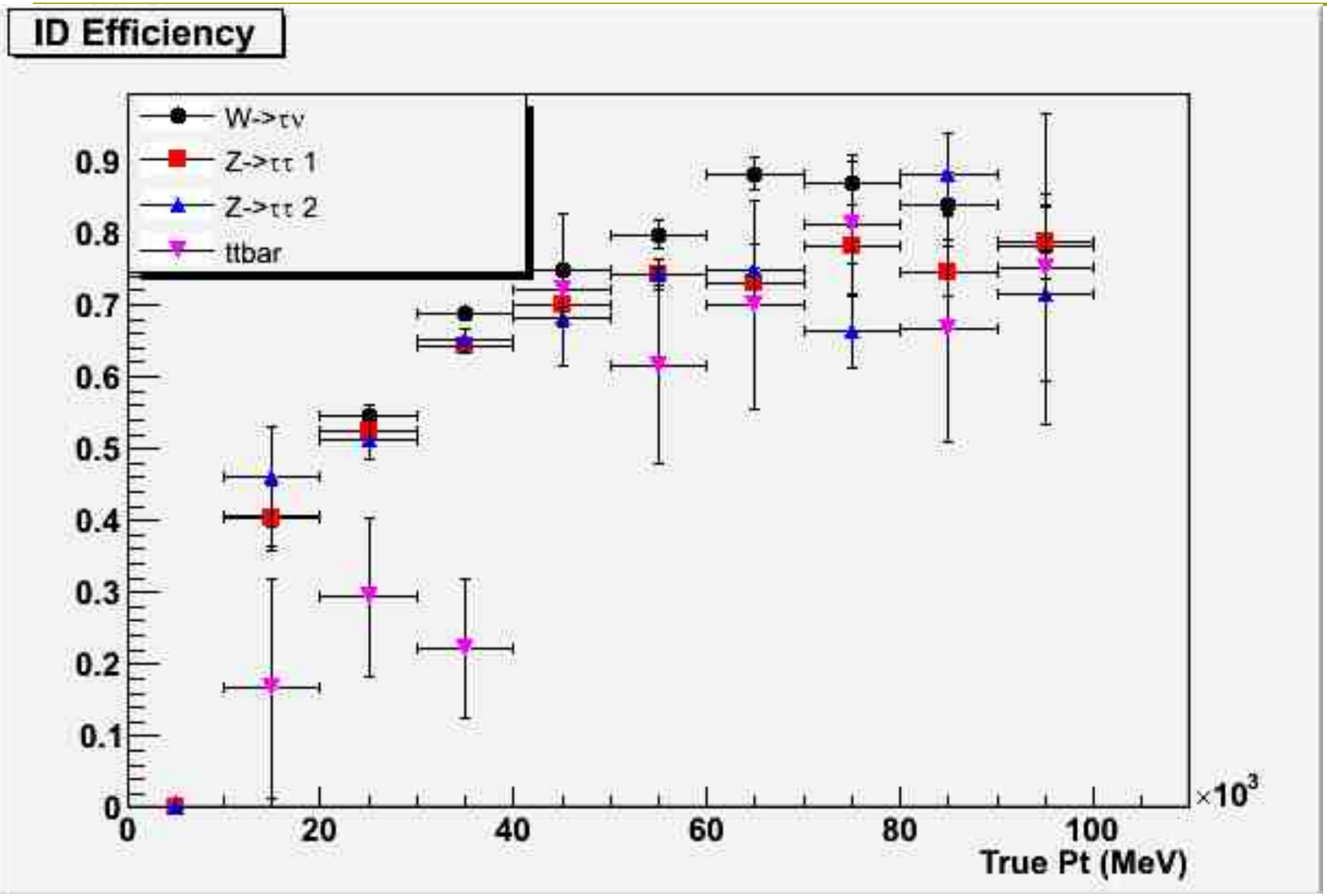


Charge


Dijet 8-17 GeV
Dijet 17-35 GeV
Dijet 70-140 GeV
W->τν
Z->ττ
0.6
0.5
0.4
0.3
0.2
0.1
0
-6
-4
-2
0
2
4
6

$$\frac{\text{Reconstructed + Identified + Truth}}{\text{Reconstructed + Truth}}$$

Identification Efficiency



Project Status

- Truth Matching for tau1p3p implemented
  - Crude; problems bypassed with 'common sense clubbing'
- Efficiency plots made
  - Need to understand (probably unphysical) discrepancies between channels
  - Rejection/Fake rates to be plotted
- Machinery to read CBNT's created
  - Probably reinvented the wheel
  - CBNT documentation sparse
  - CBNT's should be abandoned if possible (start over)

Summary

- Taus are painful, but worth it
  - Hard to reconstruct, identify
    - Isolation best criteria
    - Background noise will make isolation difficult
  - Discovery potential for supersymmetric Higgs sector
- Tau1p3p is a new algorithm
  - Track based
  - Improved energy-scale resolution, accuracy
- Much left to do
  - Need to find & understand differences between physics channels