Tau Pioneer Report

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- Physics associated with τ's
- Run I Experience
- Run II Tau Triggers
- Run II Tau Specification
- Run II Tau Reconstruction code

Tau ≡ "τ decaying into hadrons"

Physics with Tau's

Electroweek

$p\bar{p} \rightarrow Z^0 \rightarrow \tau^+\tau^-$

$p\bar{p} \rightarrow WZ^0 \rightarrow (\tau\nu)(\tau^+\tau^-)$

$(jj)(\tau^+\tau^-)$

Higgs

$p\bar{p} \rightarrow WH^0 \rightarrow (\tau\nu)(\tau^+\tau^-)$

$(jj)(\tau^+\tau^-)$

$p\bar{p} \rightarrow H^0A^0/h^0 \rightarrow \tau^+\tau^-$

$p\bar{p} \rightarrow t\bar{t} \rightarrow (H^+b)(H^-b) \rightarrow (\tau^+\nu b)(\tau^-\nu b)$

SUSY (MSSM/SUGRA)

$p\bar{p} \rightarrow \tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \rightarrow (l\nu\tilde{\chi}_1^0)(\tau^+\tau^-\tilde{\chi}_1^0)$

$(\tau\nu\tilde{\chi}_1^0)(\tau^+\tau^-\tilde{\chi}_1^0)$

Top

$p\bar{p} \rightarrow t\bar{t} \rightarrow (W^+b)(W^-b) \rightarrow (\tau^+\nu b)(\tau^-\nu b)$

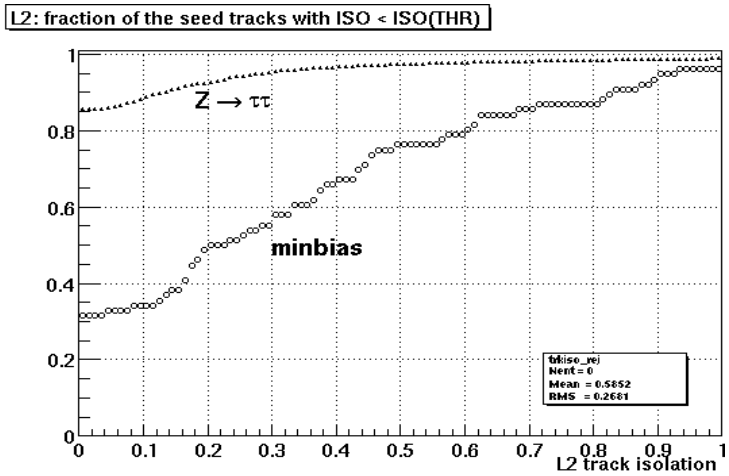
Run I Experience

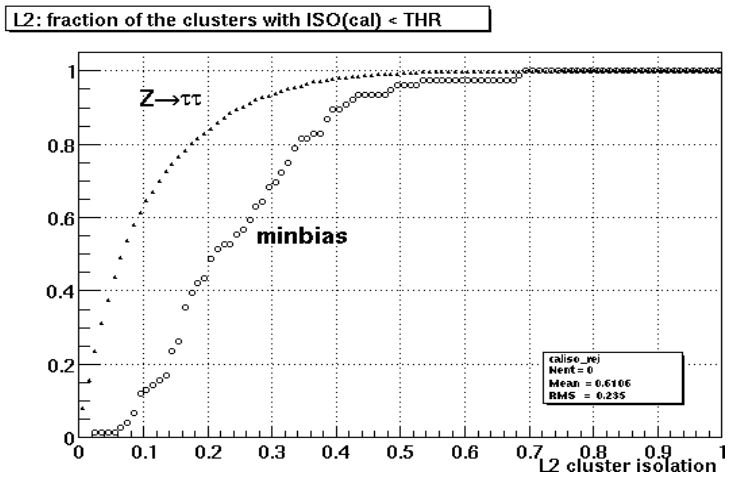
- FINDTAU module: creation of TAUO bank
  - Primary seed: a JETCLU cluster above E_T threshold found in cone 0.4 η-φ
  - Reclustering: build continuous cluster of towers above shoulder threshold
  - Compact cluster: ($N_{towers} \leq 6$)
  - Associated track: track with P_T above threshold pointing on cluster
  - Cluster parameters are recalculated according to track associated Z coordinate
  - Cone 10° is searched for associated tracks
  - Isolation annulus 10°-30° is searched for veto tracks
- TAUFND: CES is included to recover γ's (π^0's)
- CDF Notes 2616, 2661, 2490, 2854, 3061, 3545, 3585,3840, 3932, 5251,

RUN II Tau Triggers

- *e* + 2D isolated track
  - Note 4807 by M.Chertok, J.Done, T.Kamon, Y.Kato, R.Oishi, A.Savoy-Navarro, Y.Seiya
  - Note 4718, section 3.25
- μ + 2D isolated track
  - Note 5157 by M.Chertok, J.Done, T.Kamon, Y.Kato, R.Oishi, A.Savoy-Navarro, Y.Seiya
  - Note 4718, section 3.25
- $\tau_h\tau_h$, τ_h+MET
  - Under study by P.Murat and F.Ratnikov

Level 2 cross section





- conclusion: if we require efficiency to be high, the tracking isolation gives 30-40% better rejection power at the same efficiency
- require N (XFT tracks) = 0 in 10°-30° 2D annulus around the seed track
- Thresholds
  - Clustering: 8GeV/1GeV
  - Cluster Et > 10 GeV
  - Seed track Pt > 5 GeV
- 3 events out of 1.5*10**6 survive
- σ(L2) = 3*18nb = 55 nb
- total L2 budget is about1800nb
- $Z \rightarrow \tau\tau$:
  - 27% of all the events have 2 central towers with Et > 5 GeV, i.e. acceptance is a major factor
  - L2 efficiency is of the order of 40%, which is 63% per τ
  - E(L1 • L2) • acceptance = 11%

Run II Tau specification

http://www-cdf.fnal.gov/internal/upgrades/daq_trig/twg/hlo/hlo_home.html

Tau working group (J. Conway et al.): toward a creation of offline code to reconstruct taus decaying to hadronic final state (started in the May, 2K)

Version 1.0
May 24, 1999

EET Spec for Variables Needed for Tight High-P_t Central Taus
Electroweak, Exotics, and Top Trigger/DAQ Subgroups

As in the muon and electron cases, the Physics Groups need to define the quantities we would like to have readily available to cut on in order to define a tight central tau. It is hoped that the Electroweak Exotics, and Top (EET) groups can agree on a common definition for high-Et central taus as a first step. The integration of this with the QCD and B groups (a harder problem) can start at the same time. The first step is to agree on what variables will be easily available. The presumption is that we start by cutting on the things we understand well from Run I, but have available the hooks to add information from the new tracking systems as we learn.

This is intended as a draft spec for the Physics Groups to discuss and flesh out.

1 Run I Tau Variables Used

To establish a baseline, we here present which variables were used in several representative tau analyses from Run I. We note that this is *not* the list for Run II, but is to remind the gentle reader what we have done in the past. The variables we would like are listed in the section after this one..

1.1 Run I Criteria for Making a TAUO Bank

We quote a description of how a TAUO bank is made [1]: 'The tau clustering algorithm [2] begins by checking the E_t of the tower with the highest E_t in a standard CDF jet cluster[1]. If the E_t of this tower is larger than 4 GeV, it is defined as the 'seed tower' for a tau cluster. The calorimeter towers form a grid in η–ϕ space. All of the eight towers surrounding the seed tower that have $E_T > 1$ GeV become part of the tau cluster. The algorithm then selects *narrow* calorimeter clusters by requiring that there be fewer than 6 towers in a cluster. Clusters with more towers are dropped.' By default the algorithm requires a minimum total cluster E_t of 10 GeV.

'Next, the highest-p_t track with $p_T > 4.5$ GeV/c pointing within a cone of radius 0.4 in η–ϕ space from the cluster center becomes the 'seed track'. If there is no such track found the tau cluster is dropped. If there is a primary z-vertex as measured by the vertex chamber (VTX) within 5 cm of the z of the track this becomes the z-vertex of the τ jet, otherwise the z of the seed track is used. The calorimeter quantities (E_T, η) of the cluster are recalculated using this z. Tracks with $p_T > 1$ GeV/c and a z within 10 cm of the z-vertex of the τ jet, that also extrapolate to a tower in the cluster, are defined as 'shoulder tracks'. The track multiplicity of the τ jet is then defined as the number of tracks (seed and shoulder) within a 10° cone of the cluster center. Table 1 summarizes the cuts imposed at the tau cluster level.'

The variables in the TAUO bank are listed in Appendix A.

At least one calorimeter seed tower with $E_T > 4$ GeV
≤ 6 towers with $E_T > 1$ GeV in a cluster
Seed track with $p_T > 4.5$ GeV within $\Delta R < 0.4$ of cluster center

Table 1: Loose requirements for making a TAUO bank (from Hohlmann's thesis).

[1] We use jets that are clustered using a cone of radius 0.4 in η–ϕ space for this.

2.2 Tracking Quantities

For each track in both the outer cone and the inner cone, we want the following[2]:

Transient Representation	Persistent Rep.	Trans. Size	Comment
XFT track-list number			
PT,P beam-constrained (BC)			
PT,P not-BC			
Px,Py,Pz, BC			
Px,Py,Pz, not-BC			
x_0, y_0, z_0 used with BC			(depends on beam position)
x_0, y_0, z_0 of not-BC			
phi,event-eta BC			
phi,event-eta not-BC			
Charge BC			
Charge not-BC			
Extrapolated xlocal, zlocal, xslope, zslope at COT outer SL			
Extrapolated xlocal, zlocal, xslope, zslope at CEM face			
Extrapolated xlocal, zlocal, xslope, zslope at CES			
Extrapolated xlocal, zlocal, xslope, zslope at CHA exit			
Hits in ~5° around the track in COT,ISL, and SVT			
nb of axial superlayers hit by muon			
nb of stereo superlayers			
Covariance matrix for pt, d0, phi beam-constrained (BC)			
Covariance matrix for pt, d0, phi not-BC			
Beam-constraint chisquare, dof			
Pointers to track and clusters with best cluster matches			
Pointers to track and clusters with 2nd best cluster matches			
Pointers to track and clusters with 3rd best cluster matches			
difference between z vertex of event and Z0 of muon track			
sum of Pt of tracks in a cone of 0.4 (excluding the muon)			
r-phi match in CMU			
r-phi match in CMX			
r-phi match in CMP			

2.3 Calorimeter quantities

Transient Representation	Persistent Representation	Trans. Size	Comment
TOWE address of seed tower			
TOWE addresses of shoulder towers			
CALS bank number of jet (cone = 0.4) containing tau			
CALS bank number of jet (cone = 0.7) containing tau			
z position of vertex used in calculating P_T (allows recalculating P_T)			
P_T of the cluster			
E_T in each of the CEM towers in tau cluster			
E_T in each of the CHA towers in tau cluster			
E_T in each of the CEM towers bordering the cluster			
E_T in each of the CHA towers bordering the cluster			
EM Et in cone with R = 0.4 (corrected for leakage, nault. int.)			
HaD Et in cone with R = 0.4 (corrected for leakage, nault. int.)			
EM Et in cone with R = 0.7 (corrected for leakage, nault. int.)			
Had Et in cone with R = 0.7 (corrected for leakage, nault. int.)			
Mult. int. corrections (0.4,0.7)			
Leakage corrections (0.4,0.7)			
HTDC time in each CHA tower			

[2] In the definition we may require no tracks at all in the outer cone– in that case we need the following quantities only for tracks in the inner cone. However we may allow one low-momentum track in the outer cone, as in the photon case, for example, so we do not have a substantial luminosity-dependent inefficiency.

2.4 CES quantities for taus

Transient Representation	Persistent Representation	Trans. Size	Comment
Number of clusters in strip chambers in calorimeter cluster towers			
For up to N (could be all) clusters:			
Energy of strip cluster			
Z position of cluster from strip chambers			
Chi-square of strip profile			
Number of strips above threshold in cluster			
Number of clusters in wire chambers			
For up to M (could be all) clusters:			
Energy of wire cluster			
Phi position of cluster from wire chambers			
Chi-square of wire profile			
Number of wires above threshold in cluster			

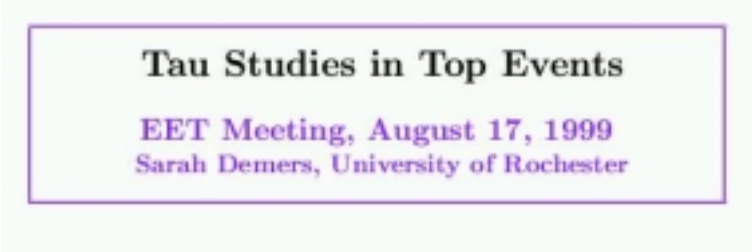
2.5 Other (miscellaneous) quantities for Taus

Transient Representation	Persistent Representation	Trans. Size	Comment
TOF information			
Cosmic filter: hit mask			
Cosmic filter: angle to bth track			
Cosmic filter: d_0 used			
Cosmic filter: 'backwards' track η, ϕ, P_T			
Conversion filter: Hit mask			
Conversion filter: Separation			
Conversion filter: Delta cotan-theta			
Conversion filter: Pair Mass			
Conversion filter: conversion r			
Conversion filter: conversion phi			
Conversion filter: conversion z			
Conversion filter: charges of 2 tracks			

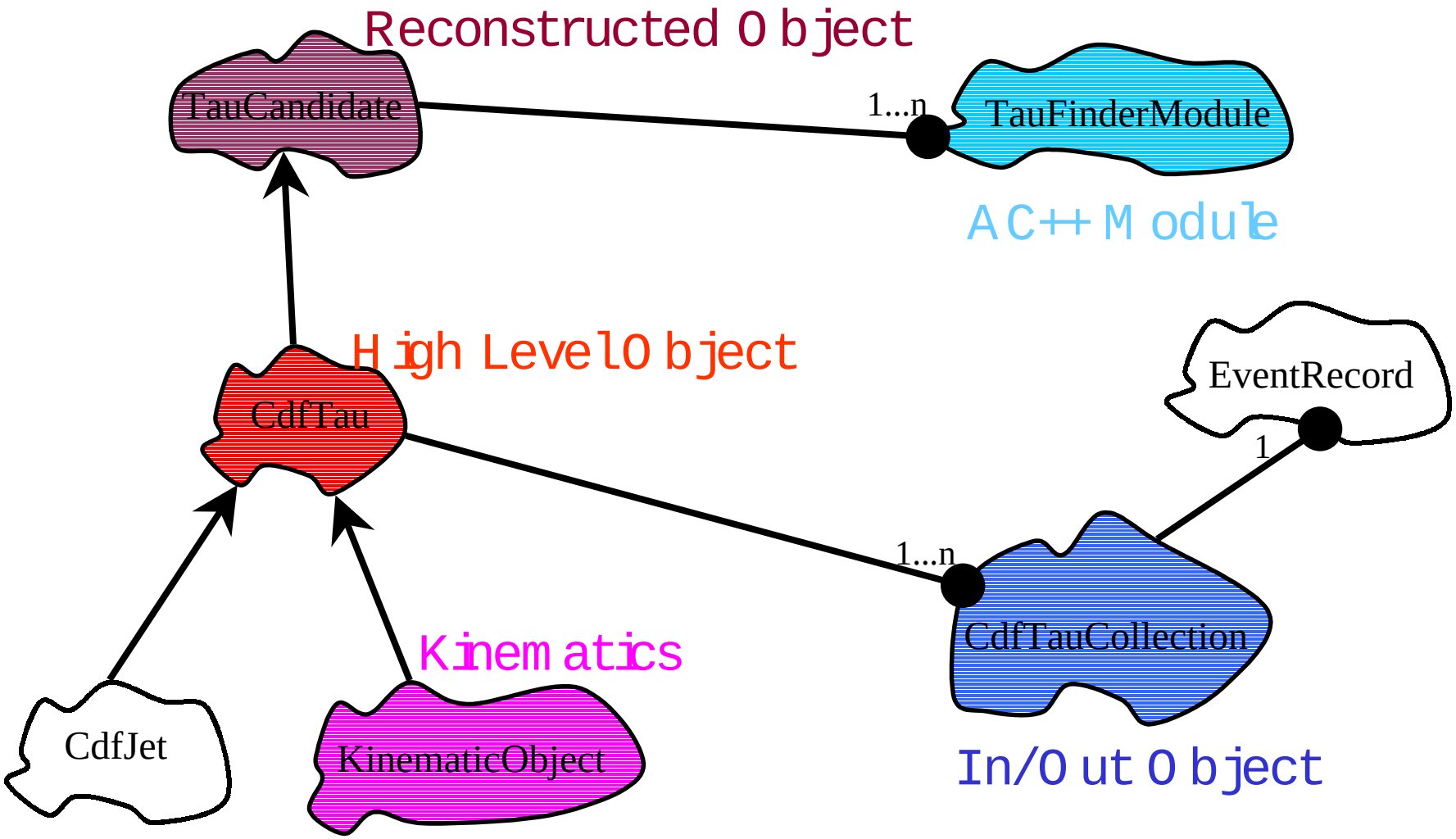
Your comments are appreciated

Run II Tau Reconstruction

- Use Run I experience
  - Start with implementation Run I algorithms in new environment
- Design software to fit Run II Framework and Run II EDM in the best way
- Include new algorithms
  - For example, include track impact parameter into consideration:



Design of τ - related AC++ objects



Netscape: CdfTau

In file TauModule/CdfTau.hh

class CdfTau : public CdfJet, public KinematicObject

CdfTau is a high level object created using calorimeter cluster and associated tracks

Inheritance:

Public Methods

	CdfTau ()
virtual	**~CdfTau** ()
virtual const CdfJet*	**seedJet** () const *Pointer to the CdfJet originally associated with this object (0 if not available)*
virtual const CdfTrack*	**seedTrack** () const *Pointer to the tau primary track seed (0 if not available)*
virtual const CdfTrackView*	**associatedTauTracks** () const *Track collection associated with this objects (0 if not available)*
double	**calorimetryIsolation** () const *isolation parameter as calculated using calorimeter information*
double	**trackIsolation** () const *isolation parameter as calculated using track information*
virtual void	**refreshParameters** () *recalculate tau parameters using current track and calorimeter assignments*
virtual double	**etToPt** () const *Cluster Et to track(s) Pt ratio*
virtual int	**numberOfTowers** () *Number of towers contributing to the cluster. Physical towers are counted now*
virtual int	**trackMultiplicity** () const *Number of tracks contributing to the tau. Currently are tracks within 10deg with appropriate vertex*
virtual int	**numberOfTracksIfTo40** () const *Number of tracks in the cone 10–40*
int	**pilMultiplicity** () const *Number of associated PIOs, reconstructed in X*ES. Not implemented yet*

Netscape: CdfTau

	*Number of associated PIOs, reconstructed in X*ES. Not implemented yet*
int	**trackCharge** ()
double	**trackMass** () *invariant mass of contributing tracks*
double	**referenceVertexZ** () const *reference Z for the object – vertex or Z of the seed track*
void	**Read** (TBuffer* tBuffer) *Root related input*
void	**Write** (TBuffer* tBuffer) *Root related output*
void	**Write** (std::ostream tStream) *Informative printout*

Inherited from KinematicObject:

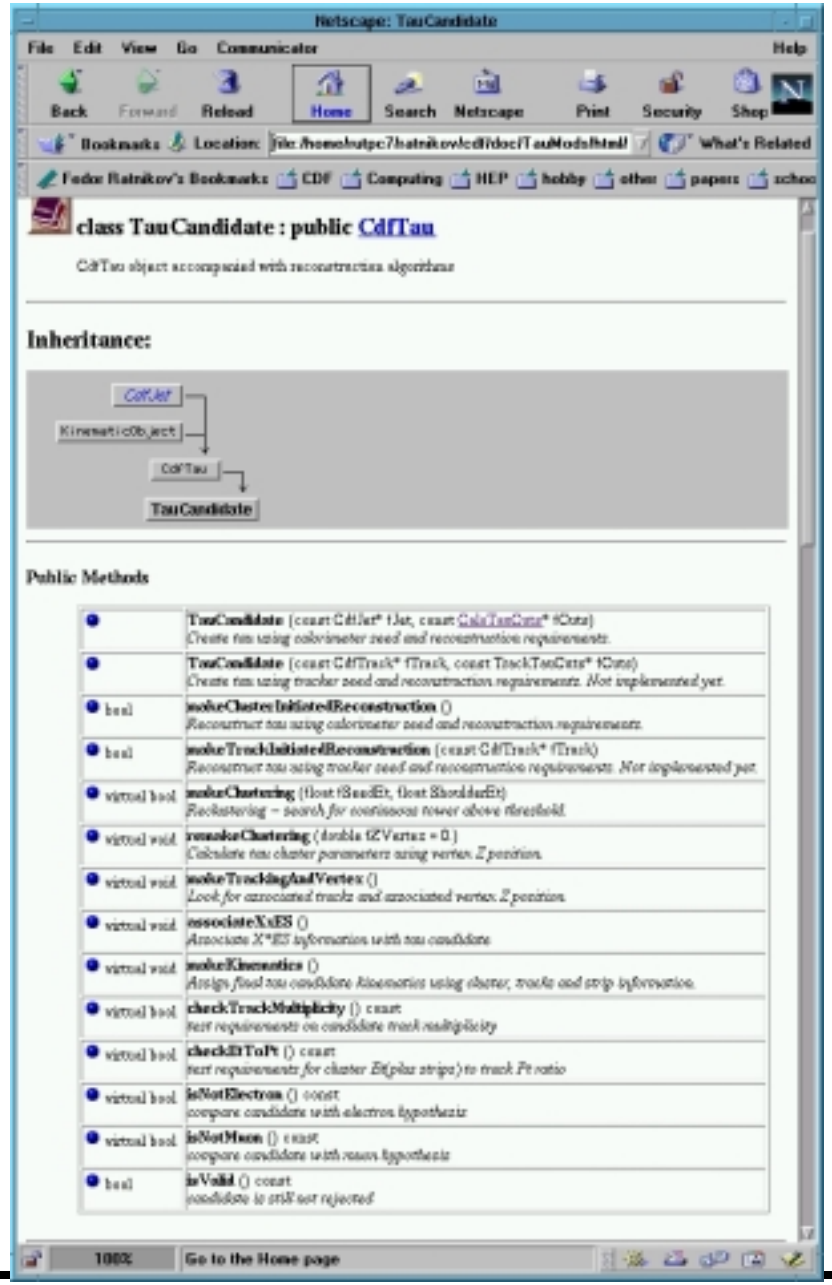
Public Methods

- double **pt**() const
- double **eta**() const
- double **phi**() const
- double **invariantMass**() const
- double **theta**() const
- double **p**() const
- double **px**() const
- double **py**() const
- double **pz**() const
- double **energy**() const
- void **fillVector**(TLorentzVector* tVector)
- void **fillVector**(HepLorentzVector* tVector)

Documentation

CdfTau is a high level object created using calorimeter cluster and associated tracks. CdfTau is essentially a result of reconstruction. Reconstruction itself affect on TauCandidate that is inherited from CdfTau

- `CdfTau()`
- `virtual ~CdfTau()`
- `virtual const CdfJet* seedJet() const`
  Pointer to the CdfJet originally associated with this object (0 if not available)
- `virtual const CdfTrack* seedTrack() const`
  Pointer to the tau primary track seed (0 if not available)


Netscape: TauCandidate
File Edit View Go Communicator Help
Back Forward Reload Home Search Netscape Print Security Shop
Bookmarks Location: file:/home/utpc7/ratnikov/cdf/doc/TauModule.html What's Related
Fedor Ratnikov's Bookmarks CDF Computing HEP hobby other papers xchoo
class TauCandidate : public CdfTau
CdfTau object accompanied with reconstruction algorithms
Inheritance:
CdfJet
KinematicObject
CdfTau
TauCandidate
Public Methods
TauCandidate (const CdfJet* fJet, const CalcTauCuts* fCuts)
Create tau using calorimeter seed and reconstruction requirements.
TauCandidate (const CdfTrack* fTrack, const TrackTauCuts* fCuts)
Create tau using tracker seed and reconstruction requirements. Not implemented yet.
bool makeClusterInitiatedReconstruction ()
Reconstruct tau using calorimeter seed and reconstruction requirements.
bool makeTrackInitiatedReconstruction (const CdfTrack* fTrack)
Reconstruct tau using tracker seed and reconstruction requirements. Not implemented yet.
virtual bool makeClustering (float fSeedEt, float fShoulderEt)
Reclustering – search for continuous tower above threshold.
virtual void remakeClustering (double fZVertex = 0.)
Calculate tau cluster parameters using vertex Z position.
virtual void makeTrackingAndVertex ()
Look for associated tracks and associated vertex Z position.
virtual void associateXsES ()
Associate X*ES information with tau candidate
virtual void makeKinematics ()
Assign final tau candidate kinematics using cluster, tracks and strip information.
virtual bool checkTrackMultiplicity () const
test requirements on candidate track multiplicity
virtual bool checkEtToPt () const
test requirements for cluster Et(plus strips) to track Pt ratio
virtual bool isNotElectron () const
compare candidate with electron hypothesis
virtual bool isNotMuon () const
compare candidate with muon hypothesis
bool isValid () const
candidate is still not rejected
100%
Go to the Home page

Summary

- Hadronic Tau's are good trigger and reconstruction objects
- Tau working group is moving ahead
  - Trigger studies
  - Software design
  - Algorithms