WW Benchmark – TauFinder

March 11, 2019

Introduction

– used Marlin Reco TauFinder processor on τ/μ signal sample
  – `https://github.com/iLCSoft/MarlinReco/tree/master/Analysis/TauFinder`

– documentation:
  – `https://github.com/iLCSoft/MarlinReco/blob/master/doc/TauFinder/TauFinderLCDNote.pdf`

Processor designed specifically for WW in 3 TeV environment at CLIC

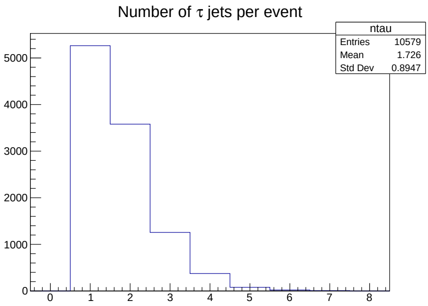
- documentation uses low statistics samples
- could be useful for 500 GeV ILD

Introduction

Basic operating cuts used:

```
                                   std::string("Signal.root") ) ;

  registerProcessorParameter( "pt_cut" ,
                                   "Cut on pt to suppress background"  ,
                                   _ptcut ,
                                   (float)0.2) ;
   registerProcessorParameter( "cosT_cut" ,
                                   "Cut on cosT to suppress background"  ,
                                   _cosTcut ,
                                   (float)0.99) ;

   registerProcessorParameter( "searchConeAngle" ,
                                   "Opening angle of the search cone for tau jet in rad"  ,
                                   _coneAngle ,
                                   (float)0.05) ;

   registerProcessorParameter( "isolationConeAngle" ,
                                   "Outer isolation cone around search cone of tau jet in rad (relativ to cone angle)"  ,
                                   _isoAngle ,
                                   (float)0.02) ;

   registerProcessorParameter( "isolationEnergy" ,
                                   "Energy allowed within isolation cone region"  ,
                                   _isoE ,
                                   (float)5.0) ;

   registerProcessorParameter( "ptseed" ,
                                   "Minimum tranverse momentum of tau seed"  ,
                                   _ptseed ,
                                   (float)5.0) ;

   registerProcessorParameter( "invariant_mass" ,
                                   "Upper limit on invariant mass of tau candidate"  ,
                                   _minv ,
                                   (float)2.0) ;
}
```

First run



- a τ jet is found for nearly event (w/o acceptance cuts)
- τ jet candidates are found for both τ and μ channels

τ Finding Performance

TauFinder Processor basic performance

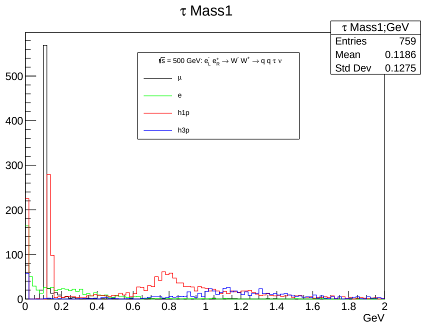
—	Inclusive	μ	e	h1p	h3p	Other
True τ's	5073	892	962	2445	767	7
$cos\theta < 0.995$	4690	842	895	2235	711	7
$\psi < 100$ mrad	4001	759	779	1845	616	2
ϵ	0.853 ± 0.005	0.901 ± 0.010	0.870 ± 0.011	0.826 ± 0.008	0.867 ± 0.012	0.29 ± 0.17

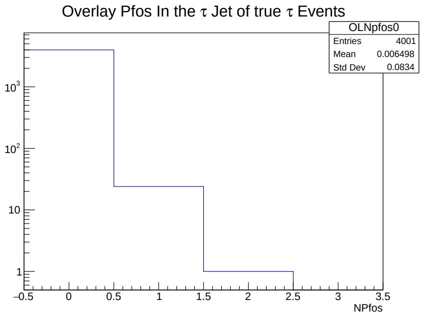
$cos\theta < 0.995$ - visible MC fermions fall within detectable range
$\psi < 100$ mrad - event has at least 1 measured τ within 100 mrad of true τ

$$\epsilon = \frac{(\#\ of\ measured\ \tau\ that\ pass\ acceptance + MCTag)}{(\#\ of\ true\ \tau\ that\ pass\ acceptance)}$$

τ quality

Can assess the quality of the MC tagged τ jets by looking at how much overlay is picked up and basic mass distributions per channel



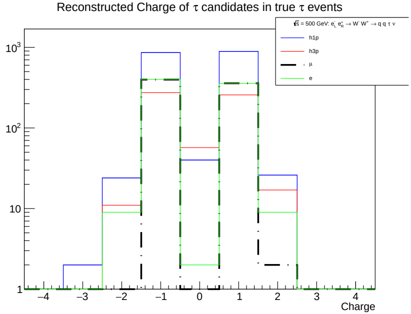


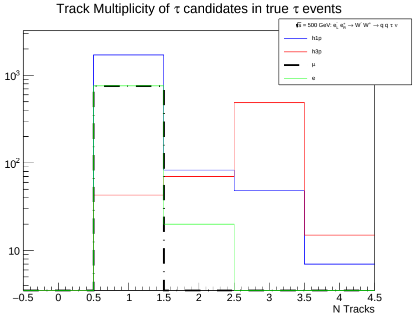
– each decay channel clearly represented in terms of masses

– almost no overlay is present in tau cones

τ charge quality

—	Inclusive	μ	e	h1p	h3p
Selected τ charge ϵ	0.9517 $\pm$ 0.003	0.9960 $\pm$ 0.0023	0.972 $\pm$ 0.006	0.947 $\pm$ 0.005	0.851 $\pm$ 0.014

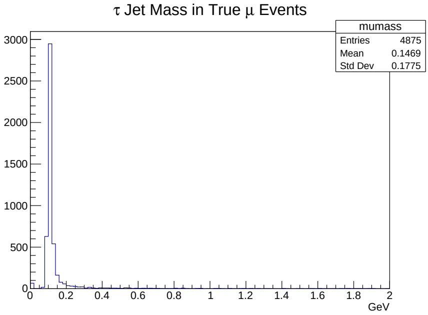


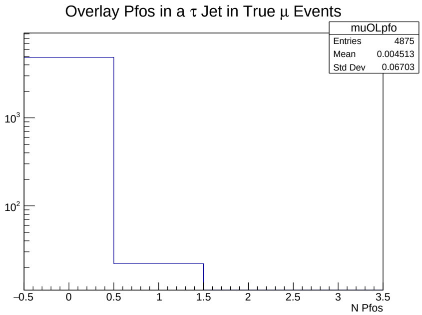


τ jets from true μs

Muon finding performance

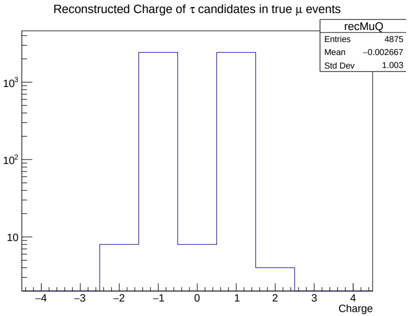
–	μ
True μs	5506
$\|cos\theta\| < 0.995$	5051
$\psi < 0.1$	4875
ϵ	0.965 ± 0.003

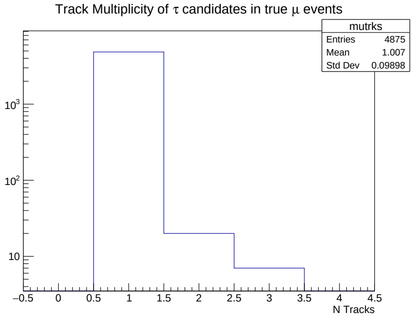




τ charge quality from true μ

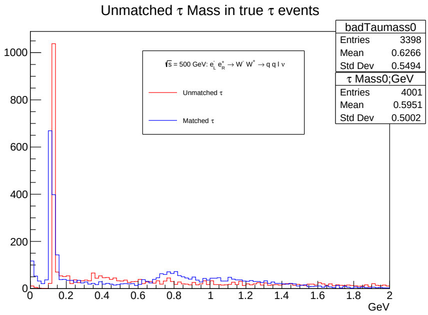
Selected μ charge ϵ	0.9959 ± 0.0010

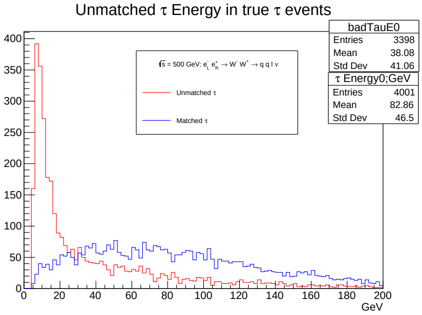




unmatched τ – true τ case

Main issue becomes how to choose the correct τ for events with $> 1\,\tau$ jets
– Here are Mass and energy distributions of τ jets not matched to true lepton

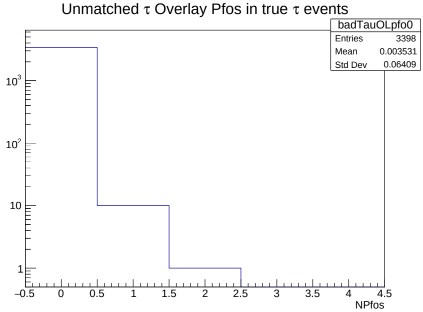




Junk τ tend to have similar mass with the matched candidate

Distinct low energy signature for unmatched τ

unmatched w/ overlay – true τ case

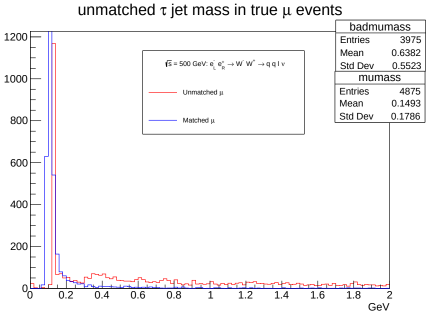


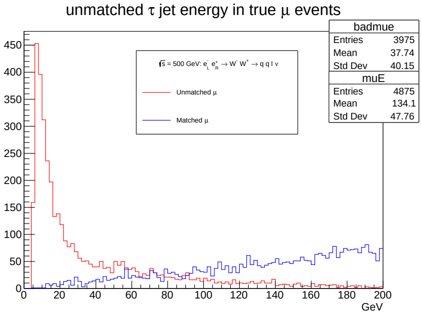
– No overlay shows these additional taus must be hadronic fragments

– Need to look at separation of tau and external jet activity, could be the best way to distinguish correct candidate

– τ matching can be slightly improved by using visible gen τ decay products rather than the gen τ

unmatched τ – true μ case

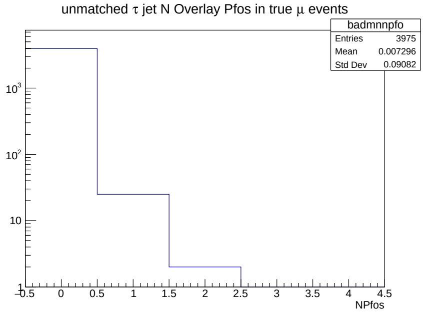




Clear mass seperation above 1 GeV

More clear energy separation than true τ case

unmatched w/ overlay – true μ case



μ case also rejects most overlay, where extra τs are coming from the hadronic jets

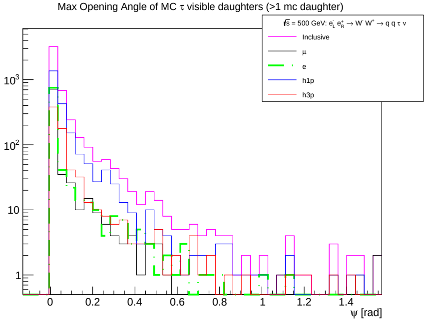
summary

- TauFinder looks promising
- need to try TauFinder on electron sample ✓
  – electron sample also has promising results, similar to τ electron decay mode
- need good selection variables for multi-tau candidate events ✗
  – Avoid this problem by requiring exactly 1 reconstructed tau jet in tau finder parameter optimization
- need to explore/optimize tau finding variables e.g. cone-size etc.
  – Optimization in progress (finished within a day)

TauFinder Optimization

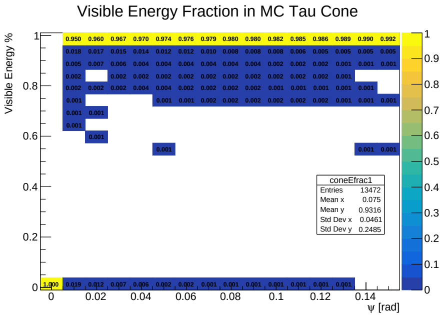
- Currently optimizing 3 main TauFinder parameters simultaneously
- searchCone size [0, 150]mrad, isolationCone size [0, 100] mrad, isolationEnergy [0, 10] GeV
- stepsizes for each are 10 mrad, 10 mrad, 1 GeV
- also did a search cone size analysis of MC Tau decays, useful if optimal parameter set contains a range of search cone sizes

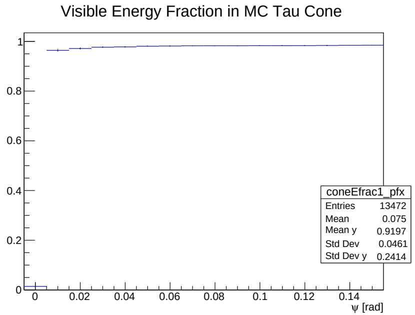
MC Tau Search Cone



- Default parameter of 50 mrad looks too small
- Could get better tau measurement with a much wider cone
- Can background rejection/ efficiency be high with a wide cone?
- How much energy is lost by only collecting particles within 50mrad?

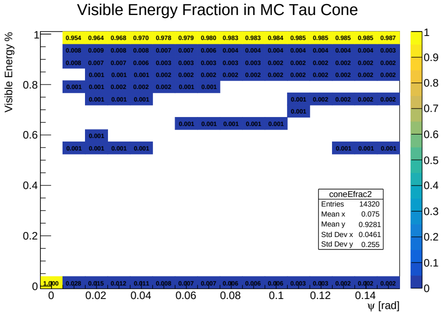
bins of 5% and 10 mrad, $\tau \to \mu\nu\nu$

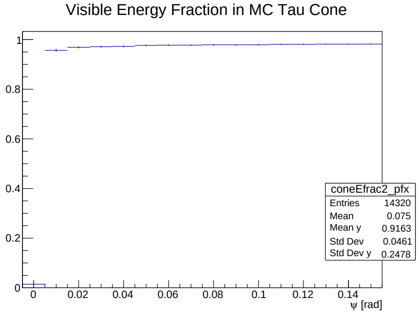




MC Tau Search Cone

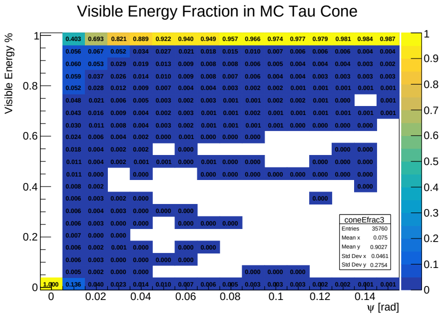
bins of 5% and 10 mrad, $\tau \to e\nu\nu$

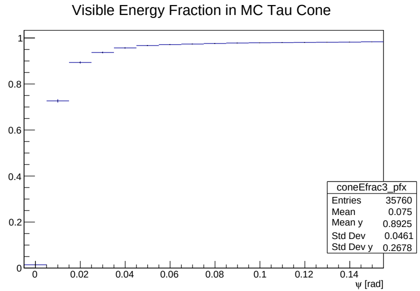




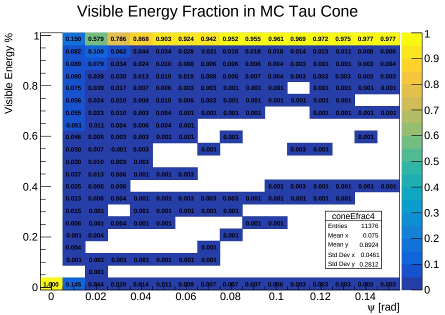
MC Tau Search Cone

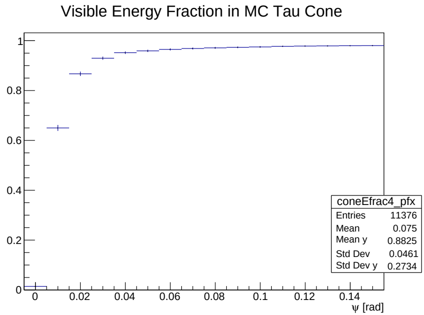
bins of 5% and 10 mrad, $\tau \rightarrow$ h1p





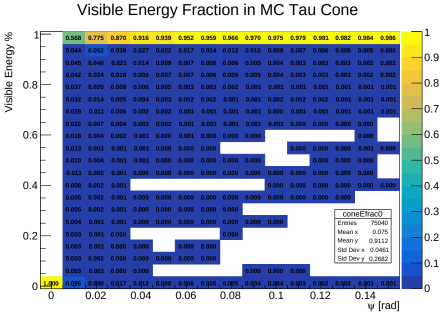
bins of 5% and 10 mrad, $\tau \to$ h3p

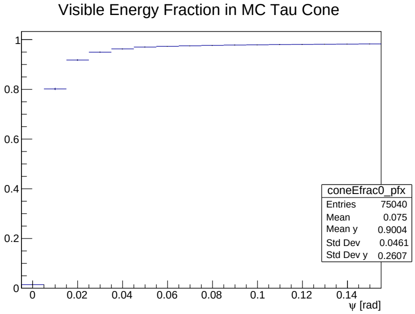




MC Tau Search Cone

bins of 5% and 10 mrad, $\tau \rightarrow$ Inclusive





TauFinder Optimization

- optimize searchCone, isolationCone, isolationEnergy
- use signal files for all 3 lepton channels $\mu\,\tau\,e$
- optimize against background $WW \to qqqq$
- define optimization variables
  – ϵ_s = N Signal Events w/ exactly 1 Tau Jet/ N Signal Events
  – ϵ_b = N BG Events with $\geq$ 1 Tau Jet / N Background Events
- purity $p = N_s/(N_s + N_b)$
- optimization points + plot $(1 - \epsilon_b)$ vs ϵ_s and $\epsilon_s * p$ – On the way, (need to fix 1 bug)

Post Optimization Goals

- Once optimization is finished assess hadronic side of event (all particles not part of the Tau Jet)
- Produce IDR plot (Gen W mass - measured hadronic W mass)
- do for all three signal lepton modes, and separate by quark flavor