

tau reconstruction study

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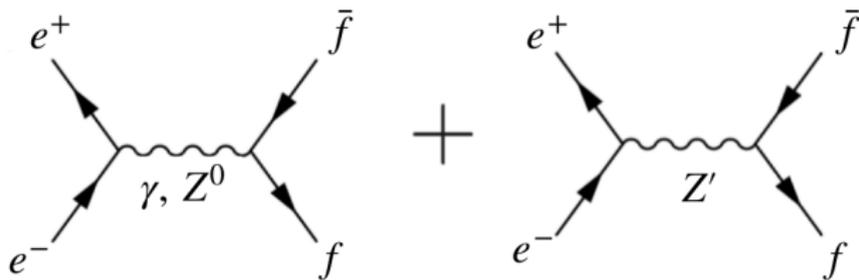
September 10, 2020

Introduction

Tau lepton is heaviest lepton and is the only lepton that can decay to hadrons.

Helicity of intermediate particle can be measured

by using $e^+e^- \rightarrow \tau^+\tau^-$ process.



it is possible to search for new physics such as heavy gauge boson Z' .

Since the last meeting

◇ Validation of new test sample generated using WHIZARD 2.8.2

2f-z-leptonic sample 250 GeV

old sample:

rv02-01.sv02-01.mILD_I5_o1_v02_nobg.E250-SetA.I499997.P2f_z_l.eL.pR.n000.d_dstm_14705_0.slcio

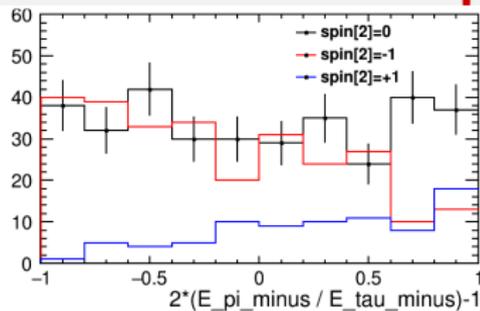
new sample:

rv02-01-02.sv02-01-02.mILD_I5_o1_v02_nobg.E250-SetA.I499989.P2f_z_l.eL.pR.n000.d_dstm_14765_0.slcio

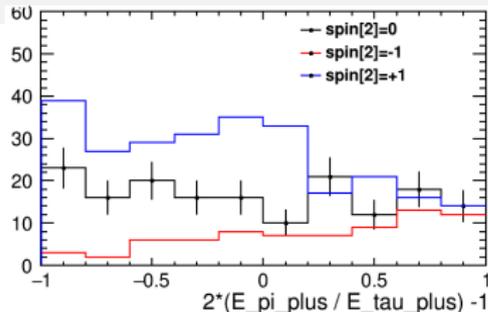
Check some problems:

- tau spin problem
- negative mass problem

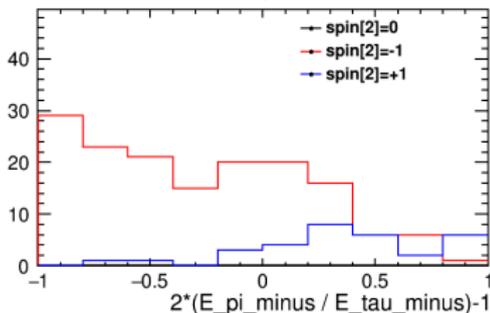
tau spin problem



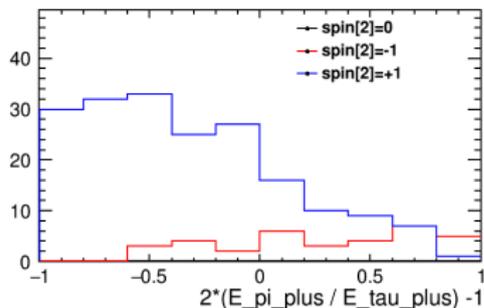
old sample τ^-



old sample τ^+



new sample τ^-

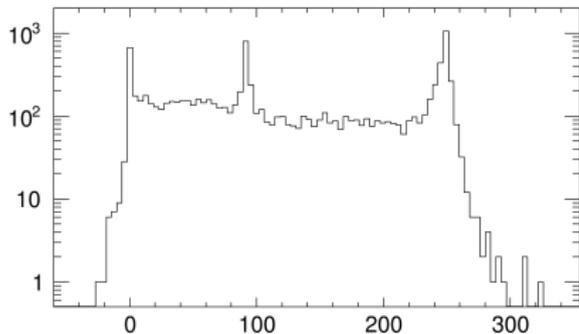


new sample τ^+

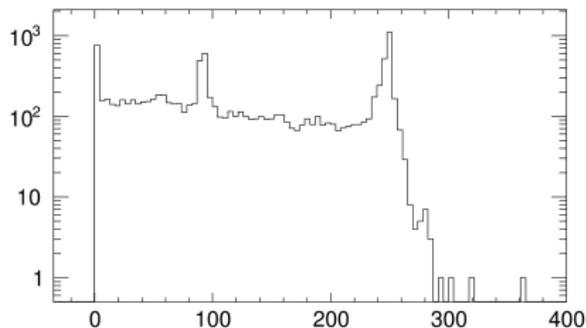
tau spin problem is now fixed.

negative mass problem

Using the old sample, sometimes PFOs have a “negative” invariant mass. problem in the new photon energy correction processor.



old sample: invariant mass of PFOs



new sample: invariant mass of PFOs

The new test sample does not have negative mass issue.

Check the new sample:

rv02-01-02.sv02-01-02.mILD_I5_o1_v02_nobg.E250-SetA.I499989.P2f_z_l.eL.pR.n000.d_dstm_14765_0.slcio

Problems of tau spin information and photon energy correction were fixed in the new test sample.

So far, there is no other problem found.

Next: tau reconstruction study
tau decay mode selection

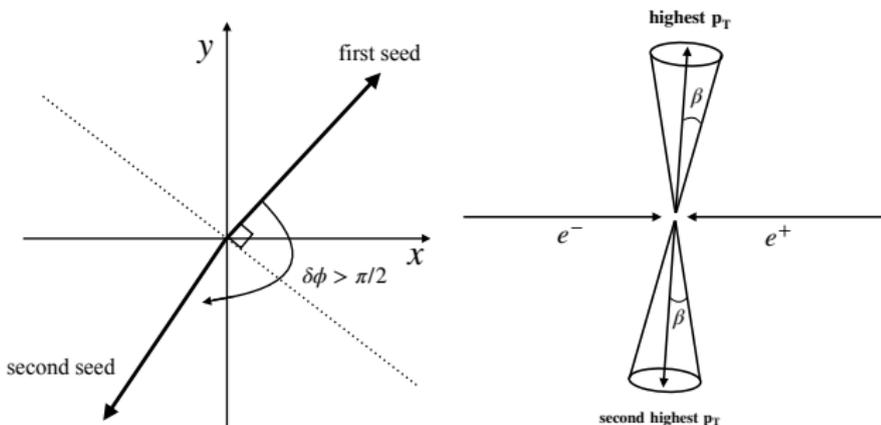
Method

1: Look for two seed direction to build tau jet candidates

first seed : the highest momentum charged PFO

second seed : the highest momentum charged PFO

separated from the first seed by at least $\pi/2$ in the $x - y$ plane ($\delta\phi$)



Tau decay mode selection

Each tau decay mode

- $\tau \rightarrow \pi\nu_\tau$: no photons, 1 charged pions
- $\tau \rightarrow \rho\nu_\tau$: 2 photons(from π^0), 1 charged pions
- $\tau \rightarrow a_{1-1prong}\nu_\tau$: 4 photons(from $2\pi^0$), 1 charged pions
- $\tau \rightarrow a_{1-3prong}\nu_\tau$: 0 photons, 3 charged pions
- $\tau \rightarrow e\bar{\nu}_e\nu_\tau$: isolated lepton
- $\tau \rightarrow \mu\bar{\nu}_\mu\nu_\tau$: isolated lepton

Tau decay mode selection

Selected 1-prong tau candidates in signal events $\epsilon_{ij} = \frac{N_j}{\sum_j N_{ij}}$

	unk	pi	rho	a1p	a13p	e	mu	i \downarrow	
MC truth									
pi	1.37	<u>82.13</u>	10.31	0.69	0.69	3.78	1.03		
rho	4.51	0.00	<u>69.28</u>	16.69	0.83	8.35	0.33		
a1p	5.41	0.90	5.86	<u>71.62</u>	3.15	9.91	3.15		
a13p	6.67	2.67	0.00	0.00	<u>90.67</u>	0.00	0.00		
e	1.19	0.48	1.19	0.24	0.00	<u>95.71</u>	1.19		
mu	0.24	1.42	0.00	0.00	0.00	0.47	<u>97.87</u>		
other	25.28	0.56	3.93	15.17	51.12	3.93	0.00		
	\xrightarrow{j}								
	reconstructed tau decay mode								

electron and muon decay selection are good!: using IsolatedLeptonTagging
 other decay mode: pi, rho, a1-1prong are not very good

Comparison: 500 GeV and 250 GeV

Selected 1-prong tau candidates in signal events $\epsilon_{ij} = \frac{N_j}{\sum_j N_{ij}}$

%	unknown	pi	rho	a1p	a13p	e	mu
pi	1.80	82.3	12.1	0.39	0.37	1.84	1.15
rho	4.99	1.01	79.9	7.40	0.96	5.15	0.58
a1p	8.47	0.87	16.8	64.3	2.16	6.78	0.66
a13p	10.4	2.48	1.87	0.43	84.8	0.05	0.05
e	2.08	0.04	0.38	0.11	0.02	97.1	0.27
mu	0.98	0.64	0.10	0.00	0.02	0.67	97.6
other	21.2	9.95	14.4	13.5	39.0	1.57	0.37

reconstructed tau decay mode

500 GeV

	unk	pi	rho	a1p	a13p	e	mu
pi	1.37	<u>82.13</u>	10.31	0.69	0.69	3.78	1.03
rho	4.51	0.00	<u>69.28</u>	16.69	0.83	8.35	0.33
a1p	5.41	0.90	5.86	<u>71.62</u>	3.15	9.91	3.15
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other	25.28	0.56	3.93	15.17	51.12	3.93	0.00

reconstructed tau decay mode

250 GeV

250 GeV is expected to have better result than 500 GeV, however, it is not so good...

Try to improve them using TMVA.

Tau decay mode selection:TMVA

TMVA setup

BDTD method:

- NTrees=400
- MinNodeSize=5%
- MaxDepth=3
- BoostType=AdaBoost
- SeparationType=GiniIndex
- nCuts=20
- VarTransform=Decorrelate

These are default setting, no tuning for now.

Tau decay mode selection:TMVA

input variables:

$m_{\pi\gamma}$:invariant mass of all charged pion PFOs and photon PFOs per cone.

m_{γ} :invariant mass of all photon PFOs per cone.

E_{γ} :highest/lowest energy of photon PFOs.

$d_{\pi\gamma}$:distance between charged pion PFOs and photon PFOs.

$d_{\pi\gamma_{highest}}$:distance between charged pion PFOs and highest energy photon PFOs.

N_{γ} :number of photon PFOs per cone.

Tau decay mode selection: TMVA

Selected 1-prong tau candidates in signal events $\epsilon_{ij} = \frac{N_j}{\sum_j N_{ij}}$

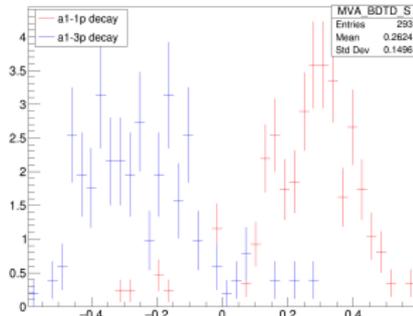
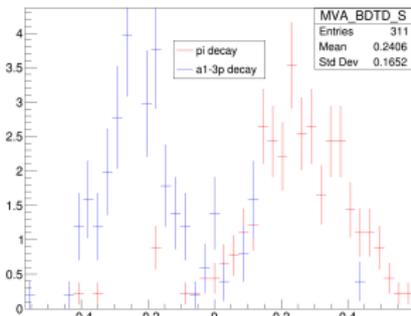
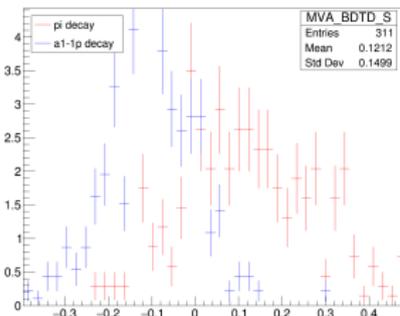
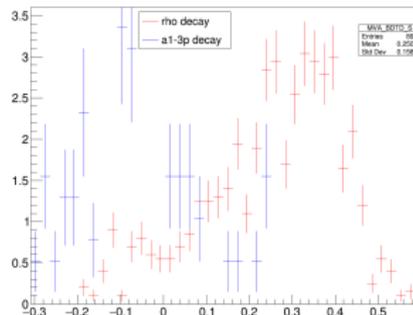
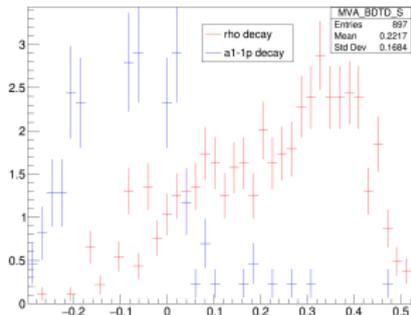
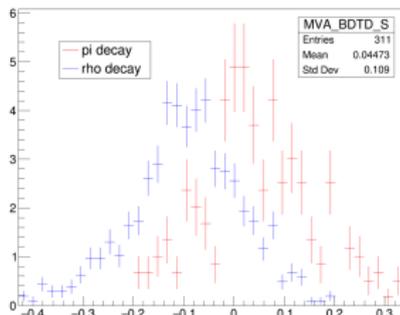
	unk	pi	rho	a1p	a13p	e	mu	i
MC truth	1.37	89.00	3.78	0.34	0.69	3.78	1.03	↓
pi	4.51	7.85	66.94	11.19	0.83	8.35	0.33	
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mu	25.28	0.56	5.06	14.04	51.12	3.93	0.00	
other								
	\xrightarrow{j}	reconstructed tau decay mode						

By including TMVA output, single pi decay is improved.
Other decay mode has no change.

Summary and Future plan

- New Tau test-sample was checked.
- Problems of tau spin information and photon energy correction were fixed.
- There is no other problem found so far.

- Tau decay mode was selected by using some variables and TMVA.
- Tau decay mode selection efficiency is not so good.
- ◇ Tuning TMVA parameters.
- ◇ Polarimeter for pi decay and rho decay.



Background rejection versus Signal efficiency

