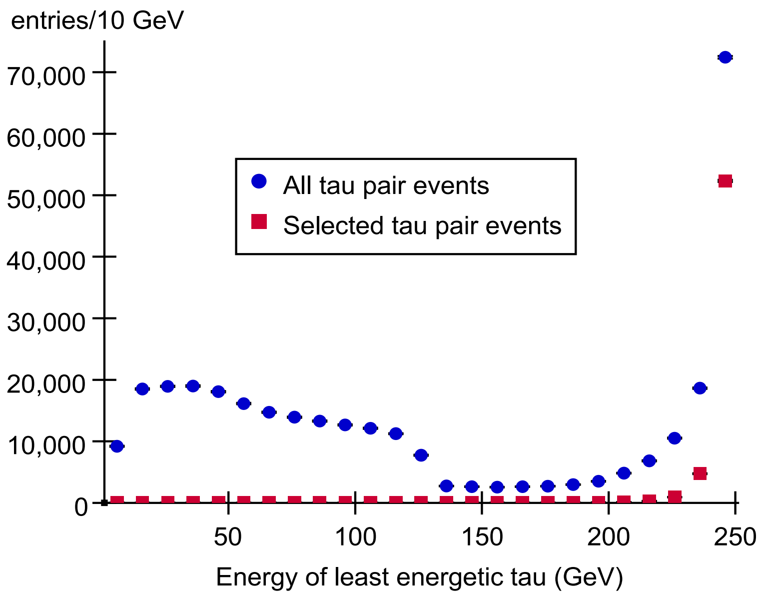
Tau Polarization Study by SiD

Tim Barklow, Ron Cassell (SLAC)
Ray Cowan (MIT)
Subhendu Chakrabarti (SUNY Stonybrook)
Apr 18, 2009

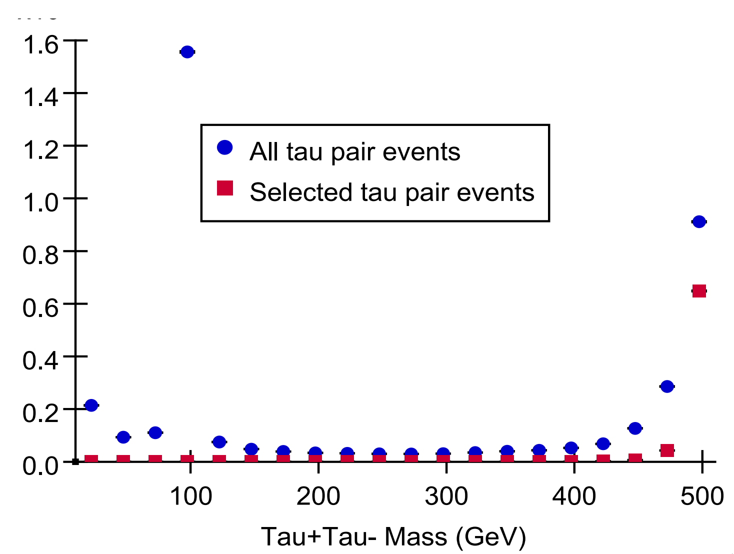
Tau selection and background

- Event cuts: 2-6 tracks, 40<Evis<450 GeV
- Tau jet clustering, 2 jets, each cosθ < .95
- Opening angle > 178 degrees
- Eliminate events with both mu or both e
- Selects 17.9% of all tau pairs, 72% of minE > 240
- Background from other SM 2.4%

+80e- -30e+ -> tau+tau-



-80e- +30e+ -> tau+ tau-



Tau pair cross section and A_{FB}

The selected sample of mostly full energy taus is used to measure the tau pair cross section and A_{FB} at $\sqrt{s} = 500$ GeV.

The total cross section precision is 0.28%.

A_{FB} was measured by fitting the tau $\cos\theta$ distribution to

$$\frac{d\sigma}{d\cos\theta} \propto 1 + \cos^2\theta + \frac{8}{3}\cos\theta$$

$A_{FB} = 0.5038 \pm 0.0021$ for 250 fb^{-1} with $e^-(80\% L)\, e^+(30\% R)$

$A_{FB} = 0.4704 \pm 0.0024$ for 250 fb^{-1} with $e^-(80\% R)\, e^+(30\% L)$

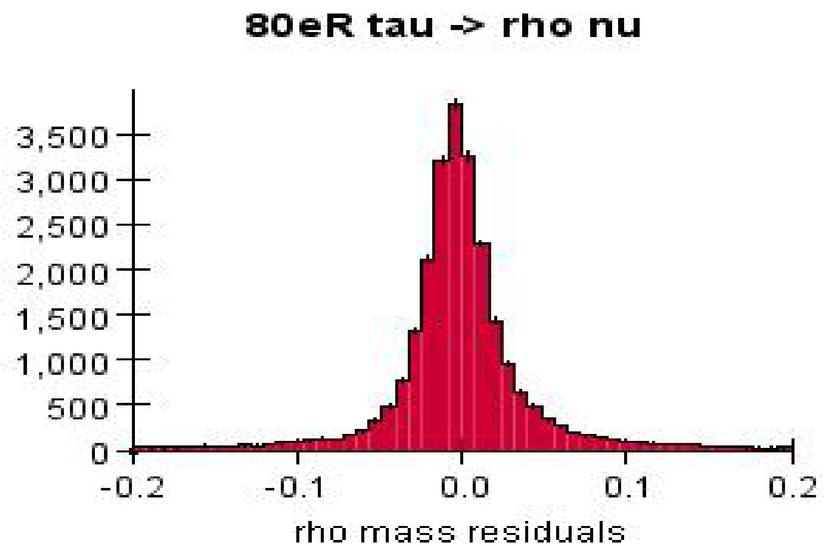
Decay mode selection using modifcation of SiD pfa

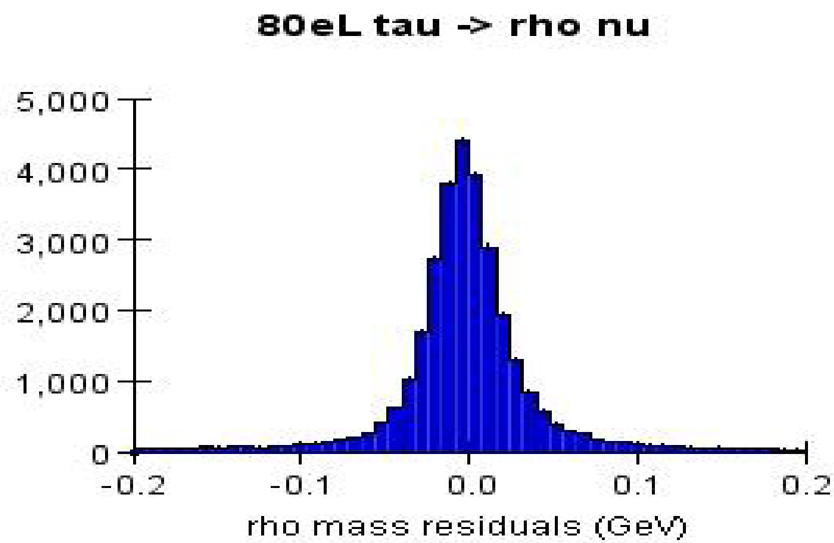
decay mode	# γ	# π^0	EPcut	other criteria
$e^-\bar{\nu}_e\nu_\tau$	0	0	-	HCAL energy < 4% of track energy.
$\mu^-\bar{\nu}_\mu\nu_\tau$	0	0	-	identified as μ by PFA
$\pi^-\nu_\tau$	0	0	2.5	-
$\rho^-\nu_\tau \to \pi^-\pi^0\nu_\tau$	1	0	2.2	0.6 GeV $< M_\rho <$ 0.937 GeV, $E_\gamma >$ 10 GeV
$\rho^-\nu_\tau \to \pi^-\pi^0\nu_\tau$	2	1	2.2	0.4 GeV $< M_\rho <$ 0.93 GeV
$a_1^-\nu_\tau \to \pi^-\pi^0\pi^0\nu_\tau$	3	1	2.2	0.8 GeV $< M_{a_1} <$ 1.5 GeV, $E_\gamma >$ 10 GeV
$a_1^-\nu_\tau \to \pi^-\pi^0\pi^0\nu_\tau$	4	2	2.2	0.8 GeV $< M_{a_1} <$ 1.5 GeV
$a_1^-\nu_\tau \to \pi^-\pi^+\pi^-\nu_\tau$	0	0	2.5	0.8 GeV $< M_{a_1} <$ 1.7 GeV

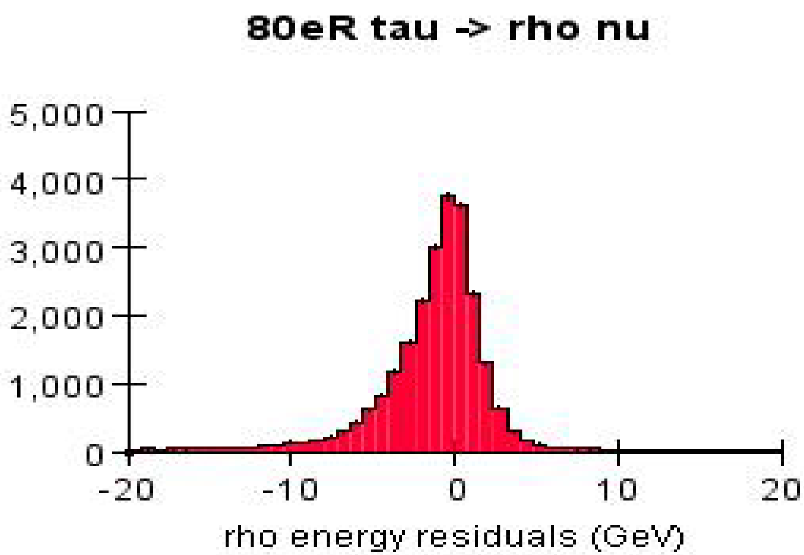
Decay mode purity and efficiency

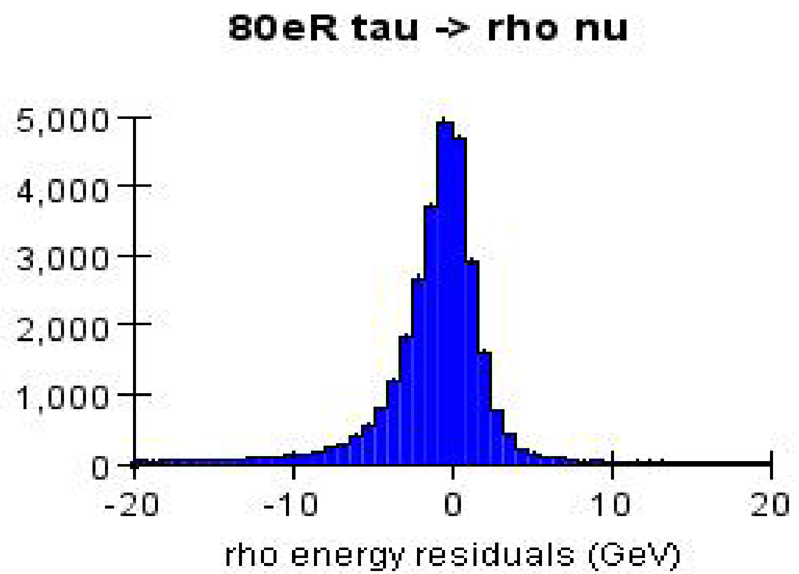
decay mode	Correct ID	Wrong ID	ID eff	ID purity	SM bgnd
$e^-\bar{\nu}_e\nu_\tau$	39602	920	0.991	0.977	1703
$\mu^-\bar{\nu}_\mu\nu_\tau$	39561	439	0.993	0.989	1436
$\pi^-\nu_\tau$	28876	2612	0.933	0.917	516
$\rho^-\nu_\tau \to \pi^-\pi^0\nu_\tau$	55931	8094	0.790	0.874	1054
$a_1^-\nu_\tau \to \pi^-\pi^0\pi^0\nu_\tau$	18259	11140	0.732	0.621	847
$a_1^-\nu_\tau \to \pi^-\pi^+\pi^-\nu_\tau$	21579	2275	0.914	0.905	141

Rho reconstruction

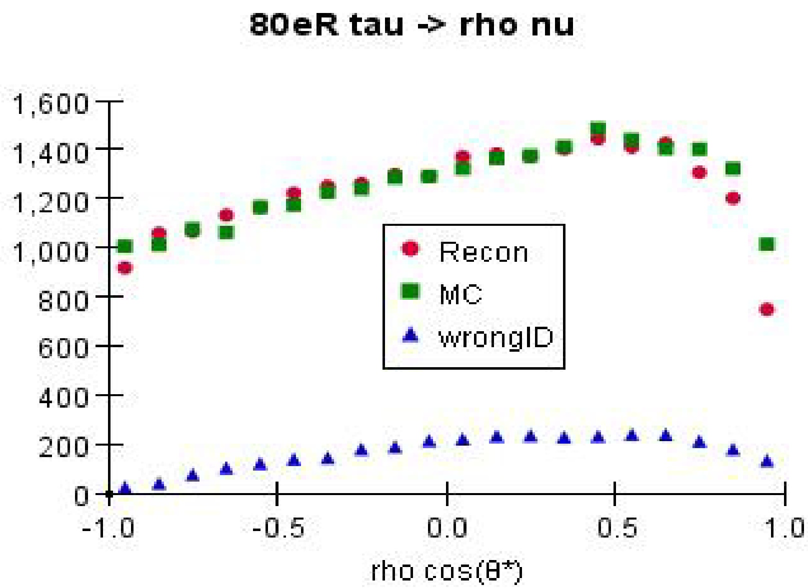


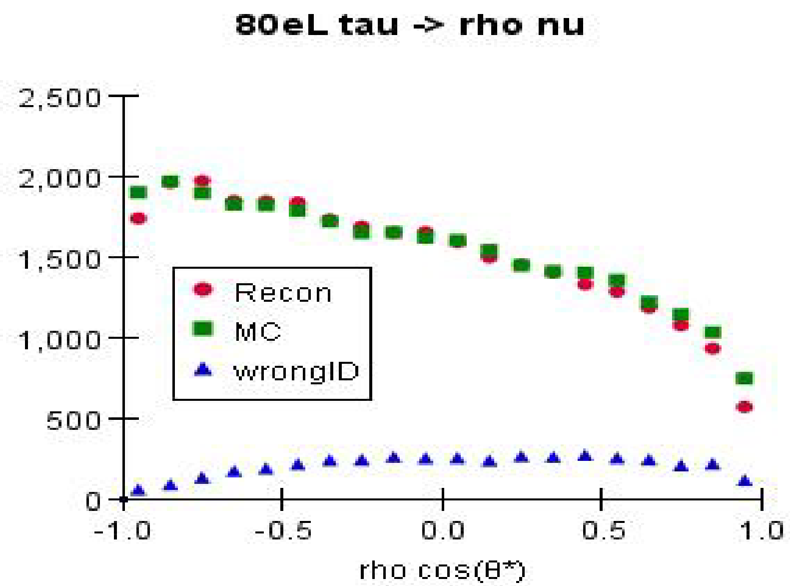


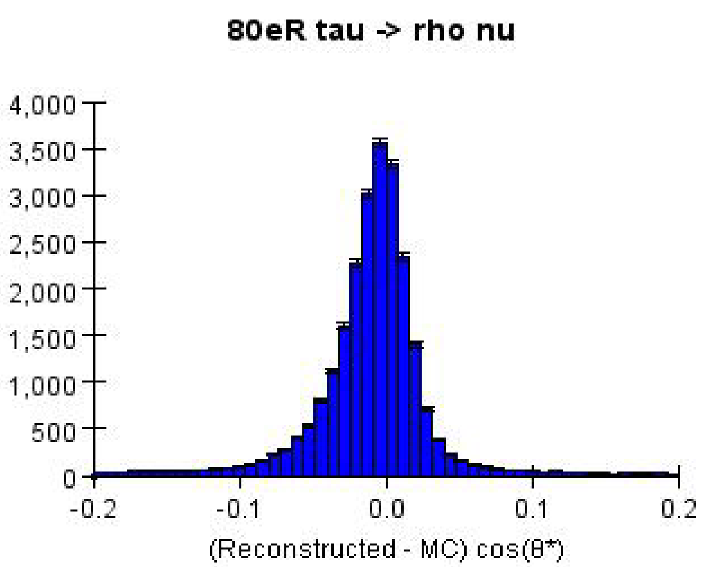


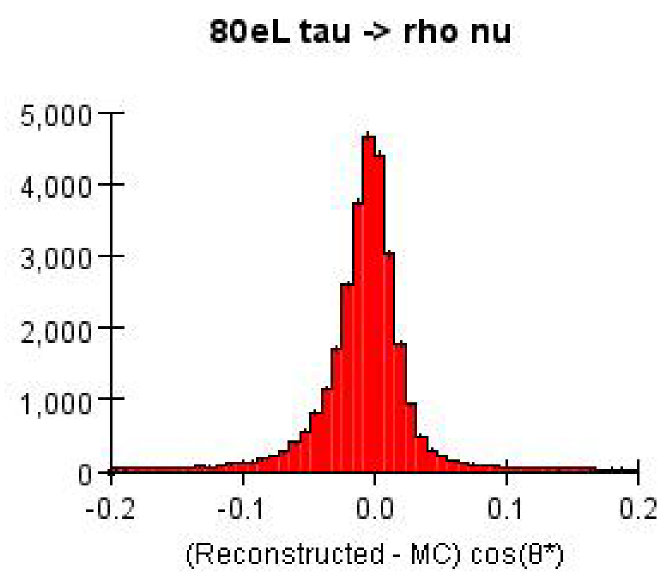


Θ* = angle between rho and tau in tau rest frame

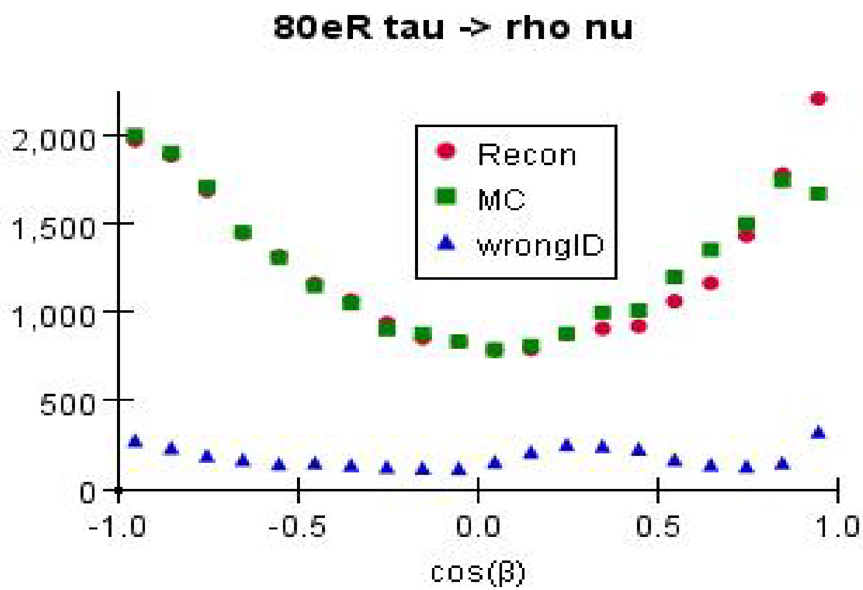


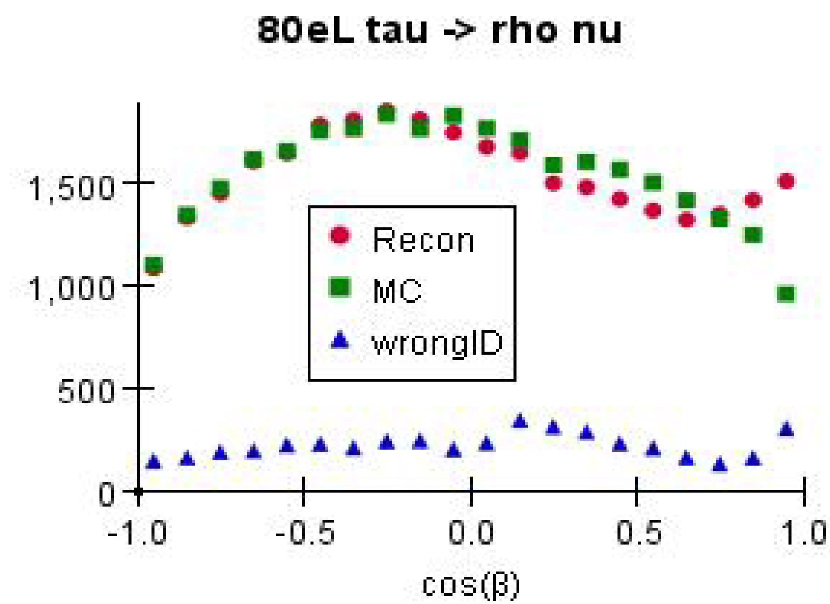


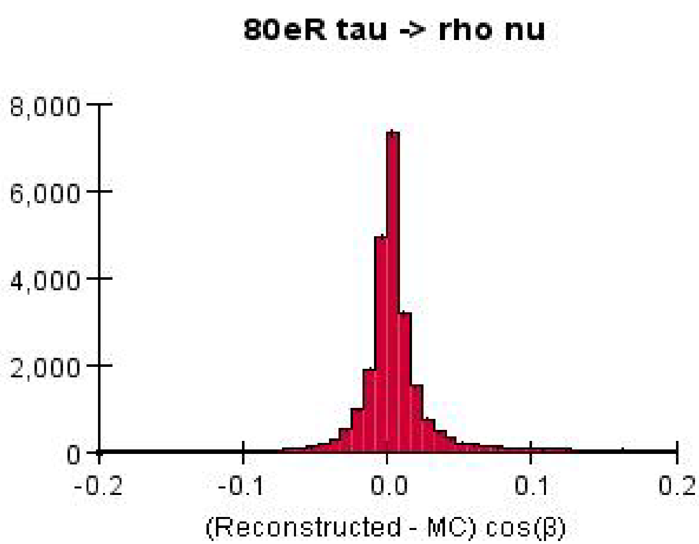


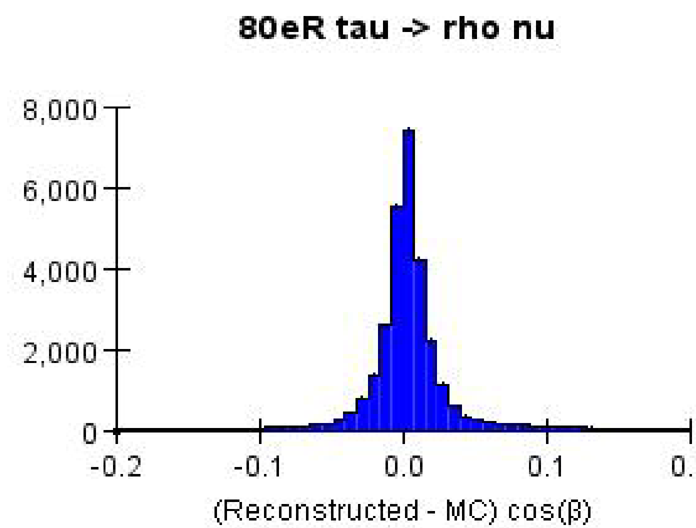


β = angle between pi+- in rho rest frame









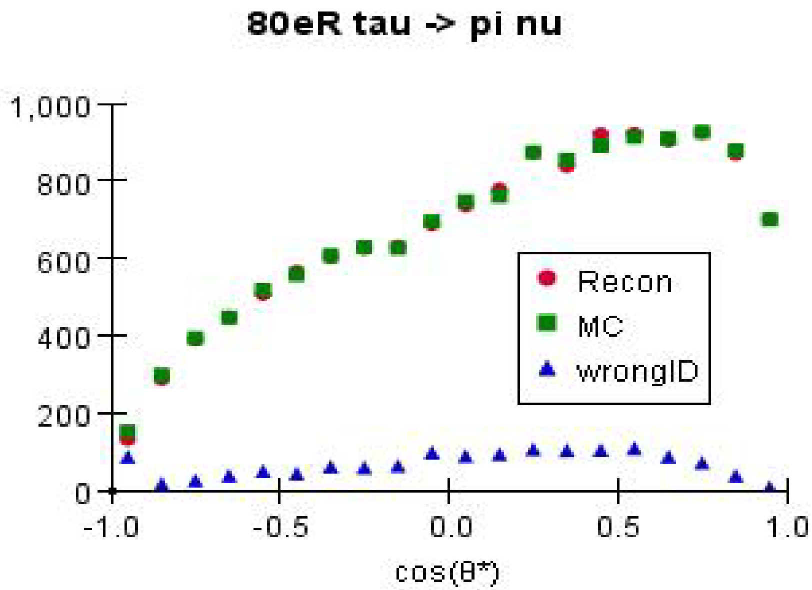
Tau polarization measurement

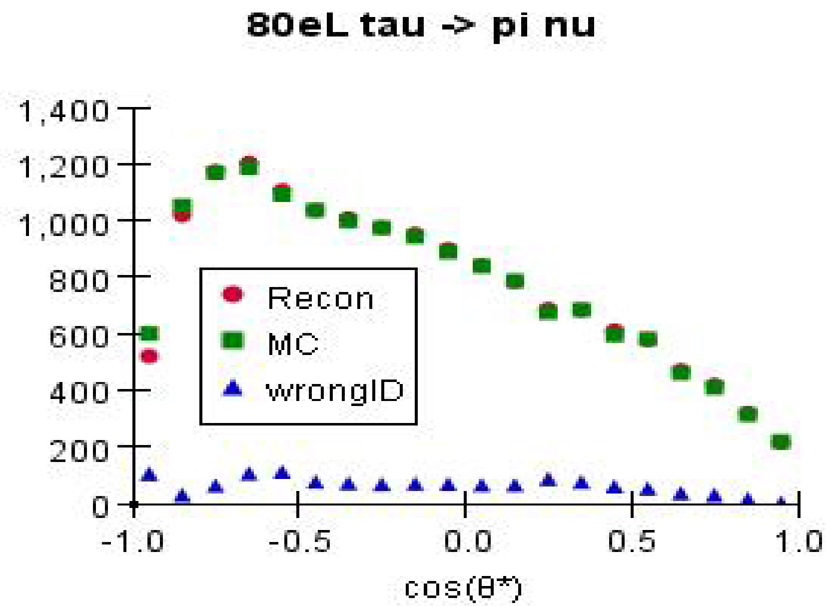
The mean tau polarization $< P_\tau >$ over all tau production angle is measured

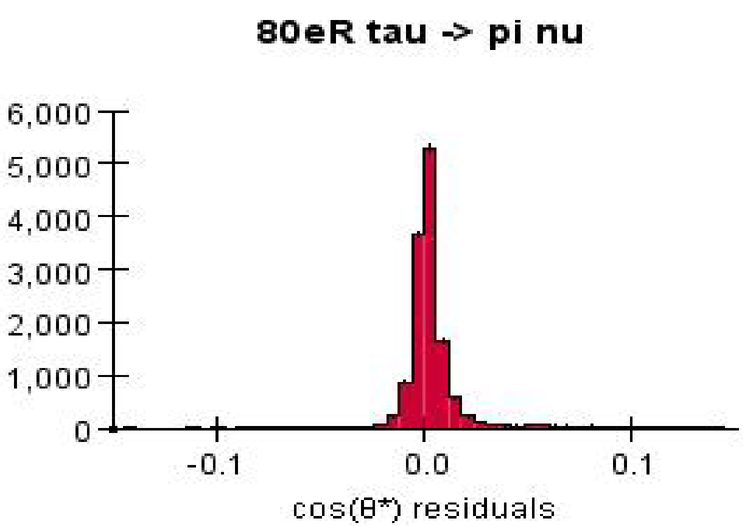
All channels except the a_1 were used.

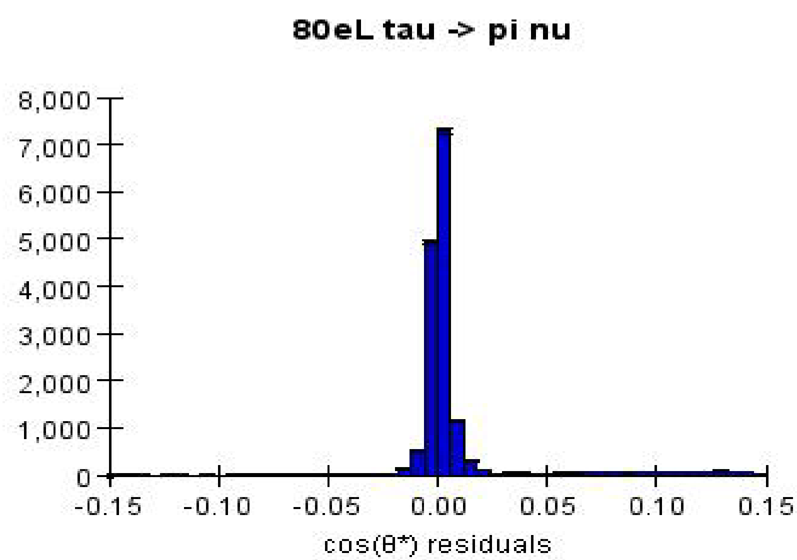
The optimal observable method was used where the optimal observable $\omega = \frac{E_{track}}{E_{beam}}$ for $e, \mu,$ and single pion decays. For the rho the optimal observable ω is a complicated function of the angles of the rho and charged pion in the tau and rho rest frames, respectively.

Θ* = angle between pi and tau in tau rest frame

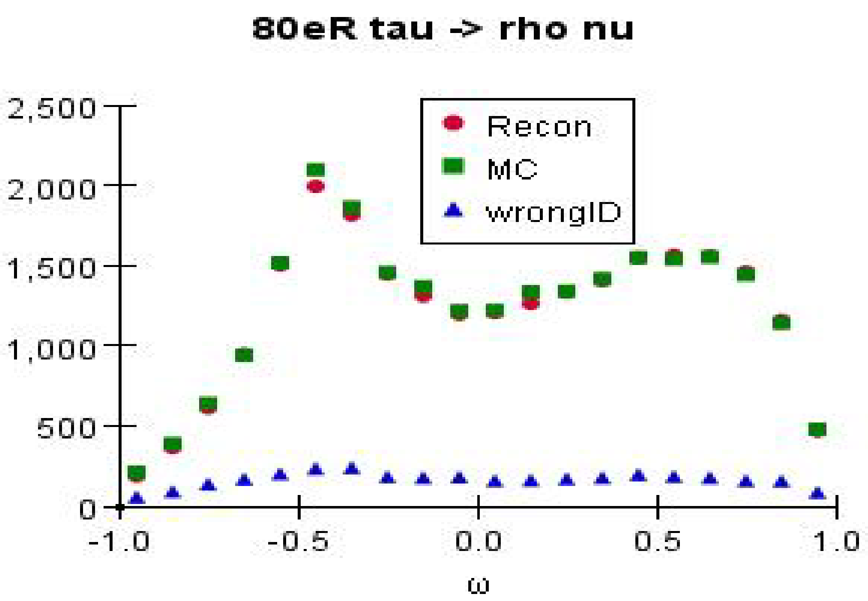


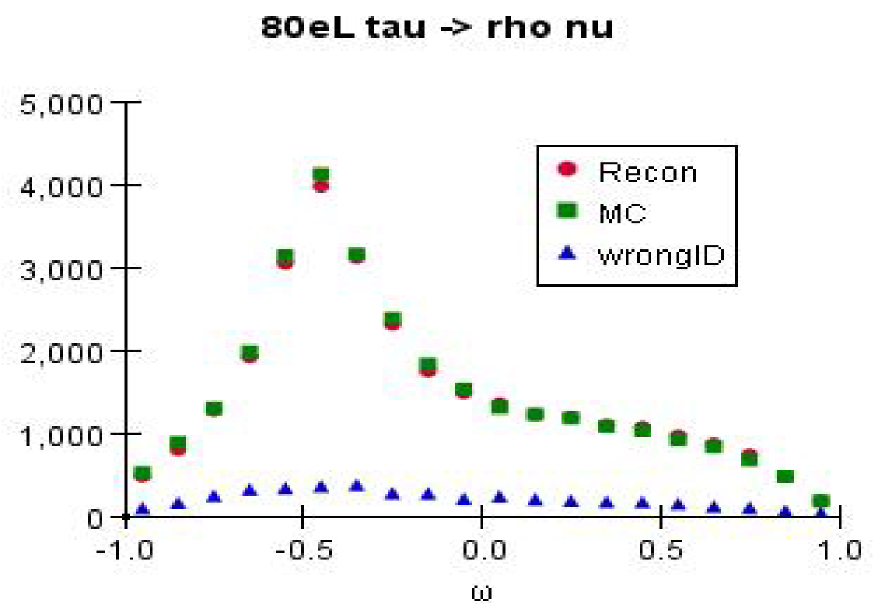


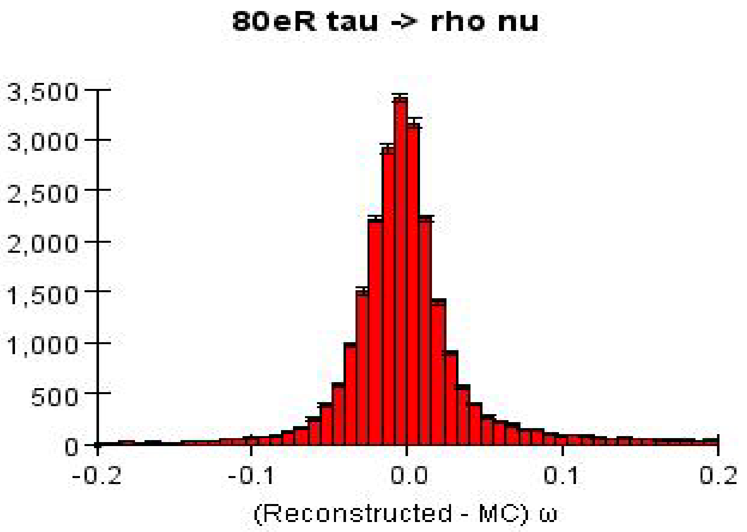


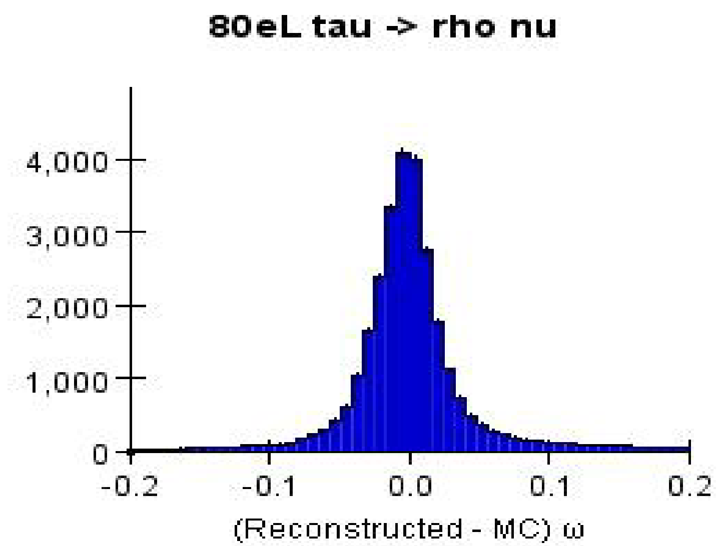


ω = optimal observable









Tau polarization precision

The average polarization $< P_\tau >$ is measured separately for initial electron and positron polarization combinations of $e^-(80\%L)\, e^+(30\%R)$ and $e^-(80\%R)\, e^+(30\%L)$ In the Standard Model the true tree-level values at $\sqrt{s}$=500 GeV are $< P_\tau >= -0.626$ and $+0.528$ for $e^-(80\%L)\, e^+(30\%R)$ and $e^-(80\%R)\, e^+(30\%L)$ respectively.

A linear least squares fit of $< P_\tau >$ over all the bins of all the reconstructed ω distributions is used to measure $< P_\tau >$. The Monte Carlo sample is divided in half with one half used for training and the other for testing. The results:

$< P_\tau >= -0.611 \pm 0.009$ stat. ± 0.005 sys. for 250 fb^{-1} with $e^-(80\%L)\, e^+(30\%R)$

$< P_\tau >= +0.501 \pm 0.010$ stat. ± 0.006 sys. for 250 fb^{-1} with $e^-(80\%R)\, e^+(30\%L)$

The systematic errors are due to the finite training sample statistics.

Summary

- Using a modified version of the SiD pfa, good tau decay mode identification efficiency and purity can be achieved for 250 GeV taus for all the dominant decay modes.
- Using all decays except the a_1 an absolute statistical precision of 0.01 can be achieved for the mean tau polarization of 250 GeV taus for a 250 fb^{-1} sample.
- Future work would include further improvements of the decay mode id, and incorporation of the a_1 into the tau polarization analysis