

Measurement of tau polarization in B to $D(^*)$ tau nu decays

Feasibility study for SuperKEKB

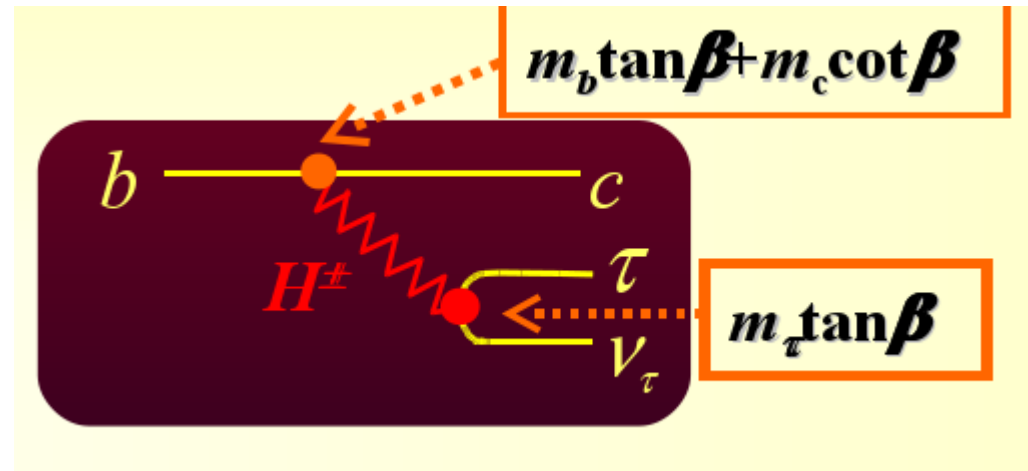
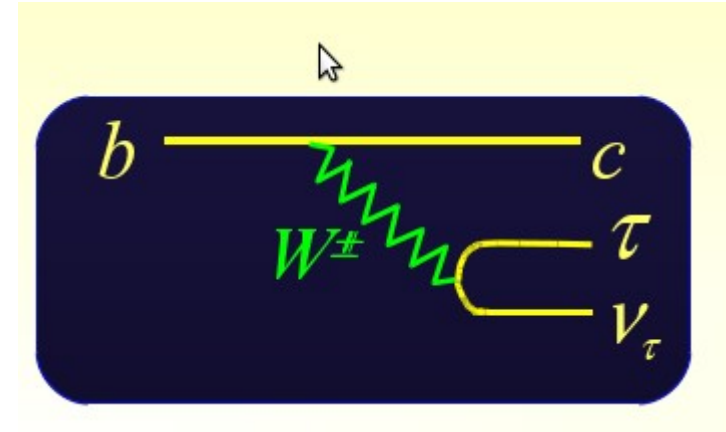
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Kraków))

Very preliminary !!!

16.05.2012, Kraków

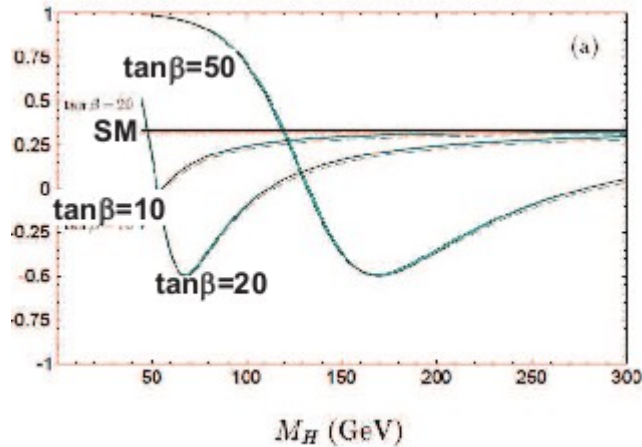
Motivation

- $B \rightarrow D(^*) \tau \nu$
- Small hadronic uncertainties (a few % in SM)
- NP at the tree level
- Many observables (D^* and tau polarization, q^2 distribution, ...)



Motivation (2)

longitudinal τ polarization in $B \rightarrow \bar{D}\tau^+\nu_\tau$



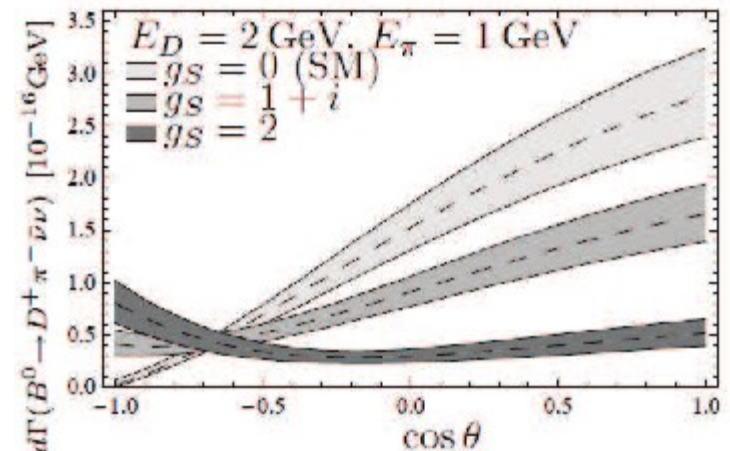
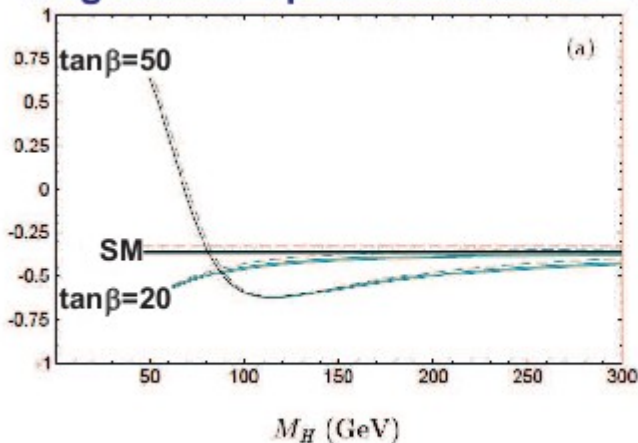
Possible large NP effects; small theoretical uncertainties

Can we measure it?

Example of an alternative observable

θ = angle between π (from $\tau \rightarrow \pi\nu$) and D in B rest frame

longitudinal τ polarization in $B \rightarrow D^*_L\tau^+\nu_\tau$

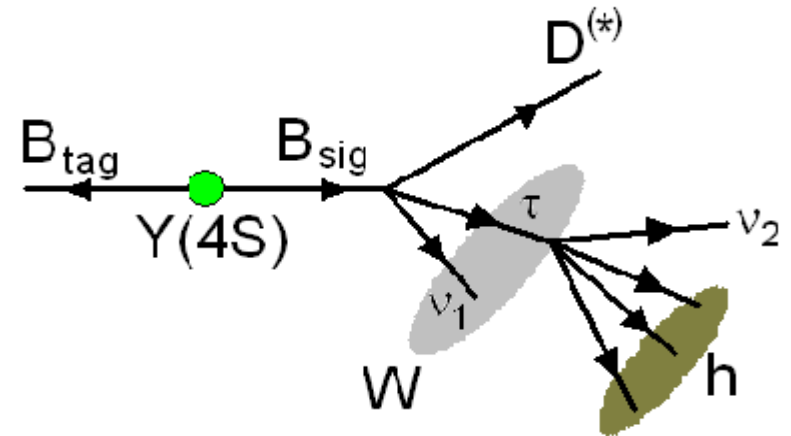


Experimental challenges

- multiple neutrinos(2-3) in final state → no clear-cut kinematic variables to identify signal
- large background from other B decays (mainly $B \rightarrow X_c l \nu$)
- crossfeeds between D^* and D modes
- crossfeeds between different tau decay (π , ρ , a_1);

Methodology at B-factory

Exploit exclusive BB pair production at Upsilon(4S)

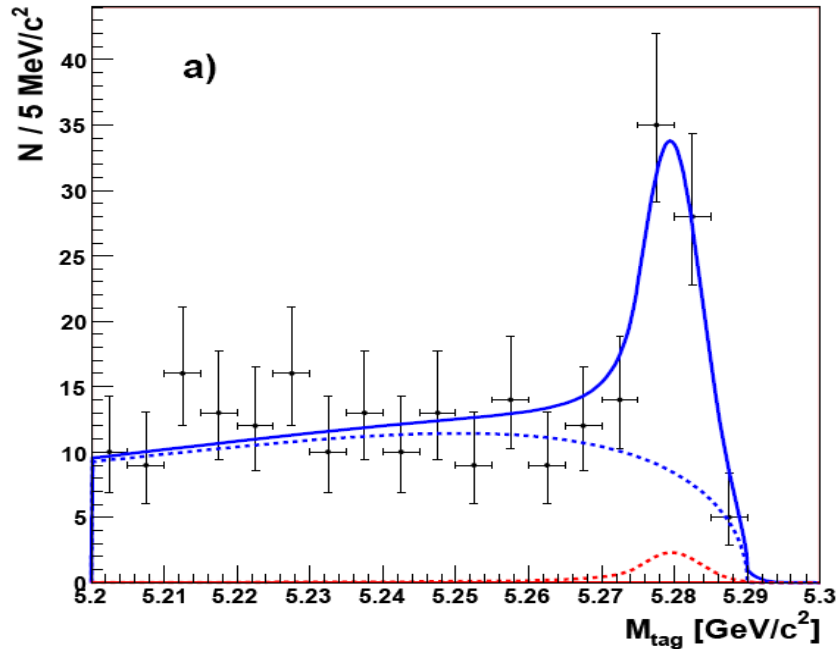


- Reconstruction of B_{tag} provides kinematical constraints on B_{sig} ($B \rightarrow D^{(*)}\tau\nu$)

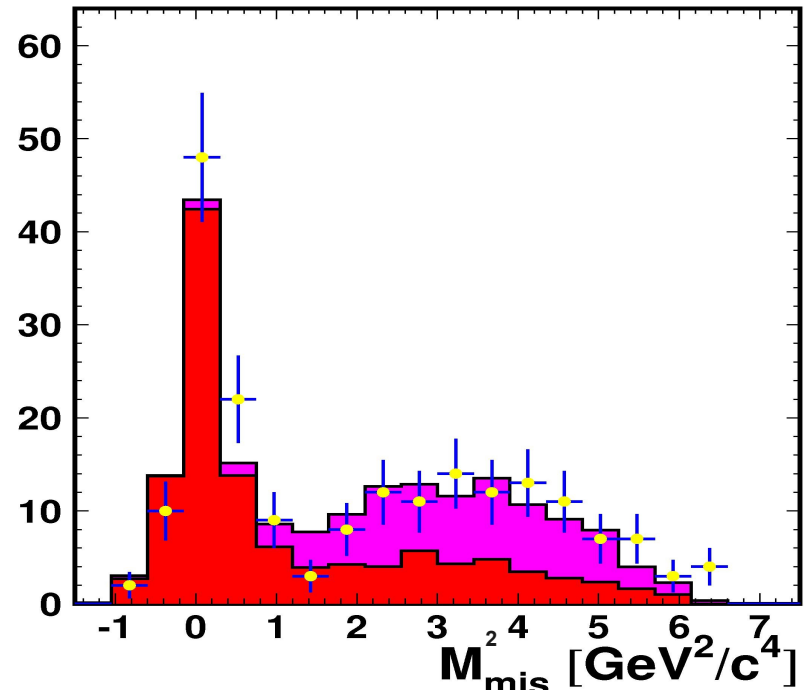
$$\vec{p}_{sig} = -\vec{p}_{tag}$$

- $M_W^2 = (p_B - p_D)^2 = (p_\tau + p_{\nu_1})^2$
- $M_M^2 = (p_B - p_D - p_h)^2 = (p_{\nu_1} + p_{\nu_2})^2$

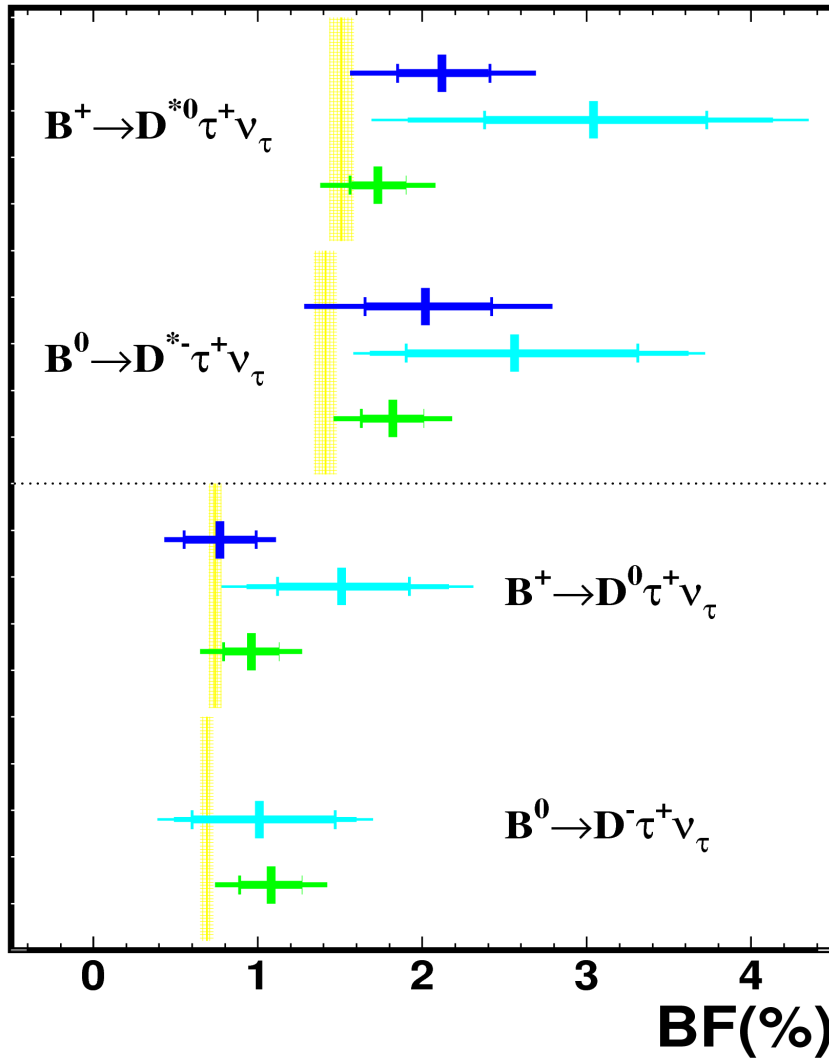
First observation of B to $D^* \tau \nu$



Belle (2007)



$B \rightarrow D(^*) \tau \nu$ BF's



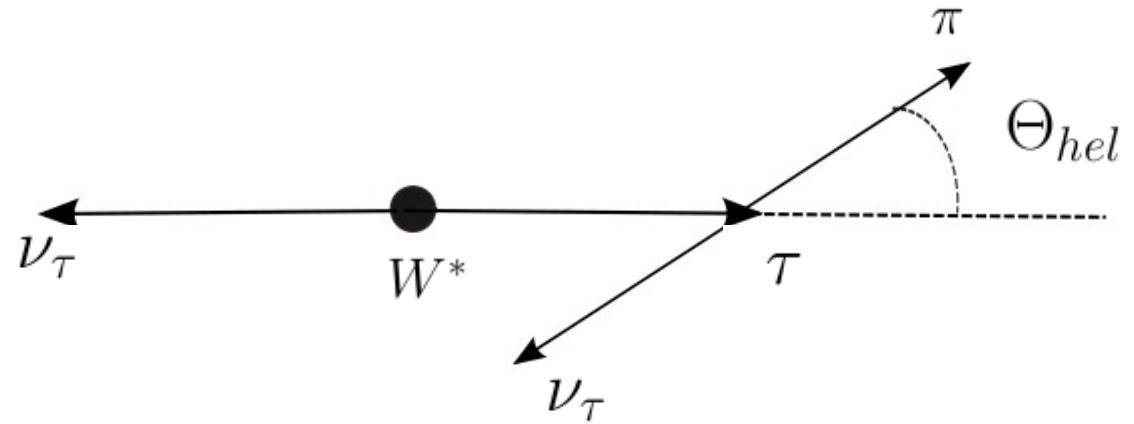
How to measure tau polarization

in CM of W^*

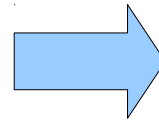
$$E_\tau = \frac{M_W^2 + M_\tau^2}{2M_W}$$

$$E_h = \frac{M_W^2 + M_\tau^2 - M_h^2}{2M_W}$$

$$\cos\Theta_{\tau h} = \frac{2E_\tau E_h - (M_\tau^2 + M_h^2)}{2E_{\nu_1} p_h}$$



boost to tau rest
frame can be done



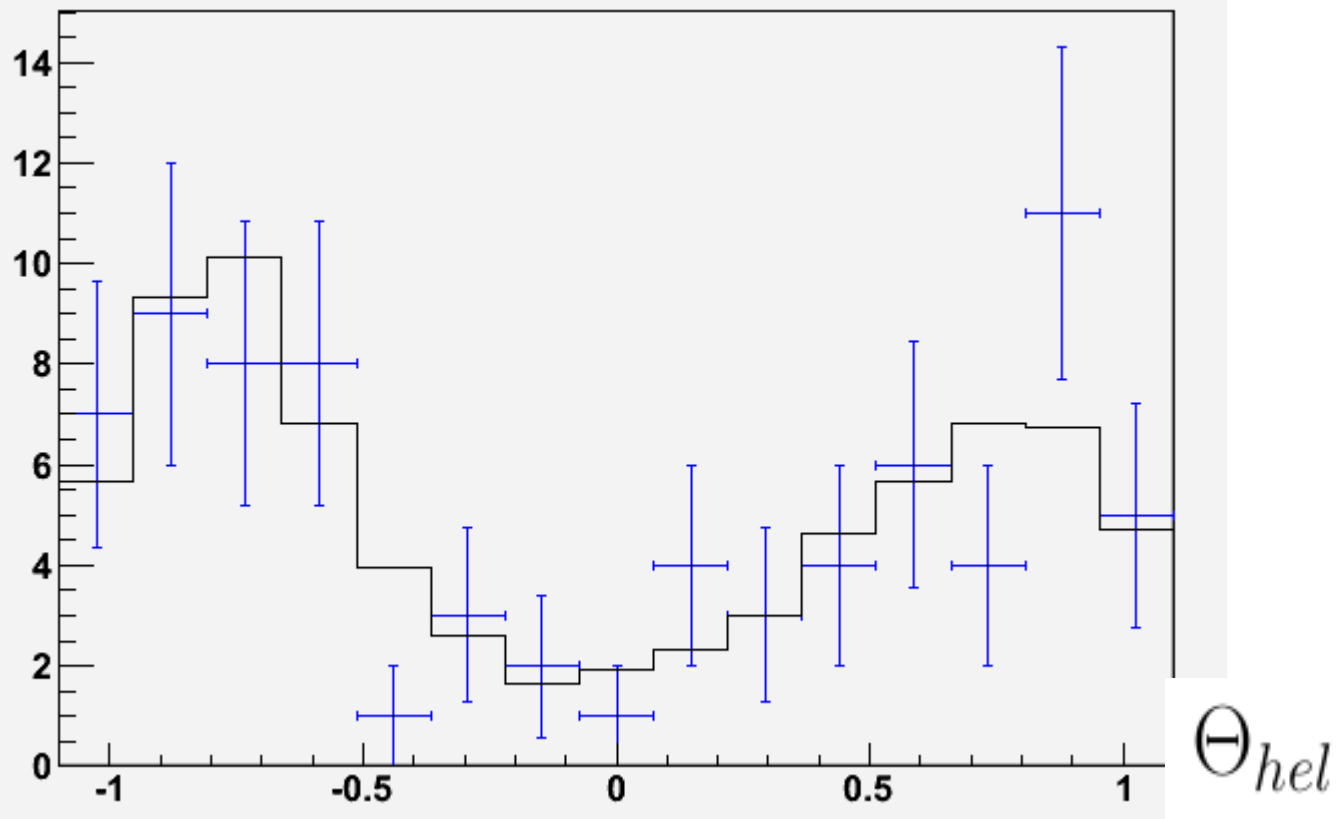
Θ_{hel}

Control sample (DATA)

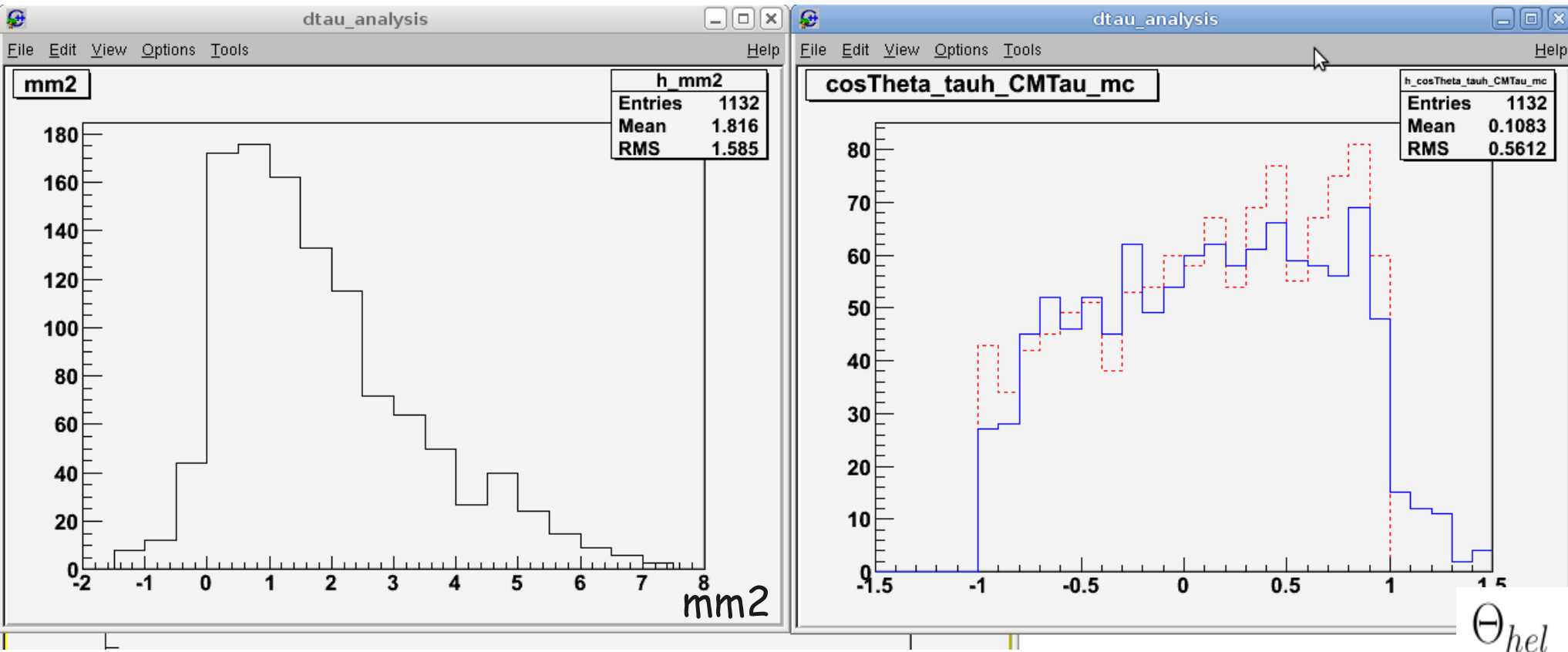
$$B^0 \rightarrow D_s^+ D^-$$

$$D_s^+ \rightarrow \phi \pi^+; \phi \rightarrow K^+ K^-$$

Measure phi polarization using K^+ momentum and Btag reconstruction; without using K^- & π^+



$B \rightarrow D \tau \nu; \tau \rightarrow \pi \nu$ (MC)

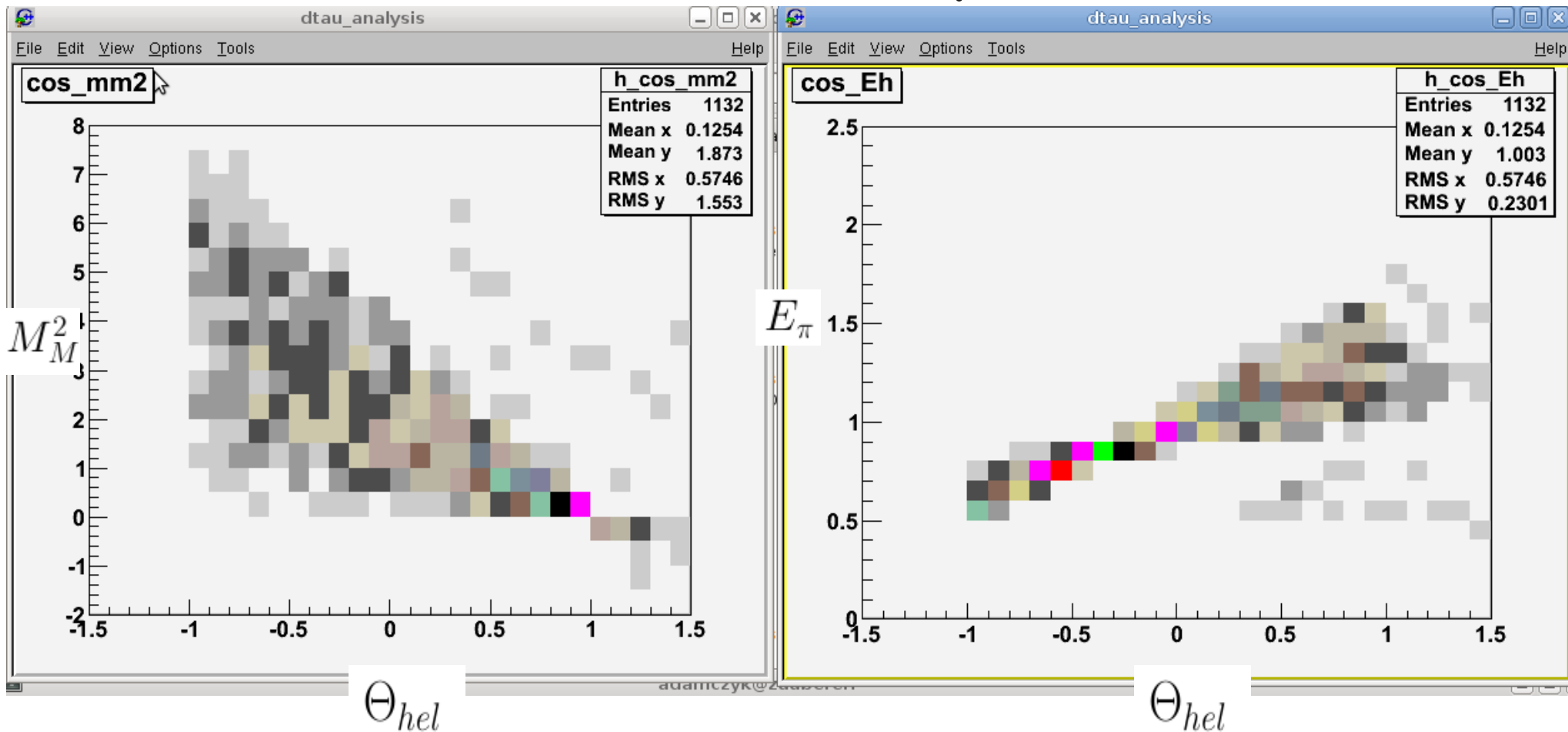


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Large background for low mm2

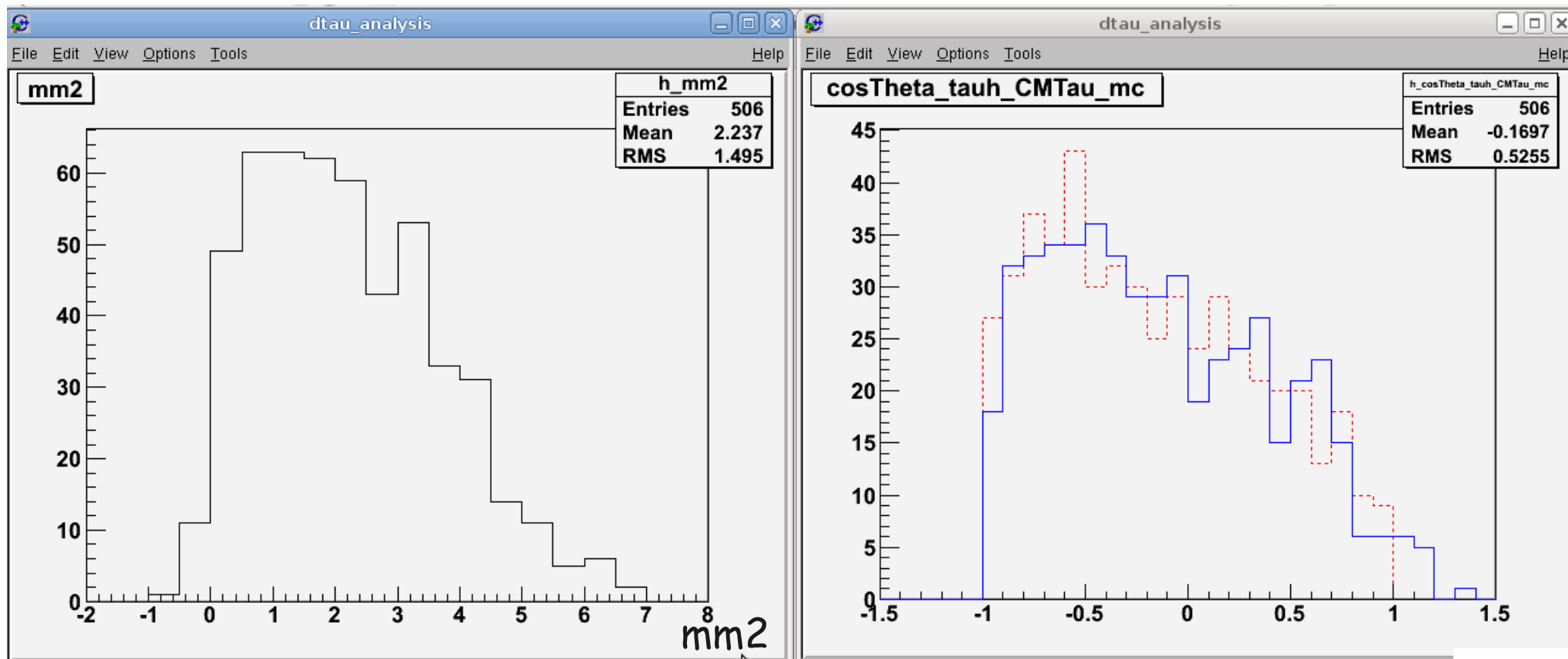
MC = EvtGen + Geant3

$B \rightarrow D \tau \nu; \tau \rightarrow \pi \nu$ (MC)



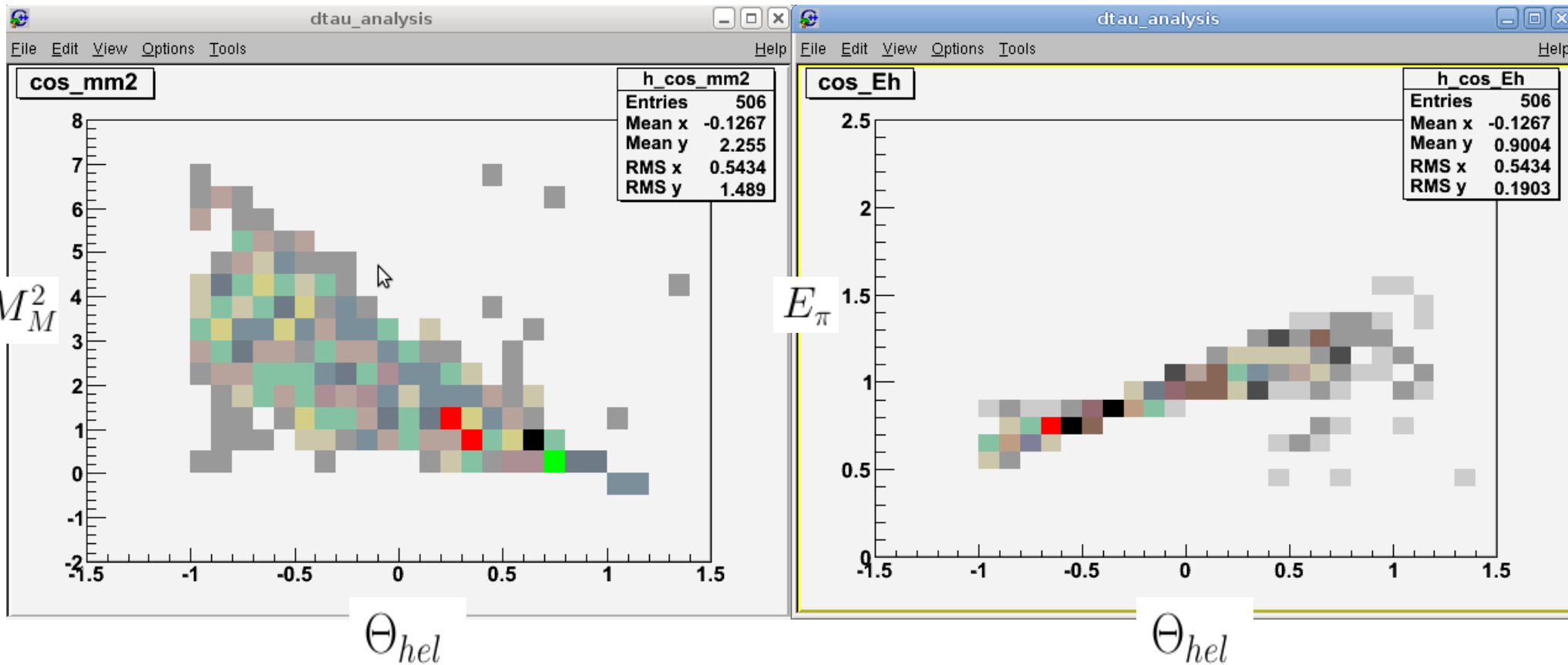
Large background for low $mm^2 \rightarrow$ difficult to measure in the full phase space

$B \rightarrow D^* \tau \nu; \tau \rightarrow \pi \nu$ (MC)



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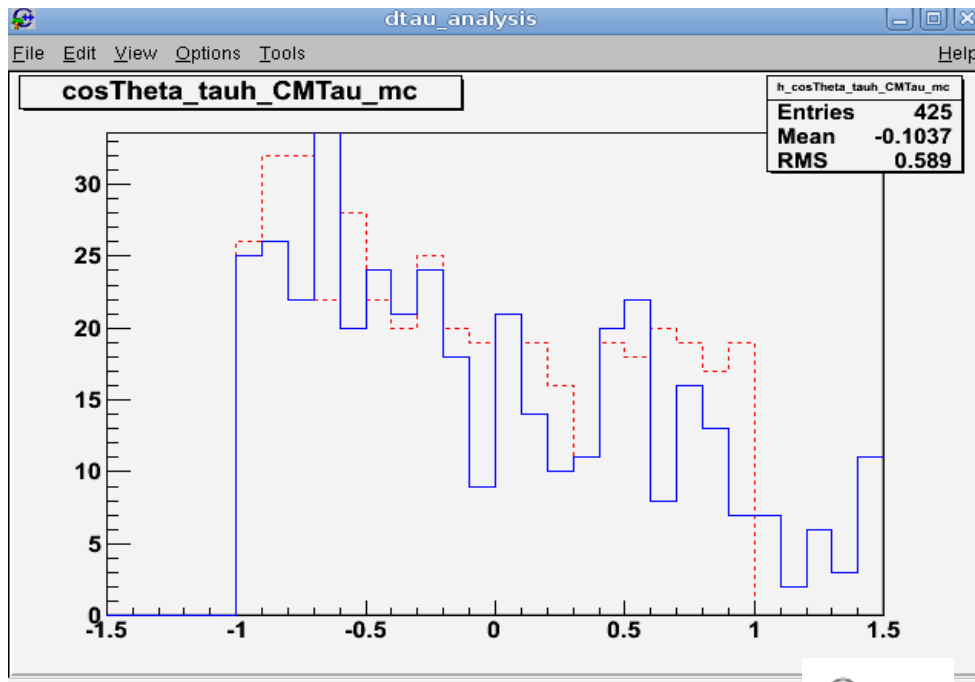
$B \rightarrow D^* \tau \nu; \tau \rightarrow \pi \nu$ (MC)



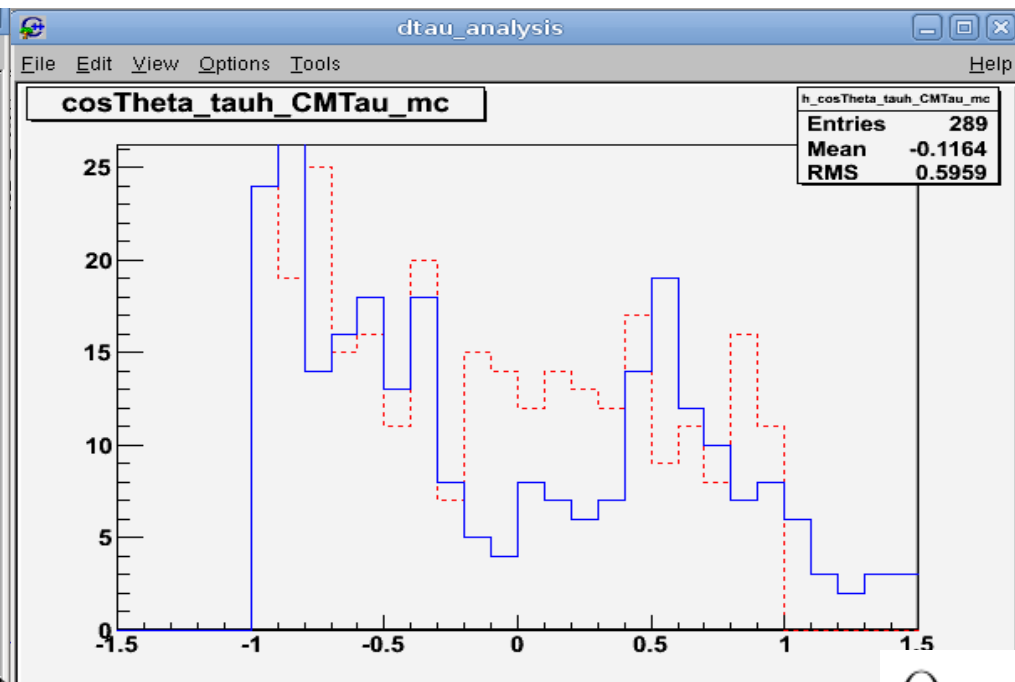
Main issue: crossfeeds from

$\tau \rightarrow \rho \nu$

$\tau \rightarrow \mu \nu \nu$



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Θ_{hel}

To do:

- Many things still to be improved (rho reconstruction, signal selection, choosing best candidate, background suppression, ...)
- Check sensitivity for different tau polarization → model to generate different tau polarization

■