Tau reconstruction study at ILC250

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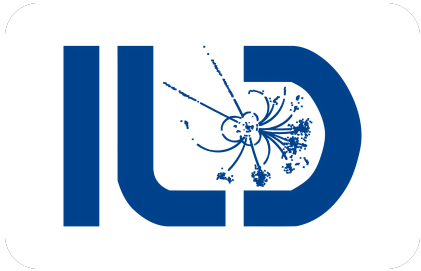

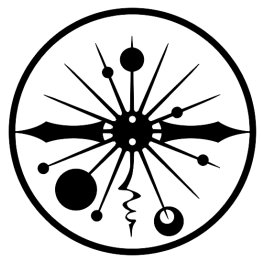

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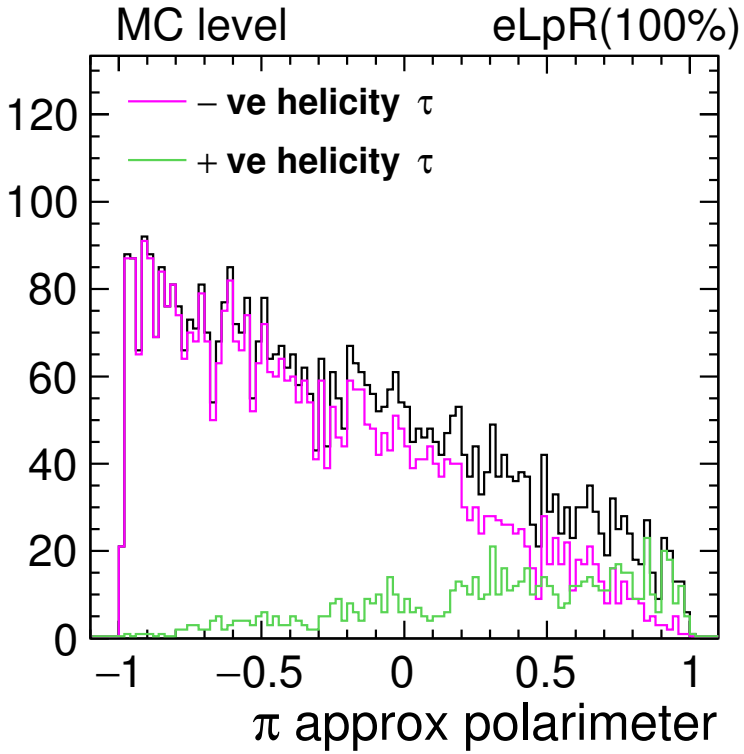
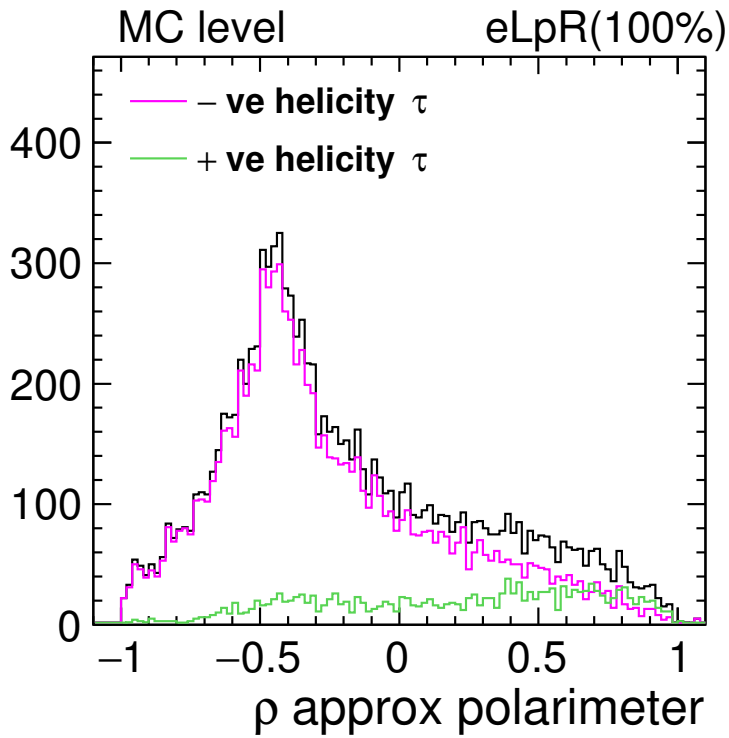
Brief introduction

Previous study:look at polarimeter without using neutrino information

"Approximate" polarimeters which are reconstructed based only on the momenta of visible tau decay products.





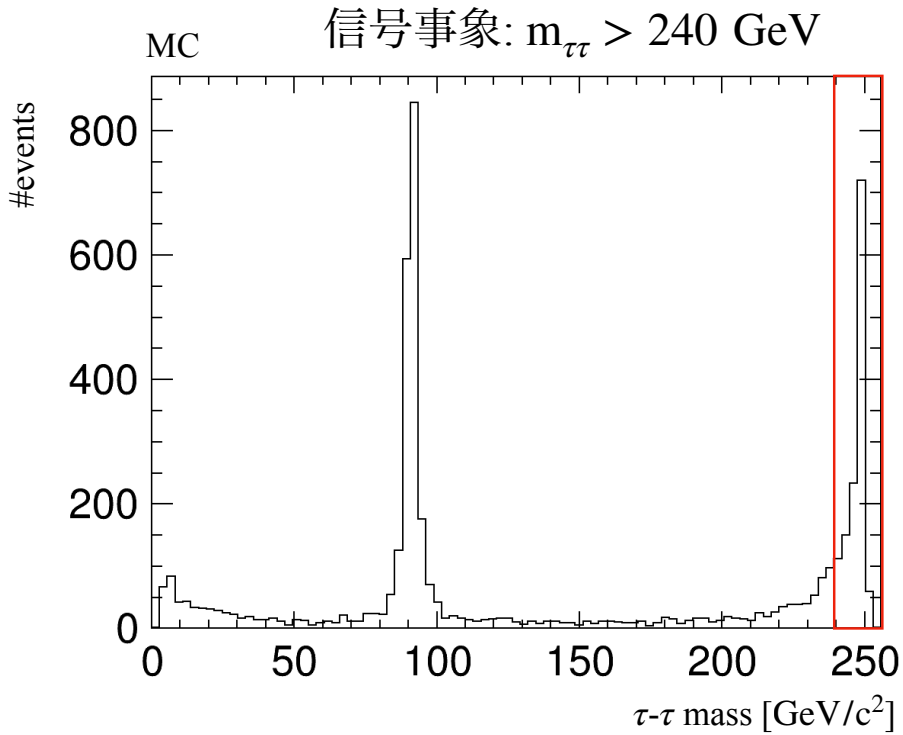
In today's talk, we explicitely extract neutrino momentum and look at polarimeters.

Assumption and setup

- Signal event sample with $100\ \%\ e^-_L e^+_R$ beam polarisations were generated using WHIZARD ver 2.8.2
- The decay of the polarised tau was done using TAUOLA
- Full simulation of ILD detector based on Geant4 and realistic reconstruction were performed.

Assume

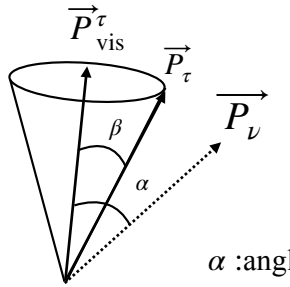
- tau-tau is back-to-back
- 1 neutrino per tau
- $m_\tau = 1.776\ \mathrm{GeV}$
- $E_\tau = \frac{E_{cm}}{2}$
  - ◇ only look at $\tau \to \pi\nu$ and $\tau \to \rho\nu$
  - ◇ $m_{\tau\tau} > 240\ \mathrm{GeV}$



Method

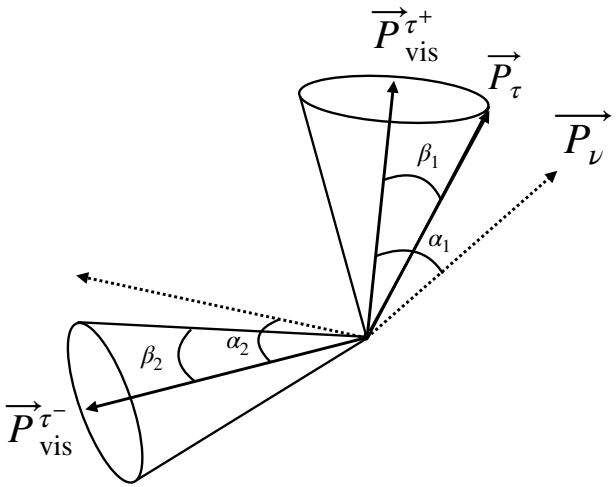
1. Using true neutrino momentum from MC.
2. Using "cone method" to reconstruct neutrino
   a) with true MC visible tau daughters.
   b) with MC linked reconstructed tau daughters.
      - for $\pi^{\pm}$ and π^{0}

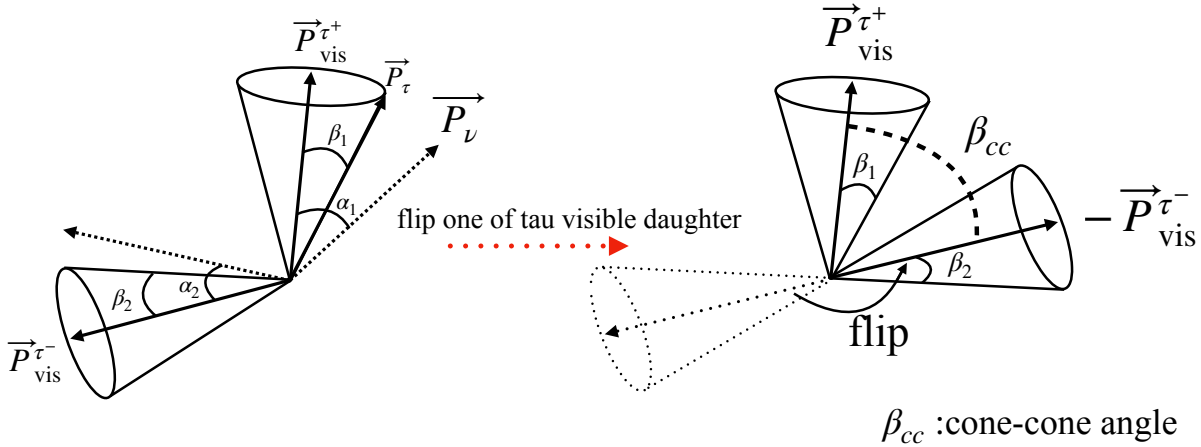
"cone method"



$\vec{P}^{\tau}_{\rm vis}$: tau visible daughter momentum
$\vec{P}_{\nu}$: neutrino momentum
$\vec{P}_{\tau}$: tau momentum

α :angle between tau visible daughter and neutrino
β :angle between tau visible daughter and tau



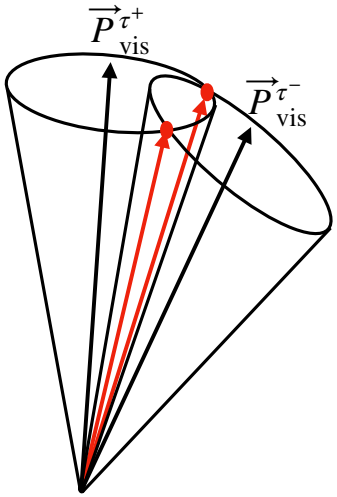


β_{cc} :cone-cone angle

Find solutions

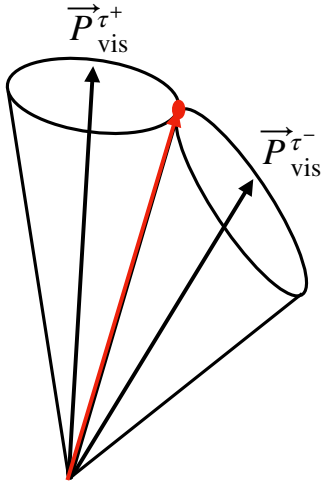
Look at angle between tau visible daughter and candidate solution.
If at least one intersection point was found, there is a solution.

$\beta_1 + \beta_2 > \beta_{cc}$



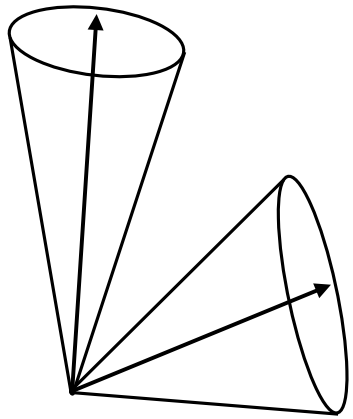
2 possible solutions

$\beta_1 + \beta_2 = \beta_{cc}$



1 possible solution

$\beta_1 + \beta_2 < \beta_{cc}$

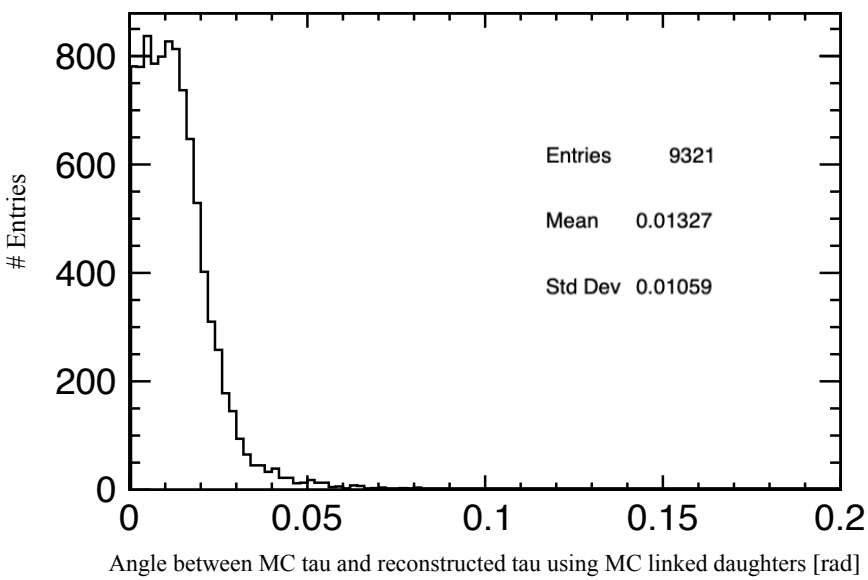


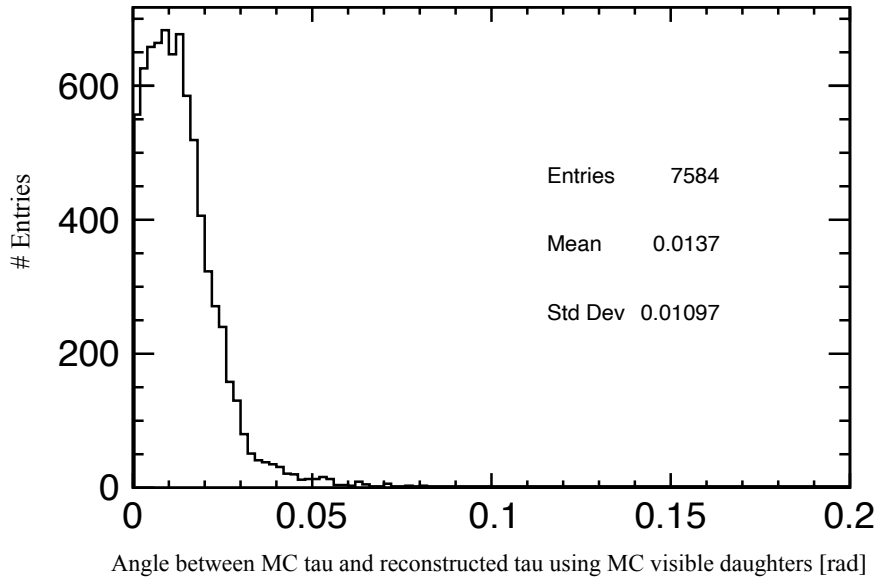
NO solutions

red line:solution = candidate tau direction
use these information to look at tau polarimeter.

Find solutions

First look at angle between MC tau direction and reconstructed tau direction.





Angle between MC τ and reconstructed τ using MC linked daughters.

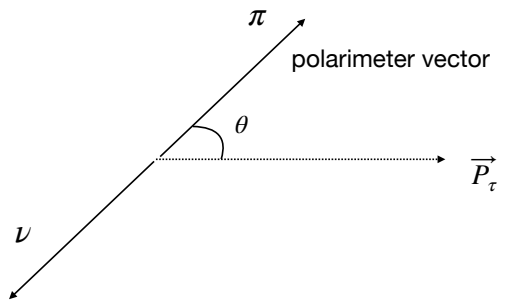
Angle between MC τ and reconstructed τ using MC visible daughters.

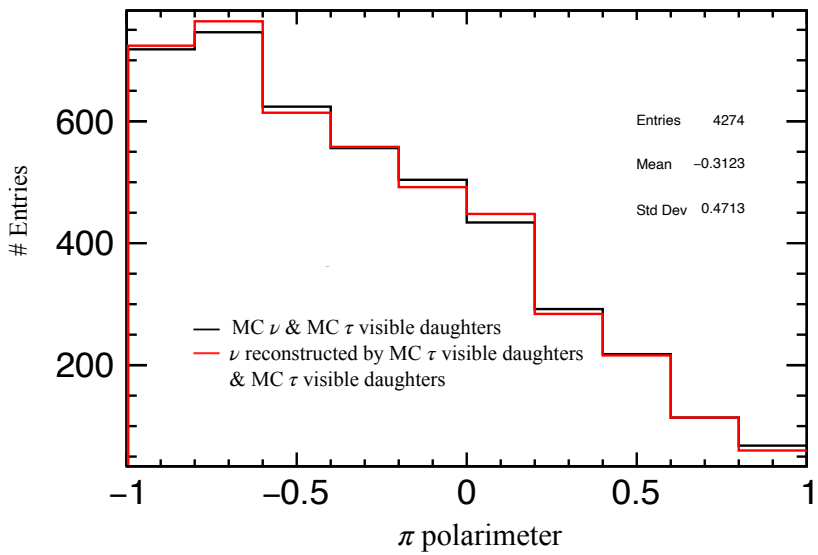
Both angles are about ~ 0.013 [rad] $= 0.74$ deg.
Reconstructed τ is close to MC τ direction.

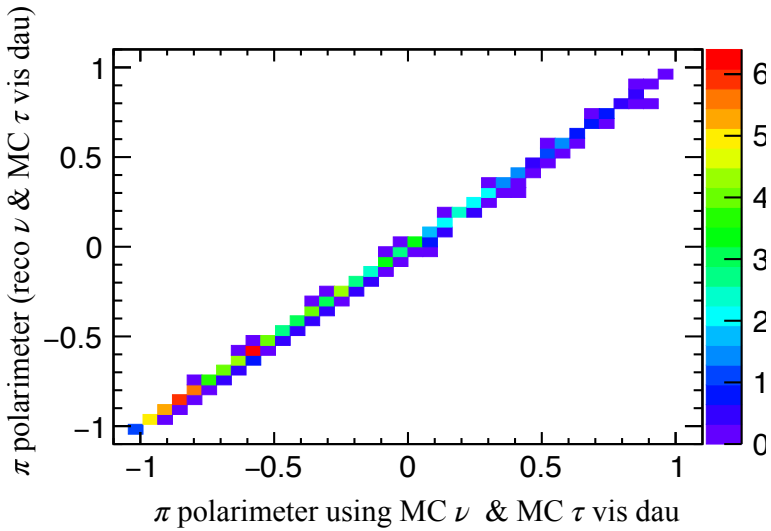
Polarimeter:single pi decay

Polarimeter vectors in τ rest frame.

$\boldsymbol{h}(\tau^{\pm} \to \pi^{\pm}\nu) \propto \boldsymbol{p_{\pi}}\pm$







using MC ν and MC τ visible daughters

using ν reconstructed by MC τ visible daughters

π polarimeter by MC ν and MC τ visible daughters vs

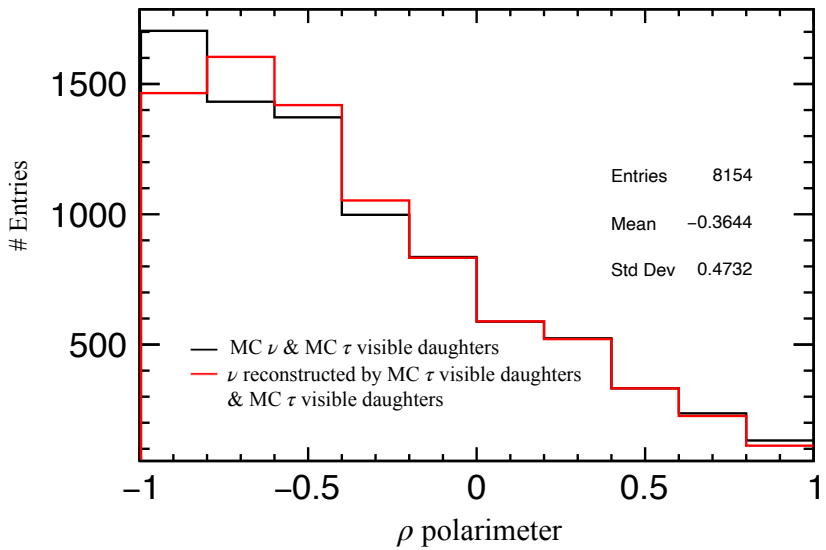
π polarimeter by reconstructed ν and MC τ visible daughters

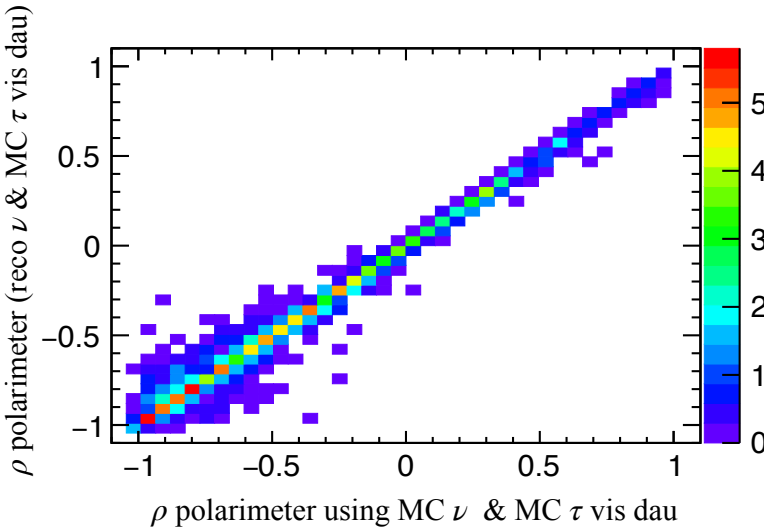
Polarimeter using reconstructed ν information is good agreement with MC one.

Polarimeter:rho decay

Polarimeter vectors in τ rest frame.

$$\boldsymbol{h}(\tau^{\pm} \to \pi^{\pm}\pi^{0}\nu) \propto m_{\tau}(E_{\pi^{\pm}} - E_{\pi^{0}})(\boldsymbol{p_{\pi^{\pm}}} - \boldsymbol{p_{\pi^{0}}}) + 2(p_{\pi^{\pm}} + p_{\pi^{0}})^{2}\boldsymbol{p_{\nu}}$$





using MC ν and MC τ visible daughters

using ν reconstructed by MC τ visible daughters

π polarimeter by MC ν and MC τ visible daughters vs

π polarimeter by reconstructed ν and MC τ visible daughters

Polarimeter using reconstructed ν information is roughly close to MC one.

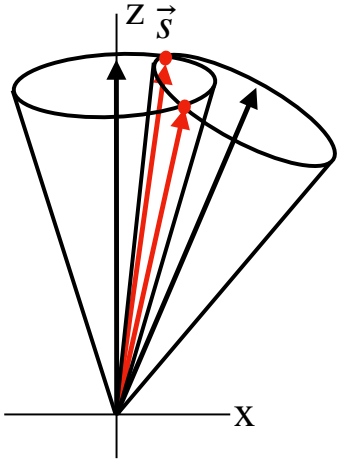
Summary and Future plan

- The reconstruction of neutirno momentum at ILC-250 was investigated
- "The cone method" works well so far.
- Reasonable agreement between MC truth polarimeter value and the one from the cone method for both $\pi\nu$ and $\rho\nu$ decay were found.

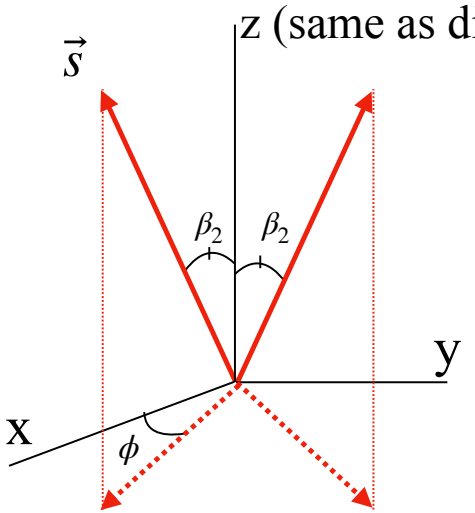
Future Plan

- ♢ Check the polarimeters for each tau decay modes without using true tau visible daughter from MC.
- ♢ Compare the result with eRpL sample result.
- ♢ Investigate the power of searching for new physics by using the tau polarisation.

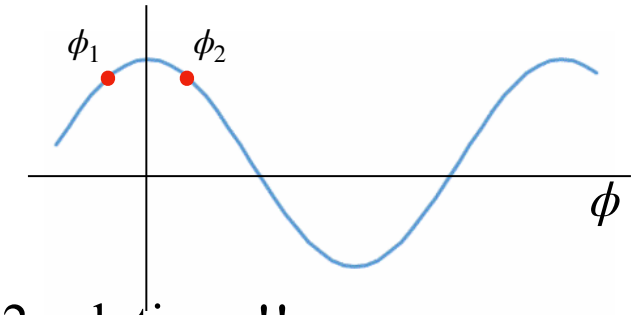
backup



$\vec{s}$:possible tau direction



$$\cos\phi = \frac{(1-\cos\theta_{cc})\cos_{\beta_1}}{\sin\beta_2 \sin\theta_{cc}}$$



2 solutions !!