Tau reconstruction study

Keita Yumino

10/02/2021 The 69th General Meeting of the ILC physics working group

Introduction

- e+e- -> τ+τ- in the ILC

  2f-z-leptonic sample@ILC250

- Tau reconstruction: Collinear approximation
  - Assume

    1-ISR photon

    neutrino is collinear with tau

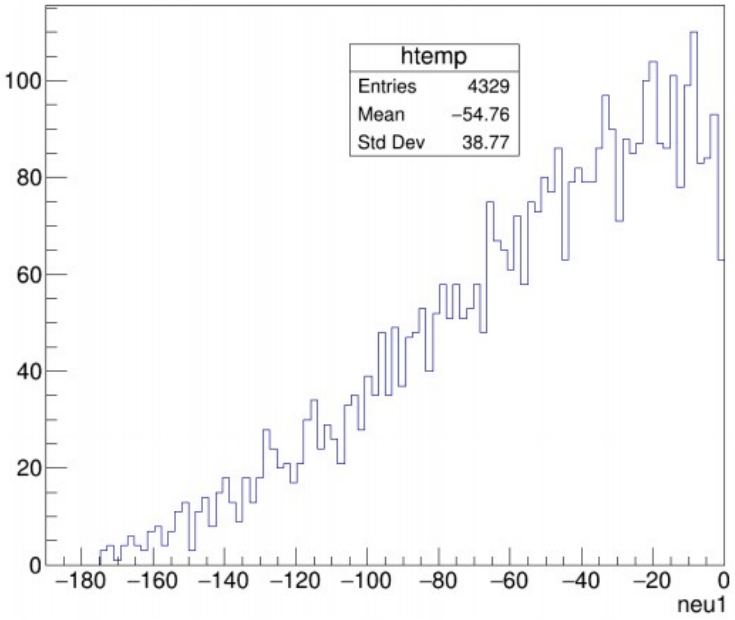
    Eτ = Ecm / 2

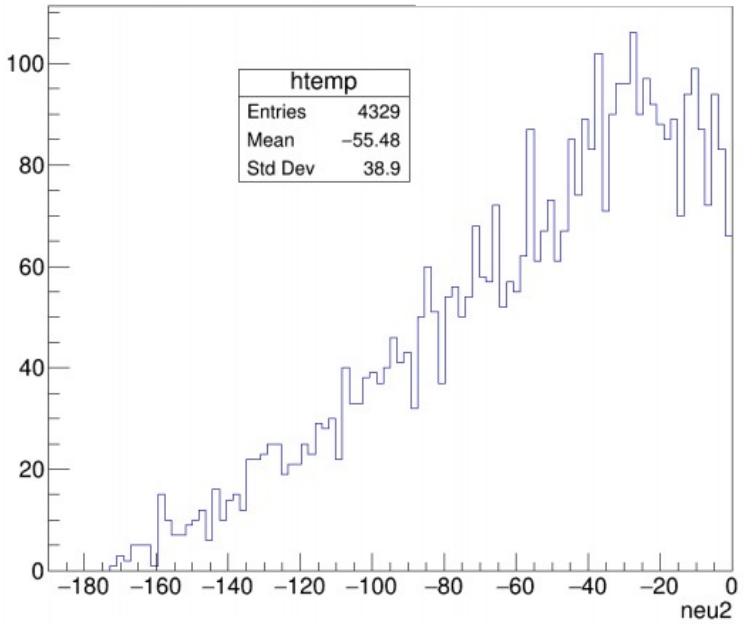
Background: w/o beam crossing angle

$$\Sigma P_x = P^{vis}_{\tau^- x} + P^{vis}_{\tau^+ x} + P^{1}_{\nu x} + P^{2}_{\nu x} = 0$$
$$\Sigma P_y = P^{vis}_{\tau^- y} + P^{vis}_{\tau^+ y} + P^{1}_{\nu y} + P^{2}_{\nu y} = 0$$

Collinear approximation

Pν // Pτ





if only ΣP_x and ΣP_y conservation are considered

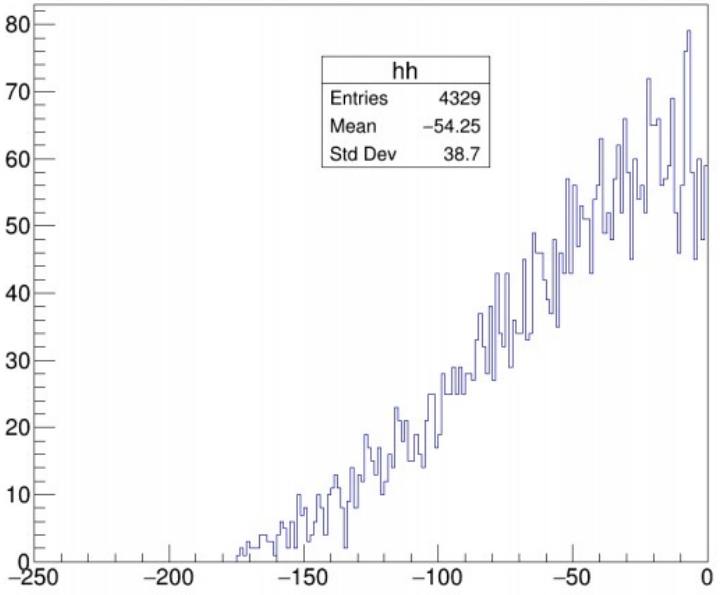
both E_ν, $E_{\bar{\nu}}$ are negative energy

collinear approximation doesn't work well

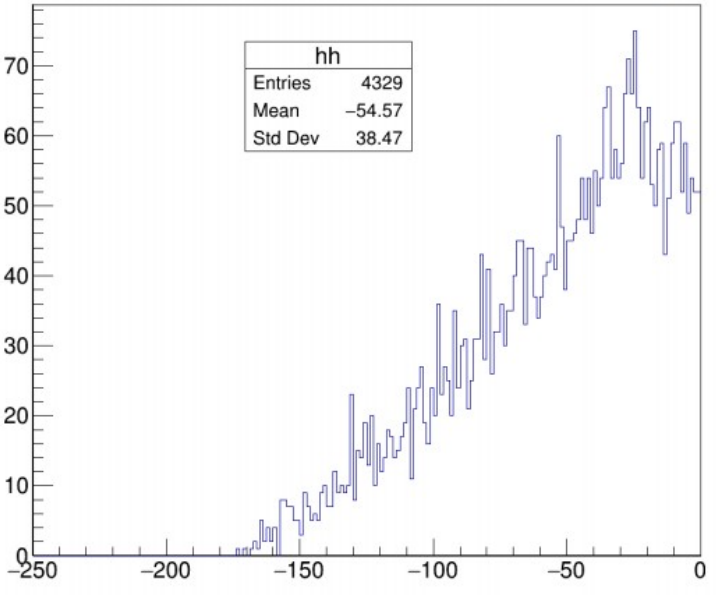
Background: w/ beam crossing angle

$$\Sigma P_x = P^{vis}_{\tau^- x} + P^{vis}_{\tau^+ x} + P^{1}_{\nu x} + P^{2}_{\nu x} = E_{CM} \sin\alpha \qquad \alpha = 7 \text{ mrad}$$

$$\Sigma P_y = P^{vis}_{\tau^- y} + P^{vis}_{\tau^+ y} + P^{1}_{\nu y} + P^{2}_{\nu y} = 0$$



if only ΣP_x and ΣP_y conservation are considered
and even if crossing angle is considered



both E_ν, $E_{\bar{\nu}}$ are negative energy

collinear approximation doesn't work well

Introduction

Collinear approximation doesn't work well

to reconstruct tau

another way of

Tau reconstruction: Cone method

- Assume

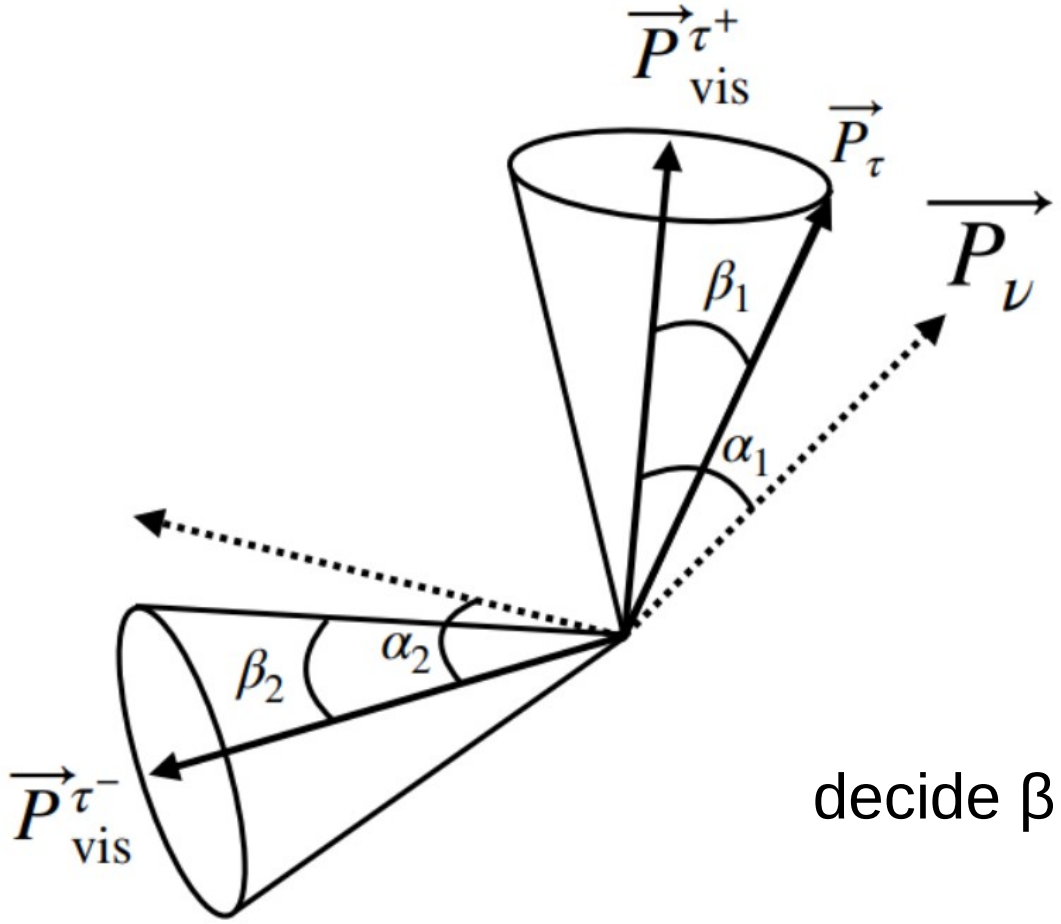
  tau-tau is back-to-back

  1-neutrino

  Eτ = Ecm / 2

very Preliminary...

Find tau visible daughters



α: angle between P_{vis} and P_{ν}

β: angle between P_{vis} and P_{τ}

Assume

tau-tau is back-to-back

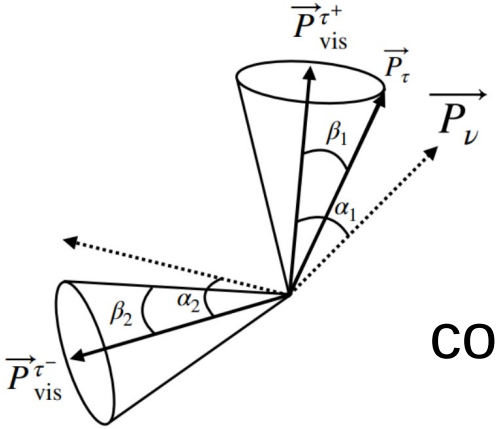
1-neutrino per tau

$E_{\tau} = E_{cm} / 2$

decide β by α

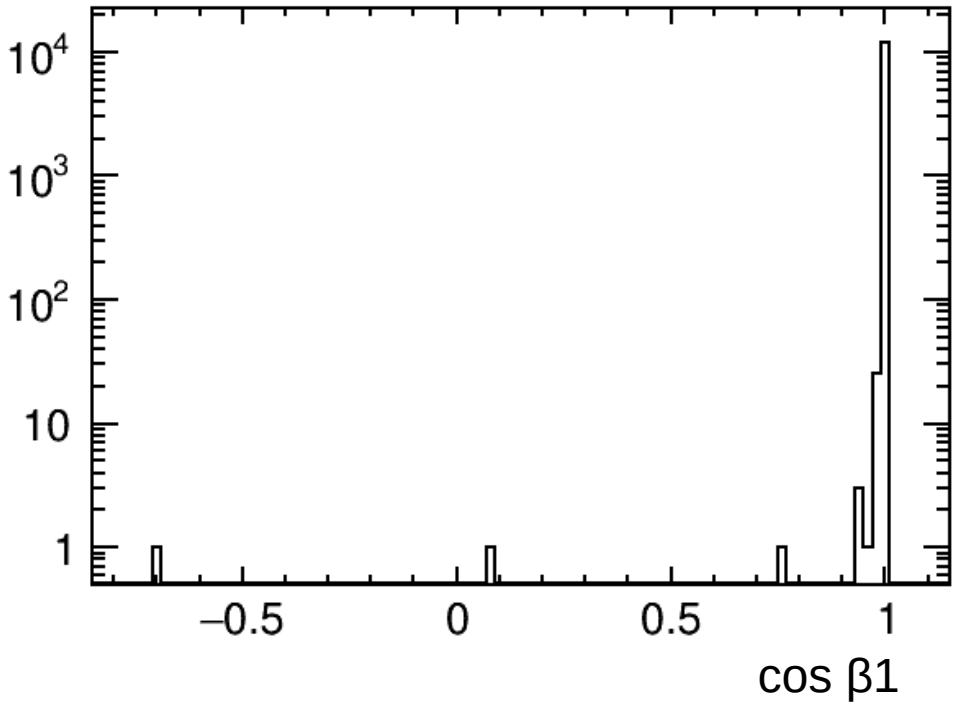
$$\cos\beta = \frac{\overrightarrow{|P_{vis}|}^2 + |P_{vis}| E_{\nu} cos\alpha}{|\overrightarrow{P_{\tau}}| |\overrightarrow{P_{vis}}|}$$

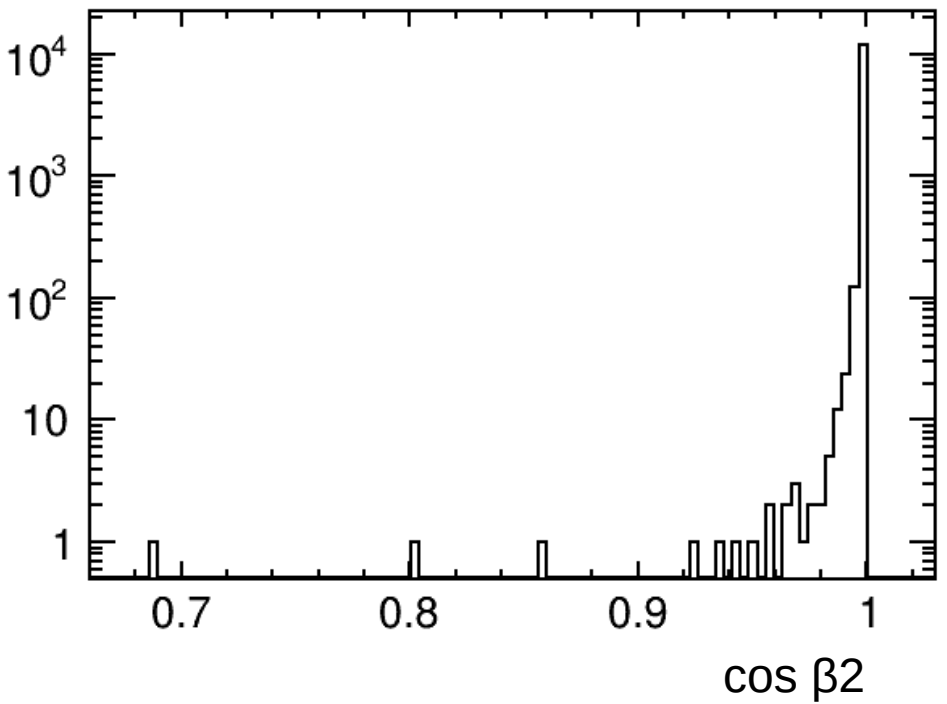
cosβ distribution



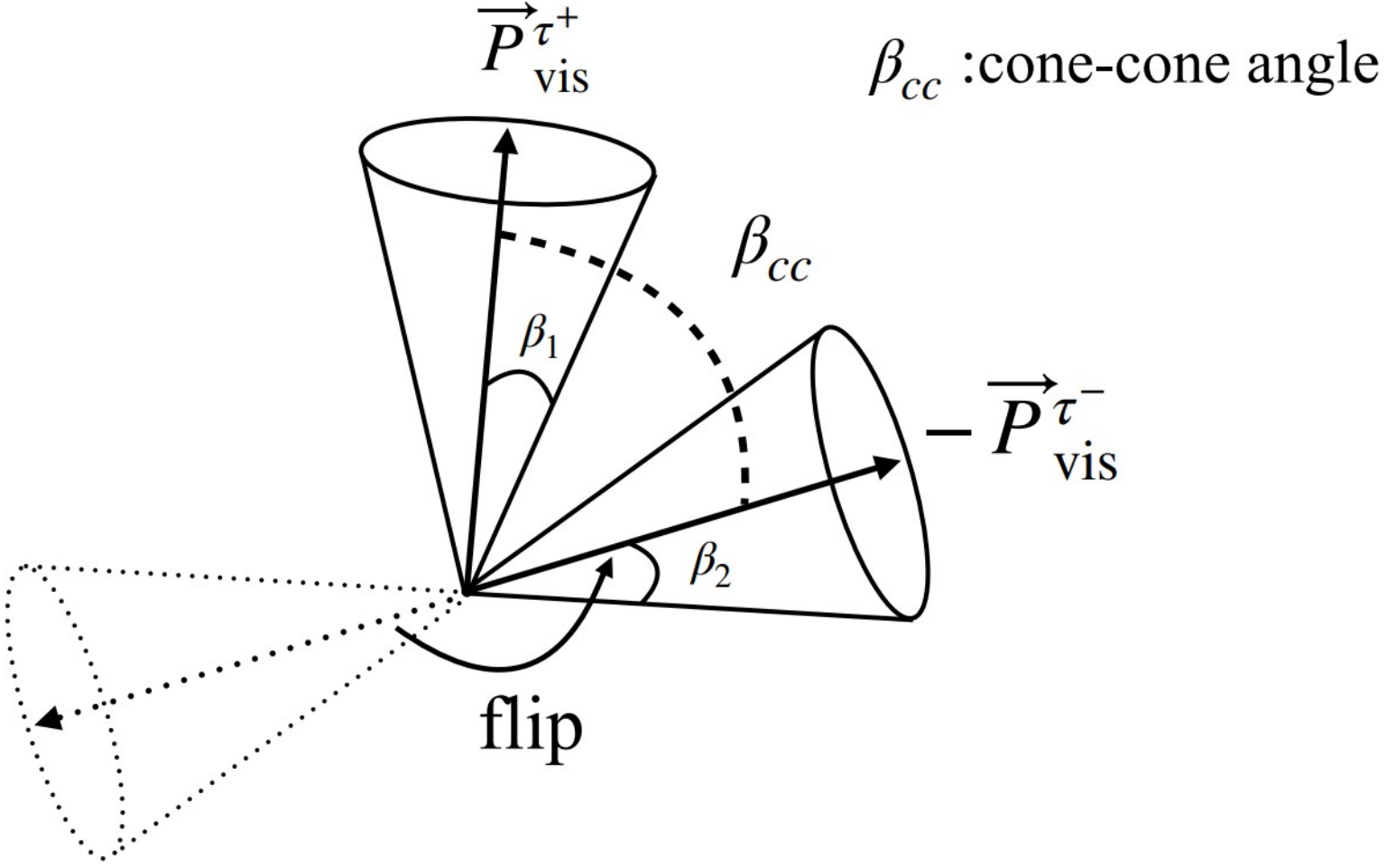
cosβ should be close to 1

mττ >240 GeV

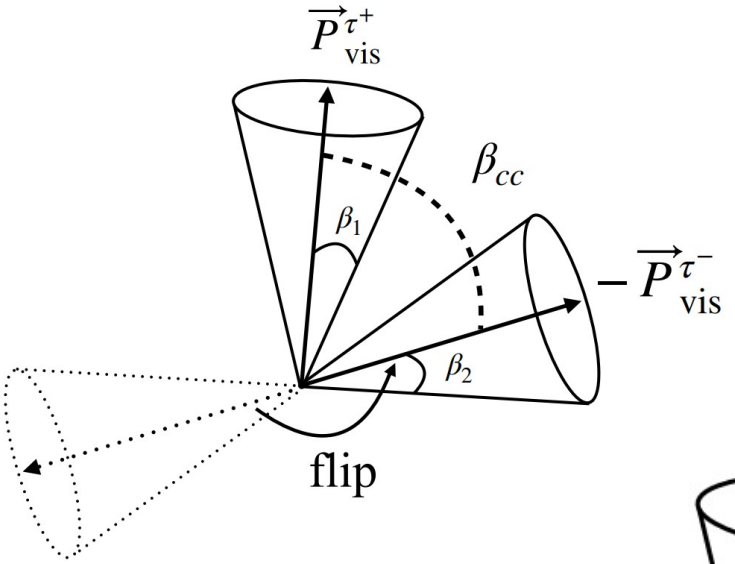


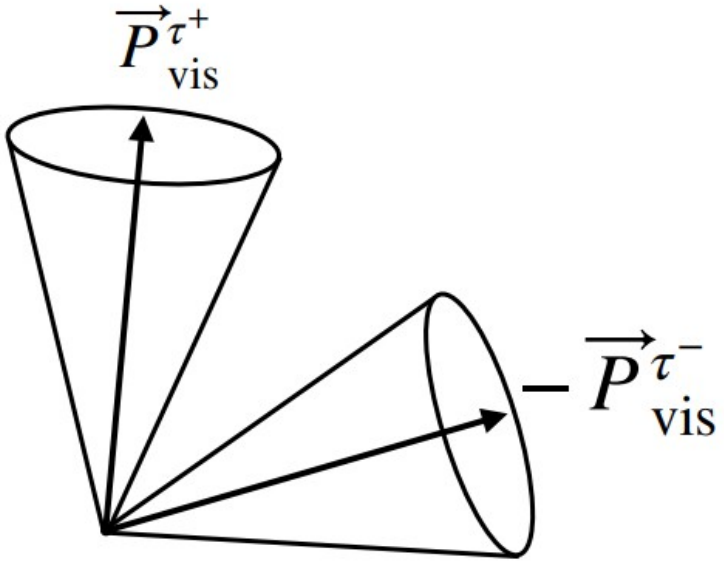


Flip one of tau visible daughter



Find Solutions





if

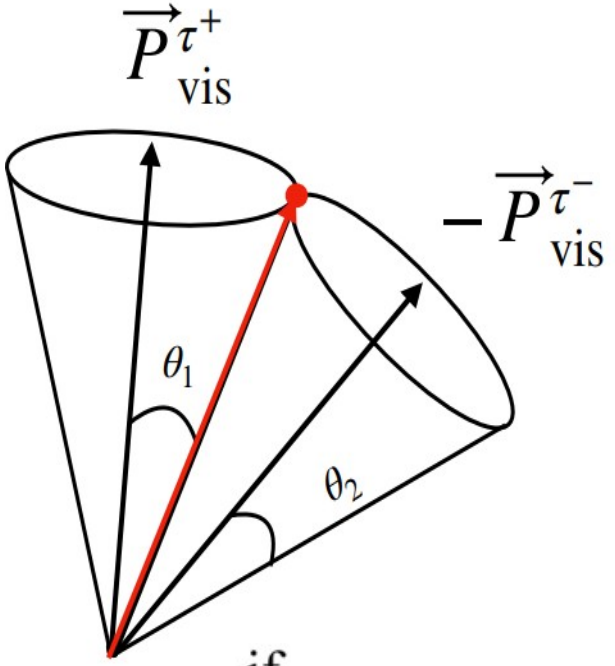
$$\beta_1 + \beta_2 < \beta_{cc}$$

then

NO solutions

tau-tau is not back-to-back

Find Solutions

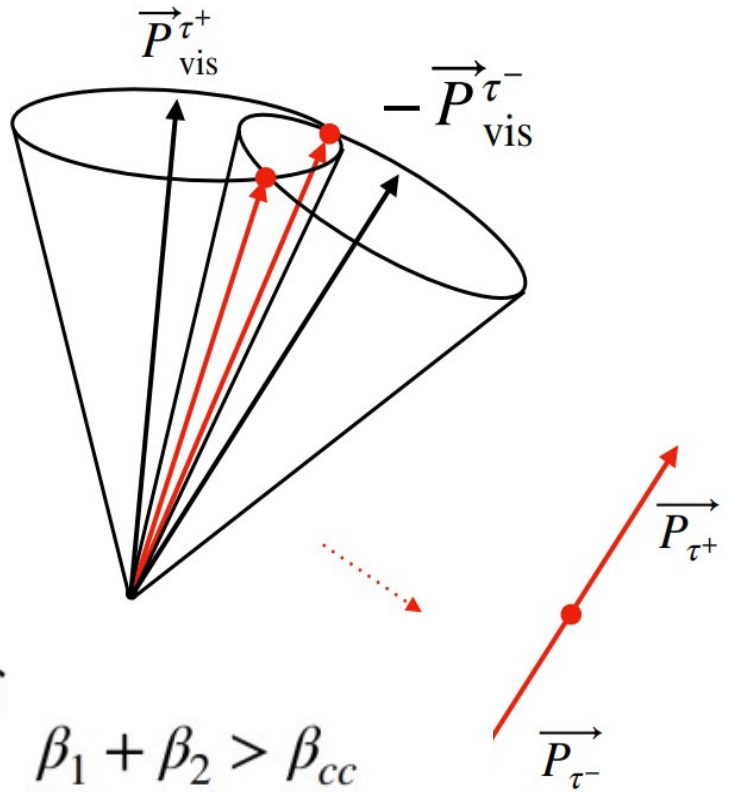


if

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

then

1 possible solution



if

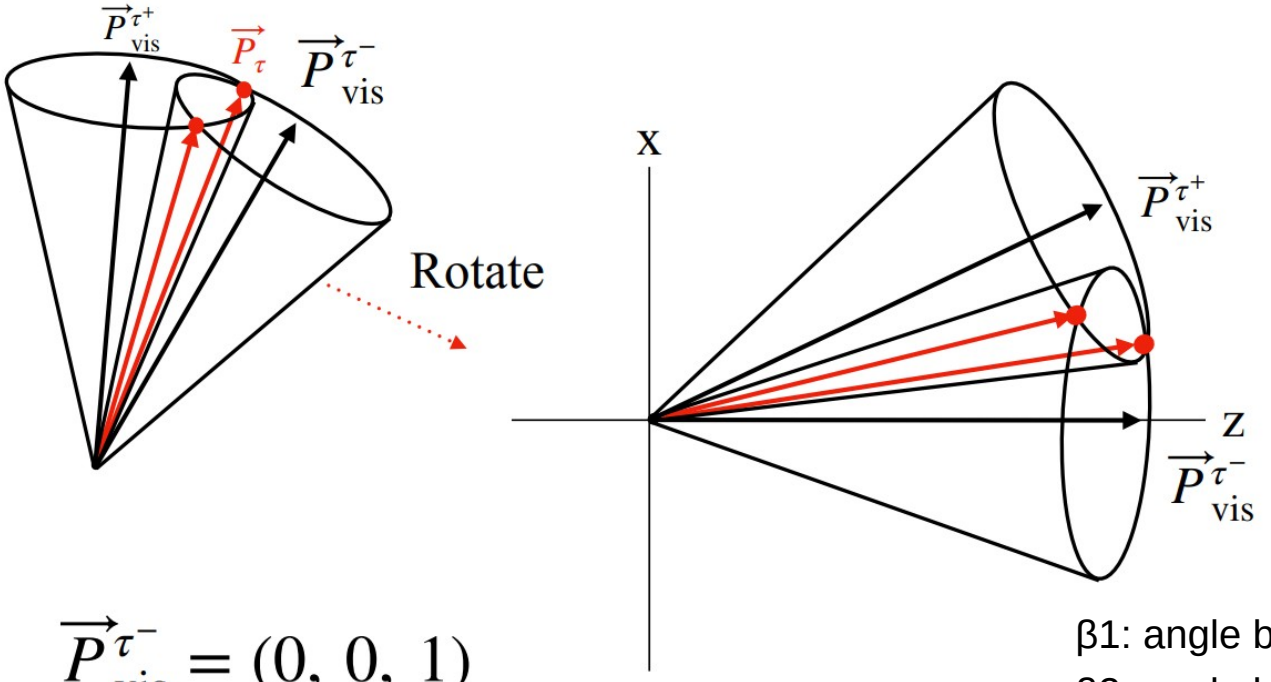
$$\beta_1 + \beta_2 > \beta_{cc}$$

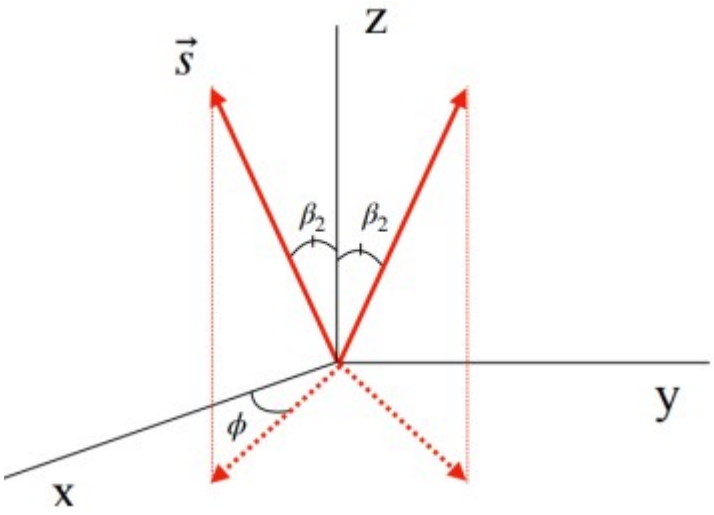
then

2 overlapped points

→2 possible solutions

Rotated to z-direction



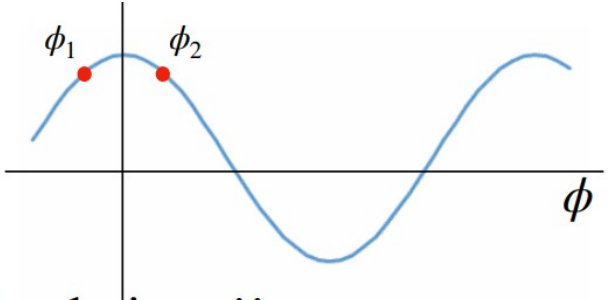


$$\overrightarrow{P}^{\tau^-}_{\text{vis}} = (0,\ 0,\ 1)$$

$$\overrightarrow{P}^{\tau^+}_{\text{vis}} = (\sin\theta_{cc},\ 0,\ \cos\theta_{cc})$$

β1: angle between P_{vis+} and $P_{\tau+}$

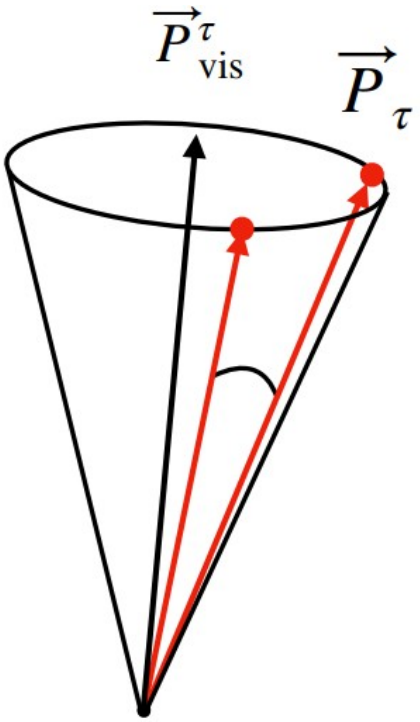
β2: angle between P_{vis-} and $P_{\tau-}$

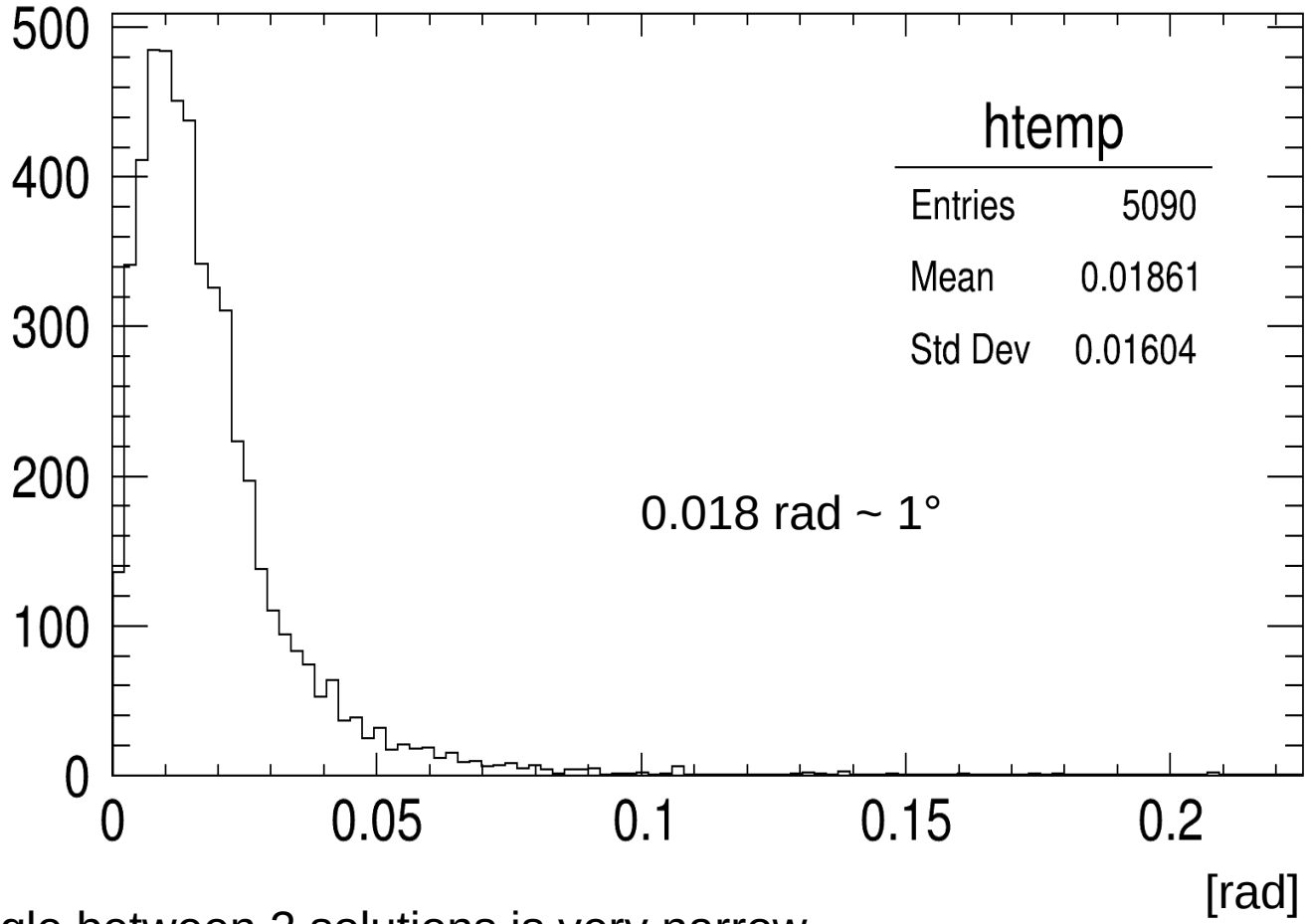


Find Φ to find 2 solutions

2 solutions !!

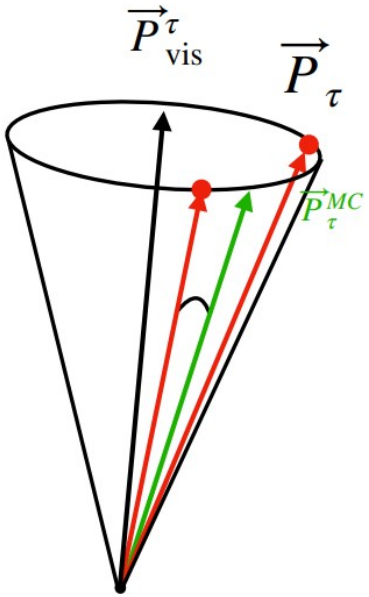
Angle between 2 solutions

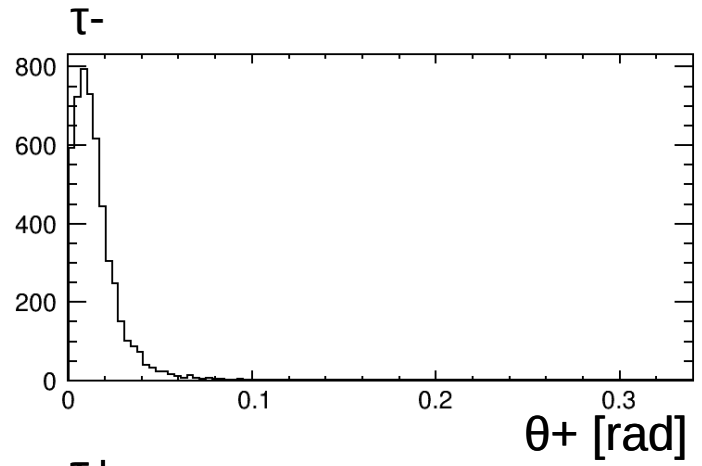


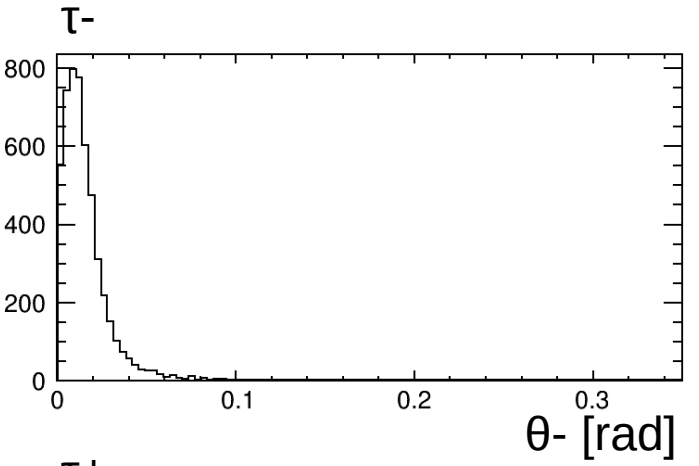


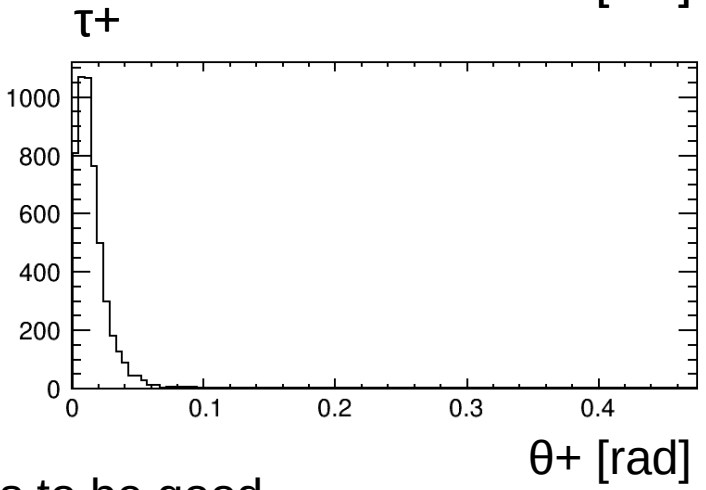
angle between 2 solutions is very narrow

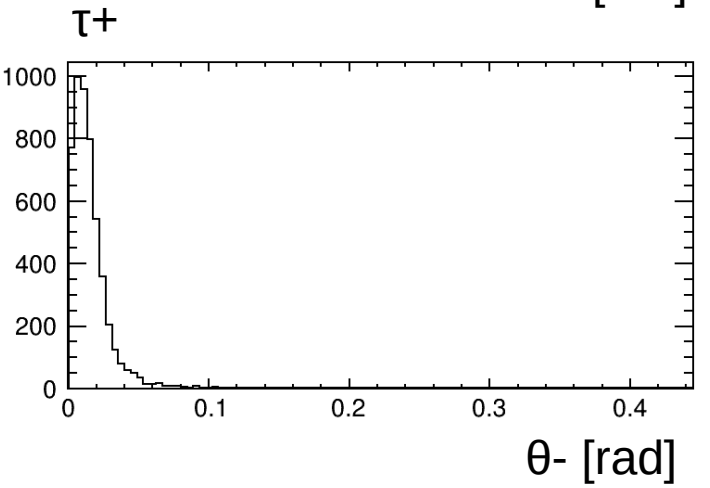
Angle between MC tau and reconstructed tau





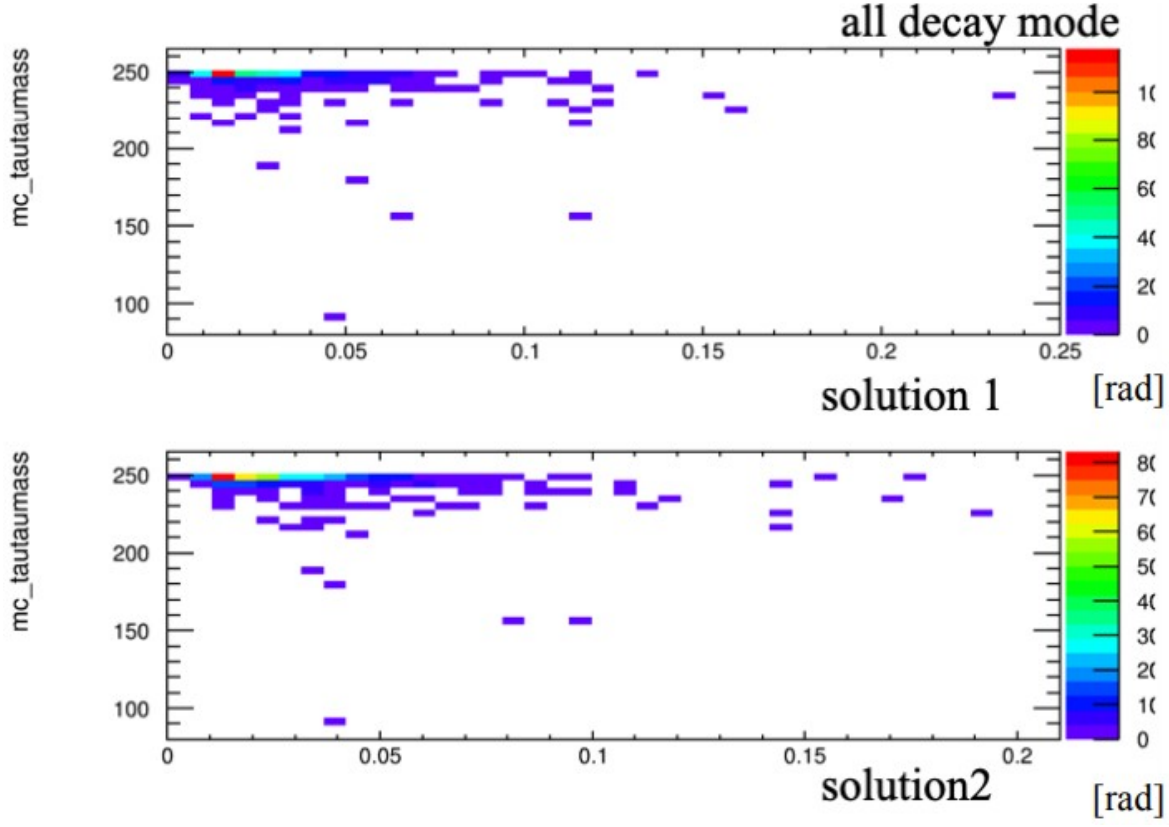


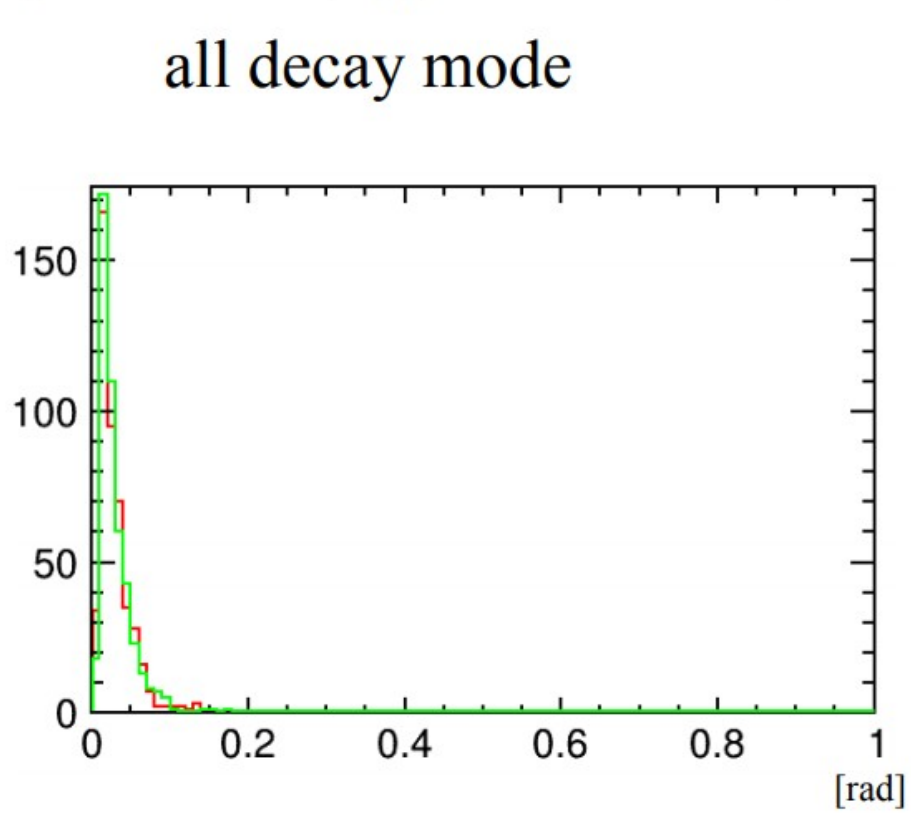




both solution seems to be good

Angle between MC tau and reco tau vs $m_{\tau\tau}$



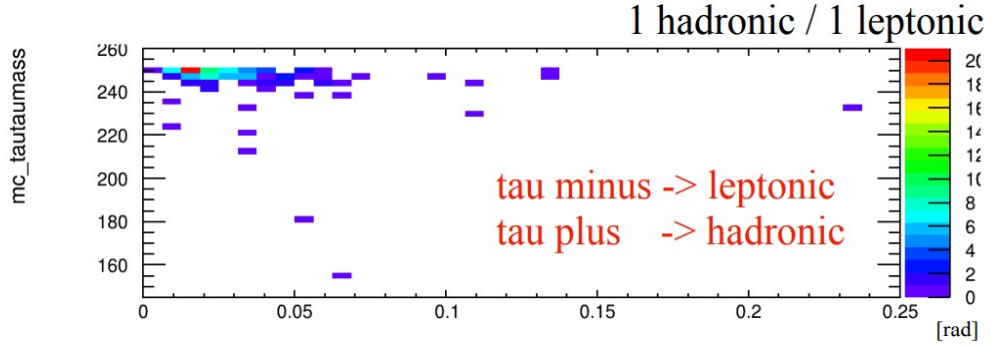


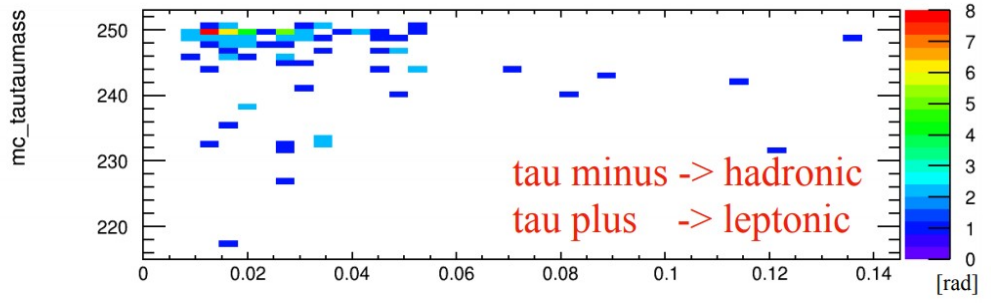
Angle between MC tau and reco tau vs $m_{\tau\tau}$

1 tau → hadronic / another → leptonic

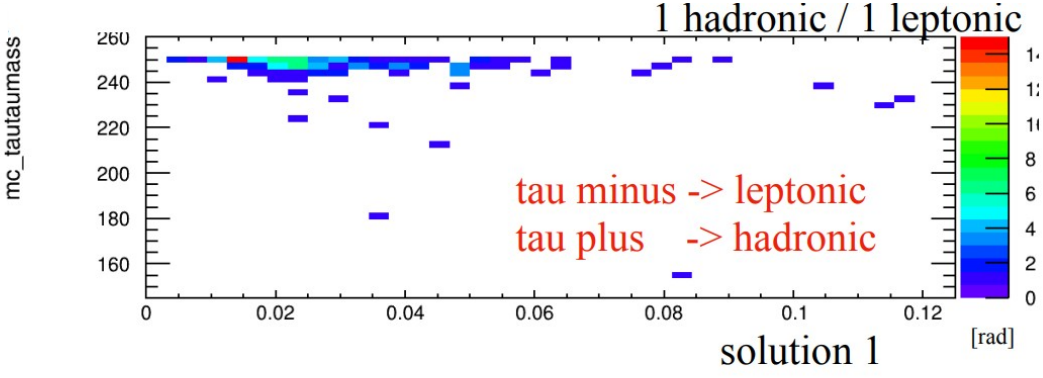
for each solutions

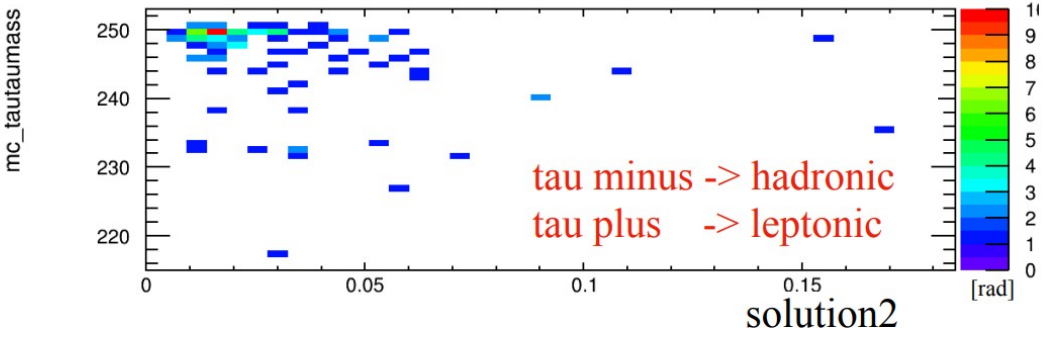
solution 1





solution 2





in principle there are no difference

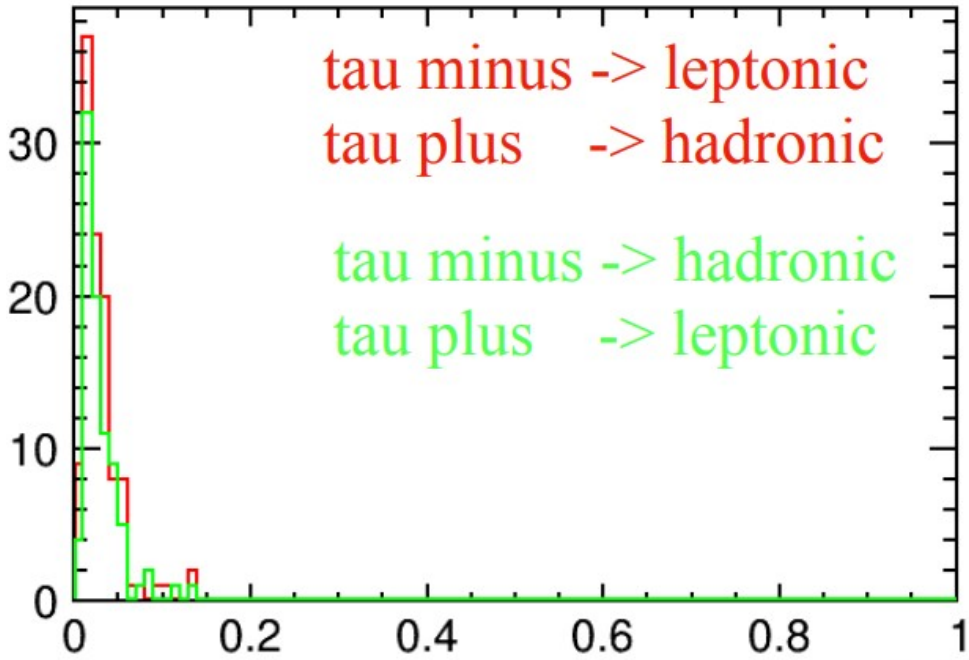
Angle between MC tau and reco tau vs $m_{\tau\tau}$

projection X ($m_{\tau\tau} > 240$ GeV)

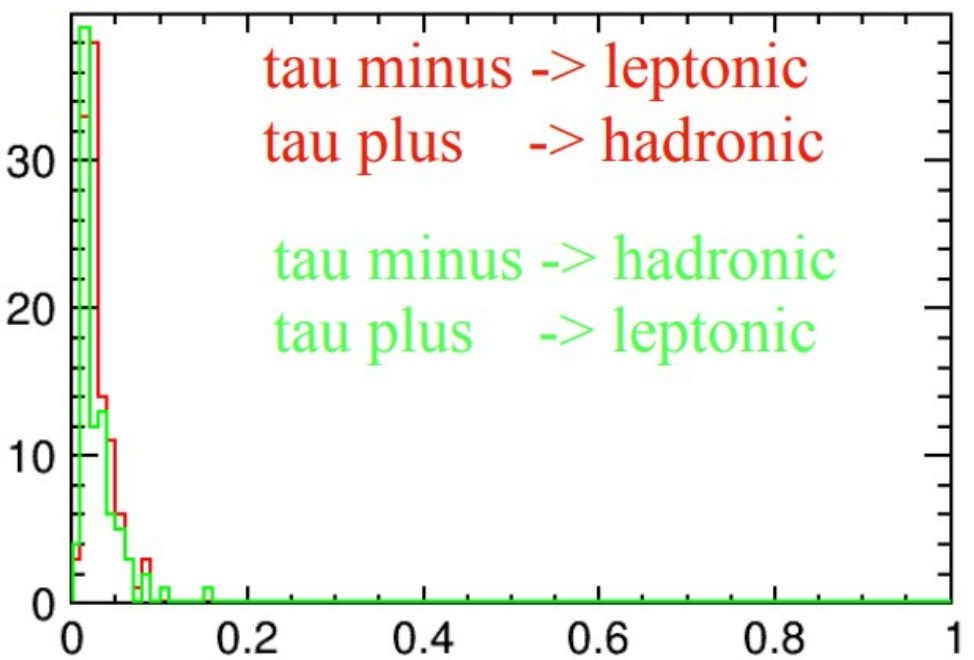
1 tau → hadronic / another → leptonic

1 hadronic / 1 leptonic

solution 1



solution 2



there are some difference between solution 1 and solution 2

need to investigate the cause of this difference...

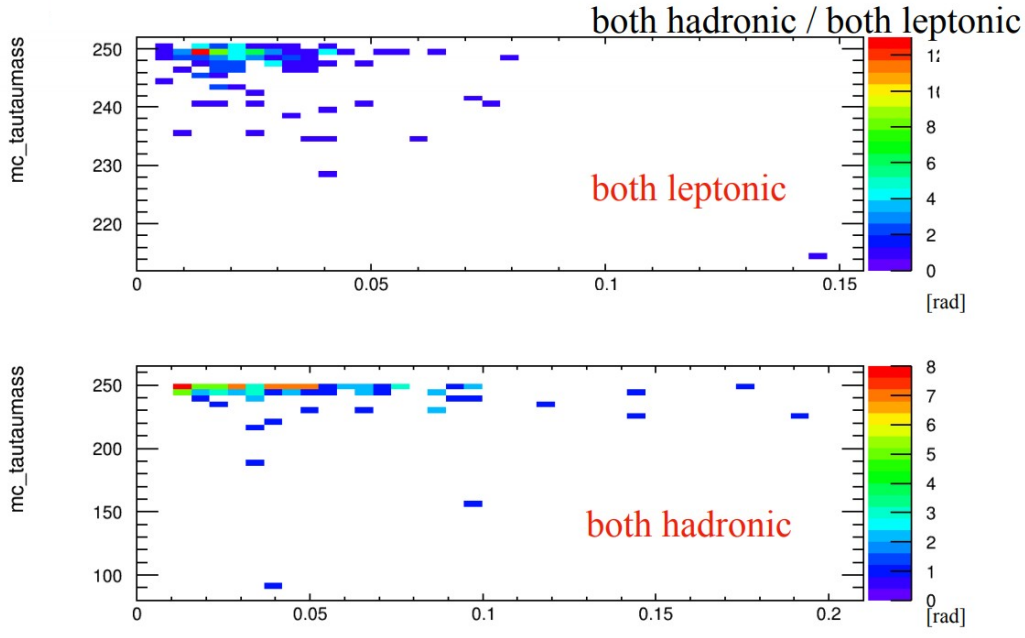
Angle between MC tau and reco tau vs $m_{\tau\tau}$

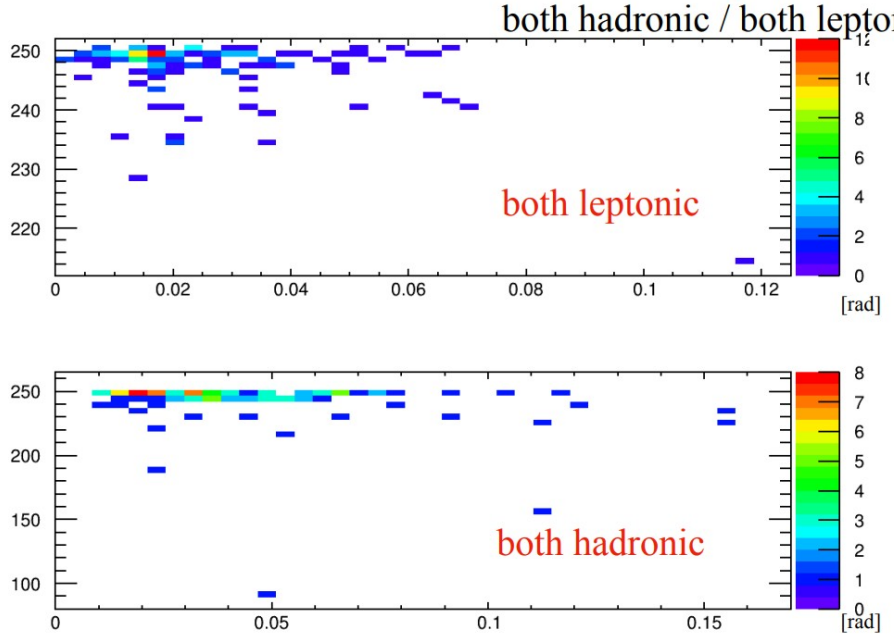
both tau → hadronic / another → leptonic

for each solutions

solution 1

solution 2





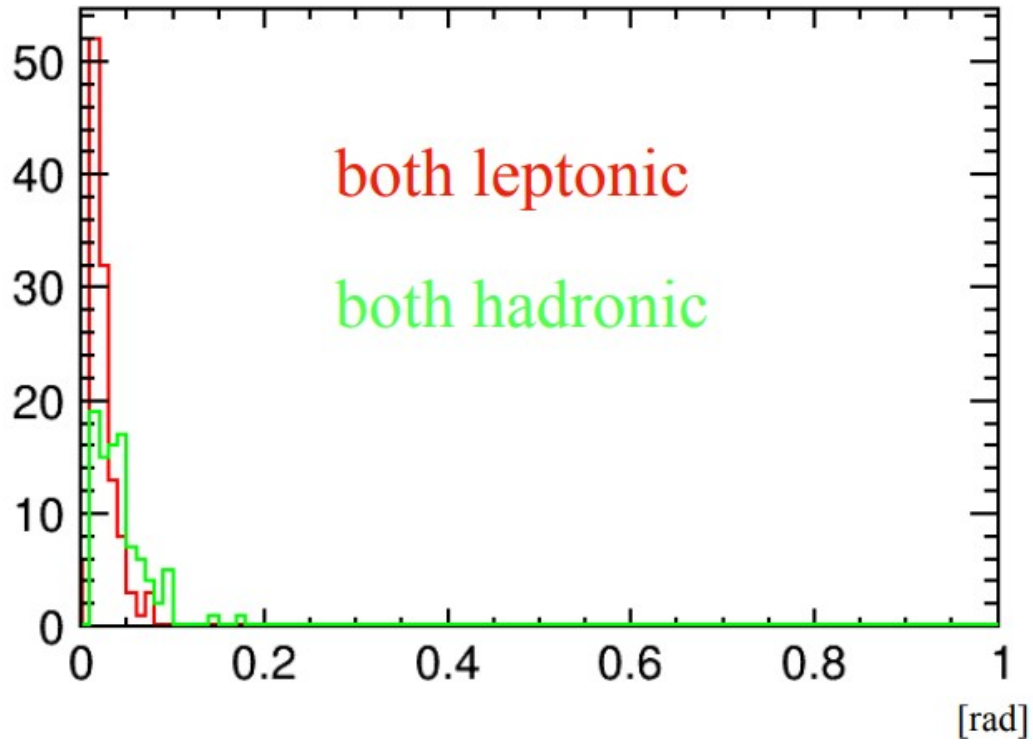
in principle this method works better in both tau → hadronic decay than both tau → leptonic decay because of number of neutrinos

Angle between MC tau and reco tau vs $m_{\tau\tau}$

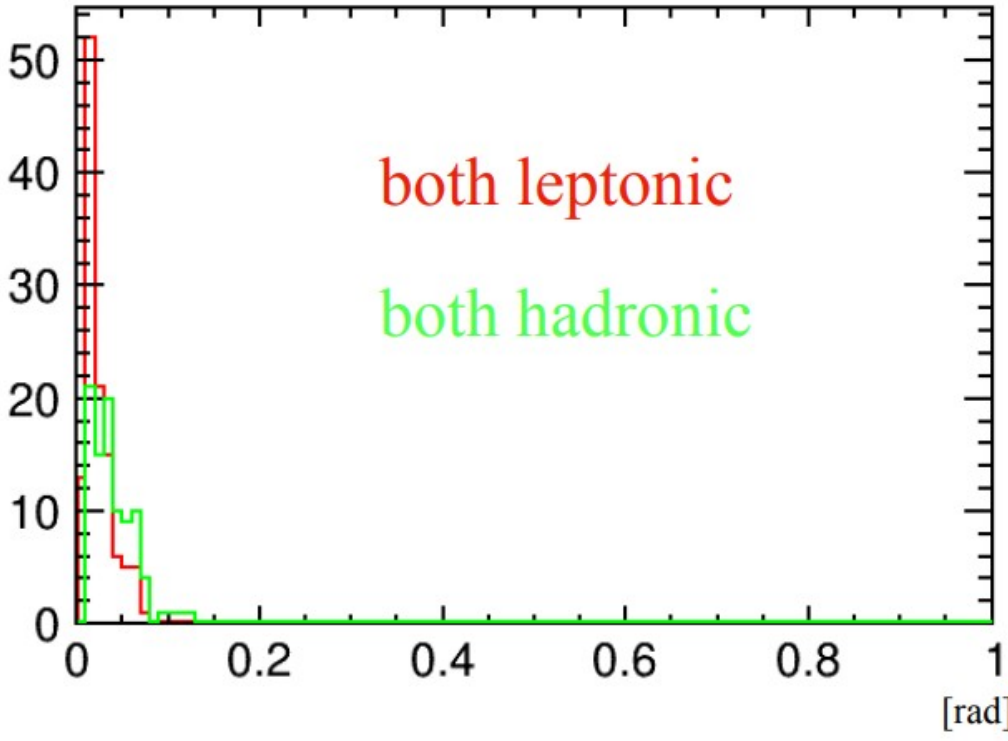
projection X ($m_{\tau\tau} > 240$ GeV)

both tau → hadronic / another → leptonic

solution 1



solution 2

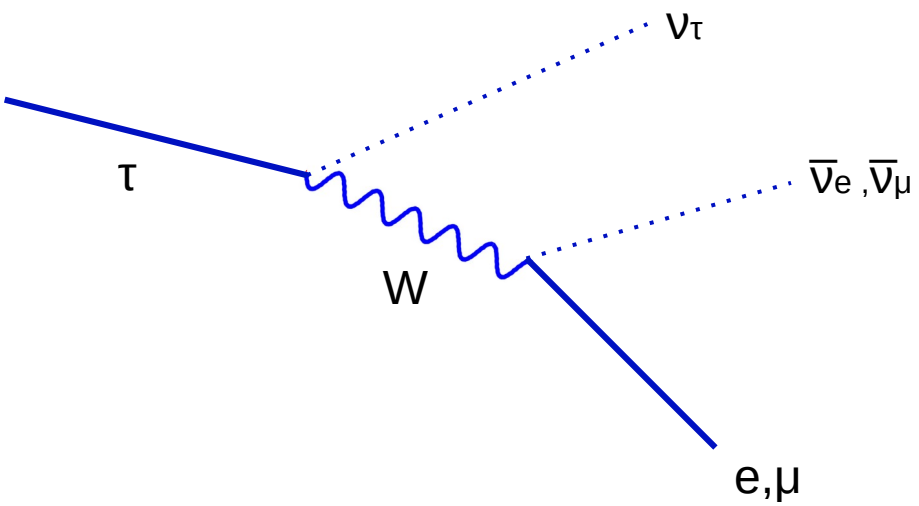


the results are the opposite to expectation…

Summary

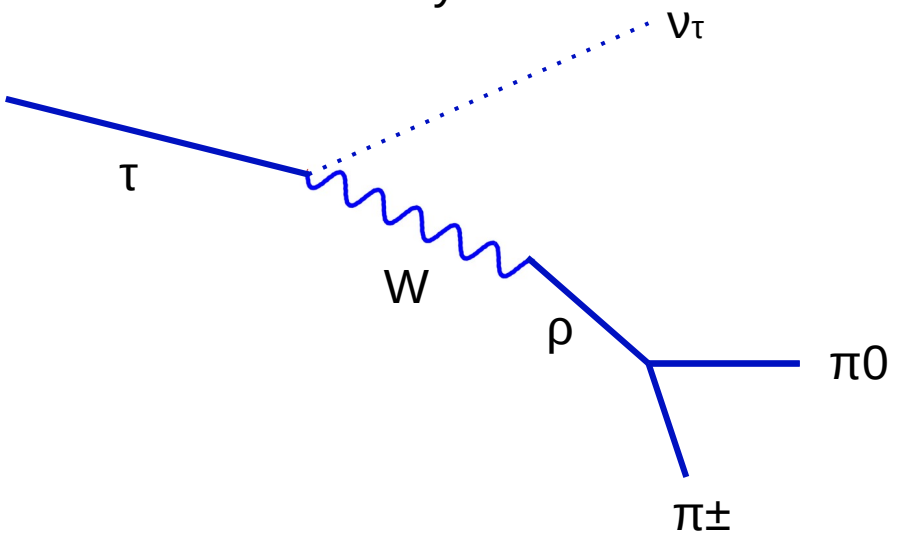
- Collinear approximation doesn’t work well so far.
- Working on cone method as a next step.
- There are some problems to investigate the reason...

leptonic decay



2 neutrino per tau

hadronic decay



1 neutrino per tau