$e^+e^- \to \tau^+ \tau^-$

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Introduction

- Tau-lepton

Tau-lepton is the heaviest lepton.

$m_\tau = 1776.86 \pm 0.12 \quad \text{MeV}$

$\tau^+\tau^-$ pair is the dominant leptonic decay of the Higgs boson.

Motivation

Correct reconstruction of tau decay mode is important for

- Constraining the spin state of tau
- Measuring the CP state of Higgs boson in $H \to \tau^+\tau^-$ decays

tau reconstruction needs particle flow

- total jet energy
- properties of each particle in jet

Motivation

– $e^+e^- \rightarrow \tau^+\tau^-$ at 500 GeV

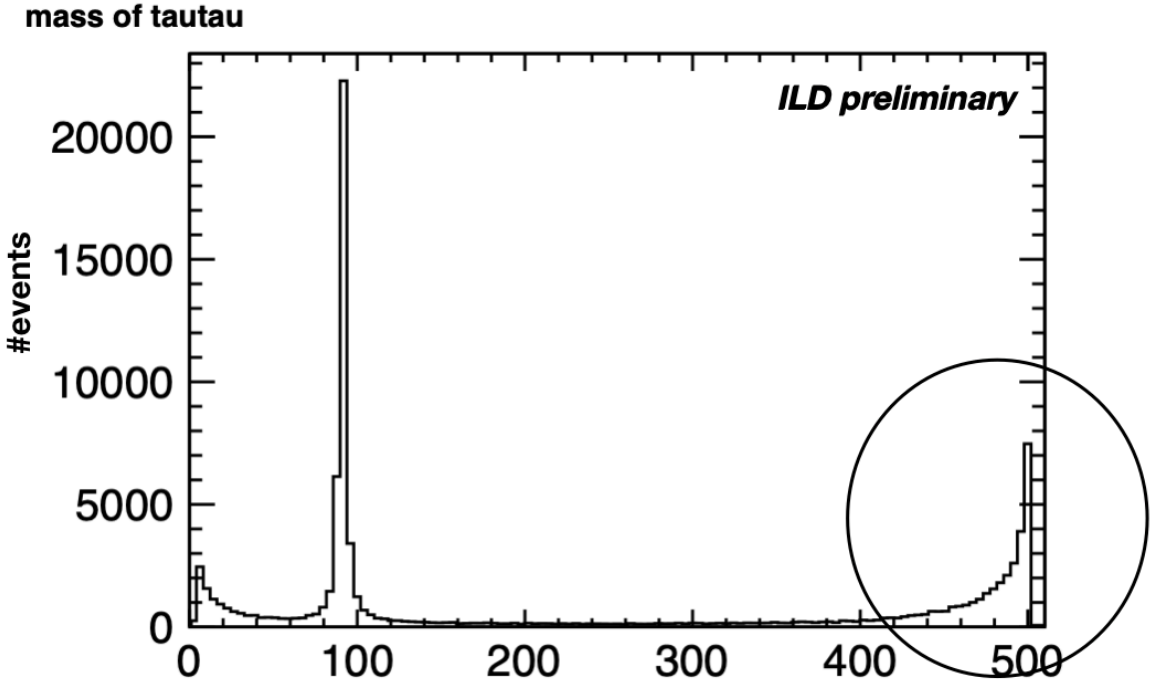
–Study coupling of $\tau_{\mathrm{L,R}}$ to Z, γ

–compare Large & Small detectors

Simulation setup

Signal: $e^+e^- \rightarrow \tau^+\tau^-$

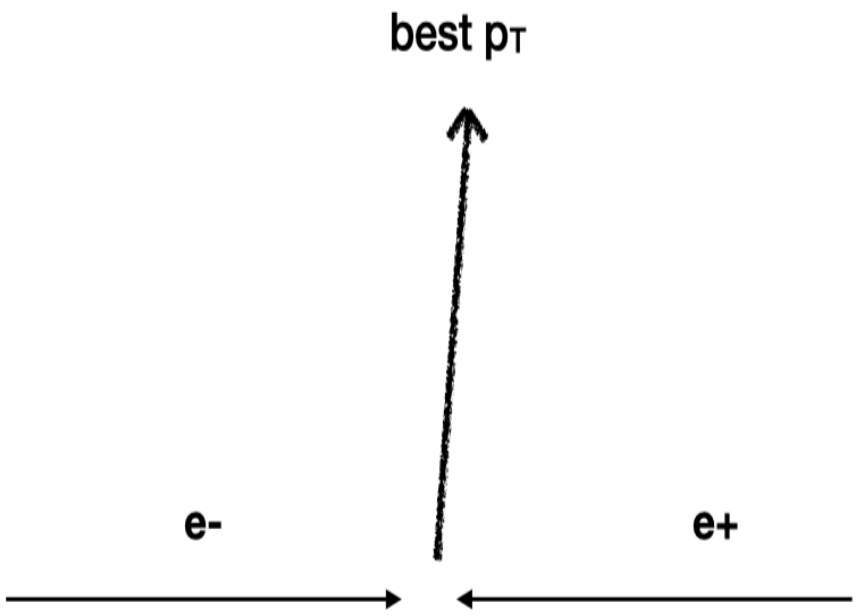
- High mass $\tau\tau$: m($\tau\tau$)>480 [GeV]
- Low mass $\tau\tau$: m($\tau\tau$)<480 [GeV]



Method

1:Find first τ seed

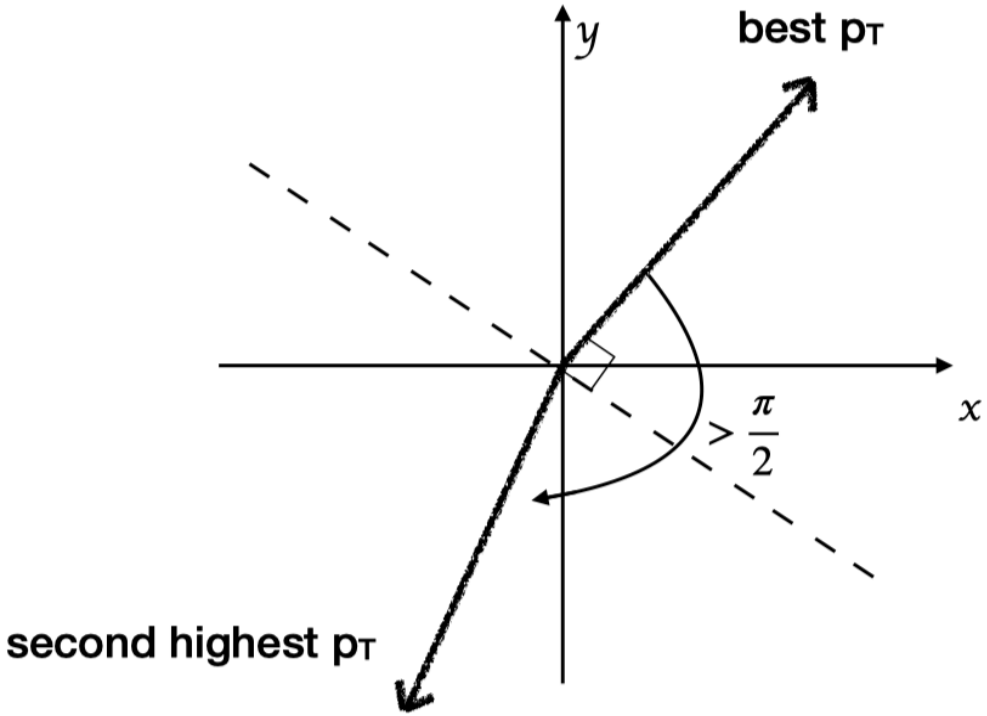
- charged PFO with highest p_T



Method

2:Find second τ seed

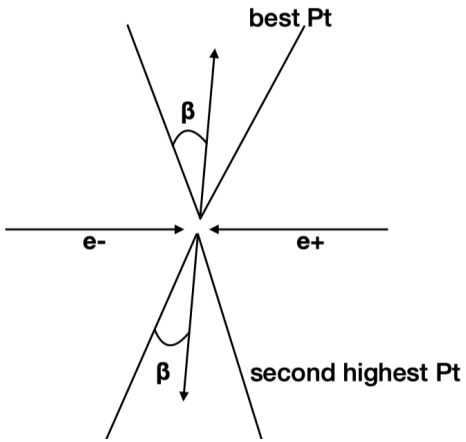
- charged PFO with second highest p_T and $\delta\phi > \pi/2$

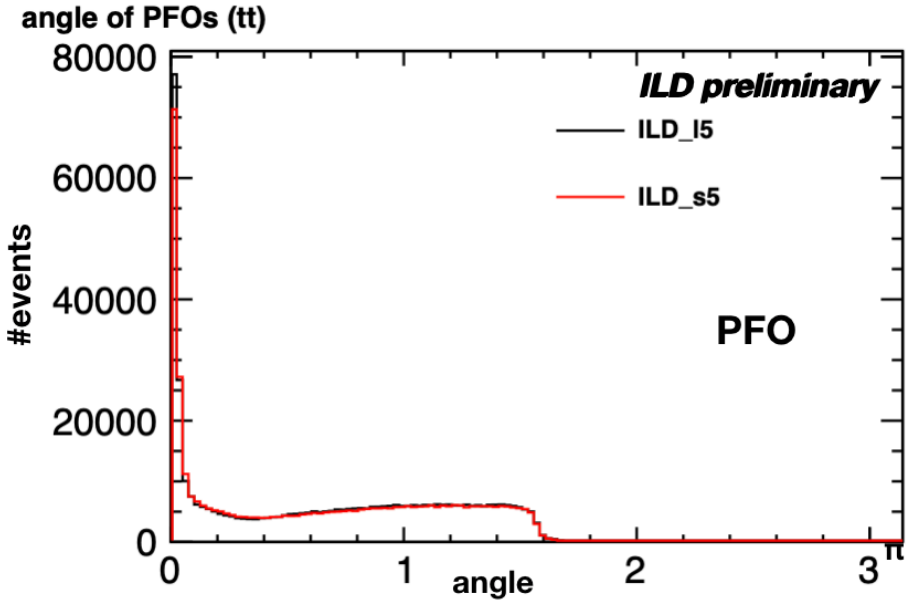


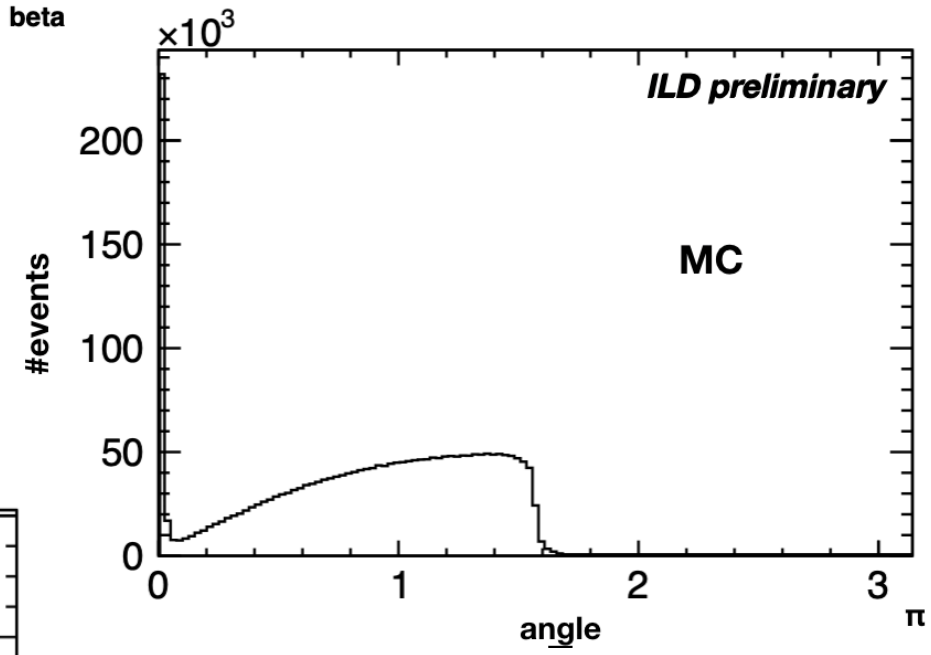
Method

3:Make cones

- Make cones to find τ jets





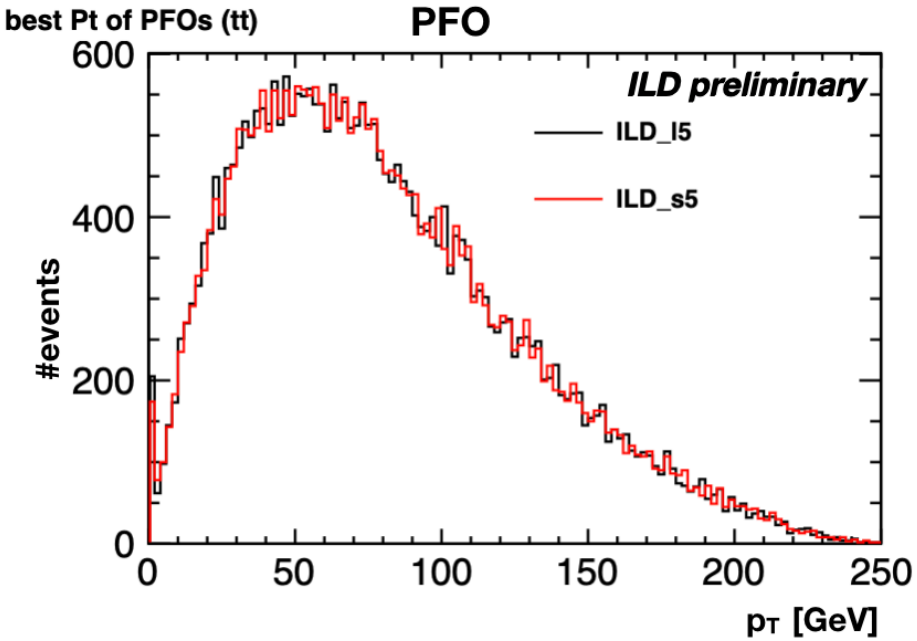


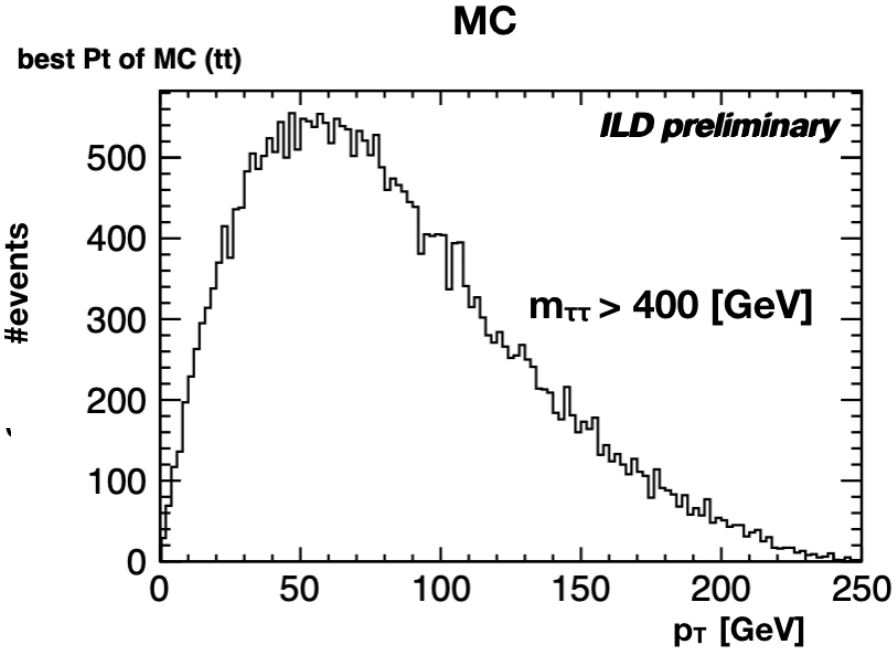
most particles are in a range of $\beta < 0.1$ $[rad]$

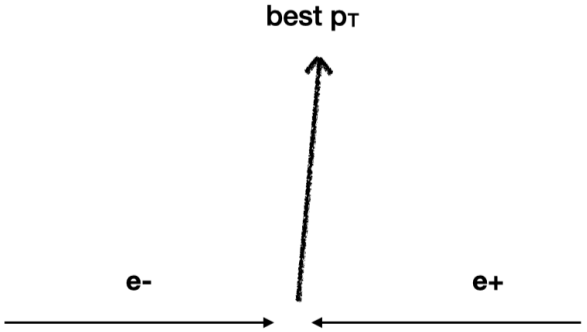
Result

- Highest p_T

test on MC truth
check on PFO level



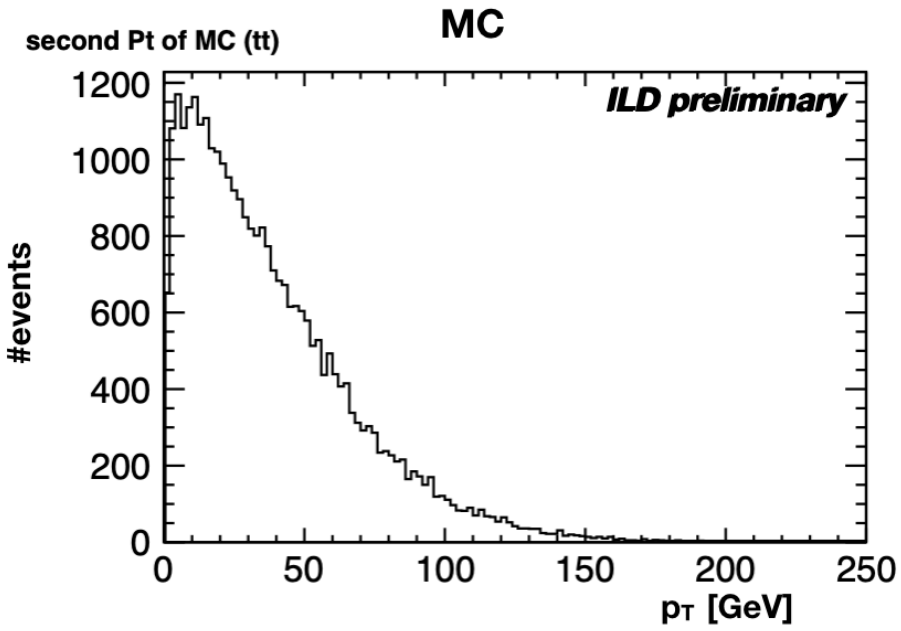


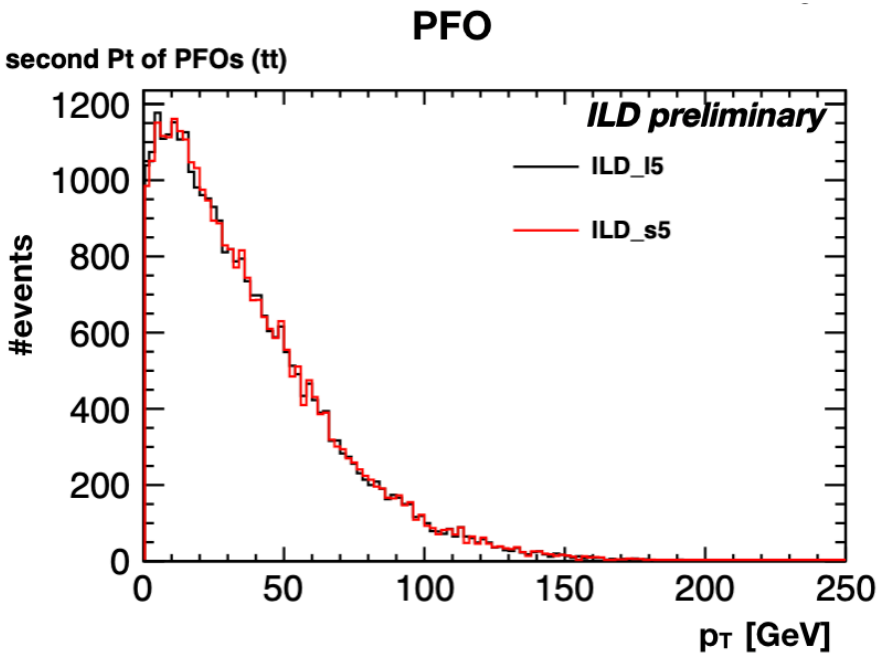


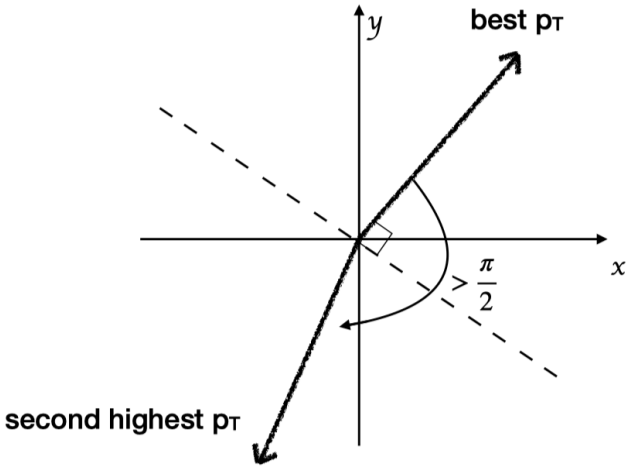
Result

- Second highest p_T

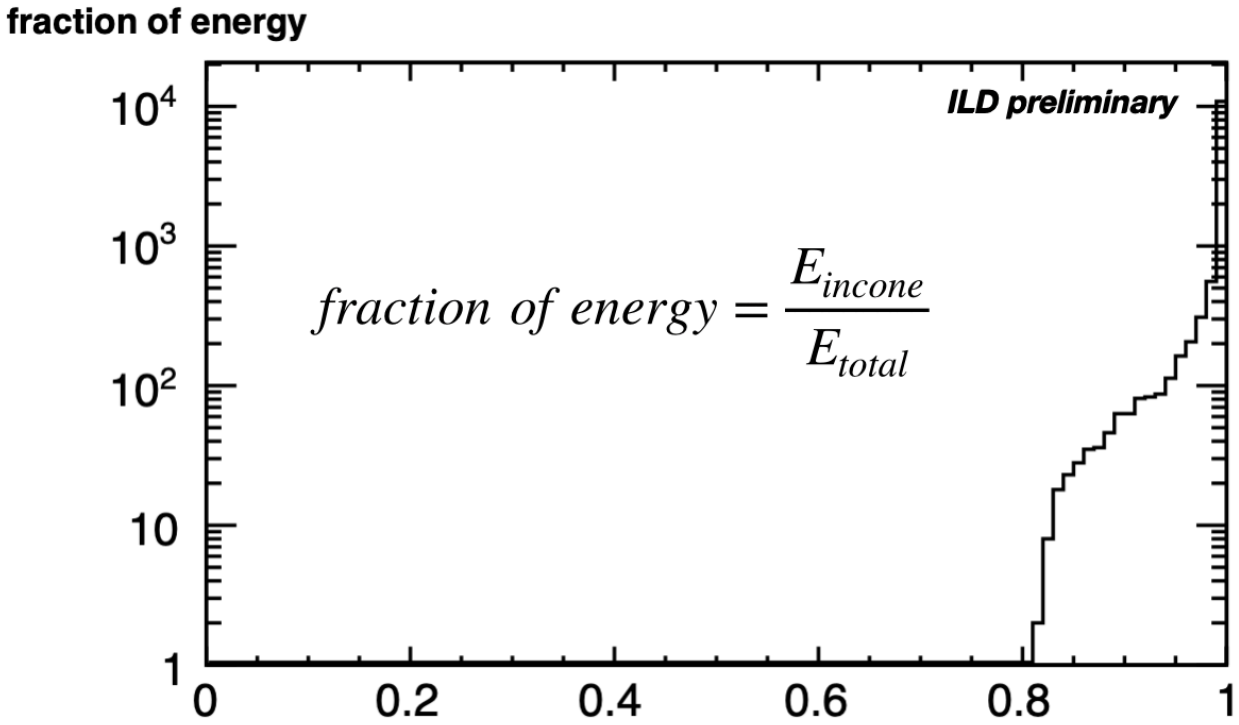
test on MC truth
check on PFO level







Result

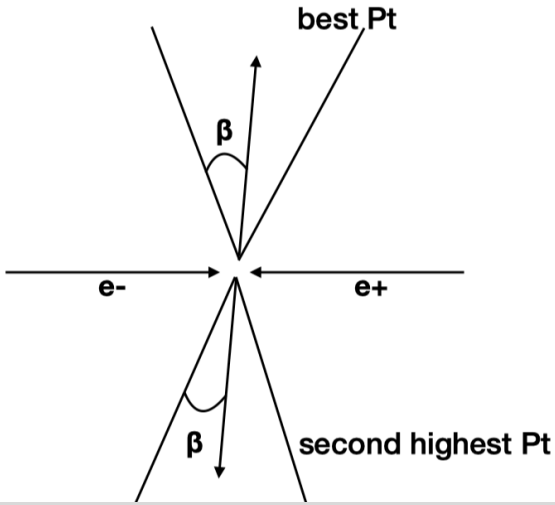


how much energy is inside cone

E_{incone} :sum of tau daughter's energy inside cone

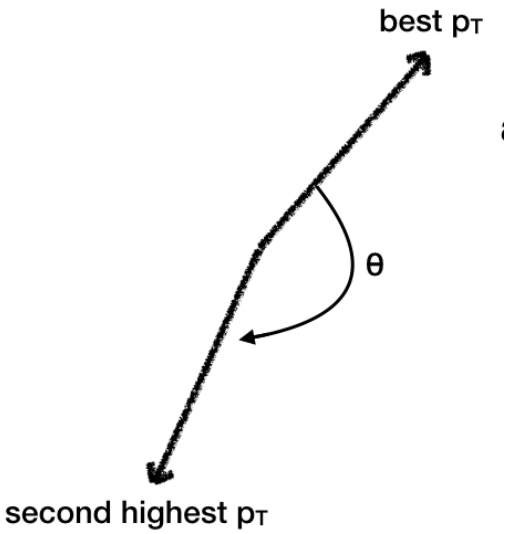
E_{total} :sum of tau daughter's energy inside and outside cone

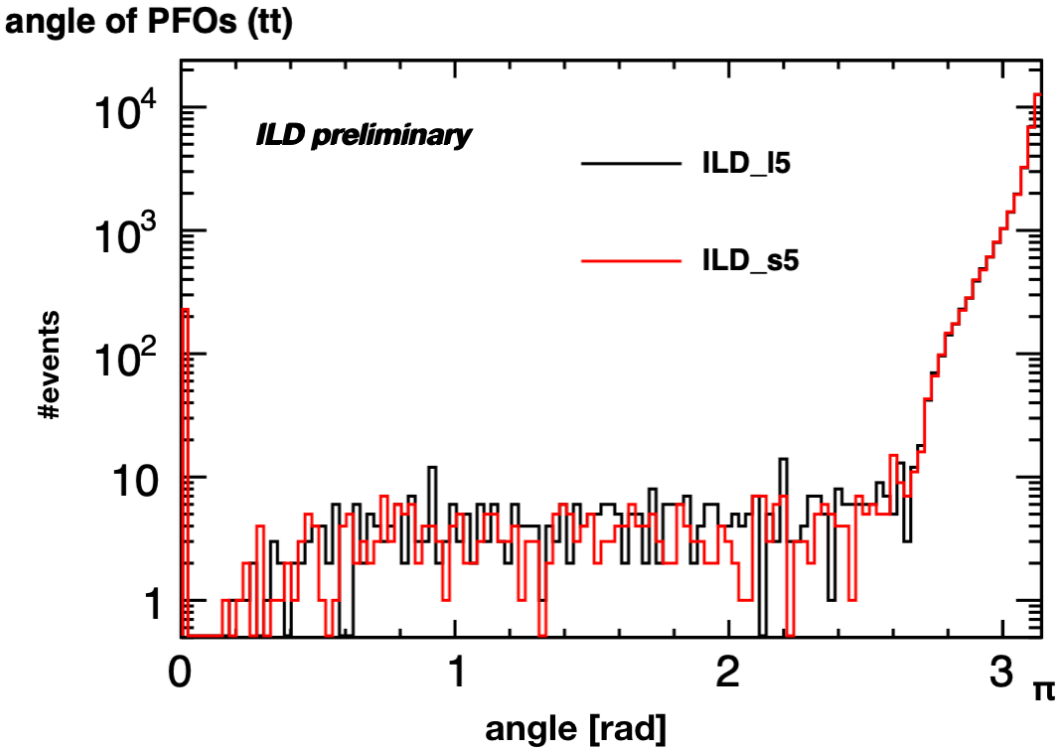
about 99% of energy is inside cone



Result

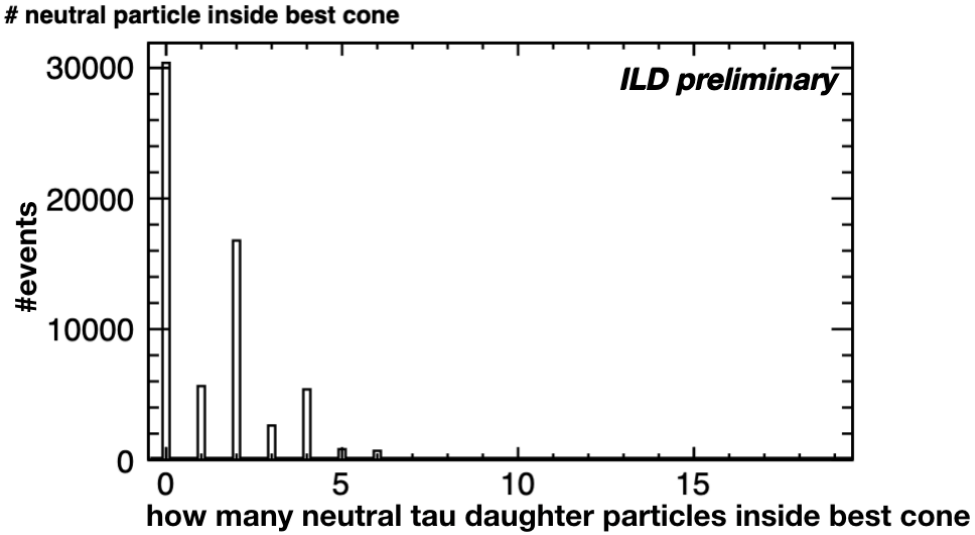
- angle θ formed by first τ seed and second τ seed

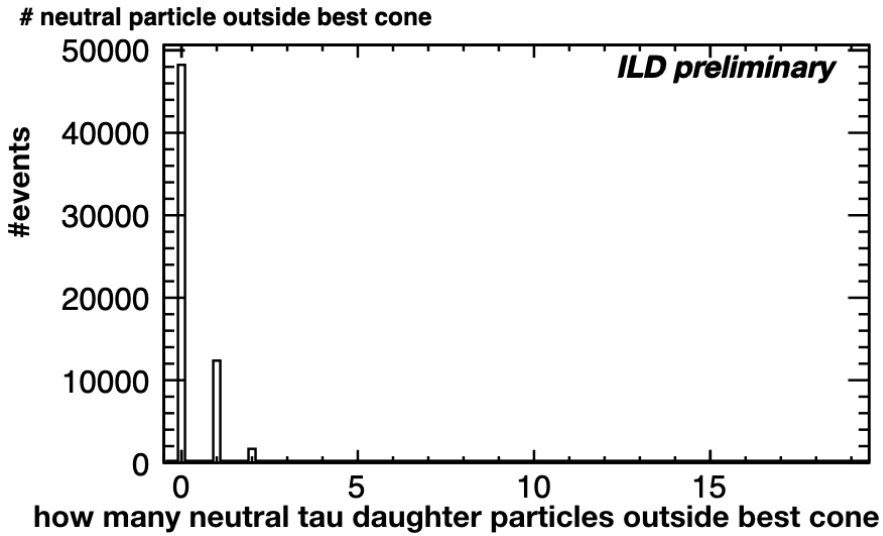




first τ seeds and second τ seeds are almost back-to-back

Result



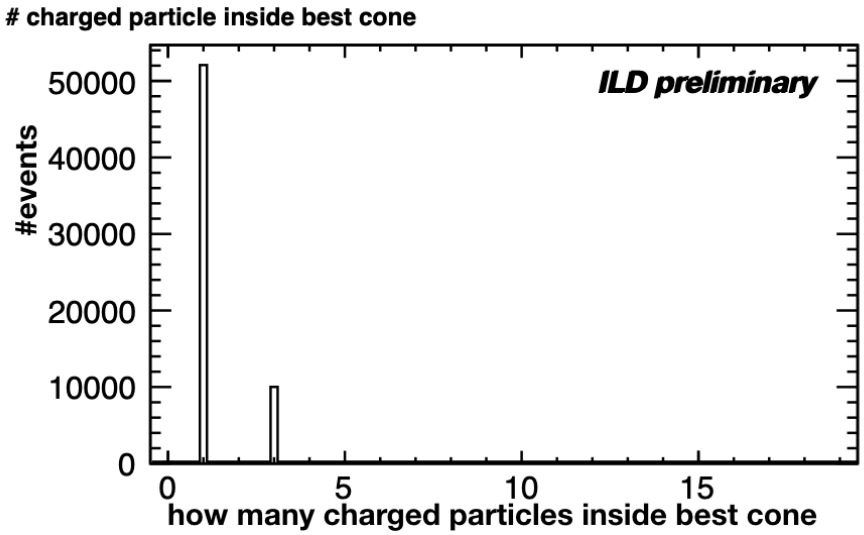


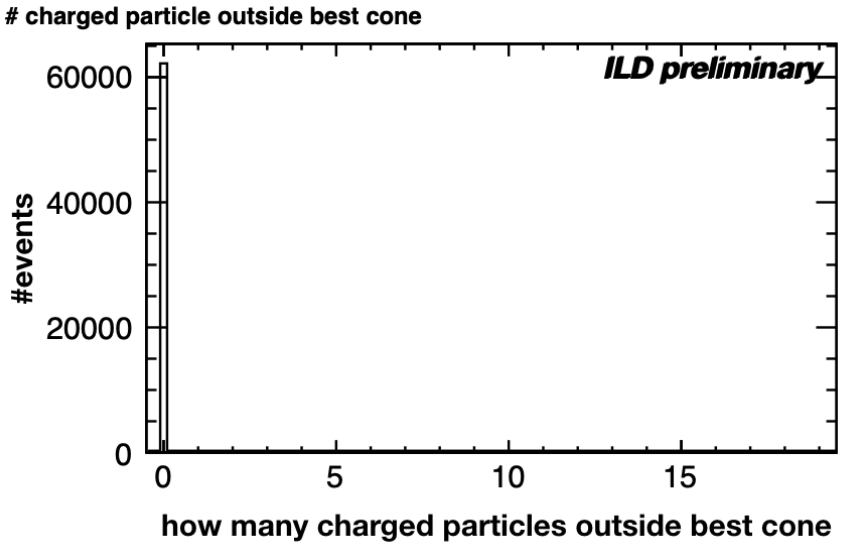
neutral tau daughters are mostly photon

sometimes neutral tau daughters

are outside cone

Result



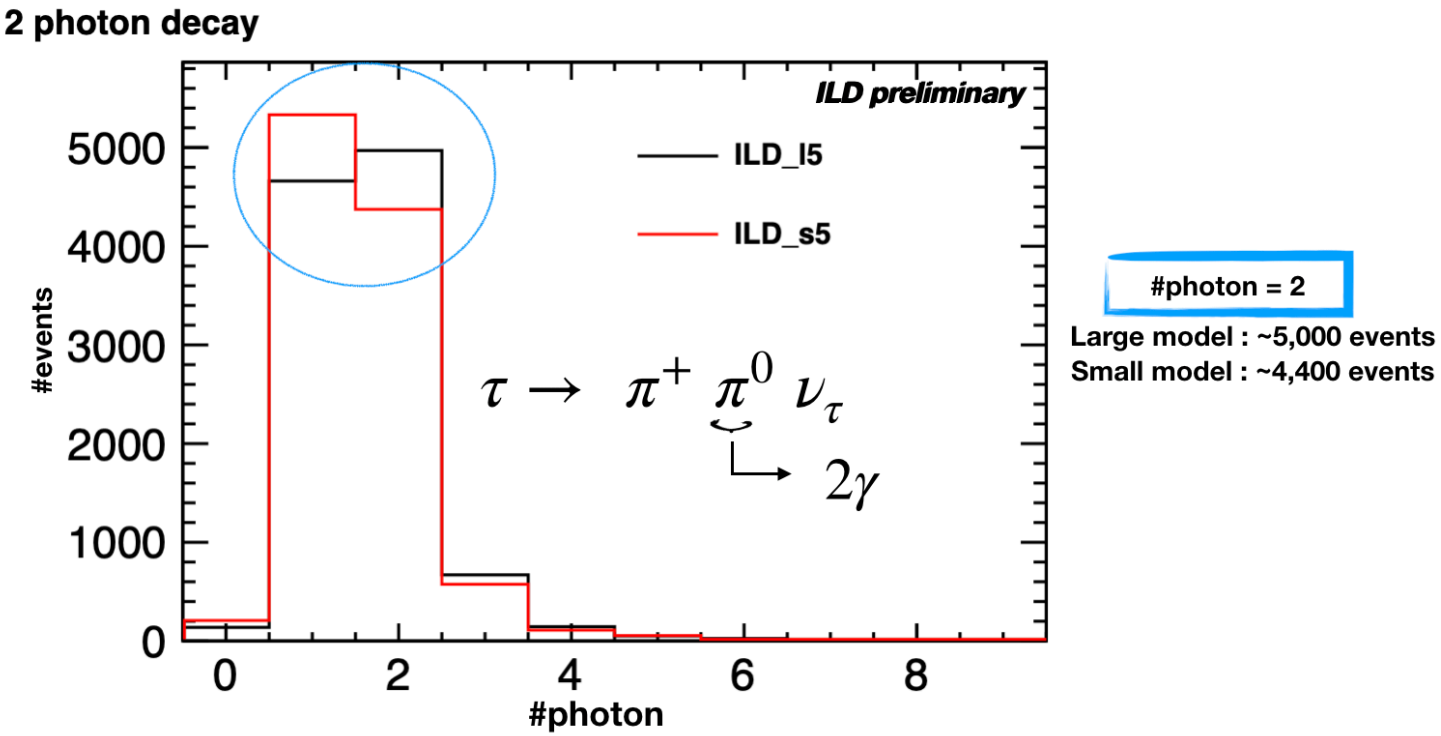


all charged tau daughters

are inside best cone

Result

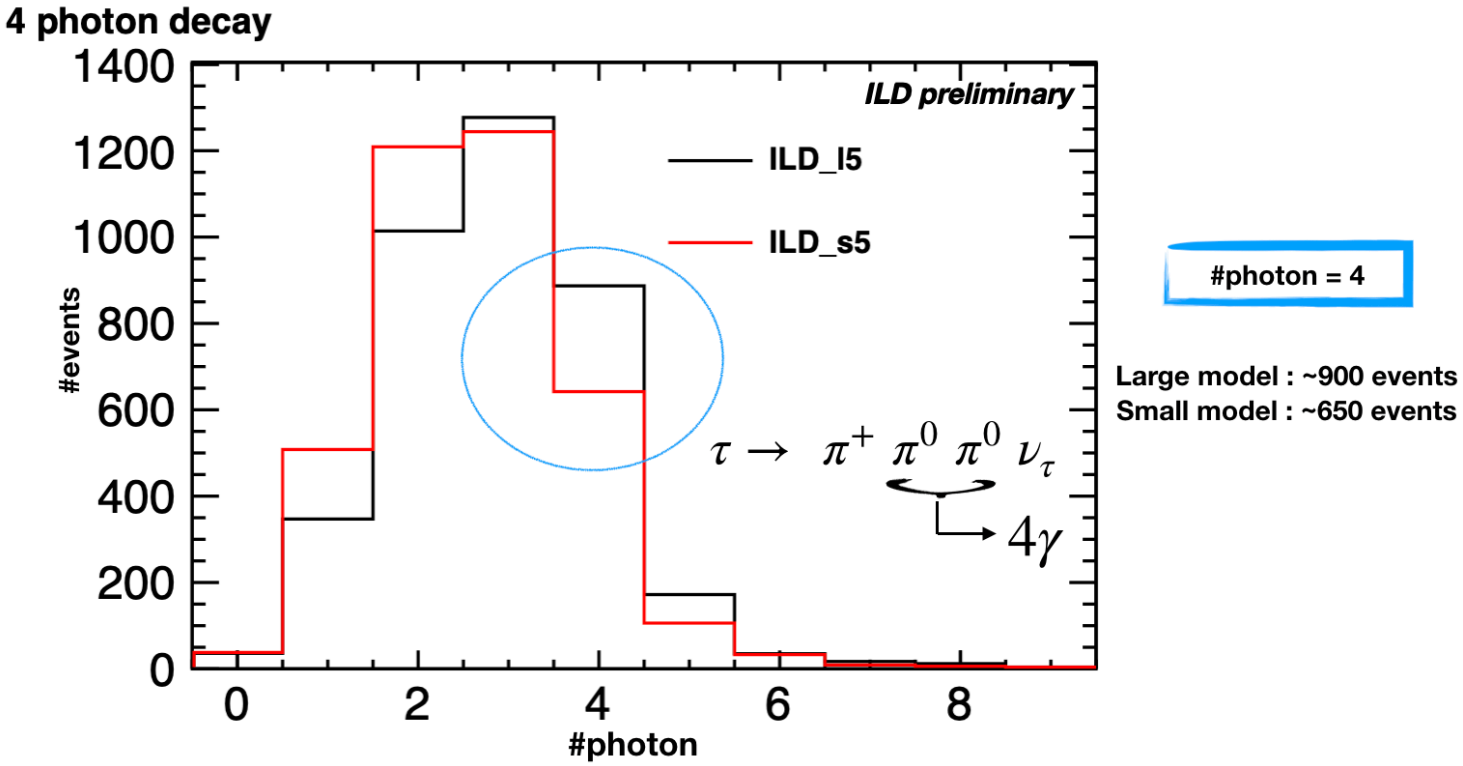
- Comparison between Large and Small ILD model



Large model is better than small model to count photons

Result

- Comparison between Large and Small ILD model



Large model is better than small model to count photons

event selection

- Cut 1:visible τ jet mass $<$ 2.5 [GeV]
- Cut2:acolineality between τ jet seed tracks $<$ 0.15 [rad]
- Cut3:energy sum of pfos outside cones $<$ 40 [GeV]
  p_T sum of pfos outside cones $<$ 20 [GeV]
- Cut4:Cone 1 particle's charge $\times$ Cone 2 particle's charge = -1
- Cut5:High energy $\mu^+\mu^-$& e^+e^- cut
- Cut6:visible mass of 2 τjet system $<$ 400 GeV
- Cut7:angle between τjet axes $>$ 3.05 [rad]
- Cut8:total number of PFOs $<$ 12

Cut table of Large detectors model

Preliminary Beam Polarisation = (-80, +30),Integrated Lumi = 1800.0

selected events/1000

PROCESS	ttHiMass	ttLoMass	mumu	4f_ZZ_WW_Mix_l	4fZZleptonic
UNCUT	593.21	2310.53	3211.59	864.47	65.52
CUT 1	492.65	1787.35	2637.14	684.99	47.76
CUT 2	482.91	272.37	873.61	119.57	4.55
CUT 3	451.89	215.55	778.98	104.84	2.01
CUT 4	428.37	197.76	764.75	96.83	1.17
CUT 5	428.35	197.76	86.20	87.72	0.83
CUT 6	427.45	197.63	24.78	70.01	0.71
CUT 7	425.51	132.11	14.05	27.50	0.48
CUT 8	425.38	132.00	14.05	27.49	0.48

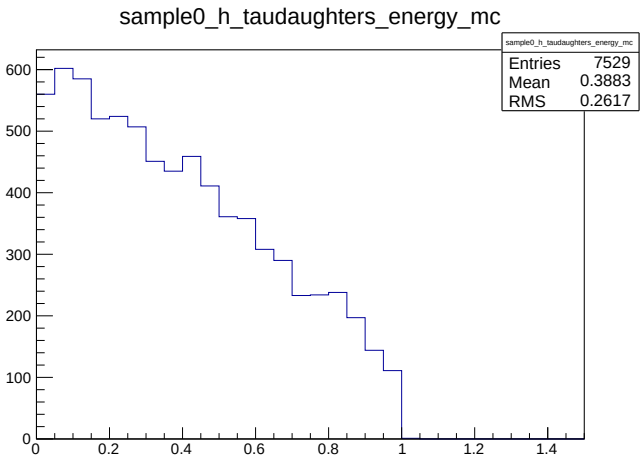
PROCESS	4fsingleZee	2fZhadronic	4f_sZ_sW_Mix_l	4fWWleptonic	4fsingleWleptonic	4fsingleZnunu
UNCUT	8090.16	35325.10	1066.31	832.88	2744.43	294.51
CUT 1	5164.76	5060.10	781.16	667.61	2071.75	184.71
CUT 2	355.88	73.24	74.44	115.51	263.39	4.39
CUT 3	159.89	8.54	59.45	101.09	221.57	3.38
CUT 4	112.08	0.73	53.05	92.18	201.93	1.72
CUT 5	104.91	0.73	50.76	92.08	201.93	1.72
CUT 6	73.81	0.73	37.21	91.06	162.92	1.71
CUT 7	48.69	0.71	14.71	37.81	65.97	0.76
CUT 8	48.69	0.71	14.71	37.81	65.97	0.76

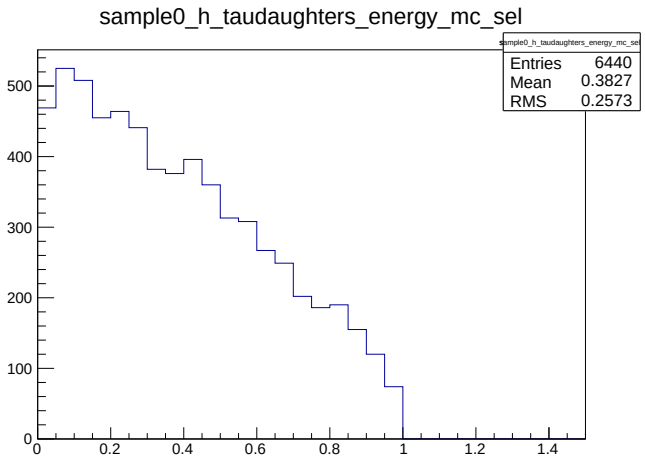
4f_ZZ_WW_Mix_l:4fZZWWMixleptonic 4f_sZ_sW_Mix_l:4fsingleZsingleWMixleptonic

Result

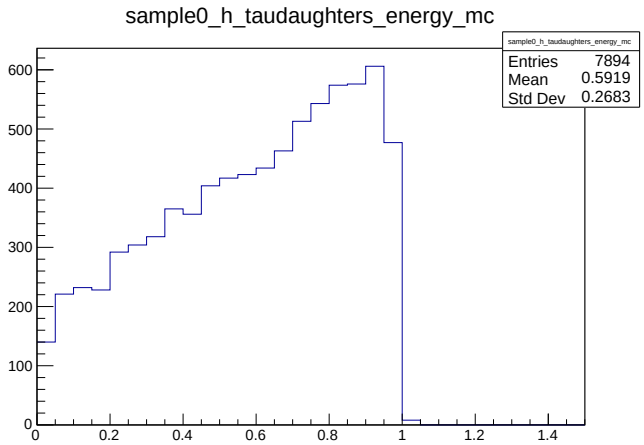
Preliminary

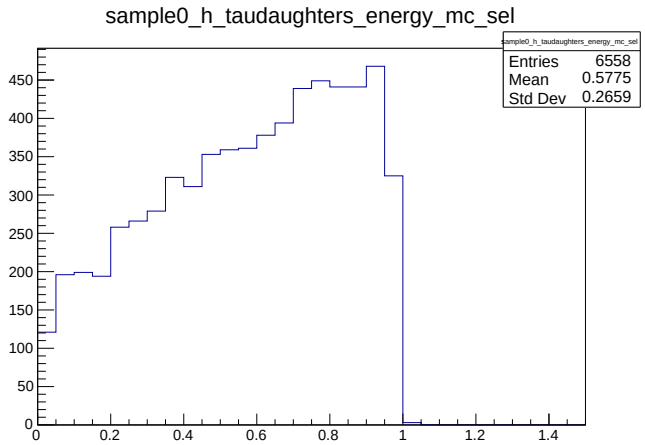
eLpR





eRpL





Summary and Plan

- I simulated $e^+e^- \to \tau^+\tau^-$ and found jets in the process
- About 99% of energy is inside cone
  - Inside cone
    - all charged tau daughters are inside best cone
    - neutral tau daughters are mostly photon and sometimes neutral tau daughters are outside cone
- Cut table including major backgrounds were made.
- After including all cuts, most of the backgrounds and Low mass $\tau\tau$ are rejected
- I measured τ polarization by using $\tau \to \nu\pi$.

backup