

# RECONSTRUCTION OF TAU EVENTS

CEPC Physics Software Meeting

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# Plan

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- ❖ Algorithm development: PID
- ❖ Di-Tau recognition
- ❖ Tau Finder

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# PID package

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- ❖ PID processor: LICH (Lepton Identification for Calorimeter of High granularity)
- ❖ Integrated in Arbor\_v3.3
- ❖ Parameters:
  - ❖ InputDectorModules, TrainingFlag, InputEnergyPoints, InputPFO, OutputPFO(TrainingFlag==0), mvacut(TrainingFlag==0), weightDir (TrainingFlag==0), TrainingEn(TrainingFlag==1)
- ❖ Step (the first two steps need to be run only once for one PFA and one Geometry):
  - ❖ Put TrainingFlag to 1 to produce root samples at each energy point
  - ❖ run TMVA to get weight files
  - ❖ Put TrainingFlag to 0 and put weightDir as the path of weight files, get identified ReconstructedParticle
  - ❖ existing weight files: /scratchfs/higgs/yudan/SingleParticle/Reco/cepc\_TMVA\_\*

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# PID package

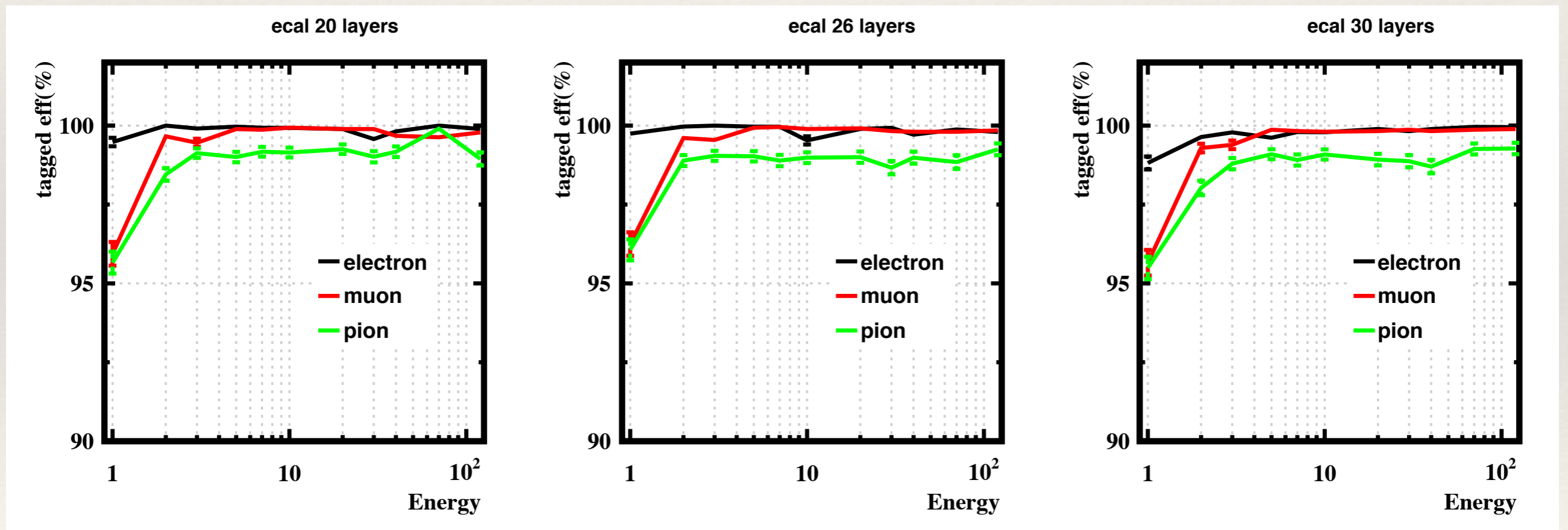
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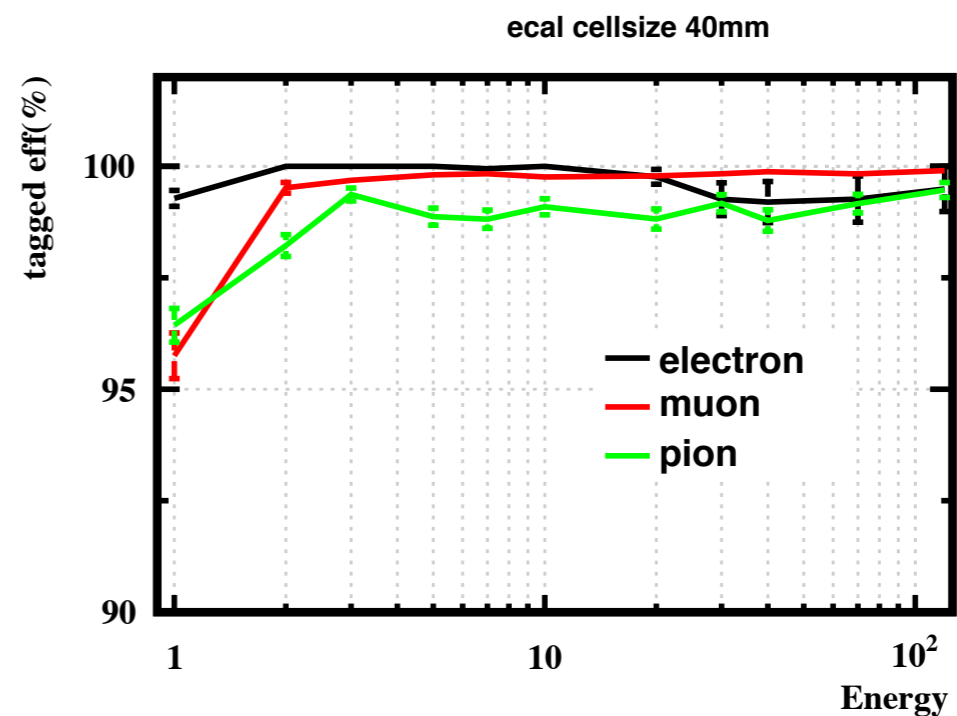
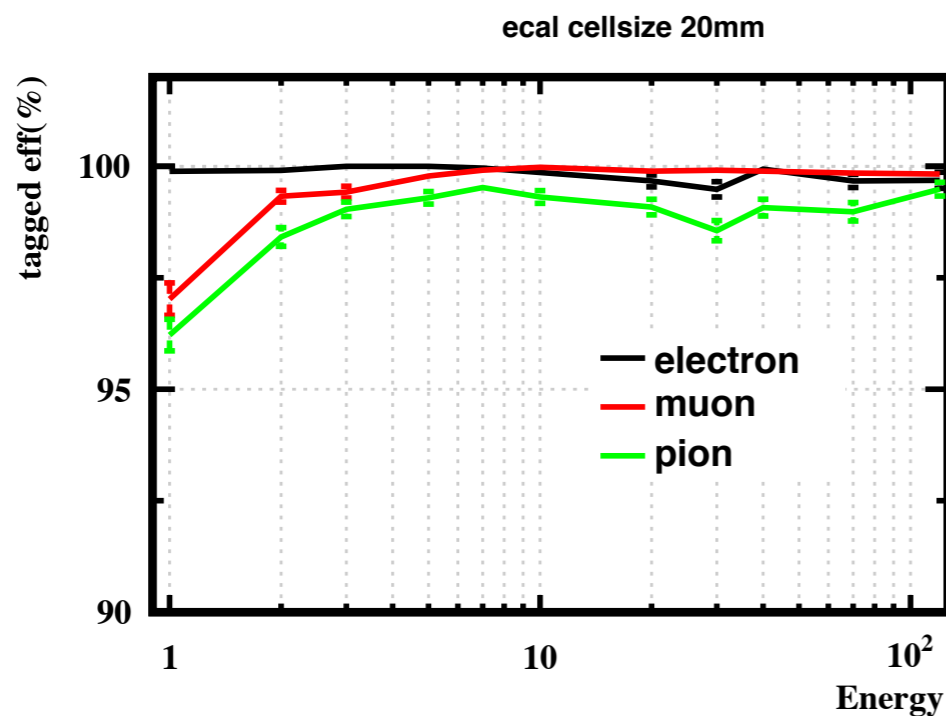
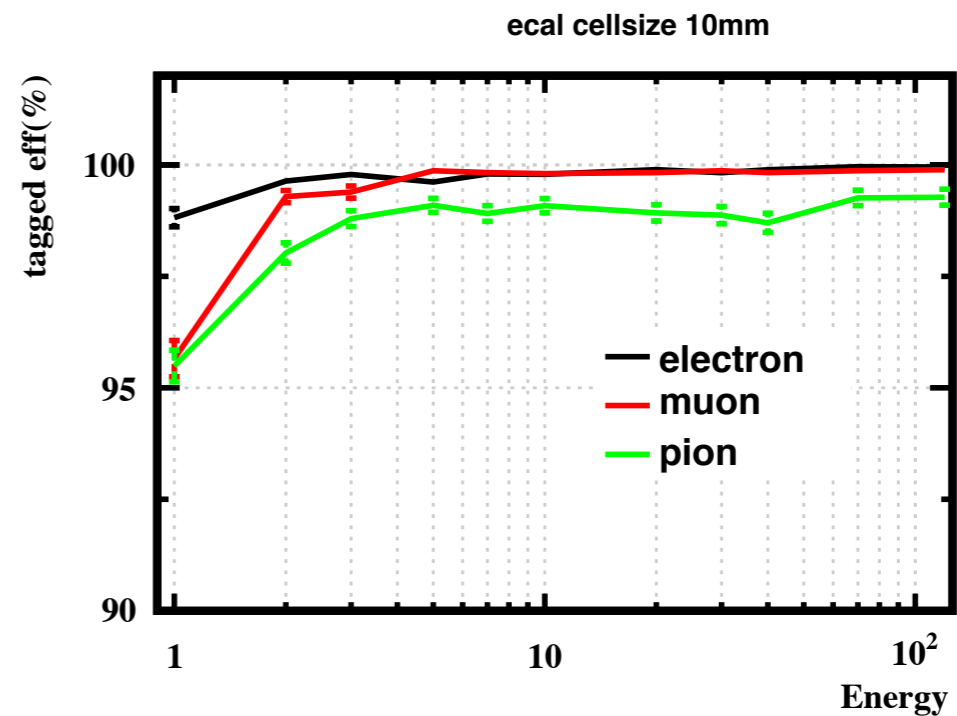
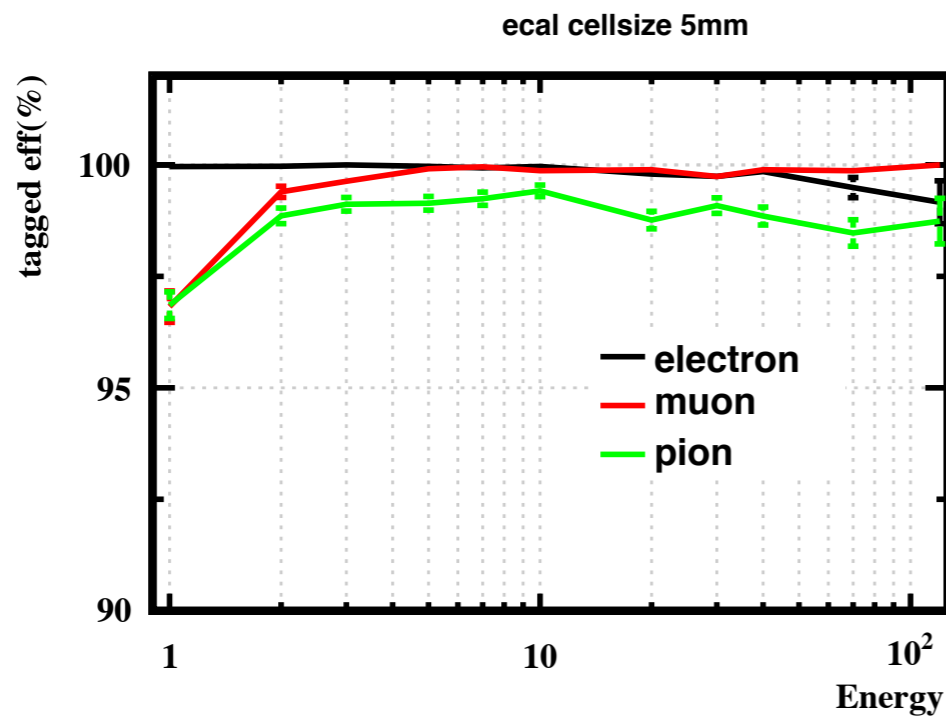
# PID package

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[ VERBOSE "MyLICH" ]
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[ MESSAGE "MyLICH" ]
[ MESSAGE "MyLICH" ] ---- MyLICH - parameters:
[ MESSAGE "MyLICH" ]     InputDetectorModules:  barrel1 barrel2 overlap endcap
[ MESSAGE "MyLICH" ]     InputEnergyPoints:  1 2 3 5 7 10 20 30 40 50 70
[ MESSAGE "MyLICH" ]     InputMCParticle:  MCParticle
[ MESSAGE "MyLICH" ]     InputPFO:  ArborPFOs
[ MESSAGE "MyLICH" ]     InputPositions:  0 0.3 0.55 0.75 1
[ MESSAGE "MyLICH" ]     OutputPFO:  typedPFOs
[ MESSAGE "MyLICH" ]     TrainingEn:  TRAININGEN
[ MESSAGE "MyLICH" ]     TrainingFlag:  0
[ MESSAGE "MyLICH" ]     TreeOutputFile:  /scratchfs/higgs/yudan/Geo/Reco/z_e2e2h/E30L_E10mm_H48L_H1
0mm/PID_e2e2h_01
[ MESSAGE "MyLICH" ]     mvacut_e:  0.5
[ MESSAGE "MyLICH" ]     mvacut_mu:  0.5
[ MESSAGE "MyLICH" ]     mvacut_pi:  0.5
[ MESSAGE "MyLICH" ]     weightDir:  /scratchfs/higgs/yudan/SingleParticle/Reco/cepc_TMVA_E30L_E10mm
_H48L_H10mm
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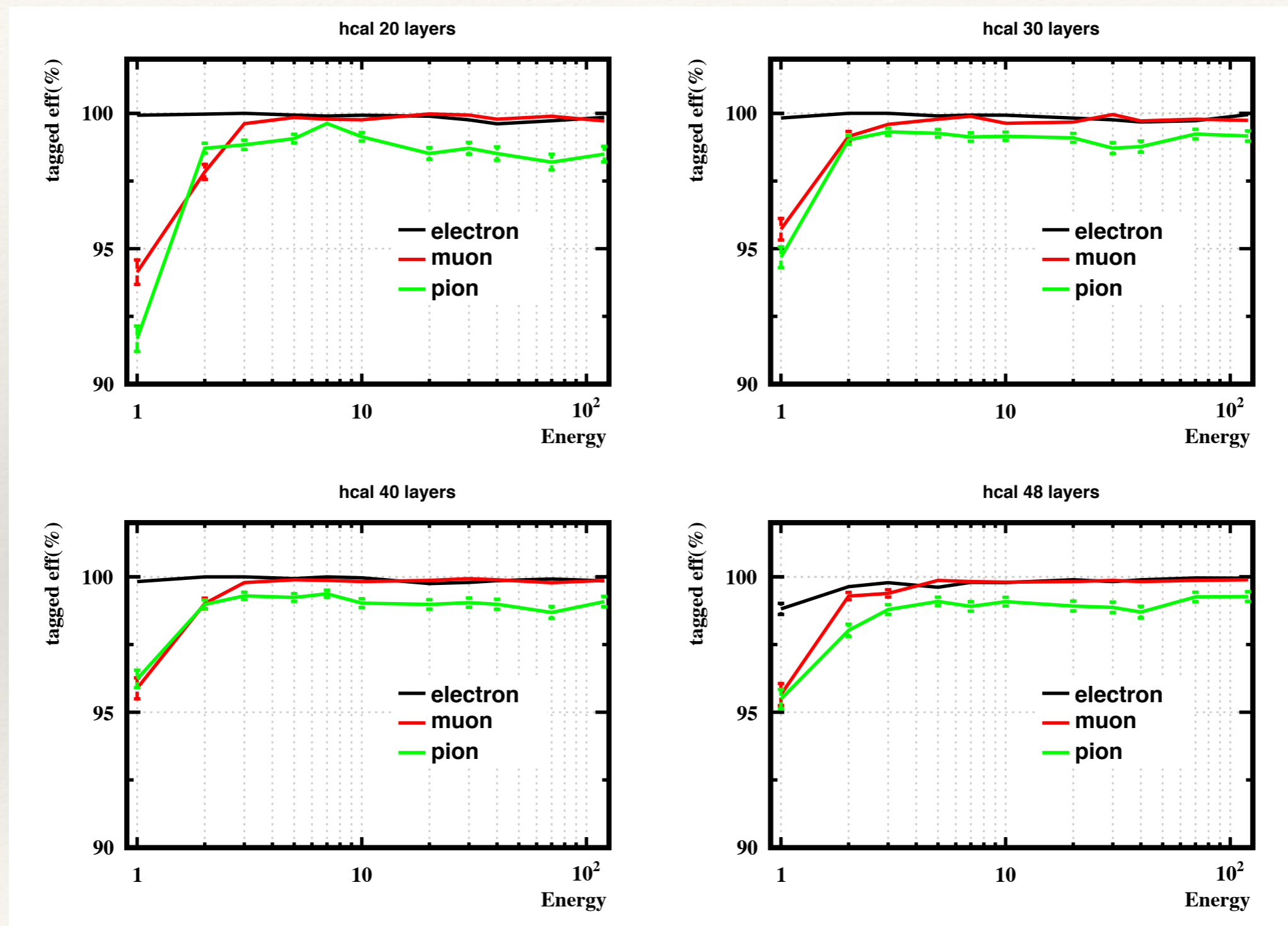
# PID efficiency @ different geometry



# PID efficiency @ different geometry

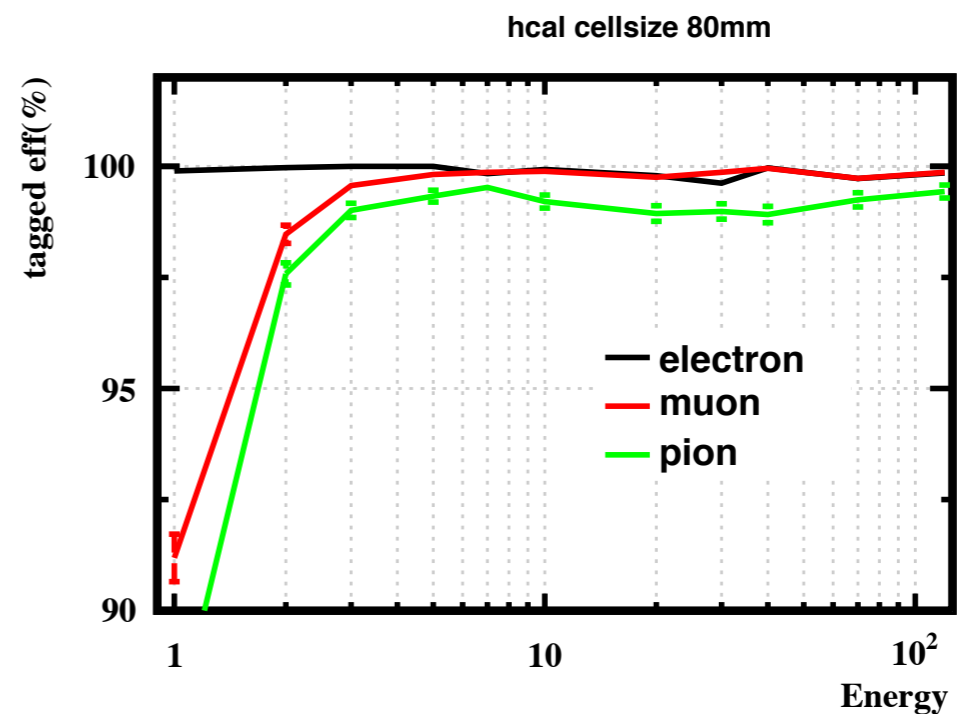
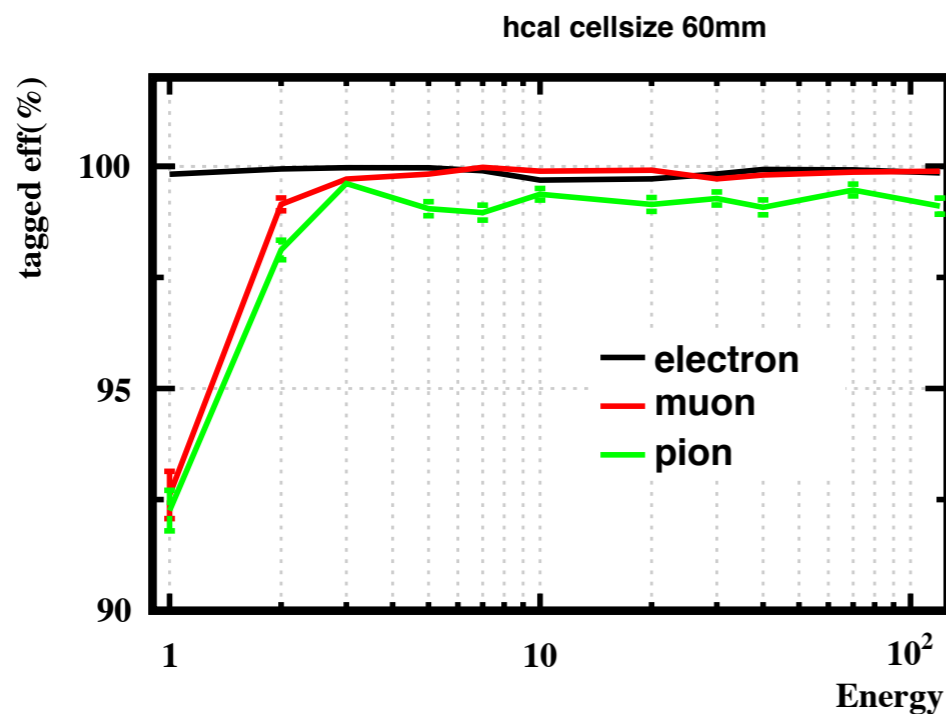
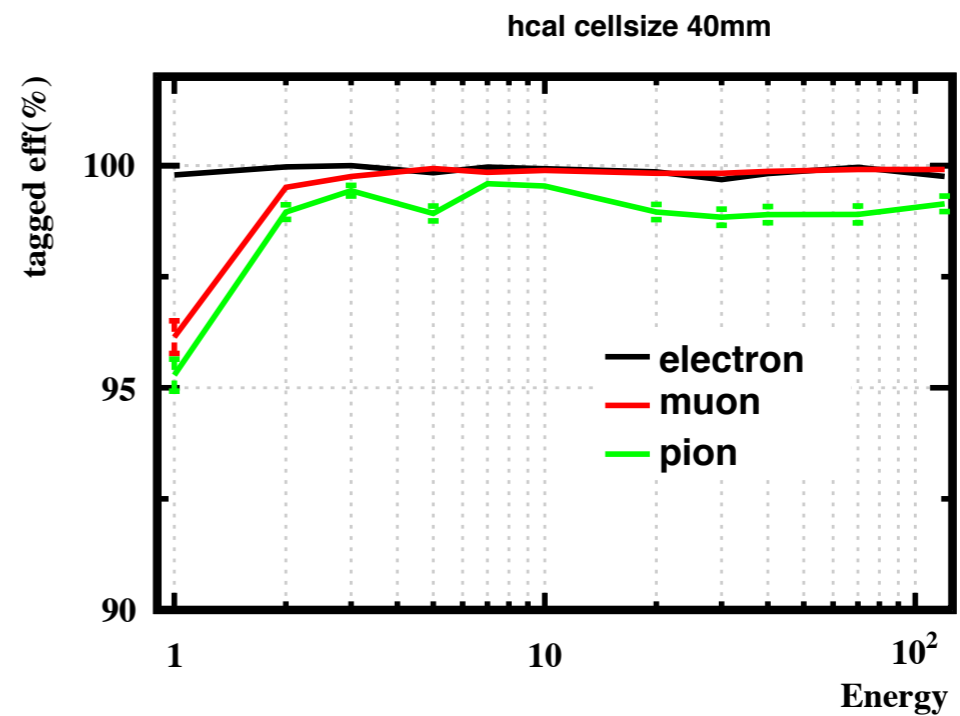
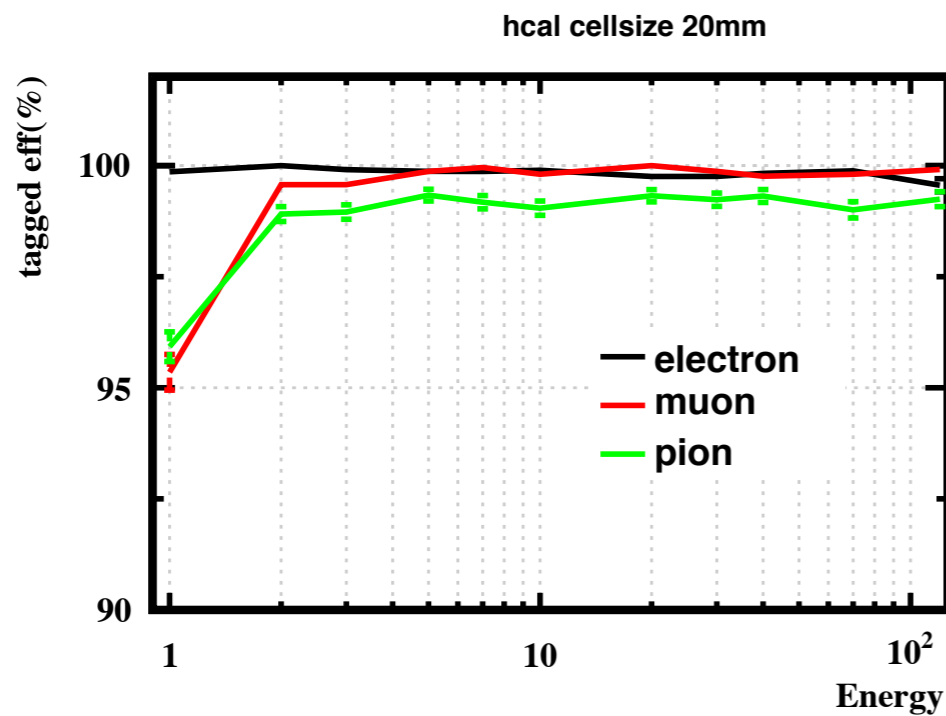


# PID efficiency @ different geometry





# PID efficiency @ different geometry



# Tau Finder

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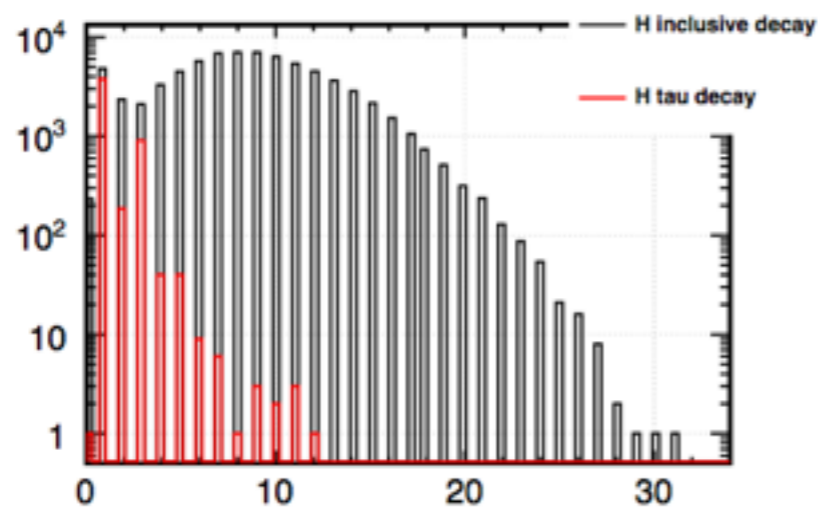
# Di-Tau Finder ( $\mu\mu H$ )

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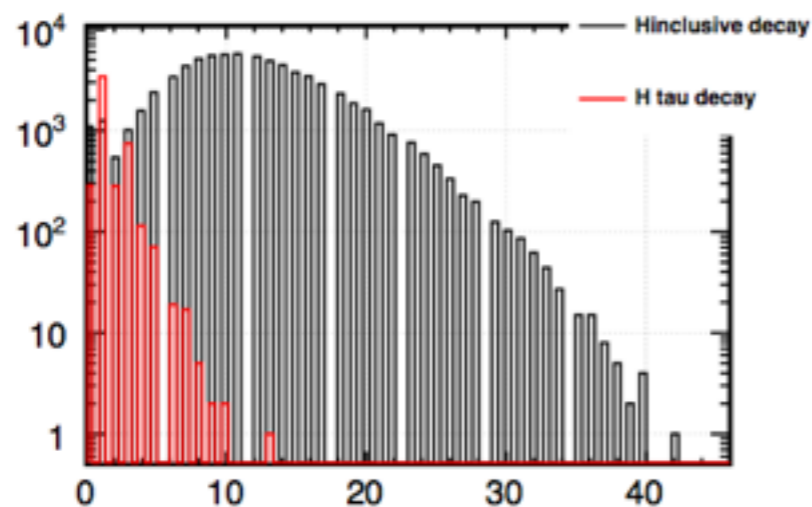
- ❖ Event:  $\mu\mu H$
- ❖ Idea: Counting ( $N_{\text{Tracks}}$  &  $N_{\text{Photons}}$ )
- ❖ Step:
  - ❖ Muon veto ( $\text{Inv } M \sim Z_{\text{Mass}}$ )
  - ❖ Find leading track (get direction)
  - ❖ Collect particles nearby (cone 1.0)
  - ❖ Collect particles in the other direction
  - ❖ Count number of tracks and photons (in two direction A & B)
  - ❖ Get track-track cones, track-photon cones

# Di-Tau Finder

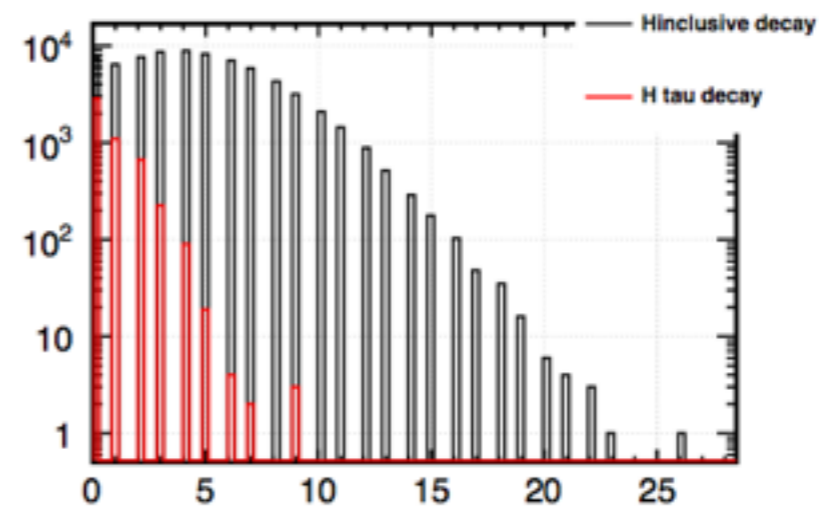
- ❖ Number of tracks and photons in cone A and cone B



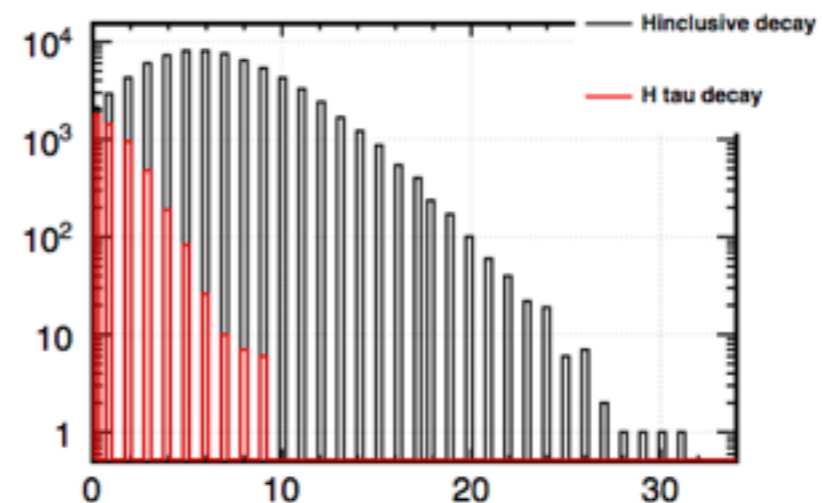
BrecoNch {MCTauNumber!=2}



ArecoNph {MCTauNumber!=2}

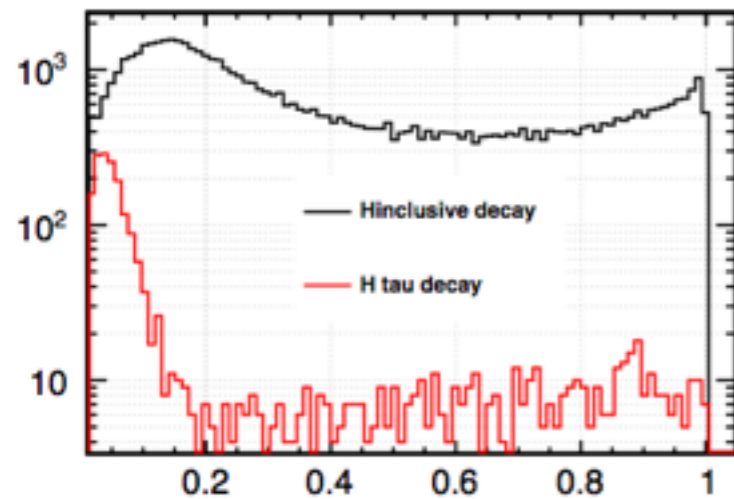


BrecoNph {MCTauNumber!=2}

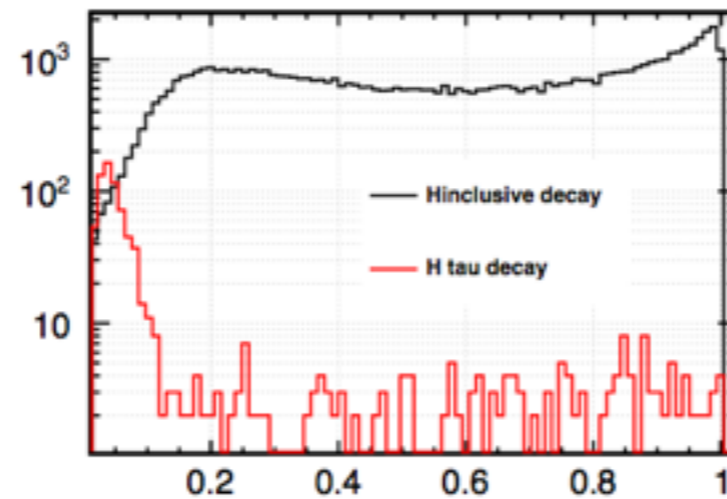


# Di-Tau Finder ( $\mu\mu H$ )

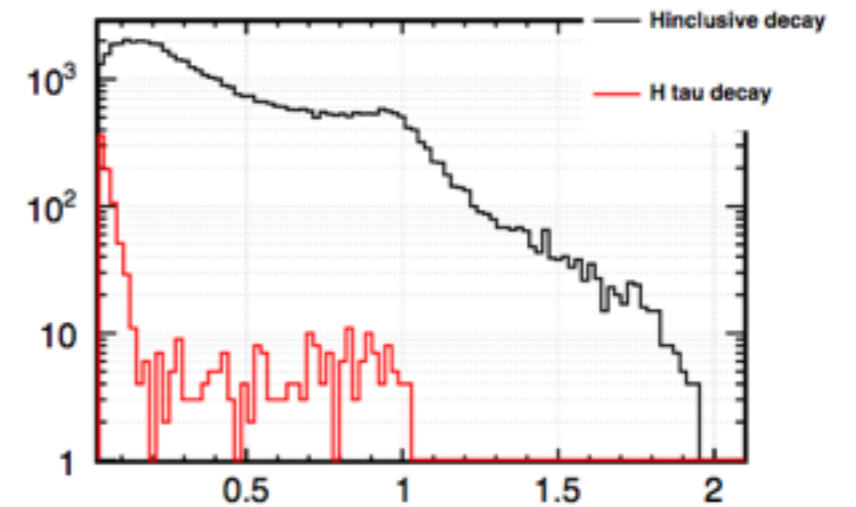
Acone1 {MCTauNumber!=2}



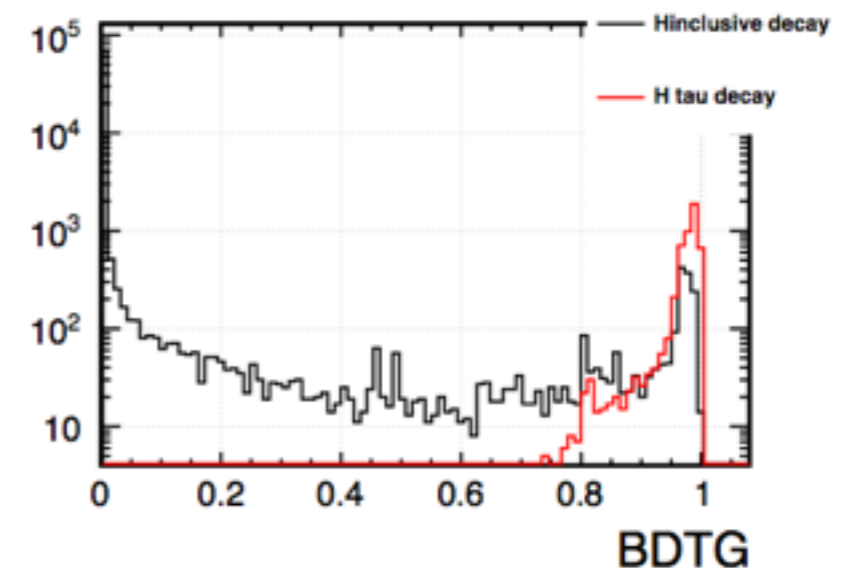
Acone2 {MCTauNumber!=2}



Acone3 {MCTauNumber!=2}

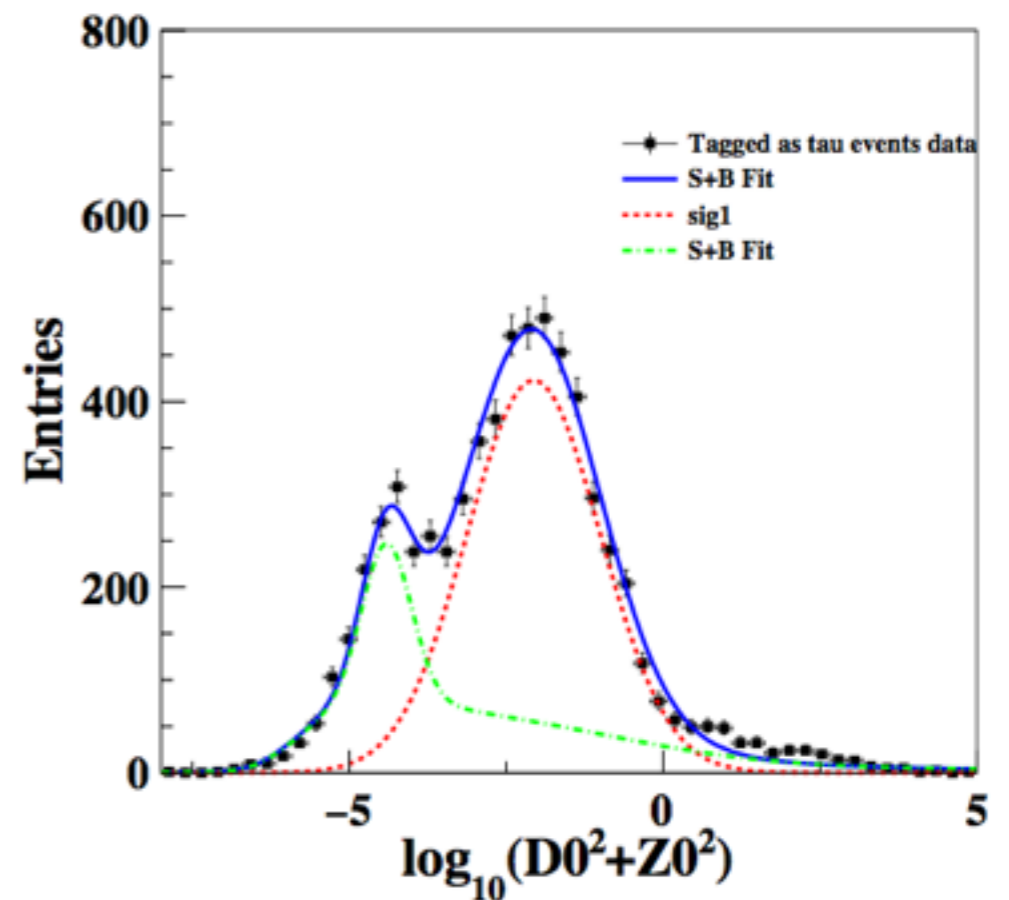
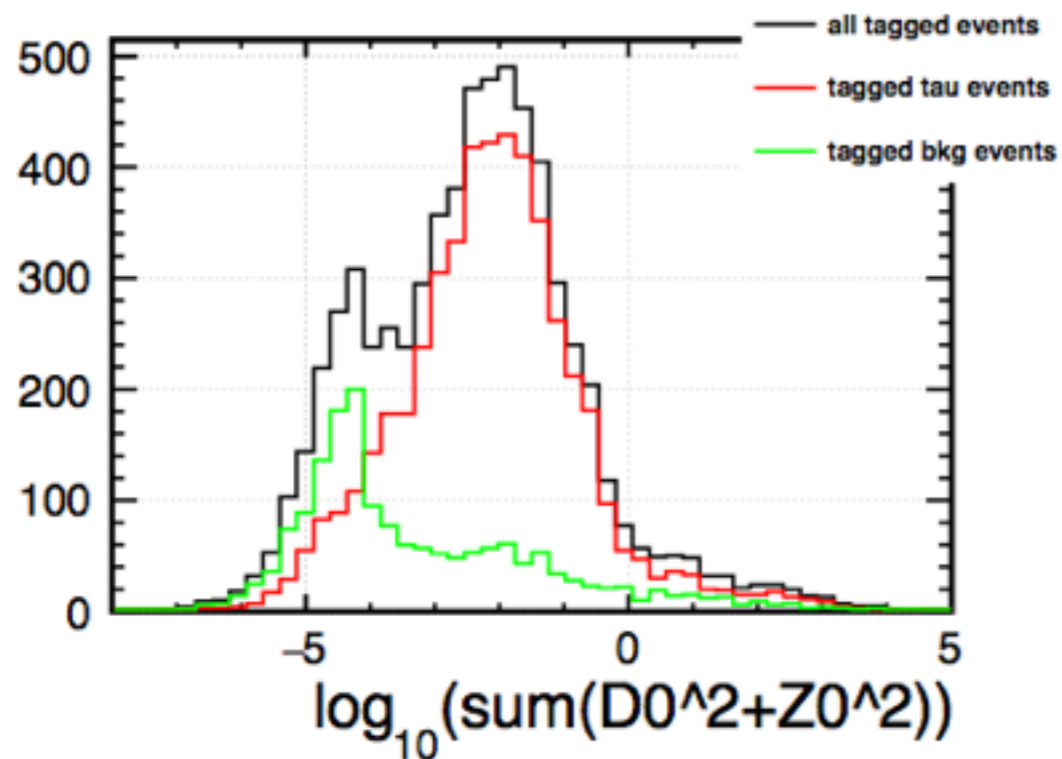


- ❖ TMVA\_BDTG: cut 0.78
- ❖ Sample: total events: 78362 Sig: 4966 Bg: 73396
- ❖ after TMVA\_BDTG: Sig: 4890 Bg: 1686
  - ❖ sig eff 98.47% purity:74.36%
- ❖ Compared with Kyushu University
  - ❖ eff 58.1%; purity 94.2%



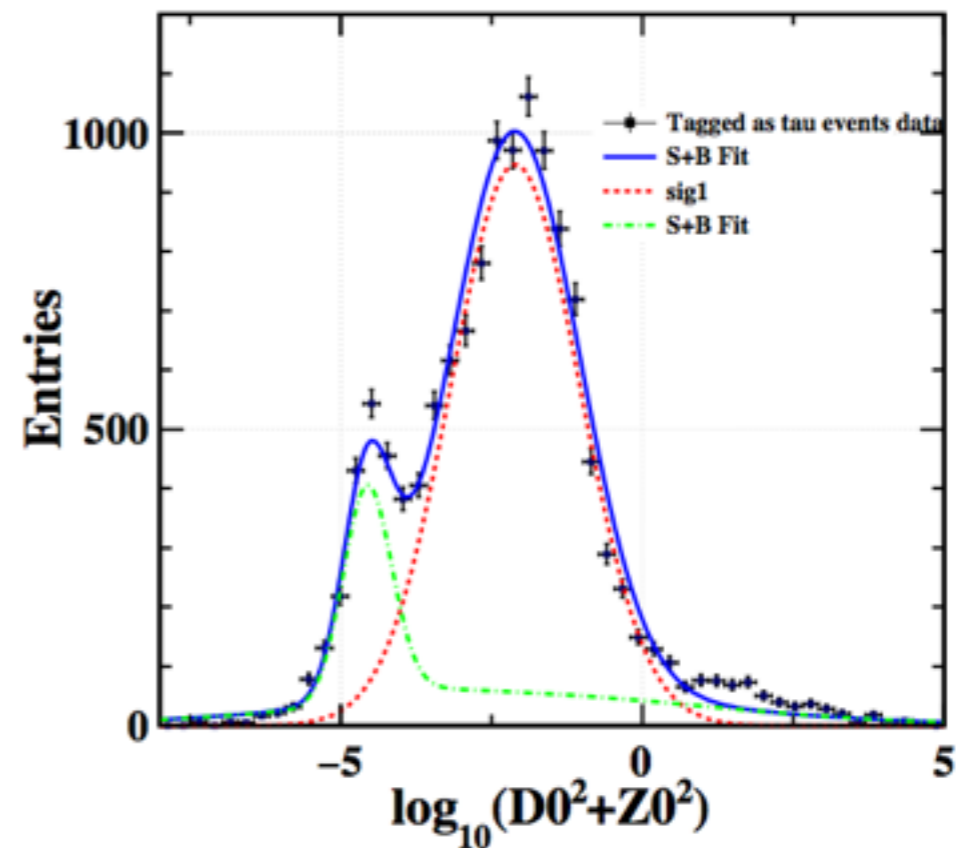
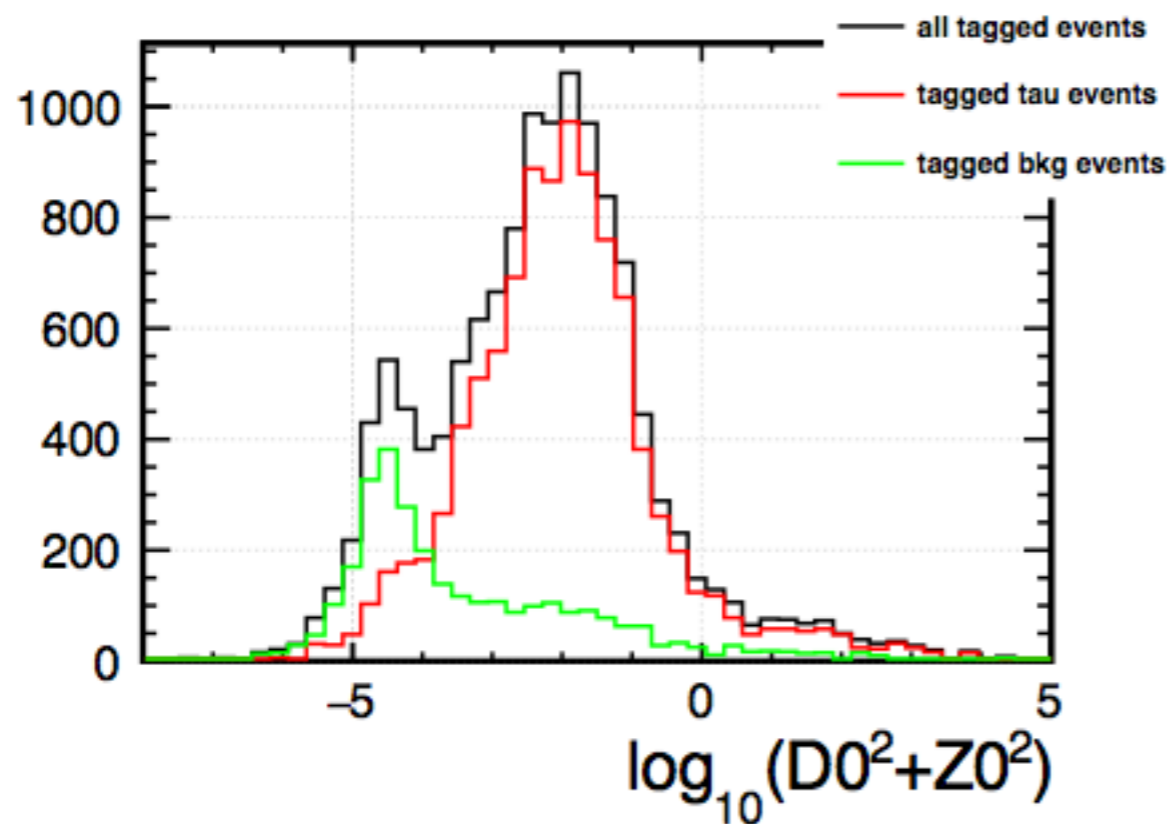
# Higgs inclusive Backgrands

- ❖  $H \rightarrow WW^*$  &  $W \rightarrow \text{leptons}$  (including taus)
- ❖ Impact parameters:  $D0, Z0$  (Sum of leading track in two cone)
- ❖ Fit result:
  - ❖ sig:  $4.6582e+03 \pm 8.15e+01$
  - ❖ BR:  $5.94 \pm 0.02 \%$



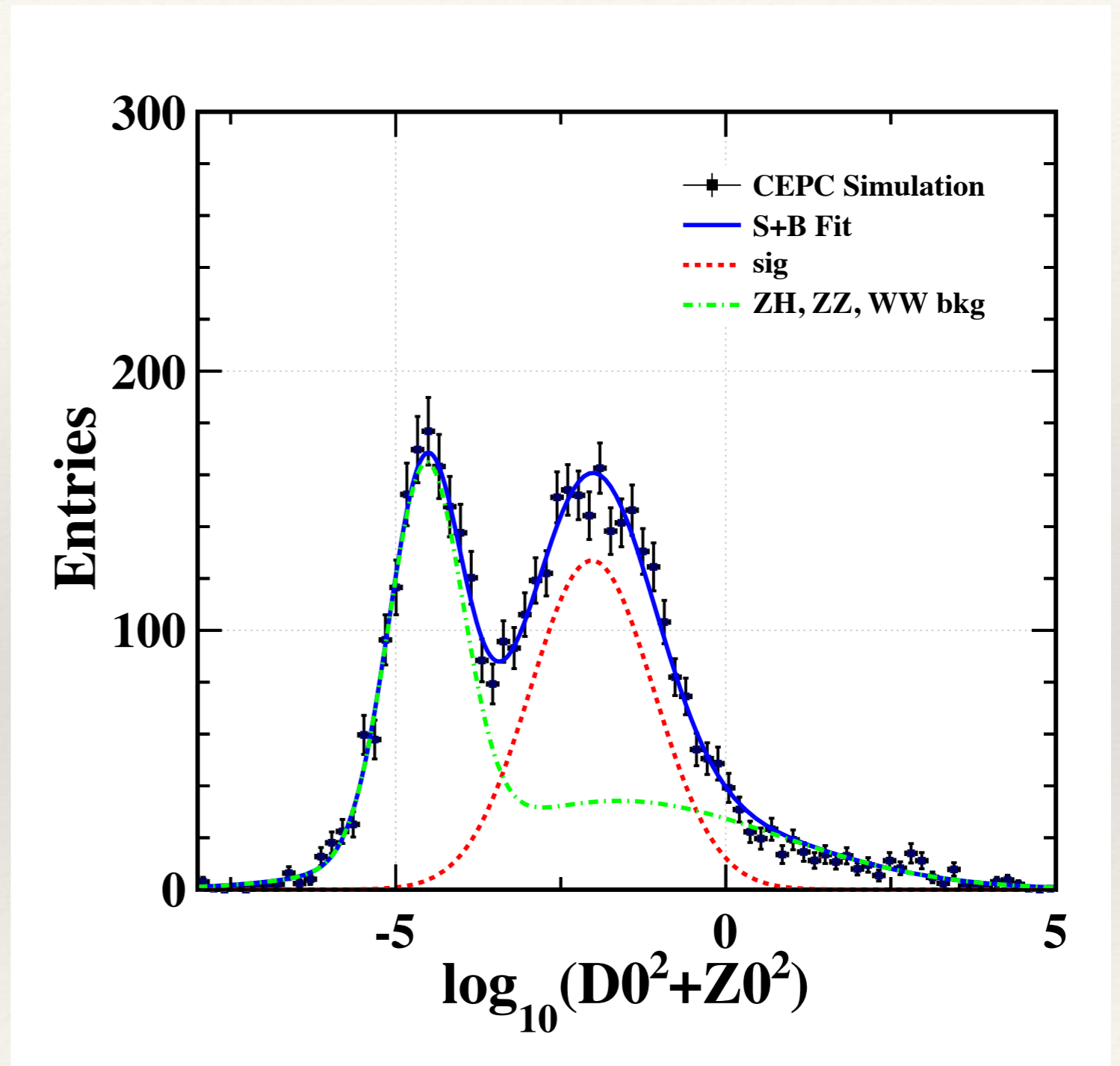
# Di-Tau Finder (nnh)

- ❖ Sample: total events: 156488 Sig: 10028 Bg:146460
- ❖ after TMVA\_BDTG: Sig: 9852 Bg: 2971
  - ❖ sig eff 96.24% purity:76.83%
- ❖ Fit result:
  - ❖ sig:  $9.5930e+03 \pm 1.12e+02$
  - ❖ BR:  $6.13 \pm 0.07 \%$



# SM Backgrands

- ❖ ZZ, WW->leptons (including taus)
- ❖ Fit result:
  - ❖ sig:  $1.8338e+03 \pm 8.86e+01$
  - ❖ bkg:  $2.5558e+03 \pm 9.26e+01$
  - ❖ 1060000 events:
    - ❖ Br:  $3.37\% * 6.32\% \sim 2.13\%$
    - ❖ calculated: 1.73%





# Tau Jet Finder

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- ❖ Idea:

- ❖ collect particles passing an energy threshold (minEn) within a cone (cone\_s)
- ❖ count track number / photon number in cone\_s
- ❖ calculate invariant mass and  $\log_{10}(D_0^2 + Z_0^2)$  in cone\_s
- ❖ calculate energy fraction (EnFrac) of particle in cone\_s and energy in a bigger cone (cone\_1)

- ❖ Cuts:

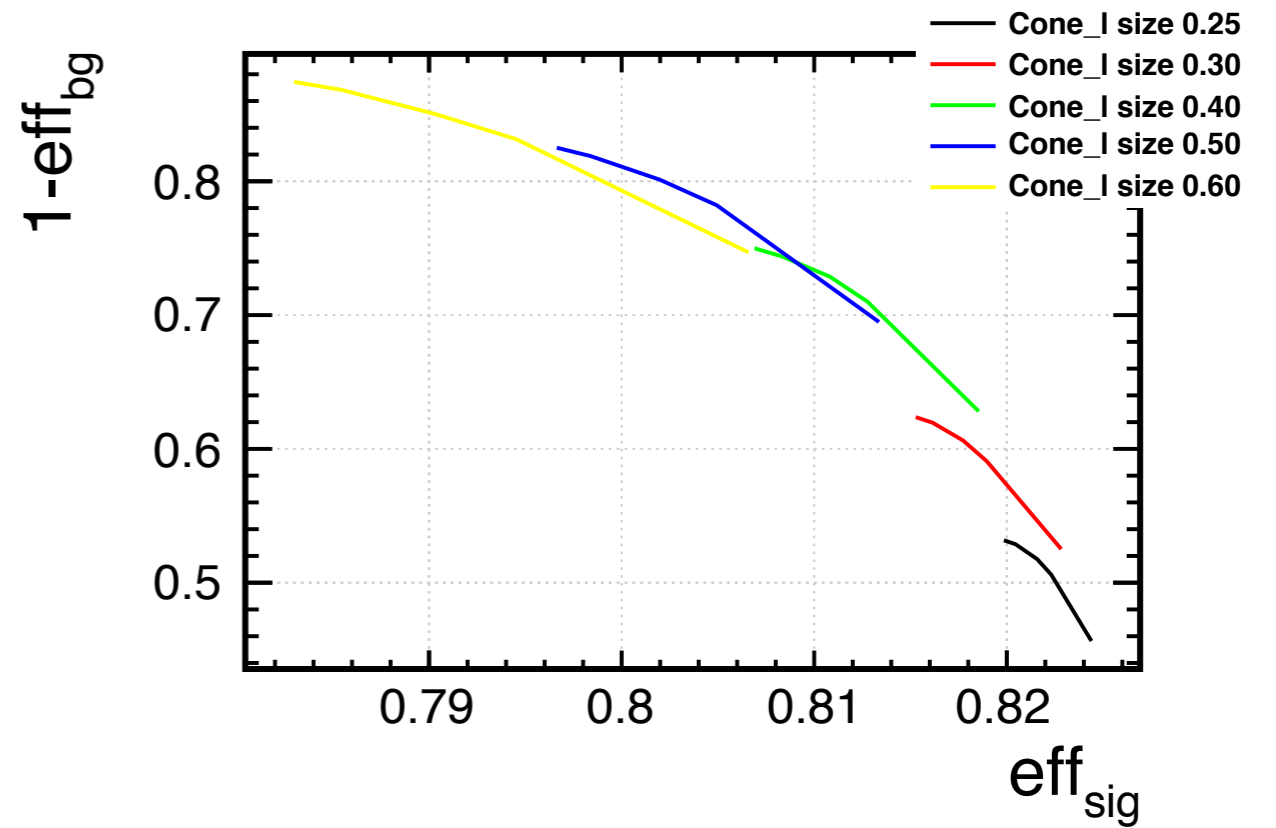
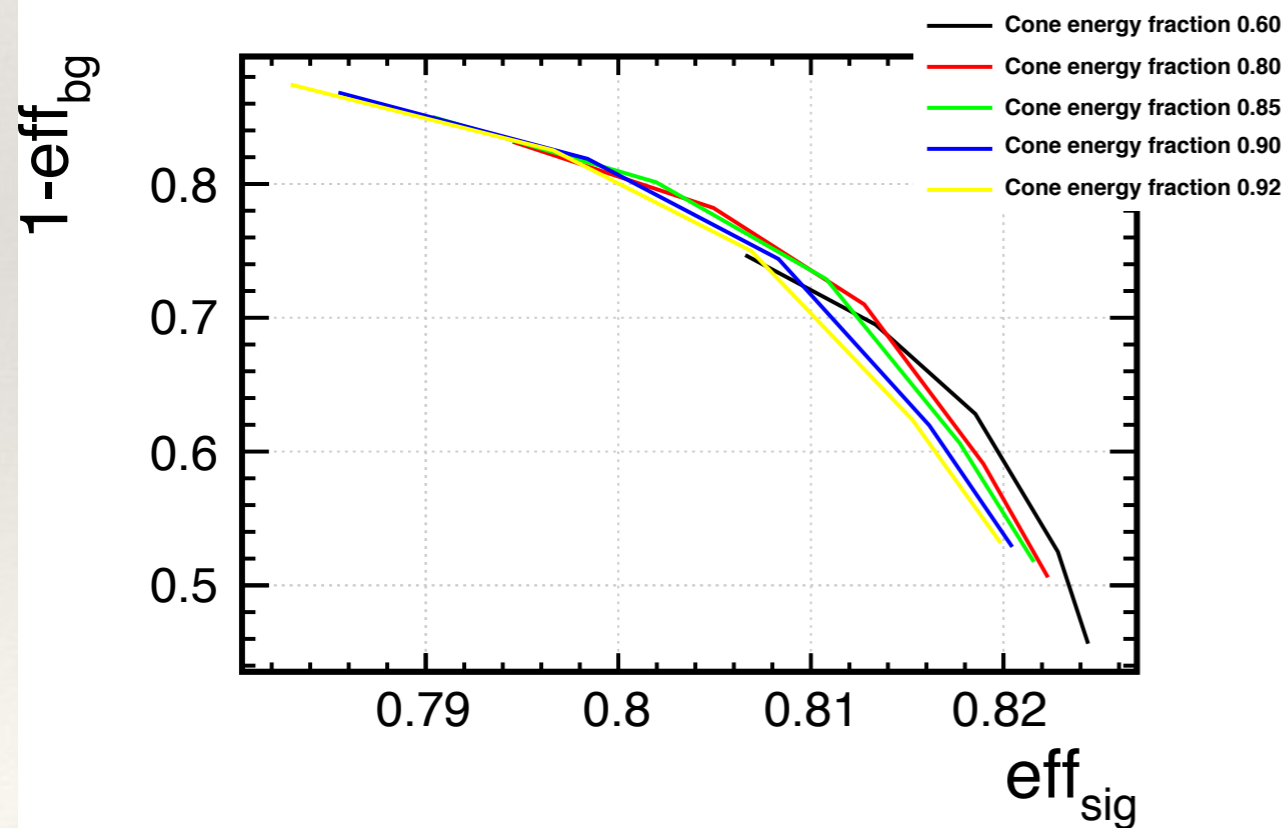
- ❖ InvMass > 2 GeV
- ❖  $\log_{10}(D_0^2 + Z_0^2) > -7$
- ❖ Ncharged < 6 && Nphoton < 5

- ❖ Parameter tuning:

- ❖ cone\_s
- ❖ cone\_1
- ❖ minEn
- ❖ EnFrac

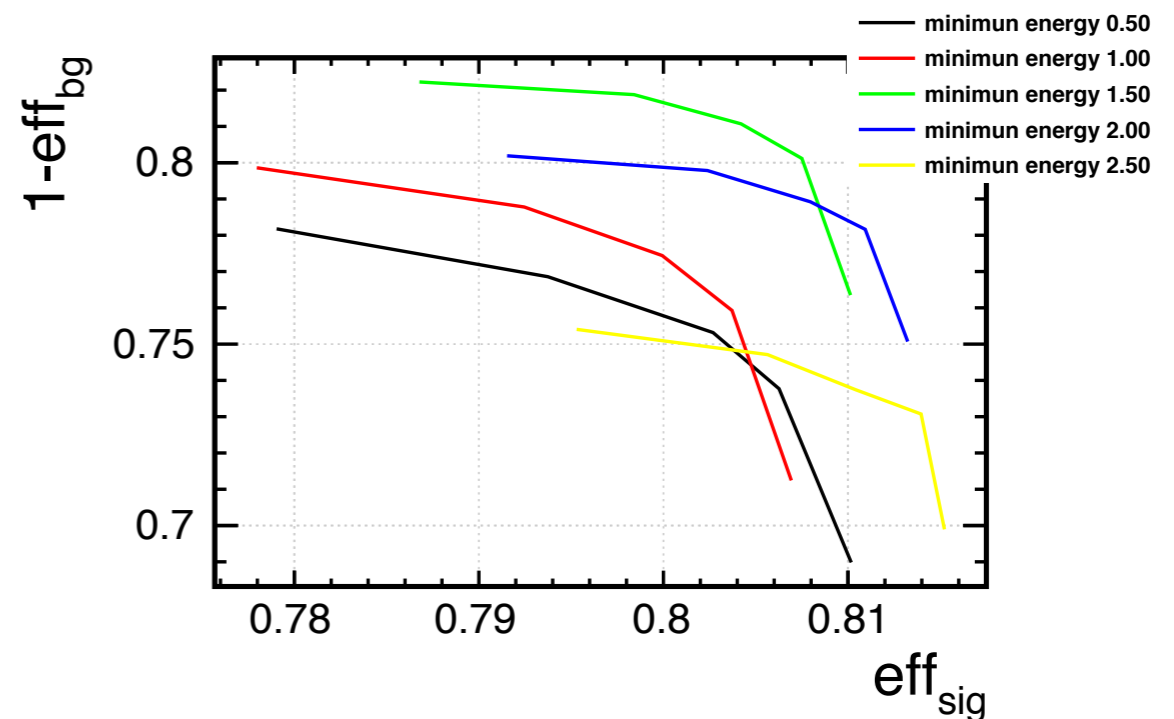
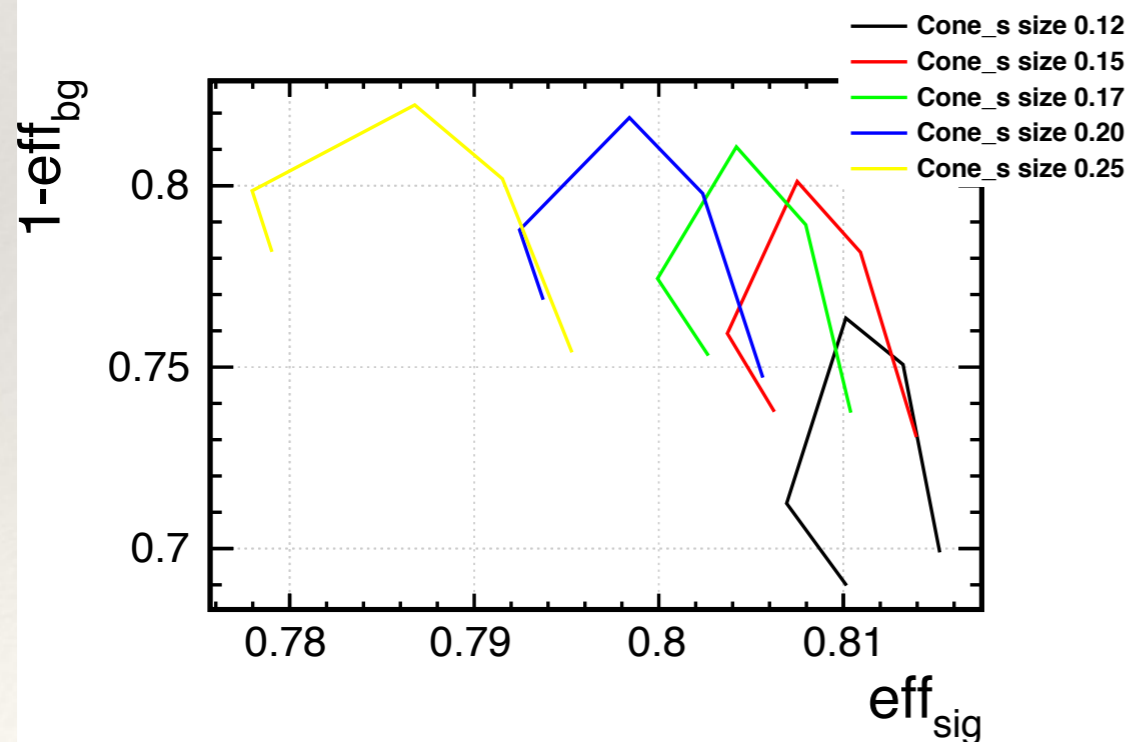
# Parameter tuning

- ❖ cone\_1 vs EnFrac tuning
  - ❖ cone\_1: 0.25, 0.3, 0.4, 0.5, 0.6
  - ❖ EnFrac: 0.6, 0.8, 0.85, 0.9, 0.92
- ❖ minEn = 1.5 GeV, cone\_s = 0.2
- ❖ Chose: EnFrac = 0.9, cone\_1 = 0.5



# Parameter tuning

- ❖ cone\_s vs minEn tuning
  - ❖ cone\_s: 0.12, 0.15, 0.17, 0.2, 0.25
  - ❖ minEn: 0.5, 1.0, 1.5, 2.0, 2.5
- ❖ EnFrac = 0.9, cone\_1 = 0.5
- ❖ Chose: minEn = 2 GeV, cone\_s = 0.2



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# Tau Jet Finder

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- ❖ Tagging efficiency (e3e3h events):
  - ❖ sig: 9048 tau jets — 7204 tagged
  - ❖ bkg: 11476 not tau jets — 1918 tagged as tau
  - ❖ eff: 79.6%
  - ❖ mis-tagged prob: 16.7%

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# Summary

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- ❖ PID efficiency improved with Arbor PFA:
  - ❖ about 97% for pions higher than 3GeV
- ❖ Di-tau finder test on SM backgrounds
- ❖ To do
  - ❖ PID: cross check — in jets
  - ❖ Tau jet finder:
    - ❖ parameters still need to be tuned
    - ❖ decay modes analysis

Thank you  
for  
your attention!