Benchmark analysis status report:

e+ e- → tau+ tau- at 500 GeV

Keita Yumimo/Sokendai
Daniel Jeans/KEK

ILD benchmarking days, Oct 20, 2018

Goal:

1. select high-mass tau pair events in 500 GeV collisions
2. identify their decay modes
3. fully reconstruct tau momenta
4. measure their polarisation
5. extract some physics
6. compare large and small

Unless otherwise stated:

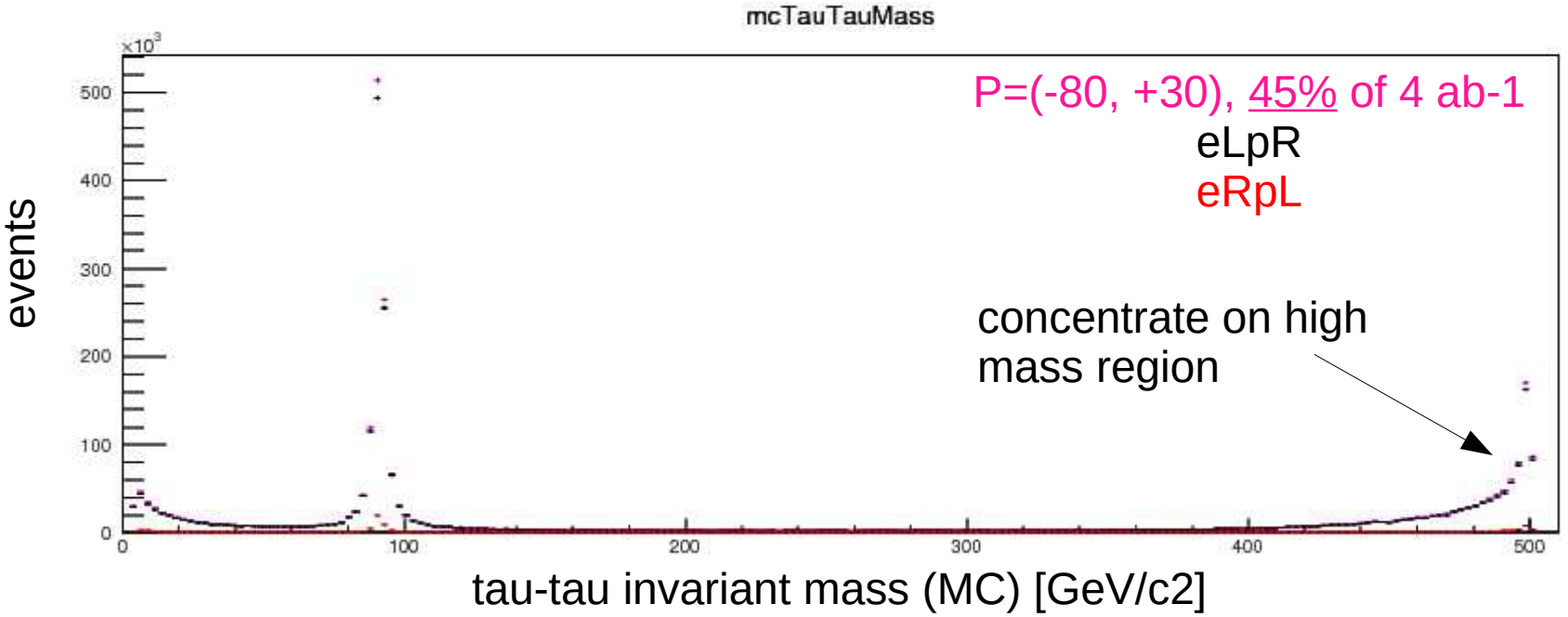
mc-opt-3, 500-TDR_ws, ILD_l5_o1_v02

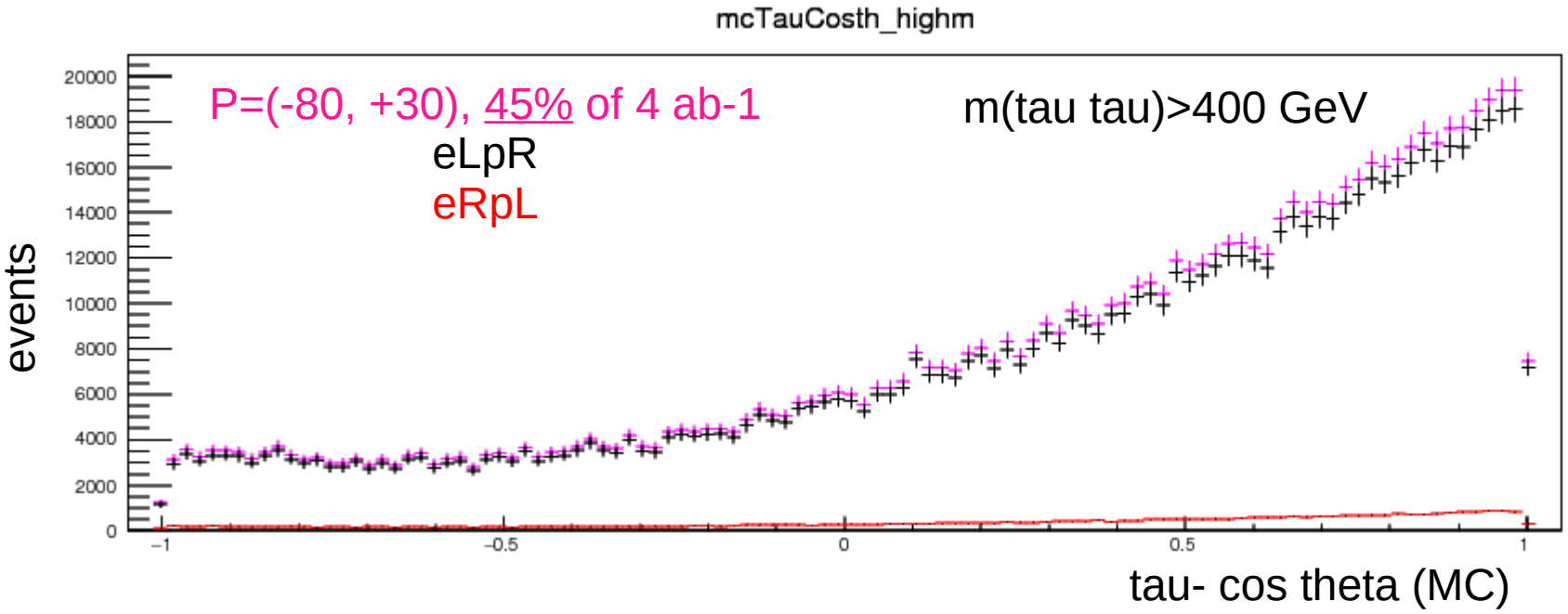
2f_Z_leptonic, 2f_Z_hadronic

eL pR event samples

PFOs from DistilledPFOs collection
(after eg pi0 finding)

PID taken from PFO->getType()


mcTauTauMass
events
P=(-80, +30), 45% of 4 ab-1
eLpR
eRpL
concentrate on high
mass region
tau-tau invariant mass (MC) [GeV/c2]


mcTauCosth_highm
events
P=(-80, +30), 45% of 4 ab-1
eLpR
eRpL
m(tau tau)>400 GeV
tau- cos theta (MC)

1. select high-mass tau pair events in 500 GeV collisions

2-tau events are relatively clean
- back-to-back if no ISR
- back-to-back in azimuthal angle if collinear ISR

beware of gamma-gamma, beam backgrounds

Each tau decays to 1,3 or 5 charged particles,
- plus possibly some neutrals (mostly pi0 → photons),
  - typically within small cone due to small tau mass

Simple di-tau finding algorithm:

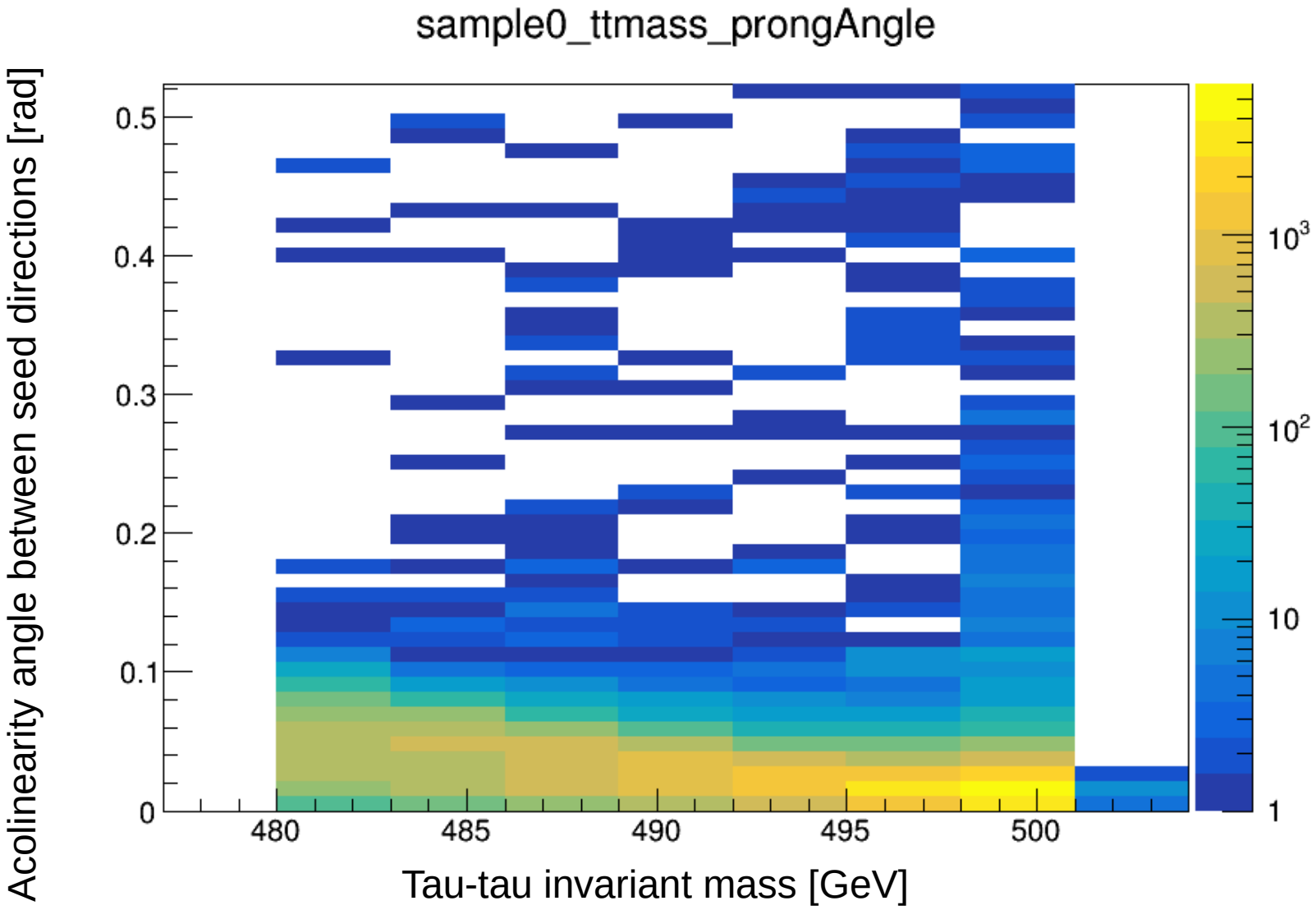
a) identify highest pT charged PFO : “first seed”

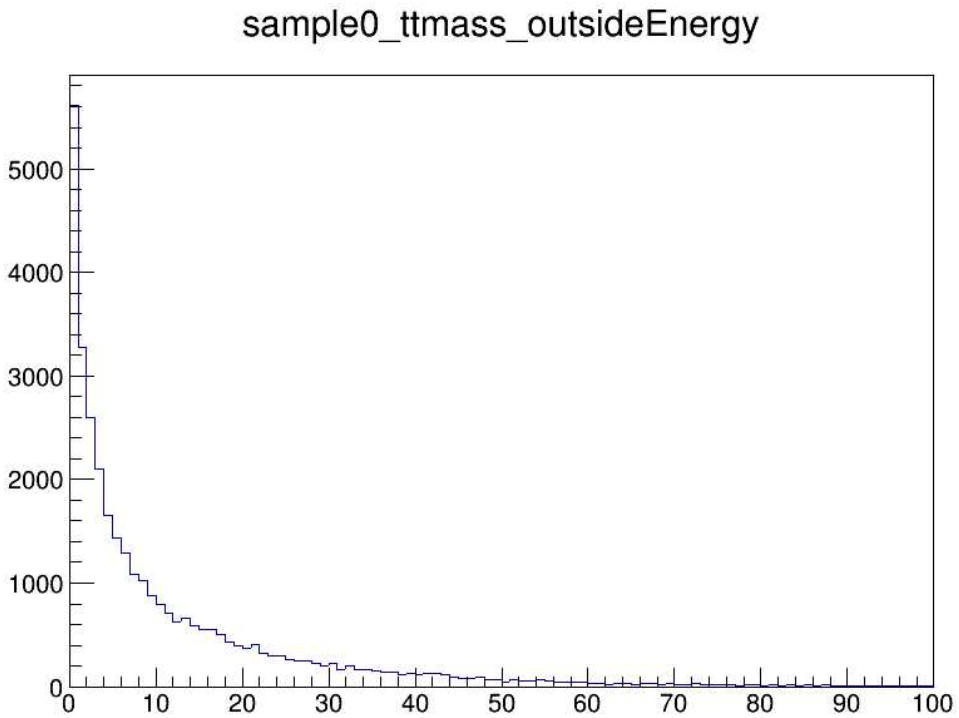
b) second seed: highest pT charged PFO,
separated from first seed by > pi/2 in azimuthal angle (phi)

c) collect PFOs within cone of 0.1 rad [~5.7 deg] around seeds

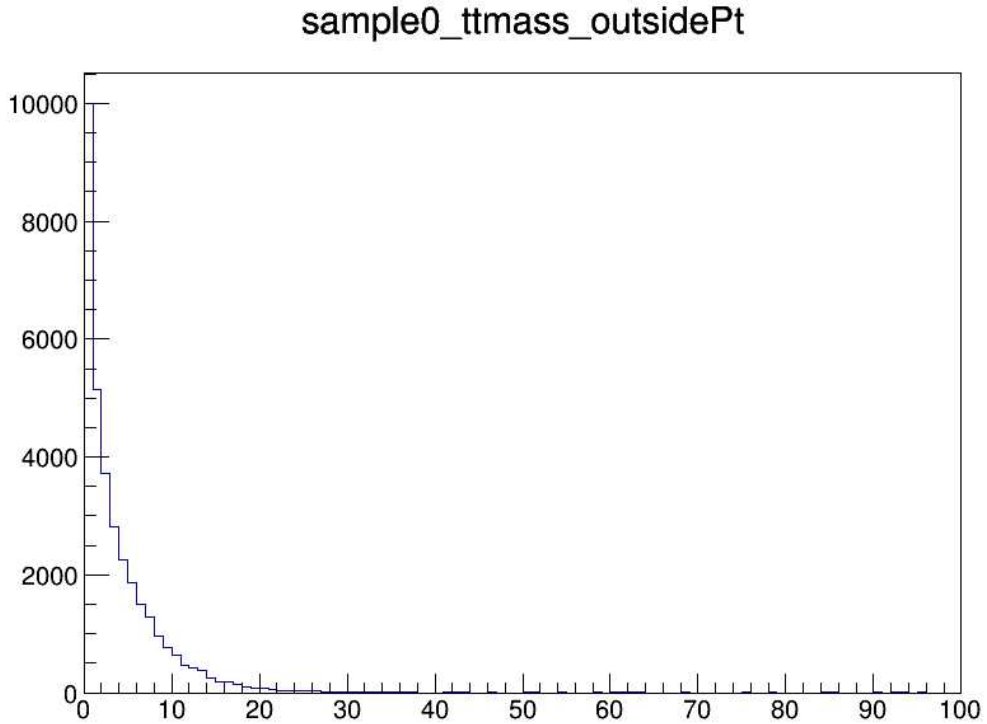
This procedure chooses seeds consistent with MC tau directions
in 97% of di-tau event with inv. Mass > 480 GeV.

Some reconstructed event distributions for high mass events





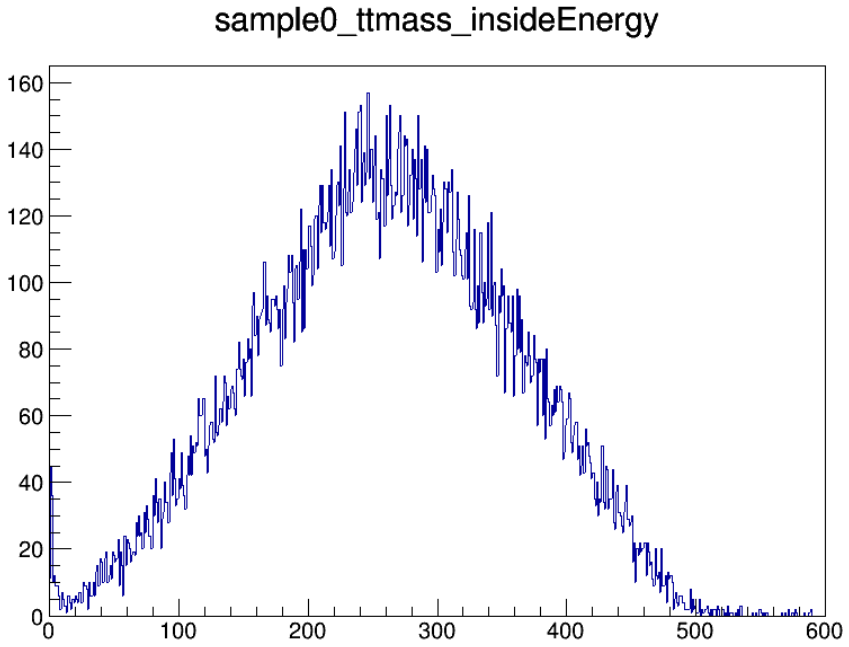
sum(PFO energy) outside the 2 cones [GeV]



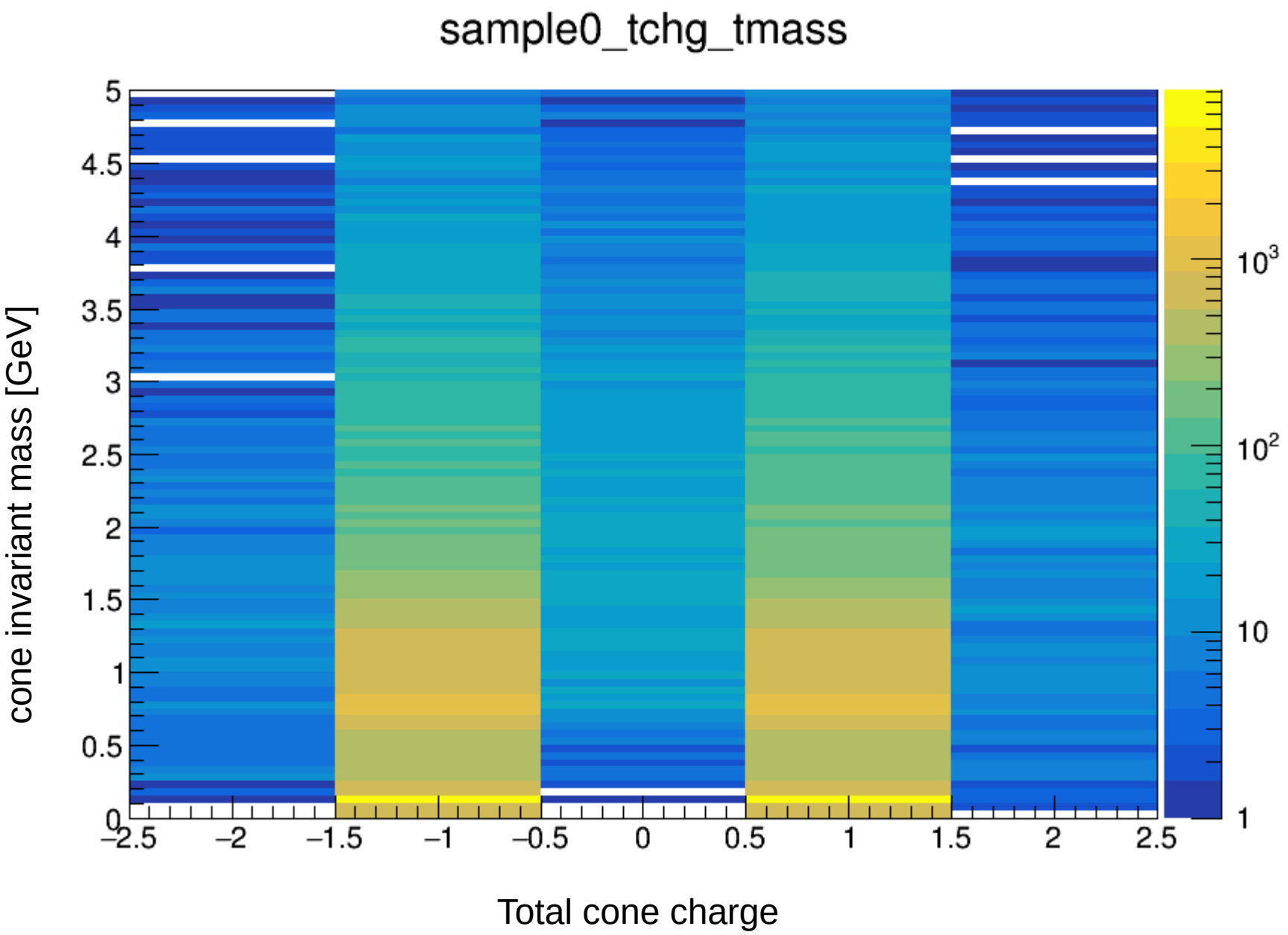
sum(PFO pT) outside the 2 cones [GeV]

High mass signal events

energy/pT inside and outside the 2 cones



sum(PFO energy) inside the 2 cones [GeV]


sample0_tchg_tmass
cone invariant mass [GeV]
Total cone charge
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
−2.5
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2
2.5
10^3
10^2
10
1

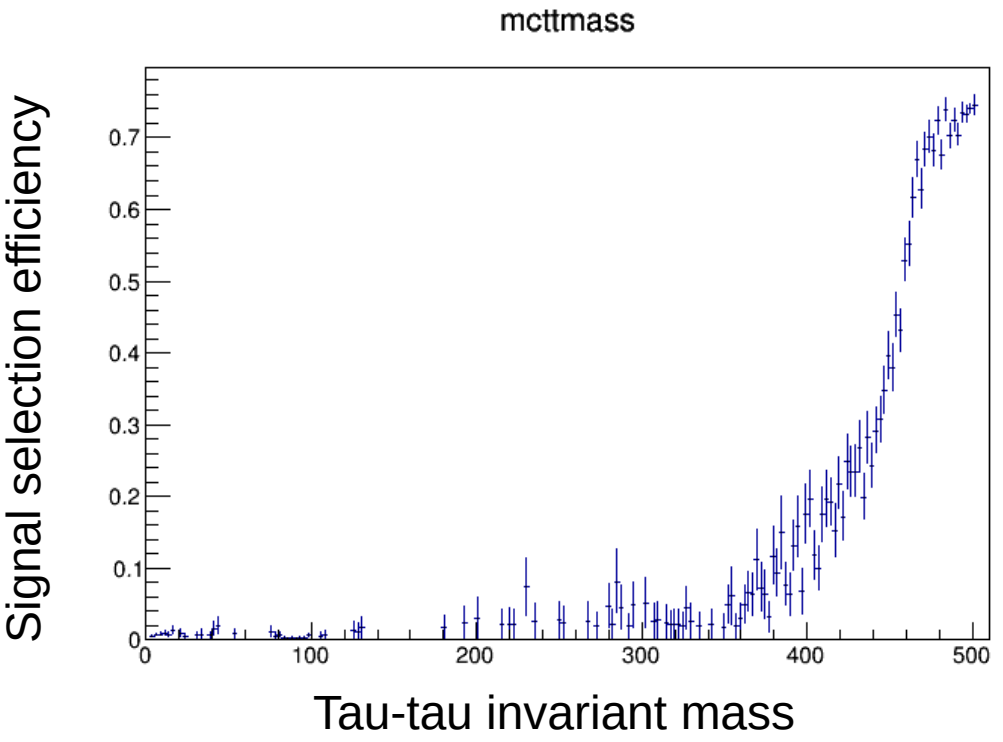
Event selection:

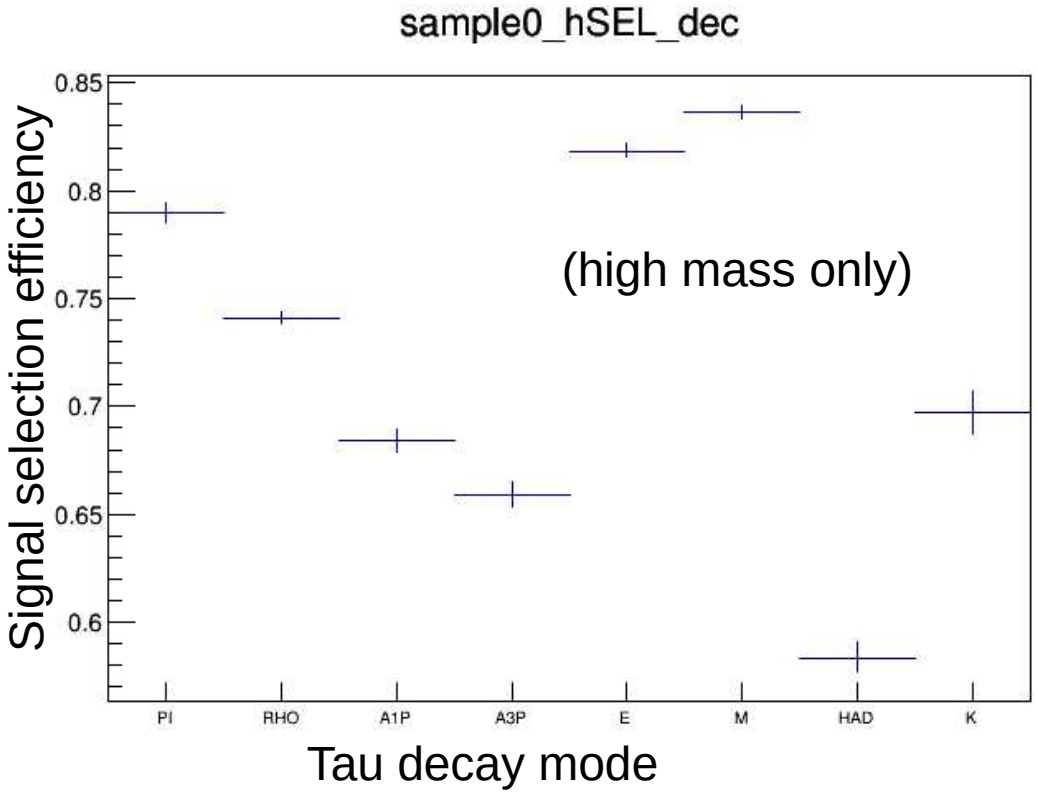
(not really optimised)

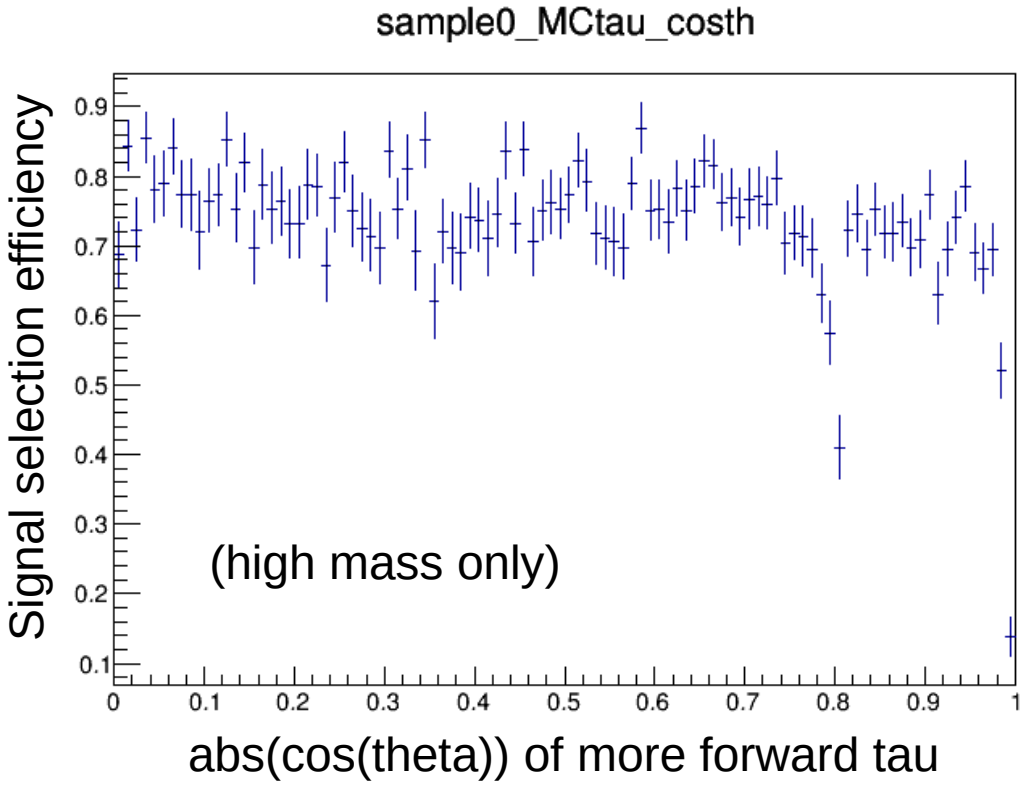
target: high-mass tau-tau pairs [tau-tau inv mass > 480 GeV]
(Z return events not so interesting for this analysis)
reject non-di-tau backgrounds (qq, mumu, ee, …)

	di-tau		mumu	qq
	>480	[75,480]		
In each cone, invariant mass of PFOs < 2.5 GeV	84%	82%	82%	14%
For particles not in cone: Sum (pT) < 20 GeV, sum (E) < 40 GeV	91%	60%	63%	11%
Acolinearity of two tau jet seed PFOs < 0.15 rad	97%	17%	29%	13%
charge(cone1) * charge(cone2) = -1	90%	73%	75%	14%
If both seed PFOs are tagged as el. or both as mu., then total energy inside the cones < 450 GeV	99%	91%	61%	96%
All cuts	73%	10%	2.7%	<0.01%

Signal selection efficiency







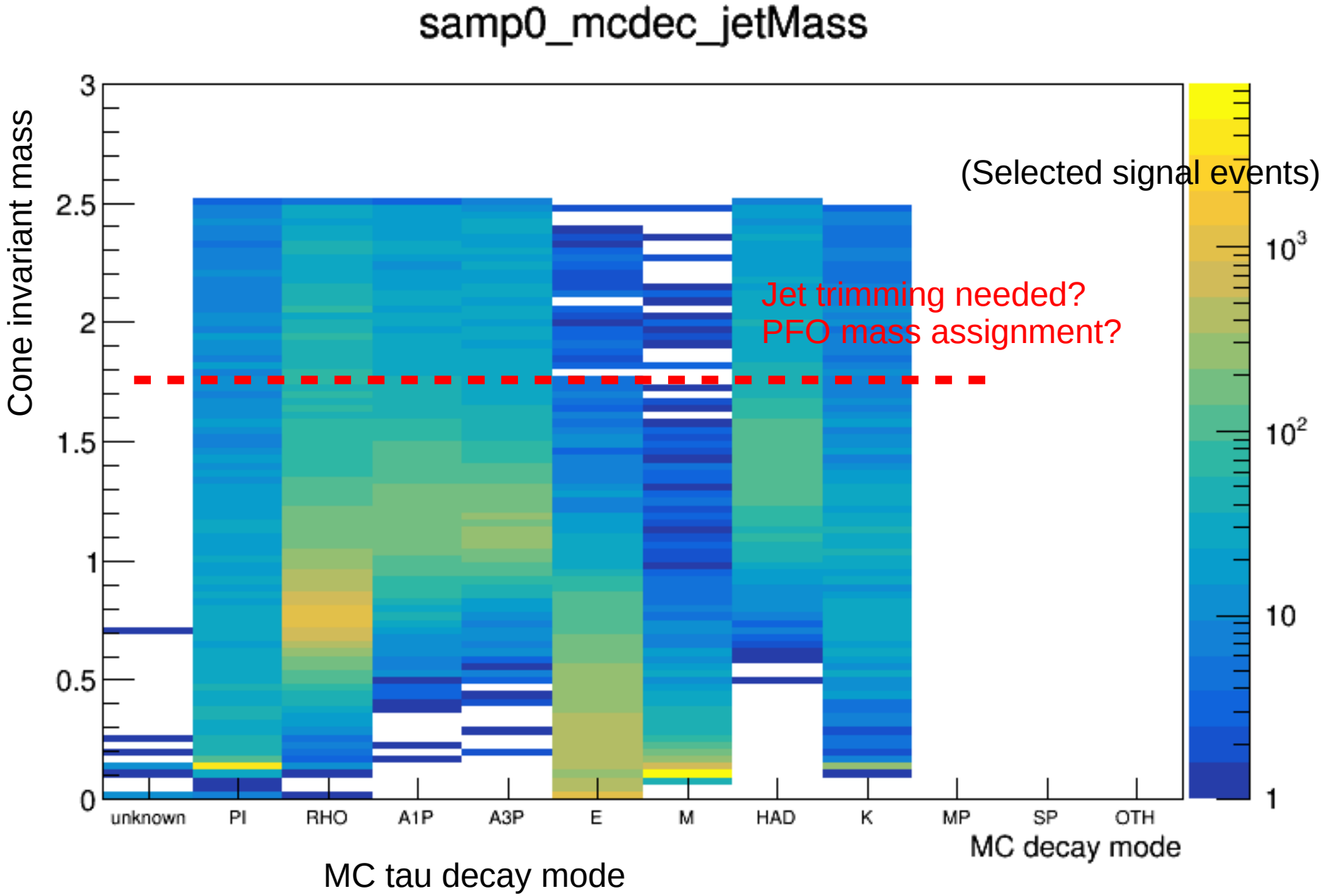
2. identify their decay mode

Based on:

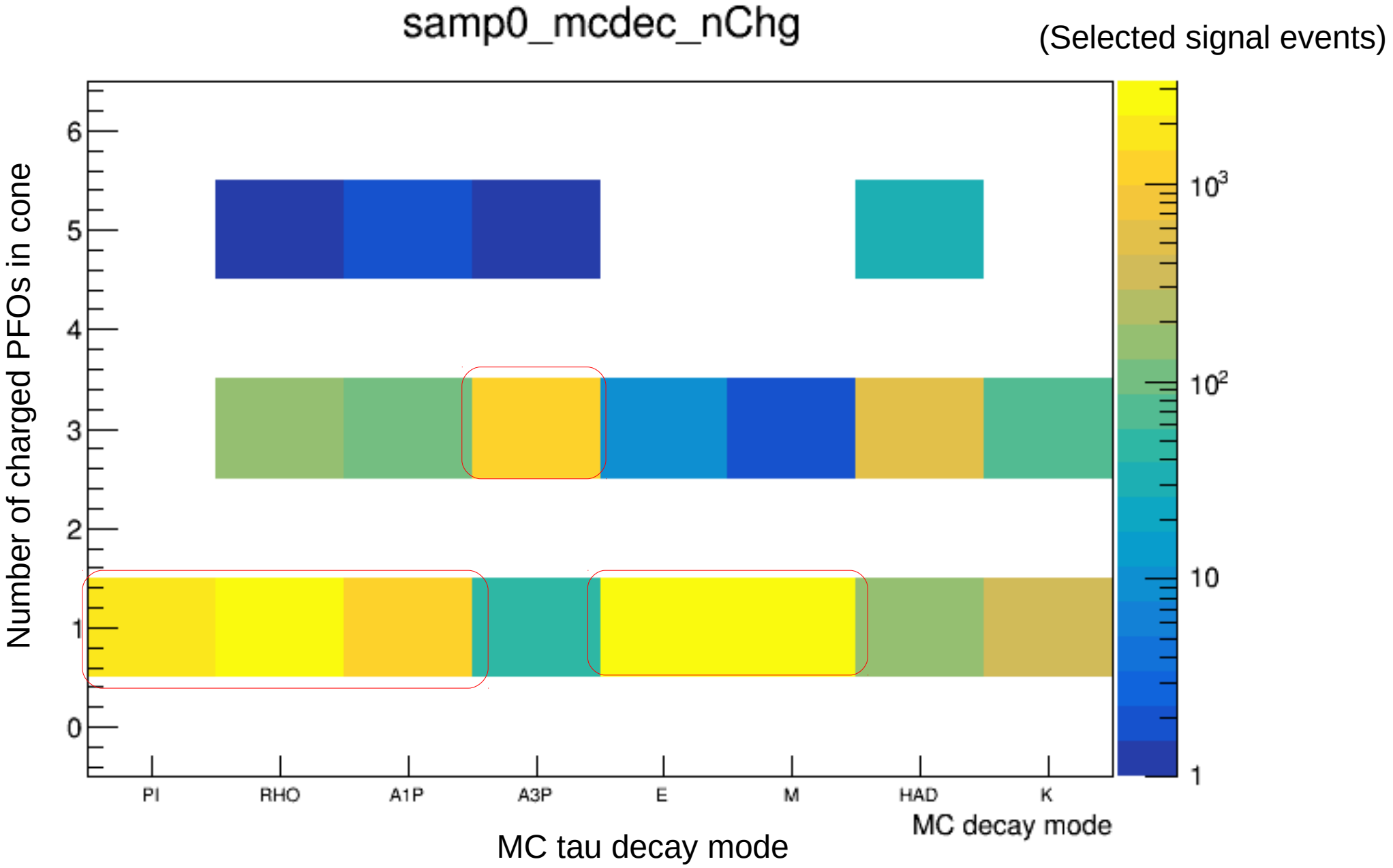
number of charged, pi0, photon PFOs inside cone

electron/muon ID

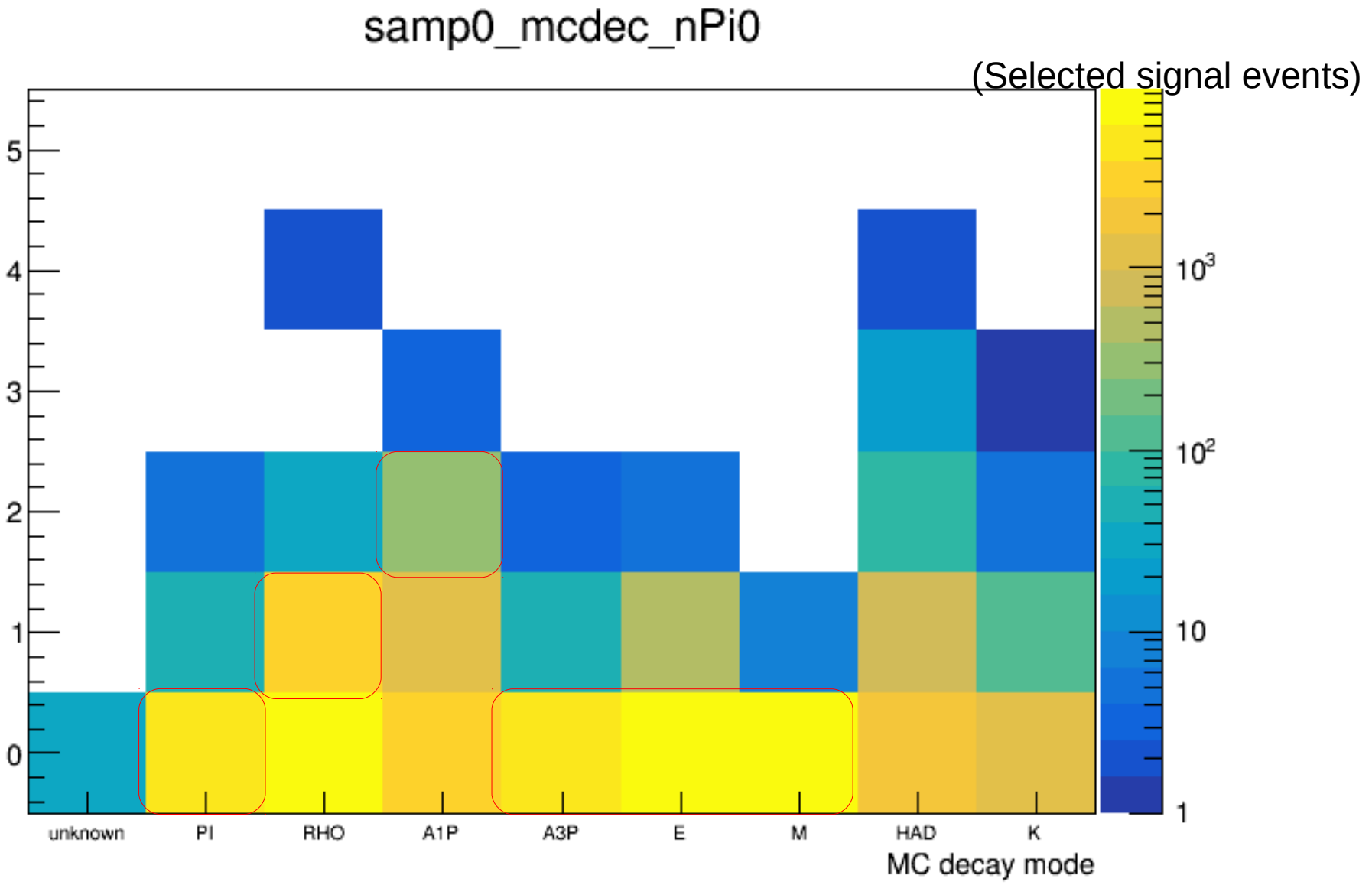
invariant mass of cone



Check reconstruction of charged particle number

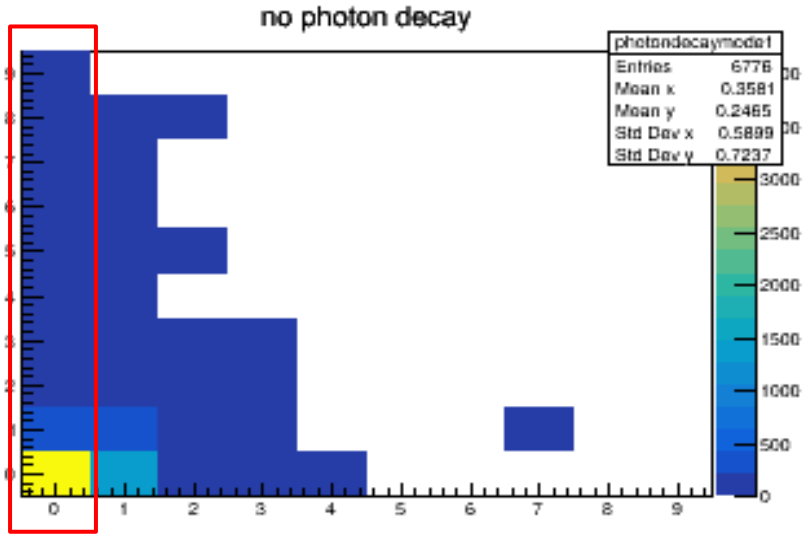


Check reconstruction of pi0 number

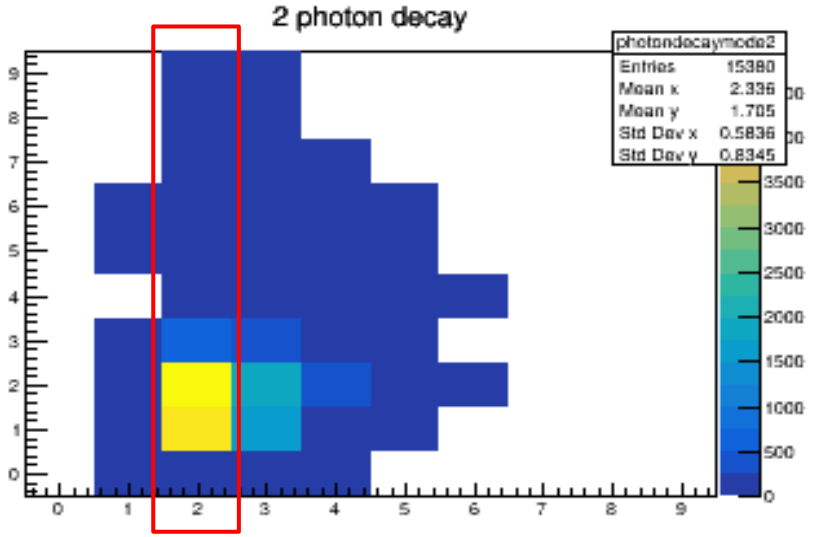


Sometimes we have extra photon from FSR, material interactions, …
Or lose one photon outside the cone for some pi0 decay angles.

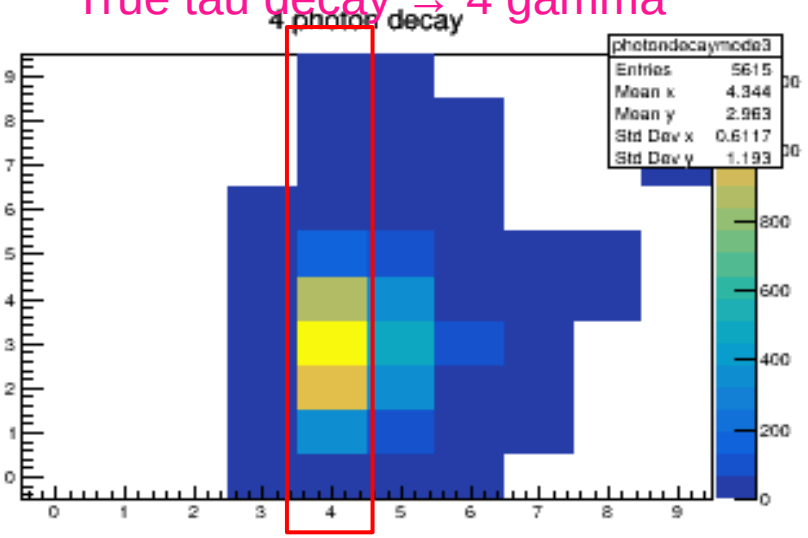
True tau decay → 0 gamma



True tau decay → 2 gamma



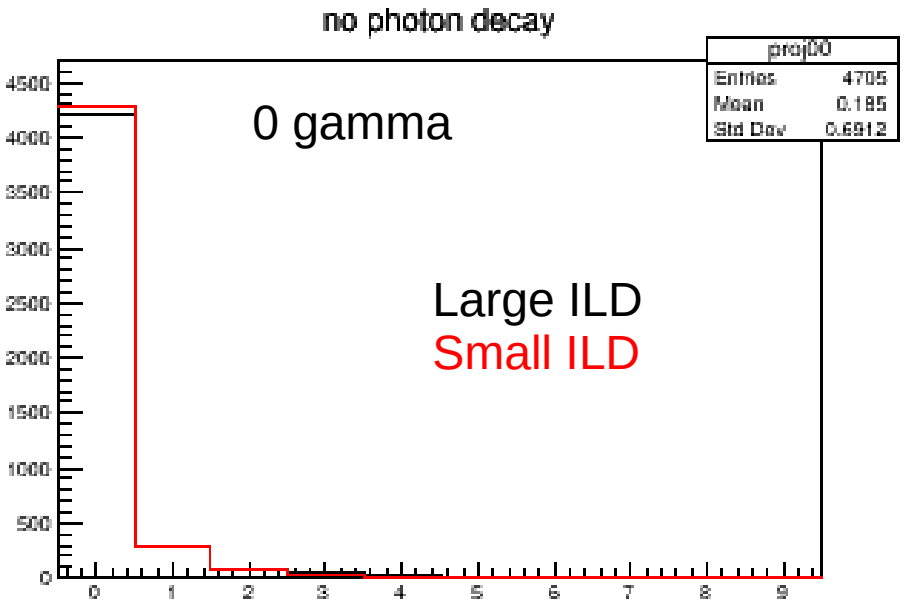
True tau decay → 4 gamma

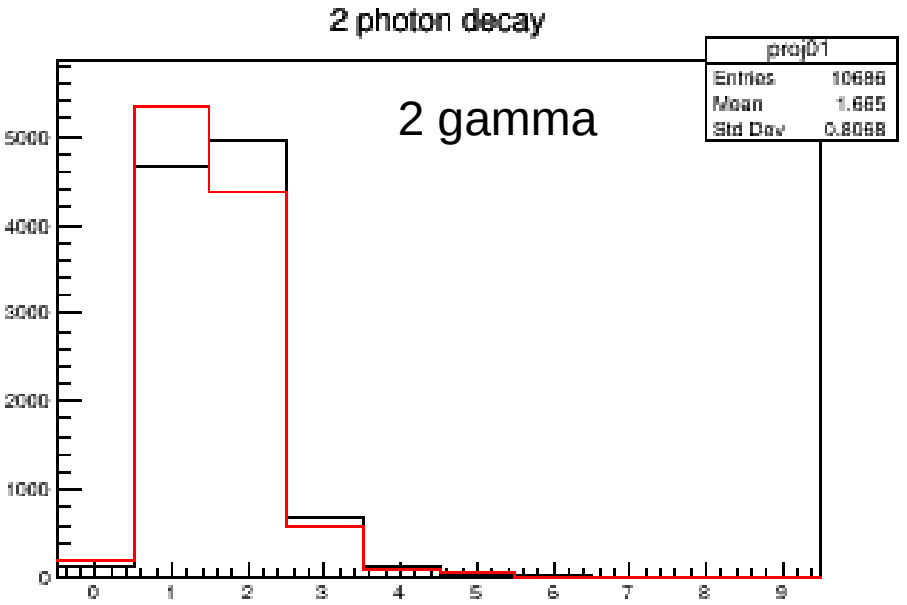


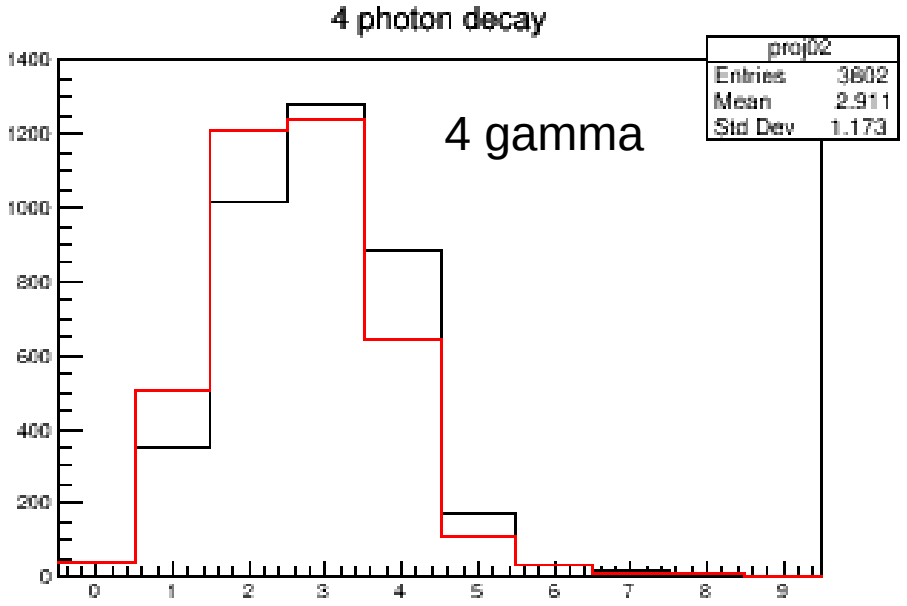
Signal only;

Reconstructed PFOs before pi0 finding

MC-based event selection (just based on tau-tau mass)







Select only tau cones in which:
#MC photons in cone ==
MC tau decay photons

(n.b. converted MC photons are counted as photons)

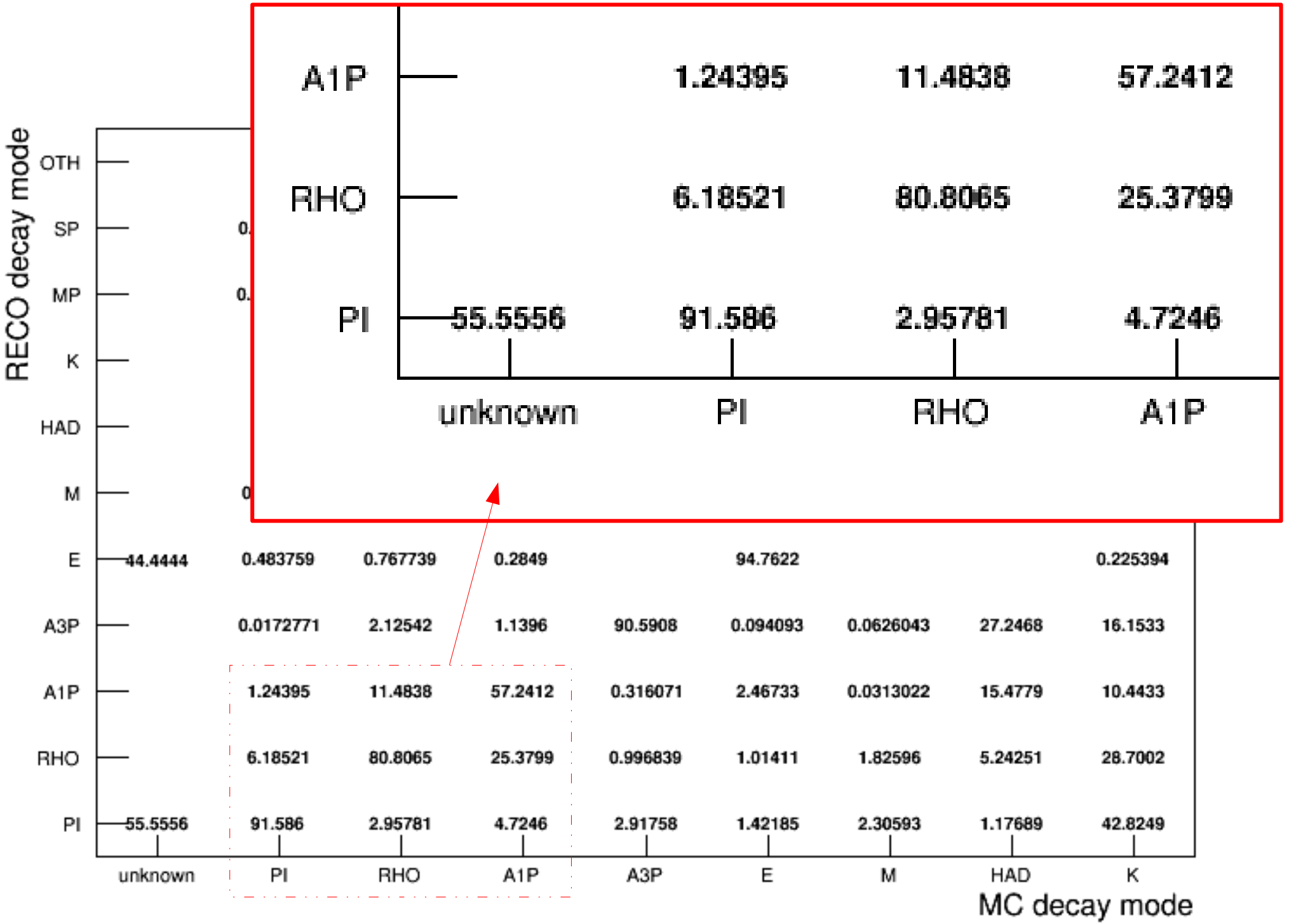
Compare # reco photons for large/small

Clear difference visible

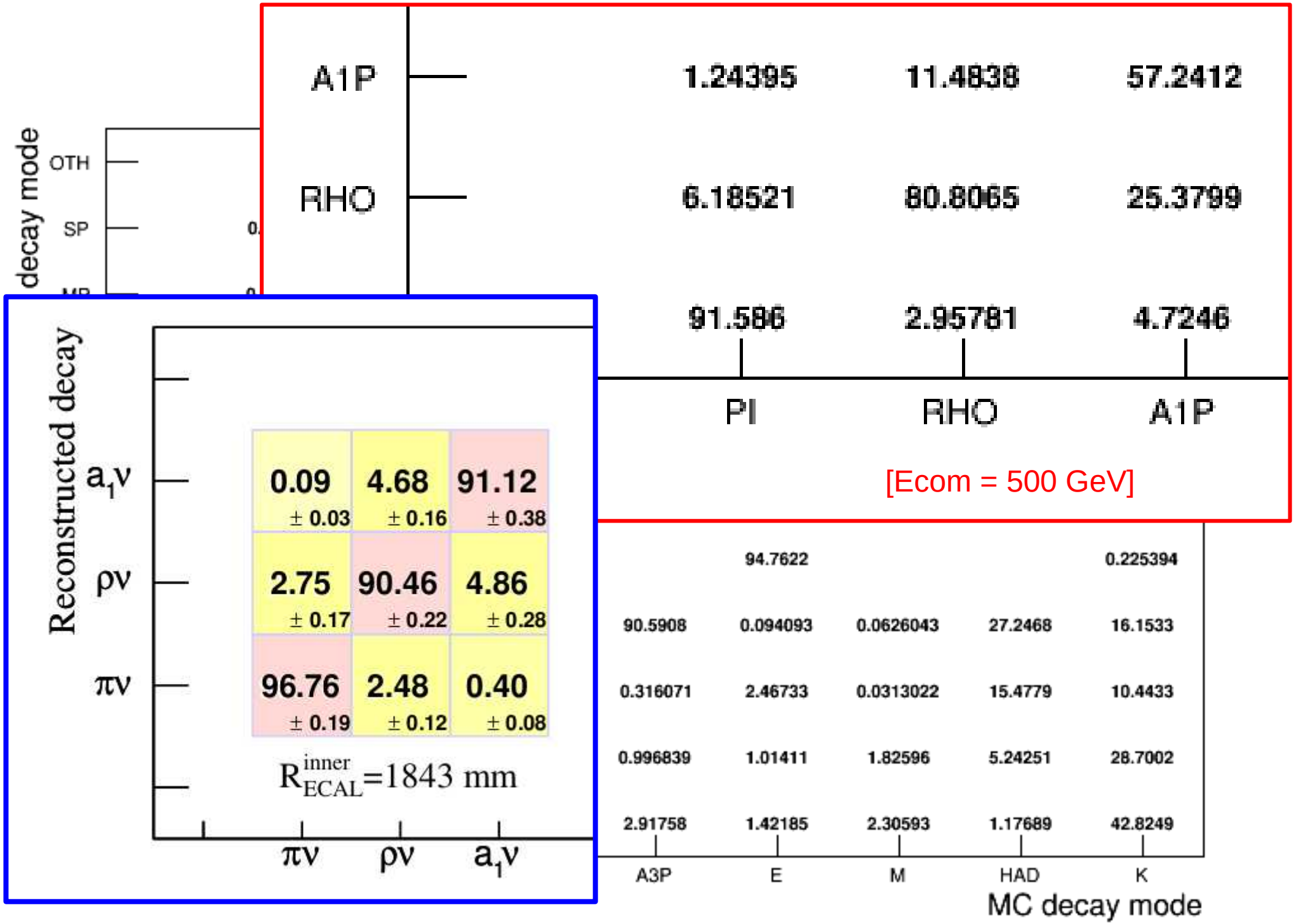
First classification attempt, for single prong decays

#chg PFO == 1

mass < 1 GeV, electron ID	→ ELECTRON
mass < 0.4 GeV, muon ID	→ MUON
0 pi0, 0 photon	→ PI
0 pi0, 1 photon, mass<0.5 GeV	→ PI
0 pi0, 1 photon, mass>0.5 GeV	→ RHO
1 pi0, 0 photons	→ RHO
(2*#pi0 + #photon) > 2, mass < 1	→ RHO
(2*#pi0 + #photon) > 2, mass > 1	→ A1



Tau decay mode identification: efficiency matrix



Corresponding figures @ 250 GeV, GARLIC photon reco, BDT, …
[T.H. Tran et al, Eur.Phys.J. C76 (2016) no.8, 468]

Physics observables:

total cross-sections (for each beam pol):

→ event selection, backgrounds

differential 3-d distribution (for each beam pol):

→ angle between polarimeter and tau direction (both tau+ and tau-)

→ cos theta (tau-)

in SM, expect no transverse spin correlations

→ limit on non-SM transverse correlations ?

[certainly not possible for us to do justice to all of these for IDR]

Potential large-small comparisons

- distinguish tau jet components
  eg photon, track counting

- identify decay modes; eff matrix

- precision on polarimeter extraction

- physics observables

summary

Goal:

1. select high-mass tau pair events in 500 GeV collisions
   → first attempt, further optimisation certainly possible

2. identify their decay mode
   → first attempt, further optimisation certainly possible

3. fully reconstruct tau momenta
   → work in progress, based on impact parameters...

4. measure tau polarisation
   → learned how to use TauSpinner (interface to TAUOLA)
   to extract polarimeters from final state particle momenta
   [particularly useful for 3-prong decays]

5. extract some physics
   → some ideas

6. compare large and small
   → simple comparisons started

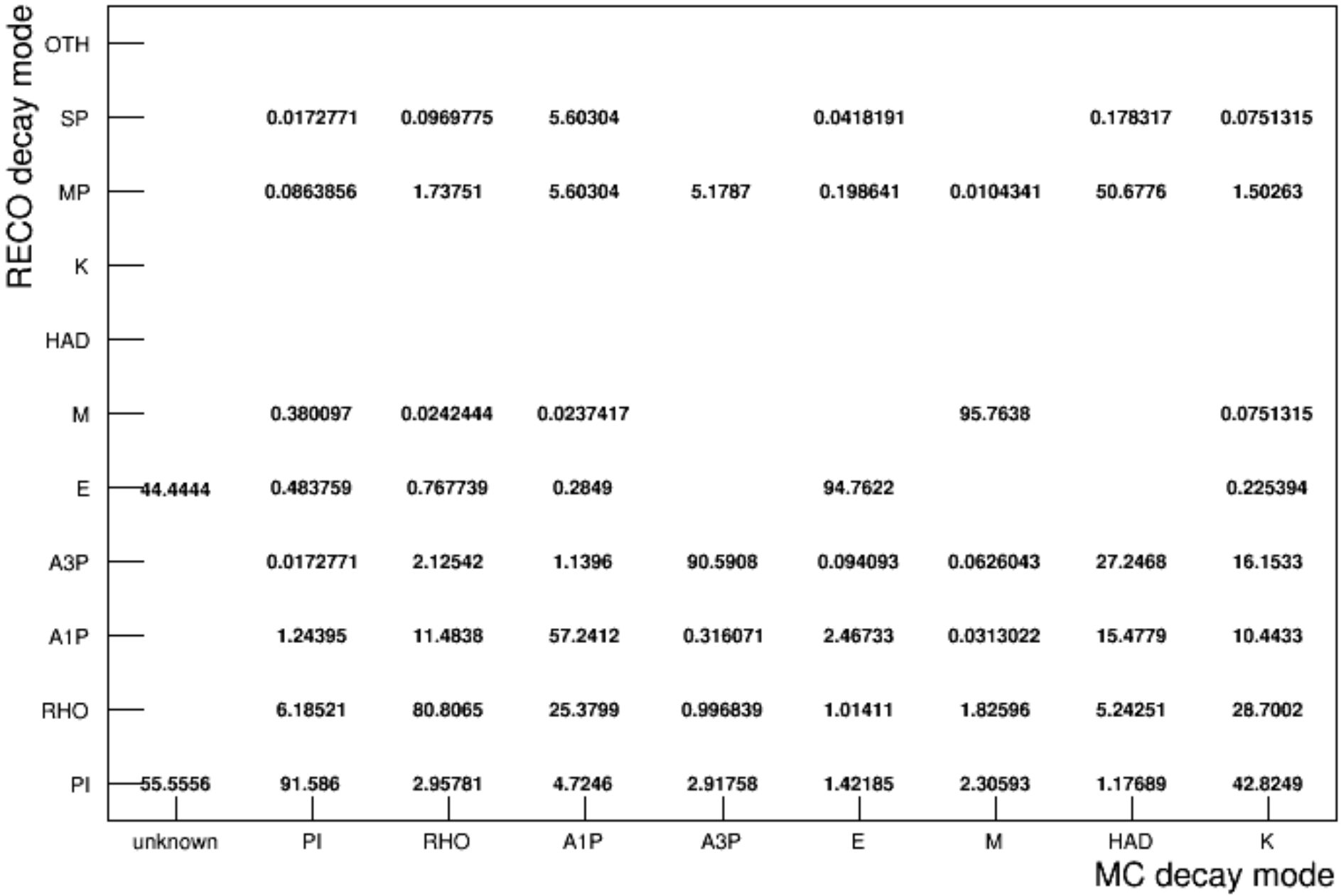
(most) analysis code uploaded to github

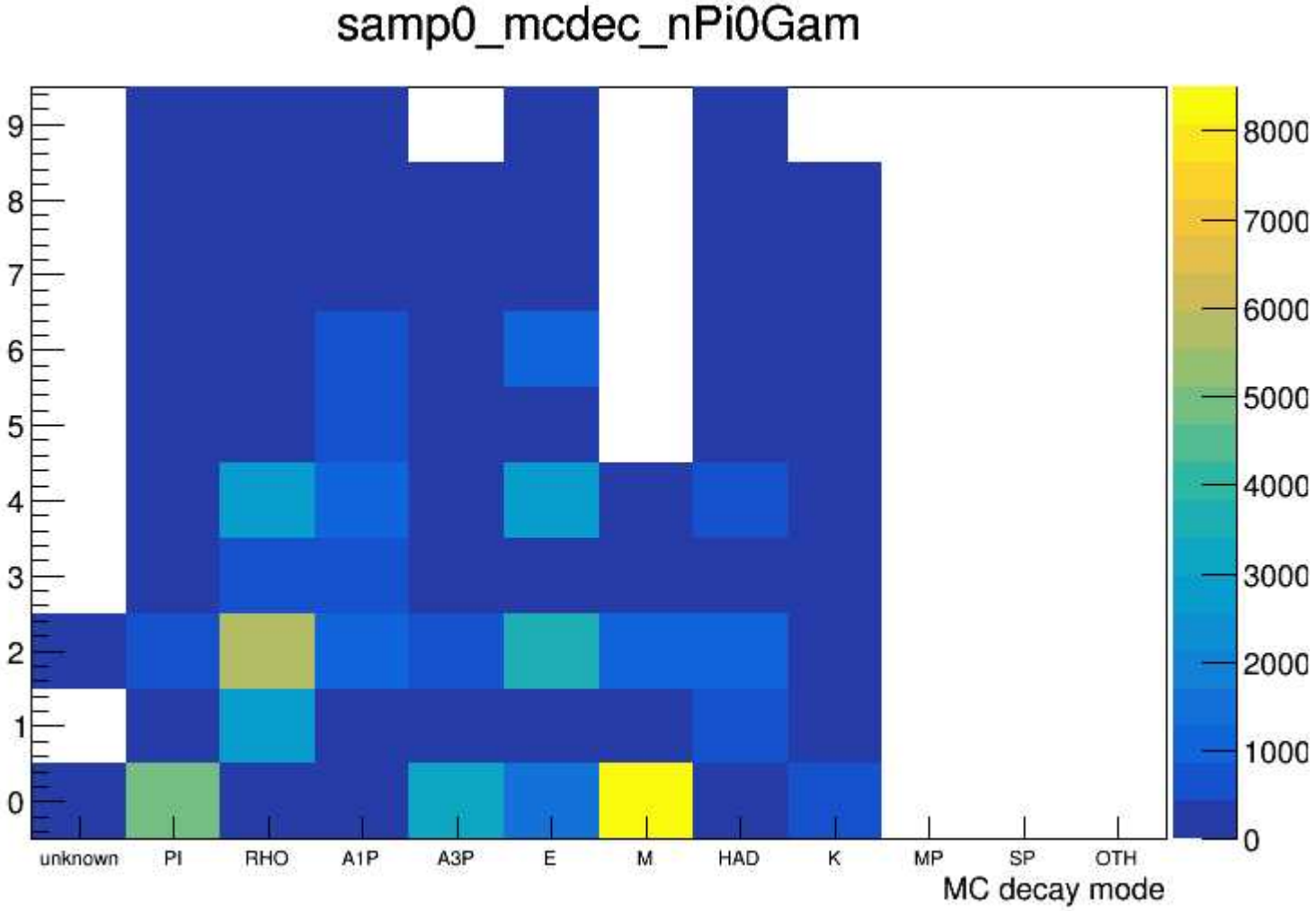
very rough note outline uploaded

still a lot of work to do

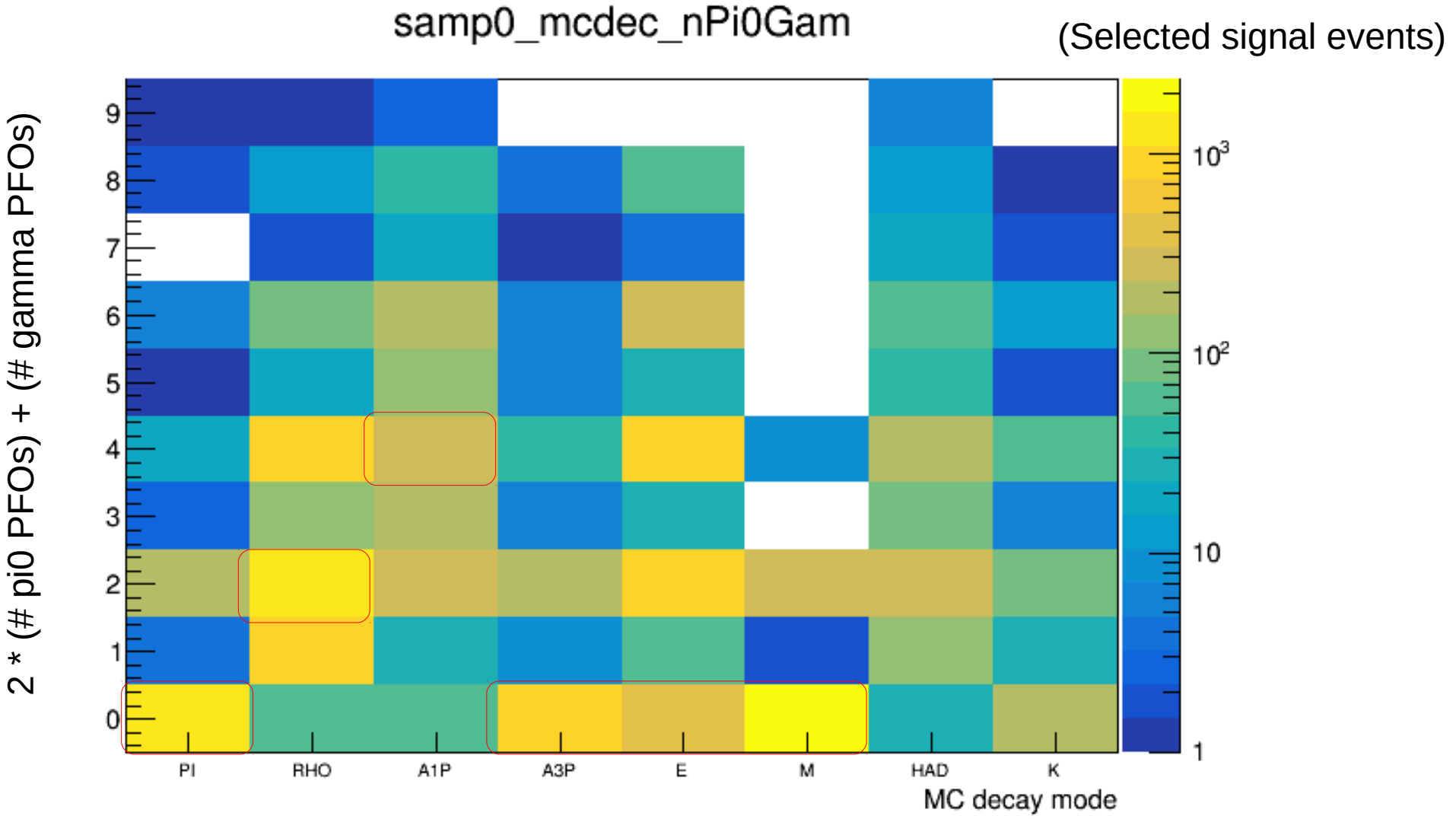
backup

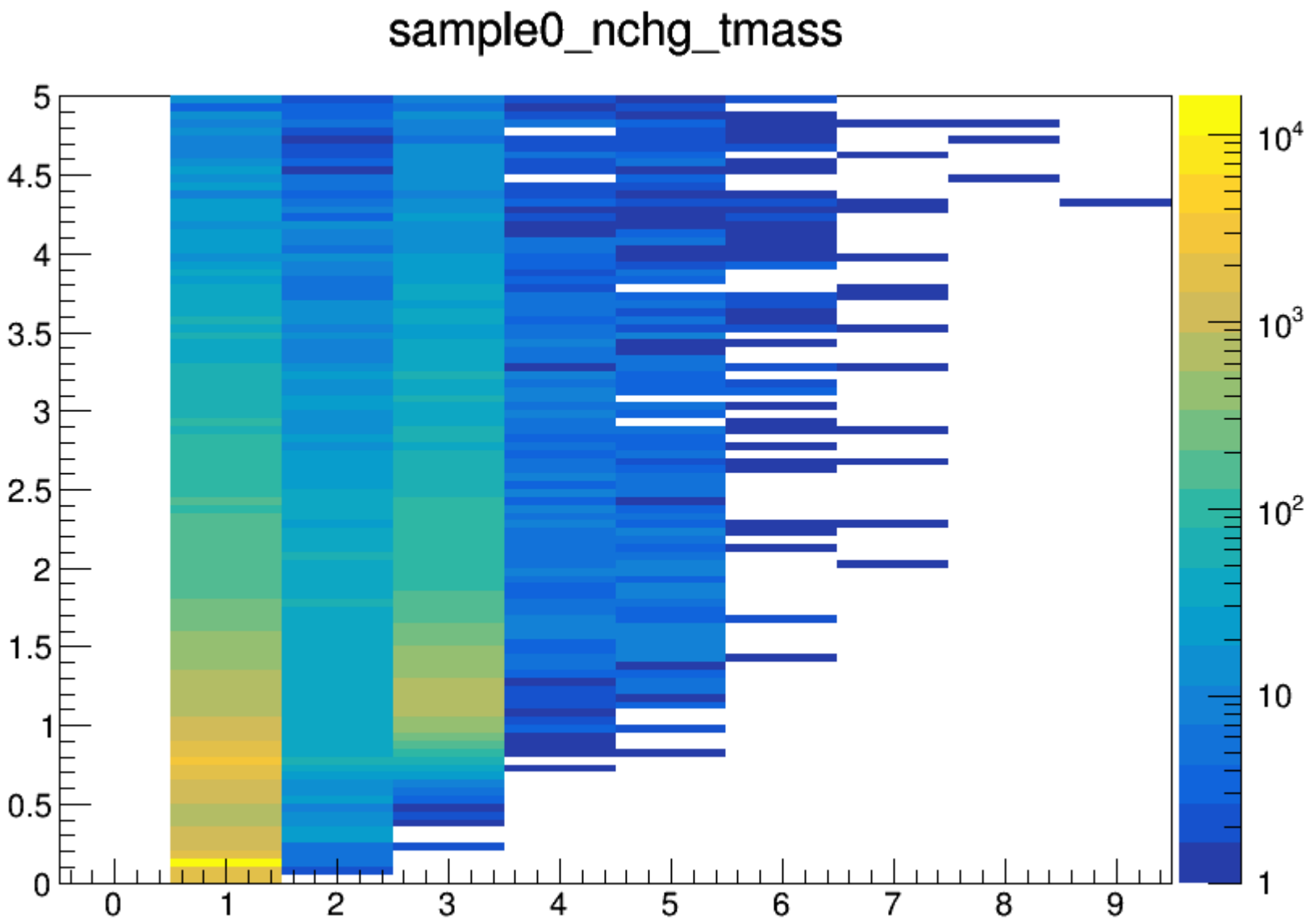
samp0_mcRecDecayEff




samp0_mcdec_nPi0Gam
9
8
7
6
5
4
3
2
1
0
unknown
PI
RHO
A1P
A3P
E
M
HAD
K
MP
SP
OTH
MC decay mode
8000
7000
6000
5000
4000
3000
2000
1000
0

Check reconstruction of photon number




sample0_nchg_tmass
5
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