Conversions in Taus

(the Vx Candidate side)

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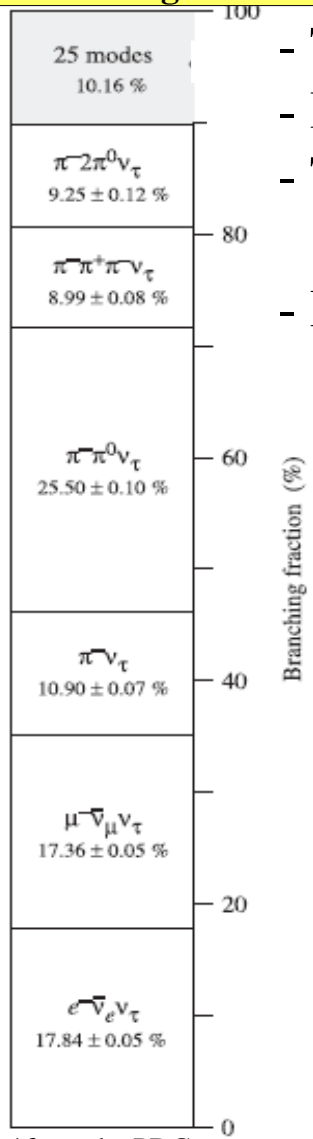
Many Thanks
To Hongbo Zhu

Hadronic Tau Decays

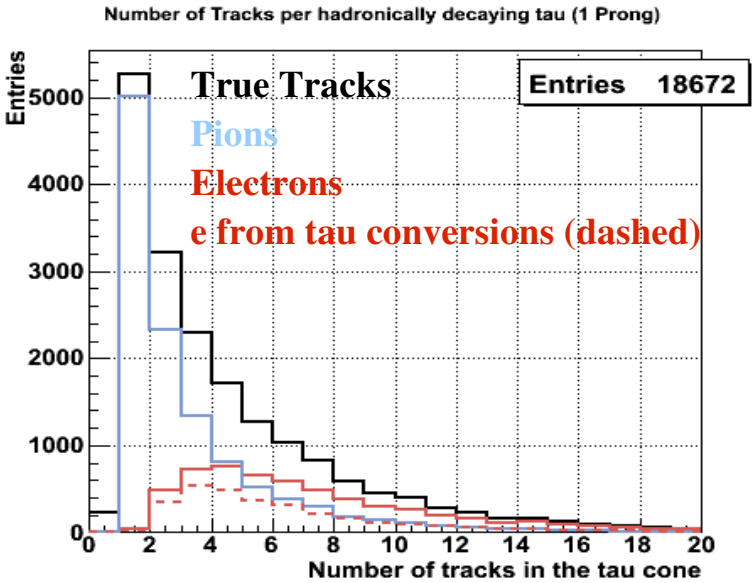
τ branching fractions

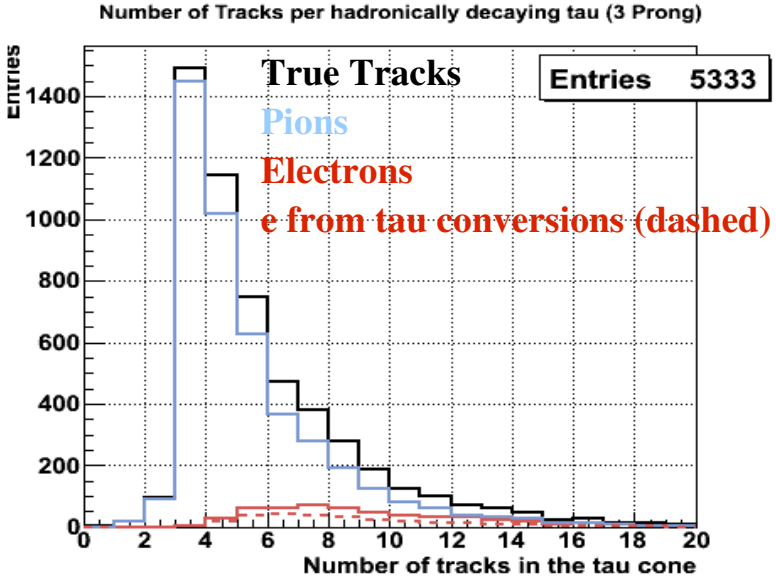


*from the PDG

- Tau decays: ~2/3 hadronic, 1-prong / 3-prong
- In Atlas' ID hadronic tau decays seen as small, isolated track collections, jets.
- Tau reconstruction algorithms rely on the number of tracks in the tau candidate cone to distinguish tau from jets and 1-Prong / 3-Prong tau decays
- Both 1-prong and 3-prong decays can involve **π0**'s, decay into photons which can convert leading to mis-identification:
  - 1-Prong τ -> 3-Prong τ or jets
  - 3-Prong τ -> jets

28,500 Z -> τ τ + (min-bias events) events





Electrons in Tau Cone

GOAL:

Identify tracks in the tau cone from conversions and remove them from the n-Prong / tau Vs jet decision

Strategy:

- Use Conversions Reconstruction as a Pid tool in tau cone

- Optimize Conversions Reconstruction Tools for Tau environment (JA et al)
  - Standard conversion finding tools optimized for isolated, high pT conversions
  - Conversions from taus are low pT, and in busy regions

- Optimize Electron Id (Michel Boehler et al)
  - take "TauVxCandidate" collection as input, further pion rejection
  - (see next presentation)

Reconstructed Tracks in Tau Cone

- Opened the cuts in the ID reconstruction for the VxCandidate

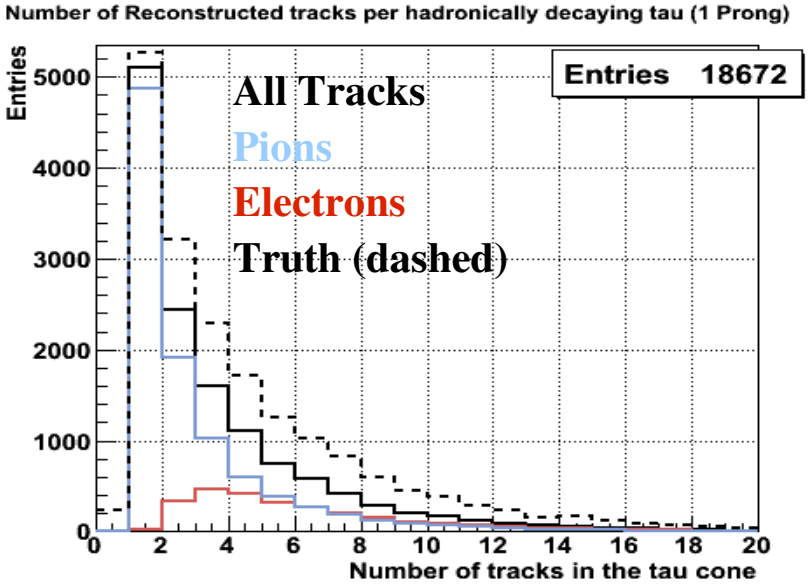
(mainly cuts on pT. impact parameters, vertex Chi2, and mass constraint)

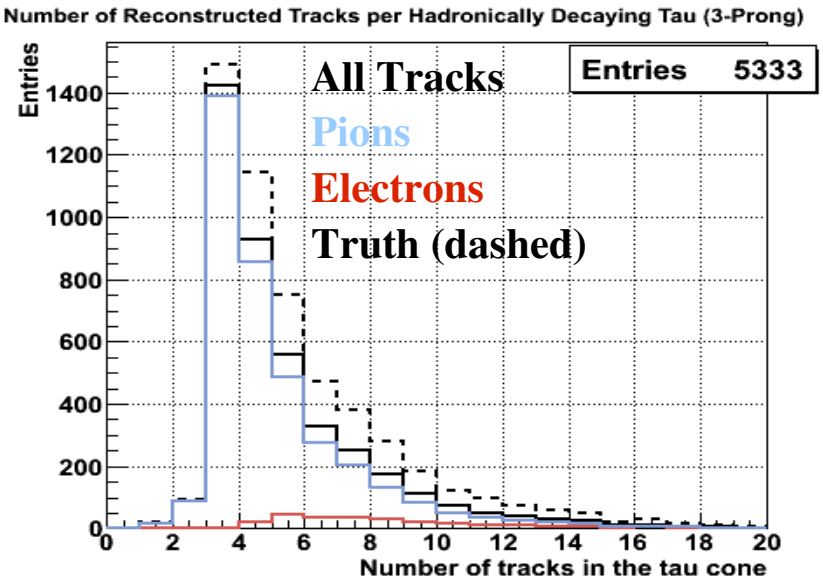
- Defined a cone of 0.3 around the hadronic tau truth

(eventually want to move to region defined by reconstructed tau)

	1-Prong	3-Prong
hadronic Taus	18672	5333
# rec tracks in tau cone	42623	20560
electrons	16014(37.6%)	2168(10.5%)
pions	24082(56.5%)	17341(84.3%)
from other	2527(5.9%)	1051(5.1%)

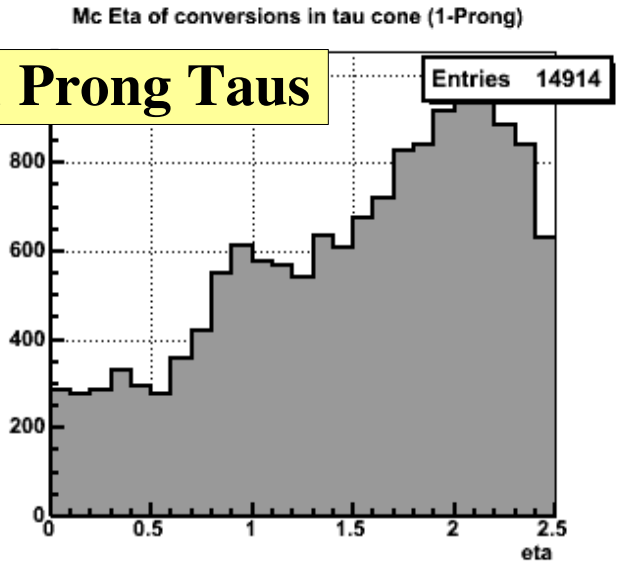
- 2.28 tracks reconstructed per 1-Prong tau cone
- 3.85 tracks reconstructed per 3-Prong tau cone

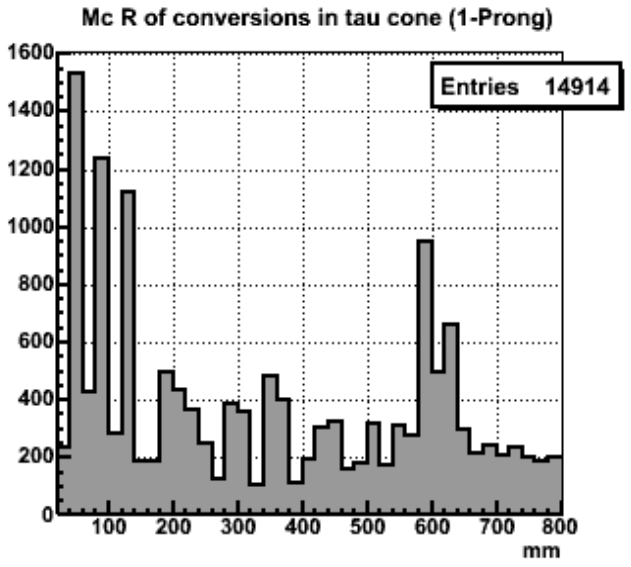


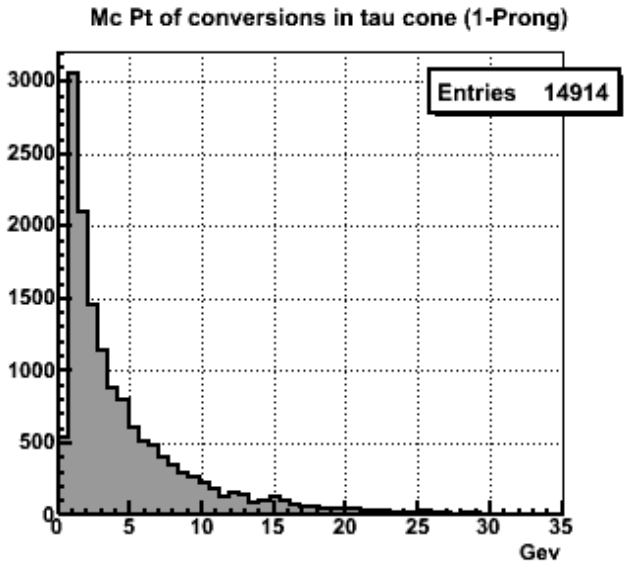


Conversions in the Tau Cone

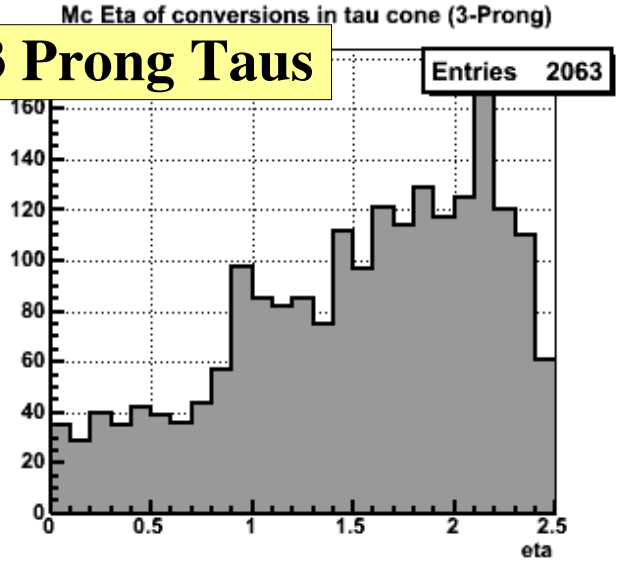
1 Prong Taus

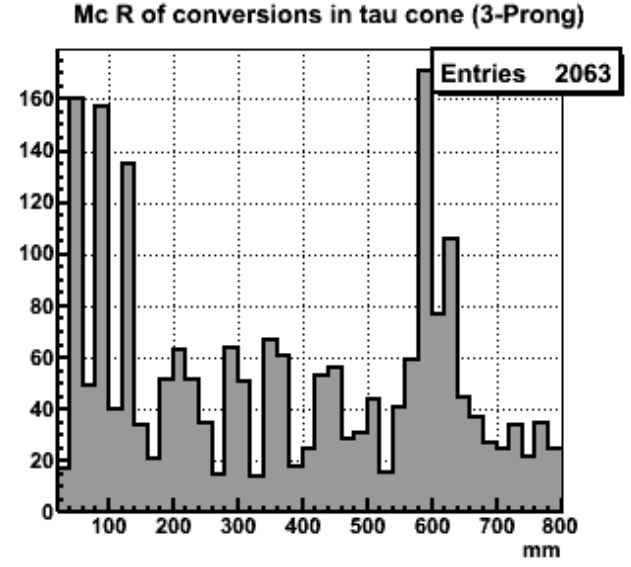


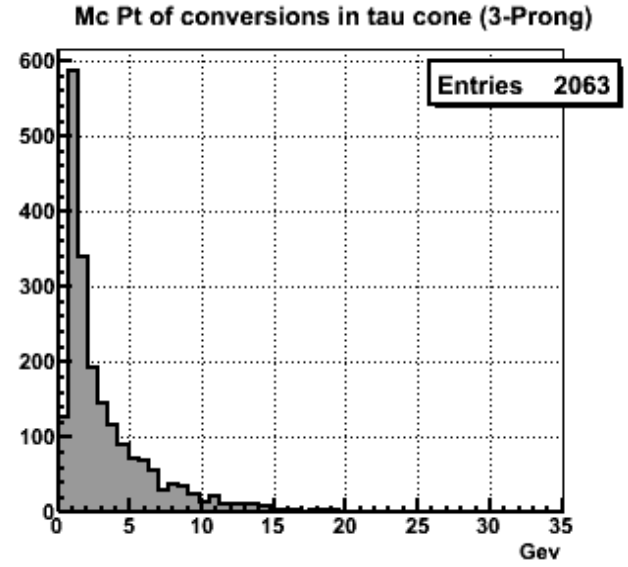




3 Prong Taus





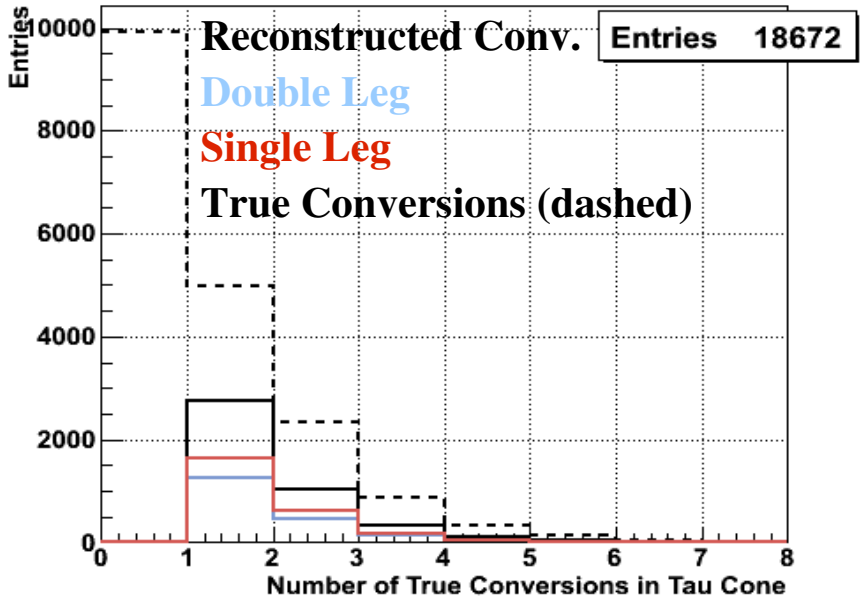


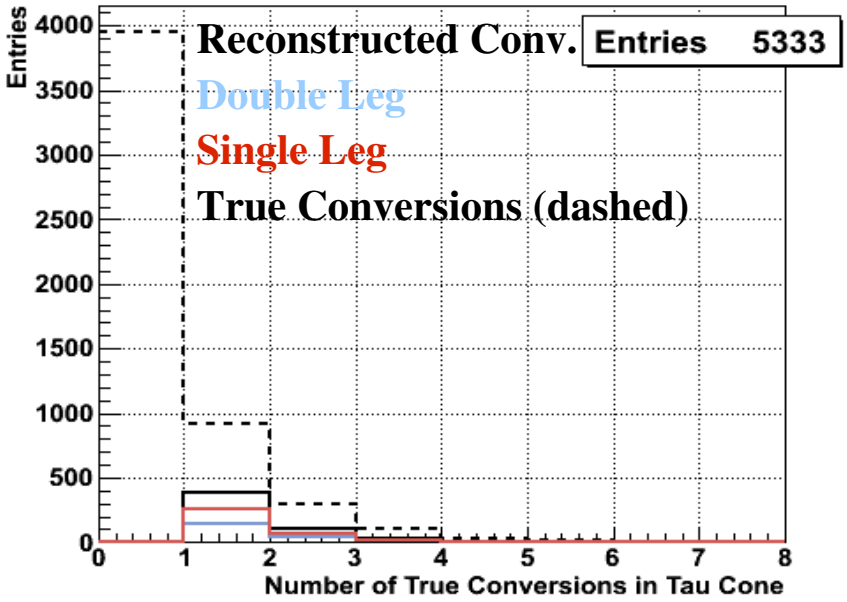
Conversions in the Tau Cone

	1-Prong	3-Prong
hadronic Taus	18672	5333
# with at least one conversion	8564	1377
# true conversions from taus	13534	1989
# true conversion in tau cone	15472	2235
# rec conversions in tau cone (%true)	13147(70.1%)	2527(47.9%)
double (%true)	6471(51.1%)	1325(23.8%)
single (%true)	6676(88.4%)	1202(74.5%)

- average of 0.8 (0.4) true conversions per 1(3)-Prong tau cone
- ~ 50 % 1 -Prong / 25% 3 -Prong taus have a conversion in TC
- ~ 1/2 of reconstructed conversions single leg (low pT + asymmetric)

Conversion Reconstruction in tau cone (1 Prong / 3 Prong)

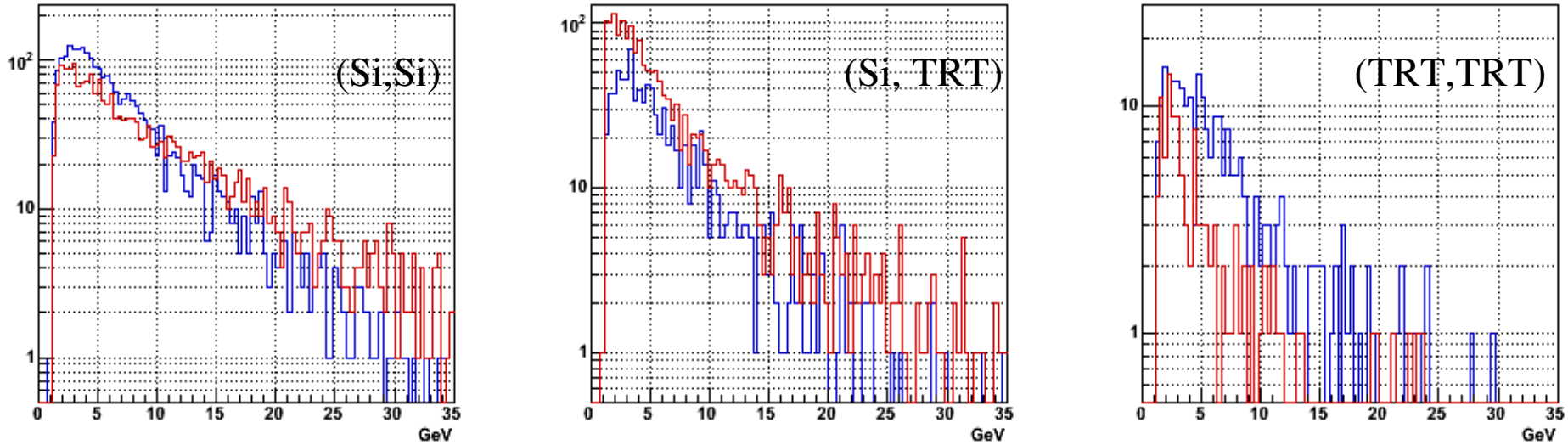




Conversions Separation

- Cuts tuned are mainly on double leg conversions
  - single leg conversions judged mainly in pid, first hit R (not pT dep, clean to begin with)
- Three types of double leg conversions (Si,Si) (Si,TRT) (TRT,TRT)
  (70%) (25%) (5%)
- Some separation of signal / background
  red: true (both legs matched to truth particles which come from same gamma)
  blue: fake (fake tracks / wrong tracks / wrong track pairs)

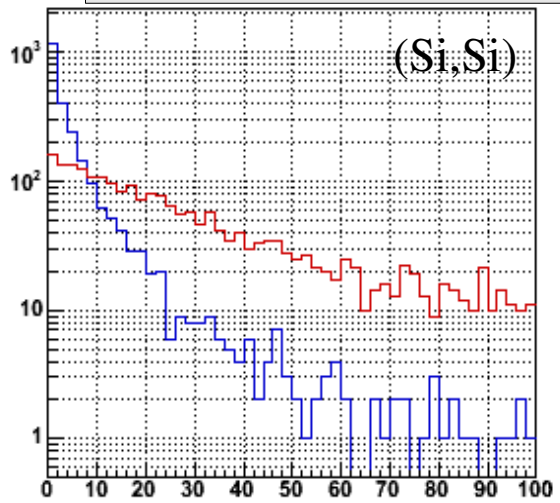
Reconstructed Photon Momentum

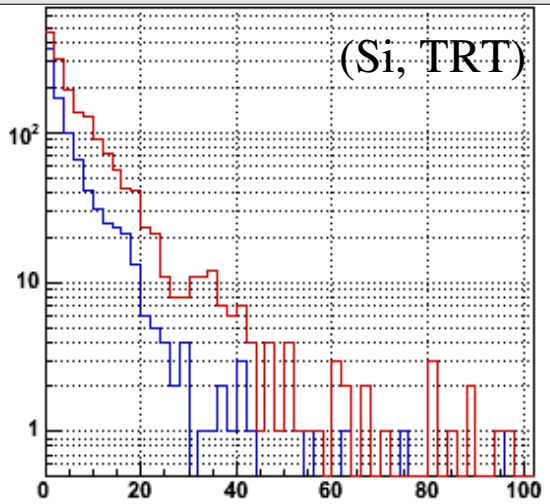


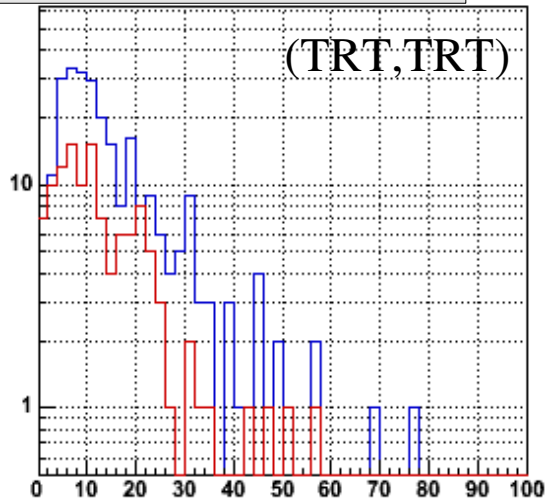
Default Cut is at 2 GeV

Conversion Separation

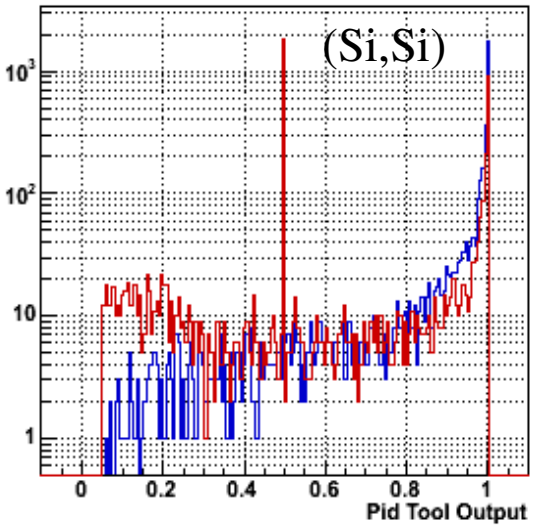
Chi2 of the vertex fit (includes chi2 of tracks + implicit mass constraint)

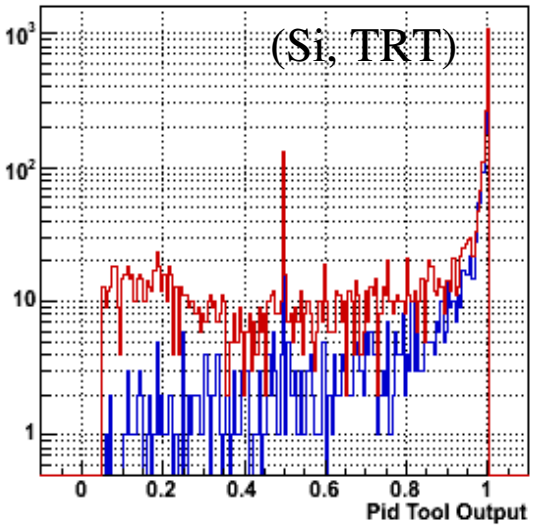


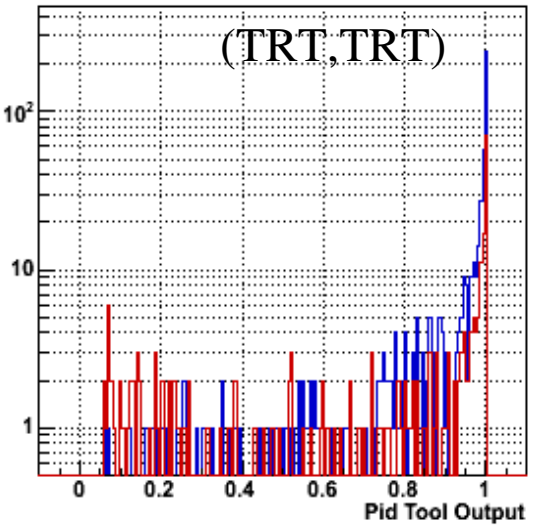




Inner Detector Pid Tool







Vetoing Tracks in Tau Cone

Criteria for cuts : optimal e rejection (stress is on e purity of tracks flagged as from
minimal π rejection conversions, not on purity of conversions themselves)

For 28586 Z -> ττ events
18672 3-Prong taus
5333 1- Prong taus

	Default cuts on Conversion Candidates		Opened cuts on Conversion Candidates		ID specific cleanup	
	1-Prong	3-Prong	1-Prong	3-Prong	1-Prong	3-Prong
# tracks from VxCandidates in tau cone	13725	2401	15532	2983	9635	1299
electrons	12179(88.7%)	1474(61.4%)	13385(86.2%)	1656(55.5%)	9193(95.4%)	1137(87.5%)
pions	1232(9.0%)	820(34.2%)	1744(11.2%)	1181(39.6%)	265(2.8%)	123(9.5%)
other	314(2.3%)	107(4.5%)	403(2.6%)	146(4.9%)	177(1.8%)	39(3.0%)
% of tracks in tau cone vetoed	32.2%	11.7%	36.4%	14.5%	22.6%	6.3%
% of electron tracks in tau cone vetoed	76.1%	68.0%	83.6%	76.4%	57.4%	52.4%
% of pion tracks in tau cone vetoed	5.1%	4.7%	7.2%	6.8%	1.1%	0.7%
% of other tracks in tau cone vetoed	12.4%	10.2%	15.9%	13.9%	7.0%	3.7%
	I		II		III	

For ID specific clean-up a cut on Pid tool output (0.8) is made on all tracks in single conversions and the pair in the double conversions
(ie: both tracks must have pid above 0.8)

Possible Next Steps

I

Use default conversion finding and extrapolate tracks found in the tau cone to the calorimeter and do cluster matching

Pros: - no need to run dedicated conversion finding in tau rec
- increased π purity

Cons: - CPU time in extrapolating to calorimeter,
- combinatorics in track and low pT clusters

II

Open all conversion container cuts run dedicated conversion finder in tau cone extrapolate tracks to calorimeter for further π cleanup

Pros: - largest potential gains in electron rejection power

Cons: - re-run conversion finding in tau cone
- larger number of tracks to extrapolate to the calorimeter

Possible next steps

III

Run dedicated conversion finder in tau cone with ID tau-specific cleanup

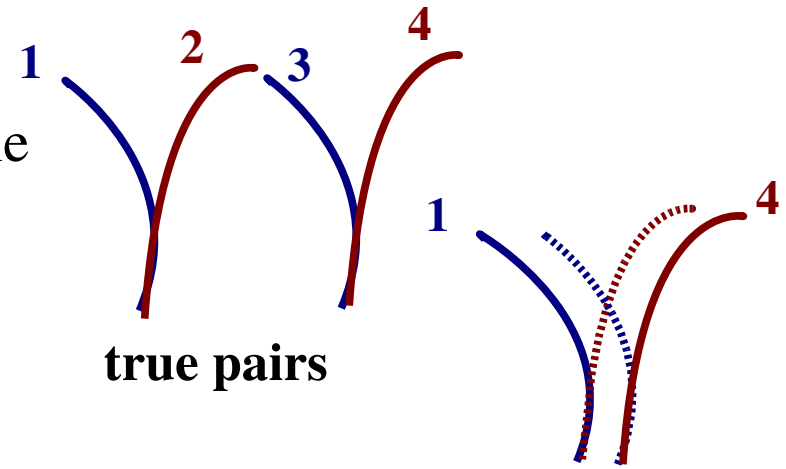
Pros: - relies only on ID specific information

- no need to extrapolate to calorimeter

Cons: - loss in electron rejection power

Further Possible Track Based Cleanup

- Aim so far.. reject electron tracks from tau-cone
- further enhance π purity
- Most backgrounds are from combinatorics
  - dense track environment
  - conversion finder algorithm uses all combinations of positive and negative



true pairs

combinatorial background

- Cut down on combinatorics by selecting preferred track pairs via scoring and then appling overlap removal
  - Chi2 of the track fit
  - distance between reconstructed vertex and first hit on track

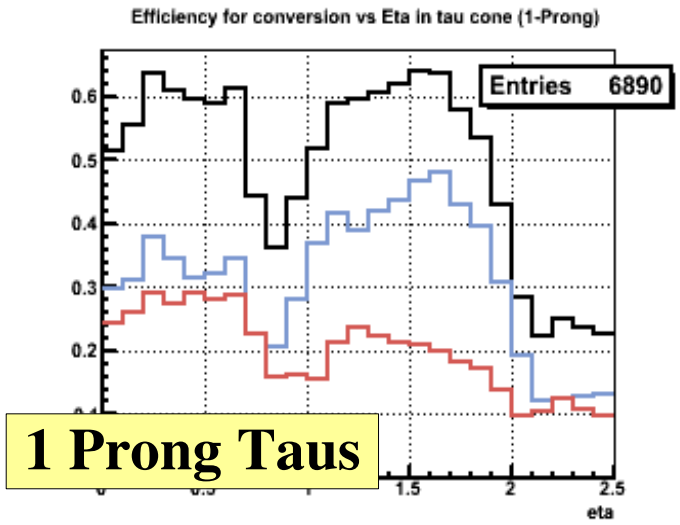
Reinforcements.

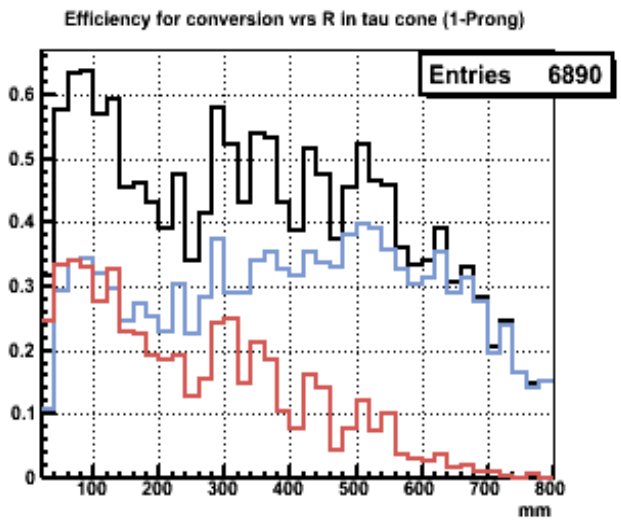
Conversion Efficiency in Tau Cone

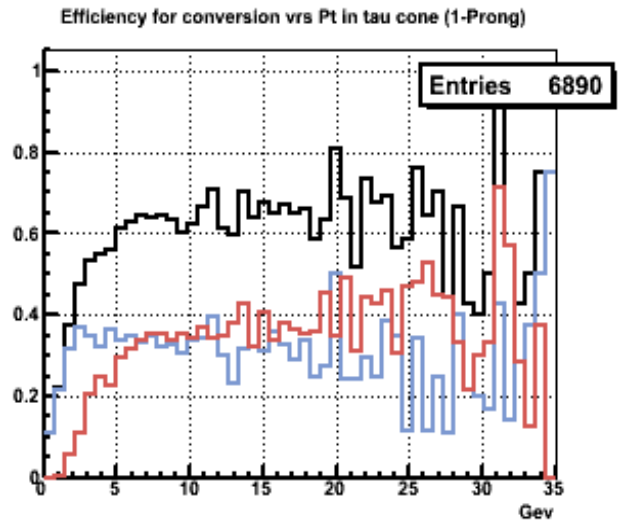
Single Leg Conversion

Double Leg Conversion

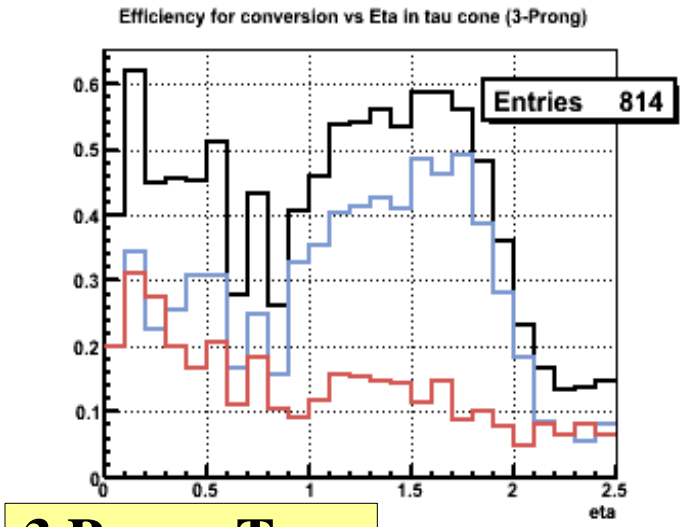
Either

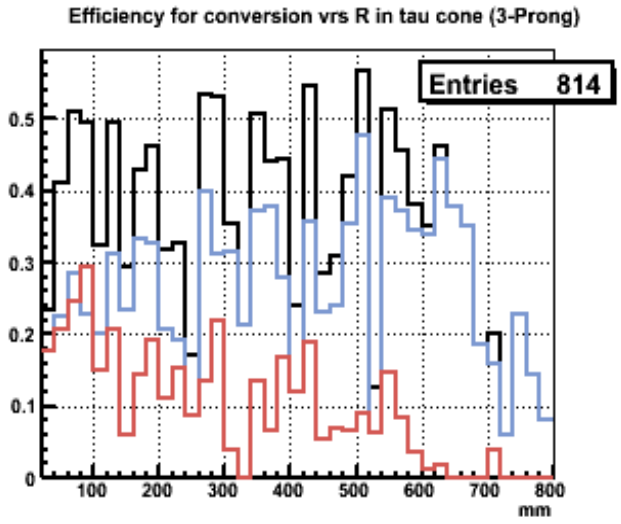


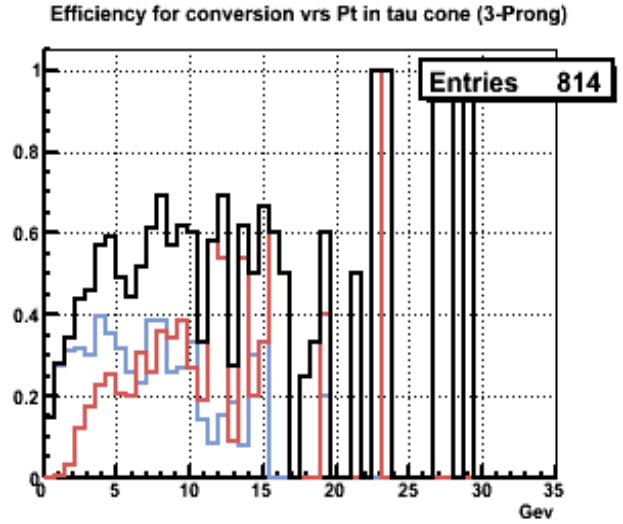




1 Prong Taus

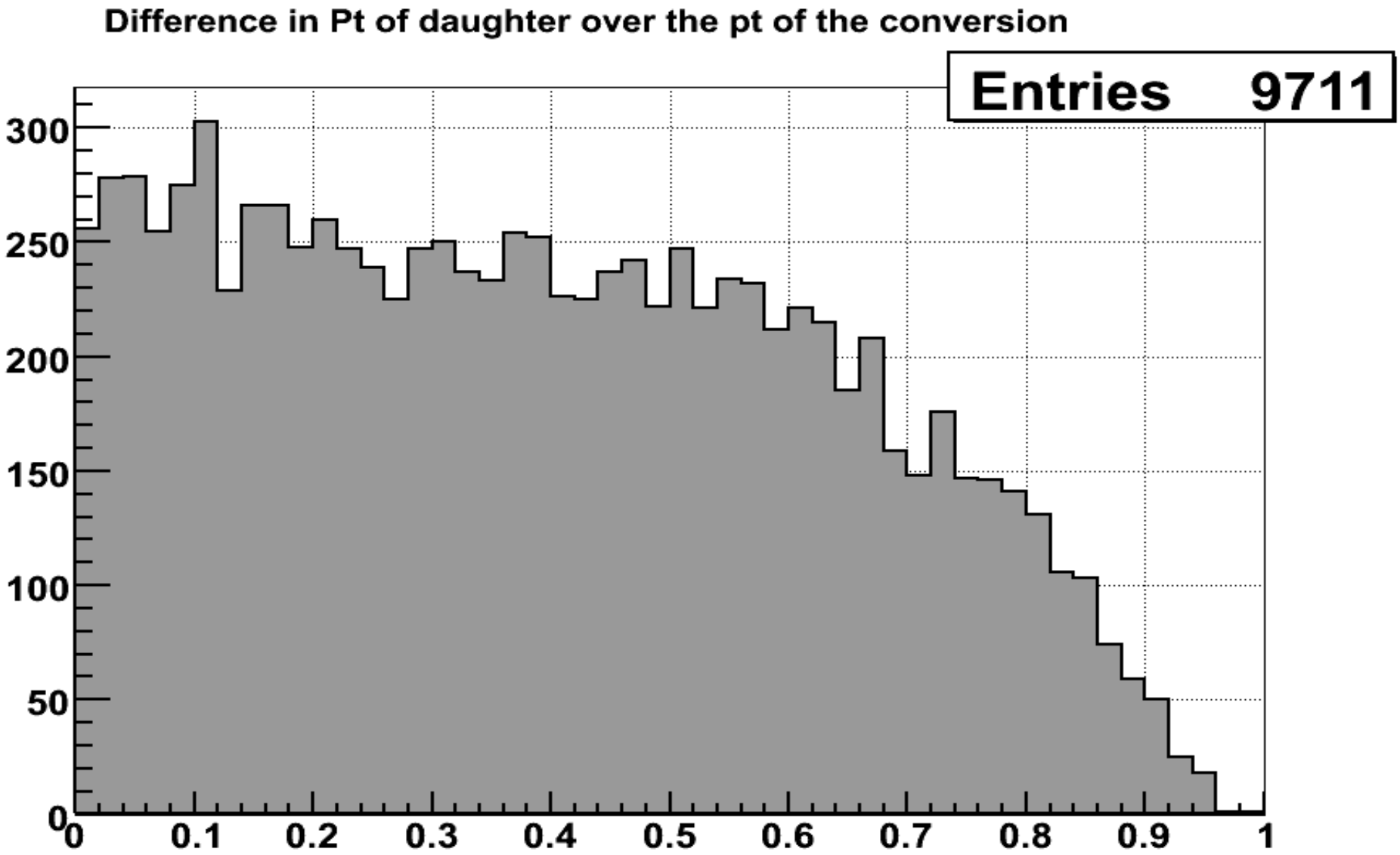




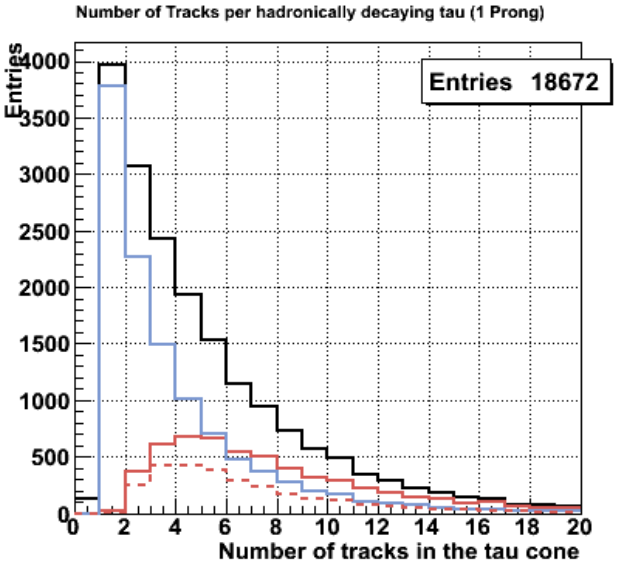


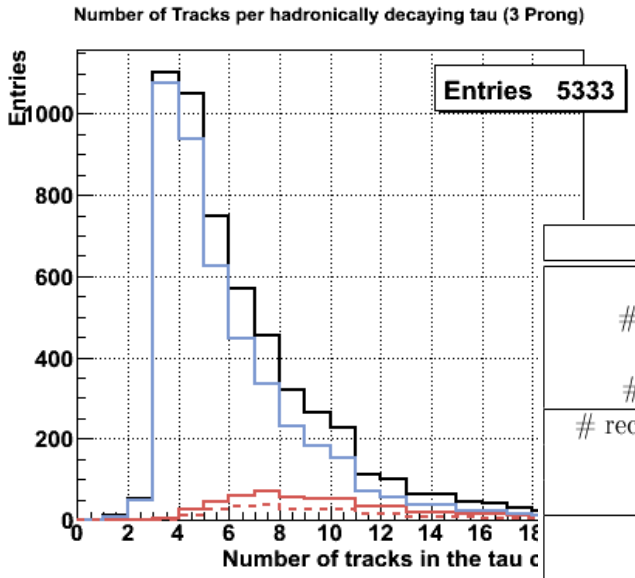
3 Prong Taus

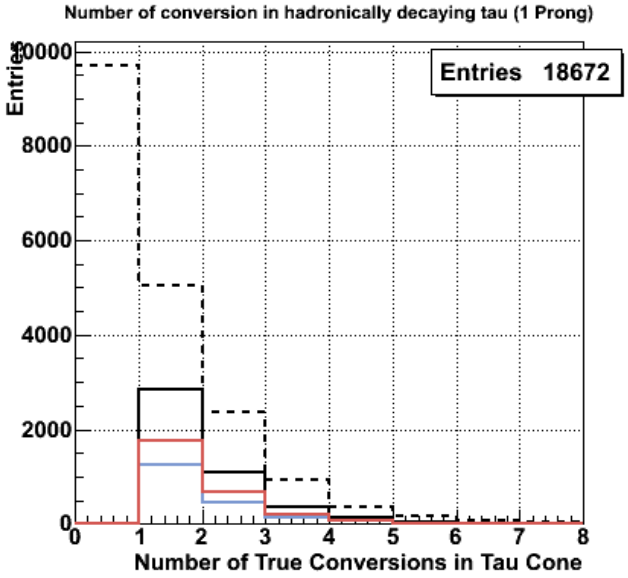
Asymmetric Conversions

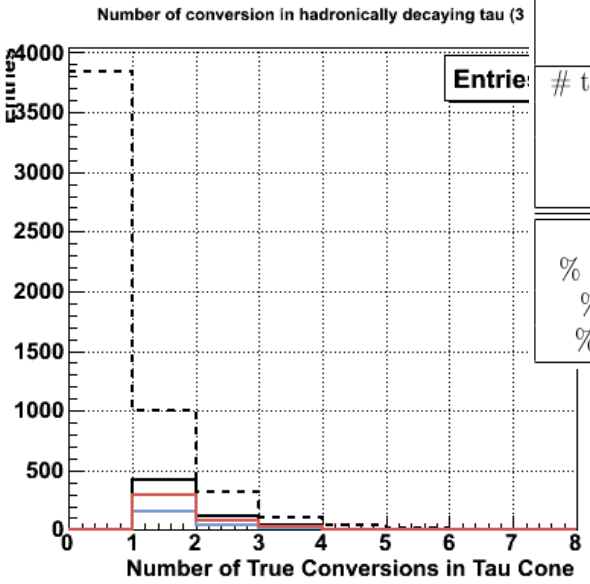


Delta R of 0.4









	1-Prong	3-Prong
hadronic Taus	18672	5333
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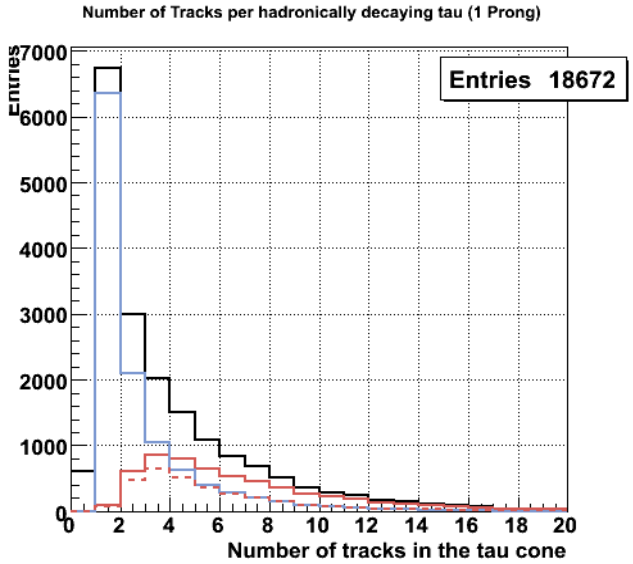
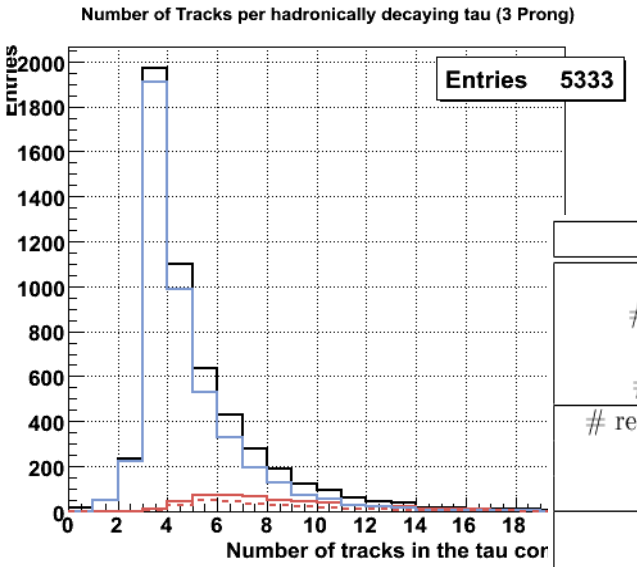
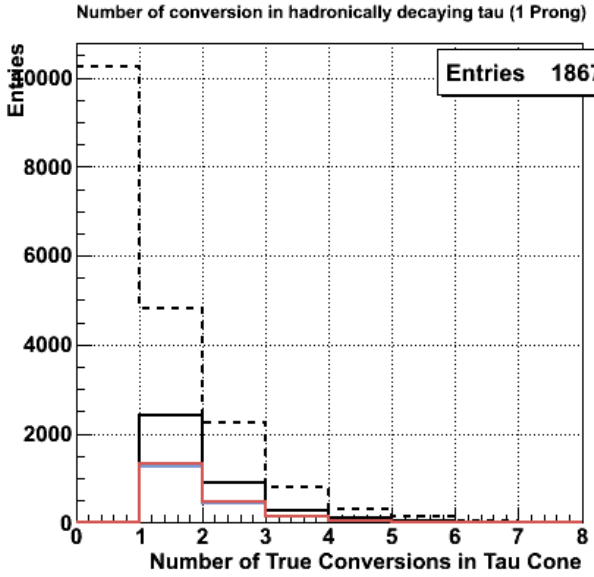
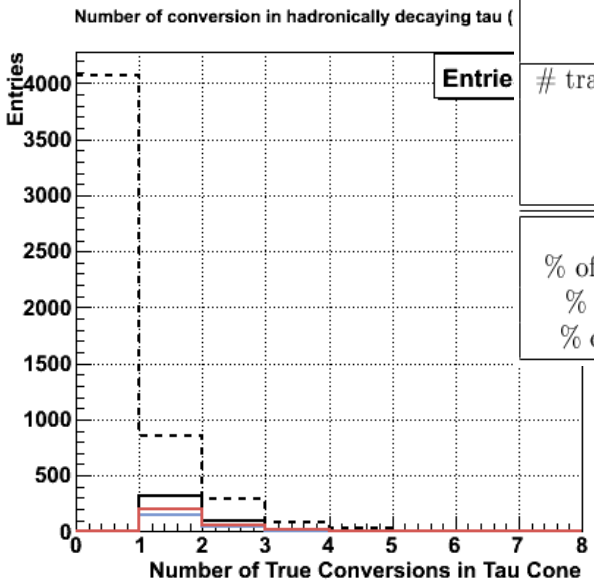
# true conversions tau	13534	1989
# true conversion in tau cone	15472	2235
# rec conversions in tau cone (%true)	13147(70.1%)	2527(47.9%)
double (%true)	6471(51.1%)	1325(23.8%)
single (%true)	6676(88.4%)	1202(74.5%)
# rec tracks in tau cone	49990	22965
electrons	17922(35.9%)	2646(11.5%)
pions	28192(56.4%)	18819(81.9%)
from other	3876(7.8%)	1500(6.5%)
# tracks from VxCandidates in tau cone	16691	3289
electrons	14240(85.3%)	1852(56.3%)
pions	1913(11.5%)	1246(37.9%)
other	538(3.2%)	191(5.8%)
% of tracks in tau cone vetoed	33.4%	14.3%
% of electron tracks in tau cone vetoed	79.5%	70.0%
% of pion tracks in tau cone vetoed	6.8%	6.6%
% of other tracks in tau cone vetoed	13.9%	12.7%

Delta R of 0.2









	1-Prong	3-Prong
hadronic Taus	18672	5333
# with at least one conversion	8564	1377
# true conversions tau	13534	1989
# true conversion in tau cone	14210	1851
# rec conversions in tau cone (%true)	10440(68.4%)	1883(42.9%)
double (%true)	6071(52.4%)	1189(24.3%)
single (%true)	4369(90.6%)	694(74.8%)
# rec tracks in tau cone	34789	18019
electrons	13083(37.6%)	1635(9.1%)
pions	20214(58.1%)	15687(87.1%)
from other	1492(4.3%)	697(3.9%)
# tracks from VxCandidates in tau cone	13707	2544
electrons	11895(86.8%)	1387(54.5%)
pions	1541(11.2%)	1051(41.3%)
other	271(2.0%)	106(4.2%)
% of tracks in tau cone vetoed	39.4%	14.1%
% of electron tracks in tau cone vetoed	90.9%	84.8%
% of pion tracks in tau cone vetoed	7.6%	6.7%
% of other tracks in tau cone vetoed	18.2%	15.2%