Status of Tau-pair Analysis in Jupiter/Marlin Framework

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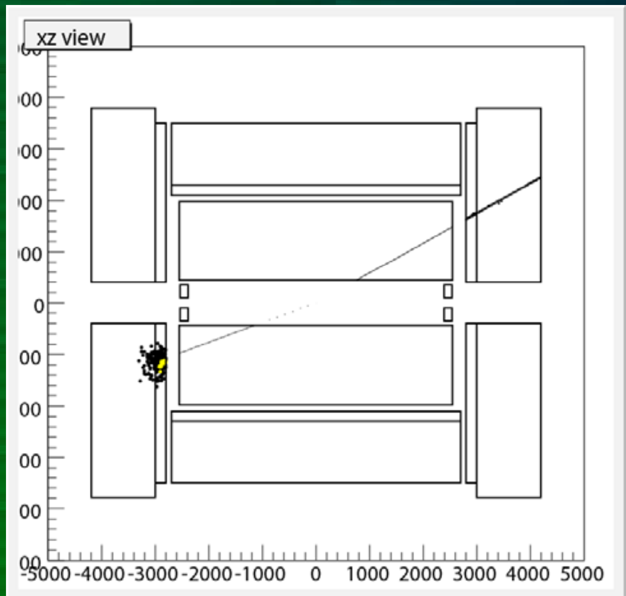
e+e- →τ+τ- Benchmark process

Processes ($e^+e^-\rightarrow$)	$\sqrt{s}$ (GeV)	Observables	Comments
ZH, ZH→e^+e^-X,	250	σ, m_H	m_H=120GeV, test materials and γ_{ID}
→$\mu^-\mu^+$X	250	σ, m_H	m_H=120GeV, test ΔP/P
ZH, H→cc, Z→νν	250	Br(H→cc)	Test heavy flavour tagging and anti-tagging of light quarks and gluon
, Z→qq	250	Br(H→qq)	Same as above in multi-jet env.
Z* → $\tau^+\tau^-$	500	σ, A_{FB}, Pol(τ)	Test π^0 reconstruction and τ rec. aspects of PFA
tt, t→bW, W→qq'	500	σ, A_{FB}, m_{top}	Test b-tagging and PFA in multi-jet events. m_{top}=175GeV
$\chi^+\chi^-$, $\chi_2^0\chi_2^0$	500	σ, mχ	Point 5 of Table 1 of BP report. W/Z separation by PFA

Jupiter tau sample

- gldddec07 geometry (previous version)
- 12500 tau-pairs at 500 GeV(11.7 fb^{-1})
- Including ISR and FSR
- No Tau Polarization! (physia generator)
  - Waiting for StdHep files with pol. info
- Analysis framework
  - Jupiter MC (Miyamoto-san)
  - Convert to LCIO
  - Marlin/PandoraPFA
  - Jet finding (original: TaJetProcessor)
  - Analysis in Marlin processor(original: TauProcessor)

Samples


xz view
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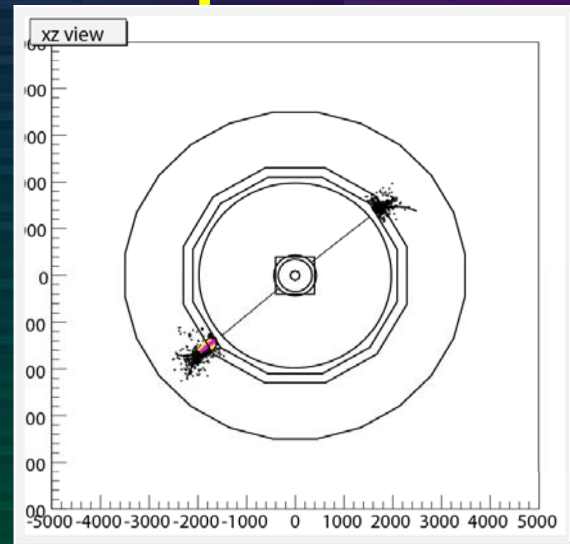
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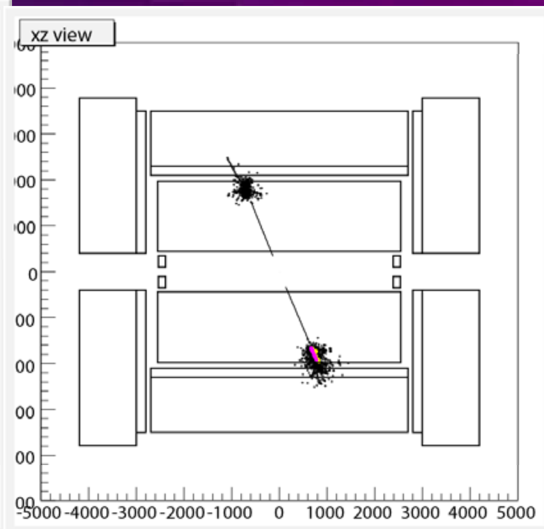
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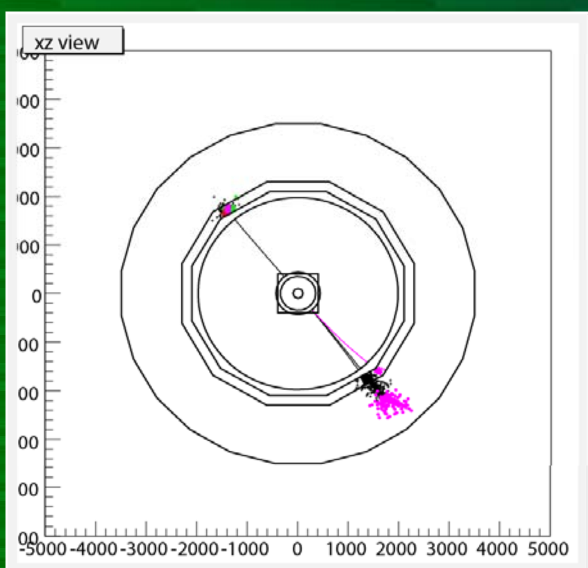
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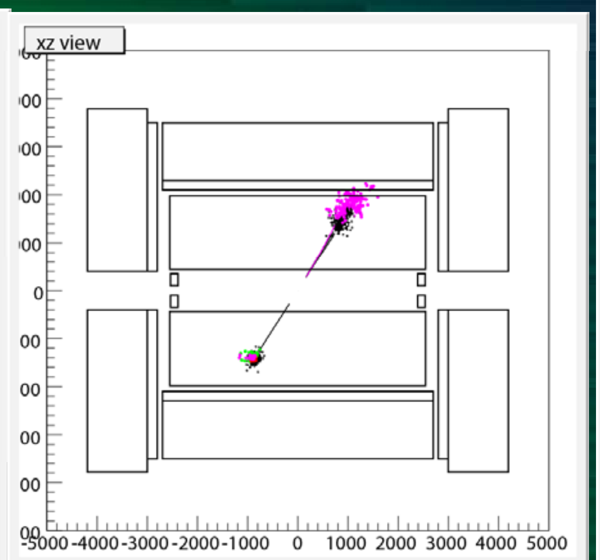
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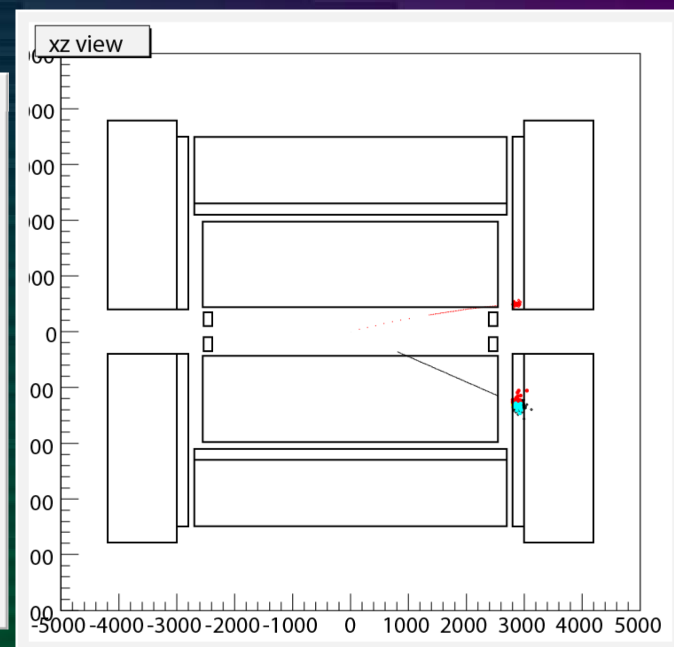
xz view
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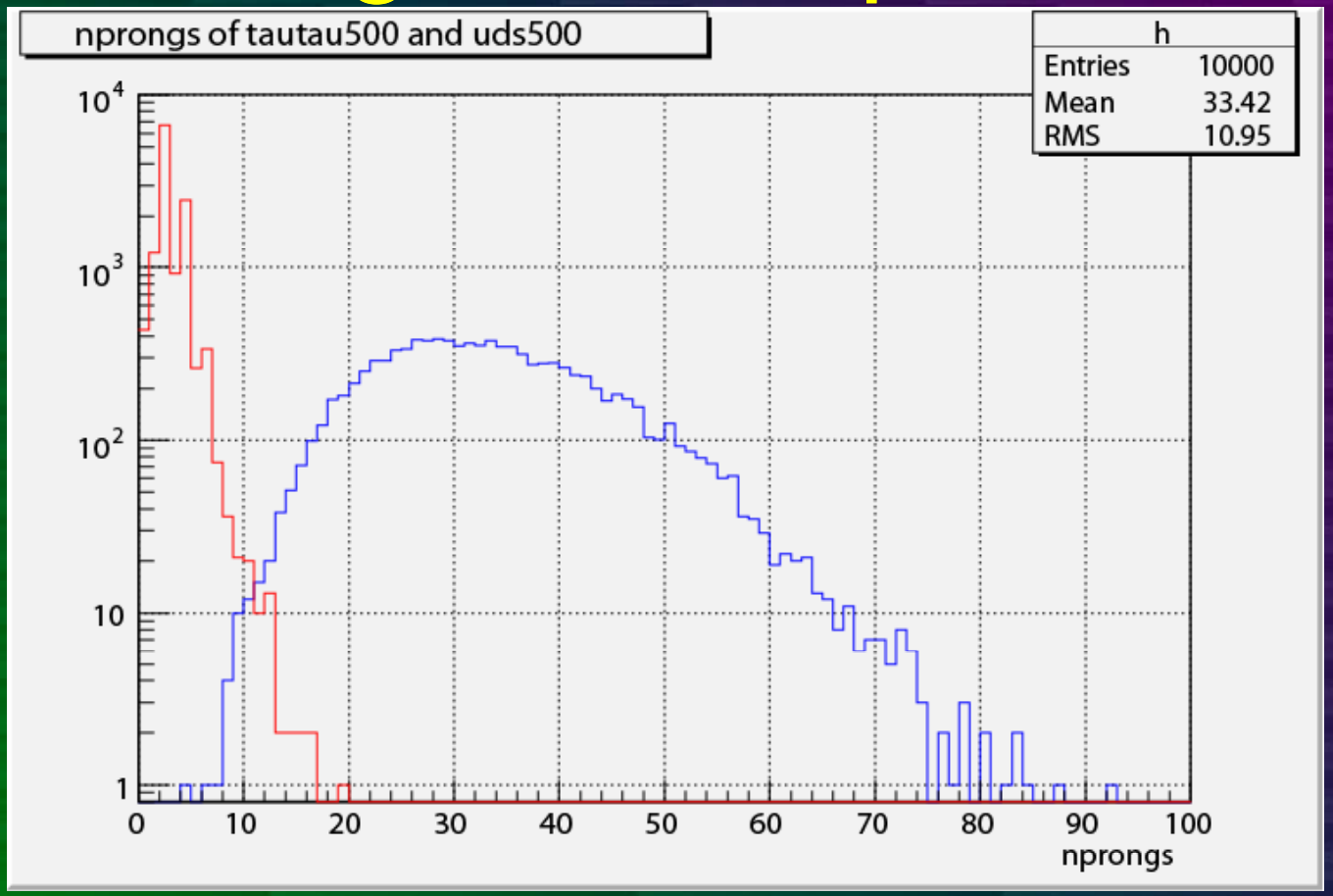
Background separation



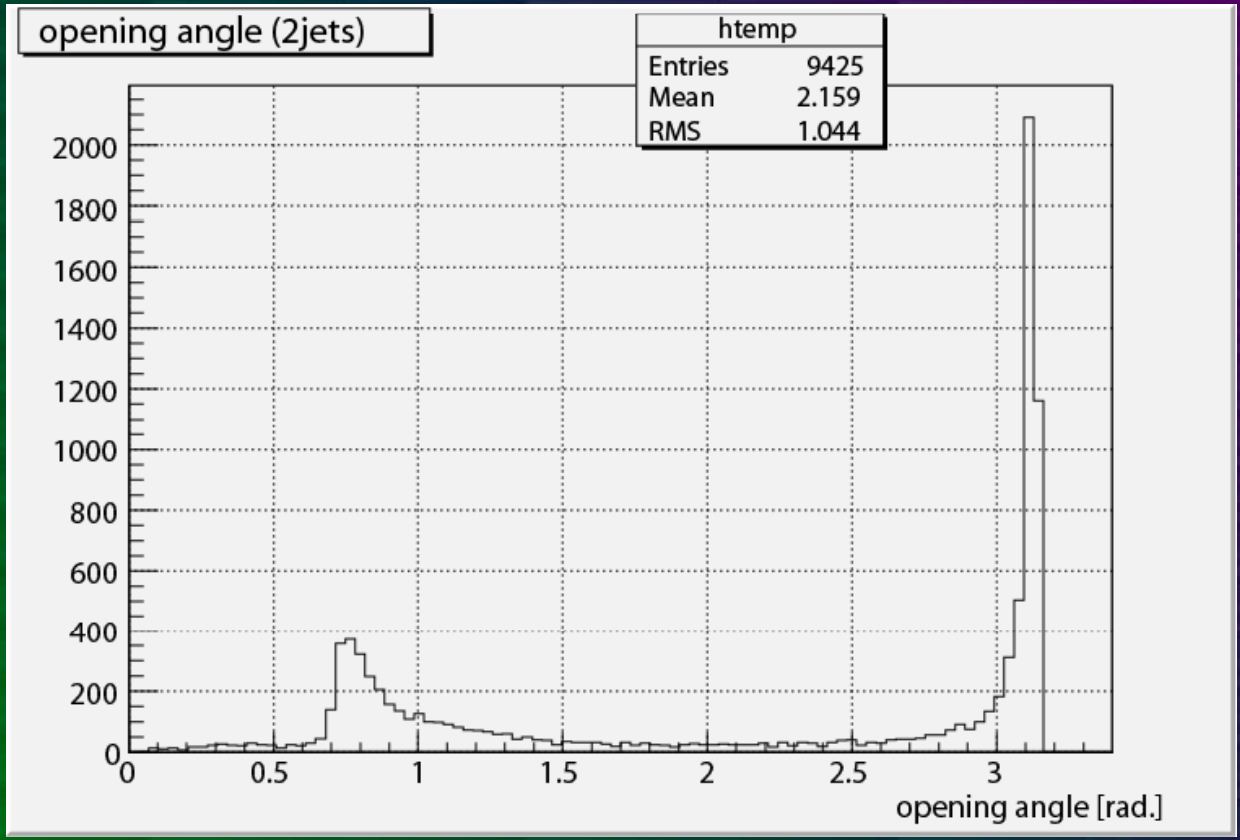
uds qqbar events can be separated by prongs <= 6
(Other errors are not considered currently).

Jet Finding

- SatoruJetFinder with Satoru mode (fixed to 2 jets)
  - not applicable for events with ISR/FSR photons
- SatoruJetFinder with Durhamycut mode (variable jets, fixed ycut)
- TaJetProcessor (original)
  - Angle-based jet finding using τ mass (1.777GeV)
  - Better performance in tau energy reco.
  - Currently adopted.

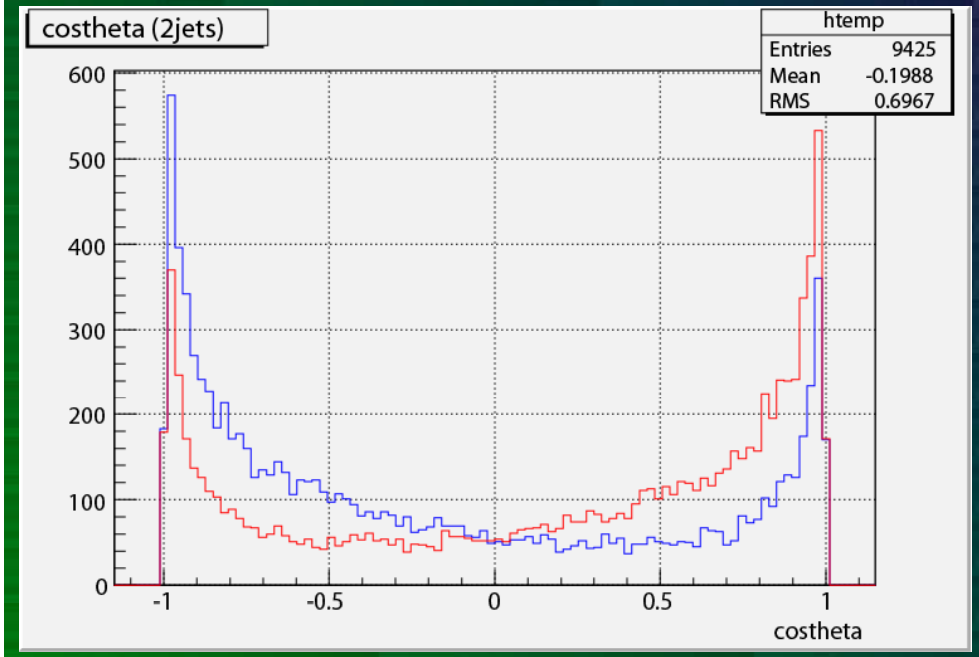
Ycut	1+1jets (12500 total)	# of jets	MC - Reco energy [GeV]
0.00001	8456	2.659	15.03
0.00002	8723	2.418	11.02
0.00005	8945	2.209	8.894
0.0001	8992	2.115	8.554
0.0002	8993	2.043	8.624
0.0005	8917	1.97	9.011
0.001	8814	1.918	9.486
0.002	8662	1.87	9.935
0.005	8350	1.803	10.18
0.01	7977	1.745	10.67
TaJet	9425	1.91	8.145

Opening angle of 2 jets

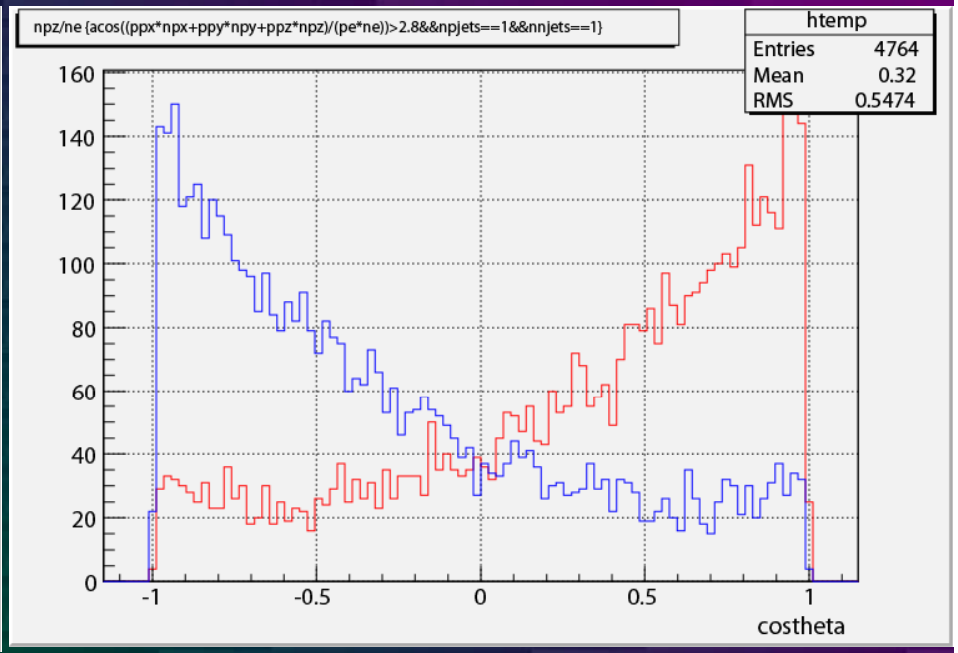


> 50% is not back-to-back event
(criteria: < 175 degree (3.05 rad.) crossing angle)
e+e- to Z*γ to ττγ may have large cross section

Forward-backward asymmetry



No angle cuts



Opening angle > 2.8 rad.

Large asymmetry for
forward(θ~1) and backward (θ~-1) events
in back-to-back events

A_{FB} by current data

- A_{FB} and statistics (bg. free)

anglecut	forward	backword	AFB	error(11.7)	error(500)
0	3516	1248	0.476	0.0127	1.95E-03
0.2	3143	934	0.542	0.0132	2.01E-03
0.4	2628	675	0.591	0.0140	2.15E-03
0.6	1951	458	0.620	0.0160	2.45E-03
0.8	1127	244	0.644	0.0207	3.16E-03

$$A_{FB} = \frac{N_F - N_B}{N_F + N_B}$$

$$\begin{aligned} \sigma A_{FB} &= \sqrt{\left(\frac{\partial A_{FB}}{\partial N_F}\sigma N_F\right)^2 + \left(\frac{\partial A_{FB}}{\partial N_B}\sigma N_B\right)^2} \\ &= \frac{2\sqrt{N_B N_F (N_B + N_F)}}{(N_F + N_B)^2} \end{aligned}$$

$$\begin{aligned} \sigma N_F &= \sqrt{N_F} \\ \sigma N_B &= \sqrt{N_B} \end{aligned}$$

Polarization of τ

- Polarization can be observed by 2 modes

  τ to $\pi\nu$ decay
  - Using π angular distribution in τ-rest frame
  - Branching ratio is not large (11.4%)
  - Back-to-back τ generation is required to move to τ-rest frame (without ν information) (back-to-back: ~40%)

  τ to $\rho\nu$ and ρ to $\pi\pi$ decay
  - Using charged π distribution in ρ-rest frame
  - Branching ratio is large (25.2%)
  - Back-to-back is not required

Event selection

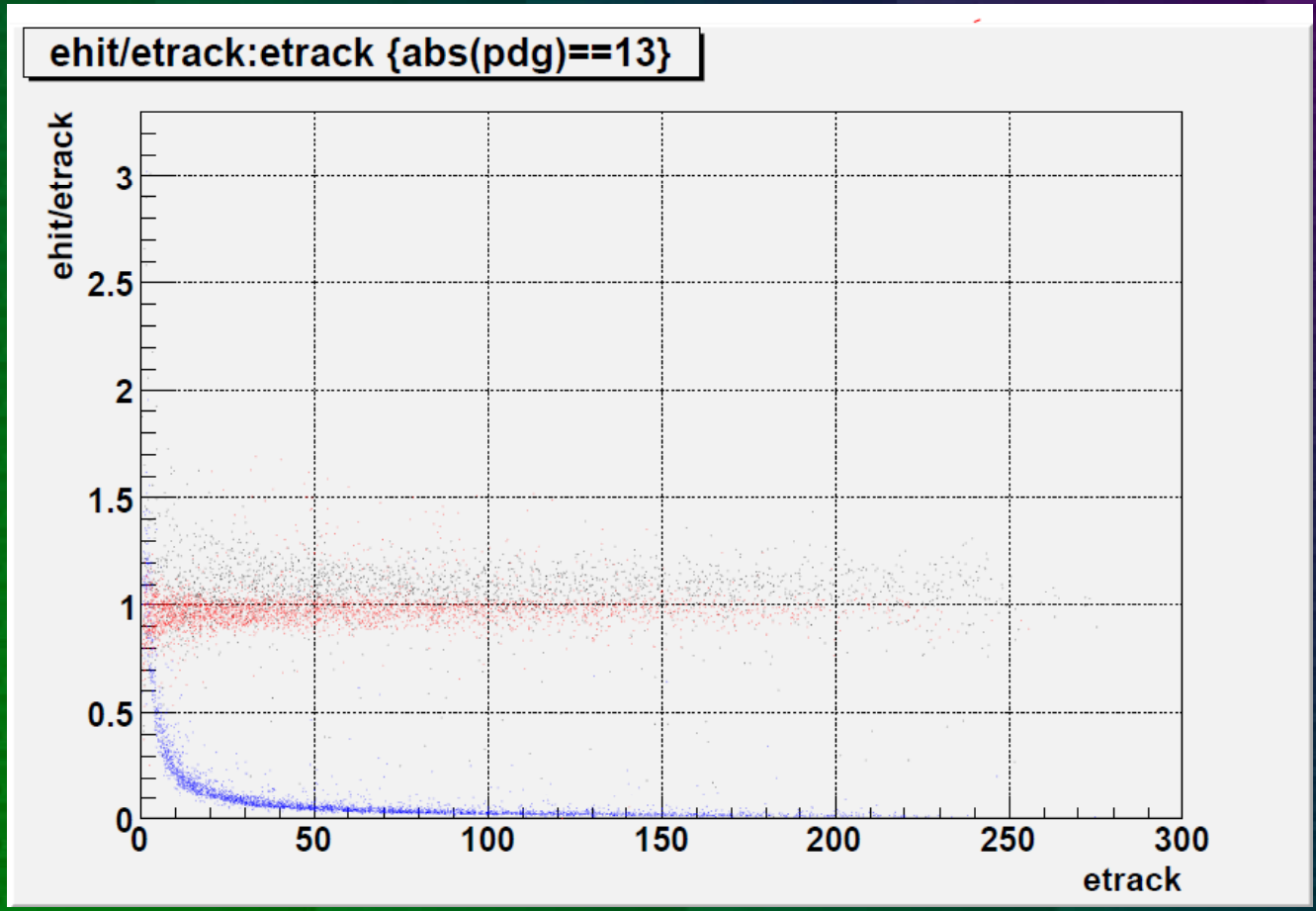
selection criteria	total	pinu	rhonu	enunu	mununu	P(pinu)	P(rhonu)
total	12500	1432	3156	2224	2147	11.46	25.25
1+1jets	9425	1107	2375	1695	1718	11.75	25.20
1 prong	7949	1103	2231	1688	1717	13.88	28.07
hit/track energy > 0.7	6009	1047	2140	1615	60	17.42	35.61
energy > 10 GeV	5558	974	2072	1416	3	17.52	37.28
ecal deposit < 90%	3927	953	1945	1	3	24.27	49.53
gamma (>1GeV) = 0	811	708	46	1	0	87.30	5.67
|costheta| < 0.98	746	669	28	1	0	89.68	3.75
jet opening angle > 175	315	288	12	1	0	91.43	3.81
ecal deposit < 97%	4100	967	2017	42	3	23.59	49.20
energy(gamma)>10GeV	2777	81	1712	2	3	2.92	61.65
Minv - Mrho < 200 MeV	1227	14	1075	0	1	1.14	87.61
Mneutral < 200 MeV	946	13	874	0	1	1.37	92.39

Red: $\pi\nu$ selection

Blue: $\rho\nu$ selection

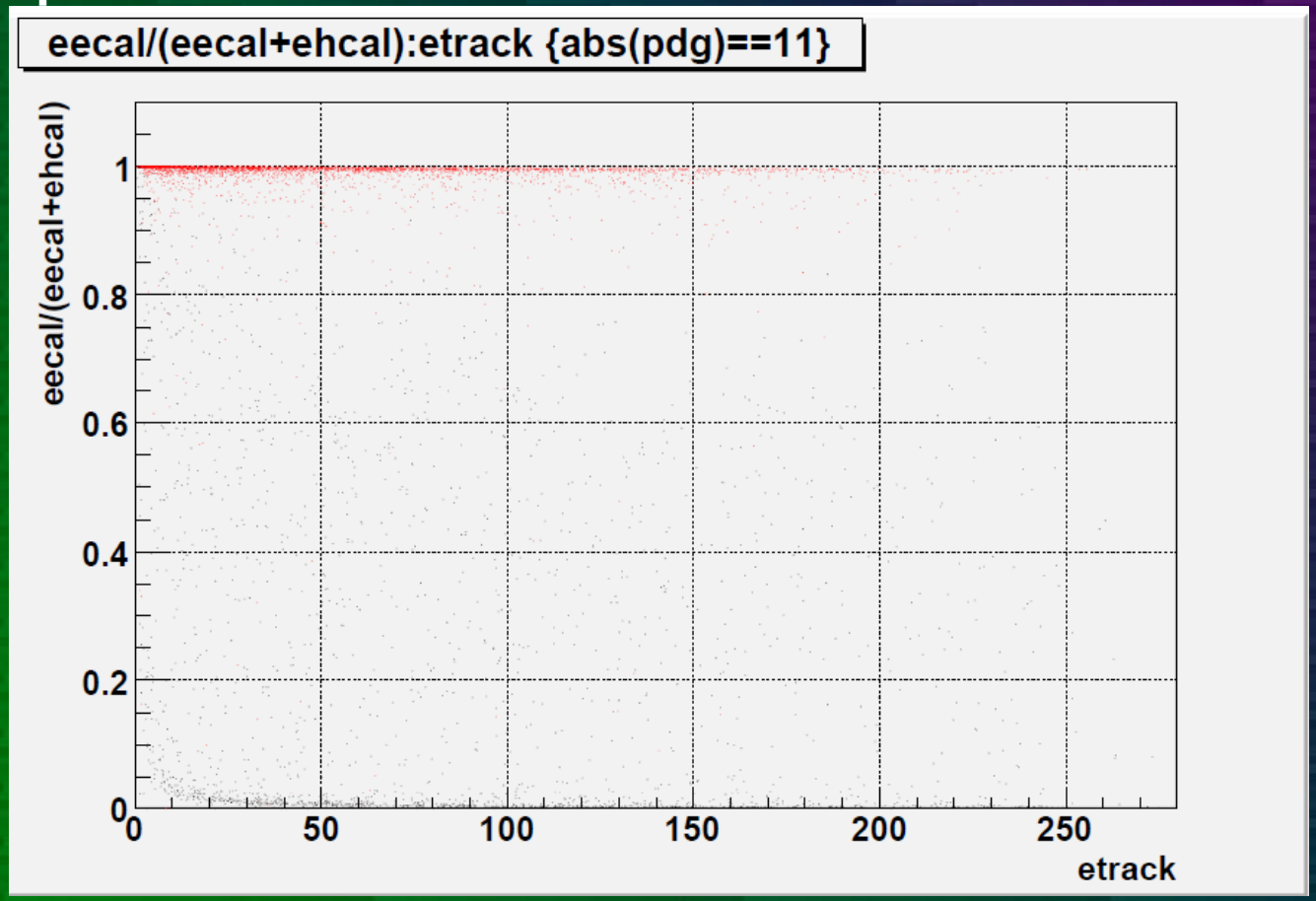
Muon ID

- Calorimeter deposit / Track energy
  (for muons calo. deposit is lower than track energy)



Electron ID

- Ecal deposit is much larger than Hcal deposit for electrons

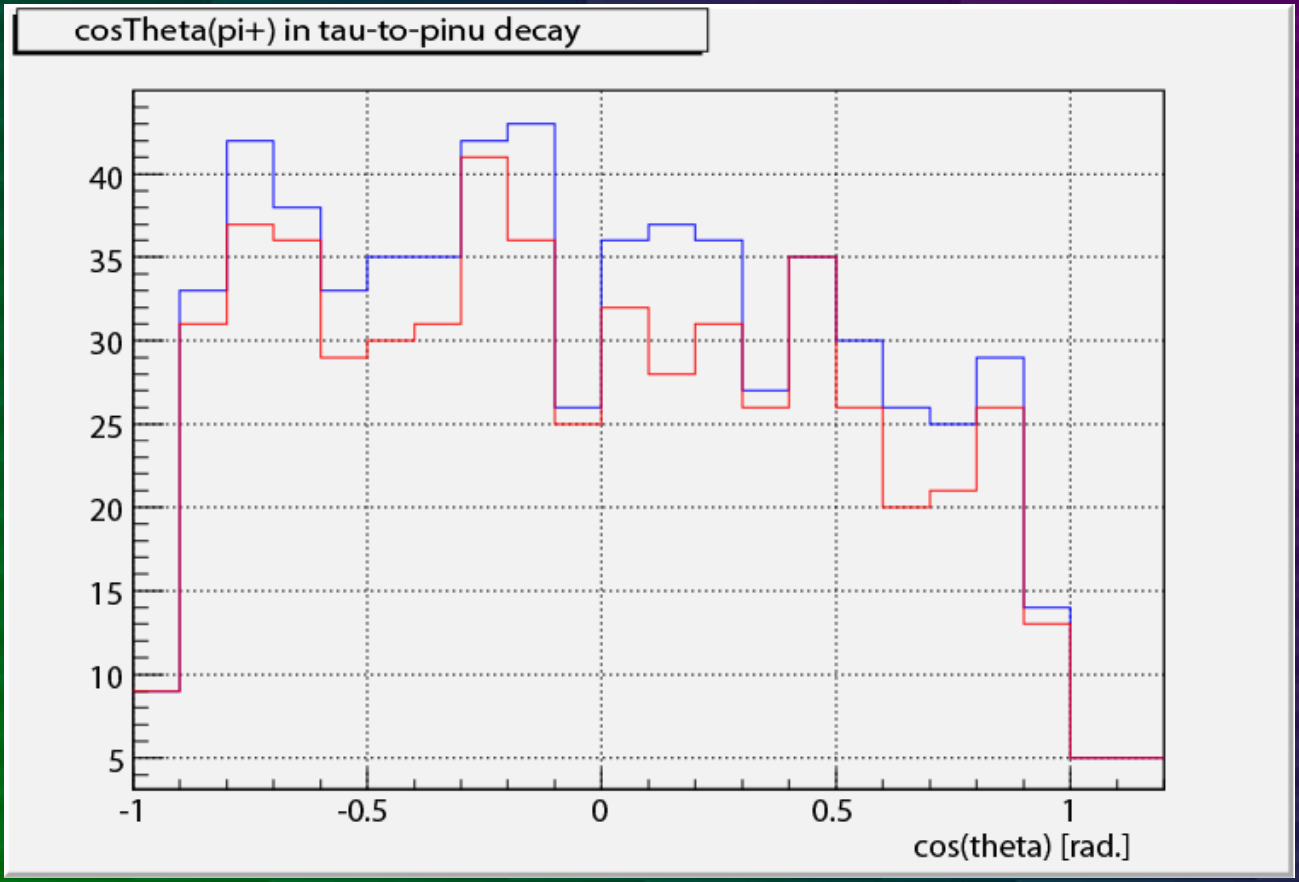


Other τ to $\pi\nu$ cuts

- No > 1 GeV gammas in PFOs
- |cos(q)| < 0.98
  for rejecting events with gammas in beam pipe
- Back-to-back (opening angle > 175 degree)

- Purity: 91.4% (288/315 events)
- Efficiency: 20.1% (288/1432 events)
  (including back-to-back cuts)

Angular distribution in τ-rest frame



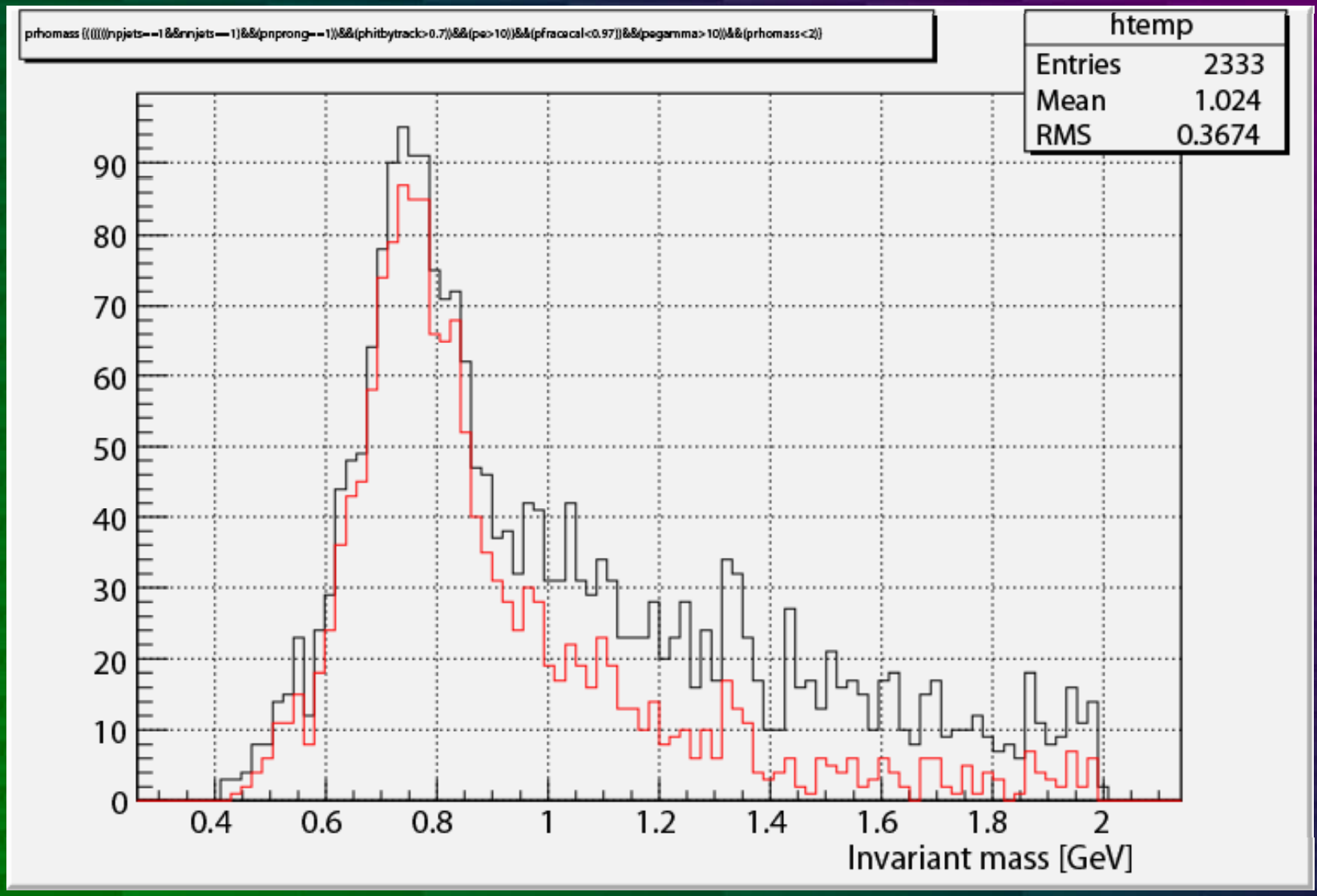
A little distortion is observed in
cos(θ) ~ 1 (mainly by imperfect back-to-back kinematics)
cos(θ) ~ -1 (by energy cut of 10 GeV)

Other τ to $\rho\nu$ cuts

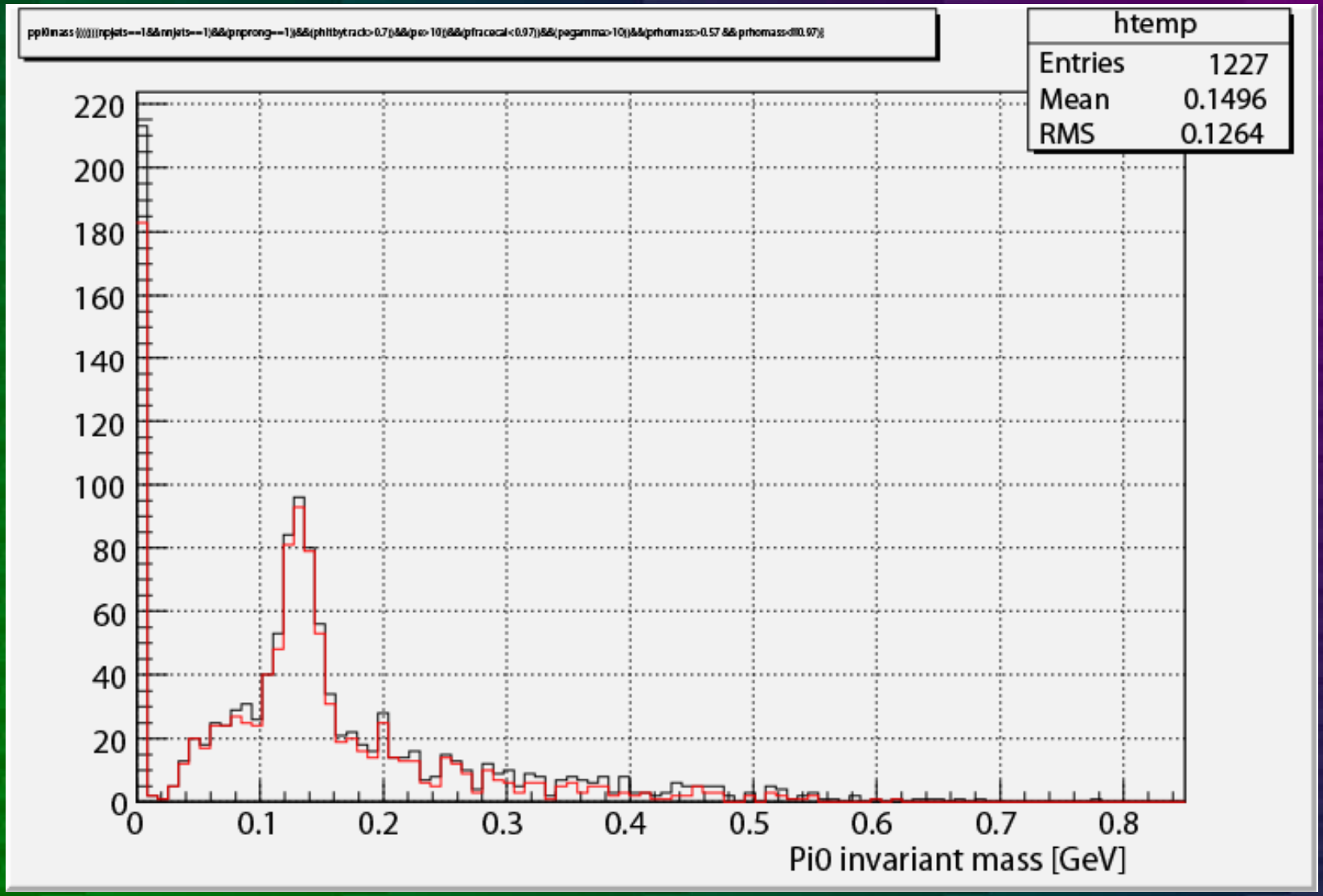
- > 10 GeV neutral particle
- Invariant mass between charged and neutral particles is 570 to 970 MeV (ρ: 770 MeV, width: 150 MeV)
- Invariant mass of neutral particle is < 200 MeV (if >= 2 neutral particles are observed)

- Purity: 92.4% (874/946)
- Efficiency: 27.7% (874/3156)

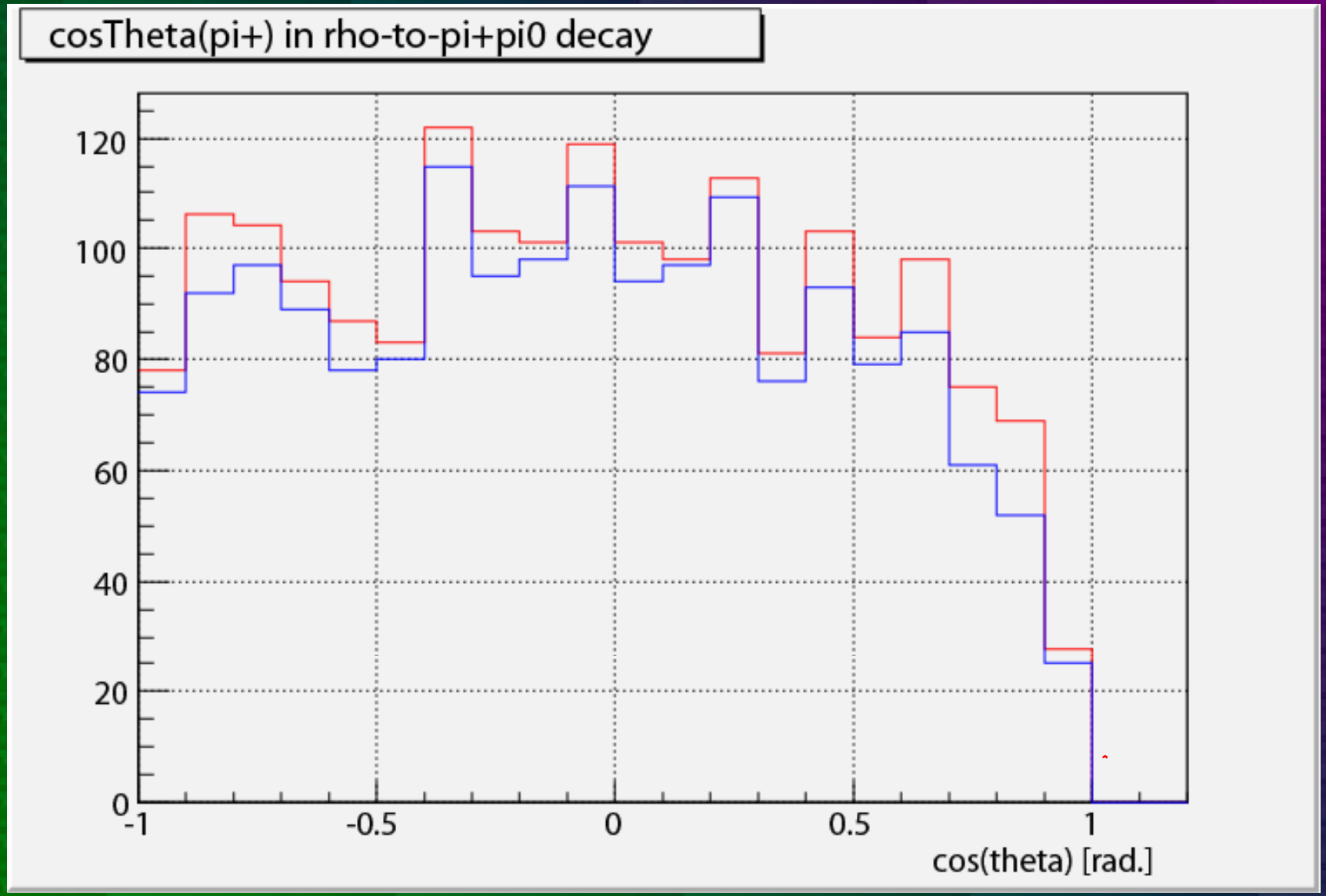
Rho invariant mass



Pi0 invariant mass



Angular distribution in ρ-rest frame



Summary

- Tau analysis is ongoing.
- AFB can be observed in < 1% resolution
- Event selection for polarization analysis is developed.
- Almost flat angular distribution is obtained (with no polarization MC sample)
- To do:
  - Jet finder improvement
  - Gamma rejection at pi0 reconstruction
  - Analysis using polarized tau MC data!