Trilepton Analysis: Failed Events

(CDF Collaboration)

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I begin the modeling of the trilepton sample with a selection of events that have a 160 GeV Higgs boson produced in association with a W boson, then the Higgs decays to two more W bosons, and finally all three W bosons are required to decay leptonically (and if that lepton is a tau, the tau also decays leptonicall). A series of cuts on the reconstructed particles of this sample then approximates what portion of this signal the CDF detector is expected to see. First, basic P_T and η cuts are imposed. Then the leading three reconstructed leptons of each event are required to pass a matching criterion to a generator-level lepton. Finally, a series of typical quality cuts are imposed on the leptons. This document detail the properties of leptons of events that fail these cuts at each level.

Contents

INTRODUCTION

Here is the table upon which the rest of this document is based. In it are the proportion of events that pass each level of cuts.

Cuts	Number (out of 100,000)	%(from previous step)
Pass $HW \to WWW \to l\nu l\nu l\nu$ filter	2358	2.36
P_T, η cuts at generator-level	1902	80.6
Lead, 2nd, 3rd Reconstructed leptons found	1539	80.9
Same P_T, η cuts at reconstruction-level	1497	97.3
Pass Matching Criterion	1201	80.2
Pass Quality/Isolation Cuts	964	80.3

TABLE I: The number of events passing each level of cuts is presented here. The sample began with 100,000 events and has 2358 left after passing the trilepton filter described in the abstract.

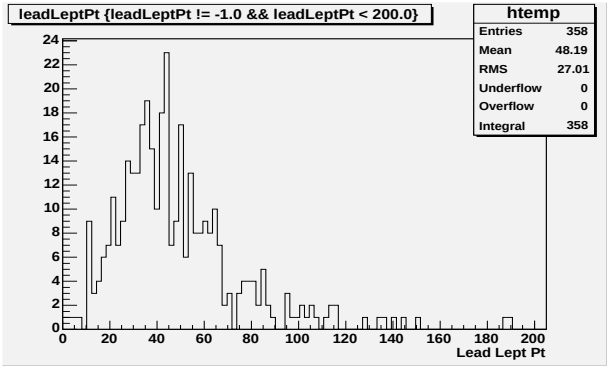

FIG. 1: P_T of Lead Reconstructed Lepton of events failing to find three reconstructed leptons.

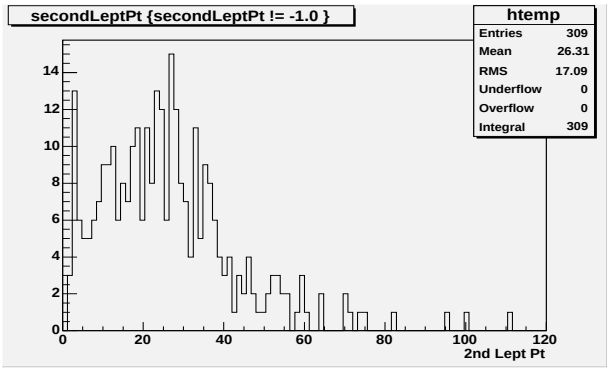

FIG. 2: P_T of 2nd Reconstructed Lepton of events failing to find three reconstructed leptons.

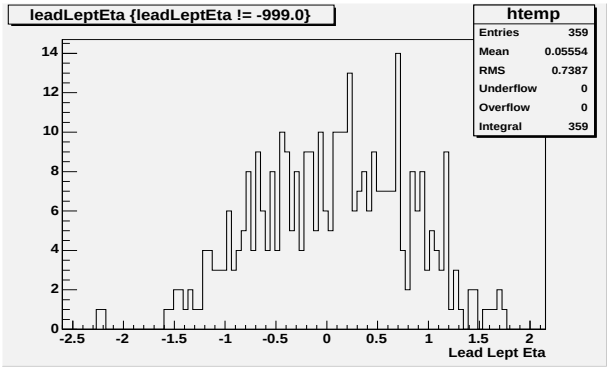

FIG. 3: η of Lead Reconstructed Lepton of events failing to find three reconstructed leptons.

EVENTS WITHOUT THREE RECONSTRUCTED LEPTONS

This section looks at events failing the step between the second and third rows in table I. Basically, there are three generator-level leptons within basic P_T and η cuts, but three reconstructed leptons were still not found for the entire event.

First, we'll look at some values of the recontructed leptons that are actually found, then take a look at the properties of the generator-level leptons that appear to have not been reconstructed. There are $1902 - 1539 = 363$ events falling into this category of failed events. 362 of these have at least one lepton and 318 have at least two leptons.

P_T and η of Reconstructed Leptons

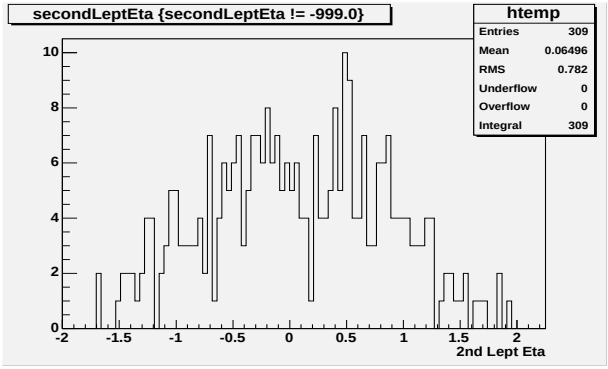

FIG. 4: η of 2nd Reconstructed Lepton of events failing to find three reconstructed leptons.

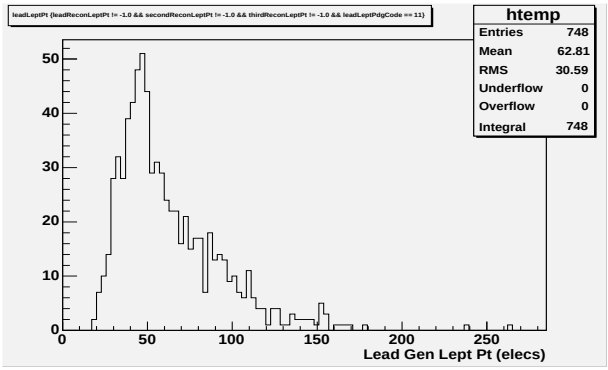

FIG. 5: Total E_T of lead generated lepton (electrons only) of events successfully finding three reconstructed leptons.

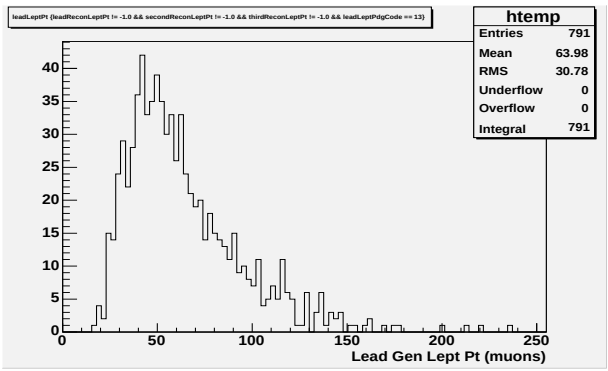

FIG. 6: P_T of lead generated lepton (muons only) of events successfully finding three reconstructed leptons.

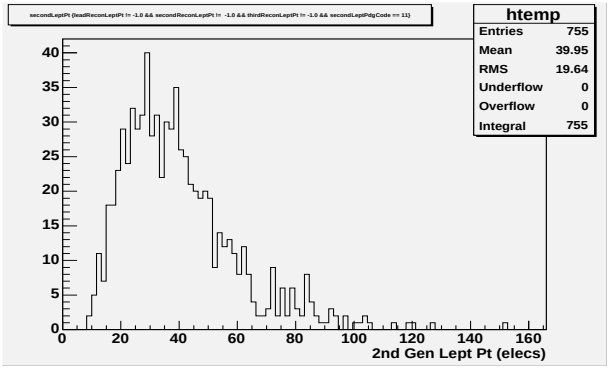

FIG. 7: Total E_T of 2nd generated lepton (electrons only) of events successfully finding three reconstructed leptons.

P_T and η of the Three Gen.-Level Leptons For Events w/ Three Recon.-Leptons

For the sake of comparison, I will provide basic P_T, η, and ϕ plots for the generator-level leptons of the 1539 events that do successfully find at least three reconstructed leptons.

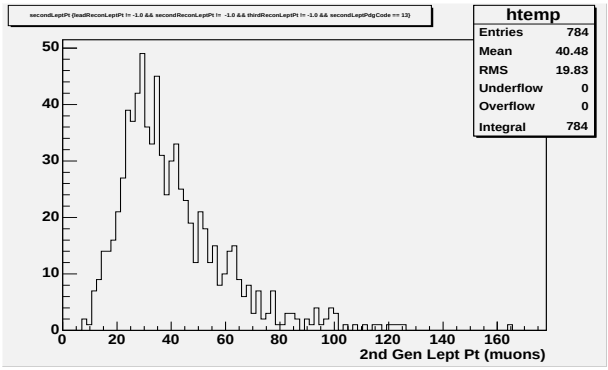

FIG. 8: P_T of 2nd generated lepton (muons only) of events successfully finding three reconstructed leptons.

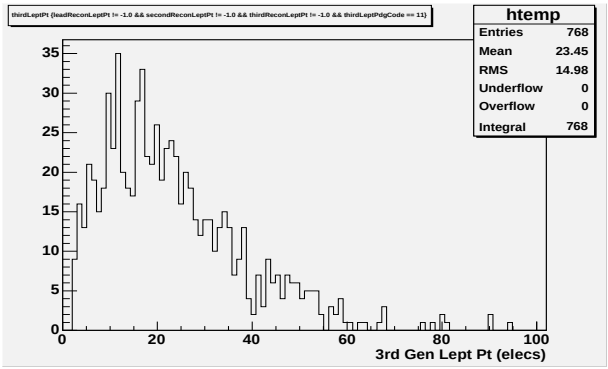

FIG. 9: Total E_T of 3rd generated lepton (electrons only) of events successfully finding three reconstructed leptons.

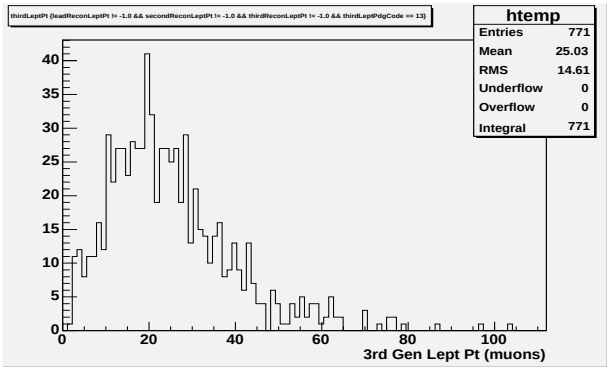

FIG. 10: P_T of 3rd generated lepton (muons only) of events successfully finding three reconstructed leptons.

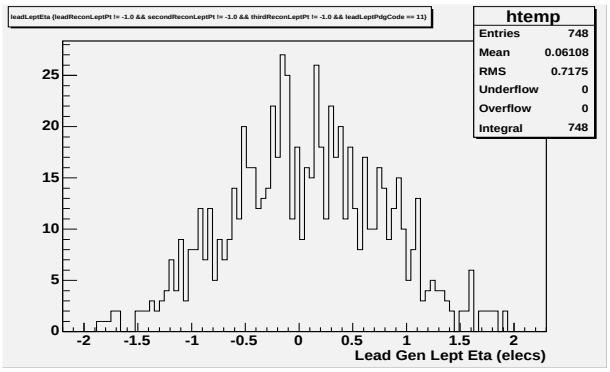

FIG. 11: η of lead generated lepton (electrons only) of events successfully finding three reconstructed leptons.

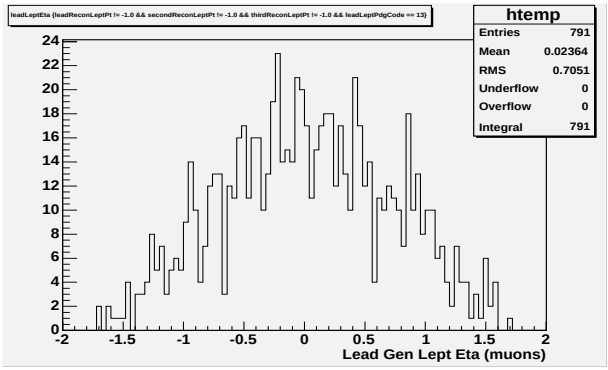

FIG. 12: η of lead generated lepton (muons only) of events successfully finding three reconstructed leptons.

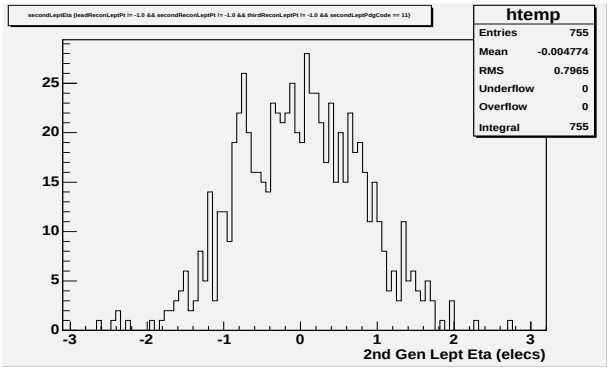

FIG. 13: η of 2nd generated lepton (electrons only) of events successfully finding three reconstructed leptons.

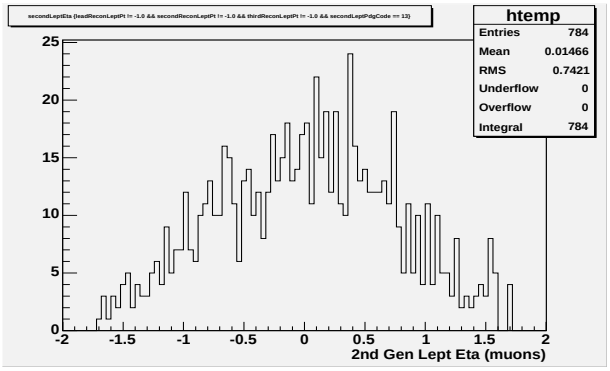

FIG. 14: η of 2nd generated lepton (muons only) of events successfully finding three reconstructed leptons.

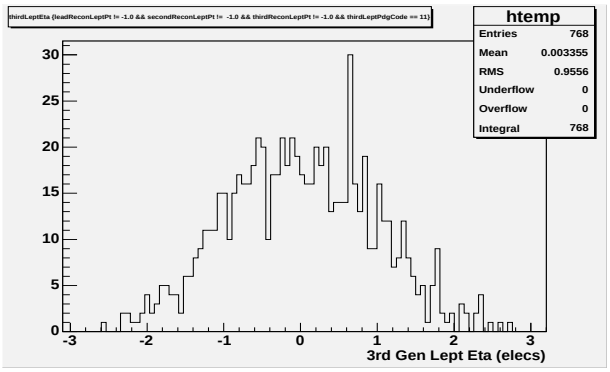

FIG. 15: η of 3rd generated lepton (electrons only) of events successfully finding three reconstructed leptons.

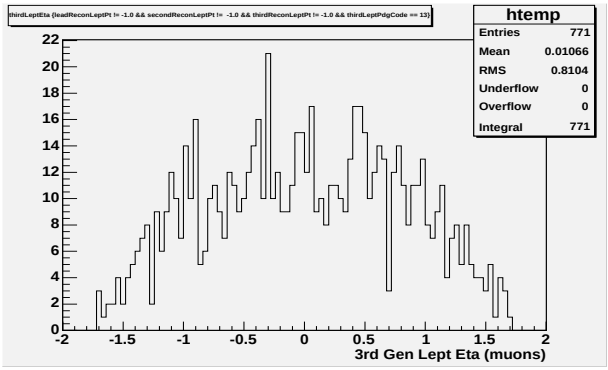

FIG. 16: η of 3rd generated lepton (muons only) of events successfully finding three reconstructed leptons.

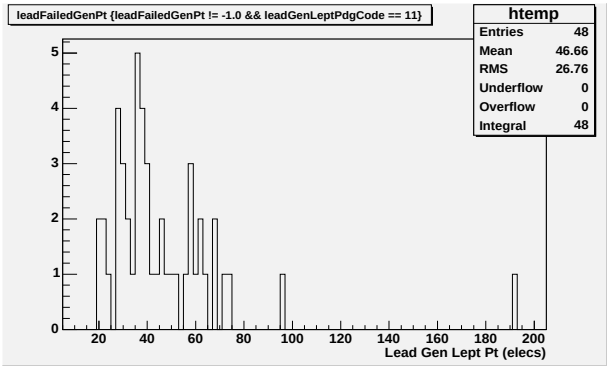

FIG. 17: P_T of lead generated lepton (electrons only) not matched to a reconstructed lepton.

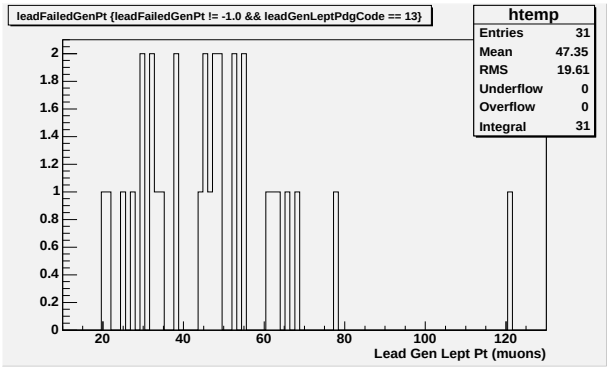

FIG. 18: P_T of lead generated lepton (muons only) not matched to a reconstructed lepton.

P_T, η and ϕ of the Generator-Level Leptons w/ No Recon.-Lepton Matching To It

It is, of course, difficult to plot the values of something the doesn't exist–in this case, there are reconstructed leptons that should exist but do not. To estimate their characteristics I take each of the three generator-level W-leptons for each event and attempt to find a match with the reconstructed electron and muon objects. If no match is found, I plot its P_T, η, ϕ, ΔR to the nearest jet-object, and the E_T of that jet. The interesting plots are the η values, which indicate that most generated leptons not reconstructed are in the forward regions where tracking becomes more difficult.

Unmatched Gen. Lepton P_T

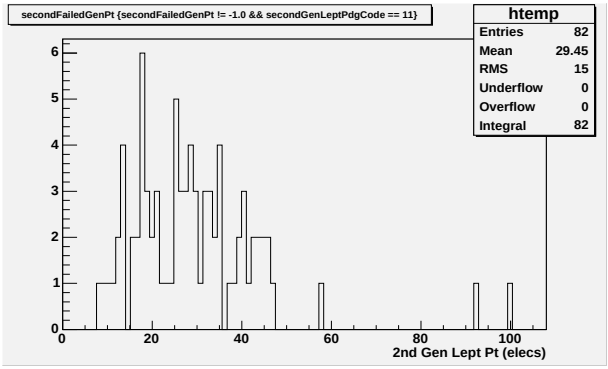

FIG. 19: P_T of 2nd generated lepton (electrons only) not matched to a reconstructed lepton.

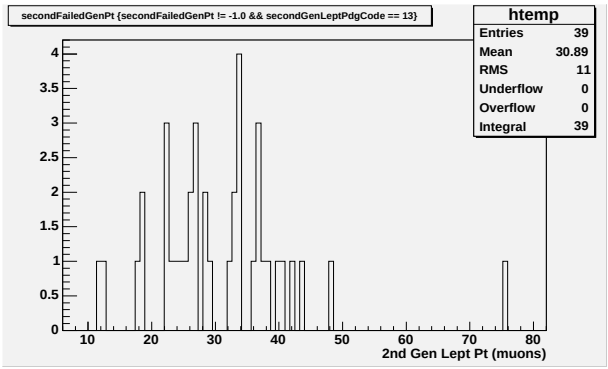

FIG. 20: P_T of 2nd generated lepton (muons only) not matched to a reconstructed lepton.

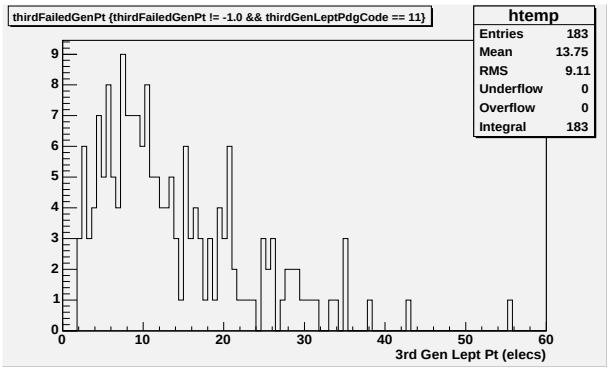

FIG. 21: P_T of 3rd generated lepton (electrons only) not matched to a reconstructed lepton.

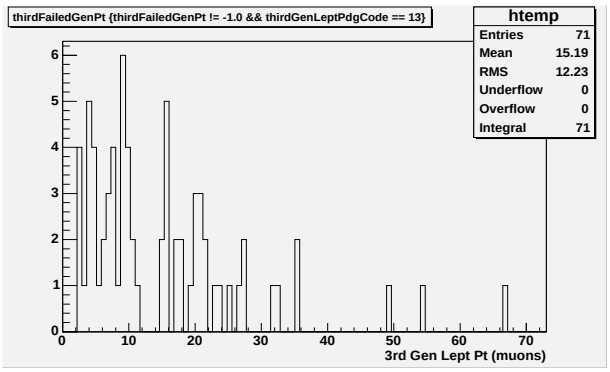

FIG. 22: P_T of 3rd generated lepton (muons only) not matched to a reconstructed lepton.

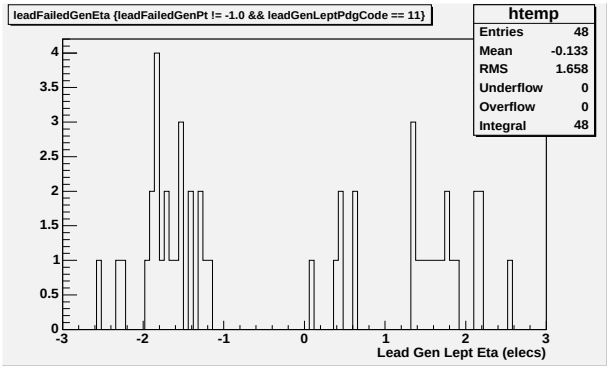

FIG. 23: η of lead generated lepton (electrons only) not matched to a reconstructed lepton.

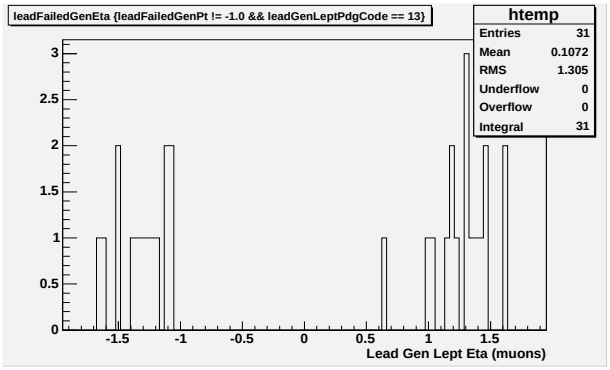

FIG. 24: η of lead generated lepton (muons only) not matched to a reconstructed lepton.

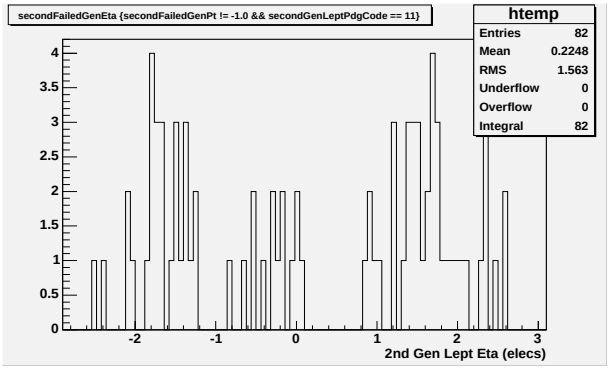

FIG. 25: η of 2nd generated lepton (electrons only) not matched to a reconstructed lepton.

Unmatched Gen. Lepton η

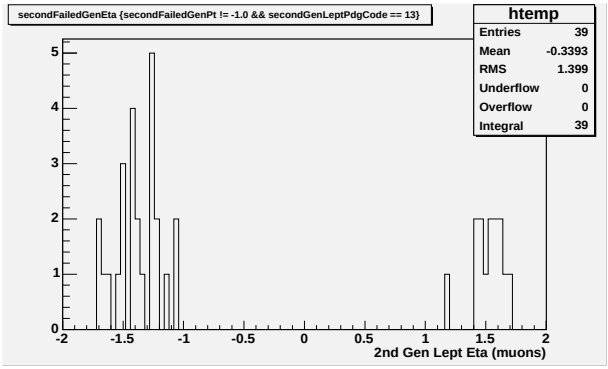

FIG. 26: η of 2nd generated lepton (muons only) not matched to a reconstructed lepton.

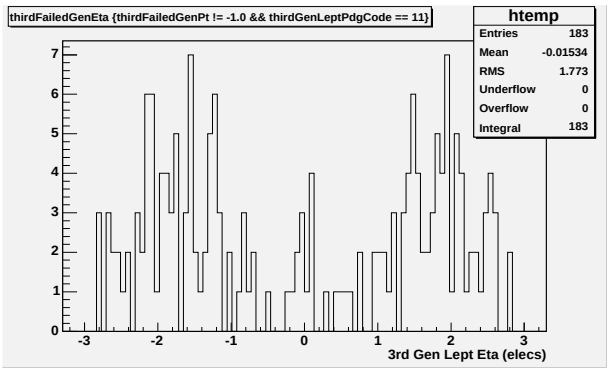

FIG. 27: η of 3rd generated lepton (electrons only) not matched to a reconstructed lepton.

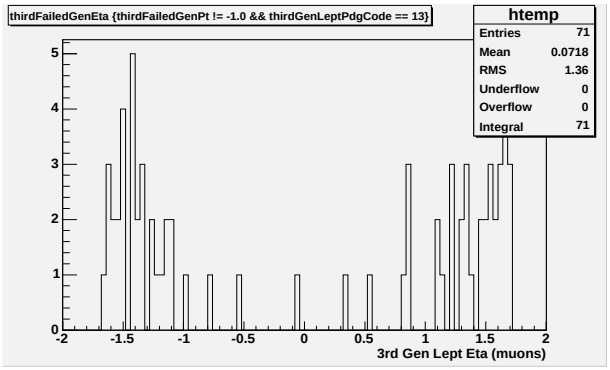

FIG. 28: η of 3rd generated lepton (muons only) not matched to a reconstructed lepton.

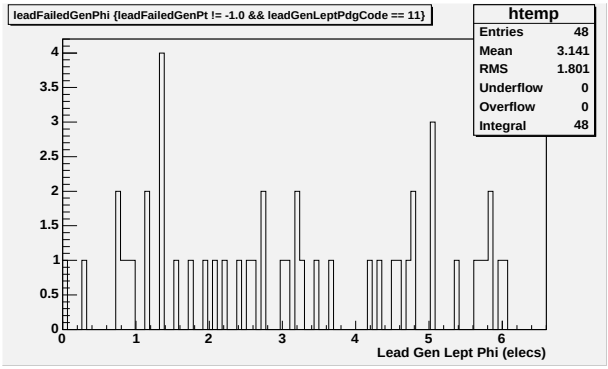

FIG. 29: ϕ of lead generated lepton (electrons only) not matched to a reconstructed lepton.

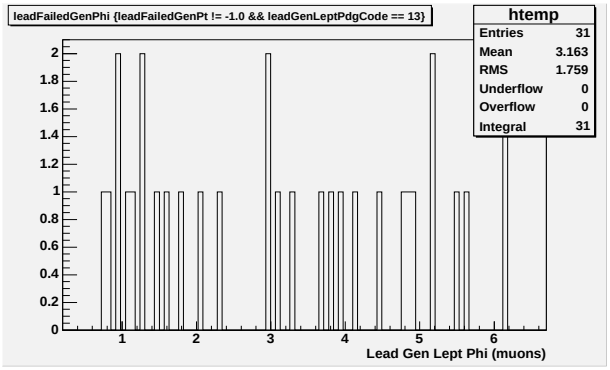

FIG. 30: ϕ of lead generated lepton (muons only) not matched to a reconstructed lepton.

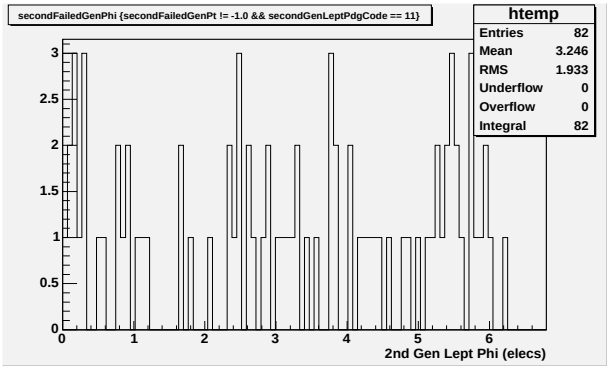

FIG. 31: ϕ of 2nd generated lepton (electrons only) not matched to a reconstructed lepton.

Unmatched Gen. Lepton ϕ

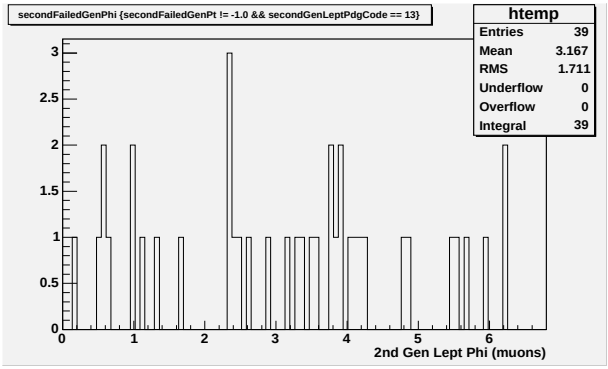

FIG. 32: ϕ of 2nd generated lepton (muons only) not matched to a reconstructed lepton.

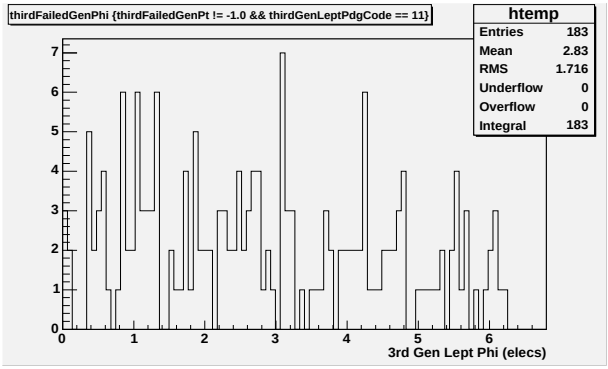

FIG. 33: ϕ of 3rd generated lepton (electrons only) not matched to a reconstructed lepton.

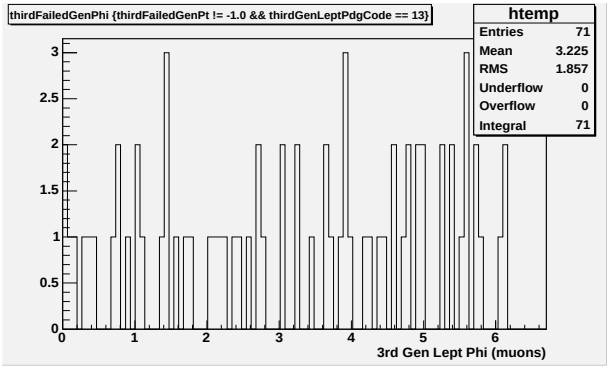

FIG. 34: ϕ of 3rd generated lepton (muons only) not matched to a reconstructed lepton.

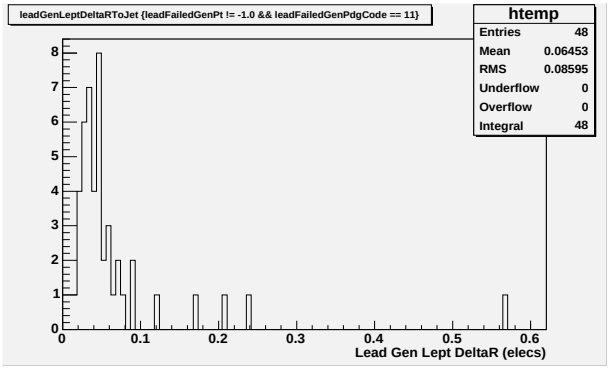

FIG. 35: ΔR between nearest jet and lead generated lepton (electrons only) not matched to a reconstructed lepton.

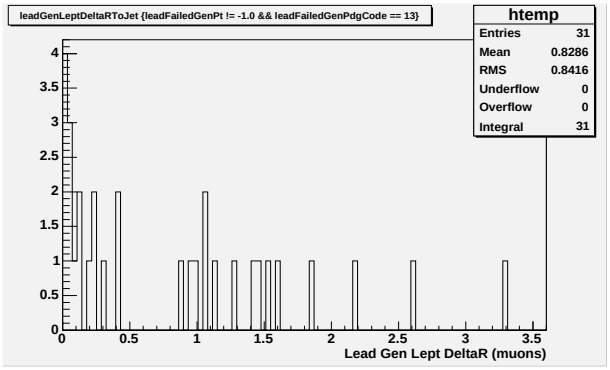

FIG. 36: ΔR between nearest jet and lead generated lepton (muons only) not matched to a reconstructed lepton.

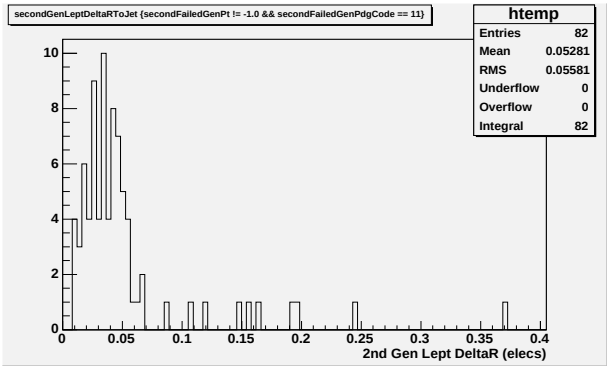

FIG. 37: ΔR between nearest jet and 2nd generated lepton (electrons only) not matched to a reconstructed lepton.

Unmatched Gen. Lepton ΔR To Nearest Jet-object

In the case of the ΔR to nearest jet and jet E_T for electrons, it must be acknowledged that the jet-object in question may just be the electron itself being listed among the jets. At this point, I have not made any attempt to remove sole electrons from the jet list.

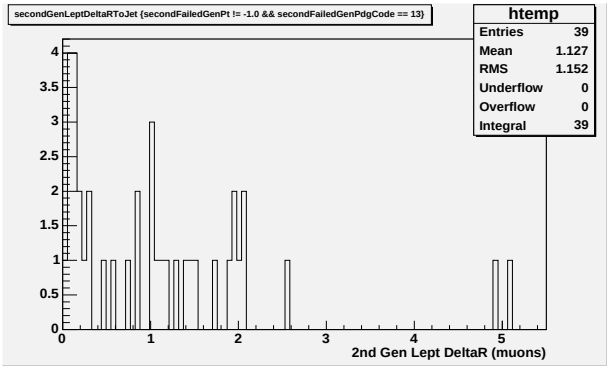

FIG. 38: ΔR between nearest jet and 2nd generated lepton (muons only) not matched to a reconstructed lepton.

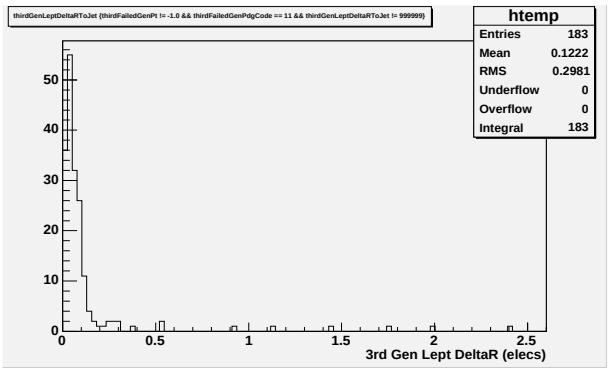

FIG. 39: ΔR between nearest jet and 3rd generated lepton (electrons only) not matched to a reconstructed lepton.

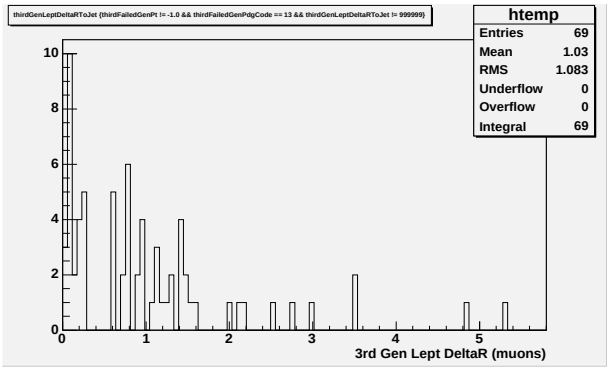

FIG. 40: ΔR between nearest jet and 3rd generated lepton (muons only) not matched to a reconstructed lepton.

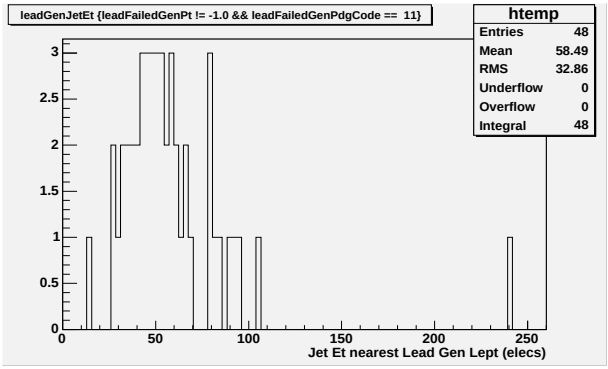

FIG. 41: E_T of nearest jet to lead generated lepton (electrons only) not matched to a reconstructed lepton.

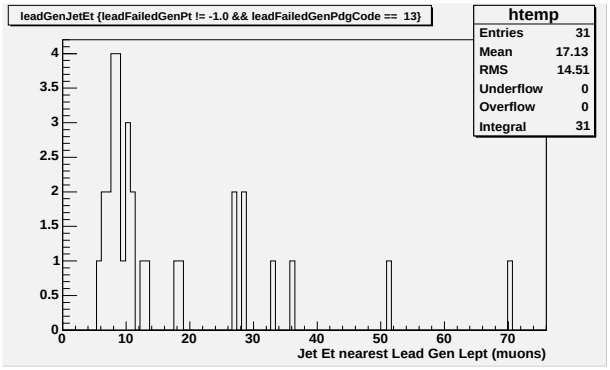

FIG. 42: E_T of nearest jet to lead generated lepton (muons only) not matched to a reconstructed lepton.

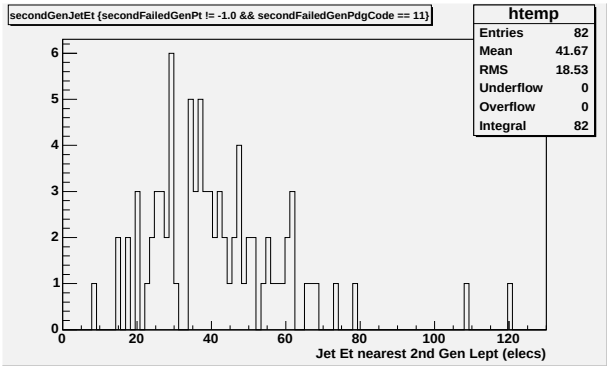

FIG. 43: E_T of nearest jet to 2nd generated lepton (electrons only) not matched to a reconstructed lepton.

Unmatched Gen. Nearest Jet E_T

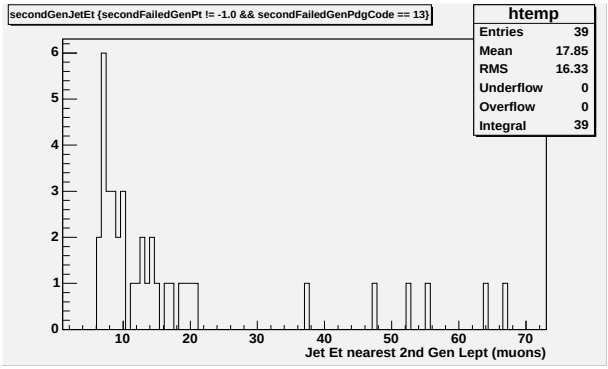

FIG. 44: E_T of nearest jet to 2nd generated lepton (muons only) not matched to a reconstructed lepton.

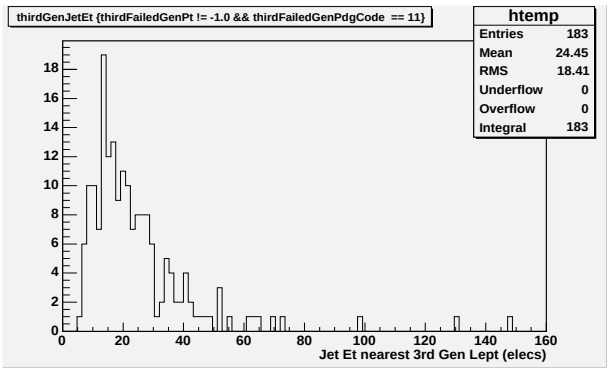

FIG. 45: E_T of nearest jet to 3rd generated lepton (electrons only) not matched to a reconstructed lepton.

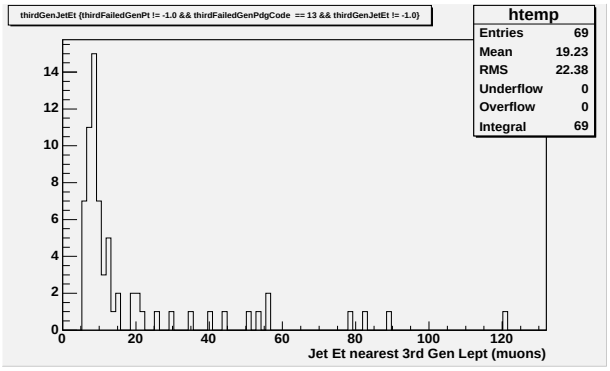

FIG. 46: E_T of nearest jet to 3rd generated lepton (muons only) not matched to a reconstructed lepton.

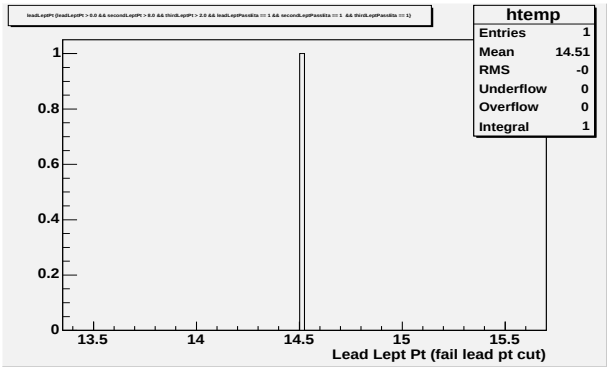

FIG. 47: Event failing because of the lead P_T cut.

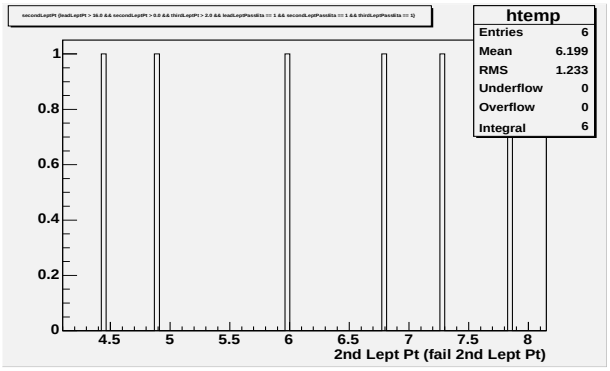

FIG. 48: Events failing because of the second P_T cut.

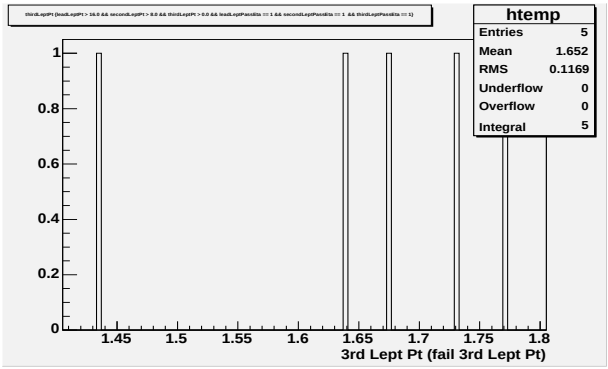

FIG. 49: Event failing because of the third P_T cut.

EVENTS FAILING P_T AND η CUTS AT RECONSTRUCTION

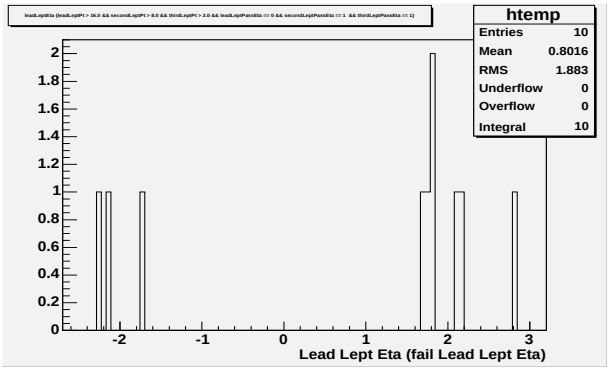

FIG. 50: Event failing because of the lead η cut.

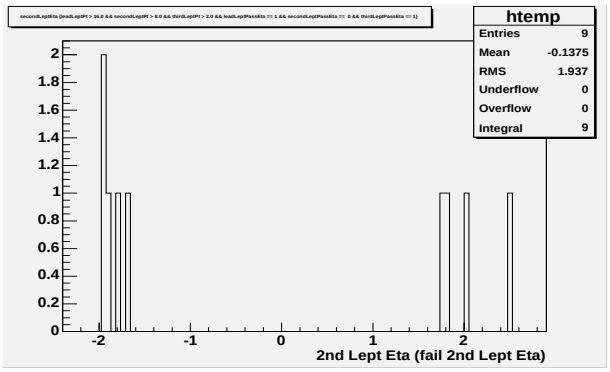

FIG. 51: Events failing because of the second η cut.

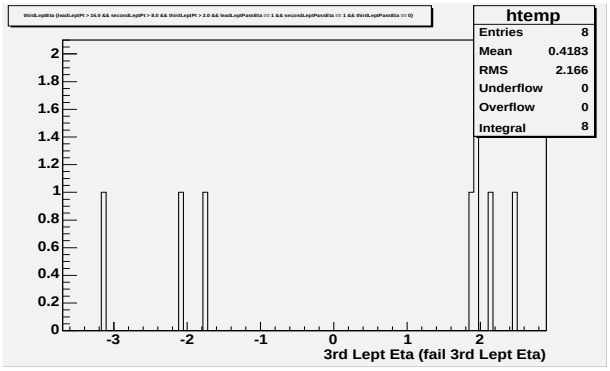

FIG. 52: Event failing because of the third η cut.

EVENTS FAILING MATCHING

There are 389 events passing P_T and η cuts on the reconstructed leptons, but do not have all three leptons pass matching. The number is not actually the same as what I indicates because there is an inherent ambiguity to studying events that fail cuts. It is the whole event that passes or fails a set of cuts, not just single leptons. If one particular lepton fails a cut, there may be other that can take its place.

Here, I am taking the events that do have the three leading leptons pass the P_T and η cuts, but have at least one of those three particular leptons fail matching. The actual algorithm, however, does not simply just check these three leptons for matching. It is plausible that if one of the three leptons fails matching, there is some fourth lepton in the event that can fill in as the third lepton for the purposes of this study. Hence, while the number of events failing matching cuts I study here is 389, the actual number of events that fail the matching criterion step is somewhat lower than this.

Lept.	Fail Matching	Pass Matching
Lead Lept.	41	347
2nd Lept.	81	308
3rd Lept.	301	88

TABLE II: These are the 389 events that fail the matching step because at least one of the three leading reconstructed leptons does not match successfully to a generator-level lepton. It is overwhelming the 3rd leptons that fail fails to match, among these.

Loose Match	Electrons	Muons	Pions	Rho	Kaons	Protons
Lead Lept. (elecs,24)	11(0)	3(3)	10(7)	0	0	0
2nd Lept. (elecs,53)	21(0)	10(8)	17(5)	0	4(4)	1(1)
3rd Lept. (elecs,217)	97(0)	5(1)	85(22)	6(1)	9(4)	15(1)

TABLE III: The matching criterion allows reconstructed electrons to search for matches only among generator-electrons, and reconstructed muons to search for matches only among generator-level electrons and muons. When that matching criterion has failed, I run the fail events through a looser matching function that will search for matches among several different possible charged particles to see if a generator-level charged particle was reconstructed with the wrong particle type. The number given is the quantity of leptons (that are electrons) that match best to particles of the given type. The number in parentheses that follows is the quantity of "best matches" that are "successful matches" (matchingFactor < 40.0).

Loose Match	Muons	Electrons	Pions	Rho	Kaons	Protons
Lead Lept. (muons,18)	6(0)	1(0)	7(2)	1(0)	2(0)	1(1)
2nd Lept. (muons,28)	3(0)	6(0)	16(7)	0	1(0)	2(1)
3rd Lept. (muons,84)	9(0)	13(1)	43(21)	1(0)	15(10)	3(2)

TABLE IV: The matching criterion allows reconstructed electrons to search for matches only among generator-electrons, and reconstructed muons to search for matches only among generator-level electrons and muons. When that matching criterion has failed, I run the fail events through a looser matching function that will search for matches among several different possible charged particles to see if a generator-level charged particle was reconstructed with the wrong particle type. The number given is the quantity of leptons (that are muons) that match best to particles of the given type. The number in parentheses that follows is the quantity of "best matches" that are "successful matches" (matchingFactor < 40.0).

In the following subsections, I plot values associated with the first columns of tables III and IV. That is, I show histograms of P_T, η, ϕ, and *matchingFactor* values for leptons that do match to the same type, but do not pass matching because *matchingFactor* > 40.0. These may represent leptons that were poorly reconstructed.

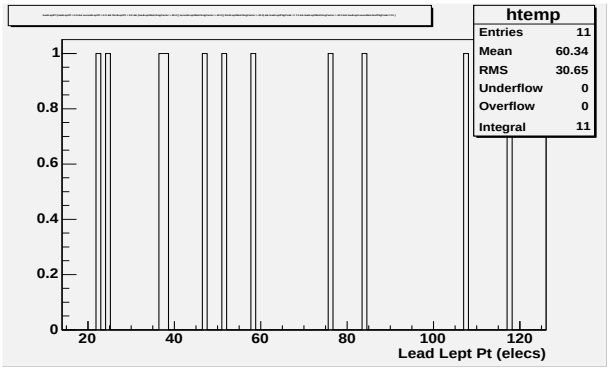

FIG. 53: Lead Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

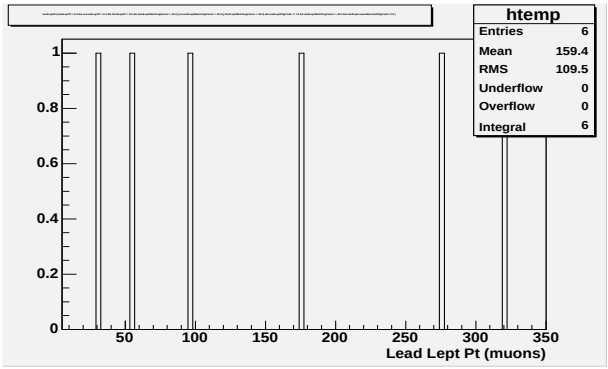

FIG. 54: Lead Lepton (muons) match to correct type, but *matchingFactor* > 40.0.

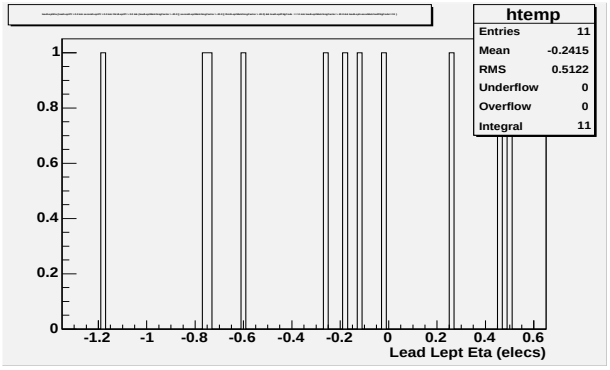

FIG. 55: Lead Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

Leading Lepts. Matching To Correct Type, But Failing MatchingFactor < 40

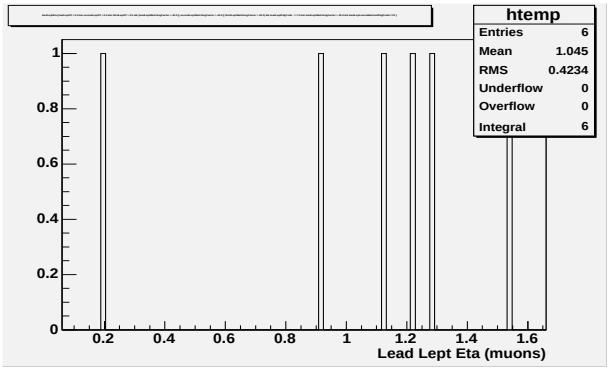

FIG. 56: Lead Lepton (muons) match to correct type, but *matchingFactor* > 40.0.

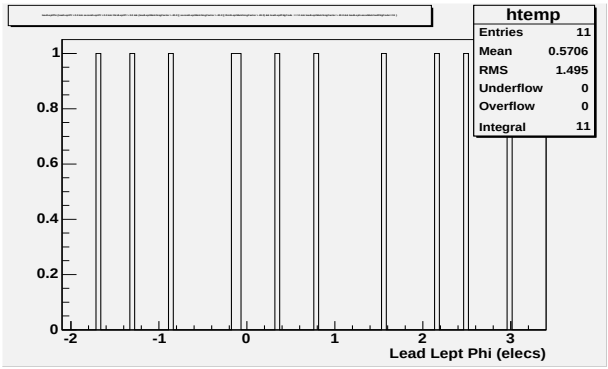

FIG. 57: Lead Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

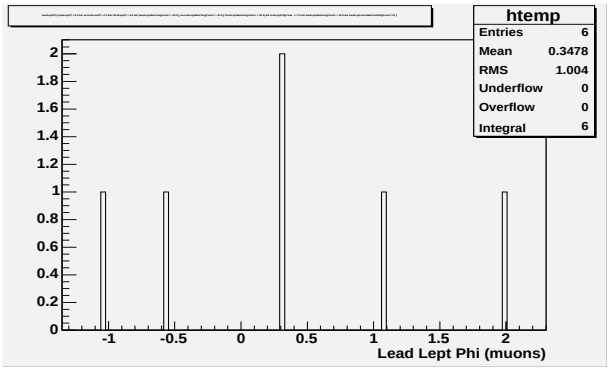

FIG. 58: Lead Lepton (muons) match to correct type, but *matchingFactor* > 40.0.

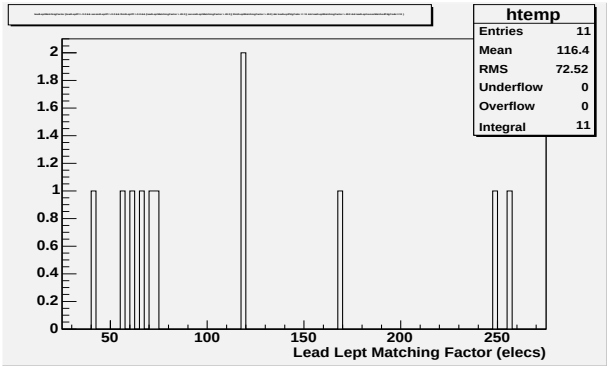

FIG. 59: Lead Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

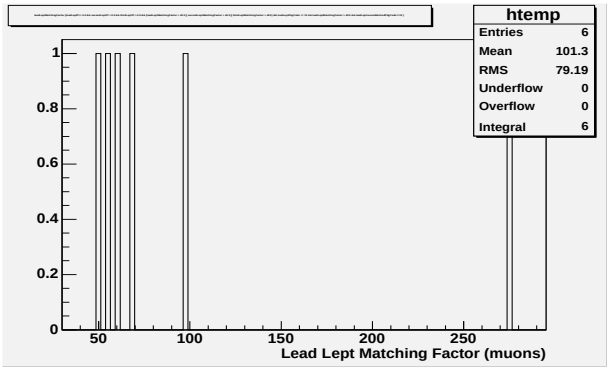

FIG. 60: Lead Lepton (muons) match to correct type, but $matchingFactor > 40.0$.

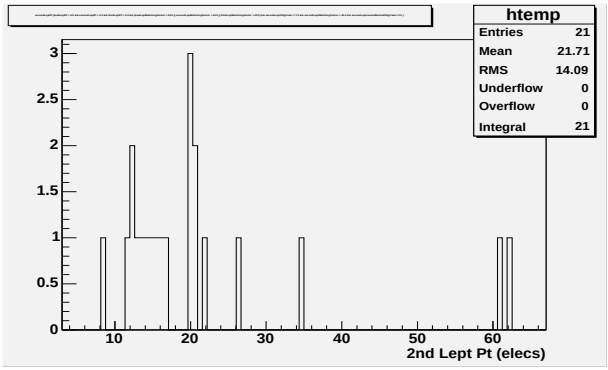

FIG. 61: second Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

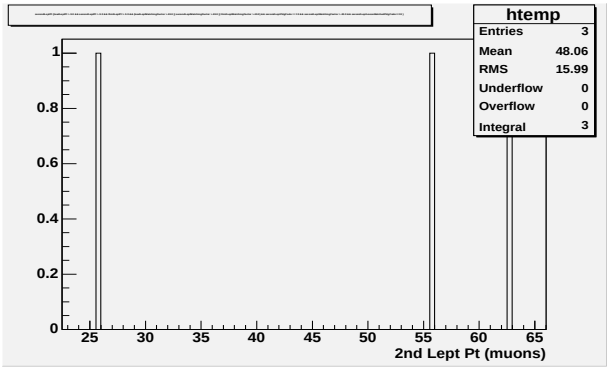

FIG. 62: second Lepton (muons) match to correct type, but *matchingFactor* > 40.0.

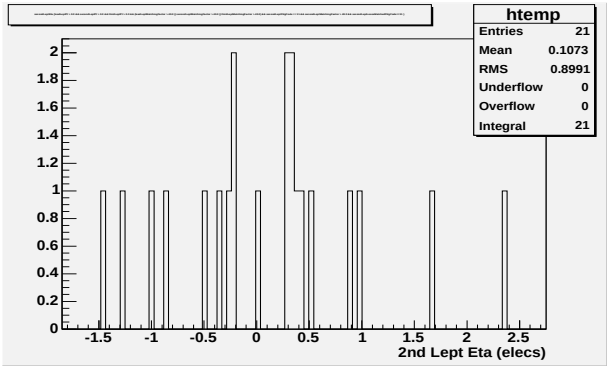

FIG. 63: second Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

2nd Lepts. Matching To Correct Type, But Failing MatchingFactor < 40

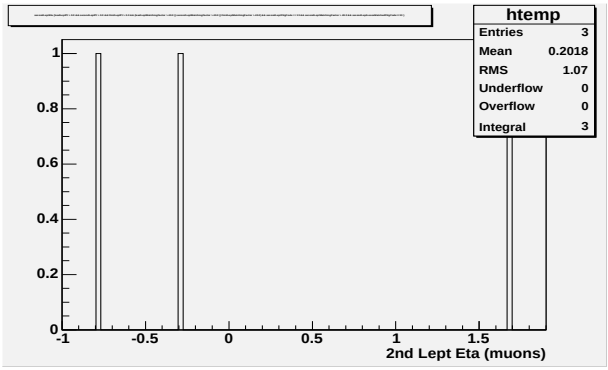

FIG. 64: second Lepton (muons) match to correct type, but *matchingFactor* > 40.0.

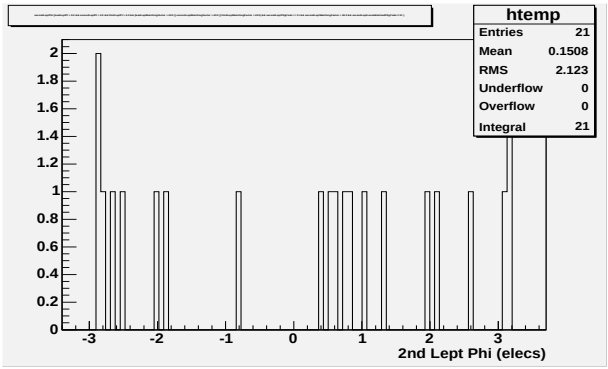

FIG. 65: second Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

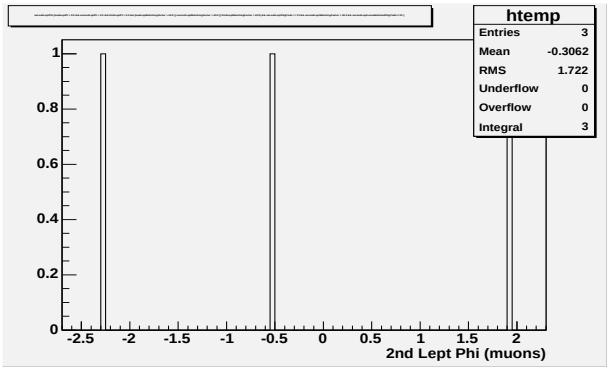

FIG. 66: second Lepton (muons) match to correct type, but *matchingFactor* > 40.0.

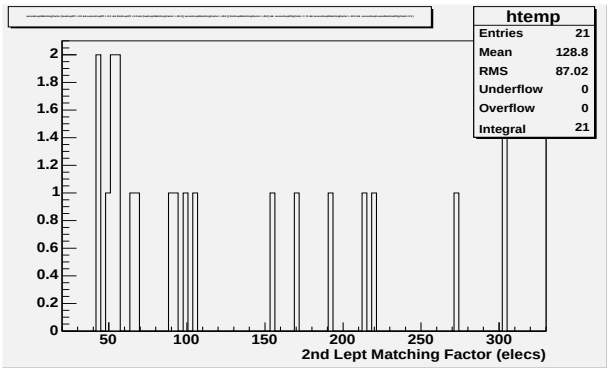

FIG. 67: second Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

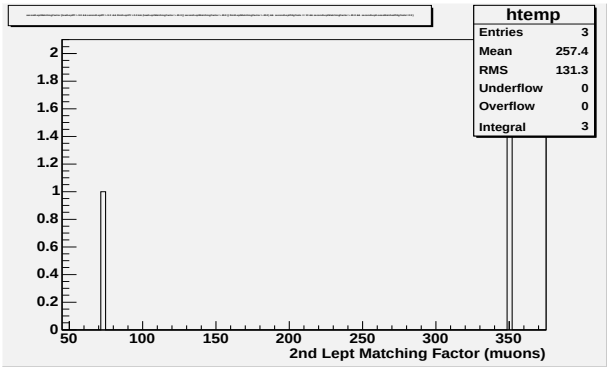

FIG. 68: second Lepton (muons) match to correct type, but *matchingFactor* > 40.0.

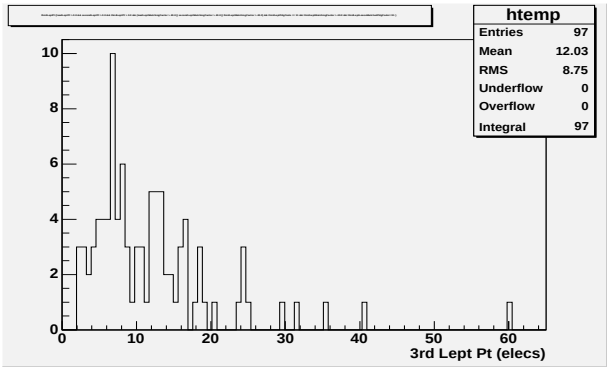

FIG. 69: third Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

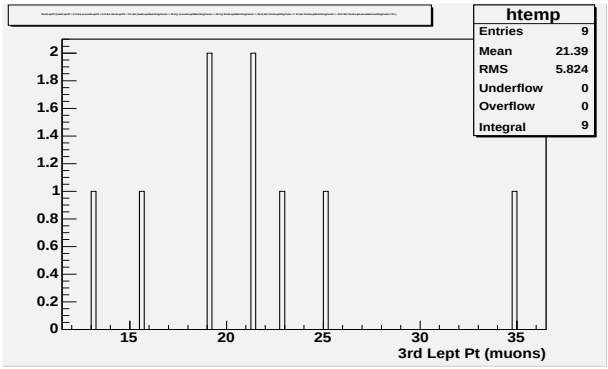

FIG. 70: third Lepton (muons) match to correct type, but *matchingFactor* > 40.0.

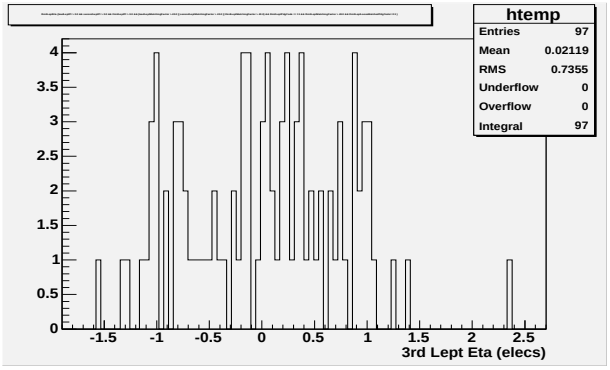

FIG. 71: third Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

3rd Lepts. Matching To Correct Type, But Failing MatchingFactor < 40

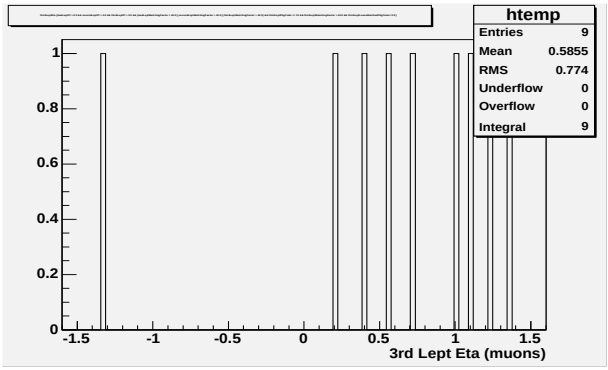

FIG. 72: third Lepton (muons) match to correct type, but *matchingFactor* > 40.0.

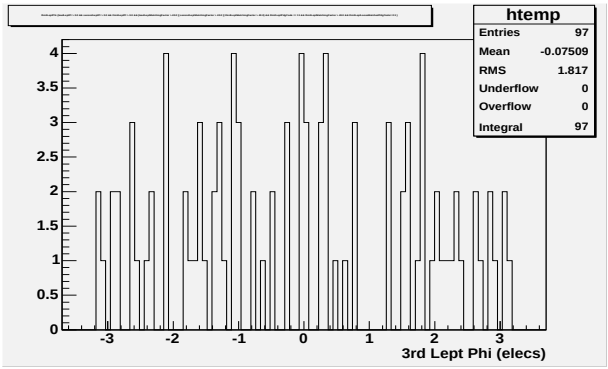

FIG. 73: third Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

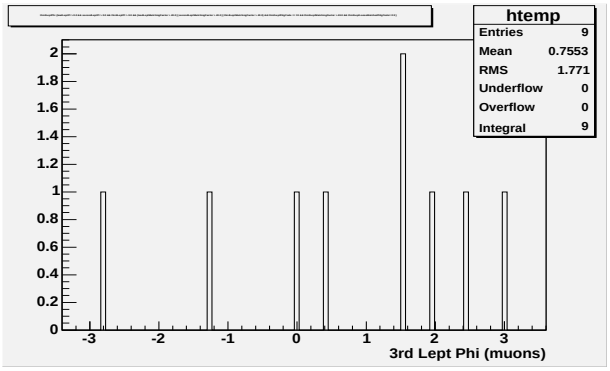

FIG. 74: third Lepton (muons) match to correct type, but *matchingFactor* > 40.0.

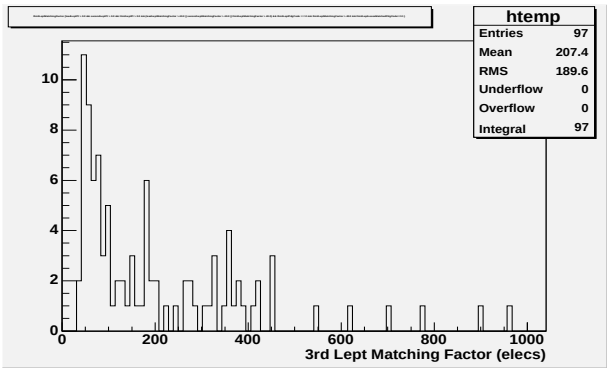

FIG. 75: third Lepton (electrons) match to correct type, but *matchingFactor* > 40.0.

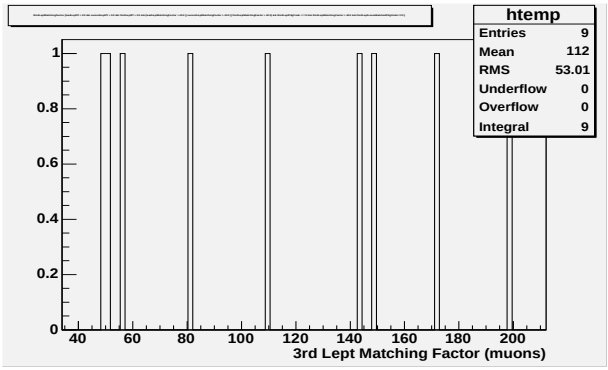

FIG. 76: third Lepton (muons) match to correct type, but *matchingFactor* > 40.0.

EVENTS FAILING QUALITY CUTS

237 events pass the matching criterion, but fail to pass the quality cuts.

Lept.	Fail Quality Cuts	Pass Quality Cuts
Lead Lept.	80	157
2nd Lept.	80	157
3rd Lept.	99	138

TABLE V: These are the 237 events that fail the quality cuts step because at least one of the three leading reconstructed leptons does not pass one of several quality cuts.

Lead Lept.	Fail Cut	Pass Cut
Elec iso/et	35	202
Elec HadE/EmE	14	223
Elec EOverP	32	205
Muon iso/pt	40	197
Muon EmE	35	202
Muon HadE	16	221

TABLE VI: These are the particular quality cuts of the leading lepton.

Lead Lept.	Fail Cut	Pass Cut
Elec iso/et	25	212
Elec HadE/EmE	9	228
Elec EOverP	6	231
Muon iso/pt	38	199
Muon EmE	19	218
Muon HadE	6	231

TABLE VII: These are the particular quality cuts of the 2nd lepton.

Lead Lept.	Fail Cut	Pass Cut
Elec iso/et	26	211
Elec HadE/EmE	5	232
Elec EOverP	11	226
Muon iso/pt	37	200
Muon EmE	21	216
Muon HadE	3	234

TABLE VIII: These are the particular quality cuts of the 3rd lepton.