Trilepton Analysis: The $WH \to WWW \to l\nu l\nu l\nu$ Signal

(CDF Collaboration)

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(Dated: 4 May 2009)

[This is still a work in progress and presently light on exposition.] I begin with estimating what the missing energy distribution is at the generator-level for the trilepton MC signal by vectorially summing the neutrino momenta for each event. Then we can compare the result to the missing energy distribution found at the reconstructed level and to the dilepton missing energy distribution from `ntp_14`.

Contents

DOUBLE COUNTED NEUTRINOS IN THE HEPG TABLE

The structure of the HEPG table of the generator-level particles for an event is peculiar in that particles from the original quarks out to the W bosons and their decay products appear twice in the table. Here's an example:

i	name	PDG	isthep	im1	im2	id1	id2	px	py	pz	e	vx	vy	vz	t
0	proton	2212	3	-1	-1	-1	-1	0.000	0.000	980.000	980.000	0.000	0.000	0.000	0.000
1	antiproton	-2212	3	-1	-1	-1	-1	0.000	0.000	-980.000	980.000	0.000	0.000	0.000	0.000
2	u	2	3	0	-1	-1	-1	1.810	-0.293	389.686	389.690	0.000	0.000	0.000	0.000
3	d_bar	-1	3	1	-1	-1	-1	1.745	-1.048	-294.329	294.336	0.000	0.000	0.000	0.000
4	u	2	3	2	-1	-1	-1	5.014	-24.241	94.531	97.718	0.000	0.000	0.000	0.000
5	d_bar	-1	3	3	-1	-1	-1	19.269	19.703	-215.306	217.063	0.000	0.000	0.000	0.000
6	h0	25	3	4	5	-1	-1	-49.920	15.657	-113.502	202.930	0.000	0.000	0.000	0.000
7	W+	24	3	4	5	-1	-1	74.203	-20.196	-7.273	111.850	0.000	0.000	0.000	0.000
8	W+	24	3	6	-1	-1	-1	-40.598	15.543	-42.735	95.610	0.000	0.000	0.000	0.000
9	W-	-24	3	6	-1	-1	-1	-9.321	0.114	-70.767	107.321	0.000	0.000	0.000	0.000
10	tau+	-15	3	7	-1	-1	-1	58.660	0.680	-39.261	70.612	0.000	0.000	0.000	0.000
11	nu_tau	16	3	7	-1	-1	-1	15.543	-20.875	31.988	41.238	0.000	0.000	0.000	0.000
12	mu+	-13	3	8	-1	-1	-1	12.364	13.334	10.071	20.787	0.000	0.000	0.000	0.000
13	nu_mu	14	3	8	-1	-1	-1	-52.963	2.209	-52.806	74.823	0.000	0.000	0.000	0.000
14	e-	11	3	9	-1	-1	-1	27.509	-13.419	-5.399	31.080	0.000	0.000	0.000	0.000
15	nu_e_bar	-12	3	9	-1	-1	-1	-36.830	13.533	-65.368	76.241	0.000	0.000	0.000	0.000
16	h0	25	2	6	-1	18	19	-49.920	15.657	-113.502	202.930	0.000	0.000	0.000	0.000
17	W+	24	2	7	-1	20	21	74.203	-20.196	-7.273	111.850	0.000	0.000	0.000	0.000
18	W+	24	2	8	-1	24	26	-40.598	15.543	-42.735	95.610	0.000	0.000	0.000	0.000
19	W-	-24	2	9	-1	22	23	-9.321	0.114	-70.767	107.321	0.000	0.000	0.000	0.000
20	tau+	-15	2	10	-1	494	496	58.660	0.680	-39.261	70.612	0.000	0.000	0.000	0.000

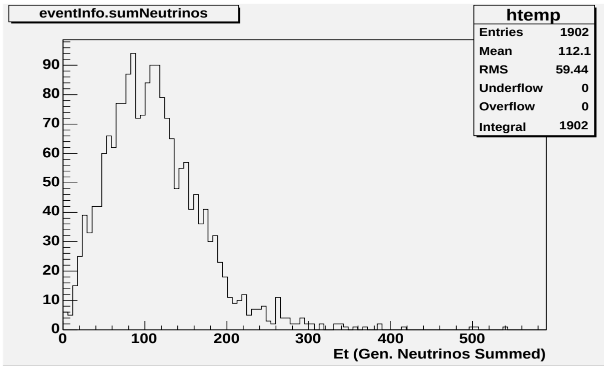

FIG. 1: E_T of the vectorial sum of all neutrinos for each event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts.

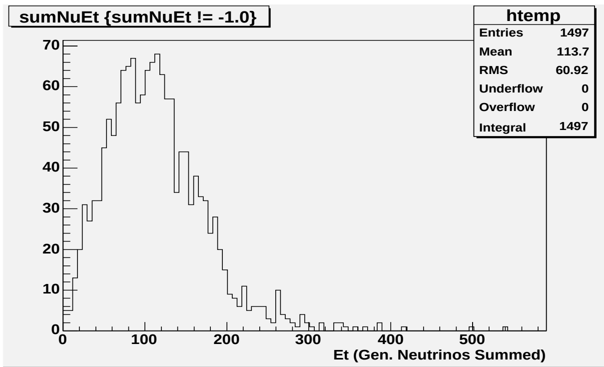

FIG. 2: E_T of the vectorial sum of all neutrinos for each event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, and also reconstruction-level P_T and η cuts.

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21 nu_tau       16    1   11   -1   -1   -1   15.543  -20.875   31.988   41.238   0.000   0.000   0.000   0.000
22 e-           11    1   14   -1   -1   -1   27.509  -13.419   -5.399   31.080   0.000   0.000   0.000   0.000
23 nu_e_bar    -12    1   15   -1   -1   -1  -36.830   13.533  -65.368   76.241   0.000   0.000   0.000   0.000
24 nu_mu        14    1   13   -1   -1   -1  -52.963    2.209  -52.806   74.822   0.000   0.000   0.000   0.000
25 mu+         -13    1   12   -1   -1   -1   12.318   13.266   10.030   20.696   0.000   0.000   0.000   0.000
26 gamma        22    1   12   -1   -1   -1    0.046    0.068    0.041    0.092   0.000   0.000   0.000   0.000
```

We can see the problem here is that the three neutrinos we are most interested in–those from the W boson's leptonic decay–appear twice. The trait that can distinguish at least one set of these double-counted neutrinos is that the second listing identifies the first as the parent particle. As such, when summing the neutrinos of an event vectorially, the neutrinos that list another neutrino as its parent are excluded.

VECTORIALLY SUM NEUTRINOS TO ESTIMATE MET AT GENERATOR-LEVEL

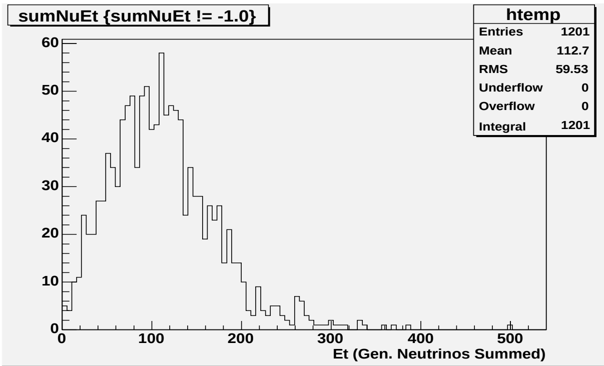

FIG. 3: E_T of the vectorial sum of all neutrinos for each event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, and matching.

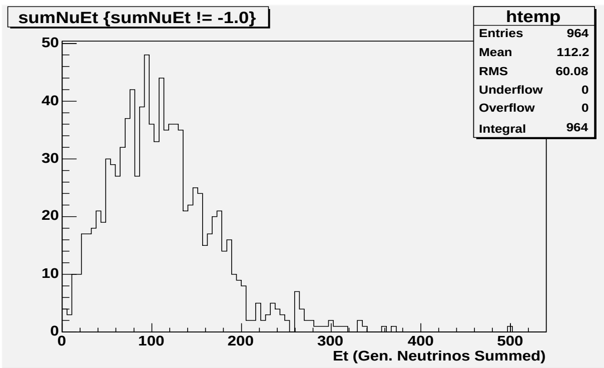

FIG. 4: E_T of the vectorial sum of all neutrinos for each event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, matching, and quality cuts.

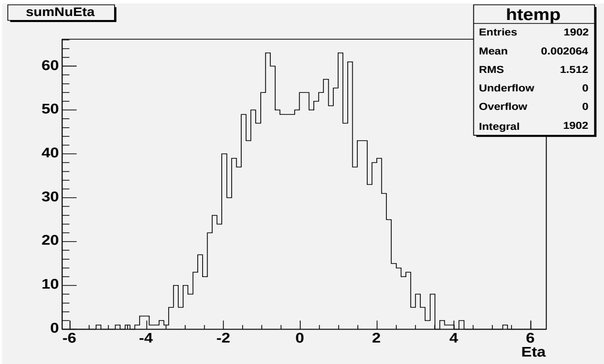

FIG. 5: η of the vector-sum of event neutrinos. The sample is all events passing the trilepton filter and generator-level P_T and η cuts.

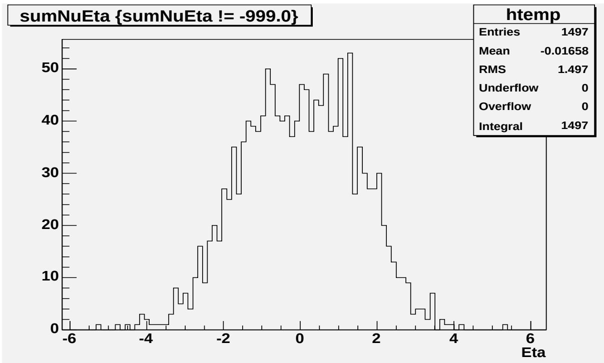

FIG. 6: η of the vector-sum of event neutrinos. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, and also reconstruction-level P_T and η cuts.

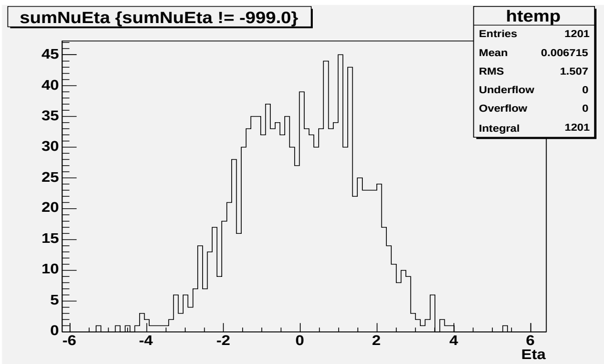

FIG. 7: η of the vector-sum of event neutrinos. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, and matching.

GENERATOR-LEVEL NEUTRINO METETA AND METPHI

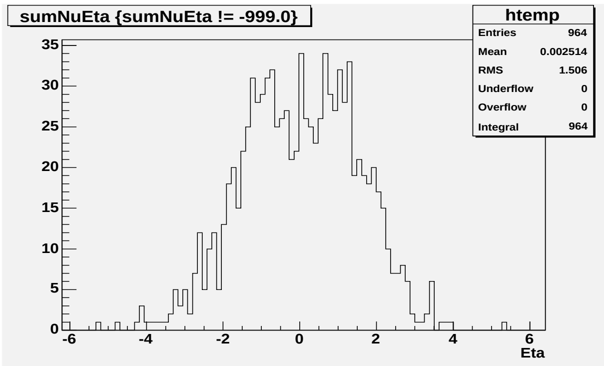

FIG. 8: η of the vector-sum of event neutrinos. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, matching, and quality cuts.

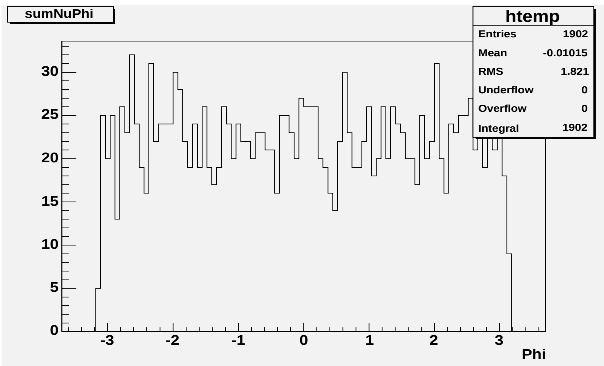

FIG. 9: ϕ of the vector-sum of event neutrinos. The sample is all events passing the trilepton filter and generator-level P_T and η cuts.

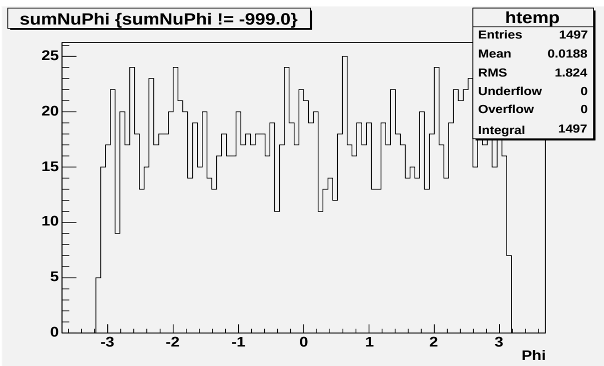

FIG. 10: ϕ of the vector-sum of event neutrinos. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, and also reconstruction-level P_T and η cuts.

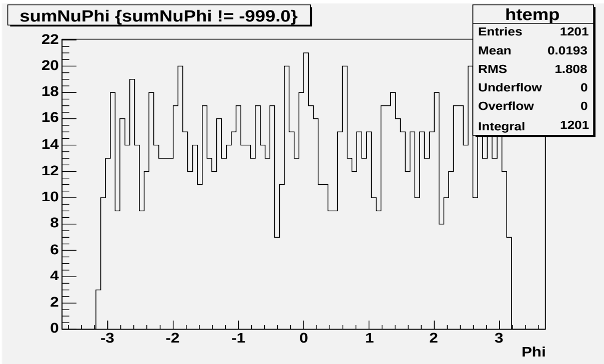

FIG. 11: ϕ of the vector-sum of event neutrinos. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, and matching.

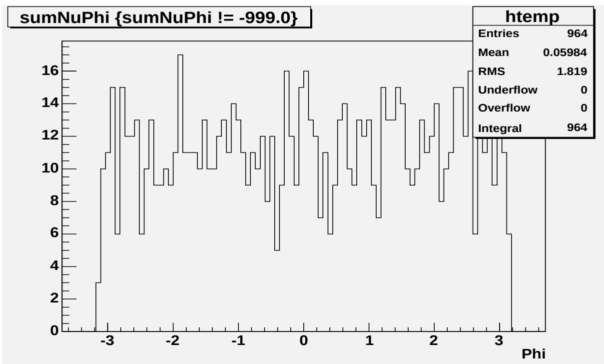

FIG. 12: ϕ of the vector-sum of event neutrinos. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, matching, and quality cuts.

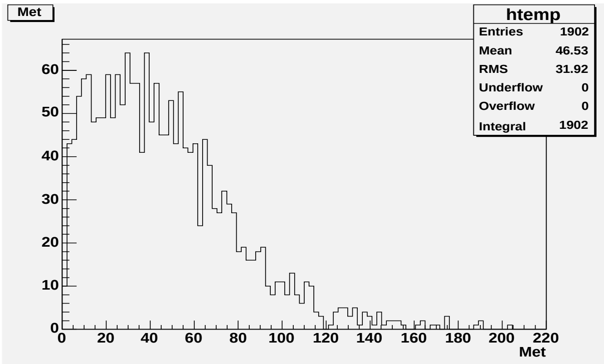

FIG. 13: Reconstructed MET (TStnMetBlock::Met[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts.

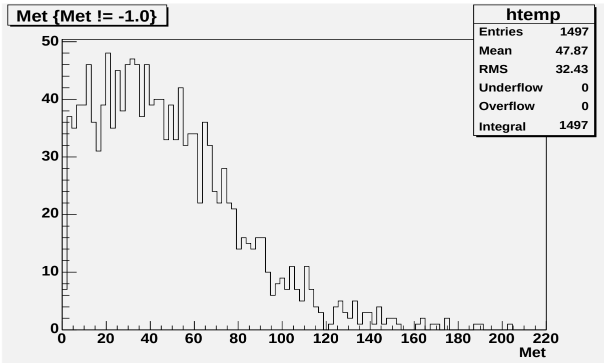

FIG. 14: Reconstructed MET (TStnMetBlock::Met[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, and also reconstruction-level P_T and η cuts.

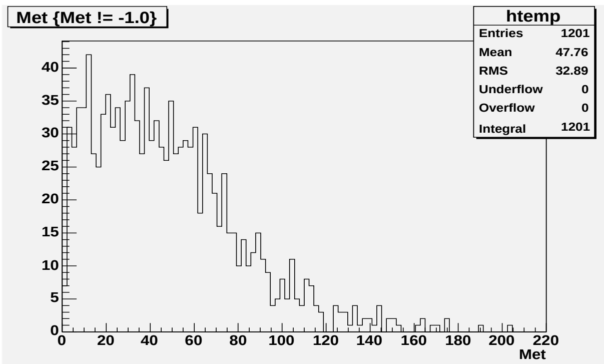

FIG. 15: Reconstructed MET (TStnMetBlock::Met[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, and matching.

RECONSTRUCTED MET

Met

MetX

MetY

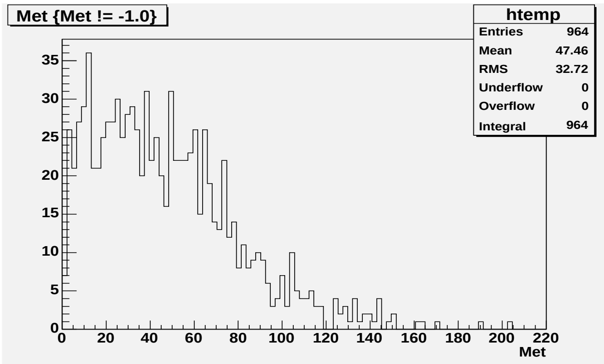

FIG. 16: Reconstructed MET (TStnMetBlock::Met[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, matching, and quality cuts.

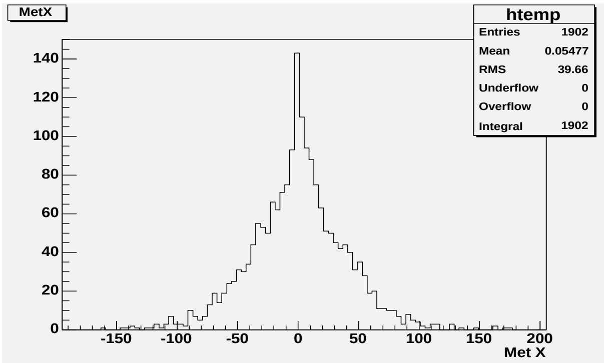

FIG. 17: Reconstructed METX (TStnMetBlock::MetX[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts.

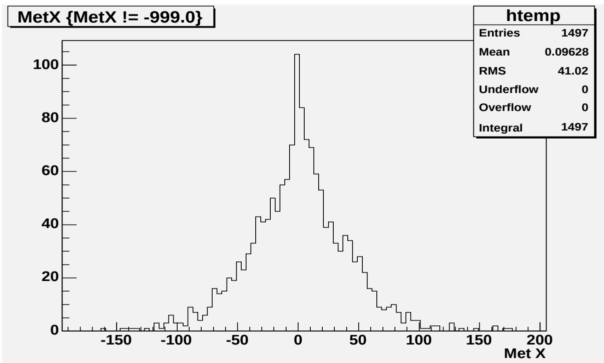

FIG. 18: Reconstructed METX (TStnMetBlock::MetX[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, and also reconstruction-level P_T and η cuts.

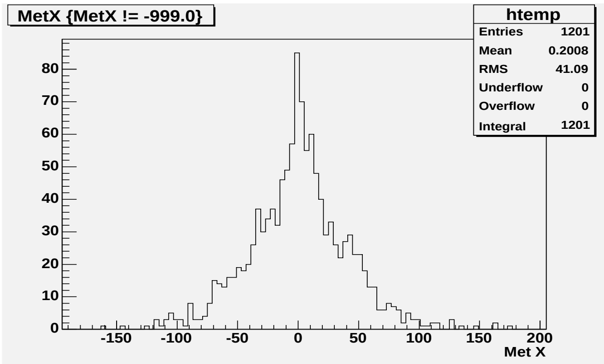

FIG. 19: Reconstructed METX (TStnMetBlock::MetX[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, and matching.

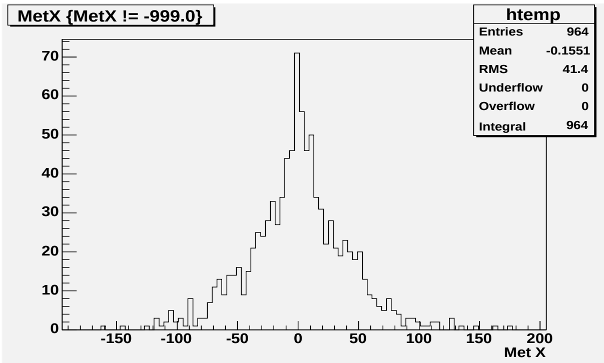

FIG. 20: Reconstructed METX (TStnMetBlock::MetX[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, matching, and quality cuts.

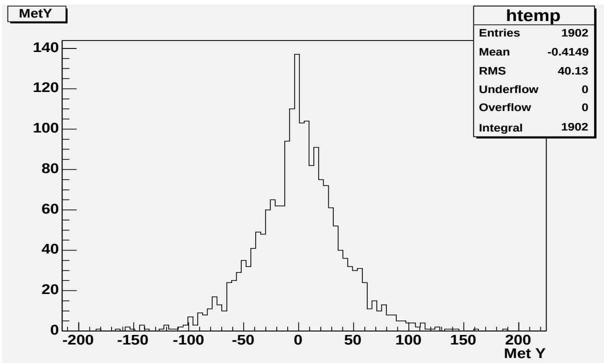

FIG. 21: Reconstructed METY (TStnMetBlock::MetY[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts.

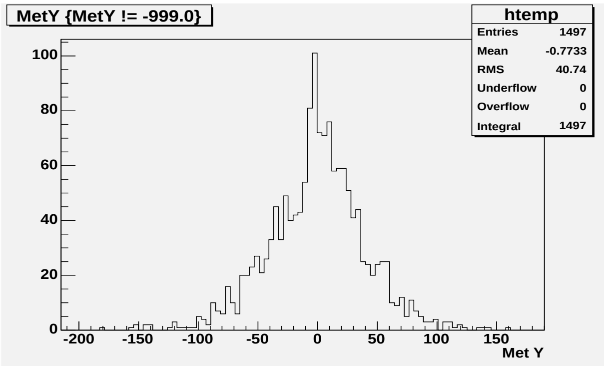

FIG. 22: Reconstructed METY (TStnMetBlock::MetY[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, and also reconstruction-level P_T and η cuts.

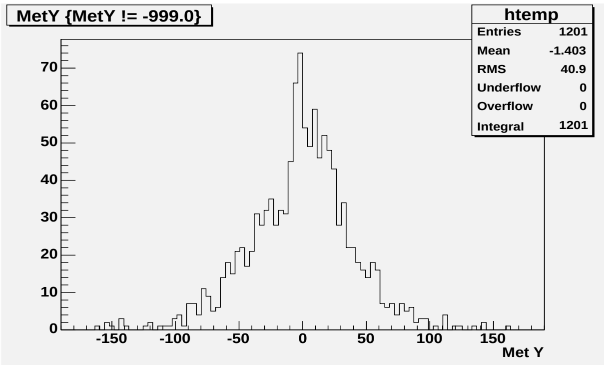

FIG. 23: Reconstructed METY (TStnMetBlock::MetY[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, and matching.

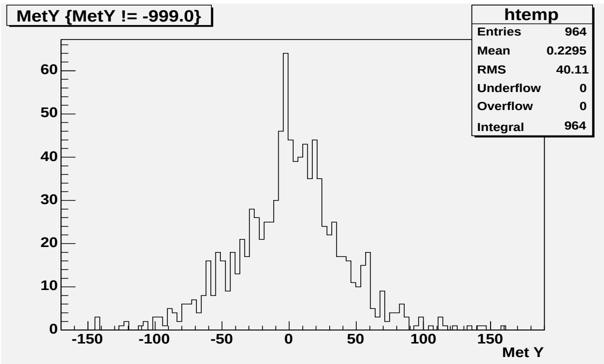

FIG. 24: Reconstructed METY (TStnMetBlock::MetY[4]) of the event. The sample is all events passing the trilepton filter and generator-level P_T and η cuts, reconstruction-level P_T and η cuts, matching, and quality cuts.

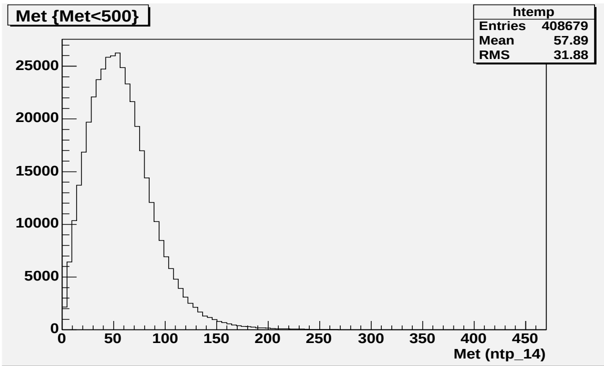

FIG. 25: Reconstructed MET from `ntp_14`

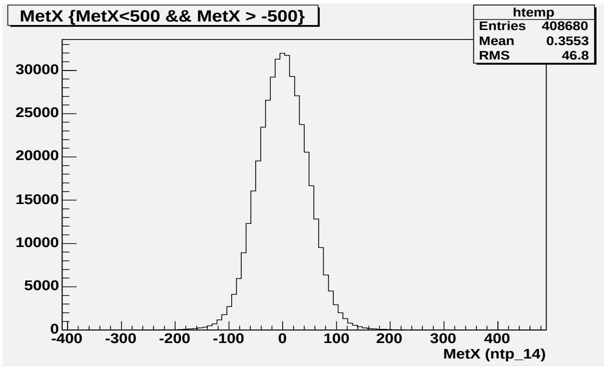

FIG. 26: Reconstructed MET from `ntp_14`

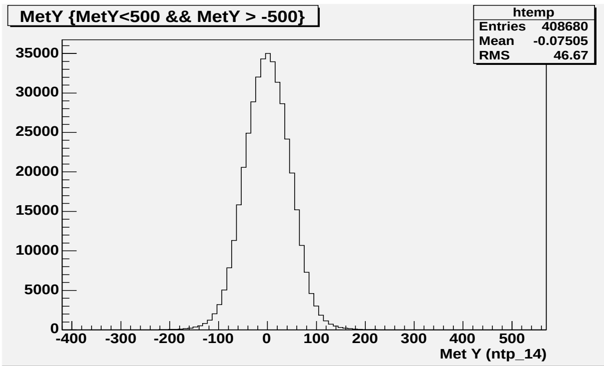

FIG. 27: Reconstructed MET from `ntp_14`

MET IN `NTP14`

GENERATOR-LEVEL NEUTRINO MET ANGLES W/ LEPTONS

EVENTS WITH CLOSE LEPTONS

	Number of Event w/ "Close Leptons"	%
P_T, η cuts at generator-level	267/1902	14.0
P_T, η cuts at reconstruction-level	241/1497	16.1
Pass Matching Criterion	175/1201	14.6
Pass Quality/Isolation Cuts	113/964	11.7

TABLE I: This is the number of events that have at least two of the three leptons within each others' 0.4 cone.

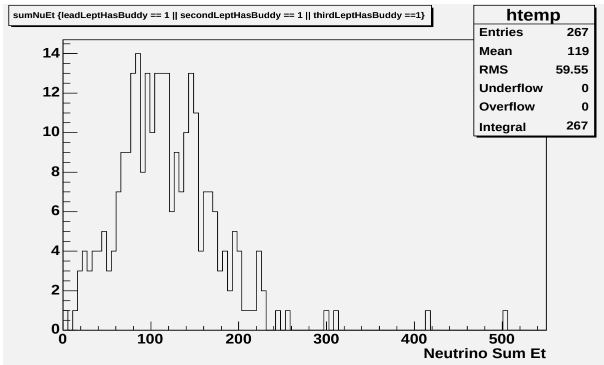

FIG. 28: E_T of summed neutrinos for events with close leptons. There does not seem to be a significant deviation from the full distribution.

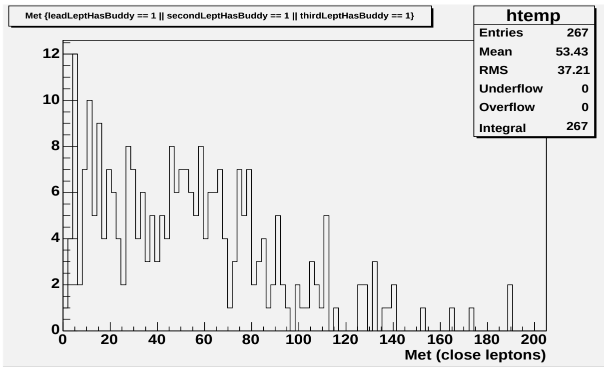

FIG. 29: Reconstructed MET for events with close leptons

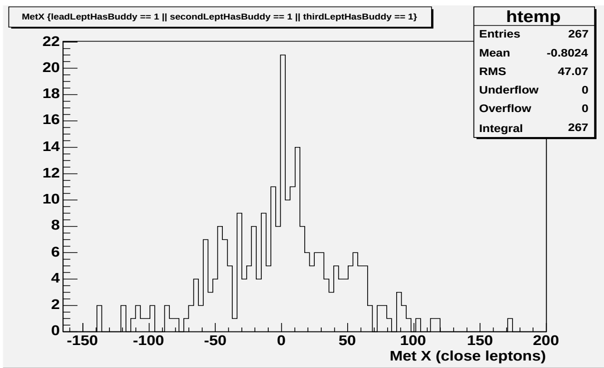

FIG. 30: Reconstructed METX for events with close leptons

Met

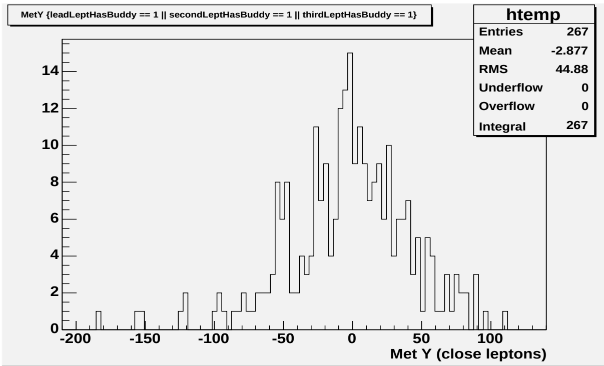

FIG. 31: Reconstructed METY for events with close leptons

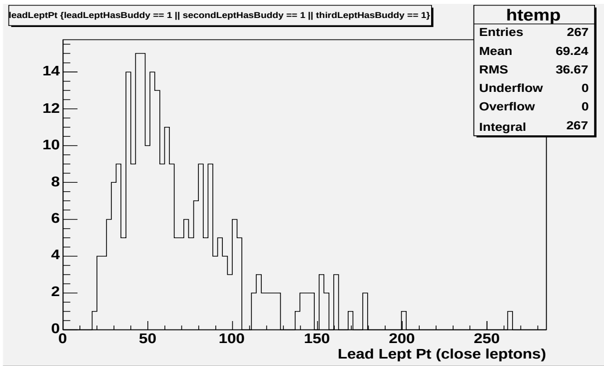

FIG. 32: Leading Lepton P_T for events with close leptons

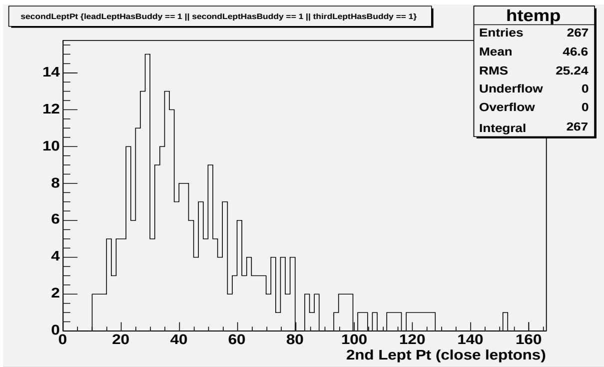

FIG. 33: 2nd Lepton P_T for events with close leptons

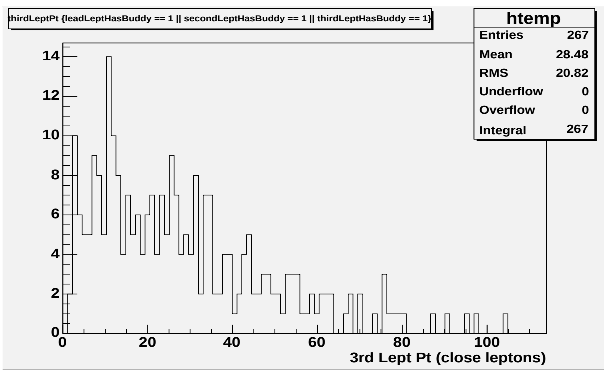

FIG. 34: 3rd Lepton P_T for events with close leptons

P_T

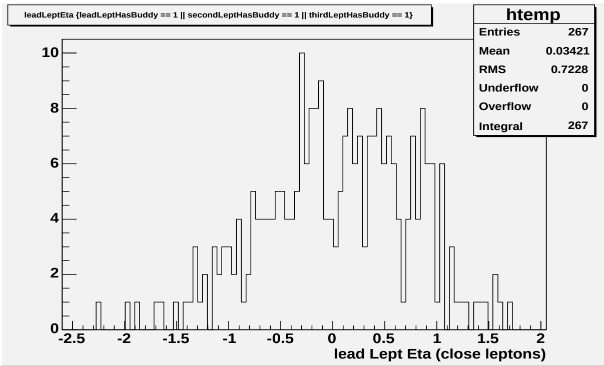

FIG. 35: Leading Lepton η for events with close leptons

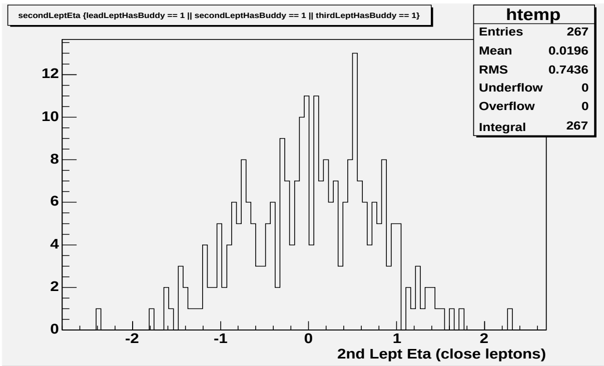

FIG. 36: 2nd Lepton η for events with close leptons

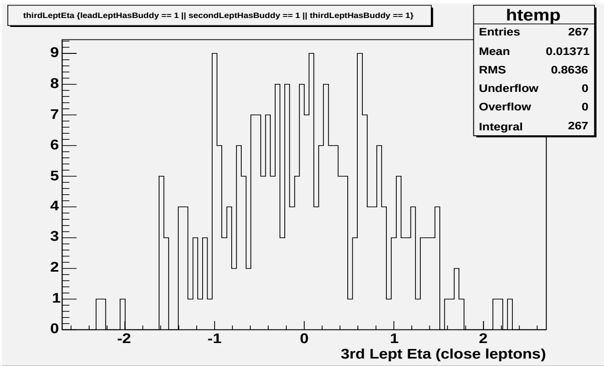

FIG. 37: 3rd Lepton η for events with close leptons

η

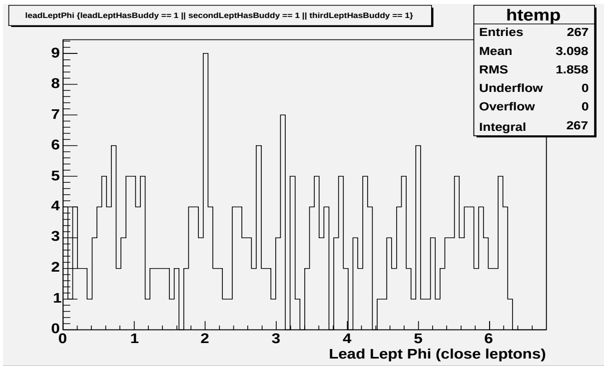

FIG. 38: Leading Lepton ϕ for events with close leptons

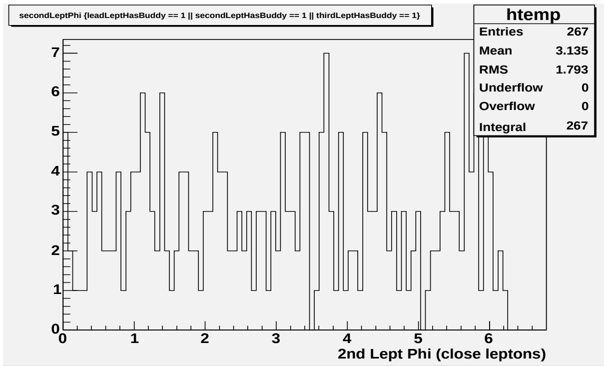

FIG. 39: 2nd Lepton ϕ for events with close leptons

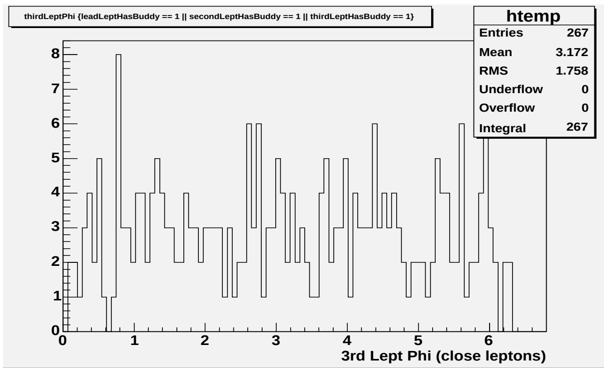

FIG. 40: 3rd Lepton ϕ for events with close leptons

ϕ