WW Analysis using semileptonic decay channel

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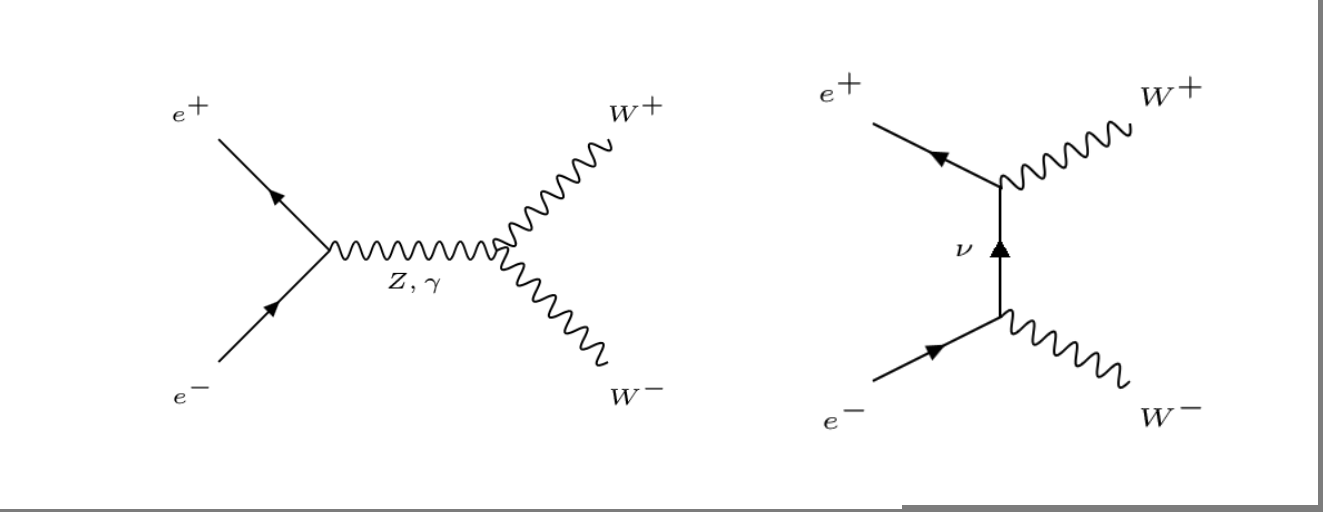
Introduction



Perform Benchmark study by obtaining physics observables:

- Dynamics associated with TGC from W^- production angle
- m_W measured from qq jets
- Measurement of the beam polarization through WW cross section

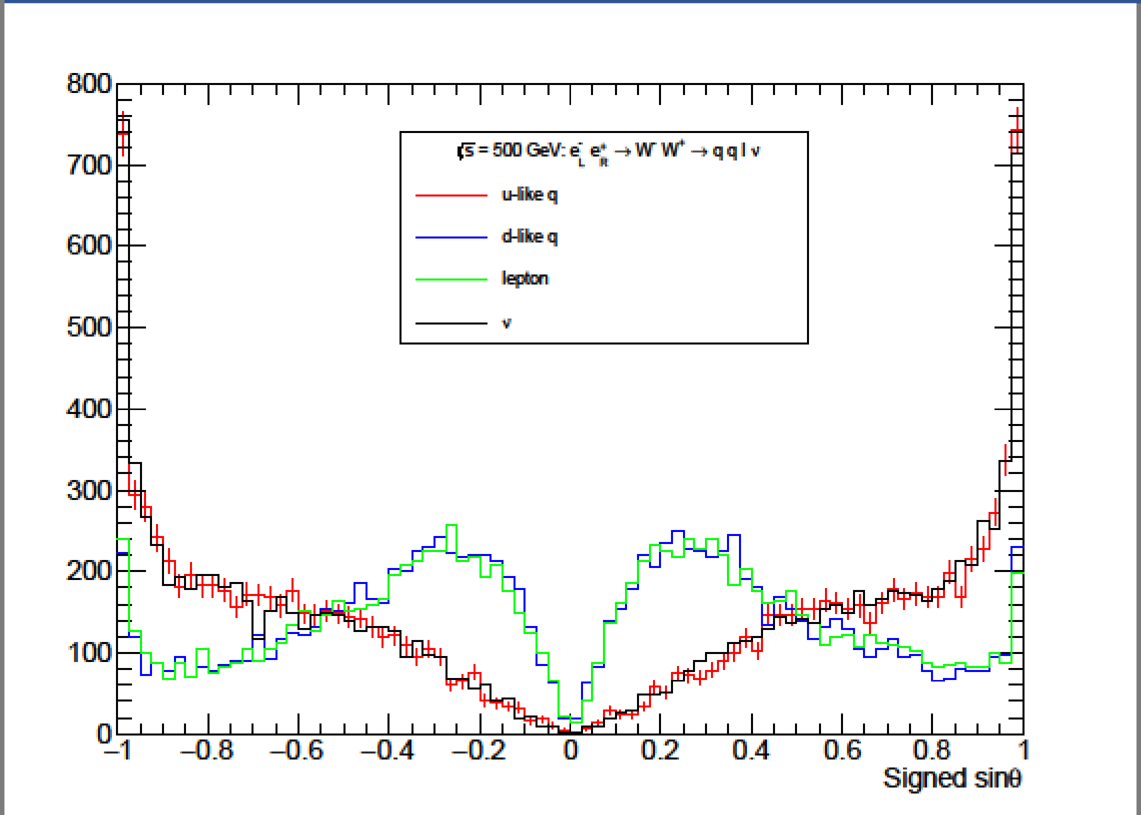
- WW → $qq\ l\nu$ semileptonic decay with $l = \mu, \tau$
- Initially use polarizations (e_L^-, e_R^+) (e_R^-, e_L^+)
- Using standard signal samples:

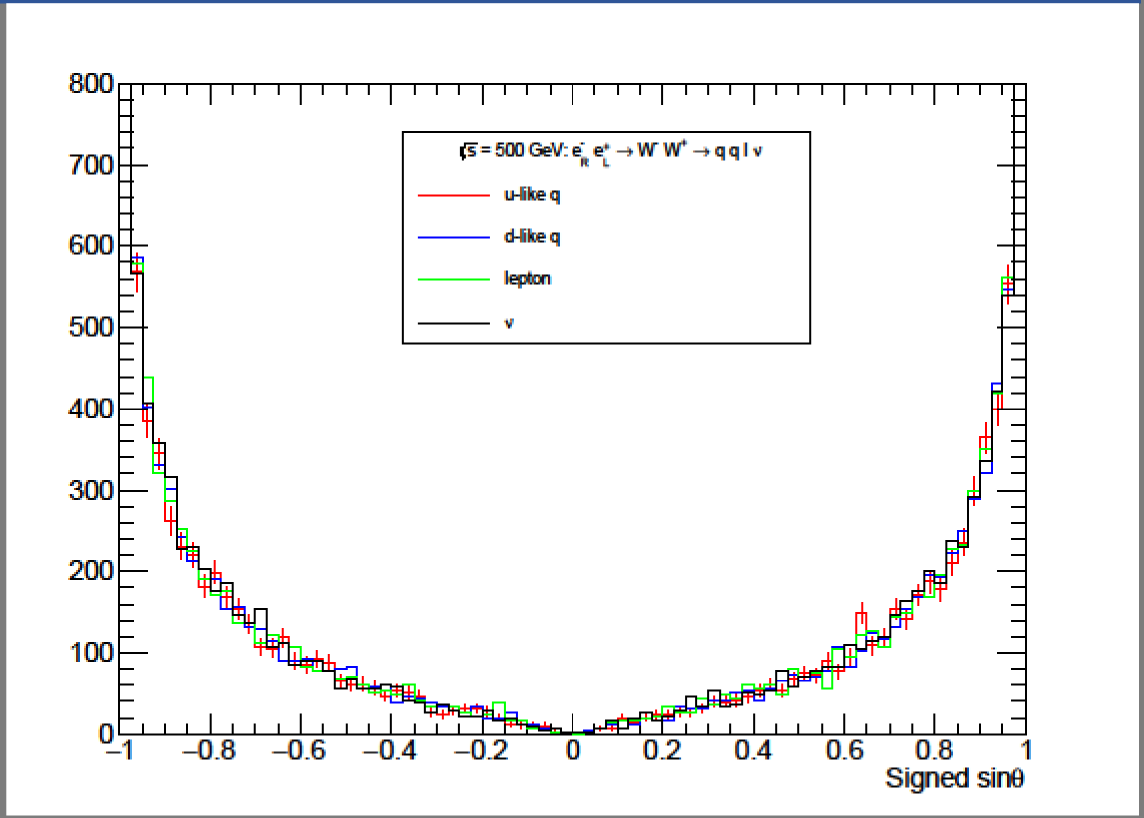
rv02-00-01.sv02-00-01.mILD_l5_o1_v02.E500-TDR_ws.I250018.P4f_ww_sl.eL.pR.n001.d_dstm_10318_0.slcio

  - Running on v2-00-02
  - Currently only addressing large detector

Decay Characteristics

- Sin of the polar angle of the 4 fermions
- LR the energetic fermions tend to be very forward
- RL few particles make it into the forward region



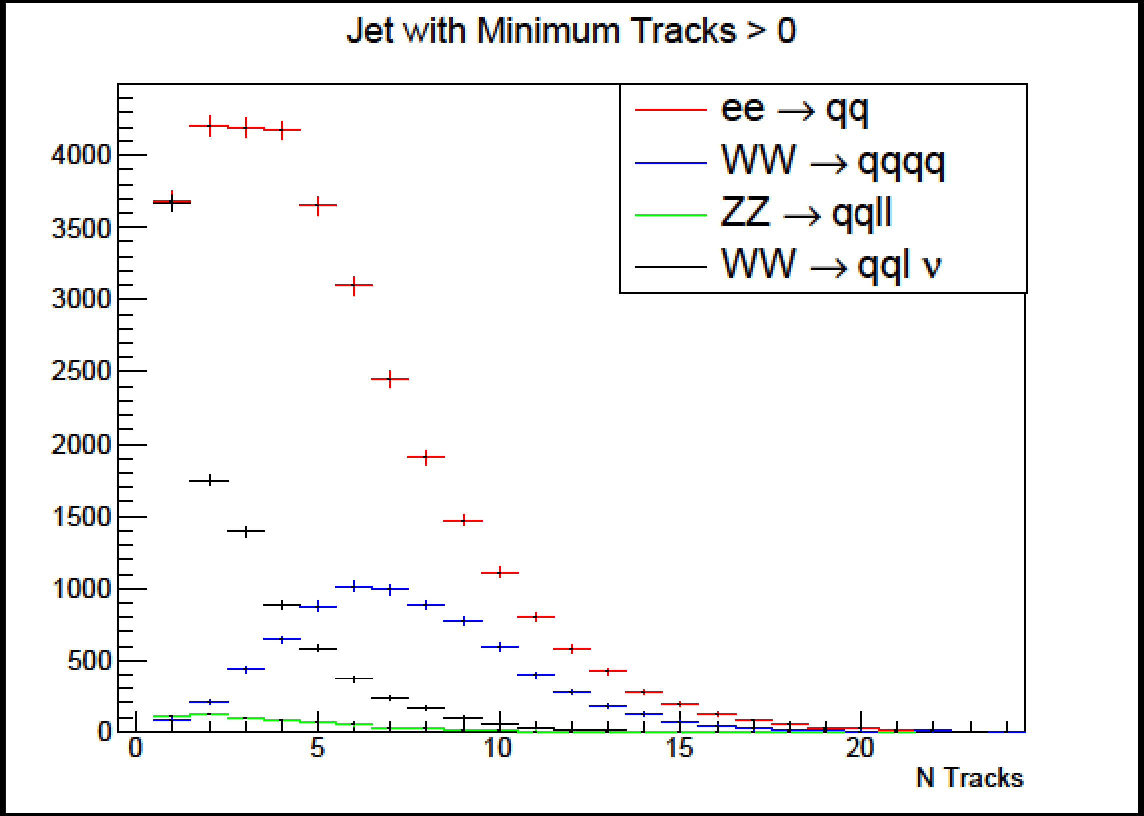


Event Selection

First look at efficiency with a sequential cut flow

	qq	qqll	qqqq	qqlnu
Total events	30600	11200	7200	11800
|cosTheta| < 0.995	27102	10176	6398	11080
nTracks > 10	26502	9892	6398	10832
Pt > 7.0 GeV	8098	7672	2178	10530
E < 500 GeV	5883	7430	1246	10274
80< M < 500 GeV	5748	7262	1245	10263
Log y-	5700	7238	1245	10263
Log y+	5696	7237	1244	10262
%	**18.61**	**64.6**	**17.28**	**86.97**

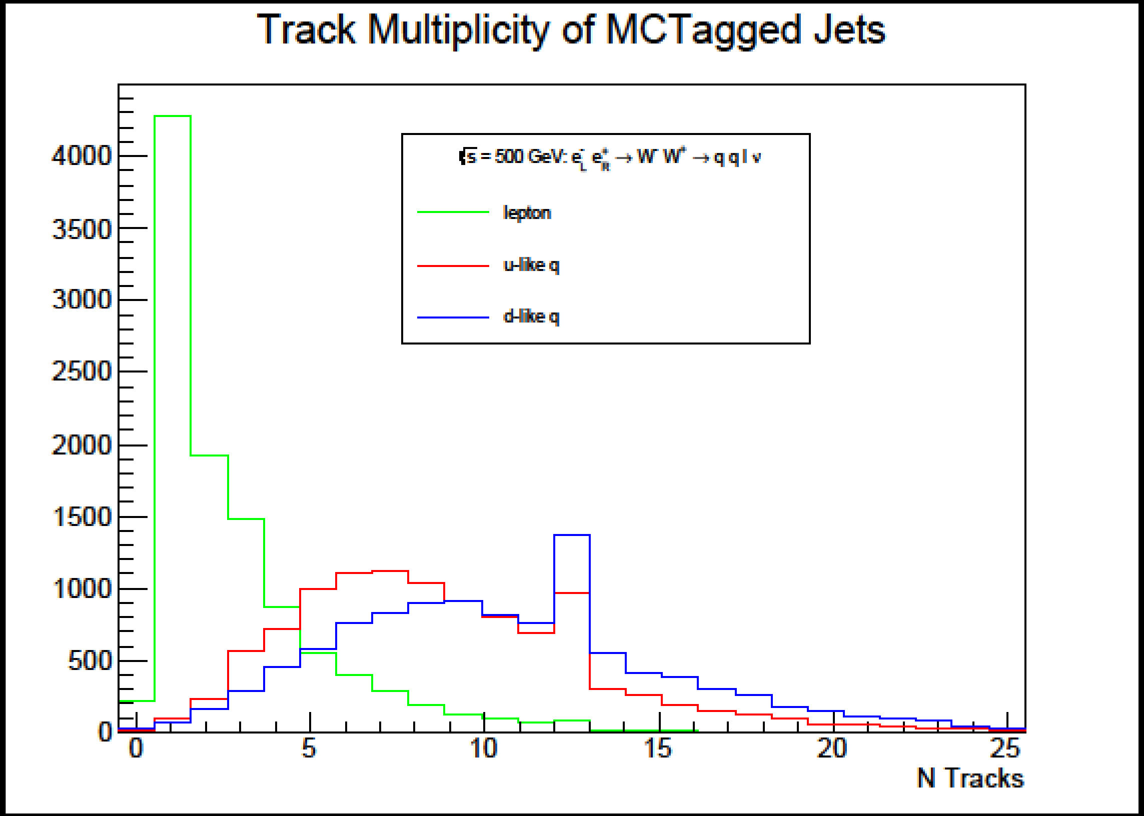
Adding additional Cuts

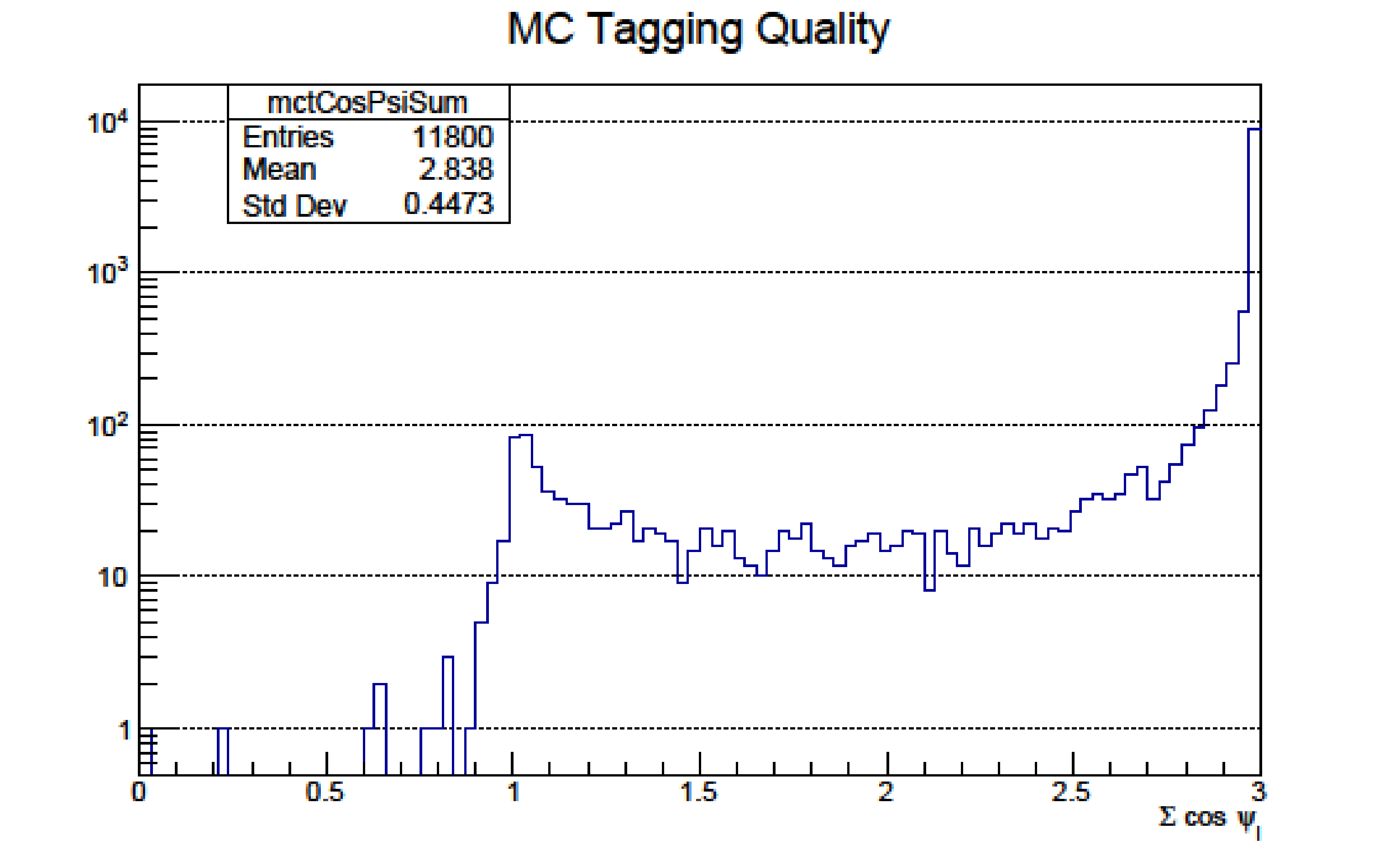


- Looking at (e_L^-, e_R^+) only, inclusive muon/tau
- Cut based on jet clustering, requiring 3 jets from Fast Jet eekt
- Veto events that do not have a jet with between 1 to 3 tracks
- Based on truth information, most signal falls in this track range if a lepton jet is properly identified/clustered
- 30% of signal events contain more than 3 tracks in least charge multiplicity jet
- Possible contamination from overlay

Signal 3 jet track multiplicity

- Track cut can benefit background rejection as well as improve lepton jet identification
- Jets are tagged using the true visible MC fermions
- $\cos\psi$ calculated for fermion/jet pairs where ψ is the opening angle between the true fermion and reconstructed jet
- Pairing is based the max $\cos\psi$ for a particular combination, the remaining pairs are chosen from the unchosen fermion/jet combinations
- A general cut is imposed where the sum of the unique matches $\cos\psi > 2.5$

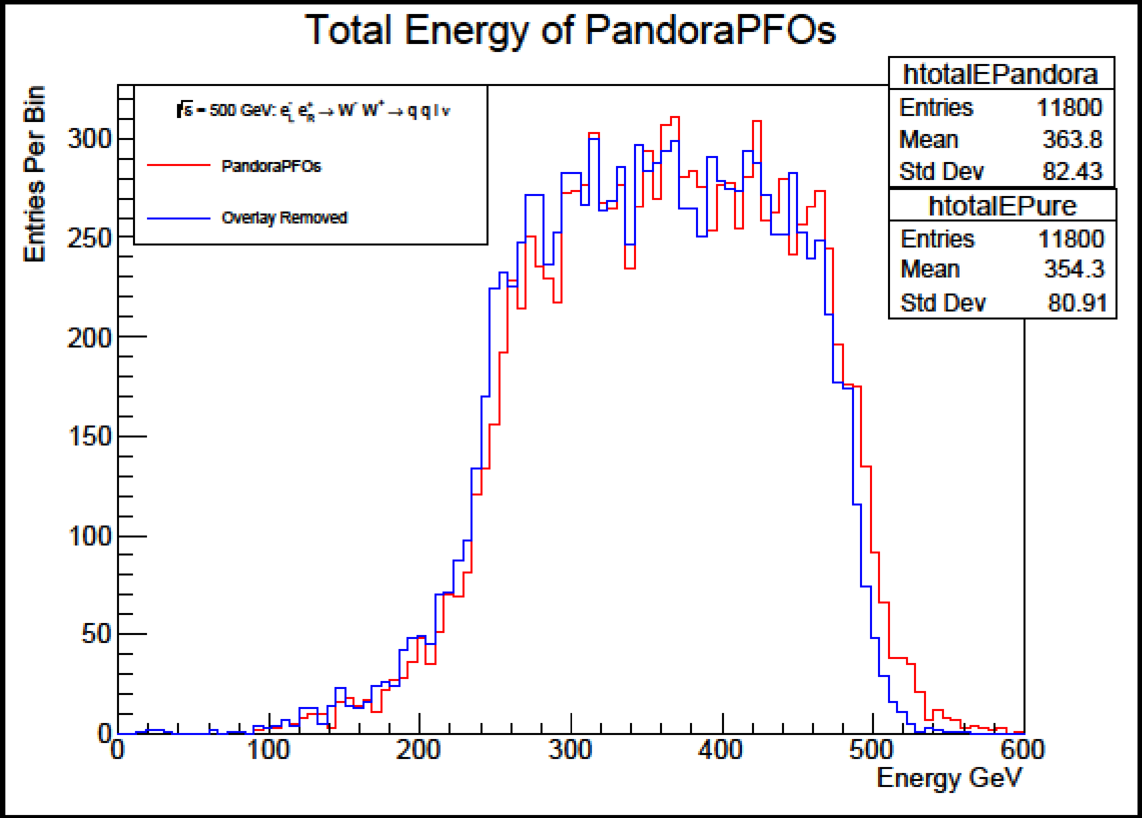


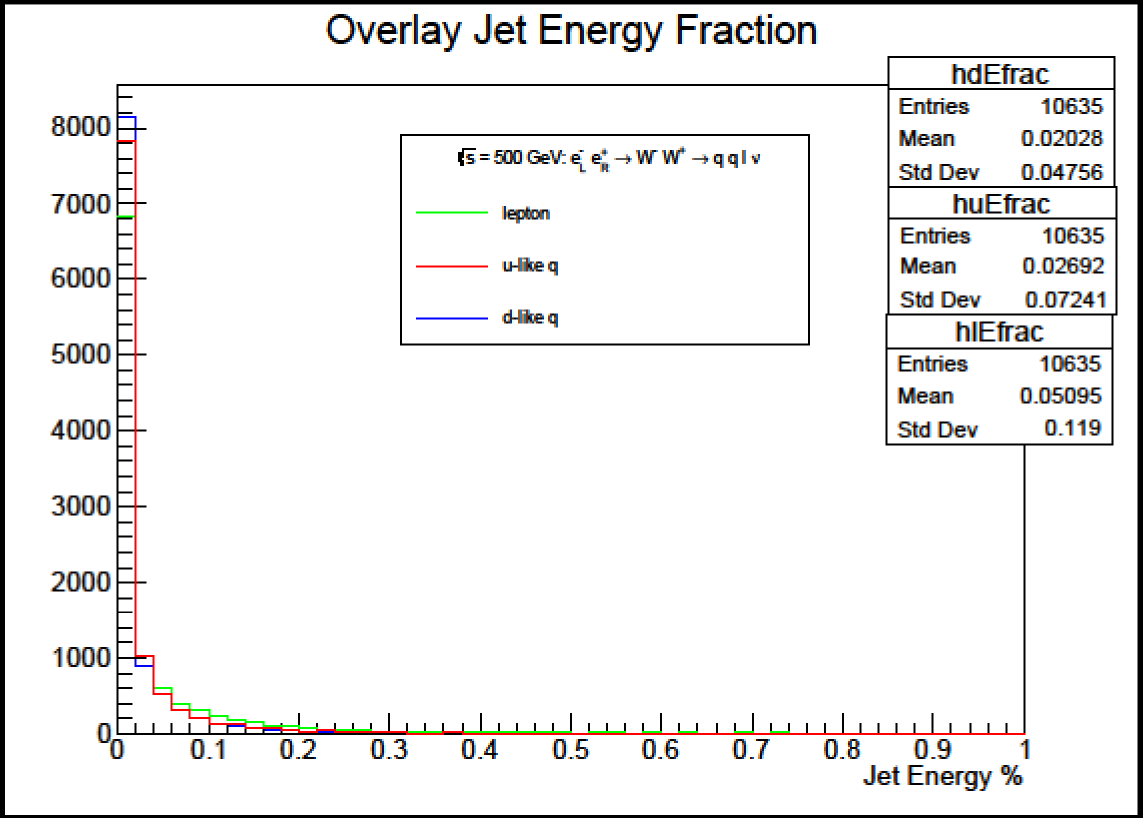


- Cuts are placed on 2.5 to try and not reject overlay effects but still obtain reasonable matching
- Tighter Cuts 2.8 and above imply perfect matching and well measured jets

Overlay

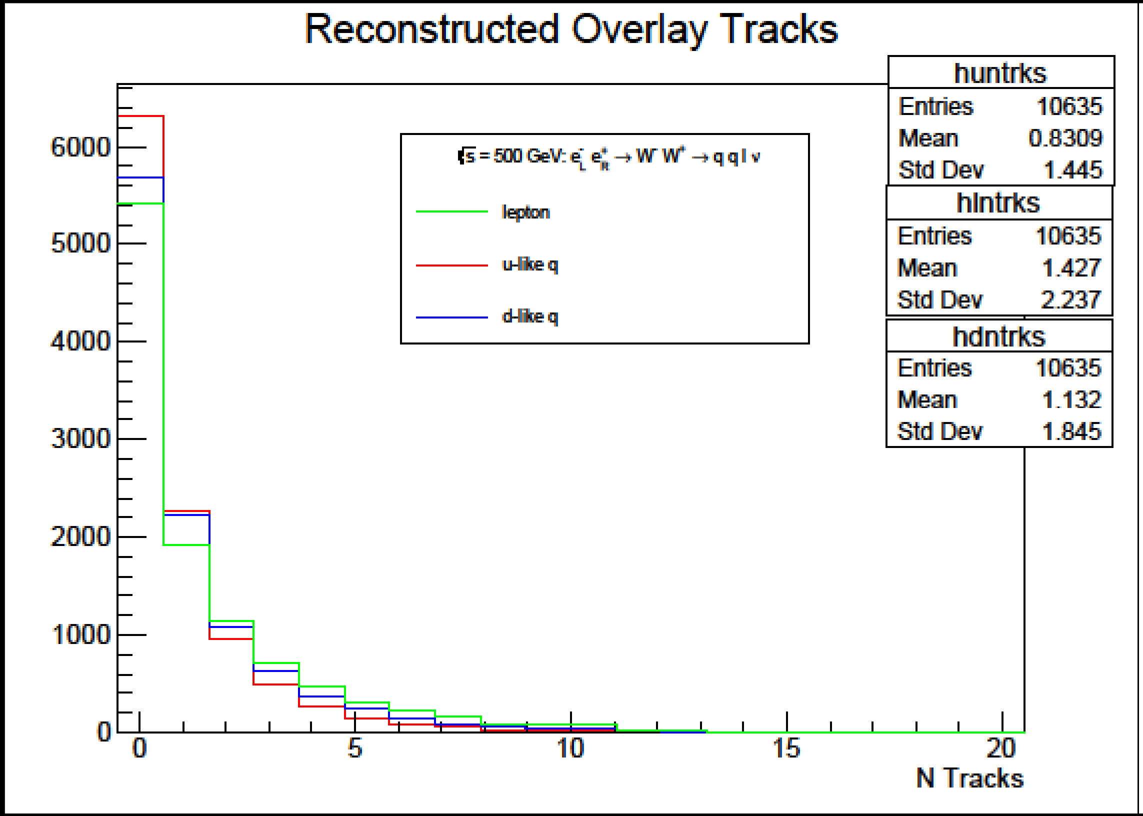
- Overall Mean Energy contribution is 3% from overlay
- Energy Contributions Per Jet similar between the 3 visible fermions
- Contribution to the lepton jet (muon/tau inclusive) is the highest
- Overlay Removal done in a preprocessor with LCRelation collection
- If a single MCParticle is overlay and contributes 50% of track hits OR cluster energy to a Reconstructed PFO it is classified as overlay

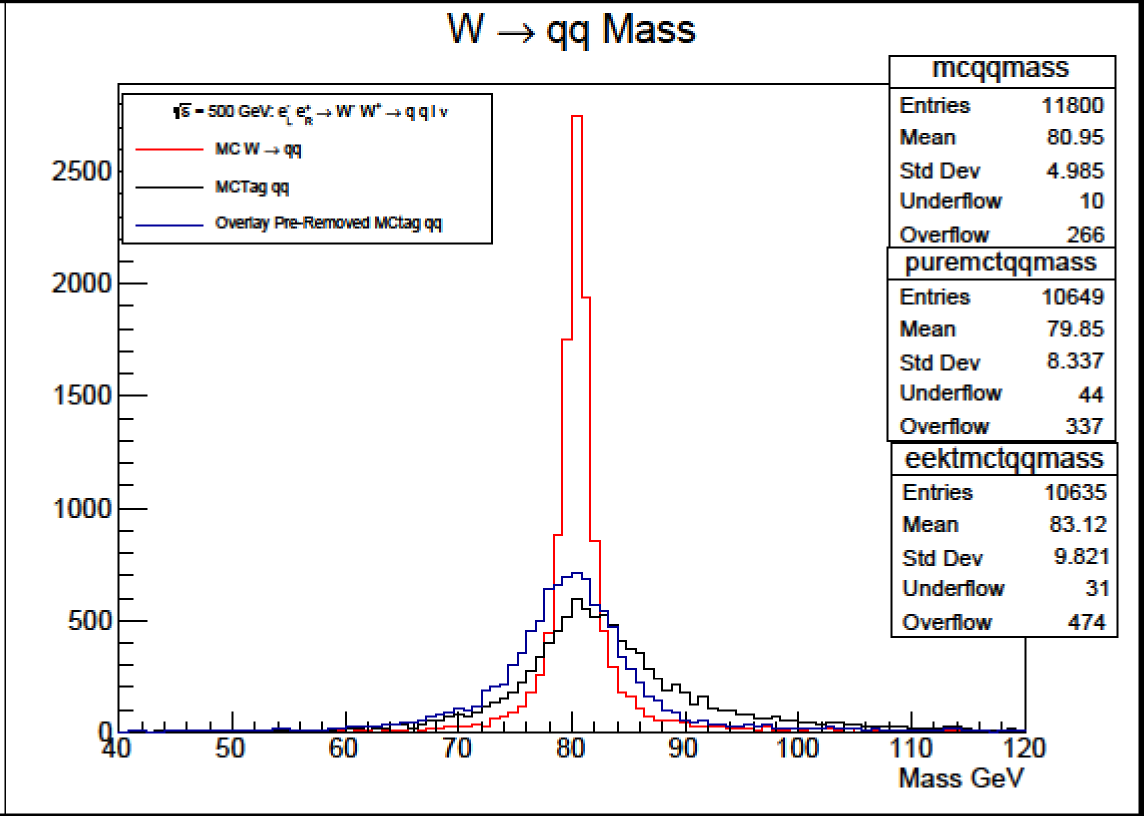




Overlay

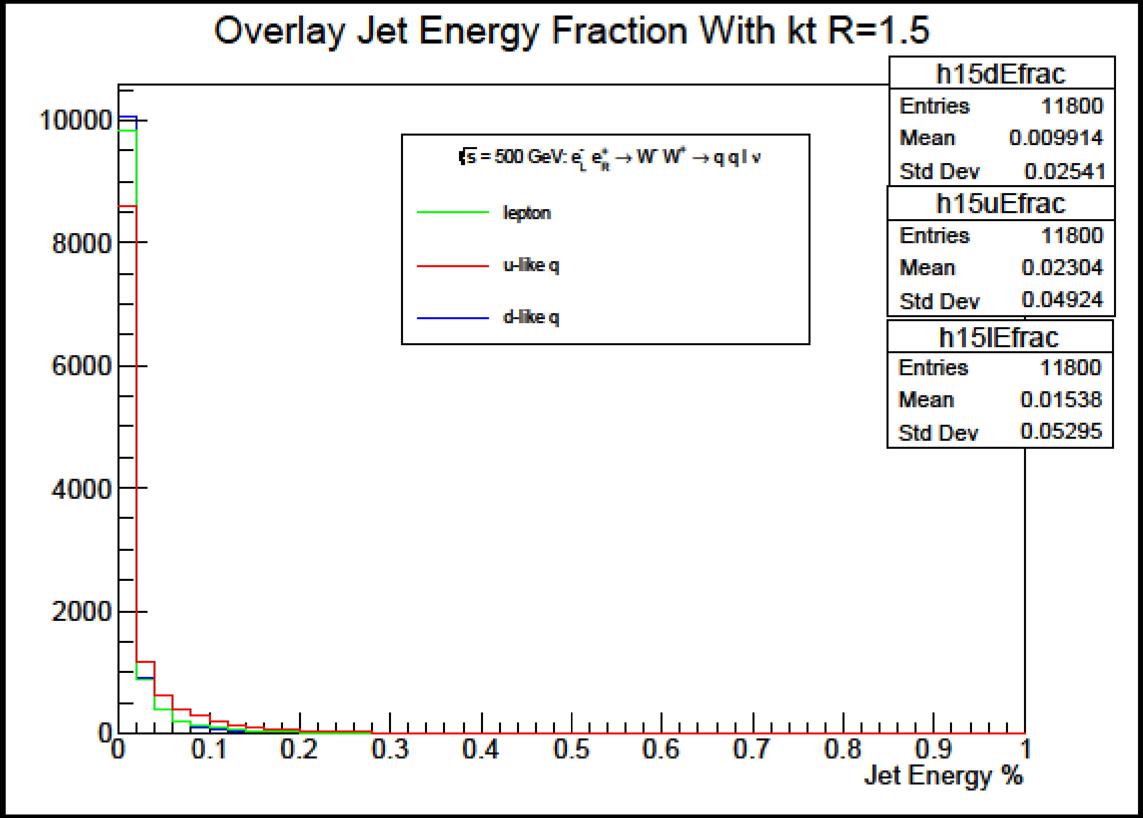
- Overlay Tracks contaminate all jets regardless of flavor
  - This will make lepton charge identification more difficult
- Hadronic mass is overestimated from additional particles
- MC tagging is less efficient in the presence of overlay, jets get skewed from true direction

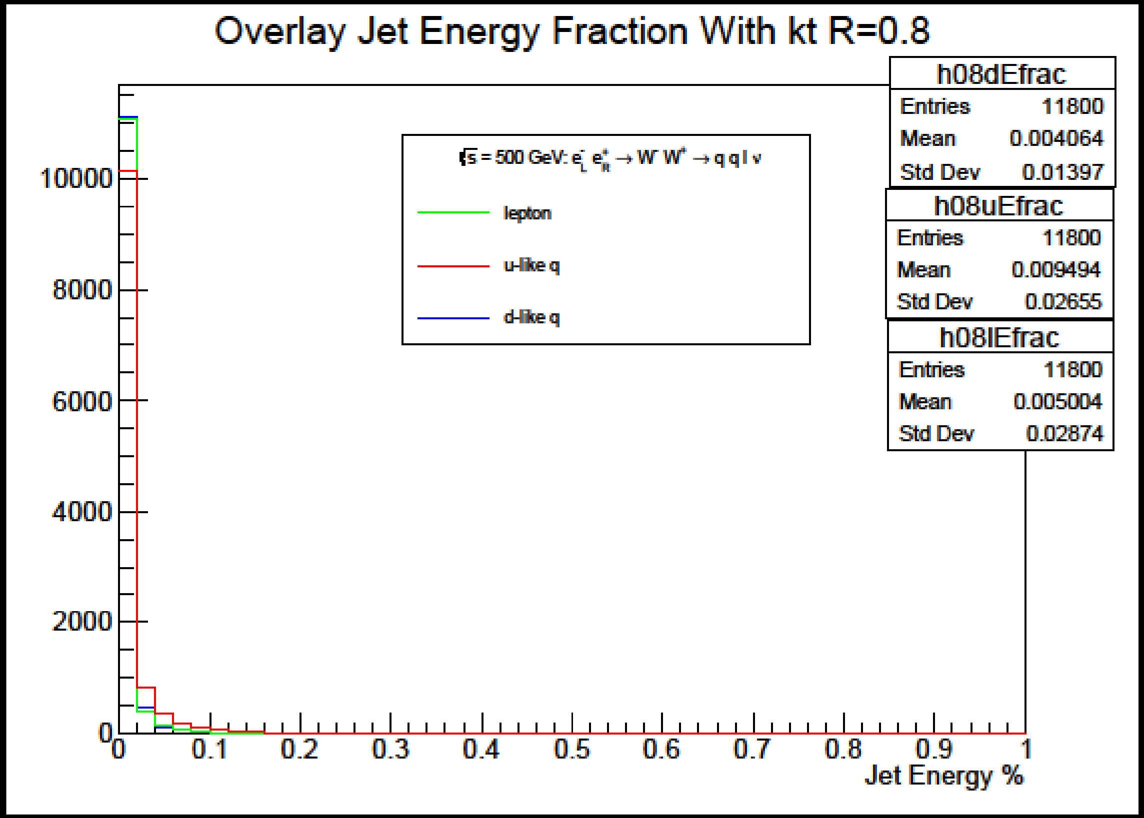




Removal techniques

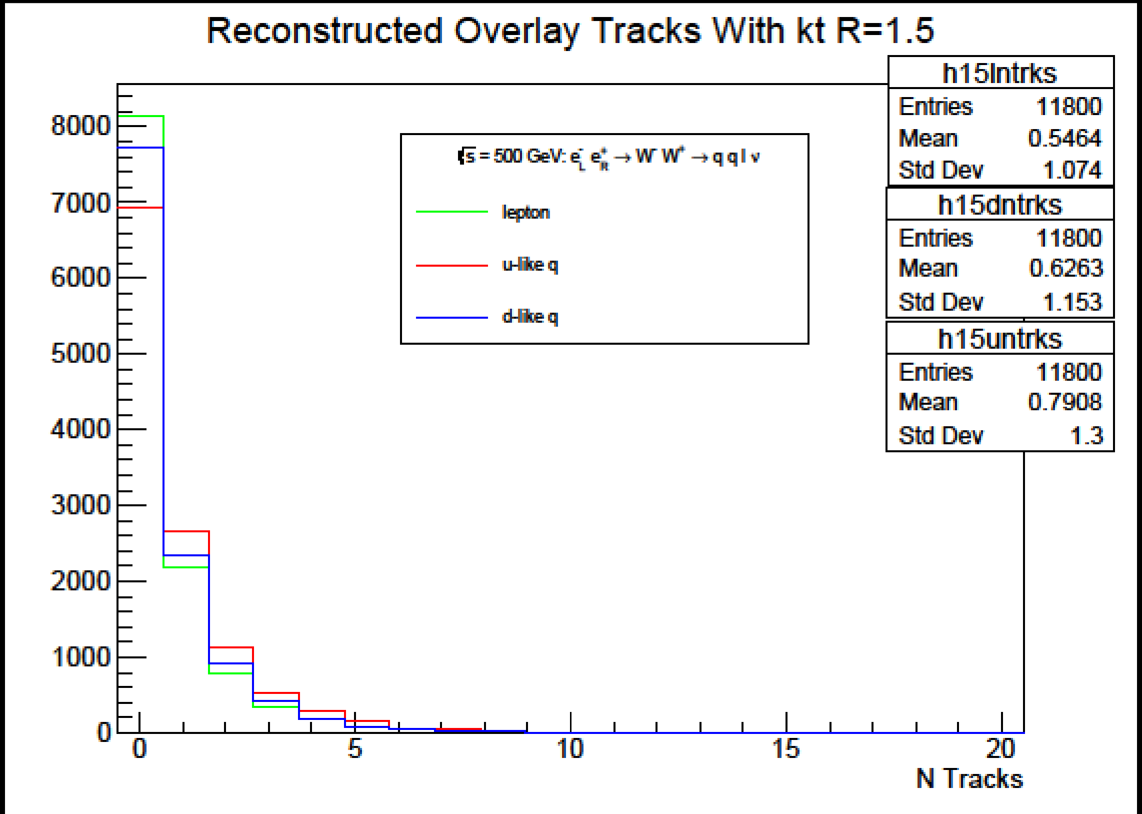
- Preprocessor: ReconstructedOverlayRemoval
    - Pure PFOset -> eekt N=3 jets
- Durham method
    - Pandora PFOs -> kt R=1.5, 0.8 N=3 jets -> Recluster with eekt N=3jets

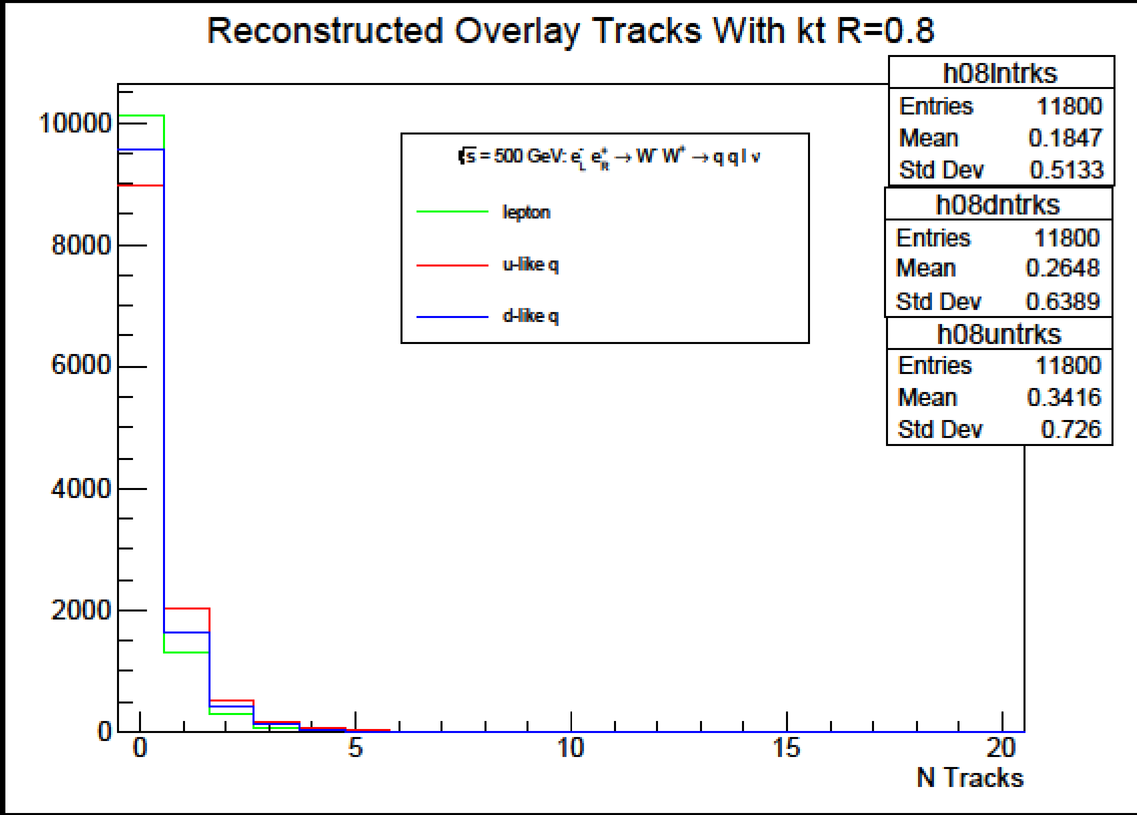




- R parameter still unoptimized, only tested wide and narrow cones
- Fraction of overlay energy is reduced significantly with smaller cone >1%

Removal techniques

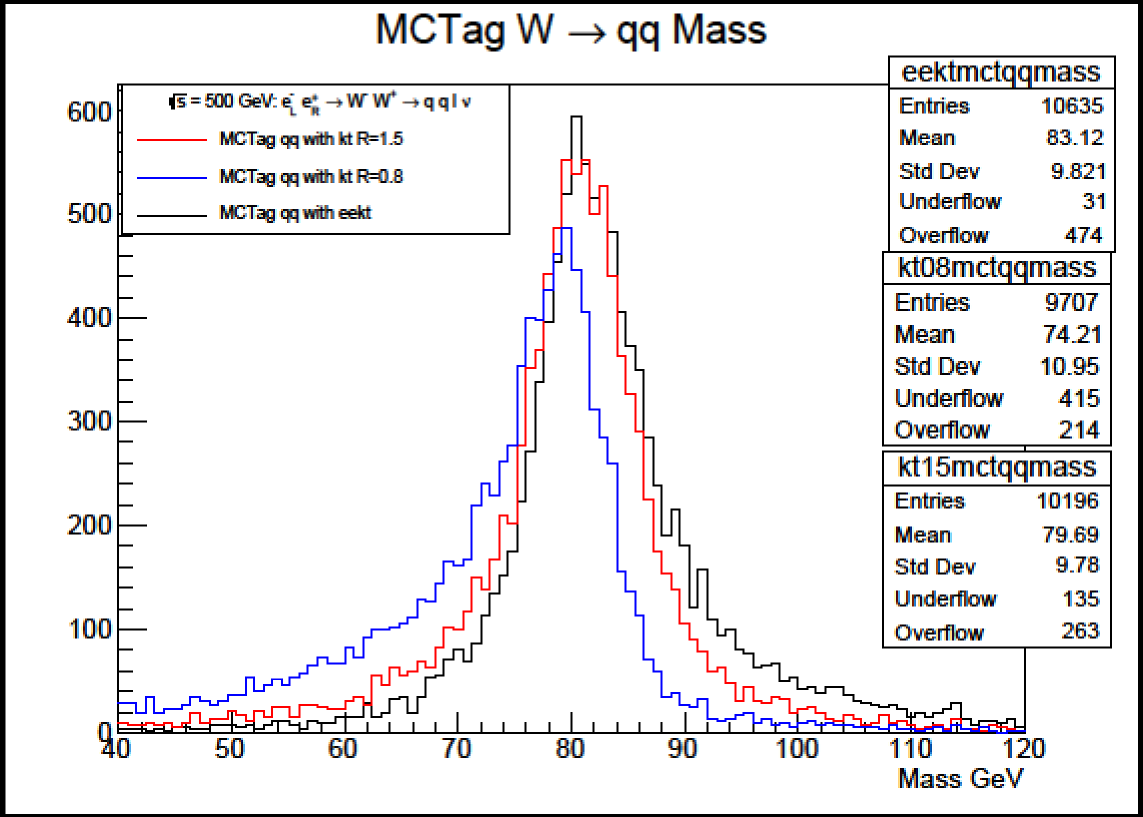




- R=1.5 reduces some tracks but not enough to ideally preserve signal events from the track cut
- R=0.8 removes most overlay tracks
  - With only 1 additional track lepton charge can be determined from leading momentum track
  - $\tau \rightarrow$3tracks will get rejected

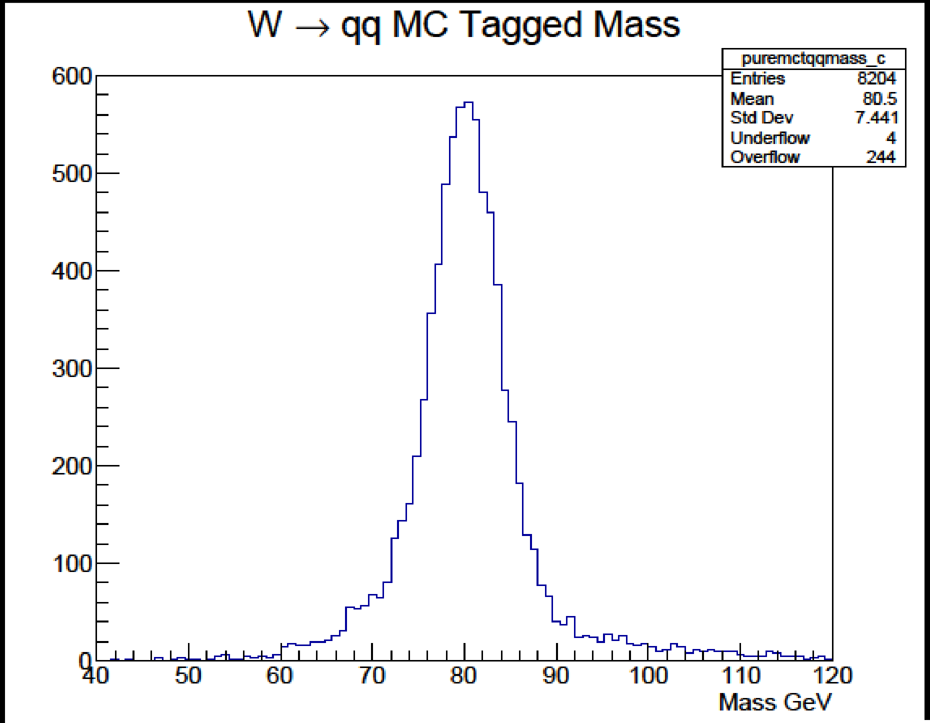
Removal Techniques

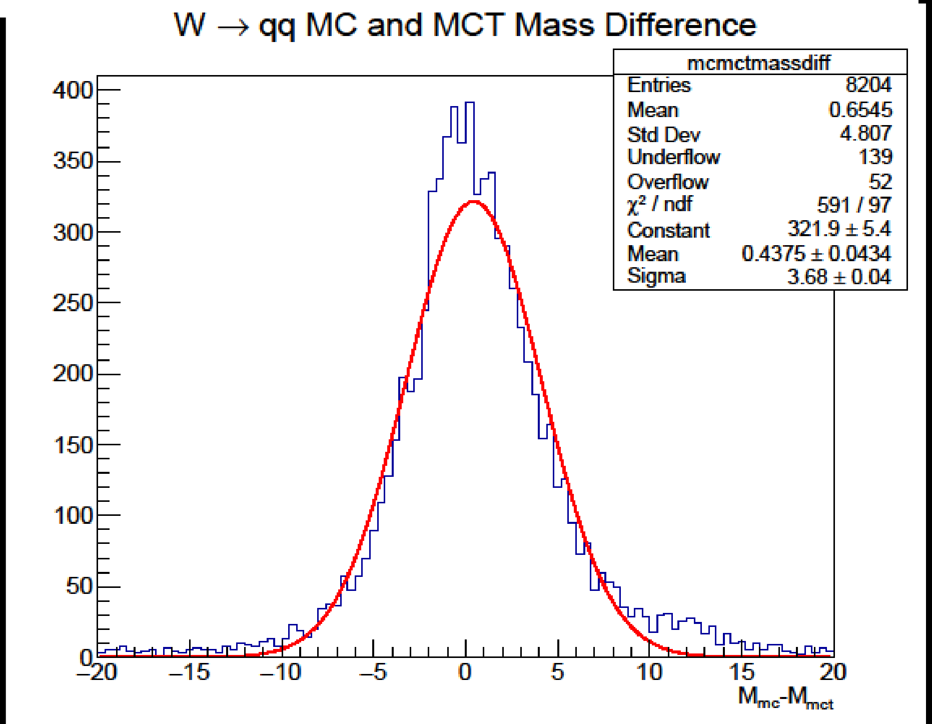
- Hadronic mass with MCTagged jets with $\sum \cos\psi > 2.5$
- Mass is overestimated with no overlay removal
- R=1.5 is similar to no overlay removal, starting to shift W peak to lower masses
- R=0.8 too many non overlay particles are removed creating a large shoulder on the LHS
- Tagging efficiency is different for each case, the more non overlay particles that are removed the worse the MCTag becomes



Idealized Results

- Using Overlay removal preprocessor, pure set of pfos are clusted with eekt N=3 jets
- Results from all cuts including track multiplicity cut and tighter MC jet tagging cut of 2.8
- Fitted Gaussian distribution between masses for MCTruth-MCTagged. Shows the optimal detector resolution on inclusive W mass of 3.7 GeV
- 500 MeV bias towards underestimating the hadronic W mass





Efficiencies

	Inclusive	μ	τ	$\tau \rightarrow \mu\nu\nu$	$\tau \rightarrow e\nu\nu$	τ →other
Total events	11800	5893	5907	1008	1086	3813
|cosTheta| < 0.995	10532	5255	5277	923	979	3375
nTracks > 10	9953	4963	4990	857	921	3212
Pt > 7.0 GeV	9702	4864	4856	835	897	3124
E < 500 GeV	9648	4801	4847	835	895	3117
80< M < 500 GeV	9639	4797	4842	834	893	3115
Log y-	9634	4793	4841	834	893	3114
Log y+	9634	4793	4841	834	893	3114
0 < minTracks < 4	9001	4220	4392	760	829	2803
Efficiency	0.854 ± 0.003	0.877 ± 0.005	0.832 ± 0.005	0.823 ± 0.013	0.847 ± 0.011	0.831 ± 0.006
MCTag $\sum \cos\psi > 2.8$	8204	4220	3984	690	748	2546
Cheated Efficiency	0.779 ± 0.004	0.803 ± 0.005	0.755 ± 0.006	0.748 ± 0.014	0.764 ± 0.014	0.754 ± 0.007

Summary

- Showed the overlay contributions on WW->qqlnu with pure LR polarization
- Demonstrated the ideal results for hadronic mass measurements with muon/tau inclusively
- TODO: experiment with Tau finding methods
    - e.g. find and remove tau and perform jet clustering on diquark system
    - Optimize overlay removal procedures (kt R parameter) or potentially use other methods

Code is on github : https://github.com/ILDAnaSoft/ILDbench_WWqqlnu

Event Selection

Begin Reproducing known results for event selection

I. Marchesini DESY-THESIS 2011

Using 3 different background samples for now:

ee-> qq

rv02-00-01.sv02-00-01.mILD_l5_o1_v02.E500-TDR_ws.I250114.P2f_z_h.eL.pR.n001.d_dstm_10410_0.slcio

(first 3 files)

WW->qqqq

rv02-00-01.sv02-00-01.mILD_l5_o1_v02.E500-TDR_ws.I250006.P4f_ww_h.eL.pR.n001.d_dstm_10398_0.slcio

ZZ->qqll

rv02-00-01.sv02-00-01.mILD_l5_o1_v02.E500-TDR_ws.I250014.P4f_zz_sl.eL.pR.n001.d_dstm_10301_0.slcio

Event Selection

All backgrounds and signal normalized to 1 fb

Use basic variables to proceed, with event selection-
Total number of tracks
Total Pt
Total visible E
Total Mass
Jet variables log(y-) log(y+)

Decay	σ	weight
qq	32470.5	1.061
qqqq	7680.69	1.067
qqll	608.57	0.054
qqlnu (signal)	9251.41	0.784