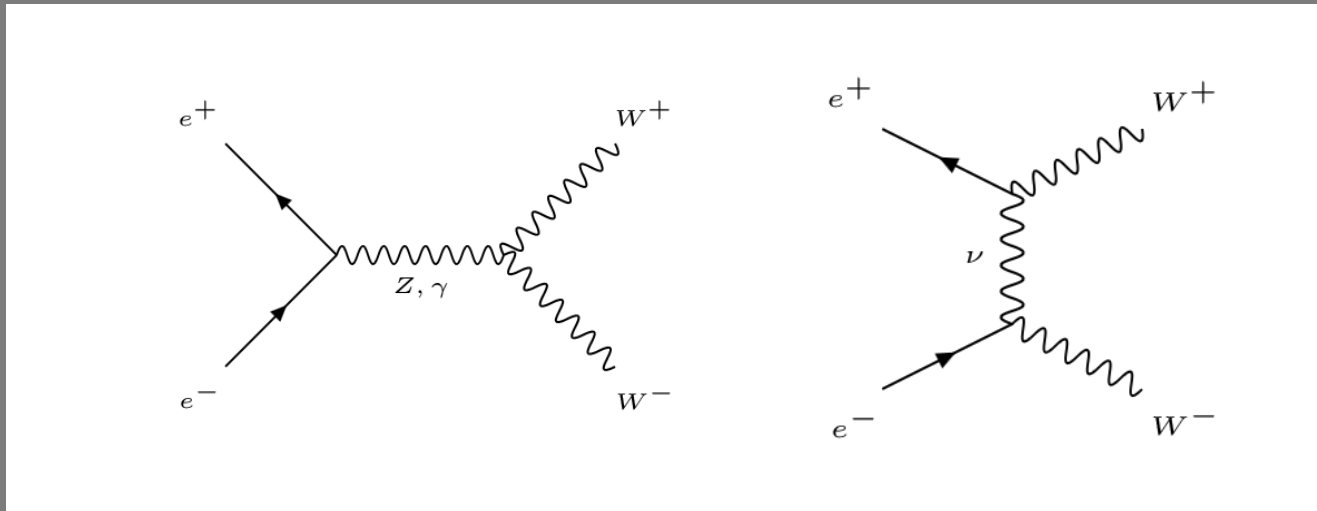


WW Analysis using semileptonic decay channel

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Introduction



- $WW \rightarrow qq l\nu$ 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_I5_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

Perform Benchmark study by obtaining physics observables:

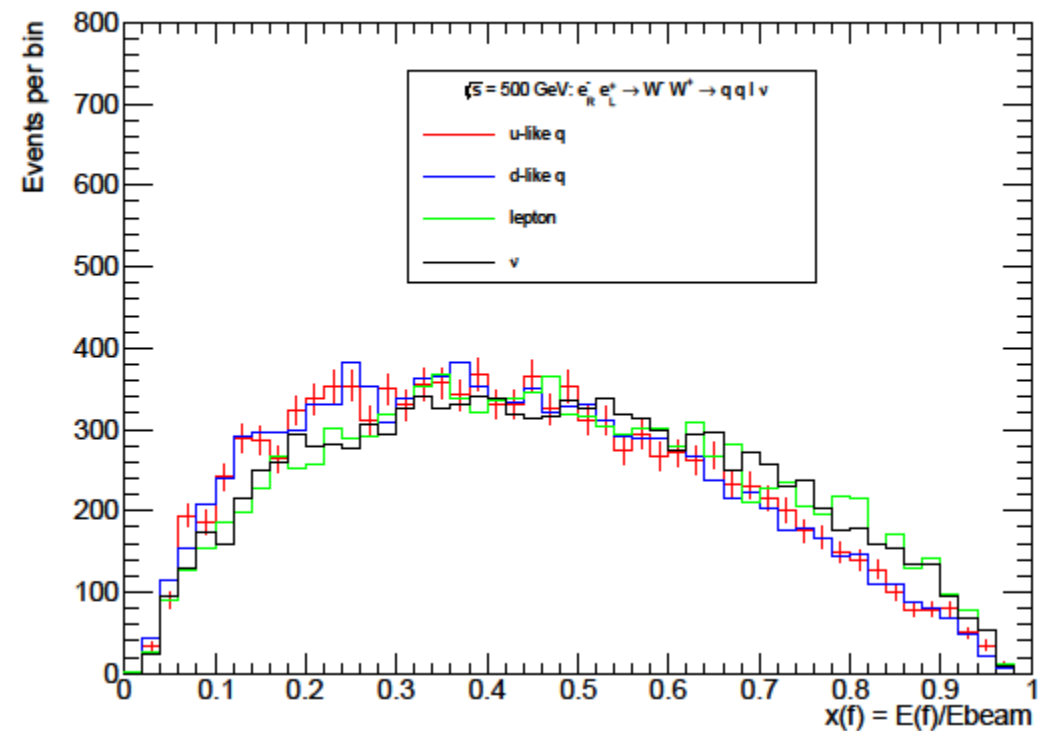
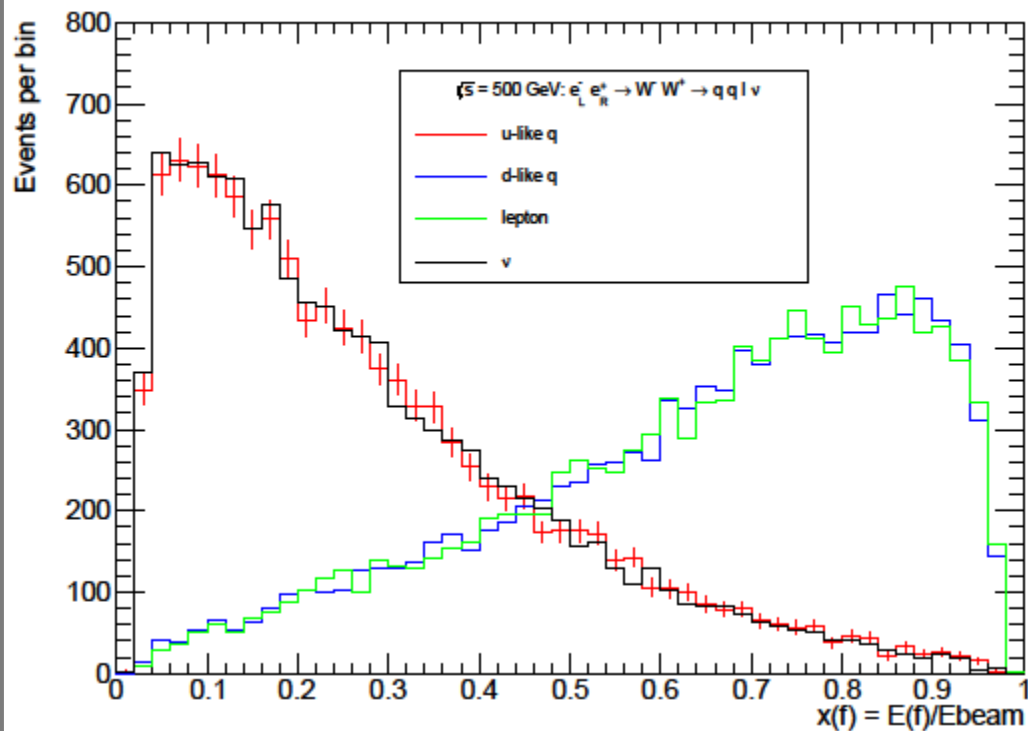
- Dynamics associated with TGC from W^- production angle
- m_W measured from qq jets
- Measurement of the beam polarization through WW cross section

Current Strategy

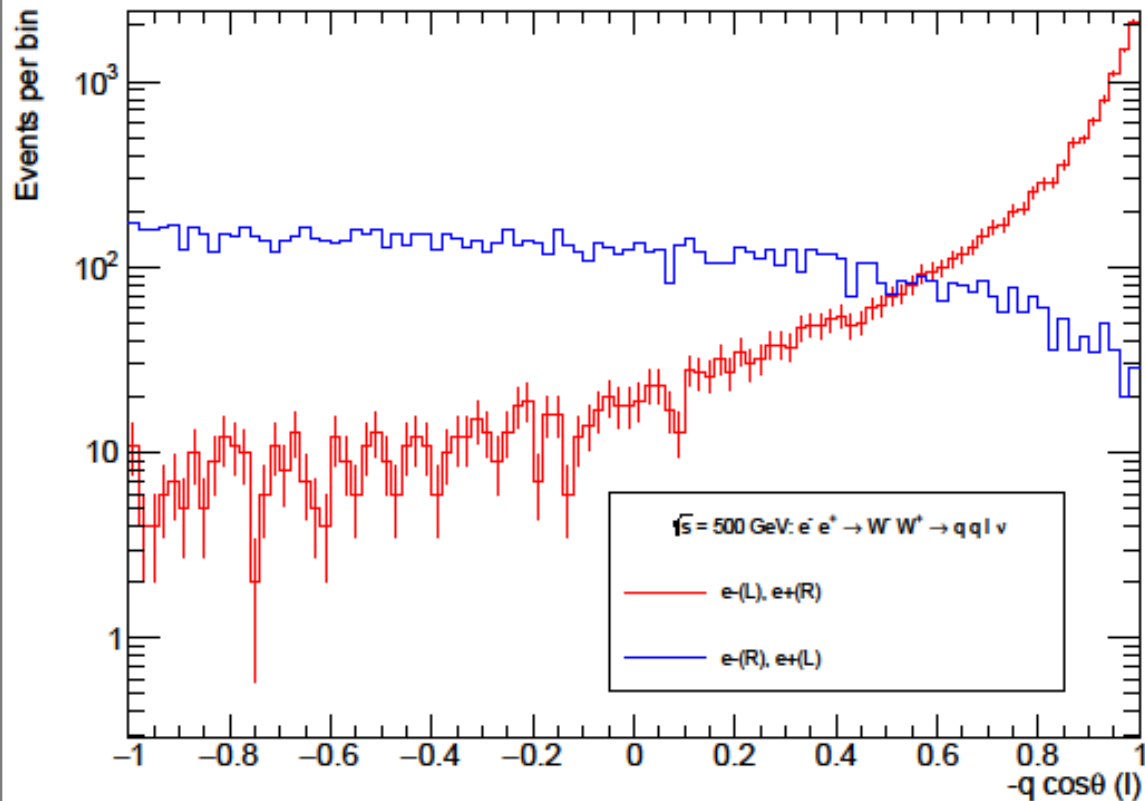
- Preliminary Analysis:
 - Examine decay characteristics on the generator level
 - (new) Do a simple event selection to determine basic efficiency with a few backgrounds
 - Run on FastJet – Require 3 jets
 - Separate events on the generator level by lepton flavor (μ, τ)
 - Identify the lepton jet/ determine the charge
 - Compare with truth information

Decay Characteristics

- First Look at the rescaled energies of the 4 fermions
- Energy Partitioning is completely different for mirrored polarizations

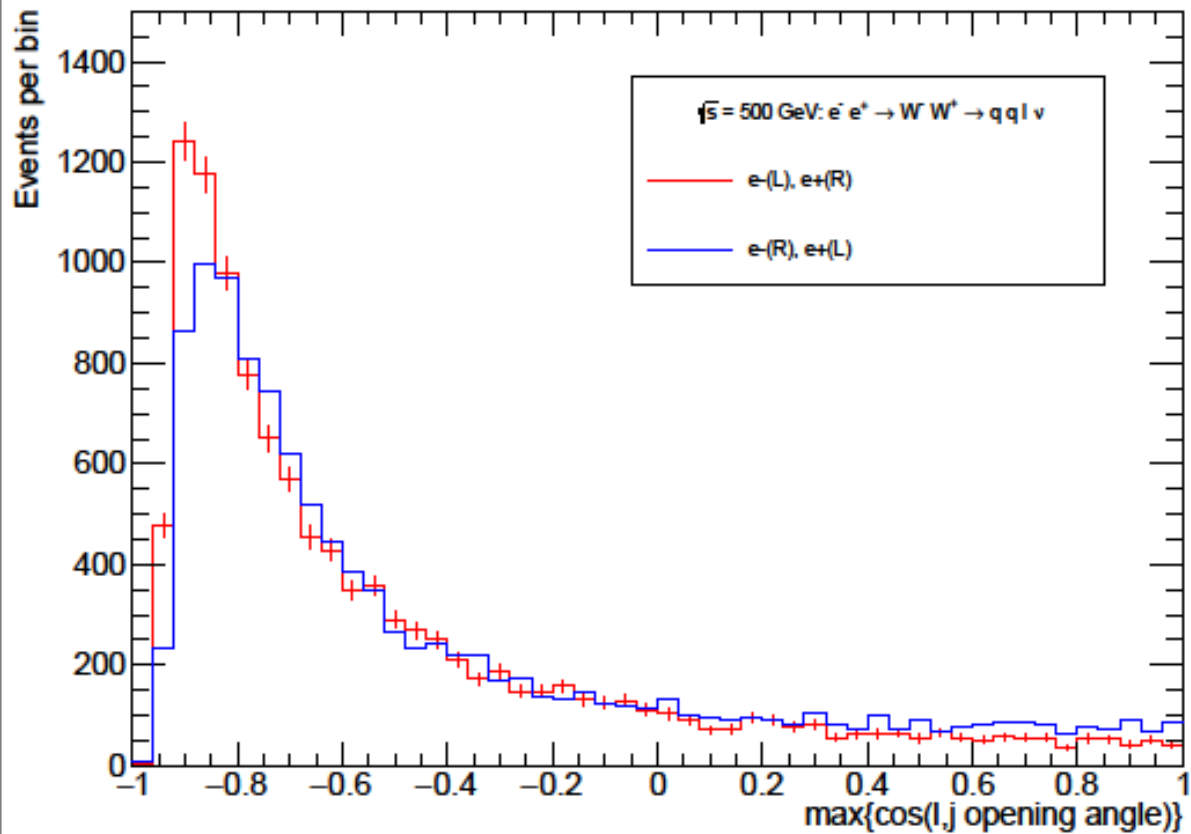


Decay Characteristics



- $(e_L^-, e_R^+) (e_R^-, e_L^+)$
 - $\cos \theta$ of the lepton
- Polarizations are very different
- LR are mostly forward
- RL is nearly flat

Decay Characteristics

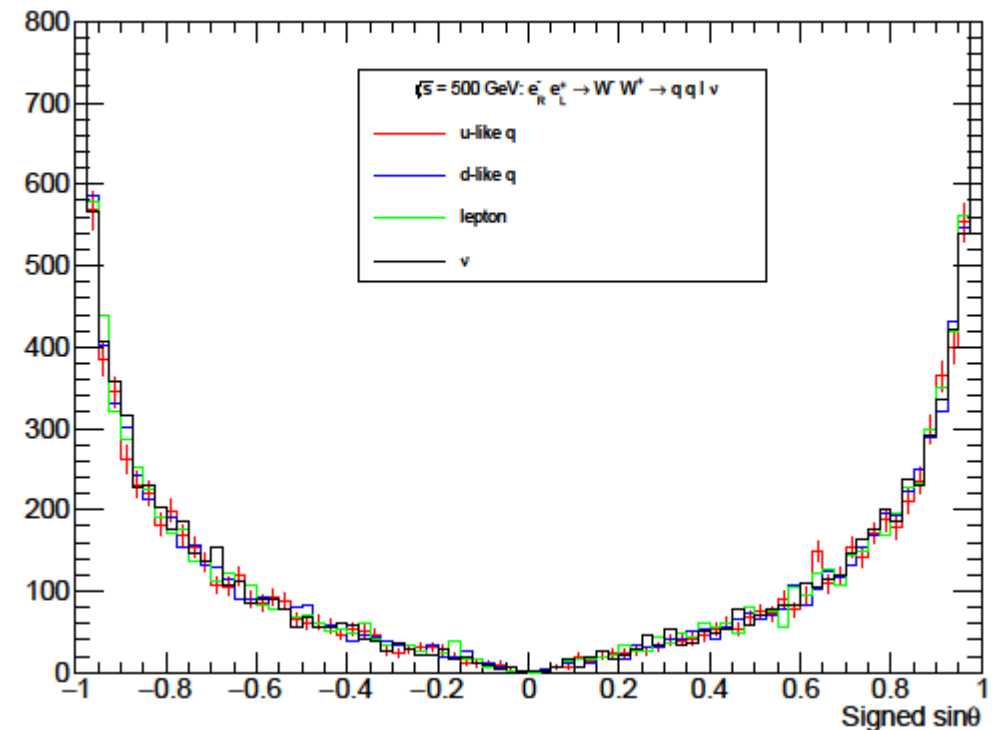
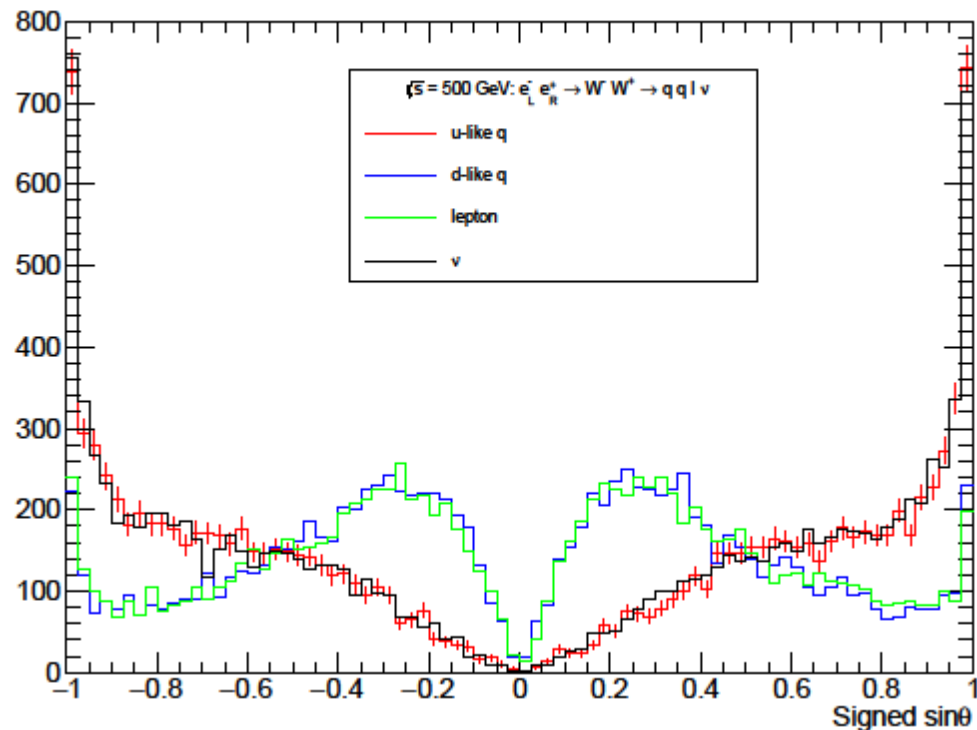


Opening angle of the lepton and the nearest quark

- Tends to have a distinct separation between the lepton and quark jets
- Similar for both polarizations

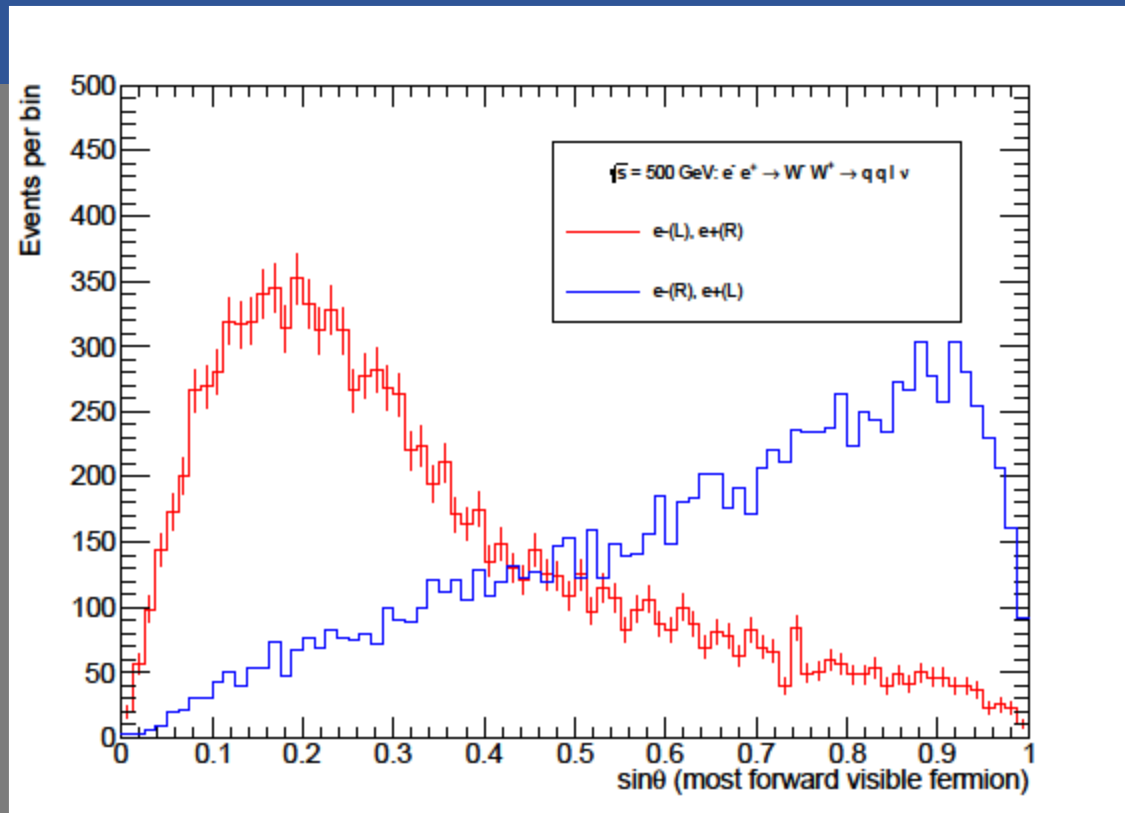
Decay Characteristics

- 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



Decay Characteristics

- Sin of the polar angle the most forward fermion
- LR polarization tends to have at least one particle on the edge of acceptance



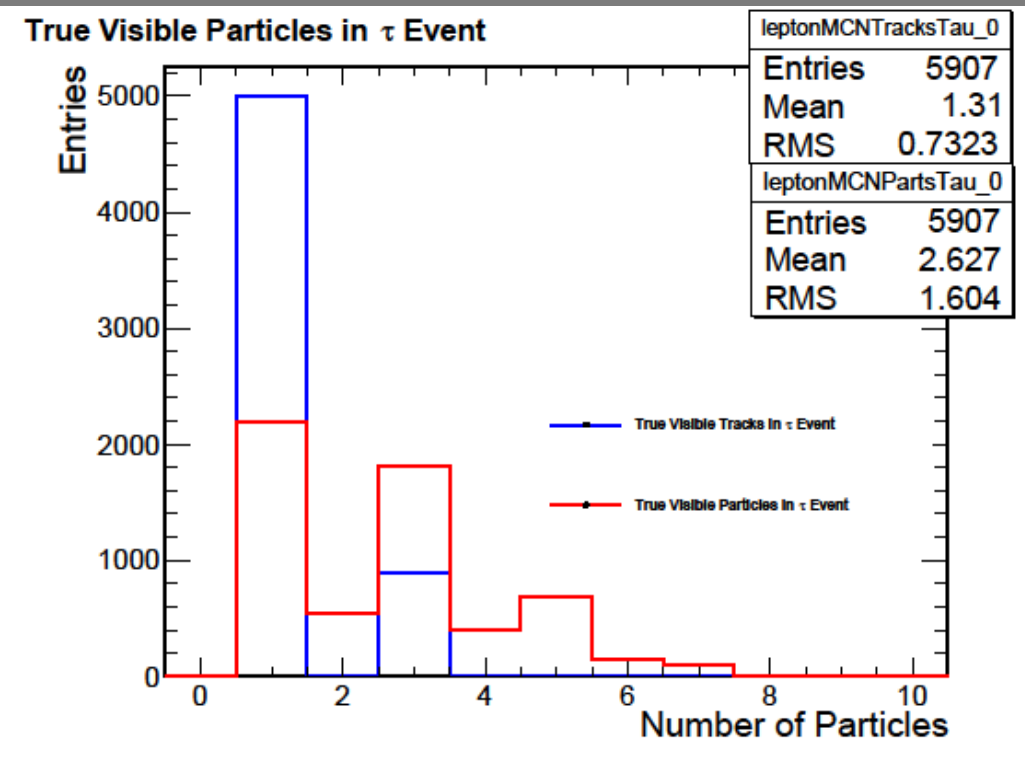
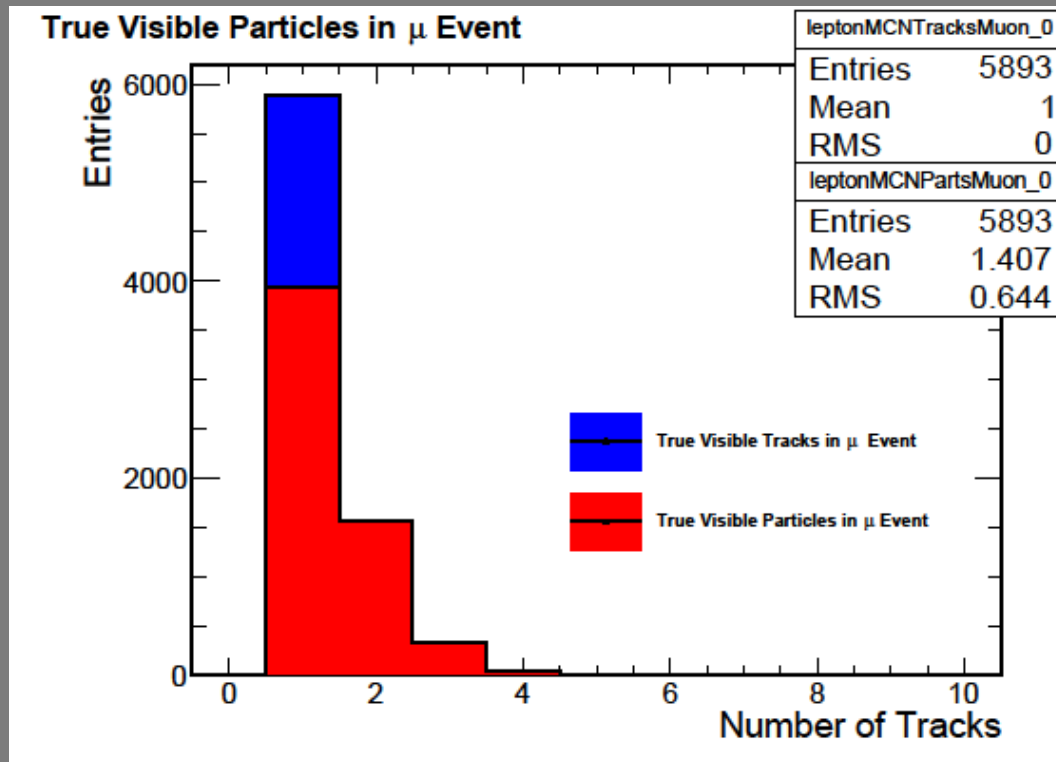
Decay Characteristics

Compare multiplicities of visible neutrals/tracks for the generator lepton

- This includes FSR(s)
- Excludes showering / detector / simulation effects (like photon conversions)

μ mostly remains a single track
Sometimes a photon is radiated

τ is dominated by hadronic decays
Mostly combinations of π^\pm, π^0



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_I5_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_I5_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_I5_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

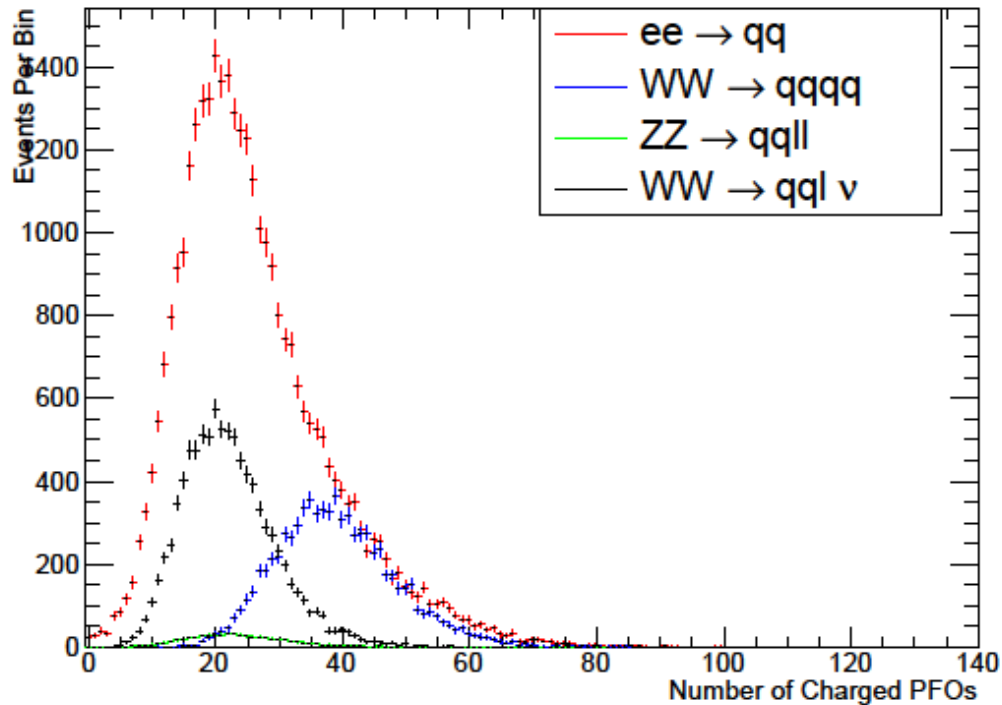
Total Mass

Jet variables $\log(y_-)$ $\log(y_+)$

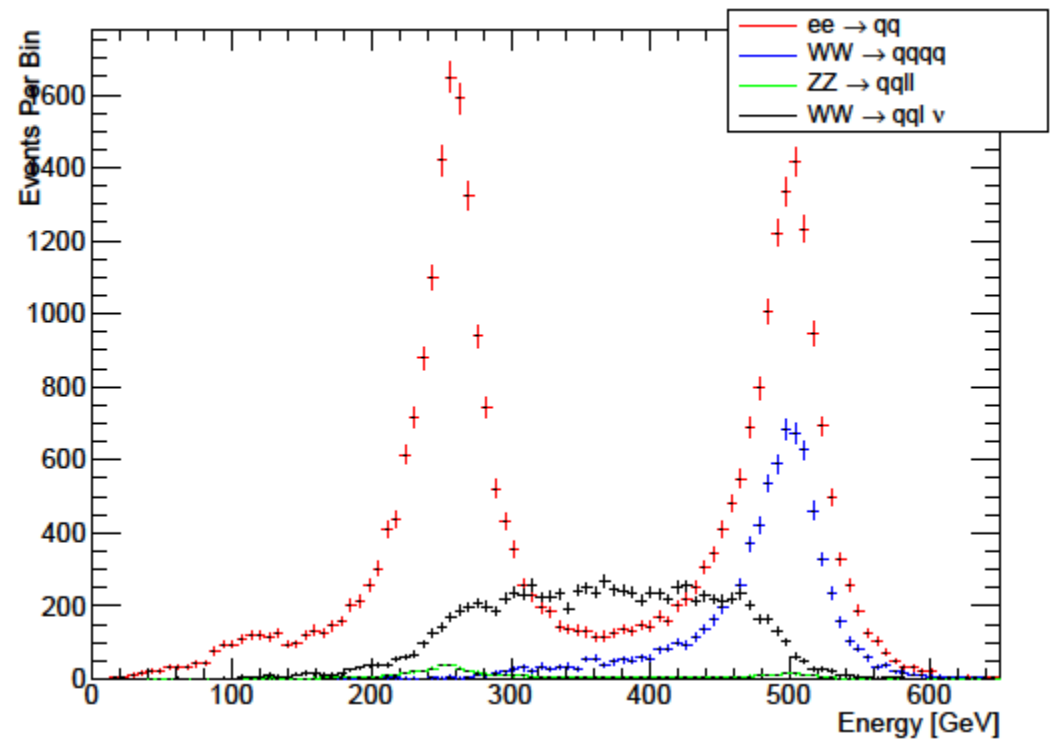
Decay	σ	weight
qq	32470.5	1.061
qqqq	7680.69	1.067
qqll	608.57	0.054
qqlnu (signal)	9251.41	0.784

Event Selection

cuts: number of tracks > 10 Energy < 500 GeV



10/9/2018

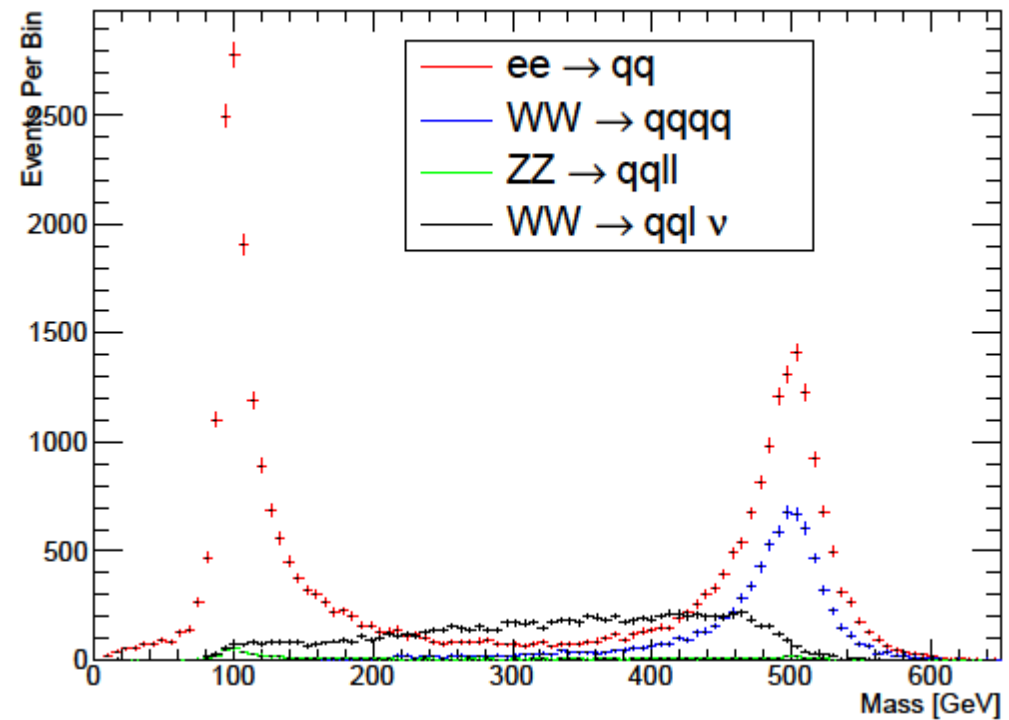
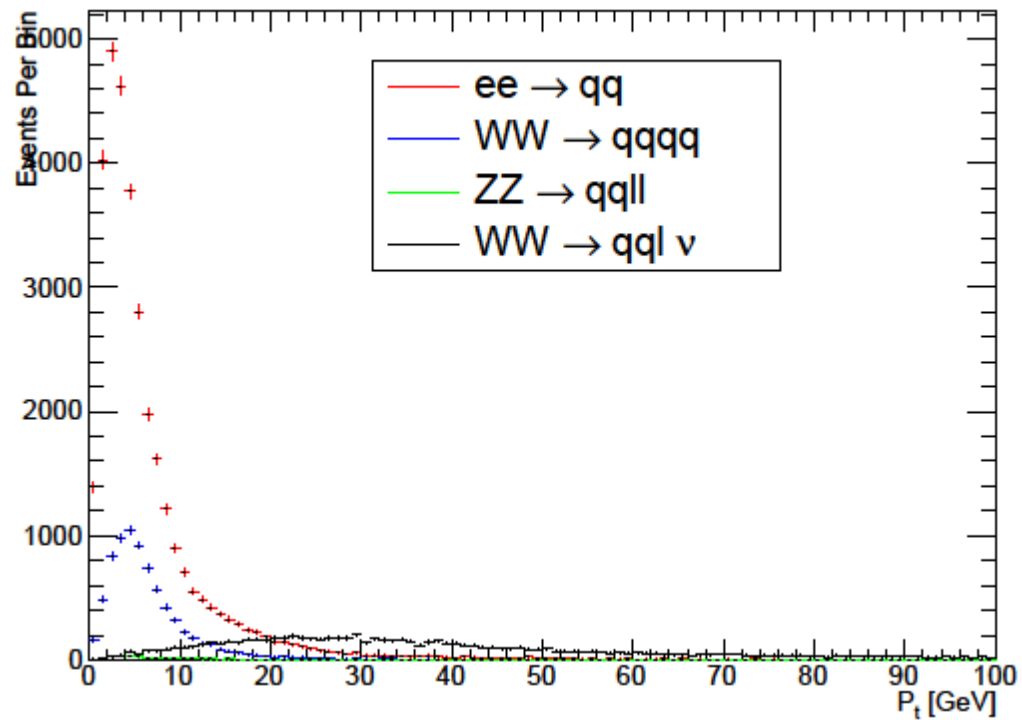


WW Analysis

12

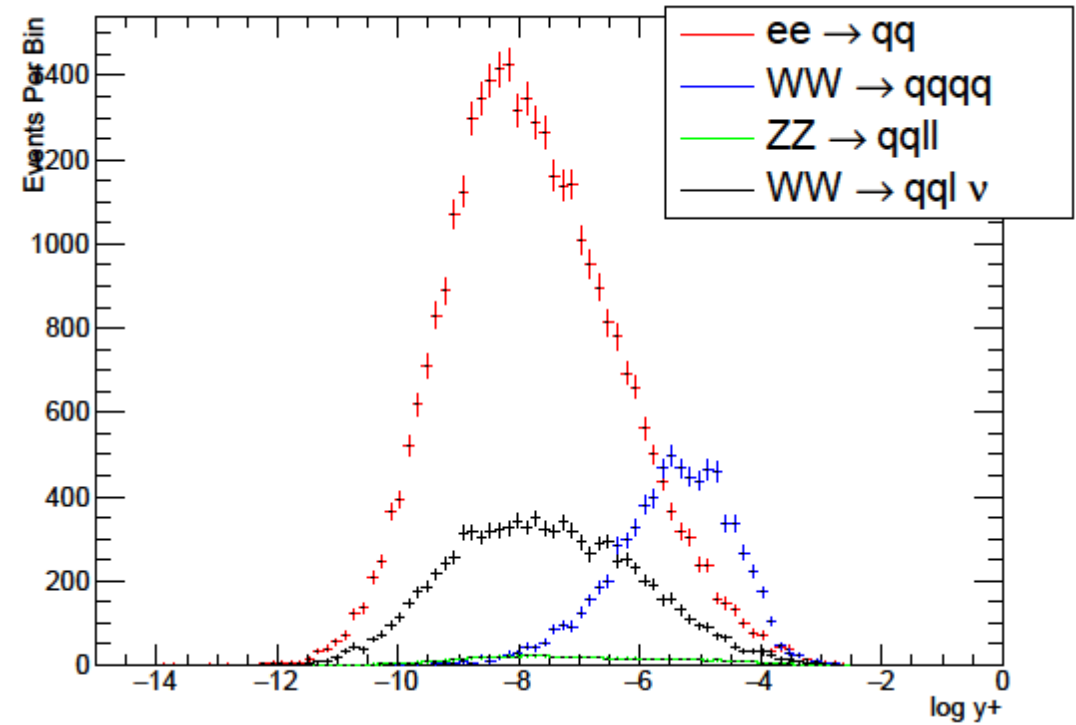
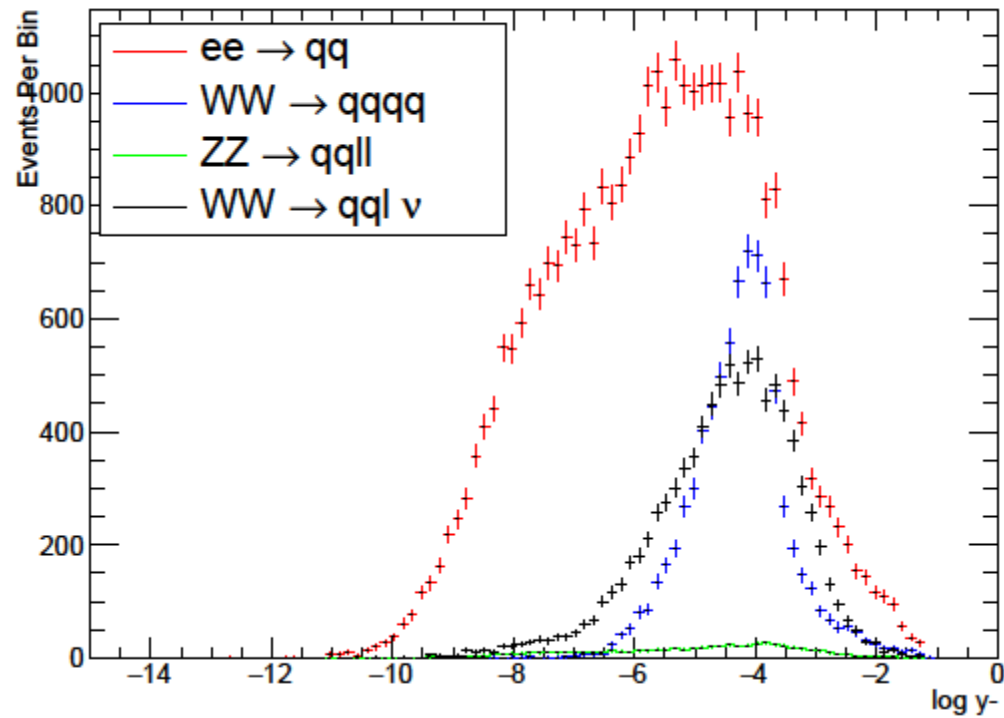
Event Selection

cuts: $p_t > 7 \text{ GeV}$, $80 < \text{Mass} < 500 \text{ GeV}$



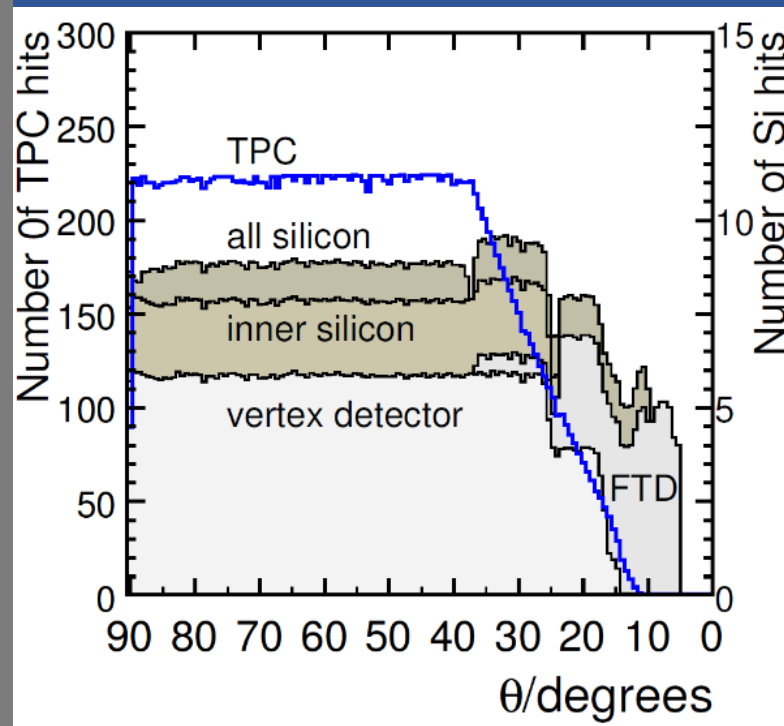
Event Selection

cuts: $\log y_- > -9.5$, $-12 < \log y_+ < -2.9$



Defining Acceptance Region

- A significant portion of the events are very forward
- We define a polar angle cut to eliminating events which have no hope of reconstructing a track



Make a safe cut for now for all 3 generator particles (lqq)

Require $|\cos \theta| < 0.995$

This corresponds to the region $\theta > 5.7^\circ$

This reduces the total reconstructable events to-

$\mu : 5893 \rightarrow 5255$ and $\tau : 5907 \rightarrow 5277$

Or total signal $11800 \rightarrow 11080$

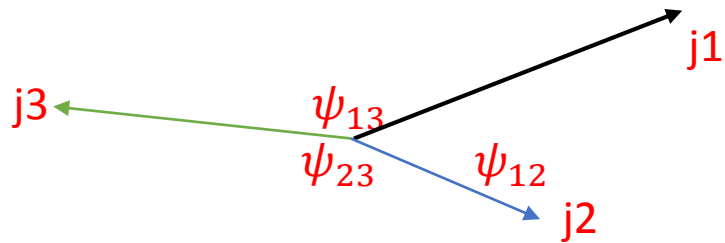
Event Selection

First look at efficiency with a sequential cut flow

	qq	qqll	qqqq	qqlnu
Total events	30600	11200	7200	11800
$ \cos\theta < 0.995$	27102	10176	6398	11080
nTracks > 10	26502	9892	6398	10832
Pt > 7	8098	7672	2178	10530
E < 500	5883	7430	1246	10274
80 < M < 500	5748	7262	1245	10263
Log y-	5700	7238	1245	10263
Log y+	5696	7237	1244	10262
%	18.61	64.6	17.28	86.97

Lepton Jet Identification

- Since we expect the lepton to be well separated from the quark jets
 - Use opening angle between the jets as selection criteria



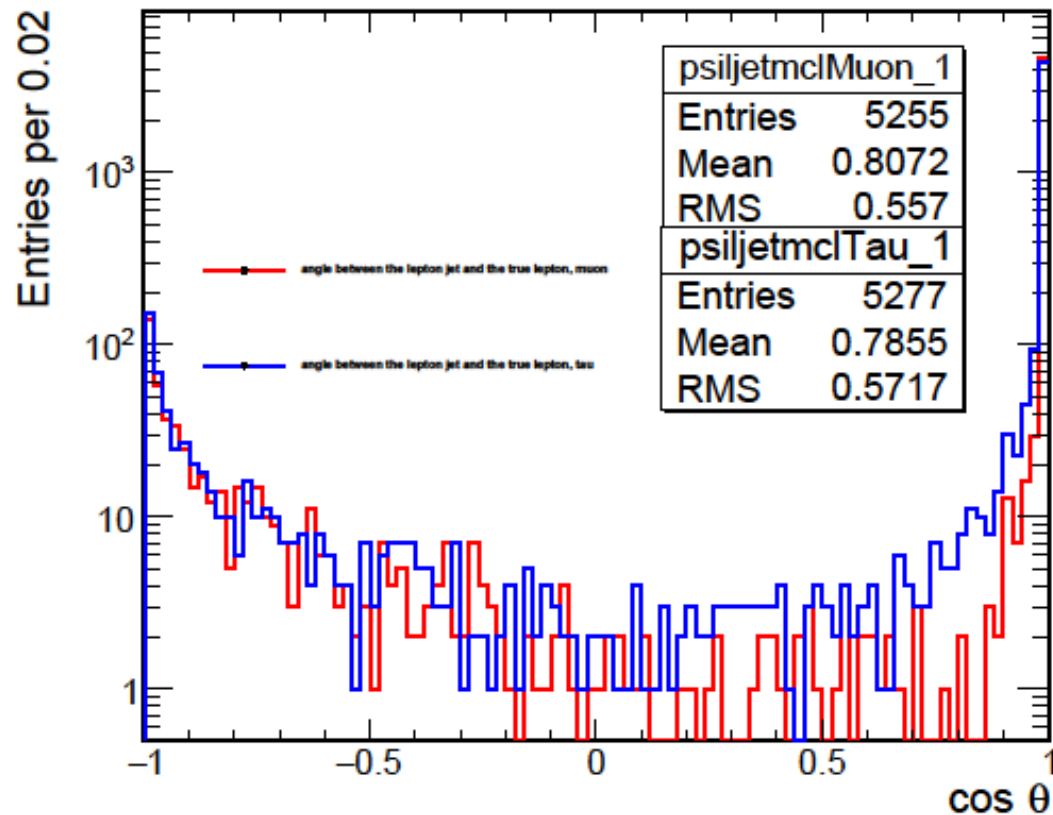
Lepton ID-

From 3 jets compute ψ_{ij}
Jet i and j that form $\min[\psi_{ij}]$ are
classified as the 2 quark jets

The jet excluded from the angle $\min[\psi_{ij}]$ is
classified as the lepton jet

Lepton Jet ID performance

Opening Angle between Lepton Jet and True Lepton



- Lepton identification method is reasonable

- Given loose match criteria

$\cos \theta > 0.7$ yield efficiencies:

μ : 4675/5255 ~89%

τ : 4606/5277 ~87%

Charge ID currently uses charge of the leading momentum track of the lepton jet

Works well for the muon

4680/5255 q correctly assessed 89%

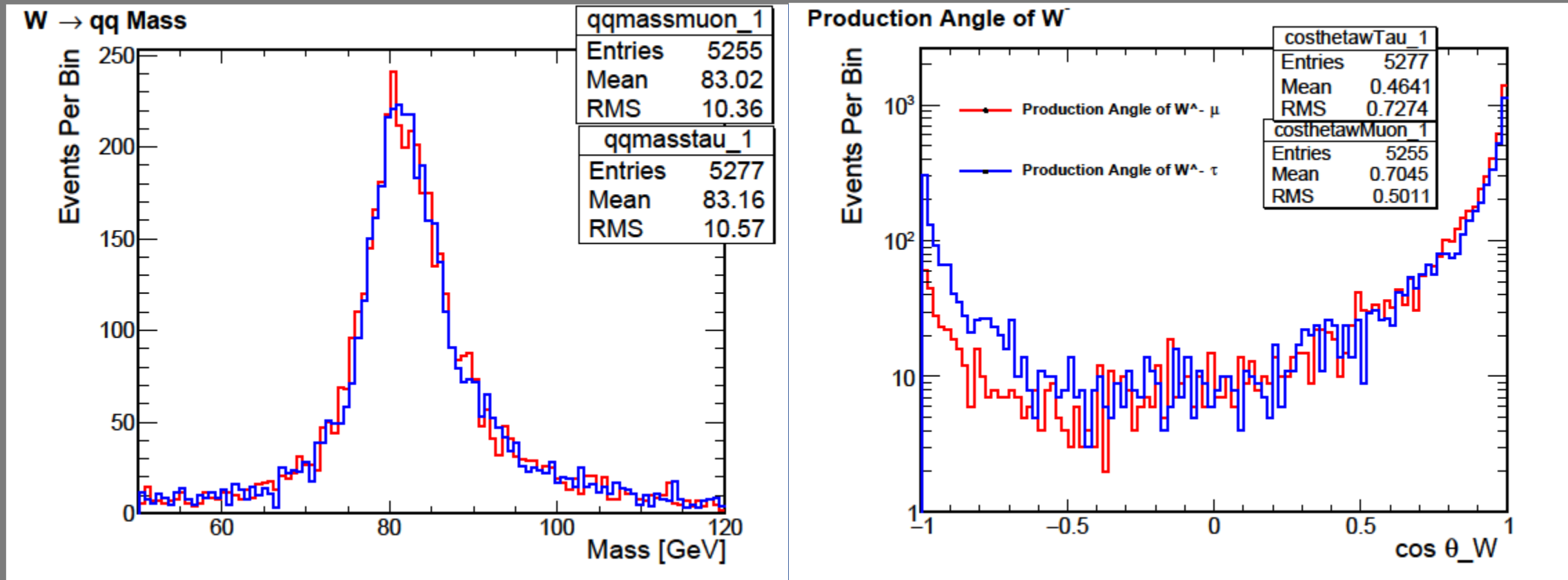
Not so well for the Tau

3427/5277 q correctly assessed 65%

Tau still needs improvement

Potentially try charge sum of all tracks

Preliminary Results



Summary

- Analyzed $WW \rightarrow qq\nu$ from the generator level for 2 polarizations LR RL
- Used Fast Jet to form a 3 jet event
- Assessed the acceptance and efficiency of lepton identification

- Code is on Github:
- https://github.com/ILDAnaSoft/ILDbench_WWqqInu

- TODO:
- muon/tau prompt/non-prompt separation
- Jet pruning to make jet mass consistent with lepton mass
- Possible charge/lepton id improvements
- Equal Mass Constrained fit for WW pair

