W Asymmetry Production at CDF Experiment

Valentina Vecchio
Supervised by Willis Sakumoto

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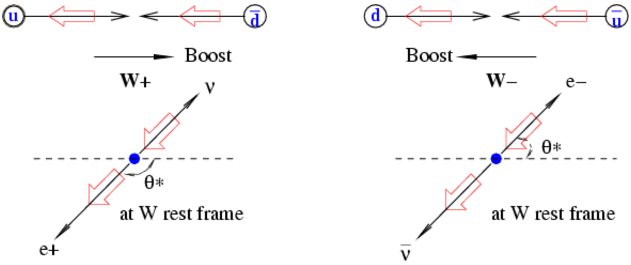
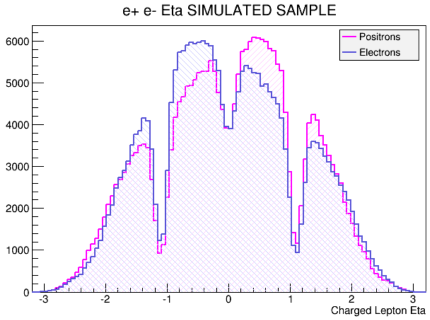
$W^{\pm}$ production and decay



- Up quarks carry more momentum than down quarks
  - W^+ will head in the p direction
  - W^- will head in the $\overline{p}$ direction

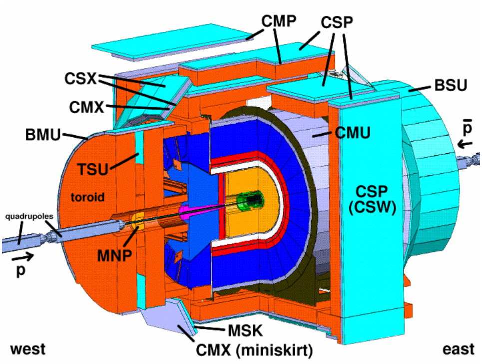
Differences between the u- and d-quark PDFs will result in different asymmetries in the W boson rapidity distribution.

W asymmetry



- Because of V-A decay angular distribution of charged lepton is $F(\theta^*)_{l\pm} = (1 \pm \cos\theta^*)^2$
- What we can measure is charged lepton η (pseudorapidity) $\eta = -\frac{1}{2} ln(\tan\frac{\theta}{2})$
- Asymmetry definition: $Asy^{obs}(\eta_e) = \frac{N_e^+ - N_e^-}{N_e^+ + N_e^-}$ →contains informations on $u(x)/d(x)$!

CDF Detector



General structure of detector is that of collider detectors

- Tracker in magnetic field: COT and SVX
- Electromagnetic Calorimeter
- Hadronic Calorimeter
- Muons detector

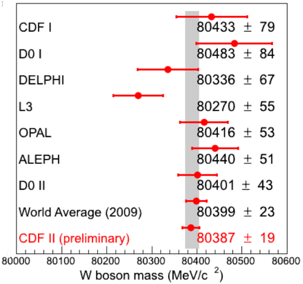
Electromagnetic calorimeter is in both central and plug region so it has high η coverage.

That's why we use $W \to e\nu$!

Why is an interesting measurement?

- Charged lepton asymmetry is a convolution of W asymmetry production and W's V-A decay.
- Without assumptions on neutrino's p_L (necessary in y_W measurement) uncertainty on PDFs is smaller.
- Improvement in PDF uncertainties will reduce total error on W mass!

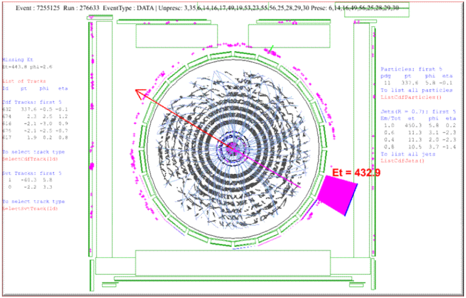
$$M_W = 80387 \pm 19 MeV/c^2$$
$$Phys.Rev.Lett.108, 151803(2012)$$



W$\rightarrow e\nu$ (SIGNAL)

In general the process we study is $W \rightarrow e\nu + X$

- Experimental signature of $W \rightarrow e\nu$ event is high electron/positron E_T associated at high $\not{E}_T$ (Missing Transverse Energy) $\rightarrow$ LO;
- At NLO one of incoming parton can emit gluons and generate jets;
- Electromagnetic shower in electromagnetic calorimeter has to match at the best with p_T track revealed by COT central tracker;
- In x-y charged lepton and $\not{E}_T$ tend to be back to back(LO).
- Very hard to recostruct because of neutrino!



W$\rightarrow e\nu$ (BACKGROUND)

Many processes can simulate a $W \rightarrow e\nu$ decay.

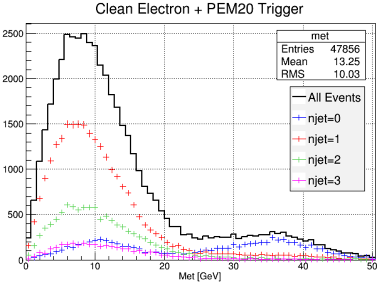
- QCD: fake electron in hadron jets comes from e^+e^- pairs, heavy quark decay (bottom or charm) and hadron that fakes electron ($\pi^\pm$) .
  Hard to simulate $\Longrightarrow$ MOST DIFFICULT!
- $Z \rightarrow ee$ in which one of two electrons is miss reconstructed or goes in dead regions of detector OK
- $W \rightarrow \tau\nu$ (small) where $\tau \rightarrow e\nu_e\nu_\tau$ OK
- $Z \rightarrow \tau\tau$ (small) where one τ decays in hadrons and the other in leptons can fake a signal event with a jet OK

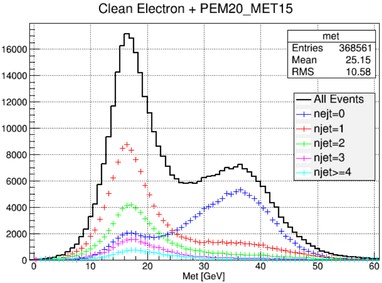
Selection of W candidates

- General selection criteria
  - Electron Et $>$ 25 GeV
  - Electron must have an associated charge particle track
  - MET $>$ 25 GeV (for the undetected neutrino)
  - Only one electron candidate in the event (removes Z's)
- Central detector region specific selections
  - Data from central single electron dataset with Et $>$18 GeV
  - Default high purity electron and track selections applied
  - Eiso4/Et $<$ 0.1: W decay electrons are typically isolated from event jet activity
- Forward plug region specific selections
  - Data is from two data sets
  - Single forward electron with Et $>$ 20 GeV (PEM20)
  - Single electron with MET $>$ 15 GeV ($MET15\_PEM20$)
  - The PEM20 online trigger rate is too large for all events to be written out only 1 in 25 are written
  - Eiso4 $<$ 4 GeV

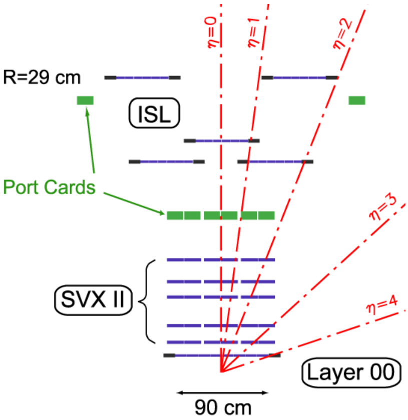
Summary of data sample with the default selections

- Central electron selections give a relatively background free W sample
- Plug electron selections have a problem: large backgrounds in the lower $\not\!\!E_T$ region
- We have found that plug tracks are mostly junk and additional track cleanup is required





Forward tracking of the plug region



- Electrons going into the forward plug region have limited acceptance in the COT central tracker
- Forward tracking utilizes the $p\bar{p}$ collision vertex, the silicon vertex detector, and the plug shower maximum position detector (PES) for tracking space points
- Forward tracks are required to pass through 3-8 layers of silicon vertex detector sensors

Plug track quality selection

Track quality parameters:

- Number of silicon layers the track traverses (nsilfid)
- Number of nhits found for the track (nnhits)
- Track fit χ^2/number of nhits

nsilfid $\rightarrow$	3	4	5	6	7	8
nhits $=3$	x	x	x	x	x	x
nhits $=4$	✓	✓	x	x	x	x
nhits $=5$	✓	✓	✓	x	x	x
nhits $=6$	✓	✓	✓	✓	x	x
nhits $=7$	✓	✓	✓	✓	✓	x
nhits ≥ 8	✓	✓	✓	✓	✓	✓

- The matrix of is used to assess
  - what to reject, and
  - what to keep and clean-up with χ^2/number of nhits cuts
- Benchmarks distributions
  - *el_Pem*3*x*3χ^2 $\rightarrow$ Plug 3*x*3 tower EM shower shape fit χ^2
  - MET distribution

Only events with electrons that satisfy nhits$\geq$nsilfid AND nhits$\neq$3 pass selections. For each of them χ^2/number of nhits has to be $\leq$10

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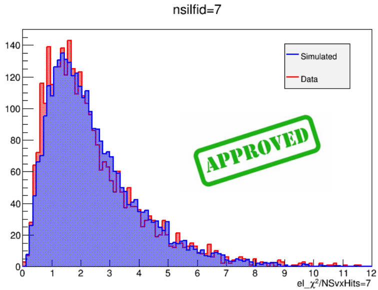
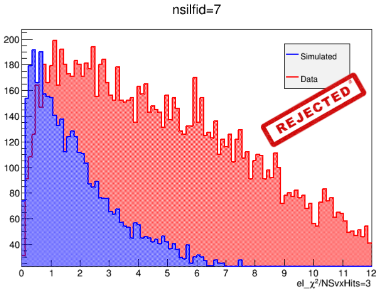
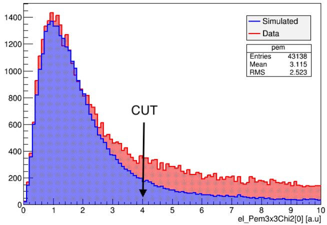
Example of matrix elements

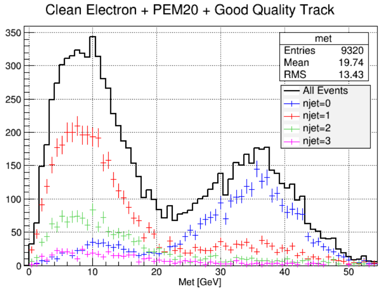


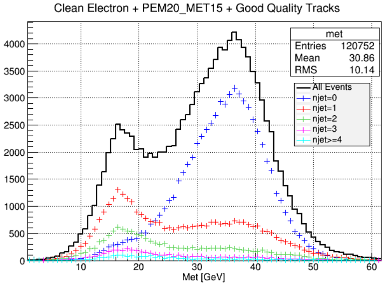


As shown in these two examples good quality tracks have a "flat" χ^2/dof distribution if nhits$\leq$layers.
This is the effect of junk tracks.

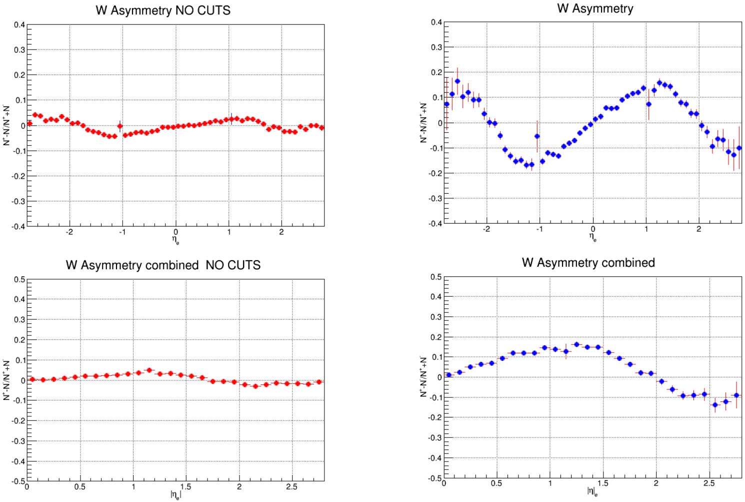
Benchmark distribution and final cut







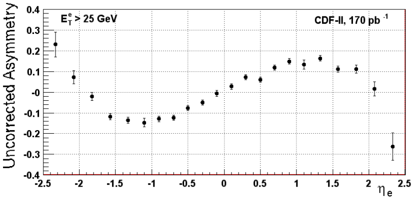
Befor & After cuts

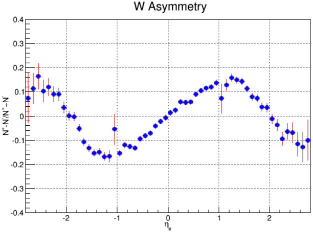


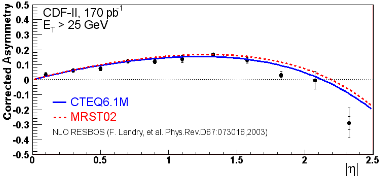
Low Instantaneous Luminosity VS High Luminosity

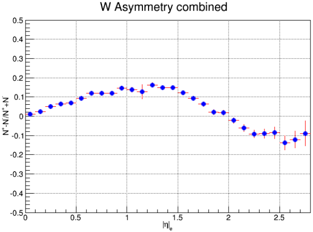
These plots don't include:

- background subtraction (the MET plots give the qualitative level)
- charge misidentification









Summary

- We studied all possible background of $W \rightarrow e\nu$ channel and focused on the bigger one: QCD background
- We checked that central region data are really good and they don't need special studies.
- Plug region events had a large amount of background in the lower $\not{E}_T$ region.
- Quality track studies before *Met* $\geq$ 25 GeV cut
- Raw Asymmetry at High Luminosity seems to fit with Low Instantaneous Luminosity measurement.
  We succeded!

BACKUP: Charge Misidentification 1

Bend Plane $r\Delta\phi$

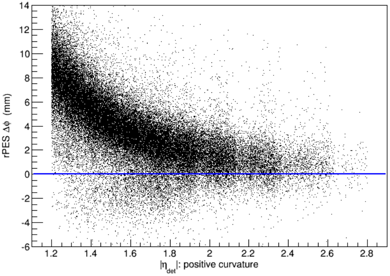


Figure: Measured

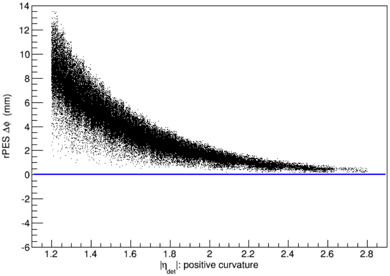


Figure: Prediction from track helix

BACKUP: Charge Misidentification 2

Figure: $\Delta\phi$ between measured and predicted ϕ at PES exit radius

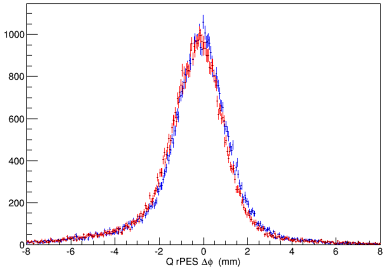


Figure: Q rPES $\Delta\phi$ vs the PES ϕ