PHYS 5326 – Lecture #8

Monday, Feb. 17, 2003
Dr. Jae Yu

1. Interpretation of $Sin^2\theta_W$ results
2. The link to Higgs

Move Wednesday's class and the makeup class to Friday 9am-12pm in rm 200, this week only!!

Last Week's Homework Assignments

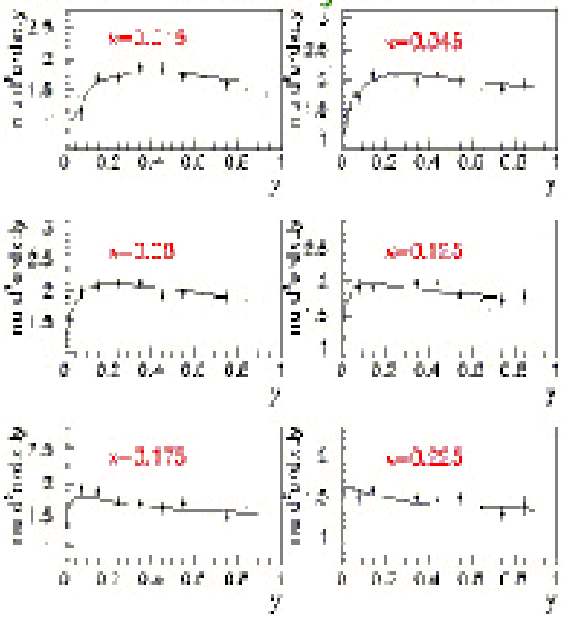
- Process the transferred TMB data files and convert them into TMBtree for root analysis
  - You can work together on this one
  - One person can produce TMBtree for all
  - Due next Monday, Feb. 17
- Produce an electron E_T spectrum of the highest E_T electrons in your samples
  - Due next Wednesday, Feb. 19

MC to Relate R_ν^{exp} to R^ν and $\sin^2\theta_W$

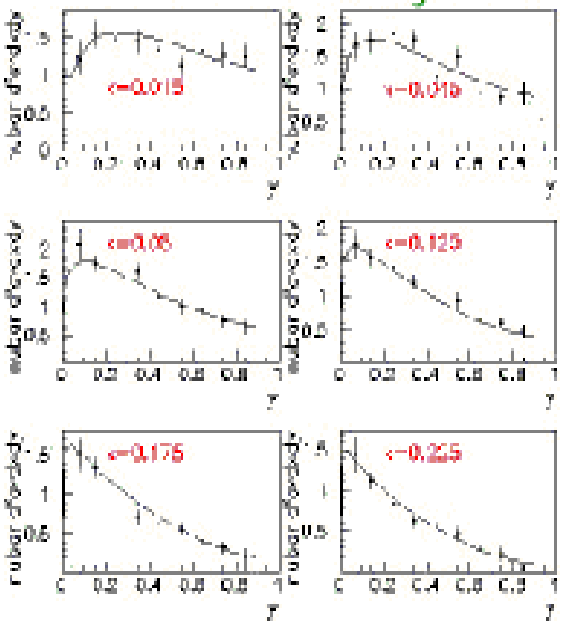
- Parton Distribution Model
  - Correct for details of PDF model ➔ Used CCFR data for PDF
  - Model cross over from short ν_μ CC events

CCFR Data

Neutrino xsec vs y at 190 GeV

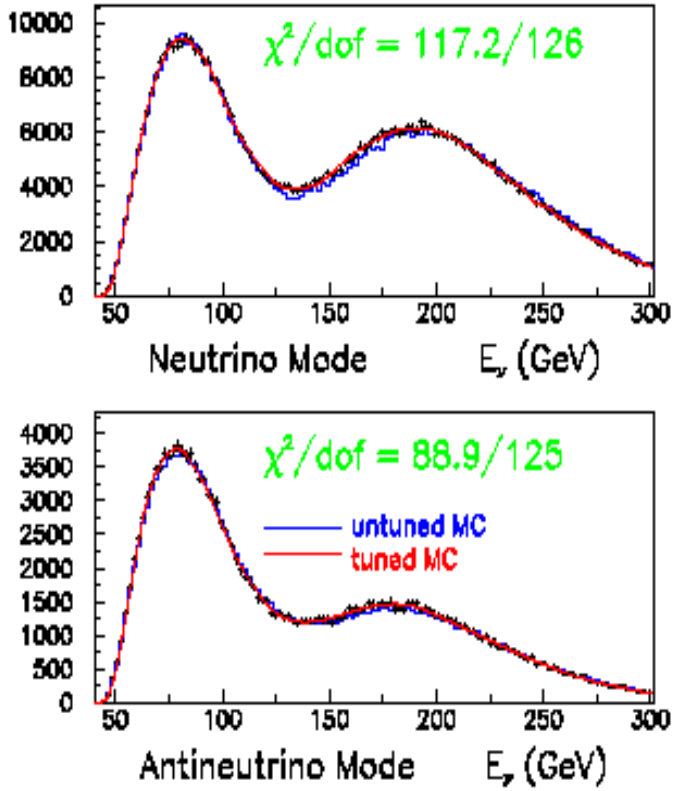


Antineutrino xsec vs y at 190 GeV



MC to Relate R_ν^{exp} to R^ν and $\sin^2\theta_W$

- Neutrino Fluxes
  - $\nu_\mu, \nu_e, \bar{\nu}_\mu, \bar{\nu}_e$ in the two running modes
  - ν_e CC events always look short
- Shower length modeling
  - Correct for short events that look long
- Detector response vs energy, position, and time
  - Continuous testbeam running minimizes systematics



$\sin^2\theta_W$ Fit to R_ν^{exp} and $R_{\bar{\nu}}^{exp}$

- Thanks to the separate beam ➔ Measure R^ν's separately
- Use MC to simultaneously fit R_n^{exp} and $R_{\bar{n}}^{exp}$ to $\sin^2\theta_W$ and m_c, and $\sin^2\theta_W$ and ρ

$$R^{n(\bar{n})} = \frac{\sigma_{NC}^{n(\bar{n})}}{\sigma_{CC}^{n(\bar{n})}} = \rho^2\left(\frac{1}{2} - \sin^2\theta_W + \frac{5}{9}\sin^4\theta_W\left(1 + \frac{\sigma_{CC}^{\bar{n}(n)}}{\sigma_{CC}^{n(\bar{n})}}\right)\right)$$

- R^ν Sensitive to $\sin^2\theta_W$ while $R^{\bar{\nu}}$ isn't

$\Rightarrow R^\nu$ is used to extract $\sin^2\theta_W$ and $R^{\bar{\nu}}$ to control systematics

$\Rightarrow$ Why???

$\sin^2\theta_W$ Fit to R_ν^{exp} and $R_{\bar{\nu}}^{exp}$

- Single parameter fit, using SM values for EW parameters (ρ_0=1)

$$\sin^2\theta_W = 0.2277 \pm 0.0013\,(stat) \pm 0.0009\,(syst)$$

$$m_c = 1.32 \pm 0.09\,(stat) \pm 0.06\,(syst) \text{ w/ } m_c = 1.38 \pm 0.14\ GeV/c^2 \text{ as input}$$

- Two parameter fit for $\sin^2\theta_W$ and ρ_0 yields

$$\sin^2\theta_W = 0.2265 \pm 0.0031$$

$$\rho_0 = 0.9983 \pm 0.040$$

Syst. Error dominated since we cannot take advantage of sea quark cancellation

NuTeV $\sin^2\theta_W$ Uncertainties

Source of Uncertainty	d $\sin^2\theta_W$
Statistical	**0.00135**
ν_e flux	0.00039
Event Length	0.00046
Energy Measurements	0.00018
Total Experimental Systematics	**0.00063**
CC Charm production, sea quarks	0.00047
Higher Twist	0.00014
Non-isoscalar target	0.00005
$s^{\bar{n}} / s^{n}$	0.00022
RadiativeCorrection	0.00011
R_L	0.00032
Total Physics Model Systmatics	**0.00064**
Total Systematic Uncertainty	**0.00162**
ΔM_W (GeV/c^2)	**0.08**

Dominant uncertainty

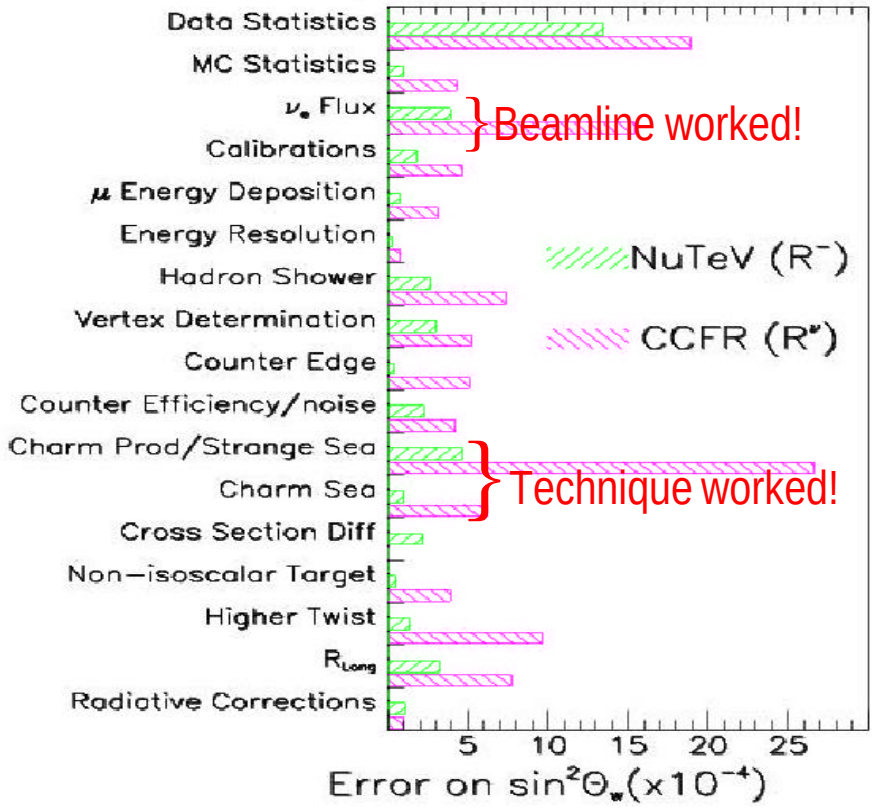
1-Loop Electroweak Radiative Corrections based on Bardin, Dokuchaeva **JINR-E2-86-2 60 (1986)**

$$d\sin^2\theta_W^{(On-shell)} = -0.00022 \times \left(\frac{M_t^2 - (175\text{GeV})^2}{(50\text{GeV})^2} \right) + 0.00032 \times \ln\left(\frac{M_H}{150\text{GeV}} \right)$$

M_{higgs} Term

M_t Term

NuTeV vs CCFR Uncertainty Comparisons



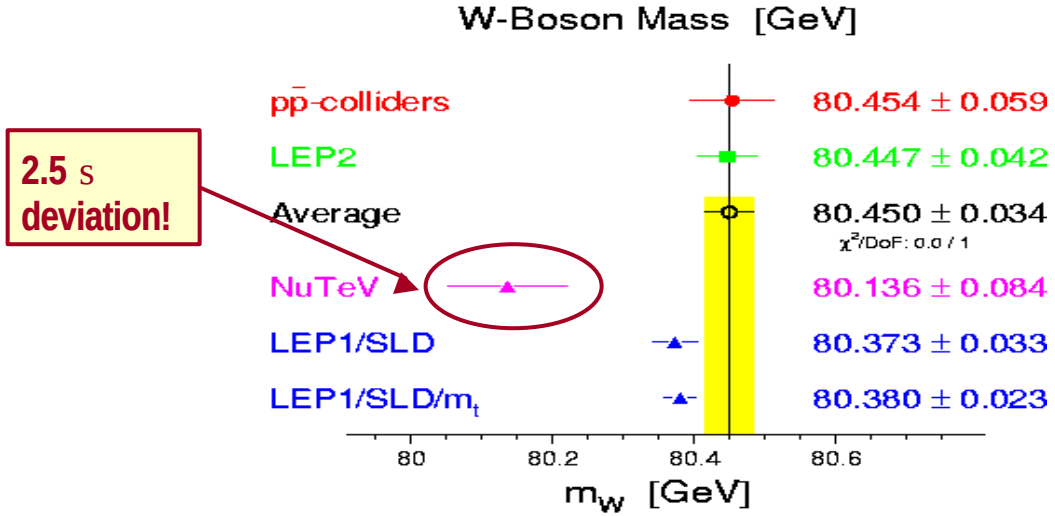
Comparison of New $\sin^2\theta_W$

$$\sin^2\theta_W^{On-Shell} = 0.2277 \pm 0.0013\ (stat) \pm 0.0009\ (syst)$$

$$\sin^2\theta_W^{On-shell} = 1 - \frac{M_W^2}{M_Z^2}$$

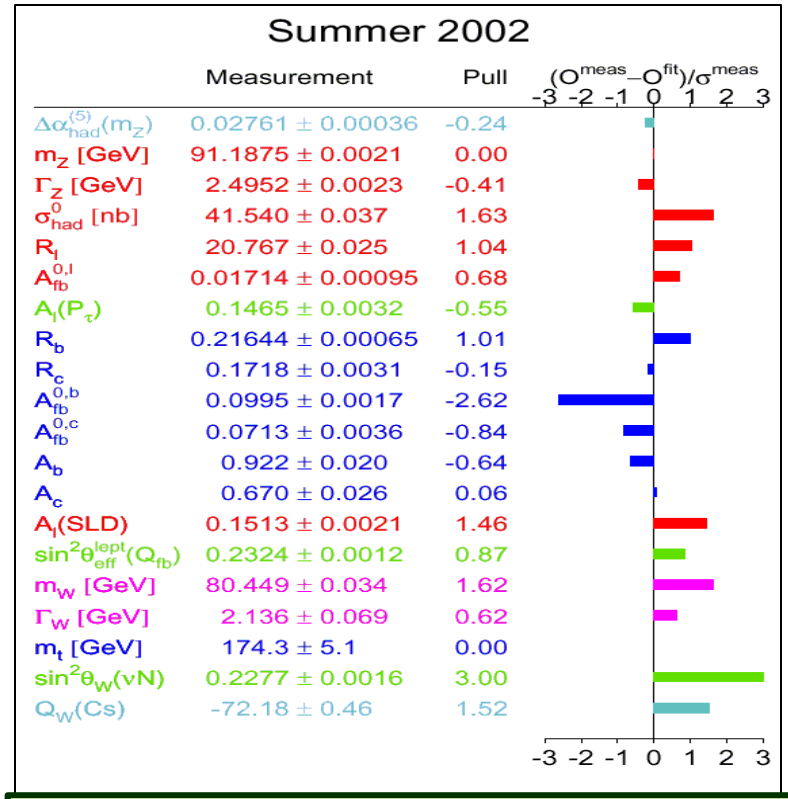
$$\Rightarrow M_W^{On-Shell} = 80.14 \pm 0.08\ GeV/c^2$$

Comparable precision but value smaller than other measurements



2.5 s deviation!

SM Global Fits with New Results



LEP EWWG: http://www.cern.ch/LEPEWWG

Without NuTeV
χ^2/dof=20.5/14: *P=11.4%*

With NuTeV
χ^2/dof=29.7/15: *P=1.3%*

Confidence level in upper M_{higgs} limit weakens slightly.