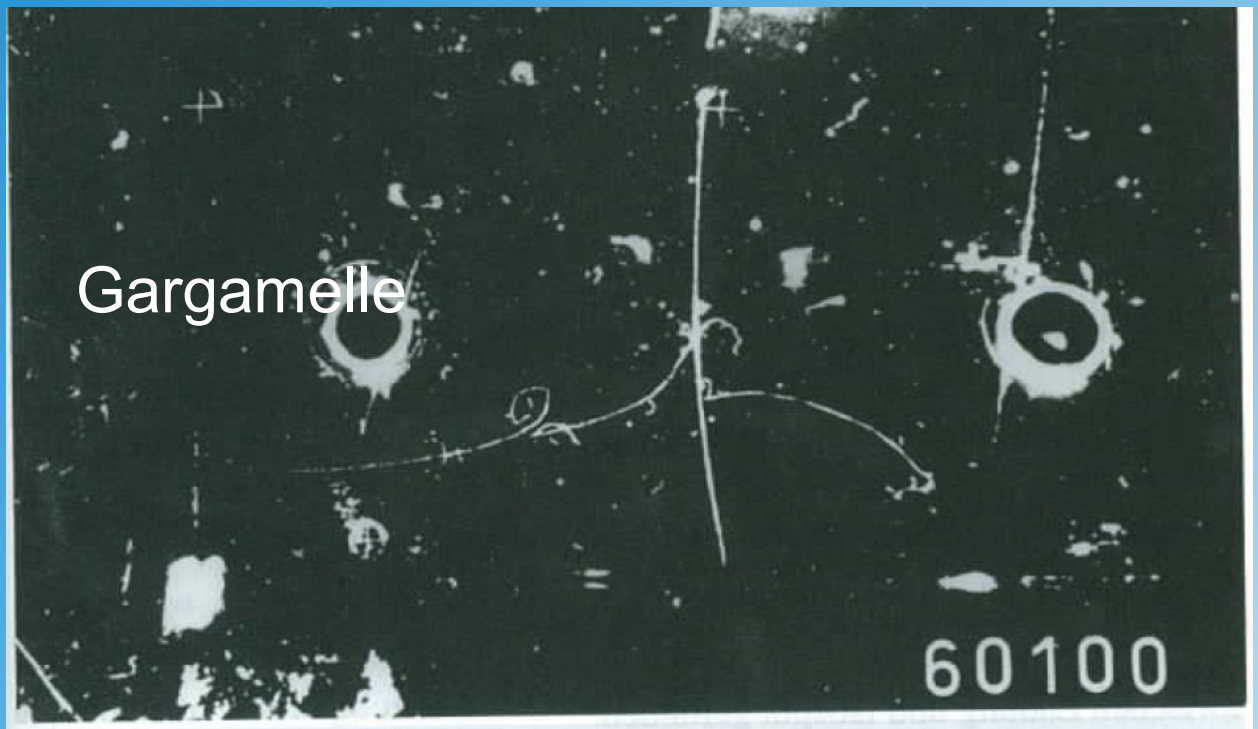
# Electroweak Physics

- Electroweak Unification
- Production of Z-bosons
- Asymmetries and Weinberg Angle
- Z-Lineshape
- weak couplings and neutral currents
- radiative corrections

# Discovery of Neutral Currents

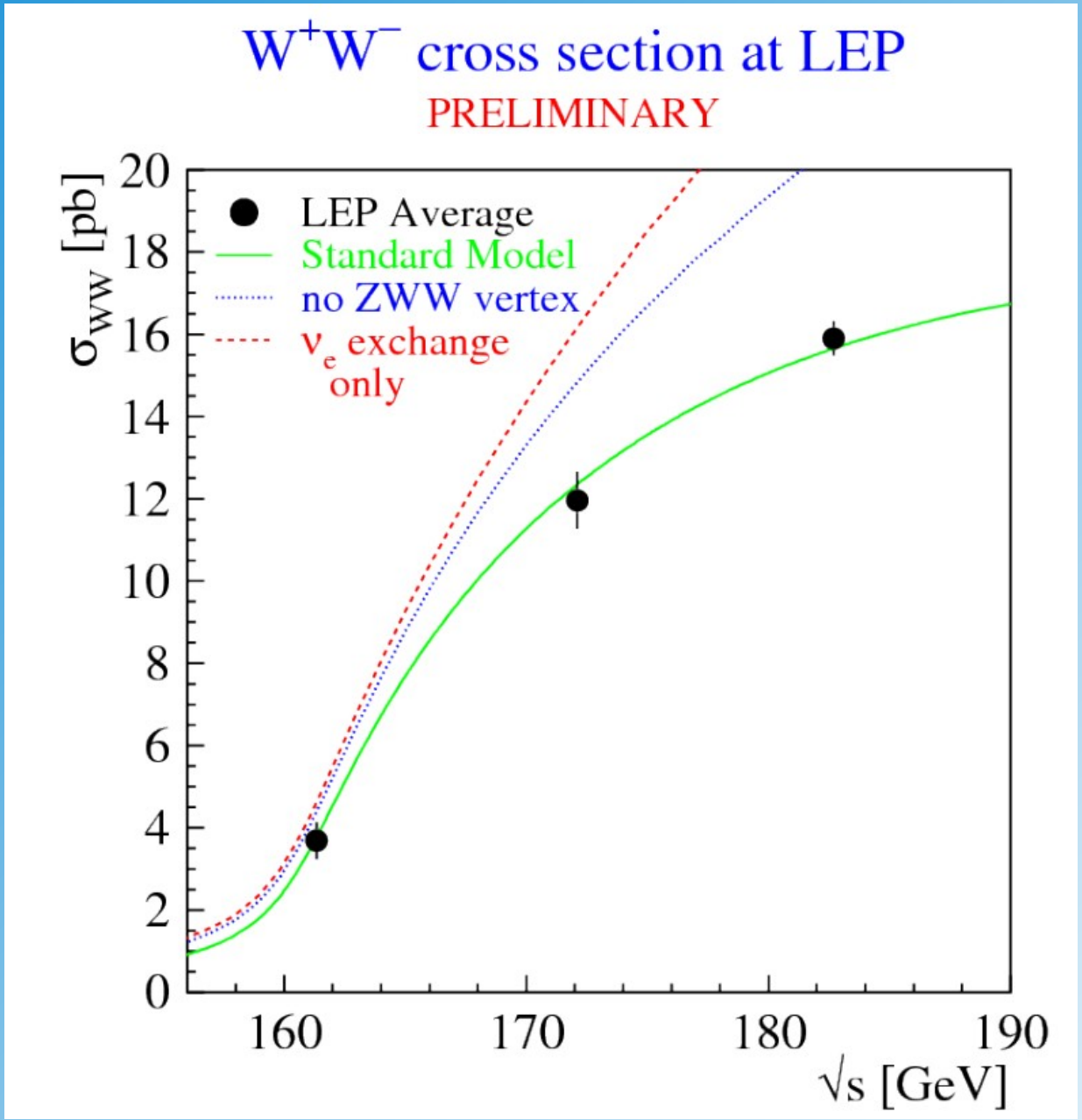



b)

**6.3.2 Elektroschwache Wechselwirkung der Leptonen**

Das Matrixelement (6.6) der $\nu_\mu e$-Streuung läßt sich, wie wir gesehen haben, als Produkt zweier linkshändiger Ströme

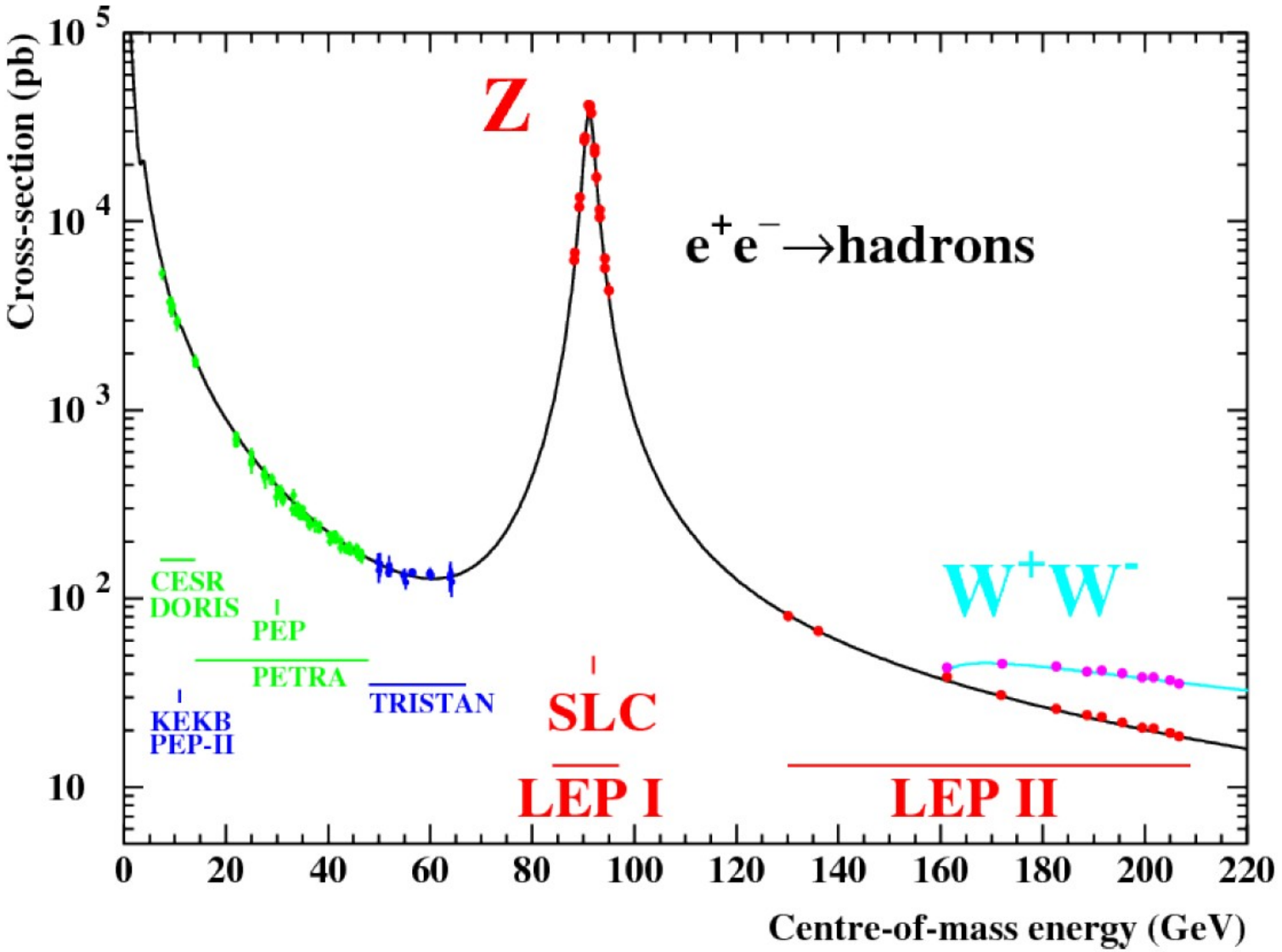
# WW Pair Production



# Z-Resonance

LEP-SLC 2006 Working Group,
Physics Reports 427 (2006) 257

http://arxiv.org/abs/hep-ex/0509008v3



# $e^+e^- \rightarrow \mu^+\mu^-$

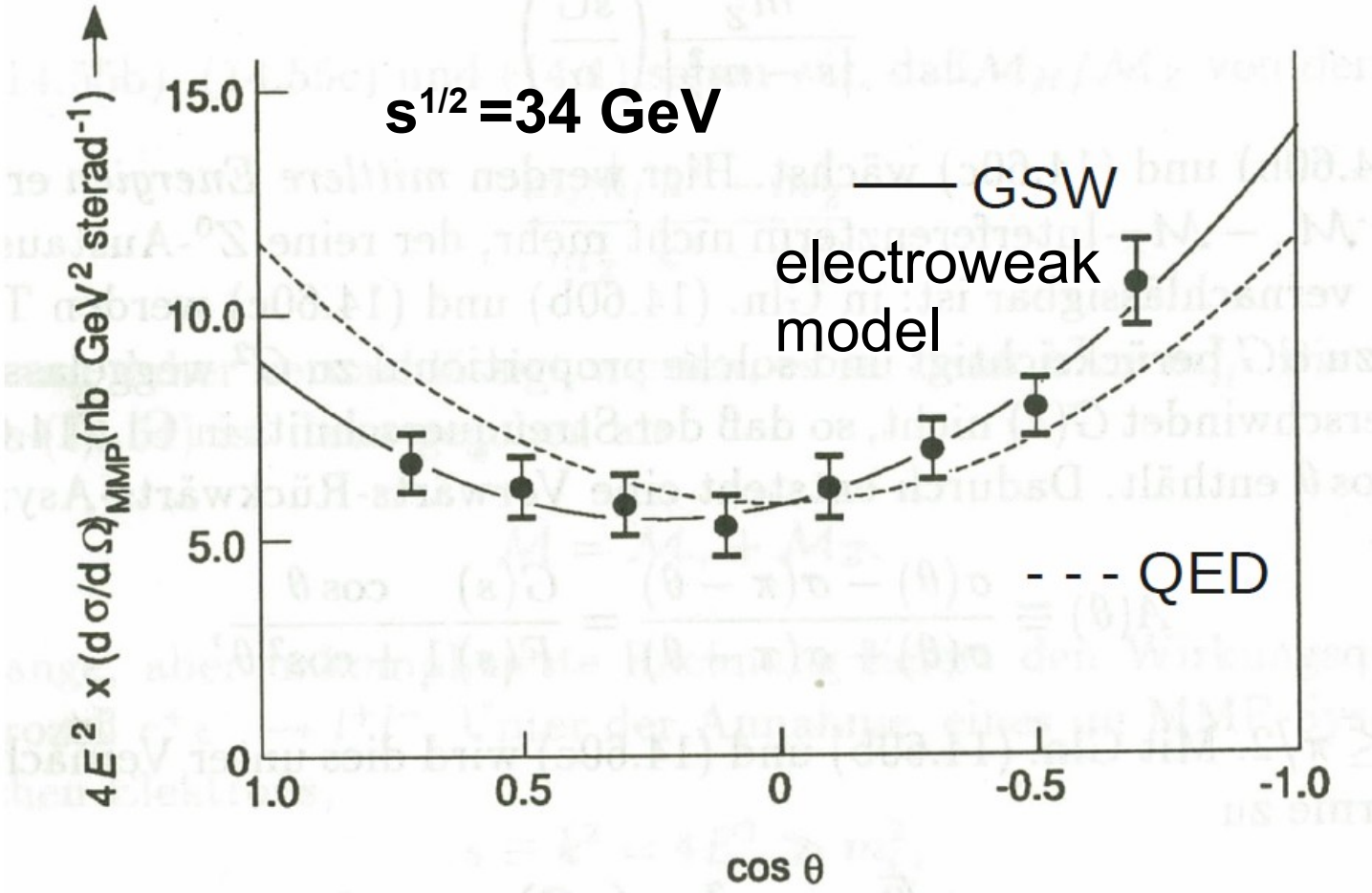



Abbildung 14.8: *Der differentielle Streuquerschnitt* $(d\sigma/d\Omega)_{MMP}$ *des Prozesses* $e^+e^- \rightarrow \mu^+\mu^-$ *bei der Gesamtenergie* $2E = 34$ *GeV. [Nach R. Brandelik* et al., Phys. Lett. **110B** *(1982), 173.]* ⊥ *: Experimentelle Daten; —: elektroschwache Theorie, – – –: QED.*

# Electroweak Unification

(Glashow, Salam, Weinberg Model)

$$H^{e.m.,weak} = g\, j_L W + \frac{1}{2} g'\, j^Y B$$

$SU(2)_L \times U(1)_Y \rightarrow SU(2)_{weak} \times U(1)_{e.m.}$

$$\begin{pmatrix} Z \\ A \end{pmatrix} = \begin{pmatrix} \cos\theta_W & -\sin\theta_W \\ \sin\theta_W & \cos\theta_W \end{pmatrix} \begin{pmatrix} W_3 \\ B \end{pmatrix}$$

isospin_3

weak hypercharge

$$\begin{pmatrix} W^+ \\ W^- \end{pmatrix} = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & -i \\ 1 & i \end{pmatrix} \begin{pmatrix} W_1 \\ W_2 \end{pmatrix}$$

→ electroweak symmetry breaking

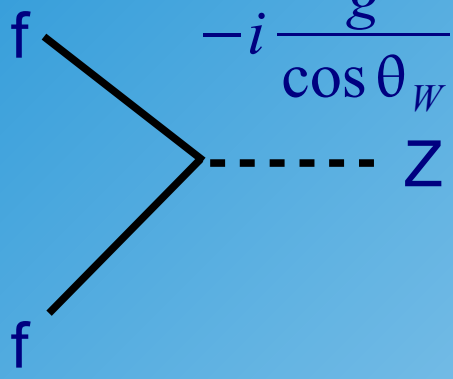
# Neutral Currents

$$H^{neutral} = g\, j_L^3 W + \tfrac{1}{2}\, g'\, j^Y\, B$$

Neutral Current:

$$j^{NC} = j_L^3 - j^{e.m.} \sin^2\theta_W$$

Vertex:




$$-i\frac{g}{\cos\theta_W}\gamma^\mu\, c$$

with

$$c = I_{3,L} - Q\sin^2\theta_W$$

for leptons:

$$c_\nu = \frac{1}{2}$$

$$c_L = -\frac{1}{2} + \sin^2\theta_W$$

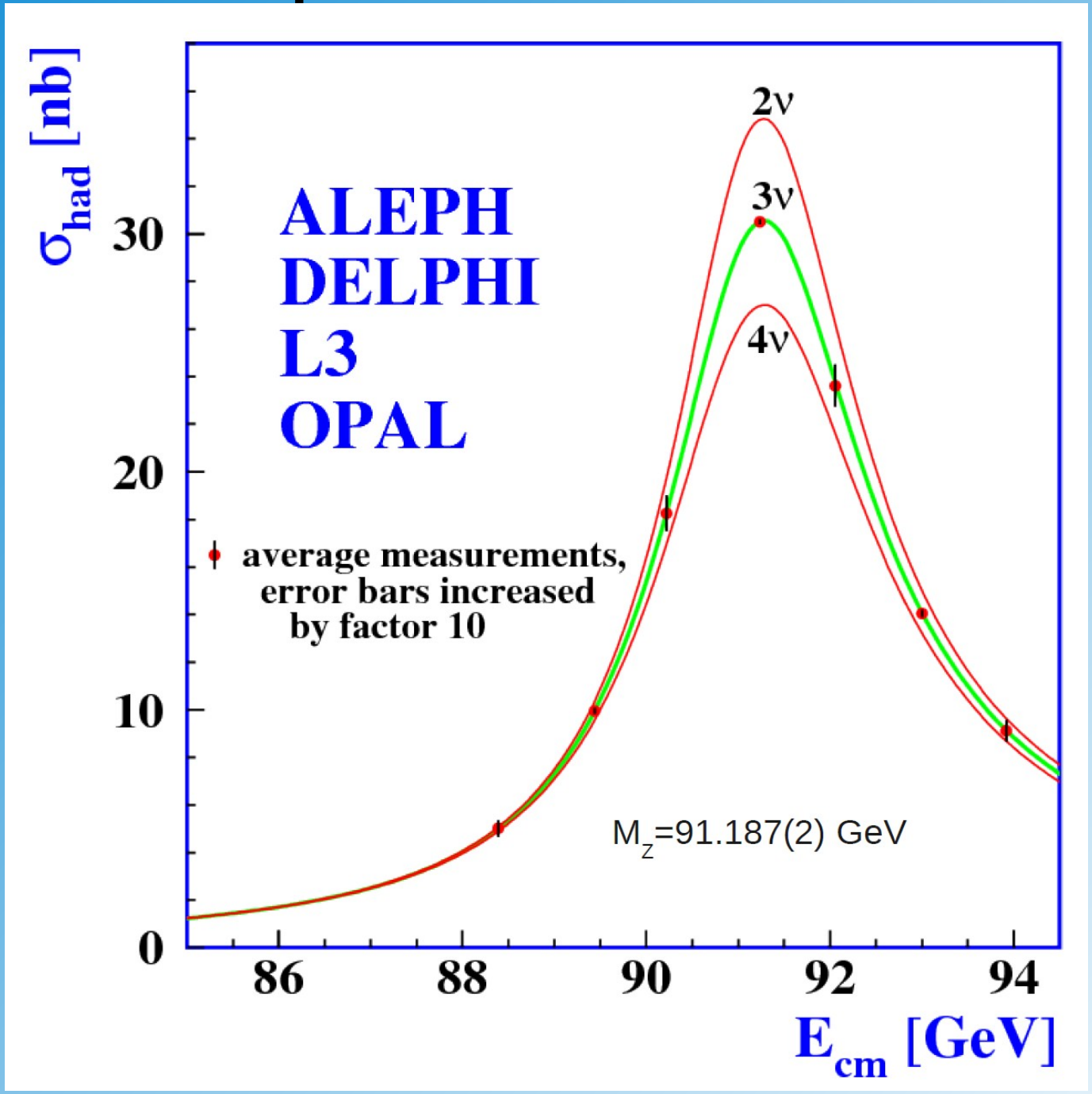
$$c_R = \sin^2\theta_W$$

$$-i\frac{g}{\cos\theta_W}\gamma^\mu\left(\frac{c_V - c_A\gamma_5}{2}\right) = -i\frac{g}{\cos\theta_W}\gamma^\mu\left(\frac{1+\gamma^5}{2}c_R + \frac{1-\gamma^5}{2}c_L\right)$$

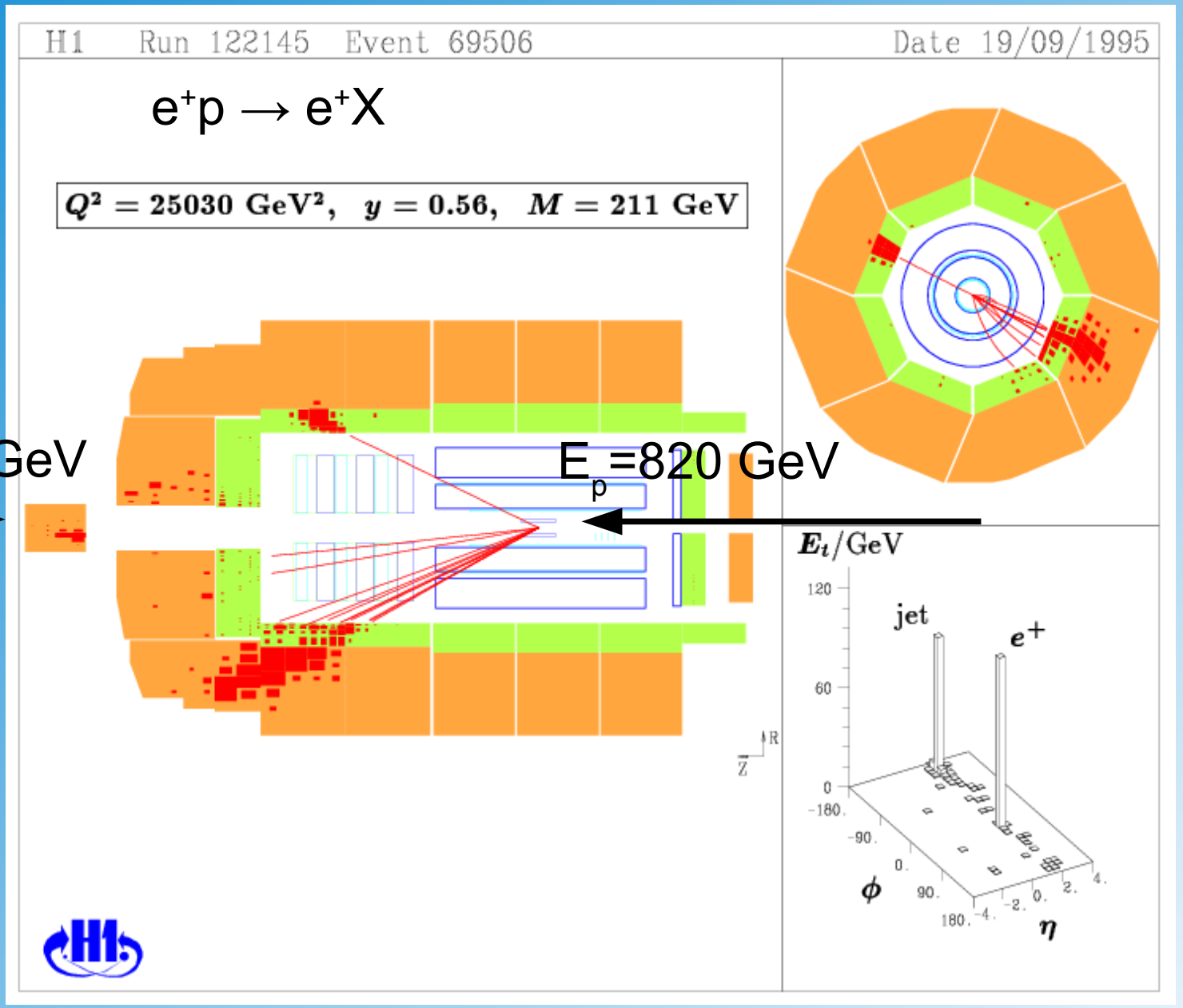
# Electroweak Couplings in SM

| | $\nu_e^L$ | $e^L$ | $\nu_e^R$ | $e^R$ | $u^L$ | $d^L$ | $u^R$ | $d^R$ |
|---|---|---|---|---|---|---|---|---|
| **Q/e** | 0 | -1 | 0 | -1 | +2/3 | -1/3 | +2/3 | -1/3 |
| $\mathbf{I_3^W}$ | +1/2 | -1/2 | 0 | 0 | +1/2 | -1/2 | 0 | 0 |
| **Y** | -1 | -1 | 0 | -2 | 1/3 | 1/3 | 4/3 | -2/3 |

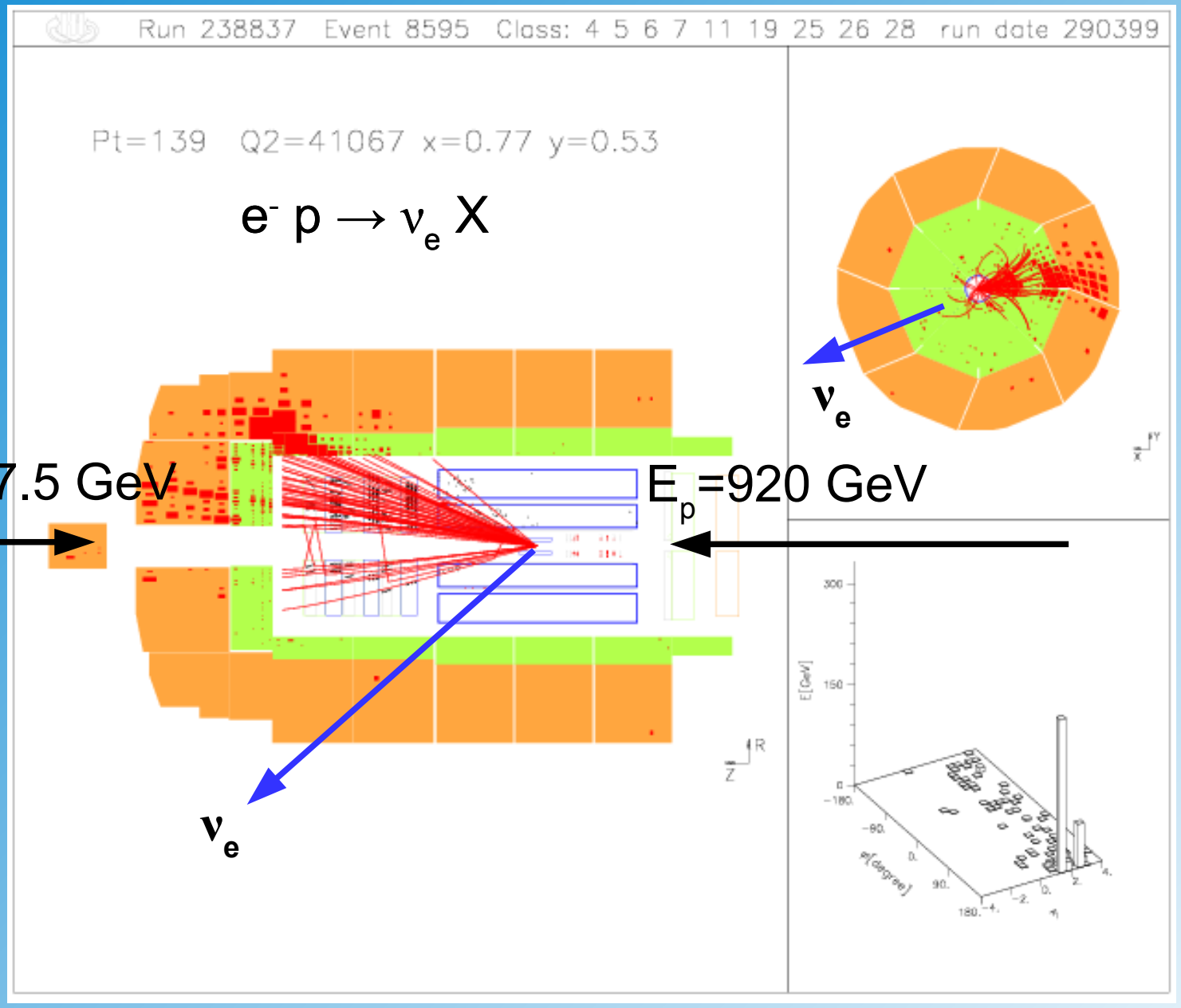
# Z-Lineshape + Neutrino Families



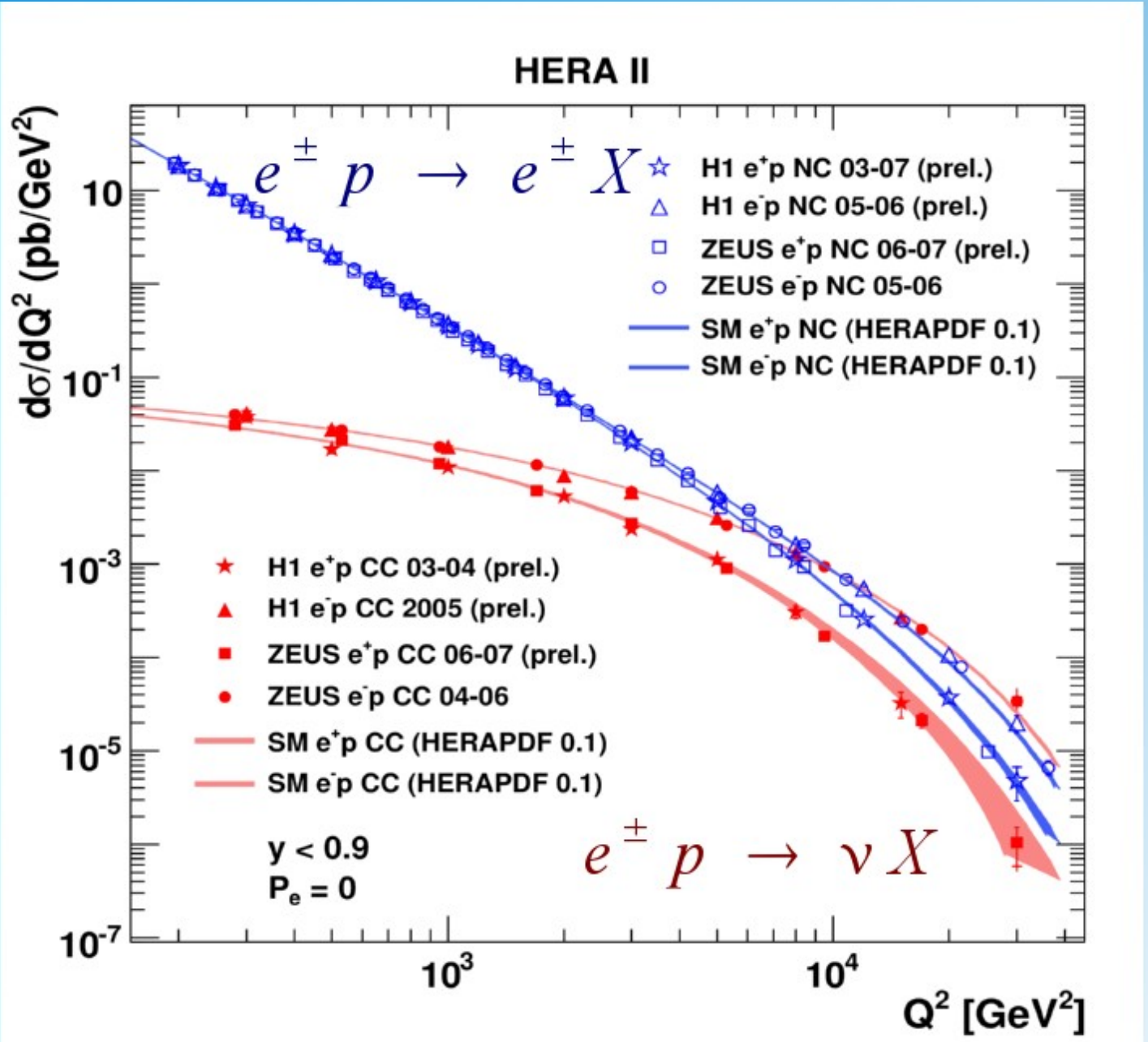
# Neutral Current Events @ HERA



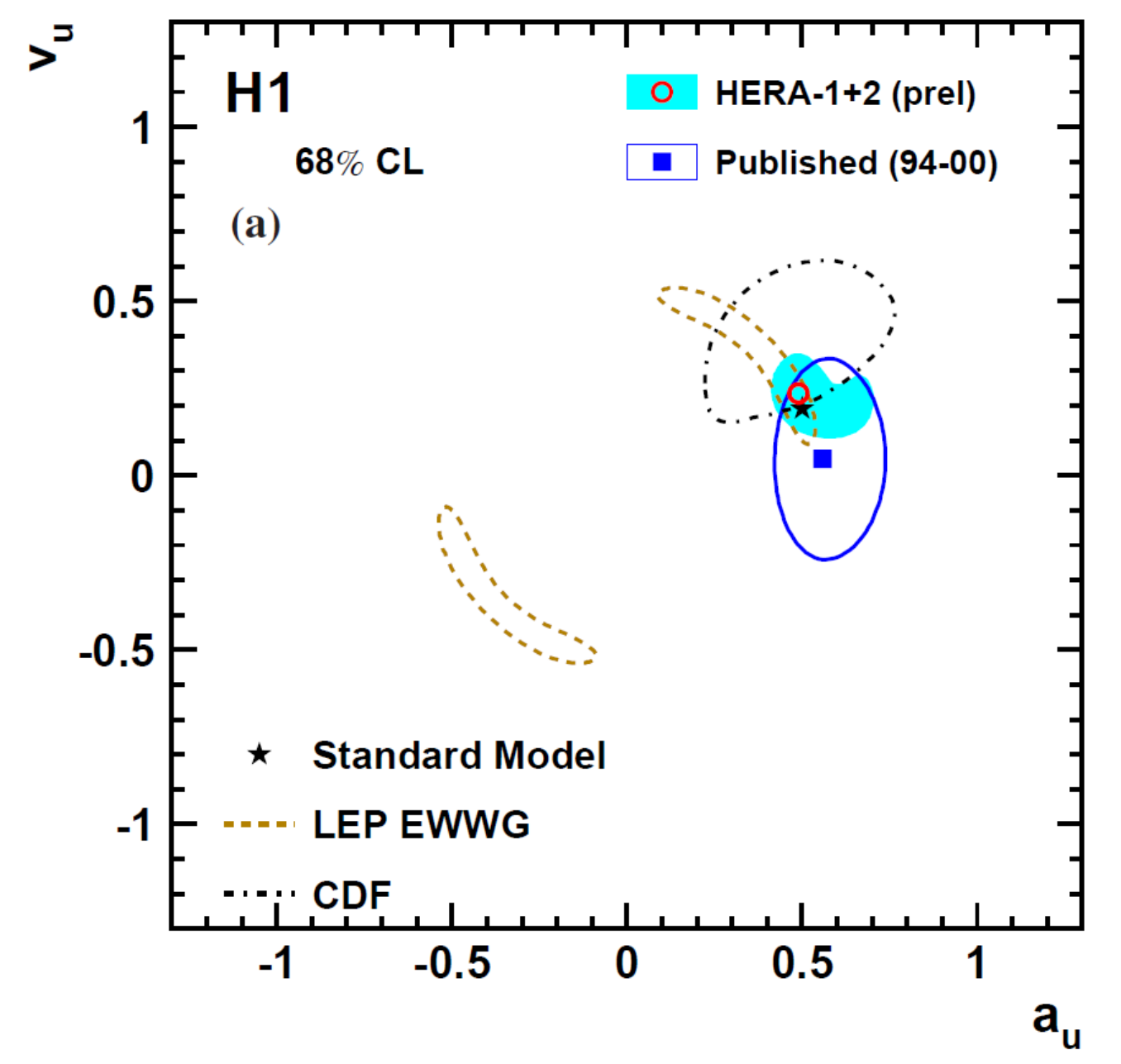
# Charded Current Events @ HERA



# Electroweak Unification @ HERA



# NC Quark Couplings



# Top Quark Mass