Determination of Electroweak couplings at HERA

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Outline

- Introduction
- Fit method
- Results
- Summary & outlook

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Introduction

In DIS Exp. Like HERA: cross sections

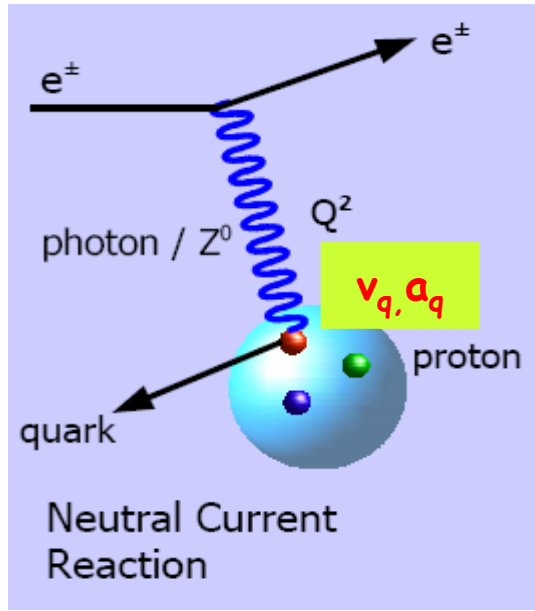
$$\frac{d^2\sigma(ep)}{dxdQ^2} \propto \sigma(eq) \otimes PDF$$

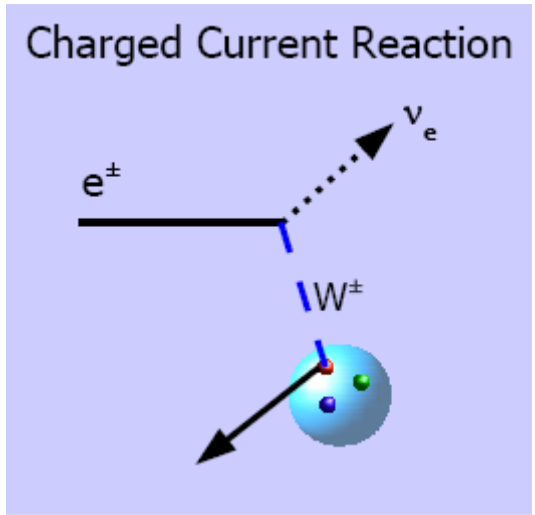
constrain 5 sets of PDFs:

gluon, up-type quark, down-type quark & their anti-quarks

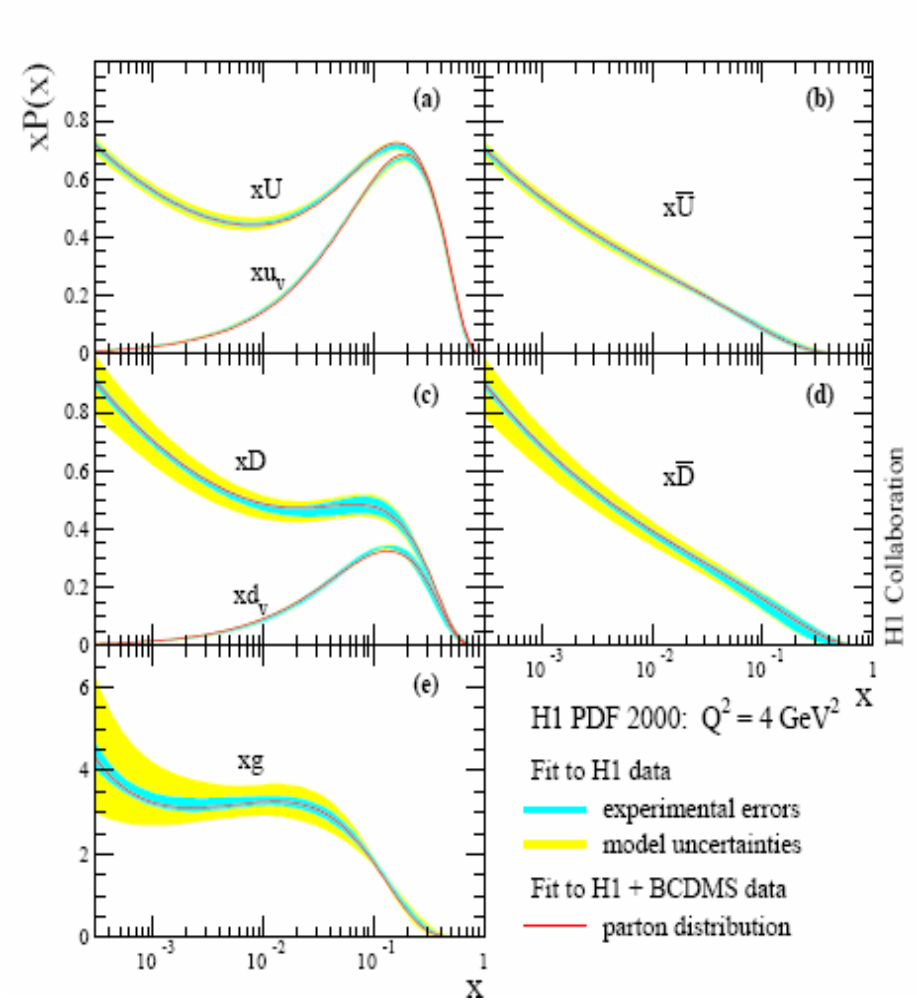
H1PDF2000: Eur. Phys. J. C30(2003)1

- NC data at high Q^2 also sensitive to quark couplings to the Z boson
- High Q^2 CC data sensitive to G, W propagator mass, or M_W, m_t

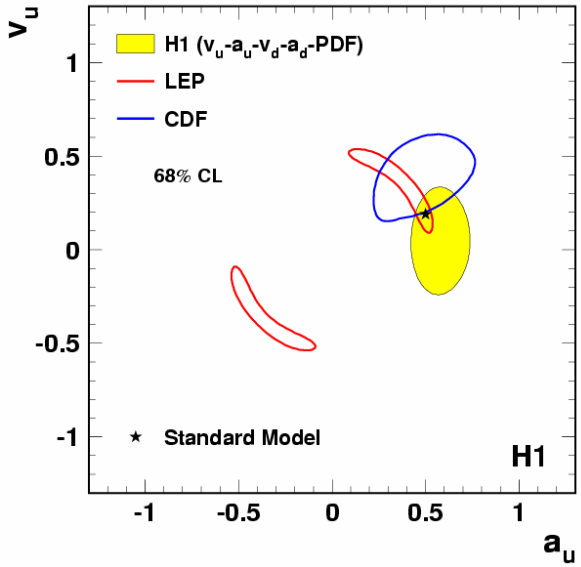


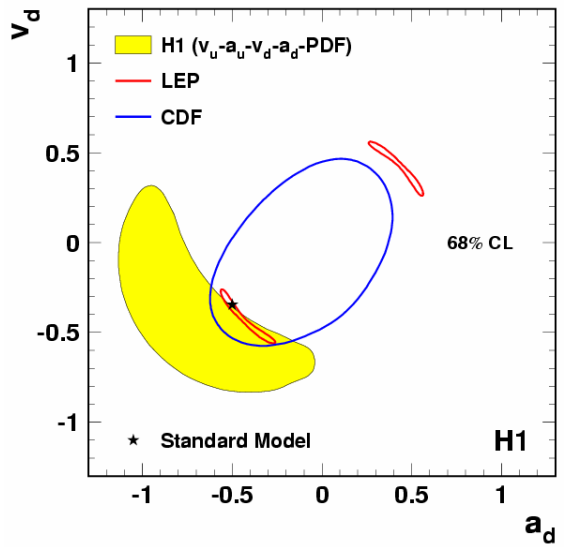


H1PDF2000



Electroweak and QCD combined fit





Phys. Lett. B632 (2006) 35-42

What's new at HERA-II?

Polarization of e^+ and e^-

$$\frac{d^2\sigma^{\pm}_{NC}}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}\phi^{\pm}_{NC}$$

$$\phi^{\pm}_{NC} = Y_+\tilde{F}_2 \mp Y_- x\tilde{F}_3 - y^2\tilde{F}_L$$

← For Neutral Current channel

$$\tilde{F}_2^{\pm} = F_2^{\gamma} - (v_e \pm P_e a_e)\chi_Z F_2^{\gamma Z} + (v_e^2 + a_e^2 \pm P_e 2v_e a_e)\chi_z^2 F_2^{Z}$$

$$x\tilde{F}_3^{\pm} = -(a_e \pm P_e v_e)\chi_Z x F_3^{\gamma Z} + (2v_e a_e \pm P_e(v_e^2 + a_e^2))\chi_z^2 x F_3^{Z}$$

χ_Z ~ Z^0 propagator

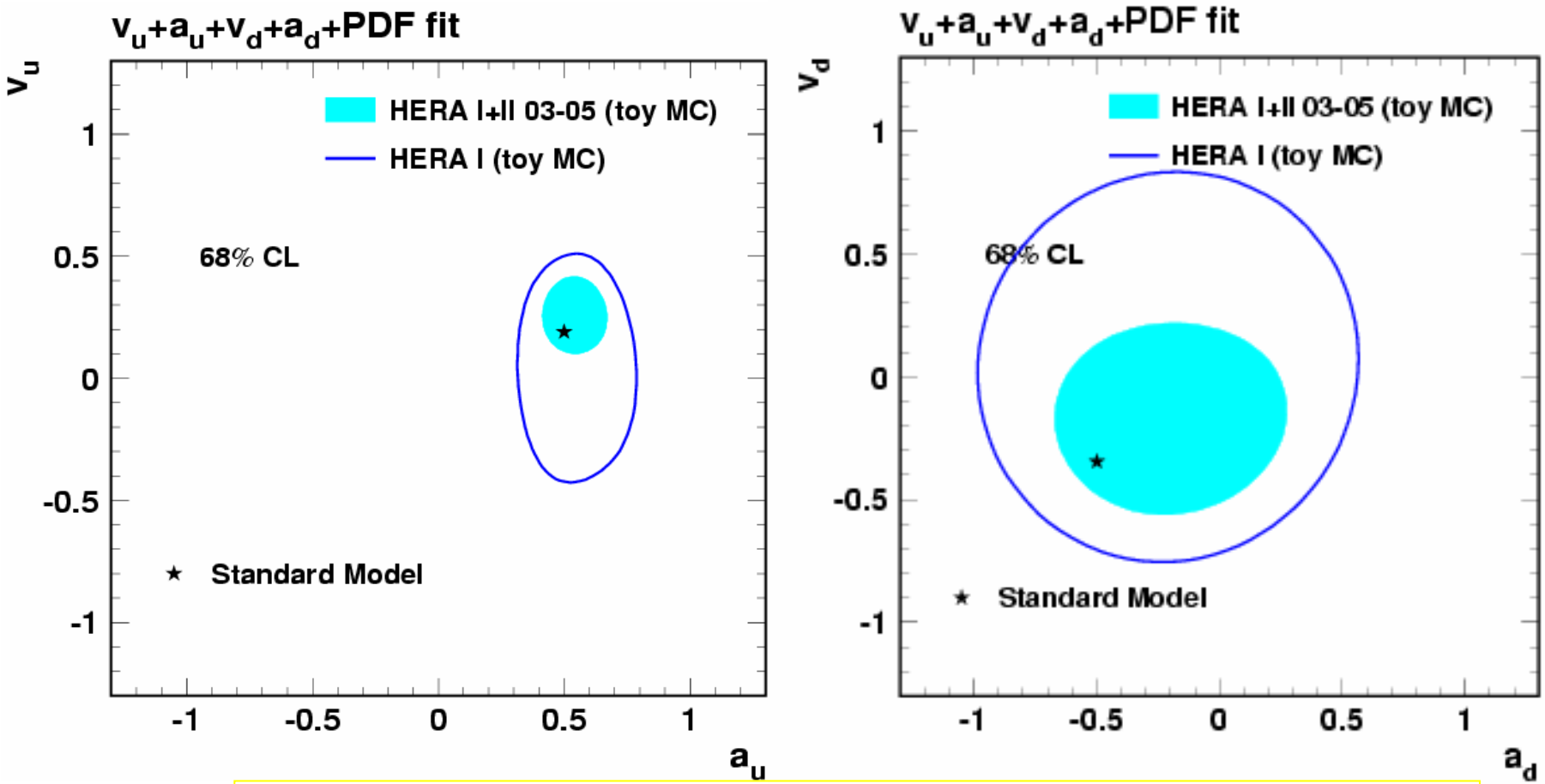
Since $\chi_z \gg \chi_z^2$ and $v_e \simeq 0.05$, we can neglect the pure Z^0 terms

$$\tilde{F}_2^{\gamma Z} = \sum 2e_i v_i (xq_i + x\bar{q}_i)$$

$$x\tilde{F}_3^{\gamma Z} = \sum 2e_i a_i (xq_i - x\bar{q}_i)$$

Additional sensitivity to axial and vector couplings of quarks to Z^0, in particular for vector coupling.

Expected sensitivity of polarization: Fit a_u-v_u-a_d-v_d-PDF (Toy MC Results)



Significant improvement mainly from polarized $e^{\pm}$ beam

This talk

HERA-I		HERA-II		
Data set	Process	Data set	Process	Pol.
H1 minimum bias 97	e^+p NC	H1 high Q^2 03-04	e^+p NC	+40%
H1 low Q^2 96-97	e^+p NC	H1 high Q^2 03-04	e^+p NC	-34%
H1 high Q^2 94-97	e^+p NC	H1 high Q^2 05	e^-p NC	+37%
H1 high Q^2 94-97	e^+p CC	H1 high Q^2 05	e^-p NC	-27%
H1 high Q^2 98-99	e^-p NC	H1 high Q^2 03-04	e^+p CC	+40%
H1 high Q^2 98-99	e^-p CC	H1 high Q^2 03-04	e^+p CC	-34%
H1 high Q^2 99-00	e^+p NC	H1 high Q^2 05	e^-p CC	+37%
H1 high Q^2 99-00	e^+p CC	H1 high Q^2 05	e^-p CC	-27%

The publications

Analysis Strategies

- **Following the published H1PDF2000 fit procedure:**
  - Use all H1 NC & CC data (e^+p & e^-p) for Q^2_{min}=3.5GeV^2
  - Parameterize 5 PDF sets: with a functional form:

$$
\begin{aligned}
xg(x) &= A_g \times x^{B_g} \times (1-x)^{C_g} \times (1+a_g x) \\
xU(x) &= A_U \times x^{B_U} \times (1-x)^{C_U} \times (1+a_U x + c_U x^3) \\
xD(x) &= A_D \times x^{B_D} \times (1-x)^{C_D} \times (1+a_D x) \\
x\bar{U}(x) &= A_{\bar{U}} \times x^{B_{\bar{U}}} \times (1-x)^{C_{\bar{U}}} \\
x\bar{D}(x) &= A_{\bar{D}} \times x^{B_{\bar{D}}} \times (1-x)^{C_{\bar{D}}}
\end{aligned}
$$

small-x high-x behavior medium-x

at Q^2_0=4GeV^2, with 10 free PDF parameters after applying momentum sum rule and u, d quark flavor counting rule

Analysis Strategies (cont'd)

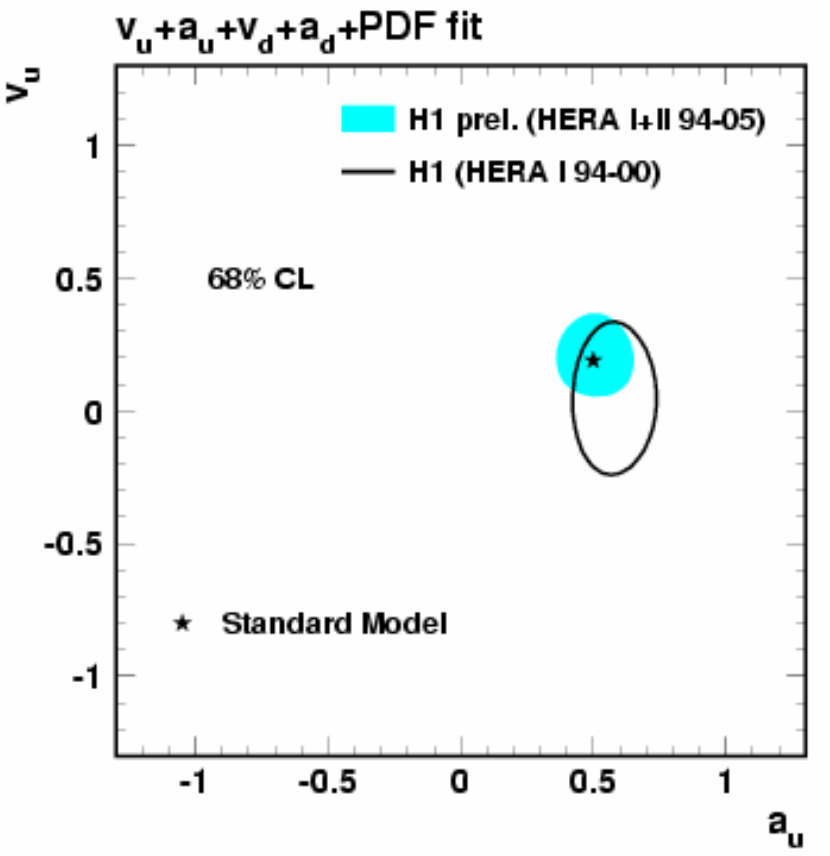
- massless scheme used for heavy quraks
- Resolve the DGLAP equations numerically to NLO
- Construct the χ^2 and minimize it

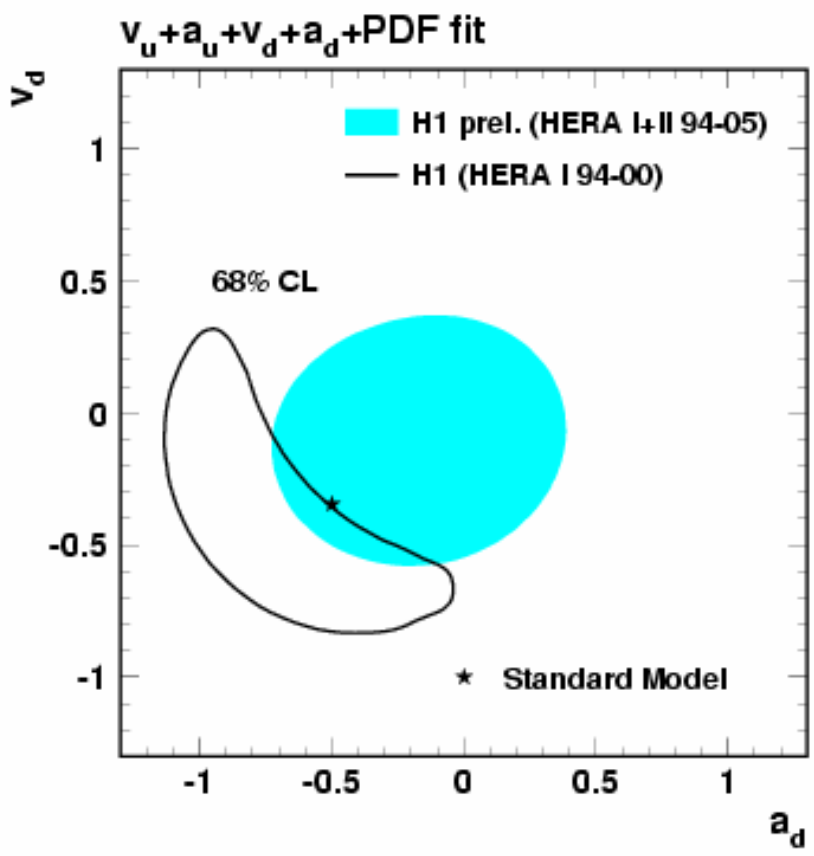
Corr'ed syst. errors

$$\chi^2(\sigma^{DT},\alpha) = \sum_{exp,data} \frac{\left[\sigma^{DT}\left(1-\sum_l \alpha_l \delta_l\right)-\sigma^{TH}\right]^2}{\delta^2_{stat}+\delta^2_{uncor}} + \sum_{exp,l} \alpha_l^2$$

- All these done with QCDFIT, developed by C. Pascaud and F. Zomer, which is used in several H1 publications.
(for more details please see:
http://h1.web.lal.in2p3.fr/divers/psfiles/notice.ps)

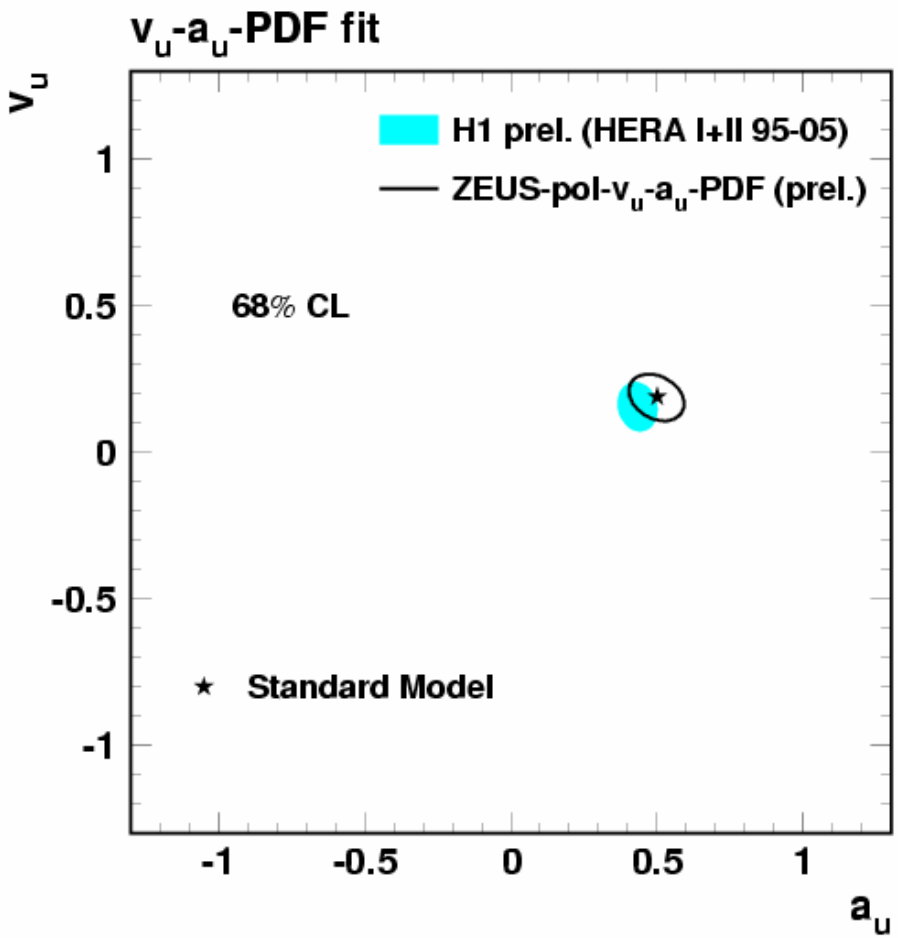
Fit Results : Improvements w.r.t. HERA-I

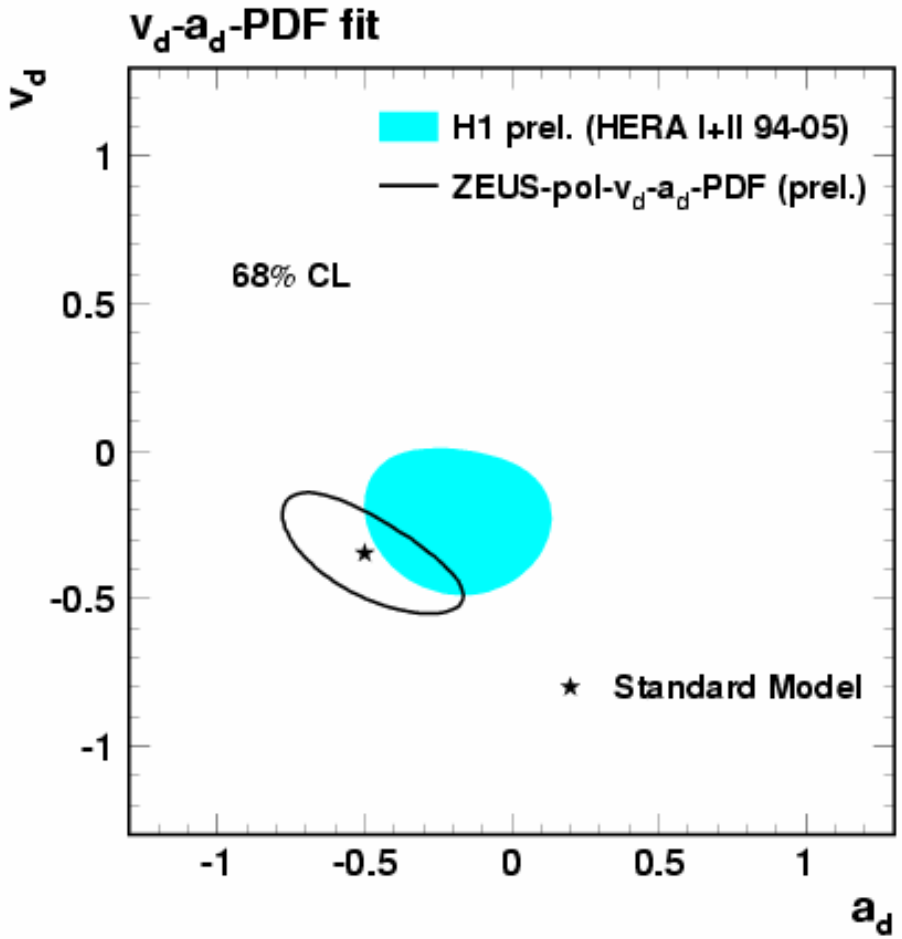




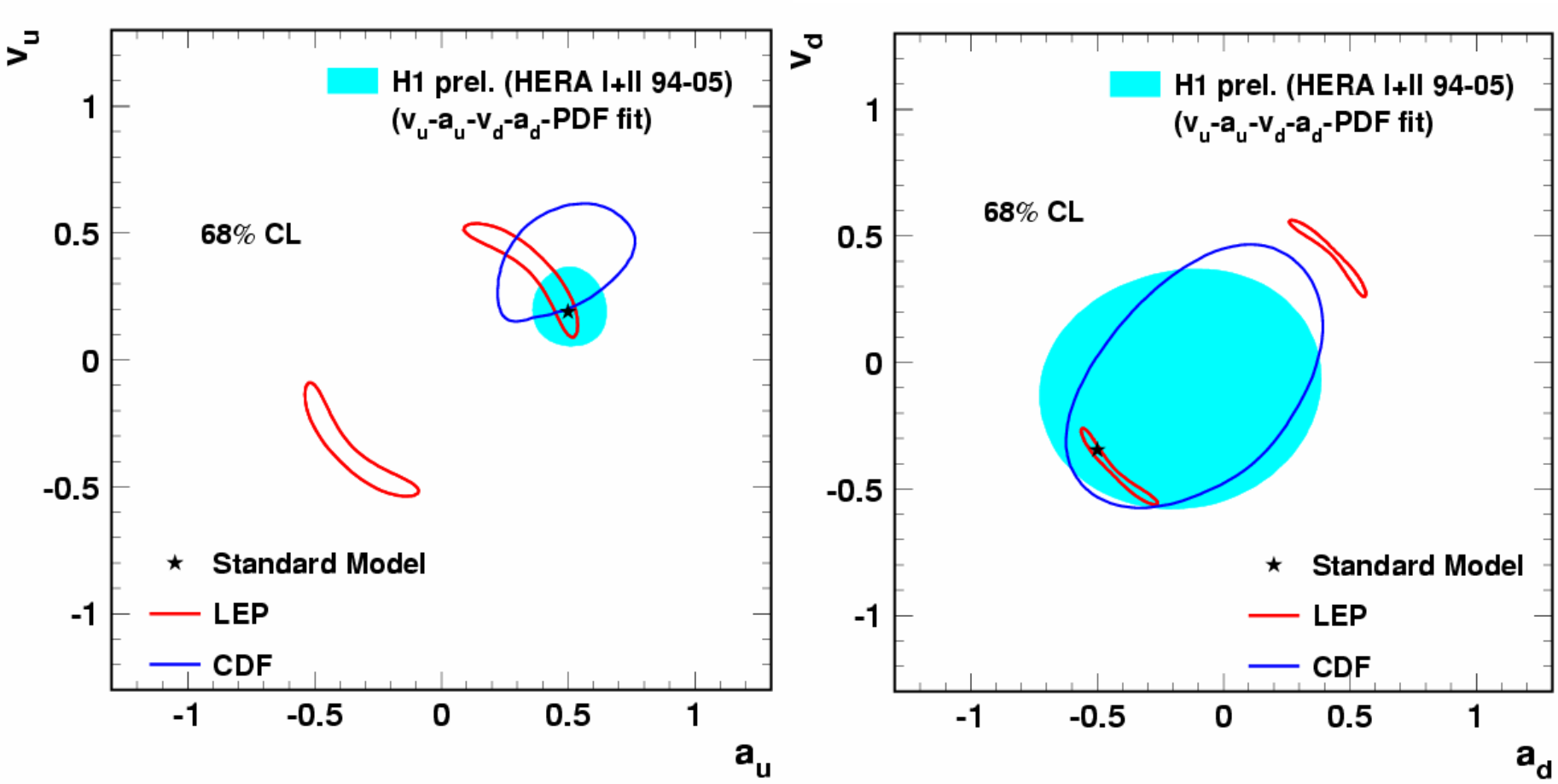
- Improved precision w.r.t. the published HERA-I fit (in particular for v_u)

Fit Results: fix d or u



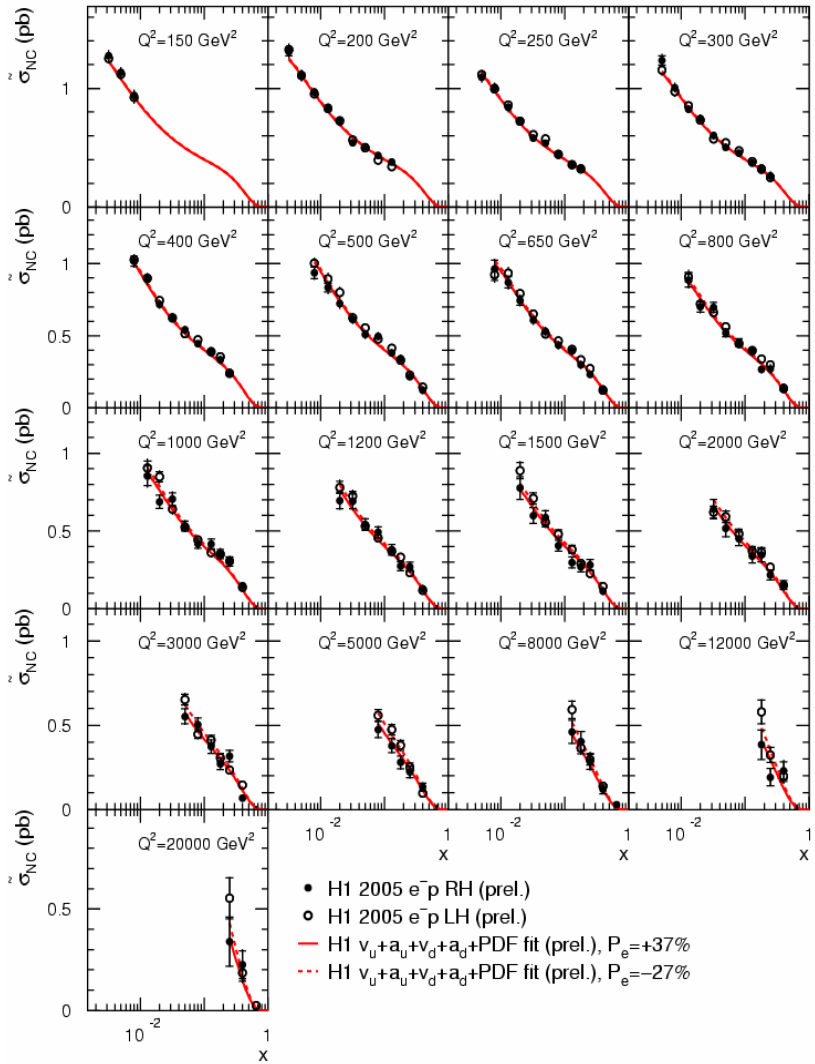


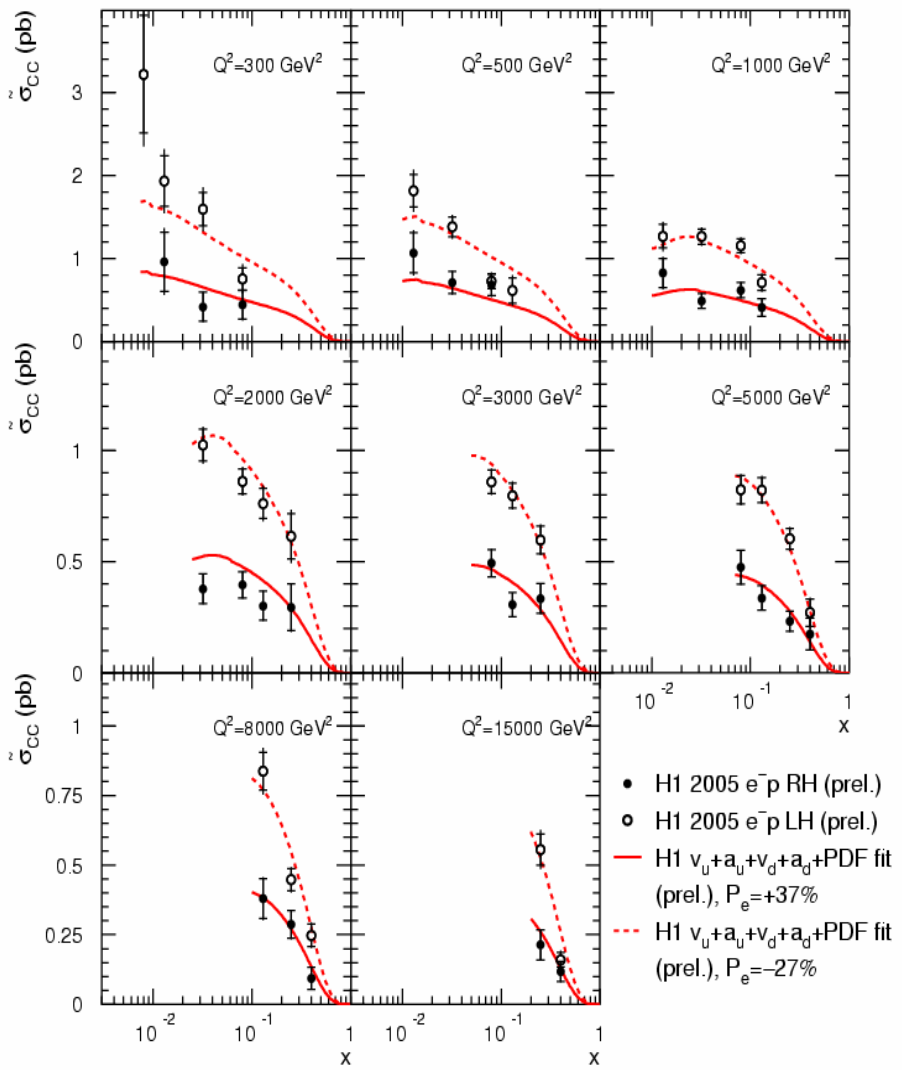
Fit Results



Better precision than Tevatron(CDF)

Comparison of fit with NC&CC data(e^-p)





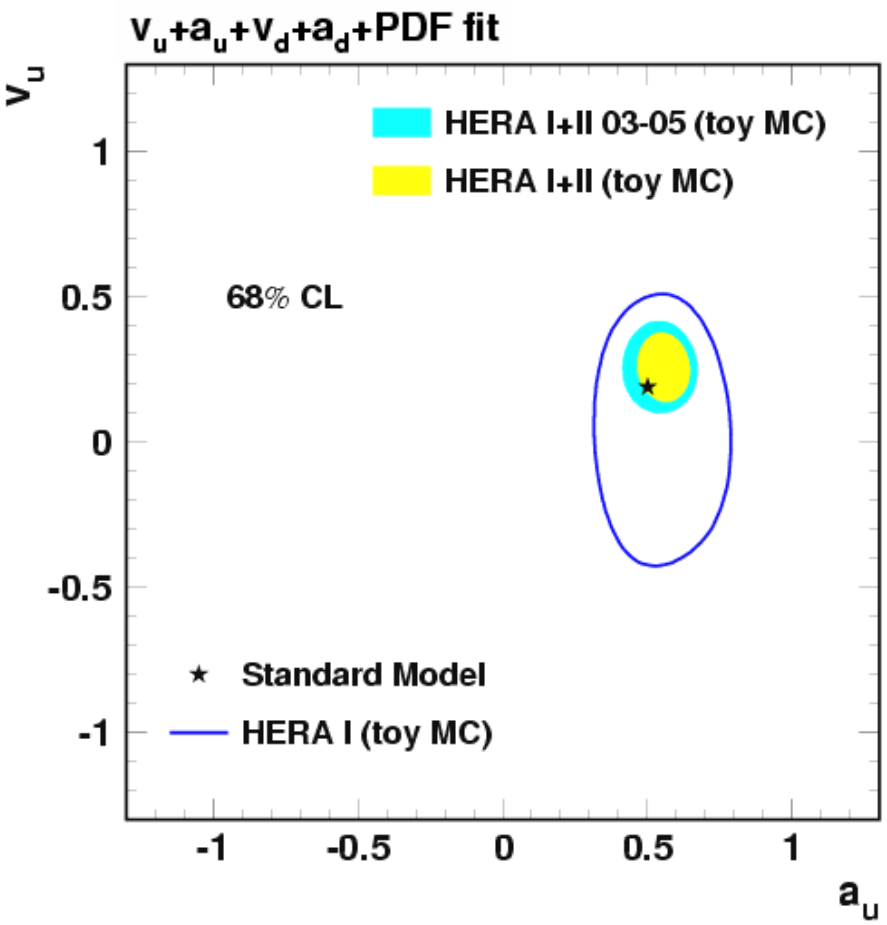
We have similar plot for e^+p

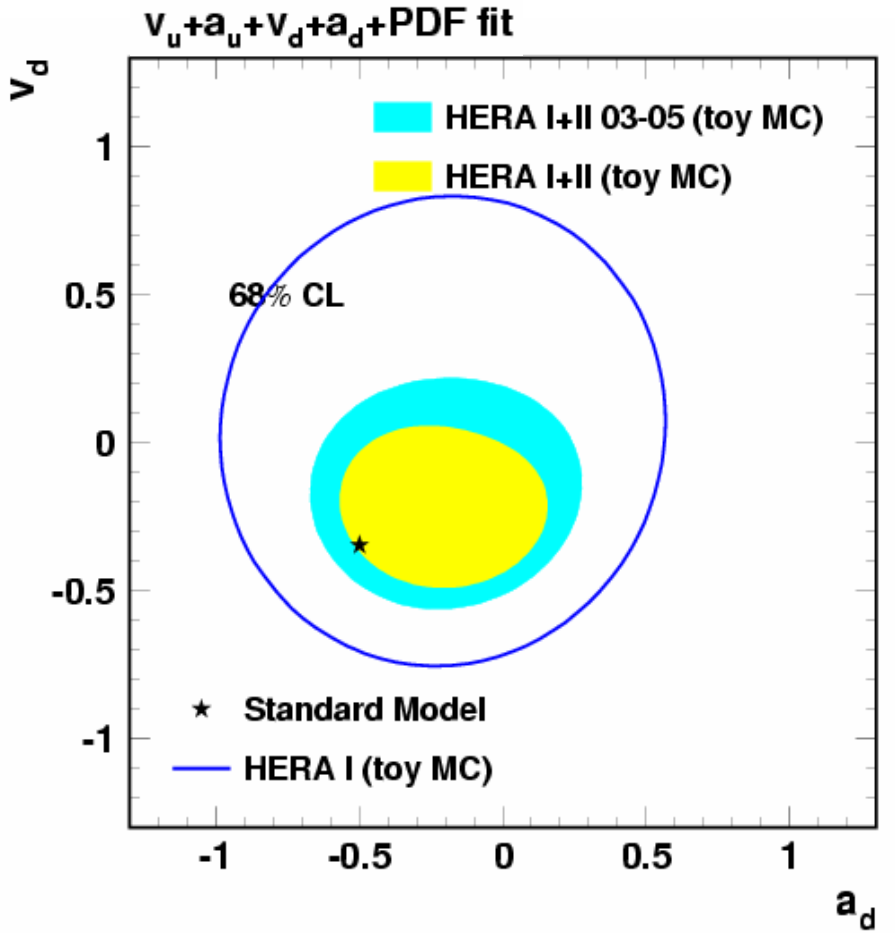
Summary & outlook

- Improved precision w.r.t. the published HERA-I fit (in particular for v_u)
- Better precision than Tevatron(CDF)
- Improved precision expected, both for PDFs and couplings with more low Q^2 precision data and full HERA-II high Q^2 data

Backup Slides

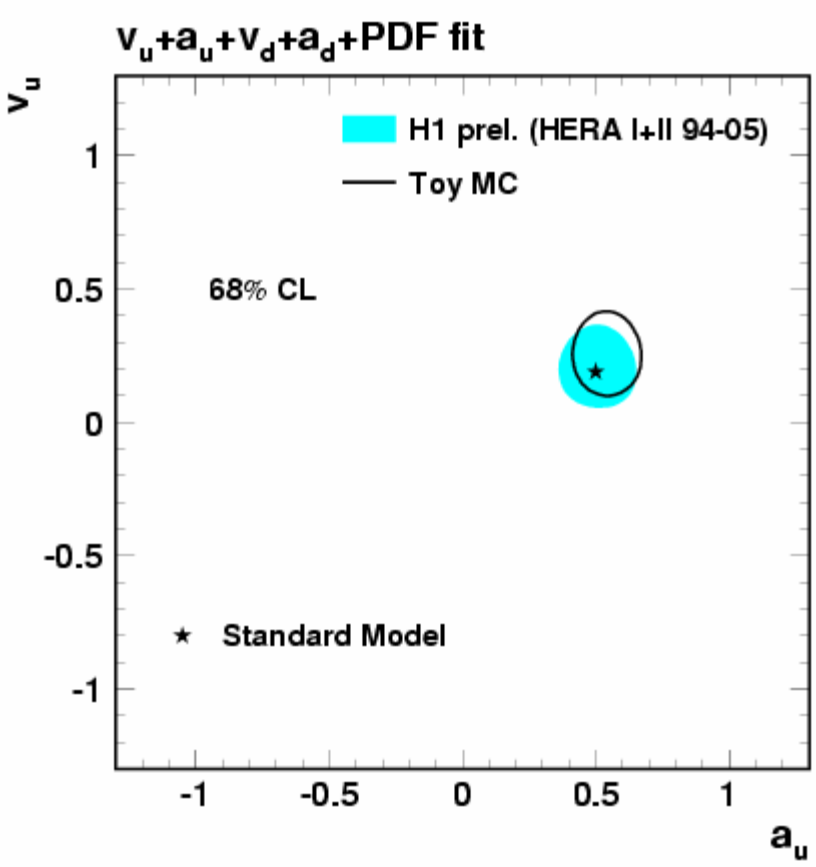
Expected sensitivity of polarization: Fit a_u-v_u-a_d-v_d-PDF (Toy MC Results)

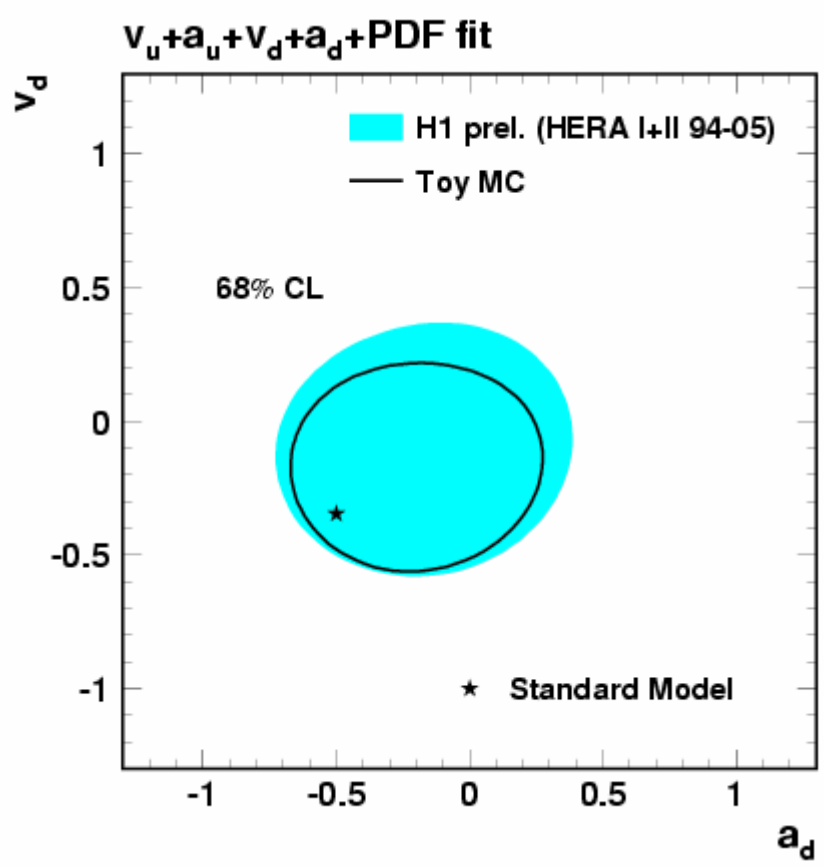




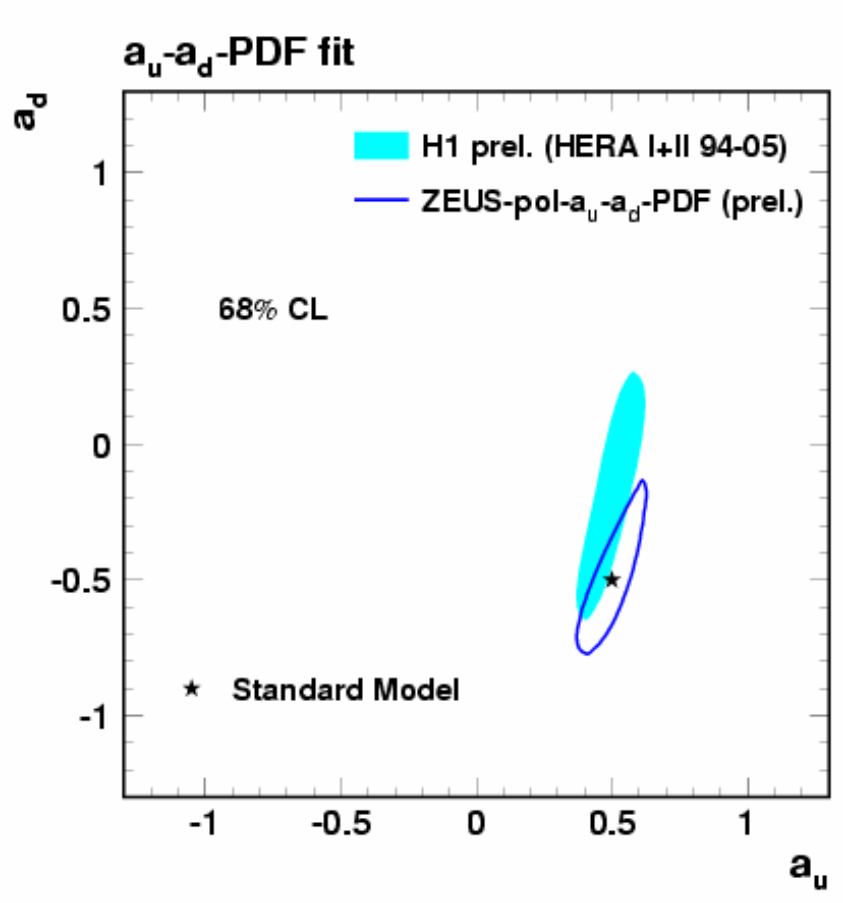
Additional improvements in precision expected with full HERA-II luminosity.

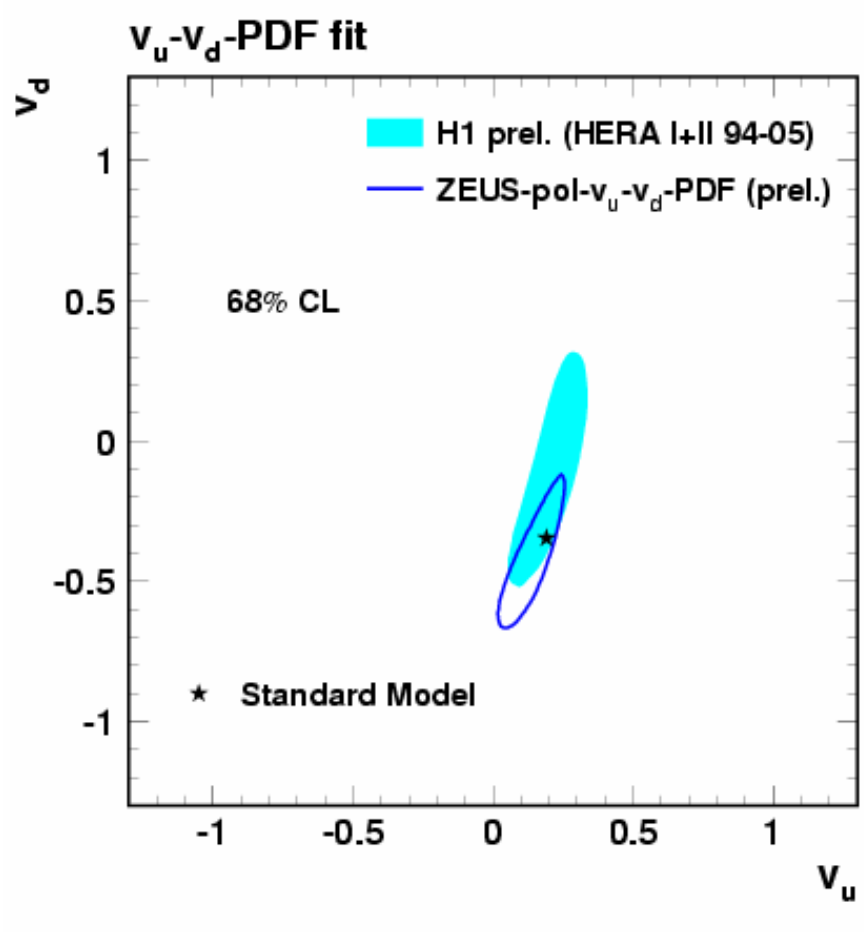
Comparison between Toy MC and HERA-II results





Fit Results: a or v coupling contours





Comparison of fit with NC&CC data(e^+p)