New Physics in Drell-Yan final states at the LHC and Parton distribution functions at medium-high x

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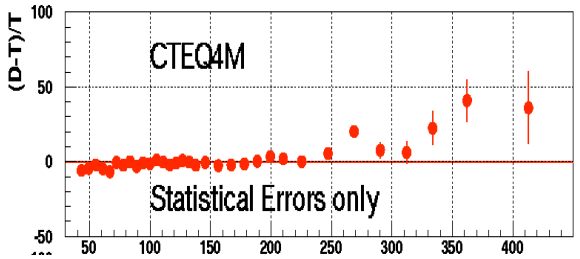
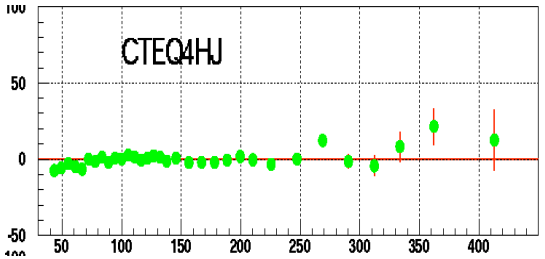
Remember the excess of high Et jets at CDF in 1995…



E_T jet (GeV)



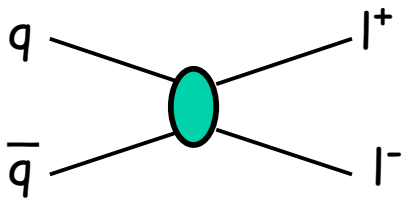
E_T jet (GeV)

→ Could different quark pdf's at medium-high x fake new physics in Drell-Yan final states at the LHC ?

→ Could LHeC data disentangle between both ?

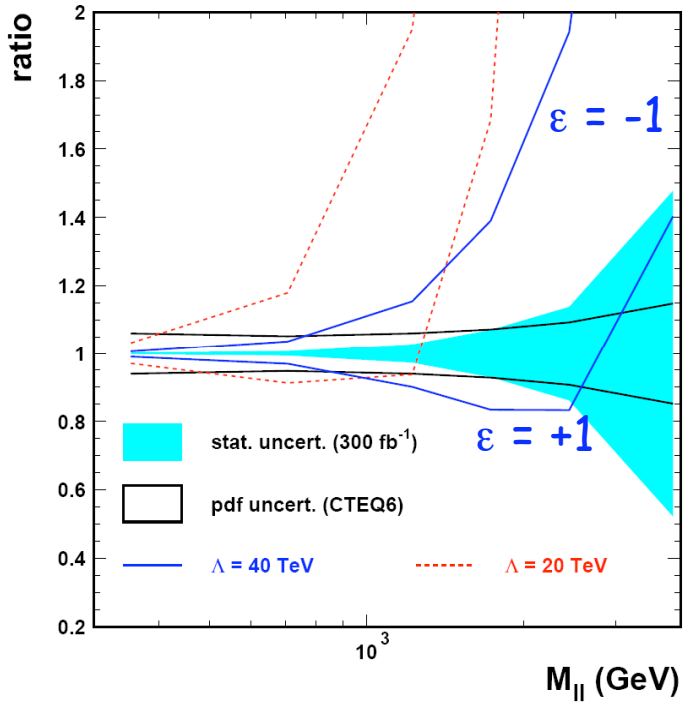
High Mass Drell-Yan at the LHC

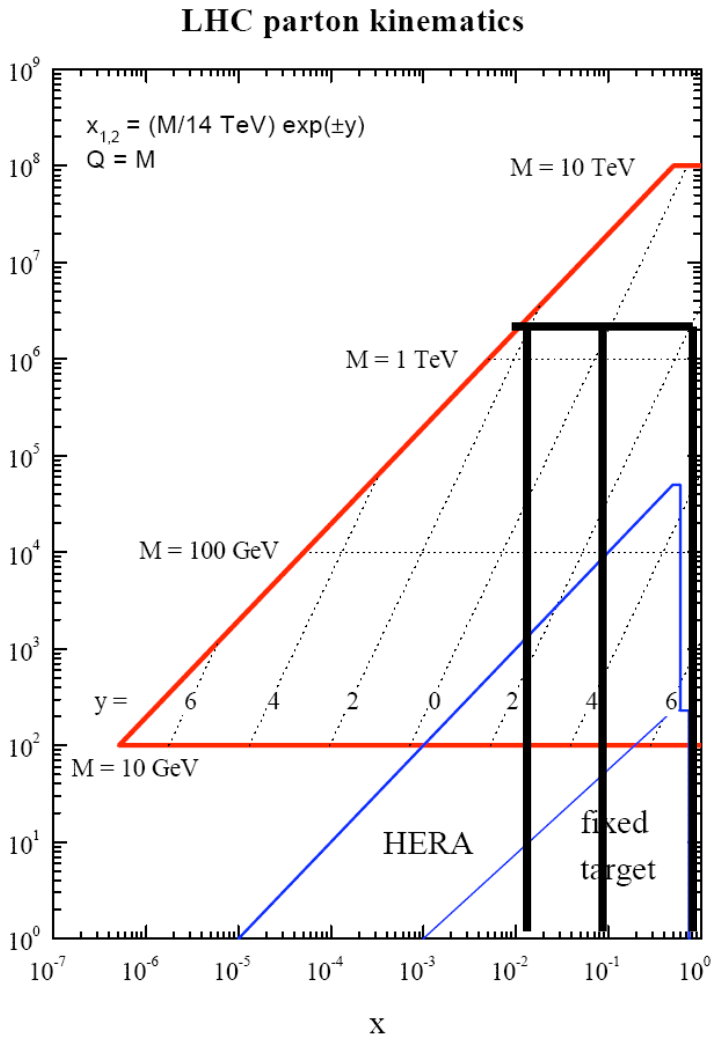
Drell-Yan with $M_{ll} \sim$ TeV involves quarks and antiquarks with $x_{Bj} \sim 0.1$



Generic approach for new physics in DY final states : contact interactions

$$\mathcal{L}_{CI} = \sum_{i,j=L,R} \varepsilon_{ij}^{eq} \frac{4\pi}{\Lambda^2} (\bar{e}_i \gamma^\mu e_i)(\bar{q}_j \gamma_\mu q_j)$$





Various models, look e.g. at "VV" model (parity-conserving).

$\varepsilon_{ij} = \pm 1$ for i,j = L,R

QCD fits and "pseudo-data"

- NLO, calculations with QCDNUM
- massless scheme
- H1 data as in H1pdf2k, BCDMS mu-p and mu-d data (combined energies)
- treatment of correlated systematic errors (a la CTEQ)
- param: g, u_{val}, d_{val}, ubar, dbar, $Q^2_0 = 1.9\ GeV^2$

"Reference" fit: to H1 and BCDMS data (SM fit, "pre-LHC").
$\chi 2 = 878$ for ndf = 948, i.e. $\chi 2$ /ndf = 0.92.

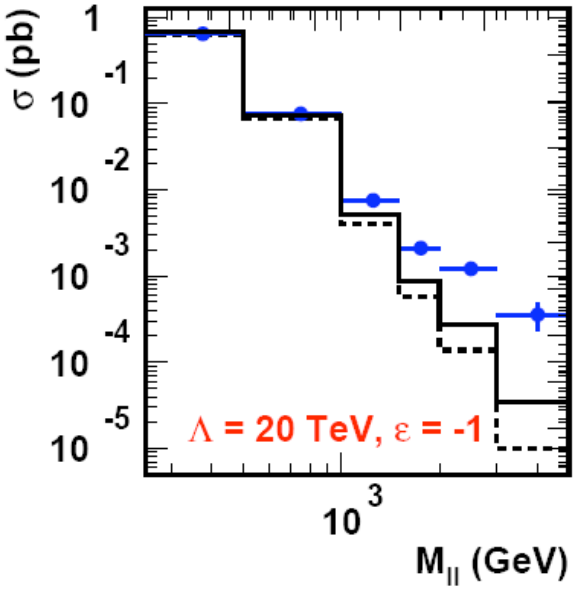
This is used to generate "pseudo-data" for Drell-Yan at LHC, under several new physics assumptions.
Cross-sections within mass bins, integrated over $|\eta_{\text{both leptons}}| < 2.4$.
Indicative (LO) cross-sections in the SM:

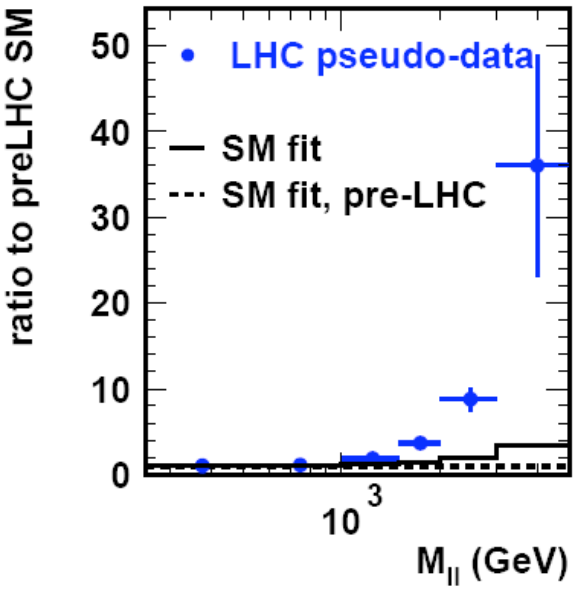
Mass bin [TeV]	0.25 – 0.5	0.5 - 1	1 - 1.5	1.5 - 2	2 - 3	3 - 5
σ [fb]	640	65	4	0.6	0.15	0.01
δ (%) for 300 fb-1	2	2	3.5	8	15	60

The "New Physics pseudo-data" are then included in the DGLAP fit (done assuming no new physics !)

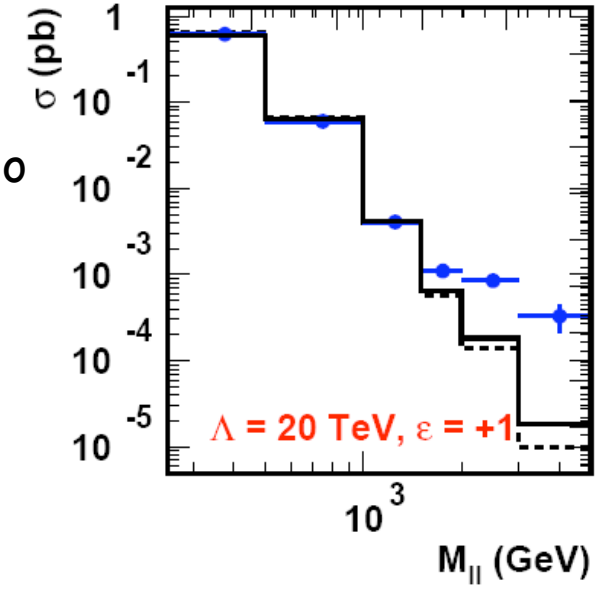
VV model, Λ = 20 TeV

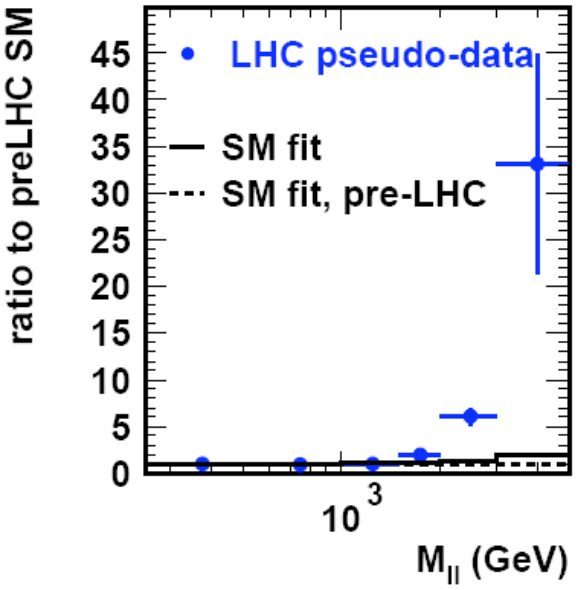
When including these pseudo-data in the fit:
- chi2 is bad
- and obviously the fit does not describe the DY data.





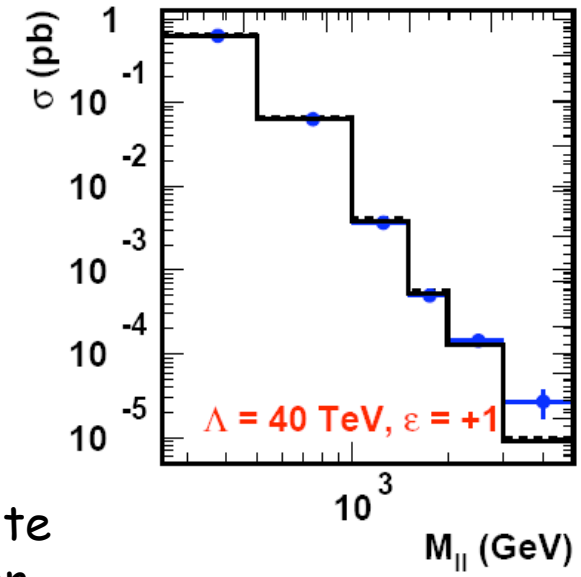
i.e. this scenario of NP can not be faked (easily) by DGLAP.
Its deviation from SM is too large.

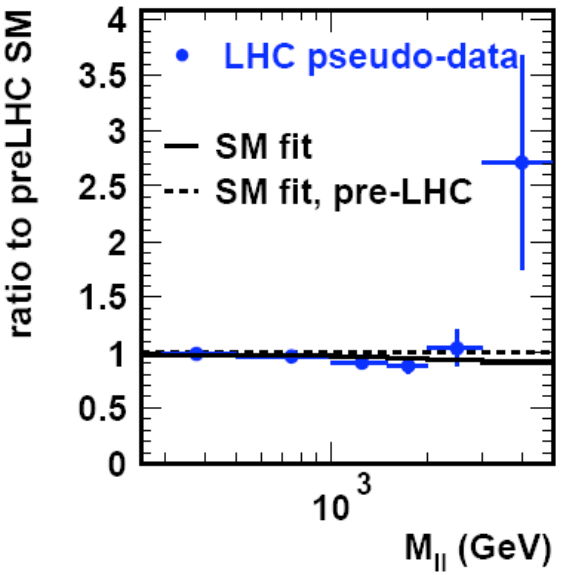




VV model, Λ = 40 TeV

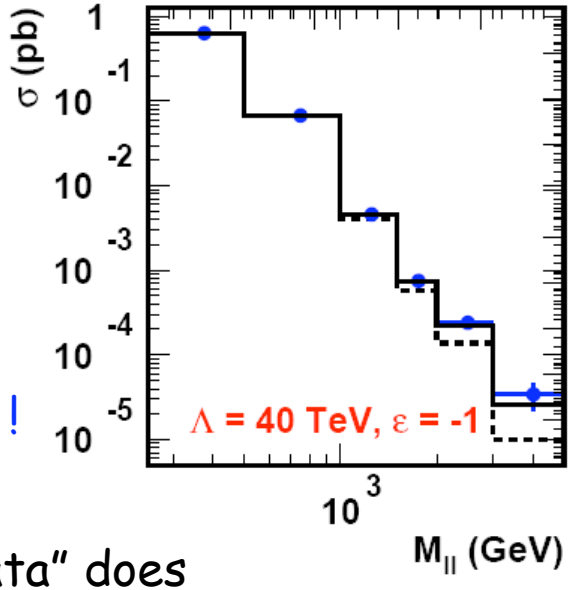
Scenario with ε = +1 does not differ much from SM.
(see also slide 3).

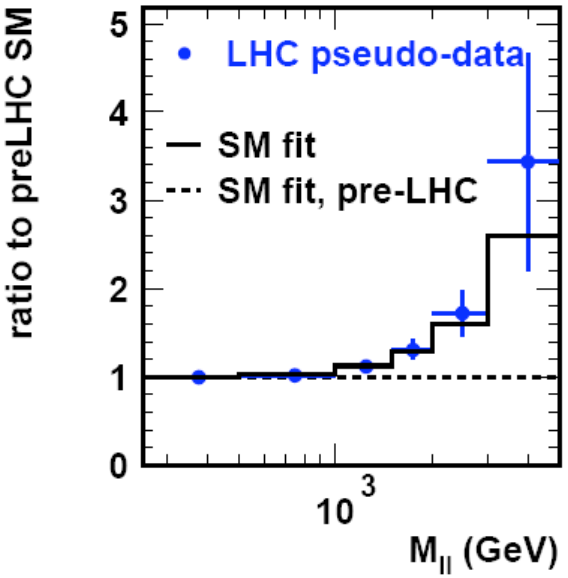




Scenario with ε = -1 looks quite different from SM, even when taking into account the stat. uncertainty of the data, and the pdf uncertainty of the SM prediction.

However, the effects of this scenario can easily be accommodated within DGLAP !





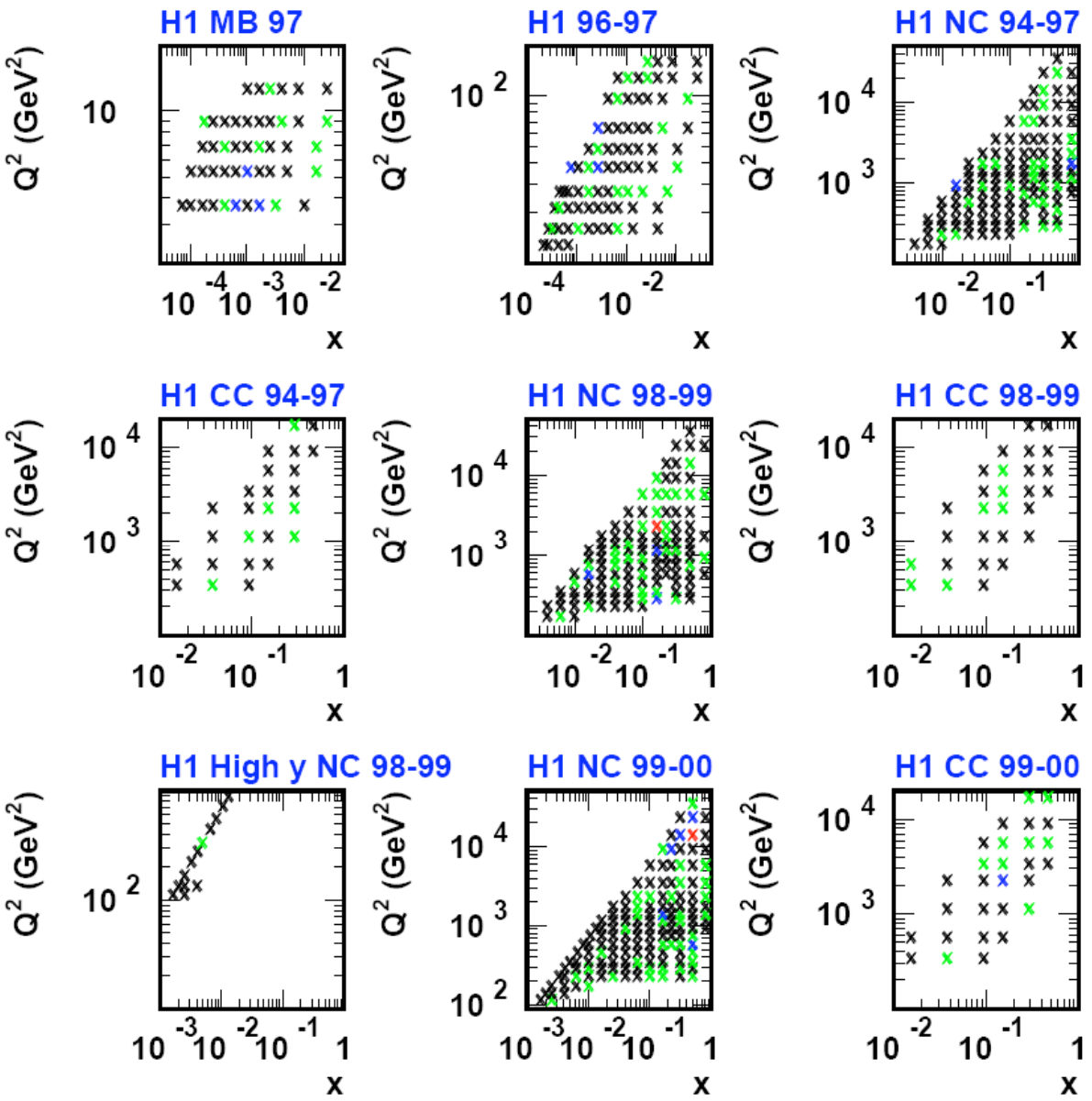
A fit including these LHC "data" does describe well all datasets ! $\chi 2$ / df = 0.93

How this fit describes the H1 data

| Pull |	color
< 1	black
1 – 2	green
2 – 3	blue
> 3	red

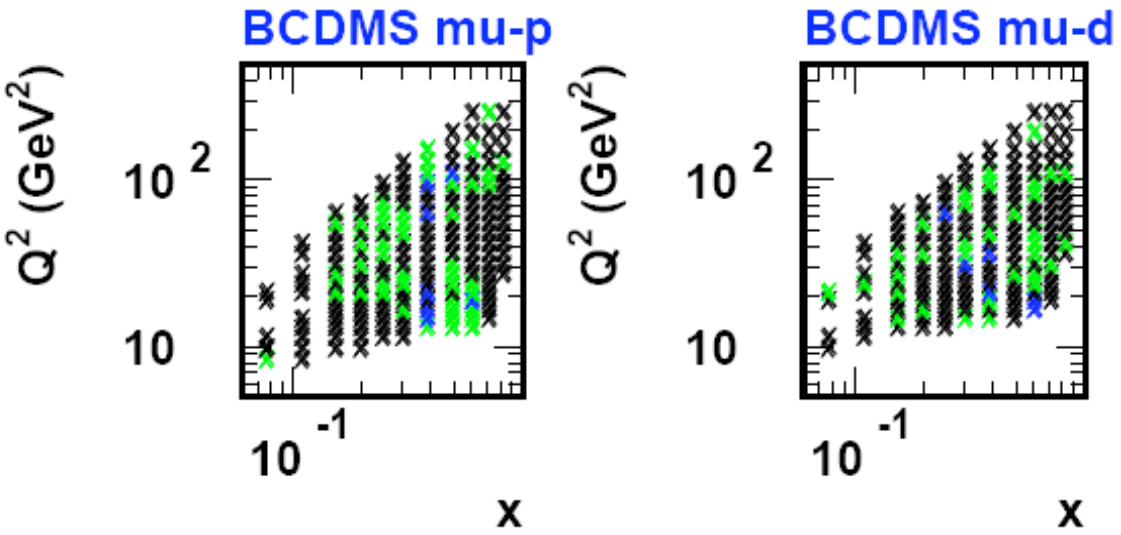
No accumulation of bad pulls at medium-high x.

Dataset	χ^2	N_{points}
MB 97	44.2	45
96-97	74.3	80
NC 94-97	95.2	130
CC 94-97	22.7	25
NC 98-99	115.8	126
CC 98-99	17.4	28
NC 98-99, HY	5.1	13
NC 99-00	148.0	147
CC 99-00	30.8	28



How this fit describes the BCDMS data

| Pull |	color
< 1	black
1 – 2	green
2 – 3	blue
> 3	red



Dataset	χ^2	N_{points}
μp	158.7	178
μd	146.5	159

Overall χ^2 to the H1 & BCDMS data greater than that of reference fit by ~ 7 units.

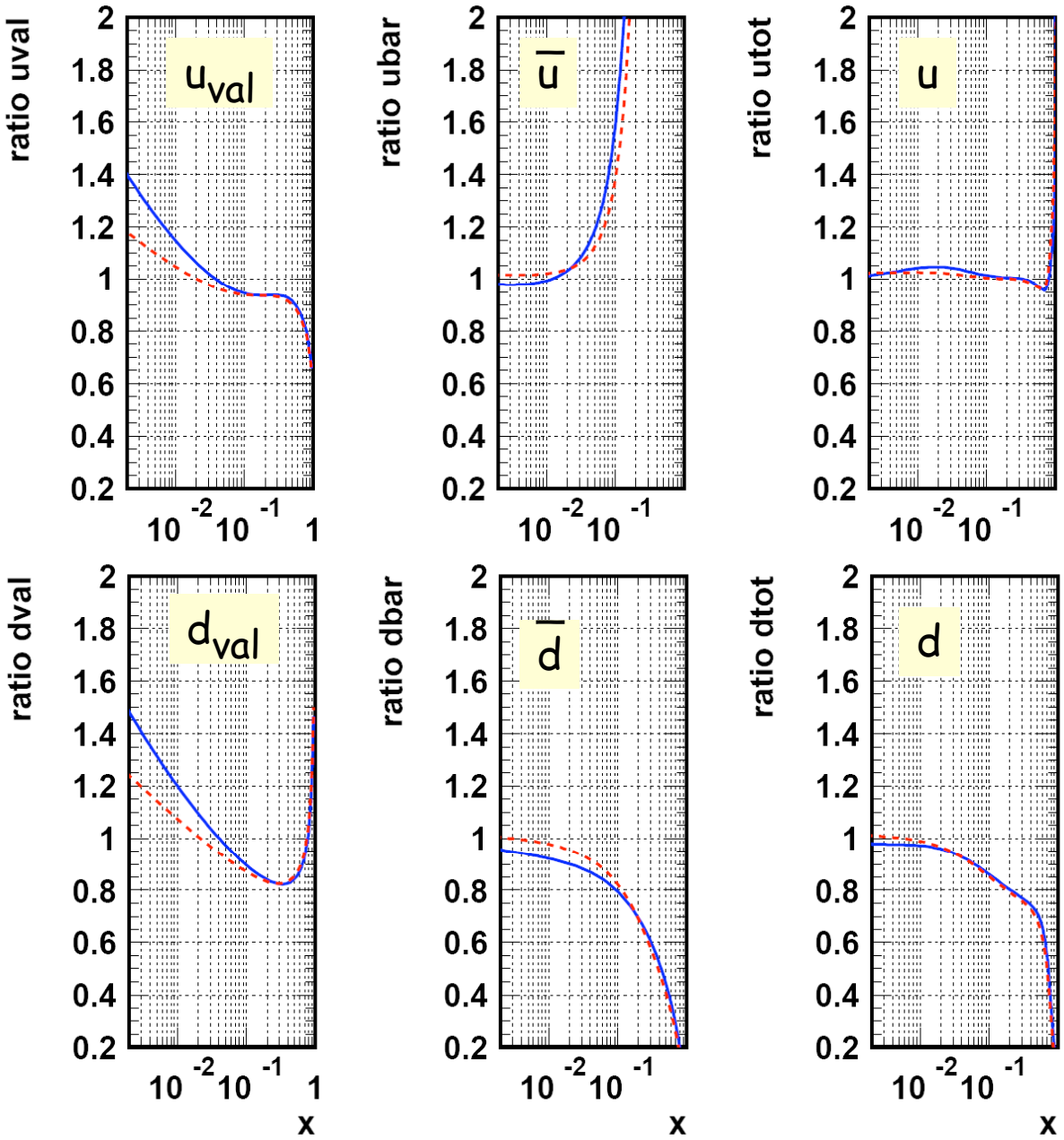
How does this fit compare with the "reference"

The plots show the ratios to the "reference" fit.

—— $Q^2 = 4\ GeV^2$

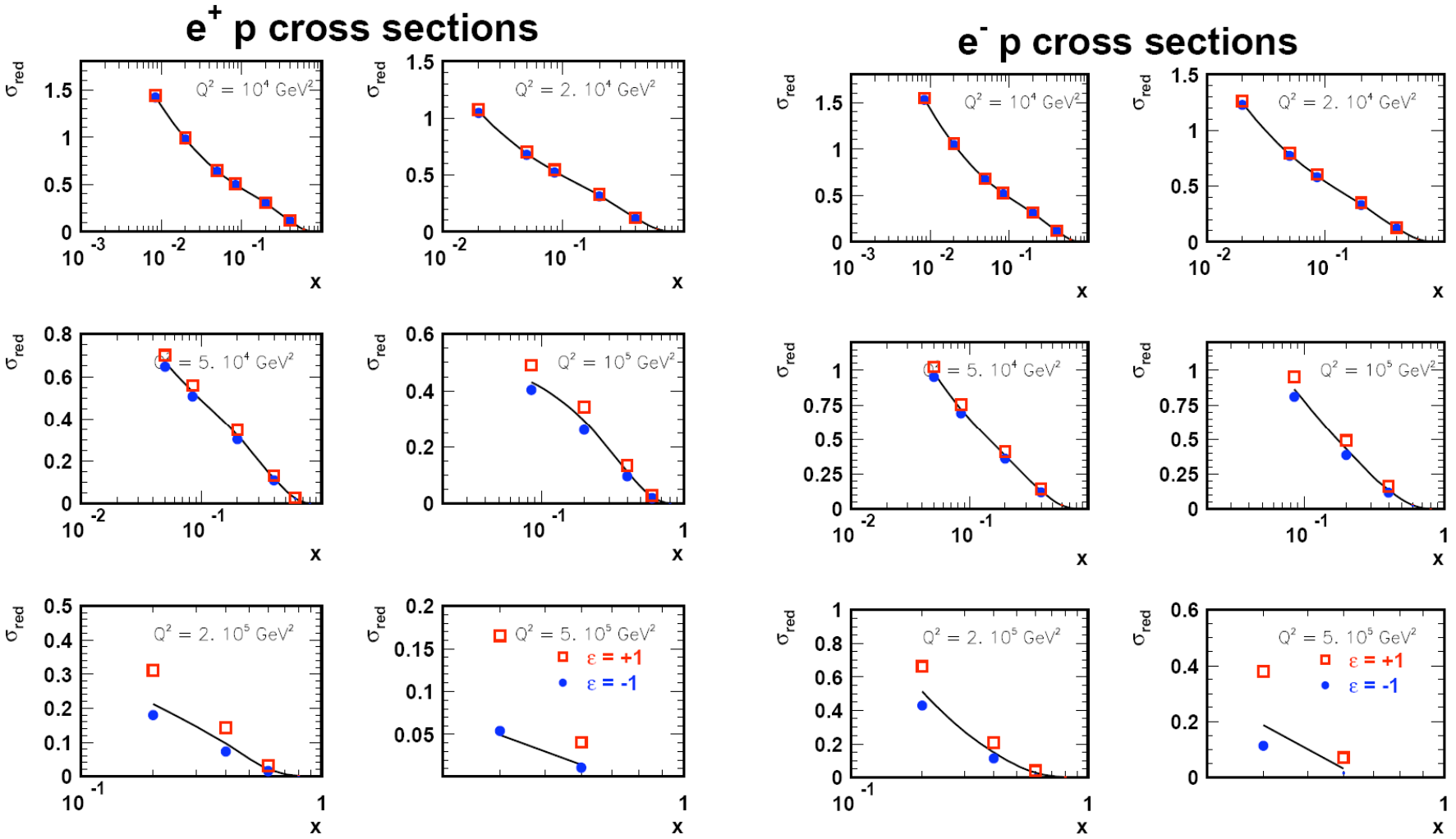
– – $Q^2 = 10000\ GeV^2$

In the "region of interest", x ~ 0.1, the fit including the LHC NP-data mainly changes the antiquarks.



What would LHeC bring us

Blue & red data points = NP scenario (Λ = 40 TeV)
Black curve = SM cross-sections



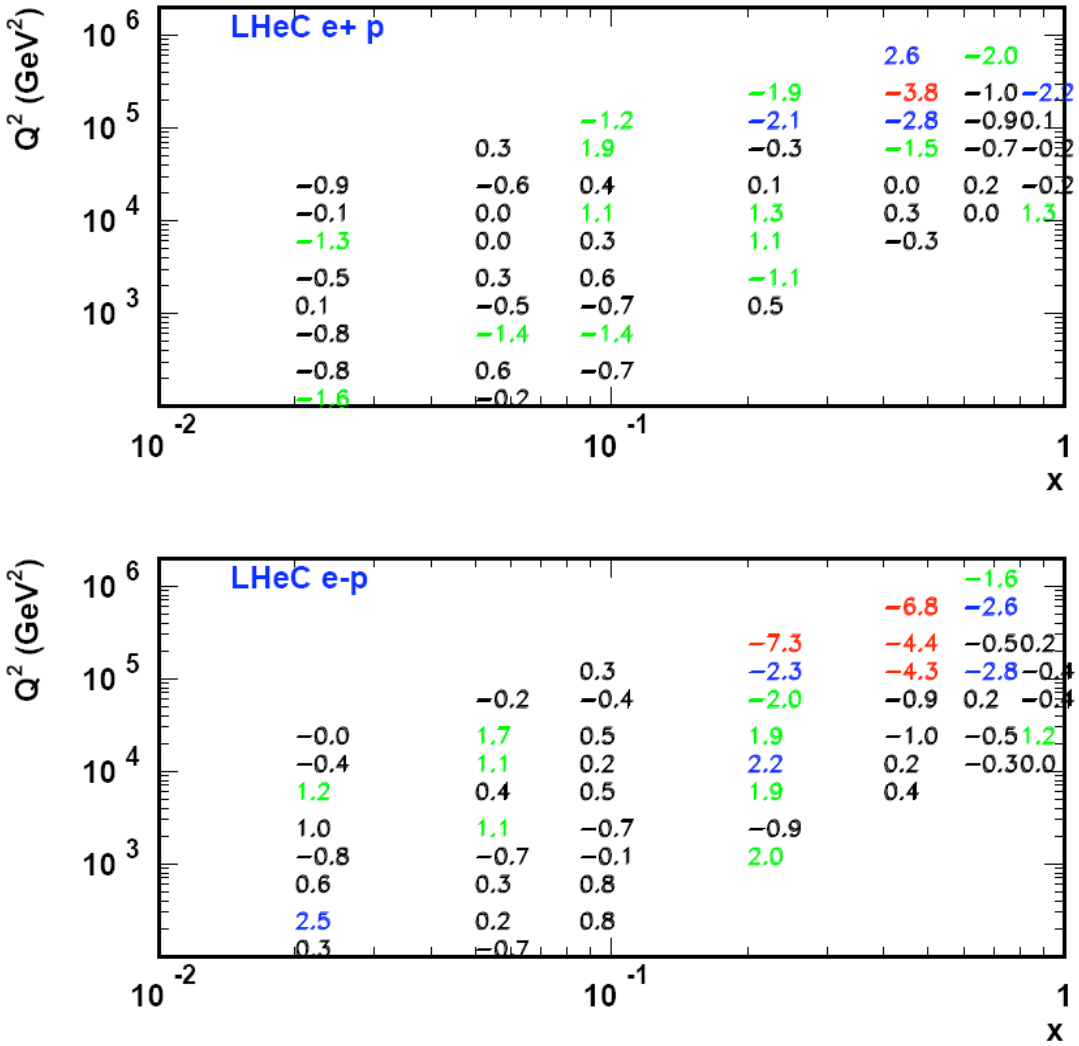
σ(e+ p) or σ(e- p) significantly affected by NP. Note that this is DIS, i.e. largest contribution comes from the u quark at x ~ 0.1 (and not the anti-u !)

DGLAP fit including LHeC DIS data (Λ = 40 TeV, ε = -1)

$\chi 2$ / df = 1.13

Dataset	$\chi 2$	N_{points}
MB 97	40.3	45
96-97	75.5	80
NC 94-97	95.2	130
CC 94-97	26.6	25
NC 98-99	112.2	126
CC 98-99	18.2	28
NC 98-99, HY	5.0	13
NC 99-00	142.7	147
CC 99-00	49.0	28
BCDMS p	145.1	134
BCDMS n	154.6	159
LHeC e+	145.1	134
LHeC e-	295.7	135

The combined fit does not describe the LHeC data.



i.e. LHeC data would disentangle between the example NP scenario and different pdfs.