
Workshop on ATLAS PDFs
Dubna, 9/10.9.2010
Max Klein, U Liverpool
WZ Meeting, CERN,30.9.10
Laboratory of Nuclear Problems (LJAP)

Three Main Topics

Data

Matthias Schott: W,Z (muons)

Jan Kretzschmar: W, W/Z (electrons)

Frank Ellinghaus: Z moving forward (e)

Elisa Piccaro: Low mass DY (di-muons)

PDF´s

Max Klein: Quark flavour sensitivity

Mandy C-Sarkar: HERA+ATLAS fits

Voica Radescu: HERA+ATLAS fits

Joey Huston: CTEQ and pdf4lhc

Eram Rizvi: Drell Yan QCD Fits

Techniques

Sasha Glazov: From data to fits..

Sasha Glazov: Combination package

Dima Bardin: Weak and FSR Corr's

Voica Radescu: H1fit methods

Mandy C-Sarkar: ZEUSfit methods

Uta Klein: NLO MC's and Acc

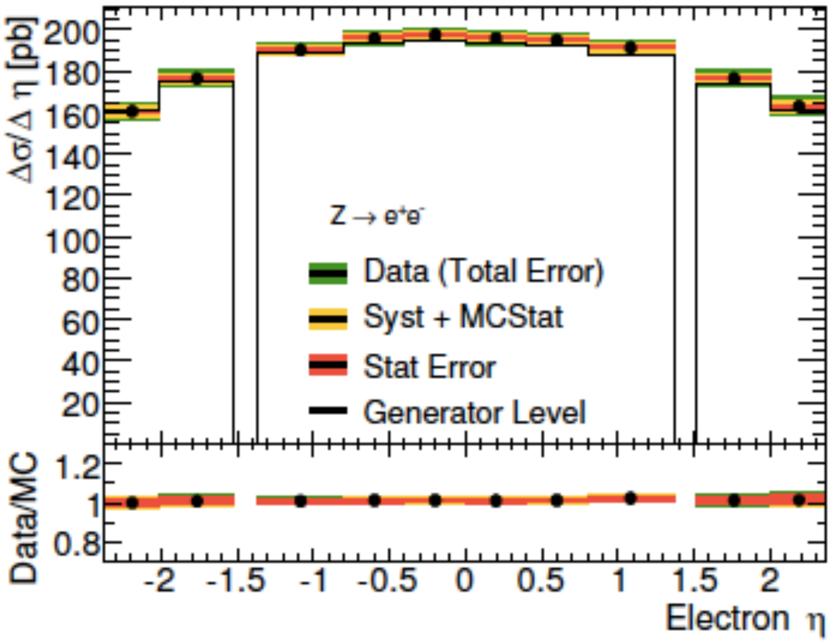
Mark Sutton: APPL Grid

Eram Rizvi: Low mass DY code

Andrey Arbuzov: FSR

Organised by UTA+SASHA with help from Dima, Karsten, Maarten, Matthias, Max and ANDREY SAPRONOV and friends

Expected Accuracy of $\Delta\sigma/\Delta\eta_e$ in Z→ ee



Statistical error:1.2% in 5 bins
for 200pb^{-1} at 10 TeV

Expect ~5% for 10pb^{-1} at 7 TeV

→ maximum 2010 Z statistics very desirable to match the systematic uncertainty of possibly about 2%

Table 17: Single differential cross section of $Z \rightarrow e^+e^-$ as function of η_e of e^-.

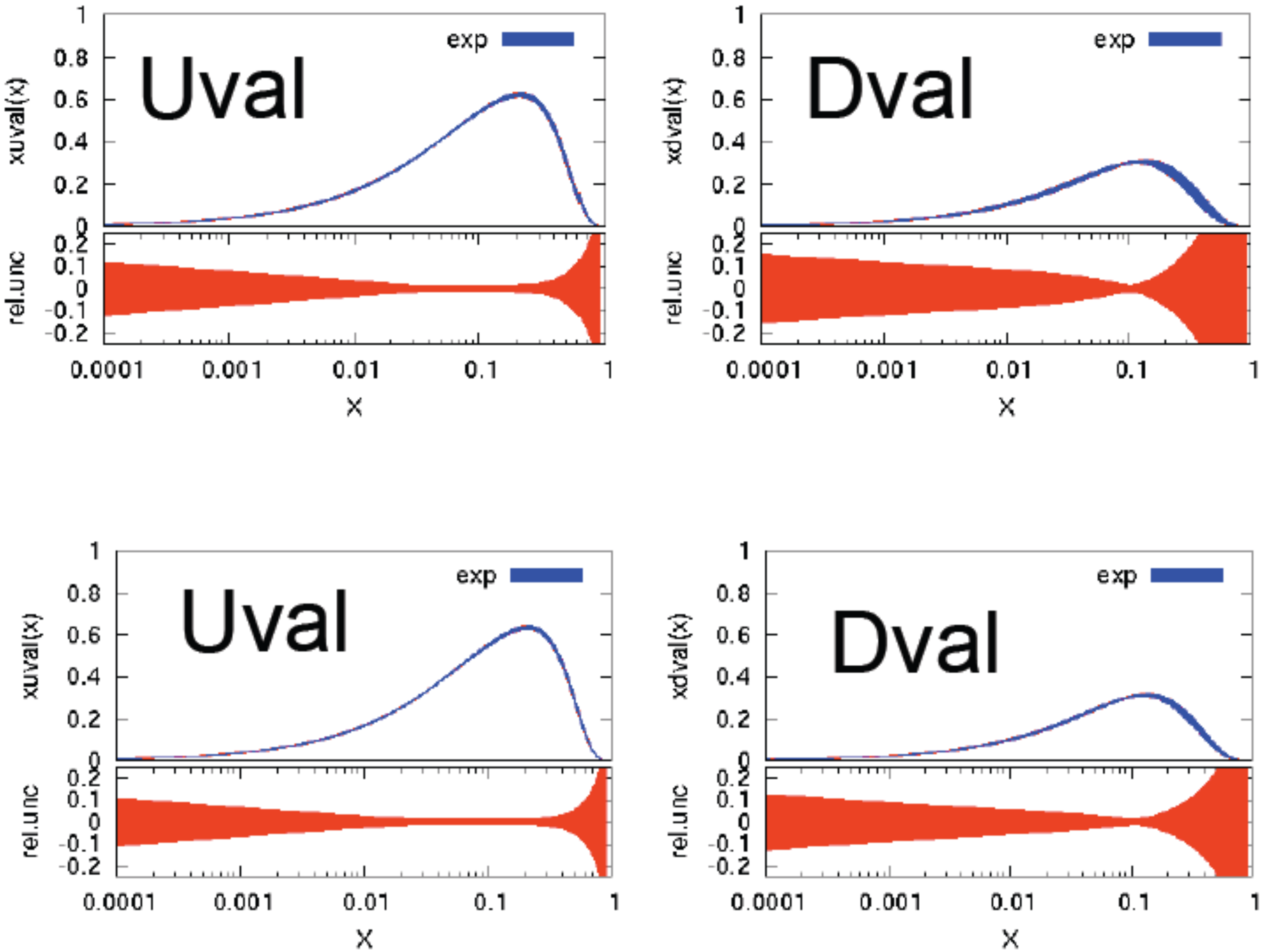
η_e^l	η_e^h	σ	δ_{tot}	δ_{sta}	δ_{MCsta}	δ_{sys}	δ_{EE}	δ_{EEN1}	δ_{EEU}	δ_{ERecU}	δ_{EIdU}	δ_{ETrU}	δ_{ERecC}	δ_{EIdC}	δ_{ETrC}	δ_{RE}	δ_{RR}	δ_{Eth}	δ_{EChg}	δ_{QCD}
−2.37	−2.01	160.6	2.85	1.80	0.48	2.15	0.29	−0.48	0.03	0.60	0.47	0.00	0.35	0.57	0.00	0.00	0.00	−0.55	−1.70	0.30
−2.01	−1.52	176.3	2.33	1.43	0.40	1.79	0.19	−0.39	0.03	0.39	0.34	0.00	0.29	0.48	0.00	0.00	0.00	−0.37	−1.44	0.45
−1.37	−0.80	190.2	1.74	1.07	0.37	1.33	0.17	−0.31	0.02	0.27	0.28	0.00	0.18	0.48	0.00	0.00	0.00	−0.17	−0.78	0.78
−0.80	−0.40	196.0	1.73	1.17	0.68	1.08	0.13	−0.25	0.02	0.25	0.26	0.00	0.14	0.47	0.00	0.00	0.00	−0.10	−0.73	0.44
−0.40	0.00	197.6	1.52	1.14	0.34	0.95	0.11	−0.22	0.01	0.21	0.24	0.00	0.12	0.41	0.00	0.00	0.00	−0.06	−0.73	0.19
0.00	0.40	196.0	1.52	1.14	0.34	0.95	0.11	−0.22	0.01	0.21	0.24	0.00	0.12	0.40	0.00	0.00	0.00	0.07	−0.73	0.19
0.40	0.80	195.0	1.73	1.17	0.68	1.08	0.13	−0.24	0.02	0.25	0.25	0.00	0.14	0.47	0.00	0.00	0.00	0.07	−0.72	0.44
0.80	1.37	191.4	1.75	1.07	0.37	1.33	0.18	−0.31	0.02	0.26	0.28	0.00	0.18	0.49	0.00	0.00	0.00	0.17	−0.77	0.78
1.52	2.01	176.3	2.30	1.43	0.40	1.75	0.19	−0.35	0.03	0.39	0.34	0.00	0.30	0.49	0.00	0.00	0.00	0.38	−1.40	0.45
2.01	2.37	162.9	2.82	1.81	0.48	2.12	0.24	−0.44	0.05	0.60	0.47	0.00	0.36	0.58	0.00	0.00	0.00	0.59	−1.66	0.30

ATL-COM-PHYS-2010-325 (“ELAN” Note → INT) Talk of Jan

Impact of Z Rapidity Measurement on pdf's

Fit to HERA I (top) and HERA+ATLAS (bottom)

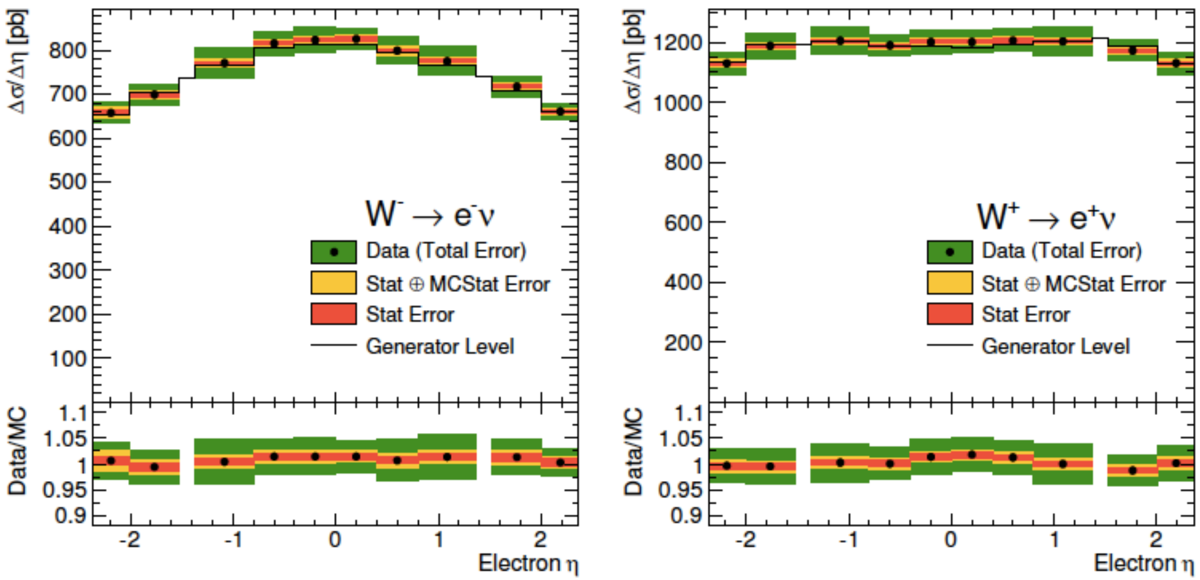
using only simulated y_Z data and 11% δL



Some gain only in valence quarks from Z precision measurement

Talk of Voica

Expected Accuracy of $\Delta\sigma/\Delta\eta_e$ in $W \rightarrow e\nu$



Statistical error: 0.5% in 5 bins
for 200pb^{-1} at 10 TeV

Expect ~1-2% for 10pb^{-1} at 7 TeV

Systematic accuracy about 3%

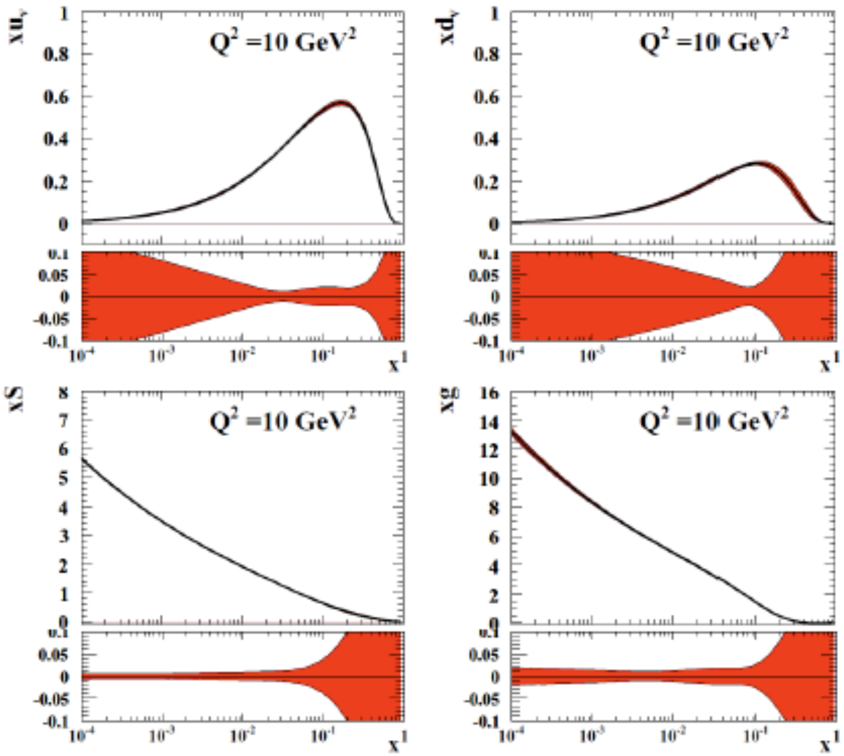
Table 23: Single differential cross section of $W \rightarrow e\nu$ as function of η_e.

η_e^l	η_e^h	σ	δ_{tot}	δ_{sta}	δ_{MCsta}	δ_{sys}	δ_{EE}	δ_{EENl}	δ_{EEU}	δ_{ERecU}	δ_{EIdU}	δ_{ETrU}	δ_{ERecC}	δ_{EIdC}	δ_{ETrC}	δ_{RE}	δ_{RR}	δ_{Eth}	δ_{EChg}	δ_{QCD}	$\delta_{W\tau}$	$\delta_{t\bar{t}}$
−2.37	−2.01	1789	3.01	0.43	0.88	2.85	1.37	−0.75	0.21	0.56	0.37	0.13	0.16	0.17	0.26	−1.31	0.99	−1.08	0.00	1.09	0.09	0.05
−2.01	−1.52	1888	3.25	0.38	0.73	3.14	1.39	−0.75	0.23	0.38	0.40	0.09	0.13	0.11	0.37	−1.13	1.00	−0.76	0.00	2.03	0.09	0.09
−1.37	−0.80	1977	3.88	0.32	0.67	3.80	1.48	−0.83	0.19	0.26	0.30	0.04	0.06	0.12	0.00	−1.04	1.15	−0.30	0.00	2.97	0.09	0.15
−0.80	−0.40	2007	3.05	0.36	0.60	2.97	1.44	−0.85	0.20	0.26	0.29	0.05	0.04	0.14	0.00	−1.37	1.38	−0.13	0.00	1.42	0.09	0.18
−0.40	0.00	2025	3.36	0.35	0.64	3.28	1.43	−0.80	0.16	0.19	0.25	0.07	0.02	0.08	0.00	−1.49	1.46	−0.07	0.00	1.90	0.09	0.19
0.00	0.40	2028	2.97	0.35	0.55	2.90	1.42	−0.78	0.13	0.19	0.25	0.07	0.02	0.08	0.00	−1.40	1.43	0.10	0.00	1.25	0.09	0.19
0.40	0.80	2005	3.32	0.36	0.69	3.23	1.44	−0.77	0.18	0.26	0.29	0.05	0.04	0.14	0.00	−1.43	1.14	0.10	0.00	2.06	0.09	0.18
0.80	1.37	1979	3.89	0.32	0.67	3.82	1.48	−0.82	0.16	0.26	0.29	0.04	0.06	0.12	0.00	−1.13	1.17	0.30	0.00	2.98	0.08	0.15
1.52	2.01	1892	2.97	0.38	0.68	2.86	1.34	−0.75	0.19	0.38	0.40	0.09	0.13	0.11	0.36	−1.08	0.78	0.72	0.00	1.78	0.09	0.09
2.01	2.37	1793	2.87	0.43	0.60	2.77	1.39	−0.79	0.21	0.55	0.37	0.13	0.16	0.17	0.26	−1.23	1.18	1.22	0.00	0.31	0.10	0.05

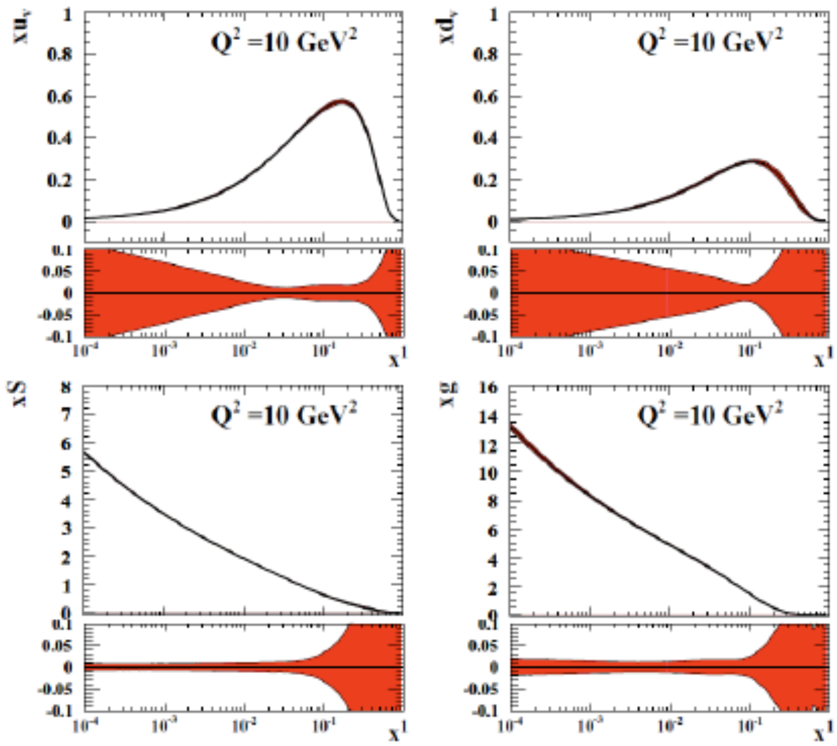
ATL-COM-PHYS-2010-325 ("ELAN" Note → INT) Talk of Jan

Impact of W and Z Measurement on pdf's

HERA (I) only



HERA+ATLAS



The sea and the gluon are rather fixed by HERA [F_2, $dF_2/d\ln Q^2$], the low x valence not

Talk of Mandy

Therefore:
Given the high precision of the HERA data (I … II) and the evolution effects it is extremely challenging to significantly improve the pdf knowledge - within the canonical assumptions:

QCD Fit Assumptions on HERA pdf's

Require **ū=đ** at low x (only constraint is HERA $F_2^p = 2x[4\bar{u}+\bar{d}+..]$) At larger x ~ 0.1 they differ (Exxx)

Valence quarks: x^B : $B_u = B_d$

Charm is generated dynamically. Usually $Q_0^2 > m_c^2$. Some 5-10% constraints from F_2^{cc} at H1/ZEUS

Beauty is generated dynamically above threshold and ~20% constraints from F_2^{bb} at H1/ZEUS

The high x region is not too well constrained (too low HERA luminosity, nuclear corrections), which results in larger pdf uncertainties at high x (large |rapidity|).

A stranger is the **strange quark distribution**. Some hints for s ≠ sbar. Some constraints from K, Φ.

Many of these assumptions may be challenged with precision W,Z measurements: W is flavour sensitive as CC, Z is not photon exchange, low mass DY is like F_2

Some Expectations

Constrain up and down sea quarks from W,Z ratios:

Change of đ [≠ ū] by 50% gives 10% in W^+/W^-

Largely dissident behaviour may be constrained already with Z (y,M)

in HERAdis the disappearance of d leads to 10%
reduced Z cross section due to NC Z weights

Strange quark distribution

50% change of s yields 10% difference in W cross sections

Learn about valence quarks from charge asymmetry

if d_v at x=0.01 is down by factor 2, W- is down by 6%

Summary slide from Max

Releasing+Restoring Sea Quark Symmetry

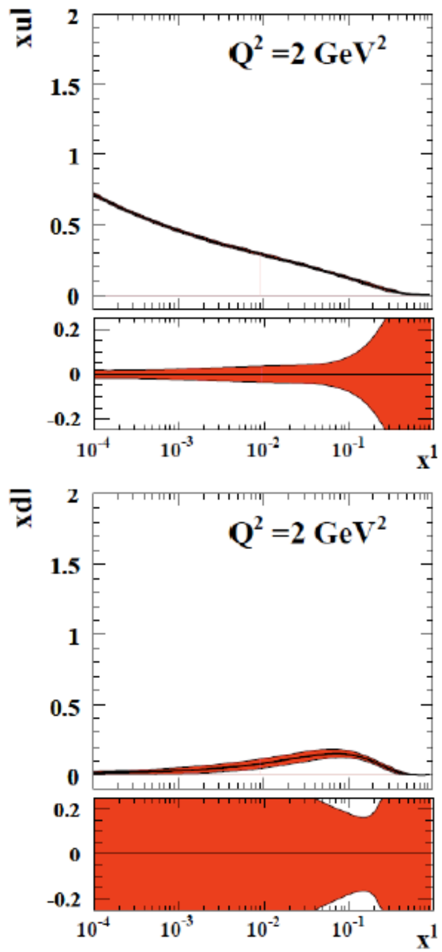
HERAdis:

Cf ELAN Note

Allow different
up and down sea

With HERA I data
anti-d disappeared
at small x, and
anti-u increased

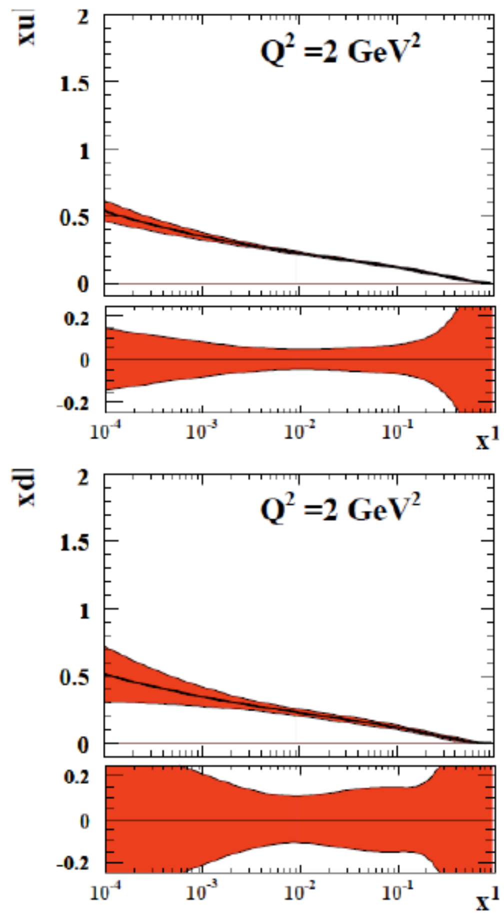
and the uncertainties
increased.



HERAdis+ATLAS:

W, Z data
[from 325 note]

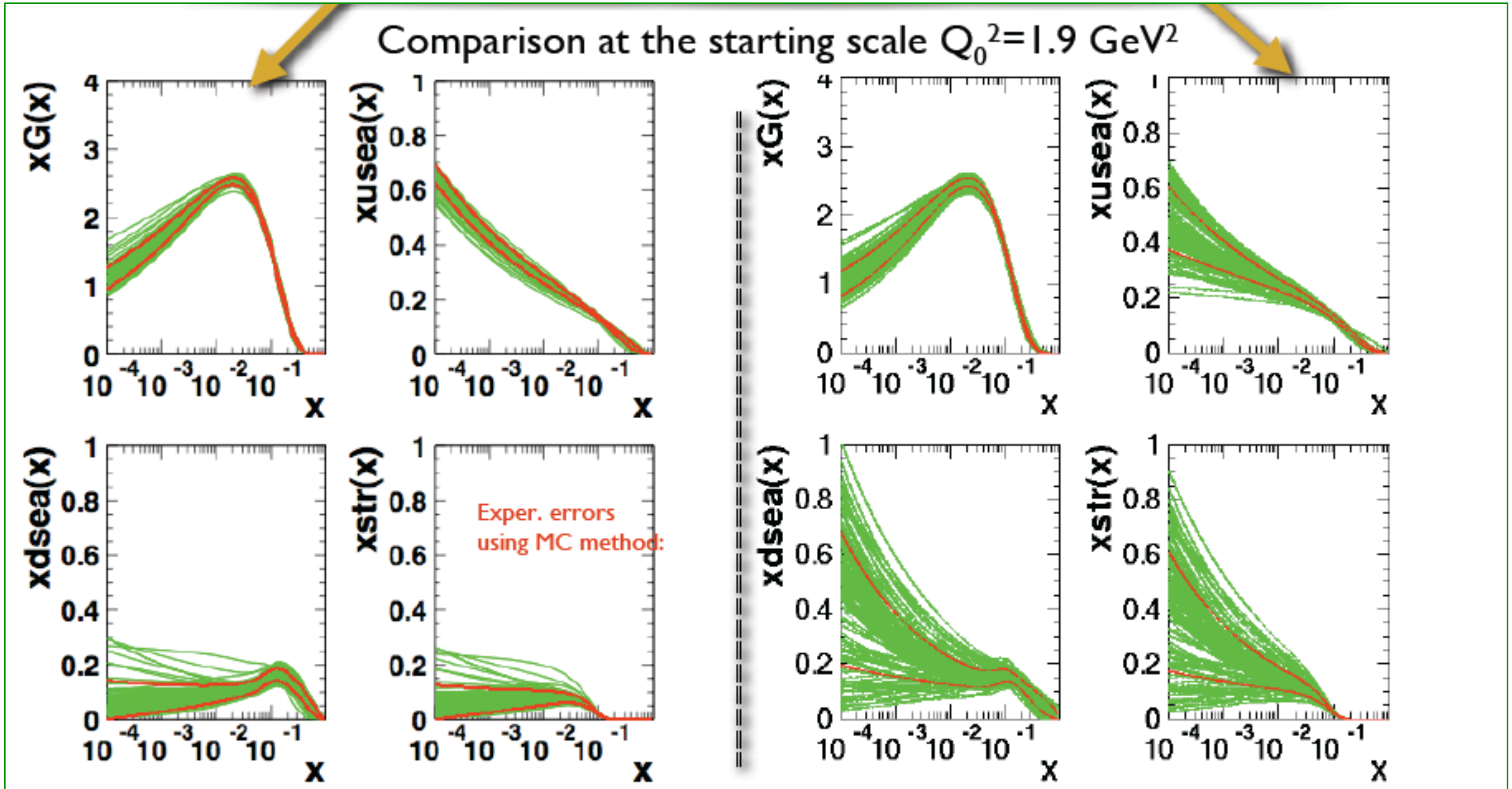
restore sea
quark symmetry
which was
assumed to hold
in the
DY simulation



Talk of Mandy

HERAdis*) Updated

HERA I　　　　HERA I+II

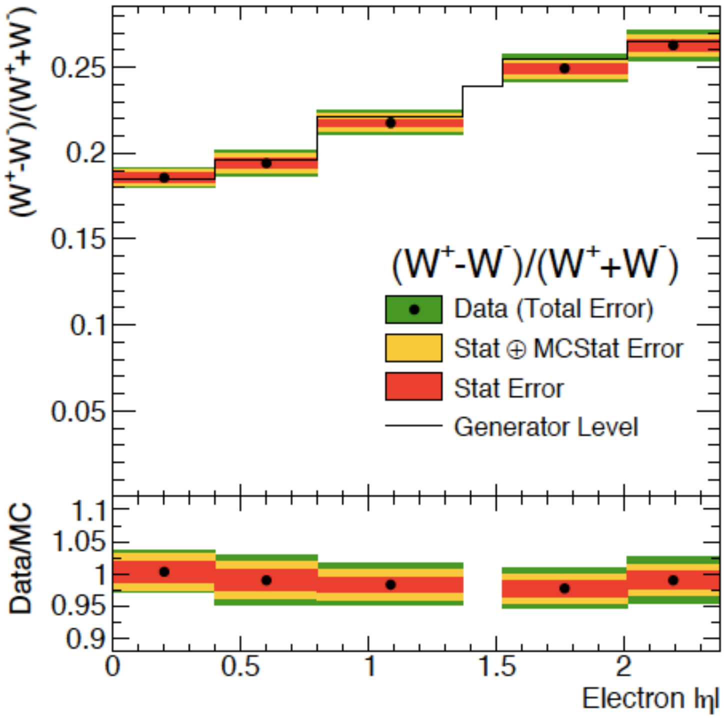


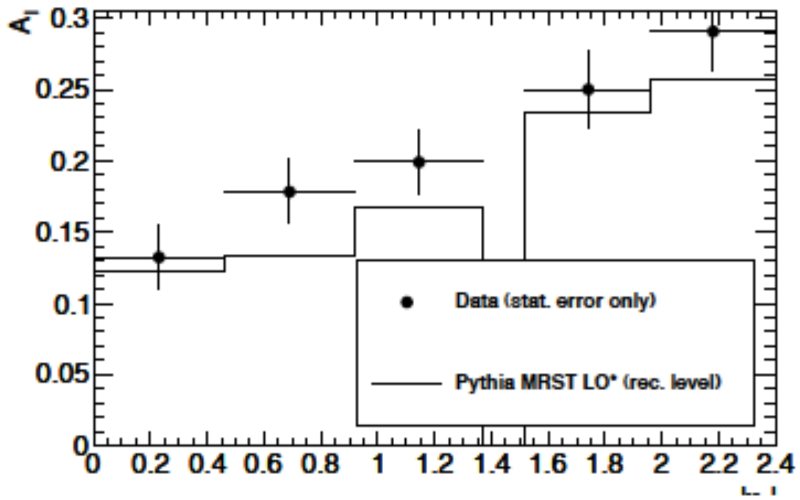
- PDF uncertainties are estimated using Monte Carlo method [arXiV:0901.2504, p 41-42]
  - RMS of ~100 MC replicas of the data represents the PDF uncertainty
- Uncertainties are larger when using HERA I+II data, because dsea, usea want to be positive

Talk of Voica

*)Have some debate about the name with H1. ``HERAPDF1.0u”

W Asymmetry





Raw asymmetry, stat.errors only from $3pb^{-1}$. starts to be of interest, but see also many problems (MC, D/MC..)

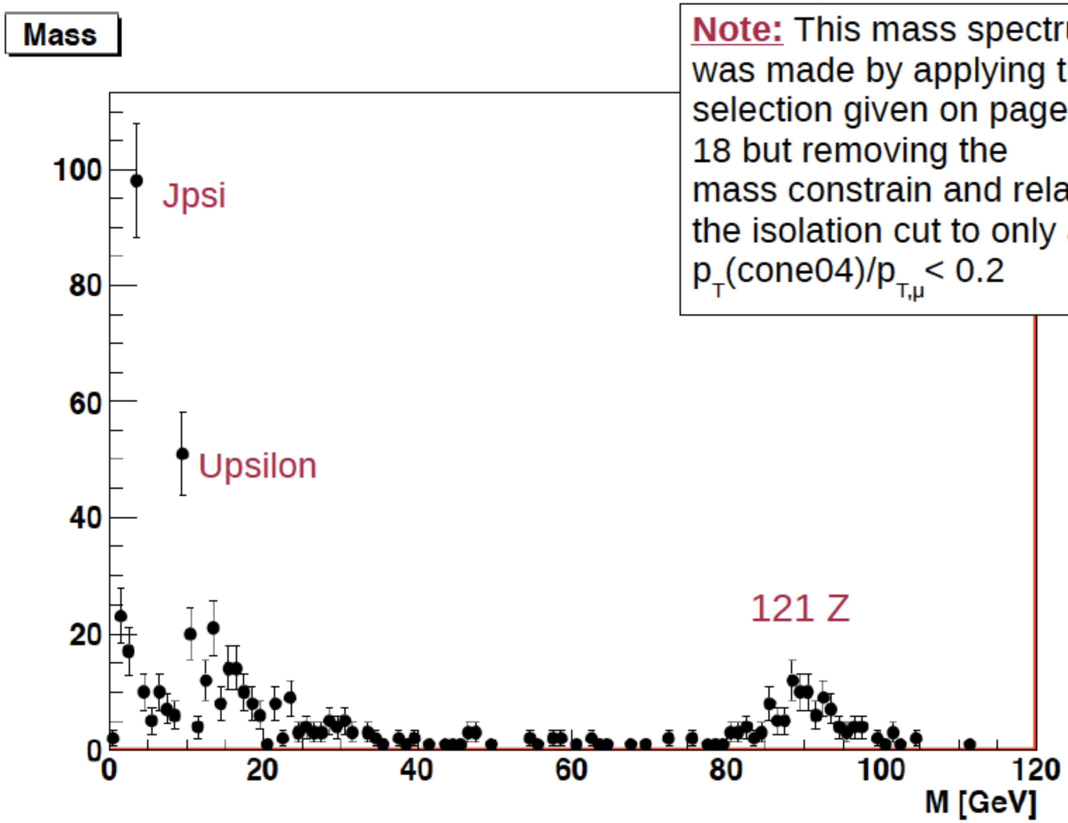
Asymmetry and ratio information of course contained in the cross section measurements
Thus in long term probably of less interest than this year.

Table 33: Cross section asymmetry $(\sigma(W^+)-\sigma(W^-))/(\sigma(W^+)+\sigma(W^-))$ as function of η_e. Note that the errors are absolute in this table.

η_e^l	η_e^h	$A(W)$	δ_{tot}	δ_{sta}	δ_{MCsta}	δ_{sys}	δ_{EE}	δ_{EEN1}	δ_{EEU}	δ_{ERecU}	δ_{EIdU}	δ_{ETrU}	δ_{ERecC}	δ_{EIdC}	δ_{ETrC}	δ_{RE}	δ_{RR}	δ_{Eth}	δ_{EChg}	δ_{QCD}	$\delta_{W\tau}$	δ_{tt}
−2.37	−2.01	0.2636	1.34	0.42	0.91	0.90	0.05	0.05	0.01	0.02	0.02	0.01	0.03	0.00	0.03	0.23	0.45	0.09	0.56	0.47	0.01	0.01
−2.01	−1.52	0.2587	0.96	0.36	0.70	0.55	0.12	0.04	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.11	0.36	0.04	0.36	0.10	0.00	0.02
−1.37	−0.80	0.2194	0.89	0.30	0.66	0.52	0.07	0.02	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.23	0.03	0.11	0.44	0.00	0.02
−0.80	−0.40	0.1859	0.73	0.35	0.59	0.25	0.07	0.05	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.04	0.00	0.08	0.22	0.00	0.02
−0.40	0.00	0.1863	0.79	0.34	0.62	0.33	0.03	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.24	0.00	0.07	0.21	0.00	0.02
0.00	0.40	0.1850	0.69	0.34	0.54	0.26	0.07	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.19	0.03	0.06	0.13	0.00	0.02
0.40	0.80	0.2024	1.08	0.34	0.69	0.76	0.06	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.19	0.02	0.08	0.72	0.00	0.02
0.80	1.37	0.2158	0.84	0.30	0.65	0.44	0.06	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.03	0.26	0.03	0.09	0.33	0.00	0.02
1.52	2.01	0.2399	0.99	0.36	0.67	0.63	0.10	0.03	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.10	0.26	0.06	0.36	0.41	0.00	0.02
2.01	2.37	0.2616	0.95	0.42	0.52	0.68	0.13	0.01	0.03	0.02	0.02	0.01	0.03	0.00	0.03	0.13	0.25	0.12	0.54	0.24	0.01	0.01

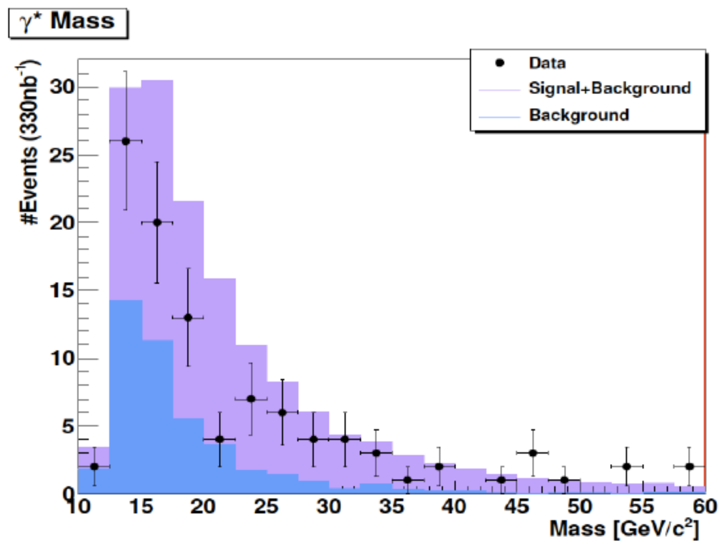
Talk of Jan

Low Mass DY



Note: This mass spectrum was made by applying the selection given on page 18 but removing the mass constrain and relaxing the isolation cut to only applying $p_T(\text{cone04})/p_{T,\mu} < 0.2$

Low mass DY resembles F_2
Comparison of Z and low mass region provides interesting constraints.
Access smaller x too



- Discrepancy between MC and Data

Talk of Elisa

From Data to Fits...

- Data analysis:
  - Measure cross-sections in single/double differential binning.
  - Report statistical/correlated/uncorrelated uncertainties
  - FSR QED radiation, EW corrections to equalise e and μ channels.
  - Combine e and μ cross sections.
- Fit:
  - Build prediction function at LO/directly NLO. Apply fiducial cuts.
  - Correct for NLO (QCD), parton shower effects.
  - Compared data to MC, by building χ^2 function, which takes into account scaling of statistical/correlated/uncorrelated uncertainties properly.

$\rightarrow$ new PDF set in LHAPDF format.

From Fits to Data...

- Tune NLO-MC for the new set.
- Generate MC based on it.
- OR Re-weight existing MC to the new PDF.
- Repeat cross-section analysis using the new set.

Talk of Sasha

The way to go - POWHEG ?

Matching NLO calculations with parton shower:
The POsitive-Weight Hardest Emission Generator

https://twiki.cern.ch/twiki/bin/view/AtlasProtected/PowhegForATLAS

Powheg can be interfaced to any shower model (Pythia, Herwig, Herwig++ ..)

- events are unweighted

- output interfaced to PHOTOS

→ combined NLO QCD and HO QED effects

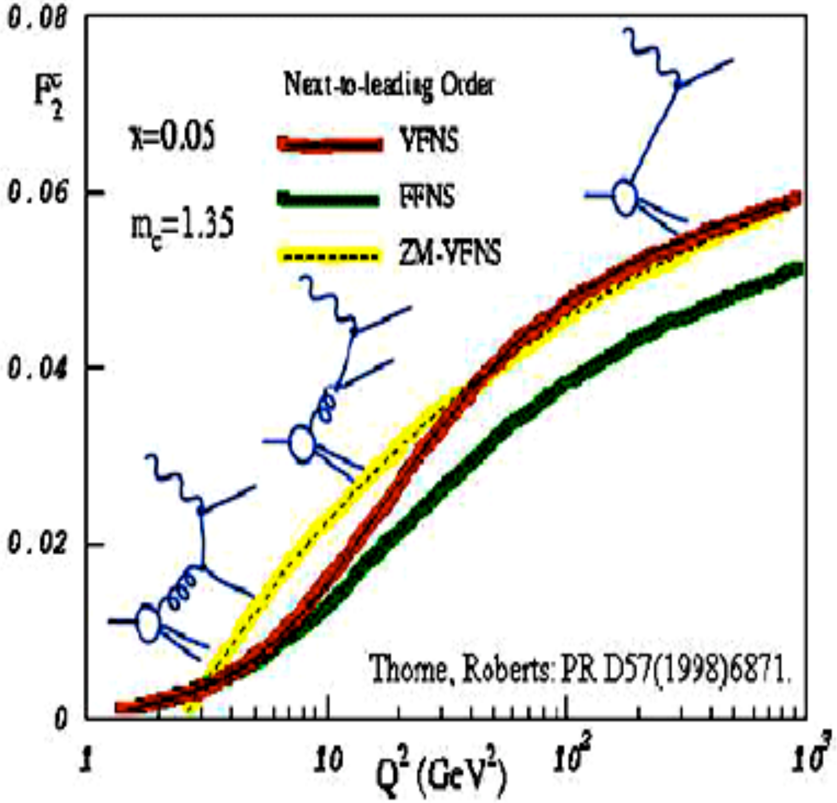
Proposal: the new default for unfolding the W and Z cross sections could be Powheg+Pythia (employ the good understanding of Pythia PS and UE tuning)

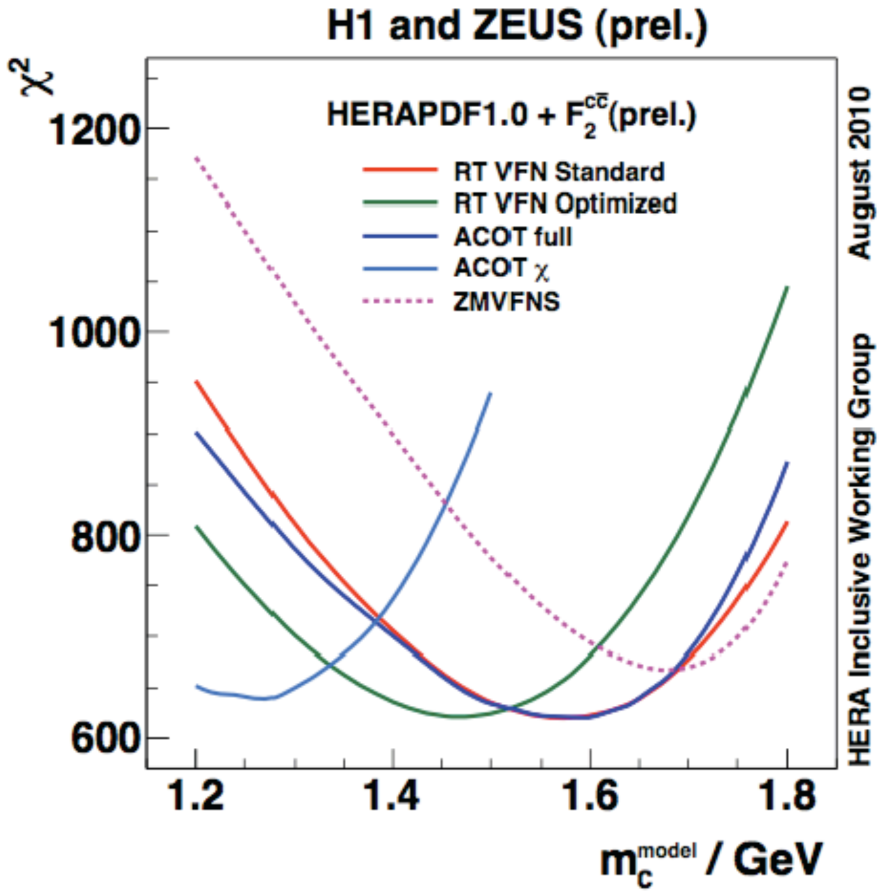
Note: one could use different PDFs for hard scattering but keep the PS part fixed (don't change the PDF for the PS tuning part)

→ so we could use 'dissident' or 'own' PDFs

Talk from Uta

Charm and α_s

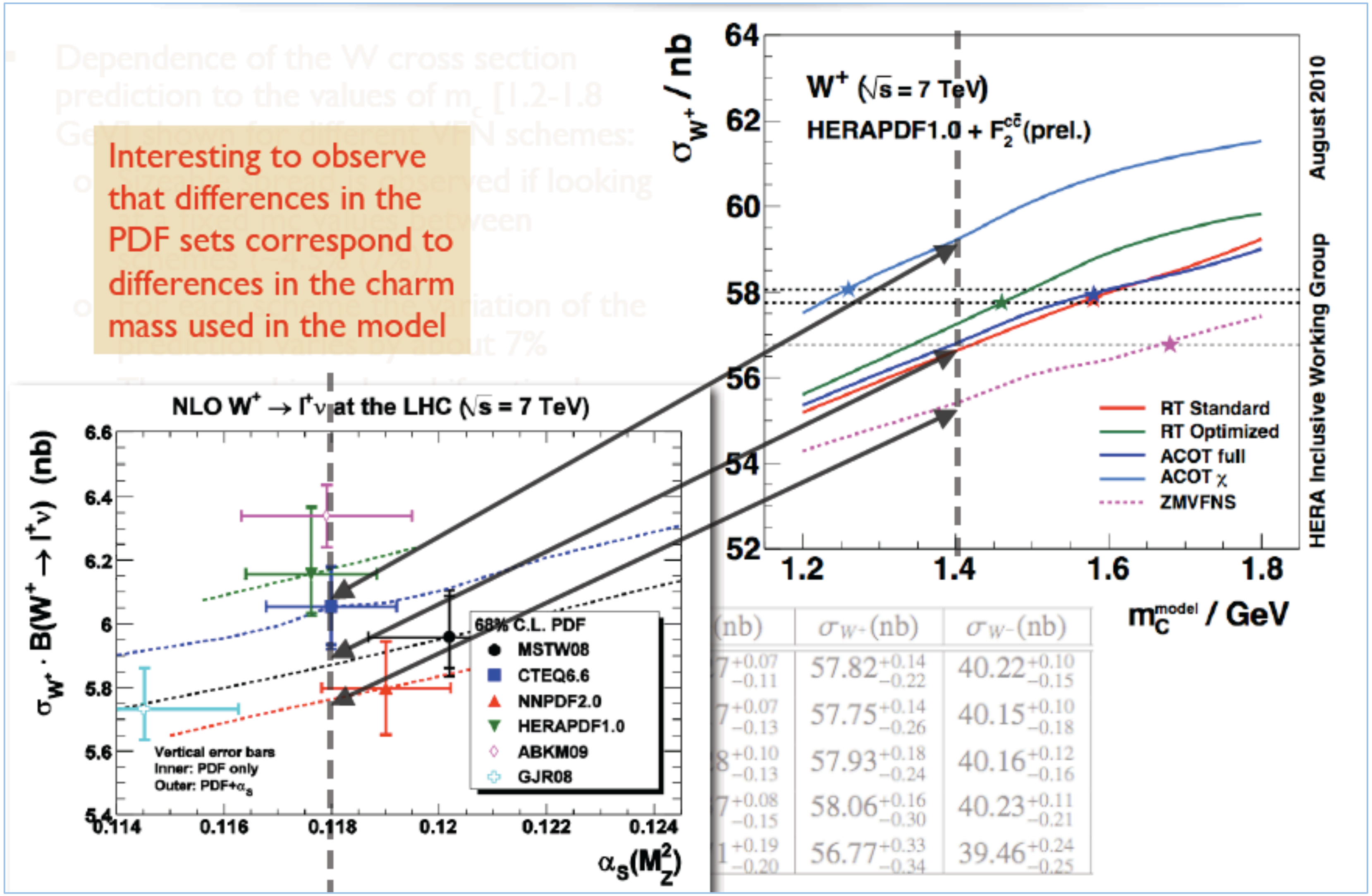




Theoretical treatment of heavy flavours is an old puzzle.
TR → RT, ACOT(s).. Can be tested with F_2, F_2^{cc} (and also F_L) data
Charm mass is model parameter. Big spread observed of preferred m_c

Talk of Voica

Charm and α_s



Talk of Voica

Spread of W cross section predictions may be related to different/same m_c's used : **Big question: What is the uncertainty of the predictions**

Many other important contributions:

Frank: Z going forward

Eram: Drell Yan h.o. Fits

Dima et al (SANC): Electroweak and weak corrections

Andrey: FSR – SANC vs PHOTOS

Voica: H1 fitting method/program

Mandy: ZEUS fitting method/program

Sasha: Combination of electron and muon cross sections

Matthias: Overview on WZ with emphasis on muons

Mark: APPLgrid:
EPJC66(2010)503

Store the weights from the Monte Carlo sampling of the phase space in a grid and perform the convolution externally.

Lots of discussions on almost everything, possible because we were just a few:

+ Dima, Lidia + EVO: Joey, Mandy, Eram, Karsten + NN from Dresden proving Russia to be difficult to enter …

A brief summary

The W and Z measurements are testing pdf's in a way complementary to HERA. The effects are small because the evolution smoothes any input variation and because HERA has measured cross sections to per cent accuracy. However:

We have seen that the assumptions on the up and down quark symmetry, both for valence and sea quarks, lead to an artificially precise level of the predictions, also when more recent HERA II data are used. The forthcoming measurements on the rapidity distributions from W and Z samples can provide new constraints. **This leads to new sets of ATLAS-HERA-PDF's**.

We could go in steps, as also discussed on Tuesday:

a) W charge asymmetry in rapidity bins for $3pb^{-1}$ and compare fits with/out fixing $B_{uv}=B_{dv}$
b) W and Z differential measurements with $O(10)pb^{-1}$, the 2010 data, and check the dissidents..
c) Study singly differential transverse distributions and ultimately double differentially [note 325]

Technically many questions have to be solved, beyond the genuine data analysis:
-An analysis has to be set up which allows an iterative determination eventually
-This requires suitable MC techniques
-QCD fit techniques need to be further developed (fast fitting DY at h.o.)
-Electron and muon data need to be averaged/combined for ultimate precision
-High precision demands care: electroweak parameters, FSR, pure weak corrections, NLO QCD…

The goal has to be the highest possible precision, not the fastest publication, as we already approach the phase where accuracy defines the physics value of these measurements. We yet may be fast as many tools are already at hand..