Fit on world data of inclusive proton DIS cross-sections

F_2 analysis

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Features of the new fit

The fit presented has the following features

1. Based on the *ALLM parameterization* which allows a very good description of the measured regions. It is a Regge-motivated approach constructed so that photoproduction data at $Q^2 = 0$ can be included.
2. *Normalization uncertainties* are considered by an acurate method involving a penalty term in χ^2.
3. *Fit uncertainties* are successfully determined and propagated to the error band.
4. *Self-consistent* with respect to the use of $R = \sigma_L/\sigma_T$.

Features of the new fit

Fits for QCD-inspired approach, 15 parameters

- first proposed by BCDMS, also used by NMC
- SMC, Phys. Rev. D, Vol. 58, 112001

Fits for regge-motivated approach, 23 parameters

- ALLM91: DESY-91068
  A parameterization of σ_T above the resonance region.
- ALLM97: hep-ph/9712415
  The ALLM parameterization of σ_{tot}, an update

$\longrightarrow$ Our fit includes newer data and covers 2740 data points. This is more than twice as much as used in ALLM97.

F_2, R and cross-sections

- The DIS cross-section in the 1-photon exchange approximation:

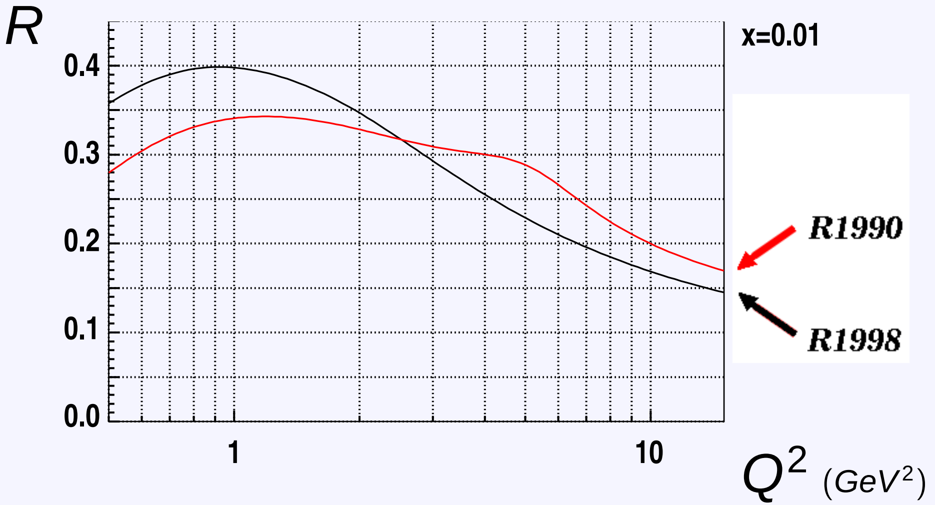
$$\frac{d^2\sigma}{dxdQ^2} = \frac{4\pi\alpha^2}{Q^4}\frac{F_2}{x}\{1 - y - \frac{Q^2}{4E^2} + (1 - \frac{2m^2}{Q^2})\frac{y^2 + Q^2/E^2}{2(1+\mathbf{R})}\}$$

- F_2 can be related to the total cross-section σ_{tot}=$\sigma_T + \sigma_L$ by:

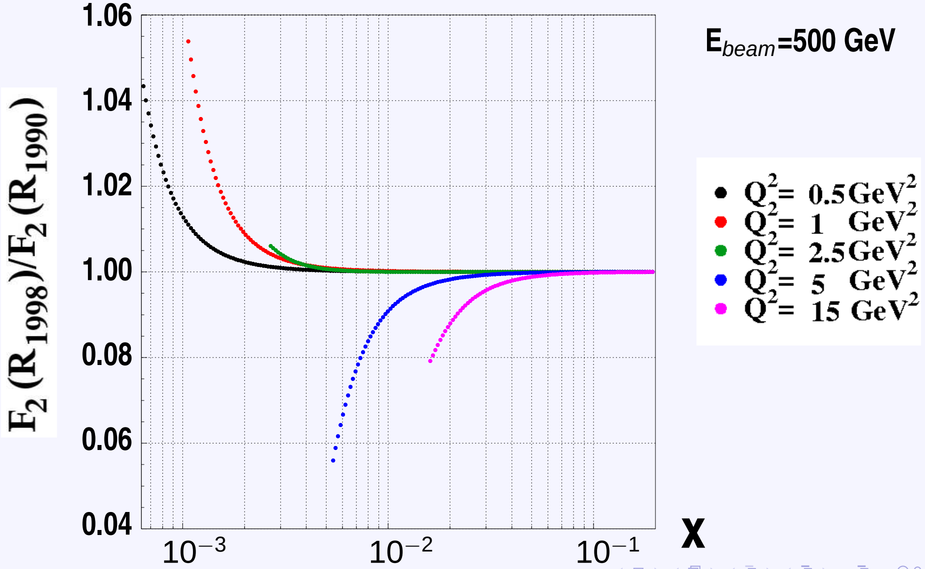
$$\sigma_{tot}(\gamma^* p) = \frac{4\pi\alpha}{Q^2(1-x)}\frac{Q^2 + 4M^2x^2}{Q^2}F_2(W^2, Q^2)$$

- Consistent treatment of **R** for all data sets

Parameterizations for R



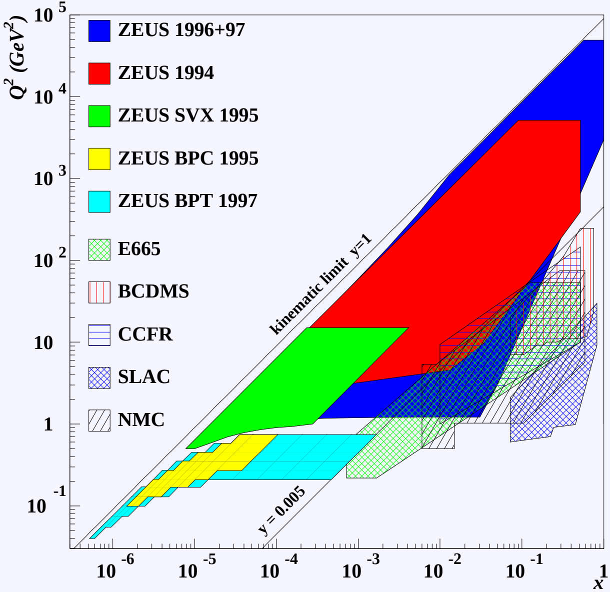
Effect of R on F_2



Experiments: F2 measurements

Collaboration	Process		
		$E_{e,\mu}(GeV)$	$E_P(GeV)$
H1	$ep \rightarrow eX$	27.5	820, 920
ZEUS	$ep \rightarrow eX$	27.5	820, 920
SLAC	$ep \rightarrow eX$	4.50-20.00	-
NMC	$\mu p \rightarrow \mu X$	90, 120, 200, 280	-
BCDMS	$\mu p \rightarrow \mu X$	100, 120, 200, 280	-
E665	$\mu p \rightarrow \mu X$	470	-

$x - Q^2$ plane coverage



taken from ZEUS, DIS 1999

Pomeron exchange

$$F_2^{\mathcal{P}}(x,Q^2) = c_{\mathcal{P}}(t)\, x_{\mathcal{P}}^{a_{\mathcal{P}}(t)}(1-x)^{b_{\mathcal{P}}(t)}$$

$$F_2(x,Q^2) = \frac{Q^2}{Q^2+m_0^2}\left(F_2^{\mathcal{P}}(x,Q^2) + F_2^{\mathcal{R}}(x,Q^2)\right)$$

Reggeon exchange

$$F_2^{\mathcal{R}}(x,Q^2) = c_{\mathcal{R}}(t)\, x_{\mathcal{R}}^{a_{\mathcal{R}}(t)}(1-x)^{b_{\mathcal{R}}(t)}$$

The functions in red and blue are formed by:

$$f(t) = f_1 + f_2 t^{f_3}$$

$$g(t) = g_1 + (g_1 - g_2)\left[\frac{1}{1+t^{g_3}} - 1\right]$$

$$e.g.\ a_{\mathcal{R}}(t) = a_{\mathcal{R}1} + a_{\mathcal{R}2} t^{a_{\mathcal{R}3}}$$

$$\chi^2 = \sum_i^{n_{max}} \frac{[\sigma_i^{exp} - \sigma_i^{th}/(1+\nu_{k(i)}\delta_{k(i)}^{norm})]^2}{\delta_{i,sta}^2 + \delta_{i,sys}^2} + \sum_k \nu_k^2.$$

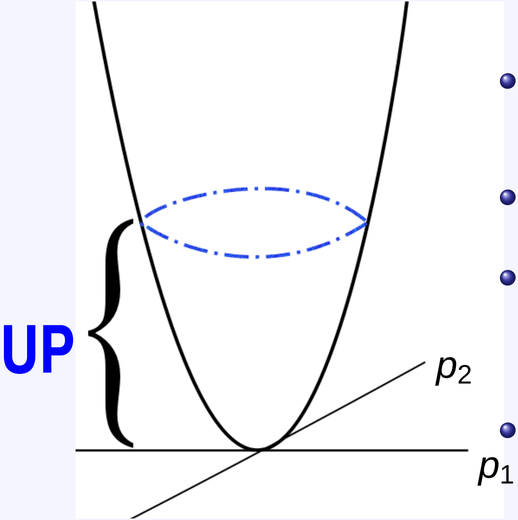
χ^2 -Minimization

- Introduce normalization parameters ν_k, considered to be normal distributed - implemented by a **penalty term**.
- The normalization parameters ν_k perform a **shift** according to normalization error $\delta_{k(i)}^{norm}$.
- The analytic solution of ν_k for a fixed set of model parameters can be obtained from $d\chi^2/d\nu_k = 0$, since ν_k are independent.

Error Propagation

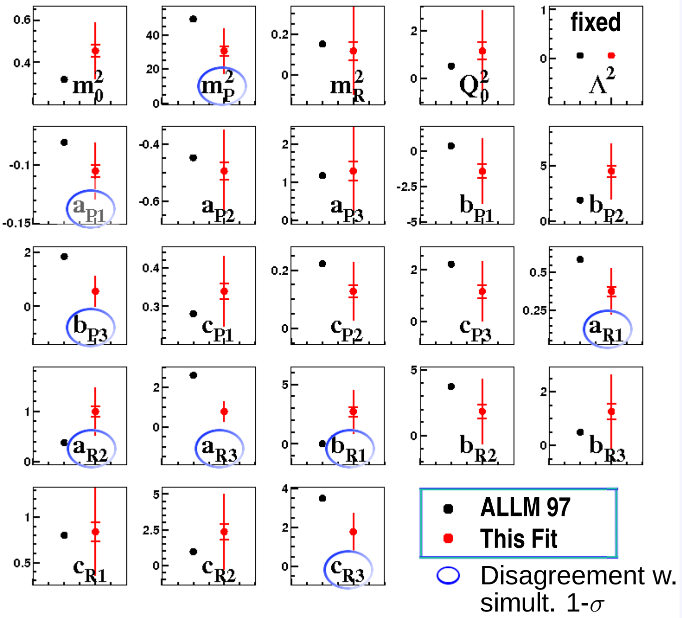
$$V(\sigma_{tot}(\mathbf{p}, x, Q^2)) = \Sigma_{i,j} cov^{p}_{i,j} \frac{d\sigma_{tot}(\mathbf{p}, x, Q^2)}{dp_i} \frac{d\sigma_{tot}(\mathbf{p}, x, Q^2)}{dp_j}$$

Error definition



- The *UP value* is the parameter in MINUIT by which uncertainties for parameters are defined.
- UP=1 defines a 1-σ uncertainty for single parameters.
- UP$\approx$ npar corresponds to the 1-σ uncertainty for the npar parameters to be simultaneously located inside the hypercontour.
- UP large: compensation for unknown systematic effects.

Model Parameters



χ^2 Contributions

Nr.	Exp	n	χ^2/n
1.	slac1	98	0.48
2.	slac2	187	1.15
3.	slac3	25	0.20
4.	slac4	94	0.68
5.	slac5	72	1.11
6.	slac6	98	0.99
7.	nmc90gev	73	0.79
8.	nmc120gev	65	1.50
9.	nmc200gev	75	1.13
10.	nmc280gev	79	0.94
11.	e665	91	1.06
12.	bcdms100gev	58	1.13
13.	bcdms120gev	62	0.73
14.	bcdms200gev	57	1.32
15.	bcdms280gev	52	1.11

16.	h1lq94a	37	0.35
17.	h1lq94b	156	0.62
18.	h1svx	44	0.48
19.	zeus94	188	1.15
20.	zeus_bpc	34	0.40
21.	zeus_svx	36	0.76
22.	zeus_γp	1	2.44
23.	PDG γp	196	0.79
24.	zeus9697	242	0.75
25.	zeus97	70	0.94
26.	h19900	147	1.01
27.	h19899	126	1.37
28.	h19497	130	0.79
29.	h1lq9697a	67	1.07
30.	h1lq9697b	80	0.82
	total	**2740**	**0.94**

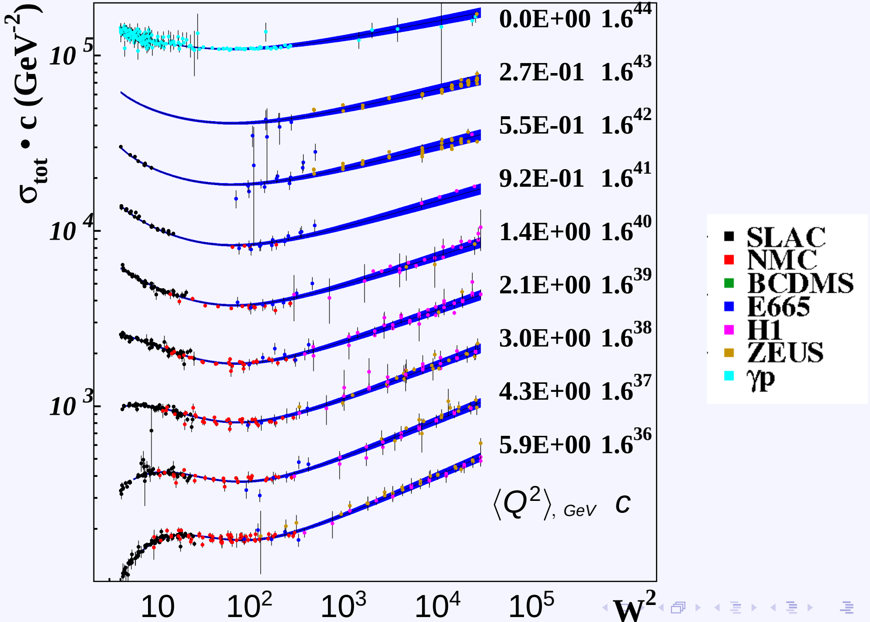
Normalization Parameters

Nr.	Exp	δ_k^{nor}	ν_k
1.	slac1	2.1	0.06
2.	slac2	2.1	-0.28
3.	slac3	2.1	0.01
4.	slac4	2.1	0.07
5.	slac5	2.1	1.31
6.	slac6	2.1	0.17
7.	nmc90gev	2.0	-0.37
8.	nmc120gev	2.0	0.14
9.	nmc200gev	2.0	-0.09
10.	nmc280gev	2.0	-0.24
11.	e665	1.8	0.67
12.	bcdms100gev	3.0	-1.20
13.	bcdms120gev	3.0	0.03
14.	bcdms200gev	3.0	-1.09

Nr.	Experim.	δ_k^{nor}	ν_k
15.	bcdms280gev	3.0	-1.03
16.	h1lq94a	3.9	0.05
17.	h1lq94b	1.5	1.13
18.	h1svx	3.0	-3.02
19.	zeus94	2.0	1.66
20.	zeus_bpc	2.4	-1.28
21.	zeus_svx	3.0	-1.00
24.	zeus9697	2.0	0.09
25.	zeus97	2.0	-2.23
26.	h19900	1.5	-1.08
27.	h19899	1.8	-1.38
28.	h19497	1.5	-1.46
29.	h1lq9697a	1.7	1.77
30.	h1lq9697b	1.7	2.02

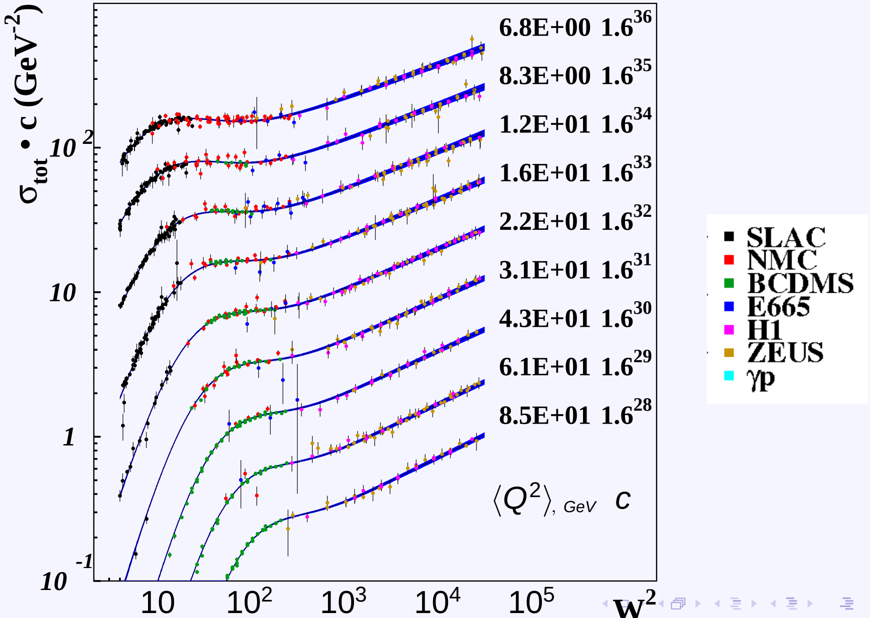
Fit Result and Data

$0\,GeV^2 < Q^2 < 6\,GeV^2$



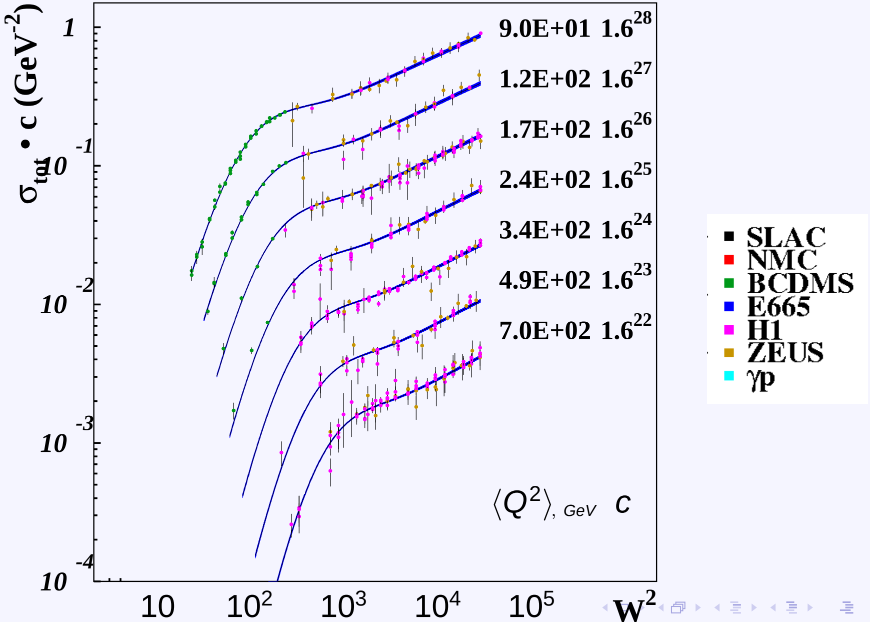
Fit Result and Data

$6, GeV^2 < Q^2 < 90, GeV^2$



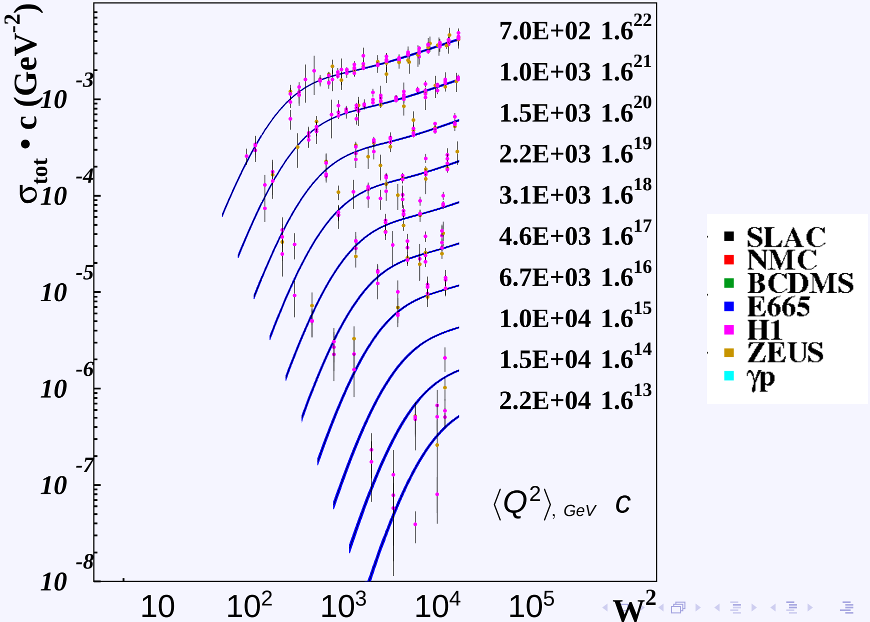
Fit Result and Data

$90\,GeV^2 < Q^2 < 700\,GeV^2$



Fit Result and Data

$700\,GeV^2 < Q^2 < 30000\,GeV^2$

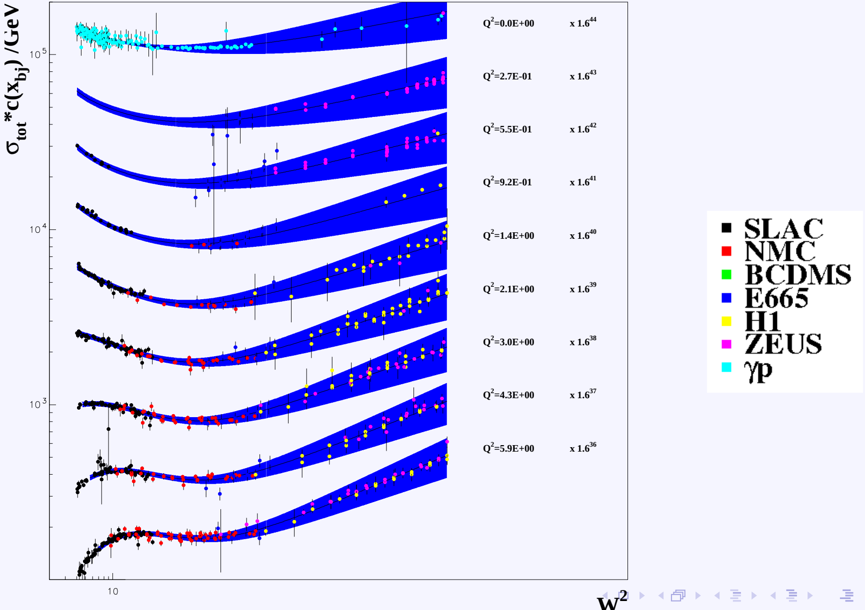


Summary

- Motivation: New fit on world data
- It reflects the most recent world knowledge on proton DIS cross sections.
- Useful for all extractions requiring F_2 as input.
- Relevant for MC at low Q^2.

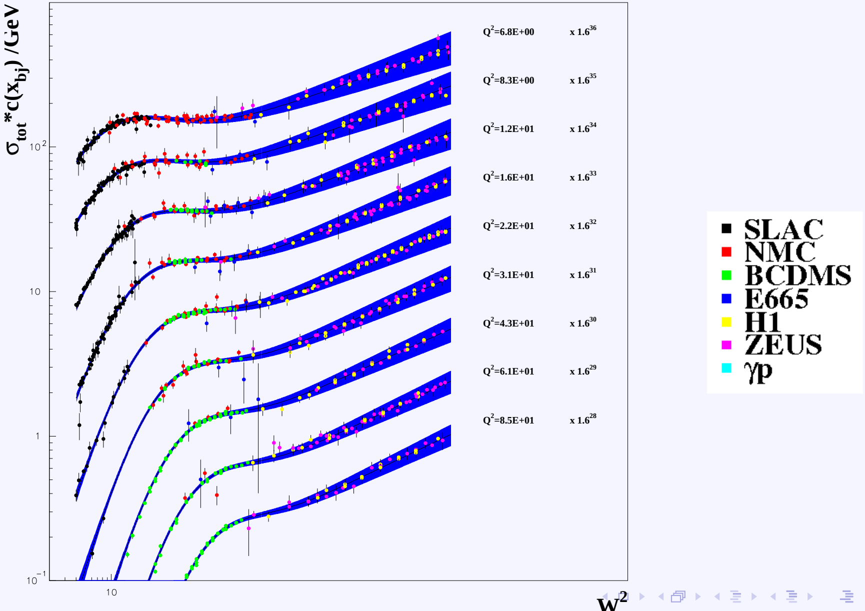
Plots

Data and Fit Result (UP=22), region 1



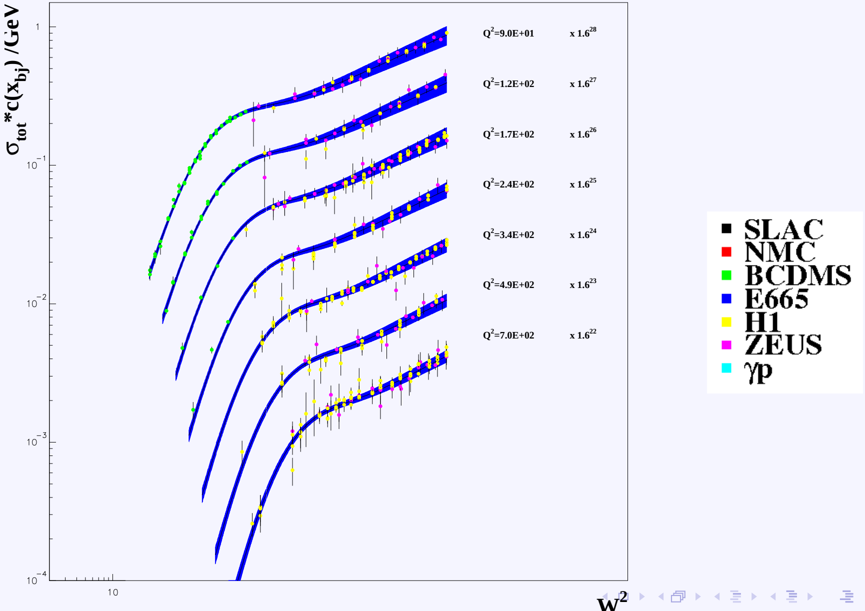
Plots

Data and Fit Result (UP=22), region 2



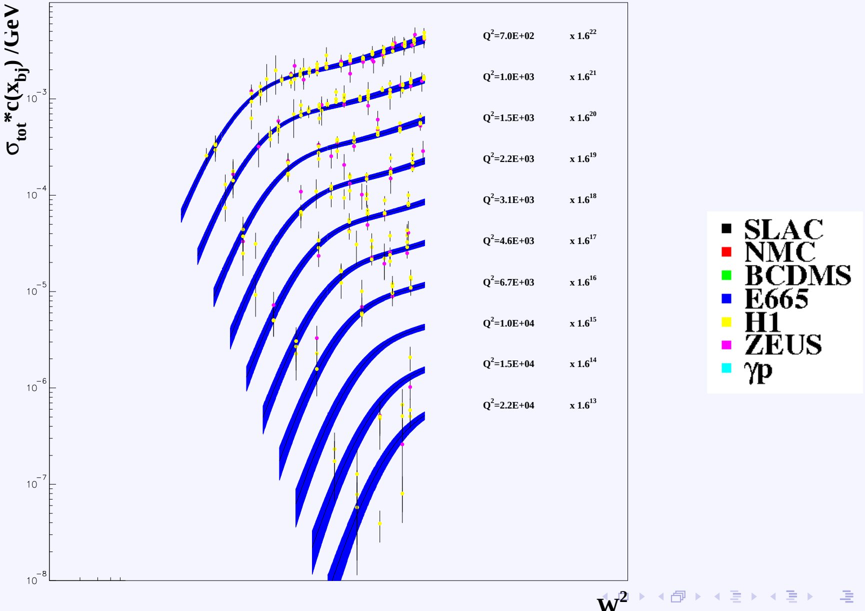
Plots

Data and Fit Result (UP=22), region 3



Plots

Data and Fit Result (UP=22), region 4



ALLM Parameterization

$$t = ln(\frac{ln(Q^2 + Q_0^2)/\Lambda^2}{ln(Q_0^2)/\Lambda^2})$$

$$\frac{1}{x_{\mathcal{P}}} = 1 + \frac{W^2 - M^2}{Q^2 + m_{\mathcal{P}}^2}$$

$$\frac{1}{x_{\mathcal{R}}} = 1 + \frac{W^2 - M^2}{Q^2 + m_{\mathcal{R}}^2}$$

Pname	ALLM91	ALLM97	this fit	single 1-σ	simult.
m_0^2	0.3051	0.3198	0.45415$\pm$	0.02836	0.14261
$m_{\mathcal{P}}^2$	10.6760	49.4570	30.70720$\pm$	2.85200	4.38179
$m_{\mathcal{R}}^2$	0.2062	0.1505	0.11700$\pm$	0.04617	0.22918
Q_0^2	0.2779	0.5254	1.15117$\pm$	0.35841	1.91861
Λ^2	0.0653	0.0653	0.06527$\pm$	0.00000	0.00000
$a_{\mathcal{P}1}$	-0.0450	-0.0808	-0.10539$\pm$	0.00510	0.02573
$a_{\mathcal{P}2}$	-0.3641	-0.3641	-0.49519$\pm$	0.03068	0.16323
$a_{\mathcal{P}3}$	8.1709	1.1709	1.29187$\pm$	0.24412	1.29744
$b_{\mathcal{P}1}$	0.4922	0.3629	-1.41348$\pm$	0.47875	2.42369
$b_{\mathcal{P}2}$	0.5212	1.8917	4.50086$\pm$	0.51887	2.72348
$b_{\mathcal{P}3}$	3.5515	1.8439	0.55277$\pm$	0.11590	0.61635

Pname	ALLM91	ALLM97	this fit	single 1-σ	simult.
$c_{\mathcal{P}1}$	0.2655	0.2806	0.33875 ±	0.01941	0.09709
$c_{\mathcal{P}2}$	0.0486	0.2229	0.12725 ±	0.02162	0.10828
$c_{\mathcal{P}3}$	1.0468	2.1980	1.15659 ±	0.24584	1.26969
$a_{\mathcal{R}1}$	0.6041	0.5840	0.37495 ±	0.03218	0.16062
$a_{\mathcal{R}2}$	0.1735	0.3788	0.99717 ±	0.10170	0.53481
$a_{\mathcal{R}3}$	1.6181	2.6063	0.77456 ±	0.11287	0.56784
$b_{\mathcal{R}1}$	1.2607	0.0114	2.71772 ±	0.39336	1.93456
$b_{\mathcal{R}2}$	1.8362	0.3788	1.82806 ±	0.53495	2.71407
$b_{\mathcal{R}3}$	0.8114	2.6063	1.26287 ±	0.29756	1.48158
$c_{\mathcal{R}1}$	0.6764	0.8011	0.83915 ±	0.10568	0.52170
$c_{\mathcal{R}2}$	0.4903	0.9730	2.35826 ±	0.55228	2.93553
$c_{\mathcal{R}3}$	2.6628	3.4942	1.77238 ±	0.20843	1.09286