$\sigma(W)$ as Luminosity Measurement in Run II

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$\sigma(W)/\mathcal{L}$ in Run I at DØ

$$\mathcal{L} = \frac{N_{cand}(1-f_{QCD})-N_Z}{\epsilon A(1+\frac{A_\tau}{A})\sigma(W)}$$

N_{cand} = number of W candidates
f_{QCD} = fraction of candidates from QCD
N_Z = number of candidates that are Z events
ϵ = lepton identification efficiency
A = acceptance
A_τ = acceptance times BR$(W \rightarrow \tau\nu)$
$\sigma(W)$ = theoretical cross section for W production

At DØ

Component	Value	Error on $\mathcal{L}$
f_{QCD}	0.064±0.014	1.5%
ϵ	0.671±0.009	1.3%
A	0.465±0.004	0.9%
N_{cand}	67078	0.4%
N_Z	621±155	0.3%
A_τ/A	0.0211±0.0021	0.2%
$\sigma(W)$	22.2±0.9 nb	4%

$\Rightarrow$ Experimental uncertainty alone is 2.2%

$\Rightarrow$ With theory "uncertainty" it's 4.6%

Going to Run II: f_{QCD}

$$f_{QCD} = 0.063 \pm 0.014 \Rightarrow 1.5\%$$

- Uncertainty dominated by systematics for electrons
- Using muons may reduce backgrounds and make them easier to understand–no serious study

$\Rightarrow$ leave at 1.5%

Going to Run II: efficiency

$$\epsilon = 0.671 \pm 0.009 \Rightarrow 1.3\%$$

- Uncertainty equal parts Z statistics and background subtraction–statistics will scale by $\sim 1/\sqrt{10}$; systematics require real work!
- Tracking efficiency will increase, but lower(?) isolation efficiency and missing E_T efficiency due to multiple interations – net zero?

$\Rightarrow$ Reduce to 0.006 (0.9%)

Going to Run II: Acceptance

$$A = 0.465 \pm 0.004 \Rightarrow 0.9\%$$

- Stay about the same in magnitude
- Uncertainty dominated by EM energy scale (0.00319) – smaller next run
- Rest are 0.0023 – scaled with lum $\rightarrow$ 0.16%

$\Rightarrow$ Assume 0.002 (0.5%)

Going to Run II: N_{cand}, N_Z, and $A_{\mathcal{T}}$

- N_{cand} – Factor 10 from luminosity + factor ~ 2 from muons $\rightarrow$1,340,000 (0.09%)
- N_Z – dominant uncertainty from MC simulation of the acceptance; irreducible uncertainty from Z statistics; with work $\rightarrow 0$
- $A_{\mathcal{T}}$ – dominant error from MC statistics: $\rightarrow 0$

Run II scenario?

Run II
QCD/WZ

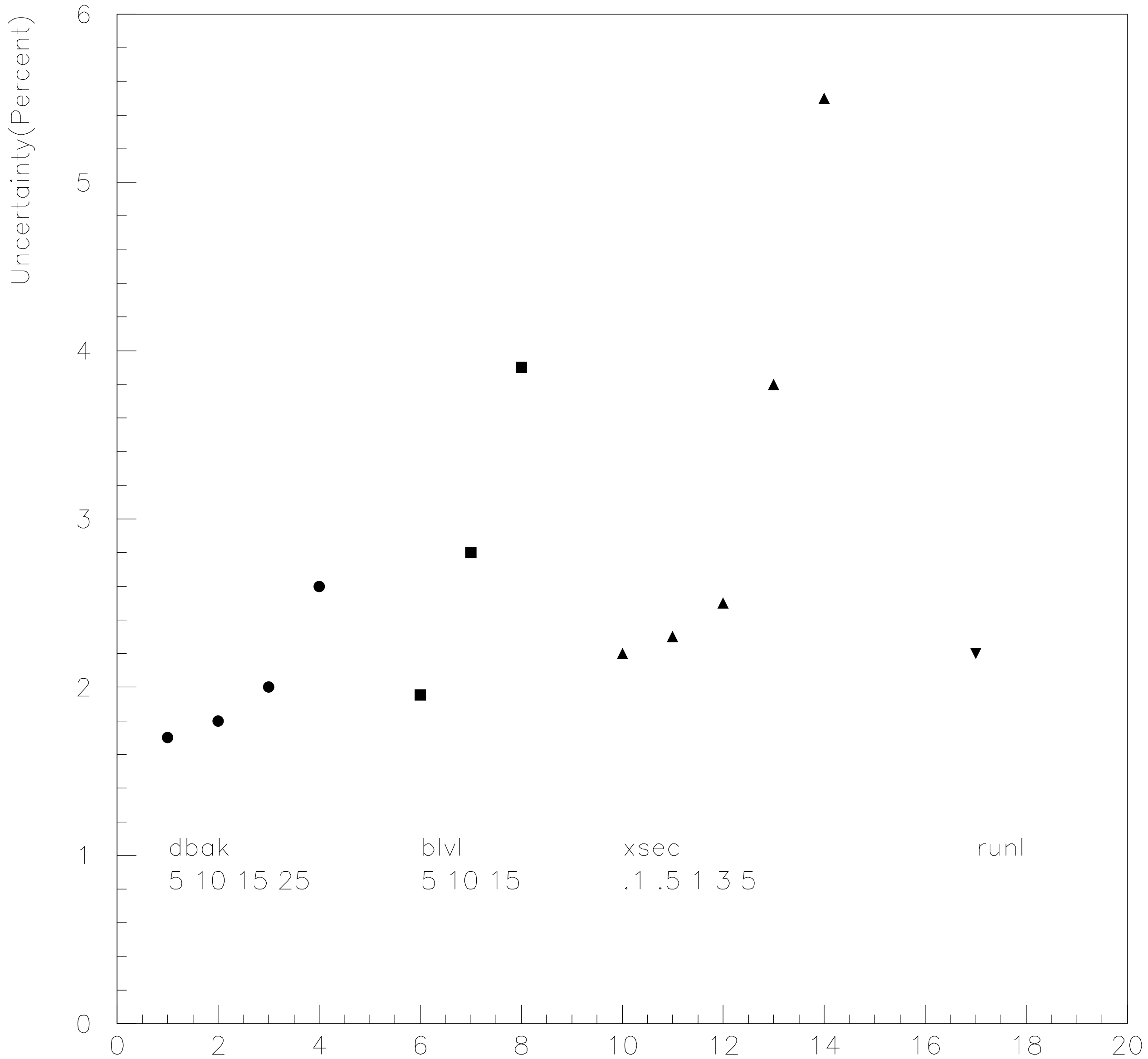
Component	Error on $\mathcal{L}$
f_{QCD}	1.5%
ϵ	0.9%
A	0.5%
N_{cand}	0.09%
N_Z	0.0%
A_T/A	0.0%
$\sigma(W)$	4%

$\Rightarrow$ Just experimental uncertainty is 1.8%

$\Rightarrow$ With theory "uncertainty" it's 4.4%

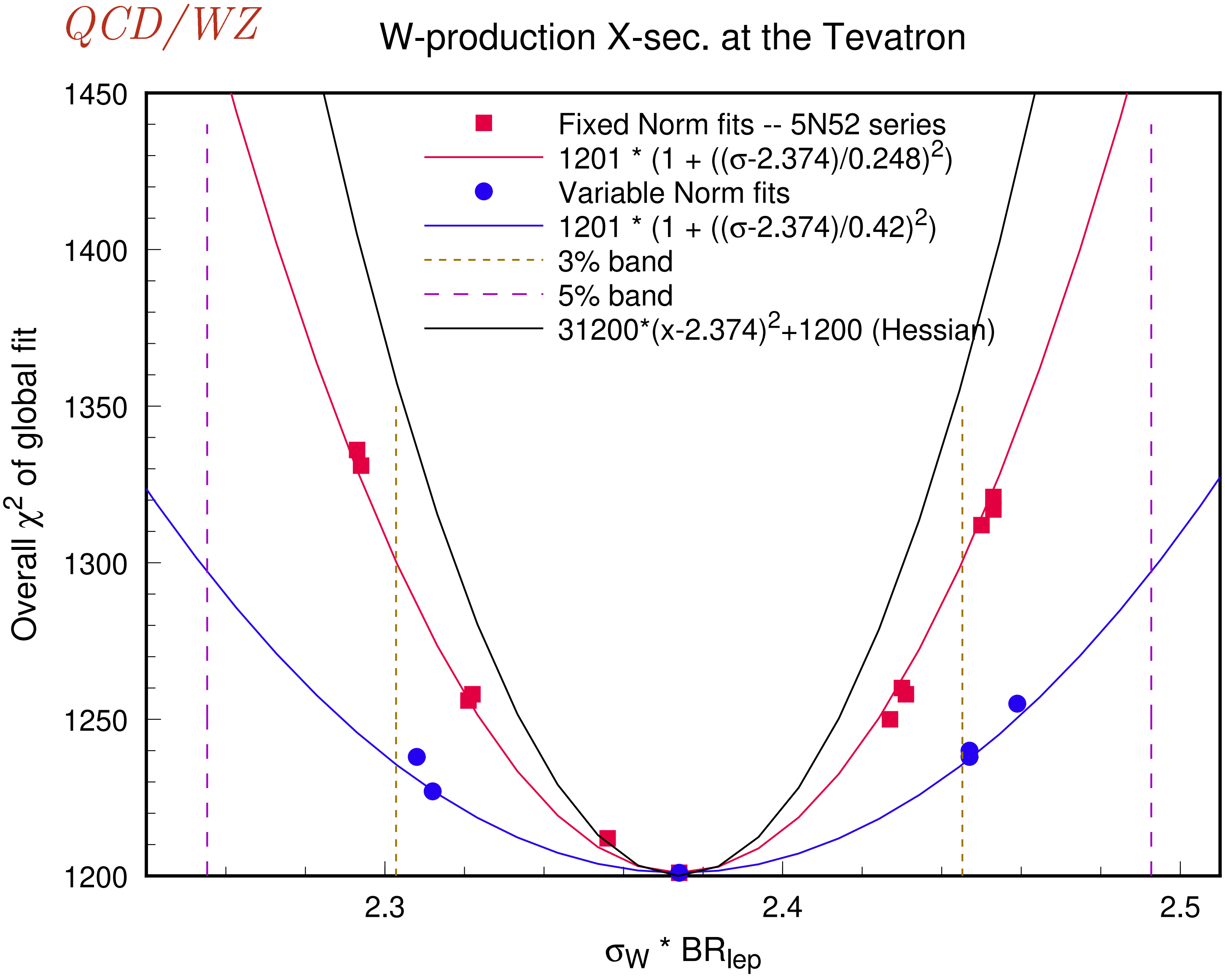
Effects of Uncertainties on $\mathcal{L}$ Measurement

Run II
QCD/WZ



For Run I: $\frac{\delta f_{QCD}}{f_{QCD}} = 22\%$, bckgn level $= 5\%$

Uncertainty on $\sigma(W)$



- Use χ^2 definition from CTEQ5M global fit to get uncertainty on $\sigma(W)$ give PDF data sets
- χ^2 needs some refinement (inclusion of known correlations)
- Expect "hard" number in coming months

Summary

- Any determination of the luminosity uncertainty from the number of W events observed is completely dominated by the uncertainty in the calculation of $\sigma(W)$
- Work in progress on by several groups
- Unlikely that anyone will believe a number better than 3-5% without significant theory developments – NNLO PDFs, quantitative uncertainties on PDFs incorporating experimental uncertainties and some theory uncertainties
- Not clear how well independent measurement of $\mathcal{L}$ will do. Better than 4.3% from Run I?