Electroweak phenomena

Eleni Vryonidou

James Stirling Memorial Conference
IPPP, 17/9/2019

Introduction

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Electroweak corrections and Bloch-Nordsieck violations in 2-to-2 processes at the LHC

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W+charm as a probe of the strange PDF

Charm production in association with an electroweak gauge boson at the LHC

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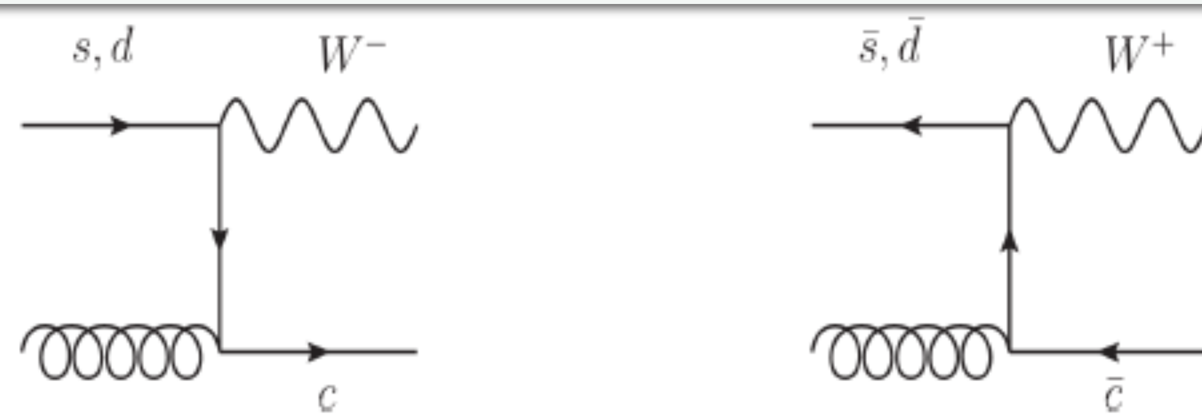


Cross-section ratios are more sensitive:

$$\boxed{R_c^{\pm} = \frac{\sigma(W^+ + \bar{c})}{\sigma(W^- + c)}}$$

$R_c^{\pm} = 1$ at the Tevatron

$R_c^{\pm} < 1$ at the LHC

$$\boxed{R_c = \frac{\sigma(W + c)}{\sigma(W + \text{jet})}}$$

Sensitive to strange plus anti-strange

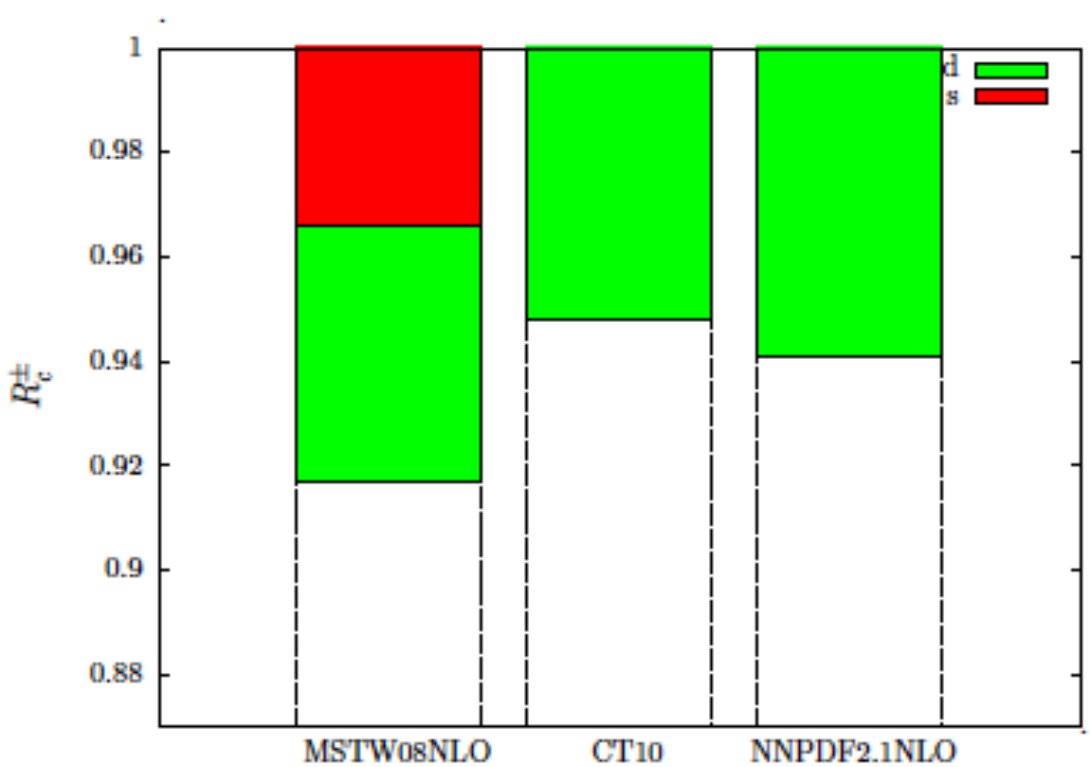
W. J. Stirling and EV Phys.Rev.Lett. 109 (2012) 082002

Comparisons of different PDF sets

Ratio	$R_c^{\pm}$	R_c
CT10	$0.953^{+0.009}_{-0.007}$	$0.124^{+0.021}_{-0.012}$
MSTW2008NLO	$0.921^{+0.022}_{-0.033}$	$0.116^{+0.002}_{-0.002}$
NNPDF2.1NLO	0.944 ± 0.008	0.104 ± 0.005
GJR08	0.933 ± 0.003	0.099 ± 0.002
ABKM09	0.933 ± 0.002	0.116 ± 0.003

$$R_c^{\pm} \sim \frac{\bar{s} + |V_{dc}|^2 \bar{d}}{s + |V_{dc}|^2 d}$$

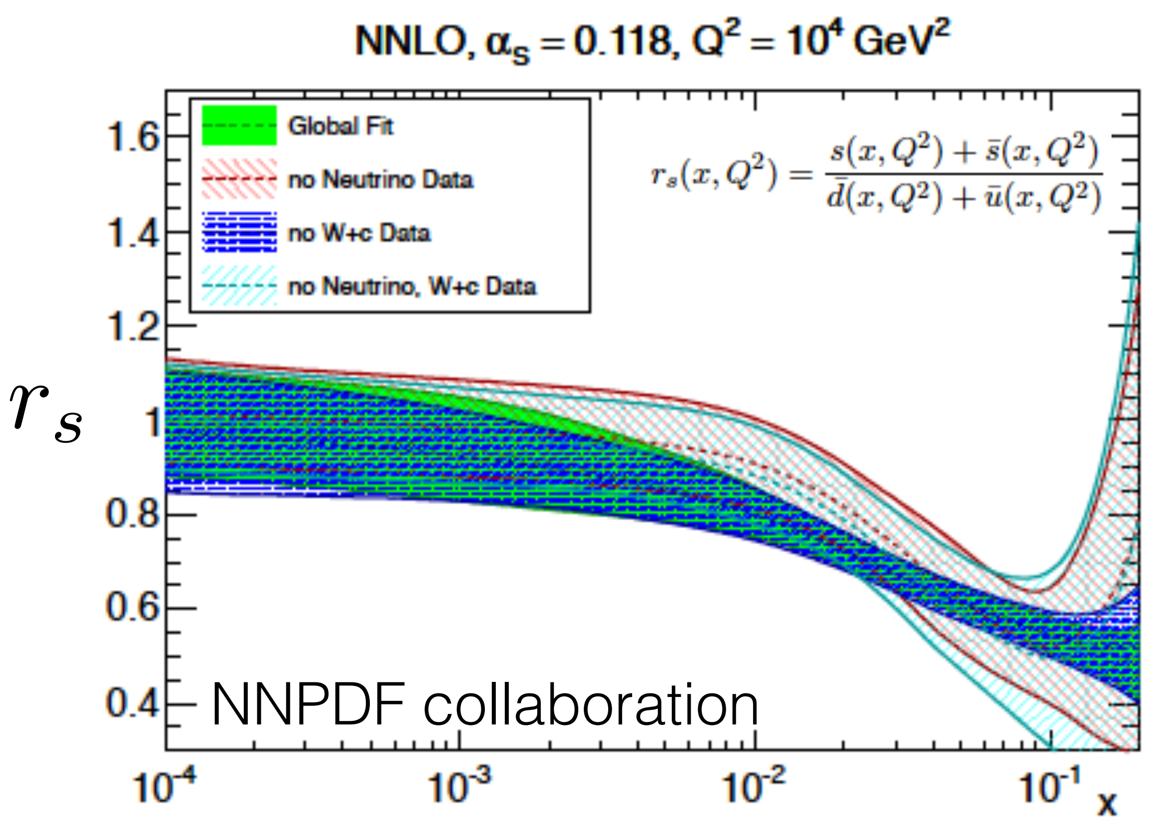
d-contribution
suppressed by factor of 20



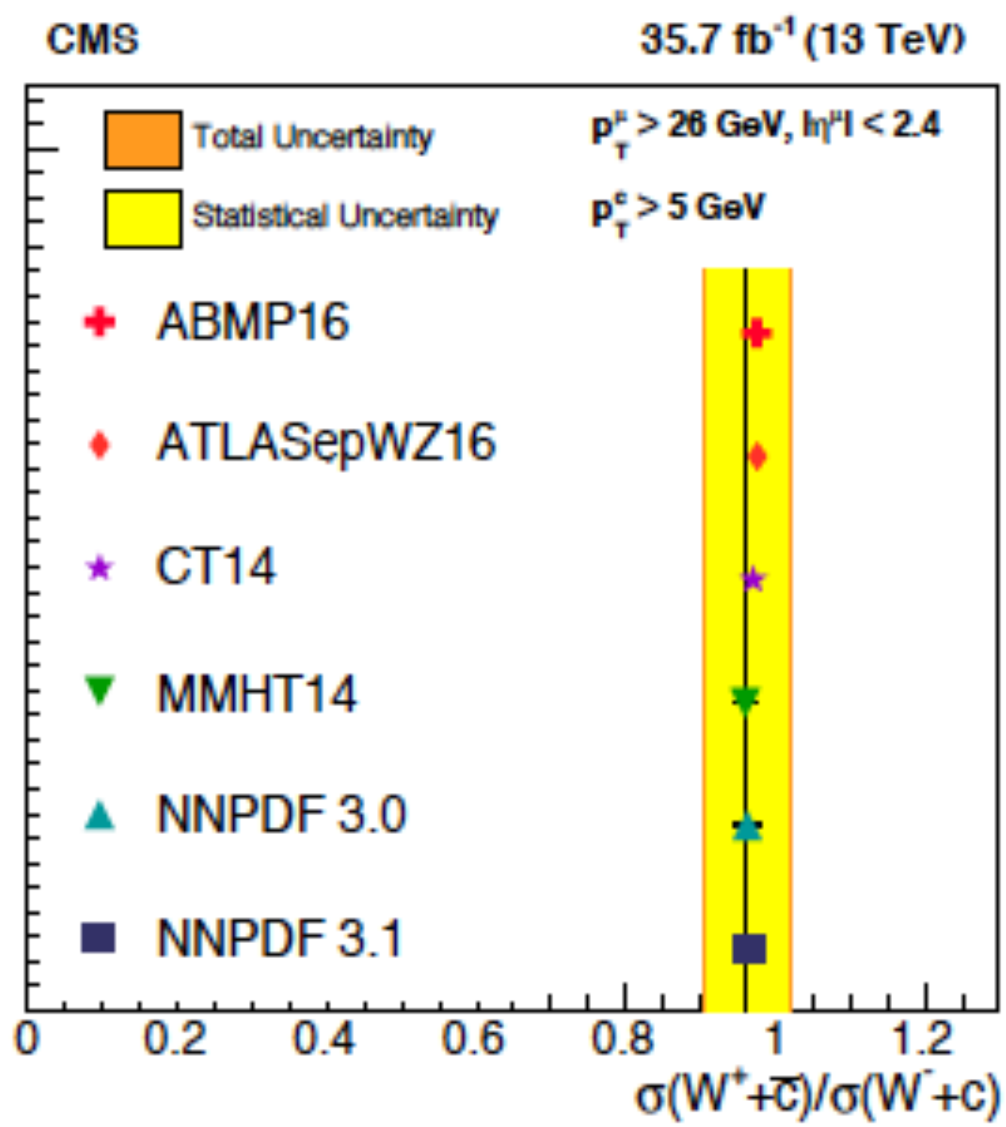
- NNPDF has a very small strange asymmetry
- CT10 no asymmetry
- MSTW larger asymmetry

W. J. Stirling and EV Phys.Rev.Lett. 109 (2012) 082002

Impact of LHC measurements



only 7 TeV data:
small impact



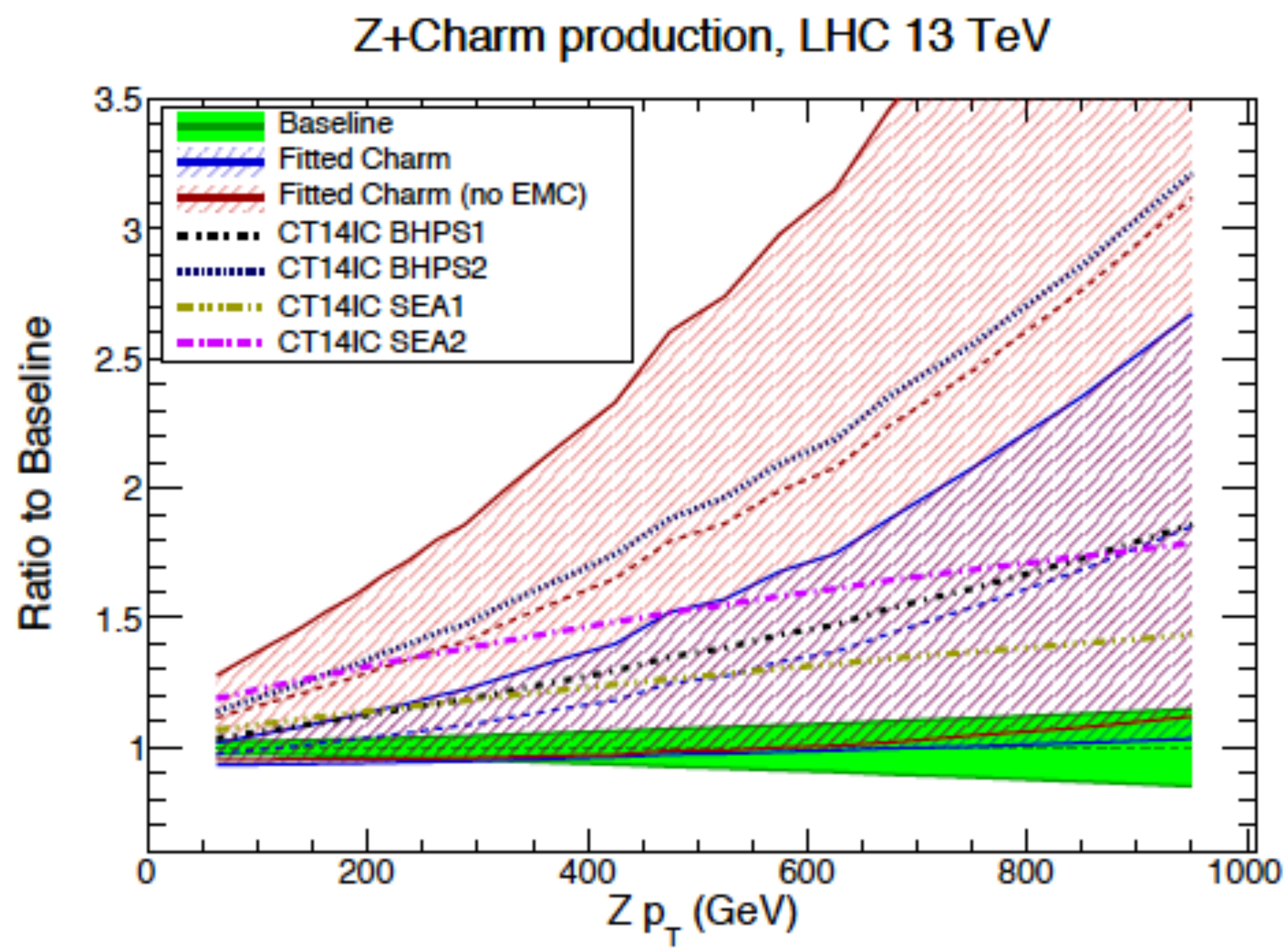
$$\frac{\sigma(W^+ + \bar{c})}{\sigma(W^- + c)} = 0.968 \pm 0.055\,(\text{stat})^{+0.015}_{-0.028}\,(\text{syst})$$

Precise 13TeV measurement more promising

What we can learn from Z plus charm

$$R_c^Z = \frac{\sigma(Z+c)}{\sigma(Z+\text{jet})}$$

PDF set	R_c^Z
CT10	$0.0619^{+0.0032}_{-0.0032}$
MSTW2008NLO	$0.0640^{+0.0014}_{-0.0016}$
NNPDF2.1NLO	0.0660 ± 0.0013
GJR08	0.0611 ± 0.0011
ABKM09	0.0605 ± 0.0019



NNPDF collaboration arXiv:1605.06515

$$R_c^{\pm}(Z) = \frac{\sigma(Z+\bar{c})}{\sigma(Z+c)}$$

A probe of intrinsic charm?

W. J. Stirling and EV Phys.Rev.Lett. 109 (2012) 082002

Gauge boson polarisation at the LHC


Electroweak gauge boson polarisation at the LHC

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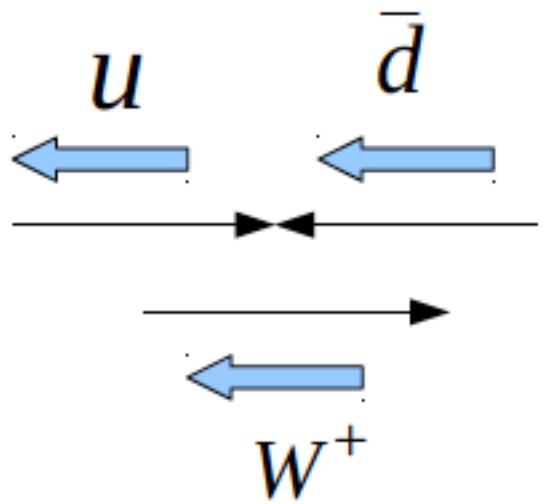


Only LH quarks and RH antiquarks couple to W (V-A)
In the proton: quark more likely to have more momentum than the antiquark $\Rightarrow$ W moves in the quark direction $\Rightarrow$ LH W^+(73%)

$$\frac{1}{\sigma}\frac{d\sigma}{d\cos\theta^*} = \frac{3}{8}(1-\cos\theta^*)^2 f_L + \frac{3}{8}(1+\cos\theta^*)^2 f_R + \frac{3}{4}\sin^2\theta^* f_0$$

$$f_0 = 2 - 5\langle\cos\theta^{*2}\rangle,$$

$$f_L = -\frac{1}{2} - \langle\cos\theta^*\rangle + \frac{5}{2}\langle\cos\theta^{*2}\rangle$$

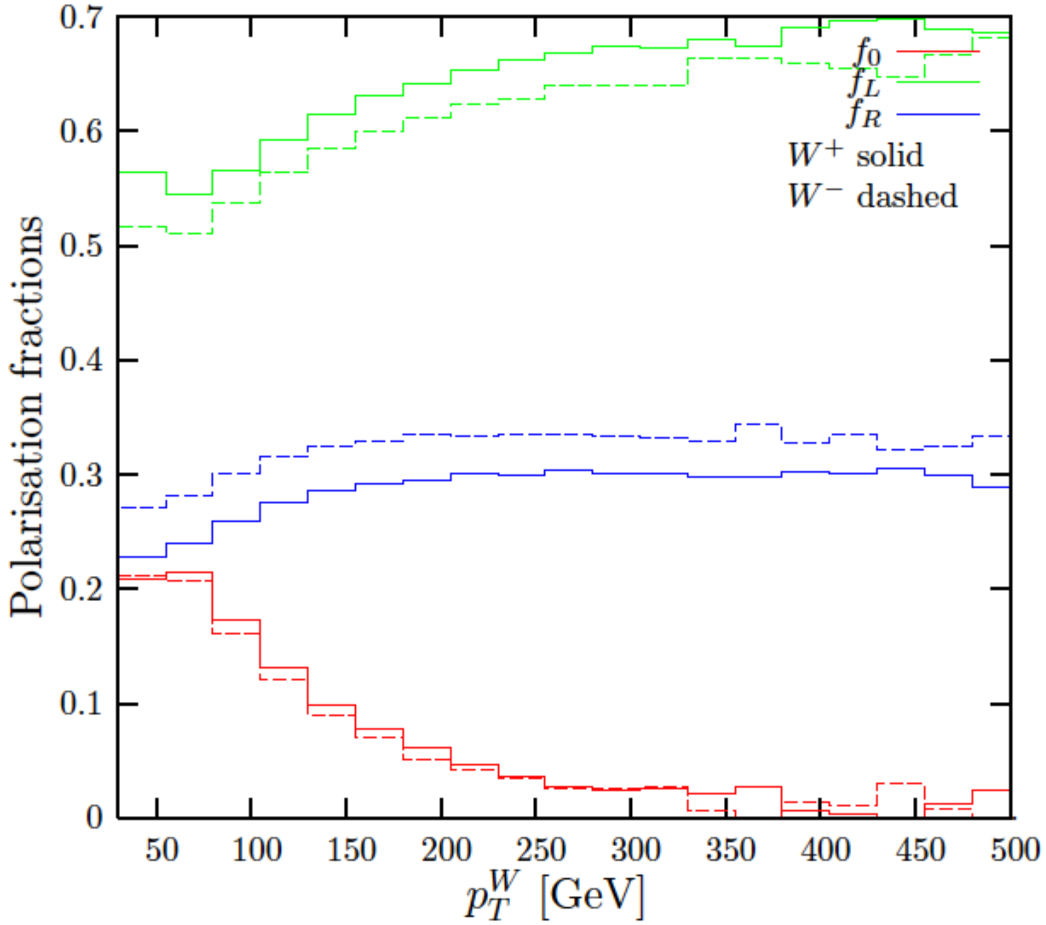
$$f_R = -\frac{1}{2} + \langle\cos\theta^*\rangle + \frac{5}{2}\langle\cos\theta^{*2}\rangle$$

W polarisation fractions

θ is the angle in the W rest frame between the charged lepton and the W flight direction in the lab frame

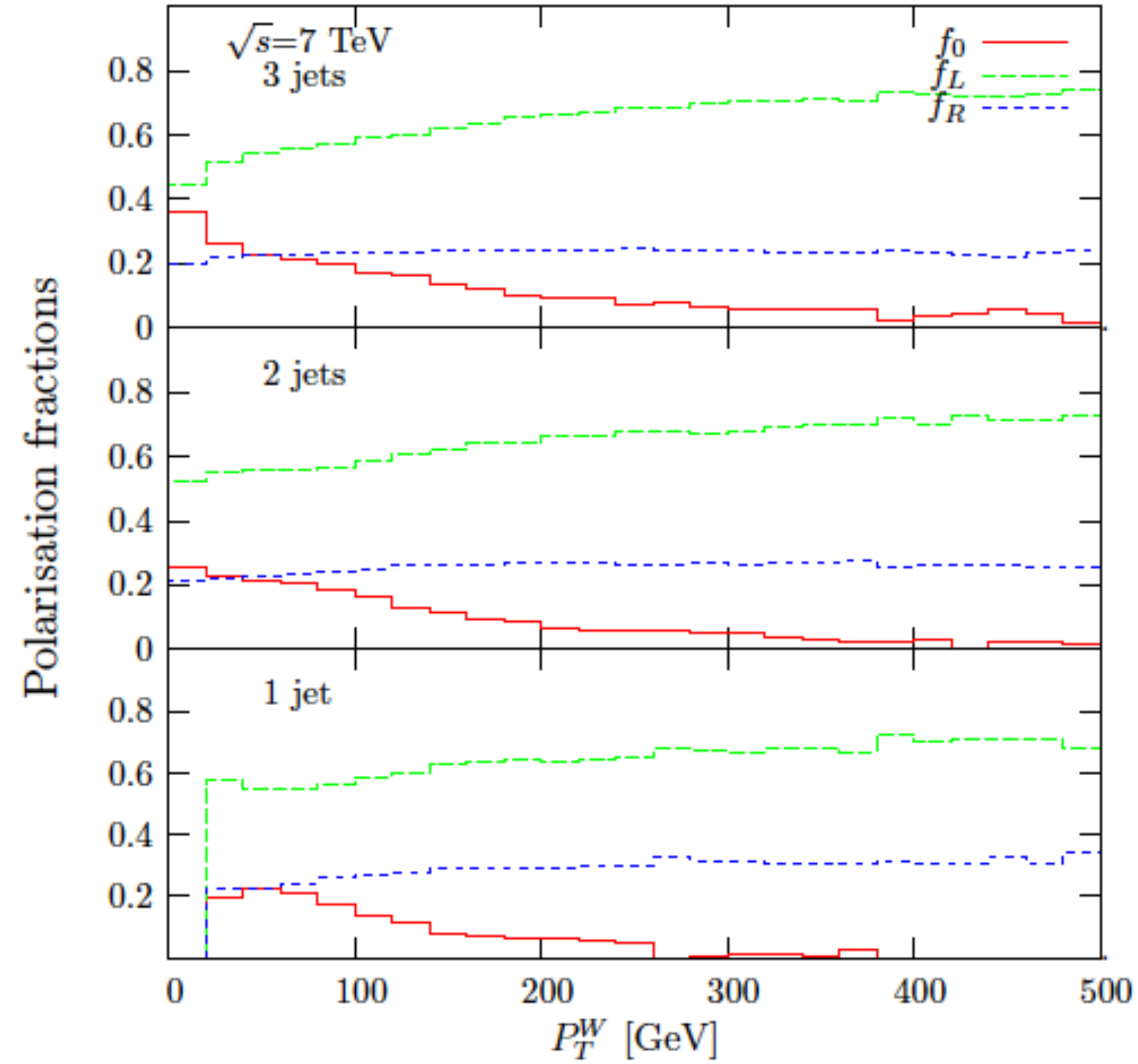
W. J. Stirling and EV JHEP 1207 (2012) 124

W+jets: polarisation fractions



Small differences between W^+ and W^- due to PDF difference of u and d-quarks.

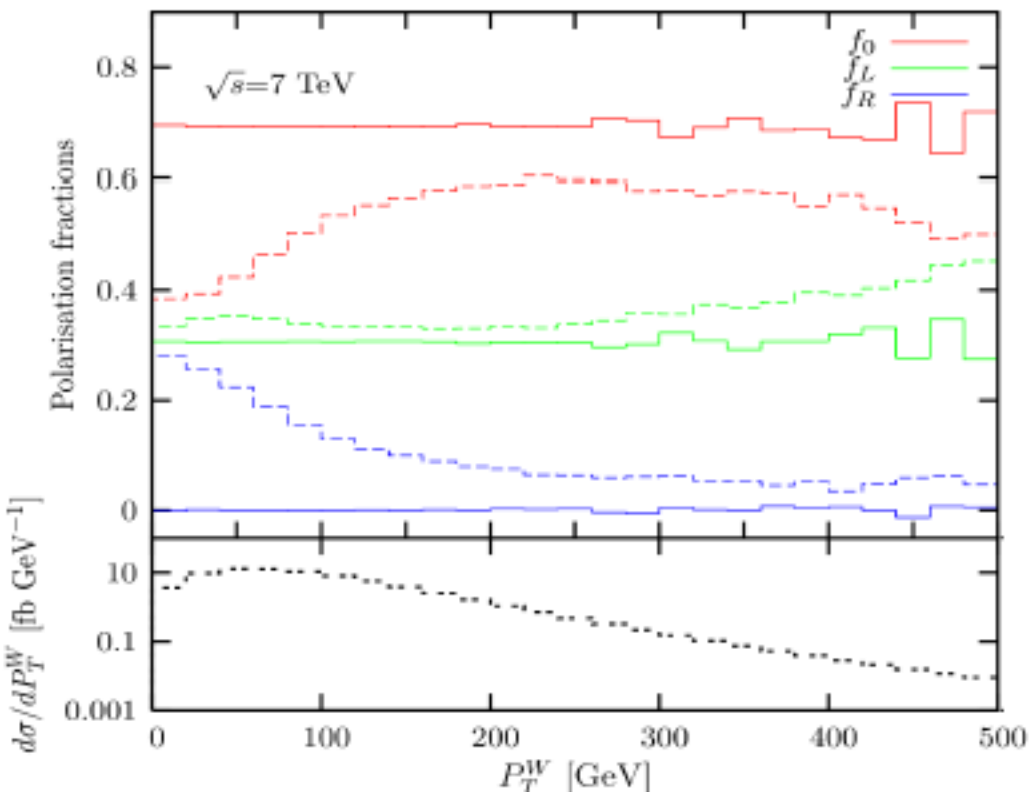
W. J. Stirling and EV JHEP 1207 (2012) 124



W bosons are predominantly left-handed at high p_T independently of the number of jets as seen also by Bern et al. Phys.Rev.D84:034008,2011

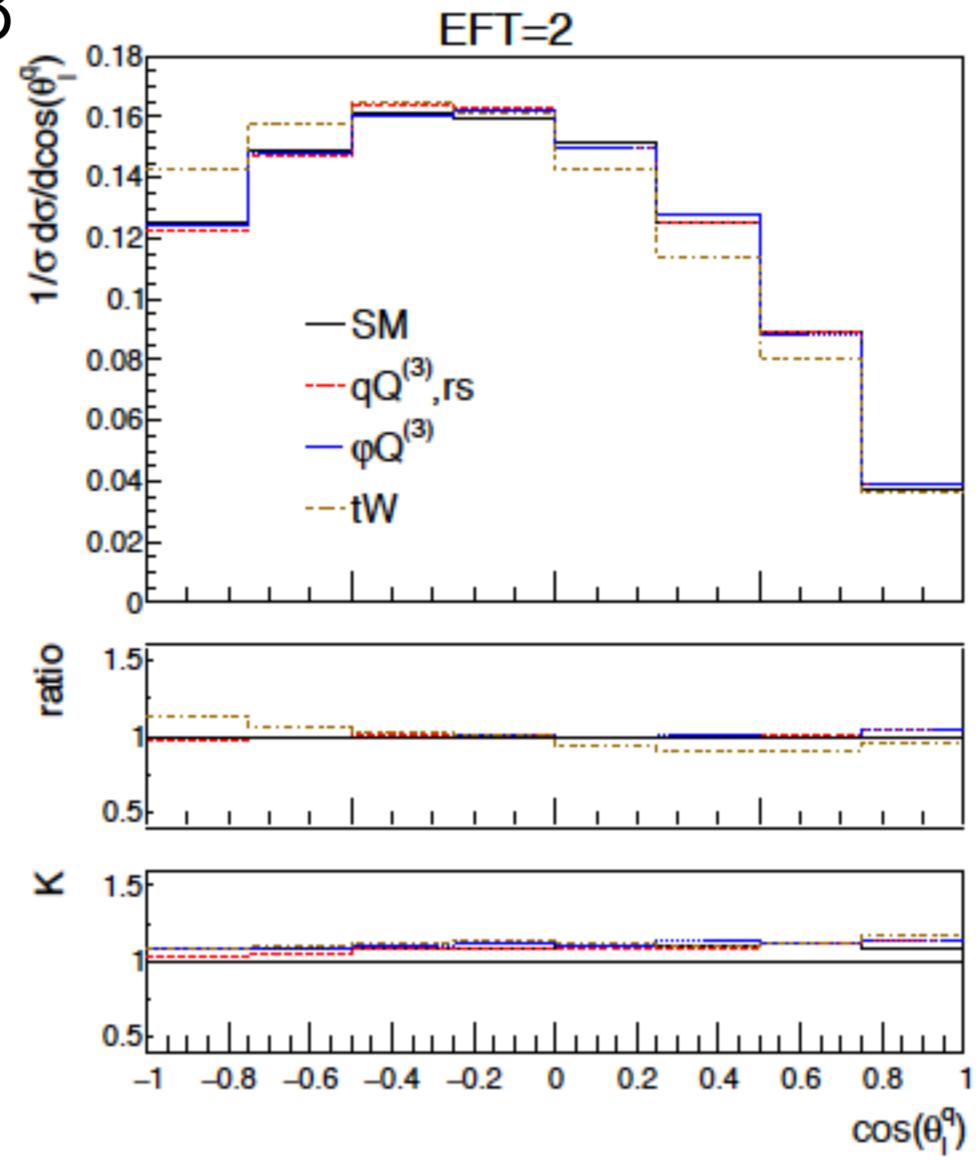
W polarisation in top production

2012



W. J. Stirling and EV JHEP 1207 (2012) 124

2018



de Beurs, Laenen, Vreeswijk, EV
Eur.Phys.J. C78 (2018) no.11, 919

Top rest frame:

$$f_0 = \frac{m_t^2}{m_t^2 + 2m_W^2} \quad \text{and} \quad f_L = \frac{2m_W^2}{m_t^2 + 2m_W^2}$$

Polarisation is frame dependent and interaction dependent

Conclusions

Thesis submitted in September 2013
Title: **Phenomenology of the Standard Model and beyond at hadron colliders**
Extremely lucky to have James as my supervisor