Study of the $W + c$ process with the ATLAS experiment

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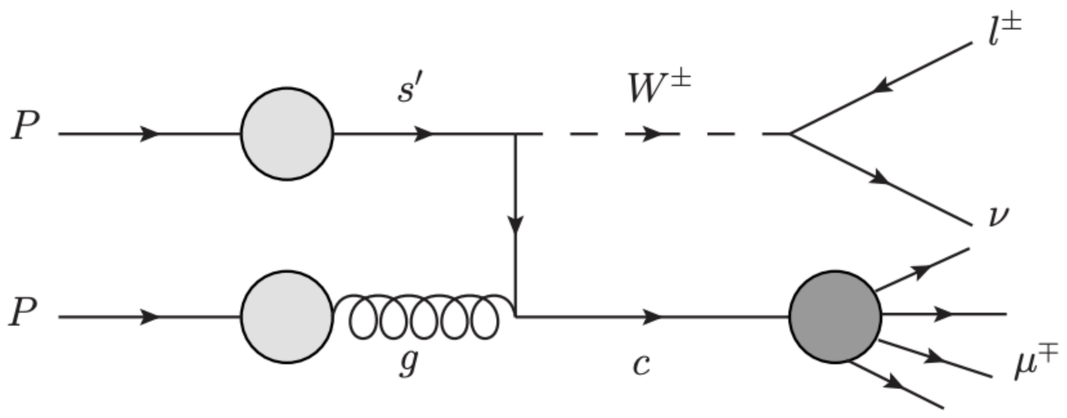
INTRODUCTION

The production of a W boson in association with a c-quark is a key process for probing the strange-quark content of the proton. Dominated by strange–gluon scattering, its cross section provides direct sensitivity to the strange parton distribution function (PDF). Previous ATLAS [1] and CMS [2] measurements were consistent with theoretical predictions, but showed tension with earlier measurements from the Tevatron. Higher-statistics studies are required to improve the precision.

MEASUREMENT STRATEGY

In $p - p$ collisions the main way the $W + c$ final state can be produced is by gluon-strange quark fusion. At the lowest perturbative order, the W boson is produced with exactly one c-jet. The two final state particles have opposite charge sign while for most background processes there is no charge preferences: they can have opposite charge sign (OS) or same charge sign (SS). For this reason, performing a subtraction OS-SS events produces a sample highly pure in signal.

The W boson is reconstructed via its leptonic decay into an electron or a muon, while the charm quark is reconstructed through its semileptonic decay into a muon that has the same sign charge as the charm.



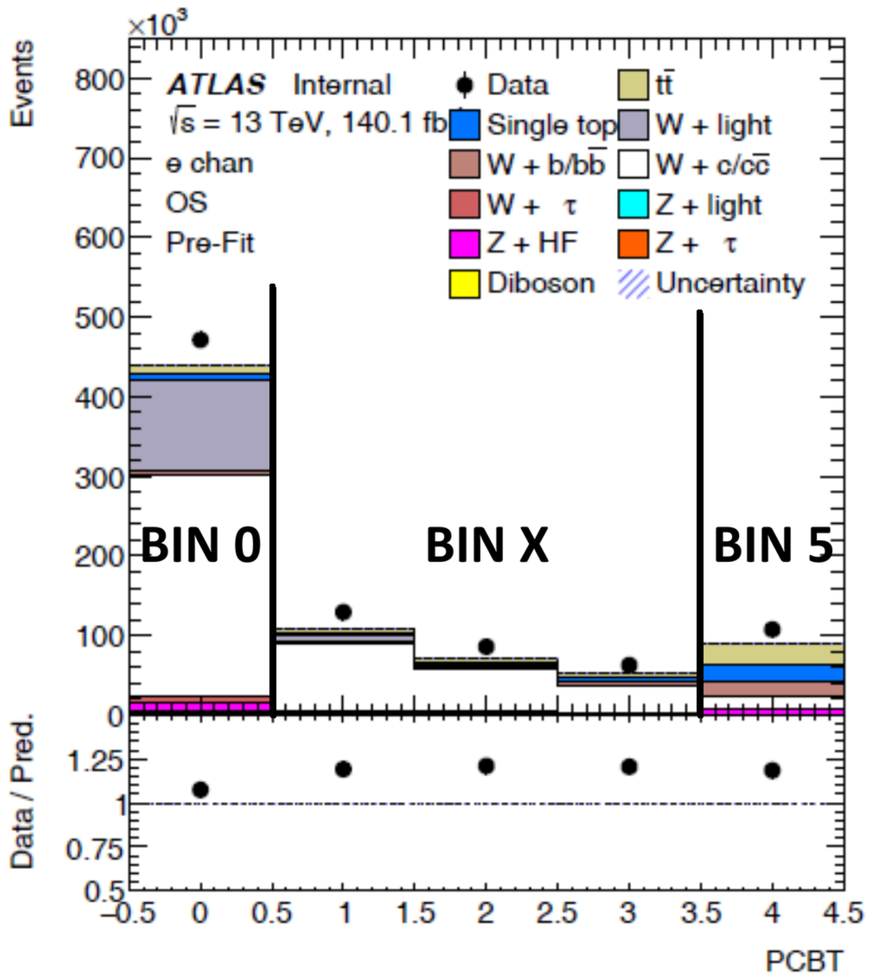
FIT STRATEGY

The fit strategy consists in a simultaneous signal-background likelihood fit. The goal is to estimate the signal shape and the background normalizations. The fit is developed in two dimensions:

- The variable of interest for the analysis which is one of three rapidities: the lepton from the W, the c jet and the soft muon from the c decay.
- The pseudo-continuous b-tagging variable (PCBT), which consists in 5 bins corresponding to different b tagging efficiencies.

In this fit the PCBT variable is divided in 3 bins:

- **Bin 0** corresponding to a b-tagging efficiency of $[100\%, 85\%]$. This region is enriched in $W + l$ events.
- **Bin X** corresponding to a b-tagging efficiency of $[85\%, 60\%]$. This region is the most pure in signal.
- **Bin 5** corresponding to a b-tagging efficiency of $[60\%, 0\%]$. This region is enriched in $W + b$ events.



CHARM MASS EFFECTS

ATLAS uses experimental requirements (p_T cut on the charm jet/hadron) that introduce lower energy scales with respect to the hard scale of the $W + c$ production ~ 80 GeV, enhancing mass effects of $\mathcal{O}(m_c^2)$. We investigated these power mass corrections in the background $W + c + \bar{c}$ cross-section, important in the OS-SS subtraction, using a numerical approach. At $m_c = 1.5$ GeV they are of 2.6%, giving motivation to calculate them for the $W + c$ production at NLO.

RESULTS

The goal of this analysis is to measure the differential and integral cross section for the production of $W + c$. After the signal is estimated from the fit, additional corrections are applied in order to take into account for detector effects in a procedure called *unfolding*.

Moreover it is interesting to measure the cross section divided into W^+ and W^- events since they are sensitive to the s and $\bar{s}$ PDFs respectively. It is also possible to reduce the systematics contributions by taking a ratio of the W^+ and W^- cross sections.

The analysis is in the revision stage before being published.

Cross section $[pb]$	Lep y	Jet y	Soft Mu y
Electron	$16.47\ ^{+0.43}_{-0.46}$	$16.38\ ^{+0.44}_{-0.43}$	$16.41\ ^{+0.46}_{-0.44}$
Muon	$16.08\ ^{0.42}_{-0.45}$	$16.00\ ^{+0.42}_{-0.42}$	$16.03\ ^{+0.43}_{-0.43}$

[1] Determination of the parton distribution functions of the proton from ATLAS measurements of differential W and Z boson production in association with jets, ATLAS collaboration.

[2] Measurement of associated production of a W boson and a charm quark in proton-proton collisions at $\sqrt{s} = 13\,TeV$, CMS collaboration.