23. Evidence for Electroweak Production of $W^{\pm}W^{\pm}jj$ in pp Collisions at $\sqrt{s}$ = 8 TeV with the ATLAS Detector

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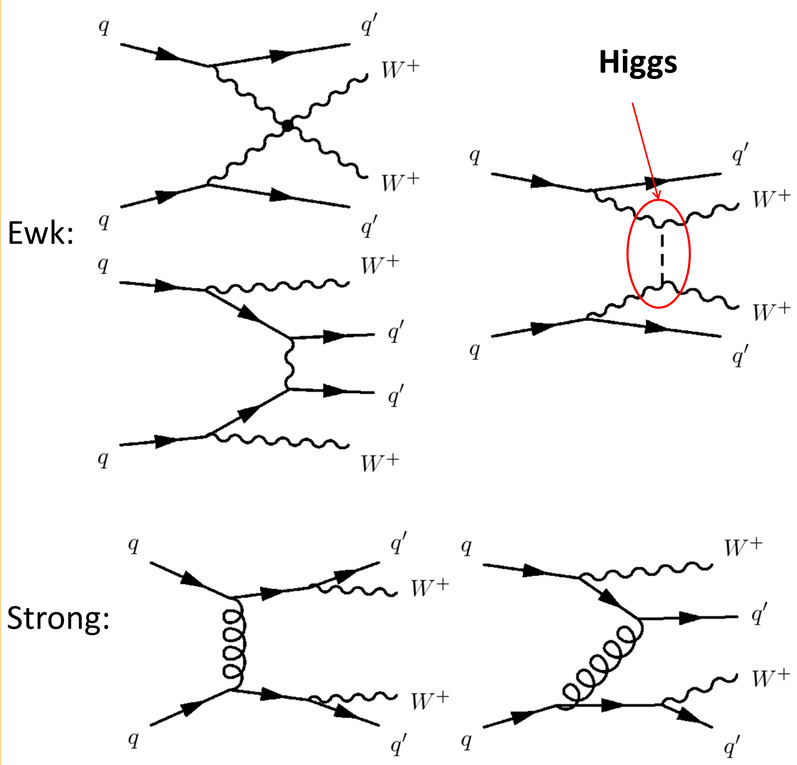
Vector Boson Scattering (VBS), $VV \to VV$ with $V = W$ or Z, is a key process to understand the nature of the electroweak symmetry breaking. A light SM Higgs boson tames the scattering amplitude of longitudinally-polarized vector bosons and preserves unitarity. However, many new physics scenarios predict enhancements in VBS either with additional resonances or if the SM Higgs only partially unitarizes this amplitude. Same-sign $W^{\pm}W^{\pm}jj$ is one of the most promising final states for a first study of VBS at LHC.

1. Ewk. vs. Strong Production

The production processes of $VVjj$ can be separated into two categories:



The Ewk. production includes the VBS diagrams. Same-sign $W^{\pm}W^{\pm}jj$ has the largest Ewk./Strong ratio at 8 TeV and thus the best sensitivity to the Ewk. production. (at least 2 leptons with p_T >5 GeV, m_{ll}> 4 GeV, at least 2 jets with p_T> 10 GeV)

Final state	Process	$VVjj$-EW	$VVjj$-QCD
$\ell^{\pm}\nu\ell'^{\pm}\nu' jj$ (same sign)	$W^{\pm}W^{\pm}$	19.5 fb	18.8 fb
$\ell^{\pm}\nu\ell'^{\mp}\nu' jj$ (opposite sign)	$W^{\pm}W^{\mp}$	91.3 fb	3030 fb
$\ell^{+}\ell^{-}\nu'\nu' jj$	ZZ	2.4 fb	162 fb
$\ell^{\pm}\ell^{\mp}\ell'^{\pm}\nu' jj$	$W^{\pm}Z$	30.2 fb	687 fb
$\ell^{\pm}\ell^{\mp}\ell'^{\pm}\ell'^{\mp} jj$	ZZ	1.5 fb	106 fb

2. Event Selection

Same-sign $W^{\pm}W^{\pm}jj$ events in the fully leptonic channel should contain:

- Exactly two isolated leptons (e or μ) of the same electric charge
- At least two high-p_T hadronic jets
- Large missing transverse energy

We measure the production cross section of the inclusive same-sign $W^{\pm}W^{\pm}jj$ process in the **inclusive analysis region**:

- The two highest-p_T jets have m_{jj}> 500 GeV

The electroweak production is then measured in the **VBS analysis region** by requiring in addition:

- The two jets are separated by $|\Delta y(jj)|$>2.4

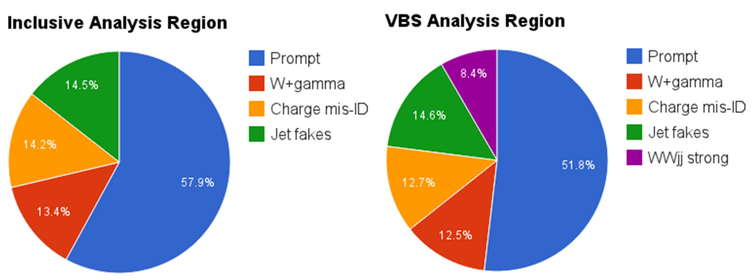
3. Background Estimation

The major backgrounds include:

1. Prompt backgrounds, which do have two same-sign leptons in the final state, including WZ/γ*+jets, ZZ+jets and $t\bar{t}$+W/Z , are estimated using MC simulation.

2. Conversion backgrounds, which involve the process of photon converting to electron-positron pair, including charge mis-ID, estimated from data, and Wγ, estimated using MC

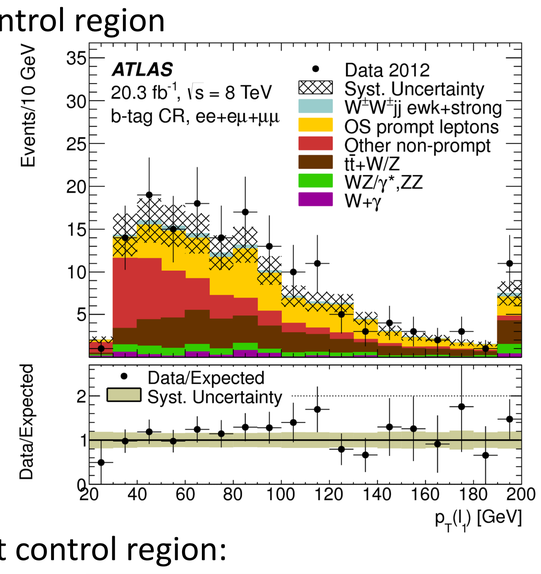
3. Jet fakes, where one of the two same-sign leptons originate from hadronic jets, are estimated from data.



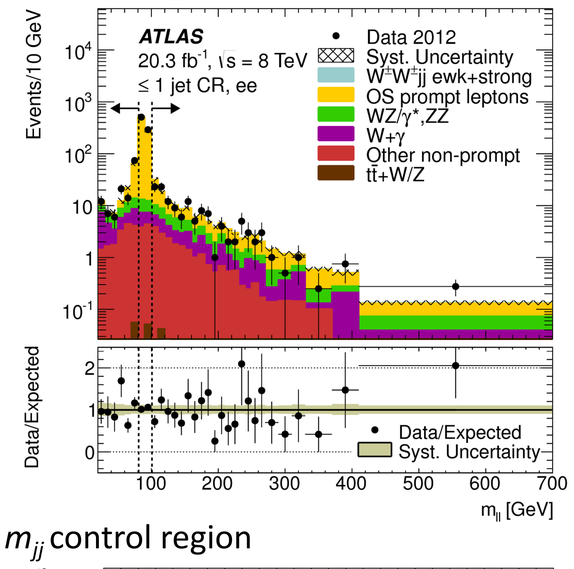
4. Control Regions

The background estimation is checked in various control regions:

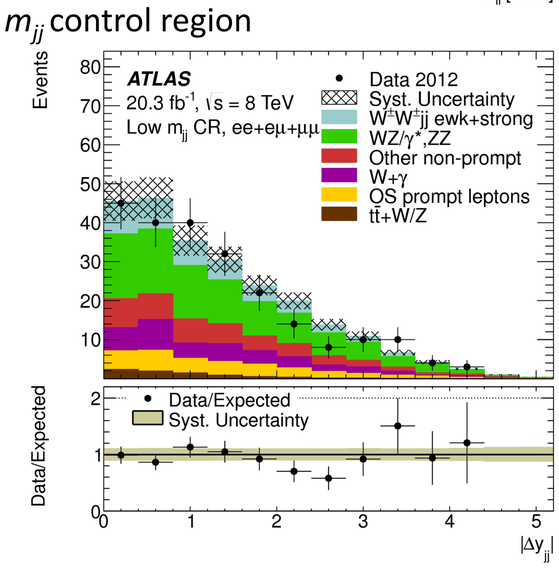
1. $t\bar{t}$ control region



2. ≤1 jet control region:

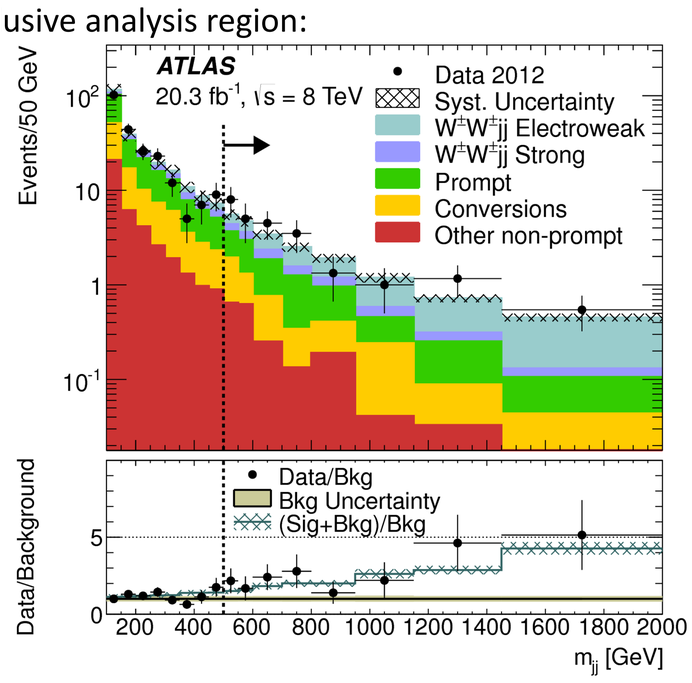


3. Low m_{jj} control region

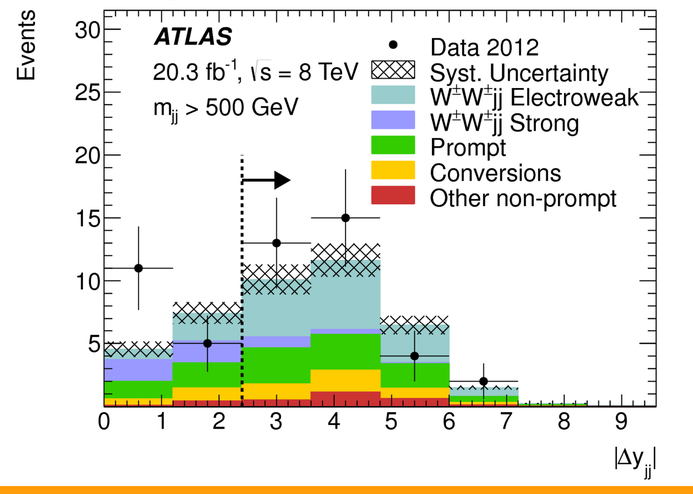


5. Signal Regions

Inclusive analysis region:



VBS analysis region:

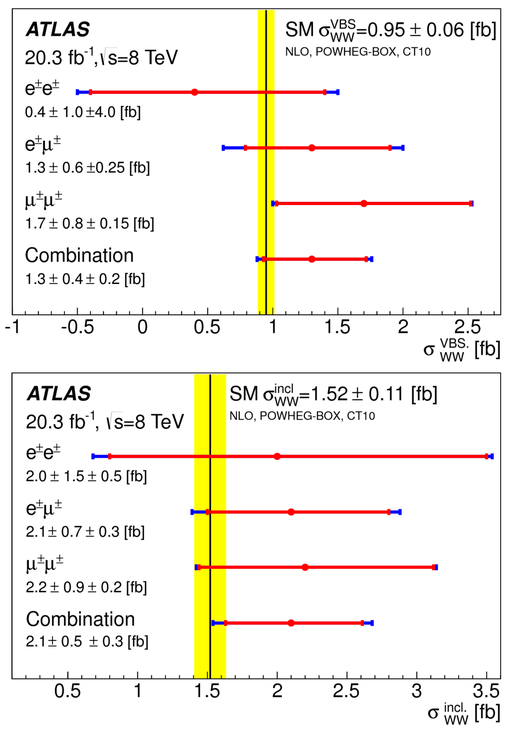


6. Cross Section Measurement

Cross sections are extracted from a likelihood function combining all three dilepton channels.

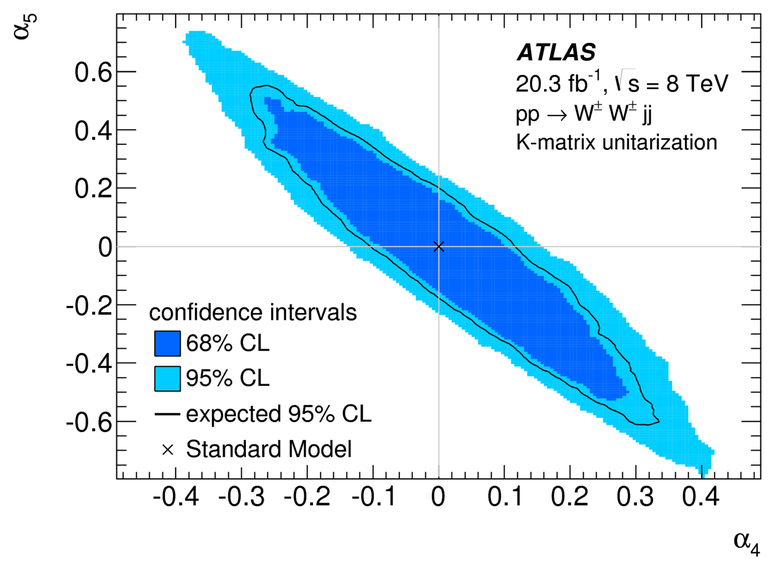
region	measured [fb]	expected [fb]	Obs.Sig.
Incl.	2.1±0.5±0.3	1.52±0.11	4.5σ
VBS	1.3±0.4±0.2	0.95±0.06	3.6σ

First evidence for both the inclusive and electroweak production of the same-sign $W^{\pm}W^{\pm}jj$ process.



7. Anomalous Quartic Gauge Coupling

VBS is sensitive to beyond SM physics. Low energy effects of new physics at high energy scale can be parametrized using effective field theories. Anomalous couplings with respect to the SM predict enhanced signal yields. Limits are set on the parameters α_4 and α_5 using the VBS analysis region.



Reference for this analysis: arXiv:1405.6241