First measurement of associated vector boson plus prompt charmonium production at the ATLAS experiment

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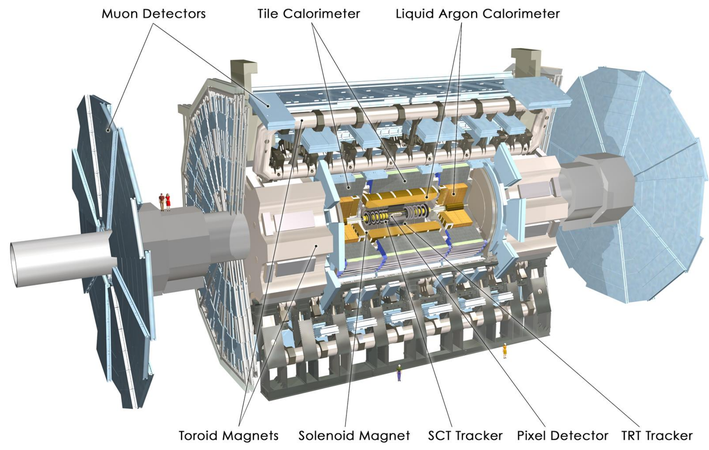
Introduction

- Although many models tried to describe the J/ψ system, its production mechanism is still not well understood
- $W^{\pm}$ + prompt J/ψ is a quark initiated process with different production mechanisms than the inclusive J/ψ
- Theory inputs
  - ☐ Prior **ATLAS** measurement: Colour octet dominated process (arXiv:1012.3798)
  - ☐ After **ATLAS** measurement: Large colour singlet contributions (arXiv:1303.5327)

The ATLAS detector

- **ATLAS** is a multi-purpose detector in the LHC ring
- Inner detector (ID) perdorms tracking of charge particles for $|\eta| < 2.5$
- Muon system (MS) covers a range of $|\eta| < 2.7$
- The combination of the ID and the MS tracking can reconstruct muons with $p_{\mathrm{T}} > 2.5\,\mathrm{GeV}$ with resolution $\sigma(p_{\mathrm{T}})/p_{\mathrm{T}}$ better than 3 % for $2.5 < p_{\mathrm{T}} < 100\,\mathrm{GeV}$

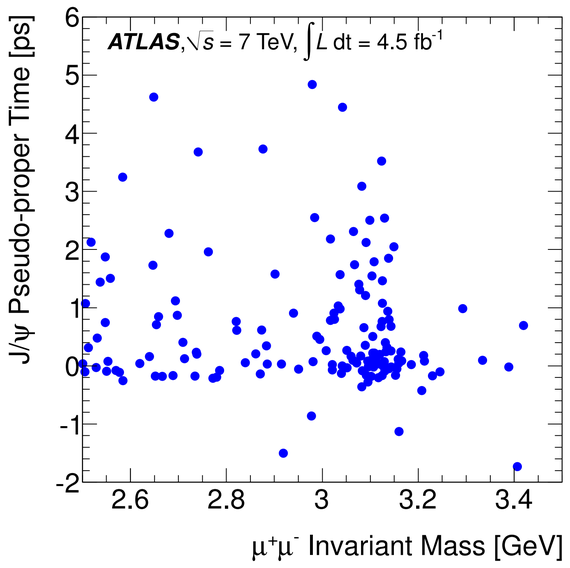


Selections - Signal extraction

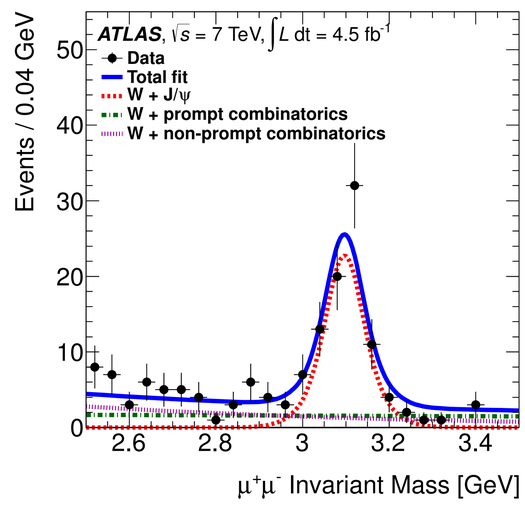
$4.5\,\mathrm{fb}^{-1}$ data of $\sqrt{s} = 7\,\mathrm{TeV}$ pp collisions collected during 2011 used in this analysis

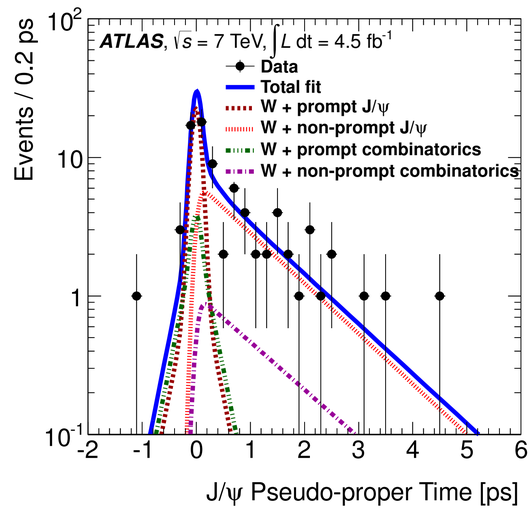
- single muons trigger is required $p_{\mathrm{T}} > 18\,\mathrm{GeV}$
- $J/\psi \to \mu^+\mu^-$ selections
  - ☐ $p_{\mathrm{T}}^{\mu} > 2.5\,\mathrm{GeV}$ and $|\eta^{\mu}| < 2.5$
  - ☐ $2.5 < m_{\mu\mu} < 3.5\,\mathrm{GeV}$
  - ☐ $8.5 < p_{\mathrm{T}}^{J/\psi} < 30\,\mathrm{GeV}$ and $|y_{J/\psi}| < 2.1$
- $W^{\pm} \to \mu^{\pm}\nu$ selections
  - ☐ $p_{\mathrm{T}}^{\mu} > 25\,\mathrm{GeV}$ and $|\eta^{\mu}| < 2.4$
  - ☐ missing transverse energy $> 20\,\mathrm{GeV}$
  - ☐ $m_{\mathrm{T}}^{W} > 40\,\mathrm{GeV}$

$W^{\pm} + J/\psi$ candidates in pseudo-proper time versus $\mu^+\mu^-$ invariant mass



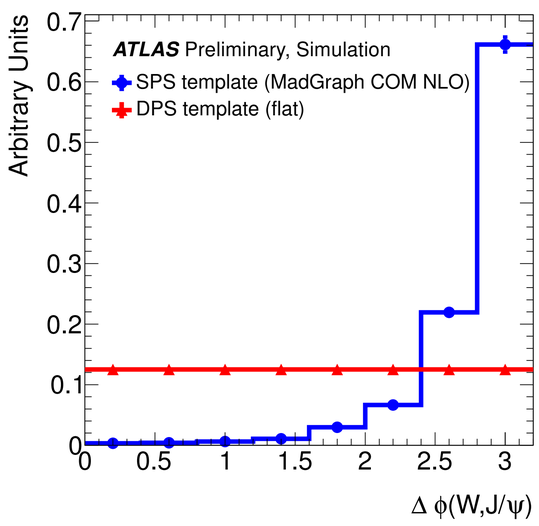
- Prompt yield is extracted with a 2D unbinned maximum likelihood fit in invariant mass and pseudo-proper time
- $27.4^{+7.5}_{-6.5}$ events are observed with a significance of $5.1\,\sigma$

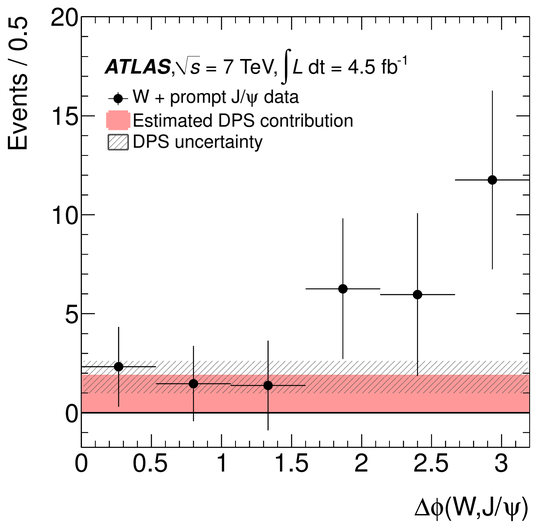




Double parton scattering

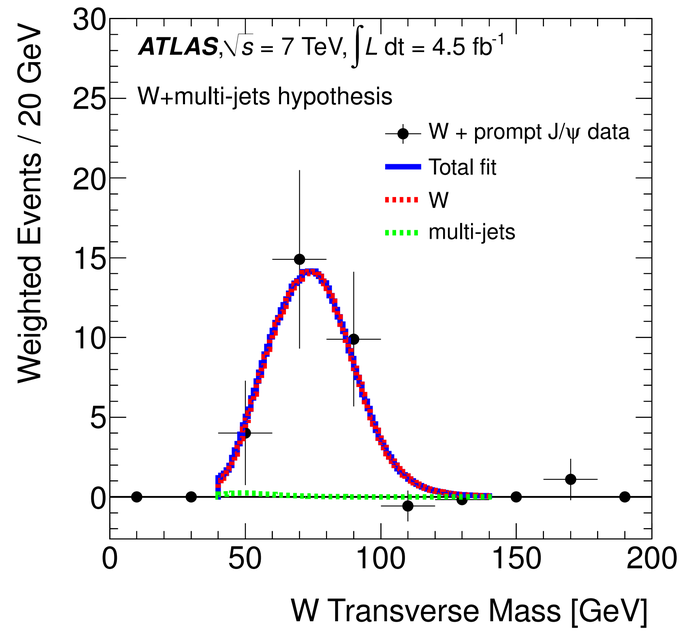
- Events originating from DPS are expected to be distributed uniformly along the azimuthal angle between the $W^{\pm}$ and the J/ψ, where events from SPS are expected to peak at $\Delta\phi = \pi$
- DPS is an intistinguishable part of the signal (estimated $\mathrm{f_{DPS}} \approx 40\%$)
- Estimation of DPS events is given from $N_{\mathrm{DPS}} = \sigma_{J/\psi} N_{W^{\pm}} / \sigma_{\mathrm{eff}} = 10.8 \pm 4.2$
- $\sigma_{J/\psi}$ and σ_{eff} come from **ATLAS** measurements (arXiv:1104.3038 and arXiv:1301.6872)
- DPS contribution consistent with **ATLAS** $W^{\pm} + 2$ jet measurement





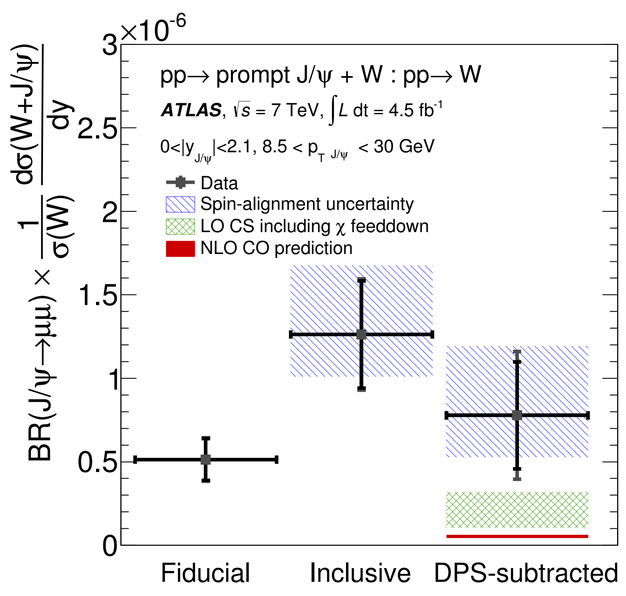
$W^{\pm}$ candidates

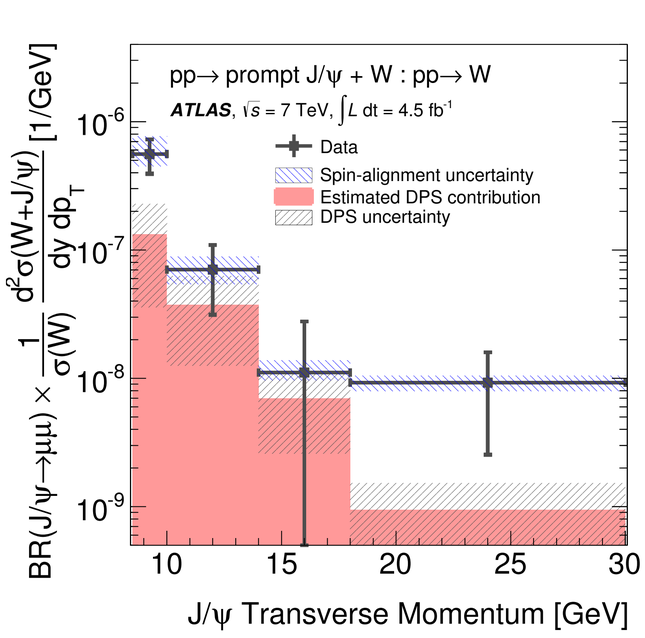
- Weights based on the prompt J/ψ yield are applied to $W^{\pm}$ candidates
- Weighted m_{T}^{W} is compared with signal and background (multi-jet) templates
- Multi-jet yield is found to be < 0.3 events



Results

- First observation of the charmonium + vector boson production (arXiv:1401.2831 - JHEP 04 (2014) 172)
- Associated production of $W^{\pm}$ + prompt J/ψ one of the rarest processes measured at the LHC
- Differential cross section ratio as a function of $p_{\mathrm{T}}^{J/\psi}$ suggests big single parton scattering contribution
- Future prospects
  - ☐ $\sqrt{s} = 8\,\mathrm{TeV}$ and RunII data will allow us to measure σ_{eff} of DPS using $W^{\pm}$ + heavy flavour
  - ☐ Search for very light scalar, h, mixing with the SM Higgs ($pp \to Wh \to \mu\nu\mu^+\mu^-$ - arXiv:1310.8042)





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