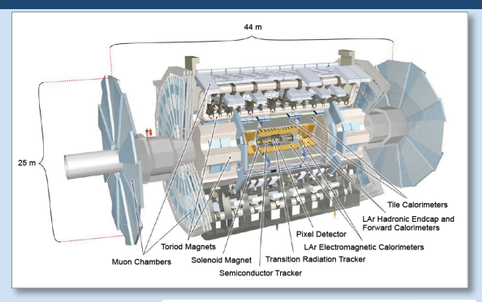
Associated production of a *Z* boson with prompt and non-prompt *J/ψ* mesons

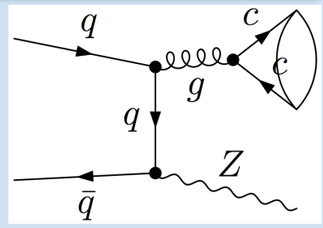
Reference: arXiv:1412.6428
submitted to EPJC

1. Introduction

- ATLAS is a multi-purpose detector in the LHC ring
- First observation of the associated production of *Z* boson with prompt and non-prompt *J/ψ* mesons

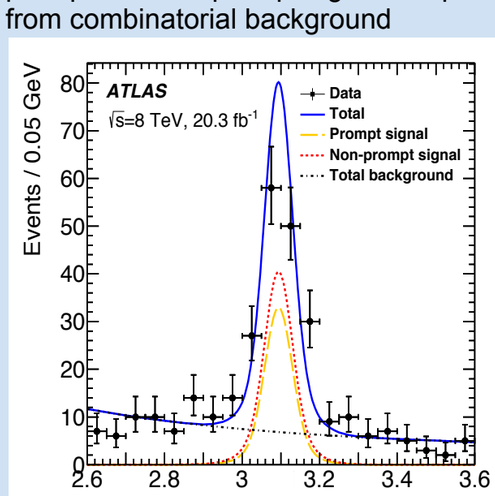


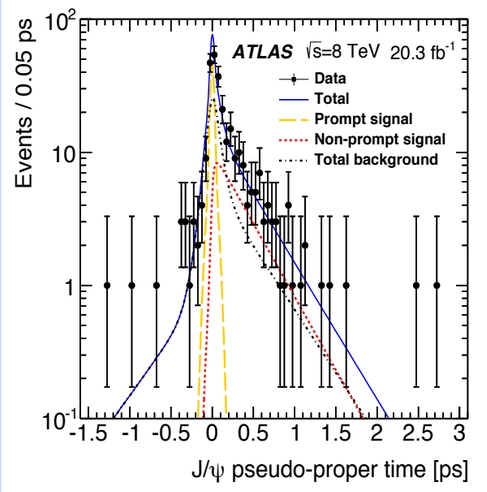
- *Z* (→*ee* and →*μμ*) boson selection
  - p_T(trigger lepton)>25 GeV
  - p_T(sub-leading lepton)>15 GeV
  - $|\eta$(lepton from *Z*)|<2.5
  - $|m_Z$-91.1876 GeV|<10 GeV
- *J/ψ* (→*μμ*) selection
  - $2.6<m_{J/\psi}<3.6$ GeV
  - $8.5<p_T^{J/\psi}<100$ GeV
  - $p_T^{\mu 1}>4.0$ GeV, $|\eta^{\mu 1}|<2.5$
  - $p_T^{\mu 2}>3.5$ GeV for $|\eta^{\mu 2}|<1.3$ OR $p_T^{\mu 2}>2.5$ GeV for $1.3<|\eta^{\mu 2}|<2.5$
- *Z* and *J/ψ* vertex separation in *z*-axis to be less than 10 mm



2. Signal extraction

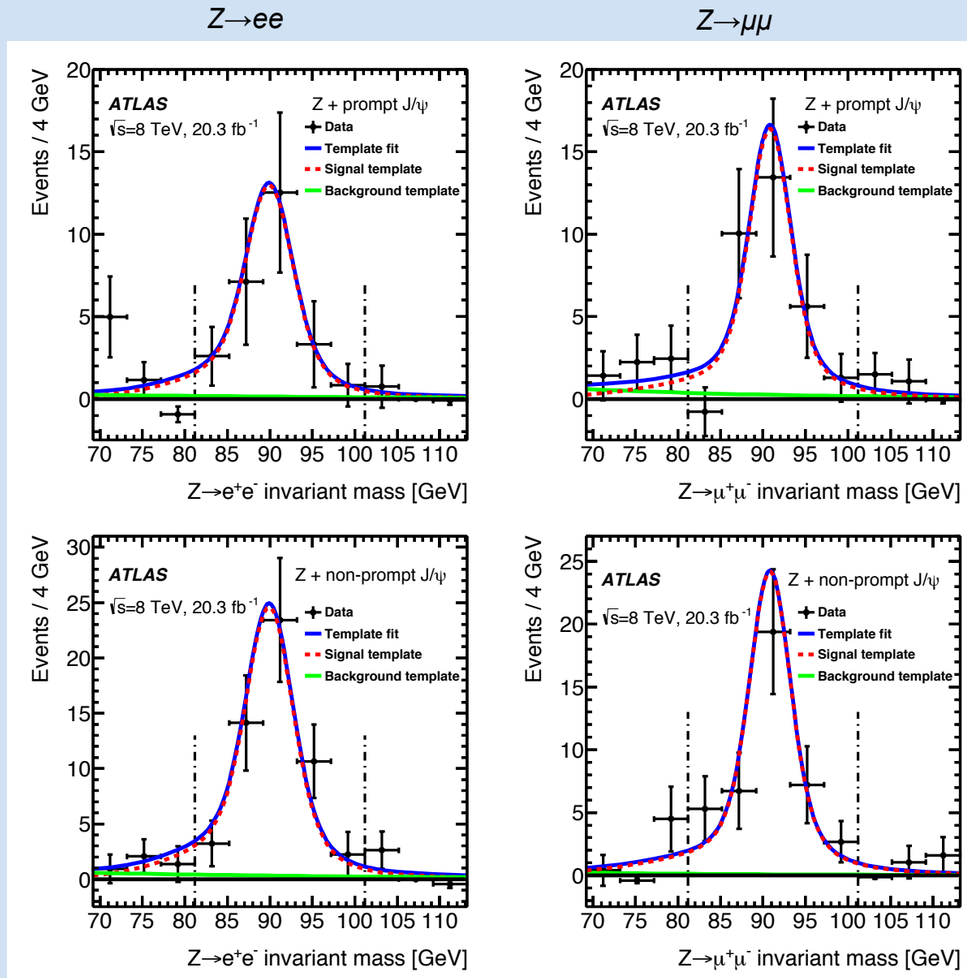
- Unbinned two dimensional fit in *J/ψ* mass and pseudo-proper time to separate prompt and non-prompt signal component from combinatorial background





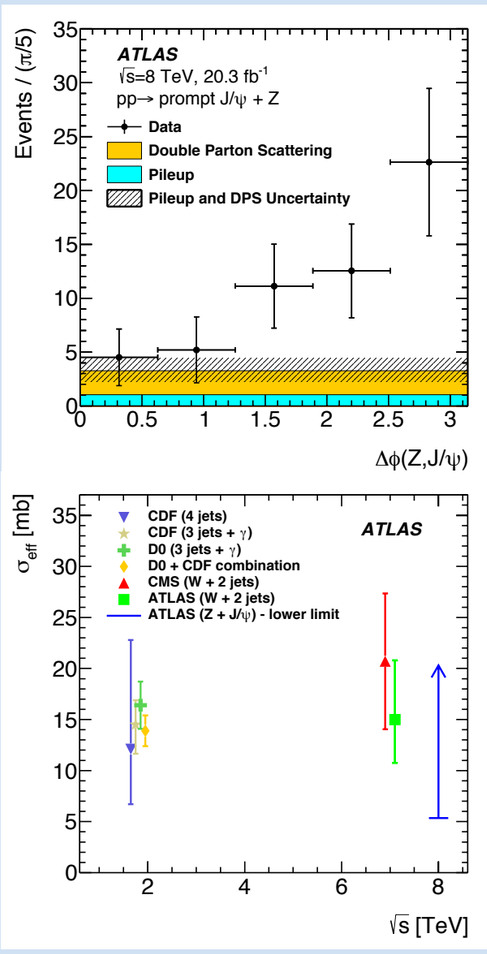
3. *Z* bosons produced in association with a *J/ψ* meson

- *Z* boson candidate mass distributions associated to prompt and non-prompt *J/ψ* determined from weights derived from mass – pseudo-proper time fit
- Weighted distributions are fitted with signal + multijet templates
  - background contribution (primarily from multijet processes) was found to be negligible



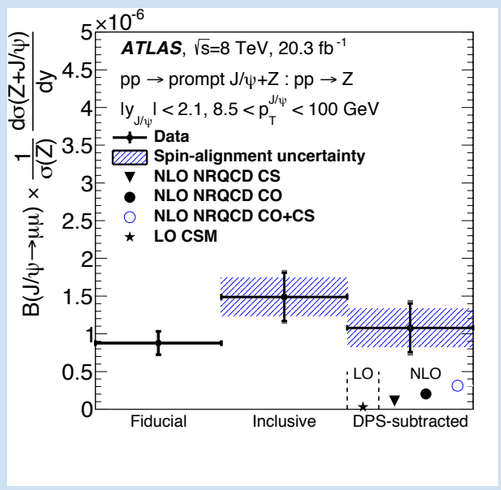
4. Double Parton Scattering (DPS)

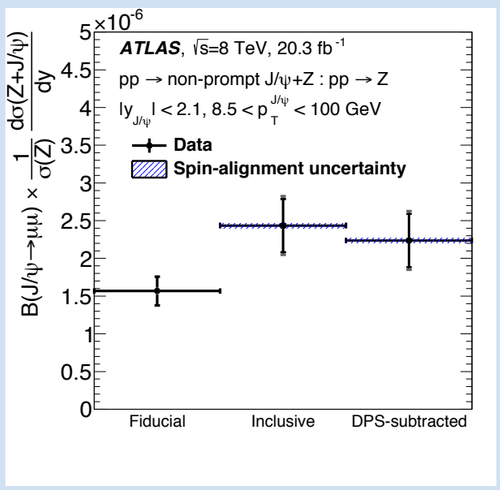
- Probability that a *J/ψ* is produced from a hard scatter in an event which also contains a *Z* is $P_{J/\psi Z} = \sigma_{J/\psi}/\sigma_{eff}$
- DPS contribution estimated using J/ψ cross-section and σ_{eff} from *W+2j* ATLAS measurement [New J. Phys. 15, 033038 (2013)]
- Also use Δ*φ* observable to set an upper limit on σ_{eff} of 5.3 (3.7) mb at 68 (95)%



5. Cross section measurements and comparison to theory

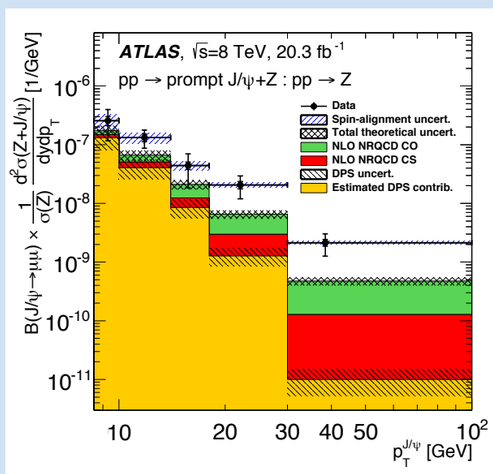
- Measurement of the production cross-section ratios of prompt and non-prompt *J/ψ* mesons in association with a *Z* boson relative to inclusive *Z* production
  - total integrated cross-section – measured in the defined fiducial volume
  - inclusive – corrected for detector acceptance effects on the *J/ψ* reconstruction
  - corrected cross-section after the subtraction of the DPS contribution
- Comparison of measured single parton scattering rates to theoretical predictions
- Production of a *J/ψ* in association with a *Z* boson occurs approximately twice per million *Z* bosons

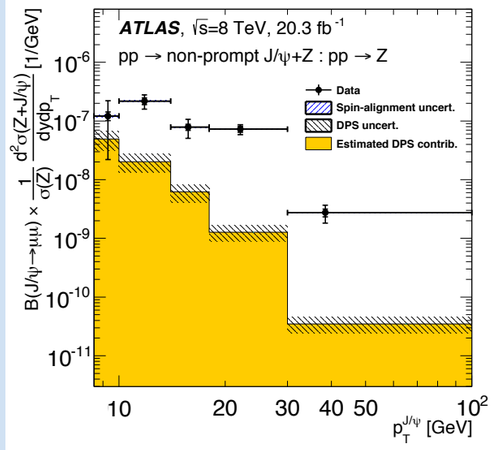




6. Differential production cross-section ratios

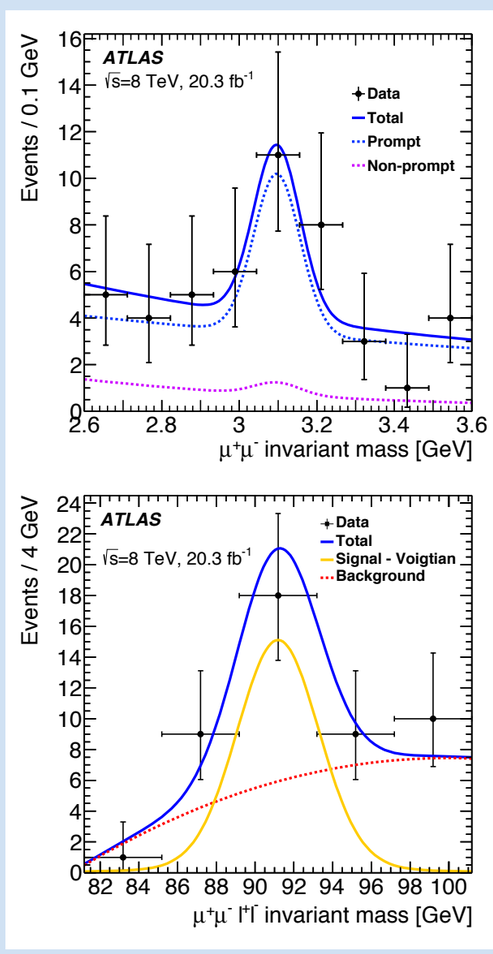
- Normalised production cross-section of *J/ψ* in association with a *Z* boson as a function of the p_T of prompt (top) and non-prompt (bottom) *J/ψ*
- Overlaid contribution from estimated DPS
- Theoretical prediction at NLO accuracy from SPS from colour-singlet (CS) and colour-octet (CO) processes stacked on DPS contribution
  - CO become dominant in higher-p_T
  - discrepancy between data and theory increases with p_T





7. *Z*→ *ℓ⁺ℓ⁻J/ψ* decay

- Check for potential contamination from the *Z*→ *ℓℓJ/ψ* decay
- *μμ* and *μμℓℓ* invariant mass distributions in the *J/ψ* and *Z* mass region
- Peak in *μμℓℓ* found to be consistent from non-*J/ψ μμ* pairs



8. Summary

- The production of prompt and non-prompt *J/ψ* mesons in association of *Z* bosons was observed with the background-only hypothesis being excluded at more than 5σ significance, using 20.3 fb^{-1} of *pp* collisions at $\sqrt{s}$=8 TeV
  - both DPS and SPS contributions present in data
- Fiducial, inclusive and DPS-subtracted cross-section ratios of the production of Z+J/ψ normalised to the inclusive Z cross-section
- Production rates in data greater than predicted by NLO theoretical predictions
- DPS rates measured to be (29±9)% for prompt and (8±2)% for non-prompt *J/ψ* production, using azimuthal angle between *Z* boson and *J/ψ*

Stefanos Leontsinis, for the ATLAS Collaboration

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