Direct measurements of DPI in ATLAS

Ellie Dobson
On behalf of the ATLAS collaboration*

MPI 2011
22/11/11

***https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2011-159/atlas_authorlist.pdf**

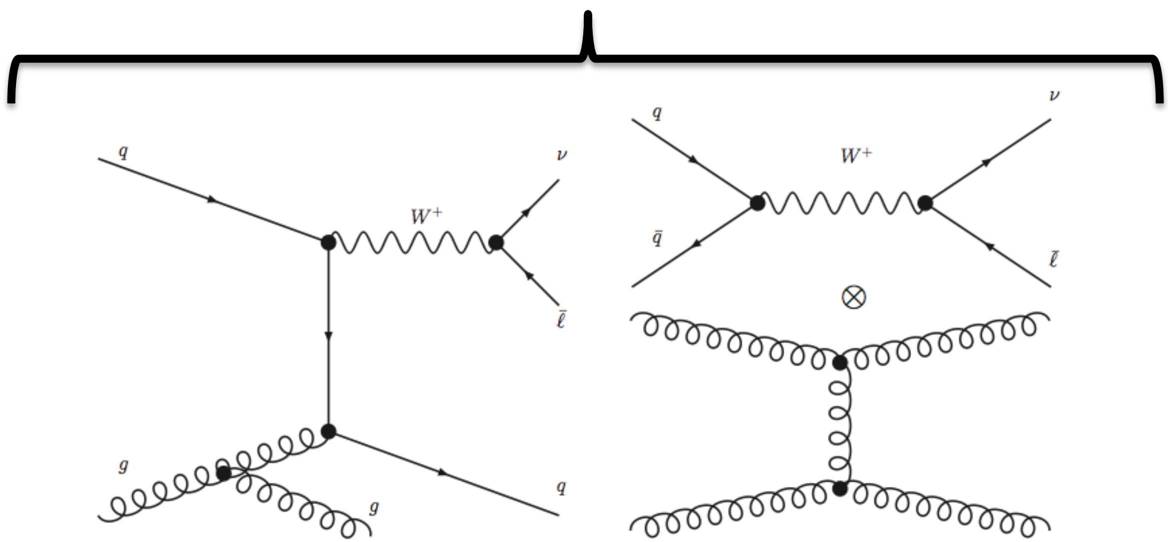
Motivation and method

Motivation: To quantify the probability of **hard** secondary scatter

- ? Hard DPI (double parton interactions) forms an irreducible BG to new physics searches and is not modelled well in MC generators
- ? Is DPI rate process independent?
- ? (How) does DPI rate depend on the collision energy?

Method: Exploit kinematic difference in DPI events to measure fraction of W+DPI contamination in W+2jet events, and use to extract σ_{eff}

These two will both pass W+2jet selection (in what fraction?)



Samples and selection

Sample	Details
Pythia inclusive	v6, AMBT tune 1
Sherpa inclusive	v1.3.1, default UE
Alpgen+Herwig+Jimmy inclusive	MLM matching, Jimmy v4.31, AUET tune, Herwig v6.510
Sherpa MPI off	As above + MI_HANDLER=NONE
Alpgen+Herwig+Jimmy MPI off	As above + remove events where both jets' closest outgoing parton with $P_T > 3.5$ GeV is not primary
Data (W sample)	All 2010 data run
Data (jet sample)	All 2010 data run

W selection
Single lepton trigger
1 lepton (e, μ) $P_T > 20$ GeV, $\eta < 2.5$
MET > 25 GeV, $M_T > 40$ GeV
2 jets, $P_T > 20$ GeV, $y < 2.8$

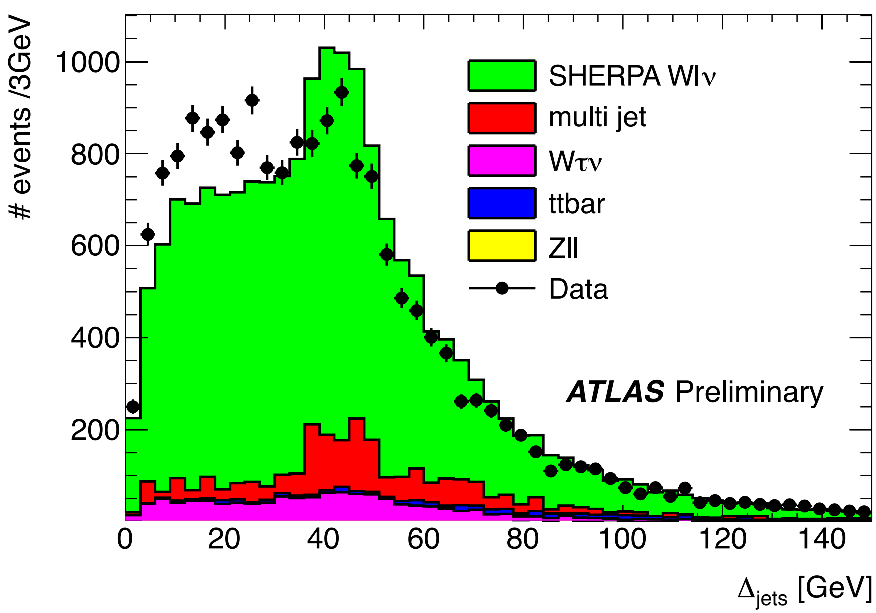
Jet selection
Minimum bias trigger
2 jets, $P_T > 20$ GeV, $y < 2.8$

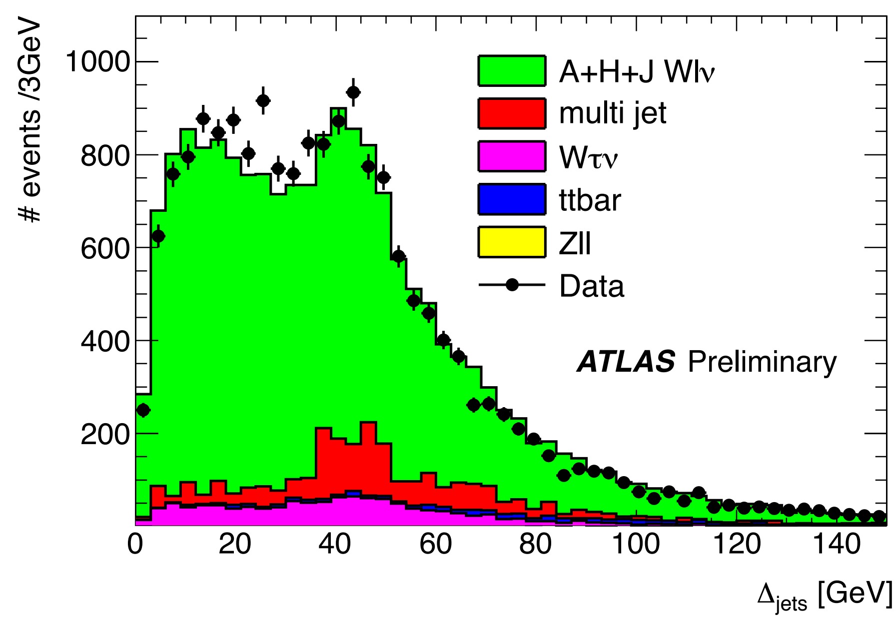
Wjj topology I

$$\Delta_{jets} = \left|\vec{P}_T^{J1} + \vec{P}_T^{J2}\right|$$

Component of jets back to back

Component of jets recoiling from W



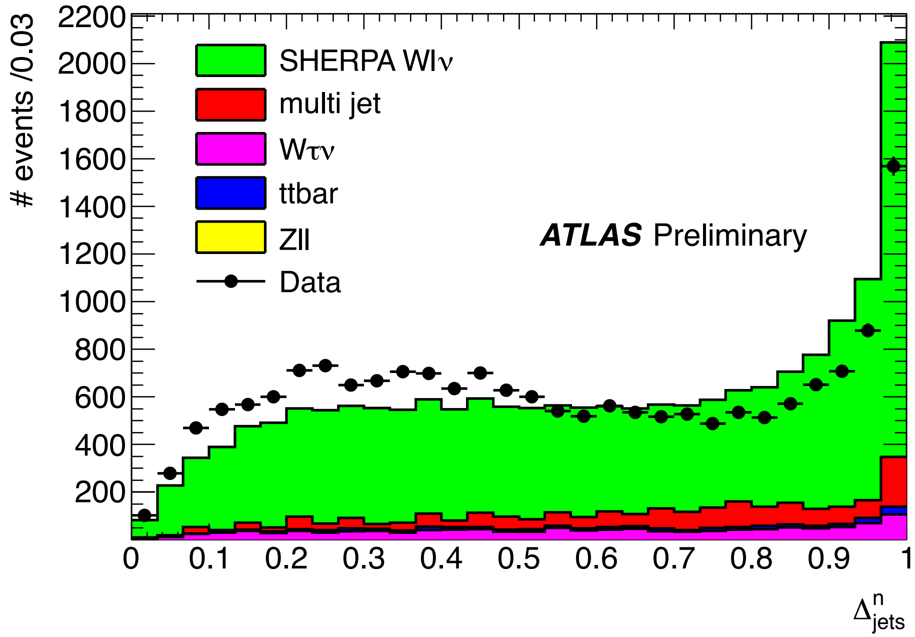


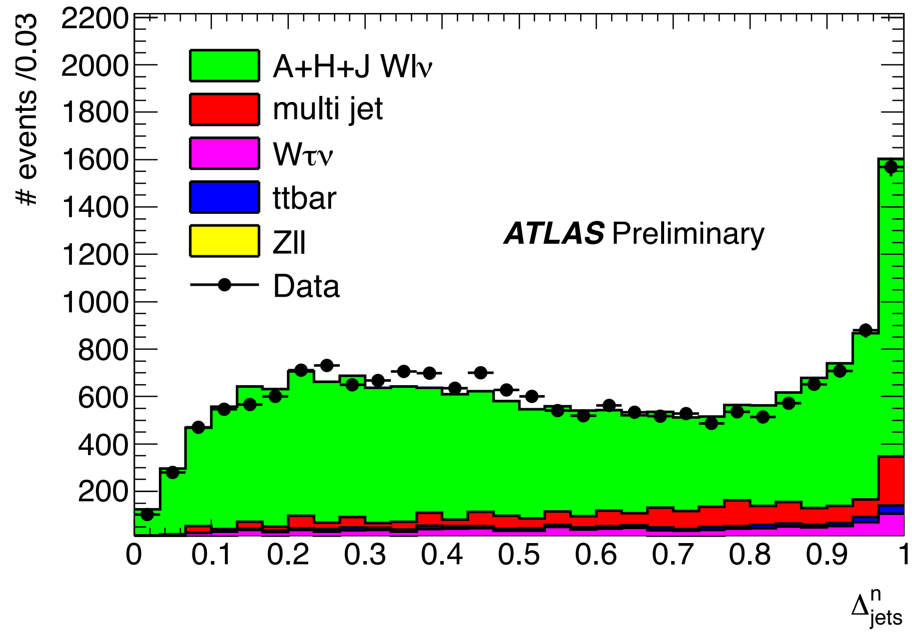
Wjj topology II

$$\Delta^{n}_{jets} = \frac{\left|\vec{P}_T^{J1} + \vec{P}_T^{J2}\right|}{\left|\vec{P}_T^{J1}\right| + \left|\vec{P}_T^{J2}\right|}$$

Component of jets back to back

Component of jets recoiling from W





Extracting DPI rate f_{DP}^R

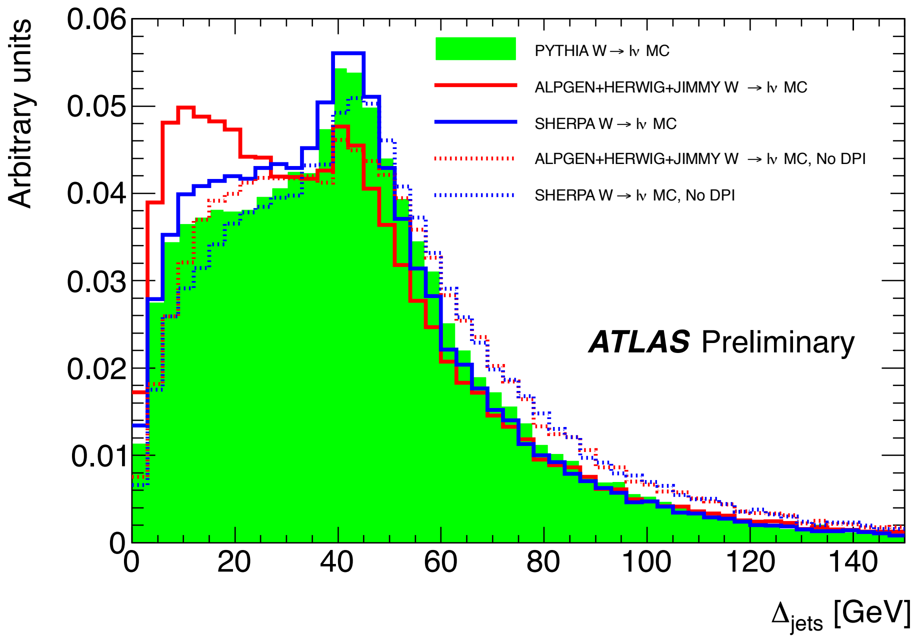
$$f_{DP}^R = \frac{N_{W_0+2j_{MPI}}}{N_{W+2j}}$$

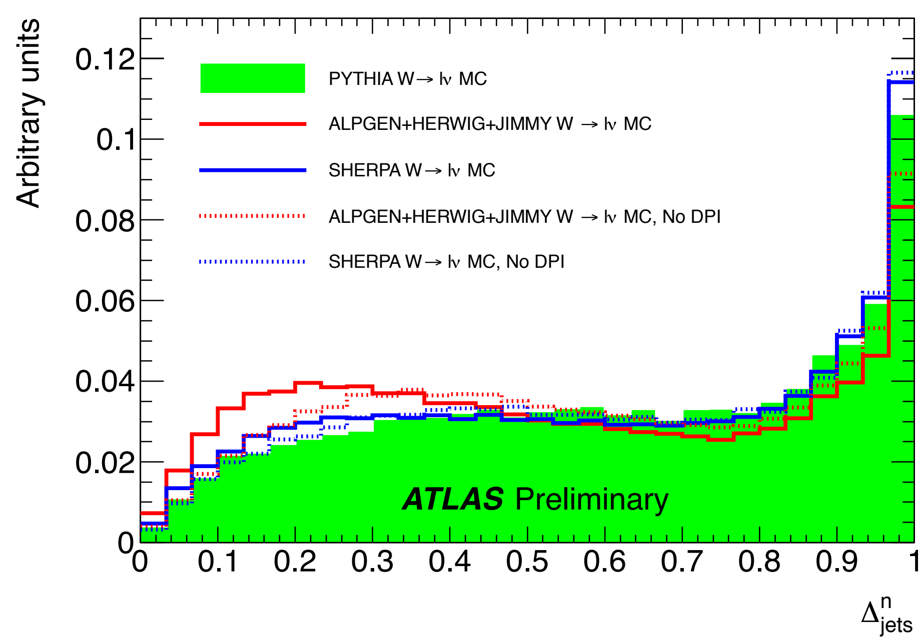
Overall distribution = $(1-f^R_{DP})$•Template A + f^R_{DP}•Template B

Template A: W+2jet (direct)

Template B: W+2jet (MPI)

Template A: DPI Off





Template B: DPI only

Dijet selection in data

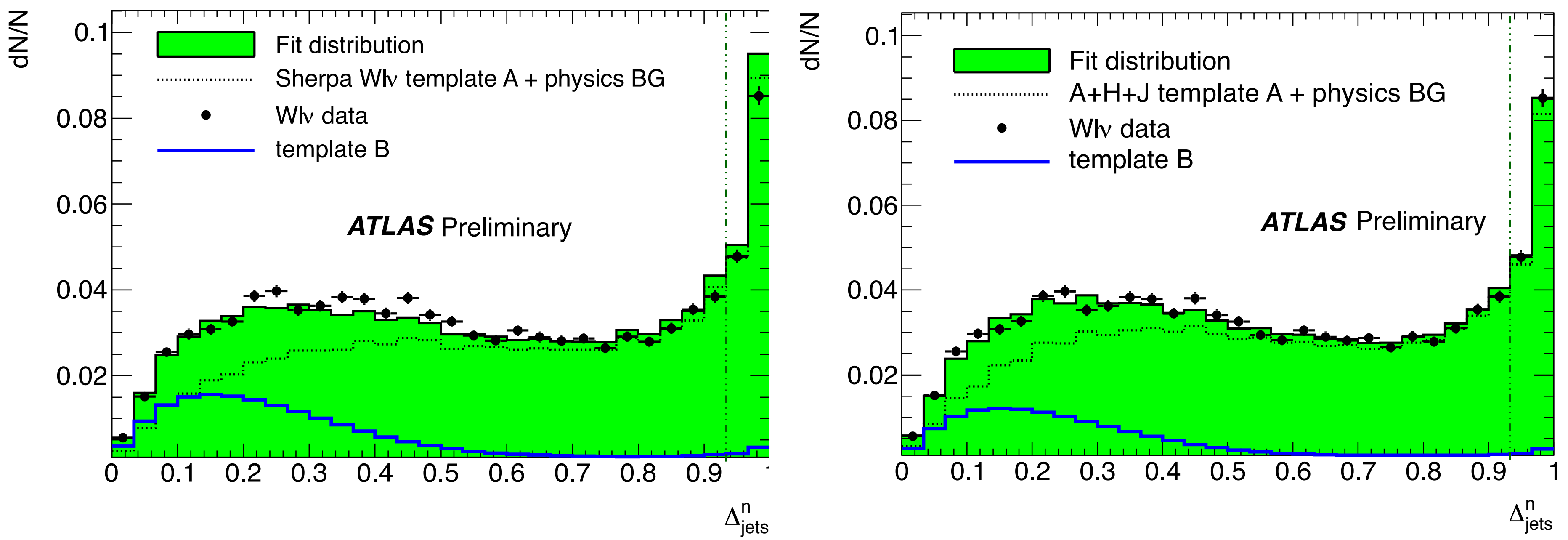
Extraction of f^R_{DP}

Overall distribution = $(1-f^R_{DP})$•Template A + f^R_{DP}•Template B

X^2 minimisation

X^2/N_{dof} 1.4, $f^R_{DP} = 0.18$

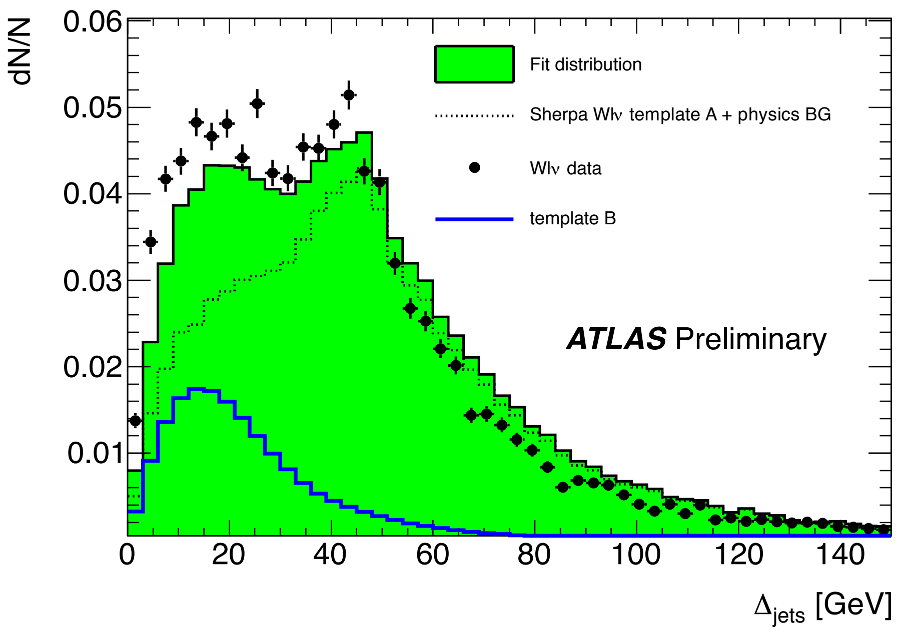
$X^2/N_{dof}=0.9$, $f^R_{DP} = 0.14$

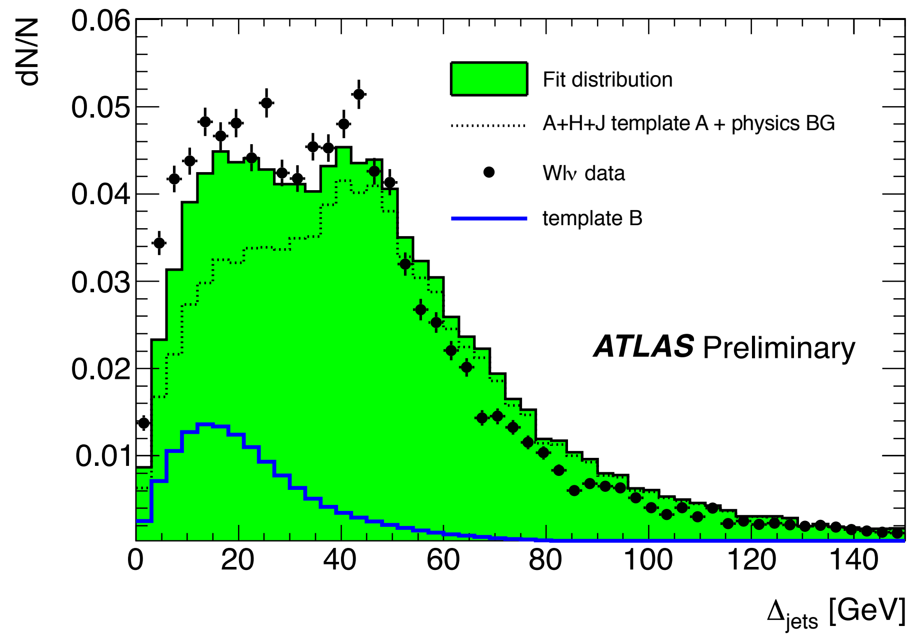


Comparison to Δ_{jets}

From previous fit

Overall distribution = $(1-f^{R}_{DP})$•Template A + f^{R}_{DP}•Template B





Translation to parton level

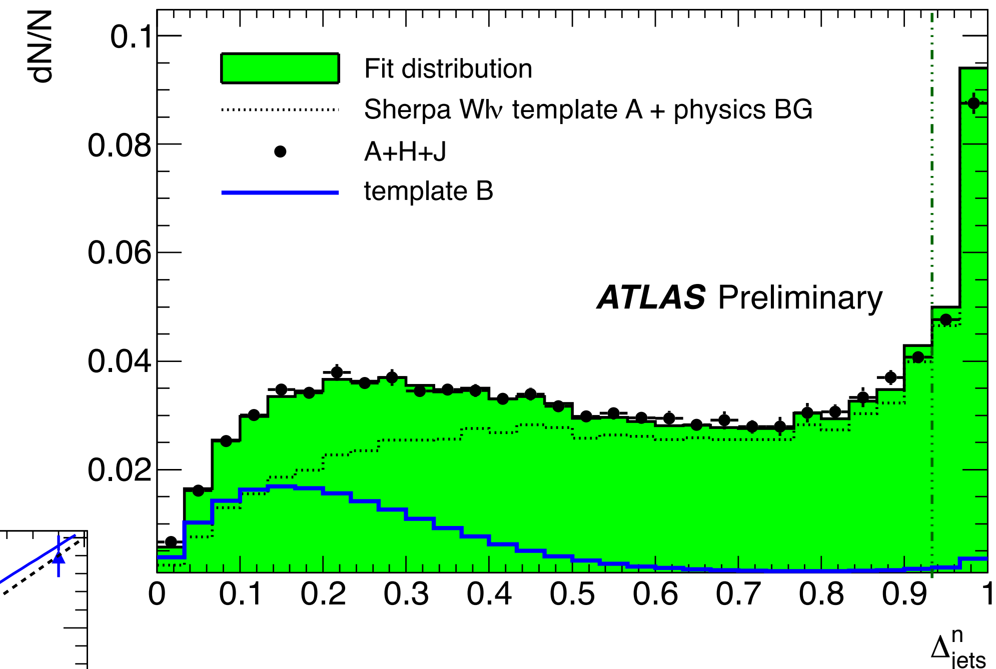
Fit

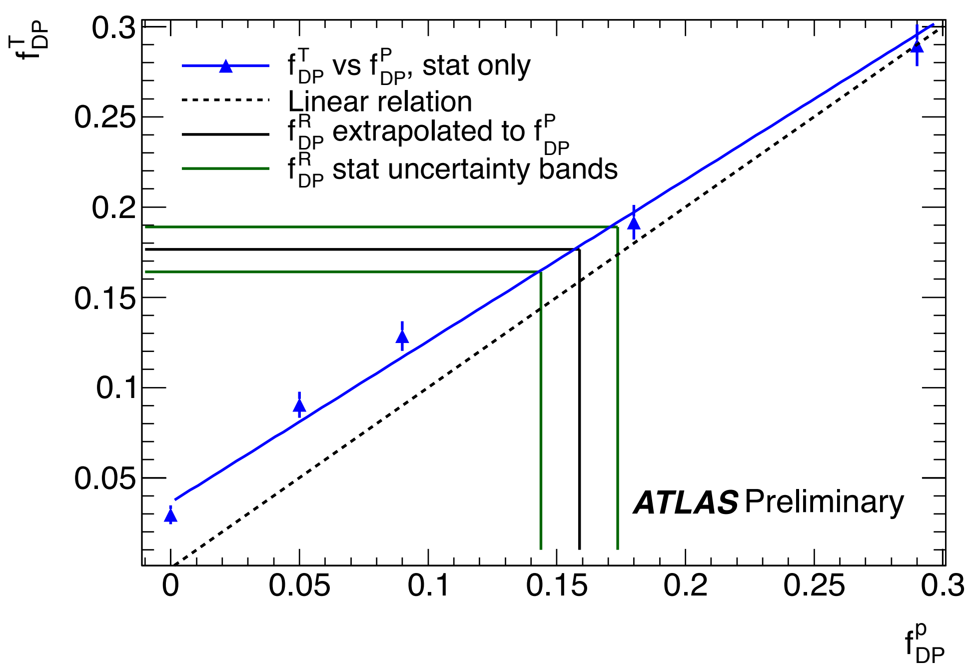
ALPGEN+HERWIG+JIMMY=

$(1-f^T_{DP})$ A (Sherpa) + f^T_{DP} B

- vary f^P_{DP} in ALPGEN+HERWIG+JIMMY

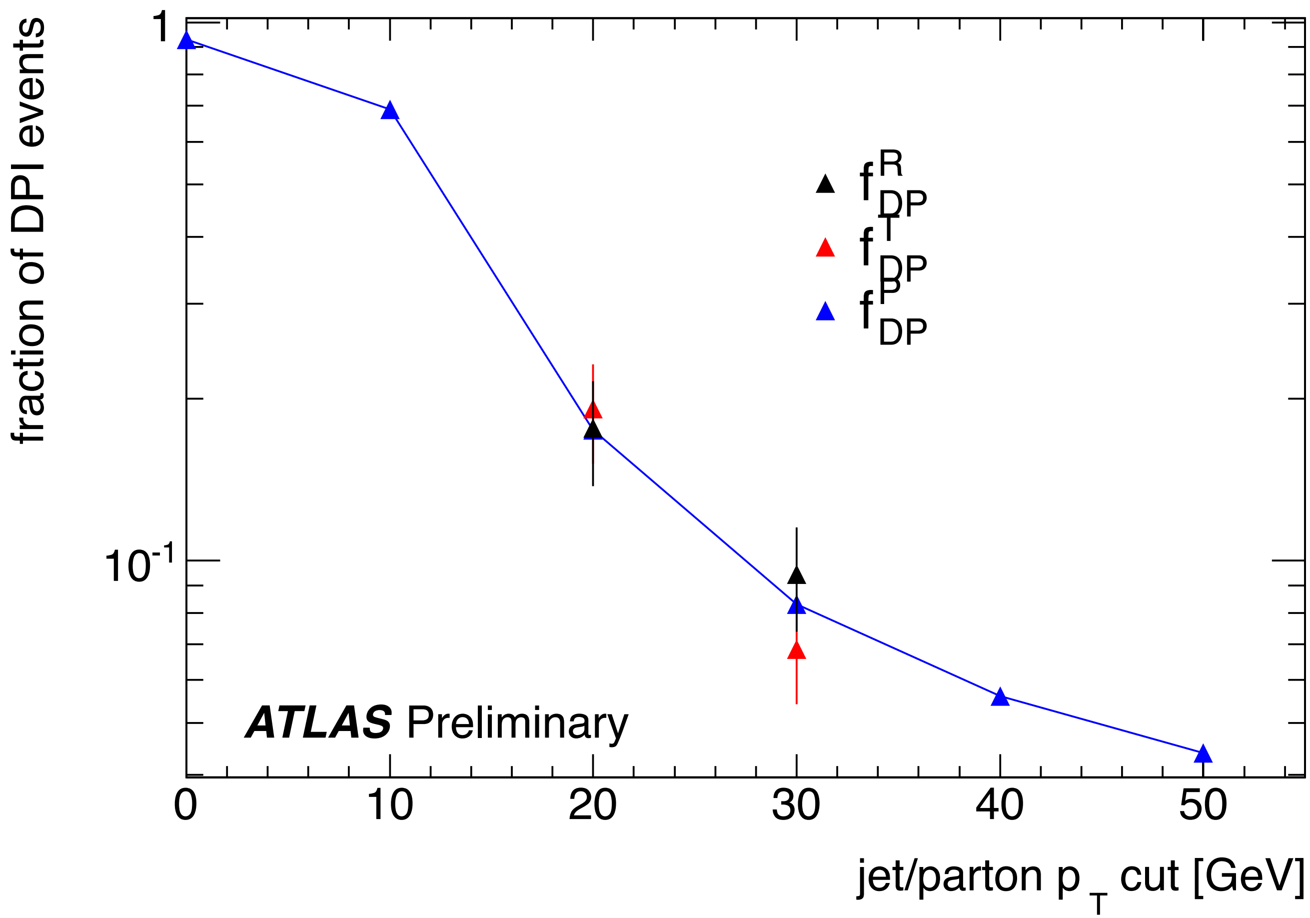
Parton level MPI rate





Variation of f^{R}_{DP} with phase space

Both predicted and extracted DPI rate decrease as P_T cut is raised



f^{R}_{DP} results

Source of uncertainty	Method of evaluation	Fractional uncertainty / %
Generator modelling	ALPGEN+HERWIG+JIMMY VS SHERPA	12
Transition to parton level	Monte Carlo studies	10
Jet reconstruction	Jet energy scale shift	10
Pileup	Varying vertex number requirement	8
Trigger bias	Comparison of data streams	5
Background modelling	Varying multi jet background normalisation	1
Total systematic	Quadratic sum of the above	21
Total statistical	$\chi^2 + 1$	7

Table 2: Summary of the uncertainties on the extraction of f^{R}_{DP}.

$$f^{R}_{DP} = 0.16 \pm 0.01\ (\text{stat.}) \pm 0.03\ (\text{sys.}).$$

Converting to σ_{eff}

Taking input definitions

$$f^{R}_{DP} = \frac{N_{W_0+2j_{DPI}}}{N_{W+2j}}, \qquad \sigma_{eff} = \frac{\sigma_{W_0} \cdot \sigma_{2j}}{\sigma_{W_0+2j_{DPI}}},$$

writing i.t.o cross sections

$$\sigma_{eff} = \frac{1}{f^{R}_{DP}} \cdot \frac{N_{W_0}\, N_{2j}}{N_{W+2j}} \cdot \frac{A_{W_0+2j_{DPI}}}{A_{W_0}\, A_{2j}} \cdot \frac{\epsilon_{W_0+2j_{DPI}}}{\epsilon_{W_0}\, \epsilon_{2j}} \cdot \frac{\mathscr{L}_{W_0+2j_{DPI}}}{\mathscr{L}_{W_0}\, \mathscr{L}_{2j}}.$$

and using input assumptions of analysis*

$$A_{W_0+2j_{DPI}} = A_{W_0} \cdot A_{2j_{DPI}},$$

$$A_{2j_{DPI}} = A_{2j}$$

Yields**

$$\sigma_{eff} = \frac{1}{f^{R}_{DP}} \cdot \frac{N_{W_0}\, N_{2j_D}}{N_{W+2j}} \cdot \frac{1}{\epsilon_{2j_D}} \cdot \frac{1}{\mathscr{L}_{2j_D}}.$$

* need small correction for overlap removal
** include additional systematic for trigger bias

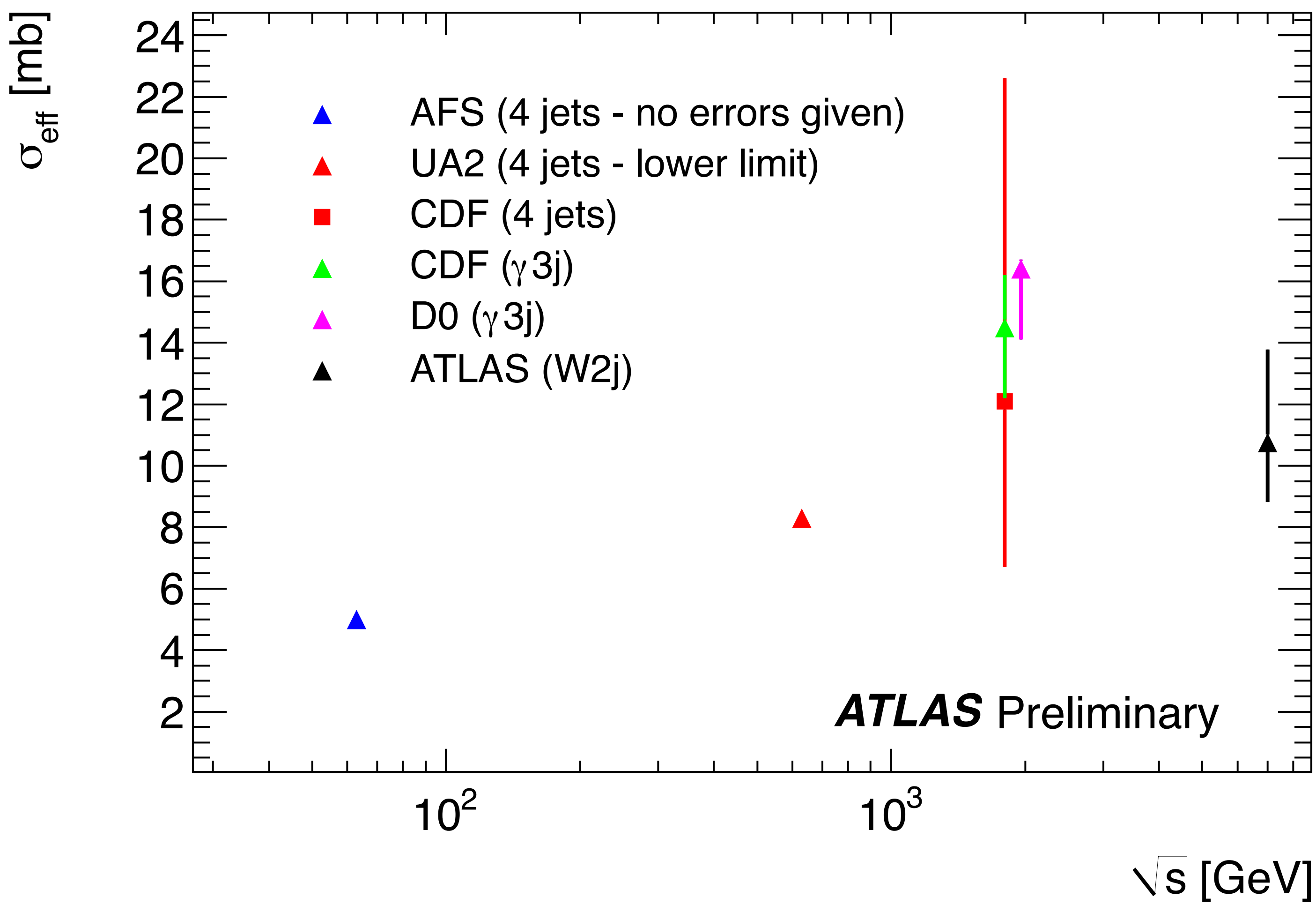
σ_{eff} results

Quantity	Systematic source	Method of evaluation	Fractional uncertainty /%
$N_{W0}/N_{W2} \cdot N_{jj}$	Acceptance cancellation	Section 6.1	< 3
N_{W0}/N_{W2}	Background modelling	Reference [53]	5
$\mathscr{L}_{jj}$	Luminosity	Beam parameters [52]	11
f_{DP}	Total	As in Table 2	21

Table 3: Summary of the systematic uncertainties on σ_{eff}.

$$\sigma_{eff}(7\,\text{TeV}) = 11 \pm 1\,(\text{stat.})\,^{+3}_{-2}\,(\text{sys.})\,\text{mb.}$$

Putting the result into context….



Results consistent with other measurements

- no real evidence for variation of σ_{eff} with channel or E_{COM}

Conclusions

The relative DPI rate is extracted for W+2jet events in the ATLAS detector:

$$f_{\mathrm{DP}}^{\mathrm{R}} = 0.16 \pm 0.01\ (\mathrm{stat.}) \pm 0.03\ (\mathrm{sys.}).$$

From this, the effective cross section is measured in 7 TeV pp collisions

$$\sigma_{\mathrm{eff}}(7\ \mathrm{TeV}) = 11 \pm 1\ (\mathrm{stat.})\ ^{+3}_{-2}\ (\mathrm{sys.})\ \mathrm{mb}.$$

This is consistent with results obtained in different channels at the Tevatron.

The analysis provides a powerful tool in constraining models for DPI as encoded in the commonly used event generators.