ATLAS Results on Soft Diffraction

Simone Monzani
Università e INFN di Bologna
On behalf of the ATLAS experiment

EDS2013
Saariselka 9-13 September 2013

Outline

- The ATLAS Detector;

- Diffraction Physics;

- Inelastic Cross Section Measurement at 7 TeV:

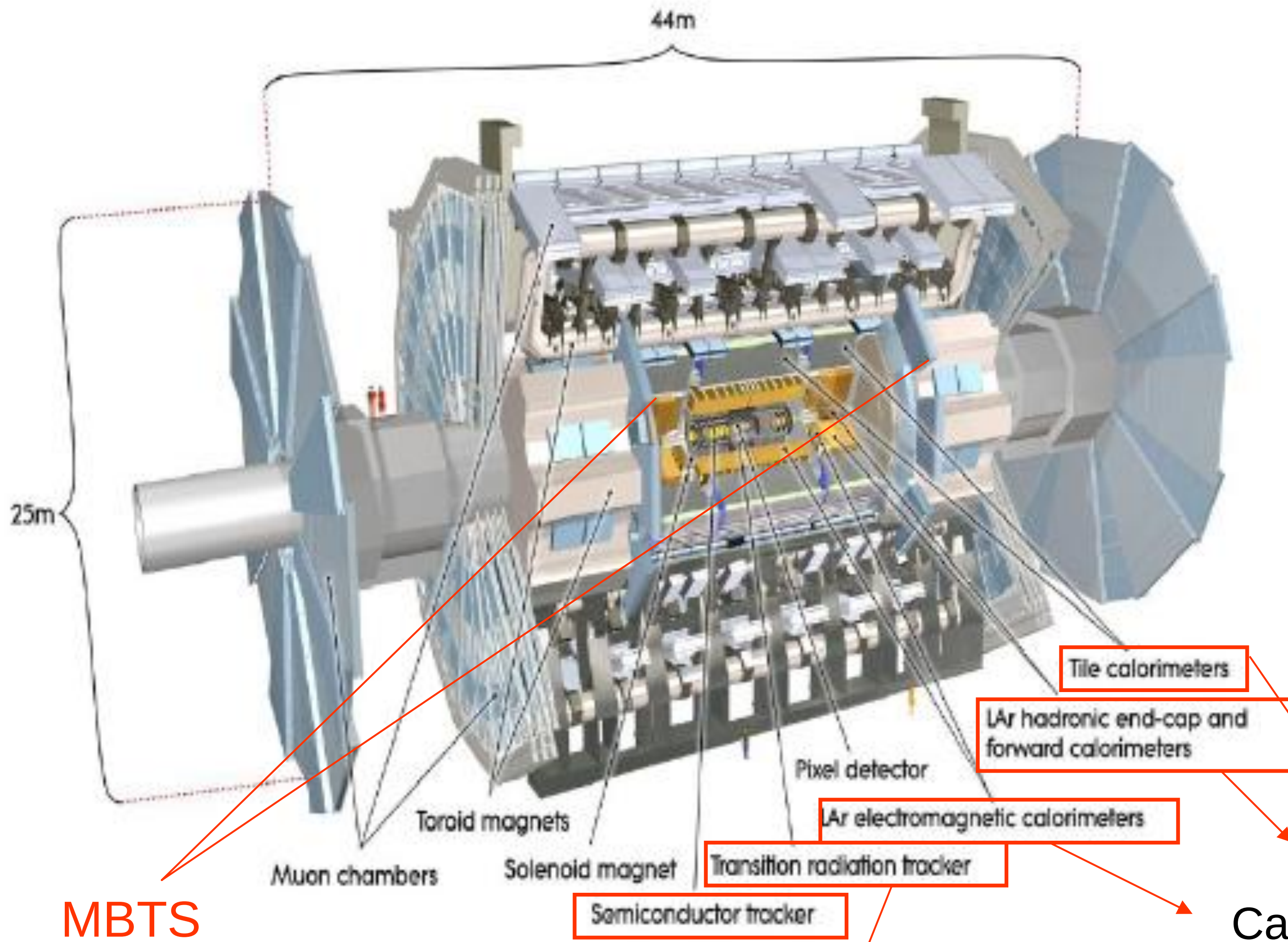
    1) Total ($20\mu b^{-1}$), "Measurement of the Inelastic Proton-Proton Cross-Section at $\sqrt{s}$ = 7 TeV with the ATLAS Detector "

    2) Differential as function of Rapidity Gap ($7.1\mu b^{-1}$)

    "Rapidity Gap Cross Sections measured with the ATLAS Detector in pp Collisions at $\sqrt{s}$ = 7 TeV"

- Conclusions.

The ATLAS detector



MBTS

Minimum Bias Trigger Scintillator

$2.1 < |\eta| < 3.8$

Inner Tracker

$|\eta| < 2.5$

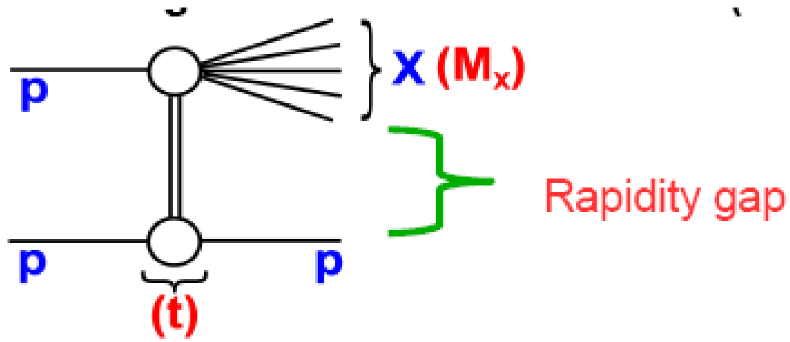
Calorimeter

$|\eta| < 4.9$

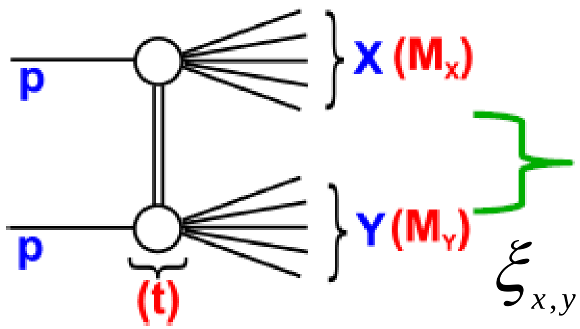
Diffractive physics

$$\sigma_{TOT} = \sigma_{el} + \sigma_{ND} + \sigma_{SD} + \sigma_{DD} + \sigma_{CD}$$ Inelastic part

Single diffractive (SD)



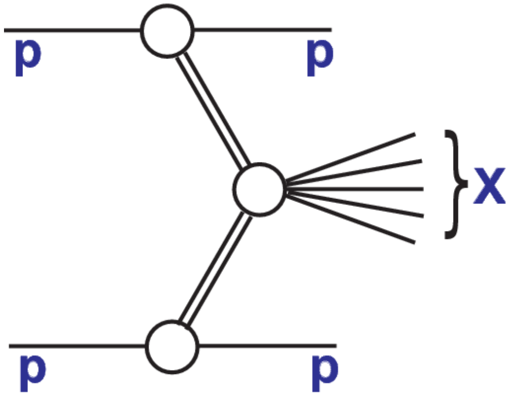
Double diffractive (DD)



$$\xi_{x,y} = \frac{(M_{x,y})^2}{s}$$

Kinematic variables

Central diffractive (CD)



Measurement of the Inelastic Proton-Proton Cross-Section at √s = 7 TeV with the ATLAS Detector

Nat. Commun. 2 (2011) 463

Event selection and background

- Third run in march 2010
- Center of mass energy 7 TeV
- Integrated Luminosity= 20 μb^{-1}, Peak Luminosity= 1.2 10^{27} cm^{-2} s^{-1}, pile up fraction=0.01
- MBTS trigger (Minimum Bias Trigger Scintillator)

- Single sided: events that have at least 2 hits on one side and no hits on the opposite one
- Inclusive: all events triggered by MBTS

- M_x>15.7 GeV (approximated) and extrapolation with M_x>M_{Proton}

Total inelastic cross section

MBTS Acceptance $M_X > 15.7 GeV$

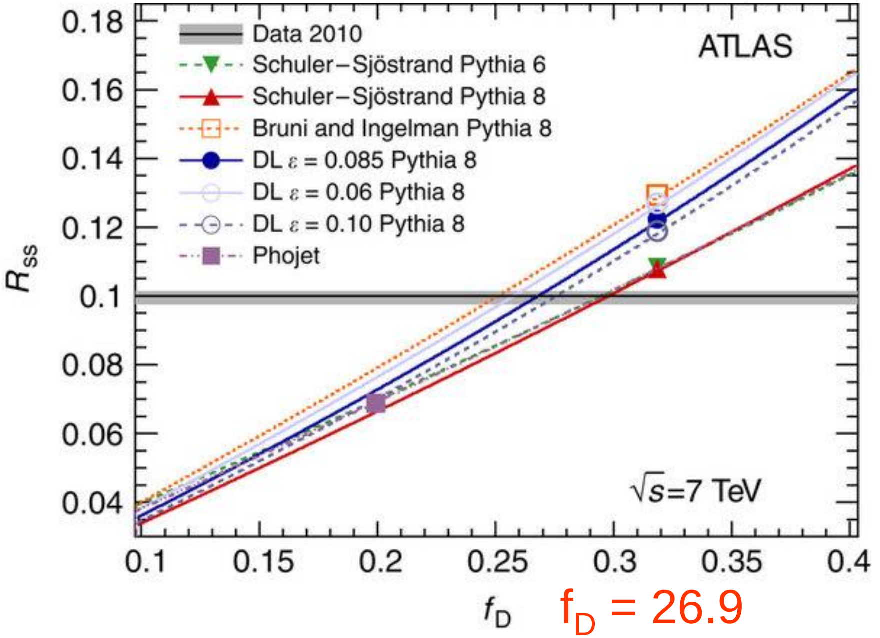
$$\sigma_{inel}(\xi > 5\cdot 10^{-6}) = \frac{(N - N_{BG})}{\varepsilon_t \cdot L_{Int}} \cdot \frac{1 - f_{\xi<5\cdot 10^{-6}}}{\varepsilon_{Sel}}$$

Selection efficiency

Trigger efficiency (99.98%)

Fraction of events passing selection but out the MBTS acceptance

ATLAS R_{SS} measurement



$f_D = 26.9$

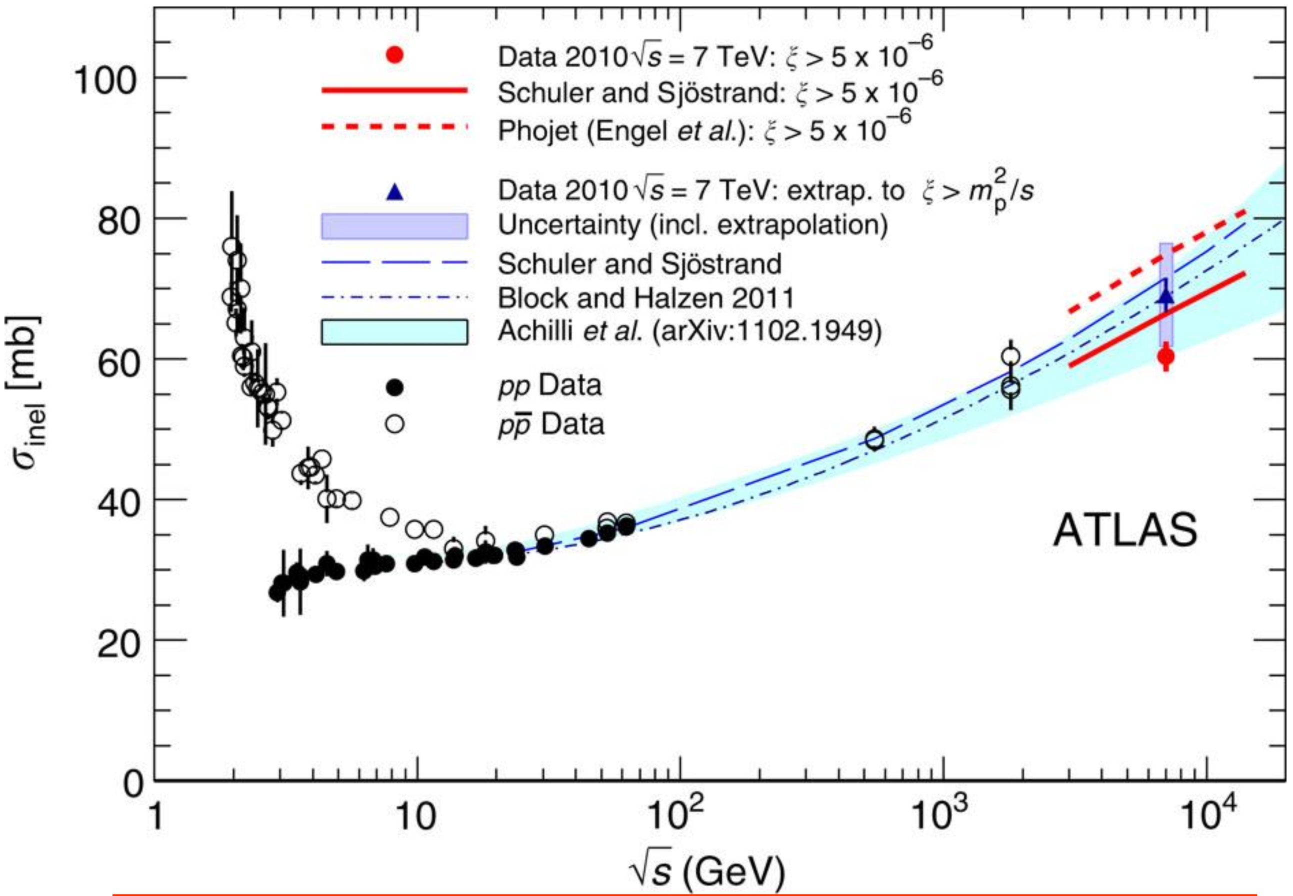
$$f_D = \frac{\sigma_{SD} + \sigma_{DD} + \sigma_{CD}}{\sigma_{Inel}}$$

R_{SS}: ratio between single sided and inclusive events

Knowledge of f_D reduces uncertainty on f and ε_{Sel}

Total inelastic cross section

Nat. Commun. 2 (2011) 463



σ_{inel} ($\xi_x > 10^{-6}$)= 60.3 ± 0.5(sys.) ± 2.1(lumi) mb $\xi > 5\ 10^{-6}$

σ_{inel} = 69.4 ± 2.4(exp.) ± 6.9(extr.) mb   Extrapolated cross section

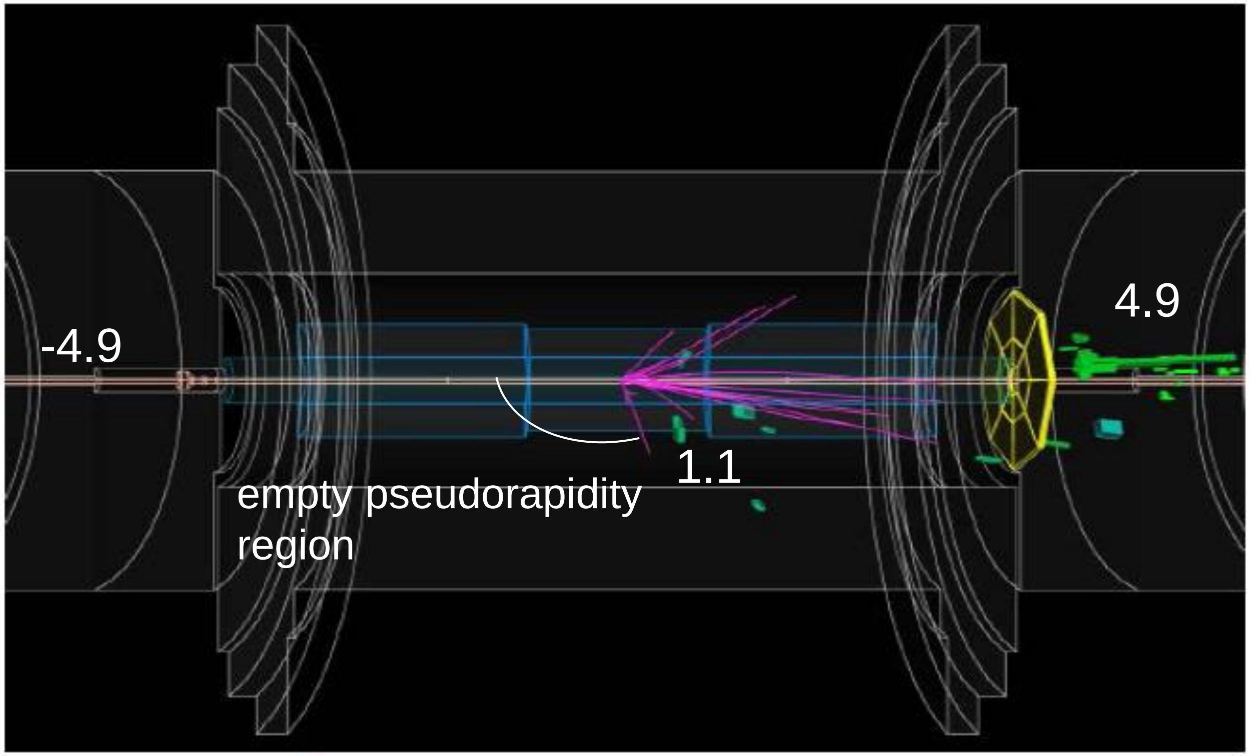
Rapidity Gap Cross Sections measured with the ATLAS Detector in pp Collisions at $\sqrt{s}$ = 7 TeV

Eur. Phys. J. C72 (2012) 1926

Event selection and background

- First run in march 2010
- Center of mass energy 7 TeV
- Integrated Luminosity = 7 μb^{-1}, Peak Luminosity = 1.1 10^{27} cm^{-2} s^{-1}, Pile up fraction< 0.005
- MBTS trigger (Minimum Bias Trigger Scintillator)

Definition of rapidity gap



$|\eta| < 4.9$: pseudorapidity region covered by calorimeters; define rings of unit-$\Delta\eta$ starting from ± 4.9

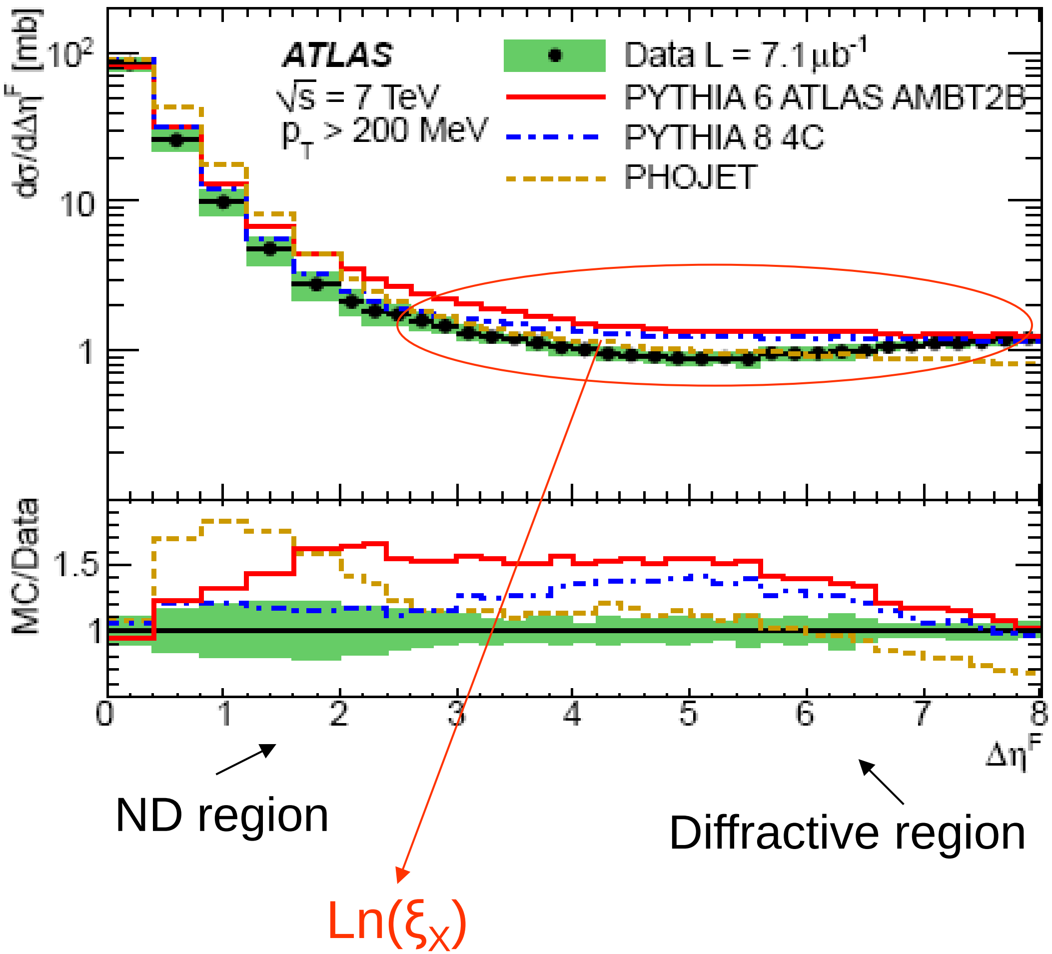
Activity in ring:
- ≥ 1 calo. cell above noise thresh. ($2.5 < |\eta| < 4.9$)
- >1 track with $p_T > p_{T,CUT} = 200$ MeV

rapidity gap observable definition ($\Delta\eta_F$): max forward pseudorapidity region without activity in calorimeter

$|\Delta\eta| < 8$: maximum observable pseudorapidity gap by MBTS acceptance

dissociation masses are closely correlated with the size of the rapidity gap

Rapidity gap cross section



At low $\Delta\eta_F$ exponential decrease (Non diffractive events)

$\Delta\eta_F > 3$, flat as predicted since

$$\Delta\eta \sim -\log\xi$$

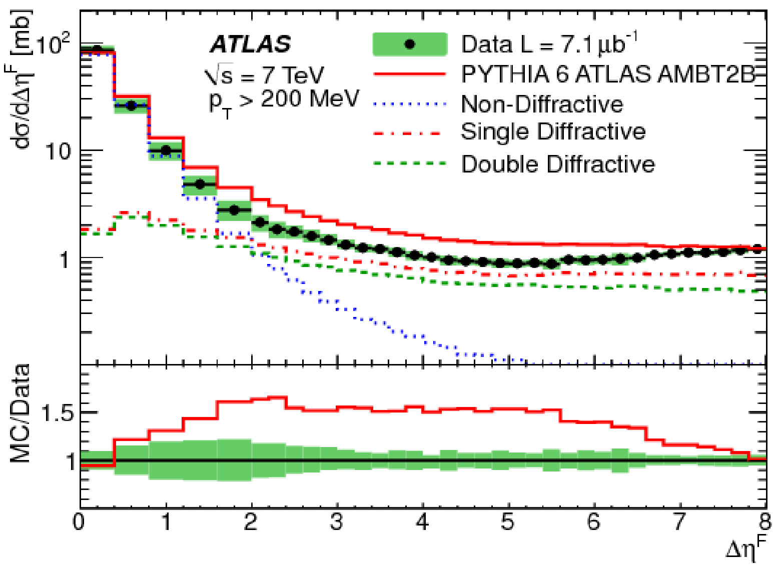
$$\downarrow$$

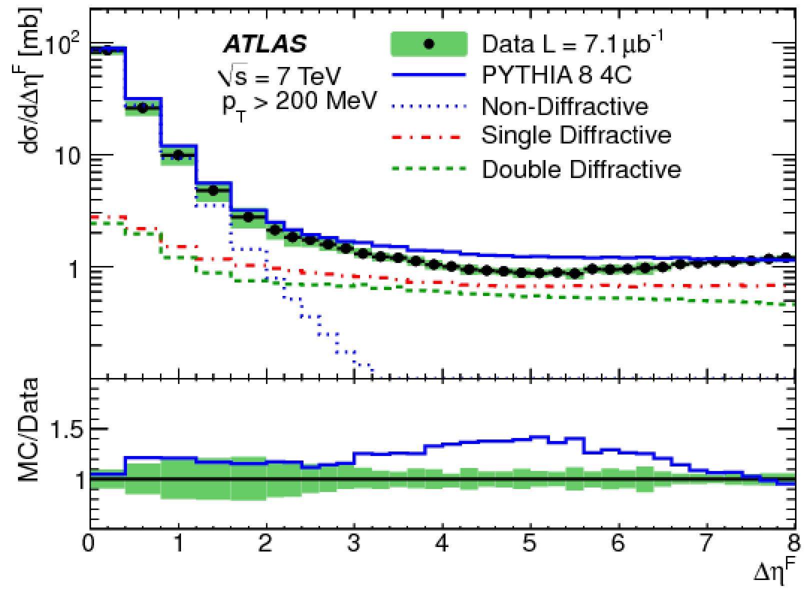
$$\frac{d\sigma}{d\Delta\eta} \sim flat$$

At high $\Delta\eta_F$ little increase not predicted by any model

Discrepancy at intermediate η due to modeling large hadronisation fluctuations in ND region or to lack of CD component in the Pythia model

Rapidity gap cross section

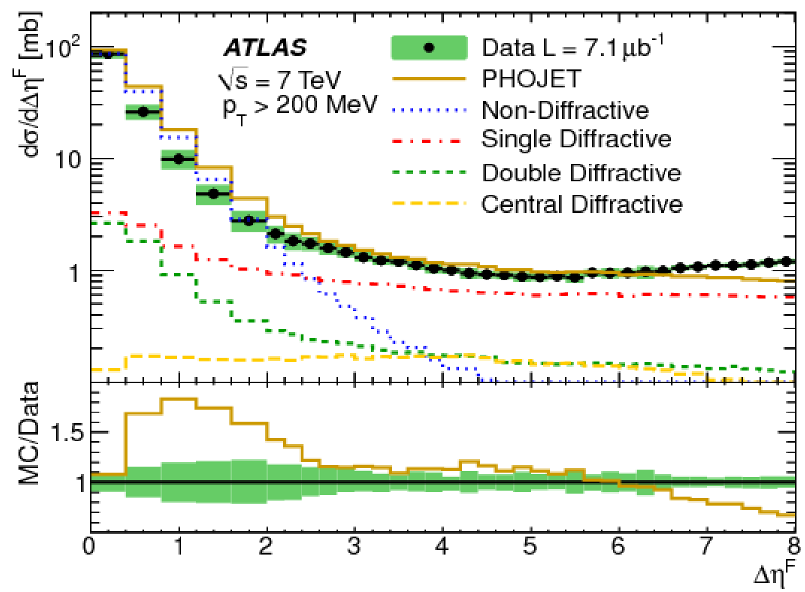




All models agree on the main ND contribution at low Rapidity gaps

MC models lie above, consistent with the overestimates of the total inelastic cross section already observed

Pythia8 most close to data at low $\Delta\eta_F$
Phojet better at intermediate $\Delta\eta_F$

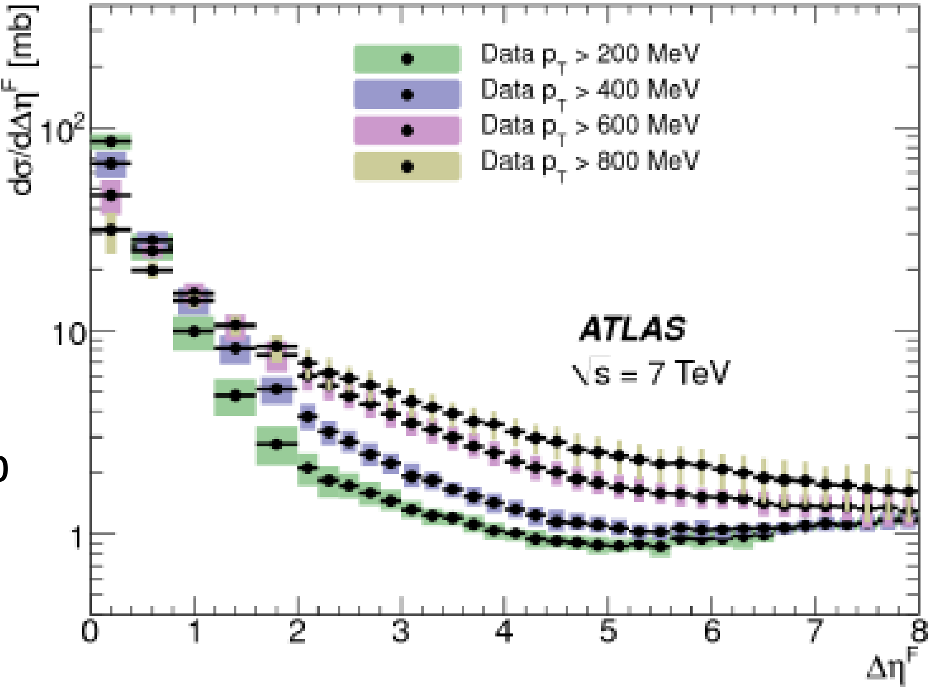


Rapidity gap cross section

Systematic uncertainties

1. MC model and unfolding method dependence
2. Modeling of diffractive contributions
3. Calorimeter energy scale
4. MBTS efficiency
5. Tracking efficiency
6. Luminosity

Uncertainty between 8% and 20%



Larger p_T^{CUT}

↓

ND events move to high rapidity gap
Uncertainty due to the choice of cut

Probe of fluctuations in the hadronisation process

Rapidity gap cross section

Assuming the triple pomeron phenomenology, data are sensitive to pomeron trajectory intercept $\alpha_{IP}(0)$

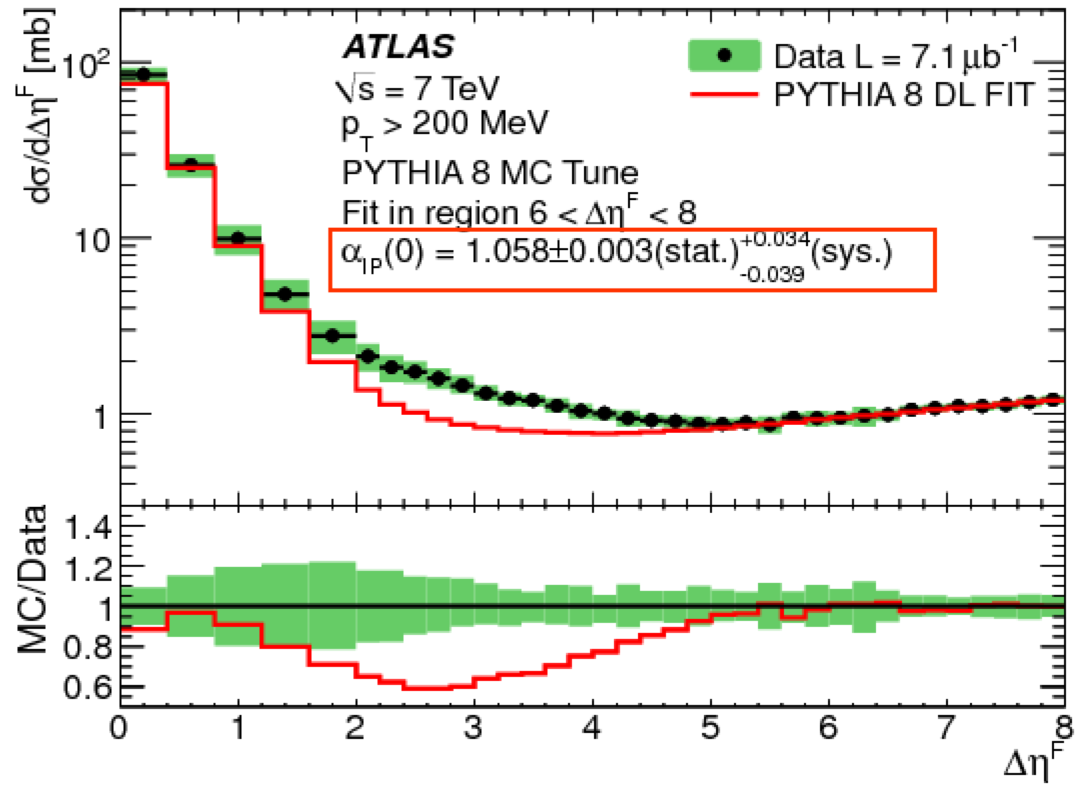
$$\frac{d\sigma}{d\xi dt} \propto \left(\frac{1}{\xi_X}\right)^{2\alpha(t)-\alpha(0)} e^{bt}$$

$$\alpha(t) = \alpha(0) + \alpha' t$$

$$\frac{d\sigma}{d\xi_X} \propto \frac{1}{\xi_X}$$

$s \gg M_X \gg t$

Pythia8 model with Donnachie and Landshoff flux parametrization



ND region Diffractive region

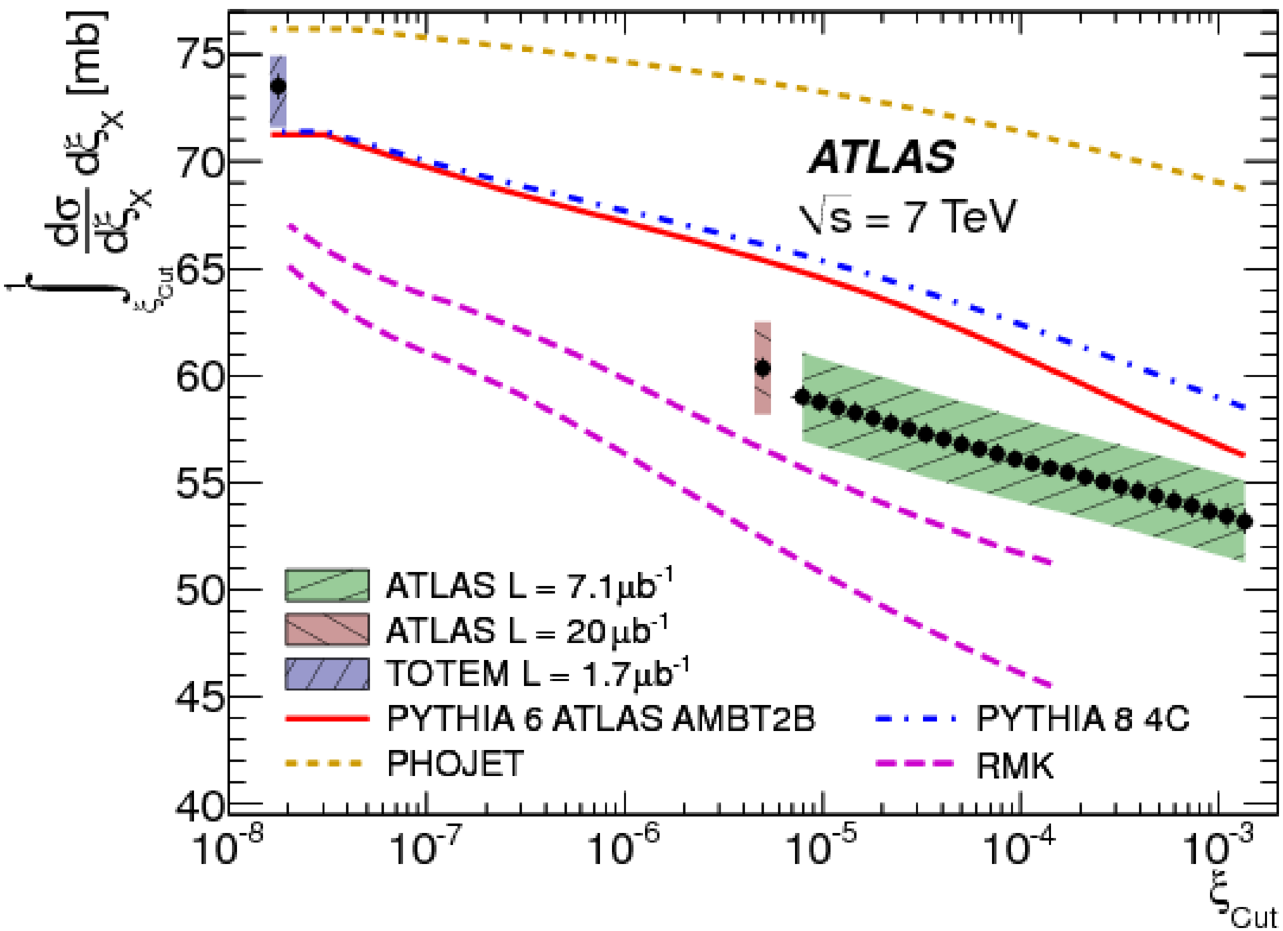
The extracted $\alpha_{IP}(0)$ relative to the whole range is obtained from the best χ^2 on the fit on MC simulation varying $\alpha_{IP}(0)$ for $\Delta\eta>6$

Inelastic cross sections as function of ξ

Inelastic cross section without diffractive effects with ξ_x lower than cut
Integrated within a maximum rapidity gap

$$\log \xi_{CUT} = -0.45\Delta\eta_{F,CUT} - 1.52$$

Systematic uncertainty for correction at most 1%



Results from TOTEM, useful for low ξ_x where PYTHIA and PHOJET underestimate

Extrapolation of ATLAS results in agreement with total inelastic cross section, in agreement with TOTEM due to large uncertainty

Conclusion

- ATLAS measured:
  1. Total inelastic cross section

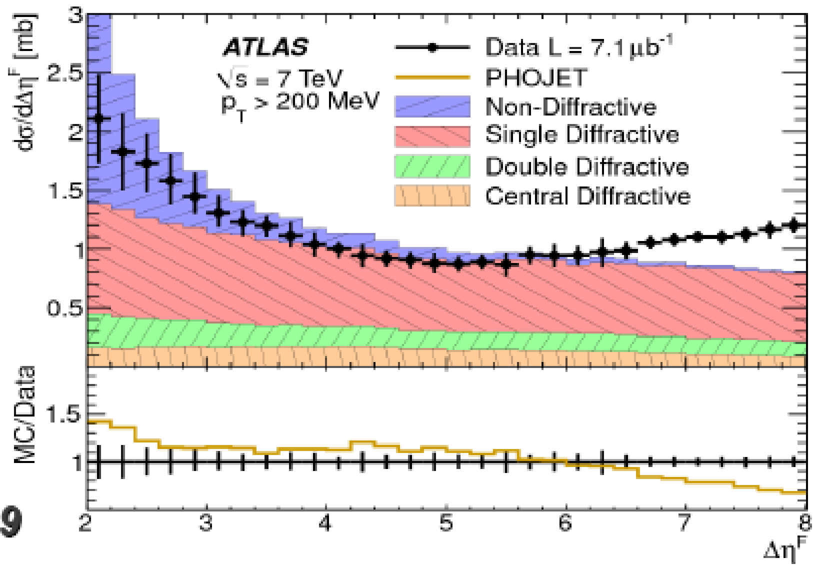
     σ_{inel} ($\xi_x > 5\ 10^{-6}$)= 60.3 $\pm$ 0.5(sys.) $\pm$ 2.1(lumi) mb
     σ_{inel} = 69.4 $\pm$ 2.4(exp.) $\pm$ 6.9(extr.) mb
     precision of 3.5%

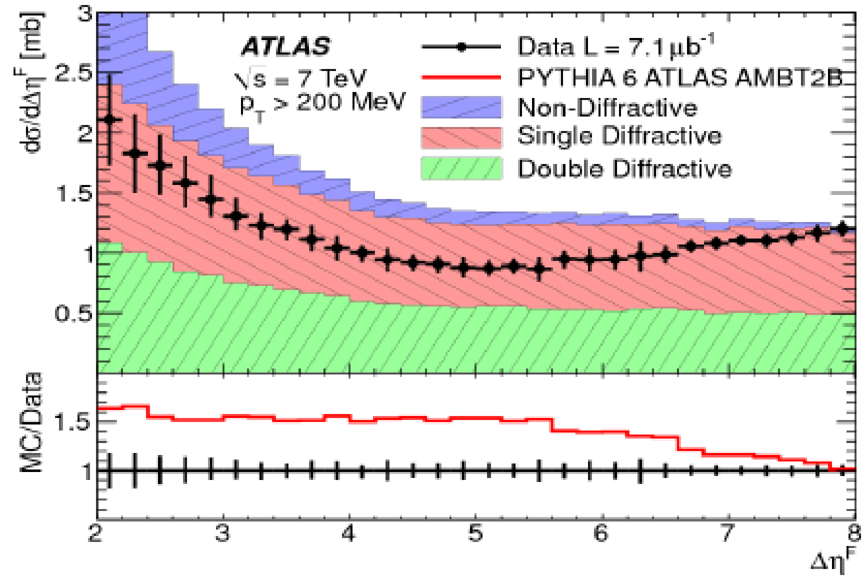
  2. Differential inelastic cross section as function of rapidity gap

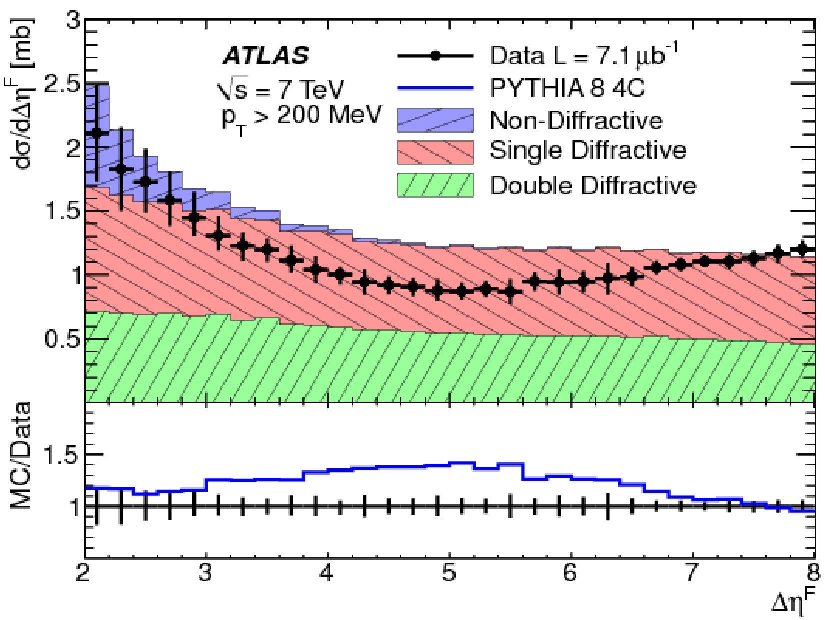
     Plateau observed for large Rapidity gaps,
     problems describing the ND region,
     all models overestimate data none of models
     predict the rise at high Rapidity gaps

Back up

Rapidity gaps measurement







At Δη < 2 differential cross section varies fastest with Δη

Diffractive and non-diffractive contributions different for the 3 methods

Δη > 3, OK flat for the models