ATLAS Studies of Soft QCD Processes at 7 TeV

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On behalf of the ATLAS Collaboration

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Soft-QCD in a new high energy and high multiplicity frontier …

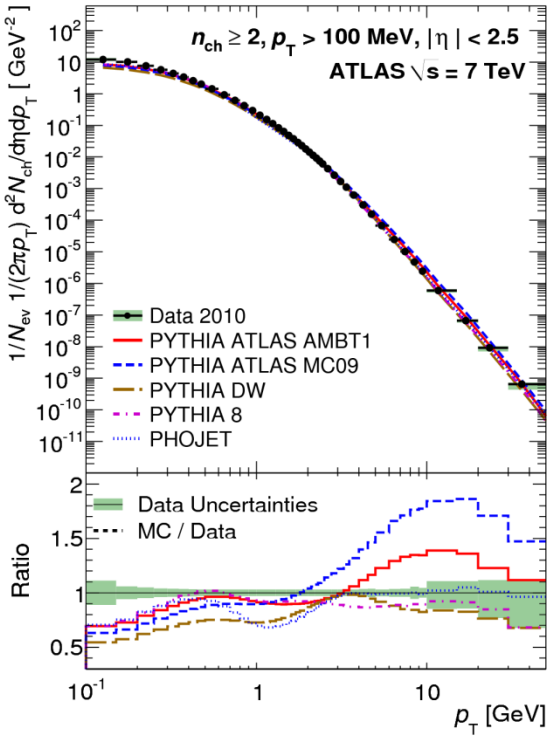
- Bulk of the total cross-section, corresponding to soft and semi-hard processes is not well understood since non-perturbative physics is involved.
- Intricately tied to measurement of high p_T observables – *i.e.* inclusive jet and b-jet cross-sections, as well as missing energy, isolation cuts, top mass, among others.
- High Q^2 and low –x phenomenon, such as the effect of high parton densities and the interplay between perturbative and non perturbative regimes is not well understood.
- We have to use the soft QCD distributions to test the phenomenological models and "tune" the Monte-Carlo event generators to give the best description of the data.

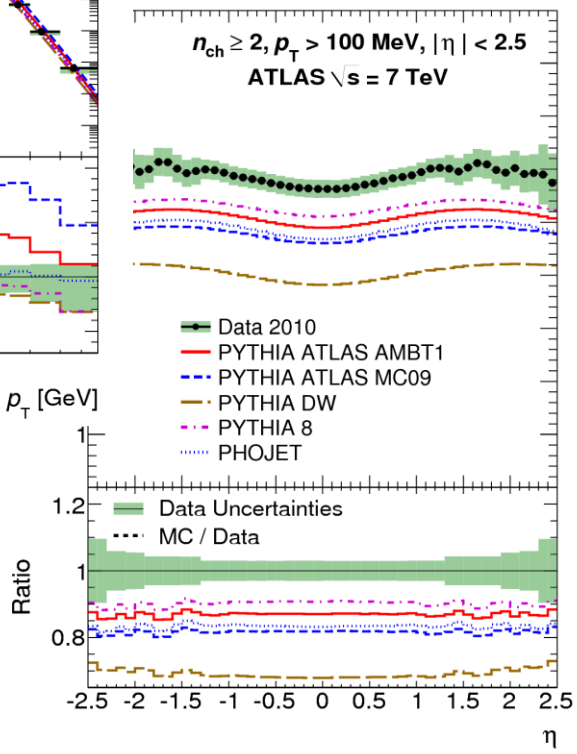
Minimum-Bias: generic term referring to events that are selected with a loose trigger, that accepts a large fraction of the inelastic cross-section.

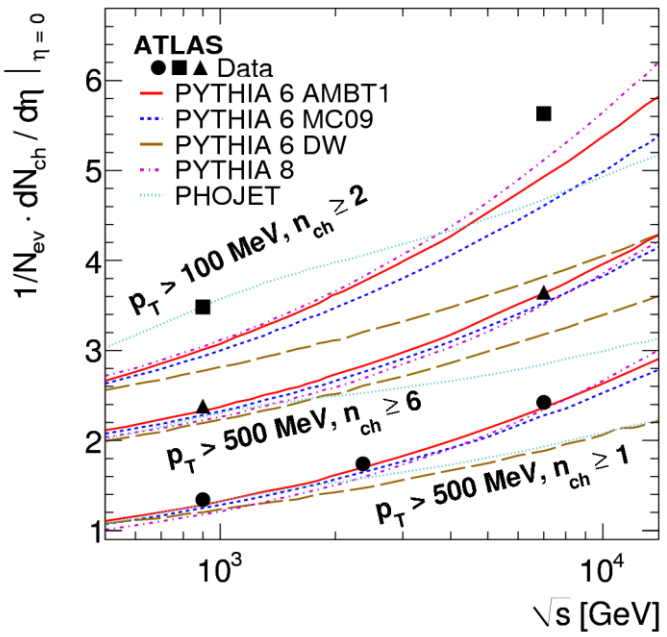
Underlying Event: defined as everything except the hard scattered part.

Minimum-Bias Results Summary

Fully inclusive-inelastic distributions in data with no model dependent corrections are compared to different MC models, and significant differences were observed.



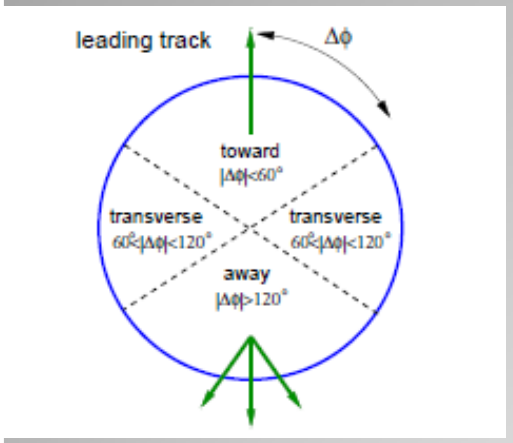


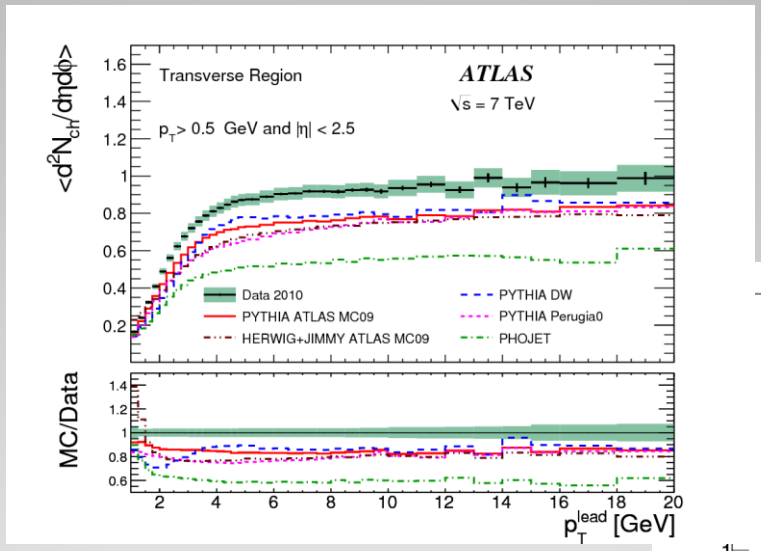


Coming soon: MB with $\sqrt{s}$ = 2.76 TeV.

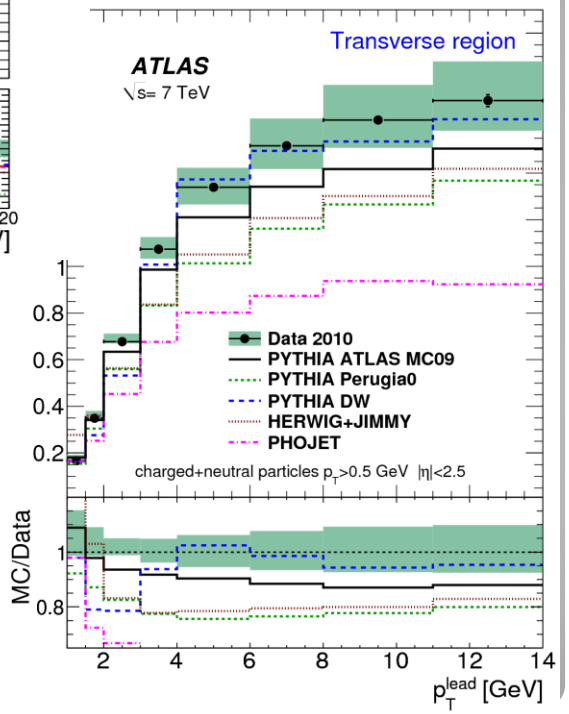
arXiv:1012.5104v2

Underlying Event Results Summary





arXiv:1012.0791v2
arXiv:1103.1816v2



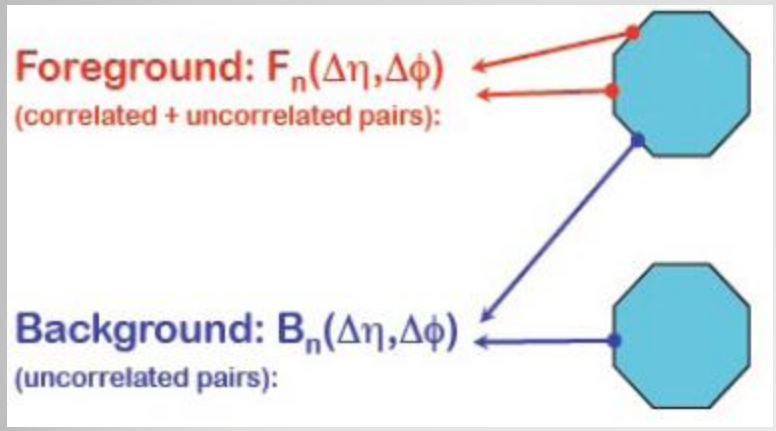
- All the pre-LHC MC tunes considered show lower activity than the data in the transverse region.
- Cluster $p_T$sum is sensitive to complete proton-proton final state including neutral.

Coming soon: interesting UE results with leading jet, in Z-boson events.

Two-Particle Angular Correlations

Correlations in the pattern of radiation emitted in proton-proton collisions can give an insight into the underlying particle production mechanism.

$$R(\Delta\eta, \Delta\phi) = \frac{\langle (N_{ch} - 1)\, F(N_{ch}, \Delta\eta, \Delta\phi) \rangle_{ch}}{B(\Delta\eta, \Delta\phi)} - \langle N_{ch} - 1 \rangle_{ch}$$



The two-particle correlation function shows the probability that given a single particle emission there will be a second particle emitted at a distance $\Delta\eta\Delta\varphi$.

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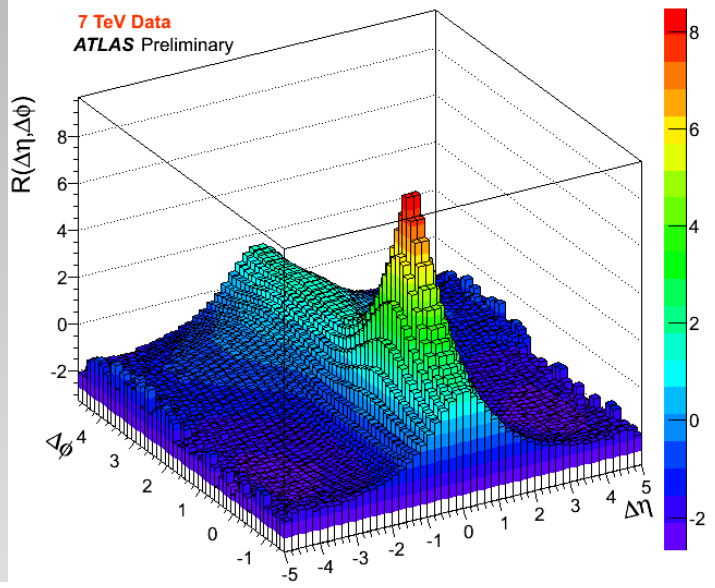
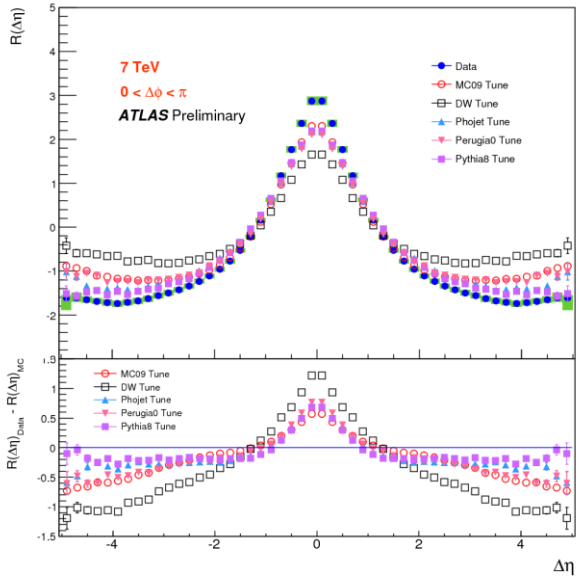
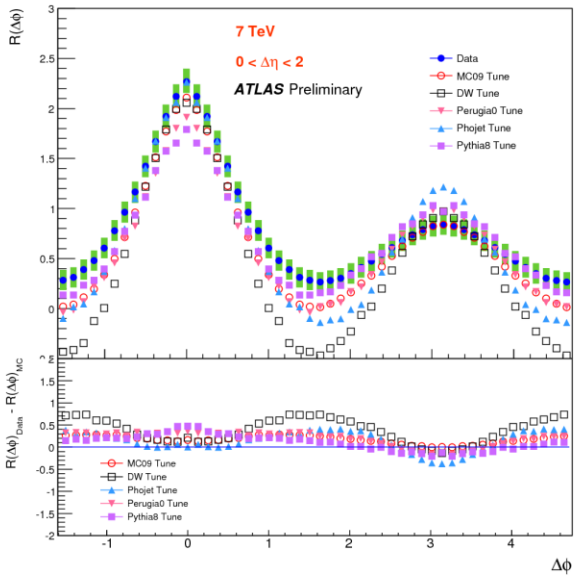
Results

Strength of the correlation seen in data is not reproduced by MC's.

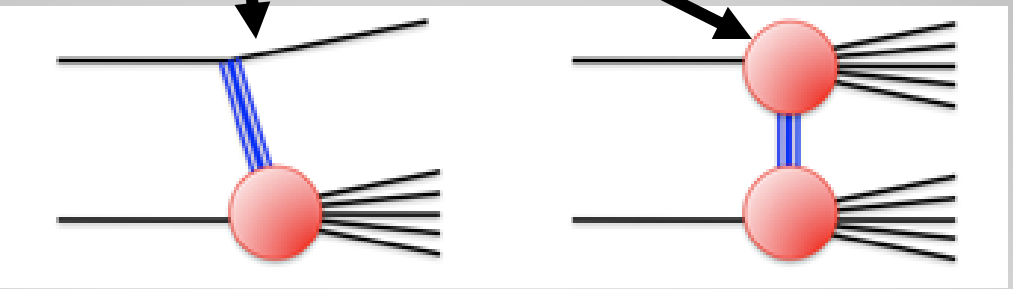






Diffraction

$$\sigma_{TOT} \equiv \sigma_{EL} + \sigma_{SD} + \sigma_{DD} + \sigma_{CD} + \sigma_{ND}$$

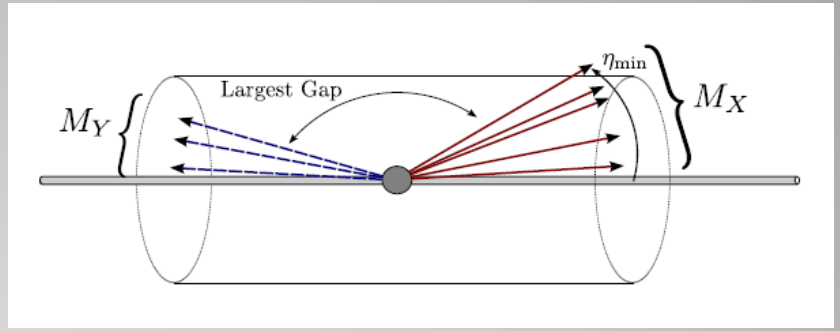


Topology of diffractive events is characterized by a gap in the rapidity distribution of final-state hadrons caused by the lack of color and effective spin of the exchanged object.

Important input to measuring total cross-secton, luminosity, soft-QCD and generally understanding diffractive particle production.

Full Inelastic Cross-Section

Define: $\xi = M^2_X/s$, calculated from the invariant mass, M_X, of hadrons selected using the largest rapidity gap in the event.



At least two MBTS hits

Background and trigger efficiency measured in Data

$$\sigma(\xi > 5 \times 10^{-6}) = \frac{(N - N_{BG})}{\epsilon_{trig} \times \int L dt} \times \frac{1 - f_{\xi < 5 \times 10^{-6}}}{\epsilon_{sel}}$$

Limit measurement to detector acceptance ($M_X > 15.7$ GeV)

From Beam Scan Calibration

Correction factors taken from MC, detector response tuned on data

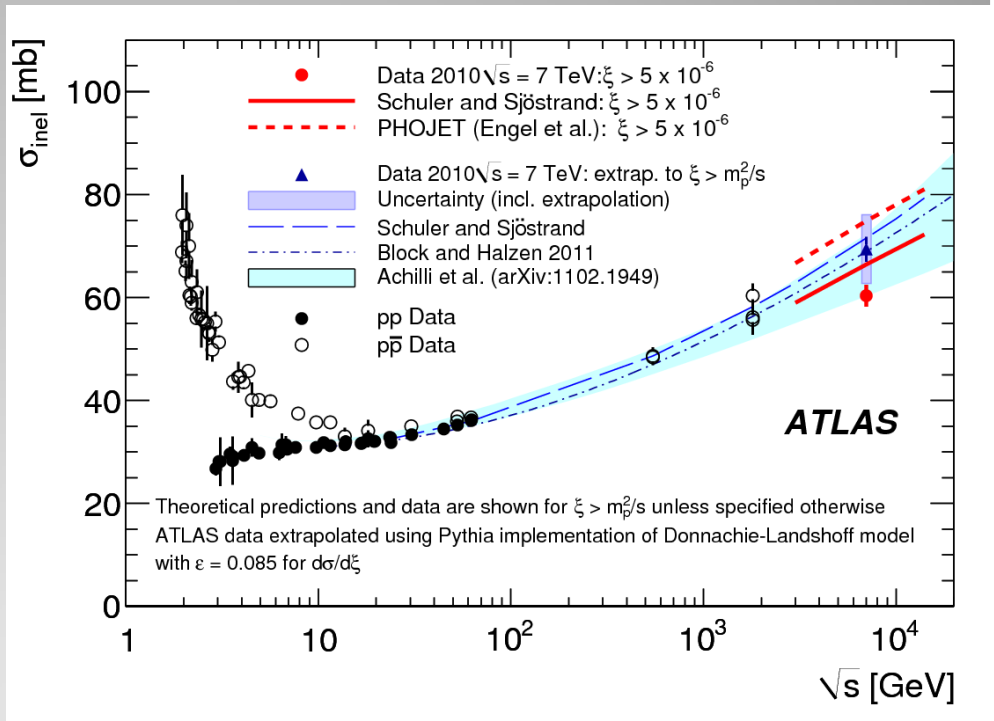
Dataset:1.2M events (2nd day of 7 TeV Stable LHC Beams)

Events are selected by requiring hits on scintillation counters mounted in the forward region of the detector.

arXiv:1104.0326v1

Results

- An inelastic cross-section of **60.3 ± 2.1 mb** is measured for ξ > 5 x 10^-6.
- Compares to 64.7 mb from Pythia (1.2σ) and 73.5 mb from Phojet (2.5σ).



- When extrapolated to $\xi > m_p^2/s$ using Pythia to compare with analytic models:, the full inelastic is determined to be **69.1 ± 2.4 (expt) ± 6.9 (extr) mb.**
- Data agree with most analytic calculations, lower than Phojet.

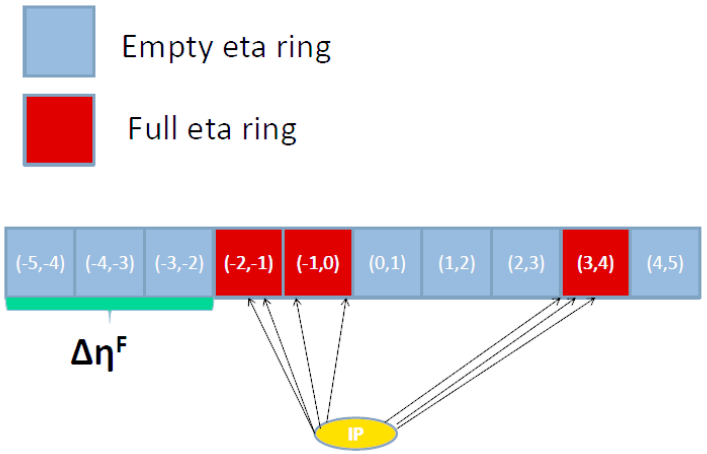
Rapidity Gap Cross-sections

Indirectly measure the mass spectrum by reconstructing rapidity gaps:

$$\Delta\eta \propto \log(1/\xi)$$

(Pseudo)rapidity rings:
η = [-4.9, 4.9] in $\Delta\eta$ = 0.2

Look for rapidity gaps with no soft emission stretching out from the edge of the calorimeter ($|\eta|$ 4.9) across the detector.



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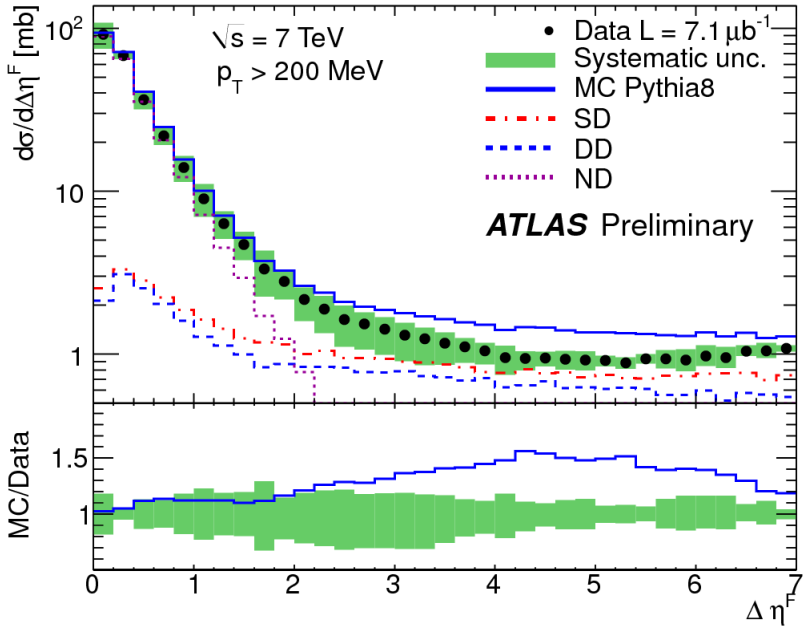
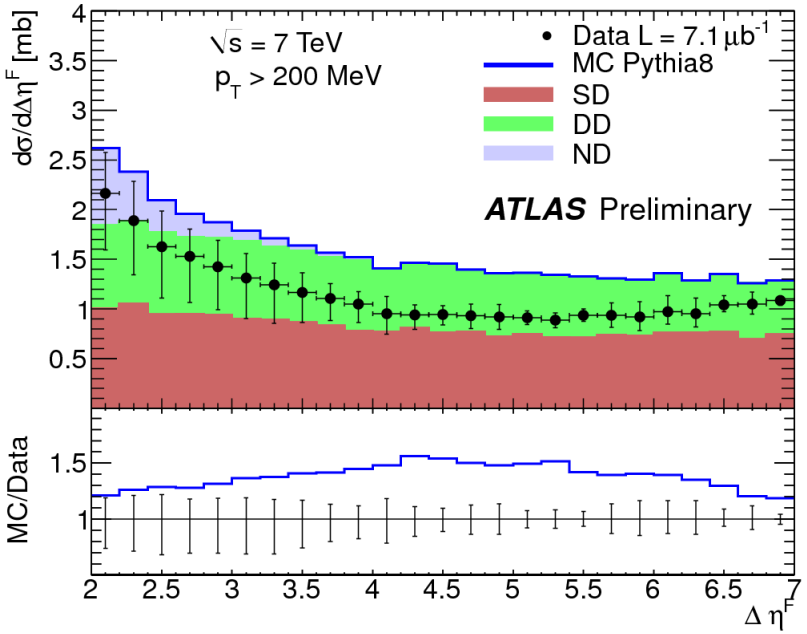
Results

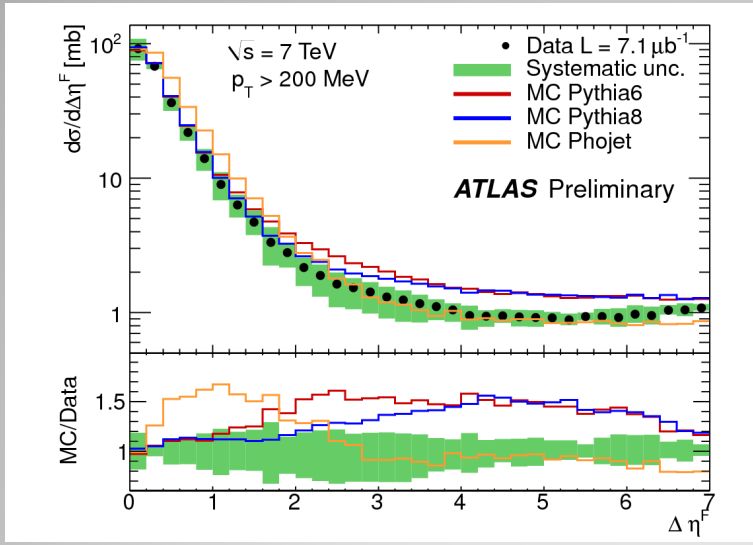


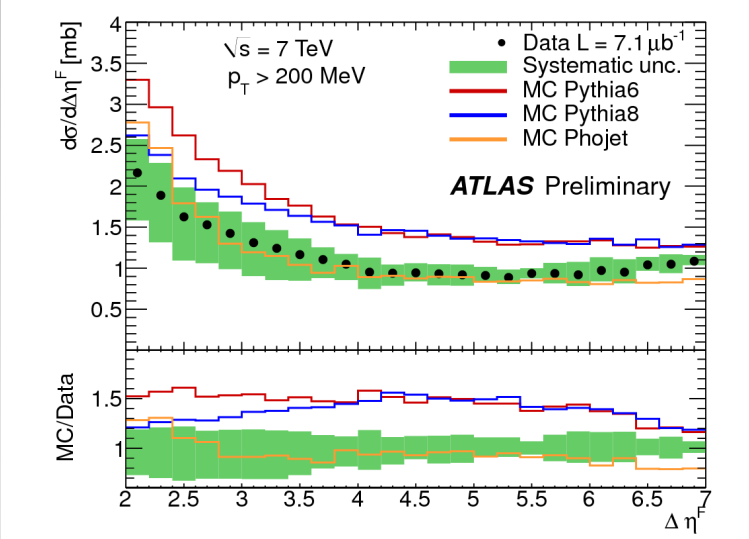


Diffractive fraction is overestimated in MC

- Diffractive contribution dominates for $\Delta\eta > 3$.
- Cross-section ~ 1mb per unit of gap size.

Results Compared with Other Models



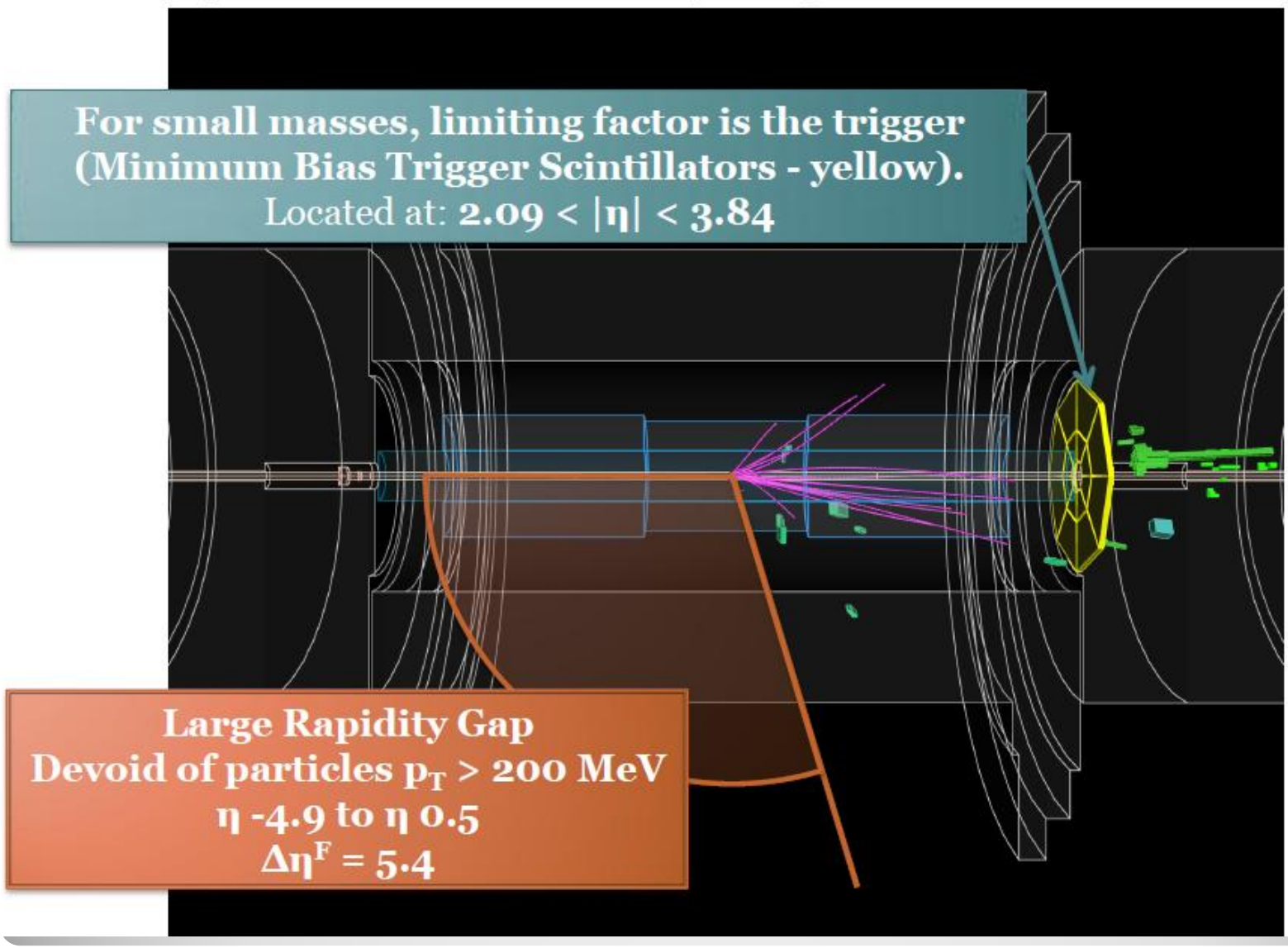


- **PYTHIA 6/PYTHIA8**
  - Reasonable description of non-diffractive component.
  - Shape of diffraction consistent with data, but normalization overestimated.
- **PHOJET**
  - ND component above data, diffractive distribution agrees well.

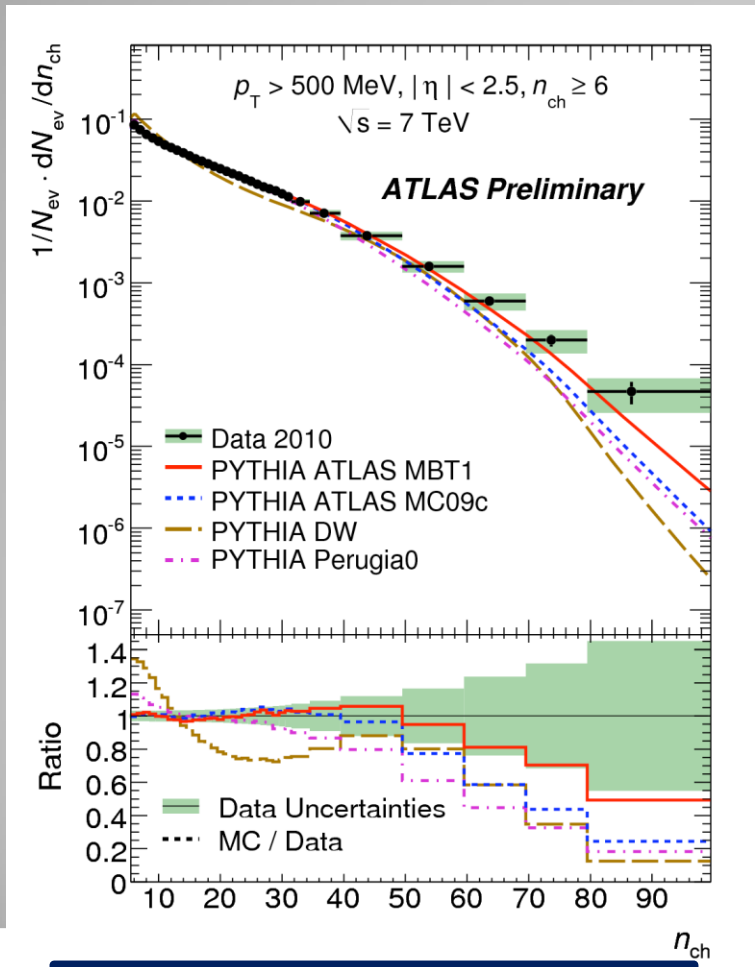
Summary:

- Pre-LHC models seen not to agree with most of the “soft”-QCD distributions.
- First measurement of of inelastic cross-section and rapidity gap signature of diffractive events.

Supporting Material

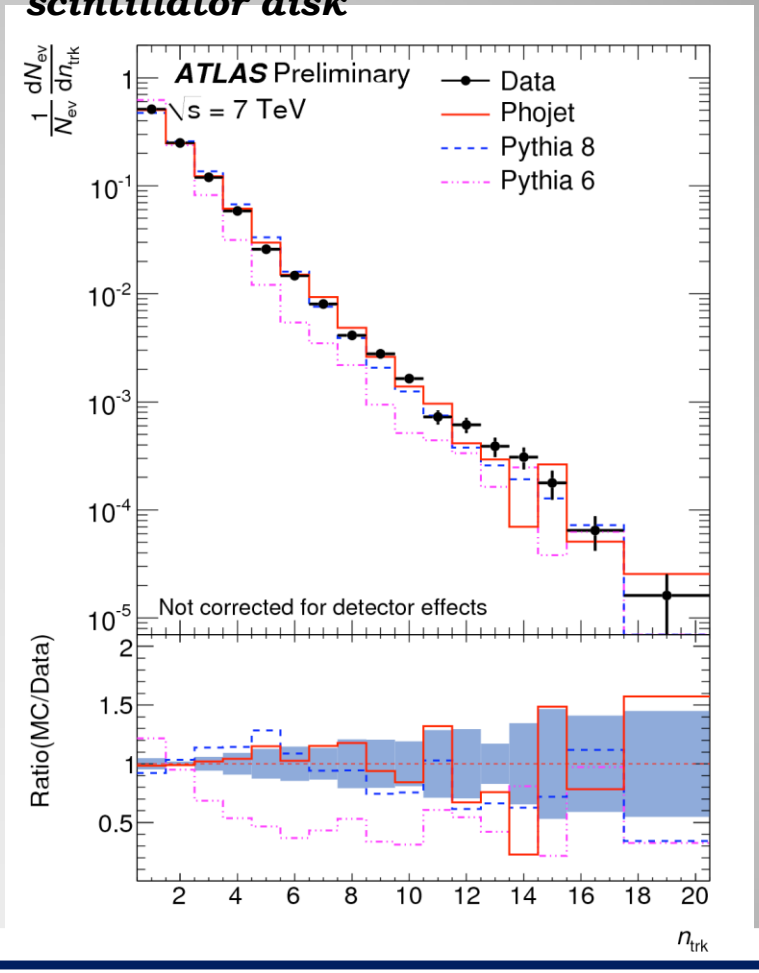

For small masses, limiting factor is the trigger
(Minimum Bias Trigger Scintillators - yellow).
Located at: 2.09 < |η| < 3.84
Large Rapidity Gap
Devoid of particles p_T > 200 MeV
η -4.9 to η 0.5
$\Delta\eta^F = 5.4$

Diffraction suppressed/enhanced samples



Increase in high N_{ch} tails

veto activity in *one forward scintillator disk*



Excellent agreement with Phojet