MPI@LHC 2011

Experimental results: status & perspectives

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MPI@LHC - advancing the debate on Multiple Partonic Interactions.

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- This workshop series attempts to connect theory-phenomenology-experiment to better understand MPI related phenomena.
  - several advances in theory predictions;
  - new physics components added to MC models;
  - remarkable advance on MC tuning;
  - experimental results discussed in these workshops have come from various sources: Tevatron, RHIC, HERA and LHC.

- (...some) **Highlights of experimental results presented this year...**

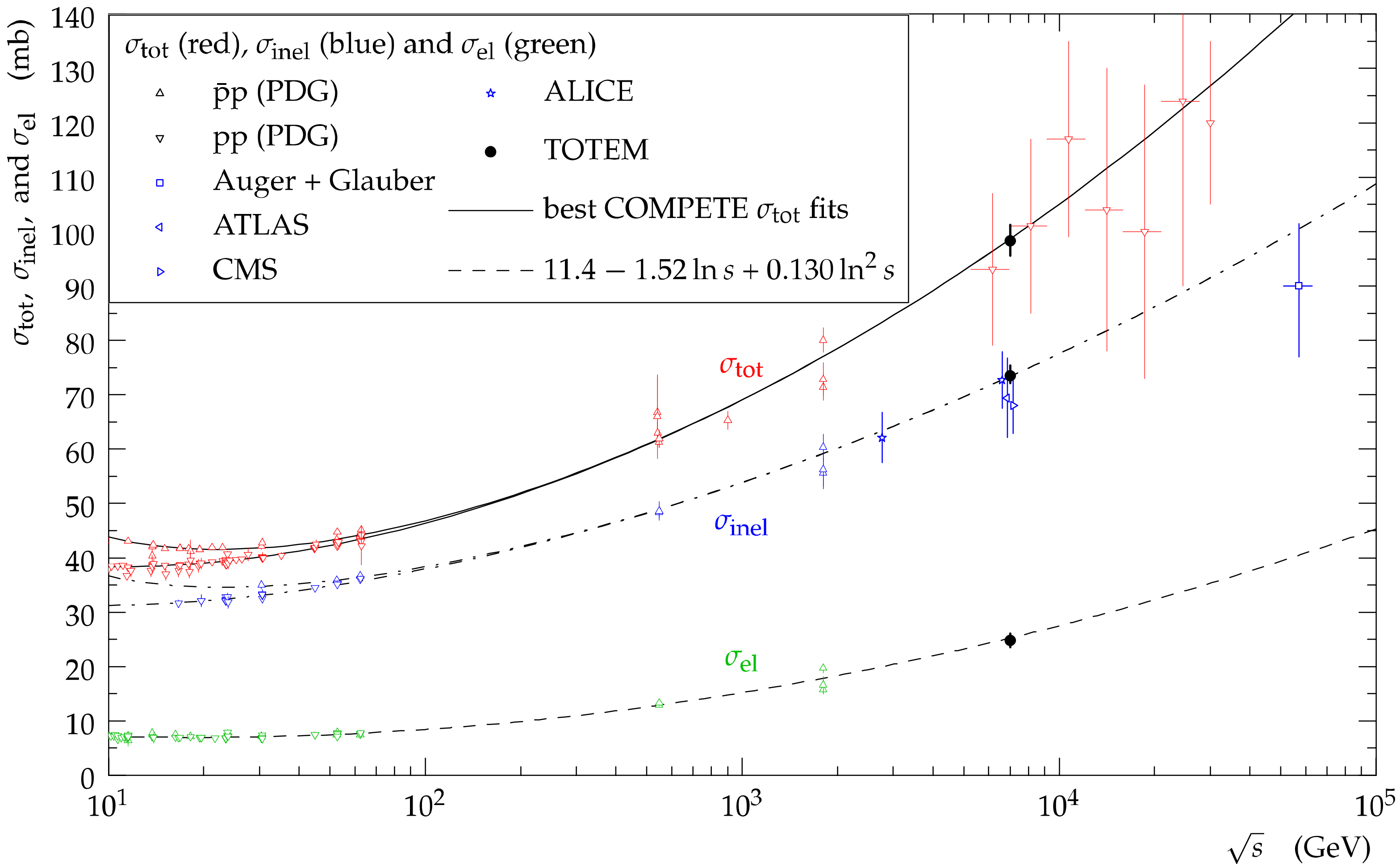
(just a small selection of plots/slides)

TOTEM results & comparison

$$\sigma_{tot} = 98.3 \pm 0.2^{(stat)} \pm 2.8^{(syst)}\ \text{mb}$$

$$\sigma_{ele} = 8.3\ \text{mb}^{(extrapol.)} + 16.5\ \text{mb}^{(measured)} = 24.8 \pm 0.2^{(stat)} \pm 1.2^{(syst)}\ \text{mb}$$

$$\sigma_{inel} = \sigma_{tot} - \sigma_{ele} = 73.5 \pm 0.6^{(stat)}\ {}^{+1.8}_{-1.3}\ {}^{(syst)}\ \text{mb}$$



σ_{inel} (CMS) = $68.0 \pm 2.0^{(syst)} \pm 2.4^{(lumi)} \pm 4.0^{(extrap)}$ mb

σ_{inel} (ATLAS) = $69.4 \pm 2.4^{(exp)} \pm 6.9^{(extrap)}$ mb

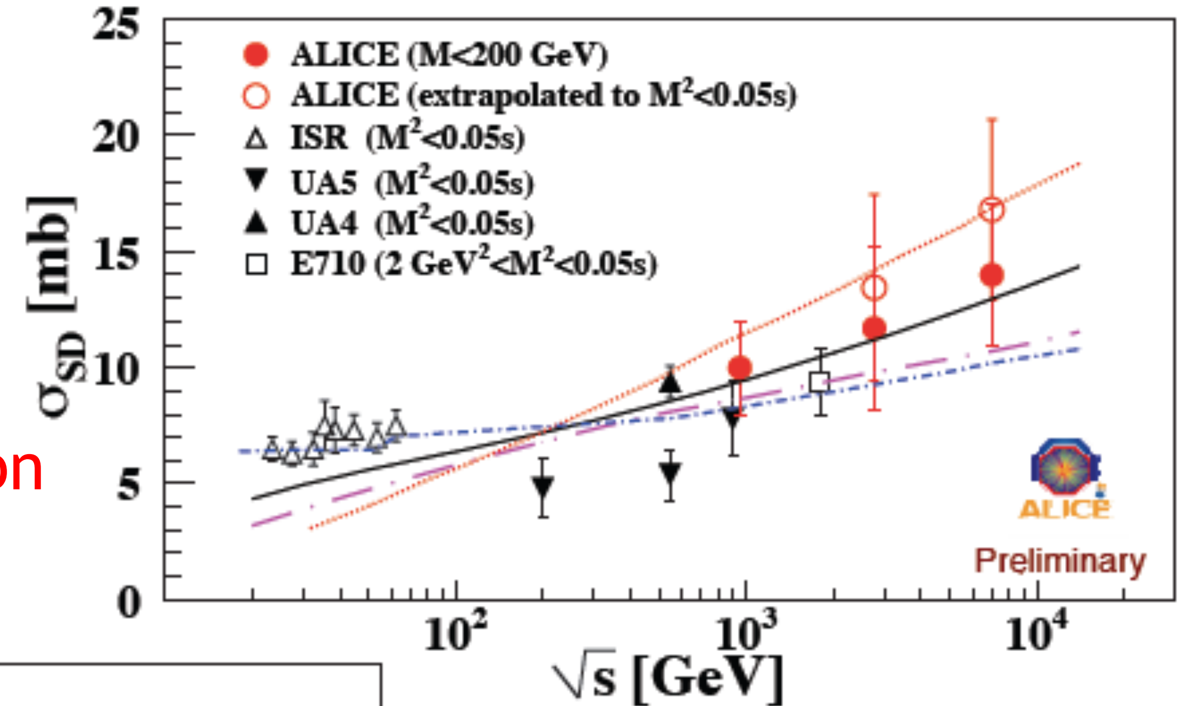
σ_{inel} (ALICE) = $72.7 \pm 1.1^{(model)} \pm 5.1^{(lumi)}$ mb

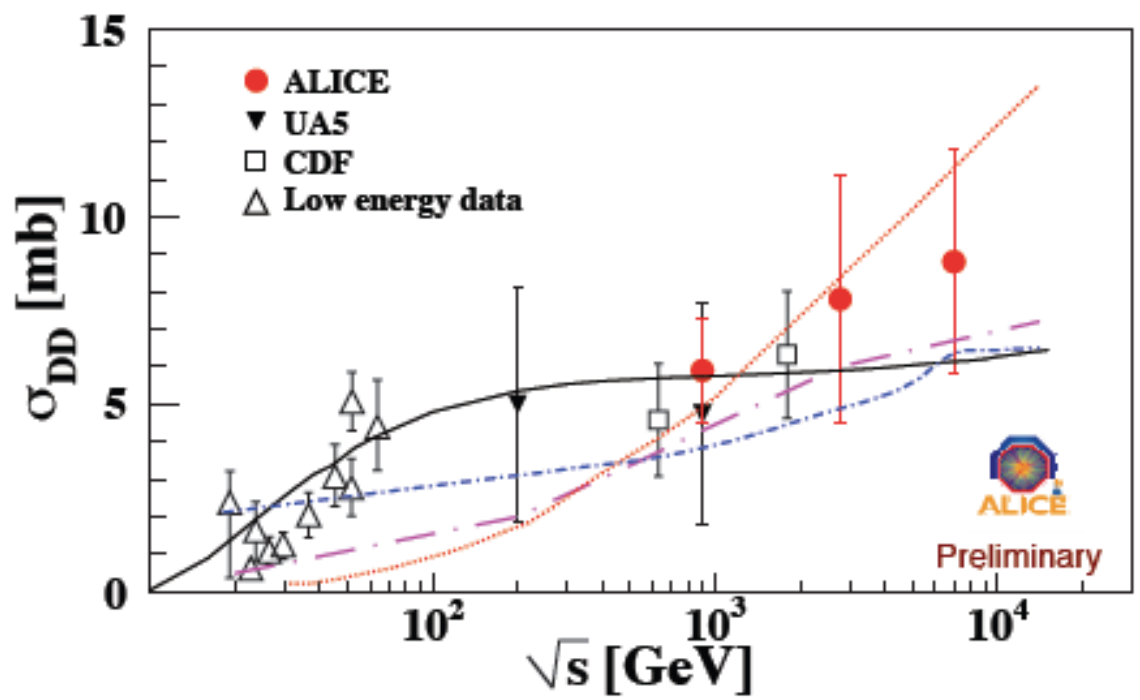
K. Österberg (Wed.)

University of Glasgow

ALICE: Total SD and DD Cross Sections

ALICE: Unfold integrated SD and DD cross sections at all three CMS energies based on gap rates and topologies.
[implies some extrapolation Into lowest ξ regions]





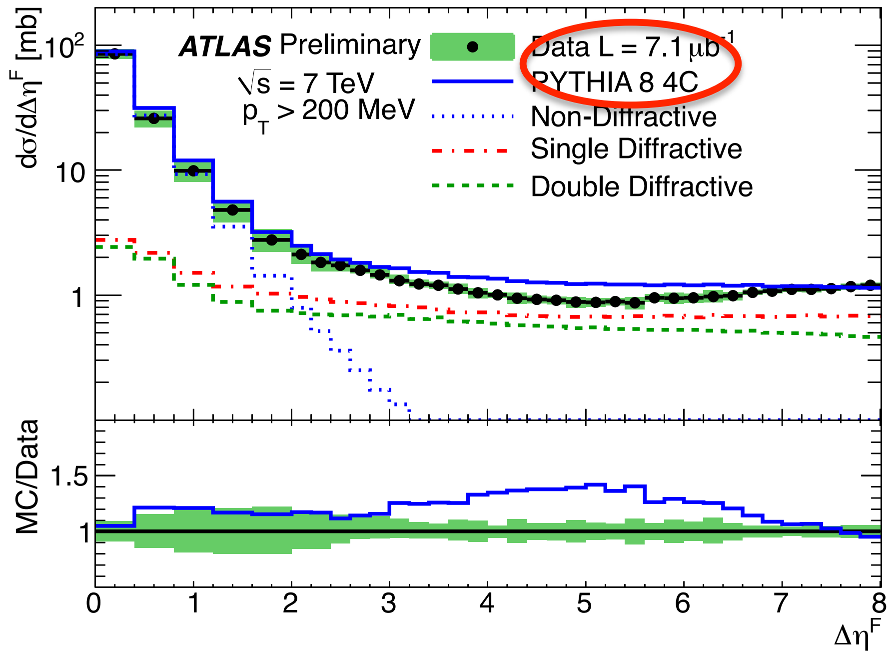
σ(SD) with ξ < 0.05

σ(DD) with gap Δη > 3

Good agreement with SPS data and wide range of model predictions

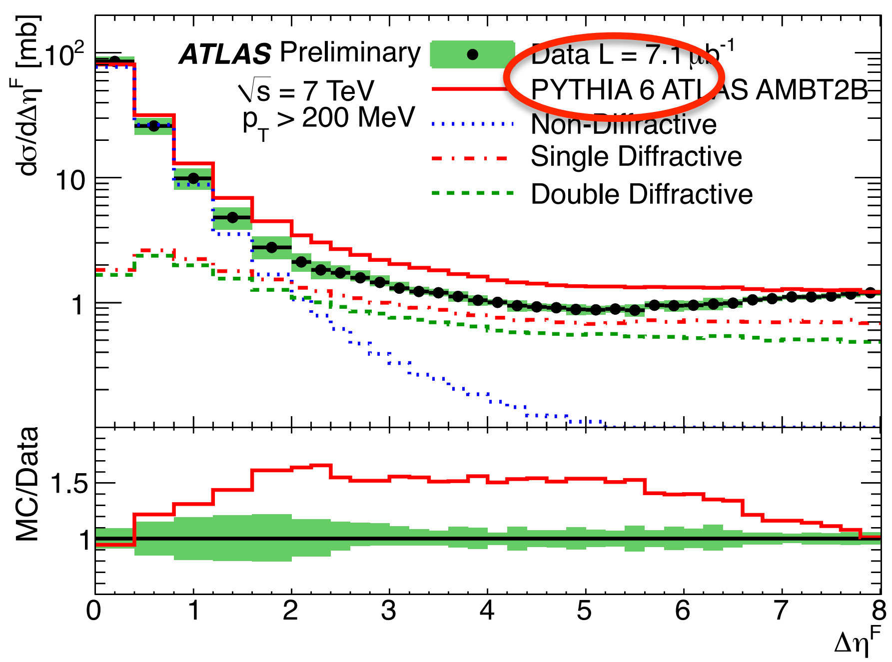
P. Newman (Wed.)

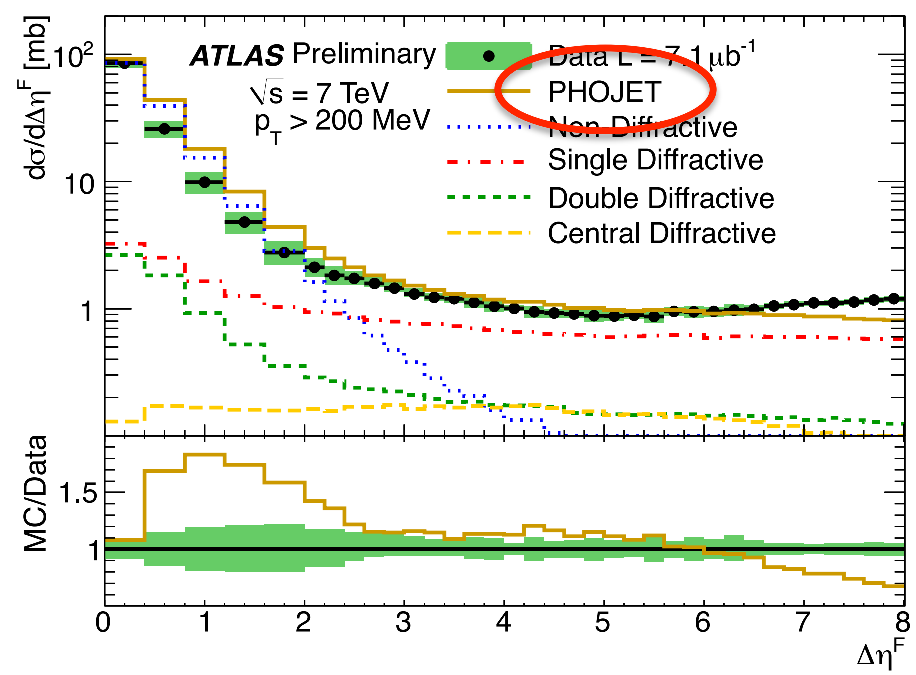
Differential gap cross-sections



Small Gaps and Hadronisation

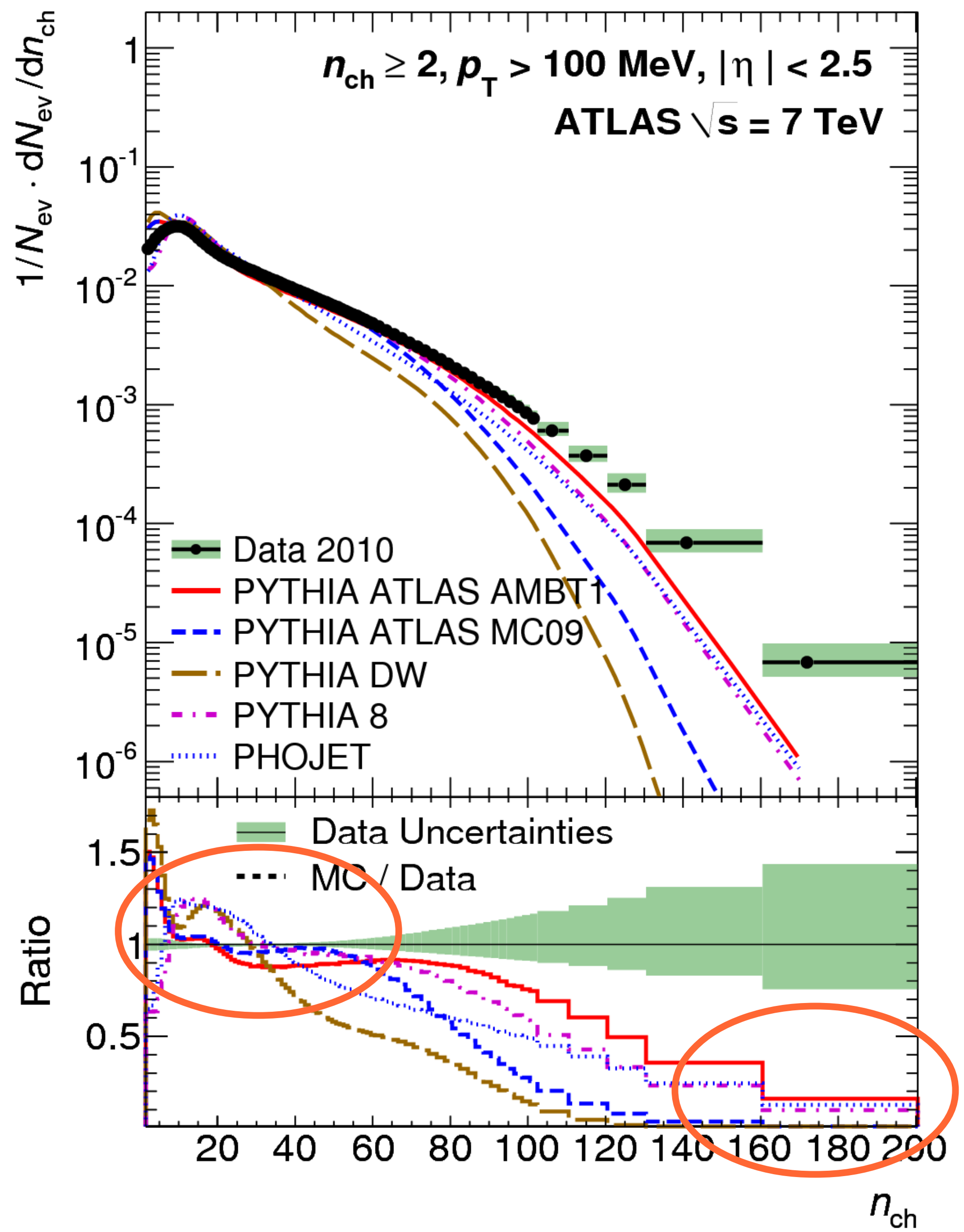
- Big variation between MCs in small non-zero gap production via ND → fluctuations / UE
- PYTHIA8 best at small gaps
- PHOJET > 50% high at $\Delta\eta^F$ ~ 1.5



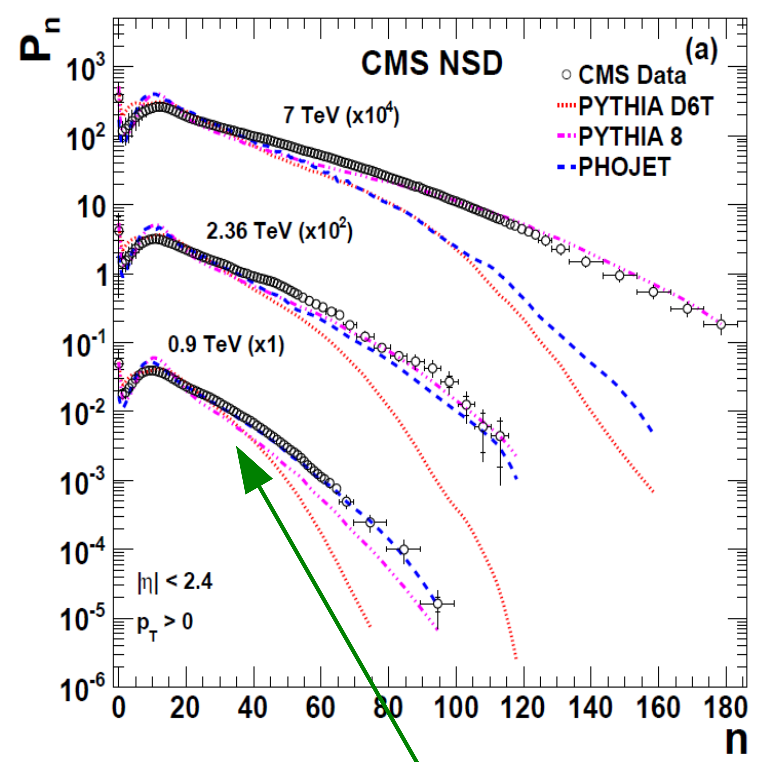


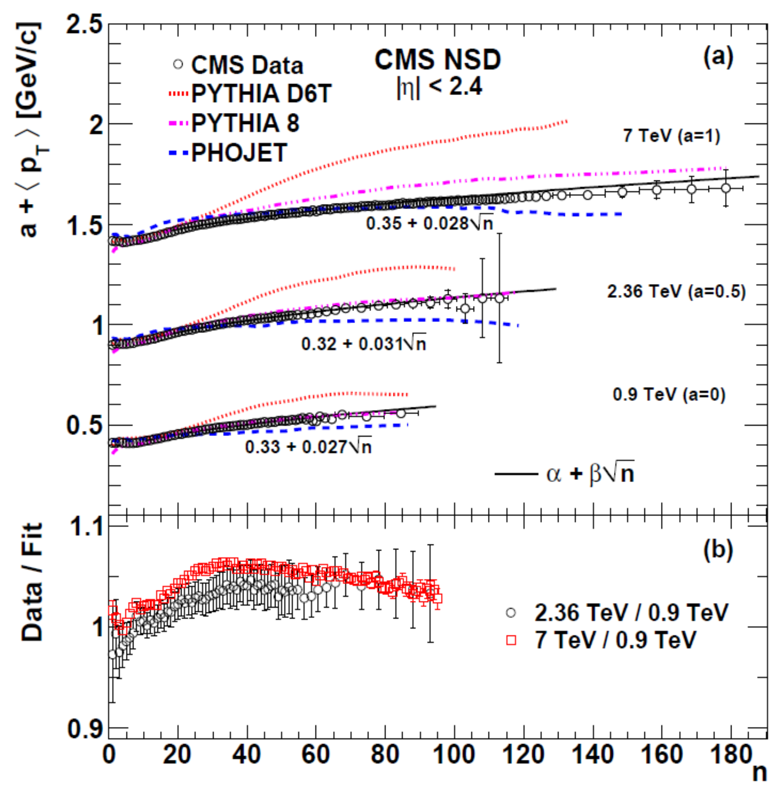
P. Newman (Wed.)

Charged particle multiplicities: minimum bias events



M. Leyton (Mon.)





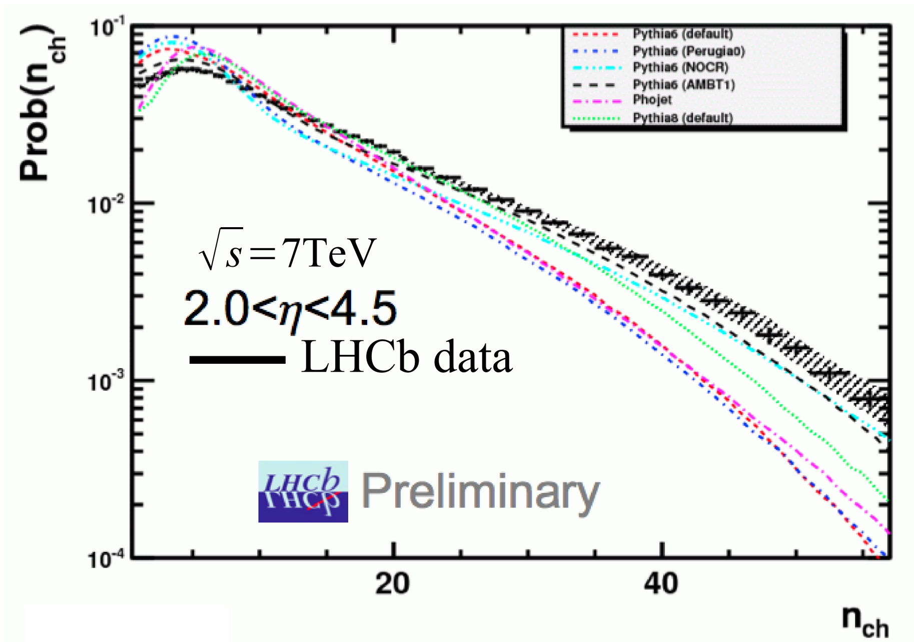
Change in slope: multi-component structure

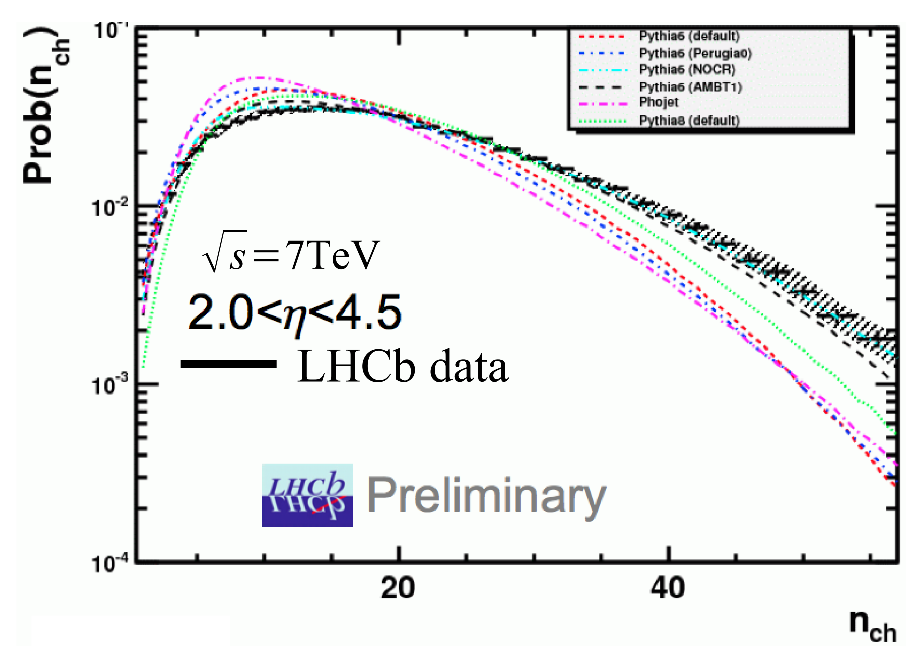
S. Bansal (Mon.)

Charged particle multiplicities (3)

- probability to have n_{ch} in an unbiased event

- probability to have n_{ch} in a hard interaction event (at least one track with p_T > 1 GeV)





- good agreement between Perugia NOCR prediction and real data (black solid line)

21.11.2011, MPI@LHC 22 D. Volyanskyy

D. Volyansky (Mon.)

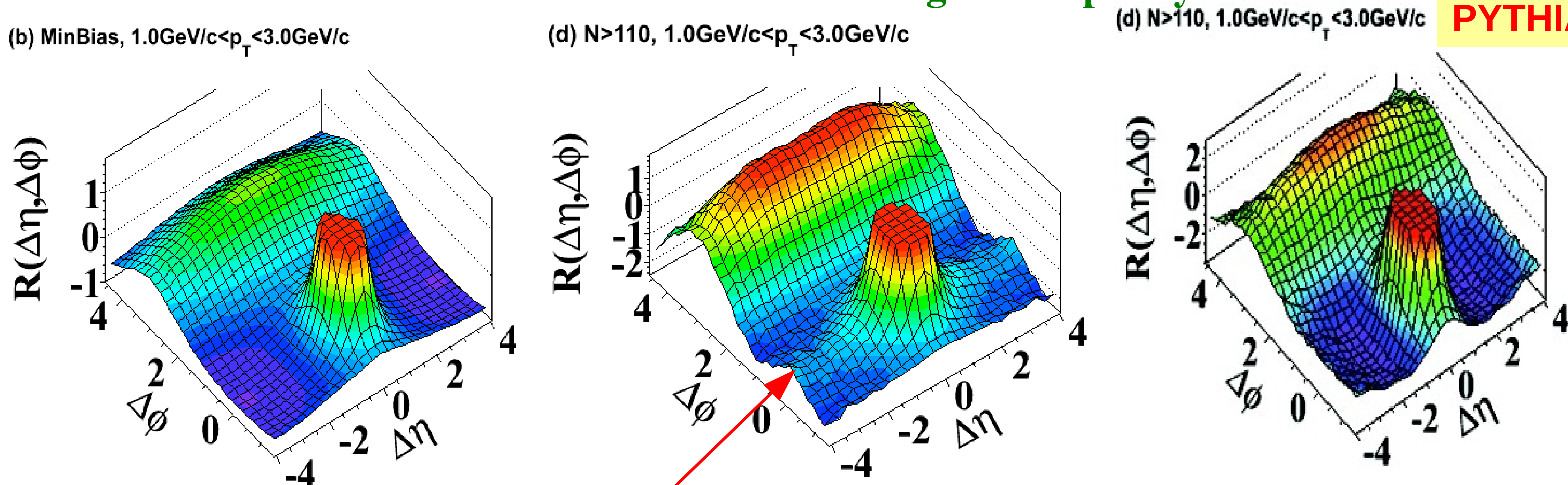
University of Glasgow

S. Bansal (Mon.)

High Multiplicity Results at $\sqrt{s} = 7$ TeV

Intermediate pT : $1 < p_T < 3$ GeV/c

MinBias | **High Multiplicity: N>110** | **PYTHIA 8**



→ **Observation of a Long-Range, Near-Side angular correlations at high multiplicity in pp events at intermediate p_T (Ridge at $\Delta\phi \sim 0$)**

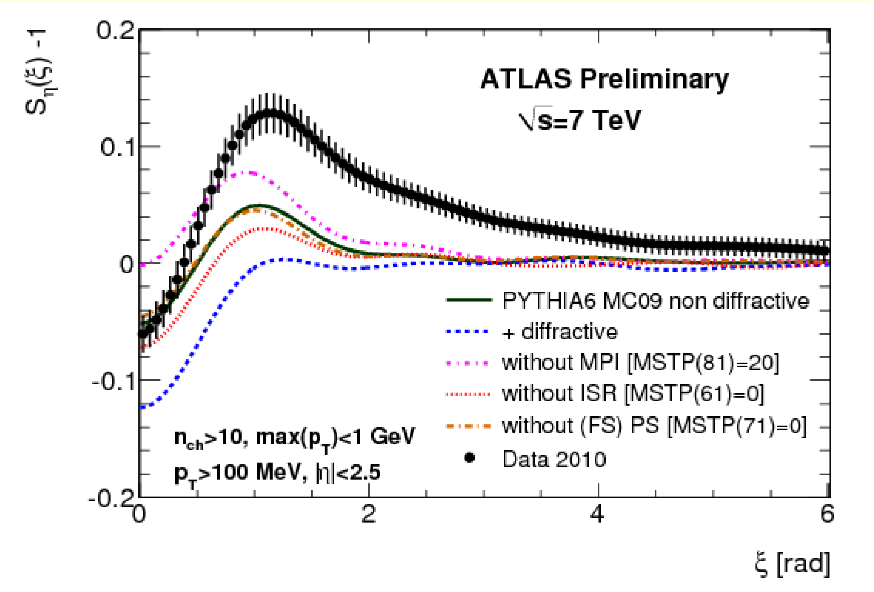
… not reproduced in PYTHIA 8 (and PYTHIA 6, HERWIG++, madgraph)

M. Leyton (Mon.)

Pythia variations

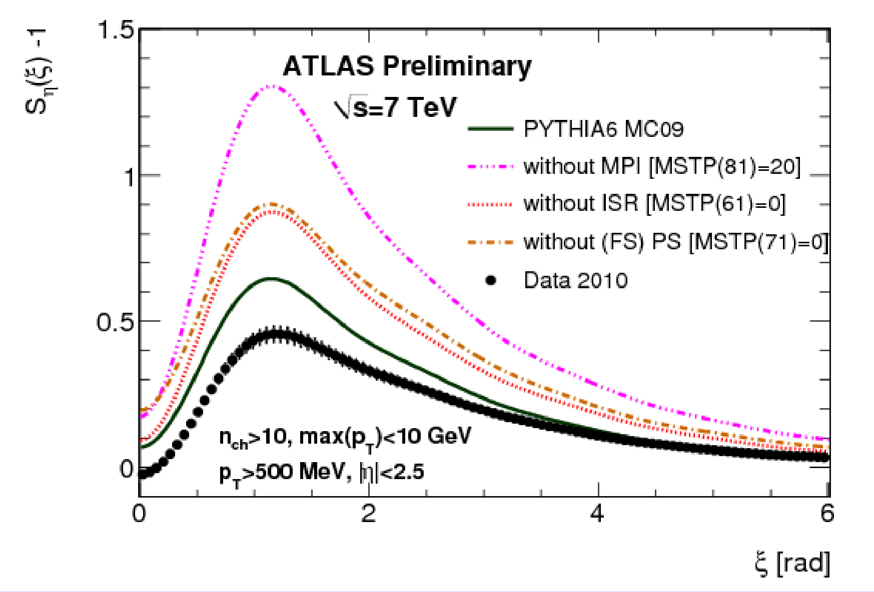
Low-pT enhanced:

- Extreme variation of model parameters cannot provide reasonable description of data
- Modeling of diffractive events is major source of discrepancy between data and models
- MPI scheme pulls model prediction away from data

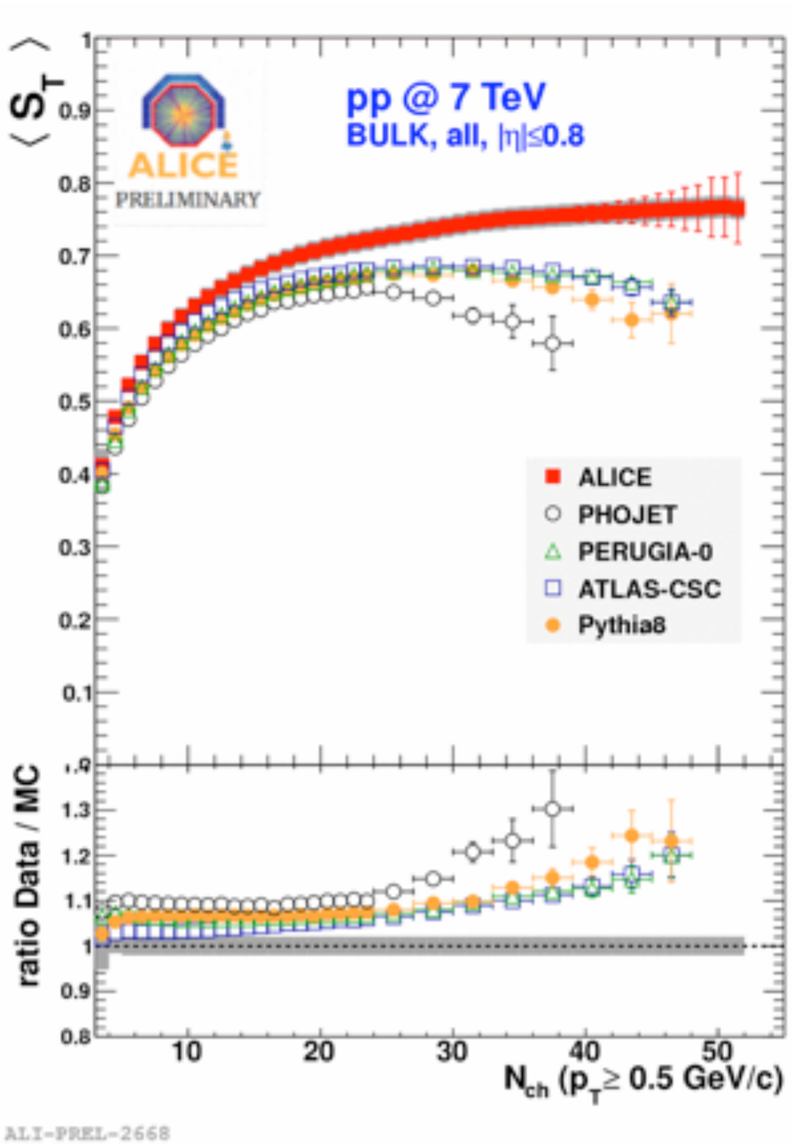


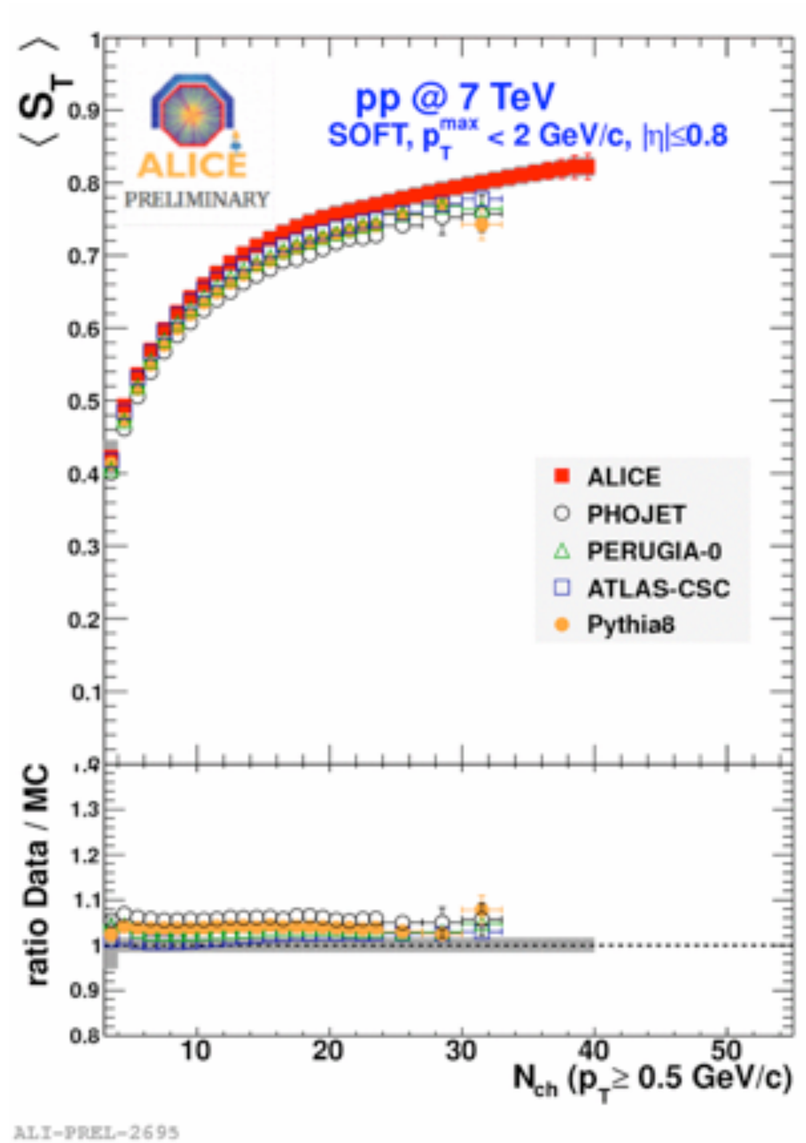
Low-pT depleted:

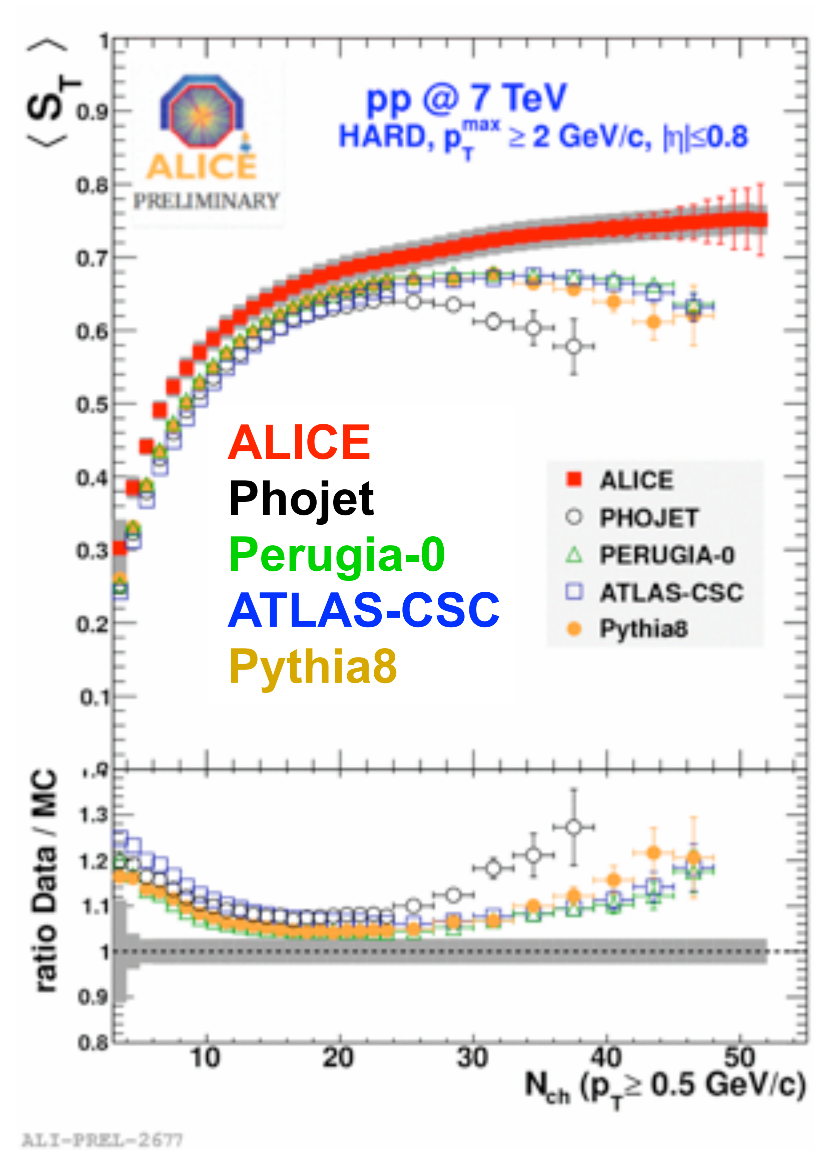
- Higher rate of MPI is required to describe the data



Transverse Sphericity





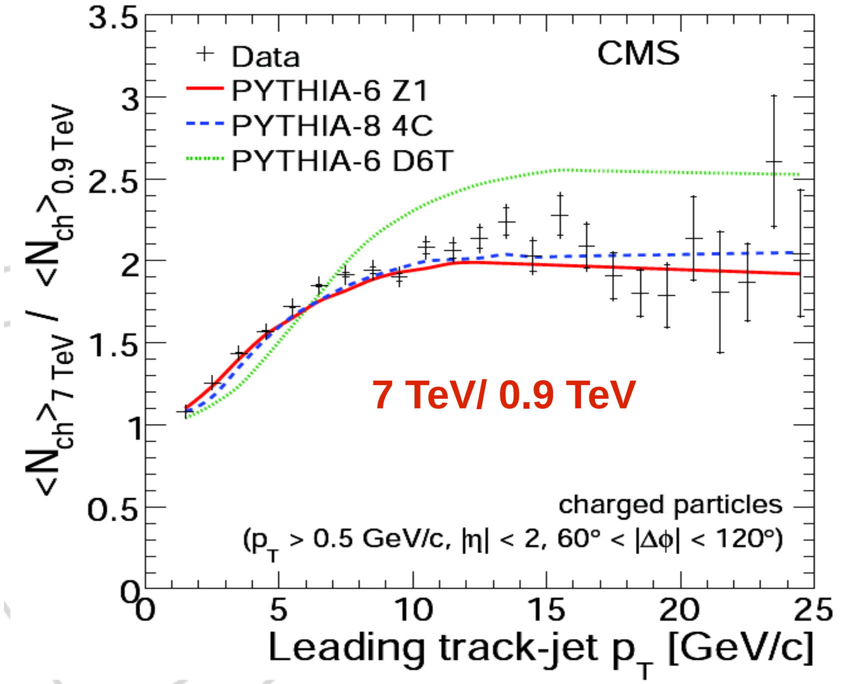


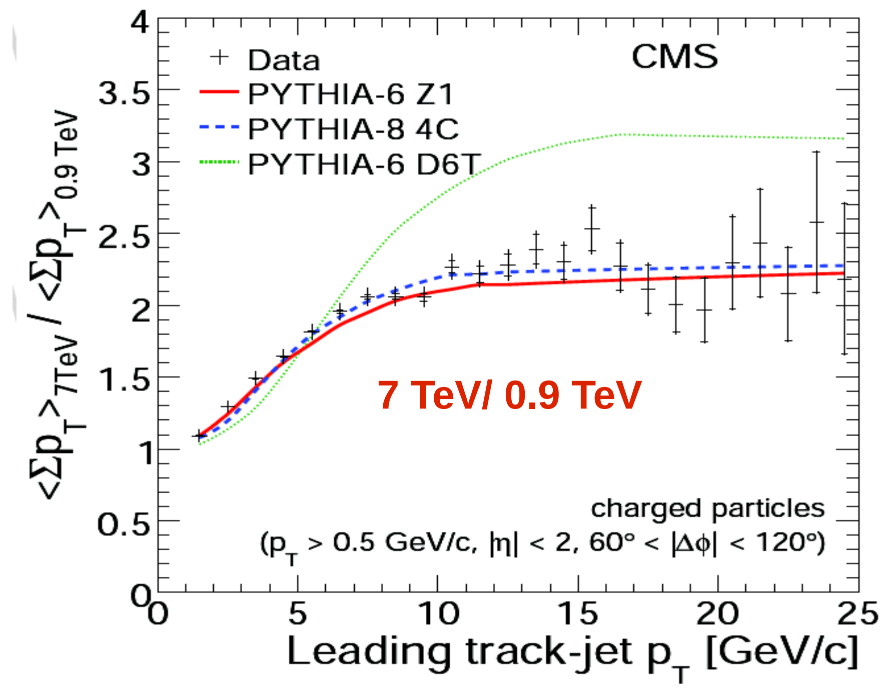
J. F. Grosse-Oetringhaus (Mon.)

The underlying event

S. Bansal (Mon.)

Comparison between 7 TeV and 900 GeV



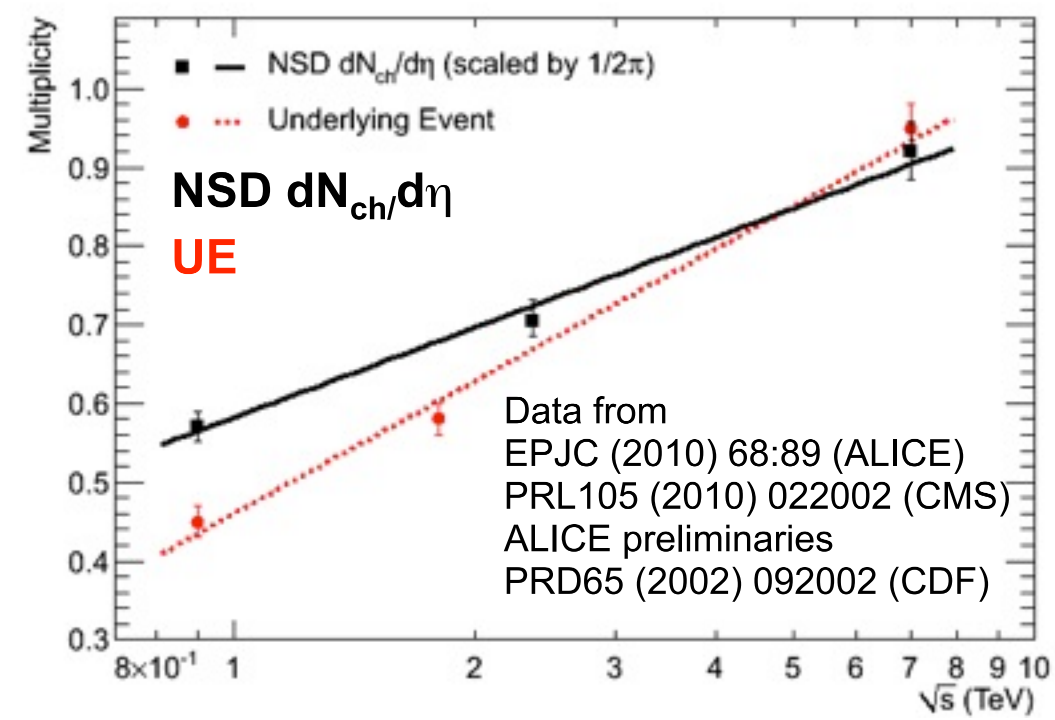


– In the presence of a large energy scale, UE grows significantly with $\sqrt{s}$

– A factor 2 going from 900 GeV to 7 TeV to be compared with 1.7 for MB.

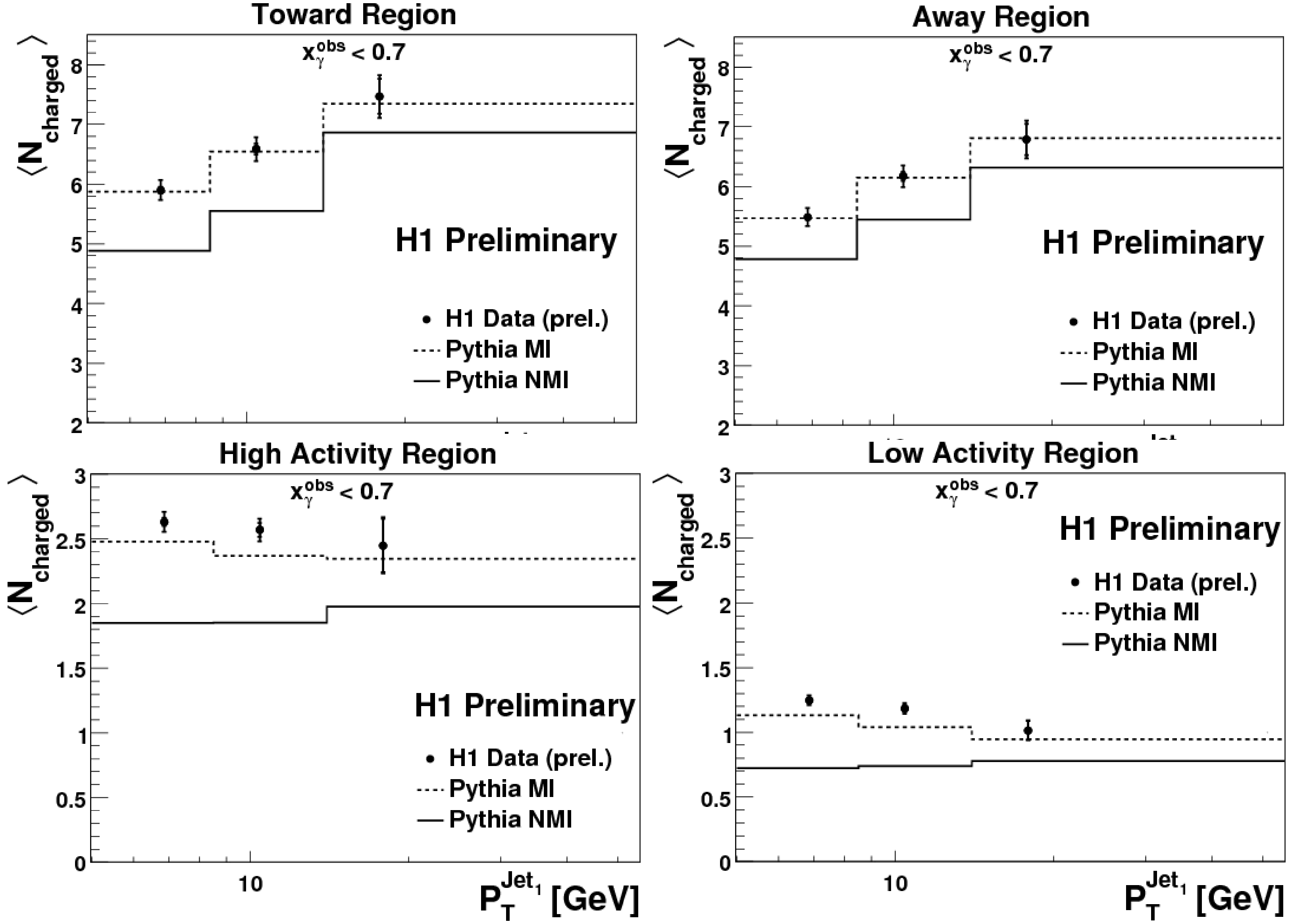
– MPI growth with $\sqrt{s}$ well described by Z1 and 4C, too pronounced in D6T.

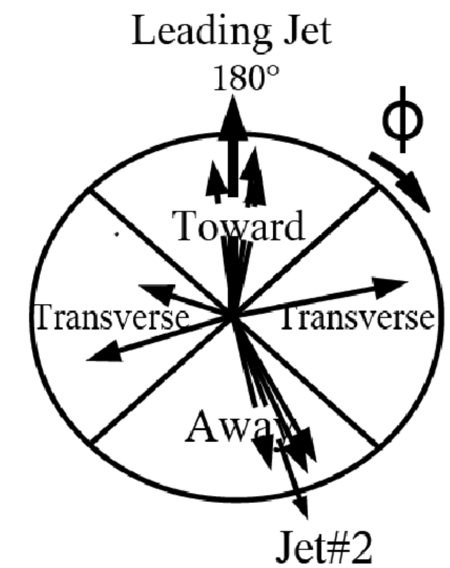
11/21/11 Sunil Bansal, MPI@LHC



J. F. Grosse-Oetringhaus (Mon.)

Charged Particle Flow in Photoproduction





- Charge particle multiplicity in hard region very well described by MI.
- Low P_t jet - MI contributes slightly more ⟶ not only pedestal effect
- MI important in transverse regions
- ... but no perfect description of data... but tuning is possible...

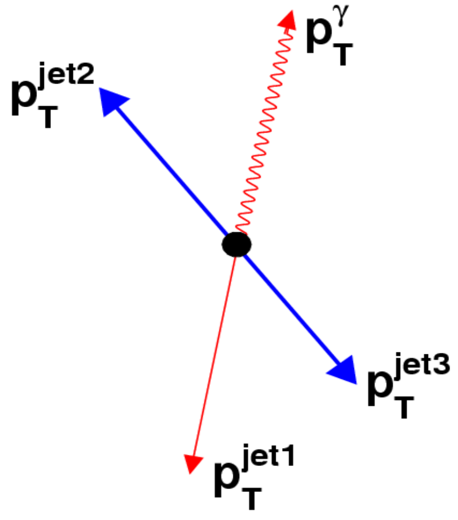
A. Knutsson (Tue.)

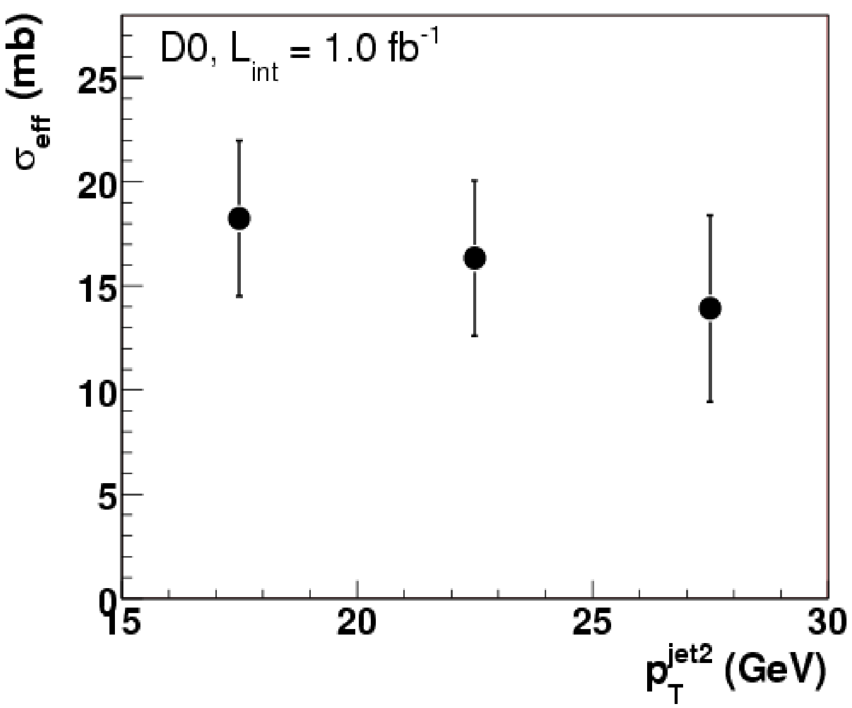
Measuring Double Parton Scattering

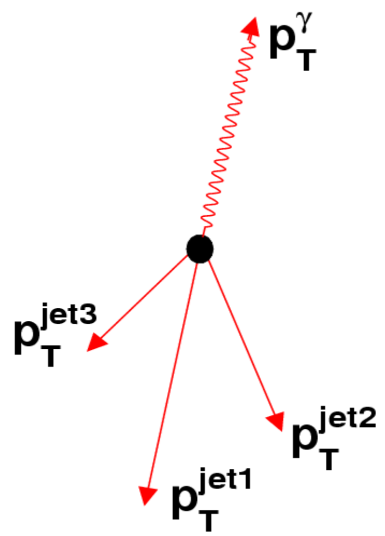
Double parton interactions in γ+3jet events in ppbar collisions at √s=1.96 TeV in D0

G. Golovanov (Tue.)

Phys.Rev.D81,052012(2010)
arXiv:0912.5104





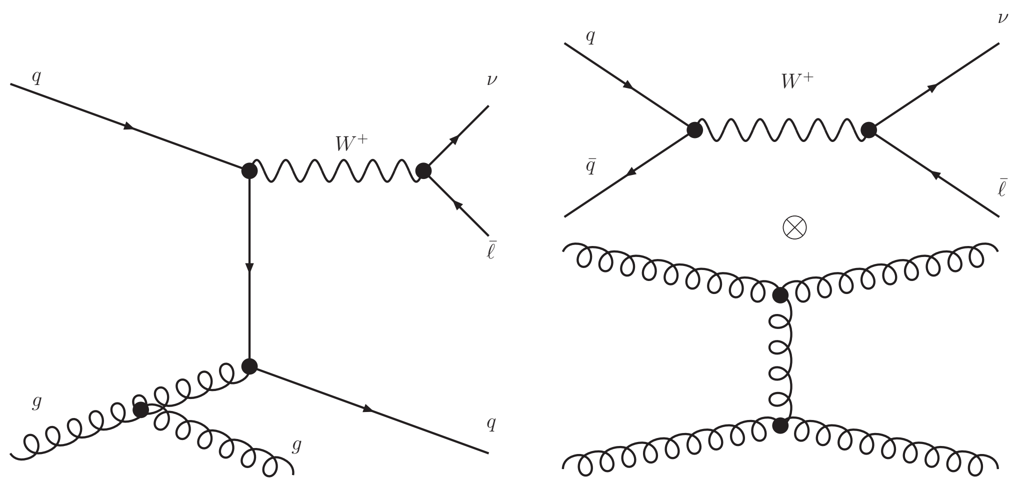


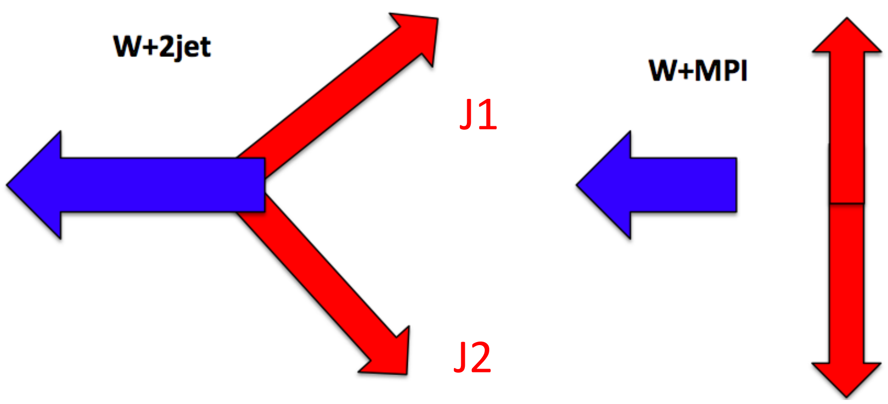
$$\sigma_{eff}^{ave} = 16.4 \pm 0.3(stat) \pm 2.3(syst)\, mb$$

Found DP fractions are pretty sizable: they drop from ~46-48% at 2nd jet pT 15-20 GeV to ~22-23% at 2nd jet 25-30 GeV with relative uncertainties ~7-12%.

Measuring Double Parton Scattering

E. Dobson (Tue.)





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

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

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

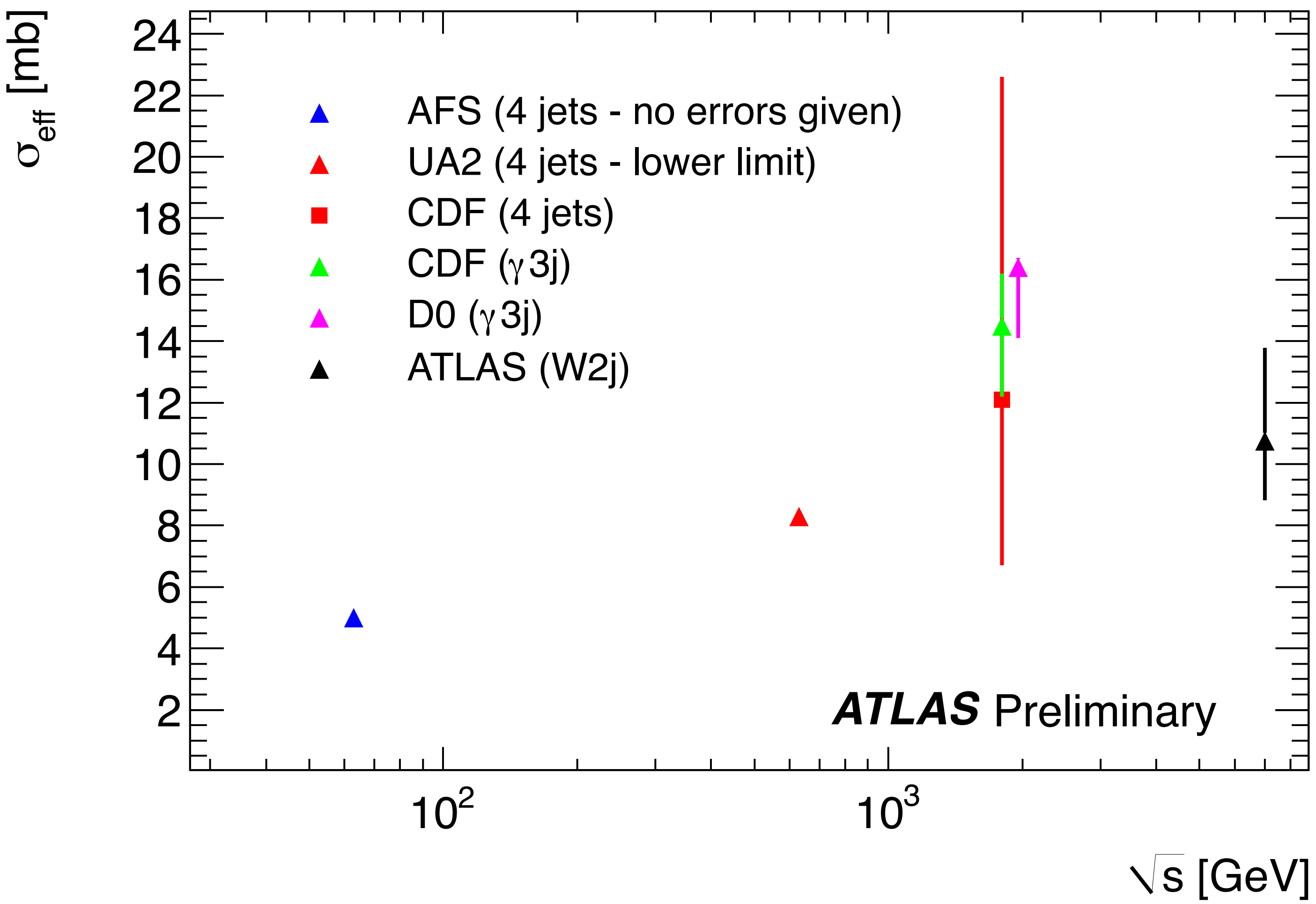
$$f^{\mathrm{R}}_{\mathrm{DP}} = 0.16 \pm 0.01\ (\mathrm{stat.}) \pm 0.03\ (\mathrm{sys.}).$$

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

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

E. Dobson (Tue.)

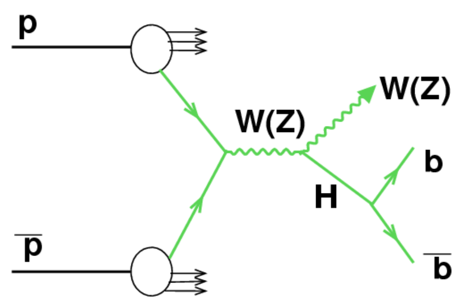
Putting the result into context….

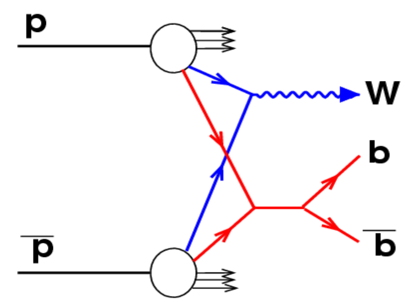


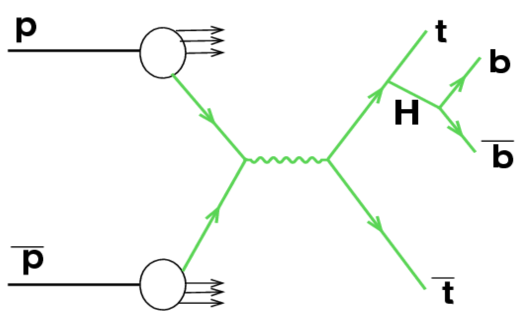
Results consistent with other measurements
- no real evidence for variation of σ_{eff} with channel or E_{COM}

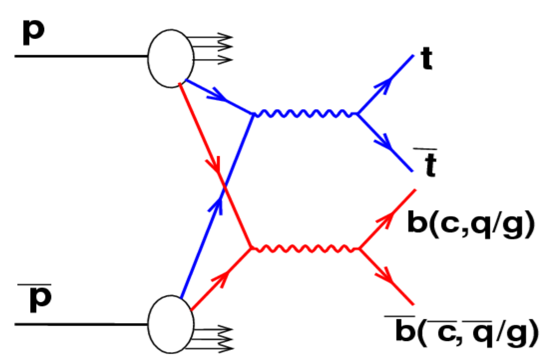
Double parton interactions as a background to rare processes

Signal | Double Parton background

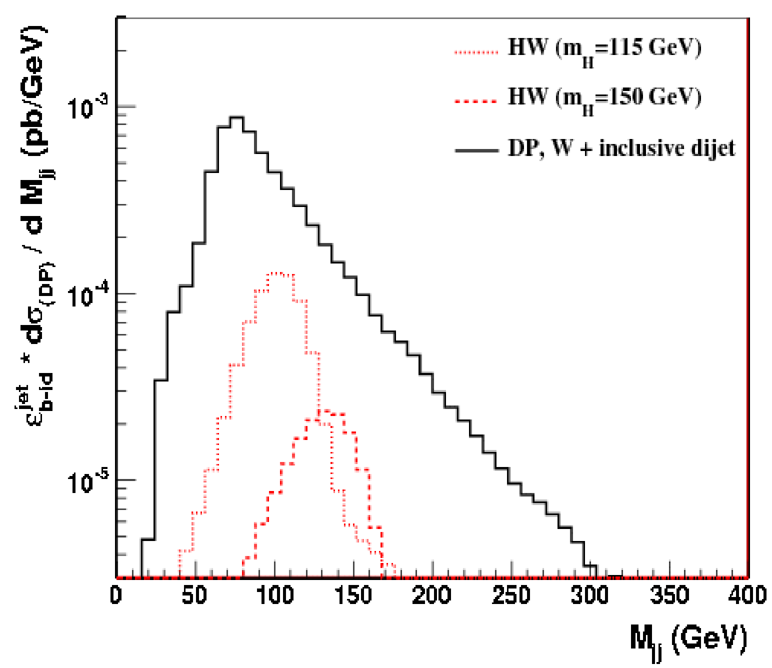


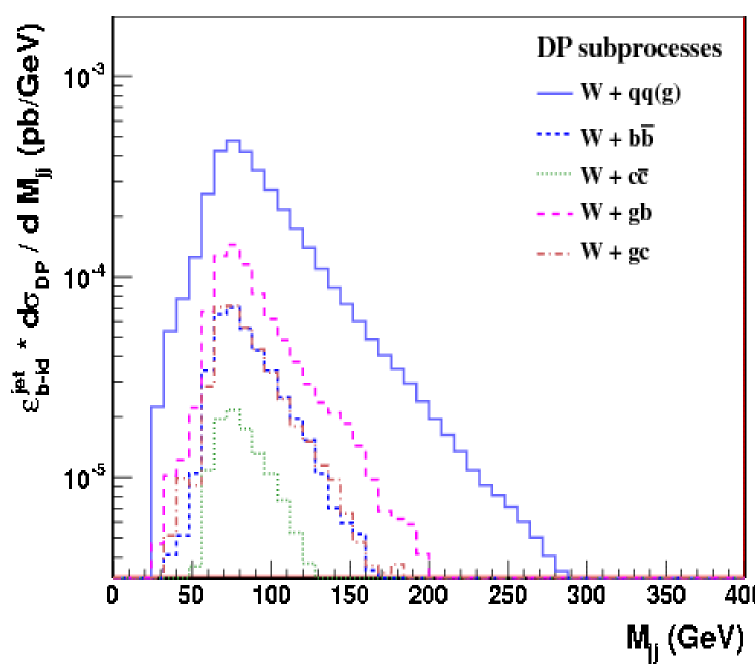






- Kinematic + bID selections are same as in actual D0 analyses.
- Dijet dσ/dM and W cross sections are normalized to D0 measurements.
- Higgs signal is suppressed even in the peak by a factor 2.5-5





G. Golovanov (Tue.)

...and many other interesting results!

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Where do we go from here?

...and many other interesting results!

Where do we go from here?

- LHC will hopefully continue to deliver a lot of data...
- Correlations in MB events are on their way to be published...
- More UE event measurements will become available soon (DY, high E_T jets, ...)
- Direct measurements of MPI processes at the LHC

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In addition to the work already in the pipeline, which measurements should we propose to our experimental collaborations?

How can we keep track of these studies so we can see them mature enough to be presented in 2012?