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# Measurement of the inelastic $pp$ cross section at $\sqrt{s} = 7$ with the CMS detector

## Abstract

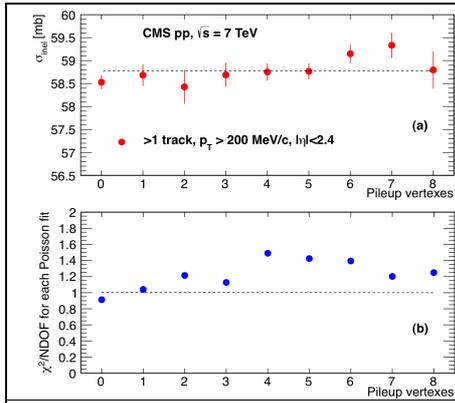
A measurement is presented of the inelastic proton-proton cross section at a centre of mass energy of  $\sqrt{s} = 7$  TeV. Using the CMS detector at the LHC, the inelastic cross section is measured through two independent methods based on information from (i) forward calorimetry (for pseudorapidity  $3 < |\eta| < 5$ ), in collisions where at least one proton loses more than  $5 \cdot 10^{-6}$  of its longitudinal momentum, and (ii) the central tracker ( $|\eta| < 2.4$ ), in collisions containing an interaction vertex with more than 1, 2, or 3 tracks with transverse momenta  $p_T > 200$  MeV/c. The measurements cover a large fraction of the inelastic cross section for particle production over about 9 units of pseudorapidity and down to small transverse momenta. The results are compared with those of other experiments, and with models used to describe high-energy hadronic interactions.

## Approved Plots from FWD-11-001 PAS ( *click on plot to get .pdf* )

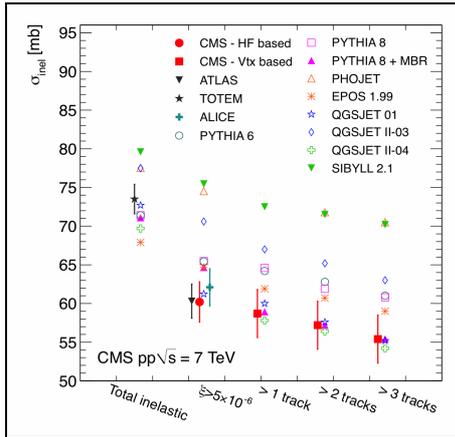
Figure	Abbreviated Caption
	<p>The normalized <math>\xi</math> distributions for <math>E_{\text{HF}} &gt; 4</math> and <math>E_{\text{HF}} &gt; 5</math> GeV from MC simulation of inelastic <math>pp</math> collisions using (a) <code>Pythia6</code>, (c) <code>Pythia8</code>, and (e) <code>Phojet</code>, are shown for the full range of <math>\xi</math>. The corresponding efficiencies are shown in (b), (d), and (f), respectively. The lowest value of <math>\xi</math> used in the analysis, <math>\xi = 5 \cdot 10^{-6}</math>, is shown on the plots as a dashed vertical line.</p>

	<p>Fraction of reconstructed events with more than 1 track, corrected for efficiency, measured as a function of the number of vertexes, in data (dots) and in Monte Carlo (histogram), for instantaneous bunch-crossing luminosities between <math>0.05 \sim 0.6 \cdot 10^{30}</math> and <math>0.6 \sim 10^{30}</math> <math>\text{cm}^{-2}</math>; <math>s^{-1}</math>.</p>
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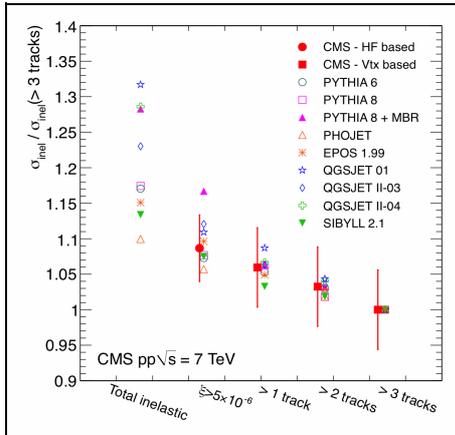
	<p>Fraction of <math>pp</math> events with <math>n</math> pileup vertexes, for <math>n = 0</math> to 8, containing more than one charged particle, as a function of instantaneous bunch-crossing luminosity. The dashed lines are the fits described in the text. The data points are plotted at the mean of the differential distribution in each bin</p>
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(a) Values of the inelastic pp cross section  $\sigma_{\text{inel}}$  and (b) their associated goodness of fit  $\chi^2/\text{NDOF}$ , obtained for each of the fits in Fig.~\ref{fig:final}, as a function of the number of pileup vertices, in interactions with  $>1$  track with  $p_T > 200$  MeV/c and  $|\eta| < 2.4$ . The line in (a) is the result of a fit to the 9 individual values of  $\sigma_{\text{inel}}$  while the dashed line in (b) indicates  $\chi^2/\text{NDOF} = 1$ .



The two types of CMS measurements of the inelastic pp cross section (red filled circle and squares) compared to predictions from several Monte Carlo models for different criteria, as labelled below the abscissa axis. The MC predictions have an uncertainty of  $\pm 1$  mb (not shown). Other LHC experimental results are also included for comparison.



Comparison of the measured inelastic pp cross sections with predictions of several Monte Carlo models, for different criteria, normalized to the value obtained for  $> 3$  tracks.

Generator	$\epsilon_{\xi}$ (%)	$b_{\xi}$ (%)
PYTHIA6	$97.5 \pm 0.6$	2.0
PYTHIA8	$99.3 \pm 0.2$	2.0
PHOJET	$99.1 \pm 0.2$	1.2

Values of efficiency ( $\epsilon_{\xi}$ ) and contamination ( $b_{\xi}$ ) for events with  $\xi > 5 \cdot 10^{-6}$  using the selection criterion of  $E_{\text{HF}} > 5$  GeV, obtained for three Monte Carlo models of hadronic production.

Run No.	$\lambda$	$f_{\text{pu}}$
132601	$(0.64 \pm 0.01)$ %	$0.0032 \pm 0.0001$
132599	$(0.78 \pm 0.01)$ %	$0.0039 \pm 0.0001$
133877	$(1.74 \pm 0.02)$ %	$0.0087 \pm 0.0001$
133874	$(3.34 \pm 0.05)$ %	$0.0166 \pm 0.0002$
137027	$(4.59 \pm 0.17)$ %	$0.0228 \pm 0.0009$
135575	$(8.41 \pm 0.04)$ %	$0.0415 \pm 0.0002$
135175	$(9.98 \pm 0.05)$ %	$0.0491 \pm 0.0003$

Mean number of collisions with  $E_{\text{HF}} > 5$  GeV per coincidence trigger ( $\lambda$ ) and fraction of overlapping collisions ( $f_{\text{pu}}$ ) for the runs used in this analysis.

Systematics source	Uncertainty on $\sigma_{\text{inel}}$	Change in $\sigma_{\text{inel}}$
Run-to-run variation	$\pm 0.8$ mb	$\pm 1.3\%$
Selection efficiency	$\pm 0.6$ mb	$\pm 1.0\%$
Contamination from $\xi < 5 \cdot 10^{-6}$	$\pm 0.3$ mb	$\pm 0.5\%$
HF tower exclusion	$\pm 0.3$ mb	$\pm 0.4\%$
HF energy threshold	$\pm 0.1$ mb	$\pm 0.2\%$
Total (in quadrature)	$\pm 1.1$ mb	$\pm 1.8\%$

List of systematic sources and their effects on the value of the inelastic cross section measured using HF calorimeters. The contribution from luminosity uncertainty is kept separated.

Systematics source	Uncertainty on $\sigma_{\text{inel}}$	Change in $\sigma_{\text{inel}}(> 1 \text{ track})$
Vertex reconstruction efficiency	$\pm 1.4$ mb	$\pm 2.4\%$
Longitudinal position of vertex	$\pm 0.1$ mb	$\pm 0.2\%$
Vertex quality	$\pm 0.7$ mb	$\pm 1.3\%$
Minimum distance between vertexes	$\pm 0.1$ mb	$\pm 0.2\%$
Transverse position of vertex	$\pm 0.3$ mb	$\pm 0.6\%$
Different sets of data	$\pm 0.9$ mb	$\pm 1.6\%$
Range of luminosity used in fit	$\pm 0.2$ mb	$\pm 0.4\%$
Reweighting MC track distribution	$\pm 0.2$ mb	$\pm 0.4\%$
Total (in quadrature)	$\pm 2.0$ mb	$\pm 3.3\%$

List of systematic sources and their effects on the value of the inelastic cross section measured using the vertex-counting method. The percentage changes are shown for  $\sigma_{\text{inel}}(> 1 \text{ track})$ . The contribution from luminosity uncertainty is kept separated.

Measurement	Result
$\sigma_{\text{inel}}(> 1 \text{ track})$	$[58.7 \pm 2.0(\text{syst}) \pm 2.4(\text{lum})]$ mb
$\sigma_{\text{inel}}(> 2 \text{ tracks})$	$[57.2 \pm 2.0(\text{syst}) \pm 2.4(\text{lum})]$ mb
$\sigma_{\text{inel}}(> 3 \text{ tracks})$	$[55.4 \pm 2.0(\text{syst}) \pm 2.4(\text{lum})]$ mb

$\sigma_{\text{inel}}$  values for interactions with  $>1$ ,  $>2$  and  $>3$  charged particles, with their uncertainties from systematic sources of the method, and from luminosity.

-- NicoloCartiglia - 01-Aug-2011

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