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Measurement of the underlying event activity at the LHC with $\sqrt{s} = 7\,\text{TeV}$ and comparison with $\sqrt{s} = 0.9\,\text{TeV}$

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Summary. — First measurement of the underlying activity in proton-proton collisions at $\sqrt{s} = 7\,\text{TeV}$ compared with 900 GeV is presented, using data collected by the CMS experiment at the LHC in 2009/2010. The multiple parton interaction rate, the main component of the underlying event activity, and its energy dependence are studied measuring the charged multiplicity and the charged energy density in a region perpendicular to the plane of the hard 2-to-2 scattering. The direction of the hard scattering and the energy scale of the event are found using the leading track-jet. Corrected results are presented, unfolding the detector effects to directly compare with Monte Carlo models predictions.

PACS 12.38.Lg – Other nonperturbative calculations.

In hadron-hadron scatterings, the "*underlying event*" (UE) is defined, in the presence of a hard parton-parton scattering with large transverse momentum transfer, as any hadronic activity that is additional to what can be attributed to the hadronization of partons involved in the hard scatter and to related initial and final state QCD radiation. The UE activity is thus attributed to the hadronization of partonic constituents that have undergone multiple parton interactions (MPI), as well as to beam-beam remnants, concentrated along the beam direction. In the present study [1] we report on the UE activity measurement at $\sqrt{s} = 7\,\text{TeV}$ and 900 GeV, for an integrated luminosity of $20\,\text{nb}^{-1}$ and $10\,\mu\text{b}^{-1}$, respectively, collected by the Compact Muon Solenoid (CMS) [2] experiment at the LHC.

To study the UE, it is convenient to refer to the difference in azimuthal angle, $\Delta\phi$, between the projections onto the plane perpendicular to the beam of the directions of the hard scatter and of any hadron in the event. With this method, the UE activity is made manifest in the "transverse" region with $60° < |\Delta\phi| < 120°$, even though it cannot in principle be uniquely separated from initial and final state radiation. The direction of the hard scatter is identified with that of the leading "track-jet", *i.e.* the object with largest transverse momentum, p_T, formed using the SISCone jet algorithm [3] applied to reconstructed tracks of particles above some minimum p_T value in the event. The leading track-jet p_T is taken as defining the hard scale in the event. The UE activity is

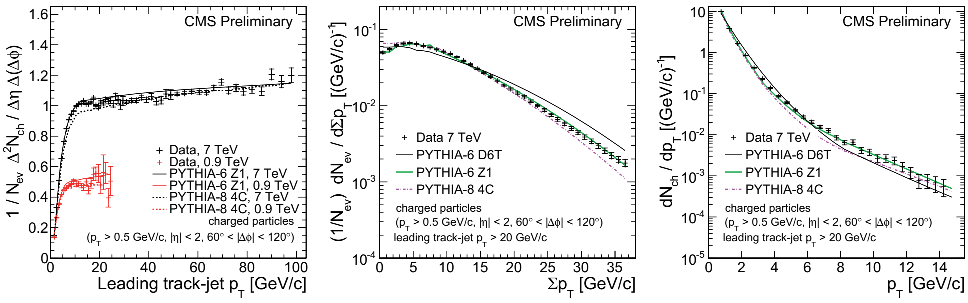

Fig. 1. – Left plot shows average multiplicity as a function of the leading track-jet p_T, at $\sqrt{s} = 0.9$ and $7\,\text{TeV}$. Central and right plots show normalized scalar Σp_T distribution and charged particle p_T distribution, respectively, in the transverse region at $\sqrt{s} = 7\,\text{TeV}$ for events with leading track-jet $p_T > 20\,\text{GeV}/c$. Fully corrected data measurements are compared to various MC tunes. The horizontal error bars indicate the bin size; the vertical inner error bars indicate the statistical uncertainties affecting the measurements; the outer error bars represent the statistical and systematic uncertainties added in quadrature.

studied looking at the charged track multiplicity and scalar-p_T sum, Σp_T, as a function of the event energy scale. Results are fully corrected for detector effects down to the particle level and compared to various Monte Carlo (MC) models and tunes [4, 5].

The hadronic activity in the transverse region is presented in fig. 1, left panel, as a function of the leading track-jet p_T, as well as its centre-of-mass energy dependence. Data points represent the average multiplicity, at $\sqrt{s} = 0.9$ and $7\,\text{TeV}$, for charged particles with $|\eta| < 2$ and $p_T > 0.5\,\text{GeV}/c$. A significant growth of the average multiplicity and of the average scalar Σp_T (here not shown) of charged particles in the transverse region is observed with increasing event scale, followed by saturation at large values of the scale. A significant growth of the activity in the transverse region is also observed, for the same value of the leading track-jet p_T, from $\sqrt{s} = 0.9$ to $7\,\text{TeV}$. Central panel of fig. 1 presents the normalized scalar Σp_T distribution for charged particles in the transverse region. Events are selected with a minimal value of the leading track-jet $p_T > 20\,\text{GeV}/c$. Right panel of fig. 1 shows the charged particle p_T spectrum for events selected with the same cuts. A hardening of the multiplicity distribution, of the scalar Σp_T distribution and of the charged particle p_T spectrum is also observed with increasing scale. A good description of most of the distributions at both energies is provided by the PYTHIA6 Z1 tune [1]. The predictions of PYTHIA8 4C tune [6] are also of good quality.

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