I am summarizing the latest jets results from the LHC.

1 Introduction

Jet production at hadron colliders is understood to proceed via the convolution of parton-parton scattering cross sections with the corresponding parton densities. Thus, jet production at the LHC is an extension to higher scales of previous studies carried out, in the most recent past, at HERA and the Tevatron. At LHC energies, jet production at moderate transverse momenta is dominated by gluon-gluon fusion. The main focus of this talk is jet production as well as the production of prompt photons. But I will start with a brief discussion of the importance of multiparton interactions which somehow represent a correction to the simple picture discussed above.

2 The importance of multiparton interactions

The importance of double parton scattering (DPS) has been investigated by both ATLAS and CMS by studying di-jet production in association with a W-boson. The DPS fraction is obtained by simultaneously fitting the relative $p_T$ balance between the jets, $\Delta p_T^{rel}$, and the azimuthal separation between the W and the di-jet system, $\Delta S = \Delta \Phi_{W-2jets}$. CMS obtains $f_{DPS} = 0.055 \pm 0.002 (\text{stat.}) \pm 0.014 (\text{sys})$. Results of a simulation indicate that this value drops very sharply when the $p_T$ of the second interaction is increased above 15-20 GeV.

3 Jet production

3.1 Inclusive and di-jet production

Both ATLAS and CMS have measured double differential cross sections for $p + p \rightarrow jet + X$, as a function of rapidity, $y$, and transverse momentum, as well as for $p + p \rightarrow jet + jet + X$ as a function of rapidity and $p_T$ or the di-jet mass, $M_{jj}$. The data have been corrected for detector effects. The systematic uncertainties in the data are dominated by those in the jet energy scale.
itself which amounts typically to $2 - 2.5\%$. The unfolding uncertainties are at most 1\%. The data compare reasonably well over many orders of magnitude with pQCD predictions obtained within NLOJET++, including non-perturbative and electroweak corrections. The factorization and renormalization scales are set to $p_{T\text{lead}}$ ($< p_{T1.2}$) for inclusive (di-jet) production. Several PDF's are used, CT10, MSTW2008, NNPDF2.1, HERAPDF1.5, ABKM09. These data begin to have an impact on global PDF fits. They can be also used to extract the strong coupling constant. The deviations between data and theory are at the level of the experimental and theoretical uncertainties unless you go to the edges of phase space, Figs. 1 and 2.

3.2 Three and four jet cross-sections

The classical way to determine $\alpha_s$, since the early days at PETRA-PEP-LEP, is to measure $\frac{\sigma(e^+e^-\rightarrow q\bar{q})}{\sigma(e^+e^-\rightarrow q\bar{q})}$ $\propto \alpha_s$. Now the idea is to measure $R_{32}$ as the ratio between the three-jet cross section ($\propto \alpha_s^2$) over the two-jet cross section ($\propto \alpha_s^2$). The CMS data$^3$ is fitted to the NLOJET++ predictions yielding $\alpha_s(M_Z) = 0.1148\pm0.0014(\text{exp.})\pm0.0018(\text{PDF})\pm0.0050(\text{theory})$ with $\mu_R = \mu_F = < p_{T1.2} >$ and $< (p_{T1.2}) >$ between 0.42 and 1.39 TeV. Thus, the running of $\alpha_s$ can be extended to scales beyond 1 TeV, see Fig. 3 for a summary including a determination from inclusive jet production.

A first measurement of the four jet cross sections has been performed by the CMS Collaboration$^4$. The data are compared to current MC expectations, including those where the $2 \rightarrow 4$ process is calculated at Born level. The lesson to be learned from these studies is that, while the transverse spectra of the leading jet is properly described by the MC models, the description of the softer pair of jets is poorer, see Fig. 3 (right).
3.3 Colour coherence

Colour coherence effects were discovered at PETRA, the so called JADE effect. At hadron colliders, these studies have seen a renewed interest by selecting $N_{\text{jet}} \geq 3$ with the two leading jets back-to-back from which the distributions in $\tan\beta = \frac{\Delta \phi_{23}}{\Delta \eta_{23}}$ are obtained. They are compared with current MC calculations and the conclusion is that further work has to be done in order to bring the expectations closer to the data, in particular in the forward region, Fig. 4 (left).

3.4 Jet shapes in $t\bar{t}$ final states

The $t\bar{t}$ final states are a copious source of b-jets in the dilepton channel, as well as light-jets in the single lepton mode via $W^+ \rightarrow ud, c\bar{s}$ decays. Integrated jet shapes in a cone of radius $r \leq R = 0.4$ have been recently measured by the ATLAS Collaboration. Light jets are narrower than b-jets and this has the potential to improve tagging algorithms, Fig. 4 (right).

4 Prompt photon production

Prompt photon production is dominated by $qg \rightarrow q\gamma$. Thus, it is sensitive to the gluon content of the proton. Measurements extend to $100 < E_T^{\gamma} < 1$ TeV and $|\eta|^\gamma < 2.4$ and conform to expectations. In particular the shape of the $\cos\theta^{\gamma}$ in the $\gamma + jet$ rest frame, Fig. 5. Di-photon production has recently been investigated by the ATLAS Collaboration. The data are compared with MC expectations PYTHIA and SHERPA. Both fall short by at least 20%. The
Figure 5 – Prompt photon production (left and center) and the distribution in $\cos\theta^*$ (right).

Figure 6 – Di-photon production compared to MC expectations (left) and pQCD predictions (right).

References