QCD AS A BACKGROUND FOR SEARCHES AND WW SYSTEMATICS

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Minutes of the first meeting of the group

The first meeting of the QCD sub-group of the LEP-2 generator WG took place on Wednesday 12-MAY-1999. Attendance: Guenther Dissertori (A), Salvador Marti and Philip Bambade (D) and Michelangelo Mangano (TH).

Nigel Watson (O), Paul de Jong (L3), and Bryan Webber (TH) could not attend but did send a few comments, which are append below as well. The meeting was devoted essentially to provide a first contact and to begin writing down a detailed list of questions which we would like this section of the WG to address.

Guenther Dissertori (A) started by listing the 3 main topics which worries Aleph.

1. Gluon splitting into heavy quarks, affecting higgs searches because of the heavy reliance on b-tagging. For $g \to \ bb$, resp. cc, the average LEP-1 measurement gives values of about 2 resp. 1.5 times larger than JETSET PS. Can anything be done better than simply reweighting events at the final stage of the analysis ? How do these scaling factors scale form LEP-1 to LEP-2 ?

2. 4-jet production, affecting mainly searches because of the need to suppress QCD background using topological variables. It is known that PS MCs don't reproduce angular distributions well. On the other hand ME MCs don't have correct energy scaling and require retuning at each energy. What is really needed is a combined ME+PS MC ! Guenther showed some data/PS comparisons of LEP-1 4 jets (Z.Phys. C 76(1997)1) showing strong disagreement for some angular variables. How sensitive are higgs searches from this to biases in their rejection of QCD ? This is still being looked at.

3. Particle production in Herwig, affecting mainly the W mass measurement. A shift of about 30 MeV has been noticed on the W mass determination between Herwig and Jetset. Is this to be taken as the hadronisation systematics ? Probably not. The goal to improve this is to tune the models at the Z0 for uds only and to use the parameters for W's, and then also for color reconnection studies. However we also know that Herwig has problems in the baryon sector (Aleph 98-050,COF 98-024). Also recently the pi0 and sum of the charged energy were found off. What is really needed is an improved description of particle production in the cluster fragmentation scheme, to enable establishing or potentially bringing down this systematic error.

Philip Bambade (D) presented the list of problems which Delphi is mostly concerned, in relation with searches.

1. Gluon splitting into heavy quarks. Here, since Guenther already mentioned this, I only added a plot from our Higgs analysis, in which we have evaluated the final impact of rescaling the gluon splitting in the last stage of the analysis on the total background level (sum of WW,QCD and ZZ processes) as a function of the efficiency to a Higgs signal, in one of our typical analyses. Rescaling by a factor 2 (based on the value measured at LEP-1) produces at the worst place a 5% increase in the total background. This "worst" place in the efficiency purity plot is naturally where QCD processes correspond to the largest fraction of the total background, since the gluon $\rightarrow$ bb splitting rate is largest in QCD at HE. For this "typical" analysis, this point is near the 40% efficiency for a higgs signal. If instead of rescaling by a factor of 2, one rescales by twice that, the increase in total background is 10% instead of 5%. These numbers illustrate roughly how well we need to know the rate and the rescaling needed wrt JETSET PS.

2. Modeling of the suppression of gluon radiation in QCD events with primary b quarks relative to primary uds quarks because of the b mass,

particularly at small ycut. For this purpose of this study, which was triggered because we have an excess of btagged 4 jet events in our 189 GeV data, we first consider the predictions from the LO massive matrix element expressions (ME) for 4 partons, using both a 5 GeV b quark pole mass (characteristic of hadronisation), and a 3 GeV running mass (relevant for hard processes at the scale of the Z boson mass), as a function of ycut (defined with the Durham measure). We propose to define the theoretical uncertainty as the band bounded by the curves corresponding to the running and pole masses in the diagram showing the predictions as a function of ycut. This definition provides a possible first rough estimate in the case of 4 jet events. It has in fact also been tested and found to be reasonable in the case of 3 jet events, thanks to the NLO massive ME expressions which are available in this case. We then compare the results obtained with the LO ME calculations to the predictions of the parton shower (PS) algorithm implemented in JETSET, and find that consistently lower rates are produced with this program. For relevant values of ycut, we find that at the Z0 (respectively at 189 GeV), this systematic effect is about - 13 $\pm$ 5 % (respectively - 5 $\pm$ 3 %) in the setup where the 3 jet rate is matched to the massive 3 parton ME expression (now the default setting of JETSET), but - surprisingly - slightly less if the massless expression is used instead of the massive one. These effects are smaller than would be needed to explain the level of our discrepancy at HE, but large enough to justify correction. As a first step the theoretical community and MC authors are asked to comment on the procedure adopted to estimate these effects. Is there a better way ? Do we need NLO massive ME for 4 partons to be sure ? In this case are there different approaches to the calculation and do they give similar results ? A WEB page describing this study in the form of a working document and is presently being circulated to interested people. It was also commented by Michelangelo that at very small ycut effects get worse and that even if the higgs analysis would have somewhat reduced efficiency it might be safer to work with larger minimum ycut definition to have less uncertainty in the background. Another way out is of course to operate the analyses in a regime with higher purity, also in this case possibly compromising slightly the performance.

3. The topic of the correctness of angular distributions potentially biasing the QCD rejection in searches and in WW X-section measurements (already mentioned by Guenther) also interests DELPHI.

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Below ar the relevant pieces in the messages from Bryan, Nigel, Paul, who could not attend:

Bryan Webber (TH):

Although I have agreed to be the theory coordinator for the QCD subgroup, it will be very difficult for me to attend meetings before I come to CERN on 1 July.

Meanwhile I will be happy to try to coordinate theory efforts remotely. In this connection I should mention:

1) HERWIG version 6.1, which will be ready "very soon", contains a 4-jet matrix element option which should be helpful for some of the points you mention.

2) My student Mark Smith (smith@hep.phy.cam.ac.uk) is working on colour connection and Bose-Einstein effects and would welcome suggestions on the most worthwhile things to be done on these topics.

Nigel Watson (Opal):

For WW physics, one area it would be useful to clarify on is the Ellis-Geiger model. The reconnection model is very interesting and I have worked with the program VNI4.12 (last version of model) for some time, but there are many outstanding technical problems, in particular far from perfect energy-momentum conservation. We changed a few parameter values in order to use the model (could be discussed in more detail if useful) but this did not cause the technical problems we found. Would it be possible to ask in the meeting what plans anyone has for this model in the future?

Paul de Jong (L3):

I have been talking to some people in L3 involved in searches, and none of them was particularly concerned about uncertainties in modeling of the QCD background as a serious limitation to searches. I anything, then it would be nice for the 4 jet rate to have the $\mathcal{O}(\alpha_s^3)$ matrix element interfaced to parton showers or string fragmentation, but this we know since a long time. Also it would be good if MC parton showers included b mass effects at NLO. For WW I am of course more worried about soft QCD, namely colour reconnection. It would be good to find out if that topic can or will play a role in this workshop; so far that topic does not rest on solid theory, but on models, favoured or disfavoured along the tastes of the theorists, and occasionally (in extreme cases) disfavoured by data.

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Document prepared by Philip Bambade