Possible reduction of the total uncertainty on the $m_W$ measurement at LEP2

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An alternative $W$ mass estimator in $e^+e^−\rightarrow W^+W^−\rightarrow q\bar{q}'q\bar{q}'$ events at LEP2 is designed to optimize the balance between the statistical uncertainty and the systematic uncertainty due to a possible Colour Reconnection effect. The preliminary result for the total uncertainty on the $W$ mass in this channel is roughly 30% lower than those obtained with the standard estimators, based on the SK-I implementation of Colour Reconnection. Also an indirect measurement of the SK-I Colour Reconnection model parameter $κ$ is inferred from the difference between both $W$ mass estimators.

1 Status

A measurement of the mass of the $W$ boson has been performed by all LEP Collaborations, this by the method of direct reconstruction of the process $e^+e^−\rightarrow W^+W^−\rightarrow q\bar{q}'q\bar{q}'$, the so-called four jet channel. The uncertainty on the LEP combined $m_W(4q)$ value however is dominated by systematical rather than statistical uncertainties. The major component comes from the assumption in the reconstruction of the event that particles from the decay of different $W$ bosons are independent in the non-pertubative fragmentation phase of the process. Physics phenomena like Colour Reconnection (CR), gluon exchange between fragmentation products, could break this assumption. Neither its theoretical knowledge nor its existence is well established in these processes.

2 Proposal

From the SK-I phenomenological model which is implemented in the JETSET fragmentation scheme, we observe that mostly low momentum particles and particles in inter-jet regions are affected by CR and hence influencing the measurant, $m_W$. Therefore we could design an alternative analysis which is neglecting those particles in the reconstruction of the momenta of the four primary partons, hence decreasing the systematical uncertainty on $m_W$ due to CR but meanwhile increasing the statistical uncertainty because we neglect part of the information content of the event.

Within the standard DELPHI $m_W$ estimator an iterative procedure was used within each pre-defined jet to find a stable direction of a cone excluding some particles in the calculation of the jet momentum. Starting with the direction of the original jet, the jet direction was recalculated only from those particles which have a opening angle smaller than $R_{cone}$ with this original jet. This process was iterated by constructing a second cone (of the same opening angle)

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around this new jet direction and the jet direction was recalculated again. The iteration was continued until a stable jet direction was found. The obtained jet momenta were rescaled to conserve the invariant mass of the jets.

The results from Monte Carlo studies using the SK-I Colour Reconnection model with fixed parameter $\kappa = 0.66$ predict a decrease of the total LEP2 uncertainty on $m_W (4q)$ when using the appropriate alternative analysis ($R_{cone} \simeq 0.5\text{rad}$) of around 30%, see Figure 1. Those results are compared with a $m_W$ estimator where simply all particles with momentum below $p_{cut}$ are rejected when calculating the jet kinematics.

An indirect measurement of SK-I model parameter $\kappa$ is possible from the direct measurement of the difference in reconstructed $m_W$ between the CR-sensitive standard and CR-not-sensitive alternative analysis. From Monte Carlo studies we observe that the statistical significance of this measurement is comparable with the one obtained from the direct measurement. Systematics can however become important.

### 3 Summary

Alternative exclusive $m_W$ estimators can be designed which have a 30% smaller total uncertainty than the standard ones used by the LEP Collaborations. Also information can be inferred about parametrized Colour Reconnection models by studying the difference between the standard and the proposed alternative $m_W$ estimators.

### References

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