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Challenges and Solutions in Reconstructing Higgs Decays to Heavy Flavour Jets

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The reconstruction of heavy flavour jets will play an important role at future e+e- Higgs factories: $H \to b\bar{b}$ is the most frequent decay mode of the SM Higgs, and $H \to c\bar{c}$ is particularly challenging to measure at the LHC. Also exotic scalars could decay into these modes, and b- and/or c-jets occur frequently in top quark as well as Z and W boson decays. While the reconstruction of light-flavoured jets has been a classic performance benchmark for Higgs factory detectors, the special challenges in precise reconstruction of heavy flavour jets have only been studied since a few years. In particular, semi-leptonic b- and c-decays suffer from the undetected four-momentum of the neutrino. For instance in $H \to b\bar{b}$, about 2/3 of the events contain at least one semi-leptonic b- or c-decay, which leads to a significantly degraded jet energy and di-jet invariant mass reconstruction.
In this contribution we will explore in how far the capabilities of the proposed Higgs factory detectors can be exploited to improve the reconstruction of $H \to b\bar{b}$.
The presented algorithms comprise the identification of charged leptons in jets as means to identify semi-leptonic decays, a newly developed algorithm to infer the missing neutrino momentum (up to a sign ambiguity) from the visible part of the decay, the vertex position and the mass of the B-hadron, and a first-principle estimate of the 4-momentum covariance matrices of jets based on their individual composition as a key ingredient for a kinematic fit for solving the last ambiguity in the neutrino momentum. Using as example the ILD detector concept, we will present a striking performance improvement in $H \to b\bar{b}$ reconstruction in ZH and ZZ events based on the combined power of these algorithms, which are now all available in Key4HEP. We will also discuss the role of the individual detector capabilities, and give an outlook on how these tools could be applied to the reconstruction of other physics processes.

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