Contribution ID: **109** Type: **not specified**

Exploring a Dark Sector Through the Higgs Portal at a Lepton Collider

Monday 5 May 2014 15:15 (15 minutes)

We investigate the prospects for detecting a hidden sector at an e+ e− collider. The hidden sector is assumed to be composed of invisible particles that carry no charges under the Standard Model gauge interactions, and whose primary interactions with ordinary matter are through the Higgs portal. We consider both the cases when the decays of an on-shell Higgs into a pair of hidden sector particles are kinematically allowed, and the case when such decays are kinematically forbidden. We find that at collider energies below a TeV, the most sensitive channel involves production of an on-shell or off-shell Higgs in association with a Z boson, and the subsequent decay of the Higgs into invisible hidden sector states. Focusing on this channel, we find that with order a thousand inverse fb of data at 250 GeV, the decay branching fraction of an on-shell Higgs to invisible hidden sector states can be constrained to lie below half a percent. The corresponding limits on Higgs portal dark matter will be stronger than the bounds from current and upcoming direct detection experiments in much of parameter space. With the same amount of data at 500 GeV, assuming order one couplings, decays of an off-shell Higgs to hidden sector states with a total mass up to about 200 GeV can also be probed. Both the on-shell and off-shell cases represent a significant improvement in sensitivity when compared to the Large Hadron Collider (LHC).

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Session Classification: Dark Matter I