Searches for new exotic scalars at the ILC

Analysis of the scalar particle S decay channel into two τ leptons
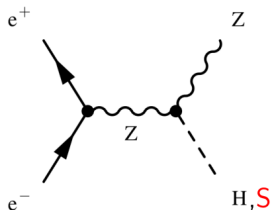
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Introduction

Exotic scalar production in scalar-strahlung process is considered.

$Z \to q\overline{q}$ and $S \to \tau^+\tau^-$ is assumed.

Look for hadronic (4 jets), semi-leptonic (3 jets and lepton) and leptonic (2 jets and 2 leptons) final states.

ILC H-20 running scenario at 250 GeV.

Events pre-selection

Only events without isolated photons and with appropriate number of jets were accepted.
Events divided into 5 categories.

category	isolated leptons	tight	loose
hadronic	zero	4 jets including 2 with τ-tag	4 jets, 1 with τ-tag and other lightest jet as second τ- tag jet
semi-leptonic	one	3 jets including 1 with τ-tag	3 jets with no τ-tag, lightest jet as τ- tag jet
leptonic	two	two jets without τ-tag	

S mass reconstruction

Assumption of high τ boost and their collinearity to jets for reconstructing S mass. From transverse momentum balance:
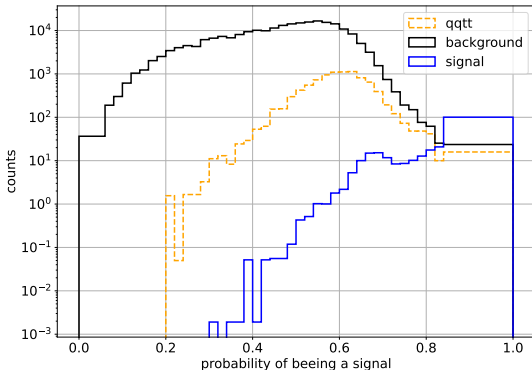
$$\overline{\not{p}_T} = E_{\nu_1} \cdot \overline{n}_1 + E_{\nu_2} \cdot \overline{n}_2$$
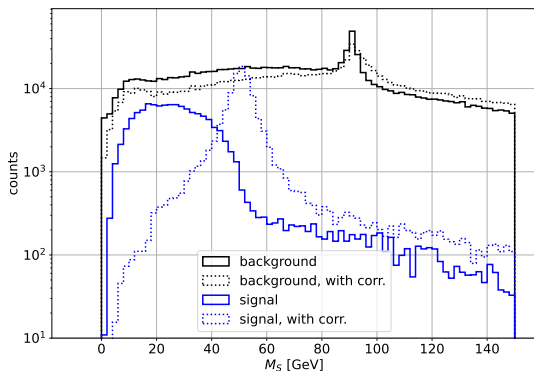
Example for $e_L^- e_R^+$ polarisation and tight event selection.
Signal for scalar mass of 50 GeV.

BDT

Separate BDT for each polarisation and event category
(hadronic, semi-leptonic or leptonic)

Example for $e_L^- e_R^+$ polarisation and tight hadronic event selection.
Signal for scalar mass of 50 GeV normalized to 1% of SM cross section.

95% C.L. limits on the production cross section

in units of the SM cross section for Higgs-strahlung process (with given scalar mass)
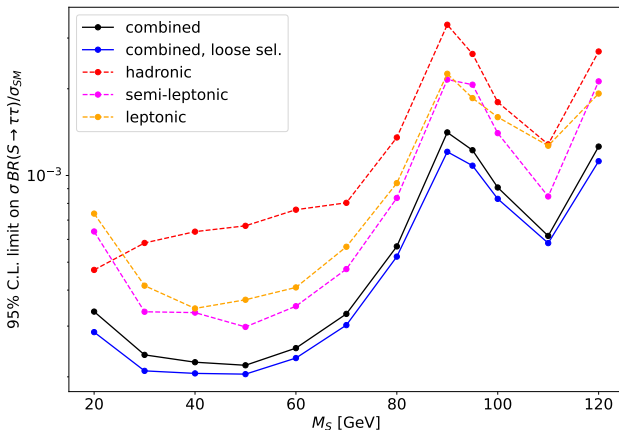
ILC H-20 running scenario at 250 GeV

Backup - other variables

Other variables used in Gradient Boosted Decision Trees (BDT):

- Z invariant mass
- Z transverse momentum
- recoil mass
- total energy
- y_{23} and y_{34} angle variables from clustering algorithm
- azimuthal distance of two τ candidates
- polar angle of Z
- τ emission angle in S rest frame with respect to S momentum direction