Full simulation study on H→ μ μ with the ILD detector
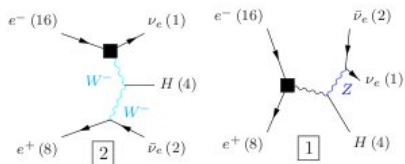
C. Calancha (IPNS, KEK)
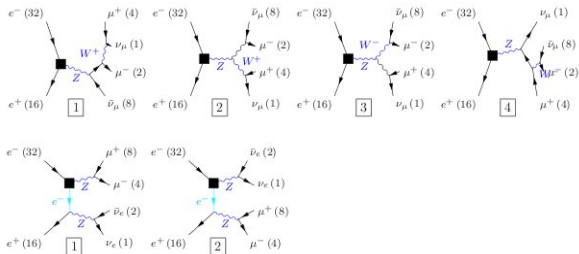LCWS12, Arlington (USA)

Oct 25, 2012

$H \rightarrow \mu^+ \mu^-$

Benchmark analysis for the DBD: test of the expected linear relation between fermion mass and its coupling to the Higgs boson.

- E=1 TeV, L=1 ab^{-1}
- Small branching ratio: Expected $\approx$ 91 events with beam polarization (e^{-1},e^{+1})=(−0.8,+0.2)
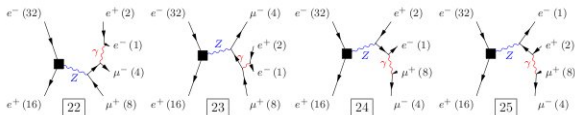- clean signature.
- ILCSOFTv16

Background

- Irreducible background: same final state: $ZZ(WW) \rightarrow \nu\nu\mu\mu, Z \rightarrow \nu\nu\mu\mu$

Other sources considered:

- $\mu\mu e^+ e^-$ (leptons being forward)

- $Z \rightarrow \mu\mu$
- Effect from $\gamma\gamma \rightarrow \mu\mu$ is negligible after applying final selection.

# Samples/Software

*Ecm* = 1 TeV beam polarization (e-,e+): (-0.8,+0.2)
Signal

- $H \rightarrow \mu^+ \mu^-$

Background

- processes with 2 or 4 fermions in the final state.
  - Only the irreducible backgrounds give relevant contribution.

- All samples fully simulated with ILD_o1_v05 and reconstructed with ILC software relase v01-16
- No overlay $\gamma\gamma \rightarrow$ *hadron*.

$\gamma\gamma \to \mu\mu$ **Contribution**

- Photons from the beam produce low Pt muons
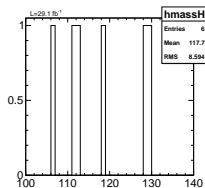- After a cut on Pt of the Higgs (Pt>20) there is no contribution.
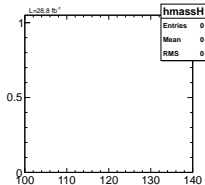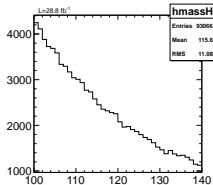
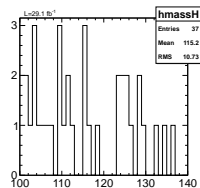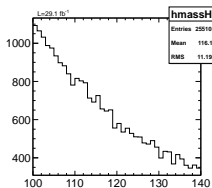- Weizsaecker-Williams photons also negligible after selection cuts
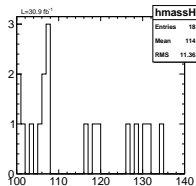- virtual photon (e side) beam γ (p side):
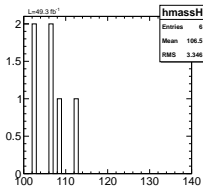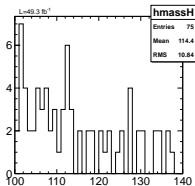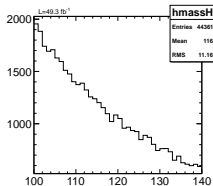
$\gamma\gamma \rightarrow \mu\mu$ **Contribution**

- beam γ (e side) virtual photon (p side):

- Two virtual photons:
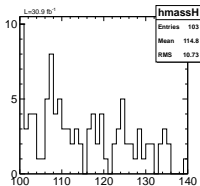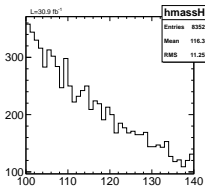
$\gamma\gamma \to \mu\mu$ **Contribution**

- $\gamma\gamma \to \mu\mu$ contribution is negligible with loose cuts:
    - # tracks < 5
    - missing $E_T > 20$ GeV
    - $|cos\theta(\mu_i)| < 0.95$
    - $|cos\theta(H)| < 0.98$
    - $E(H) < 400$ GeV
    - energy all tracks - $E(\mu_1)$ - $E(\mu_2) < 200$ GeV/c

Preselection

Muon selection use deposited energy on the calorimeters:

- Charged track.
- ecal/totcal < 0.5
- totcal/ $|p| < 0.3$
- 95 % signal muons pass this requirement.

$H \rightarrow \mu^+ \mu^-$ preselection
- Two muons with $E > 15 GeV$, |M(μ,μ)-125<30| GeV/c^2
- and E(H)<400 GeV/c

77 signal events pass this selection (85 % from the expected 91)

Optimization
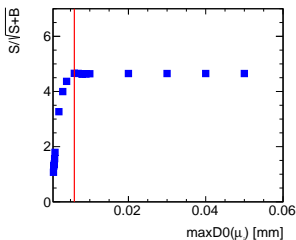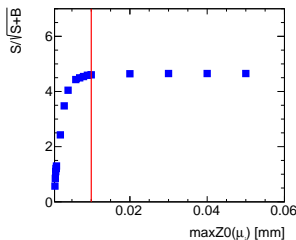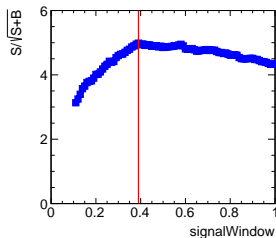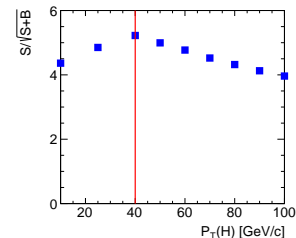
- Final cuts optimized in order to get maximum $S/\sqrt{S+B}$

Signal region defined as: $|M(\mu,\mu) - 125| < 3 * \sigma * F = 0.468$,
F after optimization $\rightarrow 0.39$

Cut Table

| Process	Pres.	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7	cut 8	cut 9
signal	54	50	44	43	41	39	38	38	36	32
z_vv	49	23	23	23	23	0	0	0	0	0
zzorww	30	24	12	11	11	8	8	8	7	4
sznu	13	12	9	9	6	6	6	6	6	6
sze	322	91	0	0	0	0	0	0	0	0
$\sqrt{S+B}/S$ (%)	39	27	21	21	21	18	18	18	19	20

1. # tracks < 5
2. missing $E_T > 40$ GeV
3. missing Energy > 600 GeV
4. energy all tracks - $E(\mu_1)$ - $E(\mu_2) < 10$ GeV/c
5. $d_0(\mu_i) < 0.006$ mm
6. $|z_0(\mu_i)| < 0.01$ mm
7. $p_T(H) > 40$ GeV/c
8. $|cos\theta(\mu_i)| < 0.95$
9. $|cos\theta(H)| < 0.90$

Last cuts prevent from $\gamma\gamma \to \mu\mu$ contribution.

Results
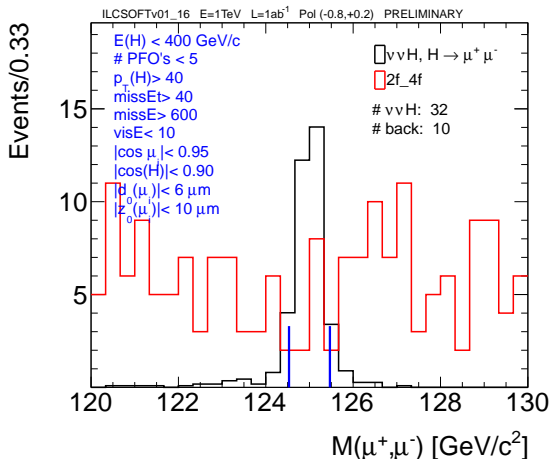
- Statistical precision ($\sqrt{S+B}/S$) of $\sigma \times BR \approx 20\,\%$
  - CLIC *CDR*: 15 % (at 2 ab^{-1}, beam pol. (0,0))
- Signal selection efficiency 35 %

Summary

- $H \to \mu^+ \mu^-$: Benchmark analysis for the DBD
- $E_{cm} = 1$ TeV, L=1 ab^{-1} beam pol. (-0.8,0.2)
- $\sigma \times BR$ Statistical error ≈ 20 %

moving forward

- Include $\gamma\gamma$ overlay.
- Explore selection with MVA tools.

BackUp