$\mathrm{H} \to \gamma\gamma$ @250 Gev & @500 GeV at ILC

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Snowmass Energy Frontier Workshop

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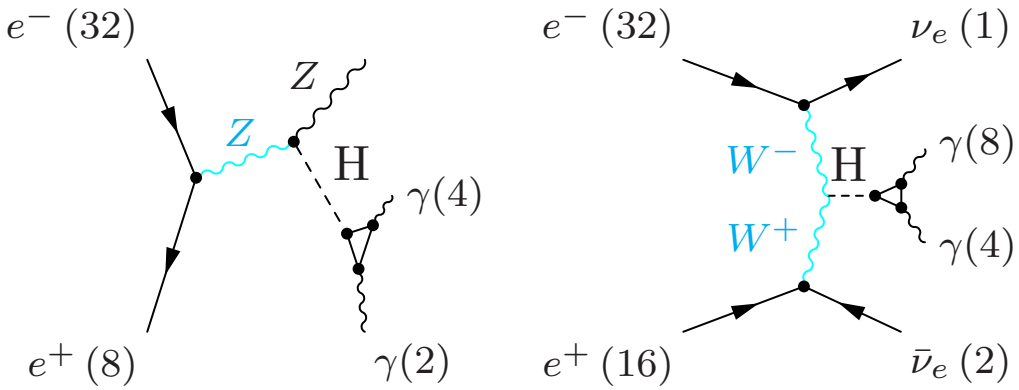
$H \to \gamma\gamma$



external Z in the left hand plot decaying to: $Z \to l^+l^-$, $Z \to \nu\bar{\nu}$, $Z \to q\bar{q}$

Expected # events ($Br = 0.00228$)

- MH=125, $\sqrt{s} = 250$: 160 (16 + 39 + 105) ((L=250 fb^{-1}))
- MH=125, $\sqrt{s} = 500$: 292 (18 + 196 + 78) (L=500 fb^{-1}))

(1) BR taken from LHC Higgs Cross Section Working Group.
(https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CERNYellowReportPageBR2)

- Analysis in progress: Still qqh not analyzed and several background to be included.

$H \to \gamma\gamma$ Main Backgrounds

- $\nu\bar{\nu}\gamma\gamma$
- $q\bar{q}\gamma\gamma$
- Other SM backgrounds included: 2f, 4f partially at 500 GeV, fully at 250 GeV, and aa_2f, 1f_3f (250 GeV).

Generation/Simulation/Reconstruction

- Generated with Whizardv1.95 (two times: first time with very old beam parameters (fixed)
- required E γ's > 20
- Applied precuts over the stdhep to reduce number of simulation jobs.
- Reconstruction as DBD
  - 250 GeV no overlay $\gamma\gamma \to \text{hadrons}$ for signal and main back.
  - (500 GeV overlay as DBD (1.7 Poisson mean) in all samples.

$H \to \gamma\gamma$ Main Backgrounds

Wrong Beam Parameters (lumi linker), reported last week

- My generated samples used very old lumi linkers (LOI way)
- I generated/simulatd/reco again with new parameters (linker 22 at 250gev, linker 21 at 500 gev)
  - Lot of additional work

Status

- New samples with right beam parameters available recently
- I've been focus on the more significant decay: nnH at 500 GeV
  - nnh 250 GeV available since last few days.
  - qqh (250 & 500 GeV pending).

Selection 250 GeV

Preselection

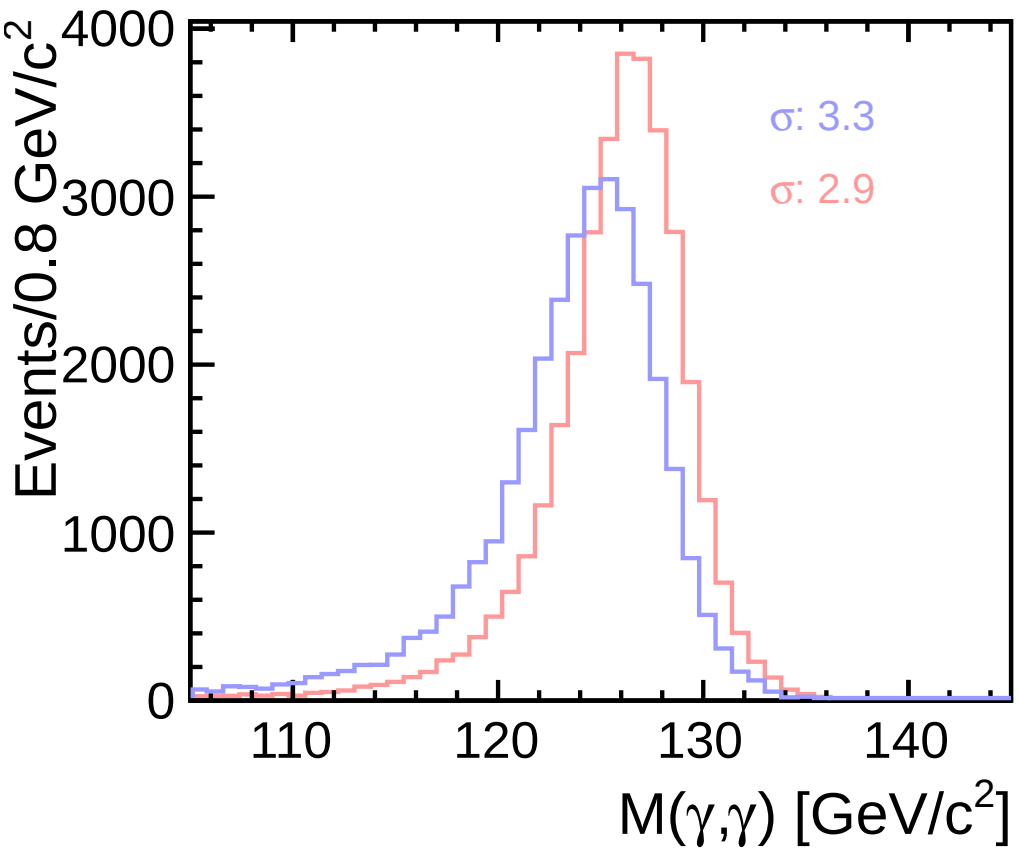
- 2 photons (using HCAL, ECAL to identify) with E $>$ 25 GeV.
- missing E $>=$ 90 GeV.
- Veto on electrons/muons with E $>=$ 20 GeV.
- $|M(\gamma,\gamma) - 125| < 30\ \mathrm{GeV/c^2}$
  - If $>$ 1 H cand we chose the one with closer M to 125.

Further cuts (Reject other SM backs before TMVA)

1. ptSum $>$ 55 GeV
2. $|cos(\gamma) < 0.85|$
3. E(H) $>$ 125 GeV
4. missing E $>$ 100 GeV
5. ptH $>$ 30 GeV
6. missing E_T $>$ 38 GeV

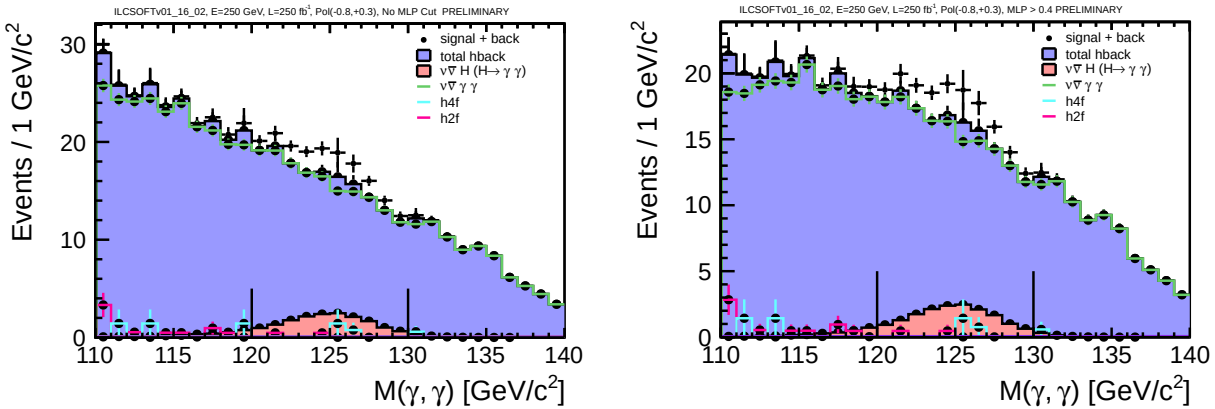
- Final selection with TMVA tools (MLP method).

Mass Resolution



- Recover by photon splitting on PandoraPFO's adding nearby photons sorrounded the photons from H decay.
  - Only P_i is added (energy is set $E = |P|$).
- Around 10% improve on resolution.
- Expected ILD det. resolution will be better than showed here.
  - Previous studies support to a resolution < 2 GeV.

Status NNH 250 GeV (L=250 fb^{-1})



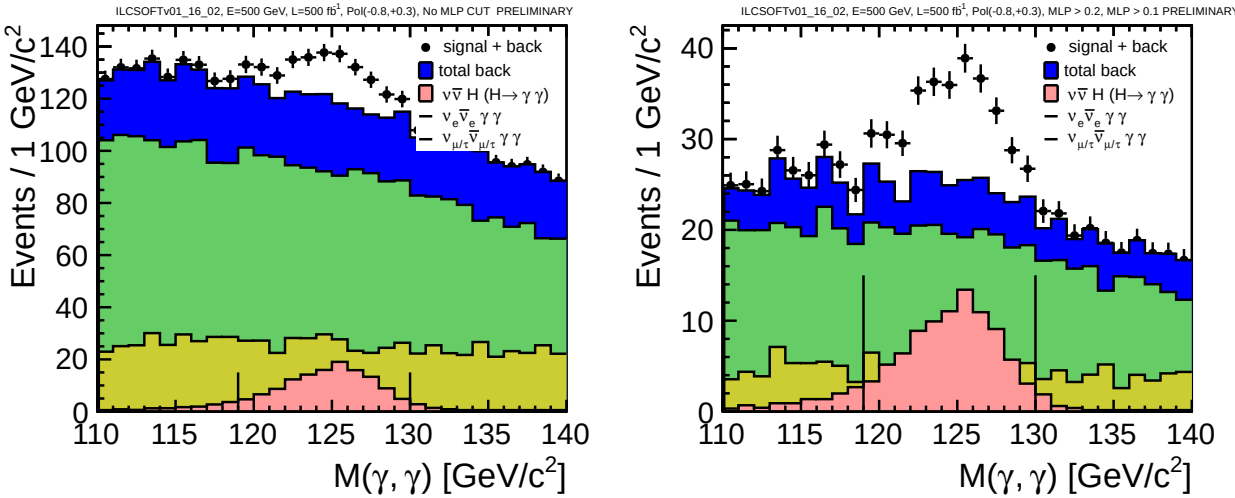
- left (right) before (after) apply cut on MLP.
- Training MLP with vars.: $\cos(\gamma)$, $pt(\gamma_1) + pt(\gamma_2)$, $E(\gamma_1) + E(\gamma_2)$
- SM backgrounds included: all 2f, 4f, aa_2f and 1f_3f.
- S/sqrt(S+B) ≈ 1
- No overlay $\gamma\gamma \longrightarrow$ *hadrons*

Cut Flow

Process	signal	vvaa	2f	4f	aa_2f	1f_3f	Signf
Cross Section	0.177	76.6 (*)	1.16e+05	4.09e+04	6.61e+05	1.22e+06	
Generated	9.54e+04	3.47e+06	8.94e+06	1.09e+07	1.65+07	3.4e+07	
Expected	44.2	1.91e+04	2.91e+07	1.02e+07	1.65e+08	3.05e+08	
Presel	33.1	9.22e+03	2.88e+03	1.78e+03	394	8.48e+03	0.219
Cut2	32.1	4.56e+03	4.58	1.05e+03	0	5.01e+03	0.311
Cut3	25.1	1.52e+03	1.72	782	0	2.04e+03	0.38
Cut4	24.6	1.27e+03	1.55	207	0	1.73e+03	0.433
Cut5	23.1	1.18e+03	0	62.9	0	713	0.52
Cut6	19.4	969	0	42.2	0	12.8	0.601
Cut7	17	835	0	33.6	0	12.4	0.568
$120 <= M(\gamma\gamma <= 130$	13.7	173	0	1.92	0	12.4	0.968

(*) corrected by the efficiency of the applied cuts.

Status NNH 500 GeV (L=500 fb^{-1})



- left (right) before (after) apply cut on MLP.
- Training MLP with vars.: $\cos(\gamma)$, $pt(\gamma_1)+pt(\gamma_2)$, $E(\gamma_1)+E(\gamma_2)$
- S/sqrt(S+B) $124/\sqrt{124+1325}\approx 3.3$ (left) , and $87/\sqrt{87+280}\approx 4.5$ (right) (very preliminary still missing backgrunds, see below)
- SM backgrounds included (No contribution with present selection): 4f_sw_l, 4f_sze_l, 4f_szeorsw_l, 4f_sznu_l , 4f_ww_l, 4f_zz_l, 4f_zzorww_l, 2f_z_l.
  - Compared with same mode at 250 Gev: missing aa_2f. 1f_3f, and hadronic/semilep modes on 2f/4f.

Summary

Work in progress

- $\nu\nu H$ mode at 500 GeV (the most significant).
  - Main back (nnaa) and 2f, 4f (leptonic final states only).
- $\nu\nu H$ mode at 250 GeV
  - Main back (nnaa) and 2f, 4f aa_2f, 1f/3f included.

Plan

- Include all available backgrounds.
- Include overlay on $\gamma\gamma \rightarrow$ *hadrons* at 250 GeV.
- qqh mode at both energies.