Status of $e^+e^- \to Z(\mu^+\mu^-)H(\mu^+\mu^-)$

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June 14th, 2018

Sample and Analysis Framework

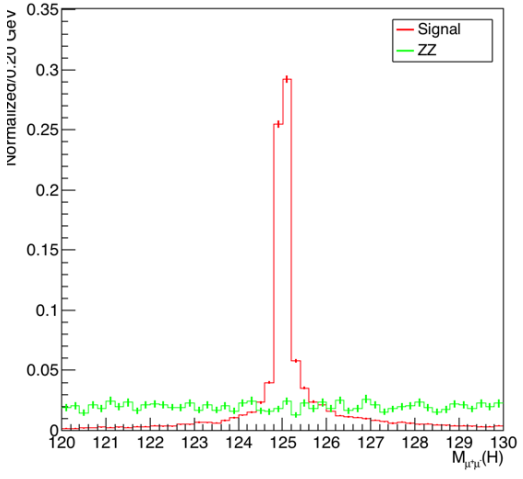
- Signal: $e^+e^- \to Z(\mu^+\mu^-)H(\mu^+\mu^-)$
  - 3T with 240 GeV with total events of 100k
  - /home/bes/lig/higgs/data/SimReco/wo_BS/CEPC_v4/higgs/smart_final_states/E240.PIlh_e2e2.e0.p0.whizard195/

- Dominant Bkg: ZZ to 4mu
  - 3.5T with 250 GeV with total events of 100k
  - /cefs/data/RecData/CEPC250/CEPC_v1/4fermions/E250.Pzz_l.e0.p0.whizard195/04mu/

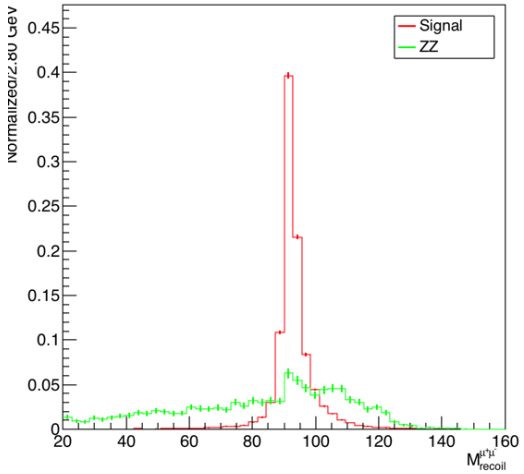
- Framework:
  - Using FSClasserProcessor, require 4 muons in the final status
  - combination to minimize $\delta = (\frac{pair1.M}{\Delta Z})^2 + (\frac{pair2.M}{\Delta H})^2$ $\Delta Z = 2.25, \Delta H = 0.625$

Signal and Bkg comparison (after $120 < \mathrm{M}_{\mu^+\mu^-}(H) < 130\ GeV$)

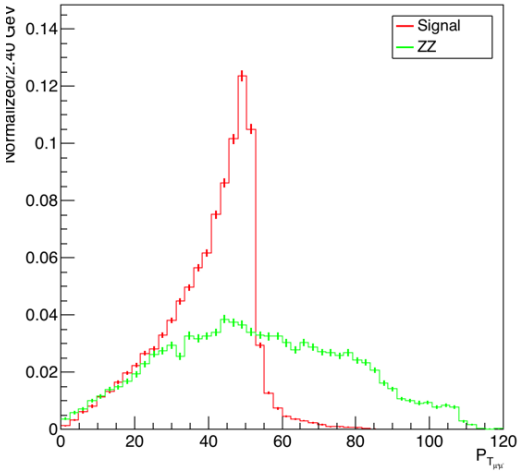
$\mathrm{M}_{\mu^+\mu^-}(H)$



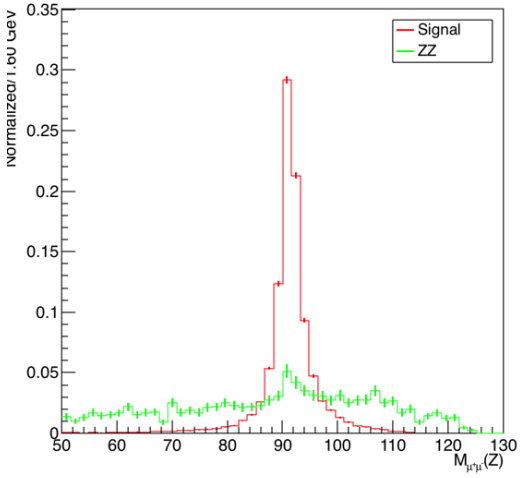
$M^{\mathrm{recoil}}_{\mu^+\mu^-}(H)$



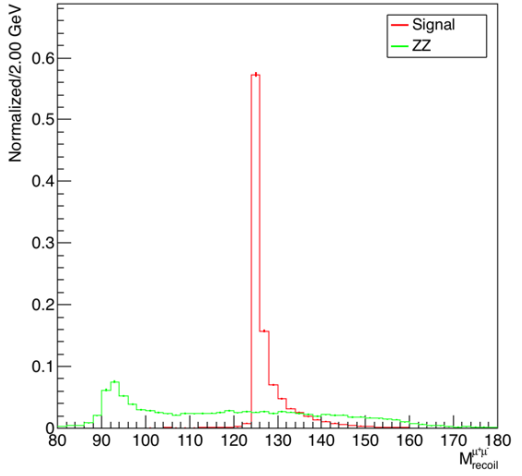
$Pt_{\mu^+\mu^-}(H)$



$\mathrm{M}_{\mu^+\mu^-}(Z)$



$M^{\mathrm{recoil}}_{\mu^+\mu^-}(Z)$



Event selection

$$120 < \mathrm{M}_{\mu^+\mu^-}(H) < 130\ GeV$$

$$80 < M^{\mathrm{recoil}}_{\mu^+\mu^-}(H) < 100\ GeV$$

$$80 < \mathrm{M}_{\mu^+\mu^-}(Z) < 100\ GeV$$

$$120 < M^{\mathrm{recoil}}_{\mu^+\mu^-}(Z) < 130\ GeV$$

$$Pt_{\mu^+\mu^-}(H) < 55\ GeV$$

$$-0.95 < cos\theta_{\mu^+\mu^-}(H) < -0.65$$

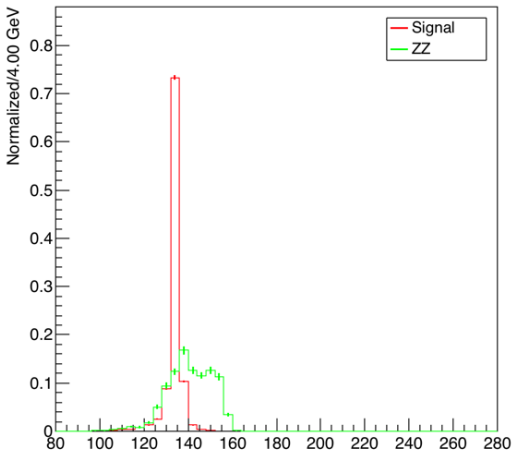
$$-0.95 < cos\theta_{\mu^+\mu^-}(Z) < -0.4$$

$$100 < E_{\mu^+\mu^-}(H) < 150\ GeV$$

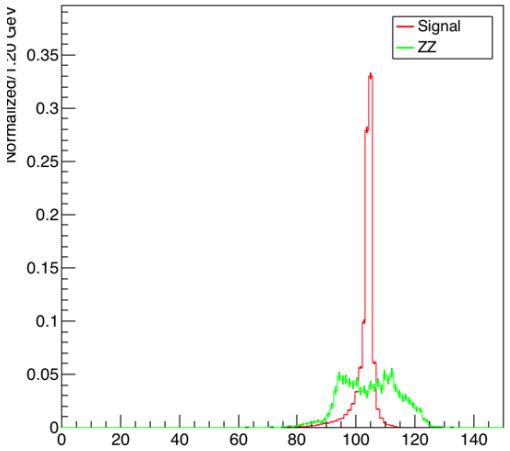
$$95 < E_{\mu^+\mu^-}(Z) < 110\ GeV$$

Signal and Bkg comparison (after $120 < \mathrm{M}_{\mu^+\mu^-}(H) < 130\ GeV$)

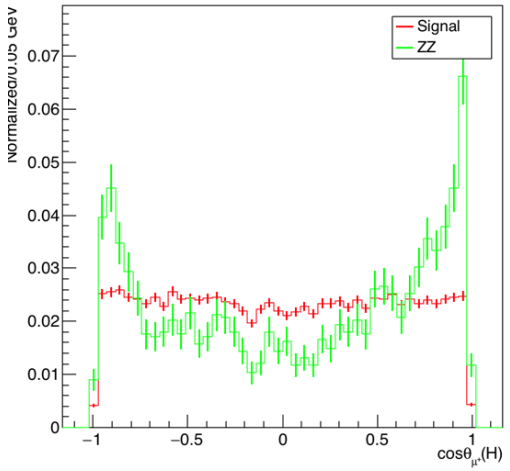
$\mathrm{E}_{\mu^+\mu^-}(H)$



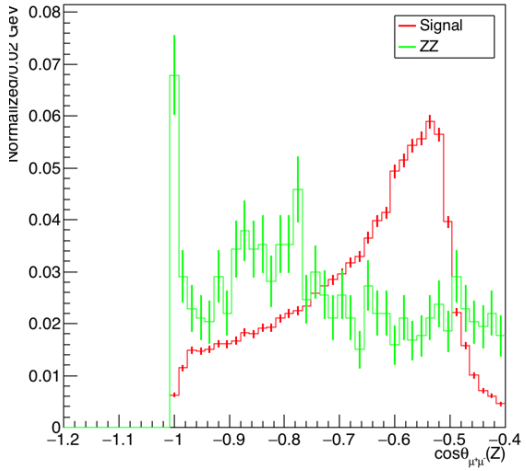
$\mathrm{E}_{\mu^+\mu^-}(Z)$



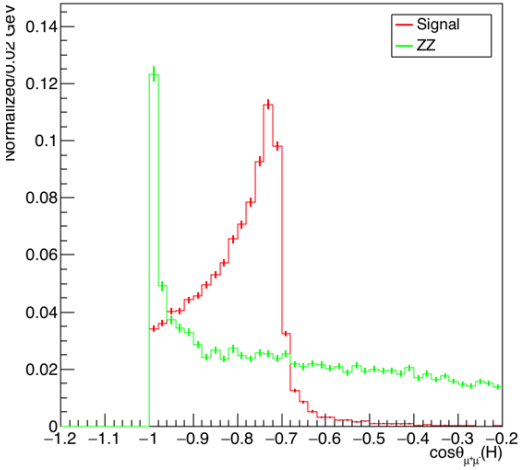
$cos\theta_{\mu^+}(H)$



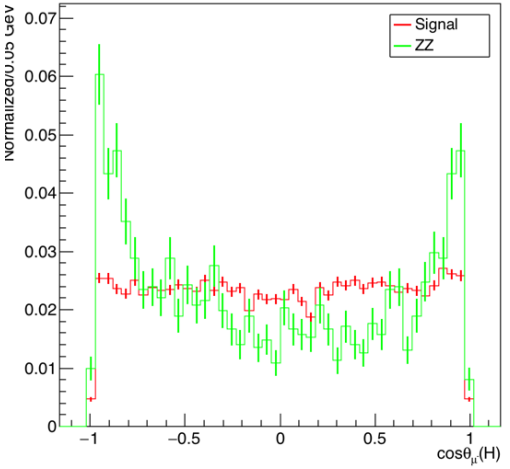
$cos\theta_{\mu^+\mu^-}(Z)$



$cos\theta_{\mu^+\mu^-}(H)$



$cos\theta_{\mu^-}(H)$



Event selection

$$120 < \mathrm{M}_{\mu^+\mu^-}(H) < 130\ GeV$$

$$80 < M^{\mathrm{recoil}}_{\mu^+\mu^-}(H) < 100\ GeV$$

$$80 < \mathrm{M}_{\mu^+\mu^-}(Z) < 100\ GeV$$

$$120 < M^{\mathrm{recoil}}_{\mu^+\mu^-}(Z) < 130\ GeV$$

$$Pt_{\mu^+\mu^-}(H) < 55\ GeV$$

$$-0.95 < cos\theta_{\mu^+\mu^-}(H) < -0.65$$

$$-0.95 < cos\theta_{\mu^+\mu^-}(Z) < -0.4$$

$$100 < E_{\mu^+\mu^-}(H) < 150\ GeV$$

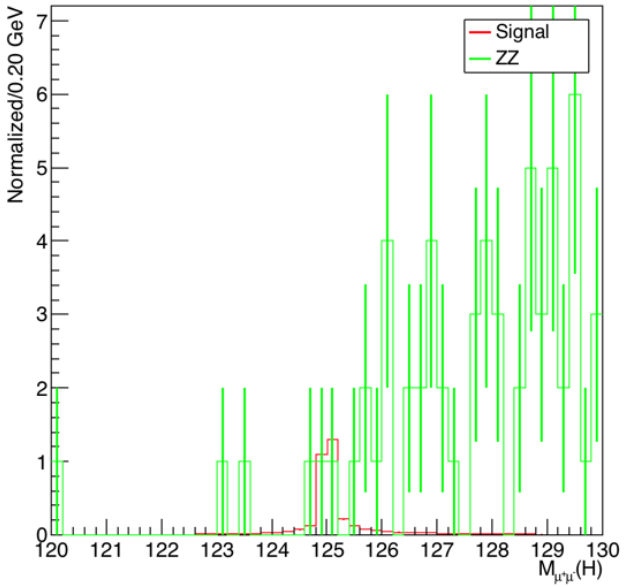
$$95 < E_{\mu^+\mu^-}(Z) < 110\ GeV$$

Cut Flow

Selection	Signal	ZZ
Pre-selection	6.60	23175
$Pt_{\mu^+\mu^-}(H) < 55\ GeV$	5.82	8691
$120 < \mathrm{M}_{\mu^+\mu^-}(H) < 130\ GeV$	5.22	1368
$120 < M^{\mathrm{recoil}}_{\mu^+\mu^-}(H) < 130\ GeV$	4.93	471
$80 < \mathrm{M}_{\mu^+\mu^-}(Z) < 100\ GeV$	4.62	365
$120 < M^{\mathrm{recoil}}_{\mu^+\mu^-}(Z) < 130\ GeV$	4.17	276
$-0.95 < cos\theta_{\mu^+\mu^-}(H) < -0.65$	3.81	175
$-0.95 < cos\theta_{\mu^+\mu^-}(Z) < -0.4$	3.64	147
$100 < E_{\mu^+\mu^-}(H) < 150\ GeV$ $95 < E_{\mu^+\mu^-}(Z) < 110\ GeV$	3.64	62
Efficiency	55.09%	

Compare with 3.5T results

Category	signal	ZZ	WW(SW)	ZZorWW	SingleZ	2f
Preselection	6.6	17631.0	0	0	0	0.0
$120<E_{\mu^+\mu^-}<130$	6.0	1685.2	0	0	0	0.0
$90.6< M_{recoil_\mu} <93.4$	3.9	128.8	0	0	0	0.0
$90.2<M_{\mu^+\mu^-}(\mathrm{Z})<92.8$	3.2	58.1	0	0	0	0.0
$cos_{\mu^+\mu^-}(\mathrm{H})<-0.603$	3.2	50.0	0	0	0	0.0
$cos_{\mu^+\mu^-}(\mathrm{Z})<-0.364$	3.2	47.0	0	0	0	0.0
$138.0<E_{\mu^+\mu^-}(\mathrm{H})<139.8$	3.0	15.5	0	0	0	0.0
$P_{T_{\mu^+\mu^-}}(\mathrm{H})<62.5$	3.0	14.7	0	0	0	0.0
efficiency	45.5%					



The $\mathrm{M}_{\mu^+\mu^-}(H)$ distribution after all the cuts

Next step

- Optimize the events selection, try more variables to lower the bkg
- Generate other bkg to check the contribution after selection
- Start the $e^+e^- \to Z(e^+e^-)H(\mu^+\mu^-)$ channel