Charged-Higgs Study
Di-Lepton Channel

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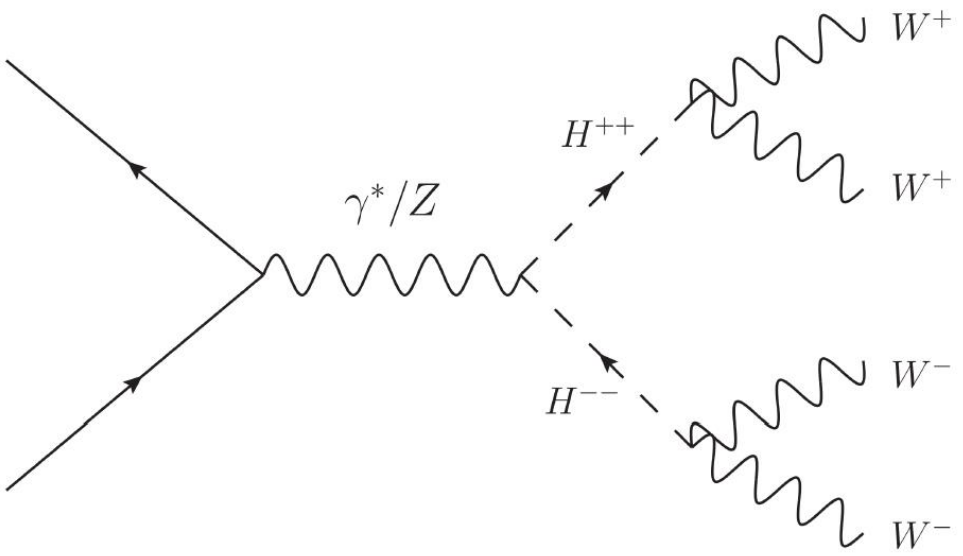
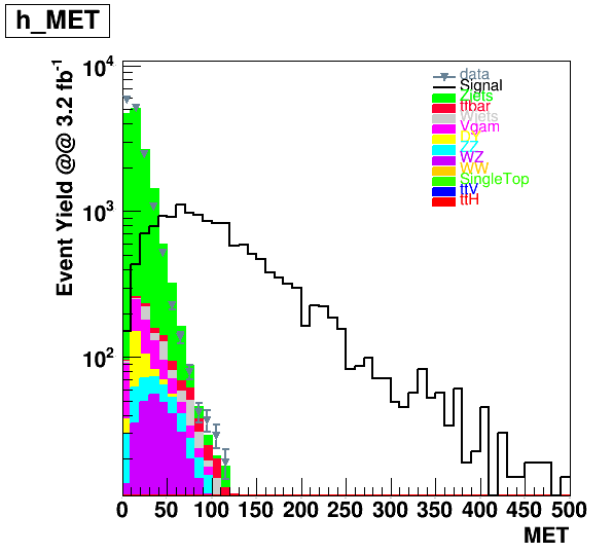
Introduction

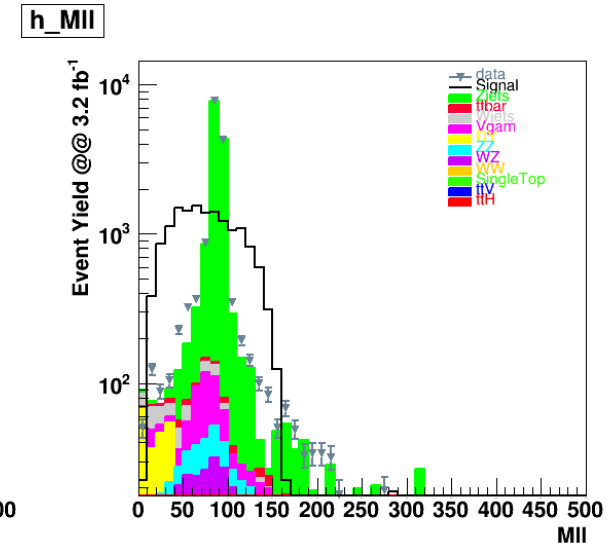
- Feynman diagrams of pair production listed.
- Focus on di-lepton final state of charged higgs model.
  - Two leptons from W and four jets from W.
  - Require two same sign leptons.
- Major backgrounds
  - Zjets, ttbar, Wjets, WW, WZ, and ZZ.

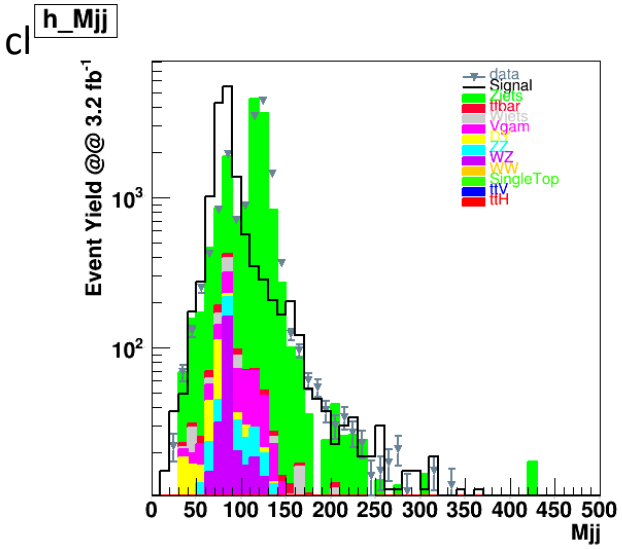


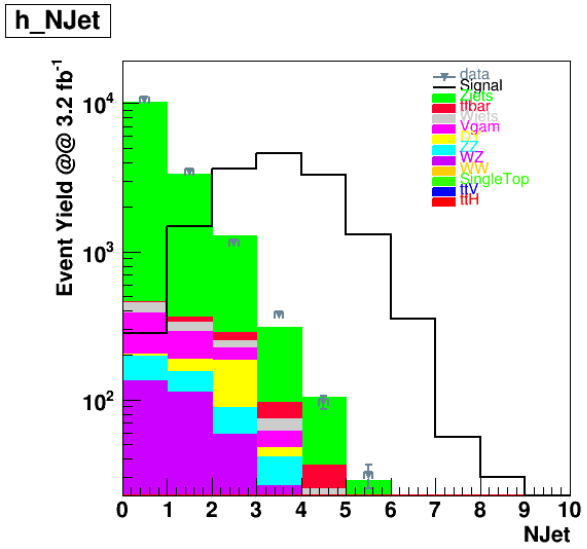
Data/MC Comparison

- Require two same sign leptons with tight ID, Isolation and pt at least 20 GeV.
  - Tight LH ID for electron while tight ID for muon.
  - IsolationGradient used for leptons
- B-jet veto applied, use working point MV2c20_77.
- MC normalized to 3.2 fb^{-1} and compare with data.
- Signal is rescaled to data for better comparison with background shape.
- Agreement between data and MC is good.

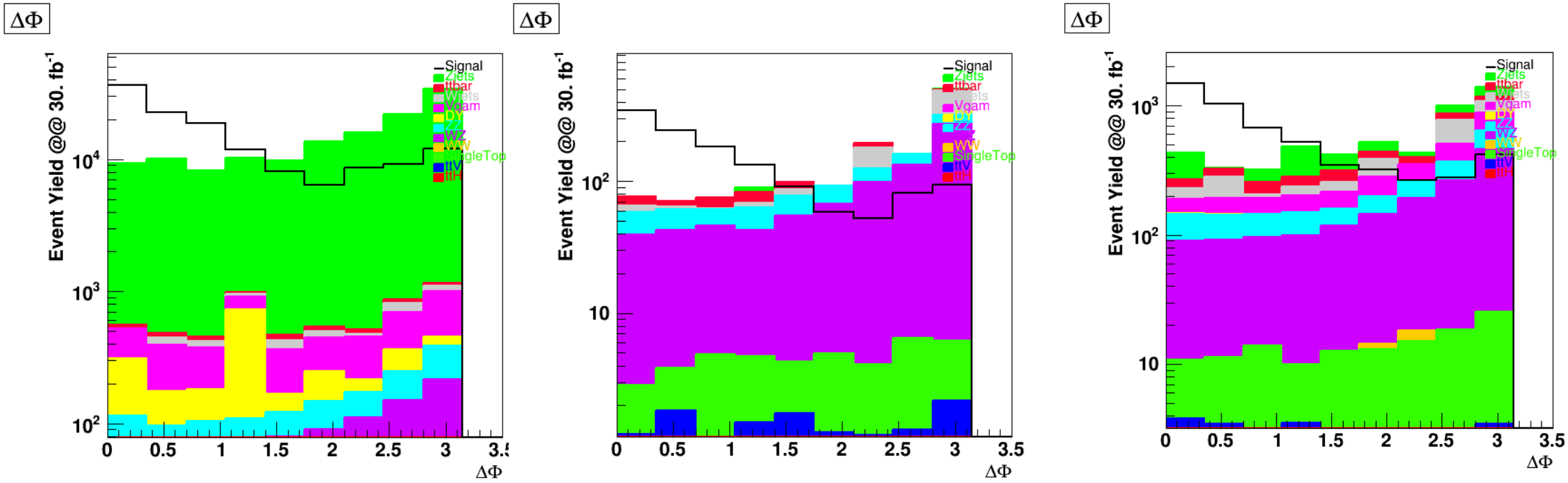






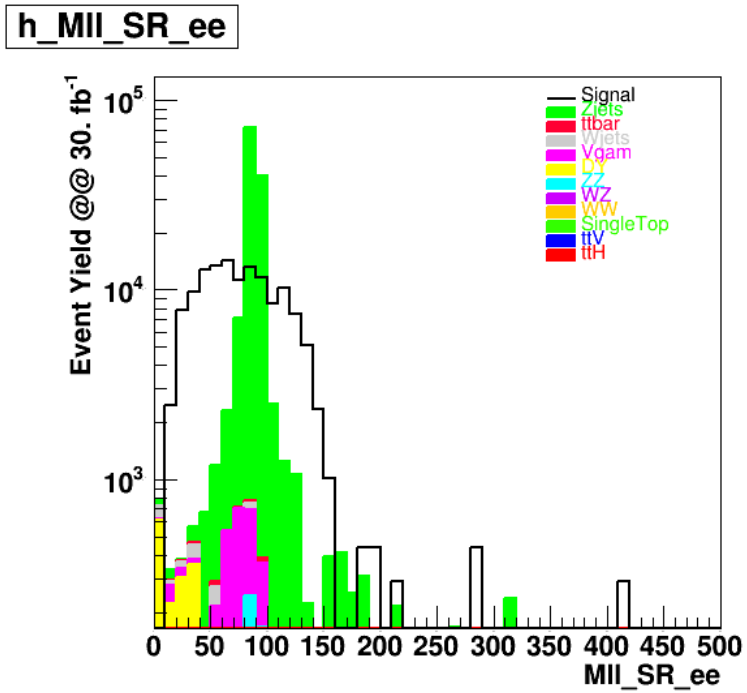


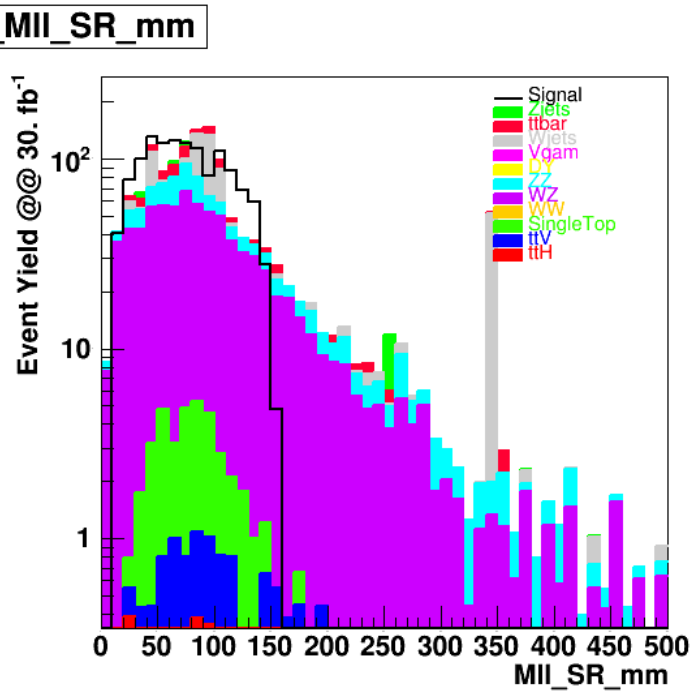
Delta-Phi between Leptons and MET

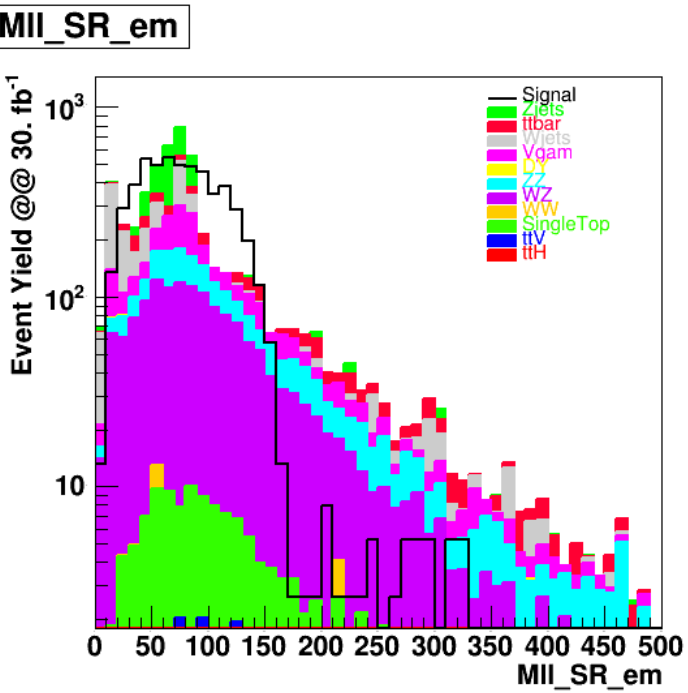


- Delta-Phi between leptons and MET for ee, mm and em from left to right.
- Signal is scaled to total background yield.
- Delta-Phi between two leptons and MET after pre-selection.
- Require delta-Phi lower than 2.25 for ee, mm and em channel.

Invariant mass of ll

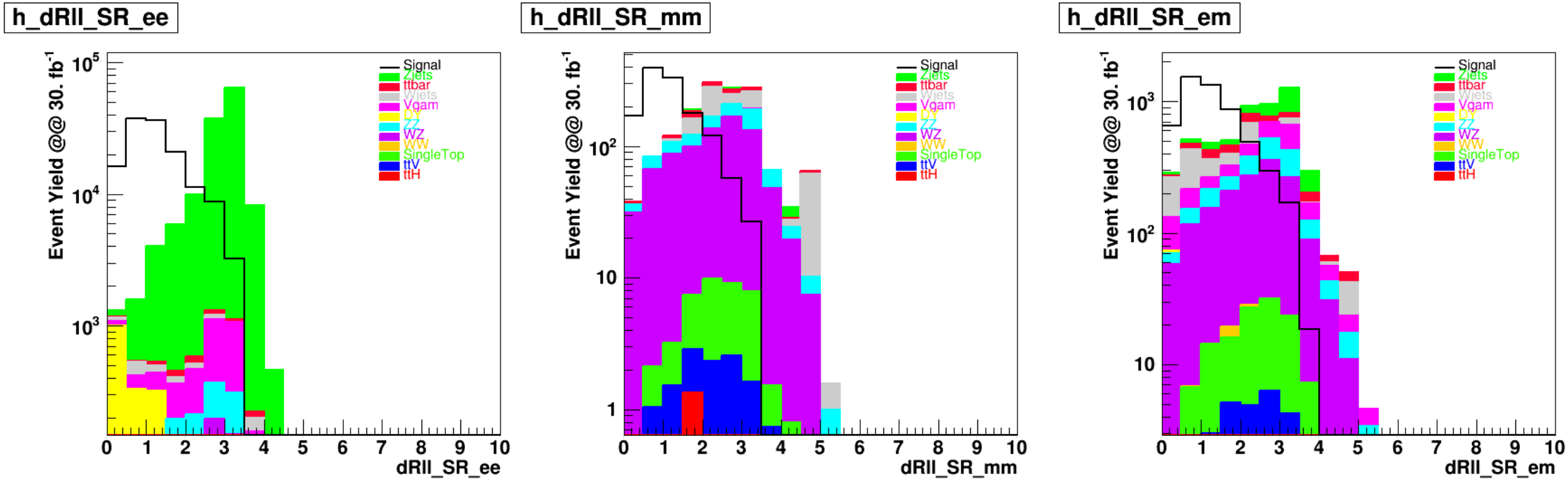






- Signal is scaled to total background yield.
- Invariant mass of two same sign leptons after pre-selection.
- Apply a Z-veto cut using invariant mass of two leptons, fabs(InvMll - ZMass) > 5 GeV for ee, mm and em channel.

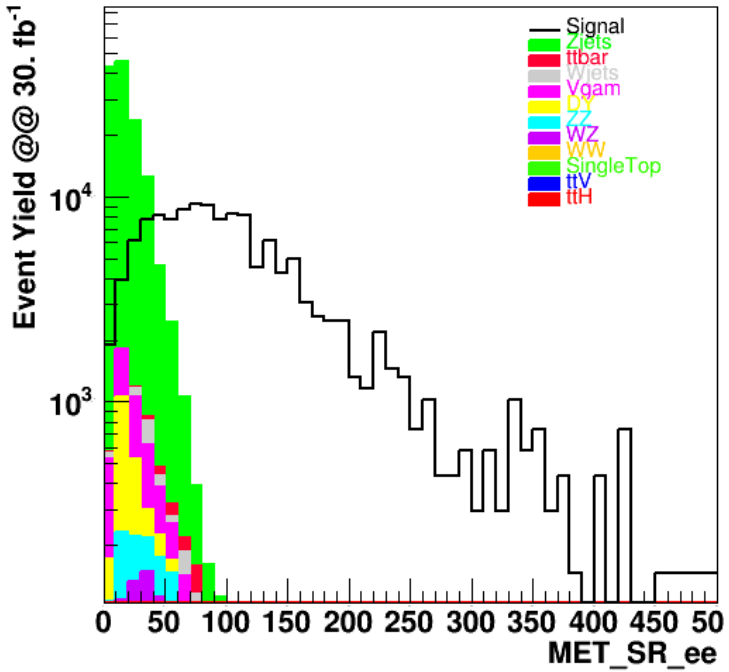
DeltaR of ll



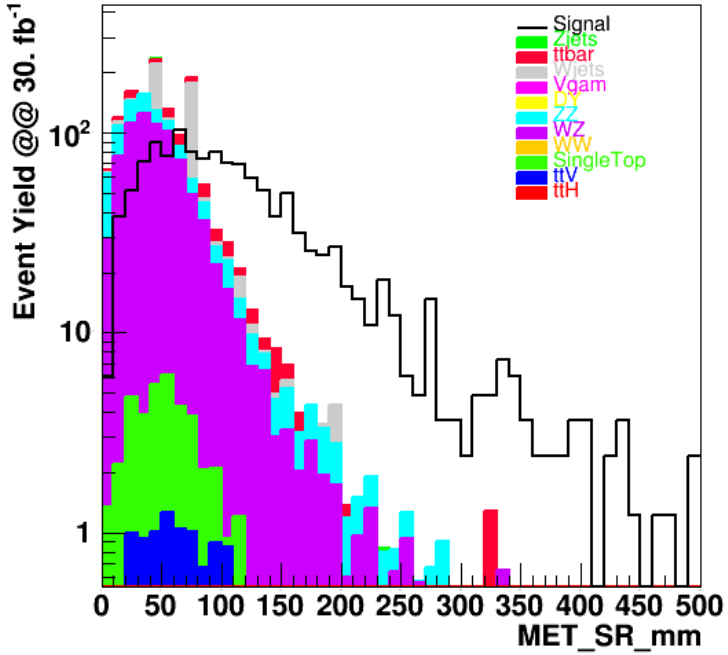
- Signal is scaled to total background yield.
- DeltaR of two same sign leptons after pre-selection.
- Require deltaR lower than 1.75 for ee channel, 1.25 for mm channel and 2 for em channel.

MET

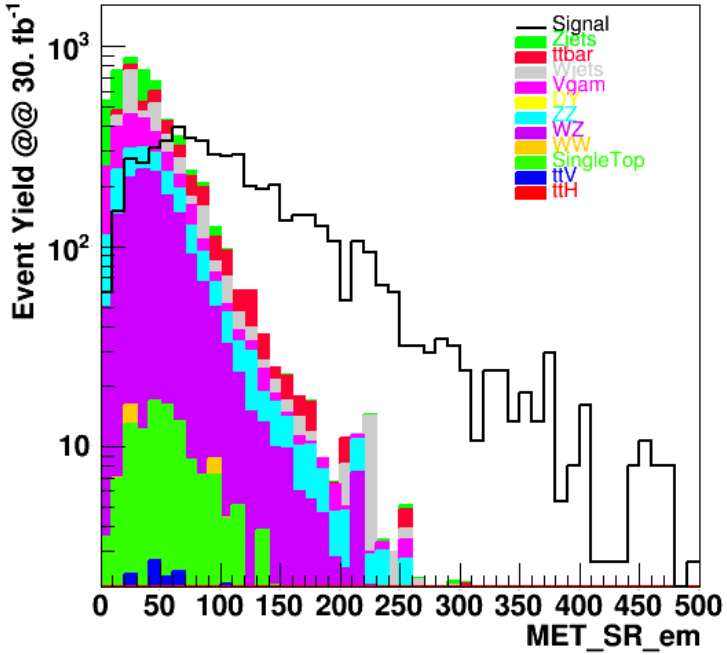
h_MET_SR_ee



h_MET_SR_mm



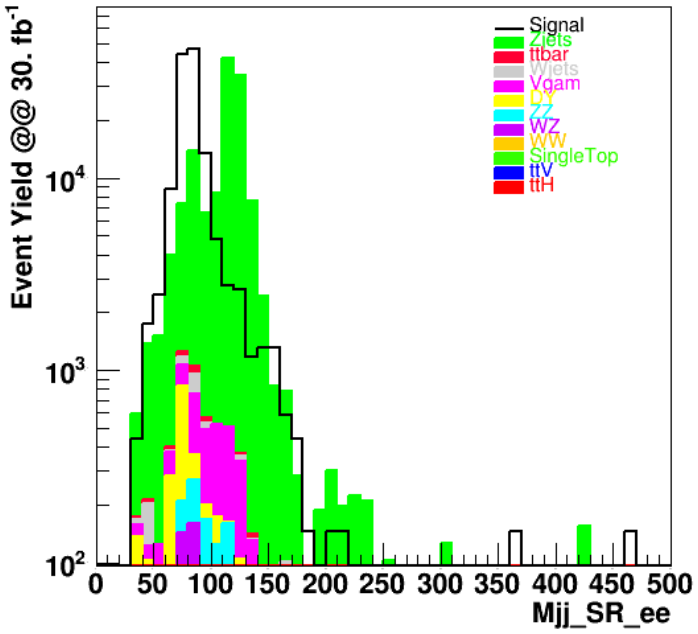
h_MET_SR_em



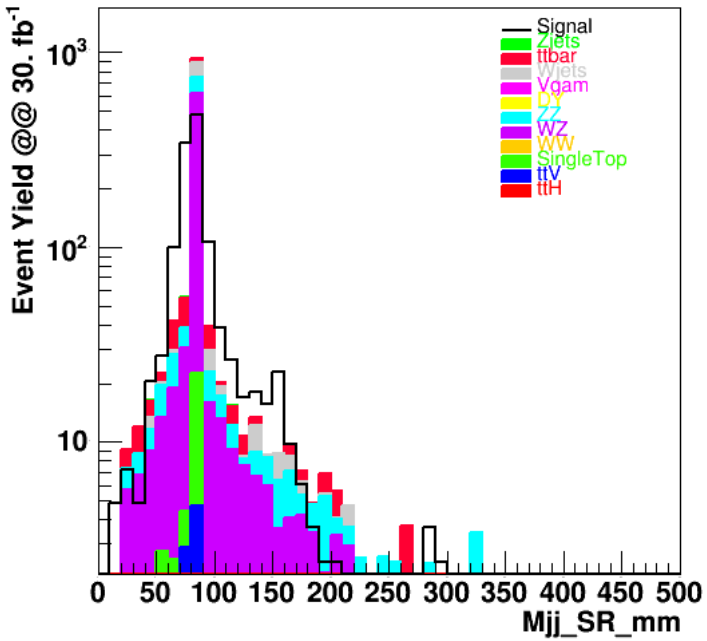
- Signal is scaled to total background yield.
- MET after pre-selection.
- Require MET greater than 60 GeV for ee, mm and em channel.

Invariant mass of jj

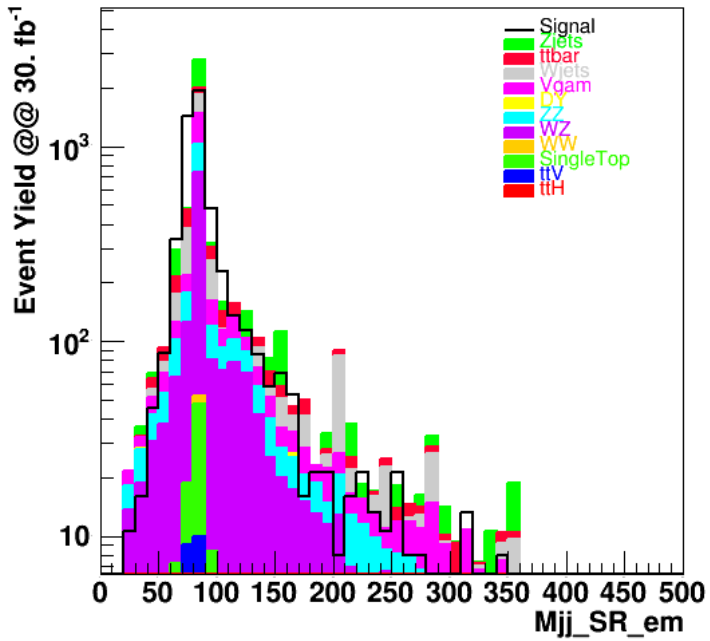
h_Mjj_SR_ee



h_Mjj_SR_mm

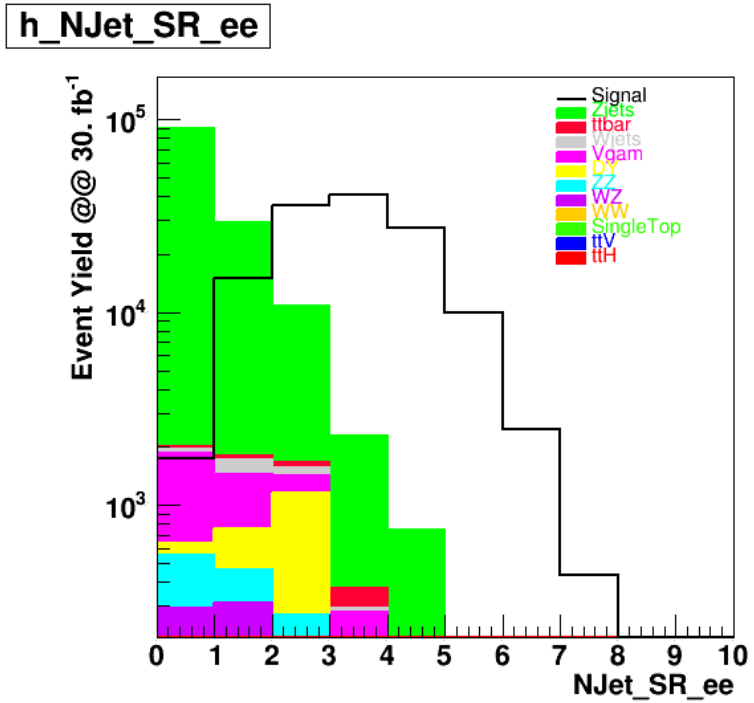


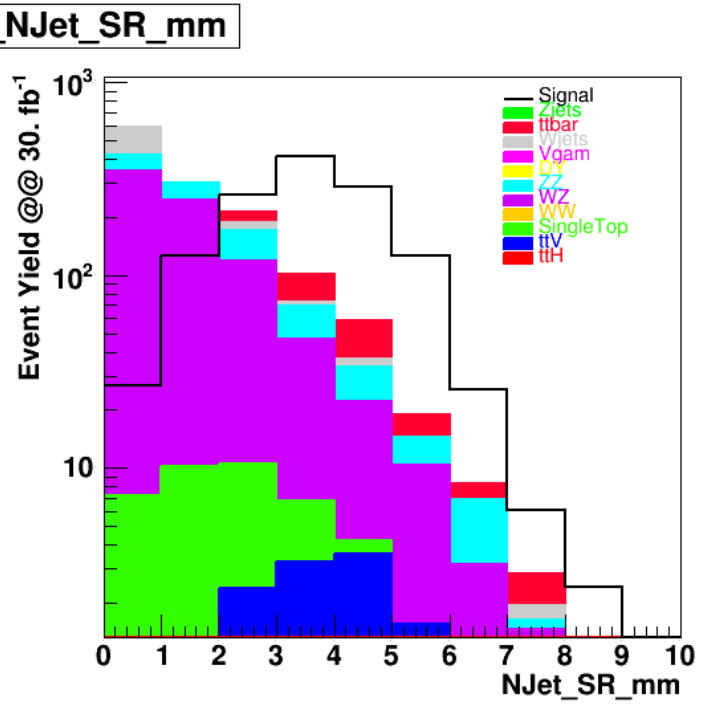
h_Mjj_SR_em

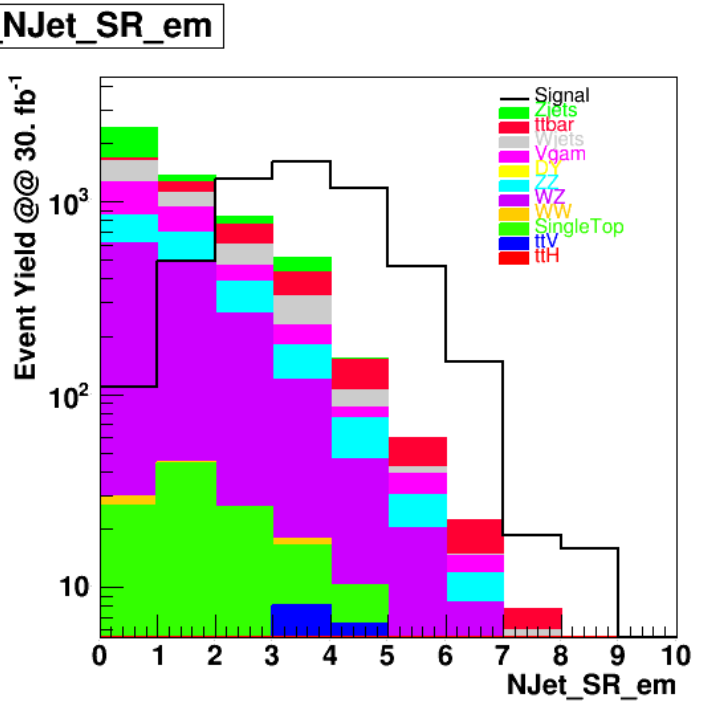


- Signal is scaled to total background yield.
- For events with at least two jets, find out two jets whose invariant mass is closest to W mass.
- Require InvMjj to be inside of W mass window(fabs(mjj - Wmass)<cut_value), the cut value is 10 GeV for ee channel, 20 GeV for mm and em channel. If the event has less than two jets, this cut will not work.

Number of jets







- Signal is scaled to total background yield.
- Number of jets after pre-selection.
- Require at least two jets for ee, mm and em channel.

CutFlow for ee channel

CutFlow for ee

@30fb-1	Raw	PreSelect	dPll_MET	Mll	dRll	MET	Mjj	NJet
ttH	200.21	2.25	1.44	1.44	0.57	0.39	0.31	0.31
ttV	561.98	10.58	7.46	7.46	1.93	1.17	0.81	0.80
SingleTop	9485.17	67.63	33.81	33.81	7.97	2.99	1.65	1.36
WZ	15172.61	815.27	417.26	417.26	138.46	40.10	17.89	14.43
ZZ	6551.31	609.95	303.29	303.29	73.28	27.65	8.52	7.44
DY	23483.50	1338.18	1119.75	1119.75	1119.77	1.75	1.16	1.16
Vgam	12796.24	2323.38	1302.64	1302.64	259.74	30.63	11.30	11.05
Wjets	104971.27	504.23	270.93	270.93	89.87	45.35	15.61	15.32
ttbar	54988.84	375.37	241.56	241.56	43.56	21.05	14.13	12.80
Zjets	415117.06	128003.31	63906.38	63906.38	4564.41	109.29	12.75	12.46
Total Bkg	643614.37	134054.22	67608.60	67608.60	6303.63	280.39	84.13	77.14
Signal	100.59	12.75	10.20	10.20	7.83	6.12	4.37	4.29

CutFlow for mm channel

CutFlow for mm

@30fb-1	Raw	PreSelect	dPll_MET	Mll	dRll	MET	Mjj	NJet
ttV	561.98	9.96	6.87	6.87	1.02	0.63	0.43	0.42
WZ	15172.61	756.28	302.93	302.93	54.33	20.39	11.89	4.97
ZZ	6551.31	222.93	131.65	131.65	20.18	6.13	3.54	1.16
ttbar	54988.84	109.67	83.77	83.77	11.56	4.50	2.13	2.13
Total Bkg	643614.37	1282.82	521.68	521.68	89.32	32.84	16.86	8.68
Signal	100.59	14.62	12.31	12.31	7.21	5.73	4.51	4.17

CutFlow for em channel

CutFlow for em

@30fb-1	Raw	PreSelect	dPll_MET	Mll	dRll	MET	Mjj	NJet
ttH	200.21	7.41	5.68	5.68	2.84	1.77	1.47	1.47
ttV	561.98	21.56	15.31	15.31	5.98	4.14	2.90	2.86
SingleTop	9485.17	102.07	56.45	56.45	17.34	5.68	3.46	2.50
WW	286.18	4.78	4.77	4.77	3.34	0.04	0.04	0.04
WZ	15172.61	1424.97	637.70	637.70	227.10	87.76	38.95	30.30
ZZ	6551.31	653.61	328.58	328.58	86.83	35.69	16.02	14.25
Vgam	12796.24	807.89	379.34	379.34	130.15	31.60	13.25	6.94
Wjets	104971.27	786.03	426.10	426.10	302.89	50.36	35.39	27.44
ttbar	54988.84	527.02	314.60	314.60	107.47	50.58	39.51	35.74
Zjets	415117.06	1016.38	643.28	643.28	91.68	33.10	6.68	6.68
Total Bkg	643614.37	5354.95	2814.43	2814.43	978.16	300.72	157.67	128.21
Signal	100.59	27.91	23.42	23.42	19.32	15.01	11.99	11.82

Statistic Interpretation

- Use profile log likelihood test to perform the computation for frequentist exclusion limits.
- Consider a hypothesized signal strength μ.
  - Define μ = 0 as the background only hypothesis.
  - Define μ = 1 as the nominal signal model.
- Signal and background follow poisson distribution so that we can construct the log likelihood ratio for likelihood ratio test.
- Use Bayesian approach to calculate the expected limits for a given CL.
- Use RooStat to perform the calculation.
  - Feed the signal and background yields of three channels obtained before to the tool.

Limits and Significance

COMBINED

lumi uncert	signal uncert	bkg uncert	limit@95% CL	significance(stdev)
3%	5%	10%	1.05	2.43
3%	10%	10%	1.05	2.43
3%	10%	20%	1.26	2.27

Tri-lepton

lumi uncert	signal uncert	bkg uncert	limit@95%CL	significance(stdev)
3%	5%	10%	1.33	2.04
3%	10%	10%	1.35	2.05
3%	10%	20%	1.46	2.00

Di-lepton

lumi uncert	signal uncert	bkg uncert	limit@95%CL	significance(stdev)
3%	5%	10%	1.78	1.35
3%	10%	10%	1.78	1.35
3%	10%	20%	1.97	1.21

Summary

- Using 30 fb-1 luminosity of this year, it is possible the discover charged higgs with both di-lepton and tri-lepton channel if it exists.
- And we can also set a limit on the signal strength at 95% CL which is 1.05 with 30 fb-1 luminosity and signal uncertainty 10%, background uncertainty 10%.

BACKUP