$H \rightarrow WW$ Trilepton Update from 4.8fb^{-1} to 5.3fb^{-1}

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Summary

Intro.

- Major changes in the newest data release:
  - $4.8\text{fb}^{-1} \rightarrow 5.3\text{fb}^{-1}$ (periods 24, 25 included)
  - Include *all* $**$ 5 GeV mass bins between $m_H = 110, 200$, instead of just $m_H = 145, 155, 165, 175$ GeV
  - Relaxed cut on central LBE to increase acceptance

Signal Region Event Counts

Process	*WH* (NoZPeak Region)	*ZH* (InZPeak Region)
WZ	$7.01 \pm 0.96_{\text{syst}} (+18\%)$	$9.01 \pm 1.74_{\text{syst}} (+18\%)$
ZZ	$1.49 \pm 0.20_{\text{syst}} (+16\%)$	$4.41 \pm 0.68_{\text{syst}} (+13\%)$
$Z\gamma$	$2.56 \pm 0.45_{\text{syst}} (+25\%)$	$3.11 \pm 0.54_{\text{syst}} (+24\%)$
Fakes (WW, Z+Jets)	$3.22 \pm 0.97_{\text{syst}} (+41\%)$	$7.74 \pm 2.32_{\text{syst}} (+26\%)$
$t\bar{t}$	$0.18 \pm 0.07_{\text{syst}}$(N.C.)	$0.03 \pm 0.01_{\text{syst}}$(N.C.)
*WH*165 Signal	$0.58 \pm 0.08_{\text{syst}} (+16\%)$	$0.02 \pm 0.004_{\text{syst}} (\sim)$
*ZH*165 Signal	$0.18 \pm 0.02_{\text{syst}} (+20\%)$	$0.58 \pm 0.08_{\text{syst}} (+14\%)$
Background Stack	$14.5 \pm 1.58_{\text{syst}} (+21\%)$	$24.3 \pm 2.96_{\text{syst}} (+20\%)$
data($4.8\ \text{fb}^{-1}$)	14 ($+2$ events, 17%)	33 ($+7$ events, 27%)

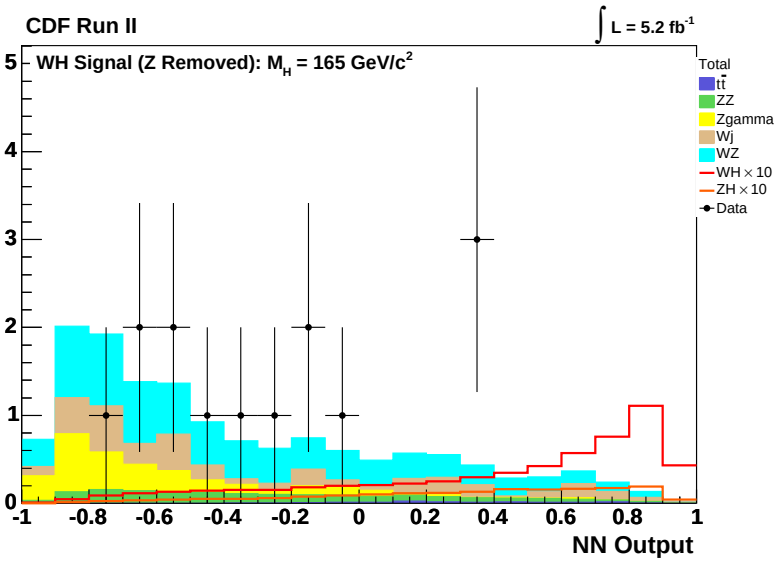
Table: Background and Signal Counts for the *WH* and *ZH* Trilepton Analyses in 5.2fb^{-1}. Note that $t\bar{t}$ does not have *b*-matching here, so is not comparable.

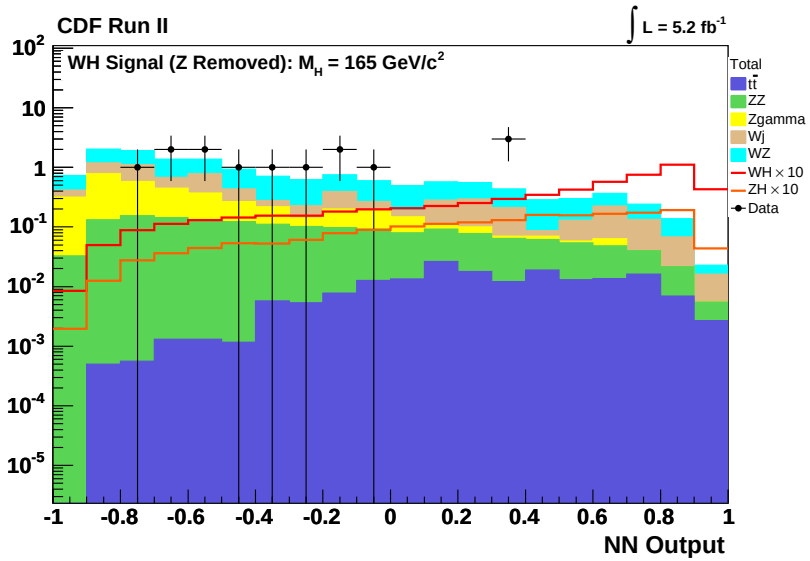
Control Region Event Counts

Process	*WH* (NoZPeak Region)	*ZH* (InZPeak Region)
WZ	$0.77 \pm 0.11_{\text{syst}} (+18\%)$	$32.0 \pm 6.19_{\text{syst}} (+16\%)$
ZZ	$0.72 \pm 0.10_{\text{syst}} (+16\%)$	$3.55 \pm 0.55_{\text{syst}} (+15\%)$
$Z\gamma$	$19.4 \pm 3.44_{\text{syst}} (+27\%)$	$5.56 \pm 1.20_{\text{syst}} (+15\%)$
Fakes (WW, *Z*+Jets)	$7.58 \pm 2.27_{\text{syst}} (+34\%)$	$9.43 \pm 2.83_{\text{syst}} (+31\%)$
$t\bar{t}$	$0.01 \pm 0.002_{\text{syst}}$(N.C.)	0 (N.C.)
*WH*165 Signal	$0.02 \pm 0.003_{\text{syst}} (\sim)$	$0.06 \pm 0.01_{\text{syst}} (\sim)$
*ZH*165 Signal	$0.01 \pm 0.002_{\text{syst}} (\sim)$	$0.06 \pm 0.008_{\text{syst}} (\sim)$
Background Stack	$28.5 \pm 4.12_{\text{syst}} (+28\%)$	$50.5 \pm 7.81_{\text{syst}} (+18\%)$
data($4.8\ \text{fb}^{-1}$)	31 (+10 events,48%)	49 (+4 events,9%)

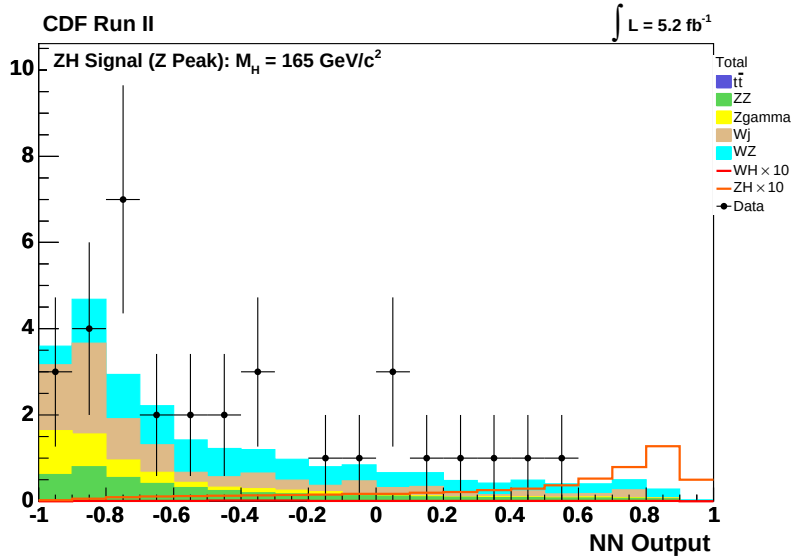
Table: Background and Signal Counts for the *WH* and *ZH* Trilepton Analyses in 5.3fb^{-1}. Note that $t\bar{t}$ does not have *b*-matching here, so is not comparable.

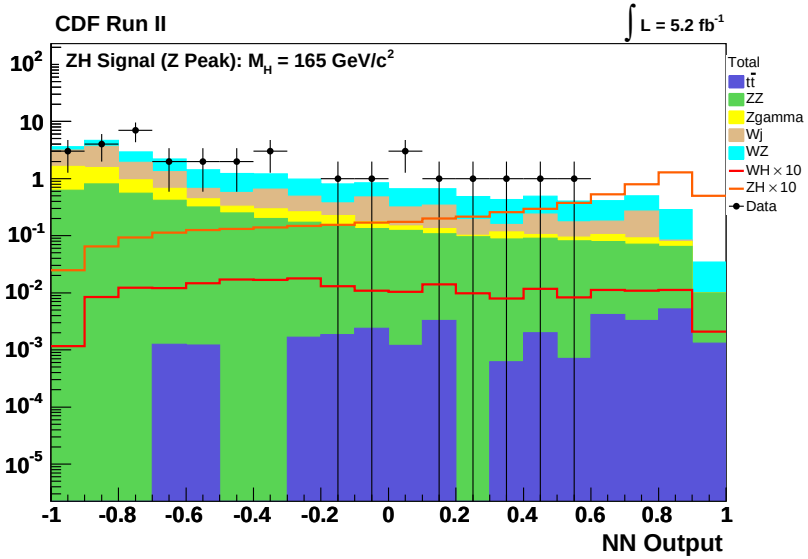
WH: Neural Net at $m_H = 165$ GeV



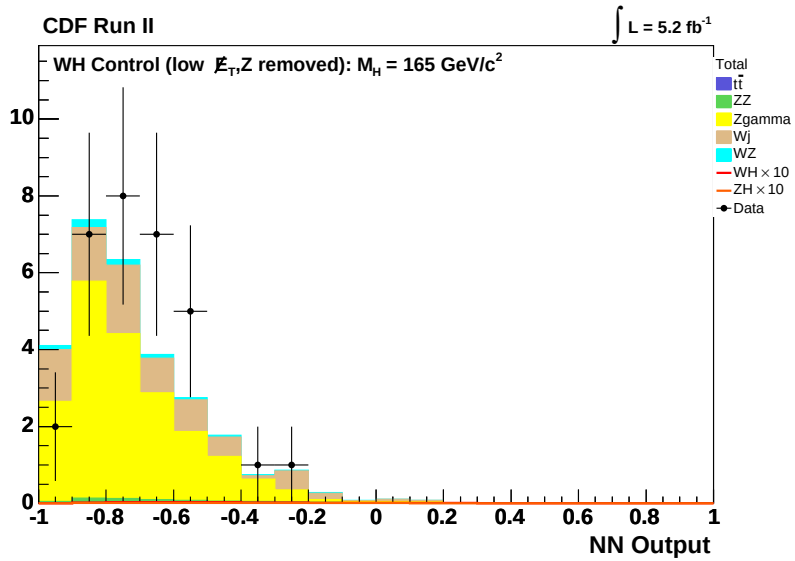


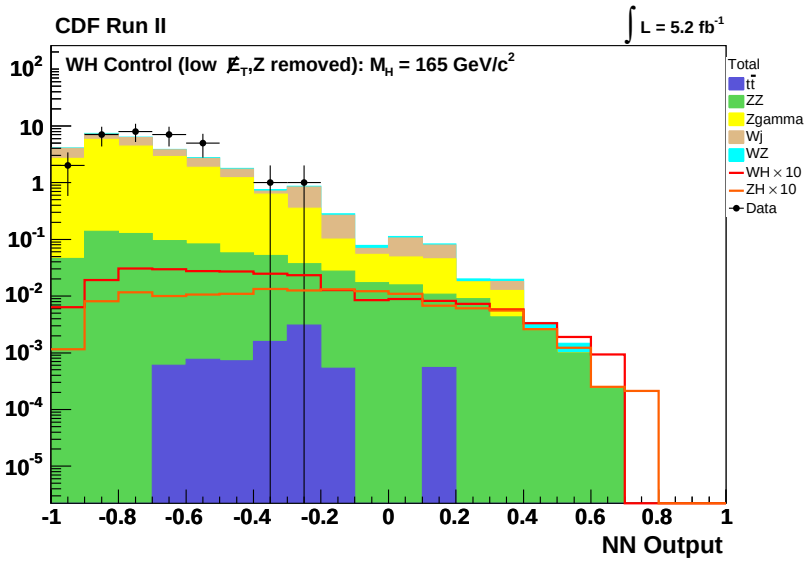
ZH: Neural Net at $m_H = 165$ GeV



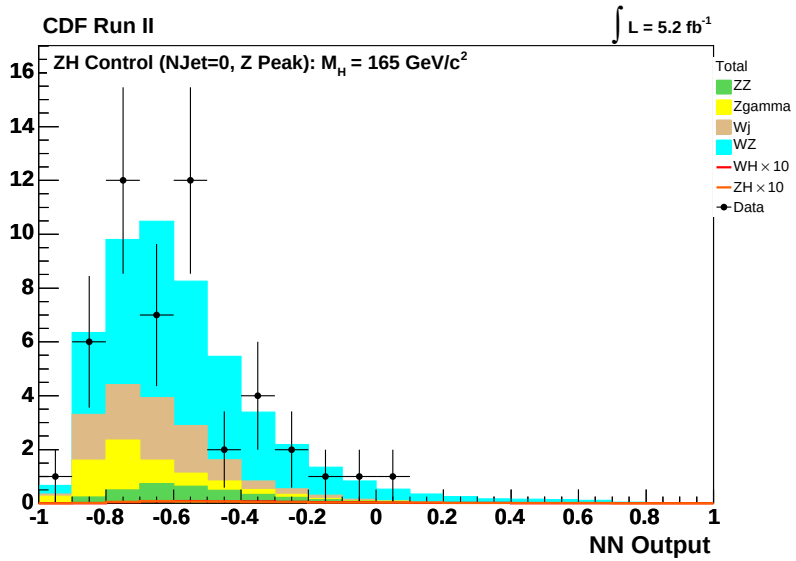


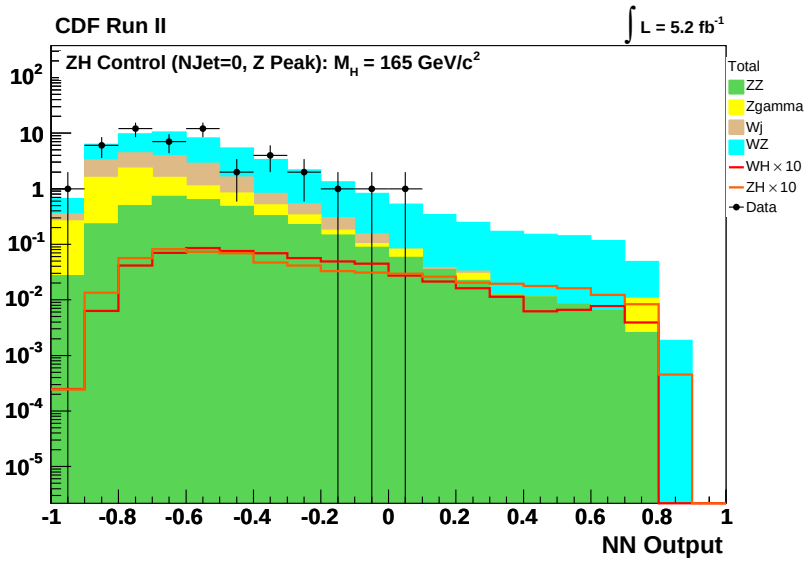
WH Control: $10.0 < \not\!\!E_T < 20.0$ NN at $m_H = 165$ GeV



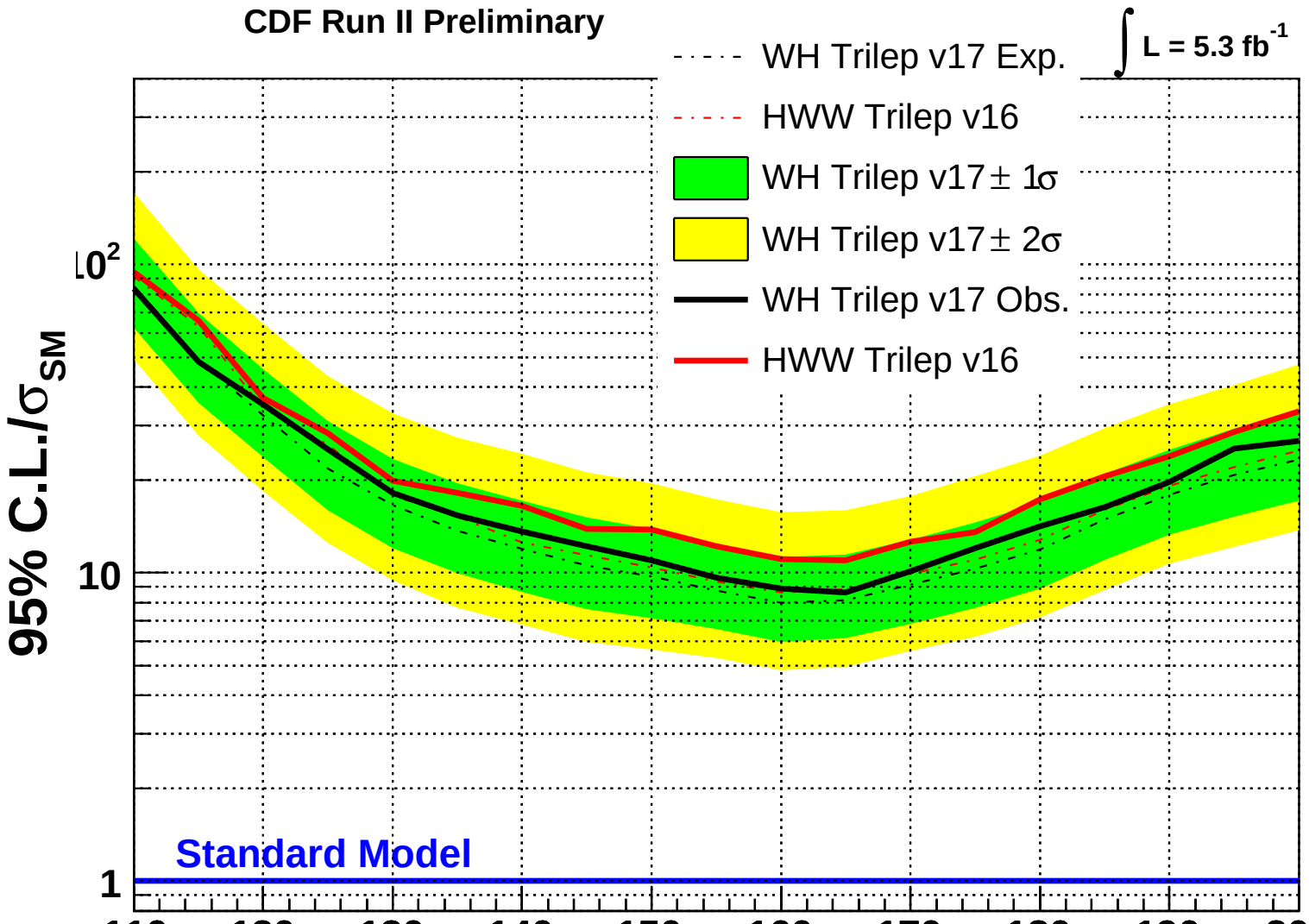


ZH Control: NJet=0 NN at $m_H = 165$ GeV





WH Analysis

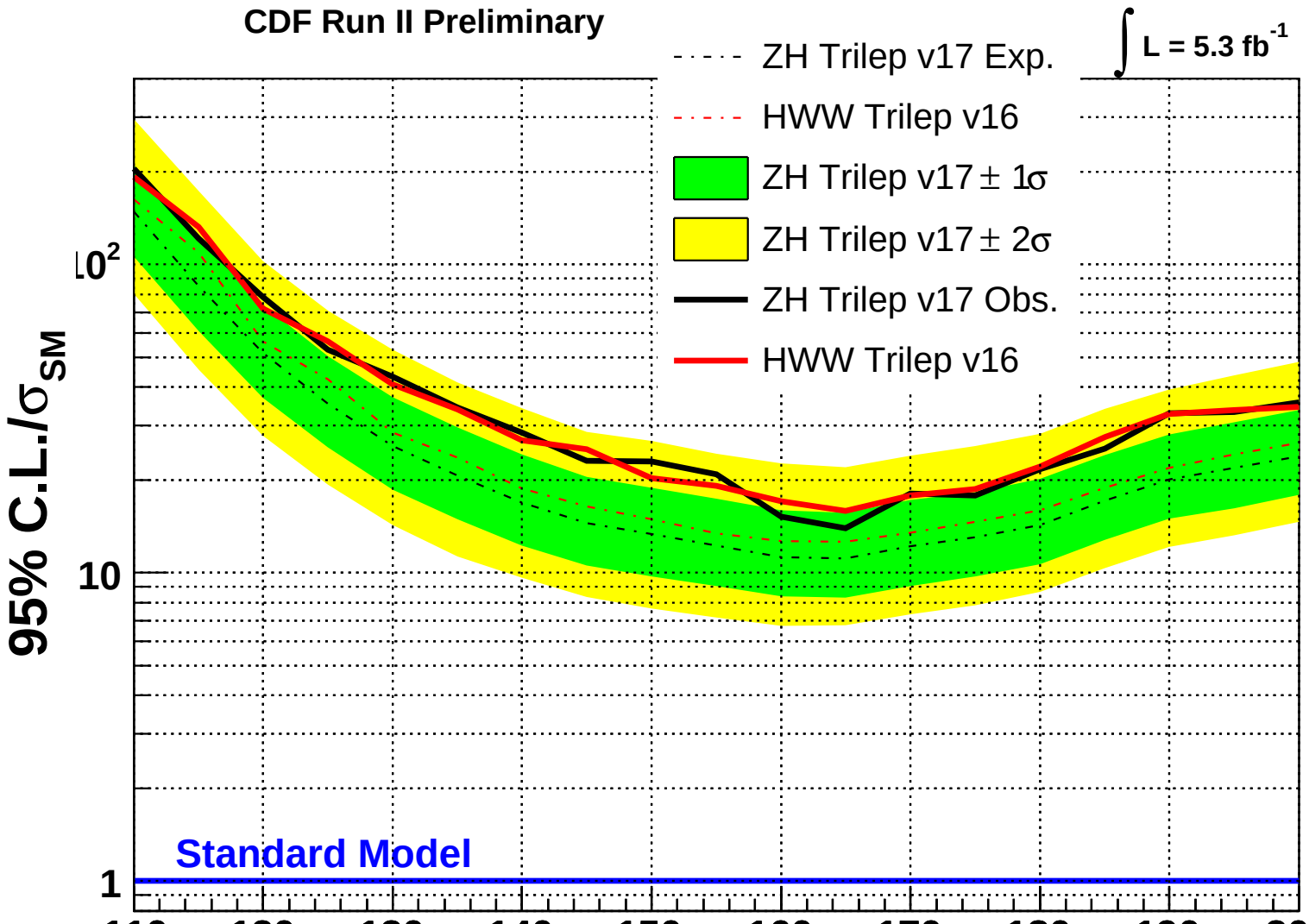

CDF Run II Preliminary
∫ L = 5.3 fb-1
WH Trilep v17 Exp.
HWW Trilep v16
WH Trilep v17 ± 1σ
WH Trilep v17 ± 2σ
WH Trilep v17 Obs.
HWW Trilep v16
95% C.L./σSM
10²
10
1
Standard Model

WH Analysis

Limits	110	115	120	125	130	135	140	145	150	155
$+2\sigma/\sigma_{SM}$	171	96.5	64.3	43.4	32.9	27.4	24.3	21.2	19.5	17.3
$+1\sigma/\sigma_{SM}$	121	69.4	45.8	31.0	23.4	19.5	17.1	15.1	13.9	12.4
Median$/\sigma_{SM}$	**85.2**	**49.1**	**32.5**	**21.8**	**16.5**	**13.7**	**12.0**	**10.6**	**9.73**	**8.77**
$-1\sigma/\sigma_{SM}$	62.3	35.6	23.7	16.0	12.0	9.96	8.69	7.62	7.14	6.56
$-2\sigma/\sigma_{SM}$	49.2	27.9	18.4	12.5	9.47	7.70	6.80	5.96	5.64	5.29
Observed$/\sigma_{SM}$	**83.4**	**48.3**	**35.2**	**25.2**	**18.2**	**15.4**	**13.6**	**12.2**	**11.0**	**9.62**
Limits	160	165	170	175	180	185	190	195	200	
$+2\sigma/\sigma_{SM}$	15.7	16.0	17.7	20.6	23.9	29.5	35.1	40.7	47.4	
$+1\sigma/\sigma_{SM}$	11.2	11.4	12.8	14.6	16.9	20.9	25.1	29.3	33.3	
Median$/\sigma_{SM}$	**7.99**	**8.16**	**9.16**	**10.3**	**11.9**	**14.9**	**17.9**	**20.7**	**23.3**	
$-1\sigma/\sigma_{SM}$	5.96	6.14	6.84	7.70	8.87	11.0	13.3	15.2	17.1	
$-2\sigma/\sigma_{SM}$	4.82	4.95	5.57	6.19	7.15	8.81	10.7	12.2	13.7	
Observed$/\sigma_{SM}$	**8.87**	**8.65**	**10.1**	**12.0**	**14.2**	**16.4**	**19.7**	**25.2**	**26.8**	

Table: *WH* trilepton analysis limits for 5.3fb^{-1}.

ZH Analysis


CDF Run II Preliminary
∫ L = 5.3 fb-1
ZH Trilep v17 Exp.
HWW Trilep v16
ZH Trilep v17 ± 1σ
ZH Trilep v17 ± 2σ
ZH Trilep v17 Obs.
HWW Trilep v16
95% C.L./σSM
10²
10
1
Standard Model

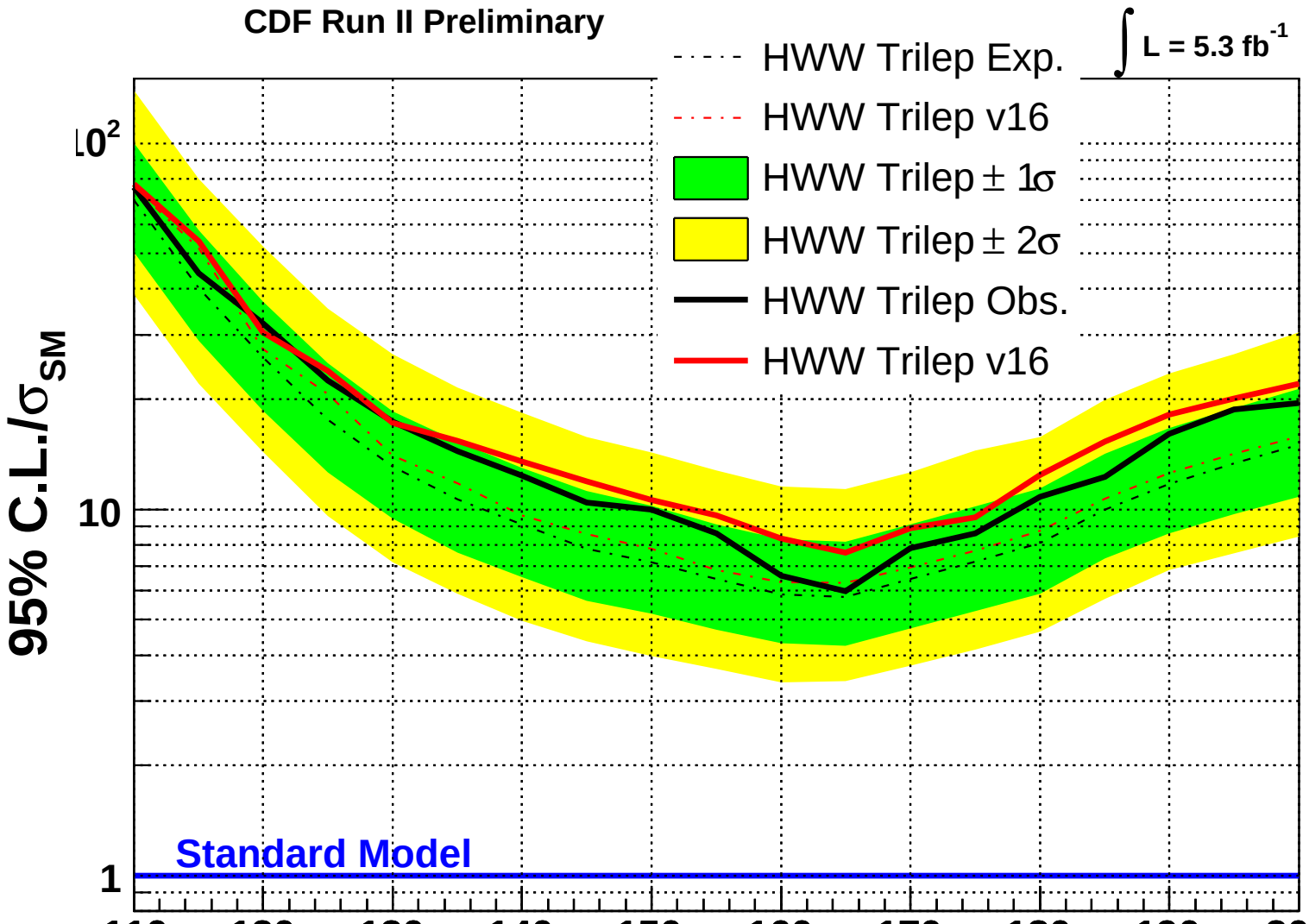
ZH Analysis

Limits	110	115	120	125	130	135	140	145	150	155
$+2\sigma/\sigma_{SM}$	296	173	103	71.0	52.9	41.5	34.2	28.6	26.8	24.3
$+1\sigma/\sigma_{SM}$	210	122.6	74.0	50.4	37.0	29.7	24.2	20.4	18.8	17.4
Median$/\sigma_{SM}$	**148**	**85.2**	**51.6**	**35.4**	**25.8**	**20.7**	**16.9**	**14.5**	**13.3**	**12.3**
$-1\sigma/\sigma_{SM}$	106	60.8	36.9	25.5	18.6	14.9	12.3	10.5	9.75	9.06
$-2\sigma/\sigma_{SM}$	80.4	45.7	27.9	19.3	14.3	11.3	9.65	8.33	7.64	7.15
Observed$/\sigma_{SM}$	**204**	**121**	**78.2**	**52.8**	**43.2**	**34.4**	**28.6**	**23.1**	**22.9**	**20.9**

Limits	160	165	170	175	180	185	190	195	200	
$+2\sigma/\sigma_{SM}$	22.6	21.9	23.9	25.7	28.3	34.1	39.4	43.6	48.4	
$+1\sigma/\sigma_{SM}$	15.9	15.7	17.2	18.3	20.2	24.1	28.1	30.7	33.7	
Median$/\sigma_{SM}$	**11.3**	**11.1**	**12.2**	**13.0**	**14.3**	**17.2**	**20.0**	**21.9**	**23.9**	
$-1\sigma/\sigma_{SM}$	8.38	8.33	9.04	9.73	10.6	12.8	15.0	16.2	17.9	
$-2\sigma/\sigma_{SM}$	6.73	6.75	7.33	7.85	8.66	10.4	12.2	13.2	14.6	
Observed$/\sigma_{SM}$	**15.2**	**13.9**	**18.0**	**17.8**	**21.7**	**25.3**	**32.8**	**33.2**	**35.7**	

Table: *ZH* trilepton analysis limits for 5.3fb^{-1}.

Combined Trilepton Analysis



Combined Trilepton Analysis

Limits	110	115	120	125	130	135	140	145	150	155
$+2\sigma/\sigma_{SM}$	139	79.8	52.2	35.3	26.5	21.5	18.3	15.8	14.3	12.8
$+1\sigma/\sigma_{SM}$	100	57.8	37.0	25.1	18.5	15.3	13.0	11.2	10.2	9.10
Median$/\sigma_{SM}$	**69.9**	**40.3**	**26.0**	**17.6**	**13.1**	**10.7**	**9.12**	**7.81**	**7.16**	**6.46**
$-1\sigma/\sigma_{SM}$	50.4	28.9	18.6	12.6	9.43	7.61	6.53	5.63	5.20	4.70
$-2\sigma/\sigma_{SM}$	38.6	22.1	14.4	9.59	7.16	5.88	4.97	4.36	3.97	3.67
Observed$/\sigma_{SM}$	**76.0**	**44.1**	**32.3**	**22.5**	**17.4**	**14.4**	**12.4**	**10.4**	**10.0**	**8.61**

Limits	160	165	170	175	180	185	190	195	200	
$+2\sigma/\sigma_{SM}$	11.5	11.3	12.6	14.5	15.8	19.9	23.5	26.5	30.5	
$+1\sigma/\sigma_{SM}$	8.3	8.15	9.11	10.2	11.4	14.2	16.7	18.9	21.4	
Median$/\sigma_{SM}$	**5.87**	**5.78**	**6.45**	**7.21**	**8.11**	**9.98**	**11.7**	**13.3**	**15.0**	
$-1\sigma/\sigma_{SM}$	4.31	4.24	4.74	5.27	5.89	7.33	8.60	9.70	10.8	
$-2\sigma/\sigma_{SM}$	3.37	3.40	3.74	4.14	4.64	5.71	6.84	7.57	8.44	
Observed$/\sigma_{SM}$	**6.58**	**5.99**	**7.83**	**8.62**	**10.8**	**12.3**	**16.1**	**18.7**	**19.5**	

Table: Combined trilepton analysis limits for 5.3fb^{-1}.

Previous Release and Intro.

- Previous *WZ* Trilepton Release:
  - Previous *WZ* trilepton measurement done with 1.1fb^{-1} (CDF note 8659)
  - Predicted *WZ*: 9.75 events
  - Predicted Total Background: 2.65 events
  - Total Expected: 12.41 events
  - Observed: 16 events
  - Measured cross section: $5.0 \pm 0.4_{\text{syst}}$ picobarns
- Proposed Region for New Measurement:
  - NLep$=3$
  - $\not\!\!E_T > 20.0$ GeV
  - NJet$=0$ or NJet≥ 0

Event Count

Process	NJet= 0	All Jet Bins
ZZ	3.35	6.58
$Z\gamma$	2.19	3.60
Fakes (WW, Z+Jets)	3.73	7.72
$t\bar{t}$	0	0.21
WZ	34.1	44.0
Background+Signal	43.4	62.1
data(4.8 fb^{-1})	39	68

Table: Background and Signal Counts for the *WZ* Trilepton Analyses in 5.3fb^{-1}

Discriminating Variable Lists

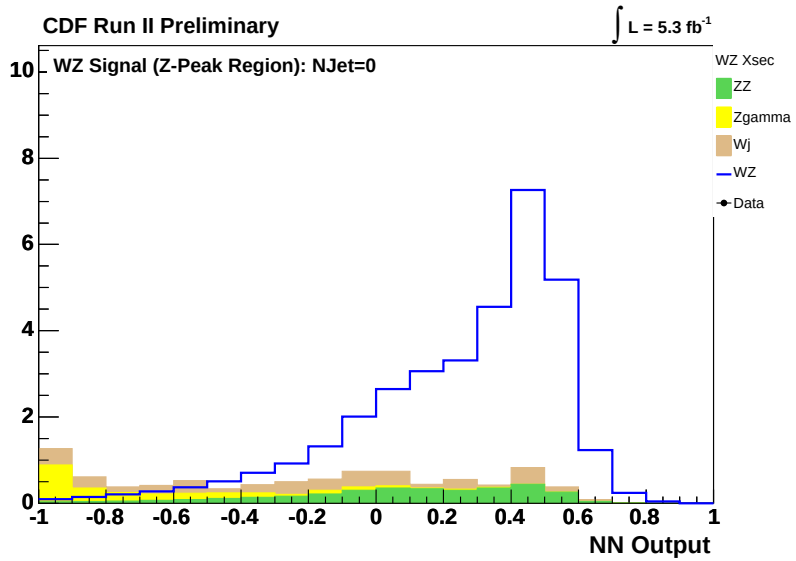
NJet= 0 Region

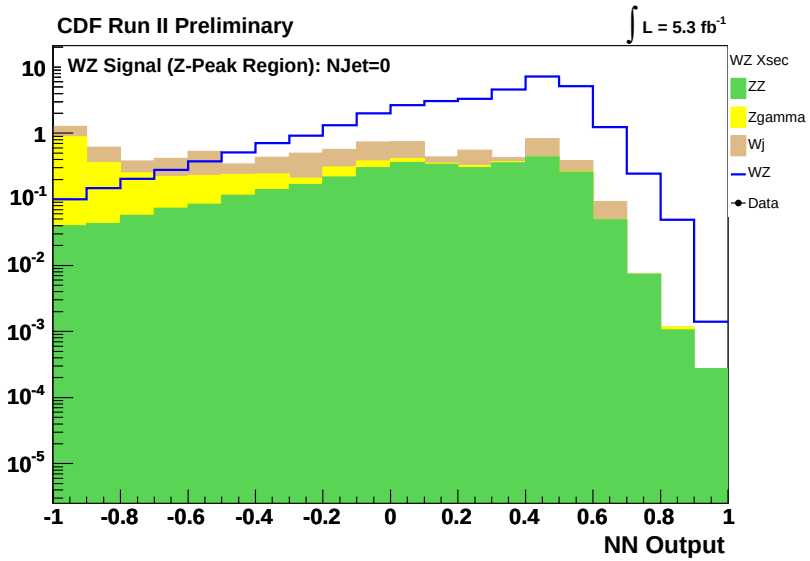
- $\Delta\phi$(2nd Lep., $\not\!\!E_T$)
- Dimass (W-Lep, $\not\!\!E_T$)
- H_T(all Lep+$\not\!\!E_T$)
- $\not\!\!E_T$
- m_T(all Lep+$\not\!\!E_T$)
- m_T(all Lep)
- Inv. Mass(3rd Lep, $\not\!\!E_T$)
- Inv. Mass(1st Lep, 2nd Lep, $\not\!\!E_T$)

All Jet Bins

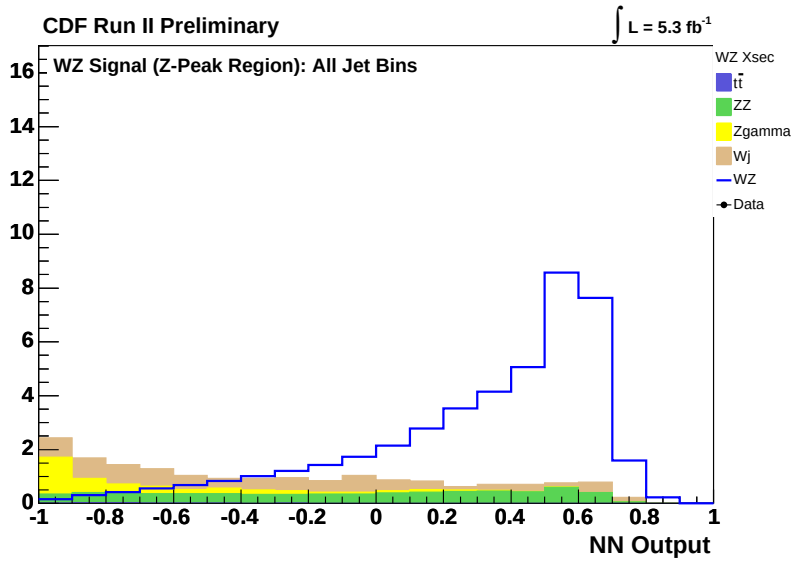
- NJet
- $\not\!\!E_T$
- $\Delta\phi$(Sum of leptons, $\not\!\!E_T$)
- $\Delta\phi$(2nd lepton, $\not\!\!E_T$)
- H_T(leptons, $\not\!\!E_T$, jets)
- Inv. Mass(3rd lepton, $\not\!\!E_T$, jets)
- Dimass (W-Lepton, $\not\!\!E_T$)
- m_T (all leptons, $\not\!\!E_T$, jets)
- m_T (jets)
- m_T (leptons)
- m_T (3rd lepton, $\not\!\!E_T$)

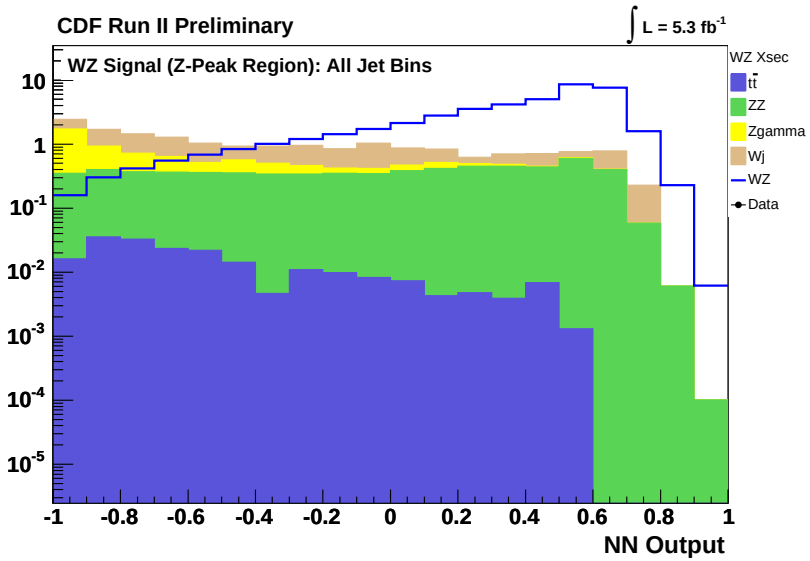
NJet=0: NN Score





All Jet Bins: NN Score





Conclusions

- Sorry, ran out of time getting the inputs into this document
- Still need to establish a control region
- Still working on refining the NN inputs and templates
- Will look at making hard cut on the NN score to improve signal to background ratio and make a measurement.

Full Disc. Variable Lists

Ordered by significance for $m_H = 160$ GeV.

ZH Variables

- NJet
- $\not{E}_T$
- Lead Jet E_T
- ΔR(*W*-Lep, Lead Jet)
- $\Delta\phi$(Leptons,$\not{E}_T$)
- m_T(Leptons,$\not{E}_T$,Jets)
- $\Delta\phi$(Lep2,$\not{E}_T$)
- ΔR b/w Opp. Sign Close Lept.
- Trilepton Inv. Mass
- Inv. Mass(Lep3,$\not{E}_T$,Jets)
- H_T(Leptons,$\not{E}_T$,Jets)
- m_T Jets
- Dimass(*W*-Lep,$\not{E}_T$)
- m_T(*W*-Lep,$\not{E}_T$)
- ΔR Opp. Sign Far Lept.
- $\Delta\phi$(*Z*-Leptons,*W*-Lepton)

WH Variables

- ΔR b/w Opp. Sign Close Lept.
- $\not{E}_T$
- Dimass b/w Opp. Sign Close by ϕ
- H_T
- $\Delta\phi$(Lep2,$\not{E}_T$)
- m_T(Leptons,$\not{E}_T$,Jets)
- p_T 2nd Lepton
- Inv. Mass(Lep3,$\not{E}_T$,Jets)
- ΔR Opp. Sign Far Lept.
- NJet
- m_T Trilepton Mass
- m_T (Lep3, $\not{E}_T$)
- Inv. Mass(Lep1,Lep2,$\not{E}_T$)

WH Signal: ΔR Opp. Sign Close

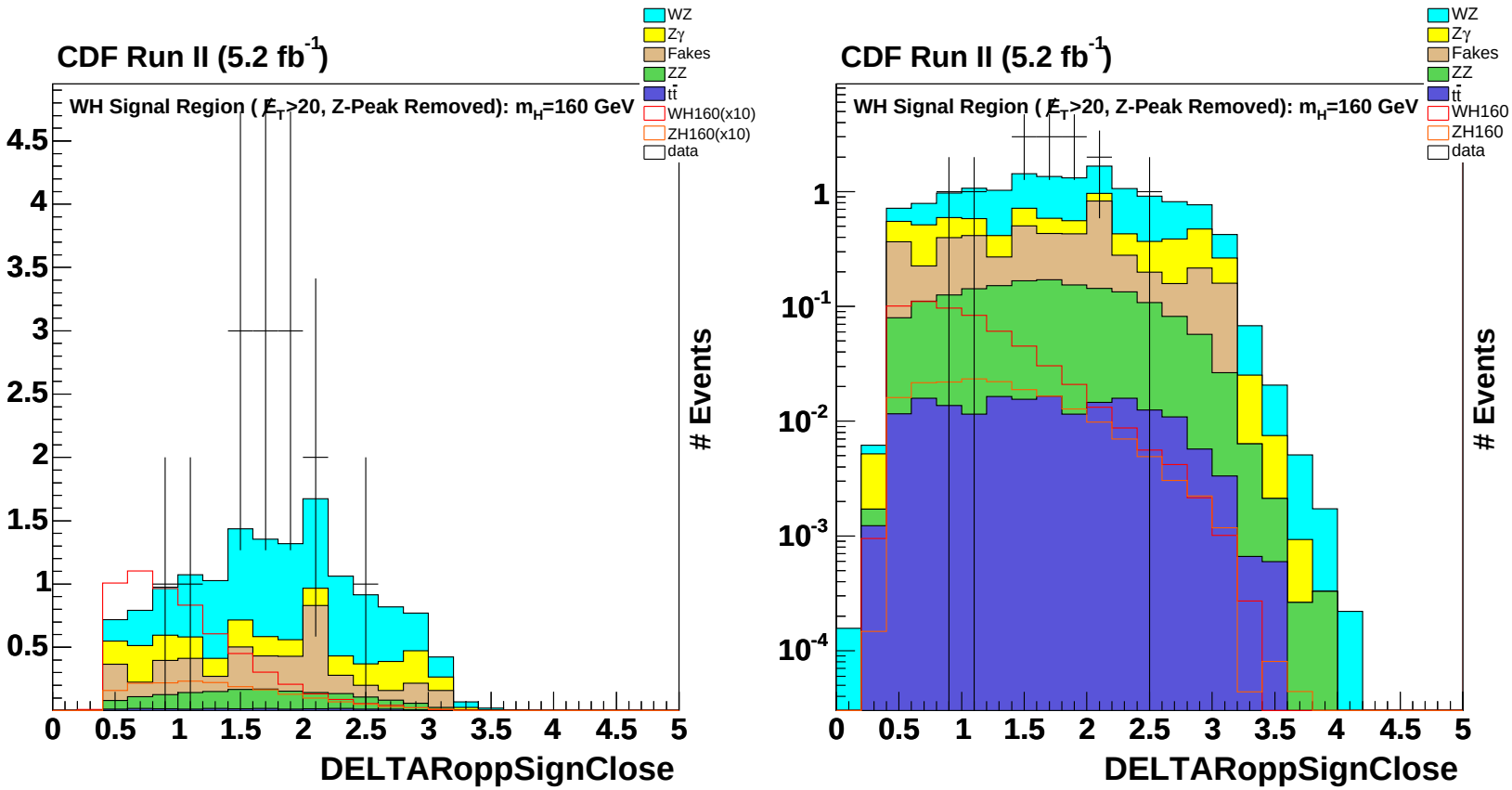


Figure: [For Public Release Blessing]

WH Signal: $\not\!\!E_T$

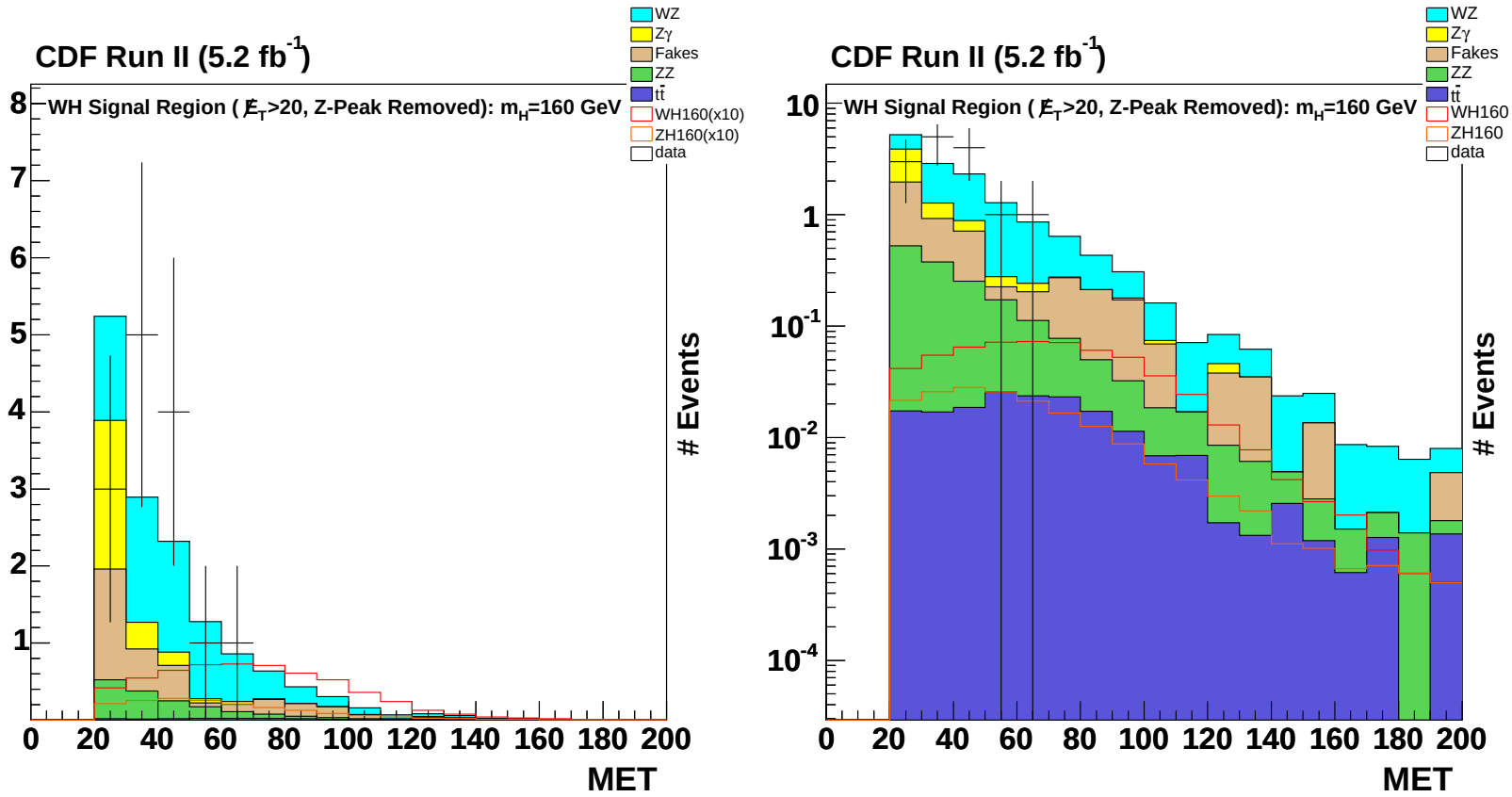


Figure: [For Public Release Blessing]

WH Signal: H_T

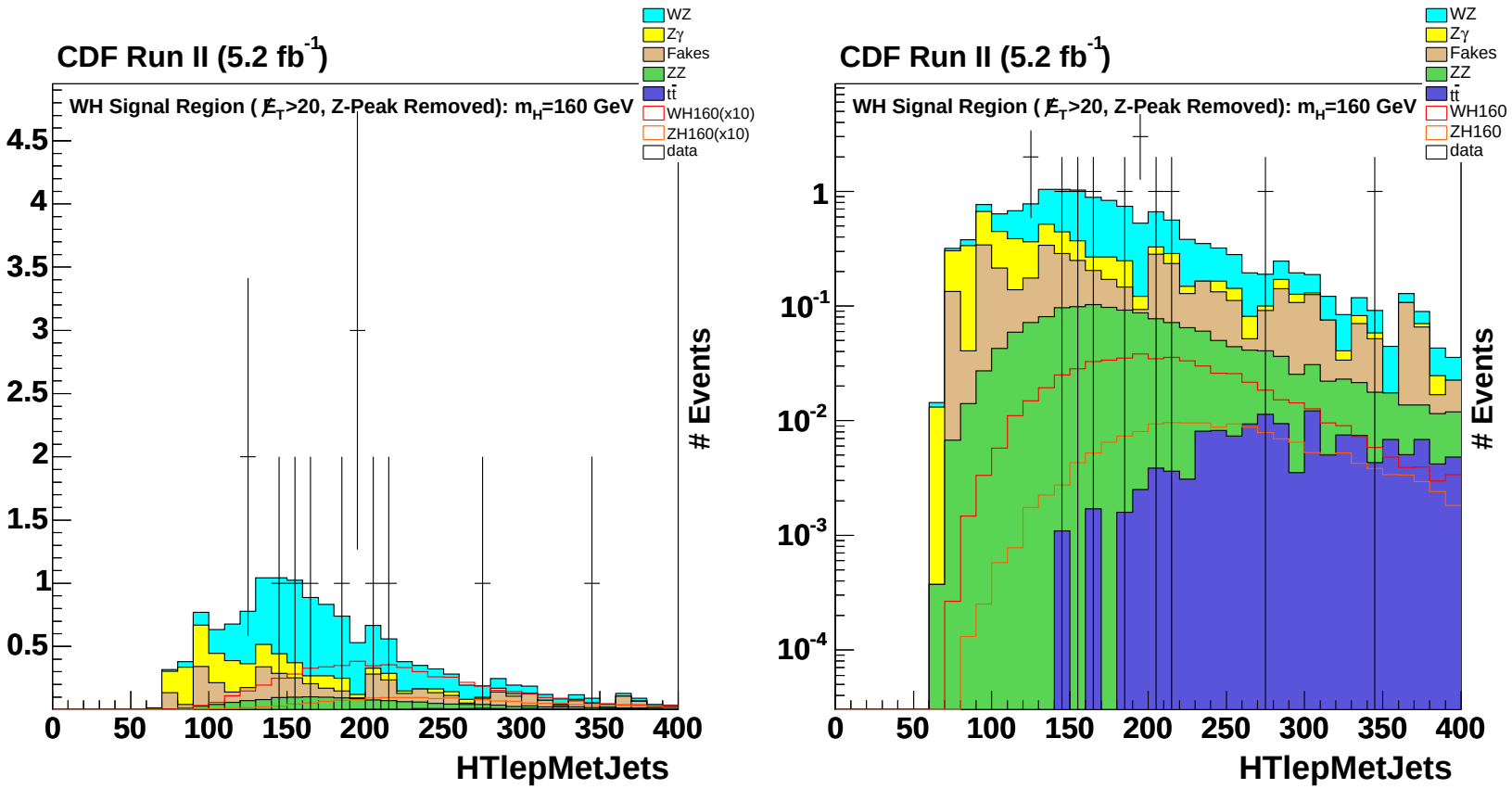


Figure: [For Public Release Blessing]

WH Signal: Dimass Opp. Sign Lepton (closer by ϕ)

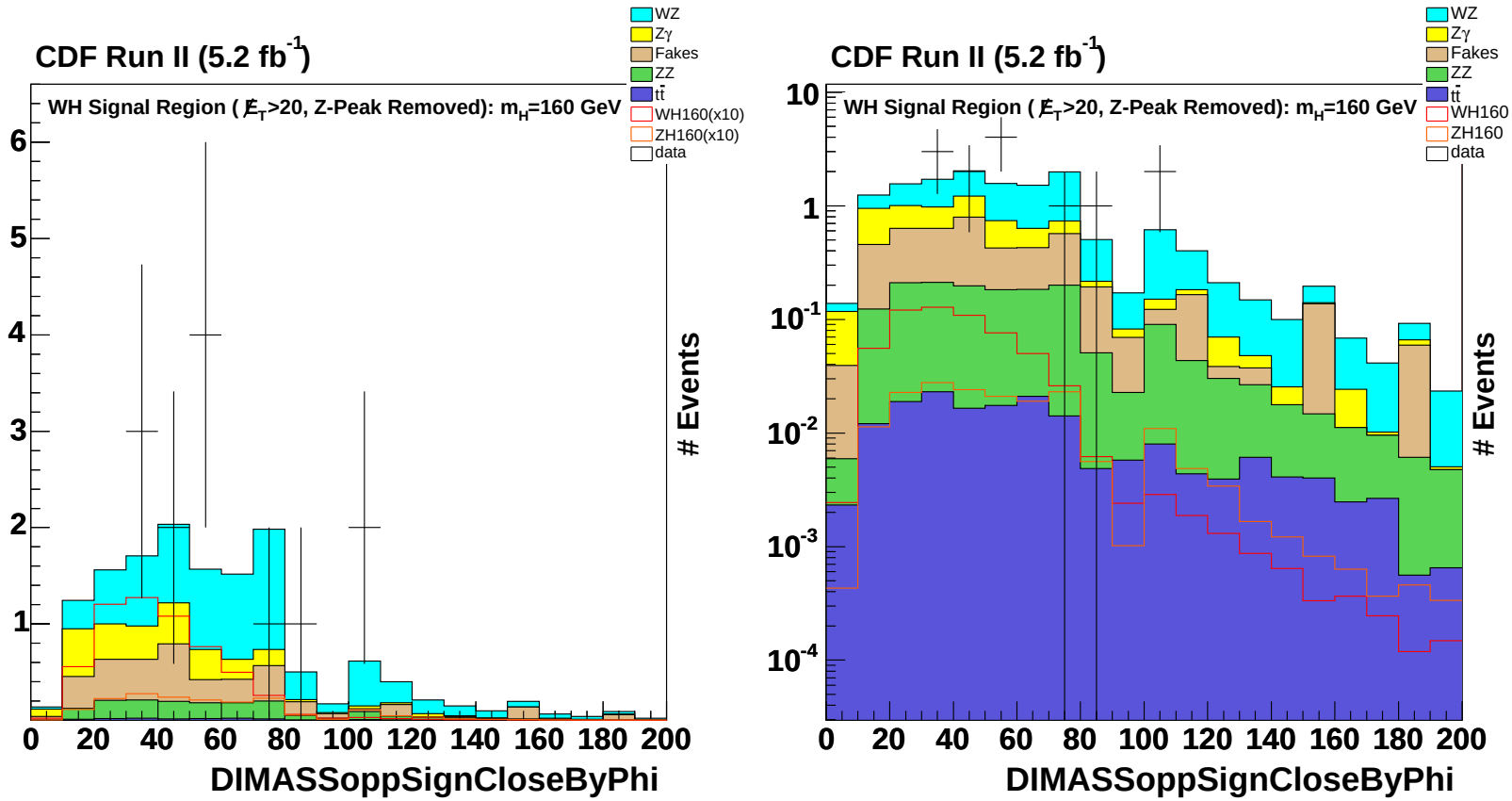


Figure: [For Public Release Blessing]

WH Signal: $\Delta\phi$ (2nd Lep, $\not\!\!E_T$)

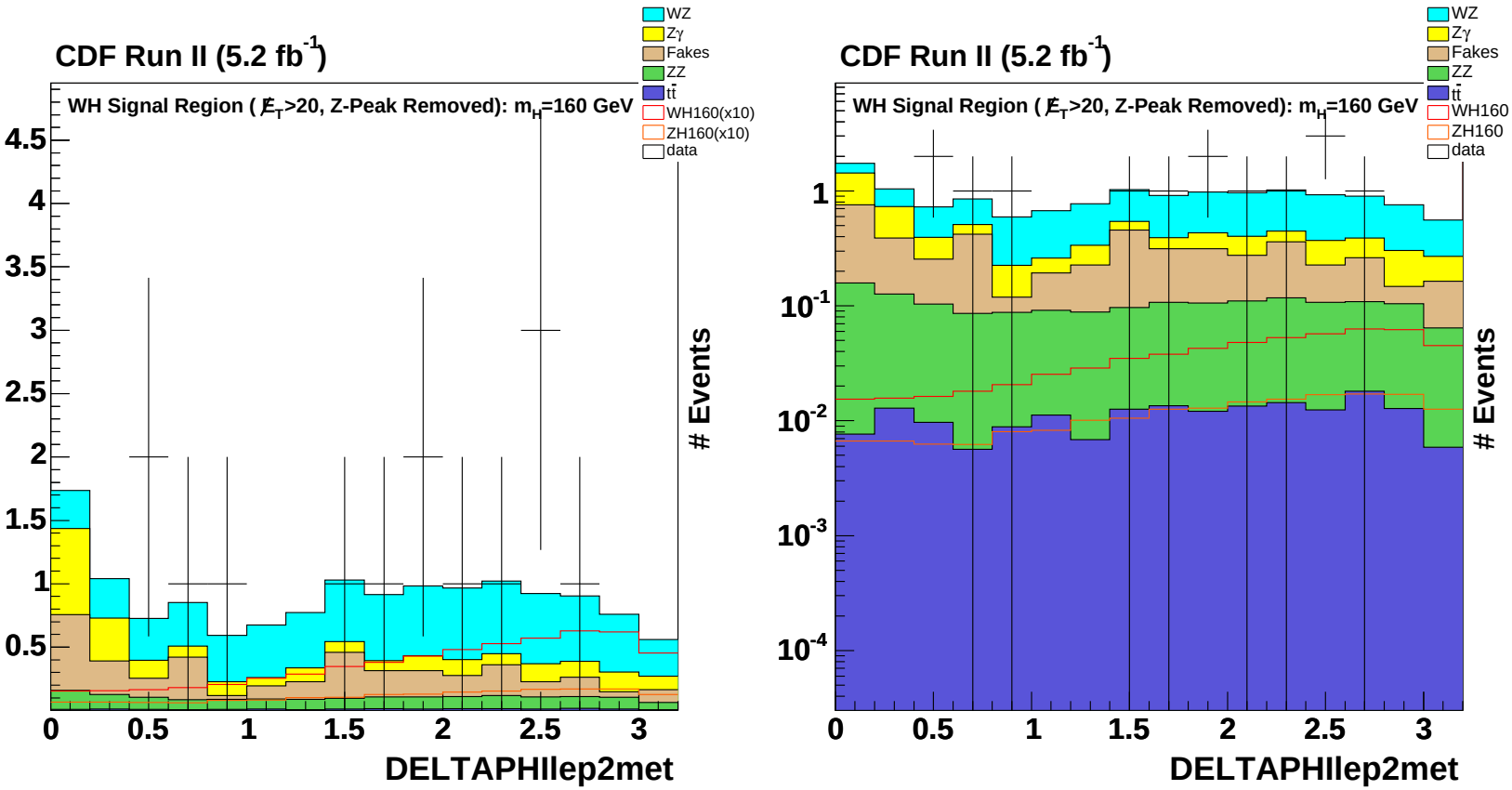


Figure: [For Public Release Blessing]

WH Signal: Inv. Mass(3rd Lep,$\not\!\!E_T$,Jets)

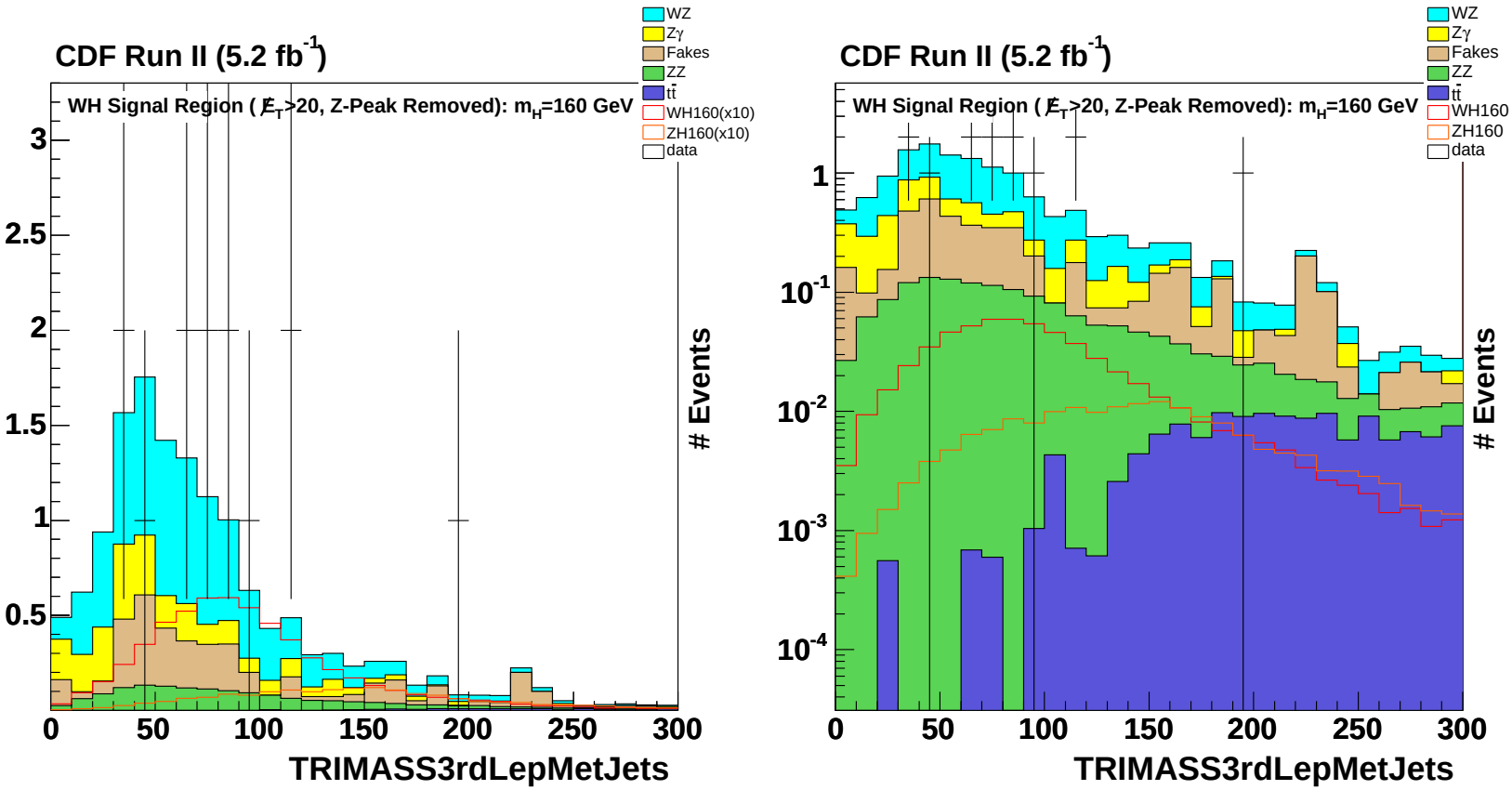


Figure: [For Public Release Blessing]

WH Signal: m_T(all Lep.,$\not\!\!E_T$, Jets)

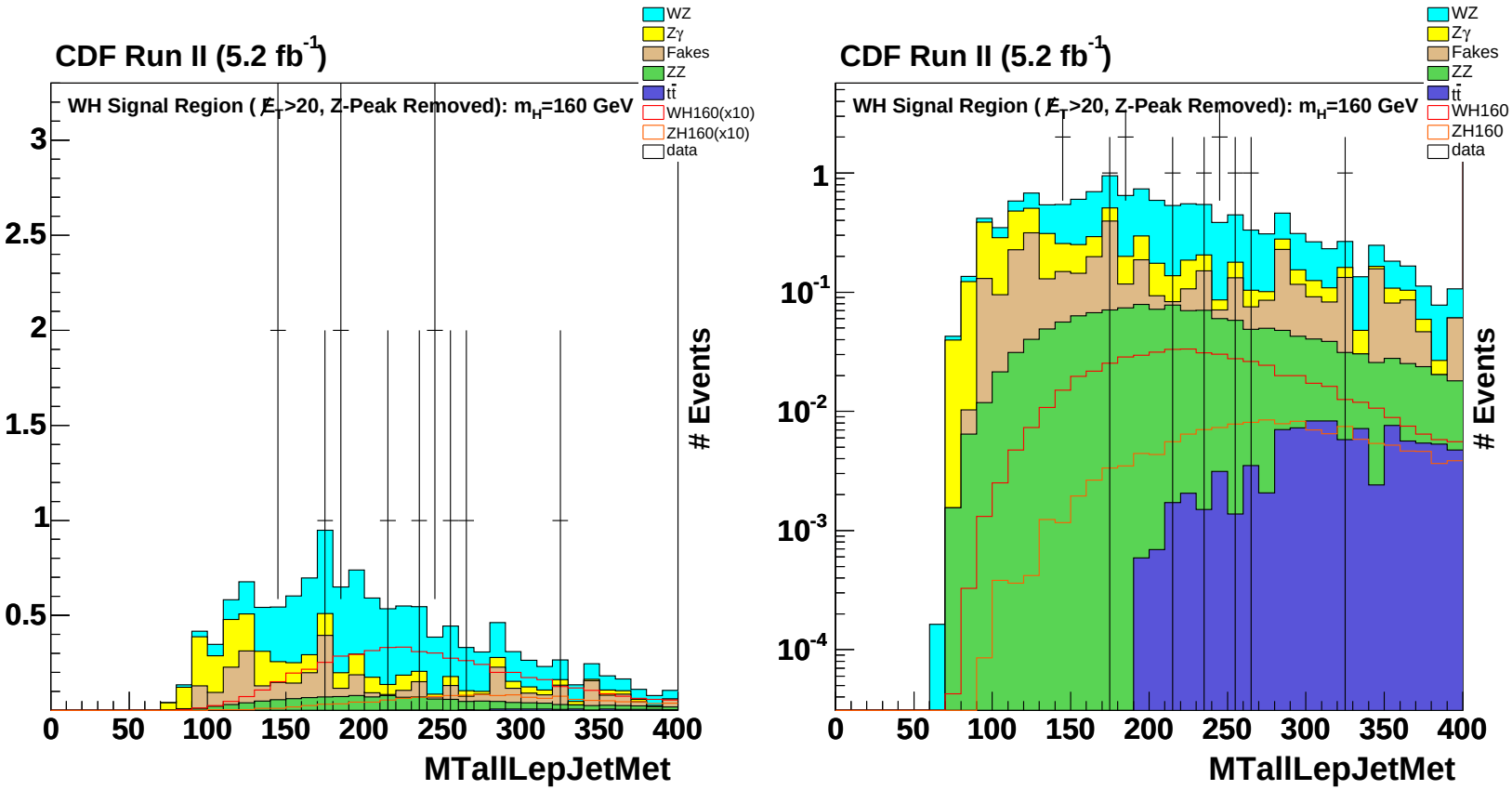


Figure: [For Public Release Blessing]

WH Signal: 2nd Lepton p_T

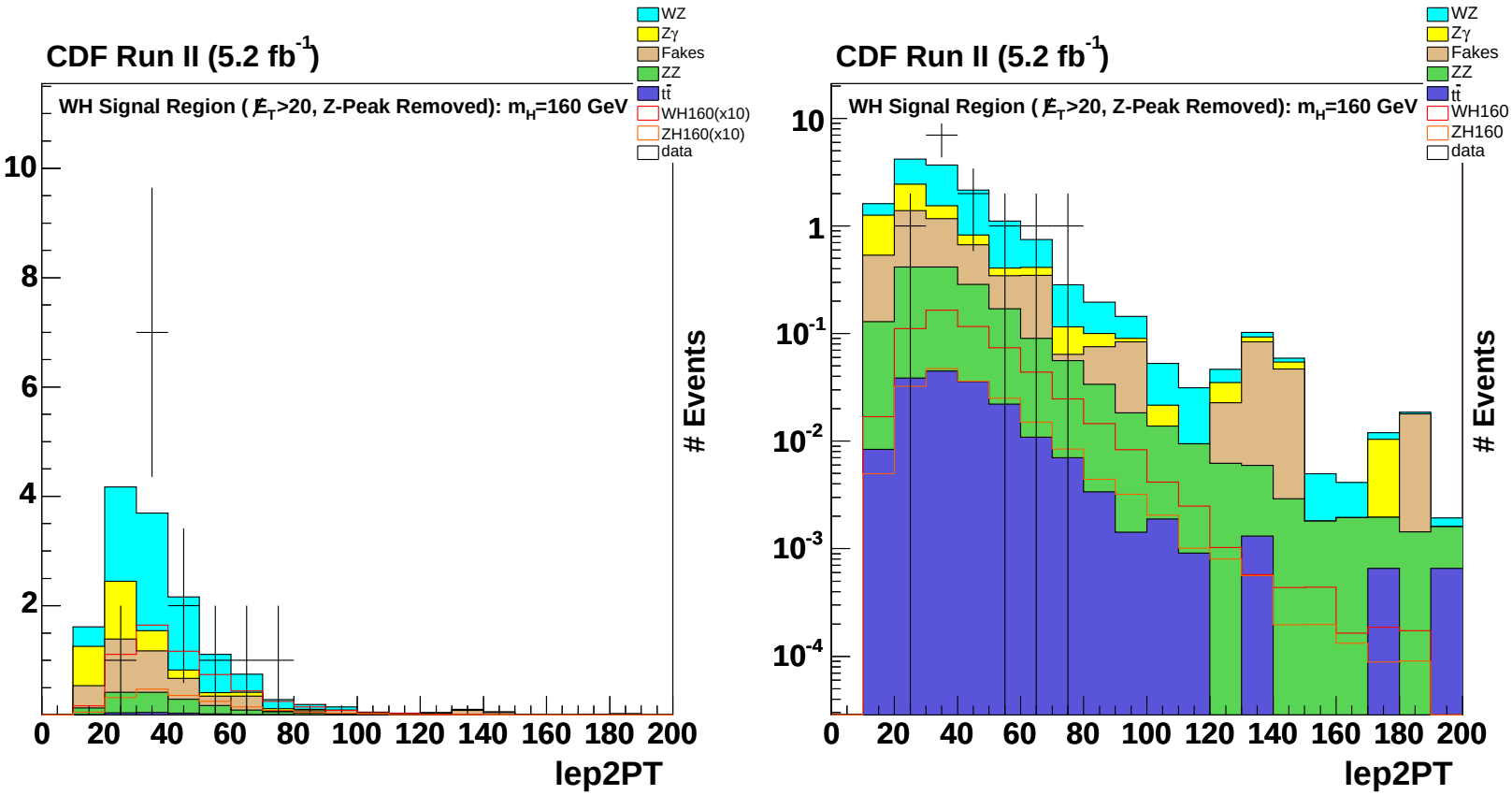


Figure: [For Public Release Blessing]

WH Signal: ΔR Opp. Sign. Leptons Far

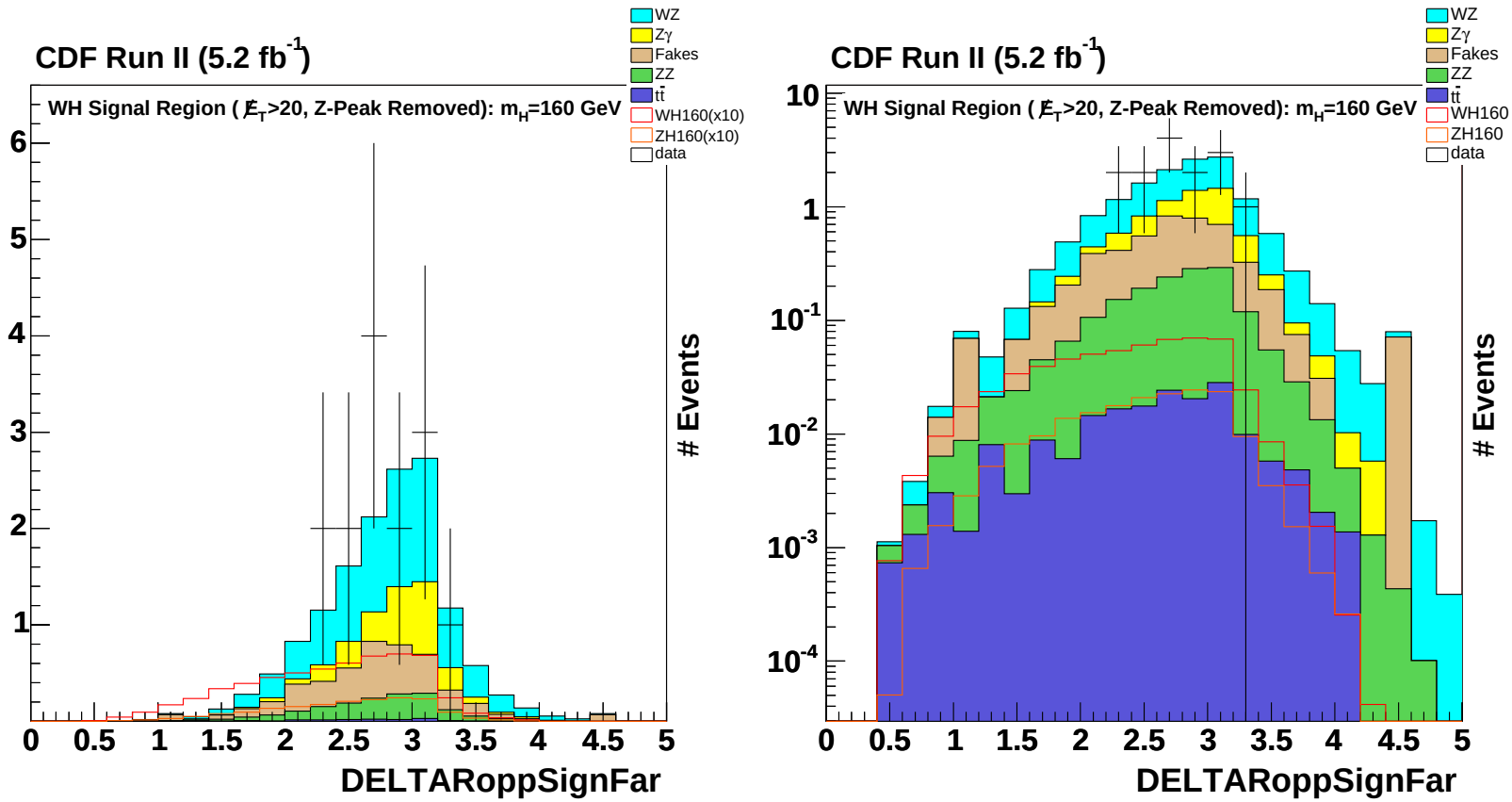


Figure: [For Public Release Blessing]

WH Signal: m_T trimass

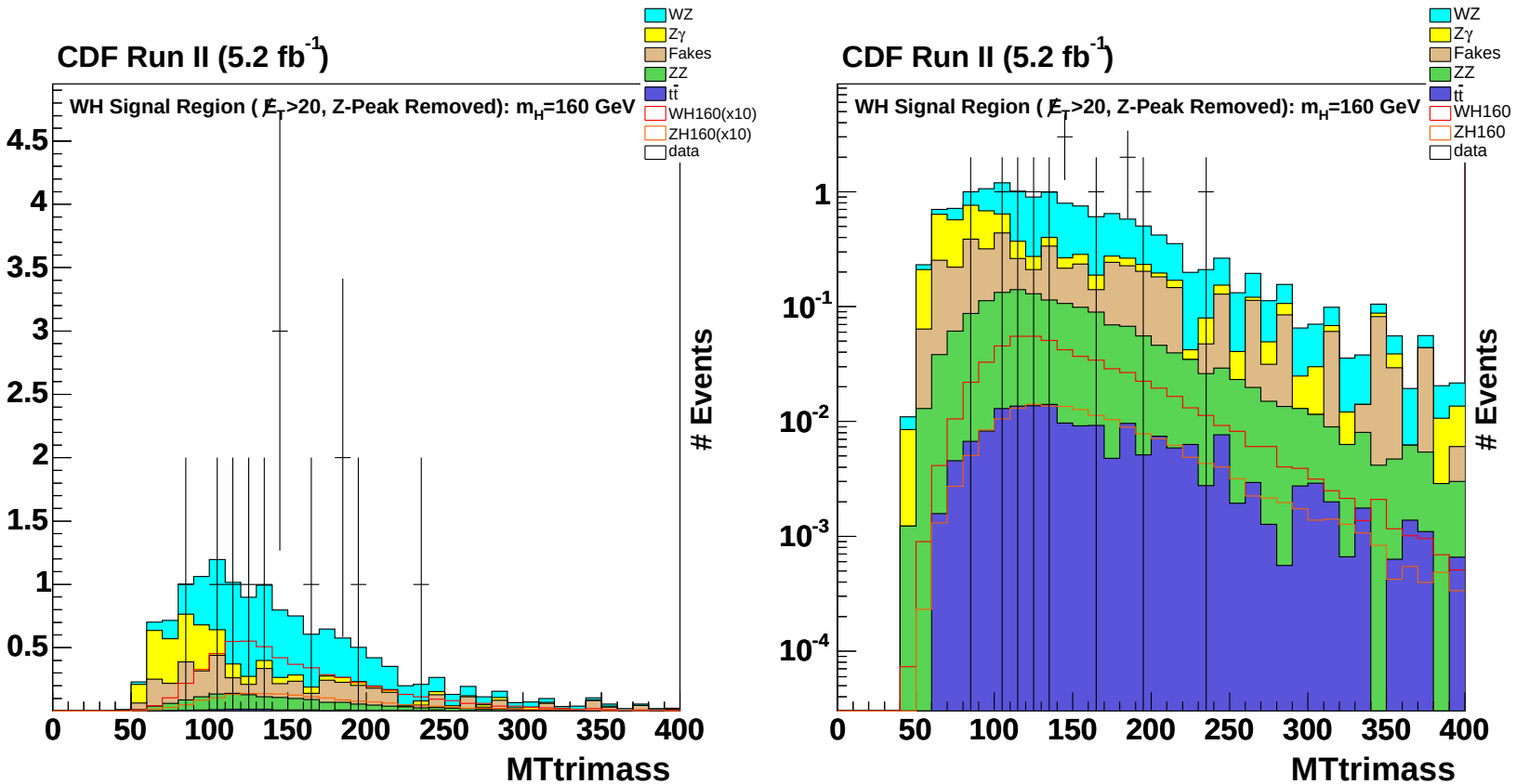


Figure: [For Public Release Blessing]

WH Signal: NJet

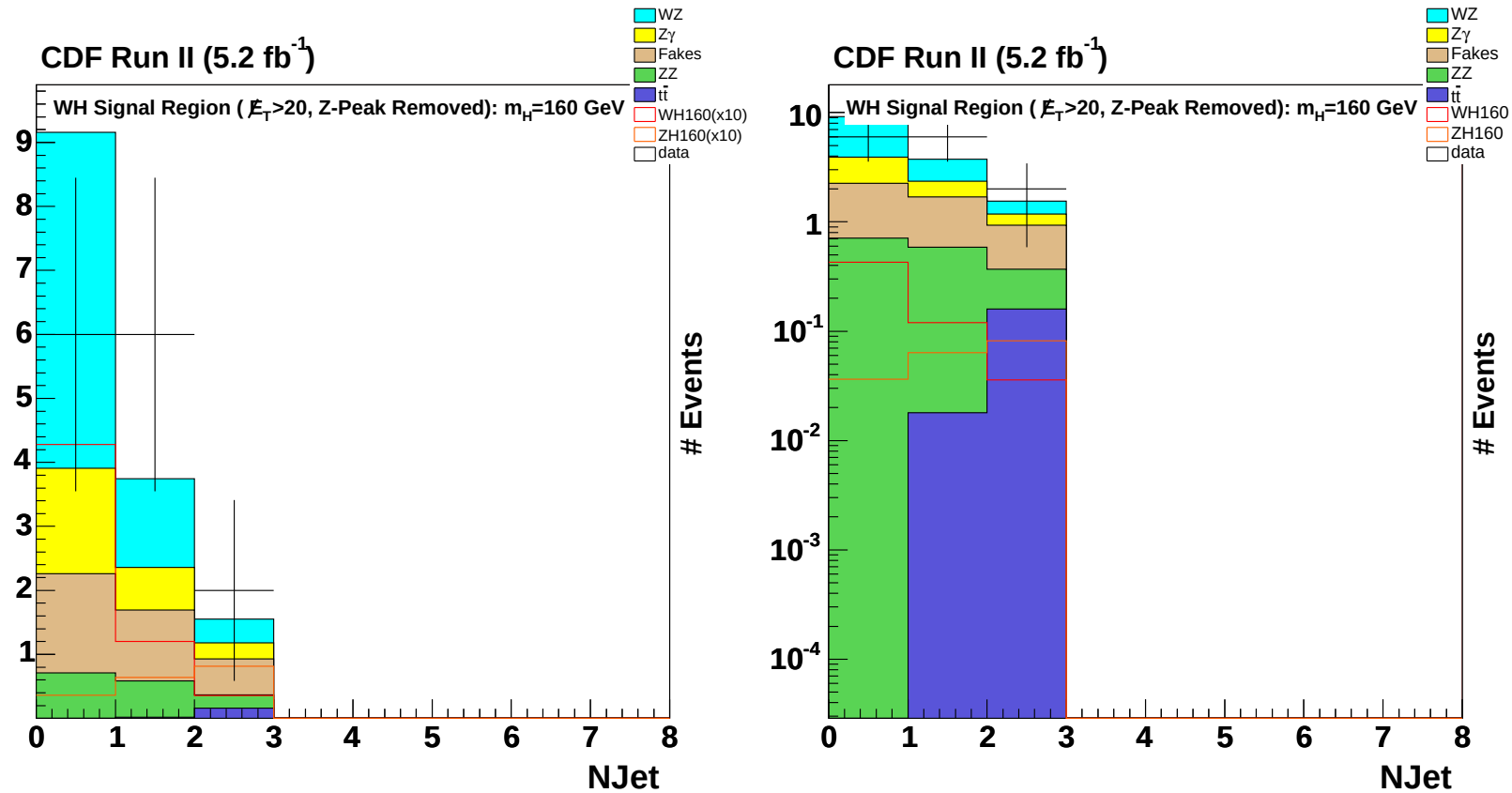


Figure: [For Public Release Blessing]

WH Signal: m_T (3rd Lep.,$\not\!\!E_T$)

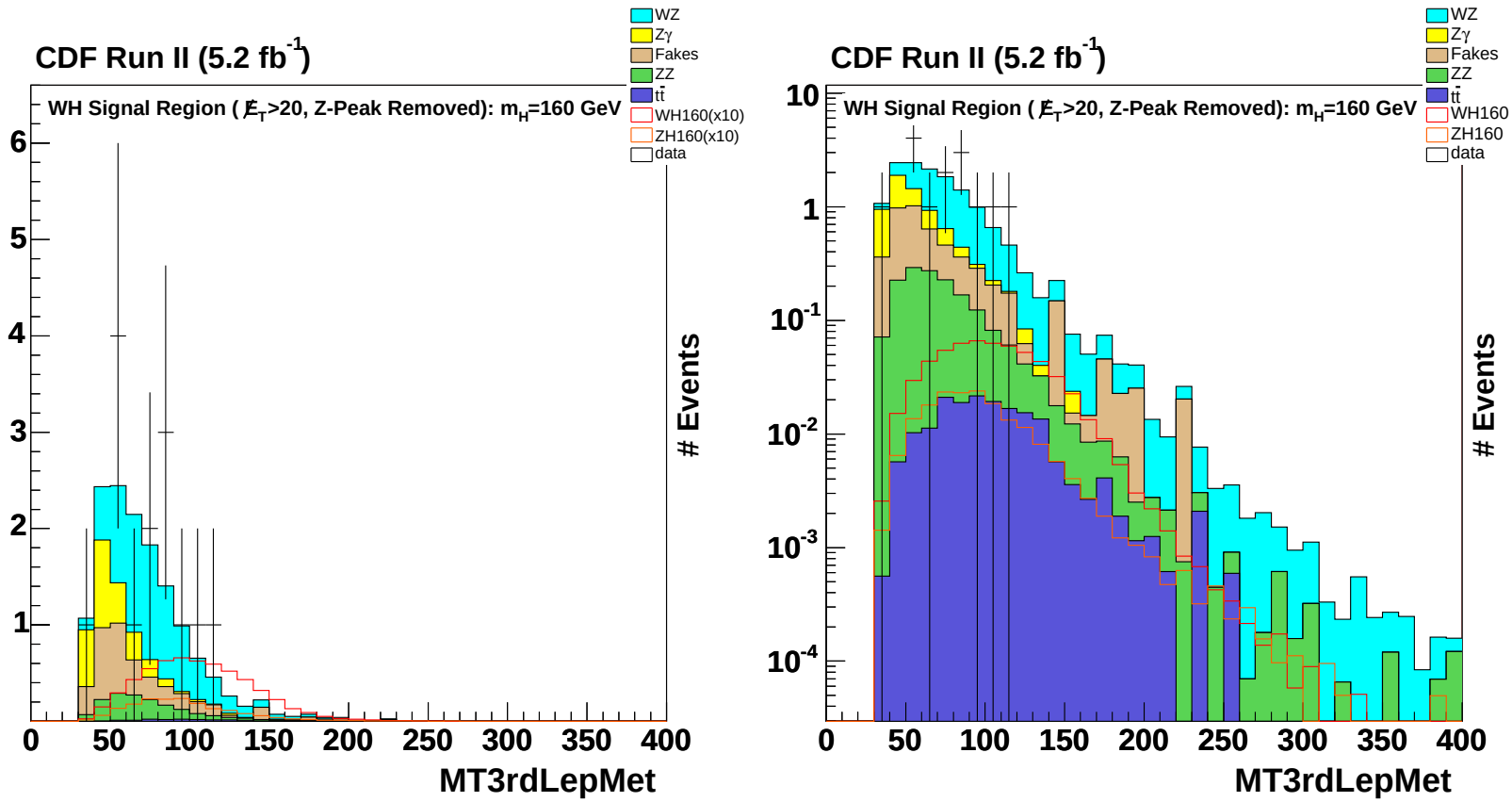


Figure: [For Public Release Blessing]

WH Signal: Inv. Mass(1st Lep., 2nd Lep., $\not\!\!E_T$)

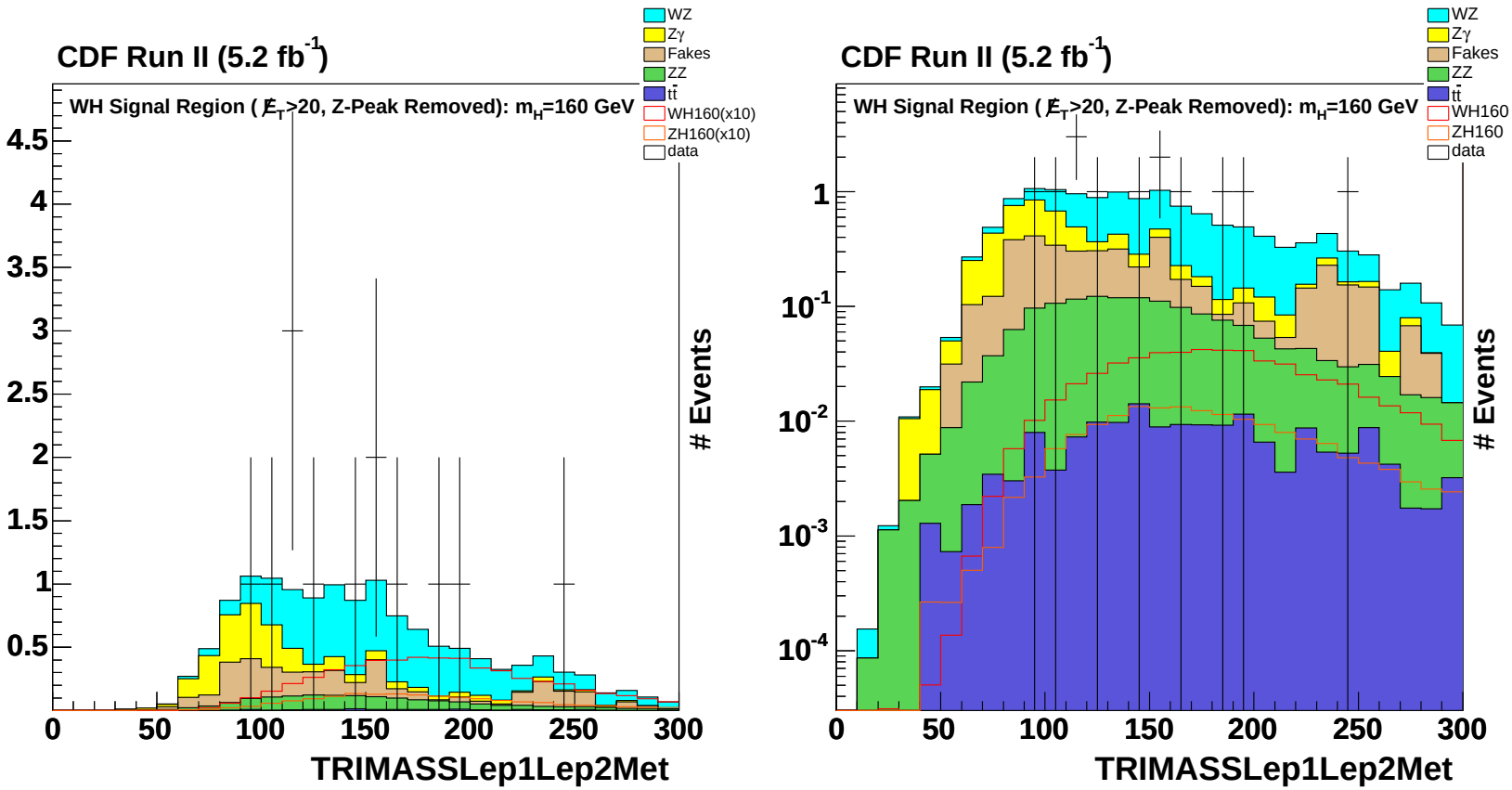


Figure: [For Public Release Blessing]

ZH Signal: NJet

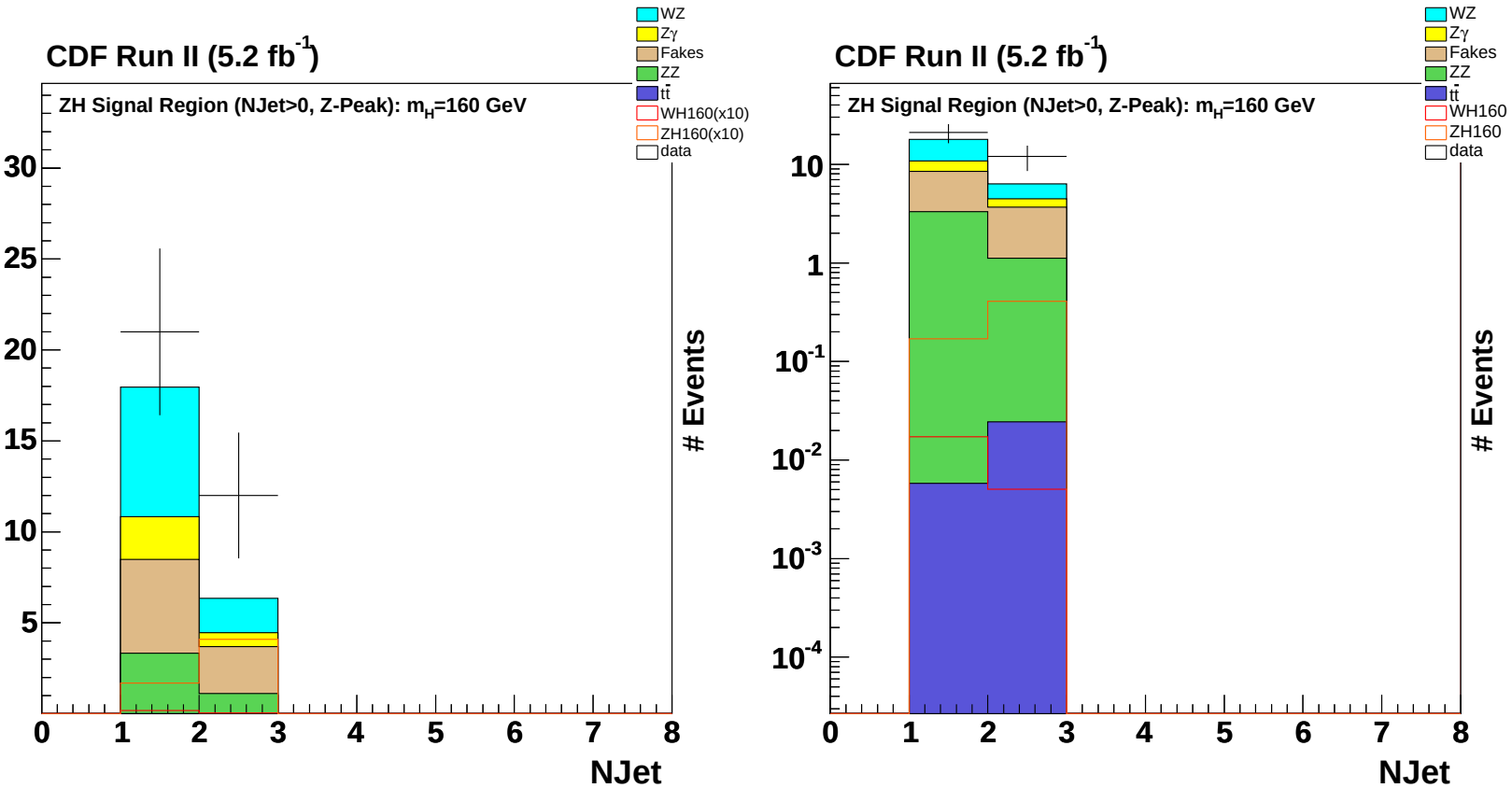


Figure: [For Public Release Blessing]

ZH Signal: $\not\!\!E_T$

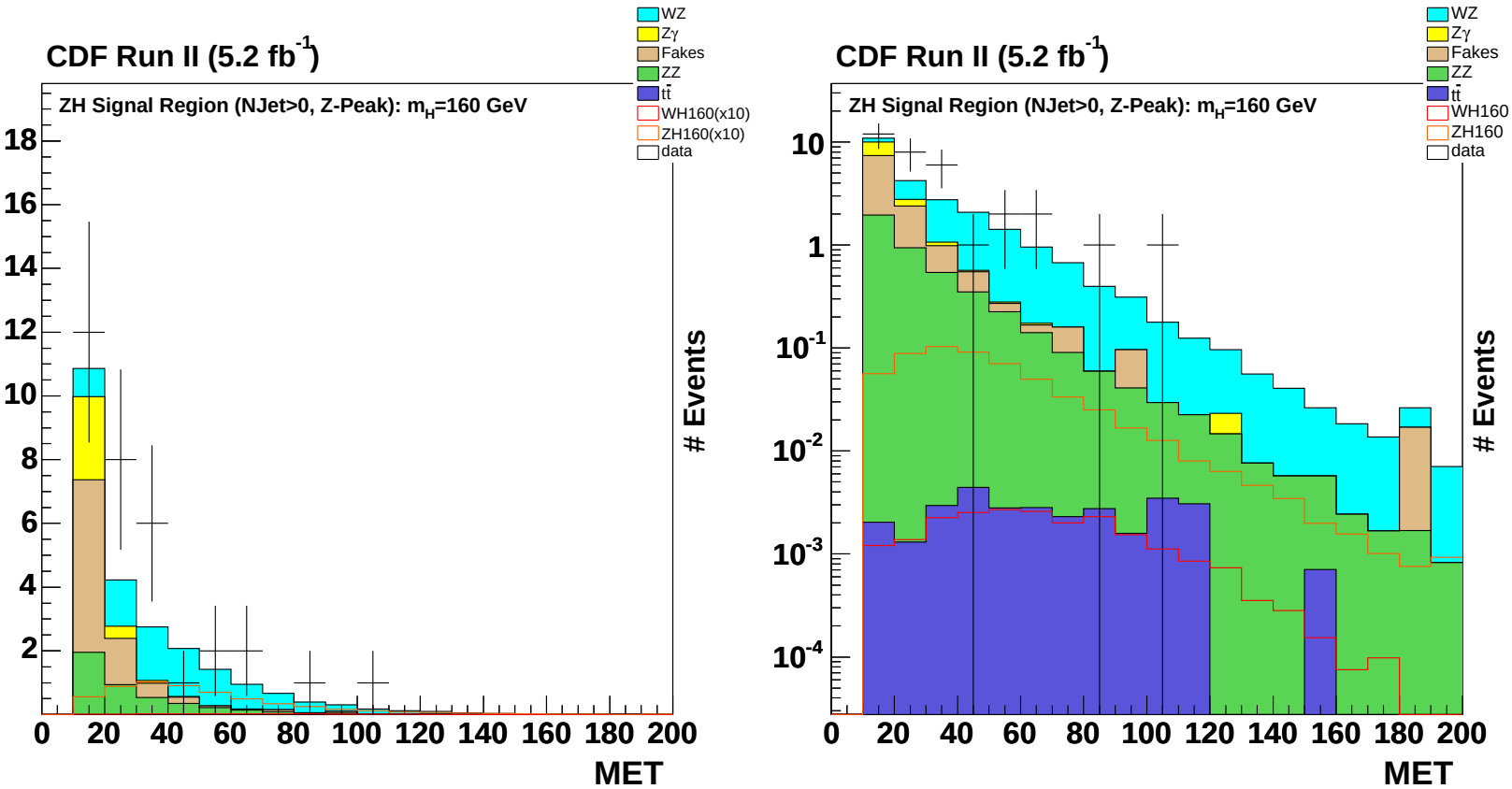


Figure: [For Public Release Blessing]

ZH Signal: Lead Jet E_T

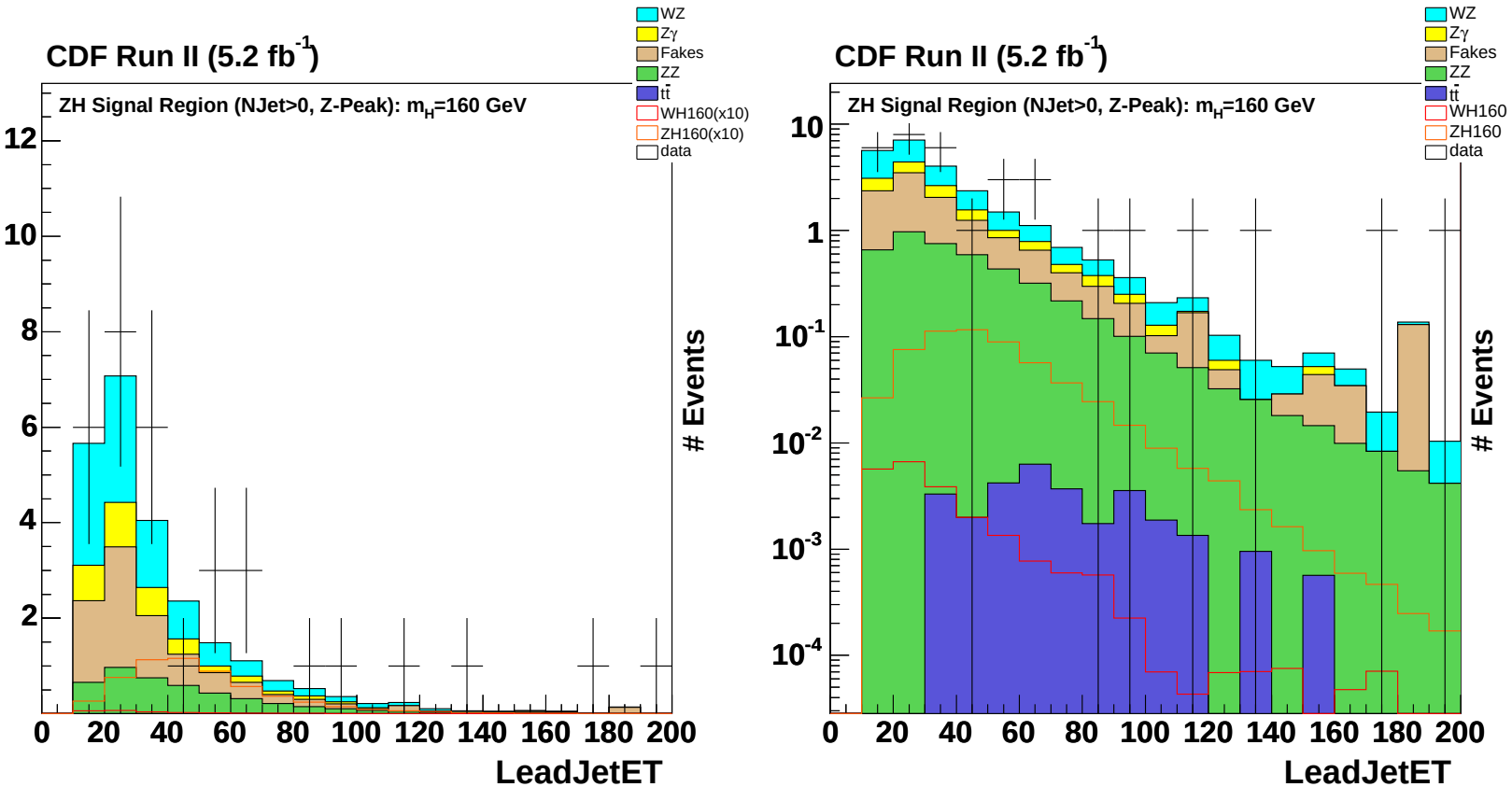


Figure: [For Public Release Blessing]

ZH Signal: ΔR(*W*-Lep.,Lead Jet)

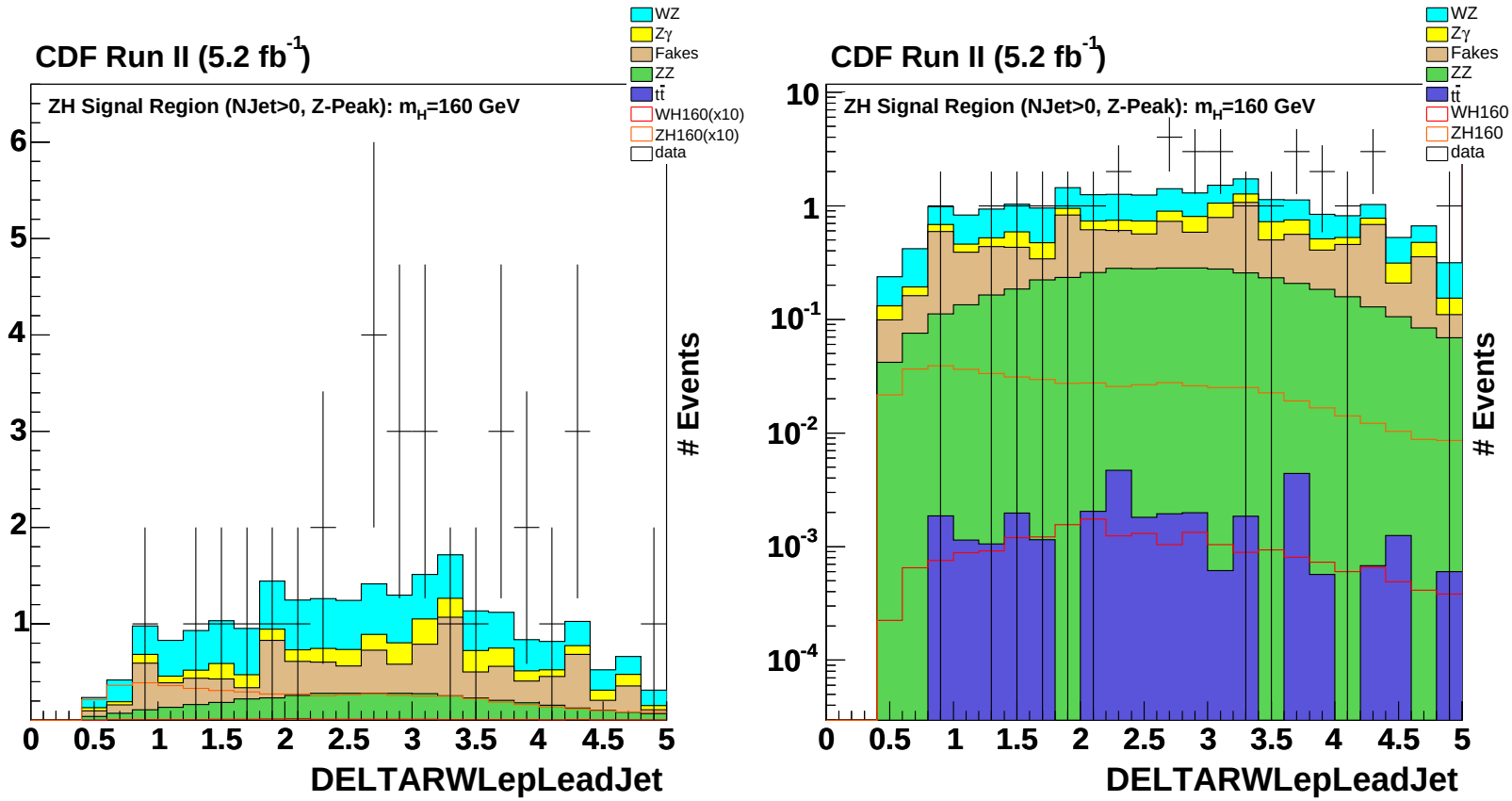


Figure: [For Public Release Blessing]

ZH Signal: $\Delta\phi$(all Lep., $\not\!\!E_T$)

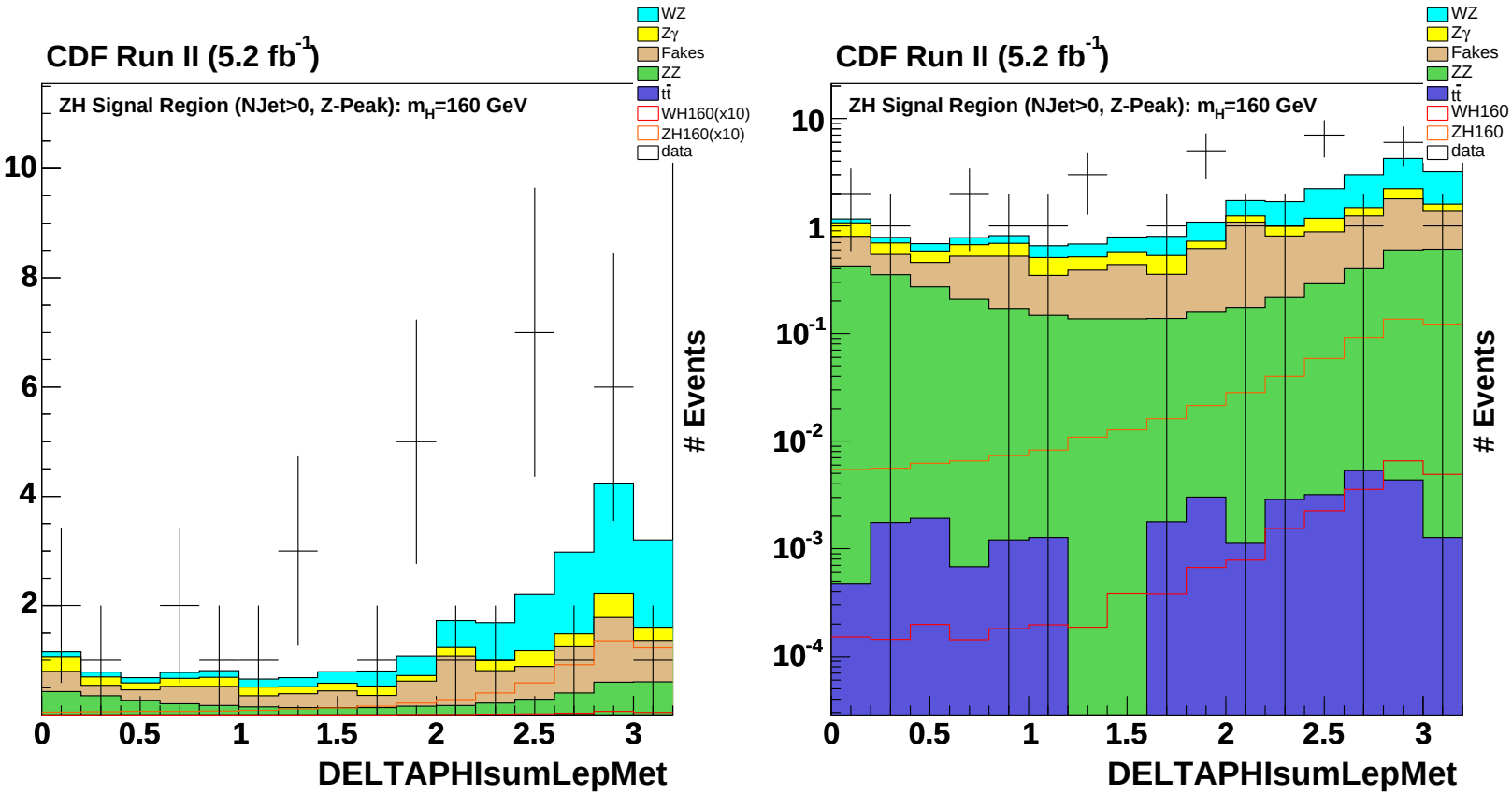


Figure: [For Public Release Blessing]

ZH Signal: H_T

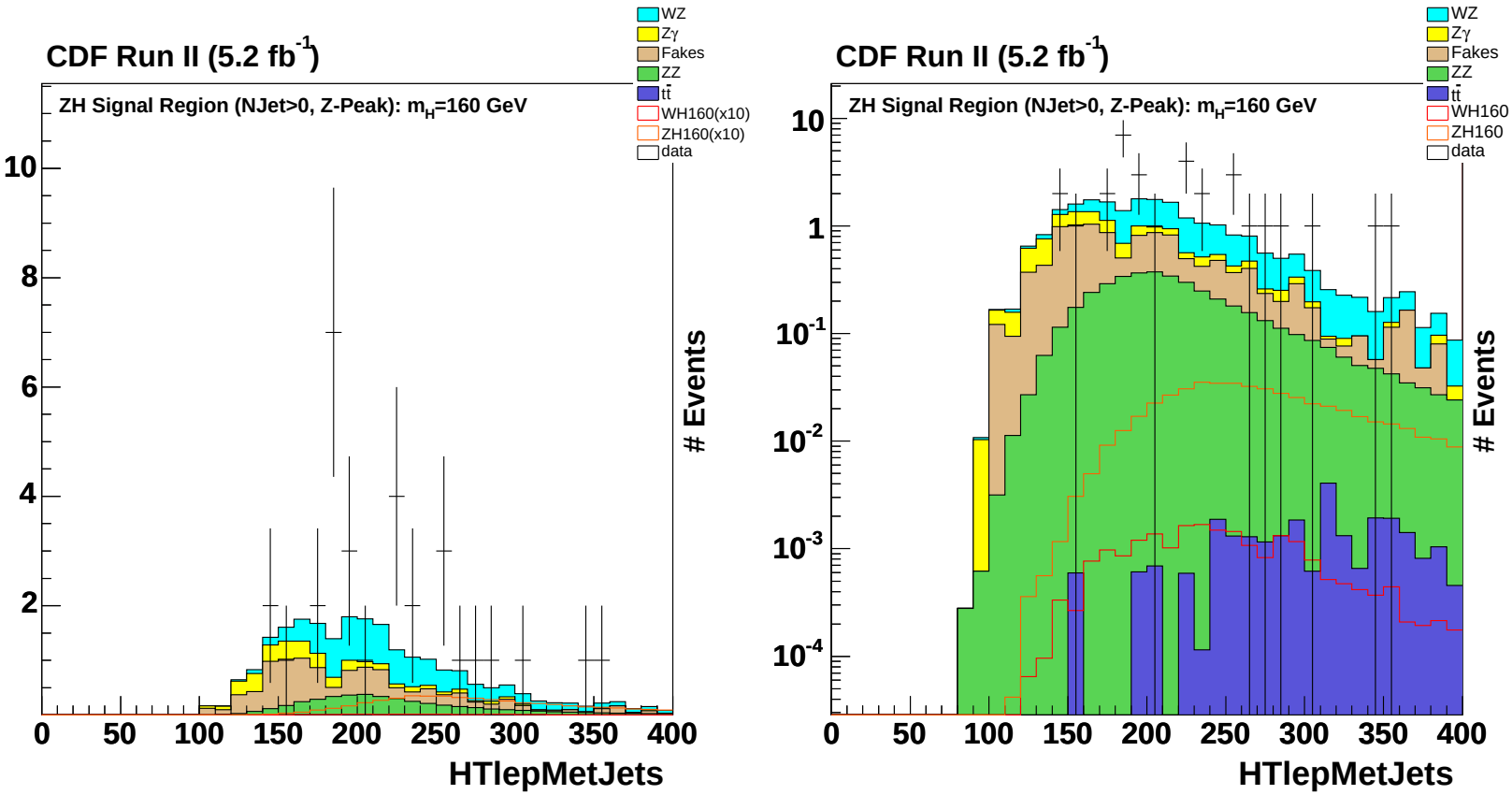


Figure: [For Public Release Blessing]

ZH Signal: m_T(all Lep.,$\not\!\!E_T$,Jets)

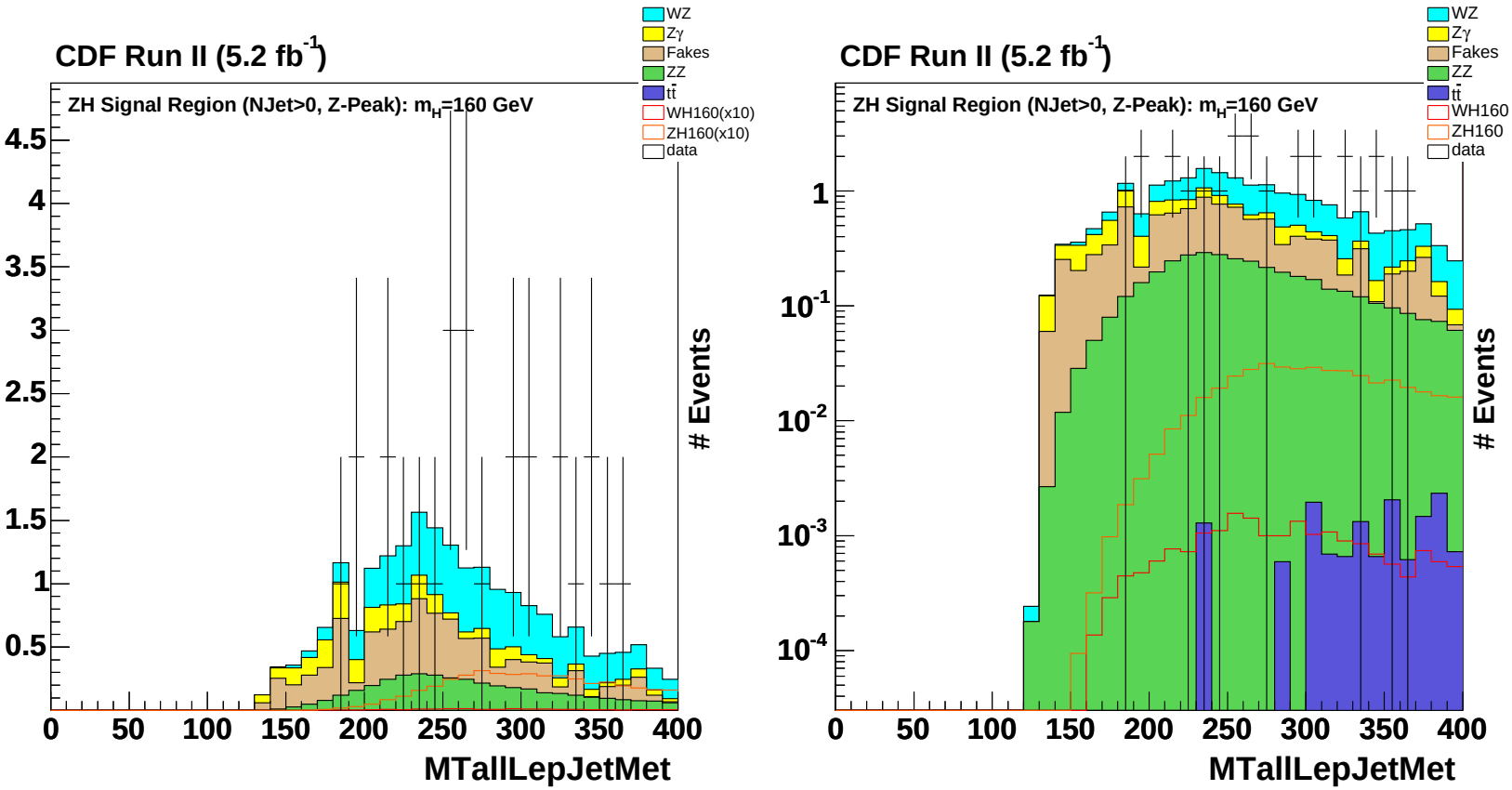


Figure: [For Public Release Blessing]

ZH Signal: $\Delta\phi$ (2nd Lep.,$\not\!\!E_T$)

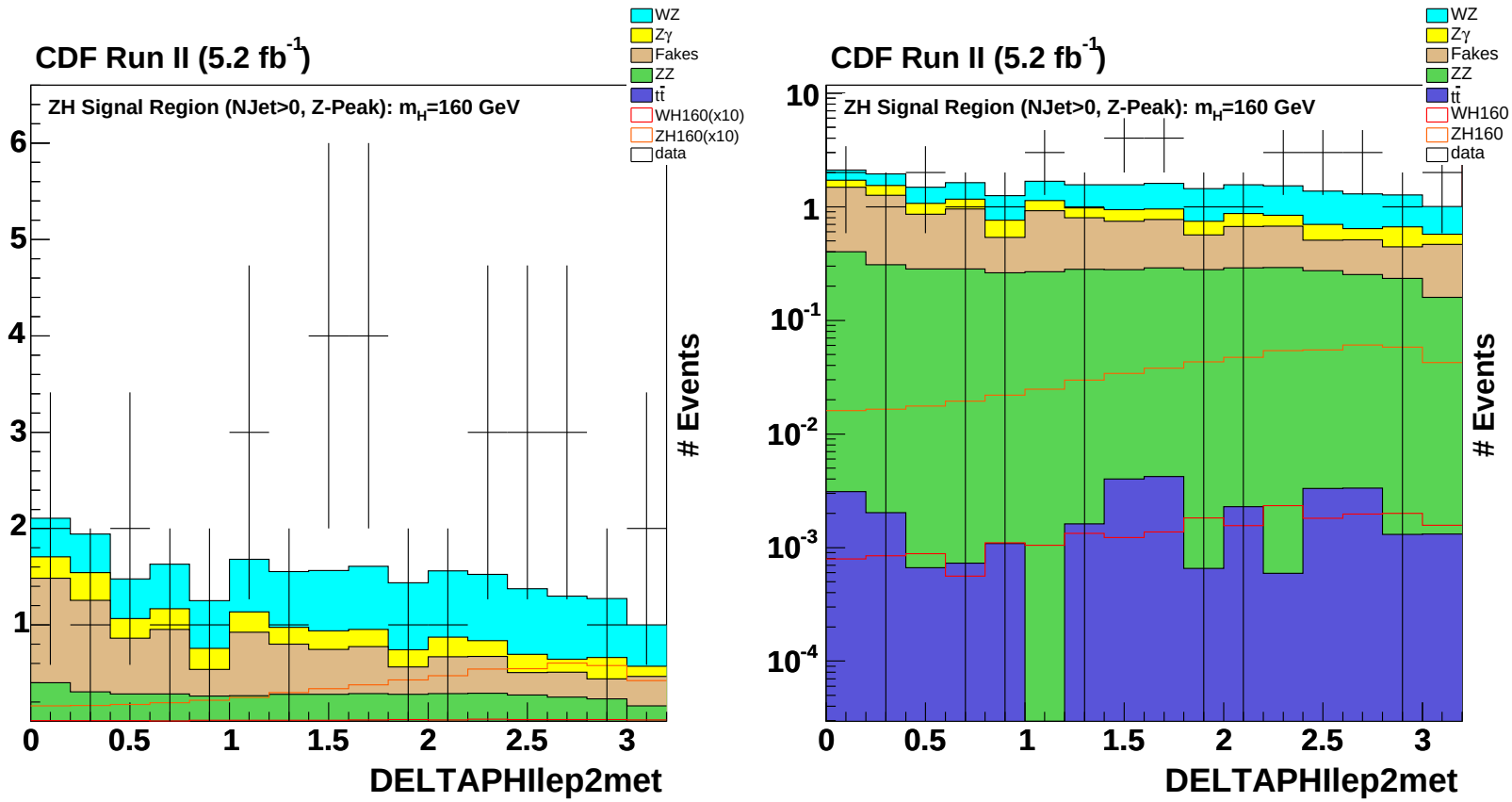


Figure: [For Public Release Blessing]

ZH Signal: ΔR Opp. Sign Closer Leptons

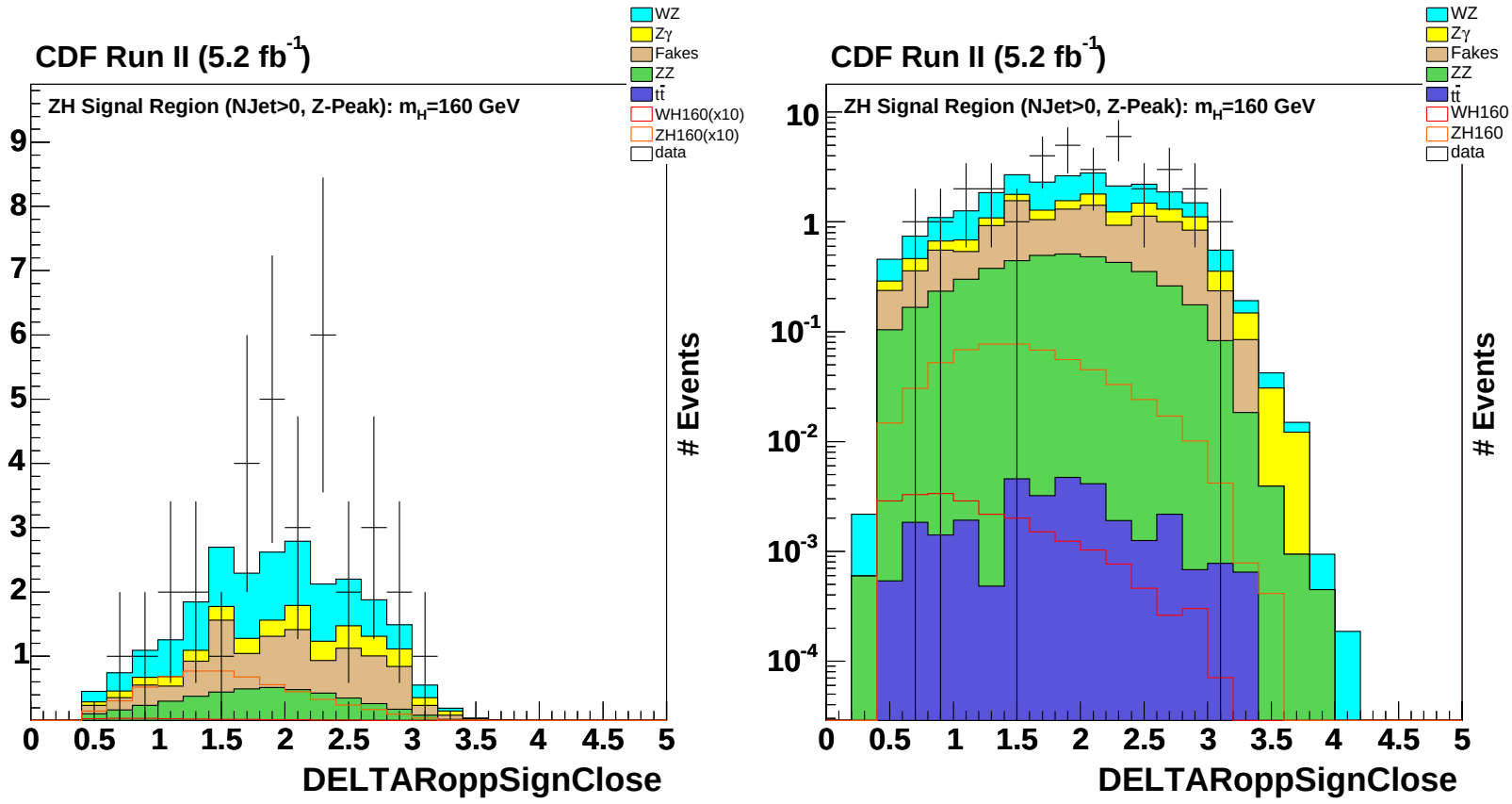


Figure: [For Public Release Blessing]

ZH Signal: Trilepton Inv. Mass

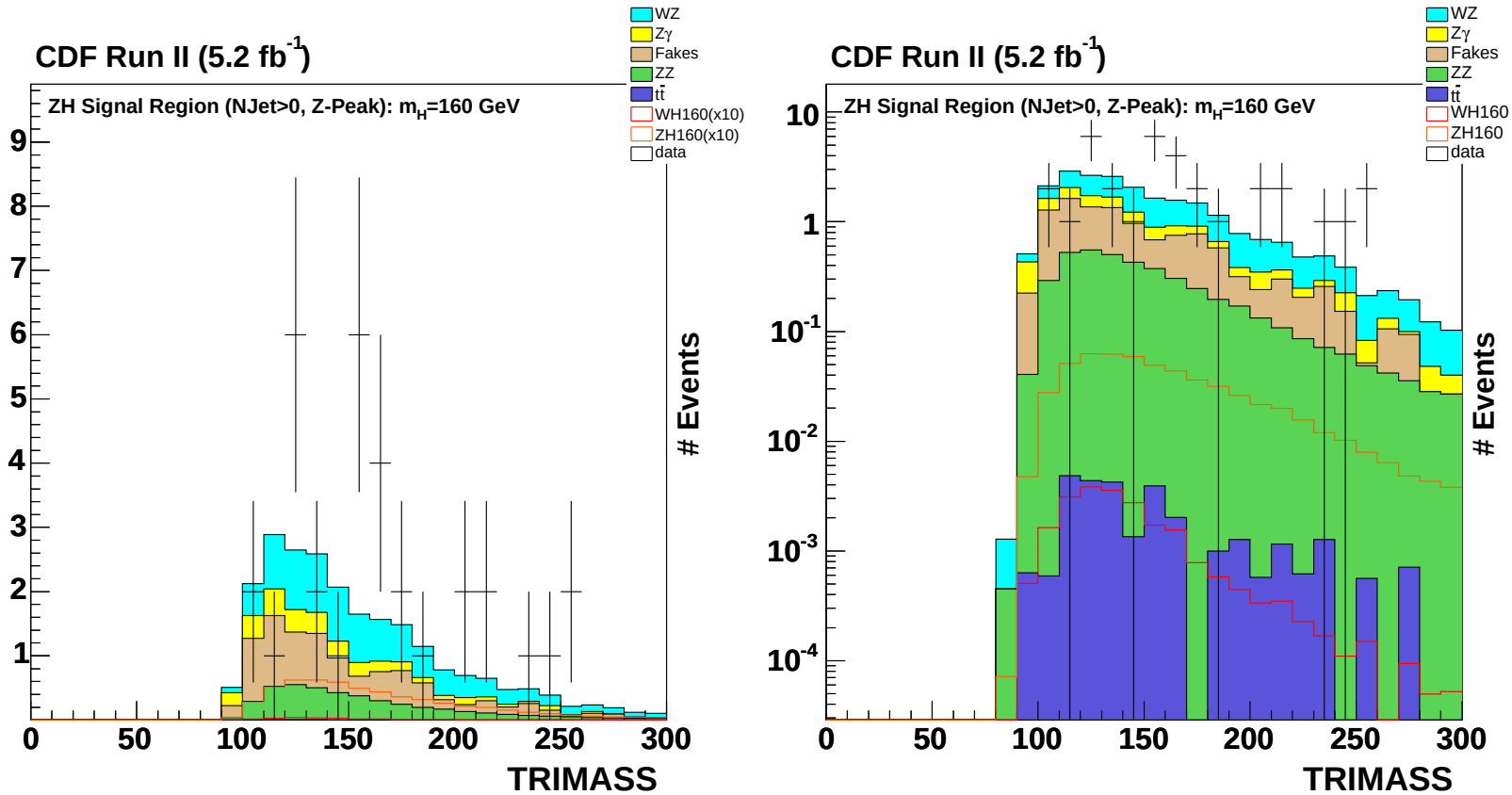


Figure: [For Public Release Blessing]

ZH Signal: Inv. Mass(3rd Lep.,$\not\!\!E_T$, Jets)

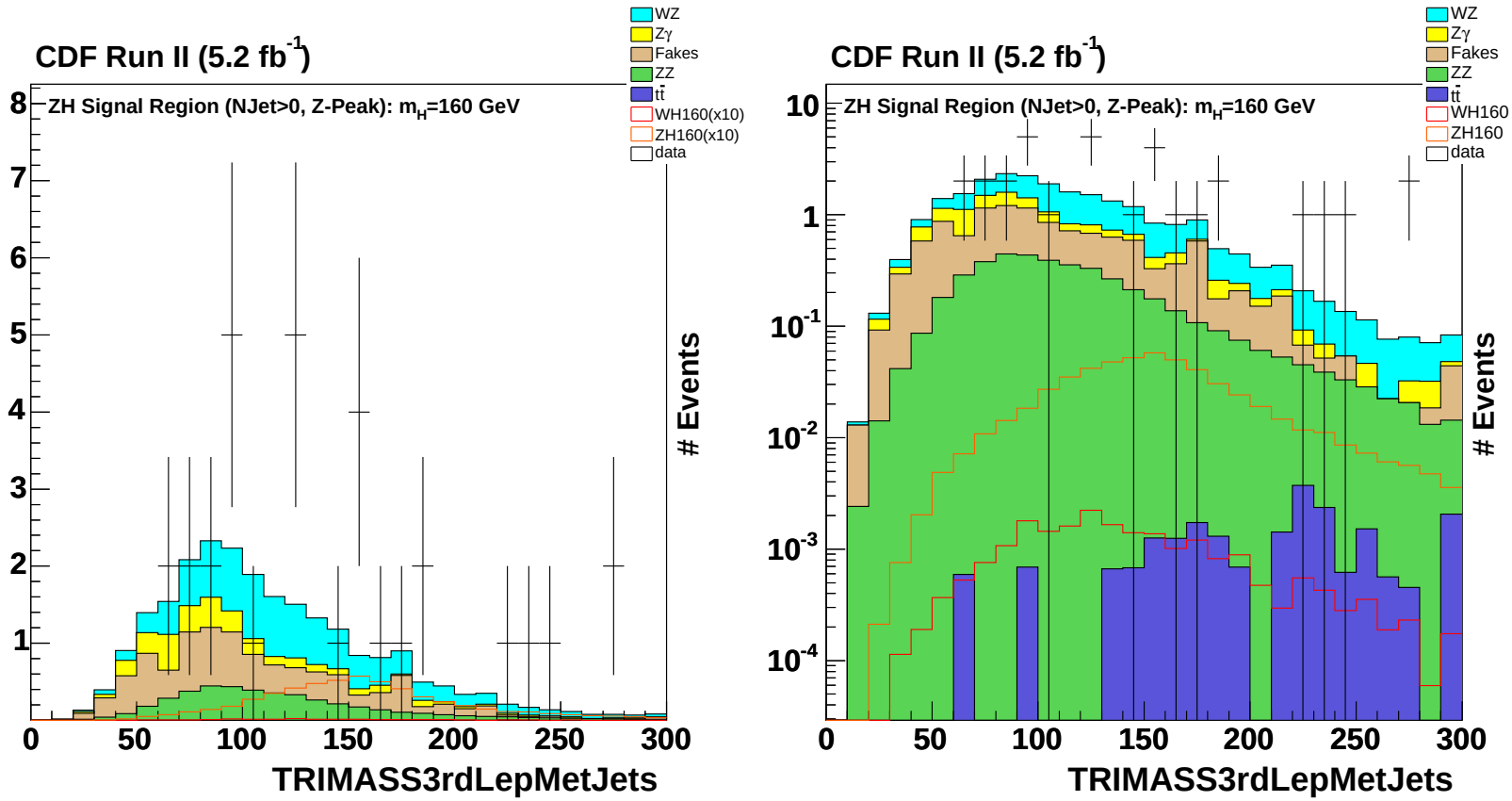


Figure: [For Public Release Blessing]

ZH Signal: Dimass (*W*-Lep., $\not\!\!E_T$)

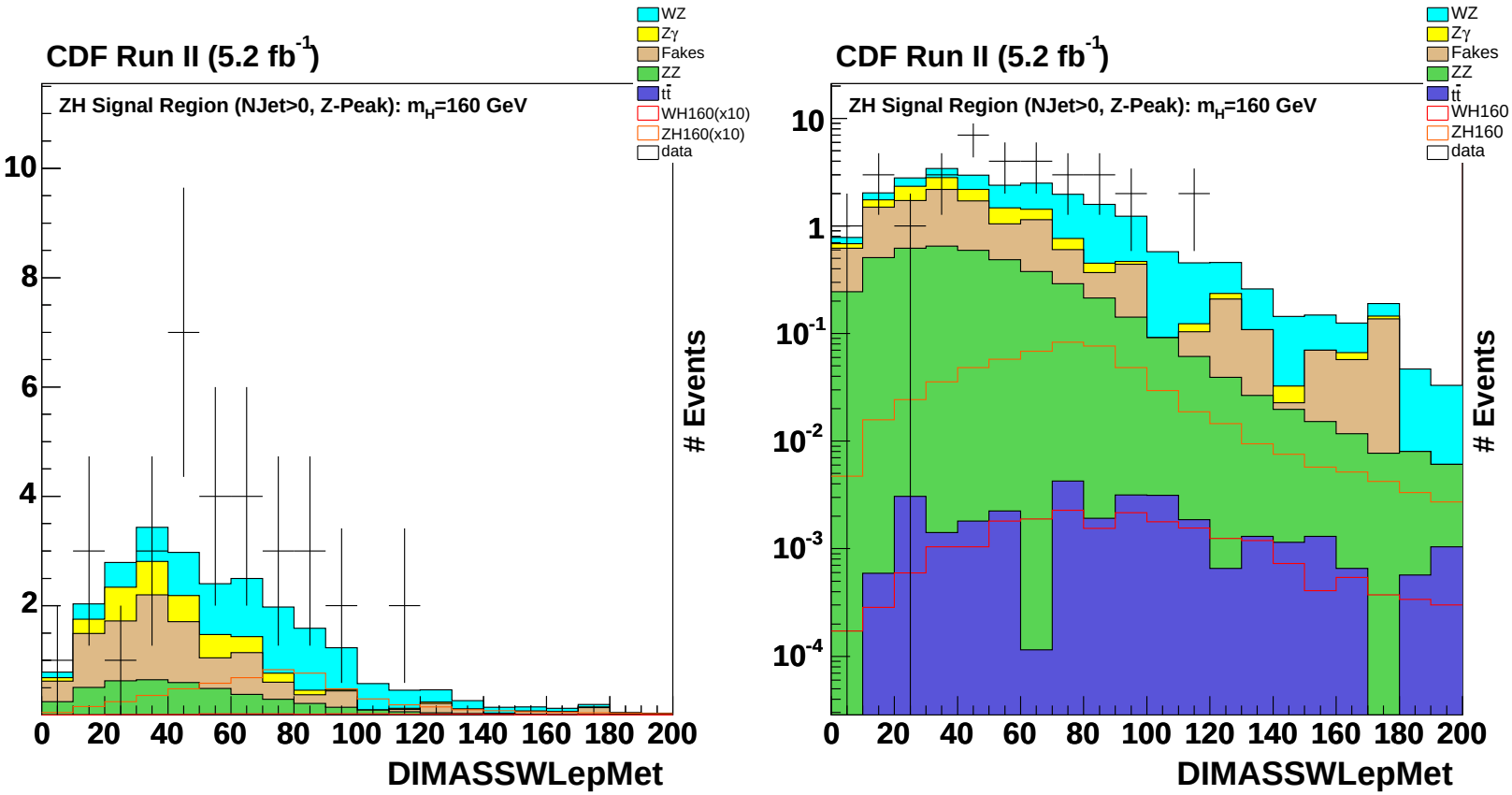


Figure: [For Public Release Blessing]

ZH Signal: m_T all Jets

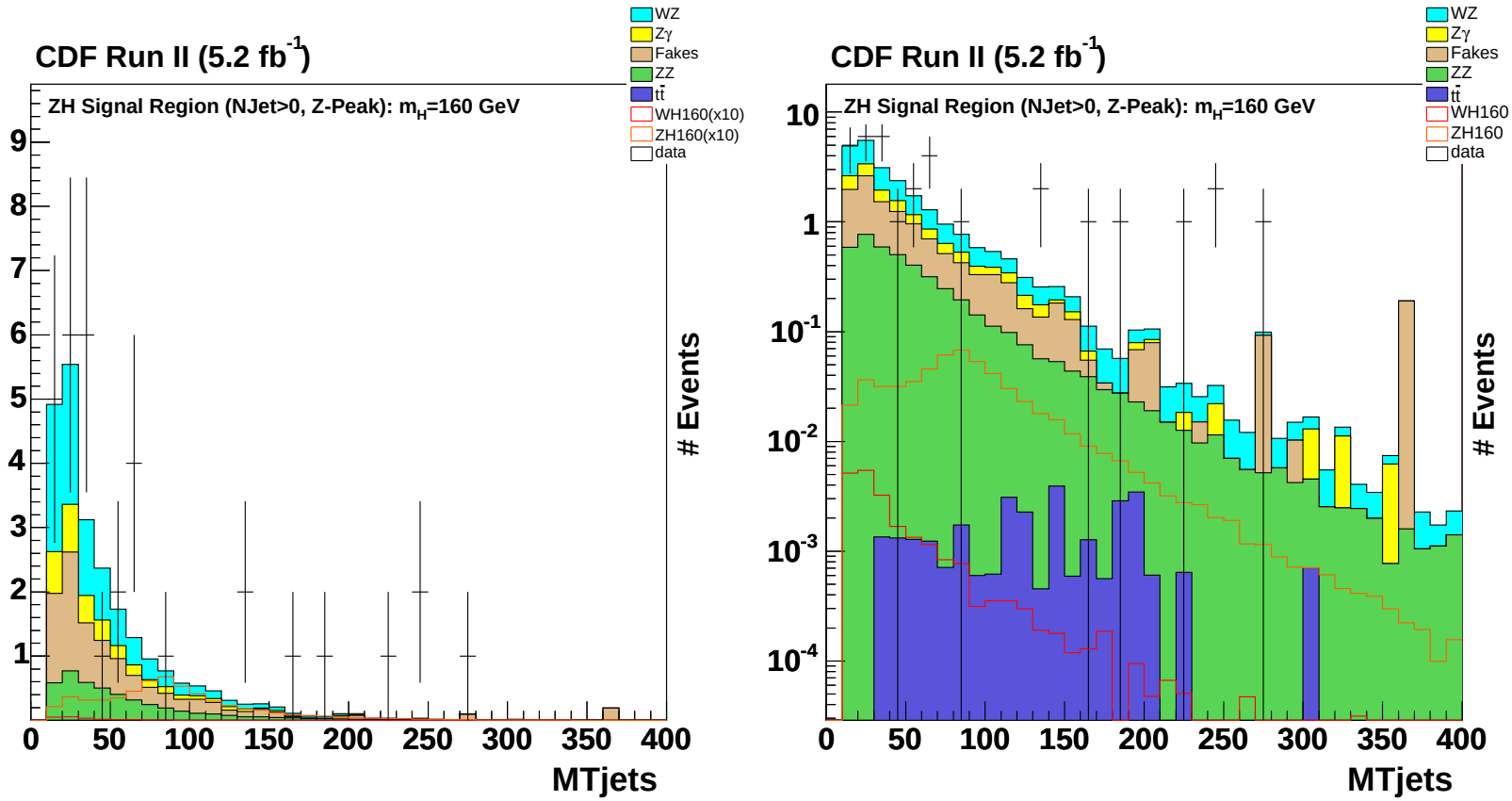


Figure: [For Public Release Blessing]

ZH Signal: m_T(*W*-Lep.,$\not\!\!E_T$)

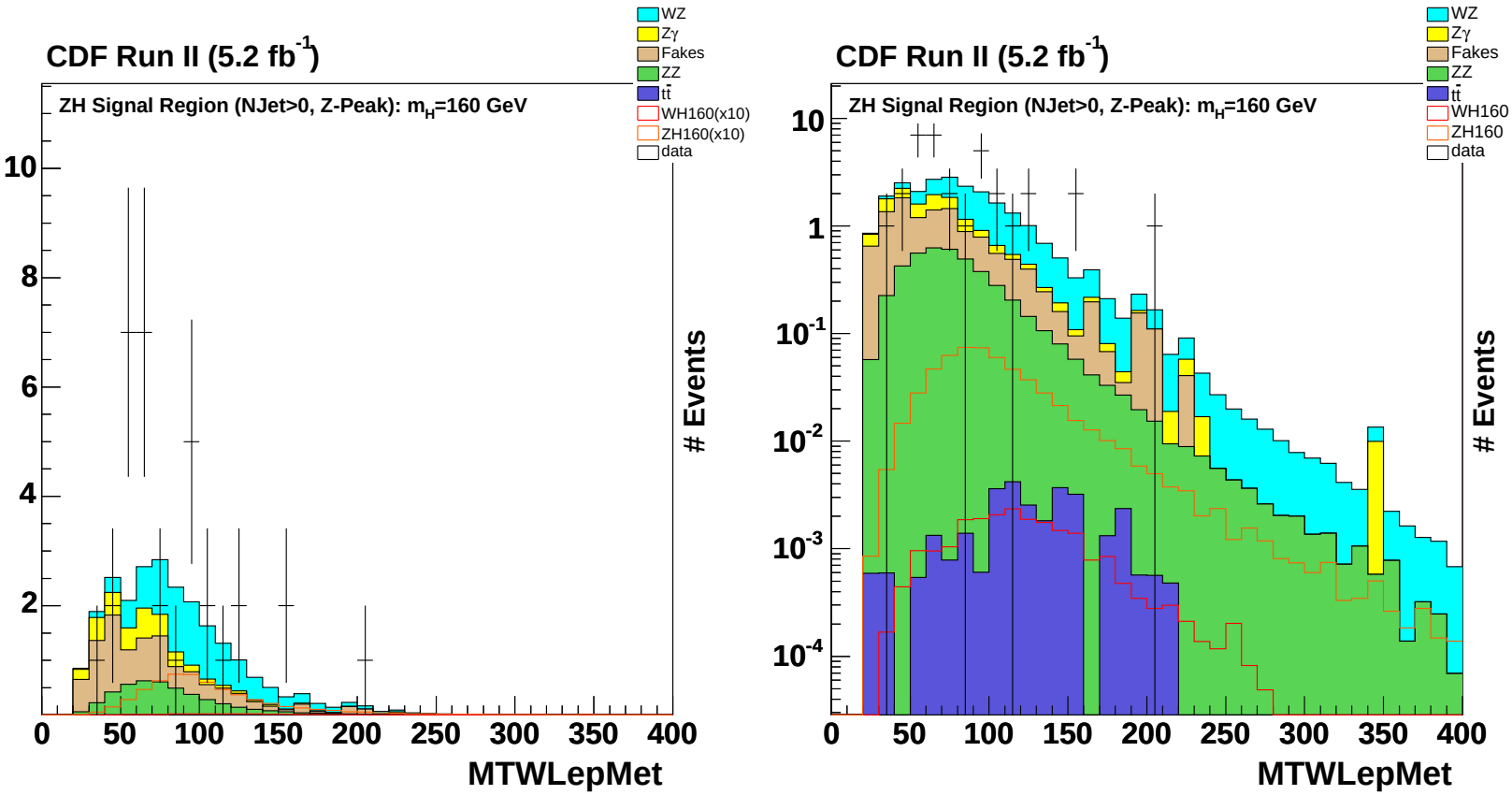


Figure: [For Public Release Blessing]

ZH Signal: $\Delta\phi$ (Sum O.S. Lep's Near *Z*-mass,3rd Lep)

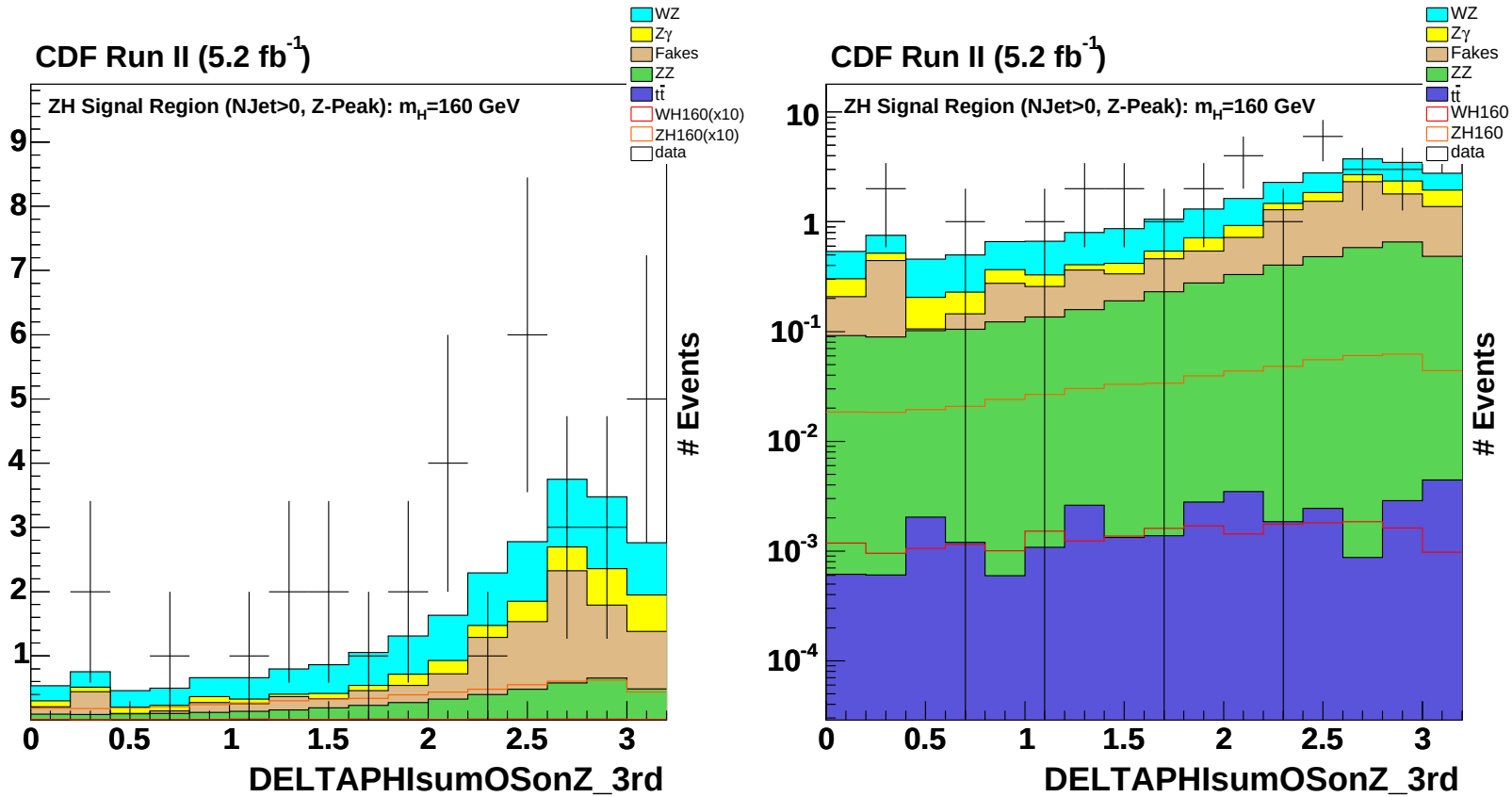


Figure: [For Public Release Blessing]

ZH Signal: ΔR Opp. Sign Leptons (far)

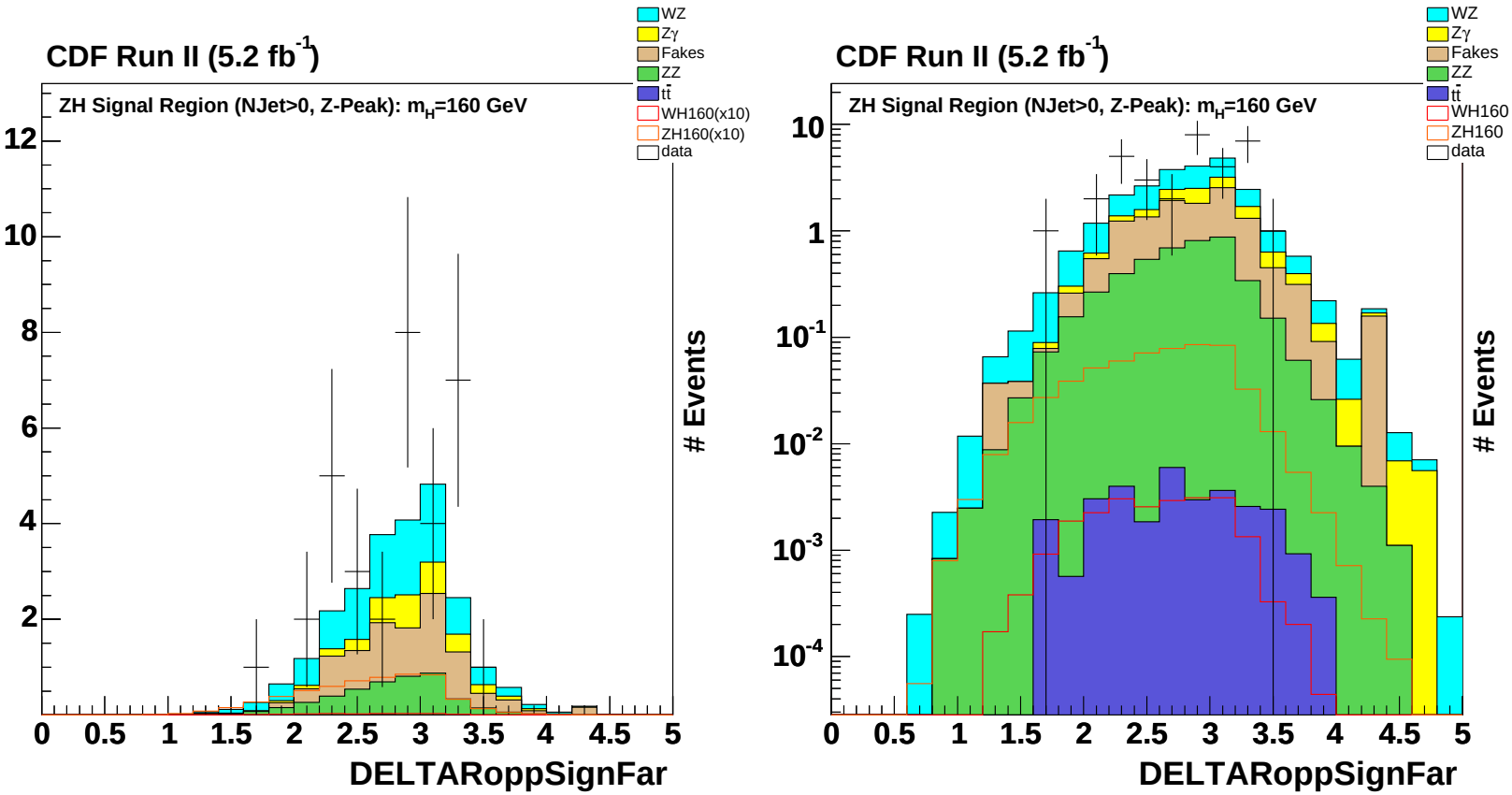


Figure: [For Public Release Blessing]