Search for a low-mass charged Higgs boson in $t\bar{t}$ decay of pp collisions at $\sqrt{s} = 13$ TeV and Muon Tomography of HGCAL detector

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Higgs PAG presentations : March 14, 2022, November 22, 2021, August 02, 2021, March 15, 2021.
HGCAL GEANT activity : Nov 12, 2021, Oct 1, 2021, Sept 17, 2021, Sept 10, 2021.
HGCAL DPG : Oct 27, 2021, Oct 13, 2021.
HGCAL General Meetings Spring 22: Mar 29, 2022.

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Plan of the talk

- Physics analysis
  - Physics Motivation
  - Signal and Backgrounds
  - Object and event selection
  - Kinematic fitting
  - Charm tagging
  - Results
  - Summary and Outlook
- Muon Tomography of HGCAL detector
  - Issues with muon energy loss in HGCAL
  - Origin of the issues
  - Validation of the solution
  - Summary and Outlook

Physics Motivation - I

- Limitations of SM
  - $m_\nu \neq 0$
  - Matter-antimatter asymmetry
  - No explanation of dark matter
  - Does not include gravity
- Two Higgs Doublet Model (2HDM)
  - A minimal extension of one Higgs doublet to two Higgs doublets $\rightarrow$ Eight scalar fields
  - Three of eight fields participate in SSB leaving five.
    - Two neutral CP-even Higgs fields (h, H)
    - One pseudoscalar (CP-odd) Higgs field A
    - Two charged Higgs $H^{\pm}$
- Four types of 2HDM based on coupling to quarks and leptons
  - Type I, II, X, Y
  - Our concern is Type II, where up-type quark interact with second Higgs doublet (ϕ_2) and down-type and leptons interact with the ϕ_1
  - MSSM corresponds type-II of 2HDM and can answer the first three problems of SM [NPB 887 (2014) 338, RMP 76 (2004) 1, JOP Conf 689(2016) 012001]

Physics Motivation - II

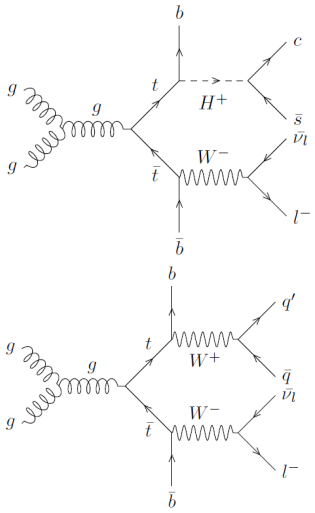
- The physical free parameters of the theory includes
  - The masses of four Higgs $[m_h, m_H, m_A, m_{H^\pm}]$
  - Combined Vacuum Expectation Value (VEV) $[\nu = \sqrt{\nu_1^2 + \nu_2^2}]$
  - Ratio of VEVs $[tan\beta = \nu_1/\nu_2]$
  - Mixing angle α
- Current study
  - SM studies do not exclude the possibility of $t \to H^\pm q$
  - The $H^\pm$ has non-zero decay possibility to heavy quarks and leptons
- Previous limit by our group : PRD 102, 072001 (2020)
  - $Br(t \to H^\pm b) < (1.68 - 0.25)\%$ for m_{H^+} (80 – 160) GeV in pp collisions at $\sqrt{s} = 13$ TeV with $\mathcal{L}_{\text{int}} = 35.9$ fb^{-1}

2016	2017	2018	Run-2
$\mathcal{L}_{\text{int}} = 35.9$ fb^{-1}	$\mathcal{L}_{\text{int}} = 41.5$ fb^{-1}	$\mathcal{L}_{\text{int}} = 59.7$ fb^{-1}	$\mathcal{L}_{\text{int}} = 137.1$ fb^{-1}

Signal and Backgrounds

- Signal : $t\bar{t} \to H^+W^-b\bar{b}$; $H^+ \to c\bar{s}$, $W^- \to l^-\bar{\nu}_l$
  - Minimal event topology : Two b-tagged jets, two light jets (one of which is tagged as c-jet), one lepton and $\not{E}_T$
  - Additional constrain : Kinematic fitting
  - The m_{jj} distribution is the observable for this search
- Backgrounds
  - SM $t\bar{t}$ + jets: [94.7% (e) or 93.6% (μ) of total background]
    - $t\bar{t} \to W^+W^-b\bar{b}$; $H^+ \to c\bar{s}$, $W^- \to l^-\bar{\nu}_l$
  - Single top quark : [3.3% (e) or 3.4% (μ)]
  - QCD multijet [0.2% (e) or 1.4% (μ)]
  - W + jets (upto 4 jets) [1.2% (e) or 1.3% (μ)]
  - Z/γ + jets (upto 4 jets) [0.4% (e) or 0.2% (μ)]
  - VV : Vector Boson Fusion [0.1% (e) or 0.1% (μ)]

(Feynman diagram of other backgrounds are at link.)



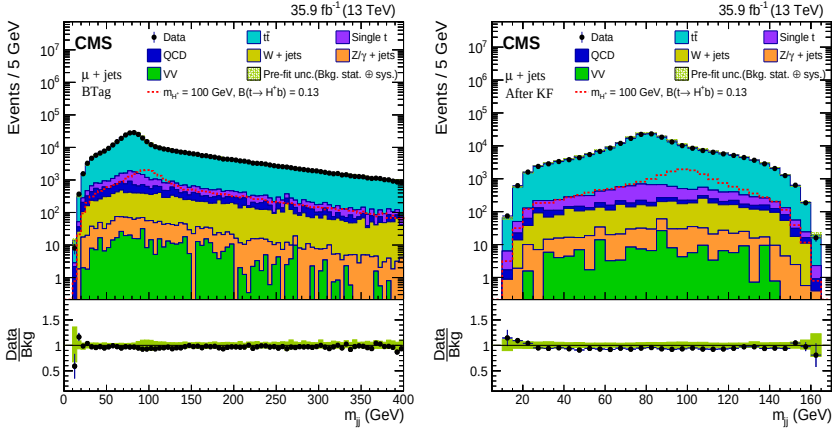
Signal(above) and SM $t\bar{t}$ background (below).

Object and event selection

Channel	Cut type	2016	2017	2018
Event	MET	MET_filter	MET_filter & ecalBadCalibFilter	MET_filter & ecalBadCalibFilter
	PV	$N^{dof} > 4$, $\rho = \sqrt{x^2 + y^2} < 2$ cm, $\lvert z \rvert < 24$ cm		
	Link: https://twiki.cern.ch/twiki/bin/view/CMS/MissingETOptionalFiltersRun2			
μ	HLT	IsoMu24 or IsoTkMu24	IsoMu27	IsoMu24
	p_T (Medium ID,Veto)	$p_T > (26, 15)$ GeV	$p_T > (30, 15)$ GeV	$p_T > (26, 15)$ GeV
	(η, I^{μ}_{rel})	Tight = $(\lvert\eta\rvert < 2.4, I^{\mu}_{rel} < 0.15)$, Veto = $(\lvert\eta\rvert < 2.4, I^{\mu}_{rel} < 0.4)$		
	N^{μ}	1		
	Link: https://twiki.cern.ch/twiki/bin/view/CMS/SWGuideMuonIdRun2			
e	HLT	Ele27_WPTight_Gsf	Ele32_WPTight_Gsf_L1DoubleEG	Ele32_WPTight_Gsf
	p_T (Medium ID,Veto)	$p_T > (30, 15)$ GeV	$p_T > (35, 15)$ GeV	$p_T > (35, 15)$ GeV
	(η, I^{e}_{rel})	Tight = $(\lvert\eta\rvert < 2.4, I^{e}_{rel} < 0.0821[0.0695])$, Veto = $(\lvert\eta\rvert < 2.4, I^{e}_{rel} < 0.3)$		
	N^{e}	1		
	Link: https://twiki.cern.ch/twiki/bin/viewauth/CMS/CutBasedElectronIdentificationRun2			
Jet/MET	$(p_T, \eta, \Delta R)$	$p_T > 25$ GeV, $\lvert\eta\rvert < 2.4$, $\Delta R(\text{lepton}, \text{jet}) > 0.4$, tight JetID, loose PU_JetID		
	$(N^{jet}, N^{b-jet}, \not{E}_T)$	$(N^{jet} \geq 4, N^{b-jet} \geq 2, \not{E}_T \geq 20$ GeV)		
	b_{tag} (DeepJet)	(M:0.2598/0.2489)	(M:0.3040)	(M:0.2783)
	c_{tag} (DeepJet)	cVsb (M:0.370/0.353), cVsL (M:0.098/0.099)	cVsb (M:0.34), cVsL (M:0.085)	cVsb (M:0.325), cVsL (M:0.099)
	Link: https://twiki.cern.ch/twiki/bin/view/CMS/JetID			
Kinematic Fitting	$\epsilon_{\chi} = [\chi^2(n-1) - \chi^2(n)]/\text{NDF}$	$\epsilon_{\chi} < 5 \times 10^{-5}$		
	$\epsilon_c = m_{inv}[b^{jet}(q\bar{q}/l\nu_l)] - m_t$	$\epsilon_c < 0.0001$, $m_t = 172.76$ GeV and $m_W = 80.379$ GeV for $(W \to l\nu_l)$		
	N_{iter}	$N_{iter} < 500$		

- Final event topology : (One lepton + two b-tagged jets + two light jets (one of which is tagged as c-jet) + $\not{E}_T$) after Kinematic fitting.
- Status reported in Higgs PAG.

Kinematic fitting for NanoAOD - I



The m_{jj} distribution before(left) and after(right) the Kinematic fitting [see CMS AN-18-061].

- Status
  - The TopKinFitter package has been used for the published result using MiniAOD.
  - We have implemented a standalone Kinematic fitting procedure which provides us more control at various stages.

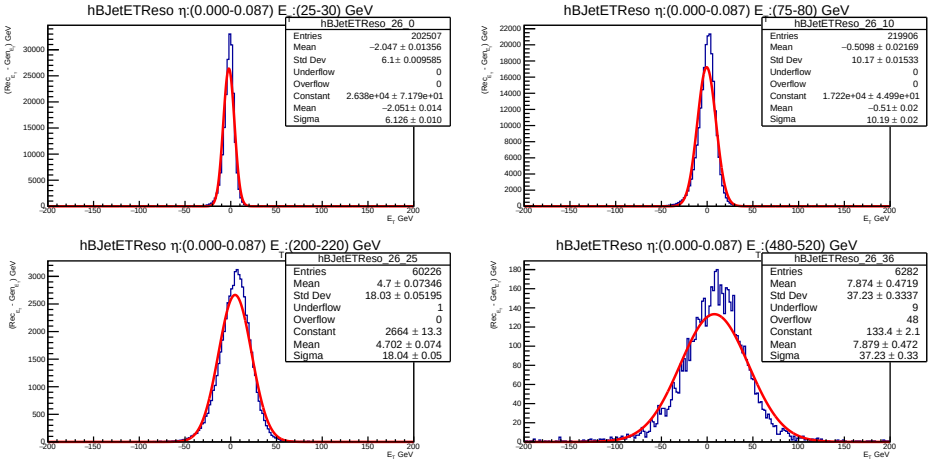
Kinematic fitting for NanoAOD - II

- Motivation
  - Improvement of the kinematic properties (p_T, η, ϕ) of reconstructed objects (μ, e, jets).
  - A χ^2 is constructed using the 4-vectors of the reconstructed objects and their kinematic constrain.
  - The χ^2 is minimized by varying the 4-vectors within allowed resolutions using Lagrange multipliers.
  - Identification of the b-jets associated with the leptonic and hadronic vertices is our motivation.
  - This allows to select the two light jets associated with the hadronic b-jet after χ^2 minimization, hence improves the shape of mass distribution.
- Inputs
  - The 4-vectors of one lepton, $\not{E}_T$, and jets along with the resolution for each object.
  - The b discriminator values and threshold (DeepJet[M]).
  - The resolution of jets, leptons and MET (evaluated separately for each year/sub-year).
- Kinematic constrain
  - The top mass for $t \to bl\nu$ and $t \to bq\bar{q}$.
  - The W mass for $W \to l\nu$.
- Selection criteria
  - The modified 4-vectors should be within $\Delta R < 0.2$ with respect to the input 4-vectors.
  - The modified 4-vectors should respect the p_T η cuts of object selection.
- Outputs
  - The modified 4-vectors of one lepton, one b jet associated with leptonic vertex, one b jet associated with hadronic vertex, two light jets and $\not{E}_T$.

KinFit object resolution and offset study

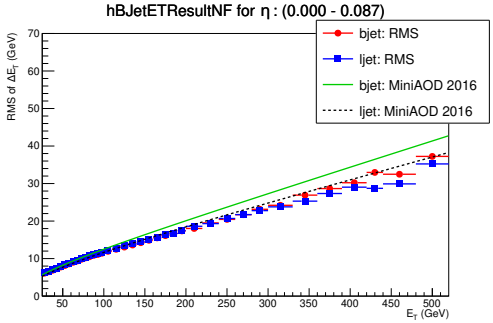
- The current study focuses to verify and update the object resolutions corresponding to UL following the methodology of CMS AN-19-247.
  - Apply event, lepton, jet selections corresponding to analysis for all backgrounds MCs (SM $t\bar{t}$, single t, W + jets, DY + jets, VV, MC QCD).
  - E_T resolution : The RMS of the ΔE_T = (Reconstructed E_T - Generated E_T)s for a given η, E_T range are obtained as a function of Reconstructed E_T of the objects.
  - Similarly obtain for $\Delta\eta$ and $\Delta\phi$ resolutions.
  - Prepare two dimensional histograms to store the resolution of (E_T, η, ϕ) as a function of (η, E_T).
- The distribution of ΔE_T expected to have a mean at zero, however an offset around the expected mean has been observed.
  - Offset correction for jet objects are applied before the Kinematic Fitting.
- Earlier the top and W mass was constrained to a fixed PDG value, which is now updated to include the mass uncertainty due to decay width at the generator level.
- No χ^2 cut has been applied as it has no effect on the S/(S+B) ratio [see plot later].

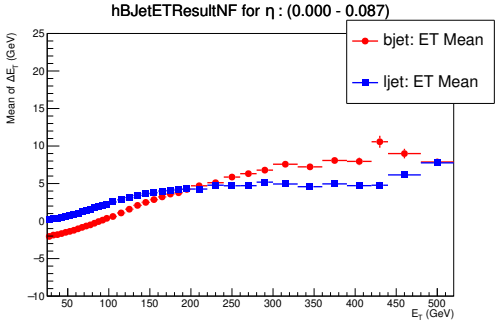
KinFit : E_T resolution and offset



- The histograms of ΔE_T fitted with normal distributions are shown for various E_T ranges.
- Change in RMS and Mean values for different E_T ranges can be observed.

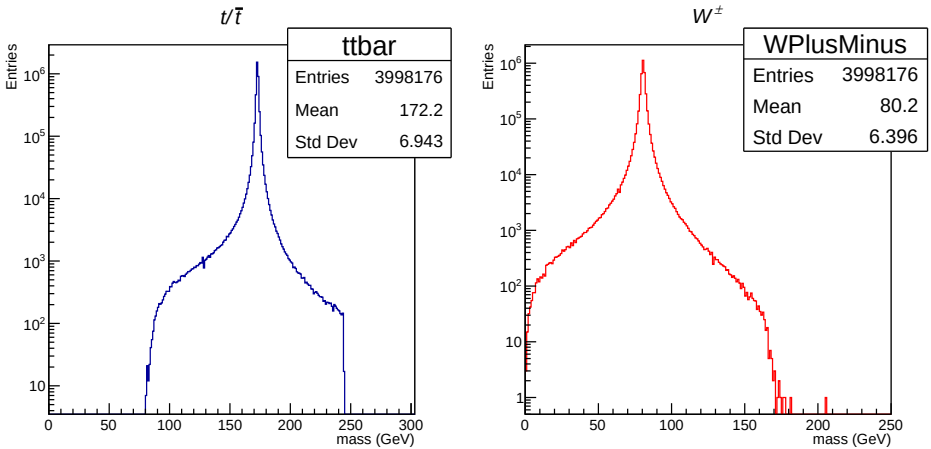
KinFit : E_T resolution and offset





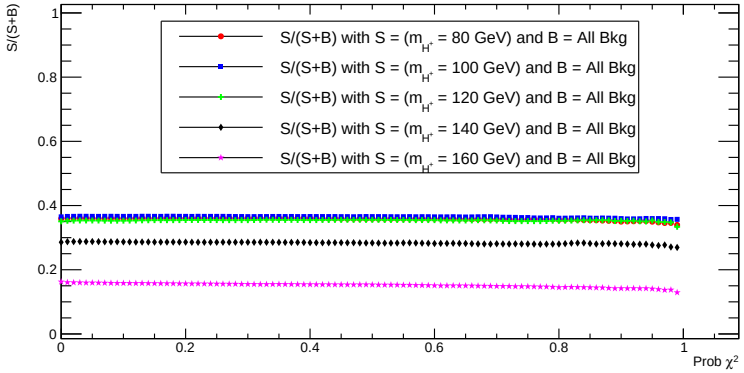
- The distributions of RMS and Mean of ΔE_T as a function E_T are shown in the left and right hand side plots, respectively.
- The default resolution functions as used in MiniAOD are shown in the left hand side plots.
- An E_T dependence of Mean of ΔE_T is observed.

KinFit : Generator mass resolution



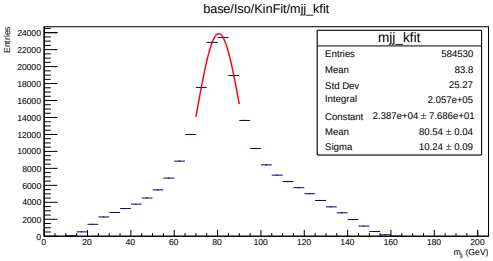
- The mass distribution of top(anti-top) and $W^+(W^-)$ at the generator level are shown in the left and right hand side plots.
- Accordingly the constraints are changed TFitConstraintM(mass) $\rightarrow$ TFitConstraintMGaus(mass,width) in Kinematic Fitting.

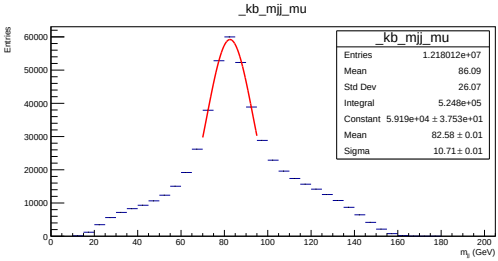
S/(S+B) as a function of χ^2 probability



- No dependence on χ^2 is observed for signal over signal + background.

Improvement in KinFit selection for SM $t\bar{t}$ sample





- The m_{jj} distribution of SM $t\bar{t}$ for MiniAOD(left) and UL(right) are shown.
- The peak region of m_{jj} distribution is fitted. A shift of 2.3 GeV with respect to W boson mass is observed in UL.

Event yields for the μ + jets 2016			
Analyses	(Trigger) + ($N_{\mu} = 1$) + ($N_{jets} \geq 4$) + (MET $\geq$ 20 GeV)	$N_{bjets} \geq 2$	KinFit Sel.
MiniAOD (published)	1.37212e+06	449363 (32.7%)	205678 (45.8%)
Legacy	1.4310e+06	577870.8 (40.4%)	347171.2 (60.1%)
Ultra Legacy	1.3470e+06	664006.7 (49.3%)	524804.2 (79%)

- At b-jet selection UL provides 48% higher yield as compared to MiniAOD results.
- At KinFit selection UL provides 250% higher yield as compared to MiniAOD results!!
  - Combined effect of improvements in b-jet seletion and KinFit selection efficiencies..

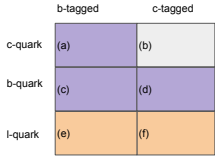
Charm Tagging

- We can benefit from c-tagging for $c\bar{s}$ final product.
- The c-tagging has improved the S/B ratio in charged higgs search results published in 2016.
- In current analysis we have applied explicit deepjet charm tagging after the KinFit for loose, medium and tight working points.

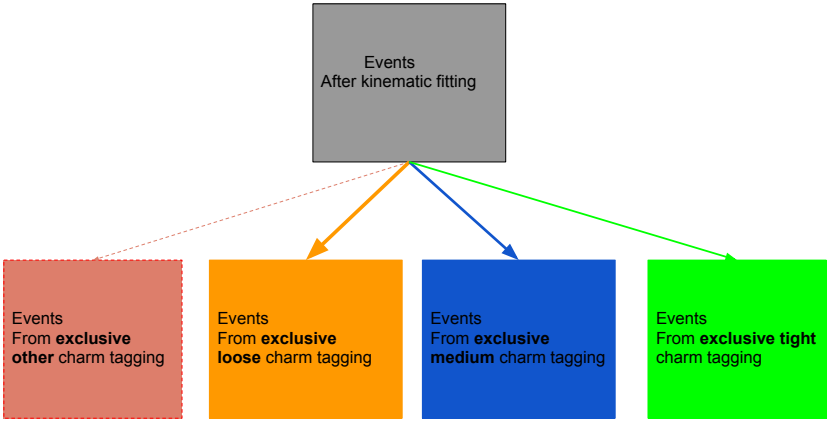
(sub)Year	loose (cVsB/cVsL)	medium (cVsB/cVsL)	tight (cVsB/cVsL)
2016 (preVFP)	0.039/0.327	0.098/0.370	0.270/0.256
2016 (postVFP)	0.039/0.305	0.099/0.353	0.269/0.247
2017	0.03/0.4	0.085/0.34	0.52/0.05
2018	0.038/0.246	0.099/0.325	0.282/0.267

- The charm and bottom productions are correlated in $H^{\pm}$ topology however SF of b-tagger and c-tagger are uncorrelated.
- Hence we vary the nominal values of b-tagger and c-tagger up/down in correlated fashion as a conservative approach to cover the discrepancy of correlated/uncorrelated following the suggestion of BTV POG during MiniAOD analysis.

  (This to be reverified/reviewed by BTV POG for UL).
  - b & c tagging 1 : c-tagging for c-quark is varied up/down.
  - b & c tagging 2 : b-tagging and c-tagging for l-quark are varied up/down simultaneously.
  - b & c tagging 3 : b-tagging for b and c quark and c-tagging for b-quark are varied up/down simultaneously.
- Note that the fixed WP file for c-tagging is recently available for UL, therefore we have reused the file of 2016 published result of MiniAOD for all following results.

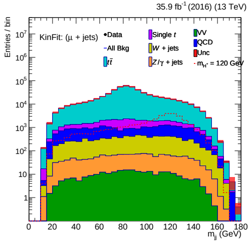


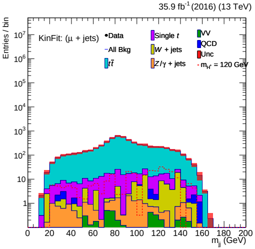
Categorization of Events

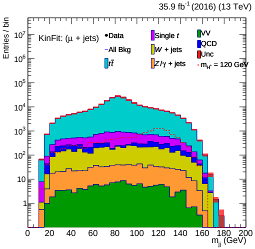


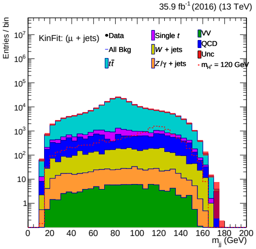
- The signal significance is different in different charm working points.
- Accordingly the events passing the KinFit selections are divided into four categories.
- In total ∼99% of the KinFit events are grouped into exclusive loose (SM $t\bar{t} \to \mu + X$: 246679/524804 = 47%), exclusive medium (210728/524804 = 40%) and exclusive tight (63343/524804 = 12%) categories.
- The remaining ∼1% (5741/524804=1%) does not fall in any of the three exclusive categories.

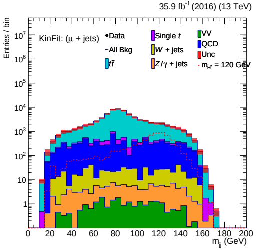
Categorization of Events : blinded m_{jj} distribution











- The m_{jj} distribution at KinFit (top) and for no excl. *c*-tagging (bottom-leftmost), excl. loose *c*-tagging (bottom-left), excl. medium *c*-tagging (bottom-right), excl. tight *c*-tagging (bottom-rightmost) are shown.
- A scale factor of $2 \times 0.065 \times (1 - 0.065) = 0.121$ is applied for signal ($m_{H^+} = 120$ GeV).

Cutflow numbers (μ + jets) : UltraLegacy (2016-18)

Event yields for the μ + jets 2016

Process	Trigger	$N_\mu = 1$	$N_{jets} \geq 4$	MET $\geq$ 20 GeV	$N_{bjets} \geq 2$	KinFit Sel.	$\geq$ 1 c-jet(incl,LWP)	$\geq$ 1 c-jet (incl,MWP)	$\geq$ 1 c-jet (incl,TWP)
Signal Integral (m_{H^+}=120 GeV)	2.0139e+06	1.7038e+06	894783.7	814596.0	368775.9	296129.5	292850.7	176756.6	53407.3
SM $t\bar{t}$	3.9883e+06	2.8724e+06	1.4661e+06	1.3470e+06	664006.7	524804.2	517903.6	277027.9	63343.2
Single t	933083.0	751919.5	102785.7	94035.1	33096.7	19120.2	18810.8	9525.1	1847.0
W + jets	3.1810e+08	2.6895e+08	835969.1	748340.5	15628.2	7398.4	7277.2	3570.0	488.9
Z/γ + jets	4.6248e+07	1.3613e+07	81532.6	65331.5	2256.6	1222.9	1195.5	565.2	99.1
VV	658785.1	465567.9	14247.3	12744.1	466.5	250.4	245.1	127.8	21.8
MC QCD	1.4354e+08	4.3433e+07	307109.8	228999.4	11436.3	7718.0	7613.3	2884.2	403.0
ALL BKG	5.1347e+08	3.3009e+08	2.8077e+06	2.4964e+06	726891.1	560514.2	553045.4	293700.2	66203.0
Data	4.7676e+08	3.1504e+08	3.0010e+06	2.6784e+06	747197.0	564956.0	560867.0	307801.0	72505.0
Data/Bkg	0.9285	0.9544	1.0688	1.0729	1.0279	1.0079	1.0141	1.0480	1.0952

Event yields for the μ + jets 2017

Process	Trigger	$N_\mu = 1$	$N_{jets} \geq 4$	MET $\geq$ 20 GeV	$N_{bjets} \geq 2$	KinFit Sel.	$\geq$ 1 c-jet(incl,LWP)	$\geq$ 1 c-jet (incl,MWP)	$\geq$ 1 c-jet (incl,TWP)
Signal Integral (m_{H^+}=120 GeV)	2.1654e+06	1.8137e+06	976695.0	895483.5	426982.6	343200.7	341388.9	236042.3	54045.7
SM $t\bar{t}$	4.2742e+06	3.0406e+06	1.5828e+06	1.4604e+06	748342.8	582093.9	577984.3	360750.5	51202.4
Single t	998555.8	791191.4	114133.9	104946.7	38590.5	21731.5	21468.6	12885.1	1433.7
W + jets	3.2421e+08	2.6020e+08	1.0683e+06	965402.0	20505.5	9184.3	9041.8	5397.4	377.8
Z/γ + jets	4.9484e+07	1.2666e+07	95253.3	79353.4	2935.1	1558.0	1530.4	882.4	70.4
VV	699817.3	481591.5	16401.4	14807.8	556.9	283.4	279.2	167.5	16.6
MC QCD	1.2335e+08	3.0011e+07	321094.6	262116.5	14557.4	9340.7	9134.7	5092.8	414.8
ALL BKG	5.0302e+08	3.0719e+08	3.1980e+06	2.8870e+06	825488.2	624191.8	619439.0	385175.7	53515.7
Data	4.9379e+08	3.0707e+08	3.2931e+06	2.9721e+06	839286.0	628277.0	627986.0	404744.0	48428.0
Data/Bkg	0.9816	0.9996	1.0297	1.0295	1.0167	1.0065	1.0138	1.0508	0.9049

Event yields for the μ + jets 2018

Process	Trigger	$N_\mu = 1$	$N_{jets} \geq 4$	MET $\geq$ 20 GeV	$N_{bjets} \geq 2$	KinFit Sel.	$\geq$ 1 c-jet(incl,LWP)	$\geq$ 1 c-jet (incl,MWP)	$\geq$ 1 c-jet (incl,TWP)
Signal Integral (m_{H^+}=120 GeV)	3.4102e+06	2.9394e+06	1.5630e+06	1.4380e+06	692487.0	550700.8	543238.2	327767.9	128064.2
SM $t\bar{t}$	6.7460e+06	4.9391e+06	2.5363e+06	2.3456e+06	1.2132e+06	944748.3	929582.1	490256.1	141864.8
Single t	1.5965e+06	1.3082e+06	180426.0	166331.0	62125.4	35400.2	34702.1	17244.4	4248.0
W + jets	5.3934e+08	4.6218e+08	1.6277e+06	1.4740e+06	33699.9	15342.4	14980.6	6865.7	1227.9
Z/γ + jets	7.7962e+07	2.3321e+07	148802.9	124026.3	4910.5	2614.5	2537.5	1179.7	248.7
VV	1.1112e+06	798697.9	25438.5	23047.4	940.7	503.6	489.9	230.6	54.8
MC QCD	2.5172e+08	8.1584e+07	618139.9	498427.0	31083.3	20364.0	19677.6	9389.5	1951.5
ALL BKG	8.7847e+08	5.7413e+08	5.1368e+06	4.6314e+06	1.3460e+06	1.0190e+06	1.0020e+06	525166.0	149595.8
Data	8.1548e+08	5.4914e+08	5.0938e+06	4.6021e+06	1.3526e+06	1.0105e+06	1.0034e+06	555317.0	150461.0
Data/Bkg	0.9283	0.9565	0.9916	0.9937	1.0049	0.9916	1.0014	1.0574	1.0058

Data and MC are in agreement within 1% at KinFit level.

Cutflow numbers (e + jets) : UltraLegacy (2016-18)

Event yields for the e + jets 2016

Process	Trigger	$N_e = 1$	$N_{jets} \geq 4$	MET $\geq$ 20 GeV	$N_{bjets} \geq 2$	KinFit Sel.	$\geq$ 1 c-jet(incl,LWP)	$\geq$ 1 c-jet (incl,MWP)	$\geq$ 1 c-jet (incl,TWP)
Signal Integral (m_{H^+}=120 GeV)	1.4677e+06	1.1814e+06	632358.2	574106.2	261279.0	210493.0	208540.1	124465.6	38074.5
SM $t\bar{t}$	2.9269e+06	1.9931e+06	1.0303e+06	943413.7	463421.0	362342.5	357532.8	190660.4	43612.0
Single t	612554.1	454137.2	70384.7	64175.9	22387.6	12705.5	12513.4	6358.5	1269.5
W + jets	1.9335e+08	1.3668e+08	559036.5	496673.4	10466.0	4772.4	4660.3	2061.1	390.0
Z/γ + jets	3.4033e+07	1.0060e+07	97176.6	72246.8	2665.1	1536.5	1502.3	782.4	121.2
VV	473626.2	297059.2	10587.9	9310.6	354.9	187.5	184.9	92.1	17.5
MC QCD	1.7250e+08	3.4787e+07	516209.0	364825.1	2876.2	885.5	887.0	515.3	0
ALL BKG	4.0389e+08	1.8427e+08	2.2837e+06	1.9506e+06	502170.9	382430.0	377280.7	200469.9	45410.2
Data	4.9328e+08	1.9426e+08	2.5057e+06	2.1456e+06	526067.0	389039.0	386091.0	211248.0	49976.0
Data/Bkg	1.2213	1.0542	1.0972	1.0999	1.0476	1.0173	1.0234	1.0538	1.1005

Event yields for the e + jets 2017

Process	Trigger	$N_e = 1$	$N_{jets} \geq 4$	MET $\geq$ 20 GeV	$N_{bjets} \geq 2$	KinFit Sel.	$\geq$ 1 c-jet(incl,LWP)	$\geq$ 1 c-jet (incl,MWP)	$\geq$ 1 c-jet (incl,TWP)
Signal Integral (m_{H^+}=120 GeV)	1.6343e+06	1.2304e+06	667028.8	608878.3	294700.1	229261.5	227962.4	156522.7	34903.8
SM $t\bar{t}$	3.2873e+06	2.0875e+06	1.1006e+06	1.0130e+06	517591.7	396608.5	393834.6	245215.8	34822.9
Single t	676705.3	461889.0	76532.6	70201.1	25546.5	13958.1	13795.9	8262.7	928.1
W + jets	2.0149e+08	1.1841e+08	698133.1	627446.4	14243.9	6107.7	6028.0	3267.0	228.6
Z/γ + jets	3.6693e+07	8.7996e+06	112108.4	89346.7	3272.9	1749.8	1718.3	1103.6	67.3
VV	524615.4	299947.3	12068.4	10778.3	433.4	214.9	211.5	129.0	12.2
MC QCD	9.6743e+07	2.3440e+07	472155.6	377631.9	11511.9	4367.9	4314.1	3794.7	0
ALL BKG	3.3941e+08	1.5350e+08	2.4716e+06	2.1885e+06	572600.3	423007.0	419902.4	261772.9	36059.1
Data	3.3418e+08	1.6459e+08	2.6431e+06	2.3266e+06	590450.0	431568.0	431318.0	277213.0	33195.0
Data/Bkg	0.9846	1.0723	1.0694	1.0631	1.0312	1.0202	1.0272	1.0590	0.9206

Event yields for the e + jets 2018

Process	Trigger	$N_e = 1$	$N_{jets} \geq 4$	MET $\geq$ 20 GeV	$N_{bjets} \geq 2$	KinFit Sel.	$\geq$ 1 c-jet(incl,LWP)	$\geq$ 1 c-jet (incl,MWP)	$\geq$ 1 c-jet (incl,TWP)
Signal Integral (m_{H^+}=120 GeV)	2.4318e+06	1.9085e+06	1.0283e+06	937850.3	449576.2	349853.3	345751.6	207446.0	83691.9
SM $t\bar{t}$	4.8749e+06	3.2310e+06	1.6779e+06	1.5448e+06	794482.4	606816.8	596918.8	314568.2	91047.4
Single t	995787.5	715621.2	115128.8	105655.3	39014.9	21417.7	21011.2	10506.9	2649.8
W + jets	2.8564e+08	1.8425e+08	1.0687e+06	961839.9	22094.2	9443.5	9211.7	4216.2	876.1
Z/γ + jets	5.4216e+07	1.5000e+07	170949.3	135557.7	5191.8	2815.7	2746.7	1403.5	268.7
VV	775489.0	471267.2	17736.0	15839.0	647.6	337.0	331.8	159.7	34.6
MC QCD	1.4625e+08	3.9322e+07	703055.6	538845.5	52295.5	20770.8	20403.3	0	0
ALL BKG	4.9275e+08	2.4299e+08	3.7535e+06	3.3026e+06	913726.4	661601.6	650623.5	330854.4	94876.6
Data	6.2295e+08	2.6343e+08	3.9738e+06	3.5029e+06	898272.0	649207.0	644612.0	354957.0	96398.0
Data/Bkg	1.2642	1.0841	1.0587	1.0607	0.9831	0.9813	0.9908	1.0728	1.0160

Data and MC are in agreement within 2% at KinFit level.

Systematic uncertainties (2016-18) [KinFit Level]

2016									
Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	0.76(0.91)	0.63(1.47)	0.00(0.00)	0.17(0.14)	3.88(3.96)	0.59(0.40)	3.74(3.46)	0.36(0.32)	6.10(6.10)	0.60(0.70)
$H^+ + H^-(m = 90$ GeV)	0.83(1.13)	0.63(1.45)	0.00(0.00)	0.14(0.14)	3.82(3.85)	0.59(0.40)	3.41(3.62)	0.20(0.24)	6.10(6.10)	0.59(0.70)
$H^+ + H^-(m = 100$ GeV)	0.82(1.00)	0.63(1.46)	0.00(0.00)	0.17(0.14)	3.75(3.74)	0.58(0.41)	3.18(3.33)	0.34(0.20)	6.10(6.10)	0.59(0.70)
$H^+ + H^-(m = 110$ GeV)	0.72(0.91)	0.63(1.46)	0.00(0.00)	0.14(0.18)	3.68(3.70)	0.59(0.40)	3.42(3.55)	0.33(0.37)	6.10(6.10)	0.69(0.83)
$H^+ + H^-(m = 120$ GeV)	0.71(1.20)	0.63(1.45)	0.00(0.00)	0.17(0.18)	3.68(3.74)	0.59(0.42)	3.74(3.58)	0.34(0.36)	6.10(6.10)	0.62(0.74)
$H^+ + H^-(m = 130$ GeV)	0.75(0.66)	0.63(1.48)	0.00(0.00)	0.26(0.27)	3.65(3.73)	0.59(0.39)	3.60(3.78)	0.13(0.27)	6.10(6.10)	0.63(0.77)
$H^+ + H^-(m = 140$ GeV)	0.49(0.90)	0.62(1.49)	0.00(0.00)	0.38(0.40)	3.83(3.82)	0.59(0.41)	4.44(4.20)	0.16(0.27)	6.10(6.10)	0.70(0.86)
$H^+ + H^-(m = 150$ GeV)	0.61(0.66)	0.63(1.51)	0.00(0.00)	0.57(0.62)	4.09(4.02)	0.61(0.41)	4.90(4.81)	0.32(0.37)	6.10(6.10)	0.74(0.87)
$H^+ + H^-(m = 155$ GeV)	0.43(0.55)	0.62(1.50)	0.00(0.00)	0.74(0.72)	4.30(4.29)	0.61(0.41)	5.07(4.97)	0.02(0.06)	6.10(6.10)	0.81(0.97)
$H^+ + H^-(m = 160$ GeV)	0.58(0.55)	0.62(1.50)	0.00(0.00)	0.83(1.00)	4.40(4.37)	0.61(0.42)	4.99(4.81)	0.25(0.26)	6.10(6.10)	0.91(1.08)
SM $t\bar{t}$ + jets	0.67(0.95)	0.63(1.48)	0.00(0.00)	0.19(0.19)	4.18(4.20)	0.63(0.45)	3.18(3.16)	1.87(1.87)	6.10(6.10)	0.03(0.04)
Single t	0.54(0.77)	0.63(1.48)	0.00(0.00)	0.67(0.69)	4.20(4.22)	0.65(0.46)	4.92(4.82)	0.22(0.16)	6.10(6.10)	0.32(0.39)
W + jets	0.87(0.48)	0.70(1.60)	0.00(0.00)	4.24(4.22)	4.10(4.17)	0.44(0.58)	12.81(8.51)	0.92(1.26)	6.10(6.10)	2.51(3.11)
Z/γ + jets	0.69(0.91)	0.71(1.50)	0.00(0.00)	4.57(5.37)	3.71(3.56)	0.68(0.64)	8.88(9.15)	1.10(0.79)	6.10(6.10)	1.41(1.25)
VV	0.19(0.23)	0.66(1.51)	0.00(0.00)	2.99(2.43)	3.91(4.13)	0.52(0.41)	7.39(7.68)	0.96(0.69)	6.10(6.10)	2.38(2.76)
DD QCD	–	–	–	–	–	–	–	–	7.79(24.86)	3.93(2.86)

2017										
Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	0.17(0.36)	0.28(1.41)	0.00(0.00)	0.10(0.11)	5.04(5.06)	0.42(0.45)	4.39(4.25)	0.40(0.21)	6.10(6.10)	0.59(0.70)
$H^+ + H^-(m = 90$ GeV)	0.31(0.69)	0.28(1.39)	0.00(0.00)	0.11(0.12)	4.92(5.03)	0.41(0.44)	4.44(4.22)	0.39(0.37)	6.10(6.10)	0.59(0.69)
$H^+ + H^-(m = 100$ GeV)	0.16(0.48)	0.28(1.40)	0.00(0.00)	0.08(0.15)	4.80(4.85)	0.41(0.45)	4.34(4.52)	0.27(0.61)	6.10(6.10)	0.58(0.68)
$H^+ + H^-(m = 110$ GeV)	0.17(0.62)	0.28(1.40)	0.00(0.00)	0.13(0.18)	4.79(4.71)	0.40(0.45)	4.05(4.09)	0.42(0.17)	6.10(6.10)	0.59(0.69)
$H^+ + H^-(m = 120$ GeV)	0.46(0.25)	0.28(1.39)	0.00(0.00)	0.18(0.14)	4.59(4.71)	0.40(0.45)	4.01(3.92)	0.37(0.52)	6.10(6.10)	0.63(0.74)
$H^+ + H^-(m = 130$ GeV)	0.29(0.39)	0.28(1.41)	0.00(0.00)	0.22(0.23)	4.66(4.59)	0.42(0.46)	4.34(4.63)	0.51(0.57)	6.10(6.10)	0.63(0.74)
$H^+ + H^-(m = 140$ GeV)	0.36(0.46)	0.28(1.41)	0.00(0.00)	0.28(0.34)	4.67(4.65)	0.42(0.45)	4.74(4.59)	0.32(0.33)	6.10(6.10)	0.71(0.81)
$H^+ + H^-(m = 150$ GeV)	0.27(0.42)	0.29(1.45)	0.00(0.00)	0.48(0.44)	5.03(4.91)	0.43(0.46)	5.68(5.73)	0.24(0.17)	6.10(6.10)	0.72(0.84)
$H^+ + H^-(m = 155$ GeV)	0.41(0.51)	0.29(1.44)	0.00(0.00)	0.73(0.60)	5.04(5.19)	0.45(0.49)	5.59(5.93)	0.19(0.60)	6.10(6.10)	0.89(1.04)
$H^+ + H^-(m = 160$ GeV)	0.02(0.30)	0.29(1.44)	0.00(0.00)	0.84(0.83)	5.39(5.26)	0.44(0.48)	5.57(5.52)	0.18(0.41)	6.10(6.10)	0.89(1.04)
SM $t\bar{t}$ + jets	0.28(0.48)	0.28(1.41)	0.00(0.00)	0.14(0.14)	5.44(5.46)	0.48(0.51)	8.35(8.32)	1.73(1.74)	6.10(6.10)	0.03(0.03)
Single t	0.06(0.23)	0.28(1.42)	0.00(0.00)	0.58(0.59)	5.33(5.37)	0.50(0.51)	6.04(5.69)	0.53(0.27)	6.10(6.10)	0.29(0.35)
W + jets	1.18(0.37)	0.31(1.44)	0.00(0.00)	4.35(4.35)	4.99(4.91)	0.43(0.65)	9.91(9.52)	1.23(0.58)	6.10(6.10)	2.07(2.33)
Z/γ + jets	1.71(1.96)	0.32(1.41)	0.00(0.00)	4.16(4.61)	4.69(4.48)	0.44(0.92)	9.97(13.60)	2.15(2.64)	6.10(6.10)	1.32(1.23)
VV	2.60(1.54)	0.29(1.40)	0.00(0.00)	2.43(2.61)	4.54(4.71)	0.33(0.55)	11.92(10.98)	2.35(2.93)	6.10(6.10)	3.12(3.43)
DD QCD	–	–	–	–	–	–	–	–	4.64(25.76)	3.94(3.65)

2018										
Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	0.52(0.66)	0.27(1.35)	0.00(0.00)	0.15(0.16)	5.03(5.12)	0.09(0.02)	5.37(5.66)	0.10(0.23)	6.10(6.10)	0.57(0.69)
$H^+ + H^-(m = 90$ GeV)	0.29(0.38)	0.27(1.36)	0.00(0.00)	0.17(0.19)	4.97(5.03)	0.09(0.01)	5.50(5.32)	0.26(0.20)	6.10(6.10)	0.56(0.68)
$H^+ + H^-(m = 100$ GeV)	0.26(0.47)	0.27(1.36)	0.00(0.00)	0.12(0.24)	4.84(4.91)	0.09(0.01)	5.22(4.98)	0.23(0.30)	6.10(6.10)	0.55(0.68)
$H^+ + H^-(m = 110$ GeV)	0.38(0.40)	0.27(1.34)	0.00(0.00)	0.19(0.19)	4.68(4.75)	0.09(0.01)	5.32(5.12)	0.23(0.38)	6.10(6.10)	0.57(0.70)
$H^+ + H^-(m = 120$ GeV)	0.42(0.54)	0.27(1.35)	0.00(0.00)	0.22(0.24)	4.58(4.59)	0.09(0.01)	5.24(5.41)	0.41(0.42)	6.10(6.10)	0.58(0.71)
$H^+ + H^-(m = 130$ GeV)	0.31(0.16)	0.27(1.35)	0.00(0.00)	0.33(0.28)	4.49(4.56)	0.09(0.01)	5.49(5.67)	0.17(0.30)	6.10(6.10)	0.60(0.74)
$H^+ + H^-(m = 140$ GeV)	0.24(0.31)	0.27(1.35)	0.00(0.00)	0.42(0.33)	4.56(4.54)	0.09(0.01)	6.13(5.90)	0.38(0.26)	6.10(6.10)	0.66(0.81)
$H^+ + H^-(m = 150$ GeV)	0.11(0.05)	0.27(1.38)	0.00(0.00)	0.63(0.67)	4.74(4.78)	0.09(0.01)	7.26(7.05)	0.28(0.06)	6.10(6.10)	0.75(0.91)
$H^+ + H^-(m = 155$ GeV)	0.24(0.36)	0.27(1.38)	0.00(0.00)	0.72(0.89)	4.96(4.81)	0.09(0.01)	7.34(7.07)	0.31(0.43)	6.10(6.10)	0.77(0.92)
$H^+ + H^-(m = 160$ GeV)	0.15(0.14)	0.28(1.39)	0.00(0.00)	1.08(0.95)	4.88(5.04)	0.09(0.01)	6.92(6.80)	0.21(0.22)	6.10(6.10)	0.85(1.04)
SM $t\bar{t}$ + jets	0.25(0.37)	0.27(1.35)	0.00(0.00)	0.19(0.19)	5.48(5.54)	0.09(0.02)	4.78(4.77)	0.15(0.17)	6.10(6.10)	0.02(0.03)
Single t	0.14(0.29)	0.27(1.36)	0.00(0.00)	0.72(0.72)	5.27(5.31)	0.09(0.01)	7.49(7.26)	0.11(0.04)	6.10(6.10)	0.23(0.30)
W + jets	1.32(0.92)	0.31(1.32)	0.00(0.00)	4.99(4.67)	4.34(4.49)	0.09(0.01)	15.12(11.99)	1.05(1.50)	6.10(6.10)	1.94(2.32)
Z/γ + jets	0.52(1.13)	0.32(1.33)	0.00(0.00)	5.24(6.19)	4.20(3.90)	0.11(0.01)	14.47(15.68)	1.37(1.38)	6.10(6.10)	1.42(1.35)
VV	1.27(0.37)	0.30(1.30)	0.00(0.00)	3.61(3.36)	4.27(4.27)	0.08(0.01)	13.93(10.84)	1.50(0.47)	6.10(6.10)	2.83(3.32)
DD QCD	–	–	–	–	–	–	–	–	10.97(21.84)	2.98(3.09)

Systematic uncertainties due to other sources were explained earlier and can be found in the backup slides.

Yields (2016-18) [KinFit Level]

2016		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$630419 \pm 3764(0.6\%) \pm 51873(8.2\%)$	$444324 \pm 3117(0.7\%) \pm 36683(8.3\%)$
$H^+ + H^-(m = 90$ GeV)	$644377 \pm 3794(0.6\%) \pm 51932(8.1\%)$	$446842 \pm 3128(0.7\%) \pm 37059(8.3\%)$
$H^+ + H^-(m = 100$ GeV)	$649685 \pm 3823(0.6\%) \pm 51538(7.9\%)$	$451959 \pm 3157(0.7\%) \pm 36624(8.1\%)$
$H^+ + H^-(m = 110$ GeV)	$640479 \pm 4410(0.7\%) \pm 51187(8.0\%)$	$439725 \pm 3657(0.8\%) \pm 35928(8.2\%)$
$H^+ + H^-(m = 120$ GeV)	$602090 \pm 3747(0.6\%) \pm 48956(8.1\%)$	$416321 \pm 3084(0.7\%) \pm 34302(8.2\%)$
$H^+ + H^-(m = 130$ GeV)	$549698 \pm 3481(0.6\%) \pm 44267(8.1\%)$	$375090 \pm 2870(0.8\%) \pm 31007(8.3\%)$
$H^+ + H^-(m = 140$ GeV)	$459059 \pm 3227(0.7\%) \pm 39134(8.5\%)$	$311593 \pm 2670(0.9\%) \pm 26597(8.5\%)$
$H^+ + H^-(m = 150$ GeV)	$317207 \pm 2332(0.7\%) \pm 28285(8.9\%)$	$223085 \pm 1946(0.9\%) \pm 19946(8.9\%)$
$H^+ + H^-(m = 155$ GeV)	$257726 \pm 2088(0.8\%) \pm 23465(9.1\%)$	$178585 \pm 1728(1.0\%) \pm 16321(9.1\%)$
$H^+ + H^-(m = 160$ GeV)	$208130 \pm 1902(0.9\%) \pm 19002(9.1\%)$	$145570 \pm 1575(1.1\%) \pm 13283(9.1\%)$
SM $t\bar{t}$ + jets	$524804 \pm 155(0.0\%) \pm 43777(8.3\%)$	$362343 \pm 128(0.0\%) \pm 30665(8.5\%)$
Single t	$19120 \pm 61(0.3\%) \pm 1717(9.0\%)$	$12706 \pm 50(0.4\%) \pm 1149(9.0\%)$
W + jets	$7398 \pm 186(2.5\%) \pm 1142(15.4\%)$	$4772 \pm 148(3.1\%) \pm 584(12.2\%)$
Z/γ + jets	$1223 \pm 17(1.4\%) \pm 151(12.4\%)$	$1537 \pm 19(1.3\%) \pm 198(12.9\%)$
VV	$250 \pm 6(2.4\%) \pm 27(10.8\%)$	$187 \pm 5(2.8\%) \pm 21(11.0\%)$
MC QCD	$7718 \pm 1143(14.8\%)$	$886 \pm 393(44.3\%)$
DD QCD	$16027 \pm 629(3.9\%) \pm 1248(7.8\%)$	$13522 \pm 387(2.9\%) \pm 3362(24.9\%)$
All background	$568823 \pm 677(0.1\%) \pm 43844(7.7\%)$	$395066 \pm 437(0.1\%) \pm 30876(7.8\%)$
Data	$564956 \pm 752(0.1\%)$	$389039 \pm 624(0.2\%)$
Data/Bkg	0.9932	0.9847

2017		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$712016 \pm 4171(0.6\%) \pm 64599(9.1\%)$	$473134 \pm 3323(0.7\%) \pm 43176(9.1\%)$
$H^+ + H^-(m = 90$ GeV)	$710721 \pm 4193(0.6\%) \pm 64224(9.0\%)$	$484257 \pm 3355(0.7\%) \pm 44122(9.1\%)$
$H^+ + H^-(m = 100$ GeV)	$723163 \pm 4214(0.6\%) \pm 64479(8.9\%)$	$496462 \pm 3379(0.7\%) \pm 45484(9.2\%)$
$H^+ + H^-(m = 110$ GeV)	$715697 \pm 4204(0.6\%) \pm 62812(8.8\%)$	$487153 \pm 3360(0.7\%) \pm 43240(8.9\%)$
$H^+ + H^-(m = 120$ GeV)	$683907 \pm 4310(0.6\%) \pm 59219(8.7\%)$	$460991 \pm 3424(0.7\%) \pm 40509(8.8\%)$
$H^+ + H^-(m = 130$ GeV)	$620522 \pm 3886(0.6\%) \pm 54934(8.9\%)$	$418566 \pm 3104(0.7\%) \pm 38021(9.1\%)$
$H^+ + H^-(m = 140$ GeV)	$502317 \pm 3545(0.7\%) \pm 45494(9.1\%)$	$350964 \pm 2857(0.8\%) \pm 31888(9.1\%)$
$H^+ + H^-(m = 150$ GeV)	$365439 \pm 2625(0.7\%) \pm 35679(9.8\%)$	$251258 \pm 2117(0.8\%) \pm 24725(9.8\%)$
$H^+ + H^-(m = 155$ GeV)	$288028 \pm 2575(0.9\%) \pm 28052(9.7\%)$	$198846 \pm 2072(1.0\%) \pm 20147(10.1\%)$
$H^+ + H^-(m = 160$ GeV)	$239644 \pm 2143(0.9\%) \pm 23772(9.9\%)$	$167324 \pm 1739(1.0\%) \pm 16618(9.9\%)$
SM $t\bar{t}$ + jets	$582094 \pm 151(0.0\%) \pm 68855(11.8\%)$	$396609 \pm 121(0.0\%) \pm 47228(11.9\%)$
Single t	$21732 \pm 62(0.3\%) \pm 2205(10.1\%)$	$13958 \pm 49(0.4\%) \pm 1404(10.1\%)$
W + jets	$9184 \pm 190(2.1\%) \pm 1241(13.5\%)$	$6108 \pm 142(2.3\%) \pm 805(13.2\%)$
Z/γ + jets	$1558 \pm 21(1.3\%) \pm 211(13.6\%)$	$1750 \pm 21(1.2\%) \pm 291(16.6\%)$
VV	$283 \pm 9(3.1\%) \pm 42(14.8\%)$	$215 \pm 7(3.4\%) \pm 30(14.1\%)$
MC QCD	$9341 \pm 1287(13.8\%)$	$4368 \pm 2256(51.6\%)$
DD QCD	$15849 \pm 625(3.9\%) \pm 735(4.6\%)$	$18792 \pm 686(3.7\%) \pm 4841(25.8\%)$
All background	$630700 \pm 674(0.1\%) \pm 68905(10.9\%)$	$437431 \pm 713(0.2\%) \pm 47504(10.9\%)$
Data	$628277 \pm 793(0.1\%)$	$431568 \pm 657(0.2\%)$
Data/Bkg	0.9962	0.9866

2018		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$1143690 \pm 6513(0.6\%) \pm 109519(9.6\%)$	$734008 \pm 5100(0.7\%) \pm 72590(9.9\%)$
$H^+ + H^-(m = 90$ GeV)	$1160370 \pm 6472(0.6\%) \pm 111540(9.6\%)$	$744238 \pm 5060(0.7\%) \pm 71742(9.6\%)$
$H^+ + H^-(m = 100$ GeV)	$1170967 \pm 6494(0.6\%) \pm 109915(9.4\%)$	$744301 \pm 5066(0.7\%) \pm 69960(9.4\%)$
$H^+ + H^-(m = 110$ GeV)	$1156530 \pm 6639(0.6\%) \pm 108288(9.4\%)$	$738493 \pm 5184(0.7\%) \pm 69327(9.4\%)$
$H^+ + H^-(m = 120$ GeV)	$1101248 \pm 6355(0.6\%) \pm 102215(9.3\%)$	$704744 \pm 4975(0.7\%) \pm 66841(9.5\%)$
$H^+ + H^-(m = 130$ GeV)	$1002515 \pm 6009(0.6\%) \pm 93976(9.4\%)$	$635243 \pm 4703(0.7\%) \pm 60993(9.6\%)$
$H^+ + H^-(m = 140$ GeV)	$823056 \pm 5462(0.7\%) \pm 80665(9.8\%)$	$529023 \pm 4298(0.8\%) \pm 51496(9.7\%)$
$H^+ + H^-(m = 150$ GeV)	$593570 \pm 4464(0.8\%) \pm 63064(10.6\%)$	$385179 \pm 3513(0.9\%) \pm 40788(10.6\%)$
$H^+ + H^-(m = 155$ GeV)	$475276 \pm 3662(0.8\%) \pm 51286(10.8\%)$	$313724 \pm 2900(0.9\%) \pm 33403(10.6\%)$
$H^+ + H^-(m = 160$ GeV)	$397574 \pm 3362(0.8\%) \pm 41743(10.5\%)$	$254512 \pm 2637(1.0\%) \pm 26912(10.6\%)$
SM $t\bar{t}$ + jets	$944748 \pm 199(0.0\%) \pm 89779(9.5\%)$	$606817 \pm 156(0.0\%) \pm 58398(9.6\%)$
Single t	$35400 \pm 81(0.2\%) \pm 3904(11.0\%)$	$21418 \pm 64(0.3\%) \pm 2351(11.0\%)$
W + jets	$15342 \pm 298(1.9\%) \pm 2712(17.7\%)$	$9443 \pm 219(2.3\%) \pm 1425(15.1\%)$
Z/γ + jets	$2614 \pm 37(1.4\%) \pm 448(17.1\%)$	$2816 \pm 38(1.3\%) \pm 520(18.5\%)$
VV	$504 \pm 14(2.8\%) \pm 82(16.3\%)$	$337 \pm 11(3.3\%) \pm 46(13.6\%)$
MC QCD	$20364 \pm 3091(15.2\%)$	$20771 \pm 20494(98.7\%)$
DD QCD	$33223 \pm 990(3.0\%) \pm 3646(11.0\%)$	$21631 \pm 668(3.1\%) \pm 4724(21.8\%)$
All background	$1031832 \pm 1057(0.1\%) \pm 89980(8.7\%)$	$662462 \pm 724(0.1\%) \pm 58656(8.9\%)$
Data	$1010457 \pm 1005(0.1\%)$	$649207 \pm 806(0.1\%)$
Data/Bkg	0.9793	0.9800

The MC QCD with limited statistics are shown for comparison and they are not added to "All Background".

Yields (2016-18) [exclusive loose category]

2016		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$251132 \pm 2413(1.0\%) \pm 23891(9.5\%)$	$178108 \pm 1998(1.1\%) \pm 17270(9.7\%)$
$H^+ + H^-(m = 90$ GeV)	$253573 \pm 2411(1.0\%) \pm 23956(9.4\%)$	$174839 \pm 1994(1.1\%) \pm 16874(9.7\%)$
$H^+ + H^-(m = 100$ GeV)	$249034 \pm 2406(1.0\%) \pm 24378(9.8\%)$	$177535 \pm 2000(1.1\%) \pm 16997(9.6\%)$
$H^+ + H^-(m = 110$ GeV)	$244021 \pm 2755(1.1\%) \pm 24372(10.0\%)$	$169985 \pm 2311(1.4\%) \pm 16505(9.7\%)$
$H^+ + H^-(m = 120$ GeV)	$229708 \pm 2355(1.0\%) \pm 23052(10.0\%)$	$161173 \pm 1943(1.2\%) \pm 15472(9.6\%)$
$H^+ + H^-(m = 130$ GeV)	$209074 \pm 2185(1.0\%) \pm 20772(9.9\%)$	$144062 \pm 1804(1.3\%) \pm 14551(10.1\%)$
$H^+ + H^-(m = 140$ GeV)	$177976 \pm 2024(1.1\%) \pm 17725(10.0\%)$	$120391 \pm 1687(1.4\%) \pm 12308(10.2\%)$
$H^+ + H^-(m = 150$ GeV)	$125266 \pm 1478(1.2\%) \pm 13972(11.2\%)$	$87318 \pm 1238(1.4\%) \pm 8970(10.3\%)$
$H^+ + H^-(m = 155$ GeV)	$103171 \pm 1343(1.3\%) \pm 12161(11.8\%)$	$72802 \pm 1116(1.5\%) \pm 8727(12.0\%)$
$H^+ + H^-(m = 160$ GeV)	$87656 \pm 1252(1.4\%) \pm 9998(11.4\%)$	$60132 \pm 1033(1.7\%) \pm 6541(10.9\%)$
SM $t\bar{t}$ + jets	$246679 \pm 106(0.0\%) \pm 21831(8.9\%)$	$170768 \pm 87(0.1\%) \pm 15309(9.0\%)$
Single t	$9606 \pm 42(0.4\%) \pm 947(9.9\%)$	$6358 \pm 35(0.5\%) \pm 616(9.7\%)$
W + jets	$3895 \pm 132(3.4\%) \pm 637(16.4\%)$	$2680 \pm 112(4.2\%) \pm 337(12.6\%)$
Z/γ + jets	$665 \pm 13(1.9\%) \pm 93(14.0\%)$	$773 \pm 14(1.7\%) \pm 111(14.4\%)$
VV	$123 \pm 4(3.3\%) \pm 15(12.5\%)$	$96 \pm 4(3.8\%) \pm 10(10.9\%)$
MC QCD	$4820 \pm 909(18.9\%)$	$342 \pm 218(63.6\%)$
DD QCD	$2151 \pm 298(13.8\%) \pm 114(5.3\%)$	$2921 \pm 175(6.0\%) \pm 803(27.5\%)$
All background	$263120 \pm 345(0.1\%) \pm 21861(8.3\%)$	$183596 \pm 228(0.1\%) \pm 15346(8.4\%)$
Data	$253066 \pm 503(0.2\%)$	$174843 \pm 418(0.2\%)$
Data/Bkg	0.9618	0.9523

2017		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$215486 \pm 2338(1.1\%) \pm 22215(10.3\%)$	$141760 \pm 1855(1.3\%) \pm 15503(10.9\%)$
$H^+ + H^-(m = 90$ GeV)	$212457 \pm 2334(1.1\%) \pm 22060(10.4\%)$	$146358 \pm 1879(1.3\%) \pm 15623(10.7\%)$
$H^+ + H^-(m = 100$ GeV)	$214882 \pm 2329(1.1\%) \pm 22938(10.7\%)$	$147401 \pm 1870(1.3\%) \pm 15032(10.2\%)$
$H^+ + H^-(m = 110$ GeV)	$212009 \pm 2315(1.1\%) \pm 22100(10.4\%)$	$142399 \pm 1853(1.3\%) \pm 15119(10.6\%)$
$H^+ + H^-(m = 120$ GeV)	$201432 \pm 2365(1.2\%) \pm 20087(10.0\%)$	$135543 \pm 1896(1.4\%) \pm 14479(10.7\%)$
$H^+ + H^-(m = 130$ GeV)	$183650 \pm 2137(1.2\%) \pm 19179(10.4\%)$	$124185 \pm 1700(1.4\%) \pm 13091(10.5\%)$
$H^+ + H^-(m = 140$ GeV)	$150548 \pm 1964(1.3\%) \pm 16411(10.9\%)$	$102778 \pm 1579(1.5\%) \pm 11324(11.0\%)$
$H^+ + H^-(m = 150$ GeV)	$111263 \pm 1476(1.3\%) \pm 12957(11.6\%)$	$77548 \pm 1192(1.5\%) \pm 8772(11.3\%)$
$H^+ + H^-(m = 155$ GeV)	$89391 \pm 1471(1.6\%) \pm 11040(12.4\%)$	$62796 \pm 1184(1.9\%) \pm 7677(12.2\%)$
$H^+ + H^-(m = 160$ GeV)	$78887 \pm 1246(1.6\%) \pm 9380(11.9\%)$	$55686 \pm 1019(1.8\%) \pm 7167(12.9\%)$
SM $t\bar{t}$ + jets	$224944 \pm 93(0.0\%) \pm 27504(12.2\%)$	$153757 \pm 75(0.0\%) \pm 18907(12.3\%)$
Single t	$9021 \pm 39(0.4\%) \pm 992(11.0\%)$	$5797 \pm 31(0.5\%) \pm 636(11.0\%)$
W + jets	$3877 \pm 114(2.9\%) \pm 570(14.7\%)$	$2862 \pm 98(3.4\%) \pm 372(13.0\%)$
Z/γ + jets	$704 \pm 13(1.9\%) \pm 116(16.4\%)$	$694 \pm 13(1.9\%) \pm 120(17.2\%)$
VV	$119 \pm 6(4.8\%) \pm 20(16.4\%)$	$89 \pm 5(5.2\%) \pm 13(14.9\%)$
MC QCD	$4316 \pm 802(18.6\%)$	$637 \pm 369(57.9\%)$
DD QCD	$130 \pm 238(183.7\%) \pm 2(1.5\%)$	$1010 \pm 179(17.8\%) \pm 293(29.0\%)$
All background	$238794 \pm 283(0.1\%) \pm 27528(11.5\%)$	$164208 \pm 220(0.1\%) \pm 18924(11.5\%)$
Data	$223320 \pm 473(0.2\%)$	$154173 \pm 393(0.3\%)$
Data/Bkg	0.9352	0.9389

2018		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$437408 \pm 4095(0.9\%) \pm 49084(11.2\%)$	$279611 \pm 3189(1.1\%) \pm 32505(11.6\%)$
$H^+ + H^-(m = 90$ GeV)	$438942 \pm 4037(0.9\%) \pm 47576(10.8\%)$	$281622 \pm 3154(1.1\%) \pm 31346(11.1\%)$
$H^+ + H^-(m = 100$ GeV)	$435956 \pm 4036(0.9\%) \pm 48165(11.0\%)$	$279769 \pm 3146(1.1\%) \pm 30828(11.0\%)$
$H^+ + H^-(m = 110$ GeV)	$428613 \pm 4097(1.0\%) \pm 47389(11.1\%)$	$272588 \pm 3213(1.2\%) \pm 30802(11.3\%)$
$H^+ + H^-(m = 120$ GeV)	$406476 \pm 3917(1.0\%) \pm 43537(10.7\%)$	$261246 \pm 3078(1.2\%) \pm 30561(11.7\%)$
$H^+ + H^-(m = 130$ GeV)	$366286 \pm 3705(1.0\%) \pm 42195(11.5\%)$	$237118 \pm 2892(1.2\%) \pm 26693(11.3\%)$
$H^+ + H^-(m = 140$ GeV)	$310942 \pm 3373(1.1\%) \pm 36788(11.8\%)$	$193820 \pm 2650(1.4\%) \pm 22717(11.7\%)$
$H^+ + H^-(m = 150$ GeV)	$229110 \pm 2793(1.2\%) \pm 30046(13.1\%)$	$149175 \pm 2220(1.5\%) \pm 20151(13.5\%)$
$H^+ + H^-(m = 155$ GeV)	$193590 \pm 2335(1.2\%) \pm 24489(12.6\%)$	$125506 \pm 1840(1.5\%) \pm 16412(13.1\%)$
$H^+ + H^-(m = 160$ GeV)	$162266 \pm 2167(1.3\%) \pm 20834(12.8\%)$	$101905 \pm 1706(1.7\%) \pm 14086(13.8\%)$
SM $t\bar{t}$ + jets	$446415 \pm 136(0.0\%) \pm 45993(10.3\%)$	$286773 \pm 107(0.0\%) \pm 29850(10.4\%)$
Single t	$17947 \pm 57(0.3\%) \pm 2116(11.8\%)$	$10782 \pm 44(0.4\%) \pm 1285(11.9\%)$
W + jets	$8411 \pm 220(2.6\%) \pm 1524(18.1\%)$	$5164 \pm 165(3.2\%) \pm 774(15.0\%)$
Z/γ + jets	$1427 \pm 27(1.9\%) \pm 266(18.6\%)$	$1436 \pm 27(1.9\%) \pm 267(18.6\%)$
VV	$267 \pm 10(3.9\%) \pm 47(17.5\%)$	$180 \pm 8(4.5\%) \pm 23(13.0\%)$
MC QCD	$10938 \pm 2080(19.0\%)$	$20403 \pm 20129(98.7\%)$
DD QCD	$2915 \pm 519(17.8\%) \pm 91(3.1\%)$	$2874 \pm 250(8.7\%) \pm 704(24.5\%)$
All background	$477381 \pm 583(0.1\%) \pm 46068(9.7\%)$	$307210 \pm 323(0.1\%) \pm 29897(9.7\%)$
Data	$448100 \pm 669(0.1\%)$	$289655 \pm 538(0.2\%)$
Data/Bkg	0.9387	0.9429

- The cross section : $\sigma_{H^\pm} = 831.76 \times 0.32\text{pb} = 266.16$ pb used for signal.
- Systematic uncertainties for DD methods in 2017 requires more attention, if not resolved with new c-tagger file.

Yields (2016-18) [exclusive medium category]

2016		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$251495 \pm 2421(1.0\%) \pm 32248(12.8\%)$	$175469 \pm 2000(1.1\%) \pm 22628(12.9\%)$
$H^+ + H^-(m = 90$ GeV)	$256840 \pm 2444(1.0\%) \pm 32454(12.6\%)$	$180078 \pm 2008(1.1\%) \pm 23164(12.9\%)$
$H^+ + H^-(m = 100$ GeV)	$260708 \pm 2467(0.9\%) \pm 32651(12.5\%)$	$179357 \pm 2029(1.1\%) \pm 22513(12.6\%)$
$H^+ + H^-(m = 110$ GeV)	$256802 \pm 2850(1.1\%) \pm 31295(12.2\%)$	$172024 \pm 2334(1.4\%) \pm 21635(12.6\%)$
$H^+ + H^-(m = 120$ GeV)	$240097 \pm 2409(1.0\%) \pm 31243(13.0\%)$	$162874 \pm 1971(1.2\%) \pm 21169(13.0\%)$
$H^+ + H^-(m = 130$ GeV)	$220612 \pm 2239(1.0\%) \pm 28653(13.0\%)$	$151131 \pm 1846(1.2\%) \pm 19111(12.6\%)$
$H^+ + H^-(m = 140$ GeV)	$179788 \pm 2074(1.2\%) \pm 23934(13.3\%)$	$124230 \pm 1715(1.4\%) \pm 16548(13.3\%)$
$H^+ + H^-(m = 150$ GeV)	$129203 \pm 1522(1.2\%) \pm 17708(13.7\%)$	$90476 \pm 1256(1.4\%) \pm 12667(14.0\%)$
$H^+ + H^-(m = 155$ GeV)	$103620 \pm 1352(1.3\%) \pm 14327(13.8\%)$	$72966 \pm 1121(1.5\%) \pm 9822(13.5\%)$
$H^+ + H^-(m = 160$ GeV)	$85221 \pm 1235(1.4\%) \pm 11333(13.3\%)$	$60459 \pm 1028(1.7\%) \pm 8223(13.6\%)$
SM $t\bar{t}$ + jets	$210728 \pm 101(0.0\%) \pm 21884(10.4\%)$	$144975 \pm 83(0.1\%) \pm 15164(10.5\%)$
Single t	$7597 \pm 39(0.5\%) \pm 937(12.3\%)$	$5031 \pm 33(0.6\%) \pm 606(12.0\%)$
W + jets	$3054 \pm 128(4.2\%) \pm 610(20.0\%)$	$1655 \pm 90(5.4\%) \pm 271(16.4\%)$
Z/γ + jets	$463 \pm 11(2.3\%) \pm 78(16.7\%)$	$658 \pm 13(2.0\%) \pm 115(17.4\%)$
VV	$105 \pm 4(3.8\%) \pm 15(14.0\%)$	$74 \pm 3(4.6\%) \pm 12(16.6\%)$
MC QCD	$2455 \pm 697(28.4\%)$	$515 \pm 299(58.1\%)$
DD QCD	$10851 \pm 512(4.7\%) \pm 598(5.5\%)$	$8163 \pm 321(3.9\%) \pm 1010(12.4\%)$
All background	$232799 \pm 539(0.2\%) \pm 21920(9.4\%)$	$160555 \pm 346(0.2\%) \pm 15213(9.5\%)$
Data	$235296 \pm 485(0.2\%)$	$161272 \pm 402(0.2\%)$
Data/Bkg	1.0107	1.0045

2017		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$372594 \pm 3075(0.8\%) \pm 52644(14.1\%)$	$247925 \pm 2448(1.0\%) \pm 34879(14.1\%)$
$H^+ + H^-(m = 90$ GeV)	$370237 \pm 3085(0.8\%) \pm 52137(14.1\%)$	$252572 \pm 2464(1.0\%) \pm 35042(13.9\%)$
$H^+ + H^-(m = 100$ GeV)	$375468 \pm 3105(0.8\%) \pm 51756(13.8\%)$	$259178 \pm 2486(1.0\%) \pm 35240(13.6\%)$
$H^+ + H^-(m = 110$ GeV)	$369864 \pm 3097(0.8\%) \pm 50379(13.6\%)$	$252979 \pm 2476(1.0\%) \pm 32950(13.0\%)$
$H^+ + H^-(m = 120$ GeV)	$353585 \pm 3171(0.9\%) \pm 49300(13.9\%)$	$239465 \pm 2514(1.1\%) \pm 32926(13.8\%)$
$H^+ + H^-(m = 130$ GeV)	$322512 \pm 2866(0.9\%) \pm 42414(13.2\%)$	$217248 \pm 2290(1.1\%) \pm 29229(13.5\%)$
$H^+ + H^-(m = 140$ GeV)	$263039 \pm 2620(1.0\%) \pm 36065(13.7\%)$	$185084 \pm 2112(1.1\%) \pm 26915(14.5\%)$
$H^+ + H^-(m = 150$ GeV)	$193077 \pm 1944(1.0\%) \pm 28189(14.6\%)$	$131832 \pm 1568(1.2\%) \pm 19668(14.9\%)$
$H^+ + H^-(m = 155$ GeV)	$153161 \pm 1914(1.2\%) \pm 22142(14.5\%)$	$103696 \pm 1533(1.5\%) \pm 15609(15.1\%)$
$H^+ + H^-(m = 160$ GeV)	$128739 \pm 1597(1.2\%) \pm 18921(14.7\%)$	$89290 \pm 1291(1.4\%) \pm 12343(13.8\%)$
SM $t\bar{t}$ + jets	$306506 \pm 113(0.0\%) \pm 40759(13.3\%)$	$208268 \pm 90(0.0\%) \pm 27830(13.4\%)$
Single t	$11369 \pm 46(0.4\%) \pm 1550(13.6\%)$	$7278 \pm 37(0.5\%) \pm 981(13.5\%)$
W + jets	$5000 \pm 154(3.1\%) \pm 894(17.9\%)$	$3030 \pm 102(3.4\%) \pm 505(16.7\%)$
Z/γ + jets	$810 \pm 16(2.0\%) \pm 137(16.9\%)$	$1033 \pm 17(1.7\%) \pm 208(20.2\%)$
VV	$150 \pm 7(4.4\%) \pm 25(16.6\%)$	$116 \pm 6(4.9\%) \pm 18(15.6\%)$
MC QCD	$4607 \pm 962(20.9\%)$	$3795 \pm 2367(62.4\%)$
DD QCD	$31829 \pm 940(3.0\%) \pm 3144(9.9\%)$	$25002 \pm 948(3.8\%) \pm 599(2.4\%)$
All background	$355664 \pm 961(0.3\%) \pm 40920(11.5\%)$	$244727 \pm 959(0.4\%) \pm 27860(11.4\%)$
Data	$356316 \pm 597(0.2\%)$	$244018 \pm 494(0.2\%)$
Data/Bkg	1.0018	0.9971

2018		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$401767 \pm 3944(1.0\%) \pm 53589(13.3\%)$	$259273 \pm 3105(1.2\%) \pm 36587(14.1\%)$
$H^+ + H^-(m = 90$ GeV)	$412455 \pm 3919(1.0\%) \pm 57864(14.0\%)$	$259179 \pm 3070(1.2\%) \pm 36740(14.2\%)$
$H^+ + H^-(m = 100$ GeV)	$410522 \pm 3930(1.0\%) \pm 55783(13.6\%)$	$263859 \pm 3076(1.2\%) \pm 35078(13.3\%)$
$H^+ + H^-(m = 110$ GeV)	$409232 \pm 4039(1.0\%) \pm 58885(14.4\%)$	$262669 \pm 3153(1.2\%) \pm 34742(13.2\%)$
$H^+ + H^-(m = 120$ GeV)	$381324 \pm 3846(1.0\%) \pm 54940(14.4\%)$	$242642 \pm 3008(1.2\%) \pm 32859(13.5\%)$
$H^+ + H^-(m = 130$ GeV)	$354399 \pm 3641(1.0\%) \pm 49152(13.9\%)$	$222961 \pm 2849(1.3\%) \pm 33681(15.1\%)$
$H^+ + H^-(m = 140$ GeV)	$287797 \pm 3325(1.2\%) \pm 42634(14.8\%)$	$188960 \pm 2620(1.4\%) \pm 26645(14.1\%)$
$H^+ + H^-(m = 150$ GeV)	$211088 \pm 2736(1.3\%) \pm 32598(15.4\%)$	$138229 \pm 2150(1.6\%) \pm 20335(14.7\%)$
$H^+ + H^-(m = 155$ GeV)	$168036 \pm 2242(1.3\%) \pm 25456(15.1\%)$	$111657 \pm 1784(1.6\%) \pm 17137(15.3\%)$
$H^+ + H^-(m = 160$ GeV)	$146668 \pm 2086(1.4\%) \pm 21951(15.0\%)$	$94025 \pm 1624(1.7\%) \pm 13534(14.4\%)$
SM $t\bar{t}$ + jets	$341581 \pm 123(0.0\%) \pm 42828(12.5\%)$	$219021 \pm 97(0.0\%) \pm 27021(12.6\%)$
Single t	$12807 \pm 50(0.4\%) \pm 1856(14.5\%)$	$7734 \pm 39(0.5\%) \pm 1082(14.0\%)$
W + jets	$5603 \pm 193(3.4\%) \pm 1135(20.3\%)$	$3313 \pm 130(3.9\%) \pm 648(19.6\%)$
Z/γ + jets	$924 \pm 24(2.6\%) \pm 205(22.1\%)$	$1125 \pm 26(2.3\%) \pm 257(22.9\%)$
VV	$173 \pm 9(5.0\%) \pm 35(20.6\%)$	$123 \pm 7(5.7\%) \pm 23(18.5\%)$
MC QCD	$7440 \pm 2188(29.4\%)$	$0 \pm 0(0\%)$
DD QCD	$53517 \pm 1299(2.4\%) \pm 172(0.3\%)$	$25261 \pm 840(3.3\%) \pm 796(3.2\%)$
All background	$414605 \pm 1320(0.3\%) \pm 42884(10.3\%)$	$256576 \pm 857(0.3\%) \pm 27662(10.8\%)$
Data	$404856 \pm 636(0.2\%)$	$258559 \pm 508(0.2\%)$
Data/Bkg	0.9765	1.0077

Yields (2016-18) [exclusive tight category]

2016		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$106838 \pm 1425(1.3\%) \pm 25212(23.6\%)$	$75612 \pm 1178(1.6\%) \pm 17869(23.6\%)$
$H^+ + H^-(m = 90$ GeV)	$112499 \pm 1455(1.3\%) \pm 26141(23.2\%)$	$77122 \pm 1199(1.6\%) \pm 18173(23.6\%)$
$H^+ + H^-(m = 100$ GeV)	$115982 \pm 1484(1.3\%) \pm 27413(23.6\%)$	$80167 \pm 1222(1.5\%) \pm 18948(23.6\%)$
$H^+ + H^-(m = 110$ GeV)	$116770 \pm 1713(1.5\%) \pm 27608(23.6\%)$	$80977 \pm 1431(1.8\%) \pm 19871(24.5\%)$
$H^+ + H^-(m = 120$ GeV)	$110204 \pm 1465(1.3\%) \pm 26115(23.7\%)$	$76929 \pm 1209(1.6\%) \pm 18662(24.3\%)$
$H^+ + H^-(m = 130$ GeV)	$99531 \pm 1357(1.4\%) \pm 23835(23.9\%)$	$66875 \pm 1117(1.7\%) \pm 16268(24.3\%)$
$H^+ + H^-(m = 140$ GeV)	$84358 \pm 1261(1.5\%) \pm 20430(24.2\%)$	$55328 \pm 1031(1.9\%) \pm 14332(25.9\%)$
$H^+ + H^-(m = 150$ GeV)	$51971 \pm 869(1.7\%) \pm 13320(25.6\%)$	$37599 \pm 734(2.0\%) \pm 9323(24.8\%)$
$H^+ + H^-(m = 155$ GeV)	$42168 \pm 768(1.8\%) \pm 10714(25.4\%)$	$27590 \pm 632(2.3\%) \pm 6904(25.0\%)$
$H^+ + H^-(m = 160$ GeV)	$29838 \pm 668(2.2\%) \pm 7634(25.6\%)$	$21319 \pm 554(2.6\%) \pm 5359(25.1\%)$
SM $t\bar{t}$ + jets	$63343 \pm 52(0.1\%) \pm 11915(18.8\%)$	$43612 \pm 43(0.1\%) \pm 8268(19.0\%)$
Single t	$1847 \pm 19(1.0\%) \pm 363(19.7\%)$	$1270 \pm 16(1.3\%) \pm 248(19.5\%)$
W + jets	$489 \pm 45(9.2\%) \pm 112(22.9\%)$	$390 \pm 39(10.1\%) \pm 98(25.2\%)$
Z/γ + jets	$99 \pm 5(4.7\%) \pm 19(19.5\%)$	$121 \pm 5(4.3\%) \pm 22(17.8\%)$
VV	$22 \pm 2(8.4\%) \pm 4(19.8\%)$	$18 \pm 2(9.0\%) \pm 3(18.5\%)$
MC QCD	$403 \pm 160(39.7\%)$	$0 \pm 0(0\%)$
DD QCD	$8107 \pm 699(8.6\%) \pm 2316(28.6\%)$	$5890 \pm 441(7.5\%) \pm 2026(34.4\%)$
All background	$73907 \pm 703(1.0\%) \pm 12144(16.4\%)$	$51301 \pm 445(0.9\%) \pm 8517(16.6\%)$
Data	72505 ± 269(0.4%)	49976 ± 224(0.4%)
Data/Bkg	0.9810	0.9742

2017		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$103064 \pm 1425(1.4\%) \pm 28247(27.4\%)$	$69055 \pm 1140(1.7\%) \pm 19047(27.6\%)$
$H^+ + H^-(m = 90$ GeV)	$105612 \pm 1455(1.4\%) \pm 29215(27.7\%)$	$70564 \pm 1155(1.6\%) \pm 19653(27.9\%)$
$H^+ + H^-(m = 100$ GeV)	$109589 \pm 1478(1.3\%) \pm 30241(27.6\%)$	$74678 \pm 1183(1.6\%) \pm 20907(28.0\%)$
$H^+ + H^-(m = 110$ GeV)	$111291 \pm 1481(1.3\%) \pm 30817(27.7\%)$	$76133 \pm 1184(1.6\%) \pm 21379(28.1\%)$
$H^+ + H^-(m = 120$ GeV)	$106354 \pm 1523(1.4\%) \pm 29554(27.8\%)$	$70114 \pm 1196(1.7\%) \pm 19813(28.3\%)$
$H^+ + H^-(m = 130$ GeV)	$94964 \pm 1361(1.4\%) \pm 27007(28.4\%)$	$63160 \pm 1084(1.7\%) \pm 18138(28.7\%)$
$H^+ + H^-(m = 140$ GeV)	$73561 \pm 1222(1.7\%) \pm 21322(29.0\%)$	$51794 \pm 985(1.9\%) \pm 14742(28.5\%)$
$H^+ + H^-(m = 150$ GeV)	$50746 \pm 871(1.7\%) \pm 15301(30.2\%)$	$34880 \pm 699(2.0\%) \pm 10588(30.4\%)$
$H^+ + H^-(m = 155$ GeV)	$37443 \pm 822(2.2\%) \pm 11471(30.6\%)$	$27100 \pm 671(2.5\%) \pm 8202(30.3\%)$
$H^+ + H^-(m = 160$ GeV)	$27392 \pm 659(2.4\%) \pm 8238(30.1\%)$	$18984 \pm 528(2.8\%) \pm 5896(31.1\%)$
SM $t\bar{t}$ + jets	$51202 \pm 42(0.1\%) \pm 12123(23.7\%)$	$34823 \pm 34(0.1\%) \pm 8307(23.9\%)$
Single t	$1434 \pm 16(1.1\%) \pm 356(24.8\%)$	$928 \pm 13(1.4\%) \pm 234(25.2\%)$
W + jets	$378 \pm 38(10.1\%) \pm 108(28.7\%)$	$229 \pm 23(10.1\%) \pm 91(39.6\%)$
Z/γ + jets	$70 \pm 4(5.9\%) \pm 16(22.1\%)$	$67 \pm 4(5.7\%) \pm 19(27.8\%)$
VV	$17 \pm 2(12.2\%) \pm 5(27.6\%)$	$12 \pm 2(14.0\%) \pm 3(24.5\%)$
MC QCD	$415 \pm 189(45.7\%)$	$0 \pm 0(0\%)$
DD QCD	$84 \pm 80(95.9\%) \pm 61(73.3\%)$	$155 \pm 66(42.4\%) \pm 57(37.2\%)$
All background	$53184 \pm 100(0.2\%) \pm 12129(22.8\%)$	$36214 \pm 79(0.2\%) \pm 8311(23.0\%)$
Data	48428 ± 220(0.5%)	33195 ± 182(0.5%)
Data/Bkg	0.9106	0.9166

2018		
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$H^+ + H^-(m = 80$ GeV)	$257335 \pm 2836(1.1\%) \pm 65805(25.6\%)$	$163405 \pm 2218(1.4\%) \pm 40615(24.9\%)$
$H^+ + H^-(m = 90$ GeV)	$258852 \pm 2840(1.1\%) \pm 66499(25.7\%)$	$169751 \pm 2215(1.3\%) \pm 42840(25.2\%)$
$H^+ + H^-(m = 100$ GeV)	$270819 \pm 2862(1.1\%) \pm 68593(25.3\%)$	$167238 \pm 2222(1.3\%) \pm 43978(26.3\%)$
$H^+ + H^-(m = 110$ GeV)	$265164 \pm 2939(1.1\%) \pm 67495(25.5\%)$	$170674 \pm 2280(1.3\%) \pm 44155(25.9\%)$
$H^+ + H^-(m = 120$ GeV)	$259715 \pm 2830(1.1\%) \pm 66077(25.4\%)$	$167753 \pm 2204(1.3\%) \pm 43625(26.0\%)$
$H^+ + H^-(m = 130$ GeV)	$232716 \pm 2661(1.1\%) \pm 60271(25.9\%)$	$144635 \pm 2084(1.4\%) \pm 37699(26.1\%)$
$H^+ + H^-(m = 140$ GeV)	$185806 \pm 2387(1.3\%) \pm 49000(26.4\%)$	$120189 \pm 1879(1.6\%) \pm 33016(27.5\%)$
$H^+ + H^-(m = 150$ GeV)	$126408 \pm 1897(1.5\%) \pm 34862(27.6\%)$	$80764 \pm 1472(1.8\%) \pm 22120(27.4\%)$
$H^+ + H^-(m = 155$ GeV)	$93519 \pm 1511(1.6\%) \pm 26568(28.4\%)$	$63081 \pm 1197(1.9\%) \pm 17885(28.4\%)$
$H^+ + H^-(m = 160$ GeV)	$73809 \pm 1348(1.8\%) \pm 20769(28.1\%)$	$48358 \pm 1056(2.2\%) \pm 13472(27.9\%)$
SM $t\bar{t}$ + jets	$141865 \pm 75(0.1\%) \pm 30909(21.8\%)$	$91047 \pm 59(0.1\%) \pm 19994(22.0\%)$
Single t	$4248 \pm 29(0.7\%) \pm 919(21.6\%)$	$2650 \pm 23(0.9\%) \pm 584(22.0\%)$
W + jets	$1228 \pm 71(5.8\%) \pm 392(31.9\%)$	$876 \pm 66(7.5\%) \pm 220(25.1\%)$
Z/γ + jets	$249 \pm 11(4.2\%) \pm 52(20.9\%)$	$269 \pm 11(4.2\%) \pm 64(23.6\%)$
VV	$55 \pm 5(8.4\%) \pm 14(25.9\%)$	$35 \pm 4(10.5\%) \pm 7(21.3\%)$
MC QCD	$1952 \pm 1144(58.6\%)$	$0 \pm 0(0\%)$
DD QCD	$3185 \pm 318(10.0\%) \pm 1662(52.2\%)$	$2686 \pm 297(11.1\%) \pm 1013(37.7\%)$
All background	$150830 \pm 335(0.2\%) \pm 30970(20.5\%)$	$97562 \pm 311(0.3\%) \pm 20930(20.5\%)$
Data	150461 ± 388(0.3%)	96398 ± 310(0.3%)
Data/Bkg	0.9976	0.9881

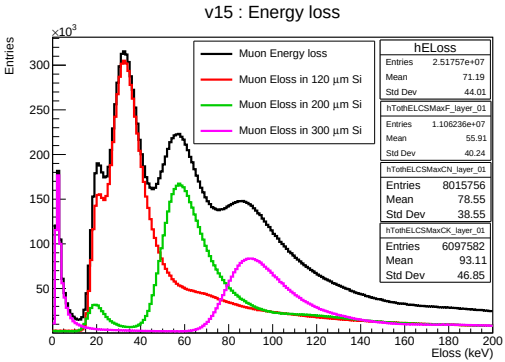
Summary and Outlook

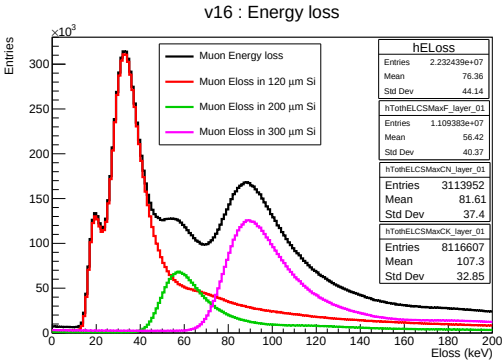
- We have presented the cut based analysis (CBA) results with Ultra Legacy dataset for 2016, 2017 and 2018.
- A significant improvement in Kinematic Fitting efficiency is reported.
- The charm tagging and associated systematic uncertainties have been incorporated to the CBA.
- We have shown the readiness of the analysis framework with relevant systematics.
- Calculation of expected upper limit is complete but yet to be reported in Higgs PAG.
- The c-tagging and pileup jet-ID scale factors are recently available for integrating to the ongoing study.
- Plan to prepare Analysis Note in next months.

Motivation of Muon Tomography

- The default HGCAL simulation workflow (link) uses Close-By-Photon generator.
- To study the response of HGCAL to muons:
  1. Study of energy loss dependence as function of thickness of depletion depth (120 μm, 200 μm, 300 μm).
  2. Obtaining the image of each layer using muon hits.
- 1M events with two muons ($\mu^+ + \mu^-$) at constant p_T (100 GeV/c) towards HGCAL ($1.3 < |\eta| < 3.1$) in +ve and -ve z directions are simulated respectively.
- The energy loss stored in simhit array for a given cell are added if found to arrive the cell between (0-25) ns [in-bunch hits].
- The energy loss distribution obtained for the cell with maximum deposited energy in a given layer is used for the present study.

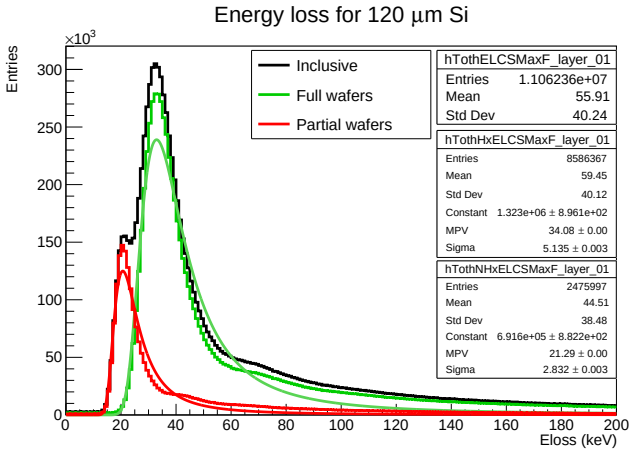
Muon Energy loss





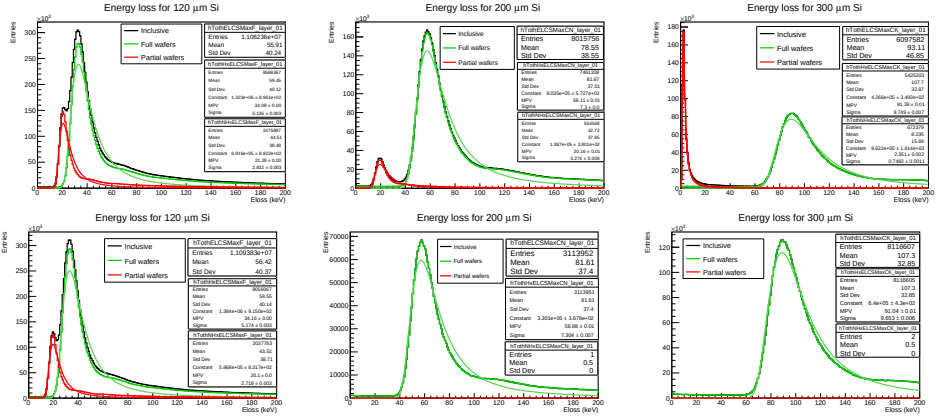
- The energy loss of muons in Si wafers are shown in black color for HGCAL geometry version v15(left) and v16(right).
- The energy loss histograms for different depletion depths, 120 μm, 200 μm and 300 μm are shown in red, green and magenta color, respectively.
- In addition to the expected energy loss peaks as per thickness of the depletion depth, several anomalous peaks for each of v15 and v16 geometries are noted.
- Number anomalous peaks for v15 and v16 are not the same.

Energy loss for Fine Wafers (120 μm depletion)



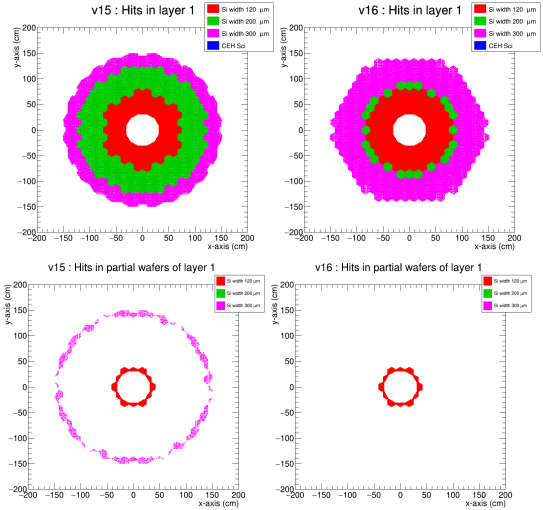
- Energy loss distribution for full wafer is normal without any anomalous peak.
- However, there is NO normal energy loss distribution for partial wafers. The observed energy loss distribution is completely anomalous.
- The energy loss distributions for full as well as partial wafers are observed to follow the Landau distribution.

Energy loss for different depletion depths



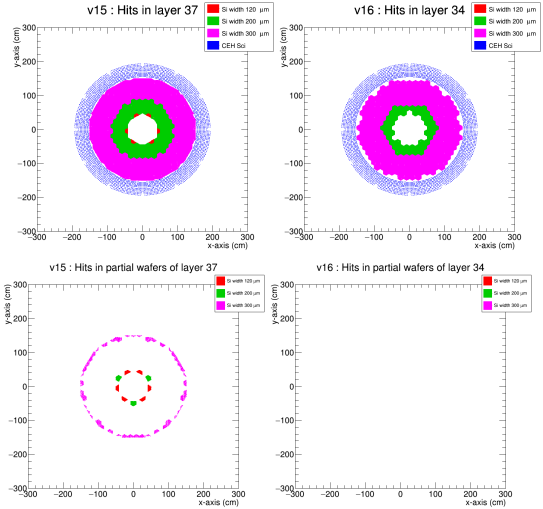
- The energy loss of muons are shown for v15(top) and v16(bottom).
- Though expected, we do not find any hits in the partial wafers corresponding to 200 and 300 μm in case of v16.
- The energy loss peaks $\sim$34 keV, $\sim$60 keV and $\sim$90 keV are observed to be in proportion with different depletion depths (120 μm, 200 μm, 300 μm).
- The anomalous low energy peak with Si wafers of 120 and 200 μm depletion depth is $\sim$20 keV and it is close to 2 keV for Si wafers of 300 μm depletion depth.

SimHit distribution for layer 1



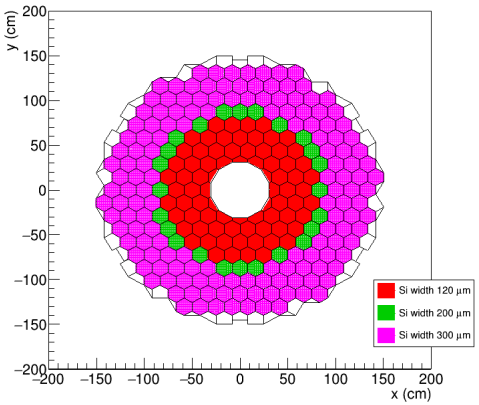
- The GEANT simhit distributions in the XY plane are shown for layer 1 of v15(left) and v16(right).
- The GEANT simhit distributions for all wafers(top) and exclusively partial wafers(bottom) are shown for layer 1.
- The partial wafers are missing in the outermost circles of Si wafers in v16 geometry.

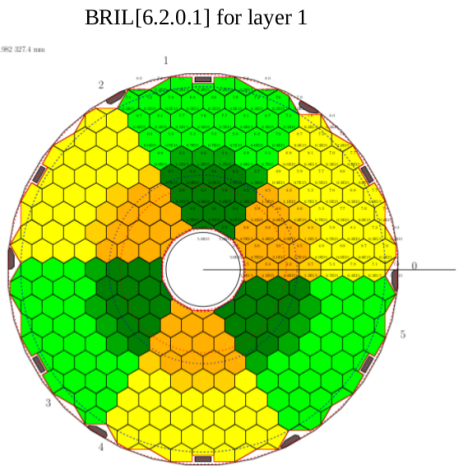
SimHit distribution in CEH for matching layer of v15 and v16



- The partial wafers are missing in innermost and outermost area of v16 geometry.

HGCAL geometry v16





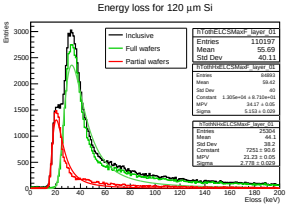
- The GEANT hit distribution in the XY plane for v16(left) is compared with the BRIL[6.2.0.1](right) result.

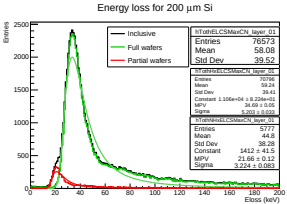
Effect of change of depletion widths

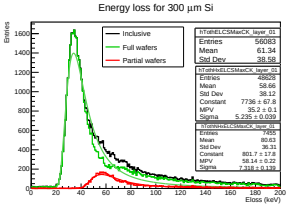
- Three separate simulation sets are produced with 10K events using v15.
  1. Depletion width all wafers changed to 120 μm.
  2. Depletion width all wafers changed to 200 μm.
  3. Depletion width all wafers changed to 300 μm.

Peak position of energy loss distribution (in keV)						
Depletion width	Full wafers			Partial wafers		
	Fine	CoarseThin	CoarseThick	Fine	CoarseThin	CoarseThick
All wafers 120 μm	34.17 $\pm$ 0.05	34.69 $\pm$ 0.05	35.2 $\pm$ 0.1	21.23 $\pm$ 0.05	21.66 $\pm$ 0.12	58.14 $\pm$ 0.22
All wafers 200 μm	58.16 $\pm$ 0.06	59.24 $\pm$ 0.07	60.14 $\pm$ 0.09	19.87 $\pm$ 0.05	20.09 $\pm$ 0.11	32.49 $\pm$ 0.13
All wafers 300 μm	88.27 $\pm$ 0.08	90.13 $\pm$ 0.09	91.41 $\pm$ 0.11	2.21 $\pm$ 0.01	2.19 $\pm$ 0.02	2.33 $\pm$ 0.02

- The energy loss distributions when the depletion width of wafers are changed to 120 μm for v15.



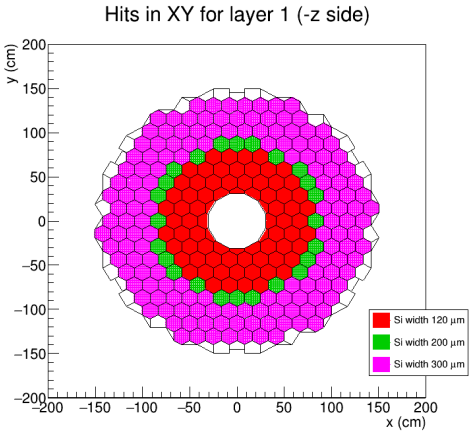


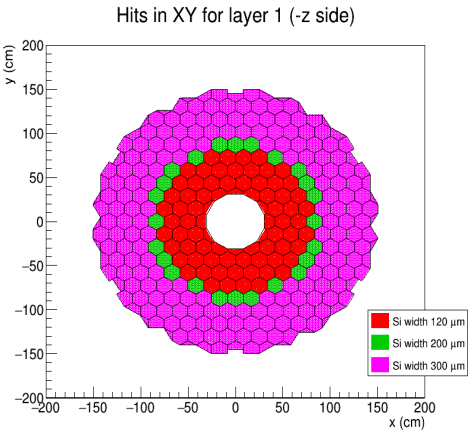


Origin of the issues

- The total width of Si wafer was defined as 310 μm for all wafer types (120 μm, 200 μm, 300 μm) in v15.
- The total width of Si wafer for different wafer types were properly set in v16.
  - 300 μm width for 120 and 300 μm type wafers and 200 μm for 200 μm.
- The GEANT simhits corresponding to the inactive regions are stored for partial wafers.
  - v15 : An additional factor applied for partial wafers to account the energy loss corresponding to the depletion width.
  - v15 : Energy loss corresponding to $\rightarrow$ 190 μm, 110 μm and 10 μm for 120, 200 μm for 300 μm wafer types respectively.
  - v16 : Energy loss corresponding to $\rightarrow$ 180 μm, 0 μm and 0 μm for 120, 200 μm for 300 μm wafer types respectively.
- With the inputs from previous mentioned studies, the issues were resolved by Prof. S. Banerjee in PR #35765 and discussed in slide 3-5 of link.

Validation of the solution of the Issues

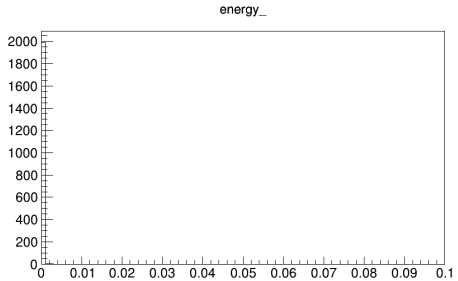


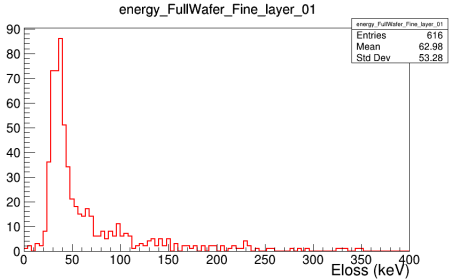


- The GEANT simhit distribution in the xy-plane of layer 1 of HGCAL before(left) and after(right) the fix.

DQM plots corresponding to Muon Tomography

- The HGCAL DPG conveners encouraged us to propagate the Muon Tomography plots in CMSSW DQM file.
- The main histograms of Muon Tomography is now in CMSSW since PR #36484.





- The energy loss distribution for HGCAL layer 1 and Si wafer of 120 μm for HGCAL layer 1 are shown in the left and right side plots.
- In total six 1D energy loss histograms and six 2D xy simhit distributions are stored for each Silicon layer of HGCAL in the DQM file.
- In addition, one 2D xy simhit distributions are stored for each Scintillator layers of HGCAL DQM in the DQM file.

Summary

- The Muon Tomography has successfully been able to pin-point the problem of detector geometry.
- The important energy loss and hit distribution histograms are now part of CMSSW DQM framework since PR #36484 by us.
- A documentation on
  - HGCAL geometry
  - tutorial to work with the HGCAL geometry

  has been integrated to the Geometry section of https://hgcal.web.cern.ch/ (PR #105, #107)

Thank you

Scale factors

- Muon scale factors
  - Isolation, Identification
  - Trigger
  - https://twiki.cern.ch/twiki/bin/view/CMS/MuonReferenceEffsRun2
- Electron scale factors
  - Reconstruction
  - Identification
  - Trigger
  - https://twiki.cern.ch/twiki/bin/view/CMS/EgammaIDRecipesRun2#Efficiencies_and_scale_factors
- MC scale factors
  - Luminosity scale factors
  - Pileup reweighting [https://twiki.cern.ch/twiki/bin/viewauth/CMS/PileupJSONFileforData]
  - Prefire scale factors [2016-17] [https://twiki.cern.ch/twiki/bin/viewauth/CMS/L1ECALPrefiringWeightRecipe]
  - b-tag [https://twiki.cern.ch/twiki/bin/view/CMS/BTagSFMethods]
  - Jet Energy Corrections [https://twiki.cern.ch/twiki/bin/view/CMSPublic/WorkBookJetEnergyCorrections#CorrPatJets]
  - MET corrections (type - 1) [https://twiki.cern.ch/twiki/bin/viewauth/CMS/MissingETRun2Corrections]

Systematic Uncertainties (I)

- Luminosity (lnN) : The uncertianty due to integrated luminosity is taken 2.5%. The systematics has been profiled as lnN in the datacard for limit calculation.
- Pileup (Shape) : Depending on the number of primary vertices, each MC event is multiplied by corresponding pileup weight. The uncertainty in the minimum bias cross-section affects the pileup distribution of data. Hence the pileup weights are varied to take into that effect.
- Lepton (lnN) : Trigger, tracking, isolation and identification efficiencies are different between MC and data. Therefore, p_T and η dependent scale factors are applied to MC events to take care of this difference. The uncertianties of the lepton scale factors are considered for systematic uncertainties.
- Jet and $\not{E}_T$ (Shape) : The p_T of jet in the MC are corrected using JES (Jet Energy Scale) and JER (Jet Energy Resolutions). The corresponding corrections are also propagated to $\not{E}_T$ as type 1 corrections. A variation of the JES and JER uncertainties and a 10% variation for $\not{E}_T$ unclustered energies are used as systematic uncertianties.

Systematic Uncertainties (II)

- b-jet tagging (Shape) : The identification of the b-jets and light-jets depends on the discriminator value at a given p_T and η. The up/down variation of the scale factors for b-jets and light-jets are used and systematic uncertainties.
- Prefire SF : The gradual timing shift of ECAL was not properly incorporated to L1 trigger primitives in 2016 and 2017. The implemented logic of L1 forbids to trigger on consecutive bunch crossings. Therefore the event can self veto if significant energy is recorded in ECAL. A prefiring probability is obtained for the cases when atleast one object has successfully prefired. The up/down variation of the prefiring probability is considered as systematic uncertainty.
- Normalization (lnN) : The MC events are normalised with a scale factor where the cross-section of the fundamental processes have been used. The variation of the normalization scale factors are used as source of systematic uncertainties.

Systematic uncertainties (2016-18) [KinFit Level]

2016										
Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	0.76(0.91)	0.63(1.47)	0.00(0.00)	0.17(0.14)	3.88(3.96)	0.59(0.40)	3.74(3.46)	0.36(0.32)	6.10(6.10)	0.60(0.70)
$H^+ + H^-(m = 90$ GeV)	0.83(1.13)	0.63(1.45)	0.00(0.00)	0.14(0.14)	3.82(3.85)	0.59(0.40)	3.41(3.62)	0.20(0.24)	6.10(6.10)	0.59(0.70)
$H^+ + H^-(m = 100$ GeV)	0.82(1.00)	0.63(1.46)	0.00(0.00)	0.17(0.14)	3.75(3.74)	0.58(0.41)	3.18(3.33)	0.34(0.20)	6.10(6.10)	0.59(0.70)
$H^+ + H^-(m = 110$ GeV)	0.72(0.91)	0.63(1.46)	0.00(0.00)	0.14(0.18)	3.68(3.70)	0.59(0.40)	3.42(3.55)	0.33(0.37)	6.10(6.10)	0.69(0.83)
$H^+ + H^-(m = 120$ GeV)	0.71(1.20)	0.63(1.45)	0.00(0.00)	0.17(0.18)	3.68(3.74)	0.59(0.42)	3.74(3.58)	0.34(0.36)	6.10(6.10)	0.62(0.74)
$H^+ + H^-(m = 130$ GeV)	0.75(0.66)	0.63(1.48)	0.00(0.00)	0.26(0.27)	3.65(3.73)	0.59(0.39)	3.60(3.78)	0.13(0.27)	6.10(6.10)	0.63(0.77)
$H^+ + H^-(m = 140$ GeV)	0.49(0.90)	0.62(1.49)	0.00(0.00)	0.38(0.40)	3.83(3.82)	0.59(0.41)	4.44(4.20)	0.16(0.27)	6.10(6.10)	0.70(0.86)
$H^+ + H^-(m = 150$ GeV)	0.61(0.66)	0.63(1.51)	0.00(0.00)	0.57(0.62)	4.09(4.02)	0.61(0.41)	4.90(4.81)	0.32(0.37)	6.10(6.10)	0.74(0.87)
$H^+ + H^-(m = 155$ GeV)	0.43(0.55)	0.62(1.50)	0.00(0.00)	0.74(0.72)	4.30(4.29)	0.61(0.41)	5.07(4.97)	0.02(0.06)	6.10(6.10)	0.81(0.97)
$H^+ + H^-(m = 160$ GeV)	0.58(0.55)	0.62(1.50)	0.00(0.00)	0.83(1.00)	4.40(4.37)	0.61(0.42)	4.99(4.81)	0.25(0.26)	6.10(6.10)	0.91(1.08)
SM $t\bar{t}$ + jets	0.67(0.95)	0.63(1.48)	0.00(0.00)	0.19(0.19)	4.18(4.20)	0.63(0.45)	3.18(3.16)	1.87(1.87)	6.10(6.10)	0.03(0.04)
Single t	0.54(0.77)	0.63(1.48)	0.00(0.00)	0.67(0.69)	4.20(4.22)	0.65(0.46)	4.92(4.82)	0.22(0.16)	6.10(6.10)	0.32(0.39)
W + jets	0.87(0.48)	0.70(1.60)	0.00(0.00)	4.24(4.22)	4.10(4.17)	0.44(0.58)	12.81(8.51)	0.92(1.26)	6.10(6.10)	2.51(3.11)
Z/γ + jets	0.69(0.91)	0.71(1.50)	0.00(0.00)	4.57(5.37)	3.71(3.56)	0.68(0.64)	8.88(9.15)	1.10(0.79)	6.10(6.10)	1.41(1.25)
VV	0.19(0.23)	0.66(1.51)	0.00(0.00)	2.99(2.43)	3.91(4.13)	0.52(0.41)	7.39(7.68)	0.96(0.69)	6.10(6.10)	2.38(2.76)
DD QCD	–	–	–	–	–	–	–	–	7.79(24.86)	3.93(2.86)

2017										
Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	0.17(0.36)	0.28(1.41)	0.00(0.00)	0.10(0.11)	5.04(5.06)	0.42(0.45)	4.39(4.25)	0.40(0.21)	6.10(6.10)	0.59(0.70)
$H^+ + H^-(m = 90$ GeV)	0.31(0.69)	0.28(1.39)	0.00(0.00)	0.11(0.12)	4.92(5.03)	0.41(0.44)	4.44(4.22)	0.39(0.37)	6.10(6.10)	0.59(0.69)
$H^+ + H^-(m = 100$ GeV)	0.16(0.48)	0.28(1.40)	0.00(0.00)	0.08(0.15)	4.80(4.85)	0.41(0.45)	4.34(4.52)	0.27(0.61)	6.10(6.10)	0.58(0.68)
$H^+ + H^-(m = 110$ GeV)	0.17(0.62)	0.28(1.40)	0.00(0.00)	0.13(0.18)	4.79(4.71)	0.40(0.45)	4.05(4.09)	0.42(0.17)	6.10(6.10)	0.59(0.69)
$H^+ + H^-(m = 120$ GeV)	0.46(0.25)	0.28(1.39)	0.00(0.00)	0.18(0.14)	4.59(4.71)	0.40(0.45)	4.01(3.92)	0.37(0.52)	6.10(6.10)	0.63(0.74)
$H^+ + H^-(m = 130$ GeV)	0.29(0.39)	0.28(1.41)	0.00(0.00)	0.22(0.23)	4.66(4.59)	0.42(0.46)	4.34(4.63)	0.51(0.57)	6.10(6.10)	0.63(0.74)
$H^+ + H^-(m = 140$ GeV)	0.36(0.46)	0.28(1.41)	0.00(0.00)	0.28(0.34)	4.67(4.65)	0.42(0.45)	4.74(4.59)	0.32(0.33)	6.10(6.10)	0.71(0.81)
$H^+ + H^-(m = 150$ GeV)	0.27(0.42)	0.29(1.45)	0.00(0.00)	0.48(0.44)	5.03(4.91)	0.43(0.46)	5.68(5.73)	0.24(0.17)	6.10(6.10)	0.72(0.84)
$H^+ + H^-(m = 155$ GeV)	0.41(0.51)	0.29(1.44)	0.00(0.00)	0.73(0.60)	5.04(5.19)	0.45(0.49)	5.59(5.93)	0.19(0.60)	6.10(6.10)	0.89(1.04)
$H^+ + H^-(m = 160$ GeV)	0.02(0.30)	0.29(1.44)	0.00(0.00)	0.84(0.83)	5.39(5.26)	0.44(0.48)	5.57(5.52)	0.18(0.41)	6.10(6.10)	0.89(1.04)
SM $t\bar{t}$ + jets	0.28(0.48)	0.28(1.41)	0.00(0.00)	0.14(0.14)	5.44(5.46)	0.48(0.51)	8.35(8.32)	1.73(1.74)	6.10(6.10)	0.03(0.03)
Single t	0.06(0.23)	0.28(1.42)	0.00(0.00)	0.58(0.59)	5.33(5.37)	0.50(0.51)	6.04(5.69)	0.53(0.27)	6.10(6.10)	0.29(0.35)
W + jets	1.18(0.37)	0.31(1.44)	0.00(0.00)	4.35(4.35)	4.99(4.91)	0.43(0.65)	9.91(9.52)	1.23(0.58)	6.10(6.10)	2.07(2.33)
Z/γ + jets	1.71(1.96)	0.32(1.41)	0.00(0.00)	4.16(4.61)	4.69(4.48)	0.44(0.92)	9.97(13.60)	2.15(2.64)	6.10(6.10)	1.32(1.23)
VV	2.60(1.54)	0.29(1.40)	0.00(0.00)	2.43(2.61)	4.54(4.71)	0.33(0.55)	11.92(10.98)	2.35(2.93)	6.10(6.10)	3.12(3.43)
DD QCD	–	–	–	–	–	–	–	–	4.64(25.76)	3.94(3.65)

2018										
Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	0.52(0.66)	0.27(1.35)	0.00(0.00)	0.15(0.16)	5.03(5.12)	0.09(0.02)	5.37(5.66)	0.10(0.23)	6.10(6.10)	0.57(0.69)
$H^+ + H^-(m = 90$ GeV)	0.29(0.38)	0.27(1.36)	0.00(0.00)	0.17(0.19)	4.97(5.03)	0.09(0.01)	5.50(5.32)	0.26(0.20)	6.10(6.10)	0.56(0.68)
$H^+ + H^-(m = 100$ GeV)	0.26(0.47)	0.27(1.36)	0.00(0.00)	0.12(0.24)	4.84(4.91)	0.09(0.01)	5.22(4.98)	0.23(0.30)	6.10(6.10)	0.55(0.68)
$H^+ + H^-(m = 110$ GeV)	0.38(0.40)	0.27(1.34)	0.00(0.00)	0.19(0.19)	4.68(4.75)	0.09(0.01)	5.32(5.12)	0.23(0.38)	6.10(6.10)	0.57(0.70)
$H^+ + H^-(m = 120$ GeV)	0.42(0.54)	0.27(1.35)	0.00(0.00)	0.22(0.24)	4.58(4.59)	0.09(0.01)	5.24(5.41)	0.41(0.42)	6.10(6.10)	0.58(0.71)
$H^+ + H^-(m = 130$ GeV)	0.31(0.16)	0.27(1.35)	0.00(0.00)	0.33(0.28)	4.49(4.56)	0.09(0.01)	5.49(5.67)	0.17(0.30)	6.10(6.10)	0.60(0.74)
$H^+ + H^-(m = 140$ GeV)	0.24(0.31)	0.27(1.35)	0.00(0.00)	0.42(0.33)	4.56(4.54)	0.09(0.01)	6.13(5.90)	0.38(0.26)	6.10(6.10)	0.66(0.81)
$H^+ + H^-(m = 150$ GeV)	0.11(0.05)	0.27(1.38)	0.00(0.00)	0.63(0.67)	4.74(4.78)	0.09(0.01)	7.26(7.05)	0.28(0.06)	6.10(6.10)	0.75(0.91)
$H^+ + H^-(m = 155$ GeV)	0.24(0.36)	0.27(1.38)	0.00(0.00)	0.72(0.89)	4.96(4.81)	0.09(0.01)	7.34(7.07)	0.31(0.43)	6.10(6.10)	0.77(0.92)
$H^+ + H^-(m = 160$ GeV)	0.15(0.14)	0.28(1.39)	0.00(0.00)	1.08(0.95)	4.88(5.04)	0.09(0.01)	6.92(6.80)	0.21(0.22)	6.10(6.10)	0.85(1.04)
SM $t\bar{t}$ + jets	0.25(0.37)	0.27(1.35)	0.00(0.00)	0.19(0.19)	5.48(5.54)	0.09(0.02)	4.78(4.77)	0.15(0.17)	6.10(6.10)	0.02(0.03)
Single t	0.14(0.29)	0.27(1.36)	0.00(0.00)	0.72(0.72)	5.27(5.31)	0.09(0.01)	7.49(7.26)	0.11(0.04)	6.10(6.10)	0.23(0.30)
W + jets	1.32(0.92)	0.31(1.32)	0.00(0.00)	4.99(4.67)	4.34(4.49)	0.09(0.01)	15.12(11.99)	1.05(1.50)	6.10(6.10)	1.94(2.32)
Z/γ + jets	0.52(1.13)	0.32(1.33)	0.00(0.00)	5.24(6.19)	4.20(3.90)	0.11(0.01)	14.47(15.68)	1.37(1.38)	6.10(6.10)	1.42(1.35)
VV	1.27(0.37)	0.30(1.30)	0.00(0.00)	3.61(3.36)	4.27(4.27)	0.08(0.01)	13.93(10.84)	1.50(0.47)	6.10(6.10)	2.83(3.32)
DD QCD	–	–	–	–	–	–	–	–	10.97(21.84)	2.98(3.09)

Systematic uncertainties due to other sources were explained earlier and can be found in the backup slides.

Systematic uncertainties (2016-18) [exclusive loose category]

2016									
Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	1.18(1.39)	0.64(1.48)	0.92(0.71)	0.74(0.79)	5.77(5.68)	0.57(0.40)	3.88(4.23)	1.19(1.11)	6.10(6.10)	0.96(1.12)
$H^+ + H^-(m = 90$ GeV)	1.25(1.72)	0.64(1.44)	0.75(0.86)	0.69(0.72)	5.49(5.68)	0.59(0.40)	4.13(3.97)	1.23(1.19)	6.10(6.10)	0.95(1.14)
$H^+ + H^-(m = 100$ GeV)	1.47(1.31)	0.63(1.48)	0.80(0.78)	0.81(0.73)	5.64(5.65)	0.58(0.39)	4.50(4.06)	1.53(0.95)	6.10(6.10)	0.97(1.13)
$H^+ + H^-(m = 110$ GeV)	1.15(1.72)	0.64(1.44)	1.21(0.87)	0.81(0.89)	5.72(5.49)	0.59(0.40)	4.85(4.37)	1.46(1.01)	6.10(6.10)	1.13(1.36)
$H^+ + H^-(m = 120$ GeV)	1.21(1.39)	0.62(1.46)	0.92(0.81)	0.86(0.77)	5.78(5.59)	0.57(0.40)	4.95(4.07)	1.33(1.27)	6.10(6.10)	1.03(1.21)
$H^+ + H^-(m = 130$ GeV)	1.36(1.35)	0.63(1.46)	0.92(0.86)	1.04(0.85)	5.72(5.73)	0.60(0.37)	4.78(4.98)	1.17(1.24)	6.10(6.10)	1.04(1.25)
$H^+ + H^-(m = 140$ GeV)	0.99(1.15)	0.62(1.47)	1.01(1.09)	0.97(1.10)	6.04(5.98)	0.58(0.39)	4.58(4.82)	0.93(1.52)	6.10(6.10)	1.14(1.40)
$H^+ + H^-(m = 150$ GeV)	1.13(1.25)	0.63(1.50)	1.04(0.95)	1.46(1.15)	6.63(6.12)	0.60(0.41)	5.93(4.89)	1.69(0.87)	6.10(6.10)	1.18(1.42)
$H^+ + H^-(m = 155$ GeV)	0.98(0.65)	0.63(1.46)	1.10(1.32)	1.52(1.62)	6.81(7.01)	0.60(0.38)	6.93(6.93)	1.43(1.49)	6.10(6.10)	1.30(1.53)
$H^+ + H^-(m = 160$ GeV)	0.78(1.12)	0.62(1.44)	1.17(1.28)	1.62(1.73)	7.08(7.11)	0.59(0.42)	5.96(4.56)	1.38(1.27)	6.10(6.10)	1.43(1.72)
SM $t\bar{t}$ + jets	1.25(1.50)	0.63(1.47)	0.44(0.43)	1.30(1.27)	5.27(5.28)	0.62(0.44)	2.63(2.57)	1.50(1.50)	6.10(6.10)	0.04(0.05)
Single t	1.18(1.41)	0.64(1.48)	0.51(0.46)	1.37(1.42)	5.31(5.29)	0.65(0.45)	5.19(4.68)	0.66(0.50)	6.10(6.10)	0.44(0.55)
W + jets	1.57(0.78)	0.70(1.57)	0.35(0.40)	4.66(4.52)	4.89(5.31)	0.44(0.56)	13.39(8.03)	1.57(1.97)	6.10(6.10)	3.40(4.19)
Z/γ + jets	0.26(0.55)	0.71(1.52)	0.57(0.64)	7.04(7.45)	4.89(4.77)	0.67(0.65)	9.11(9.31)	1.33(1.45)	6.10(6.10)	1.92(1.75)
VV	0.44(0.48)	0.64(1.50)	0.70(0.59)	3.68(3.65)	5.10(5.18)	0.48(0.37)	8.77(6.14)	1.42(0.50)	6.10(6.10)	3.34(3.84)
DD QCD	–	–	–	–	–	–	–	–	5.31(27.50)	13.84(5.98)

2017										
Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	0.73(0.50)	0.28(1.41)	1.49(1.61)	2.02(1.64)	6.55(6.72)	0.41(0.43)	4.24(5.27)	1.08(1.30)	6.10(6.10)	1.09(1.31)
$H^+ + H^-(m = 90$ GeV)	0.68(1.21)	0.27(1.36)	1.54(1.54)	1.80(1.42)	6.44(6.75)	0.40(0.42)	4.60(4.64)	1.28(1.31)	6.10(6.10)	1.10(1.28)
$H^+ + H^-(m = 100$ GeV)	0.53(1.36)	0.28(1.39)	1.55(1.68)	2.07(1.81)	6.44(6.63)	0.43(0.44)	5.23(3.47)	0.78(0.88)	6.10(6.10)	1.08(1.27)
$H^+ + H^-(m = 110$ GeV)	0.80(1.26)	0.28(1.38)	1.61(1.66)	1.25(1.66)	6.48(6.45)	0.41(0.45)	4.70(4.84)	1.50(1.09)	6.10(6.10)	1.09(1.30)
$H^+ + H^-(m = 120$ GeV)	0.90(1.17)	0.28(1.37)	1.59(1.60)	1.85(1.36)	6.39(6.44)	0.38(0.45)	3.74(4.74)	0.63(2.27)	6.10(6.10)	1.17(1.40)
$H^+ + H^-(m = 130$ GeV)	0.95(0.51)	0.28(1.41)	1.62(1.78)	1.75(1.35)	6.47(6.50)	0.42(0.46)	4.78(4.65)	0.51(1.60)	6.10(6.10)	1.16(1.37)
$H^+ + H^-(m = 140$ GeV)	0.83(1.35)	0.28(1.43)	1.64(1.66)	1.89(1.73)	6.61(6.80)	0.41(0.44)	5.41(5.24)	1.22(0.83)	6.10(6.10)	1.30(1.54)
$H^+ + H^-(m = 150$ GeV)	0.77(0.87)	0.29(1.44)	1.51(1.69)	2.10(1.86)	6.97(7.27)	0.43(0.46)	6.41(5.24)	1.09(1.09)	6.10(6.10)	1.33(1.54)
$H^+ + H^-(m = 155$ GeV)	0.92(1.21)	0.28(1.44)	1.70(1.55)	2.29(1.98)	7.35(7.28)	0.45(0.49)	7.21(6.97)	0.36(0.75)	6.10(6.10)	1.65(1.89)
$H^+ + H^-(m = 160$ GeV)	0.90(1.33)	0.28(1.43)	1.55(1.77)	2.63(2.84)	7.83(7.84)	0.43(0.50)	5.65(6.80)	0.77(2.31)	6.10(6.10)	1.58(1.83)
SM $t\bar{t}$ + jets	0.90(1.06)	0.28(1.40)	0.70(0.70)	2.93(2.90)	6.43(6.46)	0.47(0.51)	7.62(7.57)	1.64(1.65)	6.10(6.10)	0.04(0.05)
Single t	0.84(0.85)	0.28(1.43)	0.60(0.64)	2.88(2.68)	6.35(6.38)	0.50(0.51)	5.79(5.61)	0.52(0.67)	6.10(6.10)	0.43(0.54)
W + jets	0.03(0.70)	0.30(1.45)	0.46(0.65)	5.71(5.64)	5.87(5.77)	0.41(0.67)	10.50(7.60)	1.01(2.37)	6.10(6.10)	2.93(3.43)
Z/γ + jets	0.56(1.17)	0.33(1.41)	0.50(0.52)	7.97(8.38)	5.79(5.40)	0.43(0.96)	11.56(11.97)	0.97(3.48)	6.10(6.10)	1.85(1.94)
VV	2.10(0.89)	0.28(1.39)	0.61(0.80)	5.10(5.28)	5.71(6.05)	0.32(0.61)	12.58(10.39)	3.04(2.88)	6.10(6.10)	4.77(5.25)
DD QCD	–	–	–	–	–	–	–	–	1.50(28.97)	183.74(17.76)

2018										
Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	0.46(1.03)	0.27(1.34)	0.63(0.63)	0.69(0.57)	6.75(6.77)	0.09(0.02)	6.33(6.82)	1.36(1.42)	6.10(6.10)	0.94(1.14)
$H^+ + H^-(m = 90$ GeV)	0.44(0.57)	0.27(1.35)	0.71(0.81)	0.55(0.65)	6.57(6.78)	0.09(0.01)	5.85(6.00)	1.32(1.18)	6.10(6.10)	0.92(1.12)
$H^+ + H^-(m = 100$ GeV)	0.47(0.81)	0.27(1.37)	0.85(0.95)	0.58(0.53)	6.55(6.36)	0.09(0.01)	6.27(6.26)	1.08(0.92)	6.10(6.10)	0.93(1.12)
$H^+ + H^-(m = 110$ GeV)	0.76(0.61)	0.27(1.34)	0.80(1.03)	0.61(0.78)	6.28(6.48)	0.09(0.01)	6.58(6.53)	0.86(1.40)	6.10(6.10)	0.96(1.18)
$H^+ + H^-(m = 120$ GeV)	0.41(0.73)	0.27(1.34)	0.89(0.88)	0.71(0.82)	6.34(6.47)	0.09(0.01)	5.87(7.16)	1.12(1.62)	6.10(6.10)	0.96(1.18)
$H^+ + H^-(m = 130$ GeV)	0.57(0.21)	0.27(1.34)	0.87(0.73)	0.86(0.84)	6.58(6.36)	0.09(0.01)	7.00(6.64)	1.12(1.40)	6.10(6.10)	1.01(1.22)
$H^+ + H^-(m = 140$ GeV)	0.53(0.53)	0.27(1.33)	0.87(0.86)	1.03(1.02)	6.46(6.53)	0.09(0.01)	7.53(7.24)	1.46(1.14)	6.10(6.10)	1.08(1.37)
$H^+ + H^-(m = 150$ GeV)	0.25(0.27)	0.27(1.37)	1.10(0.91)	1.40(1.06)	7.22(7.02)	0.09(0.01)	8.67(9.45)	2.01(1.65)	6.10(6.10)	1.22(1.49)
$H^+ + H^-(m = 155$ GeV)	0.67(0.81)	0.27(1.36)	0.98(0.95)	1.18(1.27)	7.14(7.15)	0.09(0.01)	8.20(8.59)	1.30(1.94)	6.10(6.10)	1.21(1.47)
$H^+ + H^-(m = 160$ GeV)	0.27(0.12)	0.27(1.36)	1.14(1.06)	1.58(1.38)	7.37(7.31)	0.09(0.01)	8.23(9.61)	1.31(1.76)	6.10(6.10)	1.34(1.67)
SM $t\bar{t}$ + jets	0.54(0.66)	0.27(1.35)	0.48(0.48)	1.13(1.13)	6.53(6.58)	0.09(0.01)	4.91(4.87)	0.57(0.57)	6.10(6.10)	0.03(0.04)
Single t	0.42(0.58)	0.27(1.35)	0.39(0.42)	1.19(1.25)	6.34(6.39)	0.09(0.01)	7.72(7.74)	0.51(0.41)	6.10(6.10)	0.31(0.41)
W + jets	0.80(0.24)	0.32(1.32)	0.32(0.49)	6.32(5.58)	5.09(5.61)	0.09(0.01)	14.95(10.94)	0.94(1.79)	6.10(6.10)	2.62(3.20)
Z/γ + jets	0.33(0.40)	0.31(1.34)	0.53(0.37)	7.57(8.18)	5.49(4.80)	0.11(0.01)	14.82(14.66)	1.68(0.56)	6.10(6.10)	1.89(1.86)
VV	0.50(0.06)	0.31(1.29)	0.47(0.48)	4.08(3.63)	5.26(4.82)	0.08(0.01)	14.92(9.28)	0.63(2.79)	6.10(6.10)	3.85(4.50)
DD QCD	–	–	–	–	–	–	–	–	3.11(24.48)	17.80(8.70)

Systematic uncertainties for DD methods in 2017 requires more attention, if not resolved with new c-tagger file.

Systematic uncertainties (2016-18) [exclusive medium category]

2016

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	0.18(0.12)	0.63(1.46)	1.87(1.92)	4.31(4.33)	7.54(7.78)	0.61(0.40)	6.45(6.30)	2.42(2.04)	6.10(6.10)	0.96(1.14)
$H^+ + H^-(m = 90$ GeV)	0.27(0.17)	0.62(1.45)	1.91(1.89)	4.25(4.35)	7.61(7.60)	0.60(0.43)	6.11(6.24)	2.16(2.60)	6.10(6.10)	0.95(1.12)
$H^+ + H^-(m = 100$ GeV)	0.29(0.35)	0.63(1.45)	1.91(1.94)	4.35(4.31)	7.52(7.58)	0.60(0.43)	5.84(5.70)	2.35(2.36)	6.10(6.10)	0.95(1.13)
$H^+ + H^-(m = 110$ GeV)	0.19(0.09)	0.63(1.46)	1.84(1.92)	4.26(4.23)	7.33(7.51)	0.60(0.40)	5.53(5.84)	2.15(2.55)	6.10(6.10)	1.11(1.36)
$H^+ + H^-(m = 120$ GeV)	0.10(0.72)	0.63(1.44)	1.94(1.94)	4.32(4.37)	7.52(7.60)	0.61(0.45)	6.62(6.55)	2.92(2.35)	6.10(6.10)	1.00(1.21)
$H^+ + H^-(m = 130$ GeV)	0.38(0.42)	0.62(1.47)	2.00(1.79)	4.50(4.36)	7.63(7.28)	0.59(0.40)	6.45(6.15)	2.56(2.67)	6.10(6.10)	1.02(1.22)
$H^+ + H^-(m = 140$ GeV)	0.47(0.15)	0.62(1.49)	1.91(1.98)	4.69(4.60)	7.60(7.79)	0.62(0.44)	7.12(6.91)	2.22(2.08)	6.10(6.10)	1.15(1.38)
$H^+ + H^-(m = 150$ GeV)	0.30(0.23)	0.63(1.51)	1.87(2.06)	4.87(5.06)	7.72(8.15)	0.63(0.43)	7.69(7.45)	1.94(2.13)	6.10(6.10)	1.18(1.39)
$H^+ + H^-(m = 155$ GeV)	0.27(0.16)	0.62(1.51)	1.82(1.82)	5.10(5.09)	7.93(7.95)	0.64(0.45)	7.41(6.75)	2.44(1.86)	6.10(6.10)	1.30(1.54)
$H^+ + H^-(m = 160$ GeV)	0.14(0.55)	0.62(1.52)	1.67(1.76)	5.06(5.48)	7.60(7.89)	0.62(0.43)	6.88(6.79)	2.30(1.88)	6.10(6.10)	1.45(1.70)
SM $t\bar{t}$ + jets	0.26(0.08)	0.63(1.47)	1.11(1.11)	4.50(4.49)	6.34(6.36)	0.65(0.47)	2.69(2.66)	0.93(0.90)	6.10(6.10)	0.05(0.06)
Single t	0.46(0.38)	0.63(1.48)	1.00(1.01)	5.15(5.12)	6.09(6.17)	0.66(0.47)	6.90(6.23)	1.32(1.02)	6.10(6.10)	0.52(0.65)
W + jets	0.16(0.82)	0.70(1.66)	0.83(0.96)	9.36(9.71)	5.48(5.70)	0.46(0.55)	15.46(9.87)	2.04(1.54)	6.10(6.10)	4.18(5.44)
Z/γ + jets	1.91(1.62)	0.70(1.49)	0.87(0.75)	9.59(10.35)	5.34(4.94)	0.69(0.66)	10.71(11.32)	1.48(1.18)	6.10(6.10)	2.35(2.02)
VV	0.43(1.73)	0.68(1.51)	0.60(0.91)	7.74(6.52)	5.19(5.86)	0.57(0.45)	8.02(12.36)	2.49(1.96)	6.10(6.10)	3.81(4.58)
DD QCD	–	–	–	–	–	–	–	–	5.51(12.37)	4.72(3.93)

2017

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	0.48(0.22)	0.28(1.40)	1.82(1.88)	4.07(4.09)	8.63(8.78)	0.43(0.46)	7.73(7.35)	2.82(2.68)	6.10(6.10)	0.83(0.99)
$H^+ + H^-(m = 90$ GeV)	0.23(0.13)	0.28(1.39)	1.85(1.86)	4.08(4.14)	8.56(8.62)	0.42(0.47)	7.74(7.04)	2.75(2.94)	6.10(6.10)	0.83(0.98)
$H^+ + H^-(m = 100$ GeV)	0.55(0.50)	0.28(1.39)	1.90(1.90)	3.99(4.16)	8.58(8.55)	0.41(0.48)	7.25(6.79)	2.56(2.28)	6.10(6.10)	0.83(0.96)
$H^+ + H^-(m = 110$ GeV)	0.71(0.09)	0.28(1.42)	1.94(1.89)	4.16(4.14)	8.65(8.43)	0.40(0.46)	6.73(5.88)	2.55(1.98)	6.10(6.10)	0.84(0.98)
$H^+ + H^-(m = 120$ GeV)	0.27(0.69)	0.28(1.38)	1.92(1.99)	4.24(4.20)	8.32(8.64)	0.41(0.46)	7.45(6.77)	3.23(2.70)	6.10(6.10)	0.90(1.05)
$H^+ + H^-(m = 130$ GeV)	0.32(0.13)	0.28(1.40)	1.84(1.99)	4.21(4.30)	8.29(8.48)	0.43(0.48)	6.31(6.55)	2.37(2.06)	6.10(6.10)	0.89(1.05)
$H^+ + H^-(m = 140$ GeV)	0.40(0.34)	0.28(1.40)	1.90(2.11)	4.31(4.60)	8.38(8.68)	0.44(0.47)	7.18(8.01)	2.52(2.62)	6.10(6.10)	1.00(1.14)
$H^+ + H^-(m = 150$ GeV)	0.43(0.51)	0.29(1.46)	1.88(1.88)	4.60(4.66)	8.72(8.52)	0.44(0.47)	8.25(8.89)	2.58(2.43)	6.10(6.10)	1.01(1.19)
$H^+ + H^-(m = 155$ GeV)	0.42(0.50)	0.29(1.44)	1.95(1.82)	4.94(4.75)	8.91(8.78)	0.46(0.52)	7.60(8.62)	2.43(3.08)	6.10(6.10)	1.25(1.48)
$H^+ + H^-(m = 160$ GeV)	0.79(0.50)	0.29(1.44)	1.66(1.65)	4.98(4.91)	8.60(8.62)	0.45(0.47)	8.47(7.04)	2.14(0.80)	6.10(6.10)	1.24(1.45)
SM $t\bar{t}$ + jets	0.38(0.16)	0.28(1.41)	1.09(1.09)	4.30(4.29)	7.56(7.58)	0.49(0.53)	7.85(7.83)	0.90(0.90)	6.10(6.10)	0.04(0.04)
Single t	0.85(0.45)	0.28(1.42)	0.98(1.02)	4.89(4.87)	7.15(7.31)	0.51(0.53)	8.32(7.87)	1.56(1.37)	6.10(6.10)	0.41(0.51)
W + jets	1.85(1.65)	0.32(1.43)	0.93(1.13)	9.65(8.80)	6.61(7.03)	0.46(0.62)	11.83(9.57)	1.03(2.87)	6.10(6.10)	3.08(3.26)
Z/γ + jets	2.71(3.05)	0.31(1.41)	0.86(0.55)	9.08(9.17)	6.02(5.47)	0.46(0.89)	10.37(15.51)	3.93(1.44)	6.10(6.10)	2.00(1.68)
VV	3.43(1.62)	0.31(1.41)	0.76(0.71)	6.77(7.03)	5.75(5.96)	0.35(0.52)	12.17(10.67)	0.55(1.12)	6.10(6.10)	4.43(4.86)
DD QCD	–	–	–	–	–	–	–	9.88(2.40)	2.95(3.79)	

2018

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	0.13(0.27)	0.27(1.34)	1.56(1.67)	4.05(4.20)	8.07(8.34)	0.09(0.02)	7.33(7.98)	1.71(2.52)	6.10(6.10)	0.98(1.20)
$H^+ + H^-(m = 90$ GeV)	0.49(0.29)	0.27(1.36)	1.69(1.58)	4.15(4.16)	8.28(8.07)	0.09(0.01)	8.09(8.39)	2.28(2.56)	6.10(6.10)	0.95(1.18)
$H^+ + H^-(m = 100$ GeV)	0.39(0.29)	0.27(1.34)	1.66(1.64)	4.07(4.13)	8.09(8.11)	0.09(0.01)	7.56(7.02)	2.28(1.73)	6.10(6.10)	0.96(1.17)
$H^+ + H^-(m = 110$ GeV)	0.34(0.36)	0.27(1.32)	1.75(1.55)	4.18(4.01)	8.16(7.63)	0.09(0.01)	8.65(7.45)	2.75(1.94)	6.10(6.10)	0.99(1.20)
$H^+ + H^-(m = 120$ GeV)	0.42(0.10)	0.27(1.34)	1.75(1.68)	4.15(4.06)	7.97(7.83)	0.09(0.02)	8.85(7.65)	2.83(2.27)	6.10(6.10)	1.01(1.24)
$H^+ + H^-(m = 130$ GeV)	0.20(0.54)	0.27(1.31)	1.74(1.64)	4.34(4.31)	7.81(7.72)	0.09(0.01)	8.01(10.05)	2.82(2.69)	6.10(6.10)	1.03(1.28)
$H^+ + H^-(m = 140$ GeV)	0.76(0.37)	0.27(1.35)	1.79(1.68)	4.61(4.23)	8.07(7.78)	0.09(0.01)	9.42(8.60)	1.84(2.15)	6.10(6.10)	1.16(1.39)
$H^+ + H^-(m = 150$ GeV)	0.65(1.05)	0.28(1.39)	1.58(1.64)	4.61(4.83)	7.69(7.90)	0.09(0.01)	10.63(9.11)	2.21(2.18)	6.10(6.10)	1.30(1.56)
$H^+ + H^-(m = 155$ GeV)	0.69(0.76)	0.27(1.39)	1.66(1.72)	4.83(4.15)	8.11(8.03)	0.09(0.01)	9.67(9.87)	2.53(2.11)	6.10(6.10)	1.33(1.60)
$H^+ + H^-(m = 160$ GeV)	0.79(0.78)	0.28(1.42)	1.68(1.64)	5.34(5.29)	8.33(8.26)	0.09(0.01)	9.27(7.89)	1.64(2.51)	6.10(6.10)	1.42(1.73)
SM $t\bar{t}$ + jets	0.39(0.26)	0.27(1.35)	0.97(0.97)	4.39(4.38)	7.35(7.41)	0.09(0.02)	6.63(6.59)	1.24(1.25)	6.10(6.10)	0.04(0.04)
Single t	0.46(0.32)	0.27(1.35)	0.90(0.89)	5.16(5.12)	6.95(6.98)	0.09(0.01)	9.81(8.91)	0.84(1.21)	6.10(6.10)	0.39(0.51)
W + jets	2.59(2.07)	0.30(1.34)	0.91(0.94)	9.36(9.96)	5.55(5.33)	0.09(0.01)	15.67(15.14)	2.16(1.06)	6.10(6.10)	3.45(3.94)
Z/γ + jets	0.78(2.69)	0.32(1.32)	0.71(0.61)	10.21(11.04)	5.46(5.00)	0.11(0.01)	17.70(18.12)	2.10(1.51)	6.10(6.10)	2.57(2.29)
VV	3.34(1.16)	0.28(1.29)	0.93(0.59)	8.11(7.49)	6.20(5.22)	0.08(0.01)	16.40(14.30)	0.38(3.87)	6.10(6.10)	4.99(5.71)
DD QCD	–	–	–	–	–	–	–	–	0.32(3.15)	2.43(3.33)

Systematic uncertainties (2016-18) [exclusive tight category]

2016

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	1.37(1.22)	0.63(1.47)	6.37(6.44)	7.75(7.73)	16.54(16.72)	0.58(0.38)	9.63(9.32)	7.08(7.05)	6.10(6.10)	1.33(1.56)
$H^+ + H^-(m = 90$ GeV)	1.65(1.43)	0.63(1.45)	6.33(6.46)	7.72(7.78)	16.45(16.78)	0.56(0.36)	9.19(9.21)	6.68(6.71)	6.10(6.10)	1.29(1.56)
$H^+ + H^-(m = 100$ GeV)	1.41(1.26)	0.63(1.43)	6.57(6.38)	7.89(7.74)	16.93(16.43)	0.57(0.38)	8.80(9.78)	7.01(7.18)	6.10(6.10)	1.28(1.52)
$H^+ + H^-(m = 110$ GeV)	1.31(0.80)	0.63(1.47)	6.65(6.87)	7.88(8.17)	16.94(17.37)	0.56(0.40)	8.73(10.01)	7.07(6.80)	6.10(6.10)	1.47(1.77)
$H^+ + H^-(m = 120$ GeV)	0.73(1.27)	0.63(1.46)	6.60(6.62)	7.87(7.95)	16.87(16.94)	0.58(0.39)	9.52(9.90)	6.50(7.45)	6.10(6.10)	1.33(1.57)
$H^+ + H^-(m = 130$ GeV)	1.30(1.19)	0.63(1.50)	6.63(6.86)	8.17(8.30)	16.88(17.40)	0.56(0.40)	9.48(9.62)	6.95(6.29)	6.10(6.10)	1.36(1.67)
$H^+ + H^-(m = 140$ GeV)	0.97(1.85)	0.62(1.49)	6.72(6.94)	8.39(8.59)	17.14(17.78)	0.57(0.39)	9.79(11.26)	6.53(7.96)	6.10(6.10)	1.49(1.86)
$H^+ + H^-(m = 150$ GeV)	0.98(1.05)	0.62(1.50)	6.85(6.69)	8.79(8.99)	17.74(17.25)	0.60(0.40)	11.12(10.31)	7.43(6.70)	6.10(6.10)	1.67(1.95)
$H^+ + H^-(m = 155$ GeV)	0.42(0.78)	0.63(1.52)	6.81(6.58)	9.15(9.05)	17.72(17.21)	0.60(0.41)	10.65(10.87)	7.06(6.82)	6.10(6.10)	1.82(2.29)
$H^+ + H^-(m = 160$ GeV)	1.16(1.19)	0.62(1.58)	6.54(6.46)	9.38(9.38)	17.27(17.06)	0.62(0.41)	11.73(10.96)	6.96(7.05)	6.10(6.10)	2.24(2.60)
SM $t\bar{t}$ + jets	0.81(1.11)	0.63(1.48)	4.88(4.92)	7.66(7.69)	13.58(13.67)	0.62(0.43)	5.28(5.25)	4.52(4.58)	6.10(6.10)	0.08(0.10)
Single t	0.63(1.24)	0.63(1.50)	4.52(4.56)	8.10(8.08)	12.76(12.81)	0.62(0.42)	8.71(8.04)	4.84(5.12)	6.10(6.10)	1.05(1.27)
W + jets	0.96(1.03)	0.66(1.65)	4.21(4.10)	11.92(11.55)	12.17(11.84)	0.38(0.79)	11.27(16.38)	6.98(5.99)	6.10(6.10)	9.15(10.06)
Z/γ + jets	0.83(0.79)	0.74(1.45)	2.50(2.15)	11.40(12.12)	7.96(7.58)	0.63(0.63)	11.81(8.05)	2.01(2.14)	6.10(6.10)	4.69(4.34)
VV	1.63(1.59)	0.63(1.55)	3.64(3.13)	10.80(9.26)	10.08(10.00)	0.54(0.41)	8.47(7.32)	6.87(7.17)	6.10(6.10)	8.39(8.97)
DD QCD	–	–	–	–	–	–	–	–	28.57(34.39)	8.63(7.49)

2017

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	1.00(1.55)	0.28(1.42)	7.51(7.61)	8.02(8.15)	20.04(20.39)	0.40(0.42)	10.82(10.52)	8.56(8.27)	6.10(6.10)	1.38(1.65)
$H^+ + H^-(m = 90$ GeV)	1.17(2.24)	0.28(1.46)	7.63(7.71)	8.13(8.22)	20.29(20.38)	0.40(0.41)	10.64(11.24)	8.77(7.89)	6.10(6.10)	1.38(1.64)
$H^+ + H^-(m = 100$ GeV)	1.33(1.77)	0.27(1.41)	7.64(7.74)	8.19(8.36)	20.04(20.49)	0.36(0.41)	10.77(10.86)	8.90(8.58)	6.10(6.10)	1.35(1.58)
$H^+ + H^-(m = 110$ GeV)	1.34(1.12)	0.28(1.39)	7.73(7.82)	8.30(8.37)	20.15(20.31)	0.37(0.39)	10.72(11.26)	8.83(8.80)	6.10(6.10)	1.33(1.55)
$H^+ + H^-(m = 120$ GeV)	1.72(1.24)	0.28(1.41)	7.70(7.91)	8.28(8.38)	20.28(20.72)	0.38(0.41)	10.70(11.42)	8.82(8.08)	6.10(6.10)	1.43(1.71)
$H^+ + H^-(m = 130$ GeV)	1.18(1.39)	0.28(1.40)	7.98(8.00)	8.63(8.63)	20.67(20.68)	0.39(0.43)	11.28(11.92)	8.79(8.68)	6.10(6.10)	1.43(1.72)
$H^+ + H^-(m = 140$ GeV)	1.68(0.78)	0.28(1.43)	7.96(8.18)	8.84(9.01)	20.54(21.15)	0.40(0.42)	12.42(10.25)	9.07(8.35)	6.10(6.10)	1.66(1.90)
$H^+ + H^-(m = 150$ GeV)	1.11(1.90)	0.29(1.45)	8.23(8.24)	9.26(9.24)	21.32(21.18)	0.39(0.42)	13.52(13.95)	8.92(9.04)	6.10(6.10)	1.72(2.00)
$H^+ + H^-(m = 155$ GeV)	1.68(1.42)	0.28(1.41)	8.28(8.14)	9.77(9.65)	21.44(21.10)	0.41(0.45)	13.60(13.86)	9.46(8.81)	6.10(6.10)	2.19(2.48)
$H^+ + H^-(m = 160$ GeV)	0.80(0.62)	0.30(1.46)	8.26(8.31)	10.05(10.18)	21.49(21.36)	0.43(0.50)	12.46(14.71)	8.96(8.89)	6.10(6.10)	2.40(2.78)
SM $t\bar{t}$ + jets	1.26(1.45)	0.28(1.41)	6.60(6.65)	8.05(8.09)	18.04(18.16)	0.44(0.47)	7.66(7.62)	5.40(5.47)	6.10(6.10)	0.08(0.10)
Single t	1.14(1.25)	0.28(1.44)	6.42(6.51)	8.57(8.67)	17.31(17.29)	0.41(0.46)	10.56(11.03)	7.18(7.32)	6.10(6.10)	1.14(1.40)
W + jets	5.21(2.11)	0.30(1.44)	6.03(6.79)	12.55(10.74)	16.69(18.14)	0.44(0.61)	11.41(30.21)	12.43(11.13)	6.10(6.10)	10.10(10.08)
Z/γ + jets	0.59(1.27)	0.27(1.36)	3.17(4.13)	10.62(11.90)	10.90(11.72)	0.29(0.84)	14.01(19.15)	3.53(8.13)	6.10(6.10)	5.86(5.71)
VV	1.22(4.86)	0.30(1.40)	6.28(5.95)	9.82(10.25)	16.71(15.04)	0.28(0.44)	15.06(12.34)	8.95(4.54)	6.10(6.10)	12.21(14.00)
DD QCD	–	–	–	–	–	–	–	–	73.27(37.16)	95.88(42.43)

2018

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$H^+ + H^-(m = 80$ GeV)	1.03(1.24)	0.27(1.36)	6.60(6.64)	7.75(7.80)	18.19(18.40)	0.09(0.02)	11.62(9.46)	6.79(6.64)	6.10(6.10)	1.10(1.36)
$H^+ + H^-(m = 90$ GeV)	1.03(0.91)	0.27(1.35)	6.73(6.72)	7.85(7.90)	18.47(18.56)	0.09(0.02)	10.97(9.73)	7.29(7.10)	6.10(6.10)	1.10(1.30)
$H^+ + H^-(m = 100$ GeV)	0.75(0.73)	0.27(1.34)	6.69(6.83)	7.78(8.12)	18.24(18.76)	0.09(0.02)	10.86(11.57)	6.92(7.31)	6.10(6.10)	1.06(1.33)
$H^+ + H^-(m = 110$ GeV)	0.62(1.12)	0.28(1.36)	6.76(6.76)	7.96(8.01)	18.33(18.49)	0.09(0.01)	10.68(11.16)	7.16(7.26)	6.10(6.10)	1.11(1.34)
$H^+ + H^-(m = 120$ GeV)	1.36(0.80)	0.27(1.37)	6.84(6.87)	8.09(8.20)	18.40(18.48)	0.09(0.01)	10.40(11.16)	7.02(7.49)	6.10(6.10)	1.09(1.31)
$H^+ + H^-(m = 130$ GeV)	0.54(0.93)	0.27(1.39)	6.92(7.01)	8.27(8.30)	18.46(18.73)	0.09(0.02)	11.29(10.75)	7.00(7.42)	6.10(6.10)	1.14(1.44)
$H^+ + H^-(m = 140$ GeV)	0.83(0.58)	0.27(1.36)	6.93(7.14)	8.39(8.56)	18.64(19.08)	0.09(0.01)	11.61(12.31)	7.52(8.68)	6.10(6.10)	1.28(1.56)
$H^+ + H^-(m = 150$ GeV)	0.74(0.80)	0.27(1.37)	6.99(7.12)	8.97(8.88)	18.64(19.17)	0.09(0.01)	13.66(12.88)	7.70(6.88)	6.10(6.10)	1.50(1.82)
$H^+ + H^-(m = 155$ GeV)	0.78(0.91)	0.27(1.40)	7.06(7.21)	9.18(9.41)	19.12(19.24)	0.09(0.01)	14.80(13.76)	7.12(7.99)	6.10(6.10)	1.62(1.90)
$H^+ + H^-(m = 160$ GeV)	0.39(0.75)	0.28(1.40)	6.78(6.96)	9.73(9.61)	18.40(19.02)	0.09(0.01)	14.40(13.32)	8.22(7.53)	6.10(6.10)	1.83(2.18)
SM $t\bar{t}$ + jets	0.62(0.76)	0.27(1.35)	5.19(5.23)	7.69(7.74)	15.39(15.53)	0.09(0.02)	9.10(9.08)	5.60(5.63)	6.10(6.10)	0.05(0.06)
Single t	0.59(0.51)	0.27(1.38)	4.76(4.88)	8.30(8.31)	13.95(14.29)	0.09(0.02)	10.88(11.08)	5.04(5.19)	6.10(6.10)	0.68(0.86)
W + jets	0.99(1.96)	0.29(1.29)	4.14(4.45)	11.75(12.36)	12.67(12.70)	0.08(0.01)	25.33(15.16)	4.70(4.90)	6.10(6.10)	5.77(7.55)
Z/γ + jets	0.65(0.24)	0.32(1.27)	2.61(2.57)	11.71(12.97)	8.62(8.71)	0.10(0.02)	13.07(16.34)	3.08(1.36)	6.10(6.10)	4.24(4.15)
VV	1.97(0.31)	0.32(1.31)	4.62(4.00)	10.86(11.47)	11.97(10.90)	0.09(0.01)	18.02(11.02)	4.86(5.17)	6.10(6.10)	8.41(10.49)
DD QCD	–	–	–	–	–	–	–	–	52.18(37.71)	9.98(11.08)

Systematic uncertianties (2016) [KinFit Level]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$m_{H^-} = 80$ GeV	1.03(0.89)	0.63(1.46)	0.00(0.00)	0.19(0.19)	3.88(3.94)	0.59(0.39)	3.81(3.47)	0.36(0.42)	6.10(6.10)	0.84(0.98)
$m_{H^-} = 90$ GeV	0.78(1.20)	0.62(1.44)	0.00(0.00)	0.14(0.15)	3.84(3.84)	0.59(0.40)	3.34(3.85)	0.18(0.42)	6.10(6.10)	0.83(0.98)
$m_{H^-} = 100$ GeV	0.87(1.18)	0.63(1.46)	0.00(0.00)	0.21(0.11)	3.76(3.79)	0.58(0.42)	3.16(3.39)	0.46(0.17)	6.10(6.10)	0.82(0.98)
$m_{H^-} = 110$ GeV	0.69(0.96)	0.63(1.47)	0.00(0.00)	0.18(0.17)	3.68(3.73)	0.59(0.40)	3.50(3.76)	0.29(0.33)	6.10(6.10)	0.83(0.99)
$m_{H^-} = 120$ GeV	0.69(1.14)	0.63(1.45)	0.00(0.00)	0.19(0.20)	3.67(3.77)	0.58(0.43)	3.88(3.58)	0.30(0.29)	6.10(6.10)	0.89(1.08)
$m_{H^-} = 130$ GeV	0.96(0.32)	0.63(1.48)	0.00(0.00)	0.26(0.27)	3.68(3.73)	0.58(0.39)	3.63(4.08)	0.08(0.35)	6.10(6.10)	0.90(1.08)
$m_{H^-} = 140$ GeV	0.55(1.08)	0.62(1.49)	0.00(0.00)	0.42(0.39)	3.80(3.79)	0.58(0.40)	4.36(4.27)	0.26(0.45)	6.10(6.10)	0.98(1.21)
$m_{H^-} = 150$ GeV	0.77(0.46)	0.63(1.48)	0.00(0.00)	0.65(0.66)	4.06(3.99)	0.61(0.41)	5.15(4.77)	0.22(0.39)	6.10(6.10)	1.04(1.24)
$m_{H^-} = 155$ GeV	0.42(0.84)	0.62(1.49)	0.00(0.00)	0.76(0.68)	4.33(4.27)	0.60(0.41)	4.93(5.05)	0.43(0.11)	6.10(6.10)	1.15(1.35)
$m_{H^-} = 160$ GeV	0.79(0.37)	0.62(1.52)	0.00(0.00)	0.81(1.13)	4.37(4.32)	0.61(0.42)	5.04(5.08)	0.28(0.48)	6.10(6.10)	1.28(1.53)
$m_{H^+} = 80$ GeV	0.49(0.94)	0.63(1.48)	0.00(0.00)	0.15(0.10)	3.87(3.98)	0.58(0.40)	3.66(3.46)	0.36(0.22)	6.10(6.10)	0.85(1.00)
$m_{H^+} = 90$ GeV	0.88(1.05)	0.63(1.46)	0.00(0.00)	0.15(0.13)	3.80(3.87)	0.59(0.41)	3.60(3.47)	0.25(0.17)	6.10(6.10)	0.84(1.00)
$m_{H^+} = 100$ GeV	0.76(0.81)	0.63(1.47)	0.00(0.00)	0.12(0.17)	3.75(3.69)	0.59(0.40)	3.19(3.36)	0.22(0.40)	6.10(6.10)	0.84(1.00)
$m_{H^+} = 110$ GeV	0.76(0.86)	0.64(1.45)	0.00(0.00)	0.11(0.19)	3.69(3.67)	0.59(0.40)	3.48(3.38)	0.37(0.42)	6.10(6.10)	1.11(1.34)
$m_{H^+} = 120$ GeV	0.73(1.26)	0.62(1.46)	0.00(0.00)	0.16(0.15)	3.68(3.70)	0.60(0.41)	3.60(3.58)	0.38(0.51)	6.10(6.10)	0.87(1.01)
$m_{H^+} = 130$ GeV	0.55(0.99)	0.63(1.48)	0.00(0.00)	0.26(0.26)	3.61(3.73)	0.60(0.39)	3.69(3.88)	0.27(0.31)	6.10(6.10)	0.89(1.08)
$m_{H^+} = 140$ GeV	0.43(0.72)	0.62(1.48)	0.00(0.00)	0.34(0.41)	3.85(3.85)	0.60(0.42)	4.51(4.13)	0.31(0.09)	6.10(6.10)	1.01(1.22)
$m_{H^+} = 150$ GeV	0.46(0.87)	0.63(1.53)	0.00(0.00)	0.50(0.59)	4.12(4.06)	0.61(0.42)	4.84(4.85)	0.42(0.35)	6.10(6.10)	1.04(1.22)
$m_{H^+} = 155$ GeV	0.45(0.26)	0.63(1.50)	0.00(0.00)	0.73(0.75)	4.26(4.31)	0.62(0.42)	5.21(4.88)	0.39(0.17)	6.10(6.10)	1.14(1.38)
$m_{H^+} = 160$ GeV	0.38(0.82)	0.62(1.48)	0.00(0.00)	0.86(0.87)	4.44(4.43)	0.62(0.42)	4.94(4.53)	0.25(0.08)	6.10(6.10)	1.30(1.53)
SM $t\bar{t}$ + jets	0.67(0.95)	0.63(1.48)	0.00(0.00)	0.19(0.19)	4.18(4.20)	0.63(0.45)	3.18(3.16)	1.87(1.87)	6.10(6.10)	0.03(0.04)
Single t	0.54(0.77)	0.63(1.48)	0.00(0.00)	0.67(0.69)	4.20(4.22)	0.65(0.46)	4.92(4.82)	0.22(0.16)	5.00(5.00)	0.32(0.39)
W + jets	0.87(0.48)	0.70(1.60)	0.00(0.00)	4.24(4.22)	4.10(4.17)	0.44(0.58)	12.81(8.51)	0.92(1.26)	5.00(5.00)	2.51(3.11)
Z/γ + jets	0.69(0.91)	0.71(1.50)	0.00(0.00)	4.57(5.37)	3.71(3.56)	0.68(0.64)	8.88(9.15)	1.10(0.79)	4.50(4.50)	1.41(1.25)
VV	0.19(0.23)	0.66(1.51)	0.00(0.00)	2.99(2.43)	3.91(4.13)	0.52(0.41)	7.39(7.68)	0.96(0.69)	4.00(4.00)	2.38(2.76)
DD QCD	–	–	–	–	–	–	–	–	7.79(24.86)	3.93(2.86)

Systematic uncertianties (2016) [exclusive loose category]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$m_{H^-} = 80$ GeV	1.54(1.41)	0.63(1.46)	0.82(0.69)	0.87(0.75)	5.82(5.64)	0.57(0.39)	3.81(4.82)	0.88(1.24)	6.10(6.10)	1.35(1.57)
$m_{H^-} = 90$ GeV	1.24(1.79)	0.63(1.42)	0.67(0.84)	0.77(0.70)	5.46(5.60)	0.58(0.39)	3.91(3.67)	1.04(1.10)	6.10(6.10)	1.34(1.60)
$m_{H^-} = 100$ GeV	1.62(1.53)	0.62(1.48)	0.83(0.83)	0.80(0.78)	5.71(5.68)	0.58(0.41)	4.57(4.54)	1.79(0.83)	6.10(6.10)	1.34(1.59)
$m_{H^-} = 110$ GeV	1.12(1.58)	0.63(1.47)	1.15(0.66)	0.80(0.64)	5.64(5.27)	0.59(0.41)	4.58(4.57)	1.29(0.85)	6.10(6.10)	1.36(1.64)
$m_{H^-} = 120$ GeV	1.10(1.11)	0.63(1.44)	0.95(0.78)	0.90(0.76)	5.82(5.61)	0.57(0.41)	4.84(4.20)	1.33(1.06)	6.10(6.10)	1.44(1.74)
$m_{H^-} = 130$ GeV	1.56(1.30)	0.62(1.46)	0.89(0.84)	0.79(0.83)	5.72(5.76)	0.60(0.37)	3.87(4.17)	1.14(1.11)	6.10(6.10)	1.49(1.78)
$m_{H^-} = 140$ GeV	1.01(1.53)	0.62(1.48)	1.09(1.03)	0.85(1.06)	5.98(6.05)	0.56(0.38)	4.96(4.87)	1.24(1.74)	6.10(6.10)	1.60(1.96)
$m_{H^-} = 150$ GeV	1.09(1.36)	0.64(1.49)	1.16(0.96)	1.48(1.13)	6.64(6.11)	0.61(0.41)	5.84(5.17)	1.70(0.73)	6.10(6.10)	1.66(2.01)
$m_{H^-} = 155$ GeV	0.89(0.99)	0.62(1.44)	1.12(1.48)	1.37(1.48)	6.82(6.91)	0.59(0.38)	6.14(6.29)	1.53(1.61)	6.10(6.10)	1.84(2.15)
$m_{H^-} = 160$ GeV	1.07(0.97)	0.61(1.47)	1.38(1.31)	1.43(1.60)	7.10(7.09)	0.59(0.43)	5.06(4.37)	0.95(1.16)	6.10(6.10)	2.02(2.40)
$m_{H^+} = 80$ GeV	0.82(1.37)	0.64(1.50)	1.10(0.77)	0.74(0.83)	5.73(5.73)	0.57(0.41)	3.95(3.63)	1.51(0.98)	6.10(6.10)	1.36(1.60)
$m_{H^+} = 90$ GeV	1.26(1.66)	0.65(1.46)	0.87(0.88)	0.69(0.87)	5.52(5.76)	0.60(0.40)	4.35(4.28)	1.45(1.33)	6.10(6.10)	1.35(1.63)
$m_{H^+} = 100$ GeV	1.32(1.09)	0.63(1.48)	0.77(0.82)	0.95(0.75)	5.56(5.61)	0.58(0.38)	4.43(3.58)	1.27(1.23)	6.10(6.10)	1.39(1.60)
$m_{H^+} = 110$ GeV	1.19(1.86)	0.64(1.41)	1.26(1.08)	0.92(1.14)	5.81(5.72)	0.59(0.39)	5.13(4.18)	1.67(1.52)	6.10(6.10)	1.82(2.16)
$m_{H^+} = 120$ GeV	1.32(1.68)	0.62(1.47)	0.89(0.83)	0.91(0.90)	5.74(5.58)	0.57(0.40)	5.08(3.94)	1.33(1.48)	6.10(6.10)	1.46(1.67)
$m_{H^+} = 130$ GeV	1.16(1.45)	0.64(1.46)	0.94(0.90)	1.31(1.00)	5.72(5.71)	0.60(0.38)	5.68(5.79)	1.36(1.37)	6.10(6.10)	1.47(1.76)
$m_{H^+} = 140$ GeV	0.98(0.77)	0.62(1.46)	0.93(1.15)	1.08(1.15)	6.10(5.91)	0.60(0.40)	4.20(4.77)	0.75(1.31)	6.10(6.10)	1.61(2.00)
$m_{H^+} = 150$ GeV	1.20(1.21)	0.63(1.51)	1.08(0.94)	1.44(1.17)	6.61(6.14)	0.60(0.41)	6.02(4.60)	1.68(1.01)	6.10(6.10)	1.68(2.00)
$m_{H^+} = 155$ GeV	1.06(0.30)	0.64(1.48)	1.09(1.28)	1.68(1.75)	6.81(7.11)	0.61(0.38)	7.73(7.59)	1.76(2.43)	6.10(6.10)	1.84(2.19)
$m_{H^+} = 160$ GeV	0.52(1.55)	0.63(1.41)	1.16(1.24)	1.82(1.86)	7.06(7.14)	0.59(0.41)	6.86(4.75)	1.81(1.39)	6.10(6.10)	2.02(2.45)
SM $t\bar{t}$ + jets	1.25(1.50)	0.63(1.47)	0.44(0.43)	1.30(1.27)	5.27(5.28)	0.62(0.44)	2.63(2.57)	1.50(1.50)	6.10(6.10)	0.04(0.05)
Single t	1.18(1.41)	0.64(1.48)	0.51(0.46)	1.37(1.42)	5.31(5.29)	0.65(0.45)	5.19(4.68)	0.66(0.50)	5.00(5.00)	0.44(0.55)
W + jets	1.57(0.78)	0.70(1.57)	0.35(0.40)	4.66(4.52)	4.89(5.31)	0.44(0.56)	13.39(8.03)	1.57(1.97)	5.00(5.00)	3.40(4.19)
Z/γ + jets	0.26(0.55)	0.71(1.52)	0.57(0.64)	7.04(7.45)	4.89(4.77)	0.67(0.65)	9.11(9.31)	1.33(1.45)	4.50(4.50)	1.92(1.75)
VV	0.44(0.48)	0.64(1.50)	0.70(0.59)	3.68(3.65)	5.10(5.18)	0.48(0.37)	8.77(6.14)	1.42(0.50)	4.00(4.00)	3.34(3.84)
DD QCD	–	–	–	–	–	–	–	–	5.31(27.50)	13.84(5.98)

Systematic uncertianties (2016) [exclusive medium category]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$m_{H^-} = 80$ GeV	0.06(0.11)	0.63(1.48)	1.79(1.88)	4.28(4.40)	7.44(7.70)	0.62(0.40)	5.91(5.64)	2.44(1.87)	6.10(6.10)	1.35(1.59)
$m_{H^-} = 90$ GeV	0.22(0.04)	0.62(1.44)	1.96(1.86)	4.28(4.42)	7.70(7.53)	0.61(0.42)	6.04(6.34)	2.08(2.32)	6.10(6.10)	1.34(1.56)
$m_{H^-} = 100$ GeV	0.15(0.52)	0.63(1.46)	1.91(1.97)	4.43(4.29)	7.51(7.76)	0.59(0.43)	5.57(5.03)	2.09(2.14)	6.10(6.10)	1.32(1.59)
$m_{H^-} = 110$ GeV	0.33(0.25)	0.63(1.48)	1.81(1.95)	4.32(4.27)	7.22(7.62)	0.61(0.41)	6.06(6.15)	2.09(2.89)	6.10(6.10)	1.34(1.59)
$m_{H^-} = 120$ GeV	0.09(1.08)	0.63(1.47)	1.92(1.90)	4.36(4.36)	7.48(7.63)	0.59(0.46)	6.58(6.60)	2.78(2.23)	6.10(6.10)	1.46(1.80)
$m_{H^-} = 130$ GeV	0.22(0.97)	0.62(1.49)	2.01(1.73)	4.48(4.29)	7.70(7.11)	0.58(0.40)	6.85(6.32)	2.37(2.59)	6.10(6.10)	1.43(1.70)
$m_{H^-} = 140$ GeV	0.37(0.26)	0.62(1.49)	1.91(2.02)	4.68(4.68)	7.60(7.82)	0.62(0.43)	6.88(7.52)	2.24(2.66)	6.10(6.10)	1.60(1.96)
$m_{H^-} = 150$ GeV	0.11(0.67)	0.63(1.47)	1.92(2.03)	5.00(5.03)	7.80(8.08)	0.62(0.42)	8.77(6.81)	2.71(2.02)	6.10(6.10)	1.67(1.98)
$m_{H^-} = 155$ GeV	0.03(0.25)	0.62(1.51)	1.76(1.70)	5.18(4.86)	7.84(7.73)	0.62(0.45)	7.47(6.99)	1.79(2.29)	6.10(6.10)	1.86(2.16)
$m_{H^-} = 160$ GeV	0.19(0.63)	0.64(1.55)	1.70(1.85)	5.04(5.59)	7.60(7.98)	0.61(0.43)	8.22(7.49)	2.78(2.32)	6.10(6.10)	2.02(2.41)
$m_{H^+} = 80$ GeV	0.30(0.14)	0.63(1.45)	1.94(1.96)	4.33(4.25)	7.64(7.86)	0.60(0.40)	7.01(6.97)	2.39(2.49)	6.10(6.10)	1.37(1.63)
$m_{H^+} = 90$ GeV	0.32(0.38)	0.63(1.45)	1.85(1.92)	4.21(4.29)	7.52(7.66)	0.58(0.43)	6.18(6.14)	2.23(2.89)	6.10(6.10)	1.35(1.59)
$m_{H^+} = 100$ GeV	0.44(0.19)	0.62(1.45)	1.92(1.90)	4.27(4.34)	7.54(7.40)	0.60(0.43)	6.12(6.39)	2.62(2.59)	6.10(6.10)	1.36(1.61)
$m_{H^+} = 110$ GeV	0.08(0.26)	0.62(1.45)	1.88(1.90)	4.21(4.19)	7.44(7.40)	0.60(0.40)	5.00(5.52)	2.20(2.19)	6.10(6.10)	1.77(2.23)
$m_{H^+} = 120$ GeV	0.11(0.38)	0.63(1.42)	1.96(1.97)	4.28(4.37)	7.55(7.57)	0.62(0.43)	6.66(6.50)	3.07(2.46)	6.10(6.10)	1.38(1.62)
$m_{H^+} = 130$ GeV	0.55(0.26)	0.62(1.46)	1.99(1.85)	4.51(4.42)	7.56(7.47)	0.60(0.40)	6.05(5.97)	2.75(2.75)	6.10(6.10)	1.44(1.76)
$m_{H^+} = 140$ GeV	0.59(0.09)	0.62(1.50)	1.92(1.95)	4.70(4.52)	7.60(7.76)	0.62(0.46)	7.35(6.32)	2.42(1.73)	6.10(6.10)	1.66(1.94)
$m_{H^+} = 150$ GeV	0.59(0.21)	0.62(1.55)	1.83(2.09)	4.74(5.08)	7.65(8.22)	0.63(0.45)	6.60(8.08)	2.01(2.23)	6.10(6.10)	1.67(1.94)
$m_{H^+} = 155$ GeV	0.51(0.08)	0.62(1.51)	1.88(1.94)	5.02(5.32)	8.01(8.19)	0.65(0.45)	7.36(6.50)	3.09(2.14)	6.10(6.10)	1.83(2.19)
$m_{H^+} = 160$ GeV	0.34(0.47)	0.61(1.48)	1.64(1.67)	5.08(5.36)	7.60(7.81)	0.63(0.42)	5.50(6.09)	2.25(1.57)	6.10(6.10)	2.09(2.39)
SM $t\bar{t}$ + jets	0.26(0.08)	0.63(1.47)	1.11(1.11)	4.50(4.49)	6.34(6.36)	0.65(0.47)	2.69(2.66)	0.93(0.90)	6.10(6.10)	0.05(0.06)
Single t	0.46(0.38)	0.63(1.48)	1.00(1.01)	5.15(5.12)	6.09(6.17)	0.66(0.47)	6.90(6.23)	1.32(1.02)	5.00(5.00)	0.52(0.65)
W + jets	0.16(0.82)	0.70(1.66)	0.83(0.96)	9.36(9.71)	5.48(5.70)	0.46(0.55)	15.46(9.87)	2.04(1.54)	5.00(5.00)	4.18(5.44)
Z/γ + jets	1.91(1.62)	0.70(1.49)	0.87(0.75)	9.59(10.35)	5.34(4.94)	0.69(0.66)	10.71(11.32)	1.48(1.18)	4.50(4.50)	2.35(2.02)
VV	0.43(1.73)	0.68(1.51)	0.60(0.91)	7.74(6.52)	5.19(5.86)	0.57(0.45)	8.02(12.36)	2.49(1.96)	4.00(4.00)	3.81(4.58)
DD QCD	–	–	–	–	–	–	–	–	5.51(12.37)	4.72(3.93)

Systematic uncertianties (2016) [exclusive tight category]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
m_{H^-} = 80 GeV	1.89(1.21)	0.62(1.44)	6.39(6.43)	7.87(7.77)	16.48(16.66)	0.57(0.37)	10.34(8.39)	7.46(6.76)	6.10(6.10)	1.89(2.20)
m_{H^-} = 90 GeV	1.47(1.81)	0.62(1.45)	6.29(6.42)	7.65(7.73)	16.49(16.60)	0.54(0.36)	8.34(8.91)	6.71(7.23)	6.10(6.10)	1.80(2.13)
m_{H^-} = 100 GeV	1.24(1.49)	0.63(1.40)	6.50(6.42)	7.88(7.65)	16.78(16.50)	0.56(0.38)	8.93(10.15)	7.42(6.92)	6.10(6.10)	1.80(2.13)
m_{H^-} = 110 GeV	1.37(1.02)	0.63(1.45)	6.71(6.71)	7.83(8.03)	17.14(17.19)	0.54(0.40)	9.02(9.34)	7.07(6.16)	6.10(6.10)	1.73(2.11)
m_{H^-} = 120 GeV	0.97(0.87)	0.63(1.43)	6.63(6.52)	7.89(7.91)	16.96(16.67)	0.57(0.41)	9.98(9.32)	6.35(6.91)	6.10(6.10)	1.88(2.26)
m_{H^-} = 130 GeV	1.62(0.78)	0.63(1.48)	6.67(6.92)	8.21(8.35)	17.01(17.63)	0.56(0.40)	9.89(10.08)	7.23(6.31)	6.10(6.10)	1.93(2.41)
m_{H^-} = 140 GeV	1.17(1.72)	0.62(1.50)	6.70(6.88)	8.45(8.58)	17.08(17.70)	0.57(0.40)	9.24(10.56)	6.51(7.69)	6.10(6.10)	2.06(2.62)
m_{H^-} = 150 GeV	1.15(0.66)	0.63(1.50)	6.92(6.57)	8.90(9.08)	17.88(16.97)	0.61(0.41)	11.05(11.48)	7.12(7.44)	6.10(6.10)	2.36(2.78)
m_{H^-} = 155 GeV	0.17(1.42)	0.63(1.53)	6.84(6.66)	9.12(9.21)	17.75(17.28)	0.60(0.39)	10.50(11.24)	6.34(7.19)	6.10(6.10)	2.62(3.16)
m_{H^-} = 160 GeV	1.29(0.92)	0.61(1.54)	6.27(6.22)	9.19(9.47)	16.70(16.60)	0.63(0.37)	10.89(9.16)	6.12(6.32)	6.10(6.10)	3.14(3.58)
m_{H^+} = 80 GeV	0.86(1.43)	0.64(1.49)	6.34(6.46)	7.63(7.69)	16.60(16.78)	0.59(0.38)	8.94(10.27)	6.70(7.35)	6.10(6.10)	1.88(2.21)
m_{H^+} = 90 GeV	1.84(1.02)	0.64(1.45)	6.37(6.50)	7.80(7.84)	16.41(16.98)	0.59(0.36)	10.07(9.54)	6.65(7.18)	6.10(6.10)	1.86(2.27)
m_{H^+} = 100 GeV	1.58(1.02)	0.63(1.47)	6.65(6.33)	7.91(7.83)	17.09(16.36)	0.58(0.38)	8.67(9.40)	6.59(7.44)	6.10(6.10)	1.82(2.19)
m_{H^+} = 110 GeV	1.25(0.62)	0.64(1.49)	6.58(7.03)	7.93(8.32)	16.72(17.55)	0.58(0.41)	8.42(10.67)	7.07(7.48)	6.10(6.10)	2.40(2.83)
m_{H^+} = 120 GeV	0.48(1.67)	0.63(1.49)	6.57(6.73)	7.84(7.99)	16.78(17.21)	0.59(0.37)	9.02(10.48)	6.67(8.00)	6.10(6.10)	1.88(2.18)
m_{H^+} = 130 GeV	0.98(1.59)	0.63(1.53)	6.59(6.79)	8.13(8.25)	16.75(17.19)	0.57(0.39)	9.07(9.17)	6.76(6.50)	6.10(6.10)	1.92(2.32)
m_{H^+} = 140 GeV	0.80(1.97)	0.62(1.48)	6.73(6.99)	8.32(8.59)	17.20(17.86)	0.56(0.38)	10.36(11.95)	6.54(8.22)	6.10(6.10)	2.17(2.64)
m_{H^+} = 150 GeV	0.80(1.43)	0.62(1.51)	6.78(6.80)	8.68(8.89)	17.60(17.53)	0.59(0.39)	11.20(9.14)	7.74(5.97)	6.10(6.10)	2.37(2.74)
m_{H^+} = 155 GeV	0.87(0.29)	0.62(1.52)	6.77(6.49)	9.18(8.88)	17.69(17.13)	0.61(0.43)	10.80(10.48)	7.77(6.72)	6.10(6.10)	2.53(3.32)
m_{H^+} = 160 GeV	1.04(1.48)	0.62(1.62)	6.82(6.72)	9.57(9.29)	17.84(17.55)	0.62(0.46)	12.58(12.89)	7.81(8.11)	6.10(6.10)	3.18(3.77)
SM $t\bar{t}$ + jets	0.81(1.11)	0.63(1.48)	4.88(4.92)	7.66(7.69)	13.58(13.67)	0.62(0.43)	5.28(5.25)	4.52(4.58)	6.10(6.10)	0.08(0.10)
Single t	0.63(1.24)	0.63(1.50)	4.52(4.56)	8.10(8.08)	12.76(12.81)	0.62(0.42)	8.71(8.04)	4.84(5.12)	5.00(5.00)	1.05(1.27)
W + jets	0.96(1.03)	0.66(1.65)	4.21(4.10)	11.92(11.55)	12.17(11.84)	0.38(0.79)	11.27(16.38)	6.98(5.99)	5.00(5.00)	9.15(10.06)
Z/γ + jets	0.83(0.79)	0.74(1.45)	2.50(2.15)	11.40(12.12)	7.96(7.58)	0.63(0.63)	11.81(8.05)	2.01(2.14)	4.50(4.50)	4.69(4.34)
VV	1.63(1.59)	0.63(1.55)	3.64(3.13)	10.80(9.26)	10.08(10.00)	0.54(0.41)	8.47(7.32)	6.87(7.17)	4.00(4.00)	8.39(8.97)
DD QCD	–	–	–	–	–	–	–	–	28.57(34.39)	8.63(7.49)

Yields (2016) [KinFit Level]

Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$315384 \pm 2660(0.8\%) \pm 26156(8.3\%)$	$223917 \pm 2203(1.0\%) \pm 18476(8.3\%)$
$m_{H^-} = 90$ GeV	$324264 \pm 2685(0.8\%) \pm 26044(8.0\%)$	$226395 \pm 2211(1.0\%) \pm 19021(8.4\%)$
$m_{H^-} = 100$ GeV	$327732 \pm 2693(0.8\%) \pm 26029(7.9\%)$	$227250 \pm 2226(1.0\%) \pm 18572(8.2\%)$
$m_{H^-} = 110$ GeV	$323525 \pm 2670(0.8\%) \pm 25946(8.0\%)$	$221297 \pm 2198(1.0\%) \pm 18331(8.3\%)$
$m_{H^-} = 120$ GeV	$305961 \pm 2717(0.9\%) \pm 25052(8.2\%)$	$205828 \pm 2227(1.1\%) \pm 16973(8.2\%)$
$m_{H^-} = 130$ GeV	$273242 \pm 2458(0.9\%) \pm 22151(8.1\%)$	$187464 \pm 2032(1.1\%) \pm 15725(8.4\%)$
$m_{H^-} = 140$ GeV	$230034 \pm 2258(1.0\%) \pm 19514(8.5\%)$	$154197 \pm 1862(1.2\%) \pm 13240(8.6\%)$
$m_{H^-} = 150$ GeV	$159780 \pm 1657(1.0\%) \pm 14474(9.1\%)$	$111225 \pm 1383(1.2\%) \pm 9890(8.9\%)$
$m_{H^-} = 155$ GeV	$128481 \pm 1479(1.2\%) \pm 11633(9.1\%)$	$90531 \pm 1226(1.4\%) \pm 8325(9.2\%)$
$m_{H^-} = 160$ GeV	$104805 \pm 1345(1.3\%) \pm 9595(9.2\%)$	$72949 \pm 1113(1.5\%) \pm 6760(9.3\%)$
$m_{H^+} = 80$ GeV	$315035 \pm 2663(0.8\%) \pm 25746(8.2\%)$	$220407 \pm 2205(1.0\%) \pm 18210(8.3\%)$
$m_{H^+} = 90$ GeV	$320113 \pm 2681(0.8\%) \pm 26054(8.1\%)$	$220448 \pm 2212(1.0\%) \pm 18144(8.2\%)$
$m_{H^+} = 100$ GeV	$321953 \pm 2713(0.8\%) \pm 25517(7.9\%)$	$224710 \pm 2238(1.0\%) \pm 18155(8.1\%)$
$m_{H^+} = 110$ GeV	$316954 \pm 3509(1.1\%) \pm 25450(8.0\%)$	$218428 \pm 2922(1.3\%) \pm 17653(8.1\%)$
$m_{H^+} = 120$ GeV	$296129 \pm 2580(0.9\%) \pm 23910(8.1\%)$	$210493 \pm 2133(1.0\%) \pm 17342(8.2\%)$
$m_{H^+} = 130$ GeV	$276455 \pm 2465(0.9\%) \pm 22300(8.1\%)$	$187626 \pm 2027(1.1\%) \pm 15661(8.3\%)$
$m_{H^+} = 140$ GeV	$229025 \pm 2305(1.0\%) \pm 19637(8.6\%)$	$157396 \pm 1914(1.2\%) \pm 13370(8.5\%)$
$m_{H^+} = 150$ GeV	$157427 \pm 1641(1.0\%) \pm 13997(8.9\%)$	$111859 \pm 1369(1.2\%) \pm 10062(9.0\%)$
$m_{H^+} = 155$ GeV	$129245 \pm 1473(1.1\%) \pm 11858(9.2\%)$	$88054 \pm 1218(1.4\%) \pm 8007(9.1\%)$
$m_{H^+} = 160$ GeV	$103325 \pm 1345(1.3\%) \pm 9413(9.1\%)$	$72621 \pm 1115(1.5\%) \pm 6542(9.0\%)$
SM $t\bar{t}$ + jets	$524804 \pm 155(0.0\%) \pm 43777(8.3\%)$	$362343 \pm 128(0.0\%) \pm 30665(8.5\%)$
Single t	$19120 \pm 61(0.3\%) \pm 1582(8.3\%)$	$12706 \pm 50(0.4\%) \pm 1059(8.3\%)$
W + jets	$7398 \pm 186(2.5\%) \pm 1112(15.0\%)$	$4772 \pm 148(3.1\%) \pm 559(11.7\%)$
Z/γ + jets	$1223 \pm 17(1.4\%) \pm 143(11.7\%)$	$1537 \pm 19(1.3\%) \pm 188(12.2\%)$
VV	$250 \pm 6(2.4\%) \pm 25(9.8\%)$	$187 \pm 5(2.8\%) \pm 19(10.0\%)$
MC QCD	$7718 \pm 1143(14.8\%)$	$886 \pm 393(44.3\%)$
DD QCD	$16027 \pm 629(3.9\%) \pm 1248(7.8\%)$	$13522 \pm 387(2.9\%) \pm 3362(24.9\%)$
All background	$568823 \pm 677(0.1\%) \pm 43838(7.7\%)$	$395066 \pm 437(0.1\%) \pm 30872(7.8\%)$
Data	$564956 \pm 752(0.1\%)$	$389039 \pm 624(0.2\%)$
Data/Bkg	0.9932	0.9847

The MC QCD results are shown for comparison and they are not added to "All Background".

In addition, the systematics are not calculated for MC QCD due to limited statistics.

Yields (2016) [exclusive loose category]

Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$126002 \pm 1707(1.4\%) \pm 12011(9.5\%)$	$90279 \pm 1418(1.6\%) \pm 8986(10.0\%)$
$m_{H^-} = 90$ GeV	$127380 \pm 1707(1.3\%) \pm 11860(9.3\%)$	$88424 \pm 1414(1.6\%) \pm 8380(9.5\%)$
$m_{H^-} = 100$ GeV	$126325 \pm 1699(1.3\%) \pm 12546(9.9\%)$	$88816 \pm 1409(1.6\%) \pm 8736(9.8\%)$
$m_{H^-} = 110$ GeV	$123891 \pm 1680(1.4\%) \pm 12109(9.8\%)$	$84570 \pm 1388(1.6\%) \pm 8122(9.6\%)$
$m_{H^-} = 120$ GeV	$118509 \pm 1708(1.4\%) \pm 11845(10.0\%)$	$80519 \pm 1399(1.7\%) \pm 7728(9.6\%)$
$m_{H^-} = 130$ GeV	$103688 \pm 1544(1.5\%) \pm 9881(9.5\%)$	$71485 \pm 1273(1.8\%) \pm 6942(9.7\%)$
$m_{H^-} = 140$ GeV	$88416 \pm 1418(1.6\%) \pm 8960(10.1\%)$	$59875 \pm 1176(2.0\%) \pm 6204(10.4\%)$
$m_{H^-} = 150$ GeV	$63320 \pm 1051(1.7\%) \pm 7045(11.1\%)$	$43922 \pm 882(2.0\%) \pm 4570(10.4\%)$
$m_{H^-} = 155$ GeV	$51817 \pm 952(1.8\%) \pm 5871(11.3\%)$	$36829 \pm 790(2.1\%) \pm 4274(11.6\%)$
$m_{H^-} = 160$ GeV	$44118 \pm 889(2.0\%) \pm 4833(11.0\%)$	$30342 \pm 729(2.4\%) \pm 3260(10.7\%)$
$m_{H^+} = 80$ GeV	$125130 \pm 1706(1.4\%) \pm 11936(9.5\%)$	$87829 \pm 1408(1.6\%) \pm 8318(9.5\%)$
$m_{H^+} = 90$ GeV	$126193 \pm 1703(1.3\%) \pm 12124(9.6\%)$	$86415 \pm 1406(1.6\%) \pm 8515(9.9\%)$
$m_{H^+} = 100$ GeV	$122708 \pm 1704(1.4\%) \pm 11859(9.7\%)$	$88719 \pm 1420(1.6\%) \pm 8311(9.4\%)$
$m_{H^+} = 110$ GeV	$120130 \pm 2184(1.8\%) \pm 12289(10.2\%)$	$85415 \pm 1848(2.2\%) \pm 8443(9.9\%)$
$m_{H^+} = 120$ GeV	$111199 \pm 1621(1.5\%) \pm 11219(10.1\%)$	$80654 \pm 1349(1.7\%) \pm 7765(9.6\%)$
$m_{H^+} = 130$ GeV	$105386 \pm 1545(1.5\%) \pm 10991(10.4\%)$	$72577 \pm 1277(1.8\%) \pm 7659(10.6\%)$
$m_{H^+} = 140$ GeV	$89560 \pm 1444(1.6\%) \pm 8794(9.8\%)$	$60517 \pm 1210(2.0\%) \pm 6115(10.1\%)$
$m_{H^+} = 150$ GeV	$61946 \pm 1039(1.7\%) \pm 6939(11.2\%)$	$43396 \pm 868(2.0\%) \pm 4409(10.2\%)$
$m_{H^+} = 155$ GeV	$51354 \pm 947(1.8\%) \pm 6339(12.3\%)$	$35973 \pm 788(2.2\%) \pm 4528(12.6\%)$
$m_{H^+} = 160$ GeV	$43538 \pm 881(2.0\%) \pm 5209(12.0\%)$	$29789 \pm 731(2.5\%) \pm 3293(11.1\%)$
SM $t\bar{t}$ + jets	$246679 \pm 106(0.0\%) \pm 21831(8.9\%)$	$170768 \pm 87(0.1\%) \pm 15309(9.0\%)$
Single t	$9606 \pm 42(0.4\%) \pm 885(9.2\%)$	$6358 \pm 35(0.5\%) \pm 575(9.0\%)$
W + jets	$3895 \pm 132(3.4\%) \pm 623(16.0\%)$	$2680 \pm 112(4.2\%) \pm 323(12.1\%)$
Z/γ + jets	$665 \pm 13(1.9\%) \pm 89(13.4\%)$	$773 \pm 14(1.7\%) \pm 107(13.8\%)$
VV	$123 \pm 4(3.3\%) \pm 14(11.7\%)$	$96 \pm 4(3.8\%) \pm 10(9.9\%)$
MC QCD	$4820 \pm 909(18.9\%)$	$342 \pm 218(63.6\%)$
DD QCD	$2151 \pm 298(13.8\%) \pm 114(5.3\%)$	$2921 \pm 175(6.0\%) \pm 803(27.5\%)$
All background	$263120 \pm 345(0.1\%) \pm 21858(8.3\%)$	$183596 \pm 228(0.1\%) \pm 15344(8.4\%)$
Data	$253066 \pm 503(0.2\%)$	$174843 \pm 418(0.2\%)$
Data/Bkg	0.9618	0.9523

The cross section : $\sigma_{H^\pm} = 831.76 \times 0.32\text{pb} = 266.16$ pb used for signal.

Yields (2016) [exclusive medium category]

Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$127017 \pm 1719(1.4\%) \pm 15856(12.5\%)$	$88691 \pm 1410(1.6\%) \pm 11118(12.5\%)$
$m_{H^-} = 90$ GeV	$129241 \pm 1728(1.3\%) \pm 16368(12.7\%)$	$90732 \pm 1416(1.6\%) \pm 11643(12.8\%)$
$m_{H^-} = 100$ GeV	$131922 \pm 1737(1.3\%) \pm 16318(12.4\%)$	$90335 \pm 1433(1.6\%) \pm 11144(12.3\%)$
$m_{H^-} = 110$ GeV	$128840 \pm 1723(1.3\%) \pm 15947(12.4\%)$	$88405 \pm 1409(1.6\%) \pm 11382(12.9\%)$
$m_{H^-} = 120$ GeV	$119949 \pm 1747(1.5\%) \pm 15534(13.0\%)$	$79035 \pm 1426(1.8\%) \pm 10307(13.0\%)$
$m_{H^-} = 130$ GeV	$110511 \pm 1585(1.4\%) \pm 14575(13.2\%)$	$77069 \pm 1310(1.7\%) \pm 9723(12.6\%)$
$m_{H^-} = 140$ GeV	$90639 \pm 1454(1.6\%) \pm 11950(13.2\%)$	$60954 \pm 1197(2.0\%) \pm 8410(13.8\%)$
$m_{H^-} = 150$ GeV	$64882 \pm 1081(1.7\%) \pm 9441(14.6\%)$	$44984 \pm 893(2.0\%) \pm 6121(13.6\%)$
$m_{H^-} = 155$ GeV	$51695 \pm 959(1.9\%) \pm 7095(13.7\%)$	$37058 \pm 800(2.2\%) \pm 4973(13.4\%)$
$m_{H^-} = 160$ GeV	$43223 \pm 871(2.0\%) \pm 6103(14.1\%)$	$30048 \pm 725(2.4\%) \pm 4250(14.1\%)$
$m_{H^+} = 80$ GeV	$124478 \pm 1705(1.4\%) \pm 16413(13.2\%)$	$86778 \pm 1418(1.6\%) \pm 11577(13.3\%)$
$m_{H^+} = 90$ GeV	$127600 \pm 1728(1.4\%) \pm 16088(12.6\%)$	$89346 \pm 1424(1.6\%) \pm 11531(12.9\%)$
$m_{H^+} = 100$ GeV	$128786 \pm 1751(1.4\%) \pm 16348(12.7\%)$	$89022 \pm 1437(1.6\%) \pm 11405(12.8\%)$
$m_{H^+} = 110$ GeV	$127963 \pm 2270(1.8\%) \pm 15378(12.0\%)$	$83620 \pm 1861(2.2\%) \pm 10267(12.3\%)$
$m_{H^+} = 120$ GeV	$120147 \pm 1659(1.4\%) \pm 15711(13.1\%)$	$83839 \pm 1361(1.6\%) \pm 10871(13.0\%)$
$m_{H^+} = 130$ GeV	$110101 \pm 1582(1.4\%) \pm 14094(12.8\%)$	$74062 \pm 1301(1.8\%) \pm 9412(12.7\%)$
$m_{H^+} = 140$ GeV	$89148 \pm 1480(1.7\%) \pm 12021(13.5\%)$	$63276 \pm 1229(1.9\%) \pm 8179(12.9\%)$
$m_{H^+} = 150$ GeV	$64321 \pm 1072(1.7\%) \pm 8392(13.0\%)$	$45492 \pm 884(1.9\%) \pm 6560(14.4\%)$
$m_{H^+} = 155$ GeV	$51925 \pm 953(1.8\%) \pm 7251(14.0\%)$	$35908 \pm 785(2.2\%) \pm 4893(13.6\%)$
$m_{H^+} = 160$ GeV	$41997 \pm 876(2.1\%) \pm 5309(12.6\%)$	$30411 \pm 728(2.4\%) \pm 3987(13.1\%)$
SM $t\bar{t}$ + jets	$210728 \pm 101(0.0\%) \pm 21884(10.4\%)$	$144975 \pm 83(0.1\%) \pm 15164(10.5\%)$
Single t	$7597 \pm 39(0.5\%) \pm 899(11.8\%)$	$5031 \pm 33(0.6\%) \pm 580(11.5\%)$
W + jets	$3054 \pm 128(4.2\%) \pm 601(19.7\%)$	$1655 \pm 90(5.4\%) \pm 265(16.0\%)$
Z/γ + jets	$463 \pm 11(2.3\%) \pm 75(16.2\%)$	$658 \pm 13(2.0\%) \pm 111(16.9\%)$
VV	$105 \pm 4(3.8\%) \pm 14(13.2\%)$	$74 \pm 3(4.6\%) \pm 12(16.0\%)$
MC QCD	$2455 \pm 697(28.4\%)$	$515 \pm 299(58.1\%)$
DD QCD	$10851 \pm 512(4.7\%) \pm 598(5.5\%)$	$8163 \pm 321(3.9\%) \pm 1010(12.4\%)$
All background	$232799 \pm 539(0.2\%) \pm 21919(9.4\%)$	$160555 \pm 346(0.2\%) \pm 15212(9.5\%)$
Data	$235296 \pm 485(0.2\%)$	$161272 \pm 402(0.2\%)$
Data/Bkg	1.0107	1.0045

Yields (2016) [exclusive tight category]

Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$52924 \pm 1000(1.9\%) \pm 12727(24.0\%)$	$38129 \pm 837(2.2\%) \pm 8831(23.2\%)$
$m_{H^-} = 90$ GeV	$57375 \pm 1033(1.8\%) \pm 13139(22.9\%)$	$39956 \pm 852(2.1\%) \pm 9378(23.5\%)$
$m_{H^-} = 100$ GeV	$58202 \pm 1046(1.8\%) \pm 13774(23.7\%)$	$40669 \pm 864(2.1\%) \pm 9660(23.8\%)$
$m_{H^-} = 110$ GeV	$60076 \pm 1041(1.7\%) \pm 14362(23.9\%)$	$40474 \pm 856(2.1\%) \pm 9669(23.9\%)$
$m_{H^-} = 120$ GeV	$56797 \pm 1066(1.9\%) \pm 13593(23.9\%)$	$38854 \pm 878(2.3\%) \pm 9175(23.6\%)$
$m_{H^-} = 130$ GeV	$49466 \pm 957(1.9\%) \pm 12033(24.3\%)$	$32800 \pm 790(2.4\%) \pm 8100(24.7\%)$
$m_{H^-} = 140$ GeV	$42843 \pm 883(2.1\%) \pm 10274(24.0\%)$	$27475 \pm 721(2.6\%) \pm 6990(25.4\%)$
$m_{H^-} = 150$ GeV	$26161 \pm 618(2.4\%) \pm 6715(25.7\%)$	$18773 \pm 522(2.8\%) \pm 4751(25.3\%)$
$m_{H^-} = 155$ GeV	$20812 \pm 545(2.6\%) \pm 5238(25.2\%)$	$14136 \pm 447(3.2\%) \pm 3597(25.4\%)$
$m_{H^-} = 160$ GeV	$14979 \pm 471(3.1\%) \pm 3665(24.5\%)$	$11006 \pm 394(3.6\%) \pm 2623(23.8\%)$
$m_{H^+} = 80$ GeV	$53914 \pm 1015(1.9\%) \pm 12502(23.2\%)$	$37483 \pm 829(2.2\%) \pm 9054(24.2\%)$
$m_{H^+} = 90$ GeV	$55125 \pm 1025(1.9\%) \pm 13018(23.6\%)$	$37166 \pm 844(2.3\%) \pm 8912(24.0\%)$
$m_{H^+} = 100$ GeV	$57780 \pm 1053(1.8\%) \pm 13645(23.6\%)$	$39498 \pm 864(2.2\%) \pm 9293(23.5\%)$
$m_{H^+} = 110$ GeV	$56694 \pm 1361(2.4\%) \pm 13248(23.4\%)$	$40503 \pm 1147(2.8\%) \pm 10217(25.2\%)$
$m_{H^+} = 120$ GeV	$53407 \pm 1005(1.9\%) \pm 12528(23.5\%)$	$38075 \pm 831(2.2\%) \pm 9495(24.9\%)$
$m_{H^+} = 130$ GeV	$50065 \pm 963(1.9\%) \pm 11818(23.6\%)$	$34075 \pm 790(2.3\%) \pm 8194(24.0\%)$
$m_{H^+} = 140$ GeV	$41515 \pm 901(2.2\%) \pm 10161(24.5\%)$	$27853 \pm 736(2.6\%) \pm 7345(26.4\%)$
$m_{H^+} = 150$ GeV	$25810 \pm 611(2.4\%) \pm 6606(25.6\%)$	$18826 \pm 517(2.7\%) \pm 4587(24.4\%)$
$m_{H^+} = 155$ GeV	$21356 \pm 541(2.5\%) \pm 5481(25.7\%)$	$13454 \pm 447(3.3\%) \pm 3321(24.7\%)$
$m_{H^+} = 160$ GeV	$14859 \pm 473(3.2\%) \pm 3973(26.7\%)$	$10313 \pm 389(3.8\%) \pm 2754(26.7\%)$
SM $t\bar{t}$ + jets	$63343 \pm 52(0.1\%) \pm 11915(18.8\%)$	$43612 \pm 43(0.1\%) \pm 8268(19.0\%)$
Single t	$1847 \pm 19(1.0\%) \pm 357(19.4\%)$	$1270 \pm 16(1.3\%) \pm 244(19.2\%)$
W + jets	$489 \pm 45(9.2\%) \pm 110(22.6\%)$	$390 \pm 39(10.1\%) \pm 97(25.0\%)$
Z/γ + jets	$99 \pm 5(4.7\%) \pm 19(19.1\%)$	$121 \pm 5(4.3\%) \pm 21(17.4\%)$
VV	$22 \pm 2(8.4\%) \pm 4(19.2\%)$	$18 \pm 2(9.0\%) \pm 3(17.9\%)$
MC QCD	$403 \pm 160(39.7\%)$	$0 \pm 0(0\%)$
DD QCD	$8107 \pm 699(8.6\%) \pm 2316(28.6\%)$	$5890 \pm 441(7.5\%) \pm 2026(34.4\%)$
All background	$73907 \pm 703(1.0\%) \pm 12144(16.4\%)$	$51301 \pm 445(0.9\%) \pm 8517(16.6\%)$
Data	$72505 \pm 269(0.4\%)$	$49976 \pm 224(0.4\%)$
Data/Bkg	0.9810	0.9742

Systematic uncertianties (2017) [KinFit Level]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$m_{H^-} = 80$ GeV	0.33(0.25)	0.28(1.41)	0.00(0.00)	0.08(0.11)	5.14(5.07)	0.41(0.45)	4.62(4.61)	0.47(0.21)	6.10(6.10)	0.83(1.00)
$m_{H^-} = 90$ GeV	0.24(0.73)	0.28(1.40)	0.00(0.00)	0.13(0.13)	4.99(5.01)	0.41(0.42)	4.16(4.05)	0.42(0.53)	6.10(6.10)	0.83(0.98)
$m_{H^-} = 100$ GeV	0.24(0.42)	0.27(1.40)	0.00(0.00)	0.10(0.17)	4.79(4.85)	0.42(0.46)	4.20(4.43)	0.52(0.54)	6.10(6.10)	0.82(0.96)
$m_{H^-} = 110$ GeV	0.55(0.69)	0.28(1.41)	0.00(0.00)	0.14(0.20)	4.77(4.77)	0.40(0.46)	3.66(4.24)	0.37(0.40)	6.10(6.10)	0.83(0.97)
$m_{H^-} = 120$ GeV	0.31(0.28)	0.28(1.38)	0.00(0.00)	0.16(0.13)	4.68(4.68)	0.40(0.44)	4.18(4.11)	0.43(0.68)	6.10(6.10)	0.85(0.99)
$m_{H^-} = 130$ GeV	0.42(0.33)	0.28(1.42)	0.00(0.00)	0.27(0.23)	4.64(4.55)	0.43(0.47)	4.43(4.38)	0.90(0.43)	6.10(6.10)	0.88(1.04)
$m_{H^-} = 140$ GeV	0.48(0.36)	0.28(1.41)	0.00(0.00)	0.26(0.34)	4.66(4.63)	0.42(0.44)	4.96(4.95)	0.47(0.07)	6.10(6.10)	1.00(1.16)
$m_{H^-} = 150$ GeV	0.34(0.50)	0.29(1.45)	0.00(0.00)	0.51(0.47)	5.03(4.87)	0.44(0.46)	5.72(5.82)	0.10(0.33)	6.10(6.10)	1.01(1.19)
$m_{H^-} = 155$ GeV	0.32(0.41)	0.29(1.43)	0.00(0.00)	0.72(0.63)	5.02(5.22)	0.46(0.50)	5.89(5.88)	0.47(0.32)	6.10(6.10)	1.38(1.62)
$m_{H^-} = 160$ GeV	0.21(0.07)	0.29(1.46)	0.00(0.00)	0.85(0.76)	5.45(5.28)	0.45(0.48)	5.34(5.50)	0.41(1.03)	6.10(6.10)	1.27(1.47)
$m_{H^+} = 80$ GeV	0.10(0.49)	0.28(1.40)	0.00(0.00)	0.12(0.11)	4.94(5.06)	0.42(0.44)	4.15(3.89)	0.33(0.37)	6.10(6.10)	0.83(0.99)
$m_{H^+} = 90$ GeV	0.41(0.65)	0.27(1.39)	0.00(0.00)	0.09(0.11)	4.85(5.04)	0.41(0.46)	4.73(4.52)	0.50(0.24)	6.10(6.10)	0.84(0.98)
$m_{H^+} = 100$ GeV	0.21(0.68)	0.28(1.40)	0.00(0.00)	0.06(0.13)	4.82(4.85)	0.40(0.44)	4.49(4.60)	0.06(0.69)	6.10(6.10)	0.82(0.96)
$m_{H^+} = 110$ GeV	0.22(0.56)	0.28(1.40)	0.00(0.00)	0.11(0.16)	4.81(4.65)	0.40(0.43)	4.45(3.94)	0.49(0.26)	6.10(6.10)	0.83(0.98)
$m_{H^+} = 120$ GeV	0.64(0.34)	0.28(1.39)	0.00(0.00)	0.19(0.14)	4.51(4.73)	0.39(0.46)	3.84(3.73)	0.51(0.43)	6.10(6.10)	0.93(1.11)
$m_{H^+} = 130$ GeV	0.22(0.48)	0.28(1.39)	0.00(0.00)	0.18(0.23)	4.68(4.64)	0.41(0.45)	4.24(4.89)	0.12(0.79)	6.10(6.10)	0.89(1.05)
$m_{H^+} = 140$ GeV	0.24(0.73)	0.28(1.42)	0.00(0.00)	0.30(0.33)	4.68(4.67)	0.42(0.46)	4.59(4.54)	0.22(0.72)	6.10(6.10)	1.00(1.14)
$m_{H^+} = 150$ GeV	0.19(0.33)	0.29(1.46)	0.00(0.00)	0.45(0.42)	5.02(4.95)	0.43(0.47)	5.64(5.76)	0.38(0.26)	6.10(6.10)	1.02(1.19)
$m_{H^+} = 155$ GeV	0.51(0.60)	0.29(1.44)	0.00(0.00)	0.75(0.58)	5.05(5.17)	0.44(0.49)	6.17(5.98)	0.17(0.86)	6.10(6.10)	1.14(1.32)
$m_{H^+} = 160$ GeV	0.16(0.55)	0.29(1.43)	0.00(0.00)	0.83(0.90)	5.34(5.25)	0.43(0.48)	5.81(5.67)	0.56(0.22)	6.10(6.10)	1.26(1.47)
SM $t\bar{t}$ + jets	0.28(0.48)	0.28(1.41)	0.00(0.00)	0.14(0.14)	5.44(5.46)	0.48(0.51)	8.35(8.32)	1.73(1.74)	6.10(6.10)	0.03(0.03)
Single t	0.06(0.23)	0.28(1.42)	0.00(0.00)	0.58(0.59)	5.33(5.37)	0.50(0.51)	6.04(5.69)	0.53(0.27)	5.00(5.00)	0.29(0.35)
W + jets	1.18(0.37)	0.31(1.44)	0.00(0.00)	4.35(4.35)	4.99(4.91)	0.43(0.65)	9.91(9.52)	1.23(0.58)	5.00(5.00)	2.07(2.33)
Z/γ + jets	1.71(1.96)	0.32(1.41)	0.00(0.00)	4.16(4.61)	4.69(4.48)	0.44(0.92)	9.97(13.60)	2.15(2.64)	4.50(4.50)	1.32(1.23)
VV	2.60(1.54)	0.29(1.40)	0.00(0.00)	2.43(2.61)	4.54(4.71)	0.33(0.55)	11.92(10.98)	2.35(2.93)	4.00(4.00)	3.12(3.43)
DD QCD	–	–	–	–	–	–	–	–	4.64(25.76)	3.94(3.65)

Systematic uncertianties (2017) [exclusive loose category]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$m_{H^-} = 80$ GeV	1.07(0.66)	0.28(1.40)	1.52(1.56)	1.84(1.44)	6.63(6.75)	0.39(0.42)	4.48(5.92)	1.10(1.47)	6.10(6.10)	1.54(1.89)
$m_{H^-} = 90$ GeV	0.83(1.52)	0.28(1.36)	1.61(1.51)	1.80(1.44)	6.51(6.54)	0.40(0.41)	4.12(4.10)	1.90(1.50)	6.10(6.10)	1.56(1.81)
$m_{H^-} = 100$ GeV	0.64(0.87)	0.28(1.40)	1.56(1.61)	2.13(2.02)	6.47(6.54)	0.44(0.44)	5.39(3.93)	1.33(0.95)	6.10(6.10)	1.53(1.81)
$m_{H^-} = 110$ GeV	1.64(1.93)	0.28(1.39)	1.65(1.56)	1.12(1.47)	6.56(6.62)	0.39(0.45)	5.15(4.34)	1.91(0.96)	6.10(6.10)	1.55(1.82)
$m_{H^-} = 120$ GeV	0.93(1.38)	0.28(1.37)	1.55(1.60)	1.84(1.10)	6.52(6.23)	0.38(0.45)	3.70(5.02)	1.37(2.17)	6.10(6.10)	1.56(1.86)
$m_{H^-} = 130$ GeV	0.79(0.39)	0.28(1.44)	1.70(1.88)	1.72(1.74)	6.52(6.54)	0.42(0.48)	3.81(5.60)	0.57(2.70)	6.10(6.10)	1.64(1.95)
$m_{H^-} = 140$ GeV	1.15(1.02)	0.28(1.41)	1.54(1.56)	1.86(1.56)	6.49(6.77)	0.39(0.45)	5.40(6.01)	1.24(0.99)	6.10(6.10)	1.85(2.22)
$m_{H^-} = 150$ GeV	1.02(0.16)	0.29(1.43)	1.51(1.59)	2.18(1.92)	7.12(7.04)	0.44(0.44)	6.31(5.33)	0.63(0.10)	6.10(6.10)	1.91(2.16)
$m_{H^-} = 155$ GeV	1.32(1.35)	0.28(1.41)	1.74(1.48)	2.05(1.92)	7.21(7.39)	0.42(0.48)	7.15(6.08)	1.06(0.28)	6.10(6.10)	2.60(2.94)
$m_{H^-} = 160$ GeV	0.87(1.27)	0.28(1.45)	1.45(1.83)	2.44(2.25)	7.78(7.97)	0.42(0.52)	5.29(6.87)	0.35(1.50)	6.10(6.10)	2.22(2.60)
$m_{H^+} = 80$ GeV	0.38(0.36)	0.27(1.41)	1.46(1.65)	2.19(1.83)	6.46(6.70)	0.43(0.45)	4.00(4.65)	1.07(1.14)	6.10(6.10)	1.53(1.81)
$m_{H^+} = 90$ GeV	0.54(0.89)	0.27(1.37)	1.48(1.58)	1.80(1.40)	6.38(6.97)	0.41(0.43)	5.08(5.19)	0.67(1.12)	6.10(6.10)	1.55(1.82)
$m_{H^+} = 100$ GeV	0.42(1.84)	0.27(1.39)	1.53(1.75)	2.01(1.59)	6.41(6.71)	0.41(0.45)	5.08(3.16)	1.09(0.81)	6.10(6.10)	1.54(1.78)
$m_{H^+} = 110$ GeV	0.01(0.59)	0.28(1.38)	1.58(1.76)	1.38(1.86)	6.41(6.28)	0.43(0.44)	4.27(5.36)	1.10(1.78)	6.10(6.10)	1.54(1.86)
$m_{H^+} = 120$ GeV	0.97(1.27)	0.28(1.37)	1.63(1.60)	1.86(1.64)	6.26(6.64)	0.37(0.45)	3.88(4.45)	0.13(2.38)	6.10(6.10)	1.76(2.09)
$m_{H^+} = 130$ GeV	1.12(0.63)	0.28(1.38)	1.54(1.68)	1.77(0.97)	6.42(6.46)	0.41(0.44)	5.77(4.90)	1.13(0.51)	6.10(6.10)	1.65(1.92)
$m_{H^+} = 140$ GeV	0.67(2.17)	0.28(1.44)	1.75(1.75)	1.92(1.88)	6.73(6.83)	0.43(0.43)	5.42(4.50)	1.21(0.69)	6.10(6.10)	1.84(2.13)
$m_{H^+} = 150$ GeV	0.53(1.74)	0.29(1.45)	1.51(1.78)	2.02(1.80)	6.83(7.49)	0.43(0.48)	6.50(5.31)	1.55(2.09)	6.10(6.10)	1.84(2.19)
$m_{H^+} = 155$ GeV	0.62(1.08)	0.28(1.47)	1.66(1.62)	2.51(2.04)	7.48(7.17)	0.47(0.49)	7.27(7.81)	0.76(1.49)	6.10(6.10)	2.06(2.39)
$m_{H^+} = 160$ GeV	1.02(1.40)	0.28(1.42)	1.64(1.71)	2.82(3.43)	7.88(7.72)	0.45(0.48)	6.27(6.74)	1.20(3.55)	6.10(6.10)	2.25(2.57)
SM $t\bar{t}$ + jets	0.90(1.06)	0.28(1.40)	0.70(0.70)	2.93(2.90)	6.43(6.46)	0.47(0.51)	7.62(7.57)	1.64(1.65)	6.10(6.10)	0.04(0.05)
Single t	0.84(0.85)	0.28(1.43)	0.60(0.64)	2.88(2.68)	6.35(6.38)	0.50(0.51)	5.79(5.61)	0.52(0.67)	5.00(5.00)	0.43(0.54)
W + jets	0.03(0.70)	0.30(1.45)	0.46(0.65)	5.71(5.64)	5.87(5.77)	0.41(0.67)	10.50(7.60)	1.01(2.37)	5.00(5.00)	2.93(3.43)
Z/γ + jets	0.56(1.17)	0.33(1.41)	0.50(0.52)	7.97(8.38)	5.79(5.40)	0.43(0.96)	11.56(11.97)	0.97(3.48)	4.50(4.50)	1.85(1.94)
VV	2.10(0.89)	0.28(1.39)	0.61(0.80)	5.10(5.28)	5.71(6.05)	0.32(0.61)	12.58(10.39)	3.04(2.88)	4.00(4.00)	4.77(5.25)
DD QCD	–	–	–	–	–	–	–	–	1.50(28.97)	183.74(17.76)

Systematic uncertianties (2017) [exclusive medium category]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$m_{H^-} = 80$ GeV	0.55(0.17)	0.28(1.41)	1.85(1.87)	4.08(4.02)	8.87(8.77)	0.43(0.48)	8.05(7.24)	3.01(2.25)	6.10(6.10)	1.17(1.39)
$m_{H^-} = 90$ GeV	0.28(0.16)	0.28(1.37)	1.83(1.87)	4.06(4.22)	8.62(8.68)	0.42(0.44)	7.69(6.71)	2.41(3.26)	6.10(6.10)	1.17(1.38)
$m_{H^-} = 100$ GeV	0.59(0.17)	0.27(1.40)	1.90(1.97)	4.06(4.22)	8.54(8.78)	0.43(0.49)	6.82(7.38)	2.66(2.69)	6.10(6.10)	1.17(1.35)
$m_{H^-} = 110$ GeV	0.62(0.58)	0.28(1.42)	1.93(1.83)	4.12(4.11)	8.62(8.38)	0.41(0.48)	5.91(6.13)	2.43(1.96)	6.10(6.10)	1.18(1.38)
$m_{H^-} = 120$ GeV	0.62(0.62)	0.28(1.37)	1.95(1.97)	4.23(4.15)	8.52(8.58)	0.42(0.44)	7.71(6.78)	3.20(2.71)	6.10(6.10)	1.21(1.40)
$m_{H^-} = 130$ GeV	0.21(0.11)	0.28(1.42)	1.83(1.96)	4.25(4.25)	8.28(8.36)	0.44(0.48)	6.27(6.75)	2.45(2.19)	6.10(6.10)	1.25(1.48)
$m_{H^-} = 140$ GeV	0.27(0.29)	0.28(1.39)	1.87(2.06)	4.30(4.53)	8.29(8.52)	0.44(0.46)	7.26(8.50)	2.53(2.71)	6.10(6.10)	1.40(1.65)
$m_{H^-} = 150$ GeV	0.50(0.18)	0.29(1.45)	1.95(2.00)	4.67(4.82)	8.90(8.77)	0.45(0.46)	8.63(9.29)	2.30(2.71)	6.10(6.10)	1.42(1.68)
$m_{H^-} = 155$ GeV	0.68(0.79)	0.29(1.44)	1.98(1.89)	5.01(4.79)	9.03(8.86)	0.47(0.53)	6.52(9.28)	2.27(2.92)	6.10(6.10)	1.92(2.31)
$m_{H^-} = 160$ GeV	0.52(0.75)	0.28(1.45)	1.63(1.68)	5.03(5.02)	8.58(8.62)	0.47(0.46)	8.51(5.98)	2.46(0.32)	6.10(6.10)	1.76(2.03)
$m_{H^+} = 80$ GeV	0.50(0.27)	0.28(1.40)	1.78(1.89)	4.06(4.16)	8.39(8.78)	0.42(0.44)	7.41(7.47)	2.63(3.11)	6.10(6.10)	1.17(1.40)
$m_{H^+} = 90$ GeV	0.22(0.09)	0.27(1.40)	1.87(1.86)	4.11(4.06)	8.49(8.57)	0.43(0.49)	7.79(7.37)	3.09(2.60)	6.10(6.10)	1.19(1.38)
$m_{H^+} = 100$ GeV	0.51(0.83)	0.28(1.39)	1.90(1.82)	3.92(4.10)	8.62(8.32)	0.40(0.47)	7.67(6.20)	2.45(1.87)	6.10(6.10)	1.17(1.36)
$m_{H^+} = 110$ GeV	1.02(0.46)	0.28(1.43)	1.95(1.95)	4.19(4.17)	8.68(8.47)	0.39(0.44)	7.54(5.63)	2.68(1.99)	6.10(6.10)	1.19(1.39)
$m_{H^+} = 120$ GeV	0.09(0.79)	0.28(1.39)	1.89(2.01)	4.26(4.24)	8.12(8.69)	0.41(0.48)	7.20(6.76)	3.26(2.70)	6.10(6.10)	1.32(1.57)
$m_{H^+} = 130$ GeV	0.58(0.16)	0.28(1.38)	1.85(2.03)	4.17(4.34)	8.30(8.61)	0.42(0.47)	6.36(6.35)	2.28(1.93)	6.10(6.10)	1.26(1.50)
$m_{H^+} = 140$ GeV	0.53(0.39)	0.28(1.41)	1.94(2.15)	4.32(4.68)	8.47(8.82)	0.43(0.48)	7.10(7.54)	2.51(2.59)	6.10(6.10)	1.42(1.58)
$m_{H^+} = 150$ GeV	0.36(0.93)	0.28(1.47)	1.82(1.76)	4.52(4.50)	8.55(8.27)	0.44(0.49)	7.86(8.49)	2.87(2.28)	6.10(6.10)	1.43(1.68)
$m_{H^+} = 155$ GeV	0.25(0.22)	0.28(1.44)	1.93(1.75)	4.87(4.73)	8.80(8.71)	0.44(0.51)	8.66(7.98)	2.89(3.24)	6.10(6.10)	1.61(1.87)
$m_{H^+} = 160$ GeV	1.07(0.25)	0.29(1.43)	1.69(1.62)	4.94(4.79)	8.62(8.62)	0.43(0.48)	8.44(8.12)	1.83(1.35)	6.10(6.10)	1.75(2.06)
SM $t\bar{t}$ + jets	0.38(0.16)	0.28(1.41)	1.09(1.09)	4.30(4.29)	7.56(7.58)	0.49(0.53)	7.85(7.83)	0.90(0.90)	6.10(6.10)	0.04(0.04)
Single t	0.85(0.45)	0.28(1.42)	0.98(1.02)	4.89(4.87)	7.15(7.31)	0.51(0.53)	8.32(7.87)	1.56(1.37)	5.00(5.00)	0.41(0.51)
W + jets	1.85(1.65)	0.32(1.43)	0.93(1.13)	9.65(8.80)	6.61(7.03)	0.46(0.62)	11.83(9.97)	1.03(2.87)	5.00(5.00)	3.08(3.36)
Z/γ + jets	2.71(3.05)	0.31(1.41)	0.86(0.55)	9.08(9.17)	6.02(5.47)	0.46(0.89)	10.37(15.51)	3.93(1.44)	4.50(4.50)	2.00(1.68)
VV	3.43(1.62)	0.31(1.41)	0.76(0.71)	6.77(7.03)	5.75(5.96)	0.35(0.52)	12.17(10.67)	0.55(1.12)	4.00(4.00)	4.43(4.86)
DD QCD	–	–	–	–	–	–	–	–	9.88(2.40)	2.95(3.79)

Systematic uncertianties (2017) [exclusive tight category]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistcal
$m_{H^-} = 80$ GeV	0.88(1.27)	0.28(1.42)	7.51(7.64)	7.96(8.27)	20.01(20.42)	0.40(0.41)	10.69(11.78)	8.22(7.88)	6.10(6.10)	1.97(2.37)
$m_{H^-} = 90$ GeV	1.00(1.97)	0.29(1.52)	7.60(7.66)	8.22(8.17)	20.31(20.13)	0.40(0.40)	10.53(11.59)	8.24(7.45)	6.10(6.10)	1.89(2.31)
$m_{H^-} = 100$ GeV	1.01(1.38)	0.27(1.39)	7.63(7.76)	8.15(8.33)	20.07(20.39)	0.36(0.44)	10.96(10.10)	8.92(9.12)	6.10(6.10)	1.91(2.24)
$m_{H^-} = 110$ GeV	1.19(1.40)	0.28(1.42)	7.72(7.75)	8.30(8.39)	20.19(19.97)	0.40(0.42)	10.47(11.13)	8.41(8.85)	6.10(6.10)	1.86(2.19)
$m_{H^-} = 120$ GeV	1.88(1.03)	0.28(1.41)	7.71(7.87)	8.28(8.41)	20.27(20.59)	0.38(0.41)	10.84(11.65)	8.07(7.99)	6.10(6.10)	1.95(2.30)
$m_{H^-} = 130$ GeV	1.05(1.40)	0.28(1.39)	8.02(7.98)	8.75(8.62)	20.68(20.59)	0.40(0.47)	11.65(11.48)	9.05(8.23)	6.10(6.10)	2.01(2.37)
$m_{H^-} = 140$ GeV	1.53(0.24)	0.28(1.44)	7.93(8.24)	8.77(9.12)	20.40(21.34)	0.42(0.41)	13.87(10.27)	9.53(7.89)	6.10(6.10)	2.34(2.61)
$m_{H^-} = 150$ GeV	1.19(2.27)	0.28(1.49)	8.25(8.30)	9.29(9.43)	21.38(21.23)	0.40(0.46)	13.16(14.45)	10.28(10.56)	6.10(6.10)	2.35(2.85)
$m_{H^-} = 155$ GeV	1.88(1.71)	0.28(1.44)	8.34(8.24)	9.68(9.73)	21.47(21.55)	0.46(0.47)	13.96(13.00)	9.44(8.96)	6.10(6.10)	3.37(3.79)
$m_{H^-} = 160$ GeV	0.91(0.69)	0.31(1.48)	8.19(8.36)	10.04(10.06)	21.32(21.49)	0.47(0.47)	11.36(15.44)	9.70(8.76)	6.10(6.10)	3.46(3.91)
$m_{H^+} = 80$ GeV	1.17(1.96)	0.28(1.42)	7.51(7.59)	8.07(8.03)	20.07(20.35)	0.39(0.44)	10.95(9.28)	8.90(8.64)	6.10(6.10)	1.94(2.30)
$m_{H^+} = 90$ GeV	1.34(2.50)	0.27(1.39)	7.66(7.76)	8.03(8.27)	20.27(20.64)	0.39(0.42)	10.77(10.90)	9.34(8.32)	6.10(6.10)	2.00(2.32)
$m_{H^+} = 100$ GeV	1.65(2.17)	0.27(1.42)	7.65(7.72)	8.22(8.39)	20.02(20.59)	0.37(0.38)	10.57(11.63)	8.87(8.04)	6.10(6.10)	1.91(2.24)
$m_{H^+} = 110$ GeV	1.65(0.93)	0.27(1.37)	7.74(7.88)	8.29(8.34)	20.11(20.65)	0.34(0.37)	10.98(11.39)	9.24(8.76)	6.10(6.10)	1.90(2.21)
$m_{H^+} = 120$ GeV	1.56(1.45)	0.27(1.41)	7.70(7.96)	8.29(8.36)	20.29(20.84)	0.38(0.40)	10.58(11.18)	9.55(8.17)	6.10(6.10)	2.09(2.52)
$m_{H^+} = 130$ GeV	1.32(1.50)	0.28(1.41)	7.94(8.02)	8.51(8.64)	20.66(20.77)	0.38(0.40)	10.91(12.39)	8.52(9.15)	6.10(6.10)	2.04(2.49)
$m_{H^+} = 140$ GeV	1.89(1.40)	0.29(1.42)	8.00(8.11)	8.91(8.89)	20.68(20.95)	0.38(0.44)	10.96(10.23)	8.61(8.84)	6.10(6.10)	2.36(2.78)
$m_{H^+} = 150$ GeV	1.17(1.73)	0.29(1.42)	8.21(8.19)	9.22(9.05)	21.27(21.13)	0.39(0.39)	13.91(13.46)	8.27(8.53)	6.10(6.10)	2.51(2.81)
$m_{H^+} = 155$ GeV	1.48(1.14)	0.29(1.39)	8.23(8.05)	9.86(9.57)	21.41(20.66)	0.36(0.44)	13.25(14.70)	9.49(8.94)	6.10(6.10)	2.81(3.19)
$m_{H^+} = 160$ GeV	0.70(0.58)	0.30(1.44)	8.33(8.27)	10.05(10.30)	21.65(21.23)	0.39(0.53)	13.53(13.96)	8.33(9.02)	6.10(6.10)	3.34(3.96)
SM $t\bar{t}$ + jets	1.26(1.45)	0.28(1.41)	6.60(6.65)	8.05(8.09)	18.04(18.16)	0.44(0.47)	7.66(7.62)	5.40(5.47)	6.10(6.10)	0.08(0.10)
Single t	1.14(1.25)	0.28(1.44)	6.42(6.51)	8.57(8.67)	17.31(17.29)	0.41(0.46)	10.56(11.03)	7.18(7.32)	5.00(5.00)	1.14(1.40)
W + jets	5.21(2.11)	0.30(1.44)	6.03(6.79)	12.55(10.74)	16.69(18.14)	0.44(0.61)	11.41(30.21)	12.43(11.13)	5.00(5.00)	10.10(10.08)
Z/γ + jets	0.59(1.27)	0.27(1.36)	3.17(4.13)	10.62(11.90)	10.90(11.72)	0.29(0.84)	14.01(19.15)	3.53(8.13)	4.50(4.50)	5.86(5.71)
VV	1.22(4.86)	0.30(1.40)	6.28(5.95)	9.82(10.25)	16.71(15.04)	0.28(0.44)	15.06(12.34)	8.95(4.54)	4.00(4.00)	12.21(14.00)
DD QCD	–	–	–	–	–	–	–	–	73.27(37.16)	95.88(42.43)

Yields (2017) [KinFit Level]

Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$355140 \pm 2951(0.8\%) \pm 32855(9.3\%)$	$234879 \pm 2350(1.0\%) \pm 21840(9.3\%)$
$m_{H^-} = 90$ GeV	$358791 \pm 2971(0.8\%) \pm 32069(8.9\%)$	$243301 \pm 2381(1.0\%) \pm 21985(9.0\%)$
$m_{H^-} = 100$ GeV	$361727 \pm 2983(0.8\%) \pm 32016(8.9\%)$	$247993 \pm 2390(1.0\%) \pm 22606(9.1\%)$
$m_{H^-} = 110$ GeV	$356457 \pm 2948(0.8\%) \pm 30666(8.6\%)$	$244463 \pm 2371(1.0\%) \pm 21976(9.0\%)$
$m_{H^-} = 120$ GeV	$340706 \pm 2884(0.8\%) \pm 29917(8.8\%)$	$231730 \pm 2297(1.0\%) \pm 20554(8.9\%)$
$m_{H^-} = 130$ GeV	$312050 \pm 2752(0.9\%) \pm 27857(8.9\%)$	$210543 \pm 2198(1.0\%) \pm 18792(8.9\%)$
$m_{H^-} = 140$ GeV	$251930 \pm 2510(1.0\%) \pm 23119(9.2\%)$	$173524 \pm 2019(1.2\%) \pm 16053(9.3\%)$
$m_{H^-} = 150$ GeV	$183126 \pm 1856(1.0\%) \pm 17930(9.8\%)$	$125815 \pm 1497(1.2\%) \pm 12439(9.9\%)$
$m_{H^-} = 155$ GeV	$141779 \pm 1962(1.4\%) \pm 14058(9.9\%)$	$97084 \pm 1575(1.6\%) \pm 9806(10.1\%)$
$m_{H^-} = 160$ GeV	$119182 \pm 1512(1.3\%) \pm 11713(9.8\%)$	$83856 \pm 1229(1.5\%) \pm 8357(10.0\%)$
$m_{H^+} = 80$ GeV	$356875 \pm 2948(0.8\%) \pm 31772(8.9\%)$	$238255 \pm 2349(1.0\%) \pm 21381(9.0\%)$
$m_{H^+} = 90$ GeV	$351930 \pm 2958(0.8\%) \pm 32212(9.2\%)$	$240956 \pm 2363(1.0\%) \pm 22298(9.3\%)$
$m_{H^+} = 100$ GeV	$361436 \pm 2977(0.8\%) \pm 32506(9.0\%)$	$248469 \pm 2389(1.0\%) \pm 22903(9.2\%)$
$m_{H^+} = 110$ GeV	$359239 \pm 2997(0.8\%) \pm 32260(9.0\%)$	$242690 \pm 2380(1.0\%) \pm 21293(8.8\%)$
$m_{H^+} = 120$ GeV	$343201 \pm 3203(0.9\%) \pm 29362(8.6\%)$	$229261 \pm 2539(1.1\%) \pm 19987(8.7\%)$
$m_{H^+} = 130$ GeV	$308472 \pm 2743(0.9\%) \pm 27144(8.8\%)$	$208023 \pm 2192(1.1\%) \pm 19260(9.3\%)$
$m_{H^+} = 140$ GeV	$250387 \pm 2504(1.0\%) \pm 22489(9.0\%)$	$177440 \pm 2022(1.1\%) \pm 16170(9.1\%)$
$m_{H^+} = 150$ GeV	$182313 \pm 1857(1.0\%) \pm 17754(9.7\%)$	$125443 \pm 1497(1.2\%) \pm 12388(9.9\%)$
$m_{H^+} = 155$ GeV	$146249 \pm 1668(1.1\%) \pm 14757(10.1\%)$	$101762 \pm 1346(1.3\%) \pm 10349(10.2\%)$
$m_{H^+} = 160$ GeV	$120462 \pm 1519(1.3\%) \pm 12093(10.0\%)$	$83468 \pm 1231(1.5\%) \pm 8359(10.0\%)$
SM $t\bar{t}$ + jets	$582094 \pm 151(0.0\%) \pm 68855(11.8\%)$	$396609 \pm 121(0.0\%) \pm 47228(11.9\%)$
Single t	$21732 \pm 62(0.3\%) \pm 2070(9.5\%)$	$13958 \pm 49(0.4\%) \pm 1317(9.4\%)$
W + jets	$9184 \pm 190(2.1\%) \pm 1198(13.0\%)$	$6108 \pm 142(2.3\%) \pm 776(12.7\%)$
Z/γ + jets	$1558 \pm 21(1.3\%) \pm 201(12.9\%)$	$1750 \pm 21(1.2\%) \pm 282(16.1\%)$
VV	$283 \pm 9(3.1\%) \pm 40(14.0\%)$	$215 \pm 7(3.4\%) \pm 29(13.4\%)$
MC QCD	$9341 \pm 1287(13.8\%)$	$4368 \pm 2256(51.6\%)$
DD QCD	$15849 \pm 625(3.9\%) \pm 735(4.6\%)$	$18792 \pm 686(3.7\%) \pm 4841(25.8\%)$
All background	$630700 \pm 674(0.1\%) \pm 68900(10.9\%)$	$437431 \pm 713(0.2\%) \pm 47501(10.9\%)$
Data	$628277 \pm 793(0.1\%)$	$431568 \pm 657(0.2\%)$
Data/Bkg	0.9962	0.9866

Yields (2017) [exclusive loose category]

Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$107721 \pm 1660(1.5\%) \pm 11275(10.5\%)$	$69159 \pm 1306(1.9\%) \pm 7797(11.3\%)$
$m_{H^-} = 90$ GeV	$106014 \pm 1651(1.6\%) \pm 10958(10.3\%)$	$73710 \pm 1334(1.8\%) \pm 7650(10.4\%)$
$m_{H^-} = 100$ GeV	$107768 \pm 1645(1.5\%) \pm 11684(10.8\%)$	$73208 \pm 1322(1.8\%) \pm 7534(10.3\%)$
$m_{H^-} = 110$ GeV	$104415 \pm 1619(1.6\%) \pm 11307(10.8\%)$	$71859 \pm 1309(1.8\%) \pm 7579(10.5\%)$
$m_{H^-} = 120$ GeV	$101841 \pm 1586(1.6\%) \pm 10293(10.1\%)$	$68190 \pm 1268(1.9\%) \pm 7272(10.7\%)$
$m_{H^-} = 130$ GeV	$92397 \pm 1515(1.6\%) \pm 9299(10.1\%)$	$61884 \pm 1206(1.9\%) \pm 6994(11.3\%)$
$m_{H^-} = 140$ GeV	$74871 \pm 1387(1.9\%) \pm 8111(10.8\%)$	$50194 \pm 1113(2.2\%) \pm 5685(11.3\%)$
$m_{H^-} = 150$ GeV	$54505 \pm 1041(1.9\%) \pm 6366(11.7\%)$	$39039 \pm 844(2.2\%) \pm 4342(11.1\%)$
$m_{H^-} = 155$ GeV	$43104 \pm 1119(2.6\%) \pm 5289(12.3\%)$	$30604 \pm 899(2.9\%) \pm 3607(11.8\%)$
$m_{H^-} = 160$ GeV	$39552 \pm 877(2.2\%) \pm 4594(11.6\%)$	$27669 \pm 719(2.6\%) \pm 3527(12.7\%)$
$m_{H^+} = 80$ GeV	$107765 \pm 1647(1.5\%) \pm 10960(10.2\%)$	$72602 \pm 1317(1.8\%) \pm 7732(10.6\%)$
$m_{H^+} = 90$ GeV	$106443 \pm 1649(1.5\%) \pm 11167(10.5\%)$	$72648 \pm 1323(1.8\%) \pm 7999(11.0\%)$
$m_{H^+} = 100$ GeV	$107114 \pm 1648(1.5\%) \pm 11344(10.6\%)$	$74193 \pm 1323(1.8\%) \pm 7569(10.2\%)$
$m_{H^+} = 110$ GeV	$107594 \pm 1655(1.5\%) \pm 10888(10.1\%)$	$70541 \pm 1312(1.9\%) \pm 7648(10.8\%)$
$m_{H^+} = 120$ GeV	$99592 \pm 1754(1.8\%) \pm 9896(9.9\%)$	$67353 \pm 1410(2.1\%) \pm 7244(10.8\%)$
$m_{H^+} = 130$ GeV	$91253 \pm 1507(1.7\%) \pm 9997(11.0\%)$	$62301 \pm 1197(1.9\%) \pm 6518(10.5\%)$
$m_{H^+} = 140$ GeV	$75677 \pm 1391(1.8\%) \pm 8315(11.0\%)$	$52583 \pm 1120(2.1\%) \pm 5716(10.9\%)$
$m_{H^+} = 150$ GeV	$56759 \pm 1046(1.8\%) \pm 6606(11.6\%)$	$38509 \pm 842(2.2\%) \pm 4519(11.7\%)$
$m_{H^+} = 155$ GeV	$46287 \pm 955(2.1\%) \pm 5786(12.5\%)$	$32192 \pm 771(2.4\%) \pm 4101(12.7\%)$
$m_{H^+} = 160$ GeV	$39335 \pm 885(2.2\%) \pm 4850(12.3\%)$	$28017 \pm 721(2.6\%) \pm 3693(13.2\%)$
SM $t\bar{t}$ + jets	$224944 \pm 93(0.0\%) \pm 27504(12.2\%)$	$153757 \pm 75(0.0\%) \pm 18907(12.3\%)$
Single t	$9021 \pm 39(0.4\%) \pm 940(10.4\%)$	$5797 \pm 31(0.5\%) \pm 603(10.4\%)$
W + jets	$3877 \pm 114(2.9\%) \pm 553(14.3\%)$	$2862 \pm 98(3.4\%) \pm 359(12.5\%)$
Z/γ + jets	$704 \pm 13(1.9\%) \pm 112(15.9\%)$	$694 \pm 13(1.9\%) \pm 116(16.7\%)$
VV	$119 \pm 6(4.8\%) \pm 19(15.7\%)$	$89 \pm 5(5.2\%) \pm 13(14.2\%)$
MC QCD	$4316 \pm 802(18.6\%)$	$637 \pm 369(57.9\%)$
DD QCD	$130 \pm 238(183.7\%) \pm 2(1.5\%)$	$1010 \pm 179(17.8\%) \pm 293(29.0\%)$
All background	$238794 \pm 283(0.1\%) \pm 27526(11.5\%)$	$164208 \pm 220(0.1\%) \pm 18923(11.5\%)$
Data	$223320 \pm 473(0.2\%)$	$154173 \pm 393(0.3\%)$
Data/Bkg	0.9352	0.9389

Yields (2017) [exclusive medium category]

Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$185859 \pm 2172(1.2\%) \pm 26953(14.5\%)$	$124701 \pm 1734(1.4\%) \pm 17341(13.9\%)$
$m_{H^-} = 90$ GeV	$186766 \pm 2186(1.2\%) \pm 26189(14.0\%)$	$127220 \pm 1751(1.4\%) \pm 17606(13.8\%)$
$m_{H^-} = 100$ GeV	$187728 \pm 2203(1.2\%) \pm 25502(13.6\%)$	$129362 \pm 1752(1.4\%) \pm 18290(14.1\%)$
$m_{H^-} = 110$ GeV	$185048 \pm 2175(1.2\%) \pm 24386(13.2\%)$	$126822 \pm 1750(1.4\%) \pm 16613(13.1\%)$
$m_{H^-} = 120$ GeV	$175513 \pm 2120(1.2\%) \pm 24926(14.2\%)$	$120605 \pm 1687(1.4\%) \pm 16525(13.7\%)$
$m_{H^-} = 130$ GeV	$162433 \pm 2031(1.3\%) \pm 21353(13.1\%)$	$109233 \pm 1619(1.5\%) \pm 14726(13.5\%)$
$m_{H^-} = 140$ GeV	$132806 \pm 1857(1.4\%) \pm 18180(13.7\%)$	$90462 \pm 1491(1.6\%) \pm 13311(14.7\%)$
$m_{H^-} = 150$ GeV	$96752 \pm 1372(1.4\%) \pm 14428(14.9\%)$	$65891 \pm 1109(1.7\%) \pm 10149(15.4\%)$
$m_{H^-} = 155$ GeV	$76128 \pm 1459(1.9\%) \pm 10663(14.0\%)$	$50385 \pm 1165(2.3\%) \pm 7805(15.5\%)$
$m_{H^-} = 160$ GeV	$64140 \pm 1127(1.8\%) \pm 9465(14.8\%)$	$44984 \pm 912(2.0\%) \pm 6007(13.4\%)$
$m_{H^+} = 80$ GeV	$186735 \pm 2177(1.2\%) \pm 25706(13.8\%)$	$123224 \pm 1728(1.4\%) \pm 17554(14.2\%)$
$m_{H^+} = 90$ GeV	$183472 \pm 2177(1.2\%) \pm 25965(14.2\%)$	$125352 \pm 1733(1.4\%) \pm 17457(13.9\%)$
$m_{H^+} = 100$ GeV	$187741 \pm 2189(1.2\%) \pm 26275(14.0\%)$	$129816 \pm 1764(1.4\%) \pm 16990(13.1\%)$
$m_{H^+} = 110$ GeV	$184816 \pm 2205(1.2\%) \pm 26084(14.1\%)$	$126157 \pm 1751(1.4\%) \pm 16369(13.0\%)$
$m_{H^+} = 120$ GeV	$178072 \pm 2359(1.3\%) \pm 24395(13.7\%)$	$118860 \pm 1864(1.6\%) \pm 16404(13.8\%)$
$m_{H^+} = 130$ GeV	$160080 \pm 2023(1.3\%) \pm 21072(13.2\%)$	$108016 \pm 1620(1.5\%) \pm 14509(13.4\%)$
$m_{H^+} = 140$ GeV	$130234 \pm 1848(1.4\%) \pm 17888(13.7\%)$	$94622 \pm 1496(1.6\%) \pm 13629(14.4\%)$
$m_{H^+} = 150$ GeV	$96324 \pm 1377(1.4\%) \pm 13773(14.3\%)$	$65941 \pm 1109(1.7\%) \pm 9545(14.5\%)$
$m_{H^+} = 155$ GeV	$77033 \pm 1239(1.6\%) \pm 11578(15.0\%)$	$53311 \pm 996(1.9\%) \pm 7817(14.7\%)$
$m_{H^+} = 160$ GeV	$64599 \pm 1131(1.8\%) \pm 9464(14.6\%)$	$44306 \pm 915(2.1\%) \pm 6376(14.4\%)$
SM $t\bar{t}$ + jets	$306506 \pm 113(0.0\%) \pm 40759(13.3\%)$	$208268 \pm 90(0.0\%) \pm 27830(13.4\%)$
Single t	$11369 \pm 46(0.4\%) \pm 1498(13.2\%)$	$7278 \pm 37(0.5\%) \pm 947(13.0\%)$
W + jets	$5000 \pm 154(3.1\%) \pm 877(17.5\%)$	$3030 \pm 102(3.4\%) \pm 494(16.3\%)$
Z/γ + jets	$810 \pm 16(2.0\%) \pm 133(16.4\%)$	$1033 \pm 17(1.7\%) \pm 204(19.7\%)$
VV	$150 \pm 7(4.4\%) \pm 24(16.0\%)$	$116 \pm 6(4.9\%) \pm 17(14.9\%)$
MC QCD	$4607 \pm 962(20.9\%)$	$3795 \pm 2367(62.4\%)$
DD QCD	$31829 \pm 940(3.0\%) \pm 3144(9.9\%)$	$25002 \pm 948(3.8\%) \pm 599(2.4\%)$
All background	$355664 \pm 961(0.3\%) \pm 40917(11.5\%)$	$244727 \pm 959(0.4\%) \pm 27858(11.4\%)$
Data	$356316 \pm 597(0.2\%)$	$244018 \pm 494(0.2\%)$
Data/Bkg	1.0018	0.9971

Yields (2017) [exclusive tight category]

Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$51057 \pm 1006(2.0\%) \pm 13892(27.2\%)$	$34145 \pm 808(2.4\%) \pm 9571(28.0\%)$
$m_{H^-} = 90$ GeV	$54559 \pm 1034(1.9\%) \pm 14994(27.5\%)$	$35215 \pm 813(2.3\%) \pm 9733(27.6\%)$
$m_{H^-} = 100$ GeV	$55004 \pm 1048(1.9\%) \pm 15220(27.7\%)$	$37379 \pm 838(2.2\%) \pm 10384(27.8\%)$
$m_{H^-} = 110$ GeV	$55699 \pm 1038(1.9\%) \pm 15310(27.5\%)$	$38079 \pm 834(2.2\%) \pm 10585(27.8\%)$
$m_{H^-} = 120$ GeV	$52308 \pm 1022(2.0\%) \pm 14443(27.6\%)$	$35210 \pm 809(2.3\%) \pm 9938(28.2\%)$
$m_{H^-} = 130$ GeV	$47885 \pm 963(2.0\%) \pm 13751(28.7\%)$	$32452 \pm 769(2.4\%) \pm 9193(28.3\%)$
$m_{H^-} = 140$ GeV	$36916 \pm 864(2.3\%) \pm 10945(29.6\%)$	$26905 \pm 701(2.6\%) \pm 7675(28.5\%)$
$m_{H^-} = 150$ GeV	$26353 \pm 620(2.4\%) \pm 8033(30.5\%)$	$17219 \pm 491(2.9\%) \pm 5373(31.2\%)$
$m_{H^-} = 155$ GeV	$18628 \pm 628(3.4\%) \pm 5739(30.8\%)$	$13479 \pm 511(3.8\%) \pm 4086(30.3\%)$
$m_{H^-} = 160$ GeV	$13483 \pm 466(3.5\%) \pm 4009(29.7\%)$	$9649 \pm 377(3.9\%) \pm 3033(31.4\%)$
$m_{H^+} = 80$ GeV	$52008 \pm 1010(1.9\%) \pm 14358(27.6\%)$	$34910 \pm 804(2.3\%) \pm 9500(27.2\%)$
$m_{H^+} = 90$ GeV	$51053 \pm 1023(2.0\%) \pm 14227(27.9\%)$	$35349 \pm 820(2.3\%) \pm 9925(28.1\%)$
$m_{H^+} = 100$ GeV	$54584 \pm 1042(1.9\%) \pm 15023(27.5\%)$	$37299 \pm 835(2.2\%) \pm 10536(28.2\%)$
$m_{H^+} = 110$ GeV	$55592 \pm 1057(1.9\%) \pm 15516(27.9\%)$	$38054 \pm 840(2.2\%) \pm 10797(28.4\%)$
$m_{H^+} = 120$ GeV	$54046 \pm 1128(2.1\%) \pm 15122(28.0\%)$	$34904 \pm 881(2.5\%) \pm 9877(28.3\%)$
$m_{H^+} = 130$ GeV	$47079 \pm 962(2.0\%) \pm 13258(28.2\%)$	$30709 \pm 764(2.5\%) \pm 8949(29.1\%)$
$m_{H^+} = 140$ GeV	$36645 \pm 863(2.4\%) \pm 10403(28.4\%)$	$24889 \pm 692(2.8\%) \pm 7073(28.4\%)$
$m_{H^+} = 150$ GeV	$24393 \pm 612(2.5\%) \pm 7339(30.1\%)$	$17661 \pm 497(2.8\%) \pm 5275(29.9\%)$
$m_{H^+} = 155$ GeV	$18815 \pm 529(2.8\%) \pm 5733(30.5\%)$	$13621 \pm 434(3.2\%) \pm 4131(30.3\%)$
$m_{H^+} = 160$ GeV	$13909 \pm 465(3.3\%) \pm 4241(30.5\%)$	$9335 \pm 370(4.0\%) \pm 2864(30.7\%)$
SM $t\bar{t}$ + jets	$51202 \pm 42(0.1\%) \pm 12123(23.7\%)$	$34823 \pm 34(0.1\%) \pm 8307(23.9\%)$
Single t	$1434 \pm 16(1.1\%) \pm 352(24.6\%)$	$928 \pm 13(1.4\%) \pm 231(24.9\%)$
W + jets	$378 \pm 38(10.1\%) \pm 107(28.5\%)$	$229 \pm 23(10.1\%) \pm 90(39.5\%)$
Z/γ + jets	$70 \pm 4(5.9\%) \pm 15(21.7\%)$	$67 \pm 4(5.7\%) \pm 18(27.4\%)$
VV	$17 \pm 2(12.2\%) \pm 5(27.2\%)$	$12 \pm 2(14.0\%) \pm 3(24.1\%)$
MC QCD	$415 \pm 189(45.7\%)$	$0 \pm 0(0\%)$
DD QCD	$84 \pm 80(95.9\%) \pm 61(73.3\%)$	$155 \pm 66(42.4\%) \pm 57(37.2\%)$
All background	$53184 \pm 100(0.2\%) \pm 12129(22.8\%)$	$36214 \pm 79(0.2\%) \pm 8311(23.0\%)$
Data	$48428 \pm 220(0.5\%)$	$33195 \pm 182(0.5\%)$
Data/Bkg	0.9106	0.9166

Systematic uncertianties (2018) [KinFit Level]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$m_{H^-} = 80$ GeV	0.56(0.79)	0.27(1.35)	0.00(0.00)	0.15(0.14)	5.10(5.18)	0.09(0.02)	5.36(5.45)	0.13(0.37)	6.10(6.10)	0.81(0.99)
$m_{H^-} = 90$ GeV	0.36(0.39)	0.27(1.35)	0.00(0.00)	0.20(0.18)	5.00(4.97)	0.09(0.01)	5.30(5.20)	0.43(0.21)	6.10(6.10)	0.78(0.97)
$m_{H^-} = 100$ GeV	0.32(0.51)	0.27(1.34)	0.00(0.00)	0.13(0.20)	4.85(4.86)	0.09(0.01)	5.29(5.28)	0.23(0.48)	6.10(6.10)	0.78(0.96)
$m_{H^-} = 110$ GeV	0.58(0.45)	0.27(1.33)	0.00(0.00)	0.19(0.23)	4.70(4.71)	0.09(0.01)	5.56(4.76)	0.39(0.60)	6.10(6.10)	0.79(0.96)
$m_{H^-} = 120$ GeV	0.34(0.53)	0.27(1.36)	0.00(0.00)	0.21(0.27)	4.64(4.55)	0.09(0.01)	5.17(5.67)	0.36(0.46)	6.10(6.10)	0.81(0.98)
$m_{H^-} = 130$ GeV	0.20(0.12)	0.27(1.33)	0.00(0.00)	0.37(0.31)	4.47(4.54)	0.09(0.01)	5.77(5.65)	0.36(0.42)	6.10(6.10)	0.85(1.04)
$m_{H^-} = 140$ GeV	0.54(0.38)	0.27(1.34)	0.00(0.00)	0.45(0.33)	4.55(4.55)	0.09(0.01)	5.84(5.88)	0.35(0.26)	6.10(6.10)	0.93(1.16)
$m_{H^-} = 150$ GeV	0.08(0.05)	0.28(1.37)	0.00(0.00)	0.60(0.73)	4.83(4.74)	0.09(0.01)	7.68(6.96)	0.72(0.29)	6.10(6.10)	1.14(1.37)
$m_{H^-} = 155$ GeV	0.30(0.24)	0.27(1.40)	0.00(0.00)	0.76(0.78)	4.95(4.84)	0.09(0.01)	7.34(7.30)	0.47(0.36)	6.10(6.10)	1.08(1.31)
$m_{H^-} = 160$ GeV	0.08(0.09)	0.28(1.39)	0.00(0.00)	1.11(0.96)	4.83(4.99)	0.09(0.01)	7.24(7.04)	0.39(0.38)	6.10(6.10)	1.20(1.47)
$m_{H^+} = 80$ GeV	0.49(0.54)	0.27(1.34)	0.00(0.00)	0.16(0.19)	4.97(5.06)	0.09(0.02)	5.39(5.87)	0.08(0.23)	6.10(6.10)	0.80(0.98)
$m_{H^+} = 90$ GeV	0.22(0.37)	0.27(1.36)	0.00(0.00)	0.15(0.20)	4.94(5.09)	0.09(0.02)	5.70(5.47)	0.13(0.33)	6.10(6.10)	0.79(0.96)
$m_{H^+} = 100$ GeV	0.22(0.43)	0.27(1.37)	0.00(0.00)	0.11(0.28)	4.82(4.96)	0.09(0.01)	5.16(4.68)	0.23(0.11)	6.10(6.10)	0.78(0.97)
$m_{H^+} = 110$ GeV	0.18(0.45)	0.27(1.34)	0.00(0.00)	0.19(0.15)	4.65(4.80)	0.09(0.01)	5.25(5.48)	0.42(0.41)	6.10(6.10)	0.83(1.03)
$m_{H^+} = 120$ GeV	0.51(0.58)	0.27(1.34)	0.00(0.00)	0.24(0.22)	4.52(4.64)	0.09(0.01)	5.32(5.40)	0.62(0.37)	6.10(6.10)	0.82(1.02)
$m_{H^+} = 130$ GeV	0.46(0.21)	0.27(1.36)	0.00(0.00)	0.28(0.24)	4.51(4.58)	0.09(0.01)	5.66(5.85)	0.25(0.39)	6.10(6.10)	0.85(1.05)
$m_{H^+} = 140$ GeV	0.12(0.25)	0.27(1.36)	0.00(0.00)	0.38(0.33)	4.56(4.53)	0.09(0.01)	6.58(6.14)	0.40(0.26)	6.10(6.10)	0.95(1.14)
$m_{H^+} = 150$ GeV	0.19(0.05)	0.27(1.38)	0.00(0.00)	0.67(0.60)	4.63(4.82)	0.09(0.01)	7.47(7.24)	0.16(0.30)	6.10(6.10)	0.98(1.20)
$m_{H^+} = 155$ GeV	0.17(0.47)	0.27(1.36)	0.00(0.00)	0.68(1.00)	4.97(4.78)	0.09(0.01)	7.34(6.84)	0.14(0.51)	6.10(6.10)	1.10(1.31)
$m_{H^+} = 160$ GeV	0.29(0.20)	0.28(1.40)	0.00(0.00)	1.05(0.94)	4.93(5.09)	0.09(0.01)	7.45(7.39)	0.24(0.52)	6.10(6.10)	1.20(1.46)
SM $t\bar{t}$ + jets	0.25(0.37)	0.27(1.35)	0.00(0.00)	0.19(0.19)	5.48(5.54)	0.09(0.02)	4.78(4.77)	0.15(0.17)	6.10(6.10)	0.02(0.03)
Single t	0.14(0.29)	0.27(1.36)	0.00(0.00)	0.72(0.72)	5.27(5.31)	0.09(0.01)	7.49(7.26)	0.11(0.04)	5.00(5.00)	0.23(0.30)
W + jets	1.32(0.92)	0.31(1.32)	0.00(0.00)	4.99(4.67)	4.34(4.49)	0.09(0.01)	15.12(11.99)	1.05(1.50)	5.00(5.00)	1.94(2.32)
Z/γ + jets	0.52(1.13)	0.32(1.33)	0.00(0.00)	5.24(6.19)	4.20(3.90)	0.11(0.01)	14.47(15.68)	1.37(1.38)	4.50(4.50)	1.42(1.35)
VV	1.27(0.37)	0.30(1.30)	0.00(0.00)	3.61(3.36)	4.27(4.27)	0.08(0.01)	13.93(10.84)	1.50(0.47)	4.00(4.00)	2.83(3.32)
DD QCD	–	–	–	–	–	–	–	–	10.97(21.84)	2.98(3.09)

Systematic uncertianties (2018) [exclusive loose category]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$m_{H^-} = 80$ GeV	0.72(1.47)	0.27(1.33)	0.61(0.80)	0.62(0.61)	6.81(6.96)	0.09(0.02)	6.14(7.23)	1.07(1.30)	6.10(6.10)	1.34(1.61)
$m_{H^-} = 90$ GeV	0.60(0.22)	0.27(1.33)	0.85(0.86)	0.70(0.72)	6.55(6.75)	0.09(0.01)	5.82(6.49)	1.57(1.32)	6.10(6.10)	1.29(1.59)
$m_{H^-} = 100$ GeV	0.48(0.91)	0.27(1.35)	0.72(1.00)	0.84(0.62)	6.65(6.33)	0.09(0.01)	5.63(6.38)	0.92(0.85)	6.10(6.10)	1.30(1.59)
$m_{H^-} = 110$ GeV	0.84(0.72)	0.27(1.32)	0.75(1.11)	0.69(0.97)	6.31(6.60)	0.09(0.01)	6.67(6.31)	1.15(1.16)	6.10(6.10)	1.30(1.61)
$m_{H^-} = 120$ GeV	0.30(0.48)	0.27(1.37)	0.98(0.93)	0.78(0.85)	6.26(6.50)	0.09(0.01)	5.66(6.50)	1.43(1.69)	6.10(6.10)	1.35(1.64)
$m_{H^-} = 130$ GeV	0.53(0.16)	0.27(1.32)	0.80(0.94)	0.74(0.98)	6.54(6.47)	0.09(0.01)	6.42(6.96)	1.11(1.33)	6.10(6.10)	1.44(1.75)
$m_{H^-} = 140$ GeV	1.02(0.75)	0.27(1.33)	0.97(0.91)	1.17(1.13)	6.35(6.64)	0.09(0.01)	7.03(6.18)	1.65(0.49)	6.10(6.10)	1.52(1.93)
$m_{H^-} = 150$ GeV	0.04(0.18)	0.28(1.36)	1.10(0.98)	1.11(1.55)	7.22(6.98)	0.09(0.01)	9.04(8.57)	2.22(2.33)	6.10(6.10)	1.83(2.20)
$m_{H^-} = 155$ GeV	0.54(0.96)	0.27(1.40)	0.90(1.14)	1.34(1.03)	7.09(7.46)	0.09(0.01)	7.70(10.21)	1.70(2.45)	6.10(6.10)	1.68(2.09)
$m_{H^-} = 160$ GeV	0.40(0.17)	0.27(1.37)	1.36(1.00)	1.91(1.11)	7.48(7.13)	0.09(0.01)	6.60(9.51)	1.06(1.90)	6.10(6.10)	1.89(2.37)
$m_{H^+} = 80$ GeV	0.21(0.59)	0.27(1.35)	0.68(0.59)	0.75(0.62)	6.69(6.59)	0.09(0.01)	6.53(6.40)	1.69(1.53)	6.10(6.10)	1.31(1.61)
$m_{H^+} = 90$ GeV	0.29(0.93)	0.27(1.37)	0.58(0.75)	0.63(0.59)	6.59(6.81)	0.09(0.01)	5.89(5.52)	1.06(1.03)	6.10(6.10)	1.31(1.58)
$m_{H^+} = 100$ GeV	0.46(0.71)	0.27(1.39)	0.98(0.90)	0.77(0.64)	6.45(6.39)	0.09(0.01)	6.92(6.14)	1.27(1.25)	6.10(6.10)	1.32(1.59)
$m_{H^+} = 110$ GeV	0.67(0.60)	0.28(1.35)	0.84(0.94)	0.63(0.60)	6.24(6.37)	0.09(0.01)	6.48(6.75)	0.73(1.65)	6.10(6.10)	1.41(1.72)
$m_{H^+} = 120$ GeV	0.55(0.97)	0.27(1.31)	0.80(1.05)	0.74(0.78)	6.42(6.44)	0.09(0.01)	6.09(7.84)	0.80(1.55)	6.10(6.10)	1.38(1.69)
$m_{H^+} = 130$ GeV	0.65(0.28)	0.27(1.37)	0.97(0.74)	0.98(0.70)	6.62(6.24)	0.09(0.01)	7.58(6.32)	1.55(1.47)	6.10(6.10)	1.42(1.70)
$m_{H^+} = 140$ GeV	0.04(0.35)	0.27(1.33)	1.00(0.81)	0.89(0.90)	6.58(6.41)	0.09(0.01)	8.05(8.31)	1.38(1.80)	6.10(6.10)	1.55(1.94)
$m_{H^+} = 150$ GeV	0.56(0.56)	0.27(1.38)	1.10(0.95)	1.71(1.00)	7.22(7.06)	0.09(0.01)	8.30(10.40)	1.79(1.42)	6.10(6.10)	1.60(1.99)
$m_{H^+} = 155$ GeV	0.80(0.67)	0.27(1.32)	1.06(0.91)	1.01(1.51)	7.19(6.85)	0.09(0.01)	8.73(7.00)	1.53(1.43)	6.10(6.10)	1.74(2.05)
$m_{H^+} = 160$ GeV	0.16(0.28)	0.28(1.36)	0.94(1.12)	1.24(1.65)	7.26(7.50)	0.09(0.01)	9.88(9.72)	1.95(1.87)	6.10(6.10)	1.89(2.37)
SM $t\bar{t}$ + jets	0.54(0.66)	0.27(1.35)	0.48(0.48)	1.13(1.13)	6.53(6.58)	0.09(0.01)	4.91(4.87)	0.57(0.57)	6.10(6.10)	0.03(0.04)
Single t	0.42(0.58)	0.27(1.35)	0.39(0.42)	1.19(1.25)	6.34(6.39)	0.09(0.01)	7.72(7.74)	0.51(0.41)	5.00(5.00)	0.31(0.41)
W + jets	0.80(0.24)	0.32(1.32)	0.32(0.49)	6.32(5.58)	5.09(5.61)	0.09(0.01)	14.95(10.94)	0.94(1.79)	5.00(5.00)	2.62(3.20)
Z/γ + jets	0.33(0.40)	0.31(1.34)	0.53(0.37)	7.57(8.18)	5.49(4.80)	0.11(0.01)	14.82(14.66)	1.68(0.56)	4.50(4.50)	1.89(1.86)
VV	0.50(0.06)	0.31(1.29)	0.47(0.08)	4.08(3.63)	5.26(4.82)	0.08(0.01)	14.92(9.28)	0.63(2.79)	4.00(4.00)	3.85(4.50)
DD QCD	–	–	–	–	–	–	–	–	3.11(24.48)	17.80(8.70)

Systematic uncertianties (2018) [exclusive medium category]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$m_{H^-} = 80$ GeV	0.09(0.23)	0.27(1.37)	1.63(1.73)	4.05(4.26)	8.26(8.48)	0.09(0.02)	8.03(8.03)	1.95(3.03)	6.10(6.10)	1.40(1.71)
$m_{H^-} = 90$ GeV	0.46(0.21)	0.28(1.37)	1.63(1.48)	4.09(4.10)	8.28(7.82)	0.09(0.01)	7.07(9.26)	2.31(2.29)	6.10(6.10)	1.34(1.69)
$m_{H^-} = 100$ GeV	0.31(0.54)	0.27(1.32)	1.56(1.72)	4.05(4.16)	7.89(8.23)	0.09(0.01)	7.49(7.92)	1.95(1.95)	6.10(6.10)	1.36(1.63)
$m_{H^-} = 110$ GeV	0.13(0.24)	0.27(1.32)	1.80(1.62)	4.22(4.17)	8.26(7.72)	0.09(0.01)	9.57(7.00)	3.09(2.08)	6.10(6.10)	1.37(1.63)
$m_{H^-} = 120$ GeV	0.31(0.12)	0.27(1.35)	1.70(1.57)	4.07(4.00)	7.96(7.62)	0.09(0.02)	8.33(7.48)	2.50(1.87)	6.10(6.10)	1.42(1.70)
$m_{H^-} = 130$ GeV	0.49(0.77)	0.27(1.33)	1.79(1.62)	4.41(4.38)	7.74(7.59)	0.09(0.01)	7.58(8.46)	2.21(2.30)	6.10(6.10)	1.43(1.75)
$m_{H^-} = 140$ GeV	0.63(0.14)	0.27(1.32)	1.71(1.68)	4.60(4.22)	7.87(7.72)	0.09(0.01)	9.49(9.87)	1.37(2.64)	6.10(6.10)	1.64(2.00)
$m_{H^-} = 150$ GeV	0.22(0.78)	0.28(1.37)	1.49(1.63)	4.63(4.85)	7.52(7.90)	0.09(0.01)	10.91(9.26)	2.63(2.73)	6.10(6.10)	1.99(2.33)
$m_{H^-} = 155$ GeV	0.51(0.98)	0.26(1.40)	1.72(1.71)	4.97(4.87)	8.24(8.03)	0.09(0.01)	9.97(8.68)	3.11(1.80)	6.10(6.10)	1.88(2.23)
$m_{H^-} = 160$ GeV	0.74(0.79)	0.28(1.41)	1.76(1.74)	5.42(5.30)	8.27(8.48)	0.09(0.01)	8.60(7.94)	1.58(1.97)	6.10(6.10)	2.01(2.46)
$m_{H^+} = 80$ GeV	0.16(0.33)	0.27(1.31)	1.50(1.62)	4.06(4.14)	7.87(8.20)	0.09(0.01)	6.63(7.94)	1.45(2.01)	6.10(6.10)	1.38(1.68)
$m_{H^+} = 90$ GeV	0.52(0.37)	0.27(1.35)	1.75(1.69)	4.22(4.21)	8.27(8.32)	0.09(0.01)	9.13(7.52)	2.41(2.84)	6.10(6.10)	1.35(1.66)
$m_{H^+} = 100$ GeV	0.51(0.12)	0.27(1.35)	1.75(1.54)	4.10(4.10)	8.29(7.98)	0.09(0.01)	7.64(6.09)	2.61(1.49)	6.10(6.10)	1.35(1.67)
$m_{H^+} = 110$ GeV	0.54(0.50)	0.27(1.32)	1.71(1.48)	4.14(3.84)	8.08(7.53)	0.09(0.02)	7.77(7.91)	2.43(1.80)	6.10(6.10)	1.42(1.77)
$m_{H^+} = 120$ GeV	0.62(0.08)	0.27(1.33)	1.80(1.79)	4.23(4.11)	7.98(8.06)	0.09(0.02)	9.35(7.84)	3.15(2.68)	6.10(6.10)	1.43(1.81)
$m_{H^+} = 130$ GeV	0.21(0.28)	0.27(1.29)	1.70(1.65)	4.26(4.23)	7.90(7.85)	0.09(0.01)	8.46(11.78)	3.46(3.11)	6.10(6.10)	1.48(1.86)
$m_{H^+} = 140$ GeV	0.88(0.59)	0.27(1.38)	1.87(1.68)	4.61(4.23)	8.26(7.83)	0.09(0.01)	9.35(7.36)	2.55(1.67)	6.10(6.10)	1.63(1.92)
$m_{H^+} = 150$ GeV	1.07(1.44)	0.27(1.41)	1.67(1.64)	4.59(4.80)	7.86(7.90)	0.09(0.01)	10.35(8.96)	2.06(2.31)	6.10(6.10)	1.67(2.05)
$m_{H^+} = 155$ GeV	0.93(0.73)	0.28(1.38)	1.60(1.72)	4.68(5.43)	7.98(8.03)	0.09(0.01)	9.37(11.09)	2.39(2.44)	6.10(6.10)	1.90(2.30)
$m_{H^+} = 160$ GeV	0.89(0.80)	0.28(1.44)	1.59(1.55)	5.26(5.28)	8.00(8.04)	0.09(0.01)	9.94(7.84)	1.69(3.04)	6.10(6.10)	2.01(2.43)
SM $t\bar{t}$ + jets	0.39(0.26)	0.27(1.35)	0.97(0.97)	4.39(4.38)	7.35(7.41)	0.09(0.02)	6.63(6.59)	1.24(1.25)	6.10(6.10)	0.04(0.04)
Single t	0.46(0.32)	0.27(1.35)	0.90(0.89)	5.16(5.12)	6.95(6.98)	0.09(0.01)	9.81(8.91)	0.84(1.21)	5.00(5.00)	0.39(0.51)
W + jets	2.59(2.07)	0.30(1.34)	0.71(0.54)	9.20(8.96)	5.55(5.33)	0.09(0.01)	15.67(15.14)	2.16(1.06)	5.00(5.00)	3.45(3.94)
Z/γ + jets	0.78(2.69)	0.32(1.32)	0.71(0.61)	10.21(11.04)	5.46(5.00)	0.11(0.01)	17.70(18.12)	2.10(1.51)	4.50(4.50)	2.57(2.29)
VV	3.34(1.16)	0.28(1.29)	0.93(0.59)	8.11(7.49)	6.20(5.22)	0.08(0.01)	16.40(14.30)	0.38(3.87)	4.00(4.00)	4.99(5.71)
DD QCD	–	–	–	–	–	–	–	–	0.32(3.15)	2.43(3.33)

Systematic uncertianties (2018) [exclusive tight category]

Process	Pileup	Lepton	b & c tagging 1	b & c tagging 2	b & c tagging 3	Prefire	JEC	JER	Norm	Statistical
$m_{H^-} = 80$ GeV	0.91(0.95)	0.27(1.36)	6.76(6.52)	7.88(7.67)	18.58(18.21)	0.09(0.02)	11.41(9.25)	7.10(6.68)	6.10(6.10)	1.57(1.94)
$m_{H^-} = 90$ GeV	1.06(1.26)	0.28(1.35)	6.78(6.67)	7.89(7.86)	18.63(18.26)	0.09(0.02)	11.53(9.40)	7.36(6.78)	6.10(6.10)	1.53(1.85)
$m_{H^-} = 100$ GeV	0.70(0.89)	0.27(1.34)	6.69(6.73)	7.78(8.07)	18.27(18.57)	0.09(0.02)	11.08(11.53)	6.88(7.08)	6.10(6.10)	1.50(1.85)
$m_{H^-} = 110$ GeV	1.01(1.05)	0.28(1.35)	6.73(6.73)	7.90(8.06)	18.24(18.30)	0.09(0.02)	10.48(11.00)	7.46(6.97)	6.10(6.10)	1.53(1.82)
$m_{H^-} = 120$ GeV	0.87(0.87)	0.27(1.36)	6.92(6.83)	8.14(8.16)	18.65(18.38)	0.09(0.01)	10.55(11.85)	7.01(7.55)	6.10(6.10)	1.51(1.83)
$m_{H^-} = 130$ GeV	0.58(1.08)	0.28(1.34)	6.95(7.00)	8.30(8.23)	18.66(18.81)	0.09(0.02)	11.16(11.67)	7.05(7.49)	6.10(6.10)	1.61(2.05)
$m_{H^-} = 140$ GeV	1.01(0.23)	0.27(1.37)	6.92(7.22)	8.38(8.60)	18.67(19.28)	0.09(0.01)	10.62(12.63)	7.53(9.06)	6.10(6.10)	1.78(2.23)
$m_{H^-} = 150$ GeV	0.18(1.03)	0.28(1.38)	6.92(7.05)	8.85(8.79)	18.63(18.96)	0.09(0.02)	13.66(13.17)	7.29(7.15)	6.10(6.10)	2.28(2.82)
$m_{H^-} = 155$ GeV	1.13(0.65)	0.28(1.42)	7.08(7.37)	9.30(9.50)	19.14(19.48)	0.09(0.01)	15.35(14.46)	7.96(8.25)	6.10(6.10)	2.30(2.70)
$m_{H^-} = 160$ GeV	1.01(0.55)	0.28(1.40)	6.72(6.96)	9.74(9.74)	18.27(18.99)	0.09(0.01)	15.98(15.14)	8.51(7.85)	6.10(6.10)	2.58(3.11)
$m_{H^+} = 80$ GeV	1.20(1.53)	0.27(1.36)	6.43(6.76)	7.62(7.93)	17.79(18.59)	0.09(0.02)	11.83(9.67)	6.48(6.59)	6.10(6.10)	1.55(1.90)
$m_{H^+} = 90$ GeV	1.00(0.56)	0.27(1.34)	6.68(6.76)	7.80(7.94)	18.32(18.85)	0.09(0.02)	10.39(10.07)	7.23(7.42)	6.10(6.10)	1.57(1.84)
$m_{H^+} = 100$ GeV	0.81(0.56)	0.27(1.34)	6.69(6.94)	7.78(8.17)	18.20(18.96)	0.09(0.02)	10.64(11.61)	6.96(7.56)	6.10(6.10)	1.49(1.90)
$m_{H^+} = 110$ GeV	0.24(1.20)	0.27(1.37)	6.79(6.80)	8.01(7.95)	18.41(18.69)	0.09(0.01)	10.89(11.32)	6.86(7.54)	6.10(6.10)	1.60(1.96)
$m_{H^+} = 120$ GeV	1.86(0.72)	0.27(1.37)	6.75(6.92)	8.04(8.23)	18.14(18.58)	0.09(0.01)	10.25(10.46)	7.02(7.44)	6.10(6.10)	1.57(1.88)
$m_{H^+} = 130$ GeV	0.51(0.84)	0.27(1.44)	6.88(7.03)	8.24(8.36)	18.25(18.65)	0.09(0.01)	11.41(9.83)	6.94(7.34)	6.10(6.10)	1.62(2.02)
$m_{H^+} = 140$ GeV	0.71(0.93)	0.26(1.35)	6.93(7.07)	8.41(8.52)	18.62(18.88)	0.09(0.01)	12.66(12.00)	7.51(8.31)	6.10(6.10)	1.85(2.19)
$m_{H^+} = 150$ GeV	1.31(0.58)	0.27(1.35)	7.06(7.18)	9.09(8.97)	18.66(19.38)	0.09(0.01)	13.66(12.60)	8.11(6.62)	6.10(6.10)	1.95(2.33)
$m_{H^+} = 155$ GeV	0.45(1.15)	0.27(1.38)	7.03(7.04)	9.06(9.33)	19.10(19.00)	0.09(0.01)	14.25(13.08)	6.47(7.97)	6.10(6.10)	2.27(2.66)
$m_{H^+} = 160$ GeV	0.36(0.95)	0.28(1.39)	6.83(6.95)	9.73(9.47)	18.54(19.05)	0.09(0.01)	12.81(11.49)	7.92(7.21)	6.10(6.10)	2.59(3.07)
SM $t\bar{t}$ + jets	0.62(0.76)	0.27(1.35)	5.19(5.23)	7.69(7.74)	15.39(15.53)	0.09(0.02)	9.10(9.08)	5.60(5.63)	6.10(6.10)	0.05(0.06)
Single t	0.59(0.51)	0.27(1.38)	4.76(4.88)	8.30(8.31)	13.95(14.29)	0.09(0.02)	10.88(11.08)	5.04(5.19)	5.00(5.00)	0.68(0.86)
W + jets	0.99(1.96)	0.29(1.29)	4.14(4.45)	11.75(12.36)	12.67(12.70)	0.08(0.01)	25.33(15.16)	4.70(4.90)	5.00(5.00)	5.77(7.55)
Z/γ + jets	0.65(0.24)	0.32(1.27)	2.61(2.57)	11.71(12.97)	8.62(8.71)	0.10(0.01)	13.07(16.34)	3.08(1.36)	4.50(4.50)	4.24(4.15)
VV	1.97(0.31)	0.32(1.31)	4.62(4.00)	10.86(11.47)	11.97(10.90)	0.09(0.01)	18.02(11.02)	4.86(5.17)	4.00(4.00)	8.41(10.49)
DD QCD	–	–	–	–	–	–	–	–	52.18(37.71)	9.98(11.08)

Yields (2018) [KinFit Level]

Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$572703 \pm 4654(0.8\%) \pm 55034(9.6\%)$	$368955 \pm 3644(1.0\%) \pm 36209(9.8\%)$
$m_{H^-} = 90$ GeV	$584656 \pm 4580(0.8\%) \pm 55671(9.5\%)$	$370657 \pm 3583(1.0\%) \pm 35354(9.5\%)$
$m_{H^-} = 100$ GeV	$585756 \pm 4597(0.8\%) \pm 55225(9.4\%)$	$376255 \pm 3595(1.0\%) \pm 35901(9.5\%)$
$m_{H^-} = 110$ GeV	$575838 \pm 4548(0.8\%) \pm 54893(9.5\%)$	$372276 \pm 3557(1.0\%) \pm 34206(9.2\%)$
$m_{H^-} = 120$ GeV	$550547 \pm 4452(0.8\%) \pm 51016(9.3\%)$	$354891 \pm 3483(1.0\%) \pm 34122(9.6\%)$
$m_{H^-} = 130$ GeV	$504399 \pm 4265(0.8\%) \pm 48090(9.5\%)$	$321695 \pm 3350(1.0\%) \pm 30818(9.6\%)$
$m_{H^-} = 140$ GeV	$415461 \pm 3872(0.9\%) \pm 40014(9.6\%)$	$262442 \pm 3043(1.2\%) \pm 25538(9.7\%)$
$m_{H^-} = 150$ GeV	$296298 \pm 3388(1.1\%) \pm 32512(11.0\%)$	$194970 \pm 2671(1.4\%) \pm 20511(10.5\%)$
$m_{H^-} = 155$ GeV	$239649 \pm 2595(1.1\%) \pm 25868(10.8\%)$	$157346 \pm 2054(1.3\%) \pm 17000(10.8\%)$
$m_{H^-} = 160$ GeV	$199784 \pm 2390(1.2\%) \pm 21364(10.7\%)$	$127746 \pm 1876(1.5\%) \pm 13680(10.7\%)$
$m_{H^+} = 80$ GeV	$570987 \pm 4556(0.8\%) \pm 54540(9.6\%)$	$365053 \pm 3568(1.0\%) \pm 36418(10.0\%)$
$m_{H^+} = 90$ GeV	$575714 \pm 4573(0.8\%) \pm 55914(9.7\%)$	$373582 \pm 3574(1.0\%) \pm 36453(9.8\%)$
$m_{H^+} = 100$ GeV	$585210 \pm 4587(0.8\%) \pm 54697(9.3\%)$	$368046 \pm 3570(1.0\%) \pm 34103(9.3\%)$
$m_{H^+} = 110$ GeV	$580692 \pm 4837(0.8\%) \pm 54091(9.3\%)$	$366217 \pm 3771(1.0\%) \pm 35215(9.6\%)$
$m_{H^+} = 120$ GeV	$550701 \pm 4536(0.8\%) \pm 51261(9.3\%)$	$349853 \pm 3552(1.0\%) \pm 33228(9.5\%)$
$m_{H^+} = 130$ GeV	$498116 \pm 4233(0.8\%) \pm 47257(9.5\%)$	$313548 \pm 3300(1.1\%) \pm 30481(9.7\%)$
$m_{H^+} = 140$ GeV	$407594 \pm 3852(0.9\%) \pm 41104(10.1\%)$	$266582 \pm 3034(1.1\%) \pm 26315(9.9\%)$
$m_{H^+} = 150$ GeV	$297272 \pm 2906(1.0\%) \pm 31874(10.7\%)$	$190209 \pm 2283(1.2\%) \pm 20420(10.7\%)$
$m_{H^+} = 155$ GeV	$235627 \pm 2584(1.1\%) \pm 25425(10.8\%)$	$156378 \pm 2046(1.3\%) \pm 16412(10.5\%)$
$m_{H^+} = 160$ GeV	$197790 \pm 2364(1.2\%) \pm 21520(10.9\%)$	$126767 \pm 1853(1.5\%) \pm 13936(11.0\%)$
SM $t\bar{t}$ + jets	$944748 \pm 199(0.0\%) \pm 89779(9.5\%)$	$606817 \pm 156(0.0\%) \pm 58398(9.6\%)$
Single t	$35400 \pm 81(0.2\%) \pm 3703(10.5\%)$	$21418 \pm 64(0.3\%) \pm 2229(10.4\%)$
W + jets	$15342 \pm 298(1.9\%) \pm 2659(17.3\%)$	$9443 \pm 219(2.3\%) \pm 1387(14.7\%)$
Z/γ + jets	$2614 \pm 37(1.4\%) \pm 435(16.6\%)$	$2816 \pm 38(1.3\%) \pm 507(18.0\%)$
VV	$504 \pm 14(2.8\%) \pm 79(15.7\%)$	$337 \pm 11(3.3\%) \pm 43(12.8\%)$
MC QCD	$20364 \pm 3091(15.2\%)$	$20771 \pm 20494(98.7\%)$
DD QCD	$33223 \pm 990(3.0\%) \pm 3646(11.0\%)$	$21631 \pm 668(3.1\%) \pm 4724(21.8\%)$
All background	$1031832 \pm 1057(0.1\%) \pm 89970(8.7\%)$	$662462 \pm 724(0.1\%) \pm 58650(8.9\%)$
Data	$1010457 \pm 1005(0.1\%)$	$649207 \pm 806(0.1\%)$
Data/Bkg	0.9793	0.9800

Yields (2018) [exclusive loose category]

Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$218123 \pm 2924(1.3\%) \pm 24263(11.1\%)$	$141057 \pm 2278(1.6\%) \pm 16954(12.0\%)$
$m_{H^-} = 90$ GeV	$221399 \pm 2856(1.3\%) \pm 24056(10.9\%)$	$140674 \pm 2237(1.6\%) \pm 16024(11.4\%)$
$m_{H^-} = 100$ GeV	$219836 \pm 2857(1.3\%) \pm 23639(10.8\%)$	$140673 \pm 2232(1.6\%) \pm 15583(11.1\%)$
$m_{H^-} = 110$ GeV	$216822 \pm 2814(1.3\%) \pm 24213(11.2\%)$	$137036 \pm 2207(1.6\%) \pm 15403(11.2\%)$
$m_{H^-} = 120$ GeV	$203511 \pm 2743(1.3\%) \pm 21553(10.6\%)$	$131095 \pm 2152(1.6\%) \pm 14848(11.3\%)$
$m_{H^-} = 130$ GeV	$182378 \pm 2628(1.4\%) \pm 20308(11.1\%)$	$117288 \pm 2047(1.7\%) \pm 13525(11.5\%)$
$m_{H^-} = 140$ GeV	$157444 \pm 2394(1.5\%) \pm 18158(11.5\%)$	$97284 \pm 1875(1.9\%) \pm 10845(11.1\%)$
$m_{H^-} = 150$ GeV	$115840 \pm 2123(1.8\%) \pm 15481(13.4\%)$	$76990 \pm 1691(2.2\%) \pm 10039(13.0\%)$
$m_{H^-} = 155$ GeV	$98665 \pm 1655(1.7\%) \pm 12186(12.4\%)$	$62449 \pm 1307(2.1\%) \pm 9013(14.4\%)$
$m_{H^-} = 160$ GeV	$81562 \pm 1543(1.9\%) \pm 9770(12.0\%)$	$51476 \pm 1219(2.4\%) \pm 7024(13.6\%)$
$m_{H^+} = 80$ GeV	$219285 \pm 2867(1.3\%) \pm 24876(11.3\%)$	$138554 \pm 2232(1.6\%) \pm 15602(11.3\%)$
$m_{H^+} = 90$ GeV	$217543 \pm 2853(1.3\%) \pm 23570(10.8\%)$	$140948 \pm 2224(1.6\%) \pm 15365(10.9\%)$
$m_{H^+} = 100$ GeV	$216120 \pm 2851(1.3\%) \pm 24664(11.4\%)$	$139096 \pm 2217(1.6\%) \pm 15301(11.0\%)$
$m_{H^+} = 110$ GeV	$211791 \pm 2977(1.4\%) \pm 23229(11.0\%)$	$135552 \pm 2335(1.7\%) \pm 15426(11.4\%)$
$m_{H^+} = 120$ GeV	$202965 \pm 2797(1.4\%) \pm 22029(10.9\%)$	$130151 \pm 2200(1.7\%) \pm 15777(12.1\%)$
$m_{H^+} = 130$ GeV	$183908 \pm 2612(1.4\%) \pm 22014(12.0\%)$	$119830 \pm 2043(1.7\%) \pm 13195(11.0\%)$
$m_{H^+} = 140$ GeV	$153497 \pm 2375(1.5\%) \pm 18740(12.2\%)$	$96536 \pm 1872(1.9\%) \pm 11976(12.4\%)$
$m_{H^+} = 150$ GeV	$113270 \pm 1816(1.6\%) \pm 14592(12.9\%)$	$72185 \pm 1438(2.0\%) \pm 10243(14.2\%)$
$m_{H^+} = 155$ GeV	$94925 \pm 1647(1.7\%) \pm 12389(13.1\%)$	$63056 \pm 1295(2.1\%) \pm 7472(11.8\%)$
$m_{H^+} = 160$ GeV	$80704 \pm 1522(1.9\%) \pm 11234(13.9\%)$	$50429 \pm 1193(2.4\%) \pm 7083(14.0\%)$
SM $t\bar{t}$ + jets	$446415 \pm 136(0.0\%) \pm 45993(10.3\%)$	$286773 \pm 107(0.0\%) \pm 29850(10.4\%)$
Single t	$17947 \pm 57(0.3\%) \pm 2021(11.3\%)$	$10782 \pm 44(0.4\%) \pm 1228(11.4\%)$
W + jets	$8411 \pm 220(2.6\%) \pm 1495(17.8\%)$	$5164 \pm 165(3.2\%) \pm 753(14.6\%)$
Z/γ + jets	$1427 \pm 27(1.9\%) \pm 259(18.2\%)$	$1436 \pm 27(1.9\%) \pm 260(18.1\%)$
VV	$267 \pm 10(3.9\%) \pm 45(16.8\%)$	$180 \pm 8(4.5\%) \pm 22(12.2\%)$
MC QCD	$10938 \pm 2080(19.0\%)$	$20403 \pm 20129(98.7\%)$
DD QCD	$2915 \pm 519(17.8\%) \pm 91(3.1\%)$	$2874 \pm 250(8.7\%) \pm 704(24.5\%)$
All background	$477381 \pm 583(0.1\%) \pm 46063(9.6\%)$	$307210 \pm 323(0.1\%) \pm 29894(9.7\%)$
Data	$448100 \pm 669(0.1\%)$	$289655 \pm 538(0.2\%)$
Data/Bkg	0.9387	0.9429

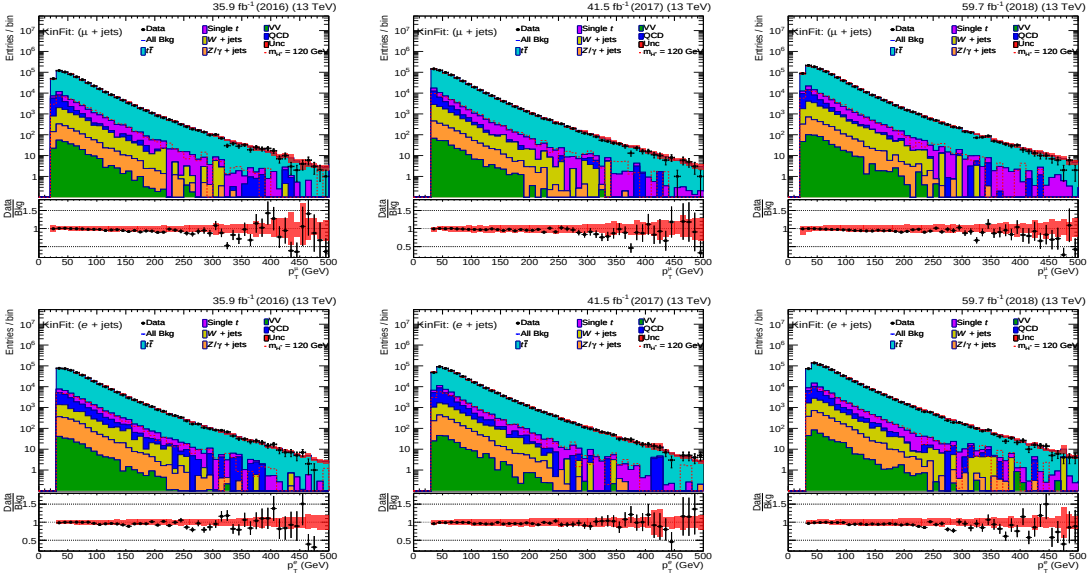
Yields (2018) [exclusive medium category]

Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$201767 \pm 2819(1.4\%) \pm 28018(13.9\%)$	$130210 \pm 2222(1.7\%) \pm 18676(14.3\%)$
$m_{H^-} = 90$ GeV	$207396 \pm 2772(1.3\%) \pm 27885(13.4\%)$	$128887 \pm 2173(1.7\%) \pm 18693(14.5\%)$
$m_{H^-} = 100$ GeV	$204258 \pm 2775(1.4\%) \pm 27277(13.4\%)$	$133892 \pm 2182(1.6\%) \pm 18642(13.9\%)$
$m_{H^-} = 110$ GeV	$200775 \pm 2759(1.4\%) \pm 30292(15.1\%)$	$132774 \pm 2160(1.6\%) \pm 17414(13.1\%)$
$m_{H^-} = 120$ GeV	$189250 \pm 2697(1.4\%) \pm 26497(14.0\%)$	$124144 \pm 2113(1.7\%) \pm 16422(13.2\%)$
$m_{H^-} = 130$ GeV	$181170 \pm 2589(1.4\%) \pm 24461(13.5\%)$	$116190 \pm 2038(1.8\%) \pm 16266(14.0\%)$
$m_{H^-} = 140$ GeV	$144017 \pm 2355(1.6\%) \pm 21150(14.7\%)$	$92809 \pm 1855(2.0\%) \pm 13882(15.0\%)$
$m_{H^-} = 150$ GeV	$104359 \pm 2080(2.0\%) \pm 16286(15.6\%)$	$70358 \pm 1638(2.3\%) \pm 10472(14.9\%)$
$m_{H^-} = 155$ GeV	$84551 \pm 1586(1.9\%) \pm 13155(15.6\%)$	$56771 \pm 1263(2.2\%) \pm 8226(14.5\%)$
$m_{H^-} = 160$ GeV	$73693 \pm 1481(2.0\%) \pm 10811(14.7\%)$	$46879 \pm 1152(2.5\%) \pm 6789(14.5\%)$
$m_{H^+} = 80$ GeV	$200000 \pm 2759(1.4\%) \pm 25616(12.8\%)$	$129062 \pm 2169(1.7\%) \pm 17933(13.9\%)$
$m_{H^+} = 90$ GeV	$205059 \pm 2771(1.4\%) \pm 30134(14.7\%)$	$130292 \pm 2168(1.7\%) \pm 18122(13.9\%)$
$m_{H^+} = 100$ GeV	$206264 \pm 2782(1.3\%) \pm 28527(13.8\%)$	$129967 \pm 2168(1.7\%) \pm 16496(12.7\%)$
$m_{H^+} = 110$ GeV	$208456 \pm 2951(1.4\%) \pm 28668(13.8\%)$	$129894 \pm 2297(1.8\%) \pm 17355(13.4\%)$
$m_{H^+} = 120$ GeV	$192073 \pm 2742(1.4\%) \pm 28478(14.8\%)$	$118499 \pm 2140(1.8\%) \pm 16451(13.9\%)$
$m_{H^+} = 130$ GeV	$173229 \pm 2560(1.5\%) \pm 24761(14.3\%)$	$106771 \pm 1991(1.9\%) \pm 17528(16.4\%)$
$m_{H^+} = 140$ GeV	$143780 \pm 2346(1.6\%) \pm 21566(15.0\%)$	$96151 \pm 1850(1.9\%) \pm 12846(13.4\%)$
$m_{H^+} = 150$ GeV	$106729 \pm 1778(1.7\%) \pm 16378(15.3\%)$	$67871 \pm 1393(2.1\%) \pm 9953(14.7\%)$
$m_{H^+} = 155$ GeV	$83485 \pm 1585(1.9\%) \pm 12377(14.8\%)$	$54886 \pm 1260(2.3\%) \pm 8946(16.3\%)$
$m_{H^+} = 160$ GeV	$72975 \pm 1468(2.0\%) \pm 11162(15.3\%)$	$47146 \pm 1146(2.4\%) \pm 6757(14.3\%)$
SM $t\bar{t}$ + jets	$341581 \pm 123(0.0\%) \pm 42828(12.5\%)$	$219021 \pm 97(0.0\%) \pm 27621(12.6\%)$
Single t	$12807 \pm 50(0.4\%) \pm 1801(14.1\%)$	$7734 \pm 39(0.5\%) \pm 1048(13.6\%)$
W + jets	$5603 \pm 193(3.4\%) \pm 1118(19.9\%)$	$3313 \pm 130(3.9\%) \pm 638(19.2\%)$
Z/γ + jets	$924 \pm 24(2.6\%) \pm 201(21.8\%)$	$1125 \pm 26(2.3\%) \pm 253(22.5\%)$
VV	$173 \pm 9(5.0\%) \pm 35(20.0\%)$	$123 \pm 7(5.7\%) \pm 22(18.0\%)$
MC QCD	$7440 \pm 2188(29.4\%)$	$0 \pm 0(0\%)$
DD QCD	$53517 \pm 1299(2.4\%) \pm 172(0.3\%)$	$25261 \pm 840(3.3\%) \pm 796(3.2\%)$
All background	$414605 \pm 1320(0.3\%) \pm 42881(10.3\%)$	$256576 \pm 857(0.3\%) \pm 27661(10.8\%)$
Data	$404856 \pm 636(0.2\%)$	$258559 \pm 508(0.2\%)$
Data/Bkg	0.9765	1.0077

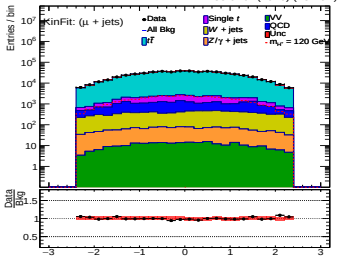
Yields (2018) [exclusive tight category]

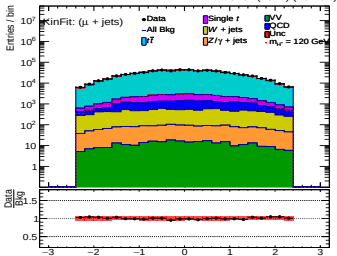
Process	$N_{events} \pm stat \pm sys$ μ + jets	$N_{events} \pm stat \pm sys$ e + jets
$m_{H^-} = 80$ GeV	$129122 \pm 2027(1.6\%) \pm 33471(25.9\%)$	$81822 \pm 1587(1.9\%) \pm 20096(24.6\%)$
$m_{H^-} = 90$ GeV	$131293 \pm 2013(1.5\%) \pm 34255(26.1\%)$	$85114 \pm 1571(1.8\%) \pm 21105(24.8\%)$
$m_{H^-} = 100$ GeV	$136095 \pm 2040(1.5\%) \pm 34613(25.4\%)$	$85215 \pm 1580(1.9\%) \pm 22190(26.0\%)$
$m_{H^-} = 110$ GeV	$131711 \pm 2020(1.5\%) \pm 33428(25.4\%)$	$86048 \pm 1563(1.8\%) \pm 22024(25.6\%)$
$m_{H^-} = 120$ GeV	$131651 \pm 1986(1.5\%) \pm 33836(25.7\%)$	$84061 \pm 1542(1.8\%) \pm 22054(26.2\%)$
$m_{H^-} = 130$ GeV	$116961 \pm 1887(1.6\%) \pm 30434(26.0\%)$	$72629 \pm 1490(2.1\%) \pm 19259(26.5\%)$
$m_{H^-} = 140$ GeV	$95109 \pm 1693(1.8\%) \pm 24701(26.0\%)$	$59600 \pm 1331(2.2\%) \pm 16630(27.9\%)$
$m_{H^-} = 150$ GeV	$63039 \pm 1437(2.3\%) \pm 17269(27.4\%)$	$39583 \pm 1118(2.8\%) \pm 10849(27.4\%)$
$m_{H^-} = 155$ GeV	$46656 \pm 1073(2.3\%) \pm 13526(29.0\%)$	$31222 \pm 844(2.7\%) \pm 9055(29.0\%)$
$m_{H^-} = 160$ GeV	$37148 \pm 957(2.6\%) \pm 10764(29.0\%)$	$24223 \pm 752(3.1\%) \pm 6996(28.9\%)$
$m_{H^+} = 80$ GeV	$128213 \pm 1984(1.5\%) \pm 32349(25.2\%)$	$81583 \pm 1550(1.9\%) \pm 20522(25.2\%)$
$m_{H^+} = 90$ GeV	$127559 \pm 2002(1.6\%) \pm 32254(25.3\%)$	$84637 \pm 1561(1.8\%) \pm 21743(25.7\%)$
$m_{H^+} = 100$ GeV	$134724 \pm 2007(1.5\%) \pm 33983(25.2\%)$	$82023 \pm 1562(1.9\%) \pm 21789(26.6\%)$
$m_{H^+} = 110$ GeV	$133453 \pm 2136(1.6\%) \pm 34083(25.5\%)$	$84626 \pm 1661(2.0\%) \pm 22134(26.2\%)$
$m_{H^+} = 120$ GeV	$128064 \pm 2016(1.6\%) \pm 32255(25.2\%)$	$83692 \pm 1575(1.9\%) \pm 21585(25.8\%)$
$m_{H^+} = 130$ GeV	$115755 \pm 1876(1.6\%) \pm 29840(25.8\%)$	$72007 \pm 1457(2.0\%) \pm 18461(25.6\%)$
$m_{H^+} = 140$ GeV	$90697 \pm 1682(1.9\%) \pm 24332(26.8\%)$	$60589 \pm 1327(2.2\%) \pm 16391(27.1\%)$
$m_{H^+} = 150$ GeV	$63369 \pm 1238(2.0\%) \pm 17604(27.8\%)$	$41181 \pm 959(2.3\%) \pm 11275(27.4\%)$
$m_{H^+} = 155$ GeV	$46863 \pm 1064(2.3\%) \pm 13078(27.9\%)$	$31859 \pm 849(2.7\%) \pm 8855(27.8\%)$
$m_{H^+} = 160$ GeV	$36661 \pm 949(2.6\%) \pm 10036(27.4\%)$	$24135 \pm 741(3.1\%) \pm 6498(26.9\%)$
SM $t\bar{t}$ + jets	$141865 \pm 75(0.1\%) \pm 30909(21.8\%)$	$91047 \pm 59(0.1\%) \pm 19994(22.0\%)$
Single t	$4248 \pm 29(0.7\%) \pm 907(21.3\%)$	$2650 \pm 23(0.9\%) \pm 577(21.8\%)$
W + jets	$1228 \pm 71(5.8\%) \pm 389(31.7\%)$	$876 \pm 66(7.5\%) \pm 218(24.9\%)$
Z/γ + jets	$249 \pm 11(4.2\%) \pm 51(20.5\%)$	$269 \pm 11(4.2\%) \pm 63(23.3\%)$
VV	$55 \pm 5(8.4\%) \pm 14(25.5\%)$	$35 \pm 4(10.5\%) \pm 7(20.8\%)$
MC QCD	$1952 \pm 1144(58.6\%)$	$0 \pm 0(0\%)$
DD QCD	$3185 \pm 318(10.0\%) \pm 1662(52.2\%)$	$2686 \pm 297(11.1\%) \pm 1013(37.7\%)$
All background	$150830 \pm 335(0.2\%) \pm 30970(20.5\%)$	$97562 \pm 311(0.3\%) \pm 20029(20.5\%)$
Data	$150461 \pm 388(0.3\%)$	$96398 \pm 310(0.3\%)$
Data/Bkg	0.9976	0.9881

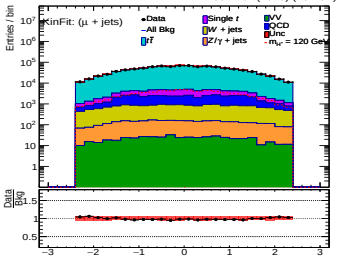
Comparison of data/MC at KinFit [1 lepton + MET + ≥ 4 jets (≥ 2 b-jets)] : p_T^{lep} dist^n

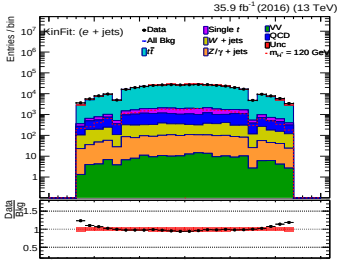


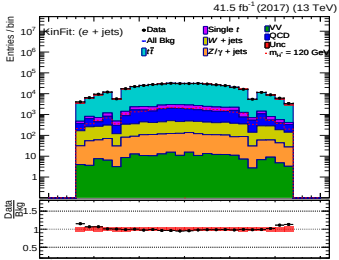
Comparison of data/MC at KinFit [1 lepton + MET + ≥ 4 jets (≥ 2 b-jets)] : η^{lep} dist^n

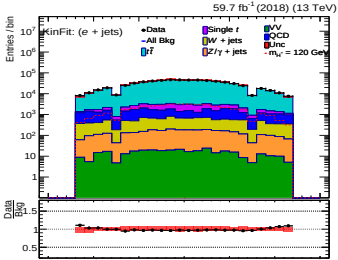




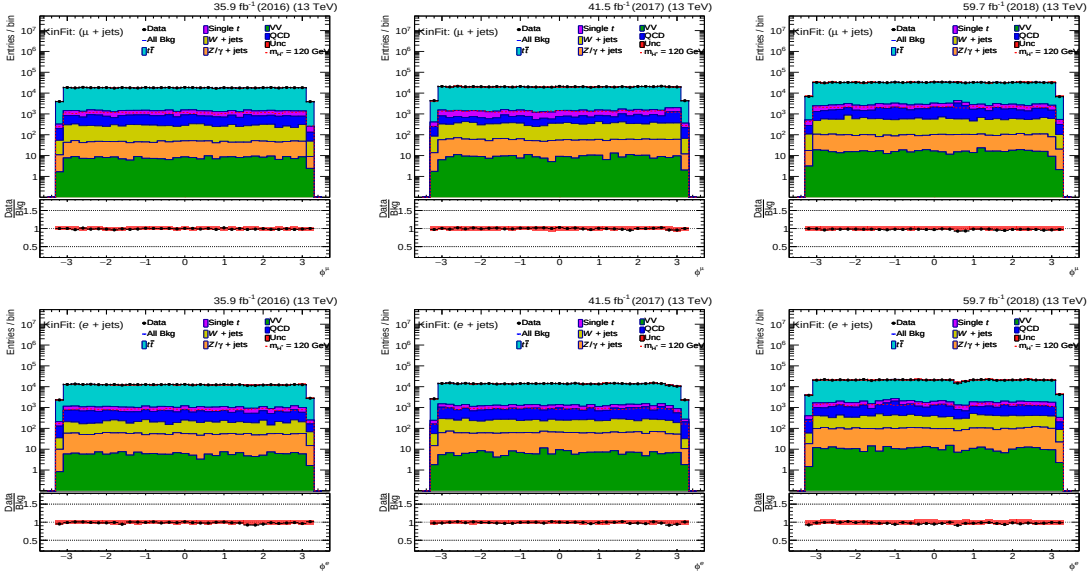




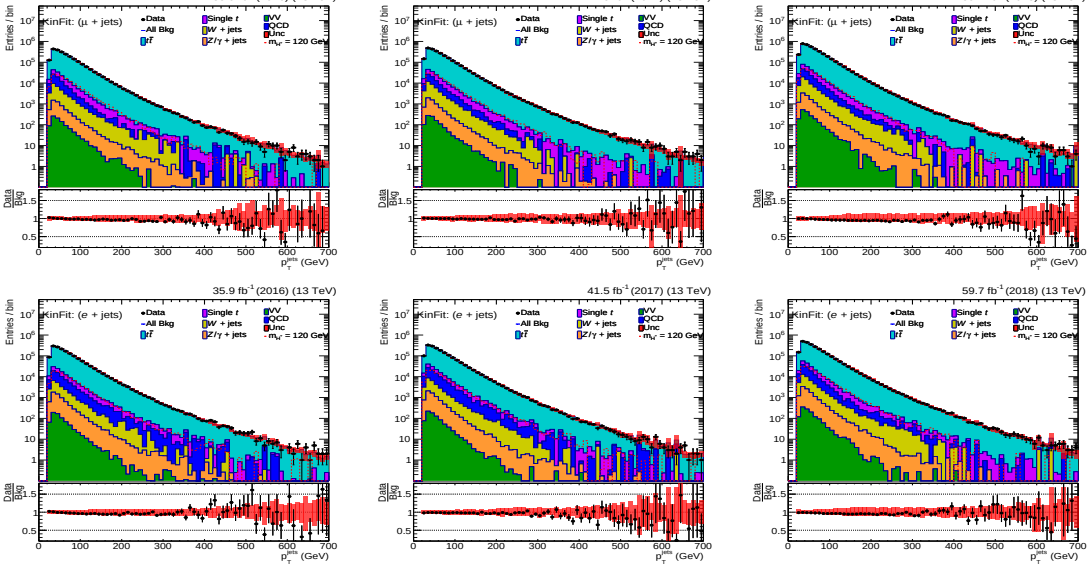




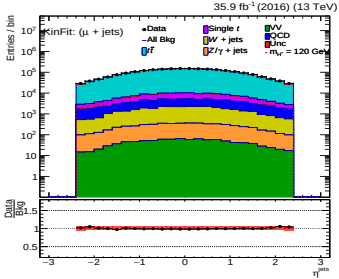
Comparison of data/MC at KinFit [1 lepton + MET + ≥ 4 jets (≥ 2 b-jets)] : ϕ^{lep} dist^{n}

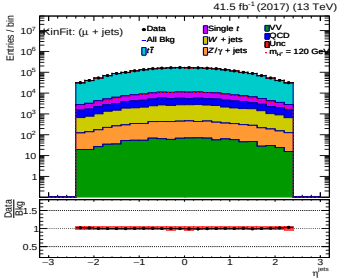


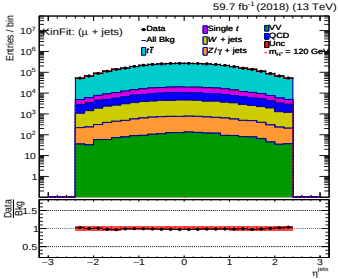
Comparison of data/MC at KinFit [1 lepton + MET + ≥ 4 jets (≥ 2 b-jets)] : p_T^{jets} dist^n

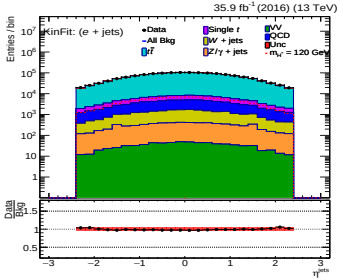


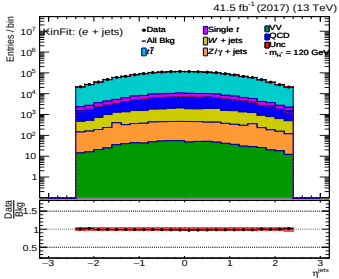
Comparison of data/MC at KinFit [1 lepton + MET + ≥ 4 jets (≥ 2 b-jets)] : η^{jets} dist^n

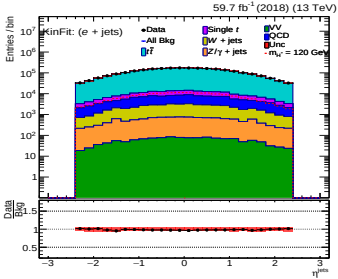




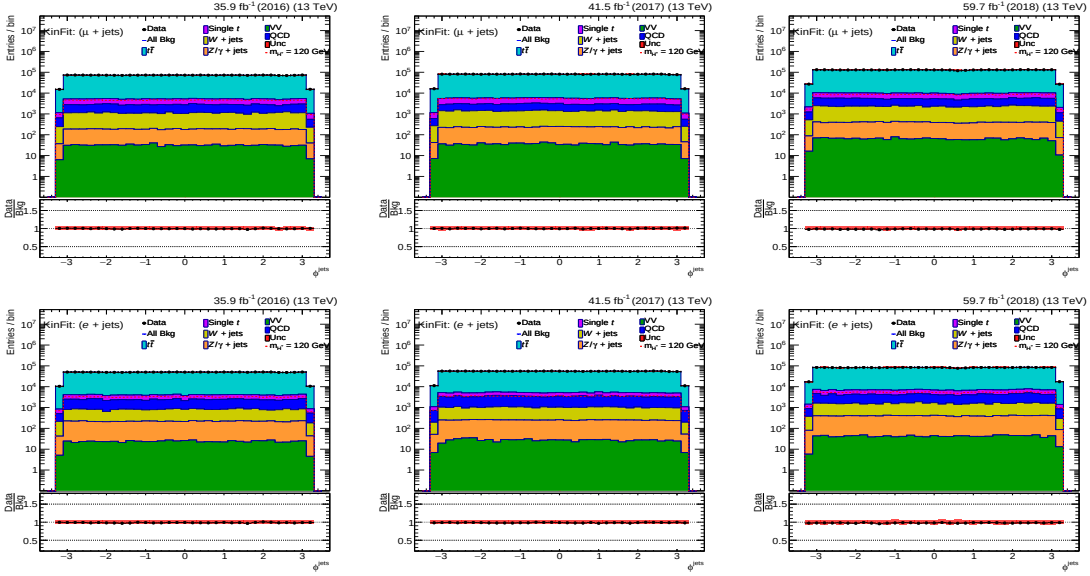




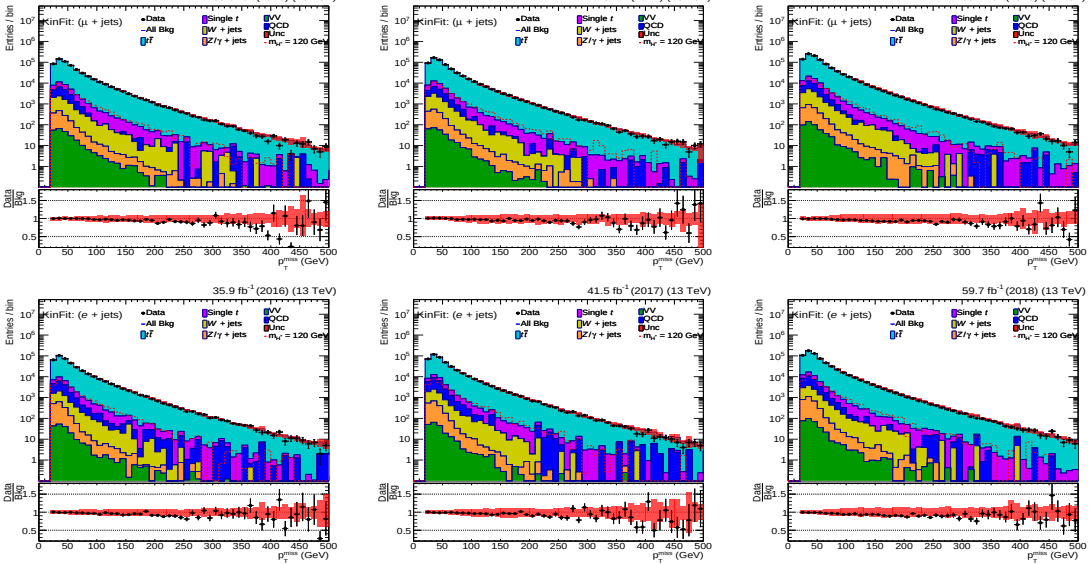




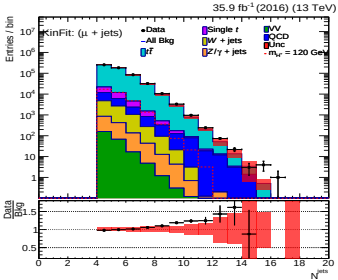
Comparison of data/MC at KinFit [1 lepton + MET + ≥ 4 jets (≥ 2 b-jets)] : ϕ^{jets} dist^{n}

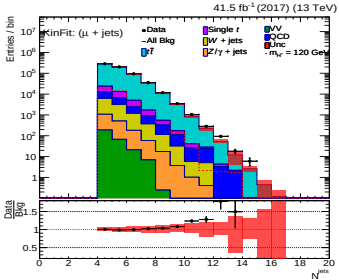


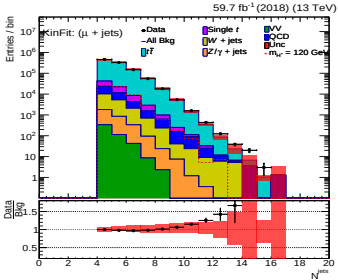
Comparison of data/MC at KinFit [1 lepton + MET + ≥ 4 jets (≥ 2 b-jets)] : p_T^{miss} dist^n

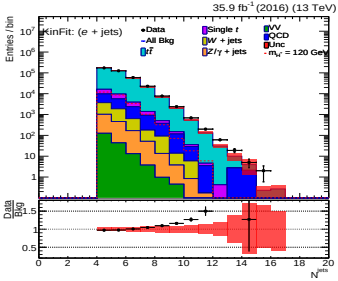


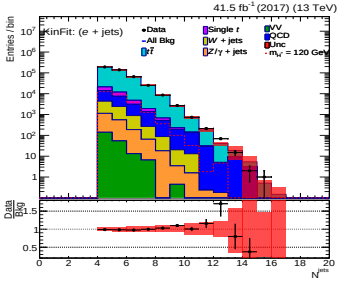
Comparison of data/MC at KinFit [1 lepton + MET + ≥ 4 jets (≥ 2 b-jets)] : N^{jets} dist^n

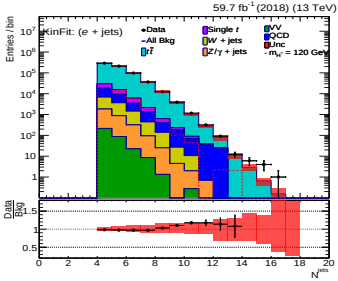




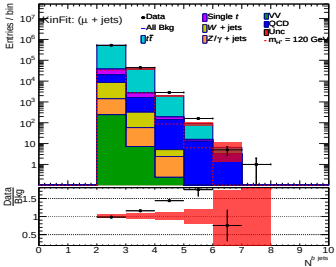


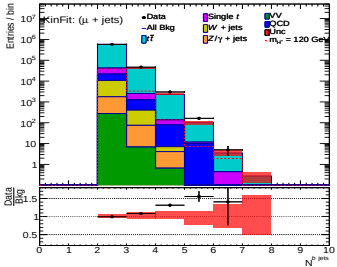


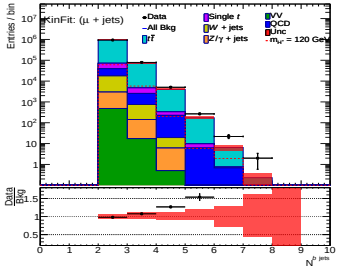


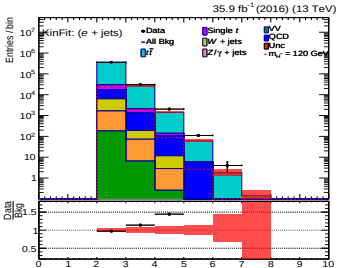


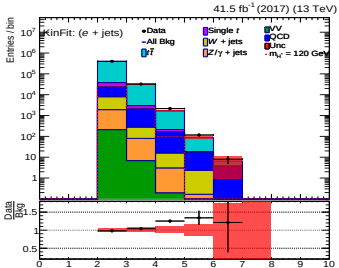
Comparison of data/MC at KinFit [1 lepton + MET + ≥ 4 jets (≥ 2 b-jets)] : N^{b-jets} dist^{n}

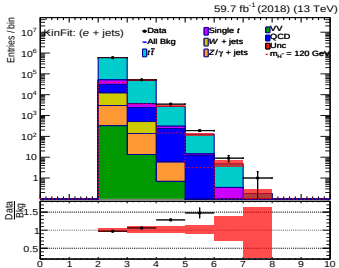












The m_{jj} dist^n at KinFit : [1 lepton + MET + ≥ 4 jets (≥ 2 b-jets)]