W charge asymmetry studies: Acceptance & asymmetry

22.02.2018

News

- News from Stephanie Brandt
- Good acceptance
- Ready for next steps

Acceptance

The acceptance $\mathcal{A}$ of the W bosons defines as a fraction of simulated events with decay products passing kinematic requirements in the fiducial phase-space.

- $p_T > 25$ GeV;
- $|\eta| < 2.4$;

Calculated* Acceptance for W^+ & W^- in muon channel:

- $\mathcal{A}(W^+) = 0.45$
- $\mathcal{A}(W^-) = 0.46$

* - acceptance when only p_T & $|\eta|$ cuts are used.

Calculated* Acceptance for W^+ & W^- in muon channel:

- $\mathcal{A}(W^+) = 0.381461$
- $\mathcal{A}(W^-) = 0.394783$

* - acceptance when object selection is performed.

Results from the

Process	A_{Gen} (Pre-FSR)	A_{Gen} (Post-FSR)
$W^+ \to \mu^+\nu$	0.45	0.44
$W^- \to \mu^-\bar{\nu}$	0.47	0.46

Eta binned results(W+ -> mu nu)

Total: 4.71501e+09 / 1.24498e+10 = 0.37872 +/- 6.47613e-06 ==eff corr:==> 0.360807 +/- 0.00310237

barrel[1]: 3.99056e+08 / 1.24498e+10 = 0.0320531 +/- 1.63006e-06 ==eff corr[1]:==> 0.0305616

barrel[2]: 3.806e+08 / 1.24498e+10 = 0.0305707 +/- 1.59078e-06 ==eff corr[2]:==> 0.0287337

barrel[3]: 4.03371e+08 / 1.24498e+10 = 0.0323997 +/- 1.63913e-06 ==eff corr[3]:==> 0.0312932

barrel[4]: 3.96931e+08 / 1.24498e+10 = 0.0318824 +/- 1.62558e-06 ==eff corr[4]:==> 0.0307903

barrel[5]: 3.89954e+08 / 1.24498e+10 = 0.031322 +/- 1.61079e-06 ==eff corr[5]:==> 0.0299129

barrel[6]: 3.89283e+08 / 1.24498e+10 = 0.0312681 +/- 1.60937e-06 ==eff corr[6]:==> 0.0294953

endcap[7]: 4.06746e+08 / 1.24498e+10 = 0.0326708 +/- 1.64619e-06 ==eff corr[7]:==> 0.0314942

endcap[8]: 4.29147e+08 / 1.24498e+10 = 0.0344701 +/- 1.69238e-06 ==eff corr[8]:==> 0.0332266

endcap[9]: 4.9364e+08 / 1.24498e+10 = 0.0396503 +/- 1.81964e-06 ==eff corr[9]:==> 0.0382124

endcap[10]: 5.03098e+08 / 1.24498e+10 = 0.04041 +/- 1.83766e-06 ==eff corr[10]:==> 0.0389353

endcap[11]: 5.23182e+08 / 1.24498e+10 = 0.0420232 +/- 1.87543e-06 ==eff corr[11]:==> 0.0381518

Eta binned results(W+ -> mu nu)

Total: 4.65864e+09 / 1.1893e+10 = 0.391711 +/- 6.77035e-06 ==eff corr:==> 0.375226 +/- 0.00327445

barrel[1]: 4.27792e+08 / 1.1893e+10 = 0.0359699 +/- 1.7701e-06 ==eff corr[1]:==> 0.0345333 +/- 0.00098118

barrel[2]: 4.2028e+08 / 1.1893e+10 = 0.0353383 +/- 1.75395e-06 ==eff corr[2]:==> 0.0333996 +/- 0.000964363

barrel[3]: 4.26984e+08 / 1.1893e+10 = 0.035902 +/- 1.76837e-06 ==eff corr[3]:==> 0.0347743 +/- 0.00101263

barrel[4]: 4.33239e+08 / 1.1893e+10 = 0.036428 +/- 1.78172e-06 ==eff corr[4]:==> 0.0352837 +/- 0.00100308

barrel[5]: 3.89079e+08 / 1.1893e+10 = 0.0327149 +/- 1.68545e-06 ==eff corr[5]:==> 0.0312791 +/- 0.00094685

barrel[6]: 4.03756e+08 / 1.1893e+10 = 0.033949 +/- 1.71797e-06 ==eff corr[6]:==> 0.0320549 +/- 0.000946603

endcap[7]: 4.36571e+08 / 1.1893e+10 = 0.0367081 +/- 1.7888e-06 ==eff corr[7]:==> 0.0354939 +/- 0.000994308

endcap[8]: 4.05794e+08 / 1.1893e+10 = 0.0341203 +/- 1.72245e-06 ==eff corr[8]:==> 0.0329891 +/- 0.000971514

endcap[9]: 4.35248e+08 / 1.1893e+10 = 0.0365968 +/- 1.786e-06 ==eff corr[9]:==> 0.0353848 +/- 0.00102721

endcap[10]: 4.34167e+08 / 1.1893e+10 = 0.036506 +/- 1.7837e-06 ==eff corr[10]:==> 0.0353007 +/- 0.0010235

endcap[11]: 4.45728e+08 / 1.1893e+10 = 0.037478 +/- 1.80814e-06 ==eff corr[11]:==> 0.0347326 +/- 0.000984858

Very raw cross section results

	Yields	Luminocity	Acceptance	Efficiency*	BR	xSection[pb]
• W+	9154760	2.3E+15	0.45	0.82	1	10740
• W-	7038593	2.3E+15	0.46	0.82	1	8078

Analysis note(SMP 16-013) results:

Source	$W \to \mu\nu$	$W^+ \to \mu^+\nu$	$W^- \to \mu^-\bar{\nu}$
Yields	17046299 ± 12022	9645191 ± 10066	7401108 ± 6573
Acceptance	0.45 ± 0.01	0.44 ± 0.01	0.46 ± 0.01
Efficiency	0.82 ± 0.01	0.82 ± 0.01	0.82 ± 0.01

Channel		$\sigma \times \mathcal{B}$ [pb] (total)	NNLO [pb]
W^+	$e^+\nu$	$11052 \pm 22\,(\text{stat}) \pm 241\,(\text{syst}) \pm 298\,(\text{lumi})$	11329^{+324}_{-269}
	$\mu^+\nu$	$11534 \pm 12\,(\text{stat}) \pm 262\,(\text{syst}) \pm 311\,(\text{lumi})$	
	$\ell^+\nu$	$11274 \pm 13\,(\text{stat}) \pm 177\,(\text{syst}) \pm 304\,(\text{lumi})$	
W^-	$e^-\nu$	$7937 \pm 16\,(\text{stat}) \pm 183\,(\text{syst}) \pm 214\,(\text{lumi})$	8369^{+244}_{-213}
	$\mu^-\nu$	$8493 \pm 8\,(\text{stat}) \pm 173\,(\text{syst}) \pm 229\,(\text{lumi})$	
	$\ell^-\nu$	$8231 \pm 9\,(\text{stat}) \pm 126\,(\text{syst}) \pm 222\,(\text{lumi})$	

Raw asymmetries

$$\mathcal{A}(\eta) = \frac{\sigma_\eta^+ - \sigma_\eta^-}{\sigma_\eta^+ + \sigma_\eta^-} = 14\%;$$

Results from SMP 014-022 (8 TeV)

	$\mathcal{A}$ (%)					
0.00–0.20	$13.31 \pm 0.06 \pm 0.17$	$13.89^{+0.55}_{-0.57}$	13.68 ± 0.25	$13.16^{+0.48}_{-0.30}$	13.69 ± 0.20	$13.71^{+0.50}_{-0.43}$
0.20–0.40	$13.70 \pm 0.06 \pm 0.18$	$14.28^{+0.56}_{-0.59}$	13.94 ± 0.23	$13.48^{+0.49}_{-0.30}$	14.04 ± 0.20	$14.07^{+0.51}_{-0.44}$
0.40–0.60	$14.27 \pm 0.06 \pm 0.18$	$14.83^{+0.56}_{-0.60}$	14.47 ± 0.21	$13.92^{+0.48}_{-0.30}$	14.66 ± 0.23	$14.58^{+0.53}_{-0.45}$
0.60–0.80	$15.18 \pm 0.06 \pm 0.18$	$15.85^{+0.55}_{-0.61}$	15.40 ± 0.19	$14.93^{+0.49}_{-0.30}$	15.52 ± 0.21	$15.42^{+0.54}_{-0.47}$
0.80–1.00	$16.19 \pm 0.06 \pm 0.19$	$17.01^{+0.57}_{-0.64}$	16.44 ± 0.19	$15.95^{+0.50}_{-0.31}$	16.59 ± 0.22	$16.49^{+0.58}_{-0.50}$
1.00–1.20	$17.69 \pm 0.07 \pm 0.20$	$18.44^{+0.55}_{-0.65}$	17.92 ± 0.19	$17.31^{+0.51}_{-0.34}$	18.11 ± 0.21	$17.69^{+0.58}_{-0.51}$
1.20–1.40	$19.52 \pm 0.07 \pm 0.22$	$20.14^{+0.56}_{-0.67}$	19.52 ± 0.20	$19.03^{+0.53}_{-0.38}$	19.70 ± 0.23	$19.13^{+0.62}_{-0.54}$
1.40–1.60	$20.75 \pm 0.07 \pm 0.23$	$21.82^{+0.56}_{-0.68}$	21.10 ± 0.21	$20.59^{+0.55}_{-0.42}$	21.26 ± 0.23	$20.63^{+0.60}_{-0.54}$
1.60–1.85	$22.83 \pm 0.06 \pm 0.23$	$23.57^{+0.55}_{-0.68}$	22.84 ± 0.23	$22.50^{+0.57}_{-0.48}$	23.14 ± 0.23	$22.26^{+0.63}_{-0.55}$
1.85–2.10	$24.61 \pm 0.06 \pm 0.22$	$25.43^{+0.54}_{-0.67}$	24.74 ± 0.25	$24.44^{+0.57}_{-0.52}$	24.99 ± 0.24	$24.01^{+0.69}_{-0.60}$
2.10–2.40	$25.96 \pm 0.07 \pm 0.21$	$26.47^{+0.50}_{-0.62}$	25.75 ± 0.28	$25.61^{+0.57}_{-0.55}$	26.19 ± 0.29	$25.05^{+0.78}_{-0.67}$

Back up

Object and event selection

For this analysis, the events are collected when triggered by the presence of at least one electron(or muon) with large transverse energy and η cut:

- $P_T > 25$ GeV
- $|\eta| < 2.5$

Several Monte Carlo event generators are used to simulate the signal and background processes:

- MadGraph5 aMC@NLO - event samples for the W and Z boson signal and top background.
- PYTHIA 8 with NNPDF3.0 - parton shower.
- PYTHIA 8 and POWHEG - diboson backgrounds.
- GEANT4 - detector response.

Probability Density Function fits*

QCD background modeled by analytical function:

f(x) = x*exp({-x^2} / {ax^2+bx+c}) *

a = 4.0 ∈ [−10.0, 10.0]
b = 6.0 ∈ [0.0, 20.0]
c = 2.9 ∈ [0.3, 6.0]
X ∈ [0.0, 2.0, 150.0]

Signal and EWK backgrounds are modeled with simulation based fitting functions.

As a minimum finder used Minos
*both codes uses the same function
*new function to come

smth like that f(x) = (x*exp({-x^2} / {ax^2+bx+c})*({ax^2+bx+c})

NEW improvements!

Lepton efficiencies are measured in different eta bins:

- **New electron eta binning:**

  -2.5, -2.0, -1.566, -1.4442, -1.0, -0.5,
  0.0,
  0.5, 1.0, 1.4442, 1.566, 2.0, 2.5

- **New muon eta binning:**

  -2.4 -2.1, -1.2, -0.9, -0.3, -0.2,
  0.0,
  0.2, 0.3, 0.9,1.2, 2.1, 2.4

Old binning:
0.0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.85, 2.1, 2.5
(for muons: up to 2.4)

Efficiency

- **The total efficiency of the electrons can be factorized as follows for the electrons with the total efficiency defined with respect to a reconstructed supercluster passing the kinematic cuts**

$$\epsilon_{total} = \epsilon_{GSF+ID+ISO} \times \epsilon_{trigger,} \; ?$$

- **For the muons, a similar factorization can be done**

$$\epsilon_{total} = \epsilon_{tracking+ID+ISO} \times \epsilon_{STA} \times \epsilon_{trigger,} \; ?$$

Included in the muon selection efficiency

- **All efficiencies implemented as a weights to events in a form:**

$$\text{weight} = \text{scale1fb} * \text{lumi} * \Pi_i \, \text{eff\_data}_i(\text{eta},\text{Pt}) / \text{eff\_MC}_i(\text{eta},\text{Pt})$$

- **Acceptance code exists but it crashes, I need to discuss it with Maria**

Summary table on event numbers for eta binned $\not{E}_T$ distributions of $W \rightarrow \mu^+$

	W-> mu plus	Selected	Signal	QCD	Other		Signal+QCD+Other	Selected / Signal+QCD+Other
0	Total:	10972017	9154760	1005162	812093		10972015	1.000000182
1	-2.4 - -2.0	597843	506271	54482	37099		597852	0.999849461
2	-2.0 - -1.566	2162007	1765001	252645	144368		2162014	0.999967623
3	-1.566 - -1.442	683300	562309	74244	46747		683300	1
4	-1.442 - -1.0	1397945	1170317	125906	101707		1397930	1.00001073
5	-1.0 - -0.5	193760	161895	31196	670		193761	0.999994839
6	-0.5 - 0.0	452744	381590	51068	20090		452748	0.999911651
7	0.0 - 0.5	454405	381027	44802	28565		454394	1.000024208
8	0.5 - 1.0	192171	156236	31358	4586		192180	0.999531689
9	1.0 - 1.442	1394476	1186889	119002	88581		1394472	1.000002868
10	1.442 - 1.566	670700	557706	76749	36251		670706	0.999910542
11	1.566 - 2.0	2171081	1739613	200562	230890		2171065	1.00000737
12	2.0 - 2.4	601585	504372	64709	32513		601594	0.999850397
	Sum over bins	10972017	9073226	1126723	772067		10972016	1.000000091
	Total / Sum over bins	1	1.008986219	0.8921110158	1.051842651		0.9999999089	

The table represents yields on signal, QCD, other(background) and total(selected) distribution for the whole region of eta and per bin.

The last row and column represents ratios to estimate possible correlation of number of events in the whole eta region and eta binned distributions.

Summary table on event numbers for eta binned $\not{E}_T$ distributions of $W \rightarrow \mu^-$

	W->mu minus	Selected	Signal	QCD	Other		Signal+QCD+Other	Selected / Signal+QCD+Other
0	Total:	8804750	7038593	1138882	626977		8804452	1.000033847
1	-2.4 - -2.0	430063	332454	63676	33942		430072	0.999790733
2	-2.0 - -1.566	1671140	1277199	263588	130358		1671145	0.999997008
3	-1.566 - -1.442	557101	440939	82959	33210		557108	0.999874351
4	-1.442 - -1.0	1185837	969787	155547	60508		1185842	0.999957836
5	-1.0 - -0.5	166746	139222	24165	3367		166754	0.999520251
6	-0.5 - 0.0	390755	321187	58570	11007		390764	0.999769682
7	0.0 - 0.5	393668	328566	45544	19562		393672	0.999898393
8	0.5 - 1.0	167513	136985	23947	6590		167522	0.999462757
9	1.0 - 1.442	1186698	984177	143105	59419		1186701	0.999997472
10	1.442 - 1.566	551268	433588	84103	33582		551273	0.999909301
11	1.566 - 2.0	1671179	1302068	275760	93367		1671195	0.999990426
12	2.0 - 2.4	432782	334737	61081	36970		432788	0.999861364
	Sum over bins	8804750	7000909	1282045	521882		8804836	0.999902326
	Total / Sum over bins	1	1.00538273	0.8883323128	1.20137694		0.9999563876	

The table represents yields on signal, QCD, other(background) and total(selected) distribution for the whole region of eta and per bin.

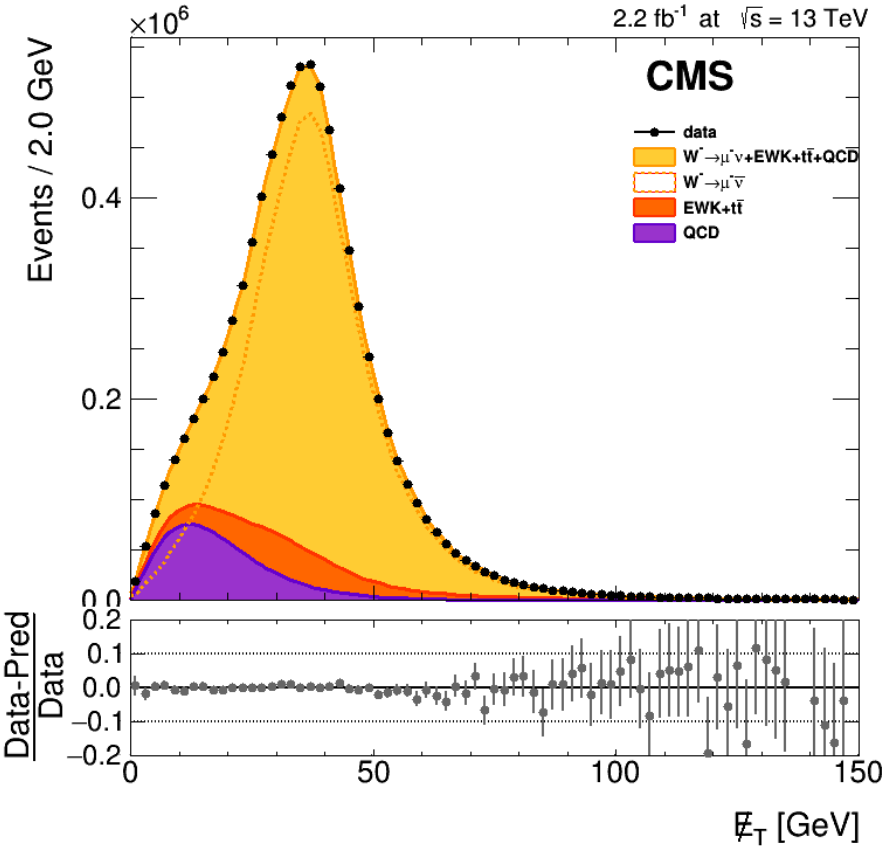
The last row and column represents ratios to estimate possible correlation of number of events in the whole eta region and eta binned distributions.

Number of events and chi2/ndf in different eta bins

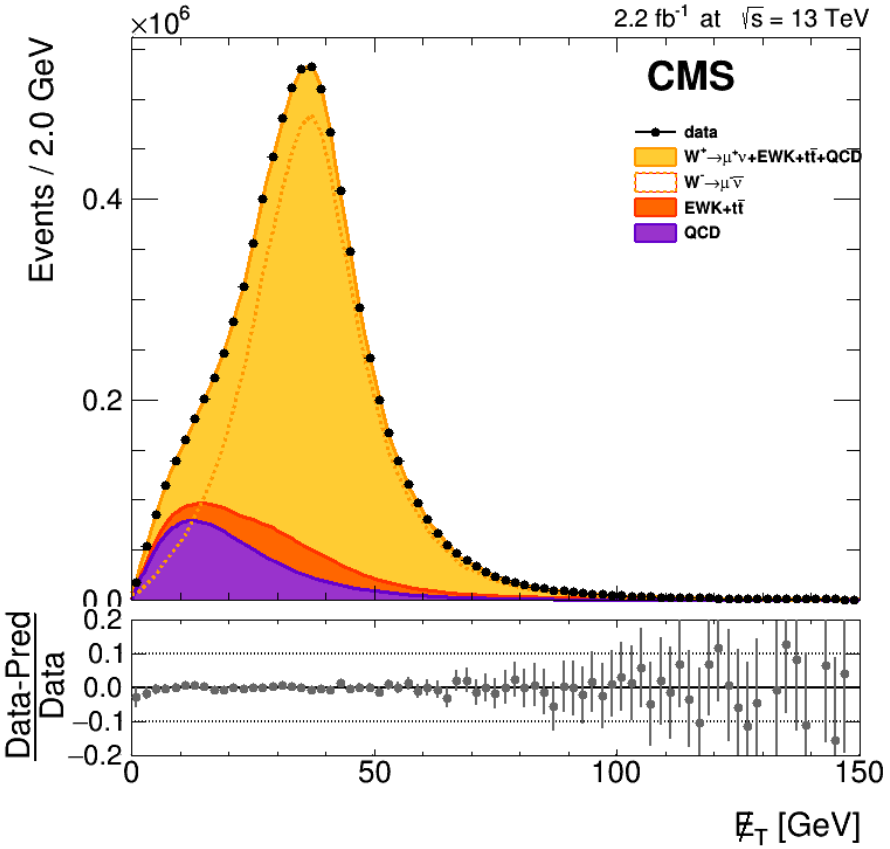
eta bins	N + (Signal)	N - (Signal)	chi2/ndf (N +)	chi2/ndf (N -)
-2.4 - 2.4	9154760	7038593	0.6562	0.408
-2.4 - -2.0	506271	332454	0.704	0.2375
-2.0 - -1.566	1765001	1277199	0.3233	0.3122
-1.566 - -1.442	562309	440939	0.4019	0.314
-1.442 - -1.0	1170317	969787	0.361	0.3224
-1.0 - -0.5	161895	139222	0.3447	0.2717
-0.5 - 0.0	381590	321187	0.3362	0.3216
0.0 - 0.5	381027	328566	0.3365	0.5061
0.5 - 1.0	156236	136985	0.3469	0.3878
1.0 - 1.442	118689	984177	0.3165	0.3373
1.442 - 1.566	557706	433588	0.4605	0.3457
1.566 - 2.0	1739613	1302068	0.9921	0.2603
2.0 - 2.4	504372	334737	0.3259	0.3012

From the table we may conclude that we overestimate uncertainties

Comparing missing E_T for the whole eta region (W^- to muon ch.)

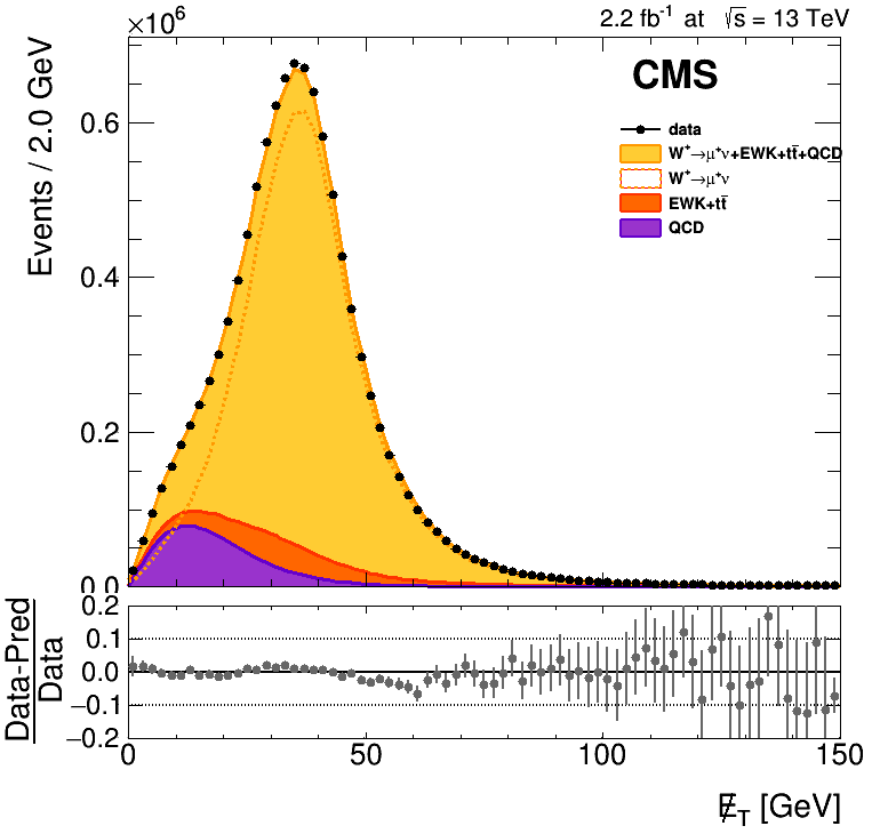


Old binning

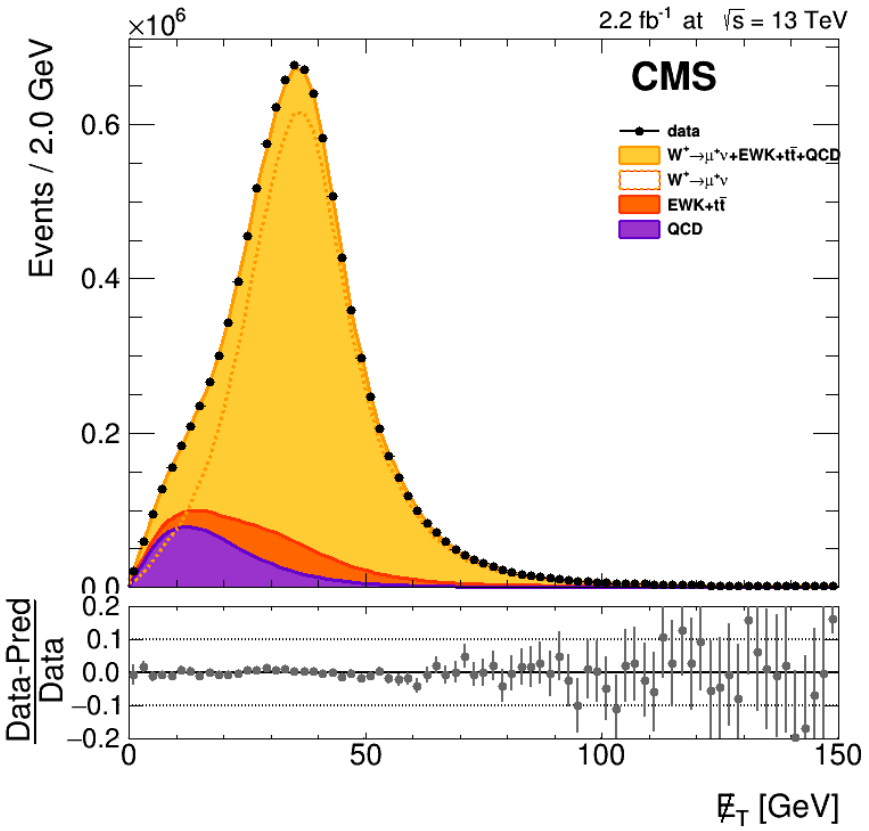


New binning

Comparing missing E_T for the whole eta region (W^+ to muon ch.)

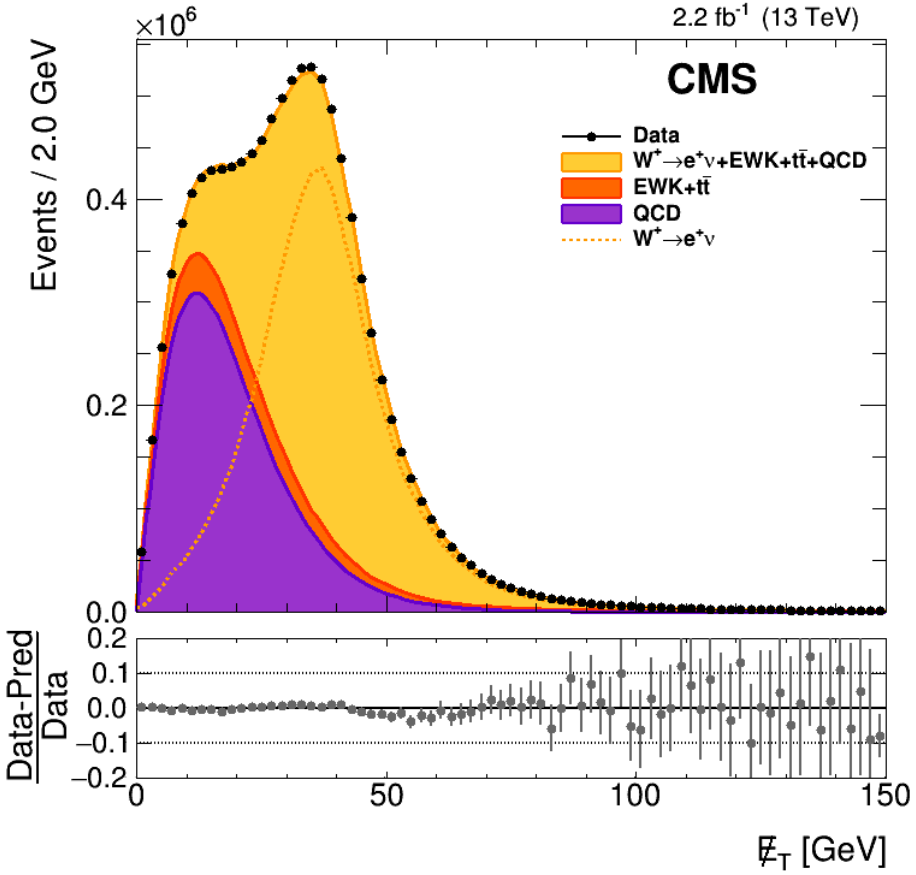


Old binning

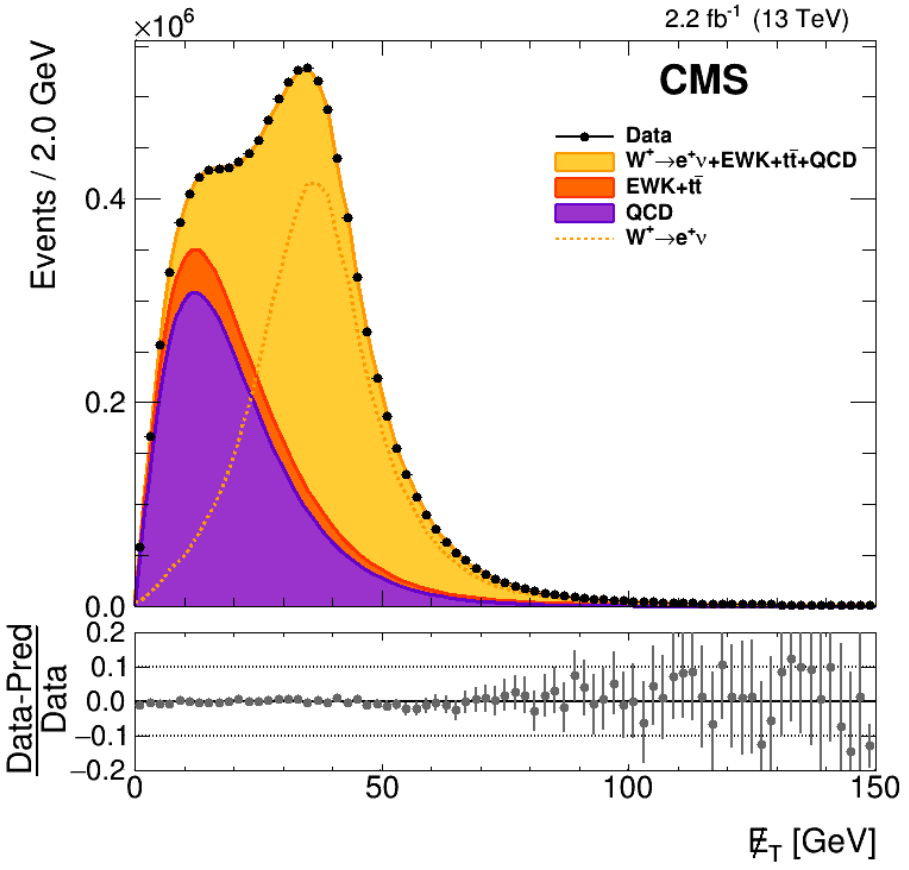


New binning

Comparing missing E_T for the whole eta region (W^+ to electron ch.)

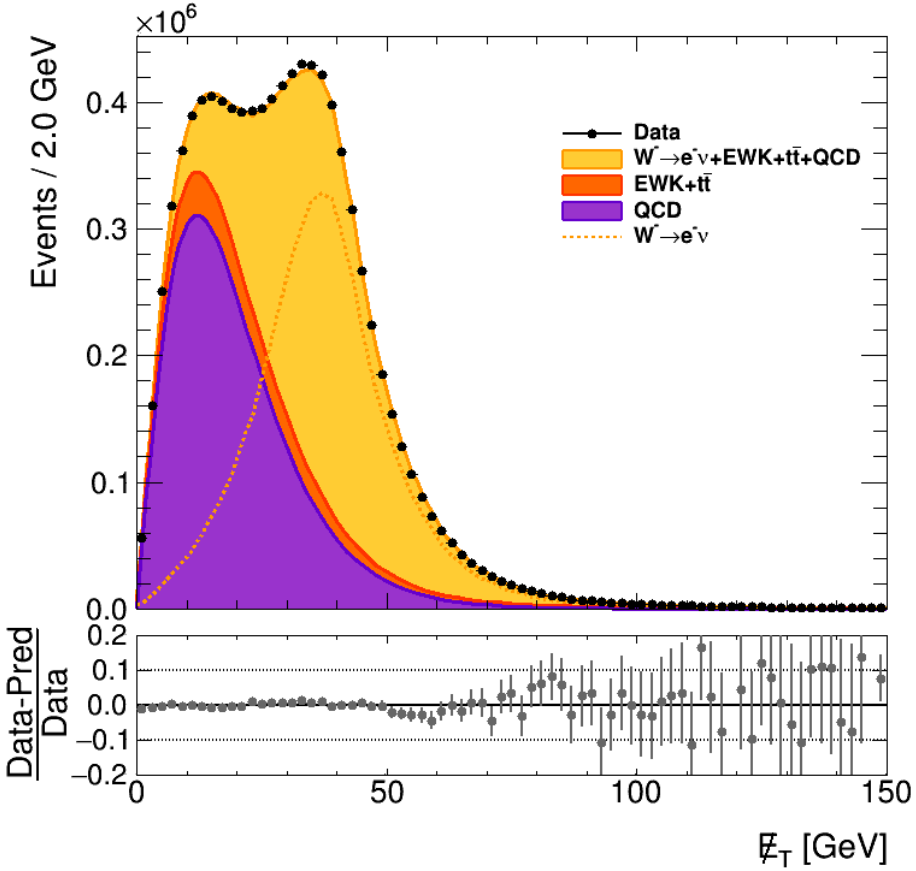


Old binning

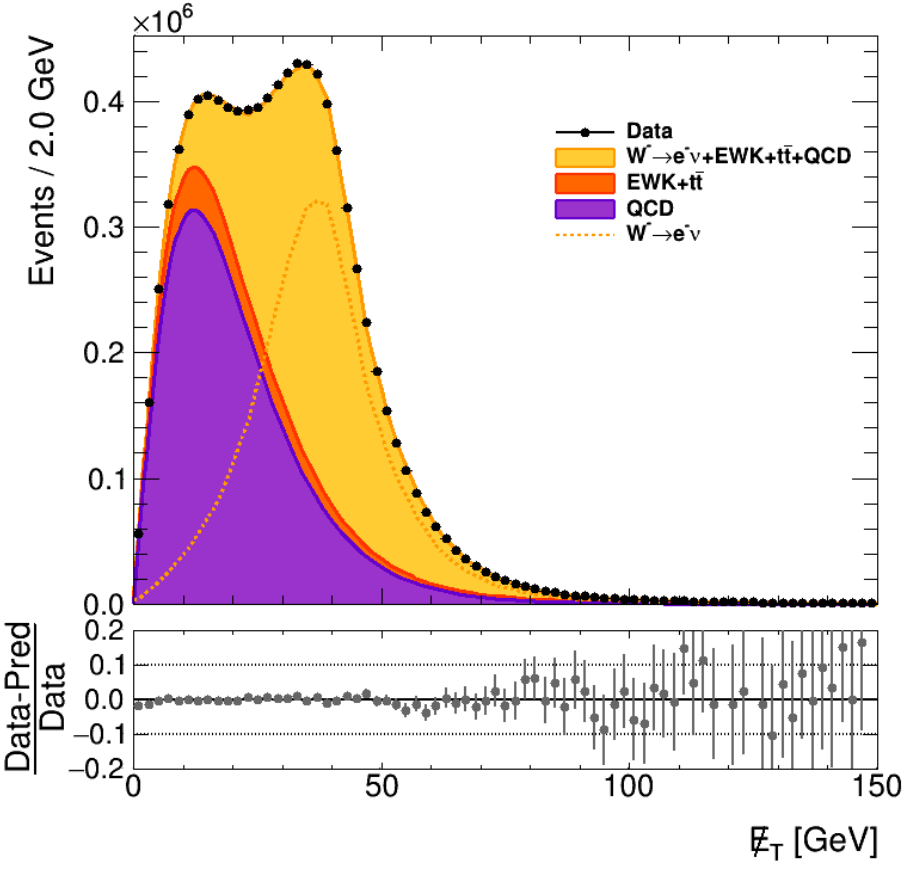


New binning

Comparing missing E_T for the whole eta region (W^- to electron ch.)

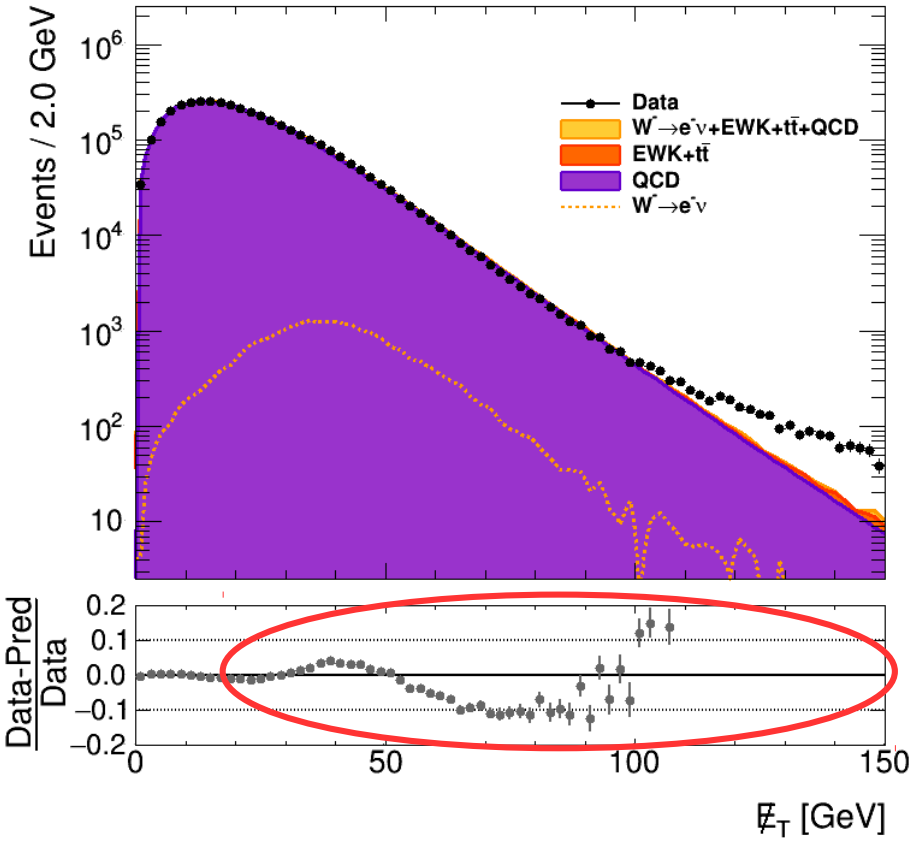


Old binning

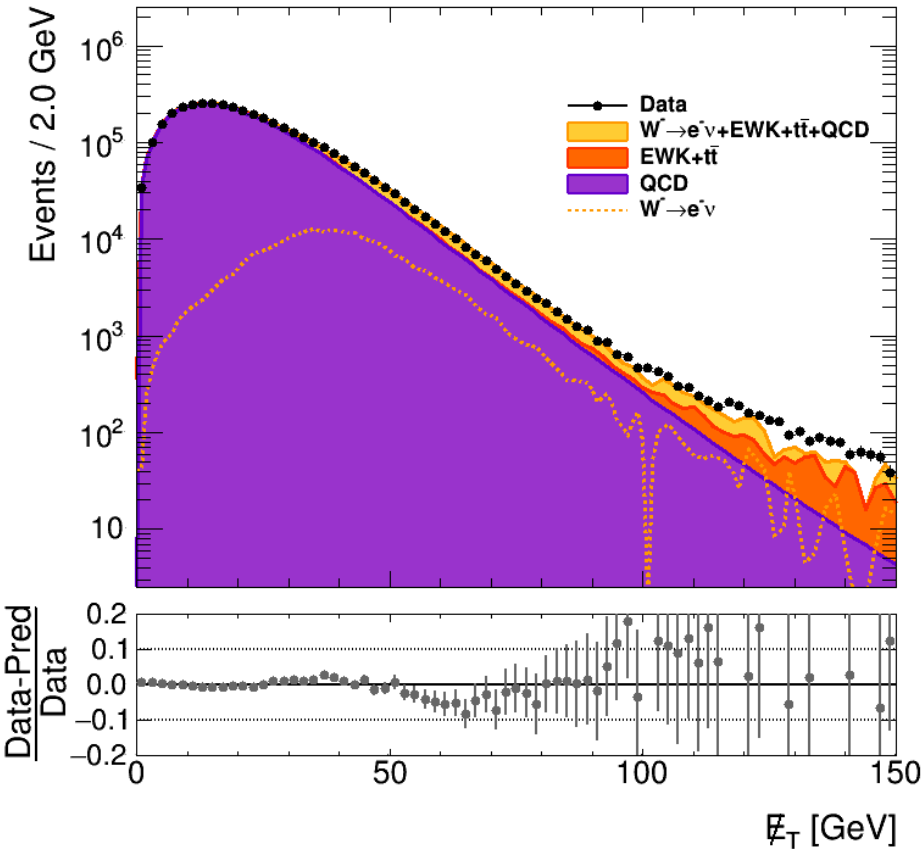


New binning

Control region

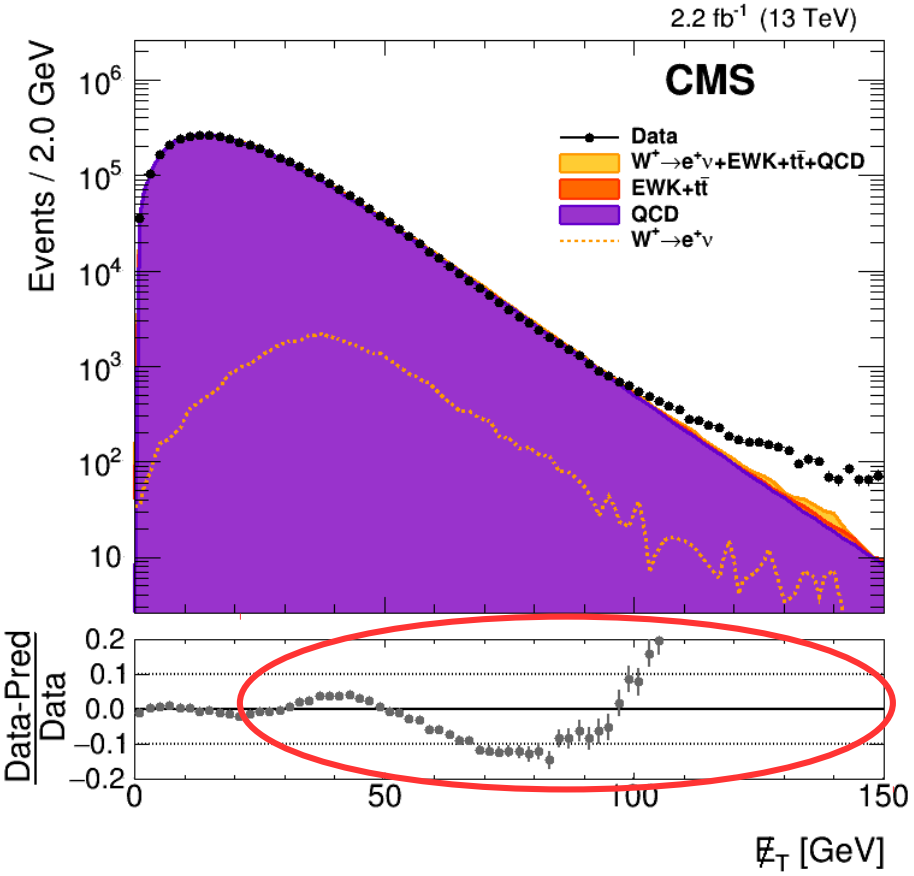


Old binning

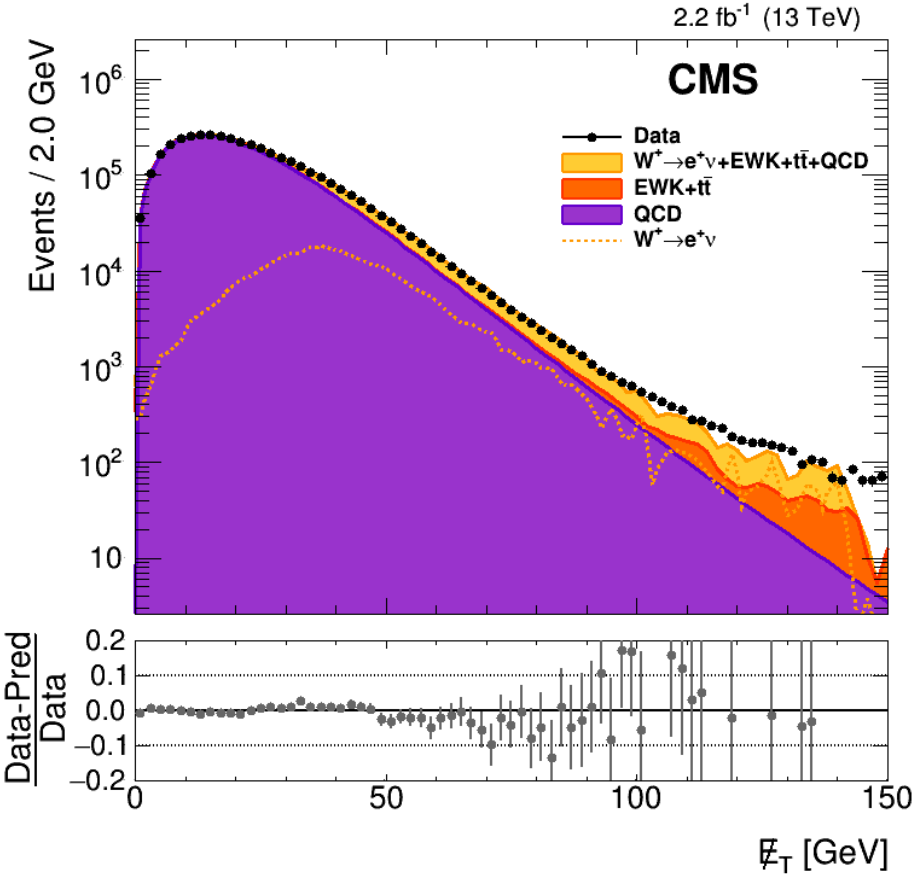


New binning

Control region



Old binning



New binning