

MC request stats proposal for muonic $D^{0,*}l\nu$ analyses

Run 2 $\mathcal{R}(D^{0,*})$



Angular $D^{*+}\mu\nu$



CPv in
 $D^{*+}\mu\nu$



$\mathcal{R}(D^{(*)})$ light



$D^{**0}\mu\nu$



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Tweaks on 20th May



Introduction

Run 1 $\mathcal{R}(D^{0,*})$ request

Run 1: Nsim = 924M / Ndisk = 65M								
#	Sample	Name	MC ID	ϵ_{gen}	Nsim [M]	Ndisk [M]	% total request	MC/ data fit
1	D0	$B^- \rightarrow D^0 \mu^- \nu$	12573010	7.0%	110.0	7.7		2.8
2	D0/D*+	$B^0 \rightarrow D^*+ \mu^- \nu$	11574020	5.9%	88.6	6.2	45.6%	1.4
3	D0	$B^- \rightarrow D^*0 \mu^- \nu$	12573031	6.0%	222.9	15.6		2.1
4	D0	$B^- \rightarrow D^0 \tau^- \nu$	12573000	5.4%	7.3	0.5		2.8
5	D0/D*+	$B^0 \rightarrow D^*+ \tau^- \nu$	11574010	5.0%	19.6	1.4	4.8%	1.4
6	D0	$B^- \rightarrow D^*0 \tau^- \nu$	12573021	5.0%	17.0	1.2		2.1
7	D0/D*+	$B^0 \rightarrow D^{**+} \mu^- \nu$	11873010	5.0%	126.7	8.9		4.0
8	D0/D*+	$B^0 \rightarrow D^{**+} \tau^- \nu$	11873030	4.9%	1.1	0.1	25.2%	3.0
9	D0/D*+	$B^- \rightarrow D^{**0} \mu^- \nu$	12873010	5.7%	103.1	7.2		4.0
10	D0/D*+	$B^- \rightarrow D^{**0} \tau^- \nu$	12873030	4.9%	1.7	0.1		3.0
11	D0	$B^- \rightarrow D^{**}(\rightarrow D^0 \pi\pi) \mu^- \nu$	12675010	5.5%	15.5	1.1		3.0
12	D0	$B^0 \rightarrow D^{**}(\rightarrow D^0 \pi\pi) \mu^- \nu$	11674400	5.0%	15.6	1.1		3.0
13	D0/D*+	$B^- \rightarrow D^{**}(\rightarrow D^*+\pi\pi) \mu^- \nu$	12675400	5.4%	11.0	0.8	7.7%	3.0
14	D0/D*+	$B^0 \rightarrow D^{**}(\rightarrow D^*+\pi\pi) \mu^- \nu$	11676010	5.0%	10.5	0.7		3.0
15	D0	$B^- \rightarrow D^{**}(\rightarrow D^*0 \pi\pi) \mu^- \nu$	12675430	5.4%	18.5	1.3		3.0
16	D0	$B_s \rightarrow D_s^{**}(\rightarrow D^0 K^-) \mu^- \nu$	13873000	5.5%	1.3	0.1	0.6%	0.8
17	D*+	$B_s \rightarrow D^{**+} \mu^- \nu$	13874000	5.4%	4.7	0.3		1.6
18	D0	$B^0 \rightarrow D^0(X_c \rightarrow \mu^- \nu X') X$	11873000	4.6%	37.8	2.6		1.8
19	D0	$B^0 \rightarrow D^0(D_s \rightarrow \tau^- \nu) X$	11873020	5.4%	2.4	0.2	9.7%	4.0
20	D0	$B^+ \rightarrow D^0(X_c \rightarrow \mu^- \nu X') X$	12873000	5.0%	40.9	2.9		1.8
21	D0	$B^+ \rightarrow D^0(D_s \rightarrow \tau^- \nu) X$	12873021	5.6%	8.4	0.6		4.0
22	D*+	$B^0 \rightarrow D^*+(X_c \rightarrow \mu^- \nu X') X$	11874050	4.8%	41.4	2.9		3.0
23	D*+	$B^0 \rightarrow D^*+(D_s \rightarrow \tau^- \nu) X$	11874070	5.6%	3.9	0.3	6.5%	4.0
24	D*+	$B^+ \rightarrow D^*+(X_c \rightarrow \mu^- \nu X') X$	12874010	4.6%	12.0	0.8		3.0
25	D*+	$B^+ \rightarrow D^*+(D_s \rightarrow \tau^- \nu) X$	12874030	5.0%	2.3	0.2		4.0

- ~ Run 1 muonic $\mathcal{R}(D^{0,*})$ estimates **sizable impacts from MC stats template uncertainties**
 - $0.016/0.020 = 80\%$ of statistical uncertainty for $\mathcal{R}(D^*)$
 - $0.048/0.060 = 80\%$ of statistical uncertainty for $\mathcal{R}(D^0)$
- ~ Suffered from **25-50% reduction in effective MC stats** due to FF/other reweighting
- ~ Our goal is to have **4 times more MC than data** to reduce impact to less than 50% of the statistical uncertainty
 - Use **tracker-only MC** and **adjust generator/filter selection** as much to trigger/stripping as possible

MC stats estimation

Run 1 $\mathcal{R}(D^{0,*})$ request

			Run 1: Nsim = 924M / Ndisk = 65M					
			FullSim + RICHless					
#	Sample	Name	MC ID	ϵ_{gen}	Nsim [M]	Ndisk [M]	% total request	MC/ data fit
1	D0	$B^- \rightarrow D^0 \mu^- \nu$	12573010	7.0%	110.0	7.7		2.8
2	D0/D*+	$B^0 \rightarrow D^{*+} \mu^- \nu$	11574020	5.9%	88.6	6.2	45.6%	1.4
3	D0	$B^- \rightarrow D^{*0} \mu^- \nu$	12573031	6.0%	222.9	15.6		2.1
4	D0	$B^- \rightarrow D^0 \tau^- \nu$	12573000	5.4%	7.3	0.5		2.8
5	D0/D*+	$B^0 \rightarrow D^{*+} \tau^- \nu$	11574010	5.0%	19.6	1.4	4.8%	1.4
6	D0	$B^- \rightarrow D^{*0} \tau^- \nu$	12573021	5.0%	17.0	1.2		2.1
7	D0/D*+	$B^0 \rightarrow D^{**+} \mu^- \nu$	11873010	5.0%	126.7	8.9		4.0
8	D0/D*+	$B^0 \rightarrow D^{**+} \tau^- \nu$	11873030	4.9%	1.1	0.1	25.2%	3.0
9	D0/D*+	$B^- \rightarrow D^{**0} \mu^- \nu$	12873010	5.7%	103.1	7.2		4.0
10	D0/D*+	$B^- \rightarrow D^{**0} \tau^- \nu$	12873030	4.9%	1.7	0.1		3.0
11	D0	$B^- \rightarrow D^{**(\rightarrow D^0 \pi\pi)} \mu^- \nu$	12675010	5.5%	15.5	1.1		3.0
12	D0	$B^0 \rightarrow D^{**(\rightarrow D^0 \pi\pi)} \mu^- \nu$	11674400	5.0%	15.6	1.1		3.0
13	D0/D*+	$B^- \rightarrow D^{**(\rightarrow D^*+\pi\pi)} \mu^- \nu$	12675400	5.4%	11.0	0.8	7.7%	3.0
14	D0/D*+	$B^0 \rightarrow D^{**(\rightarrow D^*+\pi\pi)} \mu^- \nu$	11676010	5.0%	10.5	0.7		3.0
15	D0	$B^- \rightarrow D^{**(\rightarrow D^*0 \pi\pi)} \mu^- \nu$	12675430	5.4%	18.5	1.3		3.0
16	D0	$B_s \rightarrow D_s^{**(\rightarrow D^0 K)} \mu^- \nu$	13873000	5.5%	1.3	0.1	0.6%	0.8
17	D*+	$B_s \rightarrow D^{**+} \mu^- \nu$	13874000	5.4%	4.7	0.3		1.6
18	D0	$B^0 \rightarrow D^0 (X_c \rightarrow \mu^- \nu X') X$	11873000	4.6%	37.8	2.6		1.8
19	D0	$B^0 \rightarrow D^0 (D_s \rightarrow \tau^- \nu) X$	11873020	5.4%	2.4	0.2	9.7%	4.0
20	D0	$B^+ \rightarrow D^0 (X_c \rightarrow \mu^- \nu X') X$	12873000	5.0%	40.9	2.9		1.8
21	D0	$B^+ \rightarrow D^0 (D_s \rightarrow \tau^- \nu) X$	12873021	5.6%	8.4	0.6		4.0
22	D*+	$B^0 \rightarrow D^{*+} (X_c \rightarrow \mu^- \nu X') X$	11874050	4.8%	41.4	2.9		3.0
23	D*+	$B^0 \rightarrow D^{*+} (D_s \rightarrow \tau^- \nu) X$	11874070	5.6%	3.9	0.3	6.5%	4.0
24	D*+	$B^+ \rightarrow D^{*+} (X_c \rightarrow \mu^- \nu X') X$	12874010	4.6%	12.0	0.8		3.0
25	D*+	$B^+ \rightarrow D^{*+} (D_s \rightarrow \tau^- \nu) X$	12874030	5.0%	2.3	0.2		4.0

D*+ HistFactory yields (D⁰ in backup)

h_sigmuALT:	444,109	/	792,508	=	56.0%	MC/data =	1.4	(data = 323,024)
h_D1_ALT:	44,484	/	97,042	=	45.8%	MC/data =	5.5	(data = 8,129)
h_D1p_ALT:	52,557	/	103,069	=	51.0%	MC/data =	6.2	(data = 8,470)
h_D2_ALT:	13,255	/	25,657	=	51.7%	MC/data =	6.4	(data = 2,063)
h_D1tau_ALT:	7,681	/	13,584	=	56.5%	MC/data =	64.6	(data = 119)
h_D1ptau_ALT:	8,608	/	14,822	=	58.1%	MC/data =	69.5	(data = 124)
h_D2tau_ALT:	2,106	/	3,109	=	67.7%	MC/data =	69.8	(data = 30)
h_D2Smu:	38,530	/	71,024	=	54.2%	MC/data =	5.1	(data = 7,521)
h_uDDmu:	10,913	/	21,819	=	50.0%	MC/data =	2.9	(data = 3,806)
h_dDDmu:	68,204	/	145,507	=	46.9%	MC/data =	3.9	(data = 17,634)
h_dDDtau:	13,506	/	26,325	=	51.3%	MC/data =	130.2	(data = 104)
h_uDDtau:	3,369	/	5,371	=	62.7%	MC/data =	3.4	(data = 991)

~ Scale Run 1 request by

→ Cross section

→ Luminosity

→ MC/data ratio from Run 1 fit when ratio below 4

♦ Uncertainties very large and correlated (backup) → only correct cases when ratio less than 4

~ Check MC efficiency roughly matches data

Cross section and luminosity increase

~ "Run 2 has 2× the cross section of Run 1"

→ Exactly true for 7 TeV vs 13 TeV within acceptance [1612.05140](#)

♦ $\sigma(b\bar{b})_{7 \text{ TeV}} = 72.0 \pm 0.3 \pm 6.8 \mu\text{b}$ for $2 < \eta < 5$ (295 μb total)

♦ $\sigma(b\bar{b})_{13 \text{ TeV}} = 144 \pm 1 \pm 21 \mu\text{b}$ for $2 < \eta < 5$ (560 μb total)

→ Use Pythia to rescale σ to 8 TeV → 83.4 μb

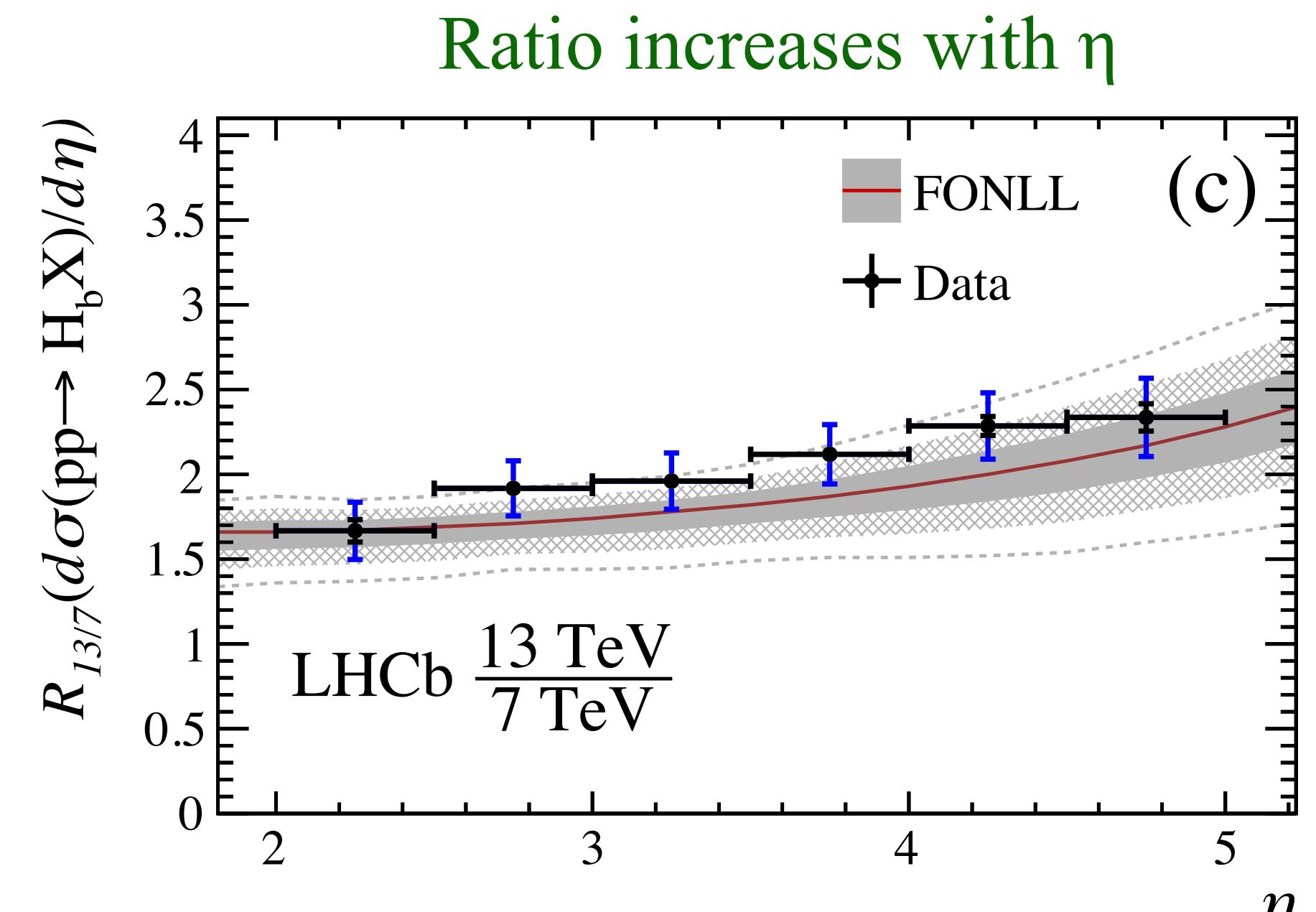
All five flavors (u,d,s,c,b) are considered in the PDFs. The total combined cross-sections given by PYTHIA are:

- 251.8 μb at 7 TeV; 291.6 μb at 8 TeV; 527.3 μb at 14 TeV.

Actual ratio around 1.8

$$\frac{\sigma(b\bar{b})_{\text{Run 2}}}{\sigma(b\bar{b})_{\text{Run 1}}} = \frac{144 \mu\text{b}}{(72.0 \mu\text{b} \times 1.1 \text{ fb}^{-1} + 83.4 \mu\text{b} \times 2.0 \text{ fb}^{-1})/3.1 \text{ fb}^1} = 1.81$$

We expect $\sim 1.81 \times 5.9 / 3.1 = 3.44$ times more B mesons in Run 2 than in Run 1



Proposed MC stats

$$N_{\text{disk}}^{\text{Run 2}} = N_{\text{disk}}^{\text{Run 1}} \times \frac{\left(\mathcal{L} \times \sigma(b\bar{b}) \times \epsilon_{\text{gen}} \times \epsilon_{\text{filter}} \right)^{\text{Run 2}}}{\left(\mathcal{L} \times \sigma(b\bar{b}) \times \epsilon_{\text{gen}} \times \epsilon_{\text{filter}} \right)^{\text{Run 1}}} \times \frac{4}{f_{\text{MC}/\text{data}}}$$

$\mathcal{L} \times \sigma(b\bar{b})$ ratio is 3.44 (previous slide)

ϵ_{gen} in table from official MC production

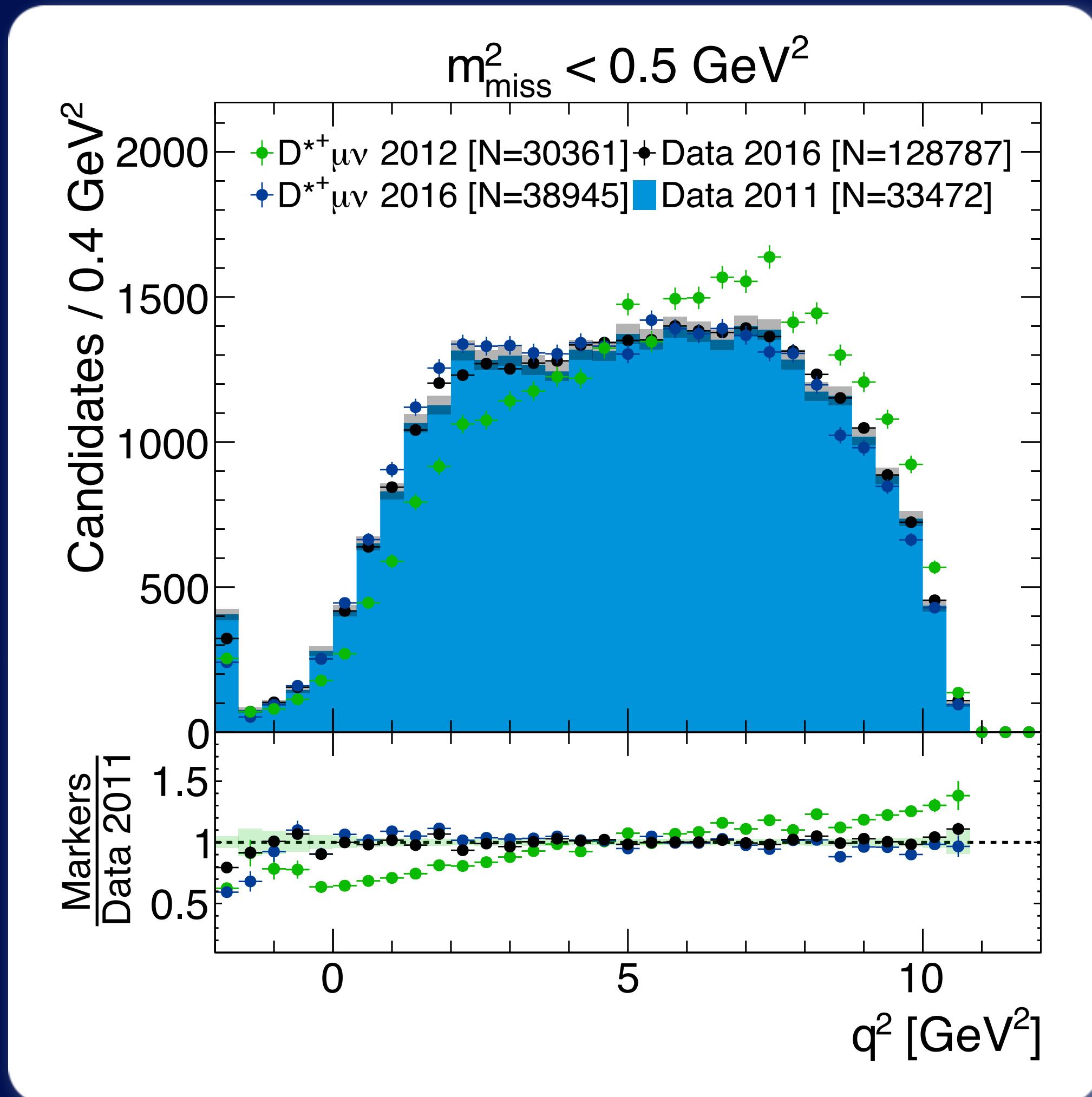
ϵ_{filter} is 7% in Run 1 and 23% in Run 2 (no trigger selection)

$f_{\text{MC}/\text{data}}$ from effective MC stats in templates and fitted yields in Run 1

7B events of simulated Tracker-only MC in Run 2

Run 1: Nsim = 924M / Ndisk = 65M FullSim + RICHless							Run 2: Nsim = 7,271M / Ndisk = 1,672M Tracker-only 2015-18						
#	Sample	Name	MC ID	ϵ_{gen}	Nsim [M]	Ndisk [M]	% total request	MC/ data fit	MC ID	ϵ_{gen}	Nsim [M]	Ndisk [M]	% total request
1	D0	$B^- \rightarrow D0 \mu \nu$	12573010	7.0%	110.0	7.7	45.6%	2.8	12573012	9.0%	700.6	161.1	53.1%
2	D0/D*+	$B0 \rightarrow D^*+ \mu \nu$	11574020	5.9%	88.6	6.2		1.4	11574021	8.0%	1195.0	274.9	
3	D0	$B^- \rightarrow D^*0 \mu \nu$	12573031	6.0%	222.9	15.6		2.1	12773410	8.1%	1966.9	452.4	
4	D0	$B^- \rightarrow D0 \tau \nu$	12573000	5.4%	7.3	0.5		2.8	12573001	7.3%	48.2	11.1	
5	D0/D*+	$B0 \rightarrow D^*+ \tau \nu$	11574010	5.0%	19.6	1.4	4.8%	1.4	11574011	6.8%	263.6	60.6	6.4%
6	D0	$B^- \rightarrow D^*0 \tau \nu$	12573021	5.0%	17.0	1.2	25.2%	2.1	12773400	6.8%	152.5	35.1	16.1%
7	D0/D*+	$B0 \rightarrow D^{**}+ \mu \nu$	11873010	5.0%	126.7	8.9		4.0	11874430	7.7%	671.1	154.4	
8	D0/D*+	$B0 \rightarrow D^{**}+ \tau \nu$	11873030	4.9%	1.1	0.1		3.0	11874440	6.6%	7.0	1.6	
9	D0/D*+	$B^- \rightarrow D^{**}0 \mu \nu$	12873010	5.7%	103.1	7.2		4.0	12873450	7.7%	482.3	110.9	
10	D0/D*+	$B^- \rightarrow D^{**}0 \tau \nu$	12873030	4.9%	1.7	0.1	7.7%	3.0	12873460	6.6%	10.4	2.4	6.3%
11	D0	$B^- \rightarrow D^{**}(\rightarrow D0\pi\pi) \mu \nu$	12675010	5.5%	15.5	1.1		3.0	12675011	7.4%	96.6	22.2	
12	D0	$B0 \rightarrow D^{**}(\rightarrow D0\pi\pi) \mu \nu$	11674400	5.0%	15.6	1.1		3.0	11674401	7.4%	106.7	24.5	
13	D0/D*+	$B^- \rightarrow D^{**}(\rightarrow D^*+\pi\pi) \mu \nu$	12675400	5.4%	11.0	0.8		3.0	12675402	7.3%	69.0	15.9	
14	D0/D*+	$B0 \rightarrow D^{**}(\rightarrow D^*+\pi\pi) \mu \nu$	11676010	5.0%	10.5	0.7	0.6%	3.0	11676012	7.3%	70.6	16.2	1.2%
15	D0	$B^- \rightarrow D^{**}(\rightarrow D^*0\pi\pi) \mu \nu$	12675430	5.4%	18.5	1.3		3.0	12875440	7.3%	115.7	26.6	
16	D0	$Bs \rightarrow Ds^{**}(\rightarrow D0K) \mu \nu$	13873000	5.5%	1.3	0.1		0.8	13874020	7.5%	29.8	6.9	
17	D*+	$Bs \rightarrow D^{**}+ \mu \nu$	13874000	5.4%	4.7	0.3		1.6	13674000	7.4%	54.8	12.6	
18	D0	$B0 \rightarrow D0(X_c \rightarrow \mu \nu X') X$	11873000	4.6%	37.8	2.6	9.7%	1.8	11894600	6.3%	395.3	90.9	11.9%
19	D0	$B0 \rightarrow D0(D_s \rightarrow \tau \nu) X$	11873020	5.4%	2.4	0.2		4.0	11894200	7.3%	11.3	2.6	
20	D0	$B^+ \rightarrow D0(X_c \rightarrow \mu \nu X') X$	12873000	5.0%	40.9	2.9		1.8	12896300	6.7%	421.2	96.9	
21	D0	$B^+ \rightarrow D0(D_s \rightarrow \tau \nu) X$	12873021	5.6%	8.4	0.6		4.0	12896310	7.5%	38.6	8.9	
22	D*+	$B0 \rightarrow D^*+(X_c \rightarrow \mu \nu X') X$	11874050	4.8%	41.4	2.9	6.5%	3.0	11894610	6.4%	258.6	59.5	5.0%
23	D*+	$B0 \rightarrow D^*+(D_s \rightarrow \tau \nu) X$	11874070	5.6%	3.9	0.3		4.0	11894210	7.5%	17.9	4.1	
24	D*+	$B^+ \rightarrow D^*+(X_c \rightarrow \mu \nu X') X$	12874010	4.6%	12.0	0.8		3.0	12895400	6.4%	75.8	17.4	
25	D*+	$B^+ \rightarrow D^*+(D_s \rightarrow \tau \nu) X$	12874030	5.0%	2.3	0.2		4.0	12895000	6.8%	11.1	2.6	

MC/data in
Runs 1 and 2



$\mathcal{R}(D^{0,*})$ trigger/stripping selection

```
L0_run1 = "mu_L0Global_TIS & (b0_L0Global_TIS |  
dst_L0HadronDecision_TOS)";  
  
HLT1_run1 = "k_Hlt1TrackAllL0Decision_TOS |  
pi_Hlt1TrackAllL0Decision_TOS";  
  
HLT2_run1 = "d0_Hlt2CharmHadD02HH_D02KPiDecision_TOS";  
  
L0_run2 = "b0_L0Global_TIS | dst_L0HadronDecision_TOS";  
  
HLT1_run2 = "k_Hlt1TrackMVADecision_TOS |  
pi_Hlt1TrackMVAeDecision_TOS | d0_Hlt1TwoTrackMVADecision_TOS";  
  
HLT2_run2 = "d0_Hlt2XcMuXForTauB2XcMuDecision_Dec";
```

Particle	Variable	Run 1	Run 2
K, π	$\chi^2_{\text{track}}/\text{ndf}$	< 3	—
	p_T	> 800 MeV	> 200 MeV
	p	> 5000 MeV	> 5000 MeV
	Max p_T	> 1500 MeV	> 800 MeV
	$\text{IP}\chi^2$	> 9	—
D^0	$DLLK$	—	> 4(K), < 2(π)
	DIRA	> 0.99985	> 0.999
	p_T	> 2000 MeV	> 2000 MeV
	Mass	1815–1915 MeV	1830–1910 MeV
	$\chi^2_{\text{vertex}}/\text{ndf}$	< 10	< 10
μ	$\text{FD}\chi^2$	> 40	> 25
	Sum track p_T	—	> 2500 MeV
	Child pair DOCA	—	< 0.1 mm
	$\text{IP}\chi^2$	—	> 16
	$\chi^2_{\text{vertex}}/\text{ndf}$	—	> 15
$D^0\mu$	DIRA	—	> 0.999
	DOCA	—	< 0.5 mm
	$\text{FD}\chi^2$	—	> 50

Higher efficiency in Run 2 thanks to
new triggers and stripping

Table 2: Stripping selection in Run 1 (Strippingb2D0MuXB2DMuNuForTauMuLine in S21) and Run 2 (Strippingb2D0MuXB2DMuForTauMuLine in S28r1).

Event-Level	Variable	Run 1	Run 2
GEC	nSPDhits	< 600	< 600
PV cut	nPV	≥ 1	≥ 1
Particle	Variable	Selection	
K, π	K, π	p_T	> 300 MeV
		p	> 2 GeV
		$\text{IP}\chi^2$	> 45
		isMuon	False?
		$DLLK$	> 4(K), < 2(π)
		GhostProb	< 0.5
D^0	D^0	$ p_T(\pi) + p_T(K) $	> 1.4 GeV
		$\chi^2_{\text{fit}}/\text{DOF}$	< 4
		DIRA	> 0.9998
		$FD\chi^2$	> 250
		$m - \langle m \rangle$	< 80 MeV
μ	μ	isMuon	True?
		$\text{IP}\chi^2$	> 45
		GhostProb	< 0.5
		PID μ	> 2
$D^0\mu$	$D^0\mu$	p	> 3 GeV
		Mass	< 10 GeV
		$\chi^2_{\text{fit}}/\text{DOF}$	< 6
		DIRA	> 0.9995

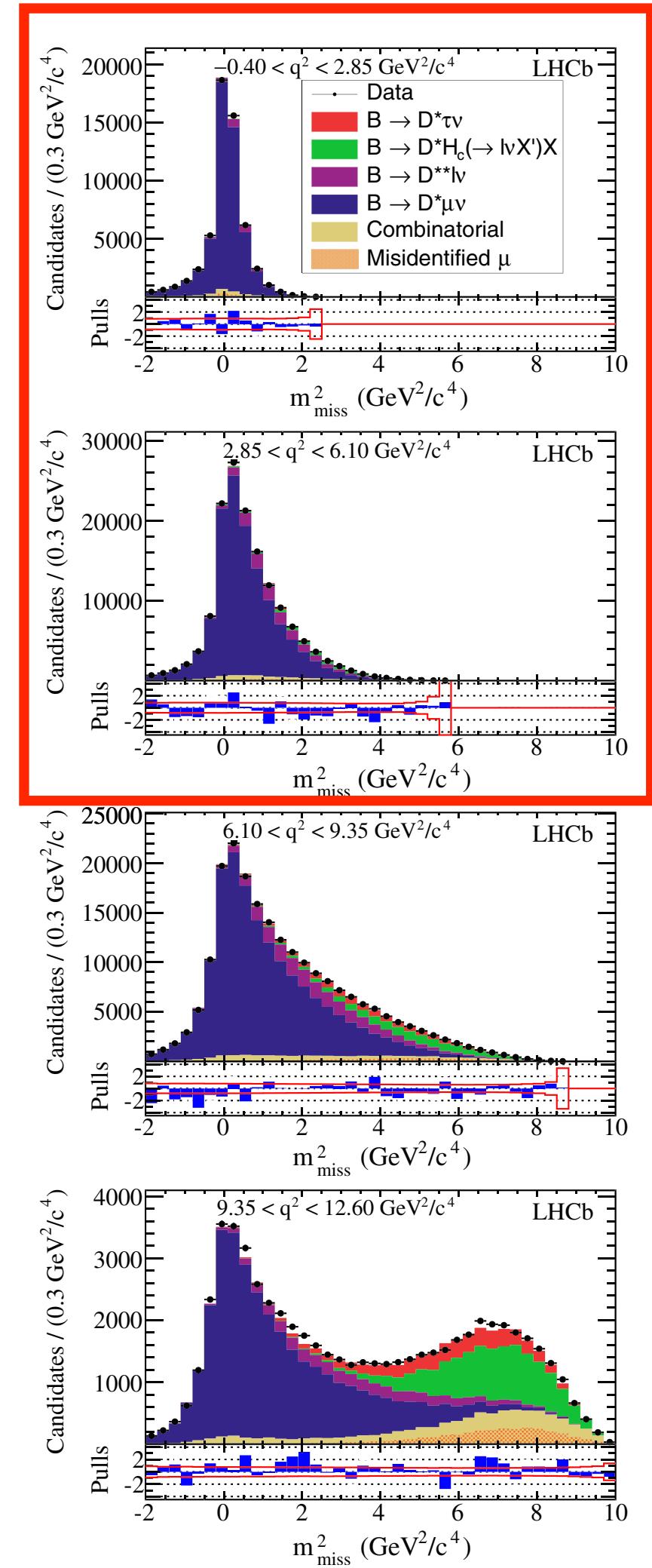
ϵ increase in Run 2 - data

Particle	Variable	Selection
K, π	p_T	$> 0.8 \text{ GeV}$
	p_T (TOS track)	$> 1.7 \text{ GeV}$
	$IP\chi^2$	> 45
D^0	p_T	$> 2 \text{ GeV}$
	$\ln IP$	> -3.5
	$IP\chi^2$	> 9
	$DIRA$	> 0.9998
	Flight dist. χ^2 (PV)	> 250
	$m - \langle m \rangle$	$< 23.4 \text{ MeV}$
	$isMuon$	true
μ	p	$< 100 \text{ GeV}$
	η	$1.7 < \eta < 5$
	$DLLmu$	> 2
	$DLLe$	< 1
	$BDTmu$	> 0.25
	$\log_{10}(1 - \vec{p}_\mu \cdot \vec{p}_i / (p_\mu p_i))$	> -6.5
	$\chi^2_{\text{fit}}/\text{DOF}$	< 10
D^{*+}	$\Delta m - \langle \Delta m \rangle$	$< 2 \text{ MeV}$
	$\pi_s \text{GhostProb}$	< 0.25
	$\chi^2_{\text{fit}}/\text{DOF}$	< 6
$\{D^0\mu\}$ subcomb.	$DIRA$	> 0.9995
	$\chi^2_{\text{fit}}/\text{DOF}$	< 6
B^0	d_{XY} (transverse FD)	$< 7 \text{ mm}$
	$DIRA$	> 0.9995
	Mass	$< 5280 \text{ MeV}$
	Max iso BDT in event	0.15

ϵ increases ~40% with Run 1 cuts

Cut	Data 2011	Data 2016	Ratio $\times 0.35$
Trig. + Strip.	213,908	3,115,751	5.16
+ Kaon	213,806	2,361,759	3.91
+ Pion	213,709	1,825,670	3.03
+ $D^0 \rightarrow K\pi$	165,262	1,074,939	2.30
+ μ	155,915	888,951	2.02
+ $D^{*+} \rightarrow D^0\pi$	125,026	688,590	1.95
+ $B^0 \rightarrow D^{*+}\mu$	120,200	652,638	1.92
+ ISO	77,156	346,689	1.59
+ PID	74,754	288,795	1.37
$q^2 < 6 \text{ GeV}^2$	32,280	125,126	1.37
$q^2 > 6 \text{ GeV}^2$	42,474	163,669	1.37
Cut	Data 2011	Data 2016	Ratio $\times 0.35$

Fairly pure $D^+\mu\nu$ for $q^2 < 6 \text{ GeV}^2$



Luminosity ratio of 1.41 and cross section ratio of 2

$$\frac{\epsilon_{2016}^{data}}{\epsilon_{2011}^{data}} = \frac{N_{2016}^{table}}{N_{2011}^{table}} \times \frac{\mathcal{L}_{2011}}{\mathcal{L}_{2016}} \times \frac{\sigma_{2011}^{b\bar{b}}}{\sigma_{2016}^{b\bar{b}}} = \frac{N_{2016}^{table}}{N_{2011}^{table}} \times \frac{1}{1.41 \times 2}$$

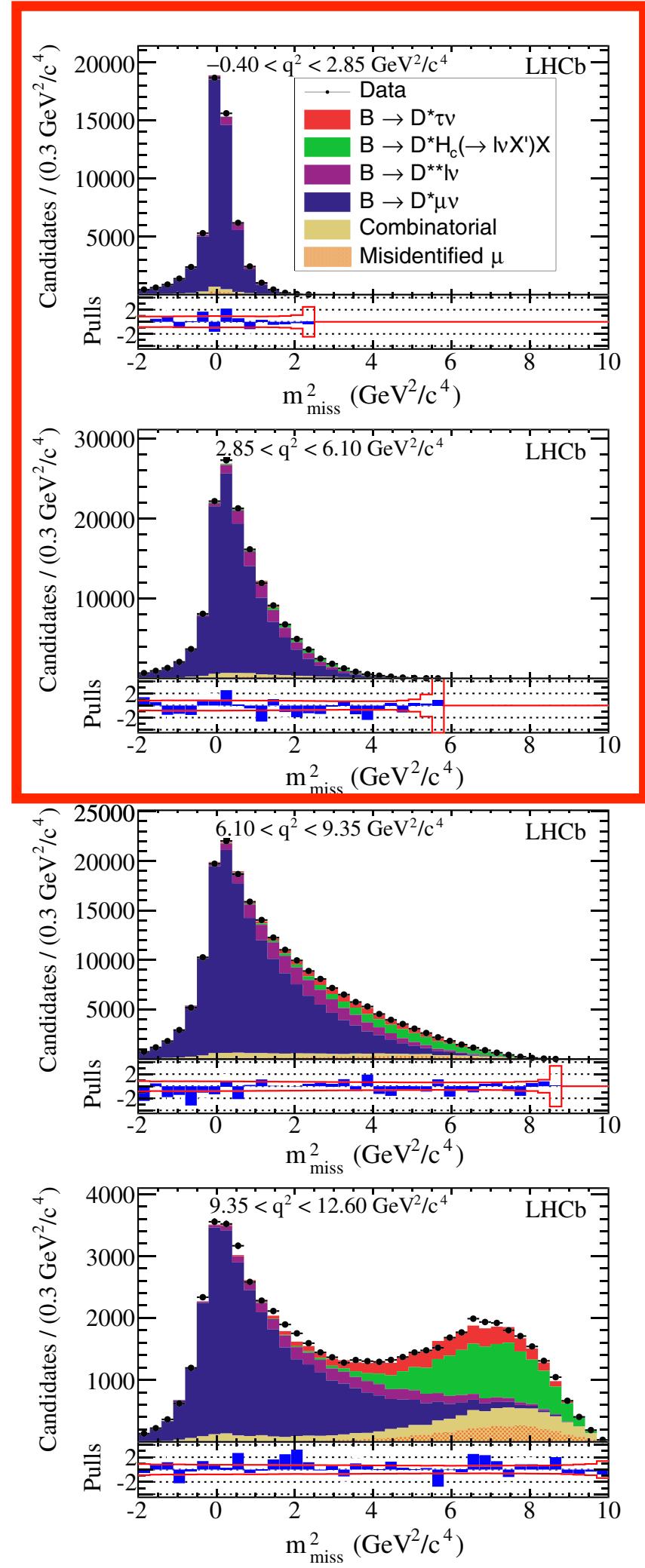
ϵ increase in Run 2 - data

Particle	Variable	Selection	Comment
K, π	p_T	$> 0.8 \text{ GeV}$	Can be loosened to $> 0.2 \text{ GeV}$
	p_T (TOS track)	$> 1.7 \text{ GeV}$	
	$IP\chi^2$	> 45	Can be loosened to > 9
D^0	p_T	$> 2 \text{ GeV}$	
	$\ln IP$	> -3.5	
	$IP\chi^2$	> 9	
	$DIRA$	> 0.9998	Can be loosened to > 0.999
	Flight dist. χ^2 (PV)	> 250	Can be loosened to > 25
	$m - \langle m \rangle$	$< 23.4 \text{ MeV}$	
μ	$isMuon$	true	
	p	$< 100 \text{ GeV}$	
	η	$1.7 < \eta < 5$	
	$DLLmu$	> 2	
	$DLLe$	< 1	
	$BDTmu$	> 0.25	Not implemented yet
D^{*+}	$\log_{10}(1 - \vec{p}_\mu \cdot \vec{p}_i / (p_\mu p_i))$	> -6.5	$i = K, \pi, \pi_s$
	$\chi^2_{\text{fit}}/\text{DOF}$	< 10	
	$\Delta m - \langle \Delta m \rangle$	$< 2 \text{ MeV}$	
$\{D^0\mu\}$ subcomb.	$\pi_s\text{GhostProb}$	< 0.25	
	$\chi^2_{\text{fit}}/\text{DOF}$	< 6	
	$DIRA$	> 0.9995	Can be loosened to > 0.999
B^0	$\chi^2_{\text{fit}}/\text{DOF}$	< 6	
	d_{XY} (transverse FD)	$< 7 \text{ mm}$	
	$DIRA$	> 0.9995	Can be loosened to > 0.999
	Mass	$< 5280 \text{ MeV}$	
Max iso BDT in event		0.15	Needs to be optimized

ϵ increases ~40% with Run 1 cuts

Cut	Data 2011	Data 2016	Ratio $\times 0.35$
Trig. + Strip.	213,908	3,115,751	5.16
+ Kaon	213,806	2,361,759	3.91
+ Pion	213,709	1,825,670	3.03
+ $D^0 \rightarrow K\pi$	165,262	1,074,939	2.30
+ μ	155,915	888,951	2.02
+ $D^{*+} \rightarrow D^0\pi$	125,026	688,590	1.95
+ $B^0 \rightarrow D^{*+}\mu$	120,200	652,638	1.92
+ ISO	77,156	346,689	1.59
+ PID	74,754	288,795	1.37
$q^2 < 6 \text{ GeV}^2$	32,280	125,126	1.37
$q^2 > 6 \text{ GeV}^2$	42,474	163,669	1.37
Cut	Data 2011	Data 2016	Ratio $\times 0.35$

Fairly pure $D^{*+}\mu\nu$ for $q^2 < 6 \text{ GeV}^2$



ϵ can increase ~170% with looser cuts

Cut	Data 2011	Data 2016	Ratio $\times 0.35$
Trig. + Strip.	213,908	3,115,751	5.16
+ Kaon	213,806	2,598,685	4.31
+ Pion	213,709	2,235,955	3.71
+ $D^0 \rightarrow K\pi$	165,262	1,767,519	3.79
+ μ	155,915	1,472,867	3.35
+ $D^{*+} \rightarrow D^0\pi$	125,026	1,104,452	3.13
+ $B^0 \rightarrow D^{*+}\mu$	120,200	1,059,868	3.12
+ ISO	77,156	581,947	2.67
+ PID	74,754	480,092	2.28
$q^2 < 6 \text{ GeV}^2$	32,280	248,735	2.73
$q^2 > 6 \text{ GeV}^2$	42,474	231,357	1.93
Cut	Data 2011	Data 2016	Ratio $\times 0.35$

ϵ increase in Run 2 - MC

Cut	$D^{*+}\tau\nu$ 2011	$D^{*+}\tau\nu$ 2016	Ratio $\times 1.00$
L0	3,403	3,796	1.12
+ HLT1	1,234	2,040	1.65
+ HLT2	498	1,113	2.23
+ Full strip.	53	152	2.87
+ Kaon	53	127	2.40
+ Pion	53	100	1.89
+ $D^0 \rightarrow K\pi$	44	76	1.73
+ μ	43	65	1.51
+ $D^{*+} \rightarrow D^0\pi$	41	57	1.39
+ $B^0 \rightarrow D^{*+}\mu$	29	52	1.79
+ ISO	27	44	1.63
+ PID	26	40	1.54
$q^2 < 6 \text{ GeV}^2$	1	4	4.00
$q^2 > 6 \text{ GeV}^2$	25	36	1.44
Cut	$D^{*+}\tau\nu$ 2011	$D^{*+}\tau\nu$ 2016	Ratio $\times 1.00$

Signal

Cut	$D^{*+}\mu\nu$ 2011	$D^{*+}\mu\nu$ 2016	Ratio $\times 1.00$
L0	62,766	71,385	1.14
+ HLT1	27,569	41,637	1.51
+ HLT2	11,669	25,804	2.21
+ Full strip.	1,086	3,119	2.87
+ Kaon	1,086	2,615	2.41
+ Pion	1,086	2,168	2.00
+ $D^0 \rightarrow K\pi$	940	1,384	1.47
+ μ	875	1,170	1.34
+ $D^{*+} \rightarrow D^0\pi$	818	1,096	1.34
+ $B^0 \rightarrow D^{*+}\mu$	785	1,041	1.33
+ ISO	649	811	1.25
+ PID	633	744	1.18
$q^2 < 6 \text{ GeV}^2$	289	342	1.18
$q^2 > 6 \text{ GeV}^2$	344	402	1.17
Cut	$D^{*+}\mu\nu$ 2011	$D^{*+}\mu\nu$ 2016	Ratio $\times 1.00$

Normalization

Cut	$D^{*+}\mu\nu$ 2011	$D^{*+}\mu\nu$ 2016	Ratio $\times 1.00$
L0	62,766	71,385	1.14
+ HLT1	27,569	41,637	1.51
+ HLT2	11,669	25,804	2.21
+ Full strip.	1,086	3,119	2.87
+ Kaon	1,086	2,799	2.58
+ Pion	1,086	2,518	2.32
+ $D^0 \rightarrow K\pi$	940	2,282	2.43
+ μ	875	1,971	2.25
+ $D^{*+} \rightarrow D^0\pi$	818	1,828	2.23
+ $B^0 \rightarrow D^{*+}\mu$	785	1,773	2.26
+ ISO	649	1,389	2.14
+ PID	633	1,247	1.97
$q^2 < 6 \text{ GeV}^2$	289	686	2.37
$q^2 > 6 \text{ GeV}^2$	344	561	1.63
Cut	$D^{*+}\mu\nu$ 2011	$D^{*+}\mu\nu$ 2016	Ratio $\times 1.00$

D^{}**

ϵ increases
~50% with
Run 1 cuts

Cocktail [11874091](#)

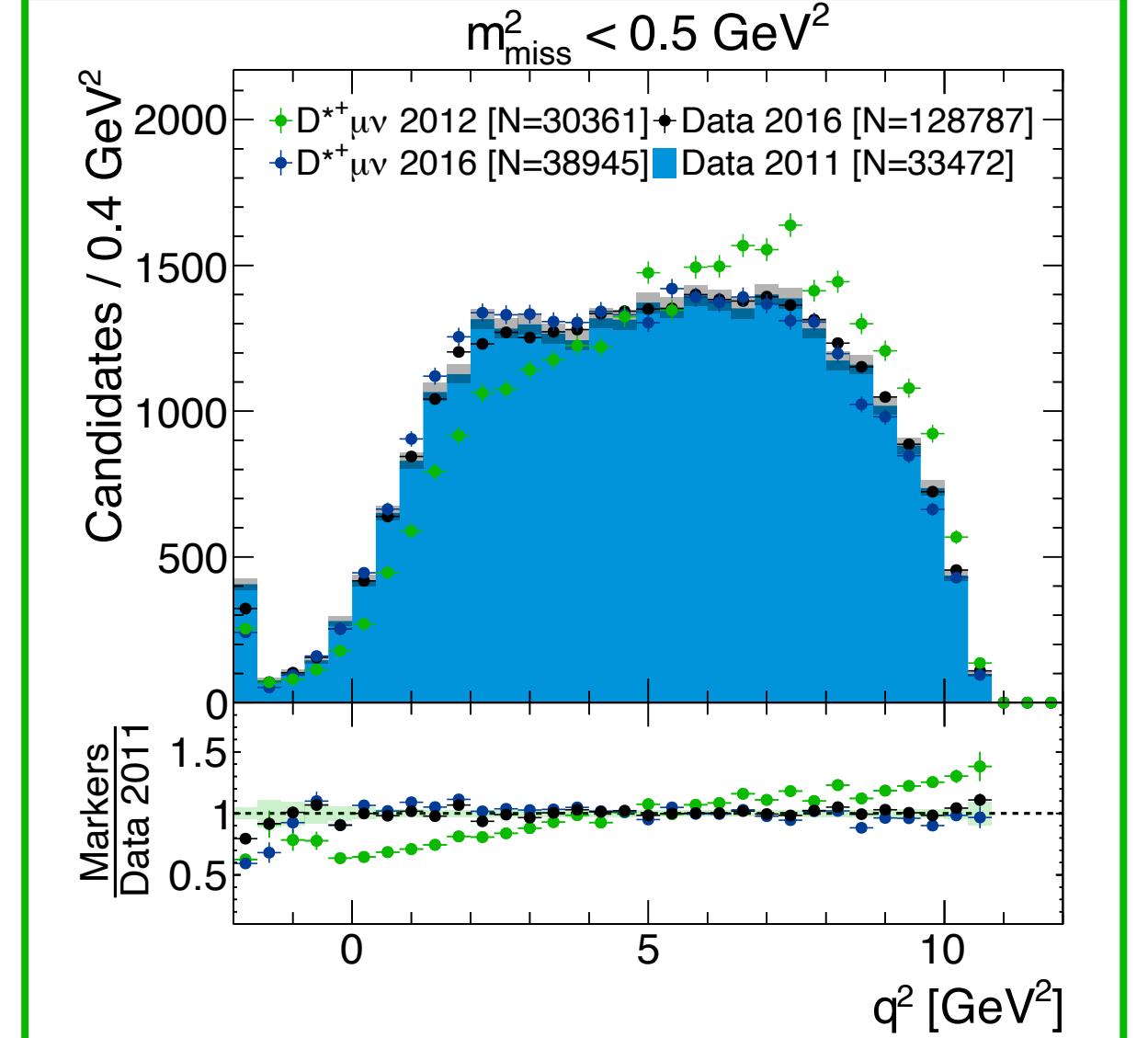
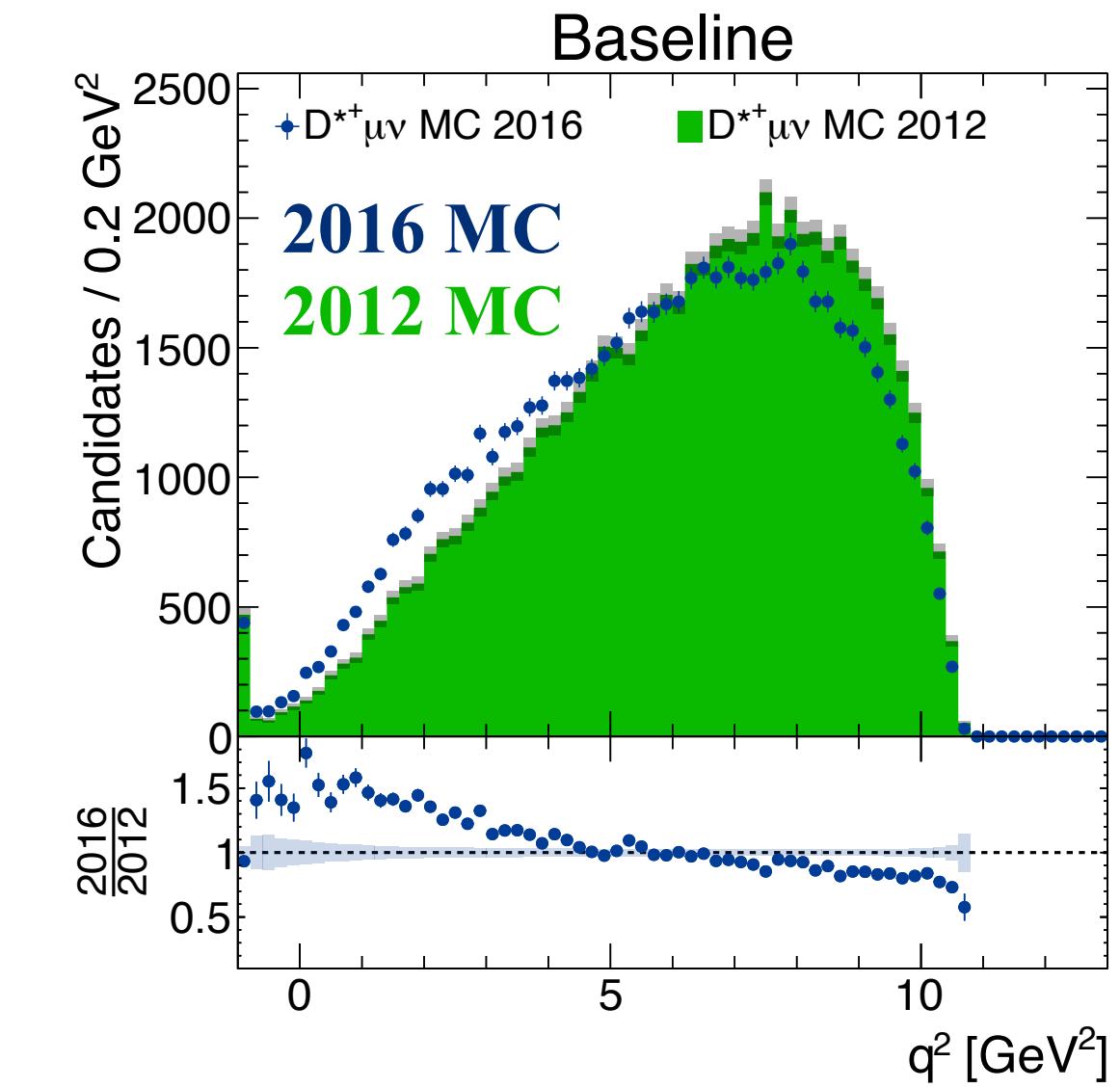
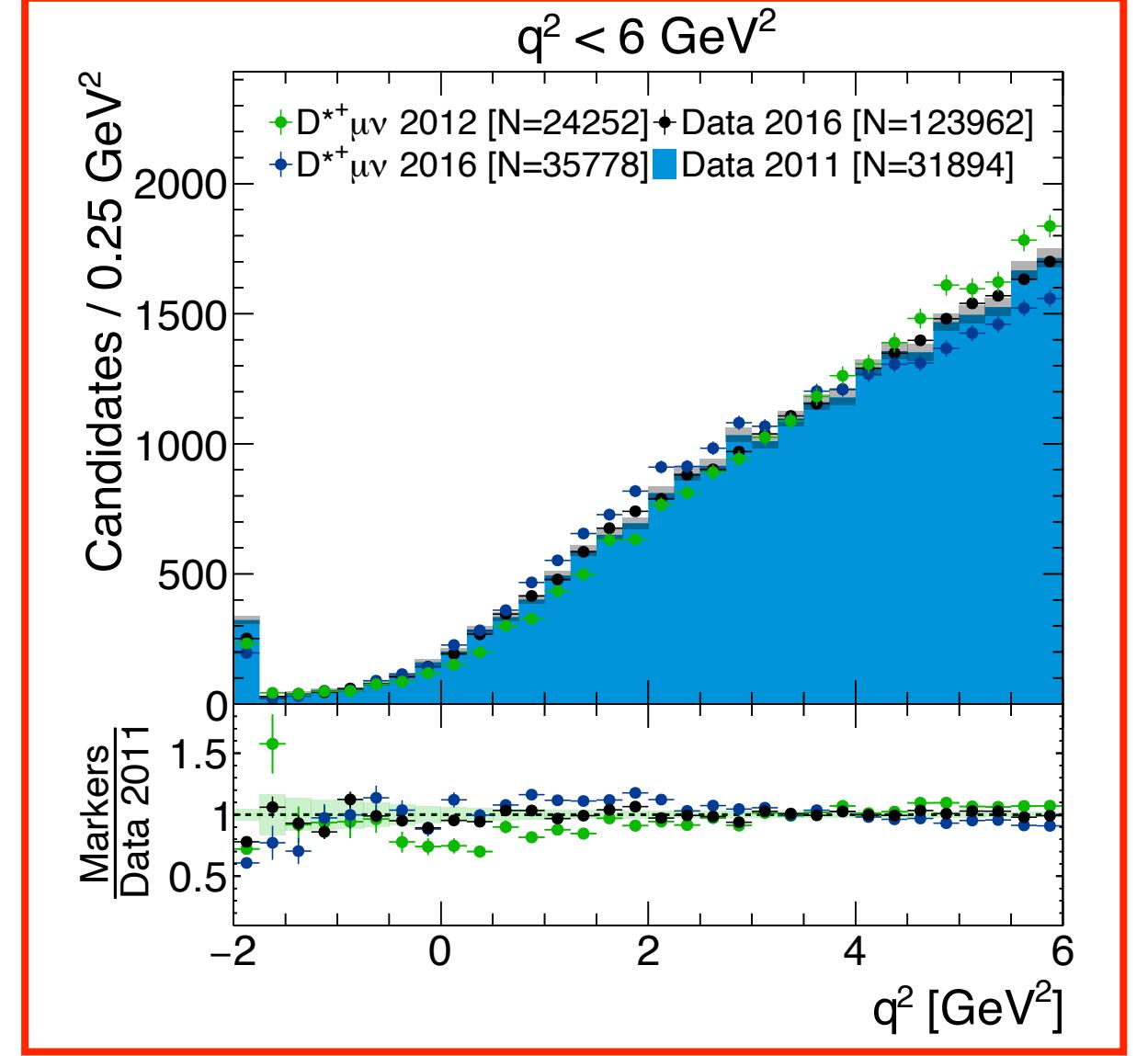
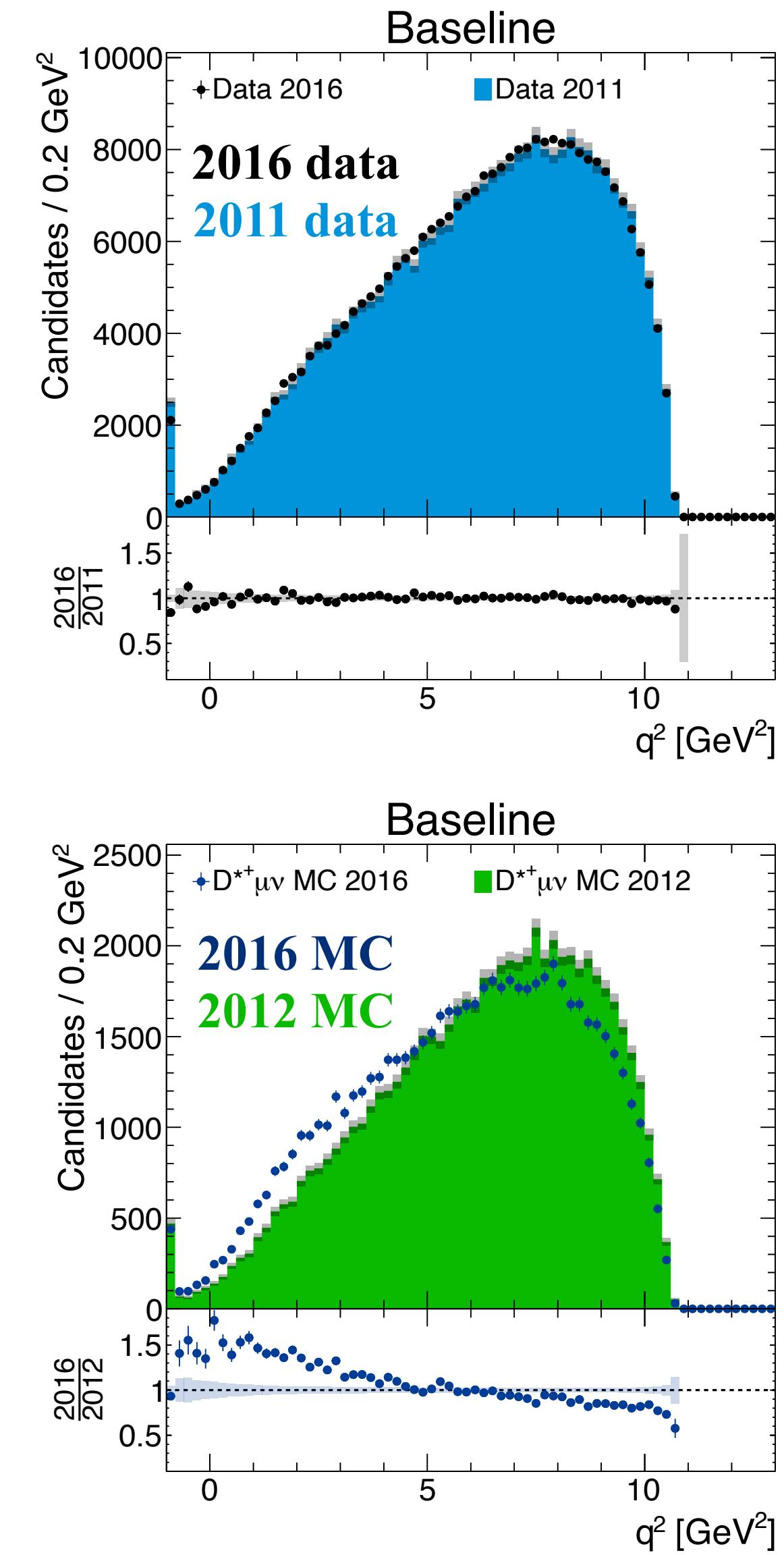
Cut	$D^{*+}\tau\nu$ 2011	$D^{*+}\tau\nu$ 2016	Ratio $\times 1.00$
L0	3,403	3,796	1.12
+ HLT1	1,234	2,040	1.65
+ HLT2	498	1,113	2.23
+ Full strip.	53	152	2.87
+ Kaon	53	138	2.60
+ Pion	53	128	2.42
+ $D^0 \rightarrow K\pi$	44	110	2.50
+ μ	43	97	2.26
+ $D^{*+} \rightarrow D^0\pi$	41	86	2.10
+ $B^0 \rightarrow D^{*+}\mu$	29	79	2.72
+ ISO	27	64	2.37
+ PID	26	59	2.27
$q^2 < 6 \text{ GeV}^2$	1	6	6.00
$q^2 > 6 \text{ GeV}^2$	25	53	2.12
Cut	$D^{*+}\tau\nu$ 2011	$D^{*+}\tau\nu$ 2016	Ratio $\times 1.00$

Cut	$D^{*+}\mu\nu$ 2011	$D^{*+}\mu\nu$ 2016	Ratio $\times 1.00$
L0	32,364	36,978	1.14
+ HLT1	13,606	21,264	1.56
+ HLT2	5,533	12,177	2.20
+ Full strip.	206	723	3.51
+ Kaon	206	630	3.06
+ Pion	206	574	2.79
+ $D^0 \rightarrow K\pi$	185	516	2.79
+ μ	179	453	2.53
+ $D^{*+} \rightarrow D^0\pi$	150	366	2.44
+ $B^0 \rightarrow D^{*+}\mu$	140	357	2.55
+ ISO	38	124	3.26
+ PID	38	111	2.92
$q^2 < 6 \text{ GeV}^2$	13	50	3.85
$q^2 > 6 \text{ GeV}^2$	25	61	2.44
Cut	$D^{*+}\mu\nu$ 2011	$D^{*+}\mu\nu$ 2016	Ratio $\times 1.00$

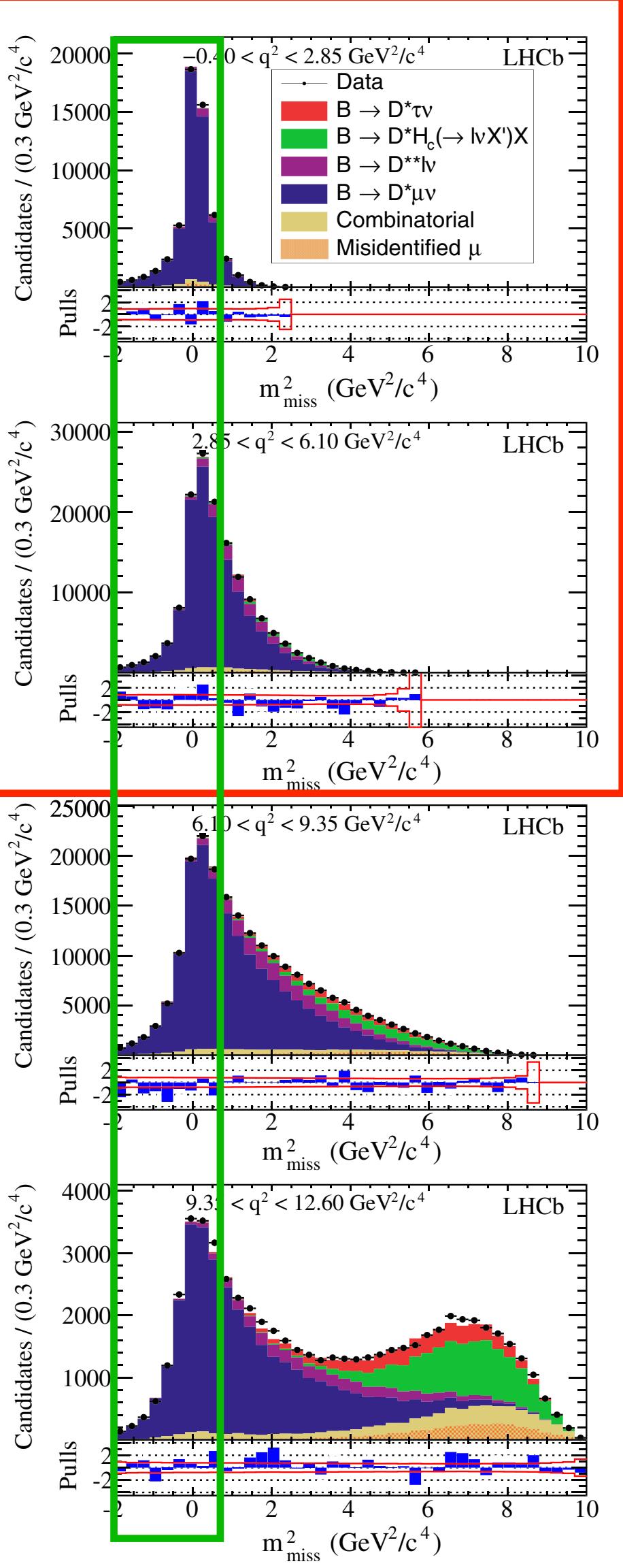
Cut	$D^{*+}\mu\nu$ 2011	$D^{*+}\mu\nu$ 2016	Ratio $\times 1.00$
L0	32,364	36,978	1.14
+ HLT1	13,606	21,264	1.56
+ HLT2	5,533	12,177	2.20
+ Full strip.	206	723	3.51
+ Kaon	206	591	2.87
+ Pion	206	486	2.36
+ $D^0 \rightarrow K\pi$	185	326	1.76
+ μ	179	289	1.61
+ $D^{*+} \rightarrow D^0\pi$	150	235	1.57
+ $B^0 \rightarrow D^{*+}\mu$	140	228	1.63
+ ISO	38	74	1.95
+ PID	38	69	1.82
$q^2 < 6 \text{ GeV}^2$	13	27	2.08
$q^2 > 6 \text{ GeV}^2$	25	42	1.68
Cut	$D^{*+}\mu\nu$ 2011	$D^{*+}\mu\nu$ 2016	Ratio $\times 1.00$

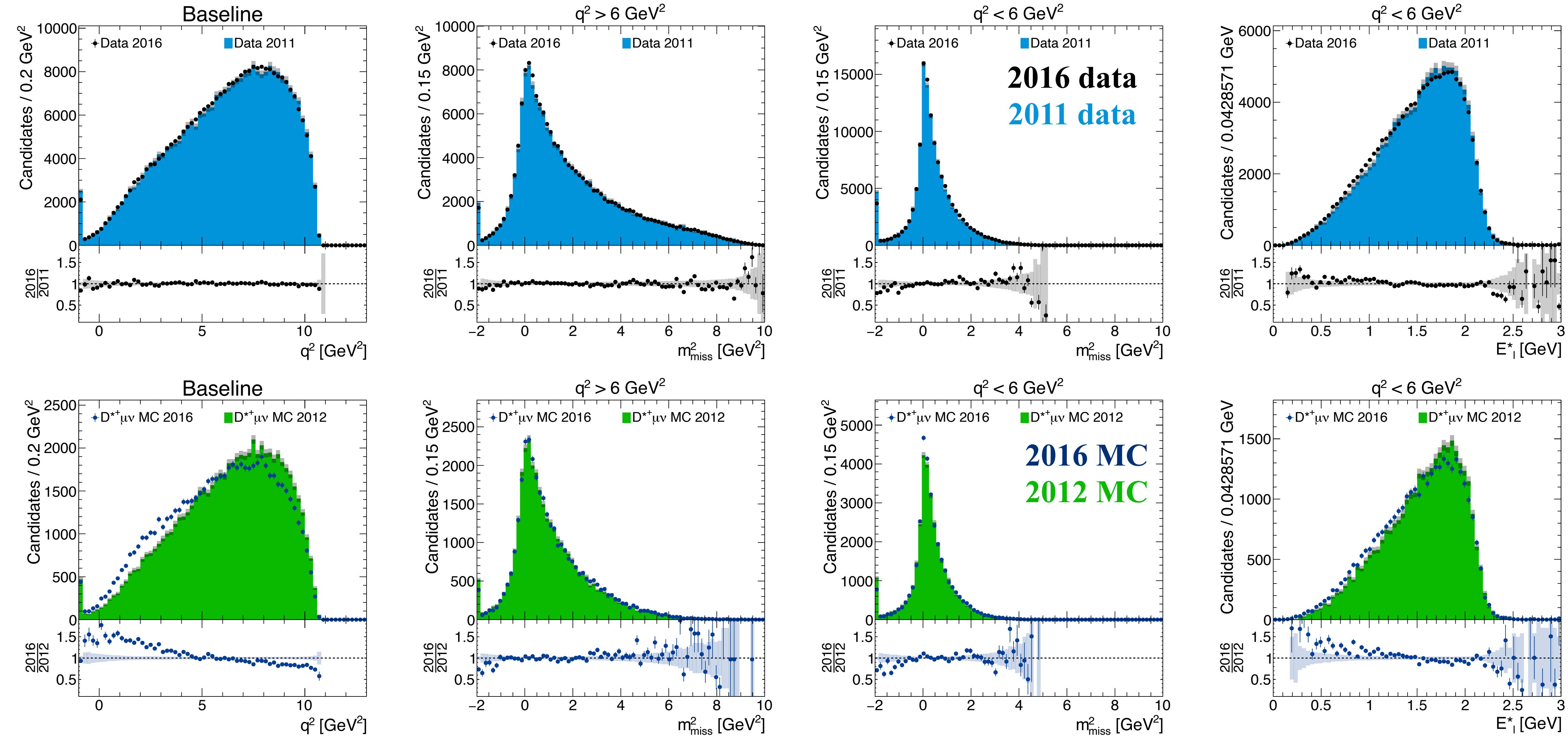
ϵ can increase
~110% with
looser cuts
(needs
optimization)

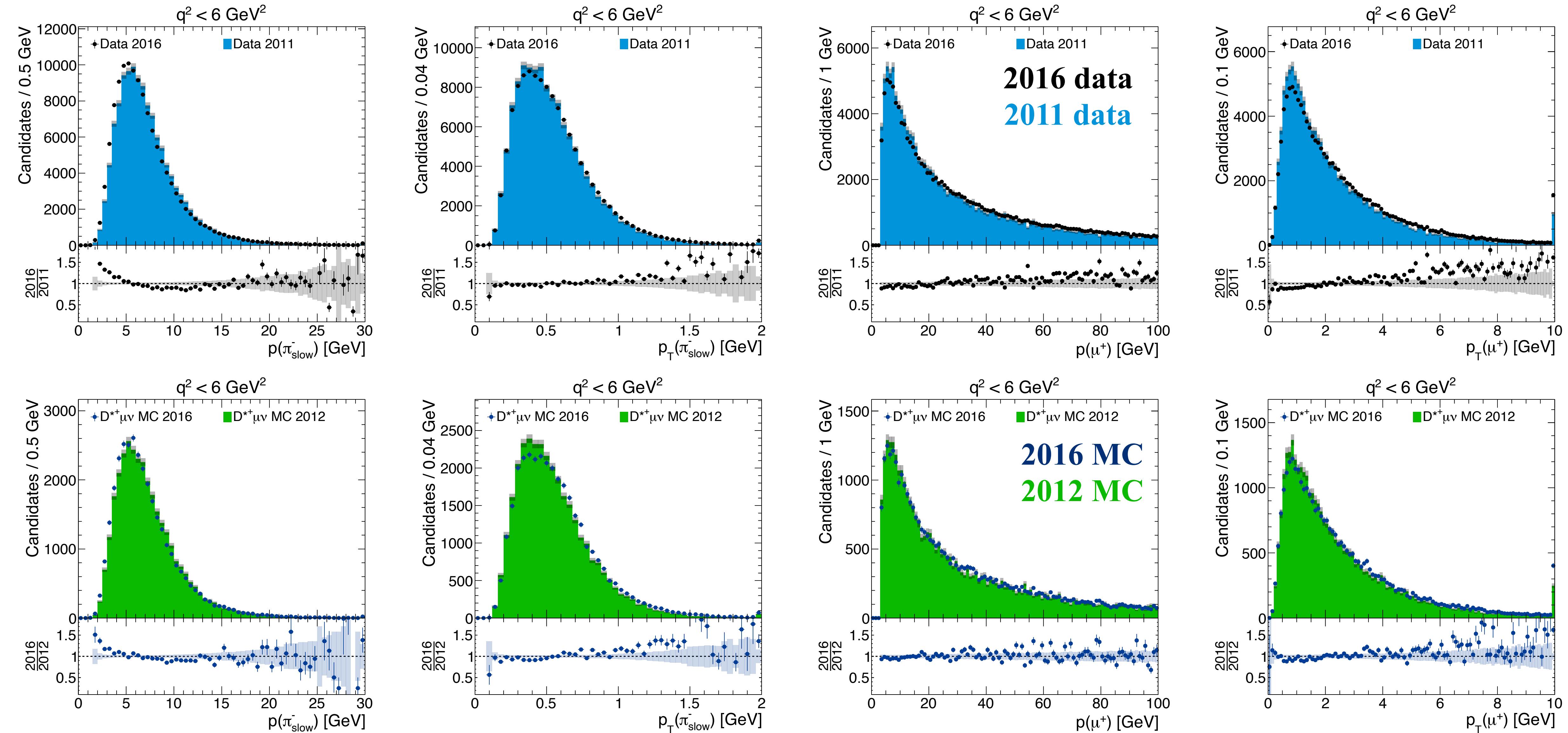
New $D^{*+}\mu\nu$ FF have better agreement



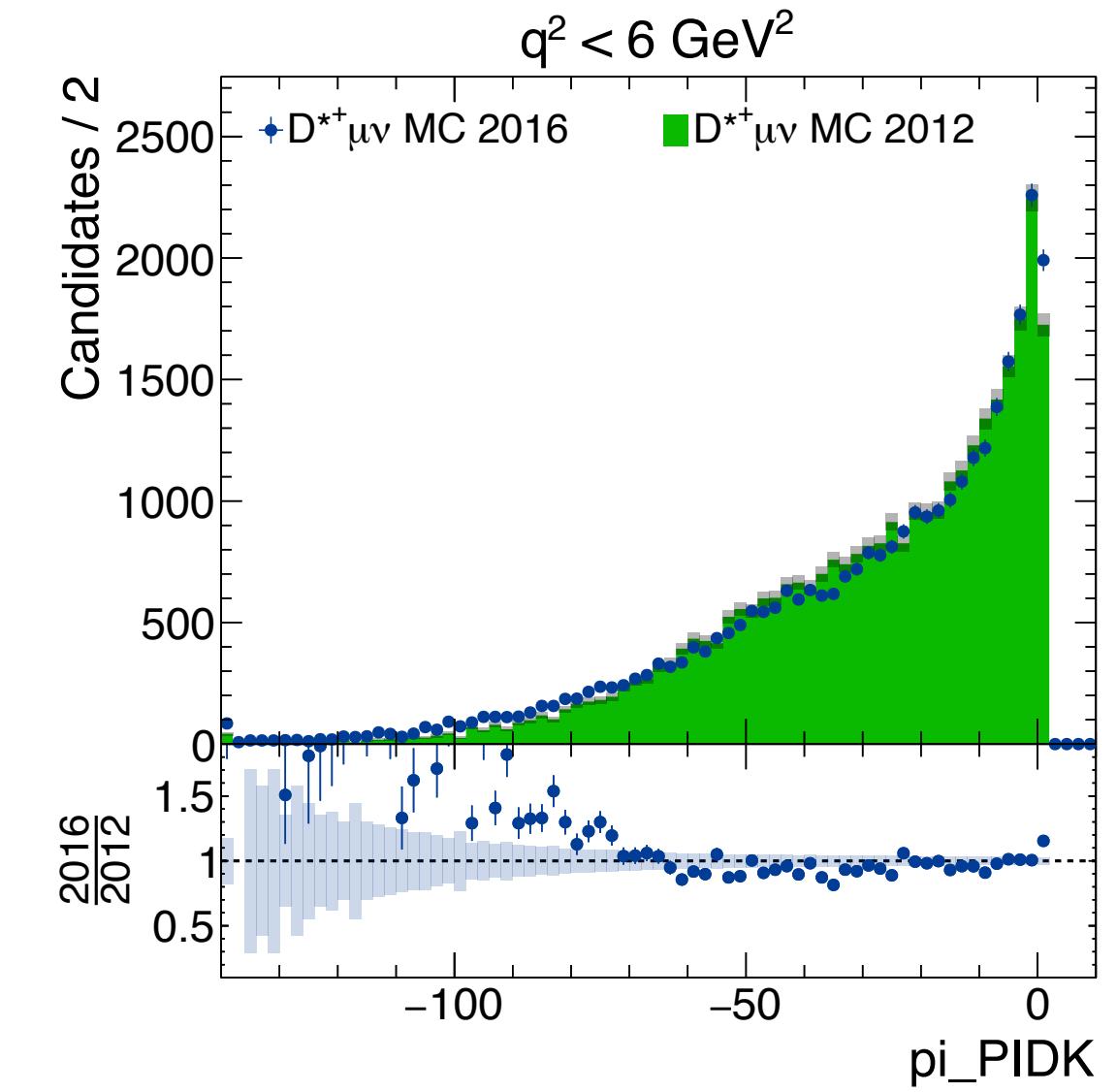
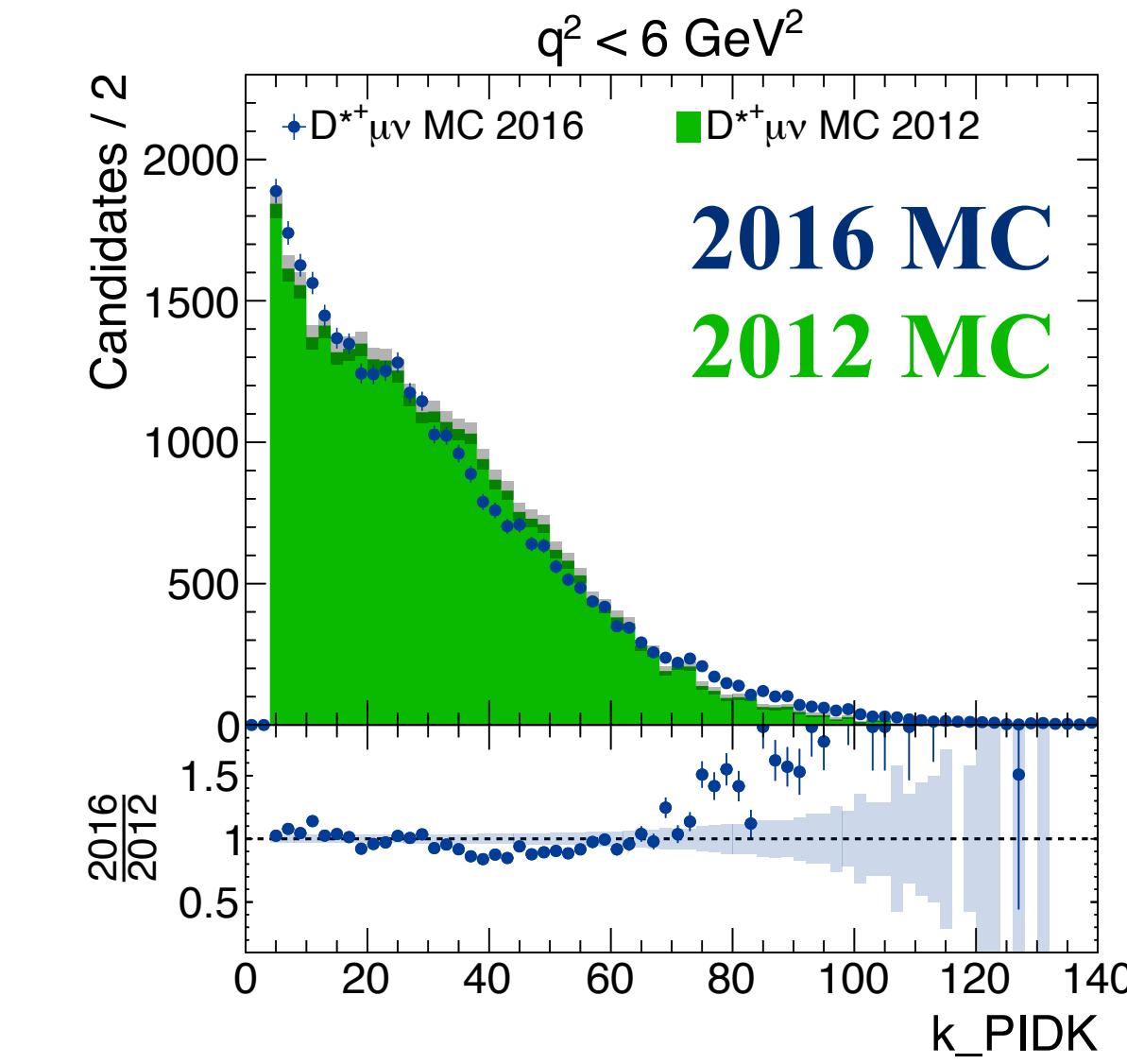
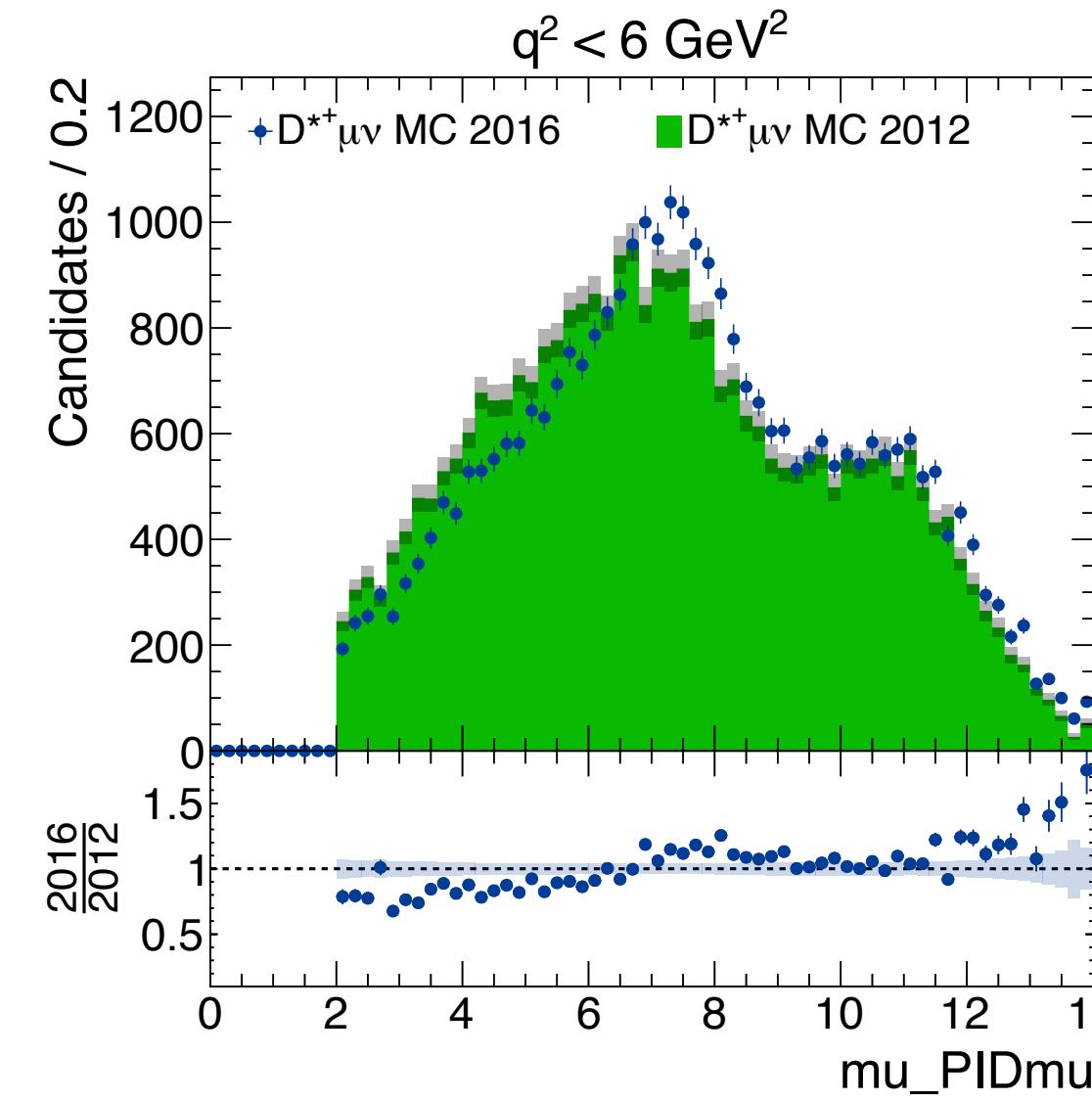
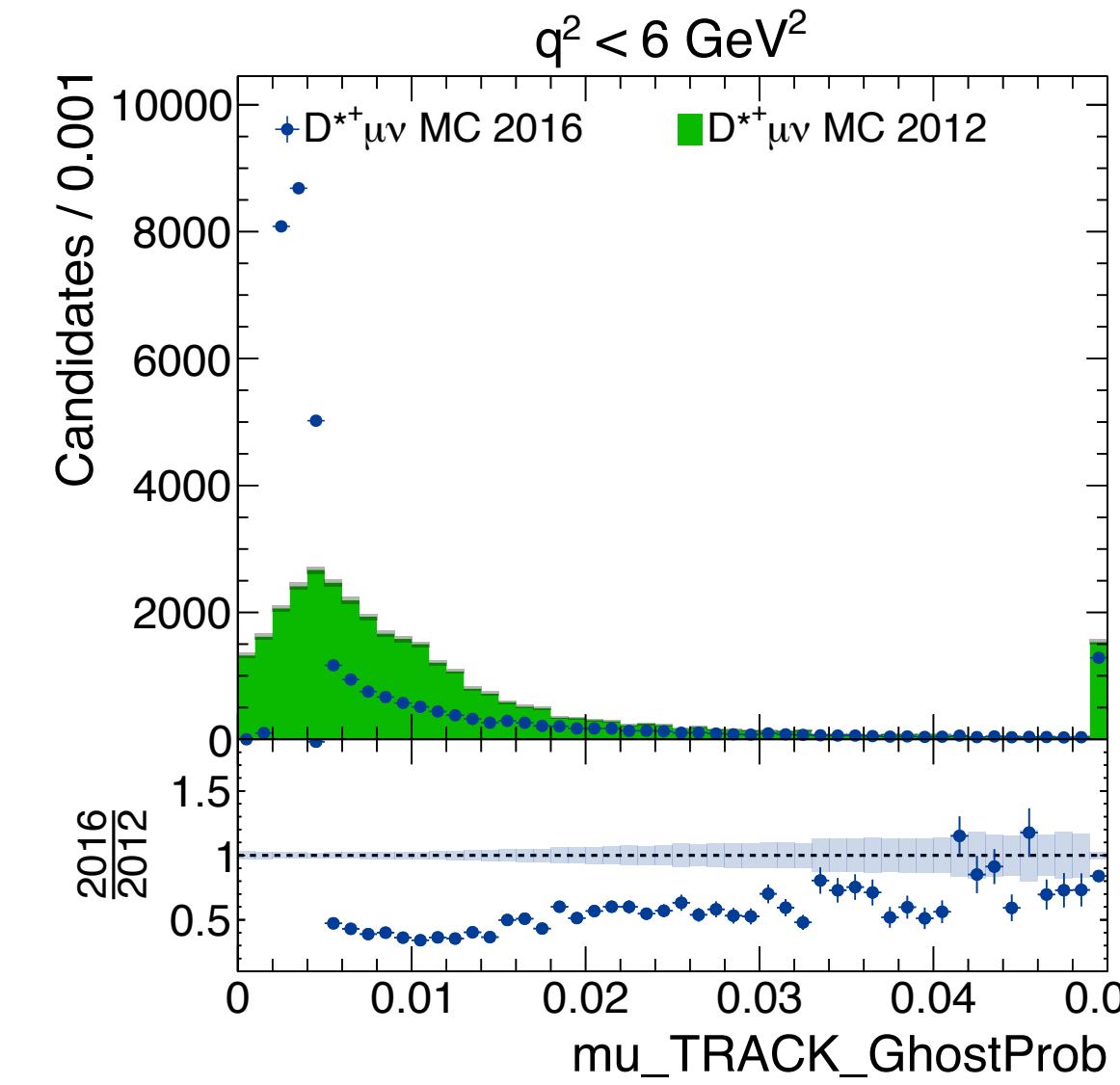
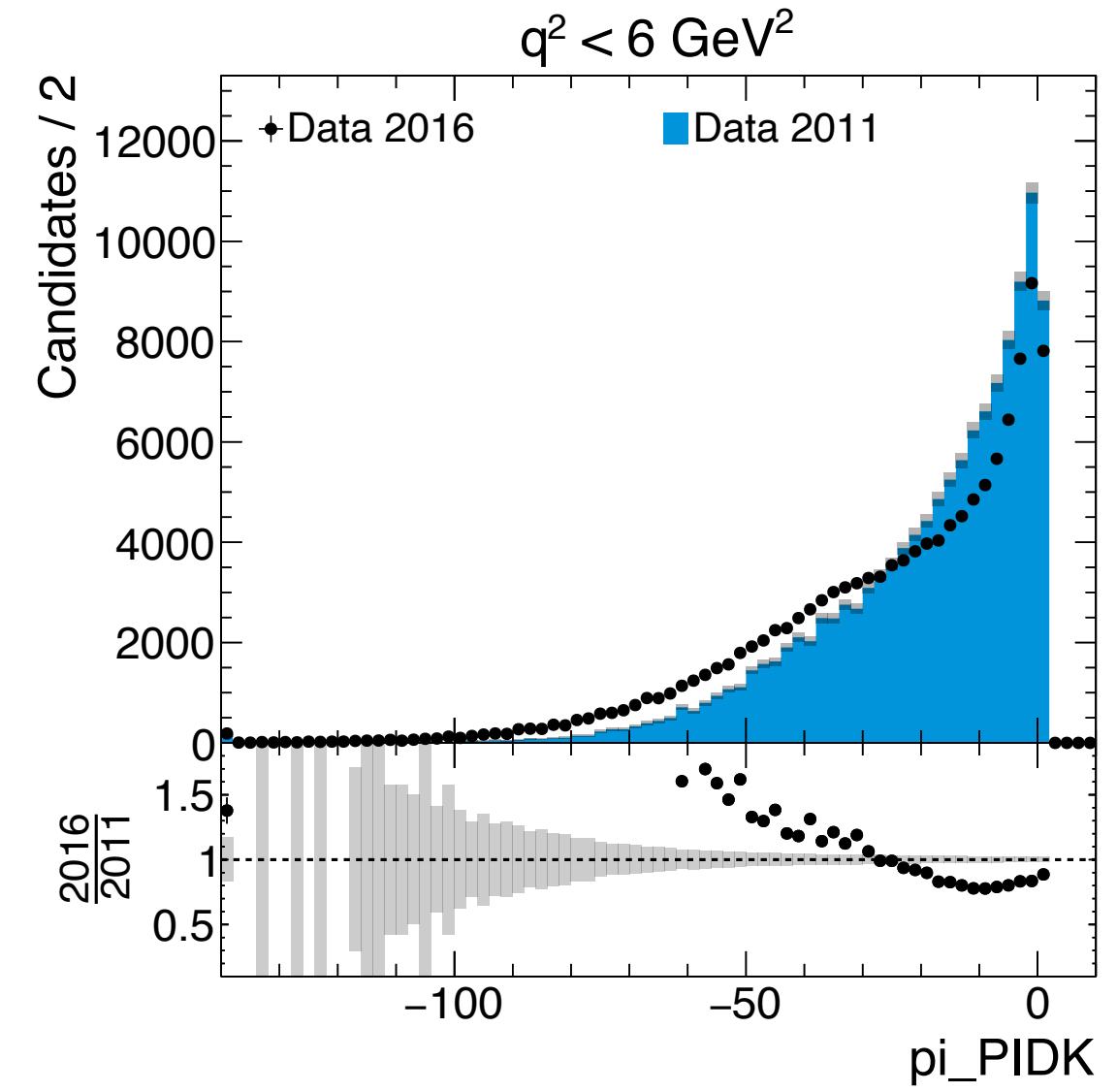
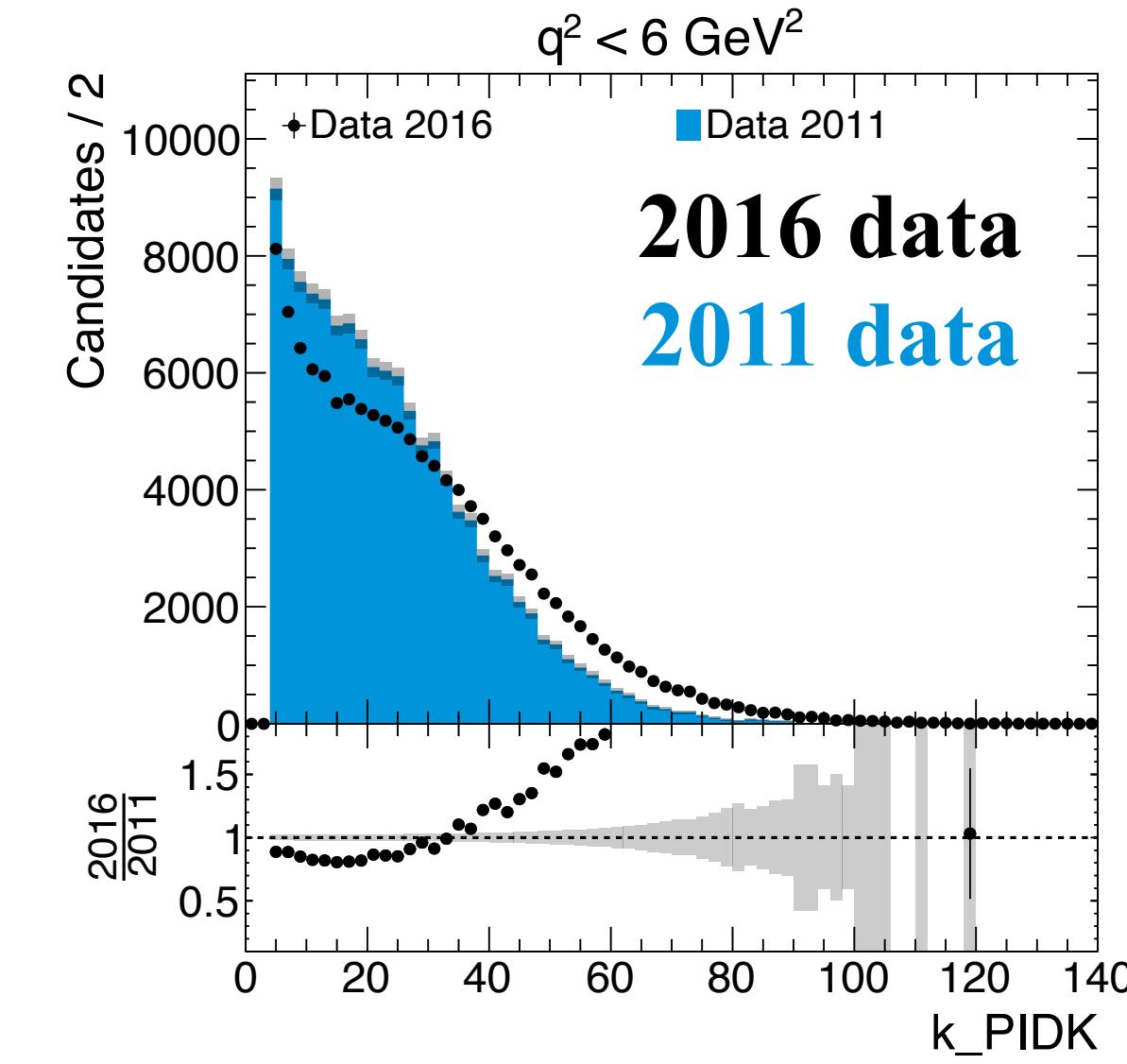
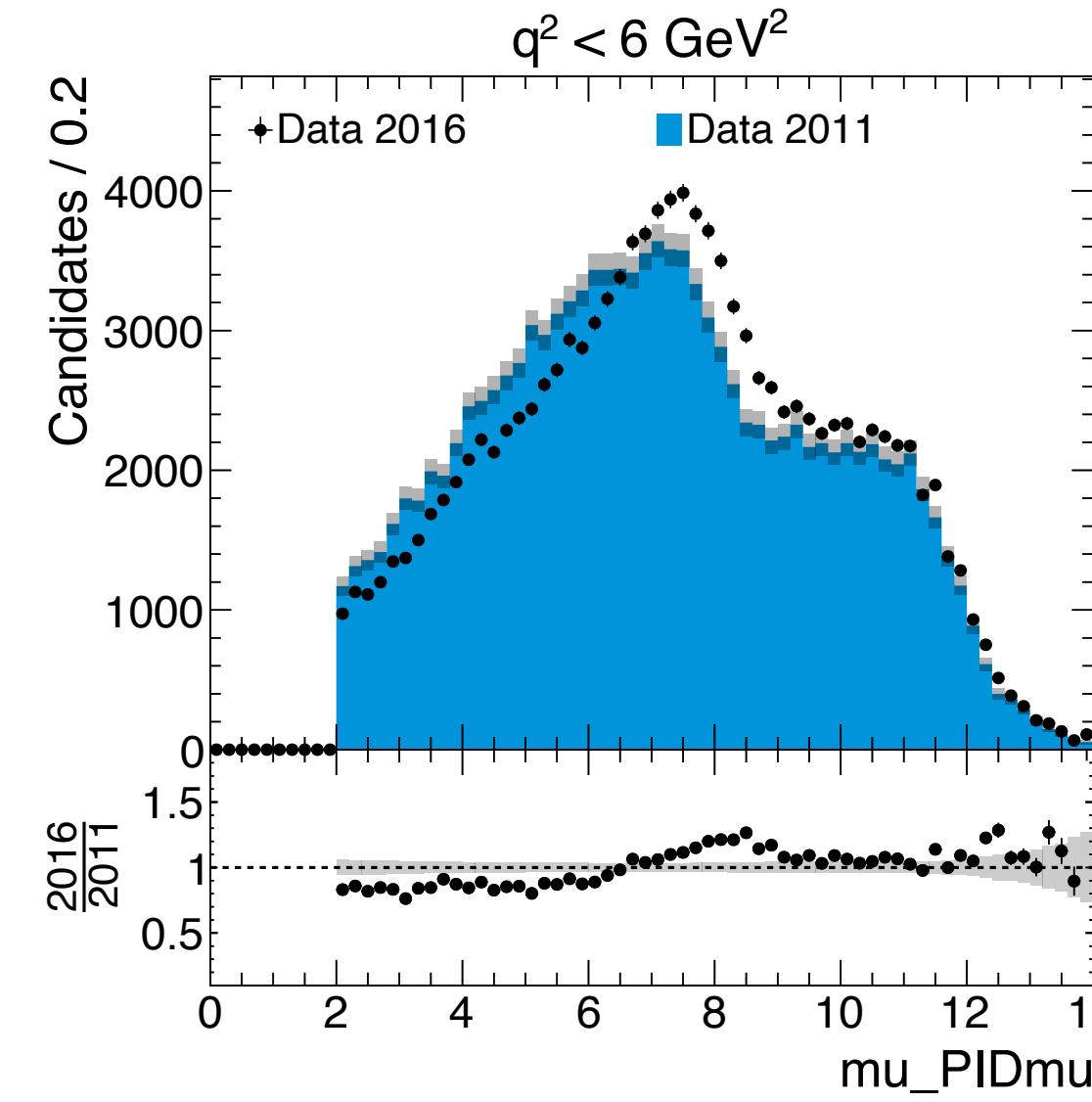
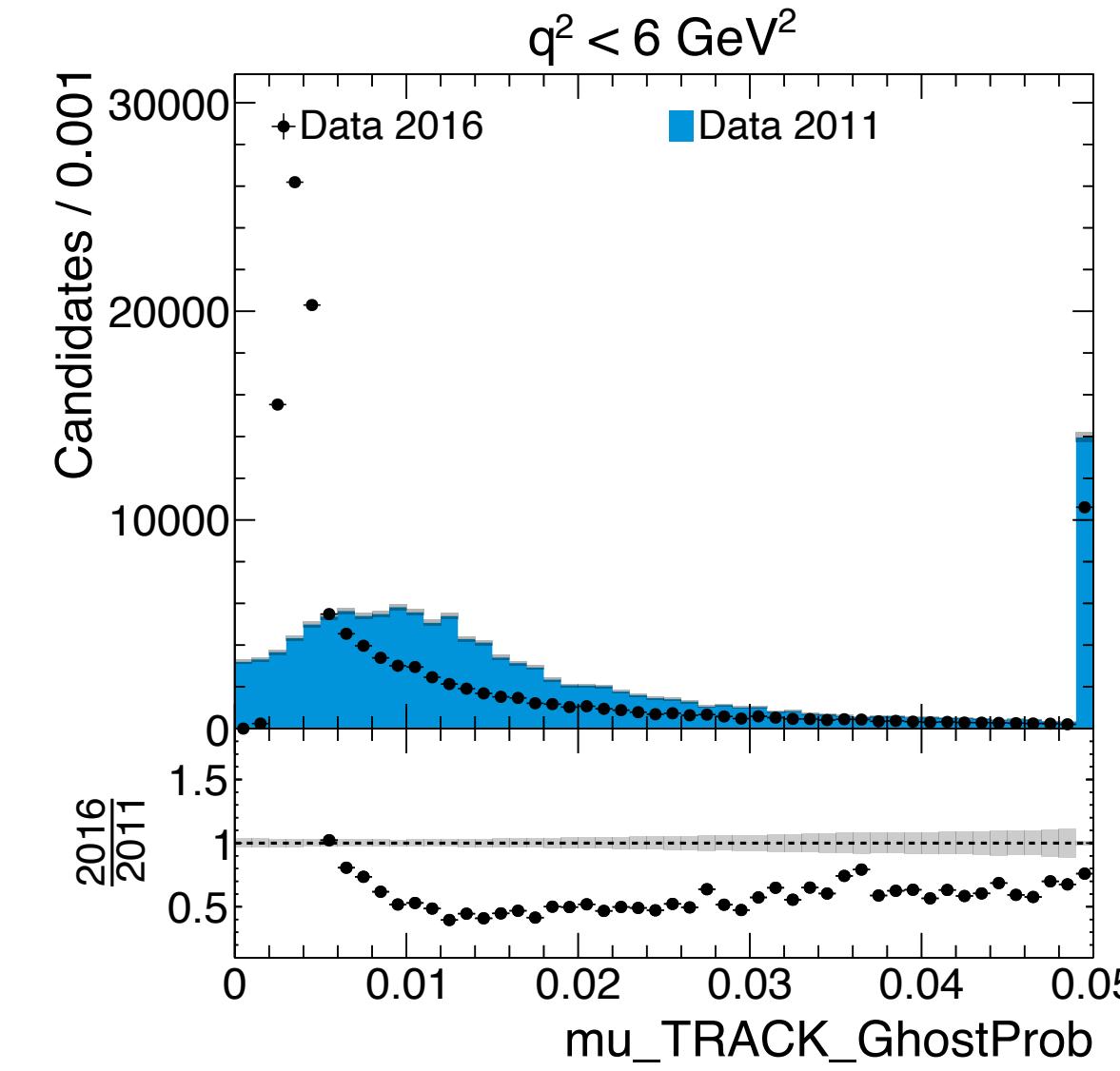
- ~ Use **low q^2** and **low m_{miss}** regions to look at data
 - Pretty pure in $D^{*+}\ell\nu$
- ~ Compare with FS MC
 - Run 1 $D^{*+}\ell\nu$ (11574020)
 - Run 2 $D^{*+}\ell\nu$ (11574021)
- ~ Updated FFs for $D^0\ell\nu$, $D^*\ell\nu$, $D^{*+}\ell\nu$
 - Bug in Run 1 $D^{*+}\ell\nu$ FFs, so larger improvement there

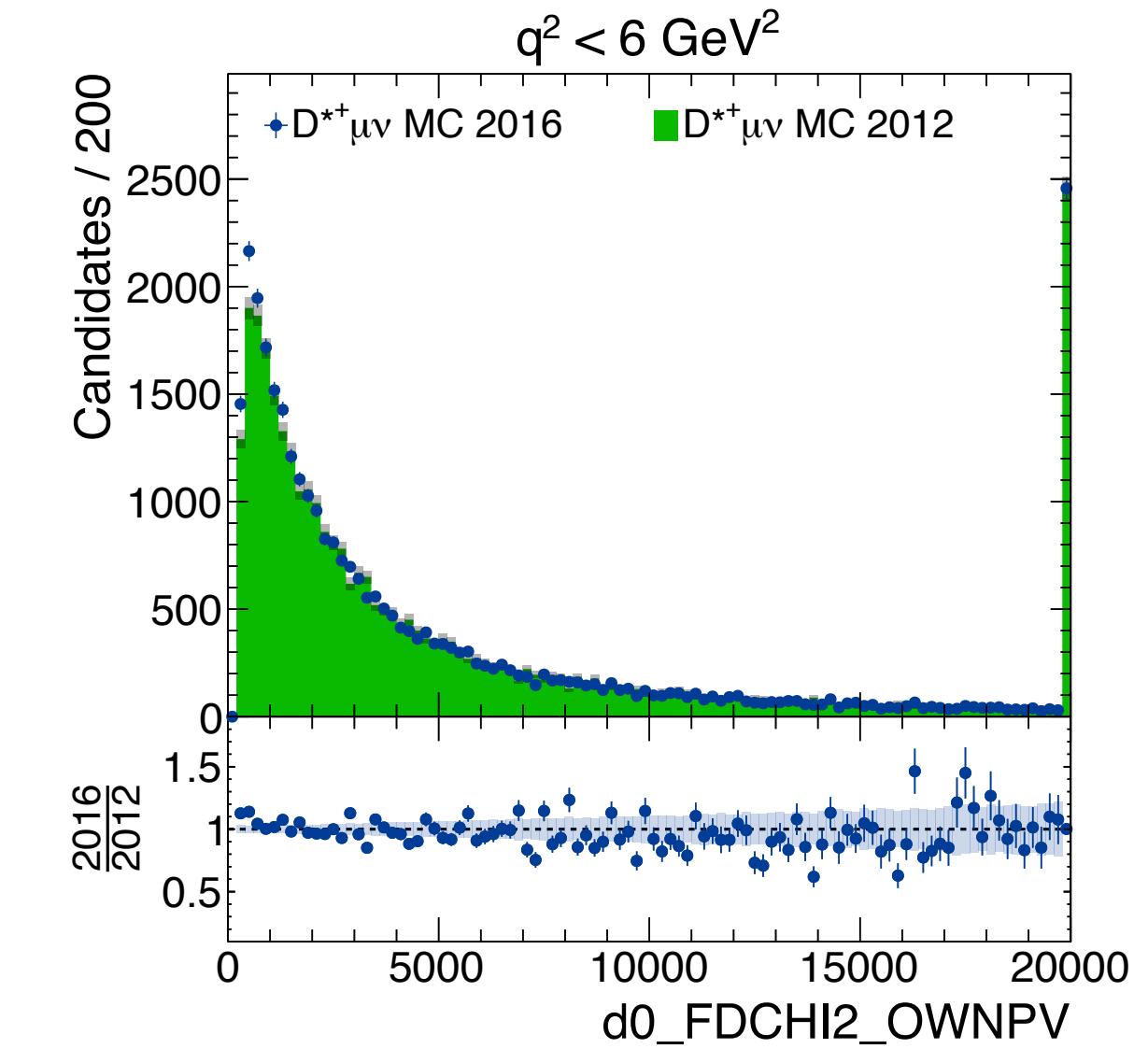
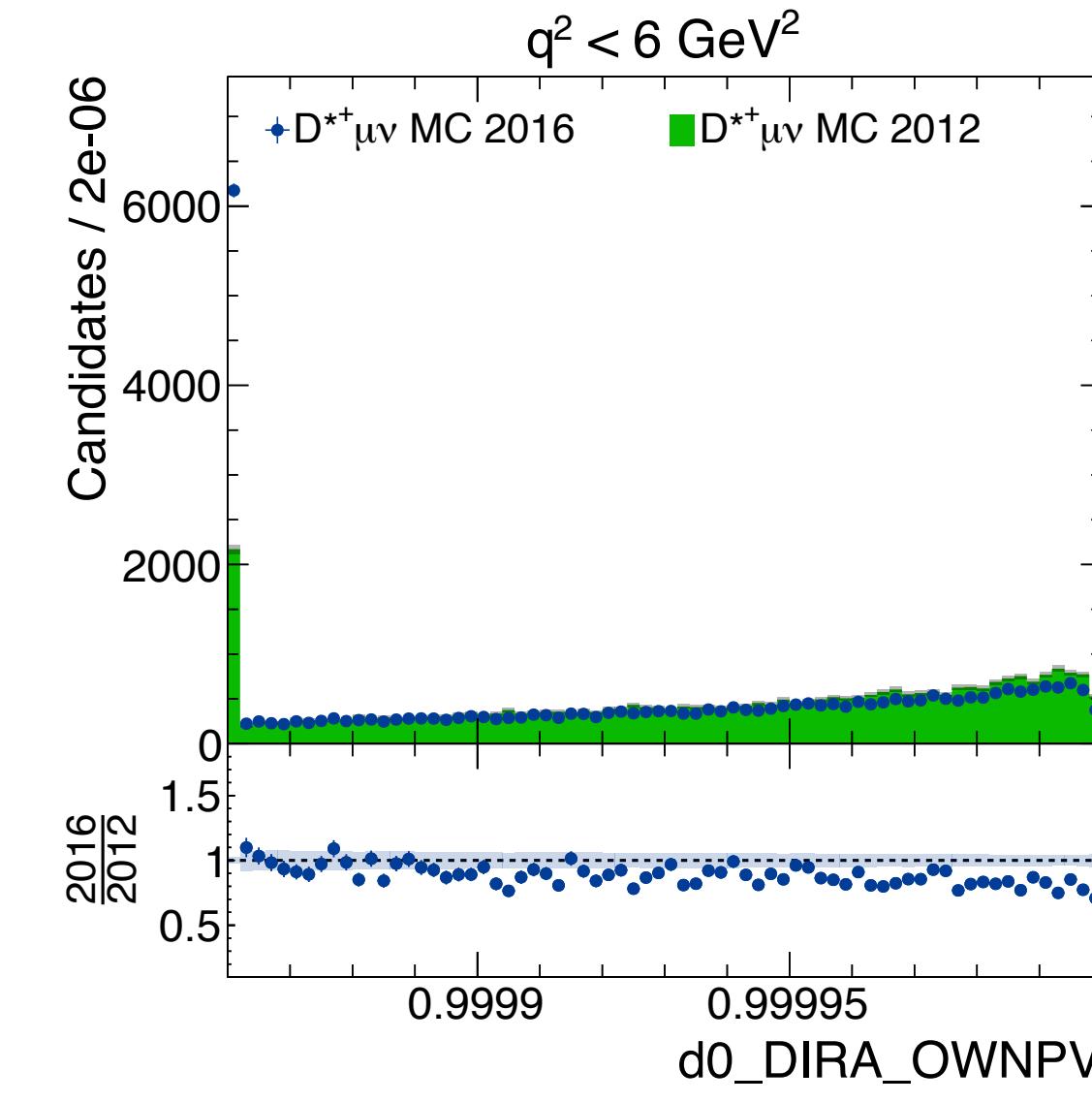
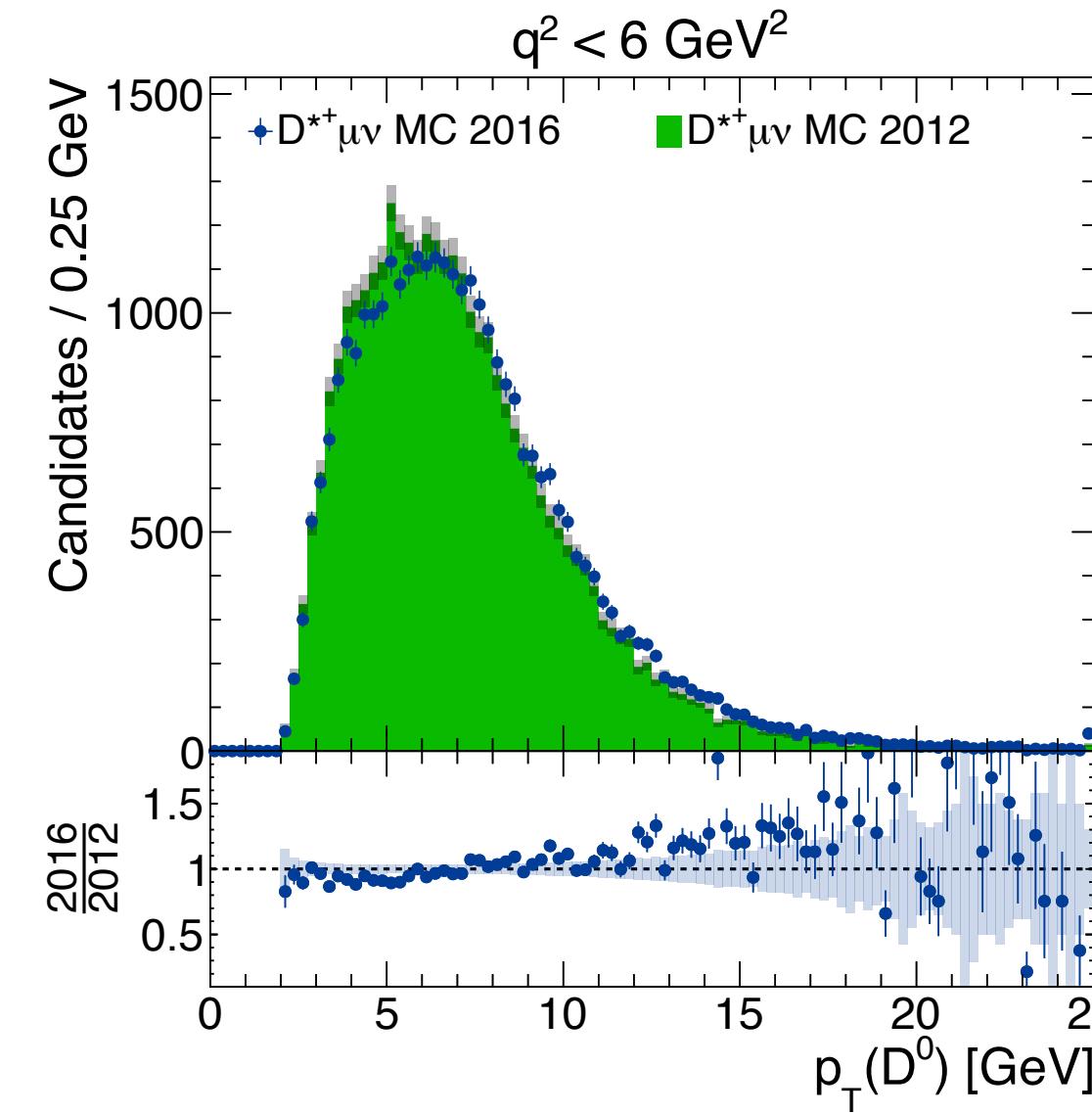
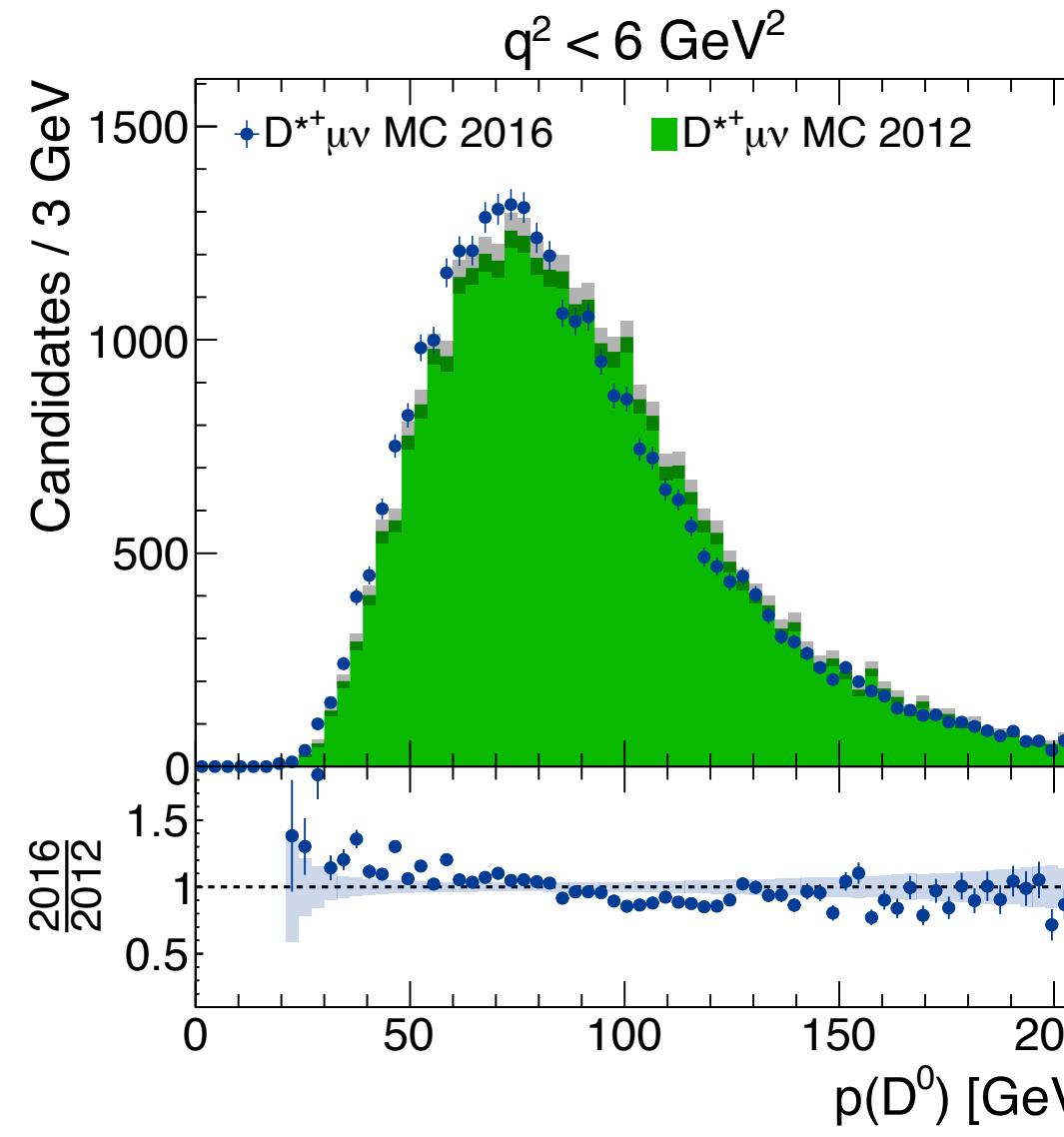
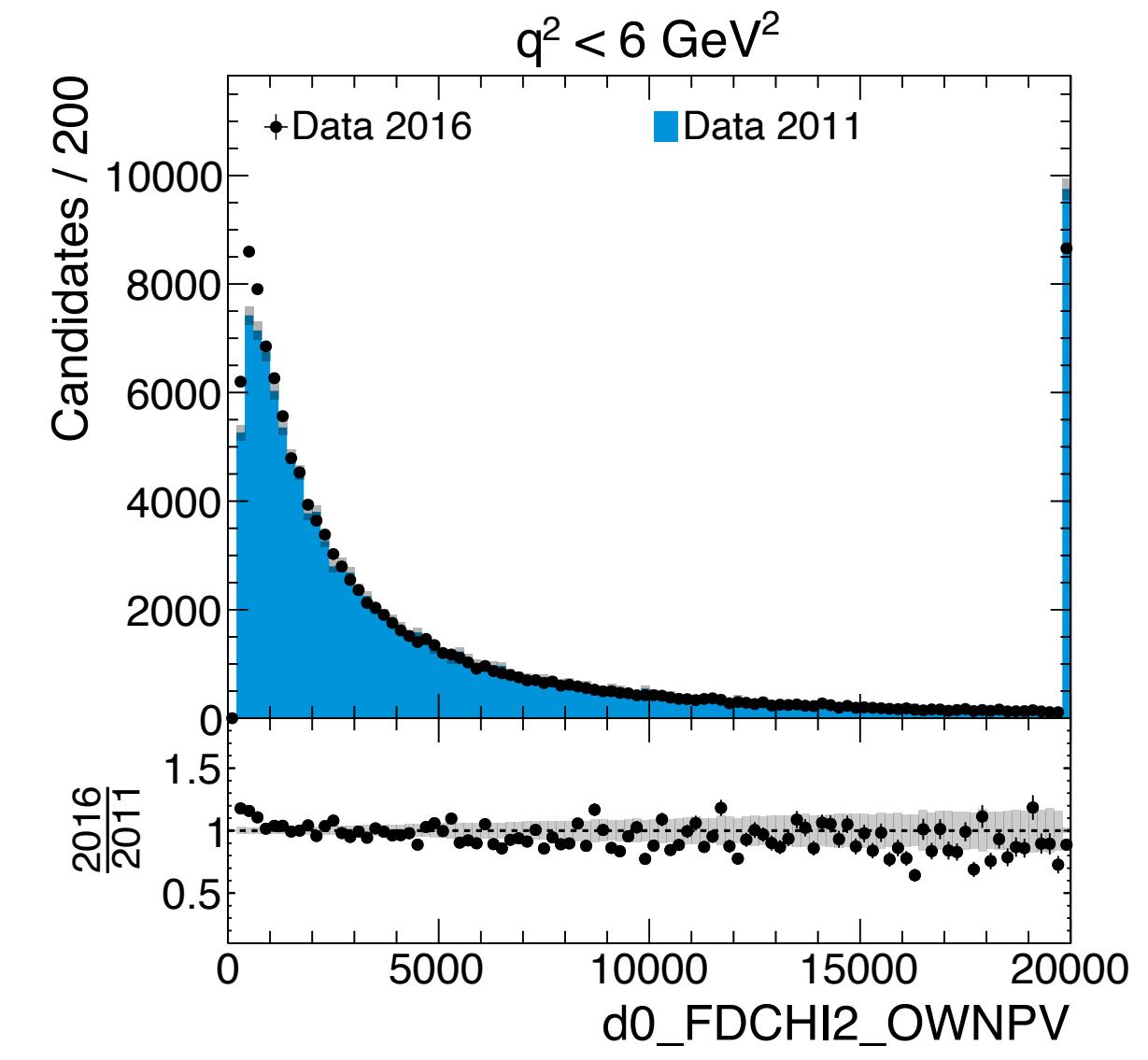
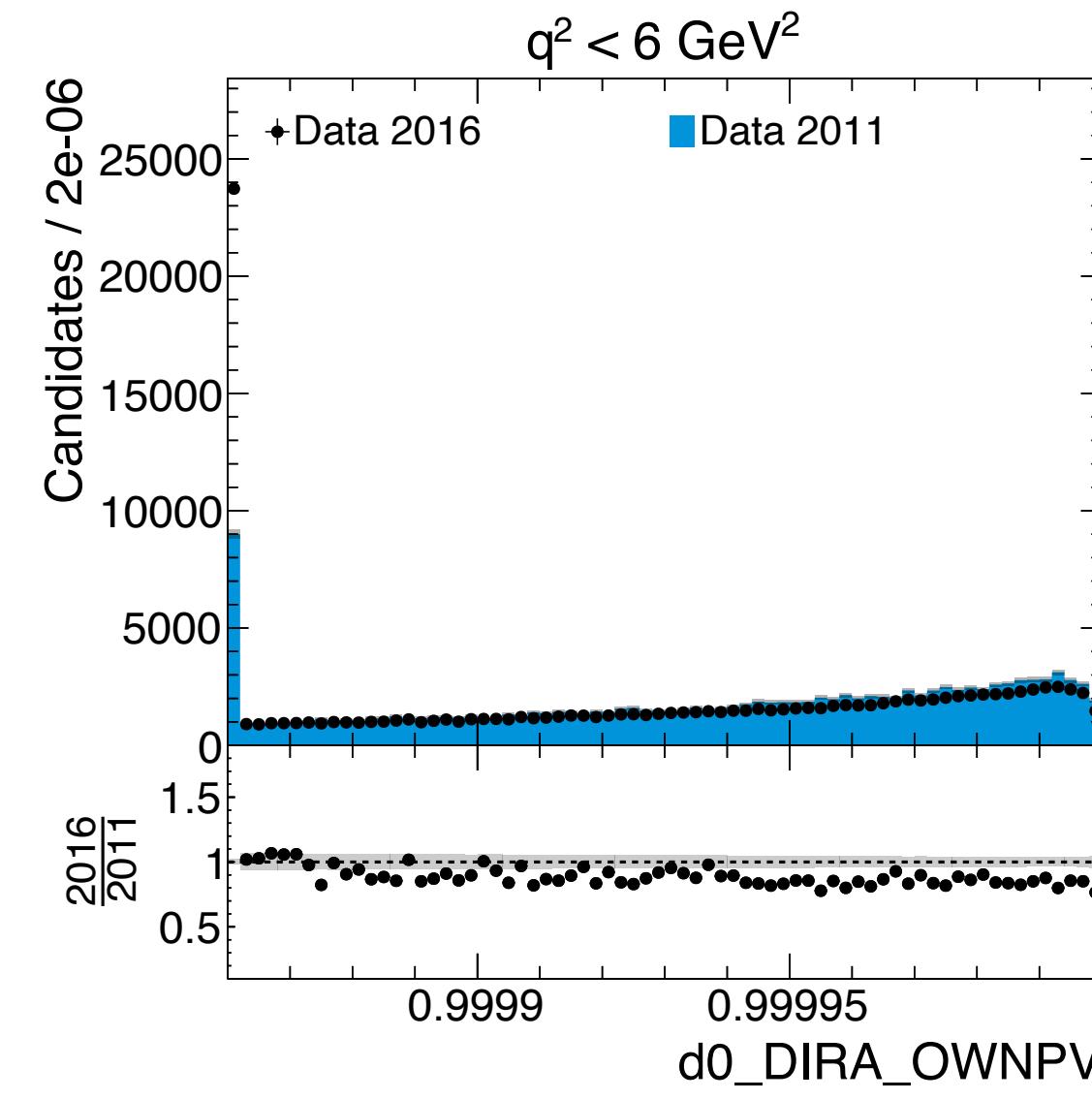
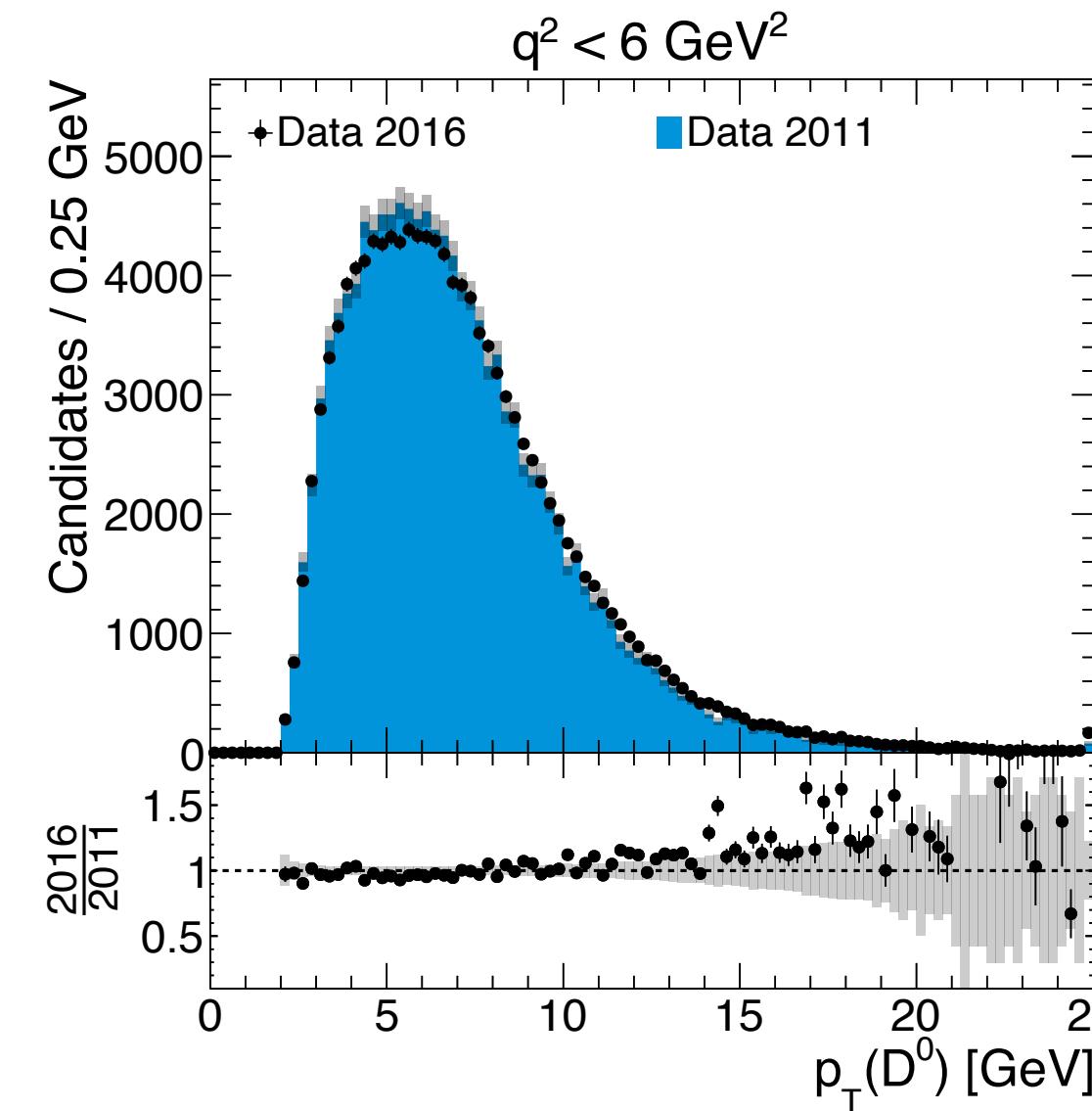
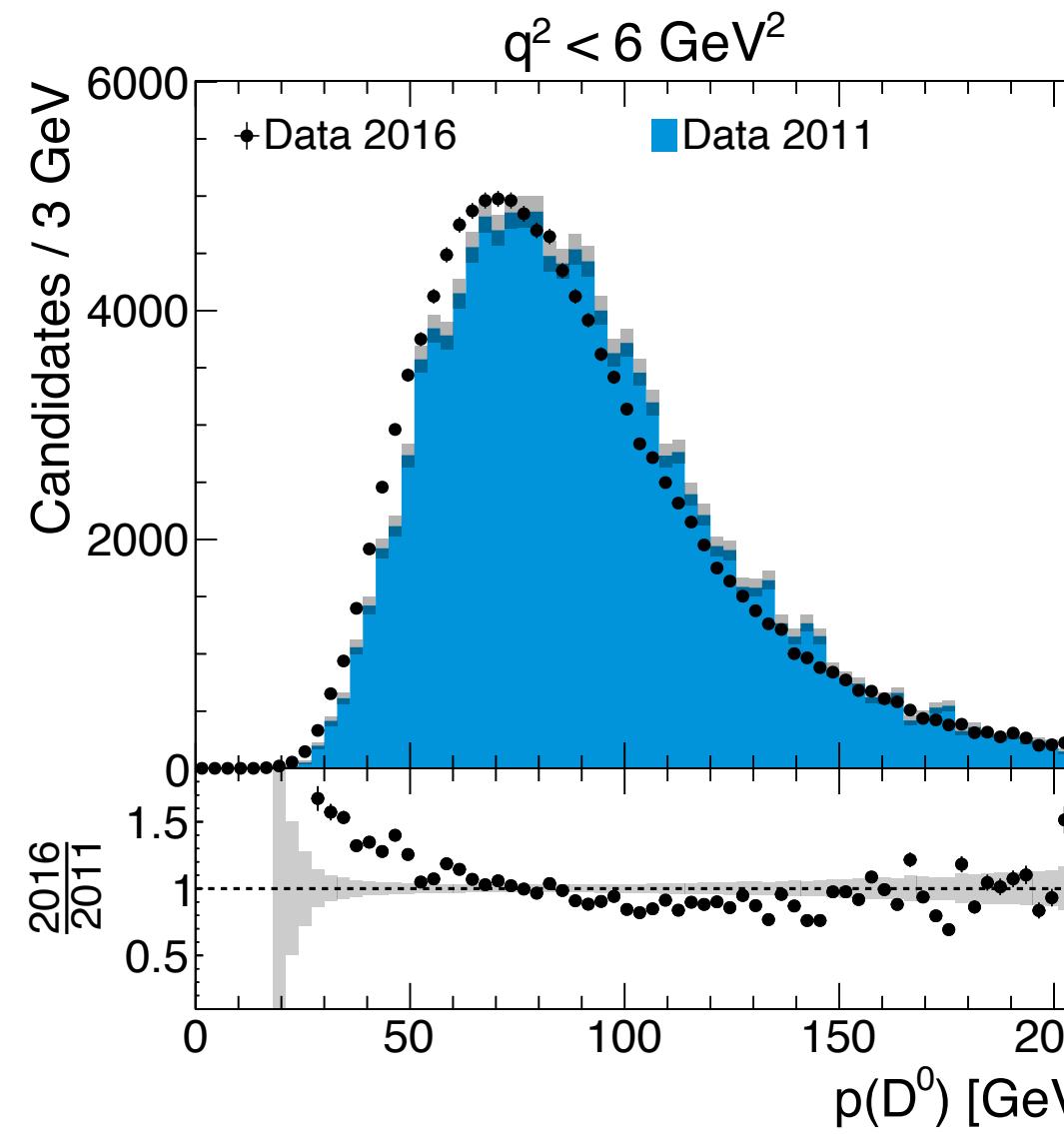


$D^{*+}\mu\nu$ Run 1-2: fit variables stable

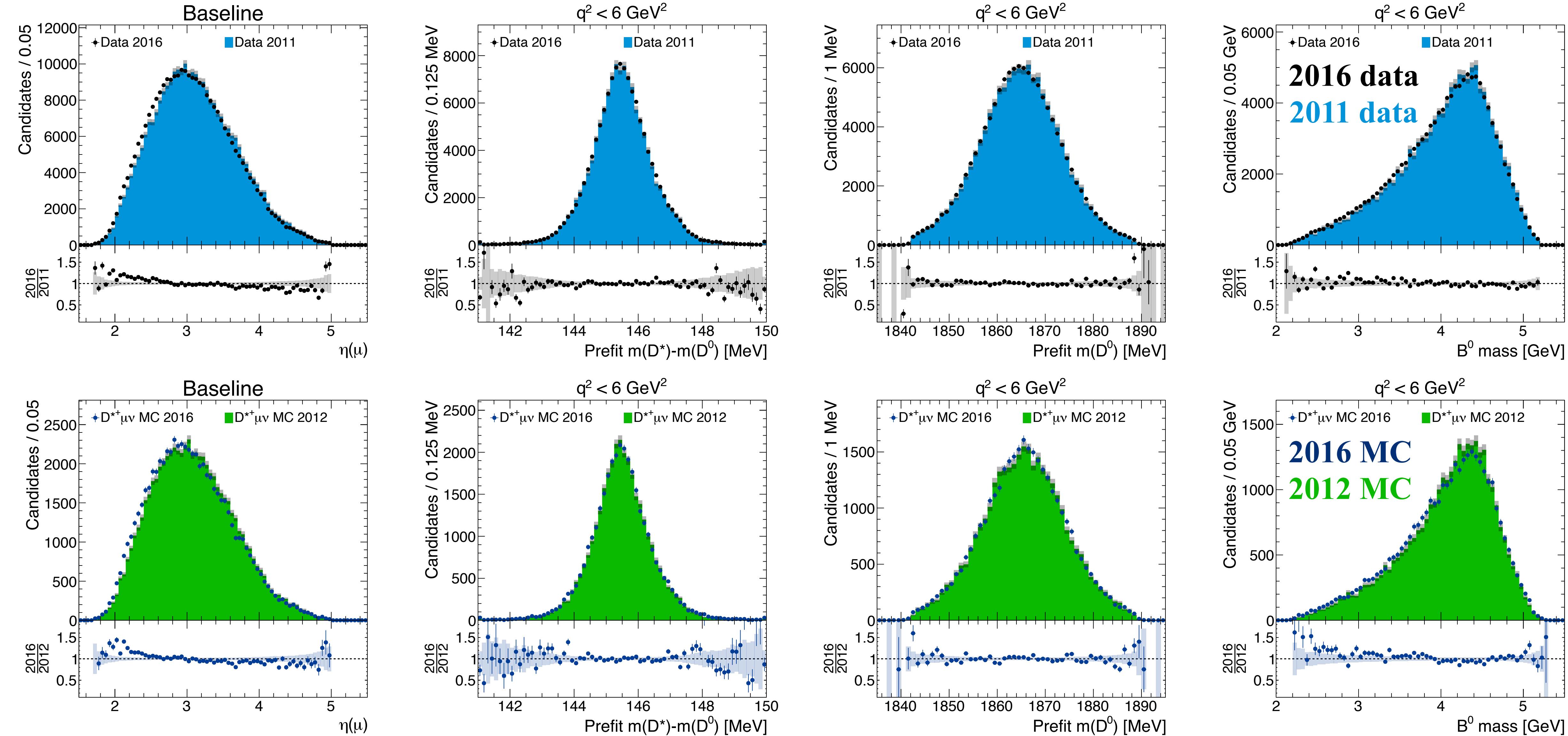
Run 1 vs Run 2: slight shift to higher $p(\mu)$ 

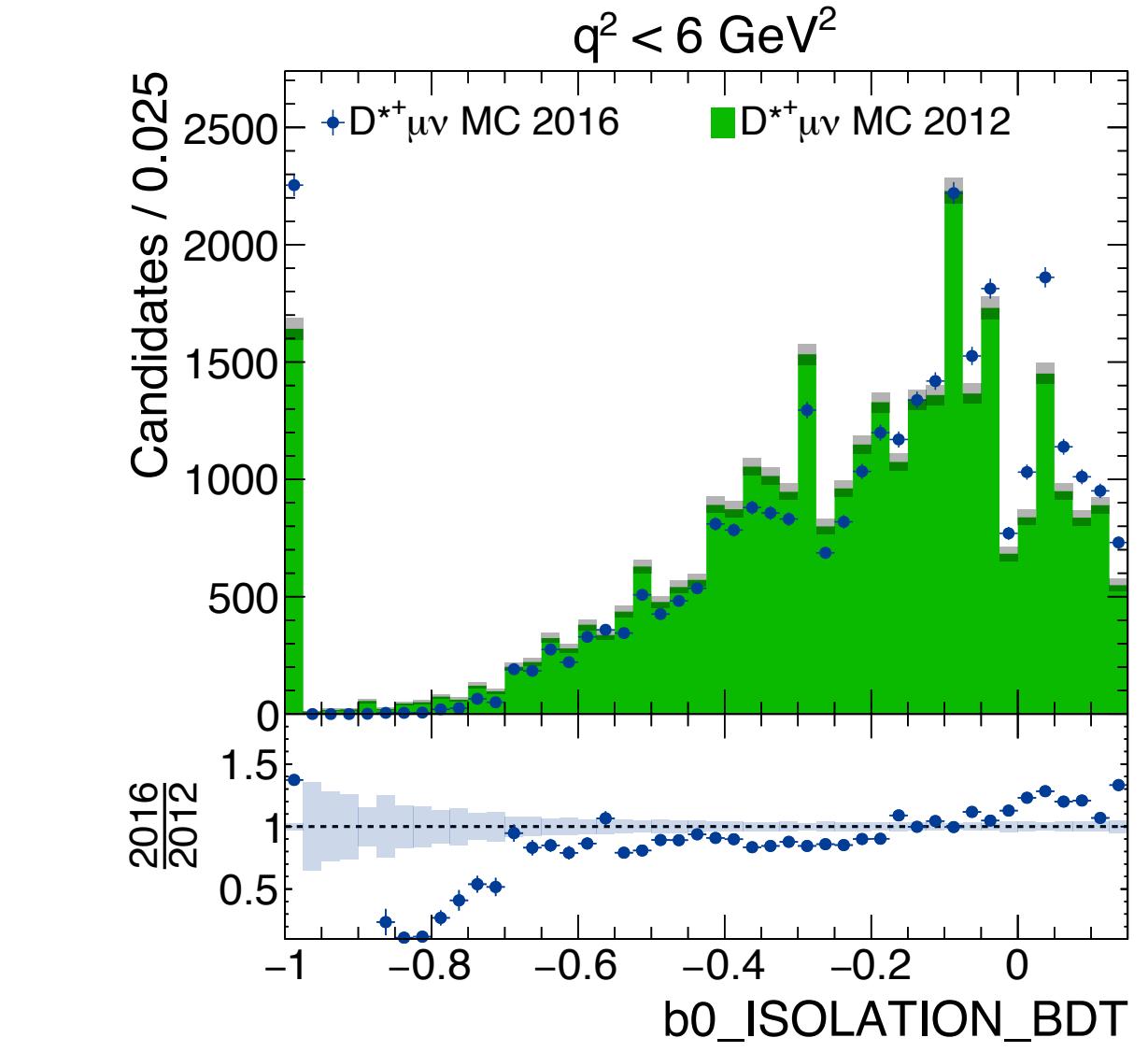
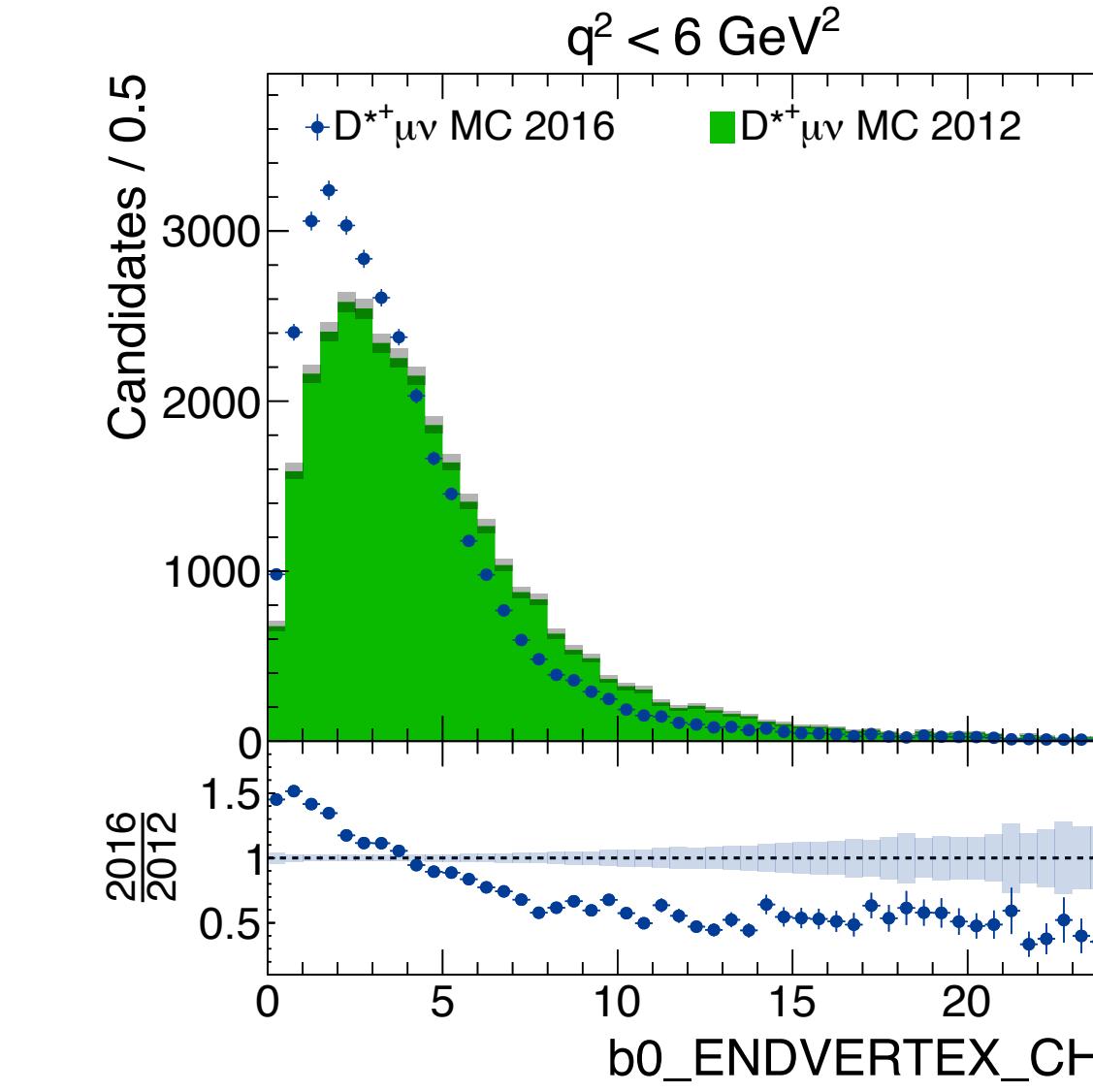
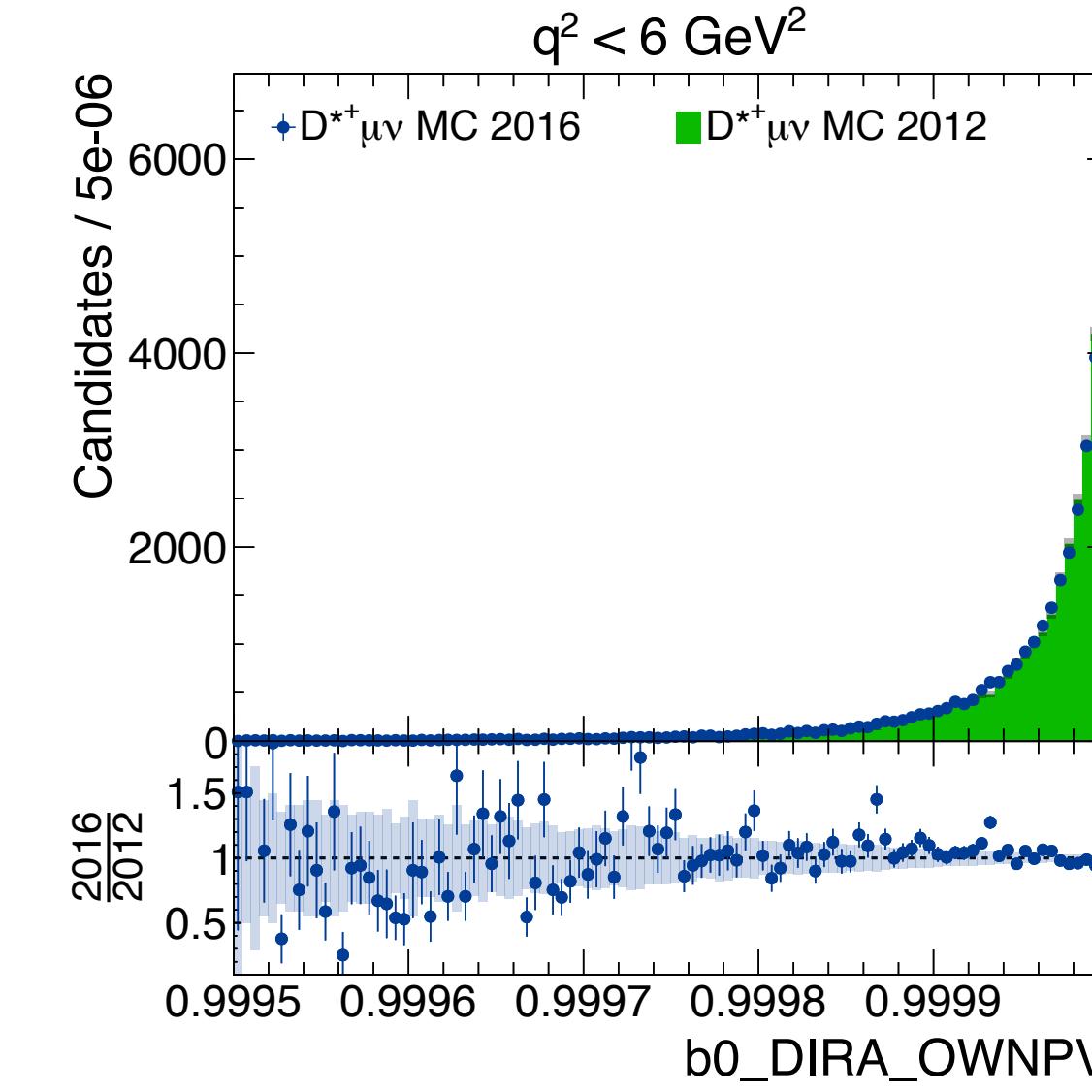
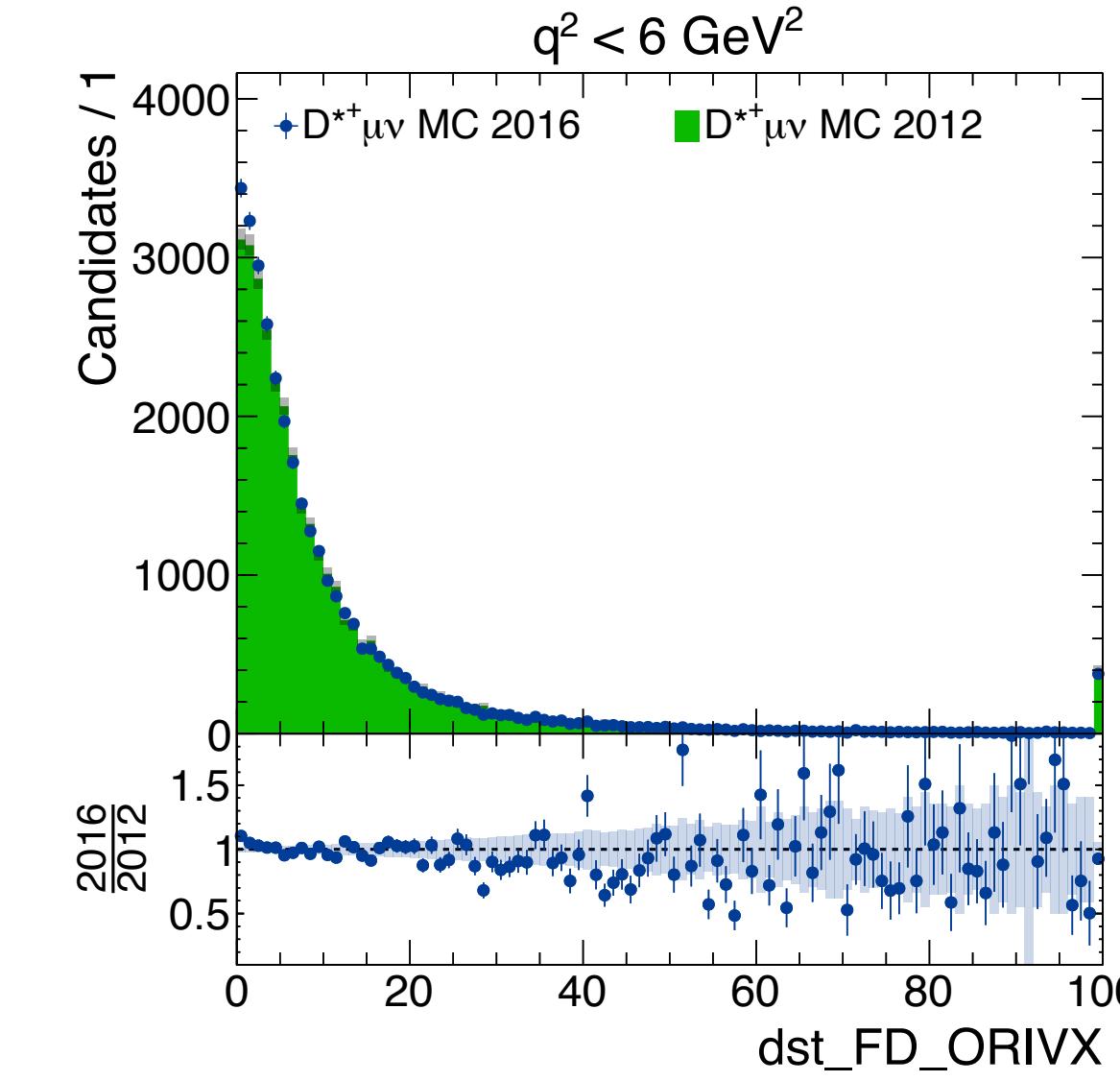
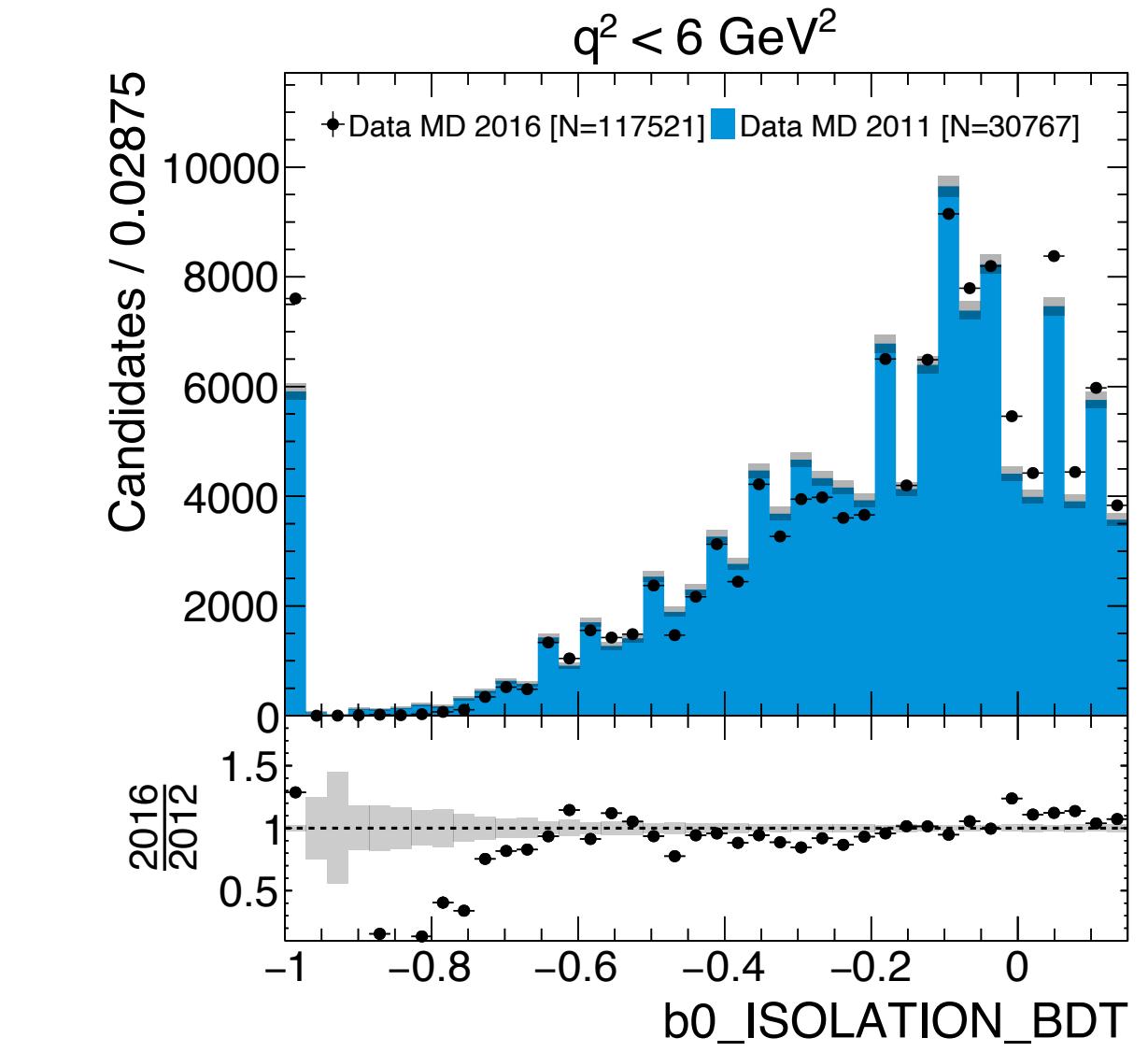
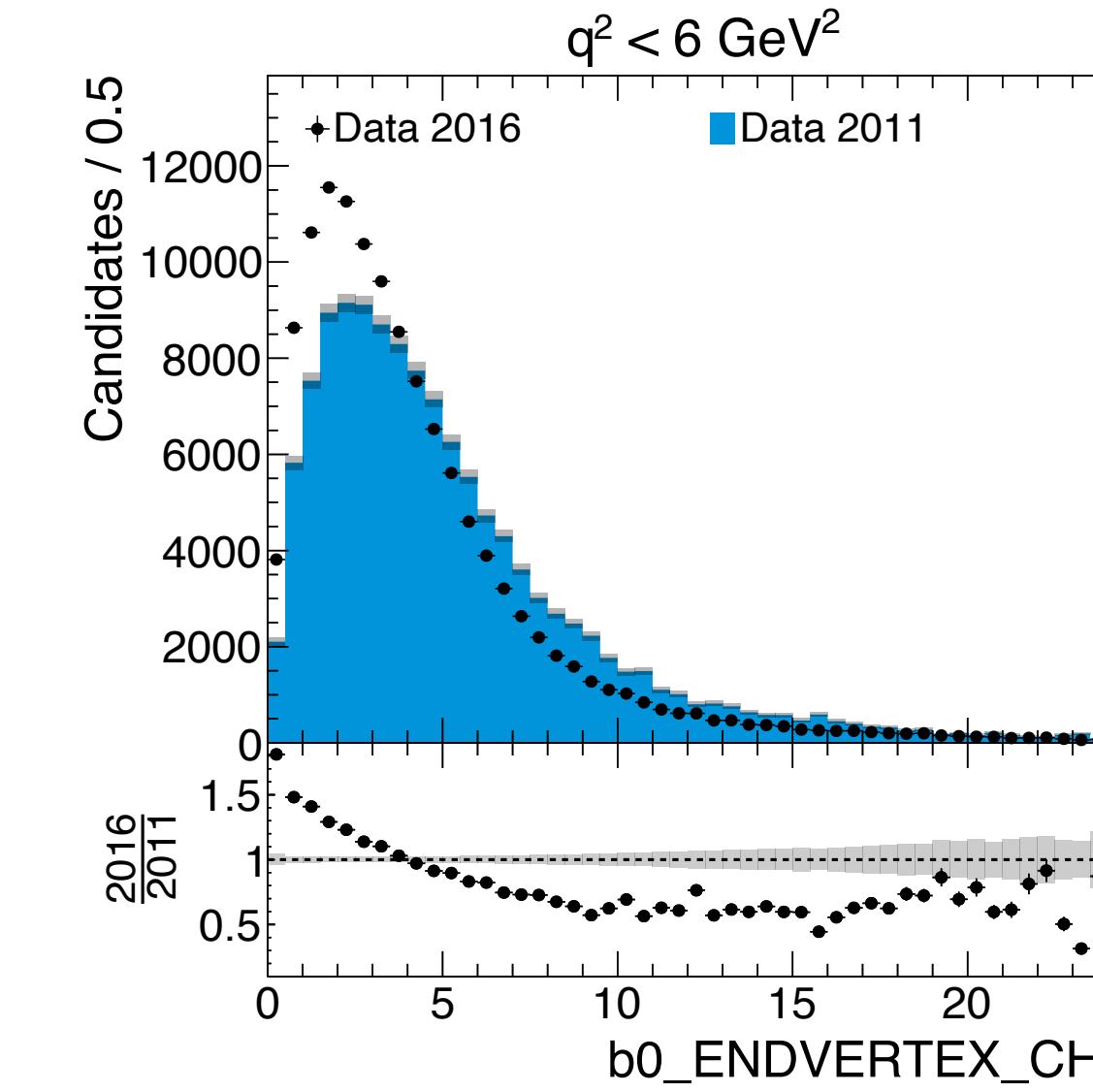
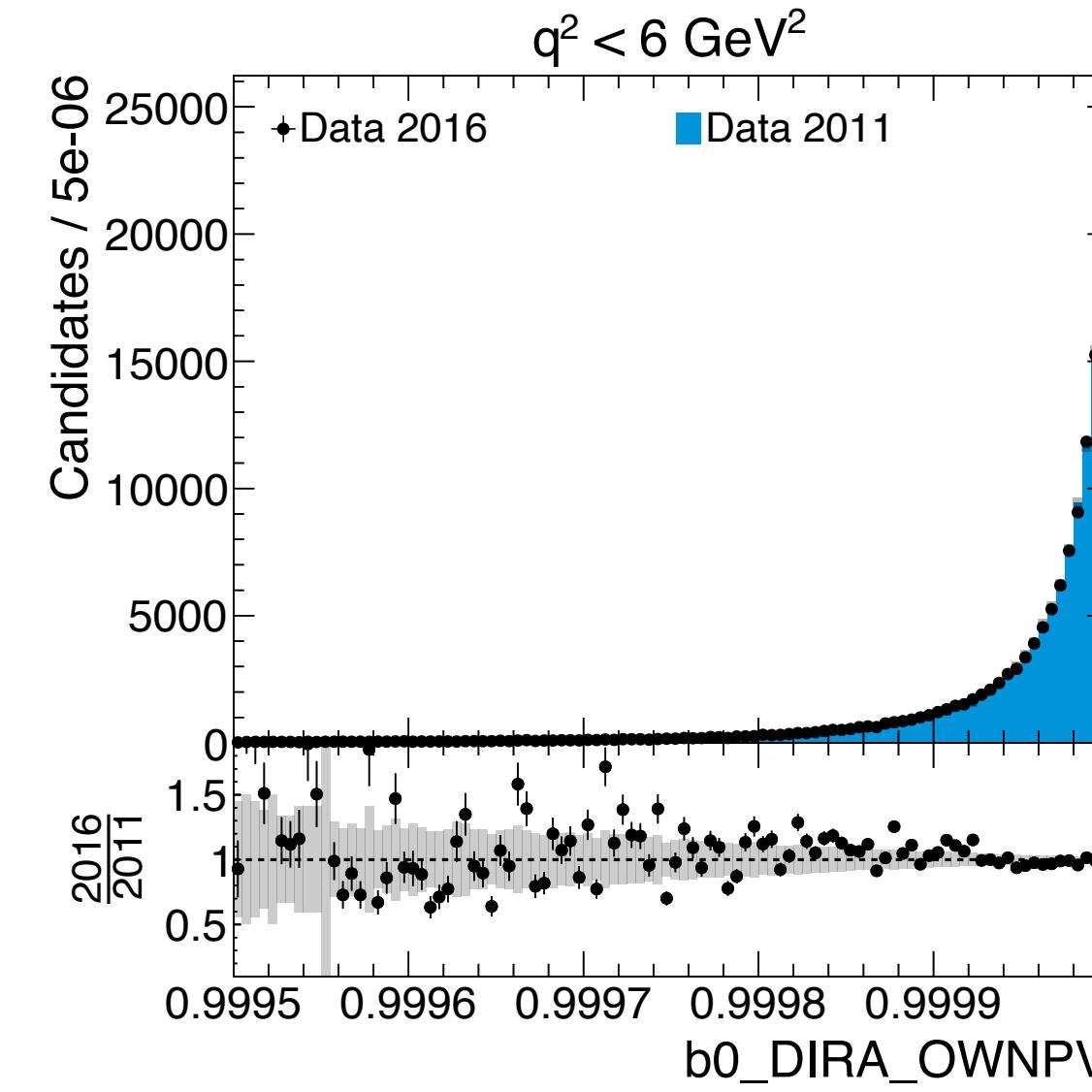
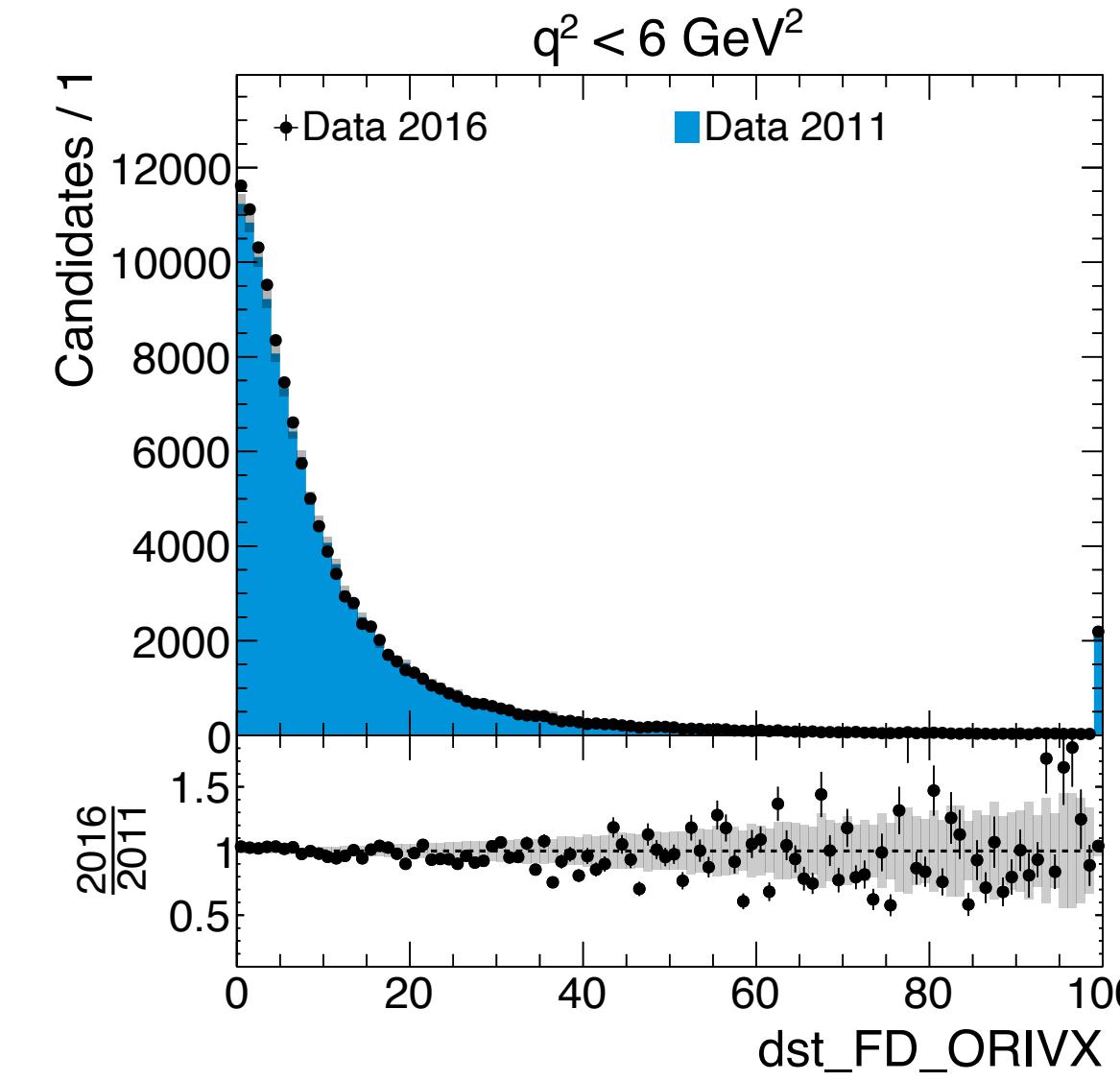
Run 1 vs Run 2: GhostProb, PID new algorithms

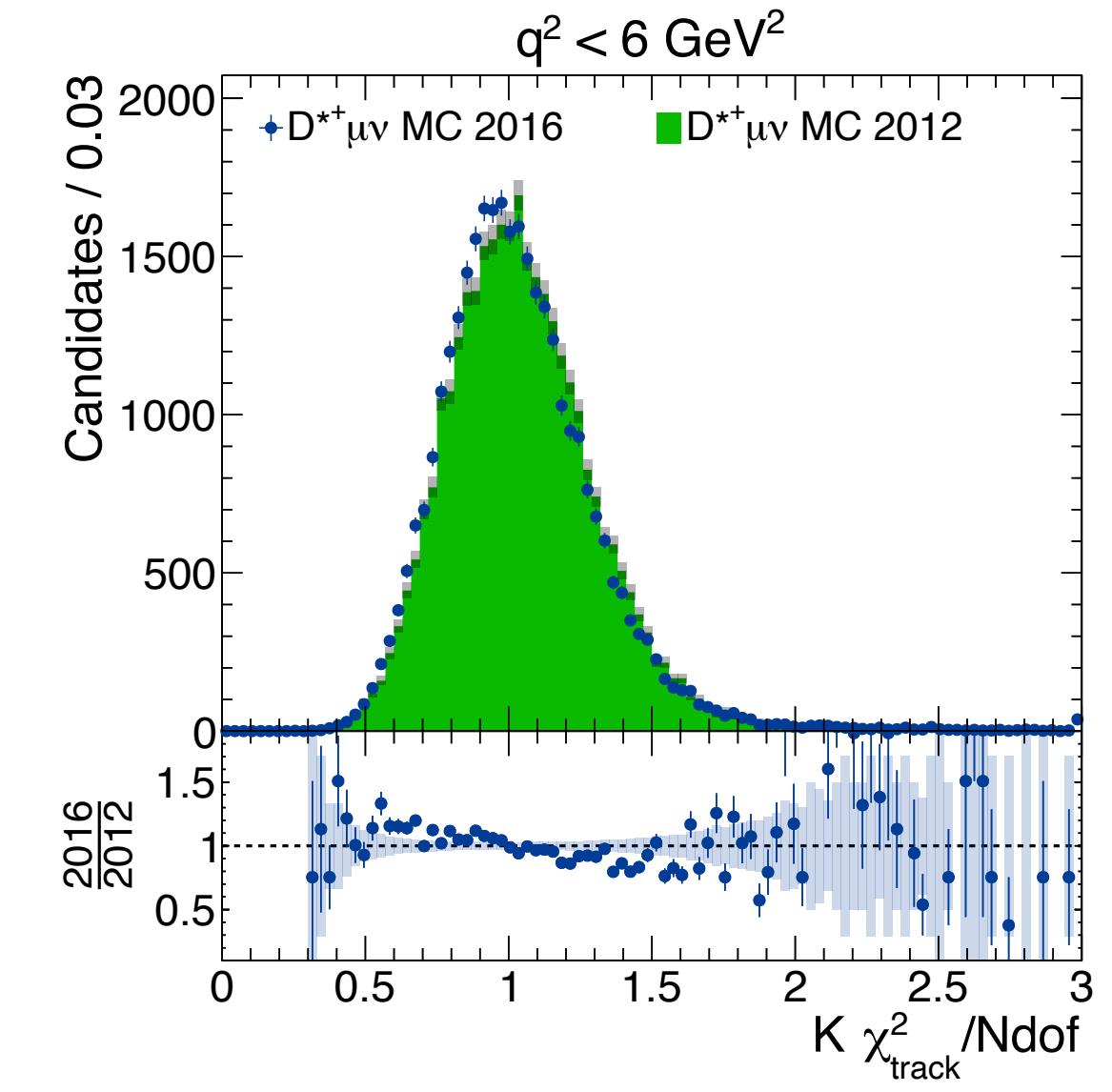
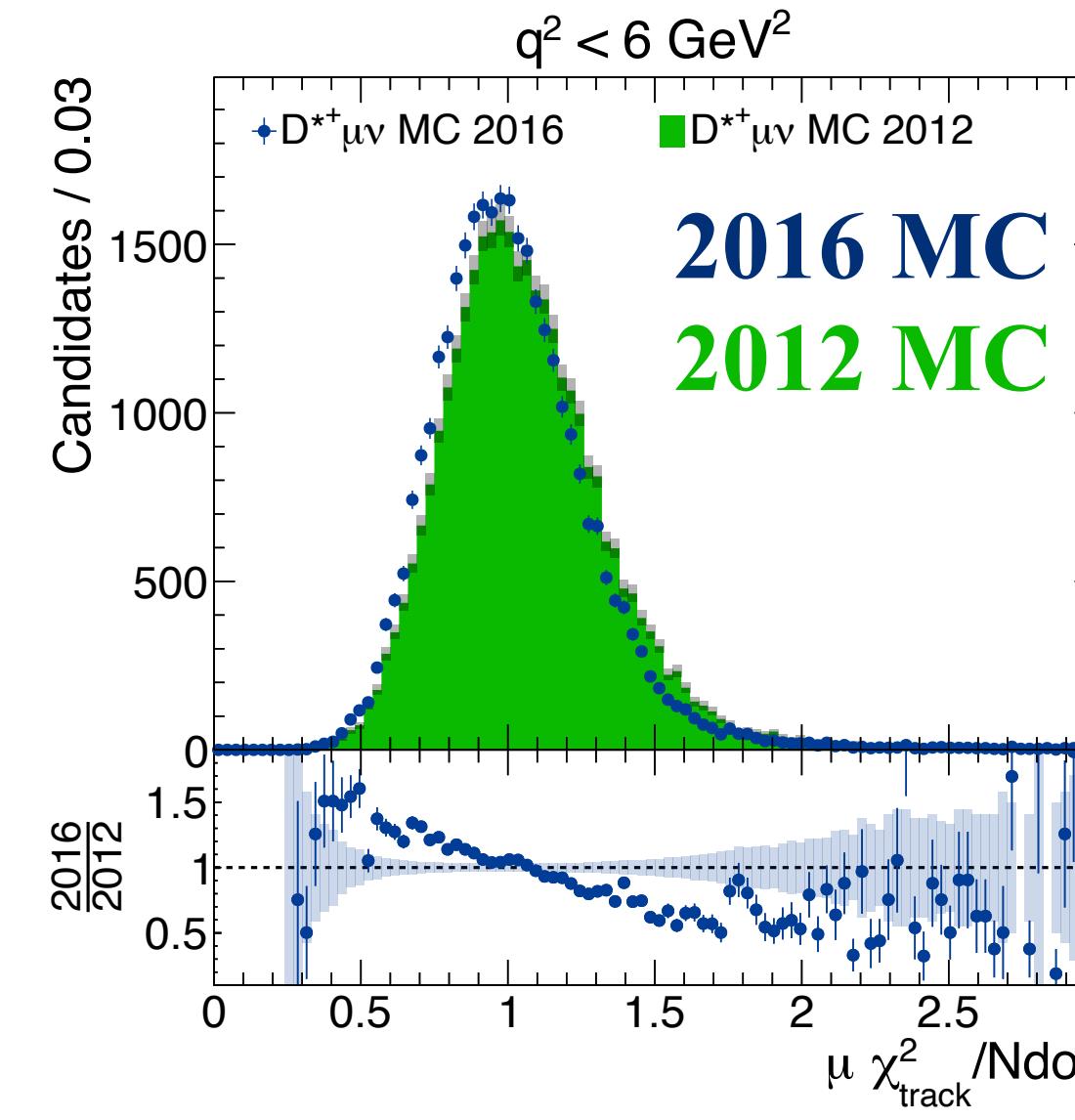
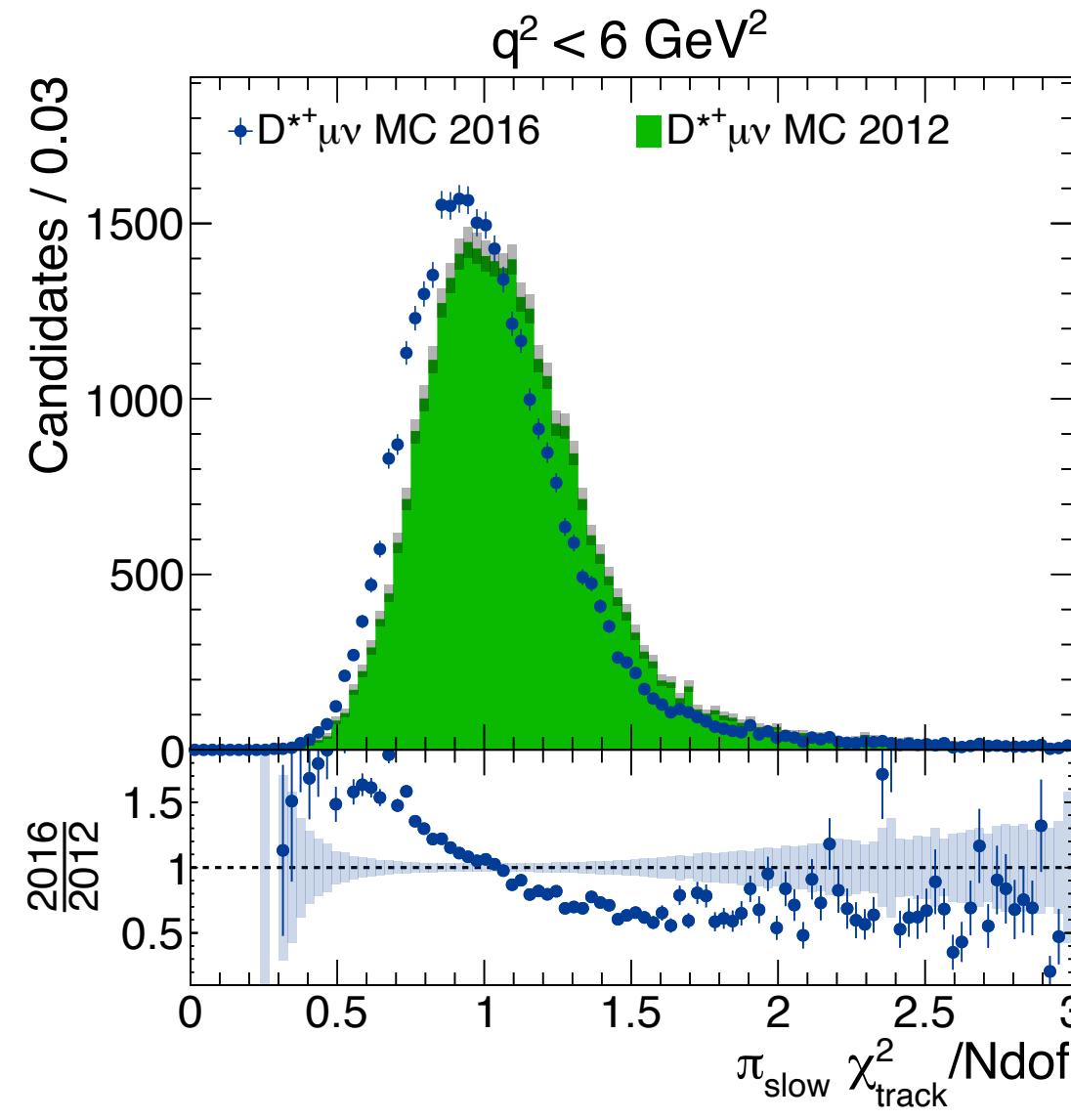
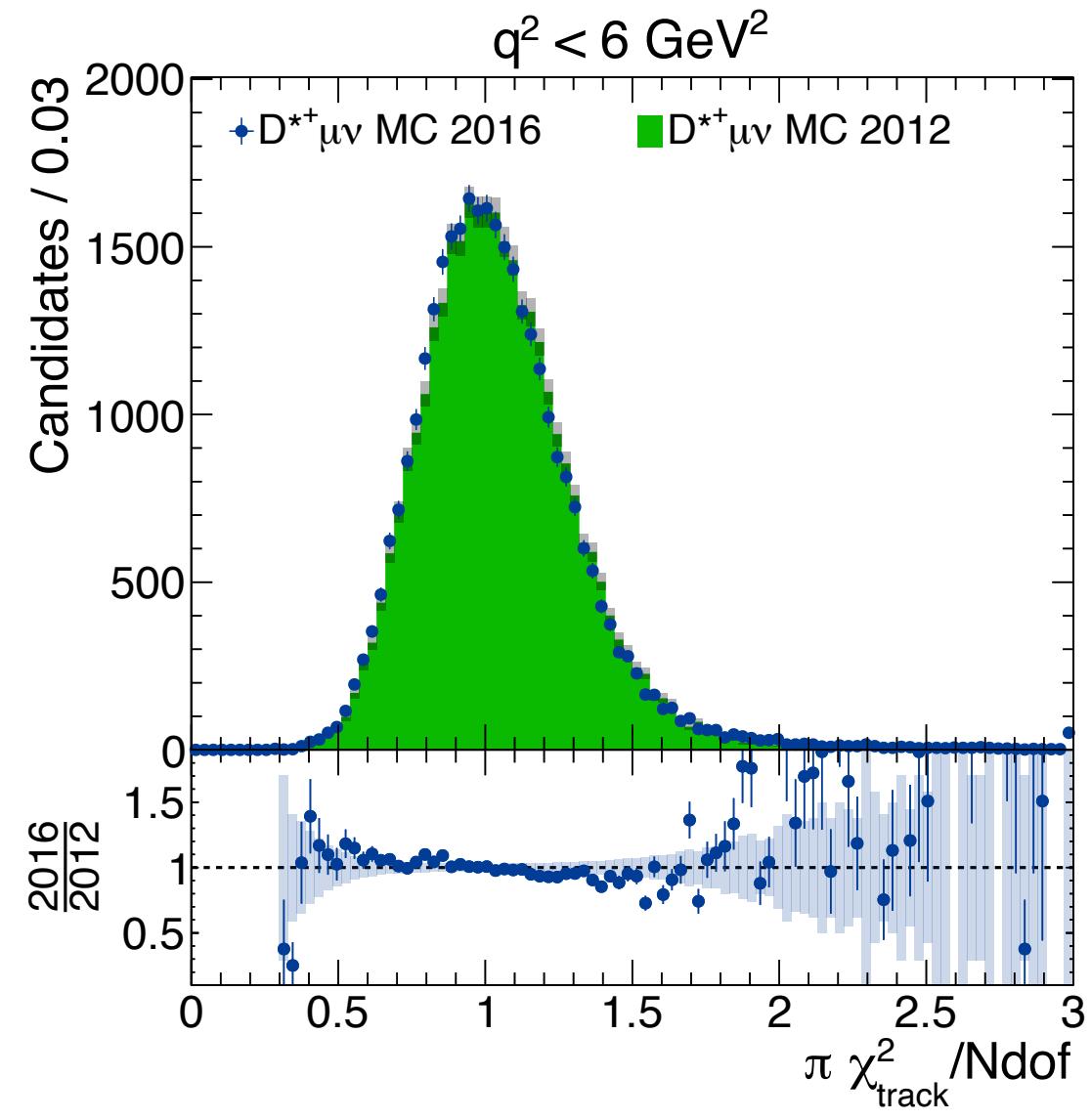
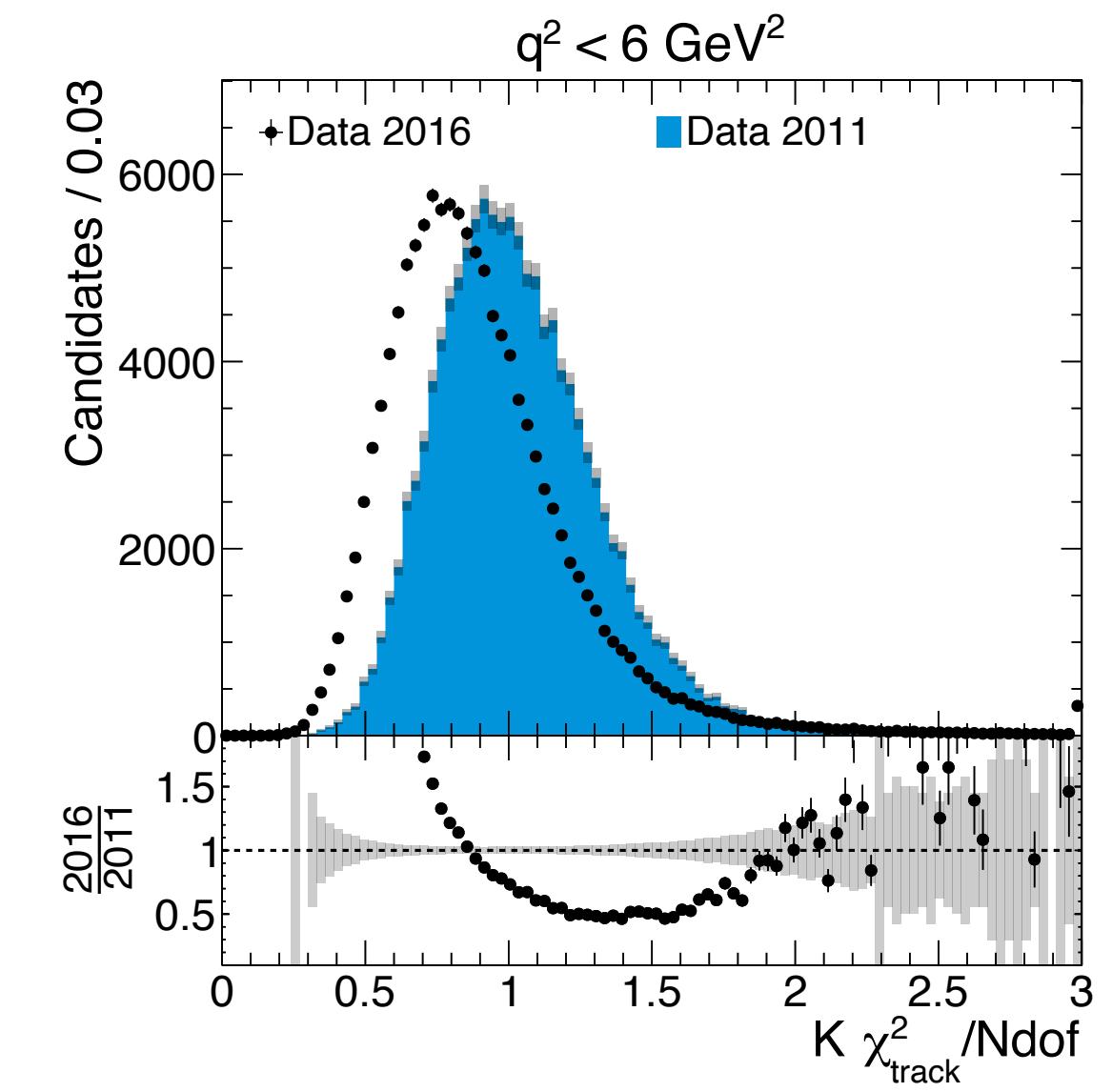
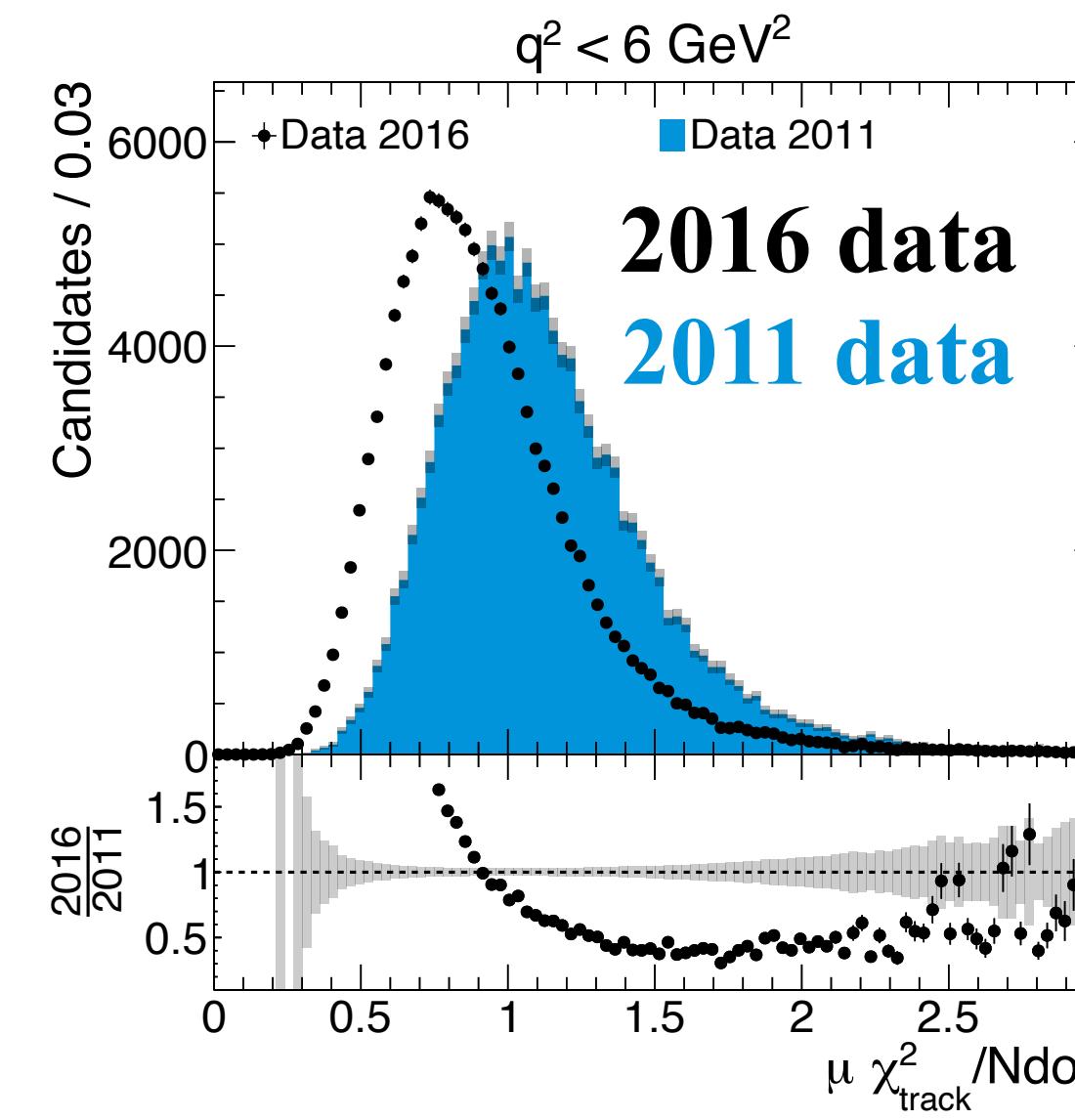
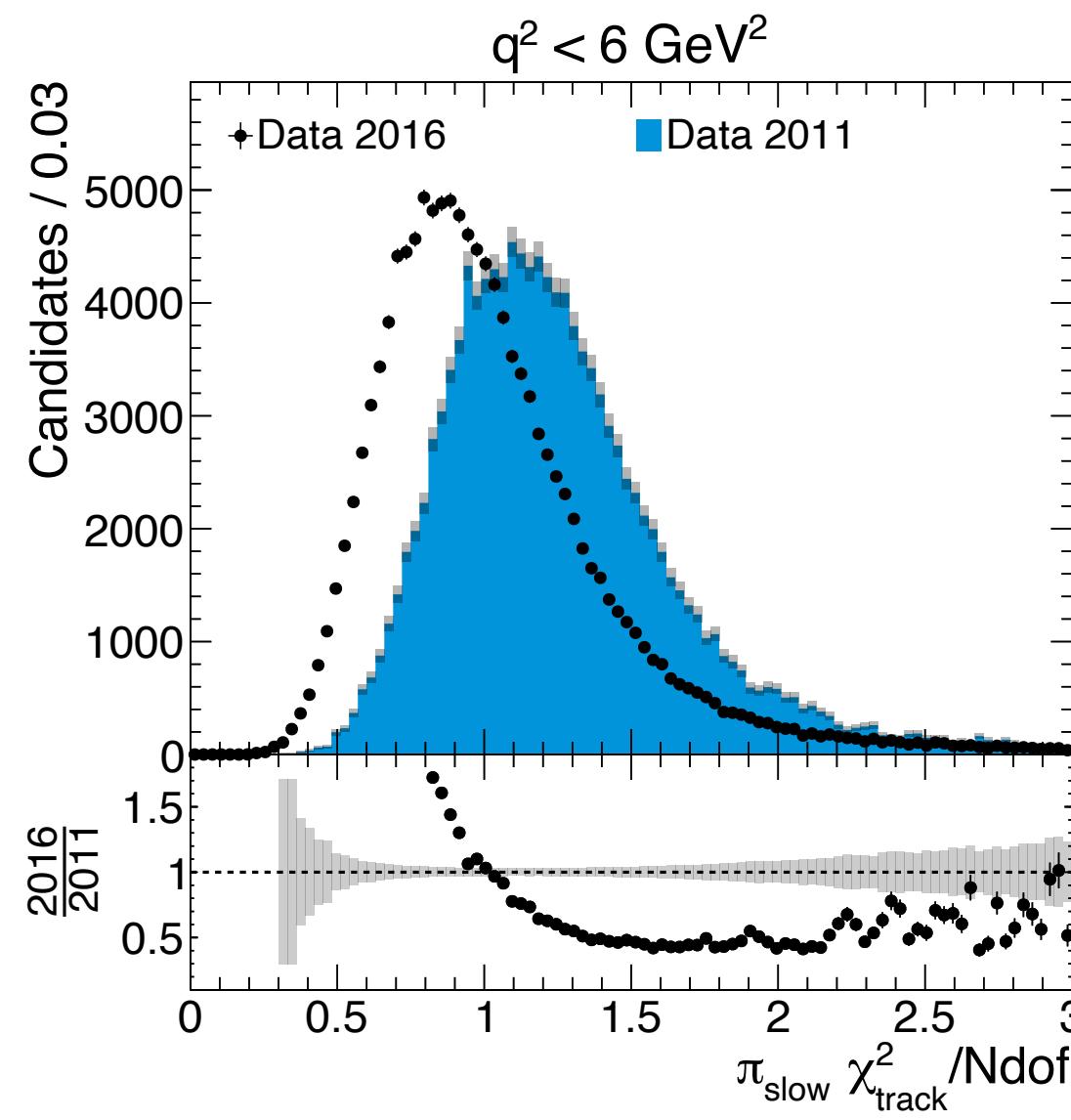
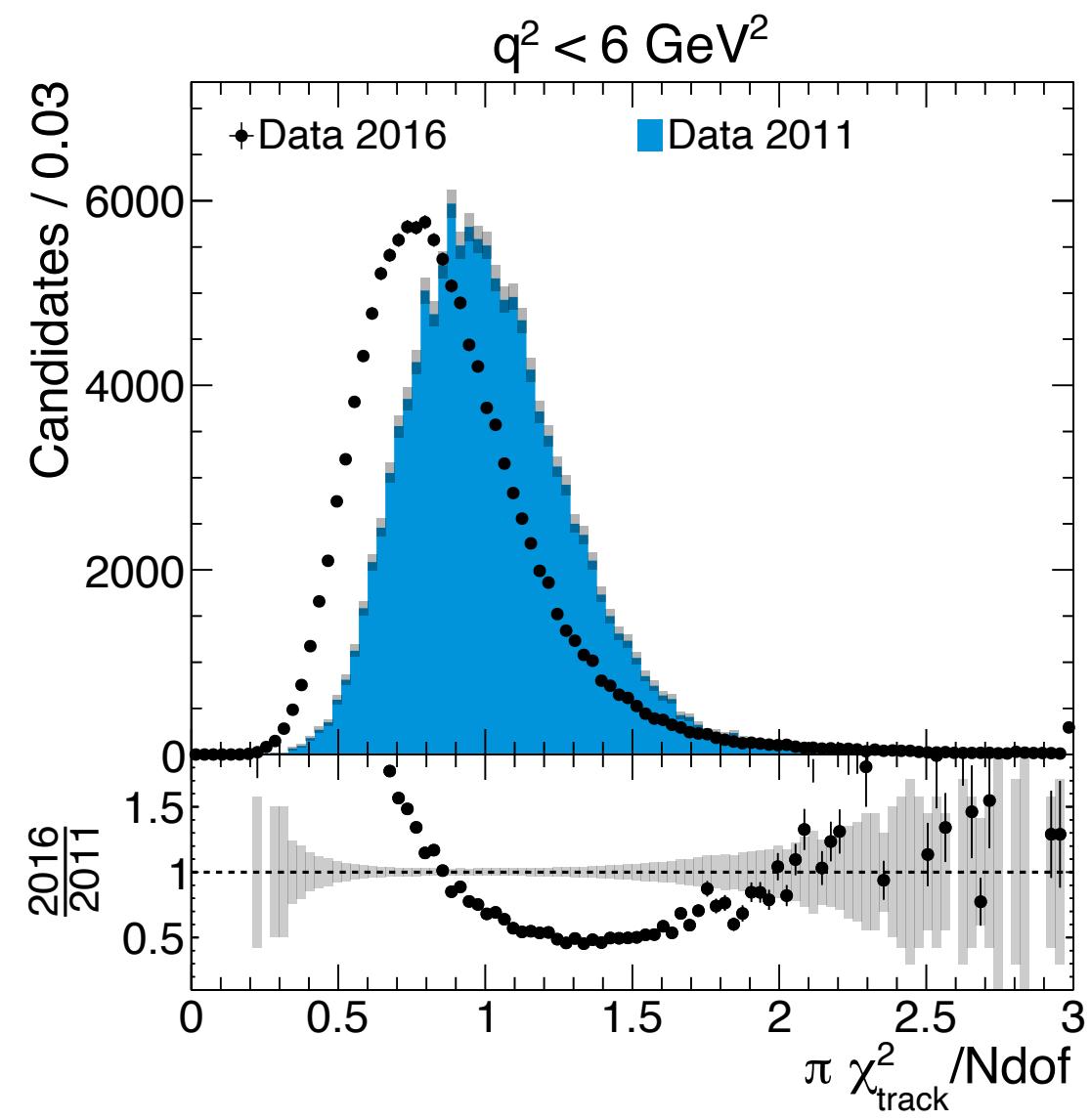


Run 1 vs Run 2: D⁰

Run 1 vs Run 2: masses stable



Run 1 vs Run 2: D^* , B^0 

Run 1 vs Run 2: issue in 2016 track χ^2 ?

Backup

Run 2 MC validation

- ~ https://github.com/umd-lhcb/group-talks-pub/blob/main/rdx/21-05-07_Yipeng_overview_MCvalidation.pdf
 - Short summary of the changes to the dec files
 - Validation of the dec files and FullSim samples
 - ♦ Estimated selection efficiencies and branching fractions
 - Tracker-only MC validation: trigger emulation and comparison of selection variables
- ~ https://raw.githubusercontent.com/umd-lhcb/group-talks-pub/main/rdx/21-03-09_alex_run2_fullsim_validation.pdf
 - All FullSim comparison plots we have looked at
- ~ https://raw.githubusercontent.com/umd-lhcb/group-talks-pub/main/rdx/21-04-20_alex_run2_trackeronly_validation.pdf
 - All tracker-only MC plots

Stats in D^* templates

Compare effective stats in MC templates with fitted yields
 Uncertainties very large and correlated → only correct cases when ratio less than 4

MCMC fit in ANA note

MCMC fit in ANA note

$D_1^+ \mu\nu$ IsoDst yield	$1.12e4 \pm 3.35e3$
$D_1^0 \mu\nu$ IsoDst yield	$0 \pm 5.59e4$
$D_{1,+}^+ \mu\nu$ IsoDst yield	$1.36e4 \pm 4.28e3$
$D_{1,+}^0 \mu\nu$ IsoDst yield	$561 \pm 3.26e3$
$D_{2,+}^+ \mu\nu$ IsoDst yield	$3.22e3 \pm 2.54e3$
$D_{2,+}^{*0} \mu\nu$ IsoDst yield	$166 \pm 1.9e3$
DstDD IsoDst yield	$2.43e4 \pm 1.01e3$
misID IsoDst yield	$4.03e3 \pm 652$
$D_{s1,+}^+ \mu\nu$ IsoDst yield	817 ± 953
$D_{s2,+}^+ \mu\nu$ IsoDst yield	$0 \pm 1.76e3$
$D_s \rightarrow \tau\nu$ IsoDst yield	$1.08e3 \pm 290$
$D^{**}\tau\nu$ IsoDst yield	459 ± 121
$D^{*+} \mu\nu$ IsoDst yield	$3.31e5 \pm 2.07e3$
Comb. IsoDst yield	$1.05e3 \pm 451$
$(D^{**} \rightarrow D^{*+} \pi\pi) \mu\nu$ IsoDst yield	$1.1e4 \pm 2.35e3$
FakeDst IsoDst yield	$9.98e3 \pm 1.97e3$

Didn't look at $D^{**}\tau$ yields, so estimated them as $D^{**}\mu \times 0.12 \times 0.7 \times 0.1741$

h_sigmaALT:	444,109 /	792,508 =	56.0%	MC/data =	1.3	(data = 331,000)
h_D1_ALT:	44,484 /	97,042 =	45.8%	MC/data =	4.0	(data = 11,200)
h_D1p_ALT:	52,557 /	103,069 =	51.0%	MC/data =	3.9	(data = 13,600)
h_D2_ALT:	13,255 /	25,657 =	51.7%	MC/data =	4.1	(data = 3,220)
h_D1tau_ALT:	7,681 /	13,584 =	56.5%	MC/data =	16.7	(data = 459)
h_D1ptau_ALT:	8,608 /	14,822 =	58.1%	MC/data =	18.8	(data = 459)
h_D2tau_ALT:	2,106 /	3,109 =	67.7%	MC/data =	4.6	(data = 459)
h_uDDmu:	10,913 /	21,819 =	50.0%	MC/data =	0.4	(data = 24,300)
h_dDDmu:	68,204 /	145,507 =	46.9%	MC/data =	2.8	(data = 24,300)
h_dDDtau:	13,506 /	26,325 =	51.3%	MC/data =	12.5	(data = 1,080)
h_uDDtau:	3,369 /	5,371 =	62.7%	MC/data =	3.1	(data = 1,080)

HistFactory yields

h_sigmaALT:	444,109 /	792,508 =	56.0%	MC/data =	1.4	(data = 323,024)
h_D1_ALT:	44,484 /	97,042 =	45.8%	MC/data =	5.5	(data = 8,129)
h_D1p_ALT:	52,557 /	103,069 =	51.0%	MC/data =	6.2	(data = 8,470)
h_D2_ALT:	13,255 /	25,657 =	51.7%	MC/data =	6.4	(data = 2,063)
h_D1tau_ALT:	7,681 /	13,584 =	56.5%	MC/data =	64.6	(data = 119)
h_D1ptau_ALT:	8,608 /	14,822 =	58.1%	MC/data =	69.5	(data = 124)
h_D2tau_ALT:	2,106 /	3,109 =	67.7%	MC/data =	69.8	(data = 30)
h_D2Smu:	38,530 /	71,024 =	54.2%	MC/data =	5.1	(data = 7,521)
h_uDDmu:	10,913 /	21,819 =	50.0%	MC/data =	2.9	(data = 3,806)
h_dDDmu:	68,204 /	145,507 =	46.9%	MC/data =	3.9	(data = 17,634)
h_dDDtau:	13,506 /	26,325 =	51.3%	MC/data =	130.2	(data = 104)
h_uDDtau:	3,369 /	5,371 =	62.7%	MC/data =	3.4	(data = 991)

Stats in D⁰ templates

MCMC fit in ANA note

h_Dmu_ALT:	990,974 / 1,748,625 = 56.7%	MC/data = 2.7 (data = 366,000)
h_uDstmuALT:	1,979,933 / 2,999,737 = 66.0%	MC/data = 2.2 (data = 917,000)
h_dDstmuALT:	121,138 / 212,140 = 57.1%	MC/data = 1.7 (data = 69,500)
h_dD0muALT:	66,847 / 108,792 = 61.4%	MC/data = 7.0 (data = 9,560)
h_uD0muALT:	154,502 / 265,129 = 58.3%	MC/data = 7.6 (data = 20,200)
h_dD1muALT:	45,443 / 82,670 = 55.0%	MC/data = 12.4 (data = 3,660)
h_uD1muALT:	66,653 / 127,437 = 52.3%	MC/data = 1.4 (data = 48,000)
h_dD1pmuALT:	65,941 / 110,942 = 59.4%	MC/data = 8.1 (data = 8,150)
h_uD1pmuALT:	78,430 / 134,704 = 58.2%	MC/data = 10.6 (data = 7,380)
h_dD2muALT:	24,060 / 40,204 = 59.8%	MC/data = 4.6 (data = 5,200)
h_uD2muALT:	50,256 / 90,745 = 55.4%	MC/data = 30.8 (data = 1,630)
h_dD0tauALT:	608 / 1,329 = 45.8%	MC/data = 0.3 (data = 1,740)
h_uD0tauALT:	1,789 / 4,152 = 43.1%	MC/data = 1.0 (data = 1,740)
h_dD1tauALT:	428 / 954 = 44.9%	MC/data = 0.2 (data = 1,740)
h_uD1tauALT:	1,081 / 2,014 = 53.7%	MC/data = 0.6 (data = 1,740)
h_dD1ptauALT:	519 / 1,272 = 40.8%	MC/data = 0.3 (data = 1,740)
h_uD1ptauALT:	999 / 2,103 = 47.5%	MC/data = 0.6 (data = 1,740)
h_dD2tauALT:	266 / 459 = 57.9%	MC/data = 0.2 (data = 1,740)
h_uD2tauALT:	731 / 1,369 = 53.4%	MC/data = 0.4 (data = 1,740)
h_Dpipimu:	98,306 / 155,186 = 63.3%	MC/data = 2.6 (data = 38,200)
h_Dstzpipimu:	71,983 / 113,823 = 63.2%	MC/data = 5.8 (data = 12,400)
h_Dstppipimu:	14,217 / 27,856 = 51.0%	MC/data = 4.0 (data = 3,590)
h_sDs1pmuALT:	5,613 / 10,054 = 55.8%	MC/data = 0.8 (data = 7,030)
h_sDs2muALT:	6,458 / 11,096 = 58.2%	MC/data = 1.5 (data = 4,200)
h_uDDmu:	89,930 / 181,766 = 49.5%	MC/data = 1.2 (data = 74,900)
h_dDDmu:	40,726 / 82,999 = 49.1%	MC/data = 0.5 (data = 74,900)
h_uDDtau:	41,924 / 68,678 = 61.0%	MC/data = 9.2 (data = 4,550)
h_dDDtau:	3,834 / 7,574 = 50.6%	MC/data = 0.8 (data = 4,550)

HistFactory yields

h_Dmu_ALT:	990,974 / 1,748,625 = 56.7%	MC/data = 2.8 (data = 358,214)
h_uDstmuALT:	1,979,933 / 2,999,737 = 66.0%	MC/data = 2.1 (data = 944,864)
h_dDstmuALT:	121,138 / 212,140 = 57.1%	MC/data = 1.7 (data = 71,362)
h_dD0muALT:	66,847 / 108,792 = 61.4%	MC/data = 13.9 (data = 4,802)
h_uD0muALT:	154,502 / 265,129 = 58.3%	MC/data = 23.0 (data = 6,731)
h_dD1muALT:	45,443 / 82,670 = 55.0%	MC/data = 3.3 (data = 13,901)
h_uD1muALT:	66,653 / 127,437 = 52.3%	MC/data = 2.3 (data = 29,325)
h_dD1pmuALT:	65,941 / 110,942 = 59.4%	MC/data = 10.2 (data = 6,474)
h_uD1pmuALT:	78,430 / 134,704 = 58.2%	MC/data = 9.9 (data = 7,887)
h_dD2muALT:	24,060 / 40,204 = 59.8%	MC/data = 6.2 (data = 3,901)
h_uD2muALT:	50,256 / 90,745 = 55.4%	MC/data = 10.0 (data = 5,042)
h_dD0tauALT:	608 / 1,329 = 45.8%	MC/data = 8.7 (data = 70)
h_uD0tauALT:	1,789 / 4,152 = 43.1%	MC/data = 18.2 (data = 98)
h_dD1tauALT:	428 / 954 = 44.9%	MC/data = 2.1 (data = 203)
h_uD1tauALT:	1,081 / 2,014 = 53.7%	MC/data = 2.5 (data = 429)
h_dD1ptauALT:	519 / 1,272 = 40.8%	MC/data = 5.5 (data = 95)
h_uD1ptauALT:	999 / 2,103 = 47.5%	MC/data = 8.7 (data = 115)
h_dD2tauALT:	266 / 459 = 57.9%	MC/data = 4.7 (data = 57)
h_uD2tauALT:	731 / 1,369 = 53.4%	MC/data = 9.9 (data = 74)
h_Dpipimu:	98,306 / 155,186 = 63.3%	MC/data = 65.1 (data = 1,511)
h_Dstzpipimu:	71,983 / 113,823 = 63.2%	MC/data = 1.5 (data = 49,462)
h_Dstppipimu:	14,217 / 27,856 = 51.0%	MC/data = 3.2 (data = 4,465)
h_sDs1pmuALT:	5,613 / 10,054 = 55.8%	MC/data = 1.3 (data = 4,228)
h_sDs2muALT:	6,458 / 11,096 = 58.2%	MC/data = 4.8 (data = 1,344)
h_uDDmu:	89,930 / 181,766 = 49.5%	MC/data = 2.3 (data = 38,331)
h_dDDmu:	40,726 / 82,999 = 49.1%	MC/data = 1.3 (data = 31,484)
h_uDDtau:	41,924 / 68,678 = 61.0%	MC/data = 8.7 (data = 4,845)
h_dDDtau:	3,834 / 7,574 = 50.6%	MC/data = 3.8 (data = 1,004)

Didn't look at D^{**} τ yields, so estimated them as D^{**} $\mu \times 0.12 \times 0.7 \times 0.1741$

Stats in D⁰ templates

MCMC fit in ANA note

$D^0 \mu\nu$ Iso yield	3.66e5 $\pm 2.9e3$
$D_0^{*+} \mu\nu$ Iso yield	9.56e3 $\pm 7.77e3$
$D_0^{*0} \mu\nu$ Iso yield	2.02e4 $\pm 8.87e3$
$D_1^+ \mu\nu$ Iso yield	3.66e3 $\pm 9.85e3$
$D_1^0 \mu\nu$ Iso yield	4.8e4 $\pm 9.71e3$
$D_1^{'+} \mu\nu$ Iso yield	8.15e3 $\pm 9.84e3$
$D_1^{'+0} \mu\nu$ Iso yield	7.38e3 $\pm 1.11e4$
$D_2^{*+} \mu\nu$ Iso yield	5.2e3 $\pm 5.62e3$
$D_2^{*0} \mu\nu$ Iso yield	1.63e3 $\pm 9.48e3$
DD Iso yield	7.49e4 $\pm 2.87e3$
misID Iso yield	3.4e4 $\pm 2.24e3$
$D_{s1}^+ \mu\nu$ Iso yield	7.03e3 $\pm 3.12e3$
$D_{s2}^{*+} \mu\nu$ Iso yield	4.2e3 $\pm 2.78e3$
$D_s \rightarrow \tau\nu$ Iso yield	4.55e3 $\pm 1.16e3$
$(D^{**} \rightarrow D^0 \pi\pi) \mu\nu$ Iso yield	3.82e4 $\pm 1.02e4$
$(D^{**} \rightarrow D^{*+} \pi\pi) \mu\nu$ Iso yield	3.59e3 $\pm 5.2e3$
$(D^{**} \rightarrow D^{*0} \pi\pi) \mu\nu$ Iso yield	1.24e4 $\pm 5.48e3$
$D^{**} \tau\nu$ Iso yield	1.74e3 ± 498
Comb. Iso yield	2.37e4 $\pm 2.73e3$
$D^{*0} \mu\nu$ Iso yield	9.17e5 $\pm 1.24e4$
$D^{*+} \mu\nu$ Iso yield	6.95e4 $\pm 1.19e4$

MCMC fit in ANA note

h_Dmu_ALT:	990,974 / 1,748,625 = 56.7%	MC/data = 2.7	(data = 366,000)
h_uDstmuALT:	1,979,933 / 2,999,737 = 66.0%	MC/data = 2.2	(data = 917,000)
h_dDstmuALT:	121,138 / 212,140 = 57.1%	MC/data = 1.7	(data = 69,500)
h_dD0muALT:	66,847 / 108,792 = 61.4%	MC/data = 7.0	(data = 9,560)
h_uD0muALT:	154,502 / 265,129 = 58.3%	MC/data = 7.6	(data = 20,200)
h_dD1muALT:	45,443 / 82,670 = 55.0%	MC/data = 12.4	(data = 3,660)
h_uD1muALT:	66,653 / 127,437 = 52.3%	MC/data = 1.4	(data = 48,000)
h_dD1pmuALT:	65,941 / 110,942 = 59.4%	MC/data = 8.1	(data = 8,150)
h_uD1pmuALT:	78,430 / 134,704 = 58.2%	MC/data = 10.6	(data = 7,380)
h_dD2muALT:	24,060 / 40,204 = 59.8%	MC/data = 4.6	(data = 5,200)
h_uD2muALT:	50,256 / 90,745 = 55.4%	MC/data = 30.8	(data = 1,630)
h_dD0tauALT:	608 / 1,329 = 45.8%	MC/data = 0.3	(data = 1,740)
h_uD0tauALT:	1,789 / 4,152 = 43.1%	MC/data = 1.0	(data = 1,740)
h_dD1tauALT:	428 / 954 = 44.9%	MC/data = 0.2	(data = 1,740)
h_uD1tauALT:	1,081 / 2,014 = 53.7%	MC/data = 0.6	(data = 1,740)
h_dD1ptauALT:	519 / 1,272 = 40.8%	MC/data = 0.3	(data = 1,740)
h_uD1ptauALT:	999 / 2,103 = 47.5%	MC/data = 0.6	(data = 1,740)
h_dD2tauALT:	266 / 459 = 57.9%	MC/data = 0.2	(data = 1,740)
h_uD2tauALT:	731 / 1,369 = 53.4%	MC/data = 0.4	(data = 1,740)
h_Dpipimu:	98,306 / 155,186 = 63.3%	MC/data = 2.6	(data = 38,200)
h_Dstzpipimu:	71,983 / 113,823 = 63.2%	MC/data = 5.8	(data = 12,400)
h_Dstppipimu:	14,217 / 27,856 = 51.0%	MC/data = 4.0	(data = 3,590)
h_sDs1pmuALT:	5,613 / 10,054 = 55.8%	MC/data = 0.8	(data = 7,030)
h_sDs2muALT:	6,458 / 11,096 = 58.2%	MC/data = 1.5	(data = 4,200)
h_uDDmu:	89,930 / 181,766 = 49.5%	MC/data = 1.2	(data = 74,900)
h_dDDmu:	40,726 / 82,999 = 49.1%	MC/data = 0.5	(data = 74,900)
h_uDDtau:	41,924 / 68,678 = 61.0%	MC/data = 9.2	(data = 4,550)
h_dDDtau:	3,834 / 7,574 = 50.6%	MC/data = 0.8	(data = 4,550)