Charged low momentum pion efficiency

Belle II Germany Meeting 2025

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Motivation

- Slow pion efficiency as an important uncertainty for measurements including slow pions, like $|V_{cb}|$
- Previous studies for Belle2-NOTE-PH-2023-035
  MC15rd vs proc13+prompt
  ⇒ need updated version for
  MC16rd vs proc16+prompt
- Possible improvement by studying $ee \to c\bar{c}$ to provide more statistics
- Current relative tracking efficiency for MC15:
  (97.441 +/- 1.99 +/- 0.817)%

	ρ^2	$R_1(1)$	$R_2(1)$	$\lvert V_{cb}\rvert$
Statistical	3.0	4.1	2.8	0.7
Background subtraction	1.4	2.2	1.2	0.3
Size of simulated samples	1.2	1.7	1.1	0.3
Lepton ID efficiency	0.2	1.6	0.1	0.3
Slow pion efficiency	1.0	0.9	0.8	1.5
Tracking of K, π, ℓ				0.4
$N_{B\bar{B}}$				0.8
f_{+0}				1.3
$\mathcal{B}(D^{*+} \to D^0\pi^+)$				0.4
$\mathcal{B}(D^0 \to K^-\pi^+)$				0.4
B^0 lifetime				0.1
Signal modeling	2.6	2.6	2.0	0.5
Total	4.5	5.9	3.9	2.4

Phys Rev. D 108. 092013

Strategy

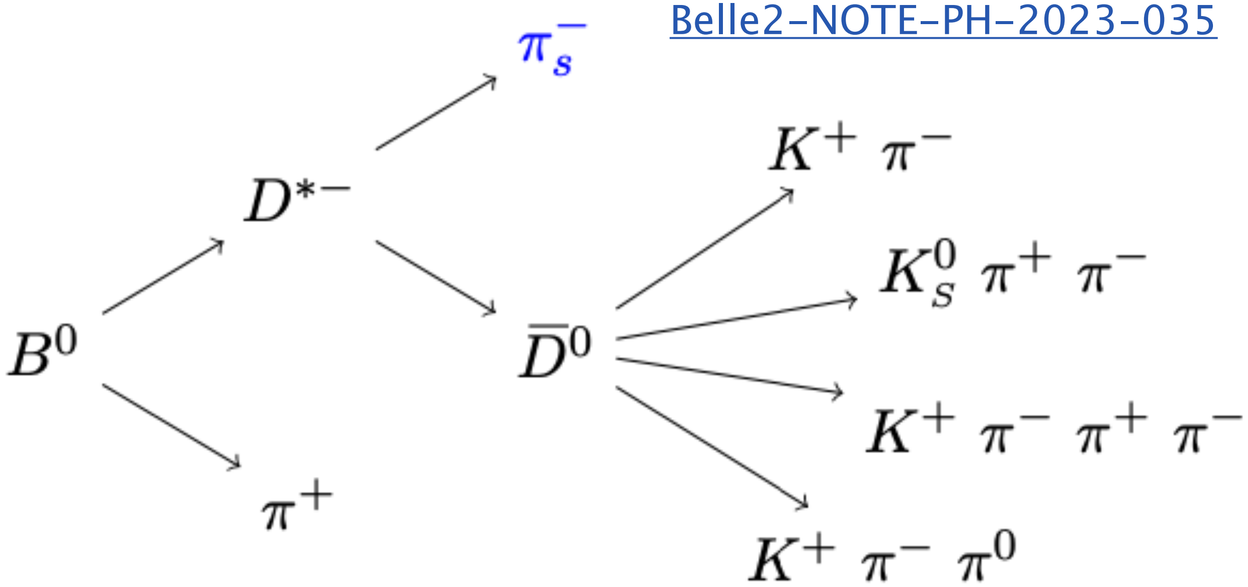
- Reconstruction of B^0
- Selections and corrections
- Finding suitable variables for fit
- 2D fit with templates
- Tests: Asimov, Pull
- Yield calculation
- Slow pion efficiency calculation

Reconstruction

- Study $B^0 \to D^{*-}\pi^+$ decay with subsequent decay $D^{*-} \to \overline{D}^0\pi_s^-$
- $\overline{D}^0$ candidates are reconstructed using a combination of four decay channels
- Charge conjugated decays included
- Using these decay chains we will determine the real tracking efficiency of data to MC16rd

- MC: MC16rd_proc16 Run1, Lumi = 1368/fb
- Data: proc16+prompt, Lumi = 358/fb
- Samples: qqbar, BBbar, taupair
- Release light-2406-ragdoll

Belle2-NOTE-PH-2023-035



Selections and corrections

Particle	Selection criteria
good track	$dr < 2cm, \lvert dz\rvert < 4cm$ and θ within CDC acceptance
π^+	good track
K^+	good track, $P_K^{binary} > 0.1$ (for $K^+\pi^-\pi^+\pi^-$ and $K^+\pi^-\pi^0$ channels)
π^0	$pi0 : eff40\_May2020$
K_S^0	$\left\lvert M_{K_S^0} - M_{K_S^0}^{PDG}\right\rvert < 0.01$ GeV
$\bar{D}^0$	$\lvert M_D - M_D^{PDG}\rvert < 0.02$ GeV
D^{*-}	$0.141 < \Delta M_{D,D^*} < 0.156$
$p_{D^{*-}}^{CMS}$	$2.0 < p_{D^{*-}} < 2.5$ GeV
Energy difference	$\lvert\Delta E\rvert < 0.2$ GeV
Beam Constrained mass	$5.270 < M_{bc} < 5.287$ GeV

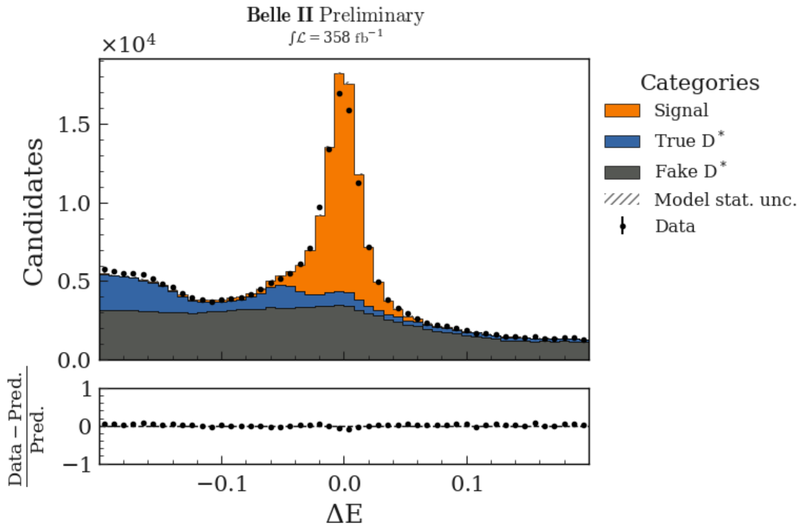
Belle2-NOTE-PH-2023-035

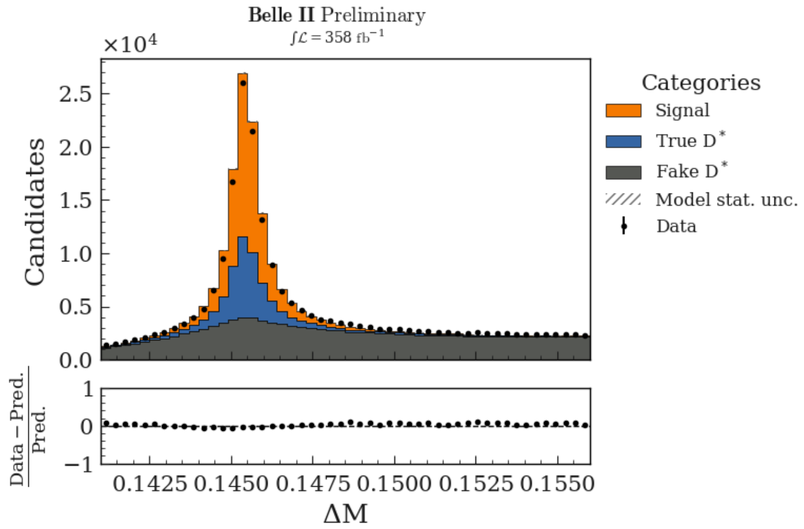
Disclaimer: have to update gamma efficiency, track momentum scaling and photon energy bias once available

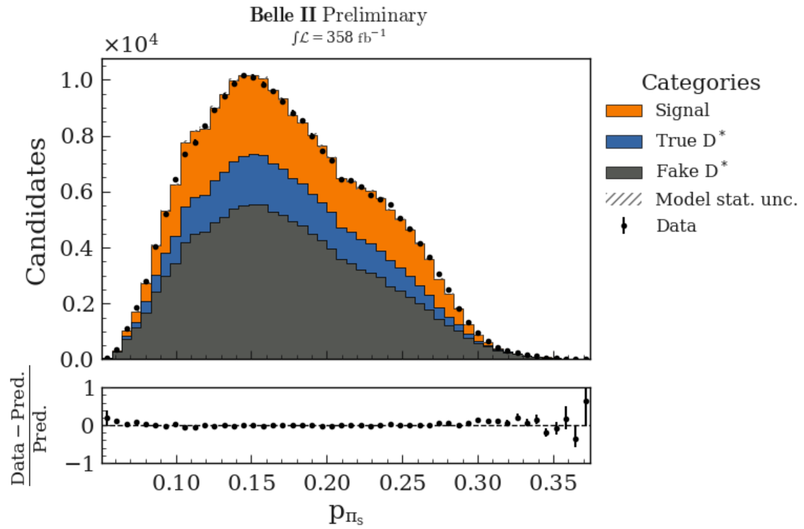
- Gamma efficiency (MC): PhotonEfficiencyDataMCRatio_proc13 MC15_November2022
- hadronID (MC): proc16+prompt
- Track momentum scaling (Data)
  via: scaleTrackMomenta
  using: tracking data Moriond23_v1
- Photon energy bias (Data)
  via: correctEnergyBias
  using: PhotonEnergyBiasCorrection_MC15ri_Nov2022

Pre-fit Data-MC agreement

All channels combined



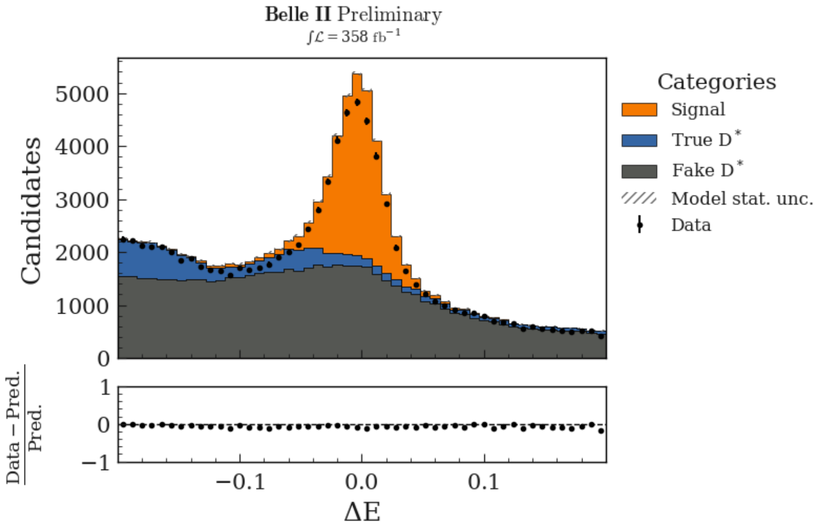


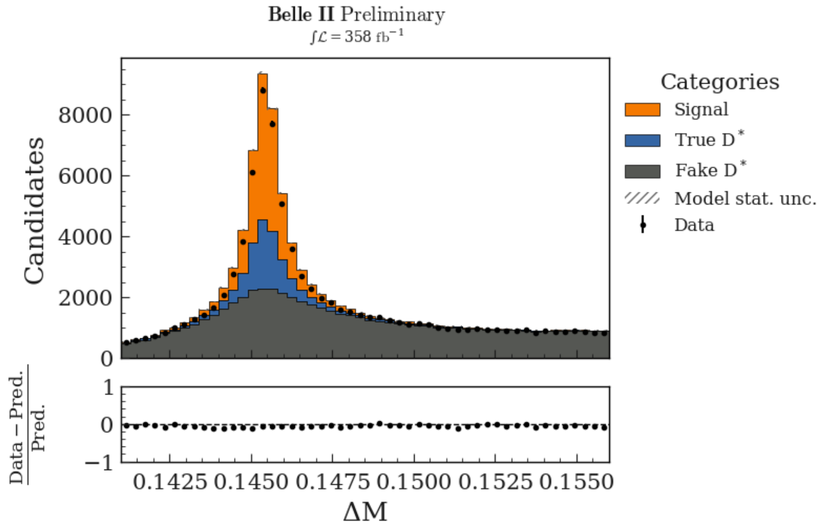


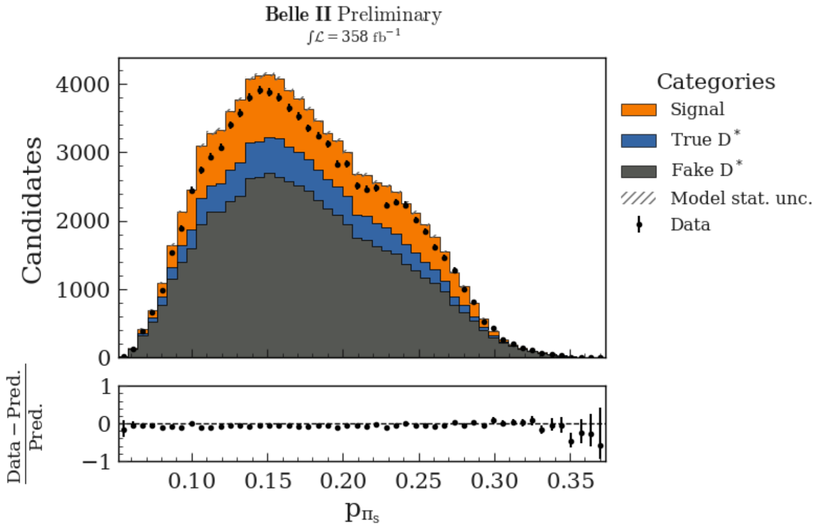
	$K\pi$	$K\pi\pi\pi$	K^0_S	π^0
N_{sig}	14549.8 ± 61.7	22839.5 ± 77.3	4543.0 ± 34.5	20008.0 ± 72.4
N_{bkg}	4257.0 ± 33.4	16852.2 ± 66.4	4857.6 ± 35.7	22235.3 ± 76.3
$\frac{N_{\text{sig}}}{\sqrt{N_{\text{sig}}+N_{\text{bkg}}}}$	106.1 ± 0.3	114.6 ± 0.3	46.9 ± 0.3	97.3 ± 0.3

Luminosity scaled signal yield N_{sig}, background yield N_{bkg} and significance of each channel in signal region, i.e. $|\Delta E| < 0.05$

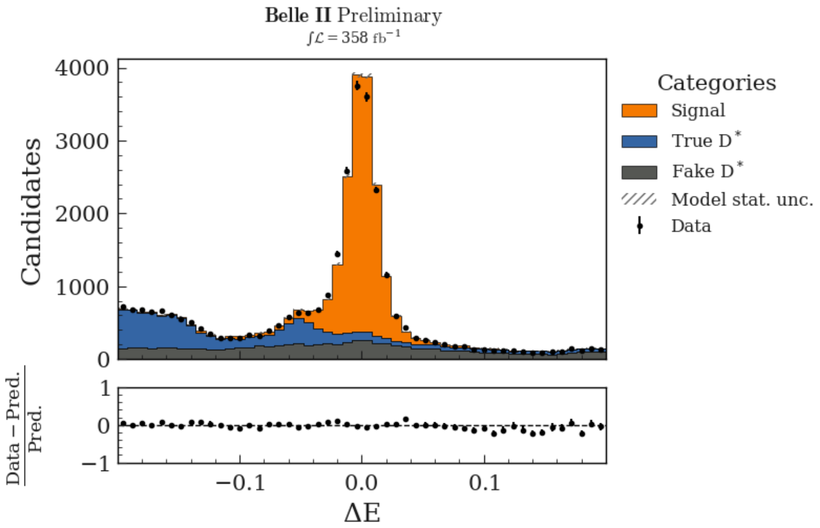
Channel $K^+\pi^-\pi^0$

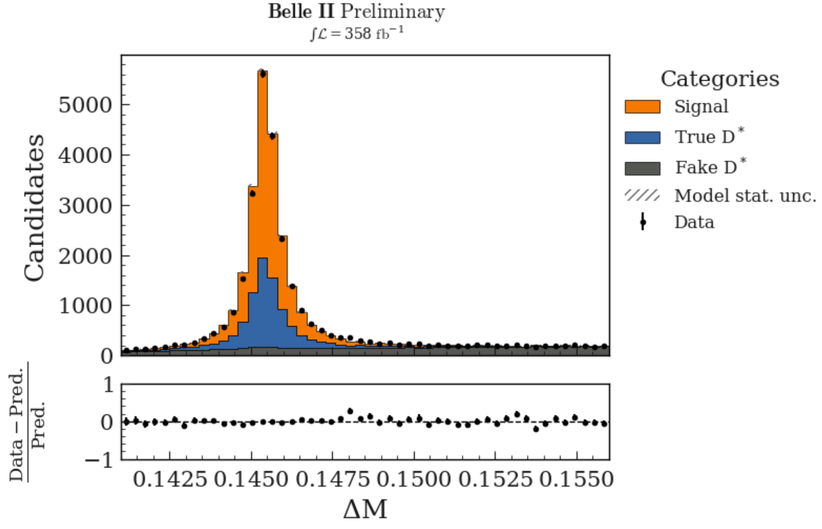


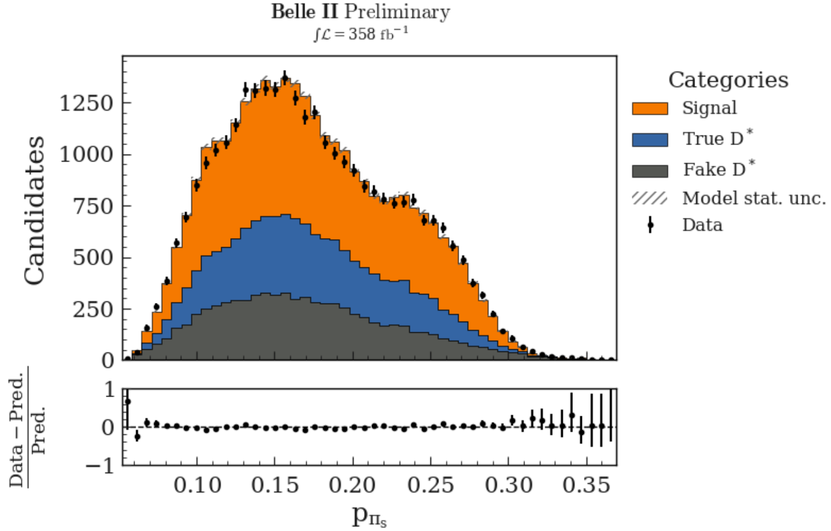




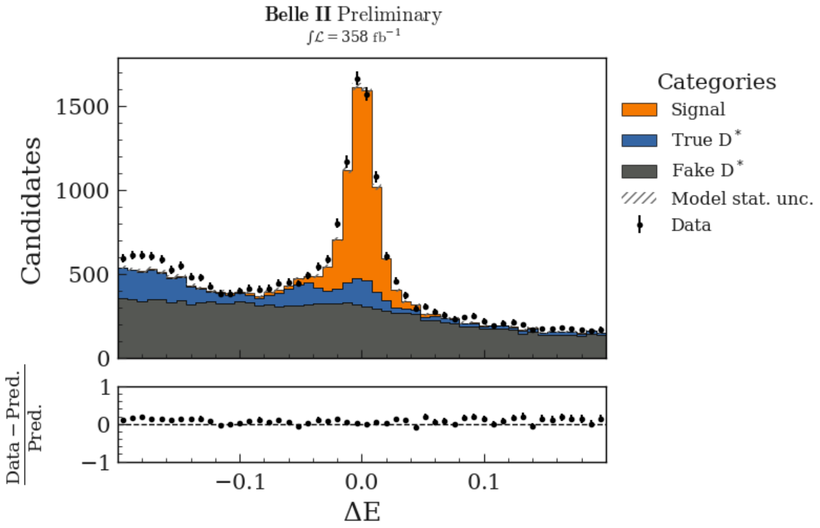
Channel $K^+\pi^-$

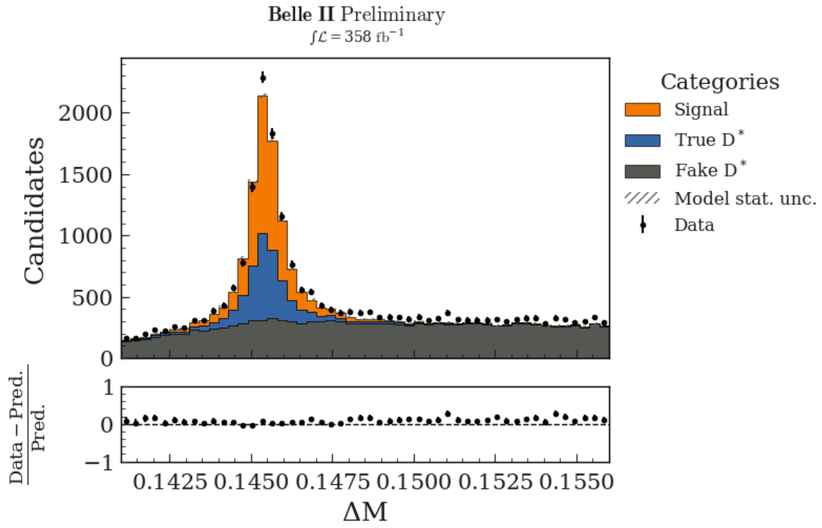


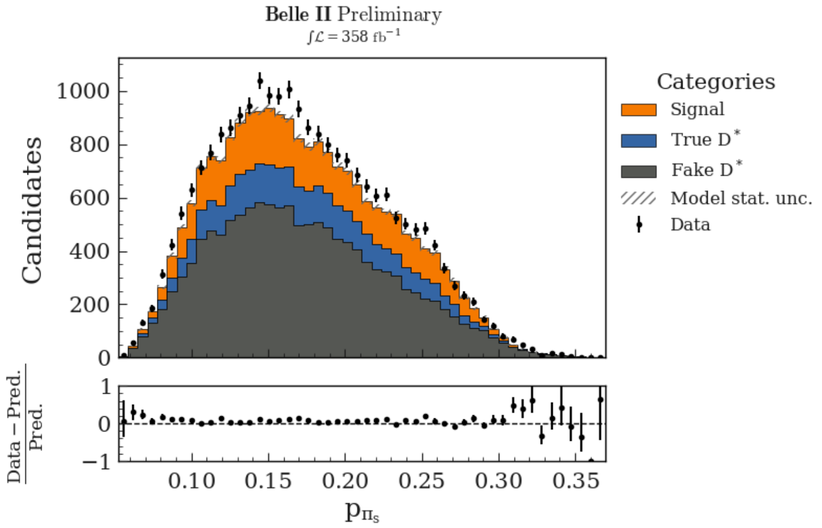




Channel $K_s^0\pi^+\pi^-$







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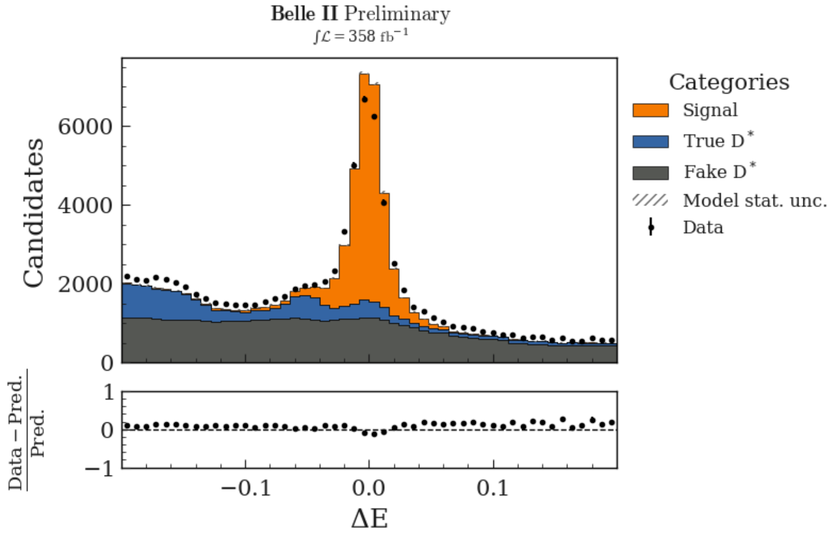
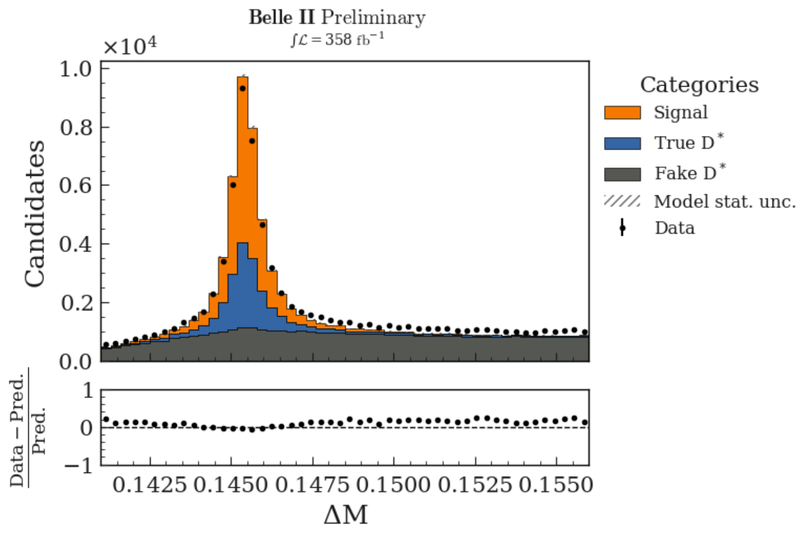
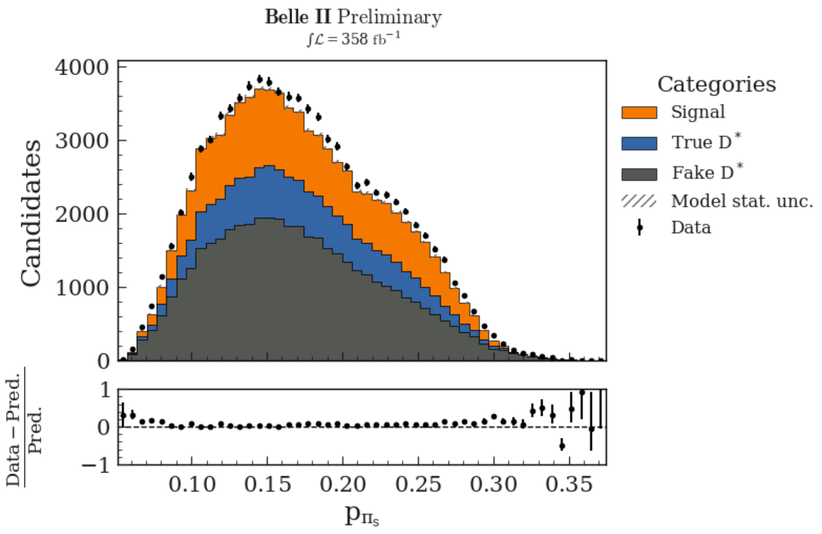


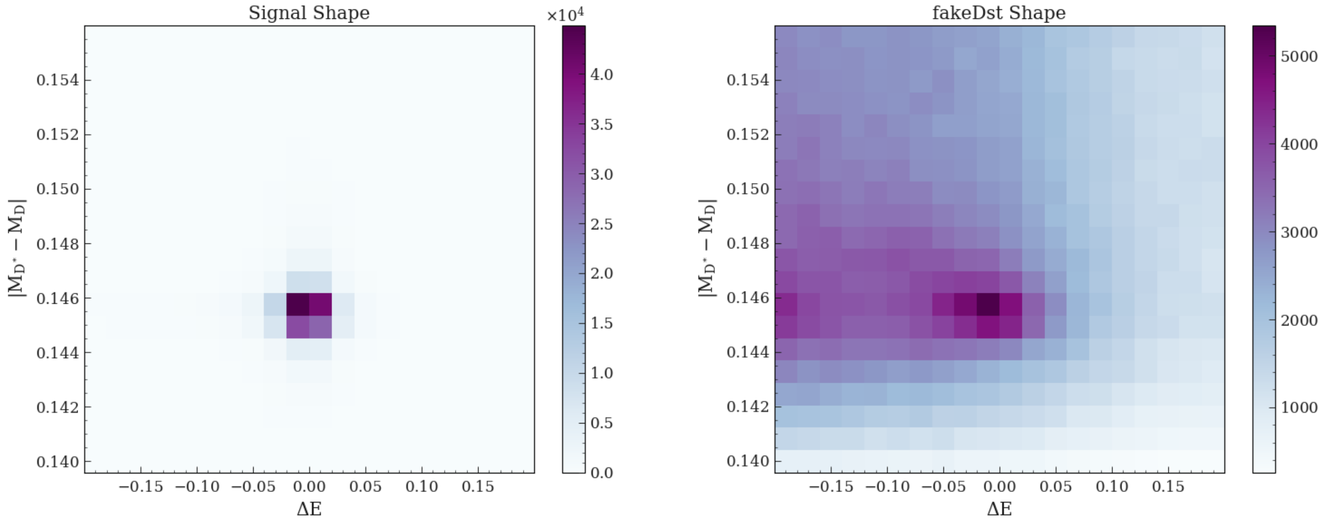


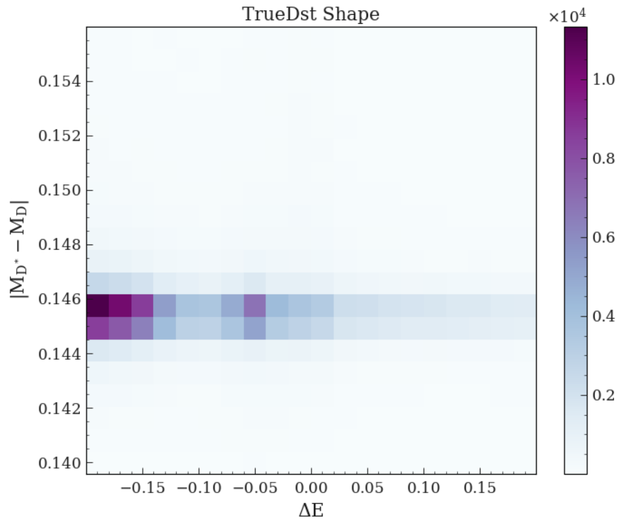


Fit templates

For relative tracking efficiency of π_s need amount of signal events in data

- Fit variables ΔE and ΔM: compare their 2D shape of data with mc
- Includes three templates (fake D^*, true D^* and Signal)
- Fake and true D^* as background templates due to their good separation in ΔM plane
- Shown spectra include whole $p(\pi_s)$ range





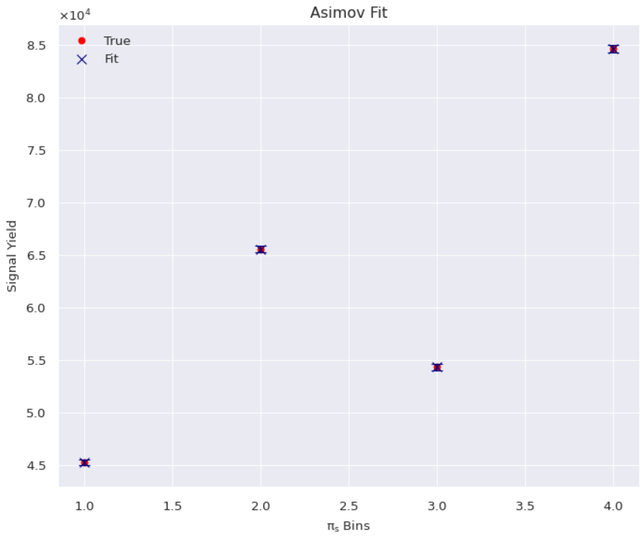
Fit procedure

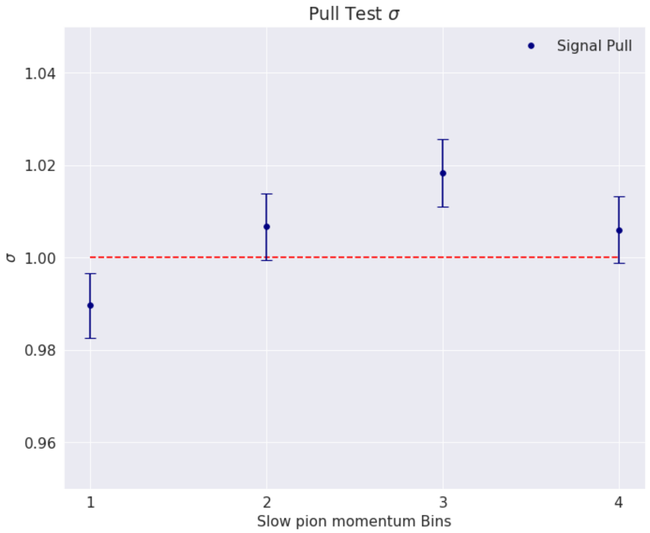
- Signal yield of data determined in 4 bins of $p(\pi_s)$ in lab frame
- Highest momentum bin used as reference for fast tracks
- All three mc components fitted onto data individually for each bin
- Extract signal yield via 2D fit with
  · 9 bins in ΔE
  · 5 bins in ΔM
  (binned maximum likelihood fit via pyhf)

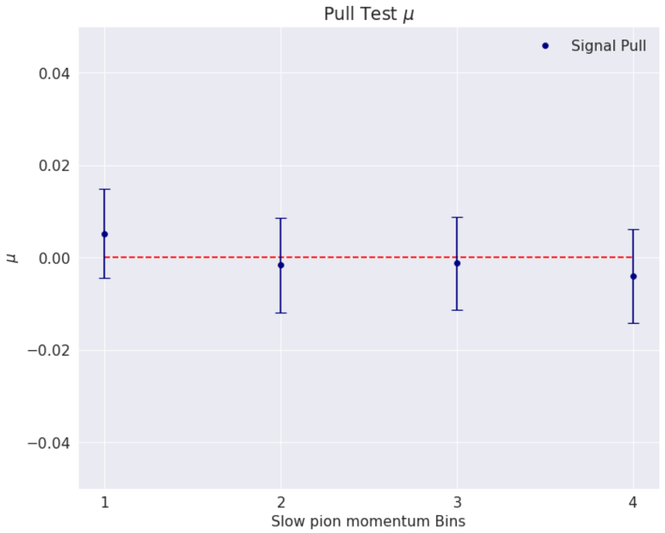
Mismodelling:

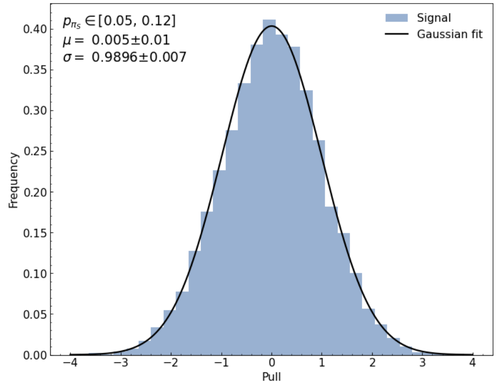
- True D^*:
  Add variation of 5% per bin
  $\Rightarrow$ mismodelling resulting from poorly known branching ratios and decay models for hadronic decays like $D^*\rho$
- Fake D^*:
  Correlated variation of 10%
  $\Rightarrow$ mismodelling of the ratio of the peaking and flat fake D^* component in signal region

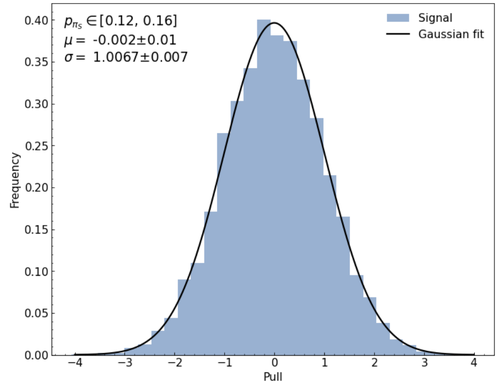
Asimov and pull test

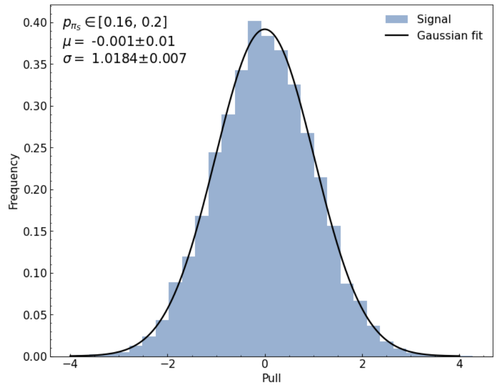


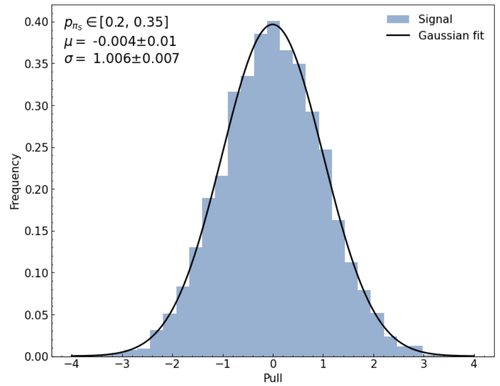






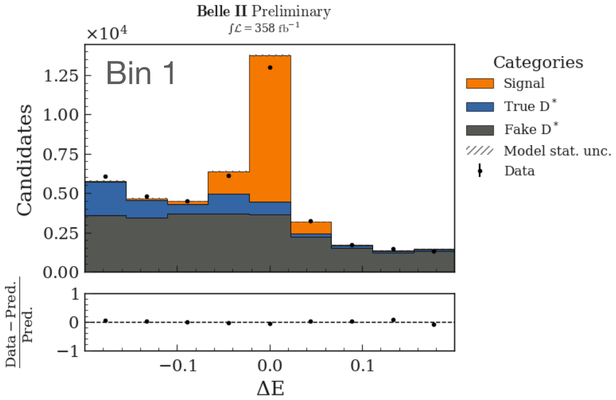


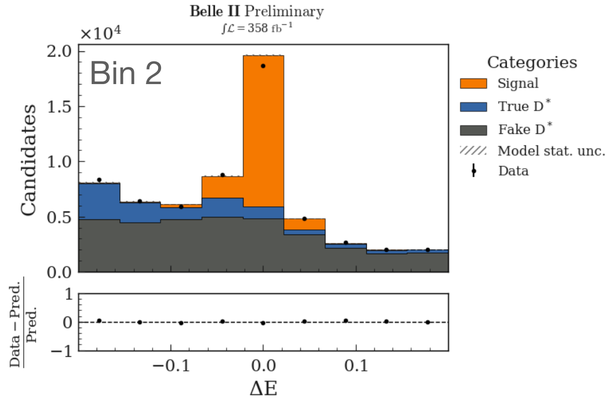


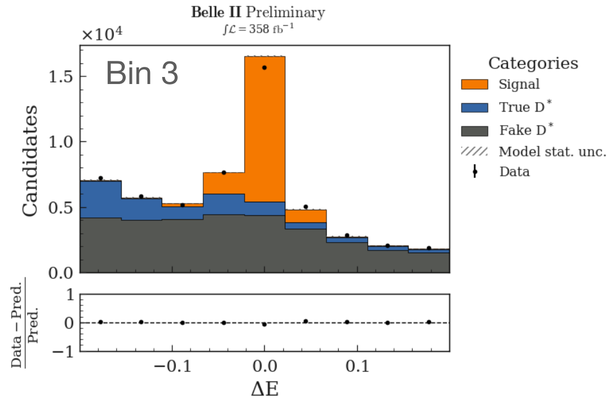


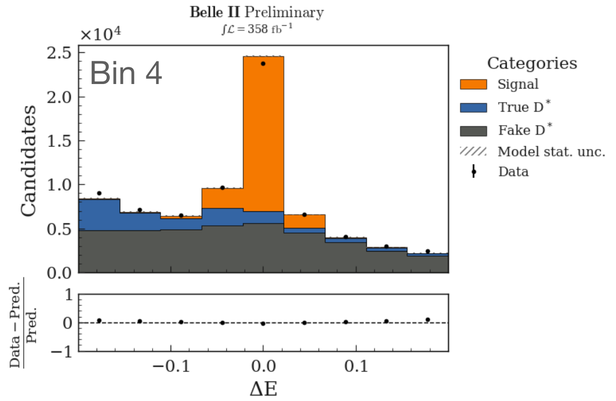
Comparison : ΔE

Pre-fit

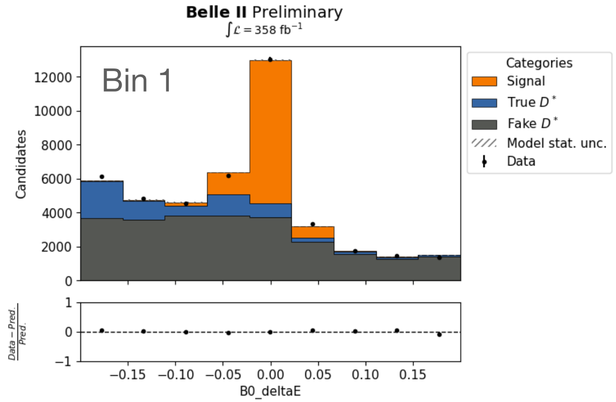


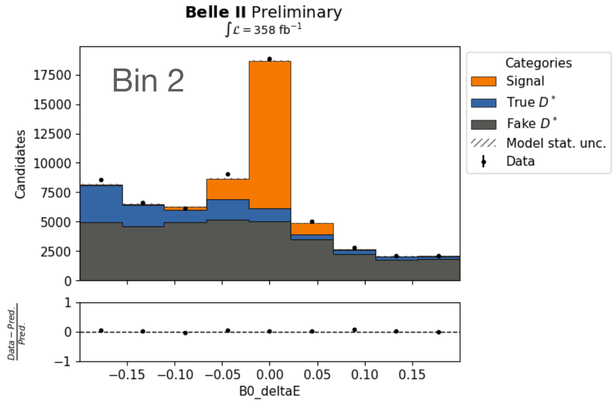


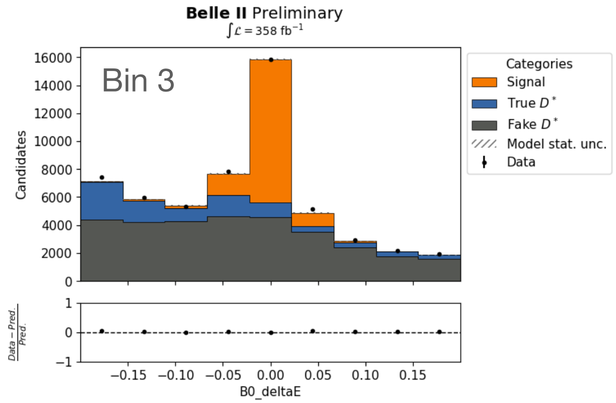


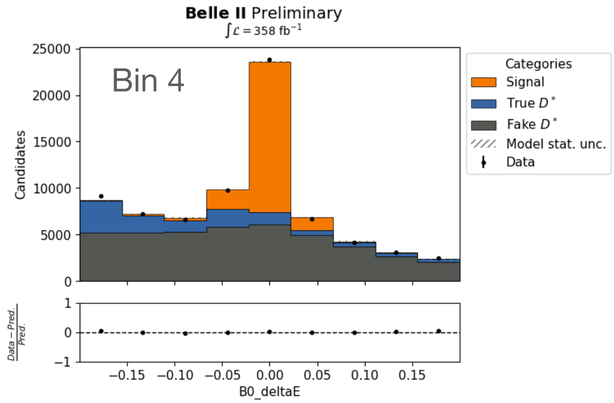


Post-fit



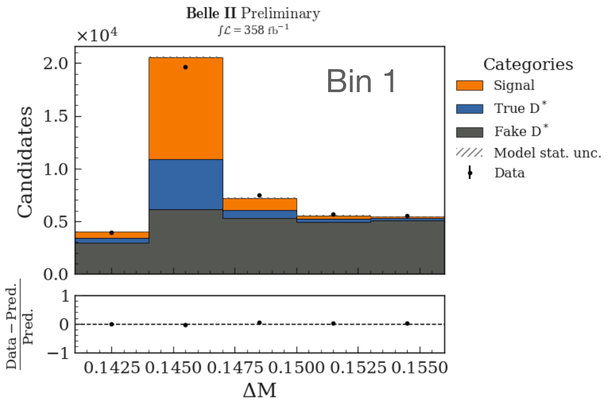


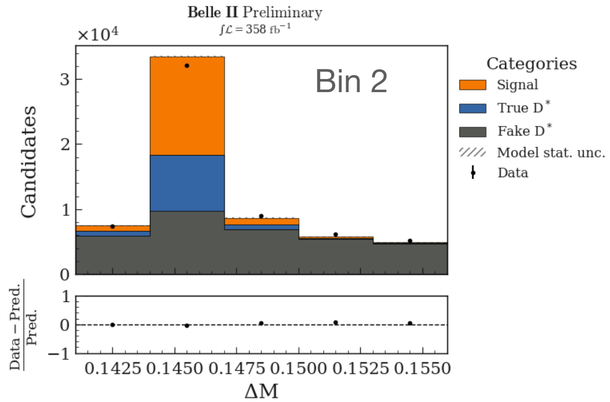


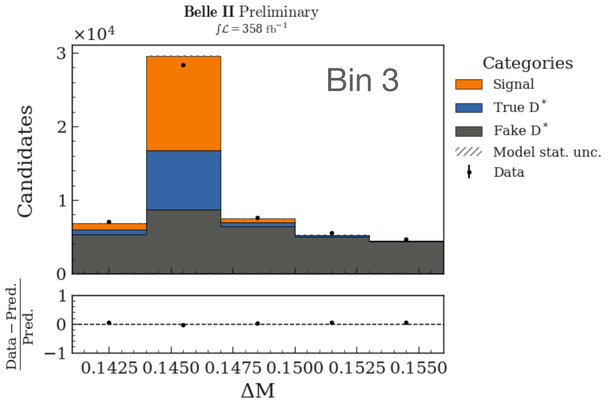


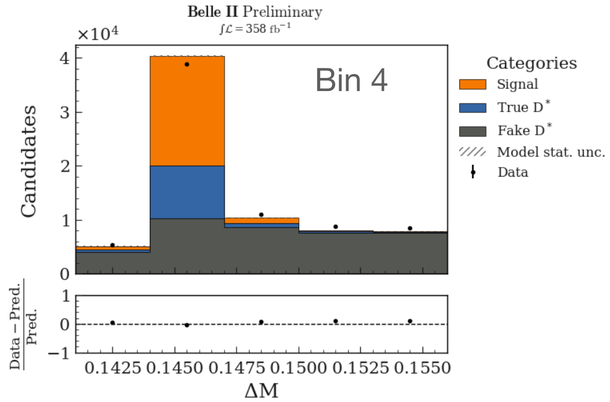
Comparison : ΔM

Pre-fit









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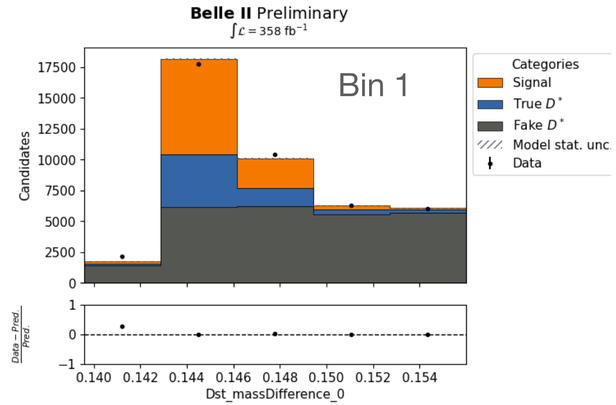

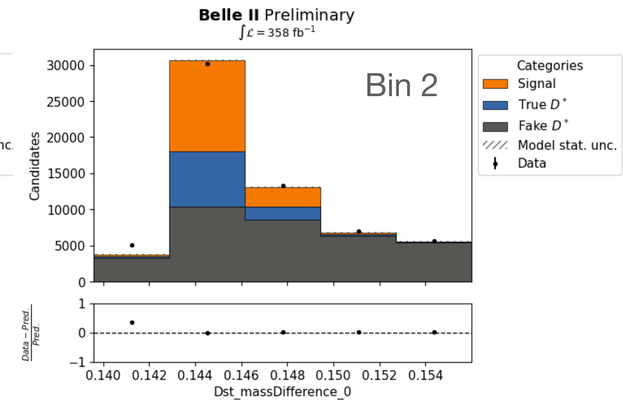

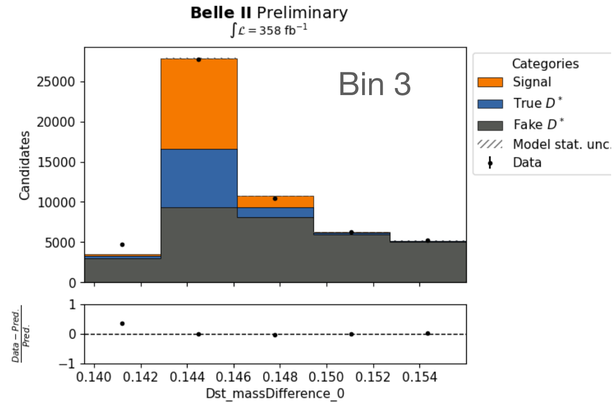

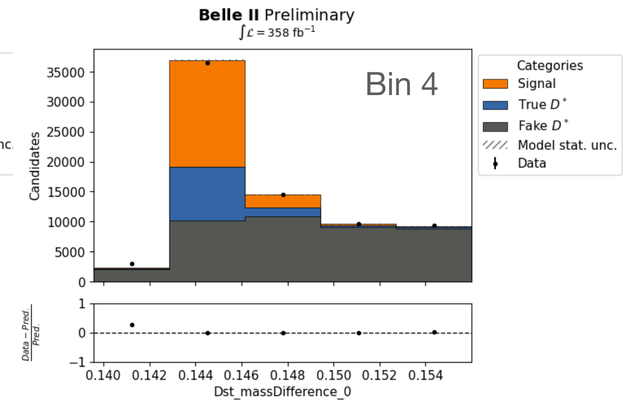

Relative tracking efficiency

- N_{fit}: extracted number of signal candidates of each bin
- $N_{\text{sig}}^{\text{MC}}$: number of candidates predicted by signal template of MC
- Relative yield factors r_i:
  measure discrepancy between efficiency of reconstruction in data and MC for each bin

$$r_i = \frac{N_{\text{fit}}}{\text{MC prediction}} \qquad \text{MC prediction} = N_{\text{sig}}^{\text{MC}} \cdot \frac{\text{luminosity data}}{\text{luminosity MC}}$$

- Normalise of the individual bins to ratio of highest momentum, i.e. r_i/r_4

- Get two statistical uncertainties (uncorrelated and correlated) obtained by linear error propagation:

$$\sigma^2_{r_i/r_4} = \left(\frac{1}{r_4}\right)^2 \sigma^2_{r_i} + \left(\frac{r_i}{r_4^2}\right)^2 \sigma^2_{r_4} = \sigma^2_{\text{uncorr}_i} + \sigma^2_{\text{corr}_i}$$

MC16rd

Relative tracking efficiency: (99.795 +/- 1.17 +/- 0.269)%
Slow pion systematic: 1.202%

$\mathbf{p}_{\pi_s}$ **range [GeV]**	**0.05-0.12**	**0.12-0.16**	**0.16-0.20**	**0.20-0.35**
MC prediction	11849 ± 56	17169 ± 67	14232 ± 61	22155 ± 76
Fitted yield	10744 ± 135	15754 ± 160	13083 ± 149	20318 ± 178
r_i	0.907 ± 0.012	0.918 ± 0.01	0.919 ± 0.011	0.917 ± 0.009
r_i/r_{max}	0.989	1.001	1.002	
$\sigma_{\text{uncorr}} \pm \sigma_{\text{corr}}$	0.013 ± 0.009	0.011 ± 0.009	0.012 ± 0.009	

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- Get two statistical uncertainties (uncorrelated and correlated) obtained by linear error propagation:

$$\sigma^2_{r_i/r_4} = \left(\frac{1}{r_4}\right)^2 \sigma^2_{r_i} + \left(\frac{r_i}{r_4^2}\right)^2 \sigma^2_{r_4} = \sigma^2_{\text{uncorr}_i} + \sigma^2_{\text{corr}_i}$$

MC16rd

Relative tracking efficiency: (99.795 +/- 1.17 +/- 0.269)%
Slow pion systematic: 1.202%

$\mathbf{p}_{\pi_s}$ **range [GeV]**	**0.05-0.12**	**0.12-0.16**	**0.16-0.20**	**0.20-0.35**
MC prediction	11849 ± 56	17169 ± 67	14232 ± 61	22155 ± 76
Fitted yield	10744 ± 135	15754 ± 160	13083 ± 149	20318 ± 178
r_i	0.907 ± 0.012	0.918 ± 0.01	0.919 ± 0.011	0.917 ± 0.009
r_i/r_{max}	0.989	1.001	1.002	
$\sigma_{\text{uncorr}} \pm \sigma_{\text{corr}}$	0.013 ± 0.009	0.011 ± 0.009	0.012 ± 0.009	

Relative tracking efficiency

- N_{fit}: extracted number of signal candidates of each bin
- $N_{\text{sig}}^{\text{MC}}$: number of candidates predicted by signal template of MC
- Relative yield factors r_i:
  measure discrepancy between efficiency of reconstruction in data and MC for each bin

$$r_i = \frac{N_{\text{fit}}}{\text{MC prediction}} \qquad \text{MC prediction} = N_{\text{sig}}^{\text{MC}} \cdot \frac{\text{luminosity data}}{\text{luminosity MC}}$$

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Relative tracking efficiency

- N_{fit}: extracted number of signal candidates of each bin
- $N_{\text{sig}}^{\text{MC}}$: number of candidates predicted by signal template of MC
- Relative yield factors r_i:
  measure discrepancy between efficiency of reconstruction in data and MC for each bin

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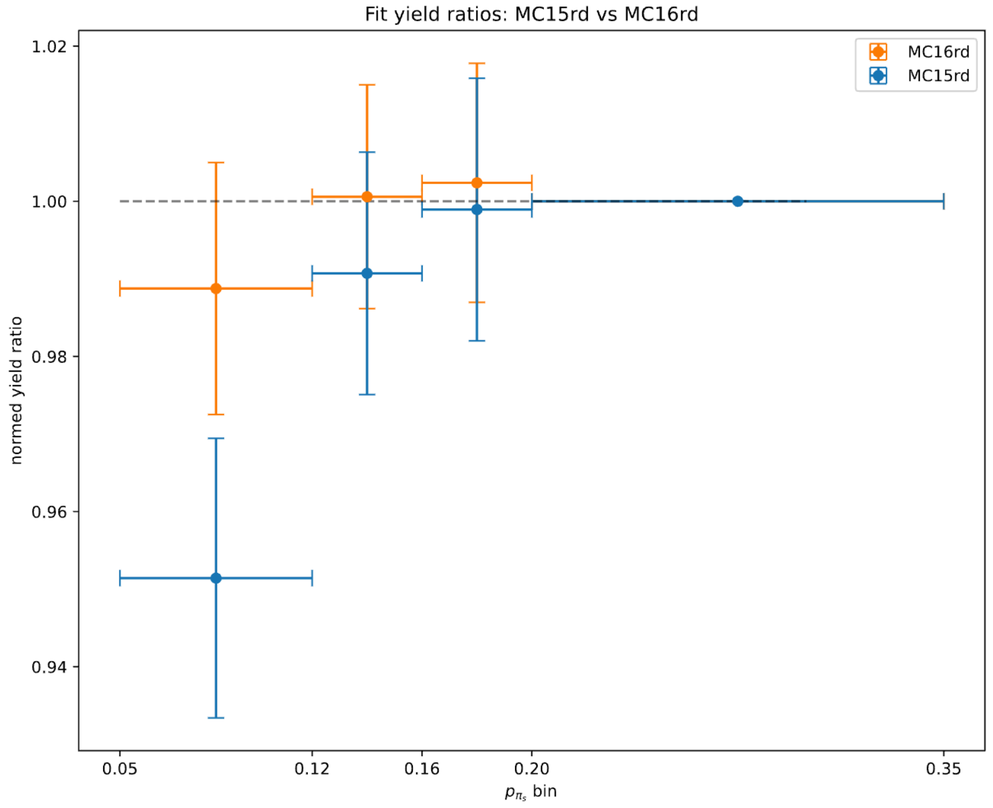
r_i/r_{max}	0.989	1.001	1.002	
$\sigma_{\text{uncorr}} \pm \sigma_{\text{corr}}$	0.013 ± 0.009	0.011 ± 0.009	0.012 ± 0.009	

Relative tracking efficiency: MC16rd vs MC15rd release 8



MC15rd

Relative tracking efficiency: (98.335 +/- 1.29 +/- 0.266)%
Slow pion systematic: 1.325%

$\mathbf{p}_{\pi_s}$ **range [GeV]**	**0.05-0.12**	**0.12-0.16**	**0.16-0.20**	**0.20-0.35**
MC prediction	9733 ± 49	15833 ± 63	12863 ± 57	20260 ± 71
Fitted yield	8918 ± 134	15105 ± 168	12374 ± 156	19510 ± 191
r_i	0.916 ± 0.014	0.964 ± 0.011	0.962 ± 0.013	0.963 ± 0.01
$r_i/r_{\max}$	0.951	0.991	0.999	
$\sigma_{\text{uncorr}} \pm \sigma_{\text{corr}}$	0.015 ± 0.01	0.012 ± 0.01	0.013 ± 0.01	

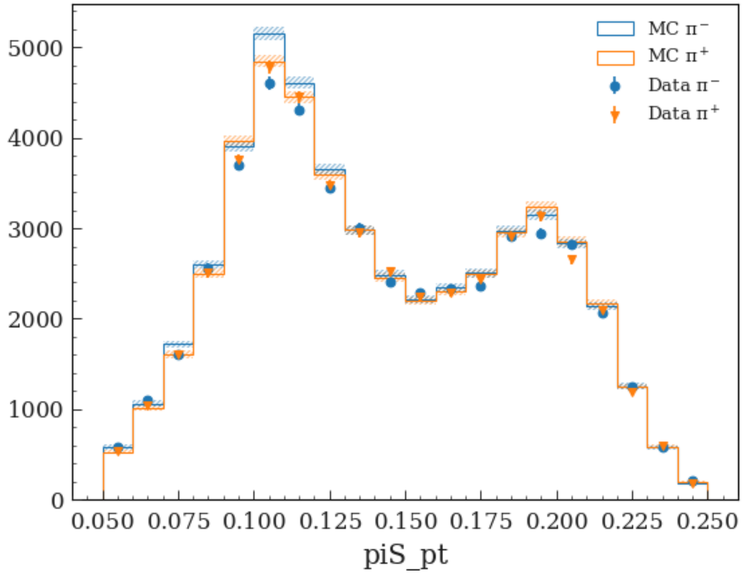
MC16rd

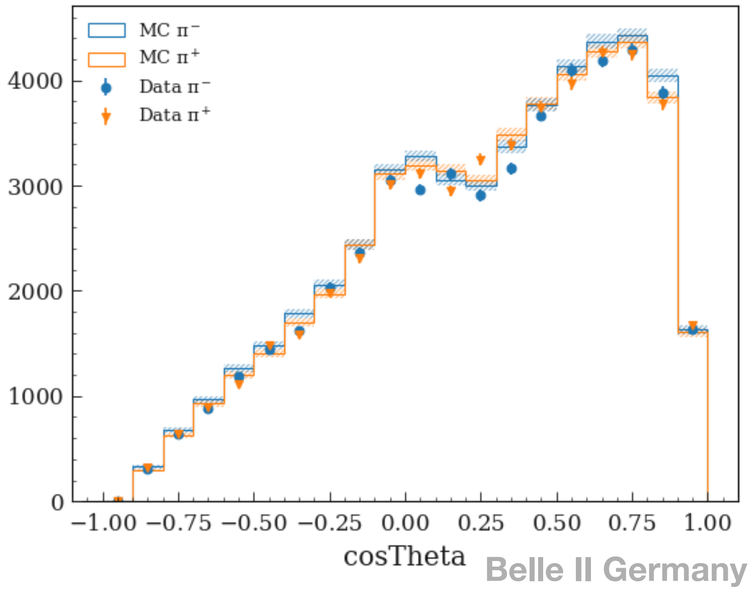
Relative tracking efficiency: (99.795 +/- 1.17 +/- 0.269)%
Slow pion systematic: 1.202%

$\mathbf{p}_{\pi_s}$ **range [GeV]**	**0.05-0.12**	**0.12-0.16**	**0.16-0.20**	**0.20-0.35**
MC prediction	11849 ± 56	17169 ± 67	14232 ± 61	22155 ± 76
Fitted yield	10744 ± 135	15754 ± 160	13083 ± 149	20318 ± 178
r_i	0.907 ± 0.012	0.918 ± 0.01	0.919 ± 0.011	0.917 ± 0.009
$r_i/r_{\max}$	0.989	1.001	1.002	
$\sigma_{\text{uncorr}} \pm \sigma_{\text{corr}}$	0.013 ± 0.009	0.011 ± 0.009	0.012 ± 0.009	

Charge asymmetry

- To monitor charge dependent inefficiencies for π_s track finding in data and MC samples
- Just to compare behaviour of the data and MC samples
  (not for providing any corrections)
- Charge of π_s candidates identified using their reconstructed PDG code
- In [0.1, 0.15] for $p_T(\pi_s)$:
  π_s^- higher reconstruction efficiency than π_s^+



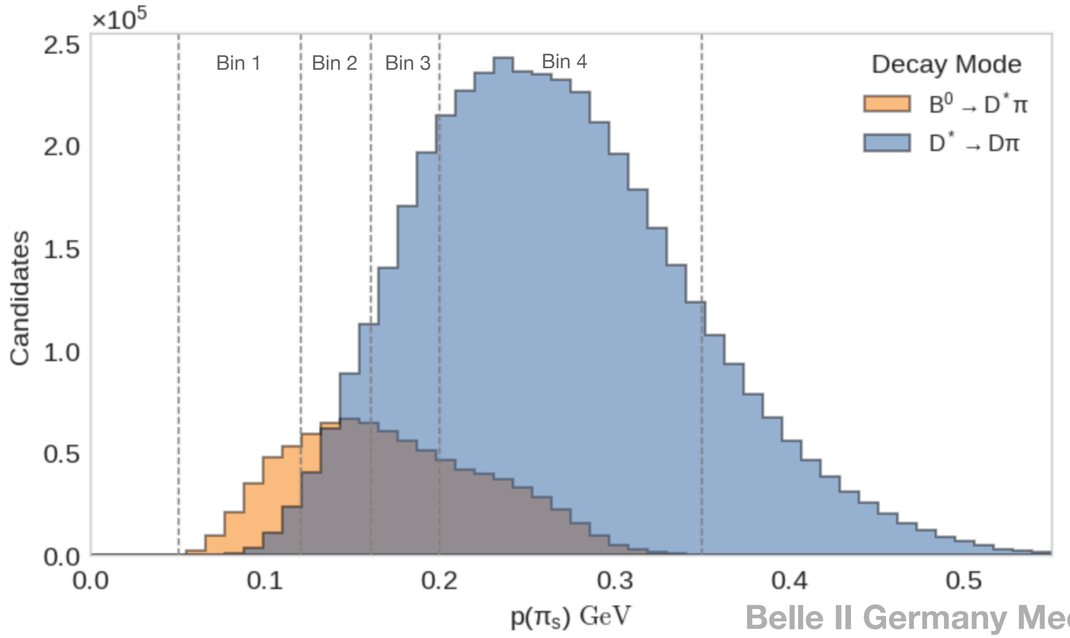


Additional tree: $D^{*+} \to D^0 \pi^+$

Belle II Note

- Instead of B decay, directly access $ee \to c\bar{c}$ for more statistics
- Overlap of slowpi momentum: expect large improvement for Bin 3 and Bin 4
- Might include additional Bin 5

Particle	Selection criteria
good track	$dr < 1cm, \lvert dz \rvert < 3cm$
π^+	good track, $P_K^{binary} > 0.8$
K^+	good track, $P_K^{binary} > 0.8$
$p_{\bar{D}^0}^{CMS}$	$p_{\bar{D}^0} \geq 2.0$ GeV
$\bar{D}^0$	$1.850 < M_D < 1.8713$ GeV
D^{*-}	$0.14 < \Delta M_{D,D^*} < 0.16$
$\bar{D}^{*-}$	$2.0040 < M_{D^*} < 2.0176$ GeV
$p_{D^{*-}}^{CMS}$	$p_{D^{*-}} \geq 2.5$ GeV



MC prediction comparison

MC16rd: $B \to D^*\pi$

Relative tracking efficiency: (99.795 +/- 1.17 +/- 0.269)%
Slow pion systematic: 1.202%

p_{π_s} range [GeV]	0.05-0.12	0.12-0.16	0.16-0.20	0.20-0.35
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Fitted yield	10744 ± 135	15754 ± 160	13083 ± 149	20318 ± 178
r_i	0.907 ± 0.012	0.918 ± 0.01	0.919 ± 0.011	0.917 ± 0.009
$r_i/r_{\max}$	0.989	1.001	1.002	
$\sigma_{\text{uncorr}} \pm \sigma_{\text{corr}}$	0.013 ± 0.009	0.011 ± 0.009	0.012 ± 0.009	

MC16rd: $D^* \to D^0\pi$

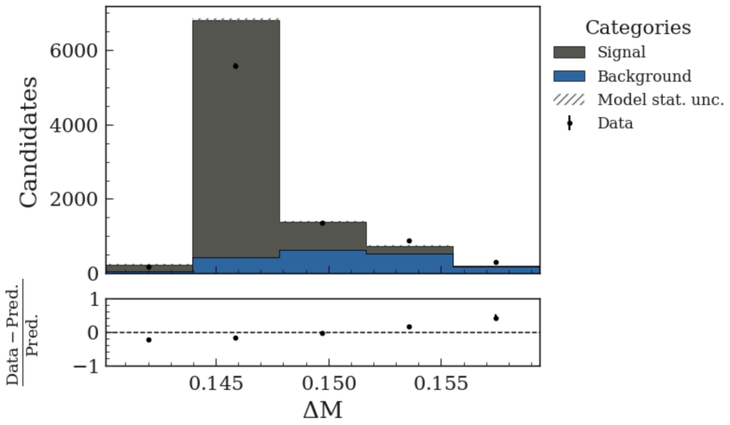
p_{π_s} range [GeV]	0.05–0.12	0.12–0.16	0.16–0.20	0.20–0.35	0.35–0.45
MC prediction	9138 ± 47	63103 ± 126	150273 ± 194	701324 ± 419	156897 ± 198
Fitted yield					
r_i					
$r_i/r_{\max}$					
$\sigma_{\text{uncorr}} \pm \sigma_{\text{corr}}$					

To be determined ...

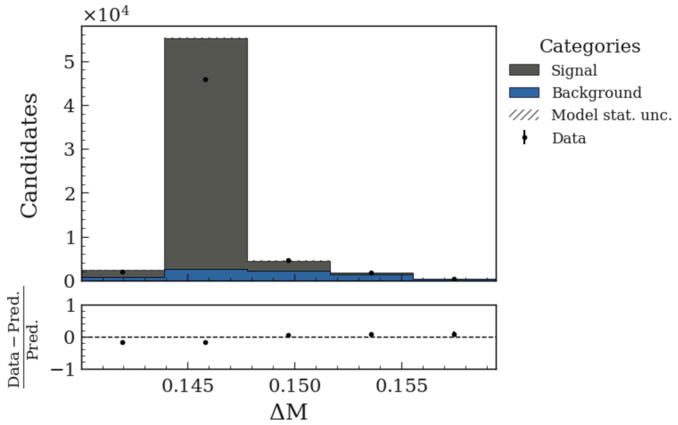
Thanks for listening

Pre-fit Data-MC agreement

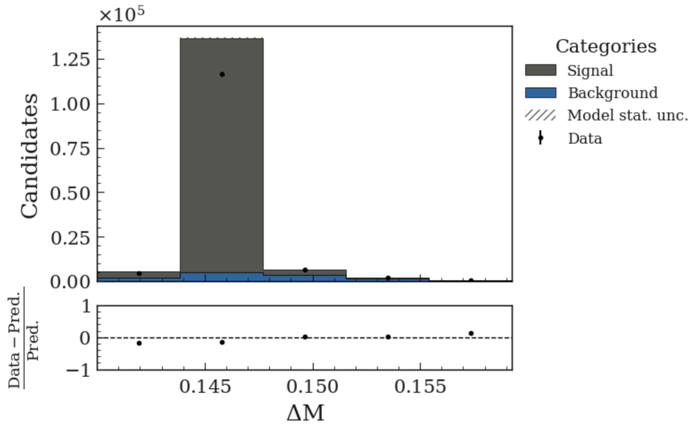
Bin 1



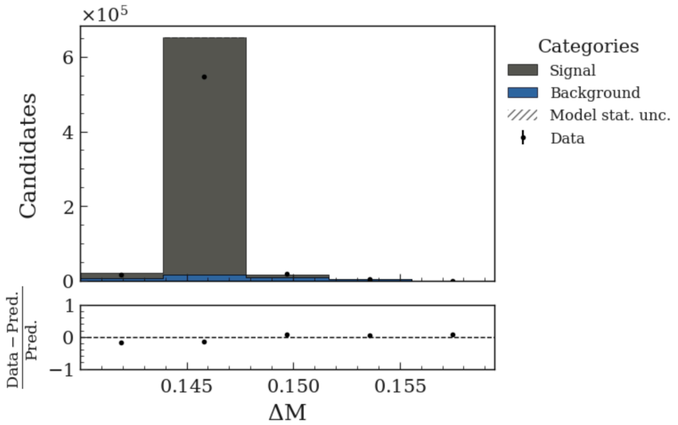
Bin 2



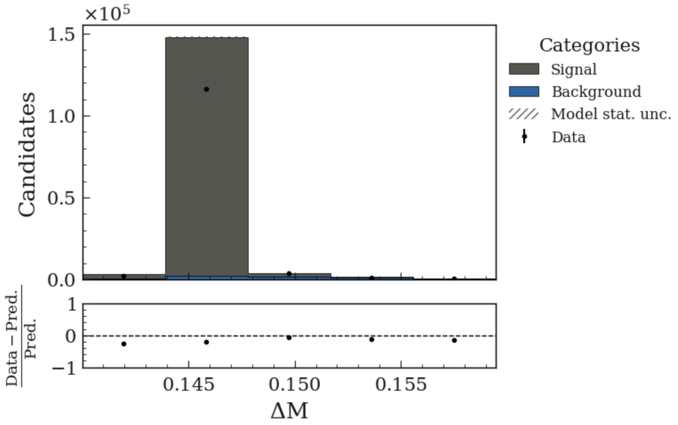
Bin 3



Bin 4

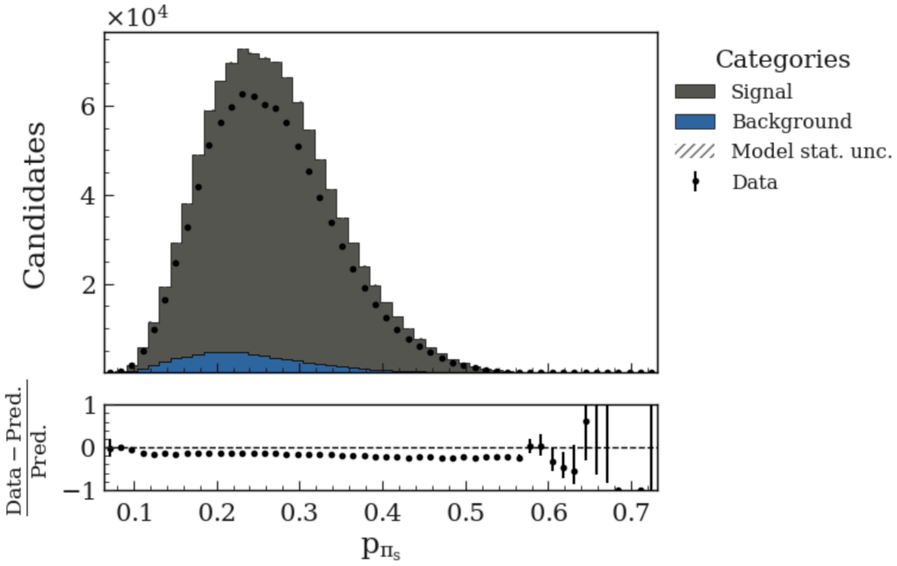


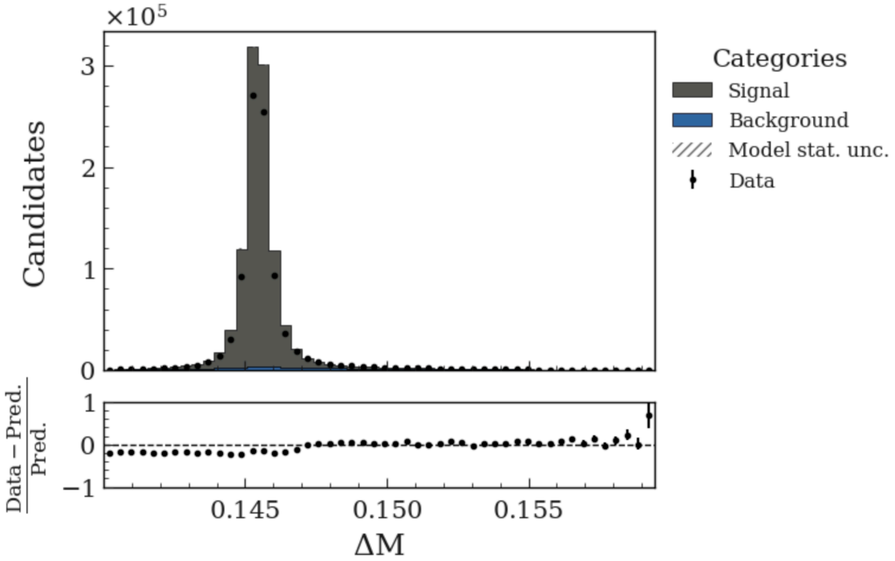
Bin 5

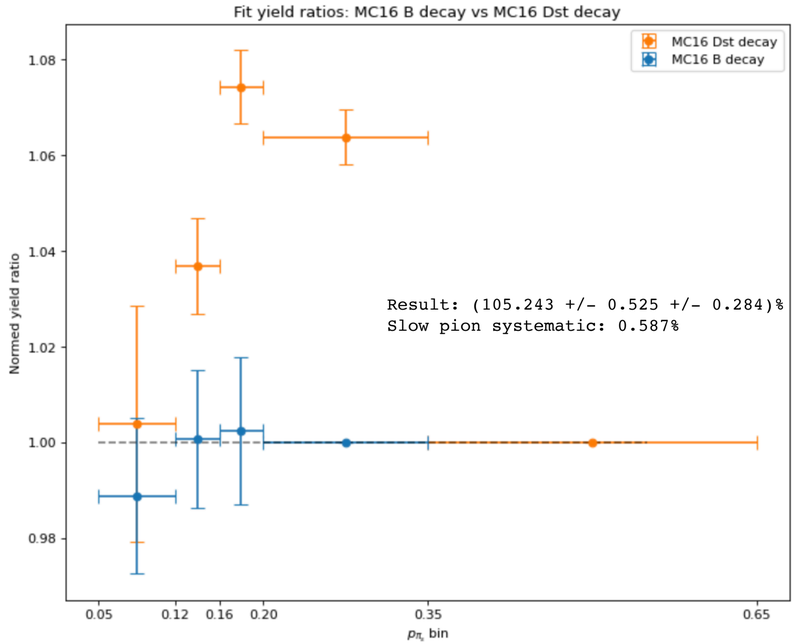


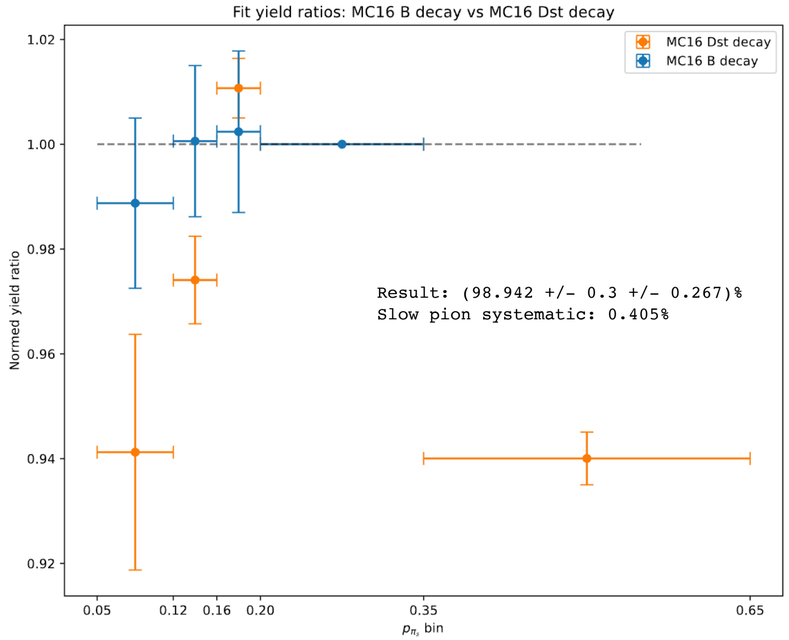
- MC16 PID corrections applied
- MC15 track mom scaling

Yield comparison

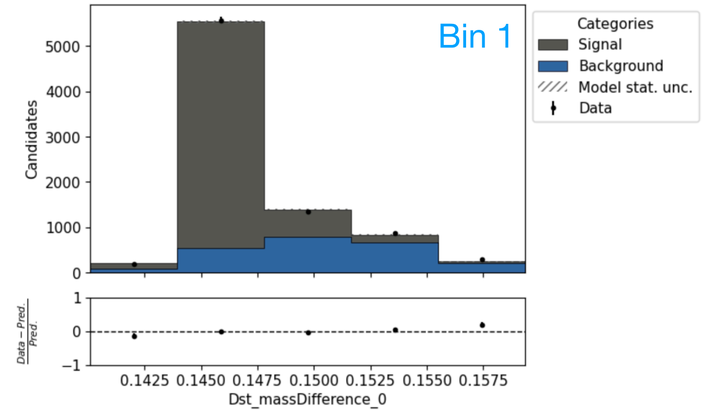


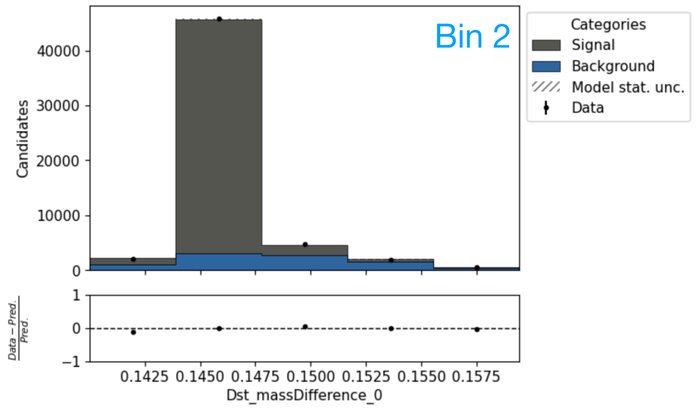


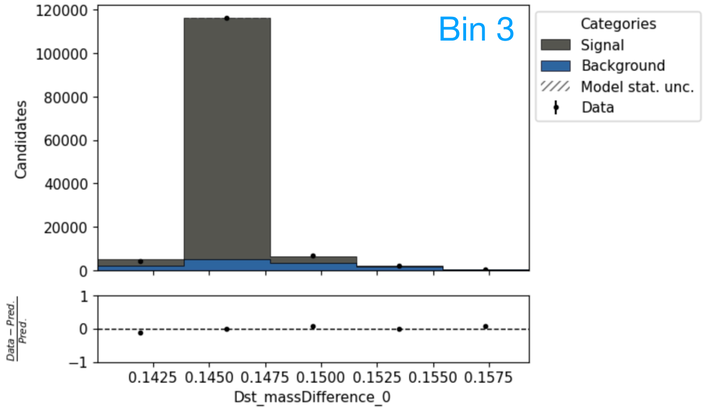


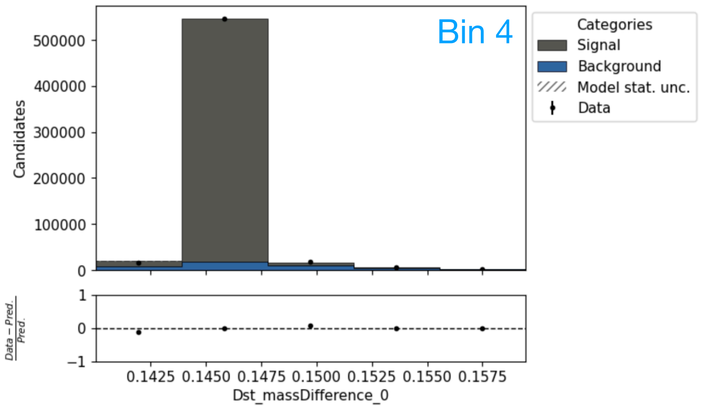


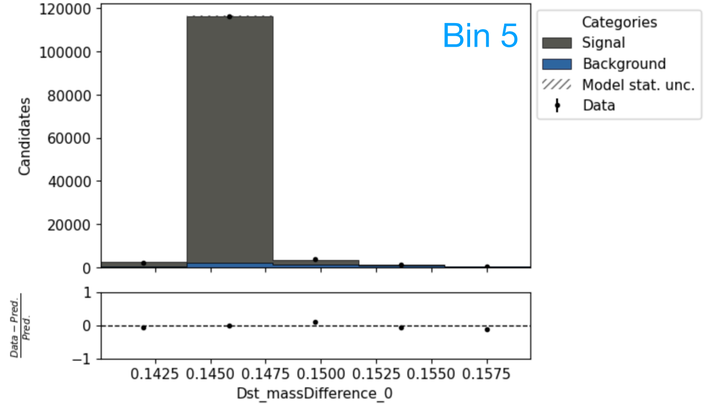
Fit results

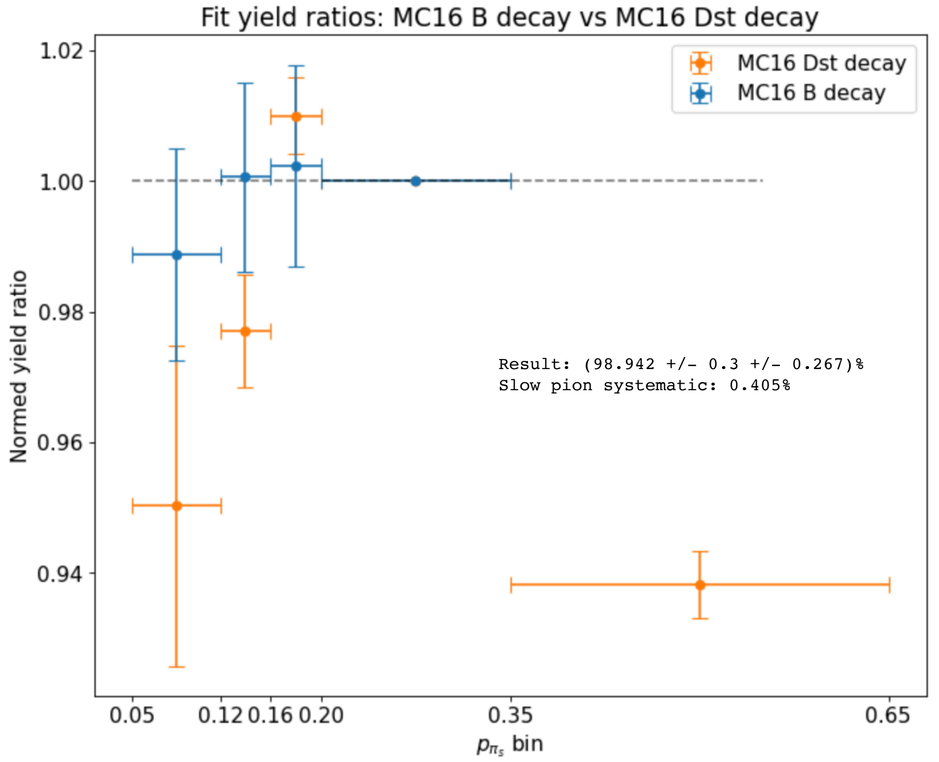

Bin 1
Categories
Signal
Background
Model stat. unc.
Data
Candidates
Data − Pred. / Pred.
Dst_massDifference_0

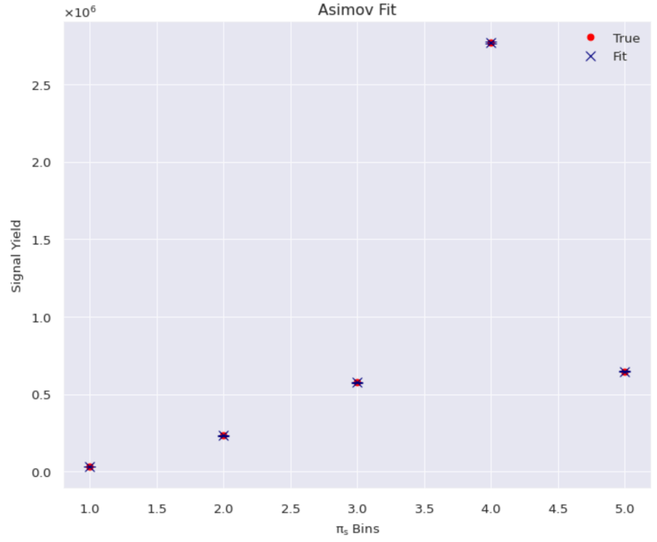

Bin 2
Categories
Signal
Background
Model stat. unc.
Data
Candidates
Data − Pred. / Pred.
Dst_massDifference_0


Bin 3
Categories
Signal
Background
Model stat. unc.
Data
Candidates
Data − Pred. / Pred.
Dst_massDifference_0


Bin 4
Categories
Signal
Background
Model stat. unc.
Data
Candidates
Data − Pred. / Pred.
Dst_massDifference_0


Bin 5
Categories
Signal
Background
Model stat. unc.
Data
Candidates
Data − Pred. / Pred.
Dst_massDifference_0


Fit yield ratios: MC16 B decay vs MC16 Dst decay
MC16 Dst decay
MC16 B decay
Normed yield ratio
Result: (98.942 +/- 0.3 +/- 0.267)%
Slow pion systematic: 0.405%
p_{π_s} bin

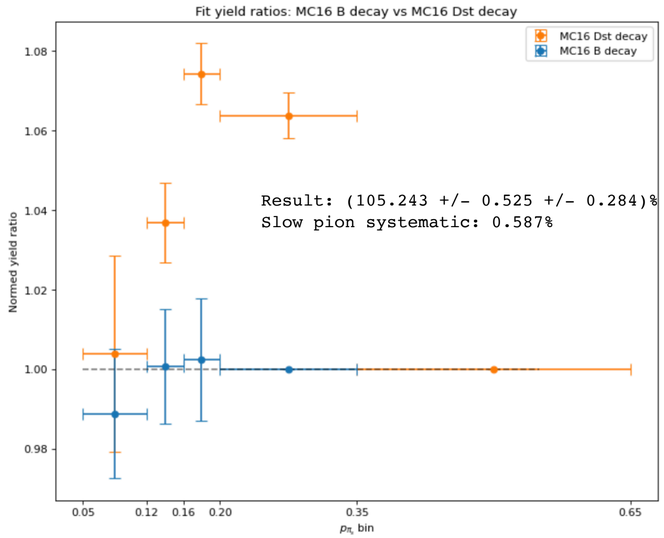

Asimov Fit
True
Fit
Signal Yield
π_s Bins

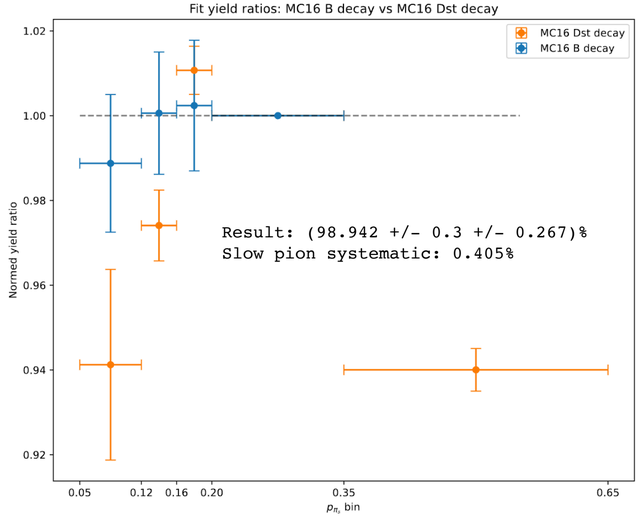
Alternatives for fitting: different bin4 range

Norm bin5

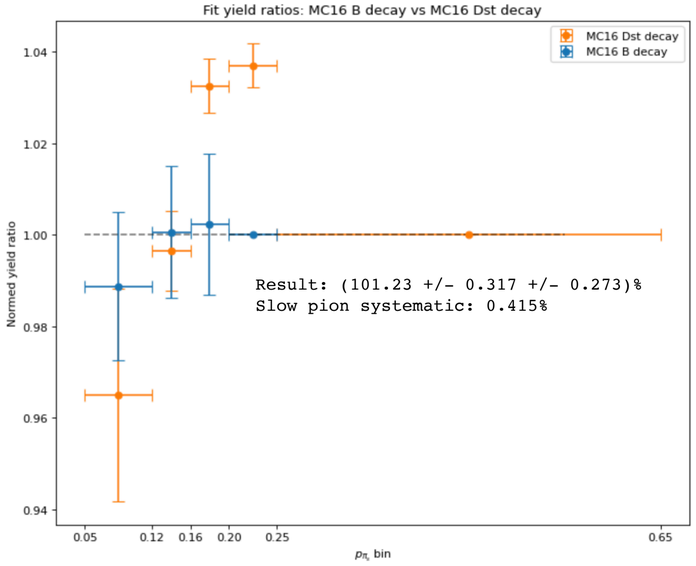
Norm bin4

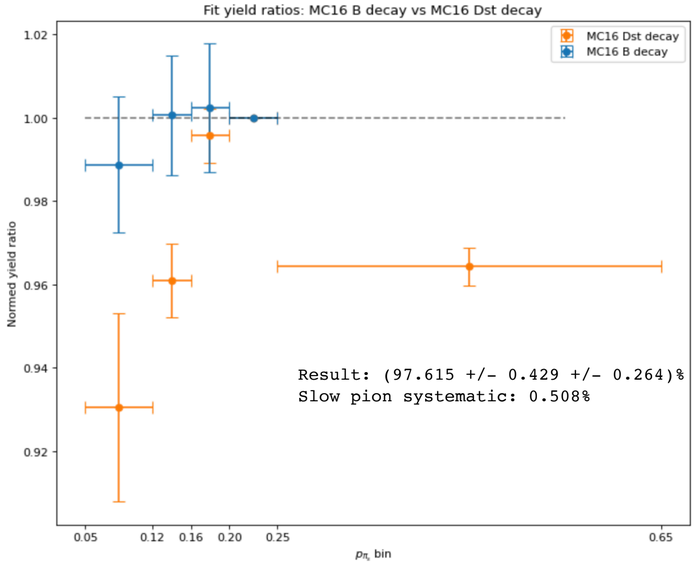
Original bins





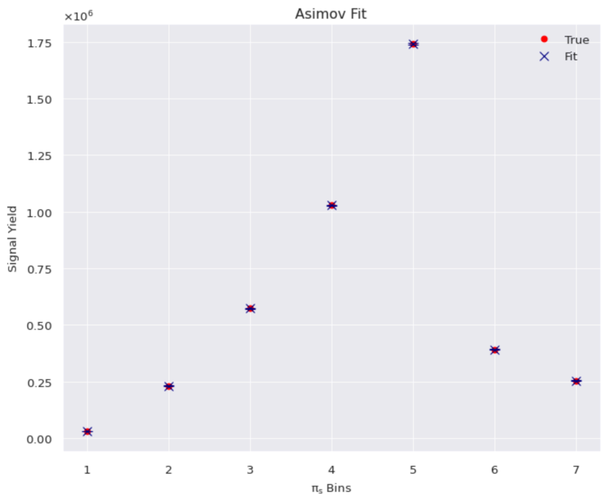
Modified bins





Alternatives for fitting: more bins

Number of bins: 7
Norm bin: Bin 7
Bin range:
[[0.064, 0.12], [0.12, 0.16], [0.16, 0.2], [0.2, 0.25], [0.25,0.35], [0.35,0.4], [0.4,0.65]]
Number bins to fit in deltaM: 20

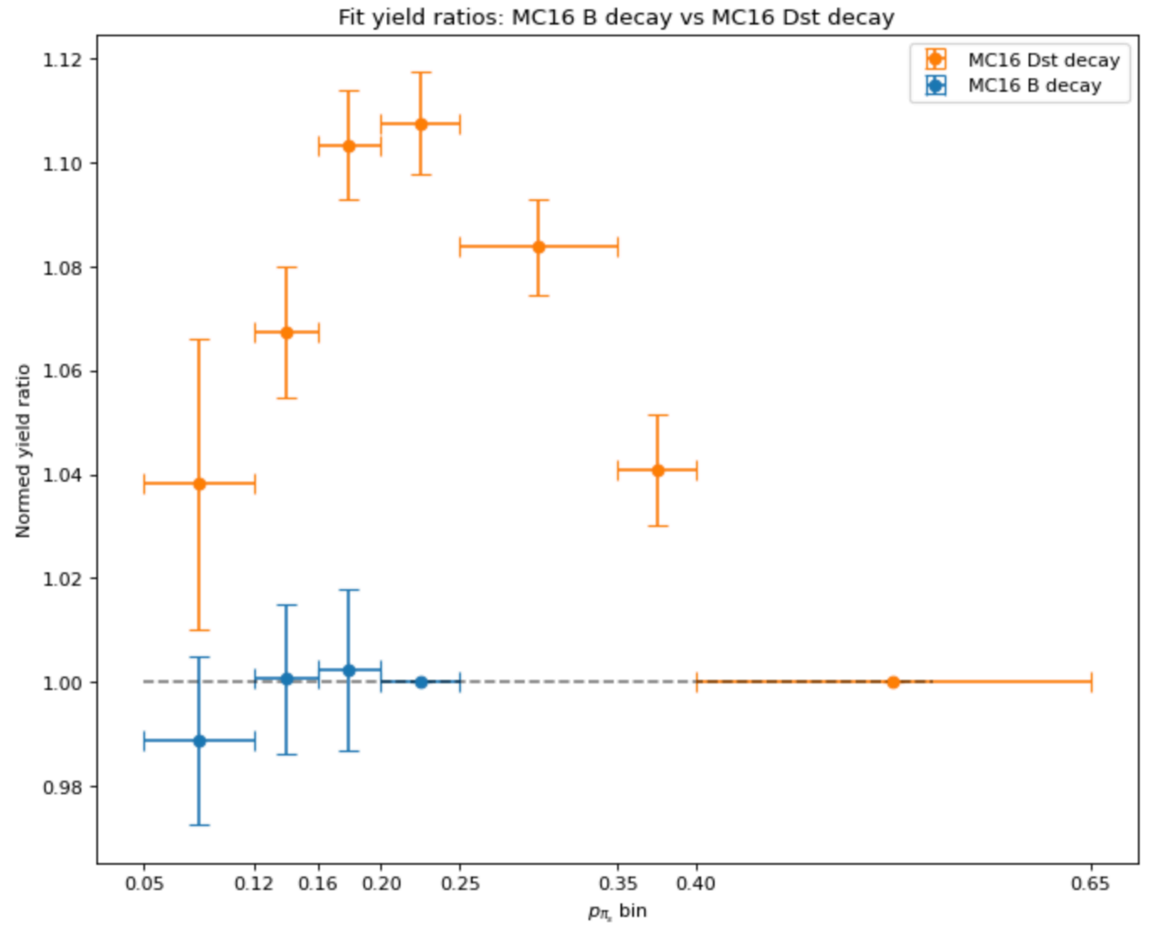



```
**********
bin 1 min: 0.064
bin 1 max: 0.12
pre split: 38000
post split: 38000
data events: 8263

**********
bin 2 min: 0.12
bin 2 max: 0.16
pre split: 263046
post split: 263046
data events: 54828

**********
bin 3 min: 0.16
bin 3 max: 0.2
pre split: 626245
post split: 626245
data events: 130192

**********
bin 4 min: 0.2
bin 4 max: 0.25
pre split: 1099755
post split: 1099755
data events: 226776

**********
bin 5 min: 0.25
bin 5 max: 0.35
pre split: 1825222
post split: 1825222
data events: 362618

**********
bin 6 min: 0.35
bin 6 max: 0.4
pre split: 406714
post split: 406714
data events: 76413

**********
bin 7 min: 0.4
bin 7 max: 0.645
pre split: 264165
post split: 264165
data events: 47673
```

```
bin1
par       fitted val        rel. err.
--------  --------------  -----------
bkg_norm  1.199 +- 0.116        0.097
sig_norm  0.790 +- 0.018        0.023
----------------------------------------

bin2
par       fitted val        rel. err.
--------  --------------  -----------
bkg_norm  1.134 +- 0.044        0.039
sig_norm  0.813 +- 0.006        0.007
----------------------------------------

bin3
par       fitted val        rel. err.
--------  --------------  -----------
bkg_norm  1.107 +- 0.034        0.031
sig_norm  0.840 +- 0.004        0.005
----------------------------------------

bin4
par       fitted val        rel. err.
--------  --------------  -----------
bkg_norm  1.156 +- 0.030        0.026
sig_norm  0.843 +- 0.003        0.003
----------------------------------------

bin5
par       fitted val        rel. err.
--------  --------------  -----------
bkg_norm  1.172 +- 0.029        0.024
sig_norm  0.825 +- 0.002        0.003
----------------------------------------

bin6
par       fitted val        rel. err.
--------  --------------  -----------
bkg_norm  1.099 +- 0.073        0.066
sig_norm  0.792 +- 0.004        0.005
----------------------------------------

bin7
par       fitted val        rel. err.
--------  --------------  -----------
bkg_norm  1.170 +- 0.112        0.095
sig_norm  0.761 +- 0.005        0.007
----------------------------------------
```

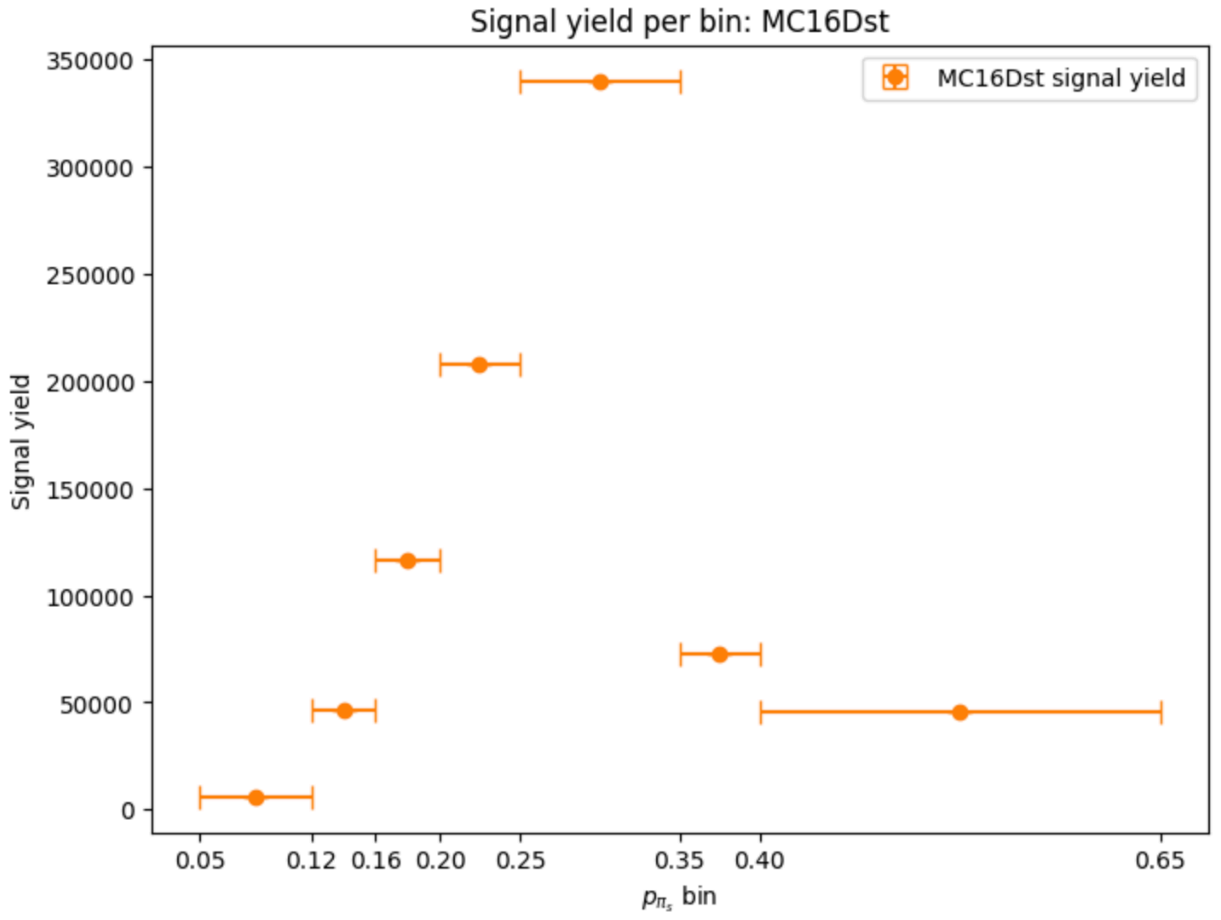
```
Results for bin1:
Signal yield: 6006.728
Signal error: 138.515
Signal rel err: 0.023
MC yield: 7599.026
MC error: 87.172
Yield ratio: 0.79
Yield ratio err: 0.02
Normed yield ratio: 1.038
Normed yield error: 0.03
Uncorr err: 0.027
Corr err: 0.008

Results for bin2:
Signal yield: 46099.039
Signal error: 344.812
Signal rel err: 0.007
MC yield: 56721.645
MC error: 238.163
Yield ratio: 0.813
Yield ratio err: 0.007
Normed yield ratio: 1.067
Normed yield error: 0.01
Uncorr err: 0.009
Corr err: 0.009

Results for bin3:
Signal yield: 116589.921
Signal error: 530.896
Signal rel err: 0.005
MC yield: 138778.8
MC error: 372.53
Yield ratio: 0.84
Yield ratio err: 0.004
Normed yield ratio: 1.103
Normed yield error: 0.006
Uncorr err: 0.006
Corr err: 0.009
```

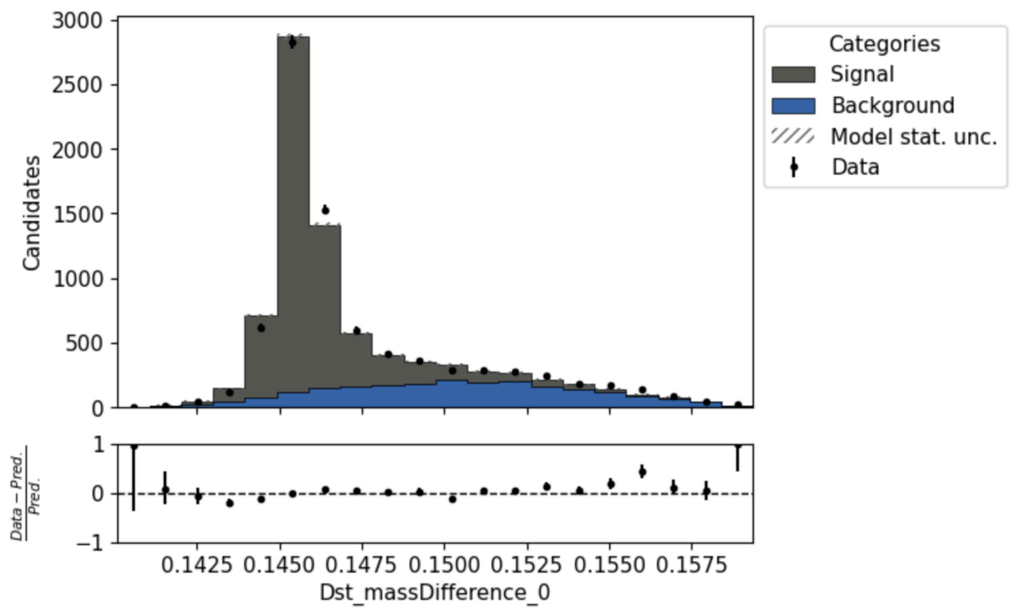
```
Results for bin4:
Signal yield: 207735.61
Signal error: 700.093
Signal rel err: 0.003
MC yield: 246354.44
MC error: 496.341
Yield ratio: 0.843
Yield ratio err: 0.003
Normed yield ratio: 1.107
Normed yield error: 0.004
Uncorr err: 0.004
Corr err: 0.009

Results for bin5:
Signal yield: 340177.735
Signal error: 867.229
Signal rel err: 0.003
MC yield: 412254.5
MC error: 642.07
Yield ratio: 0.825
Yield ratio err: 0.002
Normed yield ratio: 1.084
Normed yield error: 0.003
Uncorr err: 0.003
Corr err: 0.009

Results for bin6:
Signal yield: 72749.841
Signal error: 394.027
Signal rel err: 0.005
MC yield: 91798.0
MC error: 302.982
Yield ratio: 0.792
Yield ratio err: 0.005
Normed yield ratio: 1.041
Normed yield error: 0.007
Uncorr err: 0.007
Corr err: 0.008

Results for bin7:
Signal yield: 45468.368
Signal error: 312.915
Signal rel err: 0.007
MC yield: 59716.613
MC error: 244.37
Yield ratio: 0.761
Yield ratio err: 0.006
Normed yield ratio: 1.0
Normed yield error: 0.009
Uncorr err: 0.008
Corr err: 0.008
```

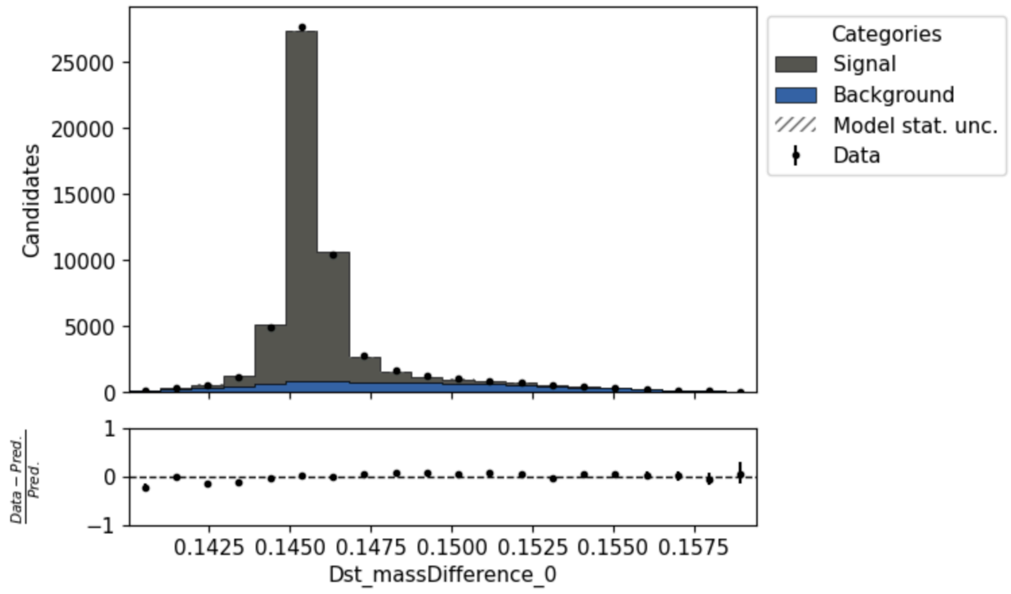


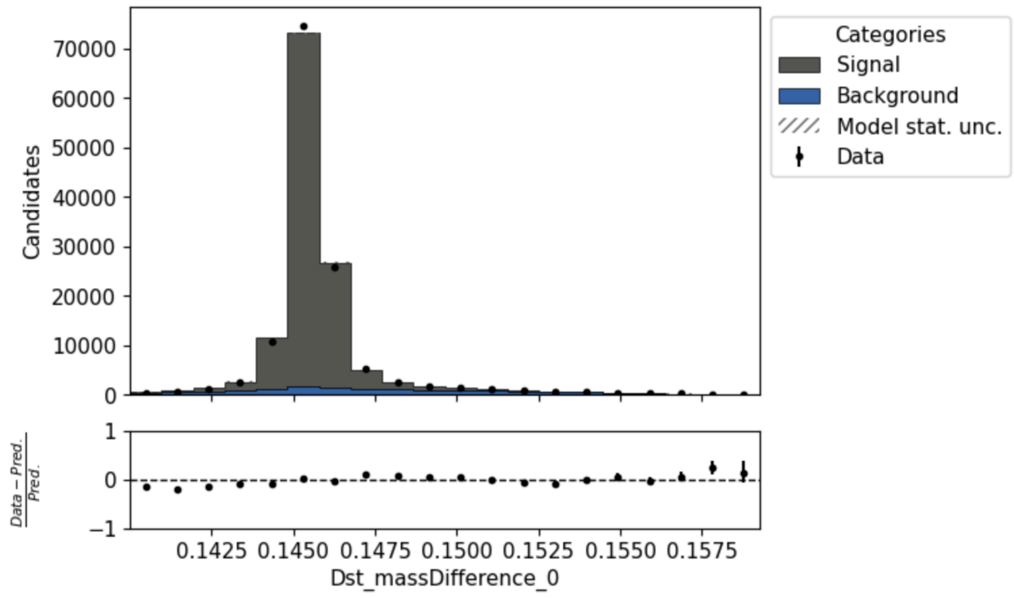
Fitted in 20 bins from 0.142, 0.150

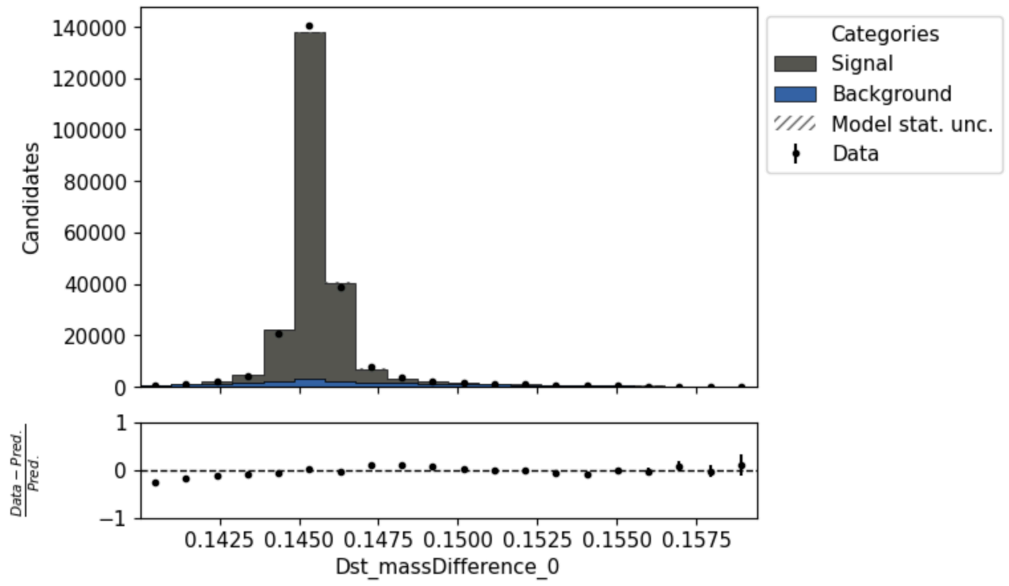
```
Result: (108.062 +/- 0.827 +/- 0.292)%
Slow pion systematic: 0.867%
```

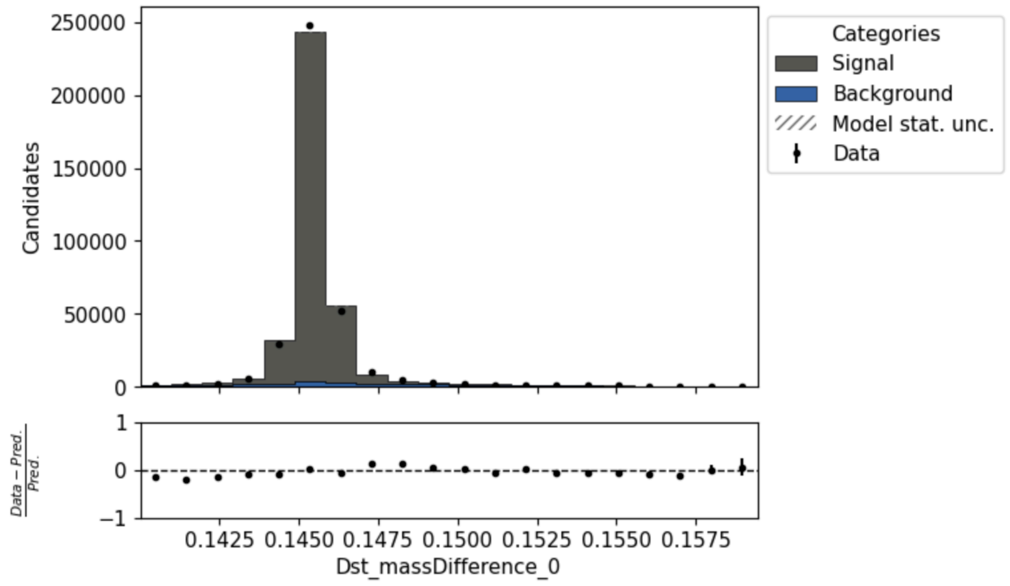


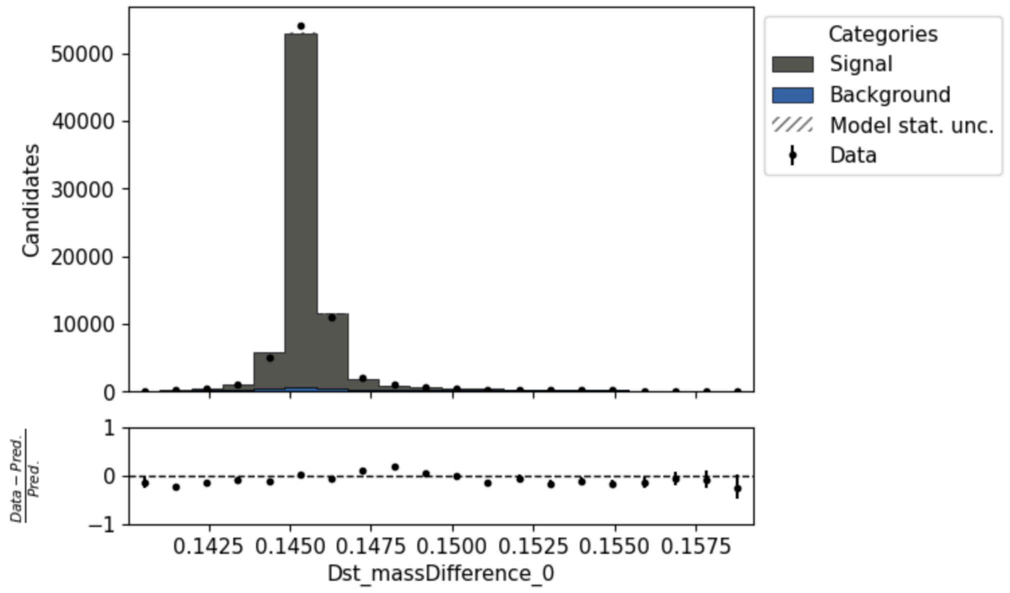


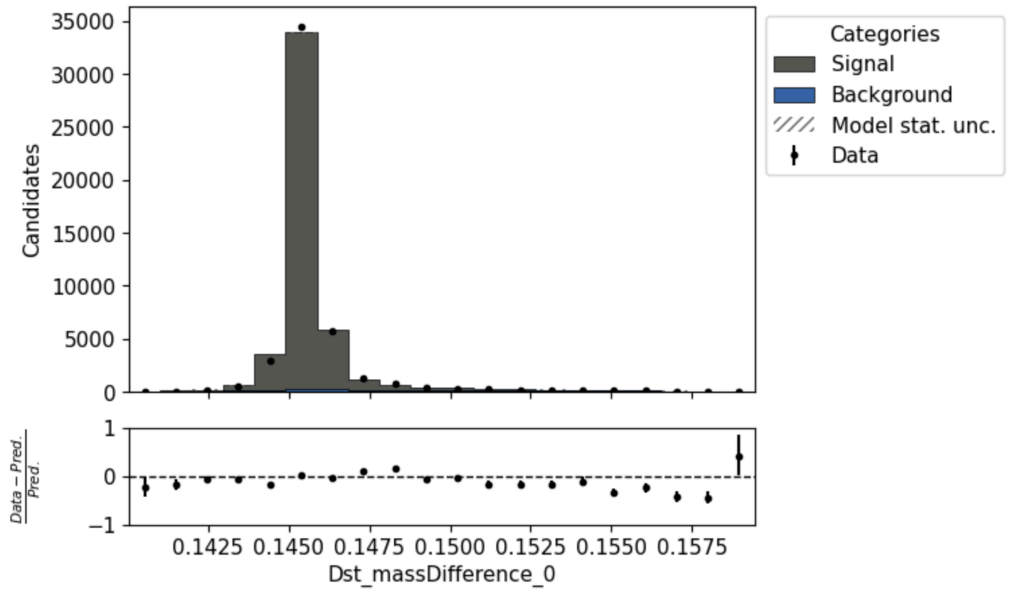




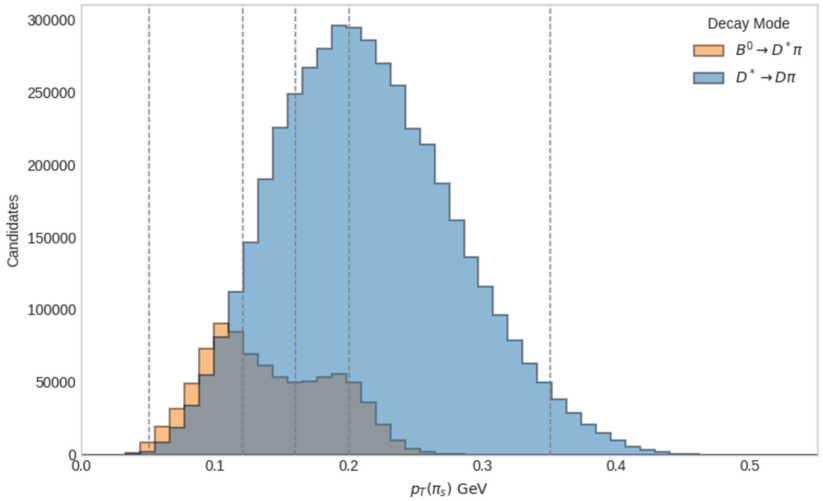


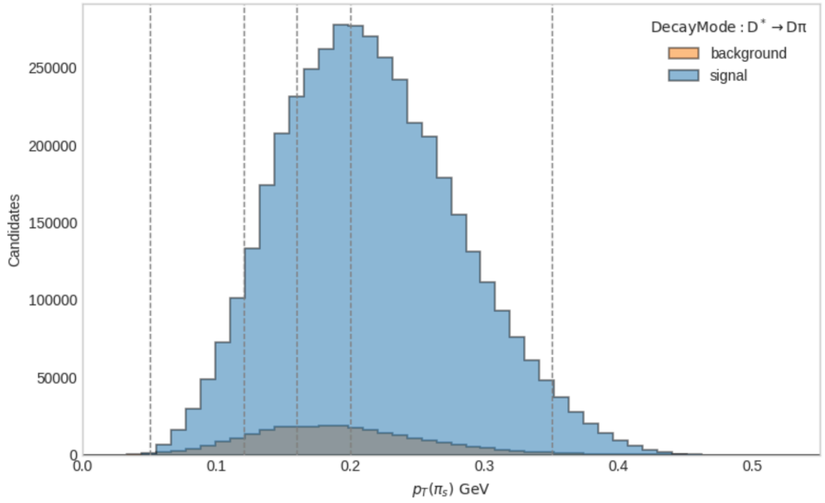




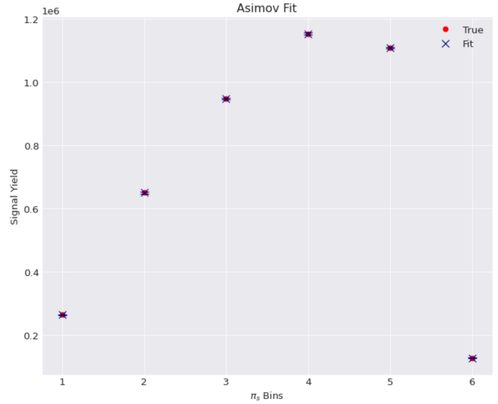


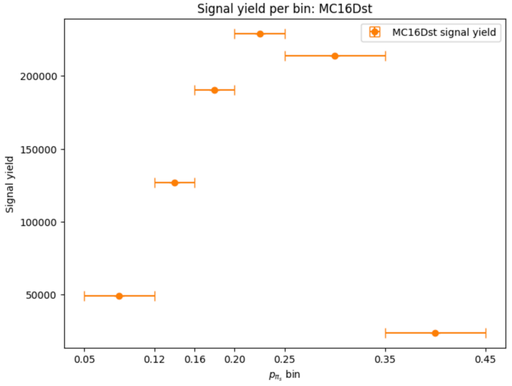
Alternatives for fitting: p_T in 6 bins

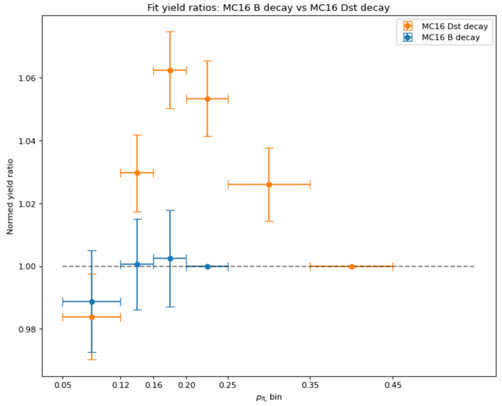





```
**********
bin 1 min: 0.06
bin 1 max: 0.12
pre split: 294485
post split: 294485
data events: 56599

**********
bin 2 min: 0.12
bin 2 max: 0.16
pre split: 707774
post split: 707774
data events: 141905

**********
bin 3 min: 0.16
bin 3 max: 0.2
pre split: 1013414
post split: 1013414
data events: 207781

**********
bin 4 min: 0.2
bin 4 max: 0.25
pre split: 1217539
post split: 1217539
data events: 247442

**********
bin 5 min: 0.25
bin 5 max: 0.35
pre split: 1153933
post split: 1153933
data events: 227100

**********
bin 6 min: 0.35
bin 6 max: 0.45
pre split: 131213
post split: 131213
data events: 25112
```

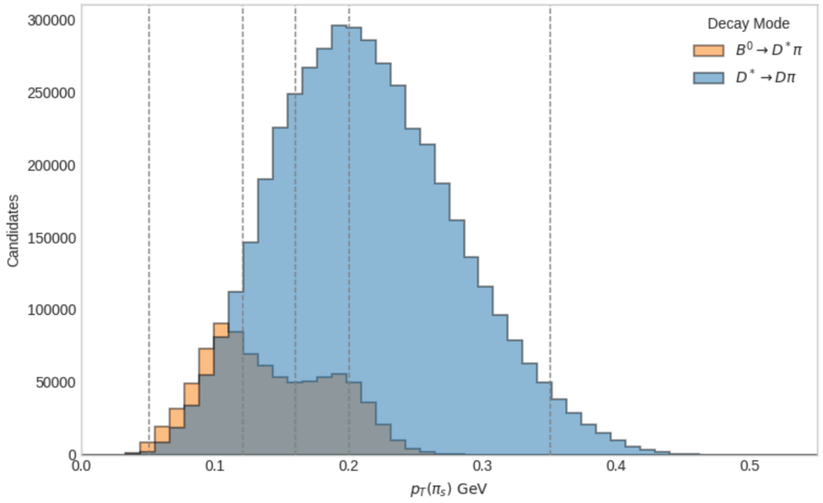


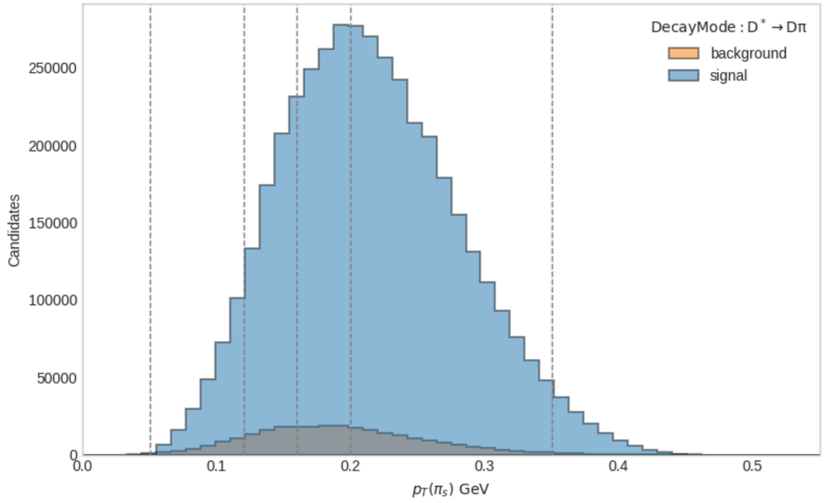




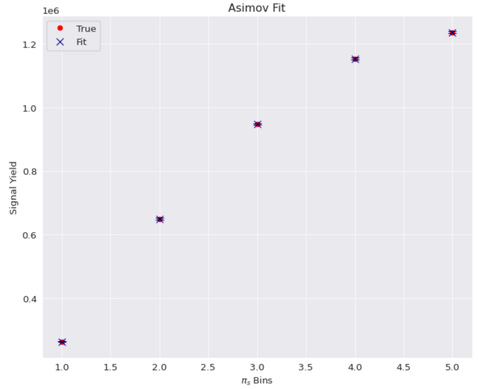
Result: (103.84500000000001 +/- 1.098 +/- 0.28)%
Slow pion systematic: 1.129%

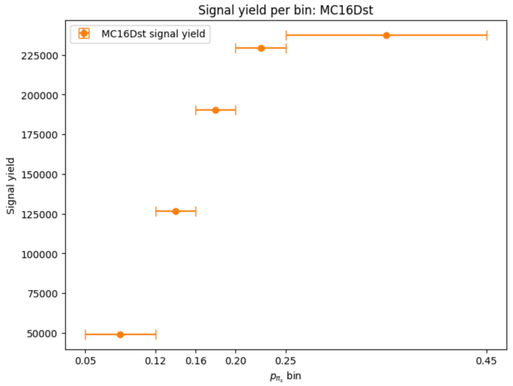
Alternatives for fitting: p_T in 5 bins

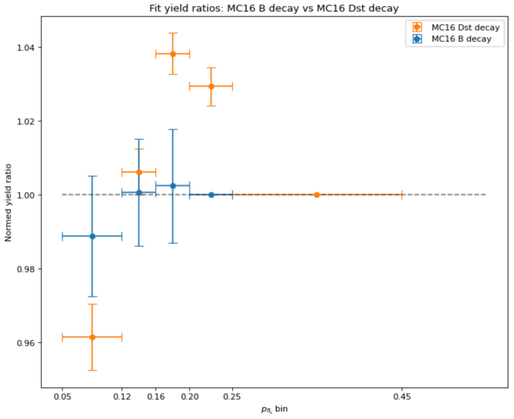





```
**********
bin 1 min: 0.06
bin 1 max: 0.12
pre split: 294485
post split: 294485
data events: 56599

**********
bin 2 min: 0.12
bin 2 max: 0.16
pre split: 707774
post split: 707774
data events: 141905

**********
bin 3 min: 0.16
bin 3 max: 0.2
pre split: 1013414
post split: 1013414
data events: 207781

**********
bin 4 min: 0.2
bin 4 max: 0.25
pre split: 1217539
post split: 1217539
data events: 247442

**********
bin 5 min: 0.25
bin 5 max: 0.45
pre split: 1285146
post split: 1285146
data events: 252212
```

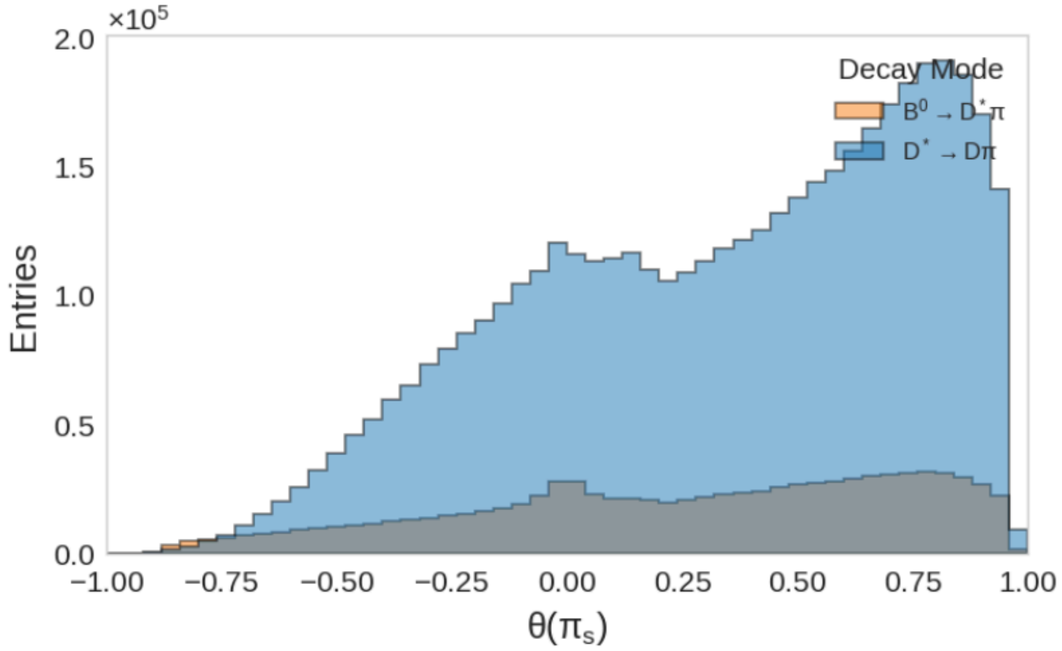


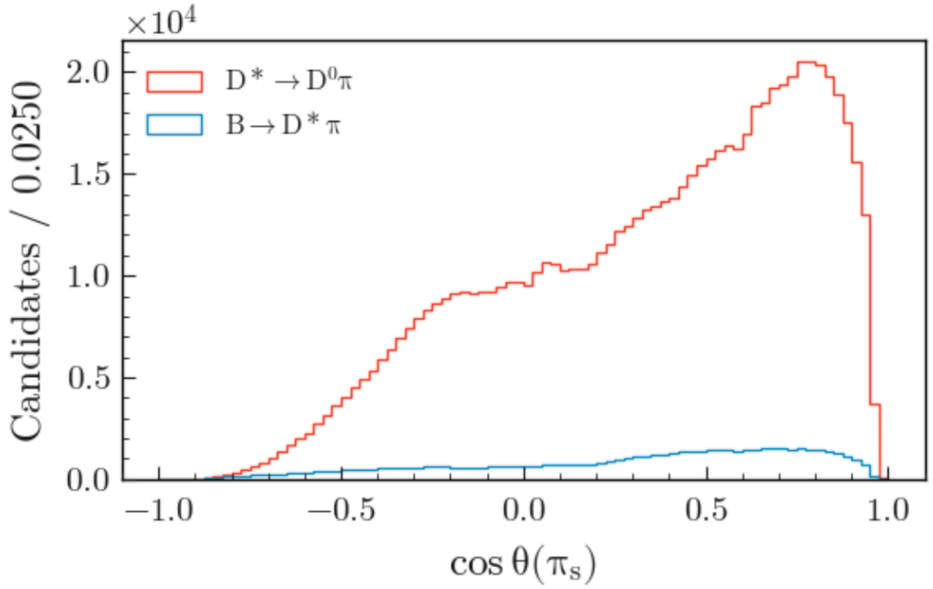




Result: (101.47999999999999 +/- 0.399 +/- 0.274)%
Slow pion systematic: 0.481%

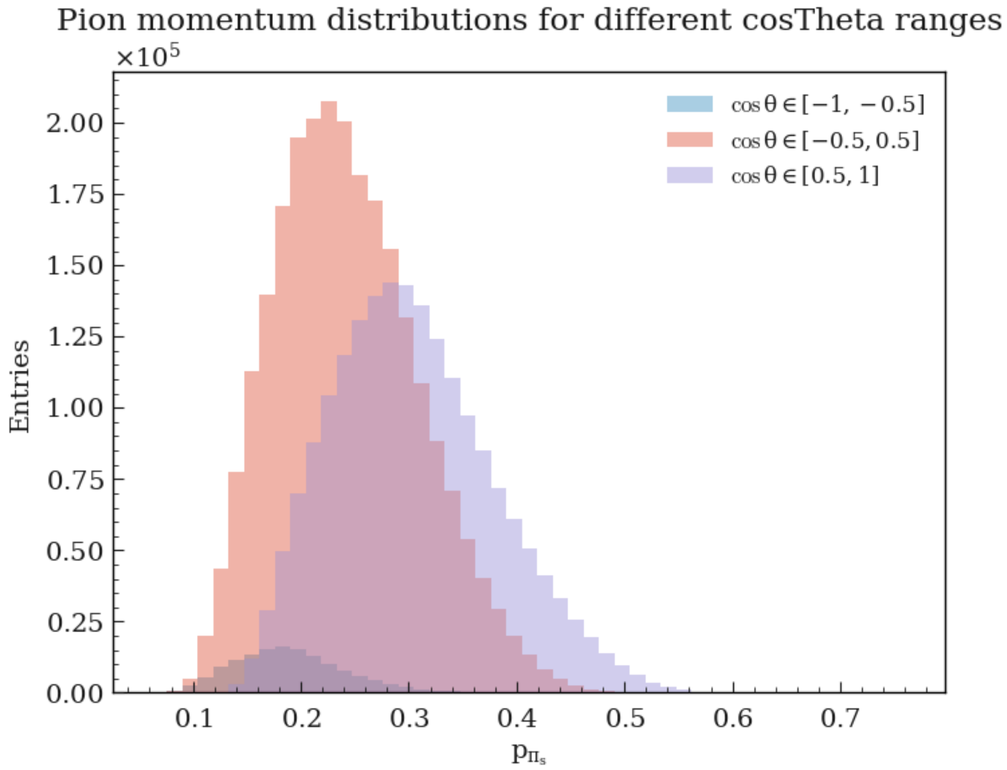
Alternatives for fitting: different deltaM range

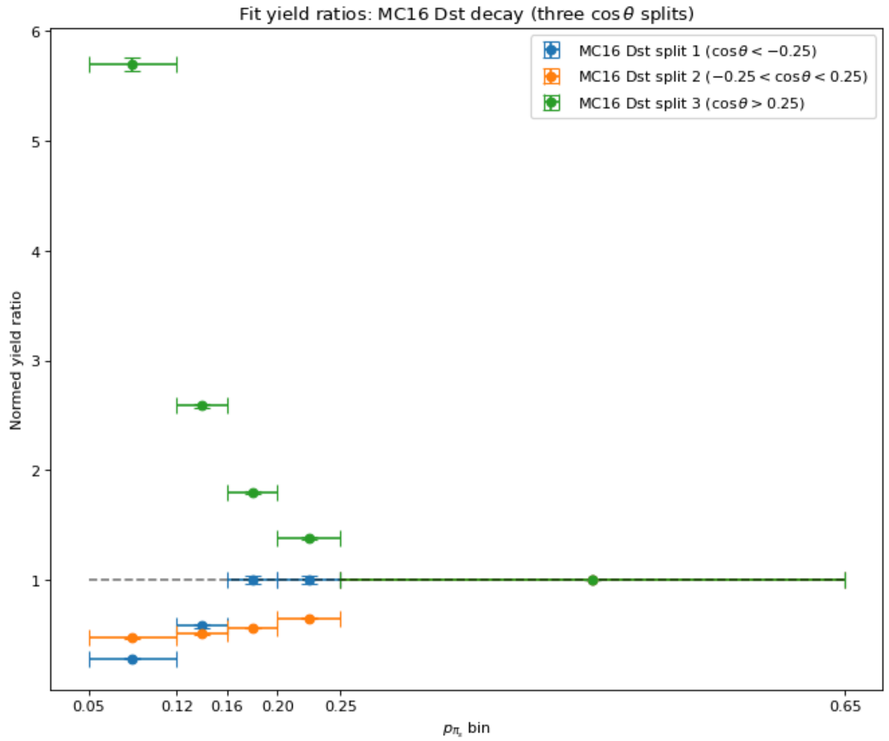




Alternatives for fitting: parametric fit via CB

Would this pose any problems later on if we want to combine them?





MC prediction comparison

Relative tracking efficiency: (99.795 +/- 1.17 +/- 0.269)%
Slow pion systematic: 1.202%

p_{π_s} range [GeV]	0.05-0.12	0.12-0.16	0.16-0.20	0.20-0.35
MC prediction	11849 ± 56	17169 ± 67	14232 ± 61	22155 ± 76
Fitted yield	10744 ± 135	15754 ± 160	13083 ± 149	20318 ± 178
r_i	0.907 ± 0.012	0.918 ± 0.01	0.919 ± 0.011	0.917 ± 0.009
$r_i/r_{\max}$	0.989	1.001	1.002	
$\sigma_{\text{uncorr}} \pm \sigma_{\text{corr}}$	0.013 ± 0.009	0.011 ± 0.009	0.012 ± 0.009	

Result: (98.942 +/- 0.247)%
Slow pion systematic: 0.405%

MC16rd: $D^* \to D^0\pi$

Depending on the Fit results?

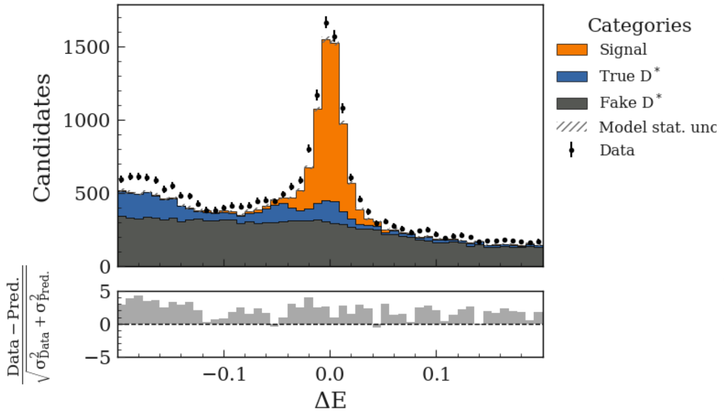
p_{π_s} range [GeV]	0.05–0.12	0.12–0.16	0.16–0.20	0.20–0.35	0.35–0.45
MC prediction	7599 ± 87	56721 ± 238	138778 ± 372	658609 ± 811	151514 ± 389
Fitted yield	6006 ± 138	46099 ± 344	116589 ± 530	547837 ± 1114	118244 ± 503
r_i	0.79 ± 0.02	0.813 ± 0.007	0.84 ± 0.004	0.832 ± 0.002	0.78 ± 0.004
$r_i/r_{\max}$	0.95 ± 0.028	0.977 ± 0.009	1.01 ± 0.005		0.938 ± 0.005
$\sigma_{\text{uncorr}} \pm \sigma_{\text{corr}}$	0.024 ± 0.002	0.008 ± 0.002	0.005 ± 0.002		0.005 ± 0.002

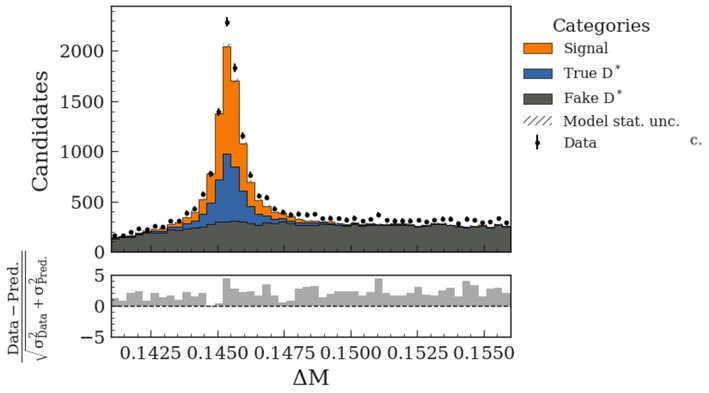
Comparison MC15rd release 6 vs MC16rd release 8

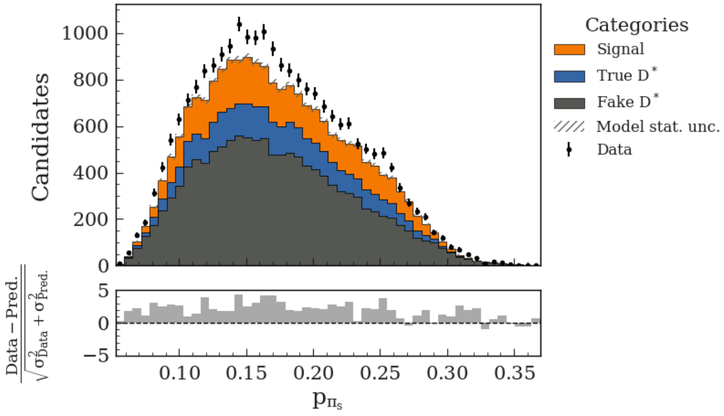
Pre-fit KS0

Previous results from Belle2-NOTE-PH-2023-035

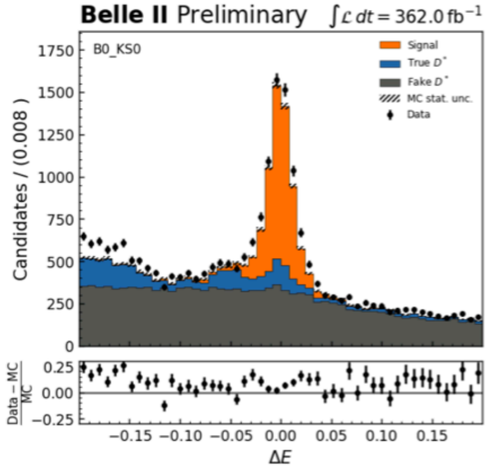
MC16rd release 8

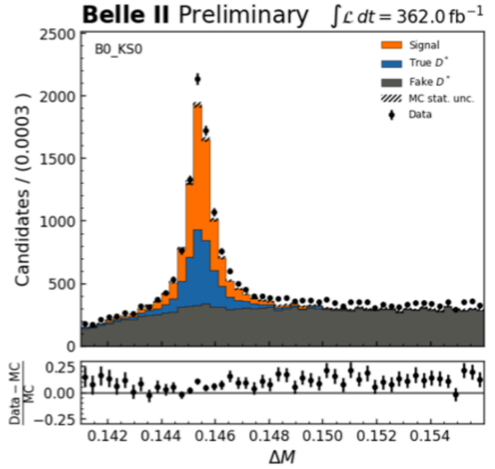


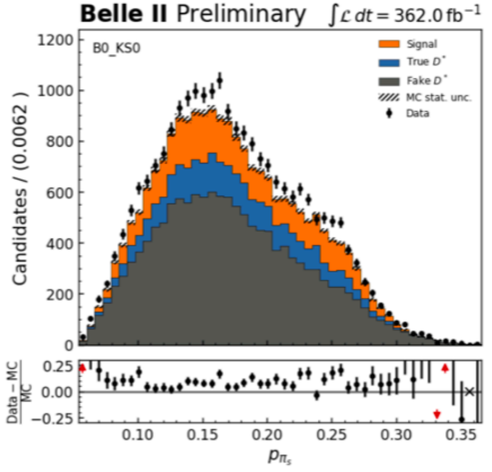




MC15rd release 6



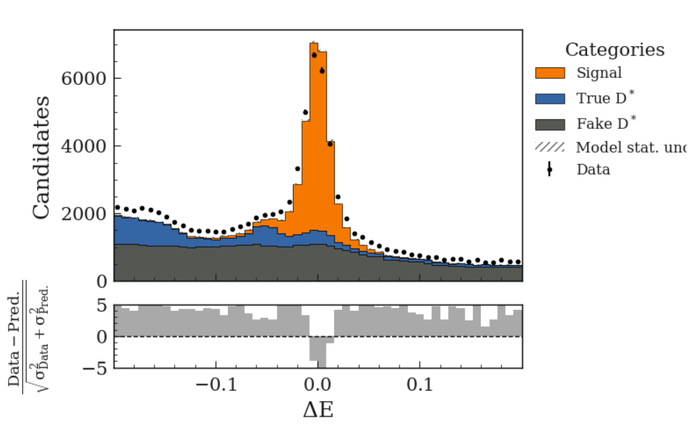


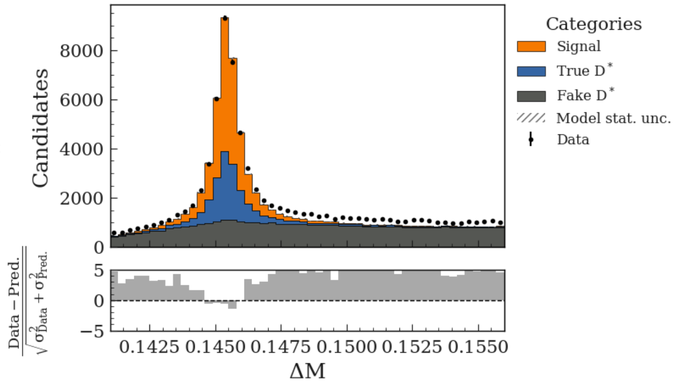


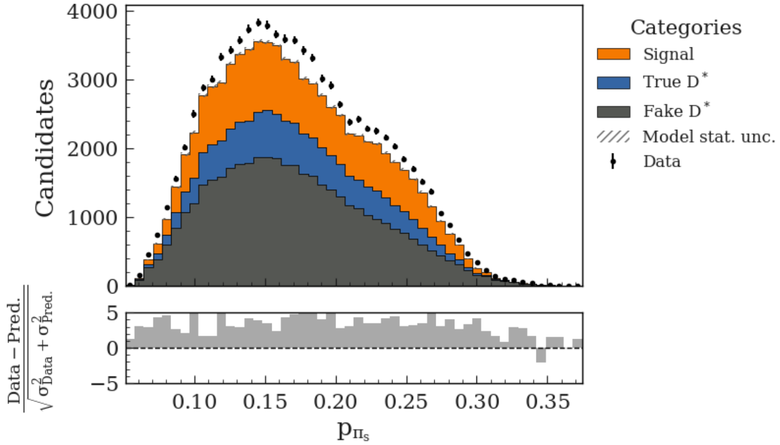
Pre-fit Kpipipi

Previous results from Belle2-NOTE-PH-2023-035

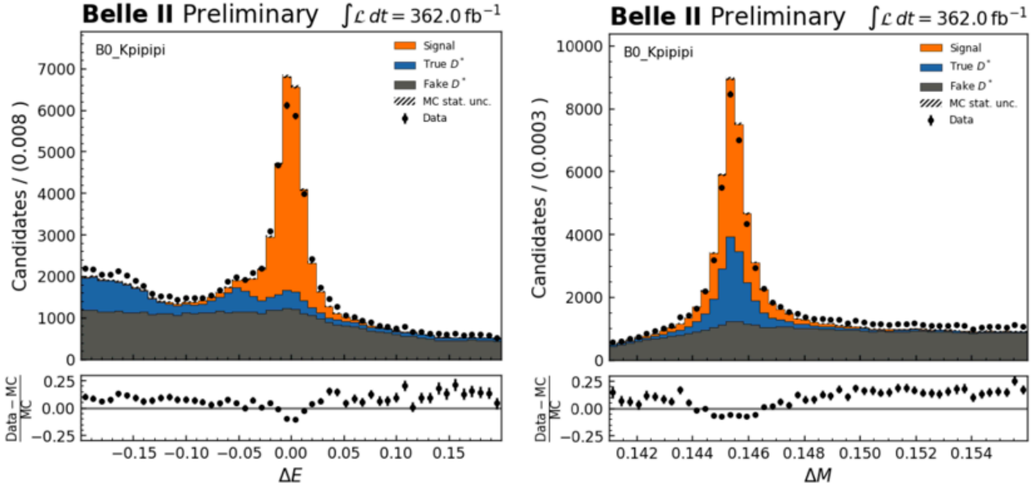
MC16rd release 8

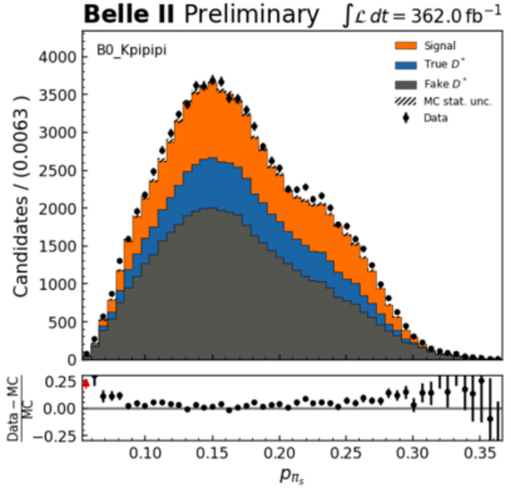






MC15rd release 6

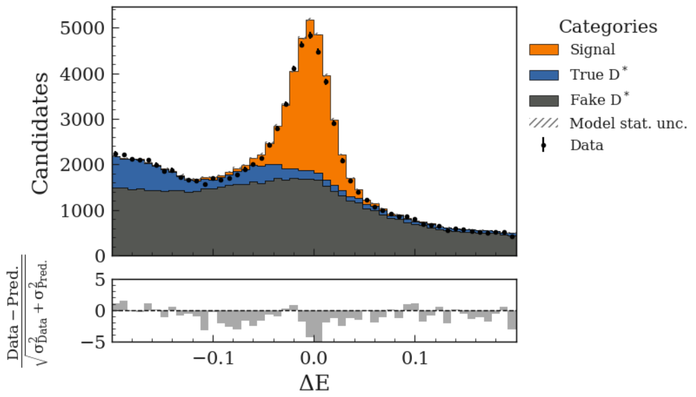


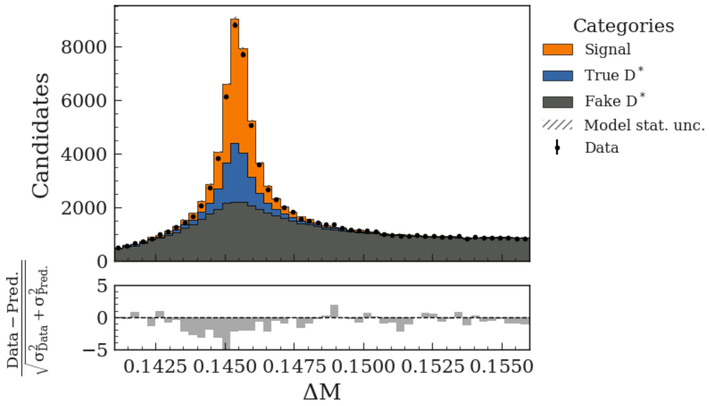


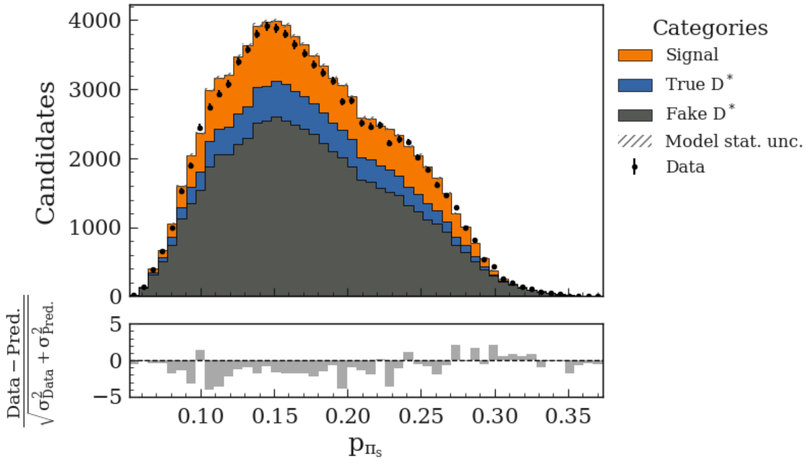
Pre-fit pi0

Previous results from Belle2-NOTE-PH-2023-035

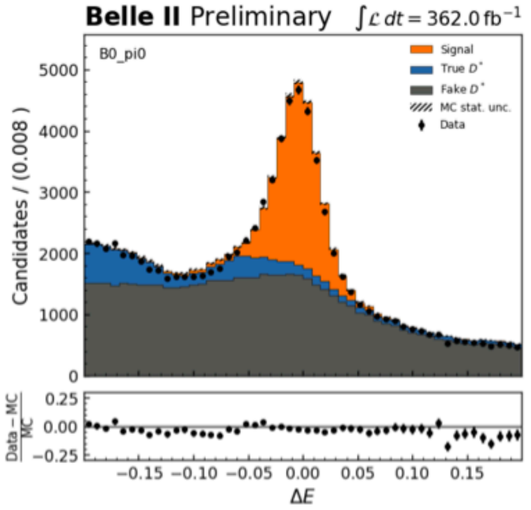
MC16rd release 8

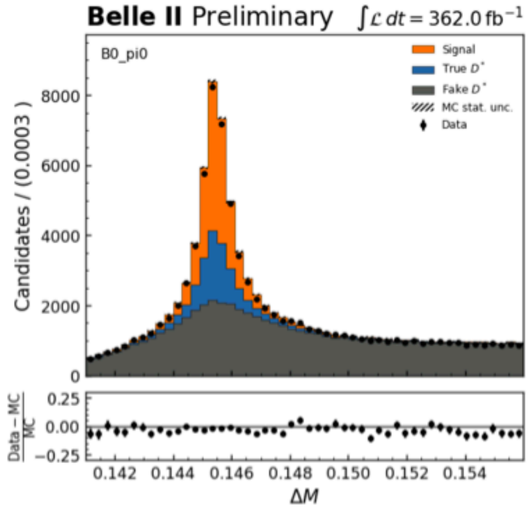


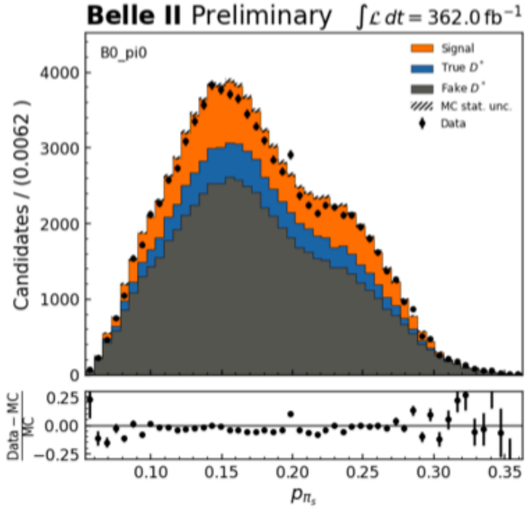




MC15rd release 6



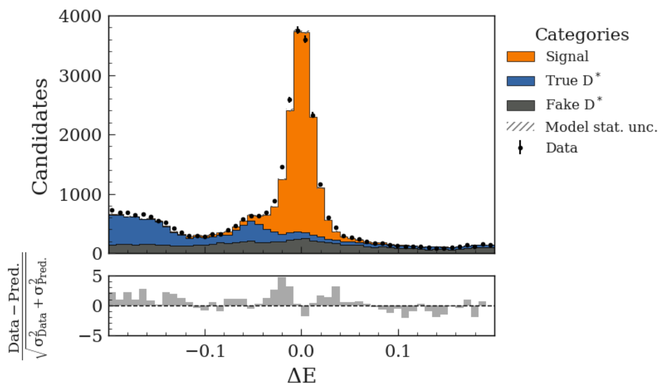


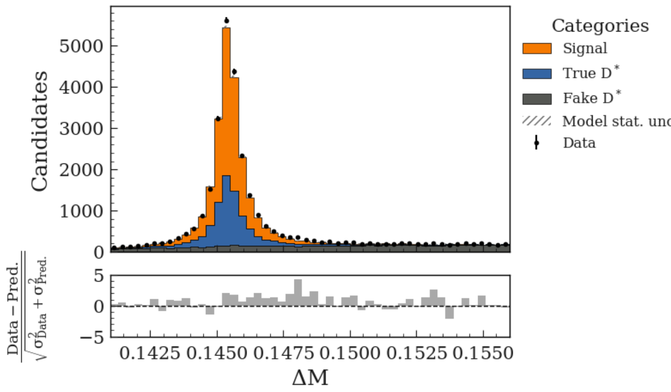


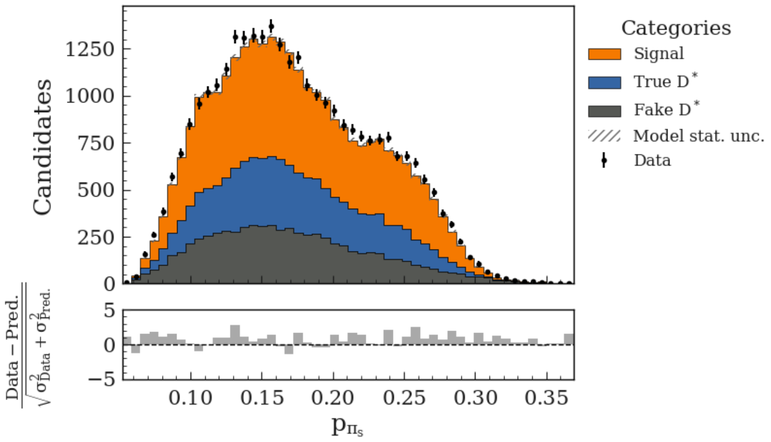
Pre-fit Kpi

Previous results from Belle2-NOTE-PH-2023-035

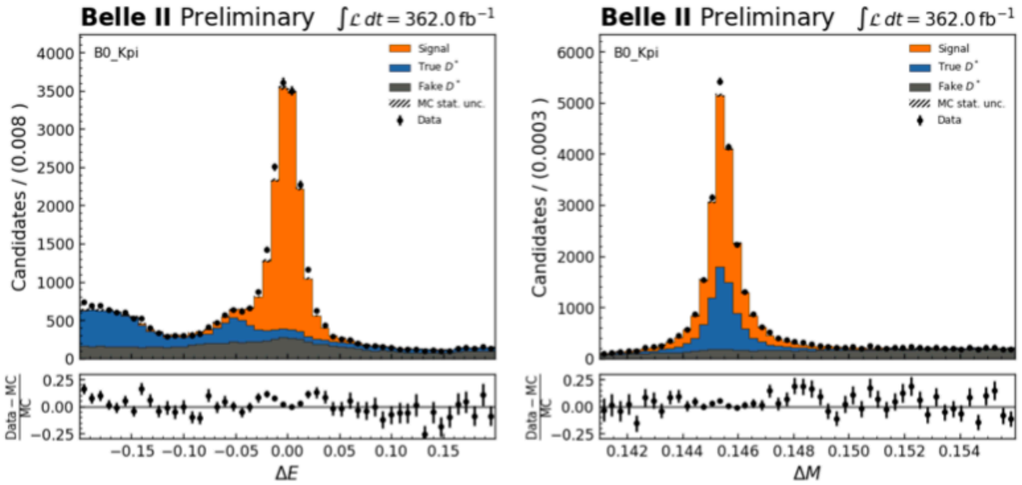
MC16rd release 8

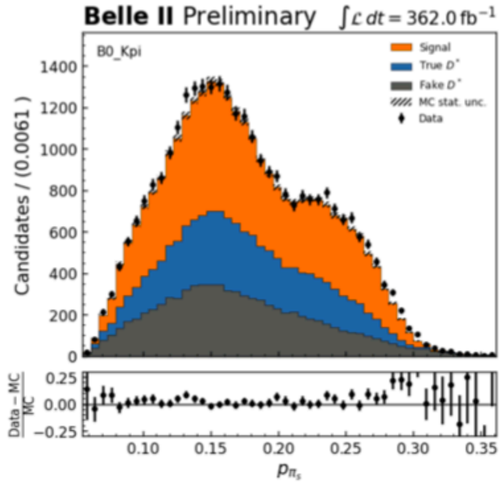






MC15rd release 6

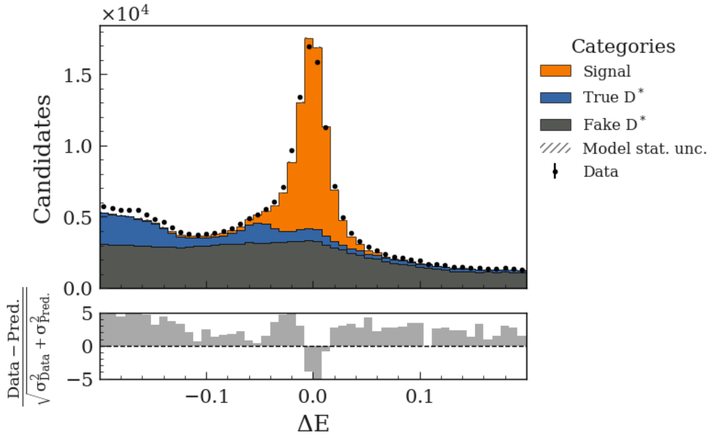


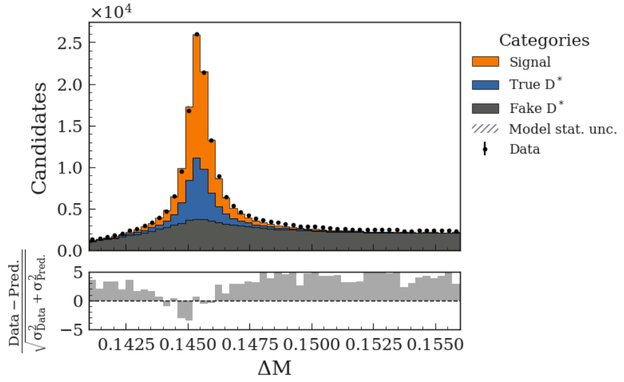


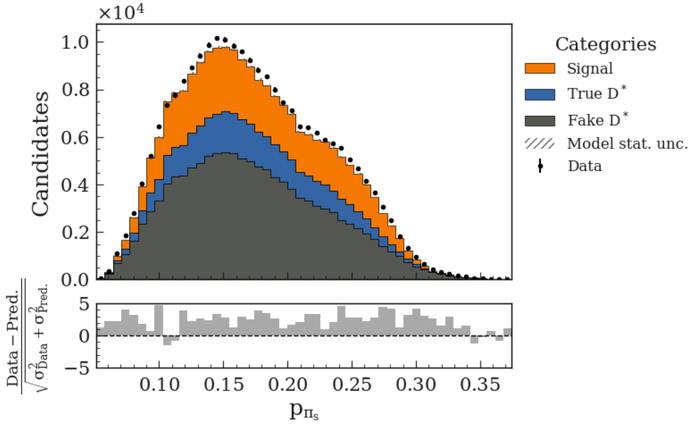
Pre-fit all channels

Previous results from Belle2-NOTE-PH-2023-035

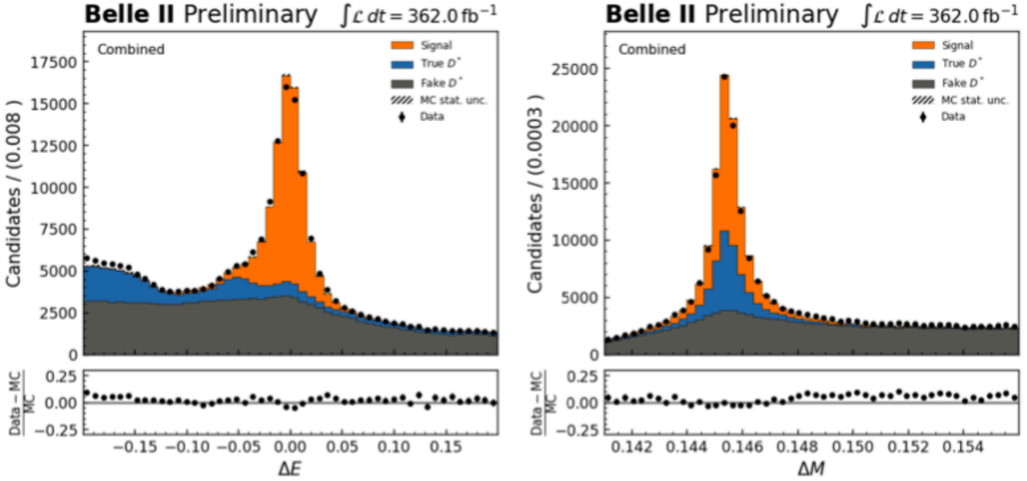
MC16rd release 8

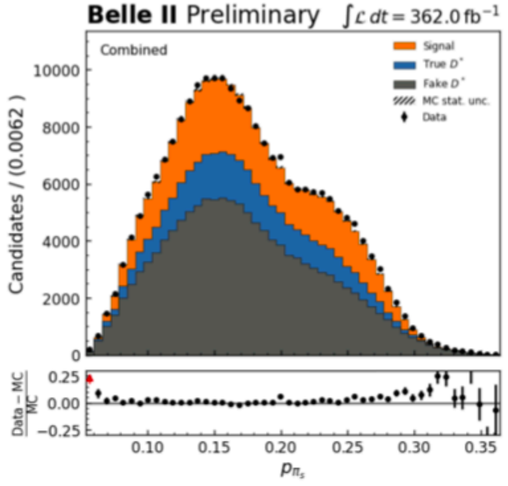






MC15rd release 6

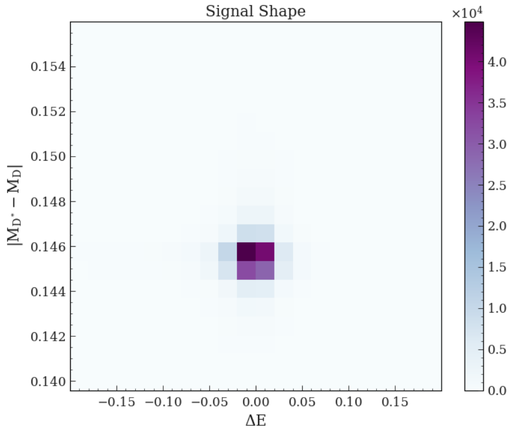


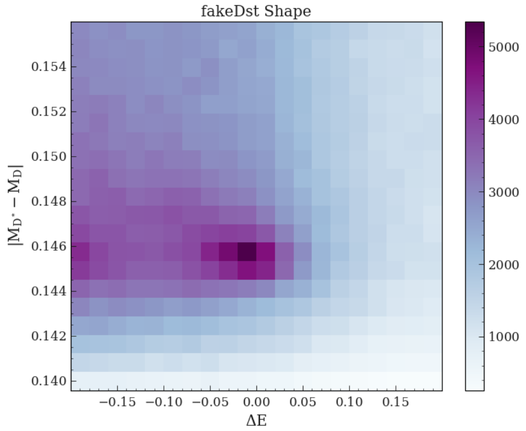


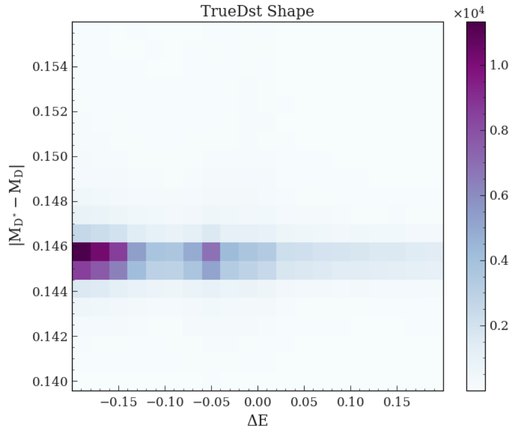
Shapes

Previous results from Belle2-NOTE-PH-2023-035

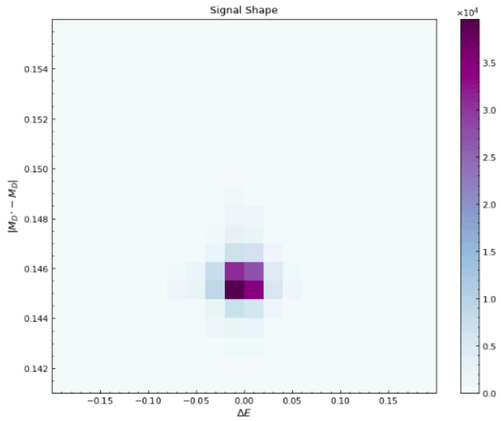
MC16rd release 8

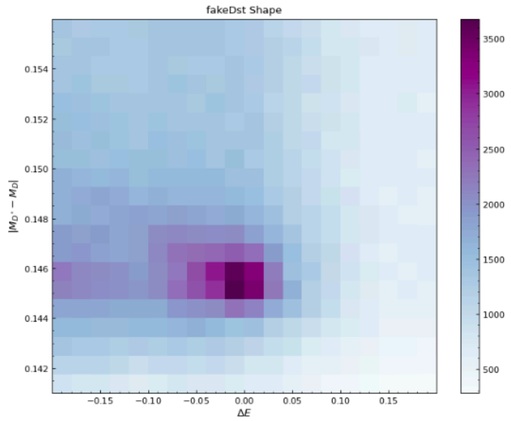


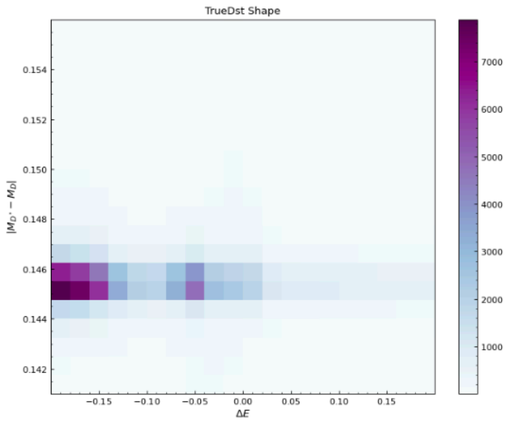




MC15rd release 6



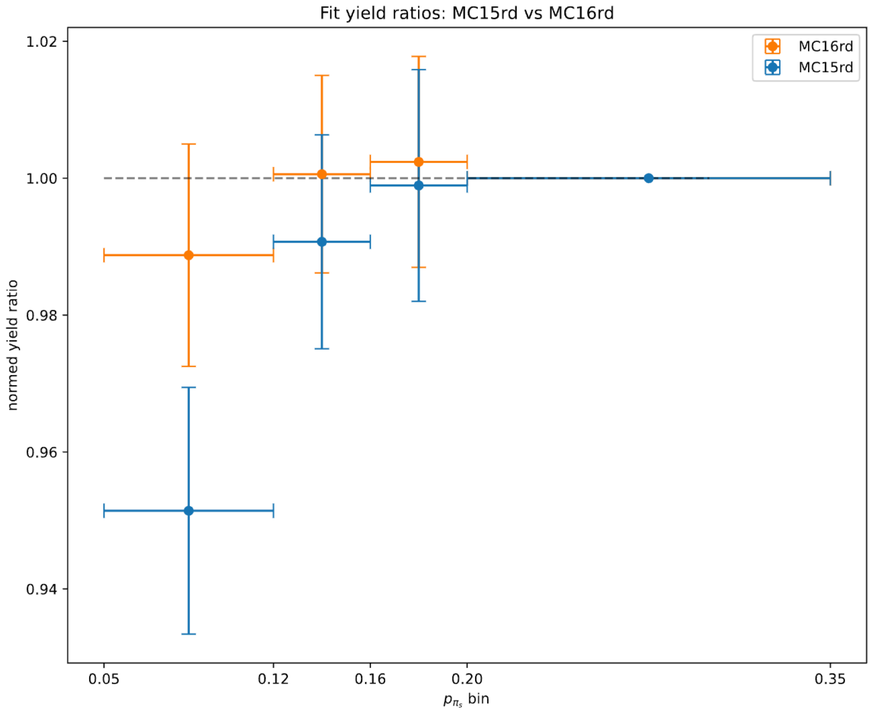




Fit: yield ratios

Previous results from Belle2-NOTE-PH-2023-035

MC16rd release 8



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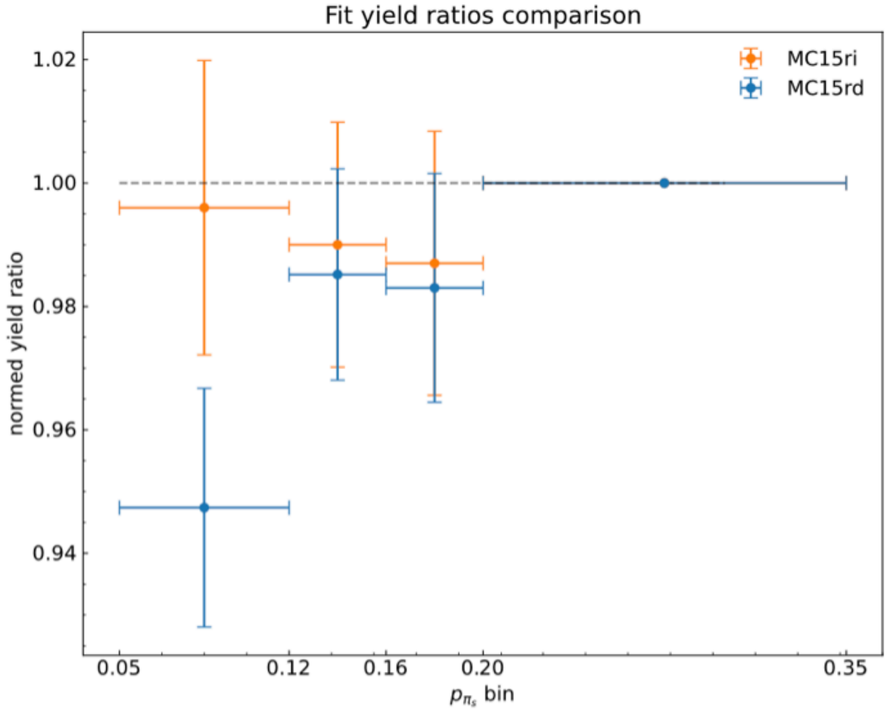


MC15rd release 8

Relative tracking efficiency: (98.335 +/- 1.29 +/- 0.266)%
Slow pion systematic: 1.325%

p_{π_s} range [GeV]	0.05-0.12	0.12-0.16	0.16-0.20	0.20-0.35
MC prediction	9733 ± 49	15833 ± 63	12863 ± 57	20260 ± 71
Fitted yield	8918 ± 134	15105 ± 168	12374 ± 156	19510 ± 191
r_i	0.916 ± 0.014	0.964 ± 0.011	0.962 ± 0.013	0.963 ± 0.01
$r_i/r_{\max}$	0.951	0.991	0.999	
$\sigma_{\text{uncorr}} \pm \sigma_{\text{corr}}$	0.015 ± 0.01	0.012 ± 0.01	0.013 ± 0.01	

	$K\pi$	$K\pi\pi\pi$	K^0_S	π^0
N_{sig}	14549.8 ± 61.7	22839.5 ± 77.3	4543.0 ± 34.5	20008.0 ± 72.4
N_{bkg}	4257.0 ± 33.4	16852.2 ± 66.4	4857.6 ± 35.7	22235.3 ± 76.3
$\frac{N_{\text{sig}}}{\sqrt{N_{\text{sig}}+N_{\text{bkg}}}}$	106.1 ± 0.3	114.6 ± 0.3	46.9 ± 0.3	97.3 ± 0.3

MC15rd release 6

Relative tracking efficiency: (97.441 +/- 1.99 +/- 0.817)%
Slow pion systematic: 1.46%

MC15 run dependent result

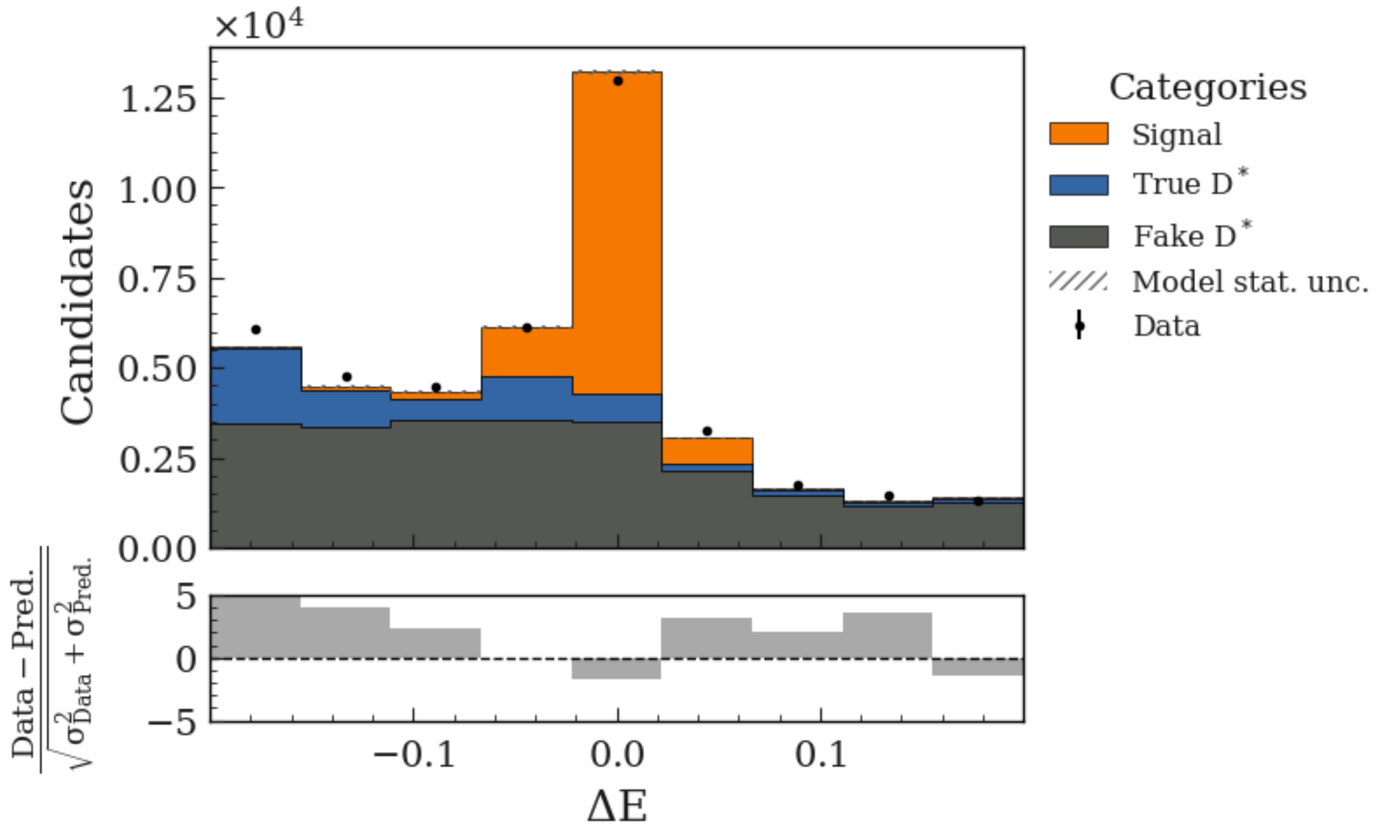
p_{π_s} range[GeV]	0.05-0.12	0.12-0.16	0.16-0.20	0.20-0.35
MC prediction	9733 ± 49	15832 ± 63	12863 ± 57	20259 ± 71
Fitted yield	9066 ± 144	15336 ± 188	12432 ± 176	19920 ± 220
r_i	0.932 ± 0.016	0.969 ± 0.013	0.967 ± 0.014	0.9833 ± 0.011
r_i/r_{max}	0.947	0.985	0.983	
$\sigma_{uncorr} \pm \sigma_{corr}$	0.016 ± 0.011	0.013 ± 0.011	0.015 ± 0.011	
σ_{track}	± 0.0027	± 0.0028	± 0.0028	

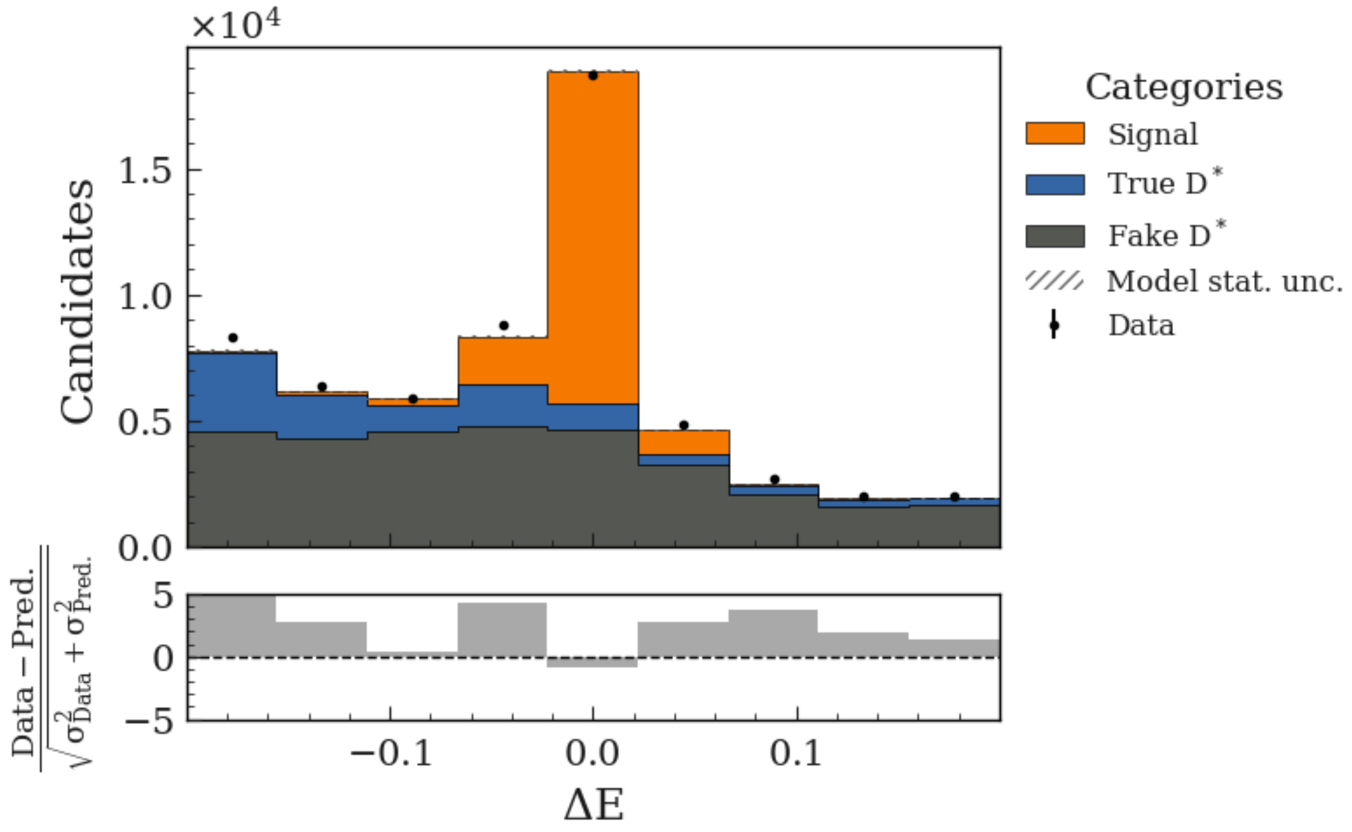
	$K^+\pi^-$	$K^+\pi^-\pi^+\pi^-$	$K^0_S\pi^+\pi^-$	$K^+\pi^-\pi^0$
N_{sig}	13135 ± 57	20836 ± 72	4000 ± 31	17529 ± 66
N_{bg}	4374 ± 33	17337 ± 65	4948 ± 35	20970 ± 72
$\frac{N_{sig}}{\sqrt{N_{sig}+N_{bg}}}$	99.3 ± 0.4	106.6 ± 0.4	42.3 ± 0.3	89.3 ± 0.3

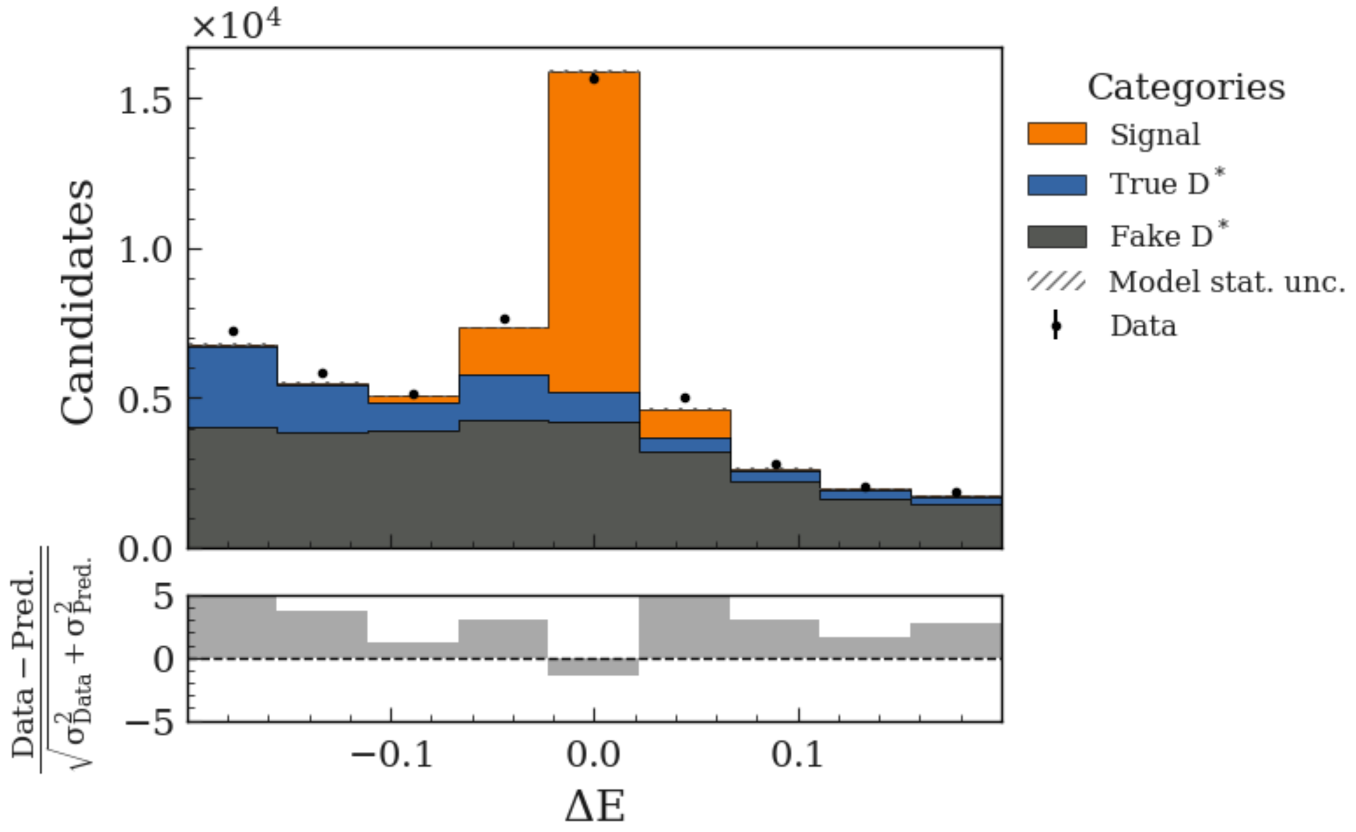
Pre-fit all channels

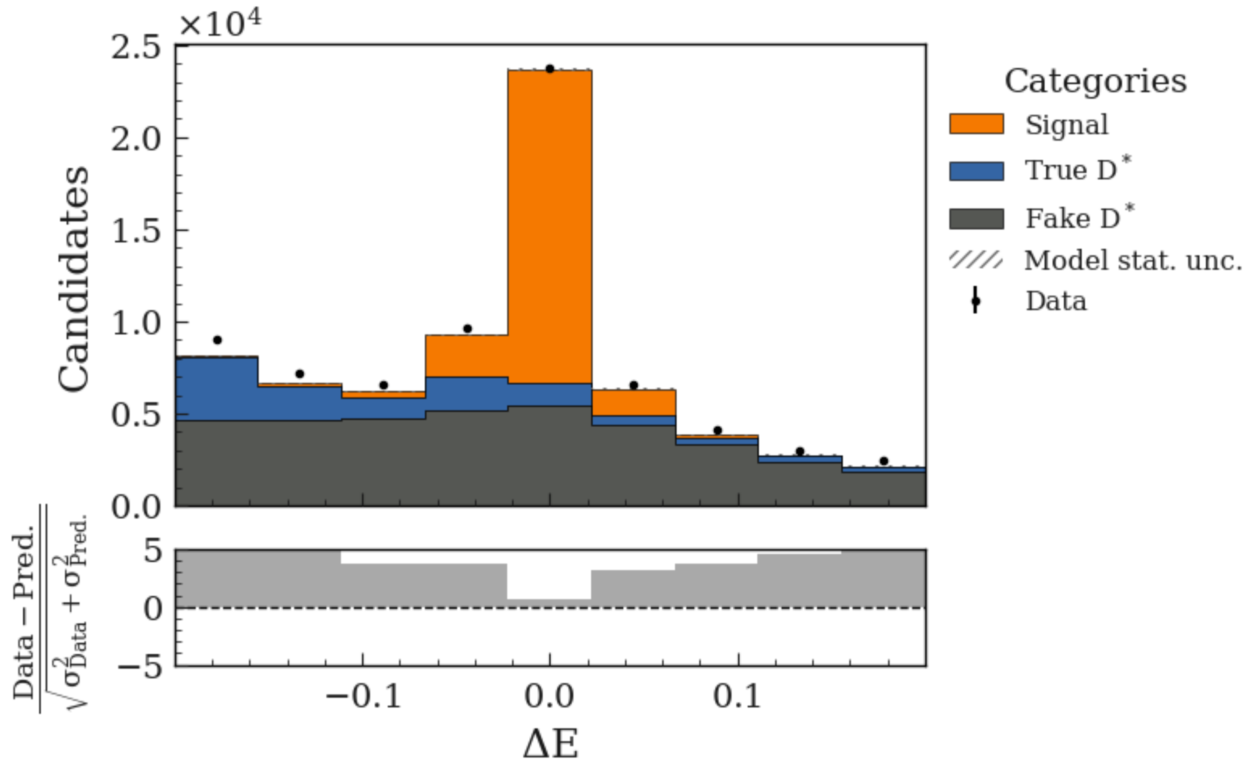
Previous results from Belle2-NOTE-PH-2023-035

MC16rd release 8

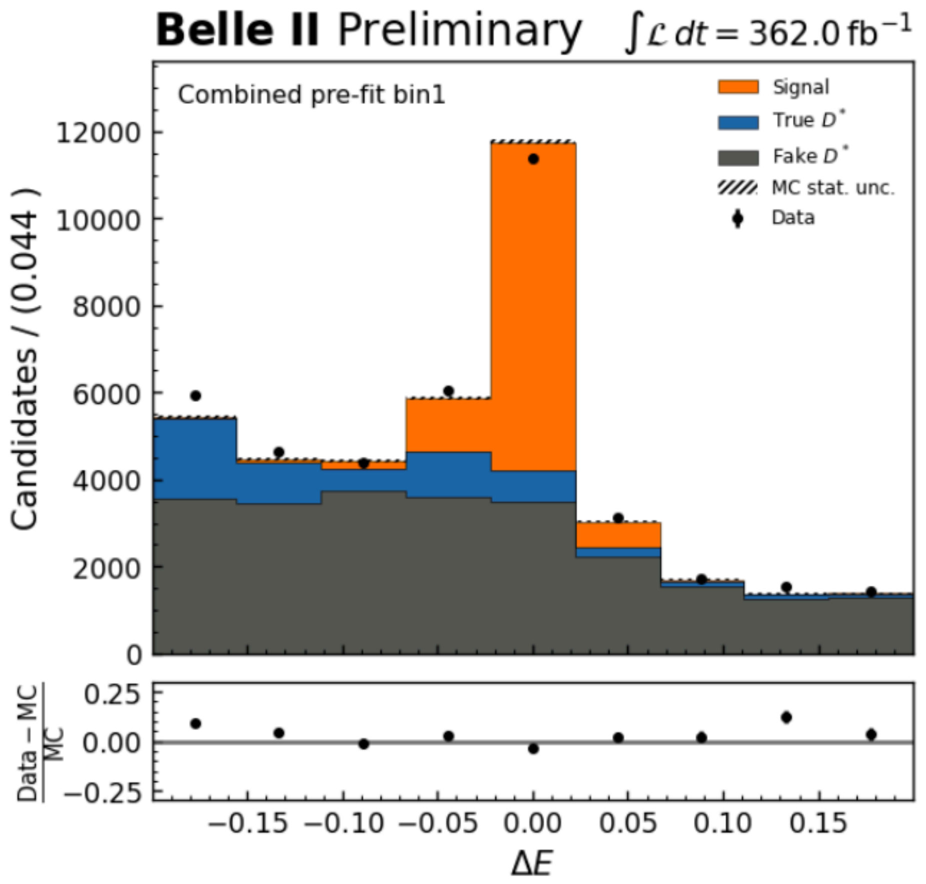


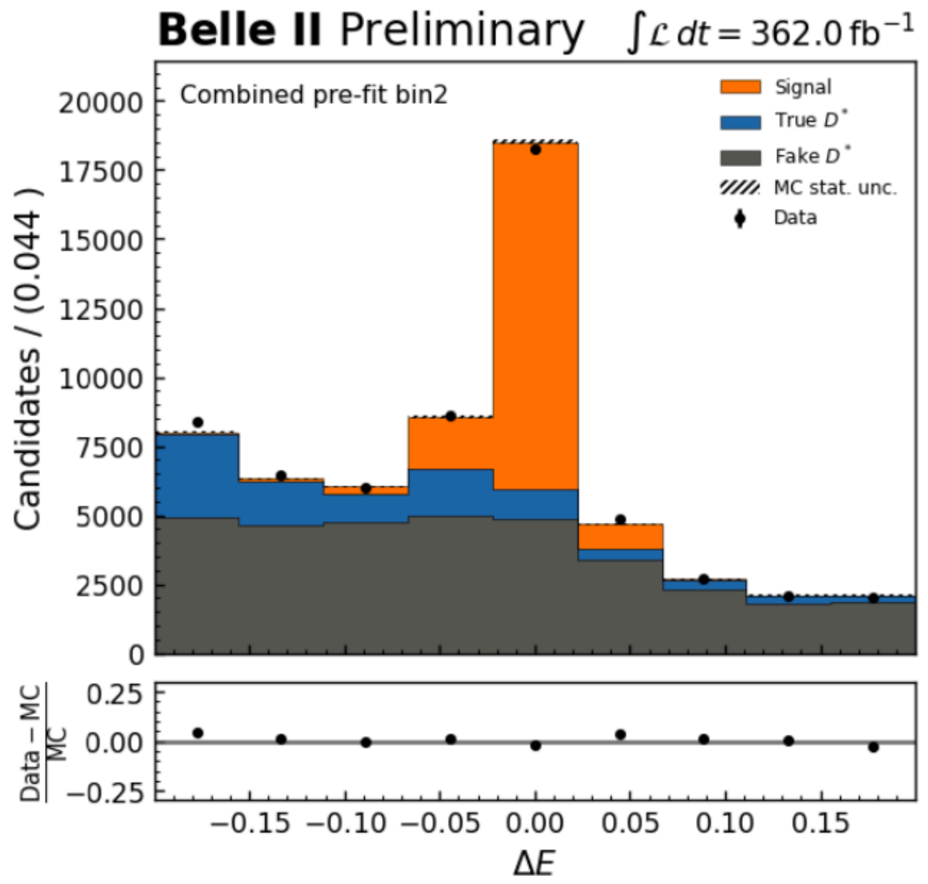


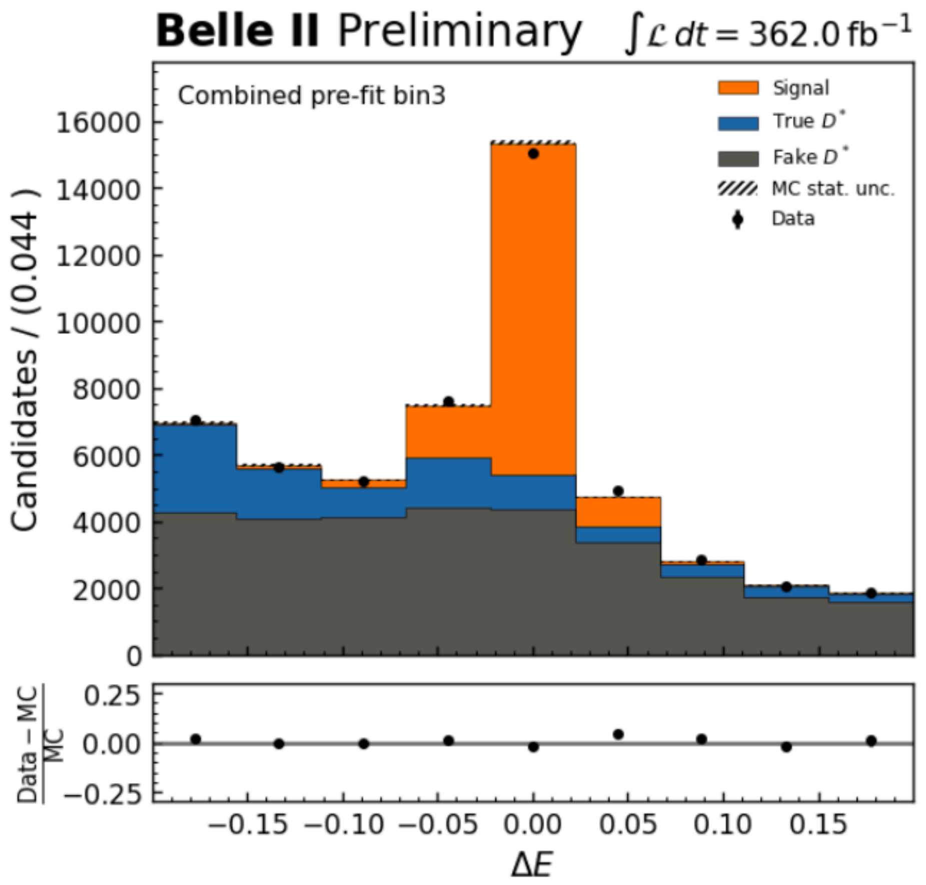


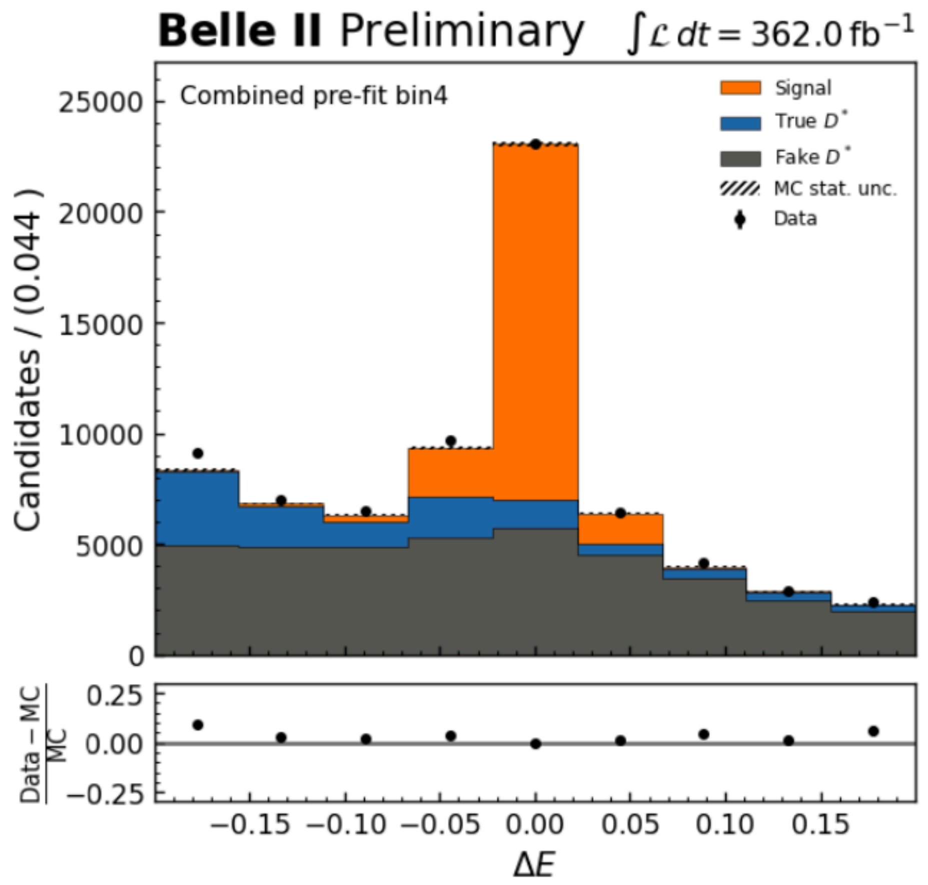


MC15rd release 6





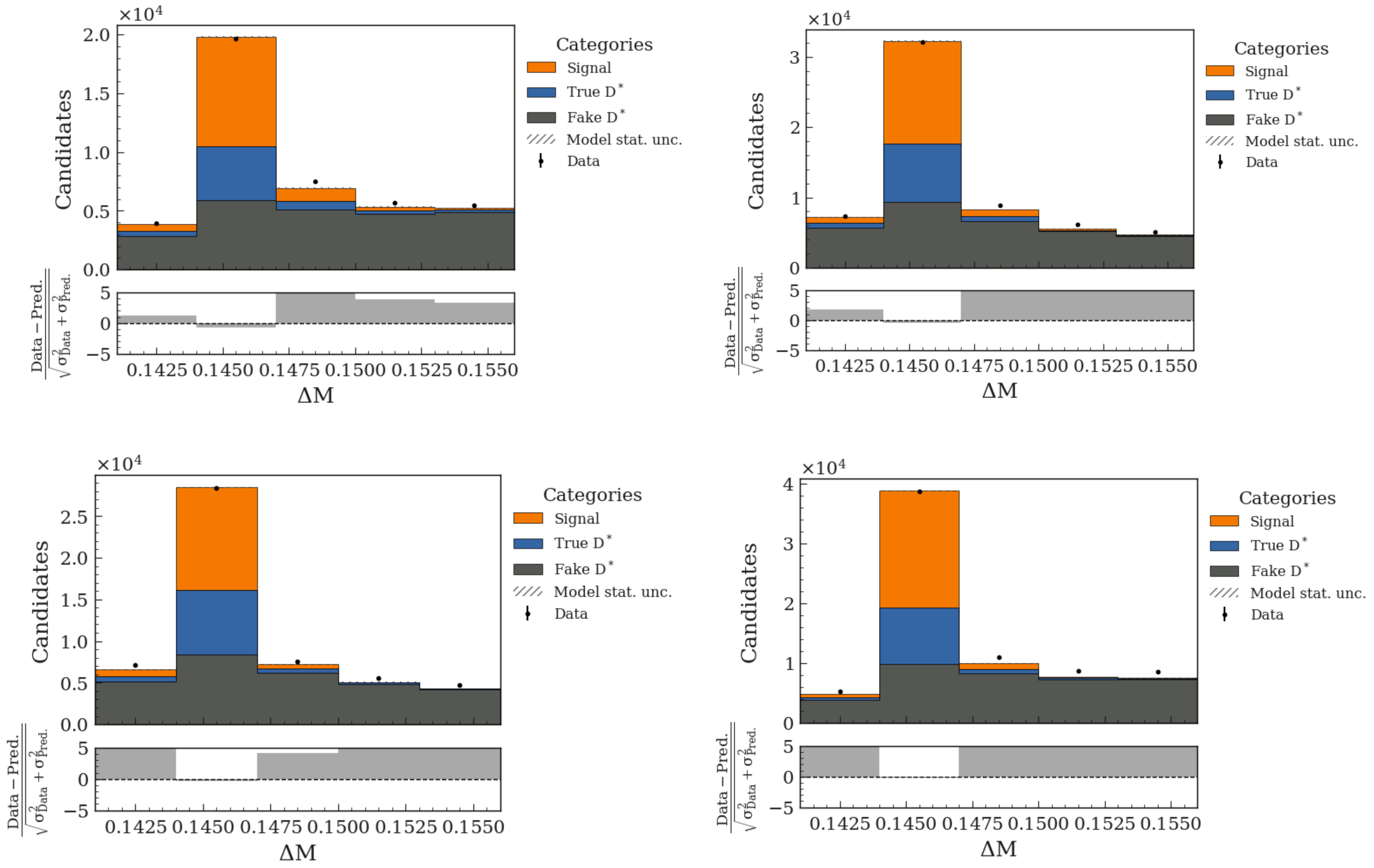




Pre-fit all channels

Previous results from Belle2-NOTE-PH-2023-035

MC16rd release 8



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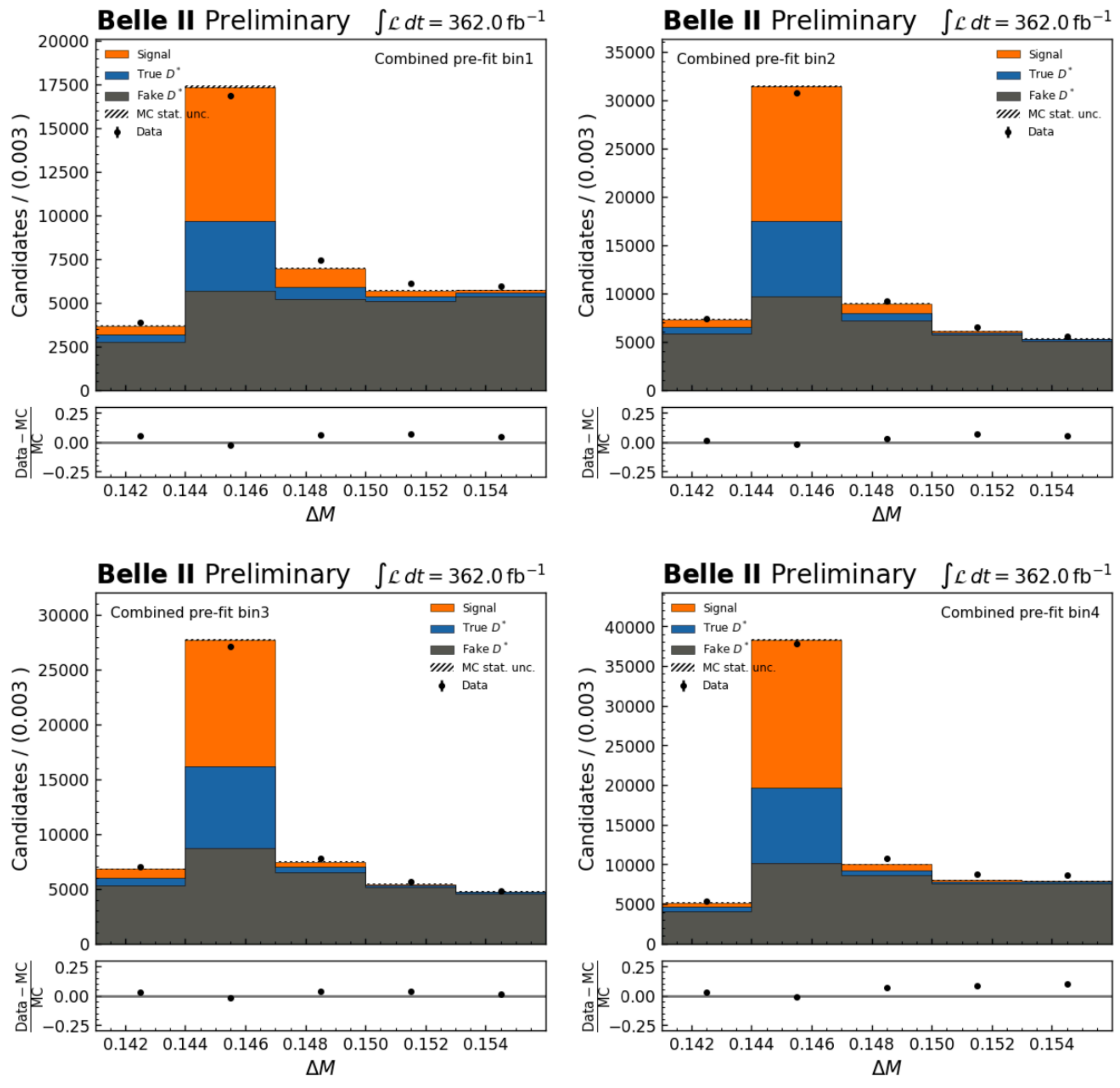
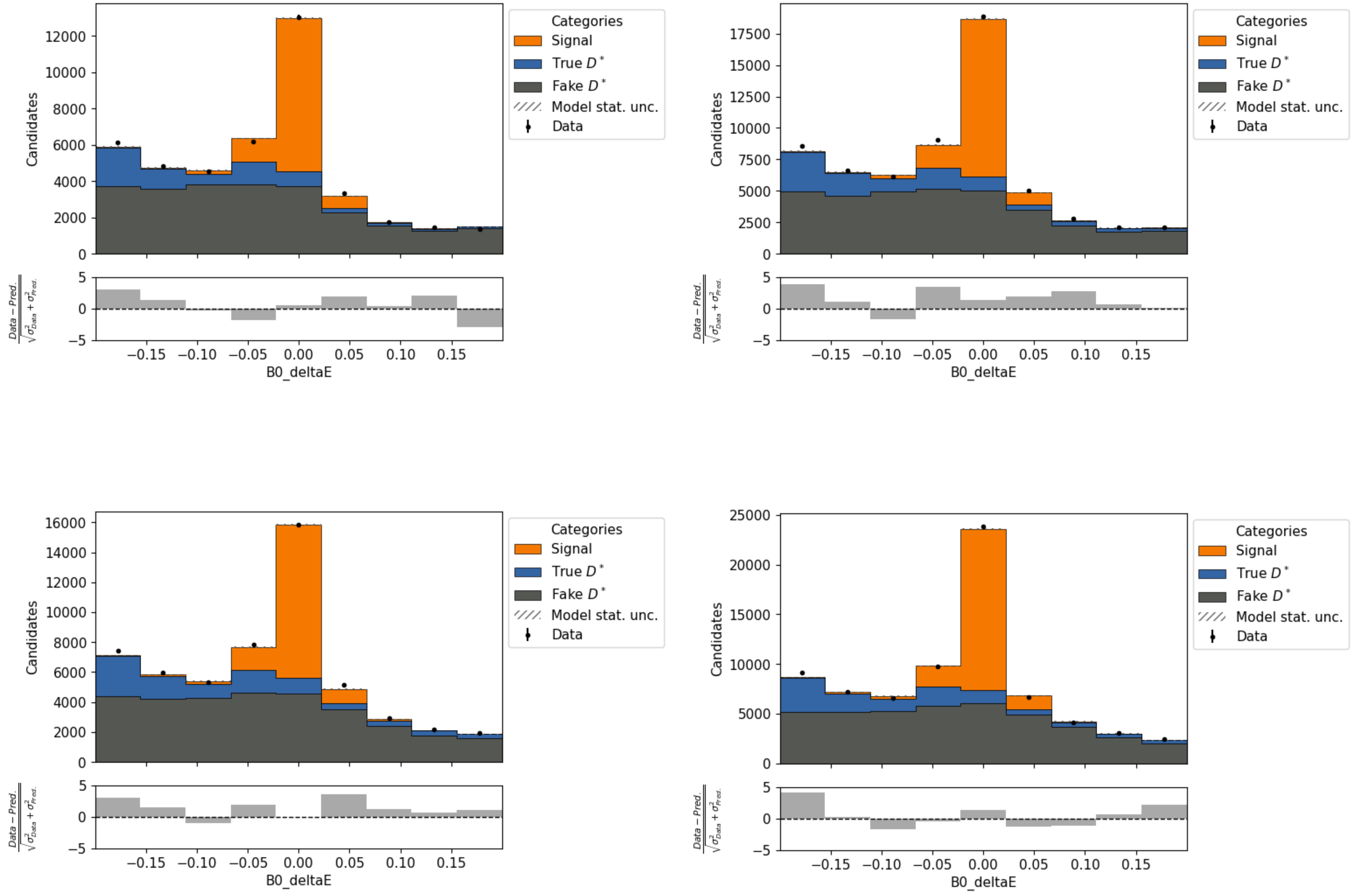


Post-fit all channels

MC16rd release 8



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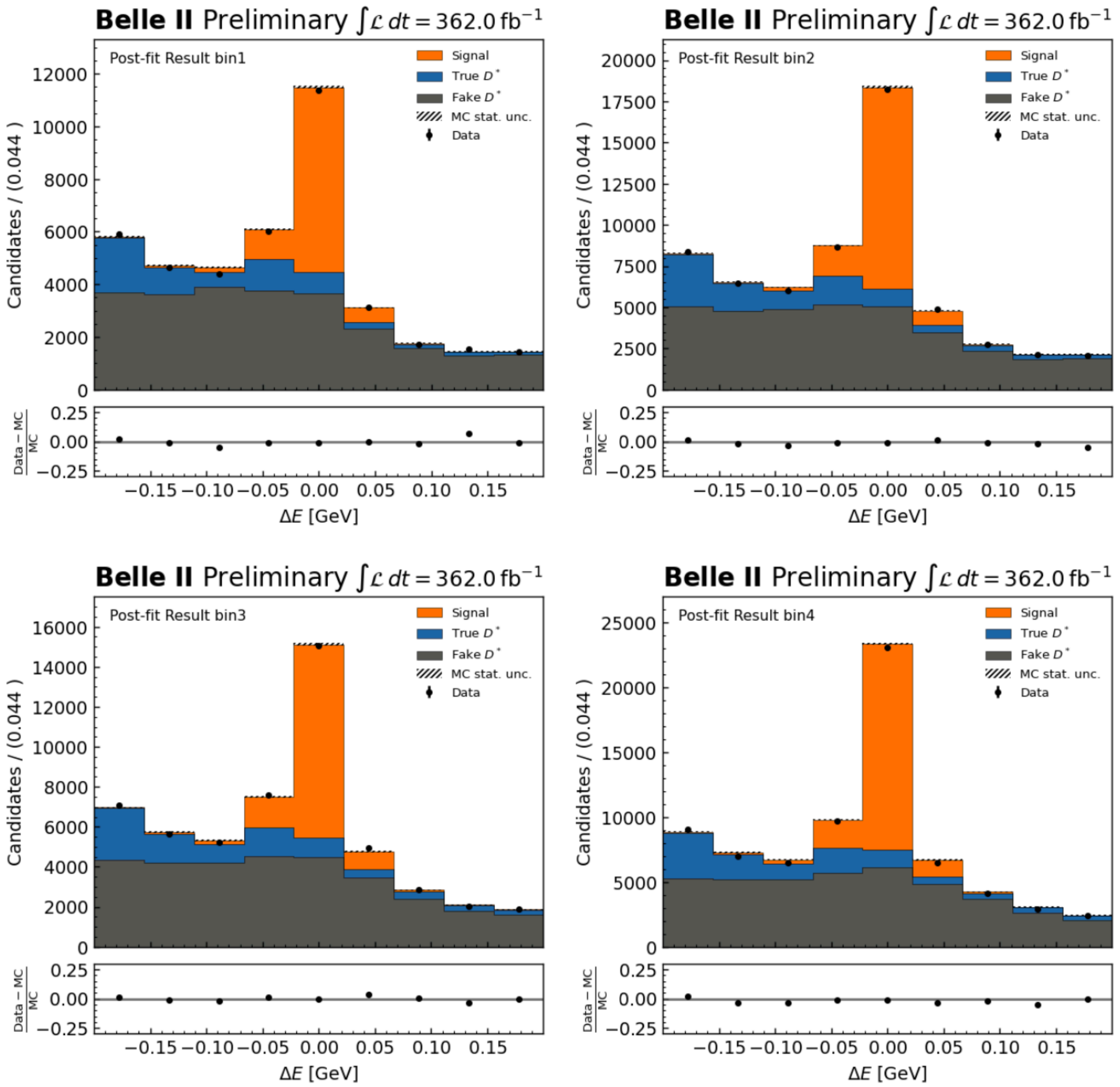

Post-fit all channels

Previous results from Belle2-NOTE-PH-2023-035

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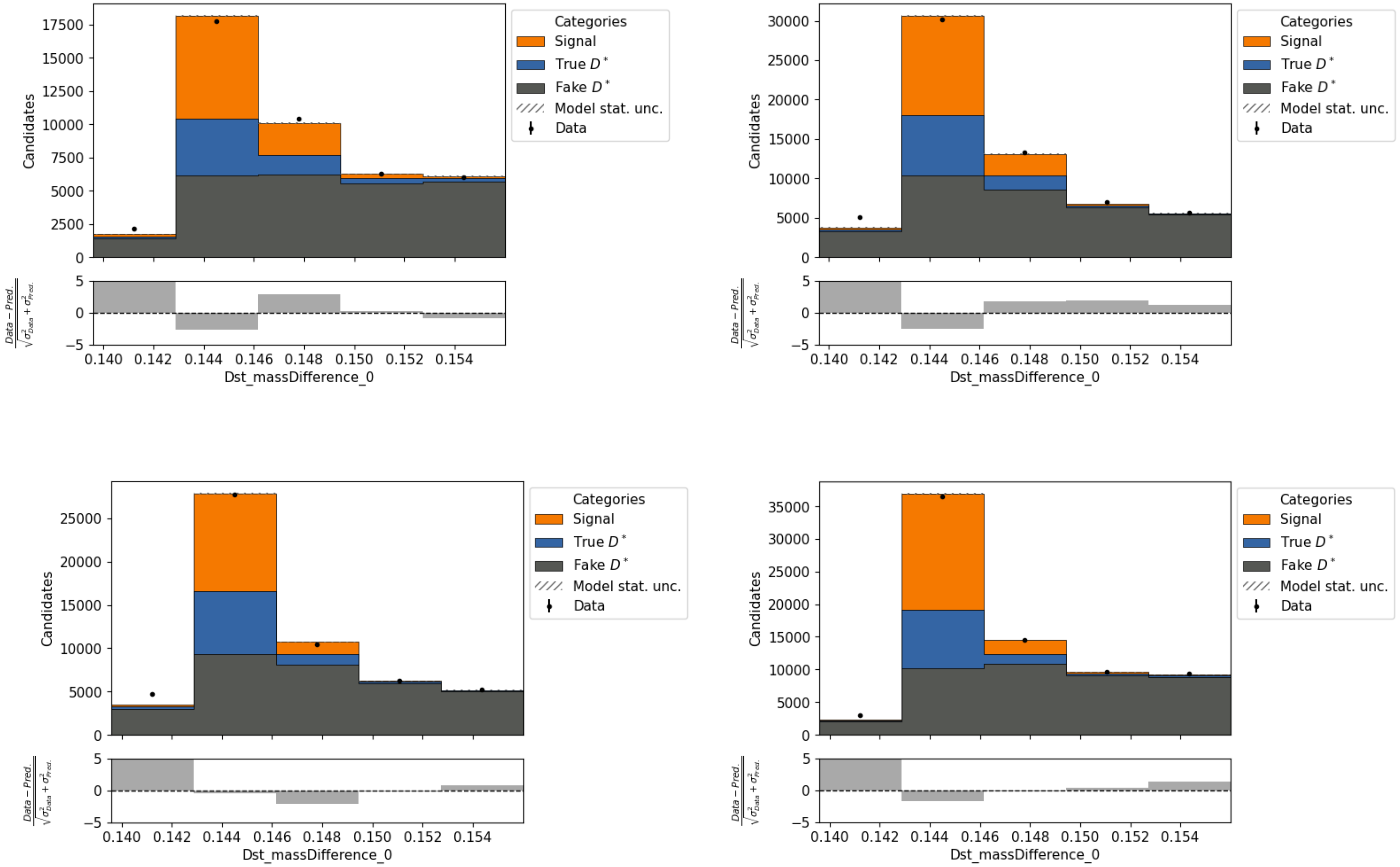

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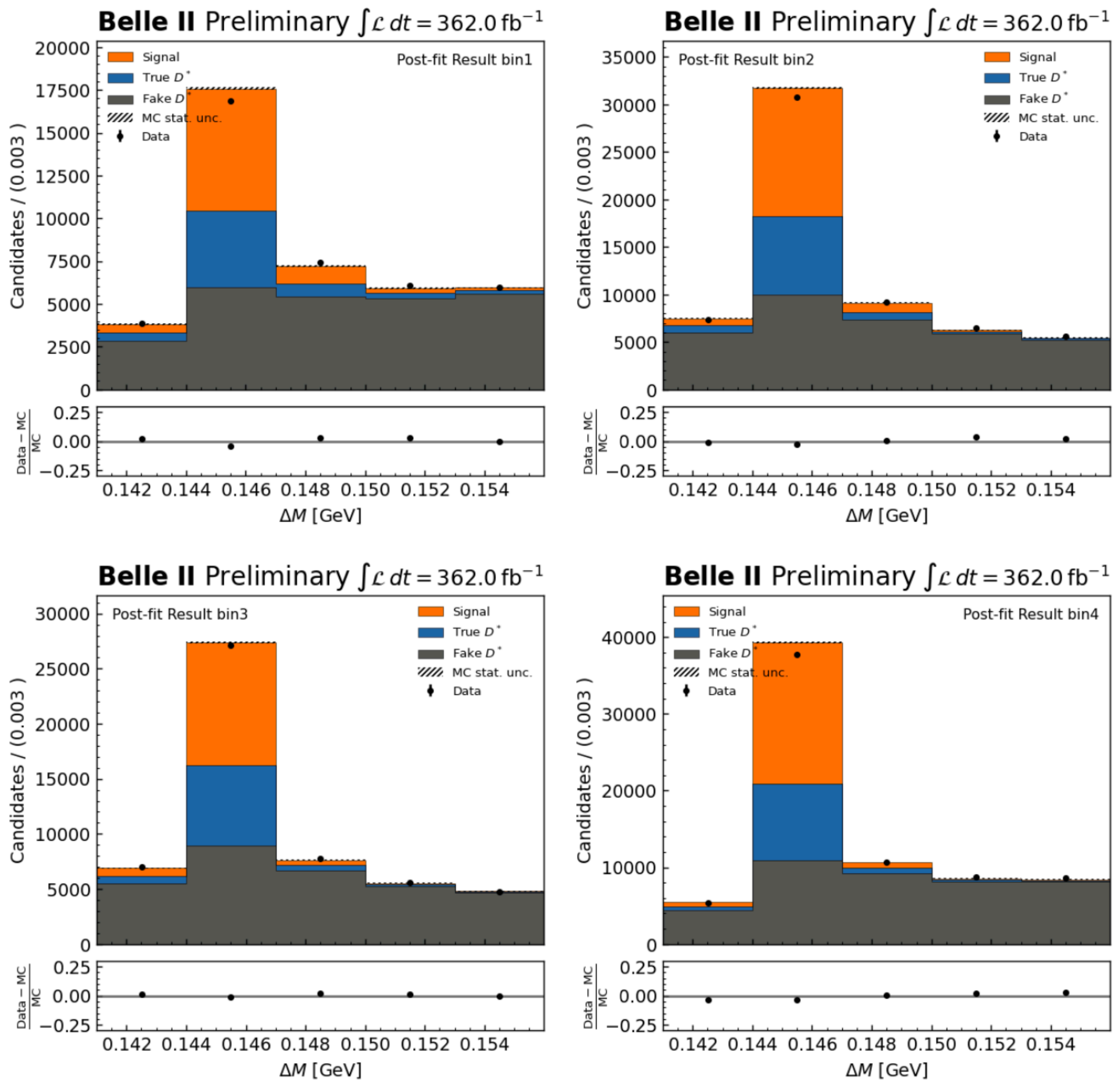

Charge asymmetry

Previous results from Belle2-NOTE-PH-2023-035

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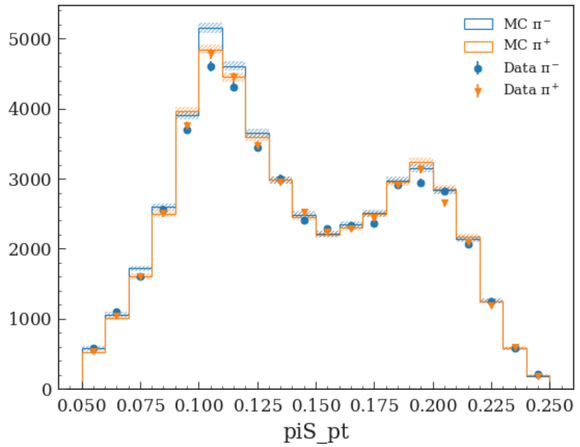

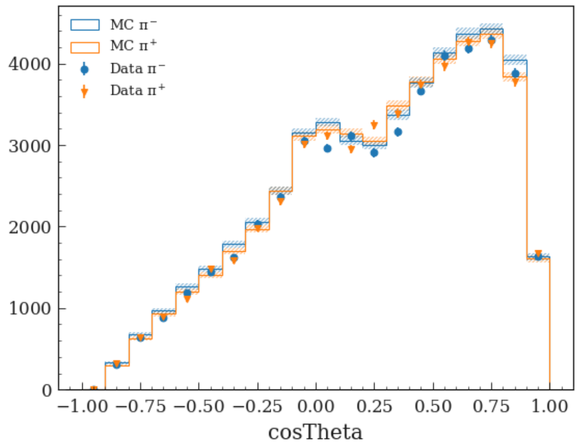

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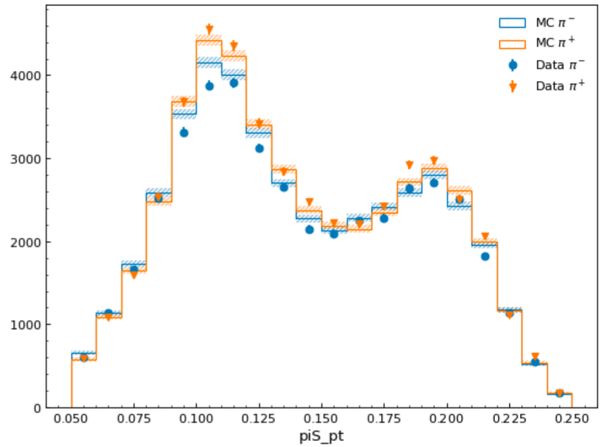

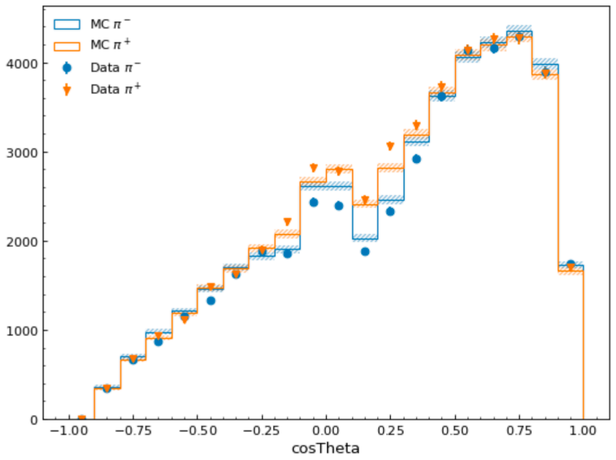

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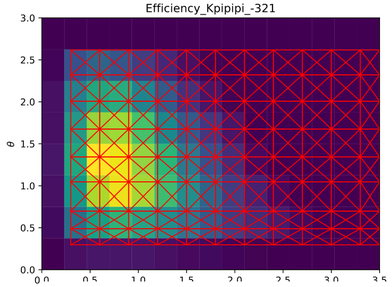
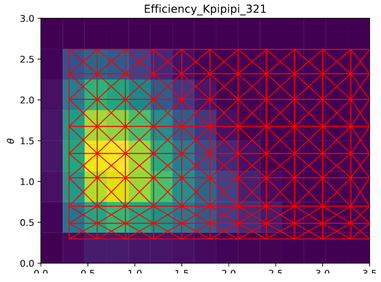
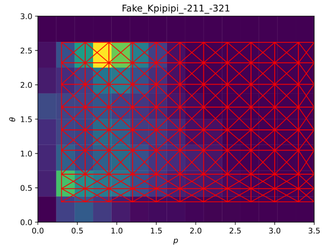
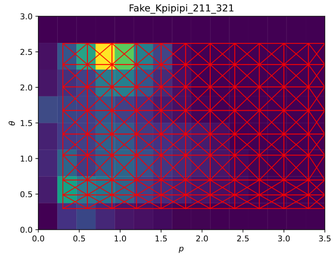
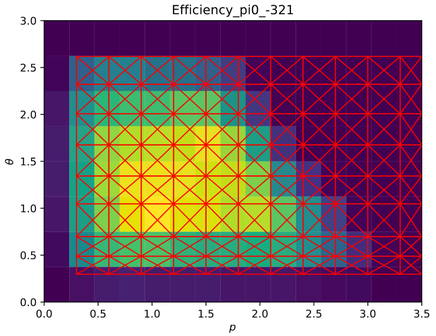
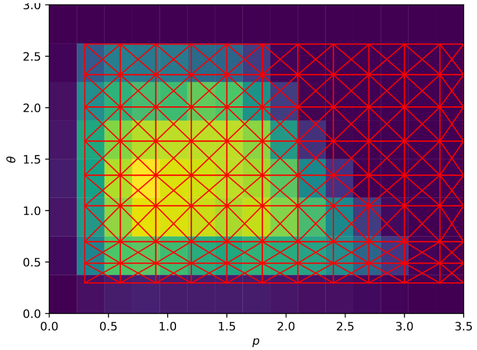


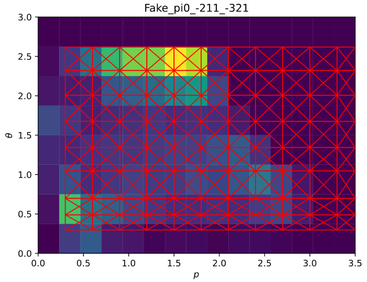


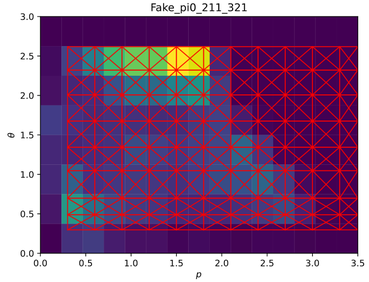




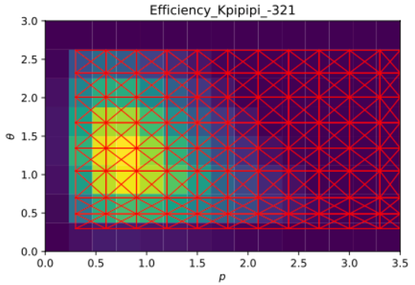


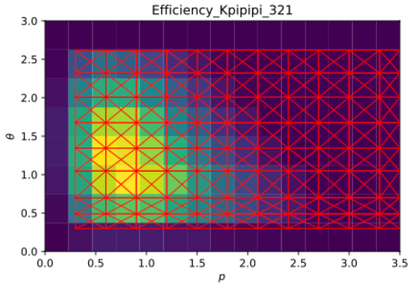


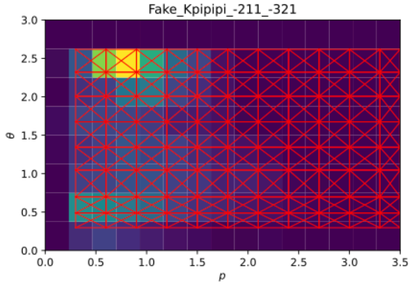


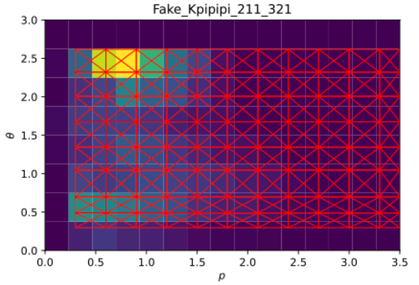


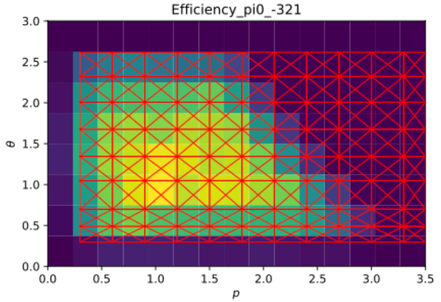
MC15rd release 6

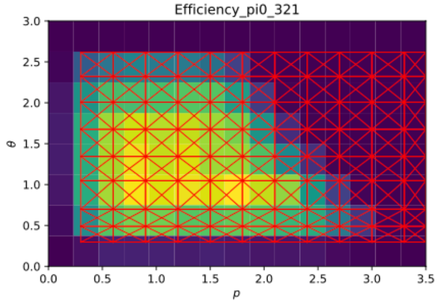


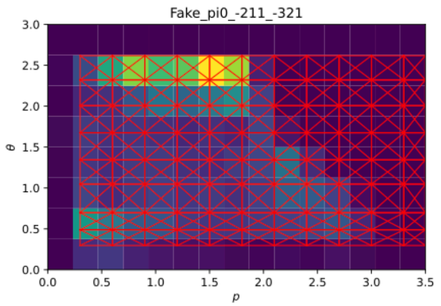


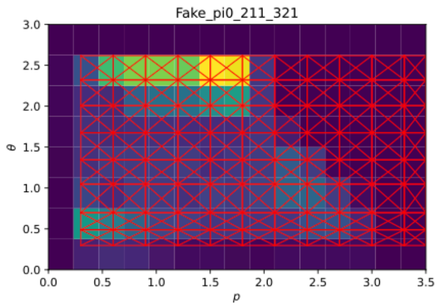












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