UNIVERSITY
OF TRIESTE

INFN

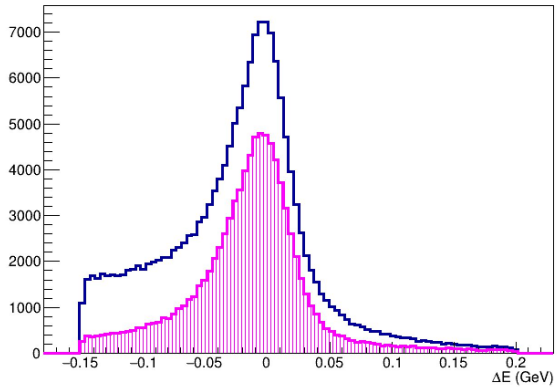
Toward $\mathcal{B}(B \to D^0 \rho)$

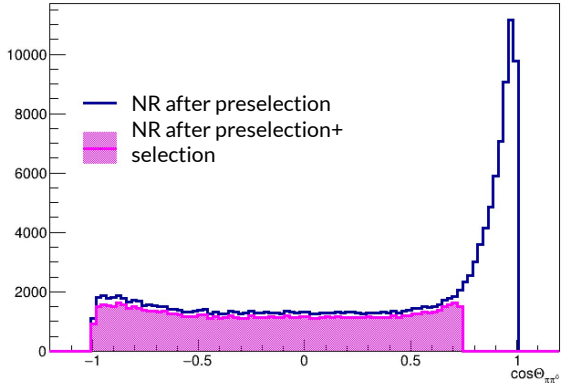
TS analysis meeting
august-october 2022

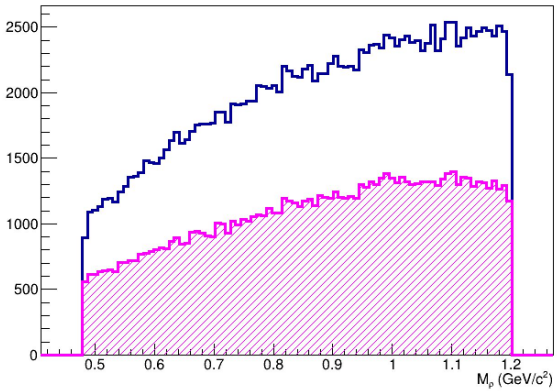
Mirco Dorigo
Riccardo Manfredi
Olga Werbycka

Efficiency for non-resonant decay B→D⁰ππ⁰

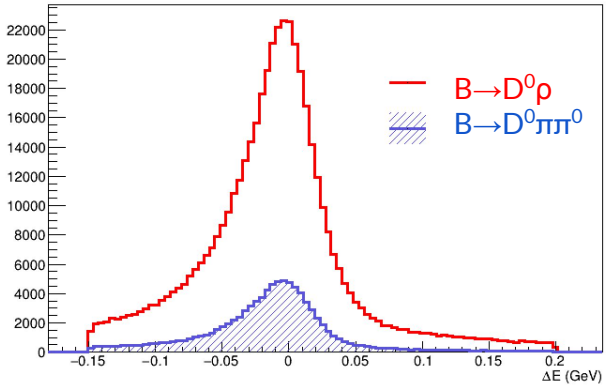
	After preselection	After preselection + selection
NR eff (ε)	~8.4%	~4.5%

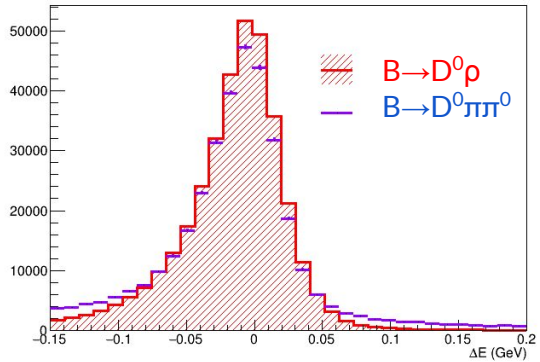


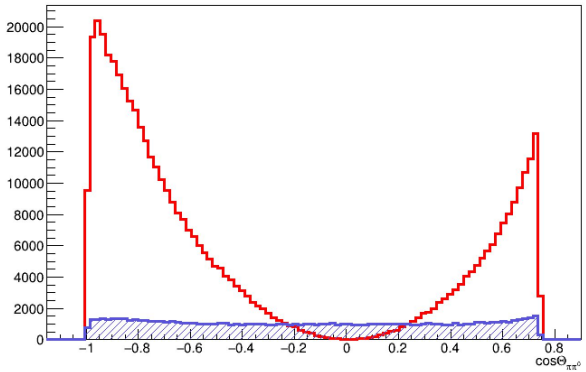


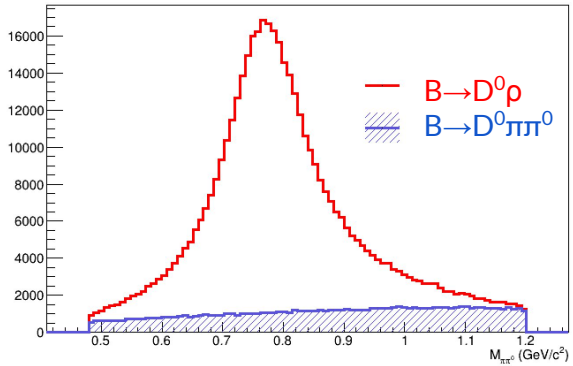


Comparison of resonant and NR signal MC





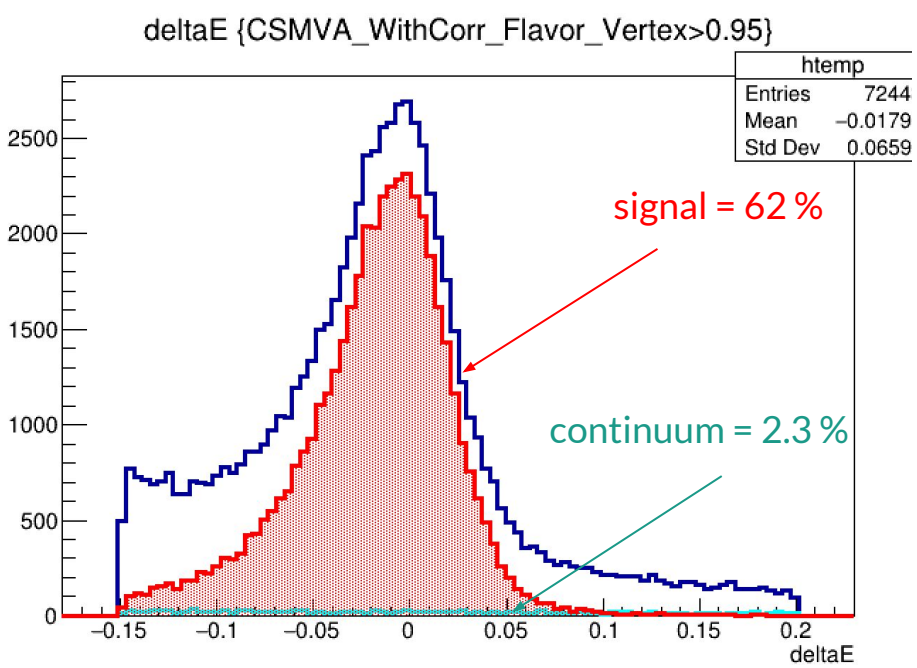


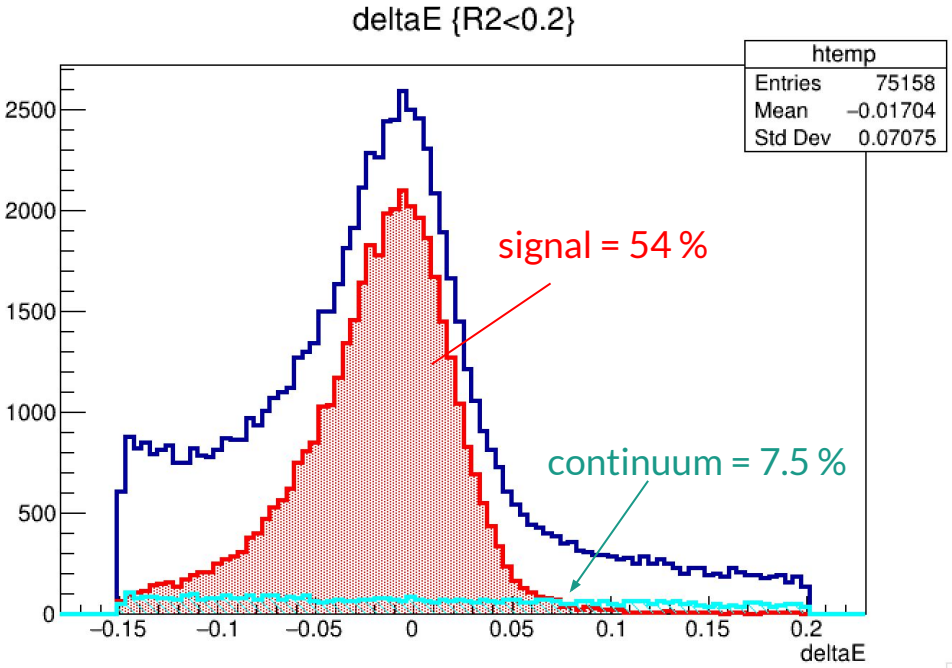


Change of Strategy

- Revision of the selection criteria in order to get rid of the continuum background
- Imposing mass cut on the ρ
- Using $B \rightarrow D^0 \pi$ as a control channel

Possibilities to reduce continuum background

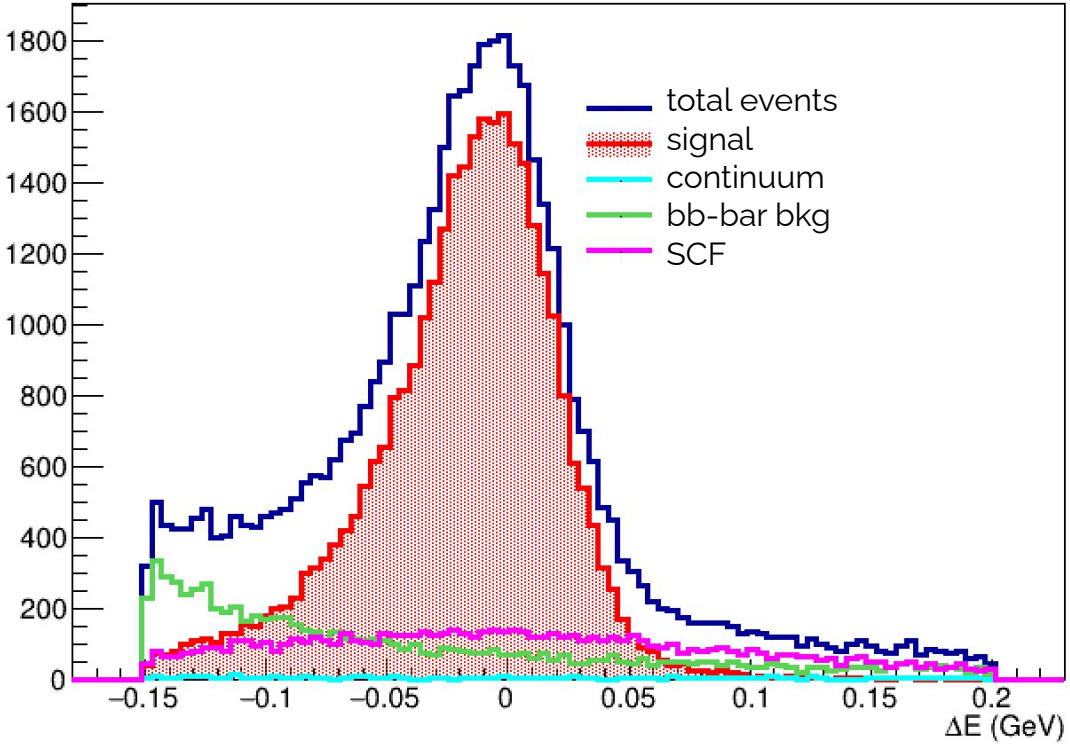




Signal efficiency vs Continuum background rejection

After cut	CSMVA > 0.95 (%)	CSMVA > 0.96 (%)	CSMVA > 0.97 (%)	CSMVA > 0.98 (%)	CSMVA > 0.99 (%)
Signal frac.	0.62	0.63	0.64	0.66	0.69
Continuum frac.	2.3	1.9	1.4	0.9	0.4
signal eff.	11.4	10.6	9.4	7.8	5.0
expected signal in Data 190fb^{-1}	**12611**	**11726**	**10399**	**8629**	**5531**

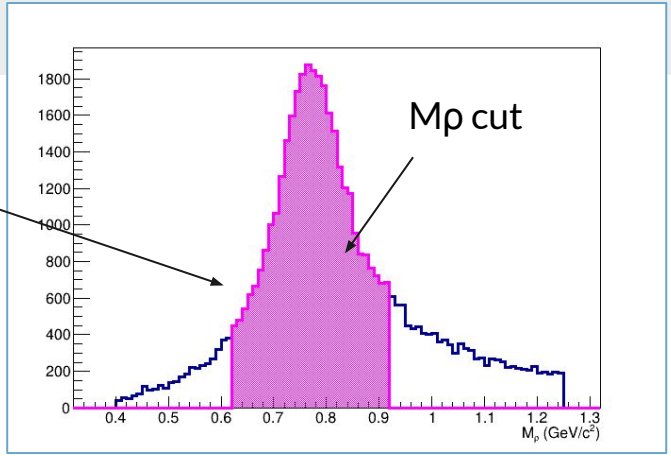
Data set composition after CSMVA>0.98 cut

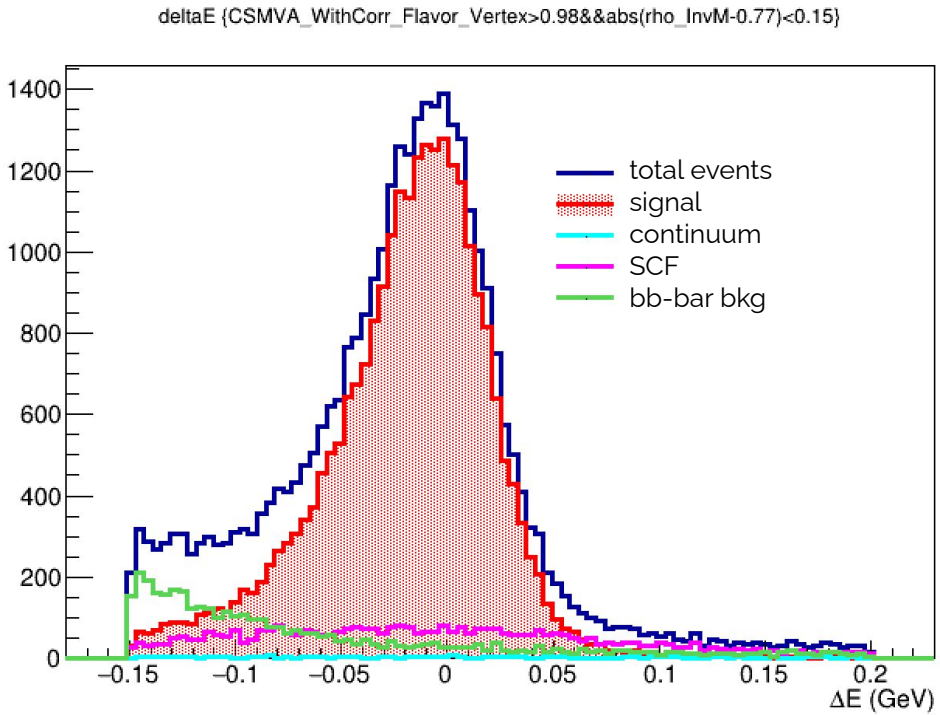


Composition	Nevents	Fraction
Signal	31375	0.66
Continuum	429	0.009
SCF	7816	0.16
BB-bar bkg	7751	0.17
Total events	47371	1.0

$MC14_{ri}$ 700fb^{-1}

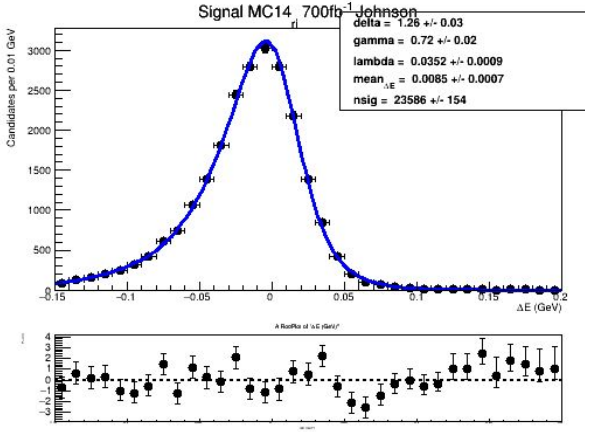
$$abs(M_\rho - 0.77) < 0.15$$



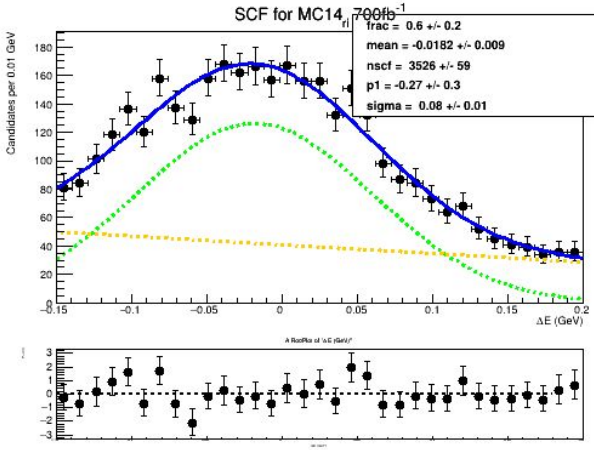


Composition	Nevents	Fraction
Signal	23586	0.76
Continuum	155	0.005
SCF	3526	0.114
BB-bar bkg	3816	0.12
Total events	30928	1.0

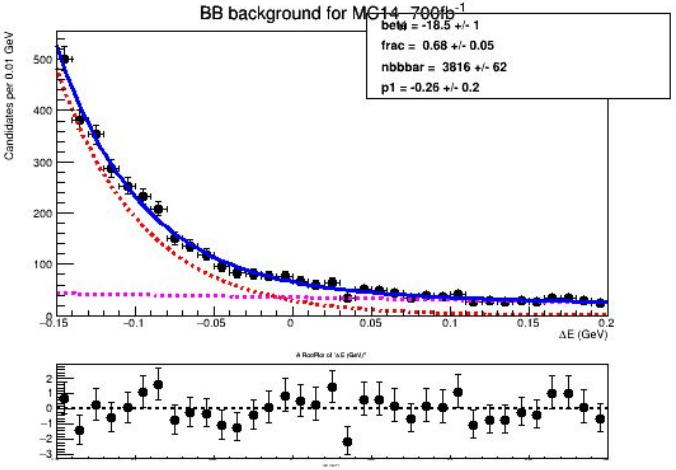
Fitting parameters



RooJohnson

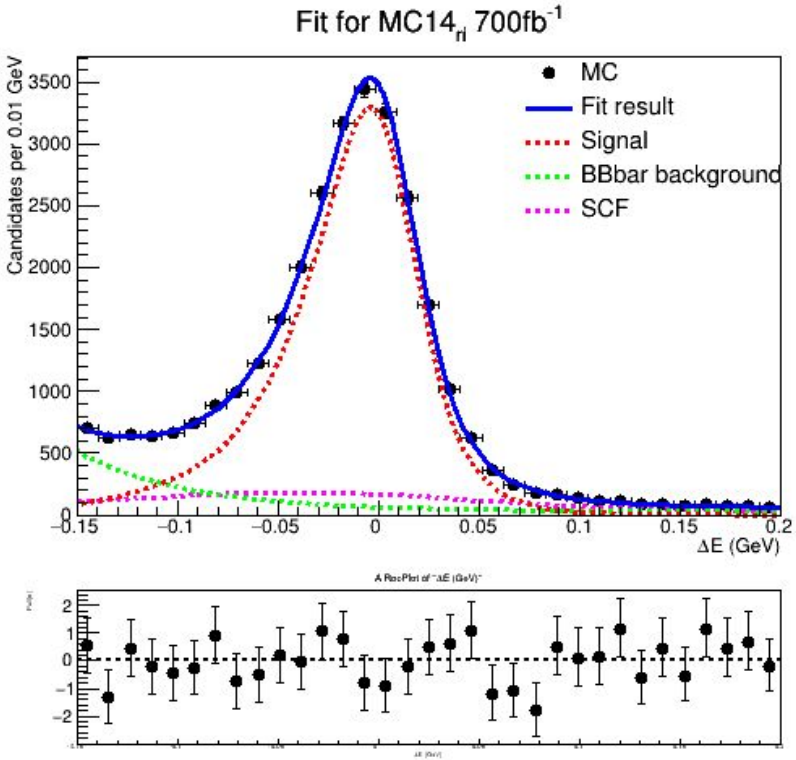


RooGaussian x
RooChebyshev(1)



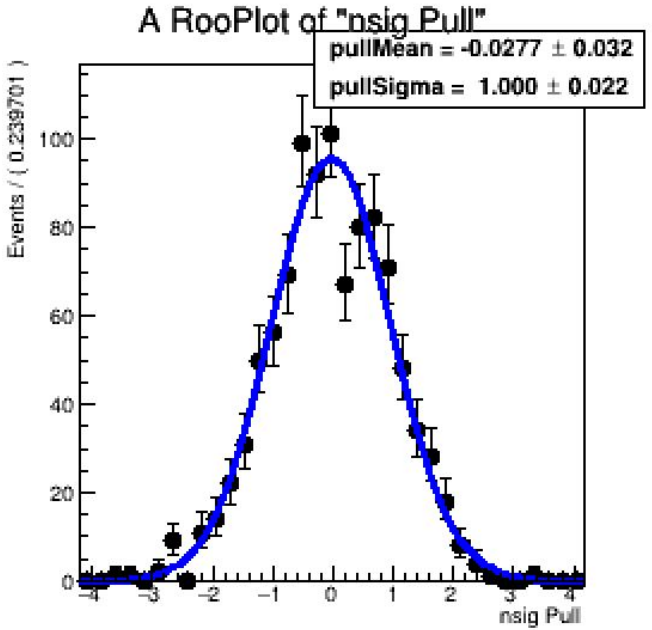
RooExponential x
RooChebyshev(1)

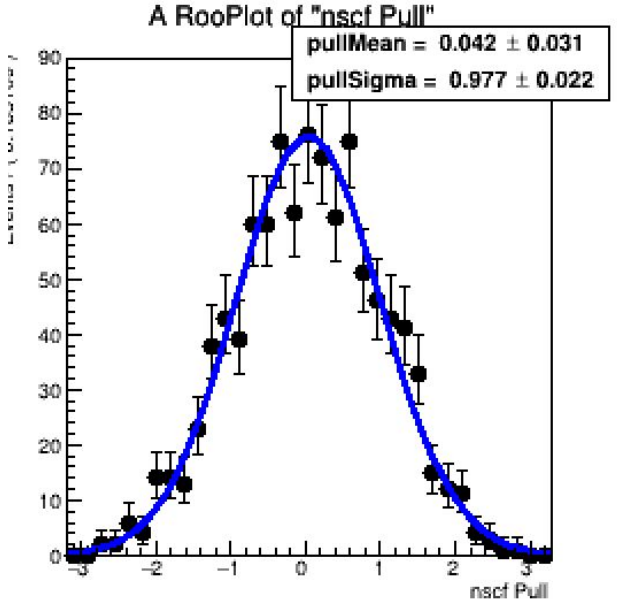
Fit result

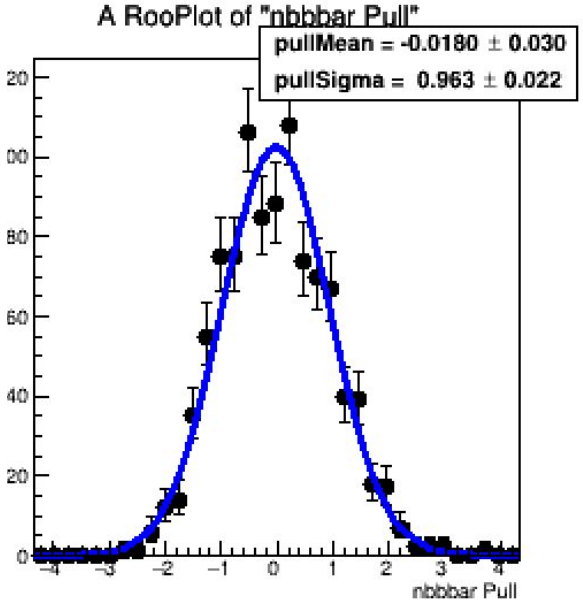


Composition	Nevents	Nfitted	σ
Signal	23586	23545 ± 233	0.2
Continuum	155	-/-	
SCF	3526	3852 ± 406	0.8
BB-bar bkg	3816	3530 ± 270	1.1
Total events	30928	30927	

TOY MC


A RooPlot of "nsig Pull"
pullMean = -0.0277 ± 0.032
pullSigma = 1.000 ± 0.022
Events / (0.239701)
nsig Pull

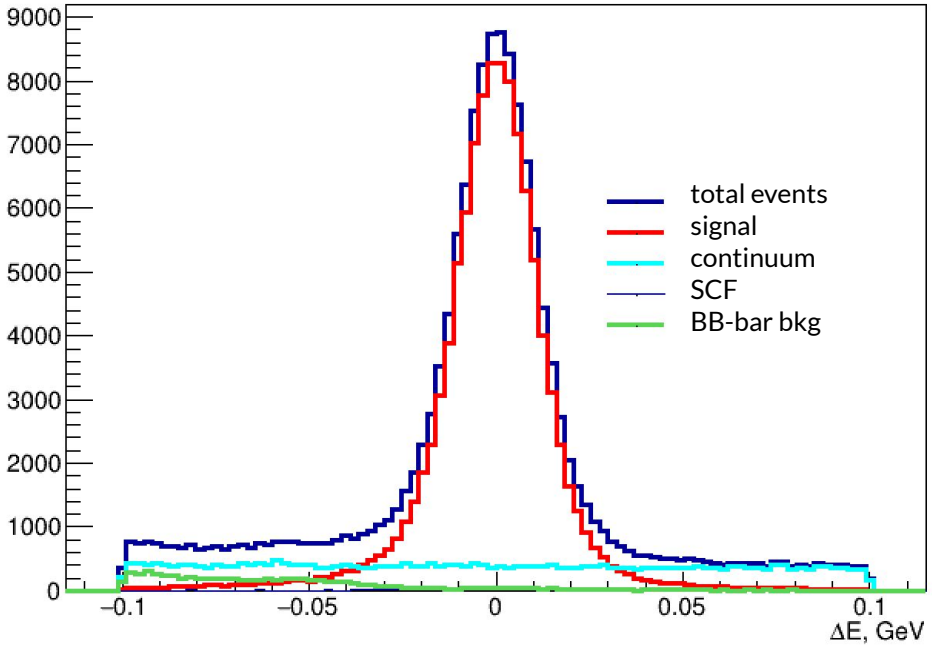

A RooPlot of "nscf Pull"
pullMean = 0.042 ± 0.031
pullSigma = 0.977 ± 0.022
nscf Pull


A RooPlot of "nbbbar Pull"
pullMean = -0.0180 ± 0.030
pullSigma = 0.963 ± 0.022
nbbbar Pull

Control channel study

Control channel $B^+ \to D^0\pi^+$ $MC15_{ri}$

Composition	Nevents	
Signal	106178	0.72
Continuum	33364	0.23
SCF	1034	0.01
BB-bar bkg	6953	0.05

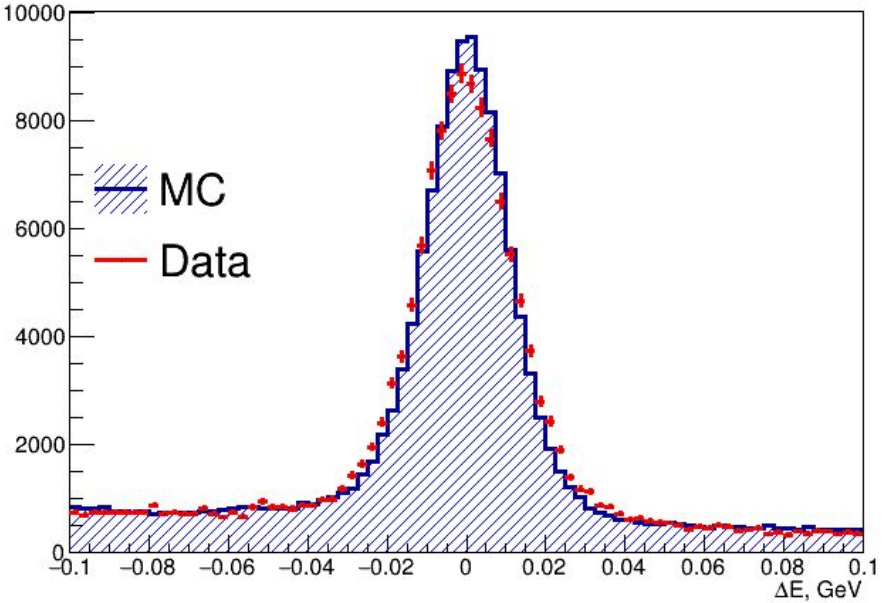


Cuts applied:

- Mbc > 5.27
- abs(ΔE) < 0.1
- binary pion PID > 0.2

Control channel $B^+ \to D^0\pi^+$ $MC15_{ri}$ vs $Data_{Proc13}$

$BF(B^+ \to D^0\pi^+) = (4.81 \pm 0.15) \times 10^{-3}$

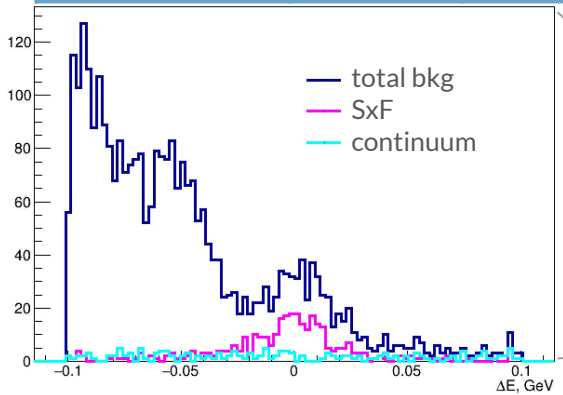


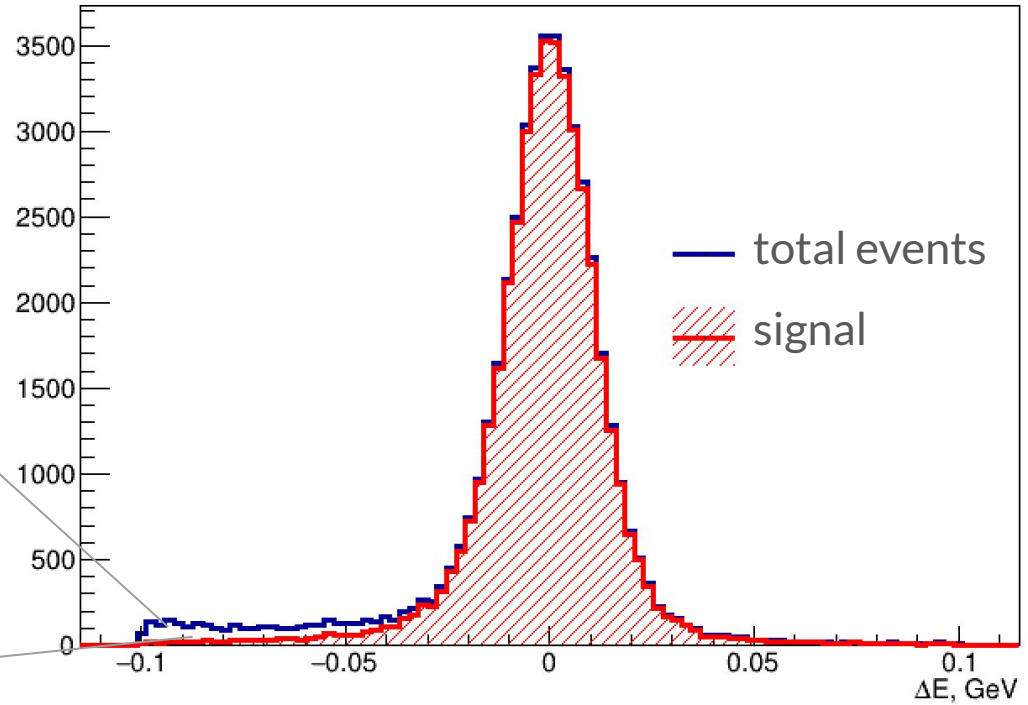
Cuts applied:

- Mbc > 5.27
- abs(ΔE) < 0.1
- binary pion PID > 0.2
- binary kaon PID < 0.8

Control channel $B^+ \to D^0\pi^+$ $MC15_{ri}$ with CSMVA cut applied

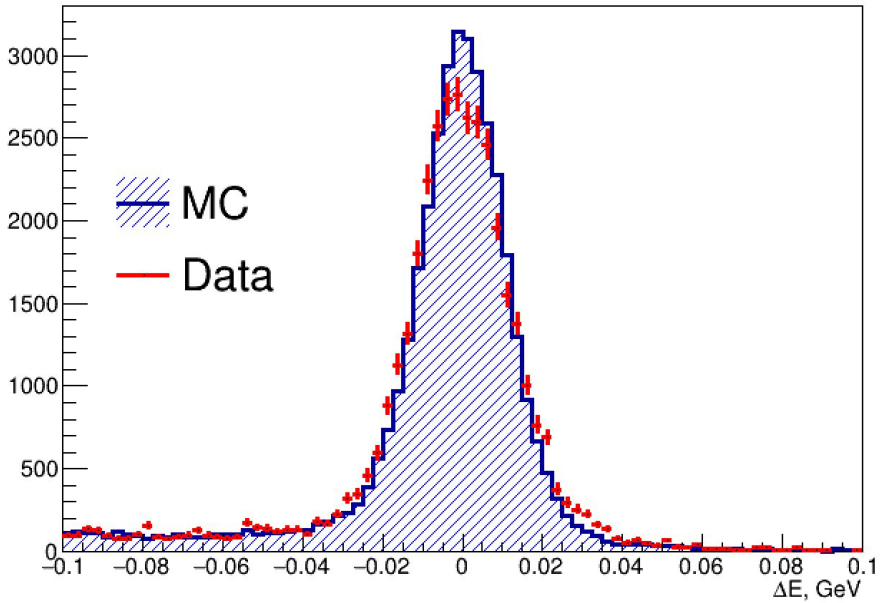
Composition	Nevents	
Signal	35123	0.936
Continuum	79	0.002
SCF	124	0.003
BB-bar bkg	2190	0.058





Control channel $B^+ \to D^0\pi^+$ $MC15_{ri}$ vs $Data_{Proc13}$

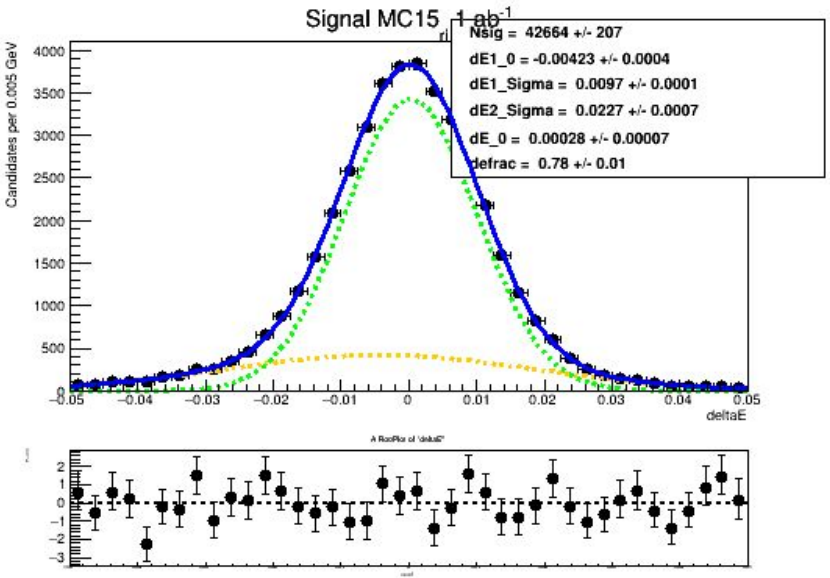
$BF(B^+ \to D^0\pi^+) = (4.81 \pm 0.15) \times 10^{-3}$

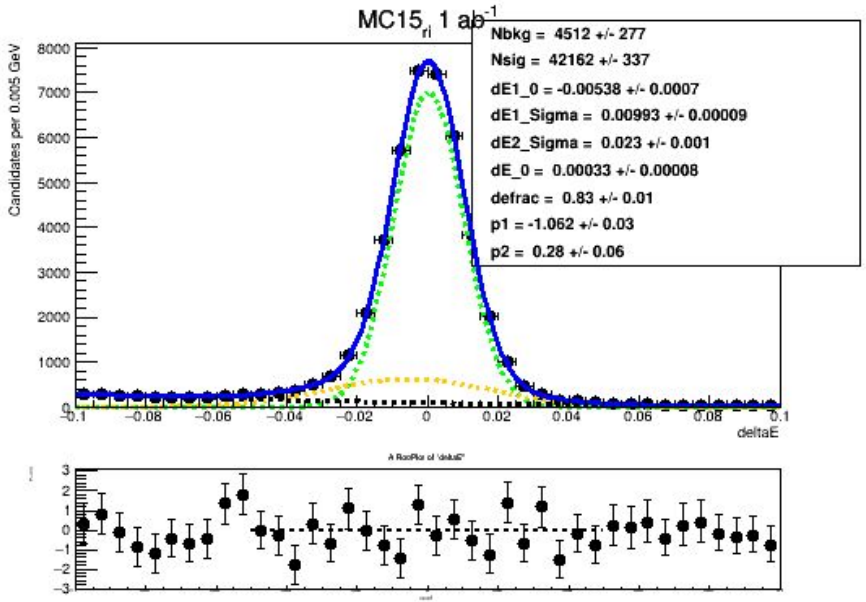


Cuts applied:

- Mbc > 5.27
- abs(ΔE) < 0.1
- CSMVA > 0.98
- 1.85 < m(Kπ) < 1.88 (~3 σ) GeV
- binary kaon PID from D^0 > 0.2
- binary pion PID from D^0 < 0.8
- binary pion PID > 0.2
- binary kaon PID < 0.8

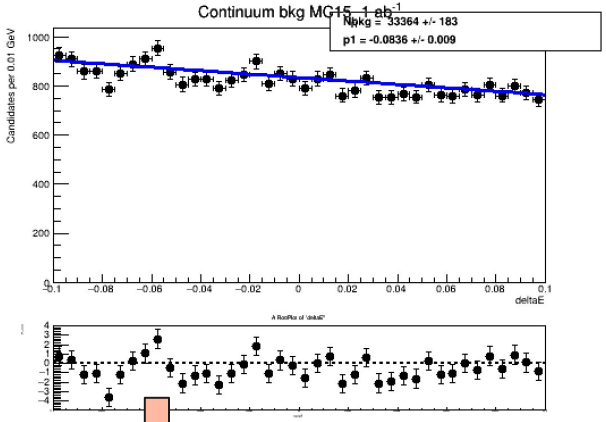
Fitting MC $B^+ \to D^0 \pi^+$

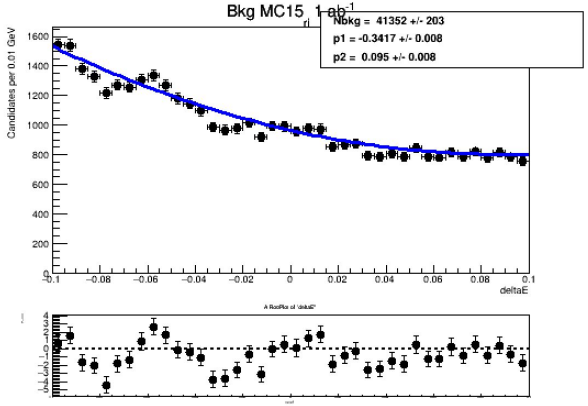


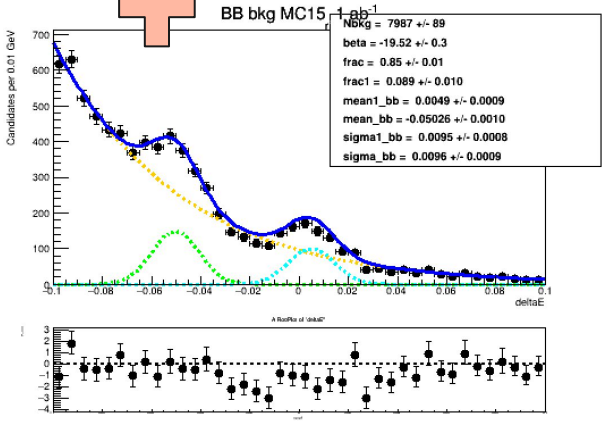


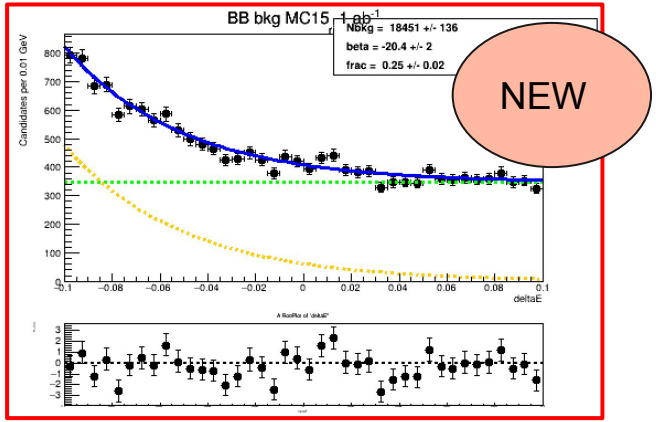
Composition	Nevents	SignalMC	Signal Yield	σ
Signal	43629	42664 ± 207	42162 ± 337	4.4

Fitting background MC $B^+ \to D^0\pi^+$ (without CSMVA cut)

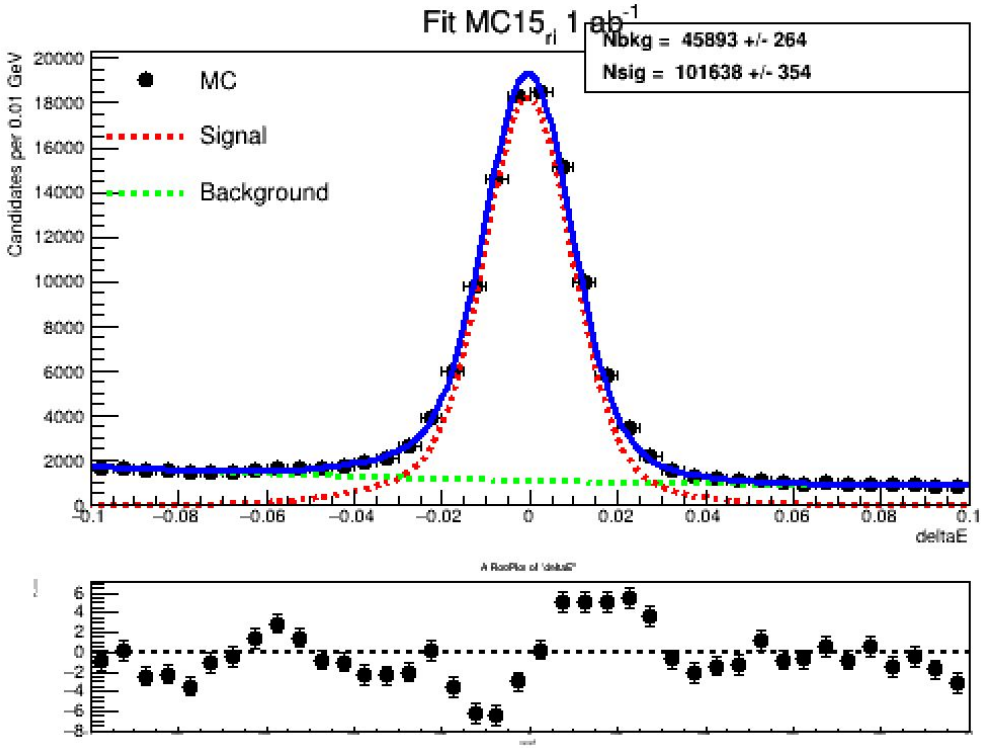






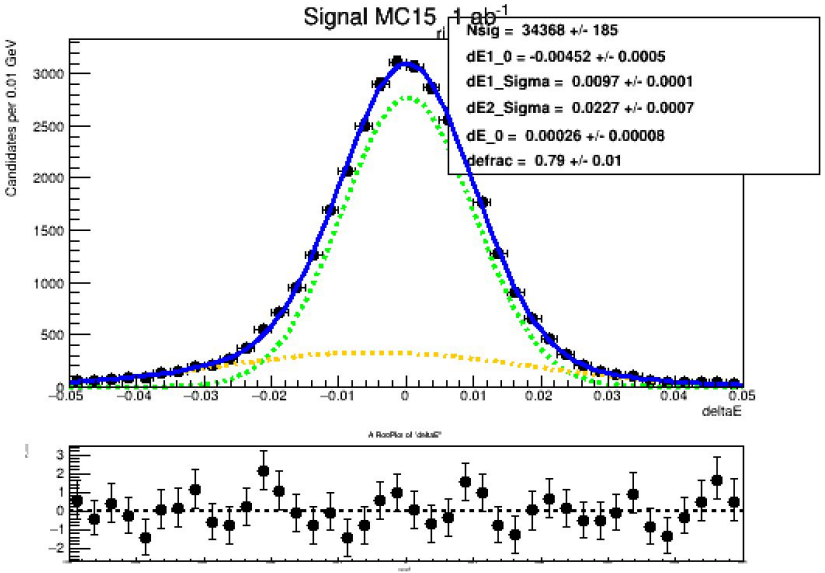


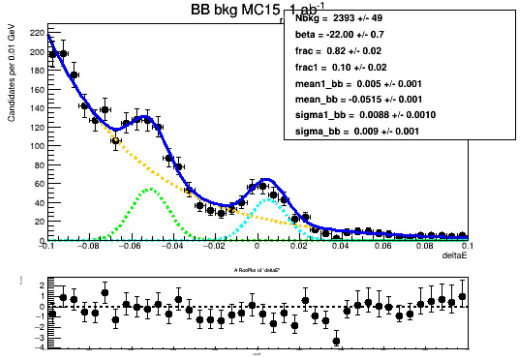
Fit MC $B^+ \to D^0 \pi^+$ with fixed parameters and without CSMVA cut

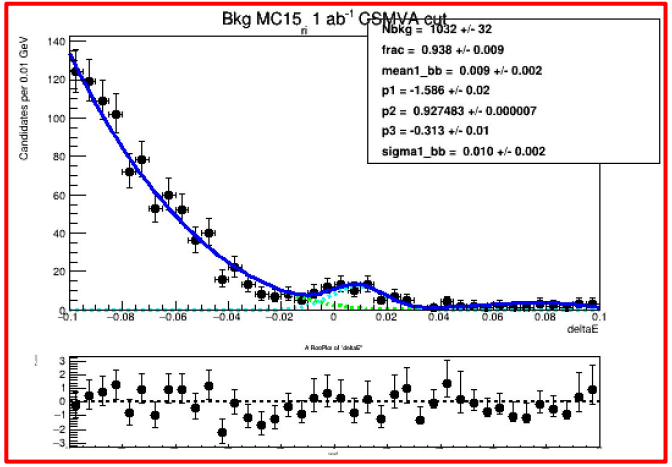


Composition	Nevents	σ
Signal	106178	> 10
Background	33364	> 10

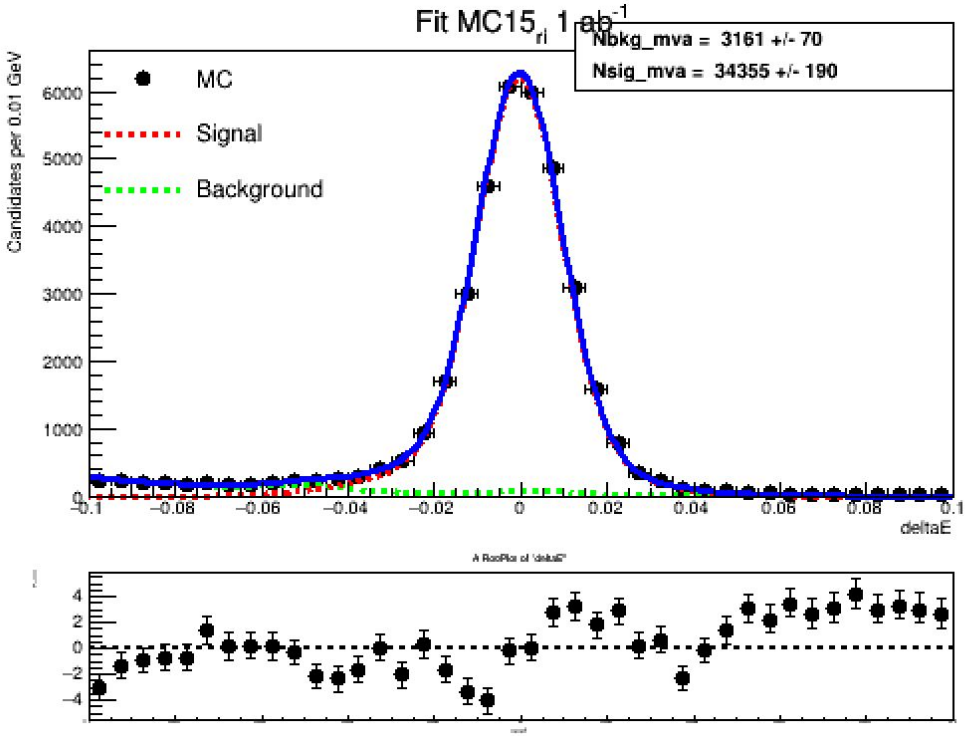
Fitting parameters MC $B^+ \to D^0\pi^+$ with CSMVA> 0.98 cut







Fit MC $B^+ \to D^0 \pi^+$ with fixed parameters and CSMVA cut



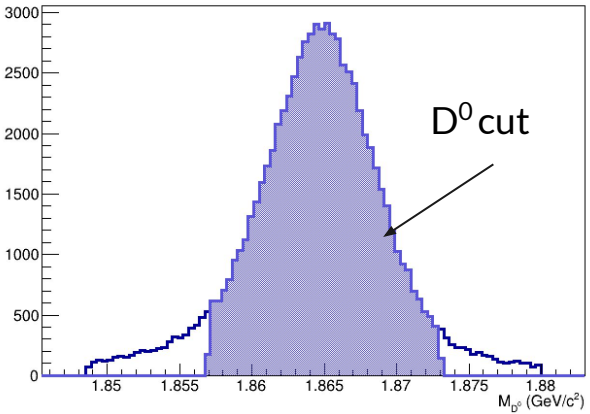
Composition	Nevents	σ
Signal	35123	4.0
Background	2393	11

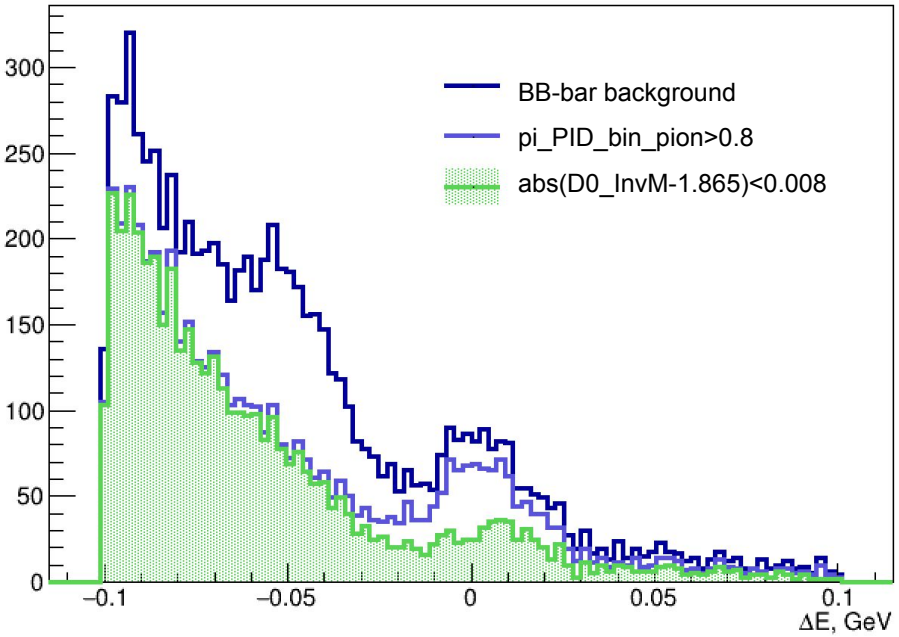
NEW cuts

BB-background MC $B^+ \rightarrow D^0\pi^+$ NEW cuts

Cuts applied:

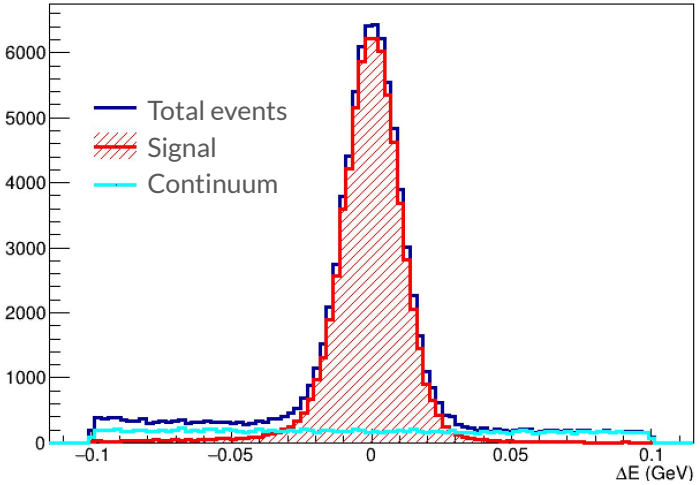
- Mbc > 5.27
- $|\Delta E| < 0.1$
- $|M_{D0} - 1.865| < 0.008 (\sim 2\sigma)$ GeV
- binary pion PID from D^0 < 0.1
- binary pion PID > 0.8

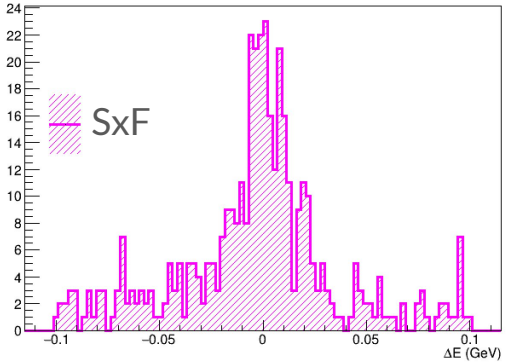


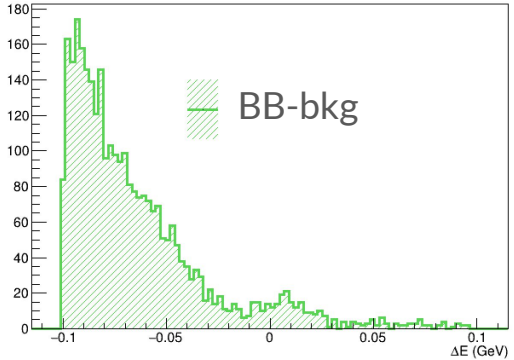


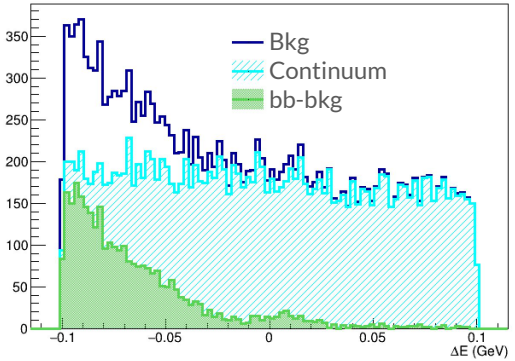
MC sample composition after new cuts

Composition	Nevents	
Signal	70618	0.789
Continuum	15388	0.172
SCF	409	0.005
BB-bar bkg	3063	0.034



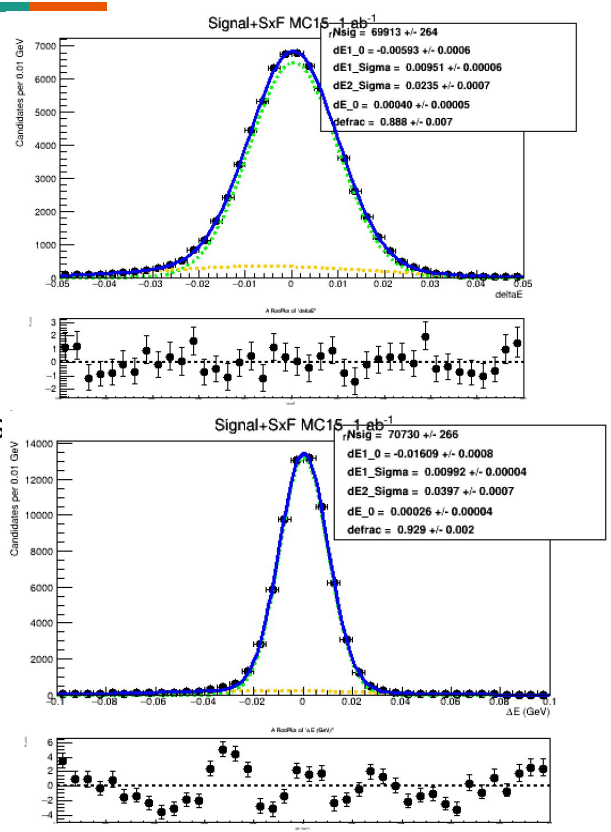


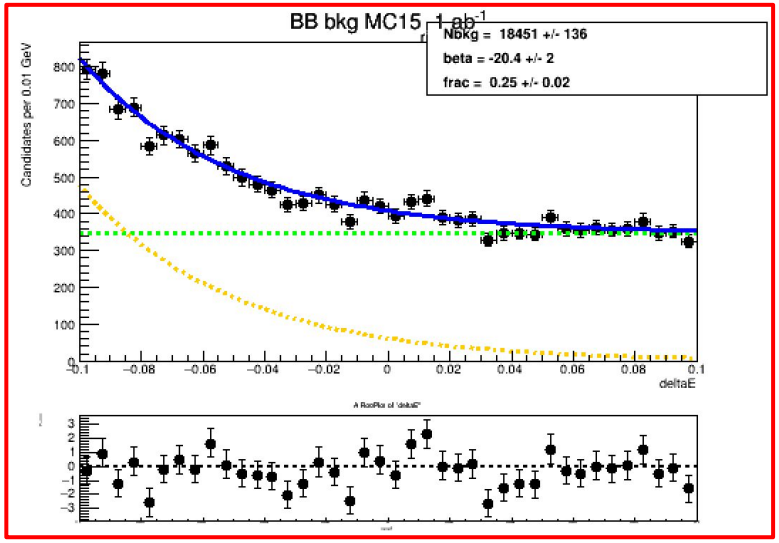




Fit MC $B^+ \to D^0 \pi^+$ Signal + SxF without CS cut

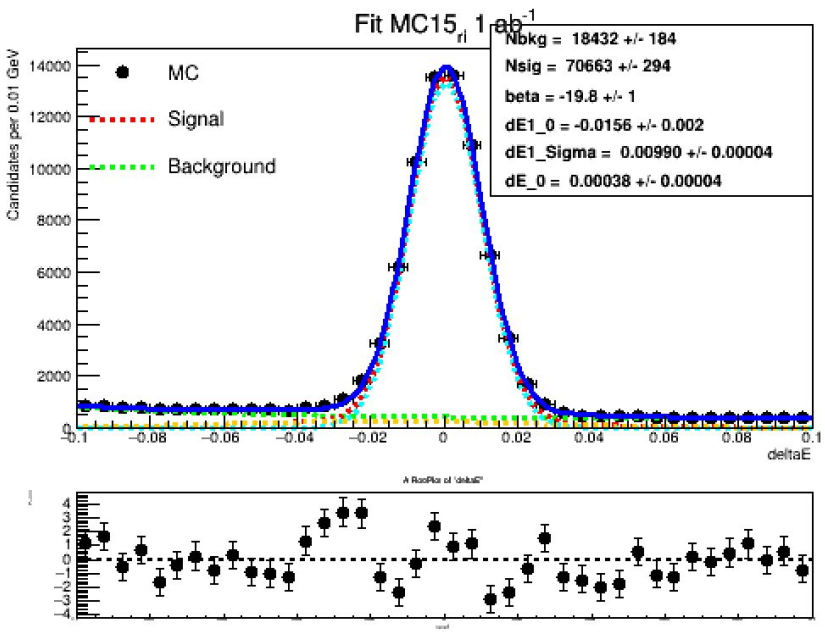
2x RooGauss

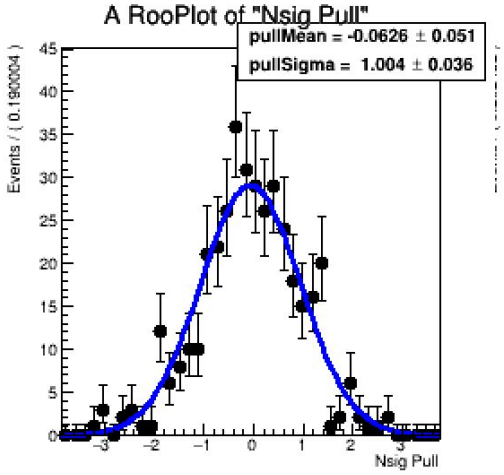


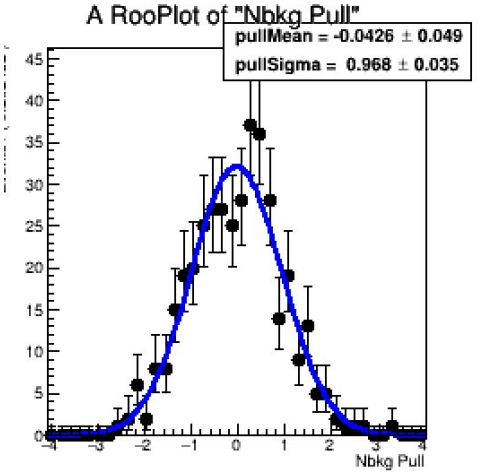


RooExponential x Cheb(0)

TOY for fit without CS cut

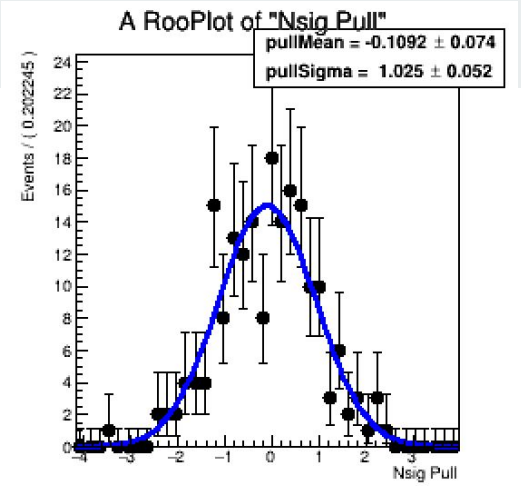


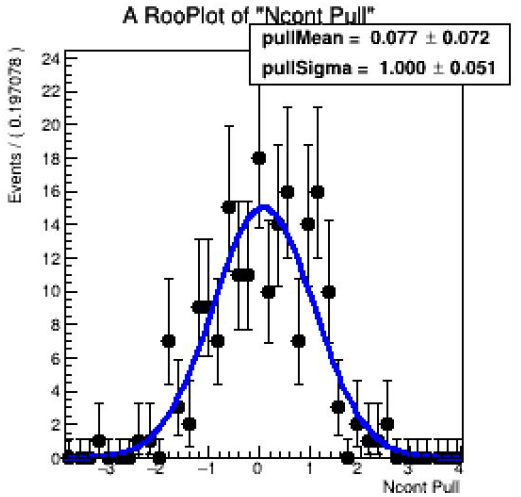


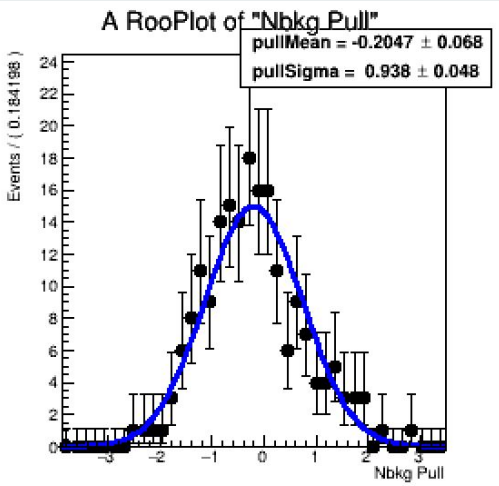


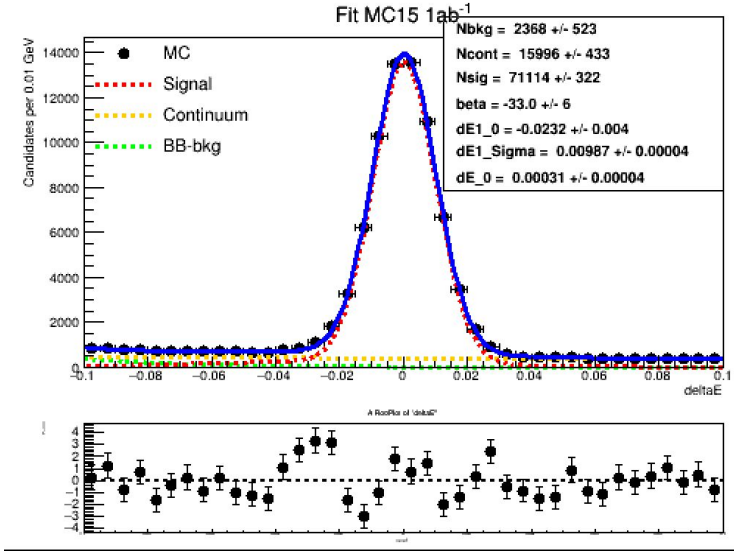
Composition	Nevents	σ
Signal + SxF	71027	1.9
Background	18451	0.1

Free: exp(beta), mean1, mean2, sigma1





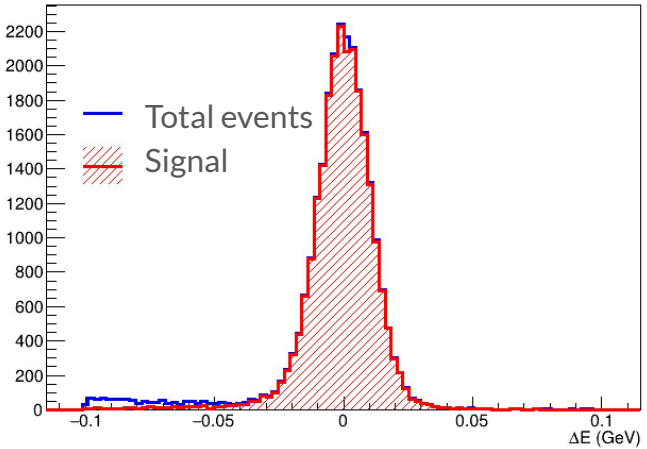


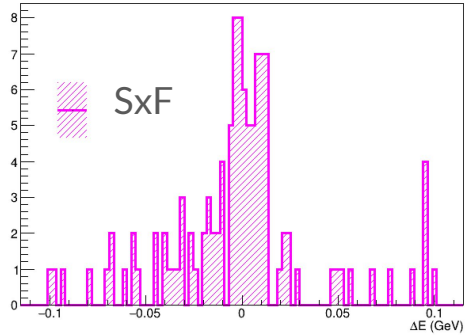


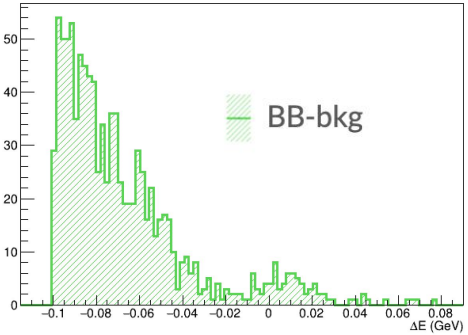
Composition	Nevents	Yields	σ
Signal + SxF	71027	71114 ± 322	0.3
Continuum	15388	15996 ± 433	1.4
BB-bkg	3063	2368 ± 523	1.3

MC sample composition after new cuts + CS cut

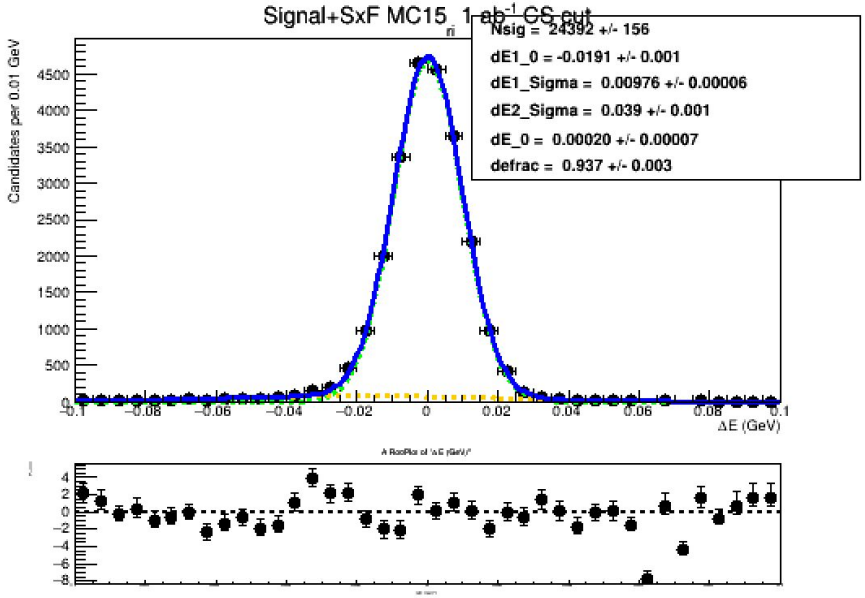
Composition	Nevents	
Signal	24279	0.955
Continuum	45	0.002
SCF	113	0.004
BB-bar bkg	987	0.039

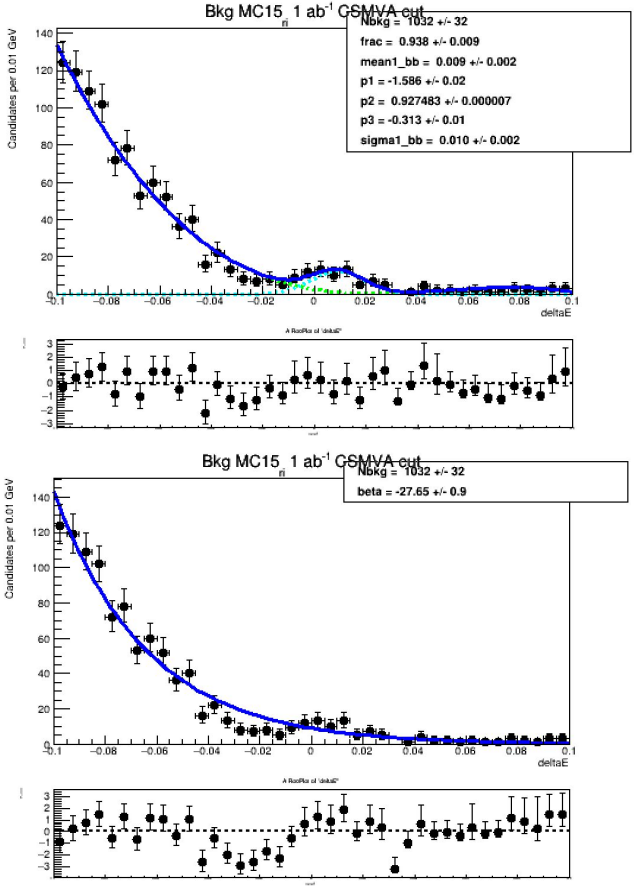






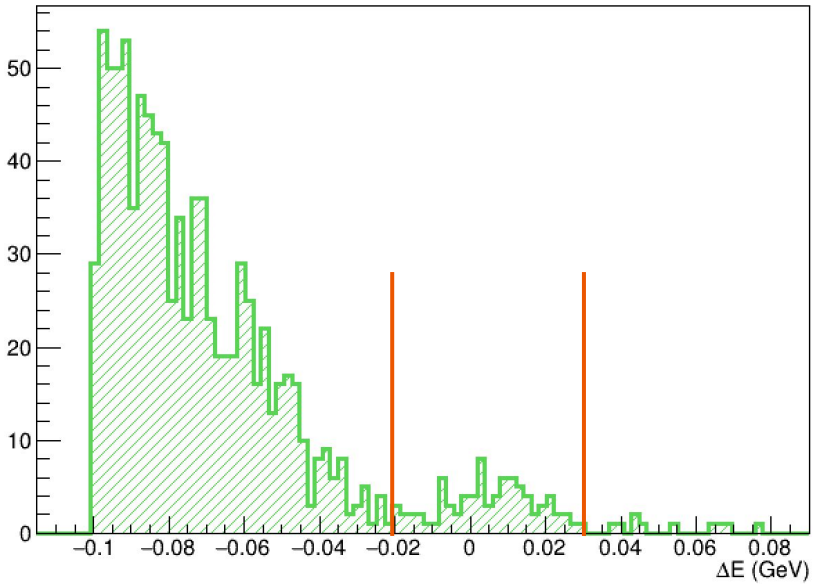
Fit parameters for MC $B^+ \to D^0\pi^+$ Signal + SxF with CS cut





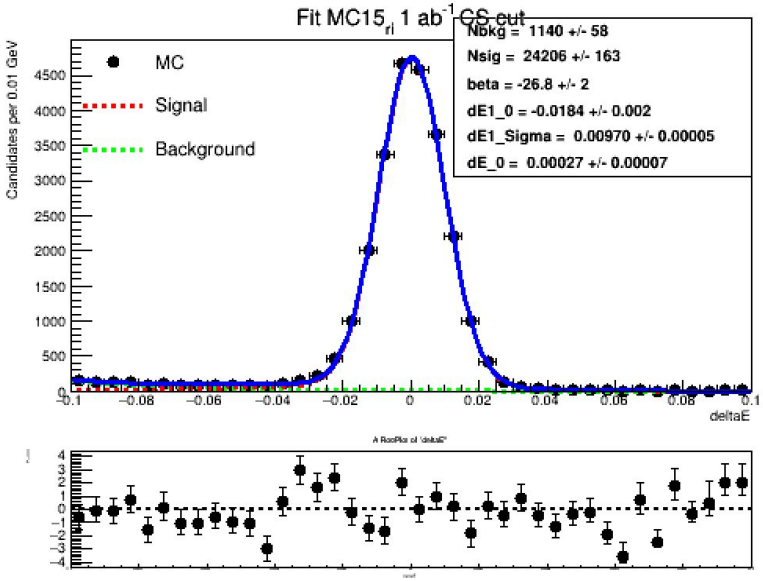
BB-bar background “bump” composition

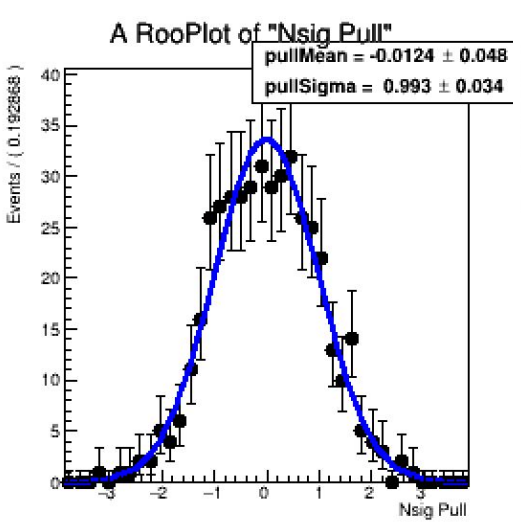
-0.02 < ΔE < 0.03 GeV

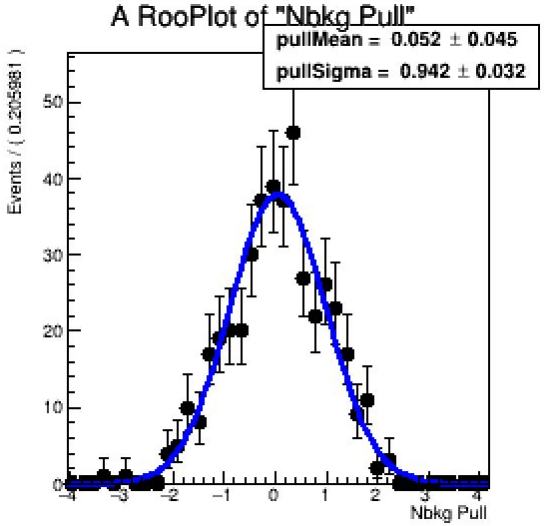


$$J/\Psi K \sim 20\%$$
$$D^{\cdot 0}\pi/l \sim 24\%$$
$$D^0 K/\pi/l \sim 16\%$$

Fit MC $B^+ \to D^0\pi^+$ Signal + SxF with CS cut



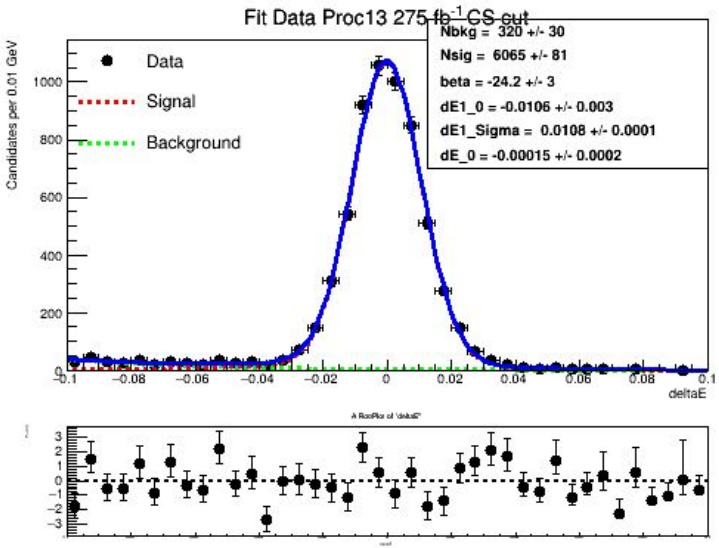


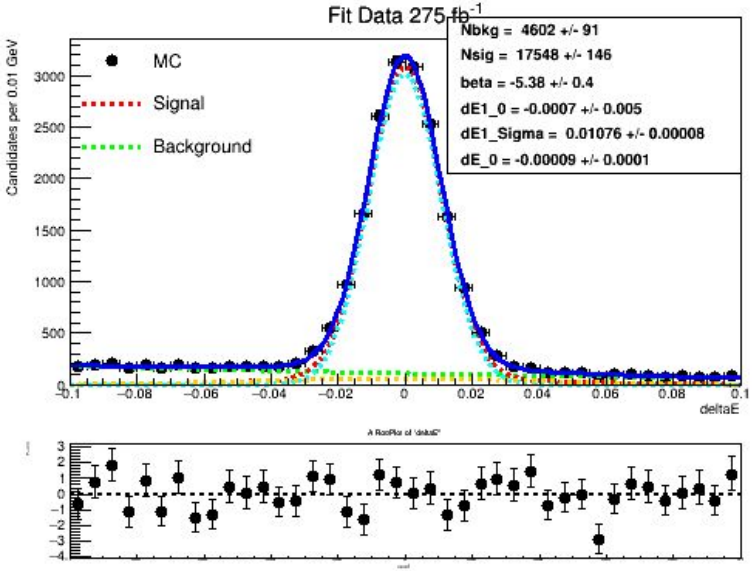


Free: exp(beta), mean1, mean2, sigma1

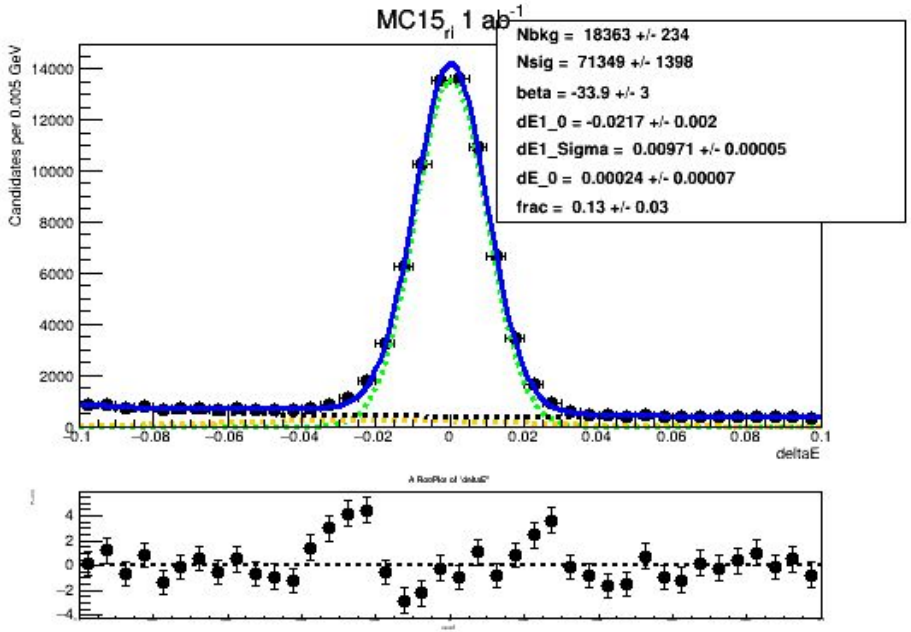
Composition	Nevents	σ
Signal + SxF	24392	1.1
Background	1032	0.1

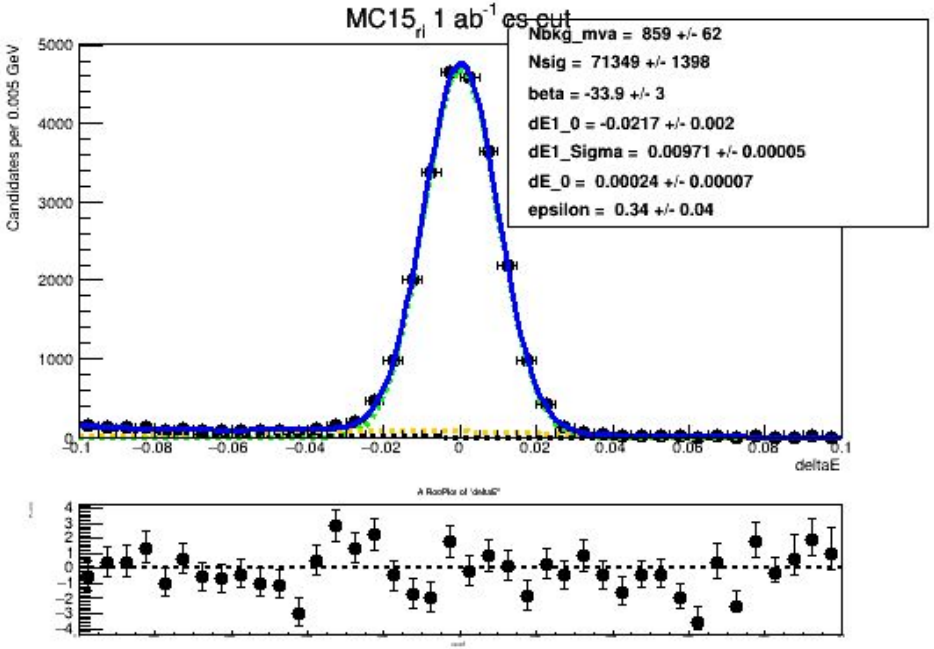
Fit Data $B^+ \to D^0 \pi^+$ Signal + SxF with CS cut



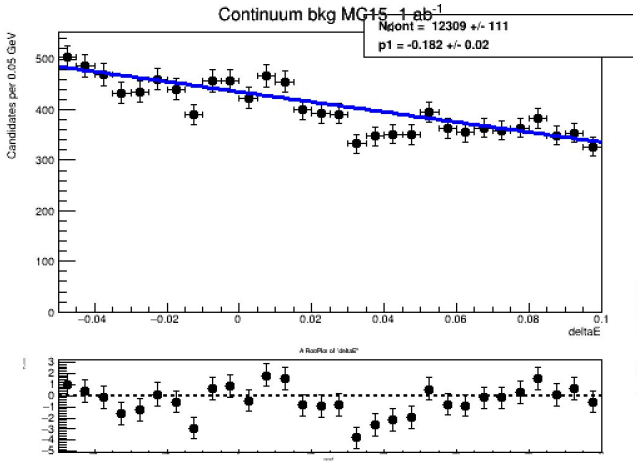


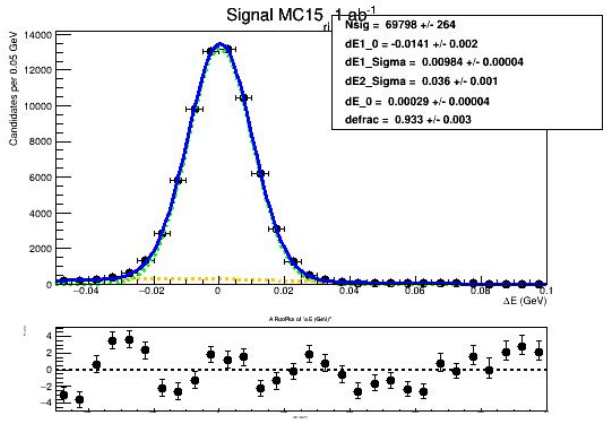
Simultaneous fit MC15



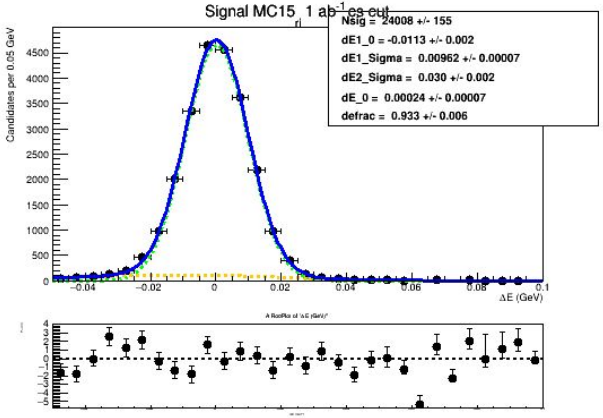


deltaE > -0.05





Composition	Nevents	
Signal	69796	0.850
Continuum	11234	0.137
SCF	360	0.004
BB-bar bkg	715	0.009

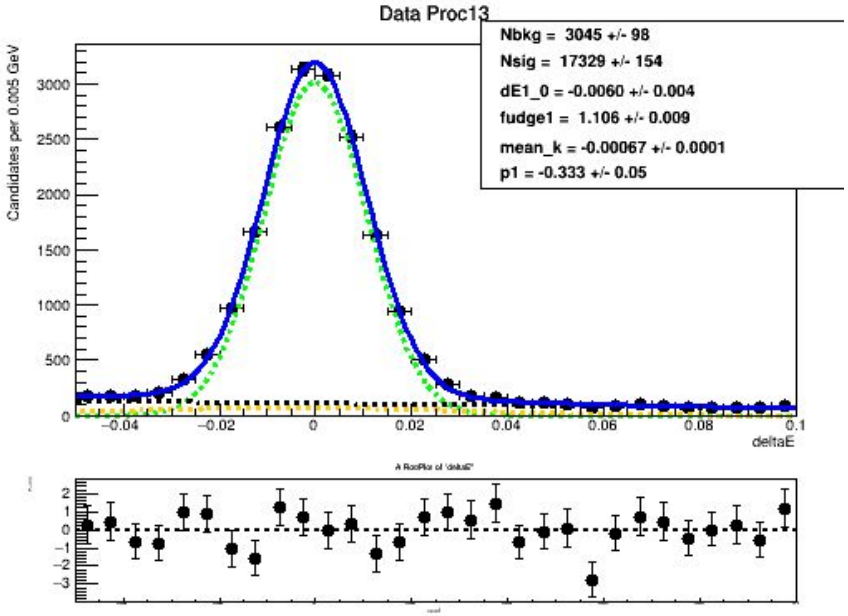


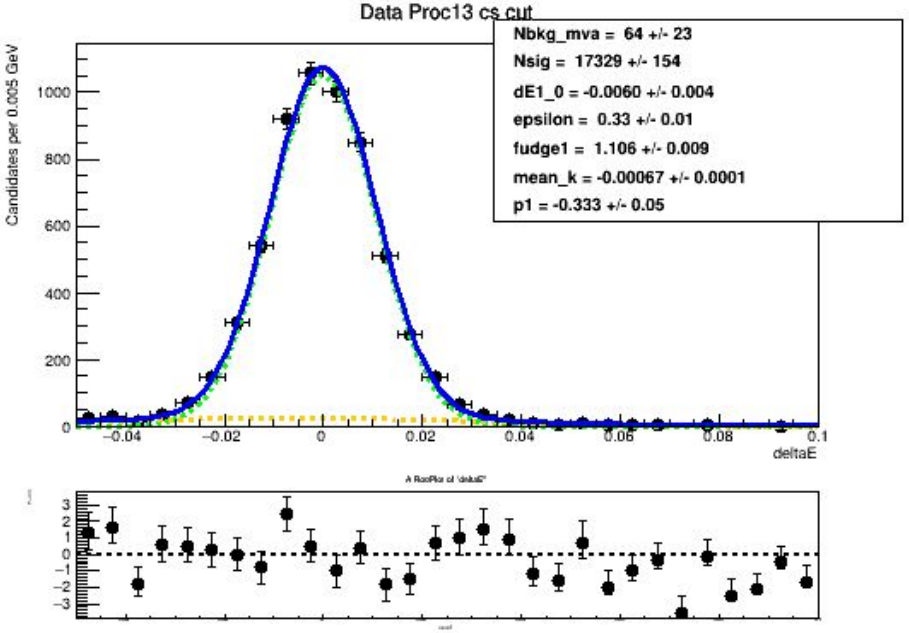
cs cut applied

Composition	Nevents	
Signal	24008	0.989
Continuum	33	0.001
SCF	102	0.004
BB-bar bkg	190	0.008

Result for Data

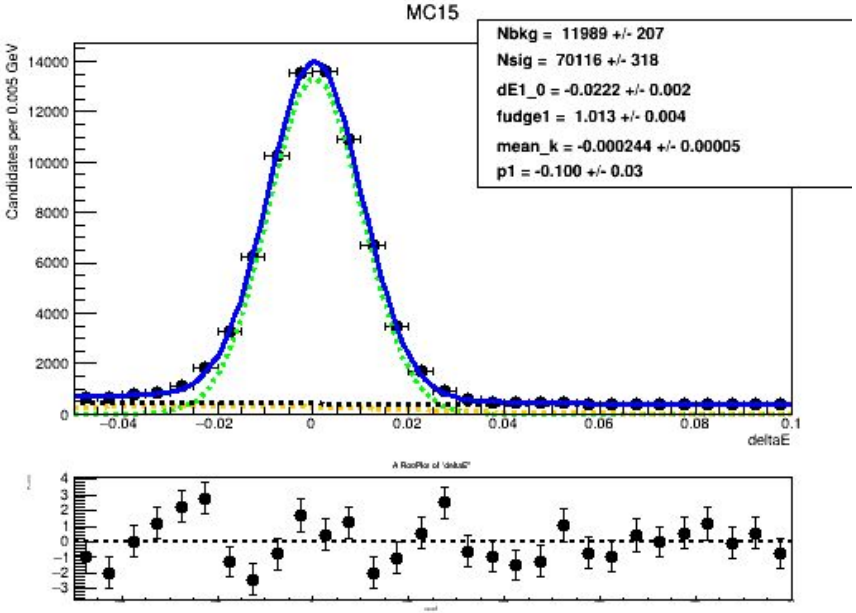
$$\epsilon_{Data} = 0.33 \pm 0.01$$

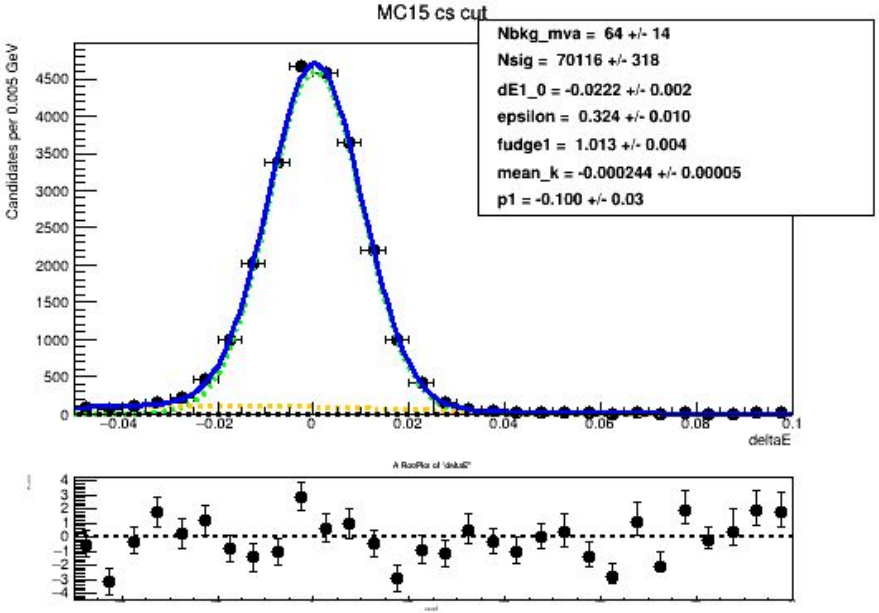




Result for MC

$$\epsilon = 0.324 \pm 0.010$$





Efficiency before CSMVA > 0.98 cut

$$BF = \frac{N_{signal}}{L \cdot \epsilon \cdot \epsilon_{K\pi}} \implies \epsilon = \frac{N_{signal}}{BF_{PDG} \cdot L \cdot \epsilon_{K\pi}} = 34.9\%$$

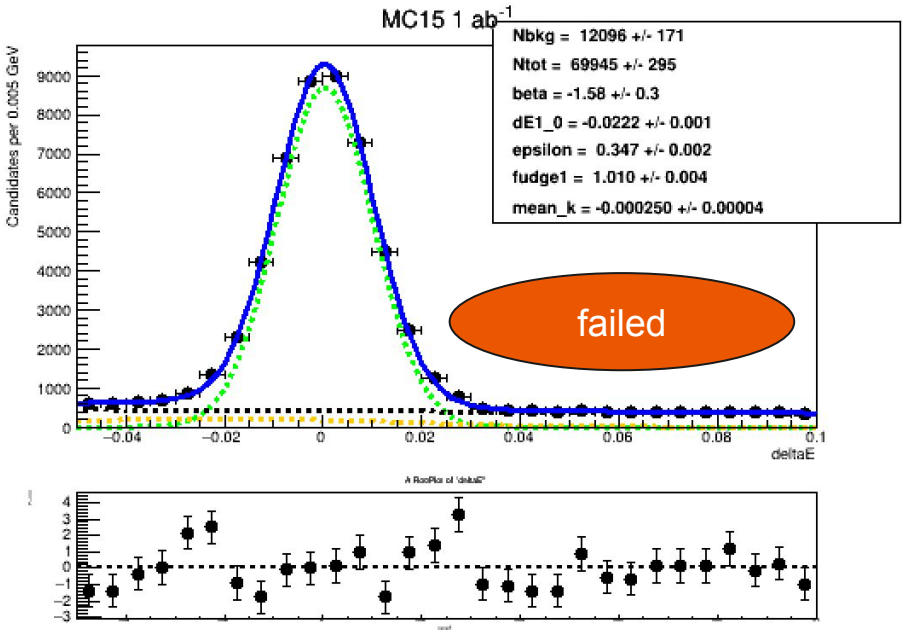
Efficiency of CSMVA > 0.98 cut

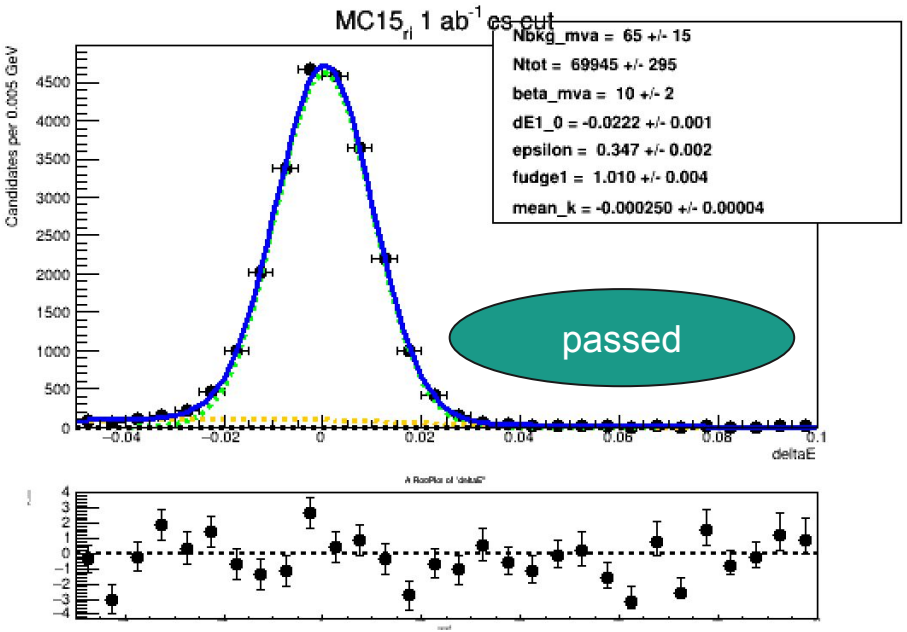
$$\epsilon_{CSMVA} = \frac{N_{sigCSMVA}}{N_{sig}} = 0.343 \pm 0.003$$

Failed : Passed approach

efficiency is calculated from the Signal Yields for events that failed and passed CS cut

Simultaneous Fit result for MC15 1 ab^{-1}

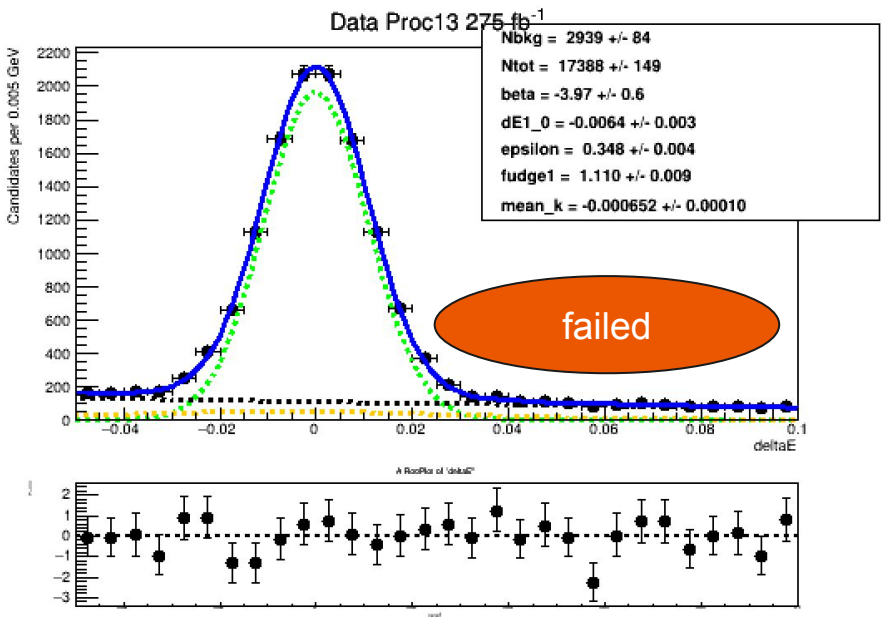


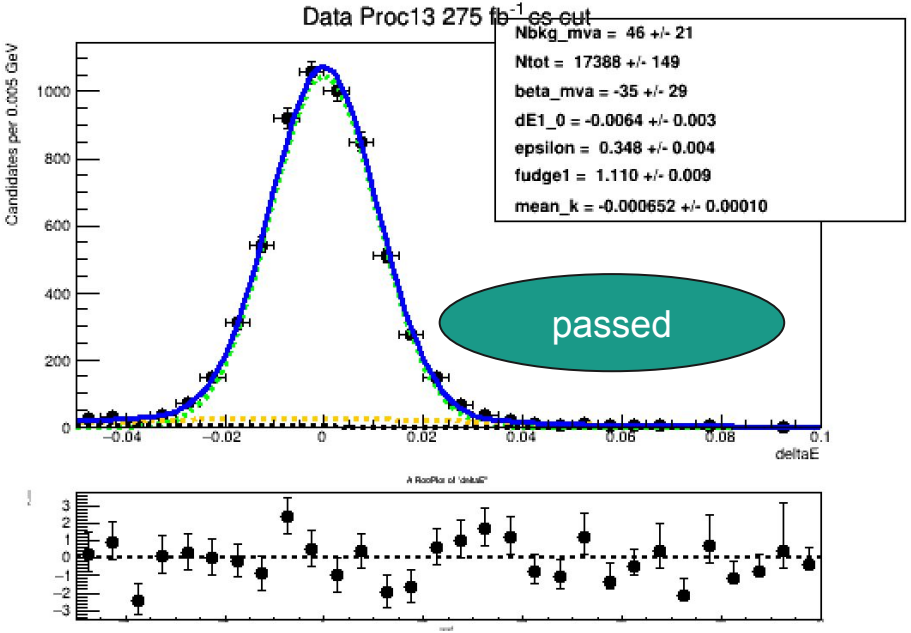


$$\epsilon_{MC} = 0.347 \pm 0.002$$

fitting script is available here: /eos/infnts/belle2/users/olgawer/fitting/D0pi_simultaneous.cc

Simultaneous Fit result for Data Proc13 275 fb^{-1}





$$\epsilon_{Data} = 0.348 \pm 0.004$$

Continuum suppression efficiency

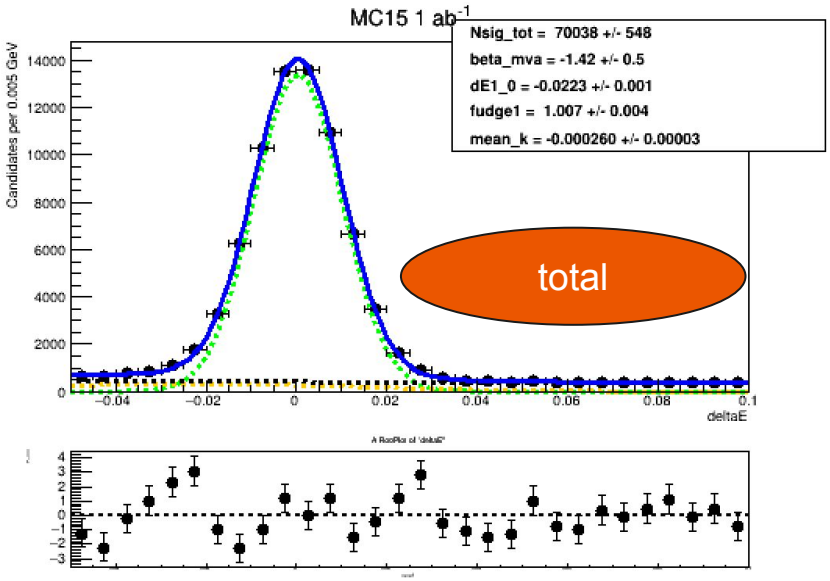
$$\frac{\epsilon_{Data}}{\epsilon_{MC}} = \frac{0.348 \pm 0.004}{0.347 \pm 0.002} = 1.003 \pm 0.013$$

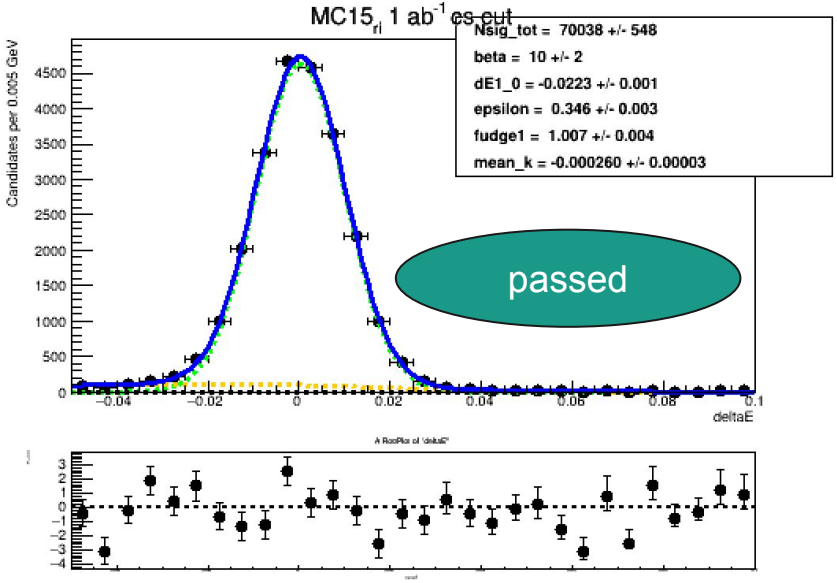
is counted as systematic uncertainty of CSMVA cut

Total : Passed approach

efficiency is calculated from the Total Yields (Nsig + Nbkg) for events that failed and passed CS cut

Simultaneous Fit result for MC15 1 ab^{-1}

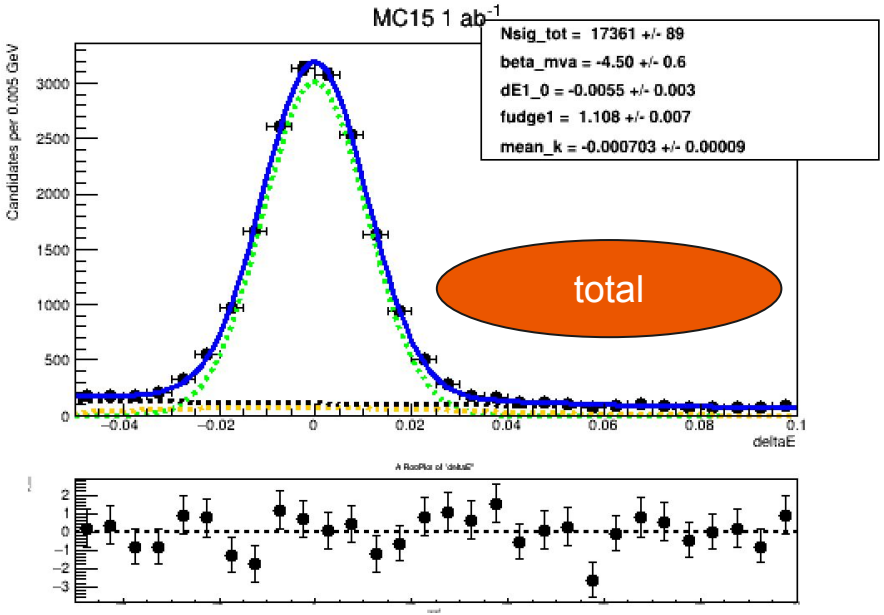


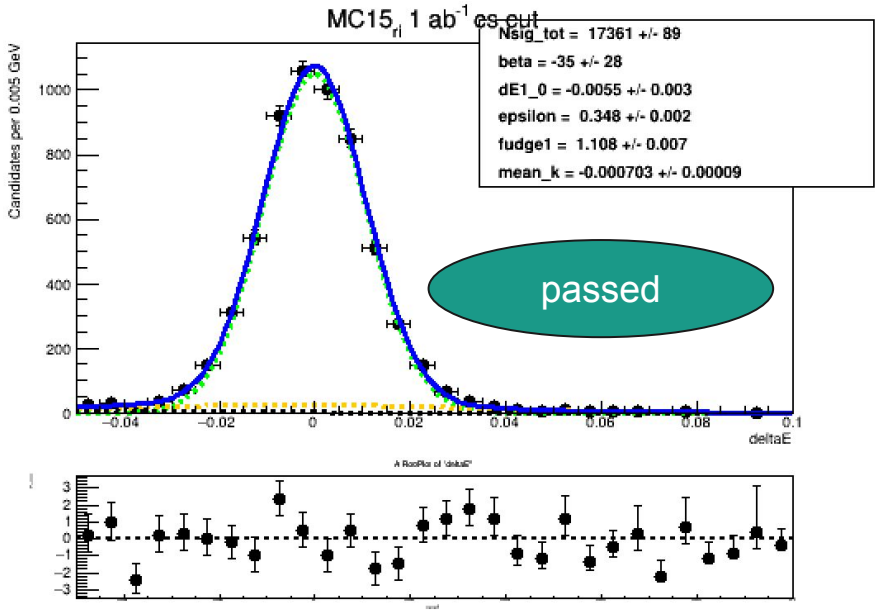


$$\epsilon_{MC} = 0.346 \pm 0.003$$

fitting script is available here: /eos/infnts/belle2/users/olgawer/fitting/D0pi_simultaneous1.cc

Simultaneous Fit result for Data Proc13 275 fb^{-1}



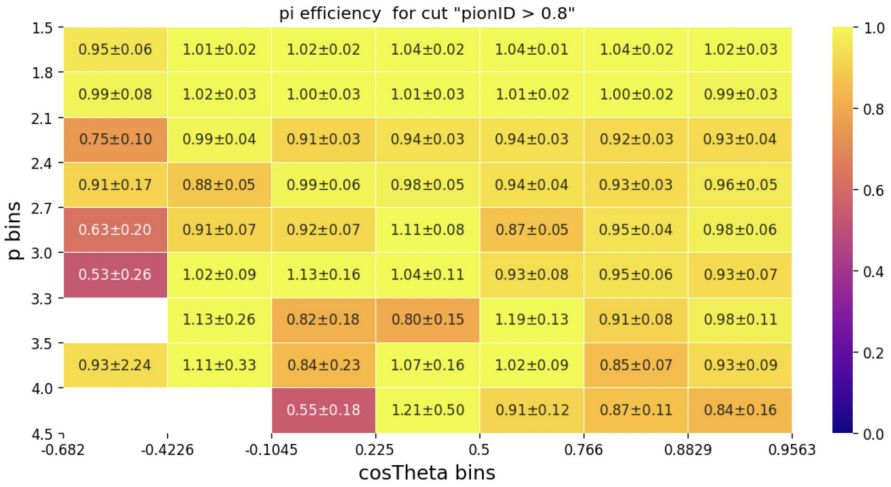


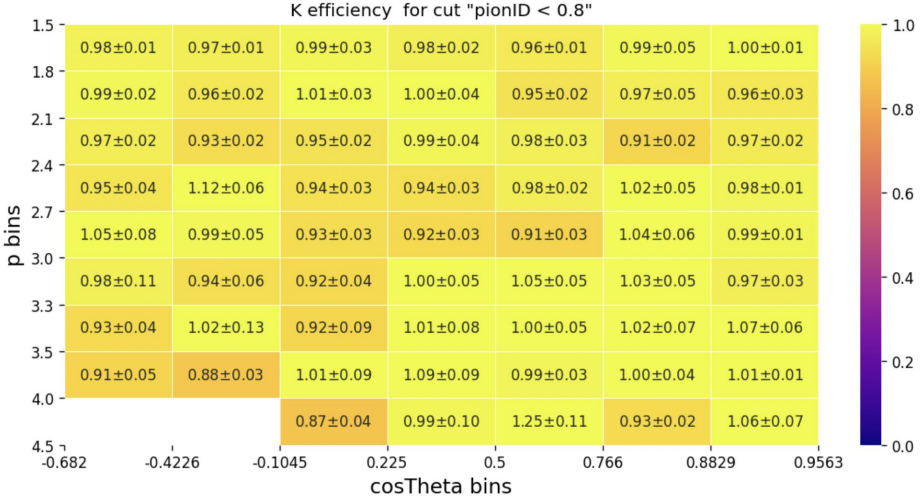
$$\epsilon_{Data} = 0.348 \pm 0.002$$

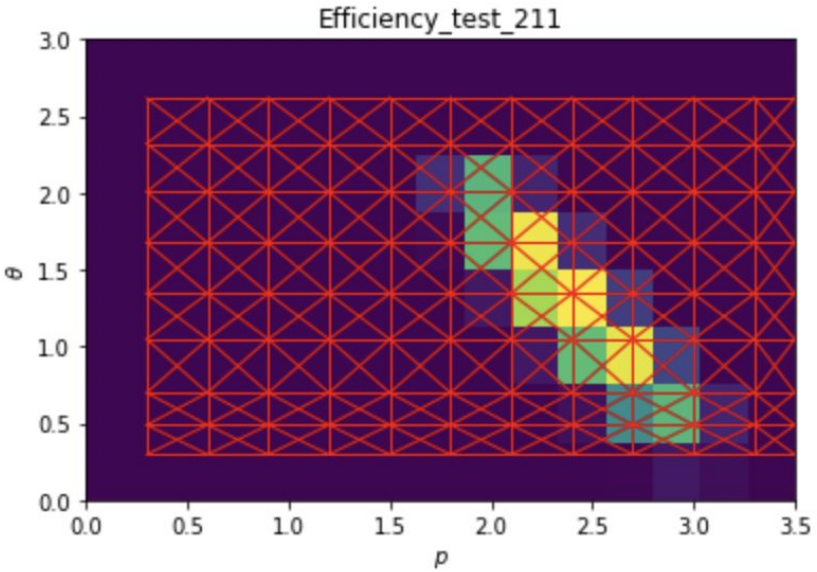
Continuum suppression efficiency

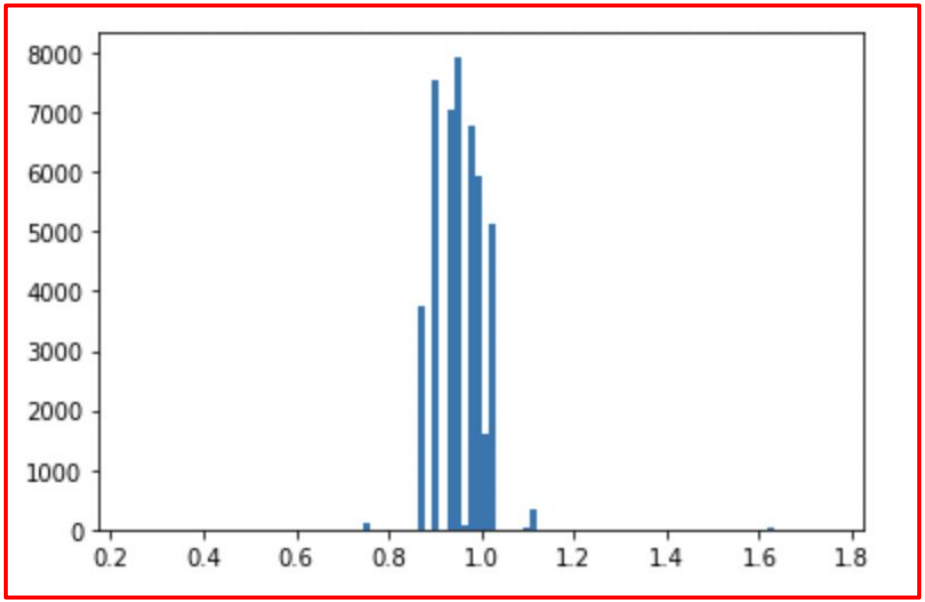
$$\frac{\epsilon_{Data}}{\epsilon_{MC}} = \frac{0.348 \pm 0.002}{0.346 \pm 0.003} = 1.006 \pm 0.010$$

PID Systematic framework

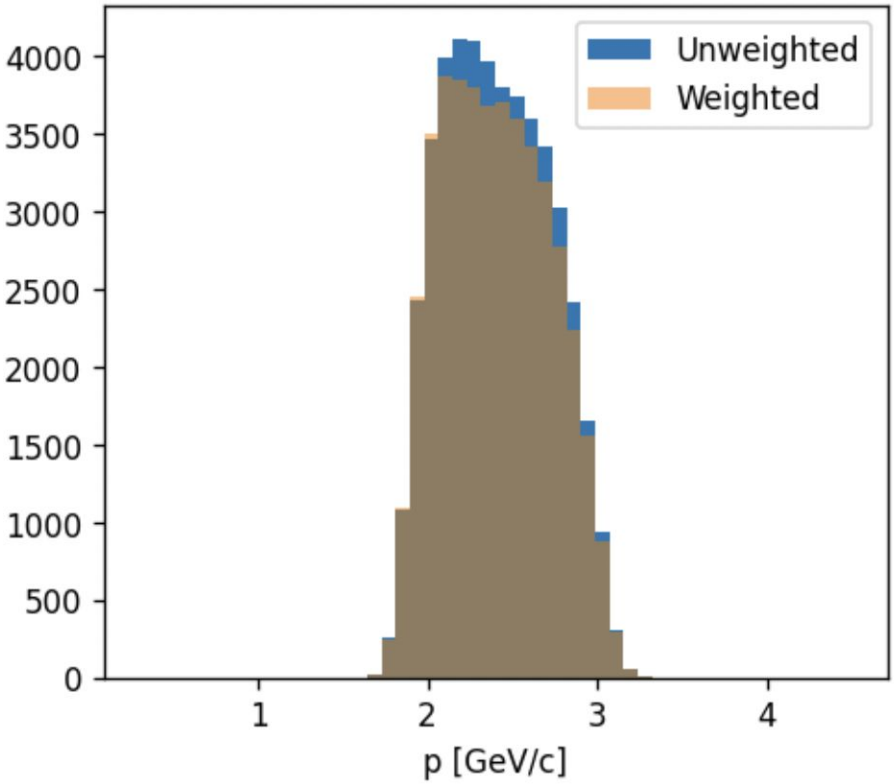


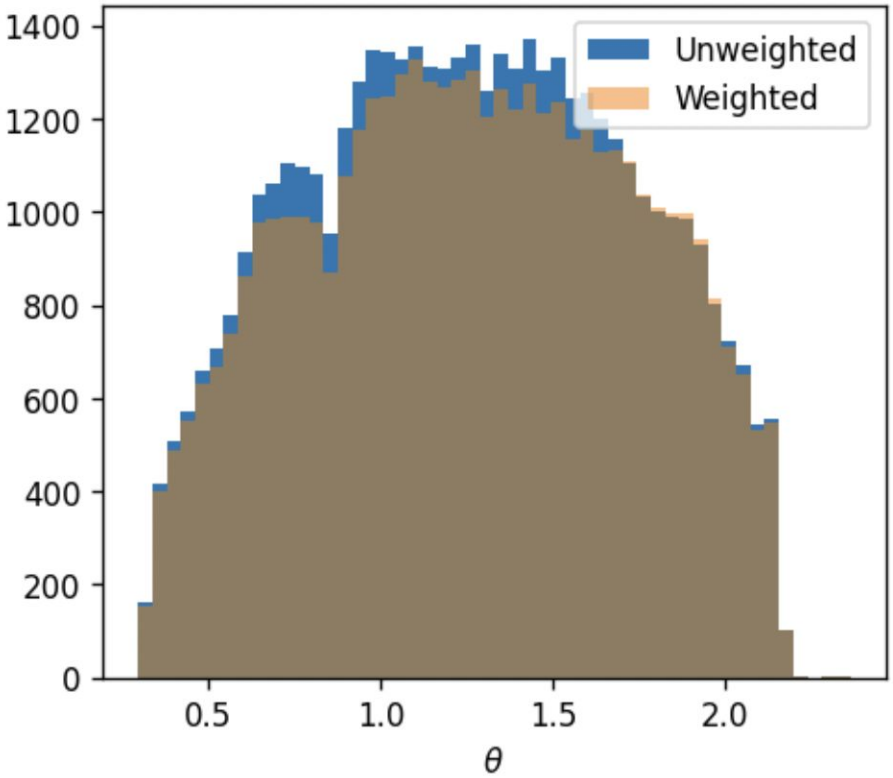



Efficiency_test_211
3.0
2.5
2.0
1.5
1.0
0.5
0.0
θ
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
p


8000
7000
6000
5000
4000
3000
2000
1000
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8

correction


Unweighted
Weighted
4000
3500
3000
2500
2000
1500
1000
500
0
1
2
3
4
p [GeV/c]

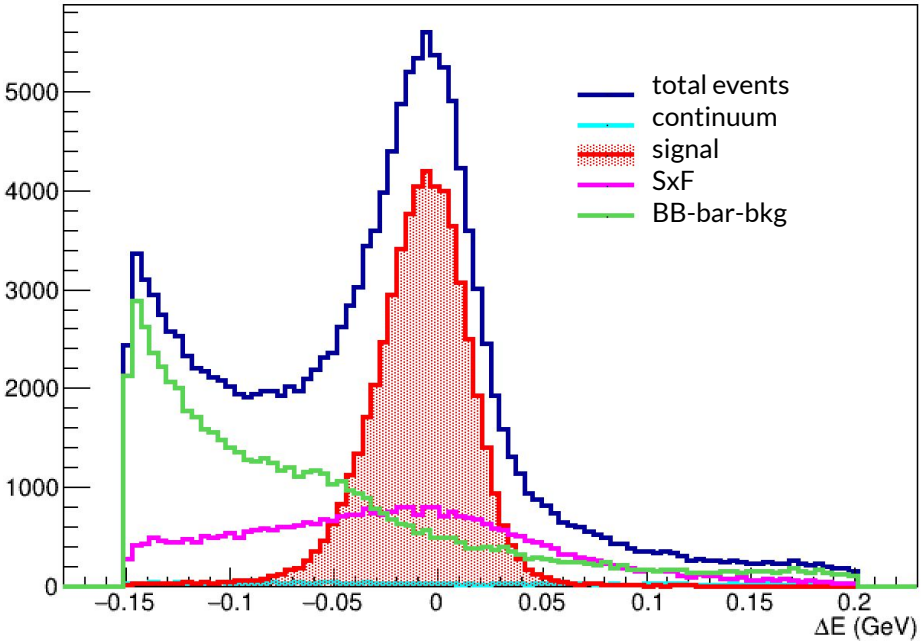

Unweighted
Weighted
1400
1200
1000
800
600
400
200
0
0.5
1.0
1.5
2.0
θ

$B^+ \rightarrow D^0(\rightarrow K\pi\pi^0)\pi$ control channel

Selection applied:

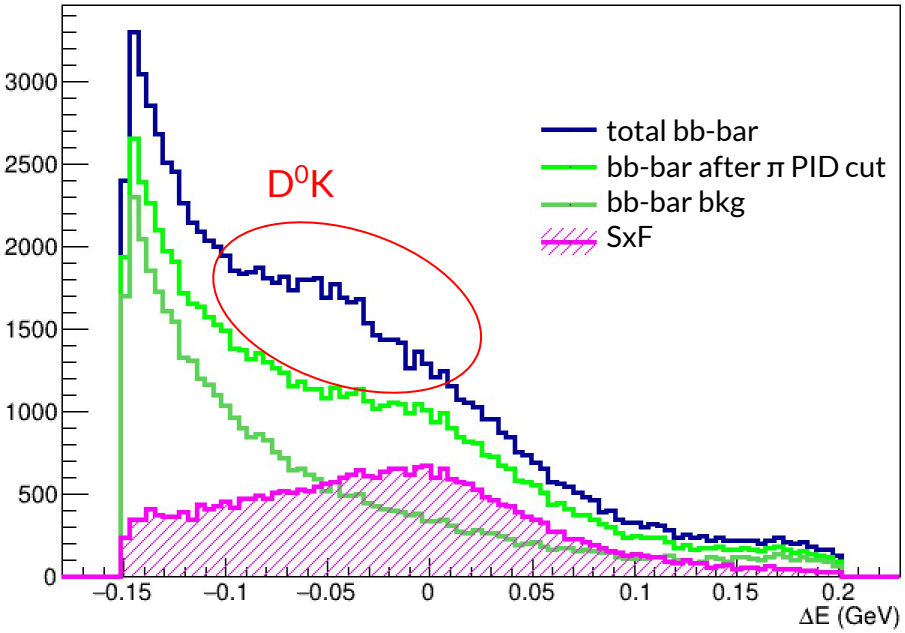
- Mbc > 5.27
- $1.84 < M_{D0} < 1.88$
- CSMVA > 0.98
- $E_{photon0} > 0.04$
- $E_{photon1} > 0.05$
- $D^0\_K_{PID} > 0.2$
- $D^0\_\pi_{PID} < 0.8$

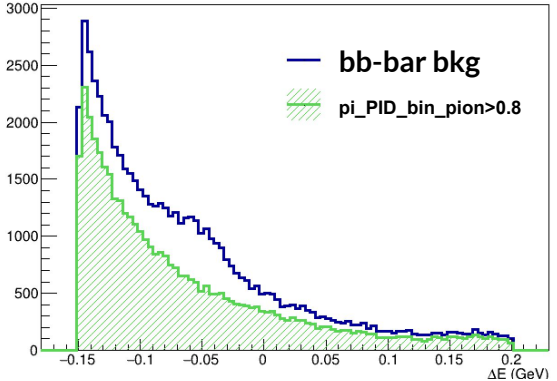
$B \to D^0(\to K\pi\pi^0)\pi$ MC15 1 ab^{-1}

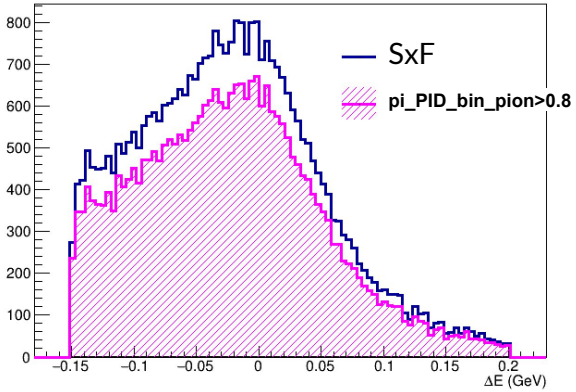


Composition	Nevents	Fraction
Signal	54424	0.36
Continuum	2252	0.015
SCF	34795	0.23
BB-bar bkg	60161	0.40
Total events	151685	1.0

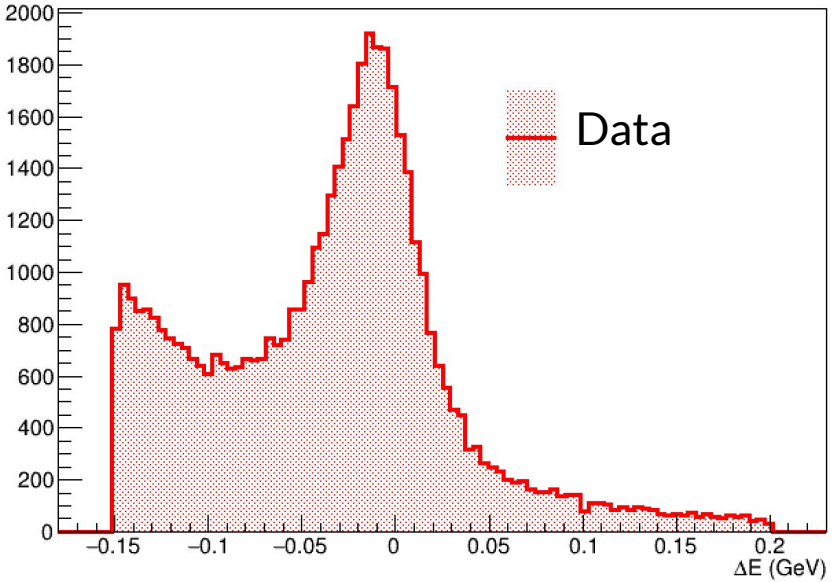
BB-bar background of B→D⁰(→Kππ⁰)π MC15 1 ab⁻¹

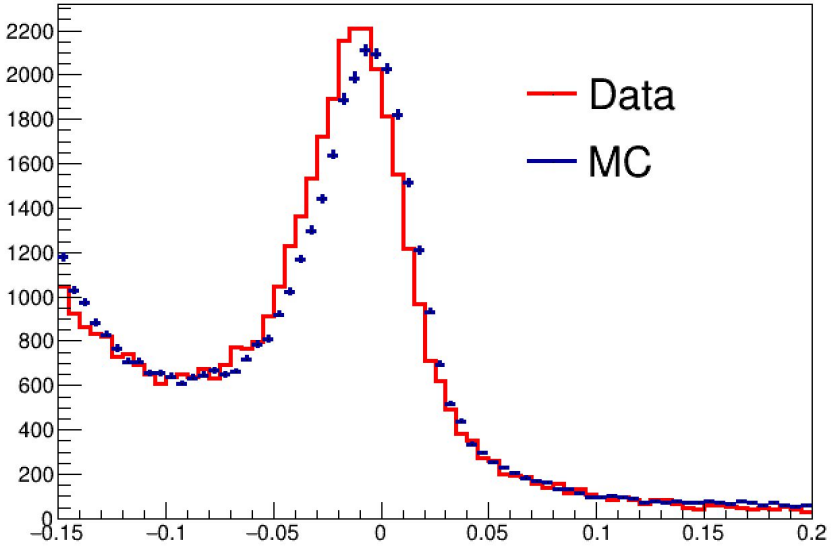




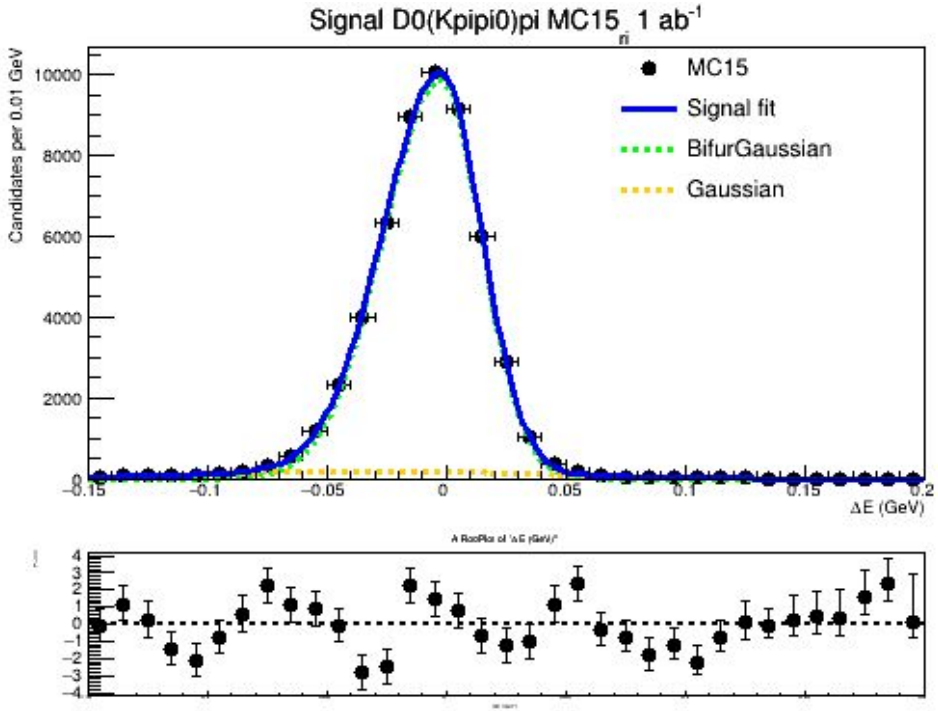


$B \to D^0(\to K\pi\pi^0)\pi$ Data proc13 360 fb^{-1}





Signal fit


Signal D0(Kpipi0)pi MC15_ri 1 ab^-1
MC15
Signal fit
BifurGaussian
Gaussian
Candidates per 0.01 GeV
ΔE (GeV)

Backup

π^0 energie for $D^0(\rightarrow K\pi\pi^0)\pi$ vs $D^0\rho$