UNIVERSITY
OF TRIESTE

INFN

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

TS analysis meeting
august 2022

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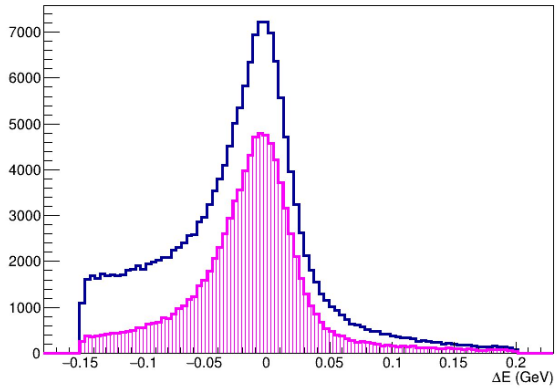
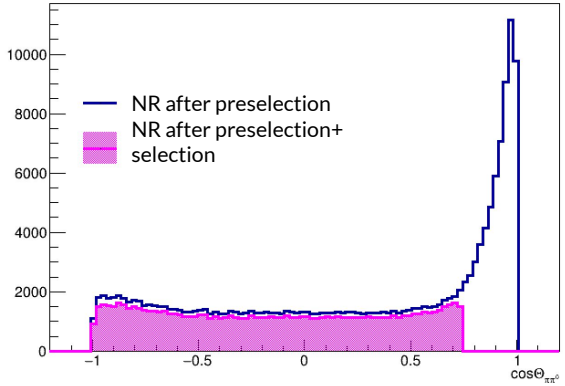
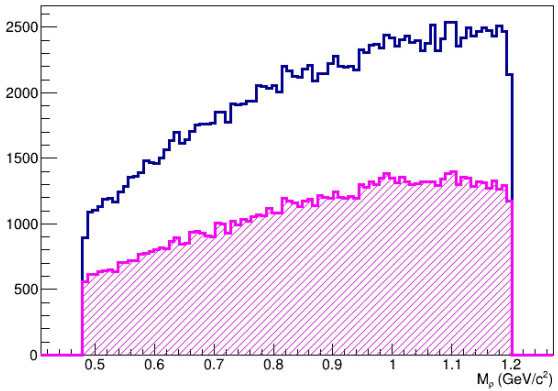
Efficiency for non-resonant decay B→D⁰ππ⁰

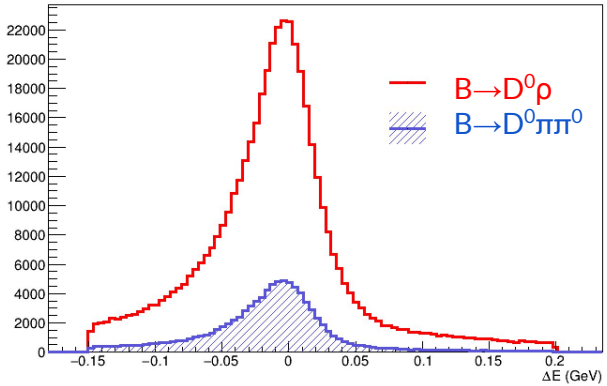
	After preselection	After preselection + selection
NR eff (ε)	~8.4%	~4.5%

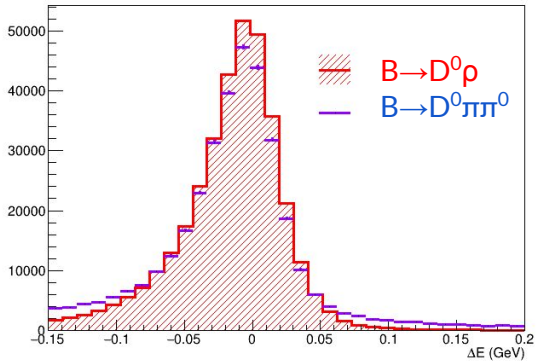


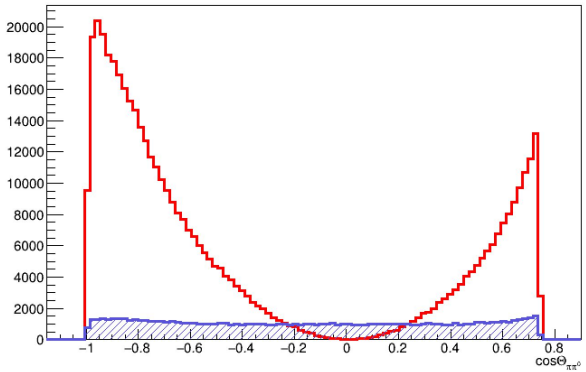


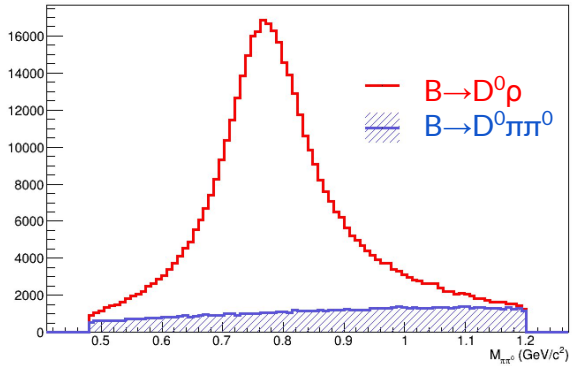


Comparison of resonant and NR signal MC





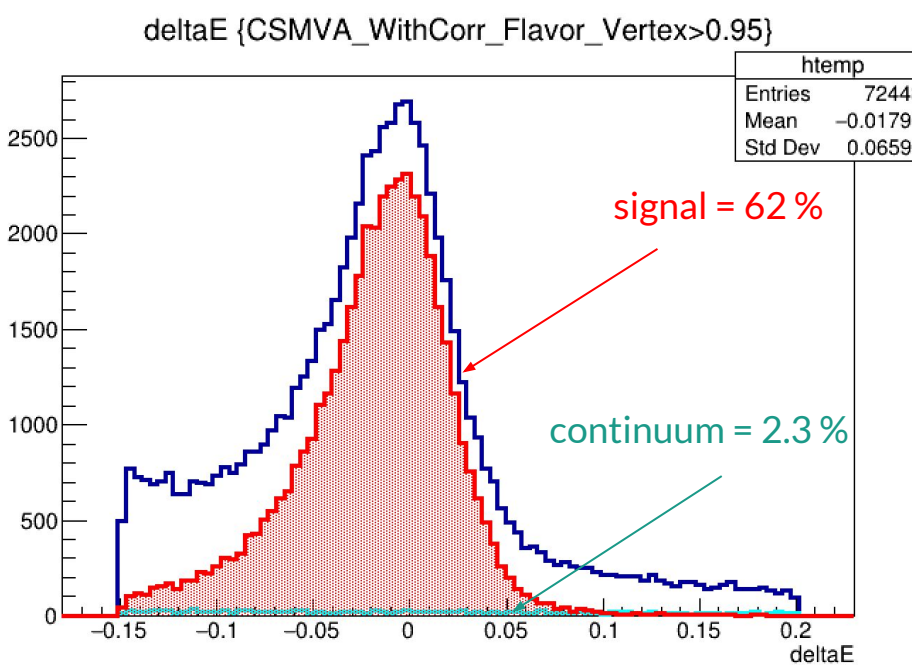


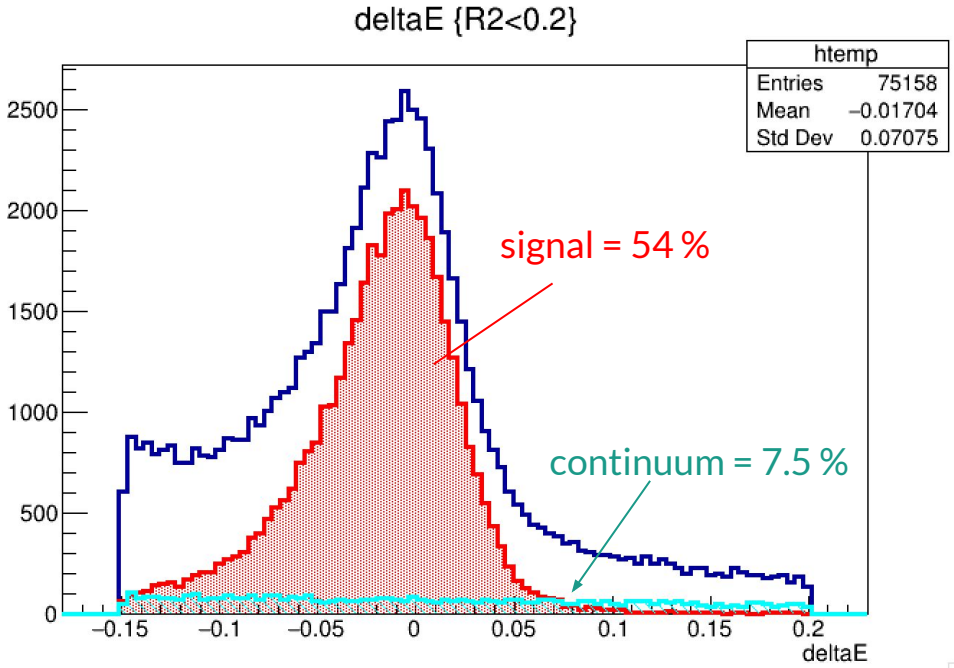


Change of Strategy

- 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

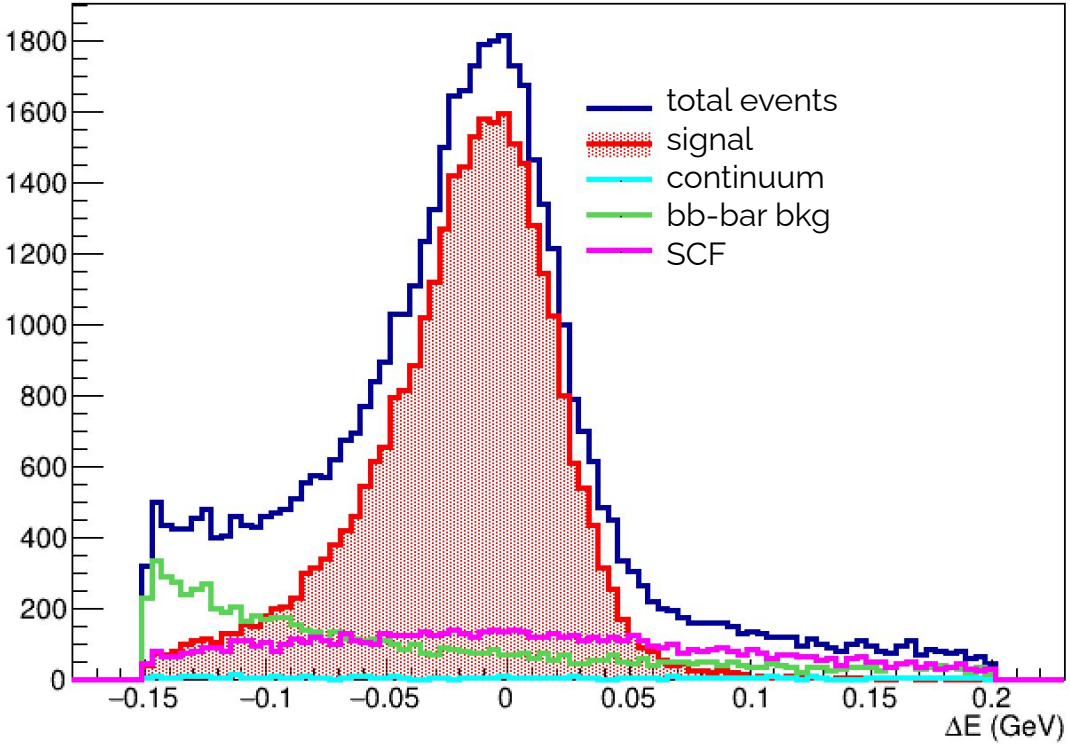




Signal efficiency vs Continuum background rejection

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**

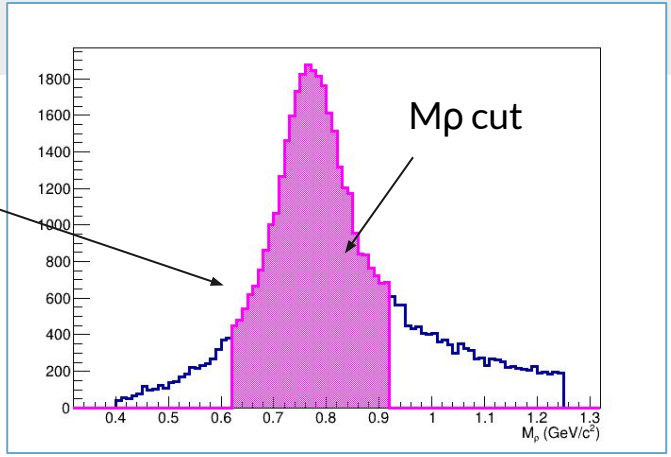
Data set composition after CSMVA>0.98 cut

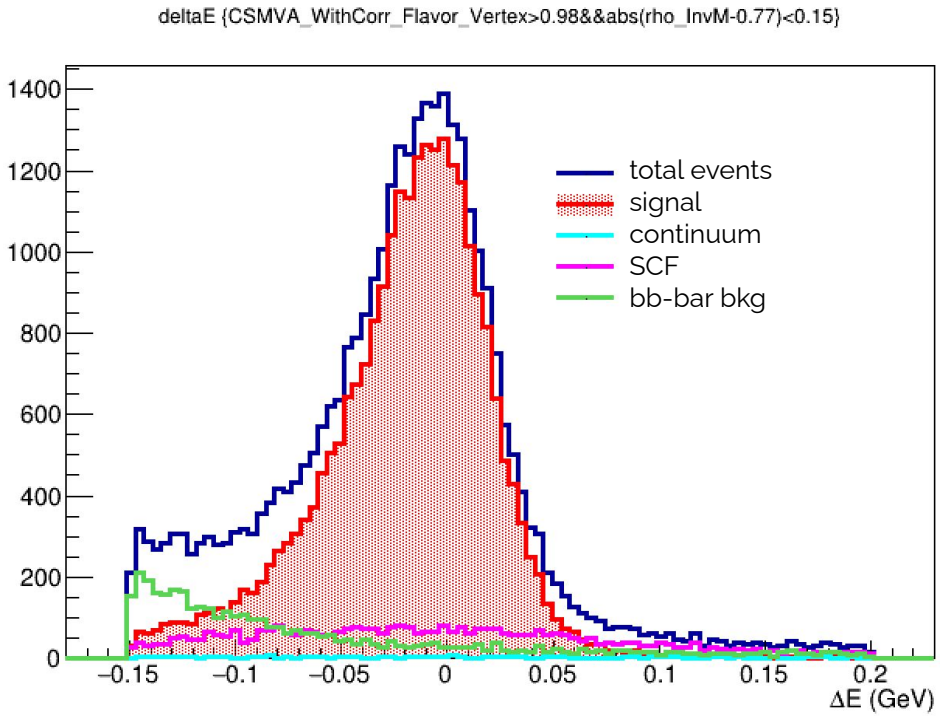


Composition	Nevents	Fraction
Signal	31375	0.66
Continuum	429	0.009
SCF	7816	0.16
BB-bar bkg	7751	0.17
Total events	47371	1.0

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

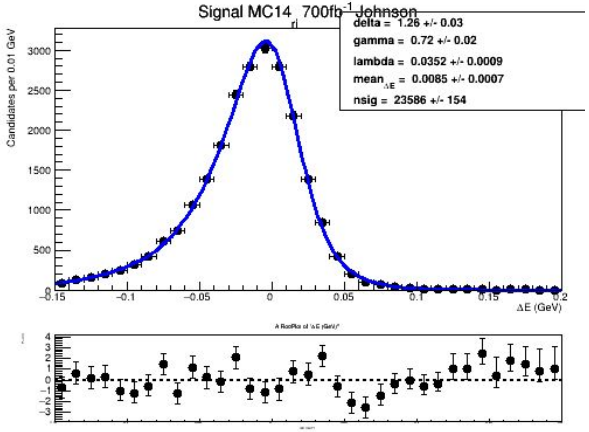
$$abs(M_\rho - 0.77) < 0.15$$



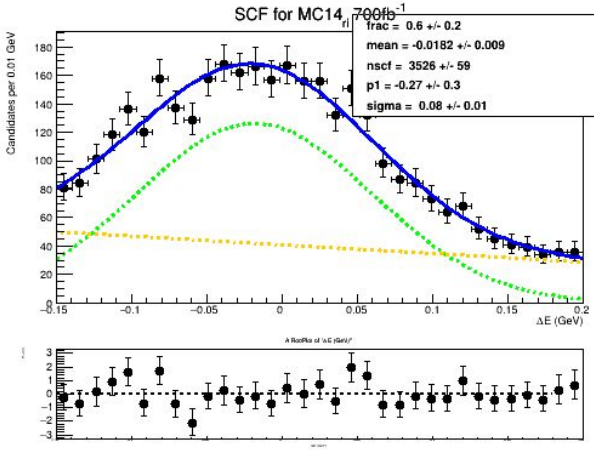


Composition	Nevents	Fraction
Signal	23586	0.76
Continuum	155	0.005
SCF	3526	0.114
BB-bar bkg	3816	0.12
Total events	30928	1.0

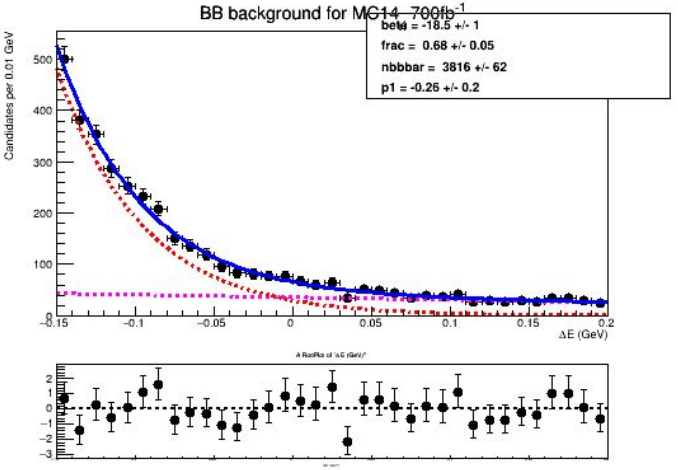
Fitting parameters



RooJohnson

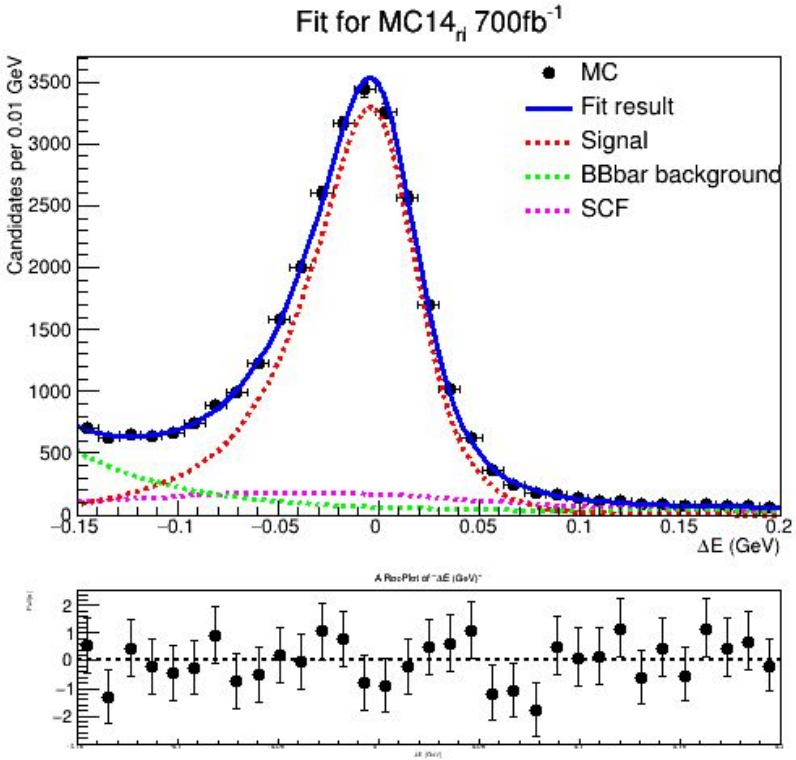


RooGaussian x
RooChebyshev(1)



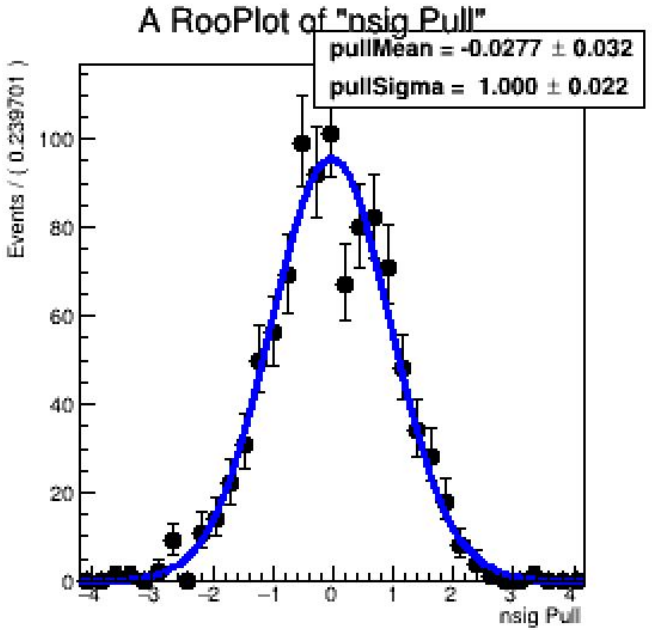
RooExponential x
RooChebyshev(1)

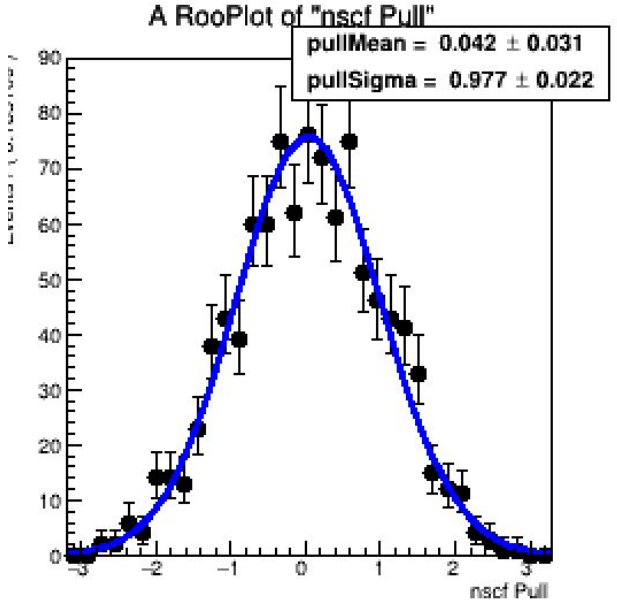
Fit result

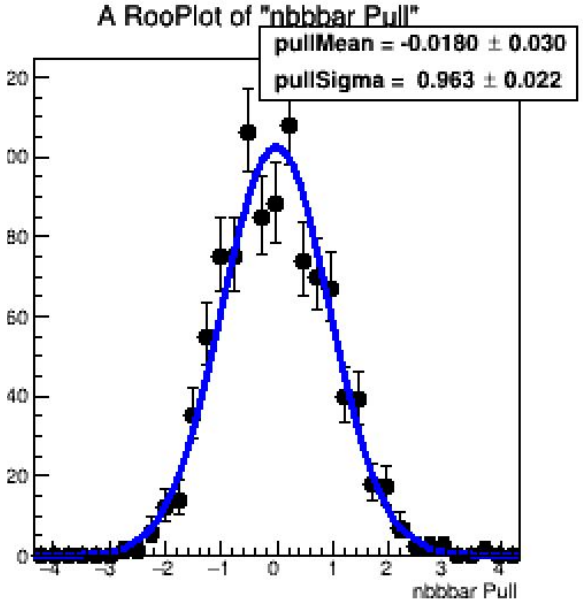


Composition	Nevents	Nfitted	σ
Signal	23586	23545 ± 233	0.2
Continuum	155	-/-	
SCF	3526	3852 ± 406	0.8
BB-bar bkg	3816	3530 ± 270	1.1
Total events	30928	30927	

TOY MC


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

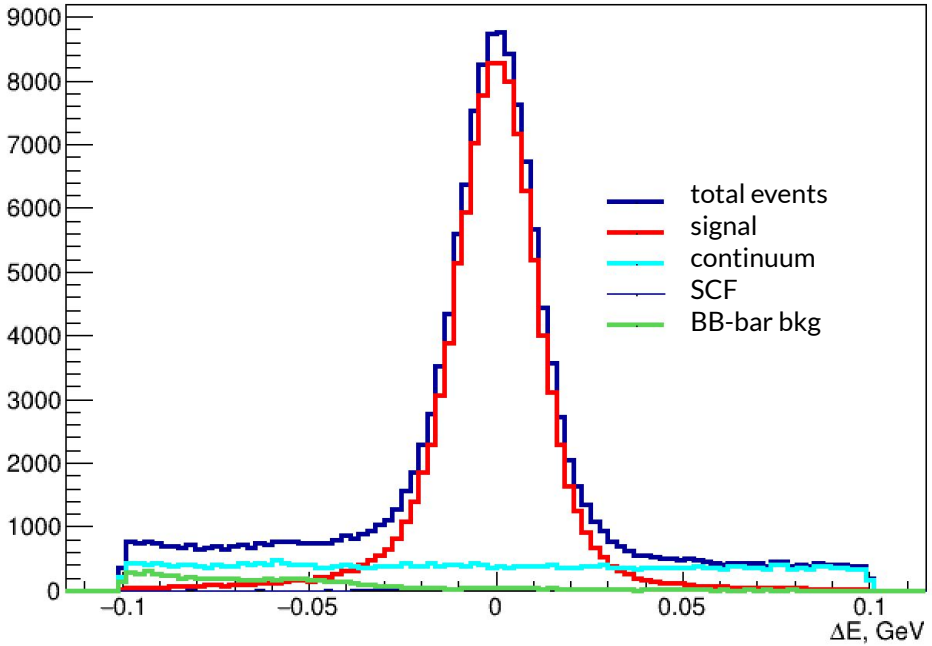

A RooPlot of "nscf Pull"
pullMean = 0.042 ± 0.031
pullSigma = 0.977 ± 0.022
nscf Pull


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

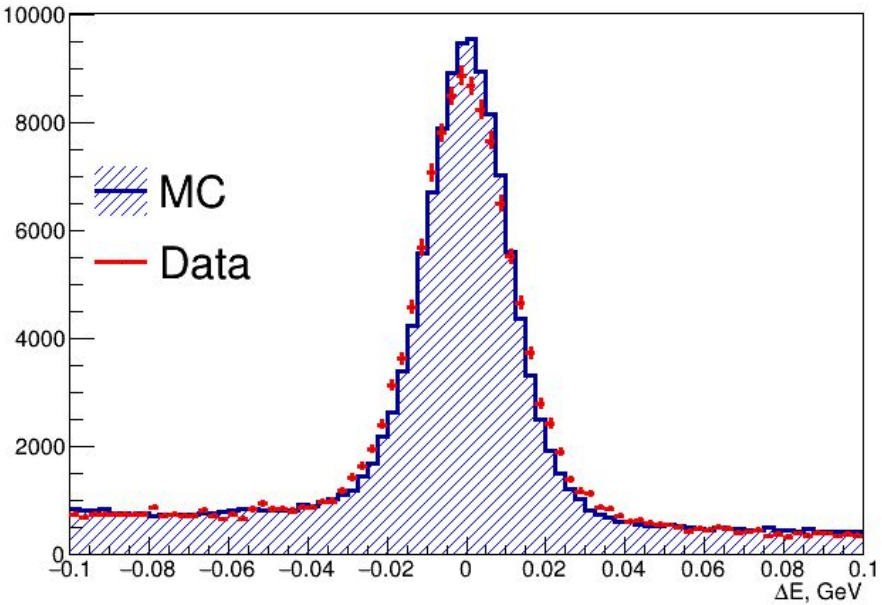


Cuts applied:

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

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

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

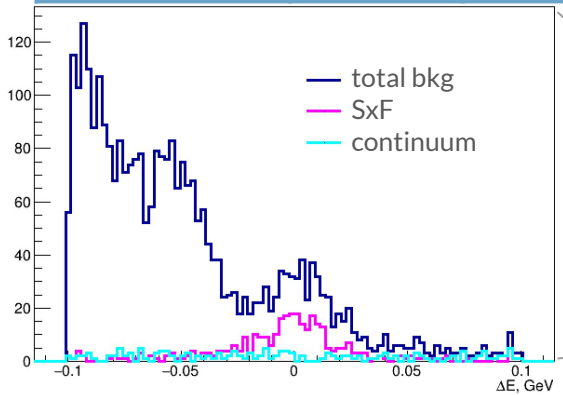


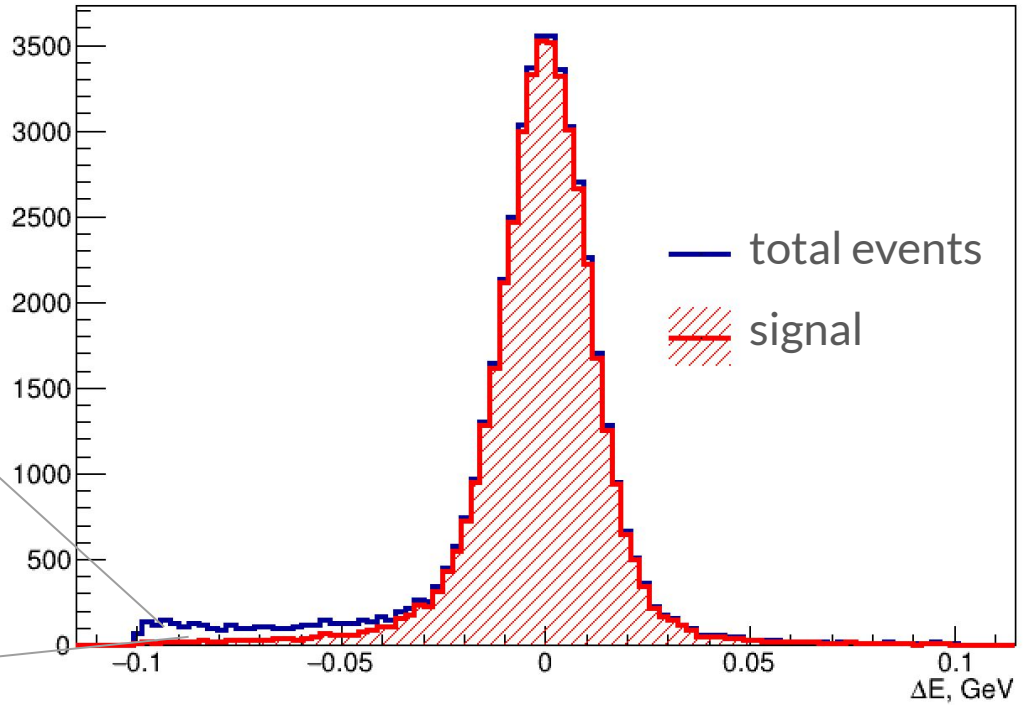
Cuts applied:

- 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

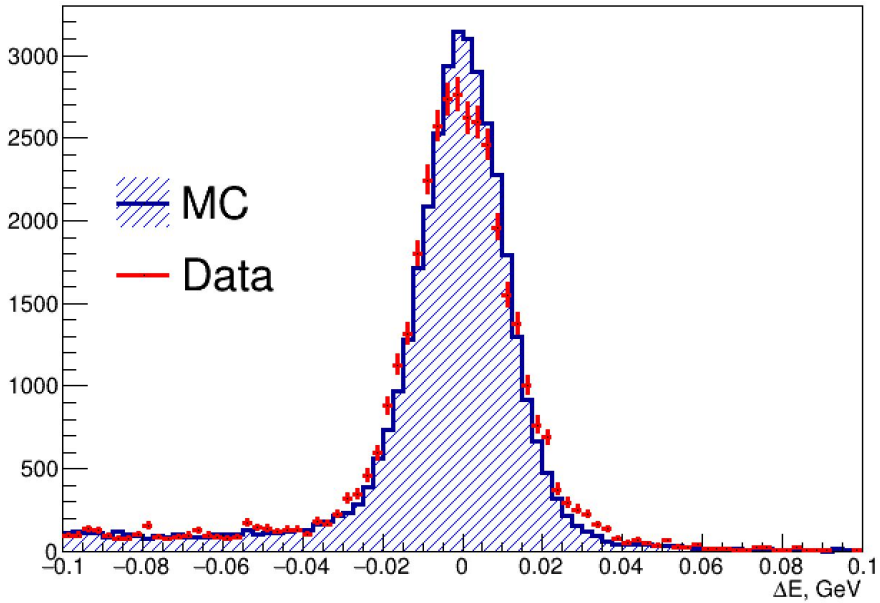
Composition	Nevents	
Signal	35123	0.936
Continuum	79	0.002
SCF	124	0.003
BB-bar bkg	2190	0.058





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

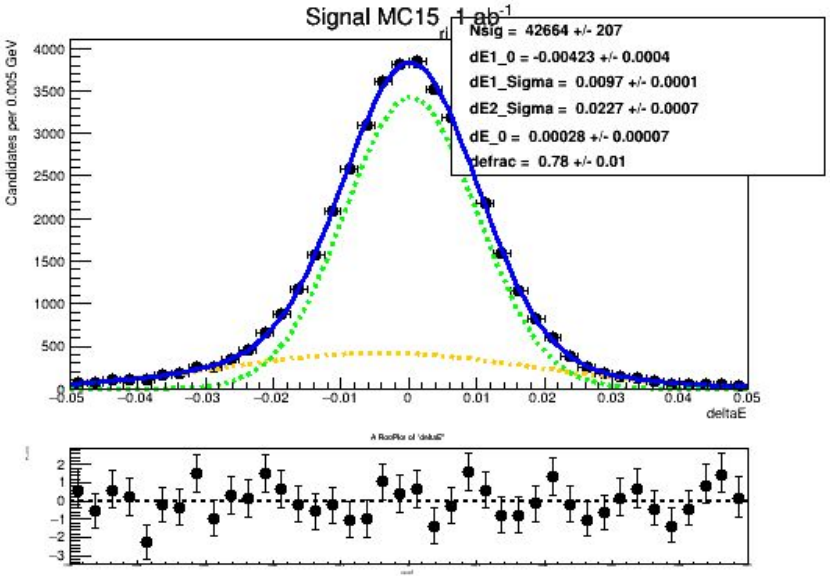
$BF(B^+ \to D^0\pi^+) = (4.81 \pm 0.15) \times 10^{-3}$

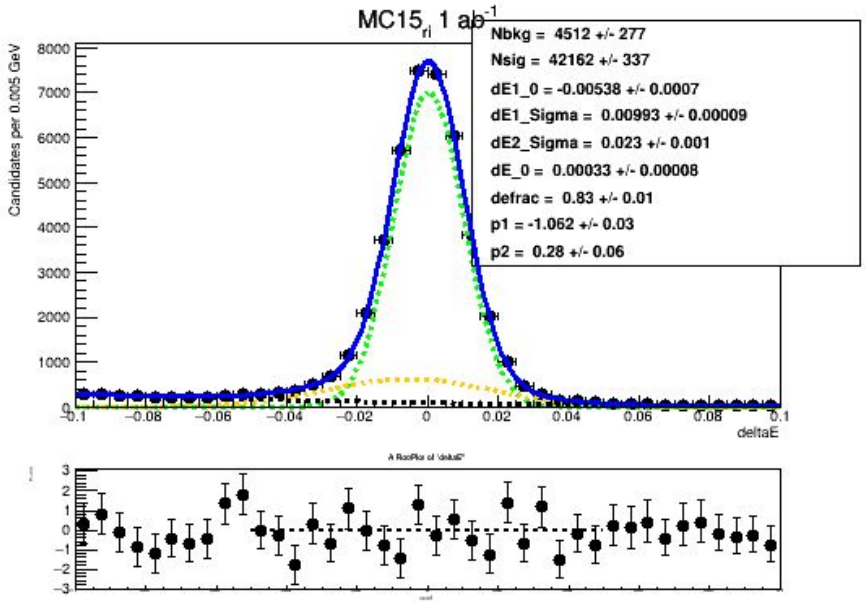


Cuts applied:

- 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

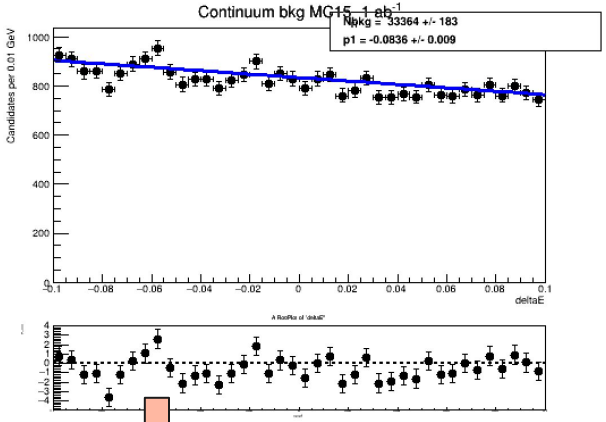
Fitting MC $B^+ \to D^0 \pi^+$

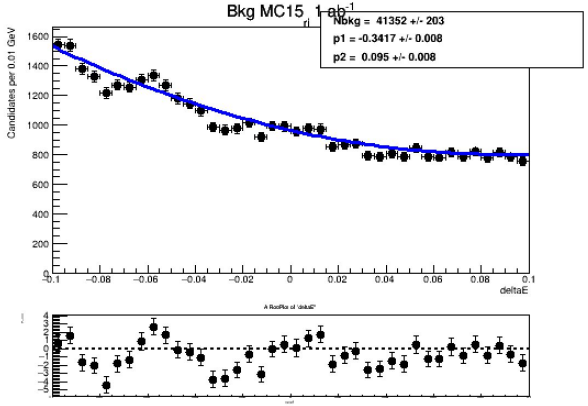


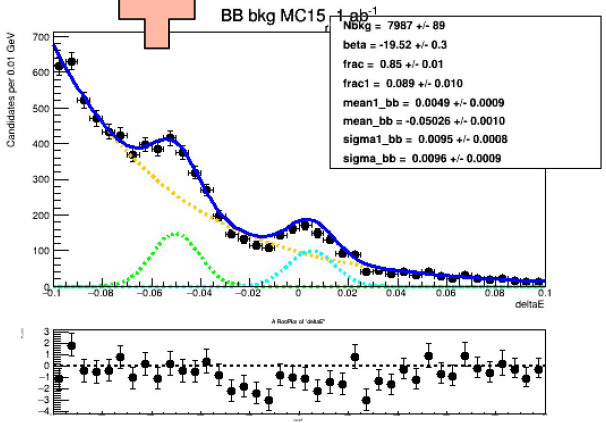


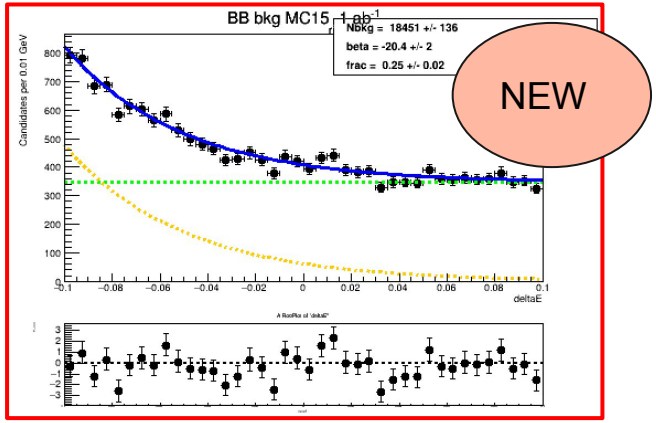
Composition	Nevents	SignalMC	Signal Yield	σ
Signal	43629	42664 ± 207	42162 ± 337	4.4

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

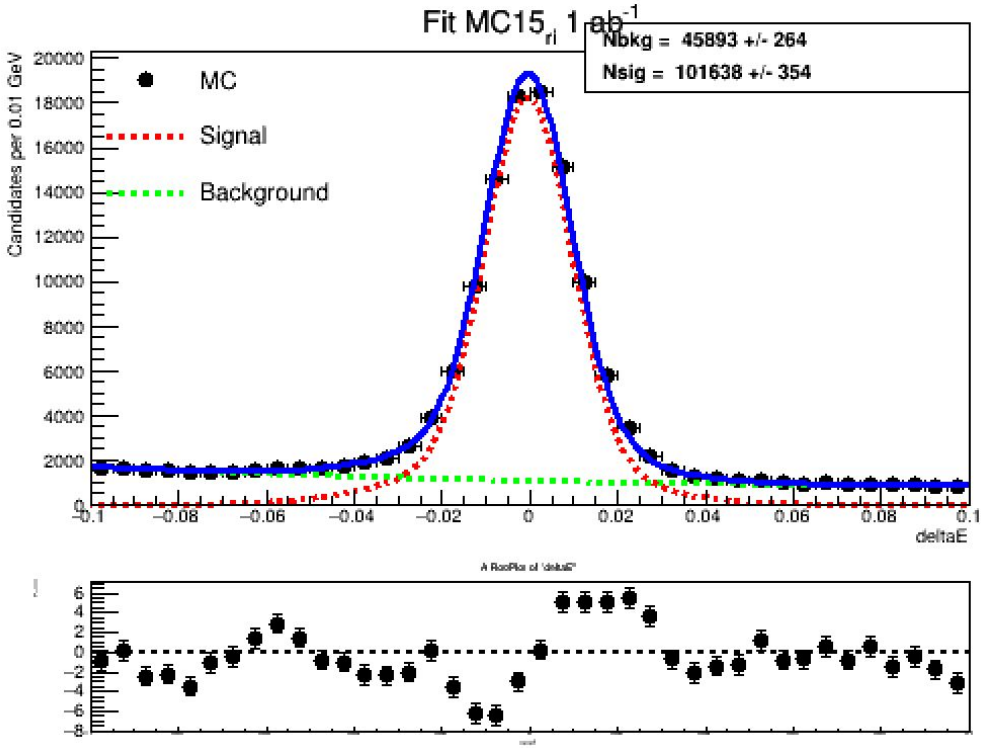






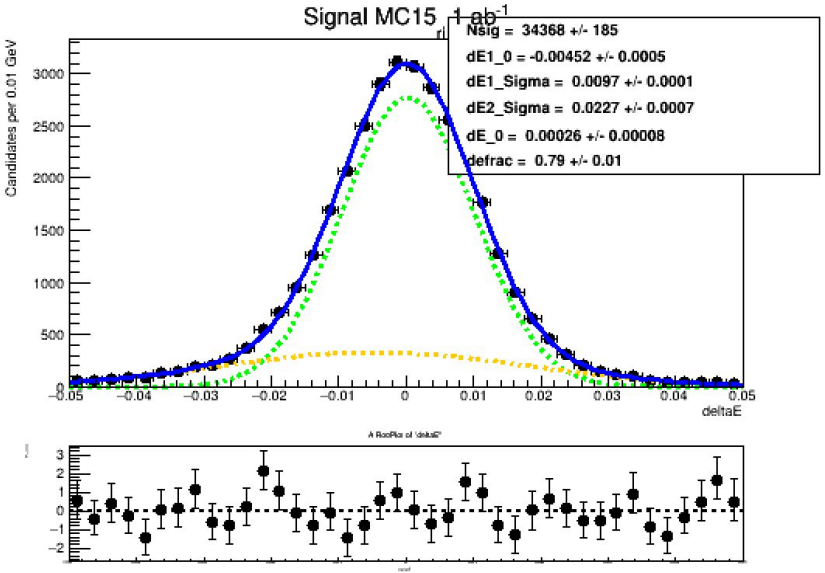


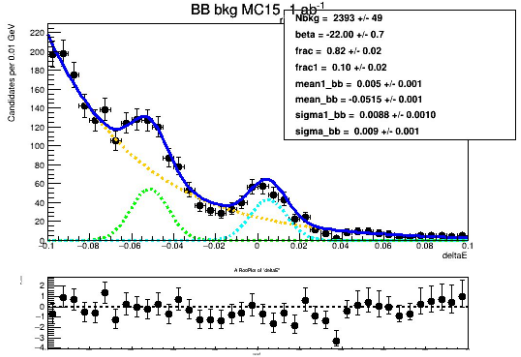
Fit MC $B^+ \to D^0 \pi^+$ with fixed parameters and without CSMVA cut

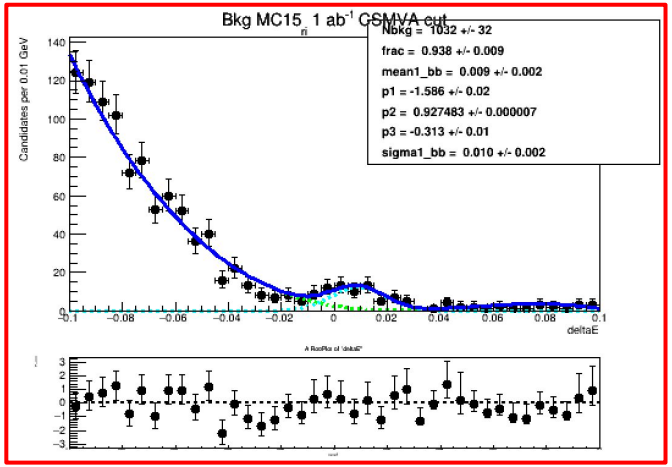


Composition	Nevents	σ
Signal	106178	> 10
Background	33364	> 10

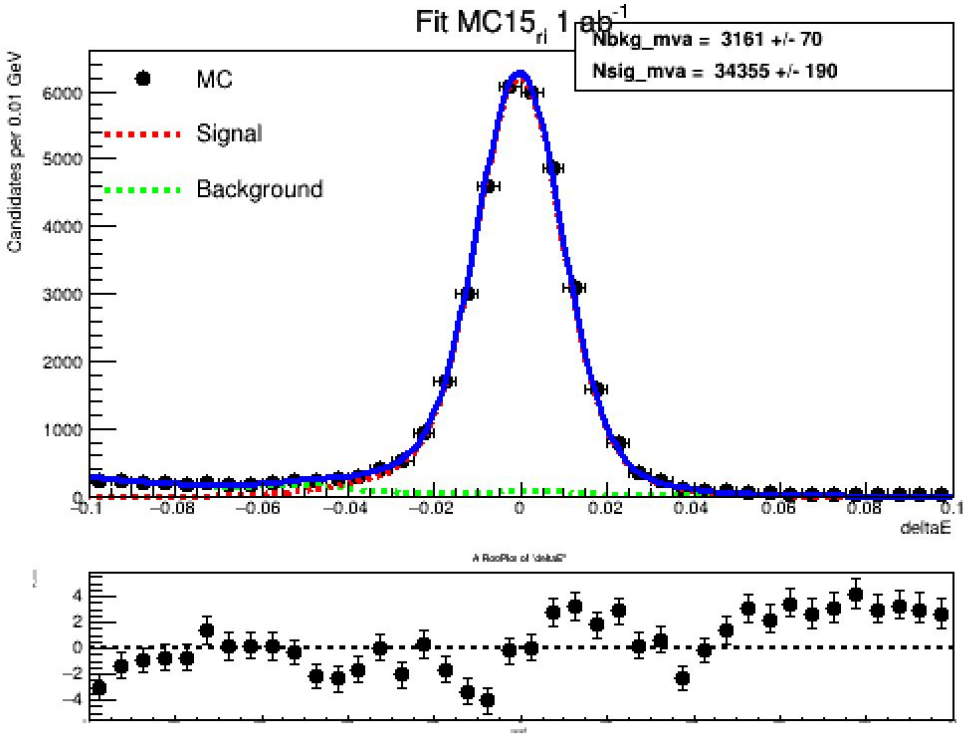
Fitting parameters MC $B^+ \to D^0 \pi^+$ with CSMVA> 0.98 cut







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



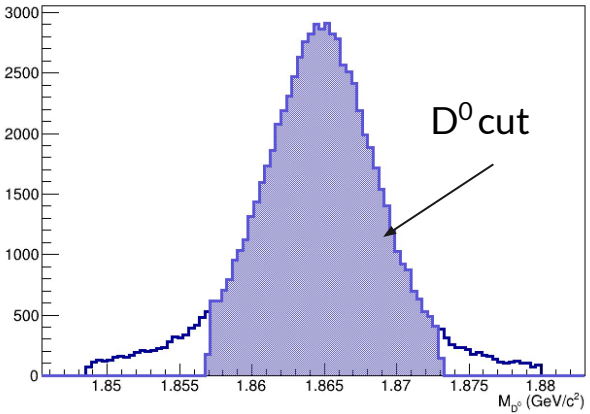
Composition	Nevents	σ
Signal	35123	4.0
Background	2393	11

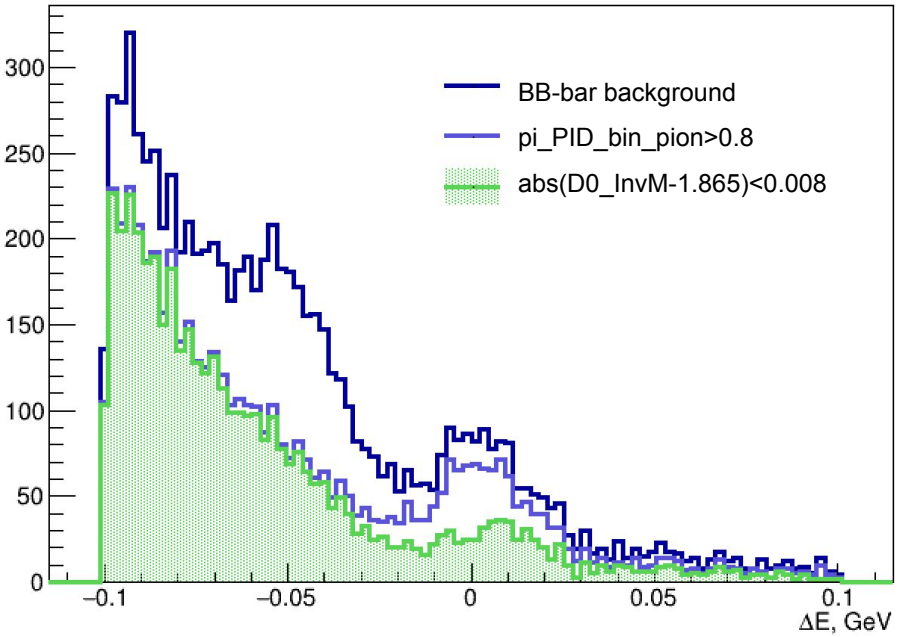
NEW cuts

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

Cuts applied:

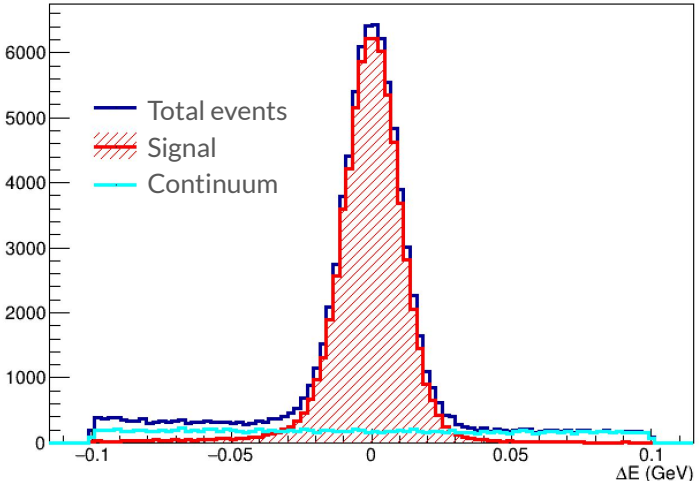
- Mbc > 5.27
- $|\Delta E| < 0.1$
- $|M_{D0} - 1.865| < 0.008 (\sim 2\sigma)$ GeV
- binary pion PID from D^0 < 0.1
- binary pion PID > 0.8

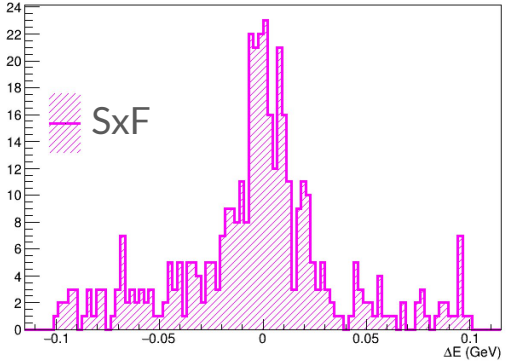


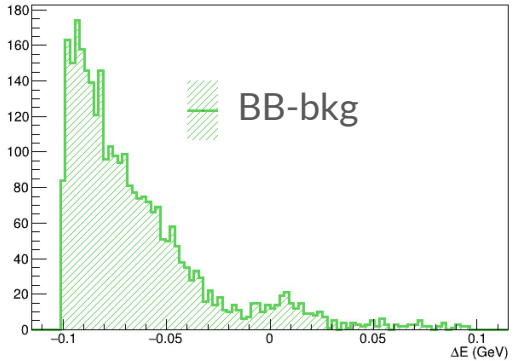


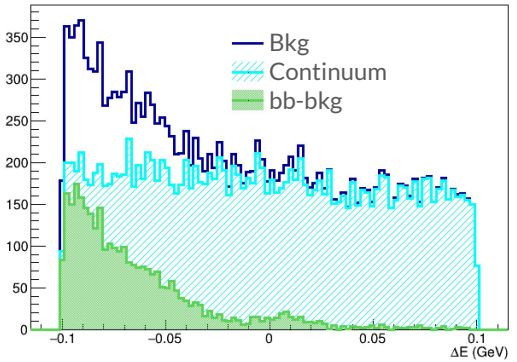
MC sample composition after new cuts

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



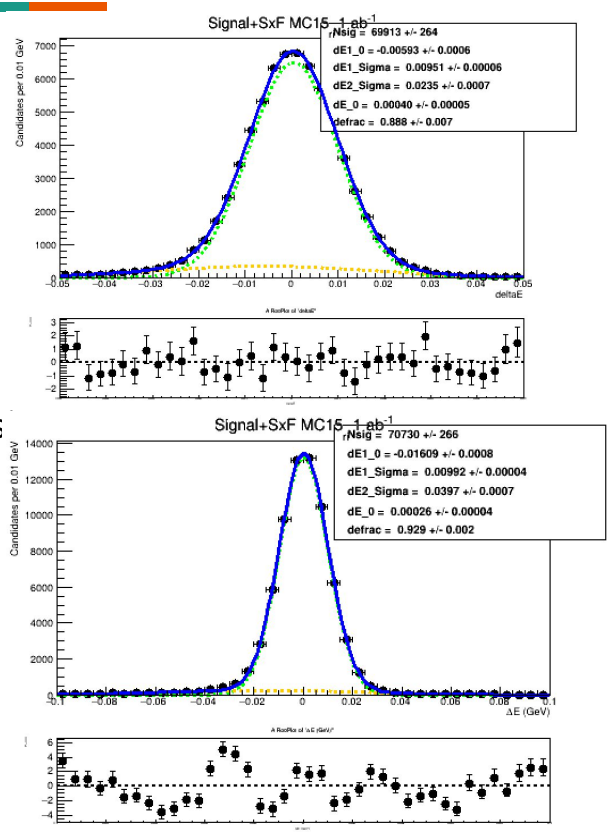


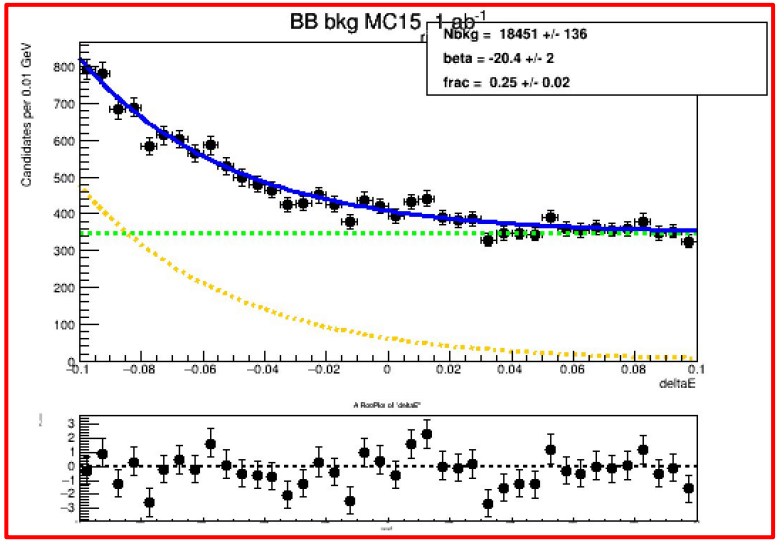




Fit MC $B^+ \to D^0 \pi^+$ Signal + SxF without CS cut

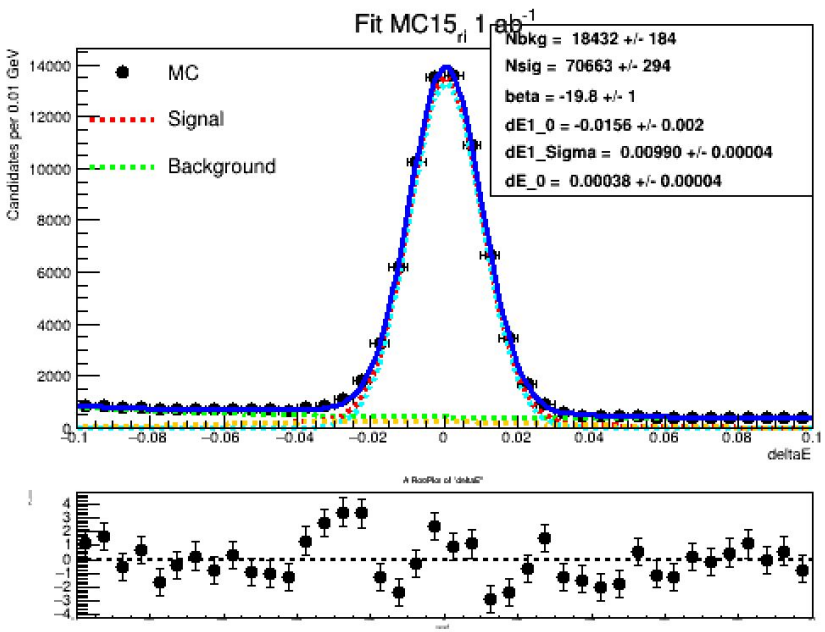
2x RooGauss

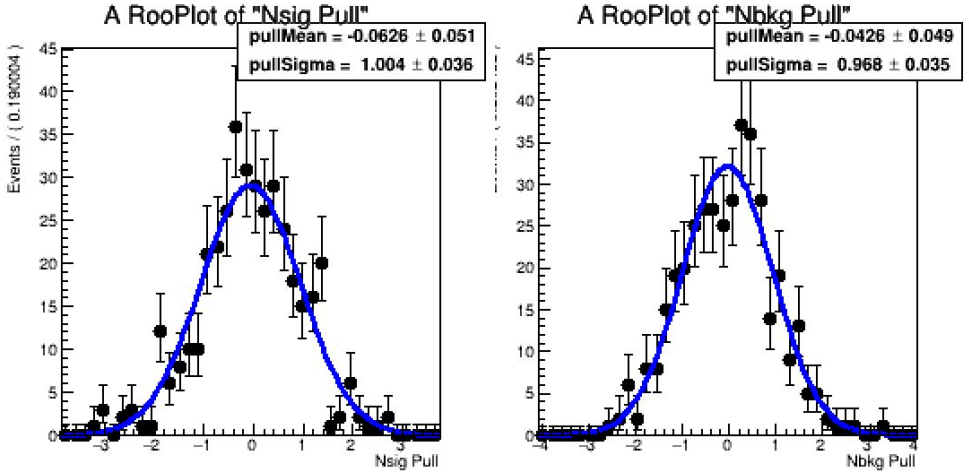




RooExponential x Cheb(0)

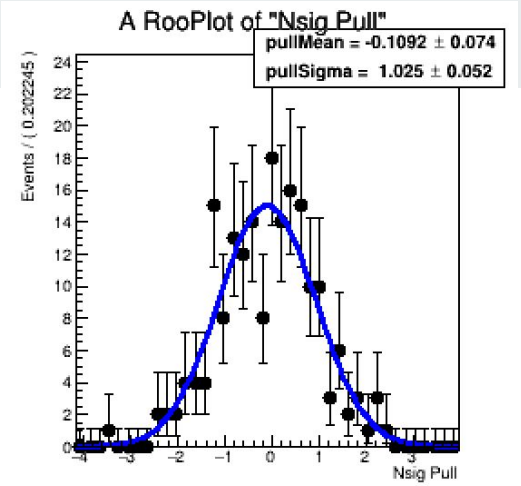
TOY for fit without CS cut

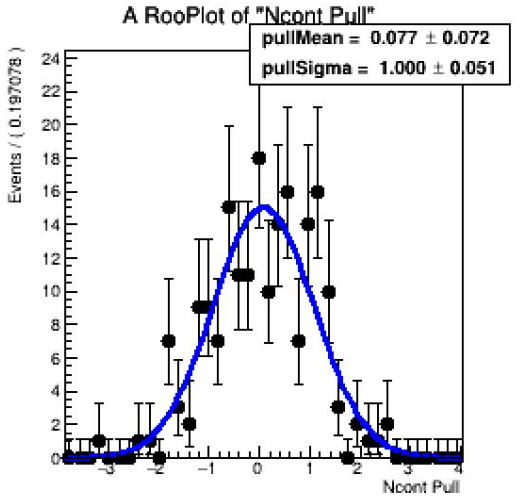


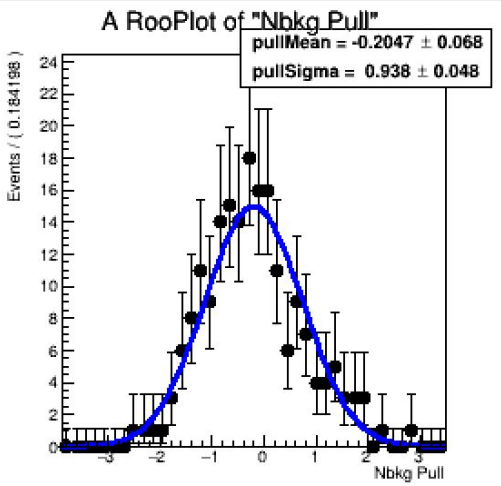


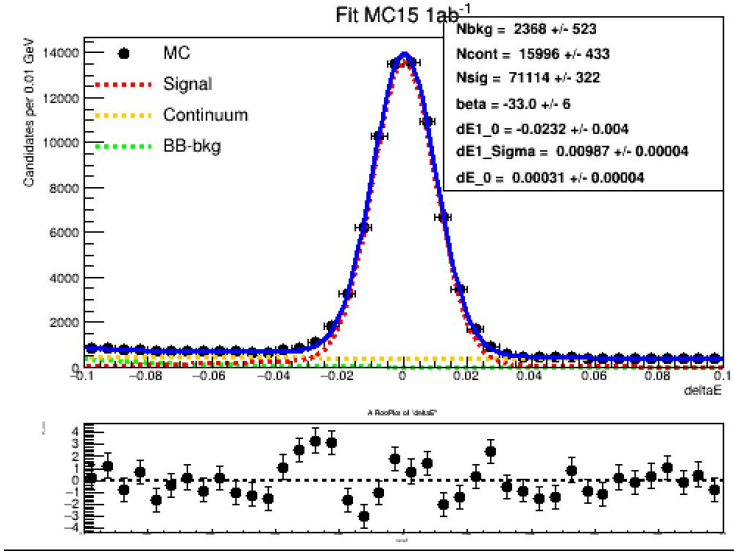
Composition	Nevents	σ
Signal + SxF	71027	1.9
Background	18451	0.1

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





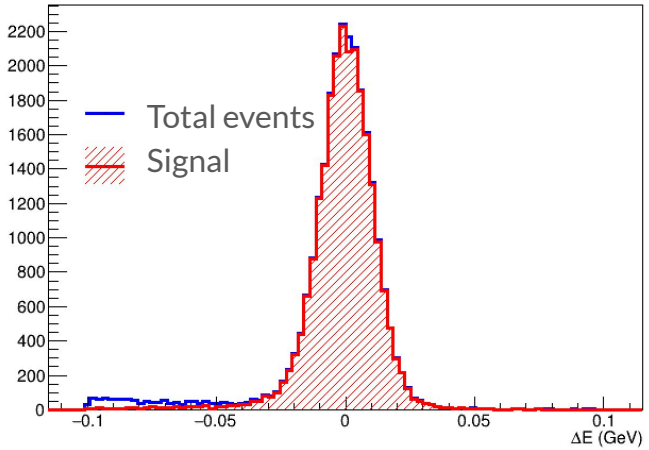


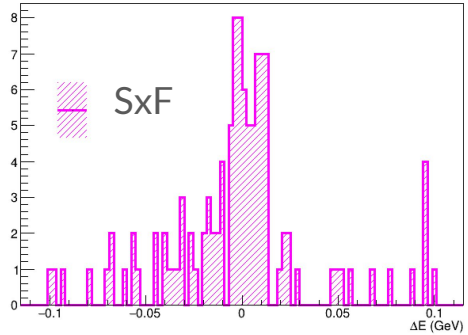


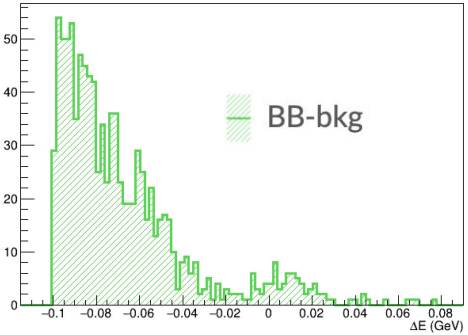
Composition	Nevents	Yields	σ
Signal + SxF	71027	71114 ± 322	0.3
Continuum	15388	15996 ± 433	1.4
BB-bkg	3063	2368 ± 523	1.3

MC sample composition after new cuts + CS cut

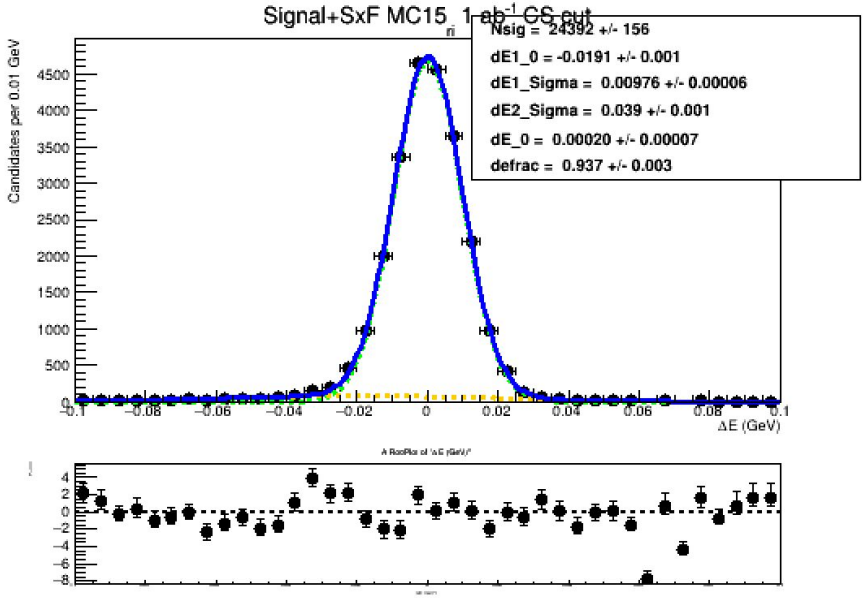
Composition	Nevents	
Signal	24279	0.955
Continuum	45	0.002
SCF	113	0.004
BB-bar bkg	987	0.039

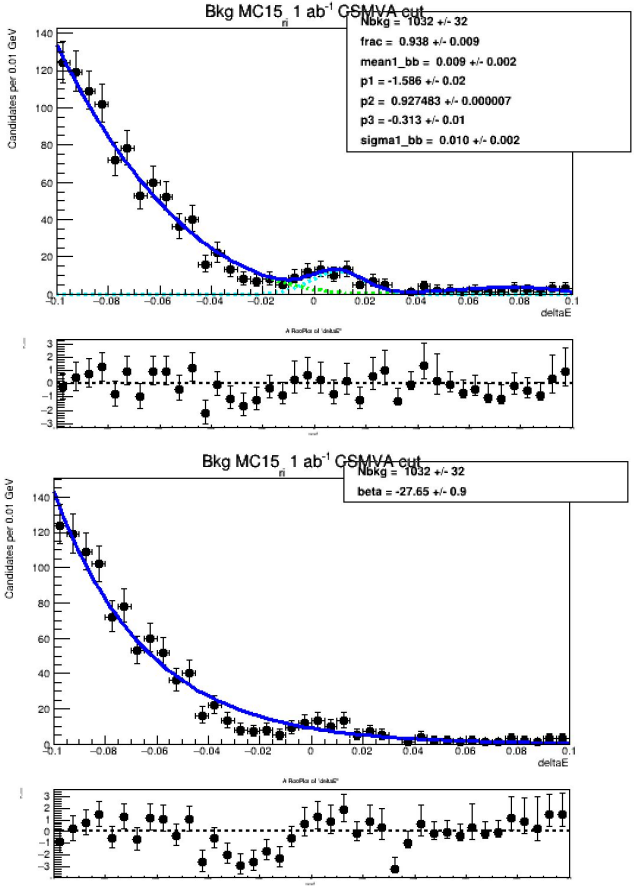






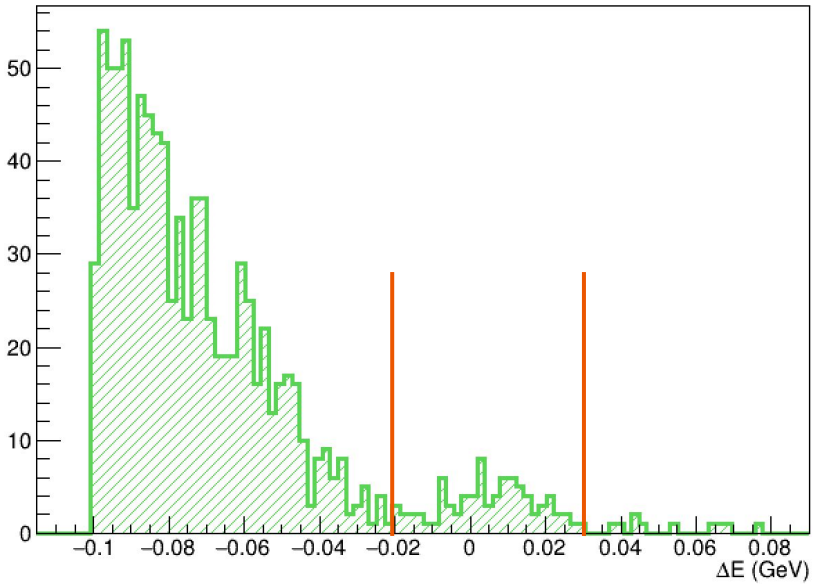
Fit parameters for MC $B^+ \to D^0\pi^+$ Signal + SxF with CS cut





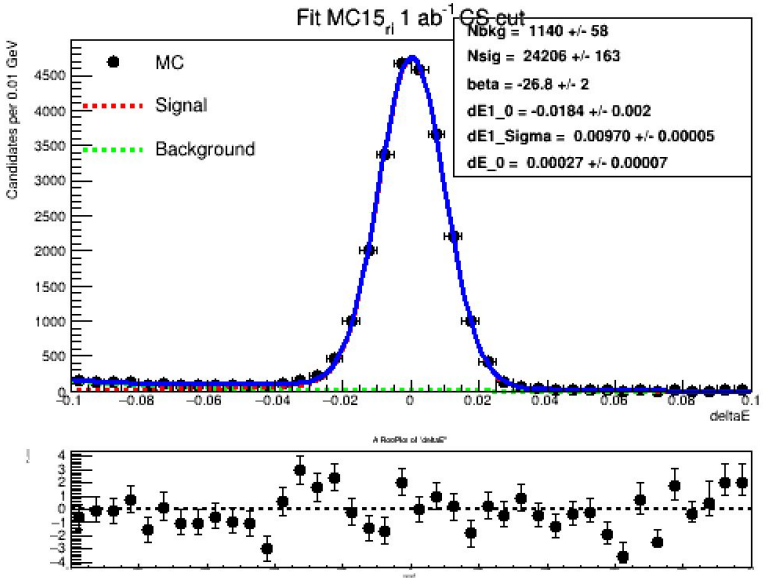
BB-bar background “bump” composition

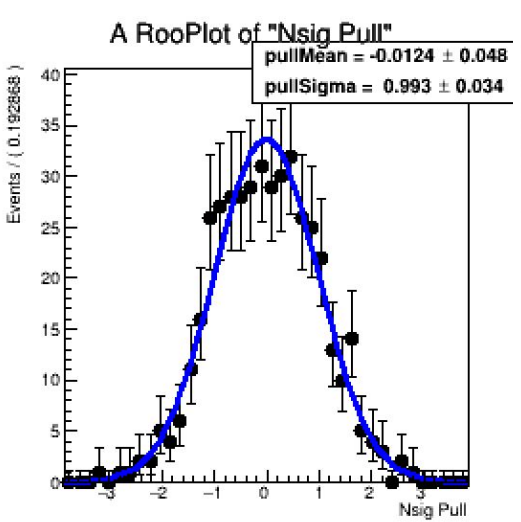
-0.02 < ΔE < 0.03 GeV

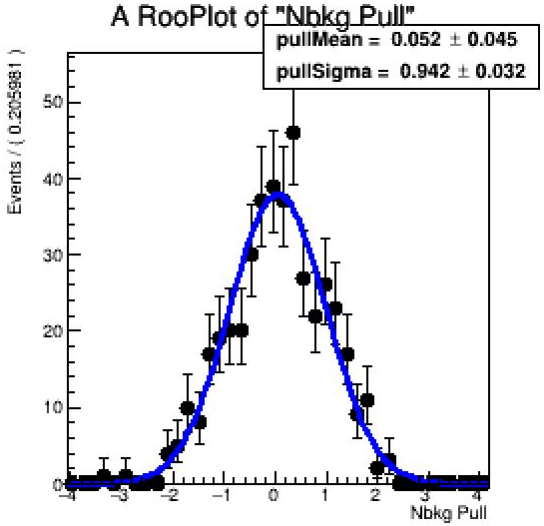


$$J/\Psi K \sim 20\%$$
$$D^{\cdot 0}\pi/l \sim 24\%$$
$$D^0 K/\pi/l \sim 16\%$$

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



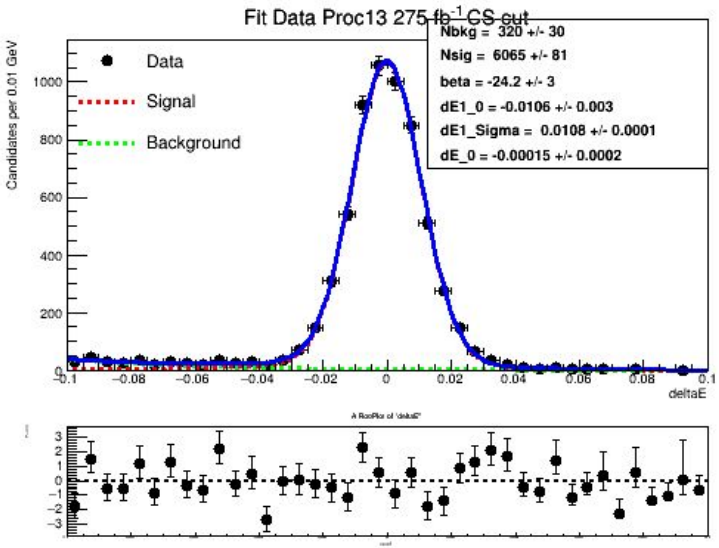


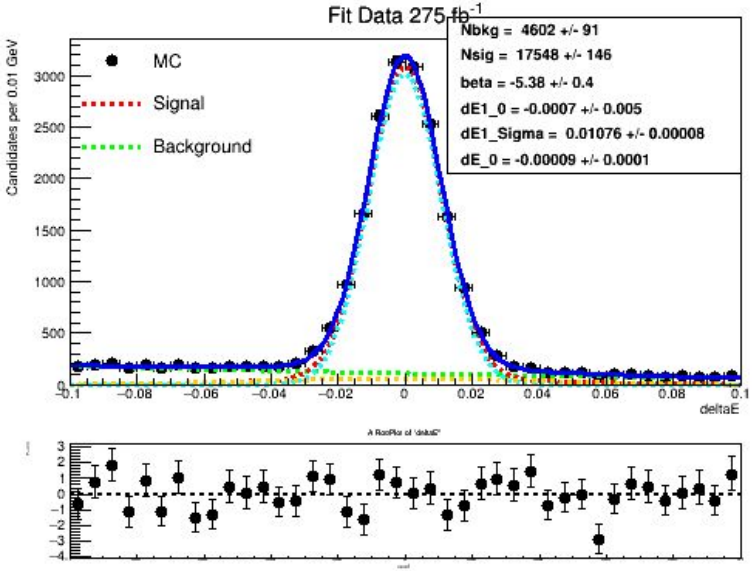


Free: exp(beta), mean1, mean2, sigma1

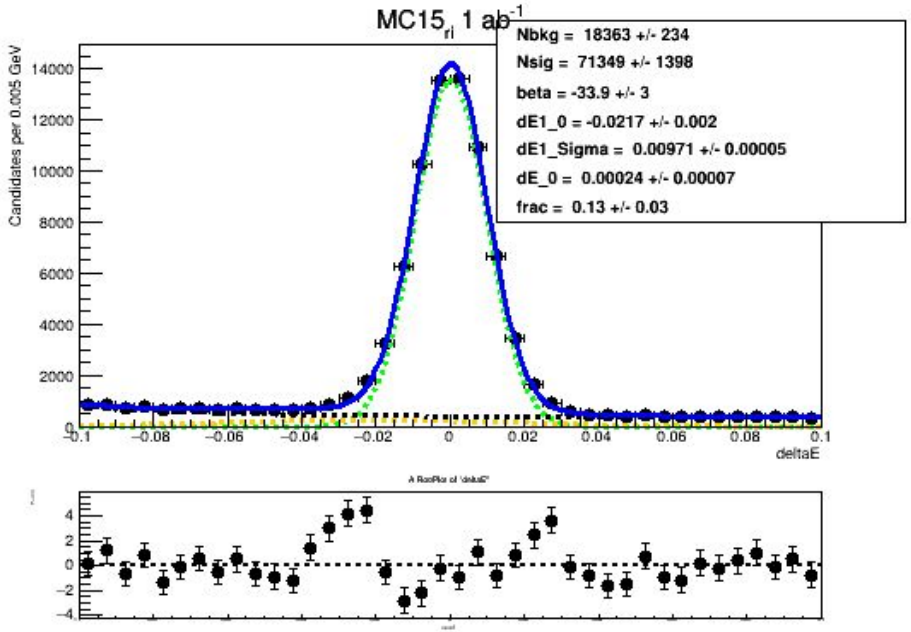
Composition	Nevents	σ
Signal + SxF	24392	1.1
Background	1032	0.1

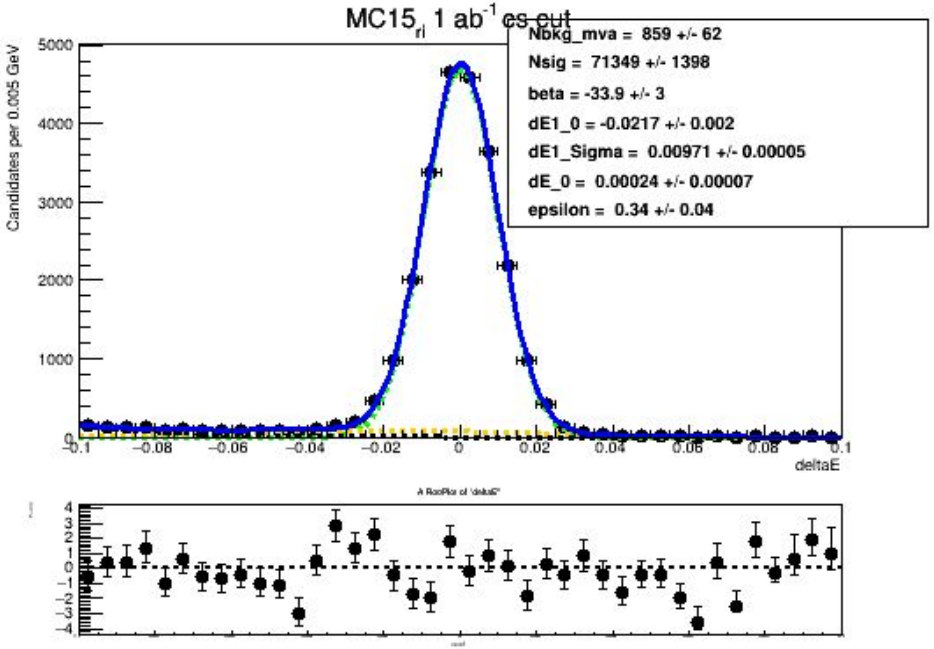
Fit Data $B^+ \to D^0 \pi^+$ Signal + SxF with CS cut



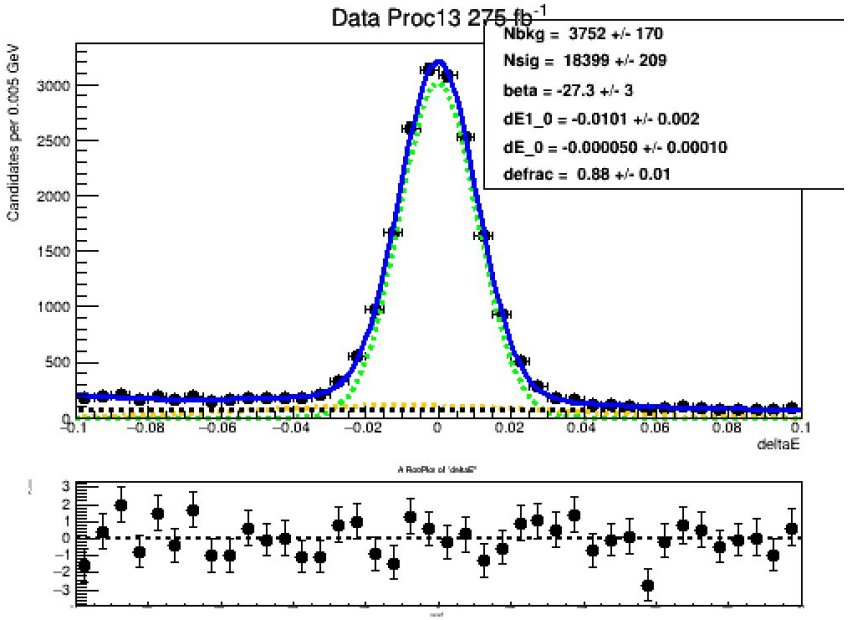


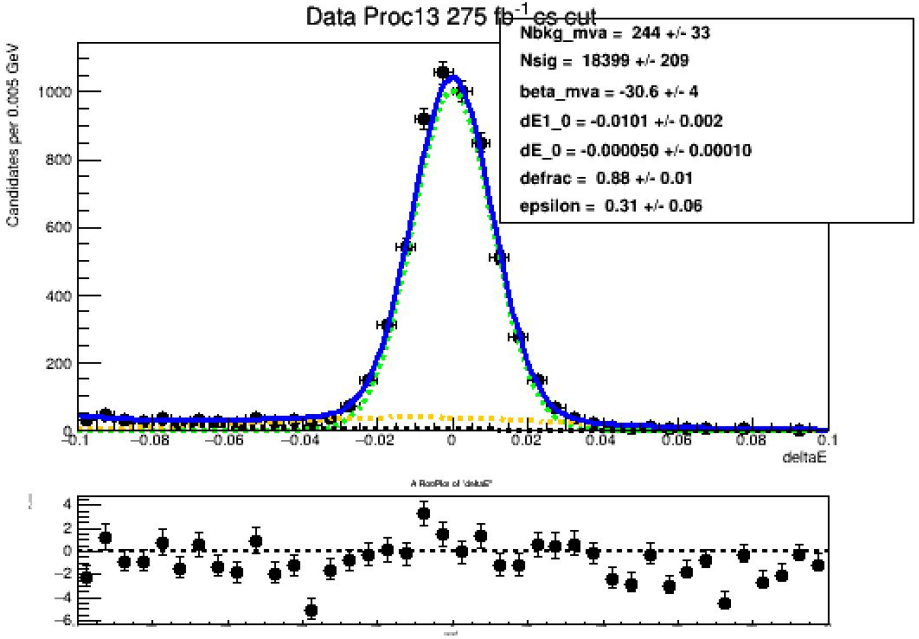
Simultaneous fit MC15



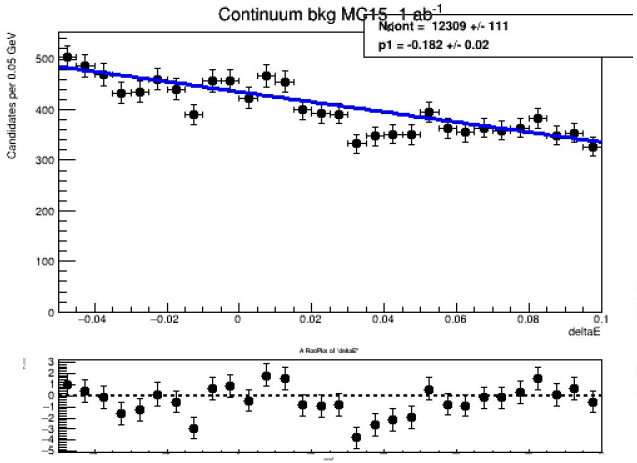


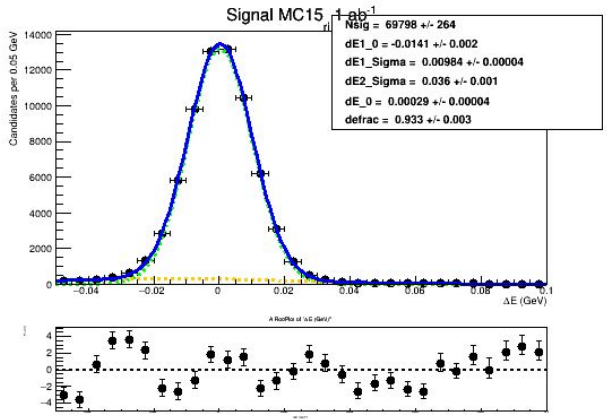
Simultaneous fit Data Proc 13

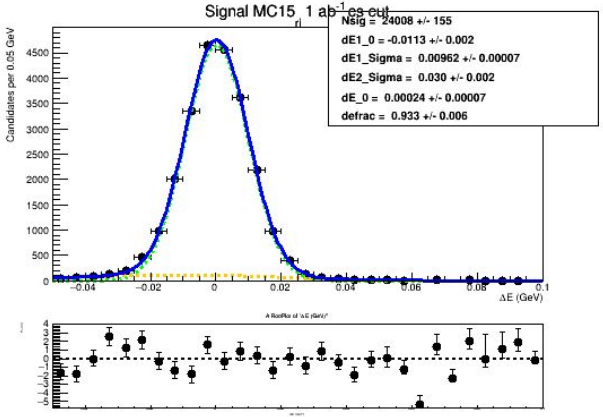




deltaE > -0.05







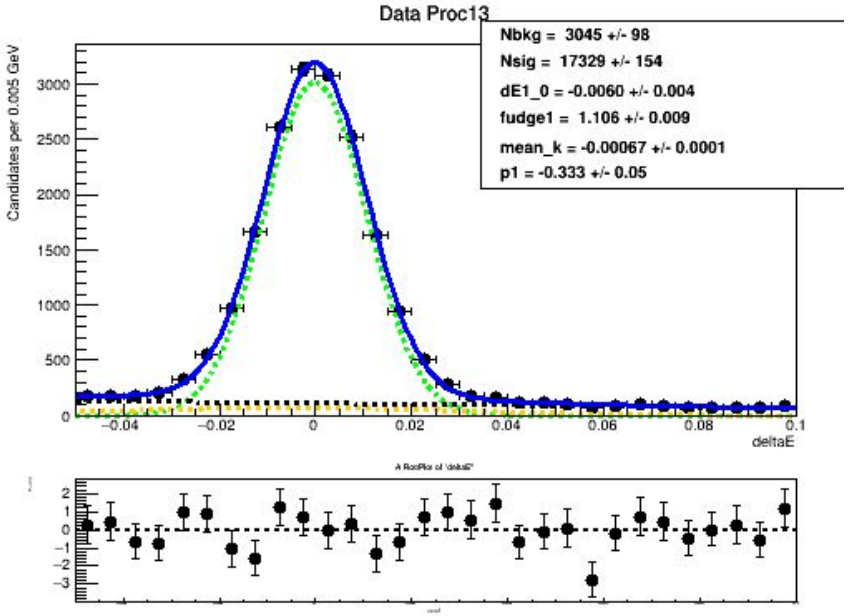
Composition	Nevents	
Signal	69796	0.850
Continuum	11234	0.137
SCF	360	0.004
BB-bar bkg	715	0.009

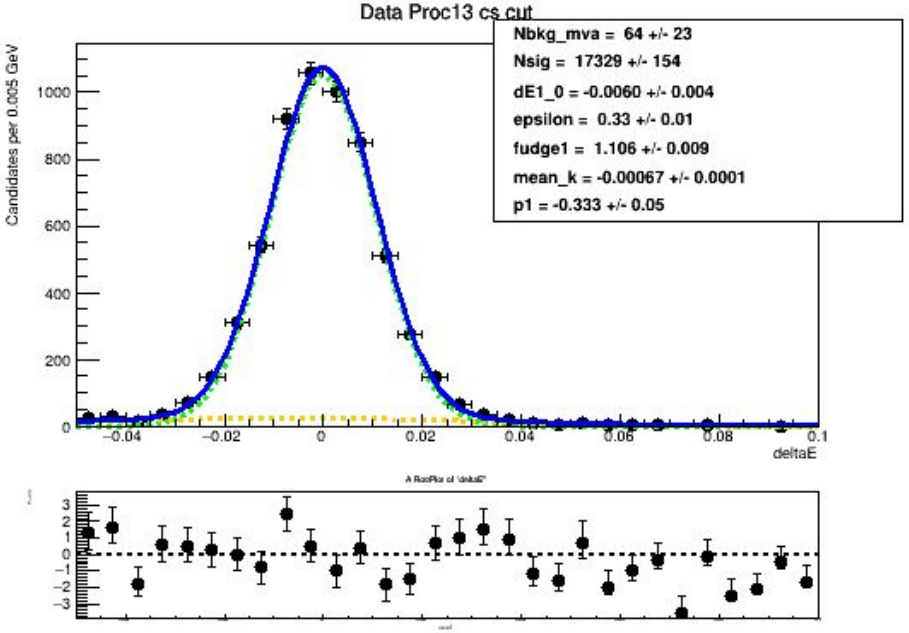
cs cut applied

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

Result for Data

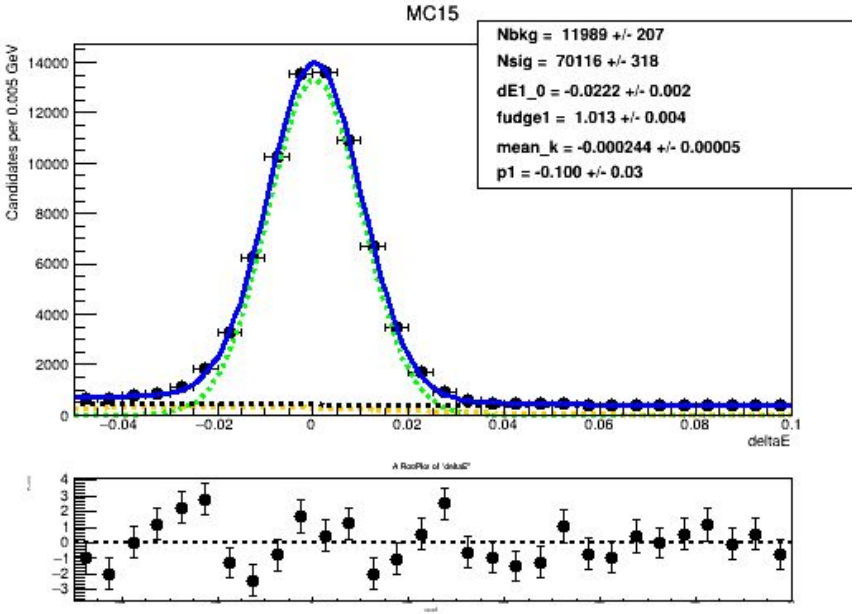
$$\epsilon_{Data} = 0.33 \pm 0.01$$

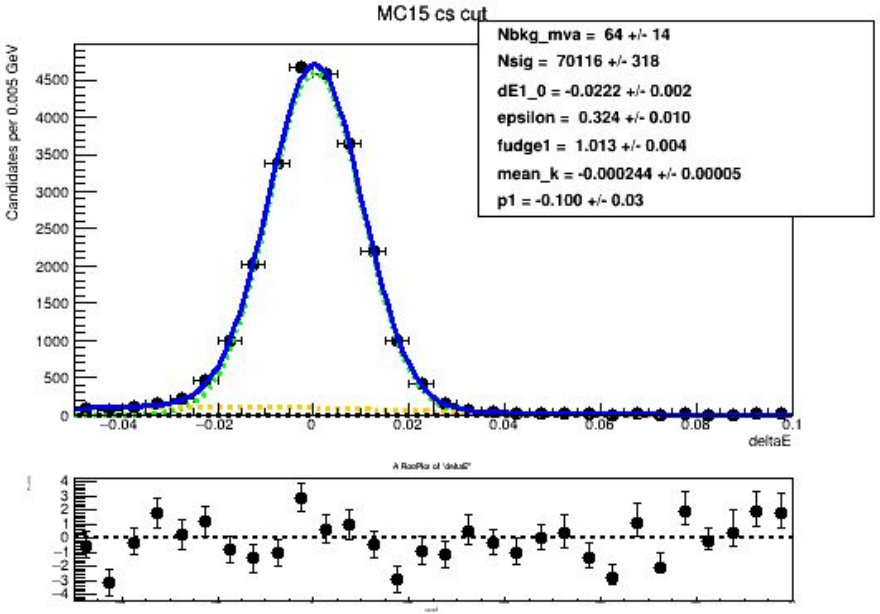




Result for MC

$$\epsilon = 0.324 \pm 0.010$$





Efficiency before CSMVA > 0.98 cut

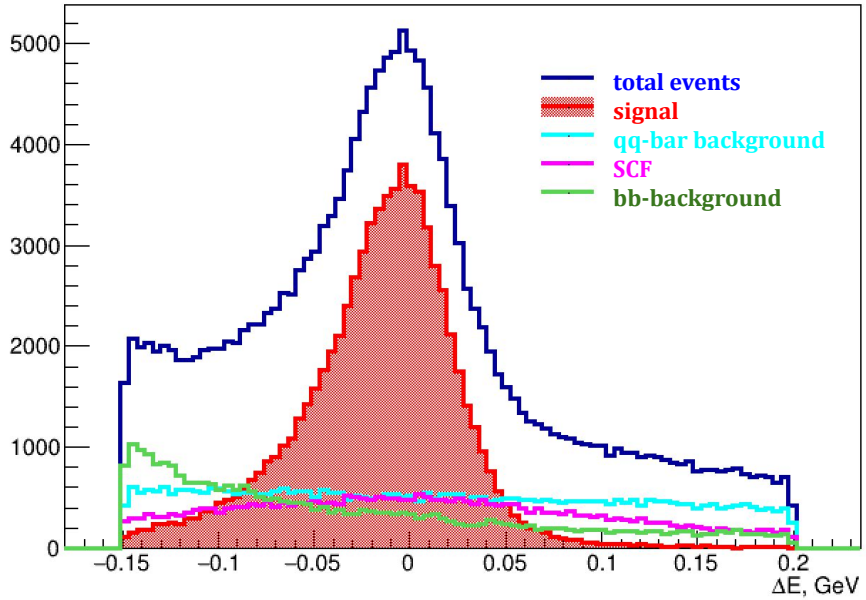
$$BF = \frac{N_{signal}}{L \cdot \epsilon \cdot \epsilon_{K\pi}} \implies \epsilon = \frac{N_{signal}}{BF_{PDG} \cdot L \cdot \epsilon_{K\pi}} = 34.9\%$$

Efficiency of CSMVA > 0.98 cut

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

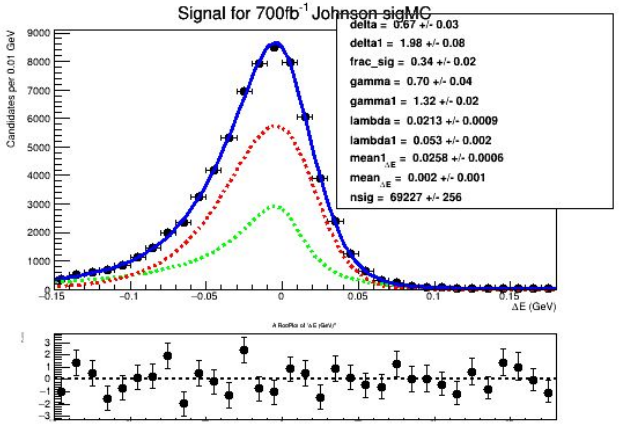
Backup

ΔE fit for $MC14_{ri}$ 700 fb^{-1}

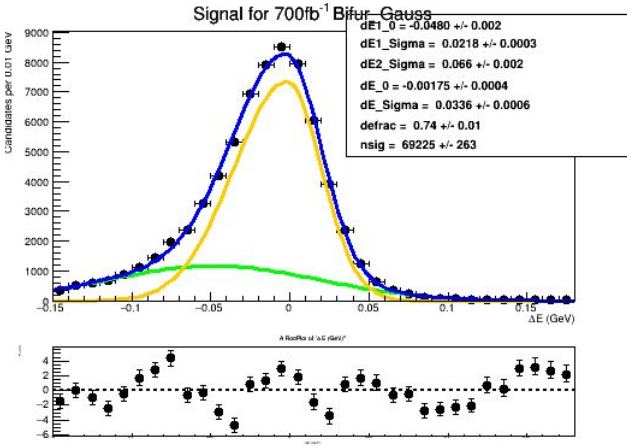


Composition	N events	Fraction
Signal	69223	0.46
Continuum	33083	0.22
SCF	24003	0.16
BB-bar bkg	24070	0.16

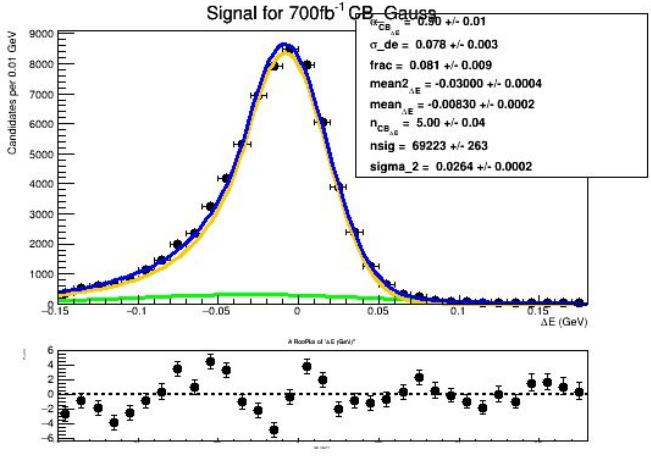
Fits for signal ΔE (MC14$_{ri}$ 700 fb^{-1})



rooJohnson x rooJohnson

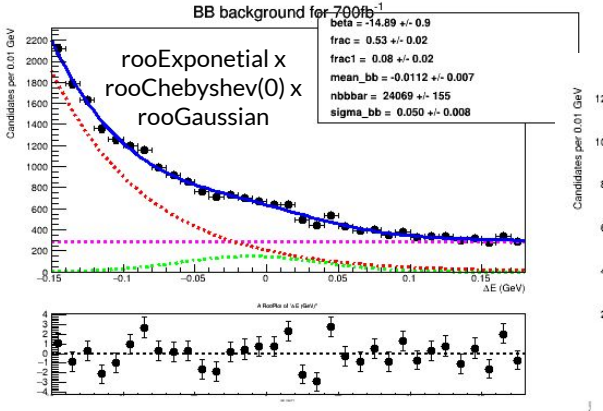


rooBifurGauss x rooGaussian

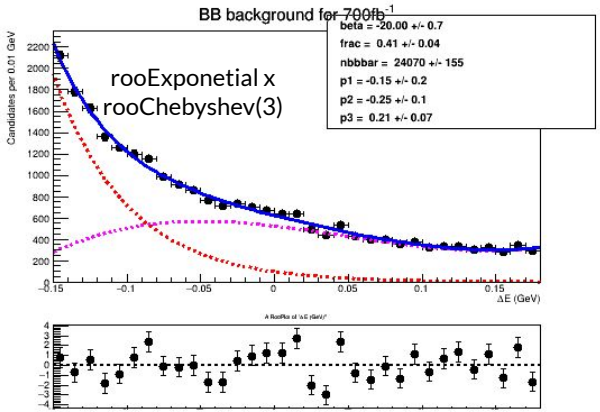


rooCBShape x rooGaussian

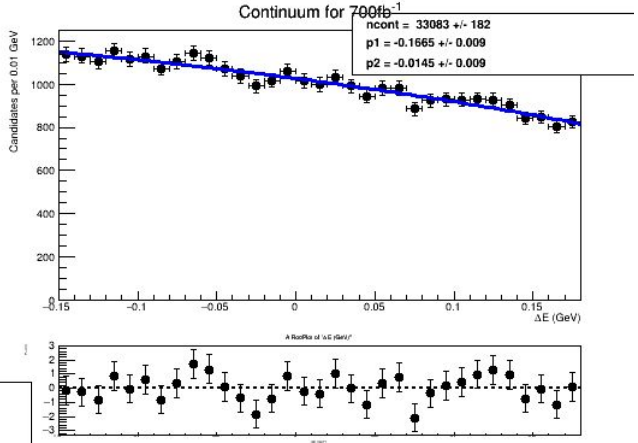
Fits for SCF, BBbar and Continuum of deltaE (700 fb^{-1})



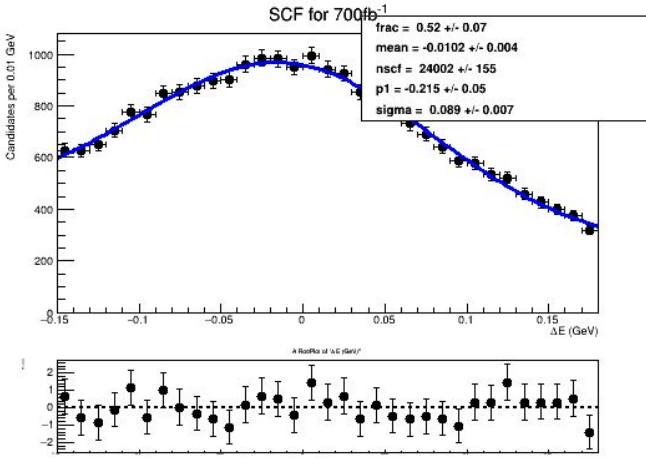
rooExponetial x rooChebyshev(0) x rooGaussian



rooExponetial x rooChebyshev(3)

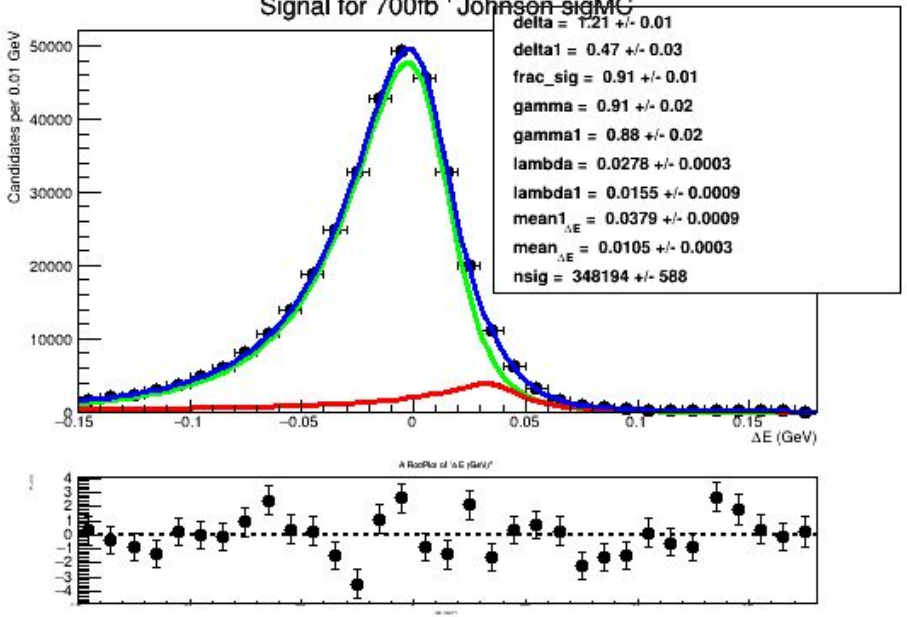


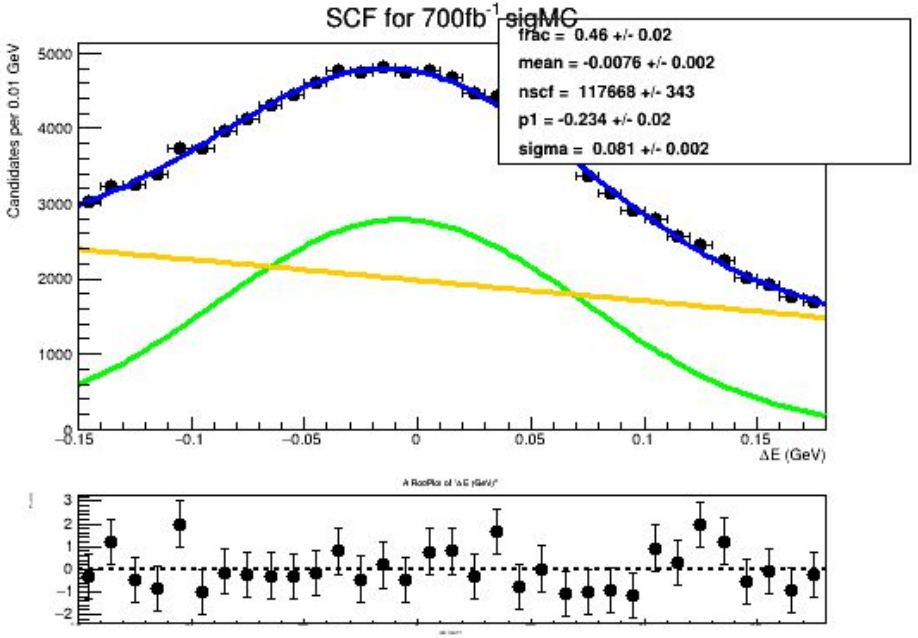
rooChebyshev (2)



rooChebyshev(0) x rooGaussian

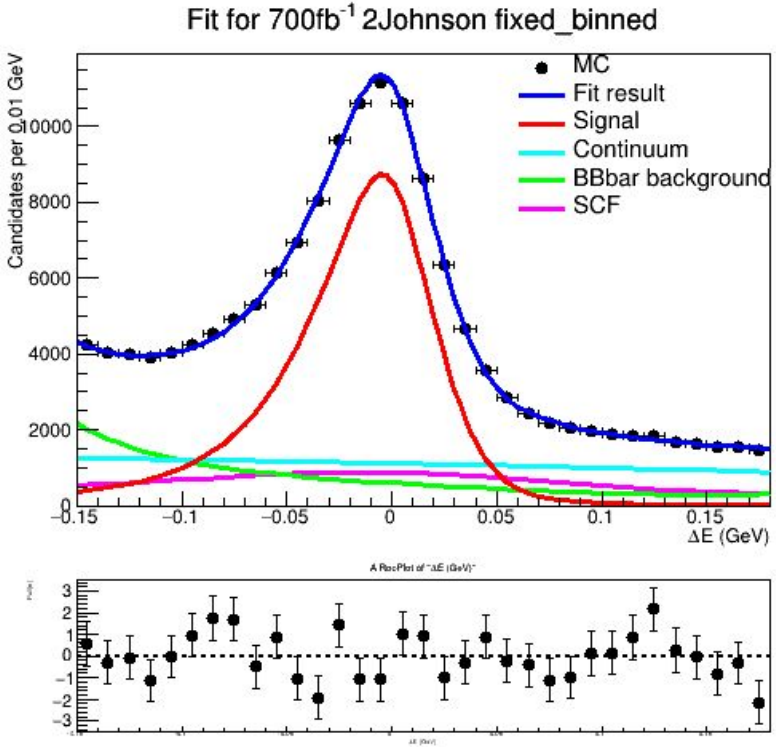
Fit parameters of signal MC for $B \rightarrow D^0 \rho$





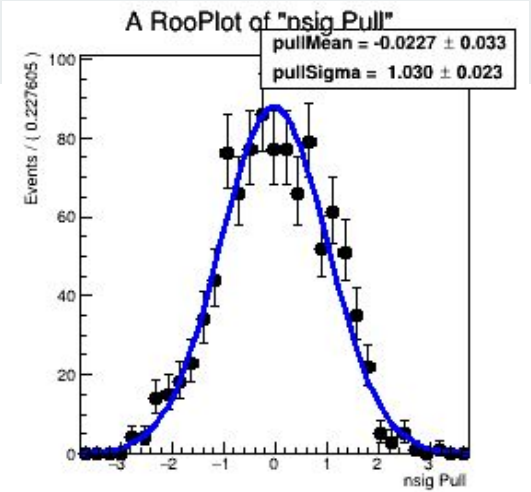
New BBbar parametrization
Signal PDF fixed from GMC

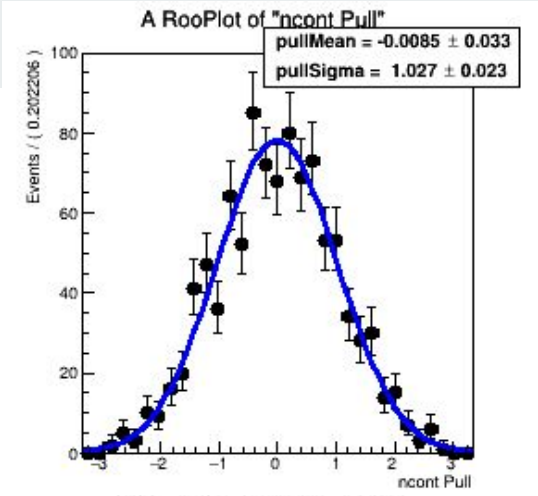
```
FCN=-1.83765e+06 FROM HESSE     STATUS=OK             23 CALLS         159 TOTAL
                     EDM=0.00066996    STRATEGY= 1      ERROR MATRIX ACCURATE
  EXT PARAMETER                                   INTERNAL      INTERNAL
  NO.   NAME      VALUE            ERROR          STEP SIZE       VALUE
   1  nbbbar       2.35989e+04   5.88740e+02   7.87054e-04  -9.35405e-02
   2  ncont        3.42478e+04   1.98056e+03   6.37768e-04   2.14022e-01
   3  nscf         2.34525e+04   2.29988e+03   7.09610e-04  -3.33525e-01
   4  nsig         6.90840e+04   5.67152e+02   3.56222e-04   4.97351e-01
                               ERR DEF= 0.5
EXTERNAL ERROR MATRIX.    NDIM=  25    NPAR=  4    ERR DEF=0.5
 3.468e+05 -2.938e+05 -5.070e+03 -2.435e+04
-2.938e+05  3.936e+06 -4.334e+06  7.259e+05
-5.070e+03 -4.334e+06  5.316e+06 -9.540e+05
-2.435e+04  7.259e+05 -9.540e+05  3.217e+05
PARAMETER  CORRELATION COEFFICIENTS
       NO.  GLOBAL      1      2      3      4
        1  0.84609   1.000 -0.251 -0.004 -0.073
        2  0.98582  -0.251  1.000 -0.947  0.645
        3  0.98786  -0.004 -0.947  1.000 -0.730
        4  0.80766  -0.073  0.645 -0.730  1.000
```

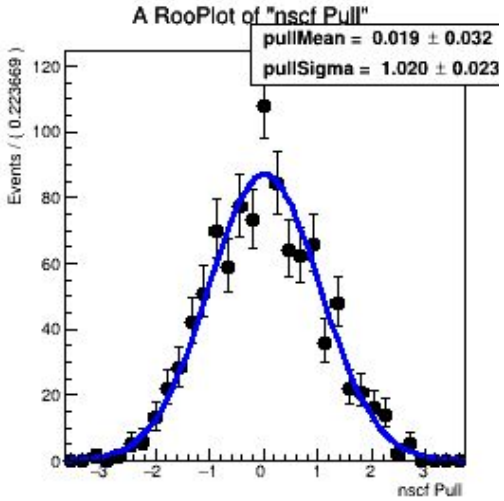


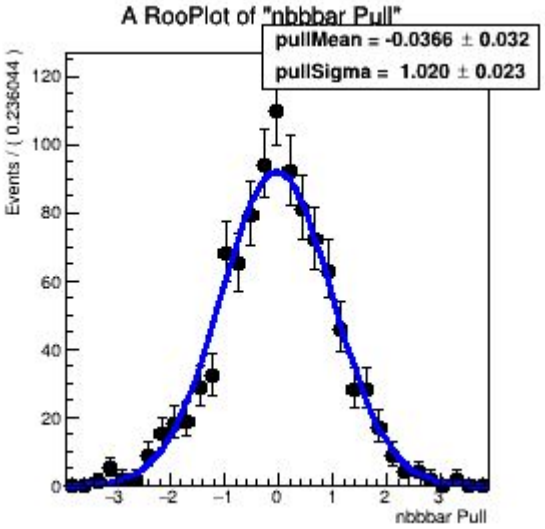
Composition	Nevents	Fraction after fit	σ
Signal	69223	69084 ± 567	-0.2
Continuum	33083	34247 ± 1981	0.6
SCF	24003	23453 ± 2300	-0.2
BB-bar bkg	24070	23599 ± 589	-0.8

TOY MC result



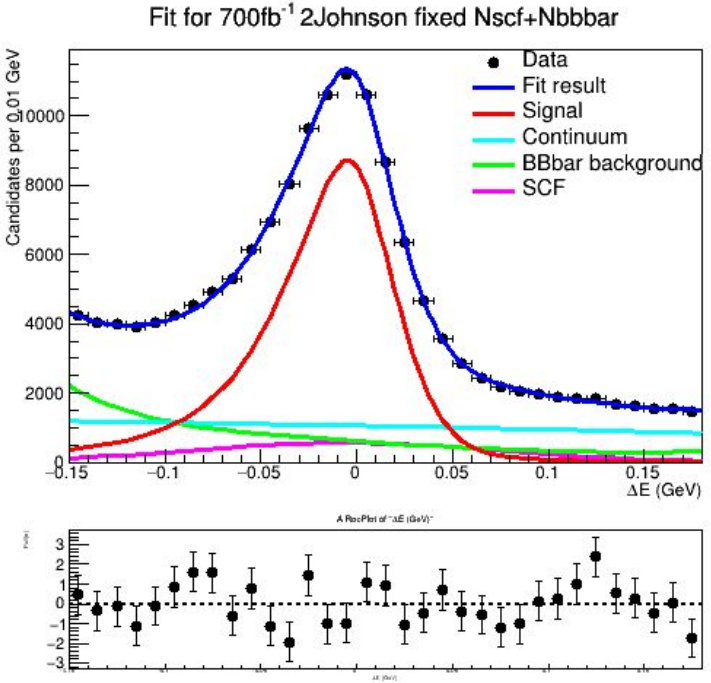






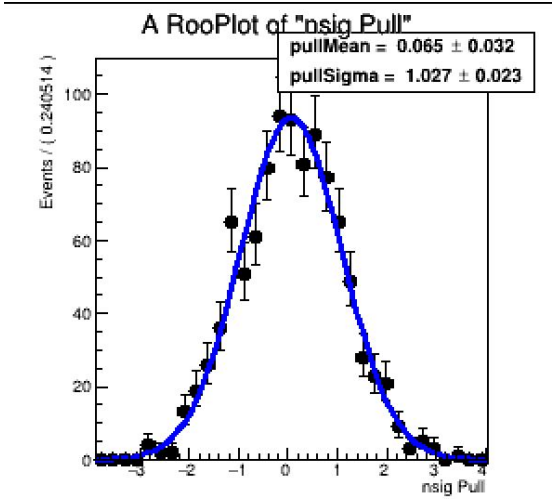
$$Nscf + b\bar{b} = f \cdot PDF_{scf} + (1 - f) \cdot PDF_{b\bar{b}} \qquad f = \frac{N_{SCF}}{N_{b\bar{b}} + N_{SCF}}$$

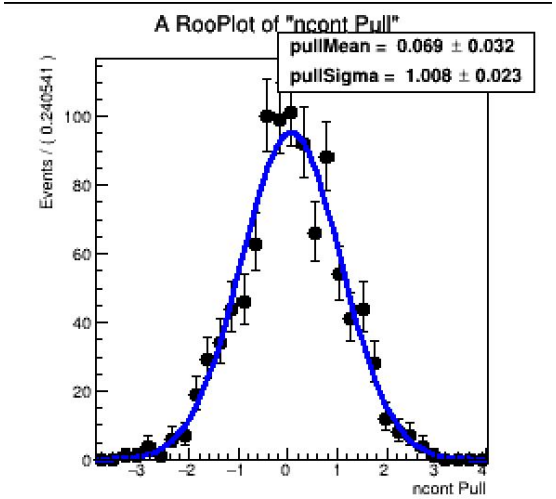
```
FCN=-1.83767e+06 FROM HESSE     STATUS=OK             16 CALLS          93 TOTAL
                     EDM=5.10093e-05    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                   INTERNAL      INTERNAL
 NO.   NAME      VALUE            ERROR          STEP SIZE       VALUE
  1  nbbbar_scf   4.71701e+04   1.13669e+03   5.07974e-04   3.59322e-01
  2  ncont        3.41289e+04   1.02579e+03   7.69649e-04   3.88494e-01
  3  nsig         6.90825e+04   4.11304e+02   4.93490e-04   7.58828e-01
                               ERR DEF= 0.5
EXTERNAL ERROR MATRIX.    NDIM=  25    NPAR=  3    ERR DEF=0.5
 1.293e+06 -1.083e+06 -1.632e+05
-1.083e+06  1.054e+06  6.312e+04
-1.632e+05  6.312e+04  1.692e+05
PARAMETER  CORRELATION COEFFICIENTS
      NO.  GLOBAL      1      2      3
       1  0.95159   1.000 -0.928 -0.349
       2  0.94596  -0.928  1.000  0.150
       3  0.58216  -0.349  0.150  1.000
```

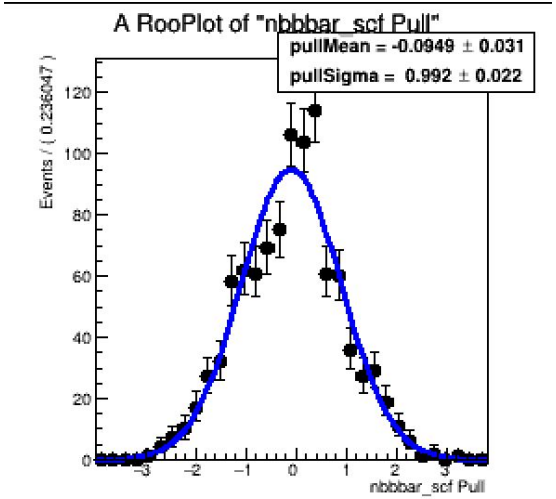


Composition	Nevents	Fraction after fit	σ
Signal	69223	69083 ± 411	-0.4
Continuum	33083	34129 ± 1026	0.5
SCF_BB-bar bkg	48073	47170 ± 1137	-0.8

TOY MC result



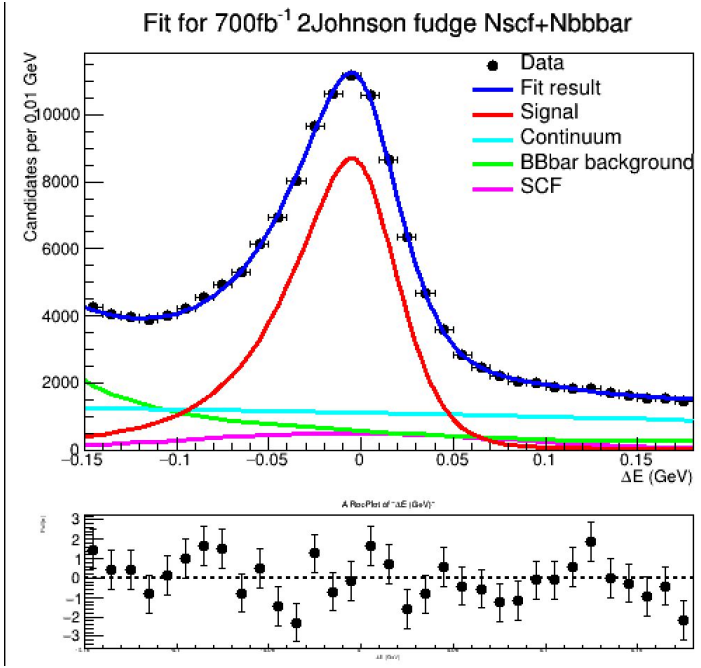




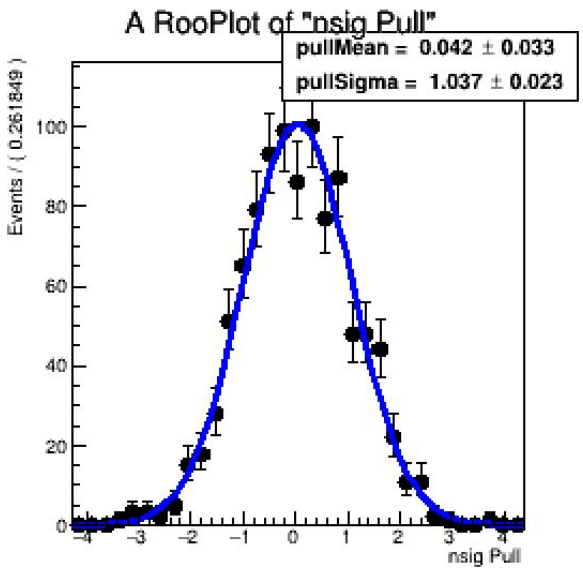
Sig PDF (Johnson + Johnson)	cont PDF (Chebyshev)	SCF PDF (Gauss+Cheb)	BBbar PDF (Exp + Cheb(3))
Sig Yield	**Cont Yield**	**SCF Yield**	**BB Yield**
gamma	Cheb1	mean_scf	beta
delta	Cheb2	sigma_scf **x fudge**	fraction1
lambda **x fudge**		Cheb(0)	Cheb1
frac_sig		frac_scf	Cheb2
mean_sig			Cheb3
gamma1			
delta1			
lambda1			
mean_sig2			

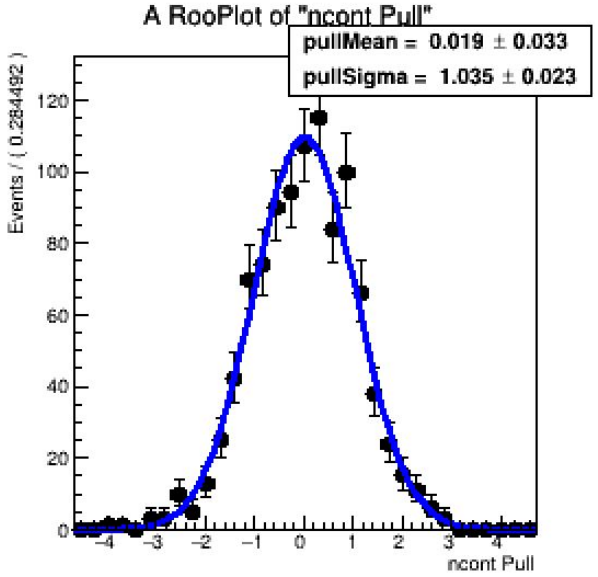
```
COVARIANCE MATRIX CALCULATED SUCCESSFULLY
FCN=-1.83767e+06 FROM HESSE     STATUS=OK             25 CALLS         140 TOTAL
                     EDM=0.00020167    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                   INTERNAL      INTERNAL
 NO.   NAME      VALUE            ERROR          STEP SIZE       VALUE
  1  fudge        1.01331e+00   4.85758e-02   2.41580e-04  -9.22871e-01
  2  nbbbar_scf   4.70140e+04   1.28670e+03   5.06797e-04   3.53267e-01
  3  ncont        3.40566e+04   1.05179e+03   7.68070e-04   3.84030e-01
  4  nsig         6.93087e+04   9.22963e+02   4.97599e-04   7.67772e-01
                               ERR DEF= 0.5
EXTERNAL ERROR MATRIX.    NDIM=  25    NPAR=  4    ERR DEF=0.5
 2.360e-03 -2.929e+01 -1.087e+01  4.015e+01
-2.929e+01  1.657e+06 -9.503e+05 -6.596e+05
-1.087e+01 -9.503e+05  1.108e+06 -1.234e+05
 4.015e+01 -6.596e+05 -1.234e+05  8.522e+05
PARAMETER  CORRELATION COEFFICIENTS
       NO.  GLOBAL      1      2      3      4
        1  0.91613   1.000 -0.468 -0.213  0.895
        2  0.96250  -0.468  1.000 -0.701 -0.555
        3  0.94868  -0.213 -0.701  1.000 -0.127
        4  0.93197   0.895 -0.555 -0.127  1.000
```

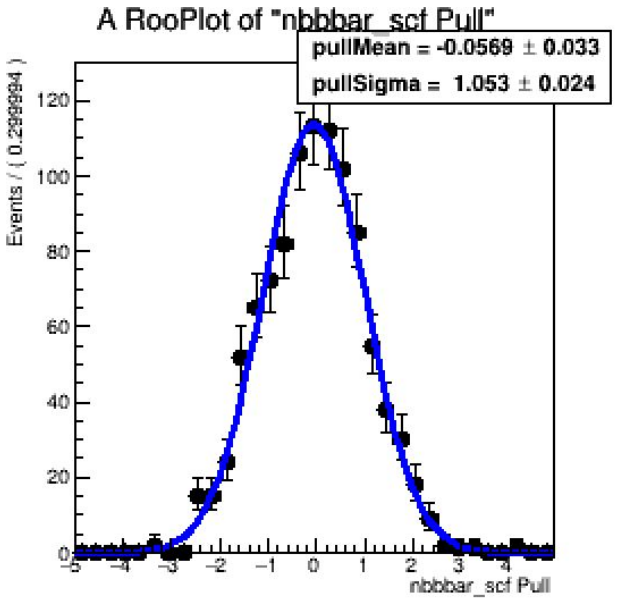
Composition	Nevents	Fraction after fit	σ
Signal	69223	69309 ± 923	0.1
Continuum	33083	34057 ± 1052	0.9
SCF_BB-bar bkg	48073	47014 ± 1287	-0.8



TOY MC result

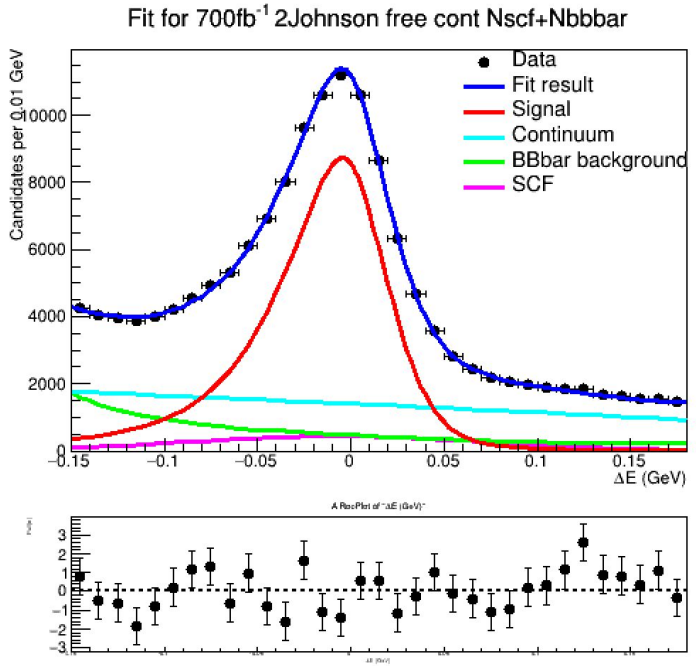






Sig PDF (Johnson + Johnson)	cont PDF (Chebyshev)	SCF PDF (Gauss+Cheb)	BBbar PDF (Exp + Cheb(3))
Sig Yield	**Cont Yield**	**SCF Yield**	**BB Yield**
gamma	Cheb1 **free**	mean_scf	beta
delta	Cheb2 **free**	sigma_scf **x fudge**	fraction1
lambda **x fudge**		Cheb(0)	Cheb1
frac_sig		frac_scf	Cheb2
mean_sig			Cheb3
gamma1			
delta1			
lambda1			
mean_sig2			

```
FCN=-1.83765e+06 FROM HESSE     STATUS=OK             52 CALLS        1125 TOTAL
                     EDM=0.000256094    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                   INTERNAL      INTERNAL
 NO.   NAME      VALUE            ERROR          STEP SIZE       VALUE
  1  fudge        9.92903e-01   7.53226e-03   1.67693e-03  -9.29665e-01
  2  nbbbar_scf   3.68513e+04   6.63765e+02   1.19044e-02  -2.35912e-02
  3  ncont        4.47758e+04   4.11900e+02   1.07730e-01   1.41055e+00
  4  nsig         6.87505e+04   5.99087e+02   1.21526e-02   7.45836e-01
  5  p1          -2.87208e-01   1.19781e-02   1.07017e-02  -2.91311e-01
  6  p2          -4.79877e-03   1.41457e-02   1.11069e-02  -4.79879e-03
                               ERR DEF= 0.5
EXTERNAL ERROR MATRIX.    NDIM=  25    NPAR=  6    ERR DEF=0.5
 5.674e-05 -2.770e+00 -8.429e-02  2.852e+00  2.701e-05  1.041e-05
-2.770e+00  4.407e+05 -1.097e+05 -2.868e+05 -7.816e-01 -3.714e+00
-8.429e-02 -1.097e+05  1.709e+05 -3.714e+03 -9.785e-01  8.634e-02
 2.852e+00 -2.868e+05 -3.714e+03  3.590e+05  1.811e+00  3.611e+00
 2.701e-05 -7.816e-01 -9.785e-01  1.811e+00  1.435e-04 -1.559e-05
 1.041e-05 -3.714e+00  8.634e-02  3.611e+00 -1.559e-05  2.001e-04
PARAMETER  CORRELATION COEFFICIENTS
       NO.  GLOBAL      1      2      3      4      5      6
        1  0.70293   1.000 -0.554 -0.027  0.632  0.299  0.098
        2  0.85006  -0.554  1.000 -0.400 -0.721 -0.098 -0.396
        3  0.62726  -0.027 -0.400  1.000 -0.015 -0.198  0.015
        4  0.83046   0.632 -0.721 -0.015  1.000  0.252  0.426
        5  0.40528   0.299 -0.098 -0.198  0.252  1.000 -0.092
        6  0.54454   0.098 -0.396  0.015  0.426 -0.092  1.000
```



Composition	Nevents	Fraction after fit	σ
Signal	69223	68751 ± 599	-0.8
Continuum	33083	44776 ± 412	28.4
SCF_BB-bar bkg	48073	36851 ± 664	-16.9