



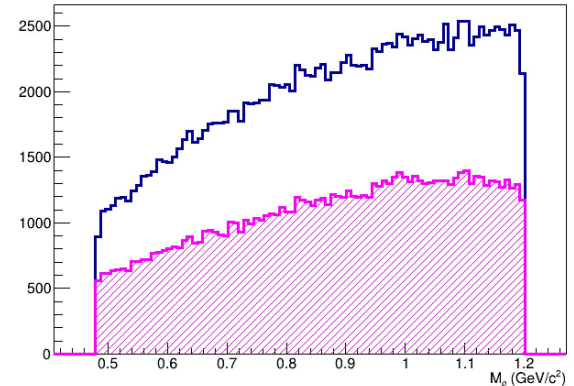
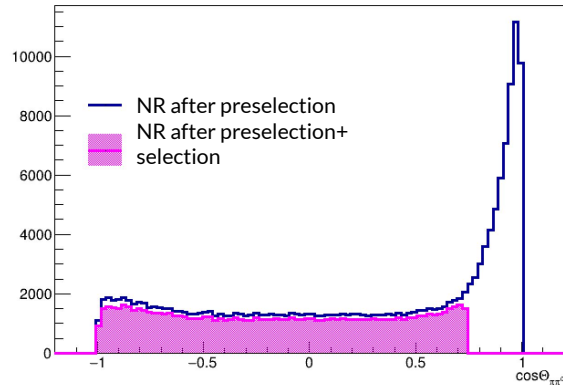
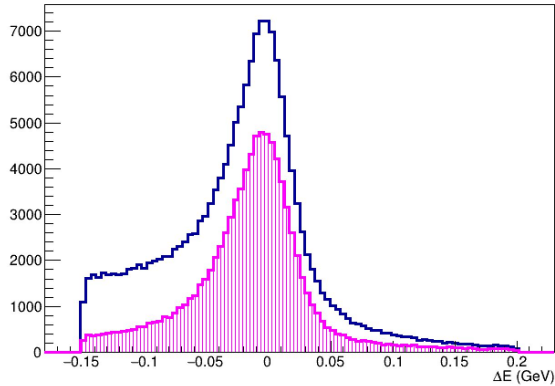
Toward $\mathcal{B}(B \rightarrow D^0 \rho)$

TS analysis meeting
august 2022

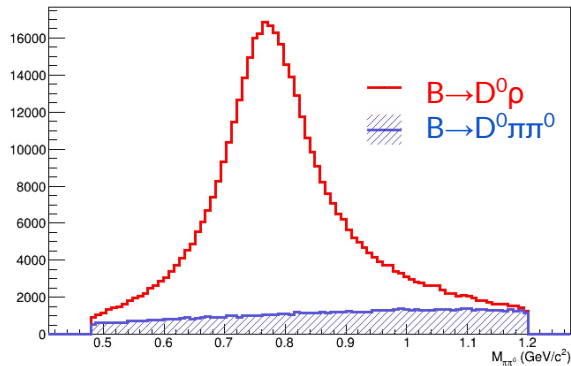
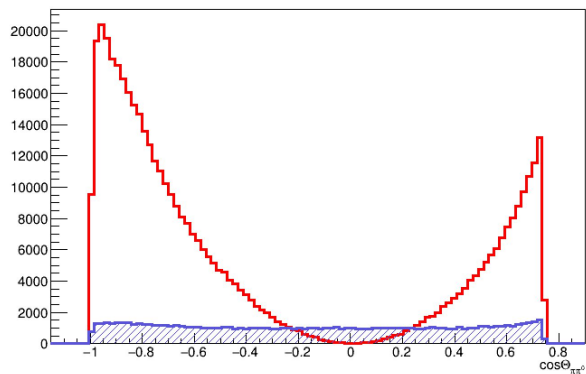
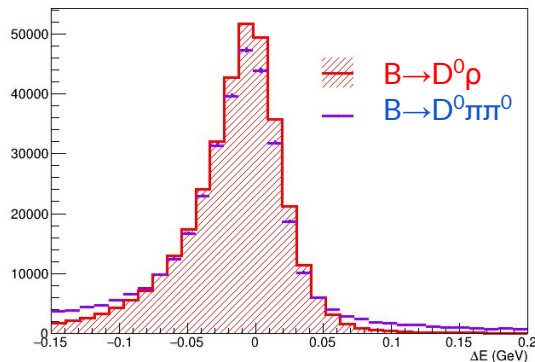
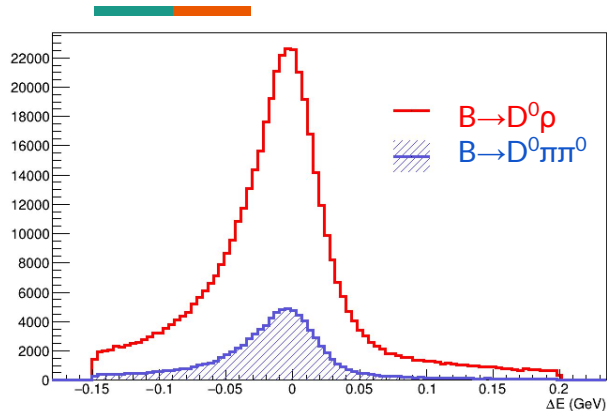
Mirco Dorigo
Riccardo Manfredi
Olga Werbycka

Efficiency for non-resonant decay $B \rightarrow D^0 \pi \pi^0$

	After preselection	After preselection + selection
NR eff (ϵ)	$\sim 8.4\%$	$\sim 4.5\%$



Comparison of resonant and NR signal MC



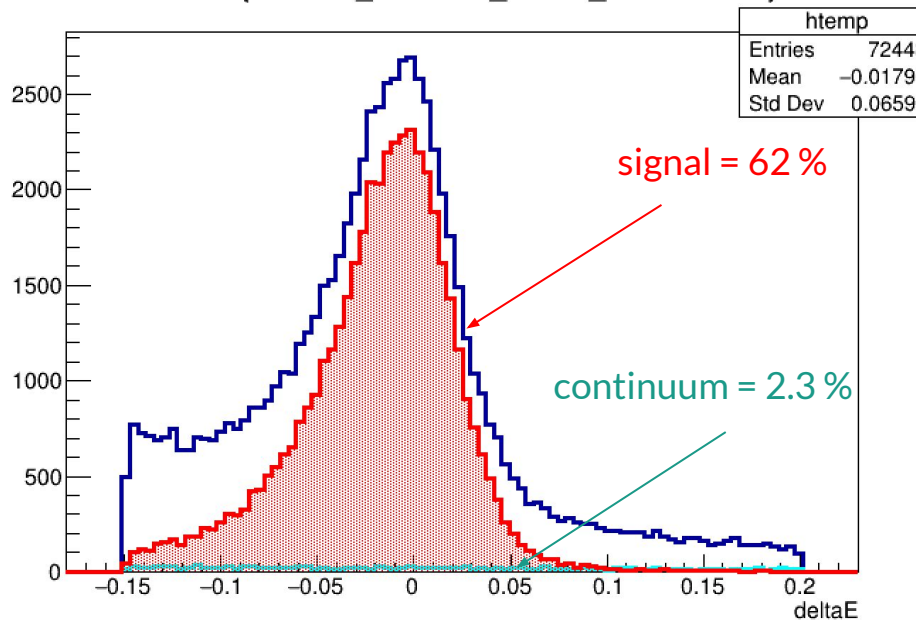


Change of Strategy

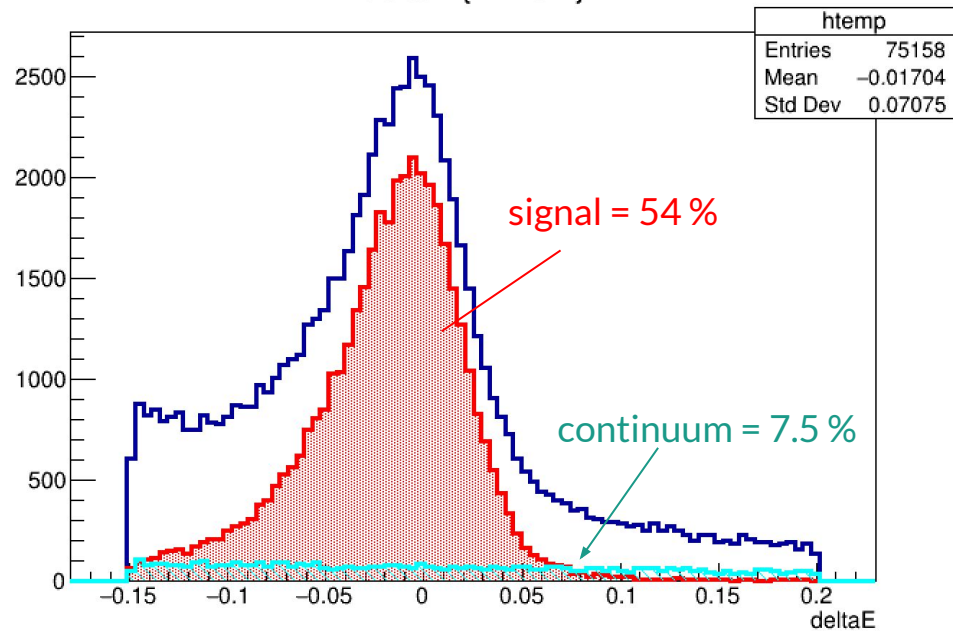
- Revision of the selection criteria in order to get rid of the continuum background
- Imposing mass cut on the p
- Using $B \rightarrow D^0 \pi$ as a control channel

Possibilities to reduce continuum background

deltaE {CSMVA_WithCorr_Flavor_Vertex>0.95}



deltaE {R2<0.2}

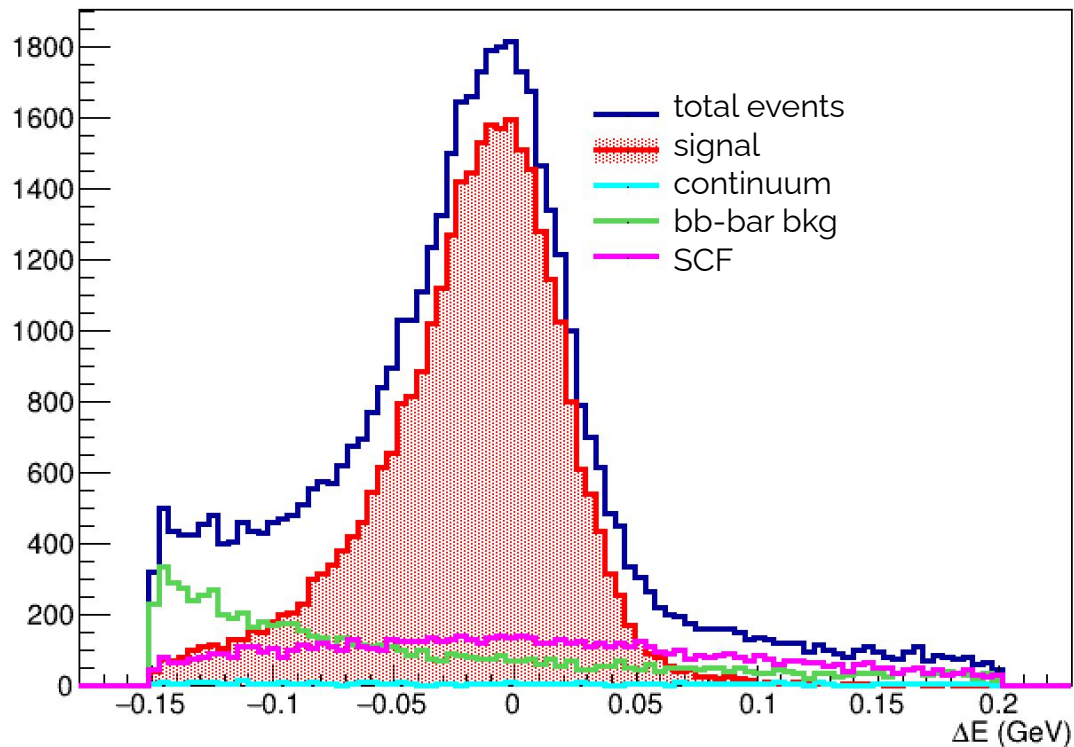


Signal efficiency vs Continuum background rejection



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

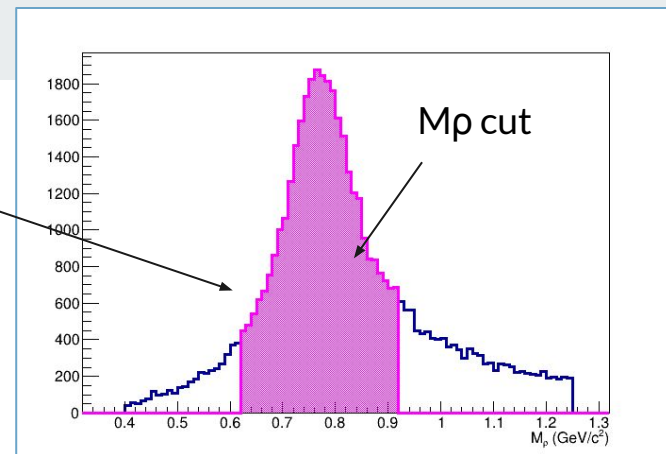
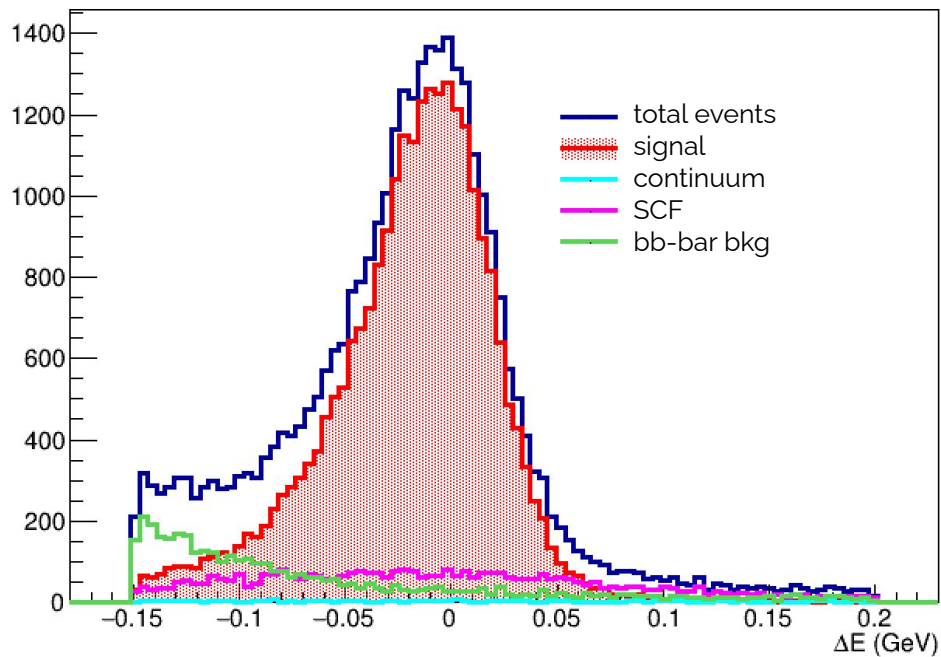


Composition	Nevents	Fraction
Signal	31375	0.66
Continuum	429	0.009
SCF	7816	0.16
BB-bar bkg	7751	0.17
Total events	47371	1.0

MC14_{ri} 700fb⁻¹

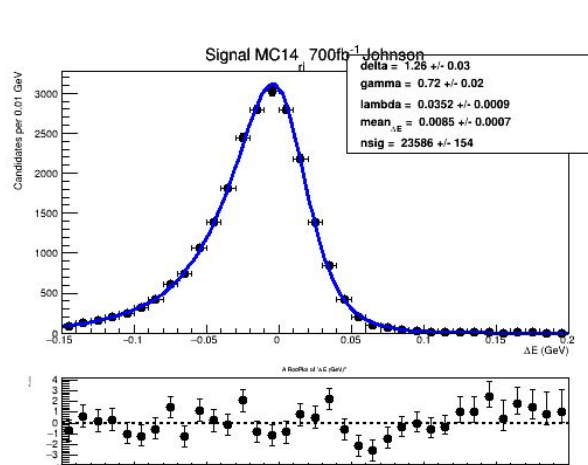
$$abs(M_\rho - 0.77) < 0.15$$

deltaE {CSMVA_WithCorr_Flavor_Vertex>0.98&&abs(rho_InvM-0.77)<0.15}

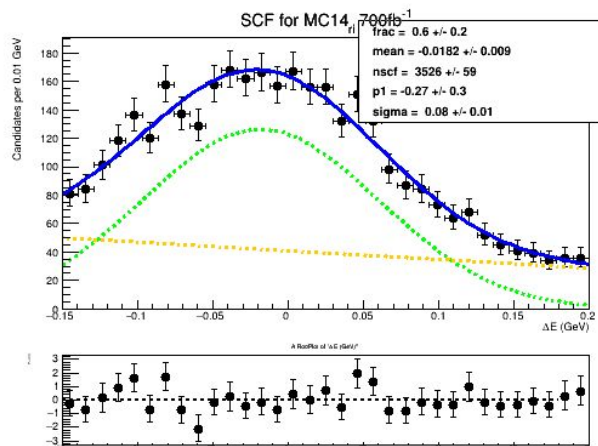


Composition	Nevents	Fraction
Signal	23586	0.76
Continuum	155	0.005
SCF	3526	0.114
BB-bar bkg	3816	0.12
Total events	30928	1.0

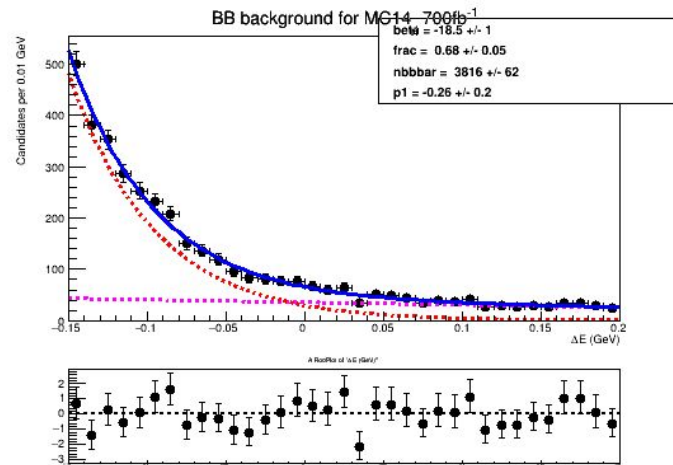
Fitting parameters



RooJohnson

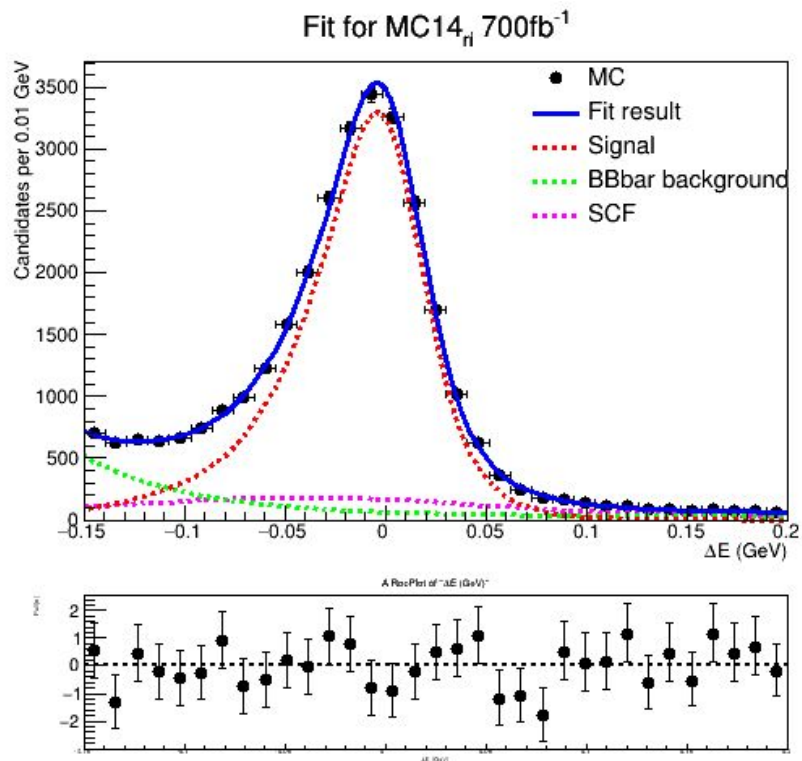


RooGaussian x
RooChebyshev(1)



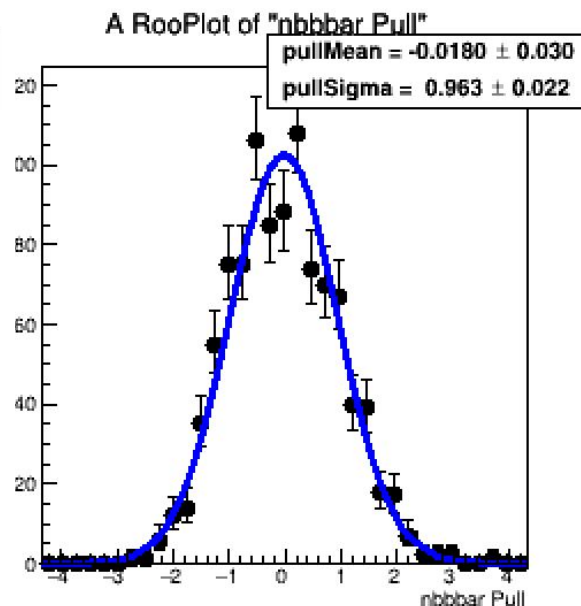
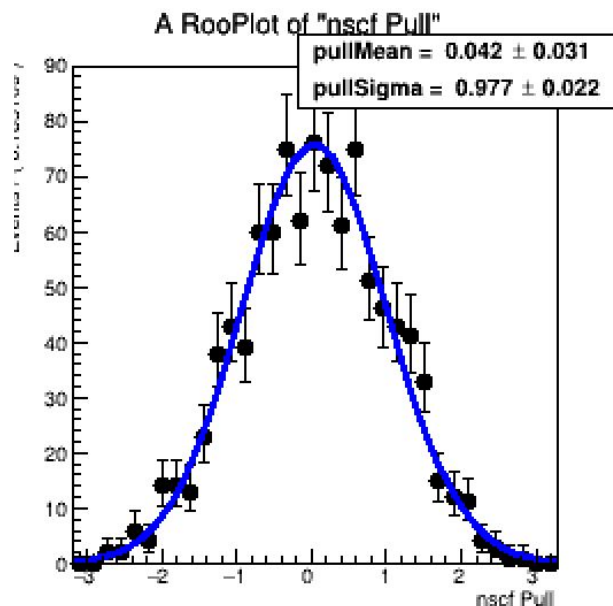
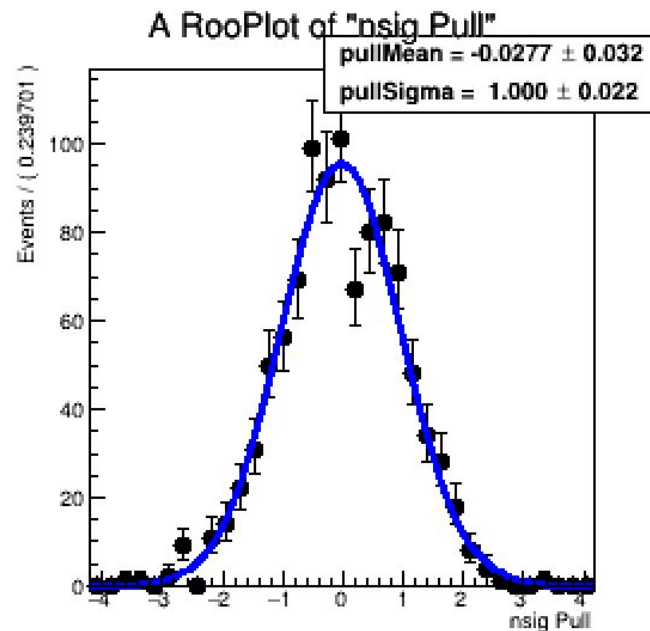
RooExponential x
RooChebyshev(1)

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





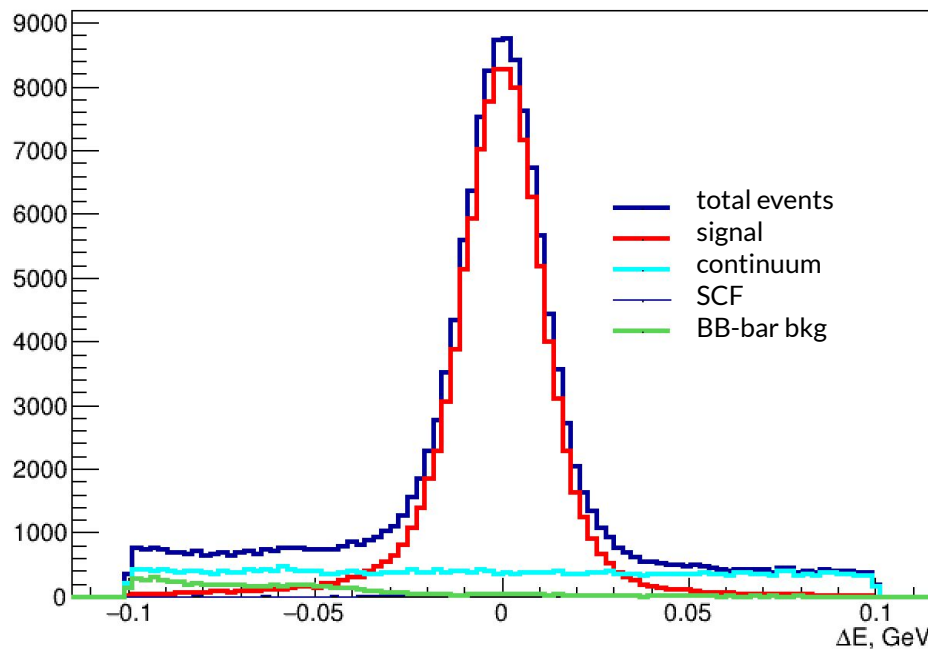
Control channel study

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

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

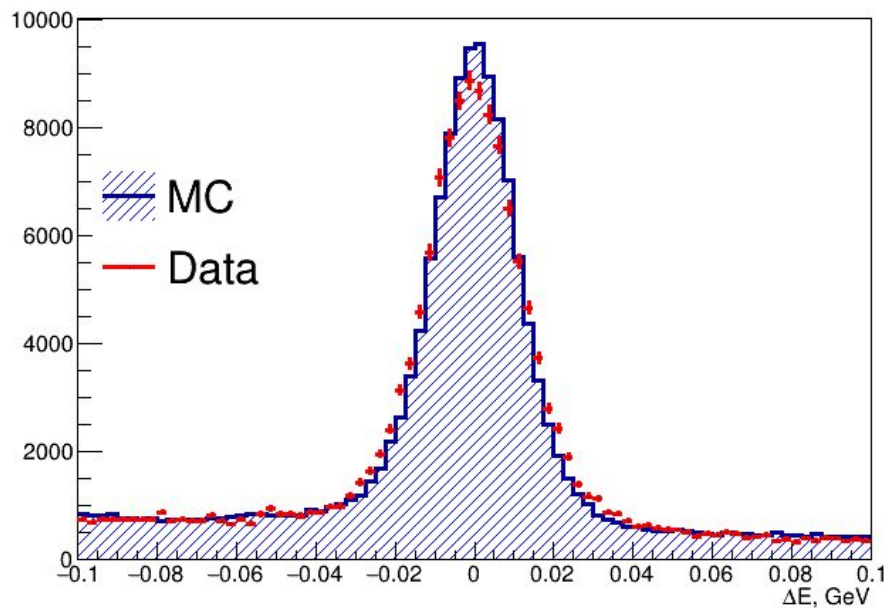
Cuts applied:

- $M_{bc} > 5.27$
- $abs(\Delta E) < 0.1$
- binary pion PID > 0.2



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

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

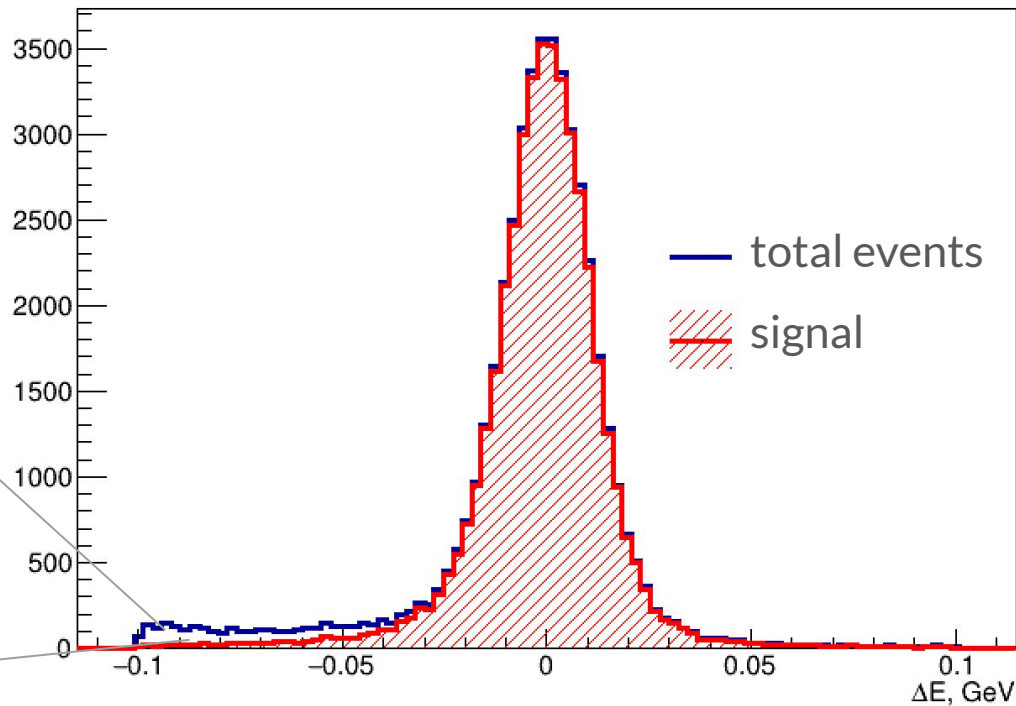
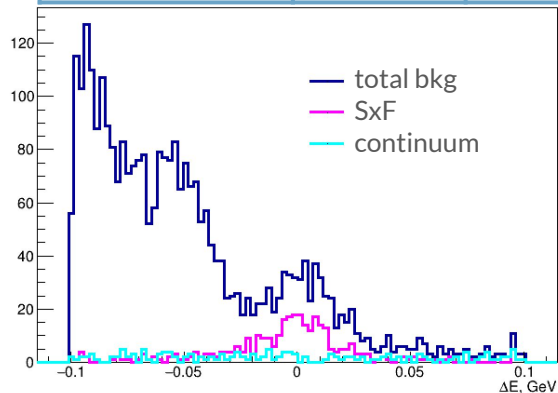


Cuts applied:

- $M_{bc} > 5.27$
- $abs(\Delta E) < 0.1$
- binary pion PID > 0.2
- binary kaon PID < 0.8

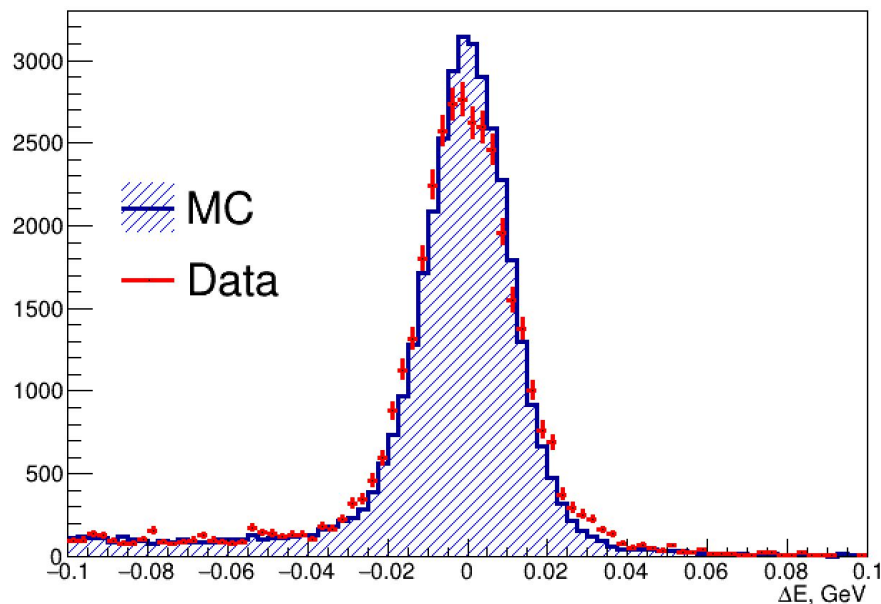
Control channel $B^+ \rightarrow D^0 \pi^+$ MC15_{ri} with CSMVA cut applied

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



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

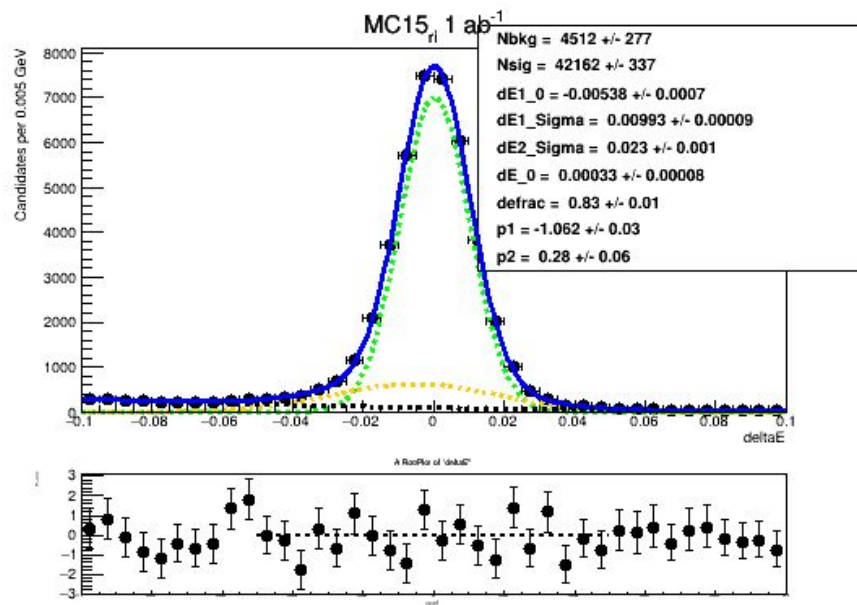
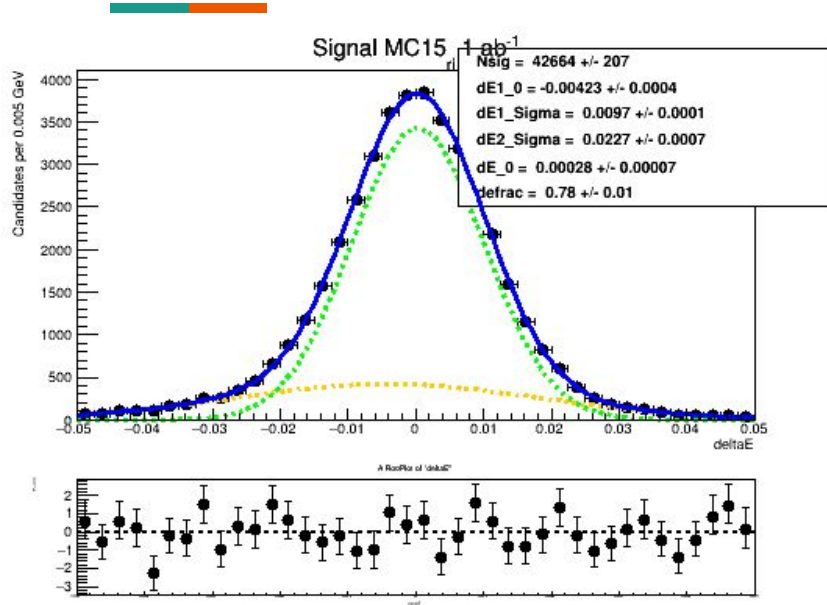
$$BF(B^+ \rightarrow D^0 \pi^+) = (4.81 \pm 0.15) \times 10^{-3}$$



Cuts applied:

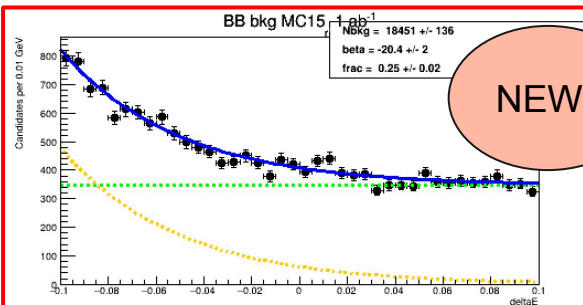
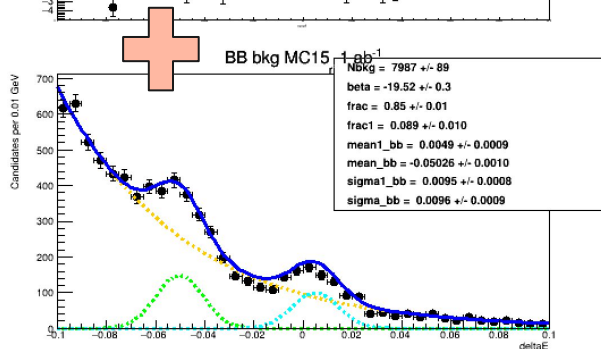
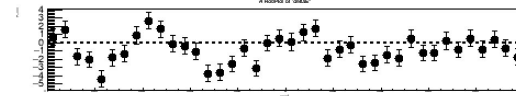
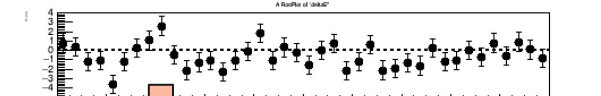
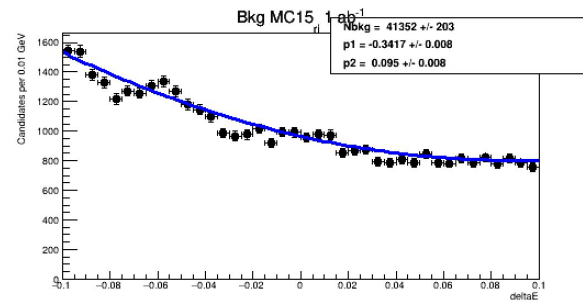
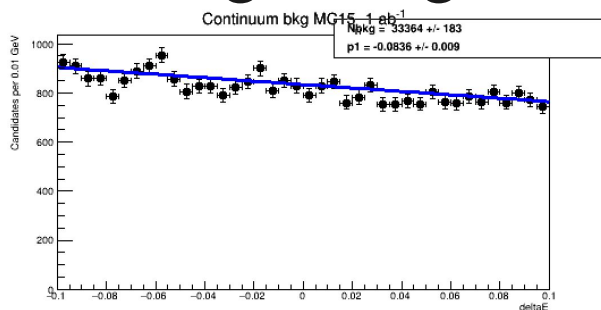
- $M_{bc} > 5.27$
- $abs(\Delta E) < 0.1$
- $CSMVA > 0.98$
- $1.85 < m(K\pi) < 1.88 (\sim 3\sigma) \text{ GeV}$
- binary kaon PID from $D^0 > 0.2$
- binary pion PID from $D^0 < 0.8$
- binary pion PID > 0.2
- binary kaon PID < 0.8

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

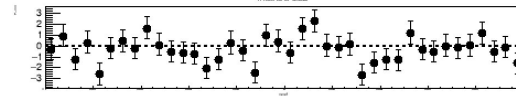
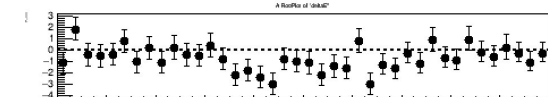


Composition	Nevents	SignalMC	Signal Yield	σ
Signal	43629	42664 ± 207	42162 ± 337	4.4

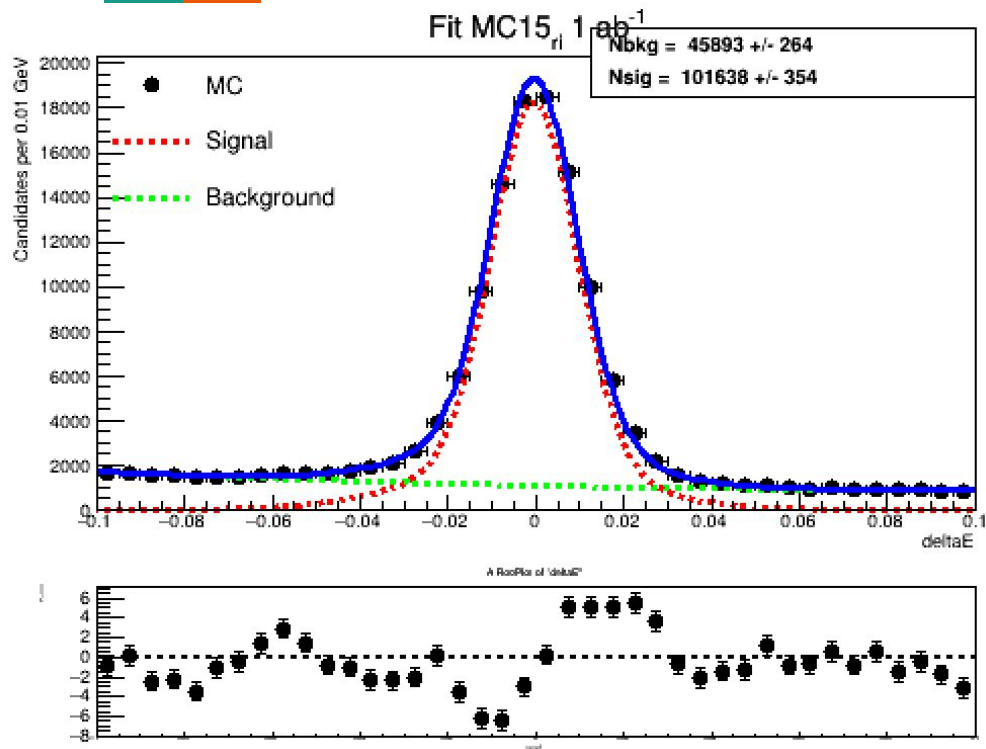
Fitting background MC $B^+ \rightarrow D^0 \pi^+$ (without CSMVA cut)



NEW

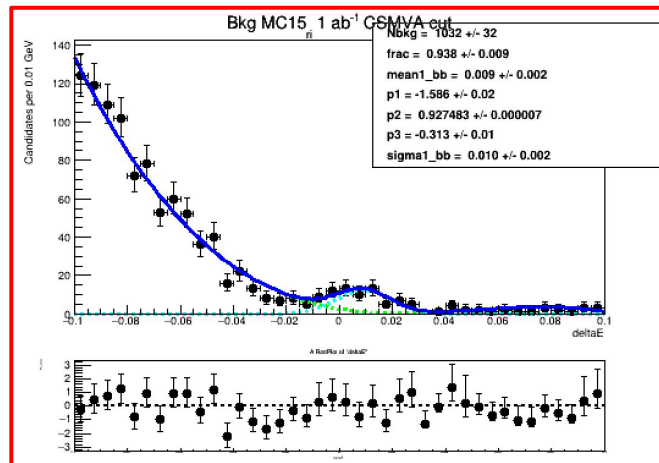
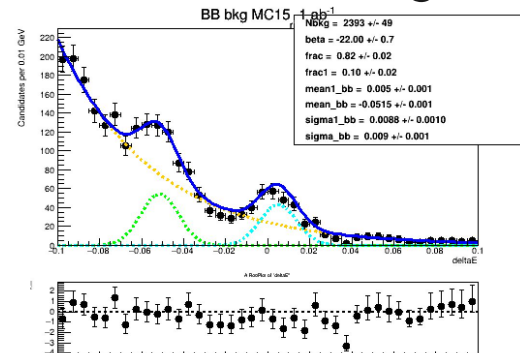
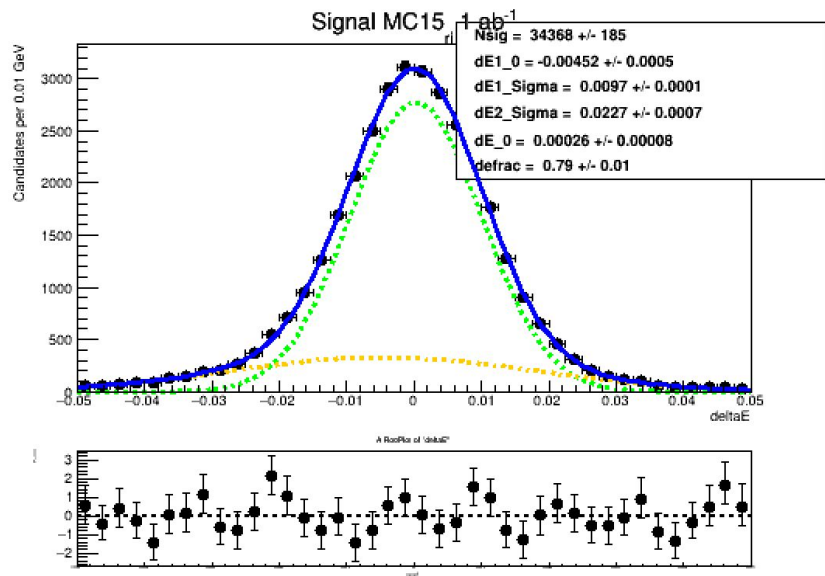


Fit MC $B^+ \rightarrow D^0 \pi^+$ with fixed parameters and without CSMVA cut

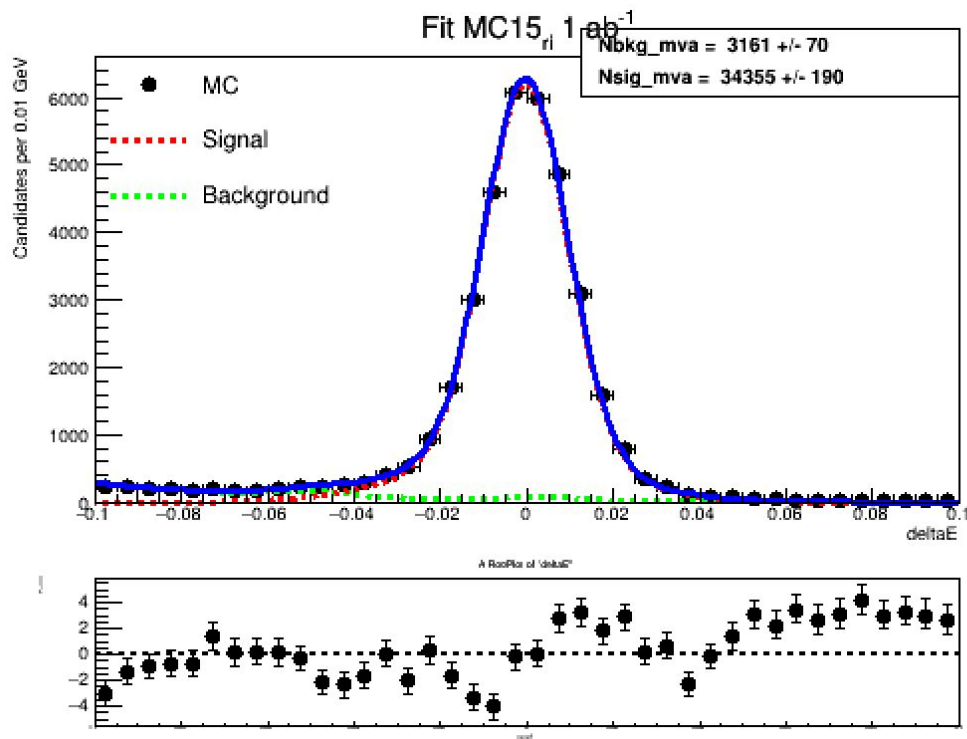


Composition	Nevents	σ
Signal	106178	> 10
Background	33364	> 10

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



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



Composition	Nevents	σ
Signal	35123	4.0
Background	2393	11

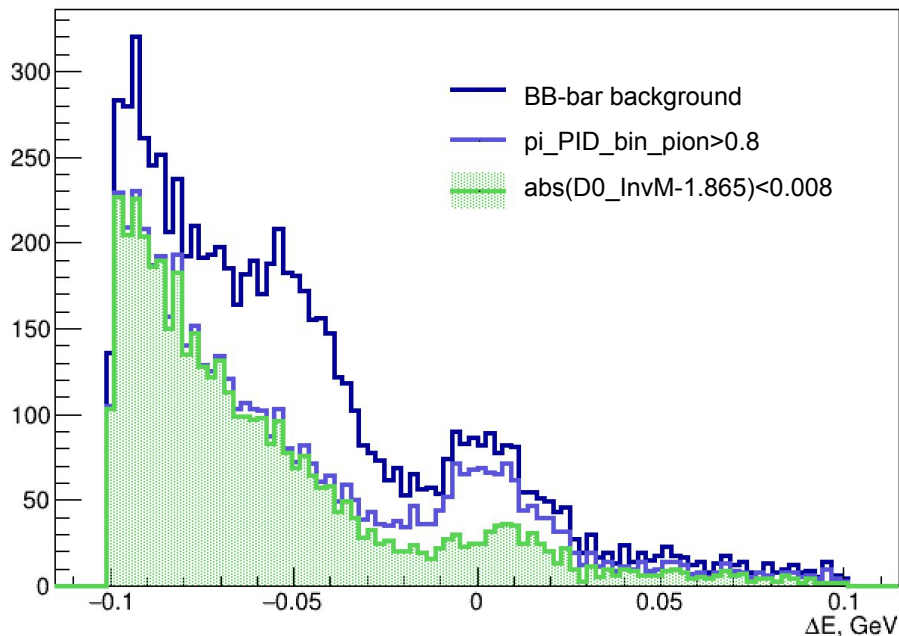
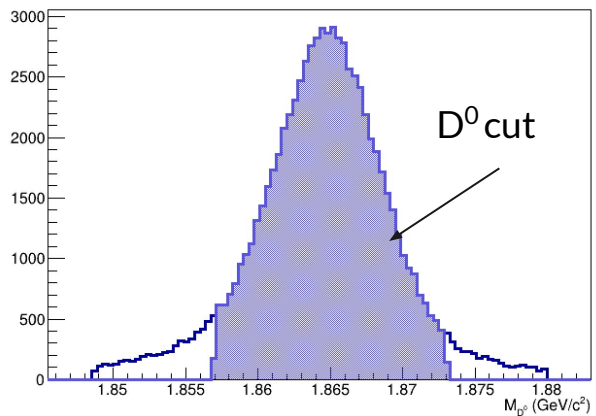


NEW cuts

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

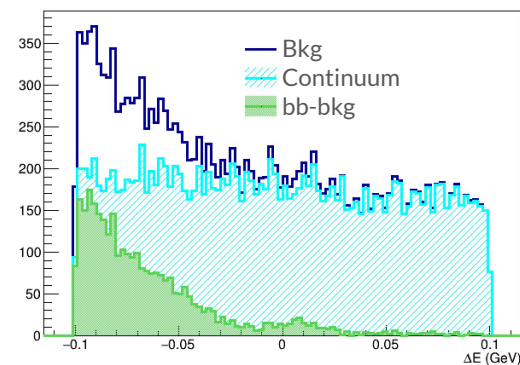
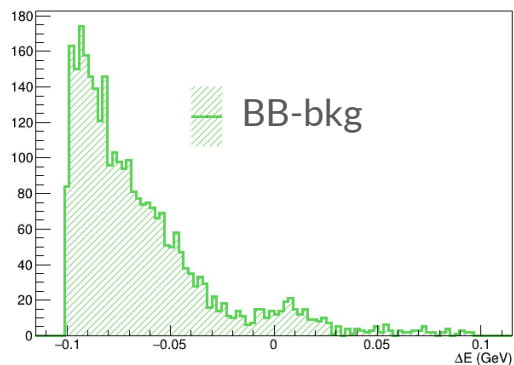
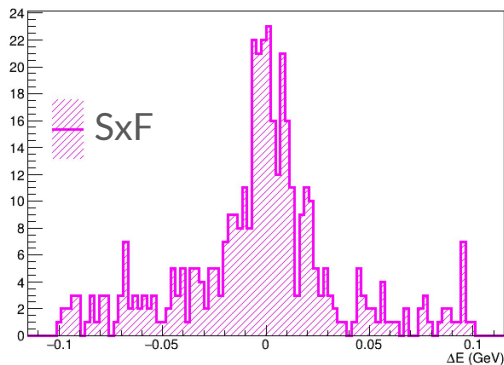
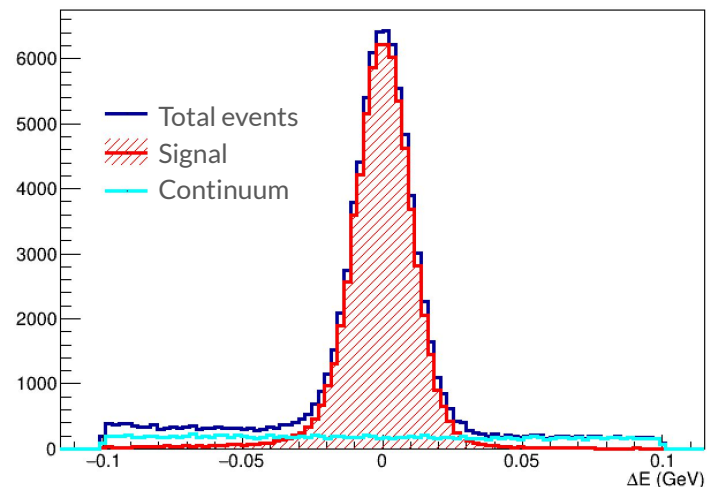
Cuts applied:

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

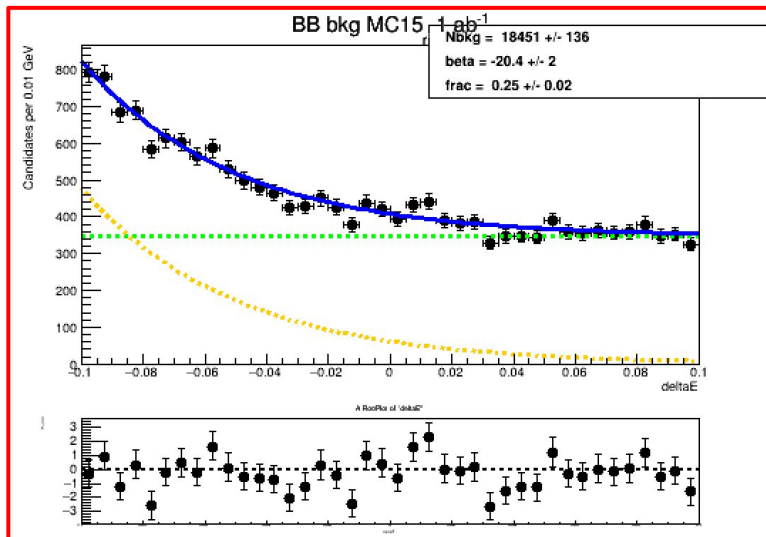
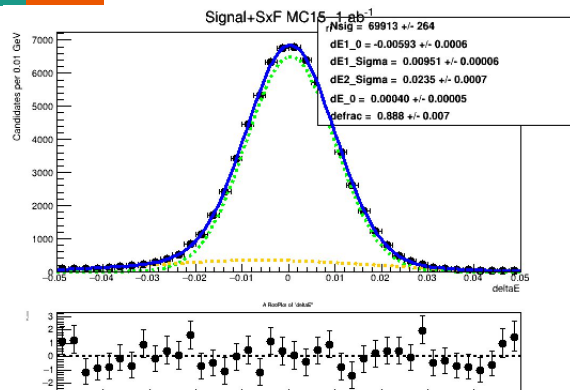


MC sample composition after new cuts

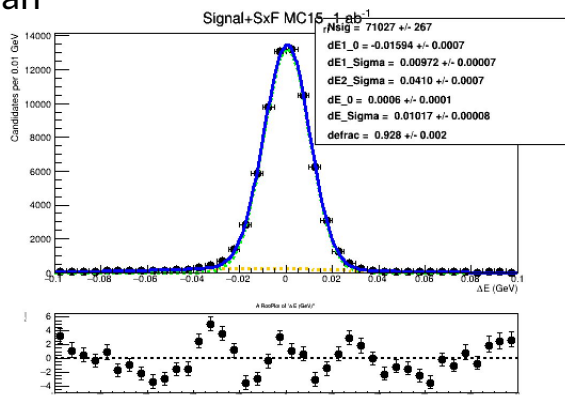
Composition	Nevents	
Signal	70618	0.789
Continuum	15388	0.172
SCF	409	0.005
BB-bar bkg	3063	0.034



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

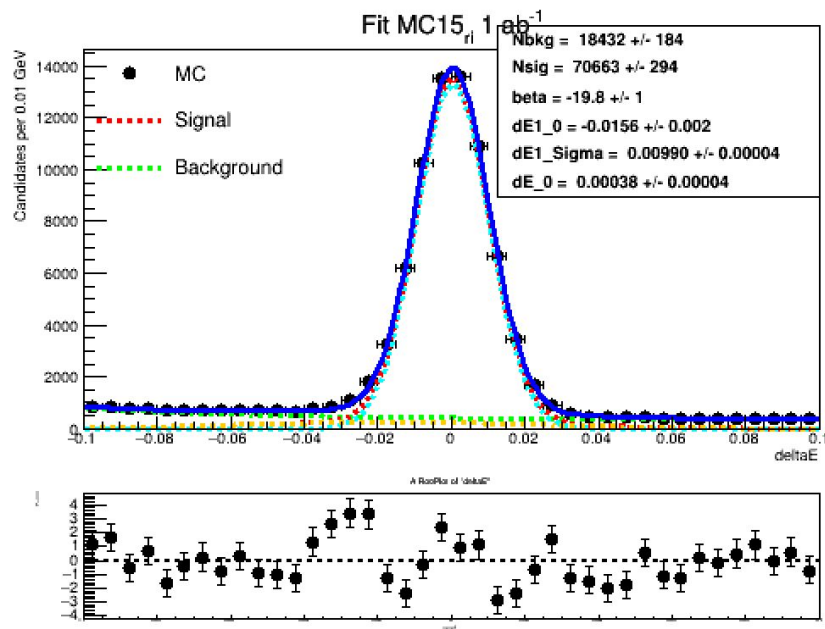


2x RooGaussian

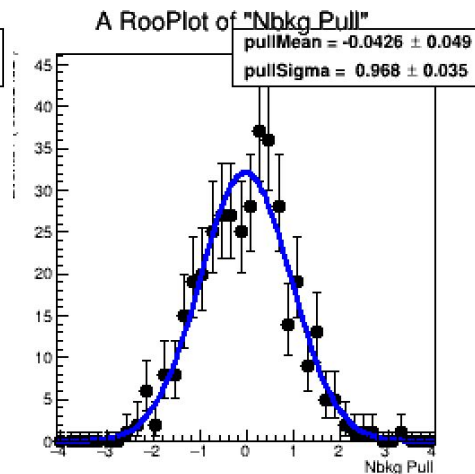
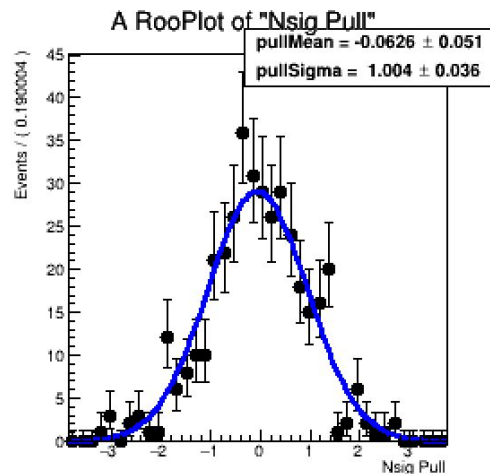


RooExponential x Cheb(0)

TOY for fit without CS cut



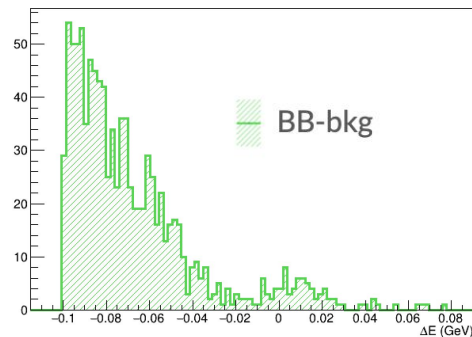
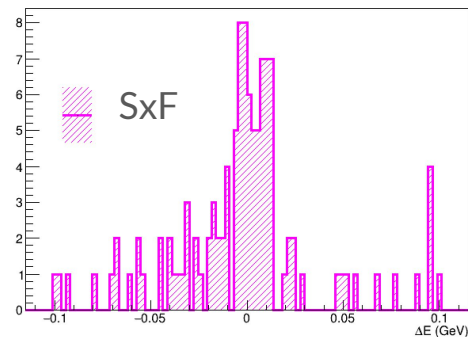
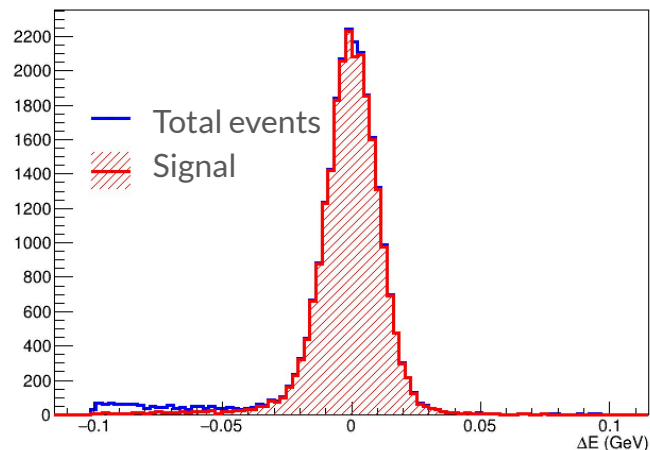
Free: exp(beta), mean1, mean2, sigma1



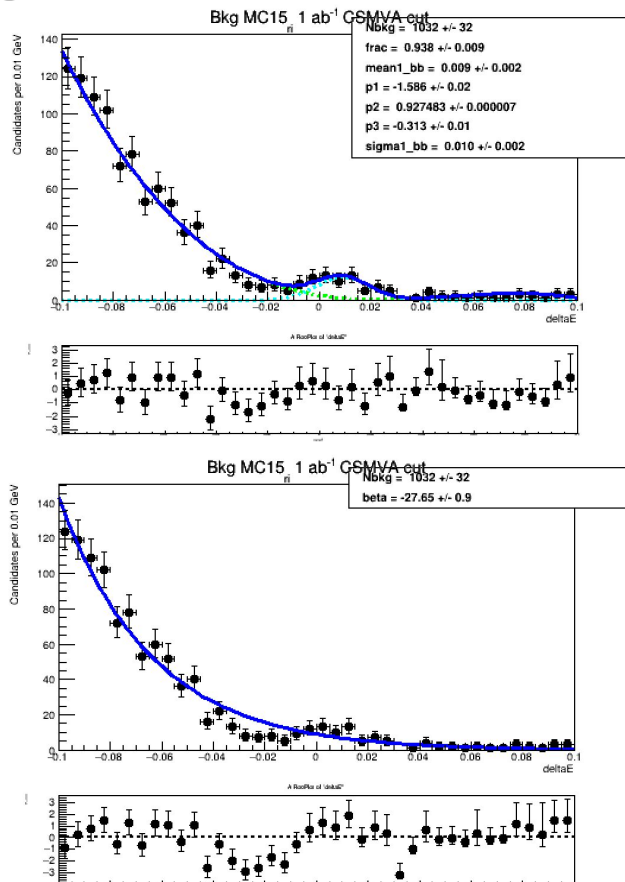
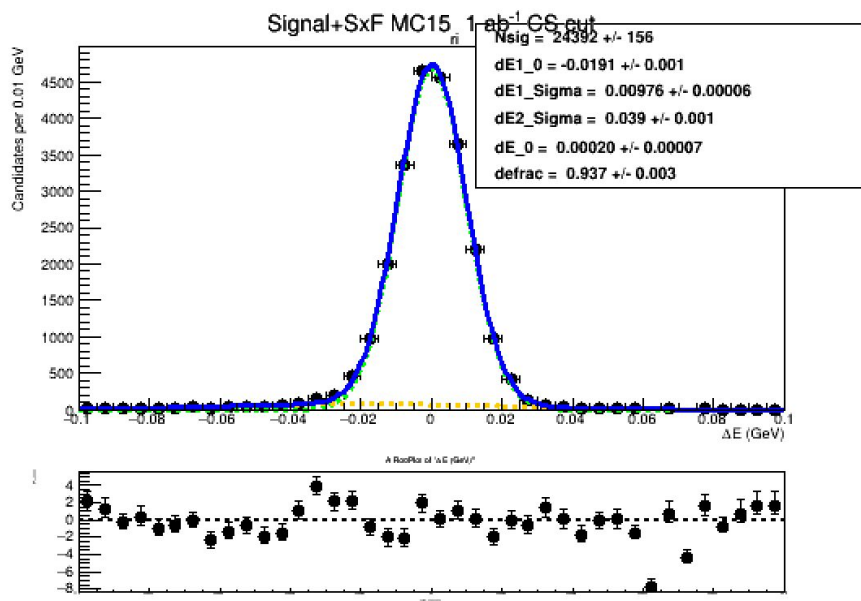
Composition	Nevents	σ
Signal + SxF	71027	1.9
Background	18451	0.1

MC sample composition after new cuts + CS cut

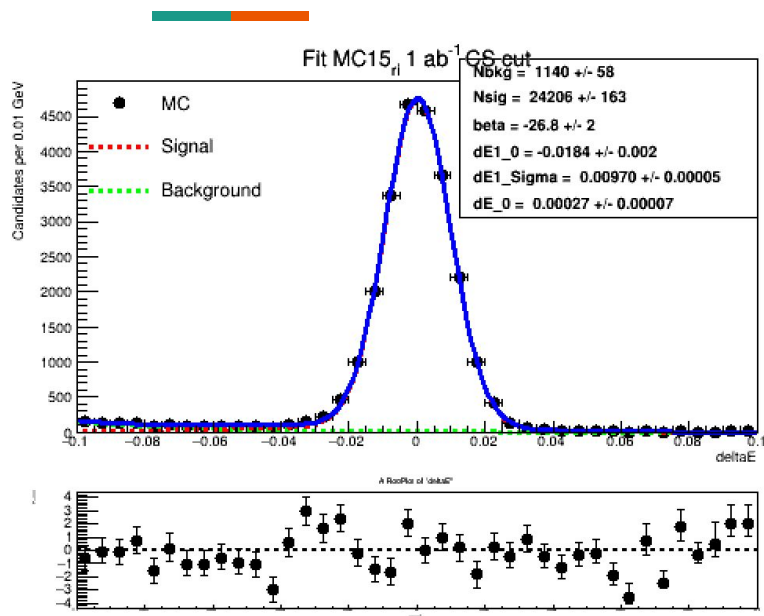
Composition	Nevents	
Signal	24279	0.955
Continuum	45	0.002
SCF	113	0.004
BB-bar bkg	987	0.039



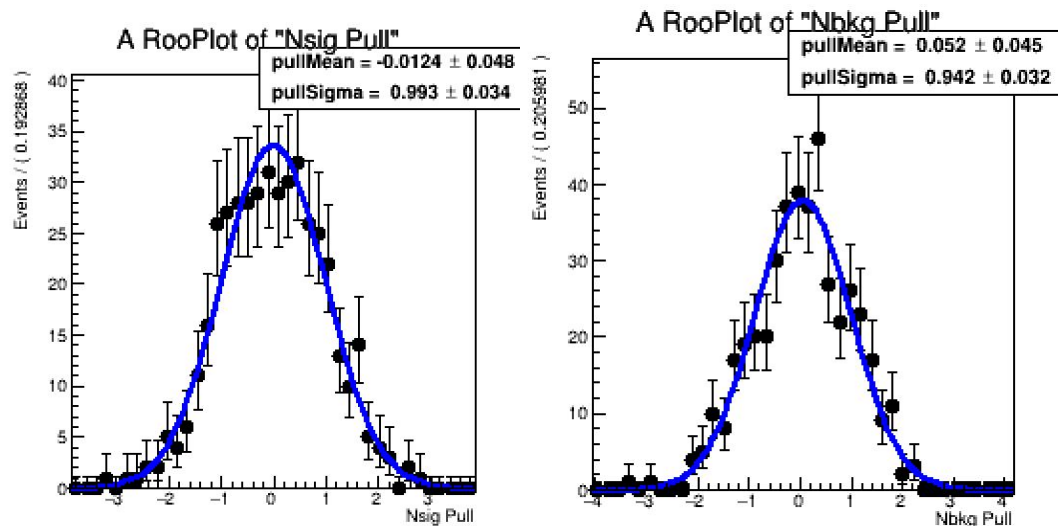
Fit parameters for MC $B^+ \rightarrow D^0 \pi^+$ Signal + SxF with CS cut



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



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



Composition	Nevents	σ
Signal + SxF	24392	1.9
Background	1032	0.1

Efficiency before CSMVA > 0.98 cut


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

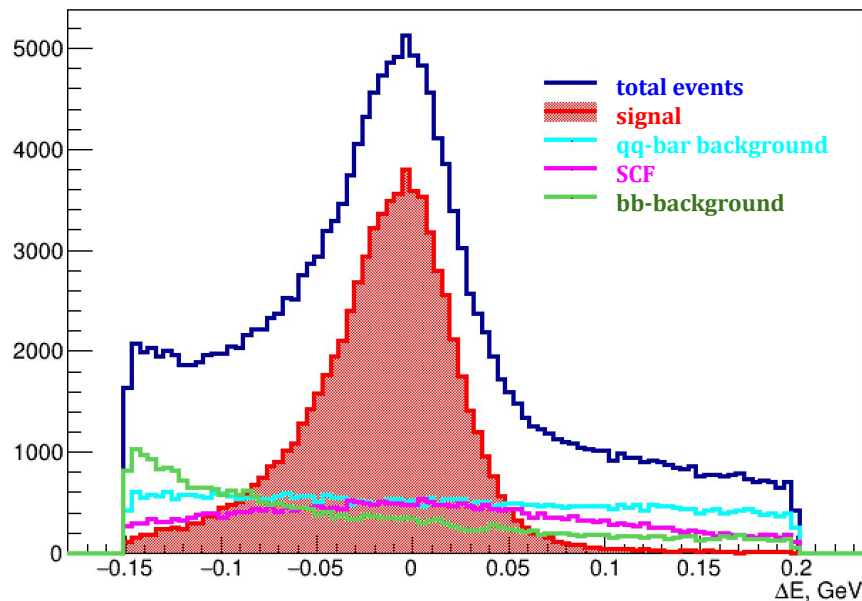
Efficiency of CSMVA > 0.98 cut

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



Backup

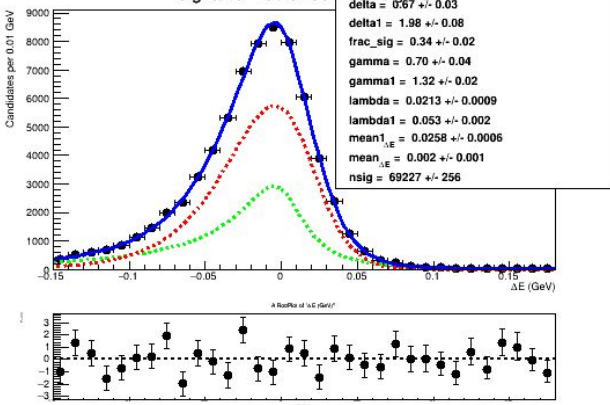
ΔE fit for MC14_{ri} 700 fb⁻¹



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

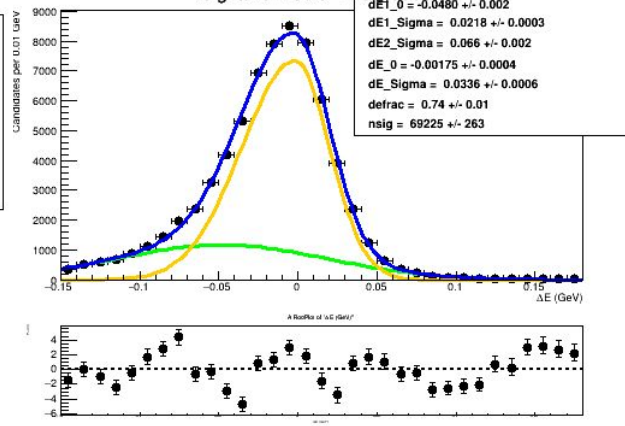
Fits for signal ΔE (MC14_{ri} 700 fb⁻¹)

Signal for 700fb⁻¹ Johnson-sigMC



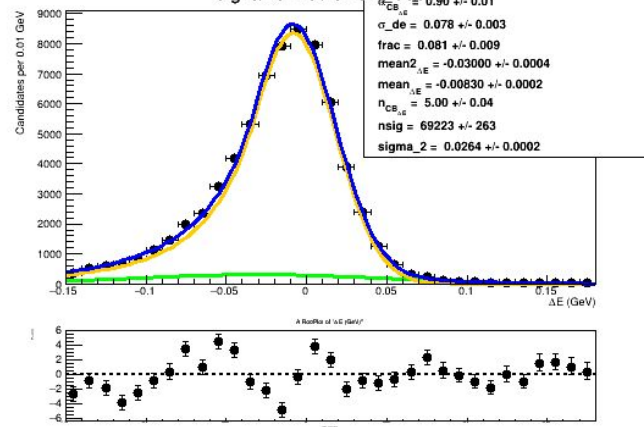
rooJohnson x
rooJohnson

Signal for 700fb⁻¹ Bifur-Gauss



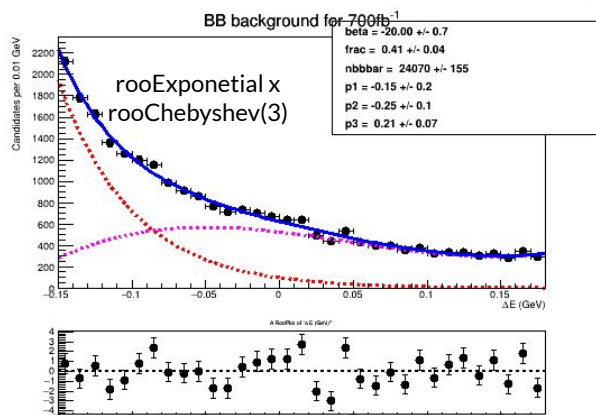
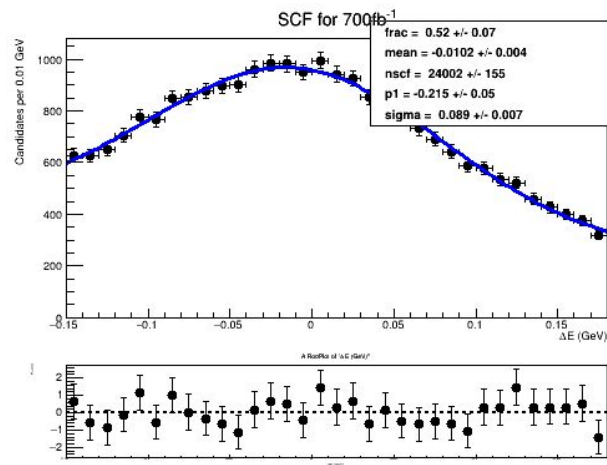
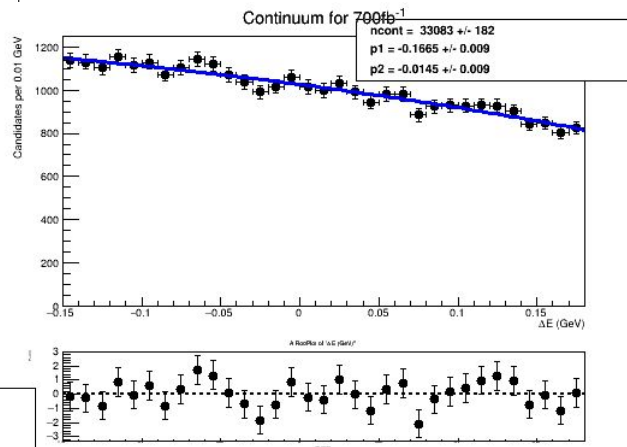
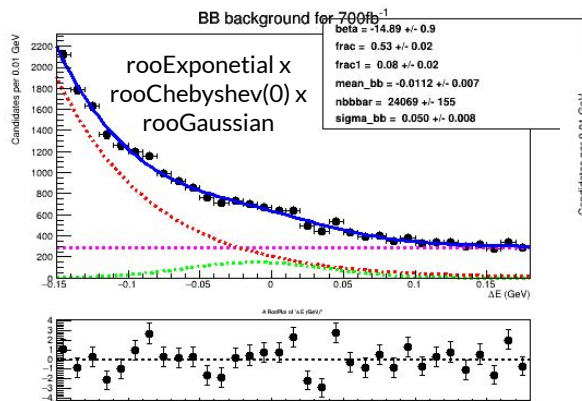
rooBifurGauss x
rooGaussian

Signal for 700fb⁻¹ CB-Gauss



rooCBShape x
rooGaussian

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

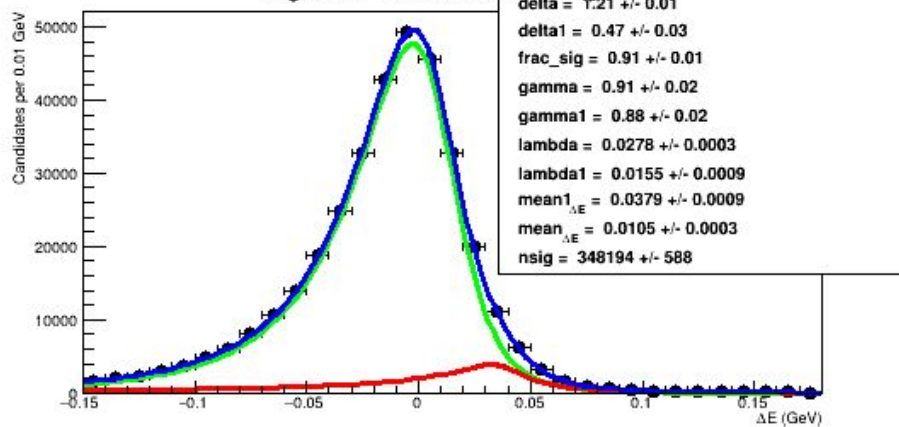


rooChebyshev (2)

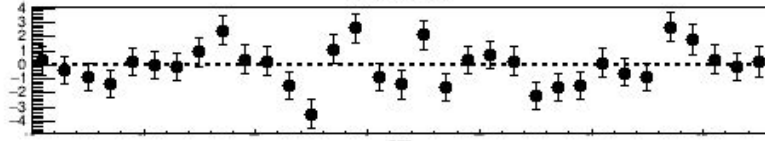
rooChebyshev(0) x
rooGaussian

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

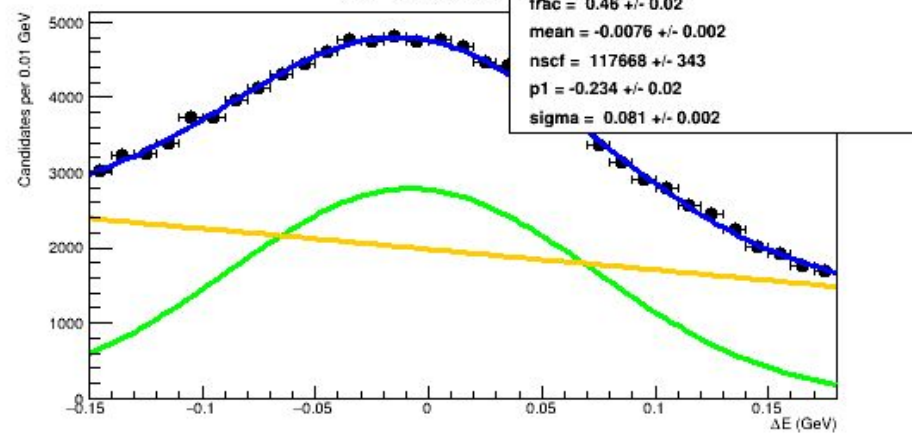
Signal for 700fb⁻¹ Johnson-sigMC



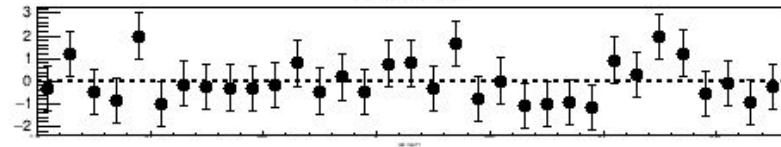
A Ratio of 1/ΔE (GeV)²



SCF for 700fb⁻¹ sigMC



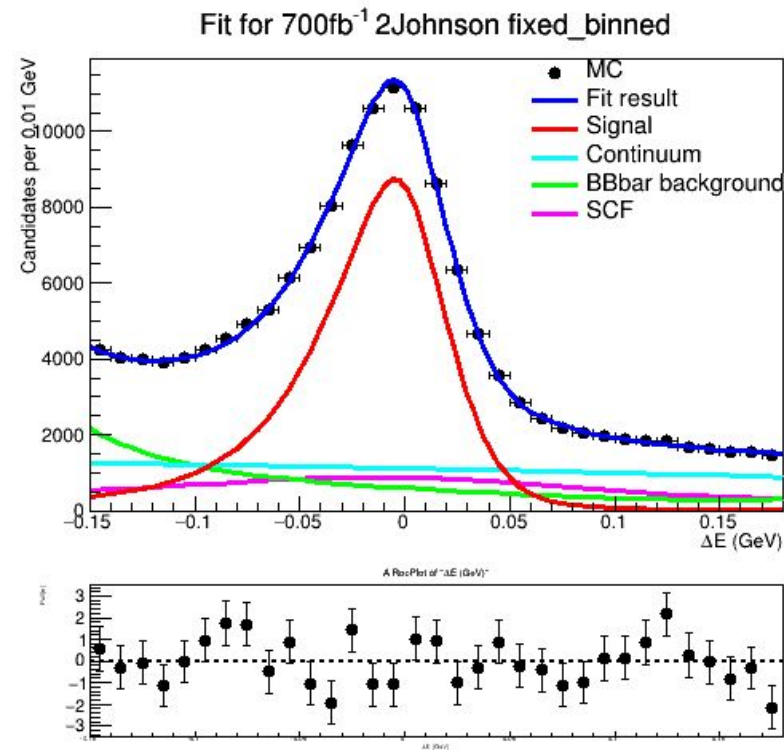
A Ratio of 1/ΔE (GeV)²



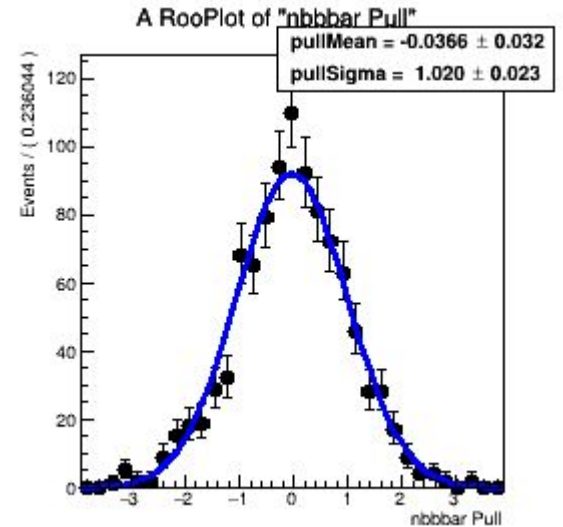
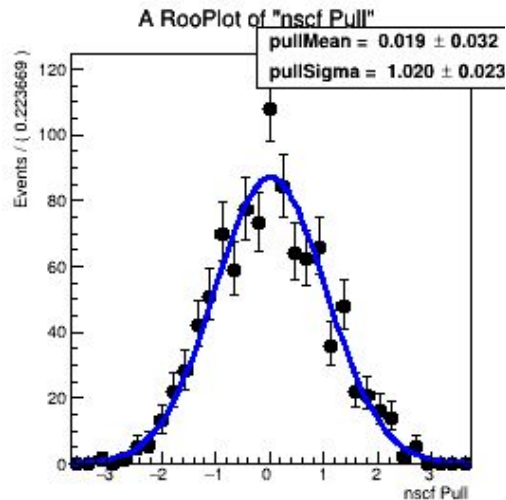
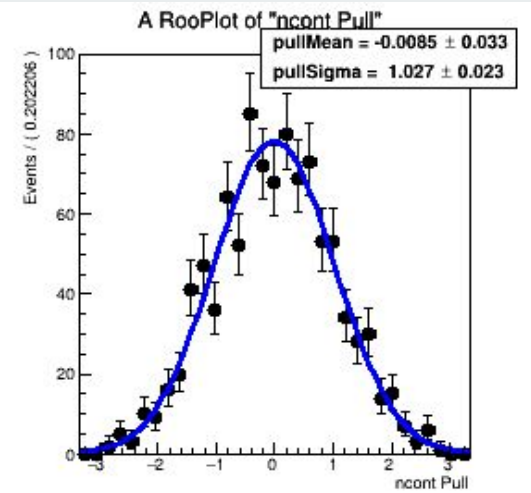
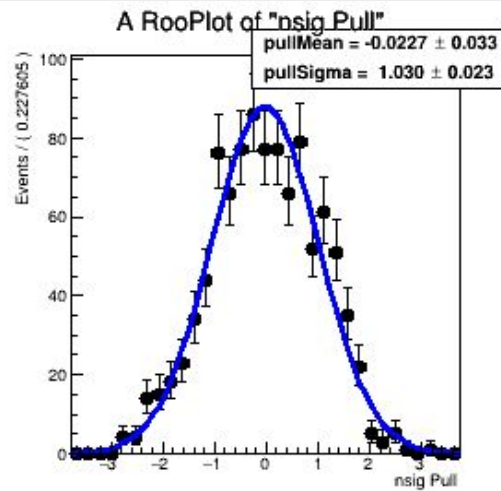
New BBbar parametrization Signal PDF fixed from GMC

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				VALUE	
1		nbbbar		2.35989e+04		5.88740e+02		7.87054e-04	
2		ncont		3.42478e+04		1.98056e+03		6.37768e-04	
3		nscf		2.34525e+04		2.29988e+03		7.09610e-04	
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	
2		0.98582		-0.251		1.000		-0.947	
3		0.98786		-0.004		-0.947		1.000	
4		0.80766		-0.073		0.645		-0.730	

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



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

```

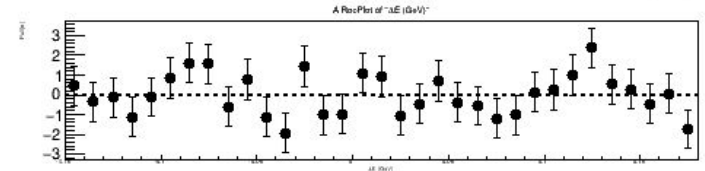
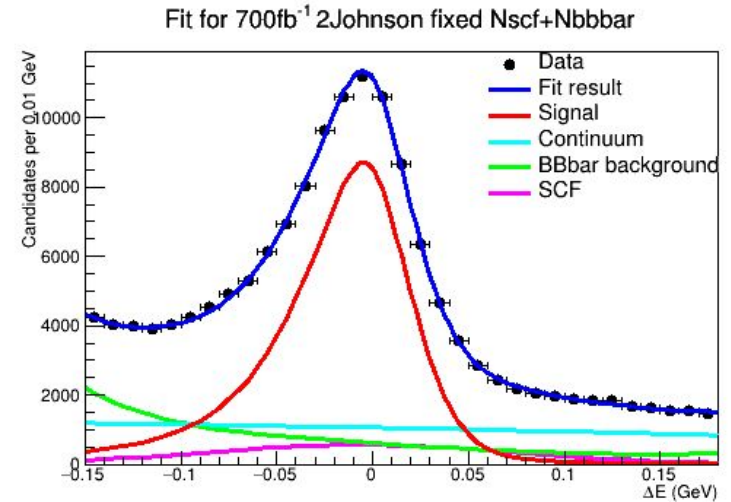
FCN=-1.83767e+06 FROM HESSE STATUS=OK 16 CALLS 93 TOTAL
EDM=5.10093e-05 STRATEGY= 1 ERROR MATRIX ACCURATE

EXT PARAMETER INTERNAL INTERNAL
NO. NAME VALUE ERROR STEP SIZE VALUE
1 nbbar_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

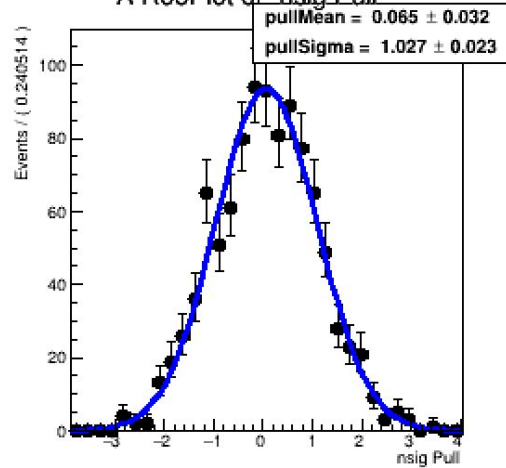
```

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

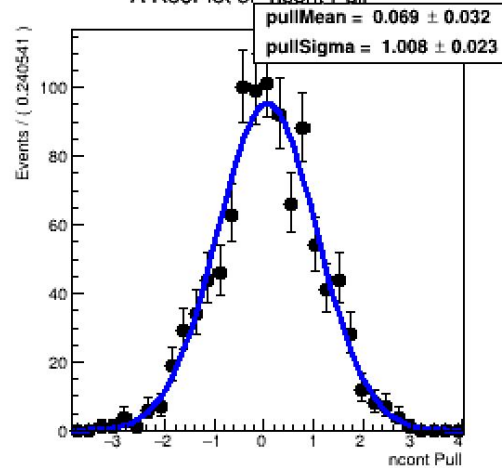


TOY MC result

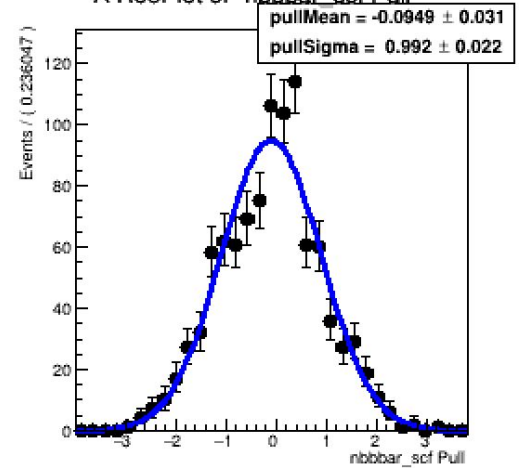
A RooPlot of "nsig Pull"



A RooPlot of "ncont Pull"



A RooPlot of "nbbar_scf Pull"



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

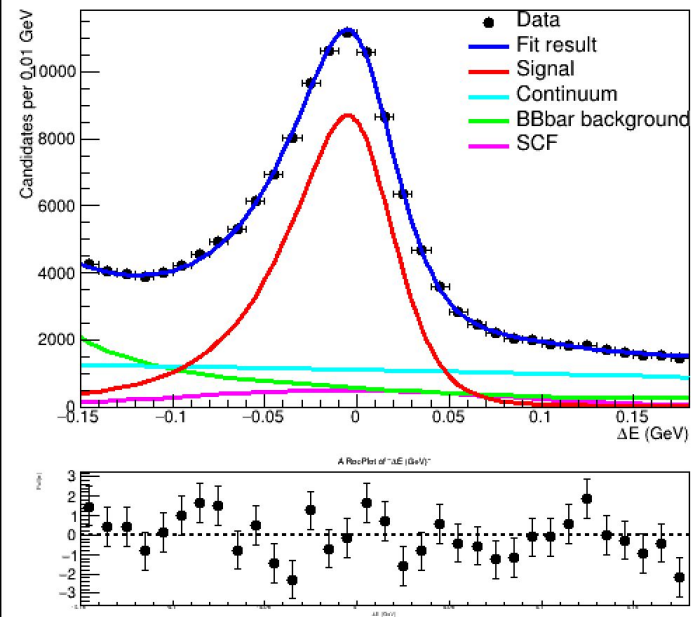
EXT  PARAMETER
NO.   NAME      VALUE      ERROR      INTERNAL  INTERNAL
      STEP SIZE  VALUE
  1  fudge      1.01331e+00  4.85758e-02  2.41580e-04 -9.22871e-01
  2  nbdbar_scf  4.70140e+04  1.28670e+03  5.06797e-04  3.53267e-01
  3  ncont      3.40566e+04  1.05179e+03  7.68070e-04  3.84030e-01
  4  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

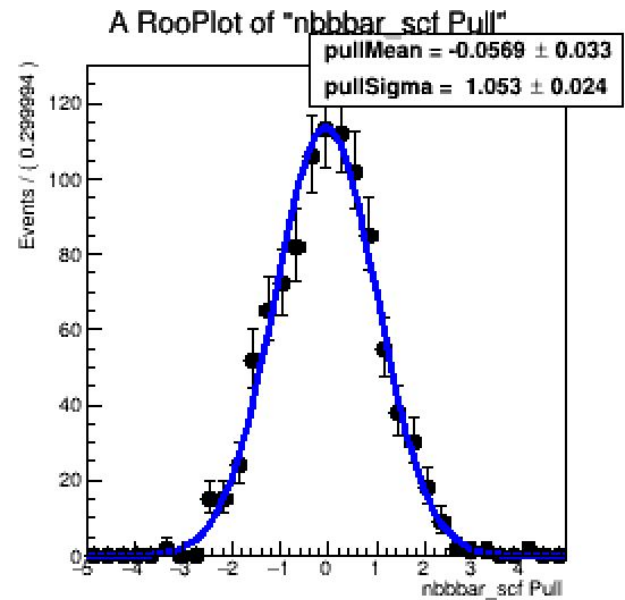
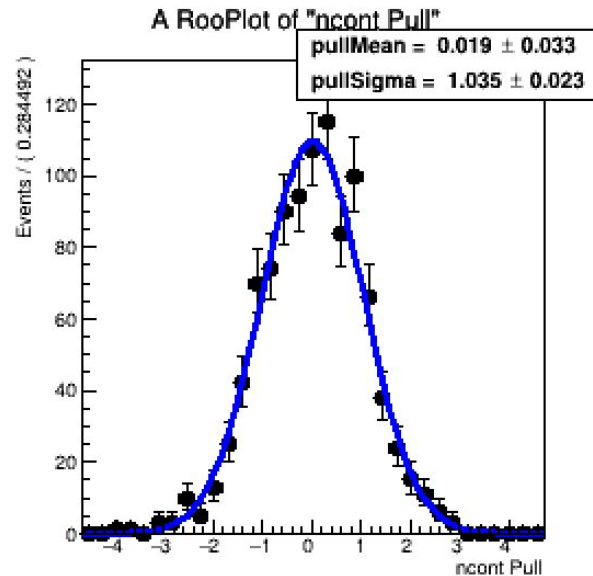
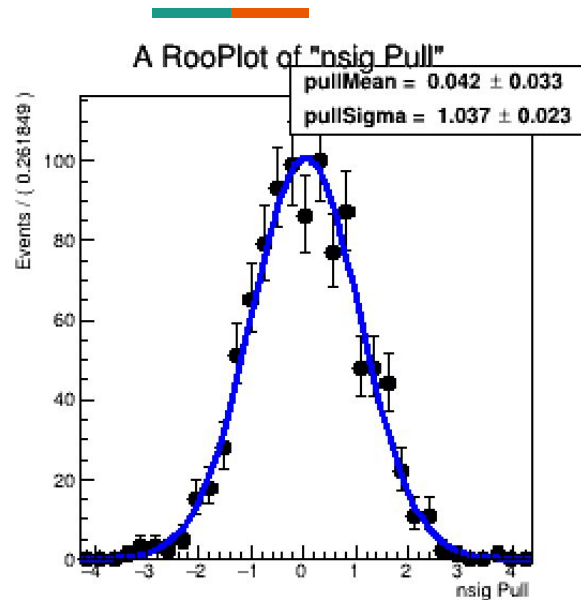
```

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

Fit for 700fb⁻¹ 2Johnson fudge Nscf+Nbbbar



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 NO.	PARAMETER NAME	VALUE	ERROR	INTERNAL STEP	INTERNAL 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

Fit for 700fb⁻¹ 2Johnson free cont Nscf+Nbbbar

