



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

TS analysis meeting  
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# Overview

- Changes in the preselection cuts
- Previous selection results
- New selection + results of 3D optimization
- BB-bar background composition
- Summary

# Preselection

Made on MC14 (200 fb<sup>-1</sup>)

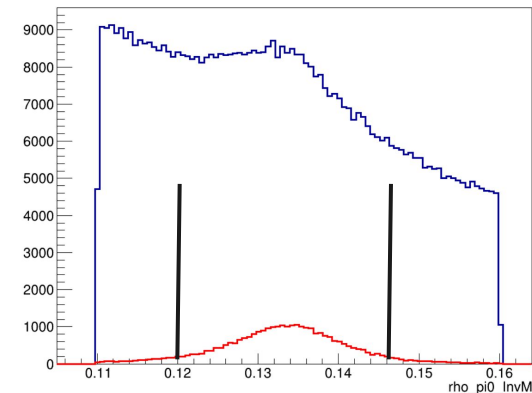
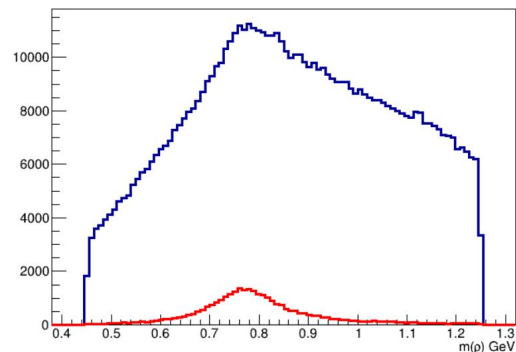
General cuts:

- $M_{bc} > 5.27$  GeV
- $1.85 < m(K\pi) < 1.88$  ( $\sim 3\sigma$ ) GeV
- binary kaon PID from  $D^0 > 0.2$
- binary pion PID from  $D^0 < 0.8$
- binary pion PID from  $\rho < 0.8$
- $-0.15 < \Delta E < 0.15$  GeV
- $0.12 < m(\pi^0) > 0.145$  ( $2\sigma$ ) GeV
- $0.45 < m(\rho) > 1.25$  GeV
- $\text{photon0E} > 0.04$
- $\text{photon1E} > 0.05$

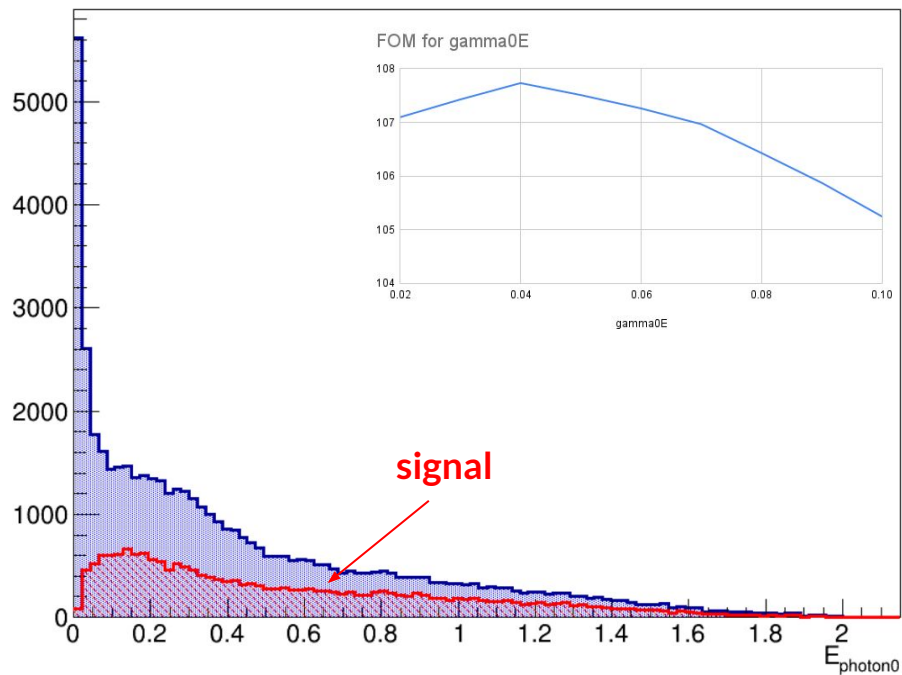
new or modified

$\pi^0$  candidates are taken from *stdPi0s\_winter2020* list

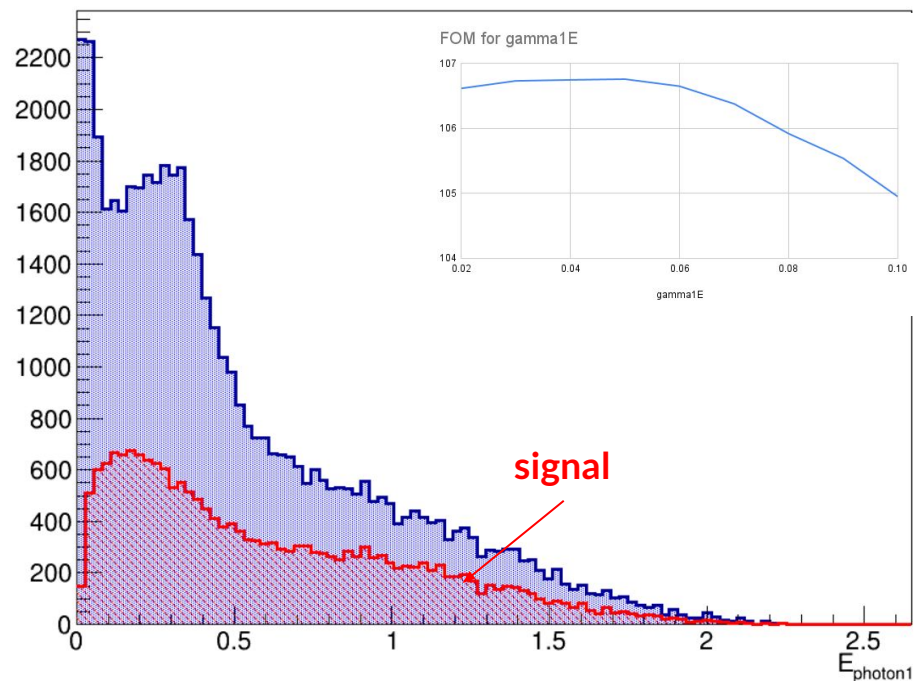
The vertex of the signal  $B$  candidate was reconstructed using *tree fitter*



# Photon energy optimization

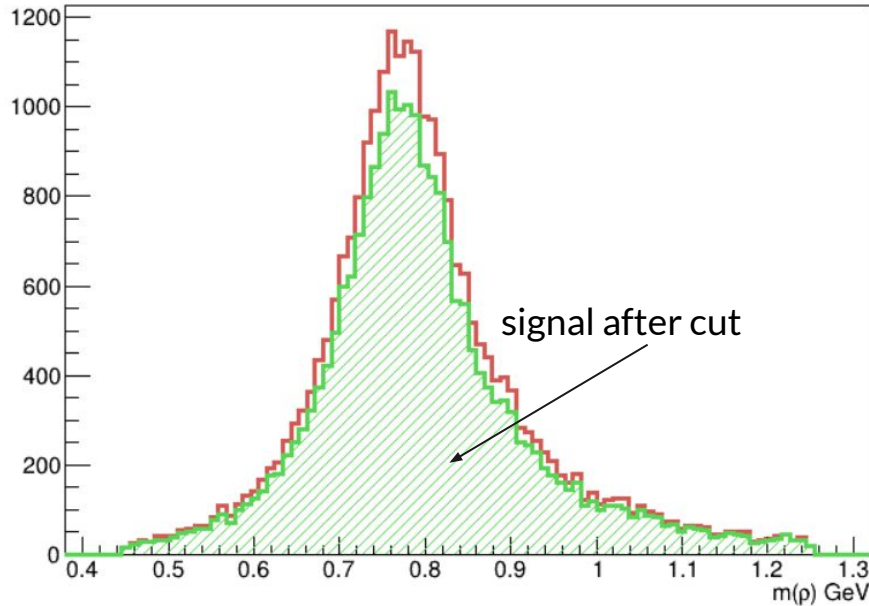


$E_{\text{photon0}} > 0.04$

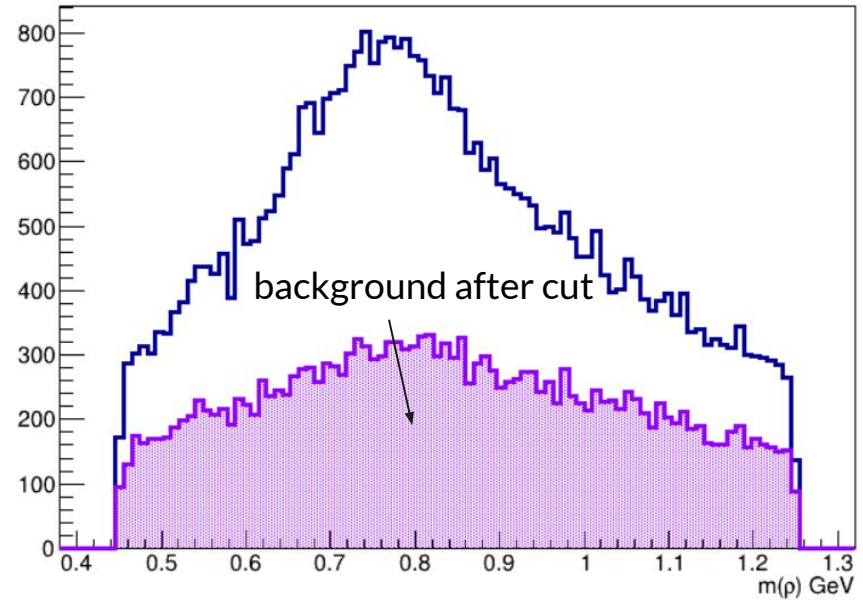


$E_{\text{photon1}} > 0.05$

# $m(\rho)$ signal and background after applying photon/ $\pi^0$ cuts



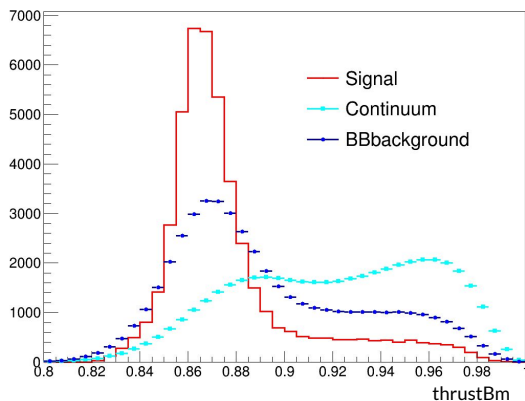
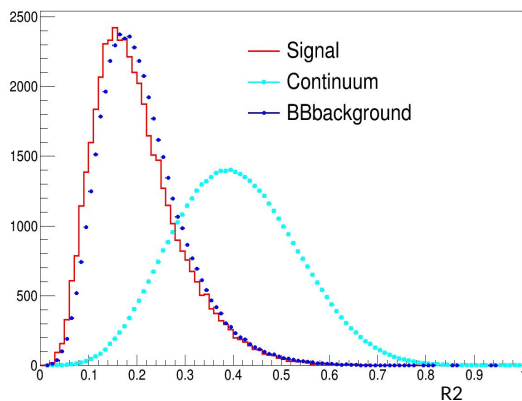
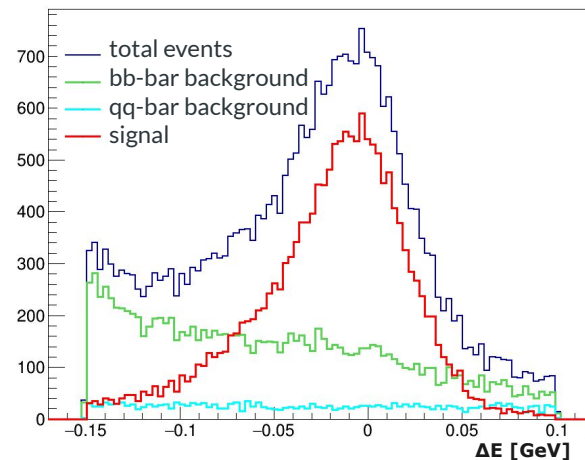
88% of signal remains



53% of background is rejected

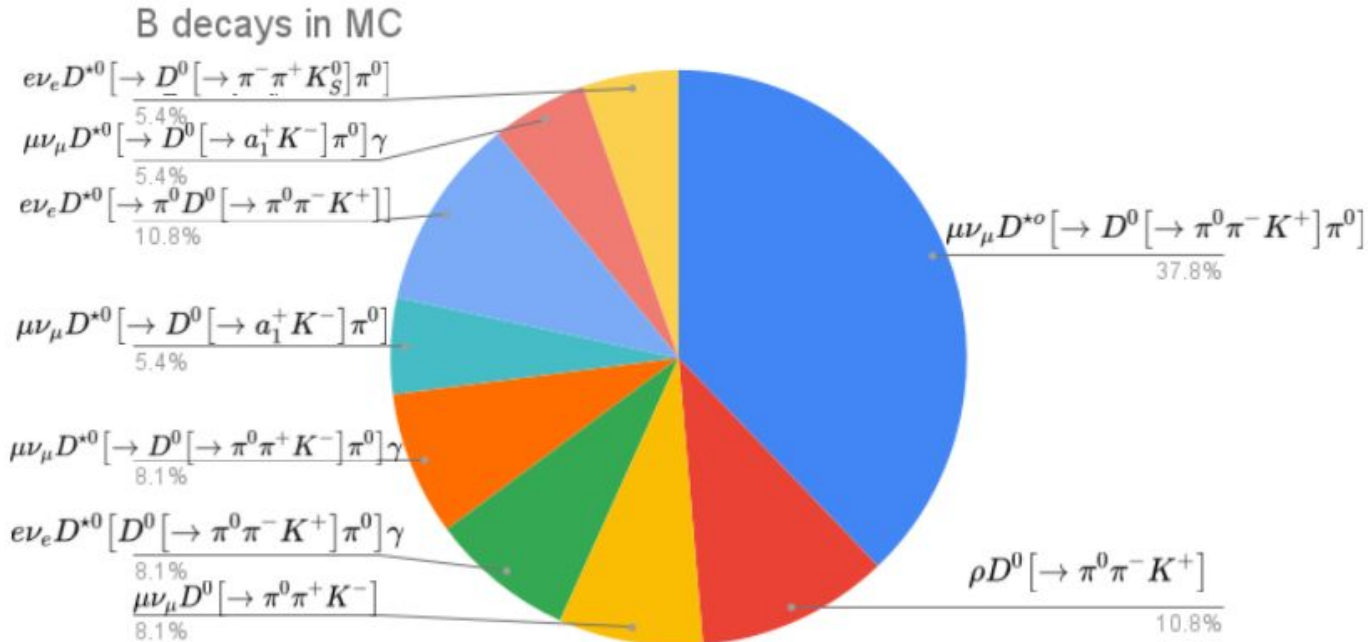
# Old Selection criteria

- $R2 < 0.28$
  - $\text{thrustBm} > 0.83$
  - $\text{thrustBm} < 0.9$
- +
- $\cos\Theta_{\pi\pi 0} < 0.62$
- 1D FOM based optimisation of  $\cos\Theta_{\pi\pi 0}$ ,
  - cuts of  $R2$  and  $\text{thrustBm}$  based on the shape only



Composition	Fraction
Signal	0.59
Continuum	0.13
BB-bar bkg	0.28

# Result of the topology analysis



The most frequent B- decays go through  $D^{*0} \rightarrow D^0 \pi^0$

# Selection variables

Focus on three variables for background suppression:  $\cos\Theta_{\pi\pi^0}$ ,  $R2$  and  $D^0_{\text{mom}}$ :

$\cos\Theta_{\pi\pi^0}$

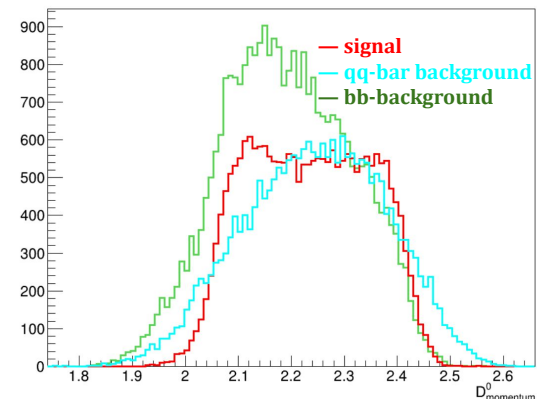
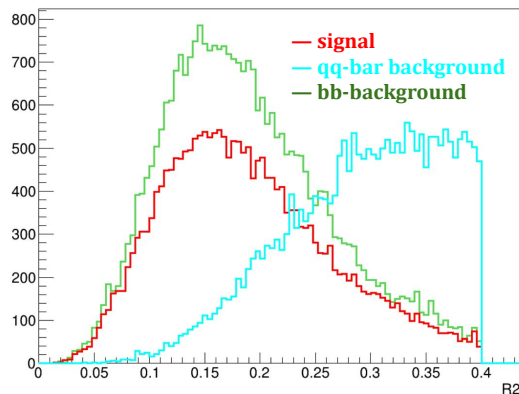
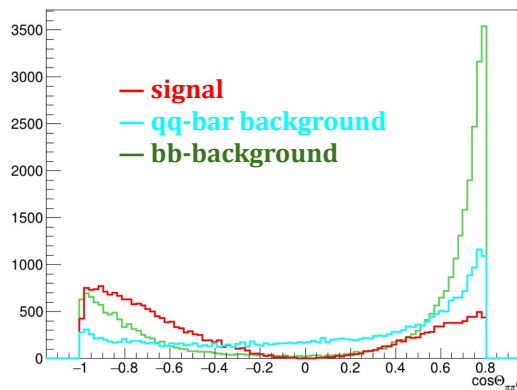
Cosine helicity angle  
between B momentum and  
pion momentum in the  $\rho$   
reference frame

$R2$

$$R2 = \mathcal{H}_2/\mathcal{H}_0$$

$D^0_{\text{mom}}$

$D^0$  momentum in CMS





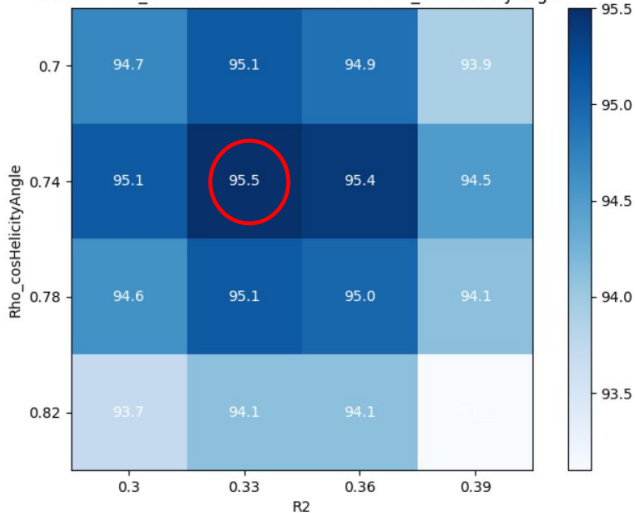
# New selection



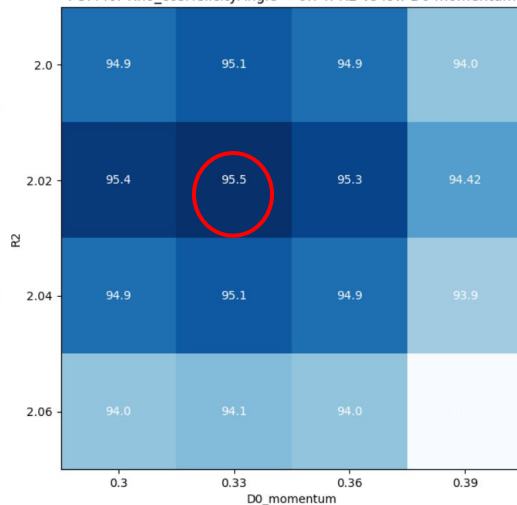
Results of 3D optimisation of  $\cos\Theta_{\pi\pi^0}$  vs R2 vs  $D^0_{\text{mom}}$ ;

- R2 < 0.33
- $\cos\Theta_{\pi\pi^0} < 0.74$
- $D^0_{\text{mom}} > 2.02$

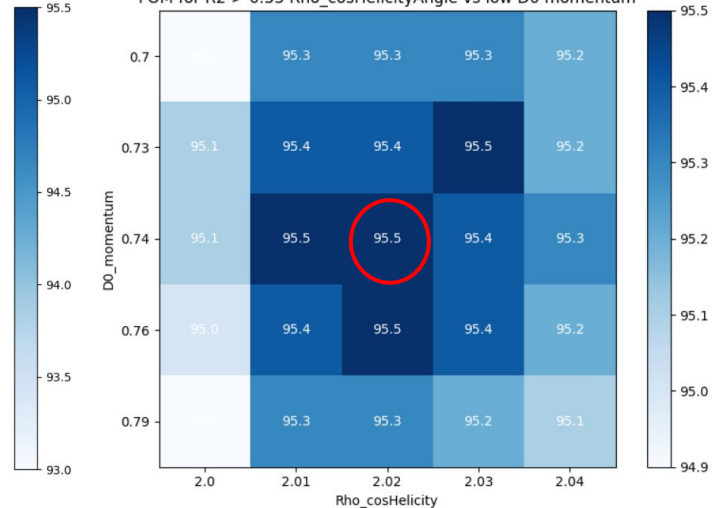
FOM for  $D^0_{\text{momentum}} > 2.02$ : R2 vs Rho\_cosHelicityAngle



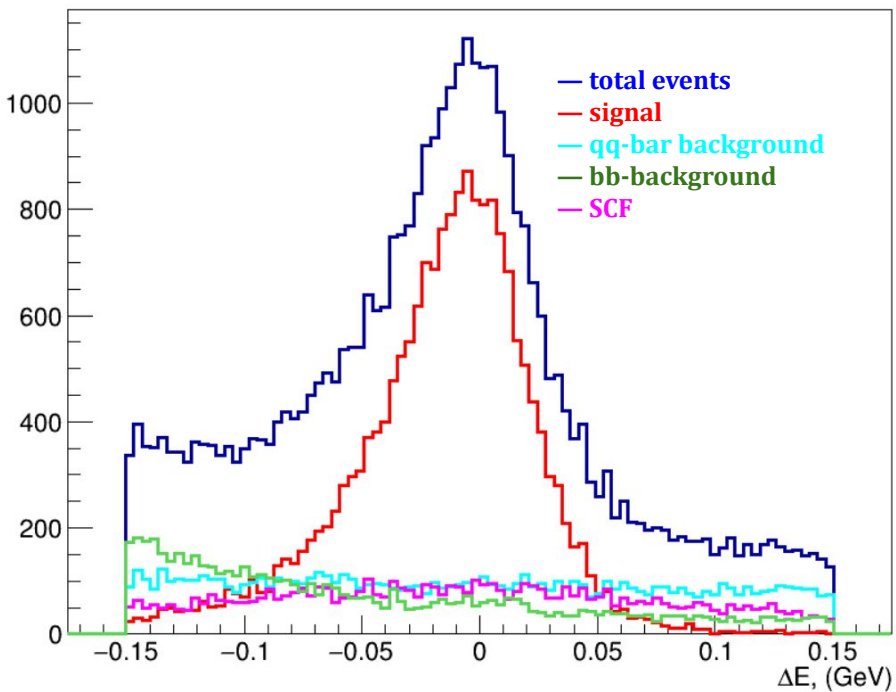
FOM for  $\text{Rho\_cosHelicityAngle} < 0.74$ : R2 vs low D0 momentum



FOM for  $\text{R2} > 0.33$  Rho\_cosHelicityAngle vs low D0 momentum

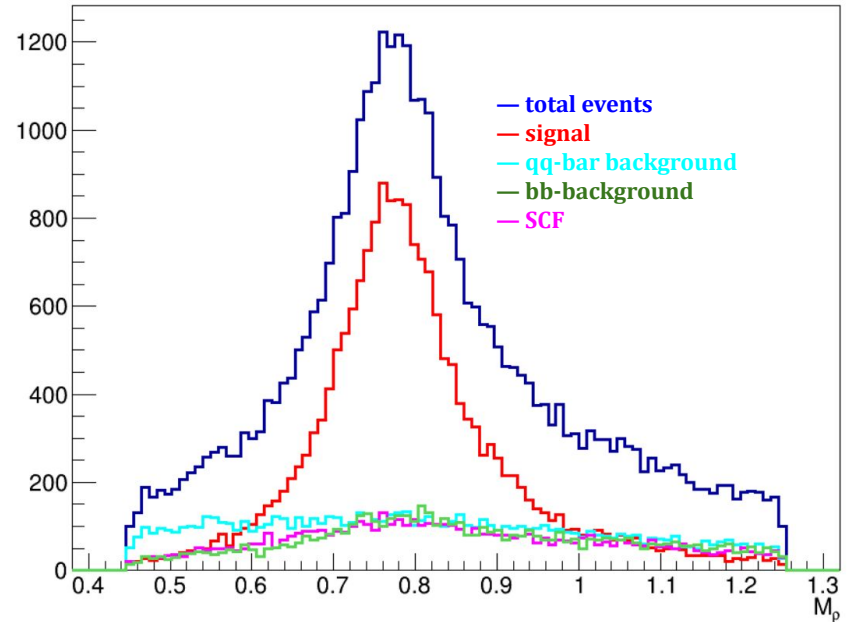
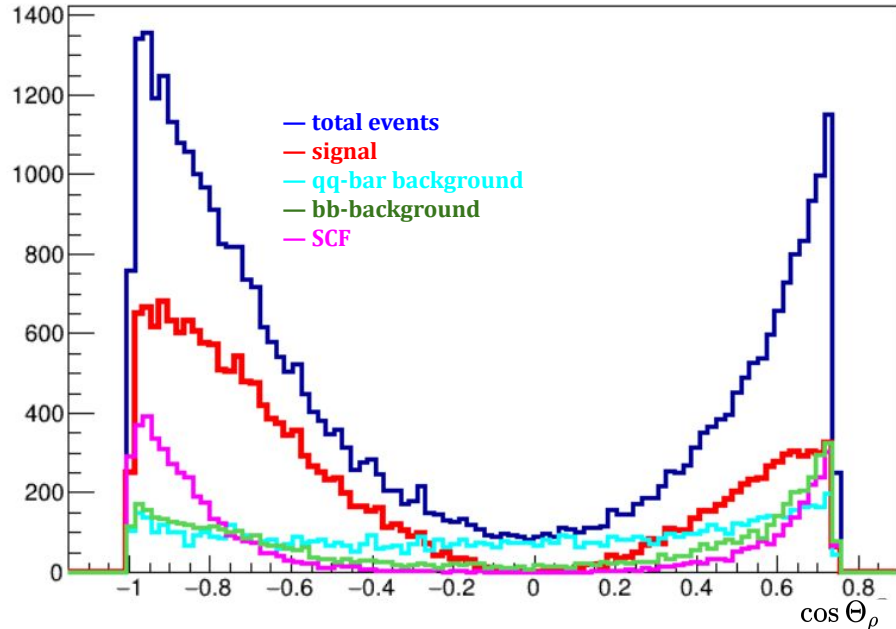


# Result



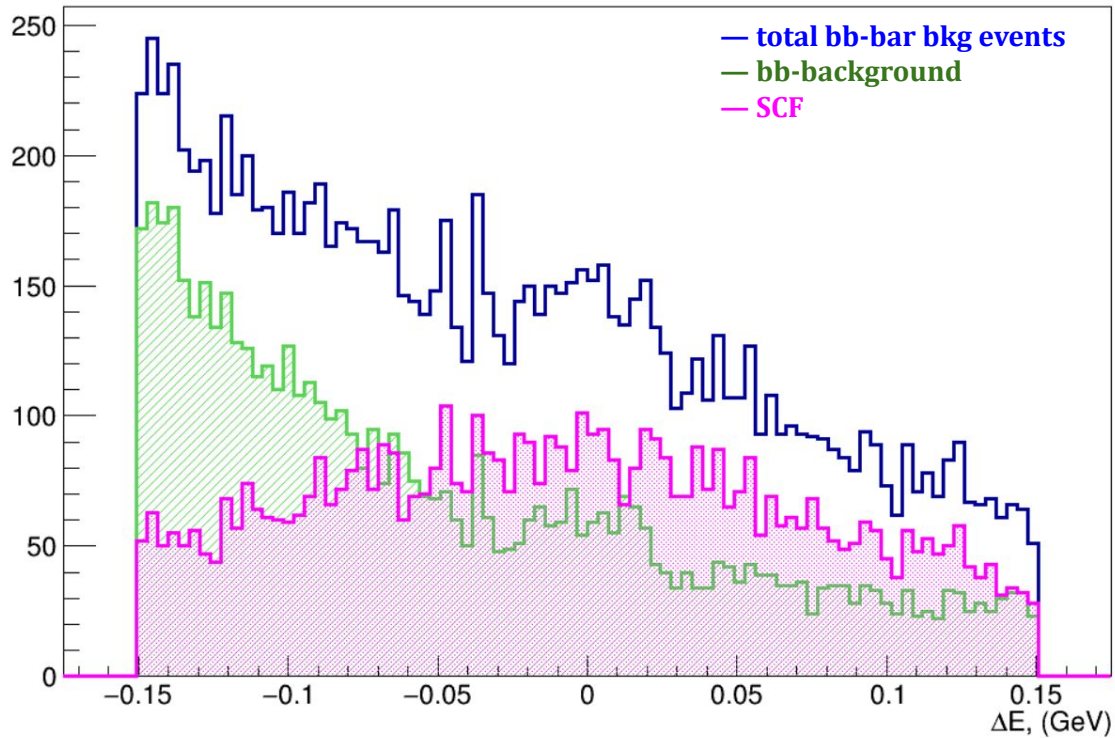
Composition	Fraction
Signal	0.48
Continuum	0.21
SCF	0.16
BB-bar bkg	0.15

## Result (2)

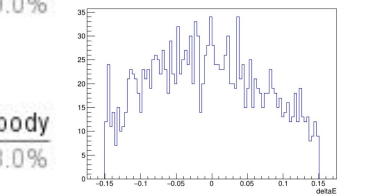
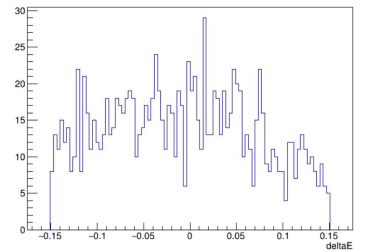
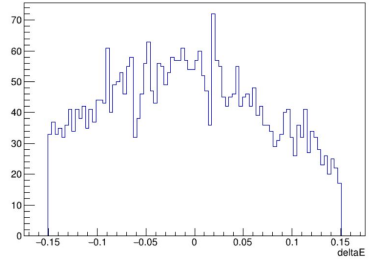
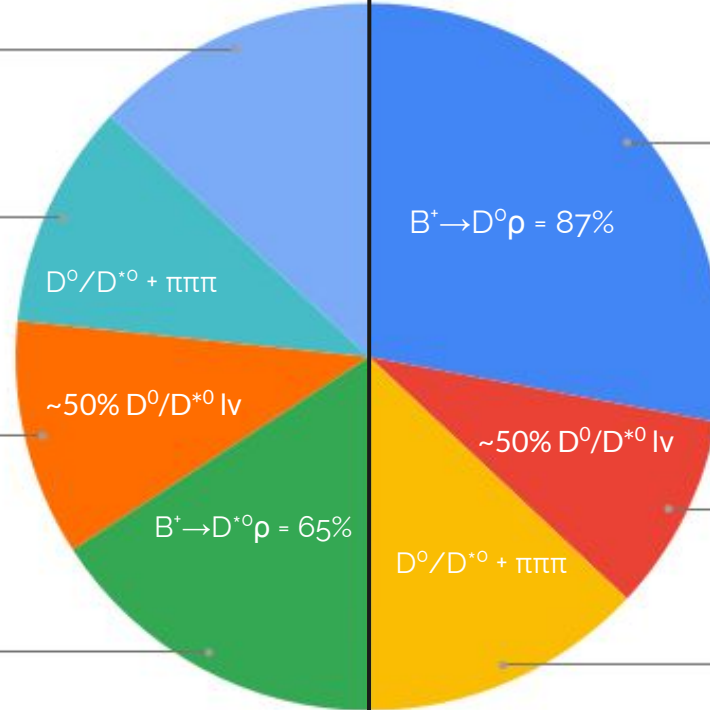
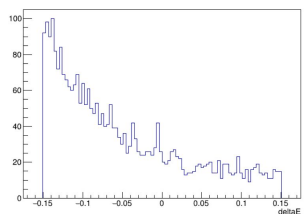
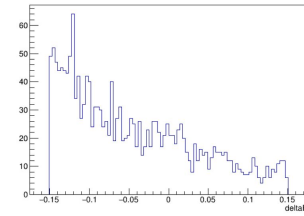
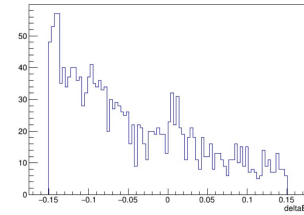
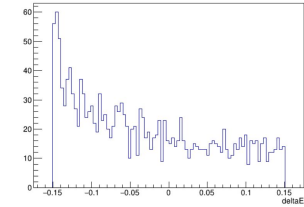


shapes between the 4 components look different in  $\cos \Theta_\rho$ . We can use its discrimination power in a 3D fit to  $(\Delta E, m(\rho), \cos \Theta_\rho)$ .

# BB-bar background composition



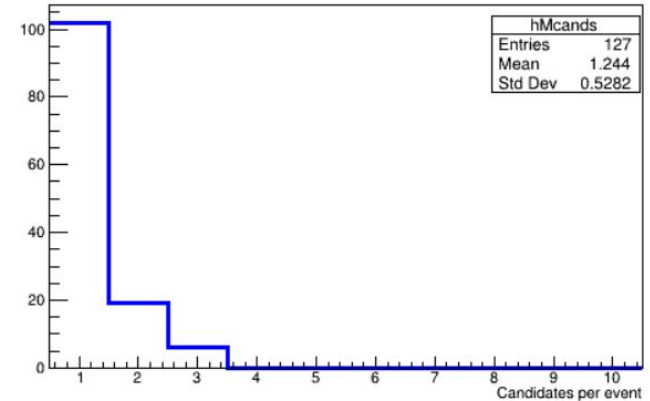
# BB-bar background and SCF compositions



# Summarizing table for MC 200 fb<sup>-1</sup>

	Before preselection	After preselection	After preselection + selection
Signal eff ( $\epsilon$ )	~41%	~24%	~17%
Background rejection	-/-	99.56%	99.94%

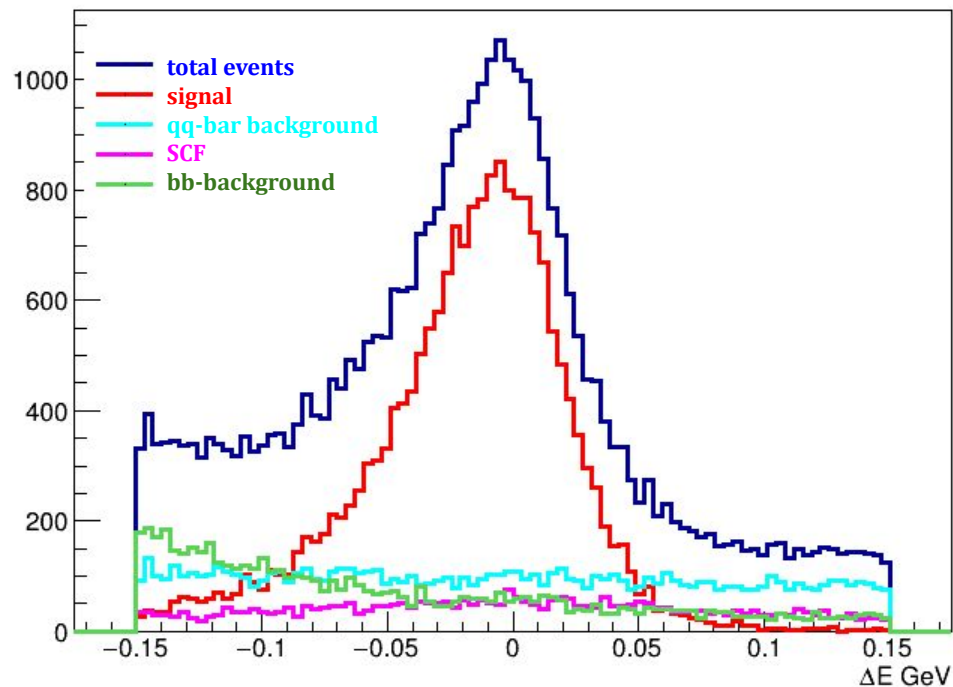
Candidate multiplicity was studied on a small generic MC dataset after applications of all selection criteria



We expect to see in data (200 fb<sup>-1</sup>) (events):

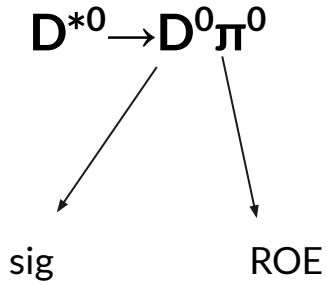
$$N_{\text{signal}} = L \times \epsilon = 19700$$

# $\Delta E$ after one candidate selection

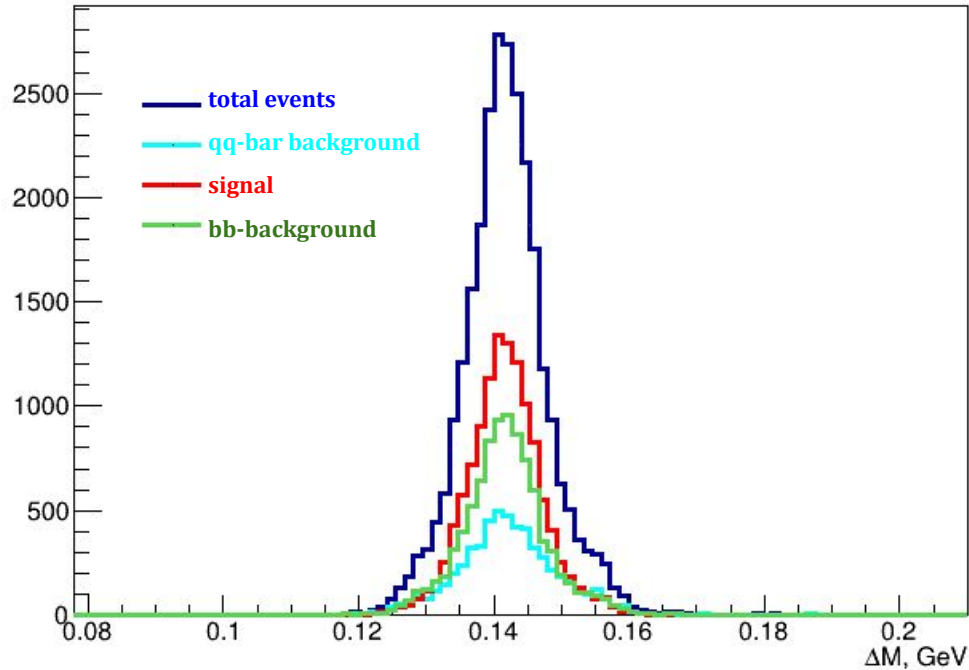


Composition	Fraction
Signal	0.52
Continuum	0.22
SCF	0.10
BB-bar bkg	0.16

# D\*<sup>0</sup> veto

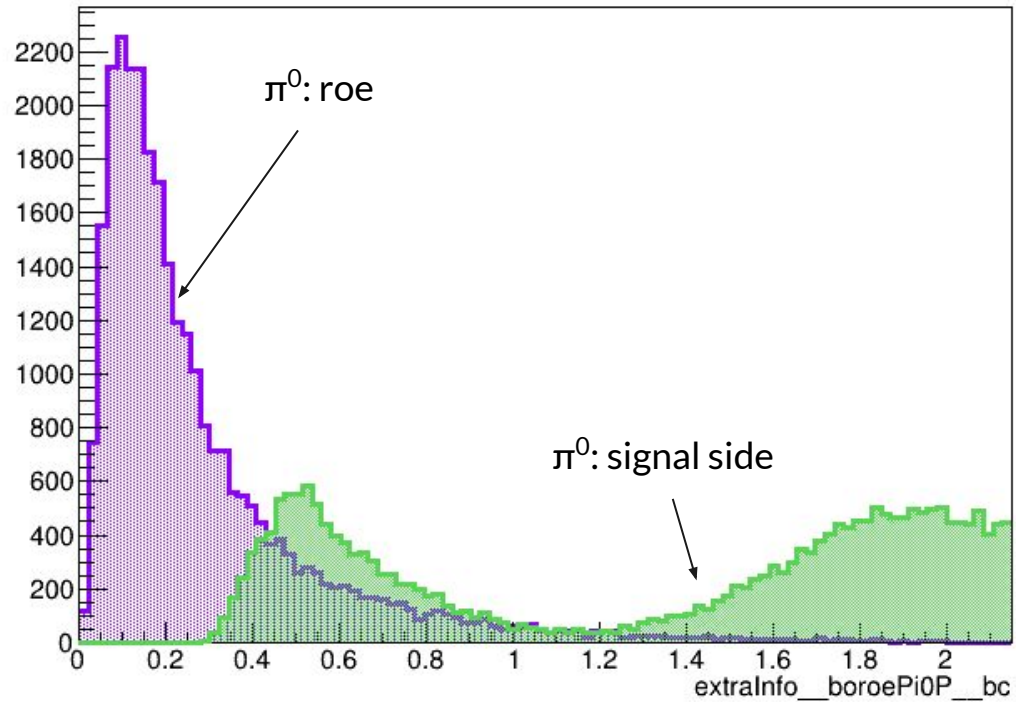


$$\Delta M = m_{D^{*0}} - m_{D^0} = 0.142 \text{ MeV}$$

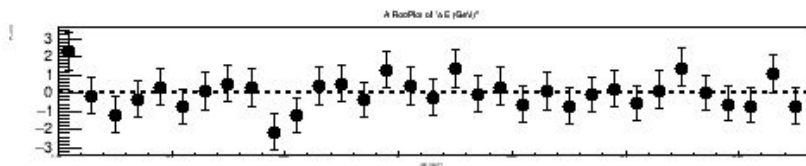
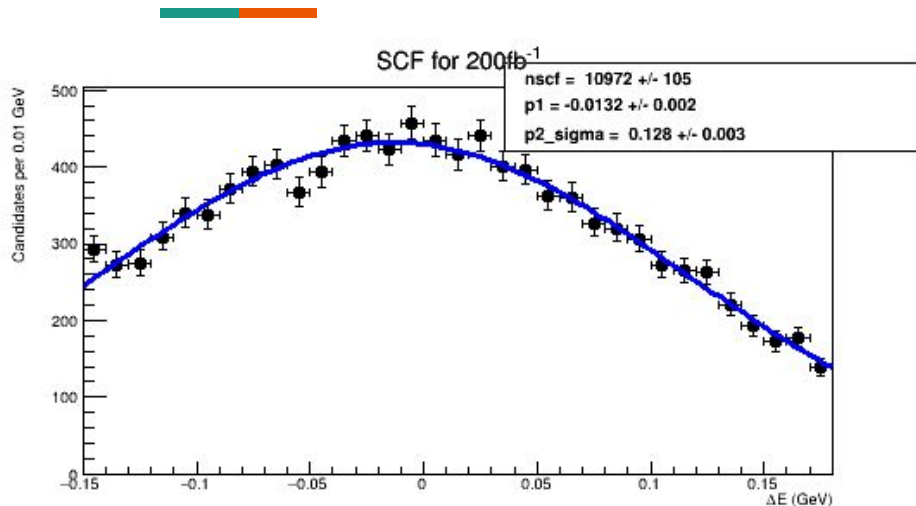




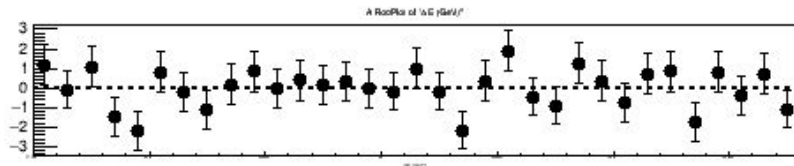
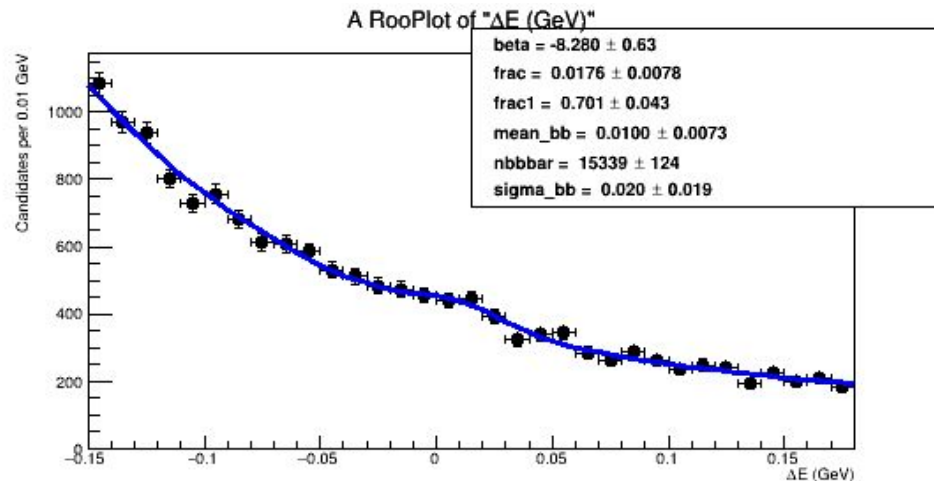
# D\*<sup>0</sup> veto: $\pi^0$ momenta



# Fits for SCF and BBbar of $\Delta E$ (200 fb<sup>-1</sup>)

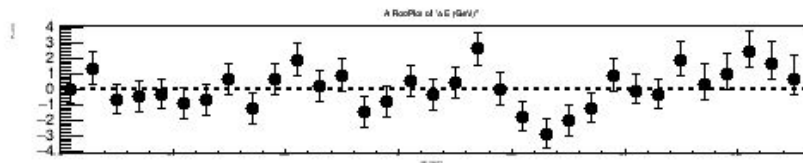
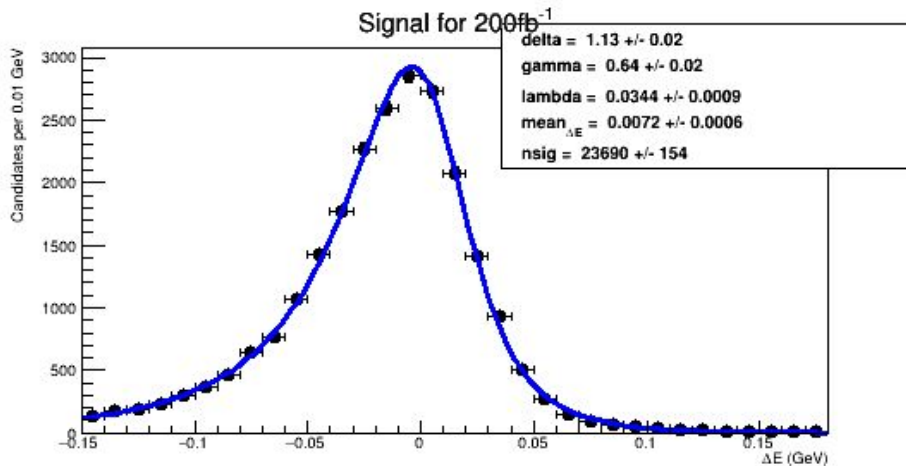


rooGaussian

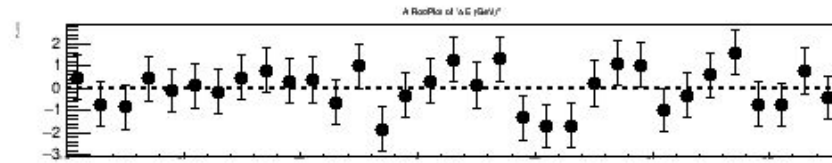
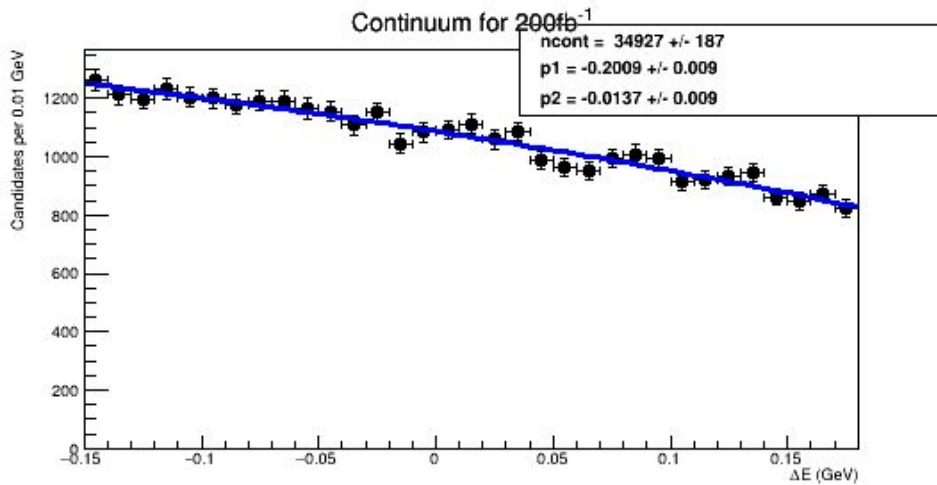


rooExponential x rooChebyshev(0) x rooGaussian

# Fits for signal and continuum of deltaE (200 fb<sup>-1</sup>)



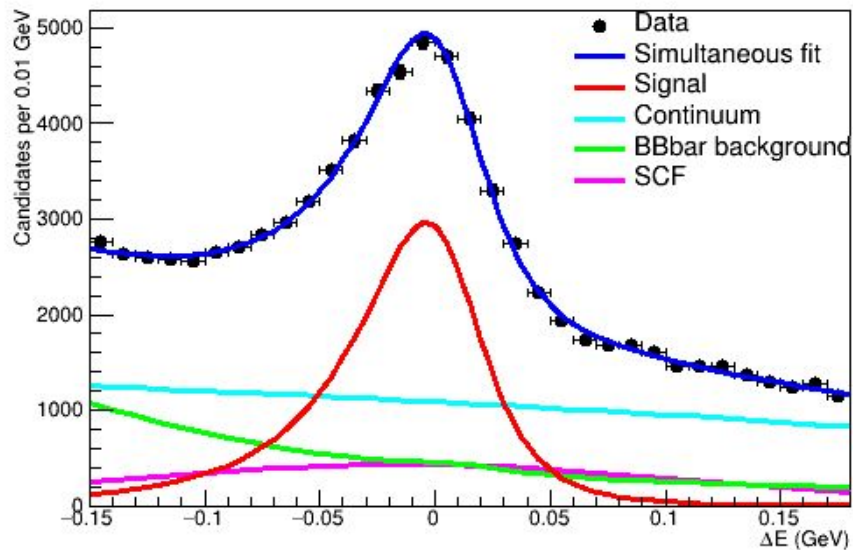
rooJohnson



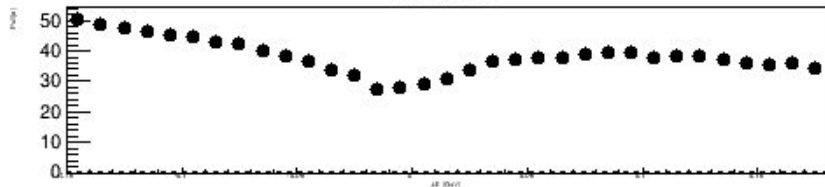
rooChebyshev (2)

# Simultaneous fit of $\Delta E$

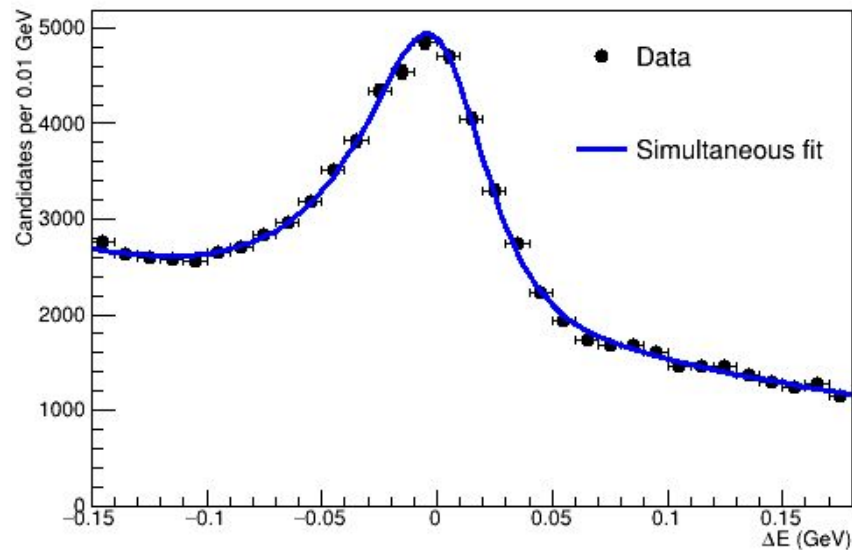
Simultaneous fit for  $200\text{fb}^{-1}$



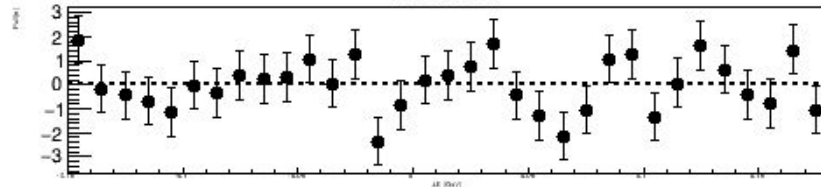
A ResPlot of " $\Delta E$  (GeV)"



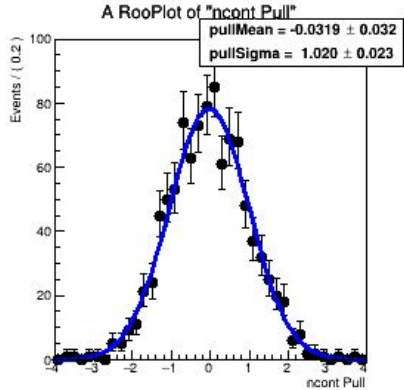
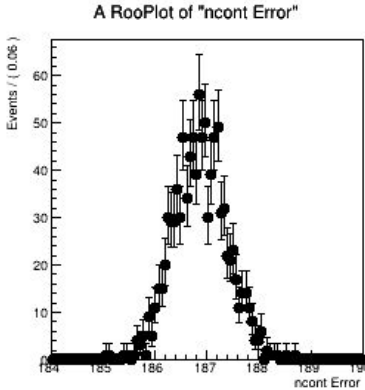
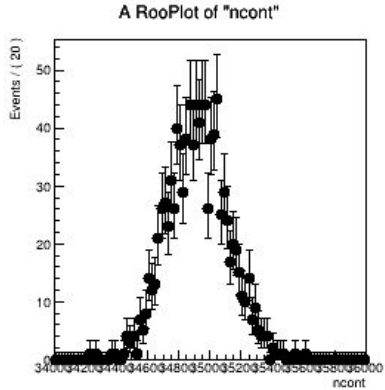
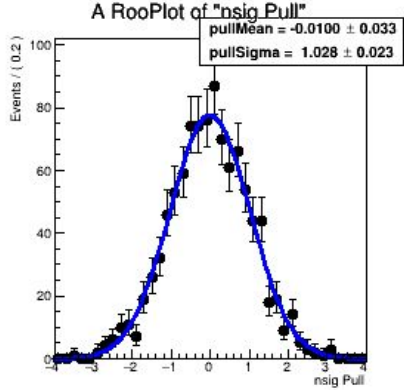
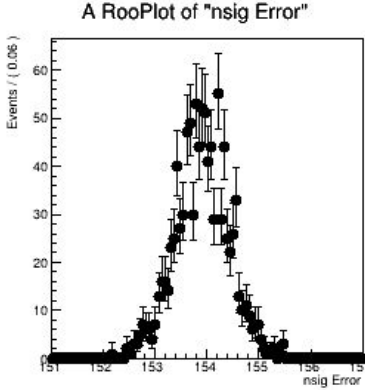
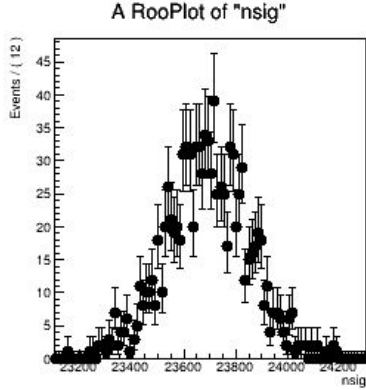
Simultaneous fit for  $200\text{fb}^{-1}$



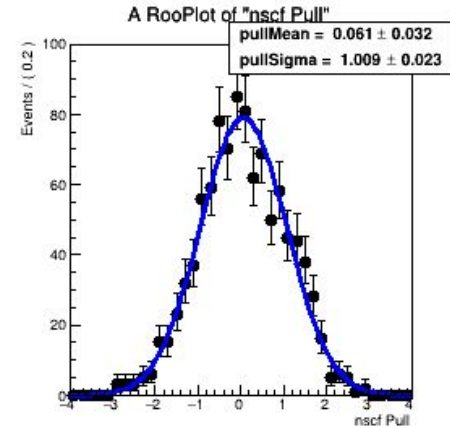
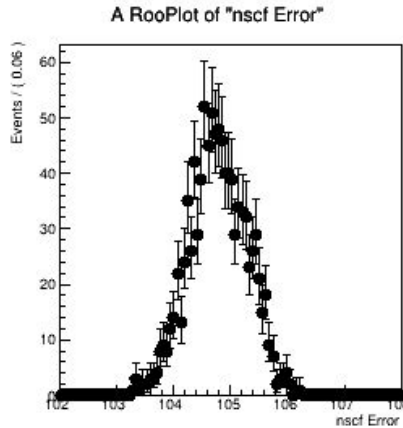
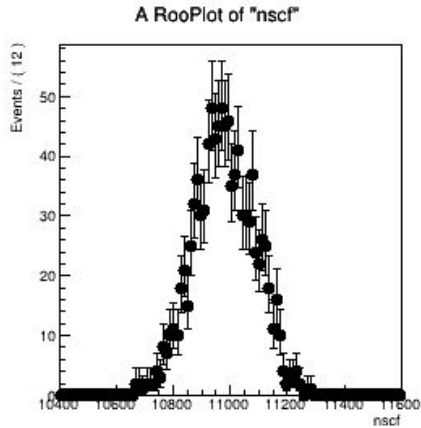
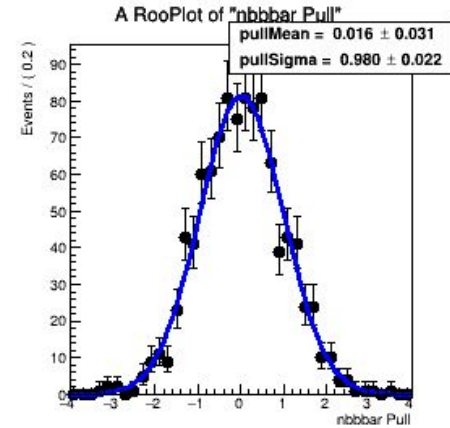
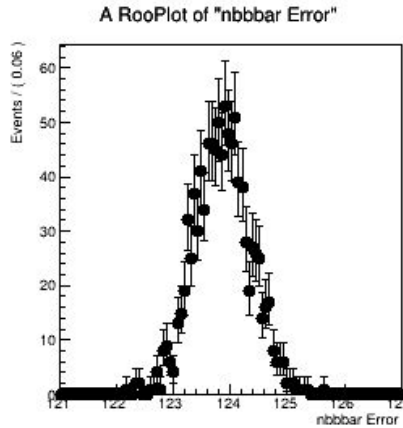
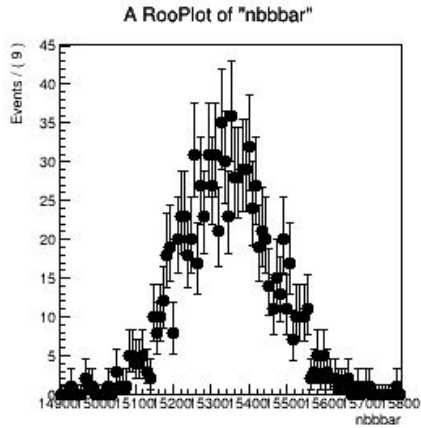
A ResPlot of " $\Delta E$  (GeV)"



# TOYs for Simultaneous fit (Signal and Continuum)



# TOYs for Simultaneous fit (BBbar and SCF)

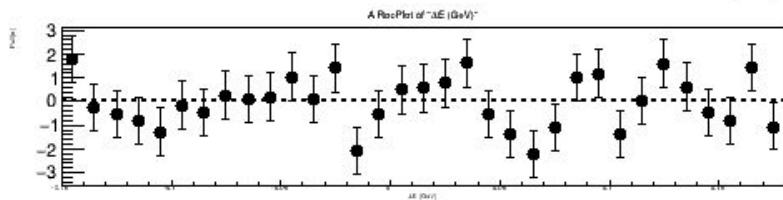
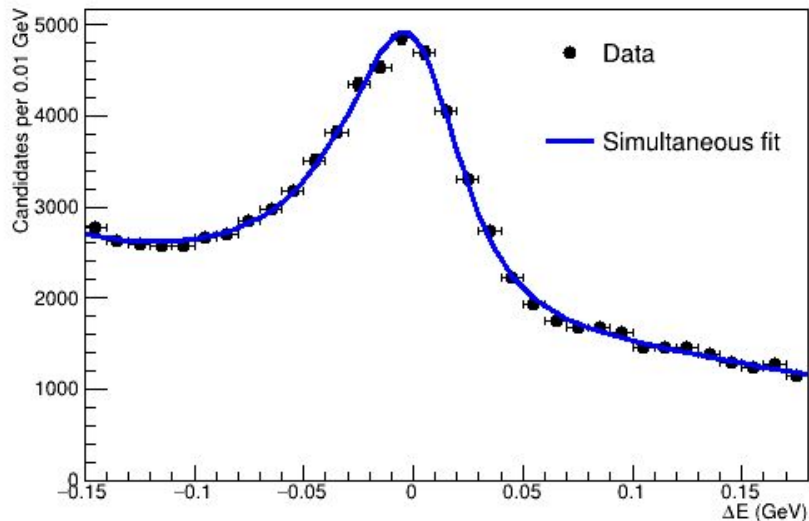




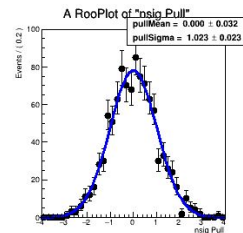
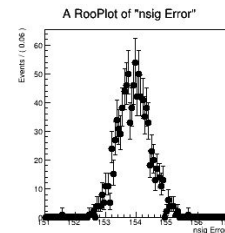
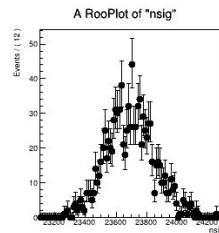
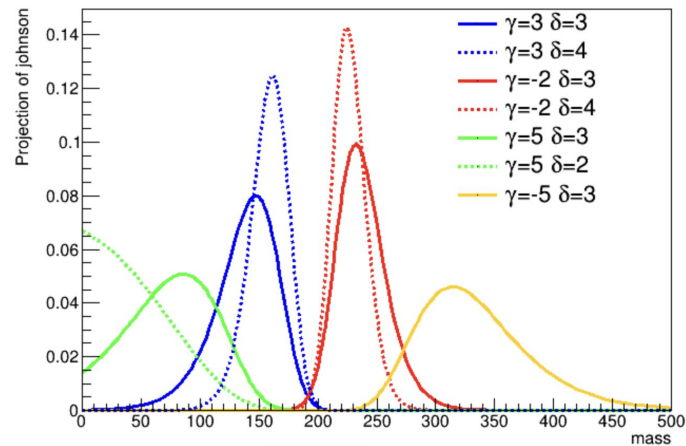
**Update 03/06/2022**

# Simultaneous fit with 2 float parameters

Simultaneous fit for  $200\text{fb}^{-1}$



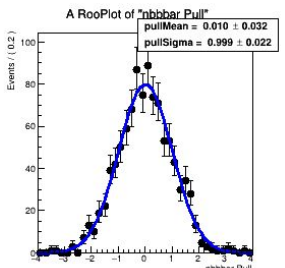
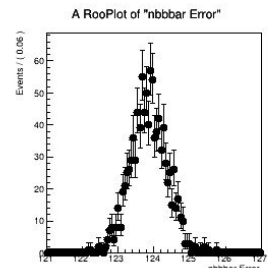
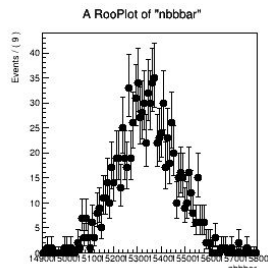
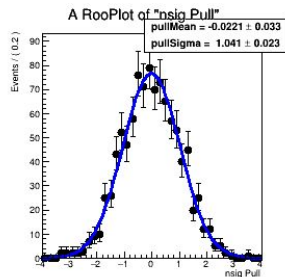
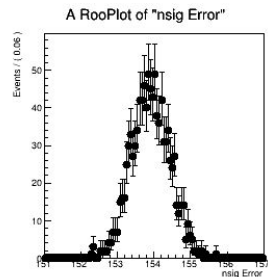
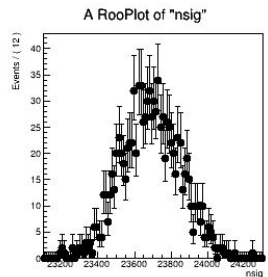
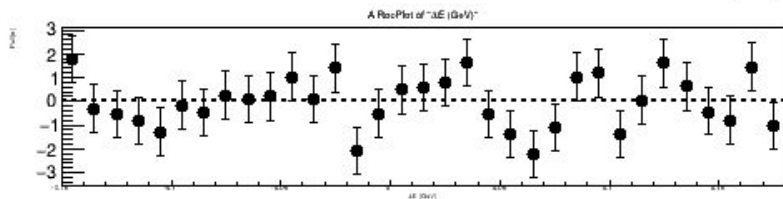
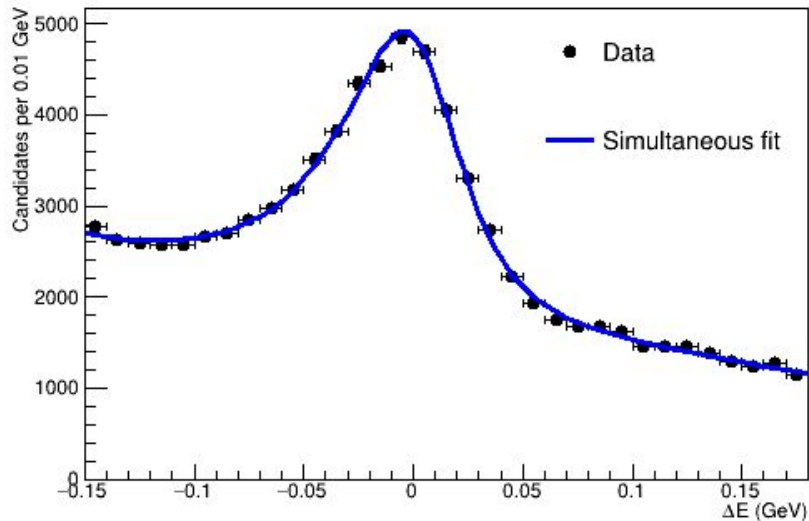
Johnson  $\mu=200 \lambda=50$





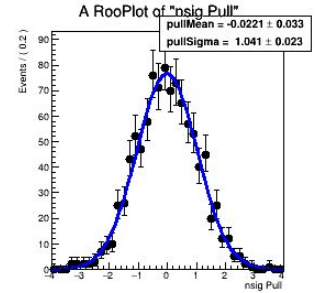
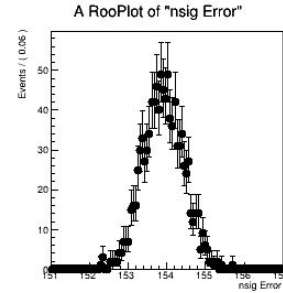
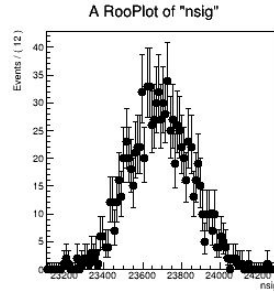
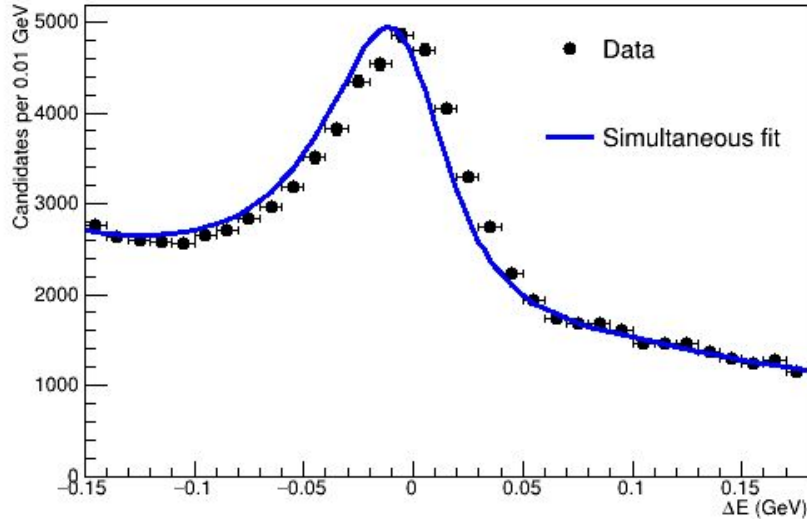
# Simultaneous fit with 3 float parameters

Simultaneous fit for  $200\text{fb}^{-1}$

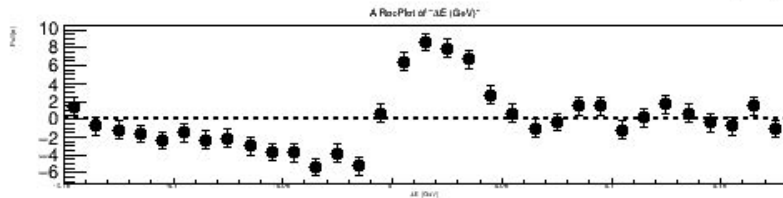


# Simultaneous fit with 3 float parameters in Sig PDF

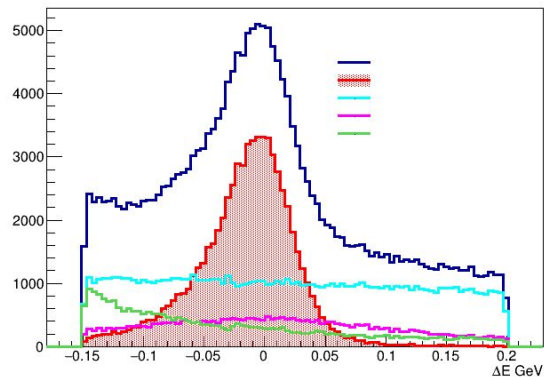
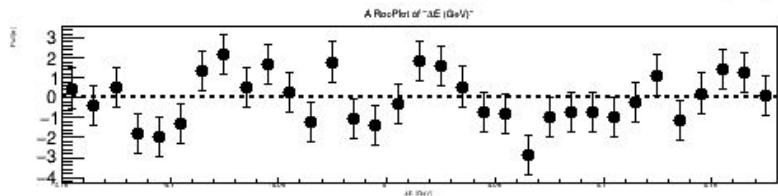
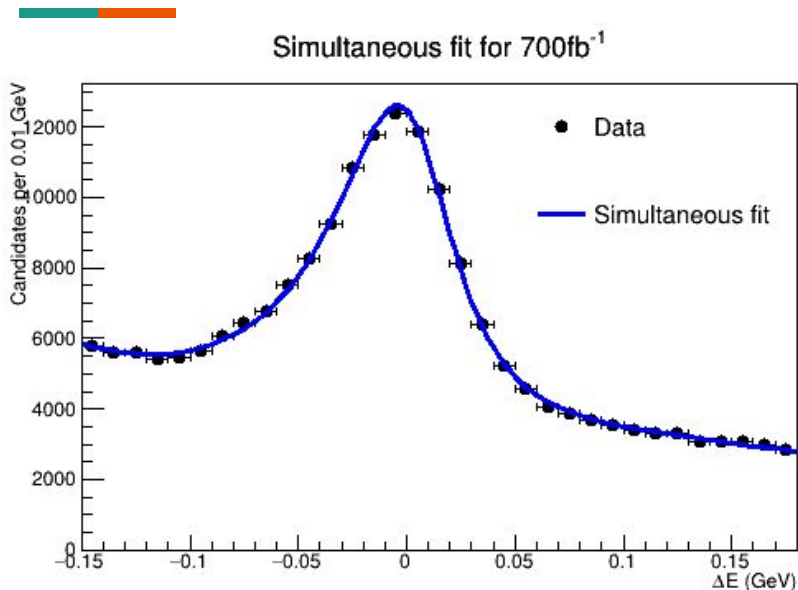
Simultaneous fit for  $200\text{fb}^{-1}$



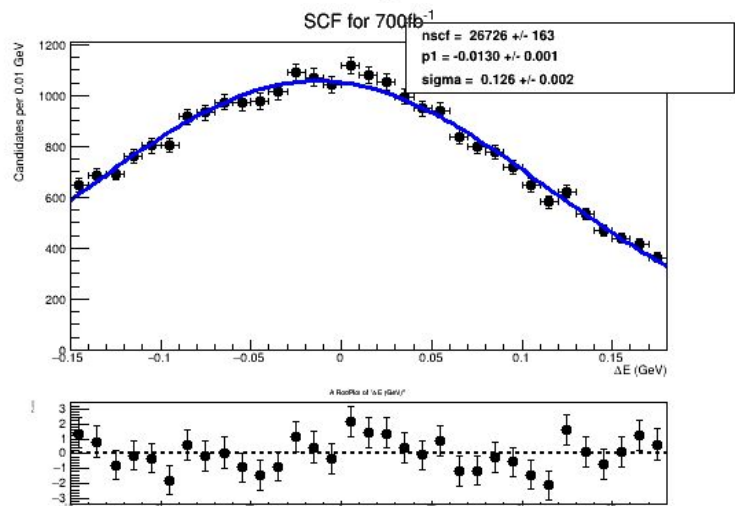
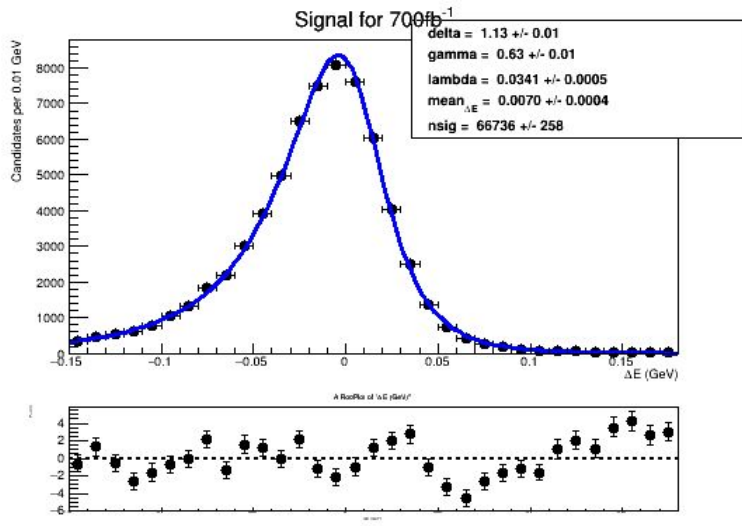
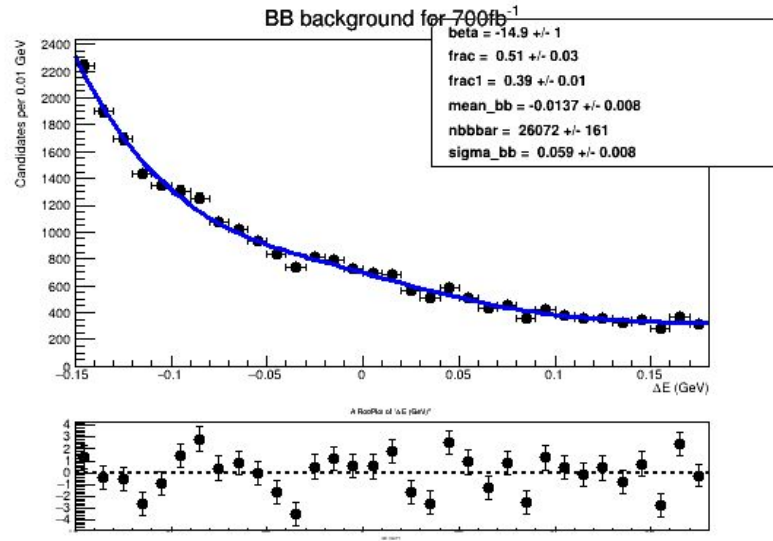
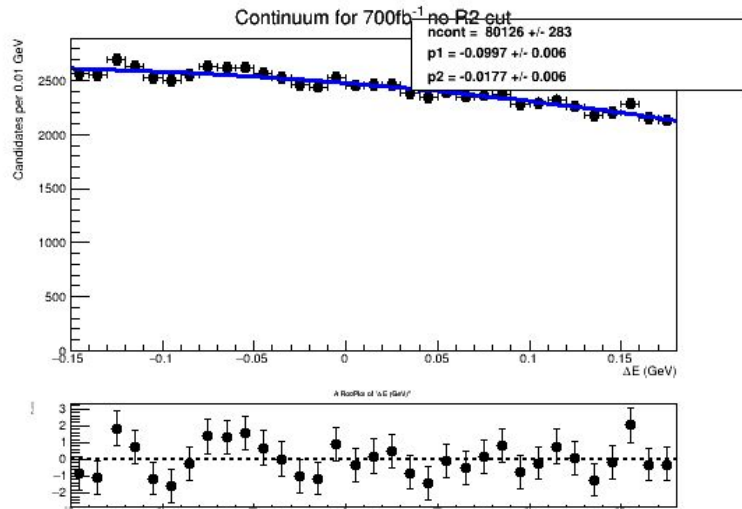
float parameters: delta, gamma, mean



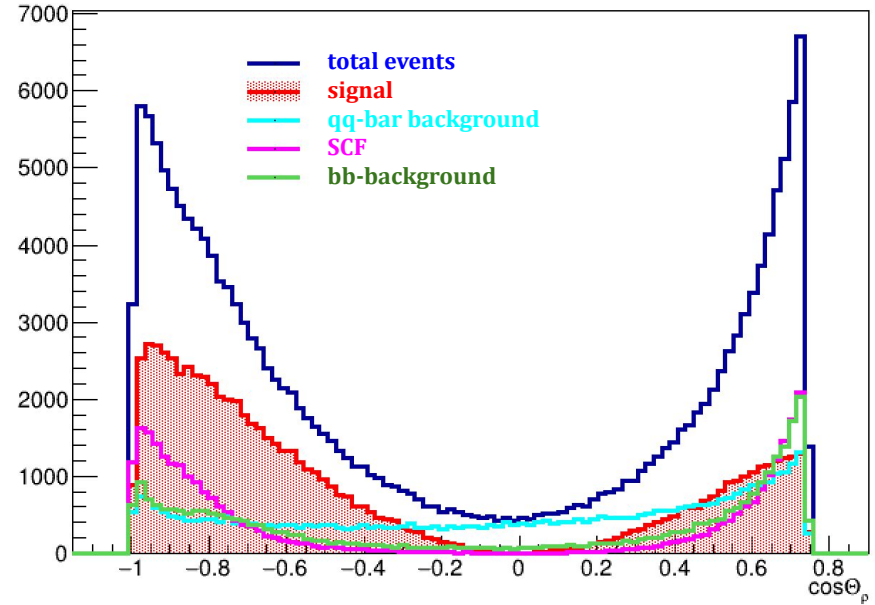
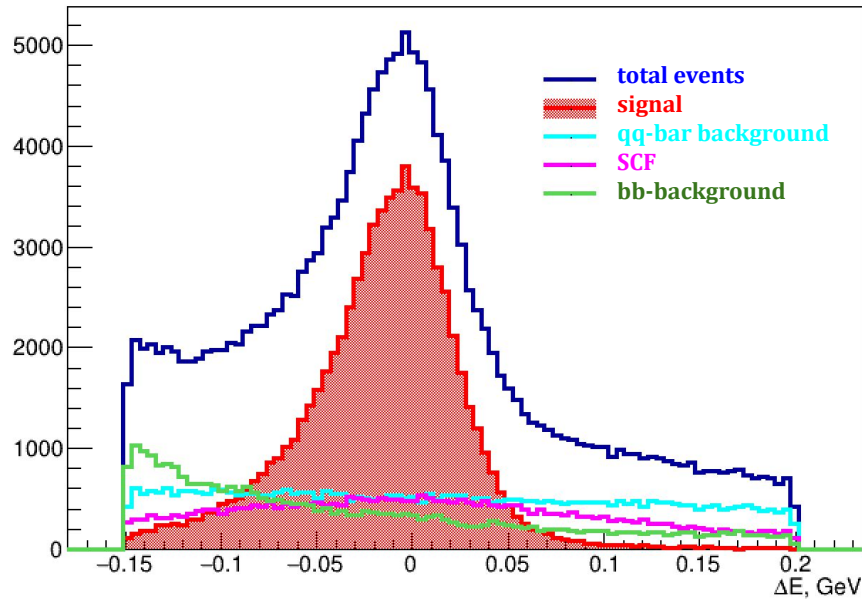
# Simultaneous fit of deltaE for 700 fb<sup>-1</sup> without R2 cut

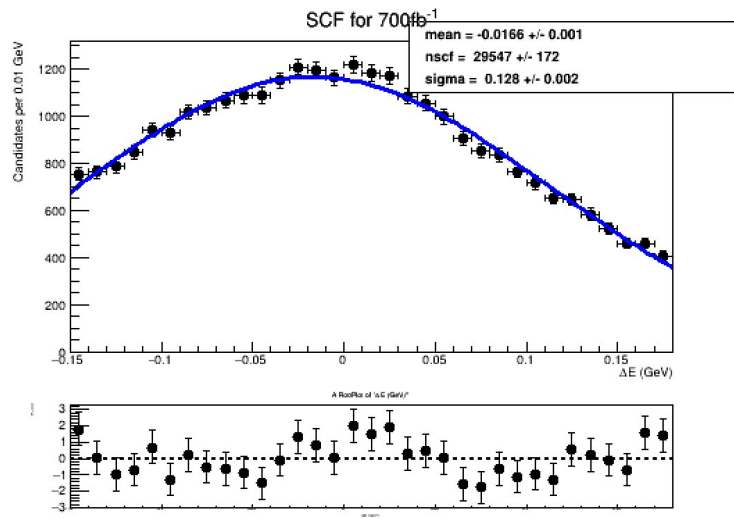
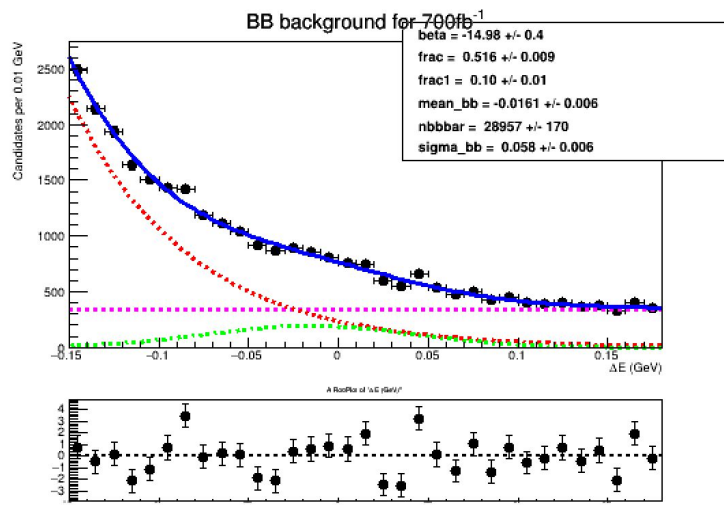
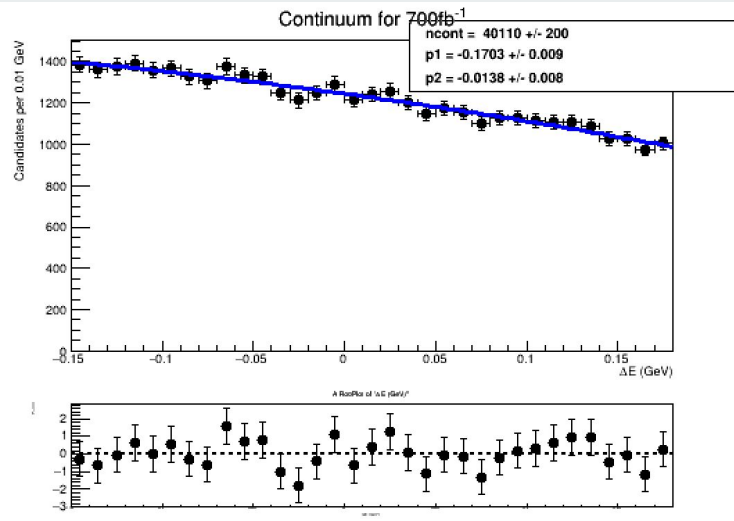
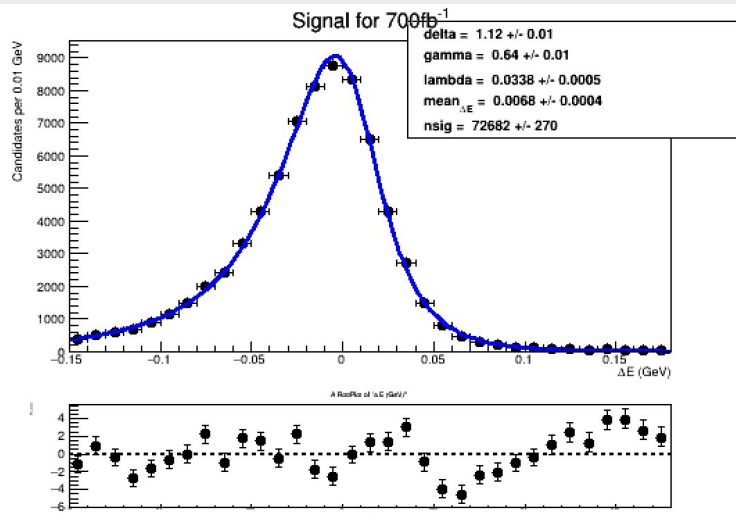


Composition	Fraction before fit	Fraction after fit
Signal	0.32	0.33
Continuum	0.41	0.4
SCF	0.13	0.13
BB-bar bkg	0.13	0.13



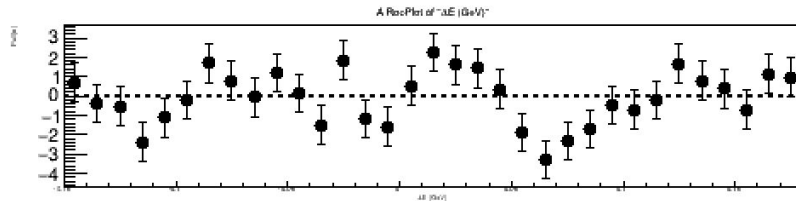
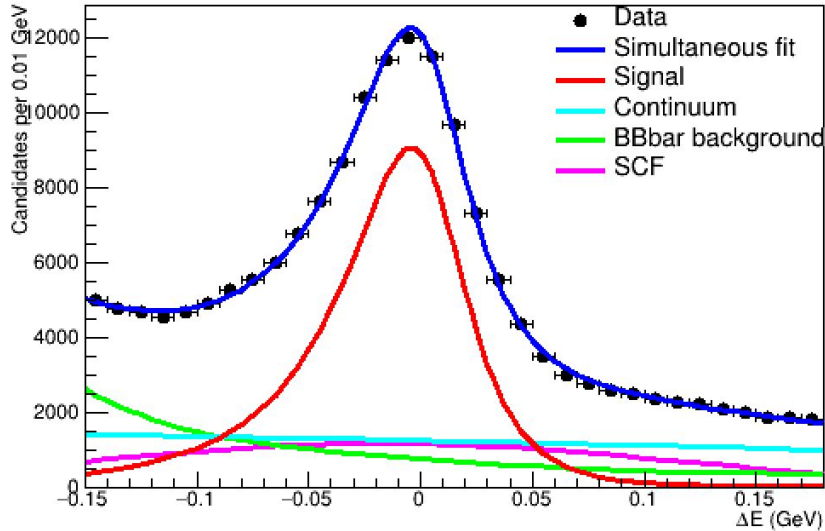
# 700 fb<sup>-1</sup> dataset





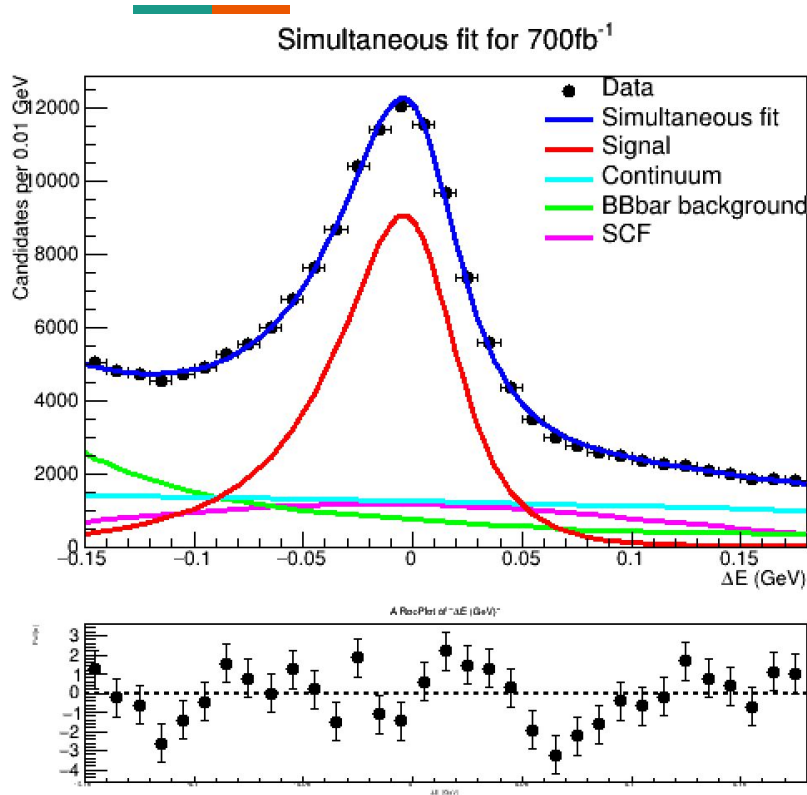
# Free parameters simultaneous fit (700 fb<sup>-1</sup>)

Simultaneous fit for 700fb<sup>-1</sup>



Composition	Nevents	Fraction after fit
Signal	72680	$72692 \pm 270$
Continuum	40110	$40109 \pm 200$
SCF	29548	$29548 \pm 172$
BB-bar bkg	28962	$28967 \pm 170$

# Free parameters simultaneous fit (700 fb<sup>-1</sup>)

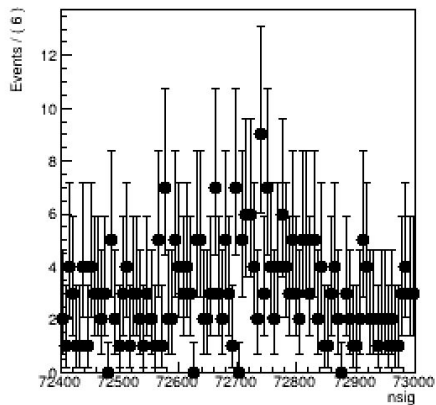


Sig PDF	cont PDF	SCF PDF	BBbar PDF
Sig Yield	Cont Yield	SCF Yield	BB Yield
$\Gamma$ _factor	Cheb1	mean_scf	beta
$\Delta$ _factor	Cheb2	sigma_factor	fraction1
mean			fraction2
			mean_bb
			sigma_bb

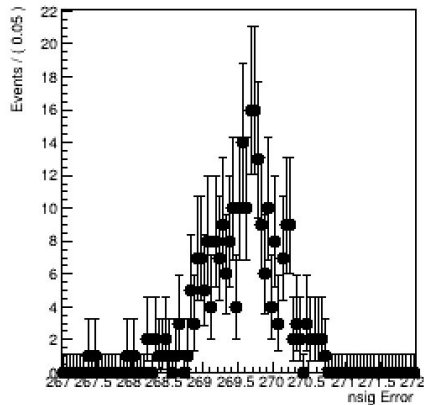


# Toy MC result for fit with 16 free parameters

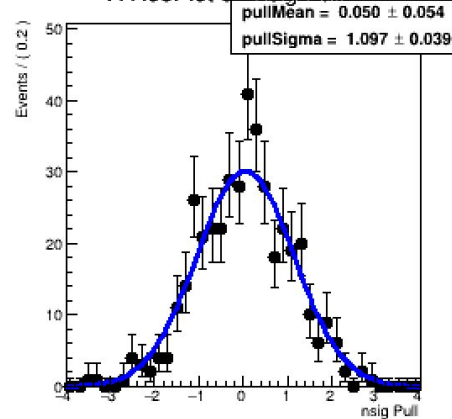
A RooPlot of "nsg"



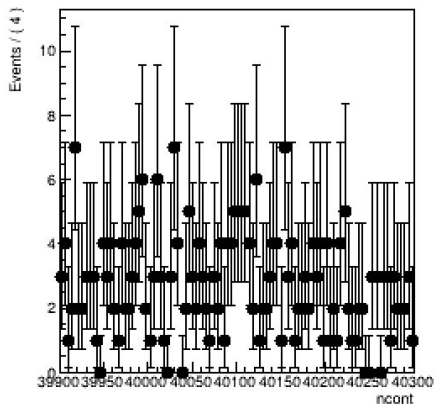
A RooPlot of "nsg Error"



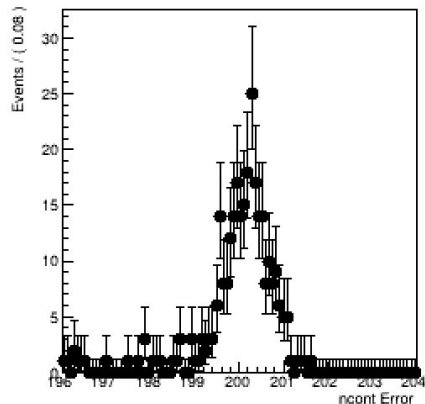
A RooPlot of "nsg Pull"



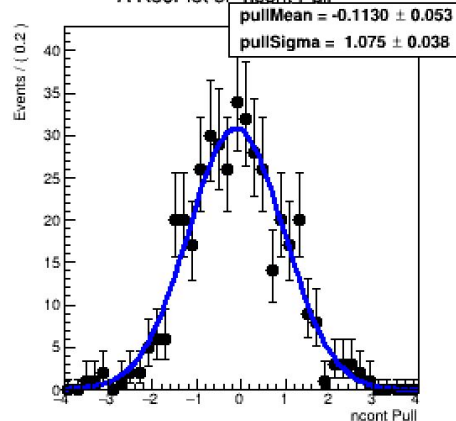
A RooPlot of "ncont"



A RooPlot of "ncont Error"

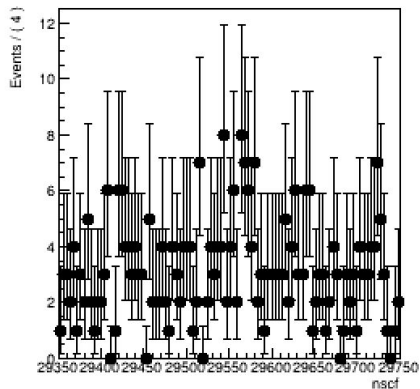


A RooPlot of "ncont Pull"

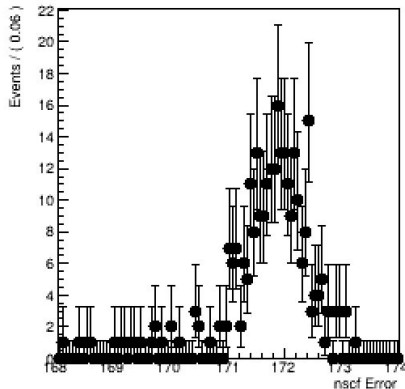


# Toy MC result for fit with 16 free parameters (2)

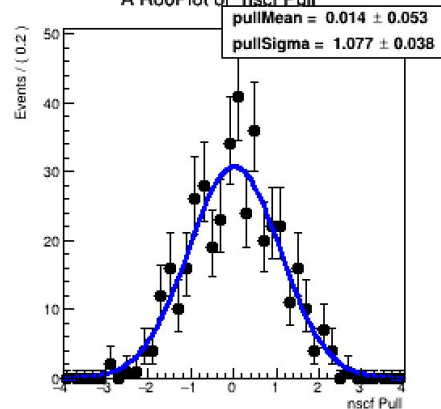
A RooPlot of "nscf"



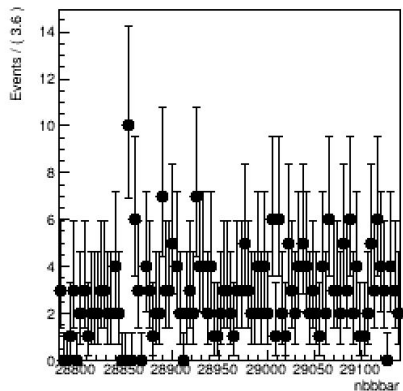
A RooPlot of "nscf Error"



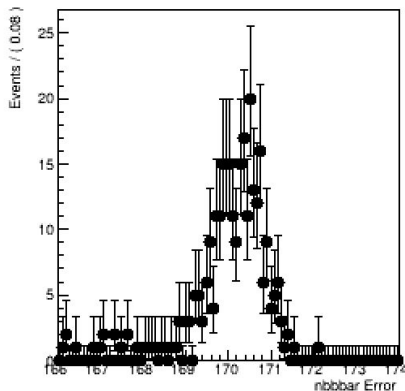
A RooPlot of "nscf Pull"



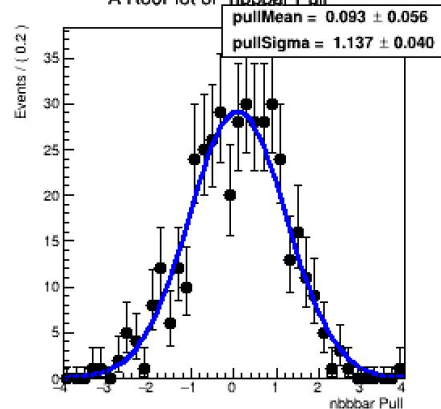
A RooPlot of "nbbar"



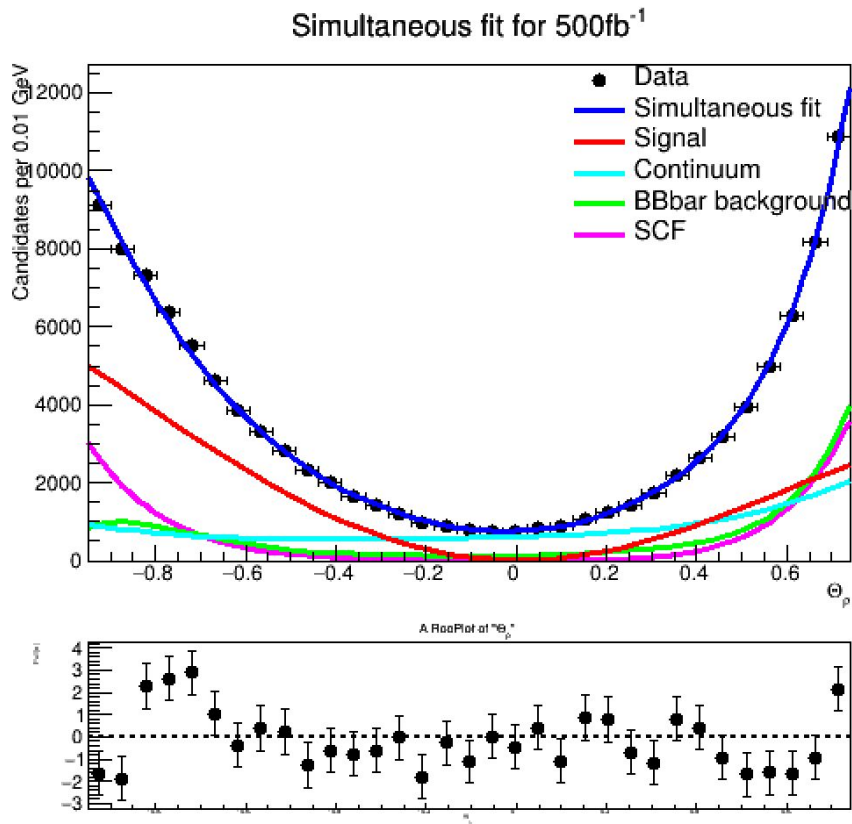
A RooPlot of "nbbar Error"



A RooPlot of "nbbar Pull"



# Simultaneous fit of $\cos\Theta_p$ with fixed parameters







# Backup



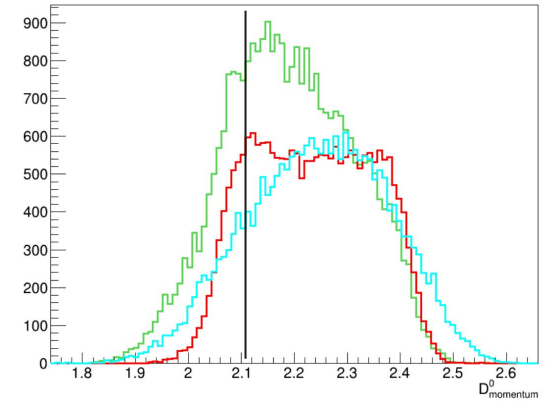
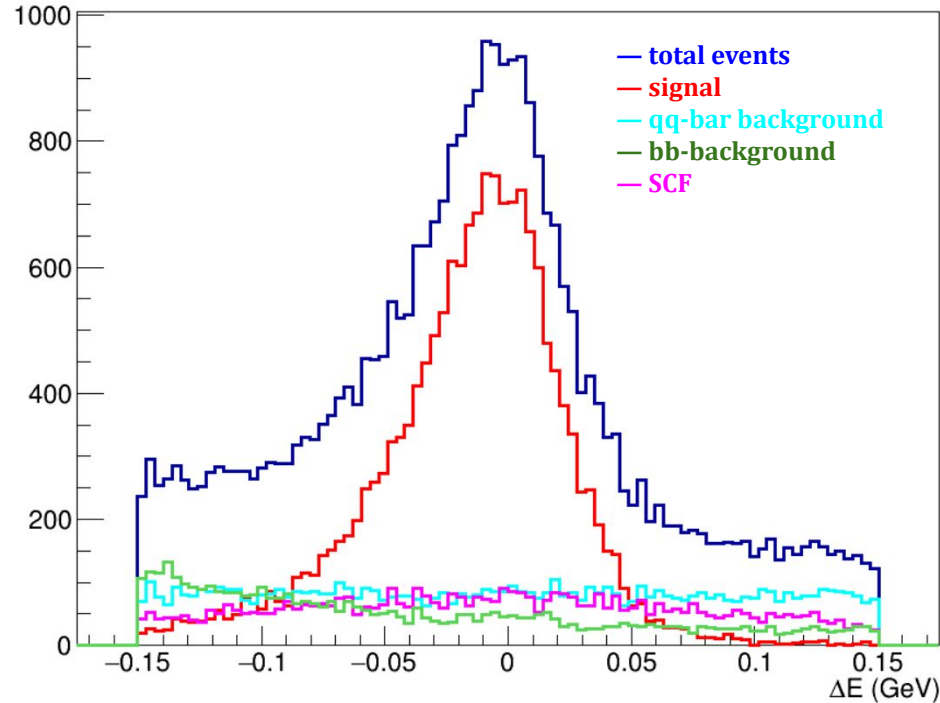
## Conclusions

- Additional pre-selection cuts were taken into account
- New optimized selection criteria were applied
- Analysis of the BB-bar background composition was performed
- With new cuts we are able to keep higher reconstruction efficiency (~20%) with smaller background fraction

### To do:

- Determine the  $B \rightarrow D\pi\pi^0$  signal yield by fitting the deltaE distribution.
- Will inspect  $m(\pi\pi^0)$  mass to separate  $\rho$  and non- $\rho$  contribution to the signal
- Will consider if using also  $\cos\theta_{\pi\pi}$  in the fit.

# Delta E with harder cut on $p(D^0) > 2.1$



Composition	Share
Signal	0.49
Continuum	0.22
SCF	0.16
BB-bar bkg	0.13

# Possible cut on the angle difference between 2 photons

