



Lab meeting

Yonsei University

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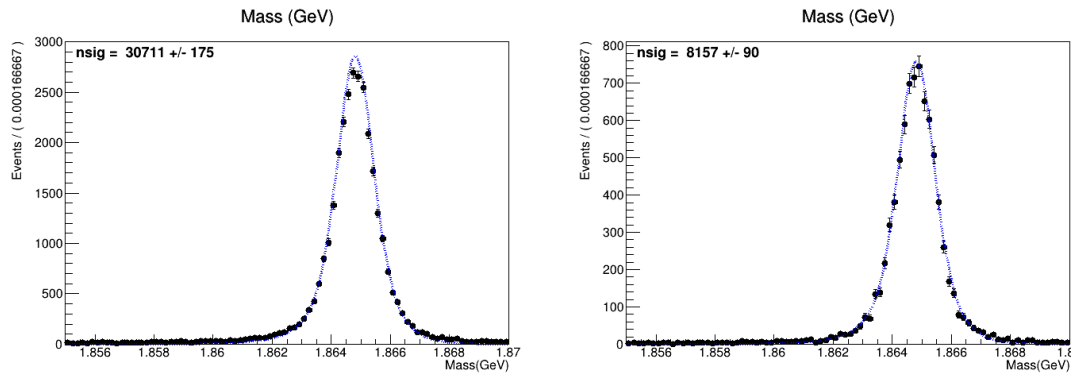
2025-02-12

Overview of progress

- BR measurement of $D^0 \rightarrow K^- \pi^+$ control sample study
 - BR measurement with fixed peak component
 - Found some problem in fitting strategy about fixing signal PDF
 - Tried with new strategy
 - New fit strategy for extraction of exclusive D^0 in my nominal fit method
⇒ seems working properly also
- Apply new fit strategy on extraction of $D^0 \rightarrow$ invisible
 - Check fit stability with Toy MC study (pull distribution & linearity test)
 - Estimation of UL from CLs method & Likelihood function integration
 - Signal extraction on signal embedded generic MC
 - Linearity test on exclusive D fit
- Decay channels to get systematic uncertainty about charm tagger...?

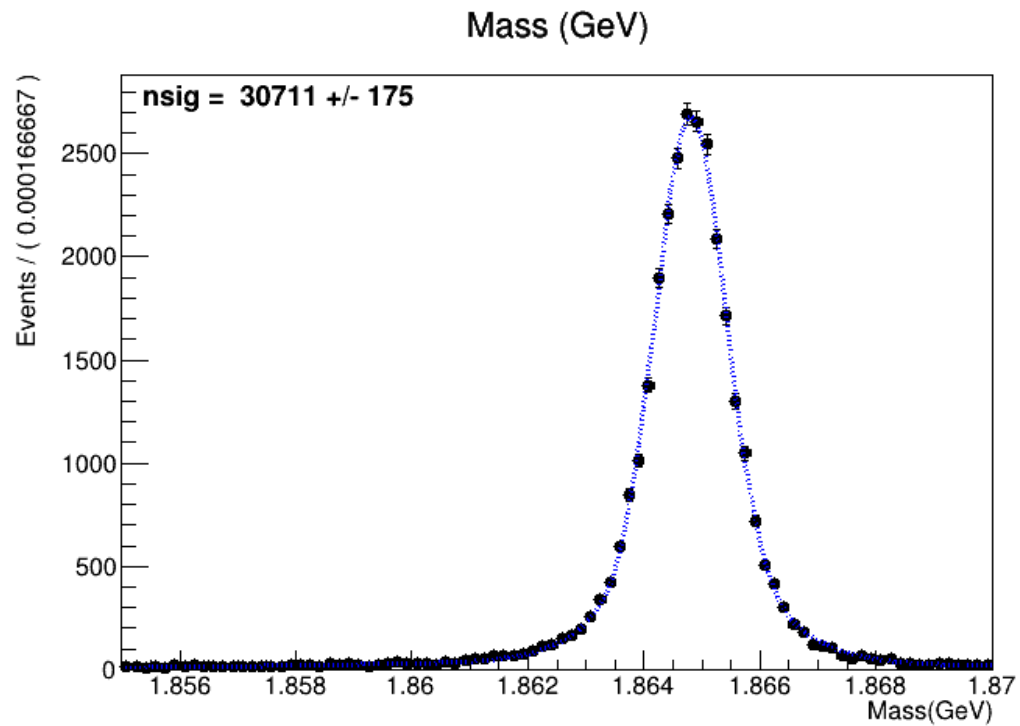
Problem in fitting strategy about fixing signal PDF

- Signal PDF shape was fixed on Inclusive D^0 fit result of signal MC
 - But, even if the peak + signal PDF shape (and the ratio of this two component) are fixed, the fitted yield of peak + signal is small than expected...
⇒ it seems the signal PDF slightly do not fit on data points even on signal MC or $D^0 \rightarrow K^- \pi^+$
⇒ so, tried with another signal PDF specifically on exclusive D^0

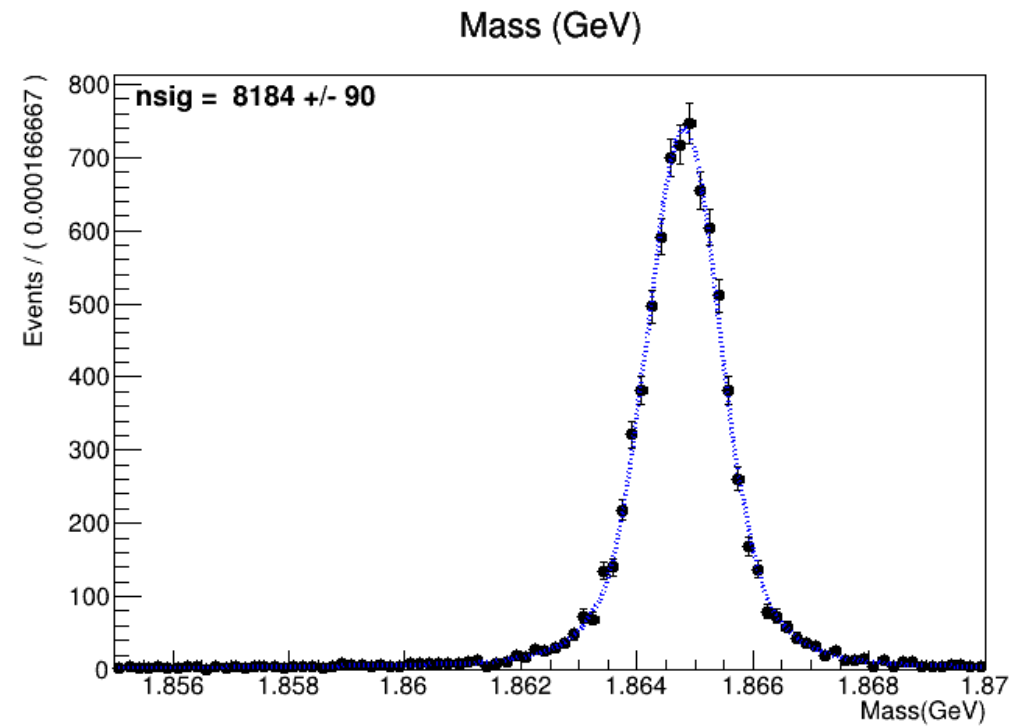


- New fit strategy for exclusive D^0 signal PDF:
 - Fixed on exclusive D^0 mass distribution
 - Exclusive $D^0 \rightarrow \nu \bar{\nu}$: fixed on exclusive D^0 of $D^0 \rightarrow \nu \bar{\nu}$ signal MC
 - Exclusive $D^0 \rightarrow K^- \pi^+$: fixed on exclusive D^0 of $D^0 \rightarrow K^- \pi^+$ signal MC

Signal PDF of exclusive $D^0 \rightarrow \nu\bar{\nu}, D^0 \rightarrow K^-\pi^+$

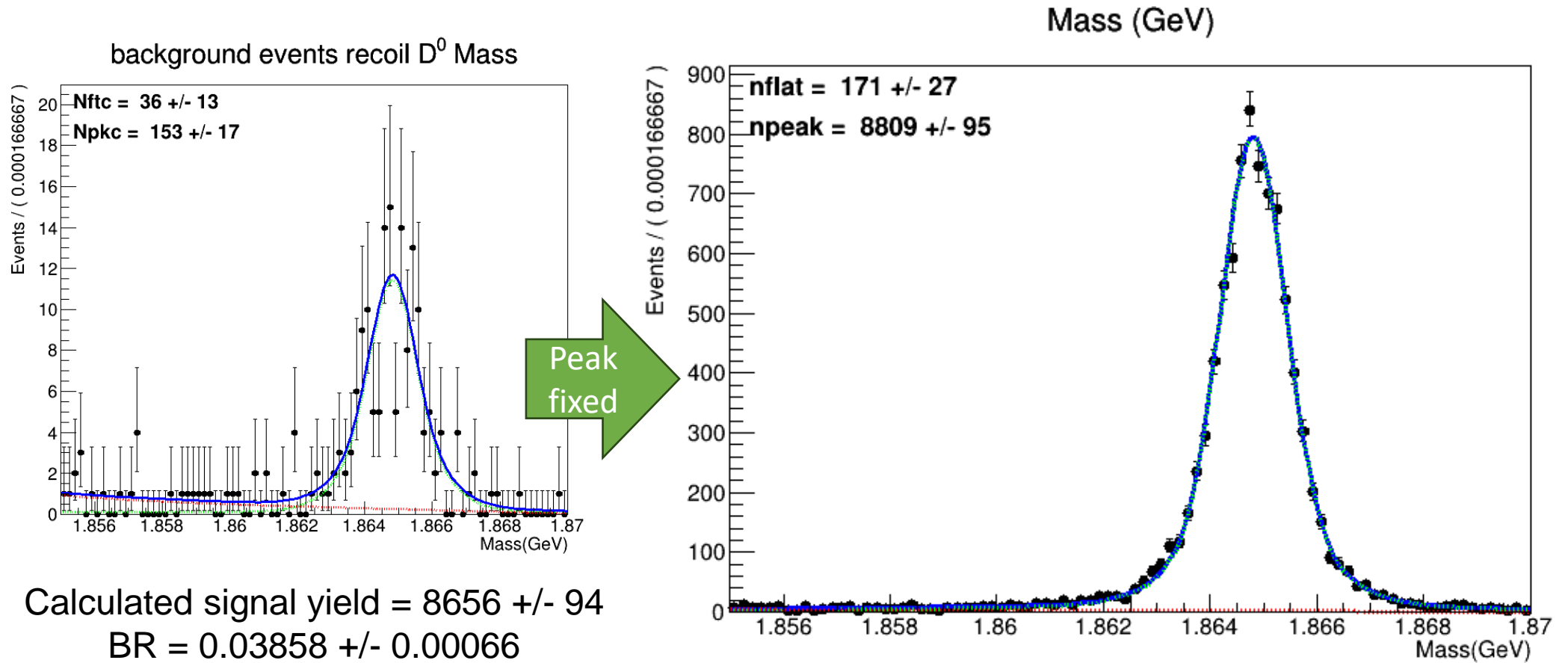


$D^0 \rightarrow \nu\bar{\nu}$

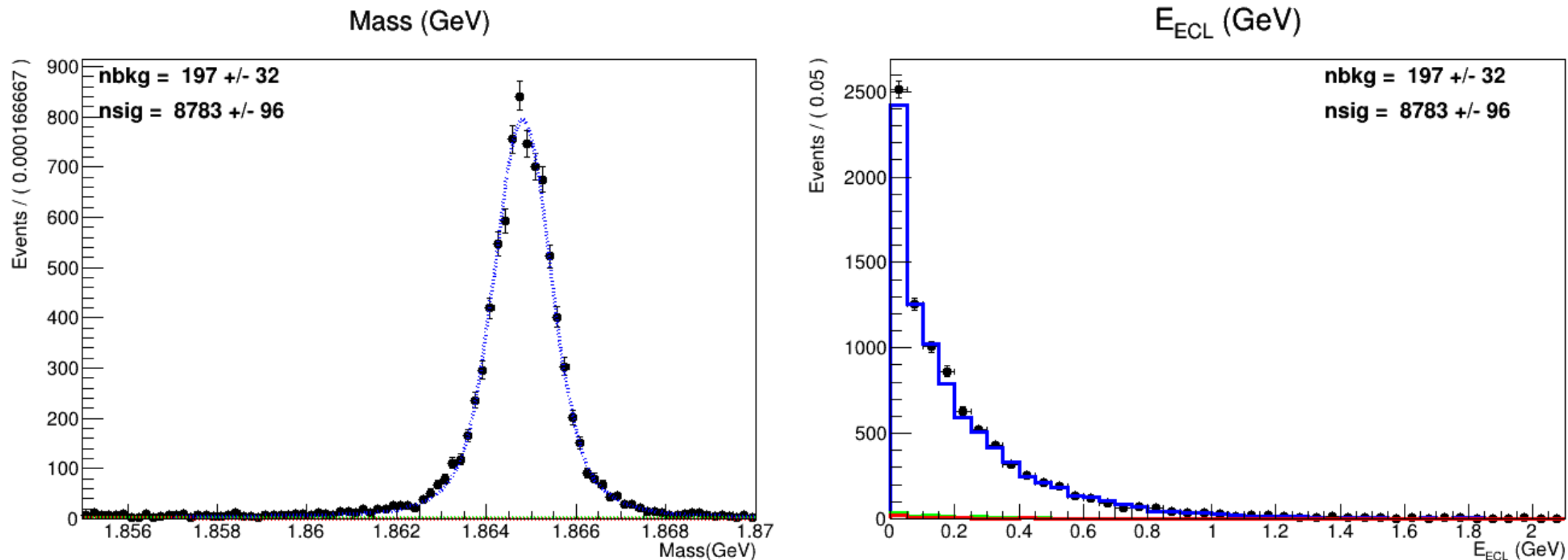


$D^0 \rightarrow K^-\pi^+$

BR measurement with fixed peak component ($D^0 \rightarrow K^- \pi^+$)

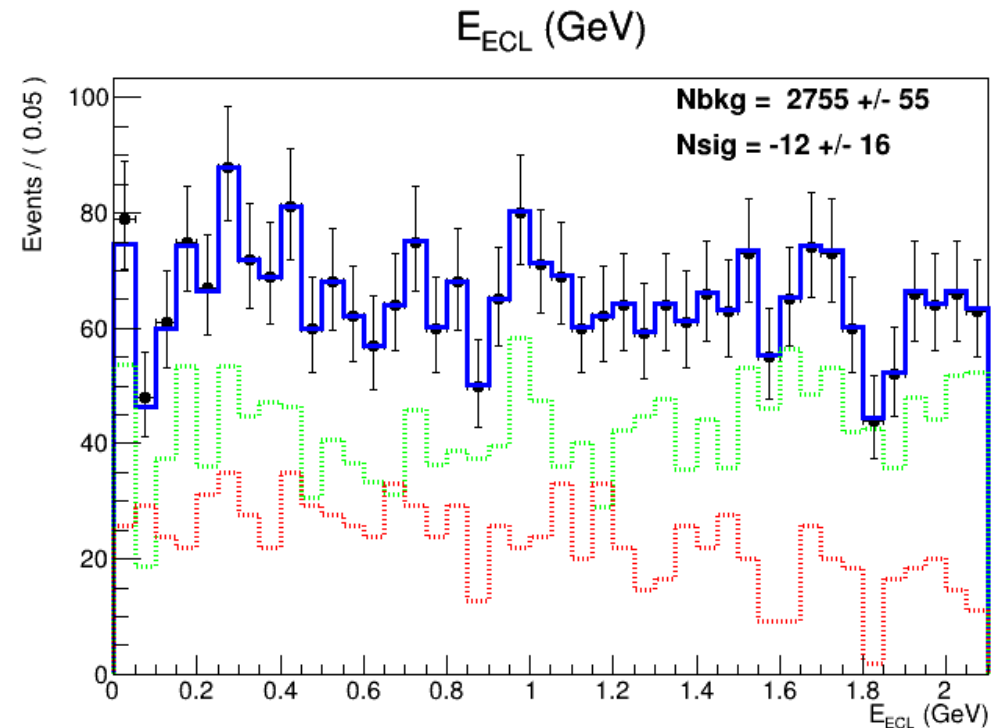
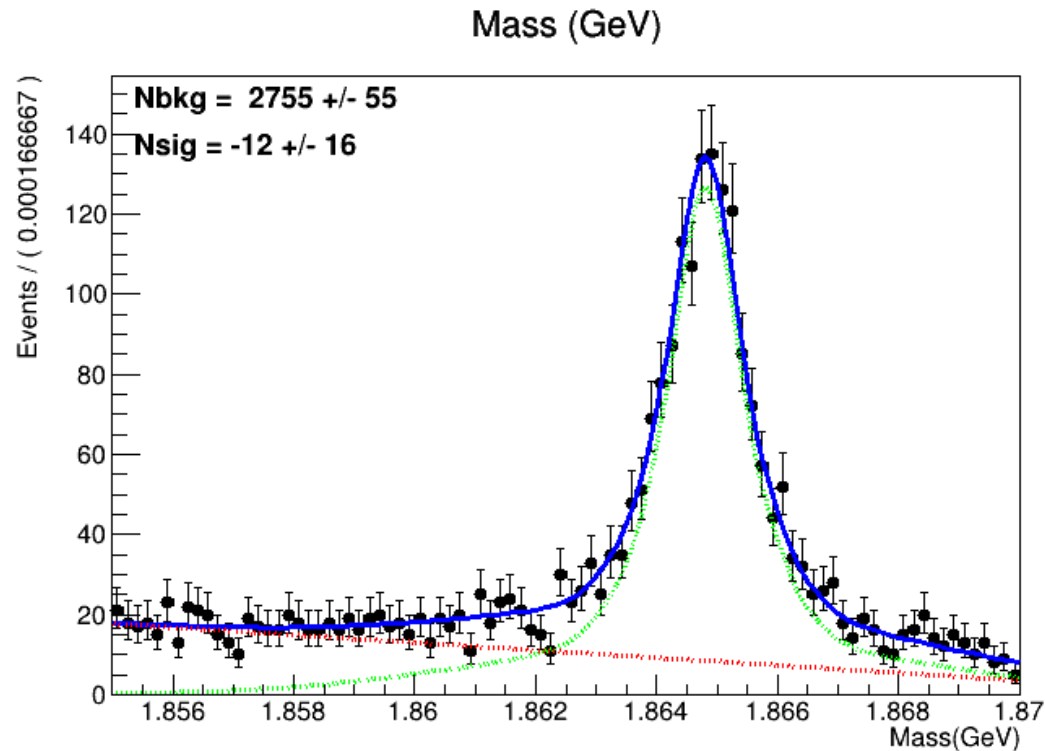


Nominal fit with new fit strategy



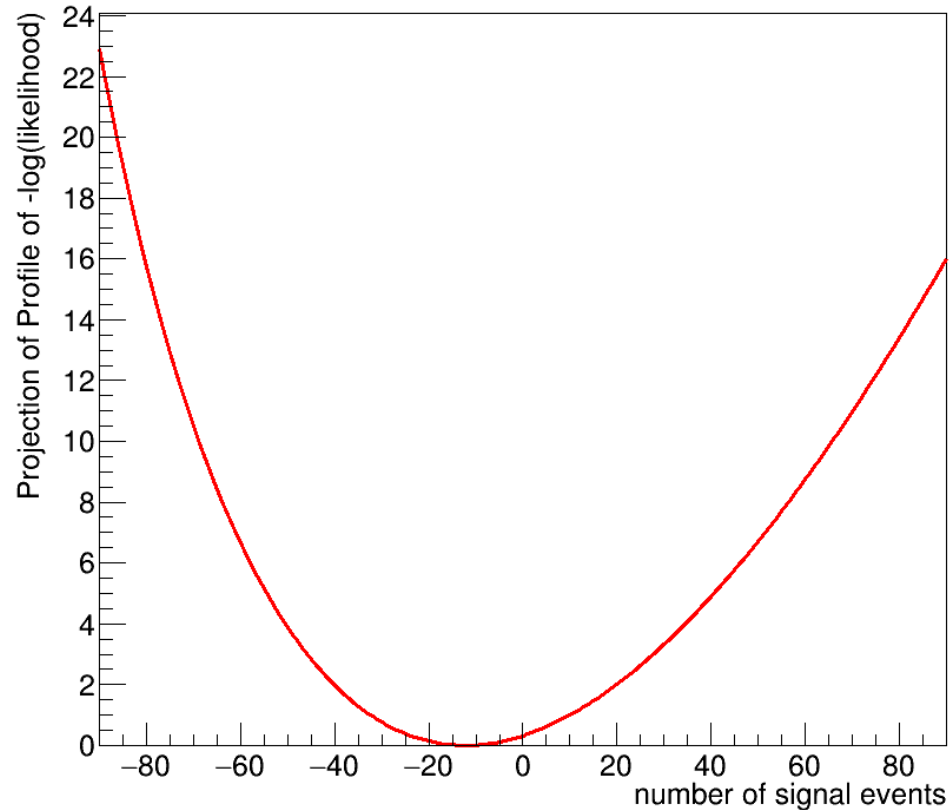
#($D^0 \rightarrow K^- \pi^+$ events) from TopoAna: 8791
The Nsig from fit result: 8783 +/- 96
BR from this result: 0.03914 +/- 0.00067
From decfile : 0.0395

Apply new fit strategy on extraction of $D^0 \rightarrow$ invisible



Upper limit of BR estimation

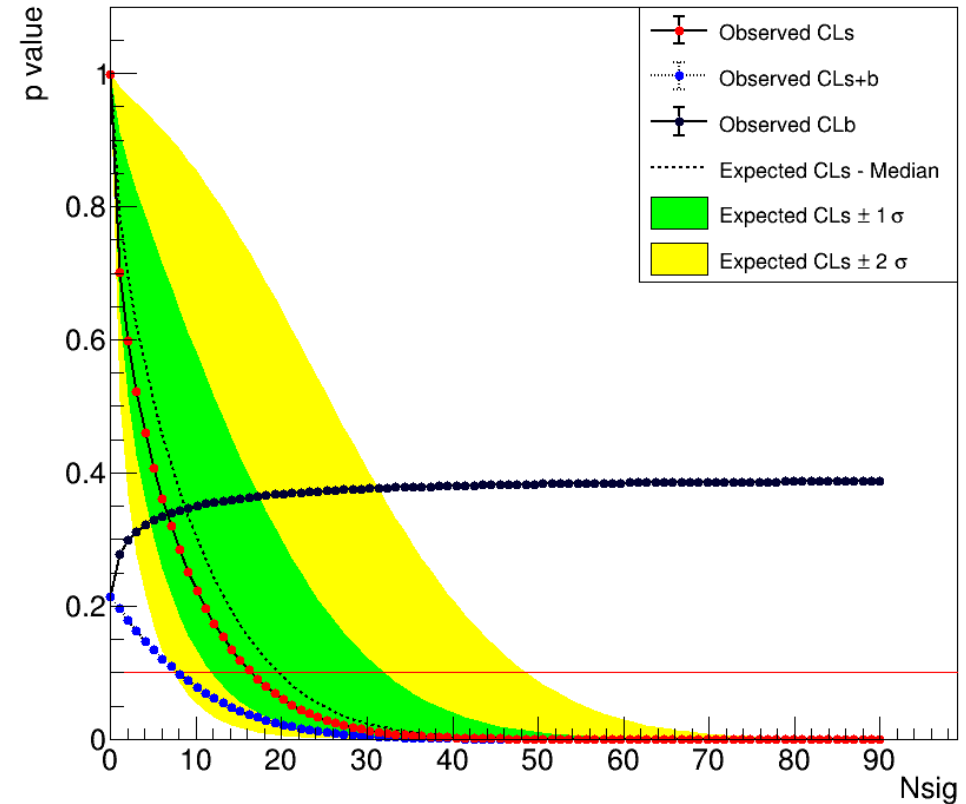
n_{sig}



UL of N_{sig} : 13.9085

UL of BR : 2.41×10^{-5} from Bayesian approach

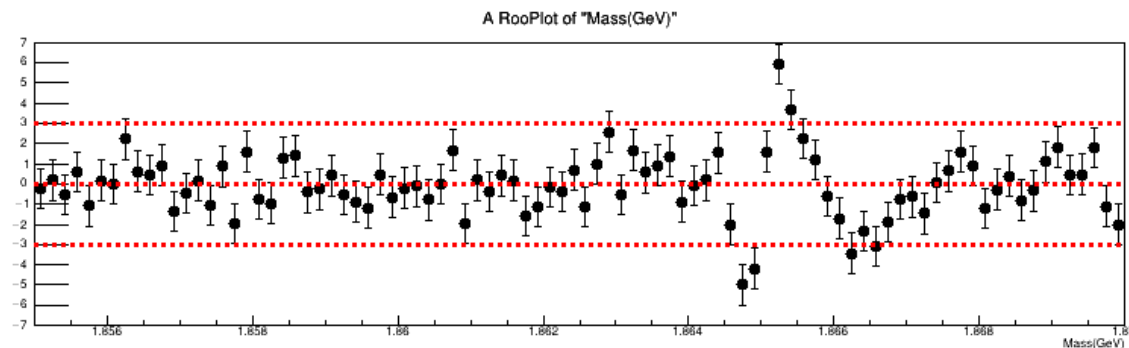
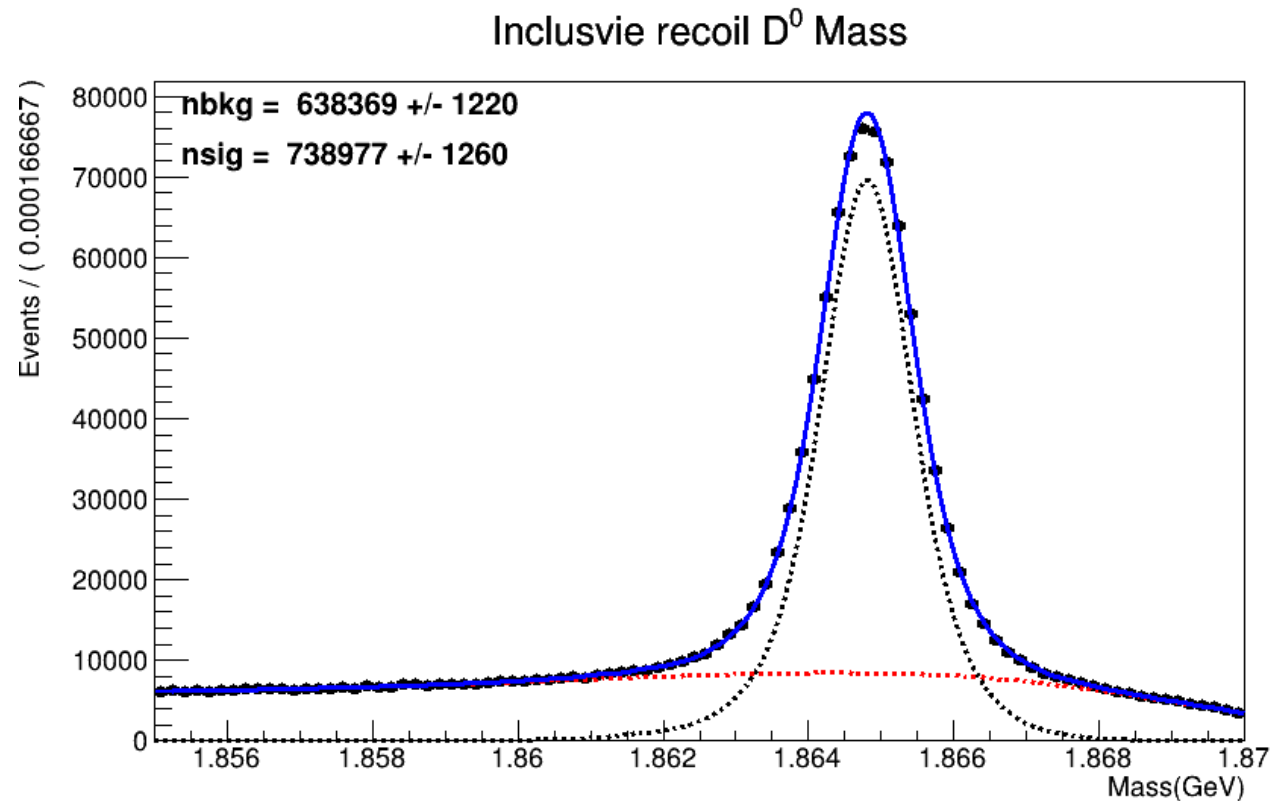
HypoTest Scan Result



UL of N_{sig} : 16.4465

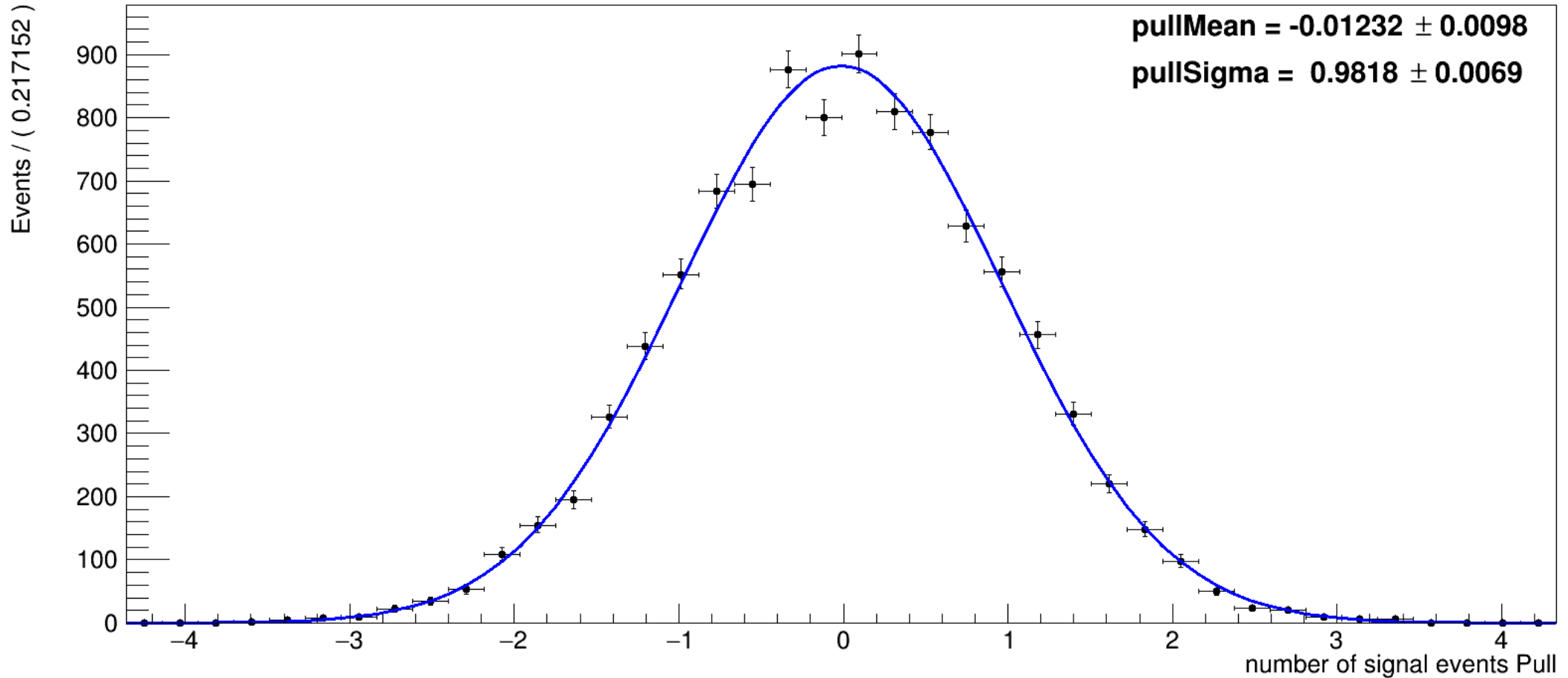
UL of BR : 2.85×10^{-5} from Frequentist approach

Inclusive D^0 fit result on generic MC



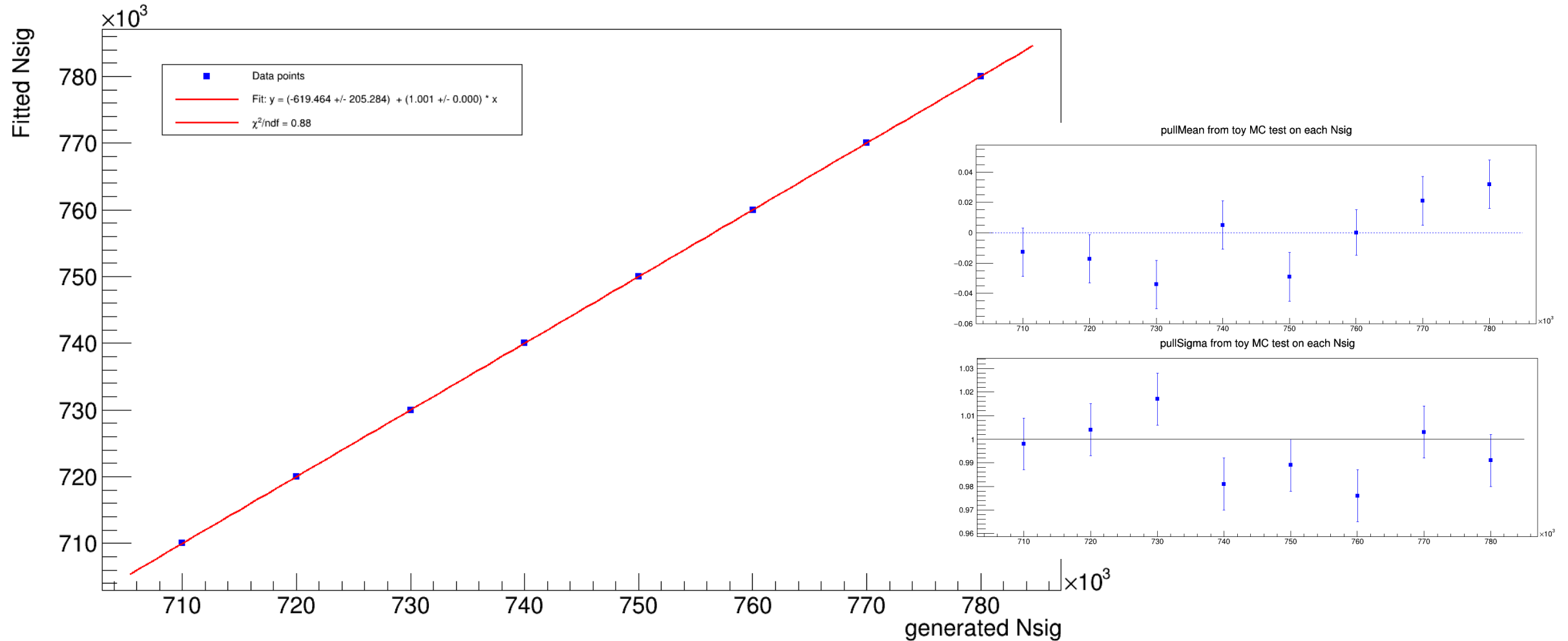
ToyMC test about inclusive D fit result

A RooPlot of "number of signal events Pull"



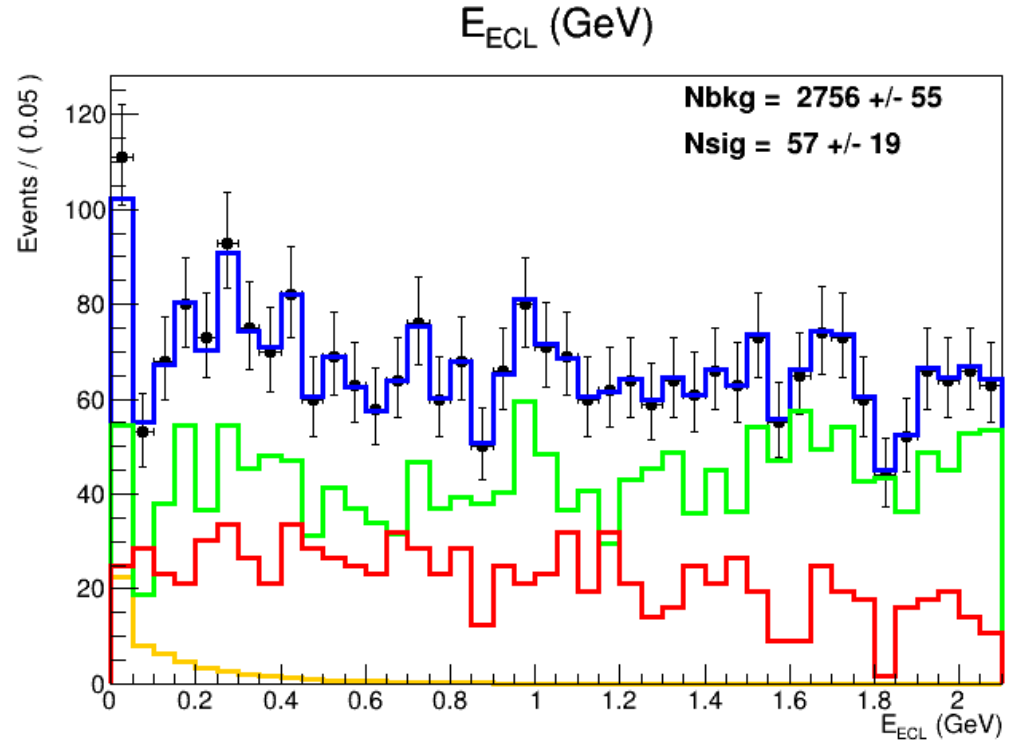
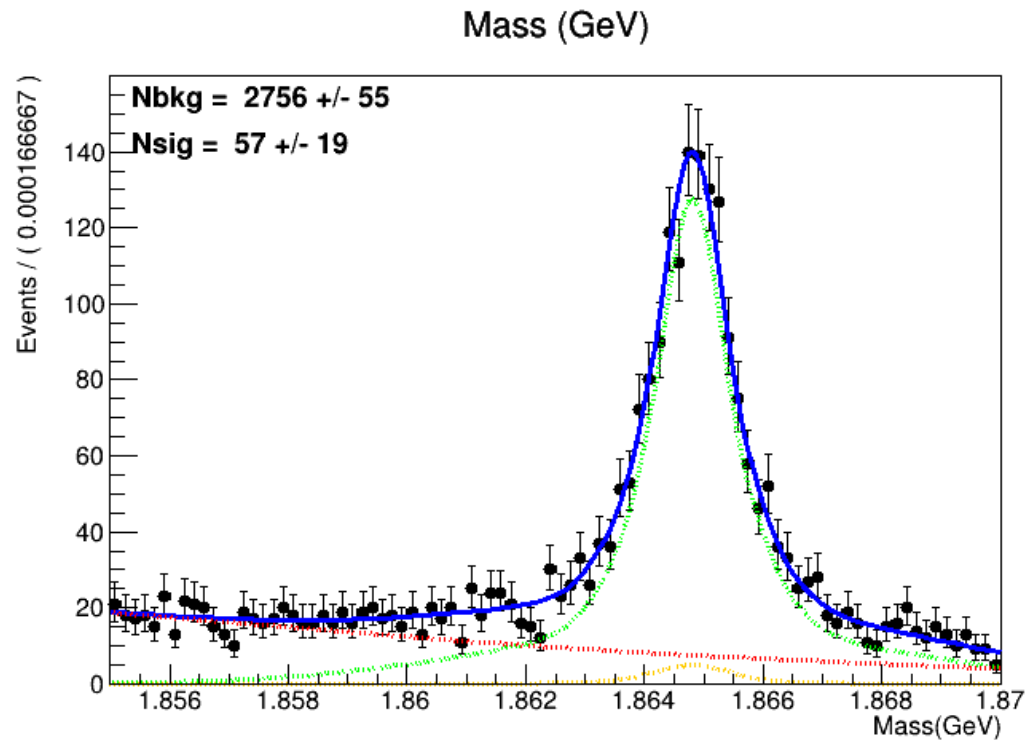
Inclusive D fit result check with Linearity test

Linearity Test



Signal extraction on signal embedded generic MC

(# of $D^0 \rightarrow$ invisibles is 70 ~ at around the UL(9.4×10^{-5}) from Y.T Lai's research)



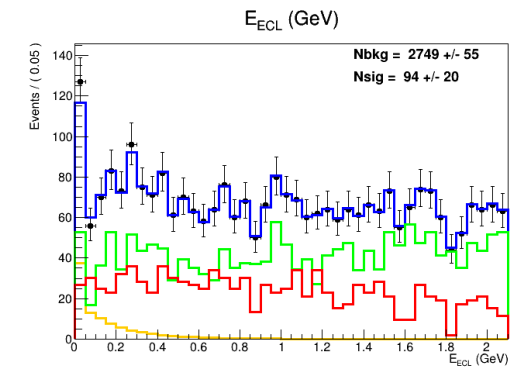
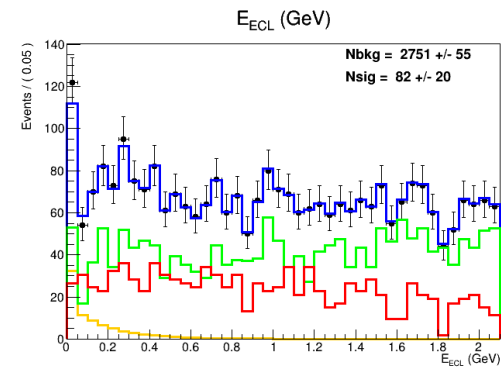
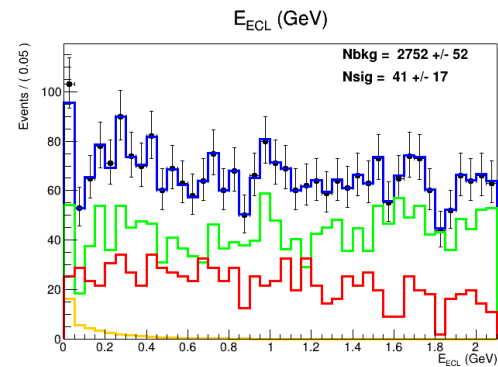
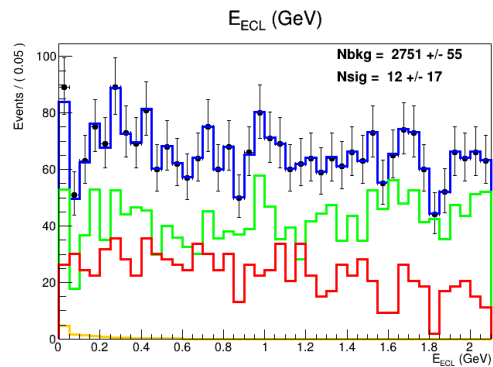
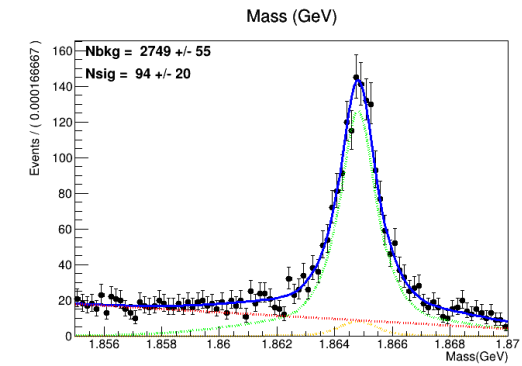
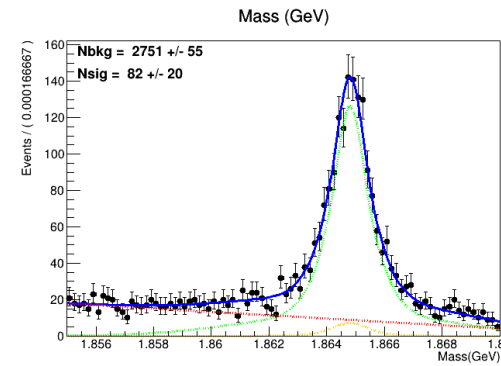
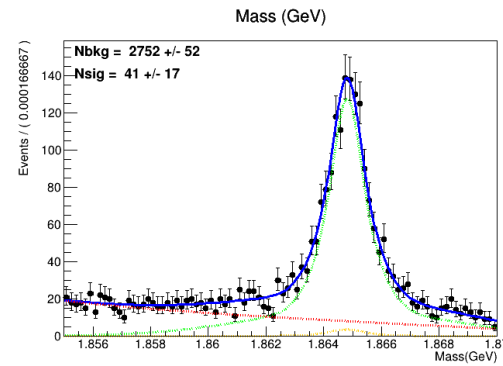
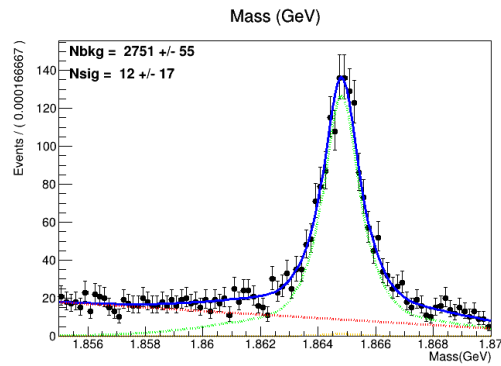
Trial with different # of $D^0 \rightarrow$ invisibles (15,20,30,50,69,70,75,90,100,150)

sig : 20

sig : 50

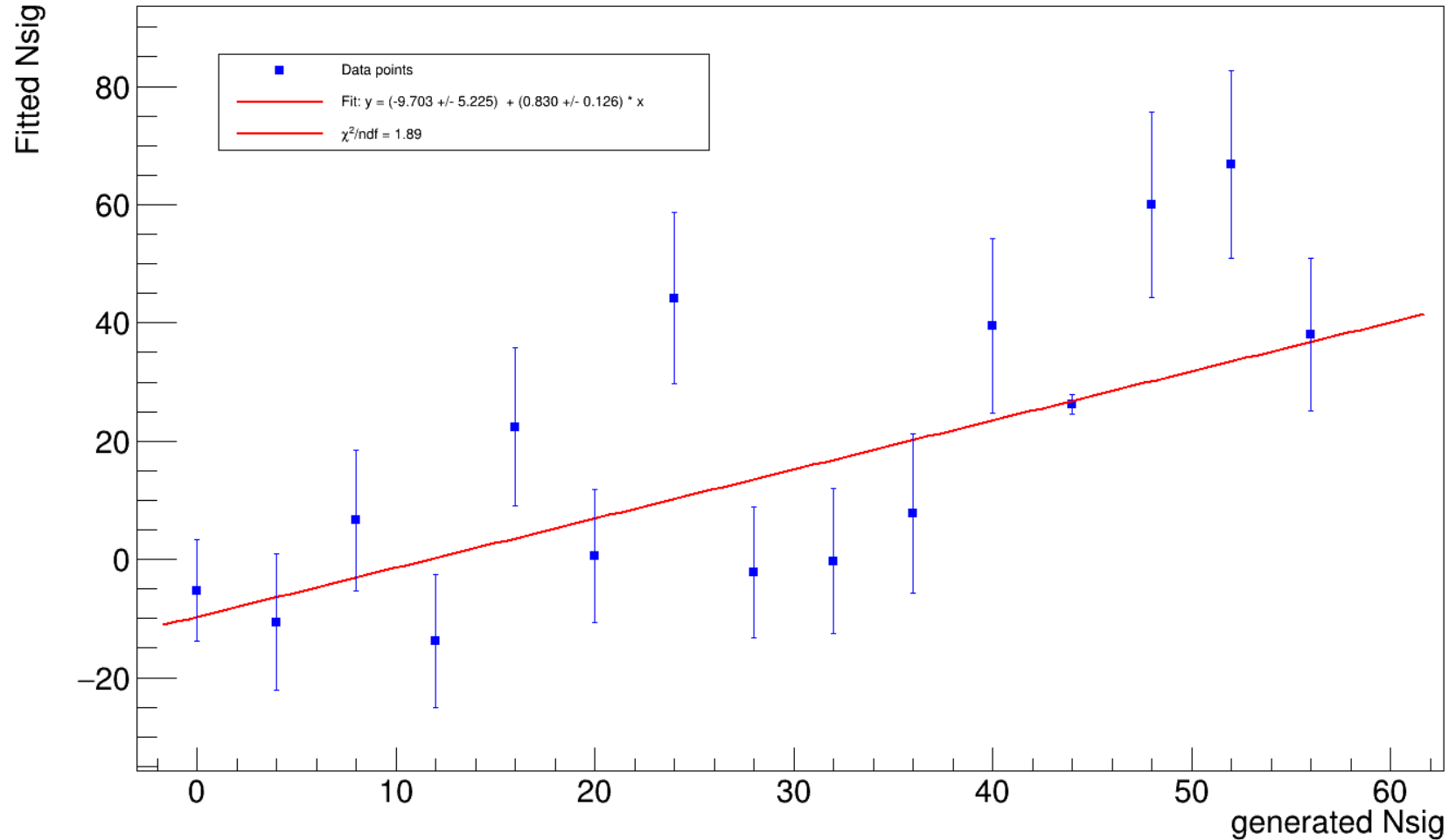
sig : 90

sig : 100

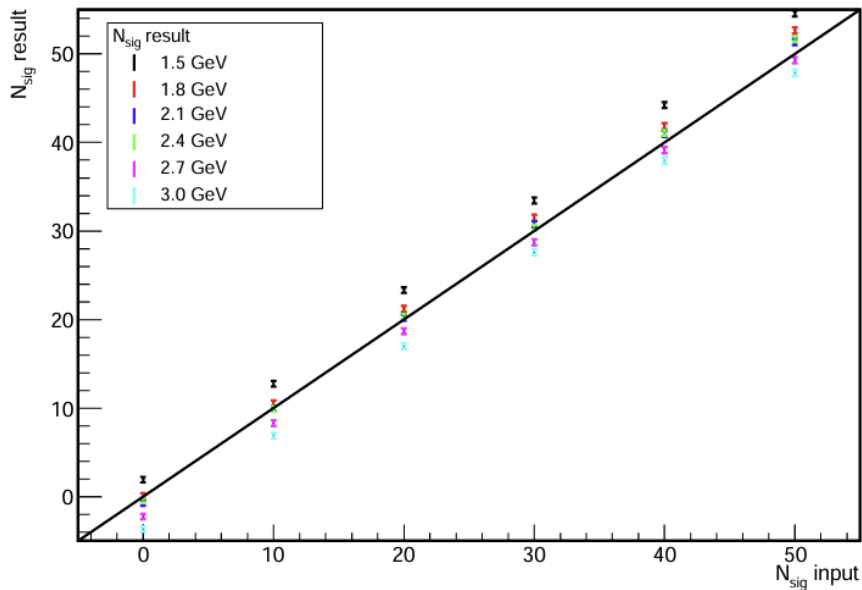


Trial to do linearity test of exclusive D fit result

Linearity Test



Check on Y.T Lai's ToyMC test



393 A Ensemble test results (obsolete)

394 A.1 $N_{flatbck}^{input}$ and $N_{peakbck}^{input}$ are from background MC

395 A.1.1 Gsim test

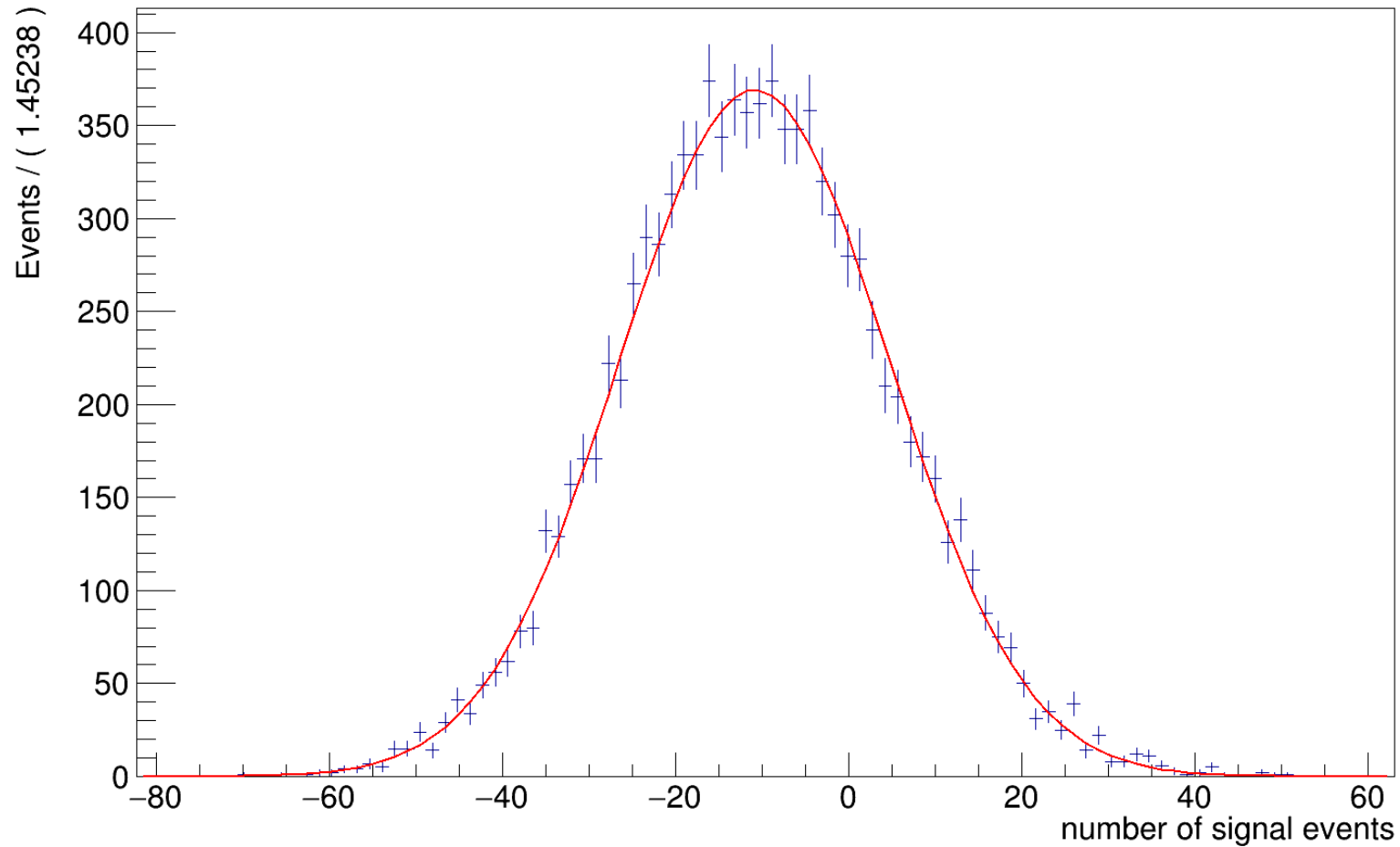
396 In order to determine the fitting region of E_{ECL} , we use gsim ensemble test
 397 with different E_{ECL} range. Upper bound of E_{ECL} varies from 1.5 GeV to 3.0
 398 GeV. For each set, linearity test with $N_{sig}^{input} = 0 \sim 50$ are done and each test
 399 includes 3000 fits. $N_{flatbck}^{input}$ and $N_{peakbck}^{input}$ are obtained from background MC,
 400 and their value under different cases are shown in Table 20. The results are
 401 shown in Figure 23. For 2.1 and 2.4 GeV cases (Table 21, 22), the outcomes
 402 show better performance on fitter (N_{sig} , $Pull_{sig}$, and $Width_{sig}^{Pull}$ can cover the
 403 expected values within 3σ).

$E_{ECL} < (\text{GeV})$	$N_{flatbck}^{input}$	$N_{peakbck}^{input}$
1.5	3773.18	1086.74
1.8	4679.82	1353.07
2.1	5550.98	1649.16
2.4	6392.18	1966.17
2.7	7170.15	2299.53
3.0	7835.85	2634.63

Table 20: $N_{flatbck}^{input}$ and $N_{peakbck}^{input}$ under different E_{ECL} range.

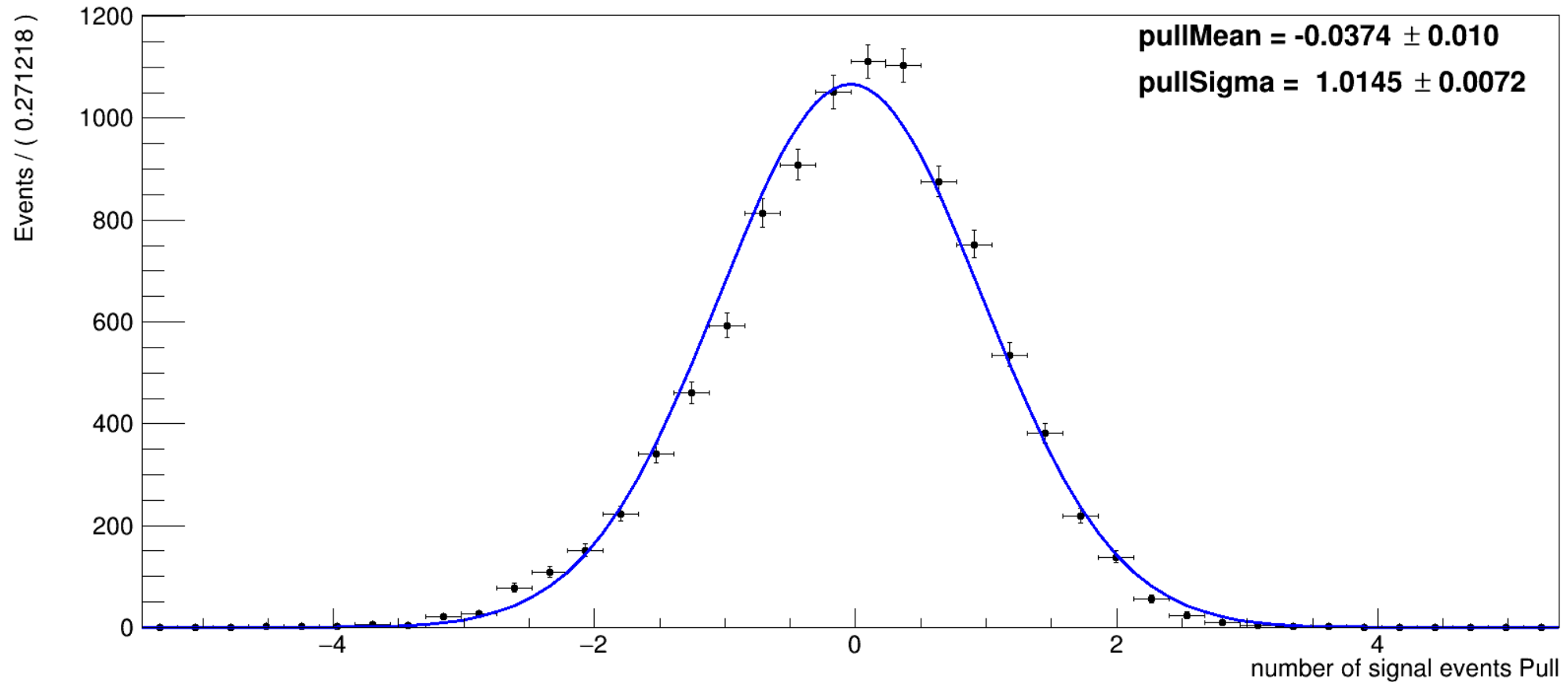
How to extract mean and sigma of fitted Nsig in Linearity test

Histogram of fitParData_model__Nsig



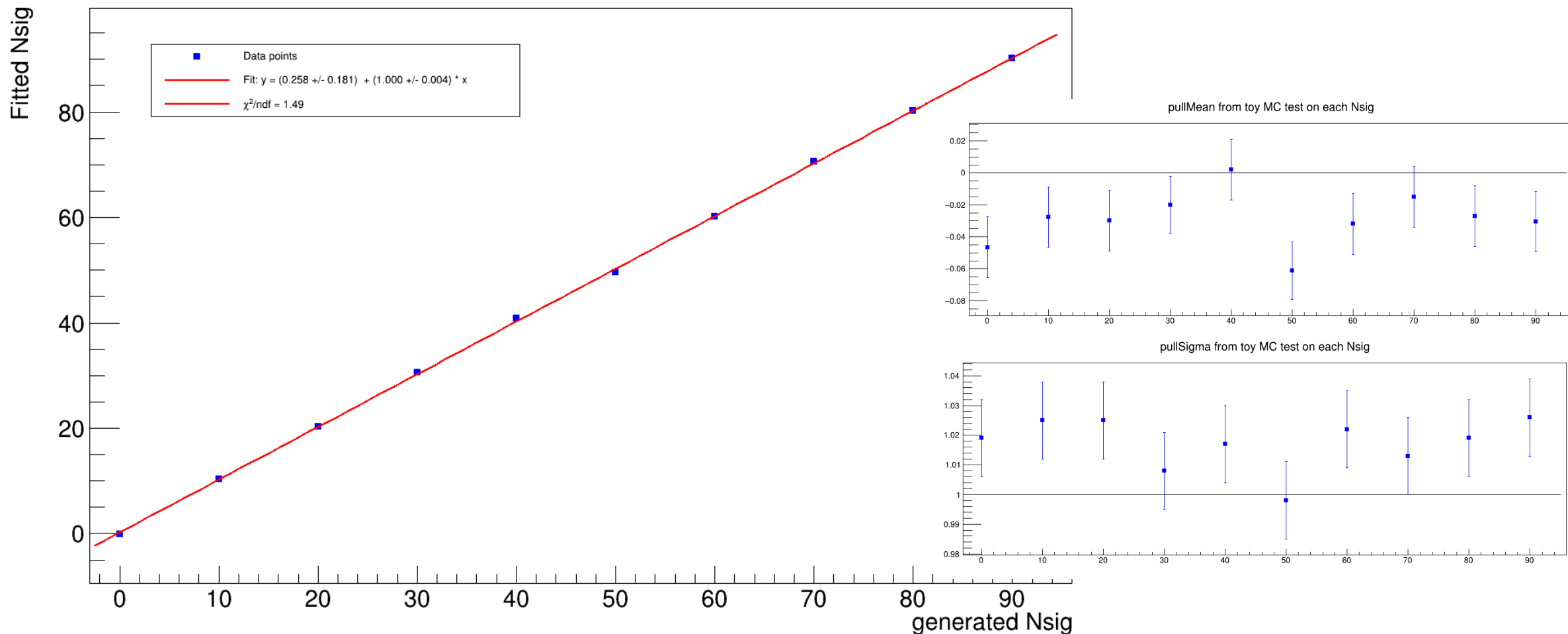
ToyMC test of 2D fit about exclusive $D^0 \rightarrow$ invisible

A RooPlot of "number of signal events Pull"



Linearity test of 2D fit about exclusive $D^0 \rightarrow$ invisible

Linearity Test



Decay channels to get systematic uncertainty about charm tagger

Decay	BF [%]
$D^0 \rightarrow K^- \pi^+$	3.948 %
$D^0 \rightarrow K^- \pi^+ \pi^0$	14.4 %
$D^0 \rightarrow K_S^0 \pi^+ \pi^-$	2.80 %
$D^0 \rightarrow K^- \pi^+ \pi^- \pi^+$	8.22 %
Total BF	29.368 %

- Rough procedure:
 - Measure BF of each decays on Data(run-dependent) and MC
 - Check the Data/MC difference on measured BF of each decays
- Need to request generation of signal MC about these decays (run-dependent samples will be needed => 1M + 1M(c.c) may be enough
 - After the presentation about this on charm group meeting
- May study semi-leptonic mode such as $K \ell \nu$ in future

The next thing will be

- B2GM charm parallel session presentation on Feb.27 with this content
 - About signal embedded fit & Toy MC test result
 - About control sample BR measurement
 - About plan of estimating the systematic uncertainty about charm tagger
- => Start to study systematics of charm tagger

Backup : signal embedded fit result (15,30,69,75,150)

sig : 15

sig : 30

sig : 69

sig : 75

sig : 150

