Search for Higgs portal Dark matter

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11/16

Upper limits

- **I included the H → ZZ* → 4ν background and estimated an upper limit of signal cross section when the signal cross section is 0 [fb] .**

1.Generating the background distributions for recoil mass by ToyMC.

→ Difinition of ToyMC : $\mathbf{X_{h\to 4\nu} \times P_{sig} + X_{bg} \times P_{bg}}$ **: (1)**

($X_{h\to 4\nu}$: number of h→4ν back ground events X_{bg} : number of background events ,

P_{bg} : pdf for background recoil mass , P_{sig} : pdf for signla recoil mass)

2.Fitting the toymc distribution by fit function, and getting parameter N_{sig} of fit function.

→ Difinition of fit function : $\mathbf{P = (N_{sig} + N_{h\to 4\nu}) \times P_{sig} + N_{bg} \times P_{bg}}$ **: (2)**

(N_{sig} : number of signal events , $N_{h\to 4\nu}$: number of h→4ν background events , N_{bg} :number of background events)

3. When 1000 experiments is performed , I can get a distribution of parameter N_{sig}(Fig 1).

4. When confidence lever is 95 % , I can get an upper limit of N_{sig} or upper limit of signal cross section .

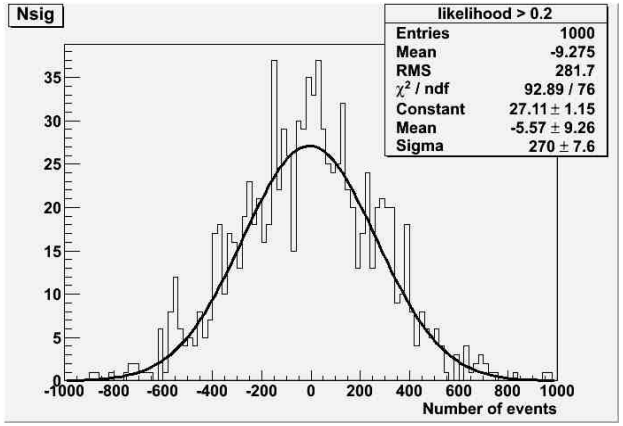


Fig1 . Distribution of parameter N_{sig}

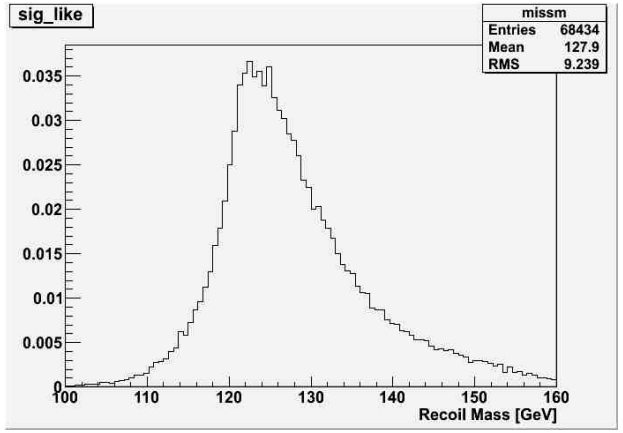


Fig2 . Pdf of signal for recoil mass

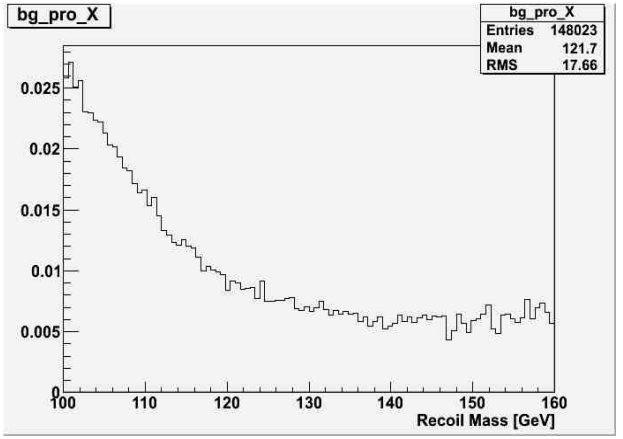


Fig3 . Pdf of background for recoil mass

Result

- I estimated upper limits when signal cross section is 0[fb]
- Optimization of the likelihood t ratio to minimize the upper limit.

→Best likelihood ratio cut is 0.4.

- I estimated the upper limit of Branting ratio H → DM,DM

$$BR(H \to DM, DM) = \frac{\sigma_{DD}^{C.L.95\%}}{\sigma(e^+e^- \to ZH)} = 3.2\times10^{-3}$$

Table 1.Previous result (BG: ZZ,ννZ,WW,eνW,eeZ) ●

likelihood ratio	Nsig (C.L 95%)	efficiency	upper limit [fb]
0	555	0.687	0.807
0.1	535	0.687	0.779
0.2	525	0.678	0.774
0.3	505	0.654	0.773
0.4	435	0.591	0.736
0.5	385	0.476	0.810
0.6	245	0.269	0.910
0.7	27	0.006	4.265

Table 2.New result(BG:ZZ,ννZ,WW,eνW,eeZ,h→4ν) ▲

likelihood ratio >	$N^{h\to4\nu}_{sig}$ (C.L.95%)	efficiency	upper limit $_{h\to4\nu}$ [fb]
0	575	0.687	0.837
0.1	575	0.687	0.837
0.2	535	0.678	0.789
0.3	515	0.654	0.788
0.4	455	0.591	0.770
0.5	395	0.476	0.831
0.6	245	0.269	0.910
0.7	28	0.006	4.423

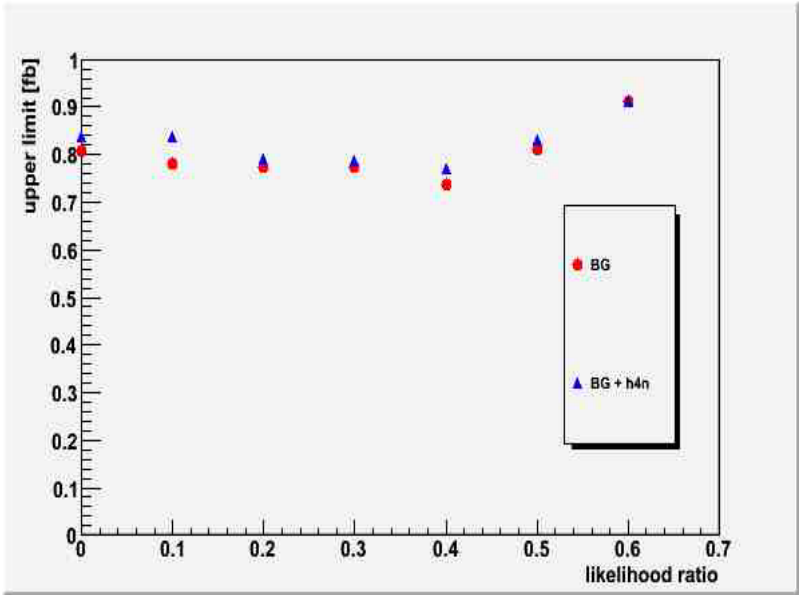


Fig2 . Likelihood vs upper limit

Summary and Plan

■Summary

- I estimated an upper limits when signal cross section is 0[fb].
- Optimization of the likelihood ratio cut to minimize the upper limit. →Best likelihood ratio cut is 0.4.
- I estimated $BR(H \to DM,DM)_{\text{upper limit}}$.

$$\longrightarrow \quad BR(H \to DM, DM) = \frac{\sigma_{DD}^{C.L.95\%}}{\sigma(e^+e^- \to ZH)} = 3.2 \times 10^{-3}$$

■Plan

I will include the following background and estimate an upper limit.

i. ZH → Z(ZZ*) →νν(Z νν)

ii. ZH → Z(ZZ*) →νν(νν Z*)

Signal and Background

■Signal event

e^+e^- → ZH → qq DM DM .

→2 Jets and 2 missing particles

Recoil mass against Z boson reconstructed from di-jet should be Higgs mass.

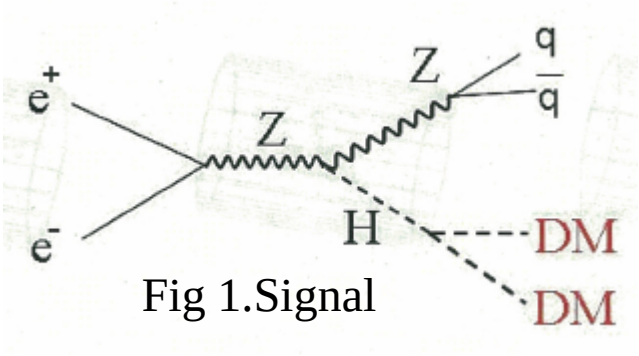


Fig 1.Signal

■background events

ZZ

ννZ → ννqq

WW

eνW→eνqq

eeZ →eeqq

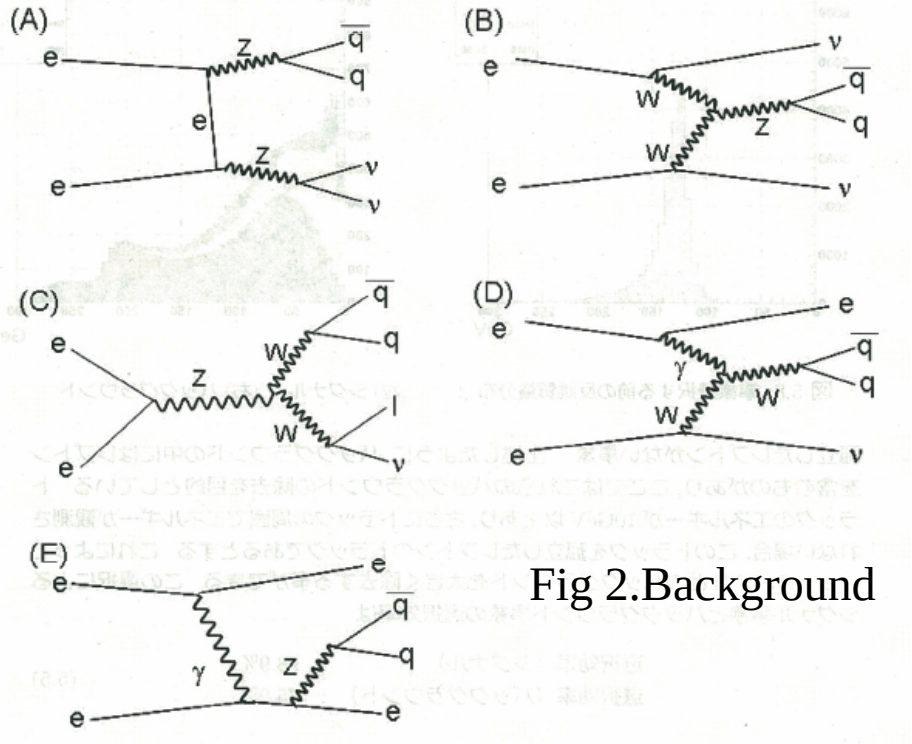


Fig 2.Background

Analysis

■ Machin Parameters

*Ecm=250GeV

DM is produced in the ee→ZH, Z→qq, H→DD process

*luminosity : 1[ab^{-1}]

*electron polarization :0.8

*positron polarization :-0.3

■ Model Parameters

*Spin of DM : 1/2

*DM mass : 50GeV

*Cf : 6.86

*Λ : 1000

■ Event Generation

* Background events of luminosity 1 [ab^{-1}] are generated .

* signal cross section is assumed 15fb.

(We will use the cross section calculated by thoerists)

Table 1. Cross section of background

Event Selection	eeZ	eνW	ννZ	WW	ZZ
Cross Section [fb]	3992	684	5	2783	982

Cross Section

- **I estimated the cross section of e+ e- to Z*H to qq 4ν background.**

  → The cross section is 0.13 [fb]

- **I generated 130 background events because luminosity is $1ab^{-1}$.**

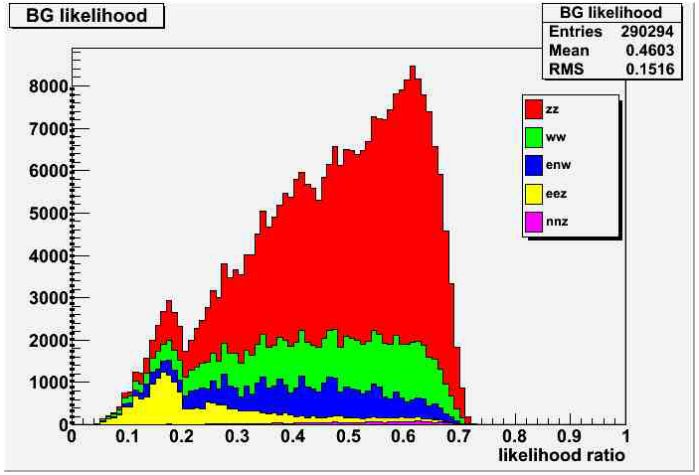
- **$\sigma = \sigma(e^+ + e^- \rightarrow Z^* \rightarrow ZH) \times BR(H \rightarrow Z^*Z) \times BR(Z \rightarrow qq) \times BR(Z^* \rightarrow \nu\nu) \times BR(Z \rightarrow \nu\nu)$**

  = 0.13[fb]

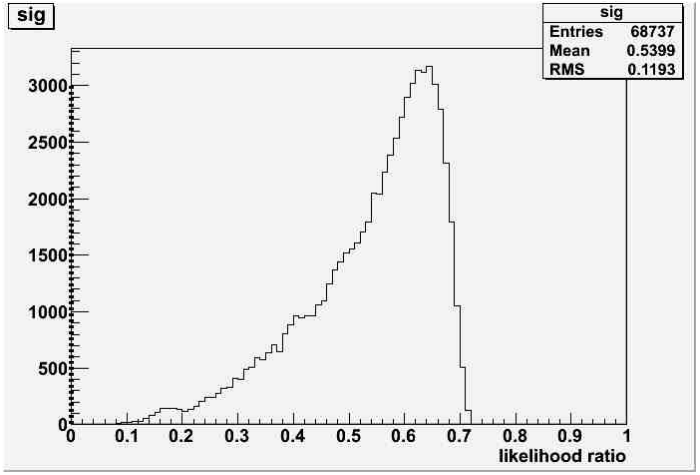
- $\sigma(e^+ + e^- \rightarrow Z \rightarrow ZH) = 234.739 \pm 0.254$fb]
- BR(H→ZZ) = 0.02
- BR(Z→νν) = 0.2
- cross section = 0.19[fb]
- BR(Z→qq) = 69.91%

・Optimization of the likelihood ratio to minimize the upper limit of signal cross section.
so , When likelihood ratio cut is smaller than 0.0,0.1,0.2,0.3,0.4,0.5,0.6 or 0.7, I showed distributions of N_{sig} parameter and pull distribution. →I found that the mode of distribution is near 0.

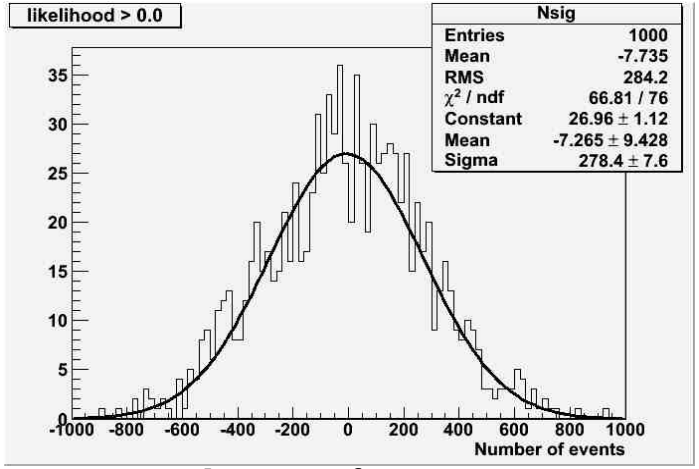
- Likelihood ratio > 0.0



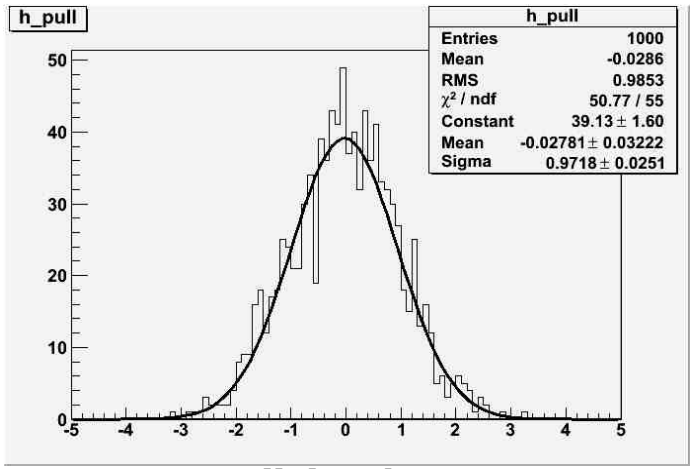
Background likelihood distribution



Signal likelihood distribution

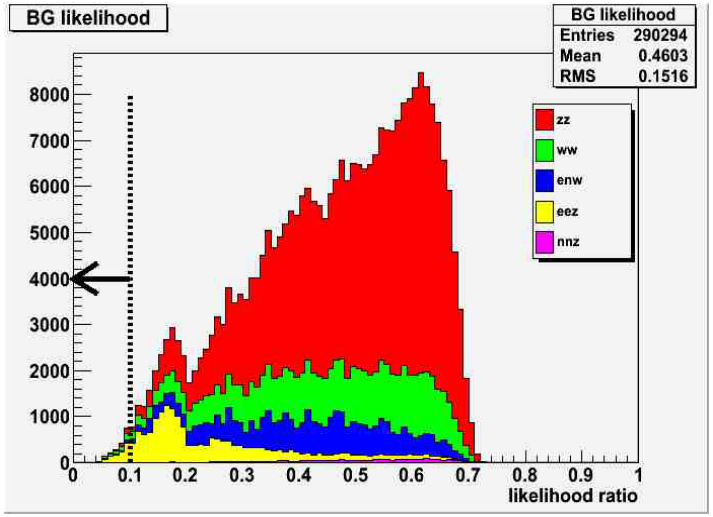


Distribution of parameter N_{sig}

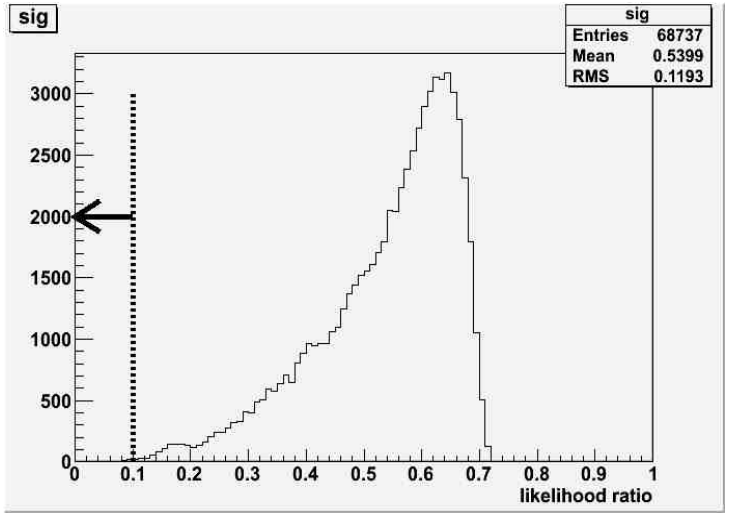


pull distribution

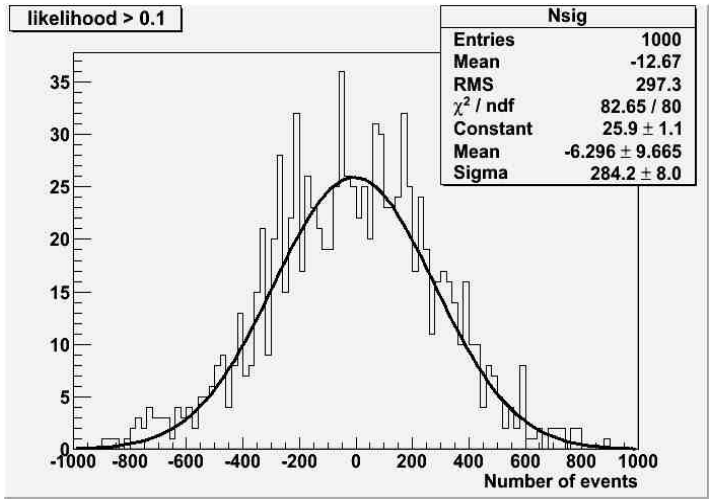
- Likelihood ratio > 0.1



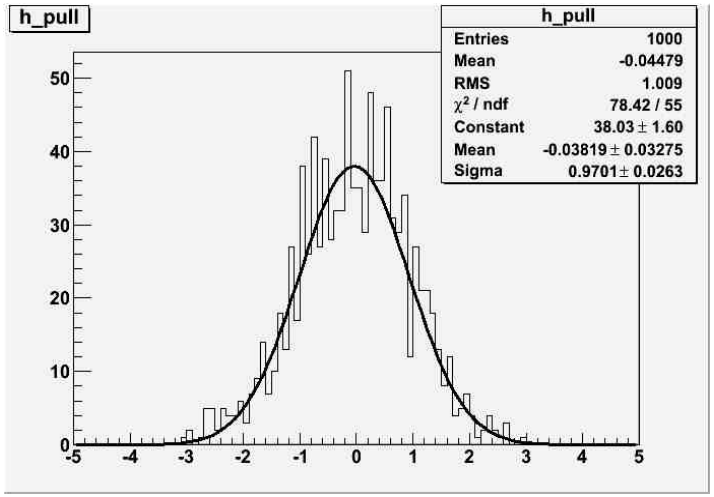
Background likelihood distribution



Signal likelihood distribution

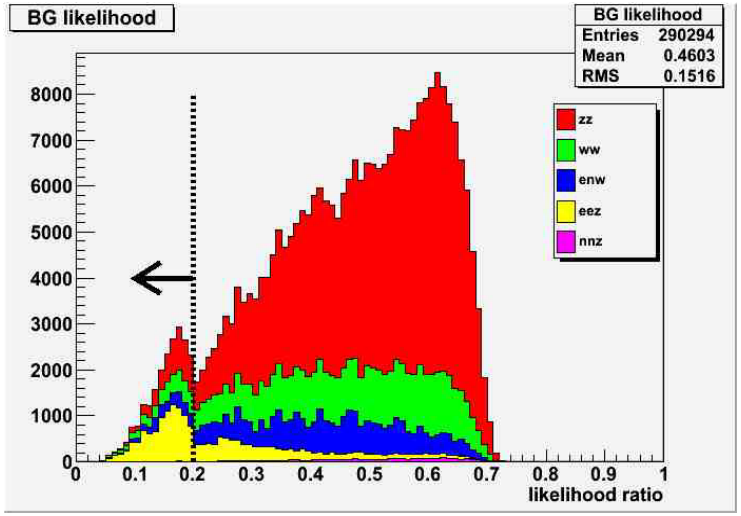


Distribution of parameter N_{sig}

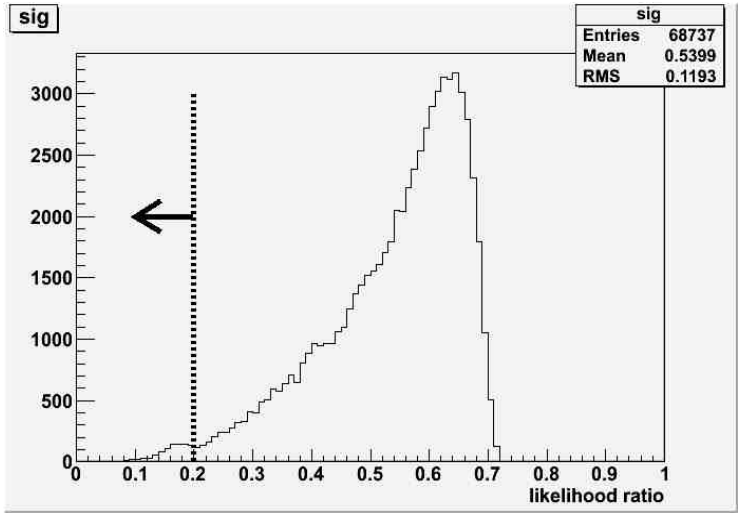


pull distribution

- Likelihood ratio > 0.2



Background likelihood distribution



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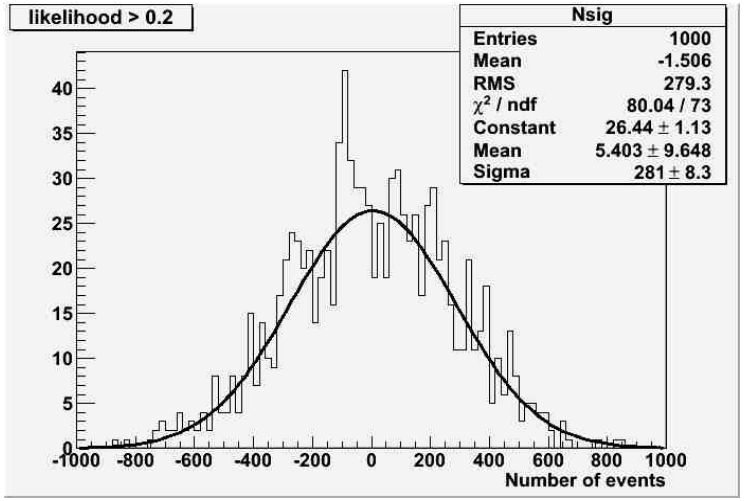
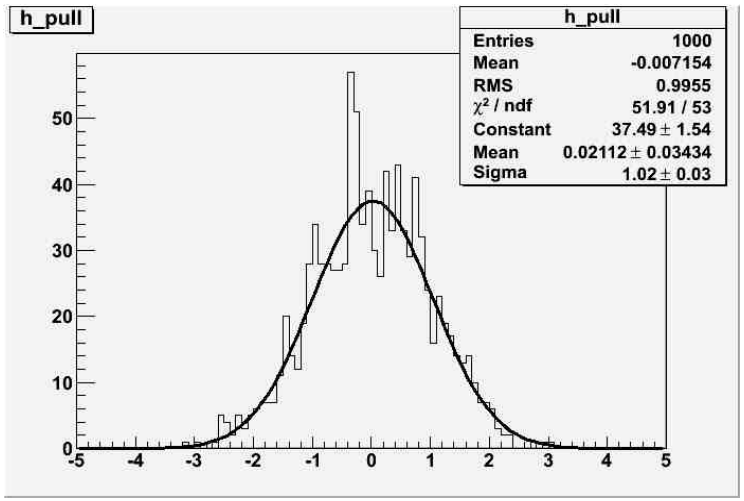
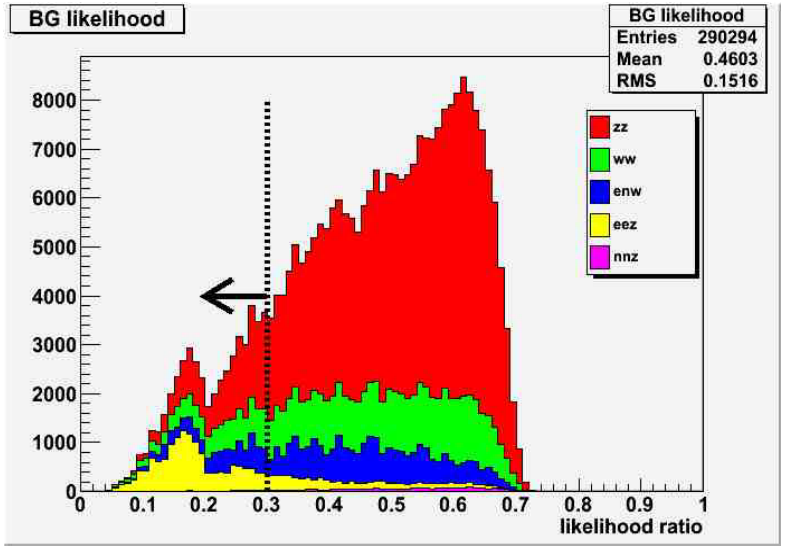


Distribution of parameter N_{sig}

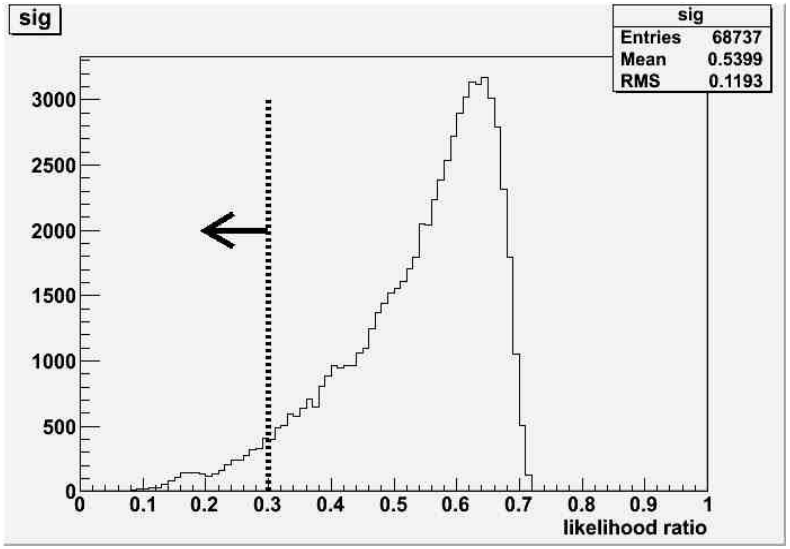


pull distribution

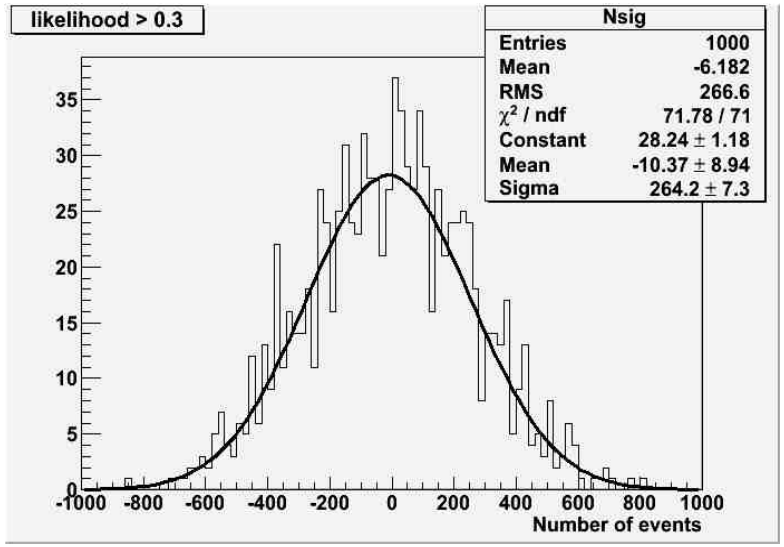
- Likelihood ratio > 0.3



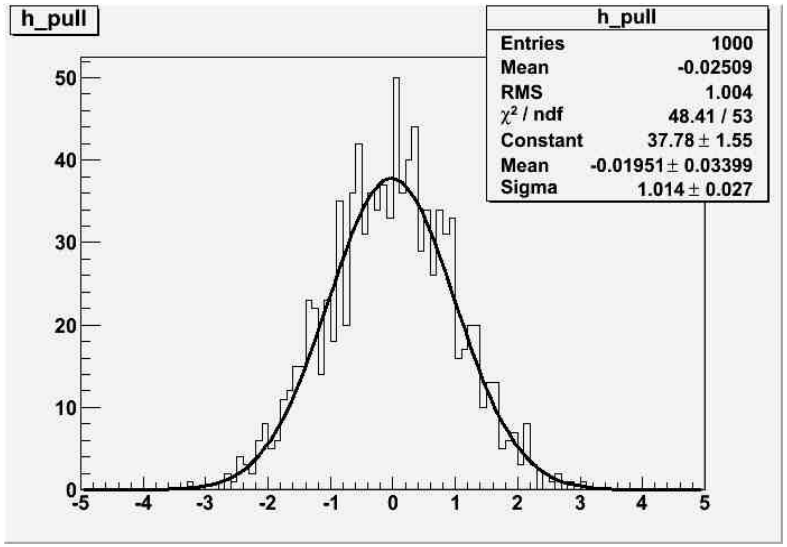
Background likelihood distribution



Signal likelihood distribution

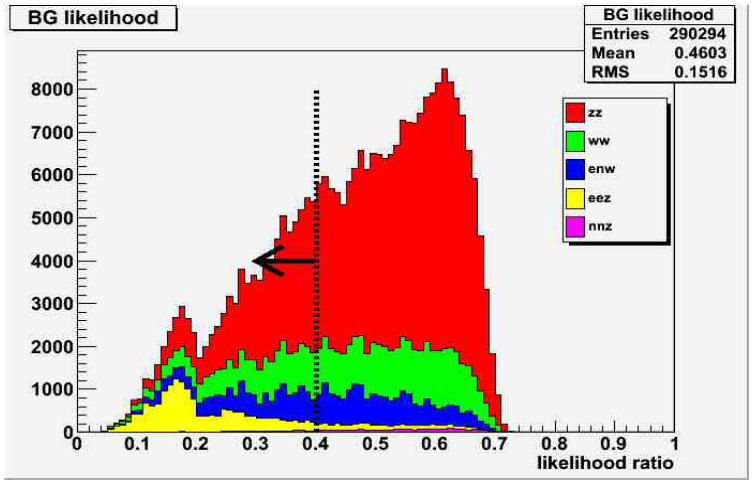


Distribution of parameter N_{sig}

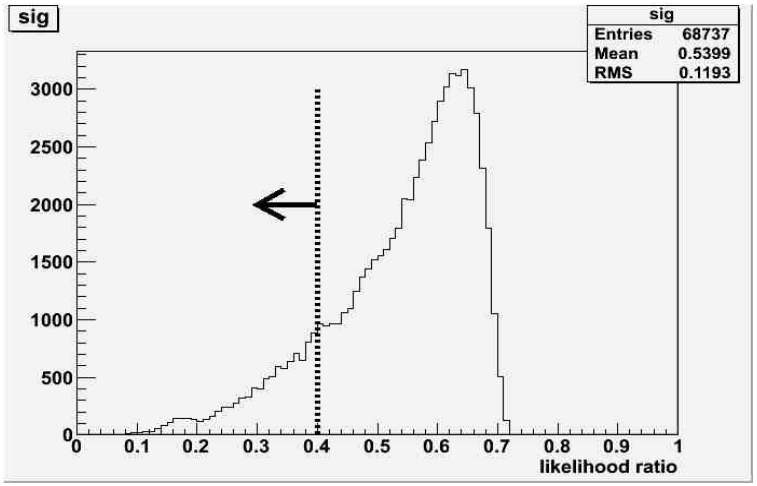


pull distribution

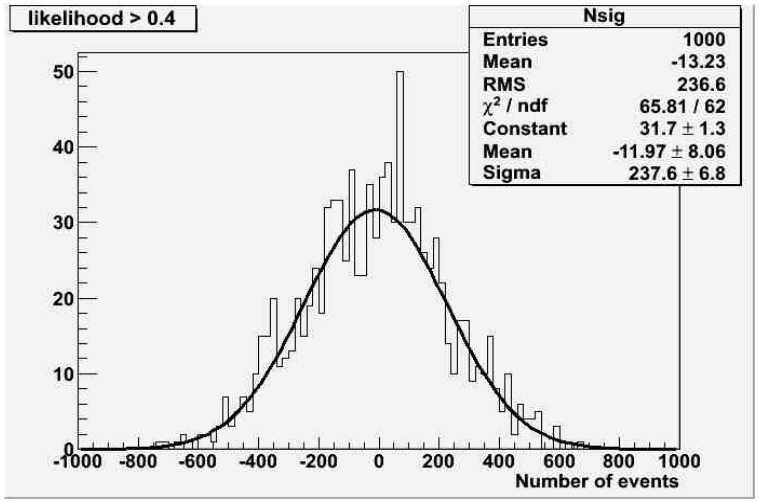
- Likelihood ratio > 0.4



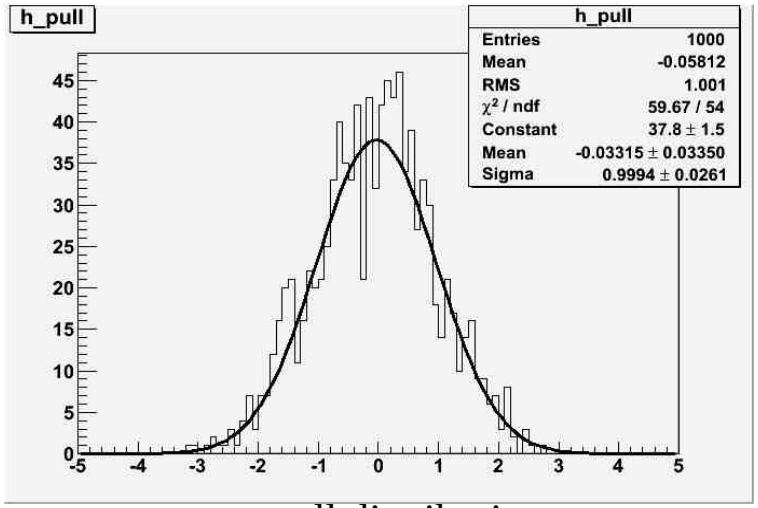
Background likelihood distribution



Signal likelihood distribution

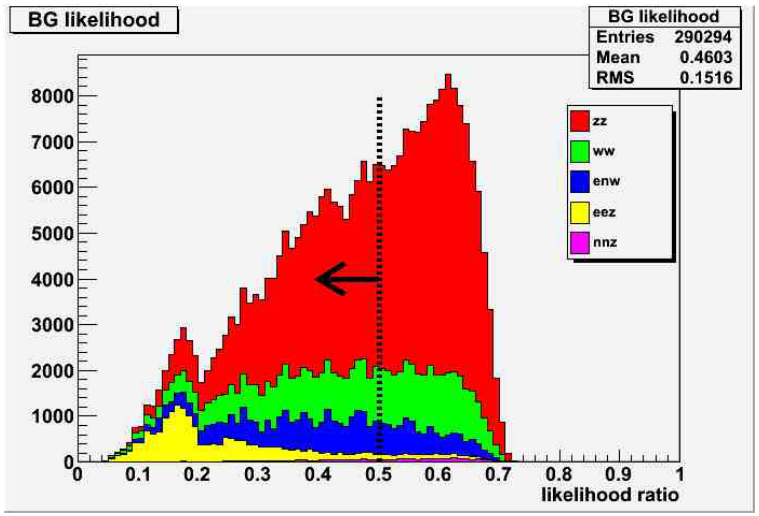


Distribution of parameter N_{sig}

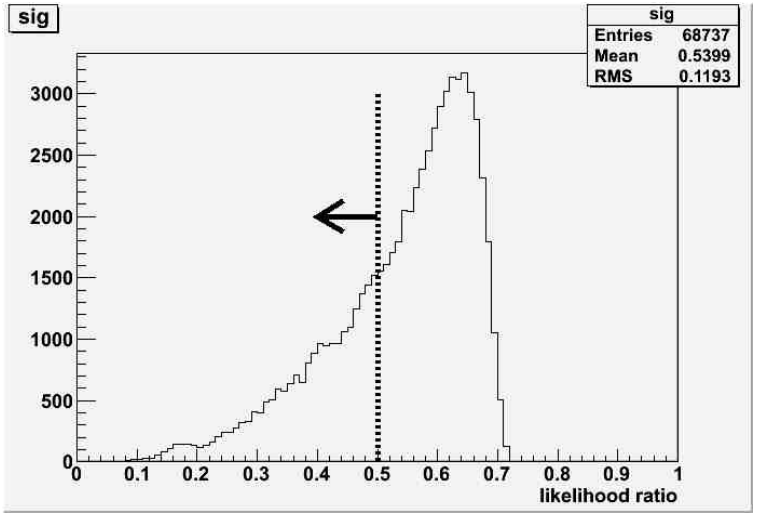


pull distribution

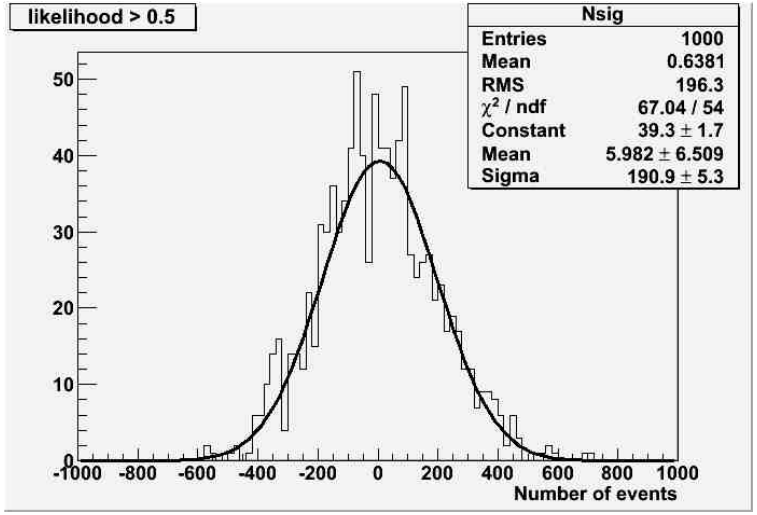
- Likelihood ratio > 0.5



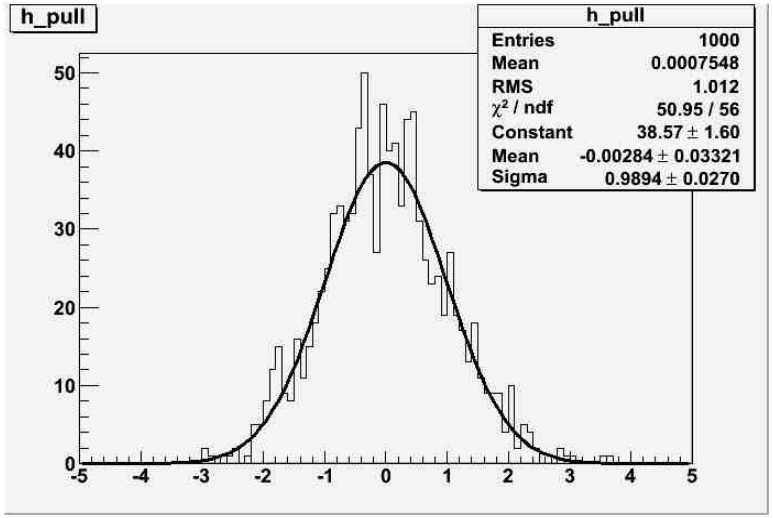
Background likelihood distribution



Signal likelihood distribution

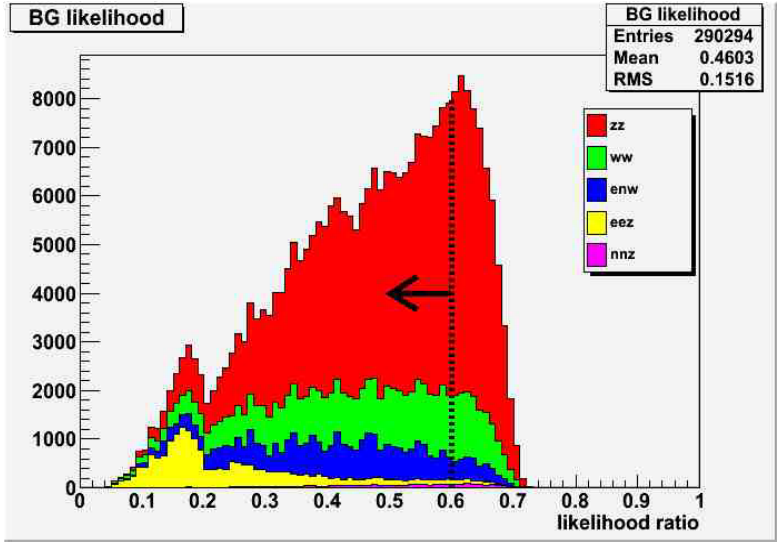


Distribution of parameter N_{sig}

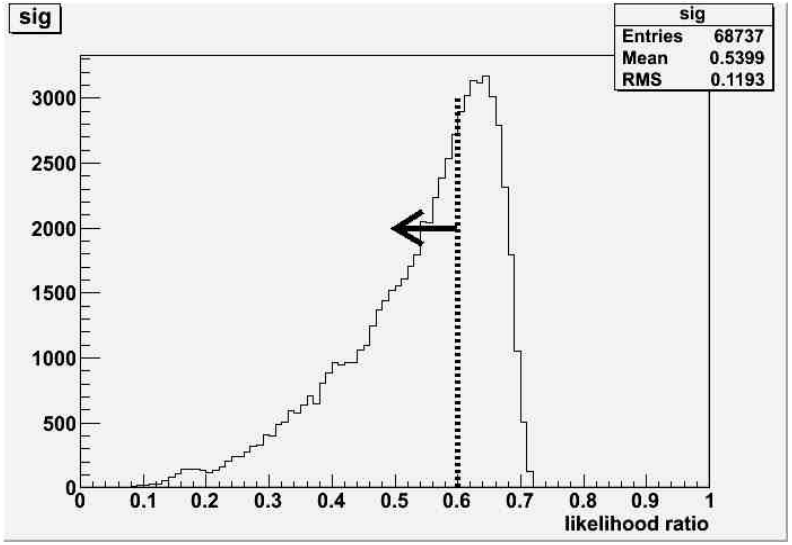


pull distribution

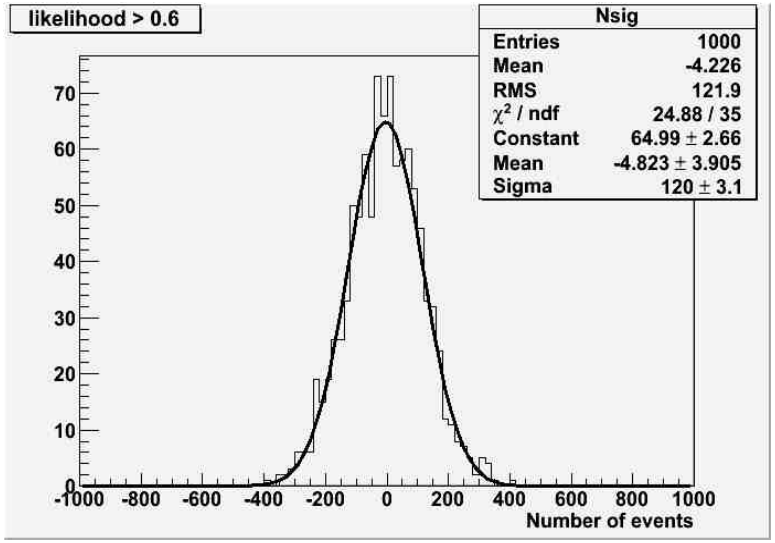
- Likelihood ratio > 0.6



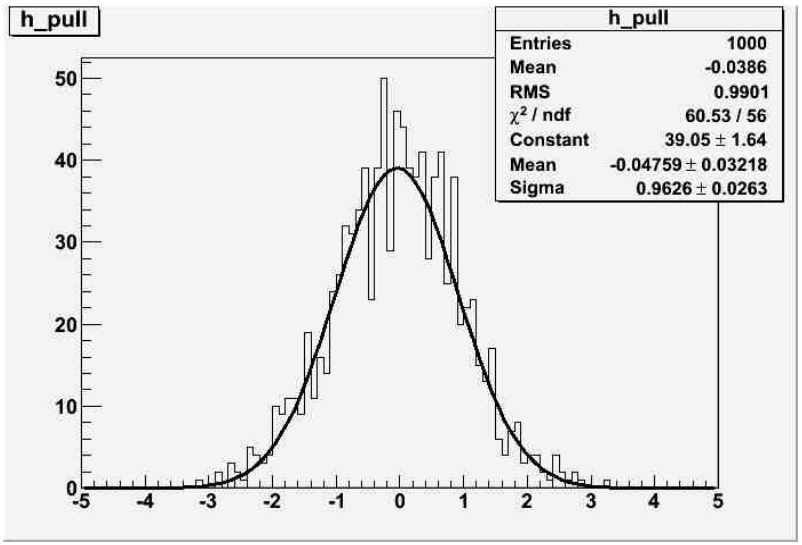
Background likelihood distribution



Signal likelihood distribution

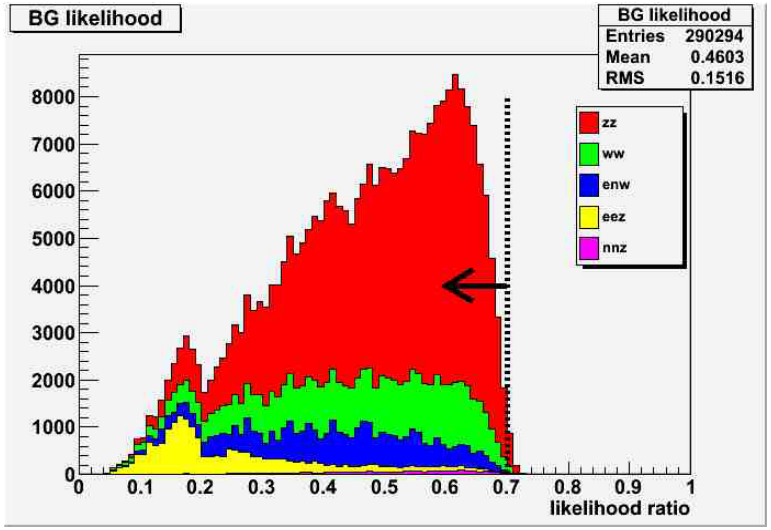


Distribution of parameter N_{sig}

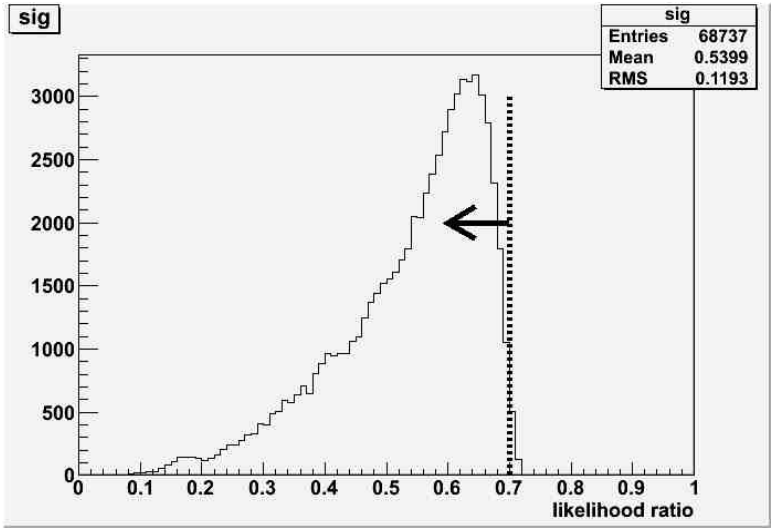


pull distribution

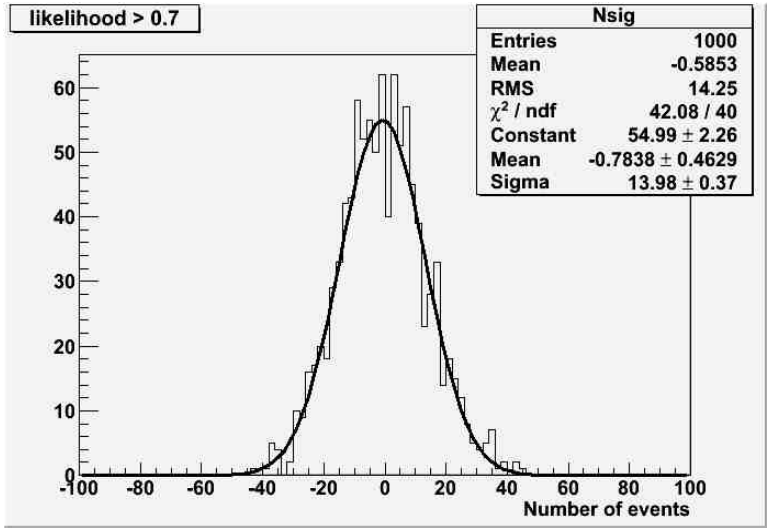
- Likelihood ratio > 0.7



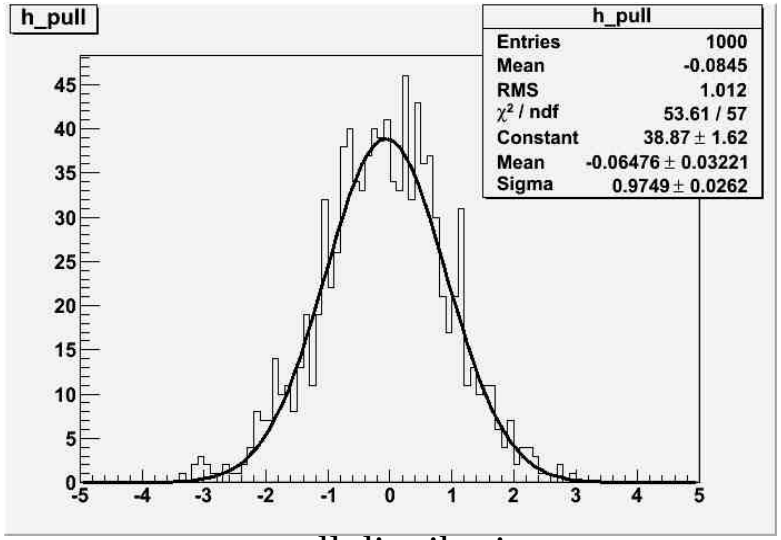
Background likelihood distributon



Signal likelihood distributon



Distribution of parameter N_{sig}



pull distribution