# THE PRELIMINARY UPPER LIMIT Of $\eta \rightarrow \gamma\gamma\gamma$ DECAY

F. LU

*E-mail: lfeng@lnf.infn.it*

*KLOE Physical Workshop*

Elba,Italy,MAY 2001

— INTRODUCTION

— EVENT ANALYSIS

— PRELIMINARY RESULT

— SYSTEMATIC ERROR

— CONCLUSION

— FURTHER PLAN

— **KLOE**

# INTRODUCTION

**$\eta \rightarrow \gamma\gamma\gamma$ is C-parity violating decay,which is a good test of C-invariance**

# Current Experimental Results:

**1984**,**GAMS**,**6**$\times$**10**$^5$ $\eta$ events generated by $\pi^-$P$\rightarrow$ $\eta$n, **Br(**$\eta \rightarrow \gamma\gamma\gamma$**)**$<$**5**$\times$**10**$^{-4}$**(95**$\%$ **CL)**

**2000**,**AGS+Crystal Ball(CB)**,**18.9**$\times$**10**$^6$ $\eta$ events generated by $\pi^-$P$\rightarrow$ $\eta$n,**Br(**$\eta \rightarrow \gamma\gamma\gamma$**)**$<$**4.5**$\times$**10**$^{-5}$**(95**$\%$ **CL), Acta,Physica Poconica 31(2000)2669**

**PDG2000,Br(**$\eta \rightarrow \gamma\gamma\gamma$**)**$<$**5**$\times$**10**$^{-4}$**(95**$\%$ **CL)**

# KLOE Experiment Status:

**Integrated luminosity:23.5pb$^{-1}$(V6:5.5$pb^{-1}$,V7:18 $pb^{-1}$), corresponding to about 9$\times$10$^{5}$ $\eta$ events generated by $\phi \rightarrow \gamma\eta$ decay**

**For this analysis 6085.3nb$^{-1}$ had been used from 2000 DATA,which is reconstructed by V7,RADIANT from Run16005 to Run17036,corresponding to about 2.3$\times$10$^{5}$ $\eta$ events**

# EVENT ANALYSIS

## Table 1. Possible BCK Channels List

| Decay Channel | BCK/SIG | MC NUM. | EXP. NUM. |
|---|---|---|---|
| $\phi \rightarrow \gamma\eta$, $\eta \rightarrow 3\pi^0 \rightarrow 7\gamma$ | 645 | 125,000 | 56 |
| $e^+e^- \rightarrow \omega\pi^0$,$\omega \rightarrow \pi^0\gamma/\pi^+\pi^-$ | 33.3 | 50,000 | 42 |
| $\phi \rightarrow \rho^0\pi^0$,$\rho^0 \rightarrow \pi^0\gamma/\eta\gamma \rightarrow 5\gamma$ | 6.2 | 50,000 | 29 |
| $\phi \rightarrow f_0\gamma \rightarrow \pi^0\pi^0\gamma \rightarrow 5\gamma$ | 17 | 50,000 | 18 |
| $\phi \rightarrow \gamma\eta$, $\eta \rightarrow \pi^0\gamma\gamma \rightarrow 5\gamma$ | 1.4 | 130,000 | 10 |
| $\phi \rightarrow a_0\gamma \rightarrow \eta\pi^0\gamma$,$\eta \rightarrow all$ | 13 | 50,000 | 9 |
| $\phi \rightarrow \omega\pi^0$,$\omega \rightarrow \pi^0\gamma/\pi^+\pi^-$ | 0.79 | 50,000 | 1 |
| $\phi \rightarrow \gamma\eta$, $\eta \rightarrow \gamma\gamma \rightarrow 3\gamma$ | 7848 | 150,000 | 0 |
| $\phi \rightarrow \gamma\pi^0 \rightarrow 3\gamma$ | 192 | 150,000 | 0 |
| $K_LK_S \rightarrow 5\pi^0$ | 3446 | | |
| $K_LK_S \rightarrow 2\pi^0 2\gamma$ | 9.6 | | |
| $K_LK_S \rightarrow 4\pi^0$ | 15 | | |
| $\phi \rightarrow \omega\gamma$,$\omega \rightarrow \pi^0\gamma/\eta\gamma \rightarrow 4\gamma$ | | | |
| $e^+e^- \rightarrow \gamma\gamma(\gamma)$ | | | |

# $\phi \rightarrow \gamma\eta$,$\eta \rightarrow \gamma\gamma\gamma$ events criteria

**Using GEANFI to create $\phi \rightarrow \gamma\eta$,$\eta \rightarrow \gamma\gamma\gamma$ decay MC sample with 30,000 events($\eta \rightarrow \gamma\gamma\gamma$ decay is created by pure phase space)**

**CUT1: Nt=0, 3<Nclu<7**

**NCLUTW: $|cos\theta|$<0.94,0.9<$\beta$<1.1,Eclu> $30$MeV**

**CUT2: NCLUTW>3**

**Ngood: $\theta_{\gamma\gamma}$>15$^\circ$,$\theta_{\gamma\gamma}$ is minimal angle of a selected photon between it and any other selected photons**

**CUT3: Ngood=4**

**CUT4: Etot>880MeV**

**CUT5: Ptot<110MeV**

**CUT6: Emin>50MeV**

**Using only 4-momentum constraint kinematic fit on four good photons final state**

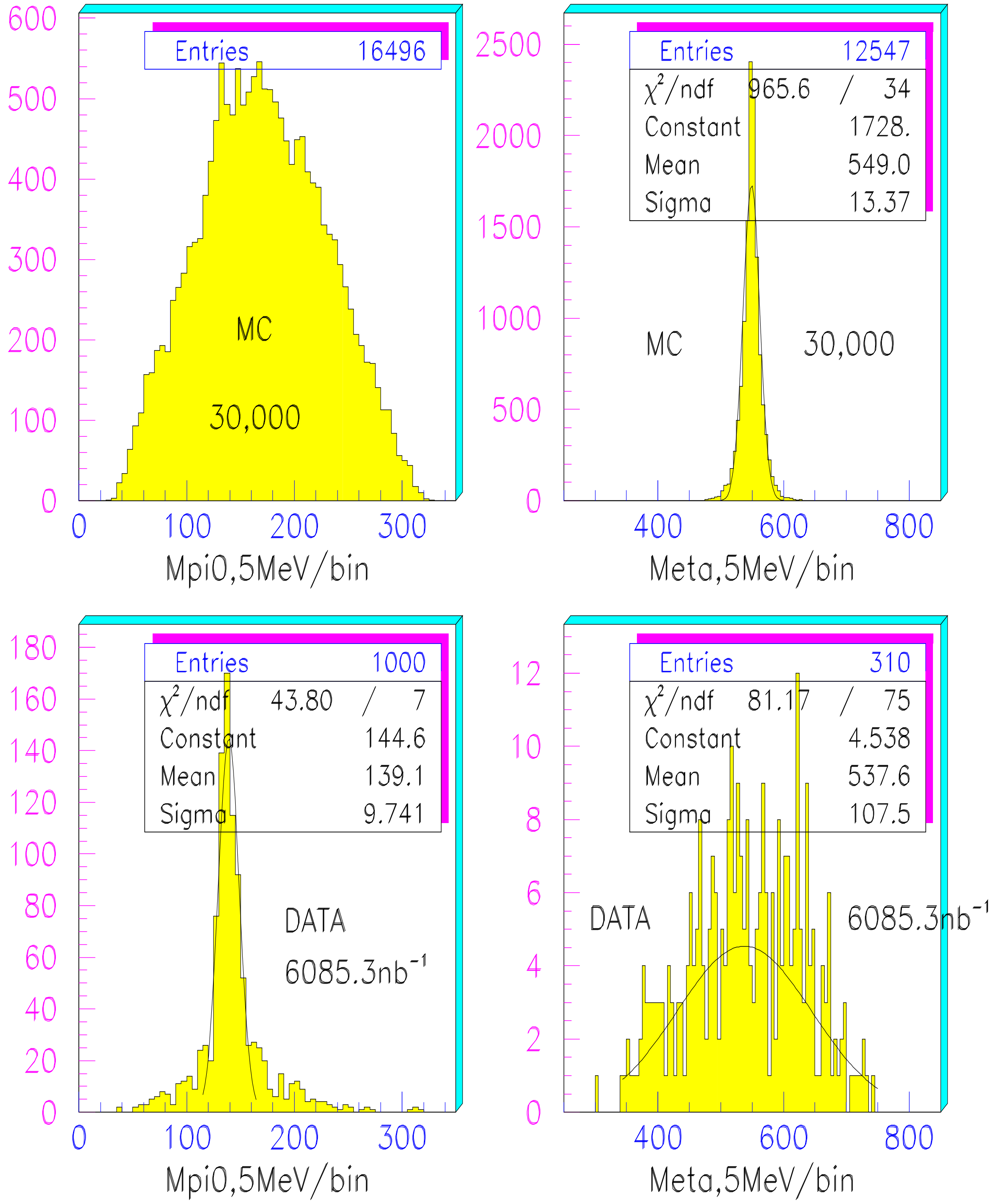
**Minimizing (Erad-363)$^2$/36 + ($M_{3\gamma}$-547$)^2$/49 to find out radiative photon and other three photons coming from $\eta$ decay**

**Minimizing $|M_{\gamma\gamma} - 135|$ to find out possible $\pi^0$ resonance (for BCK including $\pi^0$, $M_{\gamma\gamma}$ spectrum are about 140,10MeV Gaussian distribution)**

**CUT7:$M_{\pi^0}$<120MeV or $M_{\pi^0}$>160MeV**

**After above selection,Mpi0 and Meta spectrums both for MC and DATA are shown in Fig1**

Fig1. $\phi \rightarrow \gamma\eta,\ \eta \rightarrow \gamma\gamma\gamma$



# Table 2. Event Filter Statistics

| | DATA | $\eta \to 3\gamma$ | $\eta \to 3\pi^0$ | $e^+e^- \to \omega\pi^0$ | $\phi \to \rho^0\pi^0$ |
|---|---|---|---|---|---|
| In | 783,441 | 30,000 | 125,000 | 50,000 | 50,000 |
| CUT1 | 104,931 | 24,926 | 20,560 | 31,485 | 40,749 |
| CUT2 | 9,428 | 19,901 | 20,094 | 28,579 | 37,534 |
| CUT3 | 3,662 | 19,251 | 3,120 | 10,478 | 13,251 |
| CUT4 | 1,602 | 19,016 | 324 | 7,844 | 8,959 |
| CUT5 | 1,342 | 17,764 | 158 | 6,108 | 7,044 |
| CUT6 | 1,000 | 16,496 | 145 | 5,060 | 6,245 |
| CUT7 | 310 | 12,547 | 97 | 676 | 2,027 |
| EXP. | | $<$49 | 56 | 42 | 29 |

**So far,main BCK come from 7$\gamma$ and 5$\gamma$ final states**

# PRELIMINARY RESULT

Regarding **BCK** spectrum as a **linear shape**,BCK events in signal region (S.N.R.) could be estimated by left sideband(L.S.B.) and right sideband(R.S.B.) ,which are shown in **Fig2**

## Table 3. Events Statistics

| | L.S.B. | N.S.R. | R.S.B. |
|---|---|---|---|
| Range(MeV) | 500-520 | 520-580 | 580-600 |
| MC | 404 | 11710 | 294 |
| DATA | 27 | 69 | 20 |

**BCK** events in S.N.R.: $70.5 \pm 10.3$ events

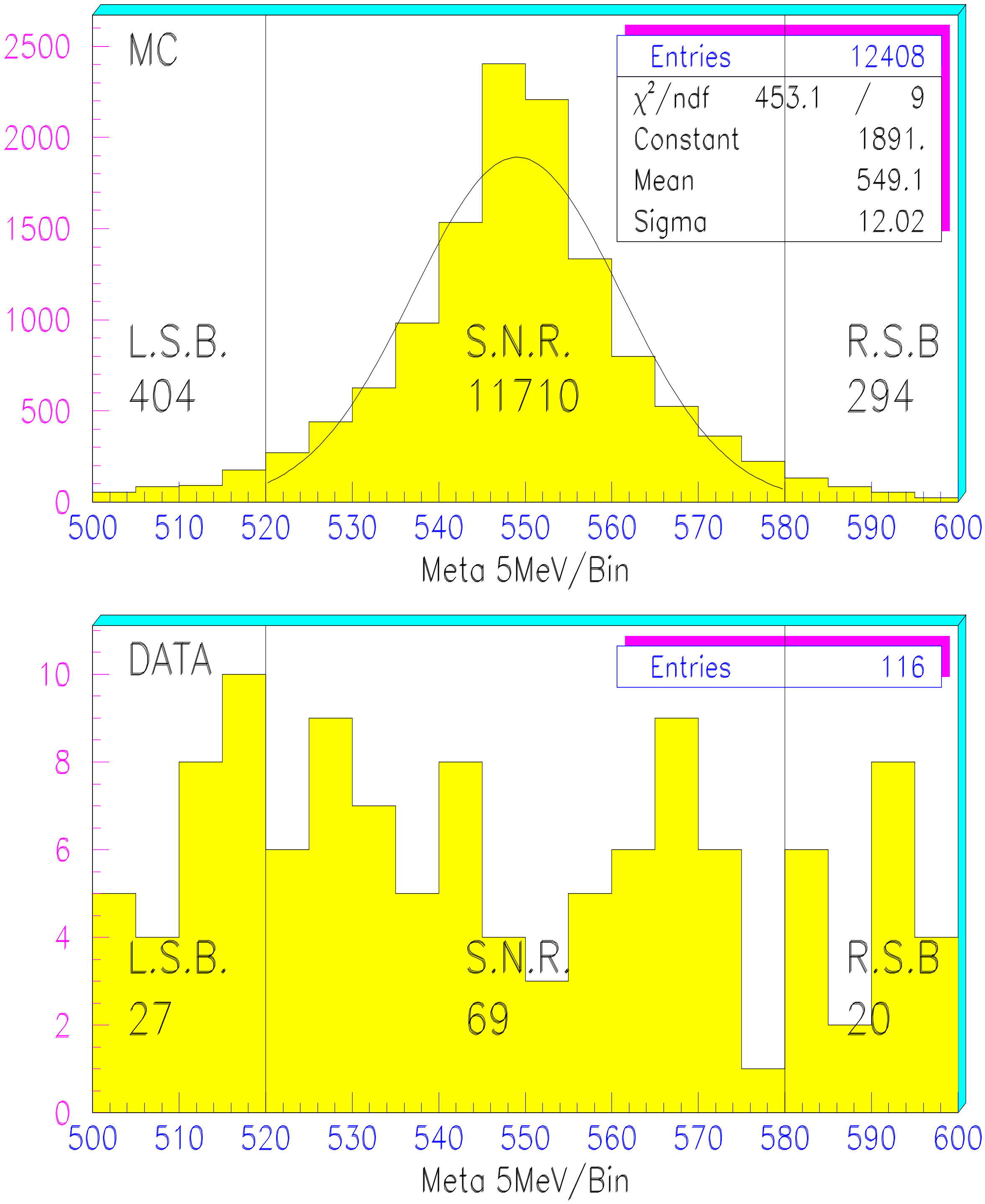
**Signal** in S.N.R.: $-1.5 \pm 13.2$ events

95% CL, **Signal** in S.N.R.: $<$**24.4** events

MC efficiency in S.N.R.: 35.54%

**Br($\eta \rightarrow \gamma\gamma\gamma$)**$<$24.4/(6085.3$\times$ 3100$\times$1.297%$\times$0.95 $\times$35.54%=**2.96$\times$10$^{-4}$(95% CL)**
taking trigger and filter efficiency as 95% temporarily

Fig2. Preliminary Result



# SYSTEMATIC ERROR

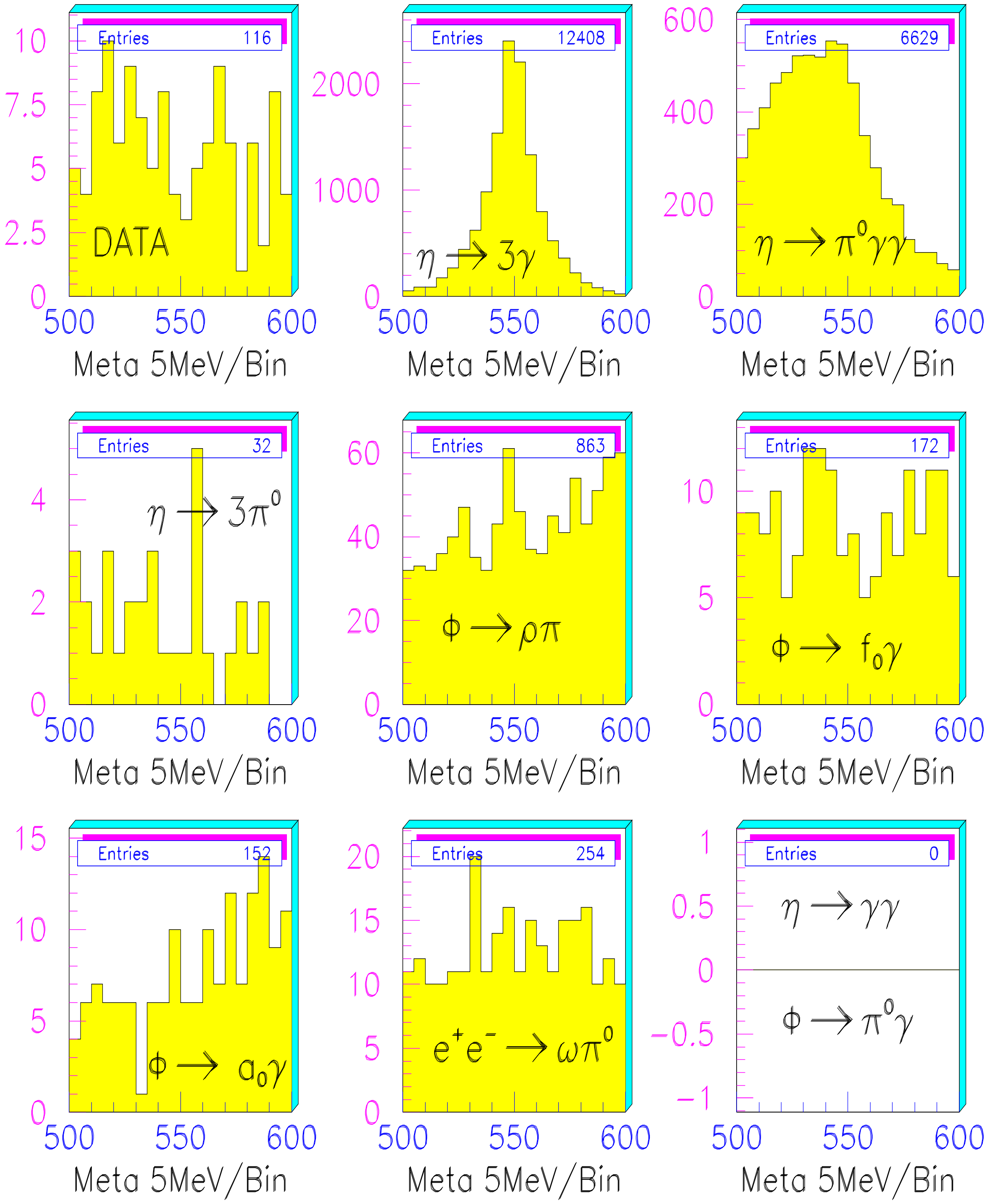
From **Fig3**,**BCK** spectrums are **consistent** with **linear shape** distributions except $\eta \to \pi^0\gamma\gamma$ channel,but it couldn't change total BCK linear shape,because :at 520-580 region,4774 -2782=**1992** MC $\pi^0\gamma\gamma$ events only corresponding to **2.5** events for 6085.3 $nb^{-1}$ real DATA, while DATA has **69** events at the region

**So linear shape is a good approximation of the BCK spectrum at 500-600 MeV**

In order to estimate systematic error coming from **band division**,adding **5MeV** into both L.S.B. and R.S.B.,**Systematic error** is about **+4.1**%($3.08\times10^{-4}$)

**Double Gaussian fit**(signal narrow Gaussian is fixed(548.2,13.39),Meta range is from 350-740MeV,6MeV/Bin,total number is 306 events,BCK Gaussian and signal number are free,so it is **three parameter-fit**,$\chi^2$=74/55) preliminary signal number:$-1.84^{+}_{-}8.94$ events, Br$<1.62 \times 10^{-4}$, so **systematic error from different methods** is about **-45.3**%**(see Fig4)**

Fig3. B.G. Linear Shape Check



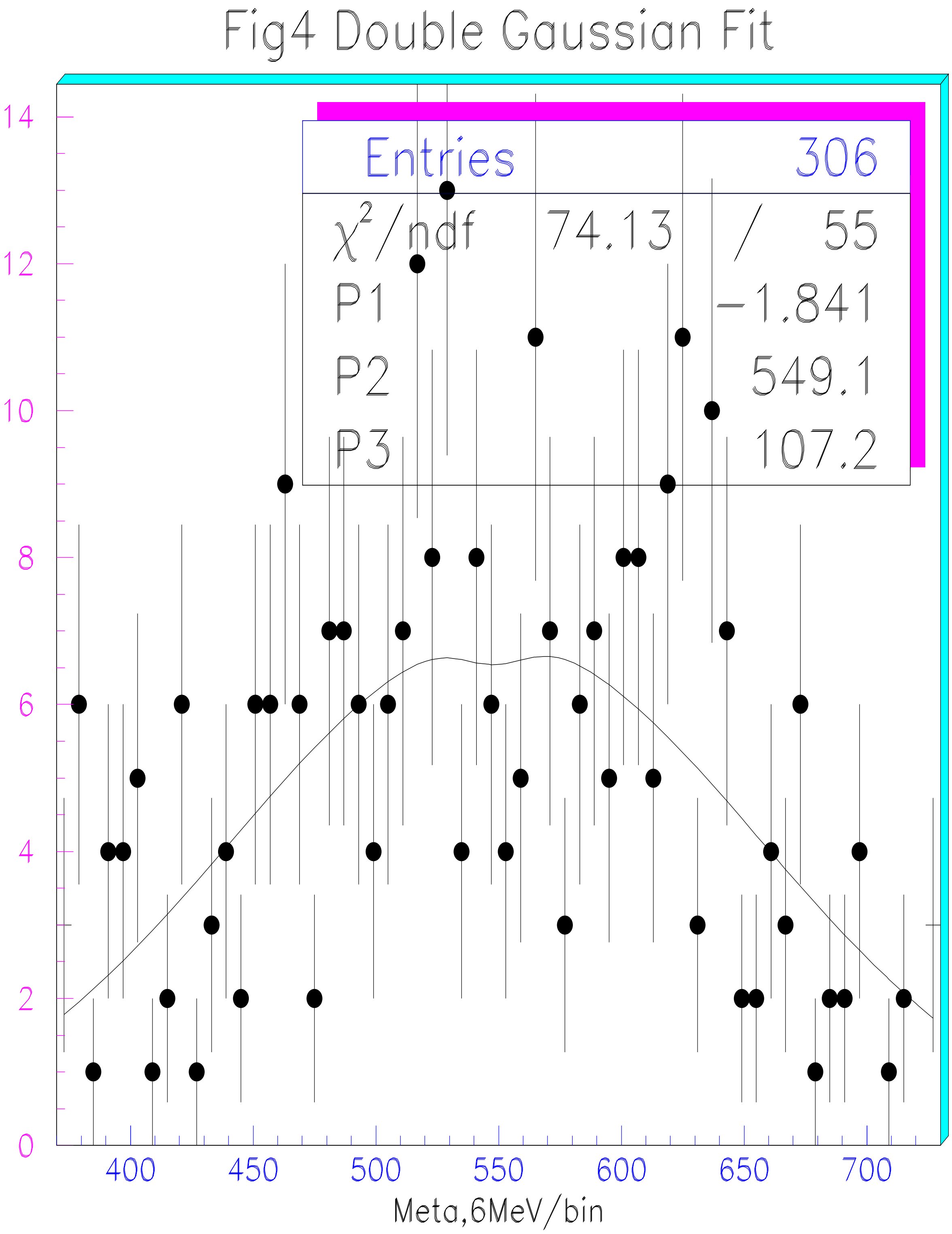


Fig4 Double Gaussian Fit
Entries 306
χ²/ndf 74.13 / 55
P1 -1.841
P2 549.1
P3 107.2
0
2
4
6
8
10
12
14
400
450
500
550
600
650
700
Meta,6MeV/bin

# CONCLUSION

Signal criteria,based on the **MC sample with 30,000** $\phi \rightarrow \gamma\eta$,$\eta \rightarrow \gamma\gamma\gamma$ ($\eta \rightarrow \gamma\gamma\gamma$ decay is created by **pure phase space**) decay events,had been developed

**No signal** had been found from $6085.3nb^{-1}$ $\phi$ DATA sample,so upper limit with 95% CL has to be made

**From sideband method:**
Signal events number is **below 24.4(**$95\%$ **CL)**
**Br(**$\eta \rightarrow \gamma\gamma\gamma$**)**$<$**2.96**$\times$**10**$^{-4}$**(95**$\%$ **CL)**

**From three-parameter double Gaussian fit method:**
Signal events number is **below 15.7(**$95\%$ **CL)**
**Br(**$\eta \rightarrow \gamma\gamma\gamma$**)**$<$**1.62**$\times$**10**$^{-4}$**(95**$\%$ **CL)**

There is about $-45.3\%$ **systematic error** between above two methods

Systematic error from **band division** is about $4\%$

# FURTHER PLAN

Continue to study event **criteria** to **improve** selection **S/N** further

Continue to study methods to **fit DATA Meta spectrum** to abstract signal event number more accurately

To **study more BCK** channels,such as $\phi \to \omega\gamma \to \pi^0 2\gamma$ $/\eta 2\gamma$ and $\phi \to K_L K_S \to 5\pi^0/4\pi^0/2\pi^0 2\gamma$ to understand BCK shape better

**Check MC efficiency** accuracy by $\eta \to 2\gamma$ and $\eta \to 3\pi^0$ channels

**Increase DATA luminosity statistics** untill **23.5** $pb^{-1}$

**Increase MC** sample **statistics** to **check** consistency of the **BCK numbers** between MC and DATA