

Hyperon Productions in Two-Photon Collisions at BELLE

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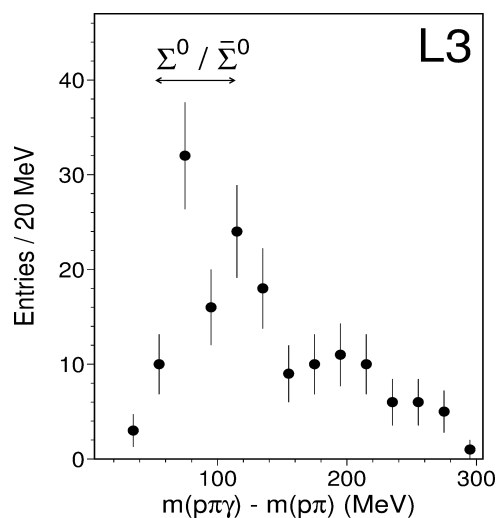
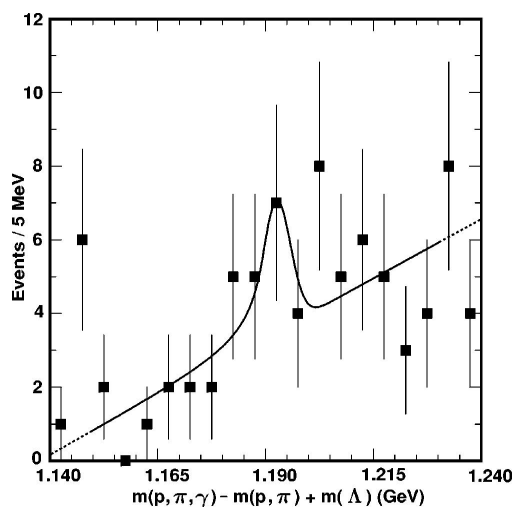
KEK-IPNS, Institute of Particle and Nuclear Studies,

High Energy Accelerator Research Organization

Photon 2003, Frascati

Motivation

- **Cross Sections for $\gamma\gamma \rightarrow \Lambda^0 \bar{\Lambda}^0$**
and $\gamma\gamma \rightarrow \Sigma^0 \bar{\Sigma}^0$
 - as a Function of $W_{\gamma\gamma}$,
 $W_{\gamma\gamma}$: the Two-Photon Invariant Mass
 - as a function of $\cos\theta^*$
- **Recent Measurements for $\sigma_{\gamma\gamma \rightarrow \Lambda^0 \bar{\Lambda}^0}$:**
 - **CLEO** ($3.5 fb^{-1}$) [Phys. Rev. D 56 (1997) 2485]
 - **$51.0 \pm 8.6 \Lambda^0 \bar{\Lambda}^0$ events, 7.5 ± 5.6 has Σ^0**
 - **L3** ($0.844 fb^{-1}$) [Phys. Lett. B 536 (2002) 24]
 - **$66 \Lambda^0 \bar{\Lambda}^0$ events, 31 has Σ^0**



Data Sample

Total 89 fb^{-1} **LowMult**

Event Selection

$$\begin{aligned}\Sigma^0 &\longrightarrow \Lambda^0 \gamma, \Lambda^0 \longrightarrow P \pi^- \\ \gamma\gamma &\rightarrow \Lambda^0 \bar{\Lambda}^0 \rightarrow P \pi^- \bar{P} \pi^+ \\ \gamma\gamma &\rightarrow \Sigma^0 \bar{\Sigma}^0 \rightarrow P \pi^- \bar{P} \pi^+ \gamma\gamma\end{aligned}$$

Events with four **GOOD** tracks and **net charge = 0**

Definition of **GOOD** tracks:

1. $|Z + 0.43| < 0.45$
2. $dgr > 15$
3. 1 P, 1 \bar{P} , 1 π^+ and 1 π^-

- **Proton or antiproton identification:**

$$\begin{aligned}&| (dE/dX)_p^m - (dE/dX)_p^e | \leq 2\sigma_p^e \\ &\text{photon electron from ACC} \leq 4\end{aligned}$$

- **Pion identification:**

$$| (dE/dX)_\pi^m - (dE/dX)_\pi^e | \leq 2\sigma_p^e$$

MC Simulation (TREPS)

Isotropic angular distribution

Same $W_{\gamma\gamma}$ distribution as $\gamma\gamma \rightarrow P\bar{P}$

pass through detector and trigger simulations,
then two photon selection (LowMult)

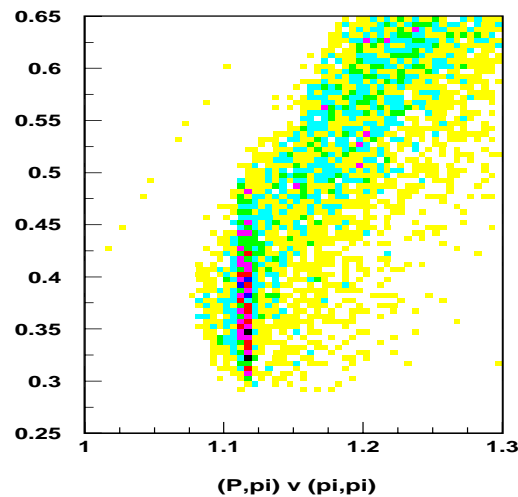
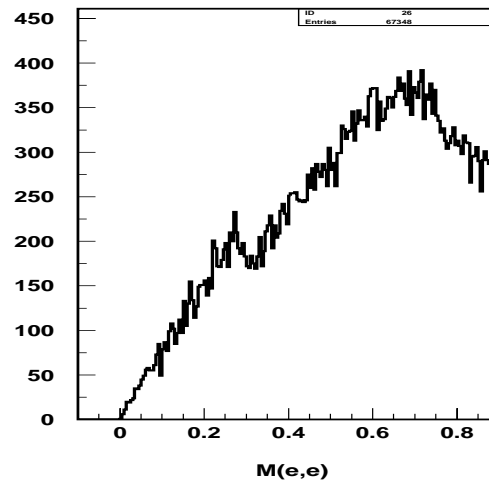
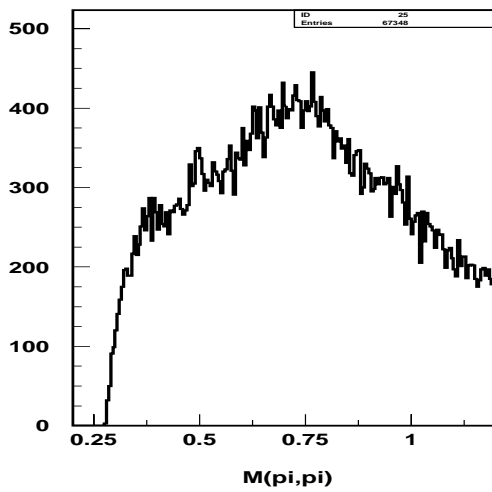
- **400,000** $\gamma\gamma \rightarrow \Lambda^0\bar{\Lambda}^0$
 $\Lambda^0 \rightarrow P\pi^-$ and $N\pi^0$
- **400,000** $\gamma\gamma \rightarrow \Sigma^0\bar{\Sigma}^0$
 $\Sigma^0 \rightarrow \Lambda^0\gamma$. $\Lambda^0 \rightarrow P\pi^-$ and $N\pi^0$
- **400,000** $\gamma\gamma \rightarrow \Xi^0\bar{\Xi}^0$
 $\Xi^0 \rightarrow \Lambda^0\pi^0$, $\Lambda^0 \rightarrow P\pi^-$ and $N\pi^0$

Λ^0 Identification

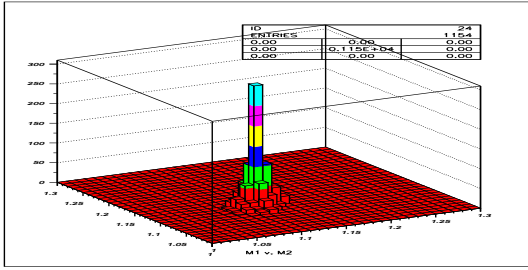
Fakes from $K s^0$ decay and from γ conversion are checked



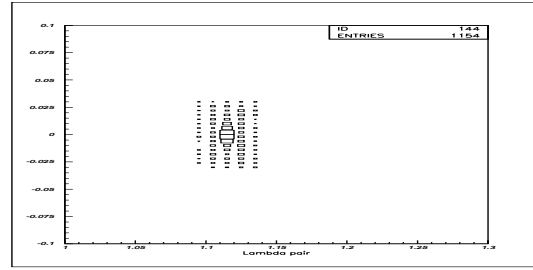
Events with tracks pass proton or pion identifications ($2p2\pi$),
 $|\Sigma \vec{P}_t| < 0.12$ GeV/c are imposed



Inclusive $\Lambda^0\bar{\Lambda}^0$ events



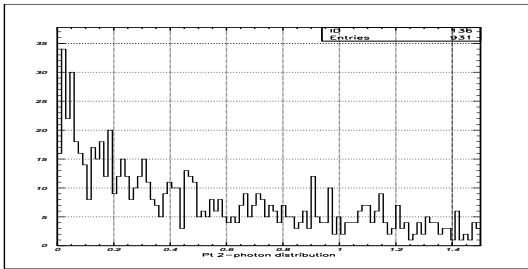
Data M_Λ vs. $M_{\bar{\Lambda}}$



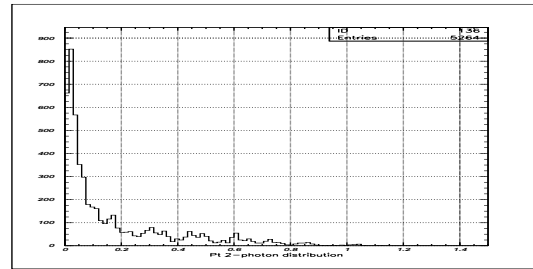
Data $\frac{M_\Lambda + M_{\bar{\Lambda}}}{2}$ vs. $|M_\Lambda - M_{\bar{\Lambda}}|$

There are 1154 events which have 1 Λ and 1 $\bar{\Lambda}$.
 $\Lambda^0\bar{\Lambda}^0$ candidate:

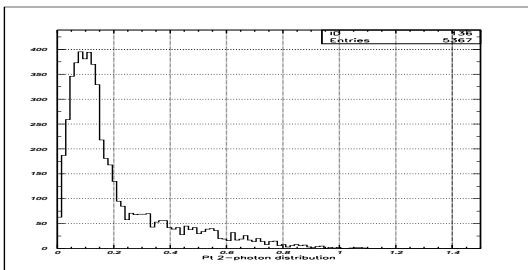
$$|M_\Lambda - M_{\bar{\Lambda}}| < 0.02, \left| \frac{M_\Lambda + M_{\bar{\Lambda}}}{2} - 1.115 \right| < 0.02$$



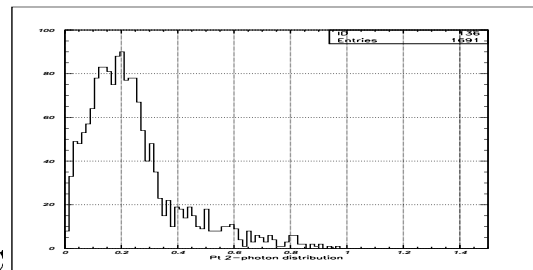
Data $|\Sigma P_T|$



MC $\Lambda\bar{\Lambda}|\Sigma P_T|$



$\Lambda\bar{\Lambda}(\Sigma^0\bar{\Sigma}^0)|\Sigma P_T|$



MC

$\Lambda\bar{\Lambda}(\Xi^0\bar{\Xi}^0)|\Sigma P_T|$

MC

$$|\Sigma P_T| < 0.2 \Rightarrow 243\Lambda\bar{\Lambda} \text{ (inclusive)}$$

$$|\Sigma P_T| < 0.5 \Rightarrow 445\Lambda\bar{\Lambda} \text{ (inclusive)}$$

Σ^0 Identification

$$\Delta M = M(p\pi^-\gamma) - M(p\pi^-) = 0.073 \text{ GeV}$$

$$m_{\Sigma^0}^o = 1.1926 \text{ GeV}, m_{\Lambda}^o = 1.1157 \text{ GeV}$$

γ identification

$$E_{\gamma} : 0.05 - 0.20 \text{ GeV}$$

No charged track match

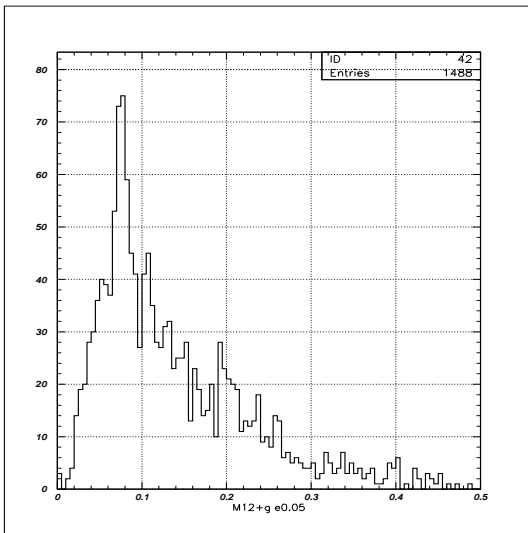
$$0.59 < \theta < 2.2 \text{ (Barrel region only)}$$

$$E9/E25 > 0.9$$

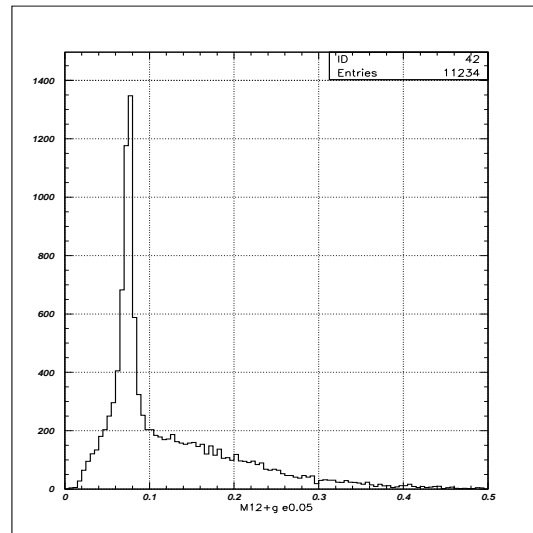
$\Sigma^0\bar{\Sigma}^0$ candidates:

Events which have 1 $\Sigma^0(\bar{\Sigma}^0)$ and 1 $\bar{\Lambda}(\Lambda)$

$$|M_{\Sigma^0} - M_{\Lambda} - 0.073| < 0.01 \text{ GeV}$$



Data $\Delta M = M(p\pi^-\gamma) - M(p\pi^-)$



MC $\Delta M = M(p\pi^-\gamma) - M(p\pi^-)$

Inclusive $\gamma\gamma \longrightarrow \Lambda^0\bar{\Lambda}^0$ and $\gamma\gamma \longrightarrow \Sigma^0\bar{\Sigma}^0$

For $|P_T| < 0.2$, $\Lambda\bar{\Lambda}$ candidate

$W_{\gamma\gamma}(\text{GeV})$	$\langle W_{\gamma\gamma} \rangle(\text{GeV})$	Events	Total no. of events
2.2-2.6	2.50	65	12760 ± 1634
2.6-2.9	2.74	80	4062 ± 472
2.9-3.3	3.09	52	1855 ± 261
3.3-4.3	3.60	12	281 ± 82

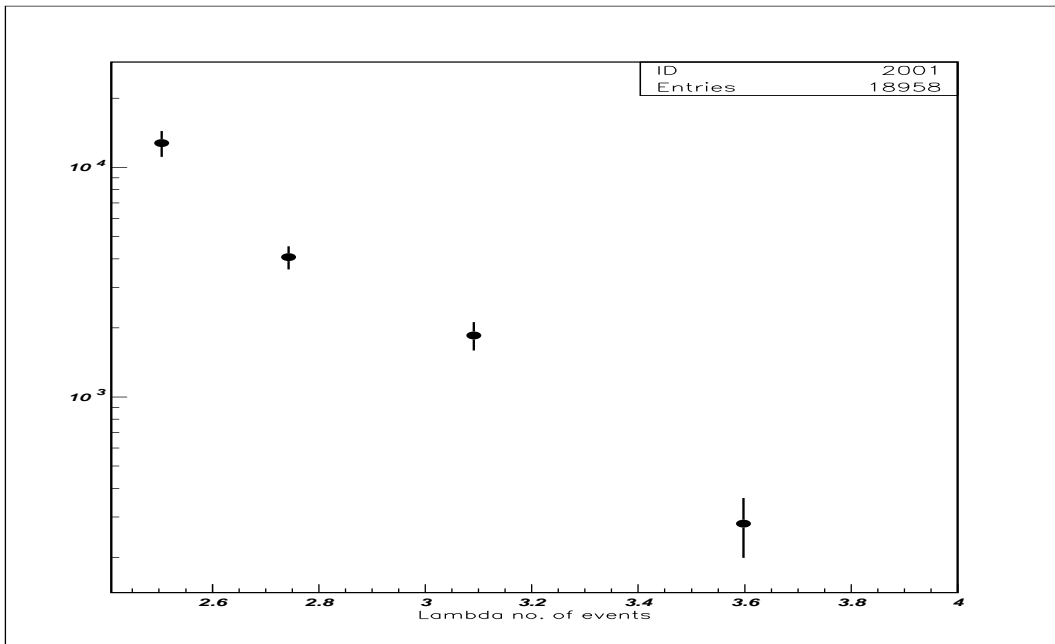
For $|P_T| < 0.2$, $\Sigma^0\bar{\Sigma}^0$ candidate

$W_{\gamma\gamma}(\text{GeV})$	$\langle W_{\gamma\gamma} \rangle(\text{GeV})$	Events	Total no. of events
2.2-2.6	2.51	18	6706 ± 1606
2.6-2.9	2.73	20	2419 ± 559
2.9-3.3	3.02	8	663 ± 238
3.3-4.3	3.64	4	248 ± 127

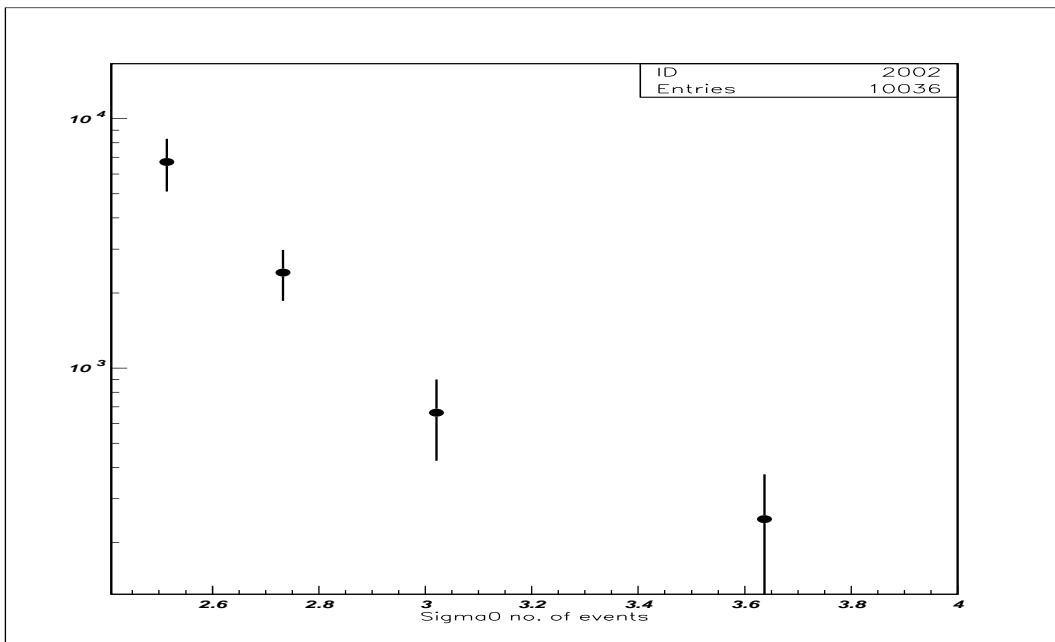
So, for $|P_T| < 0.2$, exclusive $\Lambda^0\bar{\Lambda}^0$ candidate

$W_{\gamma\gamma}(\text{GeV})$	$\langle W_{\gamma\gamma} \rangle(\text{GeV})$	No. of events
2.2-2.6	2.50	6054 ± 2291
2.6-2.9	2.74	1643 ± 731
2.9-3.3	3.09	1192 ± 353
3.3-4.3	3.60	33 ± 151

No. of events vs. $W_{\gamma\gamma}$



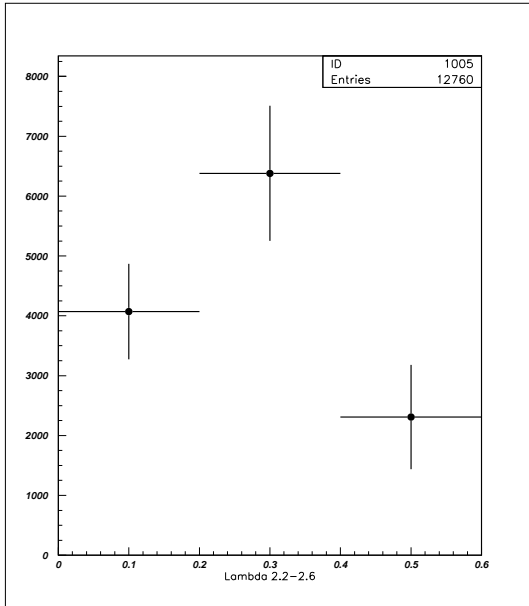
$\Lambda\bar{\Lambda}$ candidates



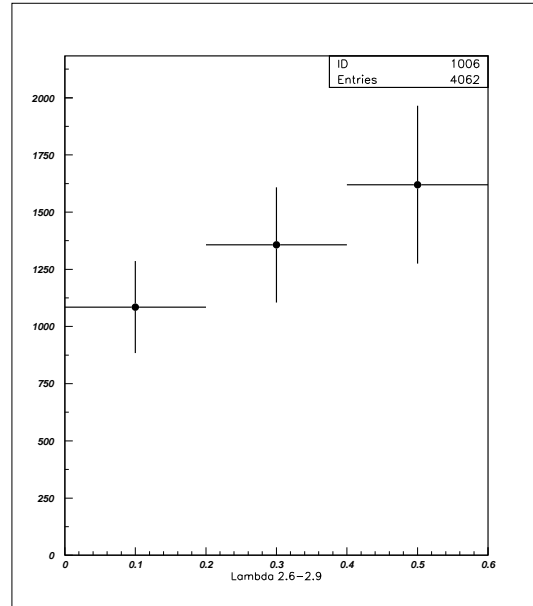
$\Sigma^0\bar{\Sigma}^0$ candidates

Number of events vs. $|\cos\theta^*|$

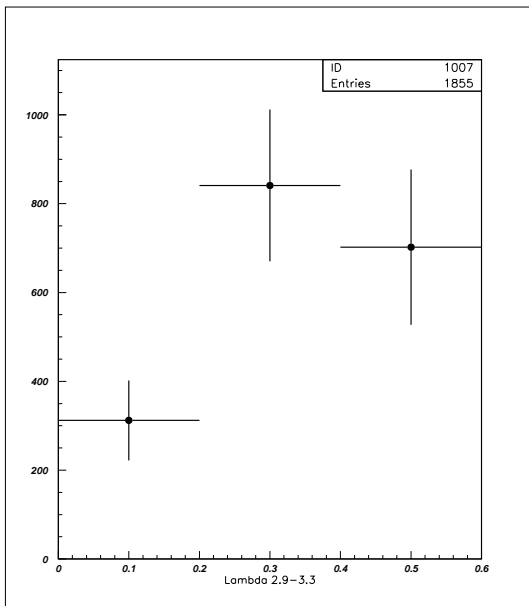
$\Lambda\bar{\Lambda}$ candidates



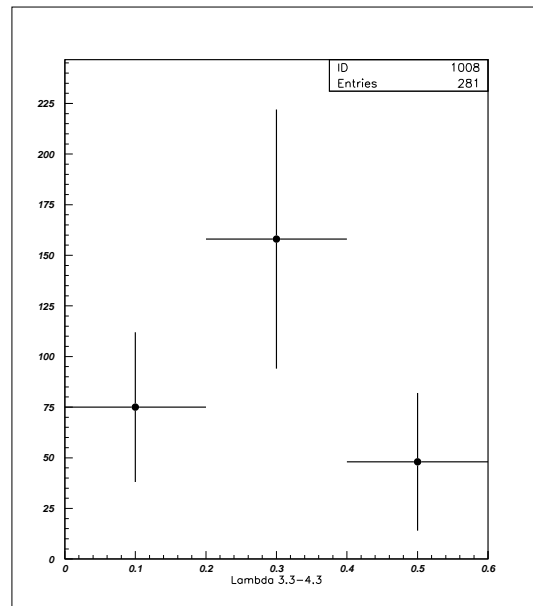
$W_{\gamma\gamma} = 2.2 - 2.6 \text{ GeV}$



$W_{\gamma\gamma} = 2.6 - 2.9 \text{ GeV}$



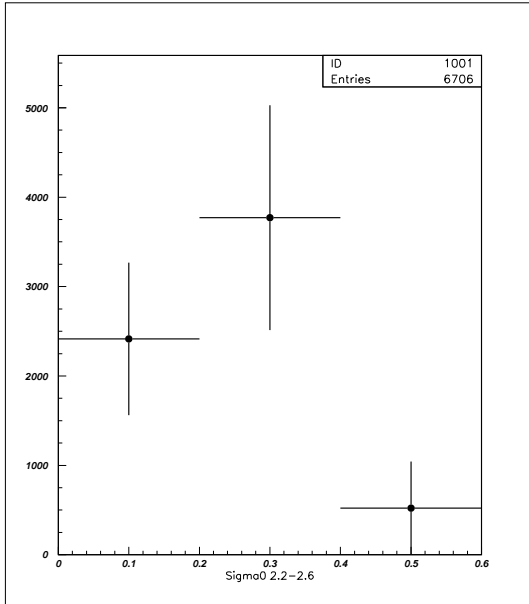
$W_{\gamma\gamma} = 2.9 - 3.3 \text{ GeV}$



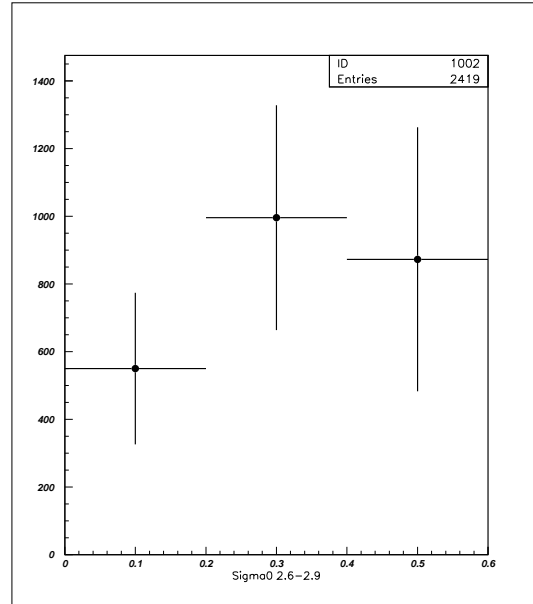
$W_{\gamma\gamma} = 3.3 - 4.3 \text{ GeV}$

Number of events vs. $|\cos\theta^*|$

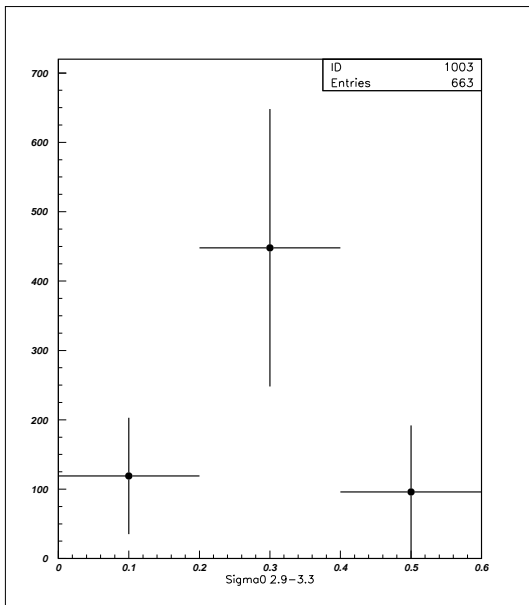
$\Sigma^0\bar{\Sigma}^0$ candidates



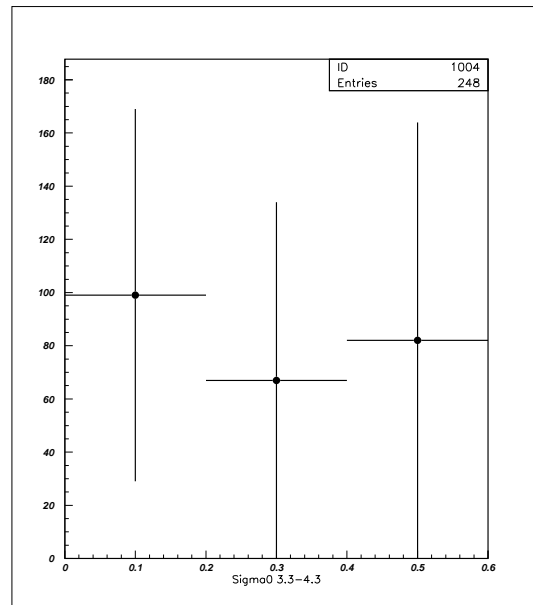
$W_{\gamma\gamma} = 2.2 - 2.6 \text{ GeV}$



$W_{\gamma\gamma} = 2.6 - 2.9 \text{ GeV}$



$W_{\gamma\gamma} = 2.9 - 3.3 \text{ GeV}$

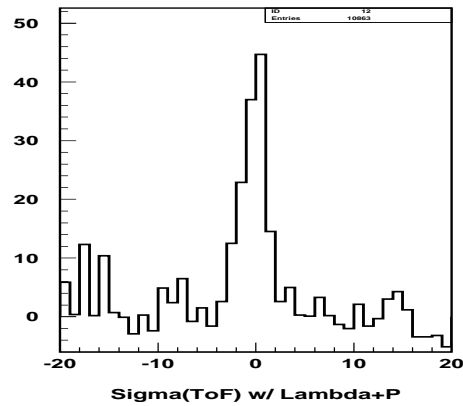
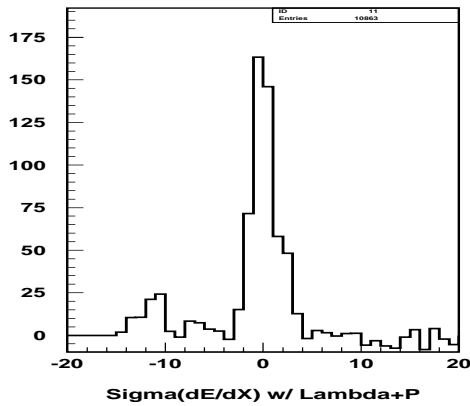
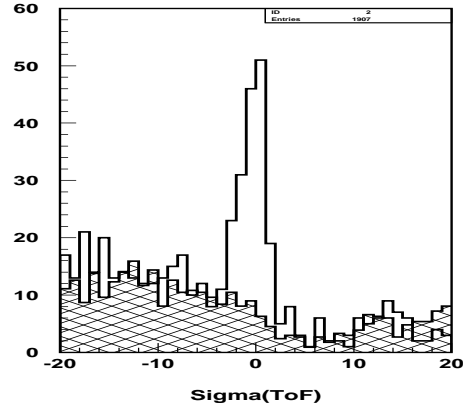
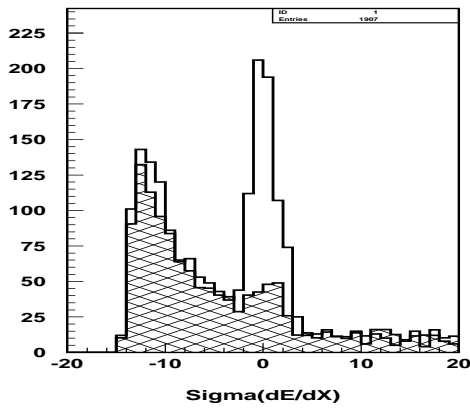
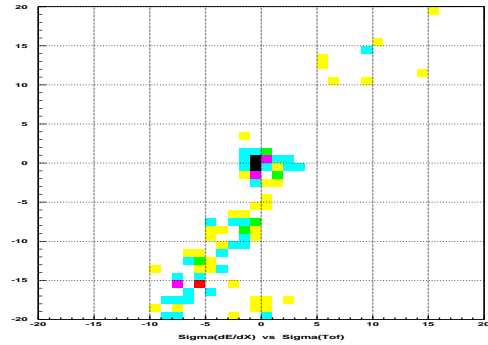
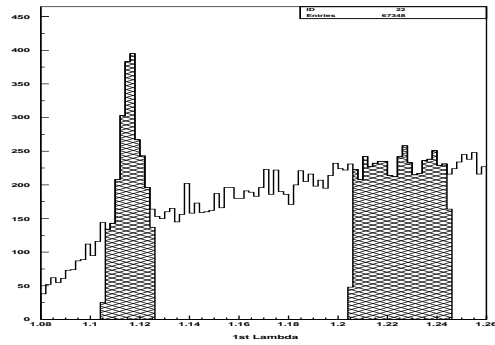


$W_{\gamma\gamma} = 3.3 - 4.3 \text{ GeV}$

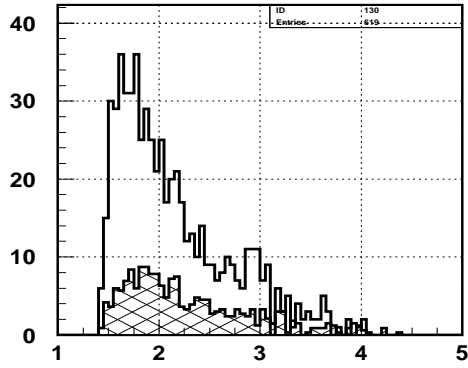
Search for $\gamma\gamma \longrightarrow \Lambda^0 \bar{P} K^+ / \bar{\Lambda}^0 P K^-$

- Events with 4 good tracks and $|\Sigma \vec{P}_T| < 0.12$ GeV/c.
~ 1000 $\Lambda/\bar{\Lambda}$ are identified (first $\Lambda/\bar{\Lambda}$)
- ~ 500 events with 2nd $\bar{\Lambda} \rightarrow \bar{P}\pi^+$ ($\Lambda \rightarrow P\pi^-$)
 $\gamma\gamma \rightarrow \Lambda^0 \bar{\Lambda}^0$
- the other ~ 500 events are $\bar{P}K^+$
 $\gamma\gamma \rightarrow \Lambda^0 \bar{P}K^+$

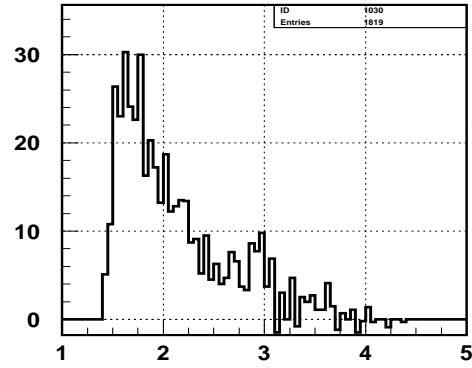
$$\gamma\gamma \rightarrow \Lambda \bar{P} K^+ / \bar{\Lambda} P K^-$$



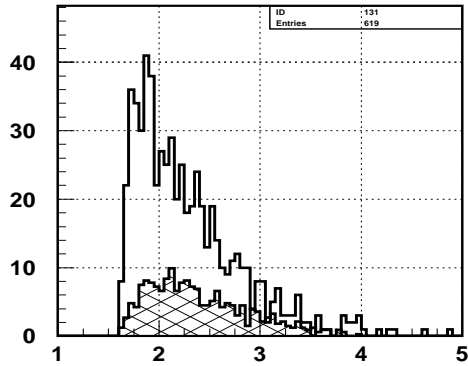
$$\gamma\gamma \rightarrow \Lambda \bar{P} K^+ / \bar{\Lambda} P K^-$$



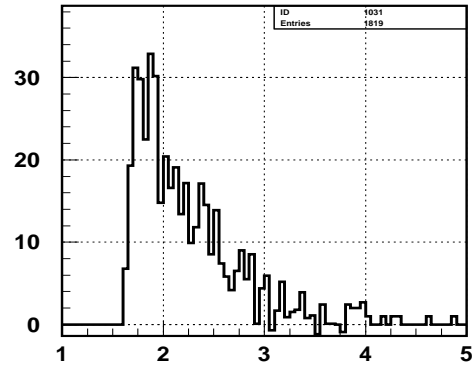
Mass(Pro,K)



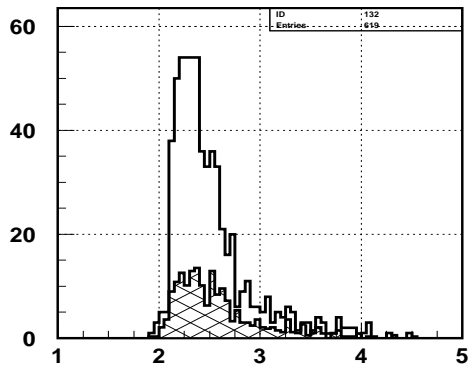
Mass(Pro,K)



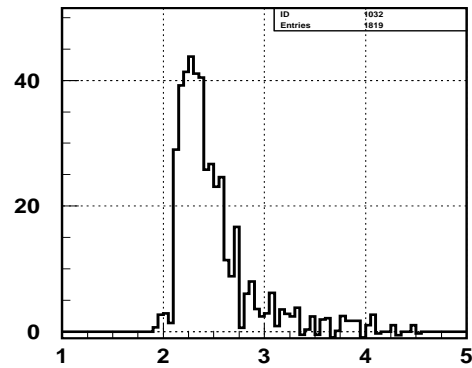
Mass(Lambda,K)



Mass(Lambda,K)

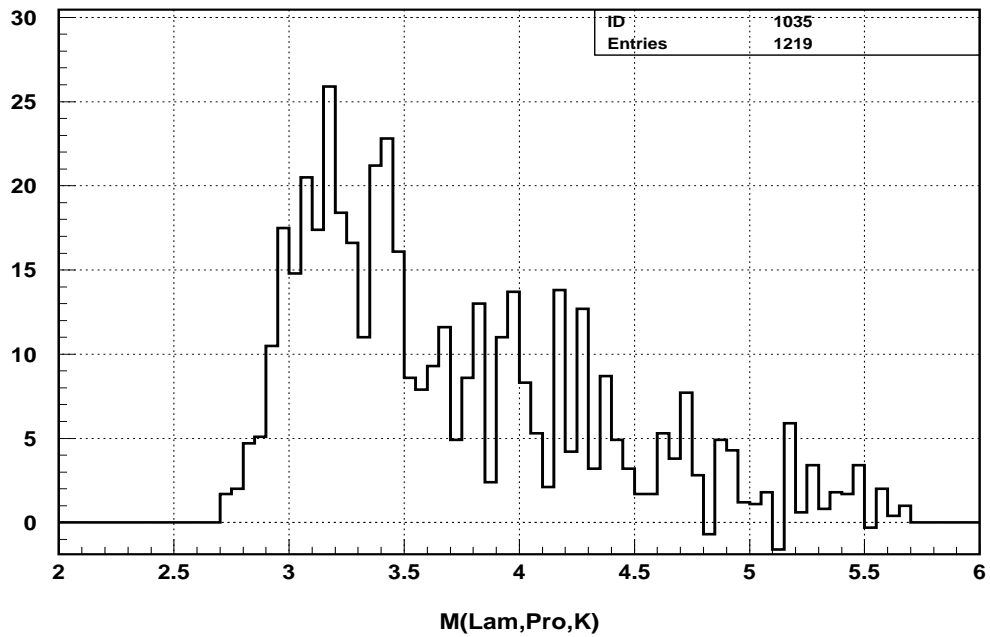
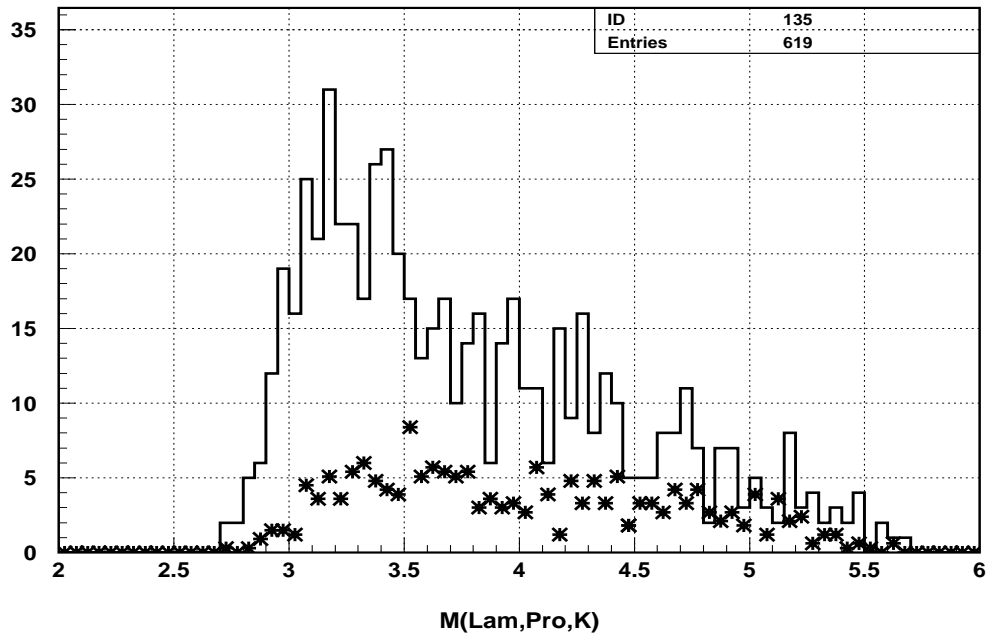


Mass(Lambda,Pro)

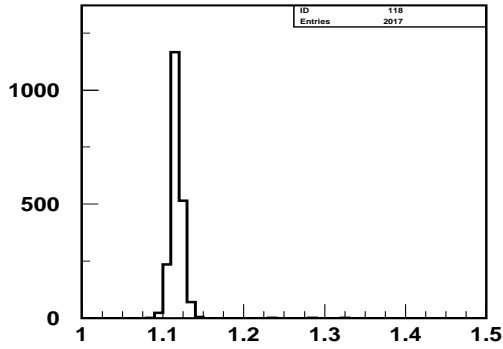


Mass(Lambda,Pro)

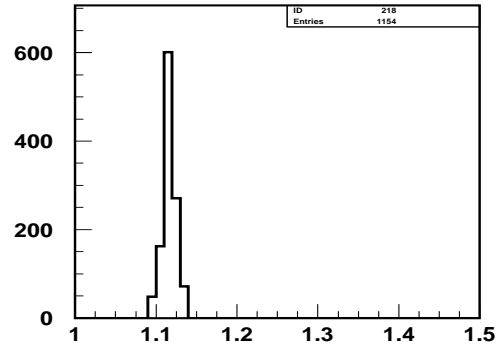
Mass($\Lambda\bar{P}K^+/\bar{\Lambda}PK^-$)



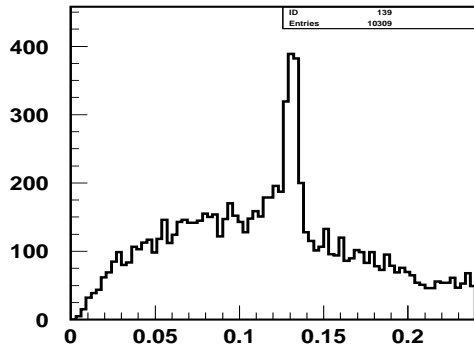
$$\gamma\gamma \rightarrow \Xi^0 \bar{\Xi}^0$$



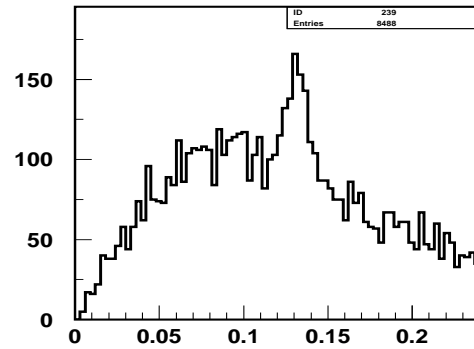
(M1+M2)/2 dM0.3 ksi mc



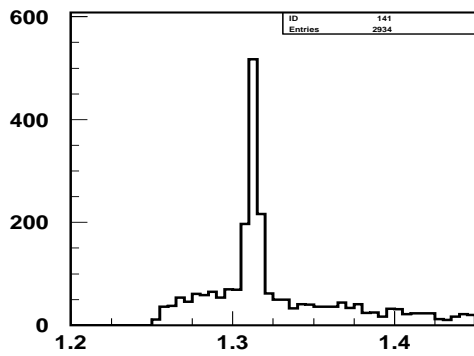
(M1+M2)/2 dM0.3 data



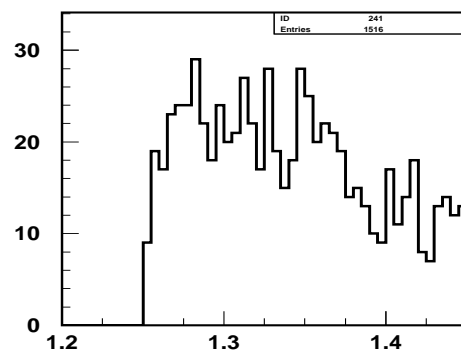
Mass(g,g) KSI MC



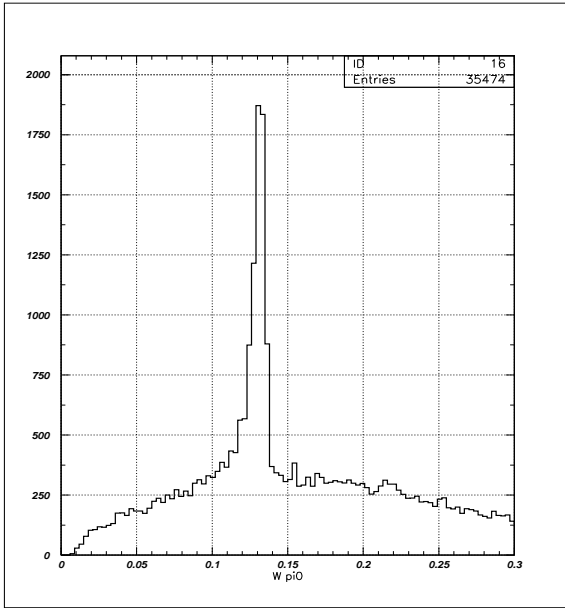
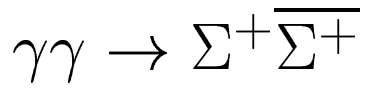
Mass(g,g) DATA



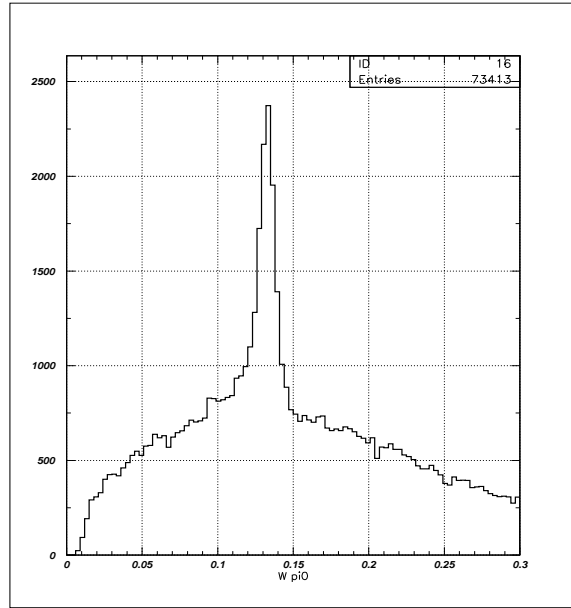
Mass(Lambda,pi0) KSI MC



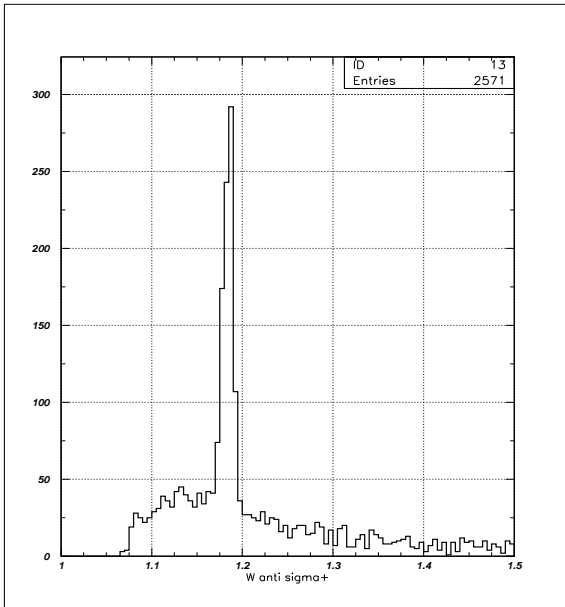
Mass(Lambda,pi0) DATA



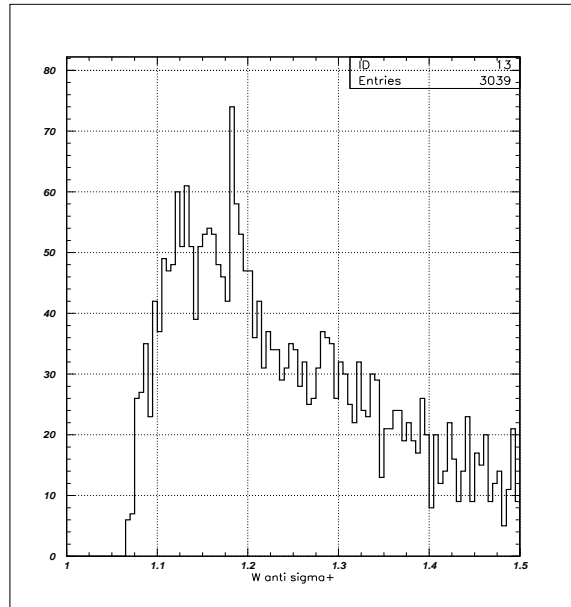
MC (5300 π^0)



Data (4400 π^0)



MC (690 $\overline{\Sigma^+}$)



Data (90 $\overline{\Sigma^+}$)

Summary

a. Preliminary results of $\gamma\gamma \rightarrow \Lambda^0\bar{\Lambda}^0$ and $\gamma\gamma \rightarrow \Sigma^0\bar{\Sigma}^0$ from 89 fb^{-1} data are presented

- Number of $\gamma\gamma \rightarrow \Lambda^0\bar{\Lambda}^0$ and $\gamma\gamma \rightarrow \Sigma^0\bar{\Sigma}^0$ are measured.
- Angular distributions of $\text{Cos}\theta^*$ of $\gamma\gamma \rightarrow \Lambda^0\bar{\Lambda}^0$ and $\gamma\gamma \rightarrow \Sigma^0\bar{\Sigma}^0$ are measured for the first time.

b. First Observation of $\gamma\gamma \rightarrow \Lambda^0 K^+ \bar{P}$

- From $\sim 1000 \gamma\gamma \rightarrow \Lambda^0 h^+ h^-$ or $\bar{\Lambda}^0 h^+ h^-$ events, ~ 500 events are $\gamma\gamma \rightarrow \Lambda^0 \bar{\Lambda}^0 \rightarrow P \bar{P} \pi^+ \pi^-$ and ~ 500 events are $\gamma\gamma \rightarrow \Lambda^0 \bar{P} K^+$ or $\bar{\Lambda}^0 P K^-$ ($P \bar{P} K^+ \pi^-$ or $P \bar{P} K^- \pi^+$)