Probe the Form Factors in decay $J/\psi \to \Sigma^0\bar{\Sigma}^0$

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Outline

Update

The angular distribution

A) The amplitude of $\Sigma^0 \to \Lambda\gamma$ decay

$$M(\Sigma^0 \to \Lambda\gamma, \Lambda \to p\pi^-) \sim 1 + \beta s_\Sigma \cdot p_\Lambda \tag{1}$$

B) The distribution is

$$\beta_\Sigma \beta_{\bar\Sigma} \Big(-\cos(\theta_1) \Big(\sqrt{1-\alpha_\psi^2}\sin(2\theta)\sin(\theta_2)\cos(\Phi)\cos(\phi_2) + 2\cos(\theta_2)\cos^2(\theta)\Big) +$$
$$\sin(\theta_1)\cos(\phi_1)\Big(\sqrt{1-\alpha_\psi^2}\sin(2\theta)\cos(\theta_2)\cos(\Phi) + 2\sin(\theta_2)\sin^2(\theta)\cos(\phi_2)\Big) +$$
$$\alpha_\psi \left(2\sin^2(\theta)\sin(\theta_1)\sin(\theta_2)\sin(\phi_1)\sin(\phi_2) - 2\cos(\theta_1)\cos(\theta_2)\right)\Big) -$$
$$2\sqrt{1-\alpha_\psi^2}\sin(\theta)\sin(\theta_2)\cos(\theta)\sin(\Phi)\sin(\phi_2)\beta_{\bar\Sigma} +$$
$$\sqrt{1-\alpha_\psi^2}\beta_\Sigma\sin(2\theta)\sin(\theta_1)\sin(\Phi)\sin(\phi_1) +$$
$$\alpha_\psi\cos(2\theta) + \alpha_\psi + 2$$

✓ Where:

$$\frac{4\,\alpha_\Lambda\left(\left(m_\Lambda^2 + m_\Sigma^2\right)\left(m_\Lambda^2 + m_p^2 - m_\pi^2\right) - 4\,m_\Lambda^2\, p_p\cdot p_\Sigma\right)}{m_\Lambda\, m_\Sigma \left(\frac{(m_\Lambda^2 - m_\Sigma^2)^2}{m_\Sigma^2}\right)^{3/2}\sqrt{\frac{(m_\pi^2 - m_\Lambda^2)^2 - 2\left(m_\Lambda^2 + m_\pi^2\right) m_p^2 + m_p^4}{m_\Lambda^2}}}$$

Likelihood

A) PDF: $\mathcal{W}(\alpha, ...; \theta, ...)$

B) Likelihood

$$\mathcal{L} = \prod_{data} \frac{\mathcal{W}}{\mathcal{N}} \tag{2}$$

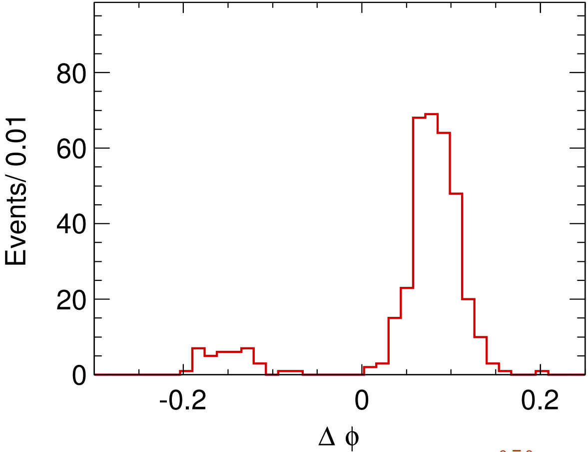
✓ The normalization factor $\mathcal{N}$ obtained by MC integral

$$\mathcal{N} = \sum \mathcal{W} \tag{3}$$

Multiple Solutions

A) There two local minimum FCNs

- ✓ Choose the solution with the minimum FCN



Fit result

A) The fit result

parameters	value
$\alpha_{J/\psi}$	-0.426 ± 0.011
Φ	0.088 ± 0.022
α_{Λ}	0.85 ± 0.20
$\alpha_{\bar{\Lambda}}$	-0.70 ± 0.17

B) fix α_{Λ} and $\alpha_{\bar{\Lambda}}$

parameters	value
$\alpha_{J/\psi}$	-0.426 ± 0.011
Φ	0.092 ± 0.022
α_{Λ}	0.75 (fixed)
$\alpha_{\bar{\Lambda}}$	-0.75 (fixed)

Comparisons

$$T_1 = \sin^2(\Theta)\sin(\Theta_1)\sin(\Theta_2)\cos(\phi_1)\cos(\phi_2) + \cos(\Theta_1)\cos(\Theta_2)\cos^2(\Theta)$$

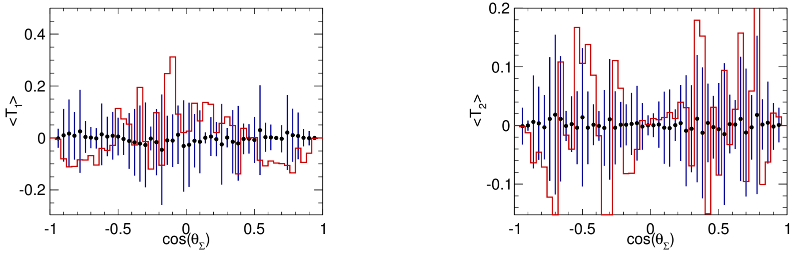
$$T_2 = \sin(\Theta)\cos(\Theta)\,(\sin(\Theta_1)\cos(\Theta_2)\cos(\phi_1) + \sin(\Theta_2)\cos(\Theta_1)\cos(\phi_2))$$

$$T_3 = \sin(\Theta)\sin(\Theta_1)\cos(\Theta)\sin(\phi_1)$$

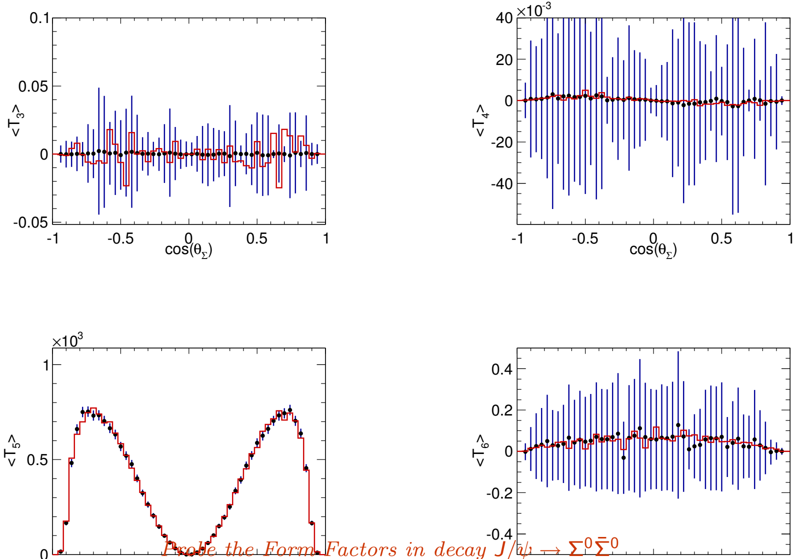
$$T_4 = \sin(\Theta)\sin(\Theta_2)\cos(\Theta)\sin(\phi_2)$$

$$T_5 = \cos^2(\Theta)$$

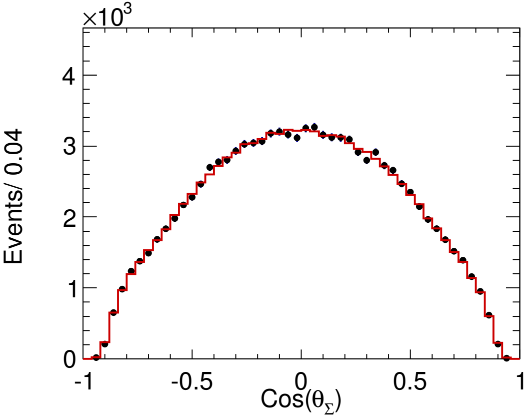
$$T_6 = \cos(\Theta_1)\cos(\Theta_2) - \sin^2(\Theta)\sin(\Theta_1)\sin(\Theta_2)\sin(\phi_1)\sin(\phi_2)$$



Comparisons (2)



Comparisons(3)

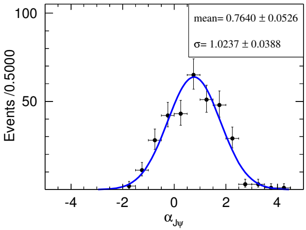


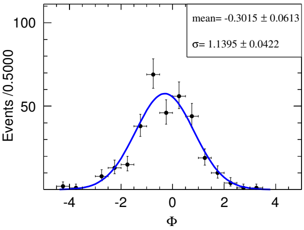
I/O check

A) Generate the MC sample with the same size as data

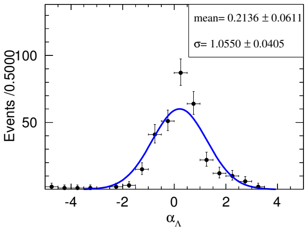
B) Repeat 300 times

C) pull value : $\frac{output - input}{\sigma}$

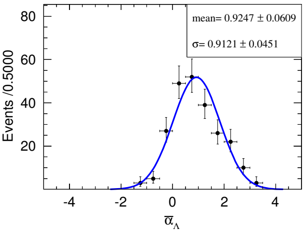




I/O check (2)



mean= 0.2136 ± 0.0611
σ= 1.0550 ± 0.0405
Events /0.5000
100
50
-4
-2
0
2
4
α_Λ

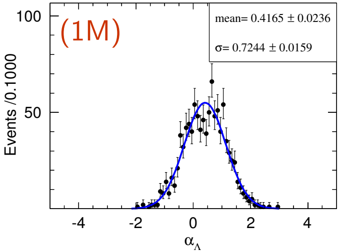


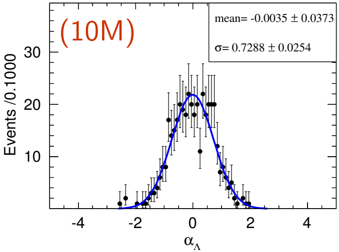
mean= 0.9247 ± 0.0609
σ= 0.9121 ± 0.0451
Events /0.5000
80
60
40
20
-4
-2
0
2
4
$\bar{\alpha}_\Lambda$

I/O check (3)

A) The small bias may be partly raised by the limited integral MC sample

B) Based on the MC truth information without any events selection requirements





Summary

A) The α_{Λ} and $\alpha_{\bar{\Lambda}}$ can't be determined well, must be fixed.

B) The phase angle Φ is first measured, and $\alpha_{J/\psi}$ is consisted with the previous value.