Decay of $\psi(2S) \to J/\psi\pi\pi$

$$\mathscr{A}\left(\Psi' \to \Psi\pi^+\pi^-\right) = -\frac{4}{F_0^2}\left\{\left[\frac{g}{2}\left(m_{\pi\pi}^2 - 2M_\pi^2\right) + g_1\left(v \cdot p_{\pi^+}\right)\left(v \cdot p_{\pi^-}\right) + g_3 M_\pi^2\right]\varepsilon_\Psi^* \cdot \varepsilon_{\Psi'}\right.$$

$$\left. + g_2\left[p_{\pi^+\mu}p_{\pi^-\upsilon} + p_{\pi^+\upsilon}p_{\pi^-\mu}\right]\varepsilon_{\Psi^*}{}^{\mu}\varepsilon_{\Psi'}{}^{\upsilon}\right\}$$

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	g	g_1	g_3	$\chi^2/d.f.$
$\psi(2S) \to J/\psi\pi^+\pi^-$	0.30 ± 0.01	− 0.11 ± 0.01	0*	25.3/24
	0.38 ± 0.03	− 0.59 ± 0.19	1.55 ± 0.58	20.1/23

- D-wave part of the dipion system and is suppresses
- Neglected in JPIPI model

$$F^J_{\lambda_1\lambda_2} = \; < JM\lambda_1\lambda_2|\mathcal{M}|JM >$$

- Construct amplitude in helicity formalism
- Only S-wave component between f_0 and J/ψ

- This part is not invariant in Lorentz transformation
- The amplitude is calculated in $\psi(2S)$ rest frame

Only S-wave

$$\mathscr{A} = \sum_{\lambda_{Z_c}}\sum_{\lambda_R}\sum_{\lambda_{\psi'}}\sum_{\lambda_{J/\psi}} A_{(Y\to\psi'\pi^+\pi^-)} \cdot \left(C \cdot F^{J_{\psi'}}_{\lambda_R,\lambda_{J/\psi}} D^{*J_{\psi'}}_{\lambda_{\psi'},-\lambda_{J/\psi}} \cdot F^{J/\psi}_{\lambda_{l^+},\lambda_{l^-}} D^{*J_{J/\psi}}_{\lambda_{J/\psi},\Delta\lambda_l}\right)$$

$$C = \left[\frac{g}{2}\left(m_{\pi\pi}^2 - 2M_\pi^2\right) + g_1\left(v \cdot p_{\pi^+}\right)\left(v \cdot p_{\pi^-}\right) + g_3 M_\pi^2\right]$$

Decay sequence $Y \to \psi(2S)\pi^+\pi^-$

$$A = \phi_\mu(m_1)\omega_\nu^*(m_2)A^{\mu\nu} = \phi_\mu(m_1)\omega_\nu^*(m_2)\sum_i \Lambda_i U_i^{\mu\nu}$$

Decay of $\psi(2S) \to J/\psi\pi\pi$

$$\mathscr{A}\left(\Psi' \to \Psi\pi^+\pi^-\right)$$
$$= -\frac{4}{F_0^2}\left\{\left[\frac{g}{2}\left(m_{\pi\pi}^2 - 2M_\pi^2\right) + g_1\left(v \cdot p_{\pi^+}\right)\left(v \cdot p_{\pi^-}\right) + g_3 M_\pi^2\right]\varepsilon_\Psi^* \cdot \varepsilon_{\Psi'}\right.$$
$$\left. + g_2\left[p_{\pi^+\mu}p_{\pi^-v} + p_{\pi^+v}p_{\pi^-\mu}\right]\varepsilon_{\Psi^*}{}^\mu \varepsilon_{\Psi'}{}^v\right\}$$

Decay of $J/\psi \to l^+l^-$

$$\mathcal{A} = ie\omega_\beta(m_2)\bar{u}_{e^-}\gamma^\beta\nu_{e^+}\frac{em_\psi}{f_\psi}$$

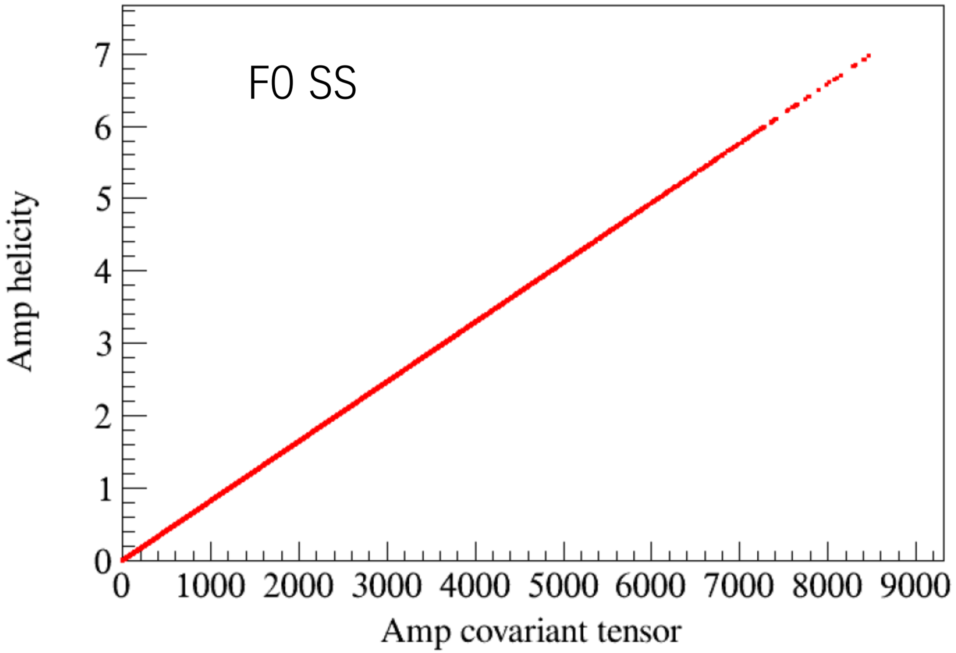
$$\mathscr{A} = \phi_\mu A^{\mu\nu}\omega_\nu^*\left(C\omega_\alpha\varepsilon^\alpha\right)\varepsilon^\beta \bar{u}_{e^-}\gamma_\beta\nu_{e^+}$$

$$C = \left[\tfrac{g}{2}\left(m_{\pi\pi}^2 - 2M_\pi^2\right) + g_1\left(v \cdot p_{\pi^+}\right)\left(v \cdot p_{\pi^-}\right) + g_3 M_\pi^2\right]$$

↓

$$\frac{d\sigma}{d\Phi_n} = 2\sum_{i,j}\Lambda_i\Lambda_j^*\sum_{\mu=1}^{2}U_i^{\mu\nu}M_{\nu\nu'}U_j^{*\mu\nu'}$$

$$M_{\nu\nu'} = CC^*\tilde{g}_{\nu\alpha}(p_{(\psi')})\tilde{g}_{\nu'\alpha'}(p_{(\psi')})\tilde{g}^{\alpha\beta}(p_{(J/\psi)})\tilde{g}^{\alpha'\beta'}(p_{(J/\psi)})$$
$$\cdot\left[p_\beta p'_{\beta'} + p'_\beta p_{\beta'} - g_{\beta\beta'}\left(p \cdot p' + p_l^2\right)\right]$$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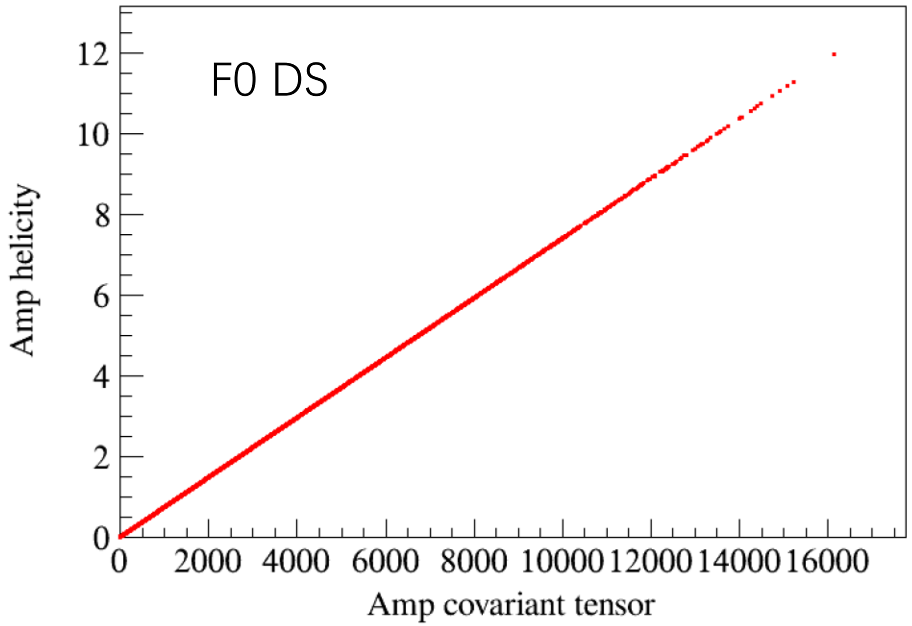
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