Angular distributions

Using spin density matrix elements

$$W(\cos\theta,\phi,\Phi)=\frac{3}{4\pi}\,[\tfrac{1}{2}(1-\rho^0_{00})+\tfrac{1}{2}(3\rho^0_{00}-1)\cos^2\theta-\sqrt{2}\,\mathrm{Re}\rho^0_{10}\sin2\theta\cos\phi-\rho^0_{1-1}\sin^2\theta\cos2\phi$$

$$-P_\gamma\cos2\Phi(\rho^1_{11}\sin^2\theta+\rho^1_{00}\cos^2\theta-\sqrt{2}\,\mathrm{Re}\rho^1_{10}\sin2\theta\cos\phi-\rho^1_{1-1}\sin^2\theta\cos2\phi)$$

$$-P_\gamma\sin2\Phi(\sqrt{2}\,\mathrm{Im}\rho^2_{10}\sin2\theta\sin\phi+\mathrm{Im}\rho^2_{1-1}\sin^2\theta\sin2\phi)\,]$$

If it is possible to choose the z axis so that s-channel helicity is conserved, W takes a particularly simple form as a function of $\Psi\equiv\Phi-\phi$, namely

$$W(\theta,\Psi)\propto(\sin^2\theta+P_\gamma\sin^2\theta\cos2\Psi). \qquad \text{(D2a)}$$

This results from the relationships

$$\rho^1_{1-1}=-\,\mathrm{Im}\rho^2_{1-1}=\tfrac{1}{2} \qquad \text{(D2b)}$$

with all other $\rho^\alpha_{ik}=0$ in (D1).

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Definition of Φ

Here, P_γ is the degree of linear polarization of the photon; Φ is the angle of the photon electric polarization vector with respect to the production plane measured in the over-all (γp) c.m. system; θ and ϕ are the polar and azimuthal angles of the π^+ in the ρ^0 rest frame. (See Fig. 12 and Ref. 36.)

Definition of z-axis

We consider the angular distribution of ρ^0 decay in three reference systems which differ in the choice of the spin-quantization axis (z axis): the *Gottfried-Jackson* system, where the z axis is the direction of the incident photon in the ρ^0 rest system; the *helicity* system, where the z axis is the direction of the ρ^0 in the over-all (γp) c.m. system, i. e., opposite to the direction of the outgoing proton in the ρ^0 rest system; and the *Adair* system, where the z axis is along the direction of the incident photon in the over-all (γp) c.m. system. The y axis is always normal to the production plane.[36] For forward-produced ρ^0 mesons, all three systems coincide.

Depending upon the production mechanism, the ρ^0 may be aligned in one of these three systems. The system which gives the simplest description of the ρ^0 is then: (1) the Gottfried-Jackson system for t-channel helicity conservation (resulting from, for example, $J^P=0^+$ exchange with no absorption); (2) the helicity system for s-channel c.m. helicity conservation; (3) the Adair system for "spin independence" in the s-channel c.m. system.[37] One

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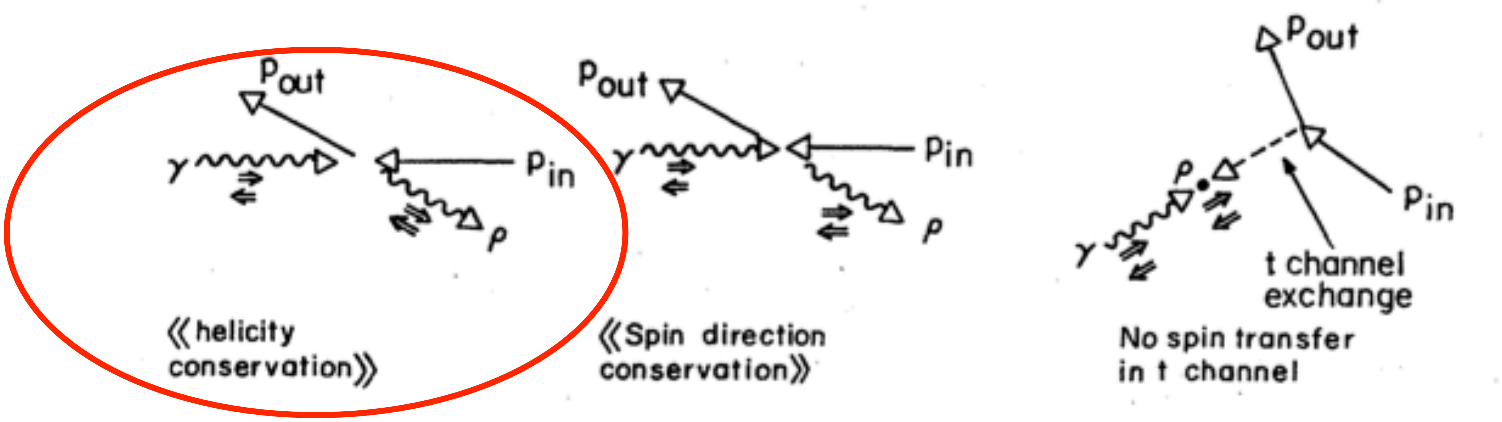
Angular Distributions in ππ rest frame

● Depending upon the production mechanism, the spin of the ρ^0 may be aligned along the z axis in one of these three systems (Gilman *et al*., 1970). The system which gives the simplest description of the ρ^0 is then: (1) The Gottfried–Jackson system for t-channel helicity conservation; (2) the helicity system for s-channel helicity conservation (SCHC); (3) the Adair system for "spin independence" in the s-channel system. Figure 85 shows a schematic representation of these three coordinate systems.



Choice of α specifies system used

- Angular distribution of π^+ is in ρ rest frame
- s-channel helicity is dominant.

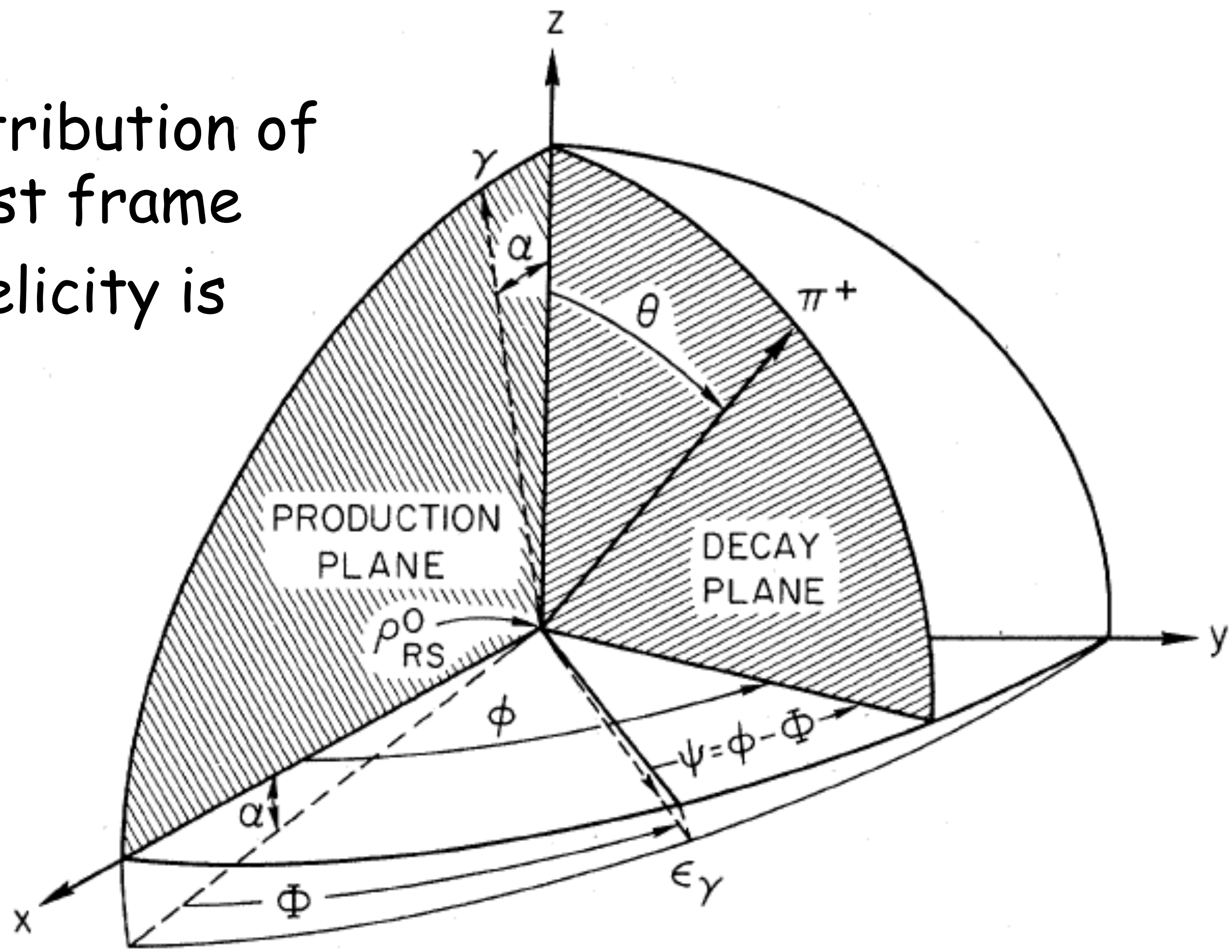


FIG. 12. Angles used in the study of ρ^0 decay. The angle α is zero in the Gottfried-Jackson system.

SCHC

$$\rho^{\alpha}_{ik} = 0, \text{ except}$$

$$\rho^{1}_{1-1} = -\,Im\,\rho^{2}_{1-1} = \frac{1}{2}$$

$$\rho^{0}_{11} = \frac{1}{2}$$

The ρ^0 decay distribution may be simplified if we use the angle $\Psi = \phi - \Phi$ which, in the forward direction, is the angle between the photon polarization and the ρ^0 decay plane. If the ρ^0 production mechanism conserves s-channel helicity, i.e., the ρ is transverse and linearly polarized like the photon, then in the helicity system

$$\rho^{1}_{1\,-1} = -\mathrm{Im}\rho^{2}_{1\,-1} = \tfrac{1}{2} \tag{6}$$

and all other ρ^{α}_{ik} in *Eq. (2)* are 0. In these circumstances Ψ is the azimuthal angle in the helicity system of the decay π^+ with respect to the ρ^0 polarization plane and the decay angular distribution is proportional to $\sin^2\theta\cos^2\Psi$. The distribution of Ψ is also related to P_σ if the helicity-flip terms are zero: For 100% linear polarization the decay is $\sin^2\theta\cos^2\Psi$ for $P_\sigma = +1$ while for $P_\sigma = -1$ the decay distribution is $\sin^2\theta\sin^2\Psi$.